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ABSTRACT

This packet contains learning modules designed for a self-paced course in aircraft environmental systems mechanics that was developed for the Air Force. Learning modules consist of some or all of the following materials: objectives, instructions, equipment, procedures, information sheets, handouts, workbooks, self-tests with answers, review section, tests, and response sheets. Topics covered in the learning modules are the following: air conditioning system, temperature control system, air supply, wiring, anti-icing system, maintenance management, inspection system, maintenance system, technical order system, aircraft hardware, Ohm's Law, series circuits, parallel circuits, series-parallel circuits, relays, DC motors, temperature-controlling bridge circuits, temperature control circuits wiring, alternating current, capacitance, inductance, AC motors, solid state devices, magnetic amplifiers, trainer aircraft air conditioning systems, decade resistors, fighter bleed air systems, temperature control panel, windshield temperature control circuit, rain removal system, and refrigeration system. (KC)

AIRCRAFT ENVIRONMENTAL SYSTEMS MECHANIC

PART 2

Chanute Technical Training Center
Chanute Air Force Base, Illinois

Technical Training

Aircraft Environmental Systems Mechanic

EQUIPMENT AIR CONDITIONING SYSTEM

8 March 1982

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

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RGL: 9.3

OBJECTIVE

After completion of this programmed text, you will associate each equipment air conditioning component with its operation with a minimum of 80% accuracy.

INSTRUCTIONS

This programmed text presents information in small steps called "frames." After each frame you are asked to respond to the information in some way. Read the material and make your response. Compare your answers with the correct answers given on the top of the next frame. If you find you are incorrect, reread the frame to get the correct information. If you are right, and you understand the information presented in that frame, proceed on to the next frame. DO NOT skip ahead unless the text directs you to do so.

Remember, you are not graded on how fast you go. You will, however be required to take an appraisal on the material to determine what you have learned.

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In this text we will cover the operation of the third air conditioning system. The first one was the system on the trainer aircraft. It was the basic air conditioning system. The second one was the cabin system on the more complex fighter aircraft.

The third system is also on the fighter aircraft. It is known as the equipment air conditioning system. As its name implies, it is an air conditioning system for the equipment.

Now you're asking yourself, "What equipment?" Well, certain electronic equipment on the aircraft will get hot during continuous operation. This can be compared to a radio or TV set. If you leave the set on for awhile, you can feel the heat coming from the back of the set. You can imagine how much damage this heat could do if it was allowed to increase. You can see that if a small air circulating fan were mounted inside your TV, the TV tubes would last longer. This will give you an idea as to why it would be beneficial to have a complete air conditioning system just for cooling the electronic equipment in an aircraft.

Here are three good reasons for having an equipment cooling system.

1. Extends component life (makes them last longer).

2. Prevents critical resistors from changing their value.

3. Prevents heat damage to equipment located in the same area, such as electrical wiring, fuel lines, etc.

Fill in the blanks to complete the following statements.

1. Keeping electronic components cool will make the components ____________ ______________.

2. The equipment cooling system is used to cool ____________ equipment.

3. The main purpose of the equipment air conditioning system is to remove the ______________ generated by certain electronic equipment.

Answers to Frame 1: 1. last longer 2. electronic 3. heat

Frame 2

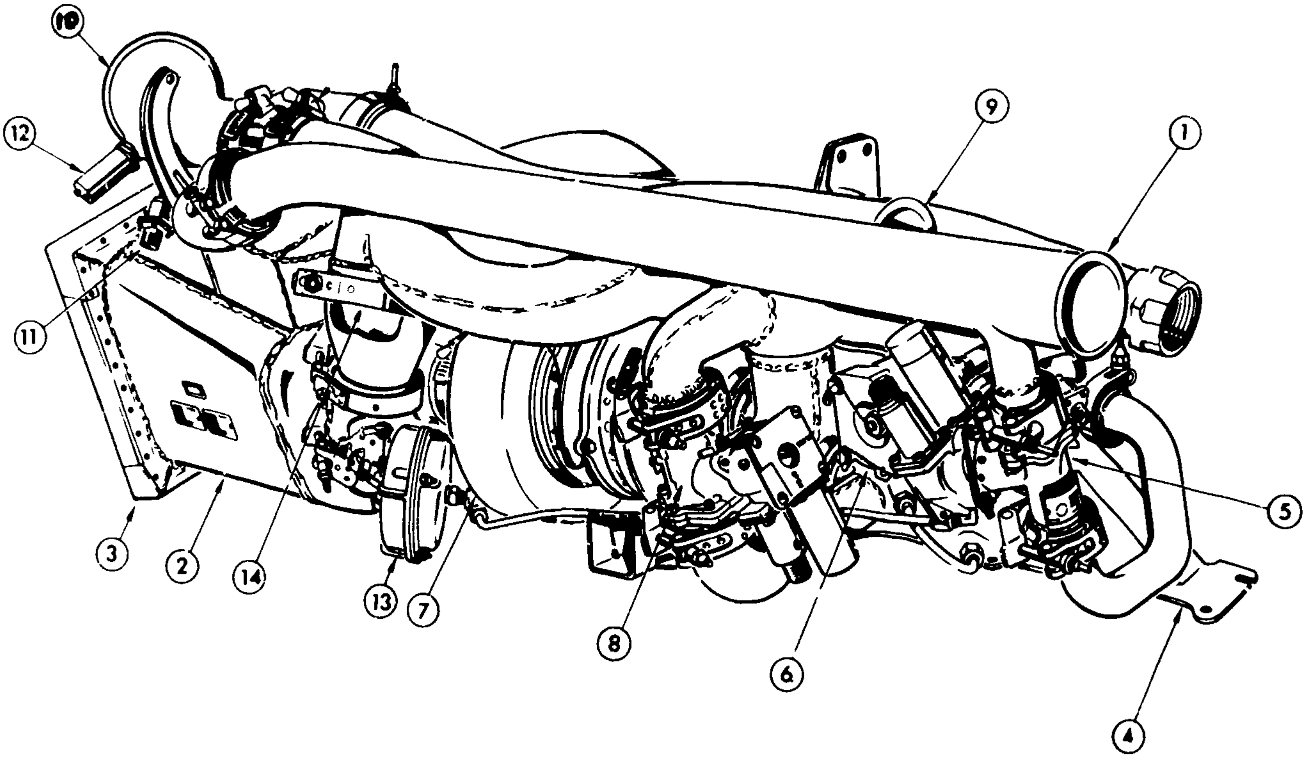
The air conditioning components for the equipment air conditioning system are grouped into an assembly called the "EQUIPMENT REFRIGERATION UNIT." This unit is often referred to as the air conditioning package.

The illustration on the opposite page shows the equipment refrigeration unit. The numbered arrows point to the major components and to the air inlet and outlets. These items, with corresponding numbers are listed below.

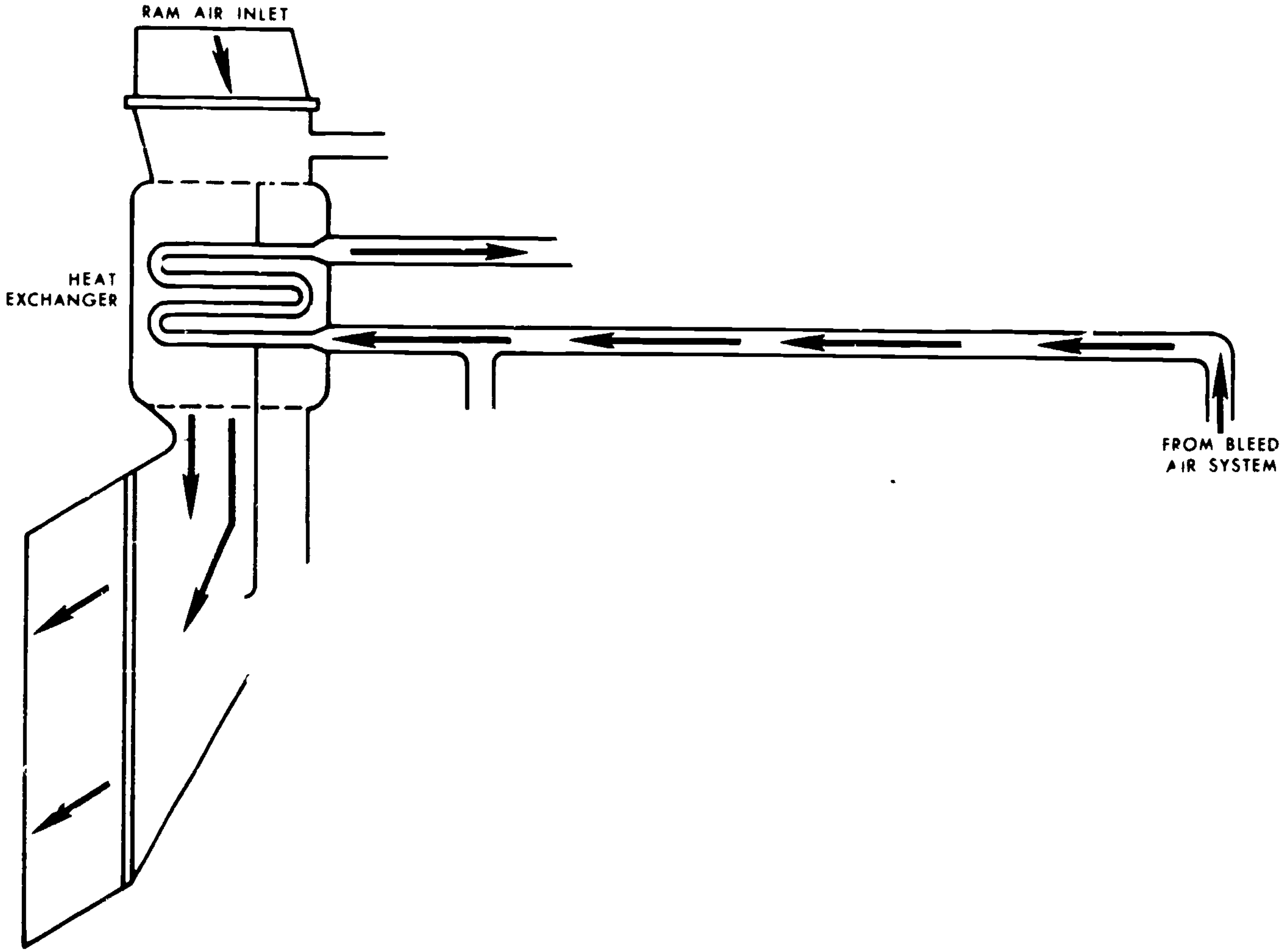
1. Engine bleed air inlet duct
2. Heat exchanger
3. Ram air inlet duct
4. Ram air outlet duct
5. Ground cooling ejector shutoff valve
6. Pressure regulator and shutoff valve
7. Turbine assembly
8. Turbine bypass valve
9. Equipment air outlet duct
10. Radar compartment air outlet
11. Temperature sensor
12. Temperature limiter
13. Ram air shutoff valve
14. Ram air check valve

In the frames that follow, each of these components will be described. As each component is described, you should refer back to the illustration of the refrigeration unit. This will help you see how each component makes up part of this system.

NO RESPONSE REQUIRED



1. Engine bleed air inlet.
2. Heat exchanger.
3. Ram air inlet duct.
4. Ram air exit duct.
5. Ground cooling ejector shutoff valve.
6. Pressure regulator and shutoff valve.
7. Turbine assembly.
8. Turbine bypass valve.
9. Equipment air outlet duct.
10. Radar compartment air outlet duct.
11. Temperature sensor.
12. Temperature limiter.
13. Ram air shutoff valve.
14. Ram air check valve.


RAM AIR INLET
HEAT EXCHANGER
FROM BLEED AIR SYSTEM

In several of the following frames, small schematic diagrams will be used to show you how the air flows through this system. These diagrams are simplified and will show only a part of the system. As you progress through the text, components will be added until the system is complete.

For example, the diagram on page 6 shows only the flow of air from the bleed air system to the heat exchanger. By following the airflow on these diagrams, it should make it easier for you to see how each component fits into this system.

From your studies of the trainer and fighter type aircraft cabin air conditioning systems, you should recall that the source of air for the air conditioning systems is from the engine bleed air system. Remember, this is hot high pressure air.

In the previous systems that you studied, the first unit in the system was the shutoff valve. Well, the equipment system is different. The first unit in this system is the <u>heat exchanger</u>. A system shutoff valve is used, but in this system, it's located after the heat exchanger.

Follow the arrows in the diagram and notice that the bleed air flows to the heat exchanger. This is an <u>air-to-air type heat exchanger</u>, similar to the cabin system heat exchanger. The bleed air flows <u>through</u> the tubes of the heat exchanger. Ram air flows in the ram air inlet, <u>over</u> the tubes and out the ram air outlet.

The heat from the bleed air is transferred to the ram air and carried overboard through the ram air outlet. The heat exchanger is the <u>first</u> stage of cooling for this system. The bleed air leaving the heat exchanger is referred to as "partially cooled air."

Remember, the ram air flows across the heat exchanger for cooling. It <u>does not</u> mix with the bleed air.

Fill in the blanks to complete the following statements.

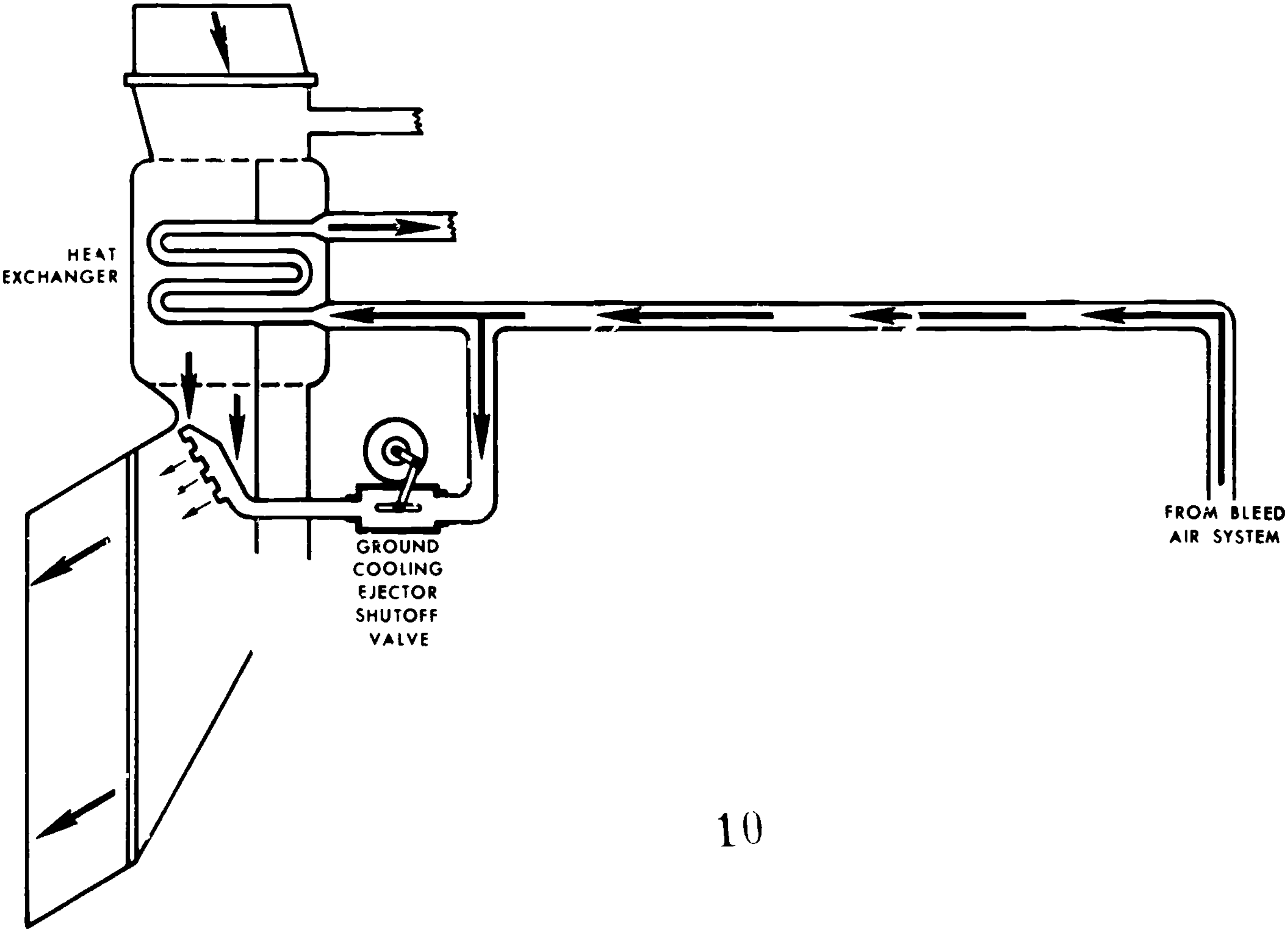
1. The unit that partially cools the bleed air is the ________ __________________.

2. The heat exchanger is the ______________ stage of cooling.

3. The source of air for the equipment air conditioning system is the _________ __________ system.

4. As the bleed air passes through the heat exchanger, the heat is removed by the ___________ ___________.

5. The engine bleed air leaving the heat exchanger is called ____________ _____________ air.


RAM AIR INLET
HEAT EXCHANGER
GROUND COOLING EJECTOR SHUTOFF VALVE
FROM BLEED AIR SYSTEM

Answers to Frame 3: 1. heat exchanger 2. first 3. bleed air 4. ram air 5. partially cooled

Frame 4

During flight, the forward movement of the aircraft provides sufficient ram airflow for heat exchanger operation. However, when the aircraft airspeed is low or the aircraft is on the ground, ram airflow stops. Naturally, if there is no cooling ram airflow, heat exhanger efficiency is lost.

Remember, on the cabin system, a ground cooling ejector assembly was used to pull ram air across the heat exchanger. The equipment system also has a ground cooling ejector assembly that serves the same purpose and operates the same way. The ejector assembly consists of a ground cooling ejector shutoff valve and an ejector nozzle.

In the illustration on page 8, notice that bleed air is tapped from the hot air duct before it enters the heat exchanger. This air is directed to the ground cooling ejector shutoff valve.

When the landing gear handle is placed to the gear down position, a microswitch on the gear handle directs electrical power to the open side of the valve. The ground cooling ejector shutoff valve then moves to the open position. This allows the bleed air to spray out of the ejector nozzle.

This action, you should recall, causes air to be pulled in the ram air inlet, thereby creating a "ram" air action across the heat exchanger. This action lets the heat exchanger operate as if it were actually getting cooling air by ram action.

Fill in the blanks to complete the following statements.

1. The ground cooling ejector assembly consists of a ground cooling ejector __________ __________ and an ejector ______________.

2. The ground cooling ejector shutoff valve is controlled by a switch on the ______________ ______________ ______________.

3. Directing bleed air through the ejector nozzle causes ______________ air to flow over the heat exchanger tubes.

Energize the auxiliary relay, pulling its armature down. This will not direct electrical power to the open side of the ejector valve.

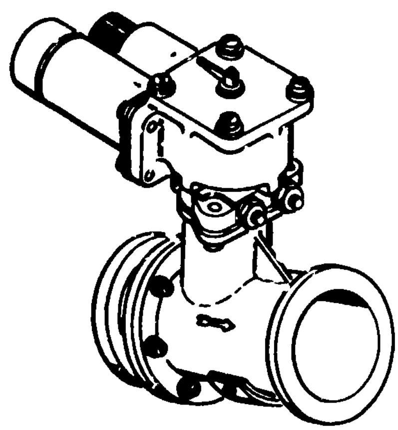
Answers to Frame 4: 1. shutoff valve nozzle 2. landing gear handle

3. ram

Frame 5

The equipment system ground cooling ejector shutoff valve, illustrated below, is identical to the ground cooling ejector shutoff valve used in the cabin air conditioning system.

It is a butterfly type valve, actuated by a 28 volt DC motor. The valve has a position indicator (pointer) that shows when the valve is open or closed.



Fill in the blanks to complete the following statements.

1. The unit that controls the airflow to the ground cooling ejector nozzle is the ground cooling __________________ __________________ ______________.

2. For the ground cooling ejector assembly to operate, the landing gear handle must be __________________ (up/down).

3. The ground cooling ejector shutoff valve is actuated by a __________V DC ______________.

4. When the landing gear handle is in the gear up position, 28V DC is directed to ______________ (open/close) the ground cooling ejector shutoff valve.

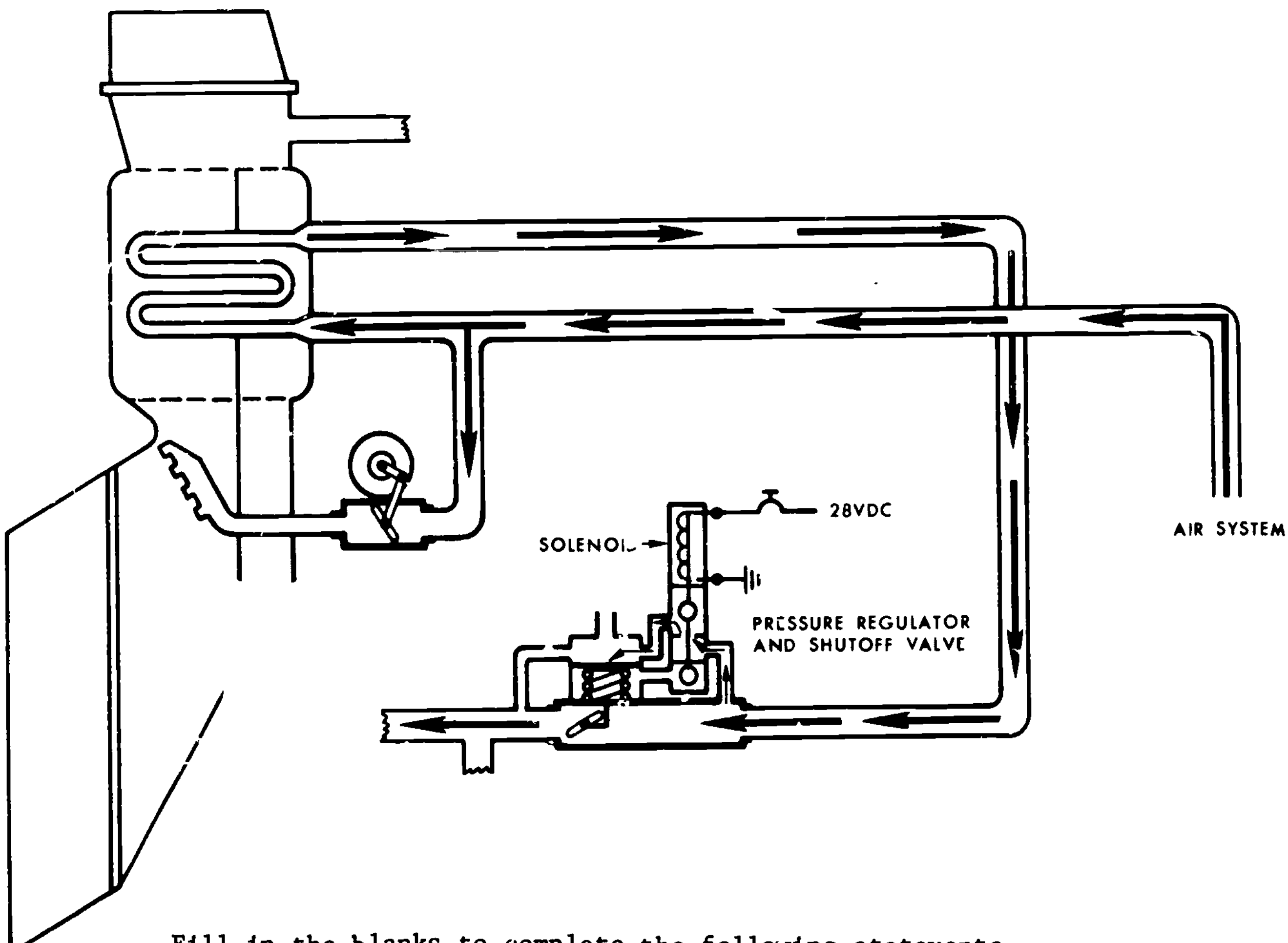
Answers to Frame 5: 1. ejector shutoff valve 2. down 3. 28, motor
4. close

Frame 6

After the air is partially cooled by the heat exchanger it goes to the pressure regulator and shutoff valve. The illustration below shows the pressure regulator and shutoff valve. The arrows show the bleed airflow through the heat exchanger and pressure regulator and shutoff valve.

The equipment system pressure regulator and shutoff valve is similar to the cabin system pressure regulator and shutoff valve. Remember, it served two purposes. The equipment system pressure regulator and shutoff valve also serves two purposes.

The two purposes are just as the name implies, that is, to serve as a control for stopping or starting the system, and for regulating the pressure going through the equipment air conditioning system. The pressure is regulated at 106 psi.



Fill in the blanks to complete the following statements.

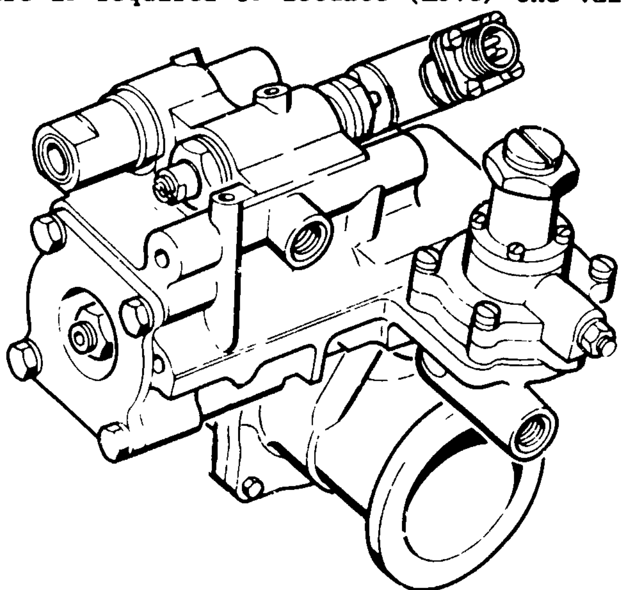
1. The unit that controls the pressure of the partially cooled air is the ________ ________ and shutoff valve.
2. The unit used to shutoff the equipment air conditioning system is the ________ ________ ________ ________ ________.

Answers to Frame 6: 1. <u>pressure regulator</u> 2. <u>pressure regulator and shutoff valve</u>

Frame 7

The pressure re, ulator and shutoff valve, shown below, is a <u>solenoid controlled</u>, <u>air actuated valve</u>.

This means electrical power is required to energize the solenoid and air pressure is required to actuate (move) the valve open.



Referring back to the illustration in frame 6, note that air is tapped off upstream of the butterfly and sent through the solenoid to the valve actuator.

When the solenoid is energized, as shown, this air is sent to the top of the actuator which forces the actuating piston down. This opens the valve.

When the solenoi- deenergized, air is vented from the top of the actuator which ... the spring close the valve. However, air is also sent from ...noid to the bottom of the actuator where it aids the spring and insures positive closing of the valve.

When the valve opens, the downstream pressure builds up to 106 psi. This pressure is sensed by a pressure control device on the valve. The press e control device causes the valve to maintain a partially open position, sufficient to maintain the 106 psi through the system.

The illustration in frame 6 also shows a basic electrical schematic for solenoid operation. Notice that power goes directly from the circuit breaker to the solenoid. There is no control switch for turning the system on or off.

Under normal conditions, when electrical power is applied to the aircraft, the pressure regulator and shutoff valve solenoid will be energized. Then as the engines are started and bleed air is available, the equipment air conditioning system will start operating automatically.

If it is desired to shut this system off, the equipment cooling circuit breaker can be pulled. This will stop electrical current going to the solenoid, causing the solenoid to deenergize, closing the pressure regulator and shutoff valve.

Fill in the blanks to complete the following statements.

1. The pressure regulator and shutoff valve is controlled by a __________ and actuated by __________ __________.

2. When the solenoid is deenergized, the valve is closed by __________ tension and __________ __________.

3. When the engines are operating, to turn off the equipment air conditioning system, the __________ __________ must be pulled.

4. Operation of the pressure regulator and shutoff valve, requires __________ __________ and __________ power.

5. The pressure regulator and shutoff valve will maintain a constant pressure of _____ psi.

Answers to Frame 7: 1. solenoid air pressure 2. spring air pressure

3. circuit breaker 4. air pressure 28V DC

5. 106

Frame 8

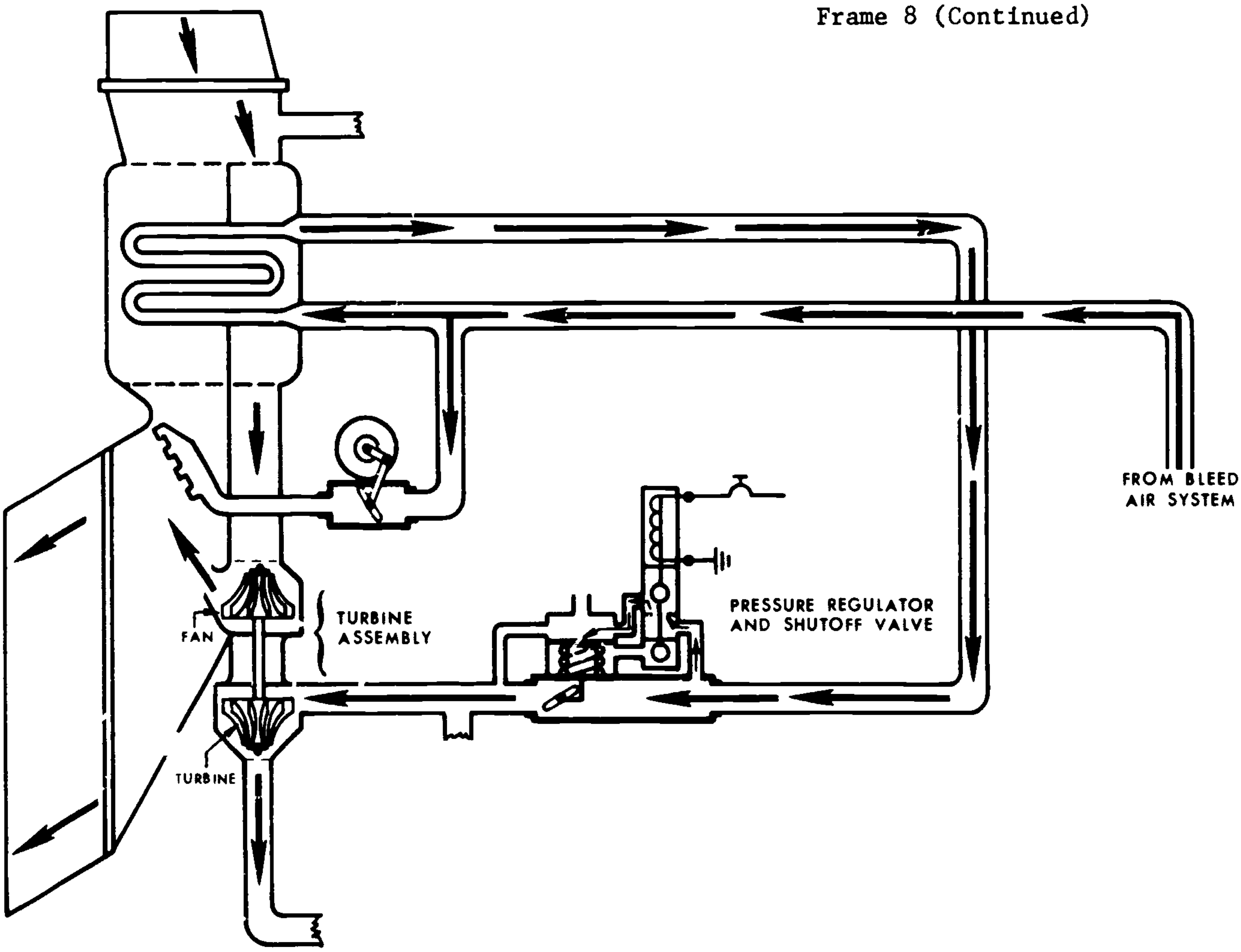
The sketch below shows the partially cooled air flowing to the turbine inlet of the turbine assembly. The turbine assembly is the second and final stage of cooling for this system.

The partially cooled bleed air is piped to the inlet of the turbine assembly. This air spins the turbine, lets go of its heat energy, and comes out of the turbine outlet as very cold air. The operation of this turbine assembly is the same as those you have studied previously.

As the air goes in the turbine inlet, it passes through several small nozzles which direct the air to the turbine wheel. This will cause the turbine wheel to spin and will result in rapid expansion of the air. When air is expanded, the temperature drops. This process of cooling the air is known as rapid expansion.

Note in the sketch that the turbine and fan are connected by a shaft. As the turbine wheel spins it also turns the fan. The fan pulls ram air in through the ram air inlet, and over the heat exchanger tubes.

The ram air passes through the fan and is discharged overboard. In this process the fan is putting a workload on the turbine. By putting a workload on the turbine, the fan is taking energy from the turbine. This takes the heat energy from the air and converts it to mechanical energy. By putting a workload on the turbine, the fan also helps to keep the turbine from overspeeding.



Fill in the blanks to complete the following statements.

1. The partially cooled air contains energy in the form of _____________ energy.

2. When the air drives the turbine and fan, the heat energy is changed to _____________ energy.

3. The turbine assembly cools air by ___________ ___________ and by changing _____________ energy to ________________ energy.

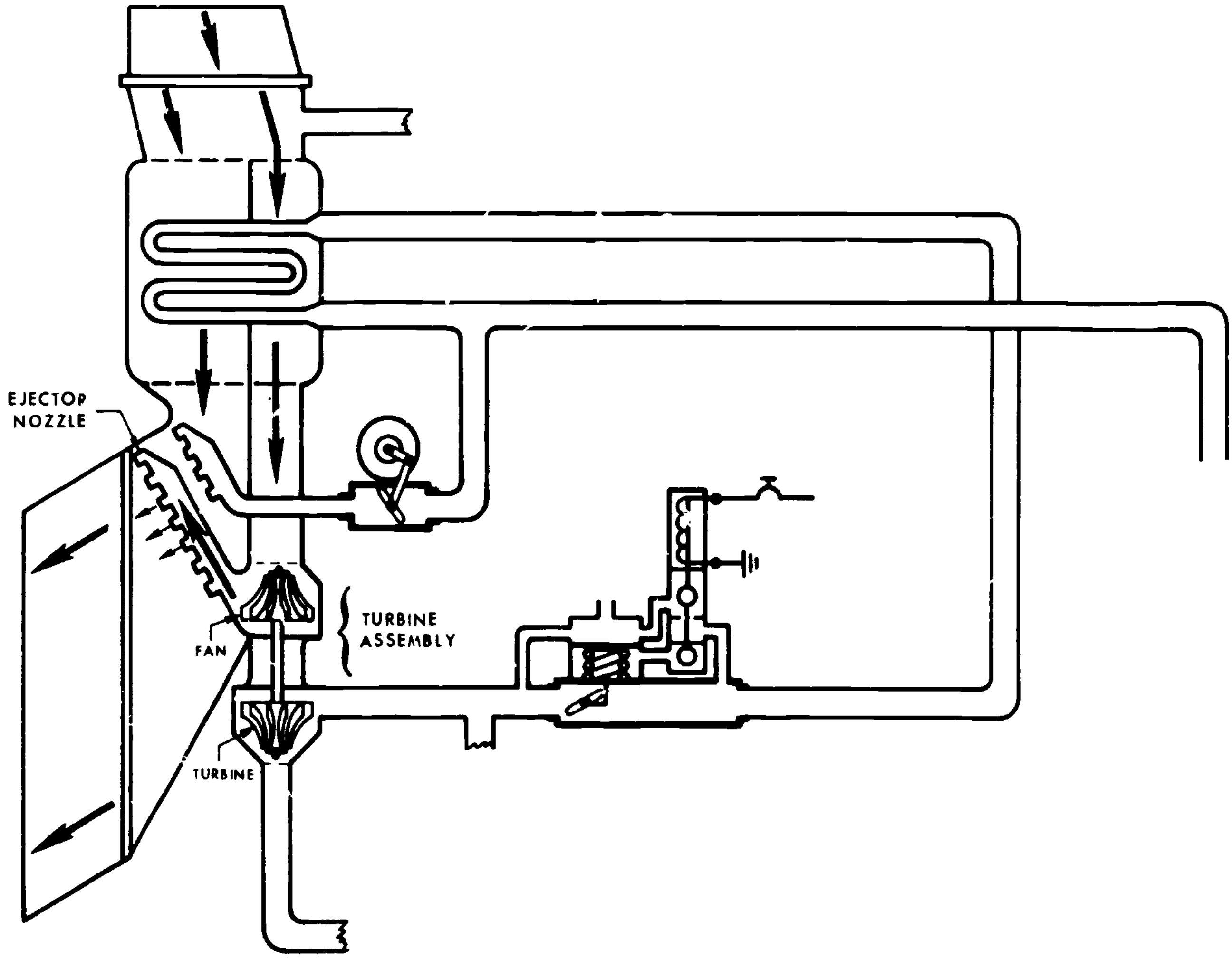
4. The fan pulls _____________ air over the heat exchanger tubes.

Answers to Frame 8: 1. heat 2. mechanical 3. rapid expansion heat mechanical
4. ram

Frame 9

The sketch below shows a second ejector nozzle. Note how the air from the fan is directed through this nozzle. The action of the fan and this ejector nozzle increases the ram airflow across the heat exchanger.

The fan pulls ram air across the heat exchanger, and as this air is discharged through the fan ejector nozzles, it causes a low pressure area behind the nozzle assembly. The low pressure area then causes air to be pulled in through the ram air inlet and across the heat exchanger.



Fill in the blanks to complete the following statements.

1. The fan and ejector nozzle help to pull ________ ________ across the heat exchanger.

2. The airflow across the heat exchanger is increased when the aircraft is on the ground and in flight by the ___________ and ___________ ___________.

Answers to Frame 9: 1. <u>ram air</u> 2. <u>fan</u> <u>ejector nozzle</u>

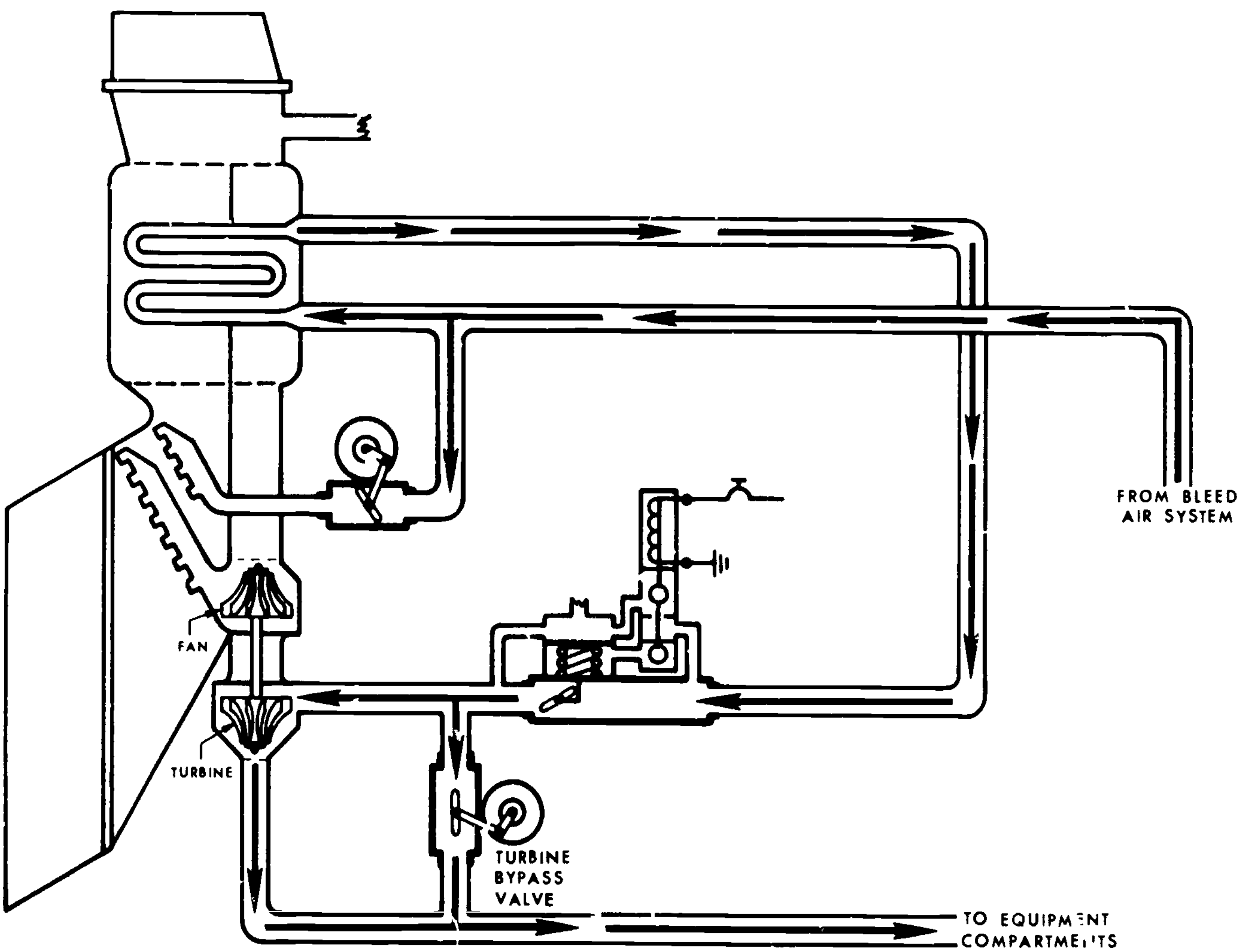
Frame 10

In the system that we have assembled so far, we can get only cold air. From the previous systems that you have studied, you should recall that temperature can be controlled by mixing the hot and cold air together. Let us see how it is done in this system.

In the sketch shown, a turbine bypass valve has been added. The purpose of this valve is to control the temperature of the conditioned air going to the electronic equipment compartments. It does this by either directing the partially cooled air in or by bypassing the turbine.

If the system calls for cold air, the valve starts to <u>close</u>, directing more air to the turbine. Now the electronic compartments get cold air.

If the system calls for hotter air, the bypass valve <u>opens</u> and air bypasses the turbine. Now the electronic equipment compartments get warm air. The desired temperature is kept by mixing the cold air from the turbine and the warm air from the turbine bypass valve.



Frame 10 (Continued)

Fill in the blanks to complete the following statements.

1. The temperature of the air entering the equipment compartments is controlled by the position of the ____________ ____________ ____________.

2. When the turbine bypass valve is fully closed, the air entering the equipment compartments will be ____________ (cold/hot).

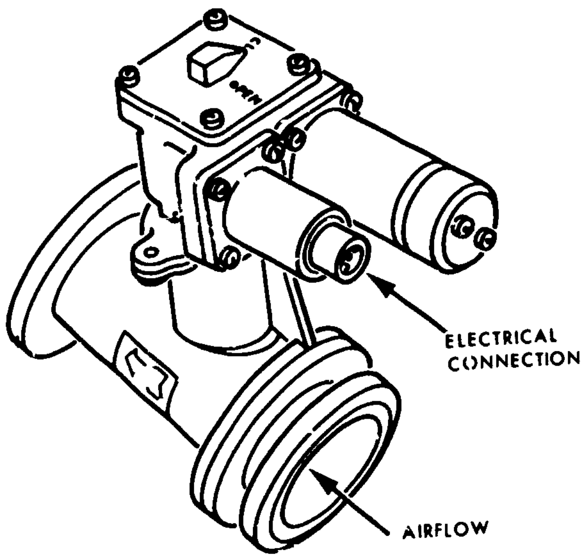
3. If the system calls for warmer air, the turbine bypass valve will move toward the ____________ (open/closed) position.

Answers to Frame 10: 1. turbine bypass valve 2. cold 3. open

Frame 11

The turbine bypass valve is shown below. This is a butterfly type valve, actuated by a 28 volt DC motor.

A position indicator is found at the top of the actuator. The position indicator shows the position of the butterfly and is marked OPEN-CLOSED.



Remember, when the valve is OPEN, the system is getting maximum hot air.

When the valve is closed, the system will receive maximum cold air.

Control of this valve is fully automatic. There is no manual control of this system as there is in the cabin system.

Fill in the blanks to complete the following statements.

1. The turbine bypass valve is actuated by a ________________ ______________ ________________.

2. When the turbine bypass valve is installed on the refrigeration unit, the position of the butterfly can be determined by observing the __________ ________________.

3. Operation of the turbine bypass valve is completely ________.

4. The desired temperature is maintained in the electronic compartments by mixing ________ and __________ air.

5. Any time the equipment air conditioning system is on, operation of the turbine bypass valve is fully _____________.

Answers to Frame 11: 1. <u>28V DC</u> <u>motor</u> 2. <u>position</u> <u>indicator</u> 3. <u>automatic</u> 4. <u>hot</u> <u>cold</u> 5. <u>automatic</u>

Frame 12

This frame is designed to check your understanding of the information that has been given so far. You are to fill in the blanks to correctly complete each of the following statements. Completing the statements may require one or more words. Try to complete each statement without looking back. Then check your answers at the back of the text. If your answers are incorrect, then back up and reread the frame that gave the information.

1. The first stage of cooling is the __________ __________.

2. As the bleed air flows through the heat exchanger, the heat is transferred to the __________ __________.

3. The unit that helps to pull ram air across the heat exchanger when the aircraft is on the ground is the __________ __________ __________ __________.

4. The ground cooling ejector shutoff valve is controlled by the __________ __________ __________.

5. The ground cooling ejector shutoff valve is actuated by a __________ __________ _____.

6. The unit that controls system pressure at 106 psi is the __________ __________ and __________ __________.

7. The pressure regulator and shutoff valve is __________ controlled and __________ actuated.

8. The pressure regulator and shutoff valve is held closed by __________ __________ and __________ __________.

9. The pressure regulator and shutoff valve will open when the solenoid is __________.

10. The second stage of cooling for the equipment system is the __________ __________.

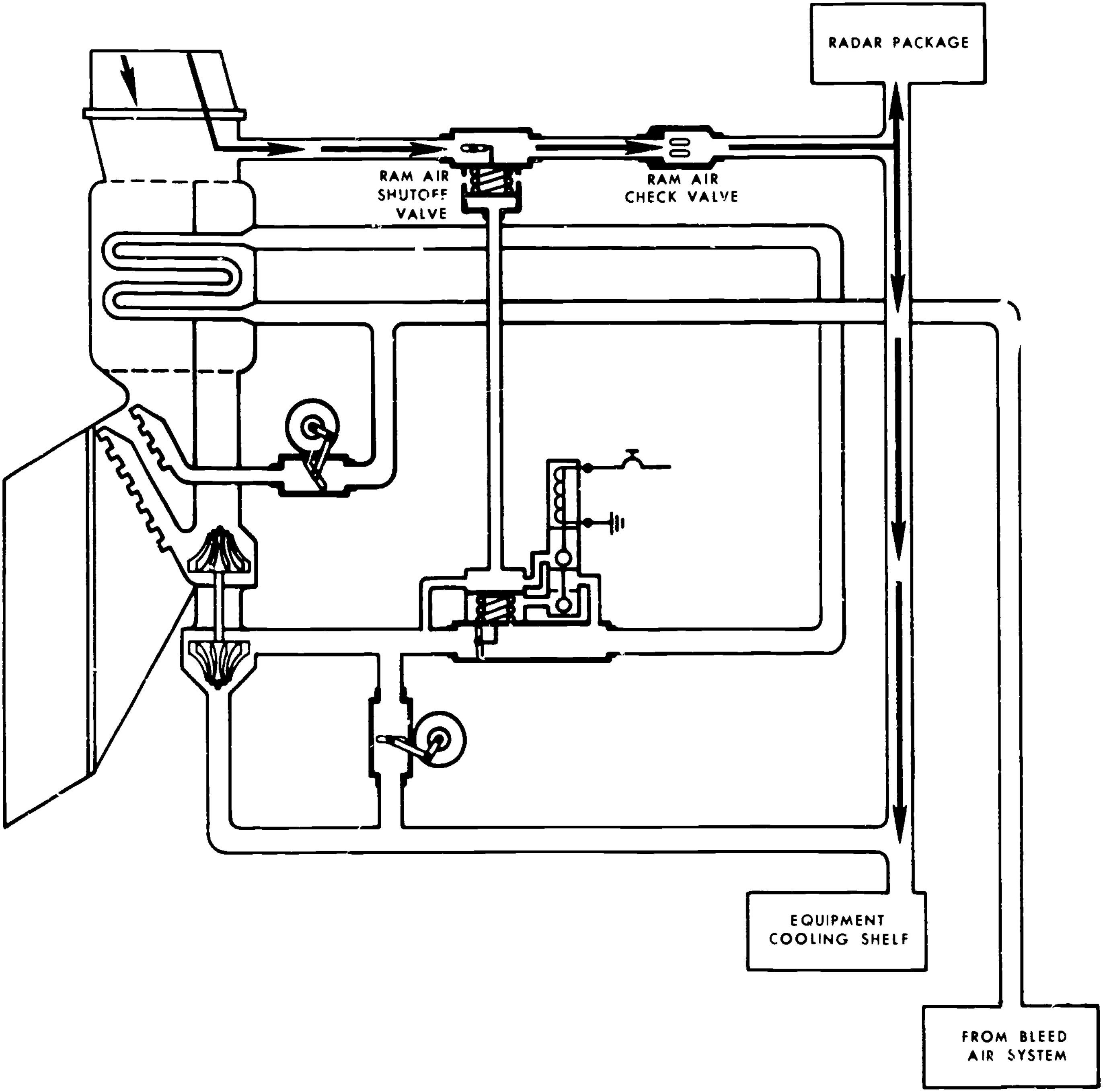
11. The unit that directs bleed air either into or around the turbine assembly is the __________ __________ __________.

12. The turbine assembly is driven by __________ __________.

13. Temperature control is accomplished by mixing __________ and __________ __________.

14. During flight, the units that help to pull ram air across the heat exchanger are the __________ and __________ __________ nozzles.

15. With the turbine bypass valve closed, if the system fails to deliver cold air, either in flight or on the ground, a probable defective unit would be the __________ __________.


RADAR PACKAGE
RAM AIR
SHUTOFF
VALVE
RAM AIR
CHECK VALVE
EQUIPMENT
COOLING SHELF
FROM BLEED
AIR SYSTEM

Answers to Frame 12: 1. heat exchanger 2. ram air 3. ground cooling ejector assembly 4. landing gear handle 5. 28V DC motor 6. pressure regulator and shutoff valve 7. solenoid air 8. spring tension air pressure 9. energized 10. turbine assembly 11. turbine bypass valve 12. bleed air 13. hot and cold air 14. fan fan ejector 15. turbine assembly

Frame 13

Like any other system, there is always the chance of a malfunction that would cause the air conditioning system to be inoperative. For example, the pressure regulator and shutoff valve could fail to work and stay closed, or the system could overheat due to the loss of the turbine assembly or the bypass valve.

In any case, this would stop the flow of conditioned air to the electronic compartments. However, it is important that some form of cooling air be available to prevent complete failure of the electronic equipment.

In case of failure of the air conditioning system, a ram air shutoff valve is provided that will open automatically and allow ram air to flow through the electronic equipment compartments. This is an emergency way to get some cooling airflow.

The sketch on the opposite page shows the ram air shutoff valve and a ram air check valve added to our system. The check valve will be explained in a later frame.

The ram air shutoff valve will be open any time the pressure regulator and shutoff valve is closed. Notice that when the ram air valve is open, ram air can flow from the ram air inlet, through the ram air shutoff valve and to the electronic compartments.

Control of the ram air valve is completely automatic. During normal operation of the air conditioning system, the ram air valve will be held closed by air pressure from the pressure regulator and shutoff valve. If there is no bleed air in the system, or if the pressure regulator and shutoff valve is deenergized, the ram air valve will be opened by spring tension.

Fill in the blanks to complete the following statements.

1. In case of failure of the air conditioning system, the electronic equipment will be cooled by ________ ________.

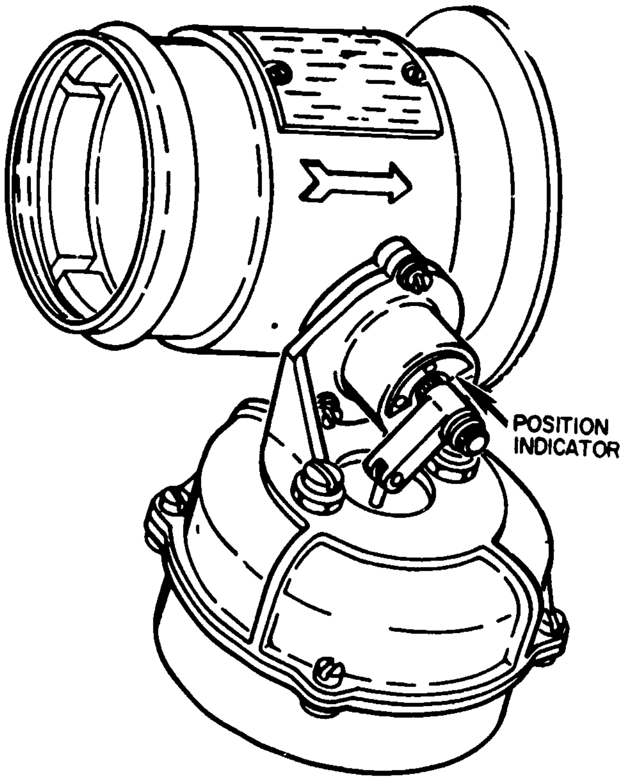
2. The unit that opens and allows ram air to enter the electronic compartments is the __________ __________ __________ __________.

3. Any time the pressure regulator and shutoff valve is closed the ram air valve will be __________.

Answers to Frame 13: 1. ram air 2. ram air shutoff valve 3. open

Frame 14

The ram air valve is shown below. It is made up of a pneumatic actuator and a butterfly type valve. It is spring loaded open and closed by air pressure.



We said in the previous frame that the ram air valve is controlled automatically. We also said previously that the pressure regulator and shutoff valve is controlled automatically.

The ram air valve is controlled by the pressure regulator and shutoff valve. Now let's see how operation of the pressure regulator and shutoff valve controls both of these valves automatically.

Look back at the sketch in frame 13 and note the air control line going from the pressure regulator and shutoff valve to the ram air valve actuator.

When the solenoid on the pressure regulator and shutoff valve is energized, it allows air pressure to enter the top of the pressure regulator and shutoff valve, opening this valve. At the same time, this air pressure is directed by the small air control line to ram air valve actuator. This pressure will overcome the spring tension, closing the ram air shutoff valve. This is normal operation; the pressure regulator and shutoff valve is open and the ram air valve is closed. The system is receiving conditioned air.

However, if a malfunction causes the pressure regulator and shutoff valve to close, or if the equipment cooling circuit breaker is pulled, no conditioned air will be available. Also since the solenoid is deenergized, no air will enter the small control line to the ram air valve, so the valve will be spring loaded open. When the ram air valve opens, ventilating air flows into the electronic compartments for cooling.

Notice that this sequence operation depended only on whether or not the solneoid on the pressure regulator and shutoff valve was energized or not. Also notice the absence of electrical connections to the ram air valve. The ram air valve is strictly pneumatically closed and spring loaded open.

This valve also has a position indicator to show when the valve is open or closed. The position indicator is located on the end of the actuator shaft, and is marked OPEN-CLOSED.

Fill in the blanks to complete the following statements.

1. The ram air shutoff valve is opened by ____________ __________.

2. Opening and closing of the ram air shutoff valve is controlled by the ________ ______ __ ____________________ and ___________ _________ ______.

3. The ram air shutoff valve is held closed by _______________ __________________________.

4. The position of the ram air shutoff valve can be determined by observing the __________________ ______________________.

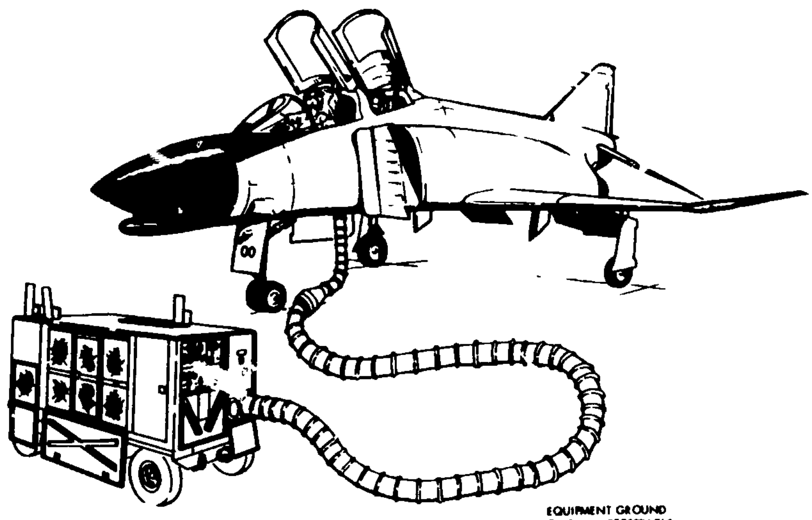
Answers to Frame 14: 1. spring tension 2. pressure regulator and shutoff valve 3. air pressure 4. position indicator

Frame 15

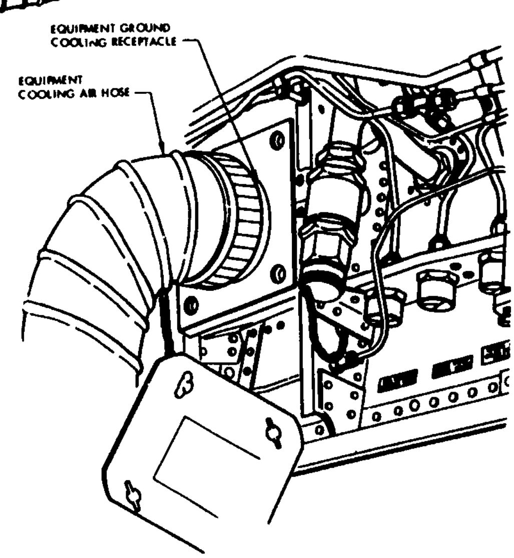
The illustration below shows a portable ground air conditioning unit being used to cool the electronic equipment compartments. The portable air conditioning unit is used when the electronic equipment is operated for ground checking.

You may be wondering, why not use the electronic equipment air conditioning system to cool the equipment? It could be used. But remember, for the electronic equipment air conditioning system to operate, the engines must be operated to supply the air.

By using the ground cooling cart instead of operating the engines, we will save the fuel required to operate the engines and also save the maintenance cost of repairing the engines.



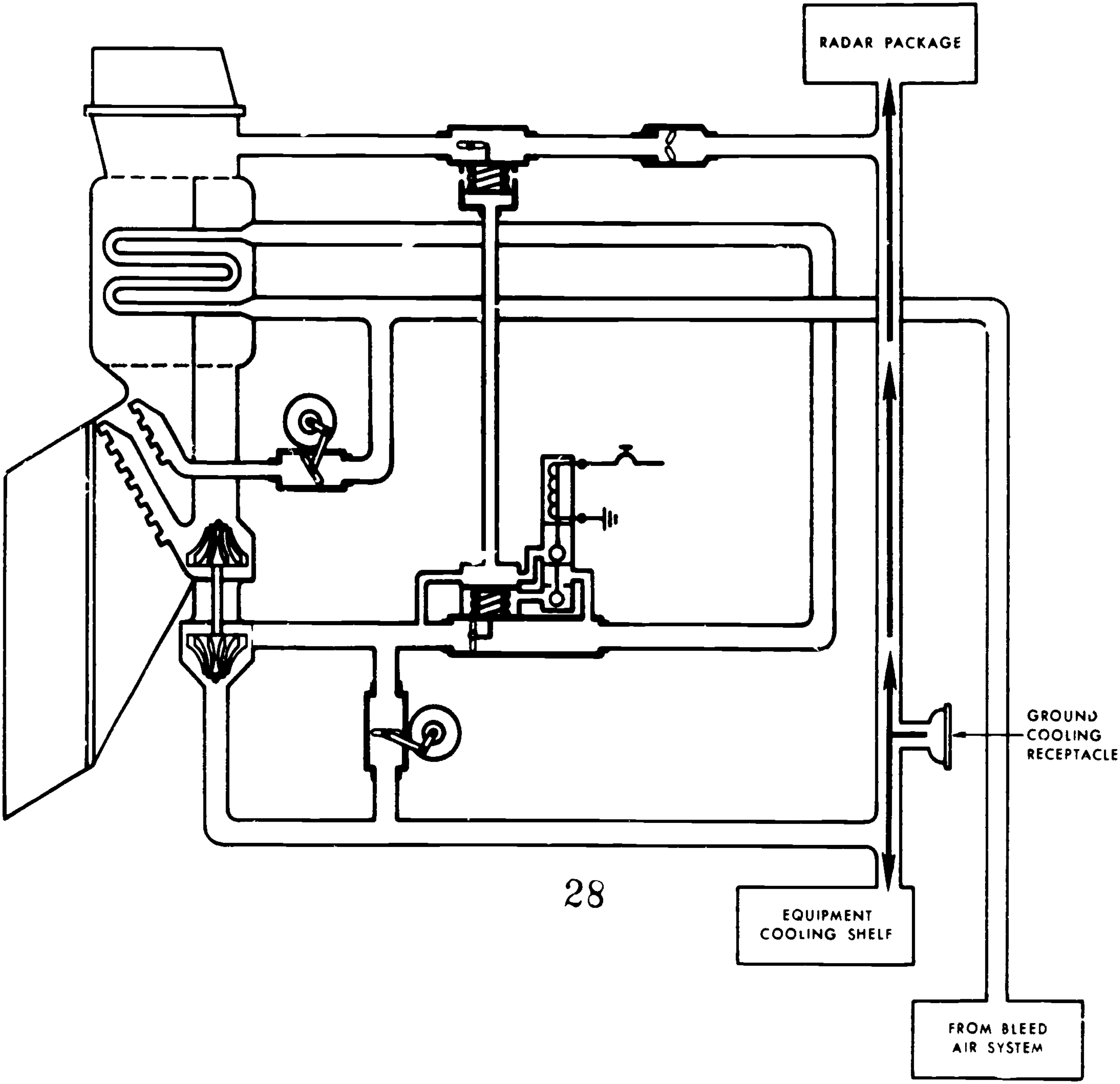
A ground cooling connection is provided. This connection allows a ground cooling cart to cool the electronic equipment compartment when the engine(s) are not running.



Equipment Ground Cooling Connections

Fill in the blanks to complete the following statement.

1. The unit which is used to cool the equipment during ground operation without running the engines is the ______________ __________ __________ ______________.



RADAR PACKAGE
GROUND
COOLING
RECEPTACLE
EQUIPMENT
COOLING SHELF
FROM BLEED
AIR SYSTEM

Answers to Frame 15: 1. ground air conditioning unit

Frame 16

Now we come to the purpose of the check valve that we identified in frame 13. The check valve stops a loss of air when using the ground air conditioning unit.

The sketch on the opposite page shows the flow of air from the ground cooling receptacle. Note that if the check valve was not in the system, this air would flow out through the ram air inlet.

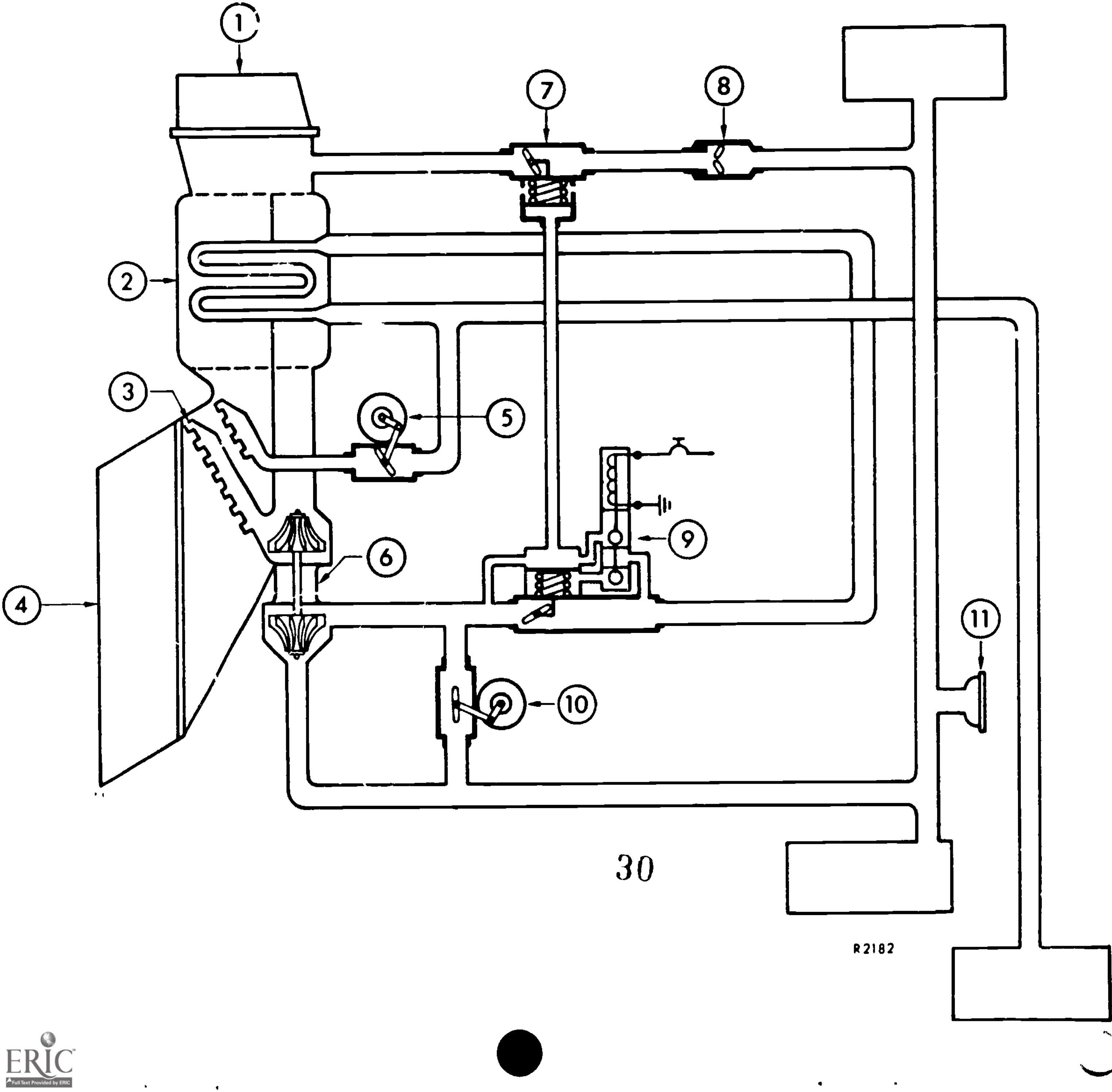
Why doesn't the ram air valve stop the air flow?..... Remember, if the pressure regulator and shutoff valve is closed, the ram air valve is open. When the air from the ground air conditioning unit tries to flow through the check valve it will close, preventing a loss of our cooling air.

The ram air check valve is a dual flapper type, similar to those used in the bleed air system. Normal (ram) airflow opens the valve and a reverse airflow closes the valve.

Fill in the blanks to complete the following statements.

1. When using the ground air conditioning unit, the unit that prevents a loss of air through the ram air inlet is the ____________ ____________.

2. When using the ground air conditioning unit, the ram air valve will be ____________ (open/closed).


1
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9
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11
R2182

Answers to Frame 16: 1. check valve 2. open

Frame 17

Using the system diagram on page 30, place the number in the blank opposite the statement below that correctly matches the information given in the statements.

Note: Several of the numbers will be used more than once.

_____1. Ram air shutoff valve.

_____2. Bleed air pressure regulator and shutoff valve.

_____3. Ground cooling ejector shutoff valve.

_____4. Ground cooling receptacle.

_____5. Ram air inlet.

_____6. Fan ejector nozzle.

_____7. Turbine bypass valve.

_____8. Heat exchanger.

_____9. Ram air outlet.

_____10. Turbine assembly.

_____11. Ram air check valve.

_____12. Allows bleed air to flow through the ground ejector nozzle when the aircraft is on the ground.

_____13. Prevents a loss of cooling air when using a ground cooling unit.

_____14. Connection for a ground cooling unit.

_____15. Regulates pressure at 106 psi.

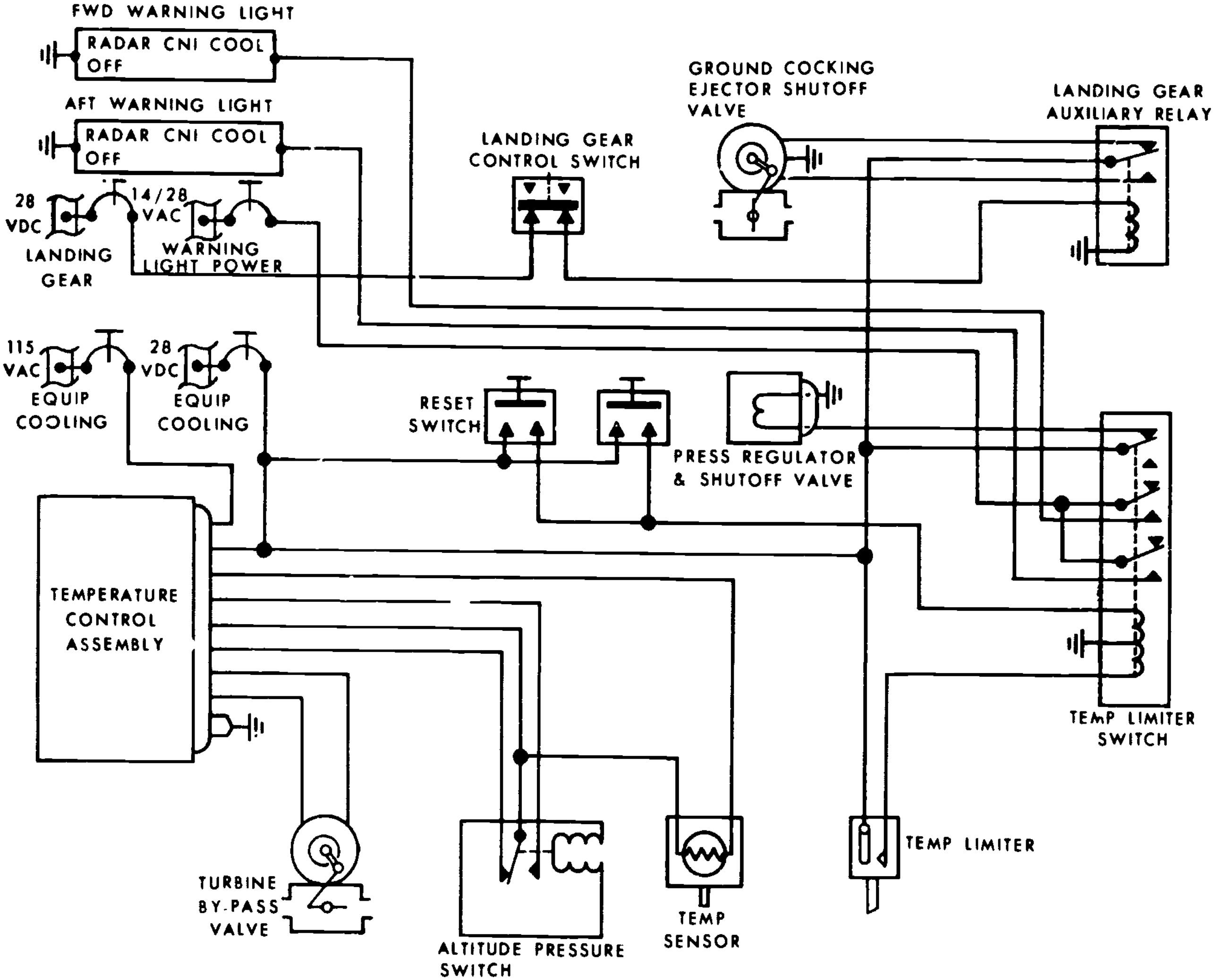
_____16. Controls the flow of precooled air into or around the turbine.

_____17. Helps to pull ram air through the heat exchanger during either flight or ground operation.

_____18. Opens to allow ram air to enter the system for emergency cooling.

_____19. Cools the air by rapid expansion and converting heat energy to mechanical energy.

_____20. Transfers heat from the bleed air to the ram air.


FWD WARNING LIGHT
RADAR CNI COOL OFF
AFT WARNING LIGHT
RADAR CNI COOL OFF
28 VDC
LANDING GEAR
14/28 VAC
WARNING LIGHT POWER
LANDING GEAR CONTROL SWITCH
GROUND COCKING EJECTOR SHUTOFF VALVE
LANDING GEAR AUXILIARY RELAY
115 VAC
EQUIP COOLING
28 VDC
EQUIP COOLING
RESET SWITCH
PRESS REGULATOR & SHUTOFF VALVE
TEMPERATURE CONTROL ASSEMBLY
TEMP LIMITER SWITCH
TURBINE BY-PASS VALVE
ALTITUDE PRESSURE SWITCH
TEMP SENSOR
TEMP LIMITER

Answers to Frame 17: 7 1. 9 2. 5 3. 11 4. 1 5.

3 6. 10 7. 2 8. 4 9. 6 10.

8 11. 5 12. 8 13. 11 14. 9 15.

10 16. 3 17. 7 18. 6 19. 2 20.

Frame 18

The previous frames have shown the path of airflow for the hot air, cold air, a mixture of hot and cold air, and for ventilating (ram) air. It has also been said that this system operates automatically. But, for this system to operate automatically, it needs electrical power to energize the pressure regulator and shutoff valve, to operate the motor on the ground cooling ejector valve, and to operate and control the turbine bypass valve.

The illustration on page 32 shows the electrical schematic for the equipment air conditioning system. The electrical units include the following:

Temperature Control Assembly.

Temperature Sensor.

Temperature Limiter.

Altitude Pressure Switch.

Temperature Limiter Switch.

Pilot's Reset Switches.

Landing Gear Auxiliary Relay.

Landing Gear Control Switch.

RADAR CNI COOL OFF Lights.

Find each of these units on the schematic. These are the controlling units for this system. The warning lights serve to warn the pilot of an overheat condition. The following frames will explain the function of each of these components.

NO RESPONSE REQUIRED

Frame 19

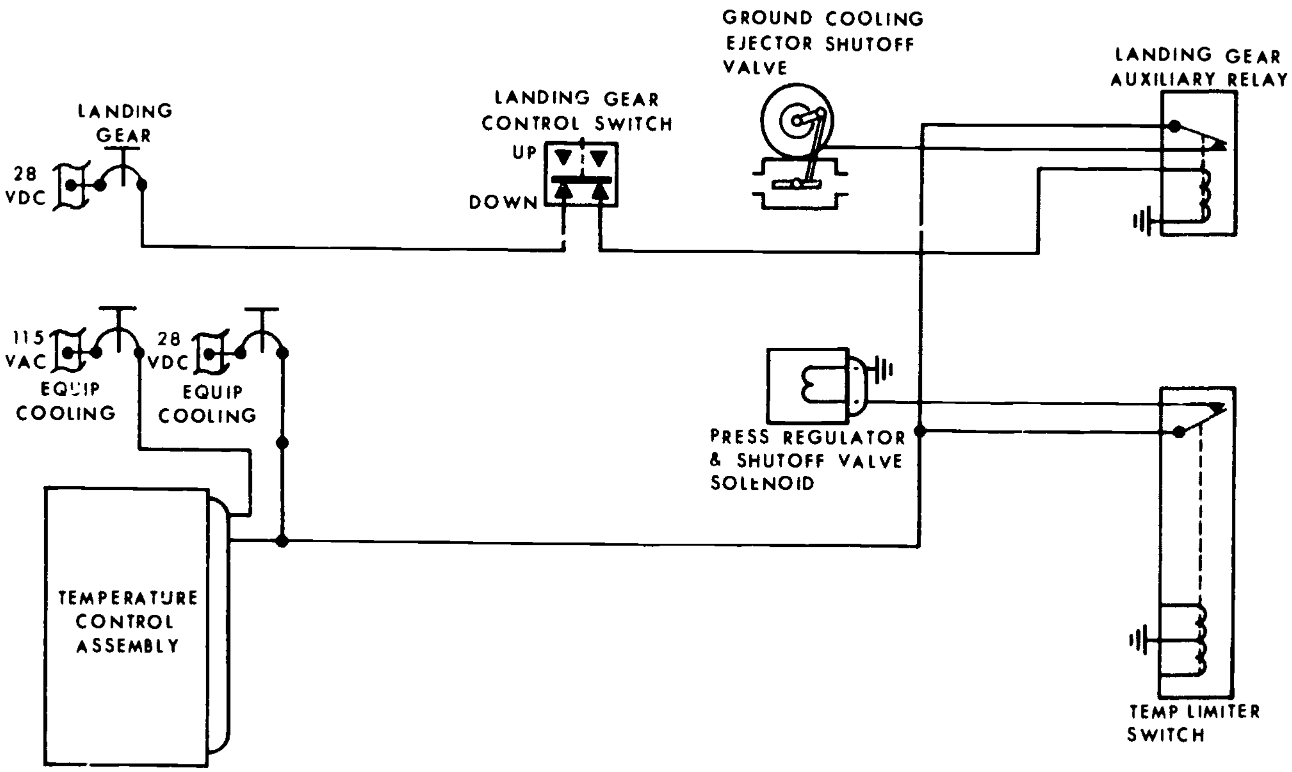
Remember, in the frame that explained the pressure regulator and shutoff valve it was said that this valve automatically opens any time electrical power and air pressure are applied to the aircraft. Also remember that if the aircraft is on the ground, the ground cooling ejector shutoff valve will be open.

The sketch shows the circuit from the 28V DC equipment cooling circuit breaker to the pressure regulator and shutoff valve and to the ground cooling ejector shutoff valve.

Note in this sketch that current goes from the 28V DC equipment cooling circuit breaker, through the temperature limiter switch (relay), to the pressure regulator and shutoff valve.

The temperature limiter switch contacts are normally in the up position as shown. Also note that current goes up through the landing gear auxiliary relay contact to the ground cooling ejector shutoff valve. The landing gear auxiliary relay is controlled by the switch on the landing gear handle.

Current also goes from the 28V DC and 115V AC equipment cooling circuit breakers to the temperature control assembly.



Fill in the blanks to complete the following statements.

1. When electrical power is applied to the aircraft, the pressure regulator and shutoff valve solenoid will be ________________ (energized/deenergized).

2. The pressure regulator and shutoff valve solenoid is energized by ____________________ (28V DC/115V AC).

3. When the landing gear handle is in the gear down position, the landing gear auxiliary relay will be _________________ (energized/deenergized).

4. When the landing gear handle is in the gear down position, the ground cooling ejector shutoff valve will be ____________ (open/closed).

5. The voltage required to operate the ground cooling ejector shutoff valve is ___________________.

Answers to Frame 19: 1. energized 2. 28V DC 3. energized
4. open 5. 28V DC

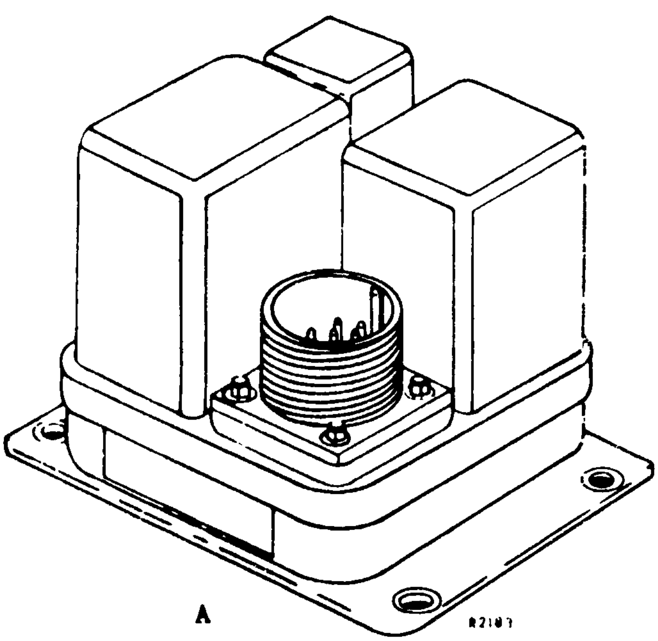
Frame 20

The illustrations below show the temperature control assembly The temperature control assembly automatically controls the position of the turbine bypass valve, thus maintaining the proper temperature in the equipment compartments.

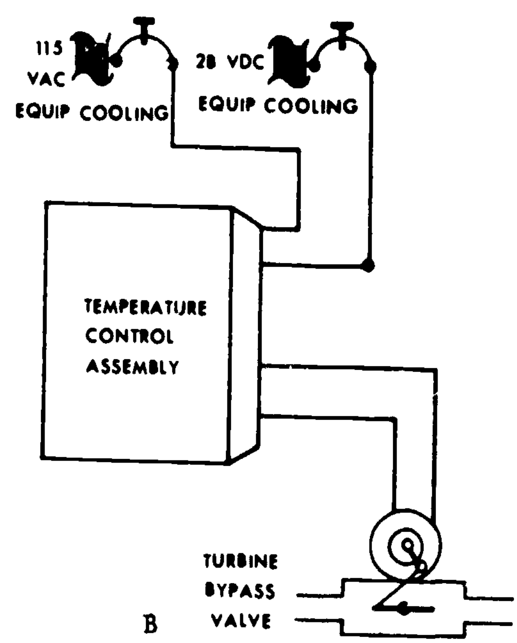
Remember, this system has no manual control. The temperature control assembly will automatically maintain the temperature in the equipment compartments at 85°F from sea level to 25,000 feet, and at 40°F for altitudes above 25,000 feet. How and why there are two temperature ranges will be explained later in the text.

Illustration A shows an external view of the temperature control assembly. This unit contains the magnetic amplifiers, transistors and a part of the bridge circuit that is used to control the position of the turbine bypass valve.

Illustration B shows the temperature control assembly connected electrically to the turbine bypass valve. Remember, the temperature control assembly controls the bypass valve by interpreting the resistance signal to the bridge circuit and allowing power to go to the hot or cold side of the valve.



A



B

Fill in the blanks to complete the following statements.

1 The temperature control assembly automatically controls temperature by controlling the ________________ ________________ ________ ________.

2. The electrical power requirements for operation of the temperature control assembly are ________________ and ________________.

3. Temperature of the equipment compartments is controlled ________________.

Answers to Frame 20: 1. turbine bypass valve 2. 28V DC & 115V AC 3. automatically

Frame 21

Before we go on, let's review some of the basic facts and principles about temperature sensors.

Different types of materials offer different amounts of resistance. Metals have low resistance whereas glass and rubber have high resistance. In most conductors (copper, aluminum, silver, iron, etc.) the resistance increases with an increase in temperature. These materials are said to have a positive temperature coefficient. The resistance of carbon and liquids decreases with an increase in temperature. These materials are said to have a negative temperature coefficient.

The temperature sensor is a specially designed resistor. Its resistance changes any time the temperature of the air around it changes. The manner in which the sensor changes resistance depends on its "temperature coefficient." That is: if the TEMPERATURE of the air across the sensor increases and the RESISTANCE of the sensor also increases, the sensor has a POSITIVE TEMPERATURE COEFFICIENT OF RESISTANCE. It follows then that with a POSITIVE COEFFICIENT the resistance will decrease if the temperature of the air decreases. The point is, they increase together and decrease together. On the other hand, if the TEMPERATURE increases and the sensor's RESISTANCE decreases at the same time, it has a Negative Coefficient. This also means the sensor's resistance will increase as the temperature decreases.

Mark the following statements true or false on your response sheet.

_____1. Heating a piece of copper wire will cause its resistance to decrease.

_____2. Glass has very high resistance.

_____3. All materials increase in resistance when heated.

Complete the statements by using the word increases or decreases.

POSITIVE COEFFICIENT	NEGATIVE COEFFICIENT
1. If temperature increases, the resistance ___________.	3. If temperature increases, the resistance ___________.
2. If temperature decreases, the resistance ___________.	4. If temperature decreases, the resistance ___________.

Answers to Frame 21: 1. F 2. T 3. F

1. increases
2. decreases
3. decreases
4. increases

Frame 22

Remember that the equipment temperature sensor forms part of the bridge circuit. Its purpose is to sense the temperature of the air going to the equipment compartment. This is done by sending a signal to the controller in the form of a resistance signal.

Here is how it is done. The sensor contains a resistance element which changes resistance with changes in temperature. This resistance element forms one leg of the bridge circuit in the equipment temperature controller. This sensing element has a negative coefficient of resistance. This means that as the air temperature around the sensor goes up the resistance value of the sensor goes down, and as the temperature around the sensor goes down, the resistance value of the sensor goes up. When the input signal (RESISTANCE SIGNAL) is received by the controller the change in resistance in that leg of the bridge circuit will unbalance the bridge. Based on this input signal (CHANGE IN RESISTANCE) the controller directs electrical power out to the turbine bypass valve. The electric motor will move the turbine bypass valve to the required position and maintain the temperature desired in the equipment compartment.

The illustration below may help you remember the basic facts about temperature sensors.

NEGATIVE COEFFICIENT SENSOR

TEMPERATURE AROUND THE SENSOR INCREASES ⇧	RESISTANCE OF THE SENSOR DECREASES ⇩	SYSTEM TEMPERATURE WILL GO COLD. ⇩
TEMPERATURE AROUND THE SENSOR DECREASES ⇩	RESISTANCE OF THE SENSOR INCREASES ⇧	SYSTEM TEMPERATURE WILL GO HOT. ⇧

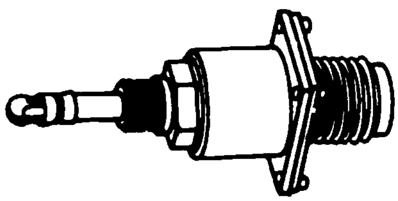
NO RESPONSE

Figure 23

Now that we have reviewed the basic principles and operation of sensors, we can see what part the equipment temperature sensor plays in maintaining the correct temperature in the equipment compartment.

Since the temperature is controlled automatically, there must be a means of sensing the temperature of the conditioned air going to the equipment compartments. We use the equipment temperature sensor to do this.

The equipment system temperature sensor is shown in illustration A. Notice that this sensor looks the same as the cabin system sensor, however, they are not interchangeable because the equipment sensor has a different resistance value from the cabin sensor.

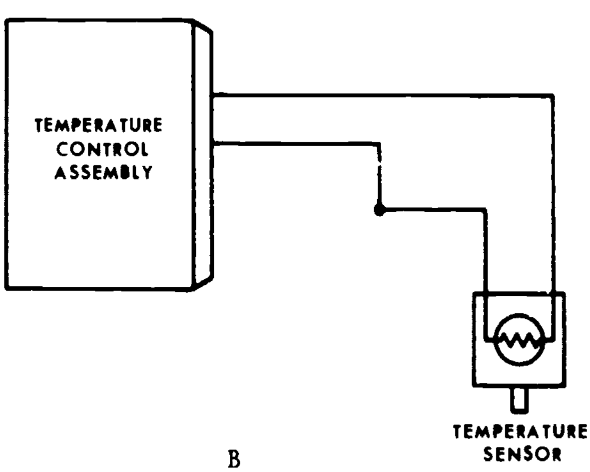


A

The temperature sensor contains a temperature sensitive resistance element. The sensing element has a negative coefficient of resistance. In this respect it is the same as the cabin system sensor.

The equipment system temperature sensor is located in the conditioned air duct between the refrigeration unit and the equipment compartments.

Illustration B shows the circuit going to the temperature control assembly. As the temperature changes, the resistance changes. This causes a signal to be sent to the temperature control assembly. This resistance signal will unbalance the bridge circuit and the temperature controller will direct electrical power to the turbine bypass valve.



B

Fill in the blanks to complete the following statements.

1. The temperature of the air going to the equipment compartments is sensed by the ________________ ________________.

2. An increase in air temperature in the conditioned air duct will cause the resistance of the temperature sensing element to ________________.

3. A change in resistance of the temperature sensing element will cause a signal to be sent to the ________________ ________________ ________________.

Answers to Frame 23: 1. temperature sensor 2. decrease
3. temperature control assembly

Frame 24

When explaining the task of the temperature control assembly it was said that it automatically keeps 85°F from sea level to 25,000 feet, and 40°F above 25,000 feet. At this point you may be asking, why change the temperature, and how is the temperature changed automatically?

The reason for changing the temperature is due to the moisture in the air. Below 25,000 feet, there is more moisture in the air than at the higher altitudes. It is necessary to keep the high temperature to stop the moisture from condensing and causing corrosion. Above 25,000 feet, there is very little moisture in the air, so the lower temperature is used.

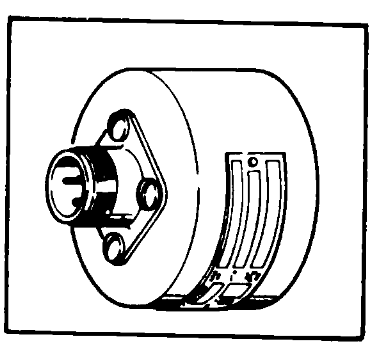
How can the temperature be changed automatically at a specific altitude? This is the task of the altitude pressure switch.

The altitude pressure switch is shown in sketch A. This unit contains an aneroid and a microswitch. The aneroid senses atmospheric pressure and controls the position of the switch contacts.

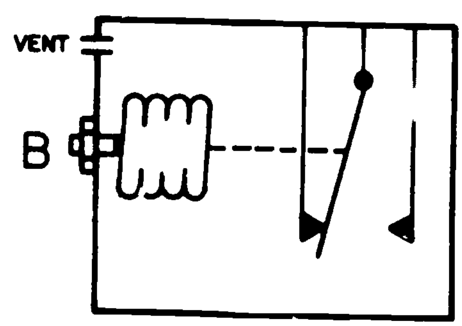
Below 25,000 feet, where the atmospheric pressure is higher, the aneroid will hold the switch in one position as shown in sketch B. As the aircraft goes above 25,000 feet, the atmospheric pressure decreases and allows the aneroid to move the switch contacts to the opposite position as shown in sketch C.

When the switch changes the resistance value in the bridge circuit, this causes the system to maintain the lower temperature above 25,000 feet.

A

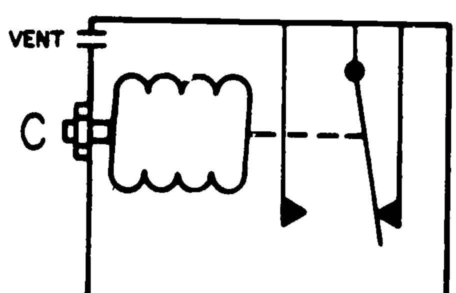


B



BELOW 25,000 FEET

C



ABOVE 25,000 FEET

Fill in the blanks to complete the following statements:

1. As the aircraft goes above 25,000 feet, the resistance value of the bridge circuit is changed by the ________________ ________________ ________________.

2. The altitude pressure switch contains an ________________ and a ________________.

3. The altitude pressure switch senses ________________ ________________.

4. As the aircraft increases altitude, the surrounding atmospheric pressure ________________ (increases/decreases).

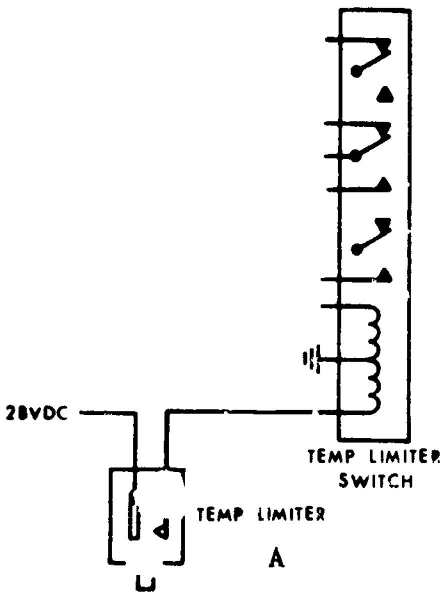
5. The atmosphere above 25,000 feet contains ________________ (more/less) moisture than at sea level.

Answers to Frame 24: 1. altitude pressure switch 2. aneroid microswitch 3. atmospheric pressure 4. decreases 5. less

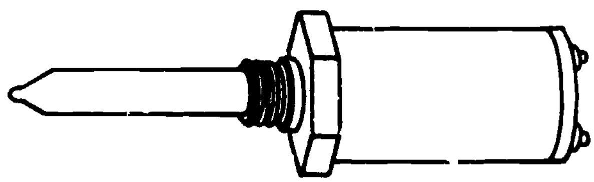
Frame 25

Under normal conditions, the temperature sensor senses the temperature and sends signals to the temperature control assembly. The temperature control assembly then positions the bypass valve to keep the proper temperature.

But what happens if the bypass valve should fail in the open position or if the sensor had an open? The system would give only hot air. In a very short time this would cause an overheat condition.



A



B

The temperature limiter and the temperature limiter switch work together to stop damage to the system from an overheat condition. When the temperature in the conditioned air outlet duct reaches 150°F, the two parts will cause the air conditioning system to shut off and a warning light to come on. A schematic of these two parts is shown in sketch A.

Sketch B shows the temperature limiter. This is a <u>normally open</u> temperature sensing switch. This type of switch is called a thermoswitch. When the temperature is below 150°F, the contacts will be open. When the temperature exceeds 150°F, the contacts will close.

Remember, this is not a sensor, it is a switch that is actuated by heat.

Fill in the blanks to complete the following statements:

1. Damage due to an overheat condition is prevented by the ________________ ________________ and the temperature limiter switch.

2. The temperature limiter is a thermo ________________.

3. The equipment system temperature limiter is normally ________________ (open/closed).

4. When the air in the conditioned air duct reaches an overheat condition, the temperature limiter will ________________ (open/close).

Answers to Frame 25: 1. temperature limiter 2. switch
3. open 4. close

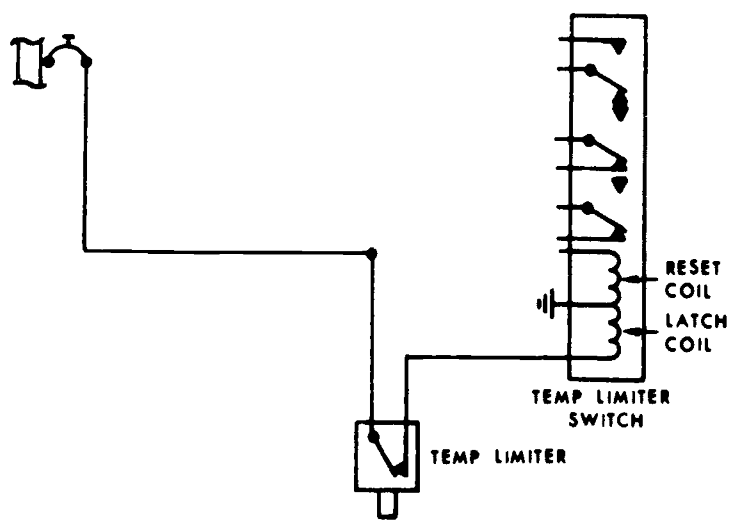
Frame 26

The sketch below shows the temperature limiter linked to the coil of the temperature limiter switch. The temperature limiter switch is a relay. In fact, it is two relays built in one. One coil is wrapped ·· the core, then a second coil is wrapped over the first, n the opposite direction.

The bottom coil is called the latch coil, and the top coil is called the reset coil. Current flow through the latch coil will energize the relay to pull the contacts down. Current flow through the reset coil will deenergize the relay to move the contacts up.

At the time of norma. operation, both coils are actually deenergized, but the relay is made so that the contacts will stay in the up position. When the temperature exceeds 150°F, the temperature limiter contacts will close, directing current flow through the latch coil.

This pulls the contacts down. When the contacts move down, it will stop the flow of conditioned air and turn on two warning lights. The sketch shows the temperature limiter contacts closed, and the latch coil energized.



Fill in the blanks to complete the following s'atements:

1. When an overheat condition occurs, the temperature limiter switch will be energized by the ________________ coil.

2. Current flow to the latch coil of the temperature limiter switch is controlled by the ________________ ________________.

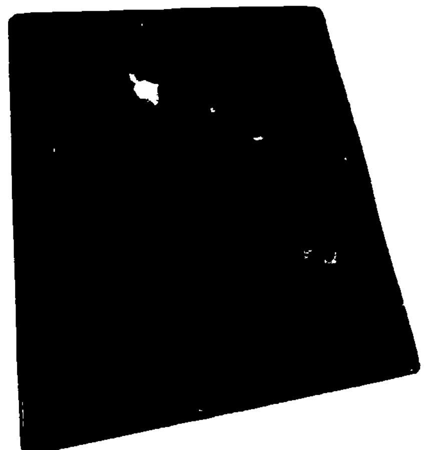
Answers to Frame 26: 1. latch 2. temperature limiter

Frame 27

The sketch below shows one of the warning light panels and the RADAR CNI COOL OFF light.

The abbreviation CNI means communication navigation instruments.

This is the purpose of the electronic equipment that we are cooling.

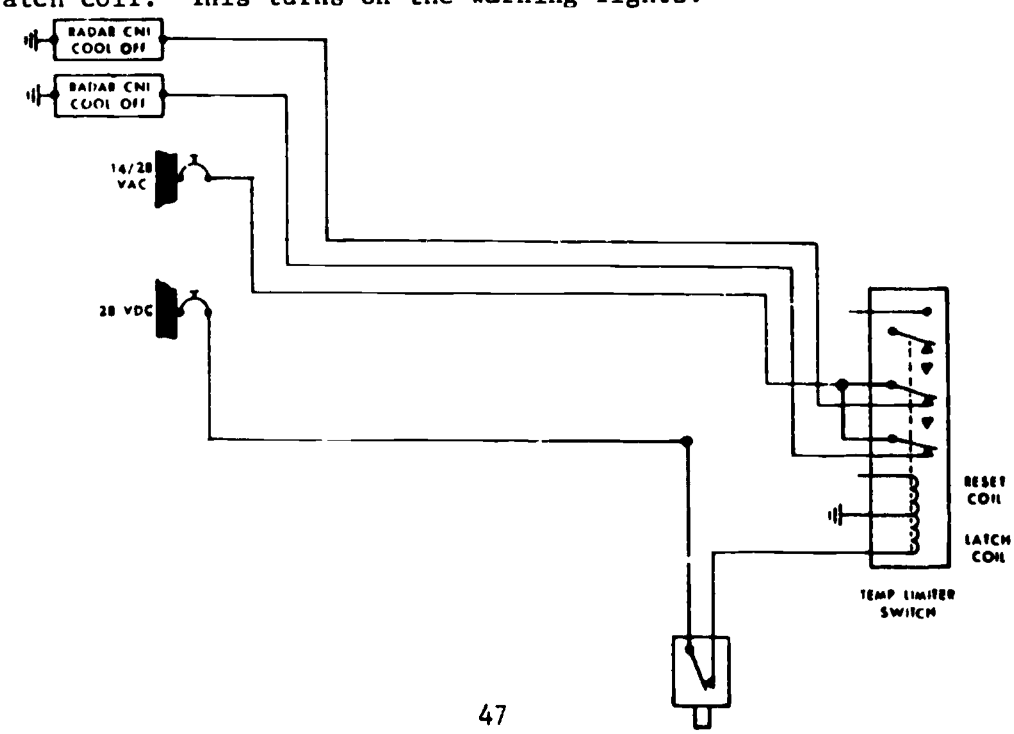


Warning Panel.

There are two RADAR CNI COOL OFF lights in this system One warning light is on the pilot's panel (forward cockpit) and the other is located on the radar pilot's panel (aft cockpit).

These lights will light any time there is an overheat condition in the equipment air conditioning system. The sketch below shows the circuit for the warning lights.

In this sketch, the temperature limiter is closed, energizing the latch coil. This turns on the warning lights.



Frame 27 (Continued)

Fill in the blanks to complete the following statements:

1. The purpose of the RADAR CNI COOL OFF lights is to warn the pilot of an ________________ ________________.

2. The RADAR CNI COOL OFF lights are turned on when the ________________ coil of the temperature limiter switch is ________________.

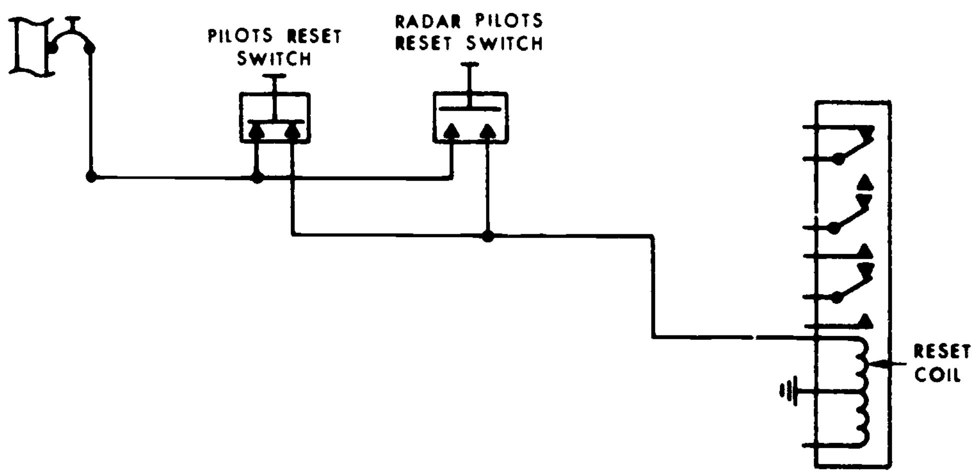
Answers to Frame 27: 1. overheat condition 2. latch energized

Frame 28

After an overheat condition has occurred, the system will not reset automatically. A reset button is used to restart the system. The reset button completes a circuit to energize the reset coil. This pulls the contacts up.

There are two reset buttons. One reset button is located in the forward cockpit, and one in the aft cockpit. This enables either pilot to reset the system.

This sketch shows the reset circuit. When either reset button is pushed in, current will flow to the reset coil, energizing the relay to the up position. The relay will stay in this position until the system overheats again.



Fill in the blanks to complete the following statements:

1. To restart the system after an overheat condition, the pilot must press the ________________ ________________.

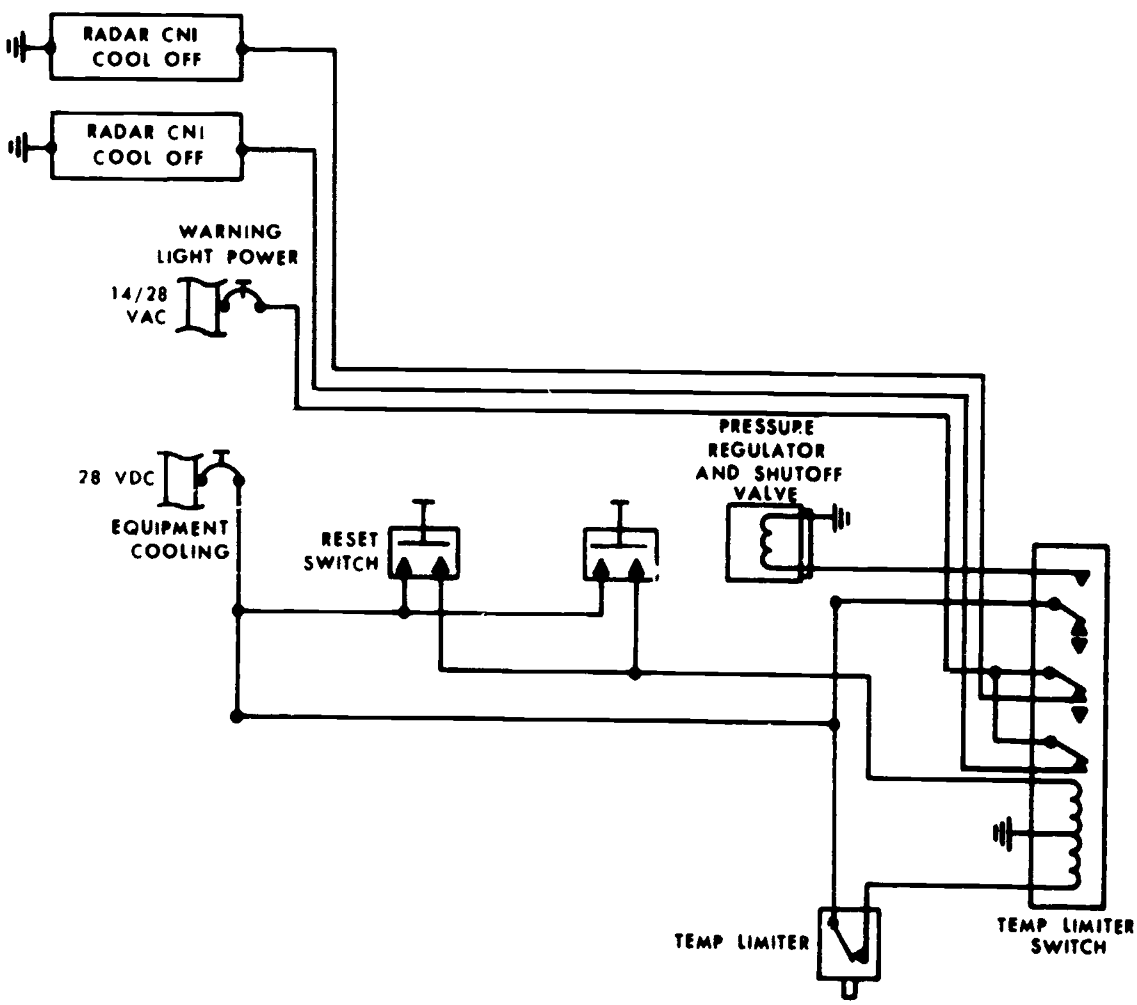
2. Current is directed to the reset coil of the temperature limiter switch by the ________________ ________________.

Answers to Frame 28: 1. reset button 2. reset button

Frame 29

The sketch in this frame shows the temperature limiter, temperature limiter switch, warning lights, and reset buttons. Notice that when the temperature limiter switch contact moves down, it completes the circuit to turn on the warning lights.

Also, notice that this opens the circuit going to the pressure regulator and shutoff valve solenoid. This deenergizes the solenoid causing the valve to close which stops the flow of conditioned air.



When the conditioned airflow stops, will the equipment compartments receive any cooling air?....Yes, they will receive ram air. Remember, any time the bleed air pressure regulator and shutoff valve closes, the ram air valve opens.

Now let's summarize what happens when the system overheats (temperature exceeds 150°F). First the temperature limiter contacts close; this energizes the latch coil of the temperature limiter switch. This causes the relay contacts to move down, turning on the warning lights and shutting the air conditioning system off. When the system shuts off, the ram air valve opens.

After the temperature cools below 150°F, the system can be reset by pressing either reset button.

Fill in the blanks to complete the following statements, or circle the correct answer.

1. If an overheat condition occurs, the pressure regulator and shutoff valve will be ________________.

2. When an overheat condition occurs, will the air conditioning system be shut off? ________________ (yes/no).

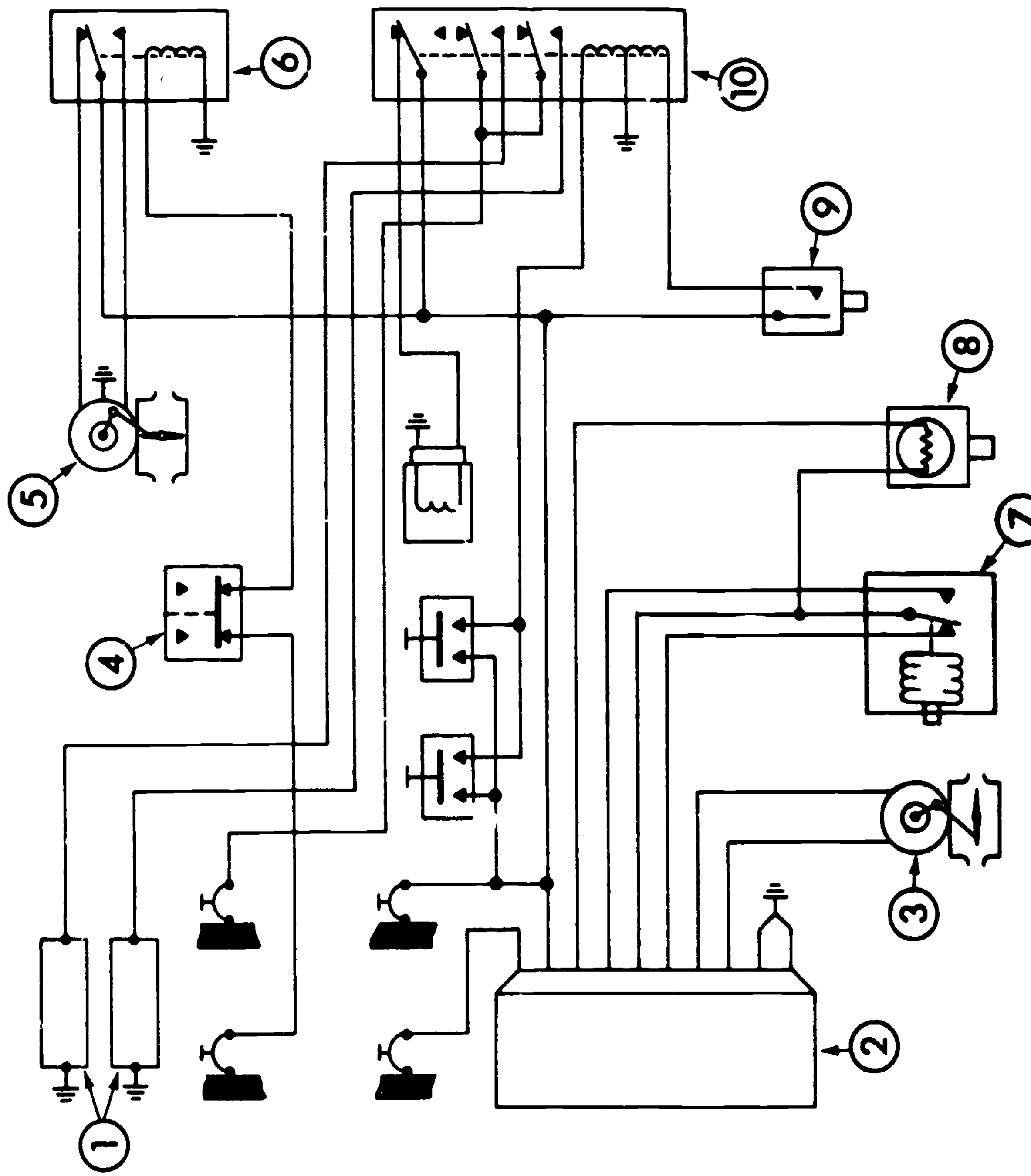
3. If an overheat condition occurs, will the electronic equipment receive any cooling air? ________________ (yes/no). If your answer was yes, then where will the cooling air come from? ____

4. What must the pilot do to restart the system after an overheat condition has occurred and the system has cooled off?

   ____

5. When the temperature of the air going to the equipment compartments overheats, how is the pilot informed?

   ____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Answers to Frame 29· 1. closed 2. yes 3. yes through the ram air valve 4. press the reset button 5. by the warning lights

Frame 30

Using the diagram on the opposite page, select the number for the component that matches the statement listed below.

_____1. Automatically controls the position of the turbine bypass valve.

_____2. Causes the temperature in the equipment compartments to decrease to 40°F when the aircraft goes above 25,000 feet.

_____3. Warns the pilot of an overheat condition.

_____4. Has a negative coefficient of resistance.

_____5. Energized when the landing gear handle is in the gear down position.

_____6. Closes when the temperature exceeds 150°F.

_____7. When energized by the temperature limiter, turns on the warning lights and shuts off the air conditioning system.

_____8. Opens when the landing gear handle is in the gear down position.

_____9. Directs partially cooled bleed air either into or around the turbine.

Answers to Frame 30: 2 1. 7 2. 1 3. 8 4. 6 5. 9 6. 10 7. 5 8. 3 9.

Technical Training

Aircraft Environmental Systems Mechanic

TEMPERATURE CONTROL SYSTEM TESTER

3 March 1983

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

RGL: 10.4

OBJECTIVE

ꞏsso·iate 4 out of 5 controls on he illustration of the . ꞏperature ꞏꞏ Svstem Tester (AN/PSM-21) with their function.

INSTRUCTIONS

This programmed t.xc presents information and procedures in small steps called frames. Within each f--me, you will be directed to complete som? statements or answer questions. Read the material pre;ented, then r.,pond on the response sheet. After you have made your response, compare your answers with the correct ar3wers given on the top of the next frame, or as otherwise noted. If your answer is incorrect, restudy the frame to get the information correct. If ne^essary, you may go back to check . 'o.mation previously given, but do not skip ahead.

Supersedes 3ABR42331-PT-204, 5 No' ember 1981.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 350; DAV - 1

While you do this lesson, you will be using the AN/PSM-21A air conditioning system tester to do an analysis of a fighter type aircraft air conditioning system. The AN/PSM-21A is made for use on the F4 type aircraft only. There are, however, several different air conditioning system testers used in the Air Force. They are usually made for use on one specific type of aircraft. The use and operating procedure are about the same on all of them. By learning to use the AN/PSM-21A tester, you will have an understanding of system testers. By following the instructions that are given in the technical order, you should be able to use this and other system testers.

Complete the following statements.

1. The air conditioning system tester used on the F4 type aircraft is the AN/_______.

2. When using an air conditioning system tester, you should always follow the instructions given in the applicable ___________ ___________.

CORRECT RESPONSES TO FRAME 1: 1. AN/PSM-21A 2. Technical Order.

Frame 2

Open the foldout at the back of this text. This foldout shows an illustration of the AN/PSM-21A tester. This tester is used to do a checkout, or to troubleshoot the temperature control systems on the F4 type aircraft. The tester will check the operation of the temperature control units in either the cabin or equipment air conditioning system. The tester can be used to check the complete temperature control system at the aircraft. It can also be used in the shop to bench check and repair each individual component.

Complete the following statements.

1. The AN/PSM-21A tester can be used to check the __________ system, and the __________ system.

2. The AN/PSM-21A tester can be used to bench check the cabin temperature _____ _____ __________ or the equipment system __________ control assembly.

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CORRECT RESPONSES TO FRAME 2: 1. cabin equipment 2. control panel temperature.

Frame 3

The cabin temperature control system units can be checked using the tester at the aircraft. The purpose of each check is given for each unit.

1. Cabin Temperature Control Panel

This unit is checked for a signal output from the cabin magnetic amplifier section to the cabin dual temperature mixing valve. The signal output is based on signals applied to the bridge circuit by a rheostat which is part of the tester. This rheostat simulates the cabin temperature sensor.

2. Cabin Temperature Sensor

This unit is checked for proper resistance in relation to ambient temperature.

3. Cabin Dual Temperature Mixing Valve

The tester checks the valve motor for operation and the valve for full travel.

Complete the following statements.

1. Increasing or decreasing the resistance in one leg of the cabin bridge circuit will cause a signal through the magnetic amplifier to be sent to the cabin ____________ ____________ ____________ ____________.

2. Changes in resistance in the bridge are simulated by a ____________ on the tester.

3. The cabin temperature sensor is checked for proper ____________.

CORRECT RESPONSES TO FRAME 3: 1. dual temperature mixing valve 2. rheostat 3. resistance.

Frame 4

The equipment air conditioning system units can be checked at the aircraft using the tester checks for each of the following units. The purpose of each check is given for each unit.

1. Temperature Control Assembly

This unit is checked for proper signal output from the magnetic amplifier to the turbine bypass valve (temperature control valve). The tester rheostat simulates the equipment temperature sensor. When the resistance in the bridge is changed with the rheostat, a signal is sent through the temperature control assembly to the turbine bypass valve.

2. Temperature Sensor

This unit is checked for proper resistance in relation to ambient temperature.

3. Turbine Bypass Valve

The tester checks the valve motor for operation and the valve for full travel.

Complete the following statements.

1. The AN/PSM-21A checks the equipment temperature control assembly for proper __________ output.

2. When checking the equipment air conditioning system at the aircraft with the AN/PSM-21A, the turbine bypass valve is checked for ______________ operation and full travel.

CORRECT RESPONSES TO FRAME 4: 1. signal 2. motor.

Note: Before operating the tester you need to be familiar with the controls that you will be using. Use the sketch shown in figure on page 16 to complete Frames 5 through 13. Observe the name of the item given at the beginning of each frame, then find the item in the sketch. Next read the information given and complete the statements. The answers to this group of frames are given on the page following Frame 13.

Frame 5

AC AND DC AIRCRAFT POWER LIGHTS

1. One light is marked __________ VAC and one light is marked __________ VDC. These lights indicate when electrical power is available to the tester.

Frame 6

SELECTOR SWITCH S1

1. The two positions of this selector switch are marked __________ system and __________ system. This switch is used to select the system being tested.

Frame 7

SELECTOR SWITCH S2

1. The two positions of this selector switch are marked __________ __________ __________ and __________ __________ __________. This switch is used to connect the sensor simulator to the system being tested.

Frame 8

SELECTOR SWITCH S3

1. The two positions of this selector switch are marked _______ ________ ________ and ______ ______ _______. This switch is used to select the altitude range when testing the equipment air conditioning system.

Frame 9

SENSOR SIMULATOR

1. This is a potentiometer (rheostat) that is used to simulate the temperature sensor. With this potentiometer you can apply various resistance values to the bridge circuit. The ranges of this potentiometer are marked __________ and __________.

Frame 10

RESISTANCE MONITOR

The resistance monitor includes two push button switches marked SENSOR and LIMITER and two connecting points for the AN/PSM-6 multimeter leads. These are marked TP5 and TP6. (TP means test point.) When testing the system you connect the multimeter leads to TP5 and TP6. Then by pressing the switch marked SENSOR you can read the resistance of the SENSOR SIMULATOR.

> Note: This does not check the resistance of the actual sensor. This indicates how much resistance is required to obtain a cold or hot signal.

1. To obtain a cold signal you would have to _____________(increase/decrease) resistance.

2. When checking the system, with the multimeter leads connected to test points TP5 and TP6, the resistance indicated on the meter is the resistance of the ______ ________ _______ ______.

AMP OUTPUT LIGHTS (Amplifier output lights)

1. There are four amplifier output lights. They are marked ___________, ___________, ___________, and ___________. These lights indicate the signal output from the cabin temperature control panel or the equipment system temperature control assembly, depending on which system you are checking. These lights will also indicate valve operation by indicating when the valve has reached full travel. DS1 and DS2 are used when checking the cabin or equipment air conditioning systems. The lights will pulse or burn steadily. This is actually the signal received from the temperature control assembly. While the valve is in travel, both lights will be on. When the valve reaches full travel one light will stay on and the other will be out. When checking the system this is how you can tell if the valve is running from full travel hot to full travel cold.

Note: DS3 and DS4 are used when checking the suit system. This system is no longer in use therefore you will not be using these lights.

2. The signal output from the cabin magnetic amplifier and an indication of full travel of the cabin dual temperature mixing valve will be indicated by lights ___________ and ___________.

3. The signal output from the equipment temperature control assembly and an indication of full travel of the equipment system bypass valve will be indicated by lights ___________ and ___________.

Frame 12

SENSOR TP1, TP2, TP3, TP4

Test points TP3 and TP4 are used when testing the cabin temperature sensor for correct resistance. When the AN/PSM-6 multimeter leads are inserted in the test points, the resistance of the sensor is read on the multimeter. When connected the tester isolates the sensor. This means you can test the resistance of the sensor without turning off the system. TP1 and TP2 are used when checking the resistance of the equipment system temperature sensor.

1. With switch S1 in the CABIN SYSTEM position, and the multimeter leads in test points TP 3 and TP4, you will be reading the resistance of the

__________ __________ sensor on the multimeter.

Note: Switch S1 has no EQUIPMENT SYSTEM position. So, you cannot put your multimeter leads into TP3, TP4, TP5 or TP6 to check the equipment system sensor. Therefore, S1 will remain in the cabin system position when you use TP1 and TP2 to check the equipment system sensor in the TP1 and TP2 check points.

Frame 13

SELECTOR SWITCH S6

Later in this text, when you are actually using the tester, the technical order instruction charts refer to this switch as the EXTERNAL METER switch. Although this switch is not marked with this nomenclature, we will use this name when referring to this switch.

1. The three positions of this switch are marked __________, __________, and __________ __________. During normal checkout procedures of the system, this switch will remain OFF. It is placed to the FLT LINE position only when checking sensor resistance through test points TP1, TP2, TP3 and TP4. It is spring loaded away from the FLT LINE position. When checking sensor resistance it must be held to the FLT LINE position. The switch can only be held to this position for a maximum of 4 seconds. The BENCH position is used when bench testing the temperature control assemblies in the shop. It is not necessary to hold the switch to the BENCH position as it is not spring loaded away from this position.

2. The external meter switch is used when checking _____ _____ resistance.

3. The external meter switch should not be held in the FLT LINE position for more than __________.

CORRECT RESPONSES TO FRAMES 5 through 13.

Frame 5. 1. 115 VAC 28 VDC.

Frame 6. 1. CABIN SYSTEM SUIT SYSTEM.

Frame 7. 1. CABIN TEMP SIMULATED SUIT TEMP SIMULATED.

Frame 8. 1. ABOVE 25,000 FT SIMULATED BELOW 25,000 FT SIMULATED.

Frame 9. 1. COLD HOT.

Frame 10. 1. decrease 2. sensor simulator.

Frame 11. 1. DS1, DS2, DS3, DS4.

2. DS1 and DS2.

3. DS1 and DS2.

Frame 12. 1. cabin temperature.

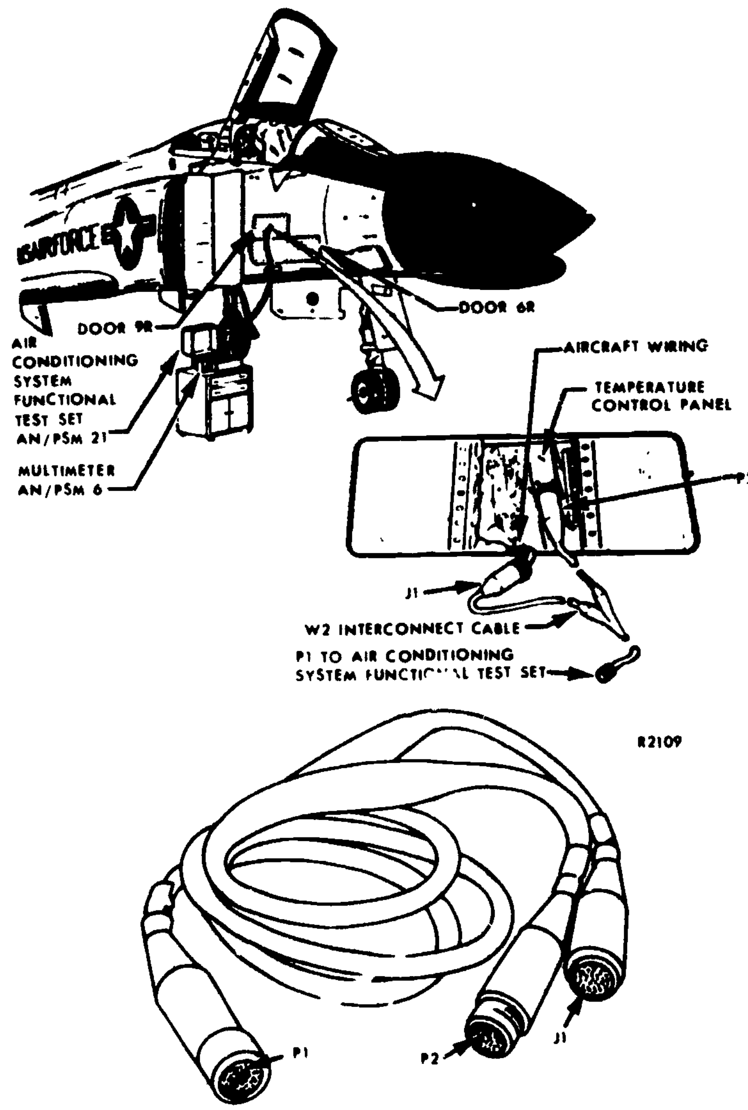
Frame 13. 1. BENCH, OFF, FLT LINE.

2. sensor.

3. 4 seconds.

Frame 14

S.ecial cables are used to connect the tester to the temperature control assemblies and to the aircraft wiring. The figure shows the cable us' when testing the cab n temperature control system. The cable has three straight AN connectors marked P1, P2, and J1. The large connector (P1) connects to the test set at the point marked AMPLIFIER CONTROL. Connector J1 connects to the aircraft wiring connector. P2 connects to the cabin temperature control panel.



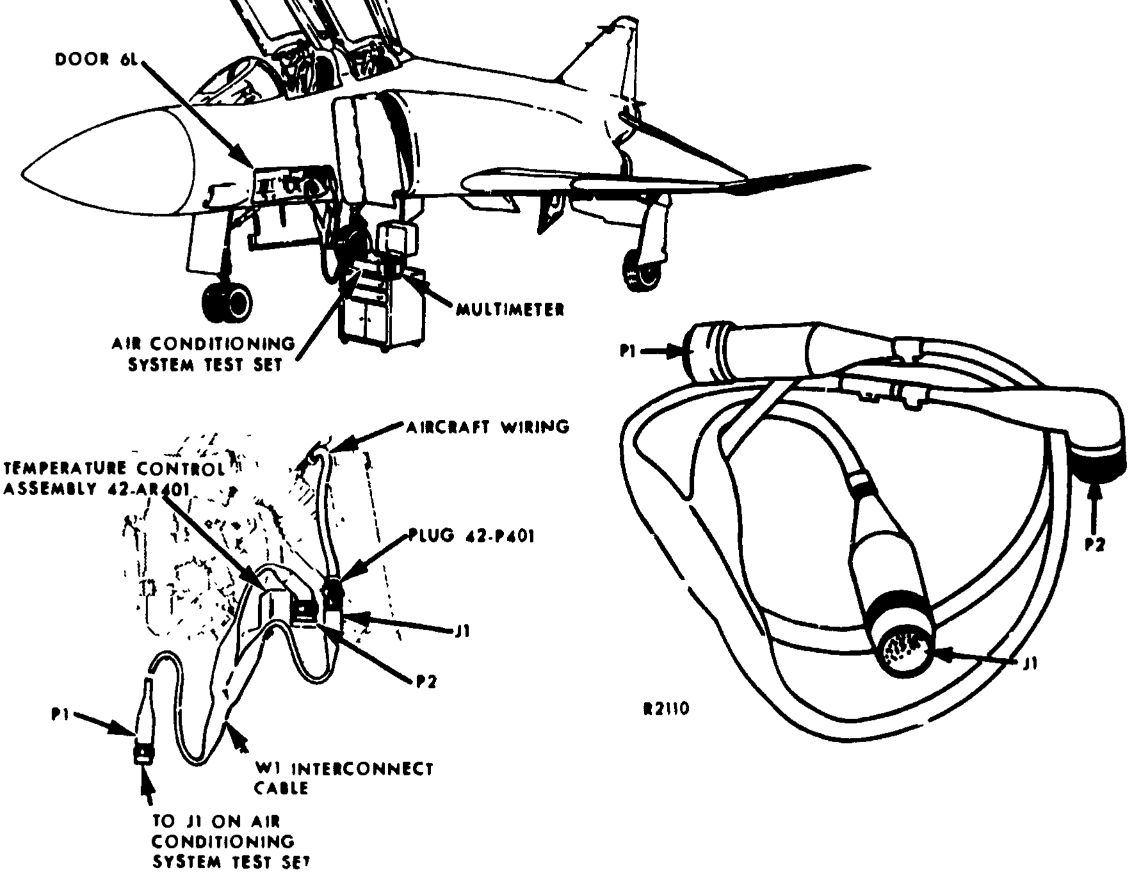
Complete the following statements.

1. The cable connects to the tester, the aircraft wiring harness and the temperature ____________ ______________.

CORRECT RESPONSES TO FRAME 14: 1. control panel.

Frame 15

A separate cable is used when checking the equipment temperature control system. This cable is shown in the figure. This cable has two straight AN connectors (P1 and J1) and one L shaped AN connector (P2). The large connector (P1) connects to the test set at the point marked AMPLIFIER CONTROL. The L shaped connector (P2) connects to the equipment temperature control assembly. Connector J1 connects to the aircraft wiring.



Complete the following statements.

1. When testing either the cabin or equipment system, the AN connector marked P1 is connected to the tester at the point marked ________ ____________.

2. The AN connector marked J1 of the test cable is connected to the ____________ ____________.

3. The notable difference between the cable used for testing the cabin system and the cable used for testing the equipment system is the L shaped connector on the __________ system cable.

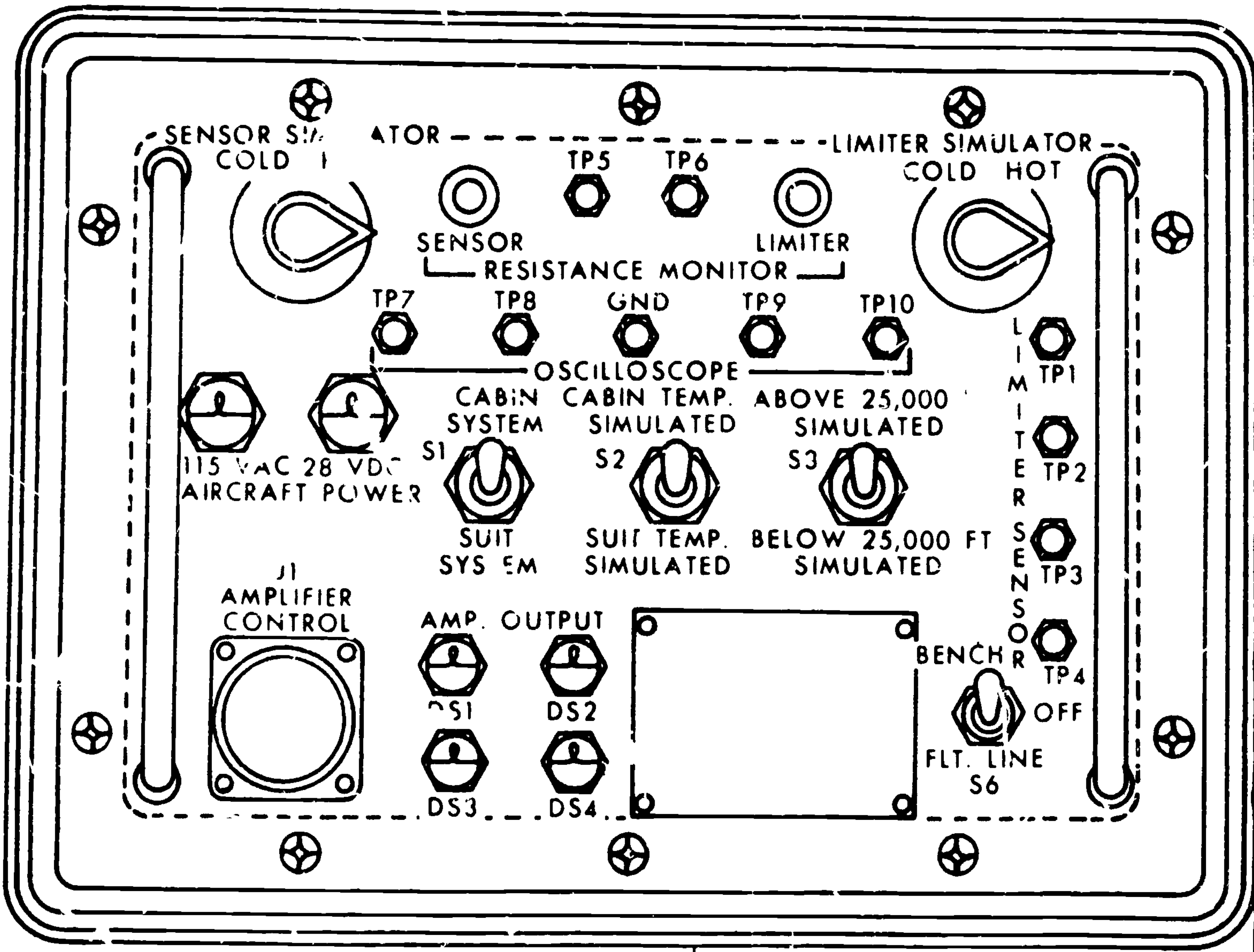
Frame 16

Match the units listed in column "B" with the statements given in column "A" by placing the letter from column "B" in the blanks provided.

COLUMN A	COLUMN B
______1. Indicates how much resistance is required to obtain a cold or hot signal from the temperature control panel.	A. AC Light
______2. Rheostat used to simulate the temperature sensor.	B. Selector Switch S3
______3. Used when testing the equipment temperature sensor for correct resistance readings.	C. Amp Output Lights
______4. Indicates when 115V AC power is available.	D. TP5 and TP6
______5. Used to select the system being tested. Cabin or Suit System.	E. Resistance Monitor
______6. Used only when checking sensor resistance through Test Points TP1, TP2, TP3, and TP4.	F. Selector Switch S6
______7. Used to connect the sensor simulator to the system being tested.	G. Selector Switch S2
______8. Indicates 28V DC power is available.	H. DC Light
______9. Used to select the altitude range when testing the Equipment Air Conditioning System.	I. Sensor TP1 and TP2
______10. Indicates the signal output from the Cabin or Equipment Temperature Control Assemblies.	J. Sensor Simulator
______11. Test points used when testing the systems and using the resistance monitor.	K. Selector Switch S1
______12. Used when testing the cabin temperature sensor for correct resistance readings.	L. Sensor TP3 and TP4

CORRECT RESPONSES TO FRAME 15: 1. amplifier control 2. aircraft wiring 3. equipment

CORRECT RESPONSES TO FRAME 16: 1. E; 2. J; 3. I; 4. A; 5. K; 6. F; 7. G; 8. H; 9. B; 10. C; 11. D; 12. L



AIR CONDITIONING SYSTEM
TEST SET AN/PSM-21A

Technical Training

Aircraft Environmental Systems Mechanic

TEMPERATURE CONTROL SYSTEM TESTING

2 June 1984

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

TEMPERATURE CONTROL SYSTEM TESTER

OBJECTIVE

Using a temperature control tester and multimeter, perform an operational check and troubleshoot the cabin and equipment air conditioning systems trainer, correctly locating 3 out of 4 of the assigned troubles.

EQUIPMENT

Tester AN/PSM-21A, Temperature
Control System
Trainer 3305, Fighter Air
Conditioning System
Multimeter

INFORMATION

Performing an operational analysis (checkout) of the system requires that you use a CHECKOUT PROCEDURE CHART. There is a chart for the cabin system and one for the equipment system. The laboratory instructor will assign you the proper chart at the work station. Look at how the charts are arranged and learn how to follow the instructions. Below is a typical chart for the cabin system.

PROCEDURE	NORMAL INDICATION	REMEDY FOR ABNORMAL INDICATION
3. <u>TEMPERATURE CONTROL PANEL FOOT HEAT CHECK</u>		
a. Place switch S1 to CABIN SYSTEM position.		
b. Place switch S2 to CABIN TEMP SIMULATED position.		
c. Place switch S3 to BELOW 25,000 FT SIMULATED position.		
d. Set the SENSOR SIMULATOR to HOT.		

Supersedes C3ABR42331-WB-205, 24 January 1984.
OPR: 3370 TCHTG
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3370 TCHTG/TTGU-P - 500; DAV - 1

e. Set the FOOT HEAT/ DEFOC lever to the FOOT HEAT position.	AMP OUTPUT lamp DS1 comes ON and DS2 lamp goes OUT.	Replace the temperature control panel.
	The cabin dual temperature mixing valve pointer moves to the OPEN position.	Replace the cabin dual temperature mixing valve.

The chart is divided into three sections; PROCEDURE, NORMAL INDICATION, and REMEDY FOR ABNORMAL INDICATION. To use the chart start at the top and read from left to right. Place the appropriate switches in the positions designated and observe for normal indications. Example: start by placing switches S1 to CABIN SYSTEM position and S2 to the CABIN TEMP SIMULATED position. Switch S3 is moved to the BELLOW 25,000 FT SIMULATED position. Then set the SENSOR SIMULATOR to HOT and the FOOT HEAT/DEFOG to the FOOT HEAT position. The normal indication should be, AMP OUTPUT lamp DS1 comes on and DS2 lamp goes OUT. The cabin dual temperature mixing valve pointer moves to the OPEN POSITION. Column three states a remedy for any abnormal indication. This procedure is followed throughout the complete checkout.

Complete the following statements.

1. When performing the steps of the sample checkout, switch S1 should be moved to the __________ __________ position; switch S2 to the __________ __________ __________ position, and switch S3 to the __________ __________ __________ __________ position.

2. When performing the temperature control panel foot heat check the FOOT HEAT/DEFOG lever should be placed in the __________ __________ position.

3. Column three shows a __________ for any __________ __________.

PROCEDURE

Remove your jewelry and report to the laboratory instructor. The instructor will provide the necessary test equipment and assign you to a trainer. You will be directed to perform an analysis of either a CABIN SYSTEM or an EQUIPMENT SYSTEM.

If you are assigned to test the CABIN SYSTEM use the checkout procedure chart given in SECTION I, Page 5. The checkout procedure chart given in SECTION II, Page 8 is used to test the EQUIPMENT SYSTEM.

When using the SENSOR SIMULATOR to obtain specific resistance values, MOVE IT VERY SLOWLY. This unit is very sensitive; a small movement will cause a large change in resistance.

CORRECT RESPONSES TO STATEMENTS:

1. CABIN SYSTEM

   CABIN TEMP SIMULATED

   BELOW 25,000 FT SIMULATED

2. FOOTHEAT.

3. REMEDY, ABNORMAL INDICATION

SECTION I

Cabin System

PROCEDURE	NORMAL INDICATION	REMEDY FOR ABNORMAL INDICATION
1. PREPARATION a. Connect the test cables to the AN connector (P1 and J1) of the temperature control panel and the connector panel, then connect the large end to the tester. b. Connect the multimeter to test set TP5 and TP6 jacks. c. Set the FOOT HEAT/DEFOG lever to the DEFOG position. d. Set the temperature control panel AUTO/MANUAL switch to the OFF position. e. Apply external electrical power to the trainer. f. Sensor simulator in "MID-POSITION."		

Note: Lights which glow dimly or flicker faintly when specified as OUT, do not indicate a malfunction.

2. TEMPERATURE CONTROL PANEL DEFOG CHECK

a. Set and hold the temperature control panel AUTO/MANUAL switch to the HOT position.	a. Test set DS2 light comes ON and DS1 light remains OUT. Cabin dual temperature mixing valve pointer moves to the CLOSE position. (Look at indicator on valve.)	a. Replace the temperature control panel. Replace the cabin dual temperature mixing va've.

b. Set and hold the AUTO/MANUAL switch to the COLD position.	b. Test set DS2 light goes OUT and DS1 light comes ON. Cabin dual temperature mixing valve pointer moves to the OPEN position.	b. Replace the temperature control panel. Replace the cabin dual temperature mixing valve.
c. Set the AUTO/MANual switch to the AUTO position and the temperature control selector to the HOT position.		
d. Set the test switches and controls as follows: S1 CABIN SYSTEM S2 CABIN TEMP SIMULATED S3 ABOVE 25,000 FT SIMULATED	d. Test set DS1 light goes OUT and DS2 light comes ON. Cabin dual temperature mixing valve pointer moves to the CLOSED position.	d. Replace the temperature control panel. Replace the cabin dual temperature mixing valve.
e. Press the test set RESISTANCE MONITOR SENSOR switch and adjust the SENSOR SIMULATOR until the multimeter reads 240 ohms.	e. DS2 light remains OUT and DS1 light remains OUT or PULSING.	e. Replace the temperature control panel.
f. Increase the SENSOR SIMULATOR until DS2 light starts to PULSE.	f. Multimeter reads 255 to 310 ohms.	f. Replace the temperature control panel.
g. Increase the SENSOR SIMULATOR until DS2 light comes ON STEADY.	g. Cabin dual temperature mixing valve pointer moves to the CLOSED position.	g. Replace the cabin dual temperature mixing valve.
h. Press the RESISTANCE MONITOR SENSOR switch and decrease the SENSOR SIMULATOR until the multimeter reads 300 ohms.	h. DS1 light remains OUT and DS2 light remains OUT or PULSING.	h. Replace the temperature control panel.
i. Decrease the SENSOR SIMULATOR until the DS1 light starts to PULSE.	i. Multimeter reads 235 to 295 ohms.	i. Replace the temperature control panel.

3. CABIN TEMPERATURE SENSOR CHECK

a. Connect the multimeter to the test set TP3 and TP4 jacks.		
b. Set S1 switch to the CABIN SYSTEM position.		
c. Set S2 switch to the CABIN TEMP SIMULATED position.		
d. Set S6 switch to the FLT LINE position for NO MORE THAN 4 seconds, observe the multimeter and record the resistance.		
e. Plot resistance versus ambient temperature using figure 1.	e. Resistance shall fall within the shaded area.	e. Replace the cabin temperature sensor.

Complete the following statements.

1. If you received an infinity reading on the multimeter during this check it would indicate ______________ (A SHORT or AN OPEN) the sensor or the sensor circuit.

2. With switch S1 in the CABIN SYSTEM position, switch S2 in the CABIN TEMP SIMULATED position, and the EXTERNAL switch (S6) DEPRESSED, the multimeter reads "0". This indicates ____________ (A SHORT or AN OPEN) in the cabin sensor.

ANSWERS TO PROCEDURE 3: Have your instructor verify your answers.

1. an open   2. a short

At this time turn to the trouble list at the back of this book. Accomplish the four troubles under the "CABIN SYSTEM" section. The instructor may assist you on one of these problems.

After you have completed this trouble list you have completed this lesson. If you had difficulty performing any of the steps, ask your instructor for assistance. If not, turn to page #9 and complete the EQUIPMENT SYSTEM lesson.

SECTION II

Equipment System

PROCEDURE	NORMAL INDICATION	REMEDY FOR ABNORMAL INDICATION
1. PREPARATION a. Disconnect connector 42P401 from temperature control assembly 42AR401. b. Connect the test set cables to the AN connector (P1 and J1) of the temperature control panel and connector to the panel then connect the large end to the tester. c. Connect the multimeter to TP5 and TP6 of the test set. d. Set the test set switches and controls as follows: SENSOR SIMULATOR Mid-position LIMITER SIMULATOR Mid-position S1 CABIN SYSTEM S2 CABIN TEMP SIMULATED S3 BELLOW 25,000 FT SIMULATED S6 OFF e. Apply external electrical power to the trainer.		

Note: Dimly lighted or flickering lights are considered OUT.

2. CHECKOUT		
a. Momentarily press the RESISTANCE MONITOR SENSOR switch and adjust the SENSOR SIMULATOR for a multimeter indication of 2150 ohms.	a. If lights DS1 and and DS2 pulse, disregard the indication.	
b. Decrease the SENSOR SIMULATOR until DS1 light light starts to PULSE. Press the RESISTANCE MONITOR SENSOR switch.	b. Multimeter indicates 1765 to 2245 ohms.	b. Replace temperature control assembly.
	DS2 light is OUT.	Replace the temperature control assembly.
c. Increase the SENSOR SIMULATOR until DS1 and DS2 lights stop PULSING, then increase further until DS2 light just starts to PULSE. Press the RESISTANCE MONITOR SENSOR switch.	c. Multimeter indicates 1850 to 2370 ohms.	c. Replace the temperature control assembly.
	DS1 light is OUT.	Replace the temperature control assembly.
d. Decrease the SENSOR SIMULATOR until DS1 light just illuminates STEADY. Press the RESISTANCE MONITOR SENSOR switch.	d. Multimeter indicates 430 to 805 ohms.	d. Replace the temperature control assembly.
	Turbine bypass valve position pointer indicates the valve is closed.	Replace the temperature control assembly.
e. Increase the SENSOR SIMULATOR until DS2 light just illuminates STEADY. Press the RESISTANCE MONITOR SENSOR switch.	e. Multimeter indicates 3888 to 6448 ohms.	e. Replace the temperature control assembly.
	Turbine bypass valve position pointer indicates the valve is OPEN.	Replace the temperature control assembly.
f. Position S3 switch to the ABOVE 25,000 FT SIMULATED position.	f. Turbine bypass valve position pointer indicates the valve is OPEN.	f. Replace the temperature control assembly.
g. Momentarily press the RESISTANCE MONITOR SENSOR switch and adjust the SENSOR SIMULATOR for a multimeter indication of 5700 ohms.	If DS1 and DS2 lights PULSE, disregard indication.	

h. Adjust the SENSOR SIMULATOR until DS1 and DS2 lights are OUT. Press the RESISTANCE MONITOR SENSOR switch.	h. Multimeter indicates 5110 to 6420 ohms. Turbine bypass valve position pointer indicates valve is OPEN.	h. Replace the temperature control assembly. Replace the temperature control assembly.
i. Increase the SENSOR SIMULATOR until DS2 light just starts to PULSE. Press the RESISTANCE MONITOR SENSOR switch.	i. Multimeter indicates 5200 to 6420 ohms.	i. Replace the temperature control assembly.
j. Decrease the SENSOR SIMULATOR until DS1 light just starts to PULSE. Press the RESISTANCE MONITOR SENSOR switch.	j. Multimeter indicates 5150 to 6335 ohms.	j. Replace the temperature control assembly.
3. <u>SENSOR RESISTANCE CHECK</u> a. Connect the multimeter leads to TP1 and TP2 jacks of the test set. b. Place the SENSOR SIMULATING selector switch, located on the front of the trainer, to the NORMAL position. c. Perform a resistance check of the equipment system temperature sensor.		

Note: The external meter switch is the switch marked S6 (BENCH, OFF, FLT LINE). Depress means to hold it to the FLT LINE position. Do not hold it in this position longer than 4 seconds.

Complete the following statements.

1. The resistance reading for the SENSOR is __________ ohms.

2. Use figure 1 to compare your readings to the value given on the chart with the present ambient temperature. Ask your instructor for the ambient temperature. Is the SENSOR resistance value within the tolerance given in the chart? _________ (YES/NO)

3. If you receive an infinity reading on the multimeter during this check it indicates ____________ (A SHORT or AN OPEN) in the SENSOR or sensor circuit.

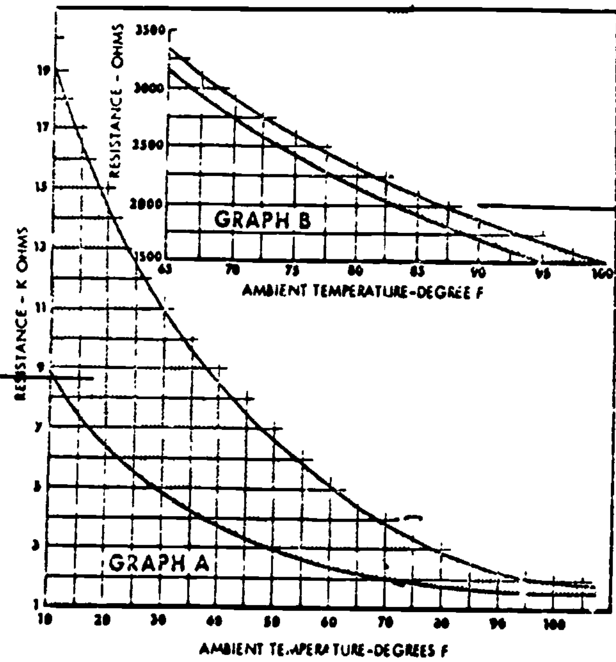
4. During this check, if the multimeter reads 0 ohms it indicates ______________ (A SHORT or AN OPEN) in the sensor or sensor circuit.

ANSWERS TO PROCEDURE 3: Have your instructor verify your answers to statements 1 and 2.

3. an open   4. a short

At this time turn to the trouble list at the back of the book. Accomplish the four troubles under the "EQUIPMENT SYSTEM" section. The instructor may assist you on one of these problems.

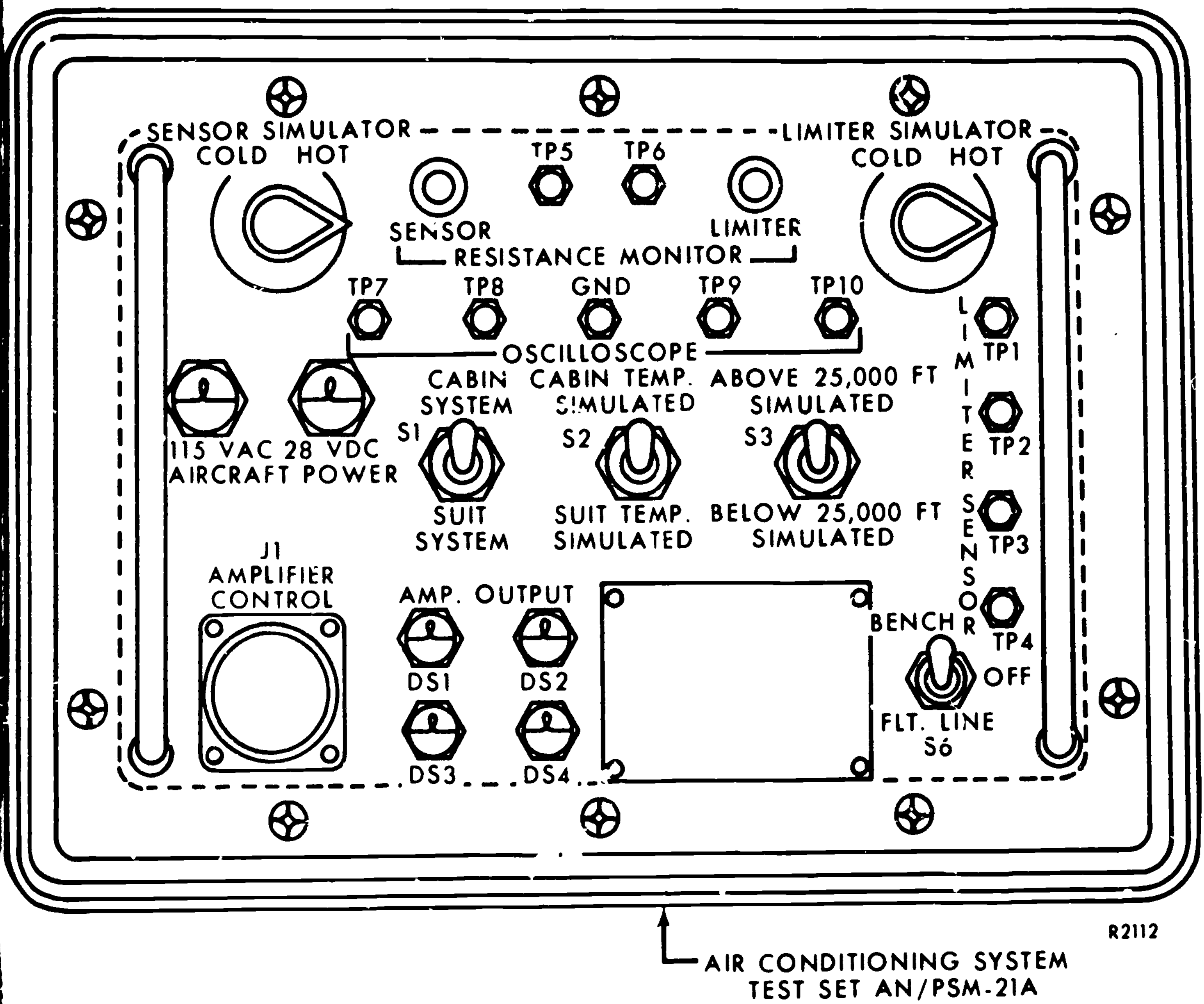
After you have completed the trouble list you have completed this lesson. If you had difficulty performing any of the steps, ask your instructor for assistance. If not, report to the instructor.



NOTES

1. FOR ANY GIVEN TEMPERATURE, RESISTANCE MUST FALL WITHIN SHADED AREA.
2. GRAPH "A", USE FOR CHECKING SENSORS AND LIMITERS WHEN INSTALLED IN AIRCRAFT.
3. GRAPH "B", USE ONLY WHEN A SENSOR OR LIMITER IS REMOVED FROM THE AIRCRAFT AND IS PLACED IN A CONTROLLED TEMPERATURE ENVIRONMENT (e.g. SUBMERGE UNIT IN WATER THAT IS TEMPERATURE CONTROLLED)

Figure 1.



Foldout 1. AN/PSM-21 Air Conditioning Tester for the F-4C, D, and E.

	CABIN SYSTEM	
SWITCH	MALFUNCTIONING COMPONENT	CONDITION
1		
4		
7		
11		

	EQUIPMENT SYSTEM	
SWITCH	MALFUNCTIONING COMPONENT	CONDITION
1		
3		
6		
12		

Envi.onmental/Pneudraulics Branch
Chanute AFB, Illinois

SERVICE TEST
C3ABR42331-SG-205
26 April 1984

TESTER FAMILIARIZATION AND OPERATION

OBJECTIVE

Relate 4 out of 5 controls of the temperature control system tester with their function.

INFORMATION

The ECS fault isolation test set (tester) is a portable te ter intended to monitor pressure, temperature, and electrical signals from the environmental control system (ECS). The tester is capable of providing signals to the ECS while monitoring other responses. The tester provides the capability to isolate malfunctions in the ECS to a defective line replaceable unit (LRU).

The tester electrically connects to the aircraft ECS test connector located near the ground air-conditioning receptacle on the left-hand side of the aircraft. Pneumatic hoses and an interconnecting electric cable with a temperature sensor are provided with the tester to interconnect the tester with test points on the ECS ducting.

Tester Familiarization

This section will consist of identifying the different parts of the tester and what they do.

We will begin with the power switch.

On/Off Power Switch

This switch located in the upper le t corner of the tester is used for turning power on or off of the tester. The tester receives power directly from the aircraft. This switch also serves as a circuit breaker (CB). A power light is located directly above the switch.

Signal Input

The signal input is located directly under the on/off switch and is used to connect the main power cord to the tester. This main power cord gives complete tester interface for all operational checks and trouble-shooting procedures.

OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 350; DAV - 1

Designed for ATC Course Use. Do Not Use on the Job.

Auxiliary Temperature Probe - The auxiliary temperature probe is located directly under the signal input connector and is used to connect an external temperature probe. The temperature probe can be used to measure ambient (outside) temperatures or it can be installed in the aircraft to measure duct temperatures.

Digital Display - The digital display consists of four displays which give different readings for different functions. The top three displays consist of temperature; pressure and multimeter. The bottom display will tell the user how the multimeter is set. All readouts are Light Emitting Diode (LED). The displays are determined by the function knob settings.

Function Knobs - (Center Row of Knobs) There are seven function knobs used for various functions, operational checks and troubleshooting.

Each knob and its function will be explained in the following paragraphs. We will start with the top knob.

Temperature - This function knob has five positions.

Cal - This position is used in conjunction with the calibration of the tester. It is calibrated at 32°F.

Cabin - When in this position the thermocouple in the cabin supply air manifold senses the temperature going into the cockpit. (T.P. 33)

Avionics - Thermocouple in the avionics supply air manifold senses temperature of air going into the avionics. (T.P. 34)

Manifold - Thermocouple in hot air manifold senses temperature of air in the manifold duct. (T.P. 26)

Aux - This position is used in conjunction with the aux temperature probe.

All temperature readouts will be found in the digital display space labeled "Temp °F".

Pressure - The pressure knob has four positions and can be found directly under the temperature knob.

The four positions of the pressure knob correspond to the pressure select handles and test ports located on the right side of the tester.

The first position of the pressure knob is 15 inches H_2O. This test position is used to measure ai pressure in inches of water.

15 psig - This position is used when measuring a pressure up to but not more than 15 psig. Used in conjunction with the 0-15 psig select handle and the four 0-15 psig input ports located to the right of the 0-15 psig select handle. These input ports are used in conjunction with select handles. (Example: 0-15 psig select handle position #1, use 0-15 psig input port #1)

60 psig - This position is used when measuring pressure of 0 to 60 psig.

300 psig - Used when measuring a pressure of 0-300 psig.

The select handle and input ports for the 60 psig and 300 psig are used just like the 15 psig position.

All pressure reading will be found in the digital display readout labeled "Pressure."

Multimeter - The multimeter function knob has 5 positions.

Int - If the internal position is used, then the next four function switches are used to check out the ECS system. This position will allow all voltage readings to be taken from the system.

This tester incorporates a built in multimeter located on the bottom left side of the tester. When using this multimeter, use the last four positions of the multimeter function knob listed below.

DC Volts - Almost all of the system is DC voltage. Use this position when checking for DC voltage.

Ohm - This position is used when checking resistances.

AC Volts - This position allows AC voltage readings to be taken.

DC MA - Used to check for DC milliampere readings.

The last (bottom) four function switches are used when troubleshooting and operationally checking the GCS system.

Located in the bottom of the tester is a storage compartment. Contained in the storage compartment is the necessary miscellaneous equipment listed below.

Multimeter leads - Ten foot set of leads used to check voltage readings and resistance readings with the built in multimeter. Use test points labeled Hi (Red) Lo (Black) for the multimeter. The other test points located under the access panel allow you to take readings from the pins of the main power cord. Jumper wires are also used to jump from one pin to another.

Hoses - 13 hoses located in the storage compartment are used to connect the tester to the aircraft. Used when checking pressure readings.

Cables (electrical) - Also found in the storage compartment is the electrical cable to connect the tester to the aircraft for power and the temperature probe and cable to connect the probe to the tester.

Unions - Used to connect the hoses to the aircraft test points.

PROGRAMMED TEXT

3ABR42331-PT-206A

Technical Training

Aircraft Environmental Systems Mechanic

BOMBER AIR CONDITIONING SYSTEM

16 March 1981

CHANUTE TEC'NICAL TRAINING CENTER (ATC)
3370 Technical Training Center
Chanute Air Force Base, Illinois

Designed for ATC Course Use.

Do Not Use on the Job.

RGL: [redacted] 10.6

OBJECTIVE

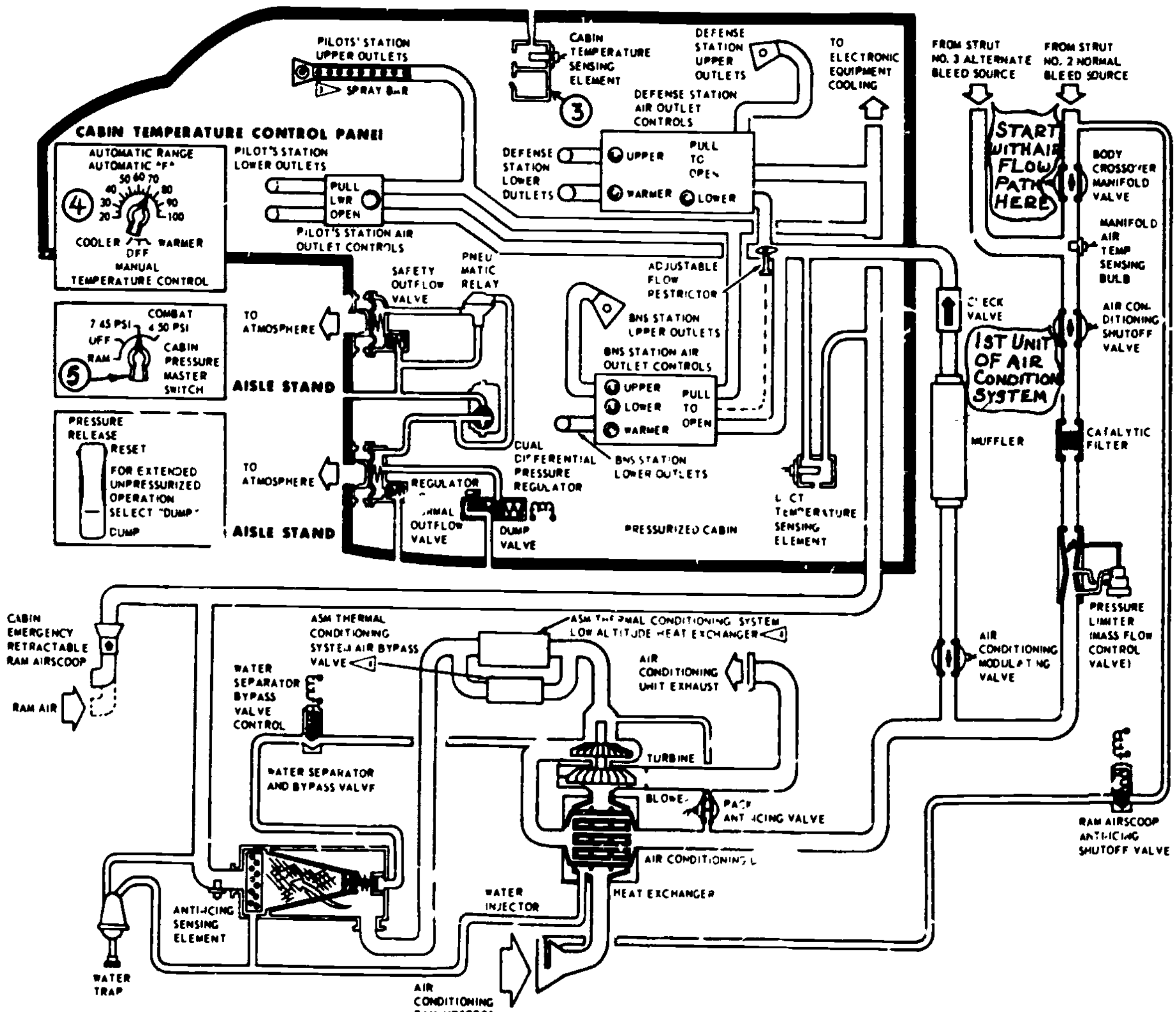
Relate the name of each cabin air conditioning system component to its operation with a minimum of 80% accuracy.

INSTRUCTIONS

This programmed text presents information in small steps called "frames." After each step you are asked to select the correct statement, match a statement, or respond in some other way to the information presented. Read the material presented and make your response as directed by the instructions. Compare your response with answers found on the next page or pages. If you are wrong, read the frame again, and then write the correct response next to your previous answer.

Supersedes 3ABR42331-PT-206A, 16 September 1980.
OPR: 3370 TCHTG
DISTRIBUTION:
3370 TCHTG/TTGU-P -1000; DAV - 1

Shown below is a schematic of the Bomber Air Conditioning System. This programmed text will go through the nomenclature (name) and purpose of each component part of the system beginning with the Air Conditioning System Shutoff Valve. Look over the schematic to find the source of bleed air and to get an idea where each part is located.



Refer to the schematic above and place the lette in the blank space before each of the following statements that are rue.

_____1. The normal source of bleed air is Strut No. 2

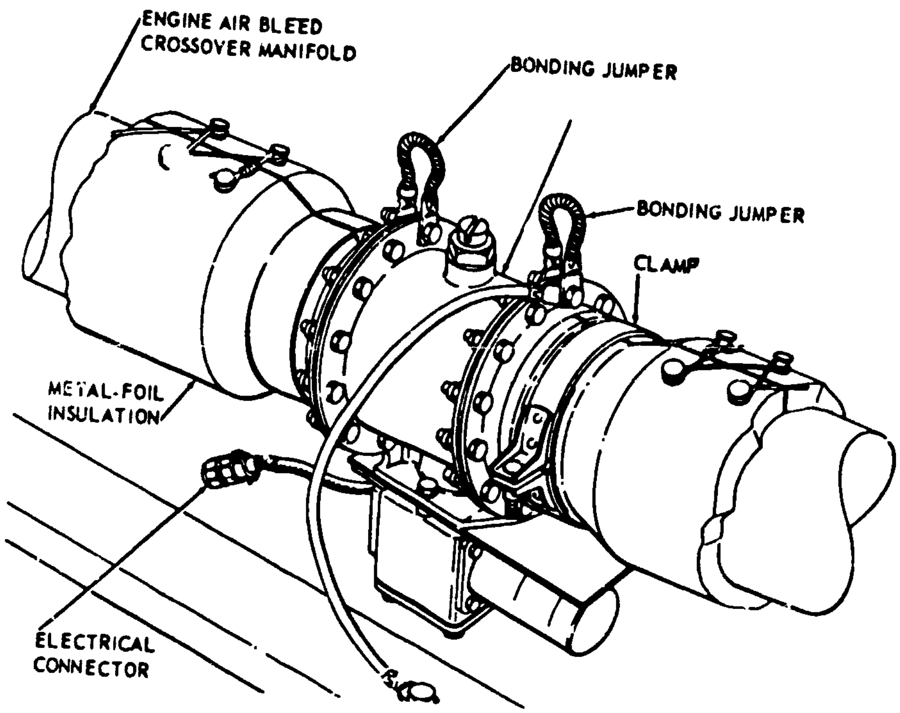
_____2. The alternate (emergency) source of bleed air is Strut No. 3.

_____3. The Air Conditioning System Shutoff Valve is used to open and close the bleed air supply line going to the air conditioning system.

Answers to Frame 1: 1. T 2. T 3. T

Frame 2

The first valve that is in the Bomber Air Conditioning System is the Air Conditioning Shutoff Valve. The shutoff valve is a butterfly type valve that is driven by a single-phase 118-volt AC motor. This valve has two purposes. The first is, the valve opens to let engine bleed air to enter the air conditioning system for normal operation. The second is, the valve will close to shut off airflow to the air conditioning system when the system is not in use or in case of an emergency. The shutoff valve is controlled by the Cabin Pressure Master Switch which, in the off or Ram position, energizes the "close" winding. When in the 7.45 psi or the Combat 4.50 psi position, the open winding is energized.



Fill in the blanks to complete the following statements:

1. The first valve in the Bomber Air Conditioning system is the ________ ____________ ________ valve.

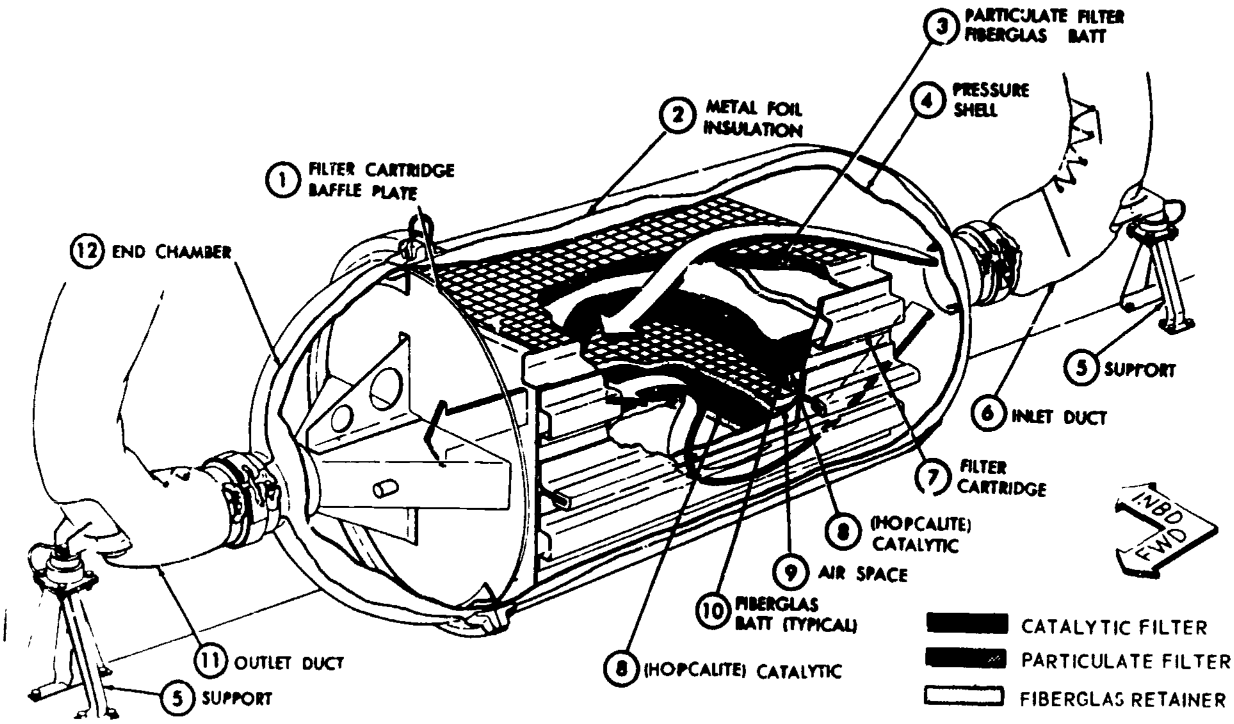
2. The Air Conditioning Shutoff valve ____________ to allow bleed air to flow into the ________________ ________ ____________ system.

3. The air conditioning shutoff valve __________ to stop bleed air flow into the Air Conditioning System.

Answers - Frame 2: 1. air conditioning shutoff
2. opens, cabin air conditioning 3. closes

Frame 3

The Air Conditioning System Filter is shown below. It is the next unit in the sequence of airflow. The filter is installed to remove contamination in the air supply. The filter consists of a pressure shell (4), an end chamber (12), and replaceable filter elements (7). The filter elements are of two types; particulate (3), which screens out solid particles, and catalytic (8), which changes any obnoxious gases and vapors into harmless products. The particulate filters are formed of layers of fiberglas batting (sheets). The catalytic filters consists of a patented granular substance (Hopcalite) held in position between the screens and fiberglas. The active catalytic material is a mixture of copper and manganese oxides which causes a reaction between any contaminates and the oxygen in the air supply, oxidizing them to harmless water or carbon dioxide. There are two particulate filters, one on each side of the filter unit, and these can be replaced without changing the inner catalytic filter element.



Answer the statements as either True or False.

_____1. Any obnoxious gases and vapors such as fules and oil fumes are turned into harmless products by the catalytic element.

_____2. Two catalytic elements and one particulate element are installed in the filter.

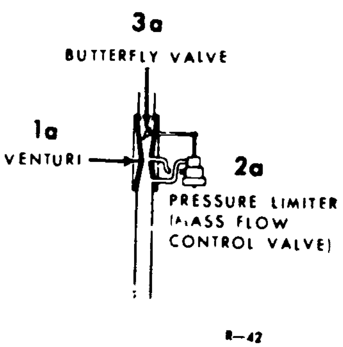
_____3. The overall purpose of the catalytic filter is to remove contamination of any sort from the air supply.

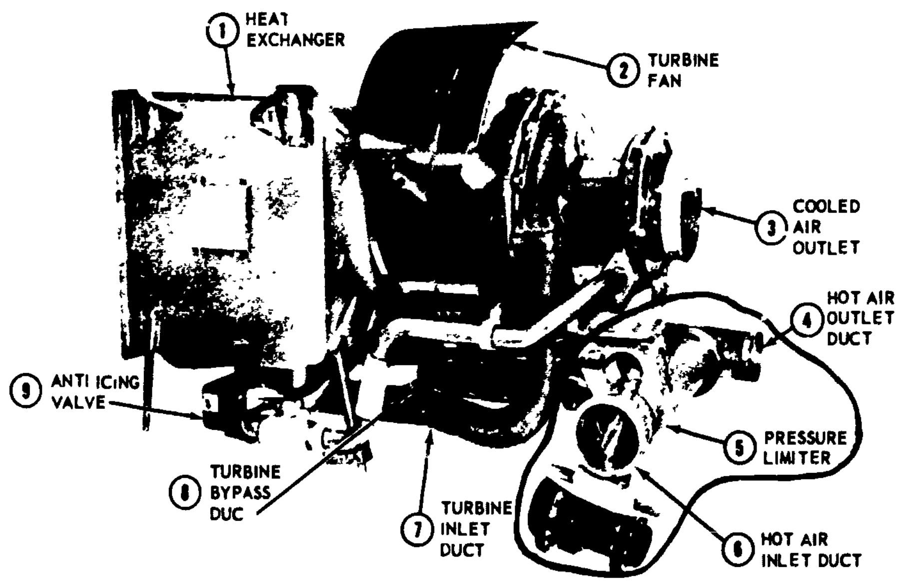
Answers to Frame 3: 1. T 2. F 3. T

Frame 4

The pack Pressure Limiter (5), is shown in the picture below. It is located on the forward lower section of the air conditioning pack. This valve maintains an even airflow through the system under varying inlet pressures and outlet flow demands. The main components of the limiter are a Venturi section (1a), a diaphragm operated control head (2a), and a pneumatically actuated Butterfly Valve (3a), which controls rate of airflow through the system. The limiter maintains a constant differential across the venturi by opening or closing the butterfly, thereby regulating system airflow to approximately 140 pounds per minute.

Go back to page 3 of this text and look at your air conditioning schematic. You will notice that airflow from the pack pressure limiter flow in two directions. Airflow from one direction flows to the heat exchanger. Air flow from the other direction flows to the air conditioning modulating valve. First, we will discuss airflow to the heat exchanger.





Circle the number of the statement that best describes the purpose of the pack pressure limiter.

1. The pack pressure limiter maintains the rated airflow capacity of the air conditioning system at approximately 140 lbs per minute.

2. The pack pressure limiter maintains a constant flow of ram air into the air conditioning system.

Answer to Frame 4: 1

Frame 5

Write the letter of the component found in column B in the appropriate space provided to the left of the purpose in column A.

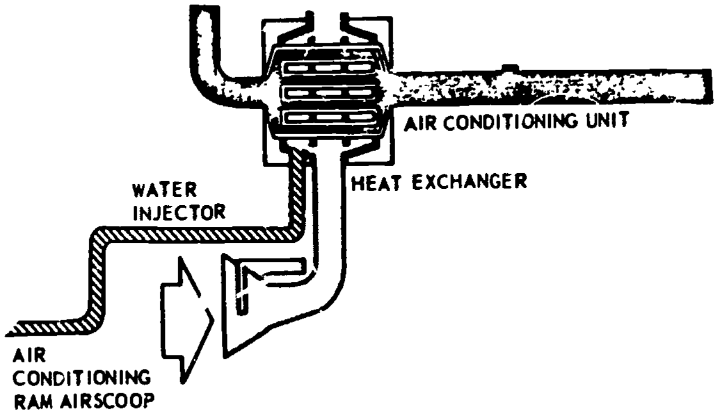
Column A	Column B
_____1. Regulates the system airflow to approximately 140 pounds per minute.	a. Air Conditioning System Shutoff Valve
_____2. Used to open and close the air supply line going to the air conditioning system.	b. Particulate Element
_____3. Changes any obnoxious gases and vapors into harmless products.	c. Catalytic Element
_____4. Removes solid particles from the air.	d. Pack Pressure Limiter
_____5. Normal source of bleed air.	e. Strut No. 3
_____6. Emergency source of bleed air.	f. Strut No. 1
	g. Strut No. 2

Answers to Frame 5: 1. d 2. a 3. c 4. b 5. g 6. e

Frame 6

A heat exchanger, shown in the schematic below, is used to cool the engine bleed air. The air conditioning ram air scoop is in the leading edge of the left wing.

Engine bleed air flowing through the heat exchanger is cooled by ram air entering the pack at the ram air inlet (shown in the sketch). The ram air which flows across the heat exchanger core cools the bleed air by transferring heat energy from the bleed air to the ram air. Additional cooling is accomplished by the water injector, which will be described to you in Frame 12.



Place the letter T in the blank space before each of the following that are true statements.

_____1. The heat exchanger cools the engine bleed air by transferring heat energy from the bleed air to the ram air.

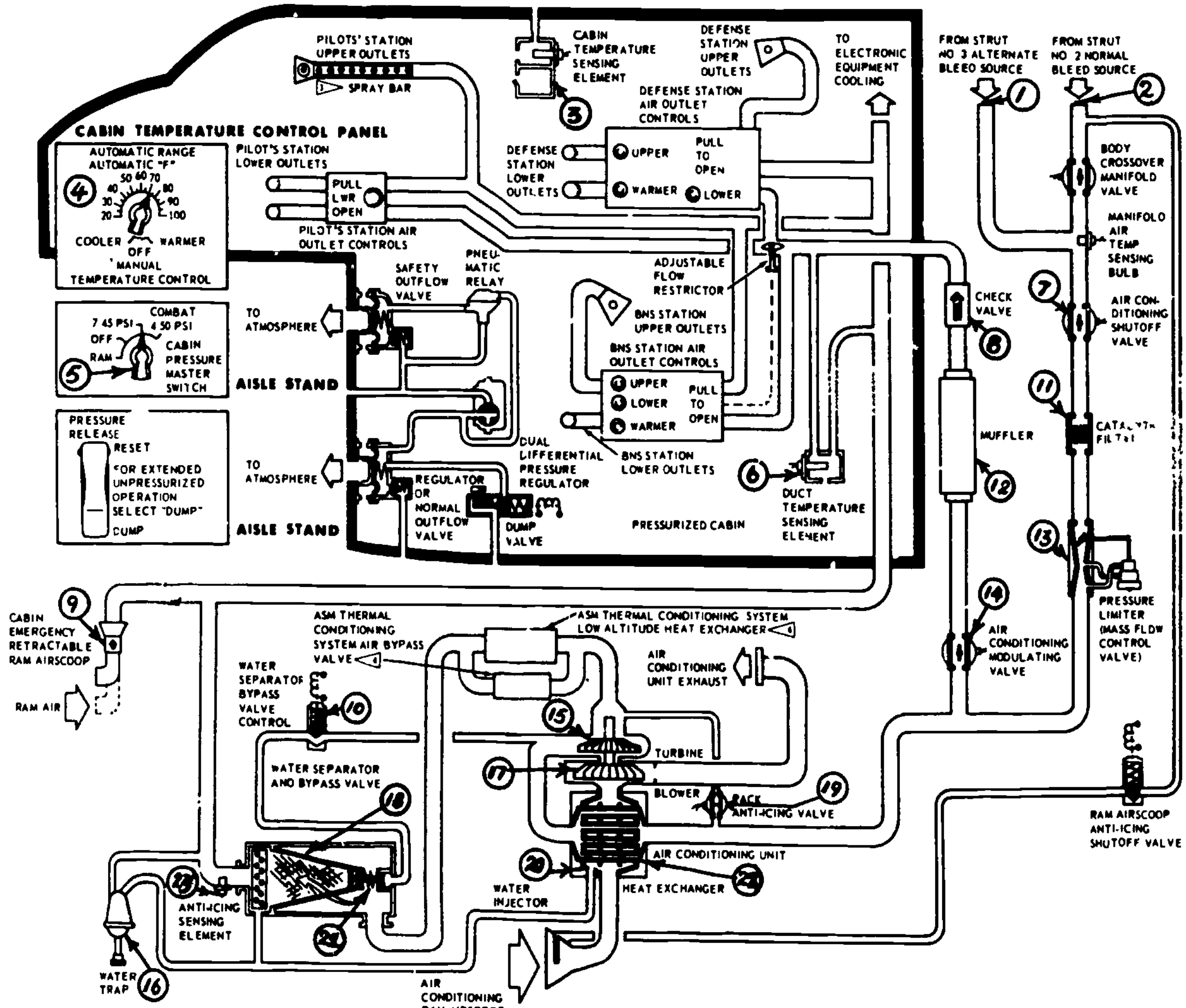
_____2. Ram air from a scoop in the leading edge of the left wing circulates around the tubes of the heat exchanger.

_____3. If the ram air scoop becomes blocked, the flow of ram air would stop. This would cause the engine bleed air to leave the heat exchanger at the same temperature at which it entered.

Answers to Frame 6: 1. T 2. T 3. T

Frame 7

Match each purpose given below with a component in the illustration and write the number from the illustration in the space provided.



_____1. Used to open and close the air supply line going to the cabin air conditioning system.

_____2. Regulates the system airflow to approximately 140 pounds per minute.

_____3. Cools the engine bleed air by transferring heat energy from the bleed air to ram air.

_____4. Removes any contamination such as solid particles and obnoxious gases from the air.

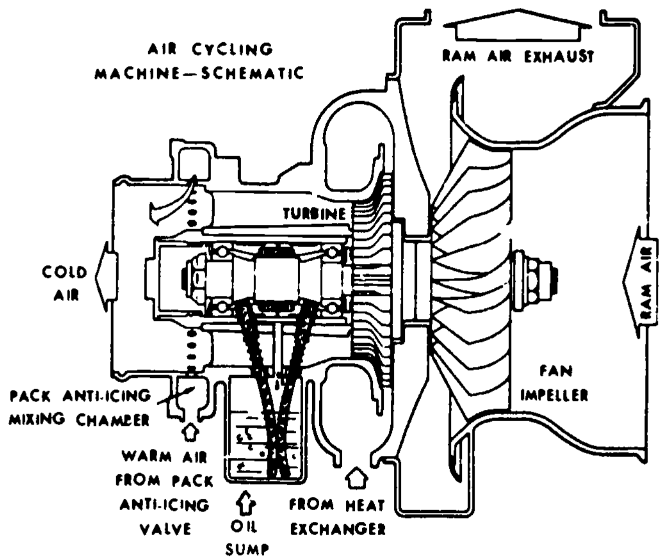
_____5. Normal source of engine bleed air.

_____ . Emergency source of bleed air.

Answers to Frame 7: 1. 7 2. 13 3. 22 4. 11 5. 2 6. 1

Frame 8

The Air Conditioning Pack Turbine Assembly, shown in the ketch, consists of a rotating shaft to which are affixed a turbine wheel and fan impellers, a housing which contains fan and turbine casi gs, the necessary shaft bearings, and an oil sump. The turbine cools the engine bleed air by converting heat energy into mechanical energy and by rapid expansion. The fan on the same shaft provides a load for the t· 'bine to prevent overspeeding and circulates air through the heat exchanger. The fan is driven by the expansion turbine. The turbine fan is also equipped with an oil sump (wick) heater. The heater prevents the turbine fan bearings from becoming damaged by preventing the temperature of the lubricating oil from dropping to a point that could cause improper lubrication.



Place the letter T alongside each of the following that are true statements.

_____1. The turbine wheel cools the engine bleed air by converting heat energy to mechanical energy and by rapid expansion.

_____2. The fan provides a load to prevent overspeeding of the turbine and circulates ram air through the heat exchanger.

_____3. The maximum temper ture drop of the bleed air takes place across the tubine.

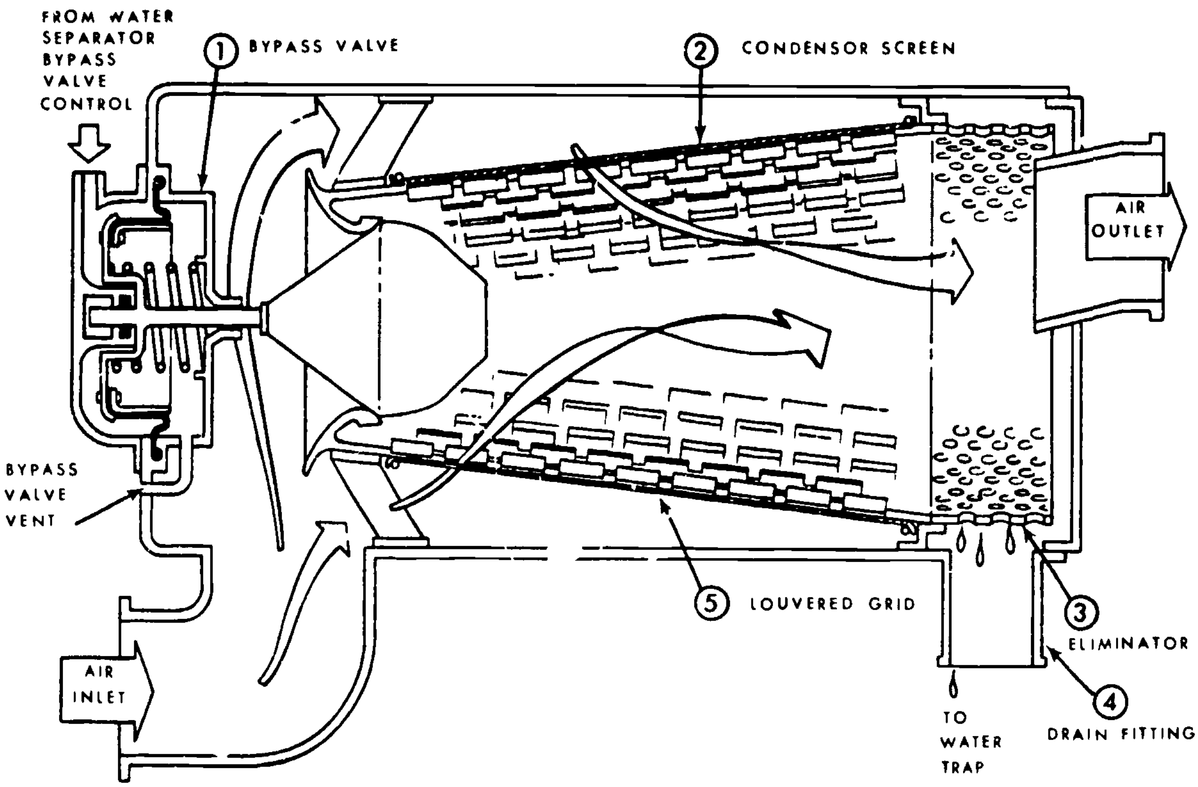
_____4. The engine bleed air cooled by the turbine comes from the ram air scoop in the leading edge of the left wing.

Answers to Frame 8: 1. T 2. T 3. T 4. F

Frame 9

The cold air, which is being discharged from the turbine, will then flow into the water separator. The water separator takes the moisture out of the air, which will reduce fogging or snowing in the cabin.

As the cooled air enters the water separator it flows through a condensor screen (2) made of a fiberglas fabric. The condensor screen is mounted on a cone-shaped grid (5) with louvered openings. In passing through the screen, water vapor is condensed into droplets which pass into the eliminator (3) and are thrown rapidly outward by the rotating force caused by the air passing through the louvered grids. The water droplets drain through circular perforations in the inner wall of the eliminator and flow downward through the annular space formed by the collector section and the outer shell of the water separator to a sump. A fitting is provided in the sump to drain water from the separator.



Circle the letter of the statement that best describes the purpose of the water separator.

A. The water separator removes moisture from the heat exchanger ram discharge air.

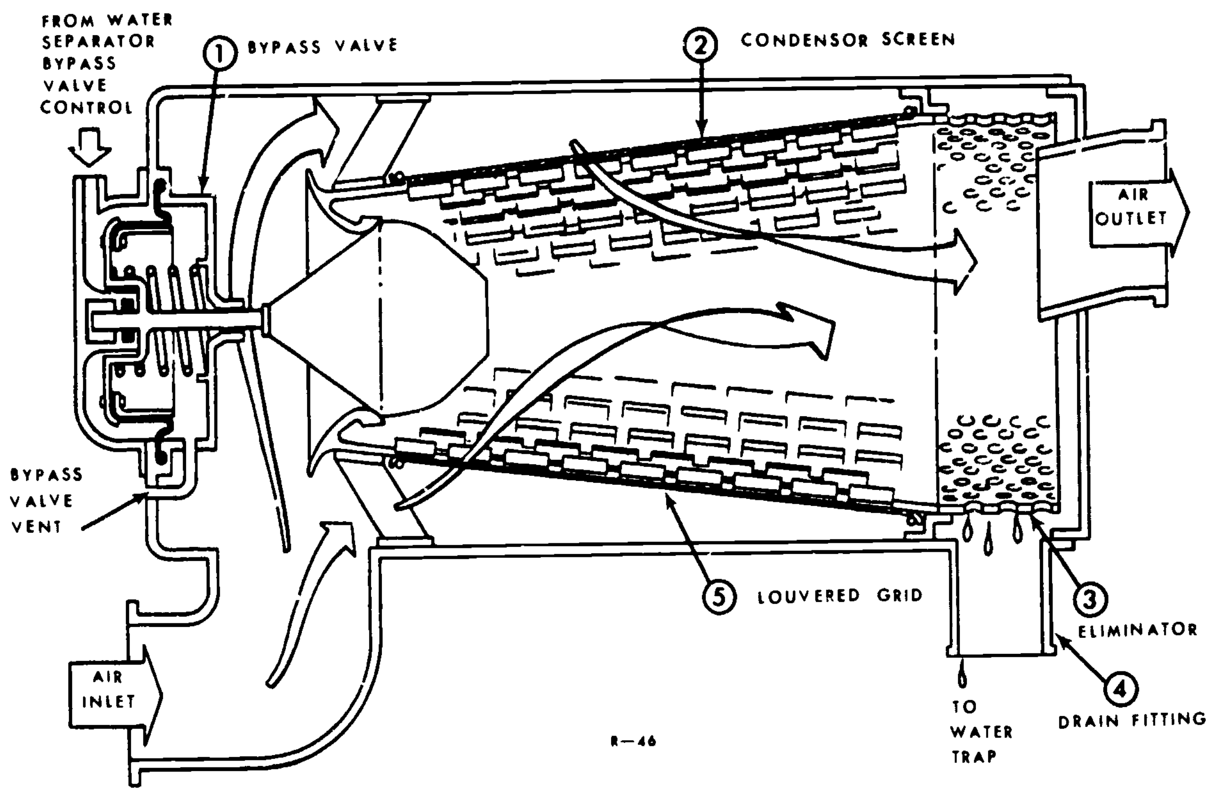
B. The water separator removes moisture from the cooled turbine discharge air and, thus, reduces fogging or snowing in the control cabin.

C. The water separator removes moisture from the ram air entering the cabin.

Answer to Frame 9: b

Frame 10

The water separator bypass valve (1) is a part of the water separator. The valve is used to bypass the water separator condenser screen under two conditions. Above 36,000 feet, the bypass valve will open so that the cooled air can bypass the condenser screen; and, if the condenser screen should ice up or get clogged, the bypass valve would open then, too.



Place the letter T alongside each of the following that are true statements.

_____ 1. The water separator condenser screen is bypassed at altitudes above 36,000 feet because of the lack of moisture in the air.

_____ 2. Icing or clogging of the condenser screen will cause a higher than normal pressure differential across the screen that will open the bypass valve.

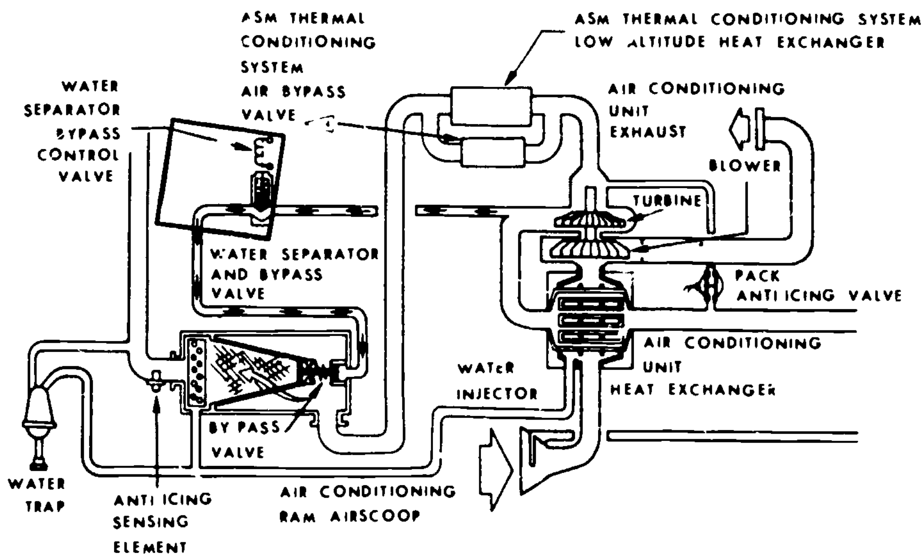
_____ 3. The bypass valve is installed in the air outlet end of the water separator.

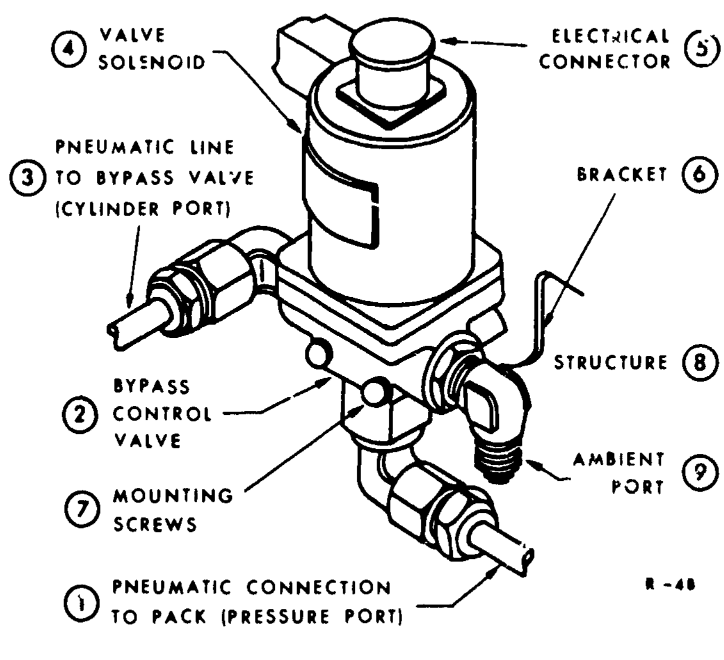
_____ 4. Opening the bypass valve forces the cooled air through the screen instead of letting the cooled air go around the screen.

Answers to Frame 10: 1. T 2. T 3. F 4. F

Frame 11

When the air conditioning system is on and the aircraft has reached 36,000 feet or above, the aneroid pressure switch opens, energizing the water separator bypass valve solenoid. This will open the valve and permit bleed air pressure to flow from a port at the top of the air conditioning pack to the control chamber of the water separator bypass valve, opening the bypass valve. Cooled air, while bypassing the condenser screen, then flows through the water separator. The water separator bypass valve control is a solenoid operated air valve. Refer to the two illustrations shown and then read each statement on the next page and place the letter T beside each of the true statements.





Frame 11 (Continued)

_____1. The water separator bypass valve control is a solenoid operated air valve.

_____2. The water separator bypass valve control will permit high pressure air to flow from a port on the air conditioning pack to the control chamber of the water separator bypass valve and force the bypass valve open.

_____3. Opening the water separator bypass valve will allow cooled air to bypass the water separator condenser screen.

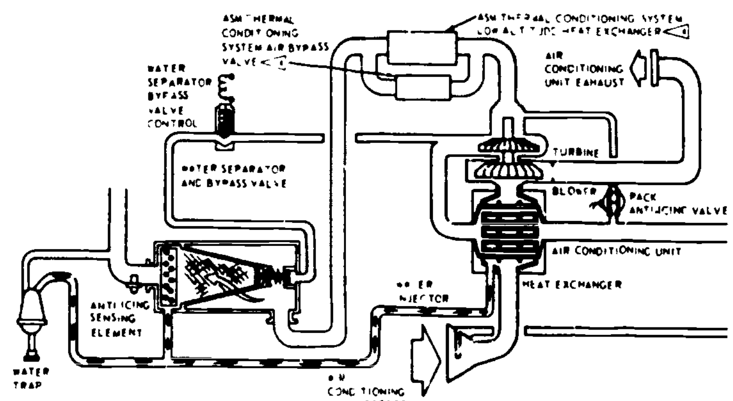
Answers to Frame 11: 1. T 2. T 3. T

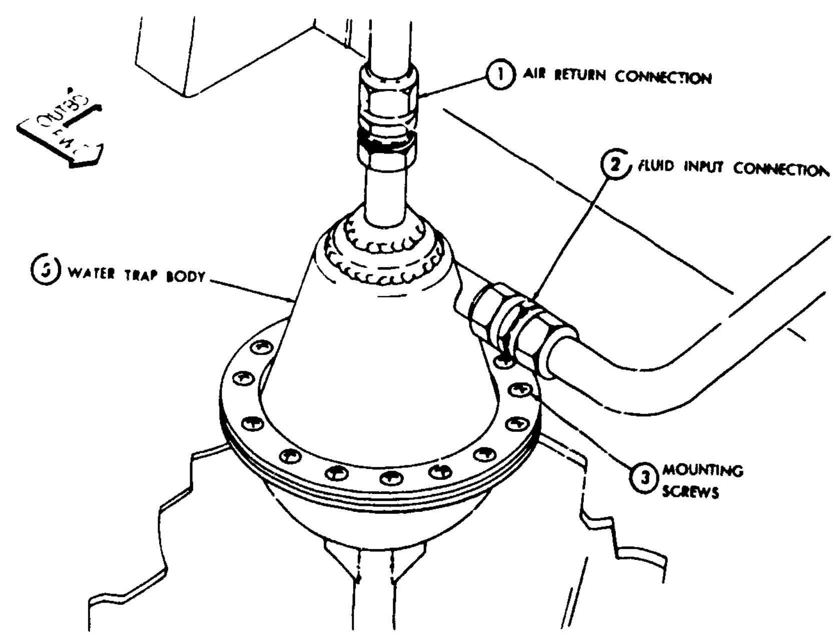
Frame 12

The moisture from the water separator will flow in two separate directions as shown by the arrows on the schematic.

The water injector shown sprays water over the heat exchanger coils to provide additional cooling of the engine bleed air.

The water trap is a float actuated drain valve. The trap is used to let the separated water be removed from the system without the loss of air. The trap is essentially a float actuated drain valve. A mixture of water and air enters the trap at the tangent fitting; the water and air are separated by rotating around the cone. The water gathers under the float and the air returns to the system through the air return tube at the top of the trap. When sufficient water is available to raise the float, the upward movement opens a valve, allowing the water to be discharged overboard. Internal trap pressure assists in closing the valve as soon as the water has been removed.





Refer to the illustration shown, then read each statement below and place the letter T beside each statement that is true.

_____ 1. Additional cooling of the engine bleed air is provided by the water injector.

_____ 2. The separated moisture will flow to the water trap and the water injector.

Frame 12 (continued)

_____3. The water trap is electrically operated.

_____4. The water trap is a float operated drain valve.

_____5. The removal of the separated water without the loss of air is performed by the water trap.

_____6 The water injector sprays the water over the heat exchanger coils in the ram air portion of the heat exchanger.

Answers to Frame 12: 1. T 2. T 3. F 4. T 5. T 6. T

Frame 13

Review Quiz

Write the letter of the component found in column B in the appropriate space provided to the left of the purpose in column A.

Column A

_____1. Sprays moisture over the heat exchanger coils and provides additional cooling of the engine bleed air.

_____2. Cools the engine bleed air by rapid expansion and converting heat energy to mechanical energy.

_____3. Permits the removal of the separated water without the loss of air.

_____4. Removes moisture from the pack air output and thus reduces fogging or snowing in the cabin.

_____5. Provides a load for the turbine to prevent overspeeding and circulates ram air through the heat exchanger.

_____6. Permits air pressure to flow from a port on top of the air conditioning pack to the control chamber of the water separator bypass valve.

_____7. Condenses the water vapor into water droplets.

_____8. Opens above 36,000 feet to allow cooled air to bypass the condenser screen.

_____9. Opens to bypass the condenser screen when the screen becomes plugged or frozen.

Column B

a. Turbine wheel

b. Fan Impeller

c. Water Separator

d. Condenser Screen

e. Louvered Grid

f. Water Separator Bypass Valve

g. Water Separator Bypass Valve Control

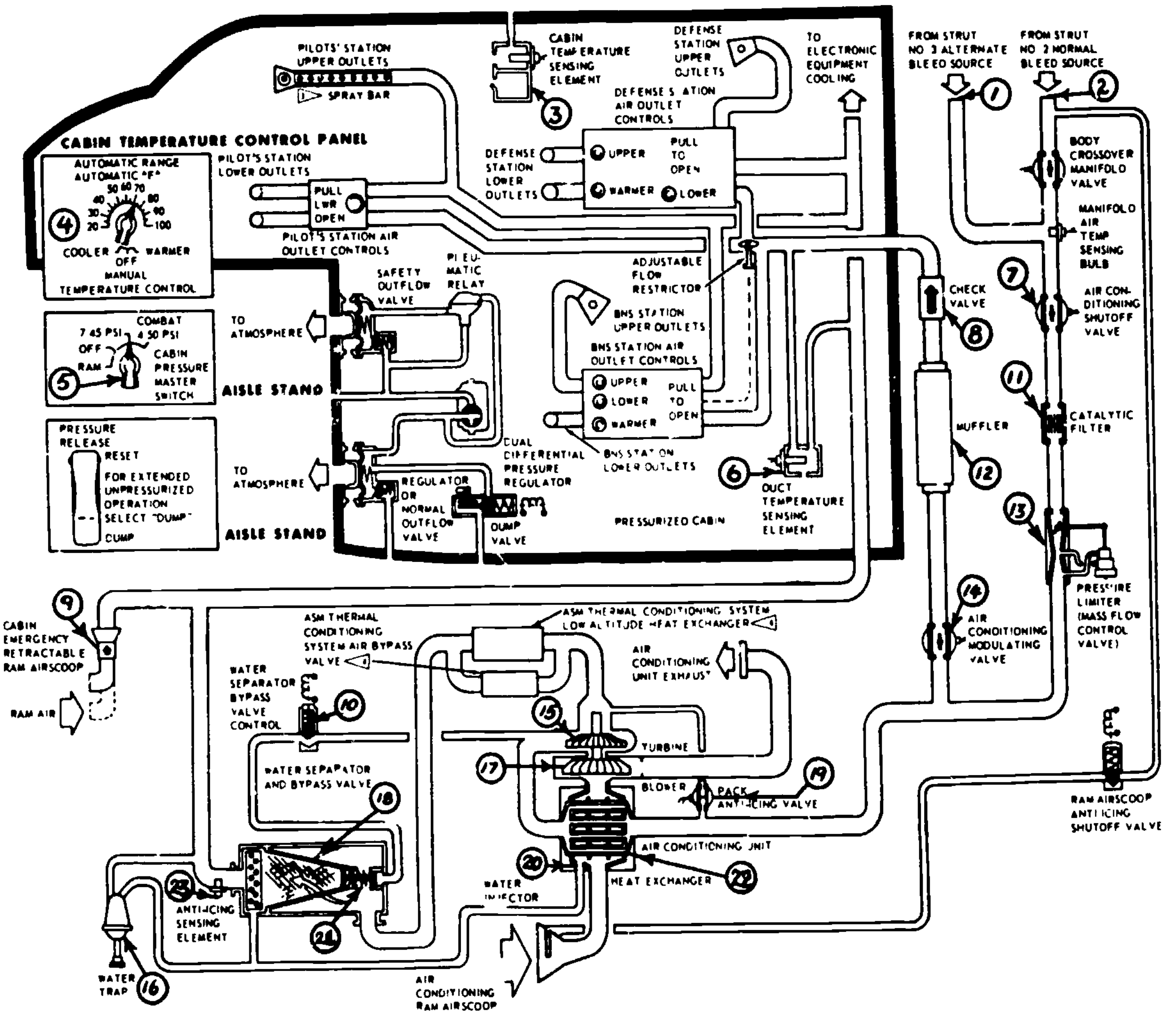
h. Water Injector

i. Water Trap

Answers to Frame 13: 1. h 2. a 3. i 4. c 5. b 6. g 7. d 8. f 9. f

Frame 14

Match each purpose given below with a component in the sketch and write the number from the sketch in the appropriate space near each purpose.



_____1. Sprays moisture over the heat exchanger coils and provides additional cooling of the engine bleed air.

_____2. Cools the engine bleed air by rapid expansion and converting heat energy to mechanical energy.

_____3. Permits the removal of the separated water without the loss of air.

_____4. Removes moisture from the pack air output and, thus, reduces fogging or snowing in the control cabin.

_____5. Provides a load for the turbine to prevent overspeeding and circulates ram air through the heat exchanger.

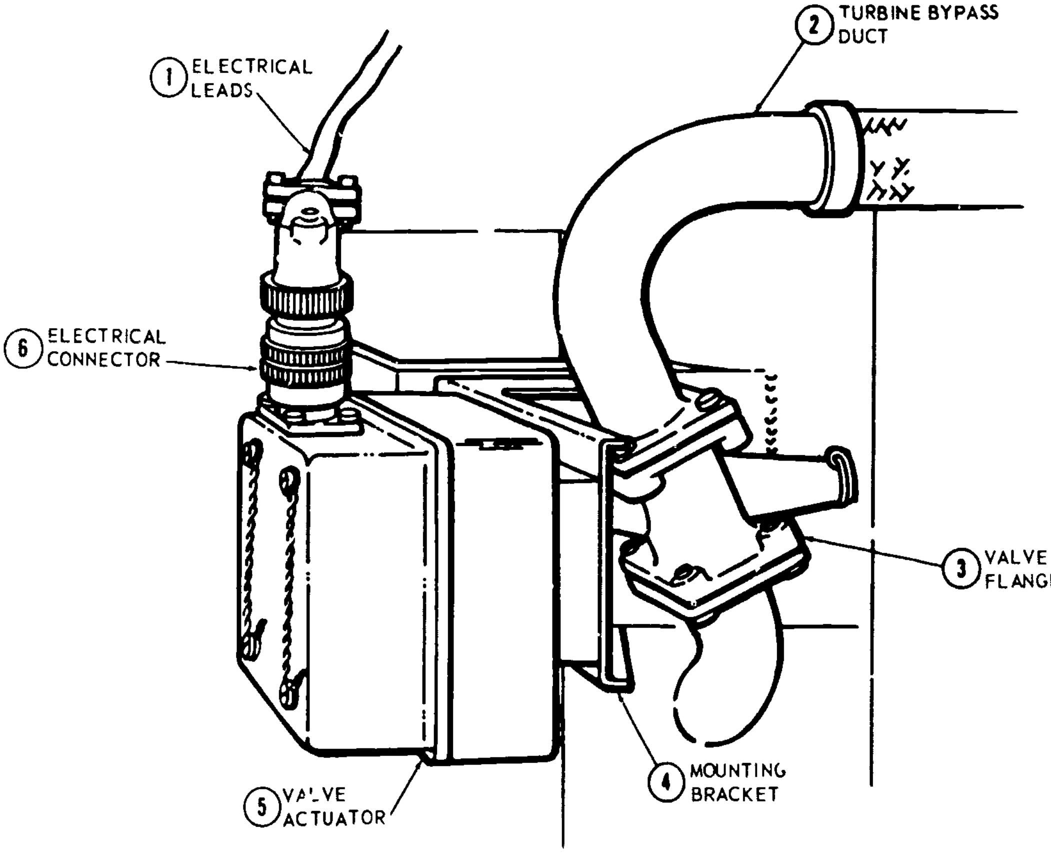
_____6. When energized open, permits air pressure to flow from a port on top of the air conditioning pack to the control chamber of the water separator bypass valve.

_____7. Will open when the condenser screen becomes plugged or frozen or at altitudes above 36,000 feet.

Answers to Frame 14: 1. 20 2. 15 3. 16 4. 18 5. 17 6. 10
7. 21

Frame 15

The pack anti-icing valve, as shown in the sketch, is mounted on the air conditioning pack. The purpose of this valve is to keep pack output temperatures from dropping below the freezing point. This valve is controlled by the pack anti-icing sensing element and the pack temperature controller. When the valve is opened, warm air will flow into the turbine discharge. Above 36,000 feet, the valve is closed by actuation of the aneroid pressure switch. The valve is powered by a 118 volt AC motor.



Pack Anti-Icing Valve

Place the letter T beside each of the following statements that are true.

_____1. By keeping the pack output temperatures above the freezing point, the anti-icing valve will keep the water separator from freezing.

_____2. The pack anti-icing valve is controlled by the pack anti-icing sensing element and the pack temperature controller.

_____3. The pack anti-icing valve will control the flow of warm air.

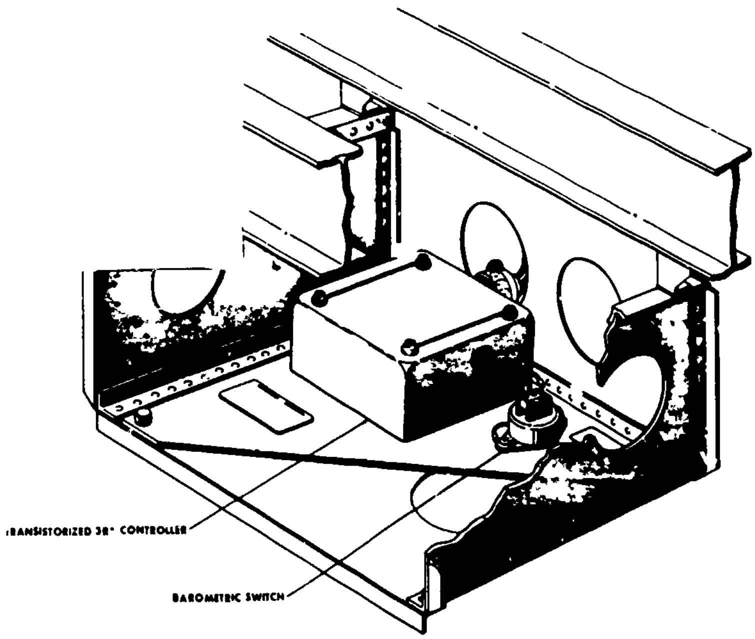
_____4. Above 25,000 feet, the pack anti-icing valve is closed by the aneroid pressure switch.

_____5. The pack anti-icing valve is closed above 36,000 feet by an aneroid pressure switch because there is very little moisture in the air.

Answers to Frame 15: 1. T 2. T 3. T 4. F 5. T

Frame 16

The air conditioning pack temperature (38°F) controller regulates the action of the pack anti-ice valve. This unit opens the valve when the pack discharge air drops below 3°C (38°F). The controller is entirely electronic and has no pneumatic or mechanical connections.



AIR CONDITIONING PACK 38° CONTROLLER

Place the letter T beside each of the following statements that are true.

_____1. The 38°F controller will open the pack anti-ice valve to let warm air enter the turbine discharge if the pack output temperature is 36°F.

_____2. If the pack output temperature was at 40°F, the pack temperature controller would close the pack anti-ice valve.

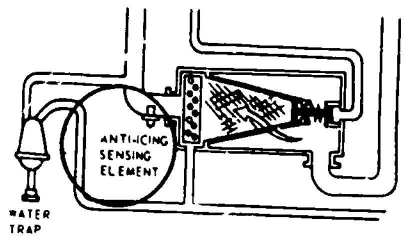
_____3. By regulating the action of the pack anti-ice valve, the 38°F controller controls the pack output temperature and tends to keep it at 38°F.

_____4. The pilot must select the temperature he would like to have maintained in the turbine discharge duct. Once selected, the 38°F controller positions the pack anti-ice valve to maintain that temperature.

Answers to Frame 16: 1. T 2. T 3. T 4. F

Frame 17

The pack anti-icing sensing element is located in the cold air outlet duct of the water separator. The anti-icing sensing element has a variable resistance with a negative coefficient of resistance. It is connected to the pack temperature (38°F) controller. The sensing element is used with the 38°F controller to regulate the opening and closing of the pack anti-icing valve.



Place the letter T beside each of the following statements that are true.

_____1. If the temperature around the sensing element increased, the resistance of the sensing element would decrease.

_____2. If the temperature around the sensing element dropped to 36°F the resistance of the sensing element would increase and the 38°F controller would open the pack anti-icing valve.

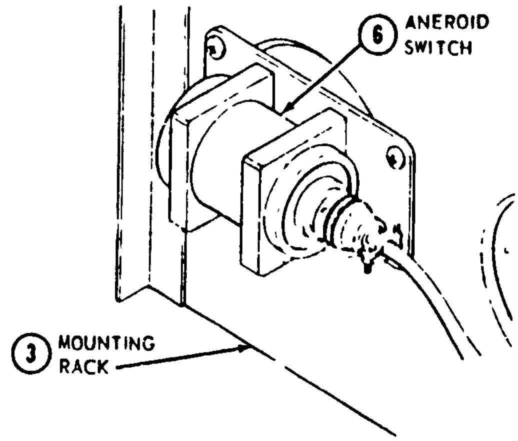
_____3. Increasing the air temperature in the water separator outlet to 40°F would decrease the resistance of the sensor and cause the 38°F controller to open the pack anti-icing valve.

_____4. By sensing the temperature of the air in the water separator outlet, the anti-icing sensing element keeps the water separator from freezing.

Answers to Frame 17: 1. T 2. T 3. F 4. T

Frame 18

The aneroid pressure switch is normally closed. It moves to the open position at 36,000 (±2,000) feet pressure altitude. When the altitude pressure switch opens, it energizes the water separator bypass valve control and closes the pack anti-icing valve.



Place the letter T beside each of the following statements that are true.

_____1. The aneroid pressure switch opens, it energizes the water separator bypass valve control at 36,000 feet and closes the pack anti-ice valve.

_____2. Since there is very little moisture in the air at altitudes above 36,000 feet and the water separator is being bypassed, the aneroid pressure switch closes the pack anti-icing valve.

_____3. The aner[illegible] [illegible]ssure switch moves to the open position by the atmosph[illegible] [illegible]essure at 36,000 feet.

109

Answers to Frame 18: 1. T 2. T 3. T

Frame 19

Review Quiz

Place the letter of the unit in column B alongside the purpose that corresponds to it in column A.

Column A		Column B
_____1. Has a negative coefficient of resistance.	a.	Pack Anti-icing Valve
_____2. Keeps the pack output temperature above the freezing point.	b.	Air Conditioning Pack 38° Controller
_____3. Actuates to the open position at 36,000 feet pressure altitude.	c.	Anti-icing Sensing Element
_____4. Controls the action of the pack anti-ice valve.	d.	Aneroid Pressure Switch
_____5. When open, admits relatively warm air into the turbine discharge.		
_____6. Closes the pack anti-ice valve above 36,000 feet.		
_____7. Energizes the water separator bypass valve control above 36,000 feet.		
_____8. Opens the pack anti-ice valve when pack output temperature falls below 38°F.		
_____9. Works in conjunction with Air Conditioning Pack 38° F controller to regulate the action of the pack anti-ice valve.		

Answers to Frame 19: 1. c 2. a 3. d 4. b 5. a 6. d 7. d
8. b 9. c

Frame 20

Four parts make up the 38°F control system. These parts are aneroid pressure switch, the pack anti-icing valve, air conditioning pack temperature controller, and the air conditioning pack anti-icing sensing element.

Place a circle around the number of the component parts that are included in the pack anti-icing system.

1. Pack pressure limiter.

2. Aneroid pressure switch.

3. Water separator bypass valve.

4. Pack anti-icing valve.

5. Water trap.

6. Anti-icing sensing element.

7. Catalytic filter.

8. Air conditioning system shutoff valve.

9. Turbine.

10. Blower.

11. Heat exchanger.

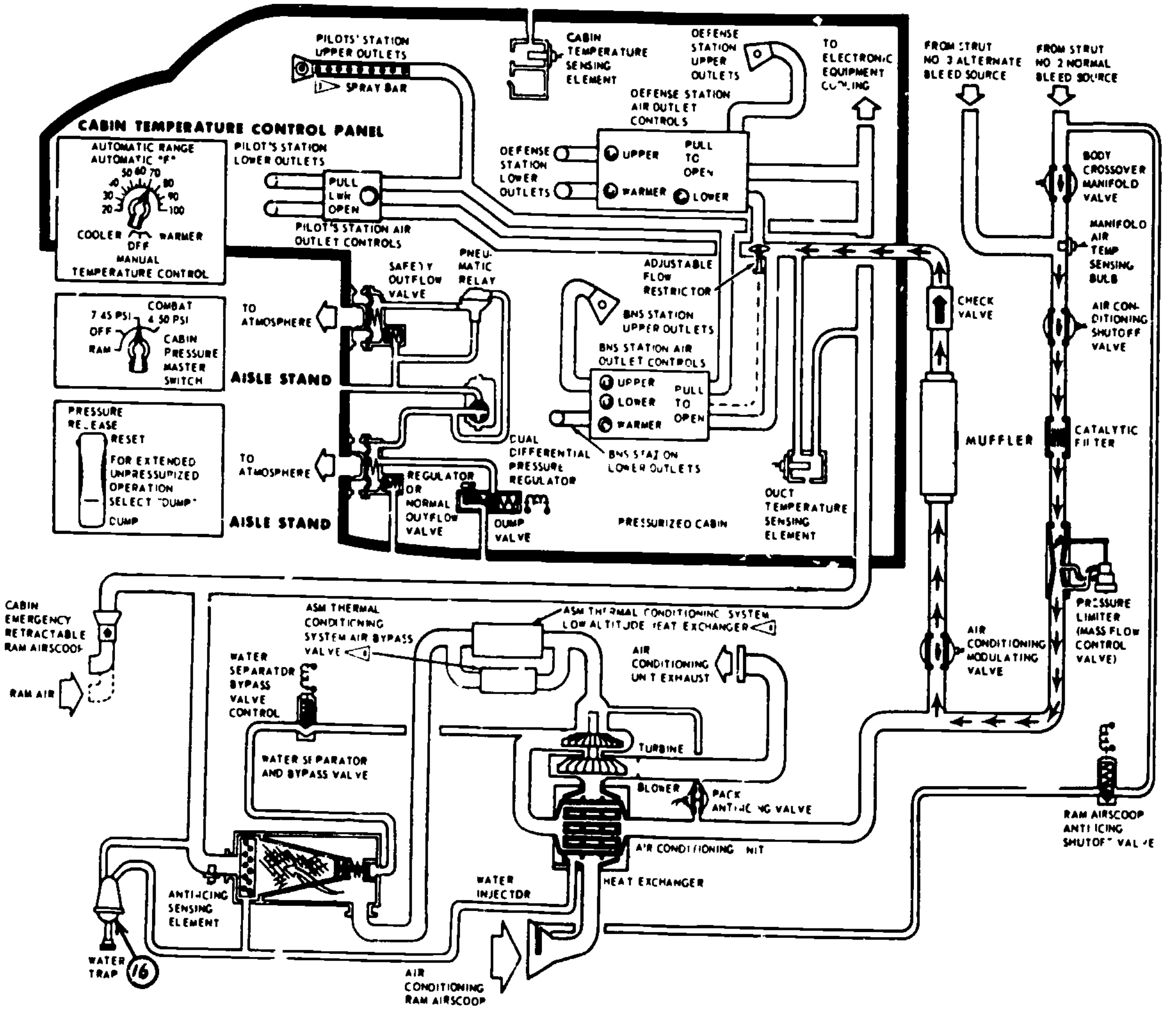
12. 38°F temperature controller.

13. Water separator.

Answers to Frame 20: 2, 4, 6, 12

Frame 21

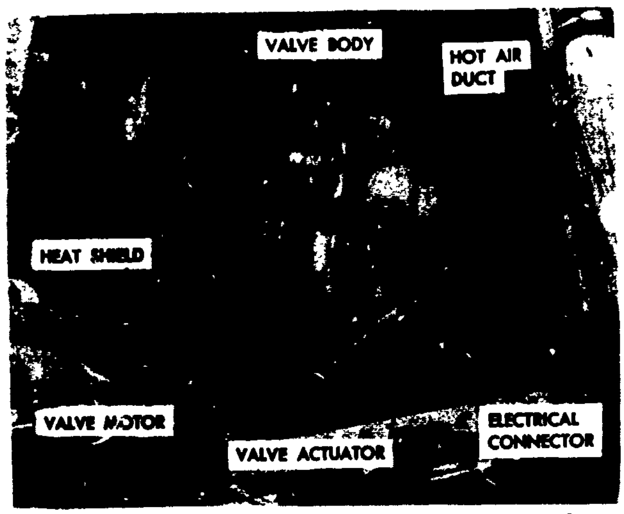
Now let us follow the path of airflow shown by the arrows in the schematic below. This path will deliver hot air to the cabin area. We shall discuss each of the units individually in the next few frames.



No Response Required

Frame 22

The air conditioning modulating valve controls the temperature of the crew compartment by varying the amount of the hot air entering the cabin. Opening the valve increases the flow of hot air to the cabin, while closing the valve decreases the amount of hot air going to the 'n. This valve can be controlled automatically by the cabin temperature regulator or manually by the cabin temperature control switch.



S-1.188

Air Conditioning System Modulating Valve

Place the letter T beside each of the following statements that are true.

_____1. To increase the temperature of the crew compartment, the air conditioning modulating valve is opened.

_____2. To decrease the temperature of the crew compartment, the air conditioning modulating valve is closed.

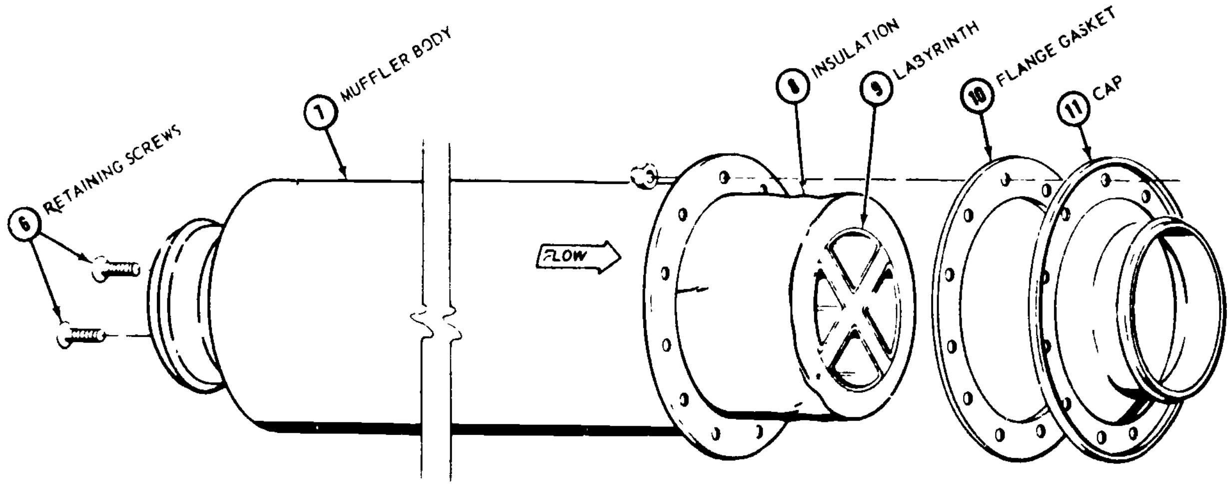
_____3. By varying the position of the air conditioning modulating valve, the amount of hot air going to the cabin is varied.

_____4. The air conditioning modulating valve is controlled manually by the cabin temperature regulator and automatically by the cabin temperature control switch.

Answers to Frame 22: 1. T 2. T 3. T 4. F

Frame 23

The hot air muffler is in the hot air line leading into the cabin. This muffler is used to absorb valve noise and to prevent noise transmission through the air conditioning ducts to the crew compartment.



Place the letter T beside each of the following statements that are true.

_____1. A malfunctioning muffler could cause the air coming in from the crew outlets to be very noisy.

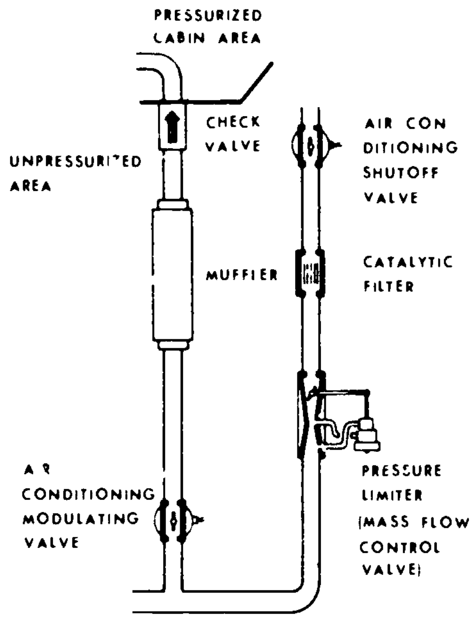
_____2. The muffler is mounted in the hot air line leading to the heat exchanger.

Answers to Frame 23: 1. T 2. F

Frame 24

The check valve, shown in the schematic below, prevents the possibility of rapid cabin depressurization due to a failure of a duct or coupling outside the pressurized area of the airplane.

The check valve will allow air to flow only in one direction and the arrow on the valve indicates the direction of airflow.



R—49

Refer to the schematic shown, then read each of the statements below and place the letter T in the blank space beside each statement that is true.

_____1. The check valve will allow airflow in one direction only.

_____2. The check valve would prevent rapid cabin depressurization if one of the clamps on the muffler failed.

_____3. The arrow on the check valve denotes the direction of outflow.

_____4. The check valve would prevent rapid cabin depressurization if the duct between the catalytic filter and pressure limiter was defective.

Answers to Frame 24: 1. T 2. T 3. T 4. T

Frame 25

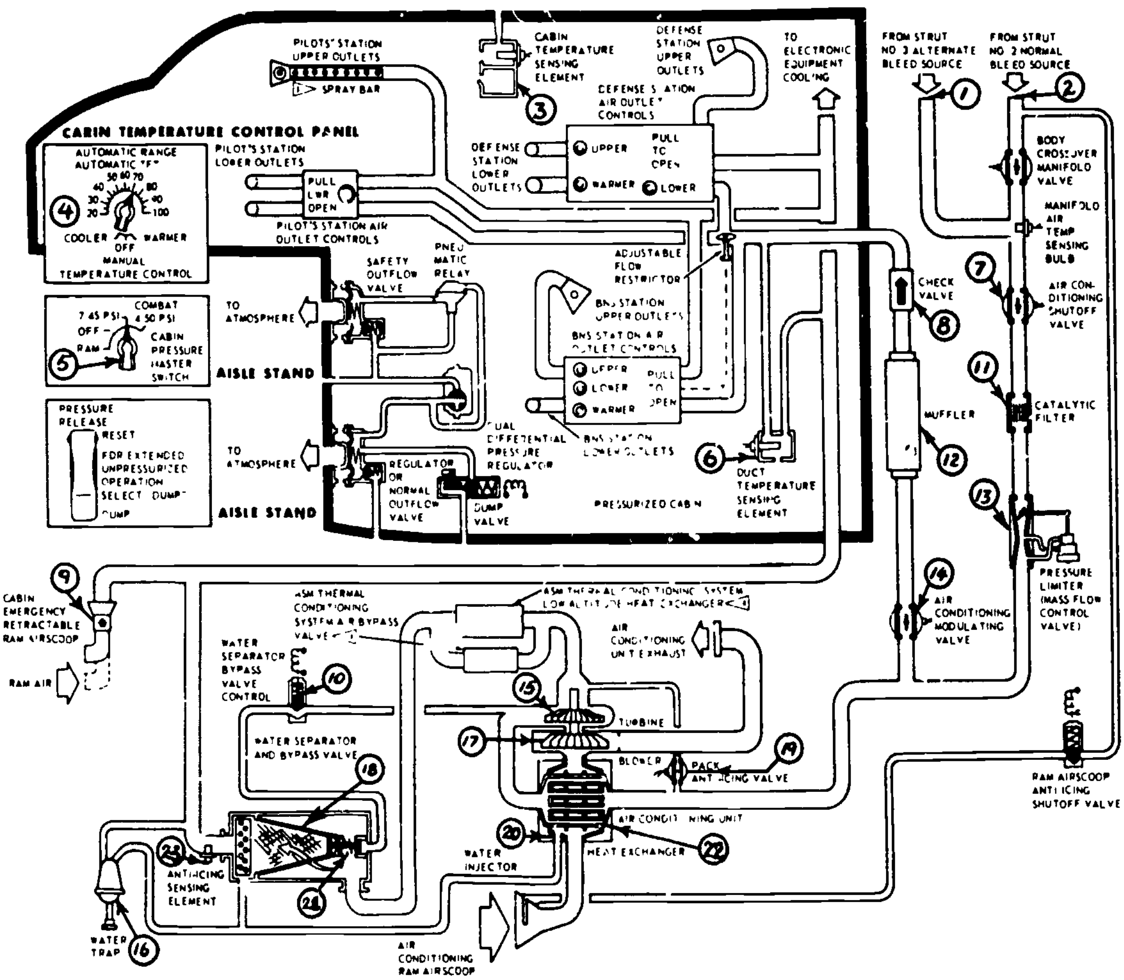
Place the letter of the unit in column B alongside the purpose that corresponds to it in column A.

Column A	Column B
_____1. This unit is used to absorb valve noise and prevent its transmission through ducts to the cabin area.	a. Air Conditioning System Modulating Valve
_____2. Controls the temperature of the crew compartment by varying the amount of hot air admitted to the cabin.	b. Hot Air Muffler
_____3. Prevents the possibility of rapid cabin depressurization due to failure of a duct or coupling outside the pressurized area of the aircraft.	c. Check Valve

Answers to Frame 25: 1. b 2. a 3. c

Frame 26

Match each purpose given below with a component in the sketch and write the number from the sketch in the appropriate space near each purpose.



_____1. Prevents turbine output temperature from dropping below freezing point, downstream from the turbine which could cause an ice build-up.

_____2. Regulates the action of the pack anti-icing valve in conjunction with the 38°F controller.

_____3. These units are variable resistance temperature sensing elements with a negative coefficient of resistance.

_____3a.

_____4. Controls the temperature of the crew compartment by varying the amount of hot air admitted to the cabin.

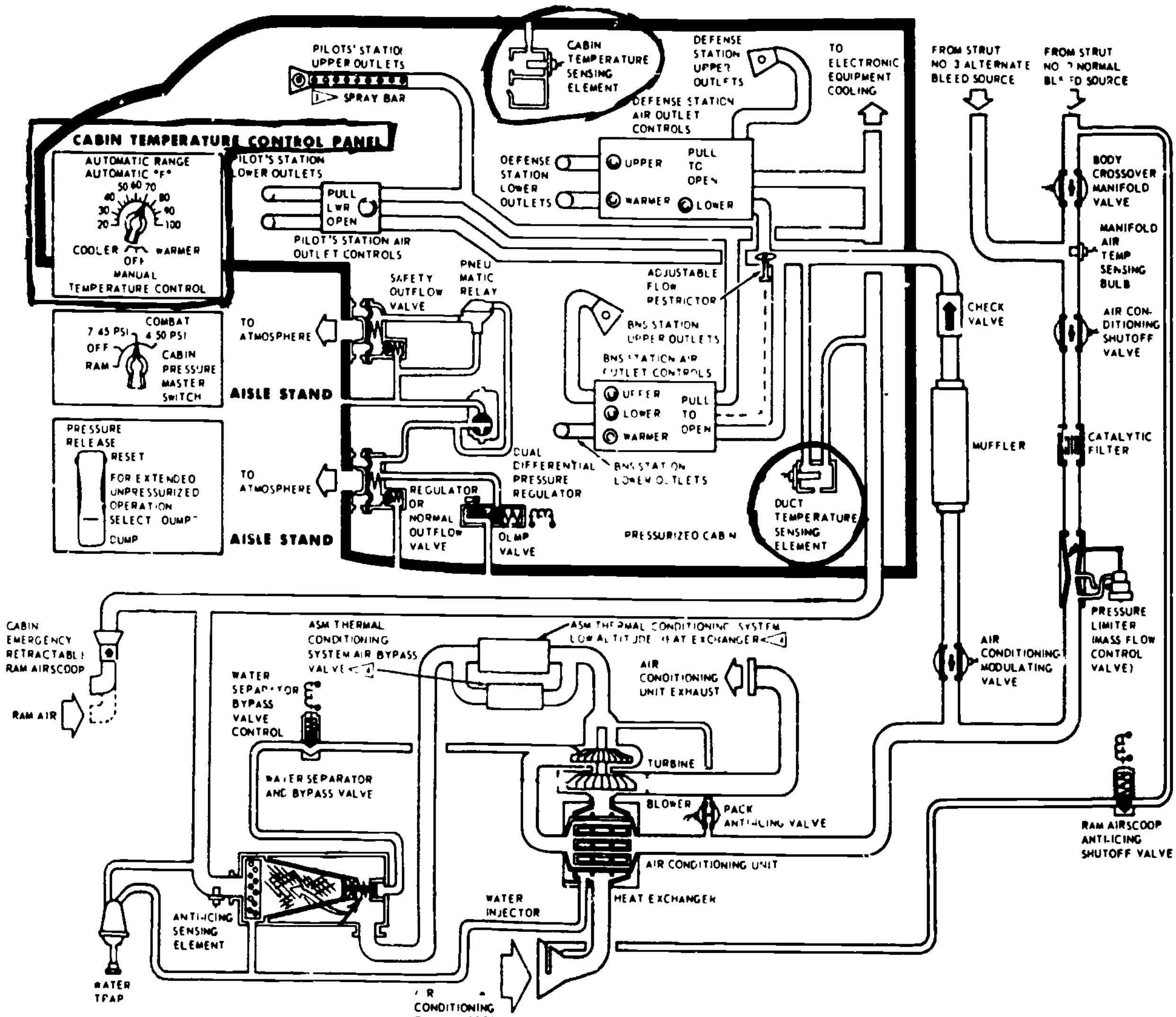
_____5. Absorbs valve noise and prevents noise transmission through the ducts to the cabin area.

_____6. Prevents the possibility of rapid cabin depressurization due to a failure of a duct or coupling outside the pressurized area of the aircraft.

Answers to Frame 26: 1. 19 2. 23 3. 23 3a. 3 4. 14
5. 12 6. 8

Frame 27

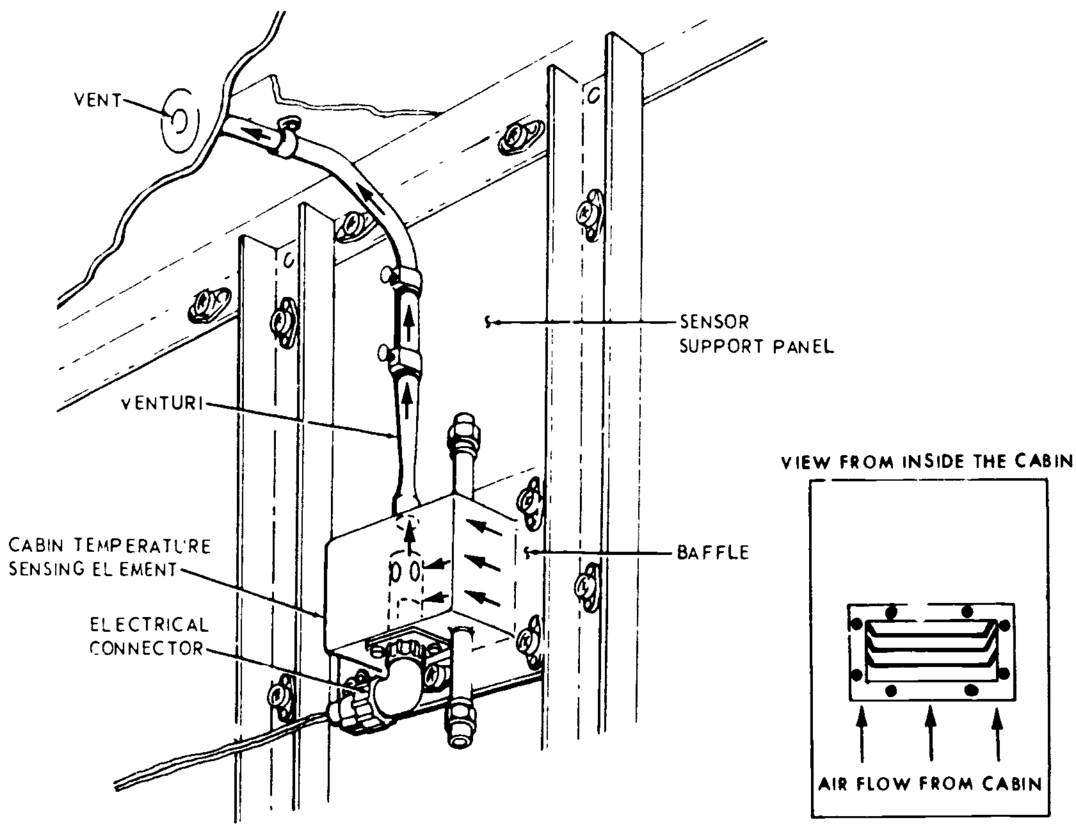
The next few frames will cover the units outlined by the circles in the schematic shown below. The cabin regulator (not shown) will also be discussed.



No Response Required

Frame 28

\The cabin temperature sensing element senses the temperature of the air in the cabin. Find the vent in the sketch. This vent is used to draw cabin air over the cabin sensing element. The vent is flush with the outside skin of the plane. Slotted holes through the baffle permit airflow over the element from cabin itself. The venturi restricts cabin airflow over the sensing element. This sensing element has a negative coefficient of resistance. The arrow indicates direction of airflow from the cabin of the aircraft, over the sensing element, then overboard.



Place the letter T beside each of the following statements that are true.

____. An increase in temperature in the cabin will cause the resistance of the sensor to decrease.

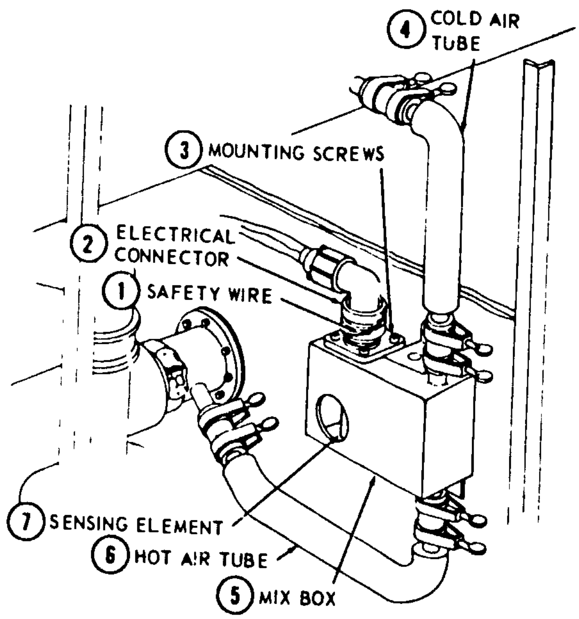
____2. An increase in cabin temperature will cause the resistance of the sensor to increase.

____3. The cabin sensor installation is vented to the atmosphere to make sure there is an airflow over the sensing element.

Answers to Frame 28: 1. T 2. F 3. T

Frame 29

The duct temperature sensing element senses the temperature in the two main ducts which are downstream of the muffler and the water separator. It provides signals to the electronic cabin temperature regulator for the control of the air conditioning system modulating valve. The element contains two sensors one with a rapid response, the other with a slow response. These sensors have a positive temperature resistance coefficient.



Place the letter T beside each of the following statements that are true.

_____1. Increasing the amount of hot air entering the mix box will increase the resistance of the sensing element.

_____2. The term positive temperature-resistance coefficient means that as the temperature surrounding the duct temperature sensing element increases, the resistance of the sensors will increase.

_____3. Two sensors can be found in the duct temperature sensing element; one with a fast response and one with a slow response.

_____4. The cabin temperature regulator receives signals from the duct temp'rature sensing element and varies the position of the air conditioning modulating valve.

_____5. Airflow from the two main ducts, which are downstream of the muffler and water separator, flows across the duct temperature sensing element.

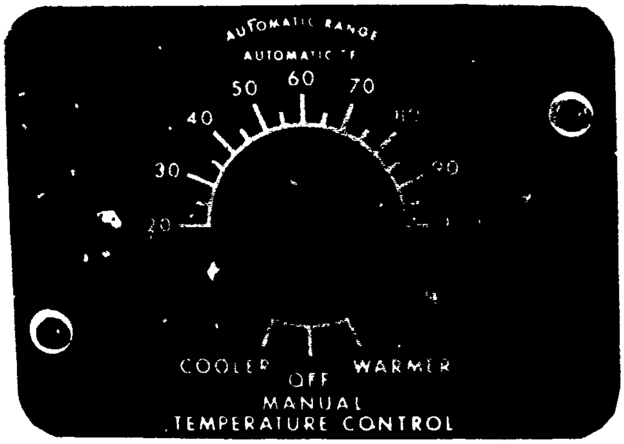
Answers to Frame 29: 1. T 2. T 3. T 4. T 5. T

Frame 30

The temperature control selector is used to vary the temperature of the cabin air inflow. The selector has two ranges, automatic and manual.

When in automatic, rotation of the temperature selector knob within the automatic range adjusts a variable resistor providing the necessary control to automatically hold the cabin temperature at the selected value. In this automatic position the temperature control selector becomes part of the temperature regulator bridge circuit.

Should the regulator malfunction, an override can be accomplished by turning the selector to manual range and holding it in the cooler or warmer position until the incoming air is at the desired temperature. When the control switch is held in the Warmer position, a signal is produced to open the modulating valve. When in the Cooler position, a signal is produced to close the modulating valve.



3-1.137

TEMPERATURE CONTROL SELECTOR

Read each statement below, refer to the illustration and then place the letter T beside each of the statements that are true.

_____1. If the temperature selector was in the 70° position, the cabin temperature regulator would control the temperature and the selector would be in the automatic range.

_____2. The "cooler" and "warmer" positions on the selector are the manual positions and are used if any portion of the automatic system fails.

_____3. While the temperature selector is in the automatic range, it becomes part of the temperature regulator bridge circuit and rotating it will unbalance the bridge circuit.

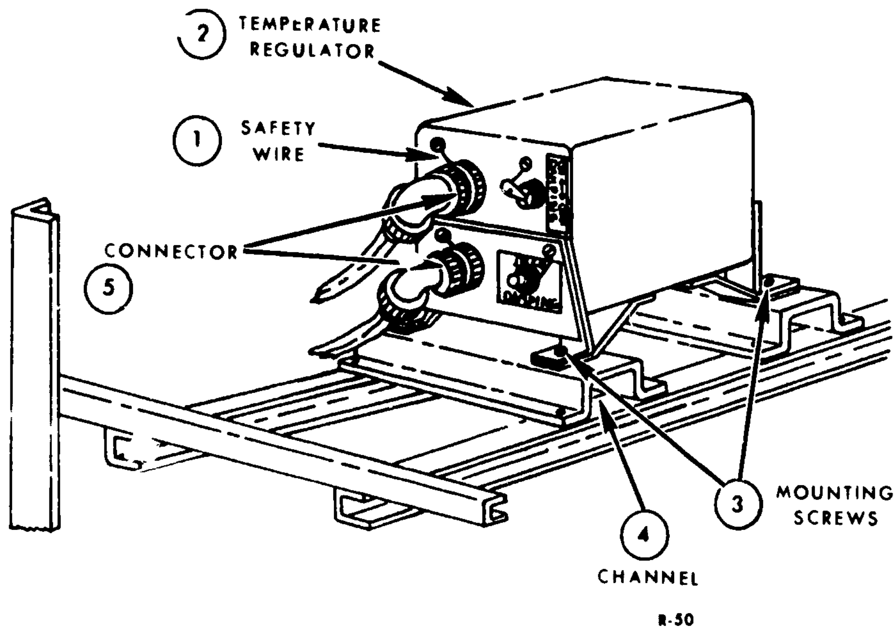
_____4. Changing the position of the temperature control selector in either the automatic or manual range will vary the temperature of the air entering the cabin.

_____5. The cabin temperature selector is used only during automatic operation of the temperature control system.

Answers to Frame 30: 1. T 2. T 3. T 4. T 5. F

Frame 31

The cabin temperature regulator (2) is an electronic control. Its function is to automatically keep the cabin temperature at the value selected. Circuit damping adjustments are accessible on the front cover of the regulator. The regulator is supplied with 24V DC to 28V DC and 118 volt, AC single phase, 400 Hz power.



Place the letter T beside each of the following statements that are true.

_____1. The cabin temperature regulator requires two sources of power, 28V AC and 118V single phase 60 cps AC for operation.

_____2. The cabin temperature regulator will maintain the cabin temperature at the valve selected by varying the position of the air conditioning modulating valve.

_____3. Dampening adjustments can be found on the front cover of the regulator.

Answers to Frame 31: 1. F 2. T 3. T

Frame 32

The cabin temperature sensor, duct temperature sensor, temperature control selector, temperature regulator, and the air conditioning modulating valve are the component parts of the automatic cabin temperature control circuit. This automatic temperature control circuit is designed to maintain the cabin temperature at the value selected by the pilot.

Circle the number of the component parts that make up the cabin temperature control system from the following list.

1. Anti-ice sensor
2. 38°F temperature controller
3. Duct temperature sensor
4. Cabin temperature regulator
5. Pack anti-ice valve
6. Air conditioning modulating valve
7. Temperature control selector
8. Cabin temperature sensor

Answers to Frame 32: 3, 4, 6, 7, 8

Frame 33

Review Quiz

Place the letter of the unit in column B alongside the purpose that corresponds to it in column A.

Column A		Column B	
_____1.	Automatically maintains the cabin temperature at the value selected.	a.	Cabin Temperature Sensing Element
_____2.	Senses the temperature of the air in the cabin.	b.	Venturi
_____3.	Used to select the temperature of the cabin air.	c.	Duct Temperature Sensing Element
_____4.	Senses the temperature in the two main ducts which are down stream of the muffler and water separator.	d.	Temperature Control Selector
_____5.	Installed in cabin sensor vent line to restrict the airflow to the atmosphere.	e.	Cabin Temperature Regulator
_____6.	Has a negative coefficient of resistance.		
_____7.	Has two resistors in the same housing.		
_____8.	Has a high positive coefficient of resistance.		
_____9.	Has two ranges, automatic and manual.		
_____10.	Can be turned to manual to override the temperature regulator if a malfunction appeared in the automatic control.		

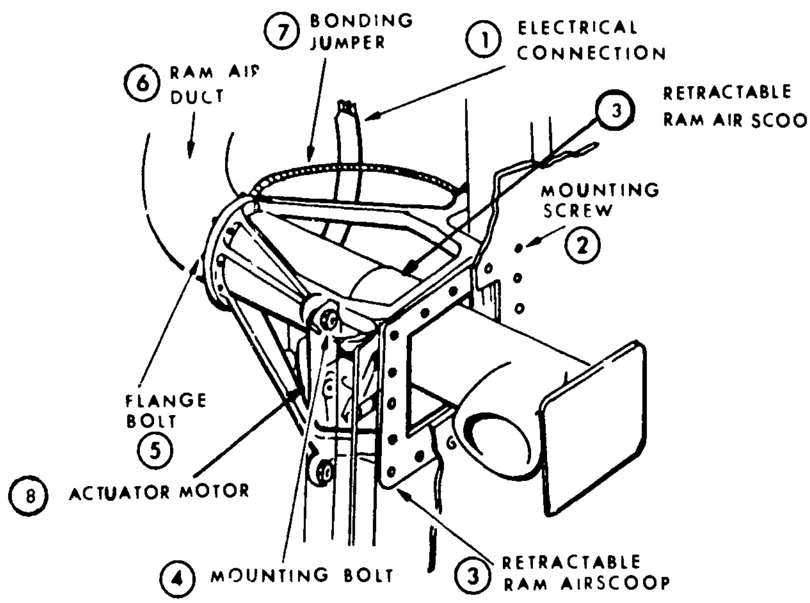
Answers to Frame 33: 1. e 2. a 3. d 4. c 5. b 6. a 7. c
8. c 9. d 10. d

Frame 34

The air conditioning emergency retractable ram airscoop is used to provide an emergency source of ram air for cooling ventilation of the crew compartment and for cooling the electronic equipment. The scoop is used only in case of emergency.

The scoop, flush with the aircraft skin when in the closed position, is actuated to both the open and closed position by a 118 volt 400 cycle single phase motor driven actuator.

Operation of the scoop is controlled by the CABIN PRESSURE MASTER SWITCH. Turning the switch to RAM position energizes the ram airscoop motor relay and allows the "open" windings in the scoop actuator motor to be energized. Turning the CABIN PRESSURE MASTER SWITCH to any position other than RAM deenergizes the airscoop motor control relay and allows the "close" windings on the scoop actuator motor to be energized.



Place the letter T beside each of the following statements that are true.

_____1. When the scoop is closed, it is in the retracted position and flush with the aircraft skin.

_____2. The flapper type check valve within the scoop prevents a loss of airflow from the cabin when the cabin is pressurized and the scoop is retracted.

_____3. The scoop is opened when it is extended.

_____4. The cabin area can be cooled and ventilated during an emergency by the ram air obtained from the ram air scoop.

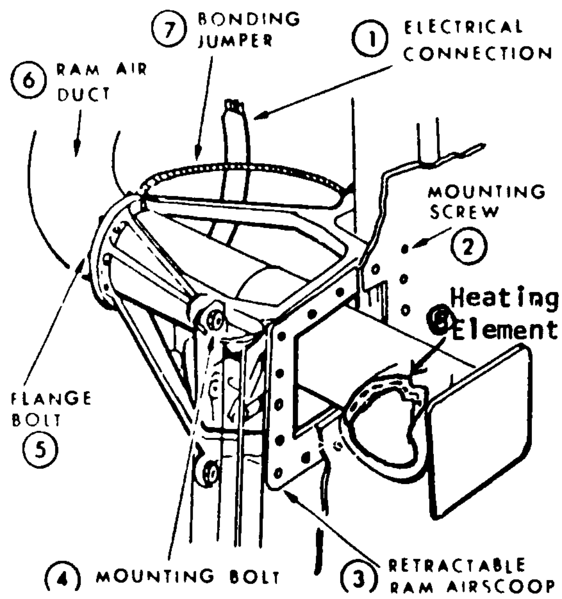
_____5. The electronic equipment located in the crew compartment can be cooled during an emergency by the ram air obtained from the ram air scoop.

Answers to Frame 34: 1. T 2. T 3. T 4. T 5. T

Frame 35

The air conditioning system emergency retractable ram air scoop motor is equipped with a time delay circuit. This circuit cycles the scoop to be extended for one minute and to be retracted for 12 to 15 seconds. This cycling is used for de-icing the scoop any time that the scoop anti-icing circuit is energized.

There is a heating element around the inlet scoop, which keeps the ice from freezing to the scoop and the retraction of the scoop scrapes the ice off.



Place the letter T beside each of the following statements that are true.

_____1. The timer motor causes ice, loosened by the anti-icing air scoop heating elements, to be scraped free from the air scoop.

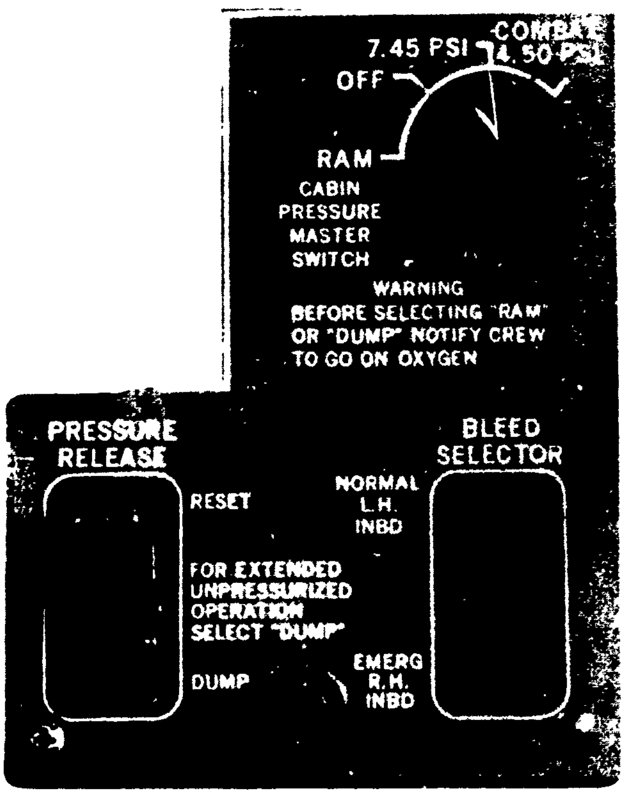
_____2. The timer motor is energized only when the air scoop anti-icing circuit is energized.

_____3. The timer motor will cause the air scoop to extend for one minute and retract for 12-15 seconds when it is energized by the air scoop anti-icing circuit.

Answers to Frame 35: 1. T 2. T 3. T

Frame 36

The cabin pressure master switch has four positions. In the "Ram" position the ram air scoop is extended and the air conditioning system shutoff valve is closed, stopping all the bleed air flowing to the air conditioning system. In the "OFF" position the ram air scoop is retracted and the air conditioning shutoff valve is closed. In the "7.45 psi" position, the cabin air conditioning system shutoff valve is open allowing bleed air to flow into the air conditioning system and receive normal pressurization. When the switch is placed to the "4.50 psi" or "Combat" position the cabin air conditioning system shutoff valve is open. The cabin pressurization then drops to a lower setting in case of a rapid depressurization during combat.



Place the letter of the switch positions in column B alongside the correct purpose for that switch position in column A.

	Column A		Column B
____1.	Retracts the ram air scoop and closes the air conditioning system shutoff valve.	a.	Ram
		b.	Off
____2.	Extends the ram air scoop and closes the air conditioning system shutoff valve.	c.	7.45 psi or Combat 4.50
____3.	Retracts the ram air scoop and opens the air conditioning system shutoff valve.		

Answers to Frame 36: 1. b 2. a 3. c

Frame 37

Place the letter of the unit or cabin pressure master switch position from column B in the blank space alongside the purpose that corresponds to it in column A.

Column A

_____1. Extends the ram air scoop and closes the air conditioning systems shutoff valve.

_____2. Causes the ram air scoop to retract and extend when the anti-icing circuit is turned on.

_____3. Retracts the ram air scoop and closes the air conditioning system shutoff valve.

_____4. Provides an emergency source of ram air for cooling and ventilation of the crew compartment and for cooling electronic equipment located in the crew compartment.

_____5. Prevents airflow from the cabin through the scoop when the aircraft is pressurized and the scoop is retracted.

_____6. Retracts the ram air scoop and opens the air conditioning system shutoff valve.

Column B

a. Retractable Ram Air Scoop

b. Retractable Ram Air Scoop Flapper Valve

c. Retractable Ram Air Scoop Timer Motor

d. Ram Position

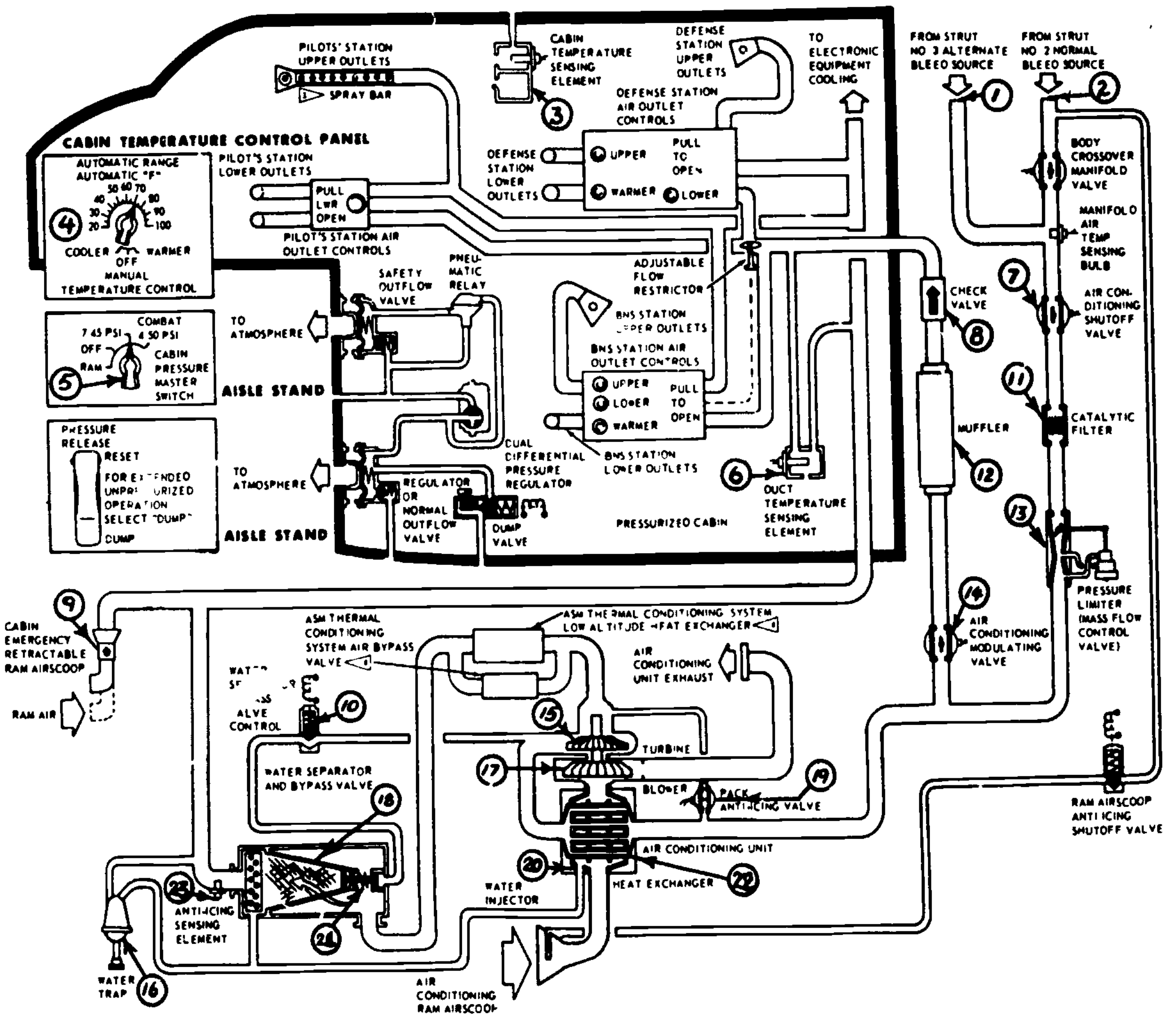
e. Off Position

f. 7.45 psi or Combat 4.50 psi Position

Answers to Frame 37: 1. d 2. c 3. e 4. a 5. b 6. f

Frame 38

Match each purpose given below with a component in the sketch and write the number from the sketch in the appropriate space near each purpose.



_____1. Senses the temperature of the air in the cabin.

_____2. Senses the temperature of the air in the two main ducts which are downstream of the muffler and water separator.

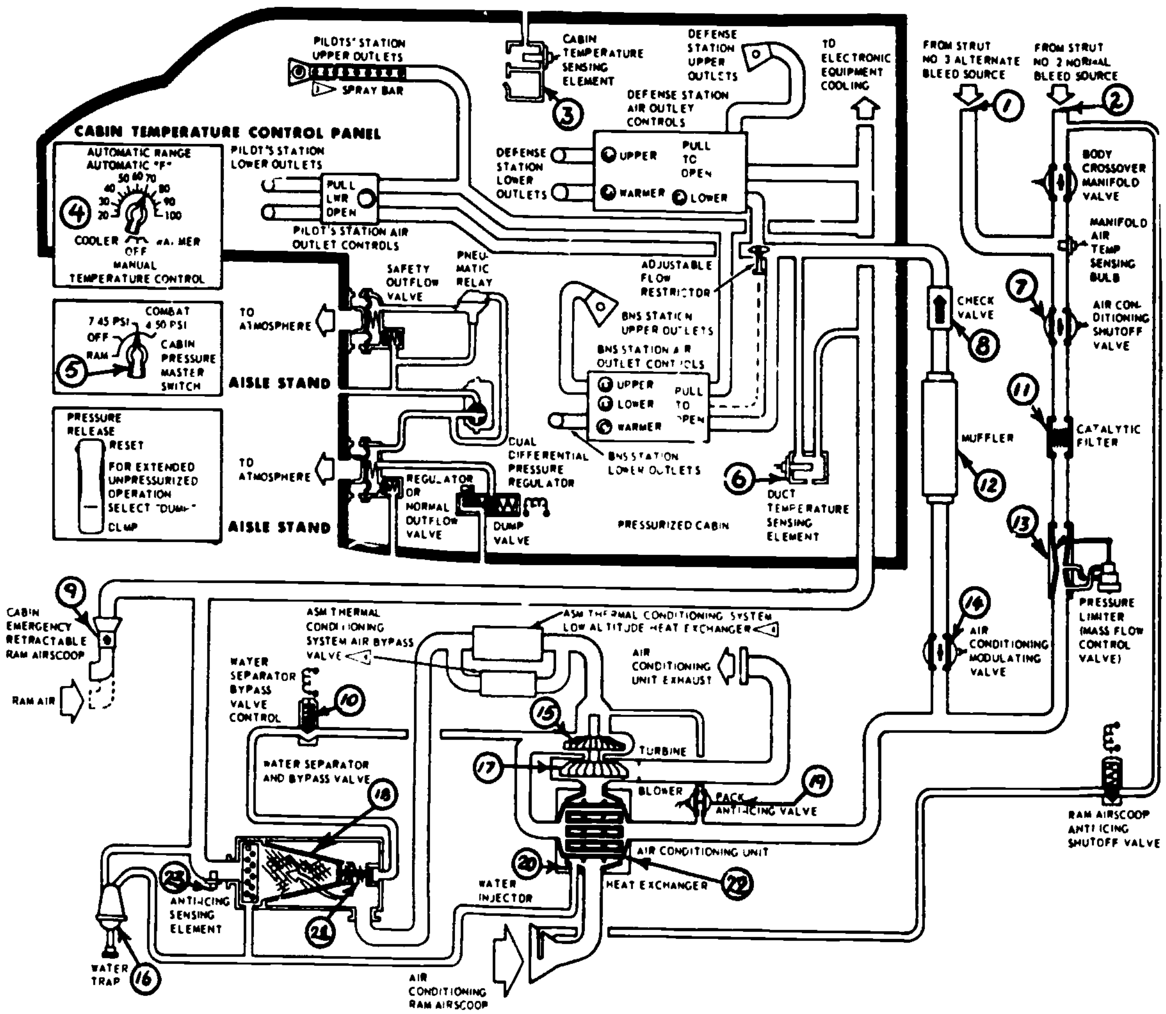
_____3. Used to vary the temperature of the cabin air inflow.

_____4. Provides an emergency source of ram air for cooling and ventilation of the crew compartment and for cooling electronic equipment found in the crew compartment.

Answers to Frame 38: 1. 3 2. 6 3. 4 4. 9

Frame 39

Match each purpose given below with a component in the sketch. Write the number from the sketch in the appropriate space near each purpose.



_____1. The ram position at this switch extends the ram air scoop and closes the air conditioning system shutoff valve.

_____2. In the 7.45 position or the 4.50 psi position this switch will retract the ram air scoop and open the air conditioning system shutoff valve.

_____3. These sensing elements have a negative coefficient of resistance.

_____3a.

_____4. This sensing element has a positive coefficient of resistance.

_____5. Has a manual override in case the automatic system fails.

Answers to Frame 39: 1. 5 2. 5 3. 3 3a. 23 4. 6 5. 4

Frame 40

Select the group of component parts that make up the 38°F control system.

Group A	Group B	Group C
Pack Anti-Ice Sensor	Cabin Sensor	Pack Anti-Ice Sensor
Pack Anti-Icing Valve	Duct Sensor	Cabin Sensor
Pack 38°F Temperature Controller	Modulating Valve	Pack Anti-Icing Valve
	38°F Temperature Controller	Cabin Temperature Controller

Answer to Frame 40: Group A

Frame 41

Select the group of component parts that make up the cabin temperature control system.

Group A	Group B	Group C
Pack Anti-Ice Sensor	Cabin Sensing Element	Pack Anti-Ice Sensor
Pack Anti-Icing Valve	Duct Sensing Element	Duct Sensing Element
38°F Temperature Controller	Modulating Valve	Modulating Valve
	Cabin Temperature Controller	Temperature Control
	Temperature Control Switch	38°F Temperature Controller

Answer to Frame 41: Group B

Frame 42

Match each purpose given below with a component in the figure on the following page and write the number from the figure in the appropriate space near each purpose.

_____1. The normal source of engine bleed air.

_____2. The emergency source of engine bleed air.

_____3. Regulates the system airflow to approximately 140 lbs pe minute.

_____4. Used to open and close the air supply line going to the cabin air conditioning system.

_____5. Cools the engine bleed air by transferring heat energy from the bleed air to the ram air.

_____6. Removes any contamination, such as solid particles and obnoxious gases, from the air.

_____7. Prevents the possibility of rapid depressurization due to a failure of a duct or coupling outside the pressurized area.

_____8. Controls the temperature of the crew compartment by varying the amount of hot air admitted to the cabin.

_____9. Absorbs valve noise and prevents noise transmission through the ducts to the cabin area.

_____10. Admits warm air to the turbine outlet to prevent the pack output temperature from dropping below the freezing point.

_____11. Cools the engine bleed air by rapid expansion and converting heat energy to mechanical energy.

_____12. Sprays moisture over the heat exchanger coils and provides additional cooling of the engine bleed air.

_____13. Provides a load for the turbine to prevent overspeeding and circulates ram air through the heat exchanger.

_____14. When energized by the aneroid pressure switch, permits air pressure to flow from a port on top of the air conditioning pack to the control chamber of the water separator bypass valve.

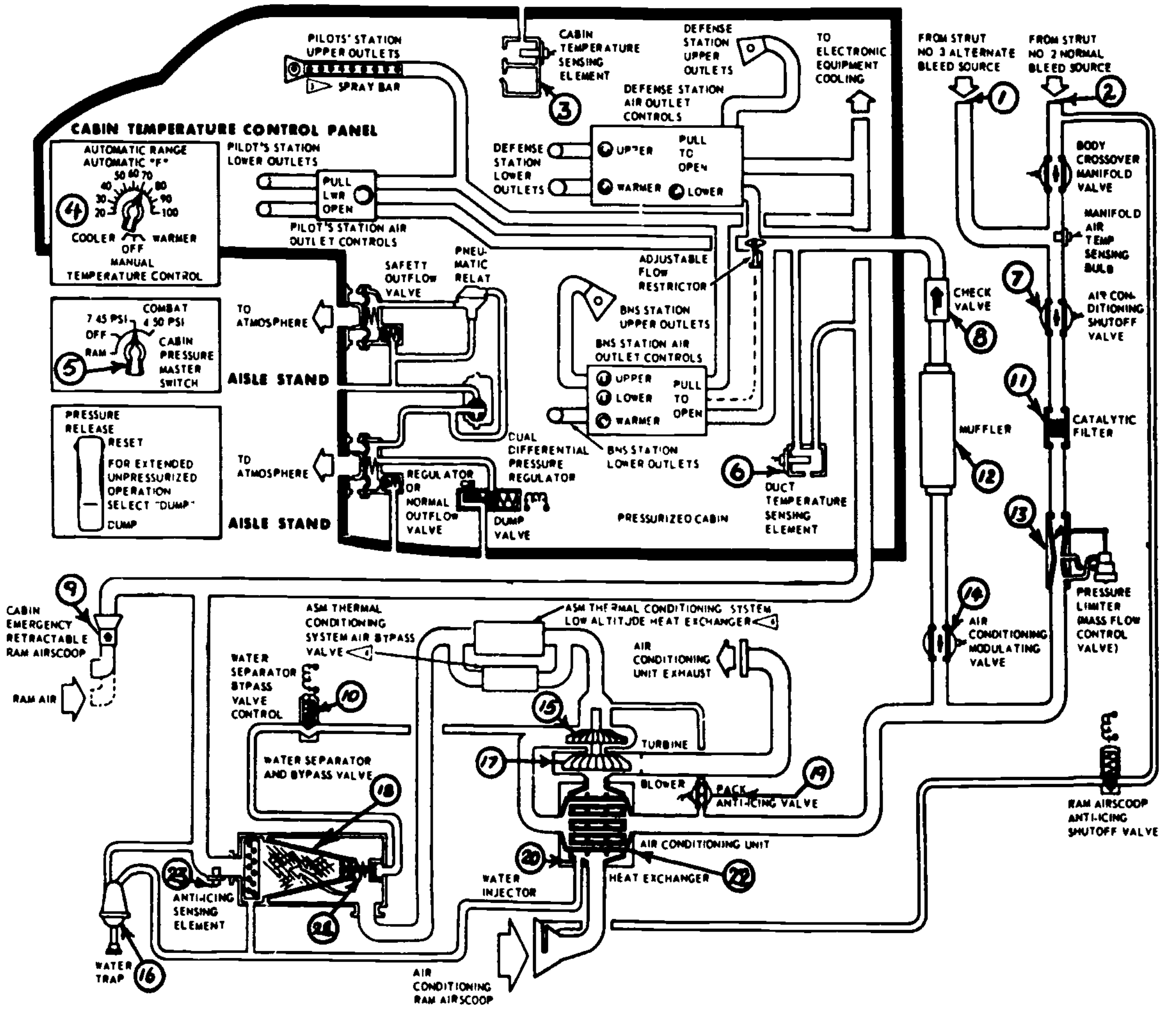
_____15. Removes moisture from the pack air output and, thus, reduces fogging and snowing in the control cabin.

_____16. Provides an emergency source of ram air for cooling and ventilation of the crew compartment.

_____17. Permits the removal of the separated water without the loss of air.

_____18. Will open when the condenser screen of the water separator becomes clogged or frozen over with ice or at altitudes above 36,000 feet.

Illustration for Frame 42



Answers to Frame 42:

1. 2
2. 1
3. 13
4. 7
5. 22
6. 11
7. 8
8. 14
9. 12
10. 19
11. 15
12. 20
13. 17
14. 10
15. 18
16. 9
17. 16
18. 21

Technical Training

Aircraft Environmental Systems Mechanic

CABIN TEMPERATURE CONTROL AND CABIN AIR DISTRIBUTION

27 April 1984

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C3ABR42331-SG-206

CABIN TEMPERATURE CONTROL AND CABIN AIR DISTRIBUTION

OBJECTIVE

Relate 8 out of 10 components to their operation.

INFORMATION

CABIN TEMPERATURE CONTROL

In the air conditioning system there must be a way of controlling the mixture of 320°F air from the hot air system and 35°F air from the cold air system.

The main temperature controlling items is the cabin temperature control valve. There are two ways to control this valve: (1) Manually controlled by the temperature selector. (2) Automatically controlled by the cabin temperature sensor/controller in conjunction with the cabin sensor and the temperature selector. The following paragraphs will explain how each control operates.

For manual temperature control there are two requisites that must be met: (1) The air source switch on the air conditioning control panel must be in NORMAL or DUMP. (2) The temperature selector, also located on the air conditioning control panel, must be in the manual position. In this position, 28 VDC power will directly control the cabin temperature control valve.

During manual operation power is supplied by the 28 VDC cabin temperature control C.B. From the C.B., power flows to the air source selector switch on the air conditioning panel, then to the cabin temperature control valve relay. From the relay power flows to the cabin temperature control valve, then to the temperature selector which is in the DOWN position.

The temperature of the air in manual will range from 35° to 177°F.

You should recall from the information about the refrigeration system that at 177°F the cabin temperature thermostat will energize, sending power to the cabin temperature control valve relay. This relay is a normally closed relay that will open when energized, which will allow the cabin temperature control valve to spring-load to the closed position stopping hot air from going into the system.

The cabin temperature thermostat will automatically reset once it cools off.

OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 350; DAV - 1

During automatic temperature control you have a selectable temperature range of 58.7°F to 81.3°F. For ease of memory round this off to 60 to 80°F.

In automatic you still have basically the same two requisites as you do in manual.

1. The air source switch must be in either "NORM" or "DUMP."

2. The temperature selector must be in automatic.

Power for the automatic operation is the same as that for manual.

In automatic, power will flow from the same C.B. that the manual power used. From the C.B., power goes to the air source switch, then to cabin temperature control valve relay. From the relay, power will flow to the temperature control valve and the temperature selector which is in the UP position.

In automatic, power just passes through the temperature selector and on through the controller.

This is not the only input the controller has coming into it in automatic. There are three inputs including the selector:

1. Selector - The temperature is selectable from auto hot to auto cold. The temperature selector will send a signal to the controller (cabin temperature sensor/controller) telling it what temperature the pilot wants.

2. The sensor portion on the cabin temperature sensor/controller senses the temperature of the air going to the cockpit.

3. The cabin temperature sensor - located in the cockpit, will send a signal to the controller portion of the sensor/controller telling it what the temperature actually is in the cockpit.

The controller will take these three signals, process them and adjust the position of the cabin temperature control valve to the temperature the pilot desires.

Let's look at an example to better understand this. Remember, there are three inputs that have to be considered:

1. Selector - What temperature does the pilot desire?

2. Sensor on controller - What temperature air is going through the duct leading to the cockpit?

3. Cabin temperature sensor - What temperature is the cabin sensor presently sensing?

Now - let's say the pilot selects an 80°F temperature with the temperature selector. The cabin temperature sensor is presently sensing a cockpit temperature of 50°F. With these two temperatures, the cabin temperature sensor/controller will demand a temperature of 120°F (duct sensor).

As the temperature in the cockpit comes closer to the desired temperature (80°F), the duct temperature demand will change. As soon as the cabin sensor and the desired temperature become the same (80° - 80°F), the duct temperature sensor will stop demanding hot air. Supply duct temperature can range from 35° - 158°F.

Both the cabin sensor and the duct sensor are negative coefficient. This simply means that with a high temperature around the sensors, resistance will decrease, calling for more cold air into the system.

What would happen if during troubleshooting you detected a short in the sensor circuit? The first thing you should determine is what coefficient is the sensor. You already know that both the duct sensor and cabin sensor are negative coefficient. Next, what kind of resistance will a short create? A short, as you already know, will give you a low resistance. Knowing these two factors, you can determine what kind of a condition you will have. A short in a negative coefficient will create a low resistance which will give you a full cold condition in automatic.

Anytime resistance decreases in a negative coefficient, you are going to get a full cold condition (only in automatic).

Now - let's say we have a low temperature around the sensor. Once again, we are working with a negative coefficient. A low temperature will cause the resistance to rise (high), calling for hot air into the system.

What would happen if you discovered an open during the troubleshooting? Once again, think about the coefficient you are working with. Now, what kind of resistance does an open create? If a short created low resistance, then an open will cause you to have a high resistance. Anytime resistance in a negative coefficient goes up (high), you will get a full hot condition in automatic.

Connected to the cabin temperature sensor is a fan. This fan is used to draw air across the sensor. It does not blow air across the sensor for this would create a cooling effect on the sensor.

There is a second fan located under the left console. The only purpose of this fan is to circulate air under the console.

Both of these fans are 115 VAC motor operated. These are the only two components that use 115 VAC power for operation in our system.

This concludes the manual and automatic operation portion of the lesson. The next part of the lesson will cover defog operation.

The defog system components consist of: cockpit (cabin) defog outlets, the defog air diverter valve, and the defog lever.

We will start out discussing the defog outlets.

The defog outlets are part of what is called the glareshield. A minimal flow of cockpit supply air through the defog outlets will prevent windshield fog.

The defog air diverter valve, is a manually operated valve that diverts cockpit supply air through the defog outlets.

Defog lever - This lever is used to control the diverter valve. It can be positioned in various positions between min and max. By controlling the diverter valve, you can control the amount of cockpit air supply going to the defog outlets and the cockpit air outlet diffusers. The defog lever is located on the left console.

The defog system can be used in both automatic and manual.

In manual there will be no change in the temperature of the airflow.

In automatic, when the defog lever is positioned to the "max" position two microswitches will be actuated (closed). This will route a signal to the 3-minute time delay module. This, in turn, will send a signal to the defog relay, energizing the relay causing a signal to be sent to the cabin temperature control valve causing it to open.

This will allow a temperature of 158°F (maximum duct supply air temperature) air to be routed to the windshield for a maximum time of 3 minutes. After the 3 minutes are up, the temperature will automatically change to the setting the pilot had selected for automatic operation.

So far in this lesson we have covered the portion of the system that controls the temperature going into the cockpit and also the defog portion.

What about distribution? How is the air distributed after temperature control has been established?

The next part of the lessons will cover just that - cabin air distribution.

Also included in the cabin distribution system is the cold air check valve and the ram air valve.

The cabin cold air check valve prevents a reverse flow of air in the event of a system shutdown. This will also prevent a loss of cabin pressure.

The ram air valve controls the flow of ram air to the cockpit and to the equipment supply manifold.

Anytime ram air is desired, the pilot selects "ram" with the air source switch. This will deenergize the valve allowing it to spring-load to the open position.

TEMPERATURE CONTROL AND DEFOG TESTER INTERFACE

The temperature control and defog tester interface is designed to be used when troubleshoting the temperature control systems (this includes defog).

The ing tests will check the operation of the temperature selector switch, cabin temperature sensor, cabin temperature control valve, cabin temperature sensor/controller and the cabin temperature thermostatic switch.

Cockpit Temp Switch

Valve Drive Test - This test will allow you to read the voltage drop across the motor of the cabin temperature control valve. This is done by placing the "cockpit temp" switch in the "VLV DR" position. This will tie the digital voltmeter (DVM) into the circuit allowing you to take a voltage reading. This reading will be displayed on the multimeter display portion of the tester.

This test must be done in manual. The reason for this is that in automatic, the cabin temperature control valve will not drive to the full open or full cold position.

In manual, with the cabin temperature control valve full cold (valve will be closed) voltage should read less than 1 volt. In full hot (valve fully open) voltage should be greater than 8 volts.

Duct Sensor Test - This test takes a voltage reading from the duct sensor portion of the cabin temperature sensor/controller. This is done with the temperature selector in the automatic mode of operation. During this test normal voltage should read between 10 to 14 volts.

Bleed Relay Test - This particular test has already been discussed in the bleed air control tester interface portion, but to refresh your memory, we will go over it again.

With the "cockpit temp" switch in the bleed relay position, voltage supply going to the air overtemp relay will be displayed on the digital multimeter (DVM). Normally, the air overtemp relay coil voltage is zero. During an overheat condition, 28 VDC is supplied to the overtemp relay. With 28 VDC being supplied to the air overtemp relay, what is going to happen? You should remember that at this point the air overtemp relay will energize. This will allow 28 VDC power to the three primary valves (7th stage bleed valve, 13th stage bleed valve and the VPR). With all three valves energized, what is going to happen to the system? This will cause the system to shut down.

This overtemperature can be simulated by placing the overtemp switch in the Hi Act position while having the cockpit temp switch in the bleed-relay position. The DVM should read 28 VDC at this time.

Relay Valve Drive - During this test you will be checking the voltage reading of the 177° output section of thermostatic switch. This reading should normally be zero.

If the air conditioning system was in an overheat condition (177°F), the thermostatic switch would send a signal to the cabin temperature control valve relay; the DVM would indicate 28 VDC. This would energize the relay, opening the electrical circuit going to the cabin temperature control valve allowing it to close.

Max Heat - With the cockpit temperature switch in the "max heat" position, the tester circuit will apply maximum current to the cockpit temperature control valve. This will drive the valve to the full open (hot) position. This full open position is obtained by grounding the valve coil power into a 200 ohm resistor.

In addition to this happening, the DVM will display the voltage on the cabin temperature control valve. Voltage should range from zero to 28 VDC during the opening of this valve.

The cabin air supply temperature may also be monitored by placing the tester <u>temperature</u> switch in the <u>cabin</u> position.

Temp Sensor - When the tester <u>cockpit temp</u> switch is in the <u>temp sensor</u> position, and the "temperature selector" is in the automatic range, voltage across the cockpit temperature sensor is presented on the tester multimeter. This voltage is used to check the sensor. Voltage will range from approximately 1.2 VDC to 1.8 VDC.

A voltage reading of zero volts will normally indicate a short. The cockpit temperature sensor has a negative coefficient. If the multimeter indicates a short in this sensor, what condition are you going to get? A short in a negative coefficient will give you a full cold condition.

During "max" defog a voltage reading of zero will occur. This will only take place during the first three minutes of operation.

A voltage reading of approximately three volts will indicate an open sensor circuit. What condition will you receive with an open in a negative coefficient? This would give you a full hot condition.

Bridge Positive - When in this position, and the temperature selector is in the auto range, the voltage on the positive side of the cockpit temperature control circuit will be displayed on the tester multimeter. The voltage should read 14.75 $\pm$.75 VDC. This voltage is used as a reference.

Bridge Negative - This test is similar to the bridge position test, the differences being that you are checking the negative side of the cockpit temperature control circuit. Voltage will also be displayed on the tester multimeter during this check. This voltage should be 11.7 $\pm$.5 VDC and will also be used as a reference.

The selector output voltages should be within 2/10 of a volt when you compare the bridge positive and bridge negative results.

Also during this test you can check the transition of the voltage between the two references. The voltage should have a smooth transition between the two references. This will check the selector for opens or shorts.

Selector output - When the cockpit temp switch is placed in the SEL OUT position, the voltage from the selector output is displayed on the tester multimeter. This is a variable voltage taken from between the bridge positive and bridge negative.

As in the bridge negative test, the voltage should transition smoothly from bridge positive to bridge negative voltage as the temperature selector knob is rotated within the automatic range. This portion of the test will check the selector for evidence of any opens or shorts in the circuit.

Valve Negative - This check does the same thing that the "valve drive" test does. The valve drive was the first check we discussed.

In this check the DVM is tied into the circuit. By tying the DVM into the circuit, you can read the voltage coming from the negative side of the valve. This reading will tell you how much voltage remains after the voltage drop across the motor. This reading should range between 28 to 20 VDC, depending on the position of the valve. A loss of voltage at this point may indicate a number of malfunctions. (Pg III - 12)

Overtemperature Switch

Lo-Act - By positioning the overtemp switch in the "Lo-Act" position, you are checking the 177° position of the cabin temperature thermostatic switch.

This is accomplished by "shorting" the sensor in the thermostatic switch. This will decrease the resistance of the thermostatic switch which will make the bridge circuit in the controller think it is hot in the duct. You should remember what happens when the thermostatic switch senses a temperature of 177°F from earlier discussion! You should recall that by sensing 177°F, the cabin temperature control valve relay will energize. With the cabin temp control valve energized, what happens to the cabin temperature control valve? This will cause the valve to close. This can be checked by monitoring the "tempo" display on the tester.

Lo-Bridge - By putting the "overtemp switch" in the lo-bridge position, you are tying the DVM into the circuit. This will allow you to take a voltage reading from the negative side of the sensor in the thermostatic switch. Normally this voltage should read 13 to 14 volts.

PROGRAMMED TEXT

C3ABR42331-PT-207

Technical Training

Aircraft Environmental Systems Mechanic

BOMBER BLEED AIR SUPPLY SYSTEM

26 January 1984

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

RGL: 10.1

OBJECTIVES

Relate eight out of ten bleed air system components to their operation.

INSTRUCTIONS

This programmed text presents information in small steps called frames. After each step you are asked to complete a statement, match some statements, or respond to the information presented in some other way. Read the material presented and make your response as directed by the frame. After you have made your response, compare your answers with the correct answers found on the top of the next frame. Any time you respond incorrectly, reread the frame to get the information correctly. Write the correct response next to your original response and then proceed to the next frame. If necessary you may go back to check a fact or principle, but do not skip ahead unless you are told to do so.

Use this simple rule: READ---RESPOND---CONFIRM---ADVANCE.

YOU WILL not be graded on how fast you complete this material. You will be tested later on what you have learned.

Supersedes 3ABR42331-PT-206, 4 May 1981, which may be used until existing stock is exhausted.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 1000; DAV - 1

The engine bleed air supply system is used to supply hot pressurized engine bleed air to the cabin air conditioning system, the air conditioning ram airscoop, and engine nacelle anti-icing systems, the hydraulic reservoirs, and engine starters.

This bleed air is taken from the last stage of engine compression. The pressure, temperature, and flow of engine bleed air is dependent upon the engine throttle setting and air demand.

Answer each of the following statements as either true (T) or false (F).

_____1. Hot pressurized air is taken from the middle stage of the aircraft's engines.

_____2. The last stage of compression on the engines provides hot pressurized bleed air to the cabin air conditioning system.

_____3. The engine throttle settings will determine the pressure, temperature and the flow of the bleed air in the system.

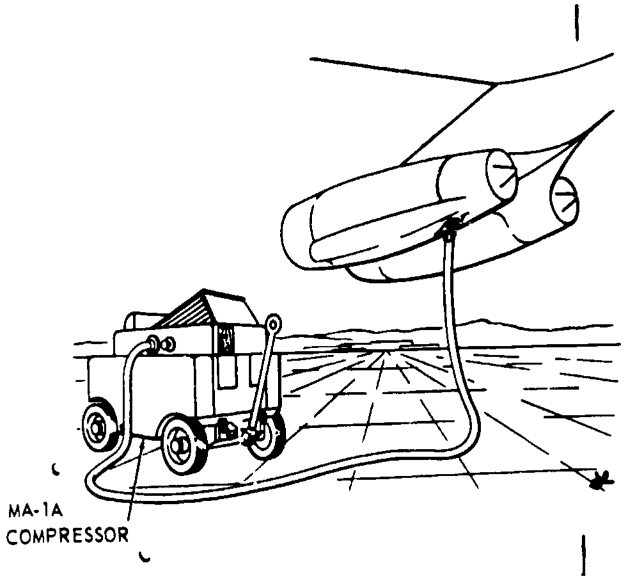
Answers to Frame 1: 1. F 2. T 3. T

Frame 2

A ground air cart, the MA-1A, is shown in the sketch below. It is used to start the planes engines, ground check the bleed air supply system and ground check the air conditioning system.

The MA-1A is connected to the engine by a ground service receptacle and this will be explained to you in the next frame.

The sketch shows the ground air cart connected to an aircraft.



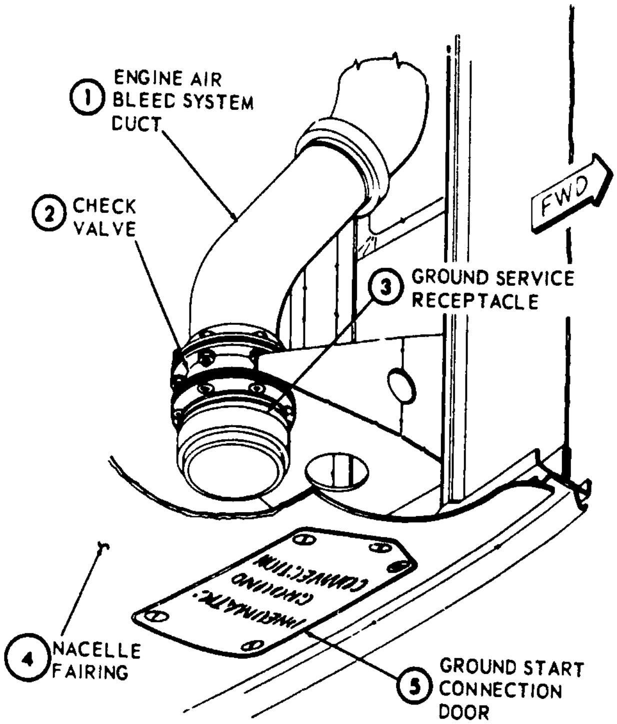
Answer each of the following statements as either true (T) or false (F).

_____1. The ground air cart used to start aircraft engines is the MA-1A.

_____2. The MA-1A compressor can also be used to ground check both the bleed air and air conditioning systems.

Answers to Frame 2: 1. T 2. T

Frame 3



The numbered items are in the sketch above.

One bleed air ground service receptacle (#3) is found in the bottom of each engine nacelle fairing (#4). This receptacle serves as a quick disconnect to permit a ground air cart to be connected to the engine bleed air system duct (#1).

The receptacles are identified by the external marking "PNEUMATIC GROUND CONNECTION" (#5).

A ground service receptacle check valve (#2) is put between the ground service receptacle and the engine bleed air system duct.

The check valve is used to prevent a reverse airflow in the system. The check valve will be open if the MA-1A is supplying air to the engine and will close when the engine starts to supply the bleed airflow.

Match the number in the sketch with the statement below and place the number of your choice on the blank line provided.

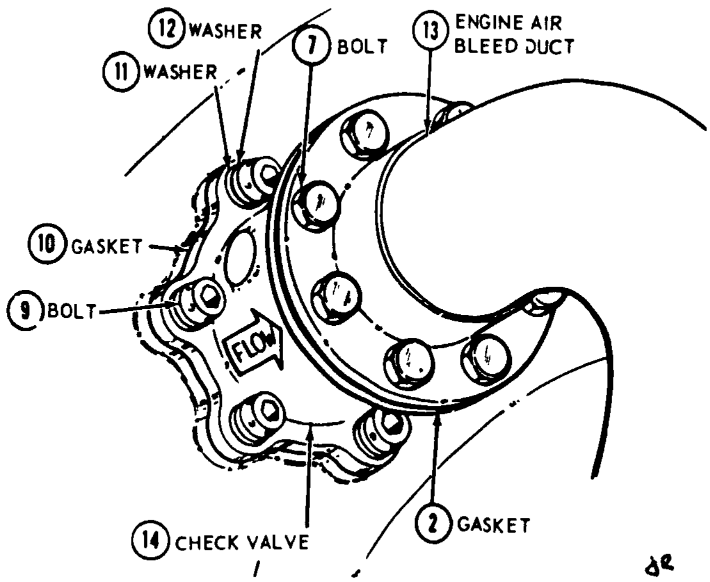
1. _____Permits an external air source to be connected to the engine bleed air system.

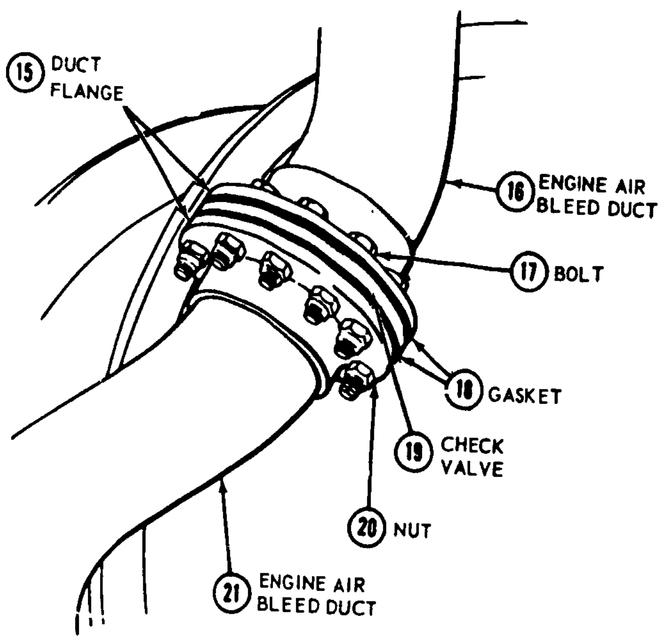
2. _____Installed between the ground service receptacle and the engine bleed air system duct to prevent a reverse air flow.

3. _____Must be closed when the engine is supplying the air pressure.

Answers to Frame 3: 1. 3 2. 2 3. 2

Frame 4





Engine bleed air flapper type check valves are installed on the bleed air system ducting to prevent a reverse airflow within the system.

During normal airflow, the check valves are in the open position. If a reverse airflow should start, the check valve will move to the closed position.

Note: The sketch shows two check valves installed in the bleed air system ducting. Both valves preven a reverse flow of air in the bleed air system.

The engine bleed air ducts, also shown in the sketch are ed to convey the hot engine bleed air to it's point of use. Ther ducts are thin walle tubes made of corrosion resistant steel.

Complete the following statements by writing in the correct word or words.

1. __________ __________ check valves are installed in the engine bleed air ducting.

2. The bleed air check valves will allow __________ __________ to f ow out of the engine compressor and will __________ if air tries to flow into the engine compressor.

3. The __________ ________ __________ are used to carry the engine bleed air to its points of use.

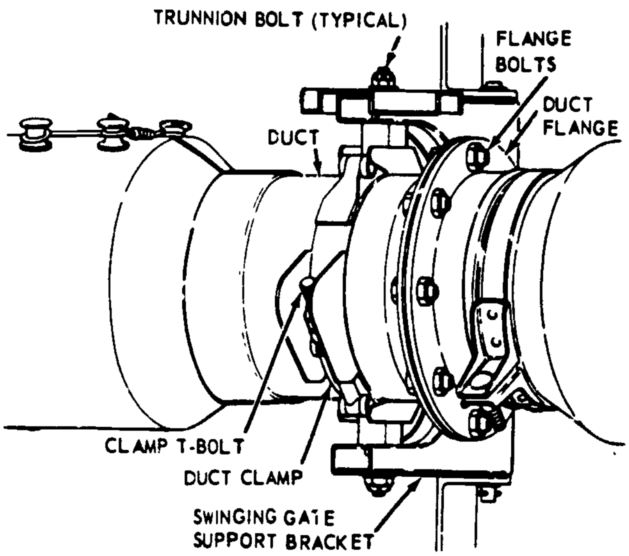
4. The bleed air ducts are made of thin walled ________________ ________________ ________________

Answers to Frame 4: 1. Flapper type 2. bleed air - closed
3. bleed air ducts 4. corrosion resistant steel

Frame 5

The engine bleed air ducts are supported by either single or double hinged swinging gate type supports, as shown in the sketch.

The supports allow for a pivoting action to take place during expansion and contraction of the duct.



Answer each of the following questions as either true (T) or false (F).

_____1. The swinging gate type support brackets will allow a pivot action to take place during expansion and contraction of the duct.

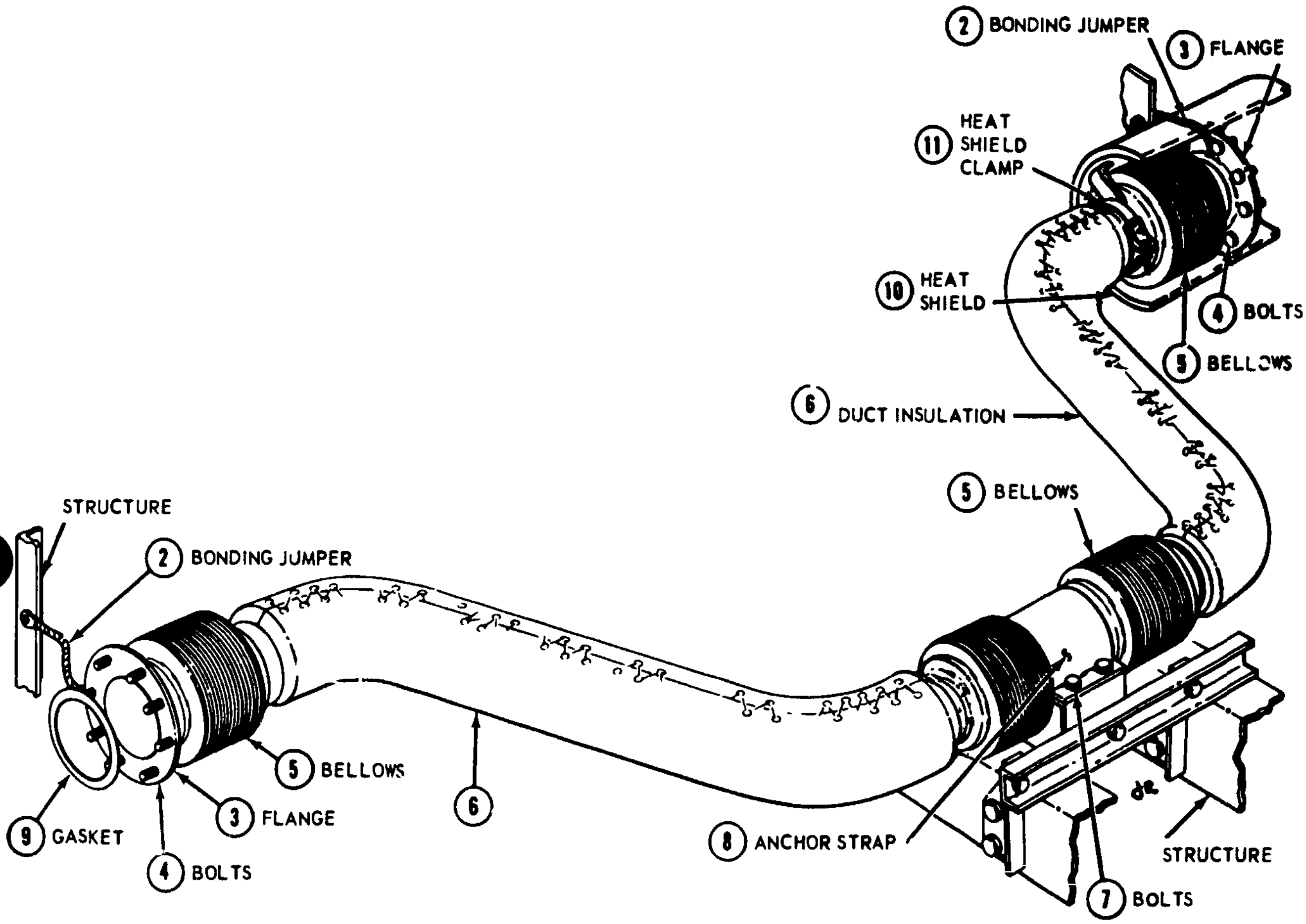
_____2. Only a single hinged swinging gate type support is used.

Answers to Frame 5: 1. T 2. F

Frame 6

In addition to the swinging gate support, a bellows assembly (5) acts as a universal joint to allow for thermal expansion.

In addition, this bellows assembly compensates for twisting and bending movements of the aircraft structure.



Complete the following statements by placing the correct word or words in the space provided.

1. The bellows assembly used in the wing ducts compensate for __ __________ ____________________.

2. Engine bleed air ducts are made of ________________ ___________ ____ ________________.

Answers to Frame 6: 1. thermal expansion 2. corrosion resistant steel

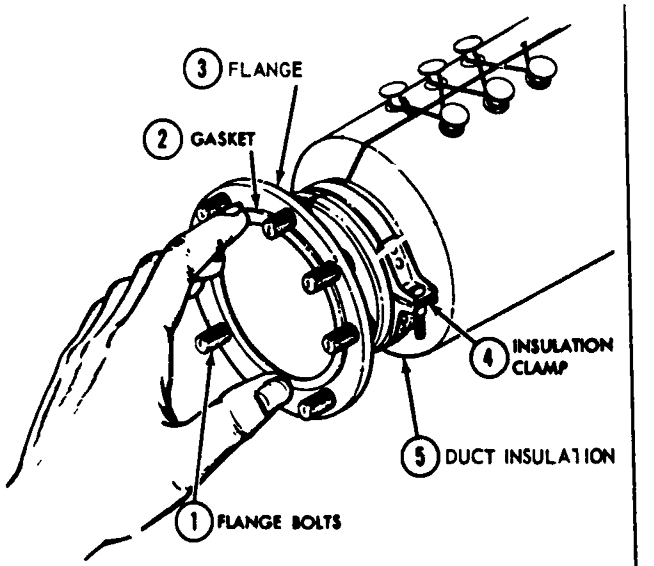
Frame 7

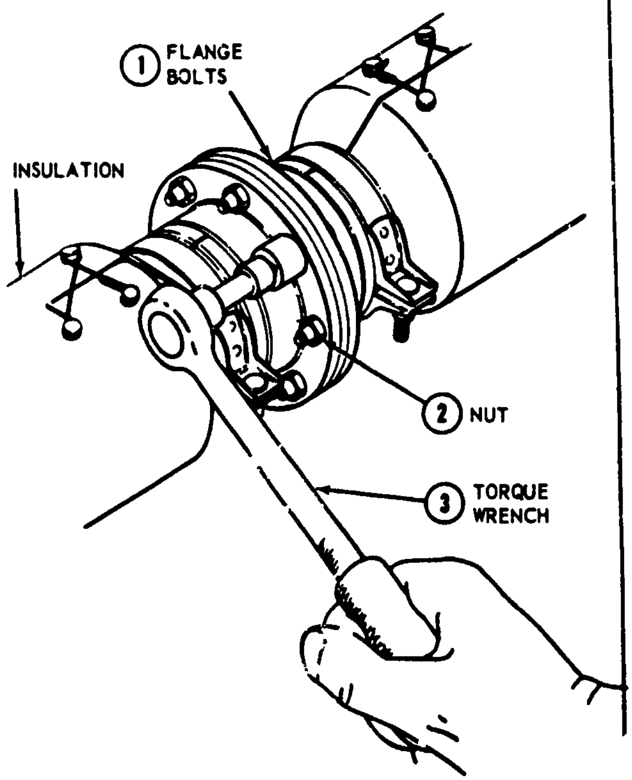
Match the component part in column B with the statement in column A that best describes that part.

Column A		Column B
_____1.	Permits an external air source to be connected to the engine air bleed system duct.	a. Last stage of compression on jet engine.
_____2.	Provides hot high pressure air for use by the air conditioning system.	b. MA-1A compressor.
_____3.	Used in the wing ducts to compensate for thermal expansion of the ducts.	c. Pneumatic ground connection.
_____4.	Will allow hot high pressure air to flow out of the engine compressor but will close if air tries to flow into the compressor.	d. Engine bleed air check valve.
_____5.	Can be used to start aircraft engines or ground check the bleed air and air conditioning systems.	e. Swinging gate type support.
_____6.	Allows a pivot action to take place during expansion and contraction of the duct.	f. Bellows assembly

Answers to Frame 7: 1. c 2. a 3. f 4. d 5. b 6. e

Frame 8





The engine bleed air ducts are made in various lengths to make it easier to remove and replace them.

The illustrations show the bolted flange method of connecting duct sections together. A gasket is put in between the two parts of the duct to prevent leakage.

Frame 8 (Continued)

A new gasket that is free of creases, imperfections, and foreign material should be put in any time a section of duct is installed.

The bolts should be tightened in gradual steps on opposite alternate diameters with a torque wrench to technical order specifications.

Answer each of the following questions as either true (T) or false (F).

_____1. For easier removal and replacement, ducts are made in various lengths.

_____2. Each time a section of duct is removed and replaced a new gasket should be installed.

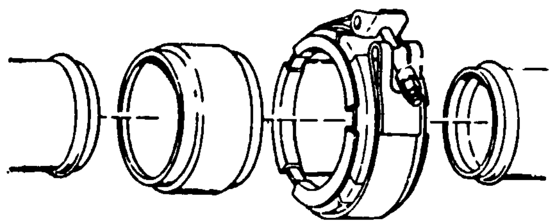
_____3. A torque wrench should be used to tighten the nuts on the flange bolts according to technical order specifications.

Answers to Frame 8: 1. T 2. T 3. T

Frame 9

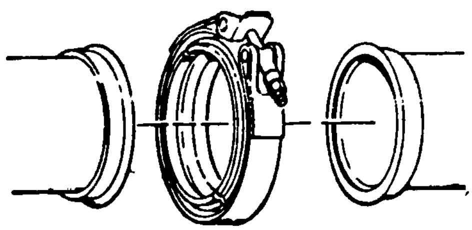
Two more ways of connecting ducts together are shown in the sketch.

The Marman Channel Band coupling is used to couple cold air ducts together in the air conditioning system.



Marman Channel Band Coupling

The Janitrol couplings can also be used to clamp components of the system to the ducts.



Janitrol Coupling

On both couplings, the nut on the T-bolt should be tightened with a torque wrench.

Mark the letter in front of your choice.

1. T-bolts on both couplings should be tightened with a/an

   a. open end wrench.
   b. box-end wrench.
   c. socket wrench.
   d. torque wrench.

2. The Marman Channel Band coupling is used on

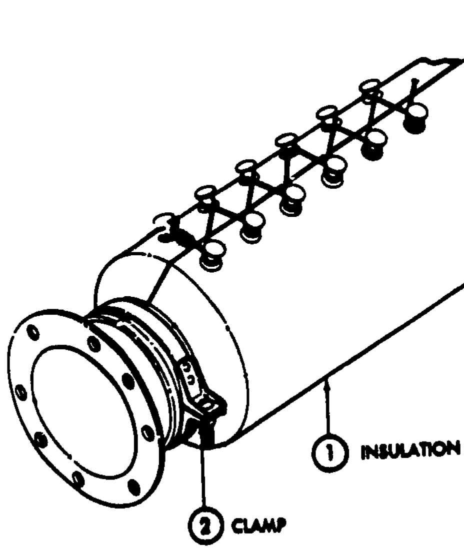
   a. hot engine bleed air ducts.
   b. cold and hot air ducts.
   c. cold air ducts.
   d. hot air ducts.

Answers to Frame 9: 1. _d_ 2. _c_

Frame 10

Engine bleed air ducts in most areas are covered by metal foil insulation. This insulation is used to cut down heat loss from the ducts, prevent damage to the structure and equipment next to the hot air ducts, and help keep them from burning those coming in contact with the ducts.

The insulation is secured around the ducts with safety wire lacing as shown in the sketch.



Complete the following statements by writing in the word or words on the lines provided.

1. ________ ________ ________ placed around the ducts will prevent damage to the structure and equipment close to the ducts.

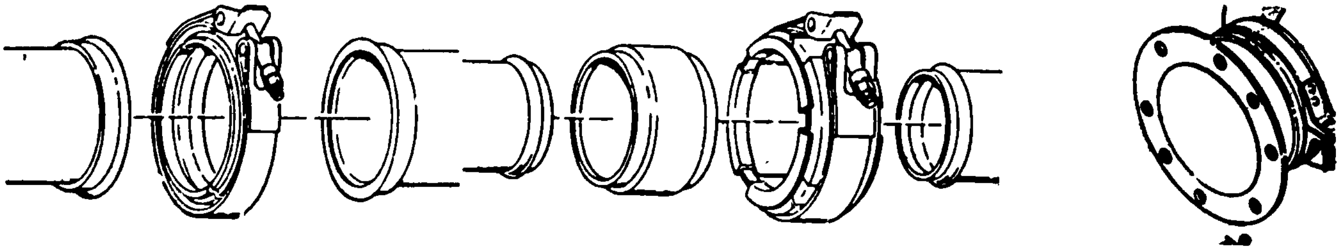
2. ________ ________ ________ is used to secure the insulation around the ducts.

3. The insulation material used on the hot air ducts is ________ ________.

Answers to Frame 10: 1. Metal foil insulation 2. Safety wire lacing
3. metal foil

Frame 11

Place the letter under each of the following schematics in the blank space alongside the correct name.



A

B

C

_____1. Bolted Flange Connection.

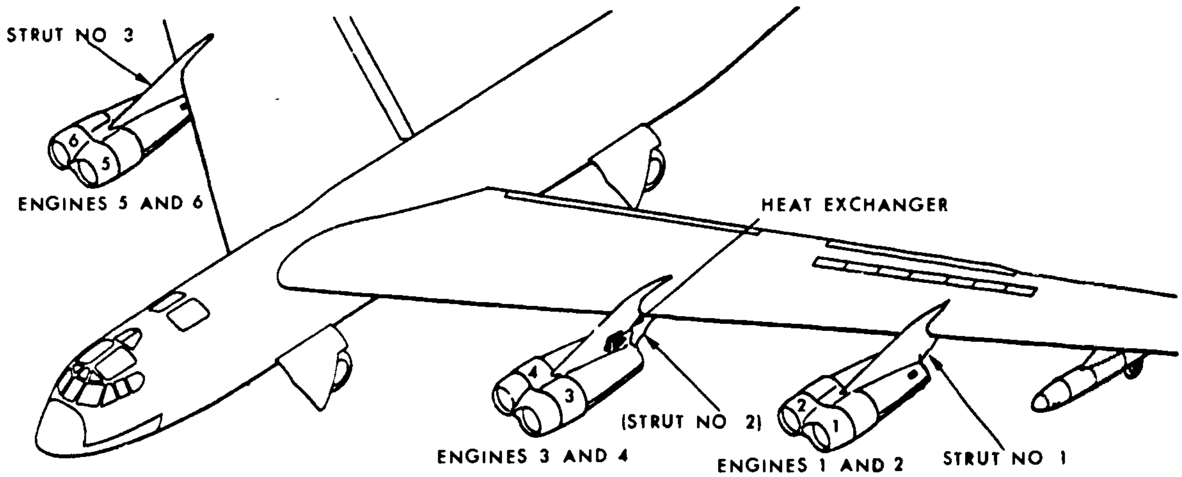
_____2. Marman Channel Band Coupling.

_____3. V Band Coupling.

Answers to Frame 11: 1. c 2. b 3. a

Frame 12

Engine bleed air for air conditioning and pressurization is normally supplied by engines 3 and 4 in strut number two. During an emergency when air is not available from strut number 2, strut number 3 with engines 5 and 6 will supply the engine bleed air. The relative positions for the struts and engines mentioned are shown in the illustration.



Match the statements in column B to the correct component in column A.

_____1. Engines Number 5 and 6.	A. Normal source of bleed air.
_____2. Strut Number 2.	B. Emergency source of bleed air.
_____3. Strut Number 3.	
_____4. Engines Number 3 and 4.	

Answers to Frame 12: 1. B 2. A 3. B 4. A

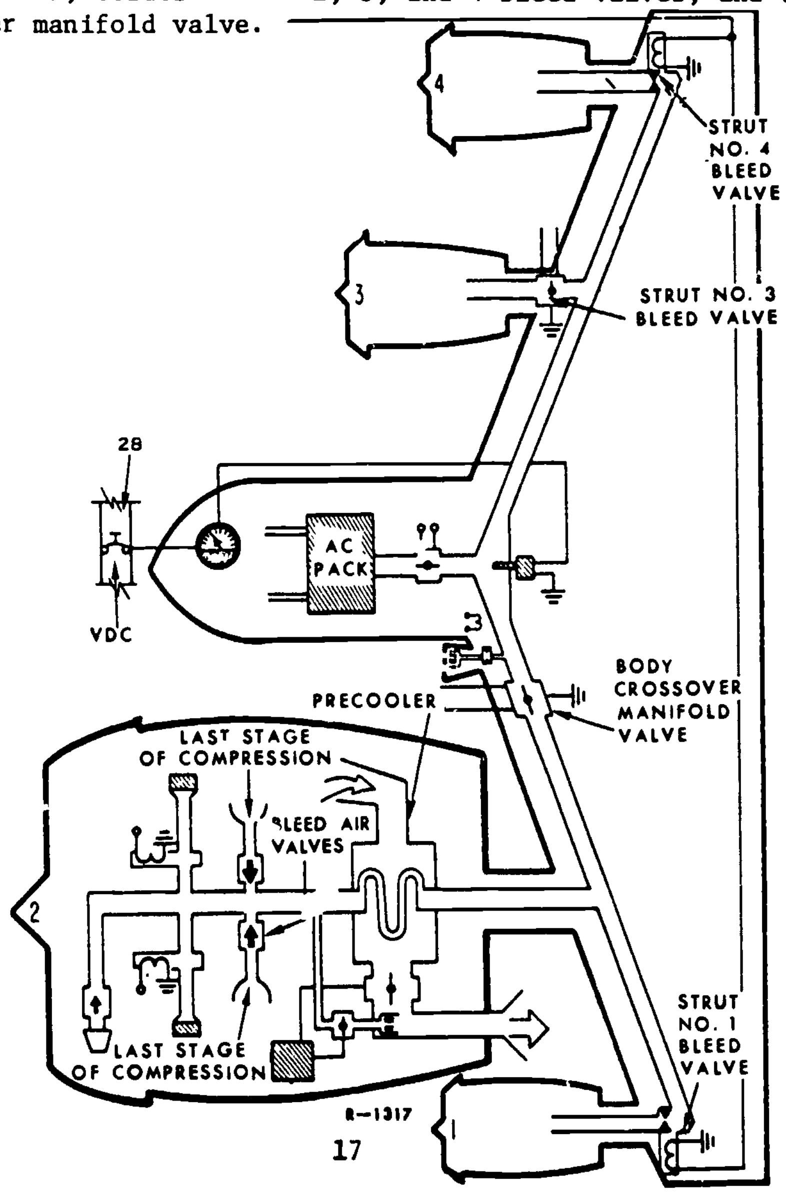
Frame 13

The illustration is a schematic of the bleed air system. Engine bleed air is taken from the last stage of compression on engines 3 and 4 of strut number two, during normal operation of the air conditioning system.

This air passes through the precooler in strut number 2 into the wing manifold and then through the body crossover manifold valve to the air conditioning package.

During emergency operation of the air conditioning system, bleed air is taken from the last stage of compression on engines 5 and 6. It passes through strut number 3 bleed valve into the wing manifold and then to the air conditioning package. The body crossover valve closes to isolate the left side of the bleed air manifold.

On the schematic shown below, note the position of the bleed air check valves, precooler, struts number 1, 3, and 4 bleed valves, and the body crossover manifold valve.



Frame 13 (Continued)

Answer each of the following questions as either true (T) or false (F).

_____1. Bleed air for normal operation of the air conditioning system is taken from the last stage of compression on engines 5 and 6.

_____2. Strut number 3 is used to supply an emergency source of bleed air for air conditioning.

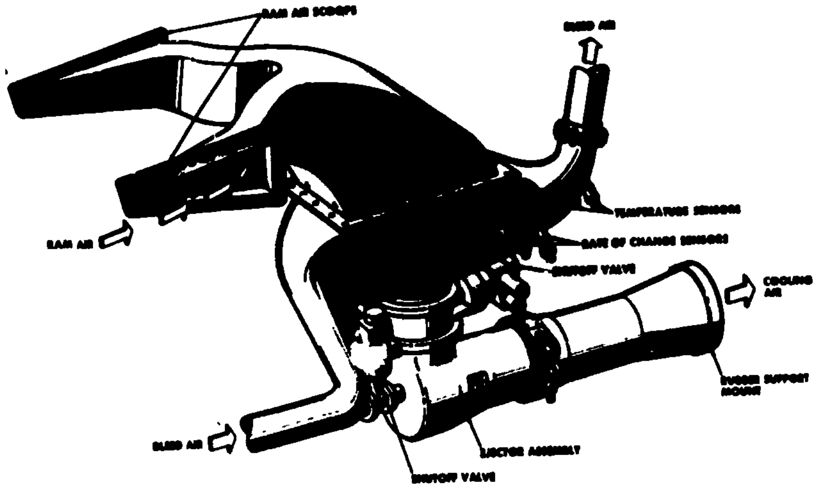
_____3. The precooler is mounted in strut number two.

Answers to Frame 13: 1. F 2. T 3. T

Frame 14

The heat exchanger (precooler), shown in the sketch is in strut no. 2. The precooler reduces the engine bleed air temperature from 740°F to a discharge temperature that will not be more than 475°F.

Cooling of the engine bleed air is done by directing the bleed air through a heat exchanger core while ram air is flowing across the core. This action transfers the heat from the bleed air to the ram air and then sent overboard.



HEAT EXCHANGER

Complete the following statements by writing the correct words on the lines provided.

1. The precooler is mounted in ________ ________ ______.

2. The precooler transfers the heat of the bleed air to ________ ________.

Answers to Frame 14: 1. strut number 2 2. ram air

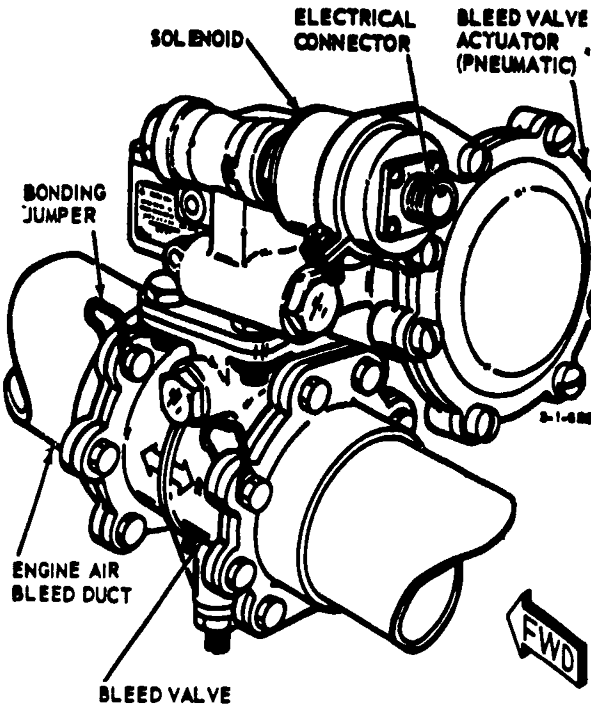
Frame 15

The bleed air valves that are installed in struts 1 and 4, as shown in the sketch, are identical units. They need a combination of 28 volts for control and are actuated by air pressure.

These valves are solenoid controlled and air actuated. These valves have a fail safe feature which will cause the valves to close any time electrical power is lost.

The only time that struts number 1 and 4 bleed valves are opened are during engine start, or when an operational check of the bleed air valves is required.

CAUTION!!! Struts number 1 and 4 cannot be used as a source of bleed air for air conditioning. Both valves are controlled by the manifold valve switch.



Complete the following statements.

1. Strut number 1 and 4 bleed valves are solenoid controlled and __________ actuated.
2. Strut number 1 and 4 bleed valves are fail safe __________.
3. Strut number 1 and 4 bleed valves __________ when electrical power is lost.
4. To start aircraft's engines, strut number 1 and 4 bleed valves are __________.
5. Strut number 1 and 4 bleed valves can be __________ when an operational check of the bleed valves is required.

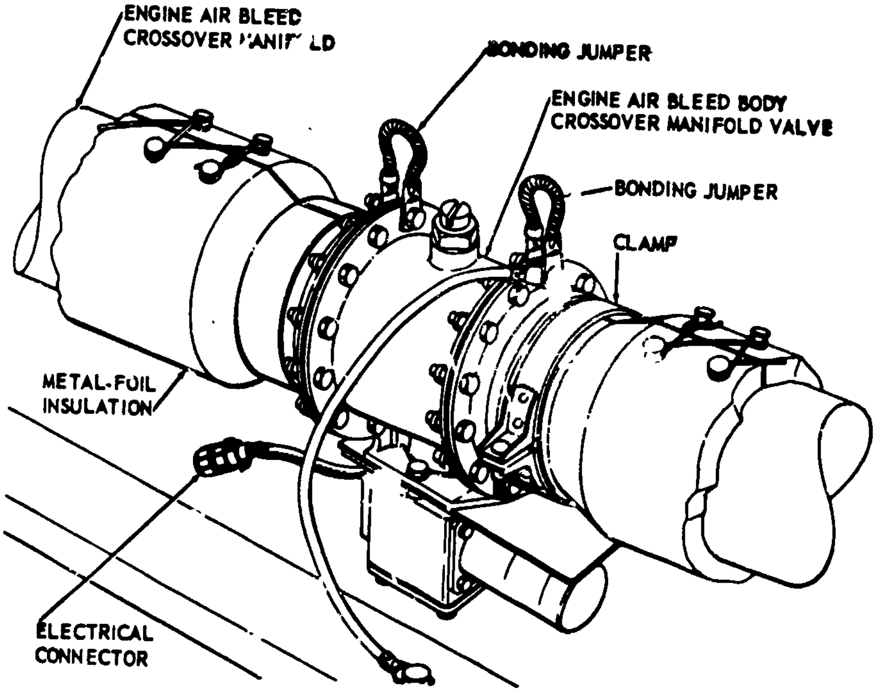
Answers to Frame 15: 1. air 2. closed 3. close
4. open 5. opened

Frame 16

The engine bleed air body crossover manifold valve is located in the left wing bleed air system manifold. This valve is operated by a 118 volt AC motor.

This valve is opened to allow engine bleed air to flow from strut #2 to the cabin air conditioning system during normal system operation. The body crossover manifold valve will also be opened during starting of the aircraft's engines.

The body crossover manifold valve is controlled by the Bleed Selector Switch or the manifold valve switch.



Mark the letter in front of your choice.

1. The body crossover valve is operated by

   a. air pressure.
   b. a hydraulic motor.
   c. a 24V DC motor.
   d. a 118V AC motor.

2. During normal operation of the air conditioning system, engine bleed air is received from strut number

   a. 1
   b. 2
   c. 3
   d. 4

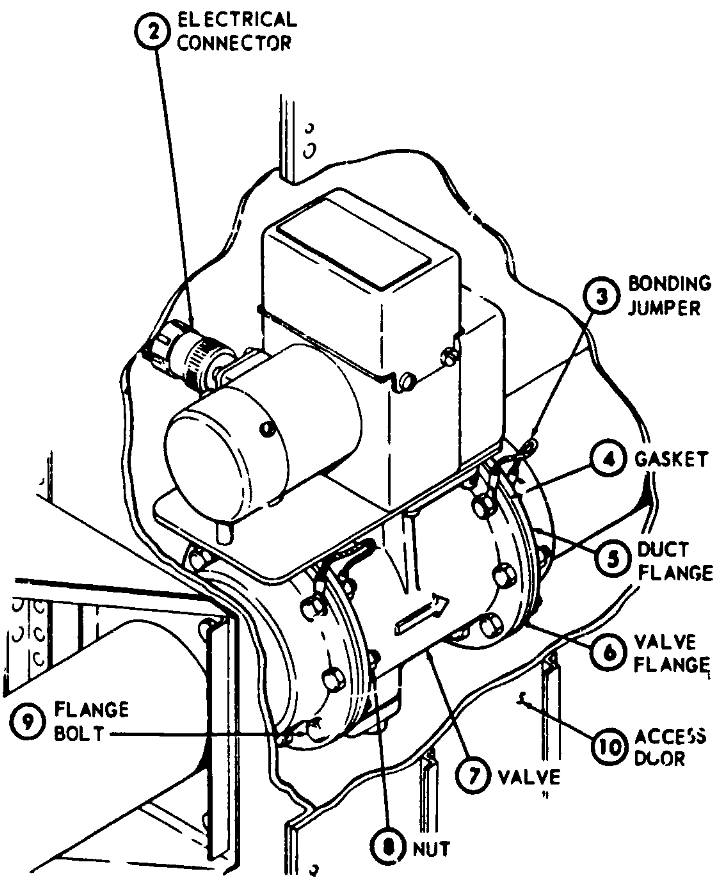
Answers to Frame 16: 1. d 2. b

Frame 17

Strut number 3 bleed valve is a 118 volt AC motor driven butterfly-type valve.

The valve is normally closed and can be controlled with either the bleed selector switch or the manifold valve switch.

The valve is opened for starting engines or to supply emergency bleed air for the cabin air conditioning system.



Answer each of the following statements as either true (T) or false (F).

_____1. Strut number 3 bleed valve is powered by a 118 volt AC motor.

_____2. Strut number 3 is used to supply emergency bleed air for the cabin air conditioning system.

_____3. Strut number 3 bleed valve is opened to start the aircraft's engines.

_____4. To supply emergency bleed air for the cabin air conditioning, strut number 3 bleed valve must be opened.

_____5. The manifold valve switch or the bleed selector switch can control strut number 3 bleed valve.

Answers to Frame 17: 1. __T__ 2. __T__ 3. __T__ 4. __T__ 5. __T__

Frame 18

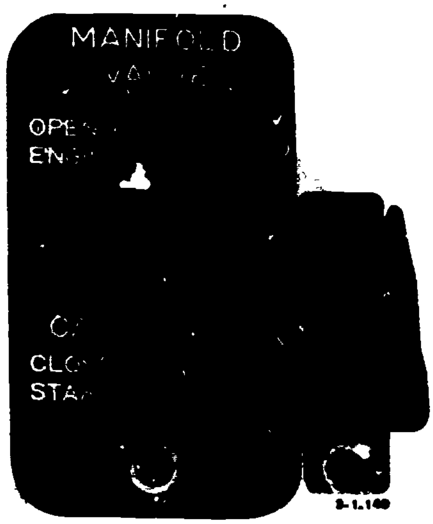
Match the component parts in column B to the statement that best describes that part in column A.

Column A	Column B
____1. Reduces the engine bleed air temperature from 740°F to 475°F.	A. Strut No. 2
____2. Provides an emergency source of bleed air for air conditioning system operation.	B. Strut No. 3
____3. Will be opened to start aircraft engines and provide the air conditioning system with bleed air from the normal source.	C. Precooler
____4. Is used as the normal source of bleed air for air conditioning and pressurization.	D. Struts No. 1 & 4 bleed valve
____5. Will be opened only to start aircraft engines.	E. Body crossover manifold valve
____6. Will be opened to start aircraft engines or supply emergency bleed air for cabin air conditioning.	F. Strut No. 3 bleed valve

Answers to Frame 18: 1. C 2. B 3. E 4. A 5. D
6. F

Frame 19

The manifold valve switch, in the illustration, is used to open all the bleed air valves only during engine starting.



MANIFOLD VALVE SWITCH

Complete the following statements by filling in the blanks provided.

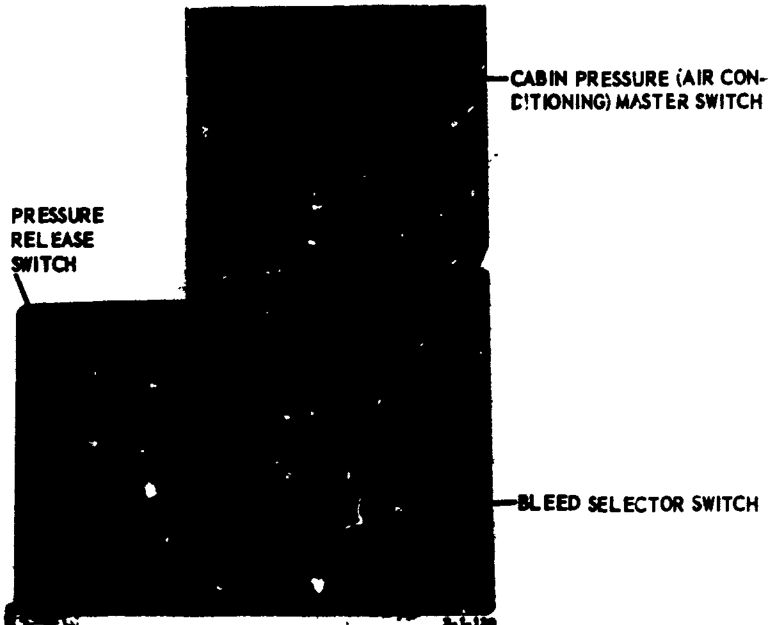
1. The manifold valve switch has two positions __________ and __________.

2. Lifting the cap and pressing the manifold valve switch to the open position will open the body crossover valve, strut No. 3 bleed valve, and struts _____ and _____.

3. The manifold valve switch is used __________ __________ __________.

Answers to Frame 19: 1. open, close 2. 1, 4
3. during engine start

Frame 20



CONDITIONING AISLE STAND PANEL

The engine bleed air system controls also consists of a cabin pressure master switch and a bleed selector switch as shown in the sketch above. The cabin pressure master switch has four positions: RAM, OFF, 7.45 psi, and COMBAT 4.50 psi.

The bleed selector switch has two positions, NORMAL and EMERGENCY. The position of the bleed selector switch determines the availability of the engine bleed air from either strut number 2 or 3 for air conditioning and pressurization.

Answer each of the following statements as either true (T) or false (F).

_____1. The four positions on the cabin pressure master switch are ram, Off, 7.45 psi, and Combat 4.50 psi.

_____2. The two positions on the bleed selector switch are Normal and emergency.

_____3. The availability of engine bleed air from either strut number 2 or 3 is determined by the position of the bleed selector switch.

Answers to Frame 20: 1. T 2. T 3. T

Frame 21

Using the switch position table shown below, complete each of the following statements.

SWITCH POSITION

AIR ROUTE	CABIN PRESSURE MASTER SWITCH	MANIFOLD VALVE SWITCH	BLEED SELECTOR SWITCH
Any strut to all other struts	RAM or OFF	OPEN	NORMAL or EMERG
No. 3 strut to air conditioning pack	7.45 PSI or COMBAT 4.5 PSI	CLOSED	EMERG
No. 2 strut to air conditioning pack	7.45 PSI or COMBAT 4.5 PSI	CLOSED	NORMAL
Individual strut only	RAM or OFF	CLOSED	NORMAL or EMERG

CAUTION

- To prevent excessive bleed air manifold temperatures which could result in a fire hazard, do not operate any engines other than No. 3 or 4 above 80% rpm with the manifold valve switch open.
- Do not exceed 246° C (475° F) when operating engine No. 5 or 6 with MANIFOLD VALVE switch in CLOSE position and BLEED SELECTOR switch in EMERG posi' .

1. To get air from strut number 2 the air conditioning system, the m. ifold valve switch is closed, the bleed selector switch will be in the _____________ position, and the cabin pressure master switch wil in the 7.45 or 4.50 psi position.

2. To get air to go from any strut to all the other struts during engine starting, the cabin pressure master switch is in the OFF or RAM position, the manifold valve switch is in the _____________________ position and the bleed selector switch will be in normal or emergency.

Answers to Frame 21: 1. NORMAL 2. OPEN

Frame 22

Using the switch position chart as a guide, write down the bleed air system control positions for each of the following situations.

SWITCH POSITION

AIR ROUTE	CABIN PRESSURE MASTER SWITCH	MANIFOLD VALVE SWITCH	BLEED SELECTOR SWITCH
Any strut to all other struts	RAM or OFF	OPEN	NORMAL or EMERG
No. 3 strut to air conditioning pack	7.45 PSI or COMBAT 4.5 PSI	CLOSED	EMERG
No. 2 strut to air conditioning pack	7.45 PSI or COMBAT 4.5 PSI	CLOSED	NORMAL
Individual strut only	RAM or OFF	CLOSED	NORMAL or EMERG

CAUTION

- To prevent excessive bleed air manifold temperatures which could result in a fire hazard, do not operate any engines other than No. 3 or 4 above 80% rpm with the manifold valve switch open.
- Do not exceed 246° C (475° F) when operating engine No. 5 or 6 with MANIFOLD VALVE switch in CLOSE position and BLEED SELECTOR switch in EMERG position.

1. To start aircraft engines with a ground cart connected to strut No. 2 the switch positions will be:

   a. Cabin Pressure Master Sw. ______ ______ ______.

   b. Manifold Valve Sw. ______.

   c. Bleed Selector Sw. ______ ______ ______.

2. To get bleed air for the air conditioning system, from the normal source the switch positions are:

   a. Cabin Pressure Master Sw. ______.

   b. Manifold Valve Sw. ______.

   c. Bleed Selector Sw. ______.

3. To get bleed air for air conditioning from the emergency source the switch positions are:

   a. Cabin Pressure Master Sw. ______________________.

   b. Manifold Valve Sw. __________.

   c. Bleed Selector Sw. ___________.

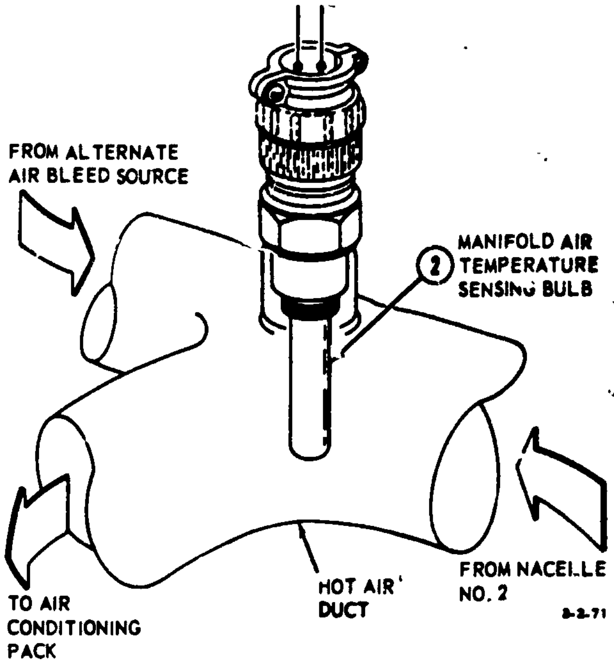
Answers to Frame 22: 1. a. RAM or OFF b. OPEN c. NORMAL or EMERGENCY
2. a. 7.45 psi or Combat 4.5 b. CLOSED
c. NORMAL
3. a. 7.45 psi or Combat 4.5 psi b. CLOSED
c. EMERGENCY

Frame 23

A manifold air temperature indicator and sensing bulb, shown in the sketch indicates the air temperature in the bleed air system. The indicator is scaled in degrees from -20° to +300°C (-4° to +575°F) and is red lined at 246°C (475°F) for maximum operating temperature.

Resistance of the temperature bulb varies with temperature changes. The indicator, is located on the copilot's auxiliary side panel and the manifold air temperature bulb is located in the engine air bleed supply system duct.

MANIFOLD TEMPERATURE INDICATOR



Answer each of the following statements as either true (T) or false (F).

_____1. A manifold air temperature indicating system is used to indicate the air temperature in the bleed air system.

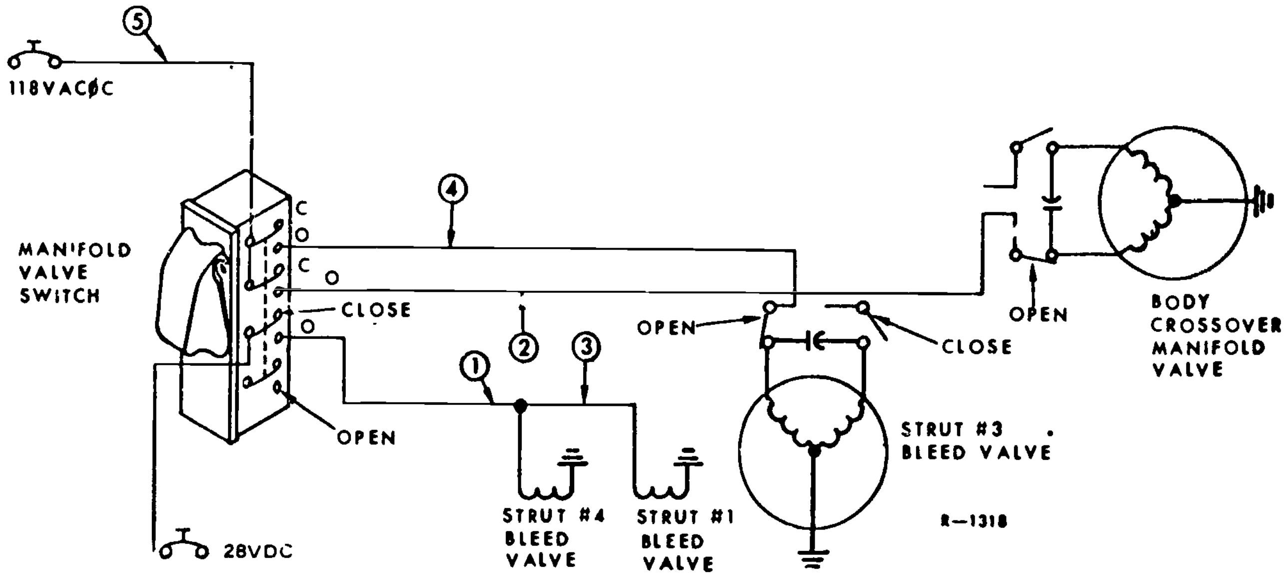
_____2. The indicator is red lined at 246°C.

_____3. The temperature of the air flowing through the bleed air system will vary the resistance of the sensing bulb.

Answers to Frame 23: 1. T 2. T 3. T

Frame 24

Using the illustration as a guide, trace the electrical circuits and complete the following statements by placing the word or words in the blank spaces that would make the statement true.



1. Strut No. 1 and Strut No. 4 bleed valves are supplied with ________ volts.

2. The body crossover manifold valve and strut No. 3 bleed valve are supplied with ____________ volts.

3. When the manifold valve switch is placed in the open position, all the _______________ air valves will open.

4. If the open wire indicated by the symbol 1 existed in the electrical circuit, both Strut No. ________ and Strut No. ________ bleed valves will not open.

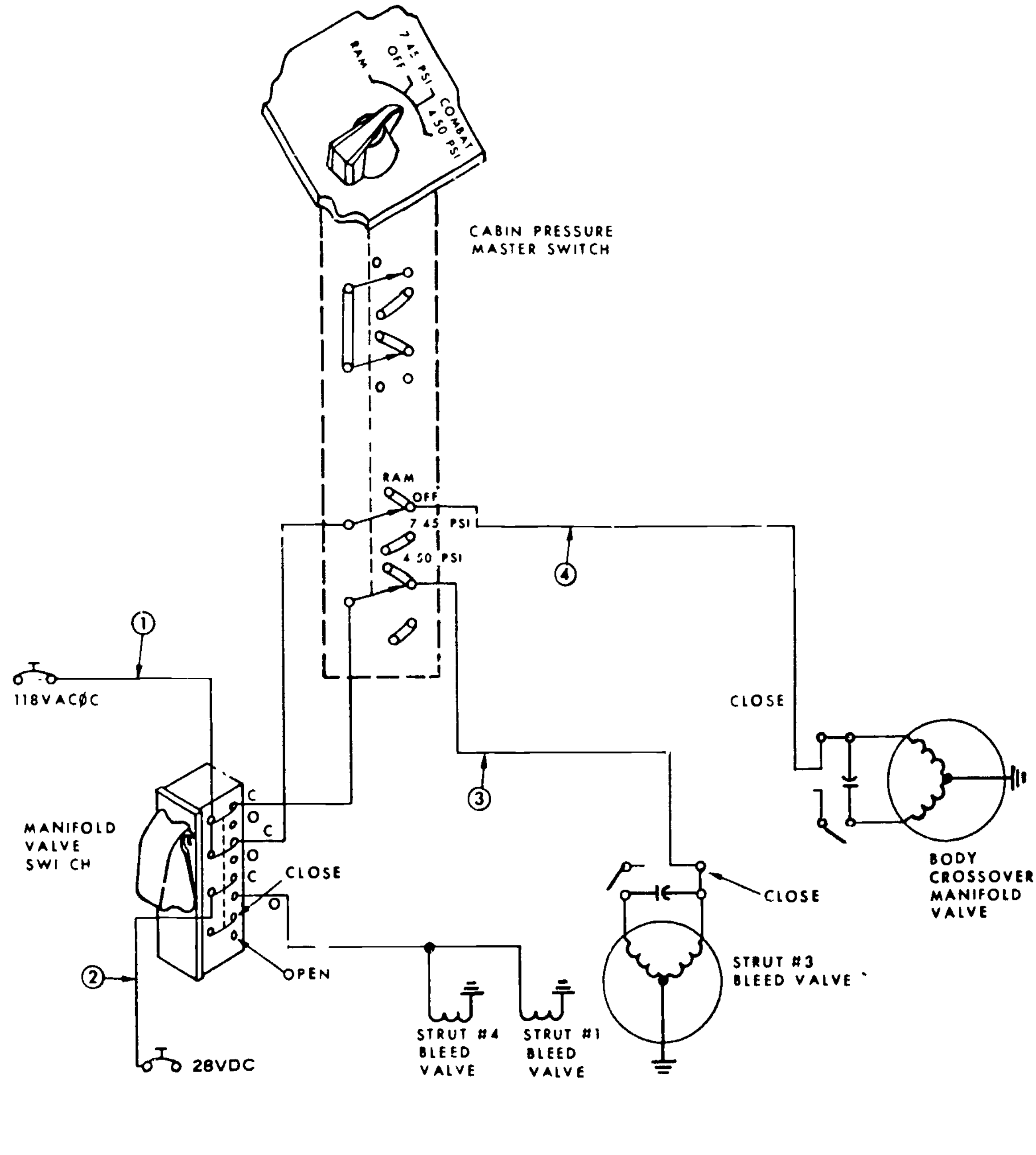
5. If the open wire indicated by the symbol 2 existed in the electrical circuit the ____________ _______________ _________________ valve will not open.

6. If the open wire indicated by the symbol 4 existed in the electrical circuit ____________ _______________ bleed valve will not open.

Answers to Frame 24: 1. 28 2. 118 3. bleed 4. 1 and 4
5. Body crossover manifold
6. Strut No. 3

Frame 25

Using the illustration shown as a guide, trace the electrical circuits and complete the following statements by placing the word or words in the blanks spaces that would make the statement true.



1. When manifold valve switch is placed in the closed position, all the ______________ air valves will close.

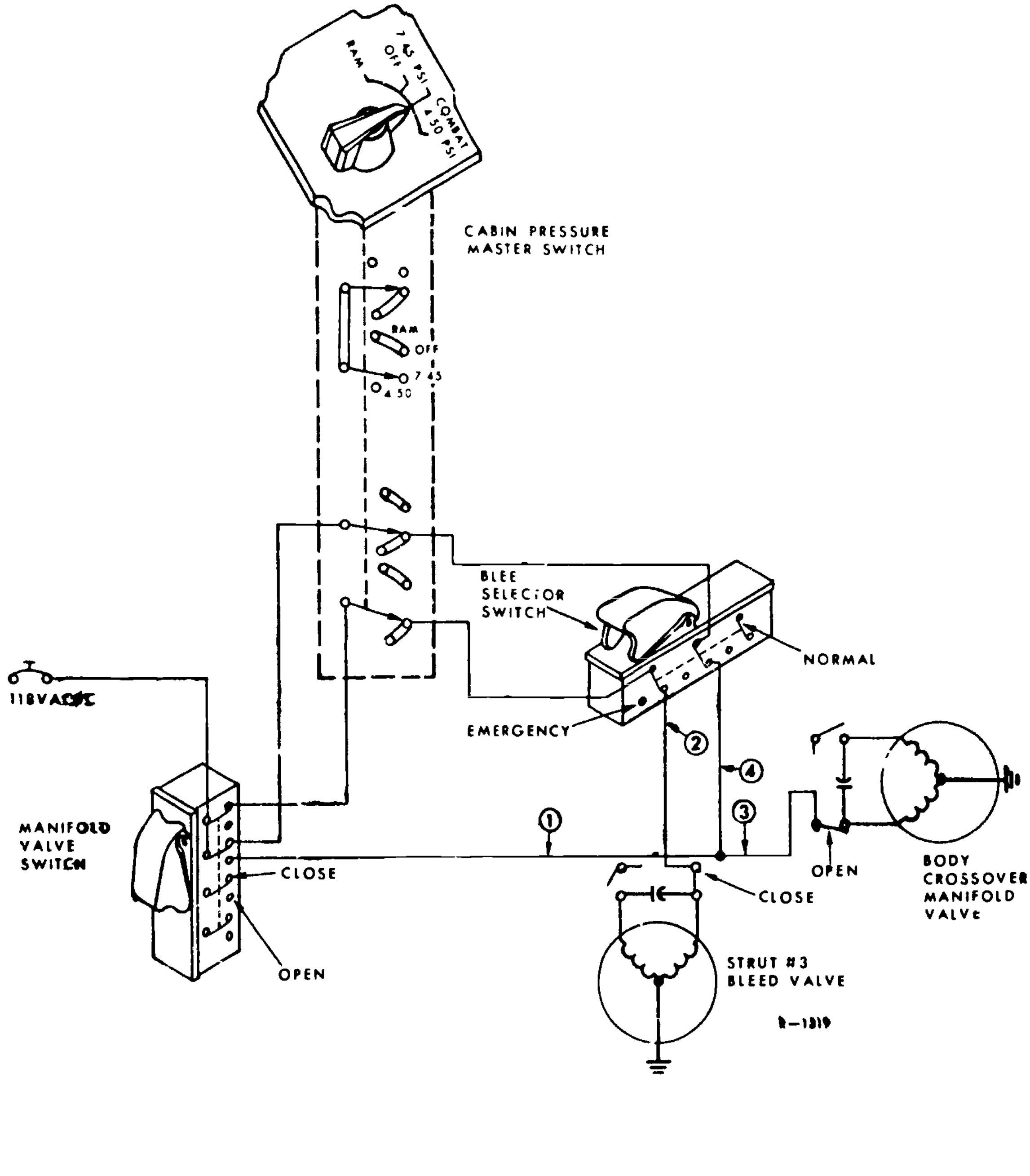
2. If the open wire indicated by the symbol (3) existed in the electrical circuit, Strut No. 3 bleed valve will not ________________.

3. If the open wire indicated by the symbol (4) existed in the electrical circuit the _____________ _______________ _________________ valve will not close.

Answers to Frame 25: 1. bleed 2. close 3. body crossover manifold

Frame 26

With the switches on the circuit shown in the following positions, complete each statement written below with the word or words that will make each statement true.



Switch Positions:

Manifold Valve
Switch-Closed
Cabin Pressure
Master Sw.
.45 psi
Bleed Selector
Switch Normal

1. Strut No. 3 bleed valve will be ____________________.

2. The body crossover manifold valve will be ____________________.

3. With the body crossover valve open, hot high pressure air will be received from Strut No. ______________.

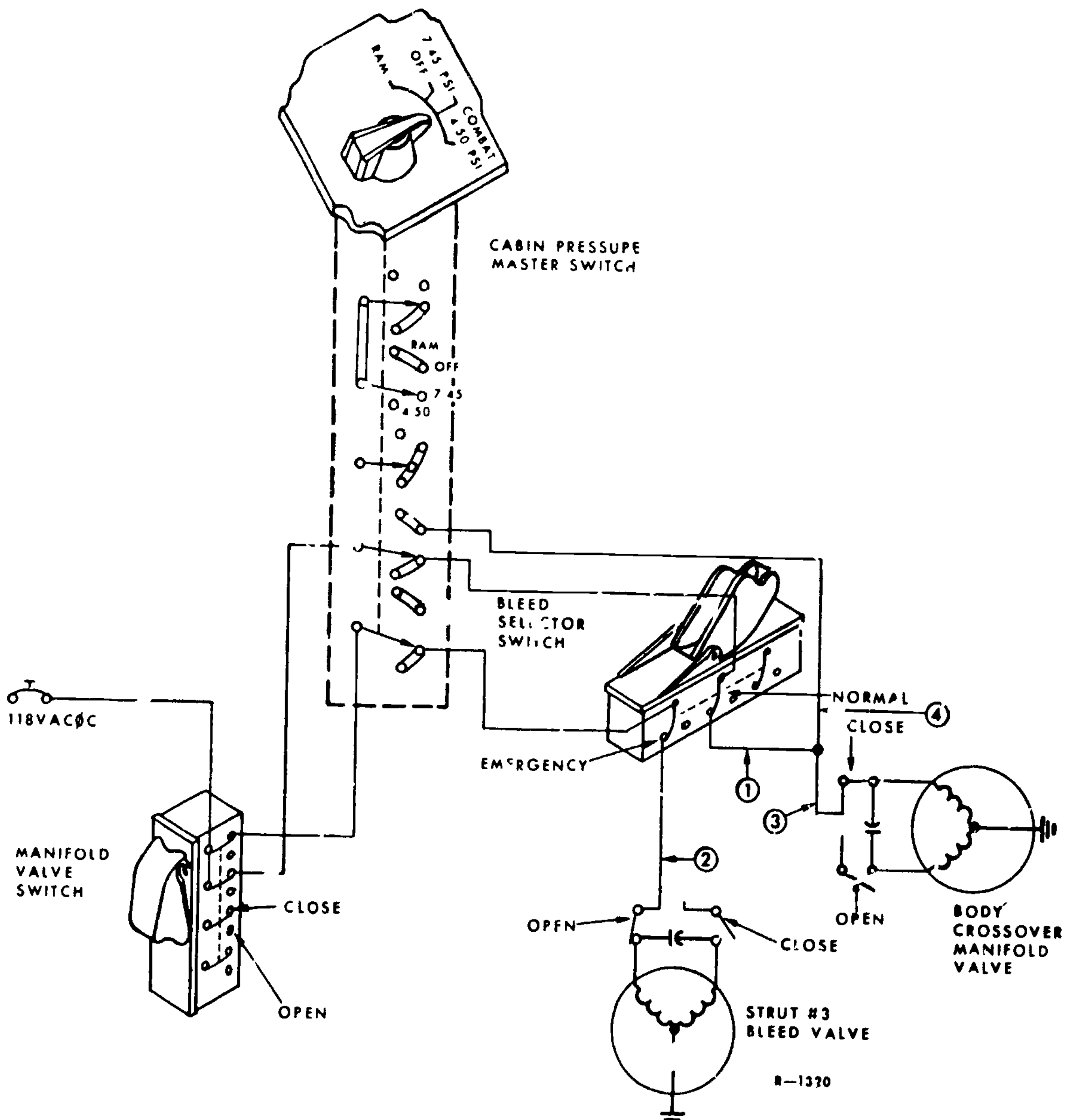
4. If the open electrical circuit indicated by the symbol (4) existed, the body crossover manifold valve would not open when the ______________ __________ ______ switch was positioned to normal.

5. If the open electrical circuit indicated by the symbol (3) existed, the ________________ ________________ __________________ valve would not open when the bleed selector switch was in the open position.

Answers to Frame 26: 1. closed 2. open 3. two
4. bleed selector 5. body crossover manifold

Frame 27

With the switches in the circuit shown in the following positions, complete each statement written below with the word or words that make each statement true.



Switch Positions:

Manifold Valve
Sw---Closed.
Cabin Pressure
Master Sw---
7.45 psi
Bleed Selector
Sw--Emergency

1. With the switch positions shown above, Strut No. 3 bleed valve will ____________.

2. With the switch positions shown above, the body crossover manifold valve will ______________.

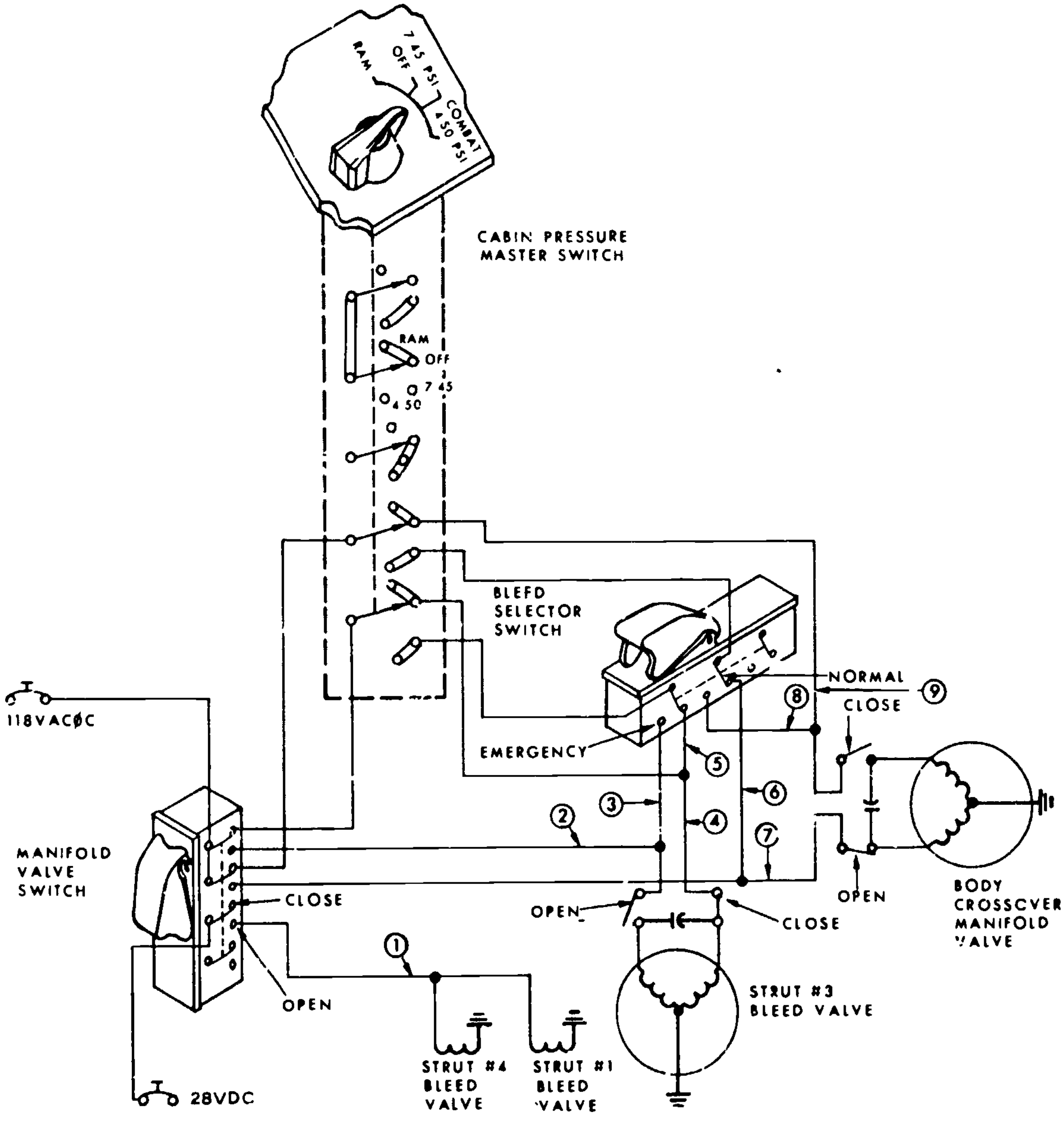
3. If the open wire indicated by the symbol (1) existed, in the electrical circuit, the ______ ___ ______________ ______________ valve will not close.

4. If the open wire indicated by the symbol (2) existed in the electrical circuit, the Strut No. 3 bleed valve will not ______________.

Answers to Frame 27: 1. open 2. close 3. body crossover manifold
4. open

Frame 28

Using the illustration shown as a guide, complete each of the following statements with the word or words that will make each statement true.



1. If the open electrical circuit indicated by circle 1 was in the circuit, both Strut No. 4 bleed valve and Strut No. 1 valve would not ________.

2. If the open circuit indicated by circle 2 and the manifold valve switch were placed in the open position, Strut No. 3 bleed valve would not ________.

3. If the open electrical circuit indicated by circle 5 was in the circuit, Strut No. 3 bleed valve will not ________ when the bleed selector switch was in the normal position.

4. If the open electrical circuit indicated by circle 6 was in the circuit, the body crossover manifold valve would not ________ with the bleed selector switch in the normal position.

Answers to Frame 28:

1. Open
2. open
3. close
4. open

WORKBOOK
C3ABR42331-WB-207A

Technical Training

Aircraft Environmental System Mechanic

BOMBER AIR CONDITIONING SYSTEM TROUBLESHOOTING

8 March 1984

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

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BOMBER AIR CONDITIONING SYSTEM TROUBLESHOOTING

OBJECTIVE

Using a multimeter and wiring diagram, troubleshoot the cabin air conditioning system trainer, locating a minimum of 5 out of , troubles correctly.

EQUIPMENT

Trainer 3018, Bomber Air Conditioning
Multimeter

PROCEDURE

1. Remove all of your jewelry. Report to the lab instructor and inform him of the lesson on which you are working. The instructor will assign you to a trainer and provide the necessary materials.

2. This workbook is presented in two sections. Section 1 is to familiarize you with the components of the bomber air conditioning system and prepare you for performing the operational check and troubleshooting. Section 2 contains the steps for operational checking these systems and the malfunctions that you are to troubleshoot. Perform each step as directed on the following pages.

Note: Be sure you signed out a PSM-37 multimeter and (1) pair of alligator leads from the storage locker.

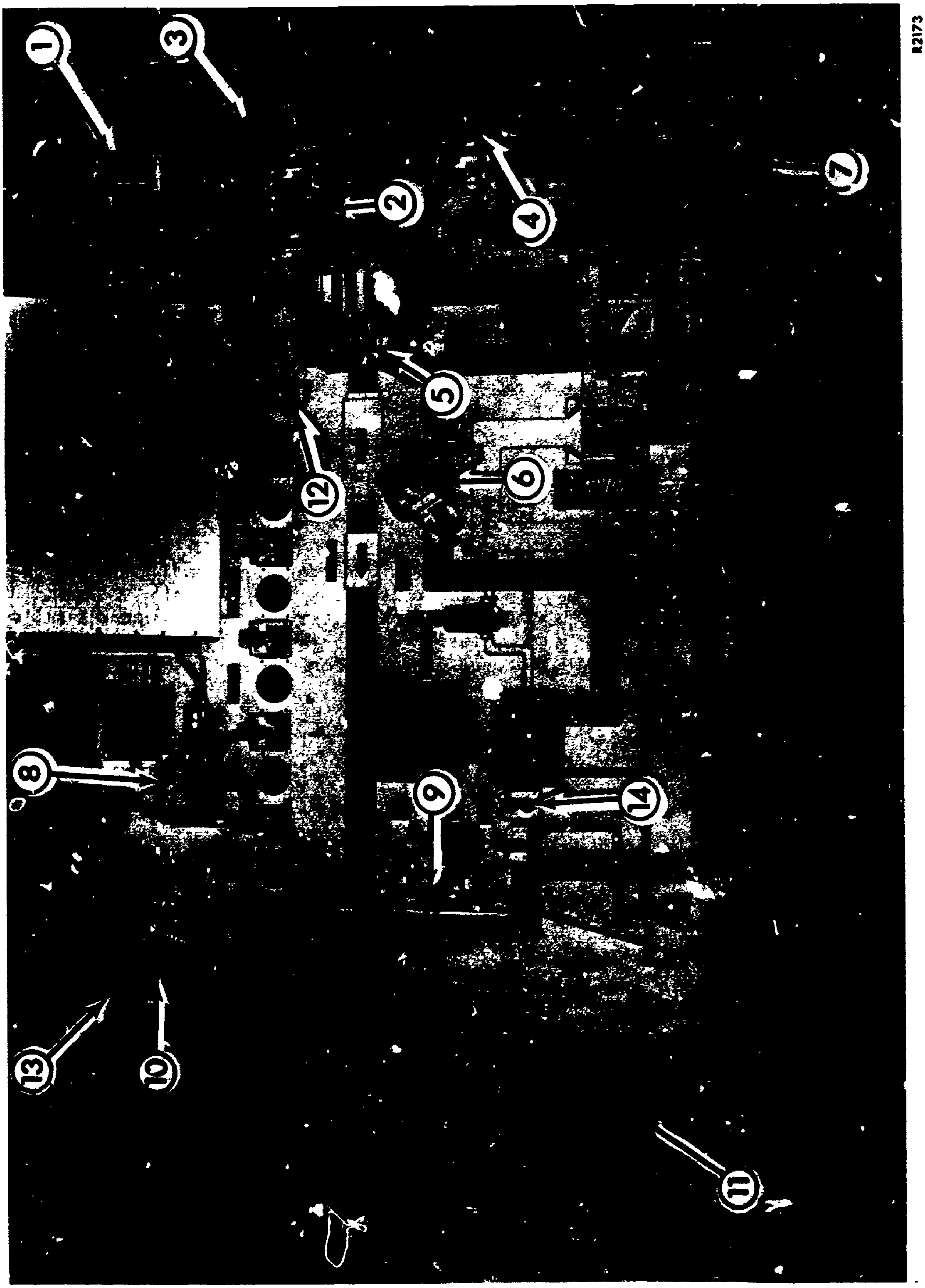


Figure 1. Bomber Air Conditioning.

SECTION 1. BOMBER AIR CONDITIONING SYSTEMS COMPONENTS

1. Location and identification of system components.

a. Using the trainer and the illustration in figure 1, locate each of the numbered items. Write the name of each of these numbered items in the blank spaces below. As you locate each component, notice the check point near the component that is used for checking the electrical circuitry.

(1)____________________________________

(2)____________________________________

(3)____________________________________

(4)____________________________________

(5)____________________________________

(6)____________________________________

(7)____________________________________

(8)____________________________________

(9)____________________________________

(10)____________________________________

(11)____________________________________

(12)____________________________________

(13)____________________________________

(14)____________________________________

Compare your answers to those on the following page.

Answers to location and identification step 1a.

(1) #1 and #4 Strut Bleed Valve.

(2) #3 Strut Bleed Valve.

(3) Body Crossover Valve.

(4) Air Conditioning Shutoff Valve.

(5) Hot Air Modulating Valve.

(6) Pack Anti-ice Valve.

(7) Ram Air Scoop.

(8) Temperature Control Box.

(9) Duct Temperature Sensor.

(10) Cabin Temperature Sensor

(11) Dump Control Valve.

(12) Altitude Pressure Switch.

(13) Landing Gear Squat Switch.

(14) Anti-ice Sensor Rheostat.

b. Using the trainer and figure 2, locate each of the numbered items. Write the names of each item in the blank spaces. As you locate the items notice the check point for checking the electrical circuit.

(1)____________________________________

(2)____________________________________

(3)____________________________________

(4)____________________________________

(5)____________________________________

Compare your answers to those on the following page.

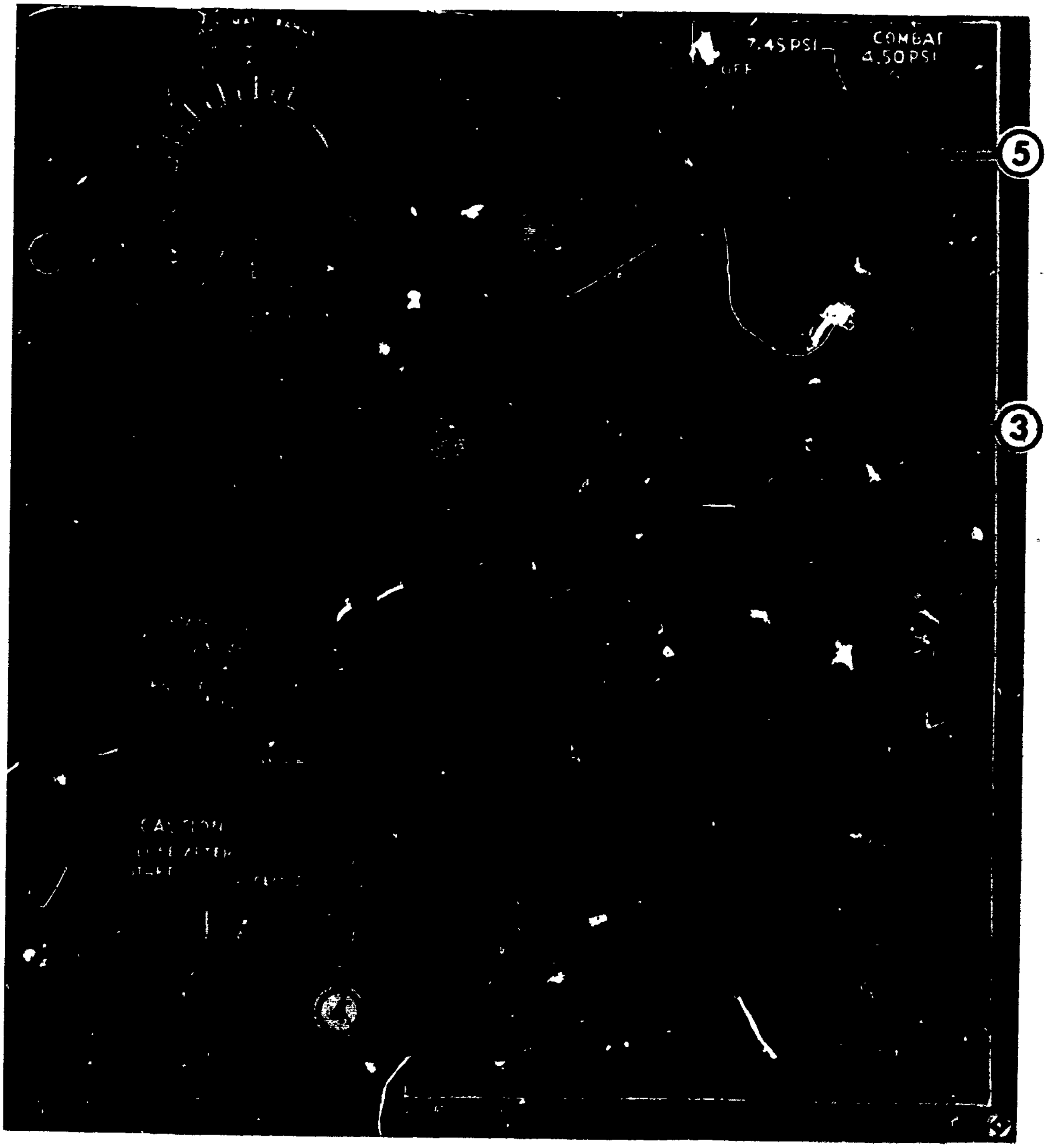


Figure 2.

Answers to location and identification step 1b

(1) Temperature Control

(2) Pressure Release Switch

(3) Bleed Selector Switch

(4) Manifold Valve Switch

(5) Cabin Pressure Master Switch

2. Trainer Preparation

a. Place all trouble switches to the OUT position. These switches are located at the left end of the trainer.

b. Place the following switches to the normal positions as listed below.

(1) Cabin Pressure Master Switch-------------------OFF

(2) Manifold Valve Switch--------------------------CLOSED

(3) Bleed Selector Switch--------------------------NORMAL

(4) Temperature Control Switch---------------------OFF

(5) Pressure Release Switch------------------------RESET

(6) Landing Gear Squat Switch----------------------AIRBORN

c. Place the trainer power switch to the ON position. This switch is located on the upper left side of the trainer.

3. Trainer operation

a. During the following steps you will operate each component of the bomber air conditioning system. When a switch is actuated be sure to notice which of the valves operate and the valve position. Actuate each switch as directed. From your observation of the trainer operation, complete each of the statements by circling the correct word.

STEP 1. Bleed air for engine start only

(1) Manifold valve switch OPEN

(a) #1 and #4 Bleed valve (energizes/deenergizes)

Note: Remember this step. Since we do not have air flow through the system you cannot observe the operation of 1 and 4 Strut Bleed Valves. However, you can check to determine if the solenoid is energized as follows: Remove the AN connector by unscrewing it from the solenoid valve. As you remove the connector you should hear an audible click as the solenoid is deenergized. Try this several times to be sure you recognize the audible sound of the solenoid energizing and deenergizing.

(b) Body crossover valve (opens/closes)

(c) #3 Strut bleed valve (opens/closes)

(2) Manifold valve switch CLOSED

(a) #1 and #4 Bleed valve (energizes/deenergizes)

(b) Body crossover valve (opens/closes)

(c) #3 Strut bleed valve (opens/closes)

(3) If the valve or valves fail to operate, it indicates a defective valve(s) or an open electrical circuit.

STEP 2. Cabin air conditioning system

(1) Cabin pressure master switch ----- 7.45 or 4.50

(a) Body crossover valve (opens/closes)

(b) #3 Strut bleed valve (opens/closes)

(c) Air conditioning shutoff valve (opens/closes)

(2) If the valve or valves fail to operate, it indicates a defective valve(s) or an open electrical circuit.

STEP 3. Cabin temperature control system; manual operation

(1) Place the cabin temperature control switch to MANUAL COOLER. The modulating valve (opens/closes)

(2) Place the cabin temperature control switch to MANUAL WARMER. The modulating valve (opens/closes)

(3) If the modulating valve fails to operate it indicates that the valve is defective or there is an open in the 28 VDC electrical circuit.

STEP 4. Cabin temperature control system; automatic operation

(1) Place the cabin temperature control switch in the 20°F position. The modulating valve (opens/closes)

(2) Place the cabin temperature control switch in the 100°F position. The modulating valve (opens/closes)

(3) If the automatic temperature control system fails to operate, this indicates an open in the 118 VAC power circuit to the controller.

STEP 5. Bleed selector switch

(1) Place the bleed selector switch to the emergency position

(a) #3 strut bleed valve (opens/closes)

(b) Body crossover valve (opens/closes)

(c) Air conditioning shutoff valve (opens/closes/remains the same)

(2) Place the bleed selector switch to the normal position

(a) #3 strut bleed valve (opens/closes)

(b) Body crossover valve (opens/closes)

(c) Air conditioning shutoff valv (opens/closes/remains the same)

STEP 6. Pressure release operation

(1) Place the pressure release switch to the DUMP position

(a) Cabin air conditioning shutoff valve (opens/closes/remains the same)

(b) Pressure dump control valve solenoid (energizes/deenergizes)

(2) Place the pressure release switch to the RESET position

(a) Cabin air conditioning shutoff valve (opens/closes/remains the same)

(b) Pressure dump control valve solenoid (energizes/deenergizes)

(3) Place the cabin pressure master switch to the ram position

(a) Cabin air conditioning shutoff valve (opens/closes)

(b) Body crossover manifold valve (opens/closes)

(c) Pressure dump control valve solenoid (energizes/deenergizes)

(d) Ram air scoop (opens/closes

(4) Place the cabin pressure master switch to the 7.45 or 4.50 position.

(a) Cabin air conditioning shutoff valve (opens/closes)

(b) Body crossover manifold valve (opens/closes)

(c) Pressure dump control valve solenoid (energizes/deenergizes)

(d) Ram air scoop (opens/closes)

(5) Place the landing gear squat switch to the "Ground" position

(a) Pressure dump control valve solenoid (energizes/deenergizes)

(6) Place the landing gear squat switch to the Airborn position

(a) Pressure dump control valve solenoid (energizes/deenergizes)

STEP 7. Pack anti-icing system operation

Note: The anti-ice sensor rheostat, located near the water separator is used to simulate a temperature change around the sensor.

(1) Rotate the anti-icing sensor rheostat to the full clockwise position.

(a) Pack anti-icing valve (opens/closes)

(2) Rotate the anti-icing sensor rheostat to the full counter-clockwise position.

(a) Pack anti-icing valve (opens/closes)

Note: The altitude switch, located in the upper right portion of the trainer is used to simulate altitudes above and below 36,000 feet.

(3) Place the altitude switch to the ABOVE 36,000 feet position

(a) Pack anti-icing valve (opens/closes)

(b) Water separator bypass valve solenoid (energizes/deenergizes)

(4) Place the altitude switch to the BELOW 36,000 feet position

(a) Pack anti-icing valve (opens/closes)

(b) Water separator bypass valve solenoid (energizes/deenergizes)

COMPARE THE ANSWERS THAT YOU HAVE SELECTED TO THOSE GIVEN BELOW.

Answers to trainer operation statements.

STEP 1. (1) energize
open
open

(2) deenergizes
close
close

STEP 2. (1) open
close
open

STEP 3. (1) close
(2) open

STEP 4. (1) close
(2) open

STEP 5. (1) opens
closes
remains the same

(2) closes
opens
remains the same

STEP 6:

(1) remains the same
energize

(2) remains the same
deenergize

(3) closes
closes
energize
open

(4) open
opens
deenergize
closes

(5) energize

(6) deenergize

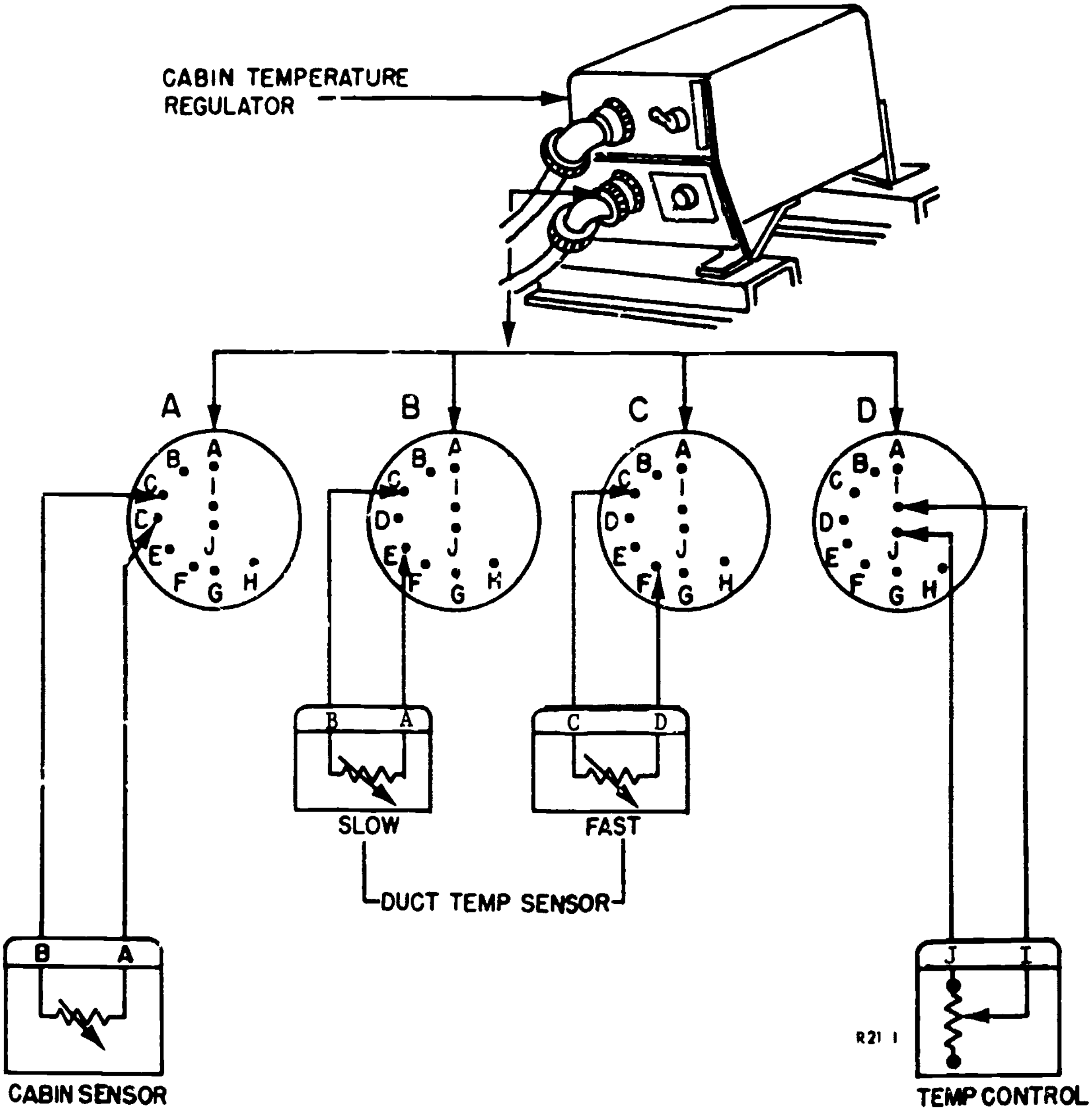
STEP 7:

(1) close

(2) open

(3) close
energize

(4) open
deenergize



The bridge circuit outside the cabin temperature regulator is shown above.

Note: The causes for a "Full Auto Hot" or "Full Auto Cold" will only be found in the bridge circuit.

Figure 3.

4. Sensor Resistance

a. Knowing the normal resistance value of the sensors will be helpful when troubleshooting. This is determined by referring to the technical order or by measuring a sensor that is known to be good.

b. To measure the resistance of the cabin and duct sensors, disconnect the lower AN connector on the temperature regulator as shown in figure 3. This is the AN connector nearest to the trainer. In figure 3 the AN connector is shown in four separate illustrations; A, B, C, and D. This is done to make it easier for you to see how to check the sensor circuit. Keep in mind that this is ONE connector.

Note: When checking resistance of the sensors, make sure the trainer power is off and you have the meter on ohms. When checking the cabin sensor, set your range selector to RX100 and when checking the duct sensor, set your range selector to RX10. Be sure you zero your meter before making any resistance checks.

c. Illustration A in figure 3 shows where to connect the meter for reading cabin sensor resistance. Check this resistance. Record the reading in the space below. Using illustrations B and C, measure the resistance of the duct sensor. Record your readings in the spaces below.

CABIN SENSOR resistance ______________________ ohms.
SLOW DUCT SENSOR resistance ___________________ ohms.
FAST DUCT SENSOR resistance ___________________ ohms.

d. Ask the lab instructor for the ambient temperature. ____°f.

e. Now that you have completed your sensor resistance check, you need to determine if the resistance is correct. Normally this is done by referring to temperature-resistance graphs in the applicable aircraft technical order. However, we have reproduced these graphs for you to use. Figure 4 is the temperature-resistance graph for the cabin sensor and figure 5 is the temperature-resistance graph for the duct sensor. Using these graphs, determine if your sensor resistance readings are correct.

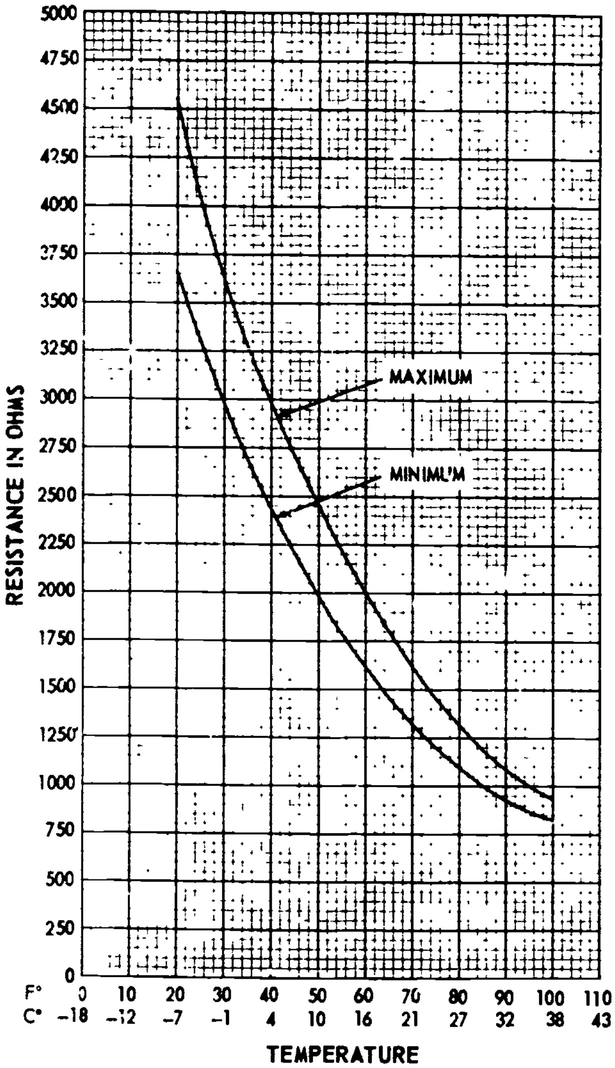


Figure 4. Cabin Temperature Sensing Element Resistance.

f. Instructions for using the CABIN temperature sensor resistance graph.

Locate the vertical lines for ambient temperature. Follow this line up to where it meets the minimum line. Then follow the horizontal lines to the left to determine the resistance in OHMS. The measured resistance should be within this range.

EXAMPLE: If the temperature is 64°F then the resistance should be between 1500 and 1875 ohms.

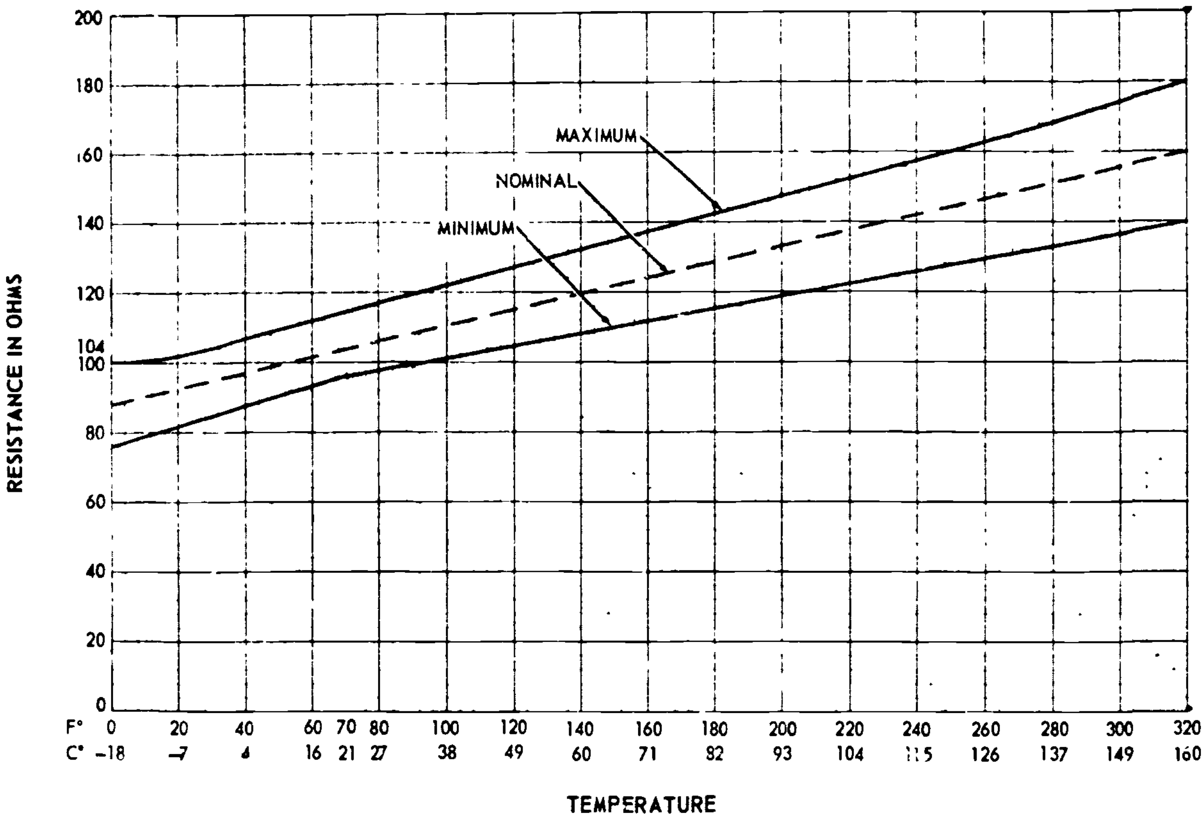


Figure 5. Duct Temperature Sensing Element Resistance.

g. Instructions for using the DUCT temperature sensor resistance graph (figure 5.)

Locate the vertical lines for ambient temperature. Follow this line up to where it meets the minmum line. Then follow the horizontal lines to the left to determine the resistance in OHMS. The measured resistance should be in this range. The fast and slow sensors should be the same.

EXAMPLE: If the temperature is 70°F, then the resistance should be between 96 and 114 OHMS.

5. Rheostat Resistance

a. Illustration D in figure 3 shows the pin connections for checking the temperature control rheostat. Place the meter leads in pins J and I, then rotate the temperature control rheostat from 20°f to 100°f. The pointer on the meter will move from left to right indicating that the temperature control rheostat is operating properly.

b. Set the temperature control rheostat at 70°f. Read the resistance and record your reading below.

Temperature control rheostat resistance ____________ ohms.

c. You should have read between 300 and 500 ohms.

Note: If your readings were all correct, then continue to the operational check. If your readings were incorrect, then ask the instructor for assistance.

SECTION 2. BOMBER AIR CONDITIONING SYSTEM OPERATIONAL CHECK AND TROUBLESHOOTING

OPERATIONAL CHECK

1. The steps that you performed in paragraph 3a of Section 1 involved operating each component in the bomber air conditioning system. They determined if each component was operating properly and are called operational checks.

2. Chart 1 on the next page formalizes the procedures for performing operational checks in outline form. To insure that you are familiar with this procedure, turn the trainer power switches ON and perform each of the steps. After you are sure you understand the operational check procedure, then continue to the troubleshooting part of this lesson. You will be required to perform a complete operational check for each trouble.

Positioning the control device	Operating Valve	Valve Position
Manifold Valve switch OPEN	All Bleed Valves	OPEN
Manifold Valve switch CLOSED	All Bleed Valves	CLOSED
Cabin pressure master switch 7.45 or 4.50 position	Body crossover valve Air conditioning shutoff valve	OPEN OPEN
Place the temperature control switch to MANUAL COOLER	Modulating valve	CLOSED
Place the temperature control switch to MANUAL WARMER	Modulating valve	OPEN
Place the temperature control to AUTO 20°F	Modulating valve	CLOSED
Place the temperature control to AUTO 100°F	Modulating valve	OPEN
Place bleed selector to the EMERGENCY position	#3 strut bleed valve Body crossover valve	OPEN CLOSED
Place bleed selector to the NORMAL position	#3 strut bleed valve Body crossover valve	CLOSED OPEN
Place the pressure release switch to DUMP	Pressure dump control valve	ENERGIZE
Place the pressure release switch to RESET	Pressure dump control valve	DEENERGIZE
Place the cabin pressure master switch to RAM	Air conditioning shutoff valve Pressure dump control valve Ram air scoop	CLOSE Energize OPEN
Place the cabin pressure master switch to 7.45 or 4.50	Air conditioning shutoff valve Pressure dump control valve Ram air scoop	OPEN DEENERGIZE CLOSE
Place landing gear squat switch to GROUND position	Pressure dump control valve	Energize
Place landing gear squat switch to AIRBORN position	Pressure dump control valve	Deenergize
Rotate sensor rheostat full CLOCKWISE	Pack anti-icing valve	CLOSE
Rotate sensor rheostat full COUNTERCLOCKWISE	Pack anti-icing valve	OPEN
Place altitude switch to ABOVE 36,000 feet	Pack anti-icing valve	CLOSE
Place altitude switch to BELOW 36,000 feet	Pack anti-icing valve	OPEN

Chart 1. Operational Check Procedure Chart.

Troubleshooting

1. For each trouble, perform an operational check to determine the malfunctioning component. After you determine the malfunction, then place a statement in the "discrepancy" block of the attached troubleshooting answer sheet, that describes the malfunction.

2. Using a waxed pencil, trace the electrical circuits that operate or control the malfunctioning component.

3. Use the multimeter to locate the cause of the trouble.

Note: When measuring voltage, be sure the meter is set to the correct voltage range. Make sure that you have the negative (black) lead to ground. Ground on the trainer is located to the left of the AN/PSM-6 multimeter bracket. When checking the manual control system, be sure to hold the temperature control switch to either cooler or warmer. When measuring resistance, be sure the trainer power switch is OFF, and the meter is set at ohms. Use the OHM portion of the multimeter only to check sensors and their circuits.

4. Record the cause of the trouble in the corresponding cause block of the troubleshooting answer sheet.

5. The trouble switch that you are to use for each problem is listed on the top line of the discrepancy block. There are 17 problems for you to troubleshoot. We will go through number 1 to show you how to arrive at the correct answer.

Note: During this exercise you will not use trouble switches numbered 2, 13, 17. Since this trainer does not have check points for the valves, it will be necessary to remove the electrical connector from the components in order to check for power with your meter.

TROUBLE NUMBER 1

1. Place number 1 trouble switch to the IN position.

2. Perform an operational check, using the operational check procedure chart.

3. As you went through the operational check you found that the air conditioning shutoff valve did not open. This means that no conditioned air was available when the master switch was put to the 7.45 or 4.50 position. Make the following statement in the discrepancy block of the troubleshooting answer sheet for trouble switch No. 1.

"Air conditioning shutoff valve will not open when the master switch was put in the 7.45 or 4.50 position."

4. The first step would be to determine which valve or valves would give you this condition. Moving the cabin pressure master switch to the 7.45 or 4.50 position, the cabin air conditioning shutoff valve should have moved to the OPEN position, but you will notice that it does not. Trace the circuit that would be affected.

5. When tracing the circuit you will notice that it requires 118 VAC to operate the cabin air conditioning shutoff valve. Check the AC power with the multimeter. Make sure your meter is set for the correct voltage. Your first check on the trainer will be at P-1772 point "G." You should read 118 VAC. Second, you check at point J on P-1773, you should read 118 VAC. Now remove the electrical connector from the cabin air conditioning shutoff valve. Check voltage at pin "B." You will notice that there is no voltage at this point. This would mean that you have an OPEN in wire H11B20V.

6. Record your findings in the cause block of the troubleshooting answer sheet. Open in wire H11B20V.

7. See your instructor.

Note: OMIT PROBLEMS 2, 13, 17.

Technical Training

Aircraft Environmental Systems Mechanic

BOMBER AIR-CONDITIONING SYSTEM WIRING DIAGRAM

26 March 1984

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE.
DO NOT USE ON THE JOB.

BOMBER AIR CONDITIONING SYSTEM WIRING DIAGRAM

OBJECTIVE

Using a wiring diagram, specify causes for the air conditioning system troubles attaining a minimum of 48 out of 60 possible points.

EQUIPMENT

Colored Pencil Set

INSTRUCTIONS

Information on the purpose and operation of the bomber air conditioning system components and the procedures for you to follow are contained in this workbook.

Pay close attention to all instructions that are given to you in this workbook. When tracing circuits or answering questions in this workbook, if your response is incorrect, restudy the information and ask questions of the instructor. There are five exercises in this workbook. Each has to do with a different circuit. Unfold and refer to figure 1 located in the back of this workbook. The circuits you are to trace are listed on page 14. The color code you are to use for tracing each circuit is shown in the block before each circuit. The wiring diagram used in this project is the same one you will use for troubleshooting this system on the trainer. If you don't understand the circuit after tracing, check with the instructor.

Note: In this diagram we are tracing current from the circuit breakers to the component's ground. This is not the way current flows, but it is the easiest because of so many ground points in the diagram. Actually this is the opposite of electron flow. REMEMBER this note when using any wiring diagram.

Section 1. BOMBER AIR CONDITIONING SYSTEM WIRING DIAGRAM

This lesson is on the Bomber Air Conditioning System Wiring Diagram. Following the instructions in this workbook, you will use figure 1 in the back of this workbook, to trace out the electrical circuits of the bomber air conditioning system.

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TRACING POWER

Remove figure 1 from your workbook. Using your purple pencil, trace the power circuits of the bomber air conditioning system. Start with the cabin emergency ram air control circuit breaker located at the upper left corner of the circuit diagram. From there, trace current flow over wire H1A20 to pin E on connector P-1772. Then current flows from pin E of P-1772 to contact lever (1) of the cabin pressure master switch and stops. Before continuing, let's discuss the cabin pressure master switch. All the sections (1 through 6) shown on the diagram are part of the one cabin pressure master switch located in the cockpit. This switch is called a wafer switch. As you can see by the dotted line, all sections are linked together. This dotted line represents the shaft which goes through the center of the switch and on which the contacts are mounted. Therefore, when one of the contact levers is moved to a certain position, all of the levers move to the same respective position. This cabin pressure master switch, with its four positions-- ram, off, 7.45, and 4.50, is used to direct the current to the various valve motors and relays used to control the engine bleed air, cabin pressurization, and air conditioning systems.

Now, let's return to tracing the power circuits. Move over to the 118 VAC circuit breaker--it is located in the upper middle section of the diagram to the left of the ram airscoop relay. Current flows from the circuit breaker over wire H1E20V to the contact lever on the ram airscoop relay. Next, move to the No. 1 and No. 4 bleed valve circuit breaker located at the left side of the diagram.

This circuit breaker is labeled right TR bus, struts 1 and 4 bleed valves. The TR stands for transformer rectified. This means the voltage is 28 VDC. Continuing with your purple pencil, trace the path of current flow from the circuit breaker over wire H2A20 to the top contact lever of the manifold valve switch and stop. Note: The manifold valve switch has three contact levers.

Continuing down the bus bar, trace current from the struct No. 3 and body crossover valves circuit breaker on wire H3A20V to the middle and bottom contact levers of the manifold valve switch and stop.

Now move to the cabin air conditioning shutoff valve circuit breaker, labeled 118 VAC. Current [illegible] from the circuit breaker over wire H9A20V to pin G on connector P-1772. Current then continues on wire H9B20V to the contact lever (4) of the cabin pressure master switch.

Next, move back to the cabin air conditioning controller circuit breaker marked right TR bus. Once again, this means 28 VDC is used for this circuit. From this circuit breaker, current flows over wire H12A20 and H14A20 to pin C on connector P-1771. Current "taps off" this wire between the circuit breaker and connector P-1771 and flows over wire H13A20 to the landing gear [illegible] relay and stops.

Current continues from pin C on wires H14B20 and H14C20 to the contact lever (5) on the cabin pressure master switch and stops. Again, current "taps off" this wire and flows down the bus bar to wires H15A20 and H15B20. From here, current flows to both the pressure release switch on wire H15A20 and to the cabin pressure master switch contact lever 6 on wire H15B20 and stops.

Now we move down to the cabin air conditioning temperature regulator circuit breaker marked 118 VAC. Current flows from here over wire H21A20V to point A2 on the temperature control relay and stops. Your next power circuit is from the 3-phase circuit breakers marked 118/205 VAC located in the lower left portion of the diagram. There are three of these circuit breakers. Current flows from each one to points B2, C2, and D2 on the open relay and stops.

Now that you have traced in your power circuits, you are ready to find out how the system operates.

Exercise 1

Fill in the blanks.

1. The bomber air conditioning and pressurization electrical systems utilize

   both ____________ and _________________ current.

2. The cabin pressure master switch has ________ sections and ___________ positions.

3. The four positions of the cabin pressure master switch are ______,

   _________, __________, and ___________.

4. Current from a circuit breaker marked TR BUS is ____________ current.

5. When one contact lever of the cabin pressure master switch is moved to a

   certain position, they all move to the ______________ ______________.

6. Struts 1 and 4 bleed valves require __________ (28 VDC/118 VAC) for operation.

7. The manifold valve switch has ___________ contact levers.

8. Current for operating the cabin air conditioning system is controlled by

   the __________ __________ __ ________ switch.

9. Current used for operating the cabin air conditioning shutoff valve is

   __ ______ (28 VDC/118 VAC).

Check with your instructor for the correct answers.

Section 2. ENGINE START CIRCUITS TRACING

Remember, the engines must be operating before you can have a source of bleed air for normal operation of the air conditioning and pressurization systems. Use your RED pencil to trace the engine start circuits.

To begin, find the manifold valve switch on figure 1 and draw the three contact levers of the switch to the up or open position. After this is done, you should notice that power is removed from wires H8A20V and H6A20V. This, in turn, removes power from two sections of the cabin pressure master switch, sections 2 and 3. With the contact levers up, current flows across the top lever and over wire H2B20 to both number 1 and 4 strut bleed valves. Although these are air pressure actuated valves, they are controlled by a solenoid. This means the valves are actually moved by air, but the solenoid controls the air applied to the valve.

As you can see, it takes both air pressure and 28 VDC to open these valves. Now, let's continue with the next part of the engine starting circuit. Current flows across the middle contact levers, over wire H4A20V to pin B on connector P-1772. From here, current flows along wire H4B20V, through the bleed selector switch, which is in the normal or down position, and out this switch on wire H5C20V to pin H on connector P-1773. From pin H on connector P-1773, current flows along wire H5E20V to pin B on the body crossover manifold valve. It continues through the valve motor and out pin C on wire H42A20N to ground. This valve will run open. Go to the bottom contact lever of the manifold valve switch. Current flows along wire H7A20V through the connectors and over to pin B on the strut number 3 bleed valve out pin C to ground. You now have number 1 and 4 strut bleed valves open, the body crossover manifold valve open, strut number 3 bleed valve open, and you are ready to start the engines. Take a good look at the circuits you have traced so far. You can see that you are ready to operate the air conditioning system from engine bleed air.

NORMAL SOURCE OF AIR CONDITIONING

Now, use your green pencil to trace the normal course of air circuit. First, draw the manifold valve switch to the closed position. This closes all strut bleed valves until air is needed for the air conditioning system, but furnishes current to open either the strut 2 or strut 3 bleed air valves, depending on the position of the bleed selector switch and cabin pressure master switch.

Next, draw the bleed selector switch to the normal position and all of the six sections of the cabin pressure master switch to the 7.45 position. With the manifold valve switch in the closed position, no current flows from the top contact to the struts 1 and 4 bleed valves. Current flows from the middle contact lever of the manifold valve switch over wire H6A20V to pin C on connector P-1772. From here, current flows over wire H6B20V through the cabin pressure master switch contact 2 and out on wire H6D20V to the top contact lever on the bleed selector switch.

Current flows over wire H5C20V to pin H on connector P-1773. From here, it flows over wire H5E20V to pin B on the body crossover manifold valve. Current continues through the valve motor and out pin C on wire H42A20N to ground. As you can see, this valve will run open.

Going back to the bottom contact on the manifold valve switch, current flows over wire H8A20V to pin D on connector P-1772.

Current continues on wire H8B20V and then H8C20V, then on to the bottom contact of the bleed selector switch. Because you are still in normal air source, current flows over wire H8D20V to pin A of connector P-1772. From there, current flows over wire H8E20V to pin A on strut number 3 bleed valve. Current continues through the valve motor and out on pin C on wire H45A20N to ground. This will run the valve closed. Moving down to the next section of the cabin pressure master switch, section 4, the current flows over wire H11A20V to pin J on connector P-1773. From here, current flows along wire H11B20V to pin B on the cabin air conditioning shutoff valve. Current continues through the valve motor and out pin C on wire H46A20N to ground. As you can see, this valve will now run open. On the next section of the cabin pressure master switch, section 5, you see that current CANNOT flow anywhere in the 7.45 position.

The sixth and last section of the cabin pressure master switch has current flowing in two directions. First current can flow over wire H19A20 to pin A on connector P-1839. Current then flows over wire H19B20 and supplies power to the temperature selector switch, located on the temperature control panel. This switch is shown in the off position so no current flows at this time. The second way current flows from the master switch section 6 is along wire H20A20, through pin B on connector P-1771, and on wire H20B20 to energize the temperature control relay. With this relay energized, the contact lever moves up and current flows from point A2 to A1. From A1, current can go in two directions. First, current flows along wire H21C20V to pin V on the anti-ice controller. The other way power flows is along wire H21B20V down to pin A on the cabin temperature regulator, where it supplies power to energize the relays in the control box. This completes the tracing of the normal source of air circuits with the green pencil, and you can see the proper valves are open for normal source of air for air conditioning. The body crossover manifold valve and air conditioning shutoff valve are open and struts 1 through 3 and 4 are closed. Also, during this tracing, you have supplied power to the temperature control and anti-ice systems.

Exercise 2

Fill in the blanks to complete the following statements.

1. The manifold valve switch is placed in the open position for ________ ________.

2. Struts 1 and 4 bleed valves are electrically controlled by a ________ and actuated by ________ ________.

3. The cabin pressure master switch is in the ______ (on/off) position when starting the aircraft engines.

4. Strut 2 is the __________ (normal/emergency) source and strut 3 is the __________ (normal/emergency) source of bleed air for the air conditioning and press tion system.

5. For normal operation of the cabin air conditioning system, the manifold valve switch is in the _______ (open/close) position, the cabin pressure master switch in the ________ (RAM/OFF/7.45/4.50) position and the bleed selector switch in the __________ (normal/emergency) position.

6. If wire number H11B20V were open, the cabin air conditioning shutoff valve would not ________ (open/close) when the cabin pressure master switch is placed in 7.45 or 4.50 position.

7. The cabin air conditioning shutoff valve is actuated by a __________ __________ (118 VAC/28 VAC) motor.

8. The cabin air conditioning shutoff valve closes normally in ram, and off, but failed to open for normal air conditioning. This could be caused by an open in wire number H11B20V or __________________.

Check with your instructor for the correct answers.

Section 3. EMERGENCY SOURCE OF AIR CIRCUITS

Use the yellow pencil to trace the emergency source of air circuit. Before you begin to trace this circuit, draw the contact levers of the bleed selector switch up to the emergency position. This is the only switch that changes positi- s. Current flows over the top contact of the bleed selector switch along wire H4D20V to pin G of connector P-1773. It continues from pin G along wire H4E20V to pin A on the body crossover manifold valve. Current continues through the valve motor and out pin C on wire H42A20N to ground. This valve will now run closed. Also, current flows over the bottom contact lever of the bleed selector switch on wire H7B20V to pin M on connector P-1772. Now, power flows from pin M of connector P-1772 on wire H7C20V to pin B on strut number 3 bleed valve. Current continues through the valve motor and out pin C on wire H45A20N to ground. This valve will now run open. You now have the body crossover manifold valve closed and strut 3 bleed valve open. This is the emergency source of air for air conditioning and pressurization.

Section 4. RAM VENT CIRCUIT

Now, use the black pencil to trace the ram vent circuit. Draw all six contacts of the cabin pressure master switch to the ram position. All other switches will be in the normal positions. This means the manifold valve switch is in the closed position and the bleed selector switch is in normal. Starting with the top section of the cabin pressure master switch, current flows through the top contact, over wire H1C20, through pin A on connector

P-1773, continues on through the ram airscoop relay, and out wire H40A20N to ground. This energizes the relay and pulls the contact lever up to make contact with point A3. Then, power from the 118 VAC circuit breaker flows over H1G20V to pin B on the retractable ram airscoop. Current continues through the scoop motor and out pin C on wire H41A20N to ground. This now runs the scoop open. As you can see, when the ram airscoop relay is deenergized, current would flow over wire H1F20V to close the scoop. Move down to the second section of the master switch. You can see that current flows the entire length of wires H4D20V and H4E20V through the body crossover manifold valve, closing the valve. For the third portion of the master switch, you can see that current flows the complete length of wires H8D20V and H8E20V through the strut number 3 bleed valve, closing the valve. With the fourth section of the switch current flows over wire H10A20V to pin K of P-1773 and from pin K to the closed side of the cabin air conditioning shutoff valve, closing this valve. Section five of the master switch directs current over wire H17B20 to pin V of P-1770 and from pin V along wire H17C20 to pin B of the pressure dump control valve.

This will dump cabin pressure allowing ram air to ventilate the cabin. Section 6 removes power from the temperature control circuit and that is all it does. This completes the ram air vent circuit. The ram airscoop is open and all other valves are closed. Also, note that if the air conditioning system is on and you need to dump pressure immediately, you could put the pressure release switch to dump and this would supply power to the pump control valve to dump cabin pressure. Review the circuits you have traced on the diagram to this point. If you have any questions, consult the instructor now; if not answer the questions in exercise 3 below.

Exercise 3

Fill in the blanks to complete the following statements.

1. With the bleed selector switch in emergency and all other switches in normal, the body crossover manifold valve will ___________ and the strut number 3 bleed valve will ____ _______ __.

2. Bleed air for emergency air conditioning and pressurization is taken from _________ ___________ bleed valve.

3. An open in wire H8E20V would cause the strut number 3 bleed valve to remain in the ___________ (open/close) position.

4. The retractable ram airscoop remained open after the cabin pressure master switch was placed to an air conditioning position; this could be caused by an open in wire ___________.

5. If wire H47A20N were open the pressure dump control valve solenoids would remain _____________ (energized/deenergized).

6. During operation of the air conditioning system in normal there is no airflow from the outlets; this could be caused by a defective ________ ________ ____________ valve or __________ __________ ______________ ____________ valve.

7. If the air conditioning system fails, __________ ____________ is used to ventilate the cabin.

8. When the cabin pressure master switch is in the ram position, the __________ __________ ___________ will energize to open the retractable ram airscoop.

9. The body crossover manifold valve controls the flow of engine bleed air from strut number ____________.

10. The switch used to select normal and emergency operation is the ___________ __________ switch.

Check with the instructor for the correct answers.

Section 5. AUTOMATIC COLD CIRCUIT

The next circuit you trace is the automatic cold circuit. However, before tracing this circuit, you need to understand some information about the automatic operation. This information pertains to both automatic hot and cold. During this discussion, do not trace the parts of the circuits. Refer to figure 1. The first item is the temperature selector, located on the temperature control panel. This unit is a variable resistor and has a positive coefficient effect on the circuit, which means a short will call for hot and an open will call for cold. This unit is connected to the cabin temperature regulator by wires H25A and H26A through pins I and J. The next unit is the slow part of the duct sensor. This part is connected to pins A and B of the sensor unit and connected to the cabin temperature regulator through wires H27A and H32A on pins C and E. This slow element of the duct sensor has a positive coefficient of resistance but will react like a negative coefficient sensor if there is an open or a short within the slow element sensor. This means an open will call for hot and a short will call for cold. This is just the opposite of the fast sensor element which has a positive coefficient of resistance. The fast sensor element is connected to pins D and C of the sensor unit and C and F of the cabin temperature regulator through wires H28A and H31A. The next sensor, which is the cabin sensor, has a negative coefficient of resistance. Once again, this means a short will call for cold and an open will call for hot. The cabin sensor connection in the circuit is from B and A of the sensor through wires H29B and H30A to pins C and D of the cabin temperature regulator. When the pilot uses the temperature selector to select a desired temperature in automatic, the sensors will maintain this temperature by controlling the operation of the air conditioning modulating valve. Now, let's trace this circuit.

TRACING AUTOMATIC

Use your orange pencil to trace this circuit. Place the temperature control switch, which is located on the temperature control panel, to the auto position. Of course, you know the cabin pressure master switch must be in either the 7.45 or 4.50 position to get temperature control. Current then flows to both the warm and cold contact levers. Because we are calling for cold, the cold relay energizes and current flows out pin G of the temperature regulator. Current taps off wire H23A and flows to pin F on the air conditioning modulating valve. Current flows through the modulating valve to pin G on connector P-1802. Current energizes the cold relay. This action pulls the three contact levers down and alternating current from the three circuit breakers flows to the modulating valve to run it closed, giving you cold air. This completes the automatic cold operation of the temperature control system. Since automatic warm operates the same way as automatic cold, it is not necessary to trace that circuit.

If you have any questions about what you have traced so far, ask your instructor NOW.

Section 6. MANUAL WARM CIRCUIT

You will use your blue pencil to trace this circuit. Place the temperature control switch to the manual warm position. Current now flows out pin F of the temperature control panel on wire H22B. Current taps off wire H22B and flows to pin D on the modulating valve. Current continues through the valve cutout switch and out pin C, then on to pin K on connector P-1802. From here, current flows over and energizes the hot relay. This pulls the three contact levers down and then alternating current from the three circuit breakers flows to the modulating valve to run it open for warm air. This concludes the tracing of the manual warm circuits. Keep in mind that the manual cold circuits function the same way.

This also concludes the tracing of the circuits in this lesson. However, let's touch lightly on one more area just for information purposes. You need not trace the circuit unless you want to. The circuit is the 4.50 position of the cabin pressure master switch. This position is used to change the amount of pressurization only. This energizes a solenoid on the cabin pressure regulator to change pressurization, but everything else operates the same as in the 7.45 position.

If you have any questions, see your instructor NOW. If you have no questions complete exercise 4.

Exercise 4

Use figure 1 to answer the following questions. Mark only the statements that are true.

_____ 1. When the pressure release switch is put to the dump position the cabin pressure regulator changes pressurization to 4.50 psi.

_____ 2. In emergency the body crossover valve will close and the strut number 3 bleed valve will open.

_____ 3. If wire H14A20 leading from the cabin air conditioning controller circuit breaker were broken there would be no temperature control.

_____ 4. With the manifold valve switch open, all bleed air valves are open or will open with air pressure.

_____ 5. When the cabin pressure master switch is placed in "ram" the cabin pressure regulator receives power to dump pressure.

_____ 6. With the bleed selector switch in normal, the body crossover manifold valve is open and strut number 3 bleed valve is closed.

_____ 7. If the cabin air conditioning shutoff valve will close but will not open, a probable cause could be wire H11B20V being broken.

_____ 8. With the cabin pressure master switch in the "off" position, the cabin air condition shutoff valve will close.

_____ 9. In the 7.45 or 4.50 position the cabin pressure master switch will provide power to BOTH the temperature control relay and the temperature control panel.

_____10. If the manual cold wire were broken at pin G on connector P-712 there would still be automatic cold operation.

_____11. A short between pin D and pin C of the fast duct sensor will call for hot air.

_____12. The strut number 1 and number 4 bleed valve circuit breaker also provides power for the body crossover manifold valve.

_____13. All the cabin pressure master switches, shown in figure 1, are mechanically linked.

_____14. The 4.50 position of the master switch is used to change cabin pressurization.

_____15. Above 36,000 feet the anti-ice valve is closed and the water separator bypass valve is open.

STOP and see your instructor. Instructor's Initials ____________

PRACTICE EXERCISE

In the following practice exericses you will be given a discrepancy. You are to find the cause and/or causes and fill in the blanks. Problem #1 explains the proper procedure for finding the causes. If you have any questions during the practice exercises you may ask your instructor for help.

Problem #1

The discrepancy reads: With the manifold valve switch in the open position, strut #1 bleed valve will not open. First you must determine the circuit for strut #1 valve. Using figure 1, and a red pencil, start from the strut number 1 and 4 bleed valves circuit breaker and trace over wire H2A20 to the open side of the manifold valve switch, over wire H2B20 to the junction of wire H2D20 and H2C20. As you car see an open in any of the wires we have traced so far would cause both number 1 and 4 strut bleed valves to be inoperative. As we are only concerned with strut #1 bleed valve, using a blue pencil trace over wire H2D20 through tne valve to ground over wire H43A20N. As you can see if either one of these wires were open it would cause strut #1 bleed valve to be inoperative. Therefore, the answer to problem #1 is H2D20 and H43A20N.

Problem #2

With the manifold valve switch in the close position and the bleed selector switch in normal, and the cabin pressure master switch is in the 7.45 or 4.50 position the body crossover valve will not open, but will close. The probable cause would be an (open/short) ________ in wires number _______ and _________.

Problem #3

With the manifold valve switch in the open position, number 1 and 4 strut bleed valves did not open. The probable cause would be an (open/short)__________ in wire numbers ________________, ______________.

Problem #4

In automatic the cabin temp goes full hot and remains.

Shorted wire numbers __________, __________, __________, __________.

This concludes the practice exercise. If you have no questions, inform your instructor that you are ready for the performance test.

PURPLE	POWER CIRCUIT
GREEN	NORMAL SOURCE OF AIR
YELLOW	EMERGENCY SOURCE OF AIR
RED	ENGINE START
BLACK	RAM VENT
ORANGE	AUTO COLD
BLUE	MANUAL HOT

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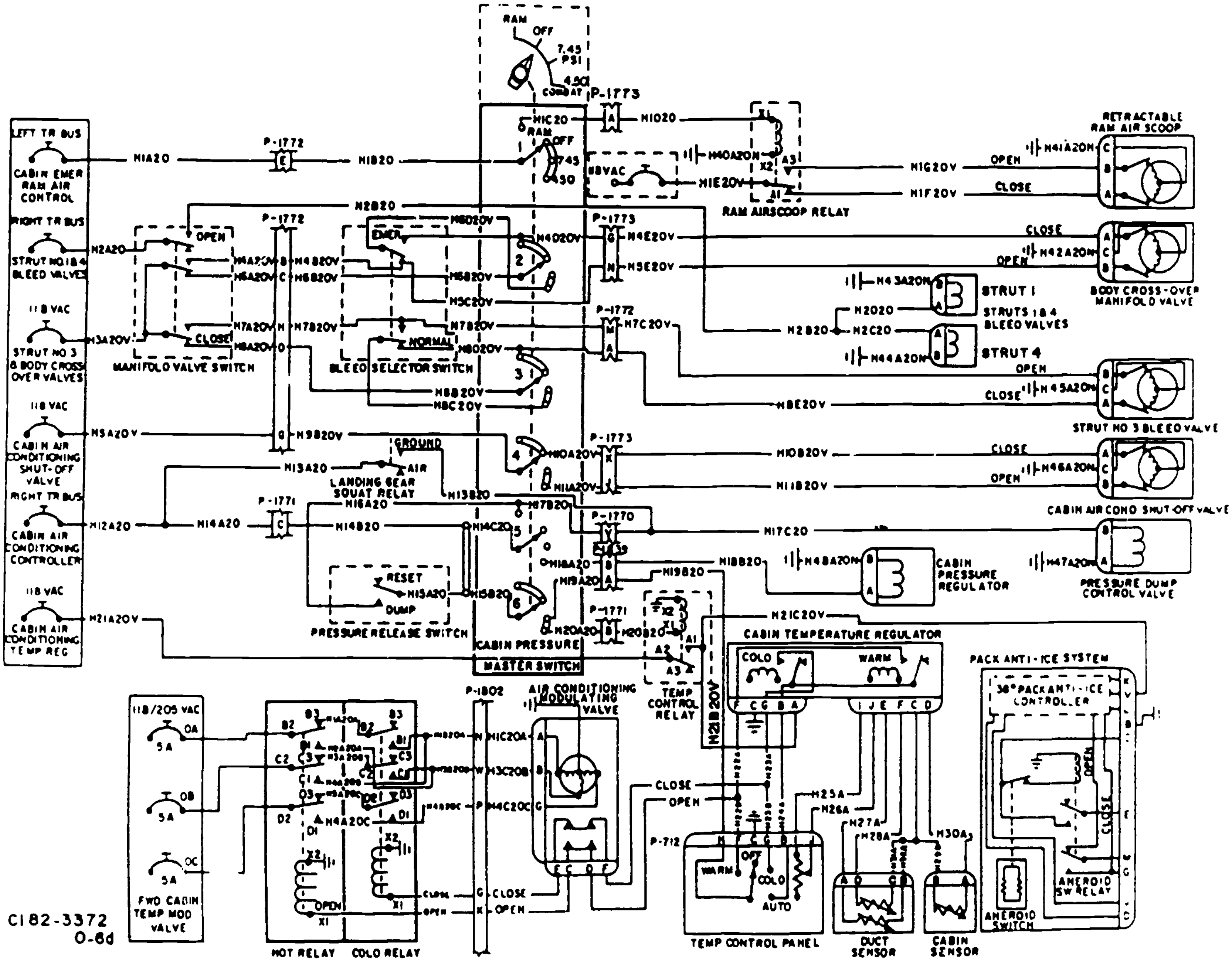

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Figure 1.

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PROGRAMMED TEXT
C3ABR42331-PT-208

Technical Training

Aircraft Environmental Systems Mechanic

CARGO AIRCRAFT ENGINE BLEED AIR SYSTEM

7 October 1983

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE

DO NOT USE ON THE JOB

RGL: 9.4

OBJECTIVE

Relate a minimum of eight out of ten cargo bleed air system components to their operation.

INSTRUCTIONS

As you progress through this text, you will be accomplishing the following tasks:

1. Identifying the purpose of the cargo aircraft bleed air system.

2. Associating the functions of the bleed air system components to their names.

3. Tracing through the bleed air system electrical control circuit to determine system operation.

4. Identifying the procedures for maintaining the bleed air system. These tasks will aid you in accomplishing the objective for this lesson.

The text presents this material in small steps called "frames." After each frame you are asked to respond by completing statements, matching statements, or by selecting the true statement. Read the material carefully before making the responses. The correct answers to the questions are given at the back of the text. If you select the correct answers, continue to the next frame. If you are incorrect, read the material again and correct your answers before continuing.

Supersedes C3ABR42331-PT-208, 18 January 1982.
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3370 TCHTG/TTGU-P - 1000; DAV - 1

In previous systems that you have studied, the hot engine bleed air was used for several purposes. On the cargo aircraft that you will be studying in this lesson, engine bleed air is also used for several purposes. These purposes are as follows.

1. Air conditioning and pressurizing the cabin (flight deck) and the cargo compartment.

2. Starting engines.

3. Defogging the windshield.

4. Preheating the engine compartments (nacelle). This is used when operating in extreme cold climates.

5. Driving an air turbine motor (ATM). An ATM is a unit that provides electrical power for emergency operation or for ground operation. The unit consists of a turbine, driven by bleed air, that drives an alternator.

6. Anti-icing the leading edges of the wings and empennage (tail section).

7. Anti-icing the engine air intake scoop and guide vanes.

8. Anti-icing the radome. (The radome covers the radar unit that protrudes from the nose of the aircraft.)

9. Anti-icing the urinal drains.

Fill in the blanks to complete the following statements.

1. Air for air conditioning the cabin and cargo compartment is supplied from the engine ________________ ________________ system.

2. The aircraft engines are started by using ____________________.

3. Anti-icing of the aircraft wing leading edges is accomplished by using hot ________________ ________________ ________________.

4. Hot engine bleed air is used for anti-icing the engines air ________________ ________________ and ________________ vanes.

Frame 2

The cargo aircraft that you will be studying in this lesson has four engines. Bleed air is taken from all four engines. The air is still taken from the last stage of compression. However, the last stage of compression on this aircraft is the 14th stage.

A ground air cart can also be used on this aircraft for starting engines and for operating the various systems when the aircraft is on the ground.

The cargo aircraft is also equipped with a Gas Turbine Compressor (GTC). The GTC is a small jet engine that is mounted in the left wheel well. This unit is only used to supply bleed air for ground operation. The GTC can be started by electrical power from the aircraft battery. Then the bleed air from the GTC can be used to start the aircraft engines, or to operate any of the systems normally operated by bleed air.

Fill in the blanks to complete the following statements.

1. The three sources of the bleed air for the cargo aircraft are the ____________________, ________________________ ______________________ compressor, and _______________________ ______________ cart.

2. During ground operation, bleed air can be supplied by a ________________ ________________________ cart, by a gas turbine _____________________, or by the engines.

3. The purpose of the GTC is to supply ____________________ air during ______________________ operation only.

Figure 1 shows the bleed air system for the left wing and fuselage, the right wing is the same as the left wing. The system consists of sections of stainless steel ducting, engine bleed air shutoff valves, and wing isolation valves.

Locate the valves in figure 1. The system of ducting that carries the bleed air to its point of use is frequently called the bleed air manifold. The bleed air is taken from each of the four engines and carried to the various systems by the bleed air manifold.

Fill in the blanks to complete the following statements.

1. The bleed air system consists of _______________ __________ ducting, engine bleed air ______________ _________________, and wing ______________ valves.

2. During flight, air for anti-icing is provided by ____________________ (1, 2, 3, 4,) engines.

3. During flight, air for air conditioning is provided by ____________ (1, 2, 3, or 4) engines.

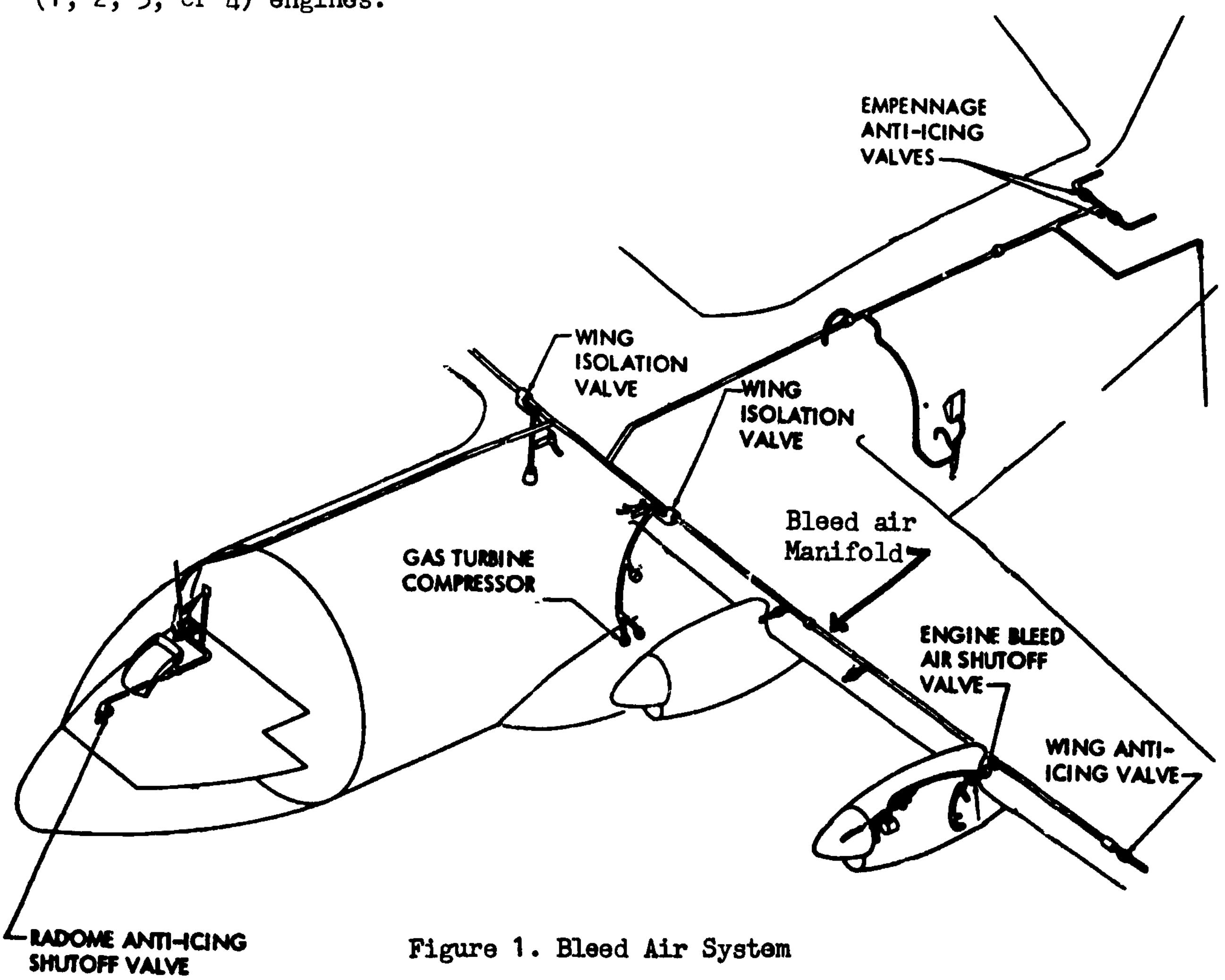


Figure 1. Bleed Air System

Frame 4

Bleed air can also be supplied to the bleed air manifold by a GTC, (gas turbine compressor). The GTC is installed in the left wheel well. The GTC installation is shown in figure 2. Again, it's only purpose is to supply bleed air to the bleed air manifold. It is only used for operating the system while the aircraft is on the ground.

Fill in the blanks to complete the following statements.

1. To perfo·m a ground operational check of a system requiring bleed air, the air can be supplied by either a ground ____________ ____________, ____________ ____________ compressor or by the aircraft ____________.

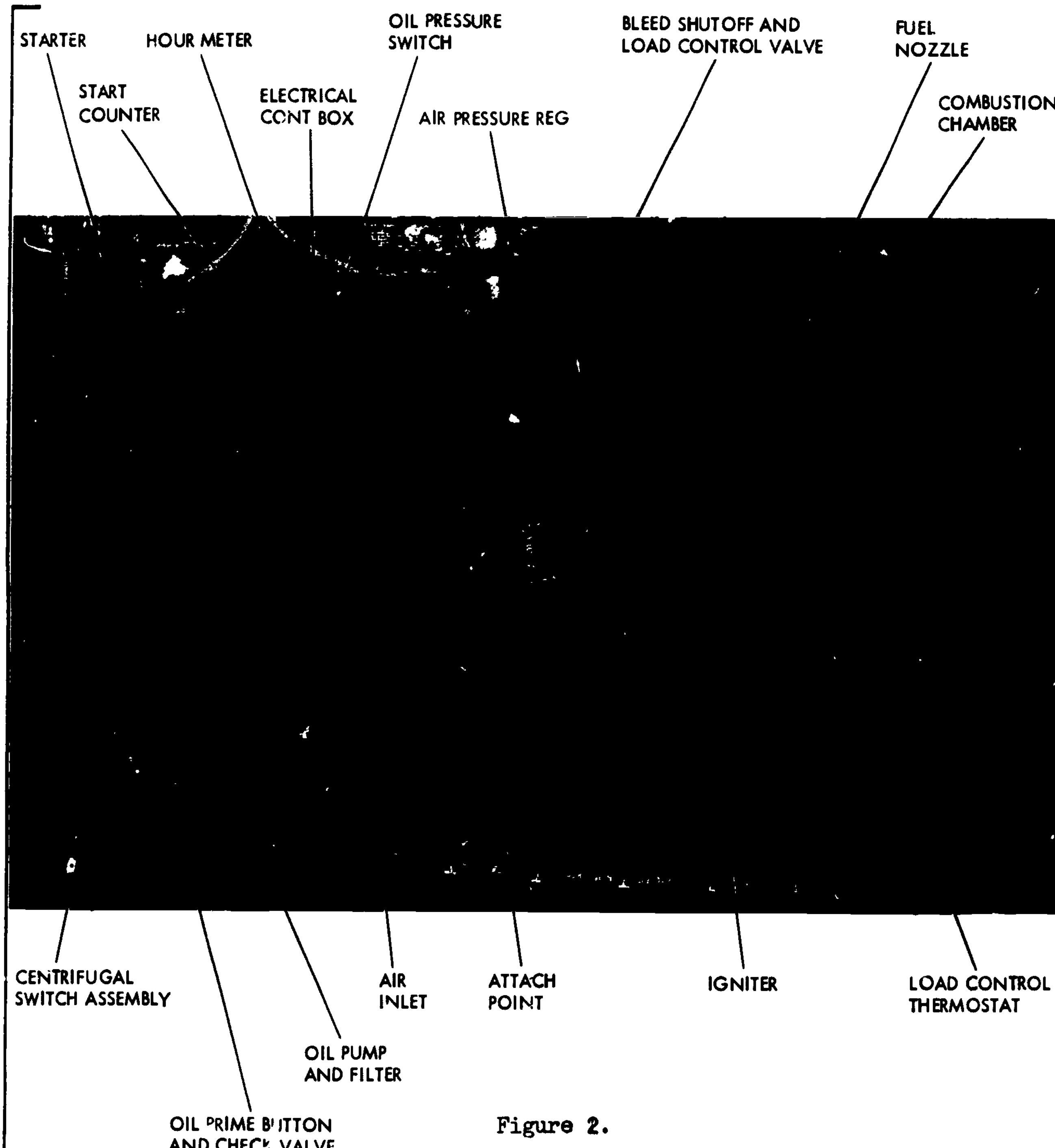


Figure 2.

We stated in frame 2 that air could be supplied to the bleed air manifold by a ground air cart. Figure 3 below shows the MA-1A ground air supply eart.

The only purpose of this unit is to supply bleed air to the bleed air manifold.

This bleed air can be used to start the aircraft engines or it can be used to operate the air conditioning, engine preheat, or anti-icing systems when performing ground operational checks.

The MA-1A ground air cart contains a small jet engine, and the necessary controls for operation and control of the unit.

As an Environmental Systems Mechanic, you may be required to operate this unit. If you are required to operate this unit, you will be trained on the operating procedures after you are assigned to a maintenance organization.

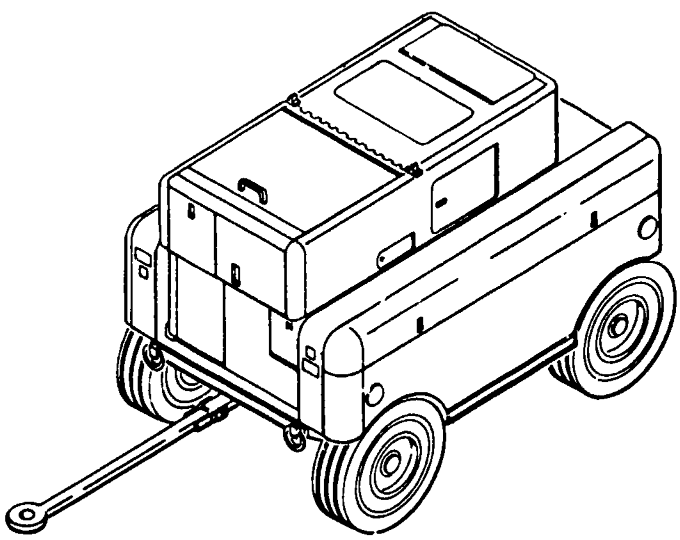


Figure 3.
MA-1A Ground Air Cart

Fill in the blanks to complete the following statement.

1. To perform a ground operational check of a system requiring bleed air you can use a ________________ ____________ ______________ as a source of air.

Frame 6

Figure 4 shows a schematic of the bleed air system. The air from the 14th stage of compression flows through a check valve, then to the engine bleed air shut off valve. This is illustrated for engine number 1, all four engines are the same.

During normal operation all four engine bleed air shutoff valves are open. This allows the bleed air from all four engines to flow into the bleed air manifold.

This means that during in-flight operation, the bleed air for air conditioning or anti-icing systems is normally supplied by all four engines.

The bleed air from the engines can also be used to operate the systems while the aircraft is on the ground. However, it is usually easier to use the GTC or ground air cart when performing ground operational checks.

Also notice the two wing isolation valves shown in the illustration. These valves are used to isolate either the left or right side of the bleed air manifold.

The wing isolation valves are normally open at all times. If a severe leak develops, the wing isolation valves are used to close that portion of the system.

For example, if a leak develops in the ducting between engines number 1 and number 2, the number 1 and number 2 engine bleed air shutoff valves would be closed, and the left wing isolation valve would be closed.

This would remove all airflow from the left manifold, but still permit air from the right engines to be used for air conditioning and pressurization.

Notice that check valves are located at each point where it is necessary to prevent a reverse flow of air. They are located at each engine, at the ground air connection, and at the GTC.

Fill in the blanks to complete the following statements.

1. Air for the bleed air system is supplied by the ____________ or the ____________ ____________ compressor, or a ____________ ____________ cart.

2. The air from the engines is controlled by an engine ____________ ____________ ____________ valve.

3. Check valves are used at each ____________, at the ground air ____________, and at the ____________ ____________ ____________.

4. If a leak should develop in the right wing area, this section of the manifold can be closed off by closing the ____________ ____________ valve.

5. During normal in-flight operations, air for air conditioning and anti-icing is supplied by ____________ ____________ engines.

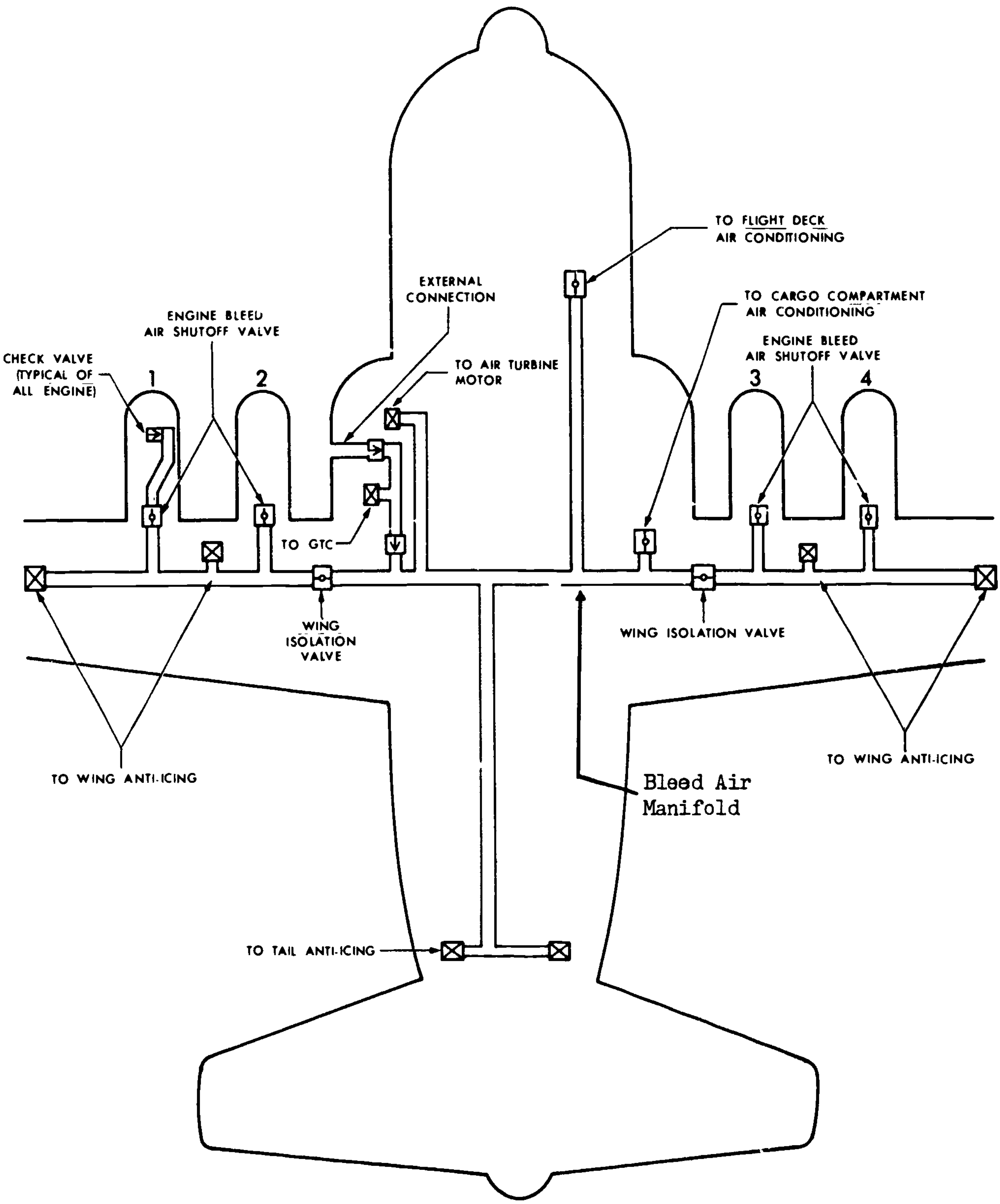

TO FLIGHT DECK AIR CONDITIONING
EXTERNAL CONNECTION
TO CARGO COMPARTMENT AIR CONDITIONING
ENGINE BLEED AIR SHUTOFF VALVE
ENGINE BLEED AIR SHUTOFF VALVE
CHECK VALVE (TYPICAL OF ALL ENGINE)
TO AIR TURBINE MOTOR
1
2
3
4
TO GTC
WING ISOLATION VALVE
WING ISOLATION VALVE
TO WING ANTI-ICING
TO WING ANTI-ICING
Bleed Air Manifold
TO TAIL ANTI-ICING

Figure 4.

Fra.ıe 7

The engine bleed air shutoff valves are 28-volt DC motor actuated, butterfly type valves. Figure 5 shows a typical engine bleed air shutoff valve.

Individual Switches are provided on the aircraft instrument panel for control of each valve. Figure 6 shows the portion of the instrument panel that contains the switches for controlling the engine bleed air shutoff valves and also the controls for the GTC.

During flight all four engine bleed air shutoff valves are normally open. However, the pilot can close anyone of the valves if necessary by placing the switch to the CLOSE position. Notice how the bleed air manifold is illustrated on the instrument panel.

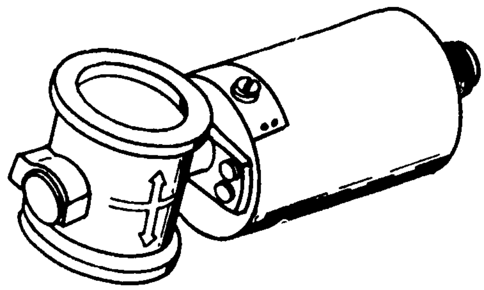
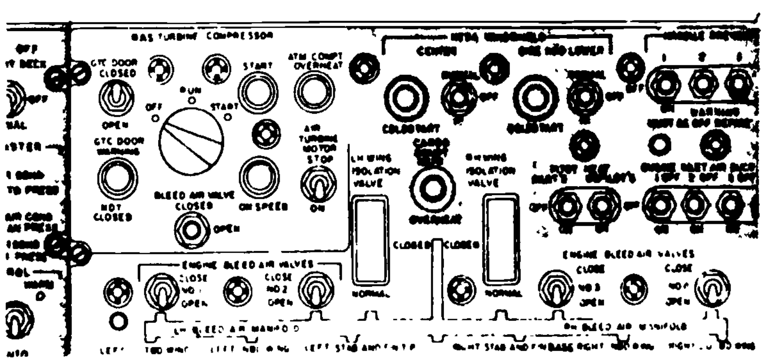


Figure 5.



GAS TURBINE COMPRESSOR CONTROL PANEL

C

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LOOKING UP

Figure 6.

Fill in the blanks to complete the following statements.

1. The engine bleed air shutoff valves are actuated by a ________ ________ ________.

2. Each engine bleed air shutoff valve is controlled by a separate ____________.

The wing isolation valves are solenoid controlled, spring actuated valves. The valve is held open by a solenoid and closed by a spring. Energizing the solenoid releases the valve poppet, allowing the valve to be closed by the spring.

The valve can only be open or reopened by deenergizing the solenoid and mechanical linkage. This is done by pulling the wing isolation valve control lever down, which pulls a latch inside the solenoid which cocks the valve open. (This could be thought of like cocking a gun before you fire it.)

When the wing isolation valve lever is pulled down it pulls a latch inside the solenoid which holds the valve open and when the solenoid is energized it releases the latch and allows the valve to be closed by the spring.

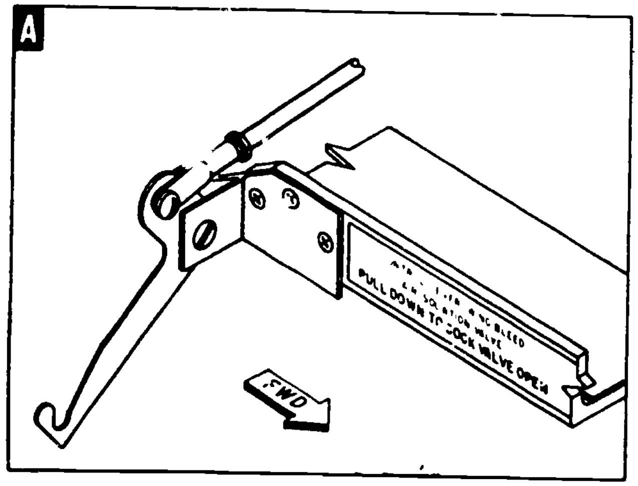


Figure 7.

Separate switches are provided on the instrument panel for closing the wing isolation valves. These switches are shown in figure 8. The switches are marked LH WING ISOLATION VALVE and RH WING ISOLATION VALVE.

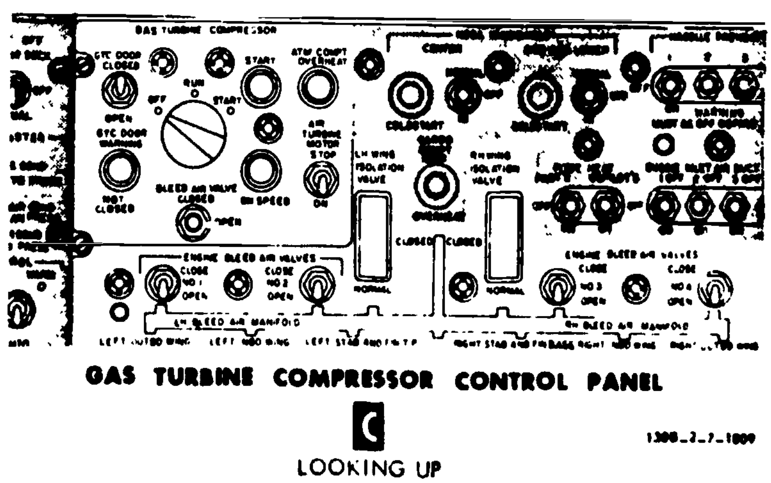


Figure 8.

Questions for Frame 8.

Fill in the blanks to complete the following statements.

1. The wing isolation valves are closed by the ________________ ________________ ________________ switches.

2. The purpose of the wing isolation valve lever is to ____________ the wing isolation valve.

3. Placing the wing isolation valve switch to closed, will energize the ____________________.

For problems 1, 2, and 3 select the statements from column B that correctly completes the statement given in column A. Place the letter of the matching statement in the blank space provided. NOTE: There are more blanks than correct matching statements.

COLUMN A	COLUMN B
1. Bleed air is used on the cargo aircraft for ______ ______ ______ ______ ______.	A. Air Conditioning. B. Starting the Engines. C. Cooling the electronic equipment compartment. D. Leading edge anti-icing. E. Rain Removal. F. Driving an ATM. G. Engine air intake anti-icing.
2. The sources of bleed air on the cargo aircraft are ______ ______ ______.	A. All 4 engines B. Engines 2 and 3 only. C. Gas turbine compressor. D. Ground air conditioner. E. Ground air cart.
3. The bleed air system consists of ______ ______ ______ ______.	A. 28V DC motor operated engine bleed air valves. B. Solenoid controlled, air actuated bleed air valves. C. Aluminum Ducting. D. Stainless Steel Ducting. E. Wing isolation valves. F. Body crossover valves. G. Check valves.

Read each of the following statements, then mark them as either True (T) or False (F).

4. _____ The wing isolation valves are held open by a solenoid.

5. _____ The wing isolation valves are closed by spring tension.

6. _____ After the wing isolation valve is closed, it can only be reopened mechanically.

7. _____ During flight, engine bleed air is normally taken only from engines 1 & 2.

8. _____ The bleed air from the GTC can be used to start the aircraft engines.

Frame 10

The electrical circuits for controlling the bleed air system are shown in Foldout 1 (the last page of this text). Open this foldout.

Locate the four engine bleed air shutoff valves and the LH and RH isolation valves. The engine bleed air shutoff valves are each controlled by an engine bleed air control switch.

Locate these switches on the diagram. Placing the switch to OPEN position directs power to open the bleed air shutoff valve.

The diagram shows each of these switches in the OPEN position. Placing the switch to the CLOSED position directs power to close the valve.

Also notice that when the switch is placed to the OPEN position, current has to go through a second switch, which is actuated by the fire control handle.

In case of an engine fire, the pilot will pull the fire control handle; this will cause several things to happen, such as closing off the fuel supply and the bleed air shutoff valve to close.

Trace the circuit for control of Engine No. 1 bleed air shutoff valve. Starting at the Engine No.1 circuit breaker, follow the path of current flow to Engine No. 1 bleed air valve control switch.

With the switch in the OPEN position, current will flow through the switch to B2 of the fire control switch. Current will go through this switch to Pin A of the No. 1 engine bleed air shutoff valve.

This will cause the valve motor to run to the open position. Now follow the path of current flow for normal closing of the valve. With the control switch in the CLOSED position, current will flow through the switch to B1 of the No. 1 engine bleed air shutoff valve.

With the NO. 1 engine bleed air valve switch in the OPEN position, if the fire control handle is pulled, it will direct power to close the valve.

When the fire control handle is pulled, it moves the switch contact, connecting B2 to B1. This directs current to the closed side of the engine bleed air shutoff valve.

Notice that all four of the engine bleed air shutoff valve circuits are identical. Since we have followed the current for engine No. 1, you should be able to analyze the electrical control for the other three.

As stated earlier, the wing isolation valves are controlled by separate switches. With the switches in NORMAL there is no current flow and the valves remain open.

Placing either switch to CLOSED permits current flow from the circuit breaker to the valve solenoid. This energizes the solenoid which releases the valve allowing the spring tension to close the valve.

Fill in the blanks to complete the following statements.

1. The engine bleed air shutoff valves are actuated by ____________ volt DC ____________________.

2. Each engine bleed air shutoff valve is controlled by a separate engine bleed air valve ____________________.

3. With the No. 3 engine bleed air valve switch in the OPEN position, pulling the fire control handle will cause the engine bleed air shutoff valve to __________________.

4. The LH wing isolation valve solenoid is energized when the LH wing isolation valve switch is in the ______________ ___(normal/closed) position.

Frame 11

A bleed manifold pressure gage is located in the cockpit. Figure 9 shows the gage and illustrates how it is connected to the bleed air manifold.

This gage indicates the bleed ai. pressure in the bleed air manifold. It serves to keep the pilot informed of the pressure in the manifold, and can also be used by maintenance personnel (you) when checking to determine if the system has excessive leakage.

When using the MA-1A ground air cart or the GTC, the gage will normally indicate approximately 40 psi. When the engines are supplying air to the manifold the gage will indicate approximately 70 psi. However this will depend on the engine throttle settings.

Fill in the blanks to complete the following statements.

1. The pressure in the bleed air manifold is indicated by a ____________ ____________________.

2. The bleed air system can be checked for excessive leakage by using the bleed manifold ____________________ ____________________.

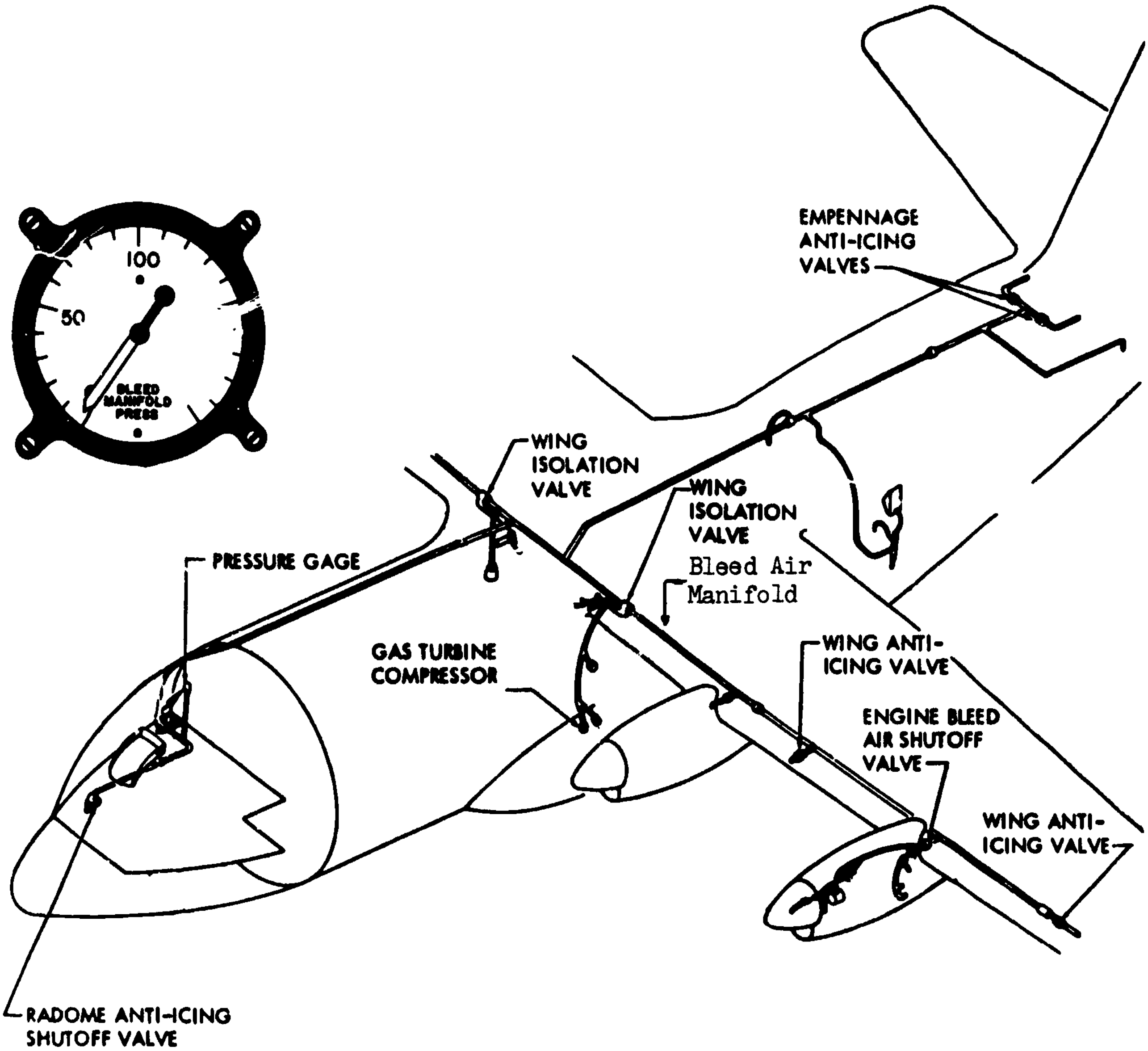

100
50
BLEED
MANIFOLD
PRESS
EMPENNAGE
ANTI-ICING
VALVES
WING
ISOLATION
VALVE
WING
ISOLATION
VALVE
Bleed Air
Manifold
PRESSURE GAGE
GAS TURBINE
COMPRESSOR
WING ANTI-
ICING VALVE
ENGINE BLEED
AIR SHUTOFF
VALVE
WING ANTI-
ICING VALVE
RADOME ANTI-ICING
SHUTOFF VALVE

Figure 9.

Frame 12

Maintenance on bleed air systems is similar for all aircraft. However, you should always refer to the applicable aircraft technical order to obtain specific instructions. General inspection and maintenance consists of:

1. Checking bleed air ducting for corrosion, cracks and dents.
2. Checking duct couplings (clamps) for security.
3. Checking duct insulation for tears or saturation from oil or hydraulic fluid.
4. Removing and replacing sections of ducting, clamps, gaskets, and components, such as bleed air valves.
5. Checking system for leakage.

Checking the system for leakage is accomplished in various ways. The system can be checked to determine if excessive leakage exists by observing the pressure gage and timing the pressure drop when the system is turned off.

This method of testing will locate extreme leakage through ruptured ducts, missing or leaking V-band couplings and gaskets.

The pressure decay method of leak testing is accomplished by assuring all systems are turned off, then pressurizing the bleed air system using the GTC or by running the engine. An example of this procedure would be as follows:

1. With the GTC running, allow the bleed air manifold pressure to buildup to 35 psi. Then close off the air from the GTC, thus trapping the air in the bleed air manifold.

2. Using a stop watch, time the pressure drop as it drops from 30 psi to 15 psi. If the time for the pressure to drop from 30 psi to 15 psi is <u>less</u> than 8.5 seconds, the leakage at some point in the manifold is excessive.

If the time is <u>greater</u> than 8.5 seconds, the leakage is not excessive. The pressure will drop as there is an allowable leakage around some valves and through the urinal drain anti-icing tubes.

Locating leaks is done by the hand survey method. This is accomplished by pressurizing the manifold with the GTC, then cautiously feeling around each duct connection or area where leakage is suspected. Remember, this air and the ducts can still be very hot.

Questions for Frame 12.

Fill in the blanks to complete the following statements.

1. To determine specific procedures for maintaining a bleed air system, you should refer to the applicable ______________ ______________.

2. To determine if the leakage from a bleed air manifold is within the allowable specifications, you should leak test the system using the ______________ ______________ method.

3. In the example given for leak checking a bleed air system, if the pressure drops from 30 psi to 15 psi in 6 seconds, this would indicate ______________ (a normal system/excessive leakage).

4. If excessive leakage is indicated when performing a leak test by the pressure decay method, the trouble could be caused by an engine bleed air shutoff valve failing to ______________.

Frame 13

Place a T or F in the blank to indicate whether the statement is True or False.

_____1. Engine bleed air is used on the cargo aircraft for starting engines, air conditioning and pressurizing the cabin, anti-icing the wings, empennage and engine intakes, and for driving an air turbine motor.

_____2. When performing a ground operational check, bleed air can be supplied by either the engines, GTC, or ground air supply cart.

_____3. During flight, engine bleed air is normally supplied by engines NO. 1 and NO. 2 only.

_____4. Closing of the wing isolation valves is accomplished by energizing a solenoid.

_____5. During flight, the wing isolation valves are normally closed.

_____6. The engine bleed air shutoff valves are actuated by a 28 volt DC motor.

_____7. The bleed manifold pressure gage is used when performing a leak test of the bleed air system by the pressure decay method.

_____8. When the bleed air system is checked for excessive leakage by the pressure decay method, the pressure drops from 30 psi to 15 psi in 20 sec.; this indicates excessive leakage.

_____9. When a fire control handle is pulled it will cause the engine bleed air shutoff valve to close for that particular engine.

Select the correct answer or answers to the following question.

10. The No. 2 engine bleed air shutoff valve fails to close. This could be caused by

a. a defective shutoff valve motor.
b. the fire control handle being pulled out.
c. the isolation valve switch being in normal.
d. an open in the electrical circuit between B1 of the fire control handle and B of the valve motor.

CORRECT RESPONSES TO ALL THE FRAMES.

Frame 1

1. bleed air
2. bleed air
3. engine bleed air
4. intake scoop and guide

Frame 2

1. engines, gas turbine, ground air
2. ground air, compressor
3. bleed, ground

Frame 3

1. stainless steel, shutoff valves, isolation
2. 4
3. 4

Frame 4

1. air cart
   gas turbine
   engines

Frame 5

1. ground air cart

Frame 6

1. engines, gas turbine, ground air
2. bleed air, shutoff
3. engine, connection, gas turbine compressor
4. wing isolation
5. all four

Frame 7

1. 28V DC motor
2. switch

Frame 8

1. wing isolation valve
2. open
3. solenoid

Frame 9

1. A B D F G
2. A C E
3. A D E G

Frame 9 (Continued)

4. T
5. T
6. T
7. F
8. T

Frame 10

1. 28 motors
2. switch
3. close
4. closed

Frame 11

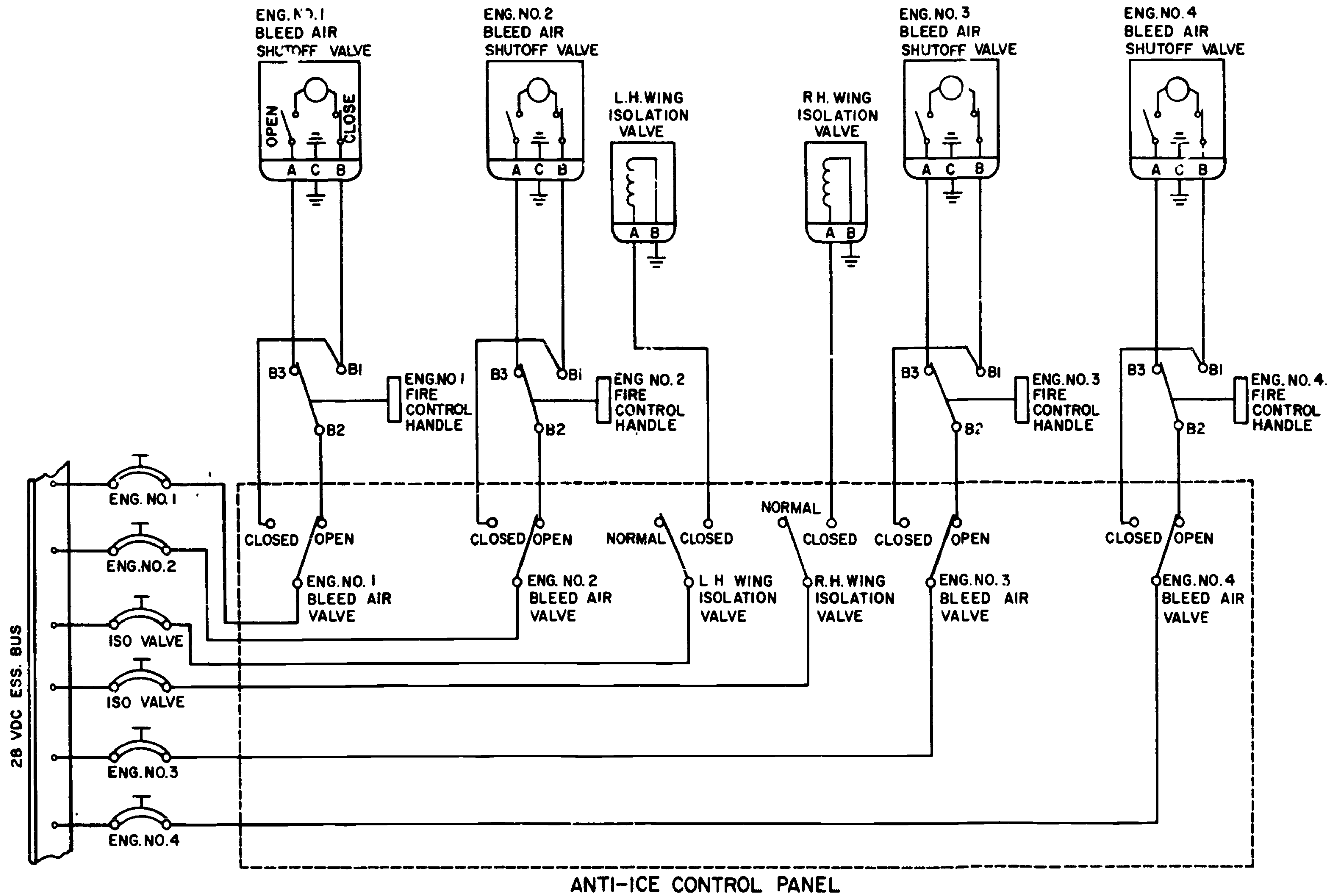
1. pressure gage
2. pressure gage

Frame 12

1. technical order
2. pressure decay
3. excessive leakage
4. close

Frame 13

1. T
2. T
3. F
4. T
5. F
6. T
7. T
8. F
9. T
10. a and d



Foldout 1.

240

PROGRAMMED TEXT
C3ABR42331-PT-208A

Technical Training

Aircraft Environmental Systems Mechanic

WING AND EMPENNAGE ANTI-ICING SYSTEMS

28 March 1983

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

Designed for ATC Course Use.

Do Not Use on the Job. RGL: 8.8

OBJECTIVES

Relate a minimum of 8 out of 10 cargo bleed air anti-icing components to their operation.

Using a wiring diagram, specify the causes for a minimum of four out of five anti-icing system control circuit troubles.

In order for you to accomplish this objective, the following areas will be covered by this programmed text:

1. The purpose of the wing and empennage anti-icing systems.

2. The function of the wing and empennage anti-icing system components.

3. The operation of the wing and empennage anti-icing control circuits and overheat warning circuits.

INSTRUCTIONS

This text presents material in small steps called "frames." After each frame you are asked to respond by completing statements, matching statements, or by selecting the true statements. Read the material carefully before making the response. The correct answers to the responses are given on the top of the next page of the text. If you select the correct answers, continue to the next frame. If you are incorrect, read the material again and correct your answers before continuing.

You will also be given a practice exercise in which you will be required to study the wiring diagram and determine the cause for system malfunctions.

This text is divided into two sections. You must meet the criterion of the first section prior to completing the second section.

Proceed to frame 1.

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3370 TCHTG/TTGU-P - 500; DAV - 1

Frame 1

In the past lesson you studied the cargo aircraft bleed air system. You should recall from that lesson that on the cargo aircraft, bleed air is used for several purposes, and that one of these purposes was to anti-ice the leading edge surfaces of the aircraft.

You should also recall that on the cargo aircraft, the bleed air can be supplied to the bleed air manifold by the engines, a GTC, or by a ground air supply cart.

In this lesson you will study the anti-icing system which stops ice from building up on the leading edge of the wings and empennage surfaces.

You will learn that hot engine bleed air is used to stop ice from forming on these surfaces and how this bleed air is controlled.

You should keep in mind that even though there are three sources of bleed air, the only source that can be used to operate the anti-icing system while the aircraft is in flight is the air from the engines.

As was said in the past text, this air is supplied from all four engines. For ground operation, the GTC or ground air supply cart can be used.

Fill in the blanks to complete the following statements.

1. One purpose of the engine bleed air is for ____________________ the wing and empennage leading edges.

2. During flight, bleed air supplied to the bleed air manifold on the cargo aircraft by the ______________________________.

Answers to Frame 1: 1. anti-icing 2. e‵gines.

Frame 2

Anti-icing systems are required to prevent ice from forming which could force the aircraft to land or crash.

Some aircraft use anti-icing systems for the wings and empennage (tail section), and for anti-icing areas such as the radome. Others may use the anti-icing systems for the engine inlet air ducts only, while others may not have any anti-icing systems.

The cargc aircraft that you will be studying has several anti-icing systems plus an ice detection system.

Figure 1 shows the main areas that are anti-iced on this aircraft. These areas include: (1) the leading edge of the wings, (2) the leading edge of the horizontal stabilizer, (3) the leading edge of the vertical stabilizer, (4) the engine inlet air duct and (5) the radome.

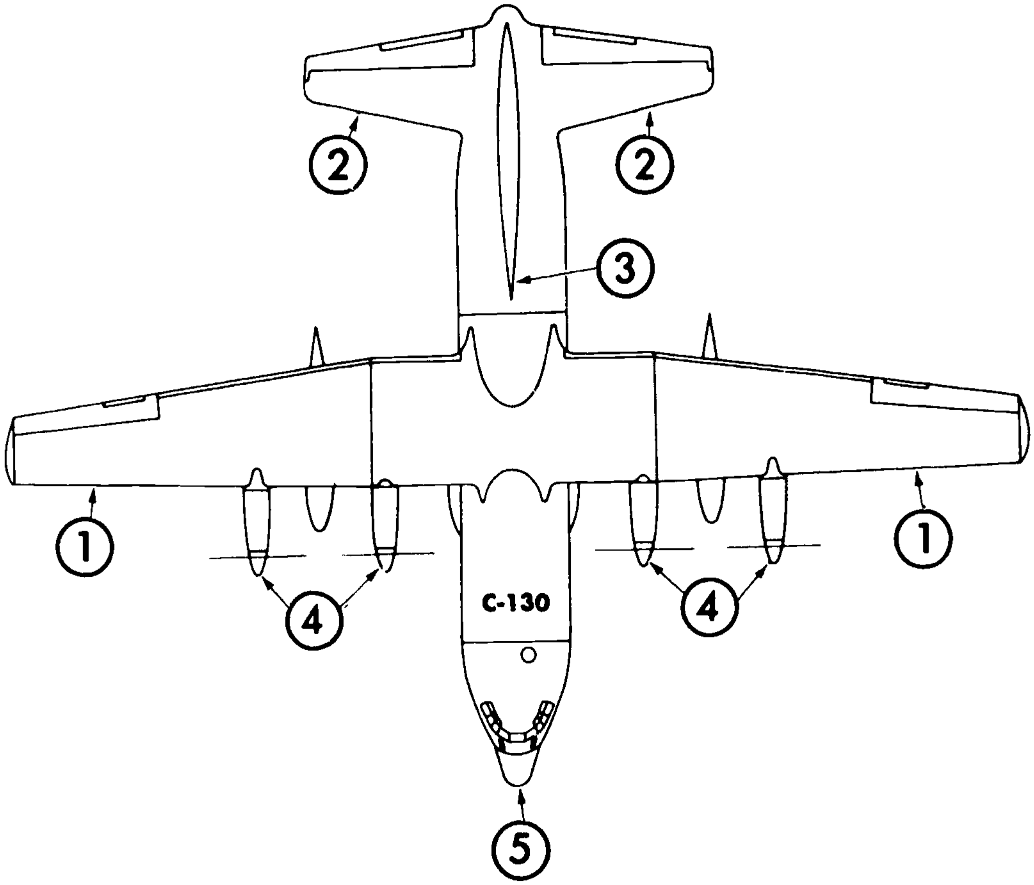


Figure 1.

Fill in the blanks to complete the following statements.

1. The purpose of an anti-icing system is to ________________ ice from accumulating.

2. The areas that are anti-iced on the cargo aircraft include the ____________ ____________ of the wings, the engine _________ ________ ___________, the leading edge of the ____________ ______________ __________ _______________ ___________________________.

Answers to Frame 2: 1. prevent 2. leading edge, inlet air duct, vertical stabilizer and horizontal stabilizer.

Frame 3

In this lesson you will study only the wing and empennage anti-icing system. The engine air intake duct anti-icing system will be talked about in your next lesson.

The wing and empennage anti-icing system is made up of the ducting and valves necessary to direct the hot engine bleed air to the leading edge surfaces.

Figure 2 shows the ducting for the right wing. The left wing is the same as the right wing so it will not be taken up.

The wing leading edge anti-icing system is split up into the left and right wing systems. Then, in each wing the anti-icing system is further split up into an <u>inboard section</u> and an <u>outboard section</u>.

In the sketch shown, (A) is the inboard section, and (B) is the outboard section. The airflow from the bleed air manifold to each section is controlled by an anti-icing shutoff valve. The inboard section is controlled by the anti-ice shutoff valve marked (C) and the outboard section is controlled by the valve marked (D).

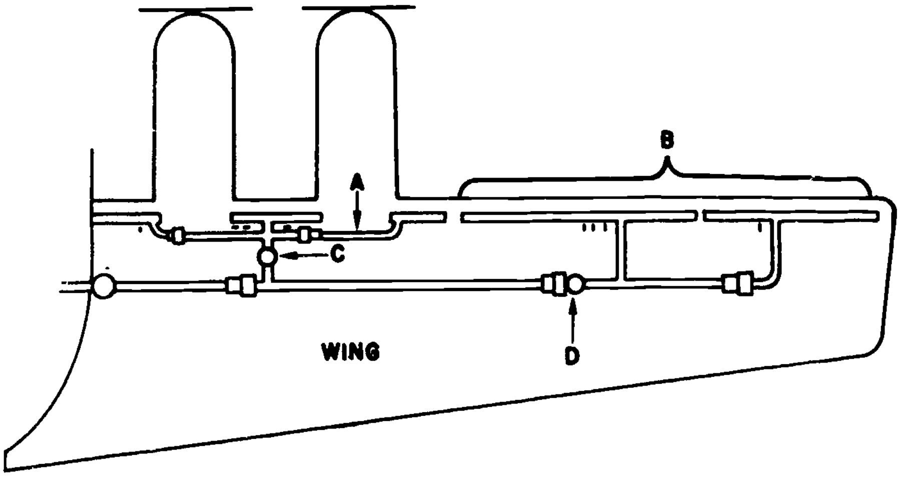


Figure 2.

Remember, this only shows the right wing. The left wing is identical. This means there are four valves that control bleed airflow for anti-icing the wing leading edge.

Fill in the blanks to complete the following statements.

1. The wing leading edge anti-icing system is divided into an _______________ and an ________________ section in each wing.
2. The bleed airflow for wing anti-icing is controlled by __________ shutoff valves.
3. The wing leading edge anti-icing is controlled by _______ (2/4) valves.

Answers to Frame 3: 1. inboard-outboard 2. anti-icing 3. four

Frame 4

The empennage anti-icing system is also split up into two sections. Figure 3 shows this system.

Section (A) provides air for anti-icing the left horizontal stabilizer and the upper portion of the vertical stabilizer.

Section (B) provides air for anti-icing the right horizontal stabilizer and the lower portion of the vertical stabilizer.

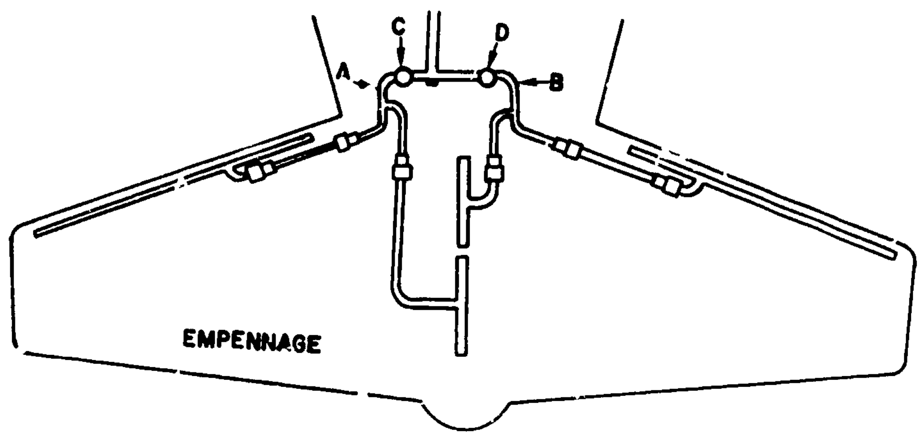


Figure 3.

Each section is controlled by a separate anti-icing system shutoff valve. The anti-ice valve marked (C) controls bleed air for anti-icing the left horizontal stabilizer and the upper portion of the vertical stabilizer.

The anti-ice shutoff valve marked (D) controls the bleed air for anti-icing the right horizontal stabilizer and the lower section of the vertical stabilizer.

This means there are a total of six anti-icing shutoff valves in the anti-icing system; two in the empennage and four in the wings.

Fill in the blanks to complete the following statements.

1. The empennage anti-icing system is divided into ________ sections.

2. The leading edge anti-icing system contains a total of ________ valves.

3. Anti-icing of the upper portion of the vertical stabilizer and the left horizontal stabilizer is controlled by ________ (the same/different) valve(s).

Answers to Frame 4: 1. two 2. six 3. the same

Frame 5

The bleed air used for the leading edge anti-icing system is controlled by air actuated, solenoid controlled valves.

In the past frames, these valves were referred to as anti-icing system shutoff valves. For the remainder of the text these valves will simply be called anti-icing valves. All six valves are the same. The anti-icing valve is shown in figure 4.

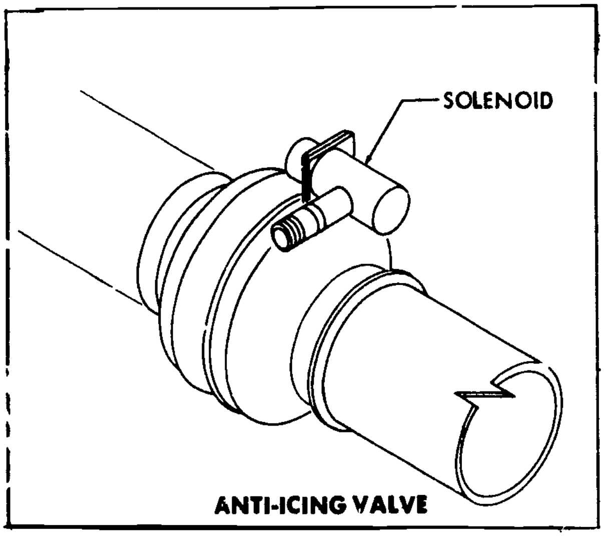


Figure 4.

Fill in the blanks to complete the following statements.

1. Anti-icing valves are actuated (opened/closed) by ______________ ______________.

2. The anti-icing valves are controlled by a ______________.

Answers to Frame 5: 1. air pressure. 2. solenoid

Frame 6

Figure 5 shows an internal view of the anti-icing valve. The operation of this valve is somewhat different from those you have studied in the past.

This valve is made up of a solenoid, actuator, piston, return spring, orifice, and orifice seal. The opening that the air flows through is called an orifice, and the plate that opens and closes is called the orifice seal.

Find each of these parts on the sketch shown.

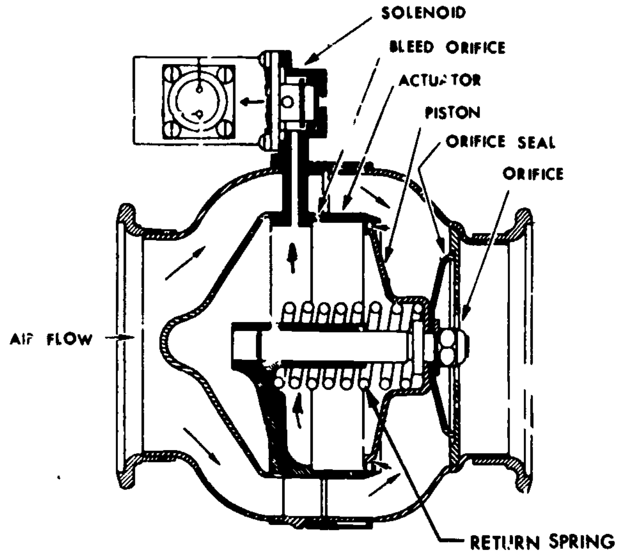


Figure 5.

The sketch shows the valve in the closed position. Let's see how the valve is held closed.

Engine bleed air from the bleed air manifold flows in and surrounds the actuator (shown by the arrows).

Now note the bleed orifice in the side of the actuator. The air that flows around the actuator will also flow into this orifice. This will equalize the pressure inside the actuator with the pressure surrounding the actuator and equalizes the pressure on each side of the piston.

Notice that the piston and orifice seal are connected. Since the pressure is the same on each side of the piston, it will not move, and the return spring will hold the orifice seal closed.

Fill in the blanks to complete the following statements.

1. The opening in the anti-icing valve that air flows through is called an ________________________.

2. When the pressure inside of the actuator is equal to the pressure surrounding the actuator, the valve will be ________________.

Answers to Frame 6: 1. orifice 2. closed.

Frame 7

We said earlier that the anti-icing valve is controlled by a solenoid. Let's see how this is done.

To open the valve, the solenoid must be energized. Remember, the valve was held closed by allowing the air pressure to bleed in through the bleed orifice. This keeps the air pressure the same on each side of the piston.

When the solenoid is energized, it opens a vent port. Note the vent port in the sketch shown.

With the vent port open, the air bleeds in through the bleed orifice and continues to flow out through the vent port. This will stop the pressure from building up inside the actuator and will result in a difference in pressure on the piston.

The pressure will be greater on side B than on side A (see figure 6). This pressure will overcome the spring tension and cause the actuator to move, which also moves the orifice seal. This will open the valve.

Figure 6 shows the valve in the open position.

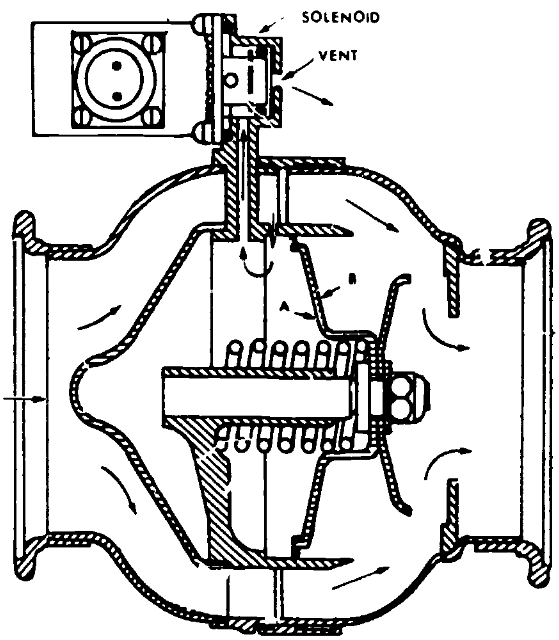


Figure 6.

Fill in the blanks to complete the following statements.

1. When the solenoid is energized, it opens a ____________ port.
2. The anti-icing valve is opened by a difference in __________.
3. When the solenoid is energized, the pressure will be ________ surrounding the actuator than inside the actuator.

Answers to Frame 7: 1. vent 2. pressure 3. greater

Frame 8

Now that you know the anti-icing valves are controlled by energizing and deenergizing a solenoid, let's see how the solenoid is controlled.

There are two switches on the instrument panel that control the leading edge anti-icing.

One switch controls the wing anti-icing and one controls the empennage anti-icing.

The switch for the wings, controls all four wing anti-icing valves, and the switch for the empennage controls both empennage anti-icing valves.

The sketch shows the circuit for controlling one valve. This same circuit controls the other valves also.

Detail A shows the switches that control the valves. When either of these switches is placed to the on position, it energizes the solenoids on the valves for that system.

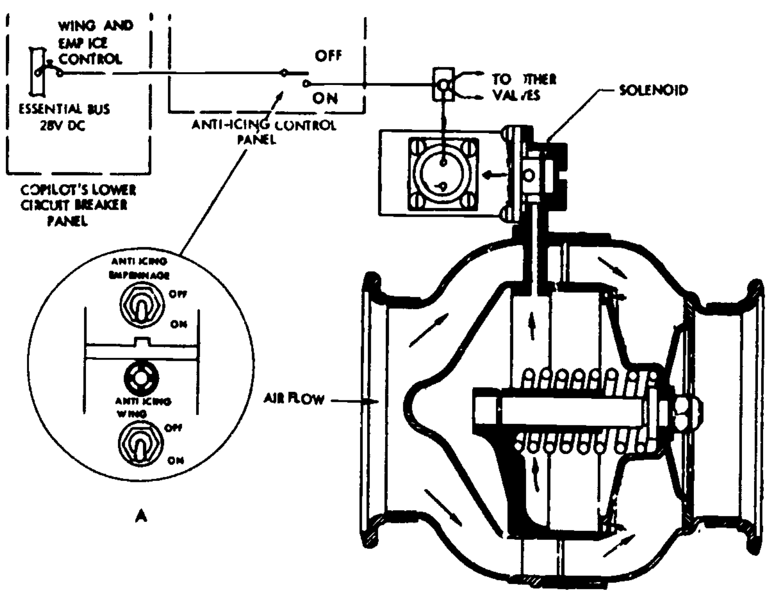


Figure 7.

Fill in the blanks to complete the following statements.

1. The horizontal and vertical stabilizer anti-icing system is controlled by the ___ _________ _______________ switch.
2. The wing anti-icing switch controls _____ (1, 2, 3, or 4) valves.
3. The voltage required for energizing the anti-icing valve solenoids is _____________.
4. The empennage anti-icing switch controls ____ (1, 2, 3, or 4) valves.
5. To open the anti-icing valves, the solenoid must be _____________.

Answers to Frame 8: 1. anti-icing empennage 2. 4 3. 28V DC
4. 2 5. energized.

With the anti-icing valves open, the hot bleed air flows into the leading edge anti-icing ducts. Remember, the bleed air is extremely hot. If the bleed air was circulated through the wing itself, it could damage the wing surface.

To reduce this temperature, the bleed air is mixed with the surrounding "ambient" air.

The bleed air is directed into an anti-icing duct that contains several small ejector nozzles. The ejector nozzles direct the bleed air into a formed venturi as shown in figure 8, detail A. This causes a low pressure area between the ejectors and the formed venturi which pulls in ambient air.

The ambient air mixes with the bleed air. The ambient air is much cooler than the bleed air and reduces the temperature of the air circulating against the leading edge surface. This mixture of bleed air and ambient air then passes through small passages in the leading edge surface. This is shown in detail B of the sketch.

After the air flows through the passages it is pulled back into the venturi by the ejectors. This mixes with more bleed air and the air recirculates through the passages.

This recirculating process continues as long as the anti-icing system is on. As the air reaches the outboard tip of the leading edge surface, some of it is vented overboard through a vent; the rest of the air continues to recirculate through the passages.

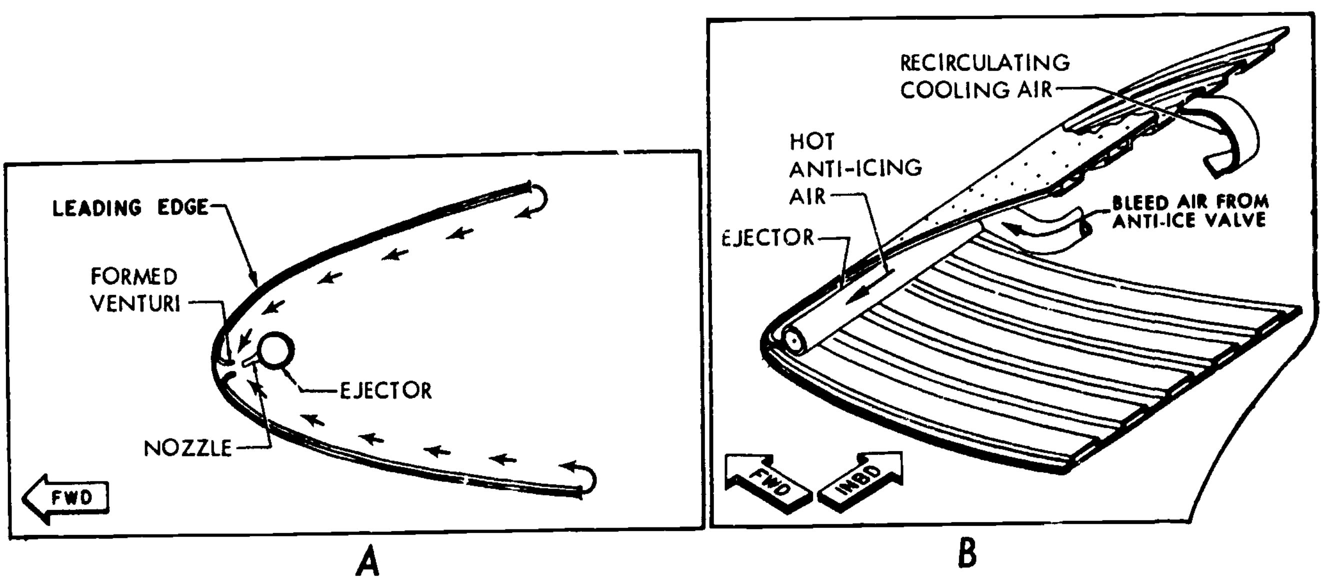


Figure 8.

Frame 9 (Cont'd)

Fill in the blanks to complete the following statements.

1. The temperature of the air circulating against the skin of the leading edge is cooled by mixing ____________ air and ___ _____ air.

2. Ambient air is mixed with bleed air by action of the ____________ ____________________ and formed _______________ ______.

3. After recirculating through the passages, the anti-icing air is __________________ overboard.

Answers to Frame 9: 1. bleed, ambient 2. ejector nozzles, venturi 3. vented

---

Frame 10

With the recirculating of air through the leading edge anti-icing ducts, the temperature in the leading edge space could still go past a safe operating range.

When the system is on, an anti-ice control thermostat is used to cycle the anti-icing valve on or off.

But, before we go through the operation of the anti-ice control thermostat, we need to bring out two concepts that may be new to you. One is how a mercury thermostat operates and the second is the use of an electrical circuit called a "holding circuit."

Mercury thermostats are used in both the anti-icing systems and the cabin temperature control system. Holding circuits are used in the anti-icing control thermostat, in conjunction with the mercury thermostat, and in the ice detection system that you will learn later.

Mercury thermostats are used to control a relay which in turn will control a valve. You are probably familiar with the common mercury thermometer. A mercury thermostat is similar to the mercury thermometer.

The mercury is housed in a glass tube. When the temperature near the glass tube goes up, the mercury will expand. This will cause it to rise in the tube. When the temperature goes down, it will shrink, which will make it fall in the tube.

Since we know that mercury is temperature sensitive, it should be easy to see that it can be used in a temperature control device.

To show how a mercury thermostat can be used as a temperature sensitive control device, we'll start with a very simple control circuit.

Figure 9 shows a mercury thermostat that controls a light bulb. In this simple circuit, when the temperature is below some set value, the light will be off. Then as the temperature goes past the set value, the light will come on, because current will flow from ground, through the mercury in the thermostat, through the lamp and to the power source. This completes the circuit and turns on the light.

The mercury thermostat acts as a switch for the light. The shaded area shows the mercury after the temperature goes up. Note that the mercury completes a circuit to turn on the light.

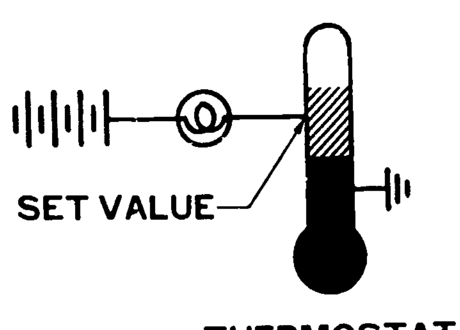


Figure 9.

Frame 10 (Cont'd)

Fill in the blanks to complete the following statements.

1. An increase in temperature will cause the mercury to ___________ (expand/contract).

2. The mercury thermostat can be used as a temperature sensitive ___________________.

3. In the basic circuit illustrated in figure 9, an increase in temperature will turn the light ____________ (on/off).

Answers to Frame 10: 1. expand 2. switch 3. on

Frame 11

Now let's put the mercury thermostat to work controlling a solenoid valve.

Figure 10 shows a circuit that uses a mercury thermostat to control a relay which in turn controls the solenoid. In this circuit, the solenoid will be deenergized when the temperature goes past some set value (let's say 180°F).

As the air temperature on all sides of the thermostat gets to 180°F, the mercury will rise to the 180°F contact point (shown by the shaded space) which completes the ground circuit for the relay.

Let's see how this circuit works. When the switch is closed (moved to the on position), a path for 28V DC is completed through point A and point B on the solenoid coil, through the relay contacts, to ground. This will energize the solenoid.

When the temperature builds up to 180°F, the mercury will rise and complete a path through the mercury to ground for the relay coil. This will energize the relay, and pull the contacts down. Note that this will open the ground circuit for the solenoid.

As the temperature drops below 180°F, the mercury will drop in the tube and open the circuit to the relay. This will deenergize the relay, and complete the circuit to the solenoid ground. Now the solenoid will again be energized. Note that the thermostat controls the anti-ice valve by making and breaking ground for the solenoid.

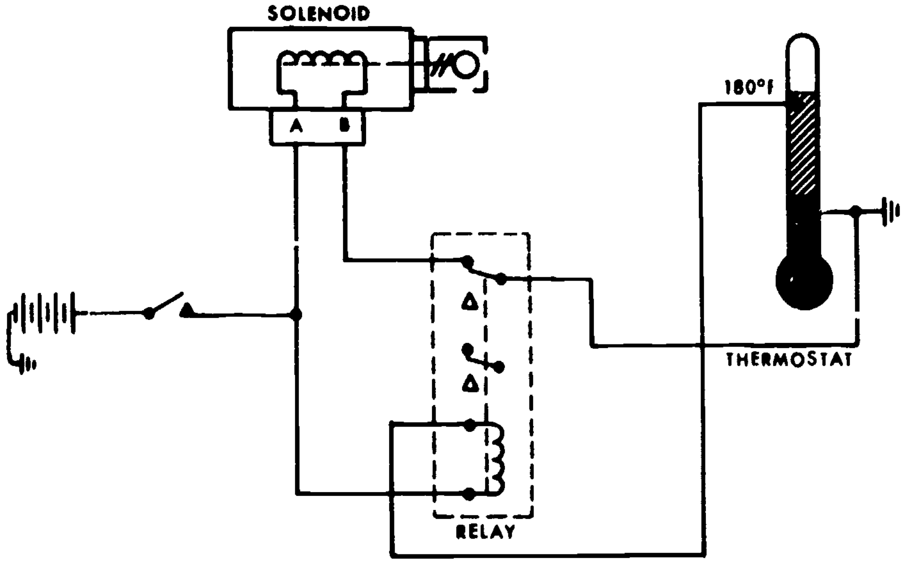


Figure 10.

Remember, the temperature of the air determines the height of the mercury. The height of the mercury determines which circuit is operating.

Frame 11 (Cont'd)

Fill in the blanks to complete the following statements.

1. When the mercury in the thermostat reaches the 180°F point, the relay will be ____________ ________ (energized/deenergized).

2. When the relay is energized, the solenoid will be __________________ (energized/deenergized).

3. The thermostat assembly (relay and thermostat) controls the ________________ circuit of the solenoid.

Answers to Frame 11: 1. energized 2. deenergized 3. ground

We've seen how a mercury thermostat can be used to deenergize a solenoid at 180°F. Now let us assume we want the solenoid to stay deenergized until the temperature drops several degrees below the 180°F setting (let's say to 158°F). This is where the "holding circuit" will be used.

Figure 11 shows the same mercury thermostat control circuit as before but now a holding circuit has been added and is shown by the dark, bold lines.

Frame 10 showed how a mercury thermostat could be used to control a valve (solenoid) at 180°F. In that circuit the relay was energized as the temperature reached 180°F, and deenergized as the temperature dropped below 180°F.

Now let's see how the thermostat control circuit can energize the relay when the temperature reaches 180°F and then keep it energized until the temperature drops below 158°F.

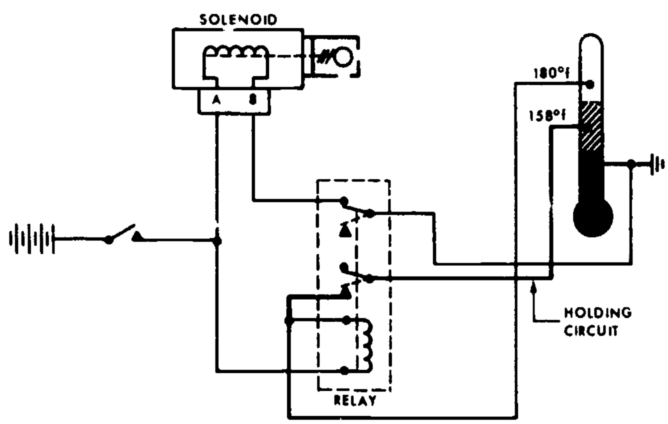


Figure 11.

Figure 11 shows the mercury on the rise due to a temperature increase. The mercury will first come in contact with the 158°F point. But, note that since the relay is still deenergized it will have no effect on our control circuit.

As the temperature goes up the mercury will rise in the tube to the 180°F point. This will complete the ground circuit to the relay coil and will energize the relay. With the relay energized, note that the relay coil now has a second path to ground through the lower relay contact and through the 158°F point on the thermostat.

Now as the temperature drops, the mercury also drops. But now the circuit through the 158°F point will keep the relay energized until the temperature drops below 158°F.

Frame 12 (Cont'd)

The circuit through the 158°F point serves to <u>hold</u> the relay energized while the temperature drops from 180°F to 158°F. This is why it is called a holding circuit.

What effect does the holding circuit have on the solenoid? When the relay is energized, the solenoid will be deenergized. From this we can see that the solenoid will be deenergized when the temperature rises to 180°F and will stay deenergized until the temperature drops below 158°F.

Fill in the blanks to complete the following statements.

1. After the temperature reaches 180°F, the solenoid will remain ____________ (energized/deenergized) until the temperature drops below 158°F due to the ____________ ____________.

2. The mercury thermostat provides the ground circuit for the ________________.

Answers to Frame 12: 1. deenergized, holding circuit 2. relay

Frame 13

The sketch below shows the anti-icing valve with the thermostat control circuit. From the information given in frames 10 through 12 you know how the thermostat assembly controls the anti-icing valve.

The thermostats are found in the leading edge, downstream of the valve outlet. There is one thermostat for each valve.

The thermostats are made to close the anti-icing valve when the temperature goes past 180°F and to re-open the valve when the temperature drops below 158°F. The sketch shows the electrical circuit for one valve. The electrical circuit is the same for the rest of the valves.

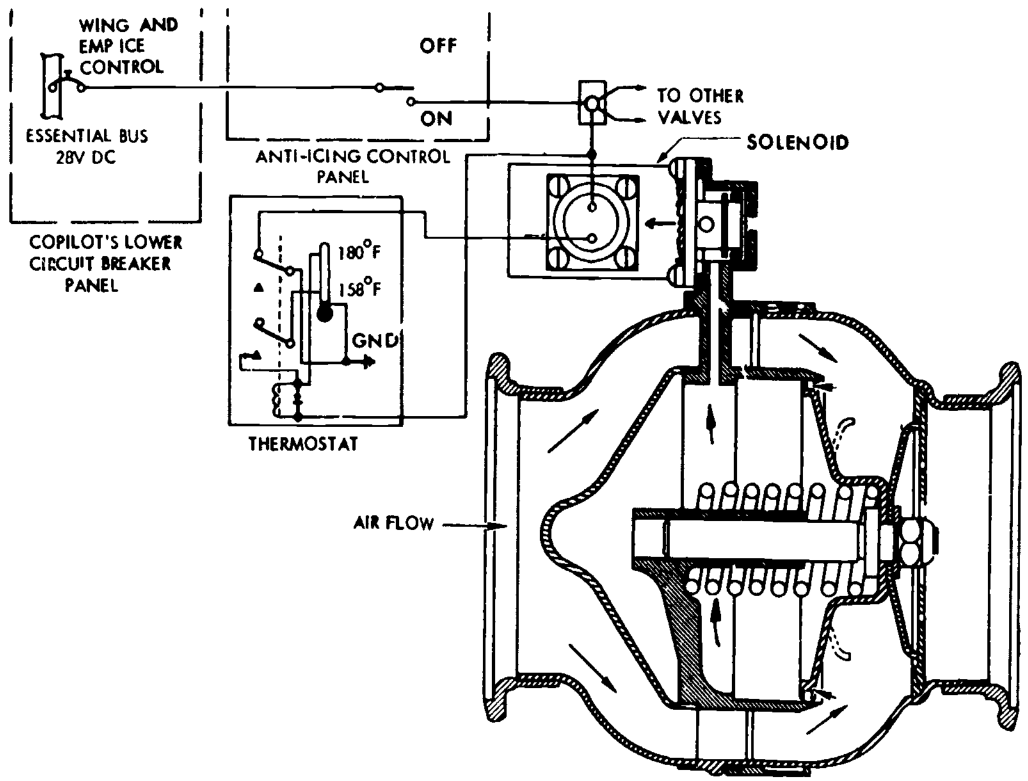


Figure 12.

Fill in the blanks to complete the following statements.

1. The leading edge anti-icing system contains ________ (2, 4, or 6) temperature control thermostats.

2. The temperature control thermostats controls the ______________ circuit of the anti-icing valve solenoid.

3. The thermostat controls the leading edge temperature by cycling the ______________ ______________ open and closed.

Answers to Frame 13: 1. 6 2. ground 3. anti-icing valve

Frame 14

So far we've seen two ways to control the temperature of the bleed air used for anti-icing. These are the mixing of the air through the ejectors which tends to cut down the temperature, and then the thermostats that control the leading edge temperature between 158°F and 180°F.

However, there is always the possibility that a thermostat will fail or a valve will stay open which would cause an overheat condition.

Temperature indicators are used to show the leading edge temperature. The temperature indicators are shown in figure 13.

These indicators are marked "inoperative," "normal operating range," and "over-heat." There are a total of six (6) indicators, one for a certain section of the leading edge. Each indicator responds to input from a corresponding temperature sensing bulb located in the leading edge section.

During system operation, if the temperature is between 93°F and 180°F, the indicators will be in the "normal operating range."

If the temperature in a leading edge section drops below 93°F, the resistance in the sensing bulb increases and thereby causes less current to be applied to the indicator, causing it to read "inoperative." (Remember the principle of a negative coefficient sensor.) If this happens, the pilot can assume that one of two conditions exist; either the anti-ice valve for that section of leading edge has failed to open or the indicator is giving a faulty reading. To verify this, the crew must perform a visual inspection of the leading edge section for an ice buildup.

Now let's see what will happen if the temperature in the leading edge section increases to above 180°F. Remembering the negative coefficient sensor principle, you can see that the resistance in the temperature sensing bulb will now decrease and cause more current to flow to the indicator. As this occurs, the indicator will climb into the "overheat" area. The pilot now can assume that either the indicator is defective or an anti-ice valve is stuck in the open position.

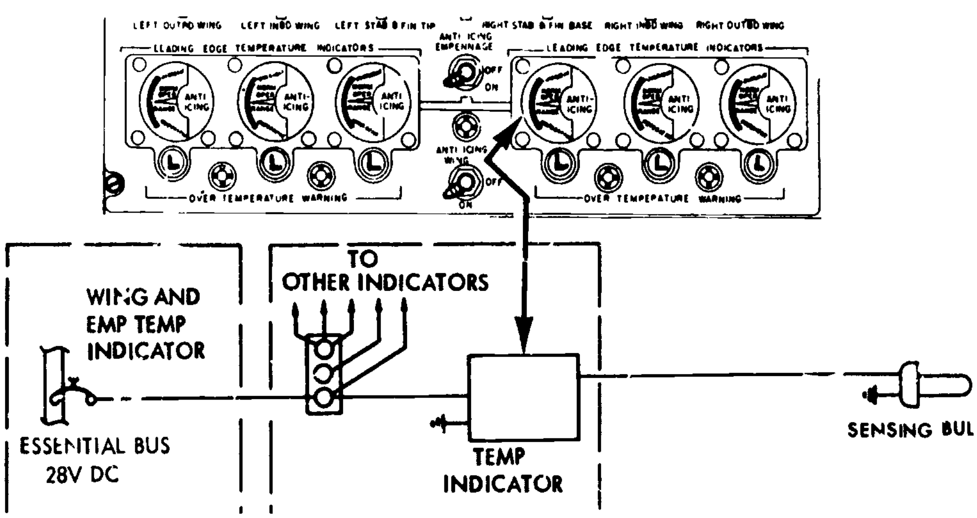


Figure 13.

In figure 13, the electrical circuit for one indicator is shown. The circuit for the other indicators are the same.

Fill in the blanks to complete the following statements.

1. When using the leading edge anti-icing system, the pilot can monitor the leading edge temperature by observing the temperature _______________.

2. The leading edge temperature indicators are marked _____________, _____________________ ___________________ ____________________, and _______________________.

3. The temperature in the leading edge is sensed by _______________ ____________________.

Answers to Frame 14: 1. indicator 2. inoperative, normal operating range, overheat 3. sensing bulbs.

Frame 15

In addition to the temperature indicators, six thermostatically controlled overtemperature warning lights are provided to monitor overheat conditions.

The overtemperature warning lights are found directly below the indicators on the anti-icing panel (see figure 14). They are used to verify an overheat condition. This means for example if the left outboard wing temperature indicator is in the overheat range, then the left outboard wing overheat light should be on. This tells the pilot that two separate indication devices are saying the same thing and that he should take the appropriate action.

The warning light only tells the pilot of the overheat condition; he must take the appropriate action to correct the problem. This could involve turning off the anti-icing system or closing the engine bleed air valves and the isolation valves for one or both wings.

The warning lights are operated by separate warning thermostats found in the leading edge. There are two overheat warning thermostats hooked to each light.

Using two thermostats allows sensing of the temperature in two different areas within each section of the leading edge.

The sketch in figure 14 shows the electrical circuit for one warning light. All six thermostats are wired the same.

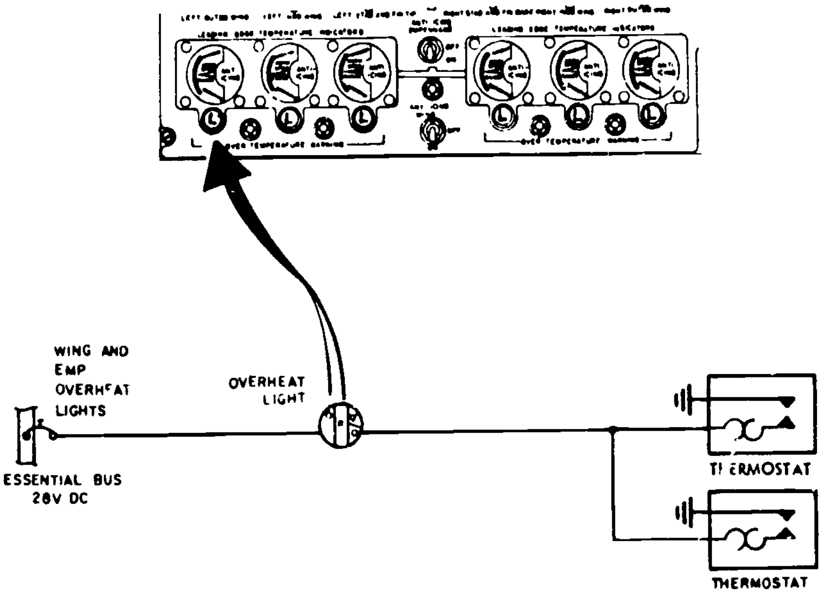


Figure 14.

Fill in the blanks to complete the following statements.

1. Should the temperature in the leading edge exceed a safe operating range, the pilot will be warned by the overtemperature ____________ ________________.

2. An overheat condition in the leading edge is sensed by overheat ______________ ____________________.

3. With the anti-icing system operating, one section of the wing leading edge over heats. This could be caused by a malfunctioning temperature control ____________________.

4. During flight, to correct the problem stated in question 3 above, the pilot would have to turn off the ______________ ______________ system.

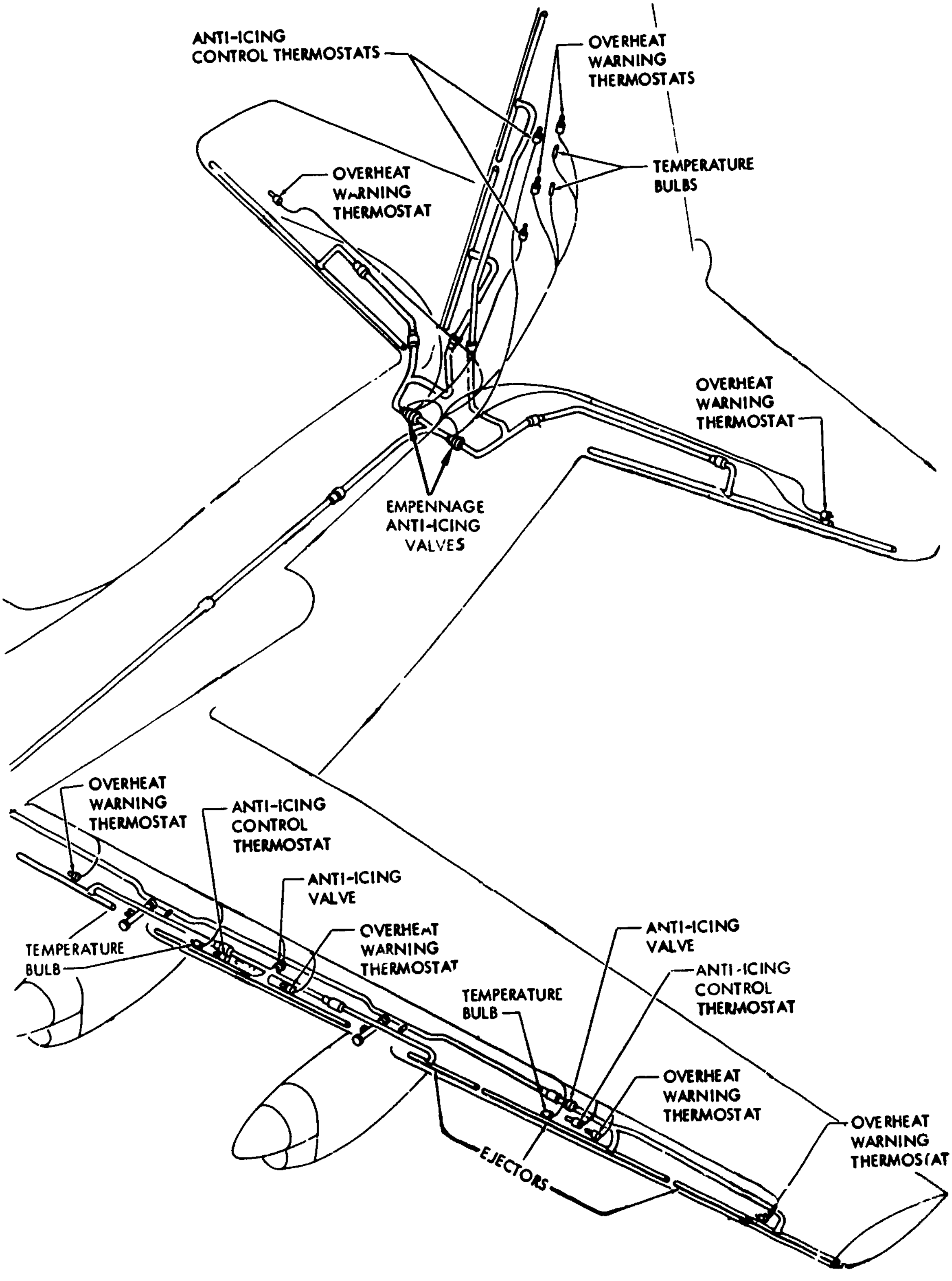

ANTI-ICING
CONTROL THERMOSTATS
OVERHEAT
WARNING
THERMOSTATS
TEMPERATURE
BULBS
OVERHEAT
WARNING
THERMOSTAT
OVERHEAT
WARNING
THERMOSTAT
EMPENNAGE
ANTI-ICING
VALVES
OVERHEAT
WARNING
THERMOSTAT
ANTI-ICING
CONTROL
THERMOSTAT
ANTI-ICING
VALVE
TEMPERATURE
BULB
OVERHEAT
WARNING
THERMOSTAT
ANTI-ICING
VALVE
ANTI-ICING
CONTROL
THERMOSTAT
TEMPERATURE
BULB
OVERHEAT
WARNING
THERMOSTAT
OVERHEAT
WARNING
THERMOSTAT
EJECTORS

Figure 15.

Answers to Frame 15: 1. warning light 2. warning thermostat
3. thermostats 4 wing anti-icing

Frame 16

Figure 15 shows the complete anti-icing system for the left wing and empennage. The right wing is the same as the left wing. Study the sketch and find each of the parts that have been discussed in the past frames. Complete each of the following statements using the sketch as an aid.

1. The leading edge anti-icing system contains __________ anti-icing valves.

2. Each empennage anti-icing valve controls air for one side of the _____________ stabilizer and half of the ___________ stabilizer.

3. The leading edge overheat warning system contains _______________ (3, 6, 8, or 12) thermostats.

4. The wing leading edge anti-icing system is divided into _________ ________________ and contains ____________ anti-icing valves.

5. The wing anti-icing switch controls __________ (2/4) anti-icing valves.

6. During operation of the leading edge anti-icing system the air temperature can be monitored by the temperature ______________.

7. The six temperature in tors are operated by changes in resistance of the temper ure sensing _________ located in the leading edge.

8. An overheat condition in the leading edge surface is indicated by the overtemperature ____________ ______________.

9. A warm air mixture is circulated through the leading edge passages by the action of the ____________ ________________.

10. When the wing leading edge anti-icing switch is placed to ON it energizes the ______________ of the wing anti-icing valves.

11. The anti-icing valve is actuated open by _________ ___________.

12. The leading edge anti-icing temperature is controlled between 158°F and 180°F by the anti-icing ____________ ________________.

13. The thermostat assembly consists of a ___________ thermostat and a ______________________.

Answers to Frame 16: 1. six 2. horizontal-vertical 3. 12
4. four sections, 4 5. four 6. indicators
7. bulb 8. warning lights 9. ejector nozzles
10. solenoid 11. air pressure 12. control thermostat
13. mercury relay

SECTION B

Frame 17

In the past frames you learned that the air for anti-icing is held in check by air actuated, solenoid controlled valves and that the solenoids are controlled by mercury type control thermostats.

At the time of normal operation of the anti-icing system, the temperature of the anti-icing air in the leading edge is shown on temperature indicators found in the cockpit.

Should the temperature in the leading edges go past a safe operating range, an overtemperature warning light will be turned on by overheat warning thermostat.

The electrical circuitry for this system is shown in foldout 1. Foldout 1 is the last page of this text, please open to this foldout now.

This sketch shows the anti-icing valve solenoids, anti-icing control thermostats, overheat warning thermostats and temperature sensing bulbs for each of the six zones. Find each of these parts on the diagram. Now find the anti-icing wing and anti-icing empennage switches, the leading edge temperature indicators, and the overtemperature warning lights.

The electrical circuitry for control of each zone is the same. Let's trace the circuits for the left outboard wing zone.

Use your RED pencil and draw the anti-icing wing switch to the ON position. Trace from the wing and empennage ice control circuit breaker, through the anti-icing wing switch, and up to pin A of the left outboard wing anti-icing valve solenoid.

Then trace through the solenoid to pin B and then down the top contact of the anti-icing control thermostat. Trace through the thermostat relay to ground.

This circuit will energize the solenoid, permitting the anti-icing valve to open if air pressure is available. Note that the circuit from the wing anti-icing switch powers each of the wing anti-icing solenoids in the same way.

With your red pencil trace from the junction below the solenoid to point X and down to the thermostat relay coil. Trace through the relay coil to the 180°F contact.

Since the mercury is down, this is an open circuit and we have only a voltage potential. As the temperature reaches 180°F, the mercury will complete the circuit, energizing the relay. This opens the ground circuit to the solenoid which closes the valve.

Using your BLUE pencil, trace the overheat warning light circuit for the left outboard wing.

Start by tracing from the wing and empennage overheat light circuit breaker to the left outboard wing overtemperature warning light. Then trace from the overtemperature warning light to pin A on each of the overheat warning thermostats.

If either thermostat contact closes, due to an overheat condition, it will complete the circuit to ground, which will turn on the warning light. Again note that the circuits for all six lights are the same and operate in the same way.

Using your GREEN pencil, trace the circuit for the left outboard wing temperature indicator.

Start by tracing from the wing and empennage temperature indicator circuit breaker to the left outboard wing temperature indicator.

Then trace from the indicator to pin A of the left outboard wing sensing bulb. Continue tracing through the sensing bulb to pin B and ground.

Remember from Frame 14 that the resistance of the sensing bulb will vary with the changes in temperature. This change in resistance will change the current flow through the indicators. The change in current flow through the indicators will inform the pilot if the system is operating normally, is inoperative, or is in an overheat condition. Notice that all six indicator circuits are the same.

Fill in the blanks to complete the following statements.

1. The overtemperature warning lights are turned on by ______________ ______________________ ______________________.

2. The anti-icing control thermostat controls the anti-icing valve ______________________ by opening and closing the ________________ circuit to the solenoid.

3. The anti-icing control thermostat consists of a ___________________ and a _____________ ______ type thermostat.

Answers to Frame 17: 1. overheat warning thermostat
2. solenoid, ground
3. relay, mercury

Frame 18

PERFORMANCE EXERCISE

On foldout 1 there are 15 circled numbers. These numbers indicate troubles, either in a circuit or a part. The numbers that point to a part mean that the part could have a short or an open circuit on the inside. Each number may be used once, more than once, or not at all.

The statements below give the condition for a trouble in the system. Read the statement, then analyze the sketch to determine the possible cause. Place the number of the trouble that could cause this condition in the blank provided.

_____ 1. The right inboard wing overtemperature warning light comes on with the anti-icing system OFF.

_____ 2. With the anti-icing switches ON, the right stabilizer and fin base temperature indicator shows inoperative.

_____ 3. With both anti-icing switches ON, the wing system operates normally, but the empennage system fails to operate.

_____ 4. During operation of the anti-icing system, the left stabilizer and fin tip temperature indicator goes to overheat and the warning light comes on.

_____ 5. With the anti-icing system turned ON, the left stabilizer and fin tip anti-icing valve fails to open.

_____ 6. During operation of the anti-icing system, the right inboard wing temperature indicator shows OVERHEAT, and the overtemperature warning light comes on.

_____ 7. During operation of the system, the right outboard wing temperature indicator shows OVERHEAT and the warning light comes on.

_____ 8. During flight, the right outboard wing temperature indicator shows an overheat condition has occurred but the warning light does NOT come on.

_____ 9. The right inboard wing temperature indicator shows inoperative with the wing anti-icing switch ON. Visual inspection reveals an ice buildup on the right inboard wing.

_____10. During flight the right inboard wing temperature indicator shows inoperative with the anti-icing switches ON. Visual inspection reveals NO ice buildup on the right inboard wing.

HAVE GRADED BY INSTRUCTOR.

____
Instructor's Signature

At this point you should know how a leading edge anti-icing system works. But your tasks as a maintenance mechanic demands that you keep this system working right. So the next points, we need to look at are the inspection and maintenance procedures:

Inspection of the system takes in a visual inspection for cracks in the ducting, corrosion, loose connections, or any signs of leaks.

The insulation should be checked for being secure and to make sure there are no tears. The system should be checked to make sure the parts are working right.

The system can be checked for operation while the aircraft is on the ground by looking at the temperature indicators for a temperature rise. Most technical manuals will caution you not to operate an anti-icing system for more than 30 seconds while the aircraft is on the ground.

Since there is no airflow over the leading edge surfaces, such as there is in flight, leaving the anti-icing system on for more than 30 seconds could damage the leading edge by warping the skin.

The general procedures for performing an operational check are as follows:

1. Make sure all systems using bleed air are OFF.

2. Apply bleed air to the system using either the GTC, ground air cart, or engines.

3. Place the wing and empennage anti-icing switches to ON. Look at the bleed air pressure gage as the switches are turned on. The bleed air pressure should drop indicating that the valves are opening.

4. Look at the anti-icing temperature indicators. The temperature indicators should show a temperature rise of approximately the same amount on all indicators. If one indicator does not show a temperature rise, then it will be necessary to check the valve in that specific location.

The operational check procedures are used to find out if the valves will open. It does not check thermostat operation. Keep in mind that the procedures given are general concepts only.

NOTE: Before doing any maintenance on an aircraft, you must always refer to the applicable technical manual for the correct procedure and to determine specifically what must be done.

Frame 19 (Cont'd)

The repair procedures depend on the cause for the specific problem. If a valve fails to operate properly, you will have to find out the cause through troubleshooting. In most cases the problem will be due to a defective valve or thermostat. This would require replacement of the defective part. Again, it's a must that you refer to the technical manual for the correct removal and replacement procedures.

Fill in the blanks to complete the following statements.

1. When performing a ground operational check, anti-icing valve operation is indicated by a temperature rise on the ________ ________ ________________.

2. The maximum time for operating the anti-icing system while the aircraft is on the ground is ________________.

3. To determine procedures for operational checking or repairing the anti-icing system, you should refer to the aircraft ____________ ____________.

Answers to Frame 19: 1. temperature indicators 2. 30 seconds
3. technical manual

Frame 20

Place a T or F in the blank to identify the statements that are either true or false.

_____1. Each section of the wing leading edge anti-icing system has an anti-icing shutoff valve.

_____2. The wing anti-icing switch controls four valves.

_____3. During flight, air can be supplied for anti-icing by the GTC.

_____4. When the leading edge anti-icing valve solenoids are energized the valve will be open.

_____5. The wing leading edge anti-icing valves are solenoid controlled and pneumatically actuated.

_____6. During anti-icing operation, the temperature of the leading edge is controlled by a mercury thermostat.

_____7. An overheat condition of the leading edge is indicated by the temperature indicator and by warning lights.

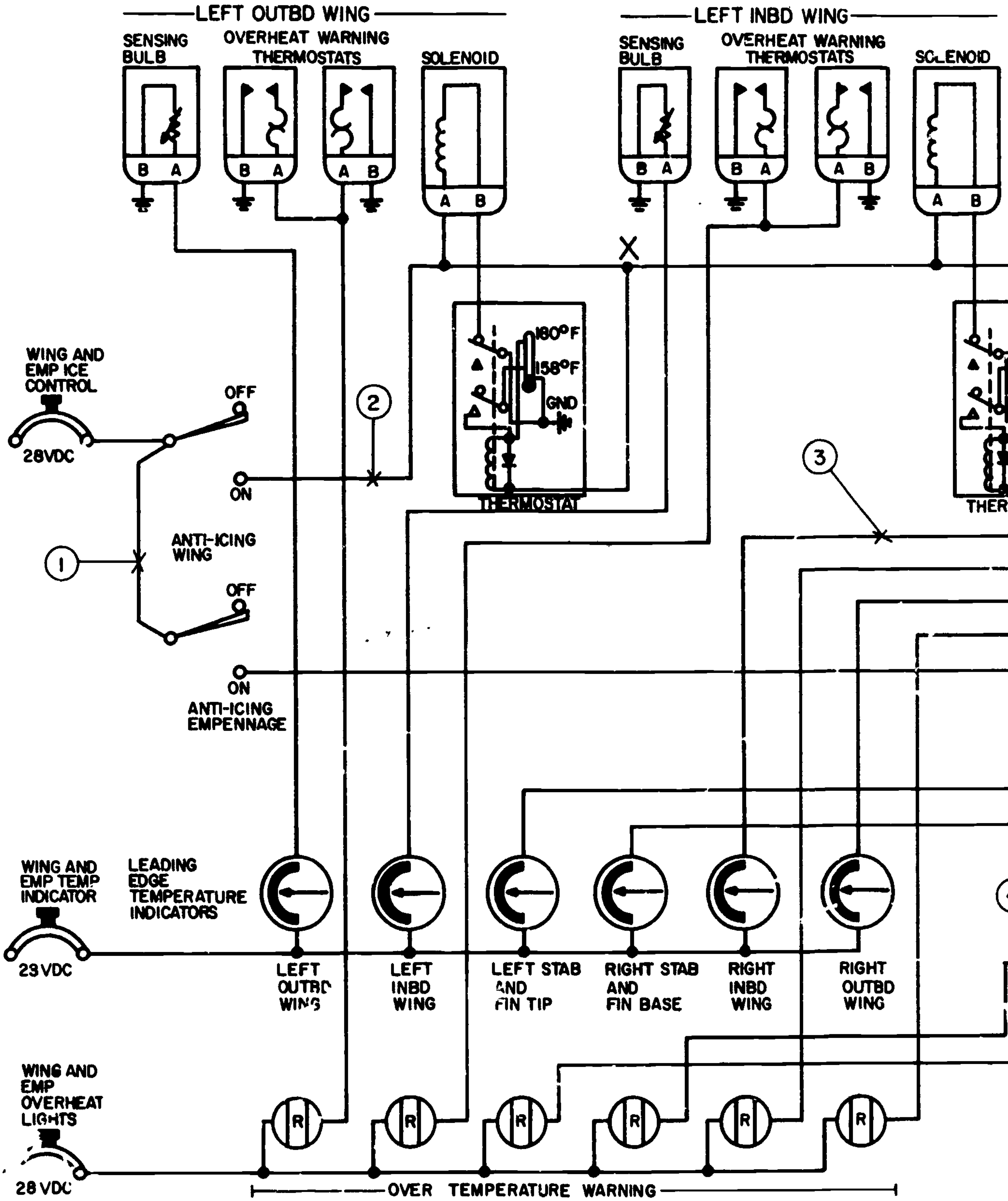
_____8. The anti-icing systems should never be operated for more than 30 seconds when the aircraft is on the ground.

_____9. To perform an operational check of the anti-icing systems, you should follow the steps given in the technical manual.

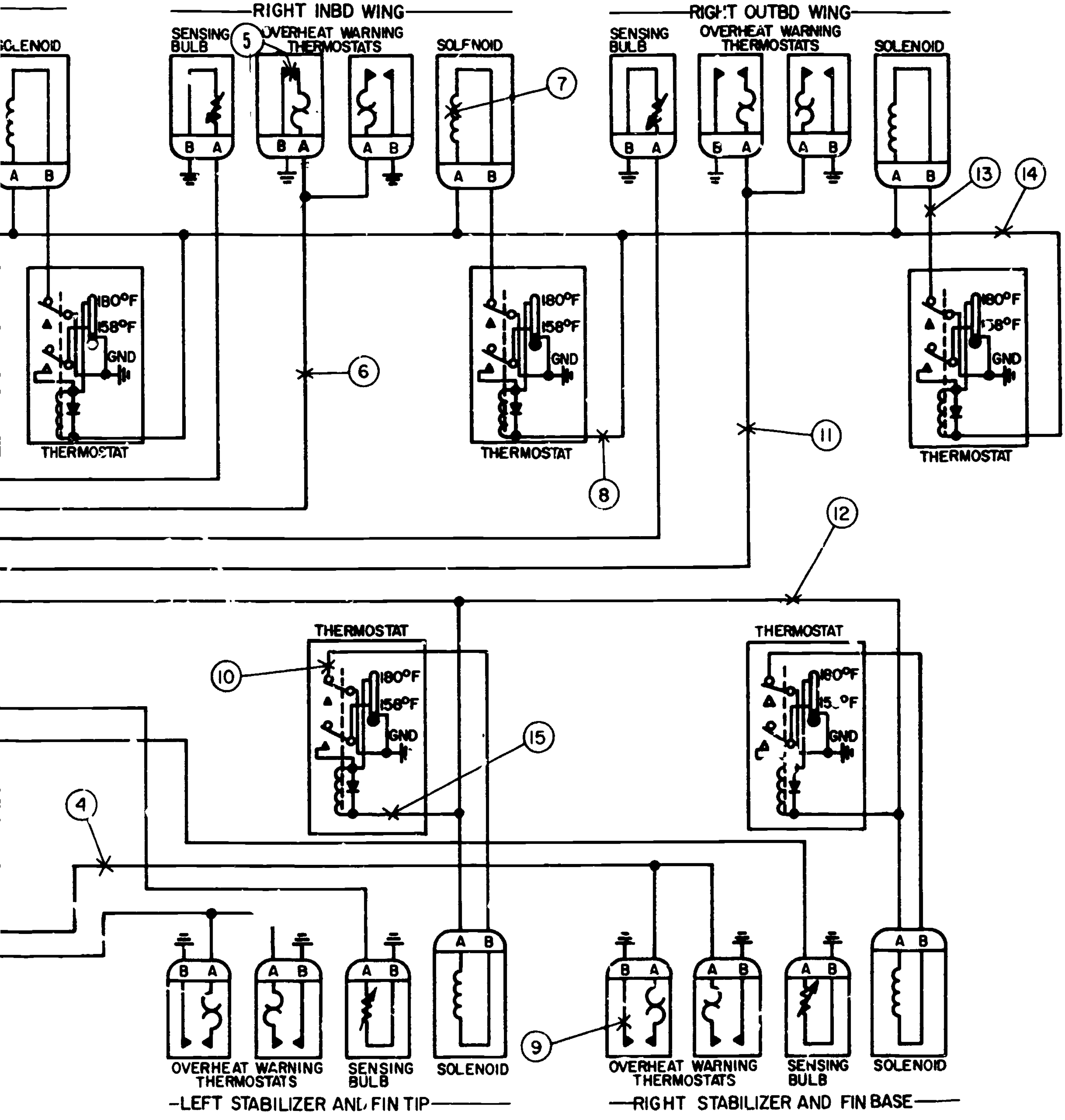
_____10. During operation of the anti-icing system, the thermostat controls thy position of the valve by opening and closing the solenoid ground circuit.

Answers to Frame 20:

1. T
2. T
3. F
4. T
5. T
6. T
7. T
8. T
9. T
10. T



LEFT OUTBD WING
SENSING BULB
OVERHEAT WARNING THERMOSTATS
SOLENOID
LEFT INBD WING
SENSING BULB
OVERHEAT WARNING THERMOSTATS
SOLENOID
THERMOSTAT
180°F
158°F
GND
WING AND EMP ICE CONTROL
28VDC
OFF
ON
ANTI-ICING WING
OFF
ON
ANTI-ICING EMPENNAGE
WING AND EMP TEMP INDICATOR
23VDC
LEADING EDGE TEMPERATURE INDICATORS
LEFT OUTBD WING
LEFT INBD WING
LEFT STAB AND FIN TIP
RIGHT STAB AND FIN BASE
RIGHT INBD WING
RIGHT OUTBD WING
WING AND EMP OVERHEAT LIGHTS
28 VDC
OVER TEMPERATURE WARNING


RIGHT INBD WING
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SOLENOID
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OVERHEAT WARNING THERMOSTATS
SOLENOID
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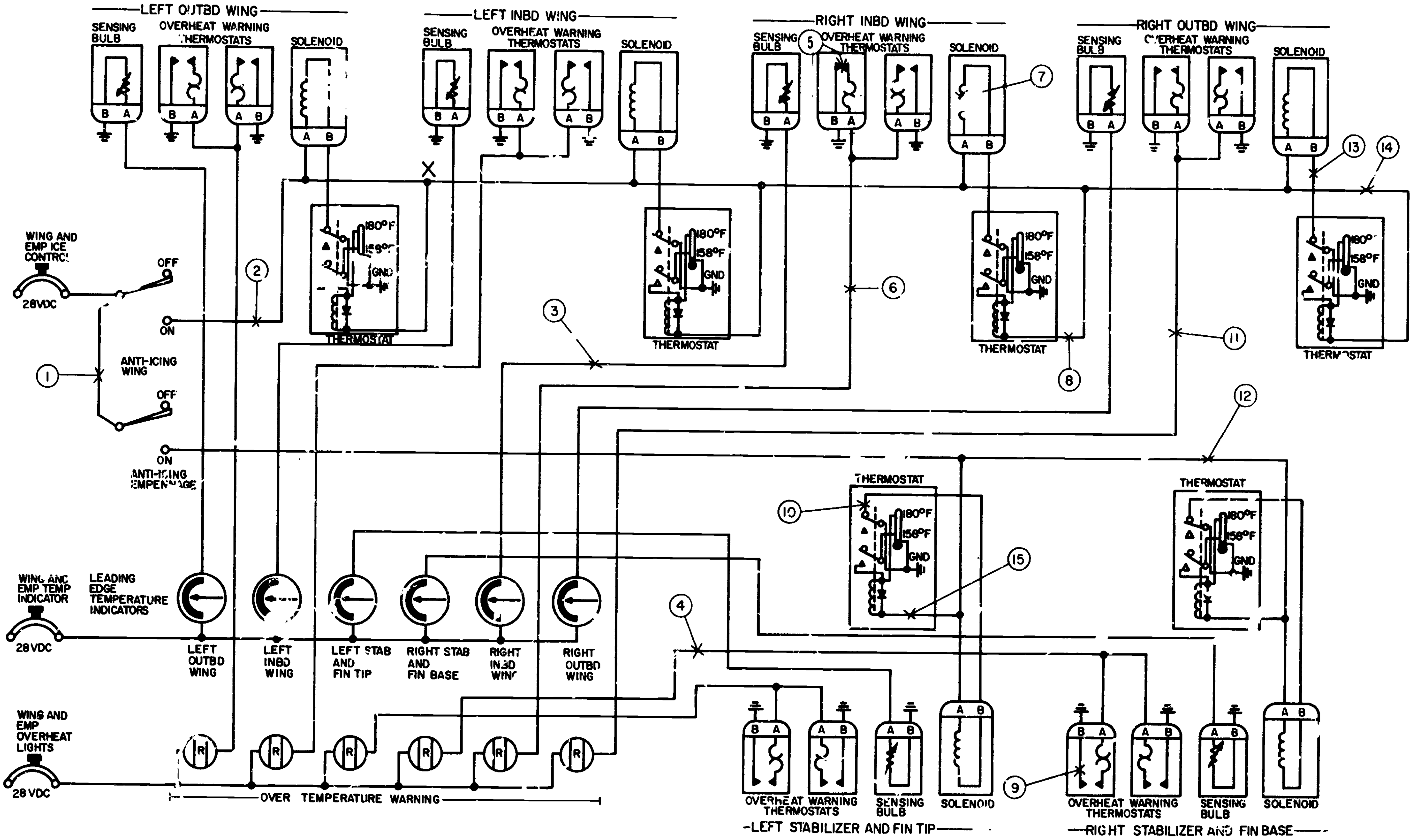
OVERHEAT WARNING THERMOSTATS
SENSING BULB
SOLENOID
OVERHEAT WARNING THERMOSTATS
SENSING BULB
SOLENOID
LEFT STABILIZER AND FIN TIP
RIGHT STABILIZER AND FIN BASE

Foldout 1.


LEFT OUTBD WING
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LEFT INBD WING
LEFT STAB AND FIN TIP
RIGHT STAB AND FIN BASE
RIGHT INBD WING
RIGHT OUTBD WING
WING AND EMP OVERHEAT LIGHTS
OVER TEMPERATURE WARNING
OVERHEAT WARNING THERMOSTATS
SENSING BULB
SOLENOID
LEFT STABILIZER AND FIN TIP
RIGHT STABILIZER AND FIN BASE

Foldout 1.

PROGRAMMED TEXT

C3ABR42331-PT-208B

Technical Training

Aircraft Environmental Systems Mechanic

ENGINE AIR INTAKE DUCT ANTI-ICING SYSTEM

9 February 1982

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE

DO NOT USE ON THE JOB

RGL: 10.0

OBJECTIVE

Using a wiring diagram, specify four out of five given air intake duct anti-icing system control circuit troubles.

INSTRUCTIONS

This text presents material in steps called frames. After each frame you are asked to respond to questions in some manner. Read the material carefully and accomplish what each frame directs you to do. The correct answers are given at the end of the next frame. If you have answered each response correctly continue on to the next frame. If you are incorrect, read the material again and correct your answer before continuing.

This programmed text will cover the function and operation of the air intake duct anti-icing system, the system components, and the ice detection system. In addition, the location of the switches on the control panel will be gone over, and you will be required to trace through the electrical circuit to learn normal operation. Finally, you will be required to analyze the wiring diagram and determine the cause for system troubles that you will be given.

Proceed on to Frame 1.

Supersedes ST 3ABR42331-PT-208B, 28 August 1981.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 1000; DAV - 1

The previous text told how hot engine bleed air is used to prevent ice from building up on the wing and empennage leading edges. In the previous text we also pointed out the various areas that were anti-iced on a typical cargo aircraft.

The sketch that was used in the previous text is shown again in figure 1 below. Note that item 4 points to the engines. If the aircraft flies into an area where icing conditions are taking place, the ice will build up on the engine air intake ducts. In fact, ice will build up in the engine inlet area sooner than on the leading edges. This is due to the increase in air velocity at the engine air intake which causes a lower temperature.

Any buildup of ice in the engine air intake system could be harmful to engine operation. In this text we'll discuss how ice is detected in the air inlet and how any buildup of ice is prevented.

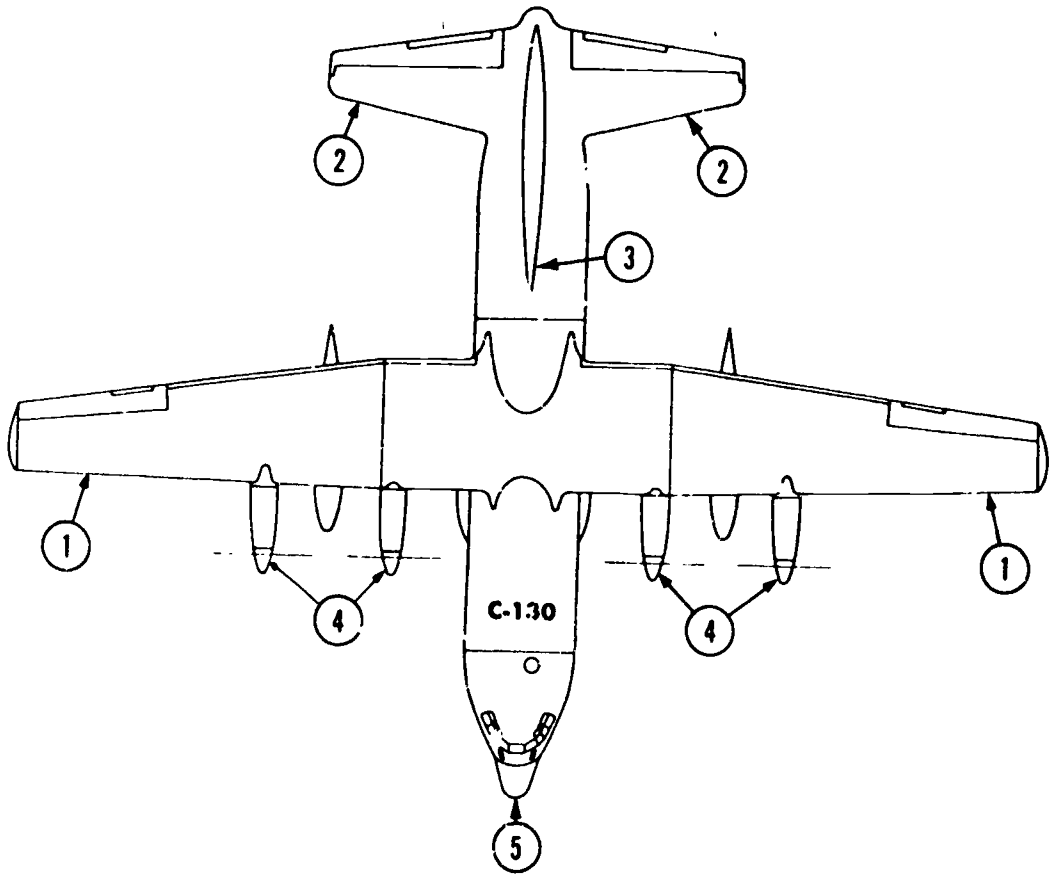


Figure 1.

NO RESPONSE REQUIRED

Frame 2

Figure 2 below shows the engine nacelle and shows how the bleed air flows from the engine to the oil cooler scoop and air intake scoop. The bleed air is taken from the last stage of engine compression. This is normally called the "engine inlet scoop" anti-icing system.

Note the arrows that show the flow of air from the bleed air tap-offs to the air intake scoop area. Also note the small arrows showing the flow of air through the passages around the air intake scoop.

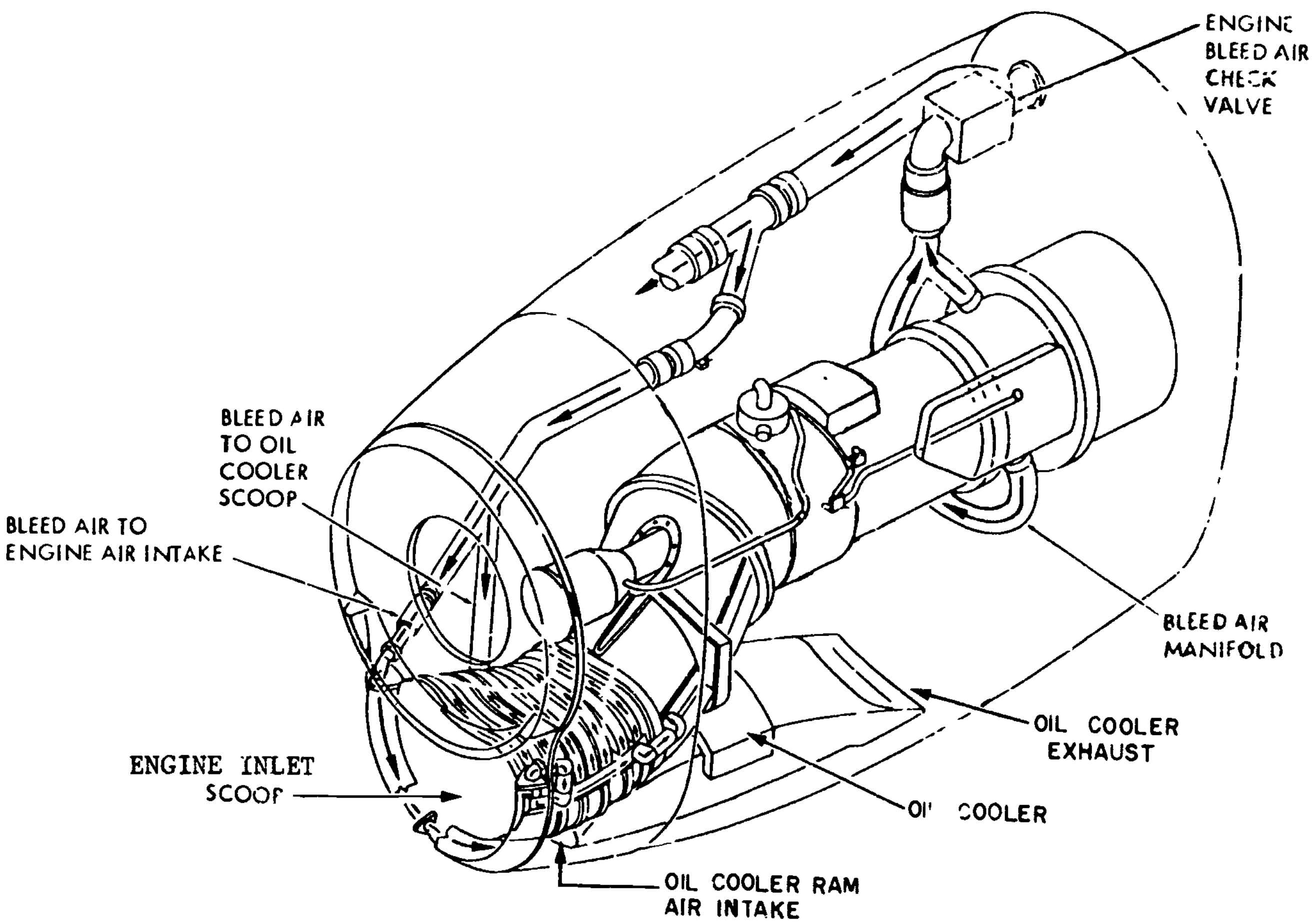


Figure 2.

Fill in the blanks to complete the following statements.

1. The air for the anti-icing system (inlet air scoop) is taken from the ______ ______________ stage of engine compression.

2. The air for anti-icing the air intake scoop is circulated through ______________ ___.

A solenoid controlled, air actuated valve is used to control air flow to the air intake and oil cooler scoops. Figure 3 shows the engine air intake and oil cooler scoop anti-icing valve. Reference point A in the illustration shows the location of this valve in the system. This valve is normally called the "engine inlet scoop anti-icing valve."

There is one feature about the engine inlet scoop anti-icing valve that is different from other valves that you've studied. On this valve the solenoid is energized to close the valve, and deenergized to open the valve. This is called a fail-safe valve. That is, if there is an electrical power failure the valve will open. This feature insures anti-icing of the scoops even with an electrical power failure.

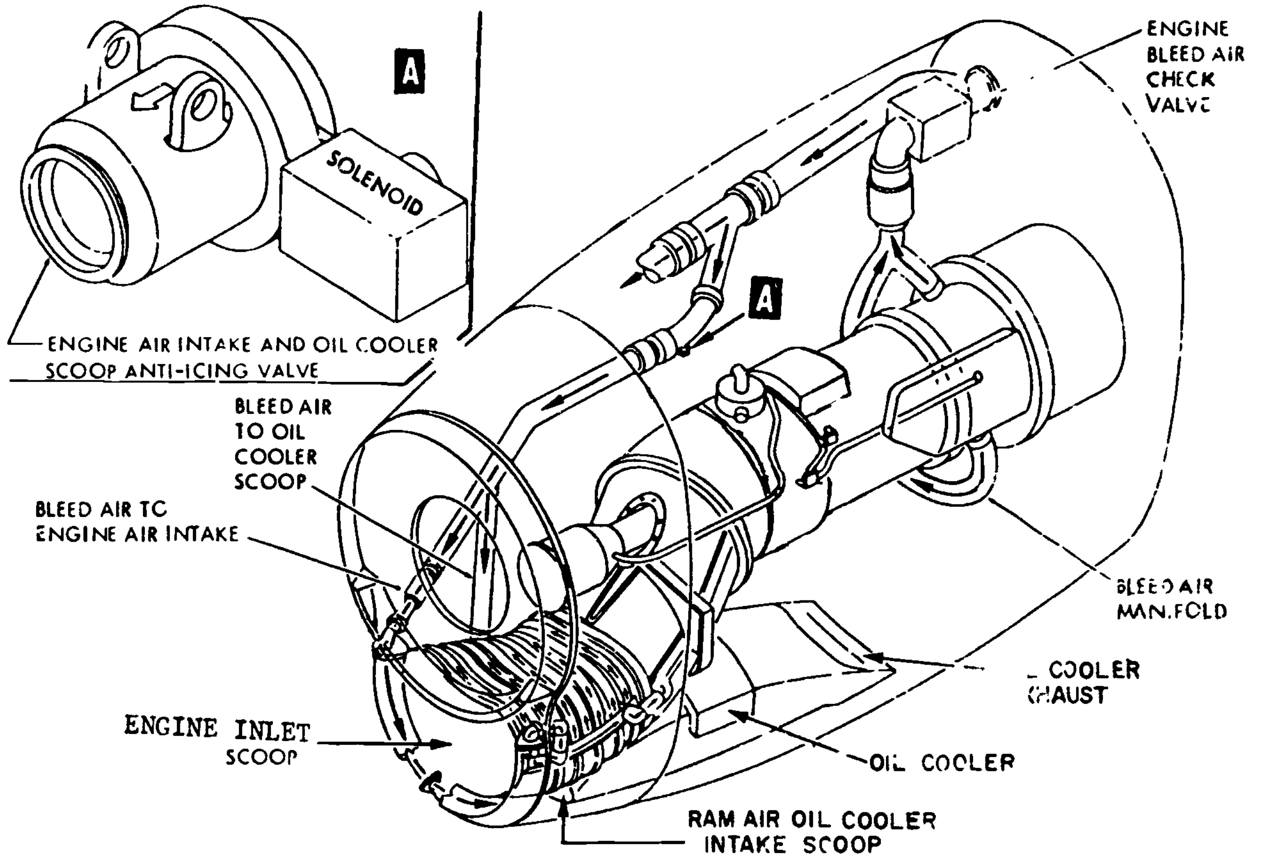


Figure 3.

Frame 3 (Cont'd)

Fill in the blanks to complete the following statements.

1. Air for anti-icing the engine air intake is contolled by the engine __________ __________ __________ valve.

2. Opening and closing of the engine inlet scoop anti-icing valve is controlled by a __________.

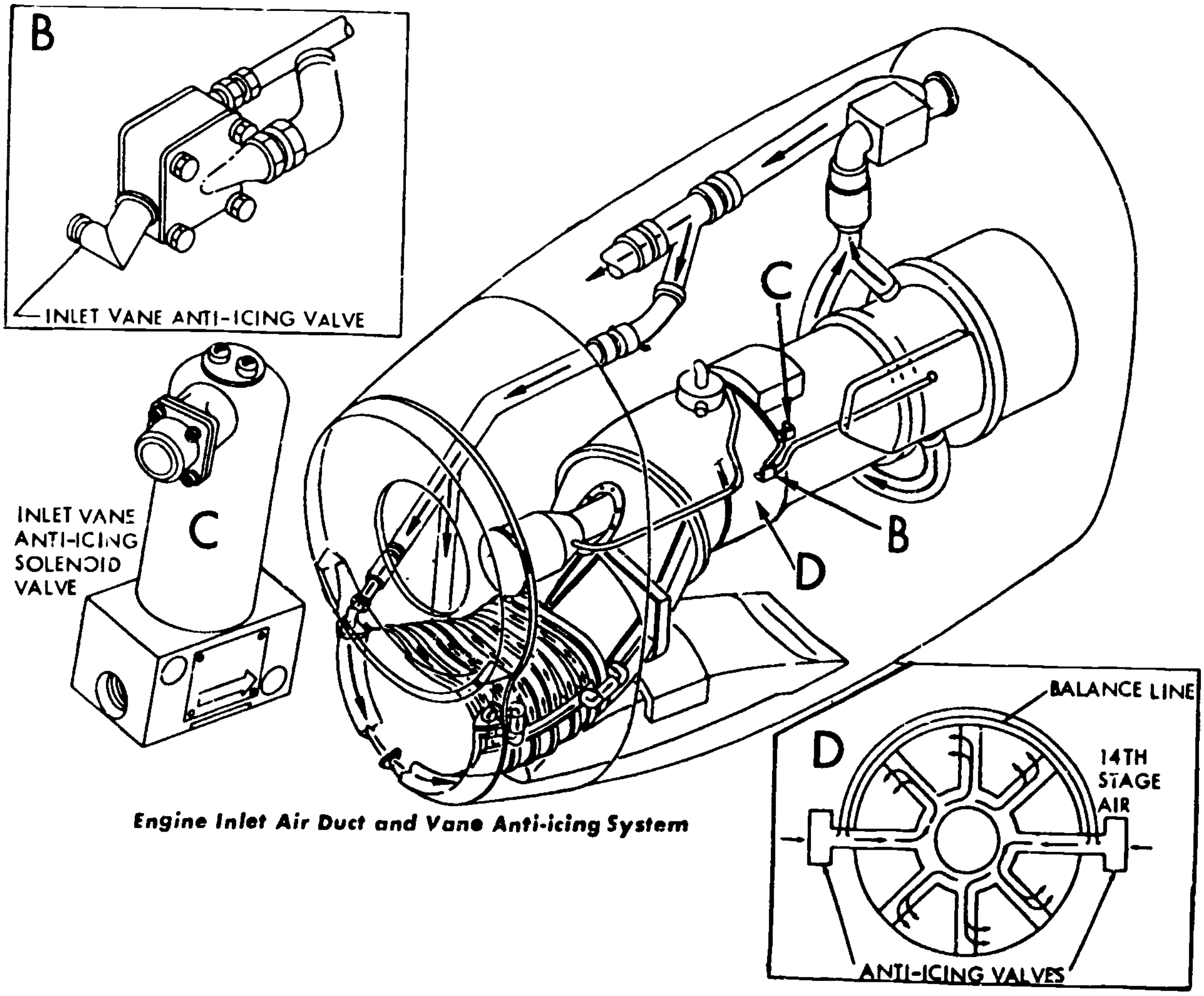
3. When the engine inlet scoop anti-icing valve is closed, the solenoid is __________ (energized/deenergized).

Answers to Frame 2: 1. last 2. passages

Another area in the air intake duct where ice can build up is the guide vanes. Figure 4 shows the guide vane anti-icing system. Detail B shows the inlet vane anti-icing valve, and detail C shows the inlet vane anti-icing solenoid valve. Note the reference points showing the location of these units on the engine.

There are two inlet vane anti-icing valves for each engine. One valve is located on each side of the engine as shown in detail D. The same solenoid controls both valves.

Detail D shows the guide vane and flow of air through the vanes. The guide vanes direct the flow of ram air to the engine compressor. Any buildup of ice on the vanes could cause engine failure.



Engine Inlet Air Duct and Vane Anti-icing System

Figure 4.

Frame 4 (Cont'd)

Fill in the blanks to complete the following statements.

1. Ice is prevented from accumulating on the engine guide vanes by circulating hot ________________ ____-____________________ through the vanes.

2. The units that control air for guide vane anti-icing are the inlet vane anti-icing _______________ valve and the inlet vane _____________ _______________.

Answers to Frame 3:
1. inlet scoop anti-icing
2. solenoid
3. energized

The inlet vane anti-icing solenoid valve controls the on and off action of the guide vane anti-icing system. The bleed air from the 14th (last) stage is directed to the anti-icing air valve as shown in the illustration below.

When the solenoid is energized, as shown, the anti-icing valve is held closed by the pressure of the bleed air. When the solenoid is deenergized it opens a vent port that vents the pressure from the poppet in the anti-icing air valve, thus allowing the valve to open. The 14th stage bleed air can now flow to the guide vanes.

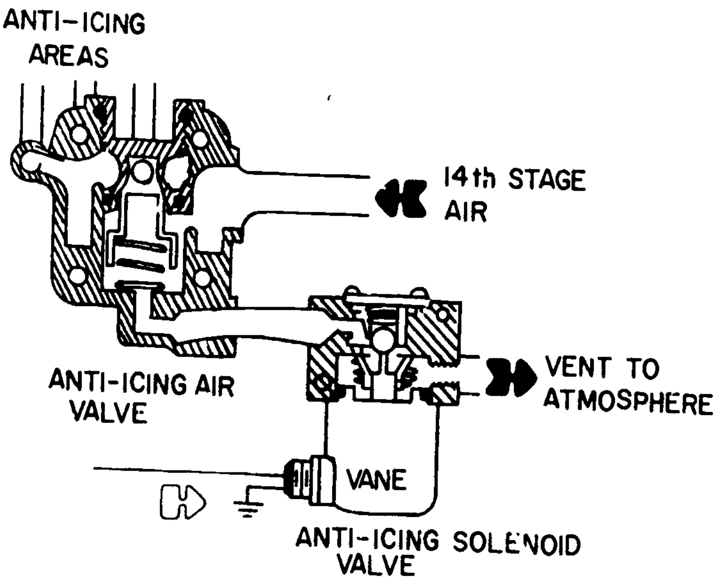


Figure 5.

Fill inthe blanks to complete the following statements.

1. The guide vane anti-icing air valve is controlled by the anti-icing ________________ ____________________.

2. Deenergizing the anti-icing solenoid valve opens a ________________ port.

3. When the anti-icing solenoid valve is energized, the anti-icing air valve will be ____________________ (open/closed).

Answers to Frame 4: 1. bleed air 2. solenoid anti-icing valve

Note: As we begin describing each component and trace the current flow through this circuit, you will notice we have attempted to simplify some of the nouns of the different components. Many of the descriptive nouns have been cut down, for example: "prop and engine anti-icing master switch" will become "the master switch," and "engine air anti-icing relay" has become simply "the anti-icing relay." In this way we hope to prevent any unnecessary confusion.

Frame 6

The engine inlet air duct and vane anti-icing system can be controlled either automatically or manually.

The MASTER SWITCH controls the manual or automatic selection. ANTI-ICING SWITCHES control the on and off selection of the anti-icing valves.

Placing the MASTER SWITCH in AUTO and the ANTI-ICING SWITCHES ON, the anti-icing valves will be closed, until an icing condition occurs. Then the ice detection system will open the anti-ice valves.

Notice the Master Switch in figure 11. This same switch is also shown in illustrations A, B, and C below. This is a three position switch. The positions are MANUAL, AUTO, and RESET.

Illustration A shows the switch in manual position. Notice that the switch armature is down. By looking at figure 11, you will see that this directs power to the reset relay coil.

Illustration B shows the switch in the AUTO position. In this position the switch simply opens the circuit to the reset relay coil. This permits the reset relay to remain deenergized.

The third position on the switch is RESET. This is shown in illustration C. Notice the contact for the reset position is triangular shaped. This means the switch is spring loaded from this position, or that it must be held in this position.

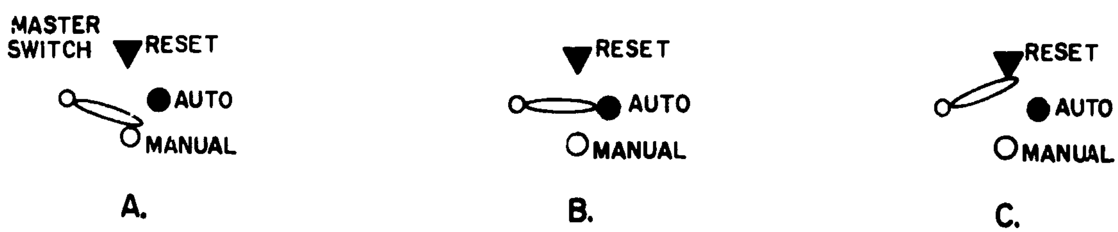


Figure 6.

Fill in the blanks to complete the following statements.

1. Manual or Auto operation of the engine air intake duct anti-icing system is selected by using the ____________ ________________.

2. When the master switch contacts are in the center position, anti-icing valves will be controlled ____________________ (automatically/manually).

Answers to Frame 5: 1. solenoid valve 2. vent 3. closed

Figure 7 shows the electrical schematic of the engine inlet air duct and vane anti-icing system. Remember, when the system is off, the solenoids are energized, and when ON the solenoids are deenergized. Let's follow the circuits for anti-icing control for number 1 engine to see how this system is controlled manually.

Follow the diagram as you read.

Placing the master switch to manual will energize the reset relay pulling the reset relay's armature down. By energizing the reset relay you are opening the circuit which energizes the anti-icing relay. The purpose of deenergizing the anti-icing relay is to take away a second path that current could flow from the anti-icing valves across the relay armature.

Now that the second path has been taken away, you can manually control the anti-ice valves by placing the anti-ice switches to either the on or off position. Notice that when the switches are off the anti-ice valves are energized, holding them closed. When the pilot places the switches to on, the valves are deenergized open. They are fail safe valves; in case of a loss of electrical power, they are deenergized open.

Note: Not all of the ice detection system is shown.

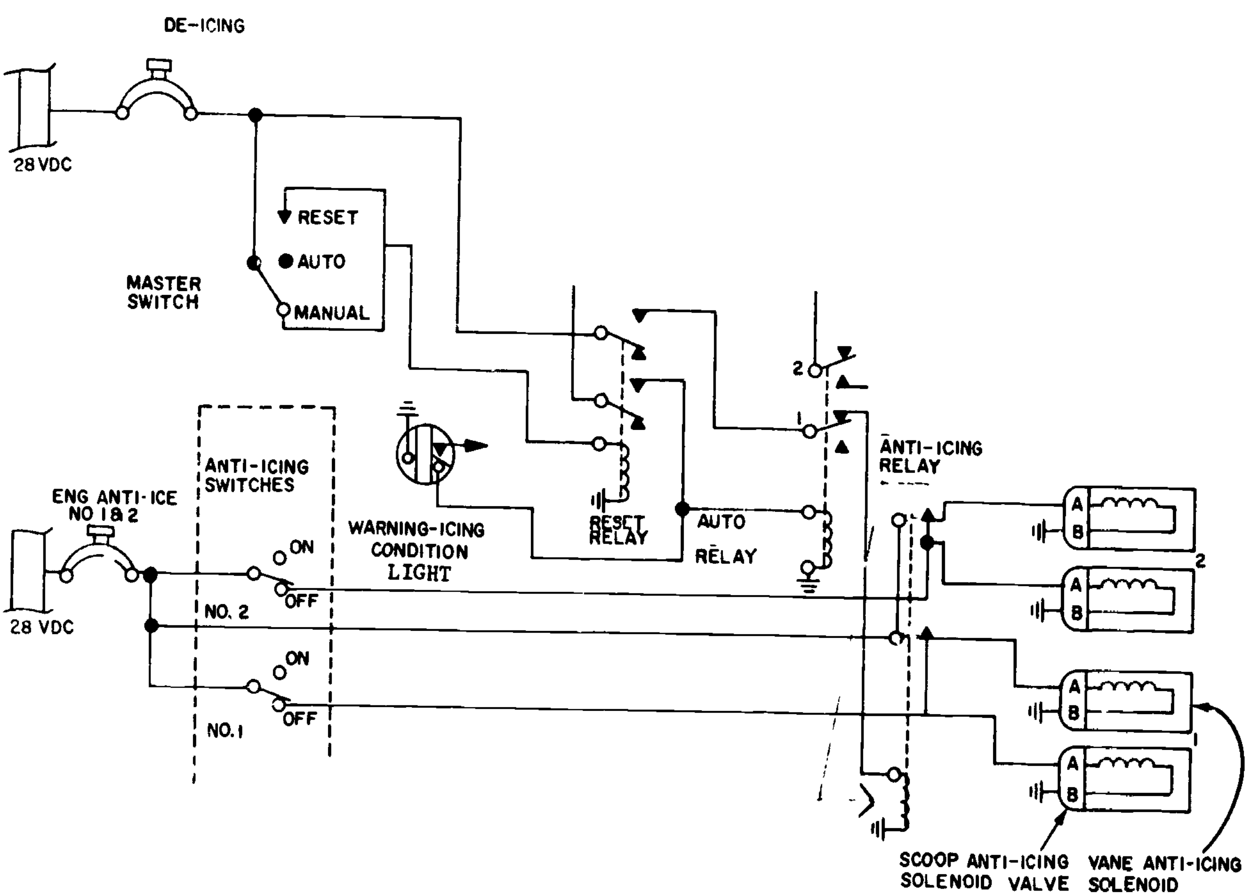


Figure 7.

Frame 7 (Continued)

Fill in the blanks to complete the following statements.

1. When the anti-icing switches are off, the engine air intake scoop anti-icing solenoid valve will be ________________.

2. The engine inlet air duct and vane anti-icing valves will be open when the solenoids are __________________.

Answers to Frame 6: 1. master switch
2. automatically

Placing the master switch to AUTO will turn on the ice detection system. With the ice detection system operating, the anti-icing switches must be placed to ON, but the valves will only open when an icing condition occurs.

Find the anti-icing relay and the auto relay on the sketch shown (figure 8). When the ice detection system is operating, with no ice, the auto relay is deenergized and completes the circuit to the anti-icing relay. This keeps the relay energized, and pulls the armatures down. This circuit is in a no ice condition. Keep in mind that anti-icing control of all four engines is the same. Note that in the no ice condition, the electrical circuit is complete to the solenoids.

When an icing condition takes place, the ice detection system will cause the auto relay to energize. This opens the circuit to the anti-icing relay causing it to deenergize. This will deenergize the solenoids opening the valves. This results in heat being applied to the engine inlet scoop and oil cooler, to melt the ice.

NOTE: Not all of the ice detection system is shown.

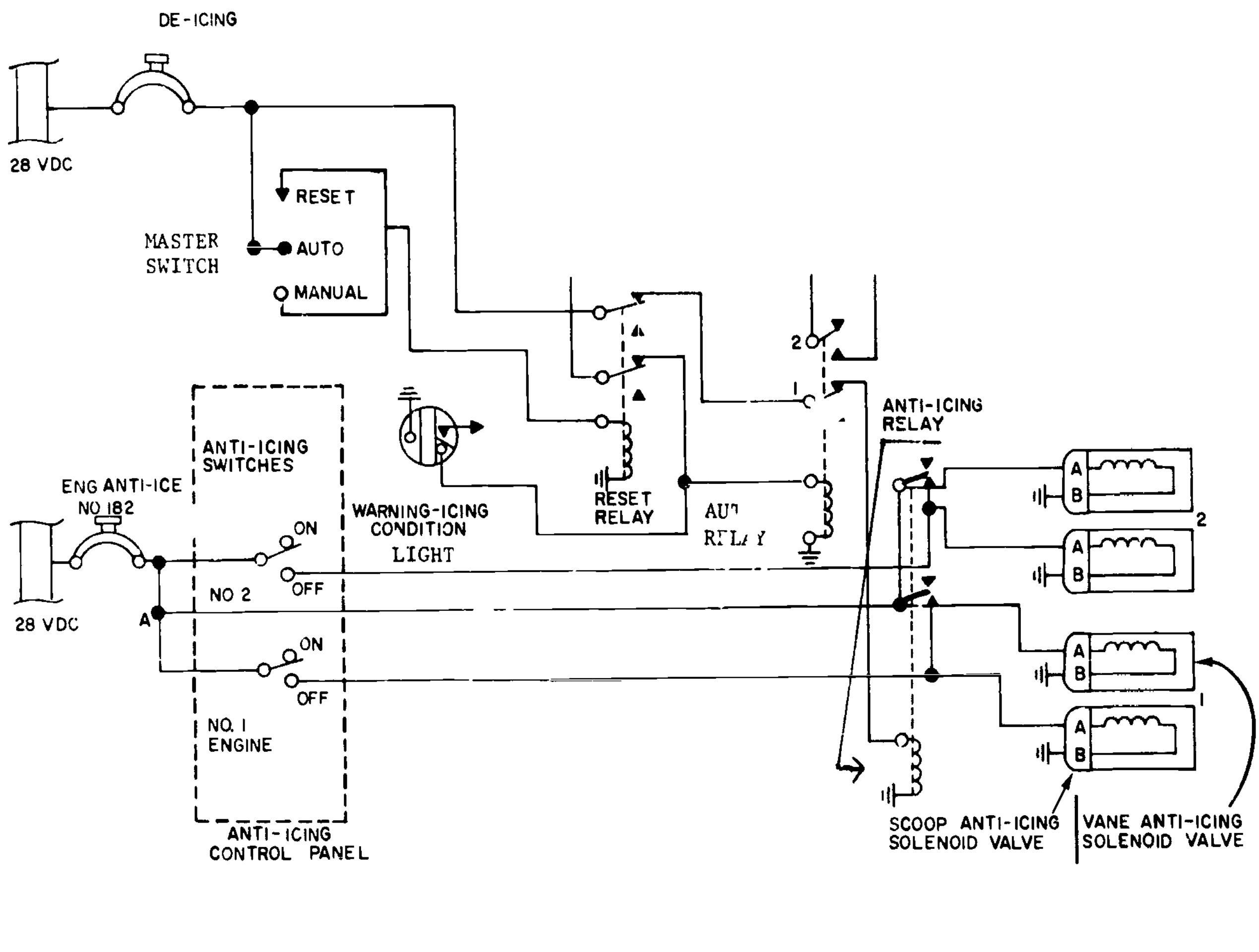


Figure 8.

Frame 8 (Continued)

Fill in the blanks to complete the following statements.

1. With the master switch in AUTO, and a no ice condition, the anti-icing relay will be ______________.

2. When the anti-icing relay is energized, the anti-icing valves will be ____________ (opened/closed).

3. The anti-icing relay is controlled by the __________________ __________________ system.

Answers to Frame 7: 1. energized 2. deenergized.

Select the component name from column B that matches the statement given in column A. Place the letter of the matching component in the blank space provided.

Column A	Column B
_____1. Controls the inlet vane anti-icing valves.	A. Engine air intake and oil cooler scoop anti-icing valve.
_____2. Controls the automatic and manual selection of the anti-icing system.	B. Inlet vane anti-icing valve.
_____3. Directs 14th stage air to passages in the guide vanes.	C. Inlet vane anti-icing solenoid valve.
_____4. Directs 14th stage air to passages in the air intake scoop.	D. Master switch.
	E. Anti-icing switch.

Answers to Frame 8: 1. energized 2. closed 3. ice detection

Frame 10

The ice detection system is used as an automatic control for the engine inlet air anti-icing system. That is, it will automatically open the engine inlet scoop and guide vane anti-icing valves when an icing condition takes place. Keep in mind that this system does not control the wing or tail leading edge anti-icing system.

The ice detection system consists of one detection unit, one interpreter, one auto relay, a warning-icing condition light, and a no ice light. The detector and interpreter are the two major components (see figure 9).

The interpreter is found on the ice detection panel. The detector is found in number 2 engine nacelle. The probe of the detector unit goes through the nacelle and into the inlet air duct just in front of the engine.

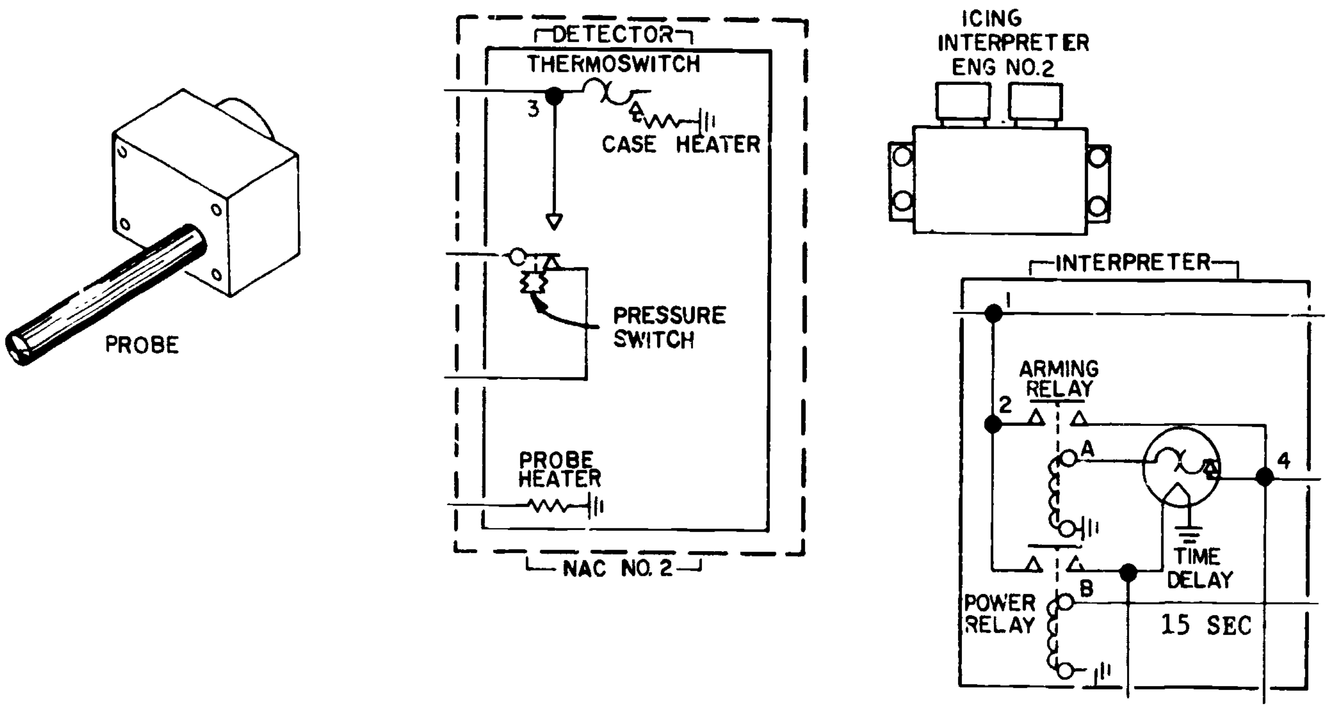


Figure 9.

Fill in the blanks to complete the following statements.

1. The ice detection system controls the opening of the ______________ ___________ ___________ and _________ _____________ anti-icing valves.

2. The two major components of the ice detection system are the ____________ and ______________.

3. The ice detector is located in the inlet scoop of engine number __________.

Answers to Frame 9: C 1. D 2. B 3. A 4.

The detector, shown in figure 10, is made up of the probe, probe heater, a pressure sensitive switch, a case heater, and a thermoswitch, the probe, extending into the inlet air scoop, senses the pressure of the incoming ram air. If there is no ice, the opening to the probe is open and the pressure of the incoming ram air is passed on to the pressure switch. This pressure will keep the pressure switch armature in the no-ice position. An airspeed of 40 knots or above (or by operating the engine) will provide enough air pressure to actuate the switch to a no-ice condition.

The case heater and the thermoswitch maintain temperature between 55 degrees and 75 degrees F in the detector unit. This prevents moisture from accumulating. The thermoswitch reacts to air temperature. If the temperature exceeds 75 degrees F, the switch contacts will contract and open. If the temperature is below 75 degrees F, the switch contacts will expand and close, completing the circuit to the heater.

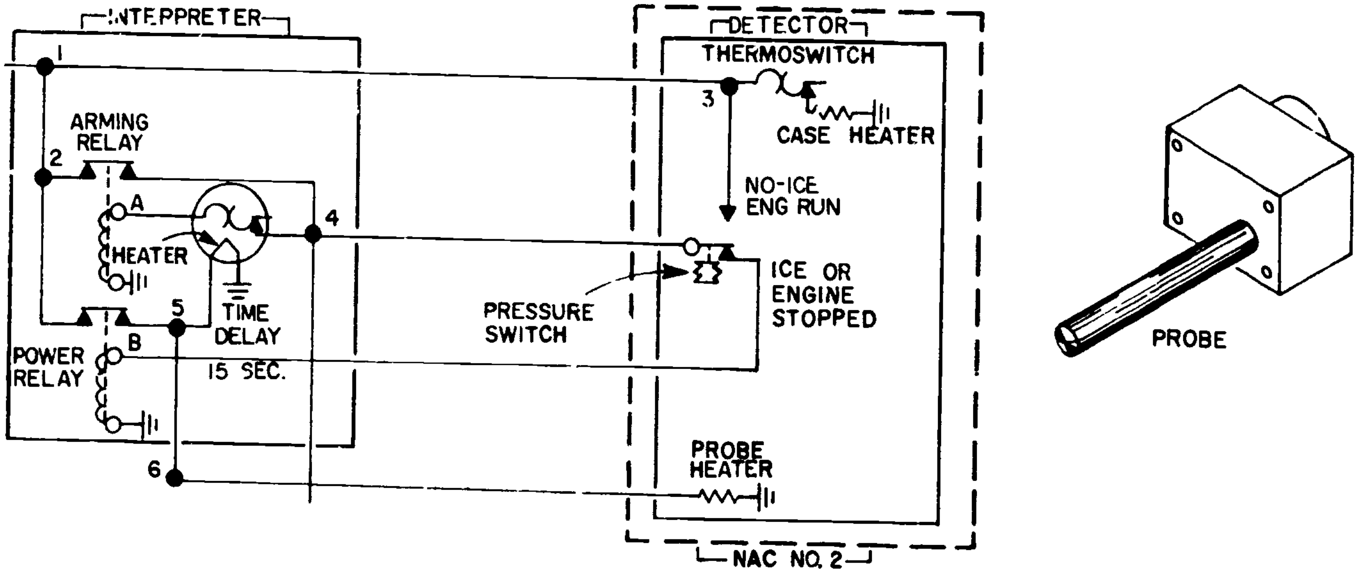


Figure 10.

When the aircraft flies into an icing condition, the ice will form over the opening in the probe. This will stop the pressure that goes to the pressure switch. The switch armature will move down to the ice or engine stopped position. This will apply a voltage potential at point B, energizing the power relay. This pulls its armature down, applying a voltage potential at junction 5.

This will energize the 15 second time delay. The time delay consists of a heater and a thermoswitch. If the heater is energized for more than 15 seconds, it will build up enough heat to open the time delay thermoswitch. This is abnormal operation. If this happens, all automatic operation will be lost.

The voltage potenital would also be applied to junction 6, energizing the probe heater. The probe heater then starts heating to melt the ice from the probe. While flying in an icing condition, the pressure switch is cycling from ice or engine stopped to no ice engine run. It does this because the probe is alternately heated by the probe heater and then iced again. This causes the pressure switch armature to move up and down, opening and closing the circuit to the power relay coil at intervals of less than 15 seconds. This will also energize and deenergize the time delay at intervals of less than 15 seconds; this is normal operation.

Frame 11 (Continued)

Fill in the blanks to complete the following statements.

1. The detector consists of a __________, pressure ___________, ___________, ___________ heater, and _____________ heater.

2. The detector detects ice by sensing air ________________.

Answers to Frame 10:
1. engine inlet scoop, guide vane
2. detector, interpreter
3. 2

We'll start circuit tracing with manual operation first. On figure 11, using an orange pencil, draw the master switch armature to the MANUAL position. Trace from the deicing circuit breaker to the master switch.

Trace through the master switch armature to the reset relay coil. When the master switch is in manual, the reset relay is energized. Without tracing, follow the circuit from the DE-ICING circuit breaker to the top armature of the reset relay. Notice that when the relay is deenergized, there is a completed circuit that goes to the anti-icing relay coil.

From this we can see that when the master switch is in manual, the anti-icing relay is deenergized and when the master switch is in Auto, the anti-icing relay will be energized.

Keep in mind that when the anti-icing switches are off, the solenoids will be energized. We'll trace the circuit for the valves in No. 1 engine. You can then notice that the circuits for the other three engines are identical.

With an orange pencil, trace from the ANTI-ICE No. 1 and 2 circuit breaker to the No. 1 anti-icing switch. With the switch in OFF, trace across the armature to the No. 1 engine scoop anti-icing solenoid valve and to the vane anti-icing solenoid valve.

This energizes the solenoids, keeping the valves closed. If we place the switch to ON, we'll open the circuit, deenergizing the solenoids, thus permitting the valves to open.

Fill in the blanks to complete the following statements.

1. The ____________ ________________ is used to select AUTO or MANUAL operation.

2. When the master switch is in manual the reset relay is ______________ (energized/deenergized).

3. The anti-icing relay is deenergized when the reset relay is ____________________ (energized/deenergized).

4. For manual operation the anti-icing relay is ____________ (energized/deenergized).

Answers to Frame 11: 1. probe, switch, thermoswitch, case, probe
2. pressure

Frame 13

Before we trace the circuits for automatic operation, locate the following items on figure 11, at the back of this text.

1. Detector
   a. Case heater
   b. Probe heater
   c. Press switch
2. Interpreter
   a. Arming relay
   b. Power relay
   c. Time delay
   d. Time delay heater
3. No-ice relay
4. No-ice light
5. Warning icing condition light
6. Auto relay

We'll start by tracing the power potential that will exist when electrical power is first put on the aircraft. We'll trace the circuits with the master switch in AUTO and the anti-icing switches ON.

With a red pencil, draw the master switch in AUTO and the anti-icing switches to ON. Note that with the master switch in AUTO the reset relay will be deenergized.

Start to trace, in red, the circuit wire from the deicing circuit breaker, through the top armature of the reset relay, and through the bottom armature of the AUTO relay. Then trace to the anti-icing relay coil. This will energize the anti-icing relay coil, pulling the armatures down. Also, trace the armatures down in red.

Starting at the ENG ANTI-ICING NO. 1 and 2 circuit breaker, trace to point A. Then from point A, trace the circuit to the bottom armature of the anti-icing relay. From this relay armature, trace the circuits to the scoop anti-icing solenoid valve and to the vane anti-icing solenoid valve. This will keep the solenoids energized. Notice that to deenergize the solenoids (open the valves) it will be necessary to deenergize the anti-icing relay. Also notice that for the system to operate in AUTO, the engine anti-icing switches must be placed to on.

With the red pencil, trace from the LH ICE DETECTOR CIRCUIT breaker to junction #1. Then trace down to the arming relay and power relay contacts. Now go back to junction #1 and trace from junction #1 to junction #3. Next trace from junction #3 to the detector thermoswitch down to the no ice engine run pressure switch contact.

Since the engines are not running, this switch will be in the ICE OR ENGINE STOPPED position. These circuits provide the voltage potential to arm the system once the engines are started.

Fill in the blanks to complete the following statements.

1. For the system to operate in AUTO, the anti-icing switches must be placed to ________________ (on/off).

2. During automatic operation, the reset relay will be ________________ (energized/deenergized).

3. With the master switch in AUTO, when electrical power is first applied to the aircraft, the anti-icing valve solenoids will be ______________.

4. When electrical power is first applied to the aircraft, if the temperature in the detector is below 55 degrees F the case heater ______________ (will/will not) operate.

5. When the solenoids are energized, the valves are ____________ (closed/open).

Answers to Frame 12:
1. master switch
2. energized
3. energized
4. deenergized

Frame 14

The next step in our sequence is the engine run condition. When the inboard engine (No. 2) is started, the air pressure in the engine air intake will be sufficient to move the pressure switch armature to the NO-ICE ENGINE RUN position.

Using a blue pencil, draw the pressure switch armature to NO-ICE ENGINE RUN.

With the blue pencil, trace from the pressure switch contact NO-ICE ENGINE RUN to junction #4.

From junction #4, trace through the time delay thermoswitch contact to the arming relay coil. This will energize the arming relay.

Draw the arming relay armature down. Now go back to the LH ice detection circuit breaker. Trace from the circuit breaker to junction #1, then down to junction #2. Then trace across the arming relay armature back to junction #4.

From junction #4 trace back through the arming relay coil. This forms a holding circuit which will keep the arming relay energized regardless of the position of the pressure switch armature.

With the blue pencil, trace from junction #4 down to the top armature of the auto relay. This provides a voltage potential at this point that will be used when ice is detected, to form another holding circuit. This circuit will be explained later in this workbook.

Fill in the blanks to complete the following statements.

1. When the pressure switch moves from the engine stopped position to the engine run position, the ice detection system will be ________________.

2. After the arming relay closes, it will be held in this position by the ________________ ________________.

Answers to Frame 13:
1. on
2. deenergized
3. energized
4. will
5. closed

If an actual icing condition is encountered (during flight), ice will form over the probe. This will cause the pressure switch armature to move to the ICE or ENGINE STOPPED position.

Using a GREEN pencil, trace the pressure switch armature to the ICE or ENGINE STOPPED position. With the green pencil, trace a dashed line from the pressure switch armature to the power relay coil. This will energize the power relay. Draw the power relay armature closed. Then trace a dashed line from the power relay armature to junction #5. From junction 5, trace a dashed line to junction #8, then to junction #9. Then trace down and across the bottom armature of the reset relay to junction #11, then to the AUTO relay coil. Now go back to junction #11 and trace to the warning icing condition light. This circuit turns on the warning light to inform the pilot of the icing condition, and also energizes the auto relay.

NOTICE that when the auto relay is energized, it opens the circuit going to the anti-icing relay. Remember, when the anti-icing relay is deenergized during automatic operation, it permits the anti-icing valves to open.

Go back to junction #6 and trace a dashed green line to the probe heater. Also trace from junction #7 to the no-ice relay coil. These circuits provide power to the probe heater and to the no-ice relay, whenever the power relay is energized.

You're probably wondering why the dashed green line. Part of this circuit is a cycling circuit. The probe heater is wound around the probe. When electrical current flows through the heater, it will melt the ice from the probe. This means that when ice forms over the probe, the pressure switch armature moves to the ice position which energizes the power relay. This in turn completes the circuit to the probe heater which melts the ice from the probe. It normally takes the probe heater less than 15 seconds to melt the ice from the probe. When this happens, the pressure switch armature moves to the NO-ICE position which deenergizes the power relay. This opens the circuit going to the probe heater which permits the ice to again form over the probe and starts the process all over again.

In the course of normal operation, the power relay should at not time stay energized for more than 15 seconds. If it should stay energized for more than 15 seconds, the time delay unit in the interpreter will dearm the system.

Let's see how this will take place. Note that when the power relay is energized, a voltage potential is now at junction 5, energizing the time delay. The time delay has a heater in it. If current flows through the heater for more than 15 seconds it will cause enough heat which will open the time delay thermal switch, which will open the holding circuit that is keeping the arming relay energized. This supplies the voltage potentials needed for automatic operation of the ice detection system.

This will open the circuit through the arming relay which turns the system off. The system will stay off until the pressure switch moves back to the NO-ICE ENGINE RUN position which will rearm the system. This would be an abnormal operation which could be caused by a trouble such as an inoperative probe heater. If this does happen, all automatic operation will be lost.

Frame 15 (Continued)

Also notice that the circuit going to the no-ice relay will also cycle for the same reason the power relay cycles, causing the no-ice relay to pulsate. However, the anti-icing valves will <u>not</u> cycle. They will stay open. We'll see how this is possible in the next frame.

Fill in the blanks to complete the following statements.

1. If the pressure switch remains in the ICE OR ENGINE STOPPED position, the system will be shut off by the __________ __________ unit.

2. During inflight operation, with the master switch in AUTO, the warning icing condition light comes on, but after 15 seconds, the light goes out. This trouble could be caused by a defective ________________ ________________.

3. The power relay receives electrical power whenever ice forms on the ______________________.

4. When the power relay is energized, current will flow through the __________ heater, ________________ relay, __________ __________ __________ light, and to the auto relay.

5. The anti-icing relay is controlled by the __________ __________.

Answers to Frame 14: 1. armed 2. holding circuit

We've noted that part of the circuit is cycling. Still, we want the anti-icing valves to stay open and the warning light to stay on as long as the aircraft is in an icing condition. This it will do. But let's see how.

We previously traced the voltage potential to the top armature (blue line) of the auto relay. When the icing state was detected, it energized the auto relay.

With the blue pencil, draw the armature of the auto relay down. Now trace the circuit from the top armature using a solid blue line to junction #8. Keep on tracing from junction #8 to junction #[illegible], then down and across the bottom armature of the reset relay. From the bottom armature of the reset relay, go to junction #11, then on to the auto relay coil, then back to junction #11, and to the warning icing condition light.

The circuit from the top armature of the auto relay, around to the auto relay coil, has formed a holding circuit that will keep the auto relay energized, even though the circuit from the power relay is cycling.

The auto relay will stay energized continuously, because of the complete circuit from the top armature to the auto relay. Also, the light will remain on continuously, for the same reason.

The circuit is also complete from the top of the auto relay armature to junction #9 and up to the no-ice relay armature, and to the thermal switch in the no-ice time delay.

With a green pencil trace circuit.

Fill in the blanks to complete the following statements:

1. When an icing condition is encountered, the pressure switch and power relay will ________________.

2. When the auto relay energizes, the top contact will complete a ______________ circuit to keep the relay energized.

Answers to Frame 15:
1. time delay
2. probe heater
3. probe
4. probe no-ice warning icing condition
5. auto relay

Frame 17

Up to this point we have traced the circuits that will cause the anti-icing valves to open by deenergizing the solenoids, and turning on the warning lights.

The next step in our sequence is the no-ice condition. When the aircraft flies out of the icing condition, the pilot has to be told so that he can turn the system off. An important point to note is that the system will <u>not</u> turn off automatically.

When the aircraft goes to a no-ice condition, the ice will stop forming over the probe. The pressure switch will then stay in the no-ice engine run position. This means the power relay will stay deenergized. When this takes place there will no longer be a complete circuit to the no-ice relay and the relay will stay deenergized.

Earlier we had traced a voltage potential to the no-ice relay armature and to the thermal switch in the no-ice time delay. Since the no-ice relay is now remaining in the deenergized position, the circuit will be complete across the armature to the heating element in the no-ice time delay.

When there is a complete circuit for 90 seconds, it will cause sufficient heat to close the contacts of the thermal switch. When the thermal switch closes, it completes the circuit to the no-ice light, turning the light on.

Using a BROWN pencil, trace from the no-ice time delay thermal switch armature to the no-ice light. Complete the circuit to the no-ice time delay heating element and then through the thermal switch, this turns on the no-ice light. This tells the pilot that he no longer needs the engine inlet air duct anti-icing system on. Remember, we stated earlier that the system will not shut off automatically; the pilot must turn it off.

Also remember, that the no-ice light will not come on until 90 seconds <u>after</u> the aircraft flies out of an icing condition.

Fill in the blanks to complete the following statements:

1. When an icing condition no l[illegible] exists, the NO-ICE light will be turned on by the ___________ ______ ___ _______________.

2. The no-ice time delay thermoswitch is closed by a ______________________ element.

Answers to Frame 16: 1. pulsate
2. holding

To stop the anti-icing system from operating, the pilot will momentarily place the master switch to reset. The switch is spring loaded from this position. When this switch is held momentarily to RESET, it will complete the circuit to the reset relay. This will energize the relay.

Now notice that when the relay is energized, it opens the holding circuit (bottom armature) to the auto relay. This deenergizes the auto relay. When the master switch is released it goes back to AUTO, which again deenergizes the reset relay.

Now notice that when the reset relay and the auto relays are deenergized, there is a complete circuit to the anti-icing relay coil. This energizes the anti-icing relay which completes the circuit to energize the scoop and vane anti-icing solenoids. This closes all valves.

Fill in the blanks to complete the following statements:

1. After an icing condition, to close the engine inlet scoop and guide vane anti-icing valves, the pilot must place the master switch to

   __________.

2. The no-ice light is turned off when the master switch is placed to

   __________.

Answers to Frame 17: 1. no-ice time delay
2. heating

PRACTICE EXERCISE

Go to figure 12. This figure contains the electrical diagram of the system with several troubles indicated by circled numbers. The following statements identify probable troubles in the system. Read the statements, then select the circled number from the diagram that would cause the trouble. When complete, have the instructor check your answers.

_____1. During flight, with the master switch in Auto, the warning icing condition light does not come on, but the valves opened.

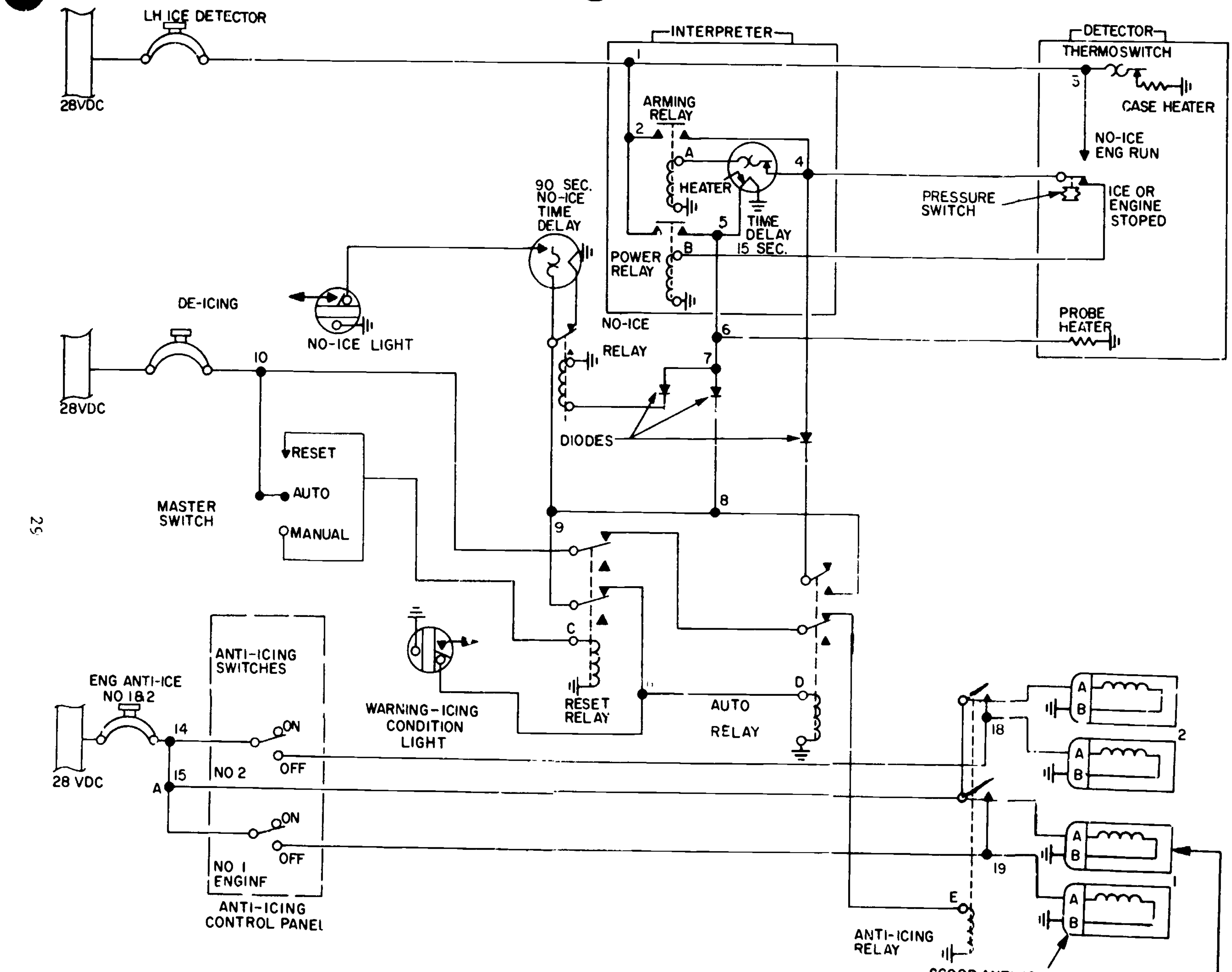
_____2. During flight, the warning icing condition light comes on, remains on for approximately 15 seconds, then goes out. To maintain engine anti-icing, the system must be operated in manual.

_____3. During flight, the master switch in AUTO, the warning icing condition light shows a pulsating operation, and the engine anti-ice valves do not open.

_____4. During operation of the ice detection system, the warning icing condition light comes on, but the no-ice light does not come on.

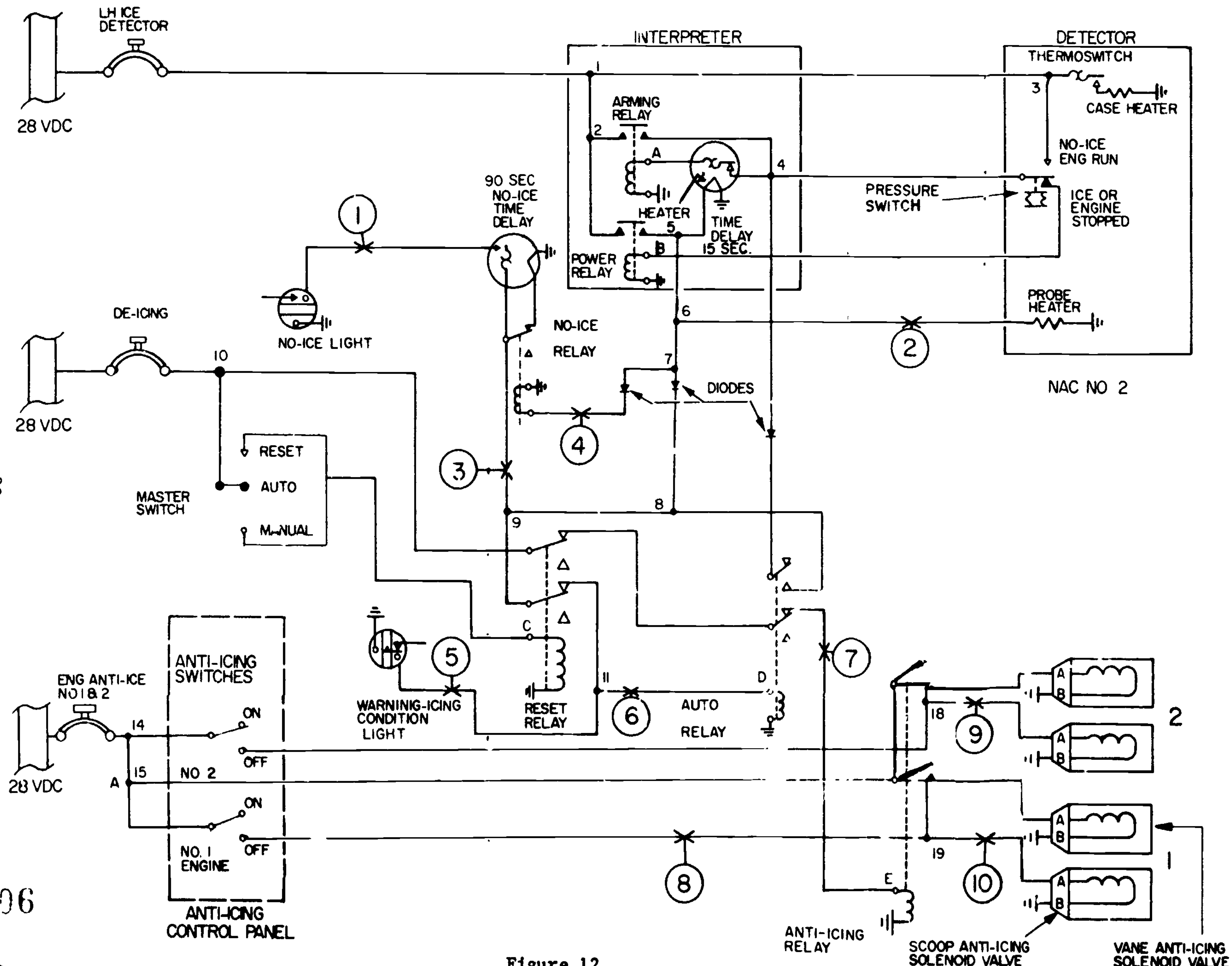
_____5. With the master switch in MANUAL, the No. 1 engine anti-icing valves remain open with the switch in off. The valves close when the master switch is placed in AUTO.

Answers to Frame 18: 1. Reset
2. Reset



LH ICE DETECTOR
28VDC
INTERPRETER
DETECTOR
THERMOSWITCH
CASE HEATER
ARMING RELAY
HEATER
TIME DELAY 15 SEC.
POWER RELAY
NO-ICE ENG RUN
PRESSURE SWITCH
ICE OR ENGINE STOPED
90 SEC. NO-ICE TIME DELAY
DE-ICING
NO-ICE LIGHT
NO-ICE RELAY
PROBE HEATER
28VDC
DIODES
RESET
AUTO
MANUAL
MASTER SWITCH
ANTI-ICING SWITCHES
ENG ANTI-ICE NO 1&2
28 VDC
ON
OFF
NO 2
NO 1 ENGINF
ANTI-ICING CONTROL PANEL
WARNING-ICING CONDITION LIGHT
RESET RELAY
AUTO RELAY
ANTI-ICING RELAY
SCOOP ANTI-ICING SOLENOID VALVE
VANE ANTI-ICING SOLENOID VALVE

Figure 11.



LH ICE DETECTOR
28 VDC
INTERPRETER
DETECTOR
THERMOSWITCH
CASE HEATER
ARMING RELAY
NO-ICE ENG RUN
HEATER
TIME DELAY 15 SEC.
POWER RELAY
PRESSURE SWITCH
ICE OR ENGINE STOPPED
90 SEC NO-ICE TIME DELAY
NO-ICE LIGHT
PROBE HEATER
NAC NO 2
DE-ICING
28 VDC
NO-ICE RELAY
DIODES
RESET
AUTO
MASTER SWITCH
MANUAL
WARNING-ICING CONDITION LIGHT
RESET RELAY
AUTO RELAY
ANTI-ICING SWITCHES
ENG ANTI-ICE NO 1 & 2
28 VDC
ON
OFF
NO 2
NO. 1 ENGINE
ANTI-ICING CONTROL PANEL
ANTI-ICING RELAY
SCOOP ANTI-ICING SOLENOID VALVE
VANE ANTI-ICING SOLENOID VALVE

Figure 12.

PROGRAMMED TEXT

3ABR42331-PT-209

Technical Training

Aircraft Environmental Systems Mechanic

CARGO AIR CONDITIONING SYSTEM

11 June 1984

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

Designed for ATC Course Use.

Do Not Use on the Job.

RGL: 8.8

Environmental/Pneudraulic Branch
Chanute AFB, Illinois

3ABR42331-PT-209

CARGO AIR CONDITIONING SYSTEM

OBJECTIVE

Relate a minimum of 8 out of 10 cargo air conditioning system components to their operation.

INSTRUCTIONS

This programmed text presents information in small steps called "frames". After each step you are asked to select a statement, match items, or answer true or false questions. Read each frame carefully before responding. The correct answers to the questions are located at the back of the text. If you select the correct answers, continue to the next frame. If you are incorrect, read the material again and correct your answers before continuing.

Supersedes 3ABR42331-PT-209, 5 November 1981.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P -1000; DAV - 1

Frame 1

Two separate air conditioning systems supply conditioned air to the interior of the cargo aircraft. The two systems are similar except for flow capacity. The higher-capacity system is used for the cargo compartment and the lower capacity system is used for the flight deck station.

NO RESPONSE REQUIRED

Frame 2

Each air conditioning system cools bleed air entering into it from the bleed air supply system, removes water from the cooled air, and conducts a mixture of hot air and cold air through ducts to outlets in the aircraft compartments. Temperature of the air supplied to the interior compartments is regulated by controlling the ratio of hot air to cold air in the mixture.

Read each statement below, then mark each one either T (true) or F (false).

____ 1. The air conditioning system refrigerates bleed air, removes water from the cooler air, and conducts a mixture of hot air and cooled air through ducts to outlets in the aircraft compartments.

____ 2. The air conditioning system cools ram air, removes water from the ram air, and conducts a mixture of ram air and atmospheric air through ducts to outlets in the aircraft compartments.

____ 3. The temperature of the air supplied to the compartments is regulated by controlling the ratio of hot air to cold air.

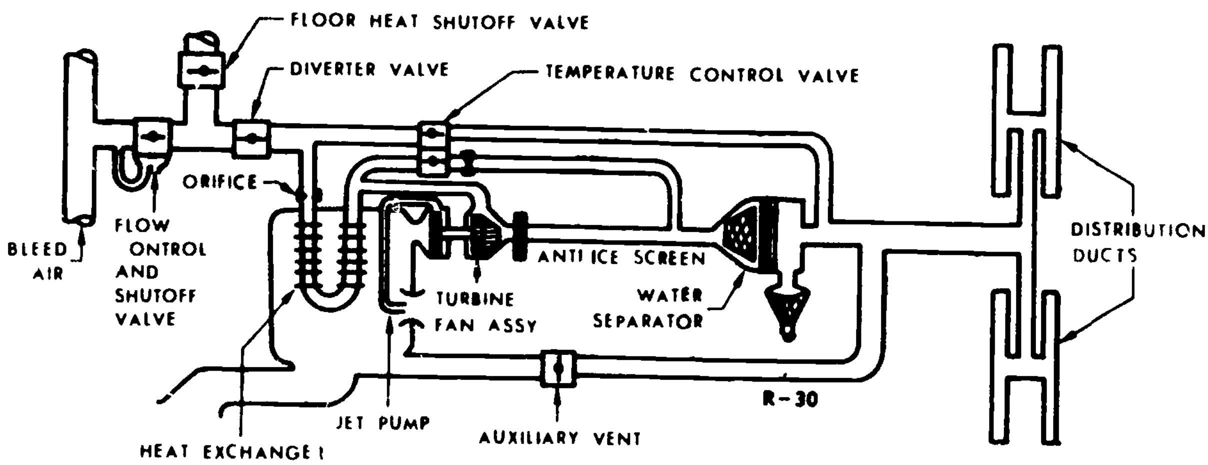
____ 4. The temperature of the air supplied to the compartments is regulated by controlling the ratio of ram air to hot air.

Frame 3

In this package we shall cover the high-capacity (cargo compartment) air conditioning system shown in the schematic below.

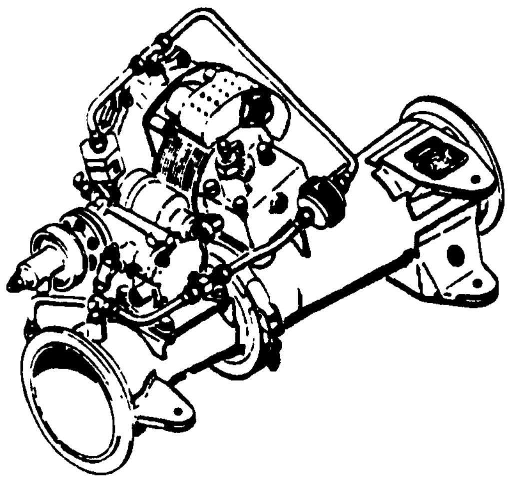
Each air conditioning system consists of a venturi-type flow control and shutoff valve, a refrigeration unit (made up of a heat exchanger, turbine and fan assembly, and jet pump), water separator, anti-ice screen, auxiliary vent valve, and distribution ducts.

The cargo compartment system includes the cargo under floor heating system made up of a floor heat shutoff valve and diverter valve for heating the cargo floor.



NO RESPONSE REQUIRED

A venturi-type flow control and shutoff valve, shown below, is the first unit mounted in the air conditioning system.



This unit is set, by the position of the air conditioning master switch, for three operating conditions:

1. Operation during flight,

2. operation on the ground with the gas turbine compressor (GTC) supplying bleed air,

3. and the shutoff condition when air conditioning or pressurization is not wanted.

During flight operation, or ground operation with the engines operating, the cargo compartment flow control valve maintains nearly a constant flow of 70 pounds per minute (PPM) of air into the cargo compartment.

The GTC supplies only a limited amount of air for ground air conditioning. The cargo compartment flow control is set to throttle flow according to pressure only, regardless of the amount of flow allowed.

The cargo compartment flow control valve is preset to maintain a pressure of 55 inches of mercury in the bleed air system to insure an adequate supply of air to the cargo compartment when the aircraft air conditioning master switch is in the AIR COND GTC position.

With the air conditioning master switch in the OFF position, the cargo compartment flow control and shutoff valve closes and stops the flow of bleed air into the air conditioning system.

Frame 4 (Cont'd)

Read each statement below, then mark each one, either T (true) or F (false).

____ 1. The flow control and shutoff valve is set for three operating conditions by the position of the air conditioning master switch.

____ 2. During flight operation or ground operation with the engines running the flow of 70 pounds per minute is maintained by the flow control and shutoff valve.

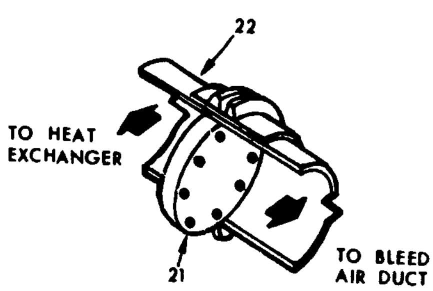
____ 3. When the air conditioning master switch is in the AIR COND GTC position the cargo compartment flow control and shutoff valve insures a pressure of 55 inches of mercury to the cargo compartment.

____ 4. With the air conditioning master switch in the OFF position, the flow control and shutoff valve is closed.

Frame 5

An eight hole orifice (21) is installed in the bleed air duct (22) leading to the heat exchanger.

The orifice is used to drop the air pressure entering the heat exchanger and prevent overspeeding of the turbine.

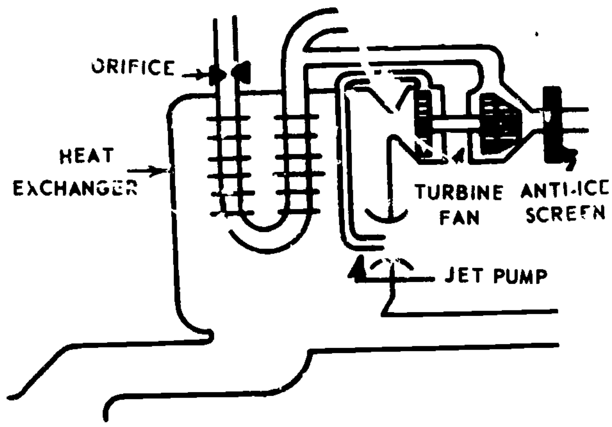


Circle the number of the statement that best describes the purpose of the orifice.

1. The orifice drops the air pressure entering the heat exchanger and prevents overspeeding of the turbine.

2. The orifice restricts the flow of air leaving the heat exchanger.

3. The orifice stops the flow of air entering the heat exchanger.



The cargo air conditioning unit (above) is made up of an air-to air heat exchanger, a turbine and fan assembly, and a jet pump.

Hot bleed air is conducted through dimpled tubes of the heat exchanger. Because outside (ram) air is drawn over the tubes, part of the heat of the bleed air is lost to the ram air which is exhausted overboard from the heat exchanger.

Circle the number of the statement that best describes the purpose of the heat exchanger.

1. The heat exchanger reduces the temperature of the bleed air by transferring heat ` ram air.

2. The heat exchanger reduces the temperature of the ram air by transferring heat to bleed air.

3. The heat exchanger increases the temperature of the bleed air by transferring heat from the ram air.

Frame 7

Ram air is drawn over the tubes of the heat exchanger by the fan of the turbine and fan assembly and a jet pump. Only a small part of the ram air passes through the fan. This part of the air is forced out at high speed through the jet pump.

The jet pump creates a low pressure area in the heat exchanger exhaust which draws a large volume of ram air through the heat exchanger.

The fan, by drawing ram air across the heat exchanger, puts a load on the turbine to keep it from overspeeding. Bleed air, partially cooled by flowing through the heat exchanger, is fed through a duct to the turbine. The high pressure air strikes the turbine blades to drive the wheel at high speed. The warm, high pressure air thus loses its heat energy by converting heat energy to mechanical energy and by rapid expansion of the air. Not all the air is cooled.

Air can flow through the turbine bypass or the refrigeration unit bypass. The amount of air flowing through the heat exchanger and turbine depends on cooling requirements established by the temperature control system.

NO RESPONSE REQUIRED

Read each statement below, then mark each one either T (true) or F (false).

____ 1. The jet pump creates a low pressure area in the heat exchanger exhaust which draws a large volume of ram air through the heat exchanger.

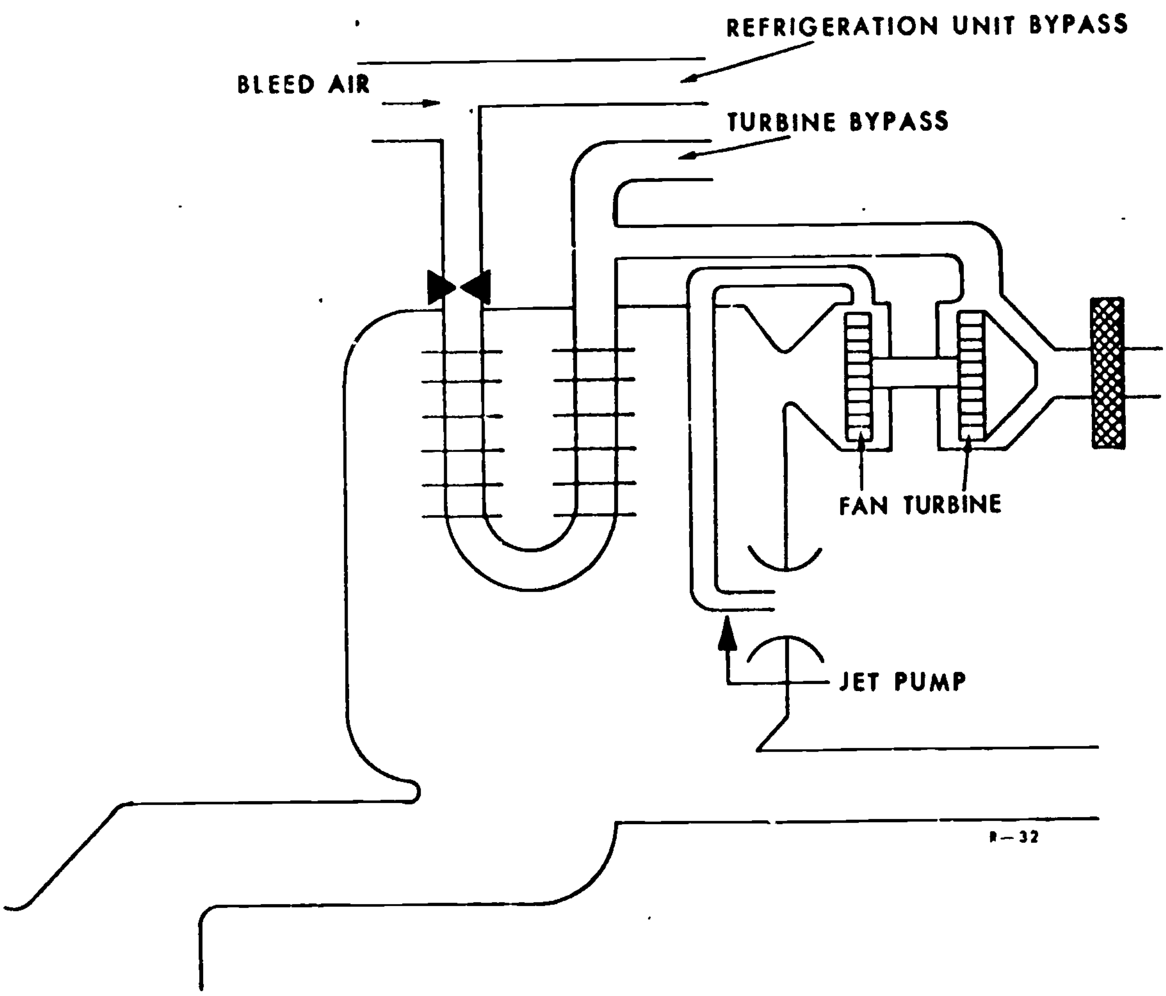
____ 2. The fan by drawing ram air across the heat exchanger, puts a load on the turbine to keep it from overspeeding.

____ 3. The turbine cools ram air by converting heat energy to mechanical energy and by rapid expansion.

____ 4. All the bleed air is cooled.

____ 5. The temperature control system establishes the cooling requirements.

____ 6. The amount of air blown through the heat exchanger and turbine depends upon the cooling requirements established by the temperature control system.

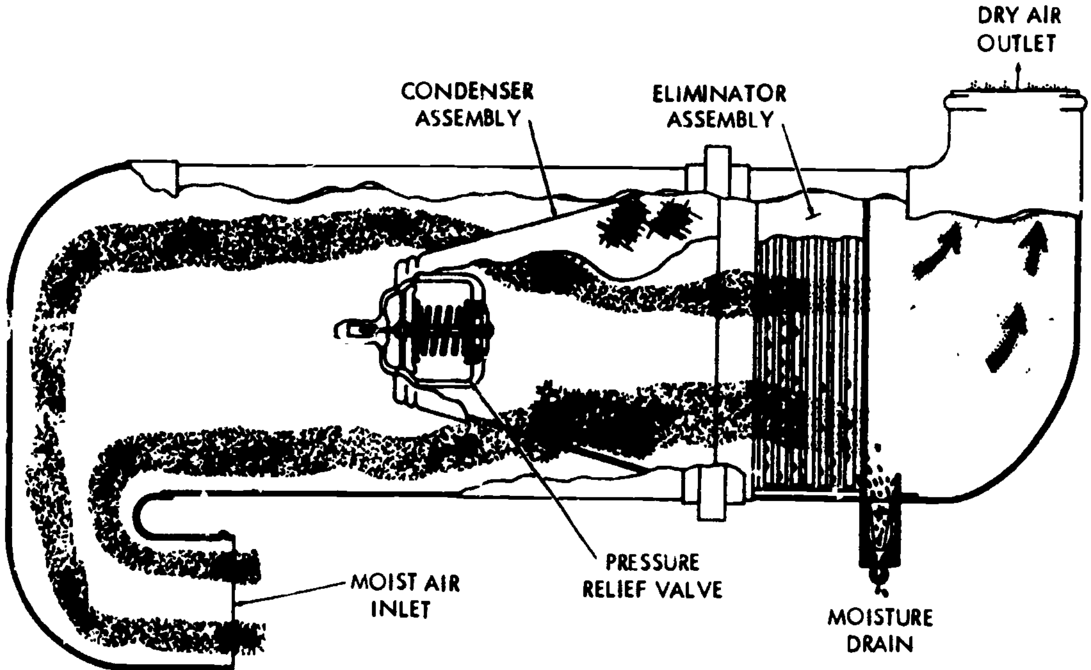


Frame 9

The condenser-eliminator type of water separator shown below is used to remove 70 to 85 percent of the water from the cooled air.

A conical fiberglas bag (condenser assembly) is used to condense the fog in the cooled air to water droplets. These water droplets are carried with the air to the eliminator section. Here they collect into larger drops, run to the bottom of the unit, and out through the moisture drain.

A bypass valve (pressure relief valve) is installed in the nose of the condenser to provide an alternate path for the air if ice or any other substance clogs the fiberglas condenser bag.



CARGO COMPARTMENT WATER SEPARATOR

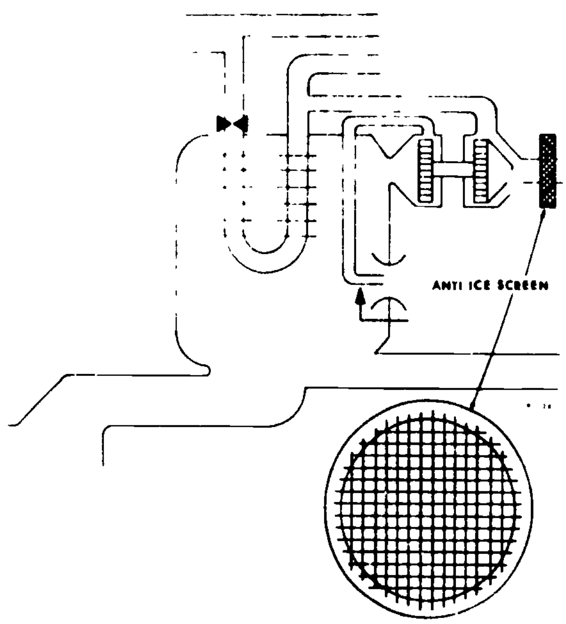
Read each statement below, then mark each one either T (true) or F (false).

____ 1. The water separator removes 70 to 85 percent of the water from the cooled air.

____ 2. A conical wire screen is used to condense the fog in the cooled air to water droplets.

____ 3. The water droplets collect into larger drops inside the eliminator assembly, run to the bottom of the separator, and drain out through the moisture drain.

____ 4. The pressure relief valve provides an alternate path for the air if ice or any other substance clogs the fiberglas condenser bag.



Anti-Ice Screen.

Icing of the water separator is prevented by an anti-ice control screen shown above. The screen is mounted in the turbine discharge duct. If the temperature of the turbine discharge air is at the freezing point and the air contains enough water, ice forms on the screen.

The ice partly blocks the screen area to cause a pressure drop across the screen, reducing airflow through the turbine. When the airflow through the turbine reduces, the speed of the turbine is also reduced. With the speed of the turbine reduced, less cooled air is produced, allowing the temperature of the turbine discharge air to rise.

When the temperature reaches the melting point for the ice on the screen, the turbine speed increases again. In this way the turbine discharge temperature is maintained at the exact freezing point for the water in the air.

Read each statement below, then mark each one either T (true) or F (false).

____ 1. The anti-ice screen prevents icing of the water separator.

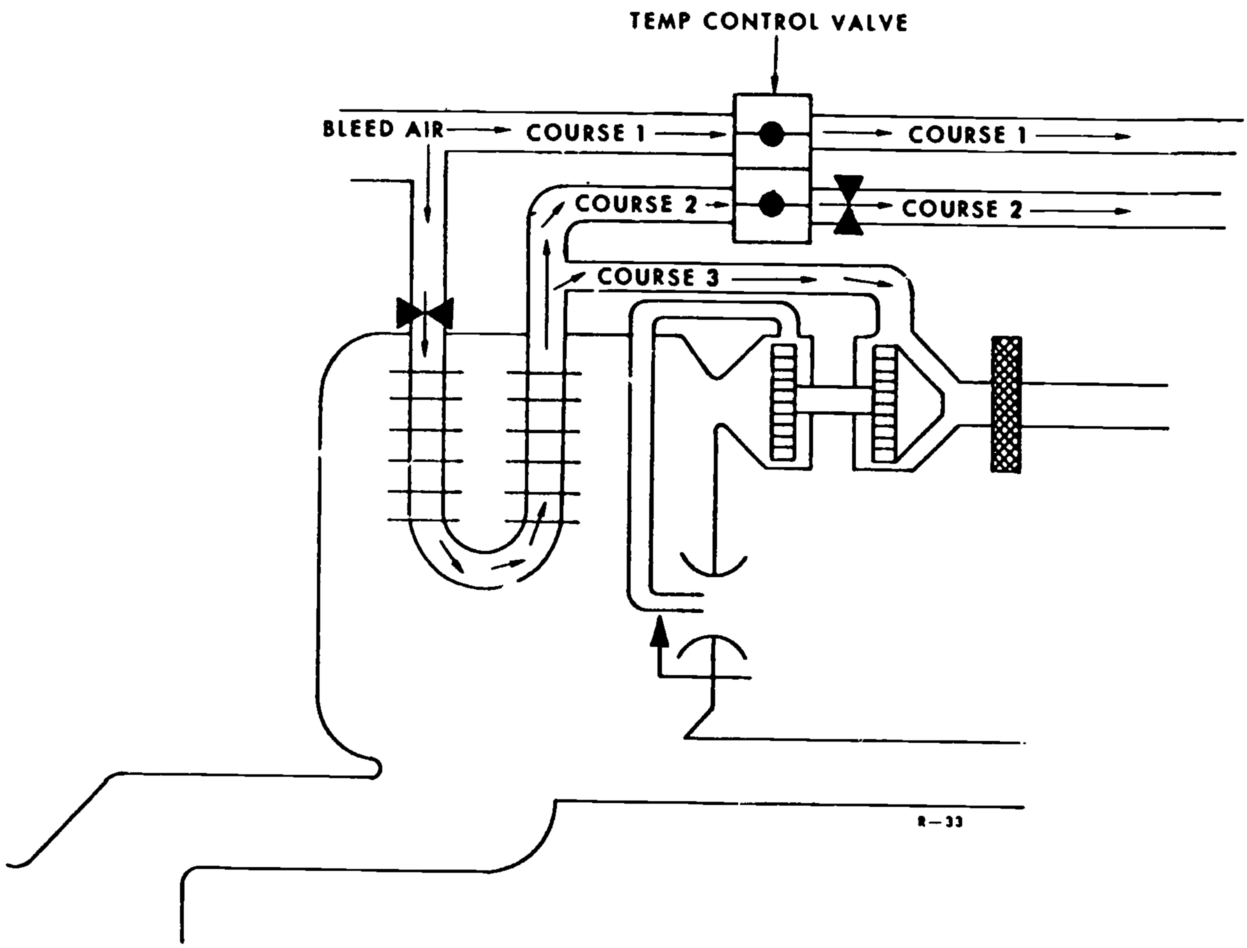
____ 2. The speed of the turbine will decrease when the anti-ice screen ices up.

____ 3. Reducing the speed of the turbine will reduce the temperature of the turbine discharge air.

____ 4. The airflow through the turbine is reduced when ice partly blocks the anti-ice screen area.

Frame 11

When bleed air flows through the cargo compartment air conditioning system, it follows three courses as shown in the schematic below.



COURSE 1: The bleed air flows directly to the overhead outlets without being cooled.

COURSE 2: The bleed air is directed through the heat exchanger, but not the turbine.

COURSE 3: The air is directed through the turbine of the turbine and fan assembly.

The air flowing from all these courses is mixed, and the mixture flows through the overhead outlets to the cargo compartment. The temperature control valve is operated to distribute the bleed airflow to these paths, thus it controls the temperature of the mixture distributed through overhead outlets to the cargo compartment.

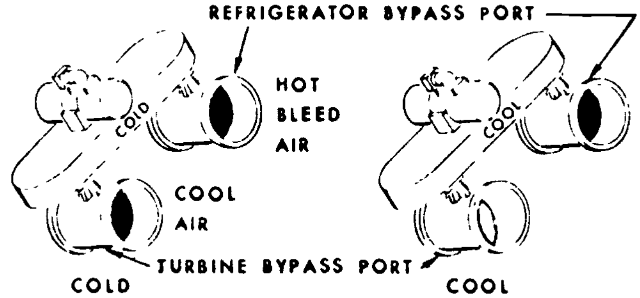
Read each statement below, then mark each one either T (true) or F (false).

____ 1. There are three paths for bleed air to flow through in the air conditioning system.

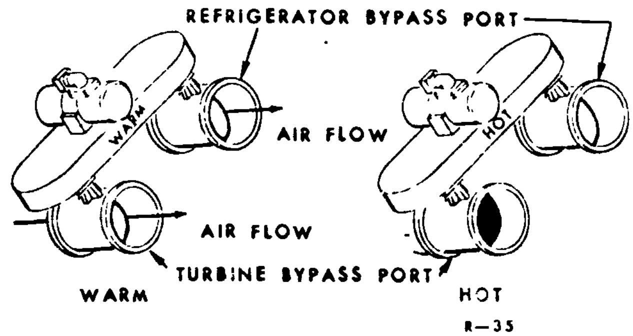
____ 2. The temperature control valve controls the mixture of air distributed through the overhead ducts by controlling the airflow through three (3) paths.

____ 3. To get hot air, the bleed air must go through the turbine of the turbine and fan assembly and then be distributed through the overhead outlets to the cabin.

Frame 12



DUAL BUTTERFLY TEMP. CONTROL VALVE POSITIONS



The temperature control valve, shown above, is a dual unit with one butterfly in the refrigerator bypass and another in the turbine bypass.

The two butterflies, actuated by an electric motor are positioned as follows:

	COLD	COOL	WARM	HOT
Turbine Bypass	CLOSED	OPEN	OPEN	CLOSED
Refrigerator Bypass	CLOSED	CLOSED	OPEN	OPEN

This valve is controlled by the temperature control system.

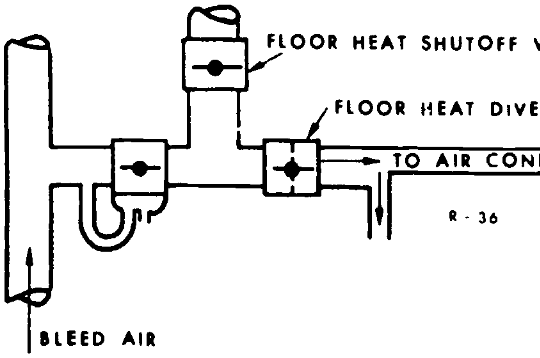
Read each statement below, then mark each one either T (true) or F (false).

____ 1. To get cold air, both the turbine bypass port and the refrigerator bypass port are closed.

____ 2. To get hot air, the refrigerator bypass port is open and the turbine bypass port is closed.

____ 3. To get warm air, the refrigerator bypass port is closed and the turbine bypass port is open.

____ 4. To get cool air, the refrigerator bypass port is open and the turbine bypass port is open.



The floor heat diverter valve is part of the under-floor heat system.

The diverter valve controls the diversion of bleed air flow from the cargo compartment air conditioning system to the floor heating system.

The diverter valve is used to maintain a comfortable temperature during operation of the aircraft at low outside ambient temperature.

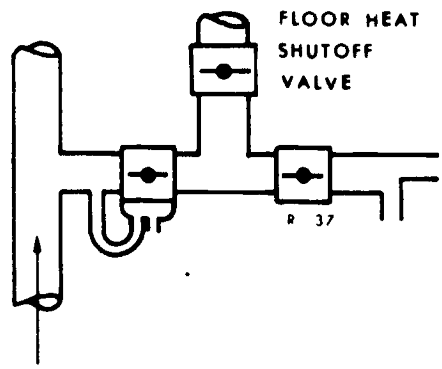
This valve is controlled by the under-floor heat temperature control system.

Circle the number of the statement that best describes the purpose of the floor heat diverter valve.

1. The floor heat diverter valve, diverts the flow of bleed air from the cargo compartment air conditioning system to the under-floor heating system.

2. The floor heat diverter valve turns the cargo compartment air conditioning system on and off.

3. The floor heat diverter valve stops the flow of air entering the cargo compartment air conditioning system.

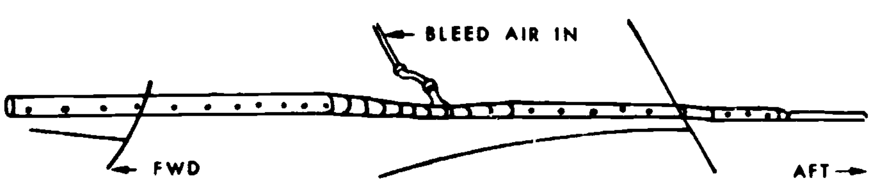


The floor heat shutoff valve is moved to the OPEN position when the under-floor heating switch is placed in the ON position.

Opening the floor heat shutoff valve allows bleed air to flow to an ejector (see the schematic below), installed under the cargo floor.

The bleed air is routed forward and aft through nozzles in the ejector (see the schematic below), into mixing chambers where bleed air is mixed with ambient temperature air from the floor cavity.

The air is then routed through distribution manifolds extending the length of the cargo compartment floor.



EJECTOR NOZZLE

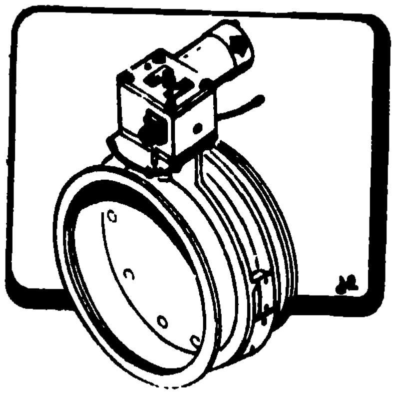
Read each statement below, then mark each one either T (true) or F (false).

____1. Opening the floor heat shutoff valve will allow bleed air to flow to an ejector under the cargo compartment floor.

____ 2. Bleed air is routed forward and aft through nozzles in the ejector into mixing chambers where it is mixed with ambient temperature air from the floor cavity.

____3. Opening the floor heat shutoff valve will position the cargo compartment temperature control valve.

____ 4. Opening the floor heat shutoff valve will remove moisture from the refrigerated air.



The auxiliary vent valve is a 28 volt DC motor actuated valve located at the ram air inlet.

This valve is controlled by the air conditioning system master switch, a differential pressure switch, and a relay.

The master switch is pos. oned in "AUX VENT" to close a circuit that energizes the relay. The relay applies DC voltage to the valve motor to open the valve.

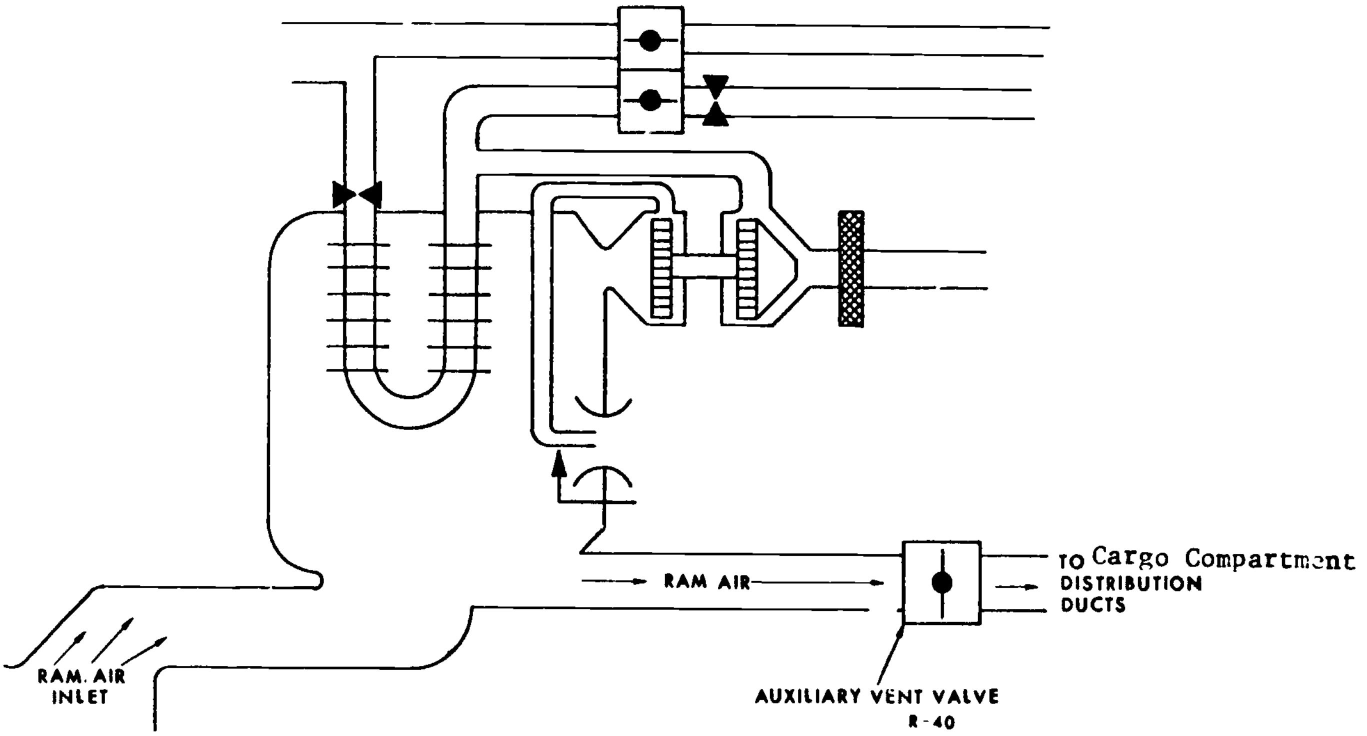
Circle the number of the statement that best describes the method of controlling the auxiliary vent valve.

1. The auxiliary vent valve is controlled by the cargo compartment shutoff switch, a relay, and an emergency depressurization switch.
2. The auxiliary vent valve is controlled by an air conditioning master switch, a differential pressure switch, and a relay.
3. The auxiliary vent valve is controlled by the "Ram-Dump" position of the cabin pressure switch.

Frame 16

The auxiliary vent valve is used to ventilate the aircraft in flight at low altitudes. It is also used to supply conditioned air to the cabin from external air conditioners when the aircraft is on the ground.

In flight, the ram air entering the heat exchanger ram air inlet is used to ventilate the aircraft in case the cabin air conditioning unit breaks down.

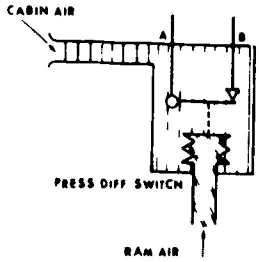


Circle the number of the statement that best describes the purpose of the auxiliary vent valve.

1. The auxiliary vent valve is used to ventilate the fuselage.

2. The auxiliary vent valve is used to ventilate the aircraft in flight at low altitudes and to supply conditioned air to the cabin from external air conditioners when the aircraft is on the ground.

3. The auxiliary vent valve is used to ventilate the electronic compartment at low altitudes and to supply conditioned air to the electronic compartment from external air conditioners.



The pressure switch, shown above, is in the auxiliary vent valve electrical circuit.

It opens its contacts when cargo compartment pressure exceeds ram air pressure in the heat exchanger ram air inlet by more than 0.28 psi.

While the switch contacts are open, the auxiliary vent valve relay cannot be energized, so the valve cannot be opened.

The purpose of the switch is to prevent collapse of the air conditioning distribution ducts resulting from differential pressure across the duct walls. This differential pressure would occur if the auxiliary vent valve was opened while the aircraft was pressurized.

Read each statement below, then mark each one either T (true) or F (false).

____ 1. The pressure switch opens its contacts when ram air pressure exceeds cabin pressure.

____ 2. While the pressure switch contacts are open, the auxiliary vent valve relay cannot be energized and the valve cannot be opened.

____ 3. The pressure switch prevents a collapse of the air conditioning distribution ducts resulting from differential pressure across the duct walls.

____ 4. The pressure switch operates on a differential pressure of more than 0.28 psi.

Correct Responses to all Frames.

Frame 2

1. T
2. F
3. T
4. F

Frame 4

1. T
2. T
3. T
4. T

Frame 5

1

Frame 6

1

Frame 8

1. T
2. T
3. F
4. F
5. T
6. T

Frame 9

1. T
2. F
3. T
4. T

Frame 10

1. T
2. T
3. F
4. T

Frame 11

1. T
2. T
3. F

Frame 12

1. T
2. T
3. F
4. F

Frame 13

1

Frame 14

1. T
2. T
3. F
4. F

Frame 15

2

Frame 16

2

Frame 17

1. F
2. T
3. T
4. T

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Technical Training

Aircraft Environmental Systems Mechanic

CARGO AIR CONDITIONING SYSTEM WIRING DIAGRAM

14 September 1981

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

CARGO AIR CONDITIONING SYSTEM WIRING DIAGRAM

OBJECTIVE

Using a wiring diagram, specify eight causes for the ten given air conditioning system electrical troubles.

EQUIPMENT

Colored Pencil Set
3ABR42331-WB-209

PROCEDURE

Figure 1 is located in the back of this booklet. The circuits you will be tracing in this text are listed in the lower left corner of figure 1. The color code you are to use for each circuit is shown in the block before each circuit. Follow directions carefully and do all the steps. Do not trace ahead of what you have read. The diagram used in this project is the same diagram you will use on the cargo air conditioning system trainer, when you troubleshoot that trainer. If you do not understand the circuit after tracing, check with your instructor.

Note: In this diagram we are tracing current from the circuit breakers to the components ground. This is not the way current flows, but it is the easiest because of so many ground points in the diagram. Remember this note when using any wiring diagram.

POWER CIRCUIT

1. Use your RED pencil to trace this circuit. Current flows from the 28V DC temperature control circuit breaker over wire 2H200A20 to pin N of bulkhead connector #2. It continues on wire 2H200B20 to the pole of the master air conditioning switch.

2. This is the system power circuit. All power for automatic and manual temperature control comes from this wire.

Note: You will trace circuits for the following functions of the air conditioning system. Manual Warm with GTC, Manual Cool in Air Conditioner and Pressure Position Automatic Warm, and Automatic Cool. Even though current is distributed over numerous other circuits, only those circuits required for a particular function will be traced.

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OPR: 3370 TCHTG
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3370 TCHTG/TTGU-P - 1000; DAV - 1

MANUAL WARM WITH GTC

1. Use your BLUE pencil to trace this circuit. First, draw the master air conditioning switch contact lever to the air conditioning GTC position.

2. Current flows over wire 2H201D20 to pin M on bulkhead connector #2. Current flows out pin M on wire 2H201E20 and over to terminal #1 on terminal strip #2.

3. It leaves terminal #1 on two wires. Current flows over wire 2H201G20 to pin A on the cabin thermostat blower. Then current flows out pin B on wire 2H207A20N to ground. The blower now operates.

4. Go back to terminal #1. Current also flows over wire 2H201F20 to pin C on the control box electrical connector #1.

5. It flows from pin C to point A inside the temperature control box. Here current flows in two directions.

6. First, it flows to point B where it flows in many directions again. Current continues to pole X1 on the more heat relay. The relay is not energized yet, so current flow stops at this point.

7. Going back to point B, current flows through both R1 and R2 to energize both the more heat and less heat relays.

8. Because we are concerned with the more heat relay, draw the contact levers on X1 and X2 to the energized position (contacts 1 and 3). This is as far as we will go for now.

9. Going back to point A, current flows to point C and out to pin F of the control box electrical connector #1.

10. It leaves pin F on wire 2H202A20 and flows to terminal #2 on terminal strip #2. From here it flows over wire 2H202B20 to pin H on bulkhead connector #2.

11. Current flows to the temperature control switch on wire 2H202C20. Draw the temperature control switch to the manual warm position.

12. Now current flows over wire 2H203C20 to pin G on bulkhead connector #2. It leaves pin G on wire 2H203B20 and flows to terminal #5 on terminal strip #2. Current flows from terminal #5 on wire 2H203A20 to pin E on the control box electrical connector #1.

13. Current flows inside the control box to X2 of the more heat relay. We are tracing only necessary circuits so we will not tap off current from this wire. The more heat relay is energized so current flows from X2, over contact 3, and out pin B on the control box electrical connector #1.

14. It leaves pin B on wire 2H212A20 and flows to pin B on the temperature control valve. Current flows through the valve motor and out pin C on wire 2H214A20N to ground. The temperature control valve now runs to warm, which was your selection.

MANUAL COOL IN AIR CONDITIONER AND PRESSURE POSITION

1. Again we are going to trace only the necessary circuits. Use your GPEEN pencil to trace this circuit.

2. First, draw the master switch to the air conditioner and press position. All the air condition positions of the master switch go to the same wire so this is the last time you will change positions on the master switch.

3. Current flows from the master switch on wire 2H201D20 to pin M on bulkhead connector #2. From here it flows over wire 2H201E20 to terminal #1 on terminal strip #2.

4. Again current flows over wire 2H201G20 to run the cabin thermostat blower. It also flows over wire 2H201F20 to pin C on the #1 electrical connector.

5. Current continues to point A inside the control box and then to point C. From point C it flows to pin F on the #1 electrical connector and out on wire 2H202A20 to terminal #2 of terminal strip #2.

6. urrent leaves terminal #2 on wire 2H202B20 and flows to pin H on bulkhead connector #2.

7. It l aves on wire 2H202C20 and flows to the temperature control switch pole. You want manual cool, so current flows to the cool contact, and over wire 2H213C20 to pin C on bulkhead connector #2.

8. Here, it leaves on wire 2H213B20 and flows to terminal #6 on terminal strip #2. Current leaves terminal #6 on two wires, but the one we are concerned with is wire 2H213D20.

9. Current flows over wire 2H213D20 to pin A on the temperature control valve. It continues through the valve motor and out pin C on wire 2H214A20N to ground. The temperat. e control valve now runs toward cool which is what you selected.

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AUTOMATIC WARM

Note: The temperature selector does not directly control the temperature control valve's operation. Instead, it controls the amount of current going to the mercury thermostat heater. This thermostat, in turn, controls the cabin relay which controls the temperature control valve's operation. As you go through this circuit, you will see how this is done.

1. Use your BLACK pencil to trace this circuit. The master switch is still in the air conditioner and pressure position, so current flows over wire 2H201D20 to pin M on bulkhead connector #2.

2. Current leaves pin M on wire 2H201E20 and flows to terminal #1 on terminal strip #2. Again current flows to the blower which causes it to operate.

3. Current also leaves terminal #1 on wire 2H201F20 and flows to pin C on the temperature control Box #1 electrical connector.

4. From here it flows to point A inside the control box where it will flow in two directions.

5. First, trace the current up to point B. At this point you want current to flow through R1 and R2 to energize the more heat and less heat relays. Current also flows over both tap-off wires and out pins H and G on the #1 electrical connector to the anticipator thermostat. Here current flow stops.

6. Now, let's go back to point A. Current flows from here through point C, down to point D. Here again current flows in two directions.

7. For now current flows from point D to point E, through R3 to point F. Remember, we are tracing only necessary circuits.

8. At point F, current flows in two directions. It flows up to energize the cabin relay and down to point G. From point G current goes in two directions.

9. First, it flows down and out pin D on #2 electrical connector and over to pin C on the control thermostat. Current flow stops at this point for now.

10. Going back to point G, current also flows out pin A on #2 electrical connector to pin B on the high limit thermostat. Here current flow stops again for the time being. You now have all three relays energized, so draw the contact levers to the energized position.

11. Going back to point C, current flows from point C to point F on electrical connector #1. From here it flows over wire 2H202A20 to terminal #2 on terminal strip #2.

12. From here it flows on wire 2H202B20 to pin H on the bulkhead connector #2. Current leaves pin H on wire 2H202C20 and flows tc the temperature control switch, which is in the automatic position.

13. Current now flows over wire 2H204C20 to pin F on bulkhead connector #2. Fro F it flows over wire 2H204B20 to terminal #7 on terminal strip urrent leaves terminal #7 on wire 2H204A20 and flows to pin D on electrical connector #1.

14. From here it flows insioe the control box and comes to X2 on the cabin relay. Since the relay is energized, current continues to contact 10 and up to point J.

15. From point J, current flows to X2 on the more heat relay. This relay is also energized, so current flows over contact 3 and out to pin B on electrical connector #1.

16. It leaves pin B on wire 2H212A20 and flows to pin B on the temperature control valve. Current continues through the valve motor and out to ground. This causes the valve to run toward hot. To determine how far the valve runs toward hot, go back to point D inside the temperature control box.

17. Current continues down from point D and out to pin F on electrical connector #2. It leaves pin F on wire 2H206A20 and flows to terminal #3 on terminal strip #2.

18. It leaves terminal #3 on wire 2H206B20 and flows to pin K on bulkhead connector #2. From here current flows over wire 2H206C20 to the temperature selector.

19. The temperature selector is toward the warm position so this puts more resistance into the circuit. This resistance causes a voltage drop as current flows through the selector. This current, at the reduced voltage, comes out wire 2H205C20 to pin J on bulkhead connector #2.

20. It leaves pin J on wire 2H205B20 and flows to terminal #4 on terminal strip #2. Current leaves terminal #4 on wire 2H205A20 and flows to pin G on the control box electrical connector #2.

21. From pin G current flows inside the control box, over R5, and to point H. From point H, it flows out pin E on electrical connector #2.

22. Current flows from pin E on wire 2H219A20 to pin B on the control thermostat. This current flows through the thermostat heater and out to ground. This heats the mercury inside the thermostat and causes it to rise. As the mercury rises, it makes contact with the 110° wire from pin C on the thermostat.

23. The potential on this wire is then grounded to the thermostat heater ground. The voltage that energized the cabin relay now has a path of less resistance to follow so the cabin relay deenergizes.

24. With this relay deenergized, you lose power at contact 10 and also to the hot side of the temperature control valve. Now the valve stops operating.

25. You have controlled the movement of the temperature control valve by controlling the amount of voltage going to the thermostat heater. If more voltage had been applied to the heater, the running time of the valve toward hot would have been much shorter.

In the next and last circuit, we will continue from where you are now and see how this system will call for a cool temperature.

AUTOMATIC COOL

Note: Use your PURPLE pencil to trace this circuit. If the temperature selector were set to cool, this would increase the amount of voltage going to the control thermostat heater, and, in turn, would deenergize the cabin relay much faster. With this in mind, we will continue with Auto-Cool

1. Start with current flow at point B inside the control box. Current flows from point B to X1 on the more heat relay. This relay is still energized, so current flows from X1 to contact #1 and over to the less heat relay.

2. It then flows from X1 on the less heat relay and since the relay is still energized, over to contact #5.

3. From here current flows to pin I on electrical connector #1. It then continues from pin I on wire 2H208A20 to pin B on the anticipator thermostat. Current continues through the thermostat heater and out to ground making a complete circuit.

4. This heater, along with duct temperature, starts the mercury rising inside the thermostat. While the mercury is rising, current is flowing from point E, inside the control box, to X1 of the cabin relay. This relay is deenergized, so current flows from X1 to contact #11 and over to X2 on the less heat relay. At this time the current cannot continue because the less heat relay is energized.

5. By now the mercury in the anticipator thermostat has risen enough to make contact with the potential at the 380° wire. This now completes a circuit through the mercury and heater ground wire. This deenergizes the more heat relay. Now power is removed from the hot side of the temperature control valve.

6. The heater on the anticipator thermostat is still in operation, so the mercury rises until it comes in contact with the 400° wire. Now the less heat relay will deenergize. The current at X2 on the less heat relay will flow over contact #8 and out to pin A of electrical connector #1. From here it flows over wire 2H213A20 to terminal #6 on terminal strip #2, and then over wire 2H213D20 to pin A of the temperature control valve. Current continues through the valve motor and out to ground. The circuit is now completed and the valve will run toward the cool position.

STOP AND SEE INSTRUCTOR. Instructor's Initials ________

PRACTICE EXERCISE:

In the following practice exercises you will be given a cause. You are to find the proper discrepancy. Problem #1 explains the proper procedure for finding the discrepancy. If you have any questions during the practice exercises, you may ask your instructor for assistance.

#1. The cause reads: An open in wire number 2H206C20. This wire is in the circuit of the temperature selector. You can see that in AUTOMATIC if you increase the resistance in the temperature selector, you will receive warm air from the temperature control valve. If you lower the resistance, you will receive cool air. Therefore, an open in wire 2H206C20 would raise the resistance and you will receive warm air. The proper discrepancy would read: Full warm air in AUTOMATIC.

#2. CAUSE: An open in wire number 2H204C20. DISCREPANCY: ____________

____.

#3. CAUSE: An open in wire number 2H200B20. DISCREPANCY: ____________

____.

This concludes the practice exercises. If you have no questions, inform your instructor that you are ready for the performance test.

ANSWERS TO PRACTICE EXERCISE PROBLEMS:

#1. Full hot air in AUTOMATIC.

#2. AUTOMATIC is inoperative.

#3. Temperature control valve is inoperative in AUTOMATIC and MANUAL.

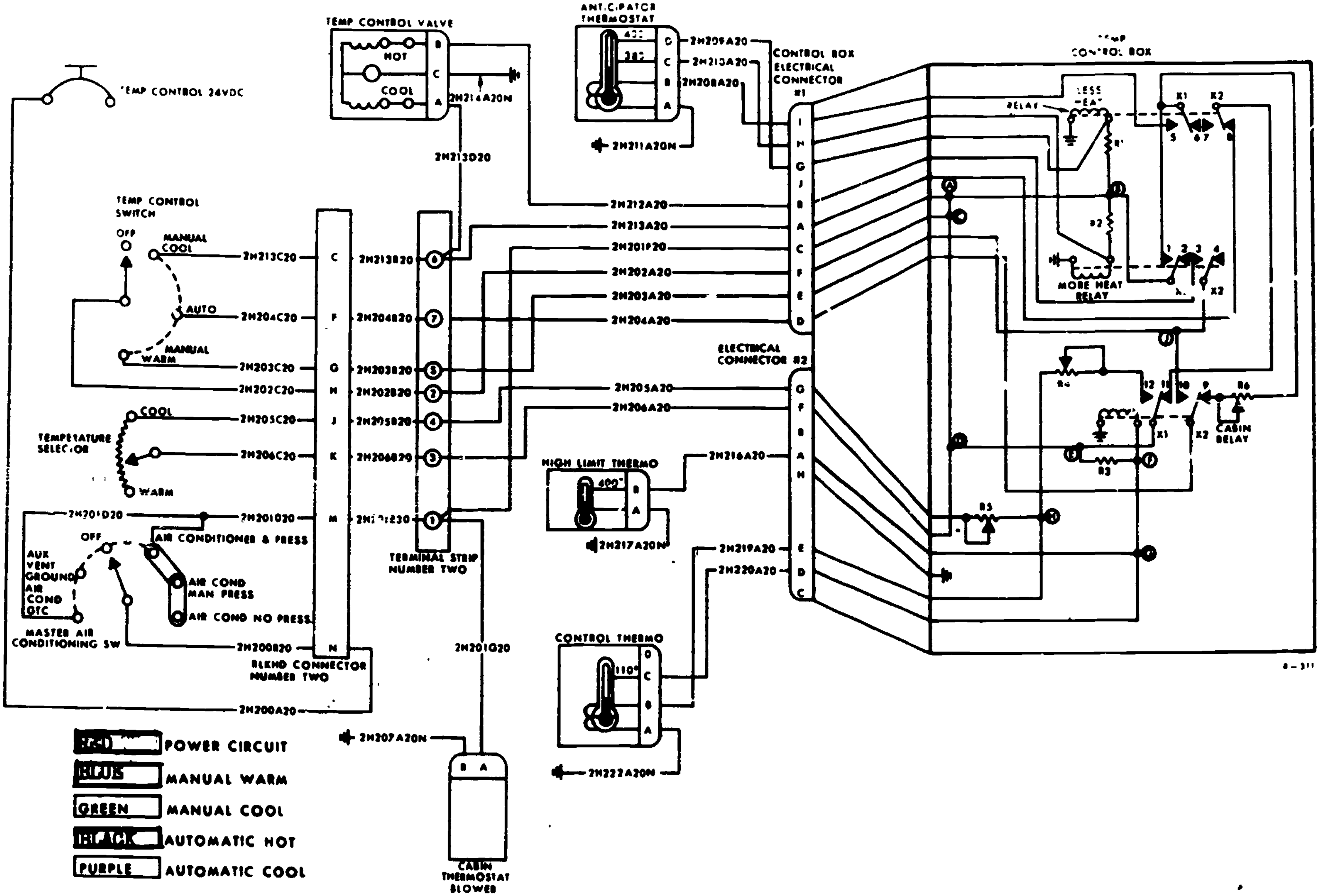

Figure 1.

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Technical Training

Aircraft Environmental Systems Mechanic

MERCURY THERMOSTAT TEMPERATURE CONTROL SYSTEM

11 June 1984

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE

DO NOT USE ON THE JOB

RGL: 9.7

OBJECTIVES

Relate eight out of ten mercury thermostat temperature control system components to their operation.

INSTRUCTIONS

This text presents material in small steps called "frames". Read the material presented in each frame and answer the questions at the end of the frame. Also answer the questions in the review exercises throughout the text and then check your responses with the correct answers found at the top of the next frame or as specified. If you are wrong or in doubt, restudy the material and correct your answers before continuing.

Frames 9 thru 15 require that you use an overlay transparency. You can get this transparency from your instructor when you reach frame 9.

Supersedes 3ABR42331-PT-209A, 9 November 1983.
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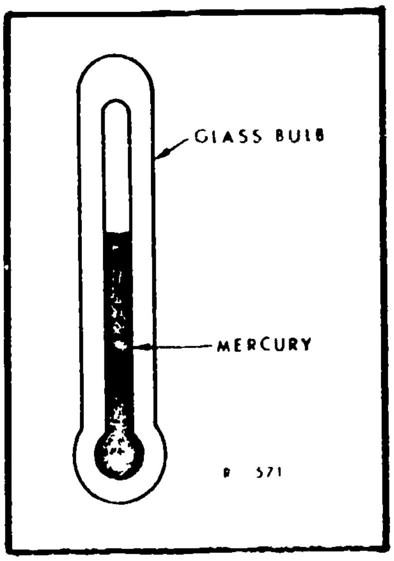
3370 TCHTG/TTGU-P - 300; DAV - 1

Frame 1

In this lesson you will learn how mercury thermostats can be used to control the temperature of conditioned air in the aircraft.

A mercury thermostat can be compared with an ordinary thermometer which you would use at home to take your temperature or to find the temperature on any day. It works on the principle that mercury expands (rises) when heated and contracts (falls) when cooled.



No Response Required

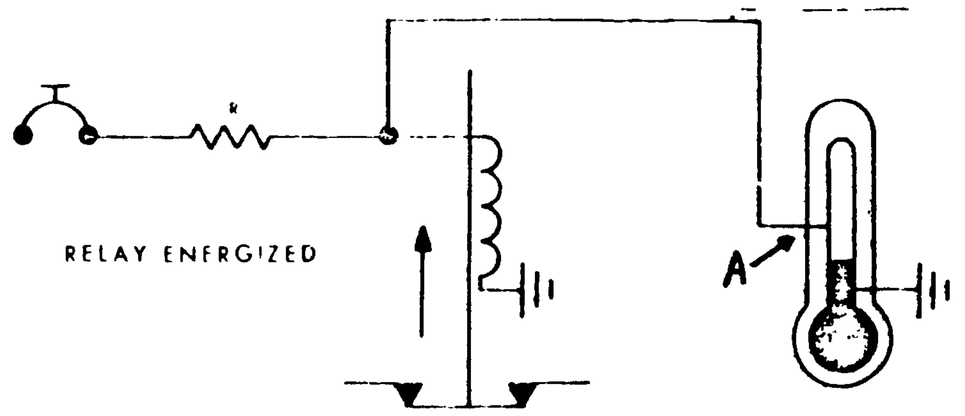
Frame 2

Now we will take a thermostat, add some wire and show you a simple thermostat control circuit.

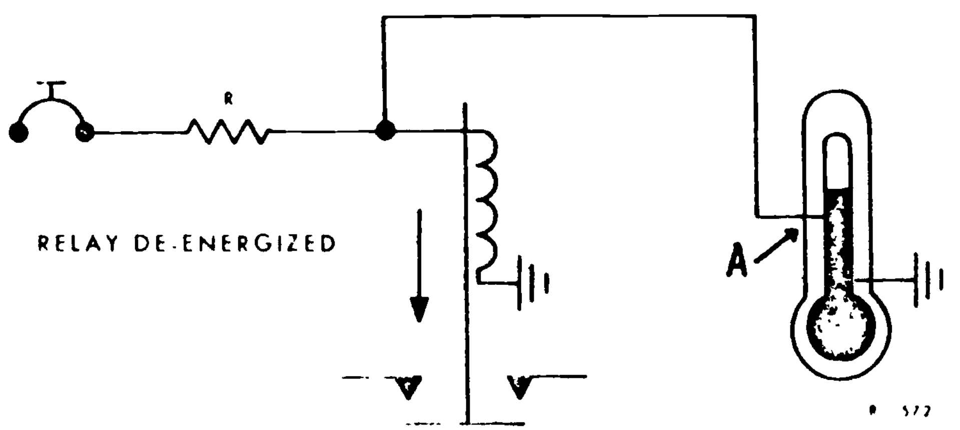
REMEMBER: Mercury inside a thermostat rises when heated.

Mercury is a good electrical conductor.

Current will follow the path of least resistance.



If the mercury is <u>below</u> the contact wire (Point A) the relay will be <u>energized</u>. This is because the circuit between Point A and the thermostats ground is open.



If mercury rises to the contact wire (Point A) then the relay will be deenergized. This is because the thermostat has provided an easier path (less resistance) to ground than the relay.

The temperature of the air in the aircraft causes the mercury to rise or fall within the thermostat. Hot air causes mercury to rise and cold air causes mercury to fall.

Mark the following statements either T (true) or F (false).

1. _____ Mercury is a good electrical conductor.

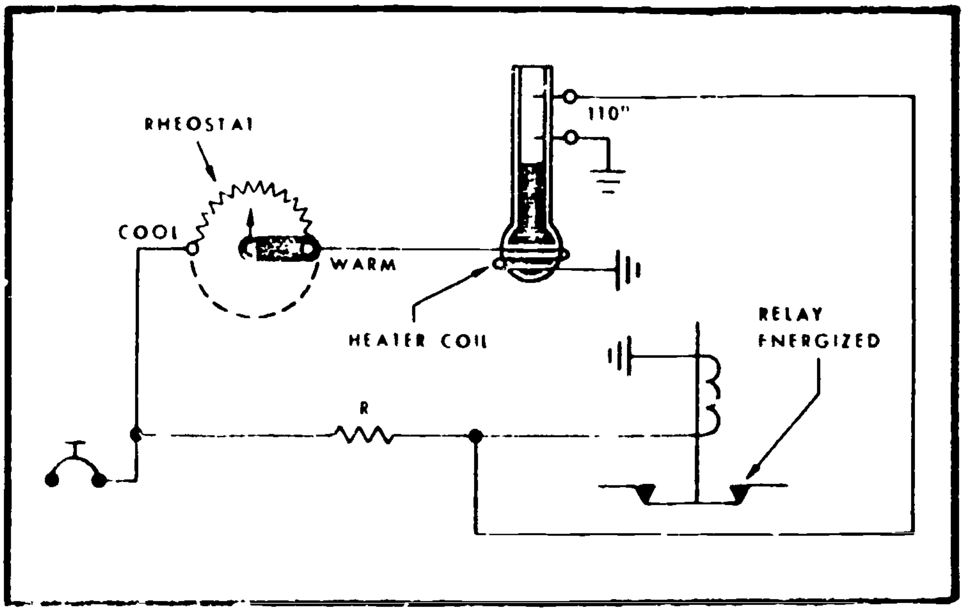
2. _____ Current takes the path of least resistance

3. _____ If the mercury reaches the contact wire then the relay will deenergize because the relay has <u>less</u> resistance.

Answers to Frame 2: 1. T 2. T 3. F

Frame 3

Now let's say that we want to complete a circuit through a thermostat but the air is not warm enough to raise the mercury to the contact wire. To raise the mercury we add a "heater" to the thermostat.



The heater is made of a small wire wrapped around the base of the thermostat. The heat that is generated by allowing current to flow through the heater coil will cause the mercury to rise. A variable resistor or rheostat is used to control the amount of current being applied to the heater.

If the rheostat is moved toward cool, the resistance in the heater circuit decreases and the current applied to the heater increases. Thus, more heat will be given off by the heater and the mercury rises faster.

If the rheostat is moved toward warm, the resistance in the heater circuit increases and the current applied to the heater decreases. Thus, less heat will be given off by the heater and the mercury will rise slower.

By using the rheostat and heater we can control the movement of mercury inside the thermostat and in turn control the temperature of the air.

Fill in the blanks to complete the following statements.

1. A ____________ ________________ can be used to control the mercury in the thermostat.

2. By using the __________ and ______________ we can control the temperature of the air in the aircraft.

Answers to Frame 3: 1. thermostat heater 2. rheostat and heater

REVIEW EXERCISE #1

Mark the following statements either T (true) or F (false).

1. _____ A mercury thermostat can control such devices as relays.

2. _____ A mercury thermostat can be used to control a complete temperature control system.

3. _____ The mercury will rise when heat is applied to the thermostat.

4. _____ A mercury thermostat can be compared to an ordinary thermometer.

5. _____ The more resistance in the rheostat the faster the heater will warm up the thermostat.

Fill in the blanks to complete the following statements.

6. If two (2) wires are connected by the ________________, current will flow through the thermostat.

7. A heater is used to heat the thermostat so the mercury will ___________ faster than normal.

8. A ________________ controls the amount of current going to the heater.

9. The rheostat and heater ________________ the movement of mercury inside the thermostat.

10. A rheostat is a _______________ resistor.

11. ___________ __________ to the thermostat heater coil can be changed by using the ______ ___________.

12. Mercury is a ____________ electrical conductor.

13. Current takes the path of ____________ _________________.

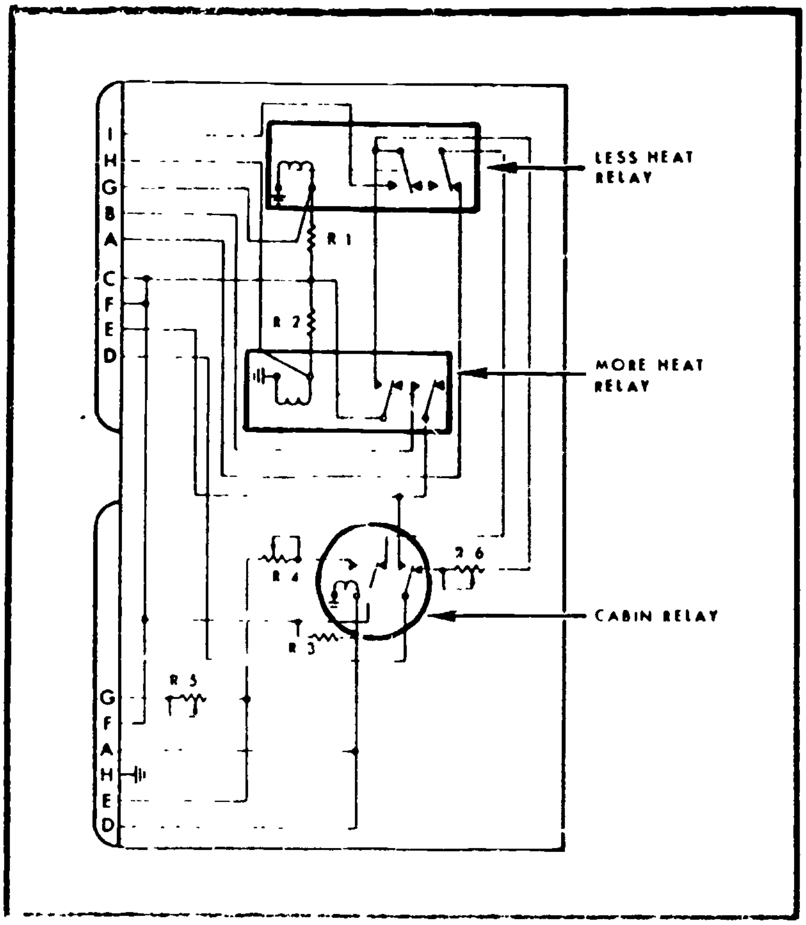
Check your responses at the top of frame 4.

Answers to Review Exercise 1: 1. T 2. T 3. T 4. T 5. F 6. Mercury 7. Rise 8. Rheostat 9. Control 10. Variable 11. Current Flow, Rheostat 12. Good 13. Least resistance.

Frame 4

The temperature control box for this system contains three (3) relays (shown below) and six resistors.

The relays are energized and deenergized by the mercury thermostats. These thermostats will control the relays and the relays will determine if the temperature control system calls for hot or cold air.



Mark the following statements either T (true) or F (false).

1. _____ The thermostats are controlled by the relays.

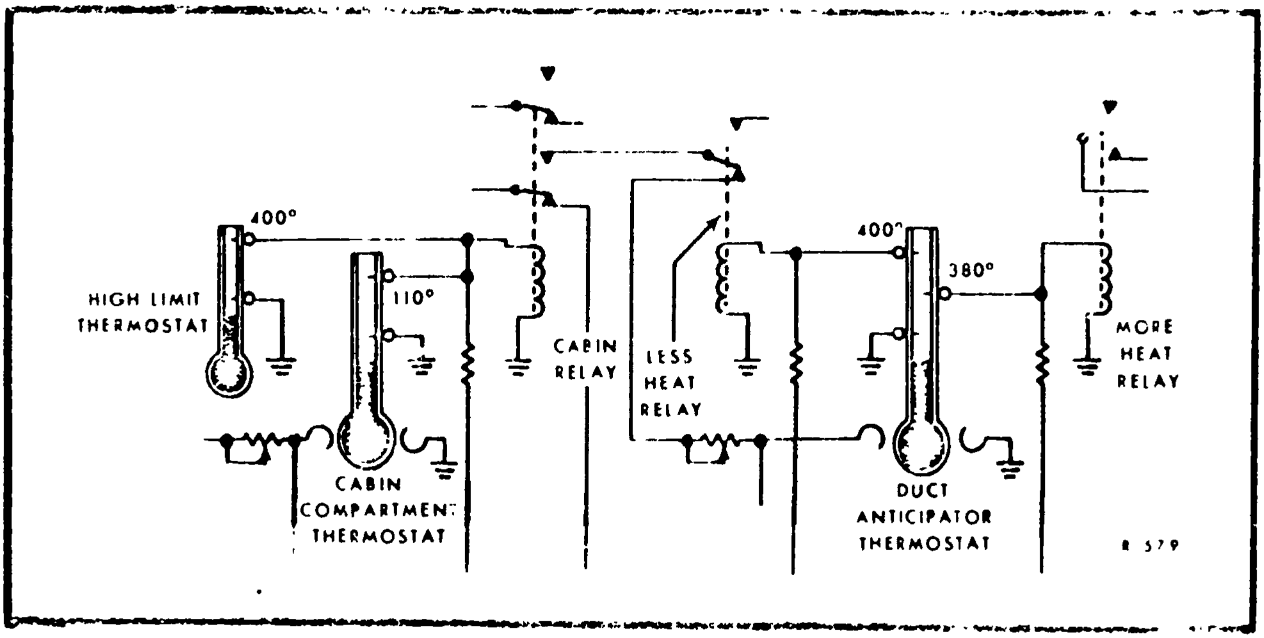
2. _____ The thermostats will determine if the temperature control system calls for hot or cold air.

Answers to Frame 4: 1. F 2. F

Frame 5

Shown below are the High Limit thermostat, Cabin Compartment thermostat, and Duct Anticipator thermostat.

Each thermostat has a different operating temperature and a different purpose to help maintain the desired cabin temperature.

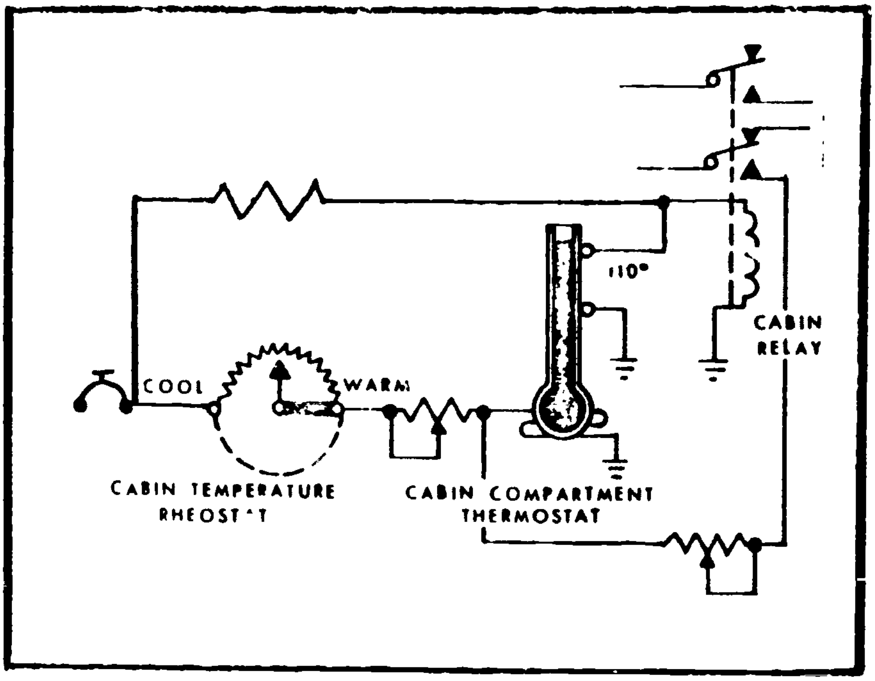


Note: Relays are shown energized.

No Response Required

Frame 6

The Cabin thermostat, shown below, controls the operation of the Cabin relay. When mercury comes in contact with the 110° contact wire the Cabin relay will deenergize. Remember, current follows the path of least resistance.



The heater of the Cabin the~mostat has two (2) current supplies:

(1) From the bottom contact of the cabin relay.

(2) From the cabin temperature rheostat.

By positioning the rheostat, the amount of current being applied to the heater can be increased or decreased. This in turn controls how fast the mercury in the thermostat rises or falls.

By controlling the movement of the mercury you can control the operation of the cabin relay. In turn, by control:ing the cabin relay you can control the temperature of the air entering the cabin.

Fill in the blanks to complete the following statements.

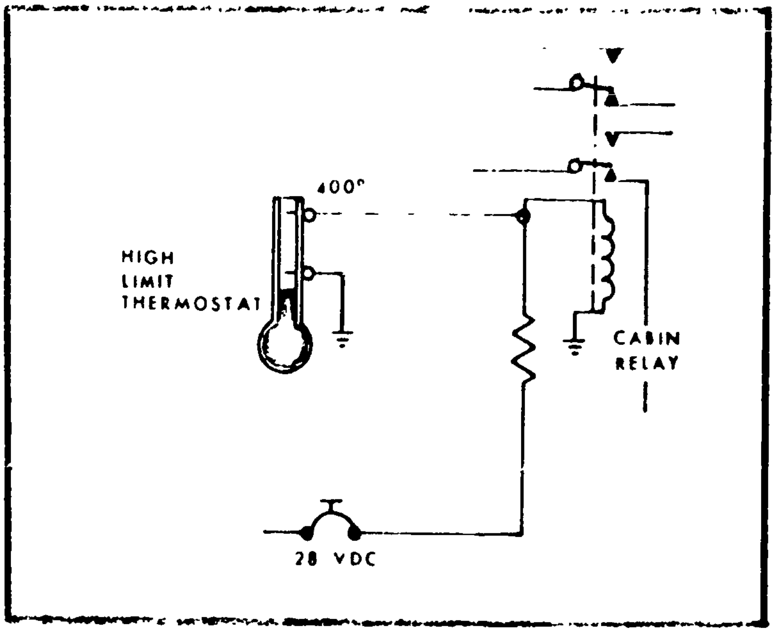
1. The Cabin thermostat heater has ________ current supplies.

2. The Cabin relay will ________________ at _________.

Answers to Frame 6: 1. 2 (two) 2. deenergize, 110°

Frame 7

The High Limit thermostat also controls the cabin relay and in turn, controls the maximum temperature that can be received from the system. This thermostat acts as a safety factor in case the other thermostats fail.



Note: Relay is shown energized.

There is no heater for this thermostat. It is located in the air conditioning duct and works from the duct temperature only. If the mercury reaches the 400° contact wire the relay deenergizes.

Fill in the blanks to complete the following statements.

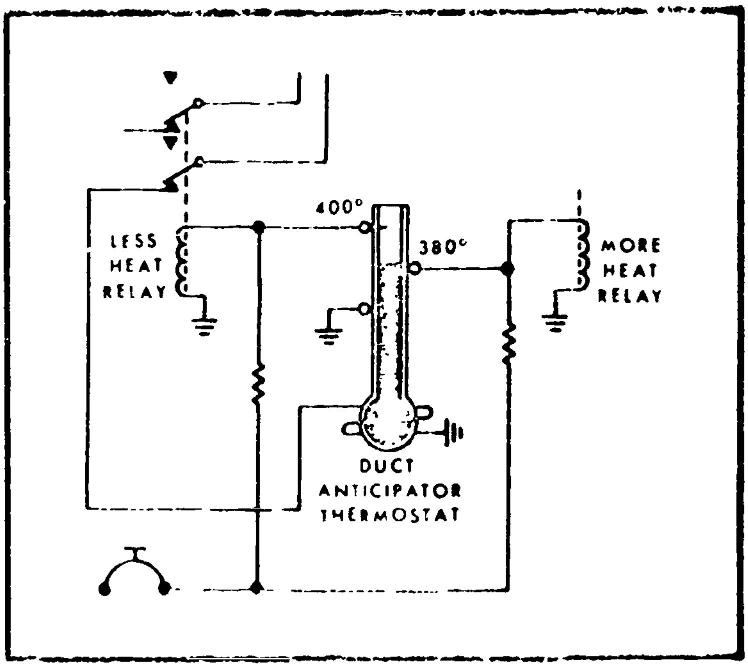
1. The ______________ temperature that can be received from the system is controlled by the high limit thermostat.

2. The cabin relay will be ________________ when the mercury in the high limit thermostat is below 400°.

Answers to Frame 7: 1. Maximum 2. Energized

Frame 8

The Duct Anticipator thermostat controls both the More Heat and the Less Heat relays. This thermostat is in the air conditioning duct next to the High Limit thermostat and works off the air temperature in the duct and a heater. The heater receives power from the bottom contact of the Less Heat relay.



When the mercury is below the 380° contact wire, the More Heat and Less Heat relays will be energized.

If the mercury reaches the 380° contact wire, the More Heat relay will deenergize. Remember, current will follow the path of least resistance. With the More Heat relay deenergized, the circuit going to the Hot side of the temperature control valve is opened. The valve will not be able to run any further towards Hot. (This will be shown completely in a later frame.)

If the temperature in the duct continues to rise, the mercury will rise with it. When the mercury reaches the 400° contact wire the Less Heat relay will deenergize. When the Less Heat relay deenergizes it removes current from the thermostat heater and sends current to the Cool side of the temperature control valve. (This will be shown completely in a later frame.)

Mark the following statements either T (true) or F (false).

1. _____ The <u>more</u> and <u>less heat</u> relays control the Duct Anticipator thermostat.

2. _____ When the less heat relay is deenergized, current will be removed from the cool side of the temperature control valve and sent to the heater coil on the Duct Anticipator thermostat.

Answers to Frame 8: 1. F 2. F

REVIEW EXERCISE #2

Mark each of the following statements either T (true) or F (false).

1. _____ The relays control mercury thermostat operation.

2. _____ All of the thermostats have the same operating temperature.

3. _____ The thermostats help maintain a desired cabin temperature.

4. _____ The heater on the thermostat causes the mercury to fall.

5. _____ The Duct Anticipator thermostat controls the cabin relay.

6. _____ When energized, the more heat relay will allow current to flow to the hot side of the temperature control valve.

7. _____ The cabin thermostat controls the cabin relay.

8. _____ Current for the Cabin thermostat heater is supplied by the cabin relay and the rheostat.

9. _____ The less heat relay will deenergize when the High Limit thermostat reaches 400°.

10. _____ The rheostat varies the current flow to the Duct Anticipator thermostat heater.

11. _____ By controlling the cabin relay you can control the cabin temperature.

12. _____ The air in the ducting causes the mercury in the High Limit thermostat to rise or fall.

13. _____ The High Limit thermostat acts as a safety factor.

14. _____ The High Limit thermostat is located in the cabin.

Fill in the blanks to complete the following statements.

15. The relays that make up the control box are the __________, __________ __________ and _______ ________ relays.

16. The thermostats that are used to control the temperature control system are the ________, _______ __________ and _________ ______________ thermostats.

17. When the _______ _________ relay deenergizes current goes to the cool side of the temperature control valve.

18. When the mercury in the Duct Anticipator thermostat reaches the 400° contact wire the more and less heat relays will be ________ ___________.

Answers to Review Exercise 2:

1. F
2. F
3. T
4. F
5. F
6. T
7. T
8. T
9. F
10. F
11. T
12. T
13. T
14. F
15. Cabin, more heat, less heat
16. Cabin, high limit, duct anticipator
17. Less heat
18. Deenergized

Now we are going to put all of these individual components together and operate a mercury thermostat automatic temperature control system. Ask the instructor for an overlay transparency. Fold all of the sheets back until only Sheet 1 is showing.

Frame 9

As you can see, Sheet 1 shows the components of the system with a voltage potential at the circuit breaker and at Pin "D" of the upper connector on the control box.

FOLD OVER SHEET 2

Current flows from the circuit breaker through Pin "C" on the upper connector and down to a contact point on the cabin relay.

Current also flows through R-3 and then can go in 1 of 2 directions:

(1) Up to energize the cabin relay

or

(2) Down through Pin "A" to the High Limit thermostat or through Pin "D" to the Cabin thermostat.

Since the mercury in these thermostats have not yet reached the contact wires these circuits are incomplete and the cabin relay is energized as shown.

No Response Required

FOLD OVER SHEET 3

Current from the rheostat flows through Pin "G" and resistor R-5 to point A in the control box. From here it flows down and out Pin "E" to the cabin thermostat heater.

Since the cabin relay is energized, current from its left contact lever flows through R-4 and down to combine with the current from the rheostat and flows to the cabin thermostat heater.

The voltage potential at Pin "D" flows across the right contact lever of the cabin relay and up to another contact point which will be shown in the next frame.

No Response Required

Frame 11

FOLD OVER SHEET 4

This sheet shows the More Heat relay circuit.

Current from the circuit breaker goes from point B in the control box through R-2 and then can go in 1 of 2 directions:

(1) Down to energize the More Heat relay.

or

(2) Up through Pin "H" to the 380° contact point on the Duct Anticipator thermostat.

Since the mercury is below 380° the circuit to the thermostat is open and the More Heat relay is energized as shown.

Current can also flow from point B to the More Heat relay left contact lever. Since this relay is energized current flows across th contact lever and up to another contact point which will be shown in the next frame.

Since the Cabin relay was energized back in Frame 9, we also have current flowing across the right contact lever to the More Heat relay. This current flows out Pin "B" on the upper connector and out to Pin B on the temperature control valve. As you can see, with both the Cabin and More Heat relays energized this valve will run toward HOT.

No Response Required

355

Frame 12

FOLD OVER SHEET 5.

This sheet shows the Less Heat relay circuit.

As you can see, the Less Heat relay receives power from the same source that is used for the More H relay. Current flows up through R-1 and can then go in 1 of 2 direction.

(1) Up to energize the Less Heat relay.

or

(2) Down through Pin "G" to the 400° contact wire on the Duct Anticipato thermostat.

Since the mercury is still below 380° this circuit is incomplete and the Less Heat relay is energized as shown.

Current has been supplied from the More Heat relay to the left contact lever of the Less Heat relay. This current flows across the contact and out Pin "I" to the duct anticipator heater. The heater, and the air temperature in the ducting, begins to raise the mercury inside the thermostat.

At this point there is no current to the Less Heat relay right contact lever. As the circuit is set up so far, we are now calling for and receiving a warmer air temperature.

No Response Required

Frame 13

FOLD OVER SHEET 6

At this point we are receiving warm air in the cabin. To make sure that the cabin does not get too hot the pilot or flight engineer has moved the temperture control rheostat toward cool. By doing this the resistance in the circuit has decreased. Therefore more current flows through the rheostat and Pin "G" to point A and down and out Pin "E" to the cabin thermostat heater.

This increased current applied to the heater will generate more heat around the thermostat. When the mercury reached the 110° wire, all of the current at point C in the control box will follow the path of least resistance and flow down and out Pin "D" through the cabin thermostat to ground. The cabin relay now deenergizes.

With the cabin relay deenergized current going to the more heat relay contact has stopped. In turn, you have stopped current from going to the HOT side of the temperature control valve. Therefore the valve will stop and the temperature will not increase.

Current from the cabin relay will now flow across both contact levers up to the contact levers on the less heat relay.

No Response Required

357

FOLD OVER SHEET 7

As the mercury in the duct anticipator thermostat rises it will make contact with the 380° wire. At this time the more heat relay deenergizes because current to the relay follows the path of least resistance through the thermostat to ground.

With the more heat relay deenergized current will be taken away from the less heat relay contact which was used for the duct anticipator heater.

FOLD OVER SHEET 8

Current is still being applied to the duct anticipator heater. It is supplied through the less heat relay contact from the deenergized cabin relay.

The mercury in the thermostat continues to rise until it reaches the 400° wire. Now the less heat relay deenergizes because current to the relay follows the path of least resistance through the thermostat to ground.

With this relay deenergized current will be taken away from the thermostat heater. From the right contact lever it will flow out Pin "A" to Pin A on the temperature control valve. The valve now runs COLD delivering cooler air to the cabin.

No Response Required

Frame 15

Notice that the mercury in the high limit thermostat has also made contact with its 400° wire. This is the safety factor that was mentioned earlier in the text.

A circuit has been compl3ted through the mercury to ground. This is a positive way to restrict the maximum temperature from the system. By deenergizing the cabin relay if the cabin thermostat should fail, taking power away from the HOT side of the temperature control valve.

No Response Required

REVIEW EXERCISE #3

Mark the following either T (true) or F (false).

1. _____ The same current that energizes the cabin relay can also flow to the cabin thermostat.

2. _____ The current for the control box comes from 2 different sources.

3. _____ If the mercury in the high limit thermostat reaches 400° the cabin relay will deenergize.

4. _____ The cabin thermostat heater receives current from the temperature control rheostat only.

5. _____ The more heat relay must be deenergized before the less heat relay will deenergize.

6. _____ The temperature control valve will not run towards hot if either the cabin relay or the more heat relay were deenergized.

7. _____ The current that energized the cabin relay will not energize the more heat relay.

8. _____ Current that flows across the cabin relay and R-4 combines with the current that flows from the rheostat and goes to the cabin thermostat heater.

9. _____ The cabin relay will not energize unless it receives a full 28V DC.

10. _____ If the mercury in the duct anticipator thermostat reaches 380° the temperature control valve will run toward hot.

11. _____ The more heat and less heat relays receive current from the same power source.

12. _____ The more heat relay will deenergize when the duct anticipator thermostat reaches 380°.

13. _____ The cabin relay must be deenergized before the control valve will run toward hot.

14. _____ The high limit thermostat will deenergize the cabin relay when the mercury reaches 110°.

Check yc .espcnses on the answer sheet at the back of the text.

MERCURY THERMOSTAT TEMPERATURE CONTROL SYSTEM REVIEW

Match the description in lumn B with the it m it describes in Column A.

Column A

1. More Heat relay
2. Cabin thermostat
3. Rheostat
4. Cabin relay
5. Thermostat heater
6. High Limit thermostat
7. Duct Anticipator thermostat
8. Less Heat relay

Column B

A. Controls both the more heat and less heat relays.

B. Controls amount of power going to the cabin thermostat heater.

C. Raises and lowers the mercury in the high limit thermostat.

D. When energized, this relay directly supplies current to the hot side of the temperature control valve.

E. Helps to raise the mercury inside the thermostat faster than normal.

F. A safety factor that will deenergize the cabin relay at 400°.

G. Controls operation of the Cabin relay.

H. When energized, this relay supplies current to a contact lever on the more heat relay.

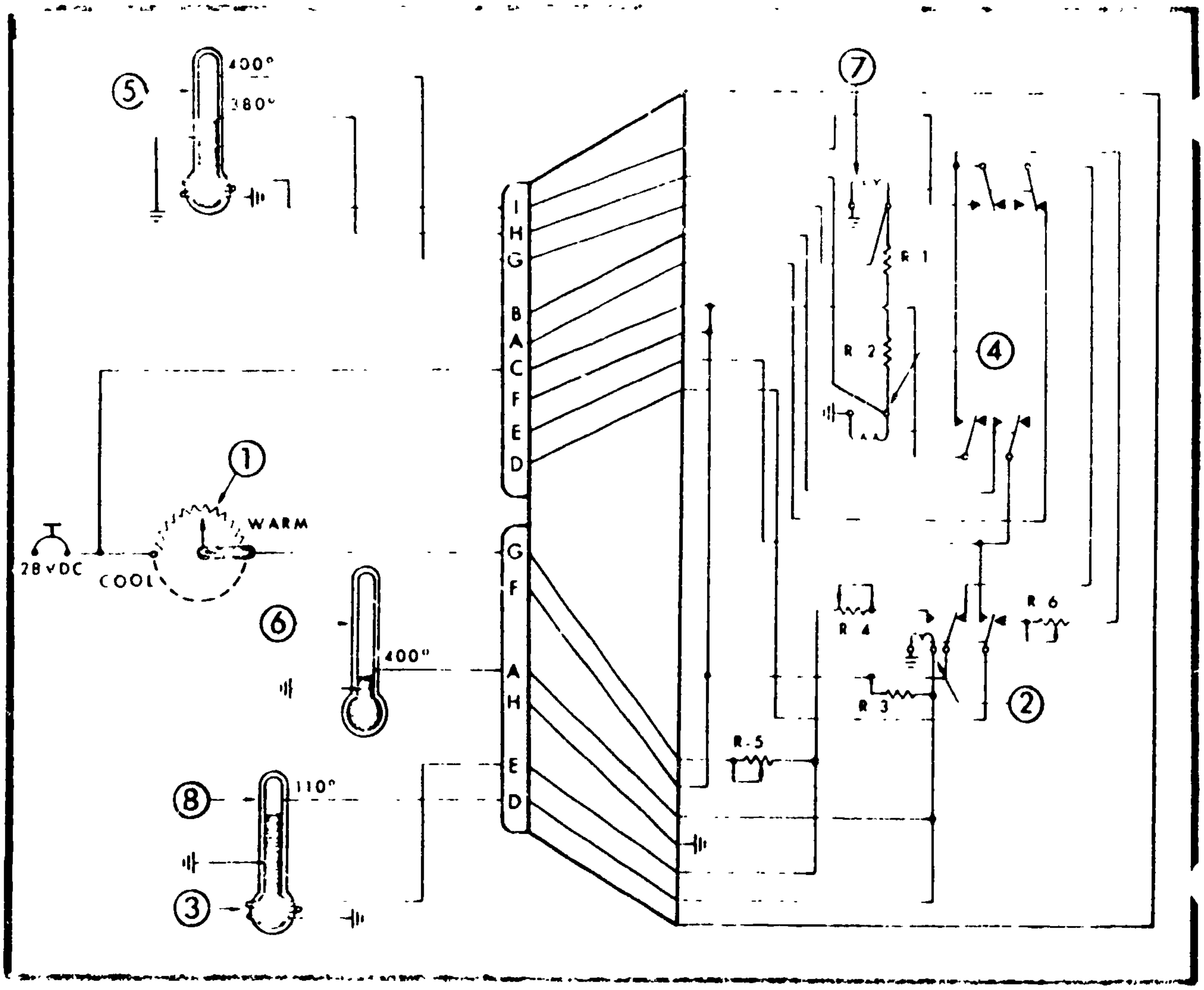
I. When deenergized, this relay supplies current to the cold side of the temperature control valve.

Refer to the overlay transparency to answer the following statements as either true or false.

9. If the temperature in the cabin reaches 110°, the cabin relay will deenergize.

10. As temperature around the duct anticipator thermostat rises, the less heat relay will deenergize <u>before</u> the more heat relay.

11. The less heat relay controls current to the cool side of the temperature control valve.



Match the circled number in the above schematic with the item listed below.

_____Rheostat

_____Cabin relay

_____Duct Anticipator thermostat

_____More Heat relay

_____Cabin the· ·stat

_____Heater co..

_____Less Heat relay

_____High Limit thermostat

Check your responses on the answer sheet at the back of the text.

CORRECT RESPONSES

Review Exercise #3

1.	T	8.	T
2.	T	9.	F
3.	T	10.	F
4.	F	11.	T
5.	T	12.	T
6.	T	13.	F
7.	F	14.	F

Mercury Thermostat Temperature Control System Review

1	D	7.	A
2.	G	8.	I
3.	B	9.	T
4.	H	10.	F
5.	E	11.	T
6.	F		

1 Rheostat	8 Cabin thermostat
2 Cabin relay	3 Heater coil
5 Duct Anticipator Thermostat	7 Less heat relay
4 More heat relay	6 High limit thermostat

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WORKBOOK

3ABR42331-WB-209A

Technical Training

Aircraft Environmental Systems Mechanic

CARGO AIR CONDITIONING SYSTEM TROUBLESHOOTING

6 March 1981

3350 TECHNICAL TRAINING WING
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

RGL: N/A

CARGO AIR CONDITIONING SYSTEM TROUBLESHOOTING

OBJECTIVE

Using a wiring diagram and multimeter, and working in a group of not more than two students, perform an operational check and troubleshoot the cargo air conditioning system trainer, locating a minimum of five out of seven troubles correctly.

EQUIPMENT

Trainer 3021 Cargo Air Conditioning System
Multimeter AN/PSM-37

PROCEDURE

Remove all of your jewelry. Report to the lab instructor and inform him of the lesson on which you are working. The lab instructor will assign you a trainer and provide the necessary materials.

This workbook is presented in two sections. Section 1A and 1B are to familiarize you with the components of the flight deck or cargo compartment air conditioning systems and to prepare you for performing the operational check and troubleshooting. Section 2 contains the steps for operational checking these systems and the malfunctions that you are to troubleshoot. Perform each step as directed on the following pages.

NOTE: You will be assigned to perform this lesson either on the flight deck system or on the cargo compartment system. Check the name of the trainer you are assigned to. If you are assigned to a flight deck system, start with Section 1A. If you are assigned to a cargo compartment system, start with Section 1B.

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SECTION 1A. FLIGHT DECK AIR CONDITIONING SYSTEM COMPONENTS

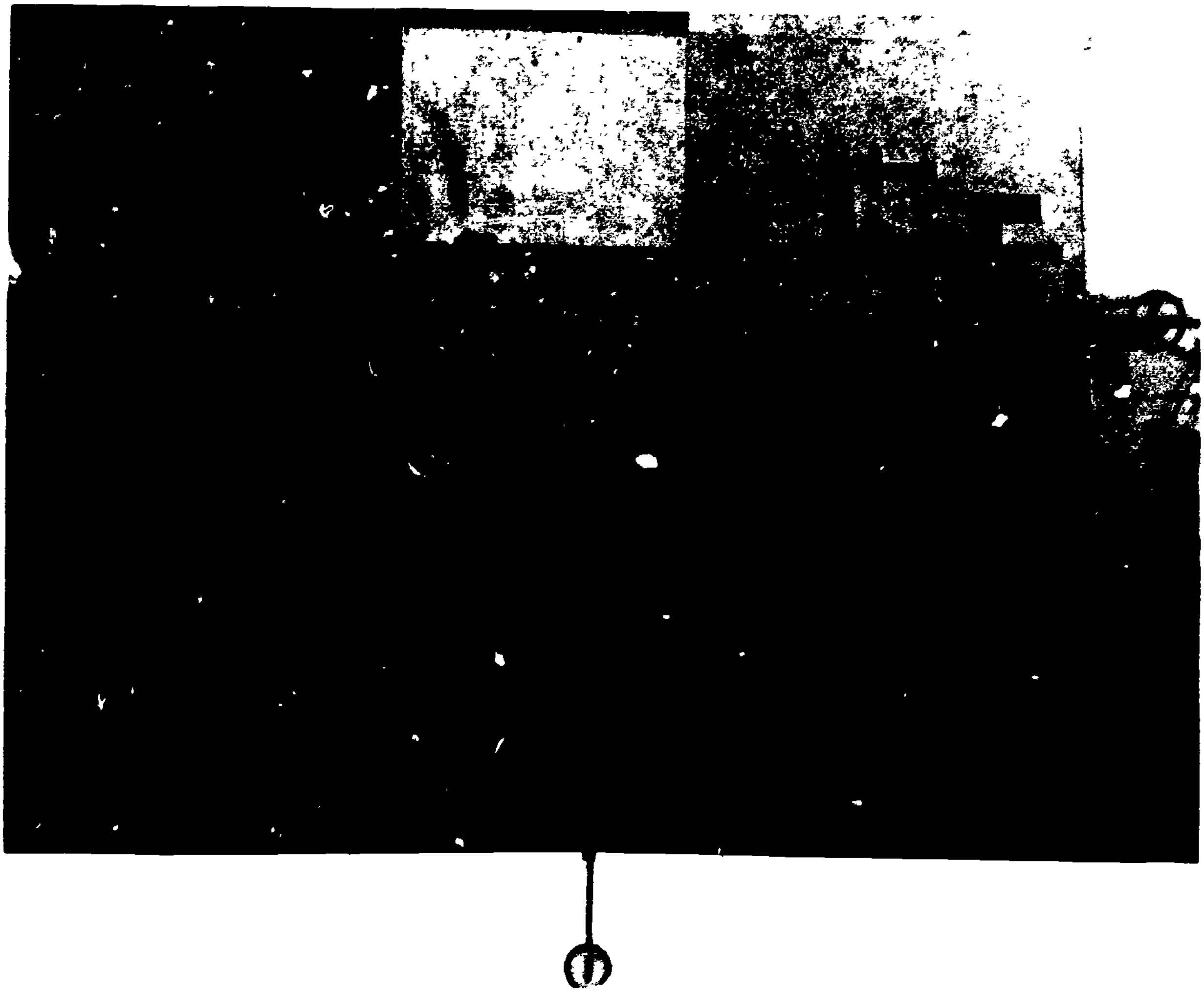


Figure 1.

1. Location and identification of system components.

a. Using the trainer and the illustrations in figure 1, locate each of the numbered items. Write the name of each of these numbered items in the blank spaces below.

(1) ____________________

(2) ____________________

(3) ____________________

(4) ____________________

(5) ____________________

(6) ____________________

(7) ____________________

COMPARE YOUR ANSWERS TO THOSE ON PAGE 5.

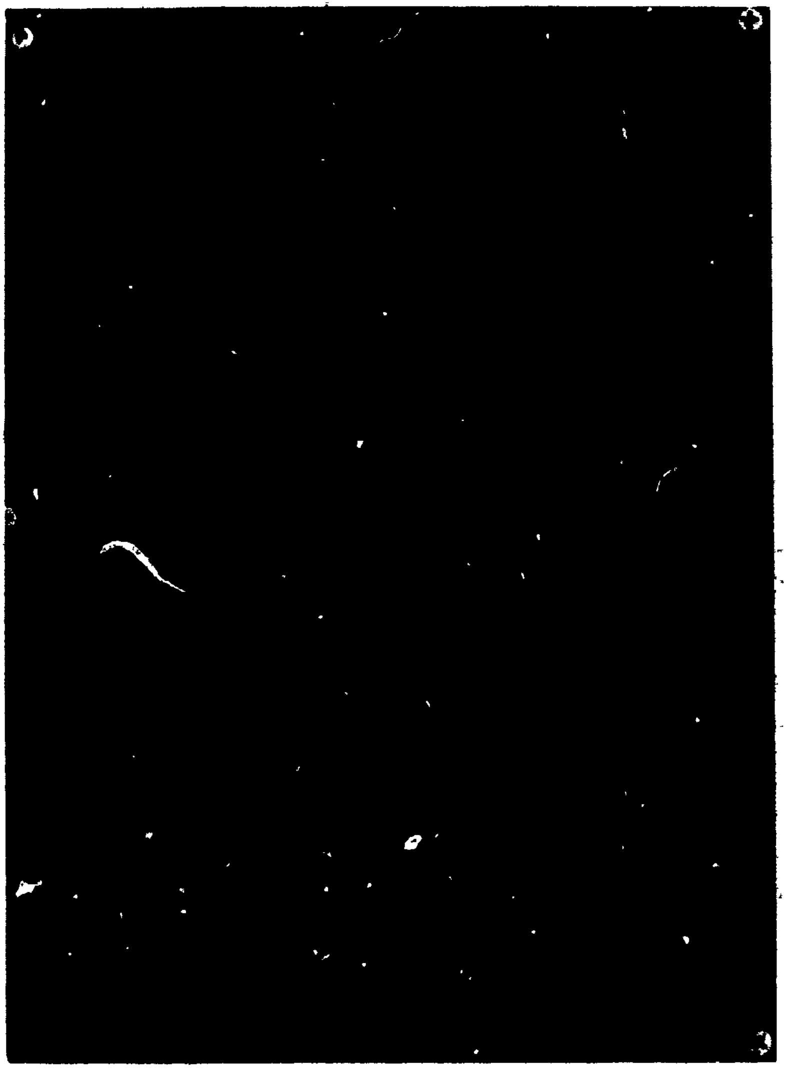


Figure 2.

b. Using the trainer and the illustration in figure 2, locate each of the numbered items. Write the name of each of these numbered items in the blank spaces below.

(1) ______________________________

(2) ______________________________

(3) ______________________________

COMPARE YOUR ANSWERS TO THOSE ON PAGE 5.

Answers to location and identification Section 1A, para 1a.

(1) Temperature Control Valve.

(2) Temperature Control Box.

(3) Duct Anticipator Thermostat.

(4) Hi-Limit Thermostat.

(5) Cabin Thermostat.

(6) Cabin Thermostat Blower.

(7) Aux Vent Valve.

Answers to locations and identification Section 1A, para 1b.

(1) Air Conditioning Master Switch.

(2) Temperature Control Switch.

(3) Temperature Selector.

After comparing your answers, turn to page 8, para 2.

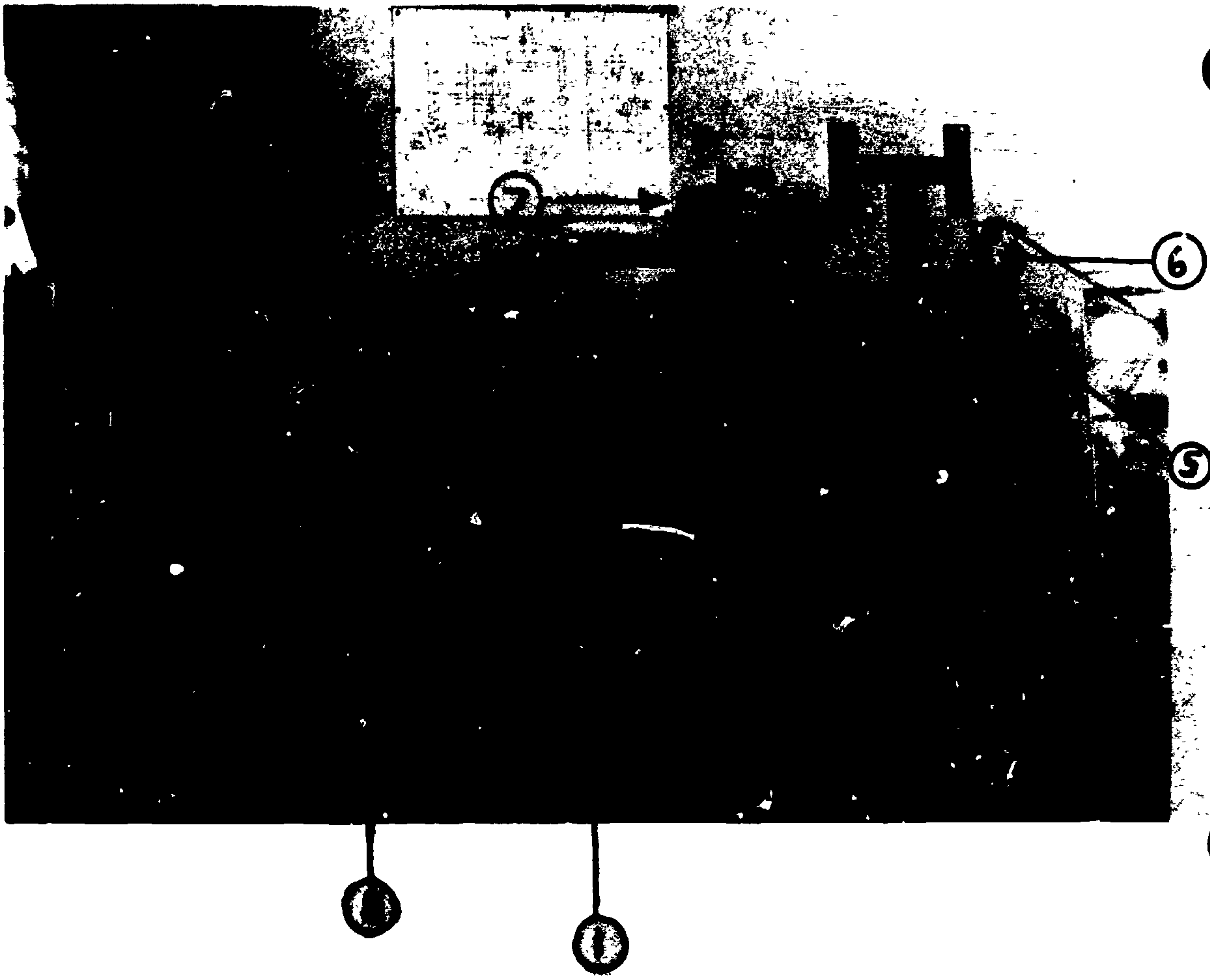


Figure 3.

SECTION 1B. CARGO COMPARTMENT AIR CONDITIONING SYSTEM COMPONENTS

1. Location and identification of system components.

a. Using the trainer and the illustrations in figure 3, locate each of the numbered items. Write the name of each of these numbered items in the blank spaces below.

(1) ____________________	(5) ____________________
(2) ____________________	(6) ____________________
(3) ____________________	(7) ____________________
(4) ____________________	(8) ____________________

COMPARE YOUR ANSWERS TO THOSE ON PAGE 10.

Figure 4.

b. Using the trainer and the illustration in figure 4, locate each of the numbered items. Write the name of each of these numbered items in the blank spaces below.

(1) ____________________________________

(2) ____________________________________

(3) ____________________________________

COMPARE YOUR ANSWERS TO THOSE ON PAGE 10.

2. Trainer preparation for the operational check and troubleshooting of the flight deck and cargo compartment air conditioning system.

a. Place all trouble switches to the OUT position. These switches are located at the left side of the trainer.

b. Make sure all circuit breakers are pushed in.

c. Place the following switches to the NORMAL positions as listed below.

(1) Air Conditioning Master Switch. . . . . .OFF

(2) Temperature Selector. . . . . .COOL

(3) Temperature Control Switch. . . . . .OFF

d Place the trainer power switch to the ON position. This switch is located on the upper left side of the trainer.

3. Trainer operation for the flight deck and cargo compartment air conditioning system.

a. During the following steps you will operate each component on either the flight deck or cargo compartment air conditioning trainer. When a switch is actuated be sure to notice which valves operate and the valve position. Actuate each switch as directed. From your observation of the trainer operation complete each statement by circling the correct word.

Step 1. Air Conditioning System Operation.

(1) Place the air conditioning master switch in the air cond - GTC position.

(a) Cabin thermostat blower runs (yes / no).

(b) Aux vent valve (open / close).

(2) If the components failed to operate, it indicates a defective component or an open electrical circuit.

Step 2. Temperature control system: Manual Operation

(1) Place the temperature control switch to Manual Cool. The temperature control valve moves toward (hot / cold).

(2) Place the temperature control switch to Manual Warm. The temperature control valve pulses toward (hot / cold).

Step 3 Temperature control system: Automatic Operation.

(1) Place the temperature control switch to the AUTOMATIC position, then rotate the temperature selector toward WARM. The temperature control valve pulses toward (hot / cold).

(2) Rotate the temperature selector toward COOL. The temperature control valve pulses toward (hot / cold).

Step 4. Aux Vent System Operation:

(1) Place the master air cond switch to aux vent position.

(a) Aux vent valve (opens / closes).

(b) Cabin thermostat blower runs (yes / no).

(c) Will the Auto and Manual temperature control operate (yes / no).

Step 5. Return all switches to the NORMAL position as indicated in paragraph 2c page 7 and place trainer power to OFF.

COMPARE YOUR ANSWERS TO THOSE ON PAGE 10.

Answers to location and identification Section 1B, para 1a.

(1) Temperature Control valve.

(2) Temperature Control Box.

(3) Duct Anticipator Thermostat.

(4) Hi-Limit Thermostat.

(5) Cabin Thermostat.

(6) Cabin Thermostat Blower.

(7) Aux Vent Valve.

(8) Floor Heat Diverter Valve.

Answers to locations and identification Sect 1B, para 1b.

(1) Air Conditioning Master Switch.

(2) Temperature Control Switch.

(3) Temperature Selector.

Answers to the trainer operation statements in Sect 1B, para 3a.

Step 1.	(1)	(a) YES	Step 3.	(1)	HOT	
		(b) CLOSED		(2)	COLD	
Step 2.	(1)	COLD	Step 4.	(1)	(a)	OPENS
	(2)	HOT			(b)	NO
					(c)	NO

If all of your answers agree with the answers above, you are ready to begin troubleshooting. If they <u>do not</u> agree, tell the lab instructor you need assistance.

SECTION 2. FLIGHT DECK AND CARGO COMPARTMENT AIR CONDITIONING SYSTEM OPERATIONAL CHECK AND TROUBLESHOOTING

OPERATIONAL CHECK:

1. The steps that you performed in paragraph 3a, of section 1B involved operating each component in the flight deck or cargo compartment air conditioning system. These steps are used to determine if each component is operating properly and they are called operational checks.

2. The chart below lists step by step procedures for performing operational checks of the system. To insure that you are familiar with this procedure, turn the trainer power ON and perform each of the steps. After you are sure you understand the operational check procedure, then continue to the troubleshooting part of this lesson. You will be required to perform a complete operational check for each trouble.

Note: This chart is provided only as a guide for learning the operational check procedure.

POSITIONING THE CONTROL DEVICES	OPERATING COMPONENT	COMPONENT OPERATION
Place the air cond master switch to the air cond-GTC position	Cabin thermostat Blower	Operates
Place the Temp Control switch to MANUAL COOL.	Temp Control Valve	Runs Toward Cool
Place the Temp Control switch to MANUAL WARM.	Temp Control Valve	Pulses toward HOT
Place the Temp Control switch to AUTO Rotate the Temp Selector to COOL.	Temp Control Valve	Pulses toward COOL
Rotate the Temp Selector to HOT.	Temp Control Valve	Pulses toward HOT
Place the Air Cond Master switch to AUX Vent.	Cabin Thermostat Blower Aux Vent Valve	No Operation Opens
Place the Temp Control switch to any position.	Temp Control Valve	No Operation
Place the Air Cond Master Switch to Air Cond - GTC position.	Cabin Thermostat Blower Aux Vent Valve	Operates Closes
Place the Temp Control Switch to any position.	Temp Control Valve	Will Operate

Operational Check Procedure Chart

TROUBLESHOOTING

1. For each trouble, perform an operational check to determine the malfunctioning component. After you determine the malfunction, then place a statement in the "discrepancy" block of the attached troubleshooting answer sheet that describes the malfunction.

2. Using a waxed pencil, trace the electrical circuits that operate or controls the malfunctioning component.

3. Use the multimeter to locate the cause of the trouble.

Note: When measuring voltage, be sure the meter is set to the correct voltage range. Make sure that you have the negative (Black) lead to ground. Ground on the trainer is located on the center left of the trainer. When checking the manual temperature control system, be sure to hold the temperature control switch to either HOT or COLD. When measuring resistance, be sure the trainer power is OFF and the meter is set in OHMS. Use the OHM portion of the multimeter only to check the system when it is isolated from the rest of the circuit.

4. Record the cause of the trouble in the cause block on the troubleshooting answer sheet.

5. The trouble switch that you are to use for each problem is listed on the top line of the discrepancy block. There are 10 problems for you to troubleshoot. We will go through the first one with you to show you how to arrive at the correct answer.

a. If you are assigned to the Flight Deck Air Conditioning System, place trouble switch number 1C to the IN position.

b. If you are assigned to the Cargo Compartment Air Conditioning System, place trouble switch number 1 to the IN position.

c. Perform an operational check (use the operational check procedures chart.)

d. As you went through the operational check you found that the Temperature Control valve will not move to the HOT position in Auto and Manual position. Make the following statement in the discrepancy block of the troubleshooting answer sheet.

"No control of the Temp Control Valve in Auto and Manual Hot."

AUTOMATIC HOT

1. Since the temperature control valve will not operate in Auto and Manual Hot, the trouble must be in a wire or component that is common to both the automatic and manual operation. What part of the circuit would affect the Auto and Manual operation?....To determine this let's trace the circuits.

2. Trace the automatic hot operation; using a grease pencil, start tracing the electrical circuit at the 28V DC circuit breaker. Follow

the circuit to the bulkhead connector number 2 at point "N" to the Master Air Conditioning Switch.

3. Now draw the master switch in "Ground Air Cond GTC" position. Trace through the switch to bulkhead connector #2 at point "M." Now proceed to terminal strip #2 at pin #"1." You will notice that there are two electrical wires at this point; trace the one going to the control box electrical connector #1 at pin "C". Then trace to point "B" inside the temp control box and through resistor R-2 to the more heat relay coil. Energizing the more heat relay moving the contacts X-1 and X-2 to the left.

4. Return to point "A" inside the temp control box. Now trace from point "A" through point "C" to point "D". From point "D" trace to point "E" through resistor R-3 and up to the cabin relay coil. Energizing it will move the contacts X-1 and X-2 to the left.

5. Return to point "C" inside the temp control box. Trace this wire to pin "F" of connector #1 and follow it to terminal strip #2 pin #2. Then trace to pin "H" on the bulkhead connector #2 and to the temperature control switch.

6. Draw the temperature control switch in the Auto position. From the Auto position to bulkhead connector #2, point "F", then to terminal strip #2, point "7", and to pin "D" on the temp control box electrical connector #1. Trace this wire to X [illegible] of the cabin relay and to X-2 of the more heat relay, across the contacts and then to pin "B" of connector #1 and to pin "B" of the temperature control valve.

7. You have now traced the automatic hot temperature control circuit. Now you will trace the manual hot circuit. Notice that this circuit will <u>bypass</u> the cabin relay.

MANUAL HOT

1. Start at the 28 V DC circuit breaker. Follow the circuit to the bulkhead connector #2 at pin "N". With the master switch in "Ground Air Cond G.T.C." trace through the switch to bulkhead connector #2 to pin "M". Now move to terminal strip #2 to pin "1". Notice that there are two electrical wires at this point.

2. Trace the one that goes to the control box electrical connector #1 at pin "C" and to the more heat relay coil. Energizing the more heat relay moves the contacts X-1 and X-2 to the left.

3. Return to point "A" inside the temp control box. Trace to point "C" inside the control box and then pin "F" of electrical connector #1. From pin "F" you trace to terminal strip #2, pin #2 and then pin "H" of the bulkhead connector; from pin "H" to the temperature control switch.

4. Now draw the temperature control switch to the manual warm position. Trace the wire to pin "G" of the bulkhead connector and then pin "5" of terminal strip #2. Now trace from pin #5 on the terminal strip to pin "E" of electrical connector #1. Follow this wire from pin "[illegible]" to X-2 of the more heat relay, through the contact to pin "B" of electrical connector #1 and to pin "B" on the temperature control valve.

a. From the circuit that you have traced, what part of the circuit is common to both automatic and manual hot?

b. Any troubles in the circuit from the 28V DC circuit breaker to the master switch and to pin "C" of the temperature control box would affect hot and cold both. So we can eliminate these circuits as possibilities for our trouble.

c. Any troubles in the circuit from auto position of the temperature control switch to X-2 of the cabin relay would affect the system in automatic operation only. Any troubles in the circuit from manual warm to pin "E" at the temperature control box would affect manual warm only. So, again, we can eliminate these circuits as possibilities.

d. However current has to travel from X-2 of the more heat relay, through pin "B" of the electrical connector #2, and to pin "B" of the temperature control valve for both auto and manual hot. Now troubleshoot to determine exactly where our problem is.

e. Set the PSM-37 to 28V DC. Place the master switch to the "Ground Air Cond G.T.C." position and the temperature control switch to automatic. Rotate the temperature selector to warm. Disconnect the electrical connector at the temperature control valve.

f. Place the black lead on the PSM-37 to ground and the red lead to pin "B" of the electrical connector. You should read 28V DC. However, you will notice that there is not voltage at this point.

g. Leaving the electrical connector disconnected, remove connector #1 from the control box. Looking at your wiring diagram, notice that when the connector is removed, the voltage is lost. This is because it goes in pin "C" of the control box and comes out at pin "B" on the control box. Due to the loss of voltage it means we will have to set the PSM-37 on OHMS.

h. After you set the meter on OHMS, place one lead in pin "B" of the temperature control valve connector and the other lead in pin "B" of the electrical connector #1. You should read continuity, but you will notice that the meter reads infinity. This reading indicates an open between these two points. Looking at your wiring diagram you will see that auto and manual must come through this wire to make the temperature control valve operate. Place this statement in the cause block.

Open Wire H212A20

Note: If you are on the flight deck air conditioning system, place trouble switch #10 out and move on to trouble #1.

If you are on the cargo compartment air conditioning system, place trouble switch #1 out and move on to trouble #2.

Note: When troubleshooting the temperature control system and either a connector #1 or #2 is removed, this disconnects the power going to the temperature control box. To continue troubleshooting the system the multimeter must be placed to the OHMS position.

Troubleshooting Response Sheet

TROUBLE SWITCH NUMBER	Discrepancy	Cause
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

WHEN COMPLETED, REPORT TO THE INSTRUCTOR

Instructors signature showing satisfactory completion of this objective.

SERVICE TEST
STUDY GUIDE

C3ABR42331-SG-301

Technical Training

Aircraft Environmental Systems Mechanic

MAINTENANCE MANAGEMENT

8 June 1984

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

Designed for ATC Course Use.

Do Not Use on the Job.

Environmental Pneudraulics Branch
Chanute AFB, Illinois

SERVICE TEST
C3ABR42331-SG-301

MAINTENANCE MANAGEMENT

OBJECTIVE

Upon completion of this unit of instruction, you should be able to identify the functions and responsibilities of the Deputy Commander for Maintenance (DCM), by answering a minimum of four of five questions correctly.

INTRODUCTION

Everyone in a maintenance career field in the Air Force should have some knowledge of maintenance management. Even first term airmen should have a basic understanding of the system so there won't be any frustration caused by not knowing what is required of them and where they are in the maintenance complex. This unit of instruction covers the basics of the maintenance management system now in use.

> Note: The technical information contained herein is sufficient for this text only. For comprehensive and in-depth coverage of the maintenance organizations and Deputy Commander for Maintenance functions, refer to the appropriate AFR 66-1 and/or 66-5.

These are the only two concepts used in aircraft maintenance organizations. Organizations operating under the procedures of AFR 66-1 use the "Centralized Maintenance Concept" (CMC), and those organizations operating under the procedures of AFR 66-5 use the "Production Oriented Maintenance Organization Concept" (POMO).

OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 250; DAV - 1

INFORMATION

MAINTENANCE ORGANIZATIONS

If any group of people work together to complete a common purpose or mission, they must be organized. When they are organized, the efforts of the group are directed toward "mission accomplishment." Without good, sound organization, individual efforts become ineffective, and chaos is apt to start.

The goal of the Air Force is to have offensive and defensive air power for the United States. To do this goal, there are many side goals that must be done. One of the most important of these side goals is assigned to the aircraft maintenance organization.

AFR 66-1 "CENTRALIZED MAINTENANCE MANAGEMENT CONCEPT"

The purpose of AFR 66-1 is to set up a staff body or agency in the maintenance unit to control the maintenance effort. AFR 66-1 is to ensure centralization, standardization, and cost effective operation of support and strategic Air Force units.

Now that you know the maintenance organization you will be using, it is just as important to know where you fit in the wing. (See figure 1.)

To know the wing structure better, we must know how each function fits into the overall wing's mission.

We will look at a wing's functions and their responsibilities to the overall mission accomplishment. As you may already know, a wing is the smallest Air Force unit which is self-sustaining. Each wing may be divided into three main functions: Operations, Maintenance, and Support. Each of these does a specific and important task to enable the wing to do its assigned mission.

OPERATIONS: As the name implies, Operations is concerned with the operation of the assigned aircraft or missiles. This responsibility includes execution of the assigned peacetime mission as well as the training of personnel to make sure of readiness for the wartime mission.

MAINTENANCE: The wing's maintenance organization, where you will work, is responsible for maintaining the aircraft and their associated hardware. Maintenance must ensure that the assigned aircraft or missiles are maintained in the best condition possible with the resources available. To accomplish this, the maintenance organization will generally control the larger part of a wing's total resources. (This is where you come in. You will be involved in some aspects of managing the wing's maintenance resources.)

SUPPORT: This is the third vital function in a wing's structure. Support includes all of the elements necessary to make the wing self-sustaining: Transportation, Supply, Medical Services, Base Services, etc.

Obviously, since these three wing functions are all dedicated to one overall wing goal, it is necessary that they work together. In fact, you will find that there will be areas in a wing where responsibilities overlap and other areas where responsibilities must be shared by two or more of the

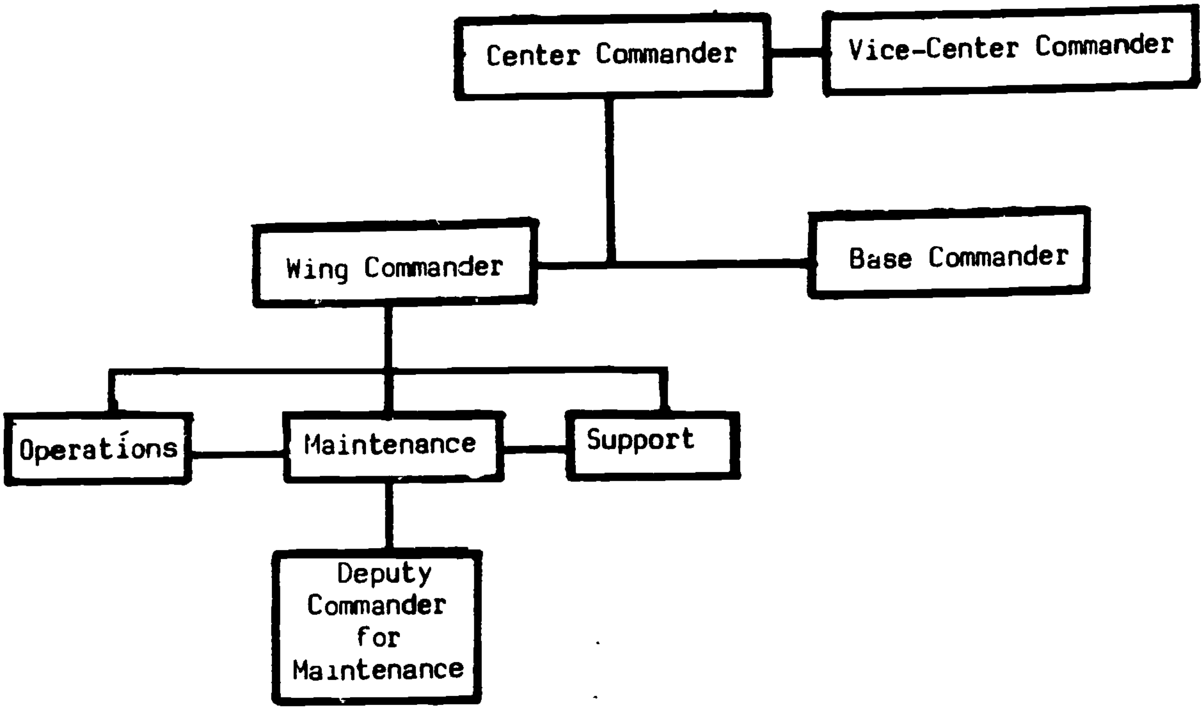


Figure 1. Chain of Command for the Deputy Commander for Maintenance.

functions involved. This type of relationship between wing functions is necessary to avoid duplication and waste. It requires a closely coordinated work effort among Operation, Maintenance, and Support to ensure that all objectives are met in an effective and timely manner.

DEPUTY COMMANDER FOR MAINTENANCE (DCM)

Since the maintenance organization is one part of the wing, you will find it easier to know the organizational structure of a maintenance complex beginning with the DCM and his/her staff. (The DCM's staff agencies will be discussed in the next PT.) Even though there are two management concepts, the DCM's responsibilities are similar. Any difference will be addressed separately in this text. Each of the management concepts will also be discussed later.

Maintenance is a vital part of the organizational structure of the Air Force. No matter where you are assigned, the personnel on the staff of the DCM are important to the mission of your unit.

The qualifications of the DCM are great and complex. The job of the DCM is like that of vice president of engineering for a big corporation. The DCM must be highly qualified in leadership, management, and administration. The maintenance organization of our operational wing is larger and more complex than the operation of many commercial companies. The DCM is a position established at the highest level of operational control and the person who is in this position is usually the senior officer and is always the most qualified maintenance officer in the organization. The DCM is the executive manager of the maintenance organization and exercises centralized contol and direction over all functions of the activity.

The DCM, through staff agencies (provided for their use as assistants), manages, plans, controls, executes, and produces the work needed to fulfill their functional responsibilities. The staff agencies act in the name of the DCM on those matters for which they have been given responsibility. The DCM's staff agencies must give the direction and guidance essential for all subordinates to start, apply, and comply with local and higher headquarters directives.

Though not limited to these, the responsibilities of the DCM are to

a. Make sure that all maintenance done on assigned equipment is timely and of high quality.

b. Give the necessary direction and guidance for implementing maintenance policies and procedures.

c. Give the amount of authority that is necessary for staff and production activities to perform assigned responsibilities.

d. Control the assignment of all maintenance personnel.

e. Make sure laws, regulations, and policies pertaining to personnel assigned to the maintenance complex are obeyed.

f. Coordinate with operations activities in establishing maintenance support requirements.

g. Make sure that requirements necessary to support the maintenance mission are included in plans, programs, and host-tenant agreements.

h. Control the assignment and use of maintenance facilities.

i. Make sure that effective safety programs are established throughout the maintenance complex.

j. Start a utilities conservation program.

k. Manage the financial program within the maintenance complex.

l. Make sure that a very good training program is established throughout the maintenance complex.

m. Make sure that Engineering and Technical Service personnel are effectively used in the maintenance training program.

n. Set up procedures to restrict nuclear weapon movement information.

o. Support the Maintenance Management Information and Control System (MMICS).

The complexity of the overall responsibilities of the DCM is such that some of them are normally handled by a group of staff agencies or sections. As we mentioned before, the DCM and staff agencies must plan, control, execute, direct, and guide subordinate activities in accomplishing the assigned mission. The supervisors of these agencies are on his staff to furnish him with the technical support, data, and coordination required for effective management of the activity. They assume responsibilities for certain control functions which are common to all maintenance activities, each agency being responsible for certain related and interdependent functions.

DCM STAFF AGENCIES
FUNCTIONS AND RESPONSIBILITIES

Objective

Identify the basic functions of the DCM's staff by answering a minimum of eight of ten questions correctly.

Introduction:

This lesson is designed to introduce you to the organizational structure of the Air Force management concepts found in AFR 66-1, Maintenance Management

Specifically, it contains an overview of the staff functior of the DCM, and the responsibilities of each.

While reading this SG, it is of your benefit to study figure 2 on the next page in this SG.

The technical information contained herein is sufficient for this text only. For a more comprehensive and indepth coverage of the maintenance management concept, refer to AFR 66-1.

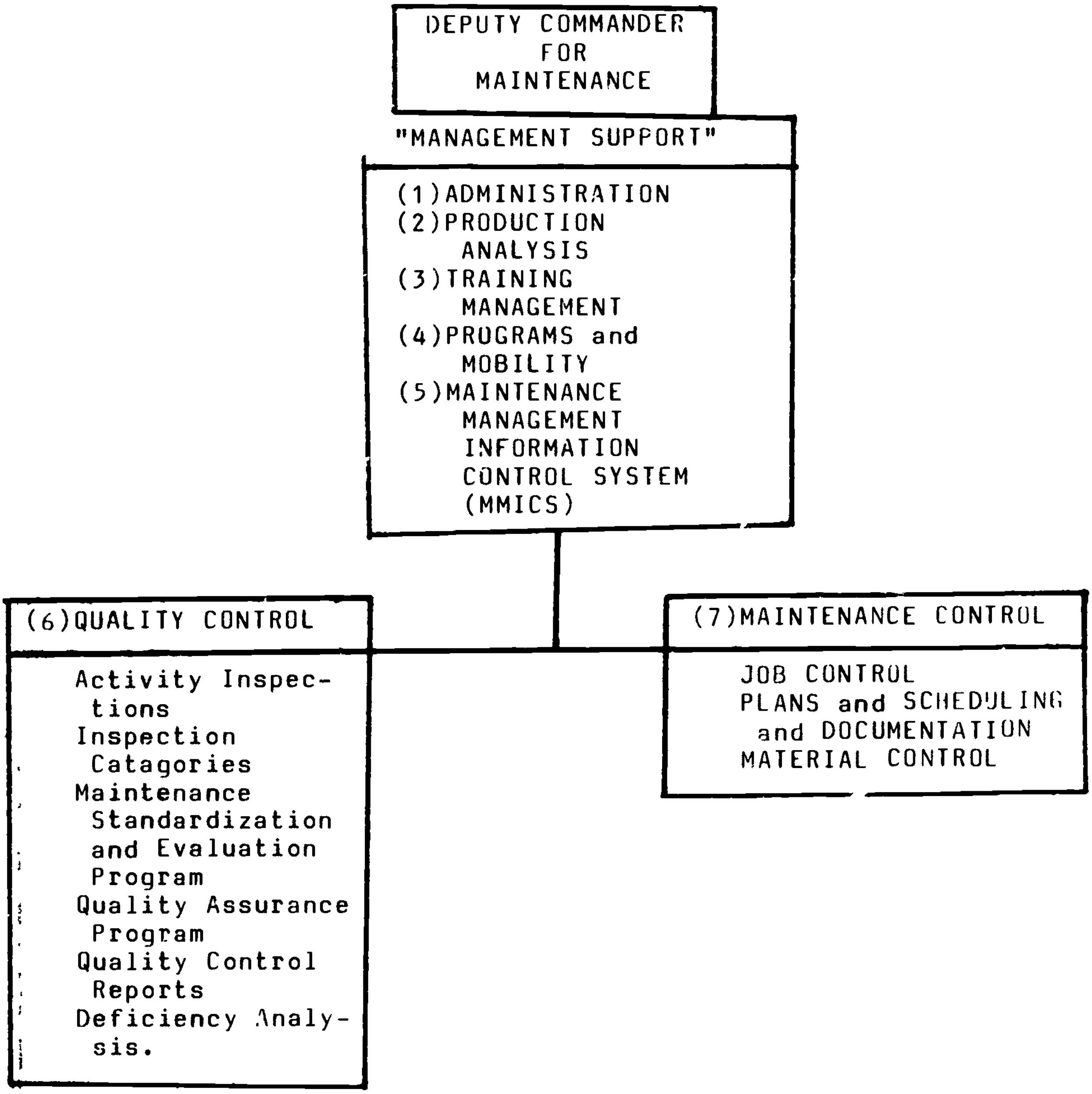
The purpose of AFR 66-1, is to set up a staff body or agency in the maintenance unit to control the maintenance effort. AFR 66-1 is to ensure centralization, standardization and cost effective operation of support and strategic Air Force units.

MANAGEMENT SUPPORT
MAINTENANCE MANAGEMENT DIVISION

Administration (1)

Administration is the administrative management center of the maintenance complex, and the focal point for all correspondance and reporting. Administration keeps correspondence files, prepares and submits maintenance reports, and controls maintenance administrative procedures as directed by the DCM.

The administration activity is responsible for administrative support of the DCM office and the maintenance complex.



DEPUTY COMMANDER FOR MAINTENANCE
STAFF AGENCIES

Figure 2.

Production Analysis (2)

Production Analysis is the primary management information source for the DCM. The overall objective is to provide information to be used to improve the maintenance operation. This is done through the examination of various maintenance management output product reports and the identification of trends that are developing. Manhour and maintenance data, equipment status, and other reports received by maintenance in the form of machine listings contain alot of data, By the analysis process information can be obtained, that would assist management to make changes. Analysis should not limit themselves to pointing out only general areas for investigation. The analysis process should identify deficiences of a workcenter, particular equipment, maintenance practices, or management actions. They will also hold the responsibility in the assigning of workcenter codes, for the various shops throughout the bace facility.

Training Management (3)

The basic responsibility for training lies with the production unit commander. This responsibility is fulfilled through the unit training activity. How ever, as the functional manager, the DCM has the overall responsibility for maintaining a balance of skills within the mainterance complex, and ensuring that maintenance personnel receive all necessary training. To fulfill this responsibility, Training Management ensures that a continuous, well organized maintenance training program is set up throughout the maintenance complex.

Programs and Mobility (4)

Programs and Mobility procides the DCM with support in developing and maintaining programs and plans. As the focal point in maintenance for mission and support plans, it essembles and gives inputs to plans. It also serves as the overall financial, manpower and facilities manager for the DCM. Programs and Mobility conducts annual staff assistance visits to each maintenance unit in order to ensure that a viable problem exists in the areas of mobility, financial management and personnel management as well as facilities monitoring.

Maintenance Management Information and Control System (MMICS) (5)
Files Maintenance (MMICS) (5)

MMICS, collects and processes maintenance information which are essential parts of Air Force maintenance management. There are several systems designed to provide needed management data as part of the overall maintenance management information system. Keeping the maintenance personnel listing is mandatory for all commands and units documenting maintenance in accordance with the base level Maintenance Data Collection System.

The MMICS is provided to help the DCM with the tasks that can be efficiently and effectively handled by a computer.

Quality Control (QC) (6)

Maintenance quality and reliability is the responsibility of all maintenance personnel. The combined efforts of QC personnel, maintenance supervisors, and technicians are necessary to insure high quality maintenance production and equipment reliability. Maintenance Supervisors are responsible for safety of flight, safety of equipment operation, and quality maintenance production. The QC staff evaluates the quality of maintenance organizations' QC program.

QC serves as the primary technical advisory agency in the maintenance activity, helping the production supervisors and the DCM in the resolution of quality problems. The evaluation and analysis of deficiencies and problem areas are a key function of QC.

QC must assure that technical and management procedures are followed.

Maintenance Control (7)

Maintenance Control is the only staff function involved directly in the maintenance production under the DCM. The staff elements are assigned directly under Maintenance Control.

Maintenance Control must direct the maintenance production activity, using resources, and controlling the actions that are required to support the mission. Maintenance Control plans, schedules, direct, and controls all maintenance on aircraft, and related equipment. To carry this out, Maintenance Control is set up into three parts:

- Job Control
- Plans & Scheduling & Documentation
- Materiel Control

If you should walk into Maintenance Control, you would find a few display boards representing the flight line and the places where aircraft and equipment are found. Some displays show the work to be done, work in progress, and projected work start and stop times. In the midst of all this you would see a few people answering phones and radio calls to dispatch specialists and equipment to a few areas on the flightline. You can readily understand why we call Maintenance Control the nerve center of the maintenance organization.

MAINTENANCE DATA COLLECTION

OBJECTIVES

Identify facts relating to Maintenance Data Collection by answering a minimum of four of five questions correctly.

Identify facts for processing and controlling material with 100% accuracy.

INTRODUCTION

Have you ever really tried to keep up with the maintenance that is done on your car? Unless you are the type that performs his/her own maintenance and inspections, and keeps accurate records, it can get confusing. You take your car to one place, and they complete forms, telling you what they've done to it; then you take it to another place and they fill out their forms which are different, and before you know it you are so confused as what is done and still needs to be done that you are pulling your hair out by the roots!!! Every place you take your car for the different "specialists" to perform their maintenance, there is a different form, with sometimes very confusing but important information.

Some maintenance can be scheduled. For example, oil changes, oil filters, air filter, spark plugs, wheel allignments, etc.can be scheduled in advance. These are things that you may work into your budget to get them done. Sometimes things happen by surprise, like transmission failure and engine proglems. These things you can't plan on and are unscheduled maintenance.

Sometimes even when we do our own maintenance, unless we keep a record of what and when the maintenance was done, we can have a difficult time remembering when certain things are due again.

As you know, you will be performing scheduled and unscheduled maintenance on aircraft. Along with this maintenance you will have to maintain maintenance and historical records on all maintenance that is performed. Just like every place you take your car for maintenance, they have a particular form and way of filling out that form, so does the Air Force. This is called the Maintenance Data Collection System.

These forms are numbered, such as AFTO Form 349, AFTO Form 350, and AFTO Form 781A. The abbreviation AFTO identifies this form as an Air Force form and has a Technical Order written in order to complete the form properly.

We will learn in this lesson how to use these TOs and when to which TO for what AFTO Form. We will also learn the AFTO form that is used to process and control material (parts) for repair or to be condemned and returned to Depot.

Before we begin, be sure to read and follow this PT very carefully. Should any problems arise, ask the instructor for help/assistance.

INFORMATION

Title Page

TO Number: The TO number is written in the upper right corner of the title page and in the upper left/right corners of the pages thereafter. (This binder contains four different 00-20 TOs. So if you ever have difficulty finding the information we are talking about, the first thing you should do is check the number in the upper left/right corner of the page.) In this case, we are in TO 00-20-1. Each TO number is divided into at least three parts and each part is seperated by a dash. Each part of the TO number identifies what the TO is all about.

00. The 00 in the first part of this TO number identifies methods and procedures.

-20. Tells us this TO pertains to the MDC system.

-1. Says General requirements for all AFTO Forms.

If we take this TO number breakdown and put it together we would have, "The methods and procedures for the MDC system that is applicable to all AFTO Forms."

TO Title: The title of this TO is "PREVENTIVE MAINTENANCE PROGRAM GENERAL REQUIREMENTS AND PROCEDURES." This is a brief statement as to the type of information that is found inside this TO and is located in the top center of the Title Page.

Distribution Statement: The distribution statement tells us that the TO is limited to US Government use, and if we would like to order a copy we must write to Tinker AFB, Oklahoma. The distribution statement is written in the bottom center of the title page.

Publishing Statement: The publishing statement says who authorized this TO to be published. The Secretary of the Air Force said this TO will be published which is like they are telling you on paper what to do. Since this is a Technical "Order," if you do not use this and comply with the orders contained in this and all TOs, you are failing to obey an order given you by the Secretary of the Air Force, which is as bad if not worse than telling your supervisor that you will not do what he is telling you to do. "ALL TOs ARE A MILITARY ORDER!"

The publishing statement is written in the bottom center of the Title page.

Dates: If you'll look in the bottom right corner, you'll see two dates. The top date of 1 January 1979 is the date this TO was published. Below this date is CHANGE 10 15 February 1983, and tells us since 1 January 1979 this TO has had 10 changes and change 10 was put in effect 15 February 1983.

TOs usually change quire a bit. The information may not be clear enough to comply with or may be misleading as it is written. Because the Air Force wants us to use these and all TOs, they go to unending limits to make the information clear and precise. Sometimes they feel they need to add information to a TO, so it is added for our benefit. TOs are written for you! Use them!

LISTS OF EFFECTIVE PAGES   Page A.

Turn the Title Page over. In the lower left corner, you'll find the letter A. This is the page letter. (Page numbers will begin later in this TO.) If you'll look in the upper left corner you'll find, inside a box, LISTS OF EFFECTIVE PAGES. If you read through this page, beginning with this box, you'll find next to this box what to do in case of a TO change. Beneath this, there is a NOTE: This note tells how we can identify a changed portion of a page, which the latest change has affected. Next we find the dates that each change was published, and below this, the total number of pages in this TO and the change number of each page, if any.

Page A is common to all TOs, and is located on the back of the title page.

Table of Contents   Page i

This page is called the Table of Contents and is a very important tool in finding information in this TO. The Table of Contents is divided into three columns. From left to right the titles of the three columns are:

SECTION   TITLE   PAGE

Section: This tells us what section of the TO information is found. Section one pertains to GENERAL information. Section II pertains to ADMINISTRATIVE REQUIREMENTS FOR MAINTENANCE DOCUMENTS. Notice under the word PAGE how the first number before the dash changes depending on what section of the TO we are in.

Title: In the center of the page we have the titles of information. Under GENERAL, Section I, we first of all have the Purpose of this TO and all information that is of general nature. In section II we will find information pertaining to the administrative requirements. Whenever I hear the word "administrative," I think of filing, typing and things that a secretary would do. Well section II pertains to just that kind of information.

Page: In column three, we find a list of page numbers. You already know that the first number, before the dash, is the section number. The number after the dash is the actual page number or the order of information in which it is found. To the left of the title we have another set of numbers. These numbers are paragraph numbers. If we were looking for information pertaining to contract maintenance operations, we would find the title in section one. We would find the information that we are looking for in paragraph 1-7 on page 1-2.

As we continue looking through e Table of Contents, you will notice a black vertical line next to page number 2-6. Remember what this stands for? If not, go back to page A in the TO and read the note in the upper center part of the page.

In section IV we have MAINTENANCE INSPECTIONS METHODS AND PROCEDURES AND ACCESSORY REPLACEMENT AND REUSE REQUIREMENTS. Turning to page ii, there are two more sections - V and VI.

Also included in the Table of Contents is the list of illustrations. This is used when you want to see a picture of, in this case AFTO Forms, what the TO is describing. On page iii, we find the list of tables, which has problem areas that a of people have had, so a table was written for these particular problems and what to do in case you should have the same problem some time in your Air Force career.

Always use the Table of Contents when you are looking for information inside a TO. It helps you to find the information much faster and easier. If there is something inside the TO that you don't understand, such as an astrisk or some kind of markings, always look to the page A for a definition of these markings. If the marking isn't listed there, it may be identified in the first paragraph of that section. If not, ask your instructor if he/she will identify it for you.

TO 00-20-2-2

ON-EQUIPMENT MAINTENANCE DOCUMENTATION FOR AIRCRAFT; AIR-LAUNCHED MISSILES; GROUND-LAUNCHED MISSILES, EXCEPT ICBMs; DRONES; AND RELATED TRAINING EQUIPMENT

Turn to TO 00-20-2-2.

Lets begin this part of the lesson by discussing this TO number. You probably already noticed this TO number has <u>four</u> parts. Lets find out what these parts identify.

00 The 00 identifies the same as in the last TO number. Methods and procedures.

-20 The 20 still identifies the same thing, MDC System.

-2 The -2 identifies a particular AFTO Form(s). In this case the <u>AFTO Form 349</u>, and the <u>AFTO Form 350</u>. (see Table of Contents)

-2 The last part is a -2, and this identifies what piece of equipment this TO applies to. You can tell by the title, this TO applies to <u>Aircraft</u>.

If we were to take this breakdown and put it all together, we would have:

The Methods and Procedures for the MDC system, for completing AFTO Forms 349/350 when working on the aircraft.

The 'A' page, and the Table of Contents work the same in this TO as in the last TO. (00-20-1), and has the same format as used in the last TO.

Lets proceed to the next TO.

TO 00-20-2-10

OFF-EQUIPMENT MAINTENANCE DOCUMENTATION FOR SHOPWORK, CONVENTIONAL MUNITIONS, AND PRECISION MEASUREMENT EQUIPMENT

In this TO number the only part that has changed is the fourth part (-10).

We still have a Methods and Procedural TO, (oo). We still have a TO that pertains to the MDC System, (-20). The Third Part is still -2, and by looking at the Table of Contents, this TO still pertains to the same AFTO Forms 349/350. Now what does the -10 in the fourth part identify? Notice the TO Title, where it says in the beginning, OFF-EQUIPMENT MAINTENANCE DOCUMENTATION FOR SHOPWORK.

So we have a Methods and Procedures TO for the MDC System, for documenting maintenance on the AFTO Form 349/350, when working IN-SHOP.

The Page 'A' is the same for all TOs except for the specifics pertaining to the TO you are using. The Table of Contents is on the same basic format as the Os, (NOTICE: the 00-20-2-2, and 00-20-2-10 Table of Contents are almost identical).

TO 00-20-5

AIRCRAFT, DRONE, AIRCREW TRAINING DEVICES, ENGINES, AND AIR-LAUNCHED MISSILE INSPECTIONS, FLIGHT REPORTS, AND SUPPORTING MAINTENANCE DOCUMENTS.

TO 00-20-5 begins no differently than the other TOs. It also has a Title Page, an 'A' page, and a Table of Contents.

The -5, in the third part of the TO number, identifies that this TO covers specific information. Unlike TO 00-20-1, which covers general information applicable to all AFTO Forms, the 00-20-5 covers specific information on specific forms.

Look through the Table of Contents, (pages ii, thru iii) and you will find this TO covers the entire AFTO Form 781 series; (there are approximately 8 different 781's). AFTO Forms 100, 100A; and AFTO Forms 98, 88, 44, and 34. (Don't worry, you will not be responsible to remember all of these AFTO Forms. Just know what TO covers them). You may also notice this TO does not cover the AFTO Forms 349/350.

Briefly review the Table of Contents before you proceed to the review questions for this frame.

Review

TO 00-20-1 "Preventive Maintenance Program General Requirements and Procedures"

This TO pertains to the methods and procedures for the MDC systems. It is general information and applies to ALL AFTO Forms.

TO 00-20-2-2, "On-Equipment Maintenance Documentation for Aircraft; Air-Launched Missiles; Ground-Launched Missiles, Except ICBMs; Drones; and Related Training Equipment"

This TO pertains to Aircraft Maintenance Documentation for AFTO Forms 349 and 350.

TO 00-20-2-10, "Off-Equipment Maintenance Documentation for Shop Work, Conventional Munitions and Precision Measurement Equipment."

This TO pertains to Maintenance Documentation for Shop work, when the equipment (system or component) was removed from the aircraft, and is for AFTO Forms 349/350.

TO 00-20-5 "Aircraft, Drone and Air-Launched Missile Inspections, Flight Reports and Supporting Maintenance Documents."

This TO pertains to specific information on specific AFTO Forms.

If you have any questions on any of this information ask now!

We have two more TOs to learn. They are TOs: 00-20-2 (in H0301) Maintenance Data Collection System.

IF-111A-06 Work Unit Code manual for an F-111A Aircraft

The reason these two TOs have been separated from the others is because they are used to find the codes that are used on AFTO Forms.

The TO 00-20-2 "MDC System", is used to find the codes that are entered on AFTO Forms 349/350.

One of the codes we will find in this TO is Standard Reporting Designator (SRD) codes. An older AFTO Forms 349-350 the SRD is called EQ/CL (Equipment Classification Codes). Whether it is SRD or EQ/CL the same code is used. They are different terms that mean the same thing.

SRD codes are used to identify aircraft and support equipment and related equipment by type or category.

All the codes in this TO are identified by aircraft type in alphabetical/numerical order. (Example: Attack, Bomber, Cargo, Figher, etc.) In order to find the SRD/EQ/CL code simply look up the type, model and series of aircraft or aircraft equipment you are working on.
(Example: An F-111A; Type 'F'=Fighter; Model 111; Series A.)

If we look up the SRD-EQ/CL Code for an F111A, we will find the code is AFV. The 'A' identifies a General type of equipment such as 'A' for aircraft. If the first character is an 'X', it identifies engines.

The FV of the SRD-EQ/CL Code identifies specific equipment (F-111A). If we were to remove the engines from an F111A, our SRD-EQ/CL code would be XFV. If we removed the Air Launched Missiles and Guided Missiles from the F111A our SRD-EQ/CL Code would be NFV.

Some bases have more than one kind of aircraft assigned. The reason for using SRD-EQ/CL Codes is because some equipment for certain aircraft may look identical, but not be interchangeable. So these codes will assist us and others in identifying that the equipment is for a specific aircraft.

These codes are also used in computer programs to facilitate data processing of specifi equipment for use in automated management information systems and to assist interchange of data between the supply and maintenance system.

The authorized abbreviation for SRD, and EQ/CL codes is SRD.

Another code the 00-20-2 TO gives us is the Category of Labor Codes. These Category of Labor Codes are to be used for differentiating the various types of maintenance resources used to support the USAF equipment maintenance program. These codes are mandatory for all units under the MDC System.

TO IF-111A-06, "AIRCRAFT MAINTENANCE WORK UNIT CODE MANUAL USAF SERIES F-111A, D, E AND F AIRCRAFT."

Looking at the Title Page of the IF-111A-06 we will find the TO number in the upper right corner, and on the top center of each page hereafter. In the center top half we will find the complete TO title. The title includes all letters and numbers. You see this TO covers the F-111 series A, D, E, and F. It will not work for series B, C of the F-111 aircraft. Below the title we will find the distribution statement, and below this, we find this TO was published under authority of the Secretary of the Air Force. Then to the right bottom corner we will find the basic date and change number along with the change date.

Behind the Title Page, we have an 'A' page. First we have the TO number, and the title of this page "List of Effective Pages." Beneath this is what to do in case of a change to the TO. Then we find how we can identify what the most recent change has affected. Now we have a NOTE: That the other TO did not have. It says "only pages listed on the 'A' page are valid." Next we find the dates of issue for the original, and changed pages along with page numbers, and change numbers that should be found for that page. The list of Effective pages covers pages A, B, C, and D. The total number of pages in this manual is 256.

On Page I-001 begins the Table of Contents. See the black vertical lines in the outer margin of this page? Remember what this means? If not, go back and read the first note on the top of page 'A'. Never try to "memorize" information that is found in a TO. They are almost constantly being changed. If you feel that you have "mastered" the information always double check before you do what is required, and remember "a TO is a military order."

Beneath the Table of Contents page we find the preface. This is where they introduce the various codes, abbreviations and symbols you will find inside the TO.

Next we see there are two groups of Type Maintenance Codes. One is for aircraft, the other is for engines. Always be sure you are in the right group for the type of maintenance you are performing. (Read paragraph 2c on page II-002.)

Getting back to the Table of Contents, we find Action taken codes listed on page V-001. The description of Action taken codes is on page II-002, paragraph 2D. Read this paragraph, then return to the Table of Contents and this PT.

After Actio. ..aken Codes we find When Discovered codes. Read paragraph 2D on Page II-002 in the TO.

Now things begin to get a little tricky. Pay very close attention to this paragraph.

There are two groups of How Malfunction Codes. The first one is an Alphabetical listing, where all the code definitions are listed under the first letter of the malfunction. Turn to Page VII-001 to see what we are talking about. Then return to the Table of Contents. The second group of How Malfunction Codes is a numerical listing where all the codes are listed according to the number of the code. (smallest number first) Turn to Page XI-001, then return to the Table of Contents.

These How Malfunction codes are further broken down into categories:

Avionics/Electrical/Computer
Physical/Mechanical
No Defect
Engine Related/Reason For Removal

This category of How Malfunction Codes is broken into sub-categories:

Observed or Recorded Operational Conditions
Identified Components
Condition Monitoring
Chance Occurances
Managerial Decisions
Nor Defect

The majority of these codes you will use will be taken from the Physical/ Mechanical category.

After the How M... ...tioned Codes Numerical Listing is Aircraft Support General Codes. All ... General Codes will begin with a zero (example: 01000, 02C.0, 03000 ...000). These codes are used like Work Unit Codes, only work unit codes will begin with a one or higher number (Example: 11000, 11ADP, 23GAE, 47ADB and etc.)

Support General Codes are used to identify a group of components that make up a ... sk. Example: If we were given the job of washing an aircraft, we would have to document all of the components on the aircraft that we washed, which would include almost every work unit code in this manual, or we could use the support general code that identifies "washing" which would include everything on the aircraft that was washed.

We could say Support General Codes are <u>verbs</u>, they <u>show action</u> taken against something. Since you can't see or touch "washing", it is something you do.

To find the Support General Code for "washing" use the Table of Contents.

The first group of Support General Codes, (page I-002) says "except 03000 and 04000". Then we notice that the next two groups are for 03000 and 04000. They have their own pages (03-001 and 04-001). Before we go any further, le.s go to these two Support General Codes and find out why they are listed separately.

Turning to Page 03-001 first, notice what is above Support General Code 03100. It says "Look" Phase of Scheduled Inspections. This is a list of all the Scheduled Inspections we will perform on a F111 aircraft.

On Page 04-001 we have a list of SPECIAL INSPECTIONS. These are inspections we will perform on F111 aircraft that are Unscheduled Inspections, or Special. There are four pages of special inspections. Due to the fact that "washing" is not an inspection of any kind, the Support General Code we are looking for must be in the first group where it says "except 03000, and 04000."

Remember 03000 Codes identify "Scheduled Inspections, while 04000 codes indentifies "Special Inspections."

Now turning to Page 01-001, we find the Code 01000. This code identifies Ground Handling, Servicing and Related tasks. Reading through the description of 01000, we cannot find anything that is related to "washing". Turning to Page 01-003 we find 02000, and it identifies Aircraft Cleaning, which includes "washing". So the Support General Code for washing is 02000.

Support General Codes are verbs. They show action.

Work Unit Codes (any five diget code that begins with a 1 or higher number) is a noun. These are things that we can see and touch, so turn to Page 11-001 and lets look at one of these codes. 11000-Airframe Fuselage.

Work Unit Codes are listed in an outline format. 11000 is a work unit code that identifies the airframe of the aircraft. Notice how all the codes on Page 11-001 begin with the same number as the page number.

Beneath the description of 11000 we will find the Airframe Fuselage is broken down into sections. In this case it is the Nose section. Now notice what happened to our work unit codes. We still have 11 but the 000 changed to AA. The 11 still identifies the Airframe Fuselage, but the AA now identifies one section of it. In this case the AA identifies the Nose Section. Go down the list of Work Unit Codes changes from AA. What does it mean when the code changes from AA to AB? Here AB identifies the Nose Section Doors/Covers. When the code changes from AB to AC we changed to another section of the airframe. In this case it is the Center Section. Looking to Code 11ACD we have the skin (D), for the Center Section AC, for the airframe (11). The only letter that changes is the last letter. This identifies a component for the sub-section, for the main section.

Lets look at Page 41-001. You all should be familiar with this system. Look at Code 41 ABA. The last A identifies the Exchanger, Heat, Air-to-air, (for F111 series A/E) for the Refrigeration Package B for the Air/Conditioning System 41A.

If you are having problems understanding these codes, ask your instructor for help.

If you have any questions about any of these TOs, ask your instructor for help.

Review on TO's 00-20-1 and IF-111A-06

The 00-20-1 TO, gives us information in codes that goes on the AFTO forms 349/350. The codes that are found in this TO are "Standard Reporting Designators", and "Category of Labor".

The IF-111A-06 TO, gives us information, in codes, that goes on the AFTO Forms 349/350/781A (as required). The codes that are found in this TO are:

Type of Maintenance
Action taken
When Discovered
How Malfunction
Aircraft Support General
and Work Unit Codes

Up to this point you have learned how to use six TOs. They are:

00-20-1	Preventive Maintenance Program General Requirements and Procedures
00-20-2	Maintenance Data Collection
00-20-2-2	On-Equipment Maintenance Documentation for Aircraft; Air-Launched Missiles; Ground-Launched Missiles, Except ICBMs; Drones; and Related Training Equipment.
00-20-2-10	Off-Equipment Maintenance Documentation for Shop Work, Conventional Munitions and Precision Measurement Equipment
00-20-5	Aircraft, Drone, and Air-Launched Missile Inspections, Flight Reports, and Supporting Maintenance Documents
IF-111A-06	Aircraft Maintenance Work Unit Code Manual USAF Series F-111A, D, E and F Aircraft.

If you have any questions concerning the use of these TOs, ask your instructor before continuing.

There are many reasons for the use of the MDC System. They are to name a few:

1. Production information about the type of work accomplished, the work center that did the work, and the equipment on which the work was accomplished.

2. Equipment maintenance schedules and inventory information for maintenance actions that are required on a calendar basis.

3. Equipment failures and discrepancy information.

4. In addition to the above, base maintenance managers and supervisors may obtain information concerning the cost of maintenance.

   (a) The cost of civilian and military manhours.

   (b) The cost to maintain aircraft, for both on and off-equipment maintenance.

   (c) Reimbursement action for transit maintenance services.

Because of the many uses it is important that the data in the MDC System be accurate. The effect of data errors varies for different information uses. For instance, some margin of error can be tolerated when determining inspection intervals. However, computing the service life of high cost, low inventory items require 100% accuracy. \4

The information provided through the MDC System is used in the management decision making process which results in many tangible benfits to Air Force logistics, especially maintenance. These benefits are not always apparent to the individual involved in the documentation of data; however, a large portion of the cost of the MDC System is returned through better management decisions that can be made with informative facts.

MAINTENANCE DATA COLLECTION RECORD

OMB NO. 21-R0227

1. JOB CONTROL NO.	2. WORKCENTER	3. I.D. NO./SERIAL NO.	4. MDS	5. SRD/CL	6. TIME	7. PRI	8. SORTIE NO.	9. LOCATION
0920013	45	1A1640			296.	3		'K'

10. ENG. TIME	11. ENGINE I.D.	12. INST ENG TIME	13. INST. ENG. I.D.	14.	15.	16.	17 TIME SPC REQ	18 JOB STD.
13	JX1926	57.	JX0517				0945	2.5/2

19 FSC	20. PART NUMBER	21. SER. NO./OPER. TIME	22. TAG NO.	23. INST. ITEM PART NO	24. SERIAL NUMBER	25. OPER TIME
			570			

ACT LINE	A TYPE MAINT	B COMP POS	C WORK UNIT CODE	D ACTION TAKEN	E WHEN DISC	F HOW MAL	G UNITS	H START HOUR	I STOP DAY	I STOP HOUR	J CREW SIZE	K CAT LAB	L CMD ACT ID	M SCH CODE	N EMPLOYEE NUMBER
1	B	1	23000	R	F	476	1	0945	092	1115	2	1			H5956
2	B	1	23000	X	F	799	1	1115	092	1145	2	1			H5956
3															
4															
5															

DISCREPANCY

#1 Engine has FOD

27. CORRECTIVE ACTION

REMOVED AND REPLACED #1 ENGINE IAW TO
OPERATIONAL CK OK IAW TO.

28. RECORDS ACTION

AFTO FORM MAY 75 349 PREVIOUS EDITION IS OBSOLETE.

*U.S. Government Printing Office: 1975 — 659-576

Figure 3. AFTO Form 349.

The AFTO Form 349 (Figure 3) is the Maintenance Data Collection Record This is a universal form. It is used to collect information on man hours, serially controlled items, time change items, type of maintenance performed, who performed the maintenance; by work center, and employee number. It is also used as a spatch from when certain blocks have been completed.

Do you remember what TOs are used to complete this form? Do you remember what TOs are used to find the codes that are recorded on this form?

In Figure 4 you will find a copy of the AFTO Form 350. This is a Reparable Item Processing Tag, and is a two part form.

Part I of the AFTO Form 350 will always be left attached to the item that is determined to be reparable and is being forwarded to other activities for repair, and is used for shop processing. Part II serves as a production control document, and is used to control the reparable item during shop processing. The Part II of this form will be retained by the Production Scheduler.

AFTO FORM 350 FEB. 1977
PREVIOUS EDITION WILL BE USED

BUDGET BUREAU
NO. 21-R0227

REPARABLE ITEM PROCESSING TAG

1. JOB CONTROL NO.	2. ID / SERIAL NO.	3. TM	3A. SRD	4. WHEN DISC
09200013	1A1640	B	XTF	F

5. HOW MAL	6. MDS	7. WORK UNIT CODE	8. ITEM OPER. TIME	9. QTY.
4Z	J-79	23000	13	1

10. FSC	11. PART NUMBER
2911	J-79-21

12. SERIAL NUMBER	13. SUPPLY DOCUMENT NUMBER
001926	

14. DISCREPANCY
FOD #1 ENGINE

15. SHOP USE ONLY

NOTICE

15A. CMD / ACT ID

TAG NO. 939570 AFTO 350 PT. I

16. SUPPLY DOCUMENT NUMBER

17. NOMENCLATURE

18. PART NUMBER

19. NSN

20. ACTION TAKEN	21. QTY.	22. RPC. USE ONLY

NOTICE

TAG NO. 939570 AFTO 350 PT. II

☆ U. S GOVERNMENT PRINTING OFFICE: 1977-758-426

WARNING

Unauthorized persons removing, defacing, or destroying this tag (or label) may be subject to a fine of not more than $1,000 or imprisonment for not more than one year or both.
(18 USC 1 36 1)

REPAIR CYCLE DATA

23. NSN	24. SRAN CODE
25. TRANSPORTATION CONTROL NUMBER	

STATUS CHANGED TO

26 SERVICEABLE

27. CONDEMNED

28. SUPPLY INSPECTOR'S STAMP

29.

BASE REPAIR CYCLE DATA		MO.	DAY	YR.	TIME
DATE REMOVED 02/04/3	REC'D BY RPC				AWM
TO:					
TO:					AWP
TO:					
TO:					
TO:					
DATE COMPLETED					

AFTO Form 350—Front. Figure 4. ***AFTO Form 350—Back.***

The Maintenance Discrepancy and Work Document is where the actual discrepancy begins , AFTO Form 781A (Figure 5). This form records all maintenance that is performed on the Aircraft, that is discovered by the pilot and maintenance personnel. This form will always be kept at, or near the aircraft, each aircraft will have its own separate group of AFTO 781 series forms.

DATE FROM	TO	CREW CHIEF	ORGN	LOCATION	MDS	SERIAL NO
02105 13	/ /	D Beavers	3370TTGP	CAFB IL	T38A	661640

SYM	DATE DISCD	WDC	JCN	TAG NO	CF TO 781A DATED	TRANSFERRED TO 781K DATE	DATE CORRECTED
X	0210513	F	0920013		P / /	/ /	02 105 13

DOC NO

DISCREPANCY
#1 ENGINE HAS EVIDENCE OF FOREIGN OBJECT DAMAGE

TRANSFERRED BY | GRADE | EMPLOYEE NO

CORRECTIVE ACTION
#1 ENGINE HAS BEEN REMOVED AND REPLACED. OPS CHECKED IAW TO 1T-38A-2-6

	NAME	GRADE	EMPLOYEE NO
CORRECTED BY	J. Johnson	SSgt.	J4927
INSPECTED BY	T. Schrenk	TSgt.	S5076
DISCOVERED BY	D. Beavers	GS-9	B7606

SYM	DATE DISCD	WDC	JCN	TAG NO.	CF TO 781A DATED	TRANSFERRED TO 781K DATE	DATE CORRECTED
X	02105 13	F	0920013	939570	P / /	/ /	02 105 13

DOC NO.

DISCREPANCY
#1 ENGINE REMOVED FOR FOD. OLD ENGINE SERIAL NUMBER 671926 TOT: 132 hrs.

TRANSFERRED BY | GRADE | EMPLOYEE NO

CORRECTIVE ACTION
#1 ENGINE INSTALLED IAW TO 1T-38A-2-6
New Engine SN 660517 TOT: 573hrs

	NAME	GRADE	EMPLOYEE NO
CORRECTED BY	S. Montgomery	SRA	M2960
INSPECTED BY	J. Johnson	SSgt.	J4927
DISCOVERED BY	S. Montgomery	SRA	M2960

SYM	DATE DISCD	WDC	JCN	TAG NO	CF TO 781A DATED	TRANSFERRED TO 781K DATE	DATE CORRECTED
	/ /				P / /	/ /	/ /

DOC. NO | DISCREPANCY | TRANSFERRED BY | GRADE | EMPLOYEE NO

CORRECTIVE ACTION

CORRECTED BY | GRADE | EMPLOYEE NO

DISCOVERED BY | GRADE | EMPLOYEE NO | INSPECTED BY | GRADE | EMPLOYEE NO

SYM	DATE DISCD	WDC	JCN	TAG NO	CF TO 781A DATED	TRANSFERRED TO 781K DATE	DATE CORRECTED
	/ /				P / /	/ /	/ /

DOC NO | DISCREPANCY | TRANSFERRED BY | GRADE | EMPLOYEE NO

CORRECTIVE ACTION

CORRECTED BY | GRADE | EMPLOYEE NO

DISCOVERED BY | GRADE | EMPLOYEE NO. | INSPECTED BY | GRADE | EMPLOYEE NO

AFTO FORM NOV 78 781A **MAINTENANCE DISCREPANCY AND WORK DOCUMENT** PREVIOUS EDITION IS OBSOLETE

Figure 5.

MAINTENANCE SYSTEM

OBJECTIVE

State general principles of the maintenance system by answering a minimum of 8 of 10 questions correctly.

INTRODUCTION

A good Air Force does not just happen by accident. It is the result of a lot of people working together for a common goal. In this programmed text, we will discuss some of these people and what their jobs are about. The people we are most concerned about, because we are mechanics, are those who work in the areas of maintenance. The two main goals in the areas of maintenance should be as follows:

- Keep Air Force equipment serviceable.
- Keep it safe to use.

Now, let us begin our adventure into the "MAINTENANCE SYSTEM."

- -

The Maintenance System is broken down into four areas. They are as follows:

Levels of Maintenance

Maintenance Squadrons

Types of Maintenance

Maintenance Symbols and Their Use

We will begin our studies with the Levels of Maintenance.

INFORMATION

LEVELS OF MAINTENANCE

Organizational Maintenance

Organizational Maintenance is limited in scope. This level of maintenance includes routine inspections, replacement of some components, minor structural repairs, and servicing with fuel, oil, etc. Organizational Maintenance may also do technical order modification that can be done with the facilities that are at the organizational level.

It is of the utmost importance that technicians at the organizational evel discover any of the indications of equipment failure soon enough to vent a major component failure. Failure to discover these indications result in an increase in the workload of the other levels of maintenance. result in a disruption of the maintenance schedules, not to mention ht failure with the possibility of a loss of life and/or equipment.

Intermediate Maintenance

Closely supporting the organizational level of maintenance is the Intermediate Level of Maintenance. Personnel in the Field Maintenance activity, usually a field maintenance squadron (FMS), performs maintenance at the intermediate level. The FMS usually has a high concentration of skilled specialists and has the most costly equipment in the maintenance organization. You will find such shops as engines, fuel systems, electrical, pneudraulics, and environmental systems, just to name a few, at this level. The actual number will depend on the size of the organization and the mission, in other words--NEED! If the DCM decides that there is a need for a shop, then the organization will make the necessary provisions for it.

The support that is provided by this level of maintenance consists of furnishing specialist assistance at organizational line maintenance, doing bench checks of equipment, and maintenance repair that is beyond the capacity of the organizational unit. When the capabilities of the maintenance activity at the intermediate level are exceeded, the problem becomes a matter for depot level maintenance.

Depot Maintenance

This is the highest level of maintenance and requires extensive equipment to do major repair and overhaul. The chief function of the depot is the performance of MAJOR modifications on the aircraft and all of the aircraft components. All systems are "inspected and repaired as necessary." Depots also supply the spare parts for Aerospace Ground Equipment (AGE), as well as Technical Order Compliance Kits (TOC) to the Organizational and Field Maintenance units through the normal supply channels.

Depot Maintenance is usually done at specifically designated bases in the United States and in some overseas areas.

MAINTENANCE SQUADRONS

AFR 66-1

Now let us take a look at the units that do the actual maintenance on the flightline. These consist of the following, for AFR 66-1:

- Organizational Maintenance Squadron (OMS)
- Field Maintenance Squadron (FMS)
- Munitions Squadron (MS)
- Avionics Maintenance Squadron (AMS)

Organizational Maintenance Squadron (OMS)

The OMS has physical charge of the assigned aircraft. Each aircraft is, in turn, assigned to an individual who is called a "Crew Chief." They are in charge of the aircraft, the aircraft forms, as well as any of the maintenance personnel assigned to work on the aircraft. Actually, we could say that the whole maintenance complex is organized to support the OMS.

The OMS itself may be further divided into the following sections or branches:

- Alert Force
- Base Flight and Transient
- Flightline
- Inspections
- Support equipment

Field Maintenance Squadron (FMS)

The FMS provides maintenance and the assistance of specialists to the other maintenance functions. FMS does intermediate level maintenance within the capability of the assigned specialties, their equipment, and their facilities. FMS may also be authorized to do so by the DCM.

FMS is usually the largest squadron in the maintenance organization. It also uses the most man-hours. Therefore, the way the people and the equipment are used by FMS will have a great effect on the maintenance capability of the wing.

FMS usually consists of the following branches:

- Fabrication
- Propulsion (Jet Engine Maintenance Shop)
- Aerospace Systems (Environmental, Pneudraulics, Electrical, etc)
- Aerospace Ground Equipment (AGE)

TYPES OF MAINTENANCE

There are two basic types of maintenance performed in the various squadrons. They are

Unscheduled maintenance, which may be done in the form of an inspection, or maintenance that is performed in between scheduled inspections. These types of maintenance are things that happen that cannot be planned into the maintenance schedule. These types of maintenance usually have a higher priority (job importance) than the next type of maintenance, which is scheduled maintenance.

Scheduled maintenance usually is done in the form of an inspection which will be covered in depth in a later lesson. This type of maintenance is planned into the days, months work schedule.

MAINTENANCE SYMBOLS AND THEIR USE

The symbols we will discuss in this section are used on some maintenance forms to make important notations instantly apparent. These serve two purposes:

- To identify the condition of the equipment.

- To form the basis of a standard system for telling at a glance the seriousness of the discrepancy noted next to the symbol.

The symbols, in order of seriousness, are

- Red X
- Circled Red X
- Red Dash
- Red Diagonal.

All symbols WILL BE ENTERED IN RED PENCIL.

Study figure 6, located on next page of this SG, as we discuss these maintenance symbols.

Red X

The red X indicates that the equipment unit is considered unsafe or unfit for use, and the equipment will not be used or flown until the unsatisfactory condition is corrected. NO ONE can authorize an aircraft to be flown or the equipment to be used until the unsatisfactory condition is corrected.

DATE FROM	TO	CREW CHIEF	ORGN	LOCATION	MDS	SERIAL NO
0? / 07 / 3	/ /	E.D. Huls	3370TTGP	Chanute	T-38A	600557

SYM | DATE DISCD / / | WDC | JCN | TAG NO | CF TO 781A | DATED / / | TRANSFERRED TO 781K DATE / / | DATE CORRECTED / /

DOC NO | DISCREPANCY | TRANSFERRED BY | GRADE | EMPLOYEE NO

The red X symbol indicates that the equipment is considered unsafe, or unfit for use. This symbol grounds the equipment.

COR This symbol must be inspected, and the inspector will clear the symbol, by placing their last name initial over the symbol. When they do this, they will assume responsibility for the work.

CORRECTED BY

DISCOVERED BY | GRADE | EMPLOYEE NO | INSPECTED BY | GRADE | EMPLOYEE NO

SYM | DATE DISCD / / | WDC | JCN | TAG NO | CF TO 781A | DATED / / | TRANSFERRED TO 781K DATE / / | DATE CORRECTED / /

DOC NO | DISCREPANCY | TRANSFERRED BY | GRADE | EMPLOYEE NO

CORRECTIVE ACTION

A red X inside a red circle indicates that an Urgent Action Time Compliance Technical Order is in process, or the time limit has expired. The equipment will not be used, and the symbol grounds the equipment.

This symbol must be inspected, and the inspector will clear the symbol, by placing their last name initial over the symbol. When they do this, they assume responsibility of the work.

CORRECT

DISCOVERED BY | GRADE | EMPLOYEE NO | INSPECTED BY | GRADE | EMPLOYEE NO.

SYM | DATE DISCD / / | WDC | JCN | TAG NO | CF TO 781A | DATED / / | TRANSFERRED TO 781K DATE / / | DATE CORRECTED / /

DOC NO | DISCREPANCY | TRANSFERRED BY | GRADE | EMPLOYEE NO

The red diagonal indicates that an unsatisfactory condition DOES exist, but is not serious enough to ground the equipment.

CD This symbol does not need to be inspected. but the signature in the Corrected By block will place their last name initial over the symbol. and assumes the responsibility of the discrepancy.

CORRECTED BY | GRADE | EMPLOYEE NO

DISCOVERED BY | GRADE | EMPLOYEE NO | INSPECTED BY | GRADE | EMPLOYEE NO

SYM | DATE DISCD / / | WDC | JCN | TAG NO | CF TO 781A | DATED / / | TRANSFERRED TO 781K DATE / / | DATE CORRECTED / /

DOC NO | DISCREPANCY | TRANSFERRED BY | GRADE | EMPLOYEE NO

The red dash indicates that an inspection is due, and will be completed as soon as possible. This symbol does not ground the equipment, it states that an unsatisfactory condition MAY exist.

COR This symbol does not need to be inspected, but the signature in the Corrected By block enters their last name initial over the symbol, and assumes the responsibility that the inspection has been completed.

CORRECTED BY | GRADE | EMPLOYEE NO

DISCOVERED BY | GRADE | EMPLOYEE NO. | INSPECTED BY | GRADE | EMPLOYEE NO

MAINTENANCE DISCREPANCY AND WORK DOCUMENT

Figure 6. Maintenance Discrepancy and Work Document.

DATE FROM	CREW CHIEF	ORGN	LOCATION	MDS	SERIAL NO.
15/12/3 / /	E. D. Huls	3372 S/S	Chanute	T-38A	600557

Block 1

SYM	DATE DISCO	WDC	JCN	TAG NO.	CF TO 781A DATED	TRANSFERRED TO 781K DATE	DATE CORRECTED
X	15/12/3	B	3490006		P / /	/ /	15 / 12 / 3

DOC NO

DISCREPANCY: OXYGEN REGULATOR FACE PLATE CRACKED.

(John Smith, TSGT.)

DISCOVERED BY: D. Jones — GRADE: SSGT. — EMPLOYEE NO.: J9999

TRANSFERRED BY — GRADE — EMPLOYEE NO

CORRECTIVE ACTION: "SYMBOL ENTERED IN ERROR, DISCREPANCY AND CORRECT SYMBOL REENTERED BELOW."

CORRECTED BY: J. Smith — GRADE: TSGT. — EMPLOYEE NO.: S8888

INSPECTED BY — GRADE — EMPLOYEE NO.

Block 2

SYM	DATE DISCO	WDC	JCN	TAG NO.	CF TO 781A DATED	TRANSFERRED TO 781K DATE	DATE CORRECTED
X	15/12/3	B	3490006		P / /	/ /	15 / 12 / 3

DOC. NO.

DISCREPANCY: OXYGEN REGULATOR FACE PLATE CRACKED. (contact: DCM, Equilvant Contractor Rep., Maintenance 9-level NCO, or Civilian Equivalent, that is authorized by DLM.)

DISCOVERED BY: D. JONES — GRADE: SSGT. — EMPLOYEE NO.: J9999

TRANSFERRED BY — GRADE — EMPLOYEE NO.

CORRECTIVE ACTION: "SYMBOL DOWNGRADED FROM RED X, TO RED DIAGONAL. DISCREPANCY REENTERED IN BLOCK 3, ON PAGE 2."

CORRECTED BY: R. Schwartz — GRADE: COL. — EMPLOYEE NO.: S7777

INSPECTED BY — GRADE — EMPLOYEE NO.

Block 3

SYM	DATE DISCO	WDC	JCN	TAG NO.	CF TO 781A DATED	TRANSFERRED TO 781K DATE	DATE CORRECTED
/	15/12/3	B	3490006		P / /	/ /	/ /

DOC. NO

DISCREPANCY: OXYGEN REGULATOR FACE PLATE CRACKED. "SYMBOL CHANGED FORM RED X, TO A RED DIAGONAL.

15 DEC. 83 Robert Schwartz COL.

3370 TCHTG/TTGUP."

DISCOVERED BY: D. JONES — GRADE: SSGT. — EMPLOYEE NO.: J9999

TRANSFERRED BY — GRADE — EMPLOYEE NO

CORRECTIVE ACTION

CORRECTED BY — GRADE — EMPLOYEE NO

INSPECTED BY — GRADE — EMPLOYEE NO

Block 4

SYM	DATE DISCO	WDC	JCN	TAG NO.	CF TO 781A DATED	TRANSFERRED TO 781K DATE	DATE CORRECTED
	/ /				P / /	/ /	/ /

DOC. NO. — DISCREPANCY

TRANSFERRED BY — GRADE — EMPLOYEE NO

CORRECTIVE ACTION

CORRECTED BY — GRADE — EMPLOYEE NO.

DISCOVERED BY — GRADE — EMPLOYEE NO. — INSPECTED BY — GRADE — EMPLOYEE NO

AFTO FORM NOV 78 781A MAINTENANCE DISCREPANCY AND WORK DOCUMENT PREVIOUS EDITION IS OBSOLETE.

Figure 7. (Sample) Maintenance Discrepancy and Work Document.

The red X symbol will be entered in the appropriate location of the applicable maintenance form IMMEDIATELY upon discovery of the condition.

- -

Notes:

The repairs made or work done to correct the condition of the equipment WILL be inspected only by maintenance personnel who are delegated such authority to clear the red X symbol as directed by the DCM.

Circled Red X

A red X inside a red circle will be used to show that the equipment is grounded or restricted from peacetime operation, pending compliance with an Urgent Action Time Compliance Technical Order (TCTO). The only time that a circled red X symbol will be used is when the urgent Action TCTO has expired.

The same rules apply for clearing the circled red X as for the red X.

Red Dash

The red dash shows that a required inspection is due. The red dash can also show that an inspection is overdue and time will not let you do the inspection before flight. This symbol shows that the condition of the equipment is UNKNOWN and that a more serious condition MAY exist. This condition will be corrected as soon as possible by doing the required inspection and completing the necessary maintenance.

Red Diagonal

The diagonal shows that an unsatisfactory condition DOES exist on an aircraft or piece of equipment but is not urgent or dangerous to warrant the grounding of the aircraft or the equipment. The red diagonal will be a straight line from the lower left to the upper right of the symbol block.

Clearing Red Symbol Entries (Figure 7).

The last-name initial in BLACK entered over the symbol in the symbol block shows that the person whose name is in the signature block related to that discrepancy has done the required work, or inspected the equipment, and has found that all things are satisfactory and is assuming the responsibility that it is OK to fly or use the equipment.

Changing Red Symbol Entries

Once a Red symbol has been placed on a maintenance form, the symbol will NEVER BE ERASED, even if entered in error! Entry of a red X, circled red X, red diagonal, or red dash on any maintenance form shows the individual's opinion as to the seriousness of the defect. Therefore, NO INDIVIDUAL is to be directed to change a symbol which they have entered.

If an individual of higher authority within the maintenance or repair activity believes that the condition is more serious than shown by the symbol, THEY WILL change the symbol themselves. They will do this by drawing a line through the name of the individual who made the entry and enter their signature and grade in parentheses above or beside the signature block. See figure 2.

If supervisory personnel think that the condition is less serious than shown by the symbol, this will be brought to the attention of the DCM, equivalent contractor representative, maintenance 9-level noncommissioned officer, civilian equivalent that has been authorized by the DCM to downgrade the symbol. Individuals who make the decision will indicate their action by a notation in the CORRECTIVE ACTION block for the defect and will read as follows: "Symbol downgraded from Red X (or Circled Red X) to a Red Diagonal (or Red Dash, whichever is applicable). Discrepancy reentered on page number _____ item number _____." When a symbol is cleared in this manner, no one need sign the INSPECTED BY block. The same discrepancy, the new symbol, and the PRINTED first initial, last name and grade of the person who found the discrepancy will be reentered in the applicable block and will be followed by an entry to read "Symbol changed from Red X (or Circled Red X) to a Red Diagonal (or Red Dash), date, employee's name, grade, and organization." This entry will remain with the discrepancy until it is corrected.

Notes:

INSPECTION SYSTEMS

OBJECTIVE

State the general principles of the inspection system by answering a minimum of 8 of 10 questions correctly.

INTRODUCTION

Well, soon you will be leaving Chanute AFB, Illinois, and going PCS to another base, probably in another state. If you plan on driving your car, you probably will not begin your trip without first preparing your car. This preparation is like an inspection that is performed on an aircraft. The only difference is, if you forget to check something on your car, before you leave, and the component stops functioning properly, you can pull over to get it repaired; but what does the pilot do if a system or component fails?

Inspections on aircraft are never ending, and none are more or less important than the other.

Note: Remove all figures located in the back of this SG at this time.

Scheduled Maintenance Inspection

Scheduled maintenance inspections required for Air Force equipment are prescribed in the applicable -6 scheduled inspection and maintenance requirements manuals and inspection workcards (WC) or checklists (CL).

The scheduled maintenance inspection intervals for aircraft or support systems, equipment end items and components are specified in the applicable -6 scheduled inspection and maintenance manuals and -6WC inspection workcards. All requirements pertaining to inspections will normally be accomplished in numerical order to avoid complications in controlling and scheduling the required maintenance. The time intervals specified for scheduled maintenance inspections such as calendar, and flying hours represent the maximum interval between accomplishment of such requirements.

Work Cards and Sequence Charts

Lets find out what "tools" (Inspection Control Documents) are used during the performance of an inspection used by you and/or your supervisor. (These tools are located in TO 00-20-1.)

The planned inspection and maintenance concept provides a means of performing required inspections and repairs on a scheduled and planned basis. This planning and scheduling is required for phased, periodic and isochronal, (iso, means equal amounts; chronal is time, usually expressed in days or months) inspections, and major maintenance on aircraft or support equipment to effectively use the people assigned to your section. A degree of planning and scheduling is also provided for by the use of inspection workcards and sequence charts.

The inspection work cards, figure 8, outline the minimum inspection requirements. They are used as a guide, and tell you what to inspect, and what to inspect it for. The inspection workcards will be a very important tool that you will use in order to complete an inspection properly, and effectively in a minimum amount of time. They are published under the authority of the Secretary of the Air Force, and each -6 inspection requirement TO, and -6WC inspection requirement inspection has its own set of workcards, with a separate TO number assigned for each set (-6, and -6WC = 1 set).

The sequence chart, figure 9, is used by your supervisor in order to control the inspection. The sequence chart is used as a guide in preparing the actual work schedules. They also serve as a means of controlling the assignment of work during the inspection, and are a ready reference for determining the progress of the inspection. To aid the supervisor in making work assignments, the inspection workcard numbers may be plotted on the sequence chart to provide the desired work schedule or sequence in which all predictable or routine maintenance can be most effectively accomplished. The use of the workcards and sequence charts, will permit the work of each individual to be planned for uninterrupted job completion. This will assure the planned use of personnel, early detection of discrepancies, and more accurate planning for the accomplishment of the required repair work.

Inspection Methods

Inspections on aircraft, or support equipment, will normally be accomplished under a "specialists" maintenance concept, which means each system specialist will perform their portion of the inspection. This will consist of an inplace method of inspection, or the dock method of inspection. The inspection crews will be supported by the specialists provided on dispatch forms (AFTO Form 349) from the various shops as scheduled.

The inplace method is used when maintenance and operational requirements say that the inspection and maintenance must be performed at the aircraft location. In other words, you go to the aircraft.

The dock method is used when maintenance and operational requirements say the aircraft be moved to a fixed station or site for accomplishment. Required maintenance crews may be permanently assigned to such stations or sites. Each "inspection dock" will be equipped with the necessary tools and equipment to accomplish the required inspection and maintenance. In this method of inspection the aircraft is brought to you.

Inspection Concepts

There are four authorized inspection concepts used for aircraft. These concepts are periodic, phased, isochronal, and programmed depot maintenance. Each of the inspections in these concepts will be accomplished in accordance with the applicable -6 inspection requirement maintenance manual, or inspection workcards.

1. Periodic Concept

   (a) Preflight (PR)
   (b) End of Runway (EOR)

(c) Thruflight (TH)
(d) Basic Postflight (BPO)
(e) Hourly Postflight (HPO)
(f) Periodic (PE)

2. Phased Concept

(a) PR
(b) EOR
(c) TH
(d) BPO
(e) Phase (PH)

3. Isochronal Concept

(a) PR
(b) EOR
(c) TH
(d) BPO
(e) Home Station Check (HSC)
(f) Minor (MIN)
(g) Major (MAJ)

4. Programmed Depot Maintenance (PDM)

As you can see, the first four (a-d) inspections performed under each concept are the same. (PR, EOR, TH, BPO) We will cover these four first, then explain the HPO, PE, PH, HSC, MIN, MAJ and PDM. Get used to using these abbreviations; they will be used quite frequently throughout your AF career.

Preflight (PR)

The preflight inspection is due prior to the first flight of the flying period.

Lets say the flying period begins at 0600 hrs. This is the time when the pilots will begin wanting aircraft. The Base Operations Office (Base Ops) lets maintenance control know ahead of time how many aircraft will be needed for the next day's mission. Maintenance Control will then distribute the total number equally between the flights and then let job control distribute the work to the various flights. Each flight will have crews for this called a "Preflight Crew." These crews usually come in to work approximately two hours earlier than when the flying period begins. (0400 hrs)

The preflight inspection includes visually examining the aircraft and operationally checking certain systems and components to insure there is no serious defects or malfunctions.

Major commands have the option of selecting a 24, 48 or a 72 hour preflight validity period. If the preflight validity period selected is 72 hours, and the aircraft does fly a mission, the preflight will be accomplished every 24 hours; but if the aircraft does not fly within the 24 hour period, the preflight will be valid for 48 hours. After

48 hours have gone by and the aircraft still does not fly, a new preflight is due. The aircraft can sit idle up to 72 hours before another PR has to be done, regardless if it will fly or not.

End of Runway (EOR)

The EOR is a final visual and/or operational check of designated aircraft systems and components. It will be performed immediately prior to take off at a designated location, usually near the end of the runway. The purpose of the inspection is to detect critical defects which may have developed or become apparent during ground operation of the aircraft. They would check things like - tires for cuts; leakage from fluid systems in the cracks of panels and doors, and making sure panels and doors are closed and fastened; covers and pins are removed, etc.

Thruflight Inspection (TH)

The TH inspection is a between flights inspection and will be accomplished between flights when an immediate turn around or sortie (mission) will happen. The TH consists of checking the aircraft for flight continuation by performing visual examinations or operational checks of certain components, areas, or systems to assure that no defects exist which would be dangerous to further flight. This inspection is the same as a pit stop at the Indy 500. When a race car comes in for a pit stop, there are only certain things done. Checking tires, refueling, cleaning the windshield, give the driver a drink and get back on the track. The TH is done basically the same way.

Basic Postflight (BPO) Inspection

The BPO is accomplished after the last flight of the flying period. This inspection consists of checking the aircraft to see if it is suitable for another flight by performing a visual examination or operational checks of certain components, areas, or systems to be sure that no defects exist which would be dangerous to flight. The BPO is "a more thorough check than the PR" or TH. The BPO is done only when the aircraft is released by Operations. This gives the specialists more time to repair discrepancies that are found before the next flying period begins.

Periodic (PE) Inspection

The PE is due upon a specified number of flying hours. The PE is more extensive than the HPO or BPO. This inspection is a thorough and searching inspection of the entire aircraft.

Hourly Postflight (HPO) Inspection

The HPO will be done upon a specified number of flying hours. This inspection adds to the BPO at the specified intervals. This means that they may both be <u>done</u> at the same time provided they are both <u>due</u> at the same time.

Phased (PH) Inspection

The PH concept consolidates the BPO and/or HPO and PE into small packages having approximately the same work content and man hours for accomplishment. The primary objective is to minimize the length of time that an aircraft is out-of-commission for any given scheduled inspection, and is done at a specified number of flying hours.

Isochronal (ISO) Inspection Concept

The ISO Concept translates flying hours into calendar periods, usually expressed in days. The PH, and PE are due after a specified number of "flying hours." The following inspections, under this concept will be due after a specified number of "calendar days," regardless of how many "hours" the aircraft has actually flown.

Home Station Check (HSC) Inspection

The HSC consists of inspection requirements arranged and designated for accomplishment when the aircraft returns from a long-range mission or upon expiration of a specified short-term calendar period. This date will be computed from the programmed start date of the last inspection. It is accomplished along with MAJ or MIN Inspections, provided they are all due at the same time.

Minor Inspection (MIN)

The MIN is due upon a specified number of calendar days. This date will be computed from the programmed start date of the last major inspection. The MIN consists of checking certain components, areas, or systems of the aircraft to determine if conditions exist which, if not corrected, could result in failure or malfunction of a component prior to the next scheduled inspection. The MIN is accomplished at the completion of the mission during which the specified calendar days accrued.

Major (MAJ) Inspection

The MAJ is due upon accrual of the number of calendar days. This date is computed from the programmed start date of the last MAJ inspection The MAJ is a thorough and searching inspection of the entire aircraft, and individual requirements may be more extensive than previous inspection items. The inspection consists primarily of checking certain components, areas and systems of the aircraft, which due to their function requires less attention than that required by other inspections. This inspection is accomplished to determine if a condition exists which, if not corrected, could result in the failure of a component or cause system malfunction prior to the next scheduled inspection. The MAJ is accomplished at the completion of the mission during which the specified calendar day is accrued.

Programmed Depot Maintenance (PDM)

The PDM is an inspection requiring skills, equipment or facilities not normally owned by the operating locations. Individual areas, components and systems are inspected to a degree beyond the other inspection requirements.

Symbol Used During an Inspection

The symbol used on maintenance documents which identifies that an inspection is due is the red dash. All discrepancies found during the inspection will be entered in the AFTO Form 781A with the appropriate symbol for that particular discrepancy, not the inspection symbol.

AFTO Forms

The AFTO Forms used during the inspections are the AFTO Forms:

349 to account for times spent performing the inspection, items repaired or replaced and defect of these items.

350 to get parts repaired that are found to be defective.

781A to record maintenance performance on aircraft and to identify at a glance the condition of the aircraft.

Phases of Inspection

There are two phases to each inspection. They are:

- Look
- Fix

When an inspection is due, you may receive a 349 that is similar to the one shown in figure 10. In Block 26 it will describe the system that is due the inspection, along with the type of inspection that is due. It will have a Job Control Number entered in Block 1; the work center code responsible to complete the inspection in Block 2; the aircraft I.D. Number entered in Block 3. The entries in Blocks 7, 9, 17 and 18 are completed only when the 349 is to be used as a dispatch form. The priority (job importance) in Block 7 tells the dispatcher what priority this particular job is. (The higher (1, 2, 3, 4) the number in Block 7 the lower the priority.) Priority ones (1's) will always be completed first; twos, second; and so forth. They will put the location of the aircraft in Block 9. This tells your dispatcher and/or supervisor what hangar or flight you will be working in. Block 17, Time Specialists Required, tells you that you have an appointment at that time to be at this aircraft with TOs and toolbox, and ready to begin your part of the inspection. If for some reason the start time is delayed, your dispatcher or supervisor will make the necessary arrangements with Job or Maintenance Control to get a new start time. Whenever an inspection is due the entire aircraft is inspected. The "scheduling specialists" allows these specialists to go in, get the inspection done and away without interferring with other specialists. The Job Standard in Block 18 is "estimated" job completion time. Experience of specialists and availability of equipment is not taken under consideration. It may or may not take this amount of time. We have approximately two hours to complete only the look phase of this inspection.

The look phase is accomplished first in order to get the necessary parts to repair the system. We never know what we will find wrong, if anything. Just follow the -6WC (inspection requirement workcards, applicable to the inspection being performed) step-by-step. The workcards are used as a guide telling you what to inspect, and what to inspect it for. (See fig 8) When you do find a discrepancy, complete the AFTO Form 349 as required in figure 11. Put the discrepancy in Block 26, and job control number, workcenter and aircraft I.D. number in Blocks 1, 2,, and 3. Each discrepancy gets a new 349. If you find 18 discrepancies, you will turn-in 18-349's to the crew or dock chief. Once you have completed all the steps in the -6WC, give all the discrepancies you found to the crew or dock chief, but keep the one that was issued to you by your dispatcher/supervisor, figure 10. It will be completed as in figure 12, then return it and yourself to your workcenter. The completed 349 for the look phase will be given to your dispatcher/supervisor. NOTICE: Under Column G "units" you took a zero '0'. This is because you never completed the inspection, you only took time for the "Look Phase." You still have the fix phase open. For an inspection, an aircraft may be down for days, or weeks. It depends on manning, availability of new parts, etc. You will daily turn in the time you spent on any job, or jobs, regardless if it was completed by you or not. You must account for your time daily.

Now what happened to the 349s you gave to the dock/crew chief? Well, since it is his/her aircraft, they will be responsible to order all the parts needed to get the inspection complete. They order the parts, enter the discrepancies in the AFTO Form 781A, Maintenance Discrepancy and Work Document, (aircraft forms), then forward the 349s to Maintenance and Job Control.

Maintenance/Job Control will make entries on the same 349 you started during the look phase, as in figure 13. When the parts come into the dock/crew chief, they will call control and let them know the job is now open. Control will route the same 349 back to your shop. Now begins the fix phase. This is where all the discrepancies found during the look phase are repaired, and/or parts replaced on the malfunctioning systems, that you found.

So far everything done on this inspection was done by you. What if the fix phase for one of the discrepancies opens on the evening shift? Do they wait for you to come back to work on the day shift? No, now anyone in your shop could get involved. Always be sure your discrepancies are clear and exactly what and where it is. This will avoid any confusion. (They may call you at home to repair your own discrepancies, if they are too badly written.) The 349 will then be completed as in figure 14, and returned to your Dispatcher/Supervisor.

Due to the fact that the entire aircraft is due this inspection, the only person who will know when all systems are A-OK, is the dock/crew chief. After all symbols and discrepancies have been cleared on the AFTO Form 781A, the dock/crew chief completes a new 349 as in figure 15. Compare figure 10 with figure 13. Remember the Methods of Inspection, Dock and Inplace? Since the crew/dock chief is assigned to the aircraft when the inspection was due, Control had the aircraft taken to them. (They performed the dock method.) Since they were not dispatched to the equipment, Blocks 7, 9, 17 and 18 are left blank. You left your workcenter to report to their workcenter (Blocks 2) to do work, so you had to be dispatched (see figure 13, Blocks 7, 9, 17 and 18). It is their (the dock/crew chiefs) responsibility to see the inspection was completed, so they take a "1" in column 'G' (units), while you take "0"; but you have all the hours, while they get nothing. You get all the work and time, while they get all the credit. It is just like a barracks inspection. You do all the cleaning, while the Squadron Commander/or First Sgt gets all the credit. (GOOD or BAD!) Just like preparing the barracks for the inspection, it takes teamwork on everyone's part to get the job done. Remember, you can fail barracks inspection and repeat it later, but when it comes to aircraft inspections, there are lives on the line and there is no second chance. Follow our TOs, they are your guide so you don't forget to check and repair. "The life you save may be mine!" Don't Forget!

CARD NO	WORK AREA(S)	TYPE MECH RQR	MECH NO	CARD	PUBLICATION NUMBER AND DATE		CHANGE
2-002	15	APG/AECS		4.37	1T-38A-6WC-3	1 MAY 82	

2ND PERIODIC (PREDOCK) — INSPECTION REQUIREMENTS — ELECTRICAL POWER: OFF — SERVICE — FIGURE — CARD NO 2-002

ITEM NO	WK RE AREA	SYS	SUB SYS AND COMP		
060	15	PR	EP	1	REMOVE FUSELAGE AFT SECTION IN ACCORDANCE WITH T O 1T-38A-2 2 (AS REQUIRED)
060	15	PR	EP	2	CLEAN ENGINE BAYS IN ACCORDANCE WITH T O 1T-38A 3 (IF ENGINES ARE REMOVED)
	15	PR	EP	*	FUSELAGE
	15	PR	EP	B	FUSELAGE AFT SECTION
00?	15	41	811	3	THROTTLE QUADRANT TO ENSURE SELF LOCKING NUT (P/N MS21042L3) HAS ADEQUATE NUMBER OF THREADS PROTRUDING THRU NUT (REF T O 1-1A-8) REPLACE NUT IF SELF LOCKING FEATURE HAS FAILED
115	15	11		4	FUSELAGE AFT SECTION REINSTALLED ON AIRCRAFT AFTER ENGINE REMOVAL (REQUIRED FOR SYSTEM OPERATION)
190	15	23		5	REMOVE ENGINE IN ACCORDANCE WITH T O 1T 38A 2 5 (AS REQUIRED)
007		47	11?	6	OXYGEN HOSE FROM REGULATOR TO DISCONNECT FOR WEAR AND SECURITY LEAK CHECK WITH TESTER IN ACCORDANCE WITH T O 15X-1-1
015		47	115	7	OXYGEN REGULATOR FOR LEAKAGE USING LEAKAGE TESTER IN ACCORDANCE WITH T.O 15X-1 1 REGULATOR FOR OPERATION (IF REGULATOR HAS TEST PORTS TEST USING TESTER 31TA2655-2) IN ALL LEVER POSITIONS IN ACCORDANCE WITH T O 1T 38A 2 4 CONNECTOR FOR SECURITY OXYGEN DILUTER LEVER 100 PER CENT OXYGEN OXYGEN REGULATOR SUPPLY LEVER SAFETIED IN ON POSITION WITH COPPER BREAKAWAY WIRE (IF INSTALLED)

CARD NO	WORK AREA(S)	TYPE MECH RQR	MECH NO	CARD TIME	PUBLICATION NUMBER AND DATE		CHANGE NO
2-002	15	APG/AECS		4:37	1T-38A-6WC-3	1 MAY 82	

Figure 8. Inspection Workcard.

BEST COPY AVAILABLE

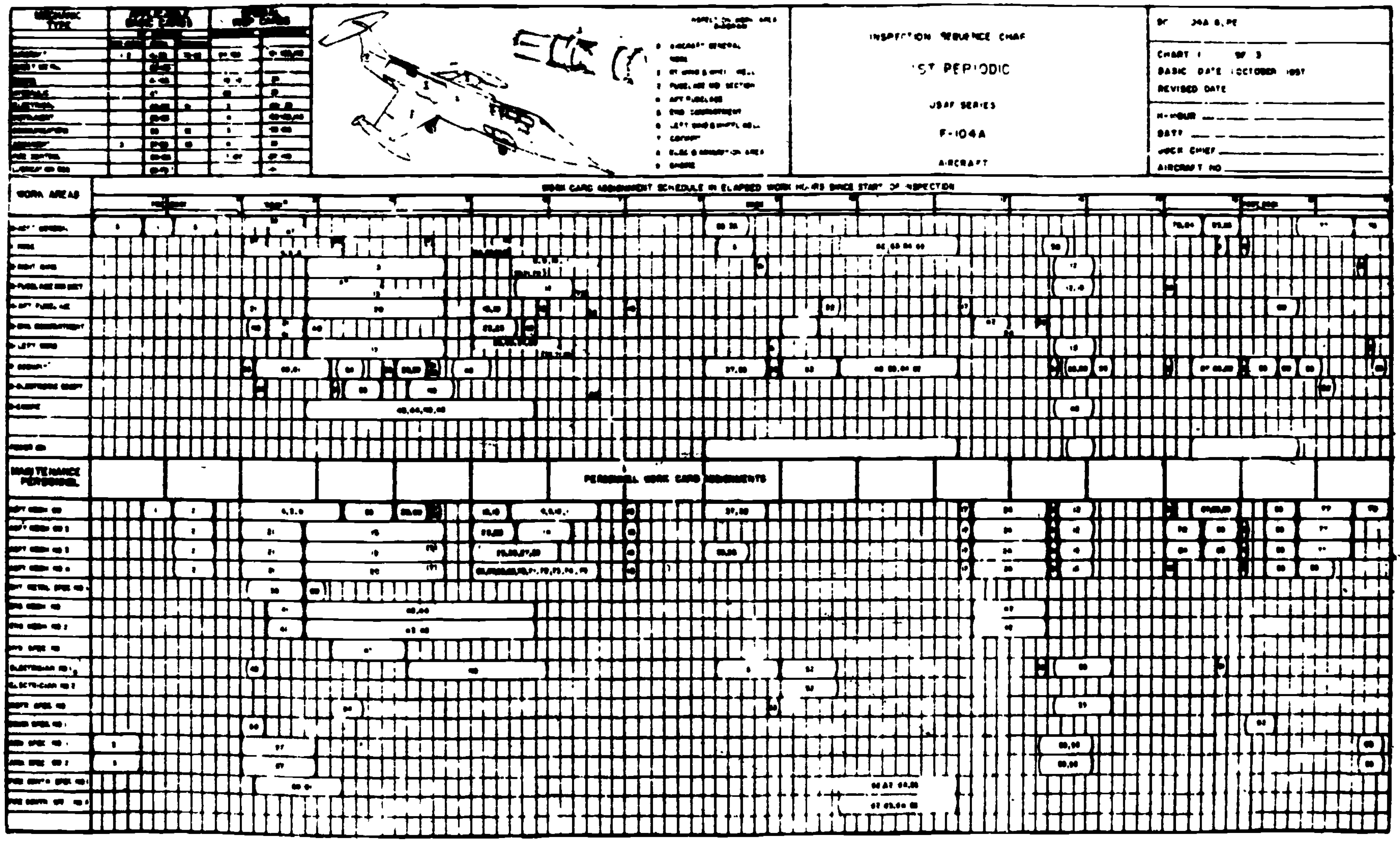


Figure 9. Sequence Chart.

MAINTENANCE DATA COLLECTION RECORD

OMB NO. 21-R0227

1. JOB CONTROL NO.	2. WORKCENTER	3. I.D. NO./SERIAL NO.	4. MDS	5. SRD	6. TIME	7. PRI	8. SORTIE NO.	9. LOCATION
2190016	Q3360	AA0557				3		P-12A

10. ENG. TIME	11. ENGINE I.D.	12. INST ENG TIME	13. INST. ENG. I.D.	14.	15.	16.	17. TIME SPC RFQ	18. JOB STD
							0930	2.0

19 FSC	20 PART NUMBER	21. SER. NO./OPER. TIME	22. TAG NO.	23. INST. ITEM PART NO.	24. SERIAL NUMBER	25. OPER. TIME

ACT. LINE	A TYPE MAINT	B COMP POS	C WORK UNIT CODE	D ACTION TAKEN	E WHEN DISC	F HOW MAL	G UNITS	H START HOUR	I STOP DAY	I STOP HOUR	J CREW SIZE	K CAT LAB	L CMD ACT ID	M SCH CODE	N AFSC/EMPLOYEE NUMBER
1															
2															
3															
4															
5															

26 DISCREPANCY

OXYGEN SYSTEM DUE 2ND PERIODIC INSPECTION

27. CORRECTIVE ACTION

28 RECORDS ACTION

AFTO FORM JAN 81 349

Figure 10.

MAINTENANCE DATA COLLECTION RECORD

OMB NO 21-R0227

1 JOB CONTROL NO.	2 WORKCENTER	3. I.D. NO./SERIAL NO.	4. MDS	5. SRD	6. TIME	7. PRI	8. SORTIE NO.	9. LOCATION
2190016	Q3360	AA0557						

10. ENG. TIME	11. ENGINE I.D.	12. INST ENG TIME	13. INST ENG. I.D.	14.	15.	16.	17. TIME SPC RFQ	18. JOB STD

19 FSC	20 PART NUMBER	21. SER. NO./OPER. TIME	22. TAG NO.	23. INST. ITEM PART NO.	24 SERIAL NUMBER	25 OPER. TIME

ACT. LINE	A TYPE MAINT	B COMP POS	C WORK UNIT CODE	D ACTION TAKEN	E WHEN DISC	F HOW MAL	G UNITS	H START HOUR	I STOP DAY	I STOP HOUR	J CREW SIZE	K CAT LAB	L CMD ACT ID	M SCH CODE	N AFSC/EMPLOYEE NUMBER
1															
2															
3															
4															
5															

26 DISCREPANCY

OXYGEN REGULATOR DILUTER LEVER BROKEN (FRONT COCKPIT)

27 CORRECTIVE ACTION

28. RECORDS ACTION

AFTO FORM JAN 81 349

Figure 11.

MAINTENANCE DATA COLLECTION RECORD

OMB NO. 21-R0227

1. JOB CONTROL NO.	2. WORKCENTER	3. I.D. NO./SERIAL NO.	4. MDS	5. SRD	6. TIME	7. PRI	8. SORTIE NO.	9. LOCATION
2190016	Q3360	AA0557				3		P-12A

10. ENG. TIME	11. ENGINE I.D.	12. INST ENG TIME	13. INST. ENG. I.D.	14.	15.	16.	17. TIME SPC REQ	18. JOB STD.
							0930	2.0

19. FSC	20. PART NUMBER	21. SER. NO./OPER. TIME	22. TAG NO.	23. INST. ITEM PART NO.	24. SERIAL NUMBER	25. OPER. TIME

ACT LINE	A TYPE MAINT	B COMP POS	C WORK UNIT CODE	D ACTION TAKEN	E WHEN DISC	F HOW MAL	G UNITS	H START HOUR	I STOP DAY	I STOP HOUR	J CREW SIZE	K CAT LAB	L CMD ACT ID	M SCH CODE	N AFSC/EMPLOYEE NUMBER
1	P		03400				0	0930	219	1130	1	1			B1663
2															
3															
4															
5															

26. DISCREPANCY

OXYGEN SYSTEM DUE 2ND PERIODIC INSPECTION

27. CORRECTIVE ACTION

LOOK PHASE OF 2ND PERIODIC INSPECTION CW IAW TO 1T-38A-6WC-3

28. RECORDS ACTION

AFTO FORM JAN 81 349

Figure 12.

MAINTENANCE DATA COLLECTION RECORD

OMB NO. 21-R0227

1. JOB CONTROL NO.	2. WORKCENTER	3. I.D. NO./SERIAL NO.	4. MDS	5. SRD	6. TIME	7. PRI	8. SORTIE NO.	9. LOCATION
2190016	Q3360	AA0557				3		P-12A

10. ENG. TIME	11. ENGINE I.D.	12. INST ENG TIME	13. INST. ENG. I.D.	14.	15.	16.	17. TIME SPC REQ	18. JOB STD.
							2045	1.0

19. FSC	20. PART NUMBER	21. SER. NO./OPER. TIME	22. TAG NO.	23. INST. ITEM PART NO.	24. SERIAL NUMBER	25. OPER. TIME

ACT LINE	A TYPE MAINT	B COMP POS	C WORK UNIT CODE	D ACTION TAKEN	E WHEN DISC	F HOW MAL	G UNITS	H START HOUR	I STOP DAY	I STOP HOUR	J CREW SIZE	K CAT LAB	L CMD ACT ID	M SCH CODE	N AFSC/EMPLOYEE NUMBER
1															
2															
3															
4															
5															

26. DISCREPANCY

OXYGEN REGULATOR DILUTER LEVER BROKEN (FRONT COCKPIT)

27. CORRECTIVE ACTION

28. RECORDS ACTION

AFTO FORM JAN 81 349

Figure 13.

MAINTENANCE DATA COLLECTION RECORD

OMB NO 21-R0227

1. JOB CONTROL NO.	2. WORKCENTER	3. I.D. NO./SERIAL NO.	4. MDS	5. SRD	6. TIME	7. PRI	8. SORTIE NO.	9. LOCATION
2190016	Q3360	AA0557				3		P-12A

10. ENG. TIME	11. ENGINE I.D.	12 INST ENG TIME	13. INST. ENG. I.D.	14.	15.	16.	17. TIME SPC RFQ	18. JOB STD
							2045	1.0

19 FSC	20. PART NUMBER	21 SER. NO./OPER. TIME	22. TAG NO.	23. INST. ITEM PART NO.	24. SERIAL NUMBER	25 OPER TIME

ACT. LINE	A TYPE MAINT	B COMP POS	C WORK UNIT CODE	D ACTION TAKEN	E WHEN DISC	F HOW MAL	G UNITS	H START HOUR	I STOP DAY	I STOP HOUR	J CREW SIZE	K CAT LAB	L CMD ACT ID	M SCH CODE	N AFSC/EMPLOYEE NUMBER
1	P		47115	R	M	070	1	2045	219	2140	1	1			DC323
2															
3															
4															
5															

26 DISCREPANCY

OXYGEN REGULATOR DILUTER LEVER BROKEN (FRONT COCKPIT)

27. CORRECTIVE ACTION

REMOVED AND REPLACED OXYGEN REGULATOR IAW TO 1T-38A-2-4

28. RECORDS ACTION

AFTO FORM JAN 81 349

Figure 14.

MAINTENANCE DATA COLLECTION RECORD

OMB NO. 21-R0227

1. JOB CONTROL NO.	2. WORKCENTER	3. I.D. NO./SERIAL NO.	4. MDS	5. SRD	6. TIME	7. PRI	8. SORTIE NO.	9. LOCATION
2190016	A1407	AA0557						

10. ENG. TIME	11. ENGINE I.D.	12 INST ENG TIME	13. INST. ENG. I.D.	14.	15.	16.	17. TIME SPC RFQ	18. JOB STD

19. FSC	20. PART NUMBER	21. SER NO./OPER. TIME	22. TAG NO.	23. INST. ITEM PART NO.	24. SERIAL NUMBER	25. OPER. TIME

ACT. LINE	A TYPE MAINT	B COMP POS	C WORK UNIT CODE	D ACTION TAKEN	E WHEN DISC	F HOW MAL	G UNITS	H START HOUR	I STOP DAY	I STOP HOUR	J CREW SIZE	K CAT LAB	L CMD ACT ID	M SCH CODE	N AFSC/EMPLOYEE NUMBER
1	P		03400				1	0000	000	0000	1	1			R1208
2															
3															
4															
5															

26 DISCREPANCY

AIRCRAFT DUE 2ND PERIODIC INSPECTION

27. CORRECTIVE ACTION

AIRCRAFT 2ND PERIODIC INSPECTION CW IAW TO 1T-38A-6

28. RECORDS ACTION

AFTO FORM JAN 81 349

Figure 15.

SERVICE TEST
HANDOUT

C3ABR42331-HO-301

Technical Training

Aircraft Environmental Systems Mechanic

CODING AFTO FORMS 349 and 350

30 September 1983

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

Designed for ATC Course Use.

Do Not Use on the Job.

Aircraft Environmental Systems Mechanic
Chanute AFB, Illinois

C3ABR42331-HO-301

CODING AFTO FORMS 349 and 350

You will make use of the standard equipment reporting designators on pages 3 through 12 when you complete block 3A of the AFTO Form 350.

On page 14, you will find the category of labor codes that are entered in column K of AFTO Form 349.

All of these codes have been taken from TO 00-20-2, The Maintenance Data Collection System.

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DISTRIBUTION: X
3370 TCHTG/TTGU-P - 250; DAV - 1

ATTACHMENT 2

PART I

Part I of Attachment 2 lists all valid SRD requirements along with the appropriate MDS, TMS, part number, noun, etc Part II of this attachment is used in conjunction with Part I to determine MDC/MICAP reportability. A "yes" in the MDC column of Part II indicates that the SRD will be used when reporting maintenance data. A "no" in the MDC column indicates that the SRD of the end item or next higher assembly will be used to report maintenance data. A "yes" in the MICAP column indicates that the SRD is authorized for use in conjunction with supply requisition reporting and a "no" indicates that it is not authorized.

NOTE

This list is not to be used for AVFUELS accountability. See Attachment 5, AFM 67-2, for codes.

A2-1. PURPOSE. Standard equipment reporting designator (SRD) codes, are designed to identify aircraft, missiles, and ground communications-electronics-meteorological (CEM) equipment. These codes also identify related equipment by type or category of work such as aerospace ground equipment (AGE), precision measurement equipment (PME), trainers, engines, munitions, real property installed equipment (RPIE), and shop work.

a. The first character of the standard reporting designator code identifies a general type of equipment, such as "A" for aircraft, "M" for ground launched missiles, "T" for training equipment, etc. The last two characters of the standard reporting designator code identify specific equipment (when used with the prefix), such as AEB for KC-135Q, XKG for the TF33-7 used on the C-141A, BKM for AN/GRR-7, etc.

b A limited number of standard reporting designator codes cover groups of equipment of type work such as YWA for conventional munitions or RSA for shop work on aerospace equipment.

c. Standard reporting designator codes are used in computer programs to facilitate data processing of specific equipment identification of equipment for use in automated management information systems and to facilitate interchange of data between the supply and maintenance system. The authorized abbreviation for standard reporting designator code is SRD code.

A2-2. STANDARD REPORTING DESIGNATOR CODES. This attachment provides an authoritative list of standard reporting designator codes that is readily available to each workcenter, and defines requirements for recording these codes.

a. The first character (prefix) of the standard reporting designator code is as follows:

Aircraft and Drones	A
Ground Radio Equipment (CEM)	B
Ground Radio Equipment (CEM)	C
Ground Radar Equipment (CEM)	E

(cont'd)

Ground Meteorological Equipment (CEM)	F

NOTE

For ground CEM equipment listed in ground launched missile work unit code manuals, the standard reporting designator code which identifies missile peculiar AGE will be used. For example, standard reporting designator code GMV would apply to ground CEM equipment listed in the missile work unit code manual, which is used in direct support of the LGM-30F.

Aerospace Ground Equipment (AGE)	G

Includes all powered and nonpowered AGE, ground CEM equipment listed in missile work unit code manuals, aircraft and missile peculiar AGE, and munitions handling equipment.

Precision Measurement Equipment (PME)	H
Ground Special Electronics (CEM)	J
Ground Fixed Wire Equipment (CEM)	K
Miscellaneous Ground CEM	L

Includes locally purchased locally manufactured or commercial equipment which is not supported by AFLC or was not centrally procured. This standard reporting designator code prefix will always be used when coding from the "Miscellaneous" ground CEM work unit code manual. Authorized second and third characters (suffix) of the standard reporting designator code for use with this prefix code will be assigned and maintained by major commands, and at their options, published as a major command supplement to TO 00-20-2.

Ground Launched Missiles	M
Air Launched Missiles and Guided Weapons	N

(cont'd)

USAFSS Command Mission Equipment (CME)	Q
Real Property Installed Equipment (RPIE), Shop Work, ECM Pods Vehicles, Gearboxes and Modules, Special Purposes Pods	R
AGE Gas Turbines, Auxiliary Power Units	S
Trainers, Mobile Training Sets (MTS) and Resident Training Equipment (RTE)	T
COMSEC Equipment	U
LRU's	W
Engines	X

This standard reporting designator code prefix applies to in-shop engine maintenance for all aircraft and missile engines. The last two characters which identifies the engine to a particular aircraft or missile by mission, design and series will be used. For example, in-shop work on a TF30-3 associated with the F-111A would be identified with SRD code XNV.

Munitions	Y
NORAD Combat Operations Center (425L and 427M)	1
439L, 469L and 490L Systems	2
492L, 493L Systems and AFICCS	3
474L, 496L and Defense Support Program Systems	4
465L System and DCSCS	5
466L, 497L Systems and DSSCS	6
486L System	7
TACS (407L and 485L), 412L and 487L Systems	8
440L System	9

b. For equipment on which new codes have been requested, the codes for nonlisted equipment in the applicable equipment category can be used until the new codes are published.

c. SRD codes for USAFSS Command Mission Equipment (CME) and COMSEC equipment are outlined in Air Force publications. Use only first position SRD code Q and last two positions from WB1-06 for CME equipment. Use first position SRD code U and last two positions from AFKAM-504( ) for COMSEC equipment.

AIRCRAFT

ATTACK

MDS	SRD	ENGINE TMS	SRD
A-7D	AA2	TF41-1	XAA
YA-7D	AAA	TF41-1	XAB
A-10A	AA1	TF34-100	XAD

(cont'd)

MDS	SRD	ENGINE TMS	SRD
A-37B	AAT	J85-17	XAH
A-37B LTF	AAR	J85-17	XAJ

BOMBER

MDS	SRD	ENGINE TMS	SRD
B-1	ABZ	F101-100	XBA
B-52C	ABC	J57-19	XBK
		J57-29	XBL
		J57-43	XBM
NB-52C	ABD	J57-19	XBN
		J57-29	XBP
		J57-43	XBQ
B-52D	ABN	J57-19	XBR
		J57-29	XBS
NB-52D	ABH	J57-19	XBT
		J57-29	XBU
B-52E	ABE	J57-43	XBV
NB-52E	ABJ	J57-43	XBX
B-52F	ABF	J57-43	XBY
B-52G	ABG	J57-43	XB1
B-52H	ABP	TF33-3	XB2
WB-57C	AB2	J65-5	XB6
B-57E	AB3	J65-5	XB7
EB-57E	AB5	J65-5	XB8
WB-57F	ABX	TF33-11	XB9
		J60-9	XCA
WB-66D	ABR	J71-13	XCD
FB-111A	AB1	TF30-7	XCF
		TF30-3	XCE
YFB-111A	ABB	TF30-7	XCG
SR-71A	ABV	JT11D-20B	XCH

(cont'd)

MDS	SRD	ENGINE TMS	SRD
		(J58)	
SR-71B	AB4	JT11D-20B (J58)	XCJ

CARGO

MDS	SRD	ENGINE TMS	SRD
C-5A	AC2	TF39-1	XCK
C-5A LTF		TF39-1	XCL
C-7A	AG2	R2000-7M2	XCN
C-9A	ACN	TF8-9	XCR
C-12	ALD	NONE	NONE
C-47A	AEL	R1830-92	XCV
C-47D	AEG	R1830-90	XCV
C-97G	ACD	R4360-59	XEA
C-118A	AJC	R2800-52	XEJ
C-121G	AJH	R3350-93	XEV
EC-121T	AEQ	R3350-93	XEY
C-123B	ACP	R2800-99	XEZ
C-123K	AC3	J85-17	XE4
		R2800-99	XE5
UC-123K	AC4	J85-17	XE8
		R2800-99	XE9
C-130A	ACF	T56-9	XGE
AC-130A	AC6	T56-9	XGF
DC-130A	AEV	T56-9	XGG
RC-130A	AJQ	T56-9	XGJ
C-130B	ACR	T56-7	XGK
WC-130B	AC9	T56-7	XGL
C-130D	AJR	T56-9	XGM
C-130E	ACH	T56-7	XGN
		T56-15	XGD

(cont'd)

MDS	SRD	ENGINE TMS	SRD
DC-130E	AEW	T56-7	XGP
EC-130E	ALB	T56-7	XH6
		T56-15	XN8
WC-130E	AJS	T56-7	XGQ
MC-130E	ALA	T56-7	XH5
C-130H	ACK	T56-15	XGR
AC-130H	AC8	T56-15	XGS
DC-130H	ACA	T56-15	XGA
HC-130H	AC7	T56-15	XGT
WC-130H	AJT	T56-15	XGU
HC-130N	AJU	T56-15	XGV
HC-130P	AJV	T56-15	XGW
C-130E (Little Rock Test)	APA	T56-7	XPA
C-131B	ACT	R2800-99	XGZ
		R2800-103	XG1
C-131D	AJX	R2800-103	XG4
C-131H	AKE	T501-13	XPN
NC-131H	AJ1	T501-13	XG7
C-135A	ACV	J57-43	XJA
		J57-59	XJB
EC-135A	AED	J57-59	XJC
KC-135A	ACX	J57-43	XJD
		J57-59	XJE
KC-135A LTF	AC1	J57-43	XJG
		J57-59	XJH
NKC-135A	AJ3	J57-43	XJK
		J57-59	XJL
NC-135A	AJ4	J57-59	AJN
		J57-43	XJV
RC-135A	AJ5	J57-59	XJP

(cont'd)

MDS	SRD	ENGINE TMS	SRD
C-135B	AEF	TF33-5	XJQ
WC-135B	AC5	TF33-5	XJS
C-135C	AJ7	TF33-5	XJT
EC-135C	AEE	TF33-9	XJU
		TF33-9	XKD
RC-135D	AJ8	J57-59	XJW
EC-135G	AJ9	J57-59	XJX
EC-135H	AGA	J57-43	XJY
EC-135J	AGB	TF33-9	XJZ
EC-135K	ALF	J57-59	XJ1
		J57-43	XH7
EC-135L	AEH	J57-59	XJ2
RC-135M	AGD	TF33-5	XJ3
EC-135N	AEA	J57-43	XJ4
EC-135P	AGE	J57-59	XJ5
KC-135Q	AEB	J57-59	XJ6
KC-135R	AGF	J57-59	XJ7
RC-135S	AGG	TF33-5	XJ8
RC-135T	AGH	J57-59	XJ9
RC-135U	AGJ	TF33-9	XKA
RC-135V	AGK	TF33-9	XKB
C-140B	AKC	J60-5	XPL
C-140A	ACZ	J60-5	XKE
YC-141B	AAG	TF33-7	XUT
C-141A	ACW	TF33-7	XKG
C-141A (NASA)	AEK	TF33-7	XEK
NC-141A	AGP	TF33-7	XKH

ELECTRONIC

MDS	SRD	ENGINE TMS	SRD
E-3A	AE2	TF33-100	XKJ
E-4A	AE5	F105-100	XKK
E-4B	AAJ		

FIGHTER

MDS	SRD	ENGINE TMS	SRD
F-4C	AFP	J79-15	XFA
F-4C LTF	AFY	J79-15	XFB
RF-4C	AFW	J79-15	XFC
YRF-4C	ANB	J79-15	XFE
F-4D	AFS	J79-15	XFF
F-4D (FOL)	ADX	J79-15	XBB
F-4D LTF	AF9	J79-15	XFG
F-4E	AFT	J79-17	XFH
YF-4E	ANC	J79-17	XFJ
F-4F	AN2	J79-17	XFK
F-4G	AN3	J79-17	XN3
F-5A	AFX	J85-13	XFL
F-5B	AND	J85-13	XFM
F-5E	AFU	J85-21	XFN
F-5E (LTF)	AF1	J85-21	XF1
F-15A	AFG	F100-100	XFP
F-15A (LTF)	ANA	F100-100	XNA
F-15B	ANE	F100-100	XFQ
F-15C	AAC	F100-100	XCS
F-15D	AAE	F100-100	XCM
F-101B	AFF	J57-55	XFZ
F-101F	ANQ	J57-55	XF5
F-102A	AFJ	J57-23	XF7
TF-102A	ANS	J57-23	XF9
F-5F	AF2	J85-21	XN2

(cont'd)

MDS	SRD	ENGINE TMS	SRD
F/RF4 Map Countires	AF8	J79-15 Map Countries	XF3
F-16A	AFA	F100-100	XFR
F-16A (IOTE)	AKA	F100-100	XES
F-16B	ANF	F100-100	XNL
F-104G	AFB	J79-11	XNG
TF-104G	AFL	J79-11	XNH
F-105B	AFM	J75-19	XNJ
F-105D	AFK	J75-19	XNM
F-105F	AFR	J75-19	XNP
F-105G	AFD	J75-19	XNQ
F-106A	AFN	J75-17	XNR
F-106B	ANY	J75-17	XNT
NF-106B	AN7	J75-17	XNU
F-111A	AFV	TF30-3	XNV
F-111D	AF5	TF30-9	XNX
F-111E	AF6	TF30-3	XNY
		TF30-4	XNW
F-111F	AF7	TF30-100	XNZ
EF-111A	AEC	TF30-3	XEC

HELICOPTER

MDS	SRD	ENGINE TMS	SRD
UH-1D	AHA	T53-13	XHA
TH-1F	AHB	T58-3	XHB
UH-1F	AHF	T58-3	XHC
HH-1H	AHE	T53-13	XHD
UH-1N	AHY	T400-400	XHE
UH-1P	AHC	T58-3	XHF
CH-3B	AHU	T58-1	XHH
CH-3E	AHH	T58-5	XHM

(cont'd)

MDS	SRD	ENGINE TMS	SRD
HH-3E	AHQ	T58-5	XHP
HH-43F	AHG	T53-11	XHU
HH-53B	AHW	T64-3	XHX
		T64-7	XHY
CH-53C	AH5	T64-7	XH1
HH-53C	AH6	T64-7	XH3
HH-53H	ALE	T64-7	XKL

OBSERVATION

MDS	SRD	TMS	SRD
O-2A	AP4	IO360-C	XPC
		IO360-D	XPD
O-2B	APC	IO360-C	XPE
		IO360-D	XPF

TRAINER

MDS	SRD	ENGINE TMS	SRD
T-33A	ATC	J33-35	XTU
NT-33A	AT6	J33-35	XTX
T-37B	ATE	J69-25	XTZ
T-37B LTF	ATK	J69-25	XT1
T-38B	AAV	J85-5	XAL
T-38A	ATF	J85-5	XT3
T-38A LTF	ATT	J85-5	XT4
NT-38A	AT9	J85-5	XT5
CT-39A	ARF	J60-3	XUR
T-39A	ATG	J60-3	XT6
CT-39F	ARG	J60-3	XUS
NT-39A	ARA	J60-3	XT7
T-39B	ARB	J60-3	XT8
T-39F	ARC	J60-3	XT9

(cont'd)

MDS	SRD	ENGINE TMS	SRD
T-41A	ATJ	0300-D	XRA
T-41.	ARE	I0360-D	XRC
-43A	ATH	TF8-9	XRD

UTILITY

MDS	SRD	ENGINE TMS	SRD
U-3B	AUB	I0470-D	XUC
U-4B	AUN	GS0480-B1A6	XUD
UV-18B	ABB	TT6A-27	XBC
OV-10A	AU1	T76-10	XUP
		T76-12	XUQ
U-2A	APJ	J75-13	XF

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ATTACHMENT 4

CATEGORY OF LABOR CODES

(ADE CA-760-XI)

A4-1. The following data codes are to be used for differentiating the various types of maintenance resources used to support the USAF equipment maintenance program. These codes are mandatory for all units under the Maintenance Data Collection System.

DATA ITEMS	DATA CODES
Military, Regular Duty Hours	1
Military, Overtime Hours	2
Federal Service Employee-Regular Duty Hours	3
Federal Service Employee-Overtime Hours	4
Local National Employee Hours	5
Contractor Labor Hours	6

A4-2. The applicable code will be entered in column K on all AFTO FORMS 349 as outlined in the 00-20-2-series technical orders.

SERVICE TEST
STUDY GUIDE

C3ABR42331-SG-301A

Technical Training

Aircraft Environmental Systems Mechanic

INSPECTION SYSTEM

18 April 1984

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE ONLY

DO NOT USE ON THE JOB

INSPECTION SYSTEM

OBJECTIVE

State the general principles of the inspection system by answering a minimum of 8 of 10 questions correctly.

INTRODUCTION

Well, soon you will be leaving Chanute AFB, Illinois, and going PCS to another base, probably in another state. If you plan on driving your car, you probably will not begin your trip without first preparing your car. This preparation is like an inspection that is performed on an aircraft. The only difference is, if you forget to check something on your car, before you leave, and the component stops functioning properly, you can pull over to get it repaired; but what does the pilot do if a system or component fails?

Inspections on aircraft are never ending, and none are more or less important than the other.

Note: Remove all figures located in the back of this study guide at this time.

Scheduled Maintenance Inspection

Scheduled maintenance inspections required for Air Force equipment are prescribed in the applicable -6 scheduled inspection and maintenance requirements manuals and inspection workcards (WC) or checklists (CL).

The scheduled maintenance inspection intervals for aircraft or support systems, equipment end items and components are specified in the applicable -6 scheduled inspection and maintenance manuals and -6WC inspection workcards. All requirements pertaining to inspections will normally be accomplished in numerical order to avoid complications in controlling and scheduling the required maintenance. The time intervals specified for scheduled maintenance inspections such as calendar, and flying hours represent the maximum interval between accomplishment of such requirements.

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Review Questions

Complete the following statements in the spaces provided. If additional space is required use notebook paper. The answers are located in the back of this study guide.

1. All requirements pertaining to inspections will normally be accomplished

2. Scheduled maintenance inspections required for AF equipment are prescribed in

3. Time intervals specified for scheduled maintenance inspections such as calendar or flying hours represent

Workcards and Sequence Charts

Let's find out what "tools" (Inspection Control Documents) are used during the performance of an inspection used by you and/or your supervisor. These tools are located in TO 00-20-1.)

The planned inspection and maintenance concept provides a means of performing required inspections and repairs on a scheduled and planned basis. This planning and scheduling is required for phased, periodic and isochronal (iso, means equal amounts; chronal is time, usually expressed in days or months) inspections, and major maintenance on aircraft or support equipment to effectively use the people assigned to your section. A degree of planning and scheduling is also provided for by the use of inspection workcards and sequence charts.

The inspection workcards, figure 1, outline the minimum inspection requirements. They are used as a guide, and tell you what to inspect, and what to inspect it for. The inspection workcards will be a very important tool that you will use in order to complete an inspection properly, and effectively in a minimum amount of time. They are published under the authority of the Secretary of the Air Force, and each -6 inspection requirement TO, and -6WC inspection requirement inspection has its own set of workcards, with a separate TO number assigned for each set (-6, and -6WC = 1 set).

The sequence chart, figure 2, is used by your supervisor in order to control the inspection. The sequence chart is used as a guide in preparing the actual work schedules. They also serve as a means of controlling the assignment of work during the inspection, and are a ready reference for determining the progress of the inspection. To aid the supervisor in making work assignments, the inspection workcard numbers may be plotted on the sequence chart to provide the desired work schedule or sequence in which all predictable or routine maintenance can be most effectively accomplished. The use of the workcards and sequence charts, will permit the work of each individual to be planned for uninterrupted job completion. This will assure the planned use of personnel, early detection of discrepancies, and more accurate planning for the accomplishment of the required repair work.

Review Questions

Complete the following statements using the information above.

1. The use of workcards and sequence charts will permit

2. The sequence chart is used as

3. The inspection workcards outline the

4. The planned inspection and maintenance concept provides a means

f

Inspection Methods

Inspections on aircraft, or support equipment, will normally be accomplished under a "specialists" maintenance concept, which means each system specialist will perform their portion of the inspection. This will consist of an inplace method of inspection, or the dock method of inspection. The inspection crews will be supported by the specialists provided on dispatch forms (AFTO Form 349) from the various shops as scheduled.

The inplace method is used when maintenance and operational requirements say that the inspection and maintenance must be performed at the aircraft location. In other words, you go to the aircraft.

The dock method is used when maintenance and operational requirements say the aircraft be moved to a fixed station or site for accomplishment. Required maintenance crews may be permanently assigned to such stations or sites. Each "inspection dock" will be equipped with the necessary tools and equipment to accomplish the required inspection and maintenance. In this method of inspection the aircraft is brought to you.

Review Questions

Answer the following questions using the information above.

1. When will the INPLACE method of inspection be used?

2. When will the DOCK method of inspection be used?

Inspection Concepts

There are four authorized inspection concepts used for aircraft. These concepts are periodic, phased, isochronal, and programmed depot maintenance. Each of the inspections in these concepts will be accomplished in accordance with the applicable -6 inspection requirement maintenance manual, or inspection work cards.

1. Periodic Concept
   a. Preflight (PR)
   b. End of Runway (EOR)
   c. Thruflight (TH)
   d. Basic Postflight (BPO)
   e. Hourly Postflight (HPO)
   f. Periodic (PE)
2. Phased Concept
   a. PR
   b. EOR
   c. TH
   d. BPO
   e. Phase (PH)
3. Isochronal Concept
   a. PR
   b. EOR
   c. TH
   d. BPO
   e. Home Station Check (HSC)
   f. Minor (MIN)
   g. Major (MAJ)
4. Programmed Depot Maintenance (PDM)

As you can see, the first four (a-d) inspections performed under each concept are the same. (PR, EOR, TH, BPO). We will cover these four first, then explain the HPO, PE, PH, HSC, MIN, MAJ and PDM. Get used to using these abbreviations; they will be used quite frequently throughout your AF career.

Preflight (PR)

The preflight inspection is due prior to the first flight of the flying period.

Let's say the flying period begins at 0600 hours. This is the time when the pilots will begin wanting aircraft. The Base Operations Office (Base Ops) lets maintenance control know ahead of time how many aircraft will be needed for the next days mission. Maintenance Control will then distribute the total number equally between the flights and then let job control distribute the work to the various flights. Each flight will have crews for this called a "Preflight Crew." These crews usually come in to work approximately two hours earlier than when the flying period begins, (0400 hours).

The preflight inspection includes visually examining the aircraft and operationally checking certain systems and components to insure there is no serious defects or malfunctions.

Major commands have the option of selecting a 24, 48 or a 72 hour preflight validity period. If the preflight validity period selected is 72 hours, and the aircraft does fly a mission, the preflight will be accomplished every 24 hours; but if the aircraft does not fly within the 24 hour period, the preflight will be valid for 48 hours. After 48 hours have gone by and the aircraft still does not fly, a new preflight is due. The aircraft can sit idle up to 72 hours before another PR has to be done, regardless if it will fly or not.

End of Runway (EOR)

The EOR is a final visual and/or operational check of designated aircraft systems and components. It will be performed immediately prior to takeoff at a designated location, usually near the end of the runway. The purpose of the inspection is to detect critical defects which may have developed or become apparent during ground operation of the aircraft. They would check things like - tires for cuts; leakage from fluid systems in the cracks of panels and doors, and making sure panels and doors are closed and fastened; covers and pins are removed, etc.

Thruflight Inspection (TH)

The TH inspection is a between flights inspection and will be accomplished between flights when an immediate turn around or sortie (mission) will happen. The TH consists of checking the aircraft for flight continuation by performing visual examinations or operational checks of certain components, areas, or systems to assure that no defects exist which would be dangerous to further flight. This inspection is the same as a pitt stop at the Indy 500. When a race car comes in for a pitt stop, there are only certain things done. Checking tires, refueling, cleaning the windshield, give the driver a drink and get back on the track. The TH is done basically the same way.

Basic Postflight (BPO) Inspection

The BPO is accomplished after the last flight of the flying period. This inspection consists of checking the aircraft to see if it is suitable for another flight by performing a visual examination or operational checks of certain components, areas, or systems to be sure that no defects exist which would be dangerous to flight. The BPO is "a more thorough check than the PR" or TH. The BPO is done only when the aircraft is released by Operations. This gives the specialists more time to repair discrepancies that are found before the next flying period begins.

Periodic (PE) Inspection

The PE is due upon a specified number of flying hours. The PE is more extensive than the HPO or BPO. This inspection is a thorough and searching inspection of the entire aircraft.

Hourly Postflight (HPO) Inspection

The HPO will be done upon a specified number of flying hours. This inspection adds to the BPO at the specified intervals. This means that they may both be done at the same time provided they are both due at the same time.

Phased (PH) Inspection

The PH concept consolidates the BPO and/or HPO and PE into small packages having approximately the same work content and manhours for accomplishment. The primary objective is to minimize the length of time that an aircraft is out-of-commission for any given scheduled inspection, and is done at a specified number of flying hours.

Isochronal (ISO) Inspection Concept

The ISO Concept translates flying hours into calendar periods, usually expressed in days. The PH, and PE are due after a specified number of "flying hours." The following inspections, under this concept will be due after a specified number of "calendar days", regardless of how many "hours" the aircraft has actually flown.

Home Station Check (HSC) Inspection

The HSC consists of inspection requirements arranged and designated for accomplishment when the aircraft returns from a long-range mission or upon expiration of a specified short-term calendar period. This date will be computed from the programmed start date of the last inspection. It is accomplished along with MAJ or MIN Inspections, provided they are all due at the same time.

Minor Inspection (MIN)

The MIN is due upon a specified number of calendar days. This date will be computed from the programmed start date of the last major inspection. The MIN consists of checking certain components, areas, or systems of the aircraft to determine if conditions exist which, if not corrected, could result in failure or malfunction of a component prior to the next scheduled inspection. The MIN is accomplished at the completion of the mission during which the specified calendar days accrued.

Major (MAJ) Inspection

The MAJ is due upon accrual of the number of calendar days. This date is computed from the programmed start date of the last MAJ inspection. The MAJ is a thorough and searching inspection of the entire aircraft, and individual requirements may be more extensive than previous inspection items. The inspection consists primarily of checking certain components, areas and systems of the aircraft, which due to their function requires less attention than that required by other inspections. This inspection is accomplished to determine if a condition exists which, if not corrected, could result in the failure of a component or cause system malfunction prior to the next scheduled inspection. The MAJ is accomplished at the completion of the mission during which the specified calendar day is accrued.

Programmed Depot Maintenance (PDM)

The PDM is an inspection requiring skills, equipment or facilities not normally owned by the operating locations. Individual areas, components and systems are inspected to a degree beyond the other inspection requirements.

Review Questions

Answer the following questions or complete the statements using the information provided on pages 6, 7, 8.

1. The four basic inspection concepts are?

a.

b.

c.

d.

2. The preflight inspection will be due prior to

3. When will the EOR be performed?

4. The aircraft lands and an immediate turnaround or sortie (mission) will happen. What inspection is due on the aircraft?

5. When will the BPO be accomplished?

6. What is the purpose of performing a BPO and then performing a PR?

7. When is the PE inspection due?

8. The abbreviation HPO identifies which inspection?

9. The HPO adds to which other inspection (provided they are both due at the same time)?

10. What is the difference between the ISO Concept and the PE/PH Concept?

11. Which inspections are due on aircraft everyday, and before each take-off or landing?

12. Which inspections are due after a specified number of flying hours?

13. Which inspections are due upon a specified number of calendar days or calendar period?

Symbol Used During an Inspection

The symbol used on maintenance documents which identifies that an inspection is due is the red dash. All discrepancies found during the inspection will be entered in the AFTO Form 781A with the appropriate symbol for that particular discrepancy, not the inspection symbol.

AFTO Forms:

The AFTO Forms used during the inspections are the AFTO Forms:

349 to account for times spent performing the inspection, it s repaired or replaced and defect of these items.

350 to get parts repaired that are found to be defective.

781A to record maintenance performance on aircraft and to identify at a glance the condition of the aircraft.

Phases of Inspection

There are two phases to each inspection. They are:

- Look
- Fix

When an inspection is due, you may receive a 349 that is similar to the one shown in figure 3. In Block 26 it will describe the system that is due the inspection, along with the type of inspection that is due. It will have a Job Control Number entered in Block 1; the work center code responsible to complete the inspection in Block 2; the aircraft ID Number entered in Block 3. The entries in Blocks 7, 9, 17 and 18 are completed only when the 349 is to be used as a dispatch form. The priority (job importance) in Block 7 tells the dispatcher what priority this particular job is. (The higher (1, 2, 3, 4) the number in Block 7 the lower the priority.) Priority ones (1's) will always be completed first; twos, second; and so forth. They will put the location of the aircraft in Block 9. This tells your dispatcher and/or supervisor what hangar or flight you will be working in. Block 17, Time Specialists Required, tells you that you have an appointment at that time to be at this aircraft with TOs and toolbox, and ready to begin your part of the inspection. If for some reason the start time is delayed, your dispatcher or supervisor will make the necessary arrangements with Job or Maintenance Control to get a new start time. Whenever an inspection is due the entire aircraft is inspected. The "scheduling specialists" allows these specialists to go in, get the inspection done and away without interferring with other specialists. The Job Standard in Block 18 is "estimated" job completion time. Experience of specialists and availability of equipment is not taken under consideration. It may or may not take this amount of time. We have approximately two hours to complete only the look phase of this inspection. The look phase is accomplished first in order to get the necessary parts to repair the system. We never know what we will find wrong, if anything. Just follow the -6WC (inspection requirement work cards, applicable to the inspection being performed) step-by-step. The workcards are used as a guide telling you what to inspect, and what to inspect it for. (See figure 1.) When you do find a discrepancy, complete the AFTO Form 349 as required in figure 4. Put the discrepancy in Block 26, and job control number, workcenter and aircraft ID number in Blocks 1, 2 and 3. Each discrepancy gets a new 349. If you find 18 discrepancies, you will turn in 18 349's to the crew or dock chief. Once you have completed all the steps in the -6WC, give all the discrepancies you found to the crew or dock chief, but keep the one that was issued to you by your dispatcher/supervisor, figure 3. It will be completed as in figure 5, then return it and yourself to your workcenter. The completed 349 for the look phase will be given to your dispatcher/supervisor. NOTICE: Under Column G "units" you took a zero '0'. This is because you never completed the inspection, you only took time for the "Look Phase." You still have the fix phase open. For an inspection, an aircraft may be down for days, or weeks. It depends on manning, availability of new parts, etc. You will daily turn in the time you spent on any job, or jobs, regardless if it was completed by you or not. You must account for your time daily.

Now what happens to the 349s you gave to the dock/crew chief? Well, since it is his/her aircraft, they will be responsible to order all the parts needed to get the inspection complete. They order the parts, enter the discrepancies in the AFTO Form 781A, Maintenance Discrepancy and Work Document, (aircraft forms), then forward the 349s to Maintenance and Job Control.

Maintenance/Job Control will make entries on the same 349 you started during the look phase, as in figure 6. When the parts come into the dock/crew chief, they will call control and let them know the job is now open. Control will route the same 349 back to your shop. Now begin the fix phase. This is where all the discrepancies found during the look phase are repaired and/or parts replaced on the malfunctioning system , that you found.

So far everything done on this inspection was done by you. What if the fix phase for one of the discrepancies opens on the evening shift? Do they wait for you to come back to work on the day shift? No, now anyone in your shop could get involved. Always be sure your discrepancies are clear and exactly what and where it is. This will avoid any confusion. (They may call you at home to repair your own discrepancies, if they are too badly written.) The 349 will then be completed as in figure 7 and returned to your Dispatcher/Supervisor.

Due to the fact that the entire aircraft is due this inspection, the only person who will know when all systems are A-OK, is the dock/crew chief. After all symbols and discrepancies have been cleared on the AFTO Form 781A, the dock/crew chief completes a new 349 as in figure 8. Compare figure 5 with figure 6. Remember the Methods of Inspection, Dock and Inplace? Since the crew/dock chief is assigned to the aircraft when the inspection was due, Control had the aircraft taken to them. (They performed the dock method.) Since they were not dispatched to the equipment, Blocks 7, 9, 17 and 18 are left blank. You left your workcenter to report to their workcenter (Blocks 2) to do work, so you had to be dispatched (see figure 6, Blocks 7, 9 17 and 18). It is their (the dock/crew chiefs) responsibility to see the inspection was completed, so they take a "1" in column 'G' (units), while you take "0"; but you have all the hours, while they get nothing. You get all the work and time, while they get all the credit. It is just like a barracks inspection. You do all the cleaning, while the Squadron Commander/or first Sgt gets all the credit. (GOOD or BAD!) Just like preparing the barracks for the inspection, it takes teamwork on everyone's part to get the job done. Remember, you can fail barracks inspection and repeat it later, but when it comes to aircraft inspections, there are lives on the line and there is no second chance. Follow your TOs, they are your guide so you don't forget to check and repair. "The life you save may be mine!" Don't Forget!

Review Questions

Answer the following questions, using the information provided on pages 10, 11, and 12.

1. What symbol identifies that an inspection is due?

2. If you enter a discrepancy on the AFTO Form 781a, that was discovered during an inspection, would you use the red dash symbol?

3. What AFTO Form identifies the maintenance performed on the aircraft, and identifies at a glance the condition of the aircraft?

4. What AFTO Form is used to account for the time spent performing the inspection?

5. What are the two phases to each inspection?

Answers to Review Questions on Page 3.

1. in numerical order to avoid complications in controlling and scheduling the required maintenance.

2. the applicable -6 scheduled inspection and maintenance requirements and Inspection Workcard (WC) or Checklists (CL).

3. the maximum interval between accomplishment of such requirements.

Answers to Review Questions on Page 4.

1. the work of each individual to be planned for uninterrupted job completion.

2. a guide in preparing the actual work schedules.

3. minimum inspection requirements.

4. performing required inspection and repairs on a scheduled and planned basis.

Answers to Review Questions on Page 5.

1. When maintenance and operational requirements say that the inspection and maintenance requirements must be performed at the aircraft location.

2. When the aircraft is to be moved to a fixed station or site.

Answers to Review Questions Page 9.

1. a. Periodic
   b. Phased
   c. Isochronal
   d. Programmed Depot Maintenance

2. The first flight of the flying period.

3. It will be performed immediately prior to takeoff at a designated location, usually near the end of the runway.

4. Thruflight (TH) inspection.

5. After the last flight of the flying period, and only when the aircraft is released by operations.

6. Because the BPO is a more thorough inspection than the PR, and it (BPO) gives the specialists more time to repair discrepancies that are found before the next flying period begins. (The PR insures the discrepancies have been repaired and no other malfunctions exist.)

7. Upon a specified number of flying hours.

8. Hourly Postflight inspection.

9. BPO, Basic Postflight inspection.

10. The ISO translates flying hours (PH/PE) into calendar periods, regardless of how many hours the aircraft has actually flown.

11. Preflight, End of Runway, Thruflight, Basic Postflight inspections.

12. Hourly Postflight, Periodic, Phased inspections.

13. Home Station Check, Minor, and Major inspections.

Answers to Review Questions on Page 12.

1. The red dash.

2. No. Enter the appropriate symbol for that particular discrepancy.

3. 781A

4. 349

5. Look/Fix

453

AFTO FORM JUN 70 26 AIRCRAFT INSPECTION WORK CARD

PRE. 1000 EDITION WILL BE USED

CARD NO	WORK AREA(S)	TYPE MECH RQR	MECH NO	CARD TIME	PUBLICATION NUMBER AND DATE	CHANGE RECORD
2-002	15	APG/AECS		4:37	1T-38A-6WC-3 1 MAY 82	

MAN MINUTES	WORK AREA	WORK UNIT CODE FOR DISCREPANCY SYS	SUB-SYS AND COMP	2ND PERIODIC (PREDOCK) INSPECTION REQUIREMENTS	ELEC POWER	SERVICE	CARD NO
					OFF		2-002

MAN MINUTES	WORK AREA	SYS	SUB-SYS AND COMP		INSPECTION REQUIREMENTS
060	15	PR	EP	1	Remove fuselage aft section in accordance with TO 1T-38A-2-2 (as required).
060	15	PR	EP	2	Clean engine bays in accordance with TO 1T-38A-3 (if engines are removed).
	15	PR	EP		A. Fuselage
	15	PR	EP		B. Fuselage aft section
005	15	11	811	-	Throttle quadrant. To ensure self locking nut (P/N MS21042L3) has adequate number of threads protruding thru nut (Ref TO 1-1A-8) replace nut if self locking feature has failed.
045	15	11	-	4	Fuselage aft section reinstalled on aircraft after engine removal (required for system operation).
090	15	23	-	5	Remove engine in accordance with TO 1T-38A-2-6 (as required).
002		47	118	6	Oxygen hose from regulator to disconnect for wear and security. Leak check with tester in accordance with TO 15X-1-1.
015		47	115	7	Oxygen regulator for leakage using leakage tester in accordance with TO 15X-1-1. Regulator for operation (if regulator has test ports. Test using tester 31TA2655-2) in all lever positions in accordance with TO 1T-38A-2-4. Components for security. Oxygen diluter lever 100% oxygen. Oxygen regulator supply lever safetied in on position with copper breakaway wire (if installed)

CARD NO	WORK AREA(S)	TYPE MECH RQR	MECH NO.	CARD TIME	PUBLICATION NUMBER AND DATE	CHANGE RECORD
2-002	15	APG/AECS		4:37	1T-38A-6WC-3 1 MAY 1982	

Figure 1. Inspection Workcard.

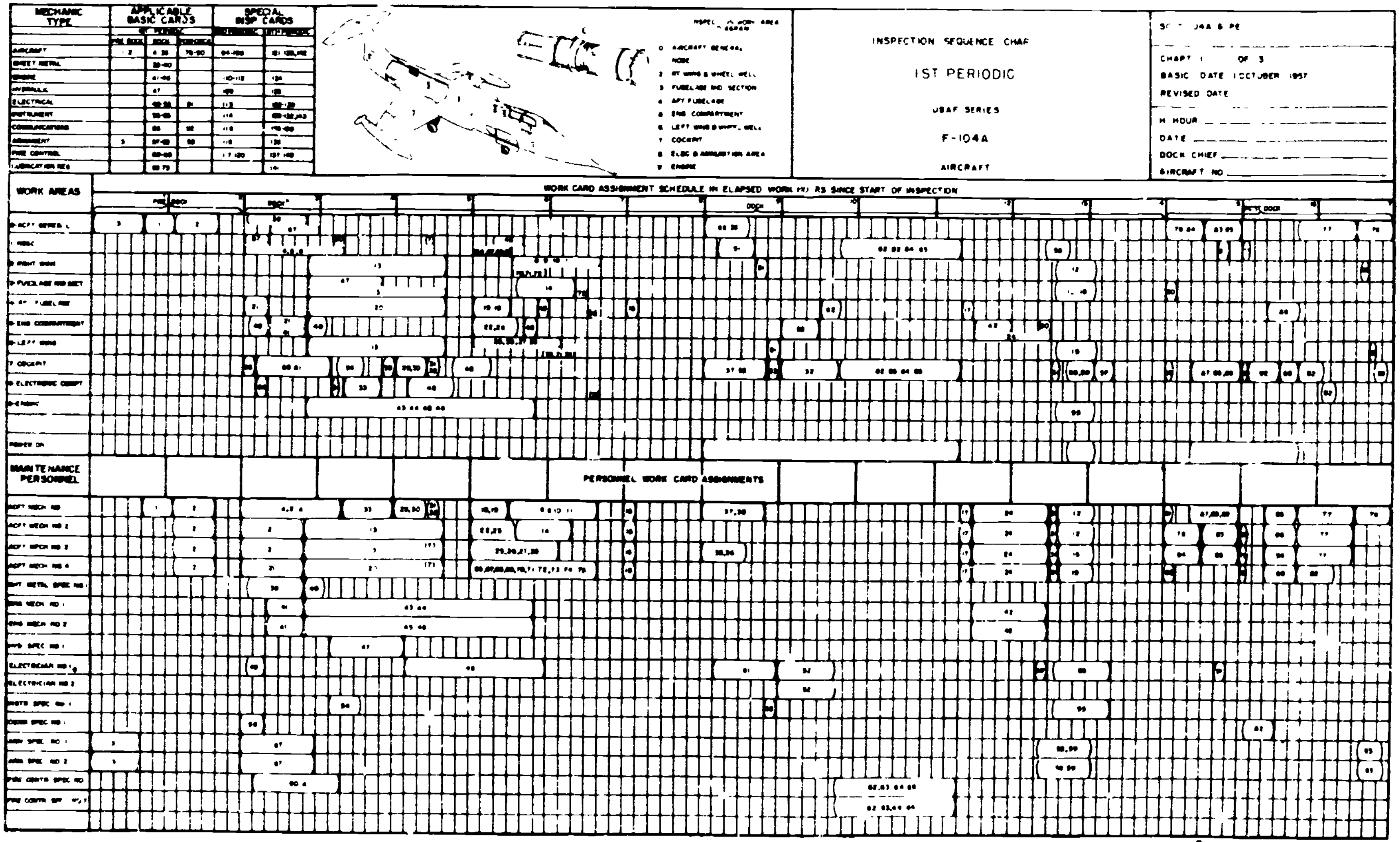

Figure 2. Sequence Chart.

16

MAINTENANCE DATA COLLECTION RECORD

OMB NO. 21-R0227

1. JOB CONTROL NO.	2. WORKCENTER	3. I.D. NO./SERIAL NO.	4. MDS	5. SRD	6. TIME	7. PRI	8. SORTIE NO.	9. LOCATION
2190016	Q3360	AA0557				3		P-12A

10. ENG. TIME	11. ENGINE I.D.	12. INST ENG TIME	13. INST. ENG. I.D.	14.	15.	16.	17. TIME SPC REQ	18. JOB STD.
							0930	2.0

19. FSC	20. PART NUMBER	21. SER. NO./OPER. TIME	22 TAG NO.	23. INST. ITEM PART NO.	24. SERIAL NUMBER	25. OPER. TIME

ACT. LINE	A TYPE MAINT	B COMP POS	C WORK UNIT CODE	D ACTION TAKEN	E WHEN DISC	F HOW MAL	G UNITS	H START HOUR	I STOP DAY	I STOP HOUR	J CREW SIZE	K CAT LAB	L CMD ACT ID	M SCH CODE	N AFSC/EMPLOYEE NUMBER
1															
2															
3															
4															
5															

26. DISCREPANCY

OXYGEN SYSTEM DUE 2ND PERIODIC INSPECTION

27. CORRECTIVE ACTION

28. RECORDS ACTION

AFTO FORM JAN 81 349 PREVIOUS EDITION WILL BE USED U.S. GOVERNMENT PRINTING OFFICE 1981

Figure 3

MAINTENANCE DATA COLLECTION RECORD

OMB NO. 21-R0227

1. JOB CONTROL NO	2. WORKCENTER	3. I.D. NO./SERIAL NO.	4. MDS	5. SRD	6. TIME	7. PRI	8. SORTIE NO.	9. LOCATION
2190016	Q3360	AA0557						

10. ENG. TIME	11. ENGINE I.D.	12. INST ENG TIME	13. INST. ENG. I.D.	14.	15.	16.	17. TIME SPC REQ	18. JOB STD.

19. FSC	20. PART NUMBER	21. SER. NO./OPER. TIME	22 TAG NO.	23. INST. ITEM PART NO.	24. SERIAL NUMBER	25. OPER. TIME

ACT. LINE	A TYPE MAINT	B COMP POS	C WORK UNIT CODE	D ACTION TAKEN	E WHEN DISC	F HOW MAL	G UNITS	H START HOUR	I STOP DAY	I STOP HOUR	J CREW SIZE	K CAT LAB	L CMD ACT ID	M SCH CODE	N AFSC/EMPLOYEE NUMBER
1															
2															
3															
4															
5															

26. DISCREPANCY

OXYGEN REGULATOR DILUTER LEVER BROKEN (FRONT COCKPIT)

27. CORRECTIVE ACTION

28 RECORDS ACTION

AFTO FORM JAN 81 349 PREVIOUS EDITION WILL BE USED U.S. GOVERNMENT PRINTING OFFICE 1981

Figure 4

MAINTENANCE DATA COLLECTION RECORD

OMB NO. 21-R0227

1. JOB CONTROL NO.	2. WORKCENTER	3. I.D. NO./SERIAL NO.	4. MDS	5. SRD	6. TIME	7. PRI	8. SORTIE NO.	9. LOCATION
2190016	Q3360	AA0557				3		P-12A

10. ENG. TIME	11. ENGINE I.D.	12. INST ENG TIME	13. INST. ENG. I.D.	14.	15.	16.	17. TIME SPC REQ	18. JOB STD.
							0930	2.0

19. FSC	20. PART NUMBER	21. SER. NO./OPER. TIME	22. TAG NO.	23. INST. ITEM PART NO.	24. SERIAL NUMBER	25. OPER. TIME

ACT. LINE	A TYPE MAINT	B COMP POS	C WORK UNIT CODE	D ACTION TAKEN	E WHEN DISC	F HOW MAL	G UNITS	H START HOUR	I STOP DAY	I STOP HOUR	J CREW SIZE	K CAT LAB	L CMD ACT ID	M SCH CODE	N AFSC/EMPLOYEE NUMBER
1	P		03400				0	0930	219	1130	1	1			B1663
2															
3															
4															
5															

26. DISCREPANCY

OXYGEN SYSTEM DUE 2ND PERIODIC INSPECTION

27. CORRECTIVE ACTION

LOOK PHASE OF 2ND PERIODIC INSPECTION CW IAW TO 1T-38A-6WC-3

28. RECORDS ACTION

AFTO FORM JAN 81 349 PREVIOUS EDITION WILL BE USED US GOVERNMENT PRINTING OFFICE 1981 /

Figure 5

MAINTENANCE DATA COLLECTION RECORD

OMB NO. 21-R0227

1. JOB CONTROL NO.	2. WORKCENTER	3. I.D. NO./SERIAL NO.	4. MDS	5. SRD	6. TIME	7. PRI	8. SORTIE NO.	9. LOCATION
2190016	Q3360	AA0557				3		P-12A

10. ENG. TIME	11. ENGINE I.D.	12. INST ENG TIME	13. INST. ENG. I.D.	14.	15.	16.	17. TIME SPC REQ	18. JOB STD.
							2045	1.0

19. FSC	20. PART NUMBER	21. SER. NO./OPER. TIME	22. TAG NO.	23. INST. ITEM PART NO.	24. SERIAL NUMBER	25. OPER. TIME

ACT. LINE	A TYPE MAINT	B COMP POS	C WORK UNIT CODE	D ACTION TAKEN	E WHEN DISC	F HOW MAL	G UNITS	H START HOUR	I STOP DAY	I STOP HOUR	J CREW SIZE	K CAT LAB	L CMD ACT ID	M SCH CODE	N AFSC/EMPLOYEE NUMBER
1															
2															
3															
4															
5															

26. DISCREPANCY

OXYGEN REGULATOR DILUTER LEVER BROKEN (FRONT COCKPIT)

27. CORRECTIVE ACTION

28. RECORDS ACTION

AFTO FORM JAN 81 349 PREVIOUS EDITION WILL BE USED US GOVERNMENT PRINTING OFFICE 1981 /

Figure 6

MAINTENANCE DATA COLLECTION RECORD

OMB NO. 21-R0227

1. JOB CONTROL NO.	2. WORKCENTER	3. I.D. NO./SERIAL NO.	4. MDS	5. SRD	6. TIME	7. PRI	8. SORTIE NO.	9. LOCATION
2190016	Q3360	AA0557				3		P-12A

10. ENG. TIME	11. ENGINE I.D.	12. INST ENG TIME	13. INST. ENG. I.D.	14.	15.	16.	17. TIME SPC RFO	18. JOB STD.
							2045	1.0

19. FSC	20. PART NUMBER	21. SER NO./OPER. TIME	22. TAG NO	23. INST. ITEM PART NO.	24. SERIAL NUMBER	25. OPER. TIME

ACT. LINE	A TYPE MAINT	B COMP POS	C WORK UNIT CODE	D ACTION TAKEN	E WHEN DISC	F HOW MAL	G UNITS	H START HOUR	I STOP DAY	I STOP HOUR	J CREW SIZE	K CAT LAB	L CMD ACT ID	M SCH CODE	N AFSC/EMPLOYEE NUMBER
1	P		47115	R	M	070	1	2045	219	2140	1	1			D0323
2															
3															
4															
5															

26. DISCREPANCY

OXYGEN REGULATOR DILUTER LEVER BROKEN (FRONT COCKPIT)

27. CORRECTIVE ACTION

REMOVED AND REPLACED OXYGEN REGULATOR IAW TO 1T-38A-2-4

28. RECORDS ACTION

AFTO FORM JAN 81 349 PREVIOUS EDITION WILL BE USED. US GOVERNMENT PRINTING OFFICE 1981 / -11

Figure 7

MAINTENANCE DATA COLLECTION RECORD

OMB NO. 21-R0227

1. JOB CONTROL NO.	2. WORKCENTER	3. I.D. NO./SERIAL NO.	4. MDS	5. SRD	6. TIME	7. PRI	8. SORTIE NO.	9. LOCATION
2190016	A1407	AA0557						

10. ENG. TIME	11. ENGINE I.D.	12. INST ENG TIME	13. INST. ENG. I.D.	14.	15.	16.	17. TIME SPC RFO	18. JOB STD.

19. FSC	20. PART NUMBER	21. SER. NO./OPER. TIME	22. TAG NO.	23. INST. ITEM PART NO.	24. SERIAL NUMBER	25. OPER. TIME

ACT. LINE	A TYPE MAINT	B COMP POS	C WORK UNIT CODE	D ACTION TAKEN	E WHEN DISC	F HOW MAL	G UNITS	H START HOUR	I STOP DAY	I STOP HOUR	J CREW SIZE	K CAT LAB	L CMD ACT ID	M SCH CODE	N AFSC/EMPLOYEE NUMBER
1	P		03400				1	0000	000	0000	1	1			R1208
2															
3															
4															
5															

26. DISCREPANCY

AIRCRAFT DUE 2ND PERIODIC INSPECTION

27. CORRECTIVE ACTION

AIRCRAFT 2ND PERIODIC INSPECTION CW IAW TO 1T-38A-6

28. RECORDS ACTIC

AFTO FORM JAN 81 349 PREVIOUS EDITION WILL BE USED. US GOVERNMENT PRINTING OFFICE 1981 / -1.

Figure 8

SERVICE TEST
PROGRAMMED TEXT

C3ABR42331-PT-301B

Technical Training

Aircraft Environmental Systems Mechanic

MAINTENANCE SYSTEM

27 October 1983

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

Designed for ATC Course Use.
Do Not Use on the Job.

Aircraft Environmental Systems Branch
Chanute AFB, Illinois

SERVICE TEST
C3ABR42331-PT-301B

MAINTENANCE SYSTEM

OBJECTIVE

State general principles of the maintenance system by answering a minimum of 8 of 10 questions correctly.

INTRODUCTION

A good Air Force does not just happen by accident. It is the result of a lot of people working together for a common goal. In this programmed text, we will discuss some of these people and what their jobs ar -bout. The people we are most concerned about, because we are mechanics e those who work in the areas of maintenance. The two main goals in the areas of maintenance should be as follows:

- Keep Air Force equipment serviceable.
- Keep it safe to use.

Now, let us begin our adventure into the "MAINTENANCE SYSTEM."

- -

The Maintenance System is broken down into four areas. They are as follows:

Levels of Maintenance

Maintenance Squadrons

Types of Maintenance

Maintenance Symbols and Their Use

We will begin our studies with the Levels of Maintenance.

OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 250; DAV - 1

LEVELS OF MAINTENANCE

Organizational Maintenance

Organizational Maintenance is limited in scope. This level of maintenance includes routine inspections, replacement of some components, minor structural repairs, and servicing with fuel, oil, etc. Organizational Maintenance may also do technical order modification that can be done with the facilities that are at the organizational level.

It is of the utmost importance that technicians at the organizational level discover any of the indications of equipment failure soon enough to prevent a major component failure. Failure to discover these indications would result in an increase in th workload of the other levels of maintenance. This may result in a disruption of the maintenance schedules, not to mention an in-flight failure with the possibility of a loss of life and/or equipment.

///////////////////////////////

NO RESPONSE REQUIRED

Notes:

FRAME 2

Intermediate Maintenance

Closely supporting the organizational level of maintenance is the Intermediate Level of Maintenance. Personnel in the Field Maintenance activity, usually a field maintenance squadron (FMS), performs maintenance at the intermediate level. The FMS usually has a high concentration of skilled specialists and has the most costly equipment in the maintenance organization. You will find such shops as engines, fuel systems, electrical, pneudraulics, and environmental systems, just to name a few, at this level. The actual number will depend on the size of the organization and the mission, in other words--NEED! If the DCM decides that there is a need for a shop, then the organization will make the necessary provisions for it.

The support that is provided by this level of maintenance consists of furnishing specialist assistance at organizational line maintenance, doing bench checks of equipment, and maintenance repair that is beyond the capacity of the organizational unit. When the capabilities of the maintenance activity at the intermediate level are exceeded, the problem becomes a matter for depot level maintenance.

//////////////////////////////

NO RESPONSE REQUIRED

- -

Notes:

Depot Maintenance

This is the highest level of maintenance and requires extensive equipment to do major repair and overhaul. The chief function of the depot is the performance of MAJOR modifications on the aircraft and all of the aircraft components. All systems are "inspected and repaired as necessary." Depots also supply the spare parts for Aerospace Ground Equipment (AGE), as well as Technical Order Compliance Kits (TOC) to the Organizational and Field Maintenance units through the normal supply channels.

Depot Maintenance is usually done at specifically designated bases in the United States and in some overseas areas.

//////////////////////////////

NO RESPONSE REQUIRED

Notes:

Review Questions

Directions:

Using information from Frames 1, 2, and 3, fill in the blanks with the correct answers.

SET 1

1. What are the three levels of maintenance?

   a. ____________________

   b. ____________________

   c. ____________________

2. The level of maintenance that is limited in scope is the ______________ level of maintenance.

3. Who has the responsibility to discover indications of equipment failure, to prevent a major component failure? ____________________

4. The shops you will find in the Intermediate level of maintenance are

   a. ____________________

   b. ____________________

   c. ____________________

   d. ____________________

   e. ____________________

5. The highest level of maintenance is the ____________________ level of maintenance.

MAINTENANCE SQUADRONS

AFR 66-1 and ·· ·· ʻ6-5

Now let us take a look at the uni... ·· ʻ ... the actual maintenance on the flightline. These consist of the following, for AFR 66-1:

- rganizational Maintenance Squadron (OMS)
- Field Maintenance Squadron (FMS)
- Munitions Squadron (MS)
- Avionics Maintenance Squadron (AMS)

If your next base is under the AFI · -5 co...cept, the maintenance squadrons are as follows:

- Aircraft Generation Squadron (AGS)
- Component Repair Squadron (CRS)
- Equipment Maintenance Squadron (EMS)

The ones that we will discuss in this PT are the ones that you may be assign. . to.

FRAME 4

Organizational Maintenance Squadron (OMS)

The OMS has physical charge of the assigned aircraft. Each aircraft is, in turn, assigned to an individual who is called a "Crew Chief." They are in charge of the aircraft, the aircraft forms, as well as any of the maintenance personnel assigned to ·rk on the aircraft. Actually, we could say that the whole maintenance com· ·x is organized to support the OMS.

The OMS itself may be further divided into the following sections or branches.

- Alert Force
- Base Flight and Transient
- Flightline
- Inspections
- Support equipment

///////// '//////////////////

NO RESPONSE REQUIRED

FRAME 5

Field Maintenance Squadron (FMS)

The FMS provides maintenance and the assistance of specialists to the other maintenance functions. FMS does intermediate level maintenance within the capability of the assigned specialties, their equipment, and their facilities. FMS may also be authorized to do so by the DCM.

FMS is usually the largest squadron in the maintenance organization. It also uses the most man-hours. Therefore, the way the people and the equipment are used by FMS will have a great effect on the maintenance capability of the wing.

FMS usually consists of the following branches:

- Fabrication
- Propulsion (Jet Engine Maintenance Shop)
- Aerospace Systems (Environmental, Pneudraulics, Electrical, etc)
- Aerospace Ground Equipment (AGE)

//////////////////////////////

NC RESPONSE REQUIRED

Review Questions:

Directions:

Using the information in Frames 4 and 5, fill in the blanks with the correct answer.

SET 2

1. The OMS has physical charge of the assigned aircraft. Each aircraft is, in turn, assigned to an individual called a "__________ - __________."

2. The abbreviation FMS identifies F__________ M__________ S__________.

3. FMS is responsible primarily for which of the three levels of maintenance? __________

4. FMS provides __________ for OMS.

5. The Inspection Branch is a part of which squadron? __________

6. OMS and FMS are under the concept of what Air Force regulation? ______

FRAME 6

Equipment Maintenance Squadron (EMS)

The EMS is responsible for the maintenance of

- AGE
- Munitions
- Off-equipment aircraft components
- Extensive on-equipment maintenance of aircraft
- Explosive Ordnance Disposal Service

FRAME 7

Component Repair Squadron (CRS)

The CRS primarily does off-equipment repair of aircraft and support equipment repair of aircraft and support equipment components, maintenance beyond the capability of the Aircraft Generation Squadron and the EMS, fabrication of parts, maintenance and operation of aircraft training devices, and repair and calibration of precision measurement equipment (PME). The squadron is functionally divided into these branches:

- Accessory Maintenance
- Propulsion
- Conventional Avionics
- Integrated Avionics
- Aircrew training devices
- Type II Precision Measurement Equipment Laboratory (PMEL)

FRAME 8

Aircraft Generation Squadron (AGS)

People assigned to the AGS perform the on-equipment maintenance of the assigned aircraft. The AGS organization provides for basic standardization and MAJCOM options to satisfy unique requirements.

Review Questions:

SET 3

Directions:

Answer the following questions either True (T) or False (F) using the information in frames 6, 7, and 8.

1. EMS i responsible for the maintenance of Aerospace Ground Equipment.

____

2. CRS squadron performs on-equipment maintenance of assigned aircraft.

____

3. AGS is the abbreviation for Air National Guard Service. __________

4. EMS disposes of explosives. __________

TYPES OF MAINTENANCE

There are two basic types of maintenance performed in the various squadrons. They are

Unscheduled maintenance, which may be done in the form of an inspection, or maintenance that is performed in between scheduled inspections. These types of maintenance are things that happen that cannot be planned into the maintenance schedule. These types of maintenance usually have a higher priority (job importance) than the next type of maintenance, which is scheduled maintenance.

Scheduled maintenance usually is done in the form of an inspection which will be covered in depth in a later lesson. This type of maintenance is planned into the days, months work schedule.

MAINTENANCE SYMBOLS AND THEIR USE

The symbols we will discuss in this section are used on some maintenance forms to make important notations instantly apparent. These serve two purposes:

- To identify the condition of the equipment.

- To form the basis of a standard system for telling at a glance the seriousness of the discrepancy noted next to the symbol.

The symbols, in order of seriousness, are

- Red X

- Circled Red X

- Red Dash

- Red Diagonal.

All symbols WILL BE ENTERED IN <u>RED</u> <u>PENCIL</u>.

Remove Figure 1, located on the back of this PT, as we discuss these maintenance symbols.

FRAME 9

Red X

The red X indicates that the equipment unit is considered unsafe or unfit for use, and the equipment will not be used or flown until the unsatisfactory condition is corrected. <u>NO</u> <u>ONE</u> can authorize an aircraft to be flown or the equipment to be used <u>until</u> the unsatisfactory condition is corrected.

The red X symbol will be entered in the appropriate location of the applicable maintenance form IMMEDIATELY upon discovery of the condition.

- -

Notes:

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The repairs made or work done to correct the condition of the equipment WILL be inspected only by maintenance personnel who are delegated such authority to clear the red X symbol as directed by the DCM.

////////////////////////////////
NO RESPONSE REQUIRED

FRAME 10

Circled Red X

A red X inside a red circle will be used to show that the equipment is grounded or restricted from peacetime operation, pending compliance with an Urgent Action Time Compliance Technical Order (TCTO). The only time that a circled red X symbol will be used is when the urgent Action TCTO has expired.

The same rules apply for clearing the circled red X as for the red X.

////////////////////////////////
NO RESPONSE REQUIRED

FRAME 11

Red Dash

The red dash shows that a required inspection is due. The red dash can also show that an inspection is overdue and time will not let you do the inspection before flight. This symbol shows that the condition of the equipment is UNKNOWN and that a more serious condition MAY exist. This condition will be corrected as soon as possible by doing the required inspection and completing the necessary maintenance.

////////////////////////////////
NO RESPONSE REQUIRED

FRAME 12

Red Diagonal

The diagonal shows that an unsatisfactory condition DOES exist on an aircraft or piece of equipment but is not so urgent or dangerous to warrant the grounding of the aircraft or the equipment. The red diagonal will be a straight line from the lower left to the upper right of the symbol block.

////////////////////////////////
NO RESPONSE REQUIRED

- -

Notes:

FRAME 13

Clearing Red Symbol Entries (Remove Figure 2)

The last-name initial in BLACK entered over the symbol in the symbol block shows that the person whose name is in the signature block related to that discrepancy has done the required work, or inspected the equipment, and has found that all things are satisfactory and is assuming the responsibility that it is OK to fly or use the equipment.

////////////////////////////////
NO RESPONSE REQUIRED

FRAME 14

Changing Red Symbol Entries

Once a Red symbol has been placed on a maintenance form, the symbol will NEVER BE ERASED, even if entered in error! Entry of a red X, circled red X, red diagonal, or red dash on any maintenance form shows the individual's opinion as to the seriousness of the defect Therefore, NO INDIVIDUAL is to be directed to change a symbol which they have entered.

If an individual of higher authority within the maintenance or repair activity believes that the condition is more serious than shown by the symbol, THEY WILL change the symbol themselves. They will do this by drawing a line through the name of the individual who made the entry and enter their signature and grade in parentheses above or beside the signature block. See figure 2.

If supervisory personnel think that the condition is less serious than shown by the symbol, this will be brought to the attention of the DCM, equivalent contractor representative, maintenance 9-level noncommissioned officer, civilian equivalent that has been authorized by the DCM to downgrade the symbol. Individuals who make the decision will indicate their action by a notation in the CORRECTIVE ACTION block for the defect and will read as follows: "Symbol downgraded from Red X (or Circled Red X) to a Red Diagonal (or Red Dash, whichever is applicable). Discrepancy reentered on page number _____ item number _____." When a symbol is cleared in this manner, no one need sign the INSPECTED BY block. The same discrepancy, the new symbol, and the PRINTED first initial, last name and grade of the person who found the discrepancy will be reentered in the applicable block and will be followed by an entry to read "Symbol changed from Red X (or Circled Red X) to a Red Diagonal (or Red Dash), date, employee's name, grade, and organization." This entry will remain with the discrepancy until it is corrected.

////////////////////////////////
NO RESPONSE REQUIRED

Notes:

Review Questions

Directions:

Using the information in Frames 9 through 14, match the symbol to its description/use. The answers may be used once, more than once, or none at all.

SET 4

SYMBOLS		DESCRIPTION/USE
1. Red X	____ a.	The most serious discrepancy.
2. Circled Red X	____ b.	Identifies that an Urgent Action TCTO has begun or time limit has expired.
3. Red Dash		
4. Red Diagonal	____ c.	Identifies that an inspection is due.
	____ d.	Identifies that an unsatisfactory condition MAY exist.
	____ e.	Identifies that an unsatisfactory condition DOES exist.
	____ f.	You discover the Air Conditioning Heat Exchanger has a hole in it. What symbol will be entered in the forms?

Answers to Review Questions

SET 1

1.a. Organizational
b. Intermediate
c. Depot

2. Organizational

3. Organizational

4.a. Engines
b. Fuel
c. Electrical
d. Pneudraulics
e. Environmental

5. Depot

SET 2

1. Crew Chief
2. Field Maintenance Squadron
3. Intermediate
4. Specialists
5. Organizational Maintenance
6. AFR 6'-1

SET 3

1. T
2. F
3. F
4. T

SET 4

1. a
2. b
3. b
4. c
5. c
6. d
7. a

DATE FROM	TO	CREW CHIEF	ORGN	LOCATION	MDS	SERIAL NO
15/12/3	/ /	E. D. Huls	3372 S/S	Chanute	T-38A	600557

SYM	DATE DISCO	WDC	JCN	TAG NO	CF TO 781A DATED	TRANSFERRED TO 781K DATE	DATE CORRECTED
$\cancel{\times}$	15 / 12/3	B	3490006		P I / /	/ /	15 / 12 / 3

DOC NO

DISCREPANCY
OXYGEN REGULATOR FACE PLATE CRACKED.

TRANSFERRED BY | GRADE | EMPLOYEE NO

CORRECTIVE ACTION
"SYMBOL ENTERED IN ERROR, DISCREPANCY AND CORRECT SYMBOL REENTERED BELOW."

(John Smith, TSGT)

CORRECTED BY J. Smith | GRADE TSGT. | EMPLOYEE NO S8888

INSPECTED BY | GRADE | EMPLOYEE NO

DISCOVERED BY ~~D. Jones~~ | GRADE SSGT. | EMPLOYEE NO J9999

SYM	DATE DISCO	WDC	JCN	TAG NO.	CF TO 781 DATED	TRANSFERRED TO 781K DATE	DATE CORRECTED
$\cancel{\times}$	15/ 12/3	B	3490006		P I / /	/ /	15 / 12 / 3

DOC. NO

DISCREPANCY
OXYGEN REGULATOR FACE PLATE CRACKED. (contact: DCM, Equilvant Contractor Rep., Maintenance 9-level NCO, or Civilian Equivalent, that is authorized by DCM.)

TRANSFERRED BY | GRADE | EMPLOYEE NO

CORRECTIVE ACTION
"SYMBOL DOWNGRADED FROM RED X. TO RED DIAGONAL. DISCREPANCY REENTERED IN BLOCK 5, ON PAGE 2."

CORRECTED BY R. Schwartz | GRADE COL. | EMPLOYEE NO S7777

INSPECTED BY | GRADE | EMPLOYEE NO

DISCOVERED BY D. JONES | GRADE SSGT. | EMPLOYEE NO J9999

SYM	DATE DISCO	WDC	JCN	TAG NO.	CF TO 781A DATED	TRANSFERRED TO 781K DATE	DATE CORRECTED
/	15/ 12/3	B	3490006		P I / /	/ /	/ /

DOC NO

DISCREPANCY
OXYGEN REGULATOR FACE PLATE CRACKED. "SYMBOL CHANGED FORM RED X, TO A RED DIAGONAL.
15 DEC. 83 Robert Schwartz, COL.
3370 TCHTG/TTGUP."

TRANSFERRED BY | GRADE | EMPLOYEE NO

CORRECTIVE ACTION

CORRECTED BY | GRADE | EMPLOYEE NO

INSPECTED BY | GRADE | EMPLOYEE NO

DISCOVERED BY D. JONES | GRADE SSGT. | EMPLOYEE NO. J9999

SYM	DATE DISCO	WDC	JCN	TAG NO.	CF TO 781A DATED	TRANSFERRED TO 781K DATE	DATE CORRECTED
	/ /				P I / /	/ /	/ /

DOC NO

DISCREPANCY

TRANSFERRED BY | GRADE | EMPLOYEE NO

CORRECTIVE ACTION

CORRECTED BY | GRADE | EMPLOYEE NO

DISCOVERED BY | GRADE | EMPLOYEE NO.

INSPECTED BY | GRADE | EMPLOYEE NO

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AFTO FORM NOV 76 781A MAINTENANCE DISCREPANCY AND WORK DOCUMENT PREVIOUS EDITION IS OBSOLETE

Figure 2. (Sample) Maintenance Discrepancy and Work Document.

DATE FROM	TO	CREW CHIEF	ORGN	LOCATION	MDS	SERIAL NO
0? / 07 / 3	/ /	L.D. Huls	3370TTGP	Chanute	T-38A	600557

SYM | DATE DISCD / / | WDC | JCN | TAG NO | CF TO 781A DATED P I / / | TRANSFERRED TO 781K DATE / / | DATE CORRECTED / /

DOC NO | DISCREPANCY | TRANSFERRED BY | GRADE | EMPLOYEE NO

The red X symbol indicates that the equipment is considered unsafe, or unfit for use. This symbol grounds the equipment.

COR This symbol must be inspected, and the inspector will clear the symbol, by placing their last name initial over the symbol. When they do this, they will assume responsibility for the work.

CORRECTED BY | GRADE | EMPLOYEE NO

DISCOVERED BY | GRADE | EMPLOYEE NO | INSPECTED BY | GRADE | EMPLOYEE NO.

SYM | DATE DISCD / / | WDC | JCN | TAG NO | CF TO 781A DATED P I / / | TRANSFERRED TO 781K DATE / / | DATE CORRECTED / /

DOC NO | DISCREPANCY | TRANSFERRED BY | GRADE | EMPLOYEE NO

CORRECTIVE ACTION

A ~~red~~ X inside a red circle indicates that an Urgent Action Time Compliance Technical Order is in process, or the time limit has expired. The equipment will not be used, and the symbol grounds the equipment.

This symbol must be inspected, and the inspector will clear the symbol, by placing their last name initial over the symbol. When they do this, they assume responsibility of the work.

CORRECTED BY

DISCOVERED BY | GRADE | EMPLOYEE NO | INSPECTED BY | GRADE | EMPLOYEE NO

SYM | DATE DISCD / / | WDC | JCN | TAG NO | CF TO 781A DATED P I / / | TRANSFERRED TO 781K DATE / / | DATE CORRECTED / /

DOC. NO | DISCREPANCY | TRANSFERRED BY | GRADE | EMPLOYEE NO

The red diagonal indicates that an unsatisfactory condition DOES exist, but is not serious enough to ground the equipment.

CO This symbol does not need to be inspected. but the signature in the Corrected By block will place their last name initial over the symbol, and assumes the responsibility of the discrepancy.

CORRECTED BY | GRADE | EMPLOYEE NO

DISCOVERED BY | GRADE | EMPLOYEE NO | INSPECTED BY | GRADE | EMPLOYEE NO

SYM | DATE DISCD / / | WDC | JCN | TAG NO | CF TO 781A DATED P I / / | TRANSFERRED TO 781K DATE / / | DATE CORRECTED / /

DOC NO | DISCREPANCY | TRANSFERRED BY | GRADE | EMPLOYEE NO

The red dash indicates that an inspection is due, and will be completed as soon as possible. This symbol does not ground the equipment, it states that an unsatisfactory condition MAY exist.

COR This symbol does not need to be inspected, but the signature in the Corrected By block enters their last name initial over the symbol, and assumes the responsibility that the inspection has been completed.

COR | GRADE | EMPLOYEE NO

DISCOVERED BY | GRADE | EMPLOYEE NO | INSPECTED BY | GRADE | EMPLOYEE NO

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BEST COPY AVAILABLE

MAINTENANCE DISCREPANCY AND WORK DOCUMENT

Figure 1. Maintenance Discrepancy and Work Document.

SERVICE TEST
PROGRAMMED TEXT

C3ABR42331-PT-301D

Technical Training

Aircraft Environmental Systems

MAINTENANCE DATA COLLECTION/PROCESSING AND CONTROLLING MATERIAL

23 September 1983

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

Designed for ATC Course Use.

Do Not Use on the Job.

OBJECTIVES

1. Identify facts relating to Maintenance Data Collection by answering a minimum of four of five questions correctly.

2. Identify facts for processing and controlling material with 100% accuracy.

3. Given a narrative problem and applicable TOs, correctly complete AFTO forms 349, 350 and 781A. This will be done with a maximum of 2 instructor assists per form.

INTRODUCTION

Have you ever really tried to keep up with the maintenance that is done on your car? Unless you are the type that performs his/her own maintenance and inspections, and keeps accurate records, it can get confusing. You take your car to one place, and they complete forms, telling you what they've done to it; then you take it to another place and they fill out their forms which are different, and before you know it you are so confused as what is done and still needs to be done that you are pulling your hair out by the roots!!! Every place you take your car for the different "specialists" to perform their maintenance, there is a different form, with sometimes very confusing but important information.

Some maintenance can be scheduled. For example, oil changes, oil filters, air filter, spark plugs, wheel allignments, etc.can be scheduled in advance. These are things that you may work into your budget to get them done. Sometimes things happen by surprise, like transmission failure and engine proglems. These things you can't plan on and are unscheduled maintenance.

Sometimes even when we do our own maintenance, unless we keep a record of what and when the maintenance was done, we can have a difficult time remembering when certain things are due again.

As you know, you will be performing scheduled and unscheduled maintenance on aircraft. Along with this maintenance you will have to maintain maintenance and historical records on all maintenance that is performed. Just like every place you take your car for maintenance, they have a particular form and way of filling out that form, so does the Air Force. This is called the Maintenance Data Collection System.

These forms are numbered, such as AFTO Form 349, AFTO Form 350, and AFTO Form 781A. The abbreviation AFTO identifies this form as an Air Force form and has a Technical Order written in order to complete the form properly.

We will learn in this lesson how to use these TOs and when to which TO for what AFTO Form. We will also learn the AFTO form that is used to process and control material (parts) for repair or to be condemned and returned to Depot.

Before we begin, be sure to read and follow this PT very carefully. Should any problems arise, ask the instructor for help/assistance.

OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 150; DAV - 1

Located in the classroom you'll find a bookcase with a group of black books with white labels facing you. Get the book that has the numbers 00-20- THRU 00-20-5 on the label and bring it back to your desk.

Open the book cover and on the right you'll find what is called the "TITLE PAGE." All TOs have a Title Page which gives us five important bits of information pertaining to the TO:

1. TO Number
2. TO Title
3. Distribution Statement
4. Publishing Statement
5. Date the TO was published with the date of the change, if any.

In order for you to learn the Maintenance Data Collection (MDC) System, you must know how to use TOs. So before we begin our lesson, we will learn how to use this set of TOs and what is in this set of TOS that all TOs have in common.

Frame 1

Title Page

TO Number: The TO number is written in the upper right corner of the title page and in the upper left/right corners of the pages thereafter. (This binder contains four different 00-20 TOs. So if you ever have difficulty finding the information we are talking about, the first thing you should do is check the number in the upper left/right corner of the page.) In this case, we are in TO 00-20-1. Each TO number is divided into at least three parts and each part is seperated by a dash. Each part of the TO number identifies what the TO is all about.

00. The 00 in the first part of this TO number identifies methods and procedures.

-20. Tells us this TO pertains to the MDC system.

-1. Says General requirements for all AFTO Forms.

If we take this TO number breakdown and put it together we would have, "The methods and procedures for the MDC system that is applicable to all AFTO Forms."

TO Title: The title of this TO is "PREVENTIVE MAINTENANCE PROGRAM GENERAL REQUIREMENTS AND PROCEDURES." This is a brief statement as to the type of information that is found inside this TO and is located in the top center of the Title Page.

Distribution Statement: The distribution statement tells us that the TO is limited to US Government use, and if we would like to order a copy we must write to Tinker AFB, Oklahoma. The distribution statement is written in the bottom center of the title page.

Publishing Statement: The publishing statement says who authorized this TO to be published. The Secretary of the Air Force said this TO will be published which is

...they are telling you on paper what to do. Since this is a Technical "Order," if you do not use this and comply with the orders contained in this and all TOs, you are failing to obey an order given you by the Secretary of the Air Force, which is as bad if not worse than telling your supervisor that you will not do what he is telling you to do. "ALL TOs ARE A MILITARY ORDER!"

The publishing statement is written in the bottom center of the Title page.

Dates: If you'll look in the bottom right corner, you'll see two dates. The top date of 1 January 1979 is the date this TO was published. Below this date is Change 10 15 February 1983, and tells us since 1 January 1979 this TO has had 10 changes and change 10 was put in effect 15 February 1983.

TOs usually change quire a bit. The information may not be clear enough to comply with or may be misleading as it is written. Because the Air Force wants us to use these and all TOs, they go to unending limits to make the information clear and precise. Sometimes they feel they need to add information to a TO, so it is added for our benefit. TOs are written for you! Use them!

REVIEW QUESTIONS FOR FRAME 1

Using TO 00-20-1 Title Page and the information you have just read, answer the following questions or complete the statements.

1. TO 00-20-1 covers the PREVENTIVE MAINTENANCE PROGRAM ______________

__________ AND ______________.

2. Where would we write to request copies of this TO?

3. What date was this TO published?

4. How many changes has this TO had since it was published?

5. This TO is published under the authority of the ____________ if the ________

________.

LISTS OF EFFECTIVE PAGES Page A.

Turn the Title Page over. In the lower left corner, you'll find the letter A. This is the page letter. (Page numbers will begin later in this TO.) If you'll look in the upper left corner you'll find, inside a box, LISTS OF EFFECTIVE PAGES. If you read through this page, beginning with this box, you'll find next to this box what to do in case of a TO change. Beneath this, there is a NOTE: This note tells how we can identify a changed portion of a page, which the latest change has affected. Next we find the dates that each change was published, and below this, the total number of pages in this TO and the change number of each page, if any.

Page A is common to all TOs, and is located on the back of the title page.

REVIEW QUESTIONS Frame 2

Using the Page a in TO 00-20-1, answer the following questions:

1. How can you identify the portion of the text affected by the changes?

2. Change 8 was put into effect on what date?

3. What did change 1 do to page 4-15?

4. What does a "0" in the change number column indicate?

5. How many pages are in this TO?

Table of Contents Page i

Now look at page i. This page is called the Table of Contents and is a very important tool in finding information in this TO. The Table of contents is divided into three columns. From left to right the titles of the three columns are:

SECTION TITLE PAGE

Section: This tells what section of the TO information is found. Section one pertains to GENERAL information. Section II pertains to ADMINISTRATIVE REQUIREMENTS FOR MAINTENANCE DOCUMENTS. Notice under the word PAGE how the first number before the dash changes depending on what section of the TO we are in.

Title: In the center of the page we have the titles of information. Under GENERAL, Section I, we first of all have the Purpose of this TO and all information that is of general nature. In section II we will find information pertaining to the administrative requirements. Whenever I hear the word "administrative," I think of filing, typing and things that a secretary would do. Well section II pertains to just that kind of information.

Page: In column three, we find a list of page numbers. You already know that the first number, before the dash, is the section number. The number after the dash is the actual page number or the order of information in which it is found. To the left of the title we have another set of numbers. These numbers are paragraph numbers. If we were looking for information pertaining to contract maintenance operations, we would find the title in section one. We would find the information that we are looking for in paragraph 1-7 on page 1-2.

As we continue looking through the Table of Contents, you will notice a black vertical line next to page number 2-6. Remember what this stands for? If not, go back to page A in the TO and read the note in the upper center part of the page.

In section IV we have MAINTENANCE INSPECTIONS METHODS AND PROCEDURES AND ACCESSORY REPLACEMENT AND REUSE REQUIREMENTS. Turning to page ii, there are two more sections - V and VI.

Also included in the Table of Contents is the list of illustrations. This is used when you want to see a picture of, in this case AFTO Forms, what the TO is describing. On page iii, we find the list of tables, which has problem areas that a lot of people have had, so a table was written for these particular problems and what to do in case you should have the same problem some time in your Air Force career.

Always use the Table of Contents when you are looking for information inside a TO. It helps you to find the information much faster and easier. If there is something inside the TO that you don't understand, such as an astrisk or some kind of markings, always look to the page A for a definition of these markings. If the marking isn't listed there, it may be identified in the first paragraph of that section. If not, ask your instructor if he/she will identify it for you.

REVIEW QUESTIONS - Frame 3

Using TO 00-20-1 (HO-301), answer the following questions:

1. What AFM tells us how to dispose of documents for aircraft or missiles that are involved in accidents or incidents which result in damage to private property?

2. What do the abbreviations IAW/TO identify?

3. What is the title of TO 00-20-2-5

4. What section is the figure of the AFTO Form 26, Aircraft Inspection Work Care found in?

5 On what page is table 4-2 located?

ANSWERS TO REVIEW QUESTIONS FOR FRAMES 1, 2 & 3.

Frame 1

General Requirements and Procedures

2. Oklahoma City ALC/MMEDT, Tinker AFB, OK

3. 1 January 1979

4. 10

5. Secretary of the Air Force

Frame 2

1. See Note. (... vertical line in the outer margins of the page.)

2. 1 Jan 82

3. Deleted that page

4. Original Page

5. 62

Frame 3

1. AFM 12-50, Par 2-7a, Pg 2-4

2. IN ACCORDANCE WITH/TECHNICAL ORDER

3. On-equipment maintenance documentation for intercontinental ballistic missiles, Par 1-2, Pg 1-1

4. Section IV, MAINTENANCE INSPECTION METHODS AND PROCEDURES AND ACCESSORY REPLACEMENT AND REUSE REQUIREMENTS. Fig 4-1, Pg 4-13

5. Fig 4-1

ON-EQUIPMENT MAINTENANCE DOCUMENTATION FOR AIRCRAFT; AIR-LAUNCHED MISSILES; GROUND-LAUNCHED MISSILES, EXCEPT ICBMs; DRONES; AND RELATED TRAINING EQUIPMENT

Turn to TO 00-20-2-2.

Lets begin this part of the lesson by discussing this TO number. You probably already noticed this TO number has four parts. Lets find out what these parts identify.

00 The 00 identifies the same as in the last TO number. Methods and procedures.

-20 The 20 still identifies the same thing, MDC System.

-2 The -2 identifies a particular AFTO Form(s). In this case the AFTO Form 349, and the AFTO Form 350. (ee Table of Contents)

-2 The last part is a -2, and this identifies what piece of equipment this TO applies to. You can tell by the title, this TO applies to Aircraft.

If we were to take this breakdown and put it all together, we would have:

The Methods and Procedures for the MDC system, for completing AFTO Forms 349/350 when working on the aircraft.

The 'A' page, and the Table of Contents work the same in this TO as in the last TO. (00-20-1), and has the same format as used in the last TO.

Lets proceed to the next TO.

//

NO RESPONSE REQUIRED

OFF-EQUIPMENT MAINTENANCE DOCUMENTATION FOR SHOPWORK, CONVENTIONAL MUNITIONS, AND PRECISION MEASUREMENT EQUIPMENT

In this TO number the only part that has changed is the fourth part (-10).

We still have a Methods and Procedural TO, (oo). We still have a TO that pertains to the MDC System, (-20). The Third Part is still -2, and by looking at the Table of Contents, this TO still pertains to the same AFTO Forms 349/350. Now what does the -10 in the fourth part identify? Notice the TO Title, where it says in the beginning, OFF-EQUIPMENT MAINTENANCE DOCUMENTATION FOR SHOPWORK.

So we have a Methods and Procedures TO for the MDC System, for documenting maintenance on the AFTO Form 349/350, when working IN-SHOP.

The Page 'A' is the same for all TOs except for the specifics pertaining to the TO you are using. The Table of Contents is on the same basic format as the -2s, (NOTICE: the 00-20-2-2, and 00-20-2-10 Table of Contents are almost identical).

//

Review Questions for Frames 4 & 5.

Using the Table of Contents in TOs 00-20-2-2 and 00-20-2-10, find the information inside the TOs to answer the following questions. (Read the questions carefully. They tell you which TO to use. If no TO is mentioned, then the question is a general question and either of the two TOs apply.

1. When working on the aircraft, what page explains Documenting Support General work?

2. When working in shop, what entry is required in Block 4 of the AFTO Form 349?

3. When working in-shop, what paragraph explains "Crew Size"?

4. When working on the aircraft, where does the entry in Block 5 of the AFTO Form 349 come from?

5. When working in-shop, and making entries on the AFTO Form 350, front side Part 1, where will the entry in Block 15A be obtained from?

6. What part of the AFTO Form 350 is the repair cycle processing tag?

7. When working in-shop, what entry is required in Block 8 of the AFTO Form 349?

8. What part of the AFTO Form 350 is used as a control document?

9. When working in-shop, what part of the AFTO Form 350 will be attached to the items that are to be repaired?

//

Answers to Review Questions for Frames 4 & 5, with TO number Page and Paragraph.

1. Pg 1-3 00-20-2-2 Page i

2. No entry required 00-20-2-10 Page 3-1 paragraph 3-1d

3. Par 3-2j 00-20-2-10 Page ii

4. 00-20-2 00-20-2-2 Page 3-1 paragraph 3-1e

5. AFTO Form 349 00-20-2-10 Page 4-2 paragraph 4-3

6. Part 1 00-20-2-2, 00-20-2-10 Page 4-1 paragraph 4-1

7. No entry required 00-20-2-10 Page 3-1 paragraph 3-1d

8. Part II 00-20-2-2, 00-20-2-10 Page 4-1 paragraph 4-1

9. Part 1 00-20-2-10 Page 4-1 paragraph 4-2b

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AIRCRAFT, DRONE, AIRCREW TRAINING DEVICES, ENGINES, AND AIR-LAUNCHED MISSILE INSPECTIONS, FLIGHT REPORTS, AND SUPPORTING MAINTENANCE DOCUMENTS.

TO 00-20-5 begins no differently than the other TOs. It also has a Title Page, an 'A' page, and a Table of Contents.

The -5, in the third part of the TO number, identifies that this TO covers specific information. Unlike TO 00-20-1, which covers general information applicable to all AFTO Forms, the 00-20-5 covers specific information on specific forms.

Look through the Table of Contents, (pages ii, thru iii) and you will find this TO covers the entire AFTO Form 781 series; (there are approximately 8 different 781's). AFTO Forms 100, 100A; and AFTO Forms 98, 88, 44, and 34. (Don't worry, you will not be responsible to remember all of these AFTO Forms. Just know what TO covers them). You may also notice this TO does not cover the AFTO Forms 349/350.

Briefly review the Table of Contents before you proceed to the review questions for this frame.

//

Review Questions for Frame 6

Using the TO 00-20-5, find the answers to the following questions in the TO.

1. What is the title of this publication?

2. What are the four basic inspection concepts?

3. The 90 day calendar inspection will affect the status of what other two inspections?

4. With what type of time compliance technical order (TCTO) is the circled red X used?

5. Which pragraph and subparagraph explains the "location" block on the AFTO Form 781A?

6. Who will establish the necessary controls to assure that inspections are done at or near their scheduled due time?

7. What is the title of AFTO Form 781A?

Answers to Review Questions, Frame 6.

1. Aircraft, Drone, Aircrew Training Devices, Engines, and Air-Launched Missile Inspections, Flight Reports, and Supporting Maintenance Documents. (Answer found on Title Page)

2. Periodic, Phased, Isochronal, and Programmed Depot Maintenance. (Answer found on page 1-8, paragraph 1-16a(1),(2),(3),(4))

3. Accomplishment of either the 30 or 90-day inspection affects only the Basic Postflight or Home Station Check inspection status. (Answer found on page 1-15, paragraph 1-29c)

4. Urgent action TCTO. (Answer found on page 1 7, paragraph 1-10)

5. 2-9f (Answer found on page 2-16)

6. The deputy commander for maintenance will establish the necessary controls to assure that the periodic, phased, or isochronal inspections are accomplished at or near their scheduled due time. (Answer found on page 1-9, paragraph 1-16)

7. "Maintenance Discrepancy and Work Document." (Answer found in Table of Contents page ii)

Review for Frames 1 thru 6.

TO 00-20-1 "Preventive Maintenance Program General Requirements and Procedures"

This TO pertains to the methods and procedures for the MDC systems. It is general information and applies to ALL AFTO Forms

TO 00-20-2-2, "On-Equipment Maintenance Documentation for Aircraft; Air-Launched Missiles; Ground-Launched Missiles, Except ICBMs; Drones; and Related Training Equipment"

This TO pertains to Aircraft Maintenance Documentation for AFTO Forms 349 and 350.

TO 00-20-2-10, "Off-Equipment Maintenance Documentation for Shop Work, Conventional Munitions and Precision Measurement Equipment."

This TO pertains to Maintenance Documentation for Shop work, when the equipment (system or comp nent) was removed from the aircraft, and is for AFTO Forms 349/350.

TO 00-20-5 "Aircraft, Drone and Air-Launched Missile Inspections, Flight Reports and Supporting Maintenance Documents."

This TO pertains to specific information on specific AFTO Forms.

//

If you have any questions on any of this information ask now!

//

We have two more TOs to learn. They are TOs: 00-20-2 (in H0301) Maintenance Data Collection System.

IF-111A-06 Work Unit Code manual for an F-111A Aircraft

The reason these two TOs have been separated from the others is because they are used to find the codes that are used on AFTO Forms.

The TO 00-20-2 "MDC System", is used to find the codes that are entered on AFTO Forms 349/350.

One of the codes we will find in this TO is Standard Reporting Designator (SRD) codes. An older AFTO Forms 349-350 the SRD is called EQ/CL (Equipment Classification Codes). Whether it is SRD or EQ/CL the same code is used. They are different terms that mean the same thing.

SRD codes are used to identify aircraft and support equipment and related equipment by type or category.

All the codes in this TO are identified by aircraft type in alphabetical/ numerical order. (Example: Attack, Bomber, Cargo, Figher, etc.) In order to find the SRD/EQ/CL code simply look up the type, model and series of aircraft or aircraft equipment you are working on.
(Example: An F-111A; Type 'F'=Fighter; Model 111; Series A.)

If we look up the SRD-EQ/CL Code for an F111A, we will find the code is AFV. The 'A' identifies a General type of equipment such as 'A' for aircraft. If the first character is an 'X', it identifies engines.

The FV of the SRD-EQ/CL Code identifies specific equipment (F-111A). If we were to remove the engines from an F111A, our SRD-EQ/CL code would be XFV. If we removed the Air Launched Missiles and Guided Missiles from the F111A our SRD-EQ/CL Code would be NFV.

Some bases have more than one kind of aircraft assigned. The reason for using SRD-EQ/CL Codes is because some equipment for certain aircraft may look identical, but not be interchangeable. So these codes will assist us and others in identifying that the equipment is for a specific aircraft.

These codes are also [illegible] in computer programs to facilitate data processing of specifi equipme [illegible] use in automated management information systems and to assist interchange [illegible] a between the supply and maintenance system.

The authorized abbreviation for SRD, and EQ/CL codes is SRD.

Another code the 00-20-2 TO gives us is the Category of Labor Codes. These Category of Labor Codes are to be used for differentiating the various types of maintenance resources used to support the USAF equipment maintenance program. These codes are mandatory for all units under the MDC System.

//

Review Questions for Frame 7

Using HO-301, answer the following questions.

1. Locate the complete Standard Reporting Designators (SRD) for each of the following:

	Aircraft	SRDs
a.	B-52C	____________
b.	WB-66D	____________
c.	TF-104G	____________
d.	C-121G	____________

2. What does the first character of the SRD Code identify?

3. What do the second two characters identify?

4. What is the first character of the SRD Code for aircraft.

//

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Answers to review questions for Frame 7

1. a. ABC (HO-301 Pg 5)
   b. ABR (HO-301 Pg 5)
   c. AFL (HO-301 Pg 10)
   d. AJH (HO-301 Pg 6)

2. The first character identifies a general type of equipment (HO-301, Par A2-1a, Pg 3)

3. The second two characters identify a specific type of equipment. (HO-301, Par A2-1a, Pg 3)

4. A (HO-301, Par A2-1a, Pg 3)

//

In the bookcase in the room, you will find some smaller TO's that have a white strip going up and down. Get the TO that has 1F-111A-06 on the side facing you.

TO IF-111A-06, "AIRCRAFT MAINTENANCE WORK UNIT CODE MANUAL USAF SERIES F-111A, D, E AND F AIRCRAFT."

Looking at the Title Page of the IF-111A-06 we will find the TO number in the upper right corner, and on the top center of each page hereafter. In the center top half we will find the complete TO title. The title includes all letters and numbers. You see this TO covers the F-111 series A, D, E, and F. It will not work for series B, C of the F-111 aircraft. Below the title we will find the distribution statement, and below this, we find this TO was published under authority of the Secretary of the Air Force. Then to the right bottom corner we will find the basic date and change number along with the change date.

Behind the Title Page, we have an 'A' page. First we have the TO number, and the title of this page "List of Effective Pages." Beneath this is what to do in case of a change to the TO. Then we find how we can identify what the most recent change has affected. Now we have a NOTE: That the other TO did not have. It says "only pages listed on the 'A' page are valid." Next we find the dates of issue for the original, and changed pages along with page numbers, and change numbers that should be found for that page. The list of Effective pages covers pages A, B, C, and D. The total number of pages in this manual is 256.

On Page I-001 begins the Table of Contents. See the black vertical lines in the outer margin of this page? Remember what this means? If not, go back and read the first note on the top of page 'A'. Never try to "memorize" information that is found in a TO. They are almost constantly being changed. If you feel that you have "mastered" the information always double check before you do what is required, and remember "a TO is a military order."

Beneath the Table of Contents page we find the preface. This is where they introduce the various codes, abbreviations and symbols you will find inside the TO.

Next we see there are two groups of Type Maintenance Codes. One is for aircraft, the other is for engines. Always be sure you are in the right group for the type of maintenance you are performing. (Read paragraph 2c on page II-002.)

Getting back to the Table of Contents, we find Action taken codes listed on page V-001. The description of Action taken codes is on page II-002, paragraph 2D. Read this paragraph, then return to the Table of Contents and this PT.

After Action Taken Codes we find When Discovered codes. Read paragraph 2D on Page II-002 in the TO.

Now thi. begin to get a little tricky. Pay very close attention to this paragraph.

There are two groups of How Malfunction Codes. The first one is an Alphabetical listing, where all the code definitions are listed under the first letter of the malfunction. Turn to Page VII-001 to see what we are talking about. Then return to the Table of Contents. The second group of How Malfunction Codes is a numerical listing where all the codes are listed according to the number of the code. (smallest number first) Turn to Page XI-001, then return to the Table of Contents.

These How Malfunction codes are further broken down into categories:

Avionics/Electrical/Computer
Physical/Mechanical
No Defect
Engine Related/Reason For Removal

This category of How Malfunction Codes is broken into sub-categories:

Observed or Recorded Operational Conditions
Identified Components
Condition Monitoring
Chance Occurances
Managerial Decisions
Nor Defect

The majority of these codes you will use will be taken from the Physical/Mechanical category.

After the How Malfunctioned Codes Numerical Listing is Aircraft Support General Code. All Support General Codes will begin with a zero (example: 01000, 02000, 03000 thru 09000). These codes are used like Work Unit Codes, only work unit codes will begin with a one or higher number (Example: 11000, 11ADP, 23GAE, 47ADB and etc.)

Support General Codes are used to identify a group of components that make up a task. Example: If we were given the job of washing an aircraft, we would have to document all of the components on the aircraft that we washed, which would include almost every work unit code in this manual, or we could use the support general code that identifies "washing" which would include everything on the aircraft that was washed.

We could say Support General Codes are verbs, they show action taken against something. Since you can't see or touch "washing", it is something you do.

To find the Support General Code for "washing" use the Table of Contents.

The first group of Support General Codes, (page 1-002) says "except 03000 and 04000". Then we notice that the next two groups are for 03000 and 04000. They have their own pages (03-001 and 04-001). Before we go any further, lets go to these two Support General Codes and find out why they are listed separately.

Turning to Page 03-001 first, notice what is above Support General Code 03100. It says "Look" Phase of Scheduled Inspections. This is a list of all the Scheduled Inspections we will perform on a F111 aircraft.

On Page 04-001 we have a list of SPECIAL INSPECTIONS. These are inspections we will perform on F111 aircraft that are Unscheduled Inspections, or Special. There are four pages of special inspections. Due to the fact that "washing" is not an inspection of any kind, the Support General Code we are looking for must be in the first group where it says "except 03000, and 04000."

Remember 03000 Codes identify "Scheduled Inspections, while 04000 codes indentifies "Special Inspections."

Now turning to Page 01-001, we find the Code 01000. This code identifies Ground Handling, Servicing and Related tasks. Reading through the description of 01000, we cannot find anything that is related to "washing". Turning to Page 01-003 we find 02000, and it identifies Aircraft Cleaning, which includes "washing". So the Support General Code for washing is 02000.

Support General Codes are verbs. They show action.

Work Unit Codes (any five diget code that begins with a 1 or higher number) is a noun. These are things that we can see and touch, so turn to Page 11-001 and lets look at one of these codes. 11000-Airframe Fuselage.

Work Unit Codes are listed in an outline format. 11000 is a work unit code that identifies the airframe of the aircraft. Notice how all the codes on Page 11-001 begin with the same number as the page number.

Beneath the description of 11000 we will find the Airframe Fuselage is broken down into sections. In this case it is the Nose section. Now notice what happened to our work unit codes. We still have 11 but the 000 changed to AA. The 11 still identifies the Airframe Fuselage, but the AA now identifies one section of it. In this case the AA identifies the Nose Section. Go down the list of Work Unit Codes changes from AA. What does it mean when the code changes from AA to AB? Here AB identifies the Nose Section Doors/Covers. When the code changes from AB to AC we changed to another section of the airframe. In this case it is the Center Section. Looking to Code 11ACD we have the skin (D), for the Center Section AC, for the airframe (11). The only letter that changes is the last letter. This identifies a component for the sub-section, for the main section.

Lets look at Page 41-001. You all should be familiar with this system. Look at Code 41 ABA. The last A identifies the Exchanger, Heat, Air-to-air, (for F111 series A/E) for the Refrigeration Package B for the Air/Conditioning System 41A.

If you are having problems understanding these codes, ask your instructor for help.

//

Review questions for Frame 8.

Using TO IF-111A-06, answer the following questions.

1. What Series of F111 does the TO IF-HIA-06 cover?

2. How many changes has this TO had since 1 October 1980, and what is the date of the last change?

3. How many pages are in this TO?

4. On what page number wi   we find a numerical listing of How Malfunction Codes for the Physica   lechanical category?

5. What does an asterisk identify between the Work Unit Code, and its definition?

6. What AFTO Form is used to recomm nd changes to this manual, in accordance with what TO?

7. What is the Type Maintenance code for performing the Basic Postflight inspection on an F111 aircraft?

8. What is the When Discovered Code for the Basic Postflight inspection?

9. What is the Action Taken Code that identifies the repair and/or replacement of minor parts hardware and softgoods?

10. What is the How Malfunction Code that describes Loose, Damaged or Missing Hardware?

11. What is the Work Unit Code that identifies the Escape Capsule Crew Module Canopy, Mechanism, atch?

12. What is the Work Unit Code that describes the engine Starting System Pneumatic Starting assembly?

13. What Support General Code describes the Oil Sampling Spectrometric analysis?

14. What Support General Code identifies the Hourly Postflight Inspection?

15. What Action Taken Code identifies cleaning?

16. What is the title of the system coded 45?

17. What is the code that describes the performance of an Excessive 'G' load inspection.

//

Answers to review questions for Frame 8.

1. A, D, E and F. (answer found on title page)
2. 6 changes. Change 6 is dated 3 May 1982. (answer found on title page lower right corner, or on Page A)
3. Total number of pages in this manual is 256 (Page D)
4. Page X11-001 (Table of Contents Page 1-001)
5. Time Change items, Items designated for configuration control, and items which require serial number control (Preface, Page 11-002)
6. AFTO Form 22. IAW to 00-5-1 (Preface Page 11-004)
7. 'C' (Page 111-001)
8. 'H' (Page VI-001)
9. "G" (Page V-004)
10. 105 (Page VIII-001 Alphabetical Listing, XII-001 Numerical Listing)
11. 16ABP (Page 16-001)
12. 23WAA (Page 23-017)
13. 04110 (Page 04-001)
14. 03300 (Page 03-001)
15. 'V' (Page V-007)
16. Hydraulic and Pneumatic Power Supply (Table of Contents Page 1-002A)
17. 04114 (Page 04-001)

If you have any questions about any of these TOs, ask your instructor for help.

Review on TO's 00-20-1 and IF-111A-06

The 00-20-1 TO, gives us information in codes that goes on the AFTO forms 349/350. The codes that are found in this TO are "Standard Reporting Designators", and "Category of Labor".

The IF-111A-06 TO, gives us information, in codes, that goes on the AFTO Forms 349/350/781A (as required). The codes that are found in this TO are:

Type of Maintenance
Action taken
When Discovered
How Malfunction
Aircraft Support General
and Work Unit Codes

Up to this point you have learned how to use six TOs. They are:

00-20-1	Preventive Maintenance Program General Requirements and Procedures
00-20-2	Maintenance Data Collection
00-20-2-2	On-Equipment Maintenance Documentation for Aircraft; Air-Launched Missiles; Ground-Launched Missiles, Except ICBMs; Drones; and Related Training Equipment.
00-20-2-10	Off-Equipment Maintenance Documentation for Shop Work, Conventional Munitions and Precision Measurement Equipment
00-20-5	Aircraft, Drone, and Air-Launched Missile Inspections, Flight Reports, and Supporting Maintenance Documents
IF-111A-06	Aircraft Maintenance Work Unit Code Manual USAF Series F-111A, D, E and F Aircraft.

If you have any questions concerning the use of these TOs, ask your instructor before continuing.

There are many reasons for the use of the MDC System. They are to name a few:

1. Production information about the type of work accomplished, the work center that did the work, and the equipment on which the work was accomplished.

2. Equipment maintenance schedules and inventory information for maintenance actions that are required on a calendar basis.

3. Equipment failures and discrepancy information.

4. In addition to the above, base maintenance managers and supervisors may obtain information concerning the cost of maintenance.

   (a) The cost of civilian and military manhours.

   (b) The cost to maintain aircraft, for both on and off-equipment maintenance.

   (c) Reimbursement action for transit maintenance services.

Because of the many uses it is important that the data in the MDC System be accurate. The effect of data errors varies for different information uses. For instance, some margin of error can be tolerated when determining inspection intervals. However, computing the service life of high cost, low inventory items require 100% accuracy.

The information provided through the MDC System is used in the management decision making process which results in many tangible benfits to Air Force logistics, especially maintenance. These benefits are not always apparent to the individual involved in the documentation of data; however, a large portion of the cost of the MDC System is returned through better management decisions that can be made with informative facts.

MAINTENANCE DATA COLLECTION RECORD

OMB NO 21-R0227

1 JOB CONTROL NO.	2. WORKCENTER	3. I.D NO./SERIAL NO.	4 MDS	5 EQ/CL	6 TIME	7 PRI	8. SORTIE	9 LOCATION
0920013	12145	1A1640			296.	3		'K'

10 ENG TIME	11 ENGINE I D	12 INST ENG TIME	13. INST. ENG I D	14.	15	16.	17 TIME SPC REQ	18 K'S STD
13.	JX1926	57.	JX0517				0945	2.5/2

19 FSC	20 PART NUMBER	21 SER NO/OPER TIME	22 TAG NO	23 INST ITEM PART NO	24 SERIAL NUMBER	25 OPER TIME
			570			

ACT LINE	A TYPE MAINT	B COMP POS	C WORK UNIT CODE	D ACTION TAKEN	E WHEN DISC	F HOW MAL	G UNITS	H START HOUR	I STOP DAY	I STOP HOUR	J CREW SIZE	K CAT LAB	L CMD ACT ID	M SCH CODE	N EMPLOYEE NUMBER
1	B	1	23000	R	F	476	1	0945	092	1115	2	1			H5956
2	B	1	23000	X	F	799	1	1115	092	1145	2	1			H5956
3															
4															
5															

26 DISCREPANCY

#1 Engine has FOD

27. CORRECTIVE ACTION

REMOVED AND REPLACED #1 ENGINE IAW TO
OPERATIONAL CK OK IAW TO

28 RECORDS ACTION

AFTO FORM MAY 75 349 PREVIOUS EDITION IS OBSOLETE. *U.S.Government Printing Office 1975 — 659-576

Figure 1 AFTO Form 349

The AFTO Form 349 (Figure 1) is the Maintenance Data Collection Record. This is a universal form. It is used to collect information on man hours, serially controlled items, time change items, type of maintenance performed, who performed the maintenance; by work center, and employee number. It is also used as a dispatch from when certain blocks have been completed.

Do you remember what TOs are used to complete this form? Do you remember what TOs are used to find the codes that are recorded on this form? If not, go back to Frame 4, and begin reading this PT again.

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In Figure 2 you will find a copy of the AFTO Form 350. This is a Reparable Item Processing Tag, and is a two part form.

Part I of the AFTO Form 350 will always be left attached to the item that is determined to be reparable and is being forwarded to other activities for repair, and is used for shop processing. Part II serves as a production control document, and is used to control the reparable item during shop processing. The Part II of this form will be retained by the Production Scheduler.

AFTO FORM 350 FEB. 1977
PREVIOUS EDITION WILL BE USED

BUDGET BUREAU NO. 21-R0227

REPARABLE ITEM PROCESSING TAG

1 JOB CONTROL NO	2. ID / SERIAL NO.	3. TM	3A. SRD	4. WHEN DISC
0920013	1A1640	B	XTF	F

5 HOW MAL	6. MDS	7. WORK UNIT CODE	8 ITEM OPER. TIME	9. QTY.
4X	J-79	23000	13	1

10 FSC	11 PART NUMBER
2911	J-79-21

12 SERIAL NUMBER	13 SUPPLY DOCUMENT NUMBER
001926	

14 DISCREPANCY

FOD #1 ENGINE

15 SHOP USE ONLY

NOTICE

15A CMD / ACT ID

TAG NO. 939570

AFTO 350 PT. I

16. SUPPLY DOCUMENT NUMBER

17. NOMENCLATURE

18. PART NUMBER

19 NSN

20 ACTION TAKEN	21. QTY.	22. RPC. USE ONLY

NOTICE

TAG NO. 939570

AFTO 350 PT. II

☆ U. S GOVERNMENT PRINTING OFFICE: 19.7-758-426

WARNING

Unauthorized persons removing, defacing, or destroying this tag (or label) may be subject to a fine of not more than $1,000 or imprisonment for not more than one year or both.
(18 USC 1 36 1)

REPAIR CYCLE DATA

23 NSN

24. SRAN CODE

25. TRANSPORTATION CONTROL NUMBER

STATUS CHANGED TO

26 SERVICEABLE

27. CONDEMNED

28. SUPPLY INSPECTOR'S STAMP

29.

BASE REPAIR CYCLE DATA		MO	DAY	YR.	TIME
DATE REMOVED 02/04/3	REC'D BY RPC				AWM
TO:					
TO:					AWP
TO:					
TO:					
TO:					
DATE COMPLETED					

AFTO Form 350—Front. Figure 2 *AFTO Form 350—Back.*

The Maintenance Discrepancy and Work Document is where the actual discrepancy begins, AFTO Form 781A (Figure 3). This form records all maintenance that is performed on the Aircraft, that is discovered by the pilot and maintenance personnel. This form will always be kept at, or near the aircraft, each aircraft will have its own separate group of AFTO 781 series forms.

DATE FROM	TO	CREW CHIEF	ORGN	LOCATION	MDS	SERIAL NO
02/05/13	/ /	D Beavers	3370TTGP	CAFBIL	T38A	661640

Entry 1

SYM: X | DATE DISCO: 02/05/13 | WDC: F | JCN: 0920013 | TAG NO: | CF TO 781A: P / / | DATED: / / | TRANSFERRED TO 781K DATE: / / | DATE CORRECTED: 02/05/13

DOC NO: | TRANSFERRED BY: | GRADE: | EMPLOYEE NO:

DISCREPANCY: #1 ENGINE HAS EVIDENCE OF FOREIGN OBJECT DAMAGE

CORRECTIVE ACTION: #1 ENGINE HAS BEEN REMOVED AND REPLACED. OPS CHECKED IAW TO 1T-38A-2-6

CORRECTED BY: J. Johnson | GRADE: SSgt. | EMPLOYEE NO: J4927

INSPECTED BY: T. Schrenk | GRADE: TSgt. | EMPLOYEE NO: S5076

DISCOVERED BY: D. Beavers | GRADE: GS-9 | EMPLOYEE NO: B7606

Entry 2

SYM: X | DATE DISCD: 02/05/13 | WDC: F | JCN: 0920013 | TAG NO: 939570 | CF TO 781A: P / / | DATED: / / | TRANSFERRED TO 781K DATE: / / | DATE CORRECTED: 02/05/13

DOC NO: | TRANSFERRED BY: | GRADE: | EMPLOYEE NO:

DISCREPANCY: #1 ENGINE REMOVED FOR FOD. OLD ENGINE SERIAL NUMBER 671926 TOT: 13.2 hrs.

CORRECTIVE ACTION: #1 ENGINE INSTALLED IAW TO 1T-38A-2-6 New Engine SN 660517 TOT: 57.3hrs

CORRECTED BY: S. Montgomery | GRADE: SRA | EMPLOYEE NO: M2960

INSPECTED BY: J. Johnson | GRADE: SSgt. | EMPLOYEE NO: J4927

DISCOVERED BY: S. Montogmery | GRADE: SRA | EMPLOYEE NO. M2960.

Entry 3

SYM | DATE DISCD / / | WDC | JCN | TAG NO | CF TO 781A P / / | DATED | TRANSFERRED TO 781K DATE / / | DATE CORRECTED / /

DOC NO | DISCREPANCY | TRANSFERRED BY | GRADE | EMPLOYEE NO

CORRECTIVE ACTION

CORRECTED BY | GRADE | EMPLOYEE NO

INSPECTED BY | GRADE | EMPLOYEE NO

DISCOVERED BY | GRADE | EMPLOYEE NO

Entry 4

SYM | DATE DISCD / / | WDC | JCN | TAG NO. | CF TO 781A P / / | DATED | TRANSFERRED TO 781K DATE / / | DATE CORRECTED / /

DOC NO | DISCREPANCY | TRANSFERRED BY | GRADE | EMPLOYEE NO

CORRECTIVE ACTION

CORRECTED BY | GRADE | EMPLOYEE NO

INSPECTED BY | GRADE | EMPLOYEE NO

DISCOVERED BY | GRADE | EMPLOYEE NO.

AFTO FORM NOV 78 781A MAINTENANCE DISCREPANCY AND WORK DOCUMENT PREVIOUS EDITION IS OBSOLETE

Figure 3

Technical Training

Aircraft Environmental Systems Mechanic

INTRODUCTION TO THE TECHNICAL ORDER SYSTEM

14 April 1981

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

RGL: 8.4

OBJECTIVE

Identify instructions contained in time compliance technical crders with 80% accuracy.

INTRODUCTION

Today, more than ever, Air Force people need to know how to use Technical Orders (TOs). This PT will give you an overall view of how Air Force TOs are set up. You should be especially interested to know how to use TOs because you, the mechanic, will have to look up information in them just about every day. There are about 70,000 TOs right now, and they are used for big, complex things like breaking down jet engines or for smaller jobs like ohming a wire for resistance.

TOs are always changing. They have to in order to keep up with the advances in technology. Because of the changes that are being made each day, there is a chance that what you learn now will not be exactly what you will see later. Don't worry. It will be just another indication to you that your Air Force is dynamic and is finding better ways of doing things every day.

The answer to a question is supplied on the page following the question. If you have answered the question correctly and understand the material, go on to the next item. If you answered incorrectly or are not sure of the material, go back and review the material. Proceed at a rate which is best suited to your learning ability.

OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 750; DAV - 1

TOs are set up to give you technical instructions so that you can do your job. They give you information so that you can operate, maintain, modify, or overhaul Air Force equipment safely and efficiently. When the Air Force talks about equipment, it is referring to a lot of things that range from Air Force planes and missiles, trucks and automobiles, radar equipment, or power supplies such as the MA-1A. TOs also have instructions on safety procedures, preparing maintenance forms, and handling Air Force material.

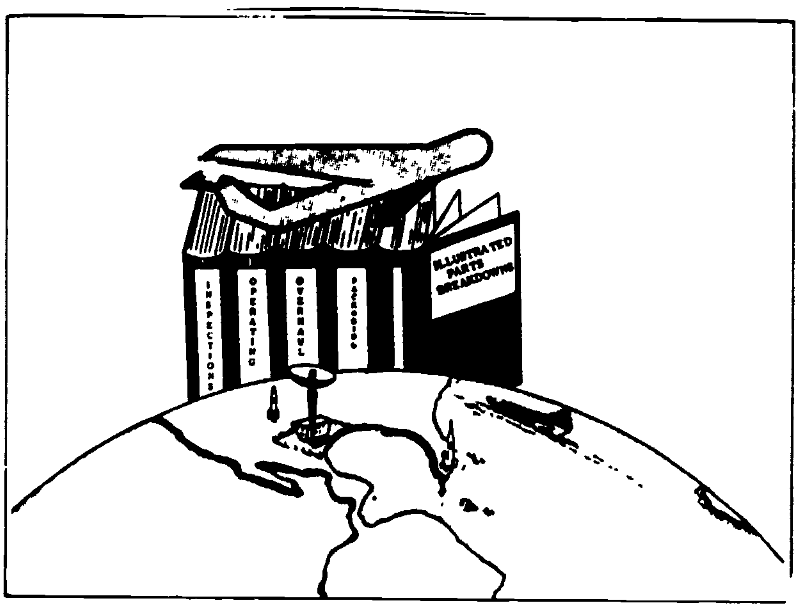
The purpose of technical orders is to provide you with instructions for

( ) a. AF equipment and materials.

( ) b. maintaining AF equipment.

( ) c. operating and overhauling AF equipment.

( ) d. all of the above.



Answer to Frame 1. d.

FRAME 2

The TO system doesn't apply to everything. For instance it does not apply to

( ) a. experimental equipment designed specifically for research purposes.

( ) b. real property (buildings and grounds).

( ) c. USAF Stock List Publications. These publications are used to find stock numbers for parts you order through the AF Supply System.

( ) d. Standard Publications such as AF regulations and AF manuals. These regulations talk about military doctrine, AF management or AF organizations.

Check those subjects below on which TOs would normally be published.

( ) a. Maintaining and operating AF equipment designed specifically for experimental purposes

( ) b. Operating the USAF Supply System

( ) c. AF management procedures

( ) d. Maintaining buildings and grounds

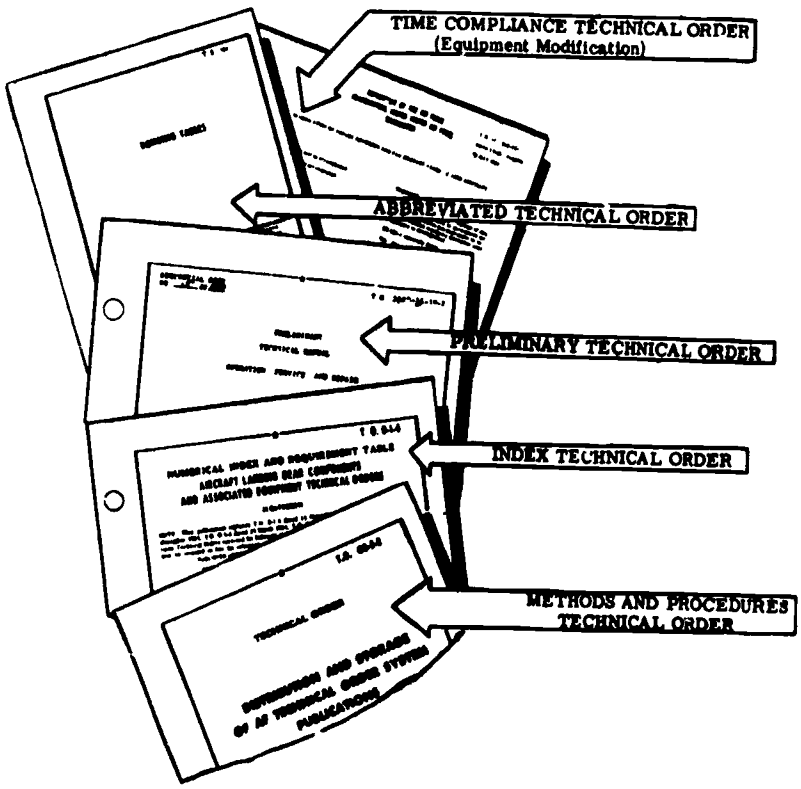
( ) e. Operating and maintaining AF equipment

( ) f. Reenlistment procedures

Answer to Frame 2. e.

FRAME 3

Not all TOs are the same. Look at ones that are shown in this frame.



Check the ones in this list that could be technical orders.

( ) a. Bombing Table

( ) b. Air Force Regulation

( ) c. Poster

( ) d. Equipment Modification Instructions

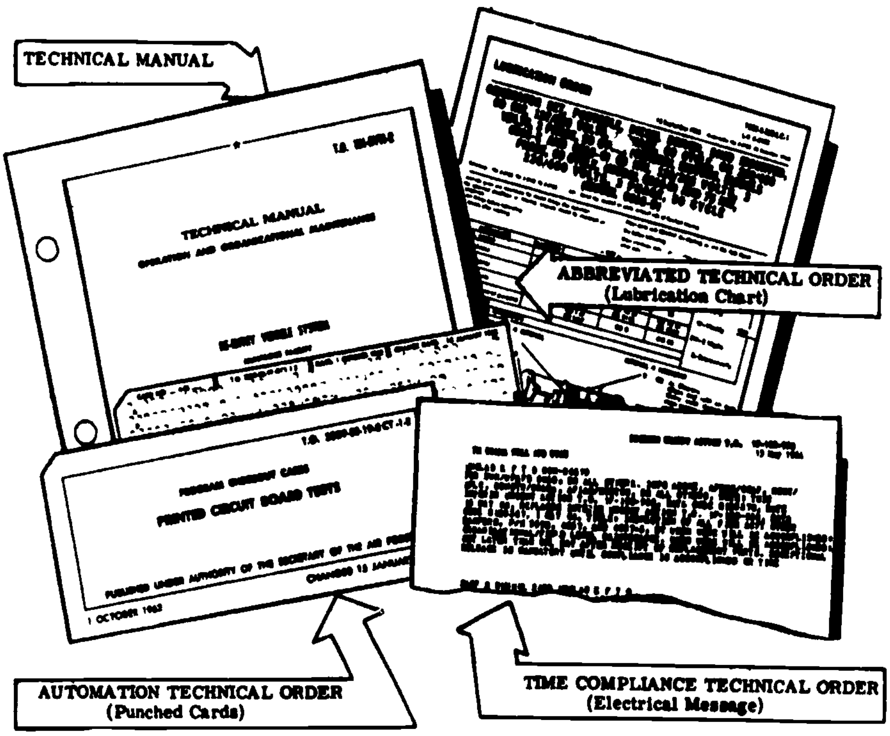
( ) e. Numerical Index and Requirement Tables

( ) f. Air Force Manual

Answers to Frame 3.   a. d. e.

Note: b and f are incorrect because TOs do not cover standard publications which include AF regulations or manuals.

FRAME 4



Here are some more examples of TOs. Check the ones in this list that could be technical orders.

( ) a. Technical Manual

( ) b. Air Force Manual (AFM)

( ) c. Electrical message co?taining special inspection instructions

( ) d. Lubrication Chart

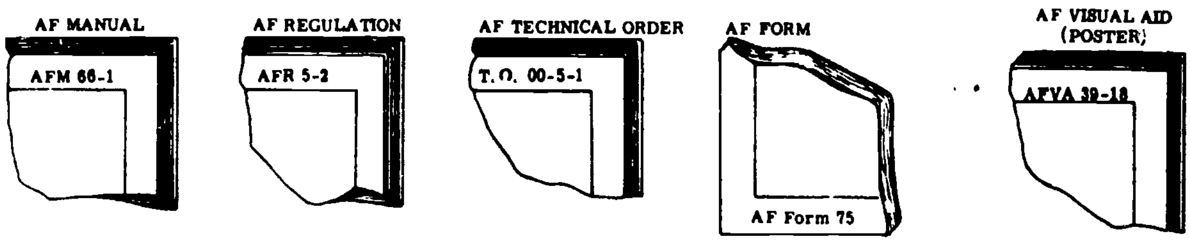
( ) e. USAF Stock L?sts

( ) f. Punched Cards (checkout)

Answers to Frame 4.   a. c. d. f.

Note: a is correct because it is a "technical manual".

FRAME 5



Technical orders are easy to identify because they have the abbreviation TO and a number following it. Forms are marked for identification. You can see some examples above.

Technical orders are generally identified by

( ) a. AFM.

( ) b. TM

( ) c. SL and an identifying number.

( ) d. TO and an identifying number.

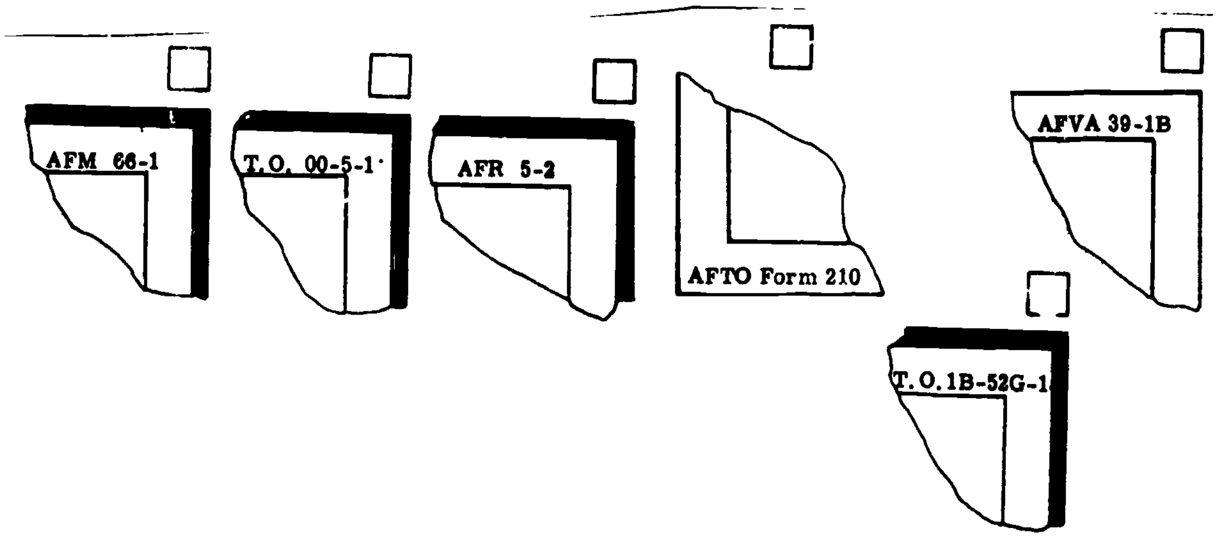
( ) e. AFTO and an identifying number.

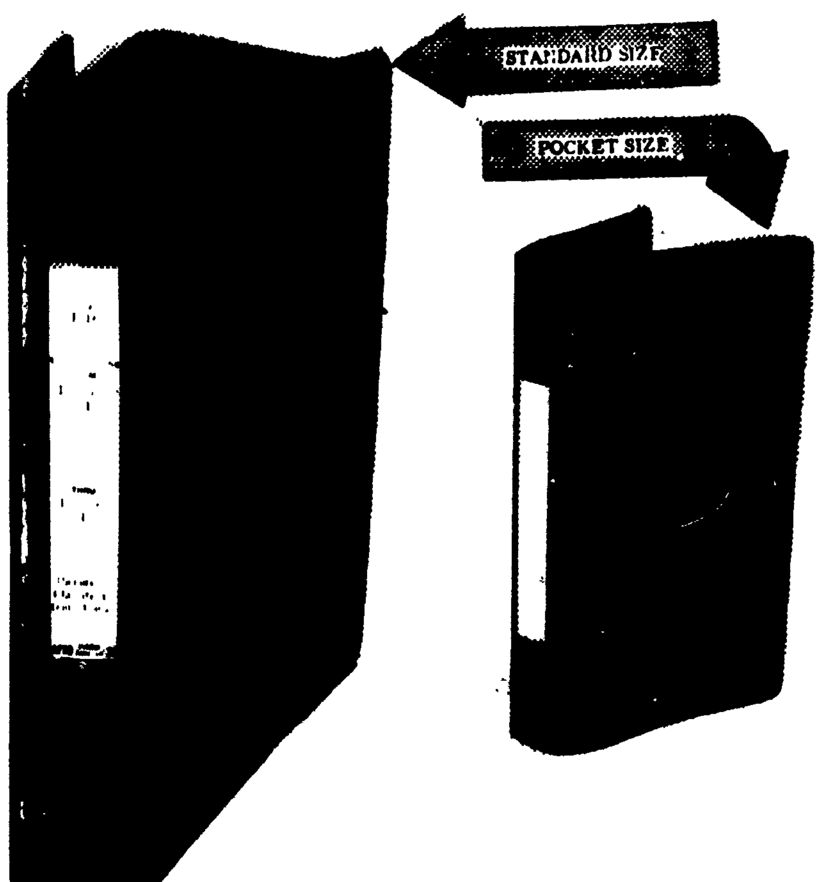
( ) f. TO

Answer to Frame 5. d.

FRAME 6

Check the boxes beside the drawings of TOs.





Technical Order BINDERS

Answers to Frame 6.   TO 00-5-1   TO 1B-52G-1

FRAME 7

Complete the following questions:

1. Technical Orders are normally identified by (check one)

( ) a. TO

( ) b. SL and Identifying Number

( ) c. TO and Identifying Number

( ) d. TM

( ) e. TF

( ) f. AFTO and Identifying Number

2. In the list below, check those which would be part of the TO System.

( ) a. Maintenance of AF equipment

( ) b. The USAF Supply System

( ) c. Experimental equipment designed specifically for research purposes, such as X15 (experimental aircraft)

( ) d. Reenlistment, military doctrine, AF management, etc.

( ) e. Operation of AF equipment

3. Check those which could be Technical Orders.

( ) a. Bombing Table

( ) b. Technical Manual

( ) c. AF Regulation

( ) d. Punched Cards

( ) e. Electrical messages containing equipment modification instructions

( ) f. AF Manuals

( ) g. USAF Stock Lists

( ) h. Posters

Answers to Frame 7. 1. c. 2. a. e. 3. a. b. d. e.

FRAME 8

TOs are written by the contractor who makes equipment for the Air Force. The Air Force tests the equipment and the TOs to be sure they are correct. After using the TOs and equipment, the Air Force can then ask for changes or more information.

Select the true statement(s) below.

( ) a. The contractor normally writes the TOs to assure operational correctness of the data for the equipment.

( ) b. The contractor normally writes the TOs and the Air Force checks to assure operational correctness with the equipment.

( ) c. Both of the above.

( ) d. Neither of the above.

Answer to Frame 8. c.

FRAME 9

Most of the technical orders for a new weapon system are first (originally) written by:

( ) a. AFSC.

( ) b. AFLC.

( ) c. USAF.

( ) d. Using Commands.

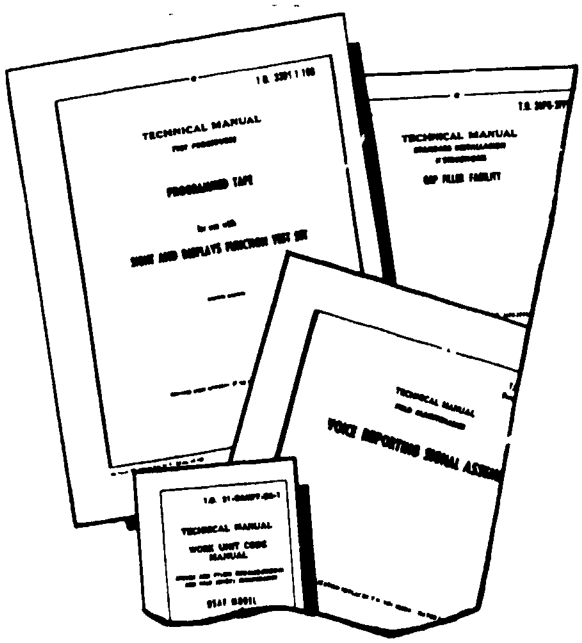
( ) e. Contractor.

Answers to Frame 9. e.

FRAME 10

TECHNICAL MANUALS

There are many types of technical orders. The most widely used type of technical order is a technical manual. The examples shown are typical technical manuals.



All of these are:

( ) a. separate technical orders.

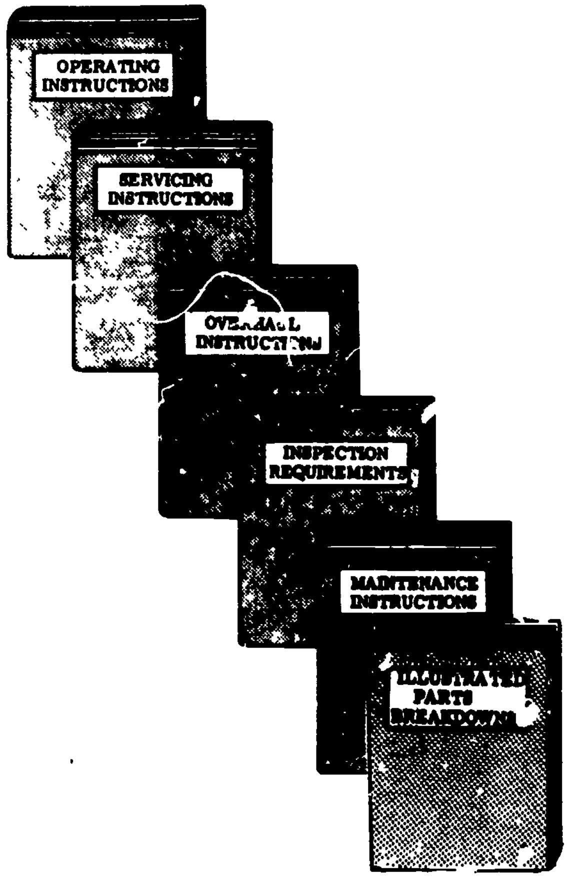
( ) b. separate technical manuals.

( ) c. both.

( ) d. neither.

Answer to Frame 10 c.

FRAME 11



Instructions for operation, service, maintenance and inspection of complex weapon systems (aircraft, missile, etc.) and overhaul of component parts, are given in separate technical manuals. They are shown above.

Write the name of the technical manual you would use to do the following work, on the blank provided.

a. Instructions on how to maintain a generator ( )

b. How to service an aircraft engine with oil ( )

c. Inspection requirements for a weapon system ( )

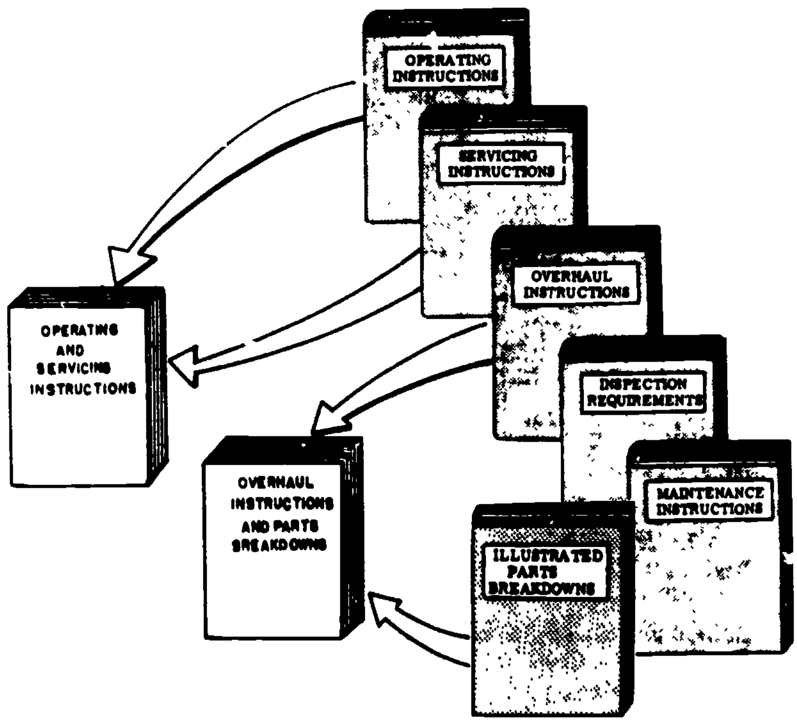
d. How to service the oxygen system on a missile ( )

e. How to overhaul a jet engine ( )

f. How to operate engines on an aircraft ( )

Answers to Frame 11. a. (MAINTENANCE) b. (SERVICING)
c. (INSPECTION) d. (SERVICING)
e. (OVERHAUL) f. (OPERATING)

FRAME 12



If the equipment is complicated, the instructions may be in more than one technical manual. (See drawing above.) Types of Instructions are: Operating, Servicing, Overhaul Instructions O/H, Inspection Requirements, Maintenance Instructions and Illustrated Parts Breakdown (IPB).

Check the technical manuals which contain more than one type of instructions.

( ) a. 34Y17-4-B-1 Operation, Service, and Overhaul instructions--Elec Lubricator...

( ) b. 34Y17-4-13 Overhaul (O/H) with Parts Breakdown (P/B)--Oil Tank Pump-up Tank....

( ) c. 6J10-3-68-3 Overhaul (O/H) with Parts Breakdown--Fuel Booster Pump....

( ) d. 6J10-3-70-3 Overhaul (O/H) Instructions--Fuel Transfer Pump....

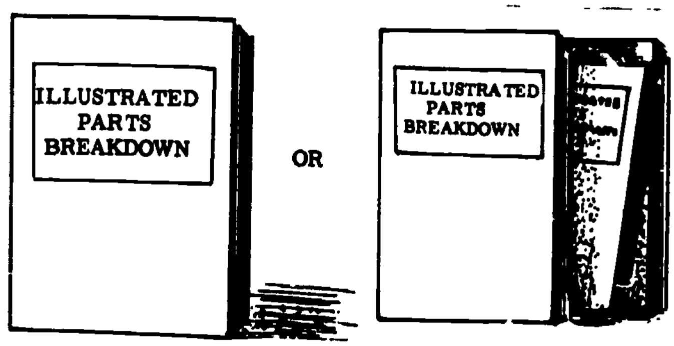
Answers to Frame 12. a. b. c.

FRAME 13

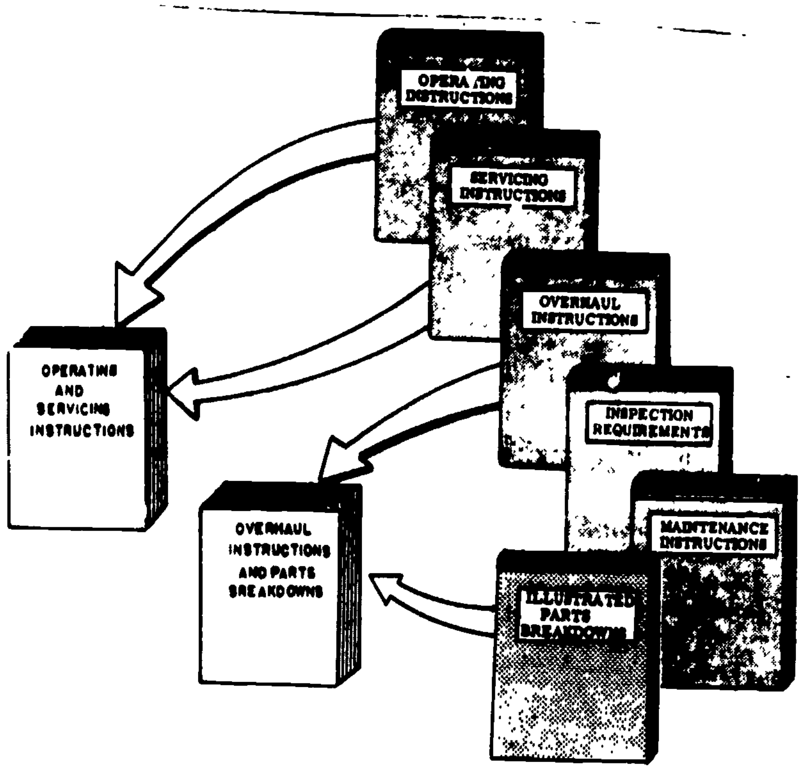
Supplemental Information

Technical manuals may also contain a listing of part number, nomenclature, (name of part) and other information necessary to maintain a piece of equipment. These manuals are called Illustrated Parts Breakdowns, and are used to identify, order from supply, and to determine equipment assembly and disassembly steps.

For example, the Illustrated Parts Breakdown, for large or complicated equipment, are usually in one or more books, as shown below.

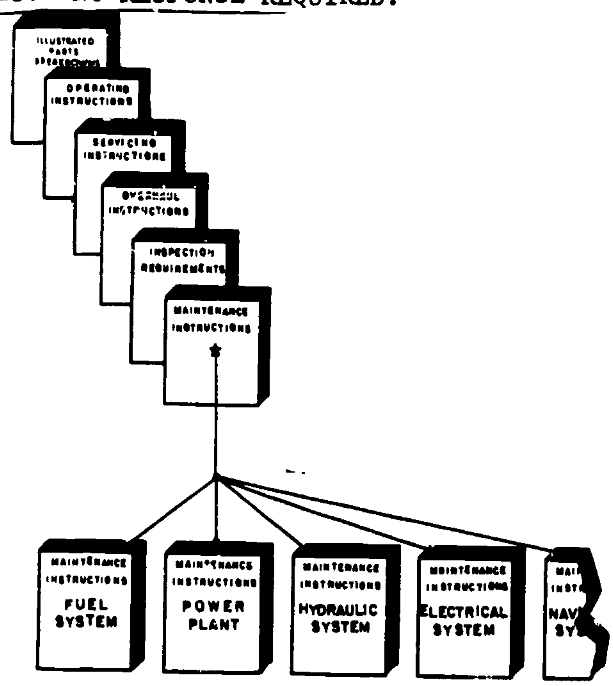


However, the parts breakdowns for pieces of equipment which contain just a few parts may be included with another manual, such as overhaul instructions (See Illustration below).



Answer to Frame 13. NO RESPONSE REQUIRED.

FRAME 14



As you learned before, when you need to find out how to operate, service, maintain, inspect, overhaul, or find parts for a plane or other piece of equipment, you may have to look in more than one technical manual. For instance, if you look at the illustration in this frame, you can see how the parts of a plane can be divided up into books that tell you about fuels, the plane's power plant, and its hydraulic or electrical system. The reason that these systems are split up this way is because the equipment that you work with in your job in the Air Force is too complex for you to be able to find out everything you need to know from just one book. Each of these new books has its own TO number and title. Besides this first split which divides the books into different systems, a second split divides the systems into subsystems... Look at the illustration again. The six books at the top are subsystems of bigger ones such as fuels or the plane's power plant. Small books like these are good for you to use because they make it easier for you to find information fast. For instance, if you want to find out how to service a part in the environmental system on a plane, the first thing you would do would be to look at the TO that contains information on that system and then turn to "servicing instructions". Any of the TOs that you will use in the Air Force can be split up into sections.

Check the technical manuals below which could be sectionalized.

( ) a. Maintenance Instructions

( ) b. Operating Instructions

( ) c. Inspection Requirements

( ) d. Servicing Instructions

( ) e. Overhaul Instructions

( ) f. Illustrated Parts Breakdowns

( ) g. All of the above.

Answer to Frame 14. g.

FRAME 15

Match the type of instructions to the technical manuals, by writing the letters in the appropriate space.

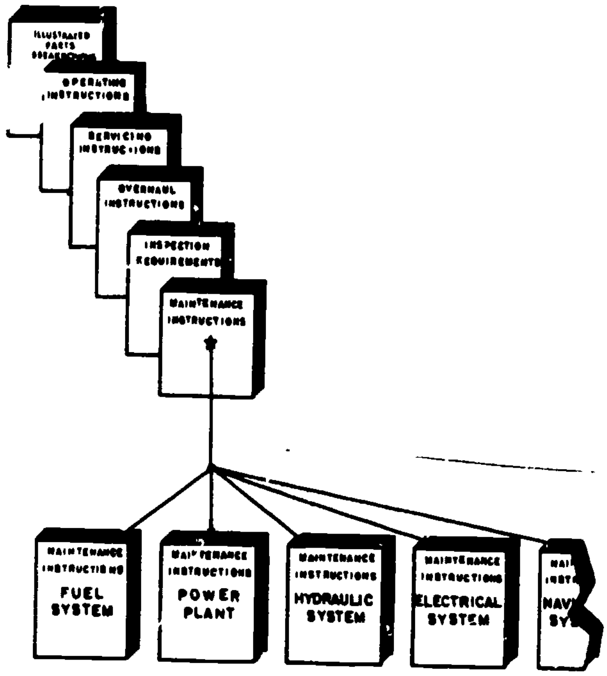
	TECHNICAL MANUALS		
1.	21M-CGM16D-6-1	Inspection Requirements	( )
2.	1F-100A-2-2	Maint -- Fuel System	( )
3.	6J1-2-3-2	Svc Instr--Electronic Control Amplifier	( )
4.	10C1-3-6-1	Opr Instr -- Camera, Sound on Film, 16mm	( )
5.	11F12-16-3-3	O/H Instr -- Missile Launch Computer	( )
6.	34Y1-126-1	Opr, Svc, Maint & Repair Instr -- Reciprocating Compressor...	( )
7.	1C-130B-1	Flt (Operation) Manual	( )

INSTRUCTIONS

A. Overhaul (O/H)
B. Operation
C. Maintenance
D. Service
E. Inspections

Answers to Frame 15. 1. (E) 2. (C) 3. (D) 4. (B)
5. (A) 6. (BCD) 7. (B)

FRAME 16



REMEMBER.....

The books that are divided up into sections like the ones in this frame are easier to use. They halp you find information faster. Remember also that any technical manual can be divided up into sections like the TO on maintenance instructions.

Check the different types of instructions that can be found in Technical Manuals.

( ) a. Overhaul

( ) b. Operating

( ) c. Modification

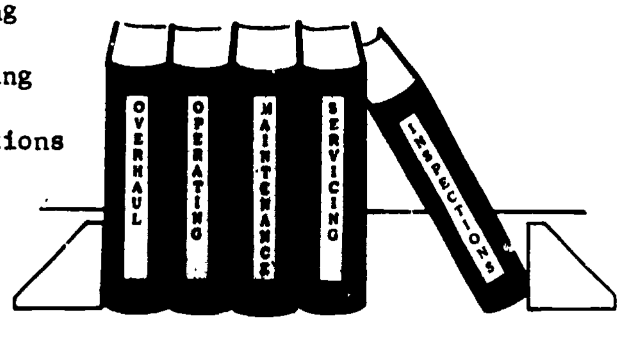
( ) d. Stock Listing

( ) e. Maintenance

( ) f. Indexing

( ) g. Servicing

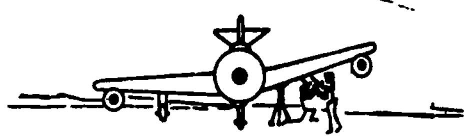
( ) h. Inspections



Answers to Frame 16. (✓) a. (✓) b. ( ) c. ( ) d.
(✓) e. ( ) f. (✓) g. (✓) h.

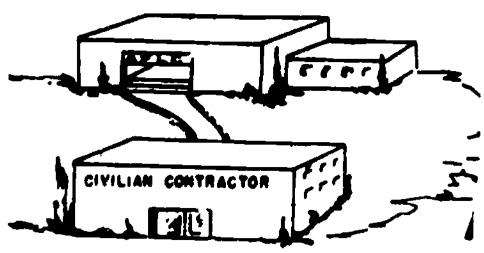
FRAME 17

Technical orders containing instructions like maintenance and overhaul are usually written for different levels of maintenance. Some examples of the levels of work performed are given below.



Removing and replacing component parts and minor repair of AF equipment are normally accomplished by Organizational level maintenance.

Bench testing and major repairs of the component parts of AF equipment are normally accomplished by Intermediate level maintenance.

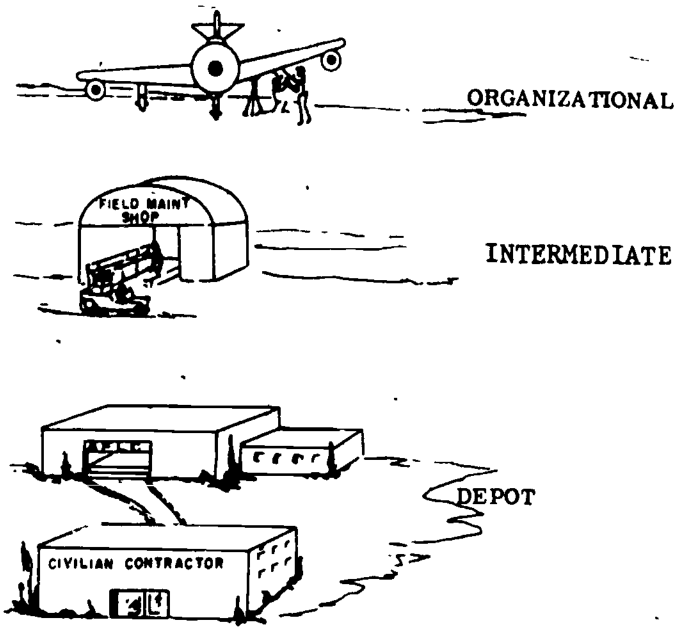


Major overhaul or the rebuilding of the component parts of AF equipment is normally accomplished by Depot level maintenance. This maintenance can be performed by either a civilian contractor or an Air Force Logistics Command Air Materiel Area.

List the three levels of maintenance for which technical orders can be written.

( ) ( ) ( )

Answers to Frame 17. (ORGANIZATIONAL) (INTERMEDIATE) (DEPOT)



FRAME 18

Match the level of maintenance to the situation requiring their use. Write the letters (A, B, or C) on the appropriate line.

WORK		LEVEL OF MAINTENANCE
1. Removal of a generator from an aircraft	( )	A. Organizational
2. A frequency shift keyer bench tested in a shop	( )	B. Intermediate
3. Overhaul of a helicopter rotor transmission	( )	C. Depot
4. Bench testing of Collins radio receiver	( )	

Answers to Frame 18. 1. (A) 2. (B) 3. (C) 4. (B)

FRAME 19

The words - Organizational, Intermediate, and Depot, as used in TOs, identify the

( ) a. levels of maintenance for which technical orders are prepared.

( ) b. official means for distributing technical orders

( ) c. types of technical orders.

( ) d. organizations responsible for procuring technical orders.

Answer to Frame 19. a.

FRAME 20

List the three levels of maintenance instructions which can be contained in technical manuals.

( ) ( ) ( )

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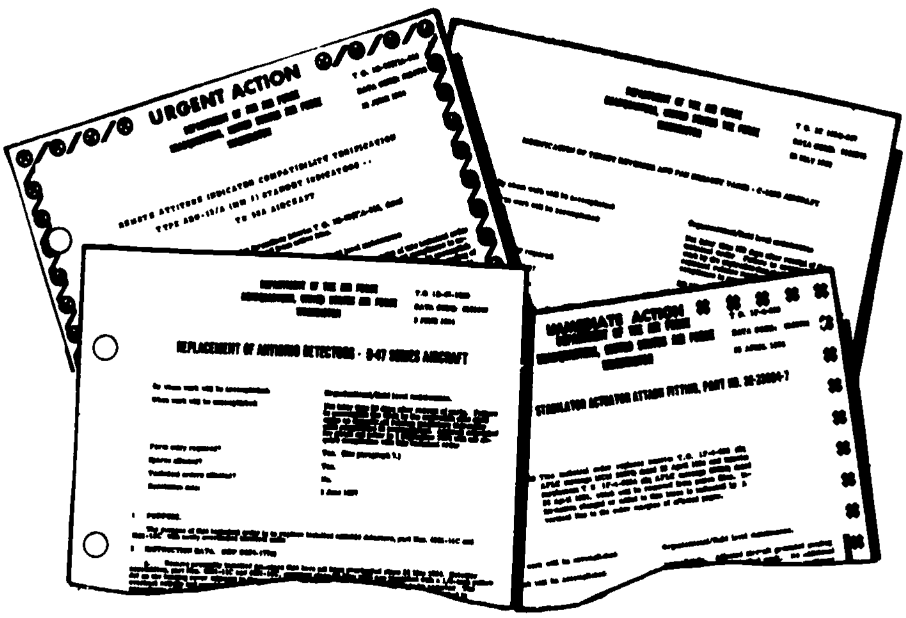
Answers to Frame 20. (ORGANIZATIONAL) (INTERMEDIATE) (DEPOT)

FRAME 21

TIME COMPLIANCE TECHNICAL ORDERS

Technical Orders which contain instructions for a modification or a one-time inspection of Air Force equipment are referred to as Time Compliance type technical orders. (Study Examples below)



Time Compliance TOs (TCTOs) contain the following types of instructions. (Check appropriate blocks)

( ) a. Service

( ) b. Operation

( ) c. Modification

( ) d. Overhaul

( ) e. Special (one-time) inspection

Answers to Frame 21. c. e.

FRAME 22

The identification "Time Compliance Technical Order" tells you that the instructions must be done by a certain time.

TCTOs specify:

- Who will do the work (level of maintenance-Organizational, Field, Depot).

- When work will be done.

Write "TCTO" next to the situations where it would apply.

A. ( ) Modification of Ballistic Computer Shock Mount. Work to be done by Field Maintenance within 30 days.

B. ( ) Replacing a broken generator with a new one.

C. ( ) Doing a routine inspection before starting a Ground Power Generator Set.

D. ( ) Installation of Refrigeration Modification Kit Control Circuit Fuse Block on Compressor. Work to be accomplished by Depot Maintenance within 180 days.

E. ( ) Removing a fuel control valve from a missile for repair.

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Answers to Frame 22. C. TCTO. D. TCTO.

FRAME 23

Time Compliance Technical Orders (TCTOs)

TCTO's are grouped by the importance and urgency of the work to be done. The amount of urgency is indicated in the instructions by telling you when work is to be done. When a TCTO is not done by the required date, the aircraft will be removed from flying status temporarily.

Answer to Frame 23. NO RESPONSE REQUIRED

FRAME 24

In addition to stating by whom and when work will be done, TCTOs, state other requirements. (Study the example of a TCTO shown and answer the question below.)

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS, UNITED STATES AIR FORCE
WASHINGTON

T.O. 1C-130E-520
DATA CODE: 0124815
22 JULY 1964

INSPECTION AND REPOSITIONING OF POWER LEADS TO AC POWER CONTACTORS - C-130E AIRCRAFT

By whom work will be accomplished:	Organizational/field level maintenance.
When work will be accomplished:	Not later than 30 days after receipt of this technical order. Failure to accomplish the work by the expiration date shall make an exceptional release mandatory thereafter until compliance is accomplished.
Form entry required:	Yes. (See paragraph 7.)
Spares affected?	No.
Technical Orders affected?	No.
Rescission date:	22 July 1967

1. PURPOSE:

a. This inspection assures that the power lead terminal lugs are properly installed on the terminal studs of the electrical contactors in the main AC power distribution panels. If a power lead lug is not properly installed, a short circuit between the barrel of the lug and the edge of the contactor housing could occur.

b. This inspection and the necessary power lead repositioning will be accomplished on the following aircraft.

MODEL	SERIAL NUMBER
C-130E	AF61-2358 through 61 2373 and 62-1784 through 62-1808.

Aircraft serial number AF62-1809 and subsequent have been inspected and corrected by the Contractor prior to delivery.

2. INSTRUCTION DATA.

a. Turn off all electrical power on the aircraft.

( ) a. When the work will be done.

( ) b. By whom work will be done (level of maintenance).

( ) c. Overhaul instructions.

( ) d. Form entries required.

( ) e. Other TOs affected.

( ) f. Rescission date of TO.

( ) g. Purpose of TO.

( ) h. Operation instructions for affected equipment.

( ) i. Instruction data for performing work.

( ) j. Equipment applicability.

Answers to Frame 24. (✓) a. (✓) b. ( ) c. (✓) d. (✓) e.

(✓) f. (✓) g. ( ) h. (✓) i. (✓) j.

FRAME 25

Match the type of technical order to the type of instructions it contains, by writing the letters "A" or "B" on the appropriate lines.

INSTRUCTIONS		TYPE OF TO
1. A special inspection of all flexible fuel lines on a ground power unit. Work to be performed by Organizational maintenance within 3 days	( )	A. TCTO
2. Inspecting wheels and tires on an aircraft during a scheduled inspection	( )	B. Technical Manual
3. Replace tube TU4 with Tube TU6 in all A1A teletype receivers. Work to be performed by Field Maintenance within 7 days	( )	
4. Ground operation of aircraft engines	( )	
5. Modification of shock mounts on all Collins Radio Receivers. Work to be performed by Field Maintenance within 30 days	( )	

Answers to Frame 25. 1. (A) 2. (B) 3. (A) 4. (B) 5. (A)

FRAME 26

Check the items specified in TCTOs.

( ) a. When work will be done

( ) b. Operating instructions

( ) c. Overhaul instructions

( ) d. Level of maintenance

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Answers to Frame 26. (✓) a. ( ) b. ( ) c. (✓) d.

FRAME 27

Check the types of information provided in TCTOs.

( ) a. Routine Maintenance instructions

( ) b. One-time Special inspection requirements

( ) c. Modification instructions

( ) d. Routine, recurring inspections

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Answers to Frame 27. ( ) a. (✓) b. (✓) c. ( ) d.

FRAME 28

METHODS AND PROCEDURES TECHNICAL ORDERS

Policies, methods, and procedures that apply to a wide variety of subjects, which are not in other types of technical orders, are found in METHODS AND PROCEDURES TOs.

Most technical orders contain information on specific weapon systems or pieces of equipment. Methods and Procedures TOs, on the other hand, are used to provide information of a general nature, such as:

- Documentation of historical records and maintenance forms for AF equipment.
- Procedures for processing reparable property.
- Cleaning of equipment used in aircraft.
- Policies and procedures on the technical order system.
- Inspection of office equipment.
- Inspection and age control of USAF equipment.
- Procedures for operating AF equipment in the arctic and tropics.
- Packing and preservation of AF equipment.

Check those subjects below which most likely would be contained in Methods and Procedures technical orders.

( ) a. Instruction for arctic operation

( ) b. Repair procedures for an electric motor

( ) c. Cleaning of aeronautical equipment

( ) d. How to order technical orders

( ) e. Crating supplies for shipment

( ) f. Overhaul procedures for a two cycle engine

Answers to Frame 28. (✓) a. ( ) b. (✓) c. (✓) d.

(✓) e. ( ) f.

FRAME 29

Match the type of technical orders to the statements, by writing the letters on the appropriate lines.

STATEMENTS		TYPES OF TOs
1. Contains procedures for an urgent modification	( )	A. Methods and Procedures
2. Instructions for tro,ic operation of equipment	( )	B. TCTOs
3. Procedures for recording data on maintenance forms	( )	
4. Lists steps in adjusting a radar set	( )	
5. Instructions for distributing and storing of TOs	( )	
6. Used for determining scheduled inspection requirements for weapon systems	( )	
7. Indicates level at which work will be accomplished	( )	

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Answers to Frame 29. 1. (B) 2. (A) 3. (A) 4. (C)

5. (A) 6. (A) 7. (B)

FRAME 30

Select the statements which identify subjects found in Methods and Procedures TOs.

( ) a. Packaging supplies for shipment

( ) b. Cleaning of aeronautical equipment

( ) c. Repairing airborne radio equipment

( ) d. Ordering procedure for TOs

Answers to Frame 30. (✓) a. (✓) b. ( ) c. (✓) d.

PROGRAMMED TEXT

C3ABR42331-PT-302A

Technical Training

Aircraft Environmental Systems Mechanic

TECHNICAL ORDER SYSTEM INDEXES AND MANUALS

16 February 1983

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

Designed for ATC Course Use.

Do Not Use on the Job.

RGL: 9.6

OBJECTIVE

Identify conditions that would require the initiation of a technical order improvement report with 80% accuracy.

INTRODUCTION

Throughout this programmed text you will be required to respond to the information in some manner that will show the instructor that you are progressing. You may be asked to underline a word or provide a missing word or even write information taken directly from technical orders. Do not mark in this text. Whatever method is used, do it carefully and progress at your own rate. The important thing is that you learn as much of this material as you can. When you have finished this text, you will be called upon to perform in the manner prescribed in the "Objectives."

INSTRUCTIONS

This programmed text presents information in small steps called "frames." Answers to each frame will be found at the top of each even numbered page. Before proceeding remove the response sheet at the back of this text. Then enter your answers on the response sheet

Supersedes C3ABR42331-PT-302A, 18 May 1982.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 350; DAV - 1

Frame 1

A technical order has been written for each piece of equipment in the Air Force. You are at a point in the course where you must find and use technical orders. There is a small training technical order file for your use in the area where you are studying.

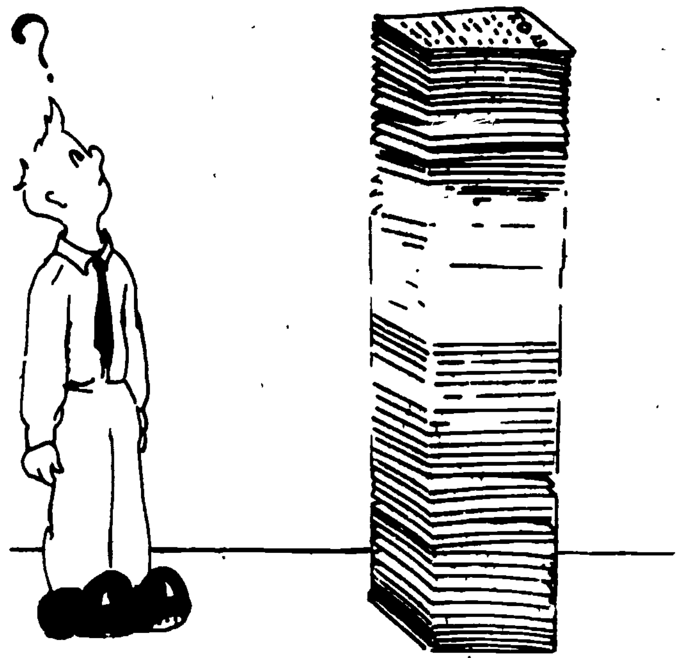


Figure 1.

NO RESPONSE REQUIRED

Answers to Frame 1: No Response Required

Frame 2

Technical orders are put in binders which are, in turn, put in a TO file (library). Each binder generally has more than one technical order in it.

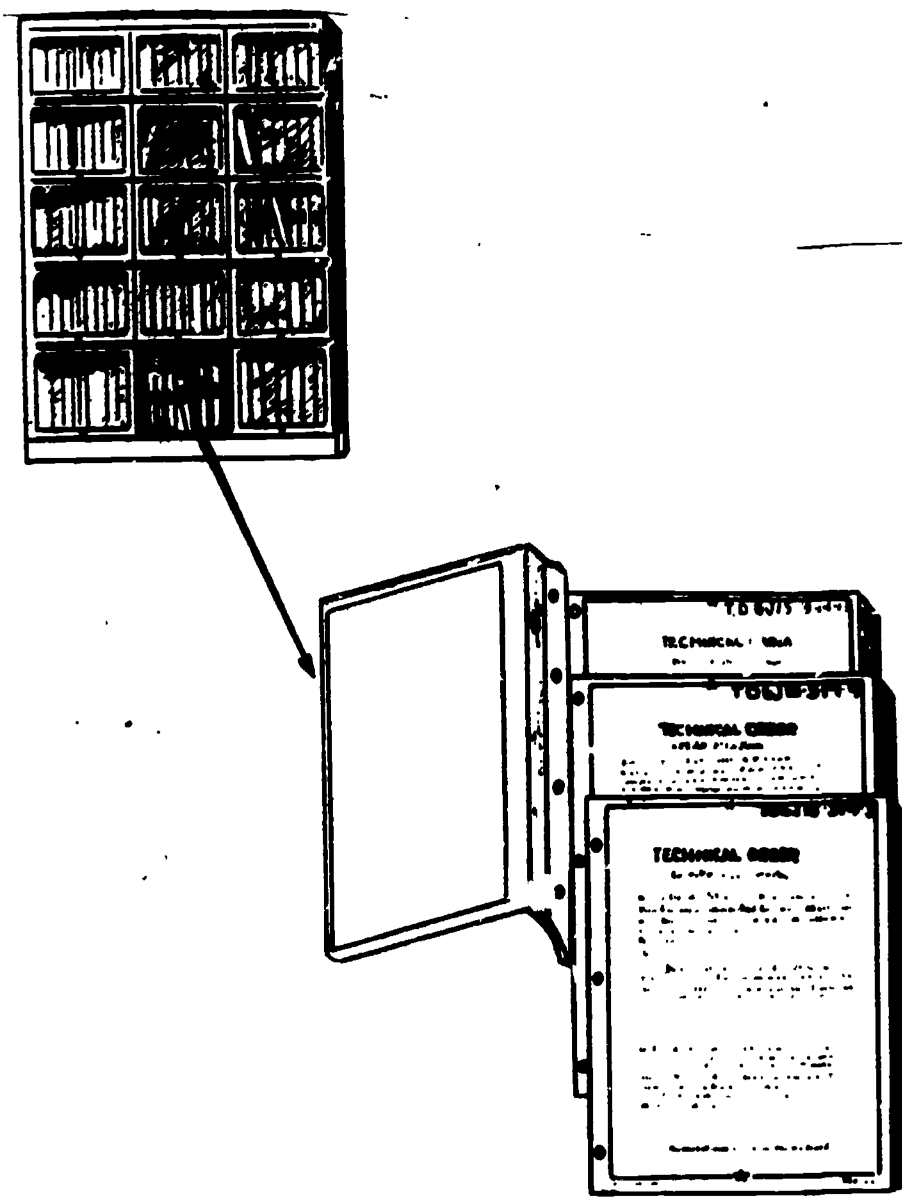


Figure 2.

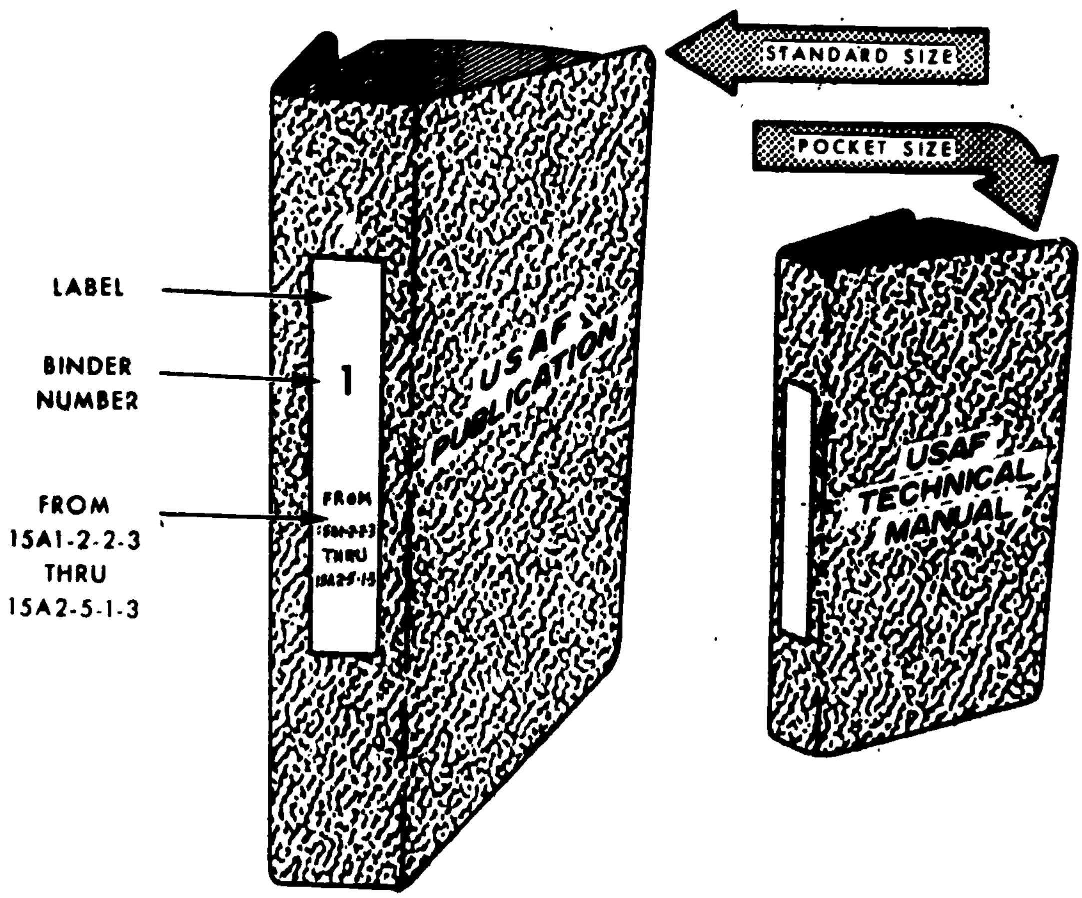
All TOs are put in the file in the numerical order which corresponds to the numbered sequence in which they are listed in their INDEXES.

Complete the following statement.

1. Technical orders are found arranged according to their ____________ ____________.

Below are examples of binders in which technical orders are kept. Sometimes a binder may have just one TO. More often, more than one TO is put in the same binder. In this case, the label on the back side of the binder is marked to show which TOs are in the binder. For example, if TO 15A1-2-2-3, 15A2-4-1-3, and 15A2-5-1-3 are put in the same binder, the label will be marked: 15A1-2-2-3 thru 15A2-5-1-3. This tells us at a glance that the books are arranged in order of their numerical sequence. Tech orders starting with the number 15A1-2-2-3 and ending with 15A2-5-1-3 are in this binder.

There is a binder number at the top on each of the labels. These numbers are used to keep the binders in order in the TO file. The numbers show at a glance which of the TO binders are not in the TO file. Binder numbers are put on the label above the "from and thru numbers".



NO RESPONSE REQUIRED

Answer to Frame 2: 1. numerical order.

Answer to Frame 3: No Response Required

Frame 4

There are approximately 75,000 TOs of all types in the Air Force TO system. The TOs are kept in some type of TO file. You will work with a limited or shop file. Most files that are set up and maintained by Air Force bases and activities are designated as limited files. The TOs that they have are limited to the TOs used to accomplish the shop mission and responsibilities. Limited files are put in the work areas or work centers in a maintenance organization. The environmental systems shop will have a limited file to use. It will have just the TOs used to accomplish maintenance on the assigned equipment. From the information above it can be said, "If you do not have the equipment on hand you are not authorized to have the TO in your limited or shop file."

Answer the following statements as true (T) or false (F).

1. The TO files on most Air Force bases are either a limited or shop file.

2. You are authorized to maintain a TO if you do not have the equipment that the TO covers.

Frame 5

Over 75,000 TOs! How do you locate the one you need in a file? The Air Force has put into use a numbering and indexing system to help you find the TOs you need. Each person in the Air Force does not have to know the TO numbers of the TOs that cover all the equipment that is on hand. However, people who use the technical order system must know how to use TO indexes. With the help of the index system they can find the information they need for the equipment that they maintain.

NO RESPONSE REQUIRED

Frame 6

In the Air Force TO system, the TO number of an index will start with a zero. For example: TO number 0-1-01, the first digit of the TO number is a zero, so the TO is an index.

Answer the following statement as true (T) or false (F).

1. The TO number of an index will start with a zero.

Frame 7

Since there are so many TOs in the Air Force TO system, we need an index to list them. One index would not be enough to list all the TOs for the many different types of equipment in the Air Force. To keep from using one large index, there is a smaller index for each type of equipment. Because there are many types of equipment, there is an index that lists all the other indexes. This index is TO 0-1-01. It is used when you need to find the index for a certain type of aircraft or category of equipment. TO 0-1-01 is called the index of indexes.

Answer the following statements as true (T) or false (F).

1. The index of indexes is TO 0-1-01.

2. TO 0-1-01 is used to find the index for a type of aircraft or category of equipment.

Answers to Frame 4: 1. T 2. F

Answer to Frame 5: No Response Required

Answer to Frame 6: 1. T

Answers to Frame 7: 1. T 2. T

Frame 8

Each digit of a TO number has a meaning. For example, look at TO index number 0-1-3. The first digit is a zero, this tells you the TO is an index. The second number is one, this tells you that the TOs in the index are in numerical order. The third digit is three, this is the type or category of equipment that the index lists TOs for. If a fourth digit is put on the end of the TO index number, it would indicate the specific information contained in the TO.

Check the best answer for the following statement.

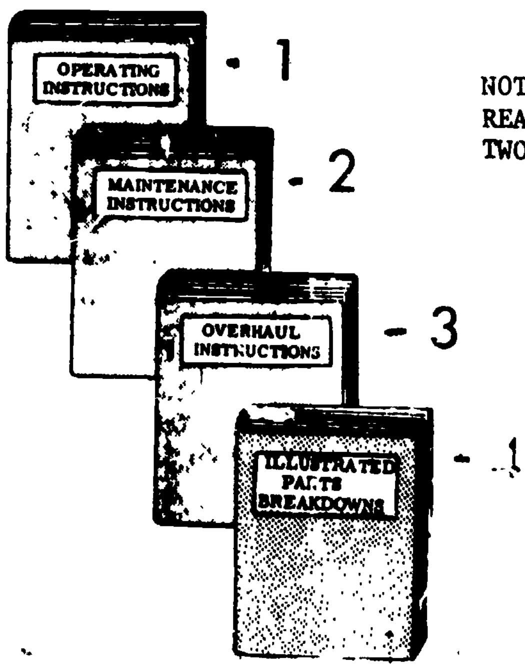
1. The second digit of a TO index number indicates

    a. whether or not it is an index.

    b. the type of plane or category of equipment.

    c. the order in which the TOs are listed in the index.

Equipment technical orders have TO numbers that are different from index TO numbers. You will now look at TO number 15X2-3-4-3 and use it as an example. The 15 indicates the category of equipment. The X is used to indicate major group of equipment in the 15 category. The 2 indicates a specific type of component in the major group. The 3 indicates a specific item. The 4 indicates the general series, model, part type or part number of the specific item. The 3 at the end of the TO number tells you that the TO has overhaul (O/H) instructions in it. <u>The last digit of an equipment TO number will tell you the kind of TO you will be working with.</u>



NOTE: THESE NUMBERS ARE READ AS DASH ONE, DASH TWO, AND SO-ON.

Figure 4.

Answer the following statements as true (T) or false (F).

1. The 4 in TO number 15X2-3-4-3 tells you the kind of TO.

2. The 2 in TO number 15X2-3-4-3 is used to show a specific type of part in the major group.

Answers to Frame 8: a. ___ b. ___ c. _✓_

Answers to Frame 9: 1. _F_ 2. _T_

Frame 10

Equipment TOs are used to give operating instructions, maintenance instructions, overhaul instructions, and illustrated parts breakdowns for parts of Air Force equipment.

NO RESPONSE REQUIRED

Frame 11

Aircraft TO numbers differ from equipment TO numbers. You will now look at aircraft TO number 1C-47A-1. The first digit is a one, this tells you the large category of equipment. The one category is aircraft. The letter C tells you the type of plane, which is cargo. The third digit is 47, this tells you the model of the plane. The letter A stands for the series of the plane. The fifth digit of the TO number is also a one. This one tells you the kind of TO or information found in the TO. The TO may be a flight manual or illustrated parts breakdown, or it may have maintenance or overhaul instructions in it. The one on the end of TO number 1C-47A-1 tells you that the TO is a flight manual.

Some examples of aircraft TO numbers are shown below.

Category	Type		Model	Series		Information
1	C Cargo		47	A	-	1 Flt Manual
1	H Helicopter	-	19	B	-	1 Flt Manual
1	B Bomber	-	52	D	-	2 Maintenance Instructions
1	B	-	52	D	-	3 Structural Repair (Overhaul Instructions)
1	B	-	52	D	-	4 IPB (Illustrated Parts Breakdown)

Answer the following statements as true (T) or false (F).

1. The second digit of an aircraft TO number tells you the model of the plane.

2. The third digit of an aircraft TO number tells you the kind of information that is in the TO.

Answer to Frame 10: No Response Required

Answers to Frame 11: 1. F 2. F

Frame 12

The fifth digit of an aircraft TO number tells you the type of information contained in the TO. When the TO is for a small piece of equipment, no further identification is used. On large pieces of equipment, a sixth digit is used to show the systems of the piece of equipment. For example, aircraft TO number 1F-111A-4-6 tells you the TO is an illustrated parts breakdown (fifth digit is -4) for F111A plane. The sixth digit (-6) tells you the TO has in it "Power Plant and Related Systems" of the F111A aircraft.

Complete the following statement.

1. A sixth digit is added to an aircraft TO number to tell you the ____________ of the piece of equipment.

Frame 13

Aircraft TOs are used for operating instructions, maintenance instructions, overhaul instructions, and illustrated parts breakdowns for planes. Operating instructions tell you how to operate the plane, such as how to start the engine. Maintenance instructions tell how to repair the whole plane. Overhaul instructions tell what has to be done to make major repairs on parts of the plane. Illustrated parts breakdowns (IPB) list all the parts on the plane by nomenclature (name and description) and part number. IPBs are used to order replacement parts. They are also used to locate parts on the aircraft.

NO RESPONSE REQUIRED

Frame 14

Below is a check to see how well you remember and understand the information given so far.

Complete the following statements.

1. All TO indexes are listed in TO 0-1-01 which is called the ________ ___ ____________.

2. In TO number 15X2-3-4-3 the last digit of the number (-3), tells you this TO provides ____________ instructions.

3. Sometimes you will find more than one TO in the same ___________.

4. All TOs are lined up in their binders and on the shelves according to their ____________ and not by their sizes.

5. In aircraft TO number 1C-47A-1 the last digit (-1) indicates the TO is a __________ __________.

Frame 15

You have learned the types of TOs and what they are used for. Now you will learn how information can be taken from a TO and used.

NO RESPONSE REQUIRED

Answer to Frame 12: 1. system

Answer to Frame 13: No Response Required

Answers to Frame 14: 1. Index of Indexes 2. Overhaul 3. binder 4. number 5. flight manual

Answer to Frame 15: No Response Required

Frame 16

The indexes in the Air Force TO system are posted to aid the mechanic in locating TOs in a shop or limited TO file. Two symbols are used for posting indexes. The symbols are the plus (+) and the minus (-) symbols. All TOs that are required in the shop TO file will have one of the symbols marked to the left of the TO number in the numerical indexes. The symbols are marked in pencil. The plus (+) symbol tells you the TO is required in the file, is on hand, up-to-date, and no pages are missing. The minus (-) symbol tells you that: (1) the maintenance shop is authorized the TO, but it is not on file, (2) the TO is on file, but not up-to-date, (3) the TO is on file, but some of the pages are not in the TO. If a mechanic sees a MINUS (-) symbol in an index for a TO he is trying to find, he should waste no more time. The TO, if on file, will not be in any condition to be used.

Answer the following questions.

1. The symbol that is used to indicate a TO has some pages missing is the ________ symbol.

2. The symbol that is used to indicate a TO is up-to-date is the ________ symbol.

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Frame 17

The Air Force TO system has an ALPHABETICAL INDEX, (0-2-1), to help you locate hard-to-find information. The TO number starts with a zero so it is an index. The second digit is a 2 which tells you that everything in it is listed alphabetically. This TO is used to find the INDEX for a CATEGORY of equipment.

Complete the following statement.

1. The TO that is used to find hard-to-find information is TO ____________.

Frame 18

At times a correction or addition may have to be made to a TO. As equipment changes and new parts are made, the procedures in the TO must be brought up-to-date. A TO is corrected by a CHANGE. A SUPPLEMENT is something added to a basic TO such as a new model or type of some equipment. A CHANGE is something that must be corrected in the TO.

NO RESPONSE REQUIRED

Answers to Frame 16: 1. minus 2. plus

Answer to Frame 17: 1. 0-2-1

Answer to Frame 18: No Response Required

Frame 19

A SUPPLEMENT, as we have said, has information that must be ADDED to the TO. Below are two statements. One shows the need for a SUPPLEMENT and the other shows the need for a CHANGE. Label them to show which will be a change and which will be a supplement.

1. The TO is amended to add ignition unit, model 925C1A, which will be overhauled and tested in accordance with the instructions given in sections II and III. This will be a ____________.

2. NOTICE: Page 17, paragraph 19b, is changed to read, ... torque the bolt to 40 inch pounds ... This will be a ____________.

When a TO is changed, a change date is put right below the basic date. The basic date of a TO is the day that it was published. The basic date of a TO will only change when there is a revision to the TO. (A revision is a new TO including all the current changes.) A revision is made after 80% of the TO has been changed. When a revision replaces the old TO, it will carry a new basic date, and the old TO is discarded. By putting a change date below the basic date, the mechanic can find out if the TO he is using has up-to-date information or not. This is determined by checking to see if the change date on the TO matches the change date that is given for that TO in the index. The basic date of the TO should also match the basic date that the index gives for that TO.

Select the best answer for each question.

1. The change date on the title page of a TO is located

   a. above the basic date.

   b. to the left of the basic date.

   c. to the right of the basic date.

   d. below the basic date.

2. The basic date of a TO is the

   a. date it was changed.

   b. date it was published.

   c. date it arrived in the shop.

   d. date of the second change.

Answers to Frame 19: 1. Supplement 2. Change

Answers to Frame 20: 1. d 2. b

Frame 21

To find information in a TO there are steps that you must take. The first step is to find in the "Index of Indexes" (0-1-01), the index for the category of equipment that you are working with. If you were looking for the index for fighter aircraft, you go to Part 1 of TO 0-1-01 and look down the titles to find fighter aircraft. Then you would look to the left of the title to find the number of the index that you are going to need. The basic date and change dates will be to the right of the title for that index.

Check the following statements as true (T) or false (F).

1. The title and number of an index for a category of equipment is found in Part 1 of TO 0-1-01.

2. The index number for a category of equipment may be found to the right of its title in TO 0-1-01.

Frame 22

When you have found the number of the TO index that you are looking for, you would remove that TO from the TO file. Once you have the index, you would look in the table of contents to see which page lists the specific type of fighter that you need information for. The table of contents is the only way to locate information in a TO index. You would then turn to that page and look down the titles to find the title of the TO that covers the particular system you are working on. When you find the title of the TO that you are looking for, look to the left of the title and find the TO number. Also look to the right of the title and look at the basic date and change dates, if any. The part number of the piece of equipment that the TO covers will be to the right of the TO title. The part number is useful in that it can help identify the TO for a specific piece of equipment. The same part may have been changed slightly so it has a different part number.

Complete the following statement.

1. The number of a page that contains specific information in a TO may be found in the TO's __________ _______ ___________________.

Frame 23

Once you know the number of the TO that you are looking for, you can remove it from the TO file. The first thing that you check is the basic date of the TO. The basic date is in the lower right hand corner of the title page. This date should match the basic date that is given to the right of the title of the TO in the index. If the two dates do not match then the TO or the index are not up-to-date. Also, if the change date that is given to the right of the title in the index does not match the change date on the TO, then one or the other of the TOs are not up-to-date. The change date of a TO is found in the lower right hand corner of the TO title page, directly below the basic date.

Complete the following statement.

1. The change date of a TO is found to the __________________ of the title of the TO in the index.

Answers to Frame 21: 1. T 2. F

Answer to Frame 22: 1. table of contents

Answer to Frame 23: 1. right

Frame 24

In all TOs there is an "A" page which is on the back side of the title page. The "A" page is titled "List of Effective Pages". The "A" page lists all the pages in the TO. This page tells you the pages of the TO that have been changed and the pages that are original (have not been changed).

NO RESPONSE REQUIRED

Frame 25

The table of contents tells the reader what is found inside the TO, by page number. To look up some information in a TO you have to look in the "Table of Contents" first. In the "Table of Contents" you can find the page number for the information you need. By turning to that page you do not have to thumb through the TO to find what you are looking for.

Answer the following question.

1. When looking for information in a TO the first place you look is in the

a. table of contents.

b. index.

c. parts listing.

d. list of effective pages.

Frame 26

When you know what page the information you need is on, you can turn right to it. This saves time and speeds up maintenance on equipment.

NO RESPONSE REQUIRED

Frame 27

Another kind of TO you will be using is the Illustrated Parts Breakdown (IPB), (-4). This manual lists all the parts used on an aircraft by nomenclature (name and description) and part number. This information is used to order replacement parts. It can be helpful in showing locations of parts on an aircraft. This is not the main use, but it is very important. This manual also contains an exploded view of all the parts that make up a major assembly. The IPB (-4) tells how many of each part are on an assembly. There will be code letters or numbers to let you know which aircraft use the parts. In the following frames you will learn how to use the IPB.

Answer the statements below as true (T) or false (F).

1. The information in the IPB is used only by supply.

2. The IPB is used primarily for ordering replacement parts.

3. From the information in the IPB you can find out which parts may be used on a specific aircraft.

Answer to Frame 24: No Response Required

Answer to Frame 25: 1. a.

Answer to Frame 26: No Response Required

Answers to Frame 27: 1. F 2. T 3. T

Frame 28

An IPB may be made up of more than one volume. In each of the volumes the foreword part tells what information is covered in the other volumes of the IPB (-4). It does this by listing the other volumes of the IPB and the systems covered in them.

Answer the statement as true (T) or false (F).

1. There is usually more than one volume to the IPB.

Frame 29

In an IPB the figures are pictures of assemblies on the aircraft. The figures show exploded views of the parts that make up the assembly. Parts that are shown in the figures are identified by index numbers. NOTE: DON'T CONFUSE INDEX NUMBERS WITH TO INDEXES. THEY ARE TWO DIFFERENT THINGS. Index numbers are the small numbers that are by each part shown. Index numbers are used to find the nomenclature (name and description) of parts used on an assembly. By using the index number, figure number, and volume number of the IPB, a specific part can be identified. With each figure there is a parts list. The parts list has the volume, figure, and index numbers, part numbers, nomenclature, units per major assembly and usable on codes. The usable on code tells you the specific plane the part can be used on

Answer the statements as true (T) or false (F).

1. A part can be identified by using the volume, figure, and index numbers.

2. Usable on codes tell which aircraft a part may be used on.

Frame 30

The IPB also contains a nume[illegible] [illegible]ex of all part numbers of parts used on the specific aircraft. When just the part number is known, this index can be used to find the name and the place of the part on the aircraft. The numerical index is a list of the part numbers in alphabetical/numerical order. The volume, figure and index numbers, source codes and repair codes are also listed in the numerical index.

Answer the following question.

1. The numerical index of part numbers is a list of the part numbers in ____________/____________ order.

Frame 31

The AFTO Form 22, Technical Order System Publication Improvement and Reply Report, is used for recommending improvements in TOs. The report is made to correct errors of a technical nature that prevent proper performance of maintenance. An improvement report is not used to correct errors of a nontechnical nature. TO 00-5-1, AF Technical Order System (Section IV), covers in detail the procedures and entries for the "Technical Order Improvement Reporting System".

Answer the following questions.

1. TO improvement reports are used for correction of data of what type? ____________

2. What TO covers procedures and form entries for the Technical Order Improvement Reporting System? ____________.

Answer to Frame 28: 1. T

A. :rs to Frame 29: 1. T 2. T

Answer to Frame 30: 1. alphabetical/numerical

Answers to Frame 31: 1. technical 2. 00-5-1

Frame 32

You will be concerned with making entries in blocks 5 through 11 of the form. Why just these blocks? The reason for thi. is that blocks 1 through 4, 12 and 13 are filled out by the Quality Control offi.. on your base. Refer to the AFTO Form 22, figure 1. The block entries are made as follows:

BLOCK 5. Enter the basic date of the TO that appears on the title page.

BLOCK 6. Enter the date of the TO change, if the improvement involves a page identified with a change date or number.

BLOCK 7. Enter the page or card number which the improvement involves. When more than one page or card number is involved, enter only the first number and explain in block 10.

BLOCK 8. Enter the identif.catio· of the specific paragraph(s) affected as it appears on the page involved. Example: Para 7-109 or A (2).

BLOCK 9. Enter the number of the figure (illustration) that is affected by the impr· ement.

Answer the following question.

1. Which block. do you fill out on the AFTO Form 22 when making an improvement report? ______________

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Four separate entries are made in Block 10:

1. This Report Concerns. Enter the specific aerospace system when it is not included in the TO number. Also, if an aerospace system is not affected, identify the equipment system or individual item of equipment affected.

2. Discrepancy. Enter a short and understandable description of the TO deficiency.

3. Recommended Change. The change recommended gives the exact language that should appear in the corrected technical order. You can attach additional sheets of paper if needed. The improvement report number must be shown in the upper right-hand corner of each sheet attached.

4. Reason for Change. Enter the reason for making the improvement report. Examples. Decrease safety hazards when performing maintenance or will save X number of man-hours of work when performing maintenance on a system, etc.

BLOCK II. Enter the signature, office symbol and telephone extension of the individual making the report.

Answer the following question.

What are the four separate entries in block 10 of the AFTO Form 22?

1. ____________________ 3. ____________________

2. ____________________ 4. ____________________

Answer to Frame 32: 1. 5 thru 11

Answers to Frame 33: 1. This Report Concerns

2. Discrepancy

3. Recommended Change

4. Reason for Change

Frame 34

The lower section of the AFTO Form 22 is for "Major Command Action". A major command uses this section to approve or disapprove the report and gives the reason for its approval or disapproval. One copy of the form will be sent to the Quality Control office on your base, you can then see the action that was taken.

NO RESPONSE REQUIRED

Frame 35

When you make a TO improvement report, you will have to follow the instructions in TO 00-5-1, Air Force Technical Order System. The Quality Control office will answer any questions you have on filling out a TO improvement report.

NO RESPONSE REQUIRED

Answer to Frame 34: No Response Required

Answer to Frame 35: No Response Required

SERVICE TEST
STUDY GUIDE

C3ABR42331-SG-302

Technical Training

Aircraft Environmental Systems Mechanic

TECHNICAL ORDER PUBLICATION SYSTEM

2 June 1984

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Aircraft Environmental Systems
Chanute AFB, Illinois

SERVICE TEST
C3ABR42331-SG-302

CONTENTS

OBJECTIVES

1. State the general principles of the technical order system by a minimum of 8 of 10 questions correctly.

2. Determine procedural instructions contained in time compliance technical orders by answering a minimum of 4 of 5 questions correctly.

3. Identify conditions that would require the initiation of a technical order improvement report with 100% accuracy.

INTRODUCTION

Let's suppose that one day you reported to work, and your supervisor pulls you aside and says... "Airman, we have this problem in the Transient Alert Section, it seems that the President was flying to Camp David, when for some reason the aircraft pressurization system malfunctioned, and now the aircraft will not hold any pressure. I know that you take a great deal of pride in your job, and are always doing outstanding work, and following the technical order to the 'T'. I also realize that you have no experience working on this type of aircraft, but it is very important that we put the best person available, on the job. I want you to know, that I want you to do this job, and as soon as everything is completed and all the symbols have been cleared you may go home, and have the rest of the day off; but you will not be allowed to leave until the job is 100% complete."

You accept the responsibility, and go to the base TO library. You walk into this large room, and all you see, for what seems like miles, is TOs. Ceiling to floor, and wall to wall of nothing but TOs. You scratch your head and say... "WOW, where do I begin?" Well, unless you know something about the TO system and how it works, you could be in for a very long day, just trying to find the correct TO.

In this lesson we will discuss the TO system; Time Compliance Technical Orders (TCTOs); and also, how to initiate changes to TOs.

OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 250; DAV - 1

SECTION I

TECHNICAL ORDER SYSTEM

The Air Force has THOUSANDS of pieces of equipment, along with HUNDREDS of THOUSANDS of TOs. There are five basic types of TOs used in the Air Force. They are:

1. Indexes

2. Methods and Procedures

3. Technical Manuals

4. Time Compliance Technical Orders (TCTOs)

5. Abbreviated Technical Orders

All TO numbers, regardless of the type of TO you are using, will contain at least three or more parts. Each part will be separated by a dash. Example: 1F-111A-06, 00-20-2-2, 1T-38A-6WC-2, 0-1-1-2, 1C-141A-801. The five examples of TO numbers is an example of the five types of TOs you will be using sometime in your Air Force career. Some of these TO types you should already be familiar with.

Compliance with Air Force TOs is mandatory. Technical Order instructions play a critical role in achieving system and equipment readiness. Let us begin our lesson on the TO system, by discusssing the five types of TOs individually.

INDEXES

These [illegible] show the status of all TOs, they provide a means of selecting needed TOs and group TOs pertaining to specific items of equipment. There are two types of indexes used by the Air Force.

- Alphabetical
- Numerical

The alphabetical index is used only when the type of equipment is known. Example: Aircraft, engines, oxygen converters, air conditioning systems and etc. The alphabetical index will refer you to the numerical index by giving you the category number for the equipment, or the THIRD PART of the numerical index TO number. For example: If you wanted the Aircraft numerical index, you would go to the alphabetical index, look up Aircraft, and across from this subject, you would find a number 1. Now that you have a number, you can go to a numerical index, and find the number of the TO that you need in order to do the maintenance, or inspection on the aircraft. The main thing to keep in mind when using an alphabetical index is to begin with the largest item that you are going to be working with, and "whittle" your way down to the actual item you will be working on. So, the alphabetical index, will refer you to the applicable numerical index.

All index TO numbers begin with the number zero (0) by itself, in the first part. So, whenever you see a number like <u>0</u>-1-1-2, you can tell by the first part, that you are looking at an <u>index</u> type TO.

The second part of an index TO number identifies if the information in the index is going to be listed numerically, or alphabetically. Example: In the TO number 0-1-1-2, the one in the second part identifies this is a numerical index, and all the information inside will be listed numerically. If we were using TO number 0-2-1, the two in the second part would identify this is an alphabetical index. Remember, an 0-2, will refer you to an 0-1.

The third part of an index TO number identifies the TO category of equipment. Example: In the TO number 0-1-1-2, the one in the third part, will identify the TO category. In this case, the number one category, identifies aircraft. So, by reading the TO number, and using what we've already learned, we would read:

0-1-1-2	0-1-1-2	0-1-1-2
INDEX	NUMERICAL	AIRCRAFT
	0-2-1	
	ALPHABETICAL	

As stated before, all TO numbers must contain, THREE OR MORE parts; but in our example that we are using (0-1-1-2), has four parts. What does the fourth part of an index TO number identify? The fourth part identifies a specific type in a TO category. Example: 0-1-1-2, the two in the fourth part, identifies BOMBER. On the bottom of this page, you will find a list of index TO numbers, along with a description of each part.

0-1-1-1,	Index -	Numerical -	Aircraft -	ALL
0-1-1-2,	"	"	"	BOMBER
0-1-1-3,	"	"	"	CARGO
0-1-1-4,	"	"	"	FIGHTER
0-1-1-5,	"	"	"	ATTACK, HELICOPTER, OBSERVATION, UTILITY and TRAINER.

All TO numbers found in the above indexes will begin with the number 1. Example: In the 0-1-1-1, ALL TO numbers will begin with the number 1, with no letter to identify the type of aircraft, because this index pertains to all aircraft, general information. In the 0-1-1-2, the TO numbers will begin with 1B-identifying Aircraft/Bomber. In index 0-1-1-3, all TO numbers listed will begin with 1C-identifying Aircraft/Cargo. In the 0-1-1-4, the TO numbers will begin with 1F-Aircraft/Fighter, in the 0-1-1-5, the TO numbers will begin with:

1A-Aircraft/Attack

1H-Aircraft/Helicopter

*1L-Aircraft/Observation

1U-Aircraft/Utility

1T-Aircraft/Trainer

*Note: I's and O's are not used in TO numbers to avoid confusion with Roman Numerials.

0-1-01, All of the numbers found in this index, will begin with a zero (0). This index, lists all INDEXES in numerical order.

0-1-02, All of the numbers found in this index will begin with a double zero, (00). These are general information type TOs, and will be discussed in the next paragraph.

0-2-1, All the TOs listed in this index will be listed alphabetically. This index lists aircraft TO categories. It will refer you to a numerical index.

0-1-15, All TO numbers in this index will begin with the number 15. It covers aircraft and missile temperature control, pressurization, air conditioning, heating, ice elimination, and oxygen equipment TOs.

METHODS AND PROCEDURES

These TOs establish policies and prescribe procedures relating to such subjects as the TO System, Preventive Maintenance, Scheduled Inspections, Maintenance Management, Maintenance Data Collection. Methods and Procedures TOs are general in content and are not issued against specific equipment or systems. They usually pertain to things that are in common in a lot of areas. There are two classes of Methods and Procedures TOs:

- Those which involve policies, methods and procedures relating to ground handling of aerospace vehicles, management of precision measurement devices, and safe use of Air Force equipment.

- Those which involve policy, methods and procedures relating to maintenance management administration, or inspection of Air Force equipment, and control and use of reparable assets.

All of the methods and procedures TOs will begin with the number 00 in the first part, and will be listed in the 0-1-02 TO. Some examples of methods and procedural TOs, are listed below.

00-5-1, Methods and Procedures pertaining to the TO system

00-5-2, " " " " " " " distribution system

00-5-15, " " " " " " TCTOs

00-20-1, " " " " " " Preventive Maintenance Program.

00-20-2, Methods and Procedures pertaining to the Maintenance Data System

00-20-2-2, On Equipment maintenance documentation for aircraft

00-20-2-4, Maintenance Documentation for in-shop engine maintenance

00-20-2-10, Off-Equipment maintenance documentation for shop work.

00-20-5, Aircraft Drone, and air-launched missile inspections, flight reports, and supporting maintenance documents.

TECHNICAL MANUALS

These types of TOs, cover installation, operation, maintenance and handling of Air Force equipment and material. Complex systems or equipment requiring a specific type of manual, such as a maintenance manual or a parts breakdown, may be published in sections. Each section constitutes a separate publication with a separate TO number. Example: Let's assume the air conditioning system on the B-52B aircraft is so complex, that it needed to be placed into two separate sections. The publisher could divide the maintenance manual or Illustrated Parts Breakdown (IPB) into two sections. One section pertains to "Hot air distribution", while the other section pertains to the "Cold air distribution." Because these TOs are divided, it now requires that each section will be listed as a separate publication, with a separate TO number assigned to each one.

The title and TO number would be similar to this:

"Maintenance Instructions, Hot air distribution, Air Conditioning System B-52B aircraft." TO #1B-52B-2-6-1

"Maintenance Instructions, Cold air distribution, Air Conditioning System B-52B aircraft." TO #1B-52B-2-6-2

If the publisher decided to separate a complex system in an Illustrated Parts Breakdown (IPB) TO, it would be similar to the example above, only pertaining to the IPB.

"Illustrated Parts Breakdown, Hot air distribution, Air Conditioning System B-52B aircraft" TO #1B-52B-4-6-1

"Illustrated Parts Breakdown, Cold air distribution, Air Conditioning System B-52B aircraft." TO #1B-52B-4-6-2

Note: SEE TO NUMBER BREAKDOWN ON PAGES 8 & 9.

1 B - 52 B - 2 - 6 - 1

TO Category. 1 identifies AIRCRAFT

Type of aircraft. B identifies BOMBER

Aircraft MODEL

Aircraft SERIES of this model

Kind of TO. -2 pertains to "MAINTENANCE INSTRUCTIONS"

System TO covers. -6 identifies AIR CONDITIONING SYSTEM

Section of a sectionalized TO, or Volume of TO. -1 pertains to the "Hot air distribution system"

1 B - 52 B - 2 - 6 - 2

Section of a sectionalized TO, or Volume of TO. -2, pertains to the "Cold air distribution system"

TO NUMBER BREAKDOWN

1 B - 52 B - 4 - 6 - 1

TO Category. 1 identifies AIRCRAFT

Type of aircraft. B identifies BOMBER

Aircraft MODEL

Aircraft SERIES of this model

Kind of TO. -4 pertains to "ILLUSTRATED PARTS BREAKDOWN (IPB)"

System TO covers. -6 identifies AIR CONDITIONING SYSTEM

Section of a sectionalized TO, or Volume of TO. -1 pertains to the "Hot air distribution system"

1 B - 52 B - 4 - 6 - 2

Section of a sectionalized TO, or Volume of TO. -2, pertains to the "Cold air distribution system"

TIME COMPLIANCE TECHNICAL ORDERS (TCTOs)

The TCTO is the authorized method of directing and providing instructions for modifying equipment, other than temporary modifications, and performing or initially establishing a one time inspection. You can identify a TCTO number because the third part of the number will always be 501 or higher. Example: 1C-141A-801. The degree of urgency is indicated by specifying when compliance is to be completed.

The five types of TCTOs are:

- IMMEDIATE ACTION
- URGENT ACTION
- ROUTINE ACTION
- INTERIM
- RECORDS

IMMEDIATE ACTION TCTOs are issued under the governing factors of safety conditions, the uncorrected existence of which, could result in fatal or serious injury to personnel or extensive damage to, or destruction of, valuable property. Such conditions involve risks which are intolerable.

The urgency of these TCTOs requires IMMEDIATE ACTION to ground aircraft, prevent launch of missiles, discontinue operation of ground support equipment, personal equipment, or munitions. When possible, methods for condition correction are included in IMMEDIATE ACTION TCTOs.

The words IMMEDIATE ACTION are printed in red at the top of the first page with a border of red Xs included around the first page. In addition to providing distinctive identification, the red Xs correspond to the symbol used on maintenance forms.

Because of their urgency, publication and distribution of IMMEDIATE ACTION TCTOs are placed on a high-priority basis and commanders shall ensure they are distributed to all affected personnel within four hours after receipt.

URGENT ACTION TCTOs are issued under the governing factors of combat necessity or potentially hazardous conditions, which could result in injury to personnel, damage to valuable property, or unacceptable reductions in combat efficiency. Such conditions compromise safety or involve risks which are calculated to be tolerable only within definite time limits.

The urgency of these TCTOs requires compliance within specified time limits. If not complied with by expiration of time limit, these TCTOs require action to ground aircraft, discontinue use of air-launched missiles, prevent launch of missiles or discontinue operation of ground communications, electronics, meterological equipment, or use of support equipment, personal equipment, materials or munitions.

The words URGENT ACTION TCTO are printed in red at the top center of the first page and a series of red diagonals alternately spaced with circled red Xs are printed around the border of the first page. In addition to providing distinctive identification, the red diagonals and circled red Xs correspond to the symbol used on maintenance forms. When the URGENT ACTION TCTO is received, all applicable maintenance forms for the equipment that the TCTO applies to, will have a red diagonal placed in the symbol block, with a statement identifying that an URGENT ACTION TCTO is due. When the specified time limit has expired, a circled red X will replace the red diagonal symbol.

Because of their urgency, commanders shall ensure that distribution is made to all affected personnel as quickly as possible.

ROUTINE ACTION TCTOs are issued for conditions which involv a degree of risk calculated to be tolerable within broad time limits. Governing factors are equipment or procedural deficiencies of material mechanical operational, or tactical nature, the uncorrected existence of which could:

- Constitute a hazard through prolonged usage, or
- Have a negative effect on operational efficiency, or
- Reduce operational life or general service utilization of systems or equipment.

Depending on the degree of the factor(s) involved will determine which symbol(s) will be used on the maintenance documents. NOTE: The circled red X is used for the URGENT ACTION TCTO only!

ROUTINE ACTION TCTOs are issued to authorize accomplishment, and record one-time Air Force requirements like inspections, modifications, etc, which are not available at the time of original manufacture.

The "time limits" mentioned in the URGENT, and ROUTINE ACTION TCTOs, will be identified on the first page of the applicable TCTO.

There are two other types of TCTOs, which are INTERIM and RECORD TCTOs. When circumstances preclude the timely publication of emergency instructions in printed form, they are issued by means of teletype, telegrams, radiogram, or air mail and are called "interims." These are used when the Air Force belives that the action required is important enough, that time is of the essence, so, instead of taking the additional time required to publish an IMMEDIATE, or URGENT ACTION TCTO, begin checking your systems or equipment NOW! Action copies of interim TCTOs will be transmitted to the headquarters of the using command for equipment affected.

The record TCTOs, do not contain step-by-step instructions in the "How work is to be accomplished" paragraph. Instead, they tabulate the equipment affected, index necessary installation drawings and instructions, and list required parts which are provided by kits. Symbol entries are not required in maintenance forms for record TCTOs. Distinguishing red markings on the first page are not required for record TCTOs, but all other aspects of the record TCTO will contain the same information and support as do other TCTOs.

The information included in all TCTOs is

by whom the work will be accomplished

when the work will be done

form entries required

other TOs that are affected

recission date of TO

purpose of TCTO

how work is to be accomplished (except record action TCTOs)

equipment that the TCTO applies to.

ABBREVIATED TOs

These TOs are primarily work simplication devices. The following type are abbreviated TOs:

- Inspection Workcards (WC), which prescribe the minimum inspection requirements for performing an inspection.
- Inspection sequence charts, which are provided primarily for scheduled inspections and describe a basic planned work schedule or sequence in which the inspection workcards can be used.
- Checklists (CL), which provide lists of items in abbreviated form for use in performing various tasks or operations in the sequence deemed most practica', to ascertain operational readiness of equipment and minimum serviceable condition. A checklist may be published when one or mor. of the following conditions exist:
    - When the steps must be followed in sequence to eliminate damage to equipment which would reduce operational readiness or cause the equipment to fail.
    - To preclude potential injury to personnel and/or damage to equipment unless prescribed sequence time phased procedures are followed.
    - When interaction or communication between two or more differing specialty skills are involved in accomplishing a function.

Abbreviated TOs, are TOs that have been put in an outline form, with the information from a larger TO. The abbreviated TOs are easier to use, but only list the MINIMUM that is required.

SECTION II

CHANGES TO TECHNICAL ORDERS

In other lessons you've heard the word "CHANGE," in reference to TOs. I suppose that maybe you've been wondering what we've been meaning, and WHO does these "changing of TOs." Well, now we are going to discuss "CHANGES" to the various types of TOs, along with who does it, how they do it, why they do it, and maybe some other questions that you may have.

First of all, I'd like to ask YOU a question. Who uses TOs....? I hope that your answer was something like "YOU AND I," because WE are the ones who submit these changes. The Air Force spends millions of dollars to help us to be more productive, and perform the best possible maintenance. They will go to great heights to make our jobs better and easier. You see, they want us to use these "books," and they know we won't use them if we can't understand, and follow them properly. The Air Force developed a form for us to use so we can submit these changes, that we feel will help us to do better work. This form is AFTO Form 22, Technical Order System Improvement Report. A TO improvement report is a recommendation for a specific TO improvement, correction of an error or omission, of a TECHNICAL NATURE, which prevents the adequate performance of functions required for mission accomplishment.

The correction of minor errors of a NON-TECHNICAL NATURE, will not be recommended on an improvement report unless it effects the meaning of instructive information or procedures. Instead, recommendations for corrections of minor errors should be by letter, message or telecon.

Each recommendation for improvement must be evaluated individually, therefore, only one improvement will be recommended on each AFTO Form 22.

When to submit improvement reports? Well, any person discovering a condition requiring a change to a TO will submit an improvement report. Emergency reports will be initiated and submitted immediately after discovery of the condition; Urgent reports on an AS QUICKLY AS POSSIBLE basis; routine reports AS SOON AS PRACTICABLE.

The supervisor, of the person submitting an improvement report will determine if the report is valid and warrants the "GO AHEAD" to submit it, and will sign the form. The supervisor will insure the initiator's signature is on the form. All copies of reports determined valid will be forwarded to the responsible Quality Control (QC), Quality Assurance (QA) or other responsible organization for review and approval.

Supervisors and QC/QA, should use the following guide.

- Check for completeness and accuracy

- Verify that the AFTO Form 22 is the proper method of reporting. DO NOT submit reports for deficiencies that are not of a TECHNICAL NATURE.

- Check the TO 'A' page of the applicable TO index, to ensure the TO is current.

- Consider the impact on other TOs.

- Determine it change is essential.

- To the best of your ability, ensure the recommeded change is comprehensive and in the exact language it should appear in the corrected TO.

- Ensure there is adequate explanation why the change is necessary; that is, mission essential, work stoppage, number of excessive manhours to do the task, impact if change not made, time lost now, saved if TO changed, and safety implications.

As you can see, the Air Force doesn't change TOs just to change. There are a lot of complications in order to get a TO changed, but if no one tries, it will never get done. If you feel that the TOs you are using requires a change, because of safety or for some technical reason, discuss it with your supervisor. It could save a life.....

Environmental/Pneudraulic Branch
Chanute AFB, Illinois

C3ABR42331-WB-302
28 June 1984

TECHNICAL MANUALS

OBJECTIVE

Using applicable technical manuals, locate selected items of information for performing maintenance with a maximum of four instructor assists.

EQUIPMENT

Training Technical Order File

PROCEDURE

This workbook is arranged in three parts. Each part must be completed in order before going to the next one. When you finish, give the workbook to the instructor for grading.

Part 1

INSTRUCTIONS

Read the statement below and look up the information that is needed to answer the questions.

You are working on a 25 liter capacity, liquid oxygen converter. The part number of the converter is 21119-1. The TO needed to overhaul the converter is 15X2-3-4-3. Sign it out from the TO file.

Note: Remember, there may be more than one TO in a binder. Be sure to check the "from" and "thru" numbers on the binder label.

1. The basic date of the TO for the converter is ____________________.

2. Has the TO been changed? ____.

3. Overhaul instructions start on page _________ of TO _______________.

4. Are any special tools required to overhaul the converter?

   ____

5. Inspeccion of the 25 liter oxygen converter is covered in section

   ____________________________, page ___________________, of the TO.

Supersedes ST C3ABR42331-WB-302, 19 September 1983.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 300; DAV - 1

Part 2

INSTRUCTIONS

Read the statements below and take from the TO file the TO that is needed or used in each situation. Answer the questions about each situation.

Using TO 15 x 2-2-5-13, answer the following questions:

1. How many pages are in this TO?

2. What is the title of section four of this TO?

3. What type of lubrication is used when overhauling a converter?

4. When performing a pressure test on the converter, should the vent relief port be capped during the final assembly pressure test?

5. When performing the calibration test of the sensing element, what TO is used as a reference for alternate test procedures?

6. What page shows an illustration of a "25-Liter Liquid Oxygen Converter?"

Using TO IF-111A-2-2-1, answer the following questions:

1. On page 5-2, Figure 5-2, there is an illustration of the "Canopy Hatch System." What do the miniature pointing hands identify, and where did you find the answer to this question?

2. How many pages are in this TO?

3. What is the title of Figure 12-14?

4. In the description of Aircraft Smoothness, when is full compliance with the requirements of this section <u>not</u> necessary?

Using TO IF-4C-4-3 to answer the following questions:

1. Use the information on the title page to answer the following questions:

    a. The title is:

    b. The basic date is:

    c. Has this TO been changed? Yes ________ No ________

2. Turn to the forward section. The forward gives information as to what systems are covered in the IPB. Supply the missing information.

   a. Instrument systems are in TO ______________________________.

   b. Aerospace support equipment is tested in TO ________________.

   c. The numerical index of part numbers is TO ___________________.

3. The next part of the IPB is the "Table of Contents." The first column on the left side in the Table of Contents is the section column. The next column to the right is the VOLUME, and FIGURE numbers column. The third column is the TITLE OF ASSEMBLIES column. The fourth column is the VOLUME AND PAGE NUMBER.

   a. The "cabin and pressure suit refrigeration unit assembly" for the F-4 C/D are shown in Figure ____________ on page __________.

4. Turn to section II, "Group Assembly parts list." In this section illustrations show exploded views of the major assemblies. Locate the first illustration in this section, Figure 3-1. We are using volume 3 of the IPB, that is why all figure and page numbers start with a 3. Referring to the illustration, the assembly is called an "outer wing leading edge boundary layer control chamber illustration." On the aircraft in the illustration there are two darkened-in areas. These show the locations of the group assembly on the aircraft. The numbers on the illustrations are called INDEX NUMBERS. These will help you to identify any part of the group assembly. The third column lists the aircraft serial number that the part can be used on.

   a. The title of section II is ________________________________.

   b. The darkened in areas on the aircraft in the illustration shows the

   ____.

   c. The numbers on the illustration are called _________ ___________.

5. On page 3-3 there is a parts list for figure 3-1. The parts list has five columns. The first column has the volume, figure, and index numbers. Find volume number 3, figure number 1 and index number 6 in the first column. Look across to the right from index number 6, you will find the part number in the second column. The third column has the descriptions of the index numbers. The fourth column tells you how many units (items) per assembly. The last column is the "usable on code" column. This code will tell you the specific aircraft on which an item can be used plus all models and series of this aircraft. At the end of the parts list, on page 3-5, there is a description of usable on codes. The second column lists the specific model of aircraft. The third column lists the aircraft serial number that the part can be used on.

Provide the missing information.

a. What is the description (name) of index number 6 in figure 3-1?

____

b. The usable on codes are found in which column of the parts list for figure 3-1? ______________________________. On which page? ______________________________.

c. The part number of the part identified by index number 6 is ______________________________.

d. What is the usable on code for an F-4 aircraft serial number 64-928? ______________________________. On which page did you find the code? ______________________________

(1) In which TO would you find information on the following?

(a) Pressurization System ______________________.
(b) Ejection Seats ______________________.
(c) Vendor Support Equipment ______________________.
(d) Master Introduction ______________________.

(2) What is the Change Number on page 3-439?

(3) What is the date of Change Number 13?

(4) On which figure would you find the Windshield Rain Removal Equipment Installation?

(5) Using figure 3-57 what is the part number for the cylinder assembly?

(6) Using the same figure and part number, what model aircraft can this part be used for?

(7) What did change 30 do to pages 3-442 and 3-443?

(8) Using figure 3-126, what is the nomenclature for index number 10?

(9) Using figure 3-129, what volume and figure number would you use for the Unit-Power Steering parts breakdown?

(10) The Group Assembly Parts List begins on what page?

(11) On page 3-111 is the beginning of the ______________________ Systems.

(12) Using figure 3-1 index 36, what does the symbol Ø mean for part number NAS1021C3?

(13) Using figure 3-43, index 6 has how many units for assembly?

(14) On figure 3-42 index 8, what kind of material is used for part number 32-69349-2057?

6. There is another way of using the illustrated parts breakdown. The foreword of TO 1F-4C-4-3 lists TO 1F-4C-4-7 as an index. This is a <u>numerical</u> index of all part numbers of parts used on the F-4C and F-4D aircraft. When only the part number of a component is known, TO 1F-4C-4-7 is used to find the name and location of the component. Assume you have a part number 2389-48 and you know that the part is for the F-4D aircraft.

   a. List the TO number for the numerical index of part numbers for the F-4C and F-4D aircraft. ______________________

7. Sign out TO 1F-4C-4-7 from the TO file. Open the TO to the "table of contents." The table of contents lists three sections. Section I is the introduction which explains how to use the -4 (IPB). Section 11 is the numerical index. This is the section you will use. Turn to page 2-1 where the numerical index starts. Turn to page 2-2. The three columns are divided into four smaller columns. The first lists the part numbers in <u>alphabetical/ numerical order</u>. The second column lists the volume, figure and index numbers. The third and fourth columns list the source codes and repair codes.

   Answer the following questions.

   a. In which of the F-4 aircraft TOs is the numerical listing of part numbers found? ______________________. On which page? ______________________.

   b. How are part numbers arranged in this listing? ______________________

8. Find part number 2389-48 in the numerical listing of TO 1F-4C-4-7. Start at the top and continue down each part number column until you find 2389-48. To assist you in finding this number start on page . Ic you do not find it, ask your instructor for assistance.

   a. List the volume, figure and index number for this component.

   ____

9. Locate in the TO file TO 1F-4C-4-3. Turn to the figure that is given in the numerical listing. Check to see if the part number in the numerical index listing matches the part number listed in the volume you are using. If the part numbers do not match, refer back to TO 1F-4C-4-7 and recheck the volume, figure and index numbers for part number 2389-48.

   Answer the following questions.

   a. What is the volume and figure you are using? ________________

   ____

   b. What is the title of this figure? ________________________

   c. What is the description for the index number that you are referred to? ______________________________________

   d. How many units per assembly? ___________________________

   e. What is the usable on code? ____________________________

   f. Which F-4D aircraft is the part used on? ________________

   ____

10. Have your instructor check your answers for the entire workbook.

584

PROGRAMMED TEXT
3ABR42331-PT-303A
3ABR32531-PT-107

Technical Training

Aircraft Environmental Systems Mechanic
Avionics Instrument System Specialist

AIRCRAFT HARDWARE

7 August 1981

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

RGL: 9.5

OBJECTIVES

At the completion of this programmed text, you should be able to complete the following objectives:

1. Using a hardware trainer or illustration, match bolts to their nomenclature. 75% accuracy is required.

2. Using a hardware trainer or illustration, match screws to their nomenclature. 75% accuracy is required.

3. Using a hardware trainer or illustration, match nuts and/or washers to their nomenclature. Four of six must be correctly matched.

4. Using a hardware trainer or illustration, match AN fittings to their nomenclature. 75% accuracy is required.

5. Without the aid of references, match aircraft tubing and hose to their purpose. 75% accuracy is required.

6. Using display boxes containing items of aircraft hardware, relate each item's number to its proper use with 80% accuracy.

INSTRUCTIONS

This text is presented in small steps called "frames." After each frame you are to select the correct statements, choose either TRUE or FALSE, or match names of items to nomenclature. All answers will be made on provided answer sheets, NOT IN THIS PT. After answering the questions compare your answers with the correct ones found at the bottom of the following page. If your answer is correct, go to the next frame. If your answer was wrong, read the frame again and see how the correct response is derived. READ VERY CAREFULLY AND DO NOT HURRY. This programmed text was designed for two courses, Aircraft Environmental Systems Mechanic, and Avionics Instrument System Sepcialist, Due to the difference of the instructional material of each course ENVIRONMENTAL SYSTEMS COURSE DO NOT USE FRAMES 48, 49, AND 50. When you come to the end of the text, be sure to use the terminal frame designed for your course. Pneudraulics use terminal Frame 51, Instrument 51A and Environmental 51B. Proceed to Frame 1 at the top of the next page and begin.

Supersedes 3ABR42231-PT-303A, 3ABR32531-PT-107, 3ABR42132-PT-110A, 8 April 1976, which may be used until present stock is exhausted.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 500; DAV - 1

Most bolts used in aircraft structures are classed as general purpose, AN (Army-Navy), NAS (National Aircraft Standard), or MS (Military Standard) bolts. These bolts are made of aluminum alloy where lightness is needed, or of steel when strength is needed. Before going any further, study the terms and their definitions. They will help you understand why so many different types of bolts are necessary in the Air Force.

1. STRAIN - Strain is the deformation of a material when some force is applied to it. Just as you can strain a muscle by trying to lift a heavy weight, a bolt can be strained by being over tightened.

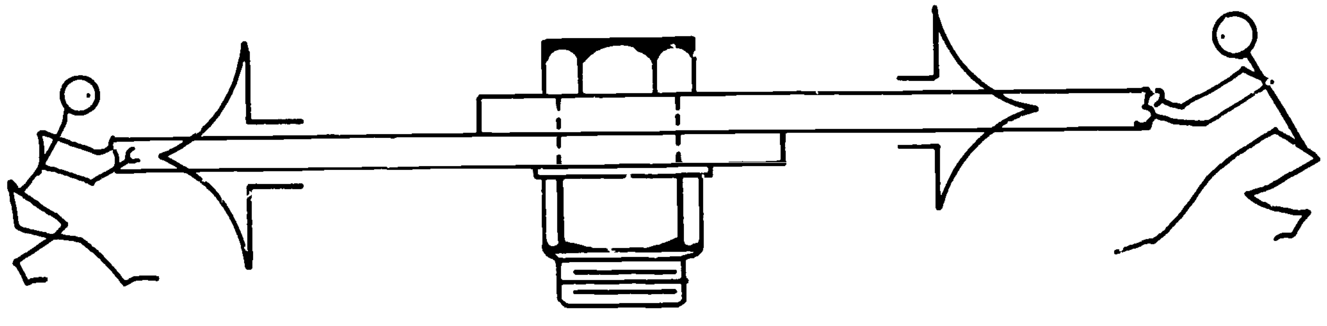
2. STRESS - Stress is a result of strain. When a bolt is being strained, it tries to resist the forces that cause the strain. Stress is measured in pounds per square inch (PSI).

3. TENSION - Tension is the act or action of stretching. Tension is also a type of stress which occurs when a bolt is elongated or stretched in a straight line.

4. SHEAR - Shear is an action or stress which causes a material to slide in a parallel plane. Shear occurs when force is applied to a bolt from opposite sides. (Think of how paper is cut with a pair of scissors.)

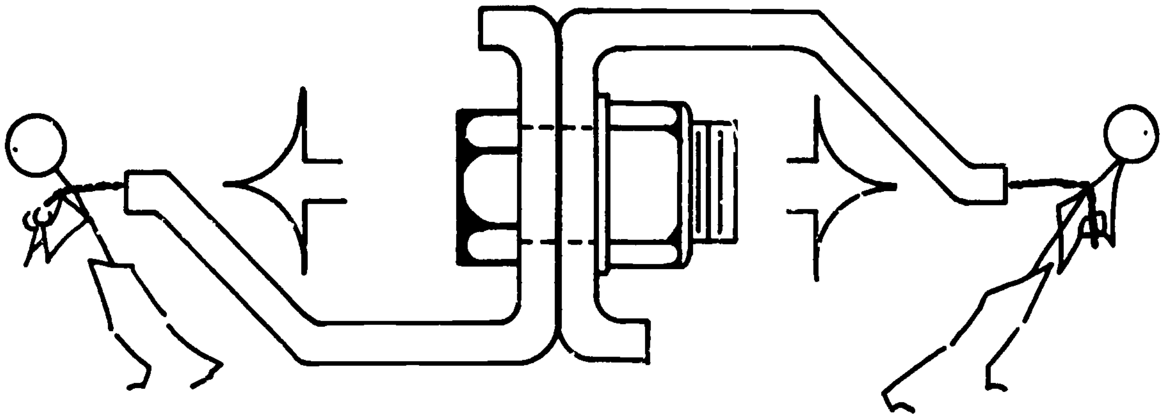
5. TENSILE STRENGTH - Tensile strength is a measure of the amount of stretch or elongation a bolt can stand and not tear apart. (Think of this as resistance to stretching or a straight line pull.)

6. SHEAR STRENGTH - Shear strength is a measure of the amount of side pressure a bolt can stand and not break in two. (Think of this as resistance to side pressure.)



Force in this direction causes SHEAR STRESS.

Frame 1 (Cont'd)

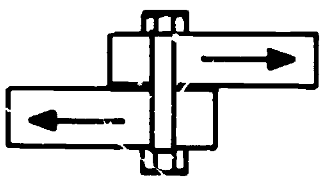


Force in this direction causes TENSILE STRESS.

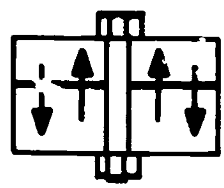
Identify the type of stress being applied to each bolt.

1. Tensile.

2. Shear.



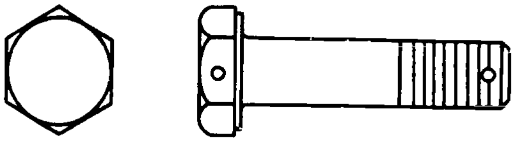
A.



B.

Three general types of bolts are: standard aircraft bolts, clevis bolts, and eyebolts.

Standard aircraft bolts (machine bolts) are all-purpose structural bolts used for general applications involving tension or shear loads. These bolts may or may not have a holed drilled in the shank or head; sometimes, both the head and the shank are drilled. The drilled hole in the head of the bolt is used when the bolt must be safety wired. The hole in the bolt shank is used when the nut must be secured by a cotter pin to keep it from turning or working loose.



STANDARD AIRCRAFT MACHINE BOLT

Answer the statements as true (T) or false (F).

1. Standard aircraft machine bolts sometimes have drilled shanks.

2. Standard aircraft machine bolts may not be used with safety wire.

Answers to Frame 1: 1. B, 2. A

Frame 3

The size of a bolt is determined by the diameter of the shank. The size wrench to use on it is determined by the distance across the flat part of the head. The length of a bolt is measured from below the head to the end of the threads. The grip length of a bolt is the unthreaded part of the shank.

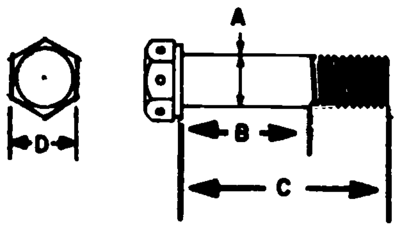
Match the names of the different parts of the bolt with the letters.

1. Diameter.

2. Length.

3. Grip.

4. Head (Wrench Size).



Answers to Frame 2: 1. T, 2. F

The grip length of a bolt should equal the thickness of the material it passes through. The threads should not bear on the material nor should the grip extend beyond the outer surface of the material.

Answer the statements as true (T) or false (F).

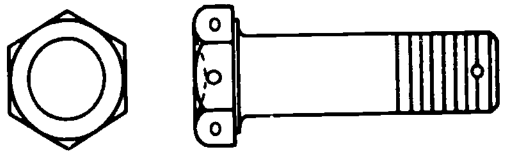
1. A bolt with a 1 inch grip length may be used to hold two pieces of 1/2 inch material together.

2. A bolt with a 1 inch grip length may be used to hold two pieces of 1/4 inch material together.

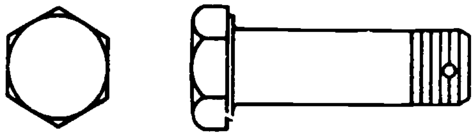
Answers to Frame 3: 1. a, 2. c, 3. b, 4. d

Frame 5

Close-tolerance hex head bolts are used where the bolted joint is subject to severe load reversals and vibration. The shank of this type bolt has a very accurate diameter (close-tolerance) which permits a very close fit in a close-tolerance hole. These bolts are available as tensile bolts with drilled heads or drilled shanks, and as shear bolts with or without a cotter pin hole.

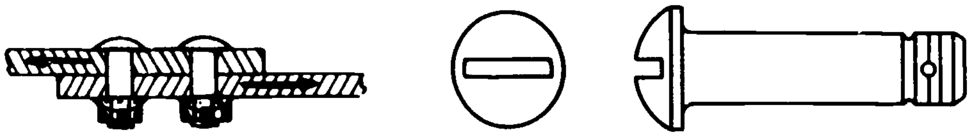


HEX HEAD, CLOSE-TOLERANCE TENSILE BOLT



CLOSE-TOLERANCE SHEAR BOLT

Clevis bolts are made of steel and are used in applications subject to shearing stress only, such as is shown in the illustration below. Note that the force exerted on the bolt is crosswise on the shank. Clevis bolts are also used as mechanical pins in control systems.



Answer the question.

1. Which bolt is used where resistance to shear is needed?

   a. Clevis bolt

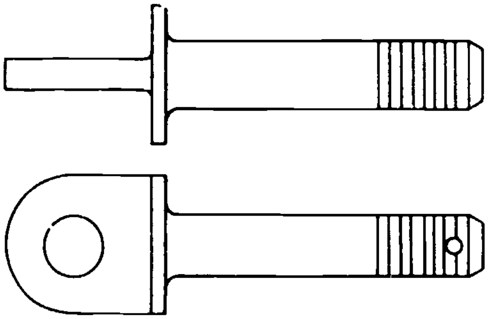
   b. Plain head aircraft bolt

   c. Drilled head aircraft bolt

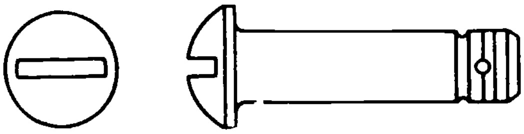
   d. Eyebolt

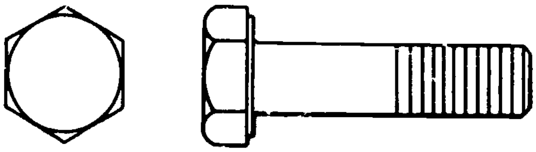
Answers to Frame 4: 1. T, 2. F

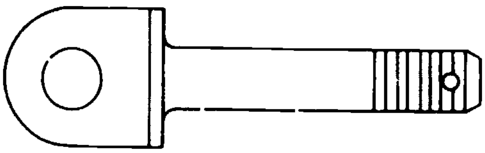
Eyebolts are used to carry external tension loads for the attachment of devices such as the fork of a turnbuckle, a clevis, or a cable shackle.



Match the illustrations to the correct name listed in the column on the right.

1. 

2. 

3. 

a. Standard Aircraft Bolt

b. Eyebolt

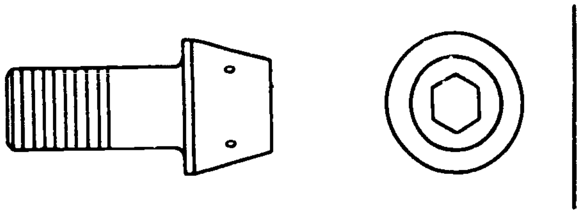
c. External Wrenching Bolt

d. Clevis Bolt

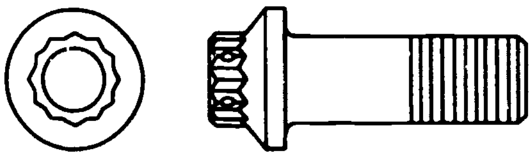
Answer to Frame 5: 1. a

Frame 7

Internal wrenching bolts are high strength steel bolts used in tension applications like bolting the wing on to the fuselage. The bolt hole must be countersunk to seat the larger corner radius of the shank at the head. If the bolt hole is not countersunk a special heat-treated washer must be used to fit the head and to provide a good bearing area. A special plain washer, also heat-treated, is used under the nut which is also a special nut for use with these bolts.



The external wrenching bolt has a 12-point head. This bolt has greater fatigue resistance and tensile strength, than conventional bolts.

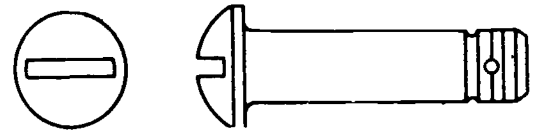


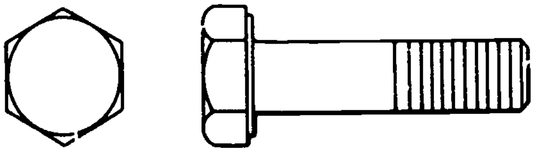
Is the statement TRUE or FALSE?

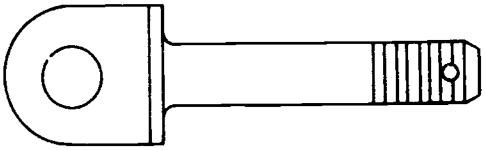
1. An internal wrenching bolt may be used with any type of nut.

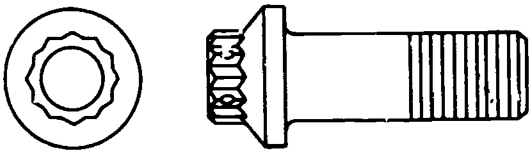
Answers to Frame 6: 1. d, 2. a, 3. b

Match the illustrations to the correct name listed in the column on the right.

1. 

2. 

3. 

4. 

a. Standard Aircraft Bolt

b. Eyebolt

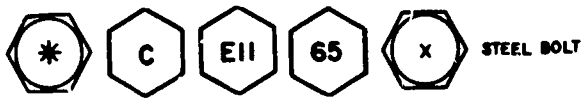
c. External Wrenching Bolt

d. Clevis Bolt

Answer to Frame 7: 1. FALSE

Frame 9

Bolt heads are marked with a code to identify their physical characteristics and materials. Steel bolts are marked with an asterisk (*), letters from A to Z, or numbers from 0 to 9, or any combination of letters, numbers, and an asterisk.

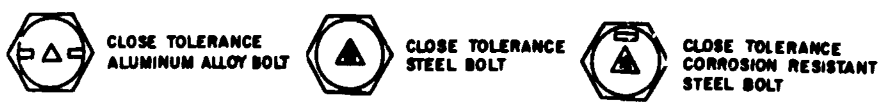


Aluminum bolts are marked with raised or recessed dashes on opposite sides of the head.

Steel and aluminum close-tolerance bolts are identified by a raised or recessed triangle on top of the head.

Corrosion resistant steel bolts are identified by a single raised or recessed dash on top of the head.

Some bolts may have a combination of materials or other characteristics, and are identified as shown.



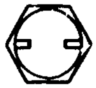
Answers to Frame 8: 1. d, 2. a, 3. b, 4. c

Match the bolts by identifying marks with the statements on the left.

1. Close Tolerance Aluminum Bolt

a. 

2. Steel Bolt

b. 

c. 

3. Corrosion Resistant Steel Bolt

d. 

4. Aluminum Bolt

e. 

5. Close Tolerance Bolt

f. 

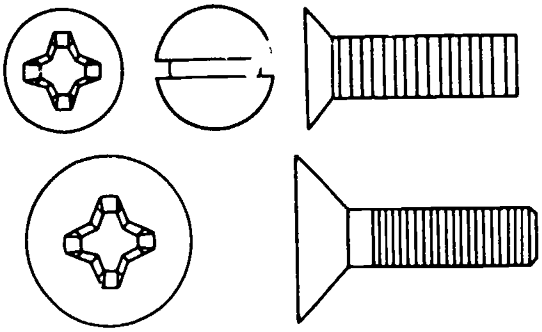
Frame 10

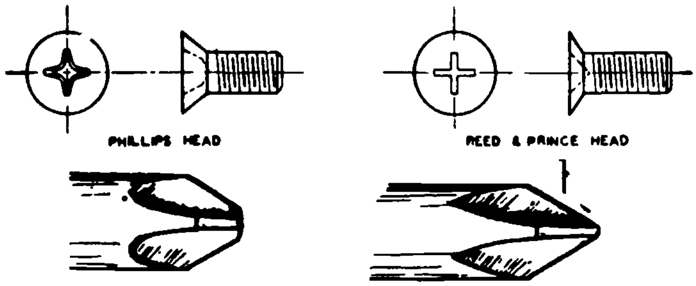
<u>Screws</u> are the most common type of fasteners used on aircraft. They differ from bolts mainly by having a lower material strength and a loose thread fit. The different types of screws have various type of slots or recesses. For each type of screw a particular type of screwdriver is used. To prevent damaging the screw head and the screwdriver, always use a screwdriver that will match the slot.

NO RESPONSE REQUIRED

Answers to Frame 9: 1. d, 2. c, 3. e, 4. b, 5. a

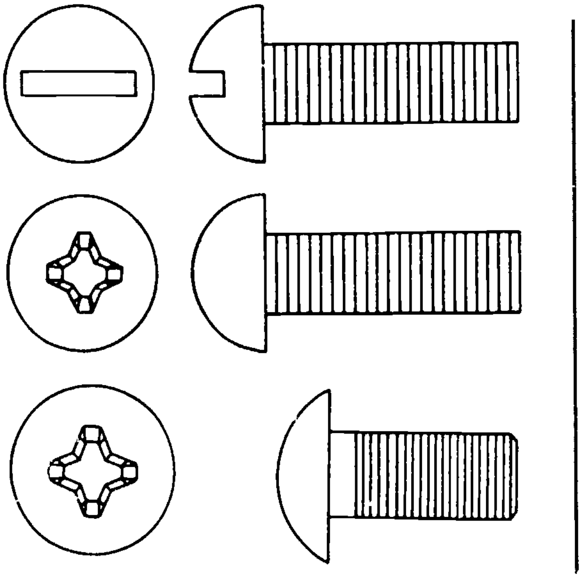
Flathead machine screws are used in countersunk holes where a flush surface is desired. These screws have various types of screwdriver slots. Such as; the Phillips, the Reed and Prince (crosspoints) and the common slot. To recognize the Reed and Prince, look for the square cut corners of the screw slot and the sharp point of the screwdriver. The Phillips screw slot is larger with curved corners and the screwdriver point is blunt.





PHILLIPS TYPE   REED & PRINCE TYPE

General purpose roundhead machine screws, like flathead machine screws, are made from different materials. They may have coarse or fine threads and slotted or recessed heads. Brass roundhead machine screws, with a slotted head are for electrical use only.



Answer to Frame 10: None Required

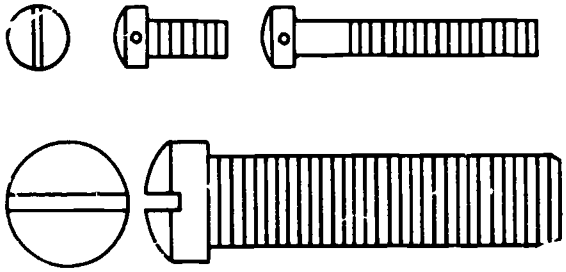
Frame 11 (Cont'd)

Answer the questions, by supplying the information required, or by indicating TRUE or FALSE.

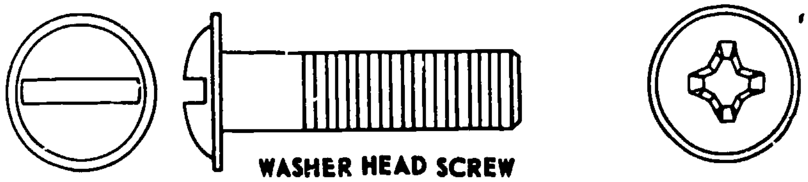
1. A flathead machine screw is used in a ________________ hole where a flush surface is required.

2. A brass roundhead machine screw is designed for general purpose use.

Fillister head machine screws are used as general purpose screws. The head are usually drilled for safety wire. Fillister head screws are made of steel and brass, and have coarse or fine threads.



The washer head screw, while not a machine screw, is used in much the same way that structural bolts and rivets are used. These screws have a high tensile strength and differ from structural bolts only in the type of head.



Complete the statement.

1. The type of screw which has a drilled head, for safety-wiring, is the

   a. washer head screw.

   b. flathead machine screw.

   c. fillister head machine screw.

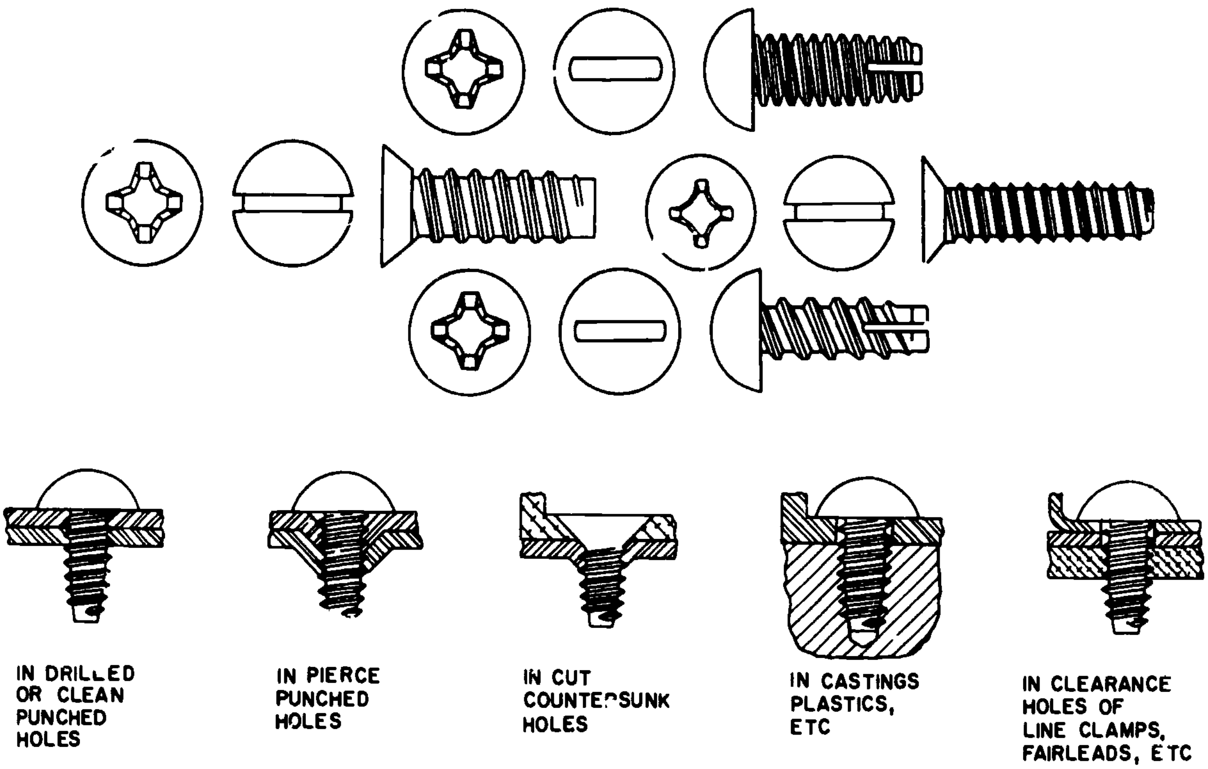
   d. roundhead machine screw.

Answers to Frame 11: 1. countersunk, 2. FALSE

Frame 13

Self-tapping screws tap their own threads. The screw should be used in untapped or punched holes slightly smaller than the outside diameter of the screws.

Self-tapping sheet metal screws are used for attaching sheet metal for riveting and for permanent assembly of nonstructural assemblies. Sheet metal screws are hardened for use on steel or aluminum sheets. They may also be used on plastic.



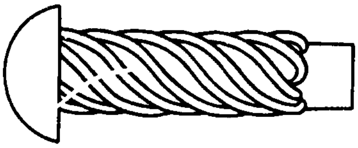
Using Sheet Metal Screws

Is the following statement TRUE or FALSE?

1. In a permanent installation, sheet metal screws must be used in tapped holes or with self-locking nuts.

Answer to Frame 12: 1. c

Drive screws are self-tapping screws used to attach nameplates to castings. The screws are also used to seal drain holes in flat structures. They differ from other self-tapping screws in that the heads are not formed to fit screwdrivers. They are not designed to be removed after installation. Drive screws are installed by driving the screw into a hole with a hammer.



ROUNDHEAD DRIVE SCREW

Complete the statement.

1. The correct tool for installing a drive screw is

   a. Phillips screwdriver.

   b. Reed and Prince screwdriver.

   c. common screwdriver.

   d. hammer.

Answer to Frame 13: 1. FALSE

Frame 15

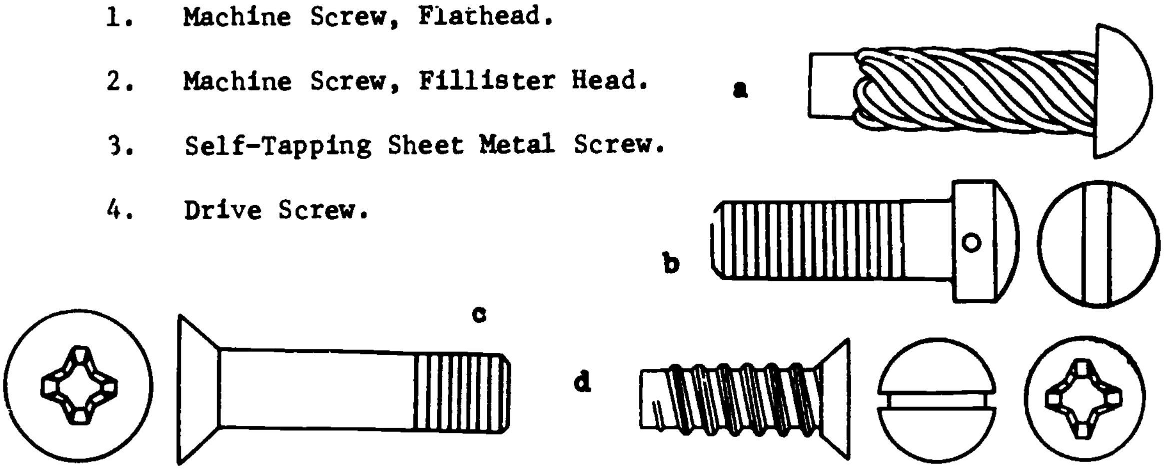
Match the screws with the correct nomenclature.

1. Machine Screw, Flathead.

2. Machine Screw, Fillister Head.

3. Self-Tapping Sheet Metal Screw.

4. Drive Screw.

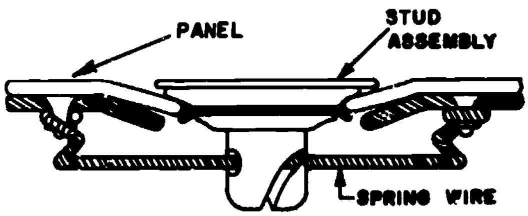


Answer to Frame 14: 1. d

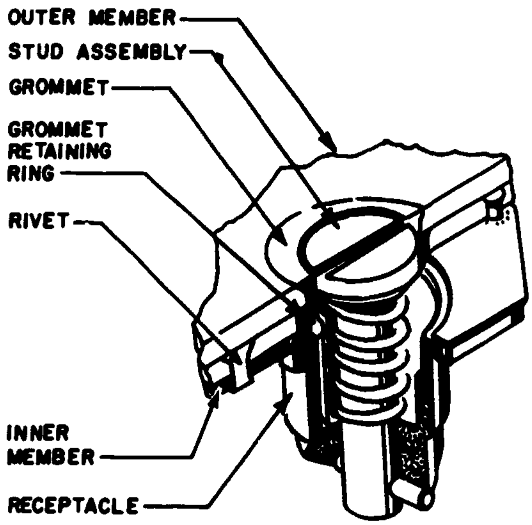
Quick release fasteners are used on aircraft access panels, plates, etc. where quick or frequent access is necessary. The two types of fasteners are the turnlock (Dzus) and Camlock. The advantage of these fasteners is that one-quarter turn locks or unlocks them.

Turnlock fasteners (see illustration "A") are made to be used on cowling (engine covering) and access doors, where there is no structural stress required.

Camlock fasteners (see illustration "B") are of high strength and are used in some areas on access panels and doors where some stress is required.



TURNLOCK FASTENER
"A"



CAMLOC FASTENER
"B"

Answer the statements as true (T) or false (F).

1. Fasteners are used where frequent and quick accesses are required.

2. Turnlock fasteners can carry high structural stresses.

Answers to Frame 15: 1. c, 2. b, 3. d, 4. a

Frame 17

Select the correct answer.

1. What type of screw is used to attach panels to aircraft where there is a threaded hole in the aircraft?

   a. Machine screw

   b. Drive screw

   c. Sheet metal screw

   d. Crosspoint screw

2. The type of machine screw which has a drilled head for securing safety wire is the

   a. flathead machine screw.

   b. washer head structural screw.

   c. roundhead machine screw.

   d. fillister head machine screw.

3. For quick access panels, cowling and plates are secured to the aircraft with

   a. flathead machine screws.

   b. sheet metal screws.

   c. fasteners.

   d. fillister head machine screws.

4. A screw that has high tensile strength and is used in the primary structure of aircraft is the

   a. sheet metal screw.

   b. drive screw.

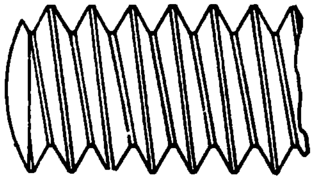
   c. crosspoint screw.

   d. washer head screw.

Answers to Frame 16: 1. T, 2. F

The more common forms of screw threads are known as unified national and American national taper pipe thread. Unified national screws are made with coarse, fine, and extra fine threads. See the illustration below.

Screw Thread Forms.



① UNIFIED NATIONAL SCREW THREAD

② AMERICAN NATIONAL TAPER PIPE THREAD

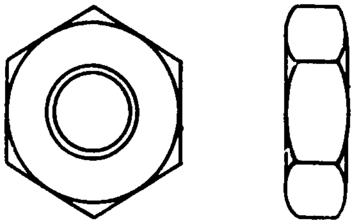
Answer the following TRUE or FALSE.

1. The unified national screw thread has a taper.

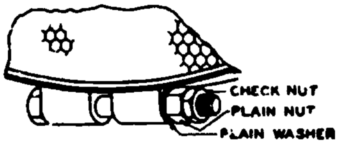
Answers to Frame 17: 1. a, 2. d, 3. c, 4. d

Frame 19

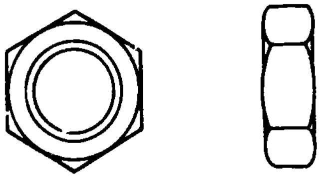
Plain nuts are not self-locking. When these nuts are used, they shall be locked with some type of locking device. The device can be a checknut or lockwasher.



Safetying by Use of Nuts.

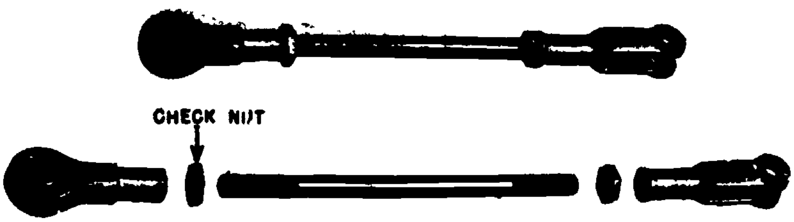


A checknut is a type of plain nut used to lock a plain nut. They are also used as locking devices for set screws and threaded rod ends. Shown are two ways checknuts are used. Study the illustrations above and below. Checknuts are thinner than plain nuts.



Is the following statement TRUE or FALSE?

1. An alternate method of locking (safetying) a nonself-locking plain nut is through the use of safety wire.

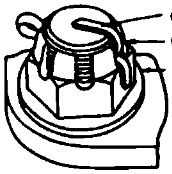


Answer to Frame 18: 1. FALSE

Castellated nuts are used on drilled shank bolts, clevis bolts, and drilled head studs. These nuts can be secured with cotter pins or safety wire. The multiple slot arrangement permits proper adjustment of tension with the correct alignment of slots and holes.

CASTELLATED NUT

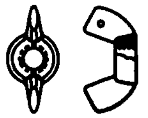
The illustration below shows how to use a cotter pin to secure a castellated nut. Shear nuts are also made for use with devices, such as: clevis bolts and threaded taper pins that are subjected to stress instead of tension. A shear nut has at least three threads below the castellations. Shear nuts are thin and are available in the self-locking style.



Safetying by Use of Cotter Pins.

SHEAR NUT

The wingnut is used where the desired tightness is obtained by the use of the fingers and where the assembly is frequently removed. When safetying of this nut is required, a hole is drilled through one of the "wings" and secured with safety wire.



WING NUT

Answer the statements as true (T) or false (F).

1. The correct use for a castellated nut is with a drilled head bolt.

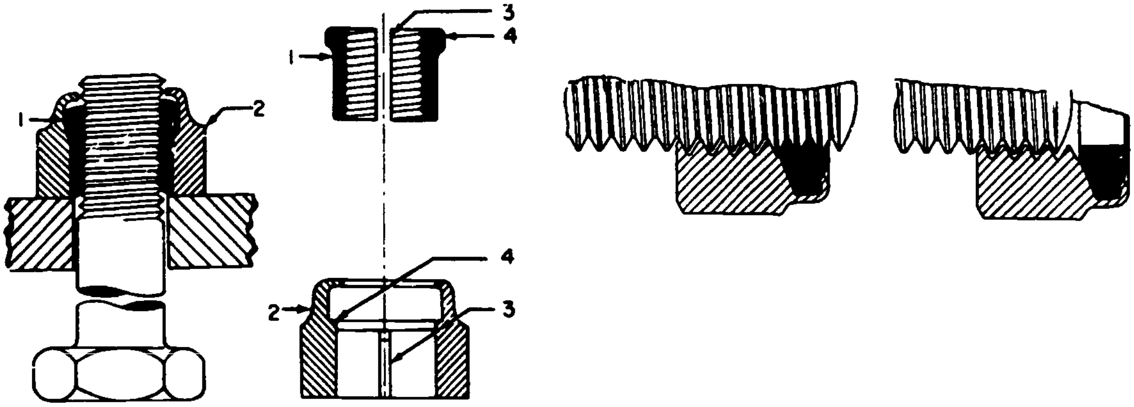
2. A shear nut is most generally used with a clevis bolt.

3. Wing nuts are used where the desired tightness is obtained by the use of the fingers.

Answer to Frame 19: 1. FALSE

Frame 21

<u>Nonmetallic type self-locking nuts</u> have a nylon insert. The insert has a smaller inside diameter than that of the bolt. The nylon puts a locking force on the bolt.



1 THREADED NUT CORE
2 NUT CASE
3 KEYWAY
4 LOCKING SHOULDER

<u>Nonmetallic self-locking nuts shall not be subjected to temperatures in excess of 250 degrees Fahrenheit</u>. As illustrated in the diagram, self-locking nuts are available in thick or thin styles.

SELF LOCKING NUTS

<u>All metal self-locking nuts</u> are similar to nonmetallic self-locking nuts except the type of insert. The nuts are used where temperatures are extremely high (3060°F. Exhaust section of jet engine). The all-metal self-locking nut has threads out of phase or pinched in at the top to bind the bolt and maintain tightness.

New self-locking nuts must be used each time components are installed in critical areas throughout entire aerospace vehicle including all flight, engine, turbopropeller, and fuel control linkage and attachments.

Answers to Frame 20: 1. F, 2. T, 3. T

Complete the statement.

1. The type of nut, which must not be used in applications where the temperature is above 250 degrees Fahrenheit, is the

   a. castellated nut.

   b. all-metal self-locking nut.

   c. nonmetallic self-locking nut.

   d. plain nut.

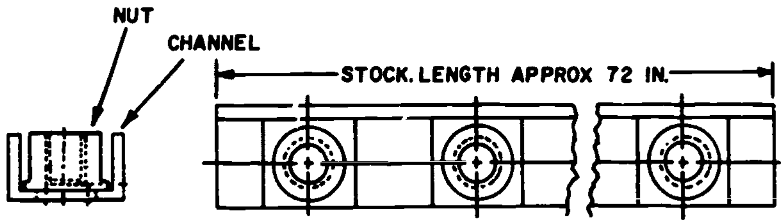
Frame 22

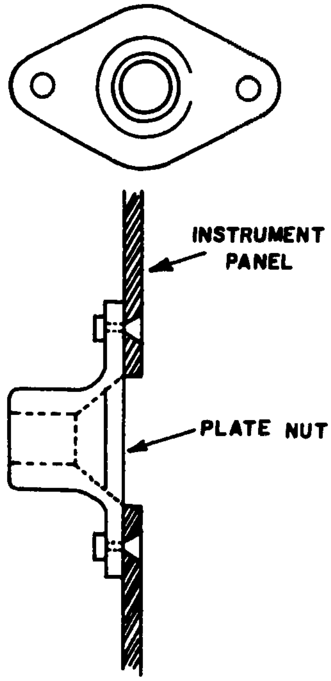
Match the descriptions on the right with the names on the left.

1.	Nonmetallic self-locking nut	a.	has slots at the top to be used with drilled bolts with a cotter pin to maintain its position.
2.	Castellated nut	b.	has threads out of phase or pinched in at the top to bind on the bolt and maintain tightness.
3.	All metal self-locking nut	c.	requires an auxiliary lockin device, such as a check-nut or lockwasher.
4.	Plain nut	d.	has a nylon insert at the top to bind on the bolt and maintain tightness.

Answer to Frame 21: 1. c

<u>Plain</u> <u>nuts</u> are used for blind mounting and for easier maintenance. They can be either self-locking or plain. They are made in a wide range of sizes and shapes. One lug, two lugs, and right-angle shapes are made to fit various nut locations. <u>Floating-type</u> <u>nuts</u> give a controlled amount of nut movement to compensate for subassembly misalignment during installation.





<u>Gang</u> <u>channel</u> <u>nuts</u> are used where anchored nuts must be equally spaced around openings. Some examples are access and inspection doors and removable leading edges. Straight or curved channel strips give a wide range of nut spacing. They are a multiple nut unit that has all advantages of float-type nuts. They are self-locking.

Answer the statements as true (T) or false (F).

1. Plate nuts are used for mountings that are easy to reach.

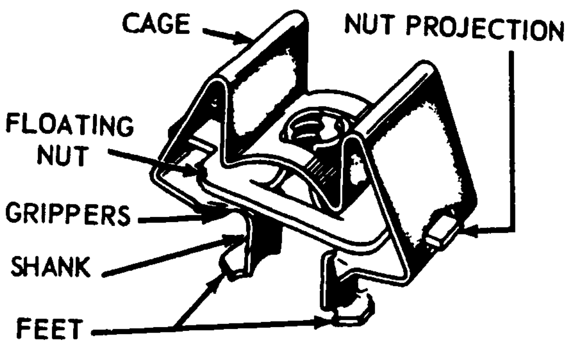
2. A float-type nut has some movement to compensate for misalignment of subassemblies.

3. Gang channel nuts are anchored and equally spaced.

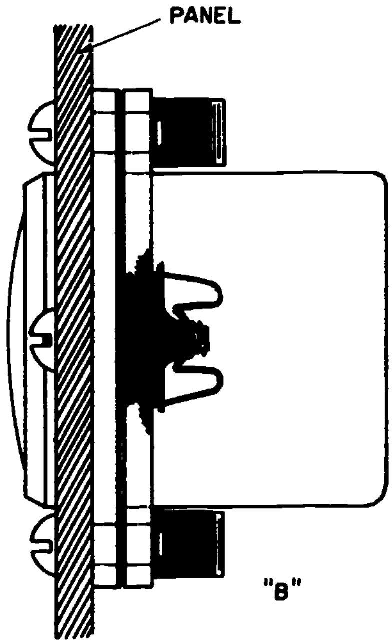
Answers to Frame 22: 1. d, 2. a, 3. b, 4. c

Frame 24

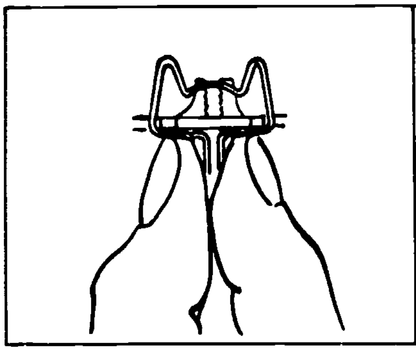
Instrument mounting nuts are used for front mounting of aircraft instruments. The nuts may be put in the instrument for rear mounting (see illustration "B"). The nut is made of nonmagnetic material and is used just with a standard instrument mounting screw, size 6-32. The names of the parts of the nut are shown in illustration "A". There are several shank lengths to fit the different panels and bezel thicknesses. Illustrations "C" through "F" shows how a nut is put in the instrument panel.



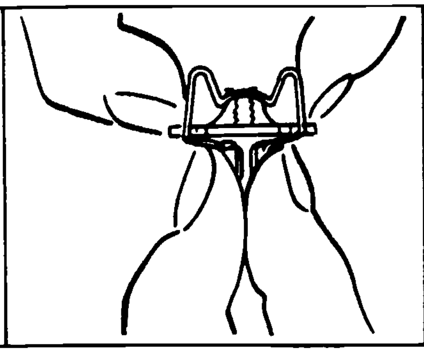
"A"



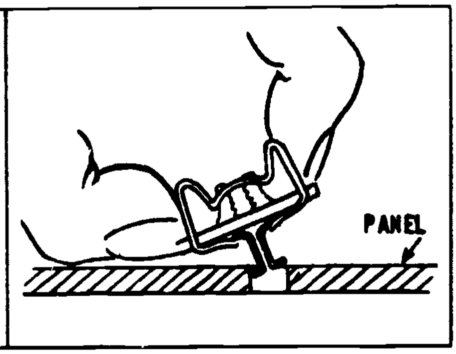
"B"



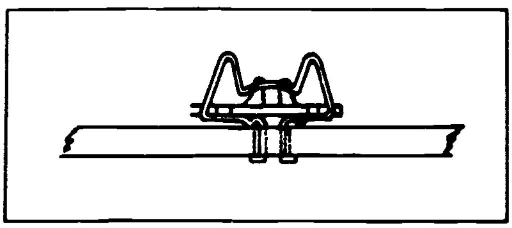
"C"



"D"



"E"



"F"

Answers to Frame 23: 1. F, 2. T, 3. T

Answer the statements as true (T) or false (F).

1. Instrument mounting nuts come in several sizes.

2. Instrument mounting nuts can be used on front mounted instruments only.

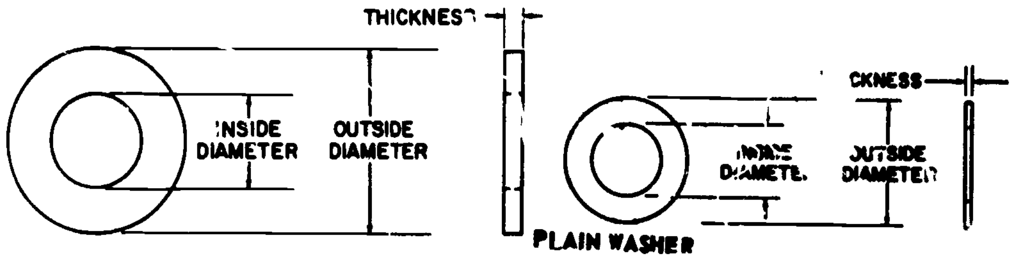
3. Instrument mounting nuts are available in several different shank lengths.

4. Instrument mounting nuts that are attached to the instrument would require the instrument to be rear mounted.

Frame 25

The types of washers used in aircraft structures are plain washers, lockwashers, and special washers.

Plain washers are used under nuts to provide a smooth bearing surface. They can be used as shims to adjust the posiiton of castellated nuts with respect to drilled cotter pin holes in bolts. They are also used under lockwashers to prevent damage to surfaces of soft material.



Complete the statement.

1. Plain washers are used under nuts to

   a. prevent a galvanic action from dissimilar metals.

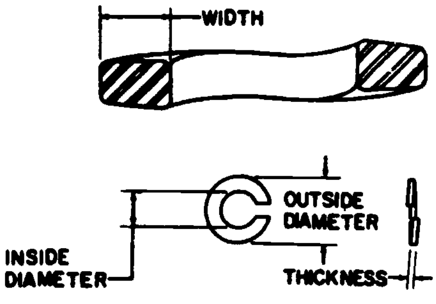
   b. provide a smooth bearing surface.

   c. prevent loosening of threaded fasteners.

   d. act as shims between the threads of bolts and nuts.

Answers to Frame 24: 1. F, 2. F, 3. T, 4. T

Lockwashers are used with plain nuts when self-locking or castellated type nuts are not used. The spring action of the washer keeps the nut from working loose. Lockwashers are not to be used where failure of the washer might cause damage or danger to aircraft or personnel. The following diagram shows a lockwasher.



LOCKWASHER

Complete the statement.

1. Lockwashers are used with plain nuts

   a. when self-locking or castellated type nuts are not applicable.

   b. on primary and secondary structures.

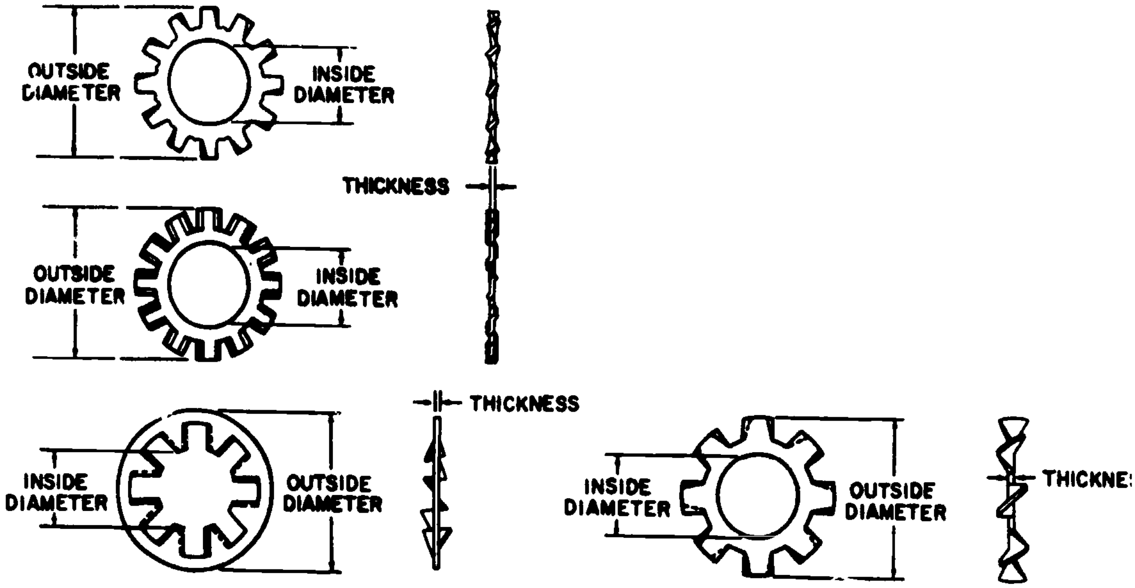
   c. on soft metals without plain washers.

   d. on exposed surfaces subject to airflow.

Answers to Frame 25: 1. b, d

Frame 27

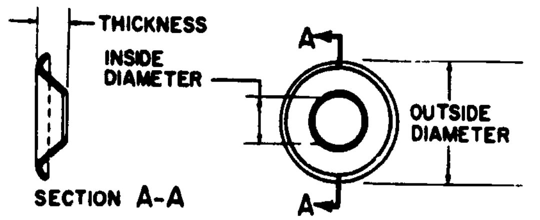
Some types of lockwashers have internal or external teeth. The teeth are twisted slightly to provide a locking effect when tightened.



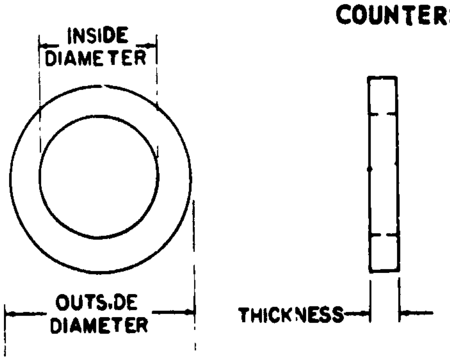
INTERNAL TEETH EXTERNAL TEETH

LOCKWASHER

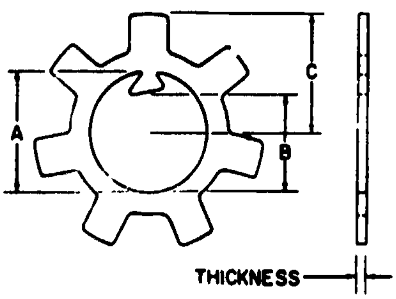
There are many types of special washers, used in various applications. Some special washers are shown in the diagrams below. These are finishing washers, phenolic fiber washers and tab type washers., On the tab type washer one or more of the tabs are bent up against the tightened nut to prevent it from loosening.



COUNTERSUNK TYPE, FINISHING WASHER



FLAT, PHENOLIC FIBER WASHER

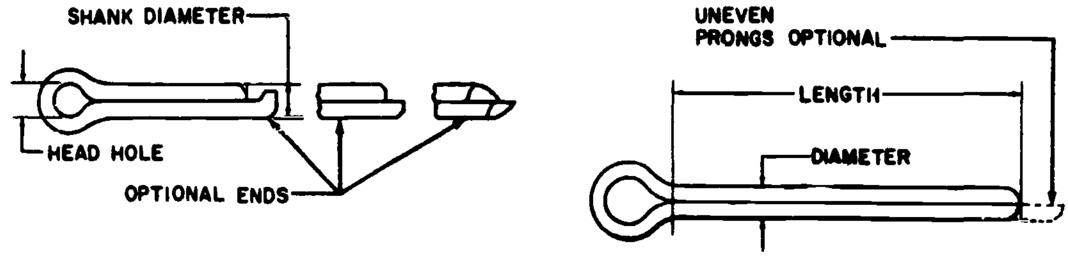


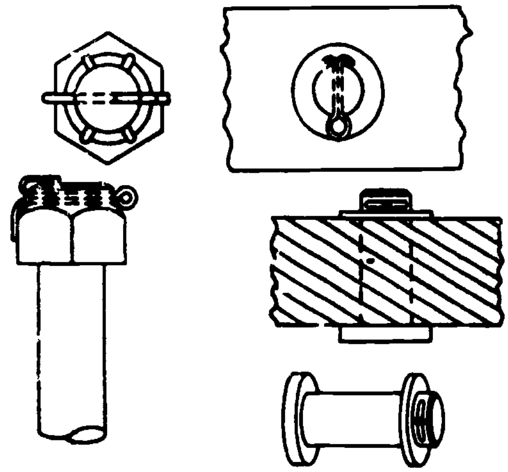
TAB TYPE WASHER

NO RESPONSE REQUIRED

Answer to Frame 26: 1. a

Cotter pins are used to secure bolts, screws, castellated nuts, and pins. A cotter pin is a "split" metal pin that is put in a hole and then spread apart, one half each way. Cotter pins are used for they can be removed and installed quickly. Cotter pins are made in various lengths and diameters. The size of a pin should be the largest size that will fit in a cotter pin hole and/or the slots in a nut. The following diagrams show some of the types of cotter pins and methods of securing them.





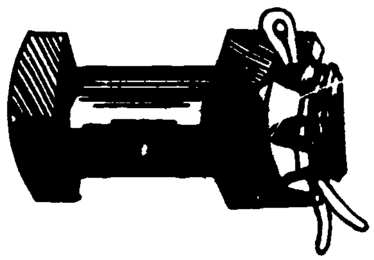
Securing With Cotter Pins

Answer to Frame 27: None Required

Frame 28 (Cont'd)

Answer the question.

1. What is the purpose of the cotter pin installed as shown in the diagram below?



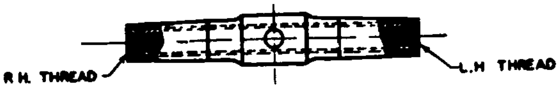
a. To keep the nut from wobbling and thereby ruining the nut threads.

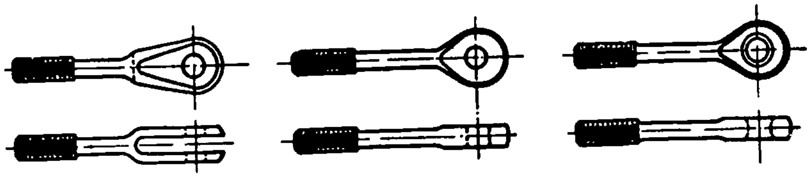
b. To hold the bolt in place.

c. To keep the nut from damaging the bolt threads.

d. To keep the nut from loosening.

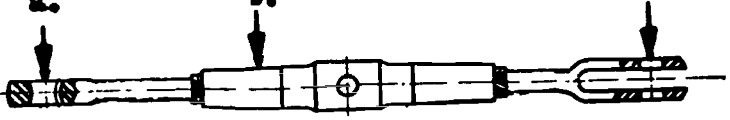
The turnbuckle used to adjust the tension on aircraft cables. It has a brass barrel with right-hand threads in one end and left-hand threads in the other. The three types of turnbuckle ends are: fork, pin eye, and cable eye. These parts are shown below. Take a look at t! /ith the left and right-hand threads in the barrel, turning the ... one way will tighten both ends and the other way will loosen both ends.





Match the letters to the names on the left.

1. Barrel.
2. Fork End.
3. Cable Eye End.



Answer the question.

4. What is the designed use of a turnbuckle?

   a. Holds two pieces of metal securely together.

   b. Used to safety a cable connection.

   c. To determine if a bolt has left or right-hand threads.

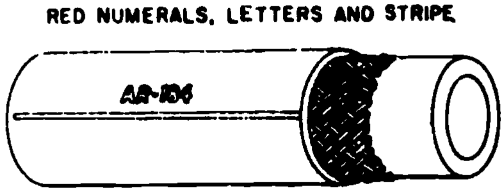
   d. Used to adjust cable tension.

Answer to Frame 28: 1. d

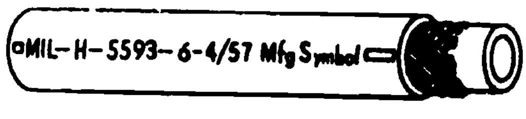
Frame 30

Flexible hose and flexible hose assemblies are used when there is an excessive amount of vibration. They are also used wnen the units they connect moves during flight.

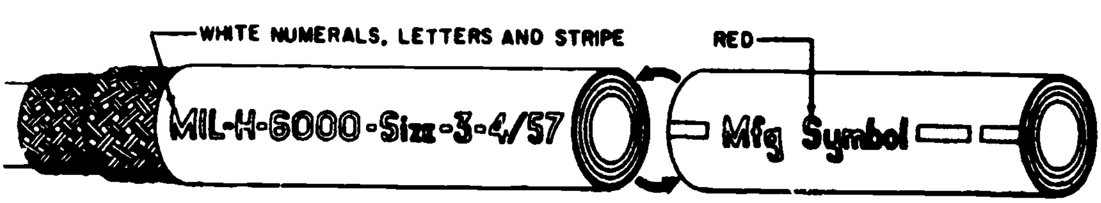
Flex'ble hose is marked with a series of dots, dashes and letters (as shown below). These markings are used for identification. The markings are color coded to show different types of hose. The markings on the hose show several things: manufacturer, the military specification, the size, and the date it was made. The size of the hose is the inside diameter measured in sixteenths of an inch. The manufacture date is shown by the quarter of the year and year the hose was made.



Self-Sealing, Aromatic-Resistant Hose.



Nonself-Sealing, Aromatic-Resistant Hose, Military Specification MIL-H-5593 (NOT HEAT RESISTANT)



(VIEWS SHOWING OPPOSITE SIDES OF HOSE)

Nonself-Sealing, Aromatic- and Heat-Resistant Hose, Military Specification MIL-H-6000

NO RESPONSE REQUIRED

Answers to Frame 29: 1. b, 2. c, 3. a, 4. d

Like the flexible hose, tubing is measured in sixteenths of an inch. However, tubing is measured on the outside diameter. If a tube is 1/2 inch in diameter it would be referred to as a number 8 tube. This is because 1/2 inch is 8 sixteenths of an inch. Tubing size varies from 1/8 inch to 2 1/4 inches. This is shown as a number 2 to a number 36.

Is the following statement TRUE or FALSE?

1. A number 6 fitting would be used with 3/8 inch OD tubing.

Answer to Frame 30: None Required

Frame 32

The tubing used in aircraft systems is made of aluminum alloy. Aluminum tubing is light and can be formed and bent easily; therefore, care must be taken in handling it so that it will not be damaged. Corrosion resistant steel tubing, is stronger but not as easily formed, is used on hydraulic systems operating at 3,000 psi or higher.

Tubing size is found by measuring the outside diameter (OD) in sixteenths of an inch. The top half of the fraction is the tubing size number. Example: A 1 inch OD tube is called number 16 tubing. 1" = 16/16ths = #16 tubing. 7/8 inch tubing is number 14 tubing 7/8" = 14/16ths = #14 tubing.

Match each size tubing the outside diameter measurement on the right.

1.	Number 4 tubing	a.	5/8" OD
2.	Number 6 tubing	b.	1/4" OD
3.	Number 8 tubing	c.	1/2" OD
4.	Number 10 tubing	d.	3/4" OD
5.	Number 12 tubing	e.	3/8" OD

Frame 33

Match the outisde diameter measurements on the left with the tubing sizes on the right.

1.	1 1/2" OD tubing	a.	Number 1 1/2 tubing
2.	1 1/4" OD tubing	b.	Number 16 tubing
		c.	Number 1 1/4 tubing
		d.	Number 20 tubing
		e.	Number 24 tubing

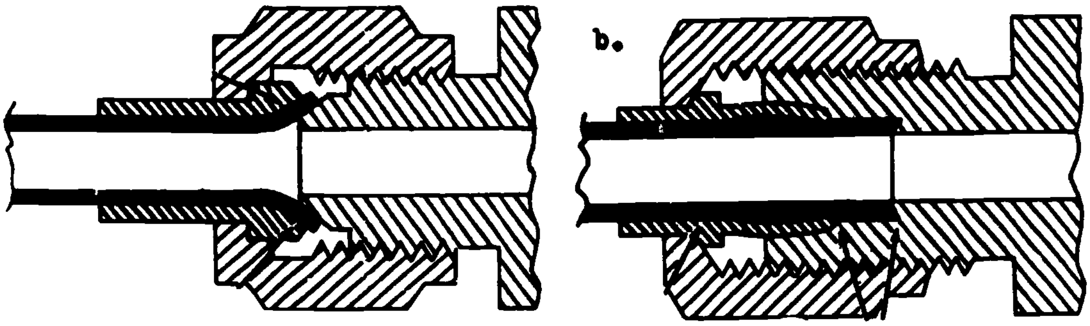
\nswer to Frame 31: 1. TRUE

The size of a fitting is determined by the outside diameter of the tubing to which it connects.

The Air Force uses two types of fittings with tubing: AN FLARE fittings, and MS FLARELESS fittings. AN fittings have a sleeve with a beveled edge to fit the flare of the tubing and to form a seal when the tubing nut is drawn tight. Tubing used with MS fittings is not flared. When the tubing nut is tightened on an MS fitting the sleeve is wedged between the tubing and the fitting to form a seal. The torque on MS fittings is critical. Too much torque will cause them to leak.

Match the two illustrations with the correct name.

1. AN fitting.
2. MS fitting.



Answer the questions.

3. What type fitting is used with tubing that is not flared?

   a. AN fitting

   b. MS fitting

   c. Both

   d. Neither

4. What type fitting is used with flared tubing?

   a. AN fitting

   b. MS fitting

   c. Both

   d. Neither

Answers to Frame 32: 1. b, 2. e, 3. c, 4. a, 5. d

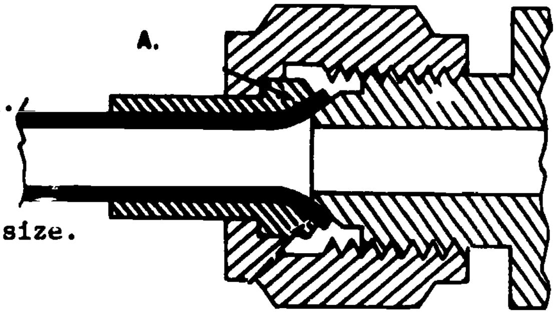
Answers to Frame 33: 1. e, 2. d

Frame 34 (Cont'd)

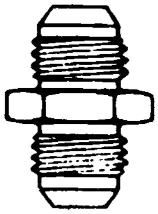
Match the illustrations with the correct uses.

5. Used when tubing is not flared.
6. Connects different sized tubing.
7. Used with flared tubing.
8. Connects two tubes of the same size.

A.

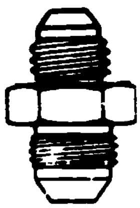


B.



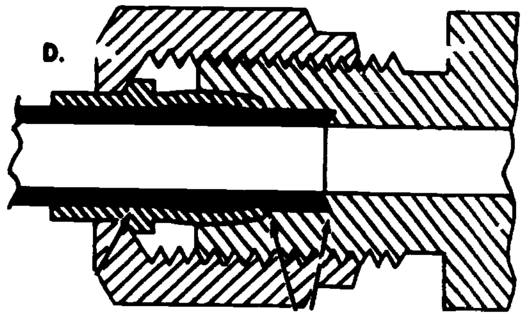
(UNION)

C.



(REDUCER)

D.



Frame 35

Fitting types and material are identified by color. Aluminum AN fittings are blue. Steel AN fittings are black. Aluminum MS fittings are gray or light yellow. Steel MS fittings are dark yellow. These fittings are not interchangeable. Steel fittings are used for high pressure where aluminum fittings will not hold. AN fittings must have flared tubing while MS fittings will not fit flared tubing.

Match the identifying color with each type fitting.

1.	MS aluminum fitting.	a.	Dark yellow
2.	AN aluminum fitting.	b.	Blue
3.	MS steel fitting.	c.	Gray or light yellow
4.	AN steel fitting.	d.	Silver
		e.	Black

Frame 36

Match the information below.

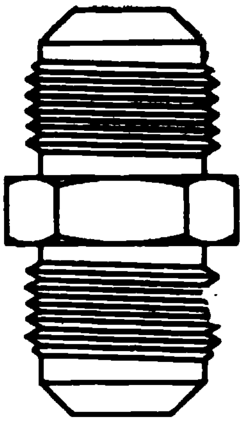
1.	Connects different sized tubing.	a.	Reducer
2.	Used where tubing is flared.	b.	Union
3.	Connects two pieces of the same size tubing	c.	MS fitting
4.	Used with flareless tubing.	d.	AN fitting

Frame 37

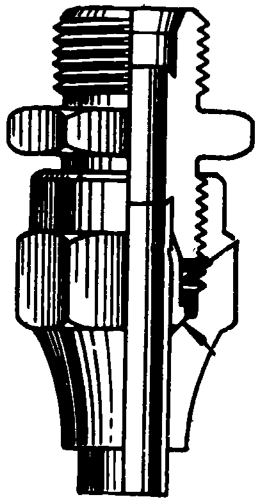
Match the illustrations to their names.

1. AN fitting.
2. MS fitting.
3. Union.
4. Reducer.

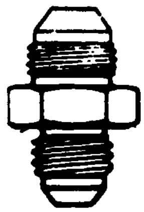
a.



b.



c.



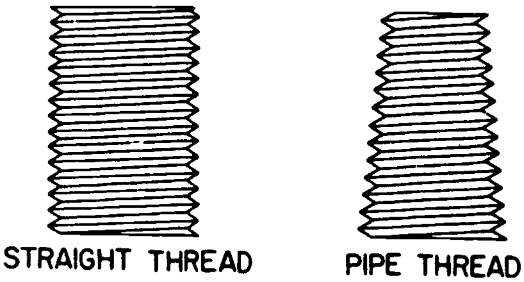
Answers to Frame 34: 1. a, 2. b, 3. b, 4. a, 5. d, 6. c, 7. a, 8. b

Answers to Frame 35: 1. c, 2. b, 3. a, 4. e

Frame 38

AN standard fittings should be used in preference to all other flared fittings. Fitting sizes must match to the size of tubing they are used with. Tubing fittings have either tapered pipe threads or straight threads. Pipe thread fittings are made in a cone shape. Straight threads are the same in diameter the entire length of the threads.

The hole the pipe thread fitting goes into is tapered like the fitting. As the pipe thread fitting is screwed in, its threads seal against the threads of the hole.



NO RESPONSE REQUIRED

Answers to Frame 36: 1. a, 2. d, 3. b, 4. c

Answers to Frame 37: 1. a, 2. b, 3. a, 4. c

Fitting types and materials are identified by color. AN aluminum fittings are blue. AN steel fittings are black. Aluminum bronze fittings are cadmium plated and are not otherwise colored. These fittings are not interchangeable, because if two dissimilar (unlike) metals are brought together they will corrode. Corrosion can cause a potential fire hazard in the presence of oxygen, or a weakness in the metal.

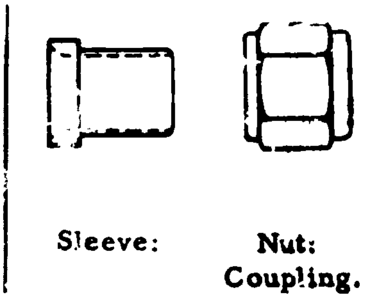
Match the identifying color with each type of fitting.

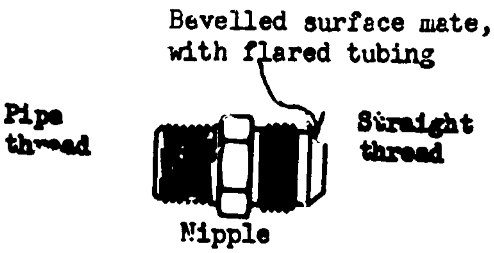
1. AN aluminum fitting.	a. Dark yellow
2. AN steel fitting.	b. Blue
	c. Gray or light yellow
	d. Silver
	e. Black

Answer to Frame 38: None Required

Frame 40

A flare and a sleeve, with a nut, are used when connecting straight threads to tubing. The sleeve is used to seal the tubing to the nut and to the fitting. The nut, of course, is used to connect the tubing to the fitting. The nipple is used to connect a piece of tubing to a device having pipe threads.



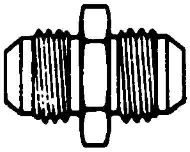


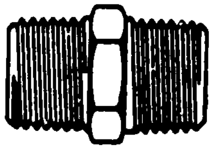
The flared tubing fittings most commonly used in the tubing systems of aircraft is the coupling nut and sleeve.

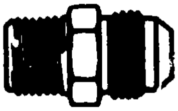
NO RESPONSE REQUIRED

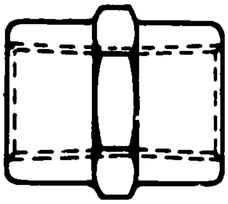
Answers to Frame 39: 1. b, 2. e

Match the fittings to the descriptions.

a. 

 b.

c. 

 d.

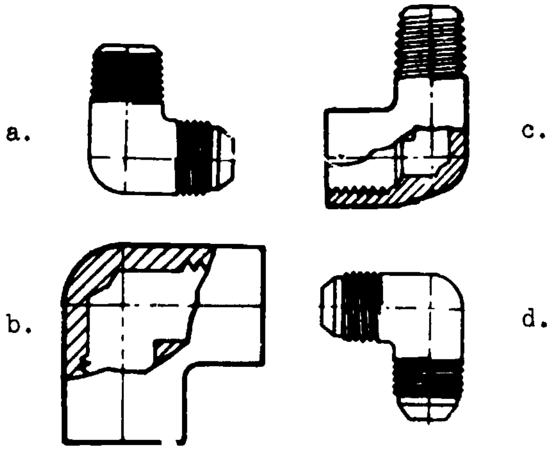
1. Nipple, flared tubing to pipe.
2. Nipple, pipe thread on both ends.
3. Union, flared tube.
4. Coupling, internal pipe thread.

Answer to Frame 40: None Required

Frame 42

In this and the following frames you will be shown various AN fittings. You may well encounter these fittings at a later time in the performance of your job. Study the illustrations carefully. Then you will demonstrate your ability to identify these fittings. Let's see how well you do with the following.

Match the fittings to the descriptions.



1. Elbow, 90° flared tube.

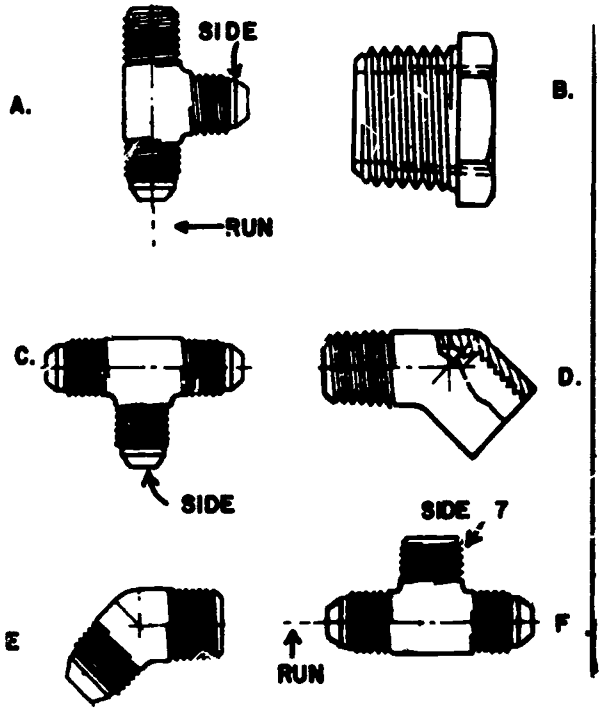
2. Elbow, 90° internal and external pipe threads.

3. Elbow, 90° internal pipe threads.

4. Elbow, 90° flared tube to pipe.

Answers to Frame 41: 1. c, 2. b, 3. a, 4. d

Match the illustrations with their correct descriptions.



1. Bushing, reducer.
2. Tee, flared tube.
3. Elbow 45° internal and external pipe threads.
4. Tee, flared tube, pipe thread on side.
5. Elbow 45° flared tube to pipe.
6. Tee, flared tube, pipe thread on the run.

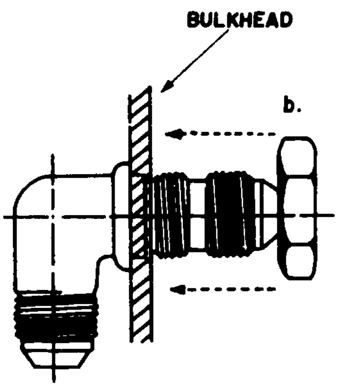
Answers to Frame 42: 1. d, 2. c, 3. b, 4. a

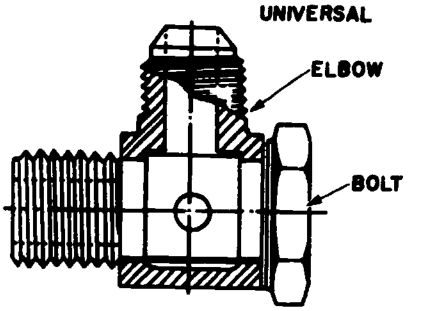
Frame 44

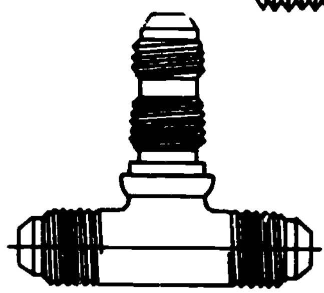
Bulkhead and universal fitting combinations can be mounted, solidly to a bulkhead or component with one outlet adjusted to any angle. "Bulkhead" means that the fitting is long enough to go through a bulkhead. "Universal" means that the fitting can be set at any angle, using a universal fitting bolt.

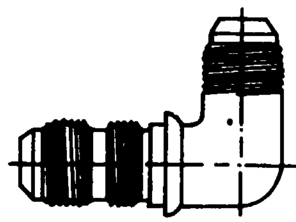
When installing a bulkhead fitting, a jam nut is used to hold the fitting securely in the bulkhead. This is shown in the following illustration. Fittings with evidence of visible damage, (stripped threads, deep gouges and nicks, wrench jaw marks, etc) will be replaced.

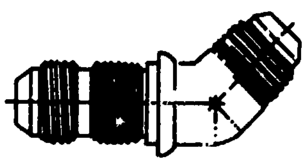
Match the fittings to the correct name.

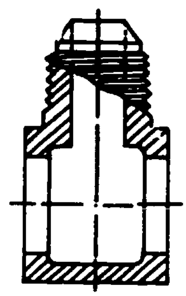


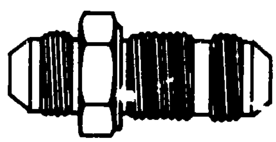


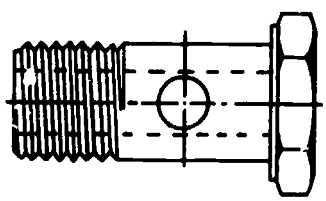
a. 

 d.

b. 

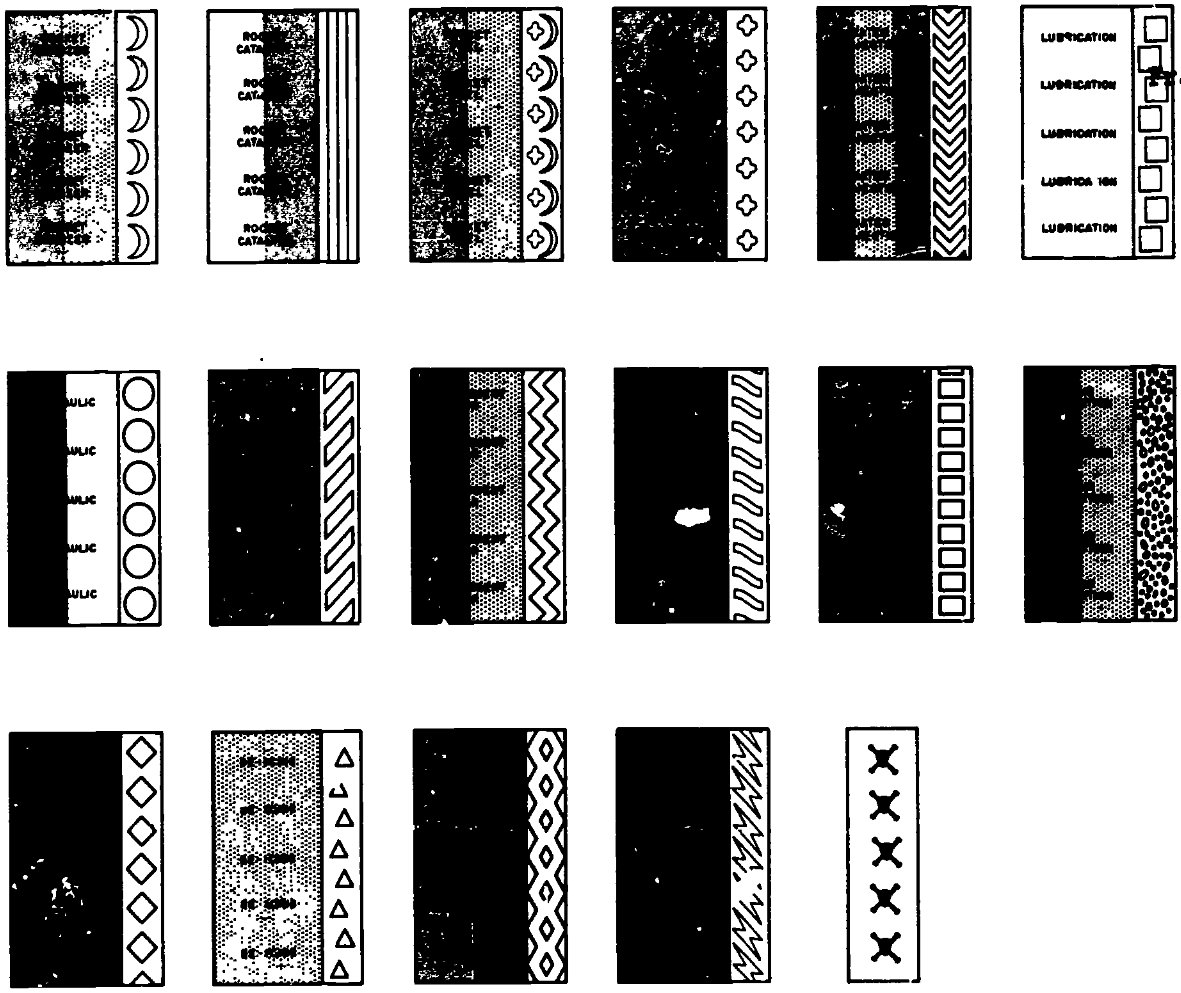
 e.

c. 

 f.

1. Bolt, universal fitting.
2. Tee, flared tube, bulkhead.
3. Elbow 90°, flared tube, bulkhead.
4. Union, flared tube, extra length, for mounting in a bulkhead.
5. Elbow, 90° universal.
6. Elbow, 45°.

Answers to Frame 43: 1. b, 2. c, 3. d, 4. f, 5. e, 6. a



Code bands of varicolored tape are attached to the tubing throughout the aircraft. These bands are placed near the joints and quickly identify the content and danger when working on or around these tubing.

A chart showing some of the color coding for tubing systems is shown above. This chart can be found in the appropriate technical orders.

Match the color code to the systems listed below.

1.	Fire protection.	a.	Gray
2.	Lubrication	b.	Blue-yellow
3.	Breathing oxygen.	c.	Brown-gray
4.	Fuel	d.	Green
5.	Air condition.	e.	Yellow
6.	Pneumatic.	f.	Red
7.	Hydraulic.	g.	Brown
8.	De-icing	h.	Red-blue

Answers to Frame 44: 1. f, 2. a, 3. d, 4. c, 5. e, 6. b

Frame 46

Answer the statements as true (T) or false (F).

1. The two most common types of tubing used in aircraft systems lines are corrosion-resistant aluminum alloy and copper.

2. Aluminum alloy tubing is most widely used in low and medium pressure systems.

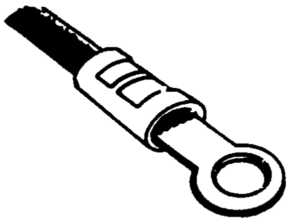
3. The color code which identifies the contents of the system as breathing oxygen is red.

4. Stainless steel tubing is used in high-pressure systems.

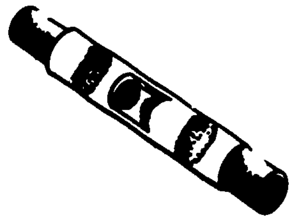
Answers . Frame 45: 1. g, 2. e, 3. d, 4. f, 5. c, 6. h, /. b, 8. a

Solderless terminal lug (A) permit easy and efficient connection and disconnection of wire from electrical equipment. Solderless splices (B) join electrical wires to form permanent continuous runs. These terminal lugs and splices come preinsulated (A) or uninsulated (B). They are made of copper or aluminum.

Note: Copper wire requires copper connectors and the aluminum wire requires aluminum connectors.



"A"



"B"

Select the correct statement(s).

1. To join electrical wires to form a continuous run, solderless terminal lugs are used.

2. Solderless terminal lugs permit easy disconnection and connection to electrical equipment.

3. Solderless terminal lugs and solderless splices may be uninsulated or preinsulated.

Answers to Frame 46: 1. F, 2. T, 3. T, 4. F

Frame 48

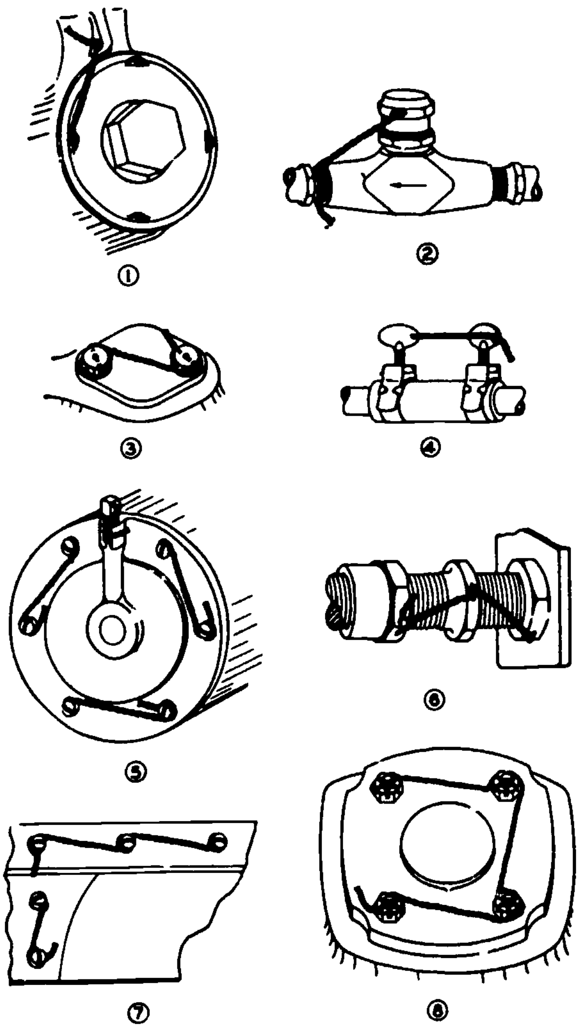
Aircraft vibration does tend to loosen or alter the adjustment of various parts. These parts are safetied by an auxiliary device, such as safety wire.

Safety wire is made of copper, aluminum or steel. Copper wire (.020-inch diameter), is used for safetying seals on equipment such as first aid kits and portable fire extinguishers.

Aluminum wire (.032-inch diameter) is used for safetying emergency valves or oxygen regulators. BE SURE TO CONSULT THE SPECIFIC TECHNICAL ORDER AND USE THE WIRE SIZE REQUIRED.

Some emergency devices use a safety or shear wire. Care must be used to be sure that the use of safety wire will not stop the emergency operation of the device.

The illustrations shown are typical examples of proper safety wire installations. Study these illustrations. Notice the proper way to install safety wire for a given situation.



NO RESPONSE REQUIRED

Answers to Frame 47: 1. F, 2. T, 3. T

Two methods of safety wiring are used: the single-wire method and the double-twist method. The single-wire method is used on emergency devices. The single-wire method is also used in areas hard to-reach and for small screws in a closely spaced pattern.

The double-twist method is the most common method used. The most common sizes of safety wire in use are .020 inch and .032 inch.

Complete the statement.

1. The two sizes of safety wire most commonly used to safety parts, using the double-twist method, are

    a. .032-inch and .037-inch.

    b. .020-inch and .037-inch.

    c. .041-inch and .047-inch.

    d. .020-inch and .032-inch.

Answer to Frame 48: None Required

Frame 50

The number of bolts, nuts, screws, etc, that may be wired together depends upon the application. When the double-twist method is used, the maximum number of wider spaced bolts that can be wired in a series is three. The number of closely spaced bolts, that can be wired by a 24-inch length of wire is the maximum number in a series.

Complete the statement.

1. The maximum number of widely spaced bolts which may be wired in a series is

   a. 1.

   b. 2.

   c. 3.

   d. 4.

Answer to Frame 49: 1. d

The correct procedure for safety wiring will be explained in the safety wiring project. In that project, you will learn the proper method by actually doing the job.

Answer to Frame 50: 1. c

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Frame 51

Note: To complete this terminal frame you must have a hardware trainer.

Match the names listed below with the correct item on the trainer. Place the number on the trainer that corresponds to the item you selected on the separate answer sheet. Some items on the trainer are not in this list.

2. Bolt, clevis.
3. Bolt, hex head steel.
4. Cotter pin.
5. Eyebolt.
6. Machine screw, flathead.
7. Screw, Reed and Prince head.
8. Reducer steel.
9. Machine screw, fillister head.
10. Plate nut.
11. Cross fitting steel.
12. Wing nut.
13. Nut, plain steel.
14. Screw, Phillips head.
15. Nut, castellated steel.
16. Bolt, drilled head steel.
17. Tee fitting bulkhead.
18. Nut, self-locking aluminum.
19. Nut steel self-locking.
20. Sleeve.
22. Elbow 90°, bulkhead.
23. Union MS.
24. Tee fitting.
25. Nipple, flared tube to pipe.
26. Elbow 90°, pipe to tube.

Answers to Frame 51:

1. 29.
2. 6.
8. 8
4. 17.
5. 12.
6. 23.
7. 22 or 23.
8. 47.
9. 14.
10. 20.
11. 44.
12. 21.
13. 41.
14. 14.
15. 27.
16. 8.
17. 36.
18. 28.
19. 25.
20. 39.
21. 51.
22. 46.
23. 18.
24. 45.
25. 42.
26. 53.

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Frame 51A

Note: To complete this frame you must have a hardware trainer.

Match the names listed below with the correct item on the trainer. Place the trainer number that corresponds with that item on the separate answer sheet. Some items on the trainer are not listed.

1. Wood washer.
2. Bolt, clevis.
3. Bolt hex head steel.
4. Cotten pin.
5. Eyebolt.
6. Machine screw, flathead.
7. Screw, Reed and Prince head.
8. Lock washer.
9. Machine screw, roundhead.
10. Plate nut.
11. Machine screw, Fillister head.
12. Wing nut.
13. Nut, plain steel.
14. Screw, Phillips head.
15. Nut, castellated steel.
16. Bolt, drilled head steel.
17. Screw, sheetmetal.
18. Nut, self-locking aluminum.
19. Nut, steel self-locking.
20. Dzus stud.
21. Splice.
22. Elbow 90°, bulkhead.
23. Tinnerman nut.
24. Tee fitting.
25. Cross fitting, internal threads.
26. Elbow 90°, pipe to tube.

Answers to Frame 51A:

1.	11.
2.	1.
3.	5.
4.	12.
5.	7.
6.	10.
7.	18.
8.	24.
9.	9.
10.	15.
11.	4.
12.	16.
13.	21.
14.	17.
15.	22.
16.	3.
17.	13.
18.	20.
19.	23.
20.	29.
21.	33.
22.	40.
23.	32.
24.	39.
25.	36.
26.	47.

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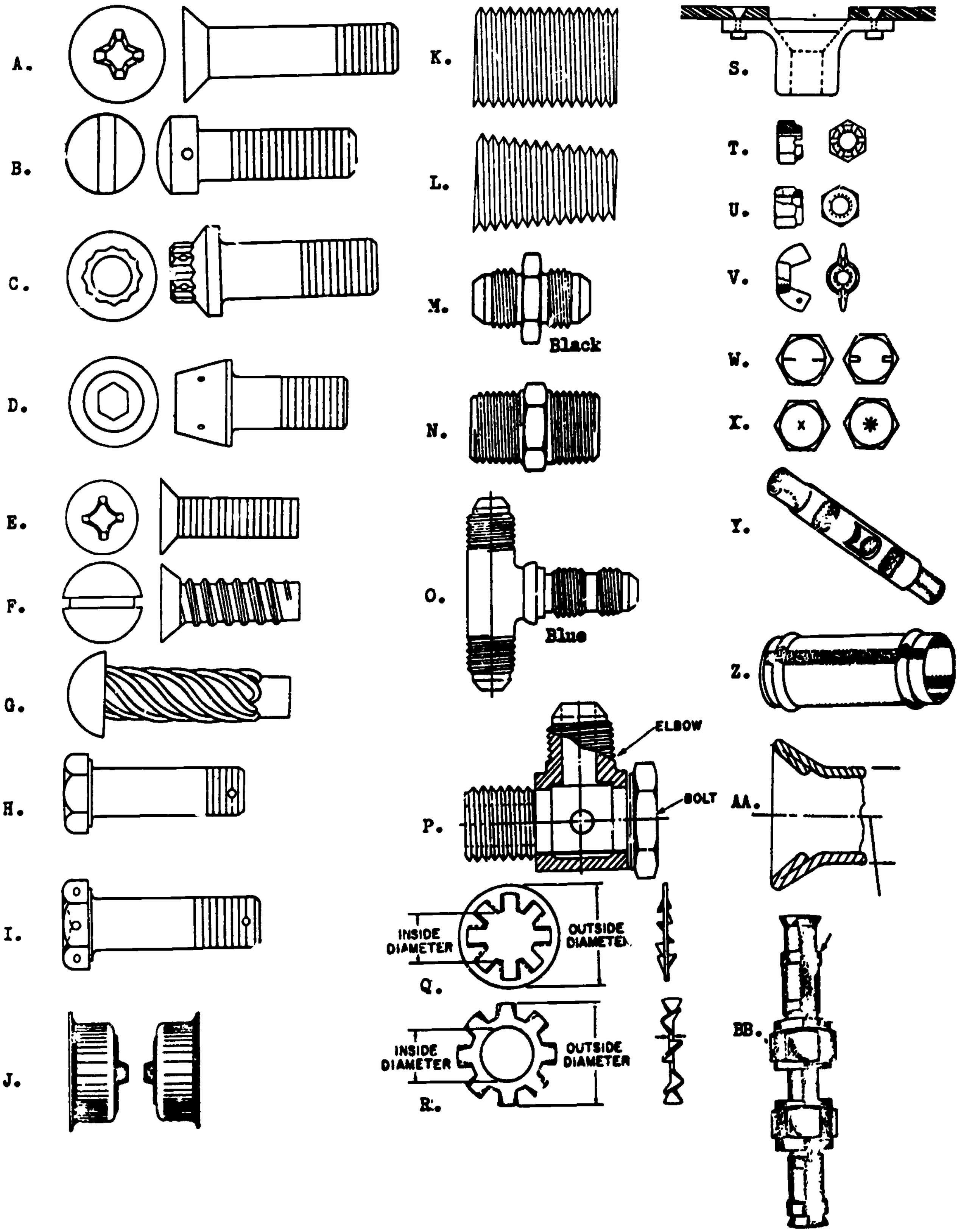

Caution: TO BE USED BY ENVIRONMENTAL COURSE ONLY.

Frame 51B

Match the names below with the correct item on the opposite page. Place the capital letter that corresponds with that item on the separate answer sheet. Some items are not listed.

2. Bolt, hex head aluminum.

3. Bolt, hex head steel.

4. Pipe thread (basic design).

5. Bolt, internal wrenching.

6. Screw, machine flathead.

7. Universal fitting combinations.

8. Lock washer, internal.

9. Tube, beaded end.

10. Nut, plate.

11. Screw, machine Fillister head.

12. Nut, wing.

13. Shock mount.

14. Screw, crosspoint.

15. Nut, castle.

16. Bolt, drilled hex head.

17. Screw, sheet metal (self-tapping).

18. Nut, fiber self-locking.

19. Joint (section) flared tubing.

20. Tube, double-flared.

21. Splice, solderless.

22. Tee, flared tube, bulkhead.

23. Steel flared fitting.

24. Nipple, pipe thread.

Answers to Frame 51B:

1. G .
2. W.
3. X.
4. L.
5. D.
6. A or E.
7. P.
8. Q.
9. Z.
10. S.
11. B.
12. V.
13. J.
14. A or E.
15. T.
16. I.
17. F.
18. U.
19. BB.
20. AA.
21. Y.
22. O.
23. M.
24. N.

648

Technical Training

Aircraft Environmental Systems Mechanic

OHM'S LAW

9 January 1981

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

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OBJECTIVES

Use Ohm's Law and power formulas to solve for unknown values in basic electrical circuits. A minimum of eight out of ten unknown values must be correct.

INSTRUCTIONS

This programmed text presents information in small steps called "frames". Carefully study the written material and/or diagram in each frame until you are satisfied that you understand its contents. Each frame requires you to respond to the information in some way. For example, you may be required to select the true statements or insert a correct answer. Specific instructions are provided in each frame. After you have made your response, compare your answers with the answers at the bottom of the next frame. If you are incorrect, study the frame again and correct your mistakes before continuing. Read carefully, select the correct answers and DO NOT HURRY.

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In the following circuits you will see what happens when the voltage, current or resistance values are changed.

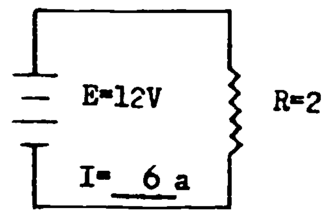


Figure 1.

1. If the circuit below, figure 2, is compared to the circuit above, figure 1, you would see the resistor value has been increased to 6 ohms. This increase will cause the circuit current to drop to 2 amps.

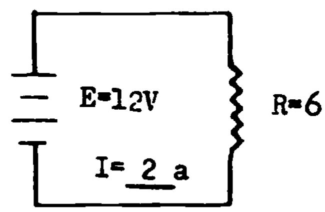


Figure 2.

Note: If the resistor was to drop in its value the current will increase.

2. If the circuit below, figure 3, is compared to the circuit above, figure 1, you can see the applied voltage was increased. This increase will cause the circuit current to increase to 12 amps.

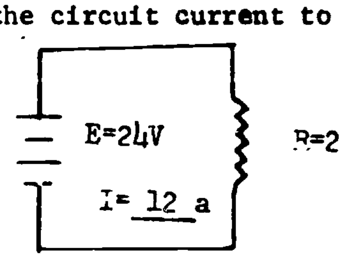


Figure 3.

Note: If the applied voltage was to drop in its value the current will decrease.

From this you can see that there are several relationships between current, voltage and resistance. To be sure you understand them, fill in the blanks on the next page with the correct term.

FRAME 1 (Cont'd)

1. Increasing the voltage in a circuit will cause the current to ___________.

2. Decreasing the voltage in a circuit will cause the current to ___________.

3. Decreasing the resistance in a circuit will cause the current to ___________.

4. Increasing the resistance in a circuit will cause the current to ___________.

FRAME 2

The relationships that we have seen in the last few frames is called Ohm's Law and is stated in general terms as follows: The current in a circuit is directly proportional to the applied voltage and inversely proportional to the circuit resistance. The term "proportional" implies that the current will change by the same factor that the voltage changes. In other words, directly proportional implies that: if the voltage is doubled, the current will be doubled. Inversely proportional implies that: the current will decrease by the same factor that the resistance increases. In other words, if the resistance is doubled, the current is halved.

Fill in the blanks with the correct term.

1. Decreasing the voltage will cause a proportional ___________ in the current.

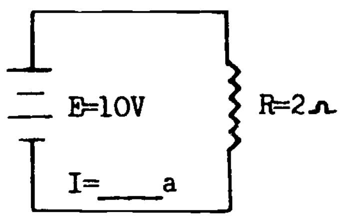
2. If the resistance is halved, the current will be ___________.

3. If the voltage is halved, the current will be ___________.

4. If the voltage is tripled, the current will be ___________.

Answers to Frame 1: 1. increase 2. decrease 3. increase 4. decrease

Ohm's Law may be shown as an equation: I = E/R, where I = current in amps, E = voltage in volts, and R = resistance on ohms. For example, in the circuit shown below we want to find the value of I. Substituting the known values into the formula, I = E/R, we have I = 10V/2 = 5a.



Solve each of the following problems for the amount of current flow.

1. E = 12V

   I = ____a

   R = 6Ω

2. E = 6V

   I = ____a

   R = 6Ω

3. E = 6V

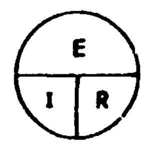
   I = ____a

   R = 12Ω

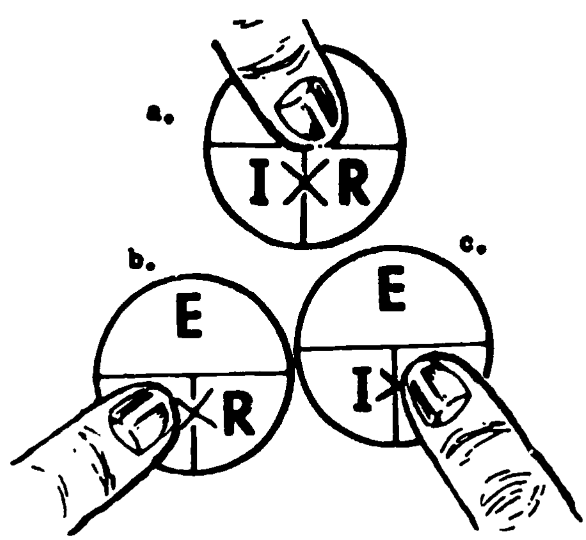
Answers to Frame 2: 1. decrease 2. doubled 3. halved 4. tripled

FRAME 4

In many circuit applications used in this course, current is known and either voltage or resistance will be the unknown. In these cases there are two additional formulas that are derived from the formula I = E/R. To find the value of R when E and I are known, use the formula, R = E/I. To find the value of E when I and R are known, use the formula, E = IxR. A simple memory device that will help you to pick the proper Ohm's Law formula is shown below.



For example, to find E, cover E with a finger as shown in figure a below. The uncovered letters indicate that E = IR. If I is unknown, it is equal to E/R, see figure b below. If R is unknown, it is equal to E/I, see figure c below.

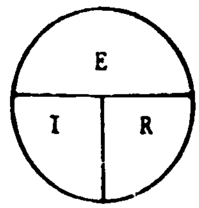


Place the following answers in the spaces provided.

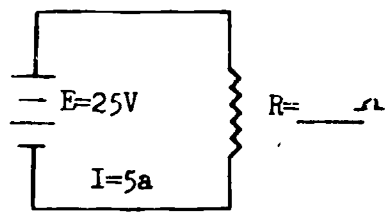
The three formulas for Ohm's Law are ___________, _____________, and _____________.

Answers to Frame 3: 1. 2A 2. 1A 3. .5A

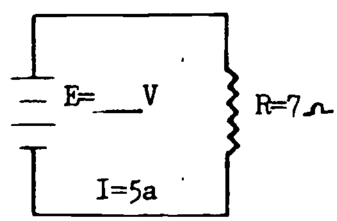
Now let's solve some problems for unknown voltages and currents.



In the diagram below, the unknown resistance can be found by using the formula, R = E/I. Substituting in the known values for E and I, we have R = 25V/5a = 5 ohms.

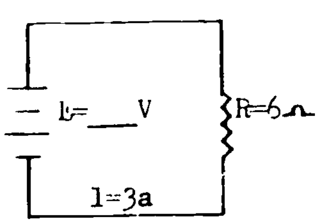


In the diagram below, the unknown voltage can be found by using the formula, E = IxR. Substituting in the known values for I and R, we have E = 5a x 7 = 35V.

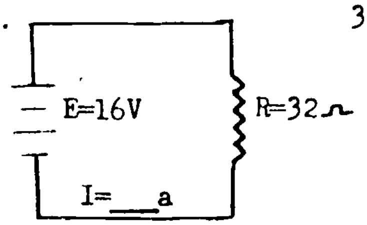


Solve each of the following problems for the unknown. Put your answers in the appropriate blank.

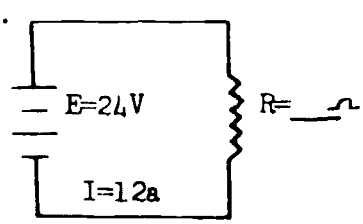
1.



2.



3.

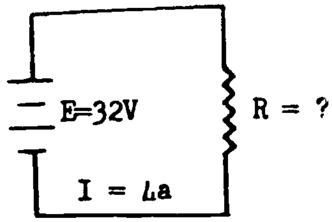


Answers to Frame 4: 1. E = IxR 2. I = E/R 3. R = E/I (any order)

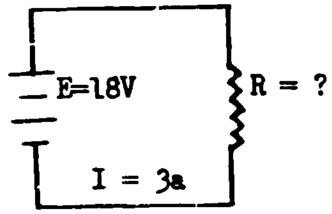
FRAME 6

Calculate the resistance in each of the following circuits. Put your answers in the appropriate blank.

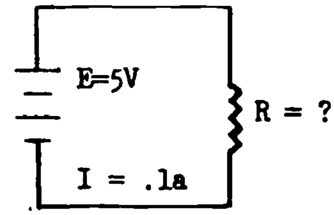
1. R = ______Ω



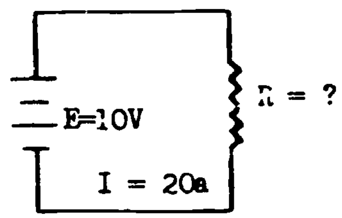
2. R = ______Ω



3. R = ______Ω



4. R = ______Ω

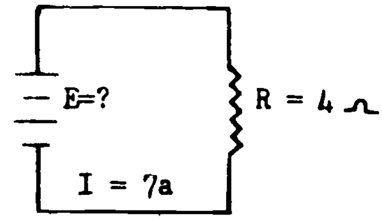


Answers to Frame 5: 1. 18V 2. .5a 3. 2 ohms

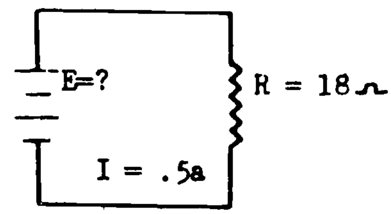
FRAME 7

Calculate the voltage in each of the following circuits. Put your answers in the appropriate blank.

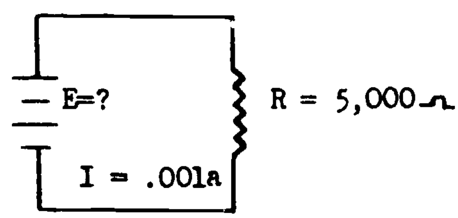
1. E = ______V



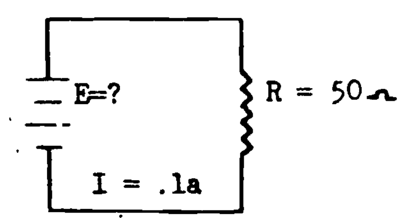
2. E = ______V



3. E = ______V



4. E = ______V

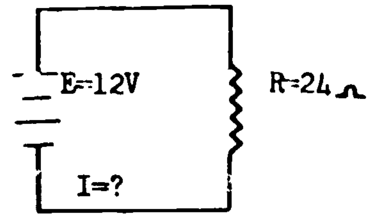


Answers to Frame 6: 1. 8 ohms 2. 6 ohms 3. 50 ohms 4. 5 ohms

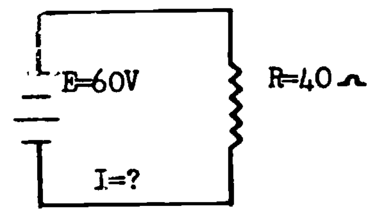
FRAME 8

Calculate the current in each of the following circuits. Put your answers in the appropriate blank.

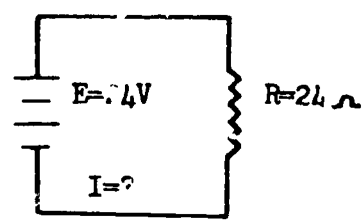
1. I = ______a



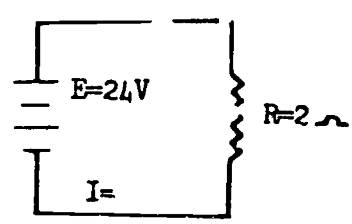
2. I = ______a



3. I = ______a



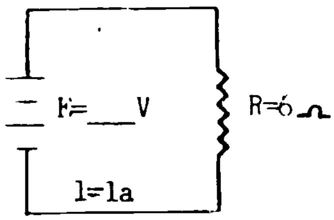
4. I = ______a



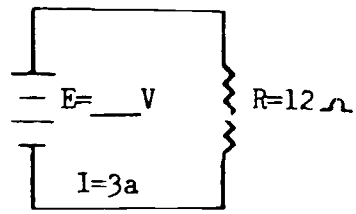
Answers to Frame 7: 1. 28V 2. 9V 3. 5V 4. 5V

Solve for the unknown in each of the following circuits. Put your answers in the appropriate blank.

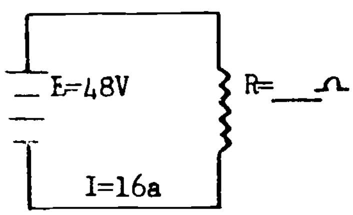
1.



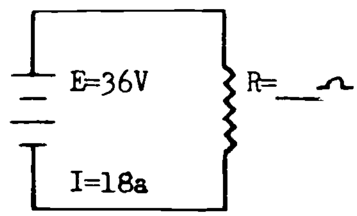
2.



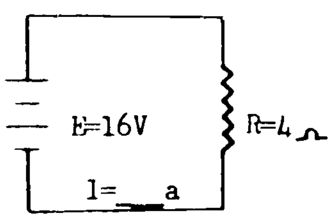
3.



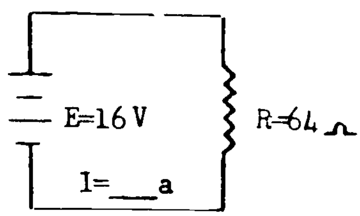
4.



5.



6.



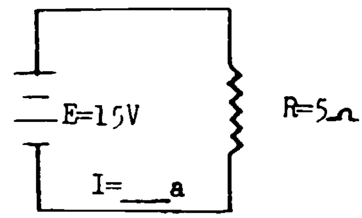
Answers to Frame 8: 1. .5a 2. 1.5a 3. 1a 4. 12a

FRAME 10

Perform each of the following steps in the sequence given. Fill in the blanks with the correct word or number.

1. In circuit (1) solve for the current.

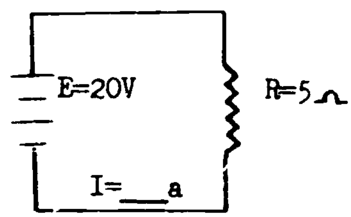
(1)



If you got I = 3a, you are correct, go to step 2. If you didn't get I = 3a, find your mistake before going to step 2.

2. In circuit (2) solve for the current.

(2)



If you got I = 4a; you are correct, go to step 3. If you didn't get I = 4a, find your mistake before going to step 3.

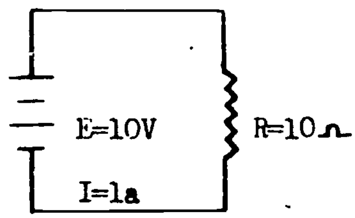
3. The only difference between circuit (1) and circuit (2) was the amount of voltage applied. When the voltage was increased from 15V to 20V, the current was increased from 3 amps to 4 amps.

No further response required, proceed to the next frame.

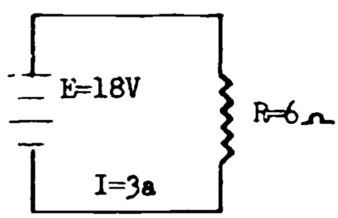
Answers to Frame 9: 1. 6V 2. 36V 3. 3 ohms 4. 2 ohms 5. 4a 6. .25a

Fill in the blanks with the correct word or number.

1. In the circuit below, if the voltage is increased to 20V, the current will (decrease/increase) ________________ to ________________ amperes.



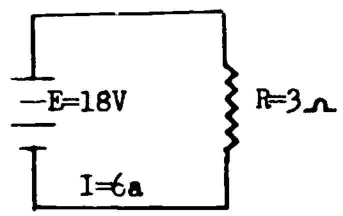
2. In the circuit below, if the voltage is decreased to 12V, the current will (decrease/increase) ________________ to ________________ amperes.



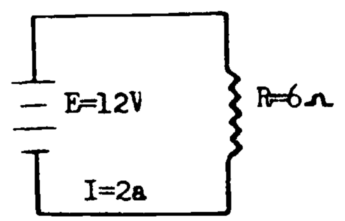
FRAME 12

Fill in the blanks with the correct word or number.

1. In the circuit shown below, if the 3 ohm resistor is replaced by a 6 ohm resistor, the current will (decrease/increase) ____________ to ____________a.



2. In the circuit shown below, if the 6 ohm resistor is replaced by a 2 ohm resistor, the current will (decrease/increase) ____________ to ____________a.



Answers to Frame 11: 1. increase 2A 2. decrease 2A

662

Fill in the blanks with the correct term or formula. The first two have been done for you.

1. Ohm's Law states that: The current in a circuit is directly proportional to the voltage and inversely proportional to the resistance.

2. The three formulas for Ohm's Law are E = IxR, I = E/R, and R = E/I.

3. Increasing the resistance in a circuit will cause a proportional (increase/decrease) ____________ in current.

4. Decreasing the voltage in a circuit will cause a proportional (increase/decrease) ____________ in current.

Solve the following problems for the unknown. Put your answers in the appropriate blank on the response sheet.

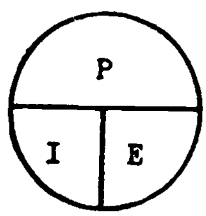
5. E = _______V	6. E = 18V	7. E = 28V
I = .25a	I = _____a	I = 14a
R = 40Ω	R = 12Ω	R = _____

Answers to Frame 12: 1. decrease 3a 2. increase 6a

FRAME 14

Power is the rate at which work is done. Work is done when a force causes motion. Previously it was shown that voltage is an electrical force and that voltage will force current to flow in a closed path. When there is voltage between two points, but current can not flow, no work is done. A total amount of work may be done in different lengths of time. For example, a given amount of electrons may be moved from one point to another in 1 second or 1 hour depending on the rate at which they are moved. In both cases the total work done is the same. When the work is done in a shorter time, the rate is greater than when the same amount of work is done in a longer time. The basic unit of power is the <u>watt</u>. The symbol for power is <u>P</u>. The basic power formula is $P = I \times E$. I is the current through, and E is the voltage across the resistor or unit for which power is being measured. The abbreviation used for the watt is w.

> Note: The formula for power will be easy to remember by spelling the work PIE. We also have the memory device shown below.



Mark the true statements with a "T".

____ 1. Work is done when a battery forces electrons to move through a circuit.

____ 2. The terms work and power have identical meanings.

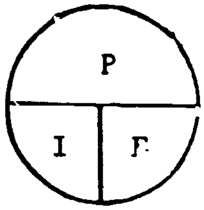
____ 3. The power in a circuit is equal to the current multiplied by the voltage.

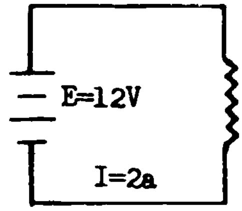
Answers to Frame 13: 1. Voltage Resistance 2. E=IxR 3. decrease
I=E/R
R=E/R

4. decrease 5. E=10V 6. 1.5a 7. 2 ohm

FRAME 15

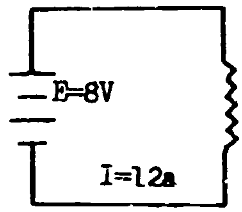
In the circuit shown below, the value of the power that the battery supplies to the resistor can be found by means of the equation $P = I \times E$. To find the power output of the battery, substitute the current, 2 amps, for I, and substitute the battery voltage, 12 volts, for E. The power in watts is equal to $2 \times 12 = 24$w.

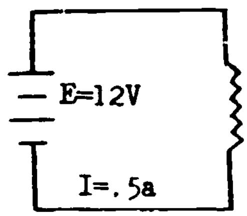




Find the power supplied by the battery in each of the following circuits. Put your answers in the appropriate blank.

1. P = ______________ w





2. P = ______________ w

Answers to Frame 14: 1. T 2. F 3. T

FRAME 16

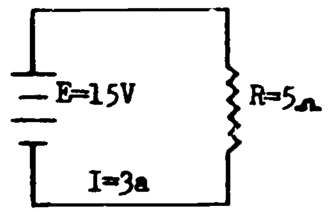
Fill in the blanks with the correct term or formula.

1. Ohm's Law states that: The current in a circuit is directly proportional to the ______________ and inversely proportional to the ______________.

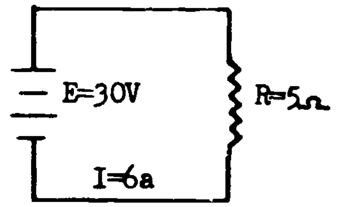
2. Increasing the resistance in a circuit will cause a proportional (increase/decrease) ______________ in current.

3. Increasing the voltage in a circuit will cause a proportional (increase/decrease) ______________ in current.

4. In the circuit shown below, if the voltage is decreased to 10V, the current will (decrease/increase) ______________ to ______________ amperes.



5. In the circuit shown below, if the 5 ohm resistor is replaced by a 15 ohm resistor, the current will (decrease/increase) ______________ to ______________ amperes.

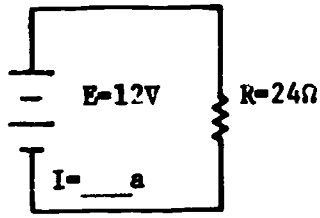


Answers to Frame 15: 1. 96w 2. 6w

666

Solve for the unknowns in each of the following problems. Put your answers in the appropriate blank.

1.



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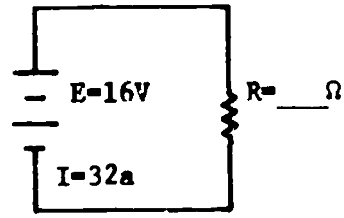

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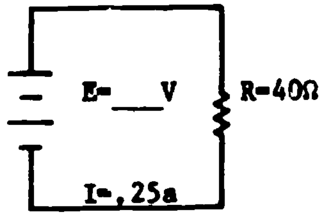

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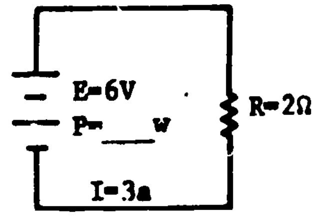

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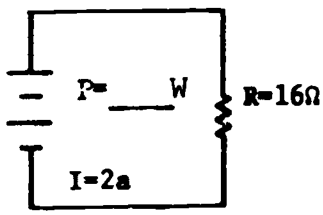

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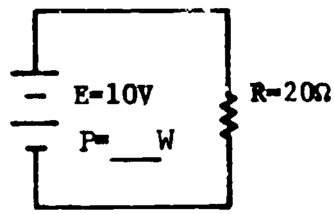

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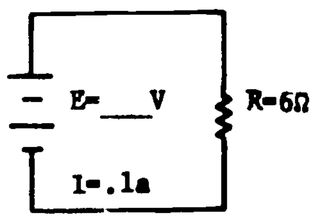

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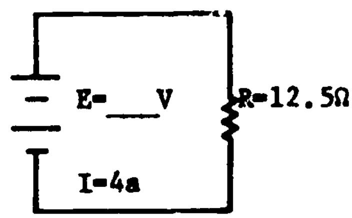

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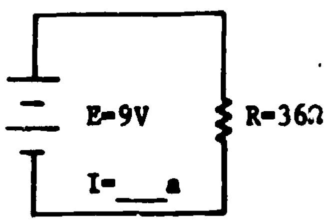

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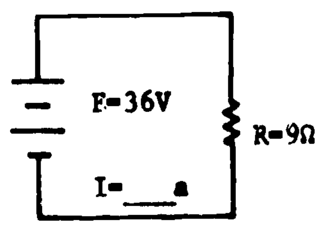

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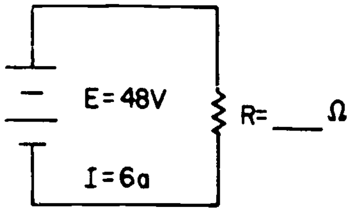

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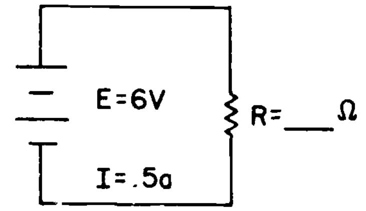

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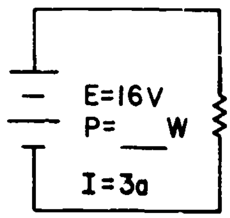

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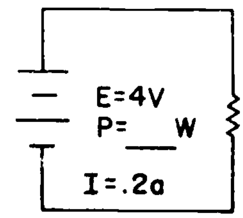

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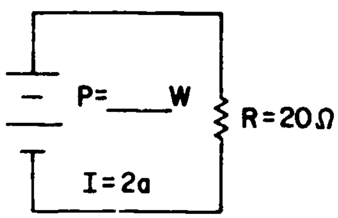

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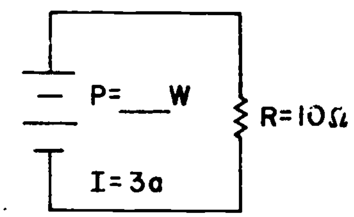

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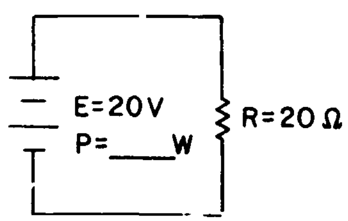

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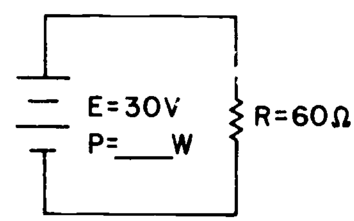

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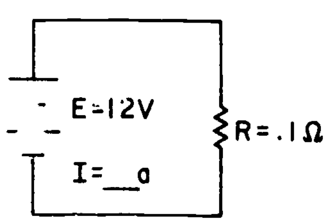
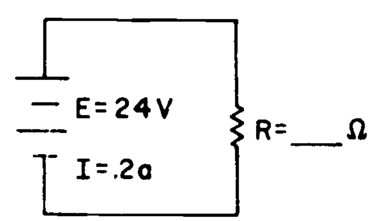


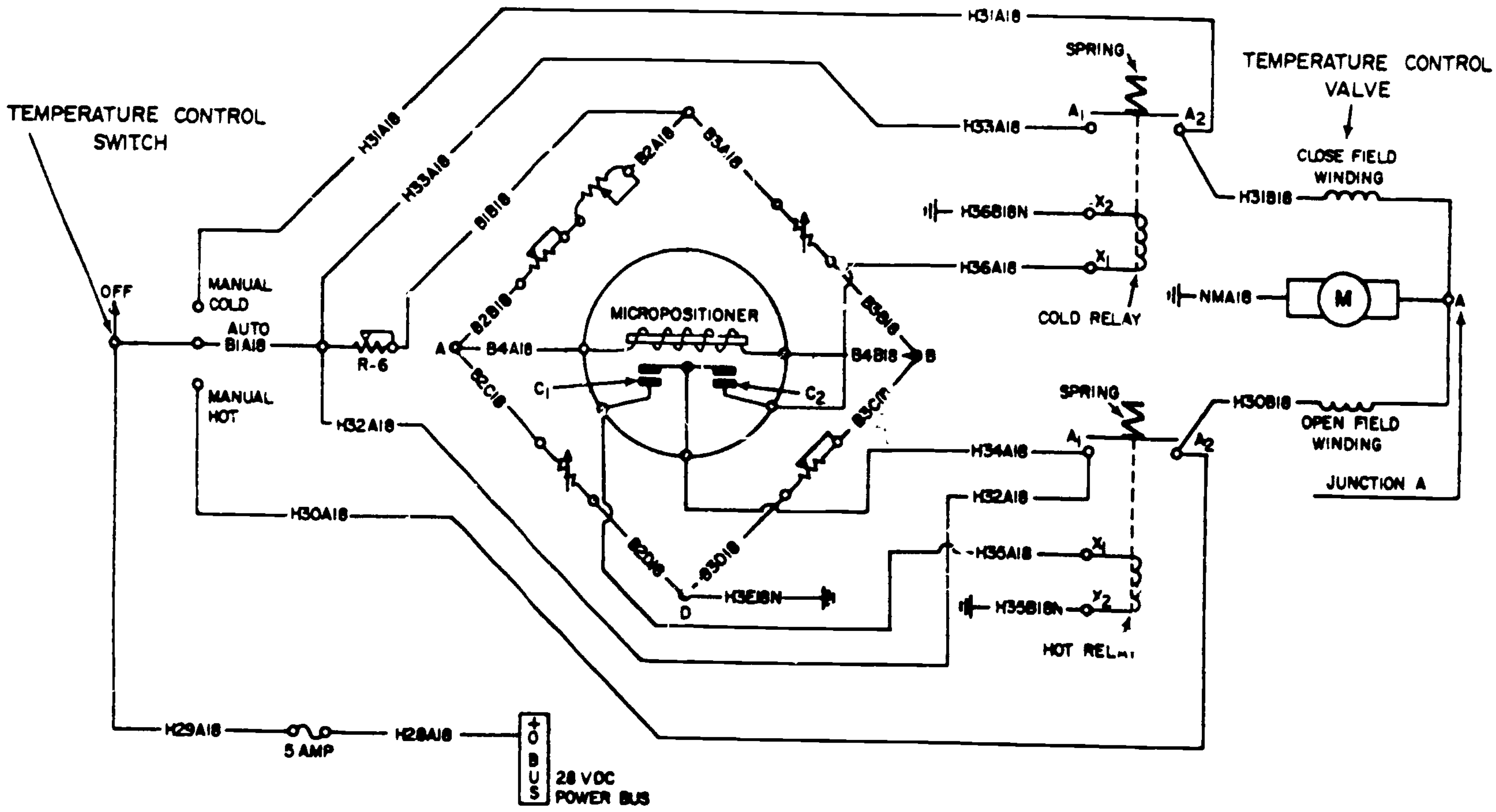
20.



Have the Instructor check your answers to this frame. Instructor's Initials ________

Answers to Frame 16:
1. voltage resistance
2. decrease
3. increase
4. decrease 2A
5. decrease 2A

TEMPERATURE CONTROL BRIDGE CIRCUIT WIRING DIAGRAM



Supercedes C3ABR42331-HO-122A, 27 January 1984
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTCU-P 150; DAV - 1

Designed for ATC Course Use. Do Not Use on the Job.

SERVICE TEST
PROGRAMMED TEXT
3ABR42331-PT-117

Technical Training

Aircraft Environmental Systems Mechanic

SERIES CIRCUITS

27 July 1981

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

RGL: 9.3

FOREWORD

This programmed text was prepared for use in course 3ABR42331, Aircraft Environmental Systems, by personnel of the Environmental/Pneudraulics Branch at Chanute AFB IL. The material contained herein has been validated with 30 students from the subject course. Ninety percent of the students achieved all the objectives as stated.

OBJECTIVES

1. Using Kirchhoff's current and voltage laws and Ohm's law, solve for unknown values in series circuits. A minimum of eight out of ten must be correct.

2. Using schematic diagrams of series circuits, malfunction indications, and meter readings, specify the type of trouble for a minimum of eight out of ten indications.

INSTRUCTIONS

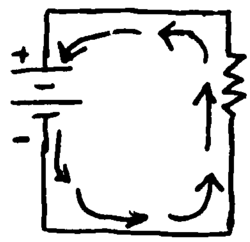
This programmed text presents information in small steps called frames. Carefully study the written material and/or schematic in each frame until you are satisfied you understand its contents. Each frame requires you to respond to the information in some way. For example, you may be required to select the true statements or solve problems. Specific instructions are provided in each frame. After you have made your response, compare your answer with the answer given on the next page or two. The answer will be located on the bottom of that page. If you are correct, go on to the next frame. If you are incorrect, study the frame again and correct your mistake before continuing. If you still cannot understand your mistakes, ask the instructor for assistance.

After completing Part 1 of this PT, proceed to the test room and take the appraisal on Part 1. After satisfactorily completing the appraisal on Part 1, begin on Part 2.

Supersedes ST 3ABR42331-PT-117, 15 May 1981.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 50; DAV - 1

INTRODUCTION

This PT is one of a series of PTs on circuits. In this PT we are going to discuss Kirchhoff's laws as applied to series DC circuits. A DC circuit is an electrical circuit in which current(I) flows in only one direction. See figure below.

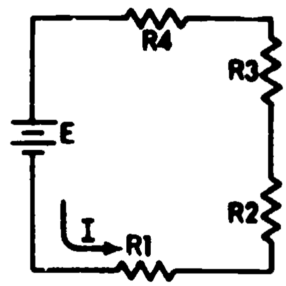


The letters "DC" are the initial letters of the words "direct current." In a later block you will study AC (alternating current). In order to be able to analyze more complicated circuits, it is essential that you have a thorough understanding of series circuits.

You will find a working knowledge of Ohm's and Kirchhoff's laws a great help in analyzing any electrical circuit. This will help you in troubleshooting.

Frame 1

An electric circuit is a complete path through which electrons (current) can flow from the negative terminal of the voltage source, through the connecting wires, through the load and back to the positive terminal of the voltage source. If the circuit is arranged so that the electrons have only <u>one</u> possible path, the circuit is called a <u>series circuit</u>. Therefore, a series circuit is defined as a circuit that contains only one path for current to flow. A typical series circuit is shown below.



Circle the letter in front of the correct answer.

1. A circuit that has only one path for current to flow is called a

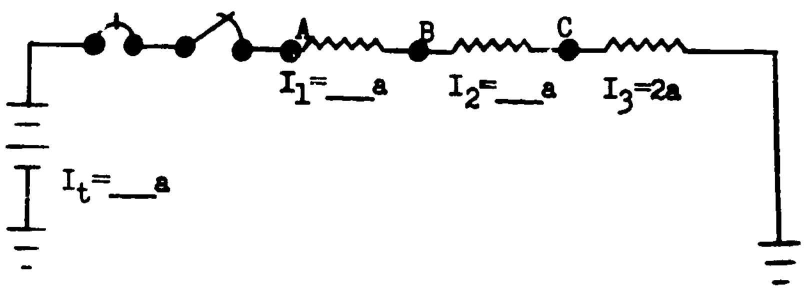
    a. bridge circuit.

    b. series circuit.

    c. parallel circuit.

    d. series-parallel circuit.

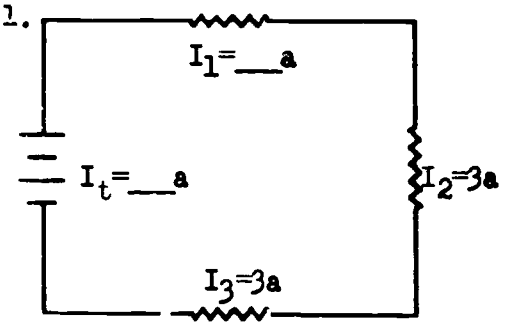
Since there is only one path for current flow, current must be the same at any point in the circuit. Let's see why. In the circuit below we want to find the value of I_t, I_1, and I_2. There are 2 amps flowing into junction C. Using Kirchhoff's current law we have 2 amps leaving junction C. Since there is only one path leaving junction C, I_2 must also be 2 amps. Thus, we have 2 amps flowing into junction B. Since there is only one path leaving B, I_1 = 2a. Since there are 2 amps flowing into junction A, I_t must also be 2 amps. Fill in 2a for I_t, I_1, and I_2 in the circuit below.



No further response required, go to the next frame.

Frame 3

Using Kirchhoff's current law (use your handout of laws and formulas) solve for the unknown currents in each of the following circuits. Put your answers on the appropriate blank.

1.


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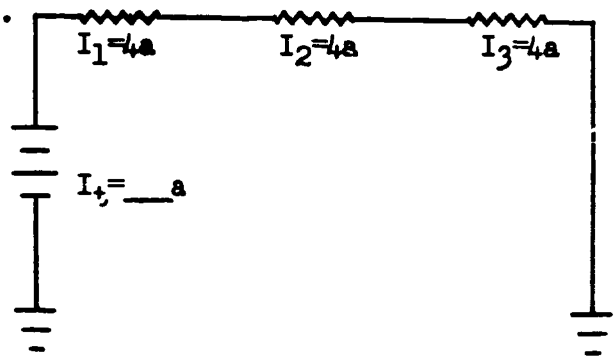
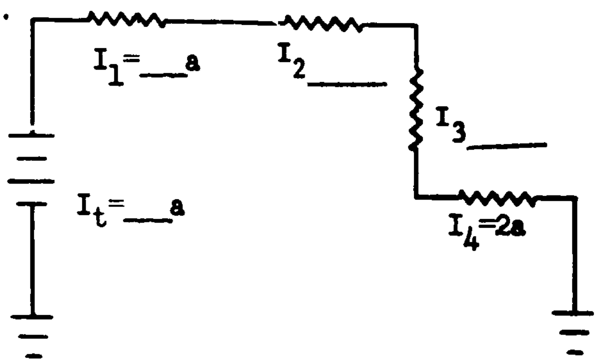
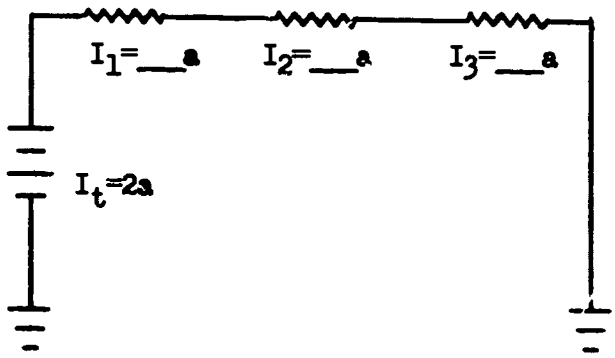


3.


4.


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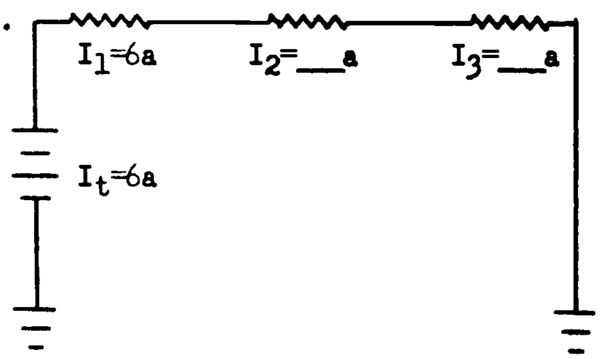

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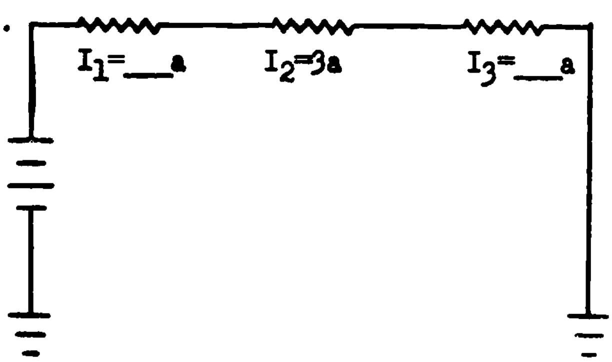


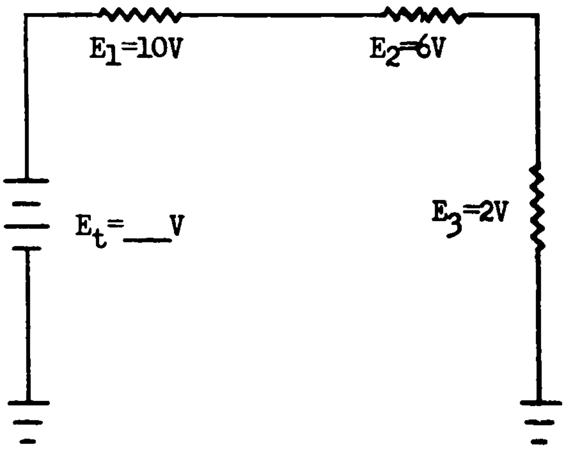
Answers to Frame 1: 1.__b__

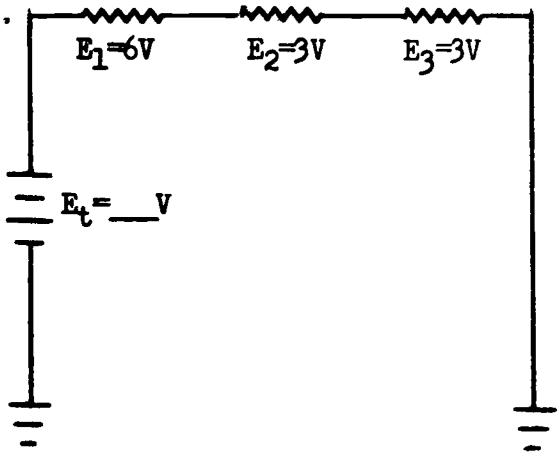
Kirchhoff's voltage law is also necessary to use in order to solve for unknowns in series circuits. Kirchhoff's voltage law states that the sum of the voltage drops in any closed path, is equal to the total (applied) voltage. A series circuit has only one closed path, therefore the total voltage is the sum of the voltage drops across each resistor.

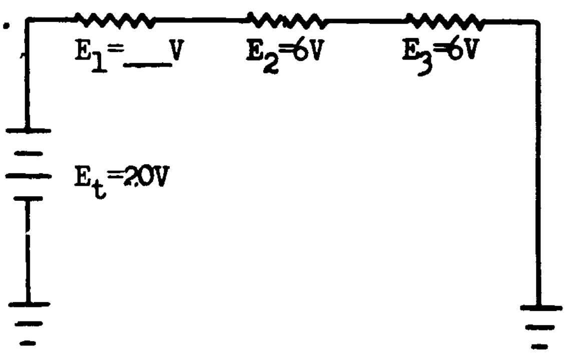
Answers to Frame 3:
1. $I_t = 3a$ $I_1 = 3a$
2. $I_t = 4a$
3. $I_t = 2a$ $I_1 = 2a$
4. $I_1 = 2a$ $I_2 = 2a$ $I_3 = 2a$
5. $I_2 = 6a$ $I_3 = 6a$
6. $I_1 = 3a$ $I_3 = 3a$

Frame 4 (Continued)

Using Kirchhoff's voltage law (use your handout of laws and formulas) solve for the unknown voltage in each of the following circuits. Put your answers on the appropriate blank.

1.


2.


3.


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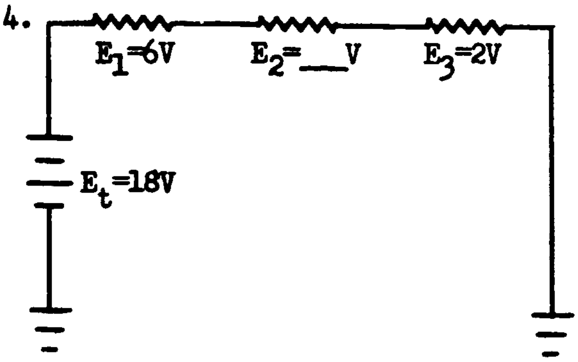

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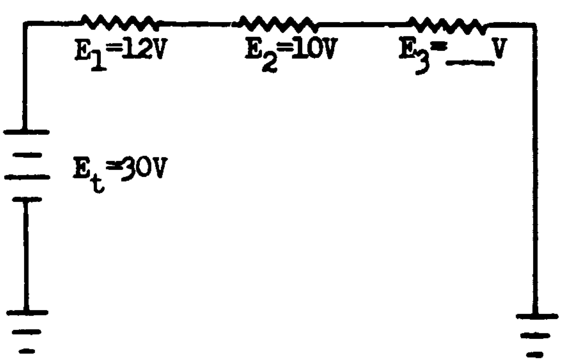

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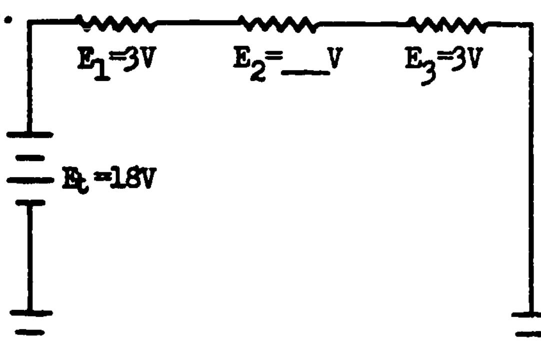
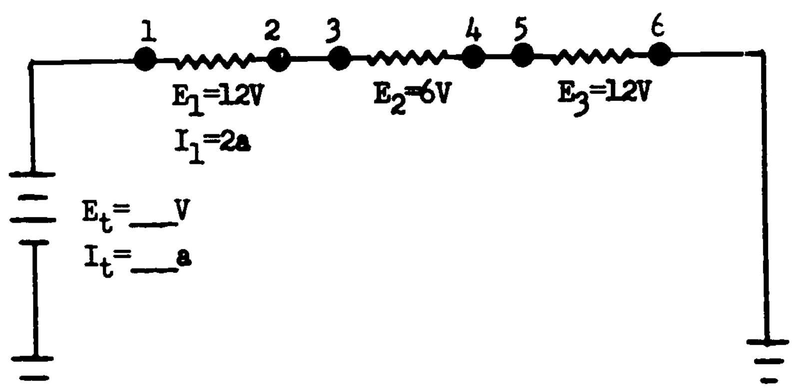


So far in this PT we have looked at Kirchhoff's current law and Kirchhoff's voltage law. We have seen how they apply to series circuits. In the circuit shown below we give you both current and voltage values. To solve for all unknowns you will need to use both Kirchhoff's current law and Kirchhoff's voltage law. However, when you use Kirchhoff's current law be sure to use only current values. When you use Kirchhoff's voltage law be sure to use only voltage values. We'll solve the problem shown below with you.

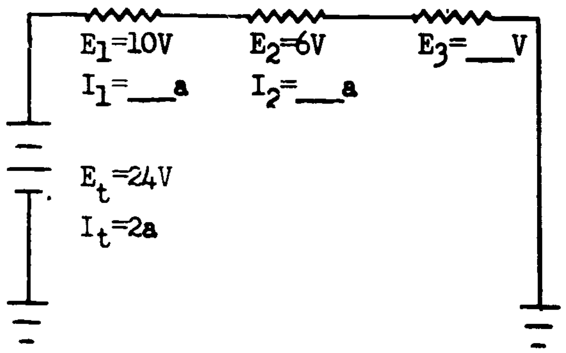
Since we need to find E_t, we will use Kirchhoff's voltage law. Applying it we have the sum of the voltage drops $(E_3 + E_2 + E_1)$ is equal to E_t. Thus, $E_t = 12 + 6 + 12 = 30V$. Fill in 30V on the blank for E_t. In order to find I_t we will use Kirchhoff's current law. Since there are 2a flowing into junction 1, there are 2a leaving junction 1. Thus, $I_t = 2a$. Fill in 2a on the blank for I_t.



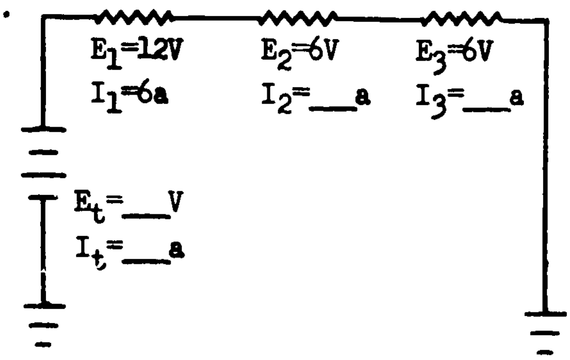
Solve for all unknowns in each of the following problems. Put your answers on the right blank. Be sure to use Kirchhoff's voltage law when you solve for unknown voltage, and Kirchhoff's current law when you solve for unknown currents. Be sure that you have a copy of the formulas and laws to use when you solve these problems.

Frame 5 (Continued)

1.



2.



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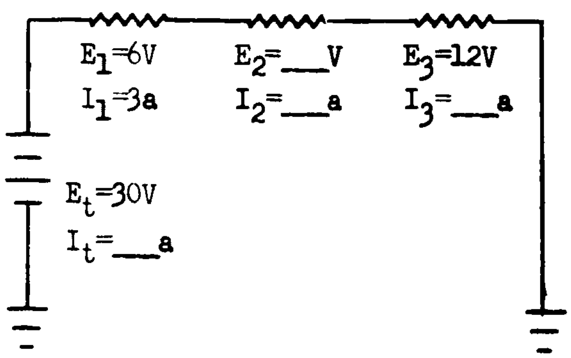
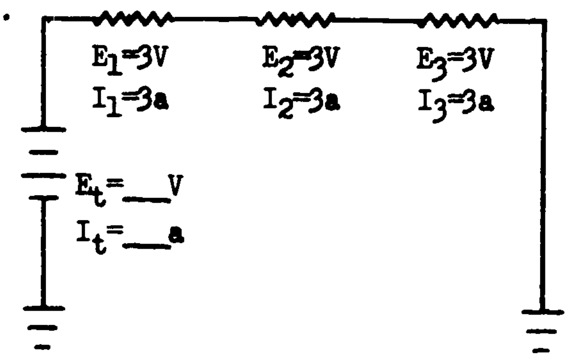
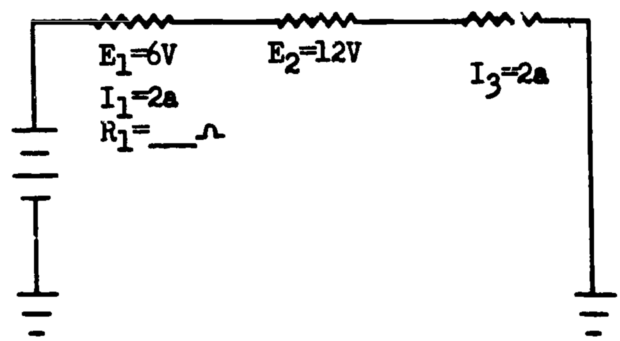


4.



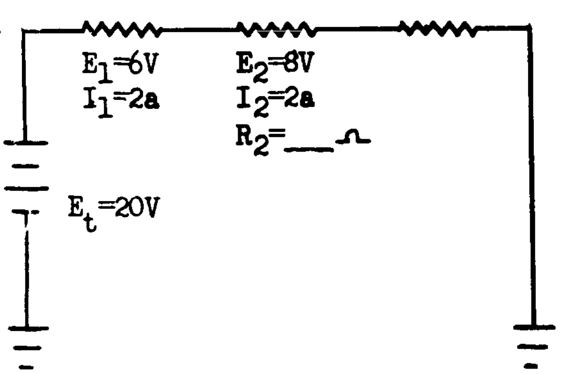
Ohm's law has many applications in solving series circuits. In using Ohm's law, the numbers used in the equations MUST be taken from the same component of the circuit. For example, the value of R_1 can be computed by the formula: $R = E/I$. Thus, $R_1 = E_1/I_1 = 6/2 = 3$ ohms.

Note: In order to find the value of R_1, we used the quantities E_1 and I_1.

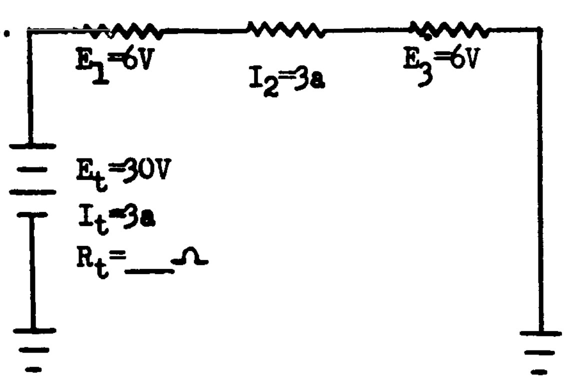


Solve for the unknown in each of the following circuits. Put your answers on the appropriate blank.

1.



2.

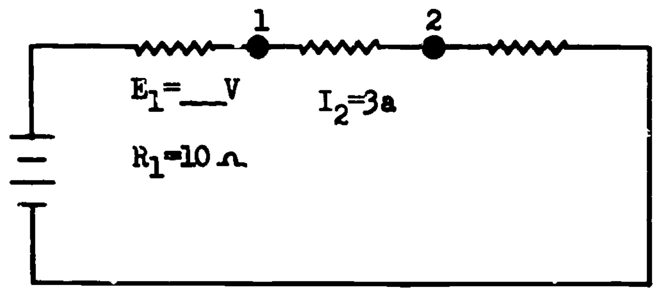


Answers to Frame 4:

1. E_t = 18V	2. E_t = 12V
3. E_1 = 8V	4. E_2 = 10V
5. E_3 = 8V	6. E_2 = 12V

Frame 7

Ohm's law can also be used to solve for unknown voltages and currents. In many problems you will need to first use Kirchhoff's voltage or current law before applying Ohm's law. Let's solve the following problem for E_1. As you complete each of the following steps place a check on the blank by the number of that step.



_____1. Since no voltage values are given, we do not have sufficient information to find E_1 using Kirchhoff's voltage law.

_____2. In order to use the Ohm's law formula $E = I \times R$ to find E_1, we need the values of both I_1 and R_1. I_1 is not given.

_____3. We can use Kirchhoff's current law to find the value of I_1. Since there are 3a flowing into junction 1, there must be 3a leaving it. Thus, $I_1 = 3a$.

_____4. Write in "$I_1 = 3a$" between $E_1 =$ ___V and $R_1 = 10$ ohms.

_____5. Thus, our problem is reduced to the following::

$E_1 =$ ____V

$I_1 = 3a$

$R_1 = 10\Omega$

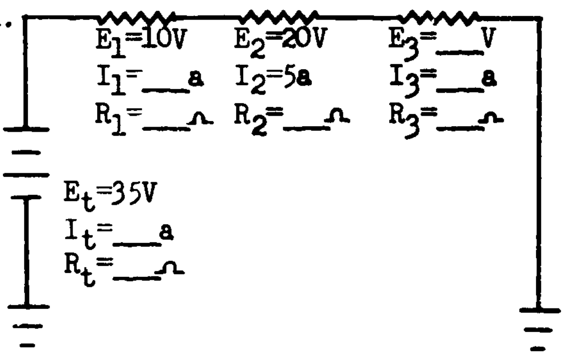
_____6. Substituting in values for I_1 and R_1 in the formula $E_1 = I_1 \times R_1$, we have $E_1 = 3 \times 10 = 30V$.

_____7. Write in 30V on the blank by E_1 and our problem is completed.

No further response required, proceed to the next frame.

Answers to Frame 5:
1. $I_1 = \underline{2a}$, $I_2 = \underline{2a}$, $E_3 = \underline{8V}$
2. $I_t = \underline{6a}$, $E_t = \underline{24V}$, $I_2 = \underline{6a}$, $I_3 = \underline{6a}$
3. $I_t = \underline{3a}$, $E_2 = \underline{12V}$, $I_2 = \underline{3a}$, $I_3 = \underline{3a}$
4. $E_t = \underline{9V}$, $I_t = \underline{3a}$

Using Kirchhoff's current and voltage law and Ohm's law solve for all unknowns in the following problems. Put your answers on the appropriate blank.

1.


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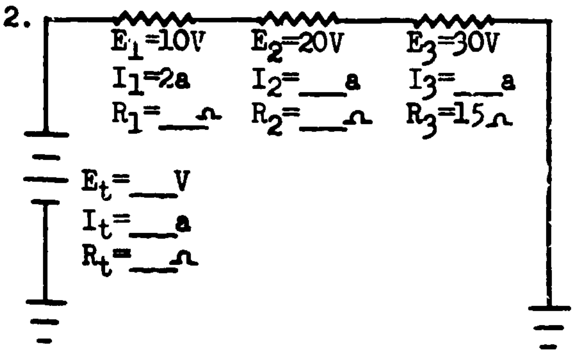
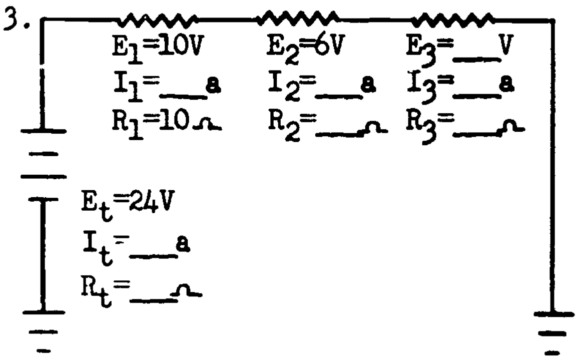


3.


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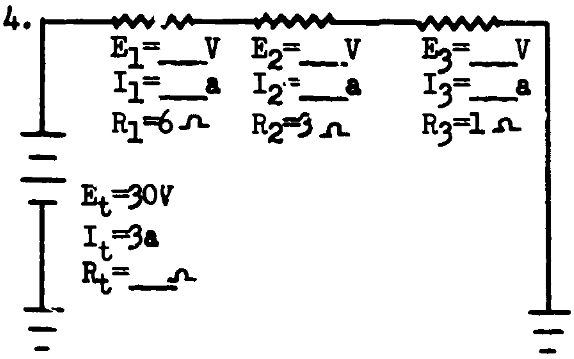
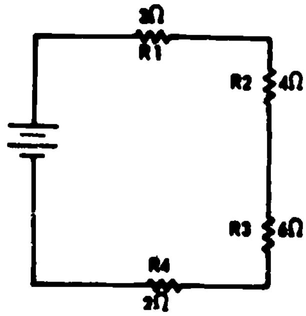


Answers to Frame 6: 1. R_2 = 4Ω 2. R_t = 10Ω

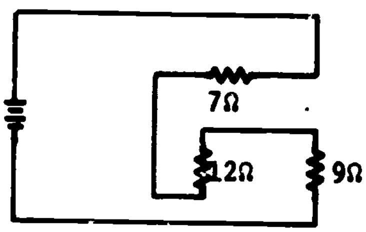
Frame 9

The current in a series circuit, in completing its path, must flow through each resistor (load) connected in the circuit. Thus, each additional resistor offers added resistance. In a series circuit, THE TOTAL CIRCUIT RESISTANCE (R_t) IS EQUAL TO THE SUM OF THE VALUES OF THE INDIVIDUAL RESISTANCES. This can be expressed in a formula as $R_t = R_1 + R_2 + R_3 + R_4$ + etc. depending on the number of resistors in the circuit. In the circuit below, the total resistance (R_t) = $3 + 4 + 6 + 2 = 15$ ohms.

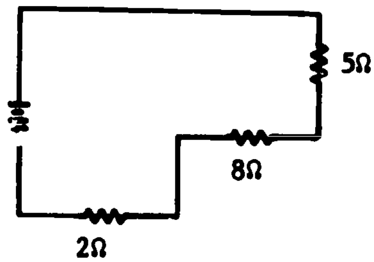


Find the total resistance in each of the following circuits. Put your answers on the appropriate blank.

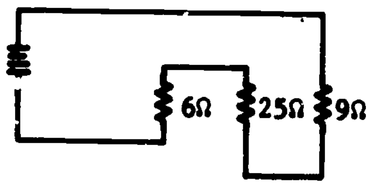
1. R_t = ________ Ω



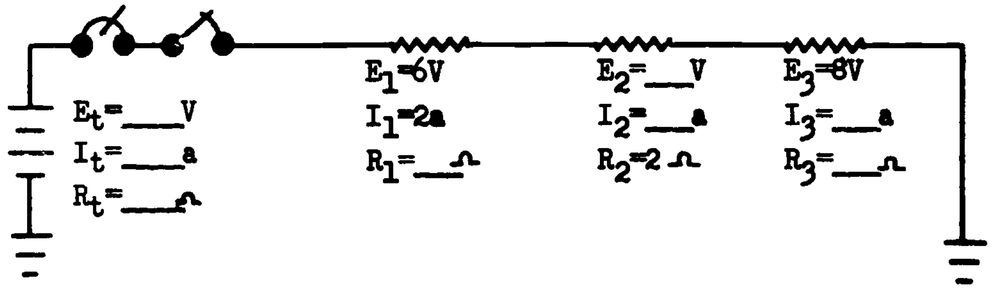
2. R_t = ________ Ω



3. R_t = ________ Ω



You have now seen how Kirchhoff's voltage law, Kirchhoff's current law, Ohm's law, and the resistance formula are used in solving for unknowns in a series circuit. Using these laws and formulas we will solve the problem shown below step-by-step with you. You need to develop a systematic approach. Since there are only four basic laws and formulas, try using them one at a time until you find one that you can apply. In the circuit below we don't have enough information to apply Kirchhoff's voltage law. Do you see why? The reason we can't find E_t is we are not given the values of all the individual voltage drops. We can't find E_2 because we don't know E_t. For now we can't use this law. However, we can apply Kirchhoff's current law. Since there are 2a flowing through R_1, we must have 2a flowing back to the battery. Thus, I_t is equal to 2a. Since there are 2a flowing into the battery, there must be 2a flowing out of the battery and into R_3. Thus, I_3 = 2a. With 2a flowing out of R_3 we must have 2a flowing into R_2. Thus, I_2 = 2a. Fill in 2a for I_t, I_2, and I_3 on the appropriate blanks in the circuit below. We'll finish working the problem in the next two frames.



No further resp[illegible] [illegible]uired, proceed to the next frame.

Answers to Frame 8: 1. I_t = 5a, I_1 = 5a, R_2 = 4Ω, E_3 = 5V

R_t = 7Ω, R_1 = 2Ω, I_3 = 5a

R_3 = 1Ω

2. E_t = 60V, R_1 = 5Ω, I_2 = 2a, I_3 = 2a

I_t = 2a, R_2 = 10Ω

R_t = 30Ω

3. I_t = 1a, I_1 = 1a, I_2 = 1a, E_3 = 8V

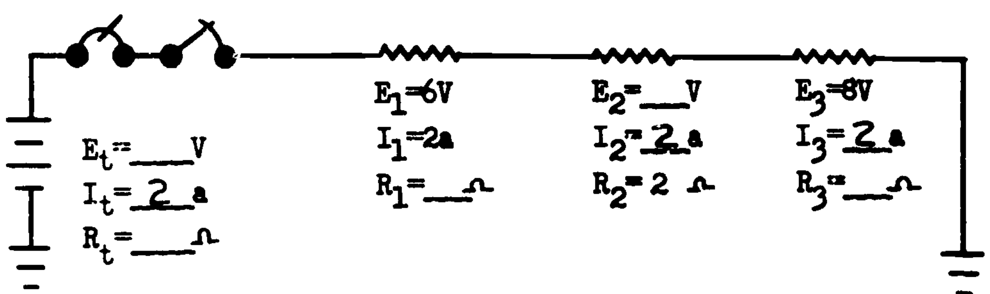
R_t = 24Ω, R_2 = 6Ω, I_3 = 1a

R_3 = 8Ω

4. R_t = 10Ω, E_1 = 18V, E_2 = 9V, E_3 = 3V

I_1 = 3a, I_2 = 3a, I_3 = 3a

The problem shown below is the same as the one in the last frame. We have filled in the values for the currents that we found in the last frame. We still can't apply Kirchhoff's voltage law as we don't know E_t. However, we can apply Ohm's law in solving for several numbers. Remember, you can use the Ohm's law formulas in finding E, I, and R, when any two of the three numbers are known for a particular component. Using the Ohm's law formula R = E/I we can solve for R_1 and R_3. $R_1 = E_1/I_1 = 6/2 = 3$ ohms. $R_3 = E_3/I_3 = 8/2 =$ 4 ohms. Fill in these values for R_1 and R_3 in the circuit below. We also have enough information to solve for E_2. $E_2 = I_2 \times R_2 = 2 \times 2 =$ 4V. Fill in this value for E_2. We'll finish solving the problem in the next frame.



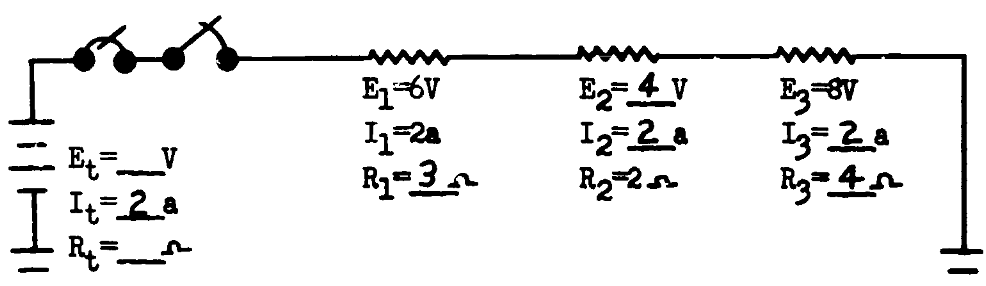
No further response required, proceed to the next frame.

Answers to Frame 9: 1. R_t = 28Ω 2. R_t = 15Ω 3. R_t = 40Ω

Frame 12

In this frame we will finish the problem we started in Frame 11. The same circuit is given below with all the values filled in that we have found. Now we have enough information to use Kirchhoff's voltage law. Applying Kirchhoff's voltage law we have $E_t = E_1 + E_2 + E_3 = 6 + 4 + 8 = 18V$. Fill in 18V for E_t in the circuit below. To find R_t we can use either Ohm's law or the resistance formula. Using Ohm's law we have $R_t = E_t/I_t = 18/2 = 9$ ohms. Using the resistance formula we have $R_t = R_1 + R_2 + R_3 = 3 + 2 + 4 = 9$ ohms. Fill in 9 ohms for R_t in the circuit below. Now you have the problem completely solved.

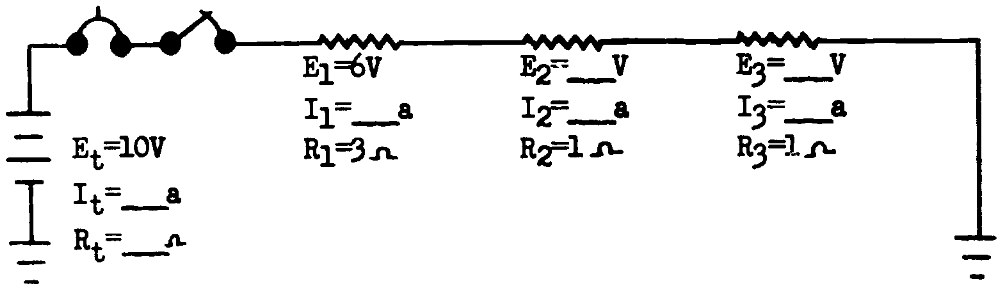
> Note: When attempting to solve a series circuit, keep trying the laws one at a time until you can find one that can be applied.



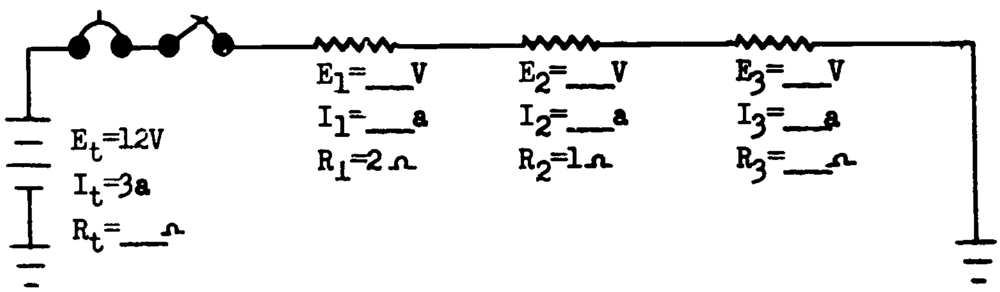
No further response required, proceed to the next frame.

Solve each of the following problems for the indicated unknowns. Put your answers on the appropriate blank.

1.



2.



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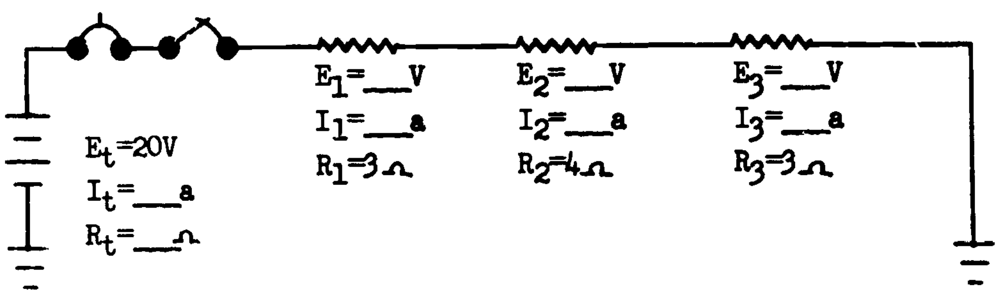

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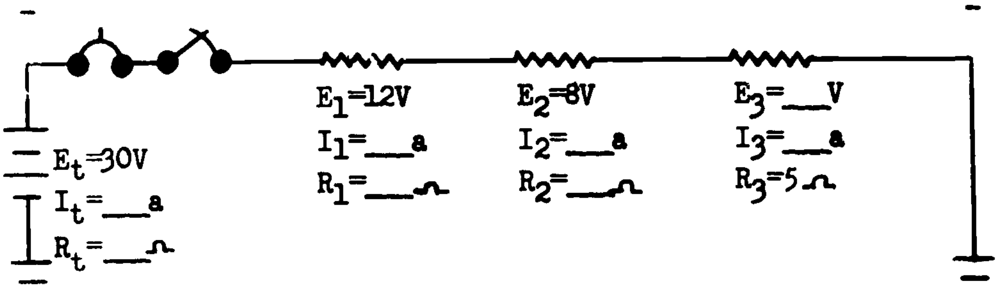
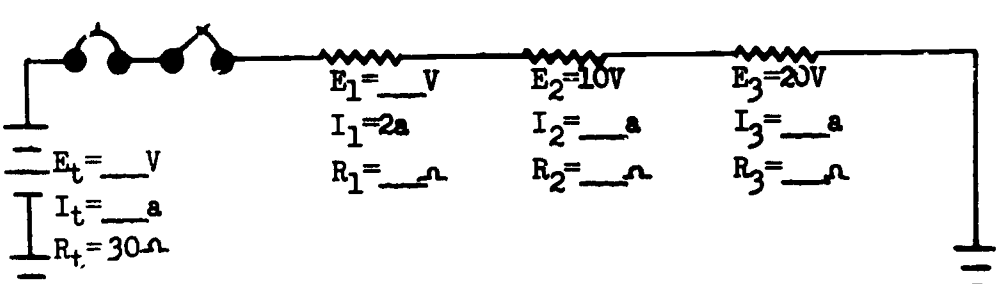


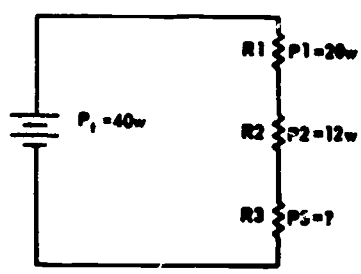
5.



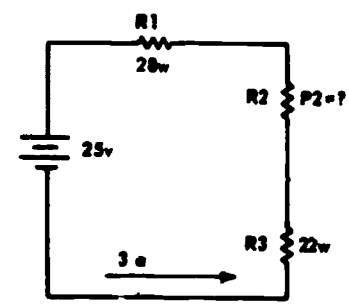
Frame 14

Each of the resistors in a series circuit consumes power which is used in the form of heat. Since this power must come from the source, the total power must be equal in amount to the power used by the total circuit resistance. In a series circuit, the total power is equal to the SUM of the power used by the individual resistors. This can be expressed as a formula: $P_t = P_1 + P_2 + P_3 + P_4 +$ etc. depending on how many resistors the circuit has. In figure A below, we want to find the power used by R_3. We know that $P_1 + P_2 + P_3 = 40w$. Therefore, to find P_3, you subtract the sum of P_1 and P_2 (32 watts) from P_t (40 watts). Thus, $P_3 = 8$ watts. In figure B we want to find P_2. First we need to find P_t. In your last lesson you learned that $P = I \times E$. Thus $P_t = I_t \times E_t = 3 \times 25 = 75w$. Now you can find P_2 by subtracting the sum of P_1 and P_3 from the total circuit power. Thus, $P_2 = 75 - 50 = 25w$.

A.



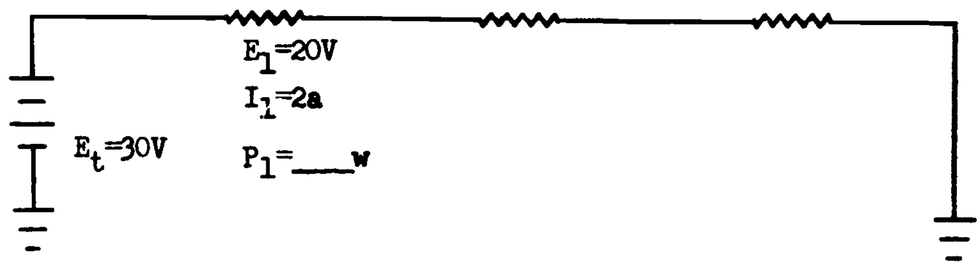
B.



Answers to Frame 13:

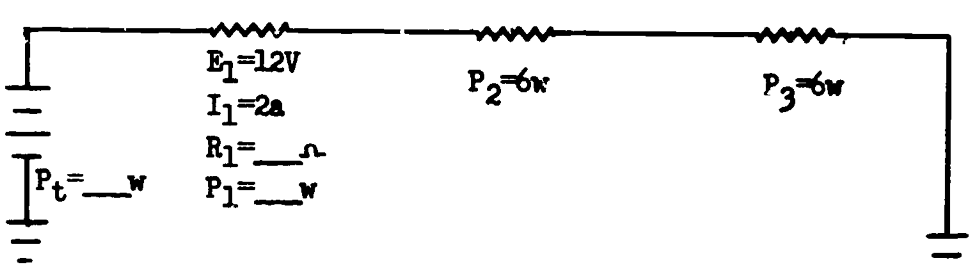
1. $I_t = 2a$ $I_1 = 2a$ $E_2 = 2V$ $E_3 = 2V$
   $R_t = 5\Omega$ $I_2 = 2a$ $I_3 = 2a$
2. $R_t = 4\Omega$ $E_1 = 6V$ $E_2 = 3V$ $E_3 = 3V$
   $I_1 = 3a$ $I_2 = 3a$ $I_3 = 3a$
   $k_3 = 1\Omega$
3. $I_t = 2a$ $E_1 = 6V$ $E_2 = 8V$ $E_3 = 6V$
   $R_t = 10\Omega$ $I_1 = 2a$ $I_2 = 2a$ $I_3 = 2a$
4. $I_t = 2a$ $I_1 = 2a$ $I_2 = 2a$ $E_3 = 10V$
   $R_t = 15\Omega$ $R_1 = 6\Omega$ $R_2 = 4\Omega$ $I_3 = 2a$
5. $E_t = 60V$ $E_1 = 30V$ $I_2 = 2a$ $I_3 = 2a$
   $I_t = 2a$ $R_1 = 15\Omega$ $R_2 = 5\Omega$ $R_3 = 10\Omega$

When using the power formula be sure that the numbers used are taken from the same component of the circuit. For example, the value of P_1 can be computed by the formula $P = I \times E$. Thus, $P_1 = I_1 \times E_1 = 2a \times 20V = 40w$.

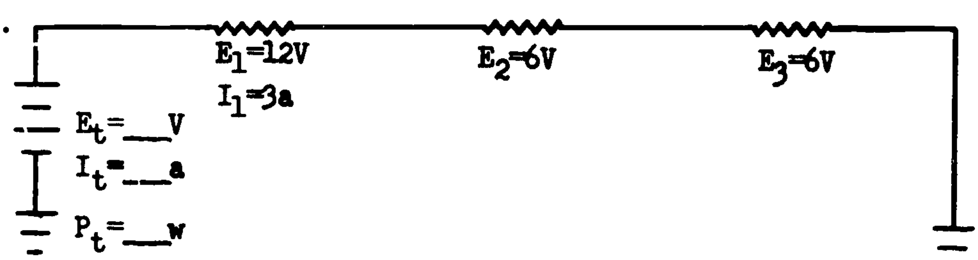


Solve each of the following problems for the indicated unknowns. Put your answers on the appropriate blank.

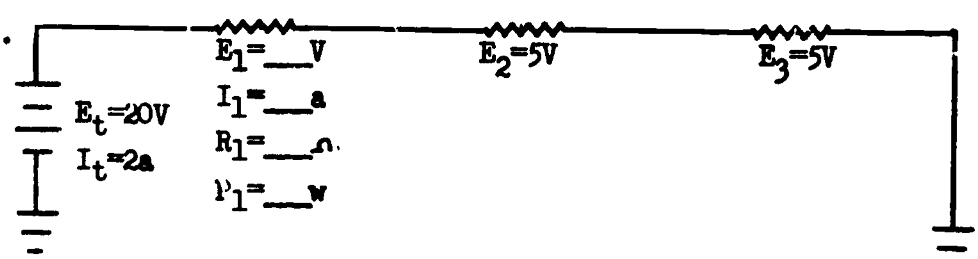
1.



2.



3.



Frame 16

In figure 1 below we are only asking you to find the value of P_t. However, we don't have enough information to find P_t until we find E_t and I_t or the values of P_1, P_2, and P_3. To establish a procedure for solving for unknowns in a series circuit we will work this problem with you.

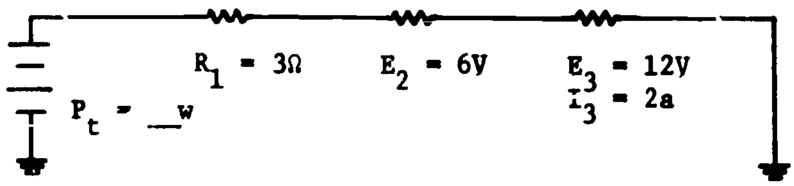


Figure 1.

1. Write in E, I, R, and P for each component in which they are missing. This has been done for you in this problem.

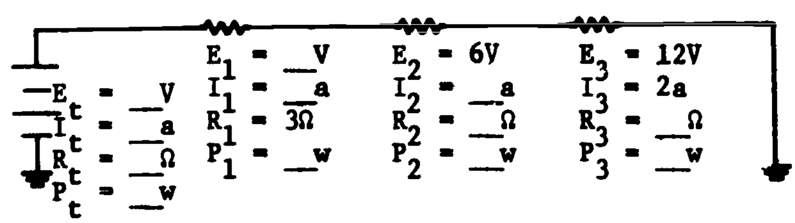


Figure 2.

2. One or more of the following laws and formulas can be used to solve for unknowns in a series circuit.

   a. Kirchhoff's voltage law

   b. Kirchhoff's current law

   c. Ohm's law formulas

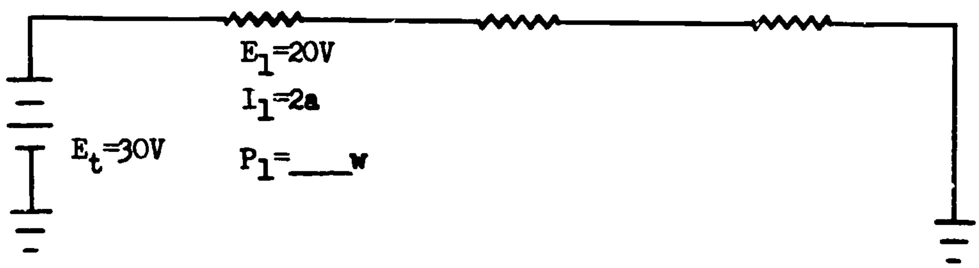
   d. $R_t = R_1 + R_2 + R_3$

   e. $P = I \times E$ ($P_t = P_1 + P_2 + P_3$)

3. Start down the list in step 2 until you find a law or formula that can be applied in this problem.

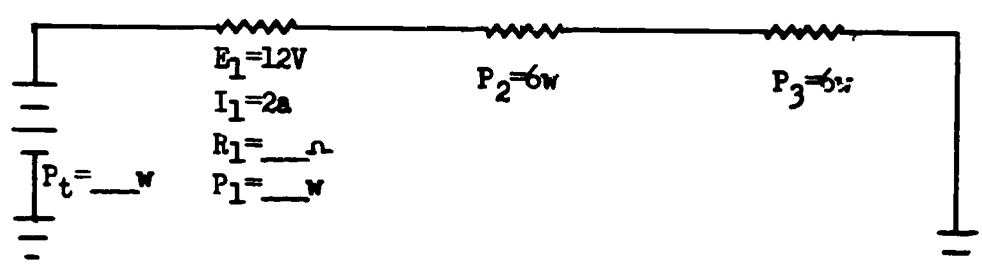
4. We don't have enough information now to use Kirchhoff's voltage law, but we can use Kirchhoff's current law. Applying it we have $I_2 = 2a$, $I_1 = 2a$, and $I_t = 2a$. Fill in these values on the appropriate blanks in figure 2.

When using the power formula be sure that the numbers used are taken from the same component of the circuit. For example, the value of P_1 can be computed by the formula $P = I \times E$. Thus, $P_1 = I_1 \times E_1 =$ 2a x 20V = 40w.

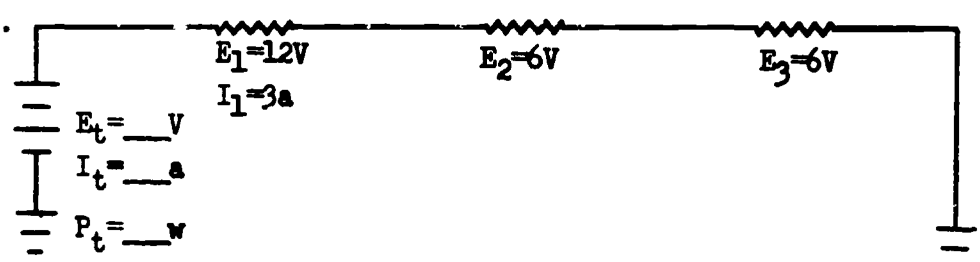


Solve each of the following problems for the indicated unknowns. Put your answers on the appropriate blank.

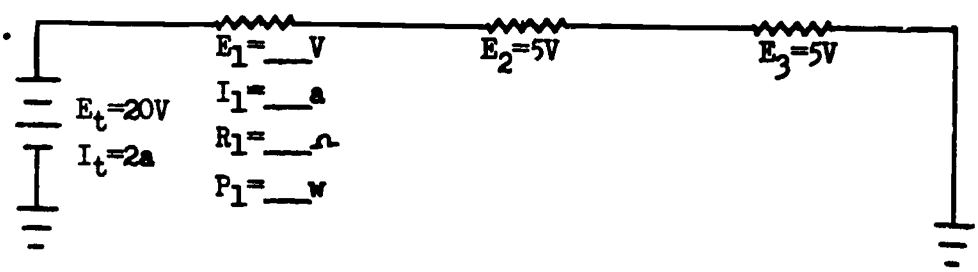
1.



2.



3.



Frame 16

In figure 1 below we are only asking you to find the value of P_t. However, we don't have enough information to find P_t until we find E_t and I_t or the values of P_1, P_2, and P_3. To establish a procedure for solving for unknowns in a series circuit we will work this problem with you.

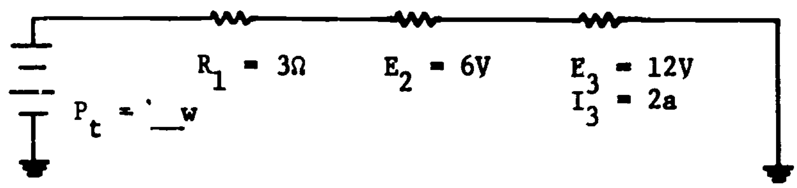


Figure 1.

1. Write in E, I, R, and P for each component in which they are missing. This has been done for you in this problem.

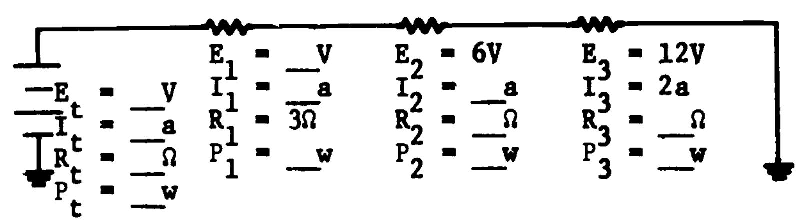


Figure 2.

2. One or more of the following laws and formulas can be used to solve for unknowns in a series circuit.

   a. Kirchhoff's voltage law

   b. Kirchhoff's current law

   c. Ohm's law formulas

   d. $R_t = R_1 + R_2 + R_3$

   e. $P = I \times E$ ($P_t = P_1 + P_2 + P_3$)

3. Start down the list in step 2 until you find a law or formula that can be applied in this problem.

4. We don't have enough information now to use Kirchhoff's voltage law, but we can use Kirchhoff's current law. Applying it we have I_2 = 2a, I_1 = 2a, and I_t = 2a. Fill in these values on the appropriate blanks in figure 2.

5. Figure 3 is the same as figure 2 with the values found in step 4 written down.

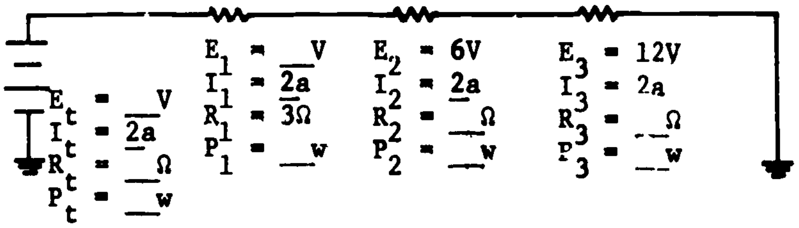


Figure 3.

6. Now we can use Ohm's law formulas to find the values of E_1, R_2, and R_3. $E_1 = I_1 \times R_1 = 2 \times 3 = 6V$. $R_2 = E_2/I_2 = 6/2 = 3$ ohms. $R_3 = E_3/I_3 = 12/2 = 6$ ohms. Fill in these values in figure 3.

7. Figure 4 is the same as figure 3 with the values found so far written down.

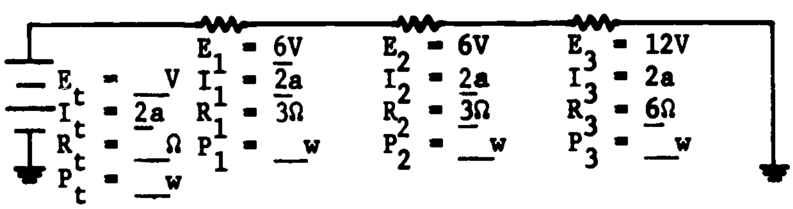


Figure 4.

8. Now we can use the resistance formulas. Thus, $R_t = 3 + 3 + 6 = 12$ ohms. Fill in 12 ohms for R_t in figure 4. Now we can use the formula $E = I \times R$ to find E_t. Thus, $E_t = I_t \times R_t = 2 \times 12 = 24V$. Fill in 24V for E_t.

9. Now we can use the power formula $P = I \times E$ to find P_1, P_2, P_3, and P_t. $P_1 = 2 \times 6 = 12w$. $P_2 = 2 \times 6 = 12w$. $P_3 = 2 \times 12 = 24w$. $P_t = 2 \times 24 = 48w$. Fill in these values in figure 4.

Frame 16 (Continued)

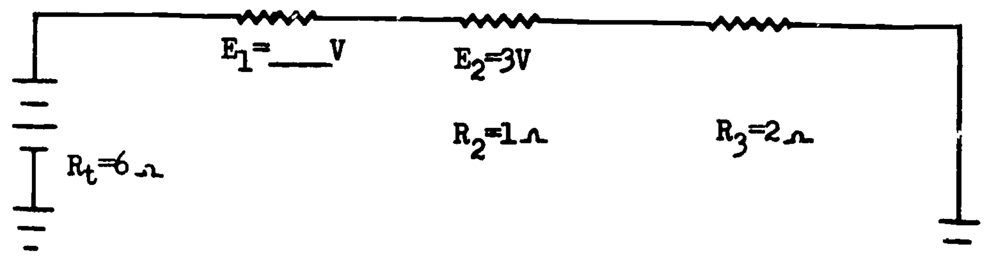
10. We have completely solved the problem using a systematic approach. If you develop a systematic approach as we demonstrated here, you will have very little trouble solving for unknowns in a series circuit.

    No further response required, proceed to the next page.

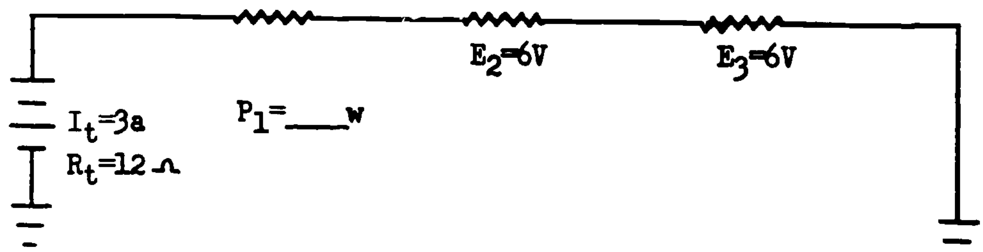
Answers to Frame 14: 1. P_1 = <u>45w</u> 2. P_1 = <u>15w</u>

Solve for the indicated unknown in each of the following problems. Put your answers on the appropriate blank.

1.



2.



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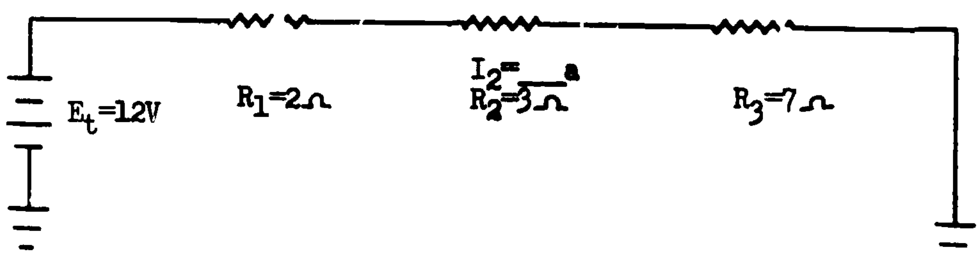
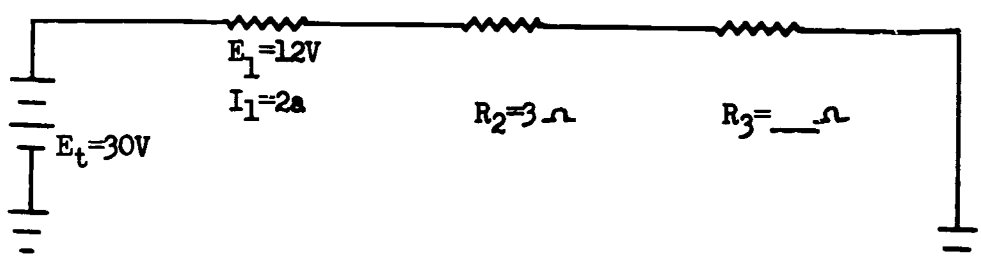


4.



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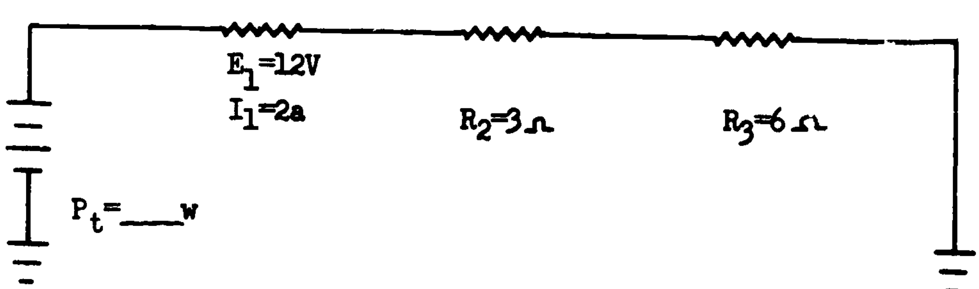


Answers to Frame 15:

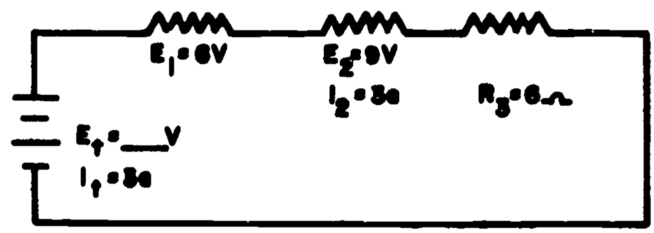
1. P_t = <u>36w</u> R_1 = <u>6Ω</u> P_1 = <u>24w</u>

2. E_t = <u>24V</u>
   I_t = <u>3a</u>
   P_t = <u>72w</u>

3. E_1 = <u>10V</u>
   I_1 = <u>2a</u>
   R_1 = <u>5Ω</u>
   P_1 = <u>20w</u>

Solve for the indicated unknown in each of the following problems. Put your answers on the appropriate blank.

1.



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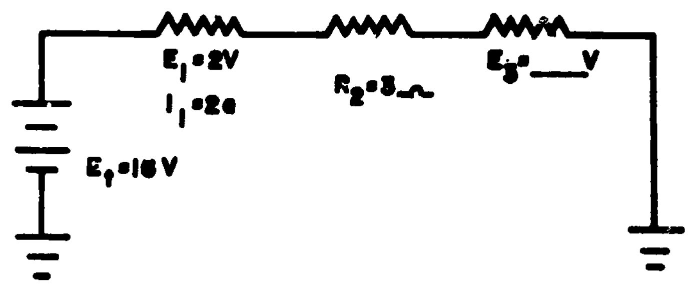

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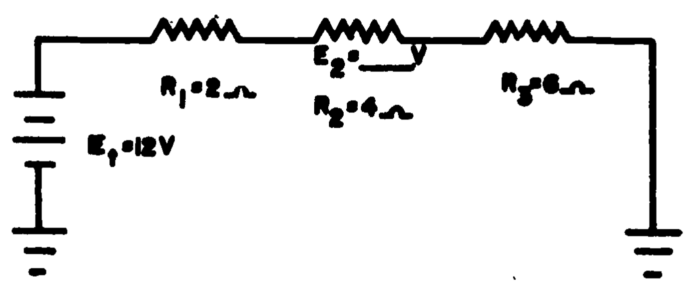

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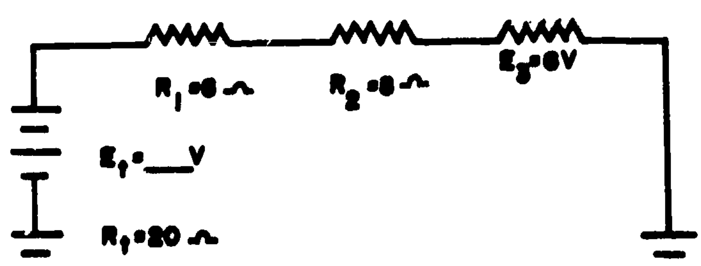

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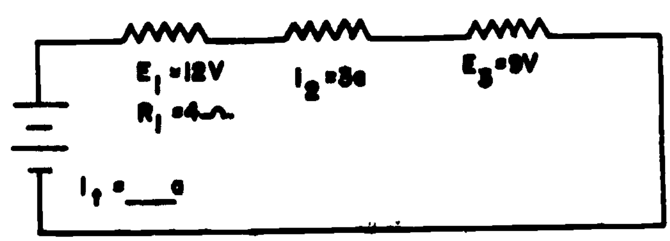
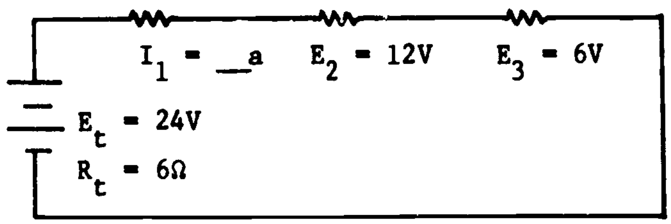


Frame 18 (Continued)

6.



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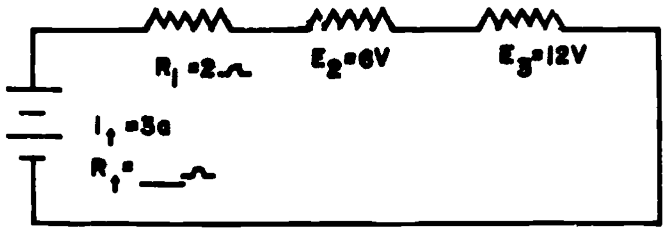

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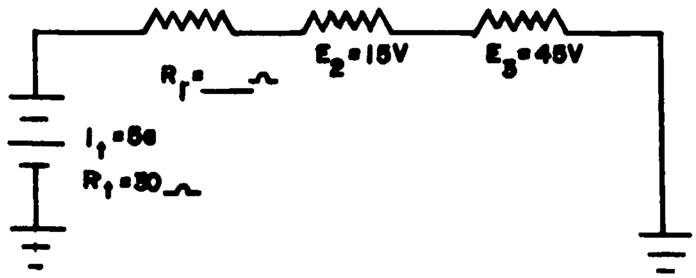
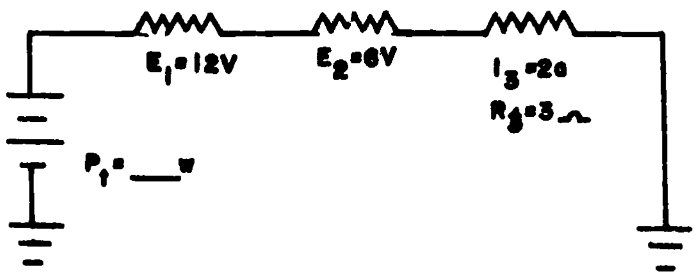
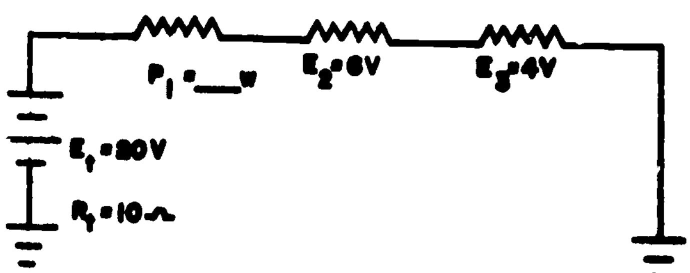


9.



10.



Have the instructor check your answers. Instructor's Initials _____

STOP! TAKE APPRAISAL ON PART 1 BEFORE CONTINUING TO PART 2.

(You must satisfactorily complete the appraisal on PART 1 before continuing to PART 2.)

Frame 19

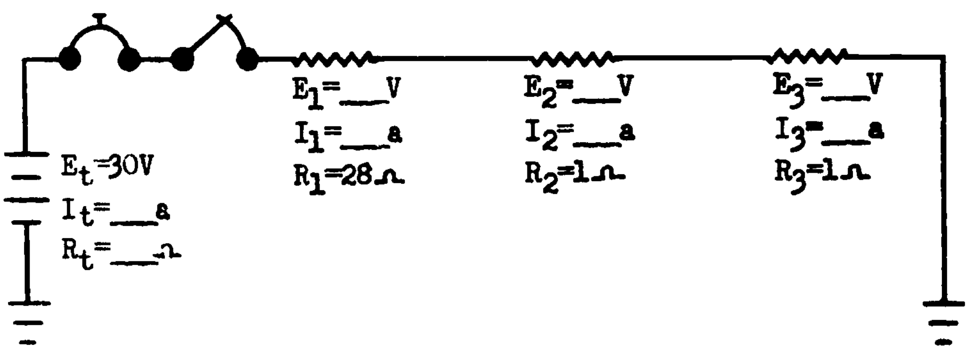
Earlier in this PT you learned how circuits worked normally. In the remainder of this PT you will learn how to troubleshoot. Electrical troubleshooting is locating a component that is causing a circuit to work incorrectly. While it is difficult to teach a person to analyze, we can teach you a few guidelines to follow. The more skillful you become at circuit analysis, the better mechanic you will become. The most important thing you should know in order to begin troubleshooting a circuit, is how the circuit is supposed to function normally. The reason for this is, if you don't know how a circuit is supposed to function, how would you know if there is a trouble in it?

Check the true statement.

_____1. In order to troubleshoot a circuit, you should know how the circuit is supposed to function normally.

Answers to Frame 17: 1. $E_1 = 9V$ 2. $P_1 = 72w$ 3. $I_2 = 1a$ 4. $R_3 = 6$ 5. $P_t = 60w$

There are several principles that we are going to review before we discuss troubleshooting. (1) In order to have a deflection (movement) of a meter needle you must have current flowing through the meter. Thus, if the meter needle is not deflecting (moving), you don't have any current flowing through it. (2) The largest resistance value in a series circuit will drop the most voltage. The smallest resistance value will drop the least voltage. To explain this we will have you work out the following problem. Solve for all indicated unknowns and put your answers on the appropriate blanks.



Check the true statements.

_____1. The largest resistor in the circuit above dropped most of the voltage.

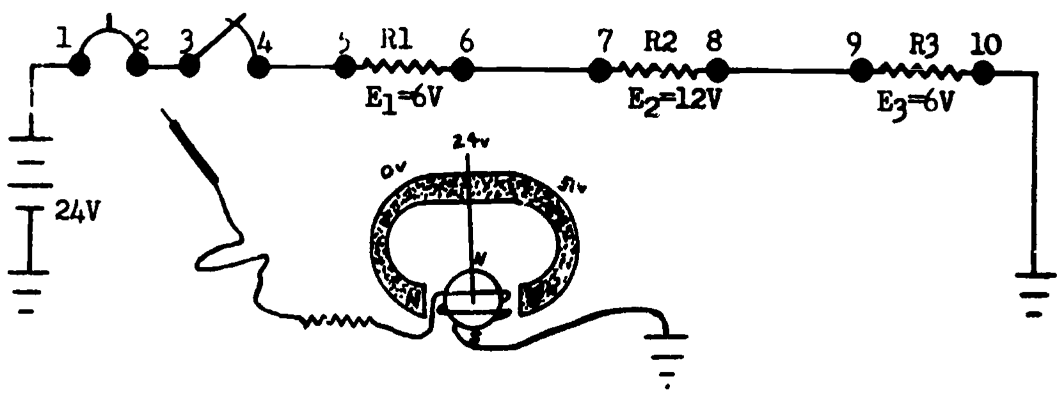
_____2. Current flowing through a meter causes the needle to deflect.

Answers to Frame 19: _X_ 1. _X_ 2.

Frame 21

In order to be able to troubleshoot you must know what readings you would get in a normal circuit. Thus, before we start troubleshooting we are going to talk about a circuit that is functioning normally. In the circuit below we have the negative lead of the voltmeter connected to ground. The positive lead was left free so it could be moved from one point to another. What should the voltmeter read if it was connected to test point 1? If you said 24V, you are correct. The only resistance in this path is the voltmeter. Applying Kirchhoff's voltage law to this path, we find that the voltmeter will drop all 24V.

Note: Wires, switches and circuit breakers should not drop any voltage, BECAUSE they are NOT loads.

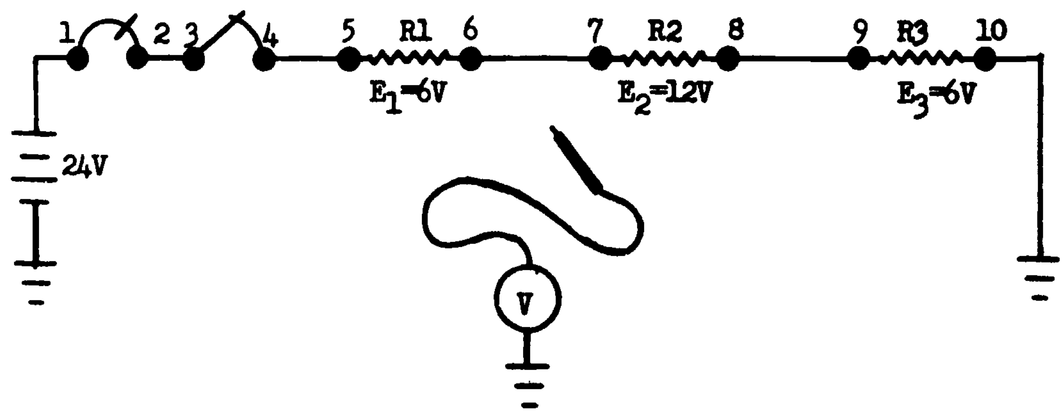


Check the true statements.

_____1. We should have a voltage drop of several volts across the circuit breaker.

_____2. A voltmeter connected from point 3 to ground should also read 24V.

We're continuing to use the same circuit as we used in the last frame. A piece of wire and a closed switch should both have 0 ohms of resistance. Thus, when connecting the voltmeter to points 3, 4, and 5, we have no other resistance in the same path as the voltmeter. Applying Kirchhoff's voltage law the voltage drop across the voltmeter is 24V at points 3, 4, and 5, since it is the only resistance in these paths. Let's connect the voltmeter between point 6 and ground. Trace out a path starting from the negative terminal of the battery through the voltmeter, R1, switch, circuit breaker, and back to the positive terminal of the battery. In this path you should have discovered that there is another unit of resistance (R1) in addition to the voltmeter. Applying Kirchhoff's voltage law to this path the sum of the voltage drops across the meter and across R1 must be 24V. Since $E_1 = 6V$, the voltmeter is dropping 18V. Connecting the voltmeter at point 7 will not add another resistance in the path with the voltmeter and R1. Thus, the voltmeter should also indicate 18V at point 7.



Check the true statements.

_____1. A voltmeter connected from point 3 to ground will read 0V.

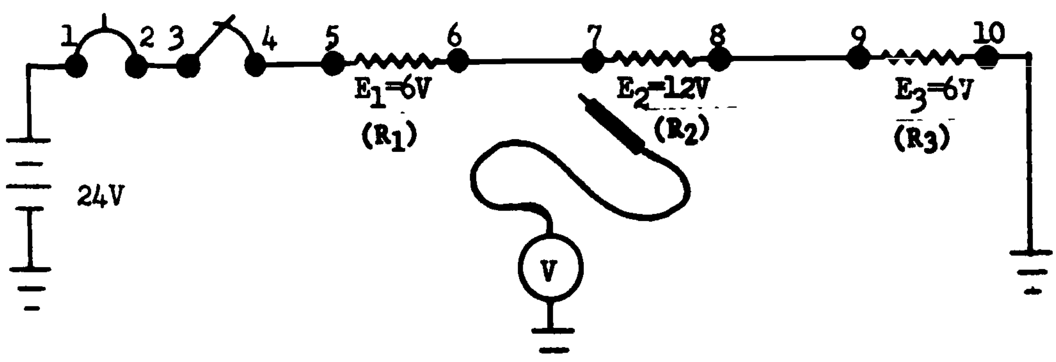
_____2. A voltmeter connected from point 5 to ground will read 24V.

_____3. A voltmeter connected from point 6 to ground will read 6V.

Answers to Frame 20: __X__ 1. __X__ 2.

Frame 23

Now we're going to connect the meter between point 8 and ground in the same circuit as we have been using. Trace a path from the negative terminal of the battery through the voltmeter, R2, R1, switch, circuit breaker, and back to the positive terminal of the battery. Applying Kirchhoff's voltage law to this path we have E_v (voltage drop across voltmeter) + E_2 + E_1 = 24V. Substituting we have E_v + 12 + 6 = 24V. Thus, E_v = 6V and the voltmeter will indicate 6V. Connecting the voltmeter at point 9 will also indicate 6V since we have not added any resistance to the path that the voltmeter is connected in. What do you think that the voltmeter will read when connected to point 10? If you said 0V, you are correct. Let's see why! Applying Kirchhoff's voltage law we have $E_v + E_3 + E_2 + E_1$ = 24V. Substituting we have E_v + 6 + 12 + 6 = 24V. Thus, E_v = 0V. Another way of explaining this reading is to recognize that the ground wire is providing a zero resistance path for the current to bypass the meter. Thus, all the current goes through the wire. With no current flowing through the meter, we have no needle deflection.



Check the true statements.

_____1. A voltmeter connected between point 6 and ground will indicate 18V.

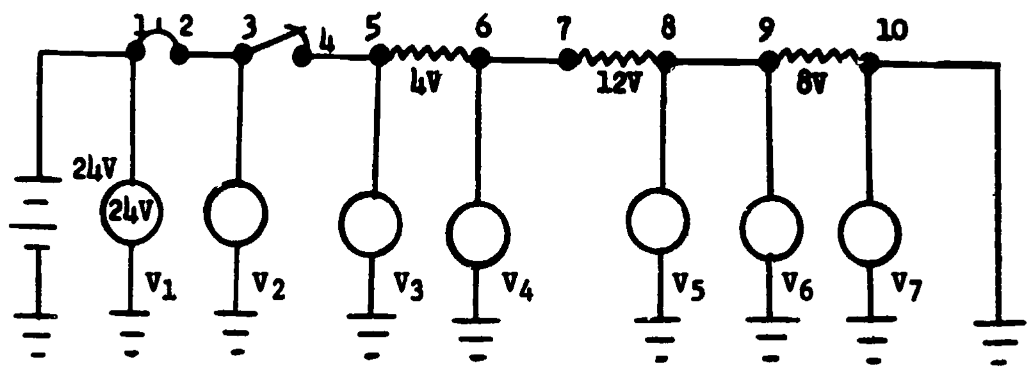
_____2. A voltmeter connected between point 7 and ground will indicate 12V.

_____3. A voltmeter connected between point 9 and ground will indicate 6V.

Answers to Frame 21: _____1. __X__2.

In the circuit below we have given you the voltage dropped across each resistor. Fill in the values that would be indicated on the voltmeter for each of the positions given. The first one has been done for you.

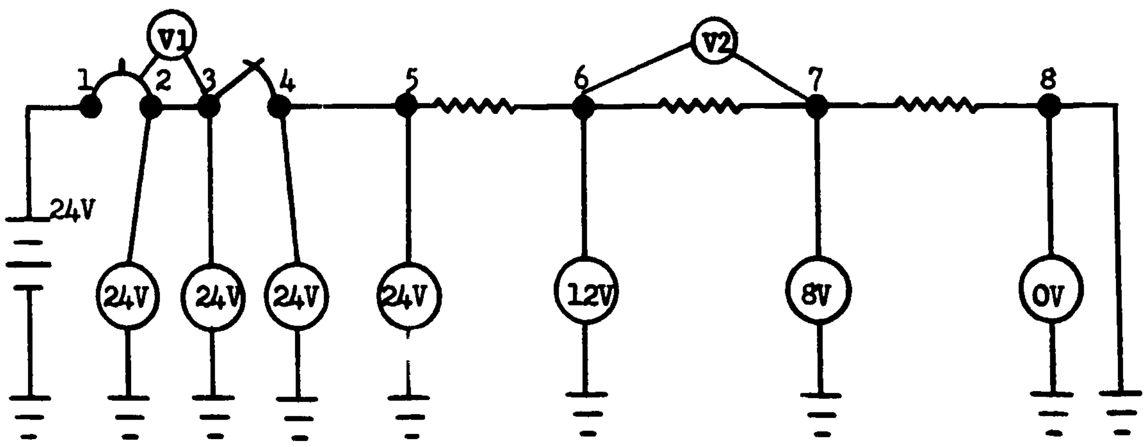
Note: We are only using one voltmeter and connecting it to the points indicated one at a time.



Answers to Frame 22: ____1. __X__2. ____3.

Frame 25

In the last few frames we have been discussing voltage readings taken between a test point and ground. You should also be able to understand readings taken between two points. An important fact to remember is that a voltmeter measures the difference in potential between the two points where it is connected. A voltmeter (V1) connected between points 2 and 3 in the circuit below would read 0V. With 24V at point 2 and 24V at point 3 the difference would be 24 - 24 = 0V. A voltmeter (V2) connected between points 6 and 7 would read 4V as the difference between 12V and 8V is 4V.



Fill in the values for the voltmeter readings between the following points.

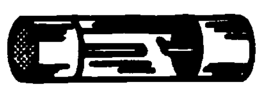
1. Between 3 and 4 _________.
2. Between 5 and 6 _________.
3. Between 7 and 8 _________.
4. Between 8 and ground _________.

Answers to Frame 23: X 1. ___ 2. X 3.

A circuit is said to be OPEN when there is a break in a complete conducting path. Although an open occurs any time a switch is turned OFF, an open may also develop accidentally due to a malfunction in the circuit. To put the circuit back to normal operation, the open must be found and corrected. Sometimes an open can be found by a close look at the circuit components. Bad components, such as burned out resistors and fuses can be found by this means. Others such as a break in a wire covered by insulation, or the melted element of an enclosed fuse, are not seen by the eye. Under such conditions, it is important that you have a good understanding of how to use a voltmeter or an ohmmeter to help you find the open component.

BURNED OUT RESISTOR

BURNED OUT LAMP BULB



BURNED OUT FUSE

BROKEN WIRE

Check the true statements.

_____1. An open can always be located visually.

_____2. An open is an incomplete path for current to flow.

_____3. An example of an open would be a switch in a circuit turned to the OFF position.

_____4. A burned out lamp bulb in a circuit would be an example of an open.

Answers to Frame 24: $V_1 = 24V$ $V_2 = 24V$ $V_3 = 24V$ $V_4 = 20V$
$V_5 = 8V$ $V_6 = 8V$ $V_7 = 0V$

Frame 27

An open was defined as an incomplete path for current to flow. Although an open occurs any time a switch is turned OFF, an open may also develop accidentally due to a malfunction in the circuit. Many opens can be located by sight; others need the use of a meter to find the bad component. Using a meter to find bad components is the topic of the remainder of this PT.

Check the true statements.

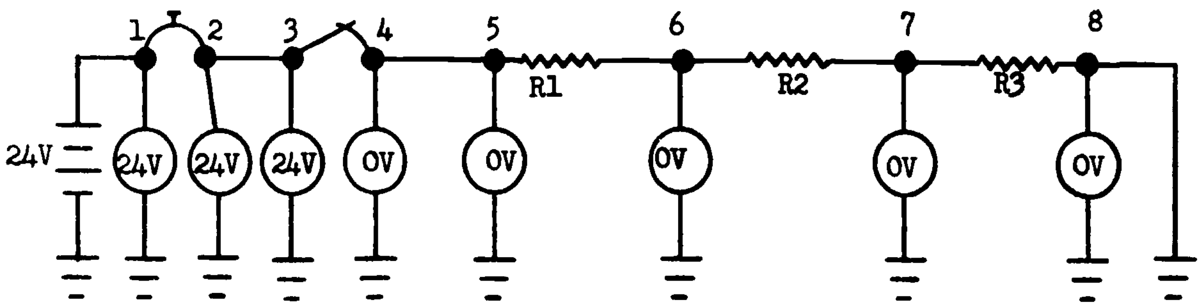
_____1. Current can still flow in an open series circuit.

_____2. A voltmeter measures the difference in potential between two points.

_____3. A voltmeter can be used in locating open components in a series circuit.

Answers to Frame 25: 1. 0V 2. 12V 3. 8V 4. 0V

Let's get some practice troubleshooting with a voltmeter. In the circuit below we have given you voltmeter readings at different points. NOTE: We are using only one voltmeter and moving the positive lead from one test point to another. The voltmeter readings at points 1, 2, and 3 indicate that we have a complete path for current flow up to point 3. Do you see why? If not, restudy frame 26. Now trace a path from the negative terminal of the battery through the voltmeter connected to point 4, the switch, the circuit breaker, and back to the positive terminal of the battery. Applying Kirchhoff's voltage law to this path we see that the voltmeter should be dropping 24V since it is the only resistance in this complete path. However, it is reading 0V. This means that no current is flowing through the meter. Thus, somewhere in this path we have an open. Since we know the path is good up to point 3, the open must be between point 3 and point 4. Thus, the switch is open.



Check the true statements.

_____1. In the circuit shown the difference in potential between point 3 and point 4 is 24 volts.

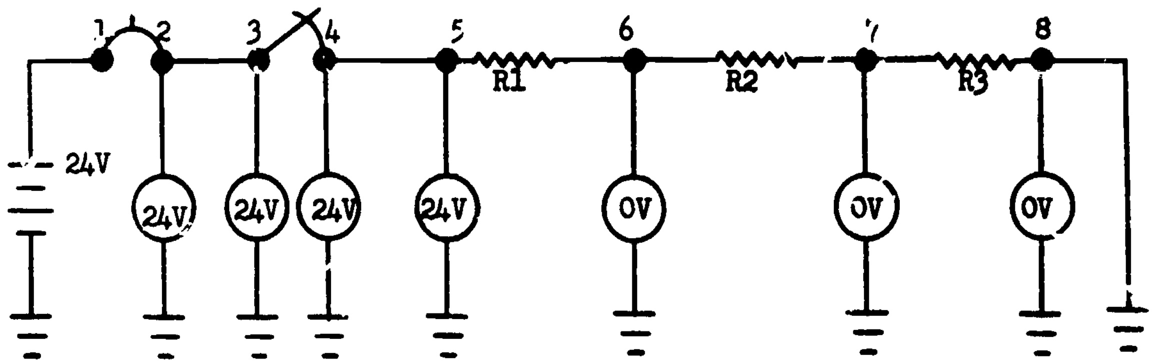
_____2. If the circuit breaker had been open, the voltmeter readings at points 2 and 3 would also have been 0 volts.

_____3. There is no current flowing through R1.

Answers to Frame 26: _____1. __X__ 2. __X__ 3. __X__ 4.

Frame 29

In the circuit shown below we have given you voltmeter readings at different points in the circuit. Since the voltmeter readings at points 2, 3, 4, and 5 are all 24V, we have a complete path up to point 5. If you are not sure why, restudy frames 26 and 27. Now, trace a path from the negative terminal of the battery through the voltmeter connected to point 6, R1, the switch, the circuit breaker, and back to the positive terminal of the battery. In this path we have two resistances, R1 and the voltmeter. The voltmeter should be dropping some of the voltage. However, it is reading 0V. This means that no current is flowing through the voltmeter. Thus, somewhere in this path we have an open. Since we know the path was good up to point 5, the open must be between points 5 and 6. Thus, R1 is open.



Check the true statements.

_____1. A voltmeter connected between points 5 and 6 would read 24V.

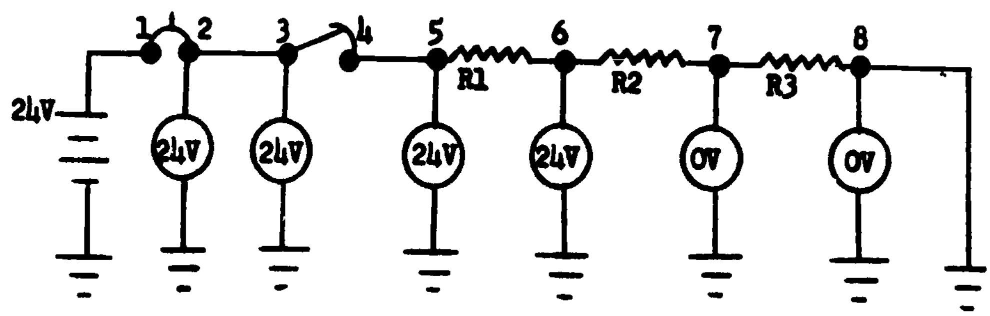
_____2. If all the readings had been 0V except the one at point 2, we would have an open switch.

_____3. There is no current flowing through R1.

_____4. A voltmeter connected between points 6 and 7 would read 24V.

Answers to Frame 27: _____1. __X__2. __X__3.

In the circuit shown below we have normal readings up to point 5. The readings at points 6 and 7 are abnormal. Even though the reading at point 6 is abnormal, we know that we have a complete path up to point 6 as the voltmeter connected there is deflecting. The voltmeter connected at point 7 reads 0V. Thus, we have no current flowing through the voltmeter when it is connected at point 7. Therefore, we have an open somewhere in this path. Since our path was good up to point 6, the open must be between points 6 and 7. Thus, R2 is open.



Check the true statements.

_____1. There is no current flowing through R2.

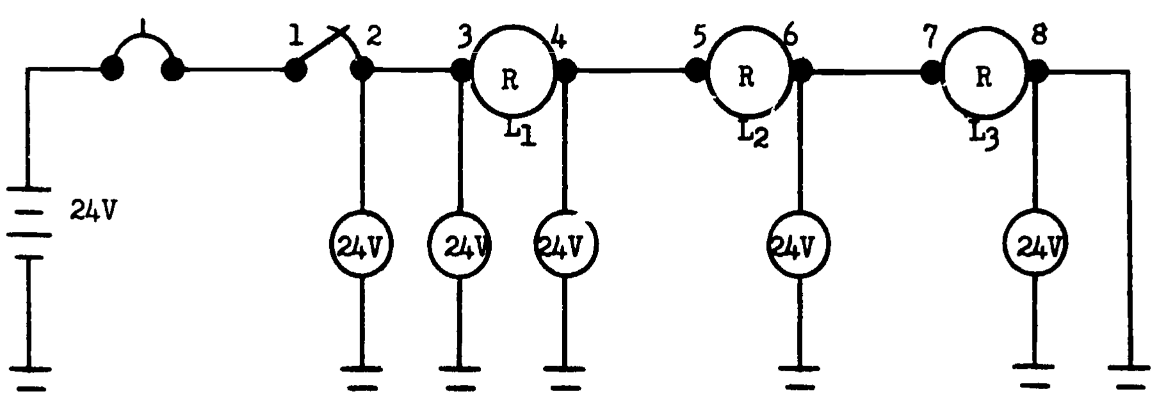
_____2. A voltmeter connected between points 6 and 7 would read 24V.

_____3. If all the readings were the same as those above except that at point 6 we had 0V, we would have an open in R2.

Answers to Frame 28: __X__ 1. __X__ 2. __X__ 3.

Frame 31

Let's think of one more problem before giving you some to do on your own. The circuit we are using has three lamps in it. For troubleshooting purposes treat the lamps just like resistors. We closed the switch and none of the lamps came on. We made voltage checks at all the points shown. Everywhere we placed the meter in the circuit it read 24V. From the readings given we know we have a complete path up to point 8. Since we know there must be an open in the circuit or the lamps would be lit, the only possibility left is between 8 and ground. Let's see why! As stated earlier the reading at point 8 would be 0V as the ground wire should provide a 0 ohms resistance path for the current to bypass the meter when it is connected to point 8. Thus, the ground wire must be open forcing the current to go through the voltmeter. Another way to explain this problem is to recall that a wire (conductor) should have 0 ohms of resistance. Since $R = 0$, the voltage drop across a wire should be 0V. Since any number times 0 is 0, $E = I \times 0 = 0V$. Thus, we should not have a measurable voltage drop across a short piece of wire. If, as in this case, the wire is dropping all the applied voltage, you have an open in the wire.



Check the true statements.

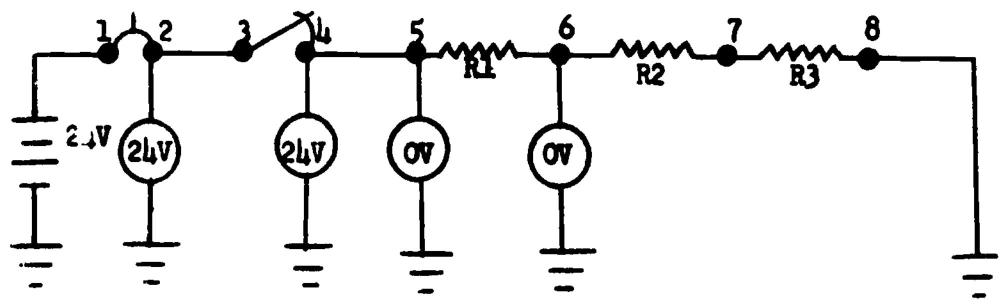
_____1. If lamp L2 burned out, lamps L1 and L3 would continue operating.

_____2. A difference of potential of 24V across a wire would indicate that the wire is open.

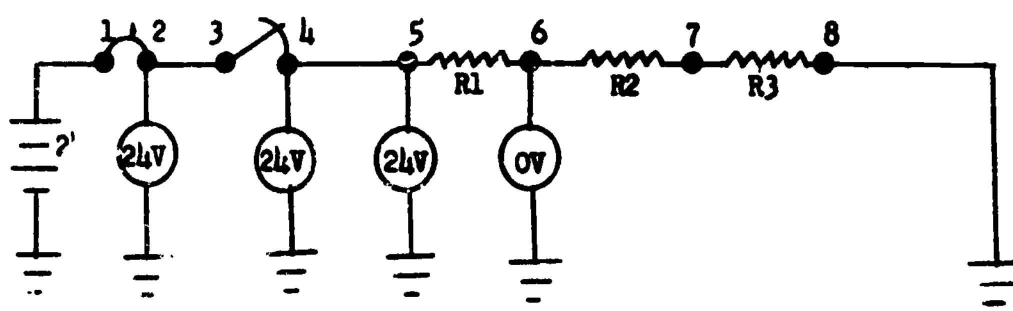
Answers to Frame 29: __X__1. _____2. __X__3. _____4.

Analyze the meter readings in each of the following circuits. On the blank provided by each circuit list the type of trouble and the faulty component. The first one has been done for you. Throughout this PT all circuits will have at most one faulty component per circuit.

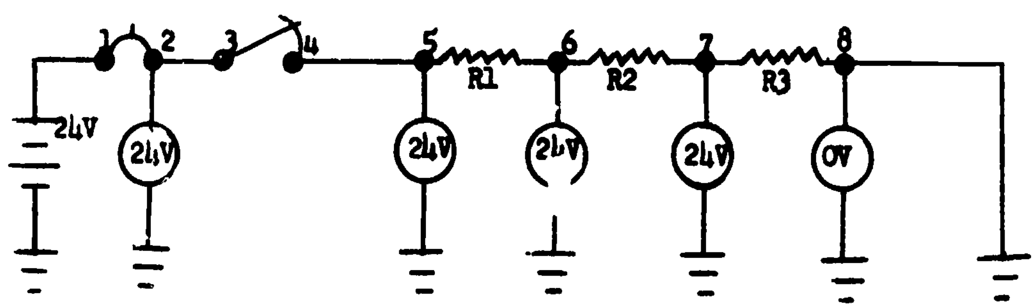
1. OPEN wire between points 4 and 5.



2. ______________________________



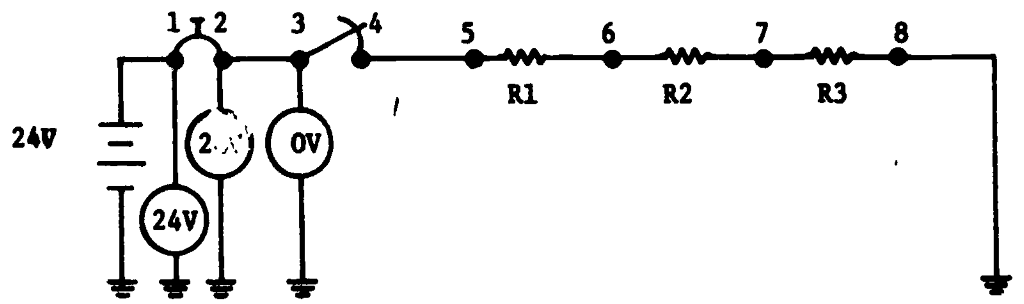
3. ______________________________



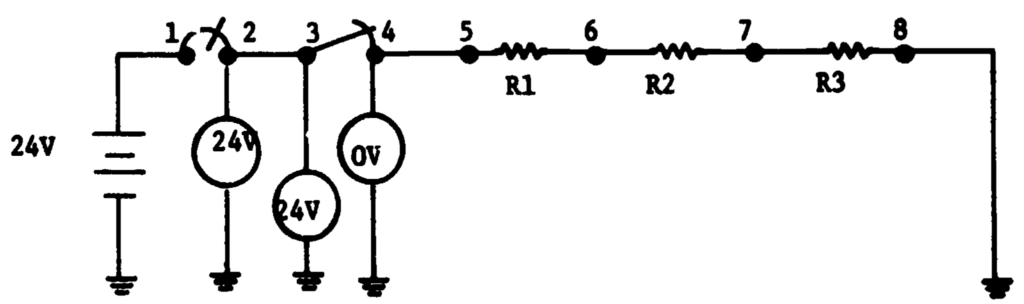
Answers to Frame 30: __X__ 1. __X__ 2. ____ 3.

Frame 32 (Continued)

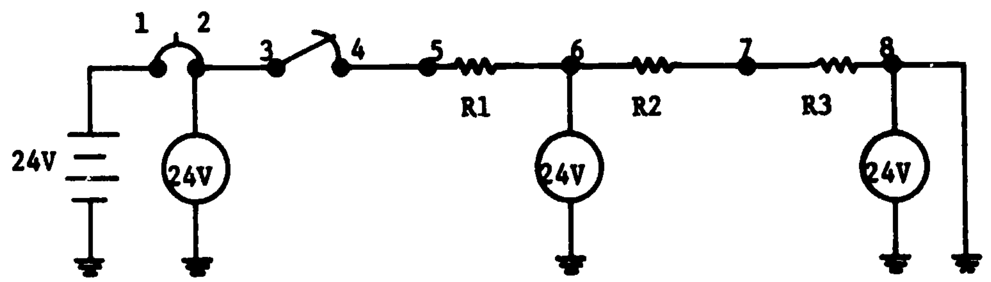
4. ______________________________



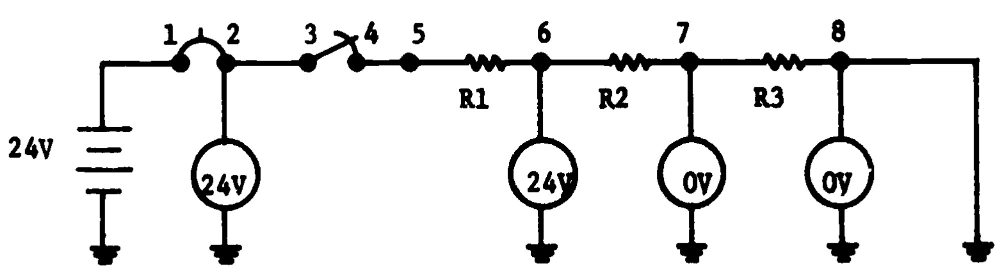
5. ______________________________



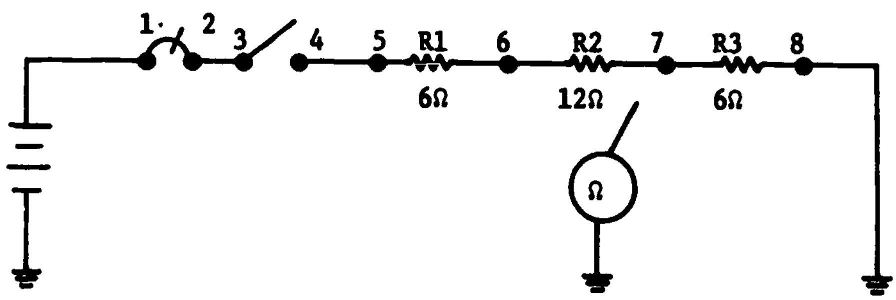
6. ______________________________



7. ______________________________



An open can also be located with an ohmmeter. Remember, an ohmmeter has its own source of power and should <u>never</u> be used in a live circuit. You must either open the circuit breaker, remove the fuse, open the switch, or disconnect the wires. Before using an ohmmeter for troubleshooting let's see w^ eadings an ohmmeter would indicate in a normal circuit. The ohmme nnected from point 8 to ground should read 0 ohms, since the resistance of the ground wire should be practically 0 ohms. An ohmmeter connected from point 7 to ground should read 6 ohms, the resistance of R3. When the ohmmeter is connected to point 6, it should read 18 ohms, the total resistance of R2 and R3. What would the ohmmeter read when connected to point 5? If you said 24 ohms, you are correct. The reason is, the ohmmeter is connected from point 5 to the circuit ground so it reads the total resistance of the circuit.



Check the true statements.

_____1. An ohmmeter connected from point 4 to ground would read 24 ohms.

_____2. An ohmmeter connected from point 6 to point 8 would read 18 ohms.

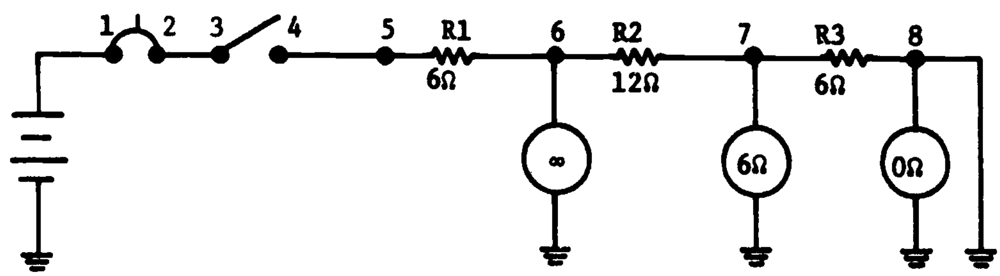
_____3. An ohmmeter connected from point 6 to ground would read 18 ohms.

Answers to Frame 31: _____1. __X__ 2.

Answers to Frame 32: 2.	<u>open points 5-6</u>	3.	<u>open 7-8</u>
4.	<u>open 2-3</u>	5.	<u>open 3-4</u>
6.	<u>open 8 to ground</u>	7.	<u>open 6-7</u>

Frame 34

Let's get some practice troubleshooting with an ohmmeter. In the circuit below we have given you ohmmeter readings at different points in the circuit. We are using only one ohmmeter and moving the one lead from one test point to another. Remember, in order to have needle deflection, you must have current flowing through the movement. An ohmmeter reading of 0 ohms at point 8 indicates that the ground wire is good. An ohmmeter reading of 6 ohms at point 7 indicates that we have a complete path up to point 7. When the ohmmeter is connected to point 6, the needle doesn't deflect. This indicates that no current is flowing through the ohmmeter when it is connected to point 6. Since we had a complete path up to point 7, there must be an open between points 6 and 7. Thus, R2 is open.



Check the true statements.

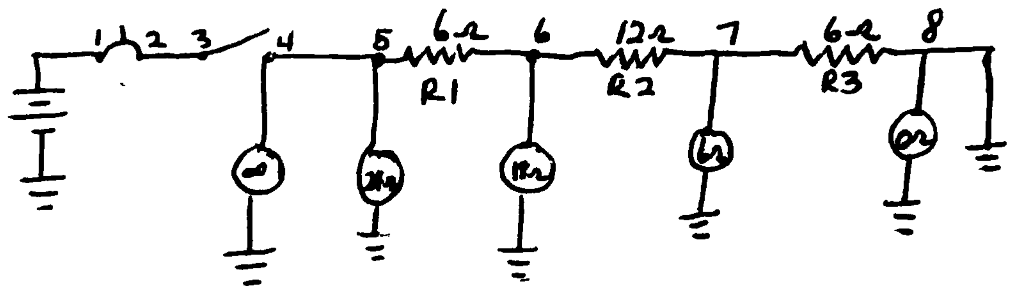
_____1. If an ohmmeter was connected to point 6 in the circuit above, the ohmmeter would read infinity (∞) indicating that R2 is open.

_____2. No deflection of an ohmmeter needle indicates that there is no current flowing through the meter movement.

_____3. An infinity (∞) reading indicates that we have an open.

Answers to Frame 33: _X_ 1. _X_ 2. _X_ 3.

In the circuit below, we have given you ohmmeter readings at different points in the circuit. Since we have needle deflection when the ohmmeter is connected to points 5, 6, 7, and 8, we must have a complete path up to point 5. Remember start at point 8 to trace your path. The infinity (∞) reading at point 4 indicates that there is not a complete path up to point 4. Since it was complete up to point 5, there is an open between points 4 and 5.



Check the true statements.

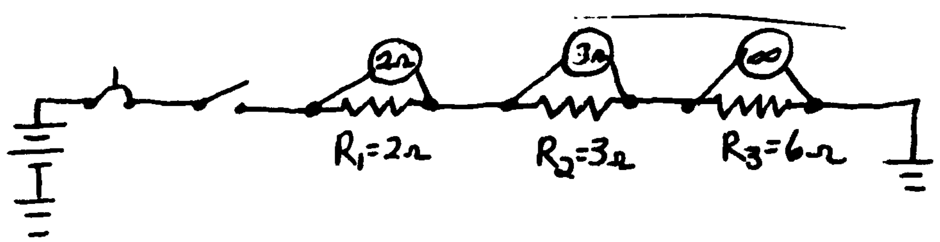
_____1. An ohmmeter connected between points 4 and 5 would indicate ∞ .

_____2. An ohmmeter reading of infinity at point 8 indicates that the ground wire is good.

_____3. An ohmmeter connected around an open will indicate infinity.

Frame 36

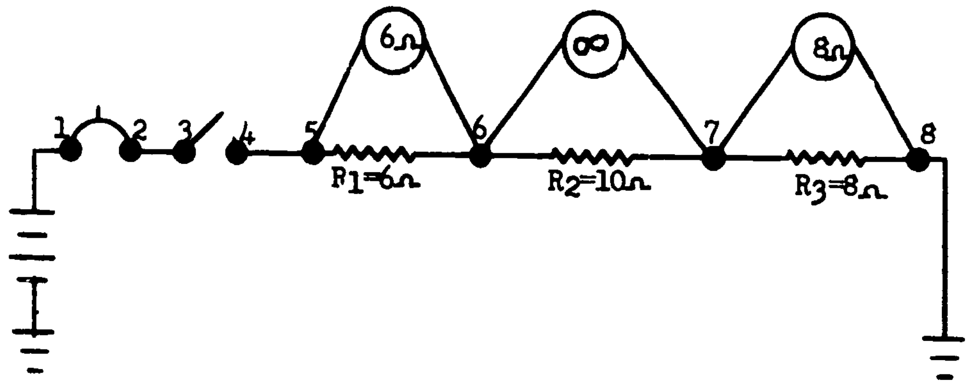
You can also measure across a resistor to see what its value is. For example, in the circuit below, if we measure across R_1, we get 2 ohms. That is a good reading since R_1 has 2 ohms of resistance. R_2 has a value of 3 ohms and we measured 3 ohms, when we measured across it. R_3 should have a value of 6 ohms, however, we are reading infinity (∞). This indicates that R_3 is open.



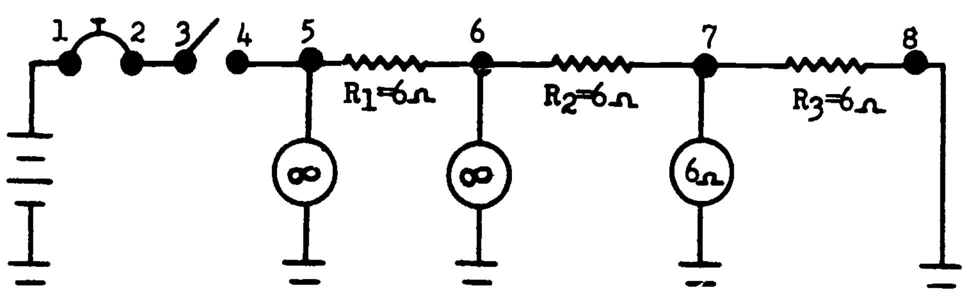
Answers to Frame 34: __X__ 1. __X__ 2. __X__ 3.

Analyze the meter readings in each of the following circuits. On the blank provided by each circuit list the type of trouble and the faulty component. The first one has been done for you.

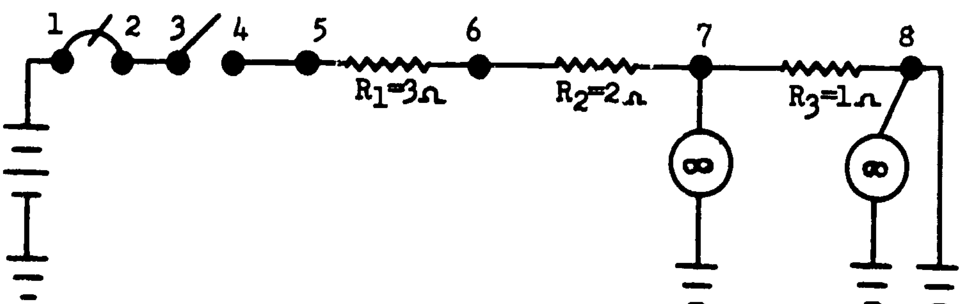
1. OPEN R2



2. ______________________________

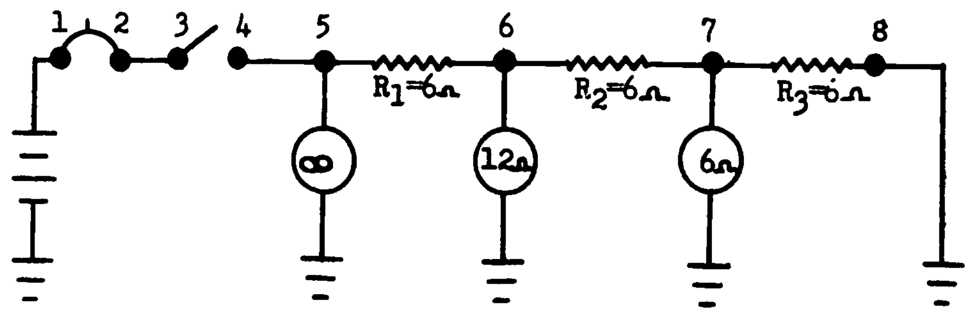


3. ______________________________

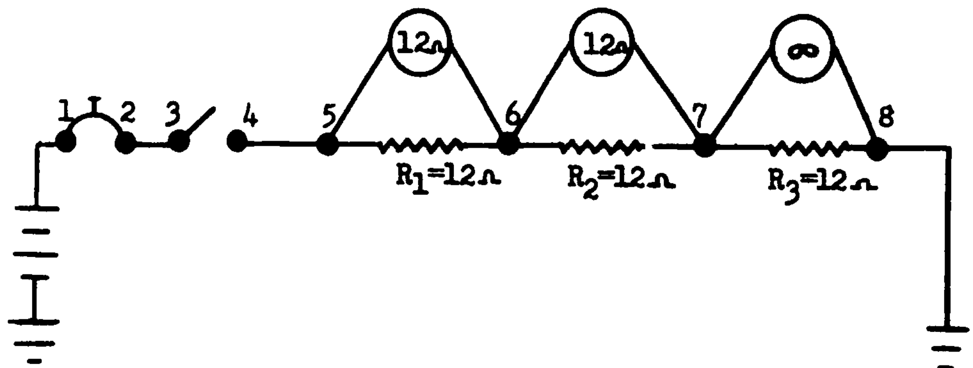


Frame 37 (Continued)

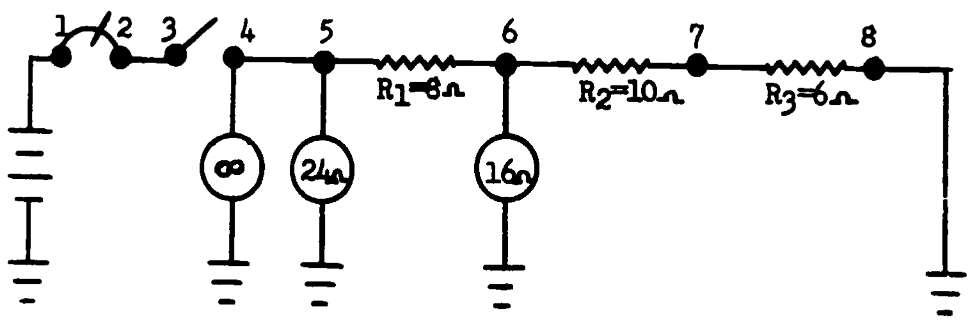
4. ______________________________



5. ______________________________



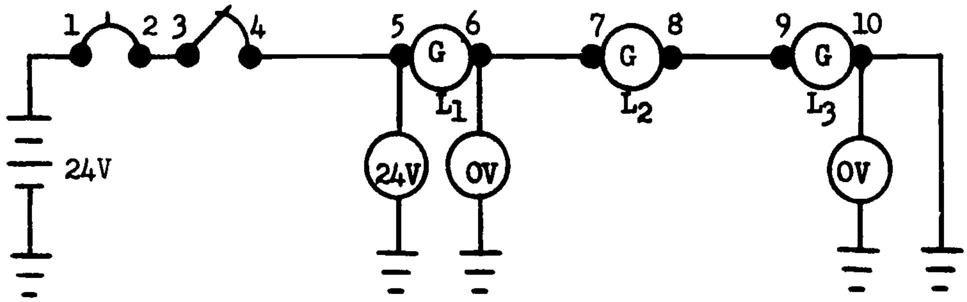
6. ______________________________



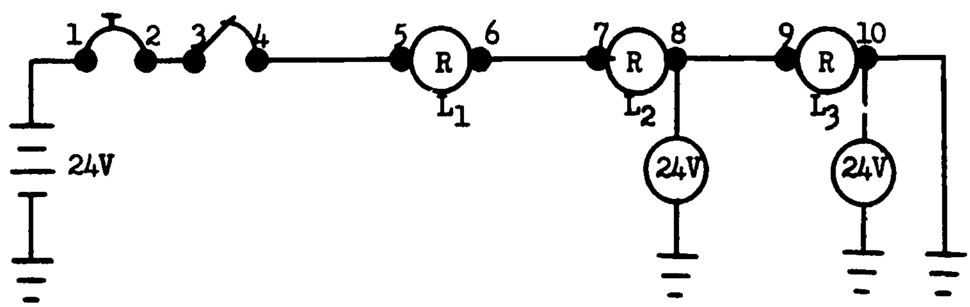
Answers to Frame 35: _X_ 1. ____ 2. _X_ 3.

Analyze the meter readings in each of the following circuits. On the blank provided by each circuit list the type of trouble and the faulty component.

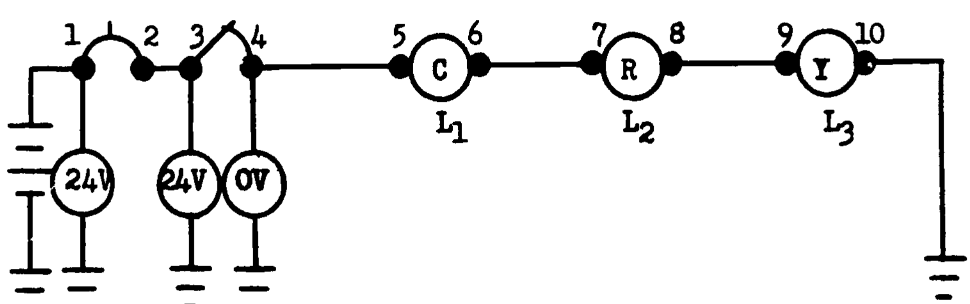
1. ____________________



2. ____________________

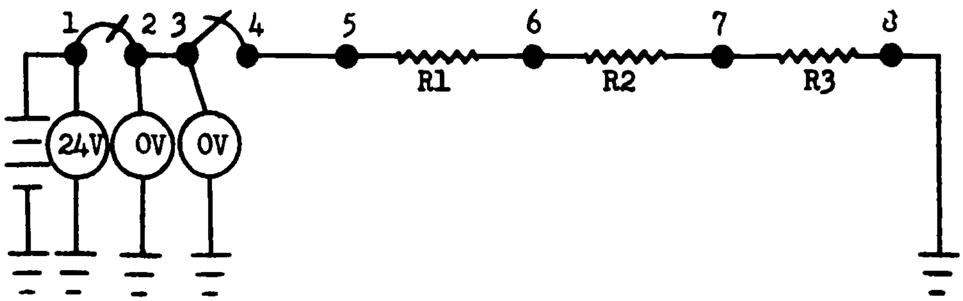


3. ____________________

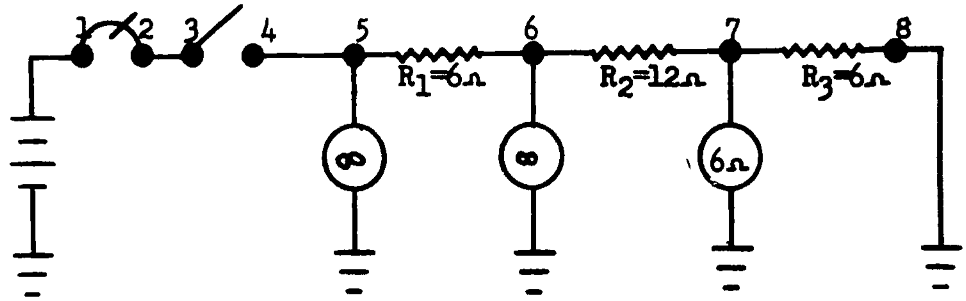


Frame 38 (Continued)

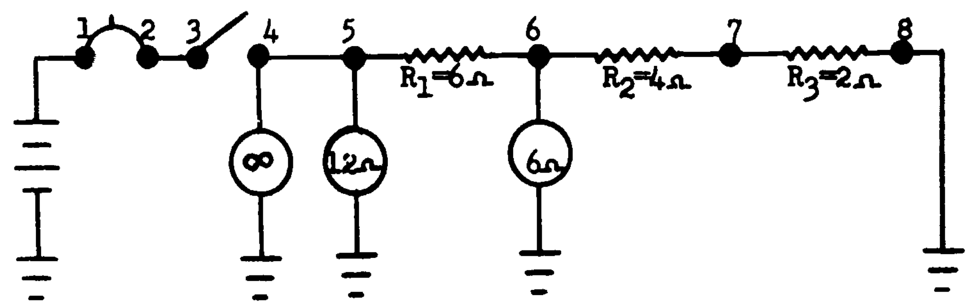
4.



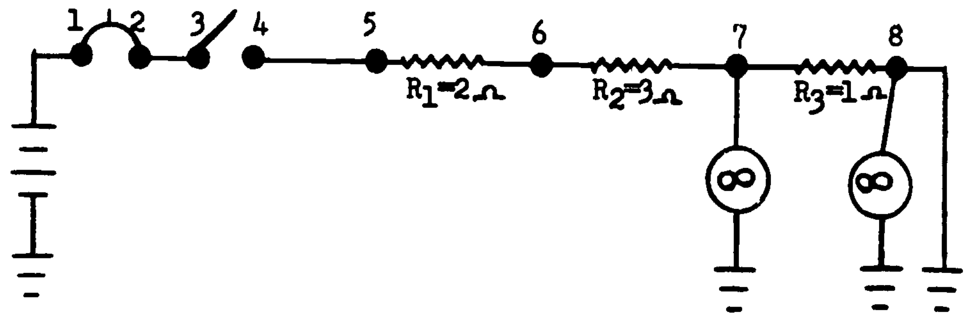
5. ____



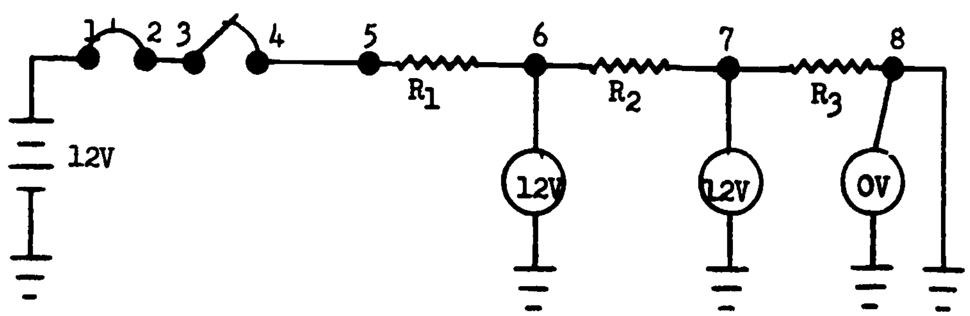
6. ____



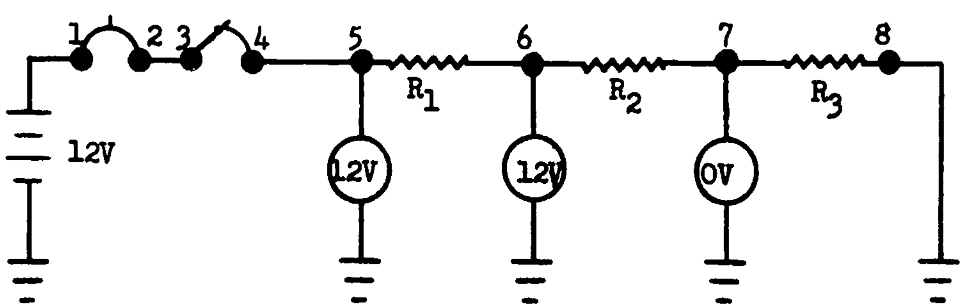
7. ____



8. ____



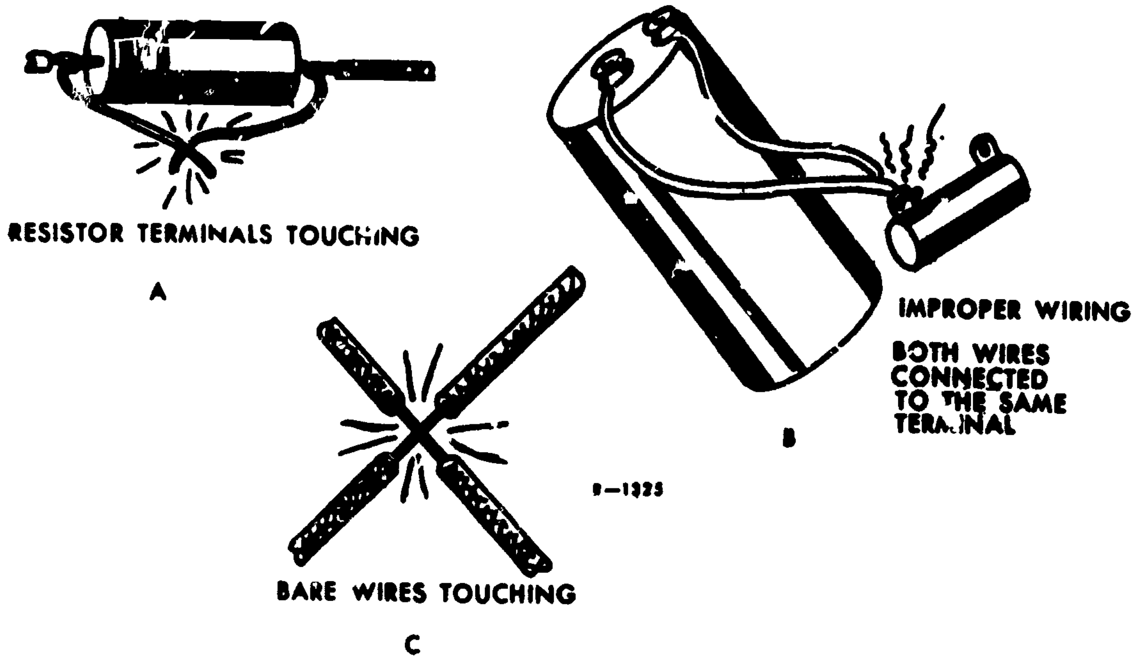
9. ____



Have the instructor check your answers. Instructor's Initials ____

Frame 39

Now let's take a look at what happens when a circuit develops a short. A <u>short circuit</u> is an accidental path of low resistance which passes an abnormal amount of current. A short circuit exists whenever the resistance of the circuit or the resistance of a path of a circuit drops in value to almost zero ohms. A short often occurs as a result of improper wiring or broken insulation. Figures A and B below show examples of shorts caused by improper wiring. Figure C shows an example of broken or worn insulation.



Check the true statements.

_____1. In figure A above, the current bypasses the resistor.

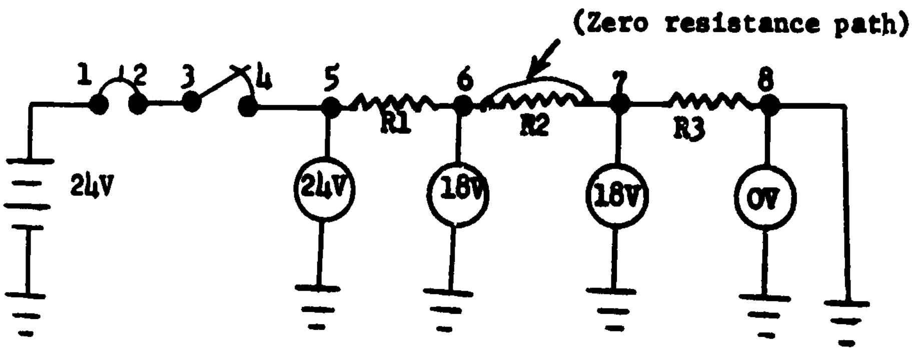
_____2. A short circuit bypasses part or all of the circuit resistance.

_____3. A short circuit causes the resistance of all or part of the circuit to drop in value to almost zero ohms.

Answers to Frame 37: 2. <u>Open 6-7 (R2)</u> 3. <u>Open 8 - ground</u>

4. <u>Open 5-6 (R1)</u> 5. <u>Open 7-8 (R3)</u> 6. <u>Open 4-5</u>

The purpose of each resistor in a series circuit is to drop some of the applied voltage. Since a shorted resistor is being bypassed by a zero resistance path, the shorted resistor will have no current flowing through it. The current will all be flowing through the zero resistance path. With no current flowing through the resistor it will not have any voltage dropped across it. In the circuit below we have given you voltmeter readings at different points. Which resistor does not have a difference in potential across it? If you said R2, you are correct. Let's see why. The potential at point 6 is 18V and the potential at point 7 is also 18V. Thus, there is no difference in potential across R2. Therefore, there is no current flowing through R2 and it must be shorted. There is current flowing through R1 and R3 as indicated by the voltage drops across them.



Check the true statements.

_____1. A voltmeter connected between points 5 and 6 will read 6V.

_____2. A voltmeter connected between points 6 and 7 will read 0V.

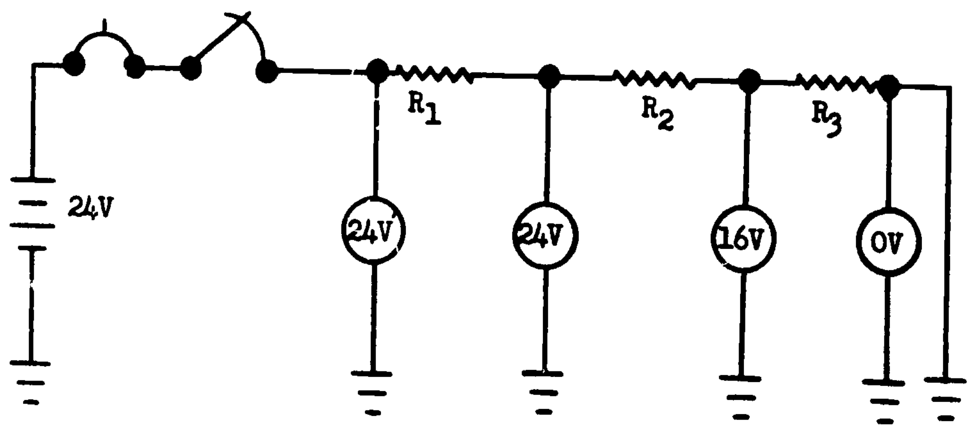
_____3. A voltmeter connected between points 7 and 8 will read 18V.

_____4. The difference in potential across a shorted resistor is 0V.

Answers to Frame 39: __X__1. __X__2. __X__3.

Frame 41

In the circuit below we have given you voltmeter readings at different points. Let's determine the faulty component. There is no differance in potential across R_1 since there is 24V on each end of it. This indicates that there is no current flowing through R_1. There is current flowing through R_2 and R_3 since there is voltage dropped across them. Since there is current flowing in the circuit, but no voltage dropped across R_1, R_1 must be shorted.



Check the true statements.

_____1. The difference in potential across a shorted resistor is 0V.

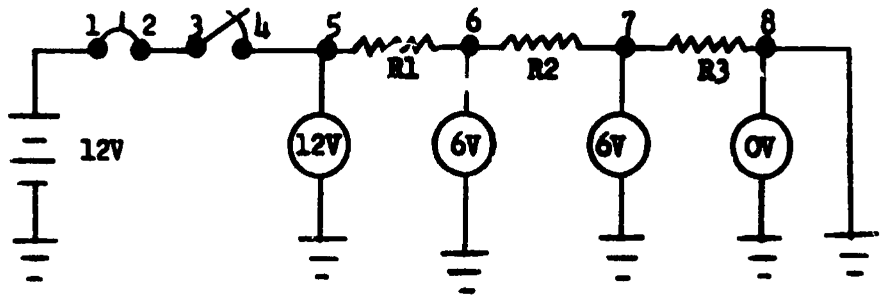
_____2. There is still current flowing through R_2 and R_3 in the circuit above.

_____3. Resistor R_3 is dropping all of the applied voltage.

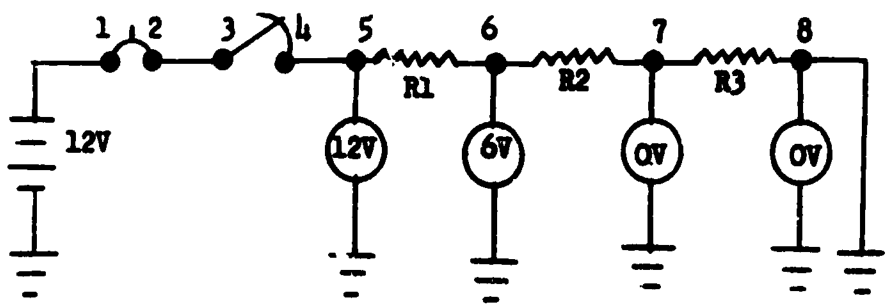
Frame 42

Analyze the meter readings in each of the following circuits. On the blank provided by each circuit list the type of trouble and the faulty component. The first one has been done for you.

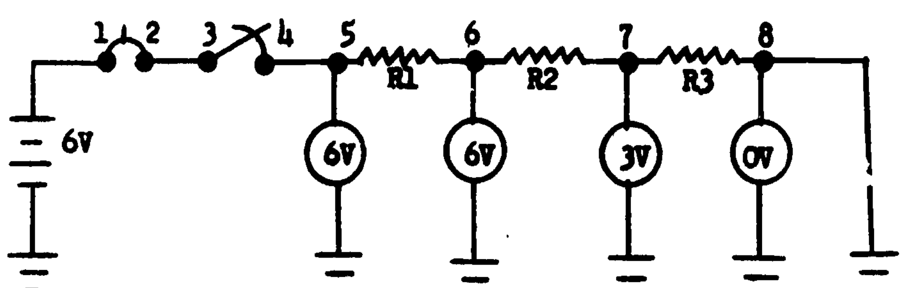
1. SHORT R2



2. ______________________________

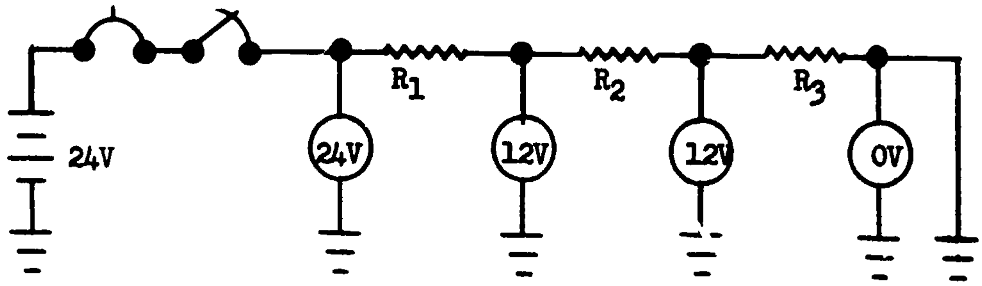


3. ______________________________

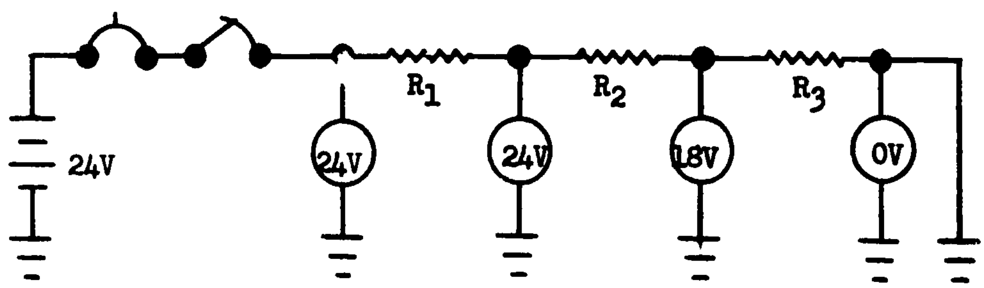


Answers to Frame 40: X 1. X 2. X 3. X 4.

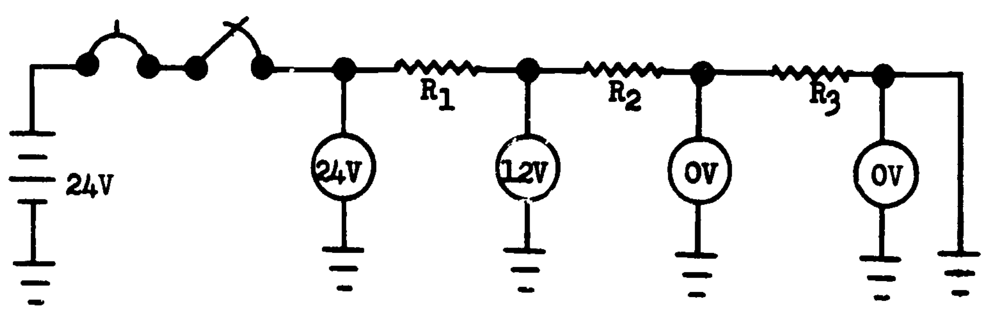
4.



5. ______________________________

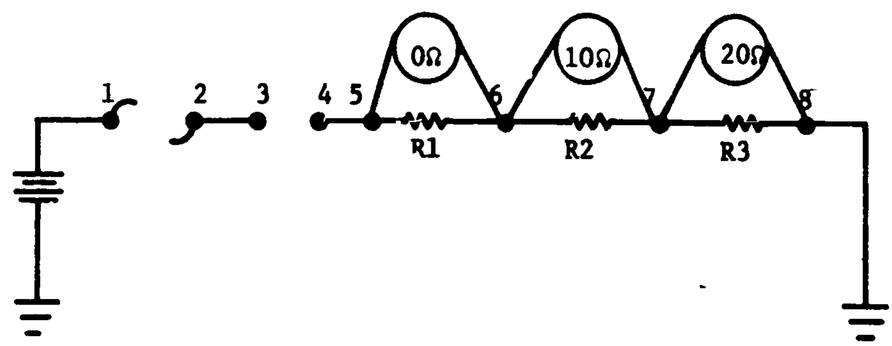


6. ______________________________



Answers to Frame 41: __X__ 1. __X__ 2. _____ 3.

Many times a short circuit will result in the fuse blowing, or circuit breaker popping. When this happens you will need to use an ohmmeter to find the faulty component. Since a shorted resistor is being bypassed by a 0 ohms resistance path, an ohmmeter connected around a shorted resistor will read 0 ohms. In the circuit below we have taken ohmmeter readings across each resistor. Which resistor is shorted? R1 is shorted since the ohmmeter connected around it reads 0 ohms.



Check the true statements.

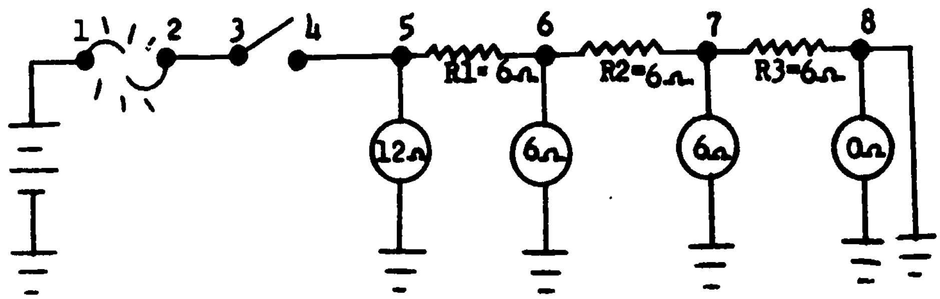
_____1. An ohmmeter connected from point 8 to ground should read 0 ohms.

_____2. An ohmmeter connected from point 7 to ground should read 20 ohms.

_____3. An ohmmeter connected from 5 to ground would read the same as one connected from 6 to ground.

Frame 44

In the circuit below we are trying to find the reason that the fuse has blown. Let's discuss the ohmmeter readings one at a time. The reading at point 8 should be 0 ohms as we are just measuring the resistance of the ground wire. The reading at point 7 should be 6 ohms as we are checking the resistance of the ground wire and R3. The reading at point 6 should be 12 ohms as we are now checking the resistance of both R2 and R3. However, the reading at point 6 is 6 ohms. This indicates that R2 is not offering any additional resistance to that of R3. Thus, there must be a path for the current to bypass R2. Therefore, R2 is shorted.



Check the true statements.

_____1. If the fuse has blown in a circuit, you probably have a short somewhere in the circuit.

_____2. An ohmmeter connected between points 5 and 6 will read 12 ohms.

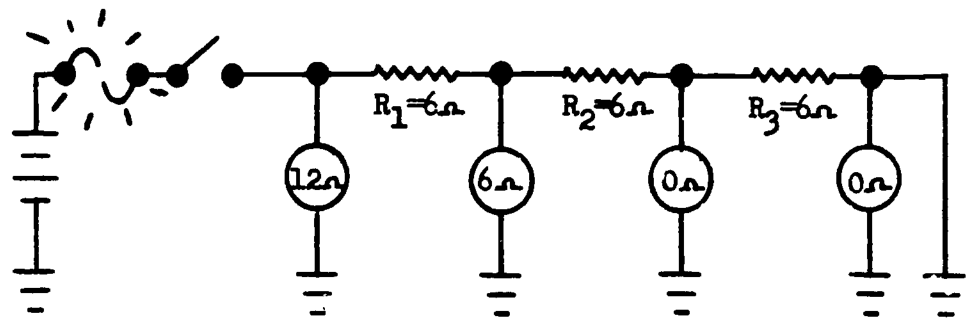
_____3. An ohmmeter connected between points 6 and 7 will read 0 ohms.

Answers to Frame 42: 2. <u>short R3</u> 3. <u>short R1</u> 4. <u>short R2</u> 5. <u>short R1</u> 6. <u>short R3</u>

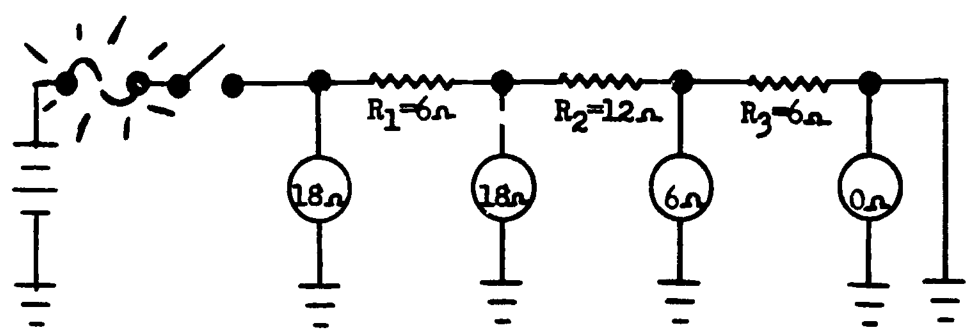
732

Analyze the meter readings in each of the following circuits. On the blank provided by each circuit list the type of trouble and the faulty component.

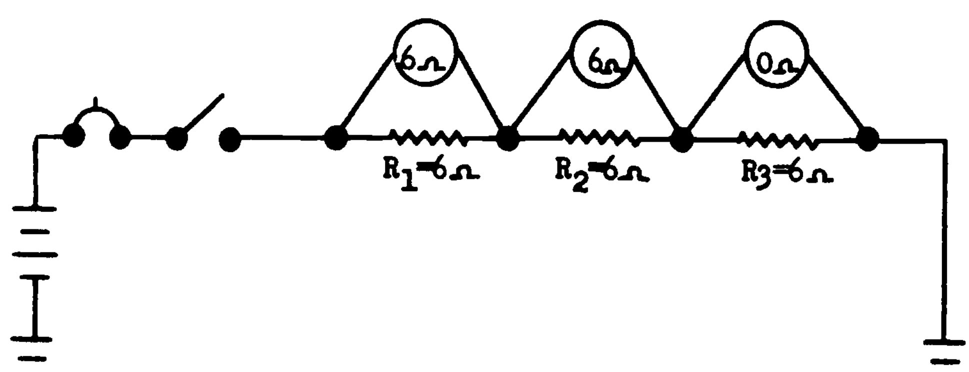
1. ______________________________



2. ______________________________



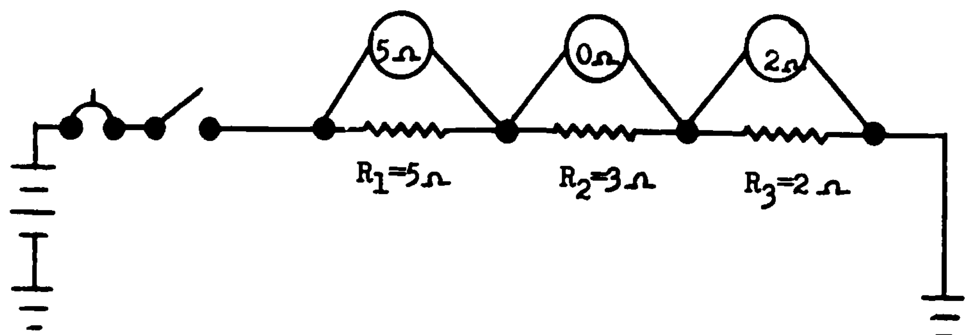
3. ______________________________



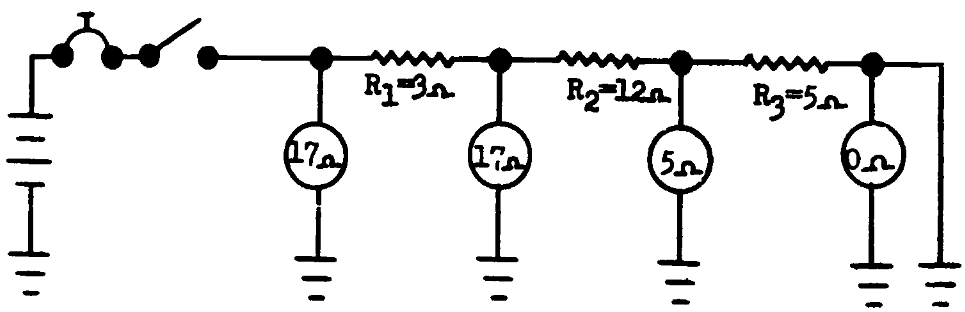
Answers to Frame 43: _X_ 1. _X_ 2. _X_ 3.

Frame 45 (Continued)

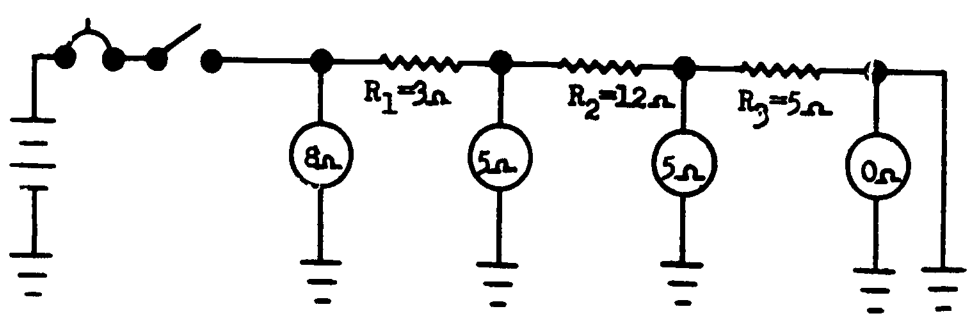
4.



5. ______________________________



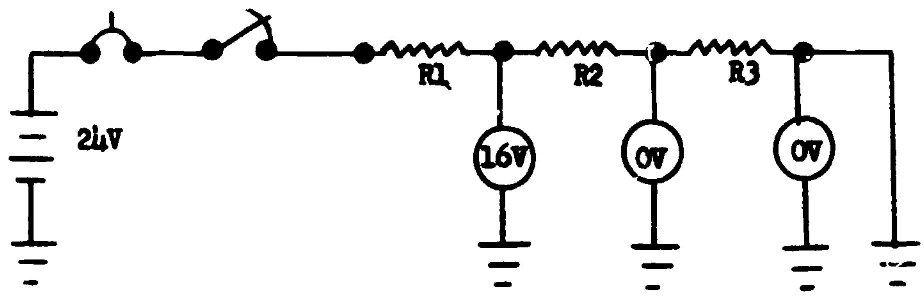
6. ______________________________



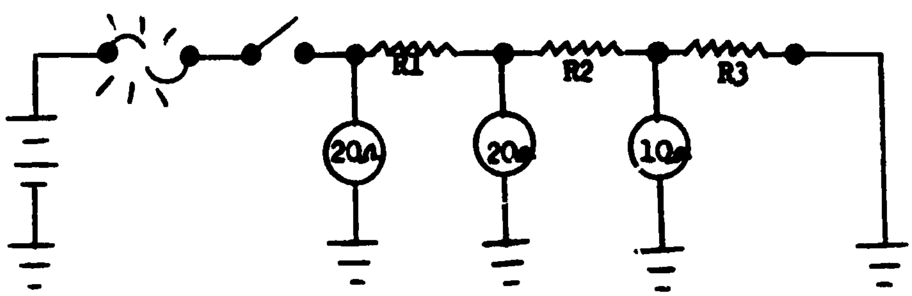
Answers to Frame 46 : __X__ 1. _____ 2. __X__ 3.

Analyze the meter readings in each of the following circuits. On the blank provided by each circuit list the type trouble and the faulty component.

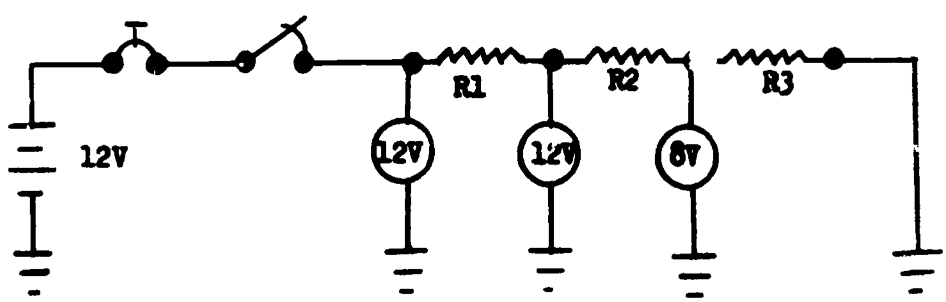
1. ______________________________



2. ______________________________

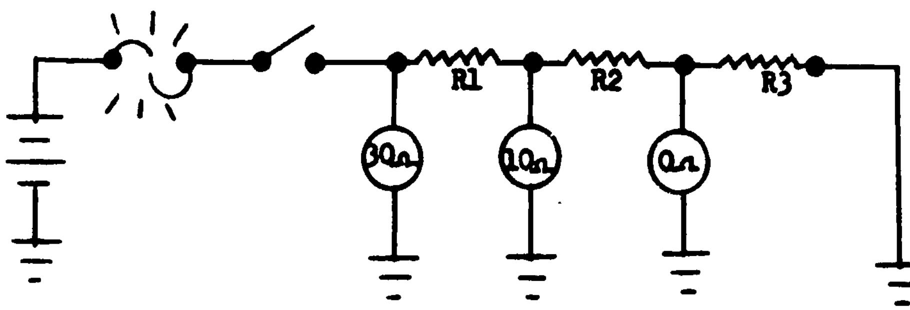


3. ______________________________

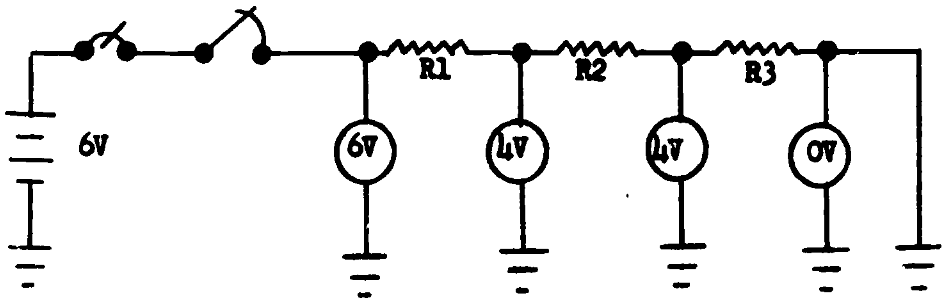


Frame 46 (Continued)

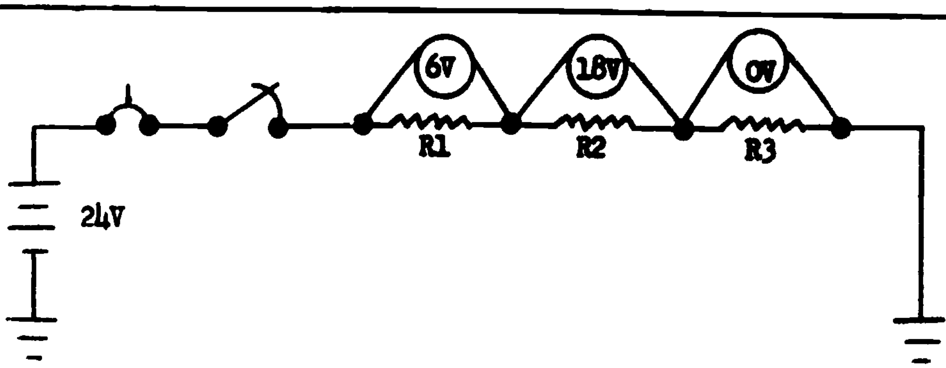
4. ____



5. ____

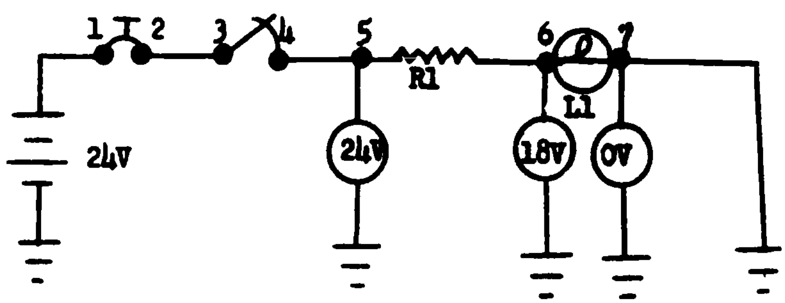


6. ____



Have the instructor check your answers. Instructor's Initials ____________

Many students have difficulty distinguishing between opens and shorts. An open is an incomplete path for current and stops the current flow in that path. A short is an accidental path of low resistance which passes an abnormal amount of current. Many times a short will cause the circuit breaker to pop. In the circuit below we have given you the normal voltage readings at the points indicated. Let's see what the readings would be if R1 became open. If R1 became open the lamp would go out as there would not be a complete path for current flow. There should still be 24V at point 5. The voltmeter would read 0V when connected at point 6. The reason is there is not a complete path up to point 6 with R1 open. With no current flowing through the meter, the needle would not deflect.



Check the true statements.

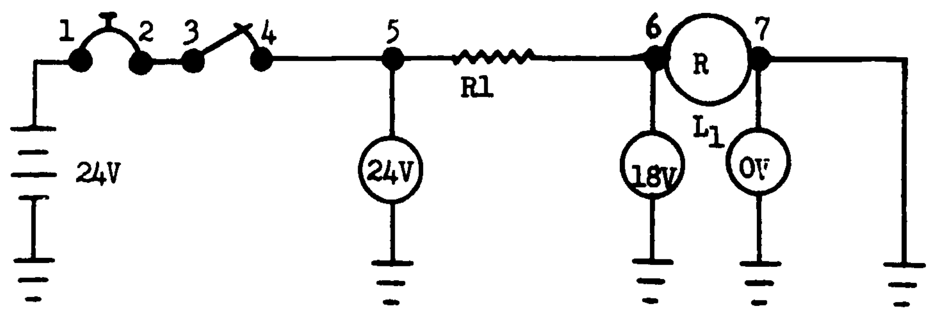
_____1. A voltmeter connected between points 5 and 6 with R1 open would read 24V.

_____2. The lamp would go out if the ground wire was disconnected from point 7.

Answers to Frame 45: 1. short R_3 2. short R_1 3. short R_3 4. short R_2 5. short R_1 6. short R_2

Frame 48

We are using the same circuit as we used in the last frame. The normal readings are given. Now we are going to assume that R1 becomes shorted and that the current doesn't get high enough to pop the circuit breaker. Would the lamp continue to burn? Yes, in fact it will be burning brighter. Let's see why! The potential at point 5 should still be 24V. What would the potential at point 6 be? If you said 24V, you are correct. The reason is the current is bypassing R1, so R1 is not dropping any voltage. Thus, it will have the same potential on each end of it. Now it should be evident why the lamp would be burning brighter. Instead of dropping 18V it is dropping all 24V.



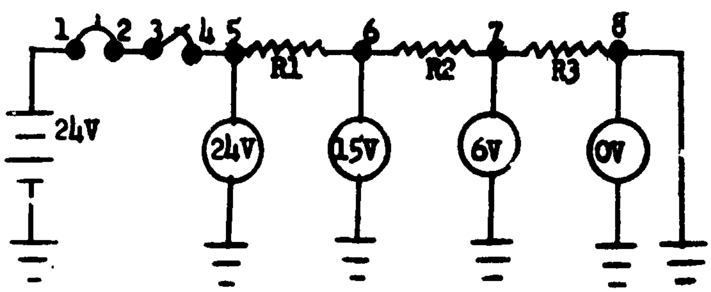
Check the true statements.

_____1. When R1 becomes shorted, L1 will bu: a brighter.

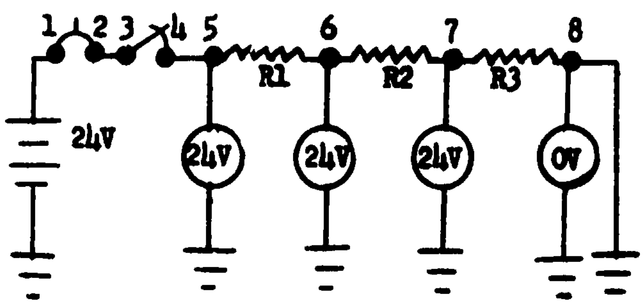
_____2. With R1 shorted a voltmeter connected around L1 would read 24V.

_____3. There is still current flowing in the circuit when the lamp burns out.

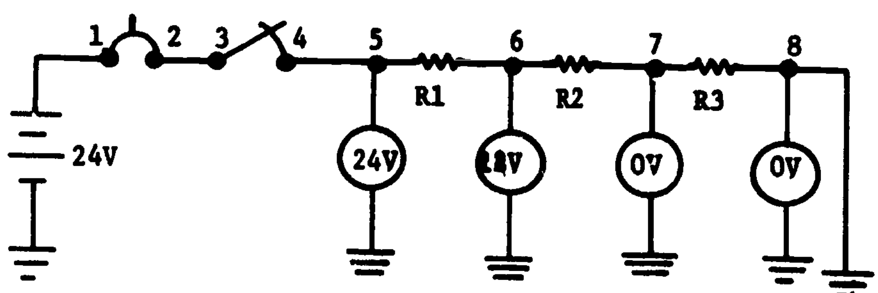
We have given you three identical circuits below. In circuit A we have given you the normal voltage readings of the circuit. In circuit B we have given you the readings that would be obtained if R3 became open. In circuit C we have given you the readings that would be obtained if R3 became shorted. In all the circuits in this lesson we will not give you any circuits with more than one faulty component. Looking at circuit B you see that we have 24V on each end of R1. Thus, your first inclination might be to say that R1 is shorted. However, look at R2. It also has 24V on each end of it. Thus, it also would have to be shorted. However, we are assuming only one faulty component per problem. Thus, R1 and R2 are not shorted. The reason they are not dropping any voltage is that with R3 open there is no current flowing in the circuit. With no current flowing in the circuit there can be no voltage dropped across R1 and R2. From the readings given we know we have a complete path up to point 7. We don't have a path to point 8. Thus, R3 must be open. In figure C we have current flow since both R1 and R2 are dropping some voltage. Thus, we know that we can't have an open in circuit C. However, R3 has the same potential on each end of it, so it is shorted.



Circuit A.
Normal Circuit



Circuit B.
Open R3



Circuit C.
Short R3

Frame 49 (Continued)

Check the true statements concerning the analysis of series circuits.

_____1. An open resistor will have a difference in potential equal to the applied voltage.

_____2. A shorted resistor has no difference in potential across it.

_____3. A voltmeter connected around R3 in circuit C would read 24V.

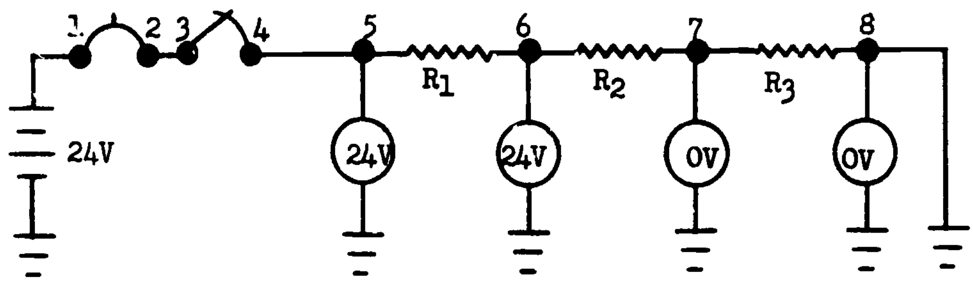
_____4. A voltmeter connected around R3 in circuit B would read 24V.

Answers to Frame 47: _X_ 1. _X_ 2.

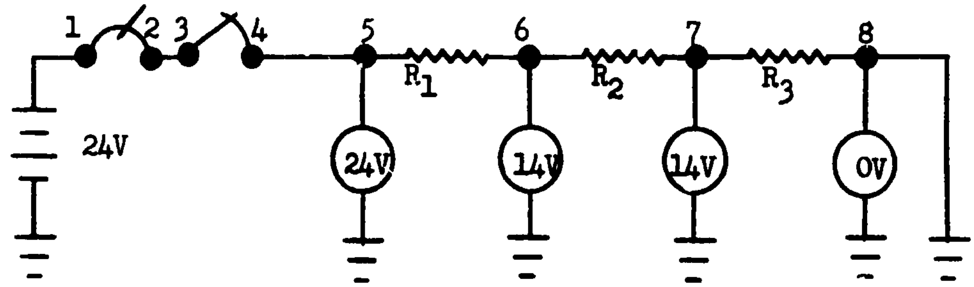
Answers to Frame 48: _X_ 1. _X_ 2. _____3.

This frame and the next three will be a review of this PT. Analyze the meter readings in each of the following circuits. On the blank provided by each circuit list the type of trouble and the faulty component. Be sure to distinguish between shorts and opens.

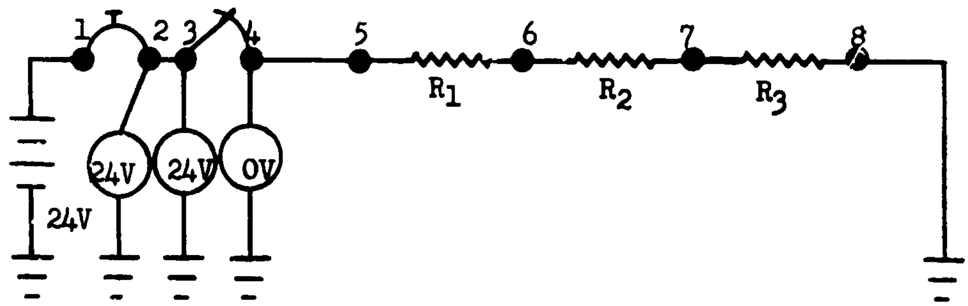
1. ______________________________



2. ______________________________



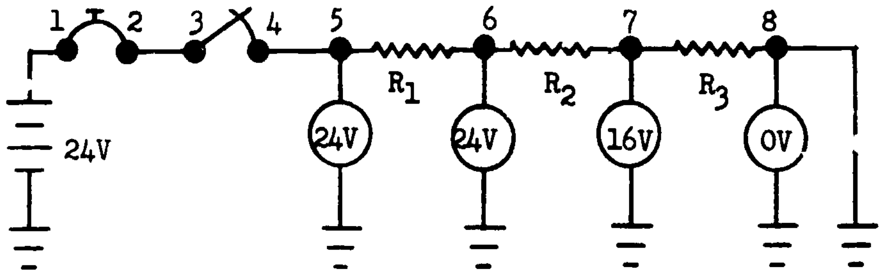
3. ______________________________



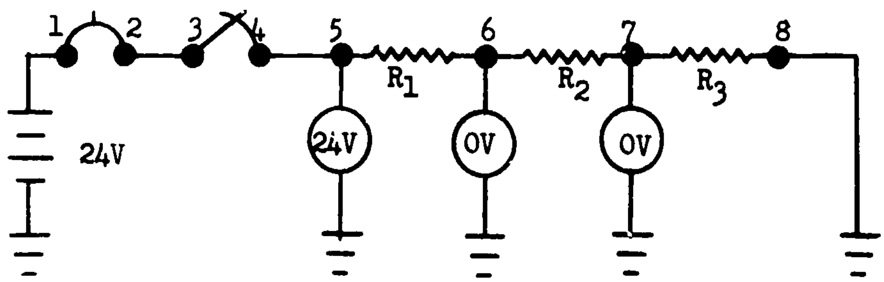
Answers to Frame 49: __X__ 1. __X__ 2. _____ 3. __X__ 4.

Frame 50 (Continued)

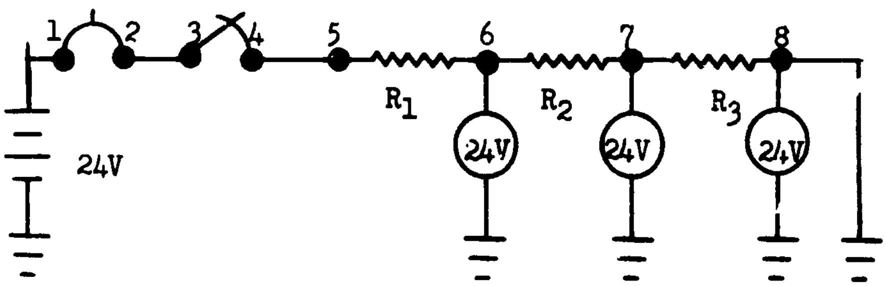
4. ____________________



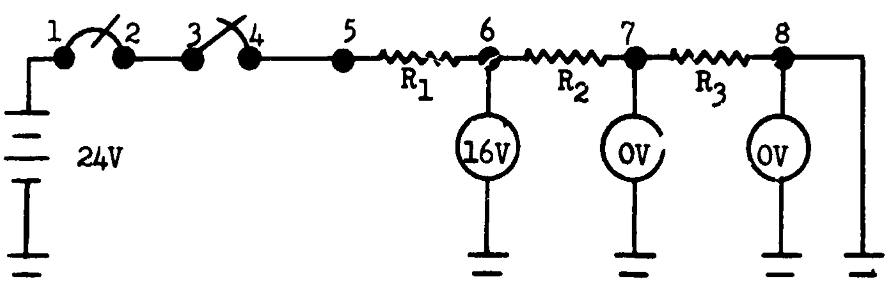
5. ____________________



6. ____________________

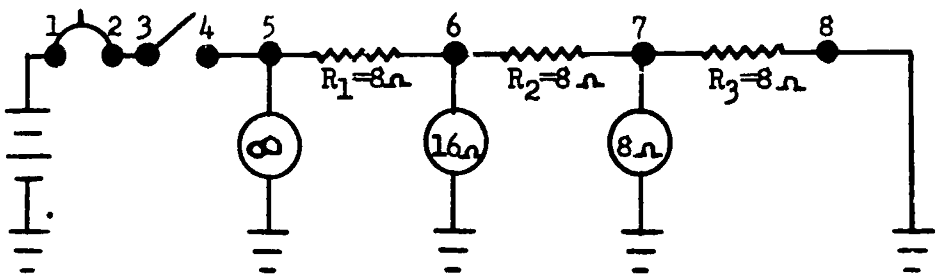


7. ____________________

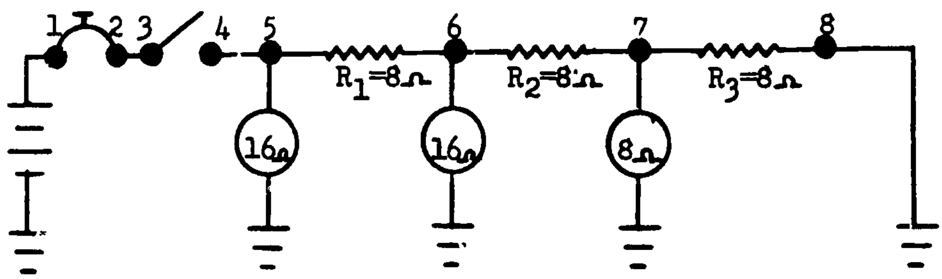


Analyze the meter readings in each of the following circuits. On the blank provided by each circuit list the type of trouble and the faulty component.

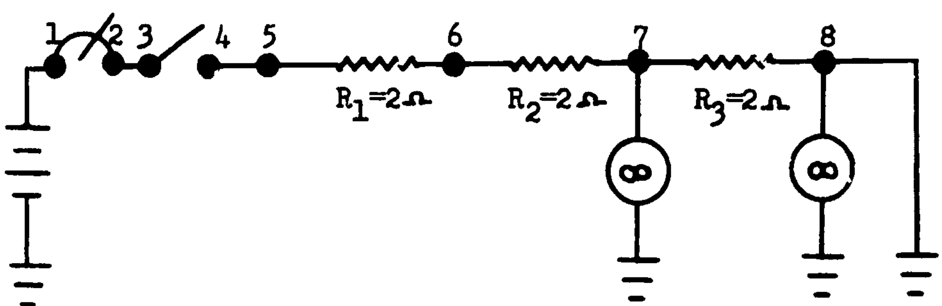
1.



2. ______________________________

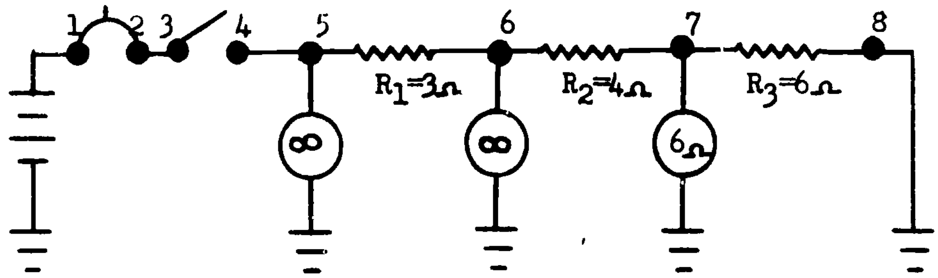


3. ______________________________

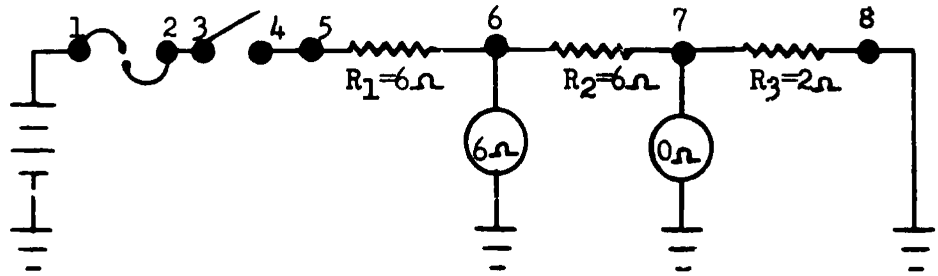


Frame 51 (Continued)

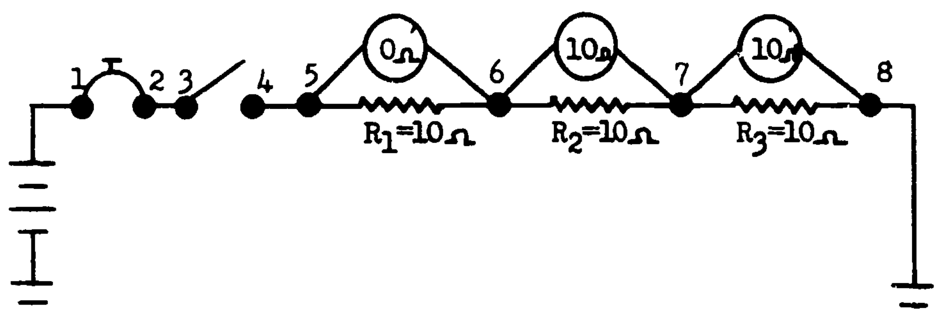
4. ____



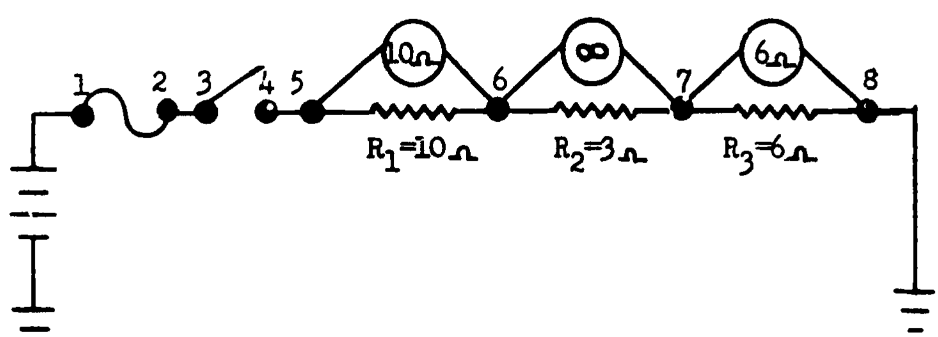
5. ____



6. ____



7. ____

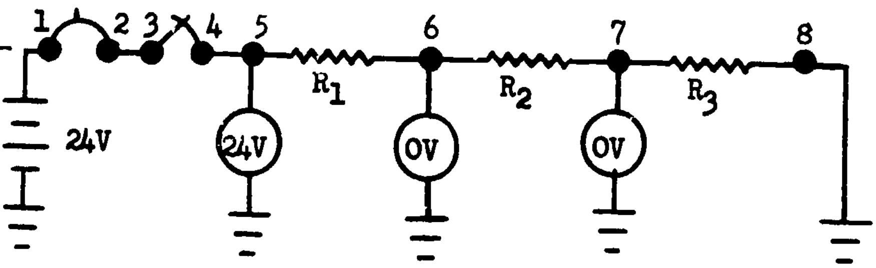


744

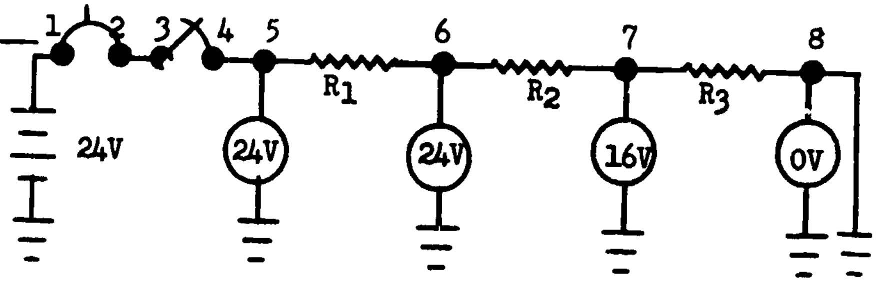
On the appropriate blank by each of the following circuits list the type of trouble and the faulty component.

Type of trouble	Faulty component

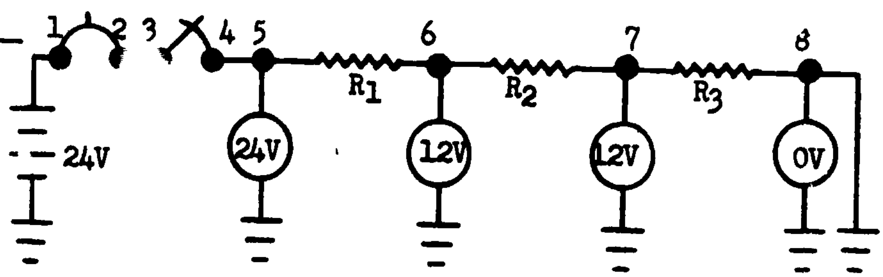
1a.______ b.__________



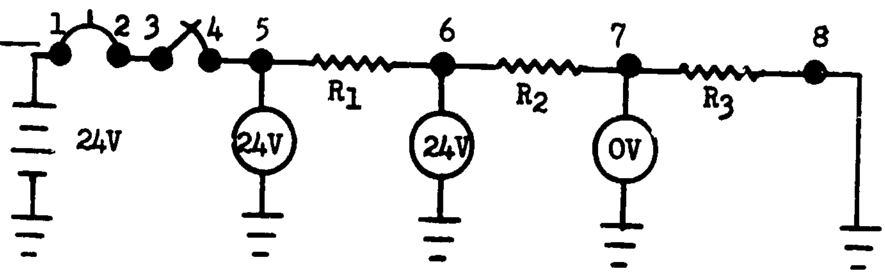
2a.______ b.__________



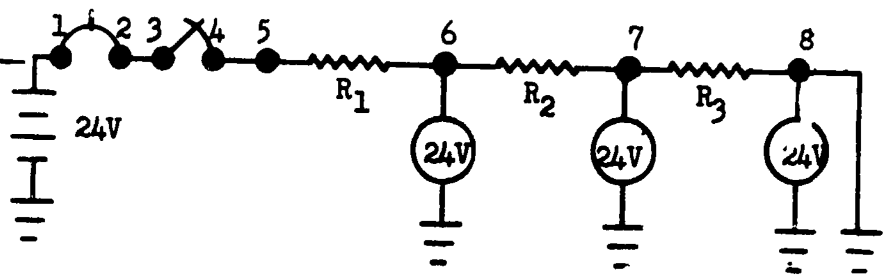
3a.______ b.__________



4a.______ b.__________



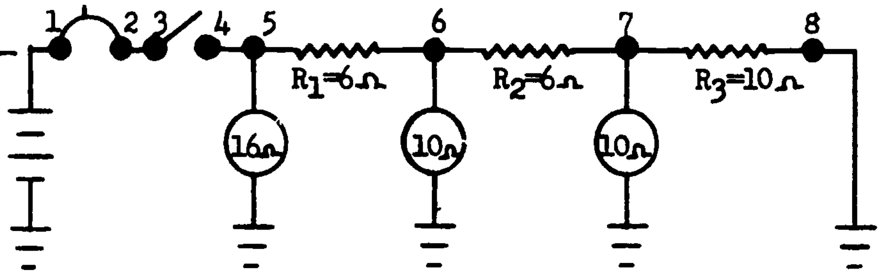
5a.______ b.__________



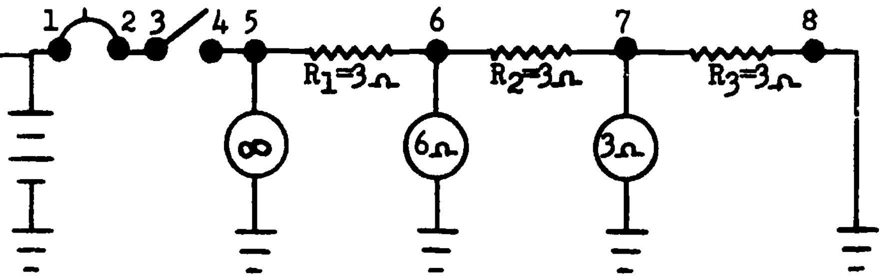
Frame 52 (Continued)

Type of trouble	Faulty component

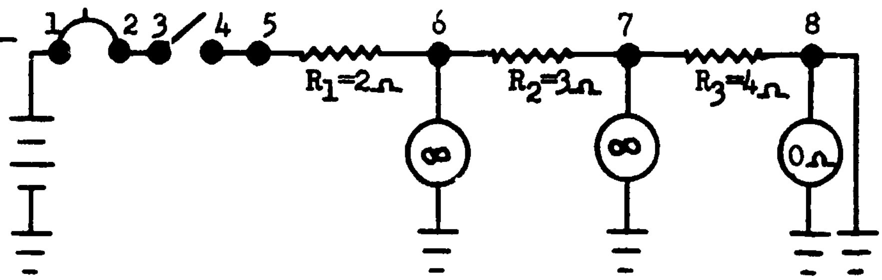
6a.______ b.____________



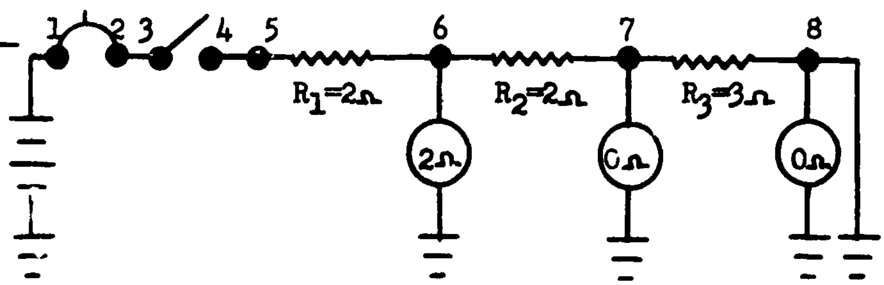
7a.______ b.____________



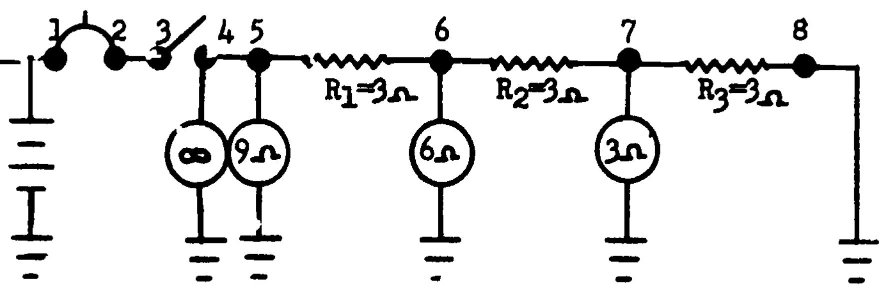
8a.______ b.____________



9a.______ b.____________



10a.______ b.____________



Have the instructor check your answers. Instructor's Initials ______

Answers to Frame 50:

1. Open R_2
2. Short R_2
3. Open 3 - 4
4. Short R_1
5. Open R_1
6. Open 8 to Ground
7. Short R_3

Answers to Frame 51:

1. Open R_1
2. Short R_1
3. Open 8 to Ground
4. Open R_2
5. Short R_3
6. Short R_1
7. Open R_2

Environmental Pneudraulics Branch
Chanute AFB, Illinois

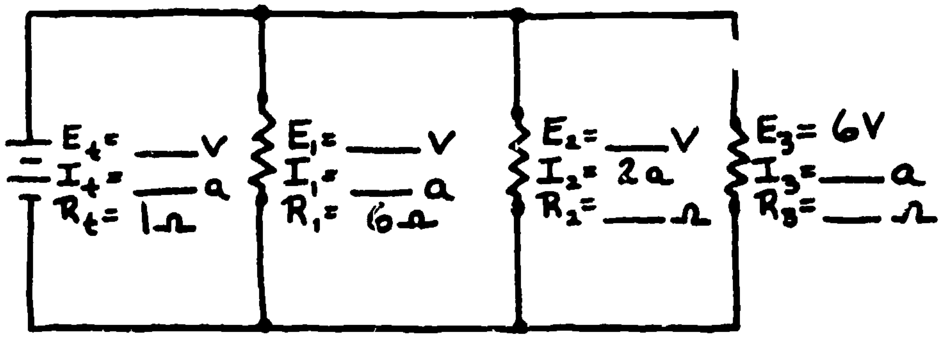
SERVICE TEST
C3ABR42331-HO-117A
8 December 1983

PARALLEL CIRCUITS

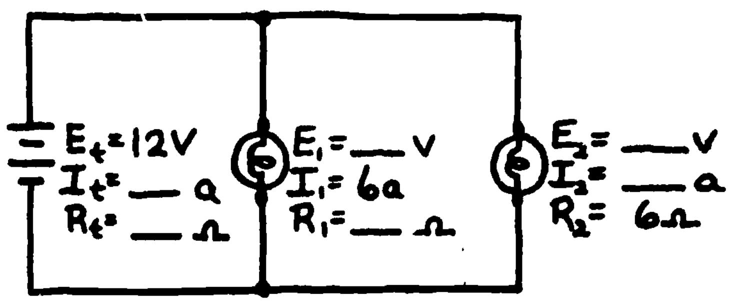
INSTRUCTIONS

Using Kirchoff's Current, Kirchoff's Voltage and Ohm's Laws, solve for the following unknown value(s).

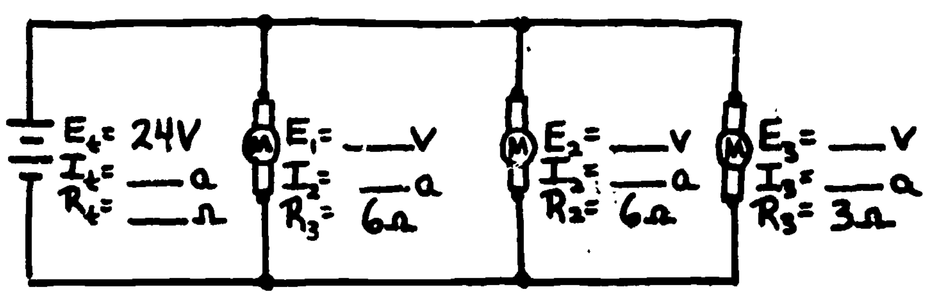
1.



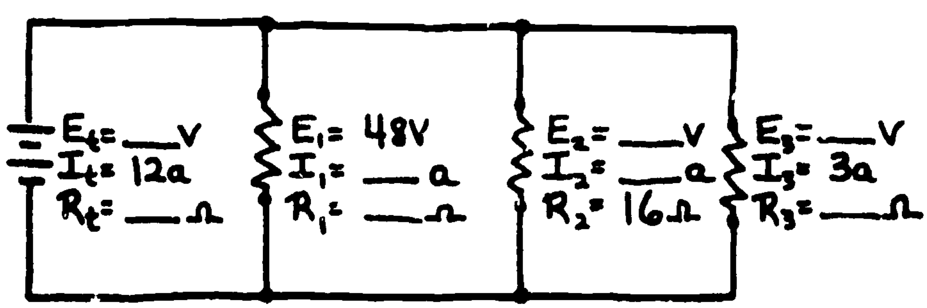
2.



3.



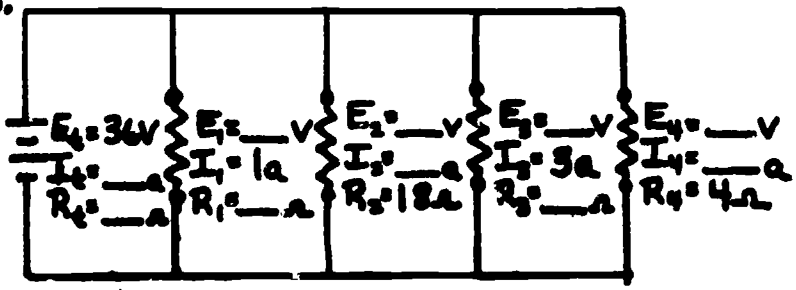
4.



OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 150; DAV - 1

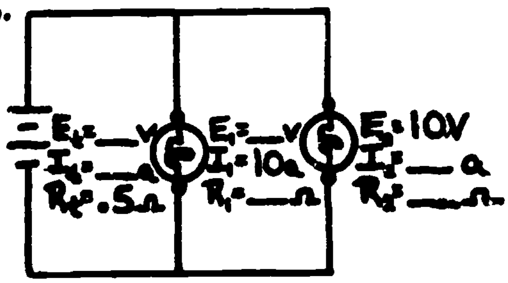
Designed for ATC Course Use. Do Not Use on the Job.

5.



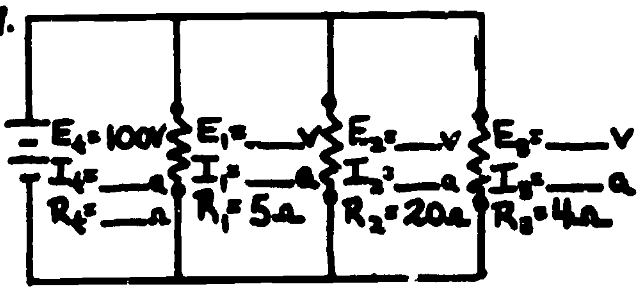
Et=36V
It=__a
Rt=__Ω
E1=__V
I1=1a
R1=__Ω
E2=__V
I2=__a
R2=12Ω
E3=__V
I3=3a
R3=__Ω
E4=__V
I4=__a
R4=4Ω

6.



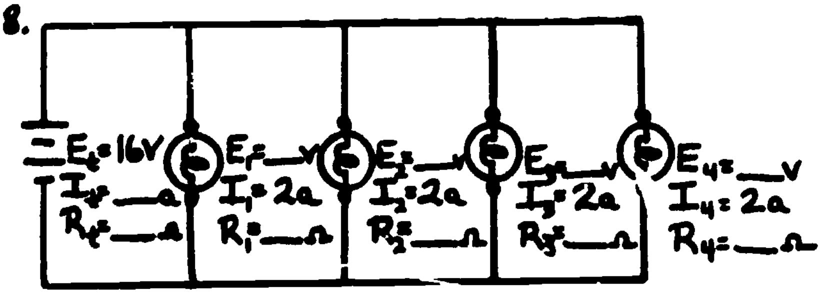
Et=__V
It=__a
Rt=.5Ω
E1=__V
I1=10a
R1=__Ω
E2=10V
I2=__a
R2=__Ω

7.



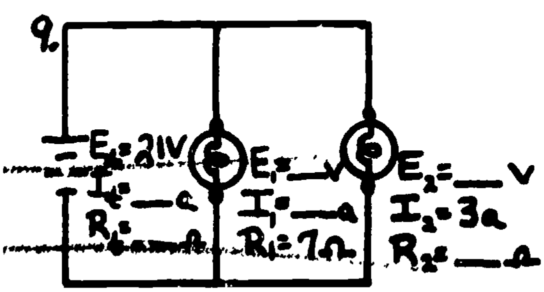
Et=100V
It=__a
Rt=__Ω
E1=__V
I1=__a
R1=5Ω
E2=__V
I2=__a
R2=20Ω
E3=__V
I3=__a
R3=4Ω

8.



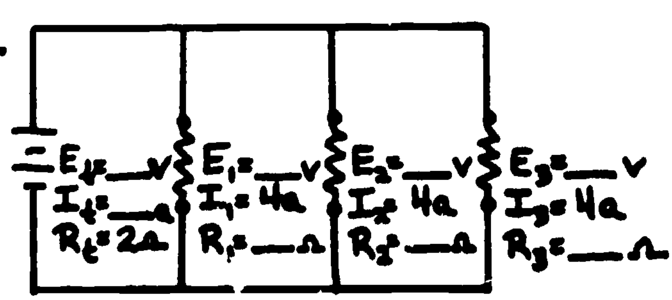
Et=16V
It=__a
Rt=__Ω
E1=__V
I1=2a
R1=__Ω
E2=__V
I2=2a
R2=__Ω
E3=__V
I3=2a
R3=__Ω
E4=__V
I4=2a
R4=__Ω

9.



Et=21V
It=__a
Rt=__Ω
E1=__V
I1=__a
R1=7Ω
E2=__V
I2=3a
R2=__Ω

10.



Et=__V
It=__a
Rt=2Ω
E1=__V
I1=4a
R1=__Ω
E2=__V
I2=4a
R2=__Ω
E3=__V
I3=4a
R3=__Ω

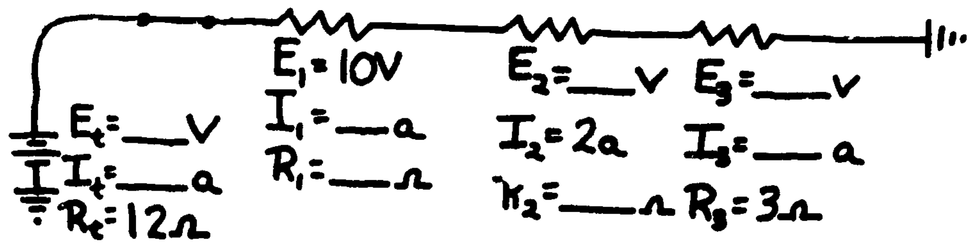
Environmental Branch
Chanute AFB, Illinois

SERVICE TEST
C3ABR42331-HO-117A
27 January 1984

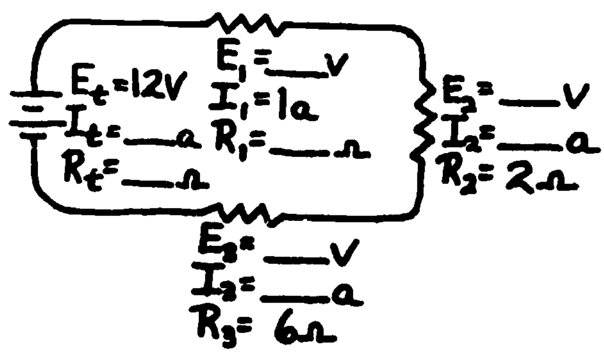
SERIES CIRCUITS

INSTRUCTIONS: Using Kirchhoff's Current, Kirchhoff's Voltage and Ohm's Laws, solve for the unknown value(s).

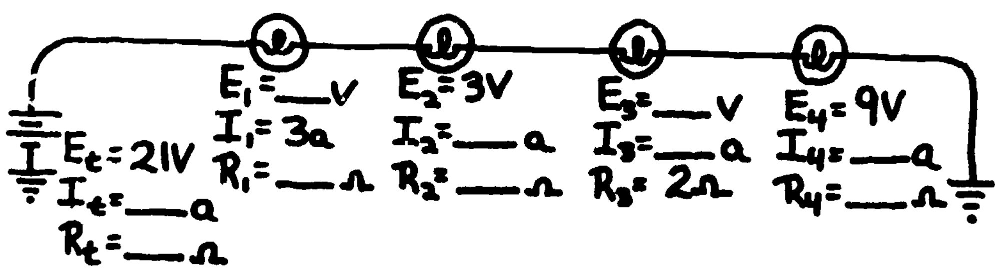
1.



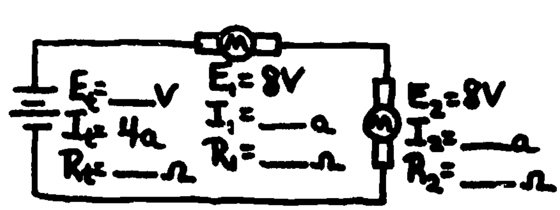
2.



3.



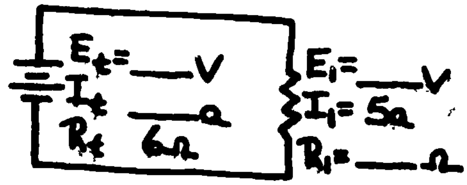
4.



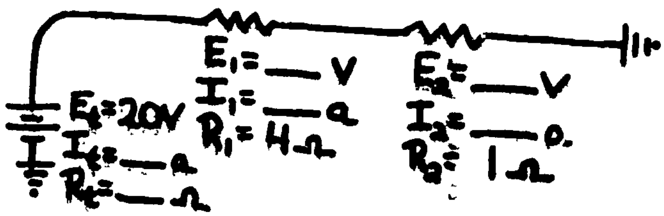
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 150; DAV - 1

Designed for ATC Course Use. Do Not Use on the Job.

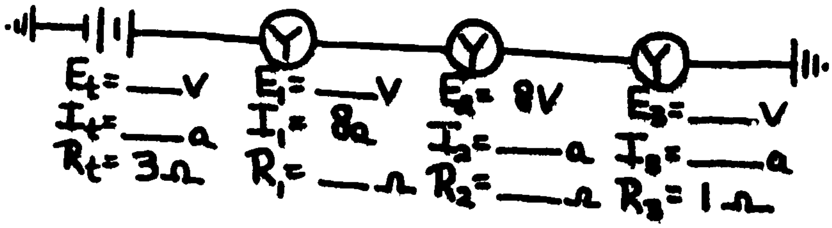
5.


Et= ___V
It ___a
Rt 6Ω
E1= ___V
I1= 5a
R1= ___Ω

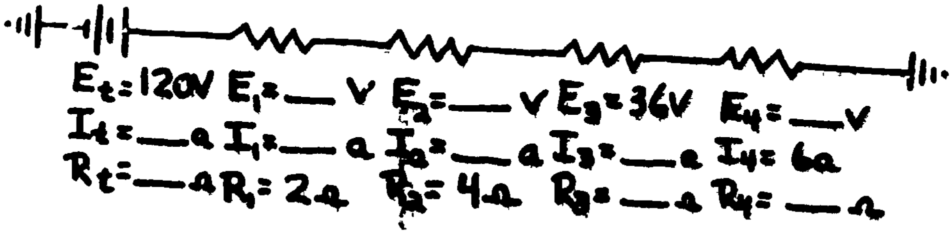
6.


Et=20V
It= ___a
Rt= ___Ω
E1= ___V
I1= ___a
R1= 4Ω
E2= ___V
I2= ___a
R2= 1Ω

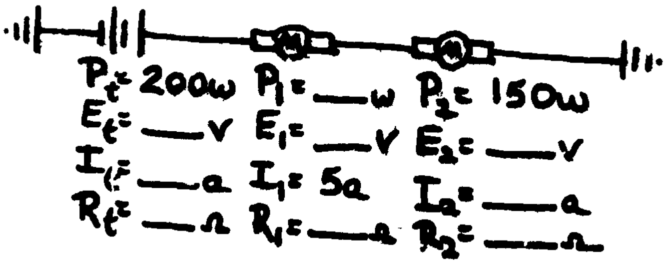
7.


Et= ___V
It= ___a
Rt= 3Ω
E1= ___V
I1= 8a
R1= ___Ω
E2= 8V
I2= ___a
R2= ___Ω
E3= ___V
I3= ___a
R3= 1Ω

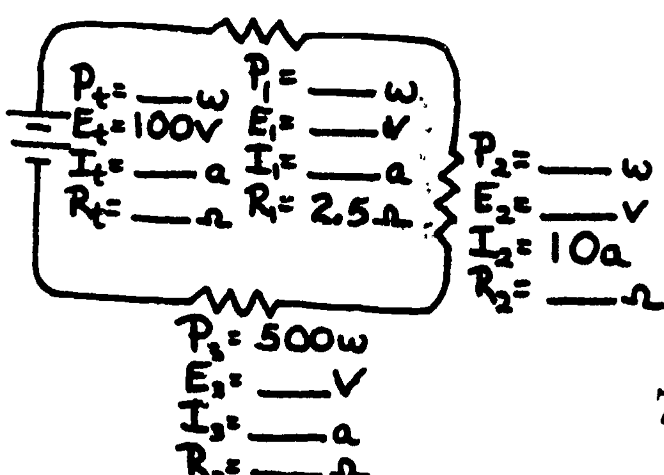
8.


Et=120V
It= ___a
Rt= ___Ω
E1= ___V
I1= ___a
R1= 2Ω
E2= ___V
I2= ___a
R2= 4Ω
E3= 36V
I3= ___a
R3= ___Ω
E4= ___V
I4= 6a
R4= ___Ω

9.


Pt= 200w
Et= ___V
It= ___a
Rt= ___Ω
P1= ___w
E1= ___V
I1= 5a
R1= ___Ω
P2= 150w
E2= ___V
I2= ___a
R2= ___Ω

10.


Pt= ___w
Et=100V
It= ___a
Rt= ___Ω
P1= ___w
E1= ___V
I1= ___a
R1= 2.5Ω
P2= ___w
E2= ___V
I2= 10a
R2= ___Ω
P3= 500w
E3= ___V
I3= ___a
R3= ___Ω

751

SERVICE TEST
HANDOUT

C3ABR42331-HO-117B

Technical Training

Aircraft Environmental Systems Mechanic

PARALLEL CIRCUIT TROUBLESHOOTING

9 December 1983

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

Designed for ATC Course Use.

Do Not Use on the Job.

Environmental Pneudraulics Branch
Chanute AFB, Illinois

SERVICE [illegible]
C3ABR42331-HO-117B

PARALLEL CIRCUIT TROUBLESHOOTING

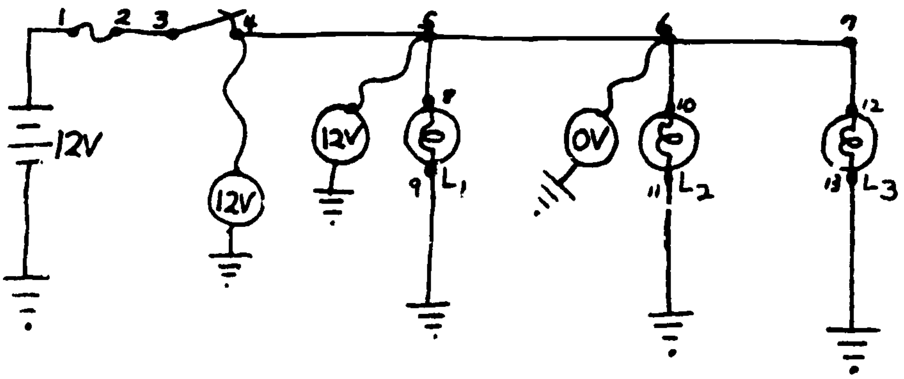
INSTRUCTIONS

Using the malfunction indication and meter readings, locate and record the probable.

Part 1a - Opens (Voltmeter)

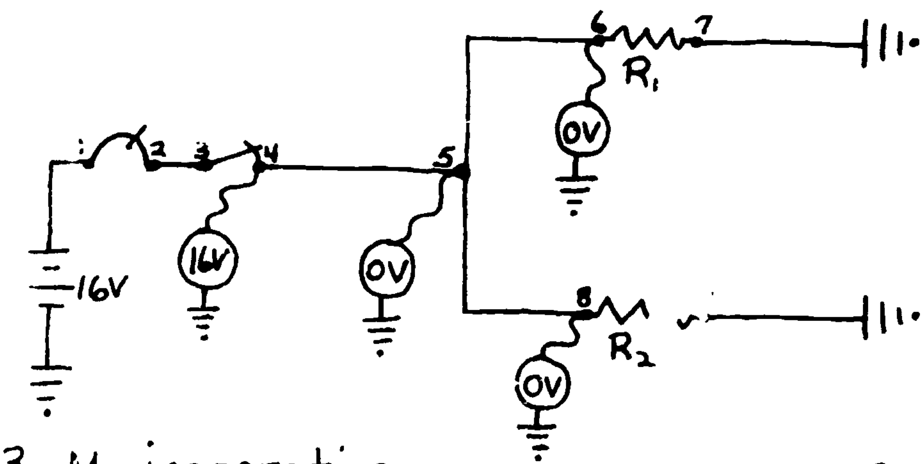
1. L_2 and L_3 inoperative

1. ______________________



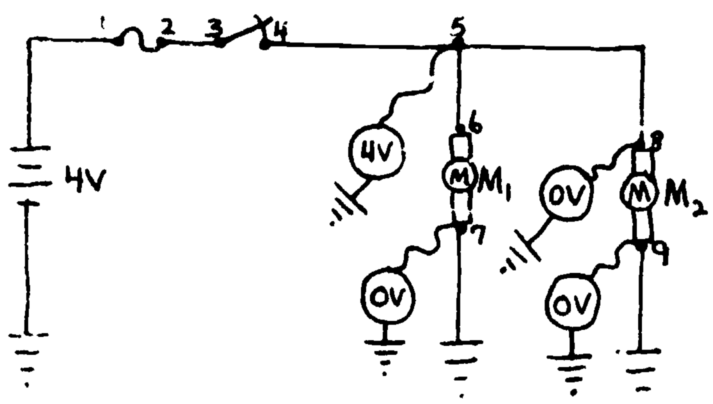
2. Neither resistor will drop voltage

2. ______________________



3. M_2 inoperative

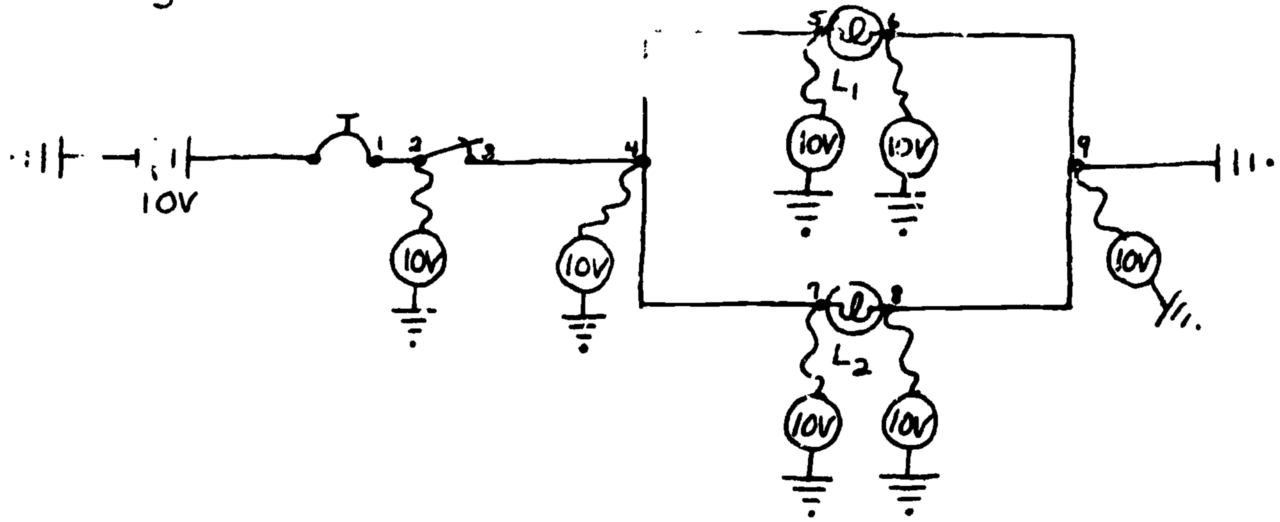
3. ______________________



OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P 150; DAV - 1

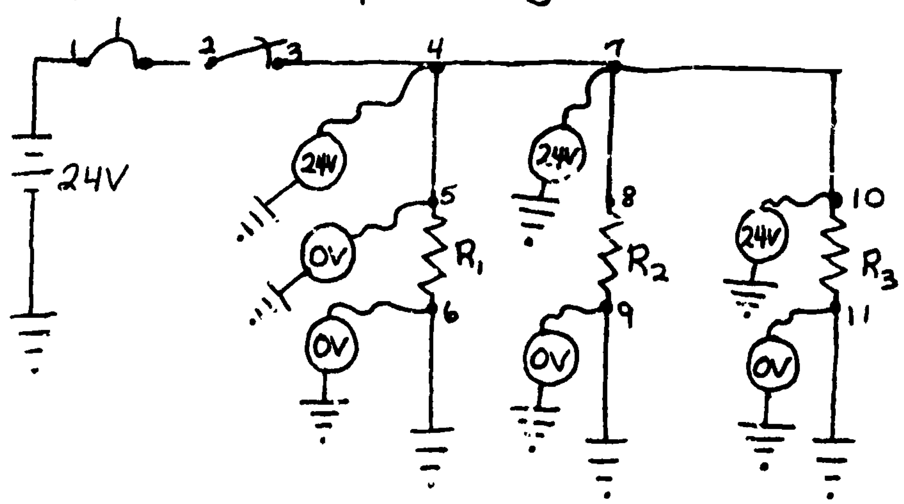
4. Both lights won't work

4. ______________________



5. R1 will not drop voltage

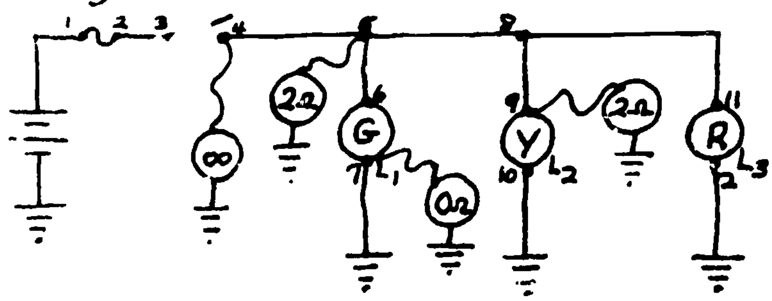
5. ______________________



Part Ib - Opens (Ohmmeter)

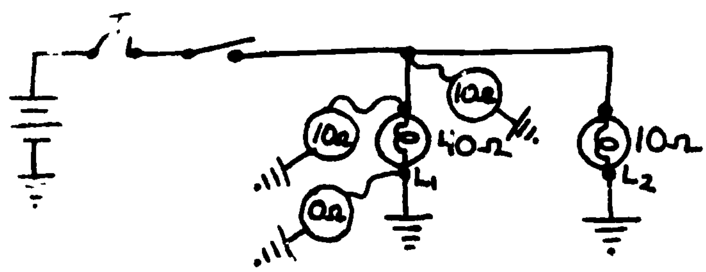
6. Lights won't work

6. ______________________



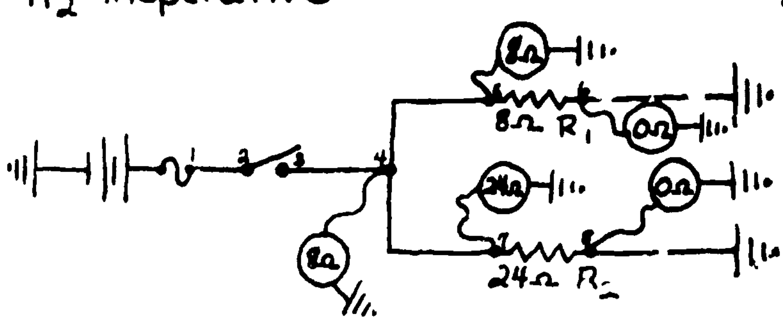
7. L_1 inoperative

7. ______________________



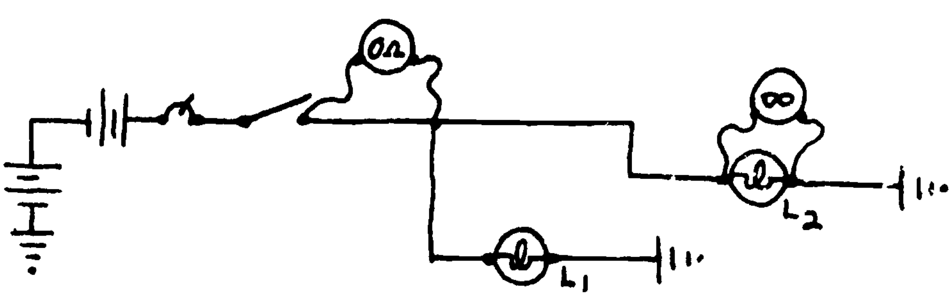
8. R_2 inoperative

8. ______________________



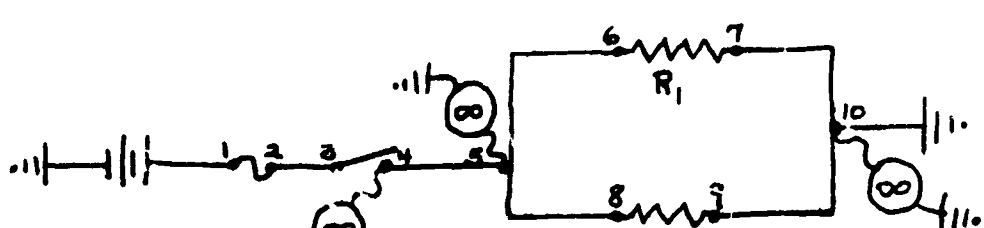
9. L_2 inoperative

9. ______________________



10. Both r sistors inoperative

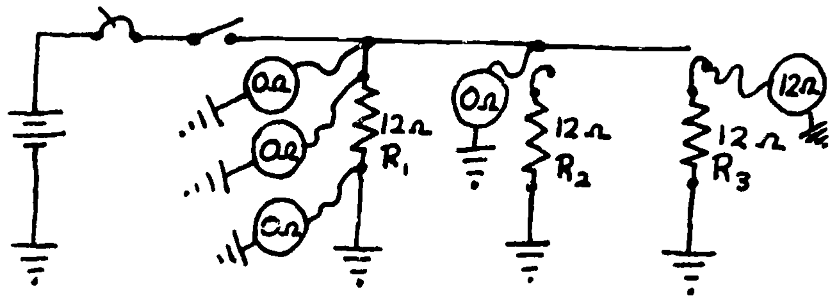
10. ______________________



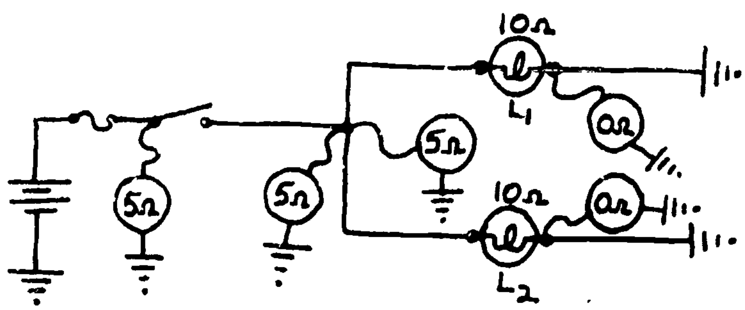
Part 2 - Shorts (Ohmmeter)

(Note: You cannot troubleshoot shorts in a parallel circuit with a voltmeter)

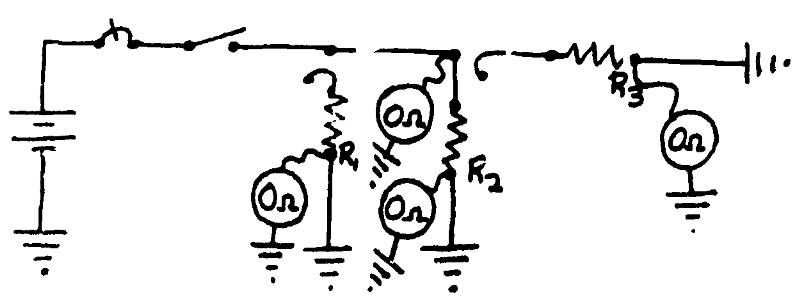
1. R_1, R_2 and R_3 will not work — 1. ______________________



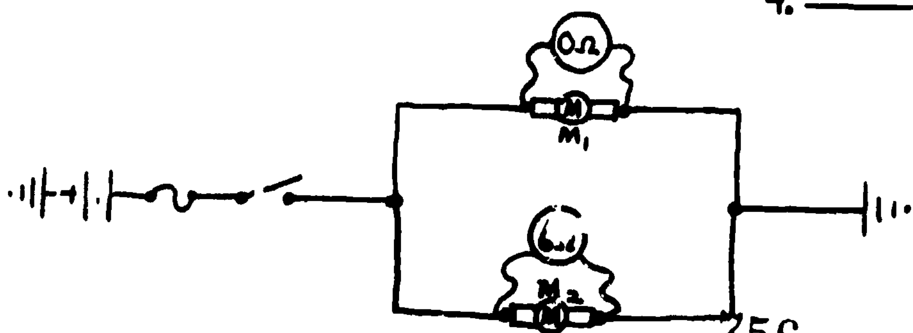
2. Lights will not turn off — 2 ______________________



3. R_2 will not drop voltage — 3. ______________________



4. Motors will not turn over — 4. ______________________



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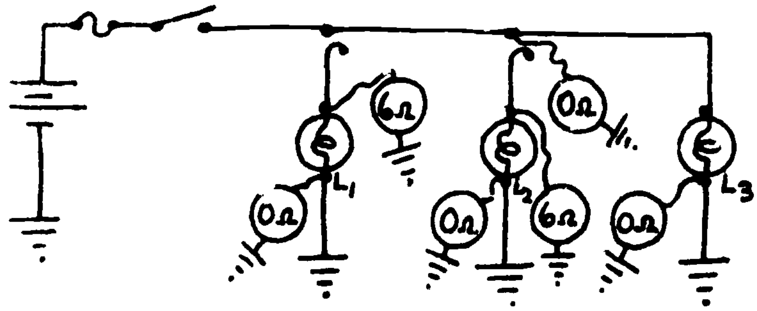
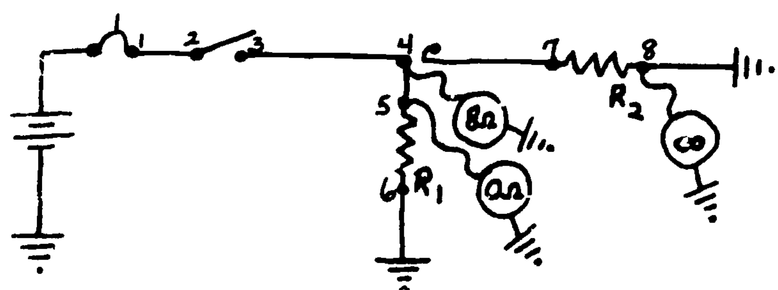
Part 3 - Opens and Shorts (Ohmmeter)

1. All lights inoperative



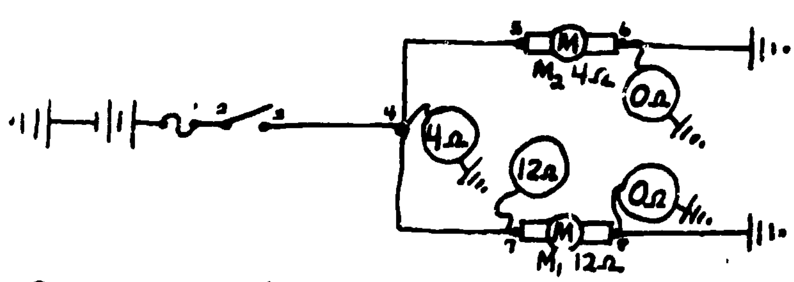
1. ______________________

2. R_2 inoperative.



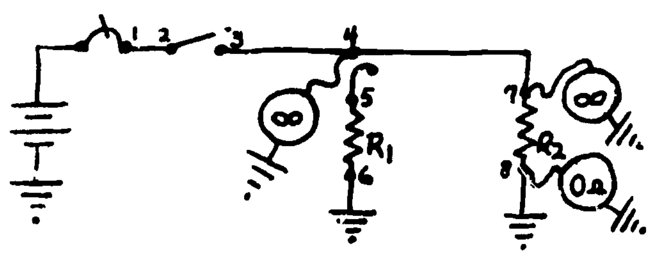
2. ______________________

3. M_1 inoperative



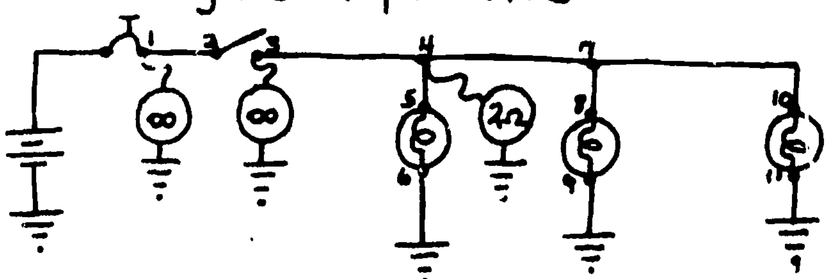
3. ______________________

4. R_2 inoperative



4. ______________________

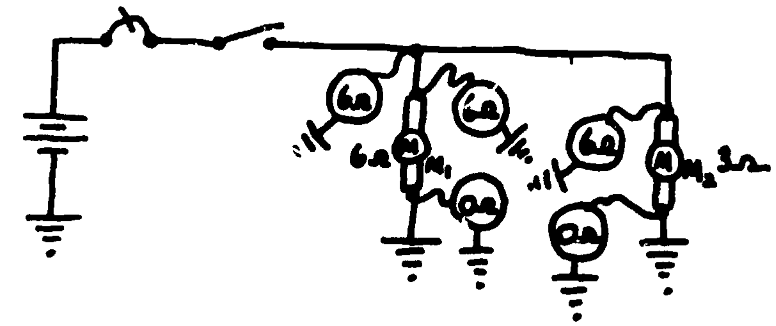
5. All lights inoperative



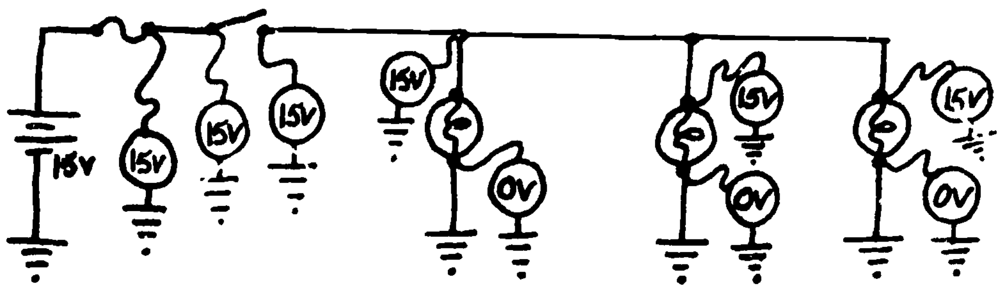
5. ______________________

Part 4 - Opens and Shorts (Volt and Ohmmeter)

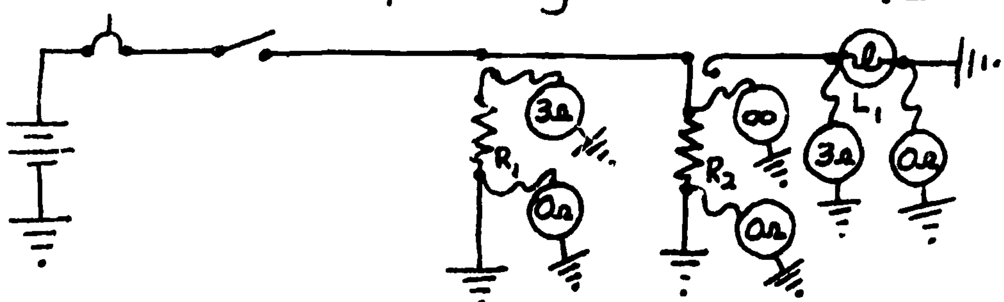
1. M₂ inoperative ______ 1. ____________



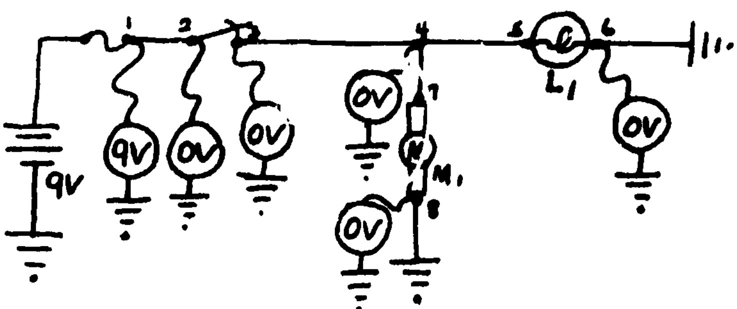
2. Lights will not turn off 2. ____________



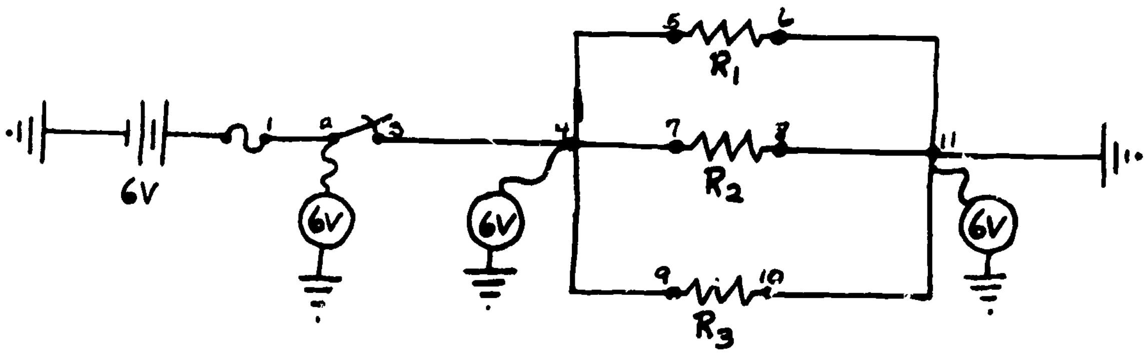
3. R_2 will not drop voltage 3. ____________



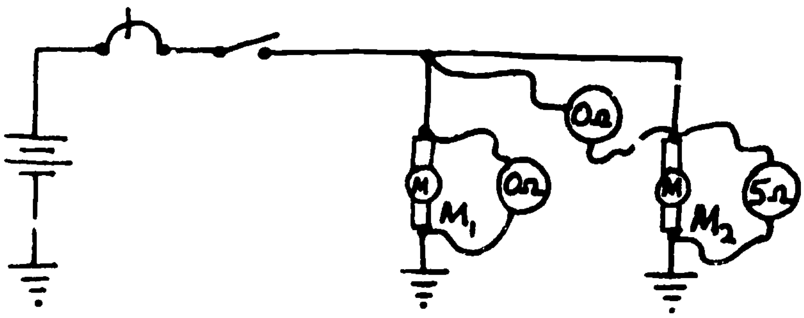
4. All loads do not work 4. ____________



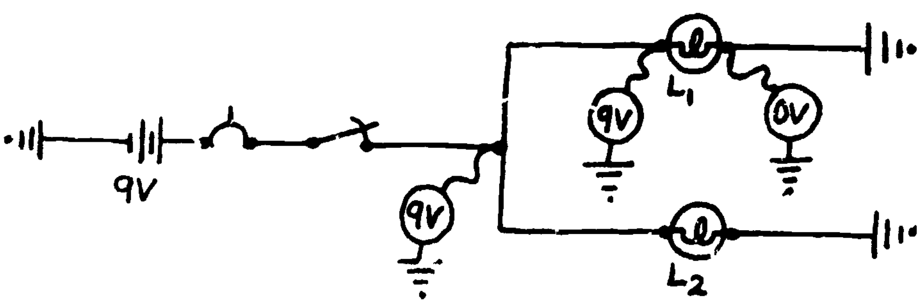
5. Resistors won't work 5.____________________



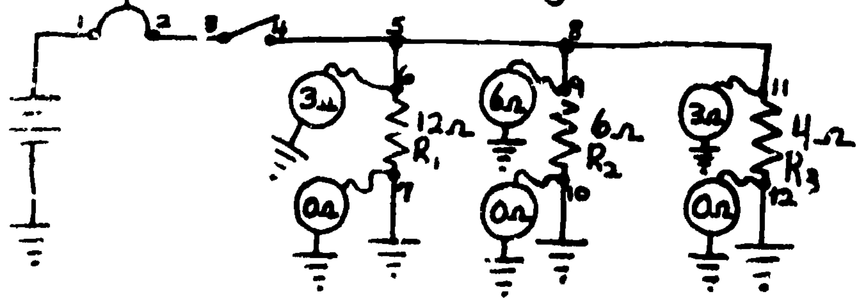
6. Motors will not work 6.____________________



7. L_1 will not light 7.____________________



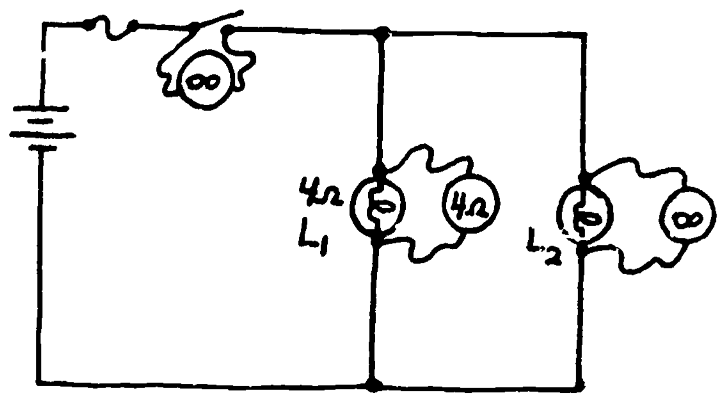
8. R_2 will not drop voltage 8.____________________



759

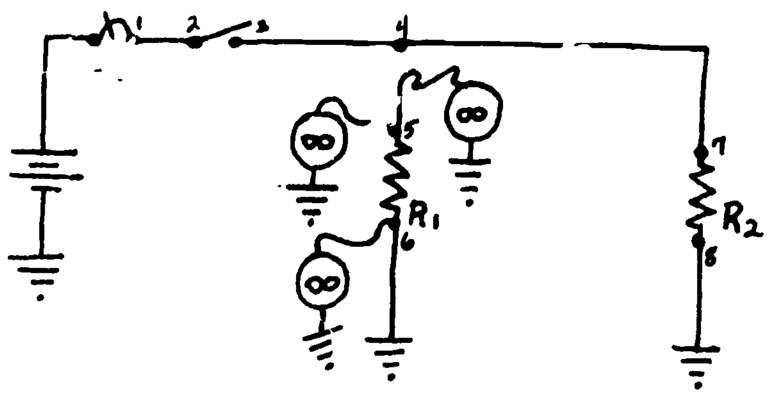
9. L_2 won't light

9. ______________________



10. R_1 inoperative

10. ______________________



SERVICE TEST
HANDOUT

C3ABR42331-HO-117B

Technical Training

Aircraft Environmental Systems Mechanic

SERIES CIRCUIT TROUBLESHOOTING

8 December 1983

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

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DO NOT USE ON THE JOB

Environmental Pneudraulics Branch
Chanute AFB, Illinois

SERVICE TEST
C3ABR42331-HO-117B

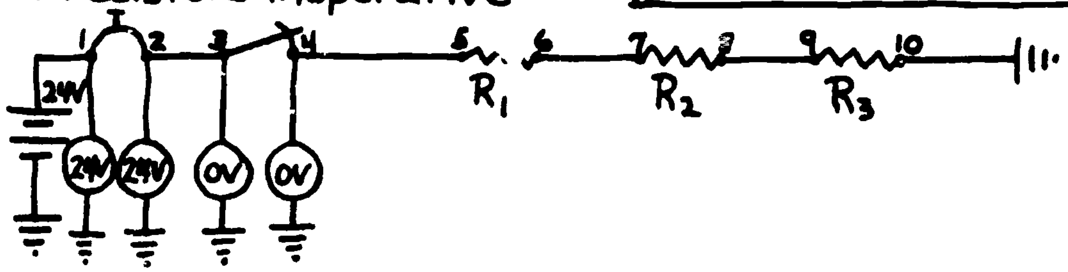
SERIES CIRCUIT TROUBLESHOOTING

INSTRUCTIONS

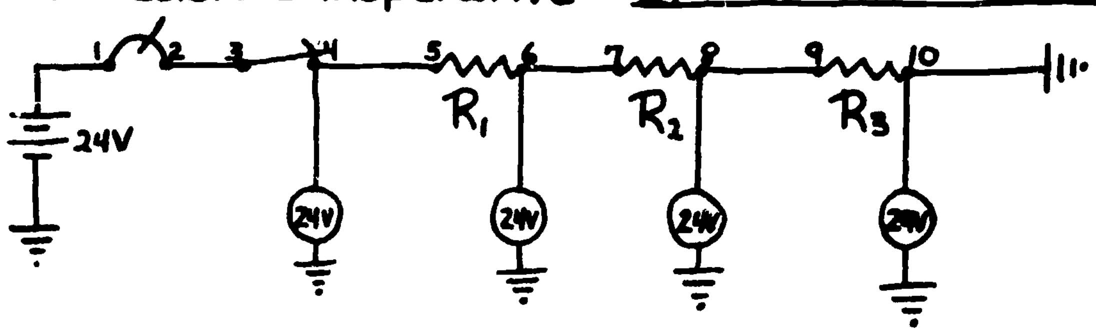
Using the malfunction indications and meter readings, locate and record the probable malfunction.

Part 1a - Opens (Voltmeter)

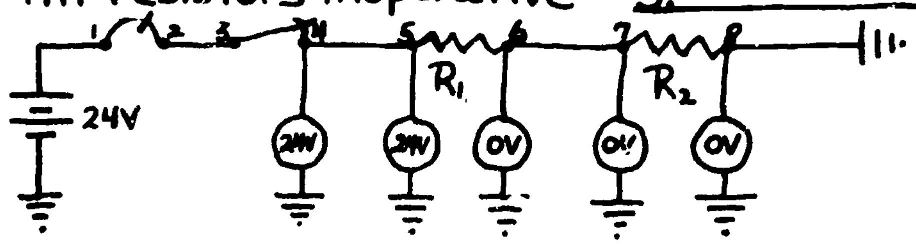
1. All resistors inoperative 1. ____________________



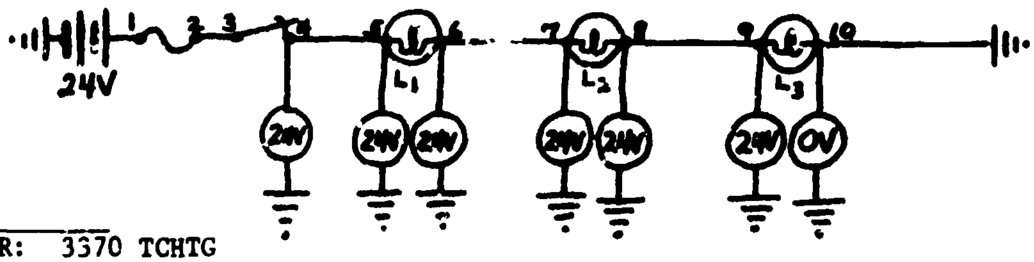
2. All resistors inoperative 2. ____________________



3. All resistors inoperative 3. ____________________



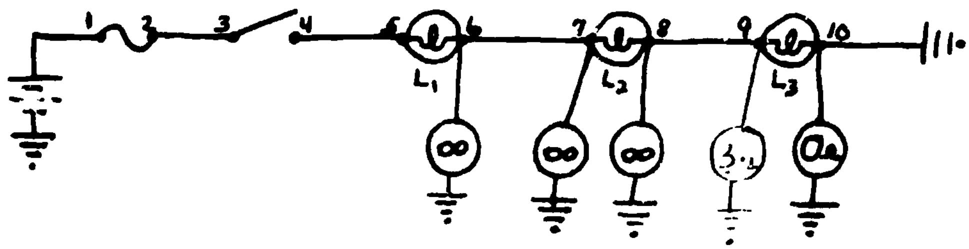
4. All lights inoperative 4. ____________________



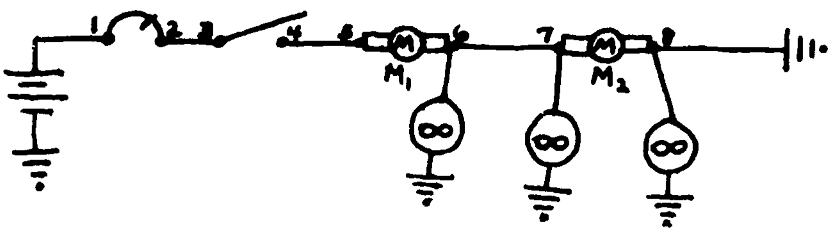
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 150; DAV - 1

Part 1b - Opens (Ohmmeter)

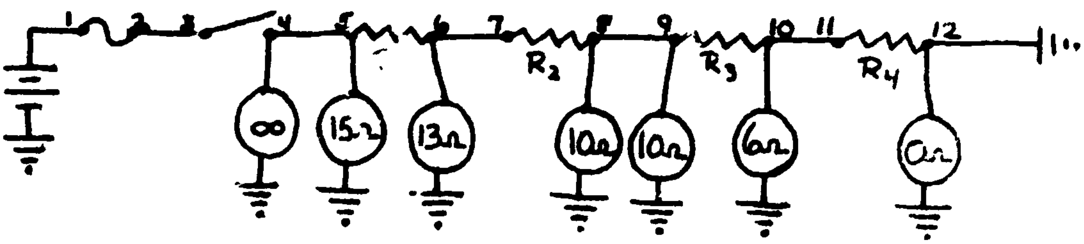
5. All lights inoperative 5. ____________



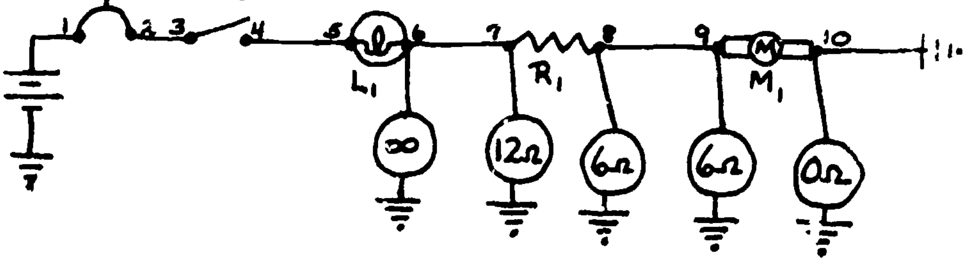
6. All motors inoperative 6. ____________



7. All resistors inoperative 7. ____________



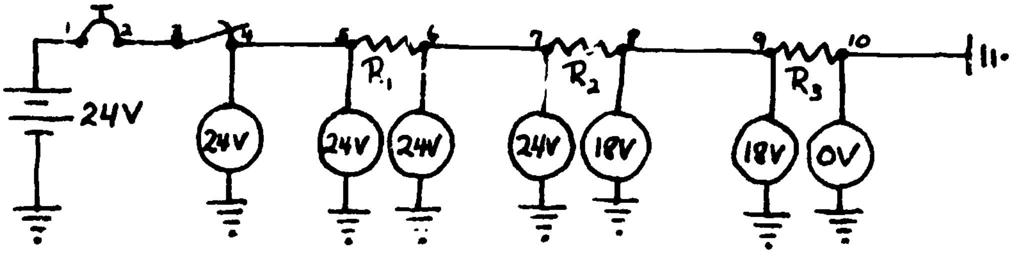
8. Everything inoperative 8. ____________



Part 2a- Shorts (Voltmeter)

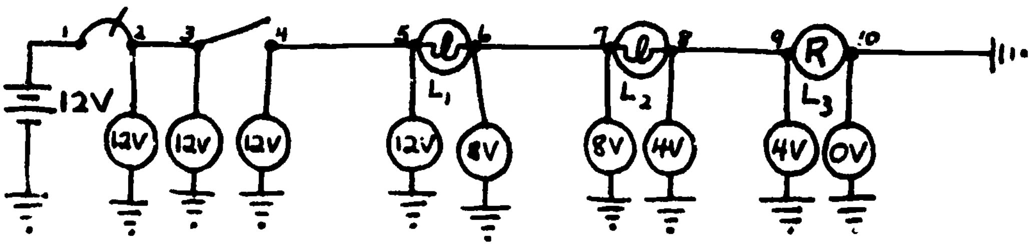
1. R_1 inoperative

1. ______________________________



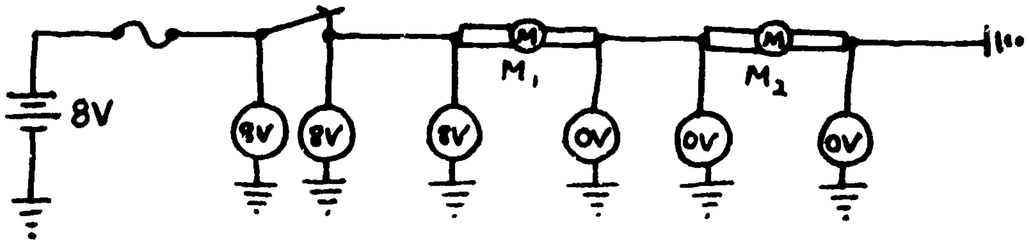
2. Lights cannot be turned off

2. ______________________________



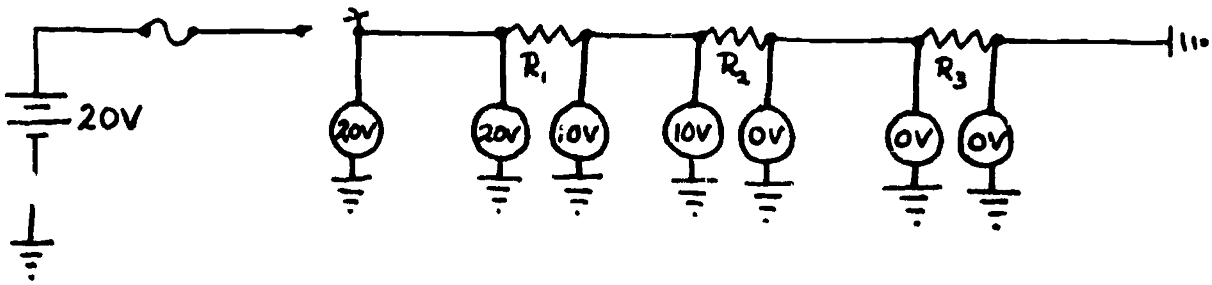
3. M_2 inoperative

3. ______________________________



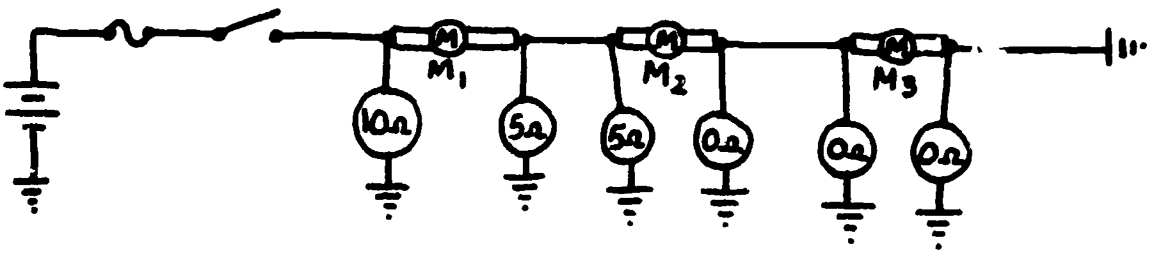
4. R_3 inoperative

4. ______________________________

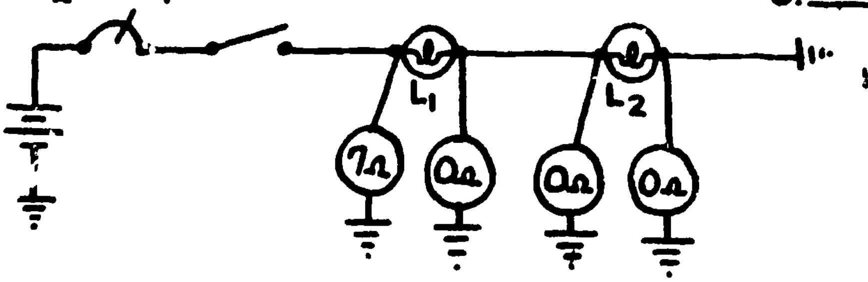


Part 2b- Shorts (Ohmmeter)

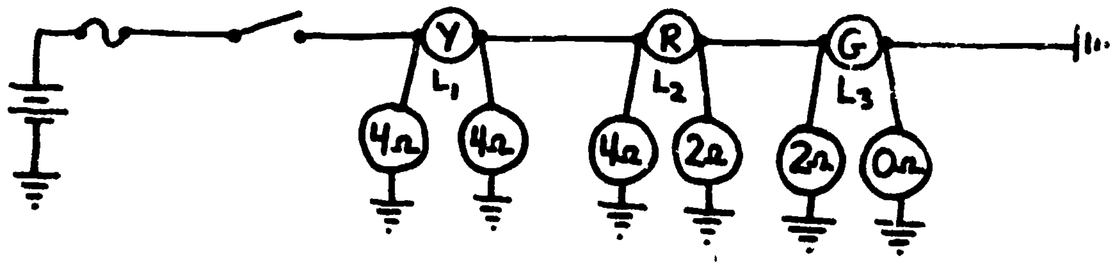
5. M_3 inoperative — 5. ____________________



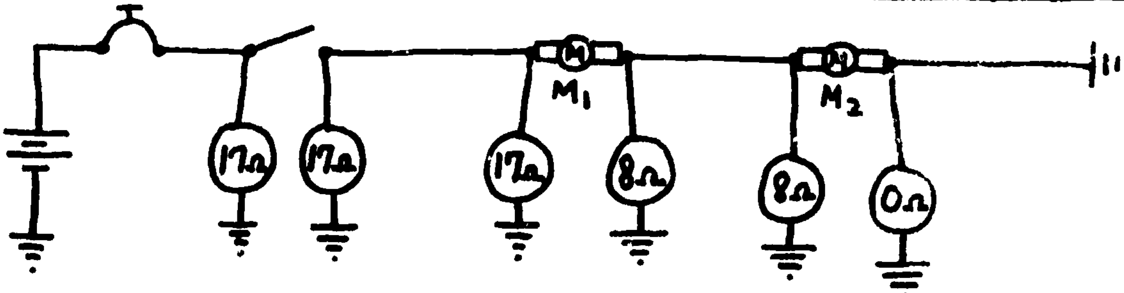
6. L_2 inoperative — 6. ____________________



7. L_1 inoperative — 7. ____________________

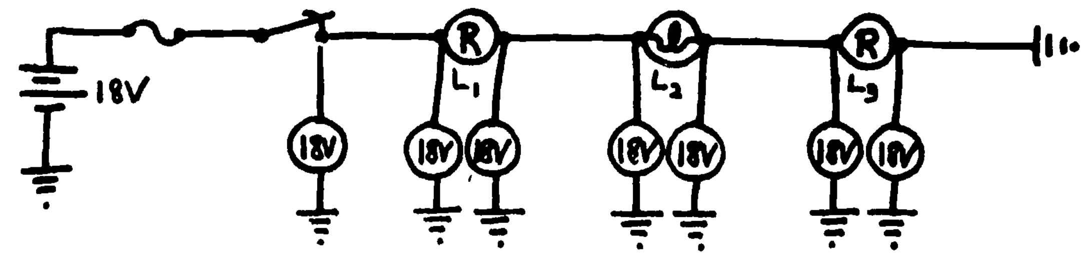


8. Motors cannot be turned off — 8. ____________________

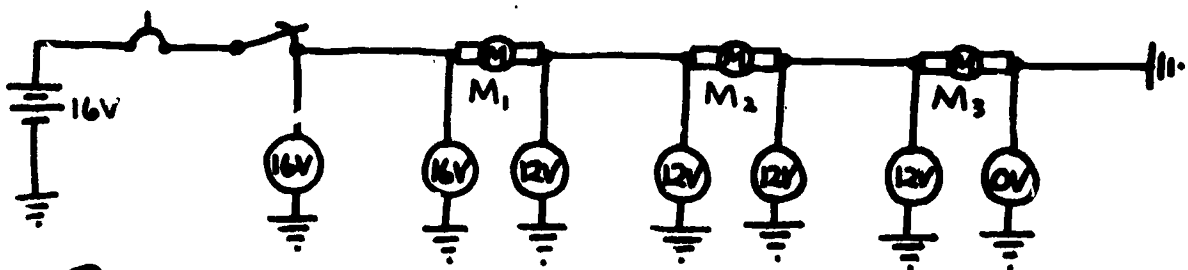


Part 3a – Opens and Shorts (Voltmeter)

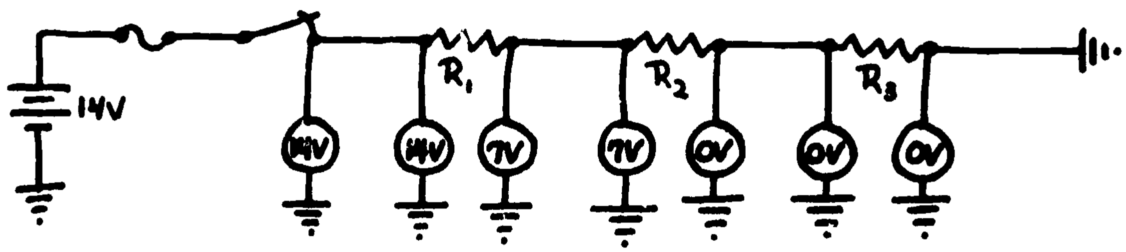
1. All lights inoperative 1. ____________________



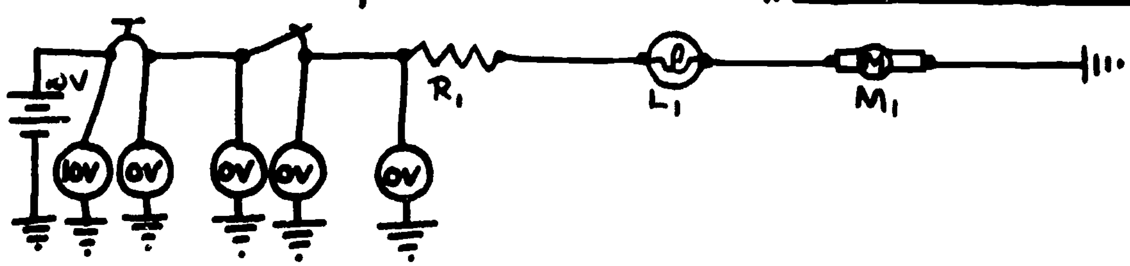
2. M_2 inoperative 2. ____________________



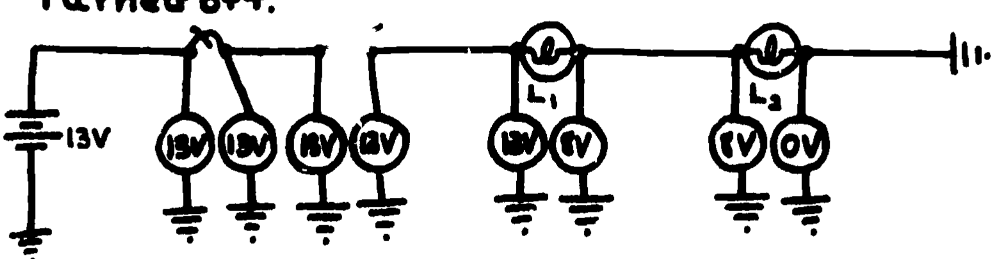
3. R_3 inoperative 3. ____________________



4. All loads inoperative 4. ____________________



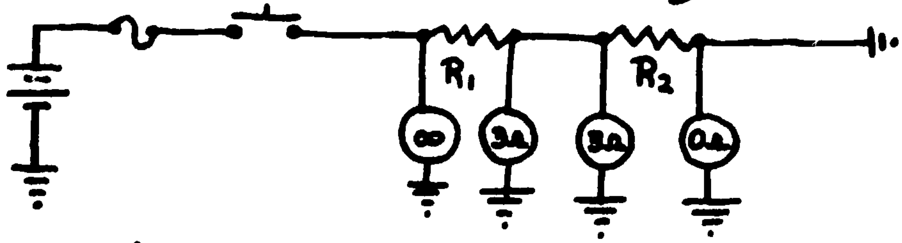
5. Lights stay on with circuit breaker turned off. 5. ____________________



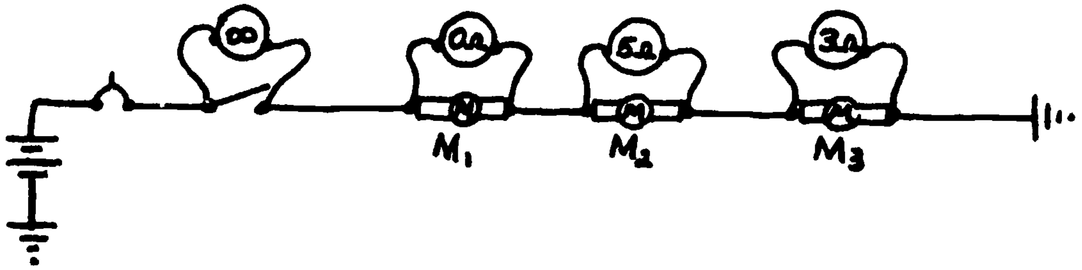
766

Part 3b- Opens and Shorts (Ohmmeter)

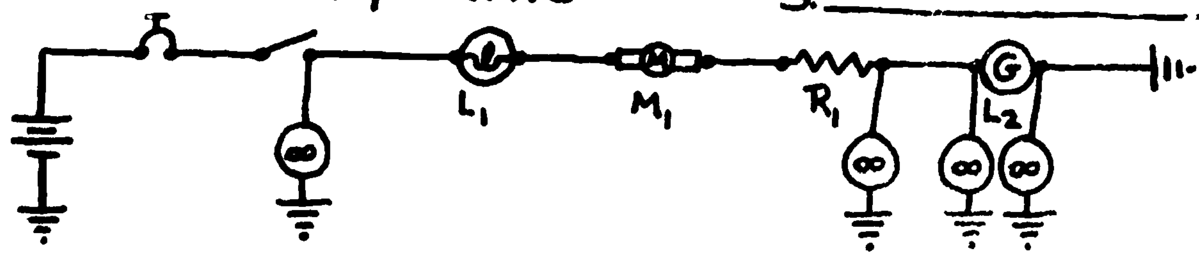
1. Resistors did not drop voltage 1. ______________



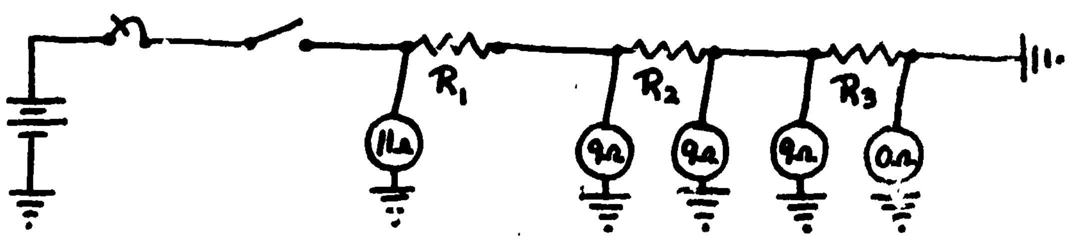
2. M1 inoperative 2. ______________



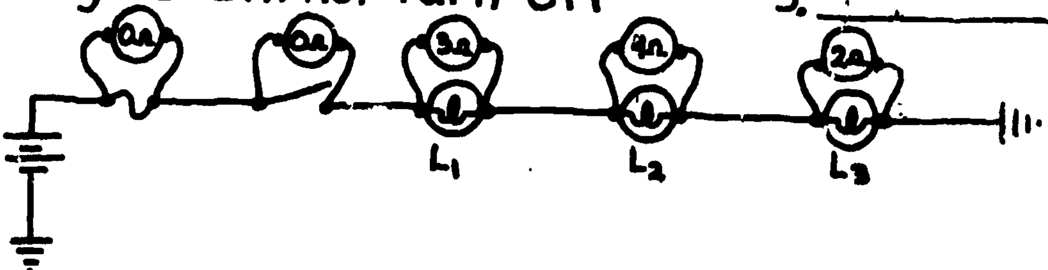
3. All loads inoperative 3. ______________



4. R2 inoperative 4. ______________

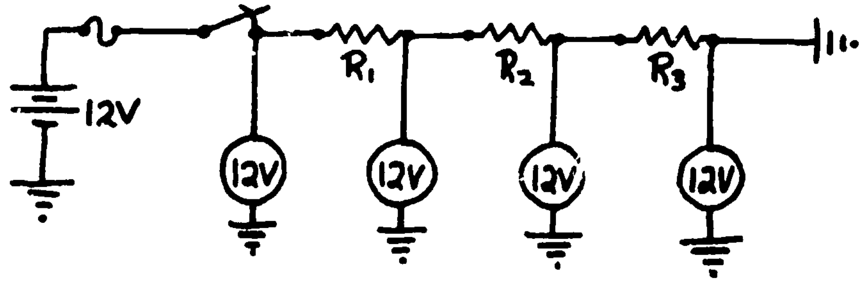


5. Lights will not turn off 5. ______________

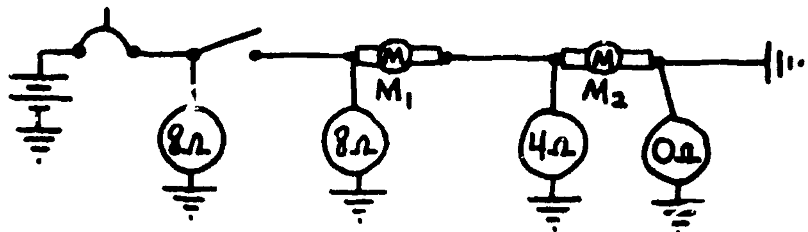


Part 4 - Opens and Shorts (Volt and Ohmmeters)

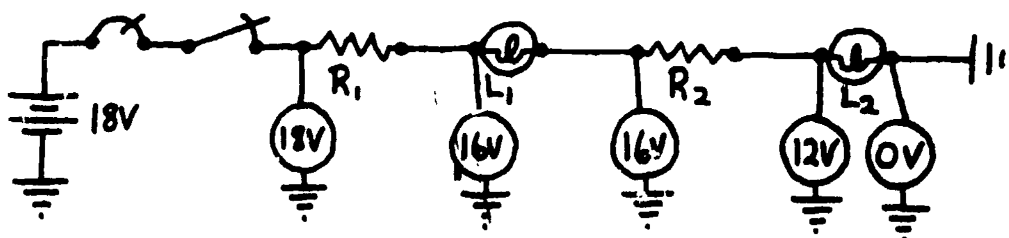
1. Resistors do not work   1. ____________________



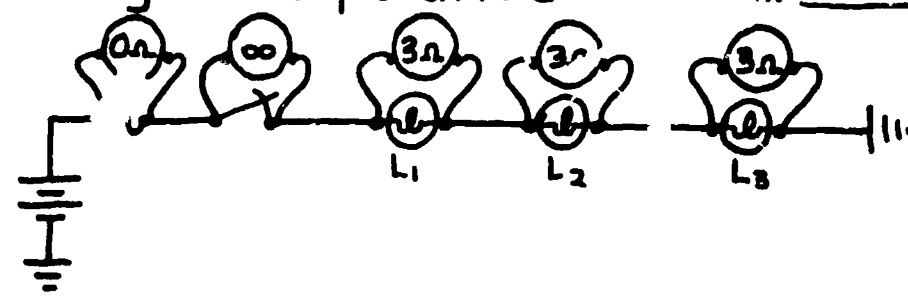
2. Motors run when turned off   2. ____________________



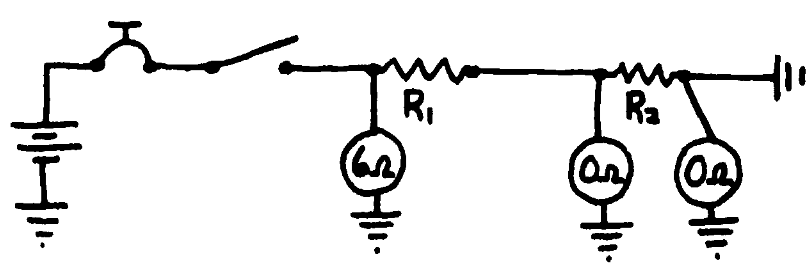
3. L1 inoperative   3. ____________________



4. All lights inoperative   4. ____________________

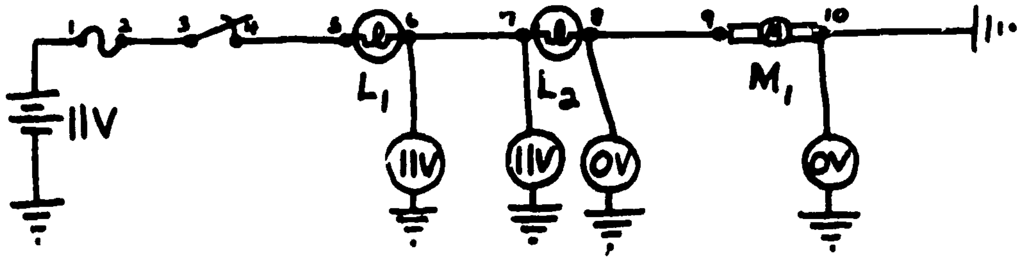


5. R2 inoperative   5. ____________________



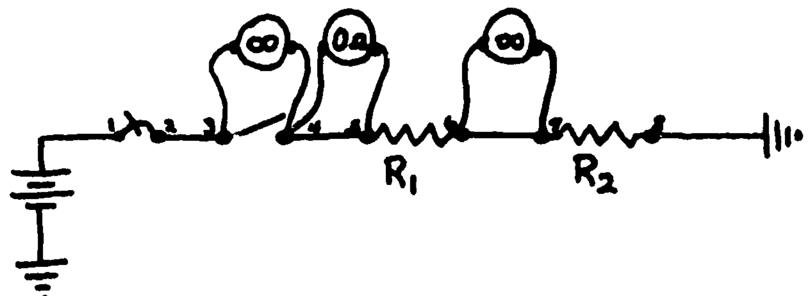
6. All loads do not work

6. ____________________



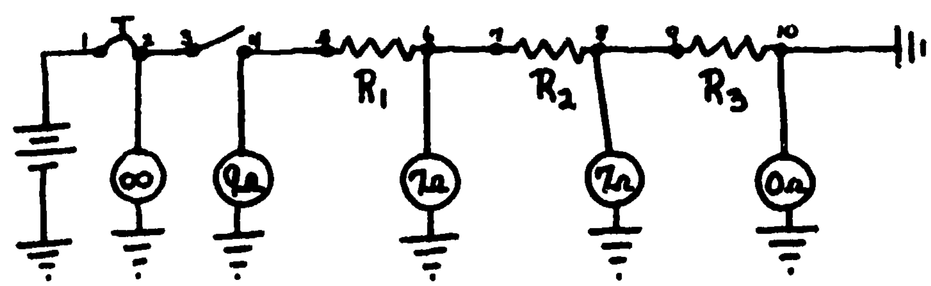
7. R_1 and R_2 do not work

7. ____________________



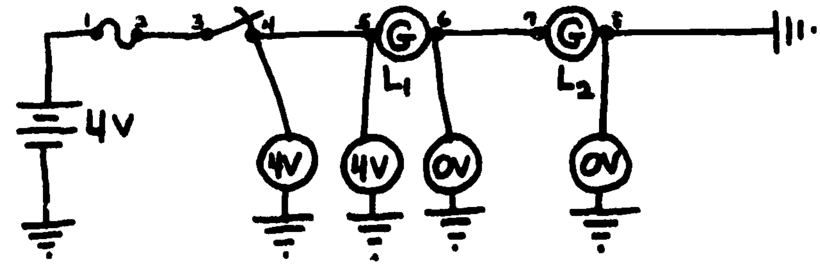
8. R_2 will not drop voltage

8. ____________________



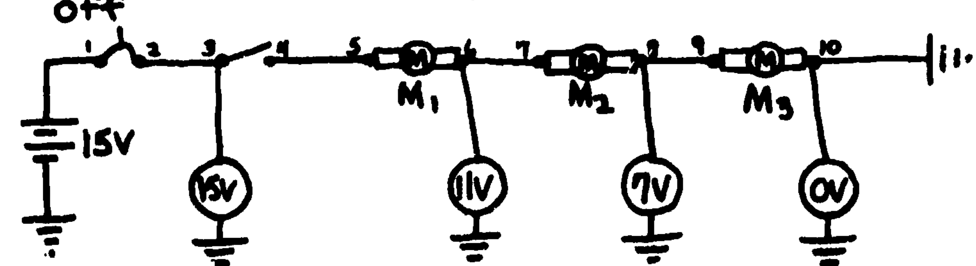
9. L_2 inoperative

9. ____________________



10. Motors will not stop when turned off

10. ____________________



hnical Training

Aircraft Environmental Systems Mechanic

PARALLEL CIRCUITS

27 October 1981

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

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RGL: 10.0

OBJECTIVES

Using pertinent laws and formulas, solve for unknown values in parallel circuits. A minimum of eight out of ten circuits must be correct.

Using schematic diagrams of parallel circuits, malfunction indications and meter readings, specify the type of troubles for a minimum of eight out of ten indications.

INSTRUCTIONS

This programmed text presents information in small steps called "frames." Carefully study the written material and/or schematic in each frame until you are satisfied you understand its contents. Each frame requires you to select true statements, solve problems, etc. Specific instructions are provided in each frame. After you have made your response in this book, compare your answer with the answer on the top of the next frame (Frames 1 thru 15) and at the bottom of the page to pages over for Frames 16 thru

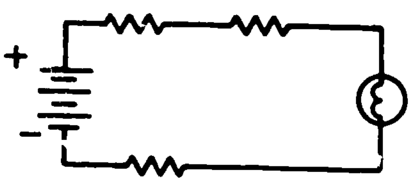
If you are correct, go on to the next frame. If you are incorrect, study the frame again and correct your mistakes before continuing. If you still can't understand your mistakes, ask your instructor for assistance. Read carefully, select the correct answer(s) and DO NOT HURRY. Be sure you have the handout (HO) in front of you called RULES, LAWS AND FORMULAS.

Supersedes 3ABR42331-PT-118, 27 May 1981.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 500; DAV - 1

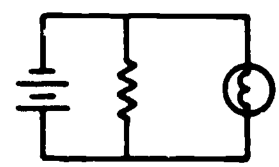
A parallel circuit is a circuit that has two or more paths for current to flow through. The components that make up a parallel circuit are arranged so that current will have more than one way to flow. Start tracing at the negative pole of the power source and follow all the paths back to the positive circuit.

Determine which circuit(s) below is/are PARALLEL CIRCUIT(s) and circle its/their number(s).

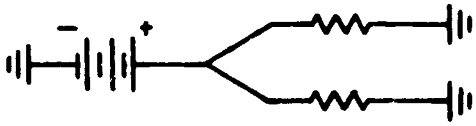
1.



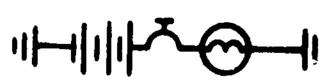
2.



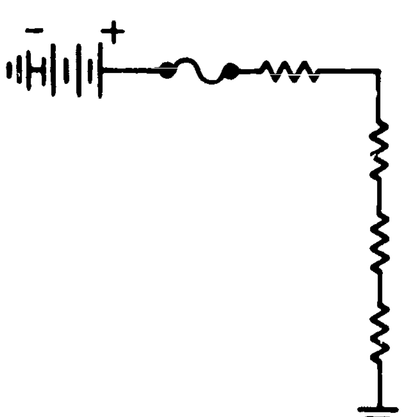
3.



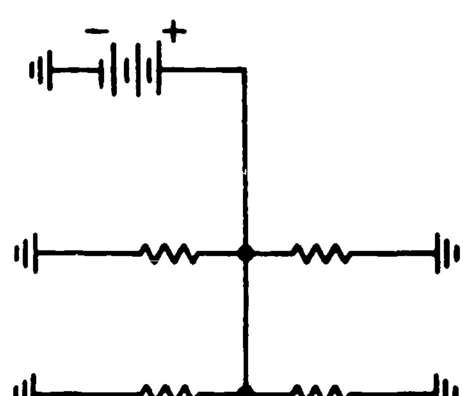
4.



5.



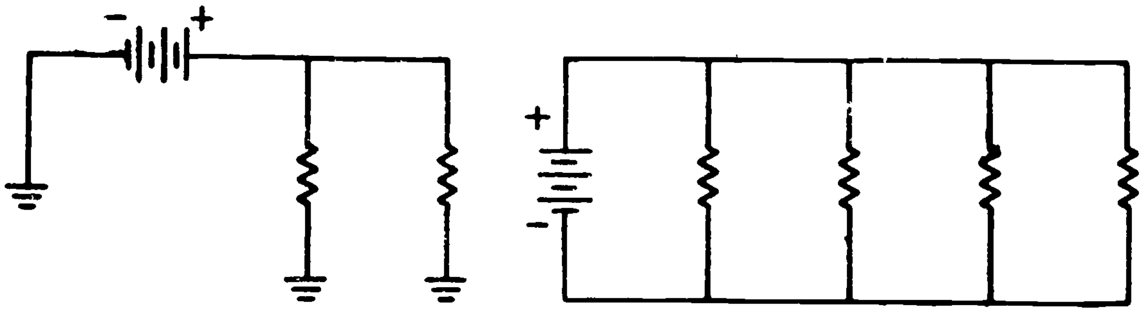
6.



Answers to Frame 1: 2, 3, 6

Frame 2

The illustrations below are parallel circuit diagrams.



Circle the number of the statement which correctly describes parallel circuits.

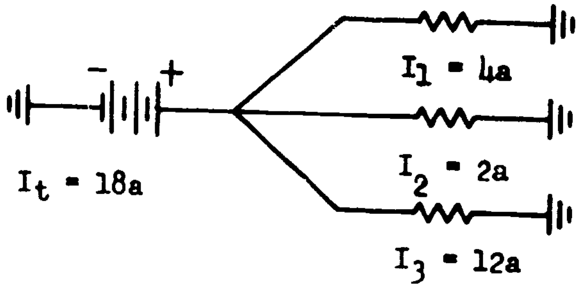
1. Circuit components are arranged such, that all the current must flow through the only path provided.

2. Current will divide and flow through all of the paths provided.

Answer to Frame 2: 2

Frame 3

Since current has been provided with more than one path in which to flow, you can see how the main current would divide and flow across each of the paths. How much of the current flows through each branch of the circuit depends on how much resistance is in each branch. Certainly there will be more current flowing in a branch that has a small resistance than there will be in a branch with a large amount of resistance. Regardless of the amount of current flowing across each branch, one thing is certain, the "TOTAL current flow in the entire parallel circuit is the SUM of the currents flowing through each branch!"



Circle the letter of the statement below that describes the characteristic of amperage in a parallel circuit.

A. Total amperage is the sum of all the amperages of the branches.

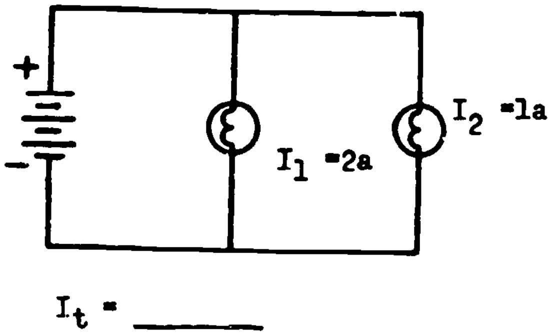
B. Total amperage is the same throughout the entire circuit.

Answer to Frame 3: A

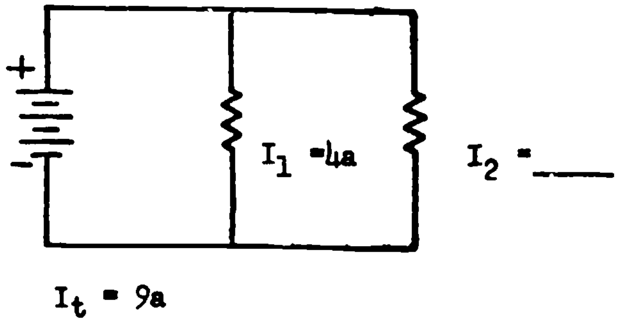
Frame 4

If you recognize total amperage as being the SUM of the amperages throughout the circuit, solve the problems below. Enter your answer in the proper space.

1.



2.



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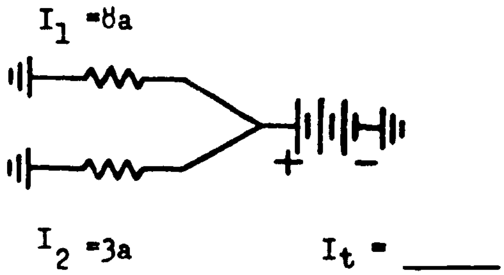

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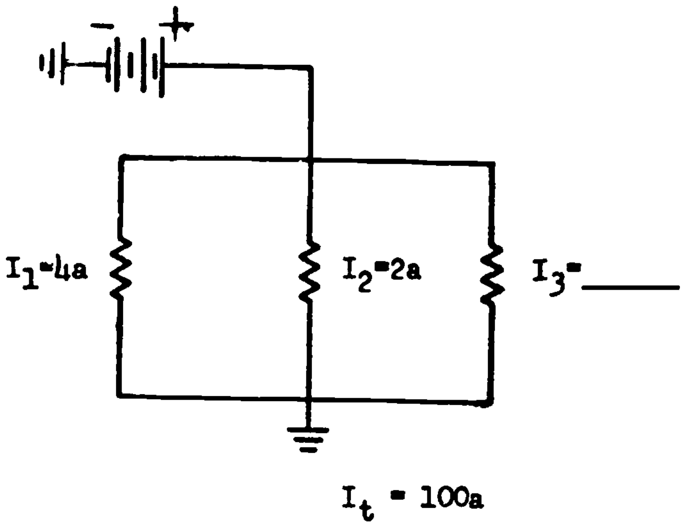
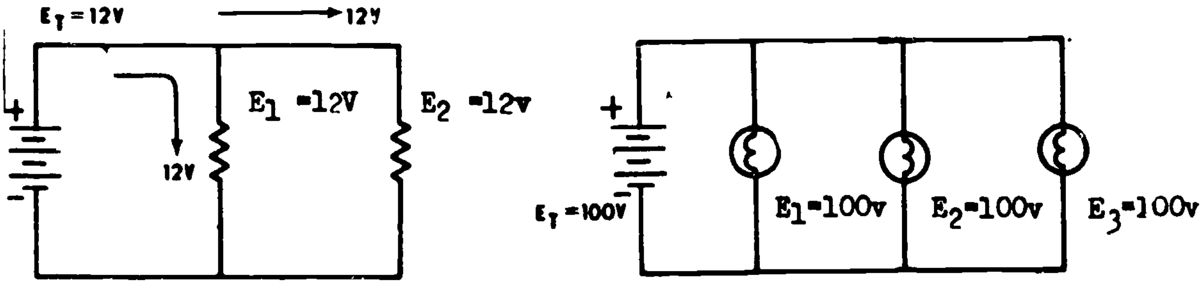


Answers to Frame 4: 1. 3a 2. 5a 3. 11a 4. 94a

Frame 5

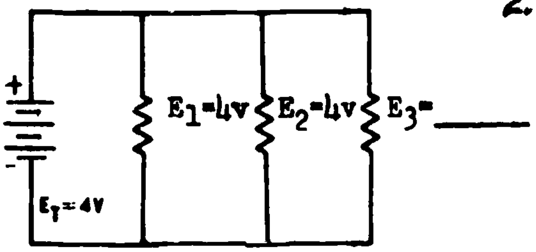
Total amperage is ALWAYS the SUM of the amperages in a parallel circuit. Let's consider the effect of voltage in a parallel circuit. Voltage in a parallel circuit pushes with equal pressure across all of the branches. Thus, what we have said here is: Voltage is the SAME across each path in the circuit.

Notice what happens to the applied voltage in the diagrams below.



Below are some parallel problems. Solve the problems and write your answers in the spaces provided.

1.



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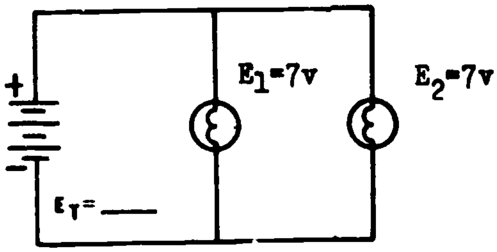

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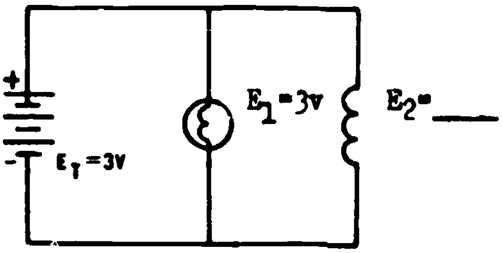

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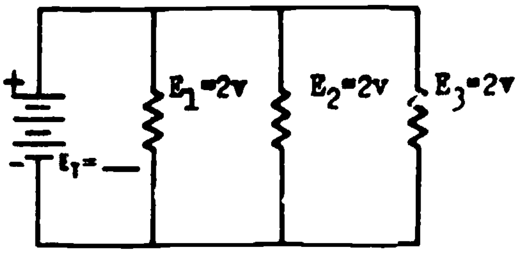
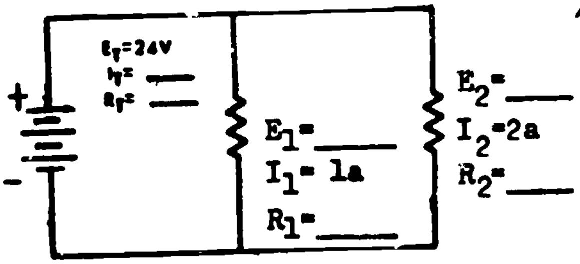


Answers to Frame 5: 1. 4V 2. 7V 3. 3V 4. 2V

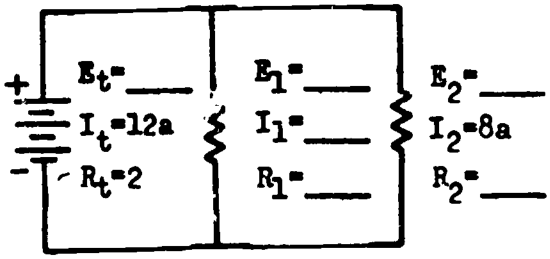
Frame 6

So far you have seen that amperage is the "SUM" and voltage is the "SAME" in a parallel circuit. Using this information and OHM'S law, solve the problems listed below and write your answers in the spaces provided.

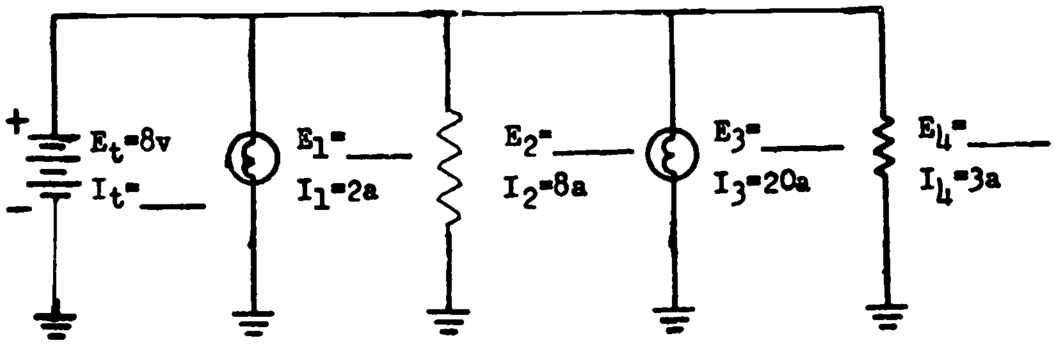
1.



2.



3.



Answers to Frame 6:

1.	E_t = 24V	E_1 = <u>24</u>	E_2 = <u>24</u>		
	I_t = <u>3a</u>	I_1 = 1a	I_2 = 2a		
	R_t = <u>8Ω</u>	R_1 = <u>24Ω</u>	R_2 = <u>12Ω</u>		
2.	E_t = <u>24V</u>	E_1 = <u>24V</u>	E_2 = <u>24V</u>		
	I_t = 12a	I_1 = <u>4a</u>	I_2 = 8a		
	R_t = 2Ω	R_1 = <u>6Ω</u>	R_2 = <u>3Ω</u>		
3.	E_t = 8V	E_1 = <u>8V</u>	E_2 = <u>8V</u>	E_3 = <u>8V</u>	E_4 = <u>8V</u>
	I_t = <u>33a</u>	I_1 = 2a	I_2 = 8a	I_3 = 20a	I_4 = 3a

Frame 7

Perhaps you noticed while you were working the problems in frame 6, that the total resistance (R_t) was even less than the smallest resistor in the circuit! If you didn't notice, go back and look at the R_t value. How can this be? By adding more resistors in parallel, the current has more paths to flow through. Therefore, the total resistance in the circuit must be lowered to allow more current flow from negative to positive.

Circle the number of the statement below that best describes resistance in a parallel circuit.

1. Adding resistors in parallel will cause resistance to increase and amperage to decrease.

2. Adding resistors in parallel decreases the resistance by offering more paths for current to flow, therefore, increasing the amperage.

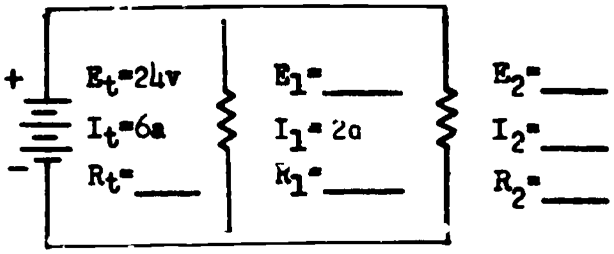
3. Total resistance is the sum of the resistors in parallel.

4. Total resistance is the same as any resistor in the circuit.

Answer to Frame 7: 2

Frame 8

Using Ohm's Law and the characteristics of voltage (same) and amperage (sum), solve this problem. Pay particular attention to the total resistance. Write your answer in the spaces provided.



Before you compare your answer with the ones on the next page, did you find the total resistance (R_t) to be less than the smallest resistor? If not, work the problem again.

779

Answers to Frame 8: E_t = 24V E_1 = 24V E_2 = 24V

I_t = 6a I_1 = 2a I_2 = 4a

R_t = 4Ω R_1 = 12Ω R_2 = 6Ω

Frame 9

Match the terms to the statements on the left by writing the letter of the terms on the right.

_____1. Remains the SAME throughout the parallel circuit.

_____2. Is the SUM of all of those in the parallel circuit.

_____3. Is SMALLER than the smallest in the parallel circuit.

a. Current

b. Voltage

c. Total resistance (R_t)

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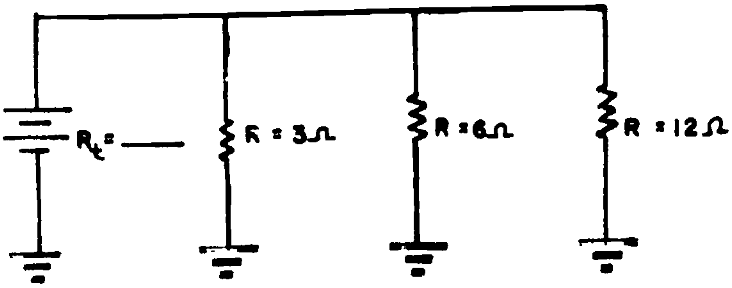
Answers to Frame 9: 1. b 2. a 3. c

Frame 10

How to mathematically solve for the total resistance in the parallel circuit without current or voltage values given in a circuit is shown below. What is the total resistance? It can't be 21 ohms since that isn't "smaller than the smallest resistor."

Using the formula shown you will be able to solve for any R_t in a parallel circuit. This is called a reciprocal formula. You should use scratch paper to work this problem below as you study it.



$$R_t = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4} + \frac{1}{R_5} + \text{etc.}}$$

Now let's take only what's needed from this formula and solve for R_t in the above circuit.

$$R_t = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$$

Because the circuit has only three resistors we will need only part of the formula to solve R for the above circuit.

$$R_t = \frac{1}{\frac{1}{3\Omega} + \frac{1}{6\Omega} + \frac{1}{12\Omega}}$$

Now substitute the resistive values into the formula.

$$R_t = \frac{1}{\frac{1}{3\Omega} + \frac{1}{6\Omega} + \frac{1}{12\Omega}}$$ → numerator → denominator

In any fraction the top number is called the numerator and the bottom number is the denominator. The lowest common denominator (LCD) is the smallest number which all denominators can be divided into evenly. In our example 12 is the LCD, (the smallest number 3, 6, and 12 can be divided into evenly).

(LCD) $12 \div 3\Omega = 4$
$12 \div 6\Omega = 2$
$12 \div 12\Omega = 1$

Replace the resistive values with equal fractions which use the LCD as their denominators. To do this, divide the denominator of each fraction (3Ω, 6Ω, and 12Ω) into the LCD and enter the result over the LCD.

$$R_t = \frac{1}{\frac{?}{12} + \frac{?}{12} + \frac{?}{12}}$$

$$\frac{1}{3\Omega} = \frac{?}{12} = 3\overline{)12}^{\,4} = \frac{4}{12}$$

$$\frac{1}{6\Omega} = \frac{?}{12} = 6\overline{)12}^{\,2} = \frac{2}{12}$$

$$\frac{1}{12\Omega} = \frac{?}{12} = 12\overline{)12}^{\,1} = \frac{1}{12}$$

$$R_t = \frac{1}{\frac{4}{12} + \frac{2}{12} + \frac{1}{12}}$$

Now, add the numerators, 4 + 2 + 1 = 7. DO NOT add the LCD, simply enter the sum of the numerators over the LCD (12).

$$R_t = \frac{1}{\frac{4 + 2 + 1}{12}}$$

$$R_t = \frac{1}{\frac{7}{12}}$$

To complete the problem you need to divide $\frac{7}{12}$ into 1 ($\frac{7}{12}$ is actually the denominator of the larger fraction and 1 is the numerator). Dividing a fraction into another number is the same as inverting that fraction and multiplying it times the other number.

$$R_t = 1 \div \frac{7}{12}$$

$$R_t = 1 \times \frac{12}{7}$$

$$R_t = \frac{12}{7}$$

The final step is to convert this fraction into a whole number. Do this by dividing the denominator into the numerator.

$$R_t = 7\overline{)12.00}^{\,1.71}$$

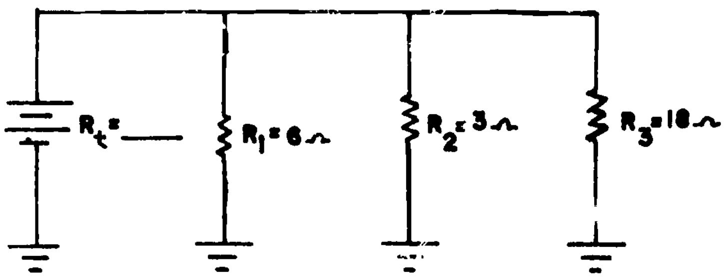
$$\begin{array}{r} 7 \\ \hline 50 \\ 49 \\ \hline 10 \\ 7 \\ \hline \end{array}$$

$$R_t = 1.71\Omega$$

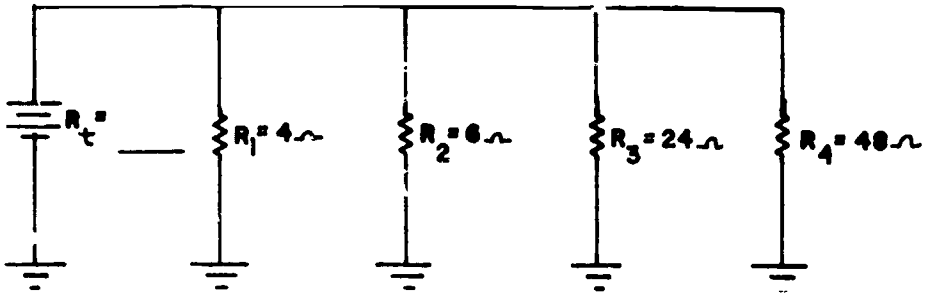
Frame 10 (Continued)

Using the reciprocal formula solve for R_t in the circuits below. Write your answers in the blanks provided.

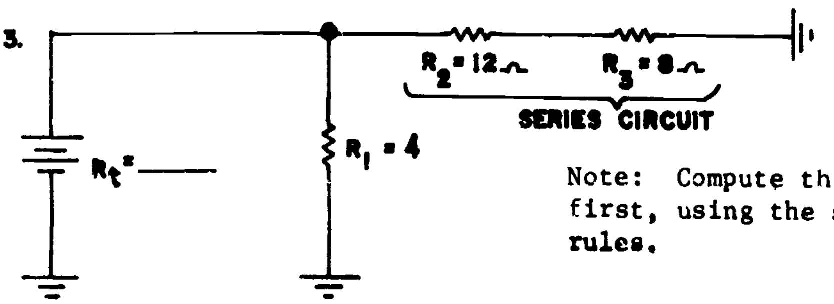
1.



2.

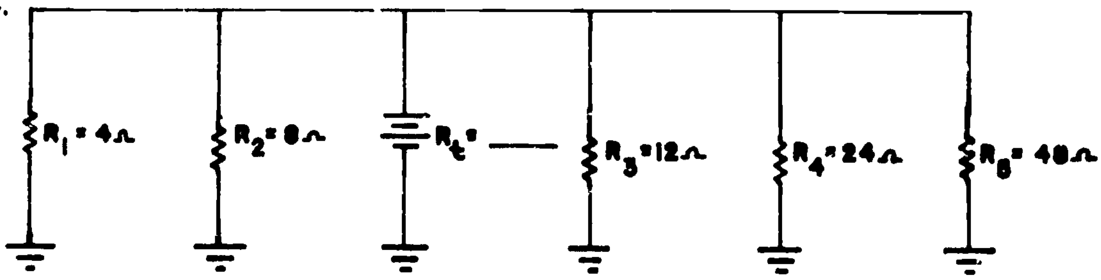


3.



Note: Compute the series circuit first, using the series circuit rules.

4.



Answers to Frame 10: 1. 1.8Ω 2. 2.09Ω 3. 3.33Ω 4. 1.92Ω

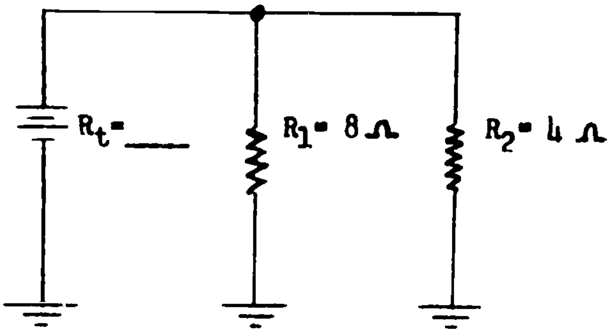
Frame 11

The next formula we will cover is the product over the sum, which is also used to solve for total resistance in a parallel circuit. This formula is primarily used when there are two (2) resistors in parallel whether they are of equal value or not.

When two (2) numbers are multiplied the answer is called a product. When two (2) numbers are added the answer is a sum. Therefore this formula is worked by multiplying two (2) numbers, then adding the same two (2) numbers, and dividing the two (2) answers.

For the circuit shown below, we will solve for R_t using the product over the sum formula. The formula you just covered in the last frame could also be used, however, at this time let's use the product over the sum.

You should use scratch paper to work this problem below as you study it.



Step (1) $R_t = \frac{R_1 \times R_2}{R_1 + R_2}$

(2) $R_t = \frac{8 \times 4}{8 + 4} = \frac{32}{12}$

(3) $R_t = \frac{32}{12} = 2.666\Omega$

(4) $R_t = 2.666\Omega$

(5) $R_t = 2.67\Omega$

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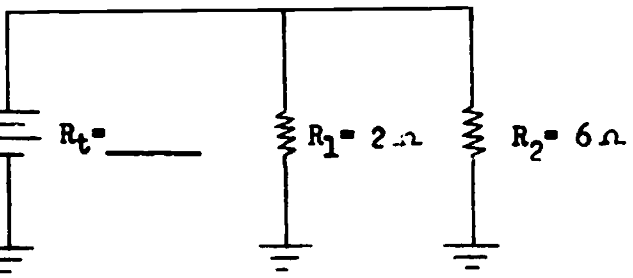
Frame 11 (Continued)

Using the product over the sum formula solve for R_t in the circuit below. Write your answer(s) in the blanks provided.

1.



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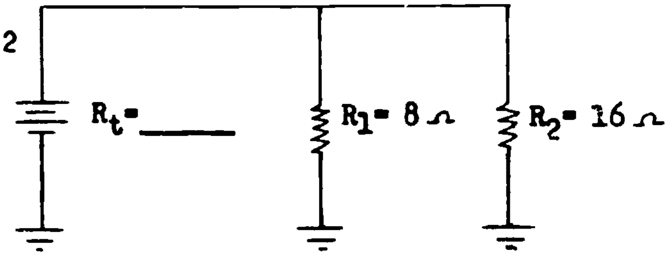

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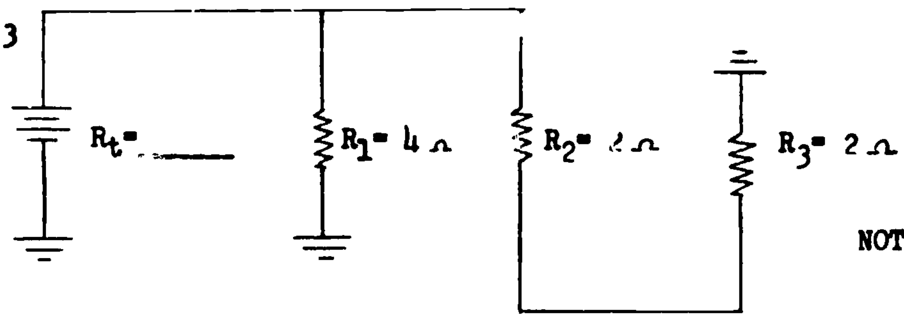
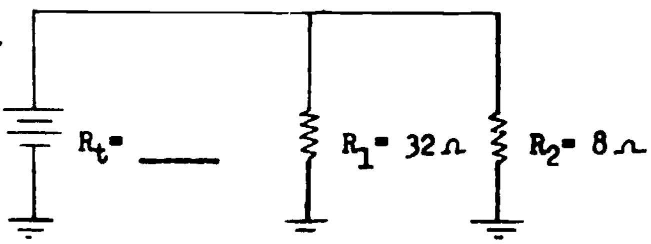


NOTE: **Compute the total resistance in the series circuit.**

4



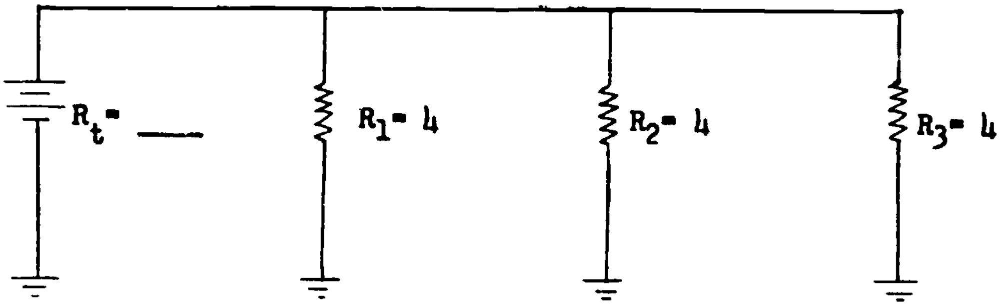
Answers to Frame 11: 1. 1.5Ω 2. 5.33Ω 3. 2.0Ω 4. 6.4Ω

Frame 12

The last formula we will cover is the resistive value over the total amount of like resistors in parallel.

This formula is primarily used to solve for total resistance in parallel circuit if all the resistance values in parallel are equal. The reciprocal formula shown in frame 10 can also be used, however the formula, shown in use below, is easier and faster to use if the resistive values are equal in value.

You should use scratch paper to work this problem.



Step (1) $R_t = \frac{R}{N}$ — The value of one of the resistors in parallel if they are all equal in value. — The number of resistors in parallel.

(2) $R_t = \frac{4\Omega}{3 \text{ ea}}$ — This 4Ω resistance is the value of one of the 4Ω resistors in parallel only if all the resistors in the circuit are of equal value. — This is the total of like resistors used in parallel with each other.

(3) $R_t = \frac{4\Omega}{3 \text{ ea}} = 1.333$

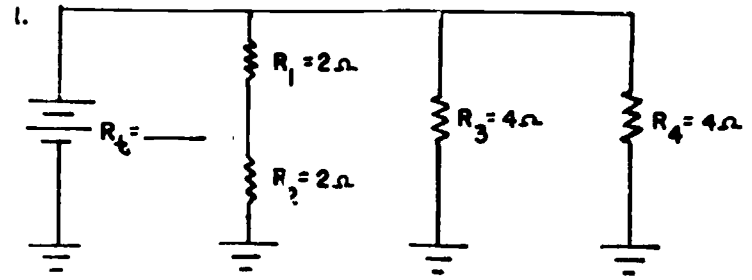
(4) $R_t = 1.333 = 1.33\Omega$

(5) $R_t = 1.33\Omega$

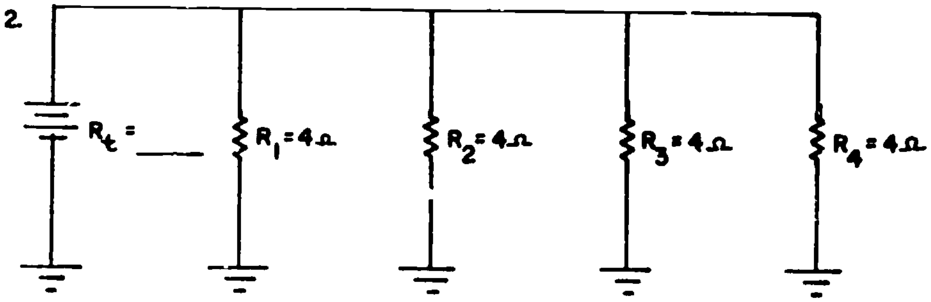
```
   1.333
3)4.000
  3
  10
   9
   10
    9
    10
     9
     1
```

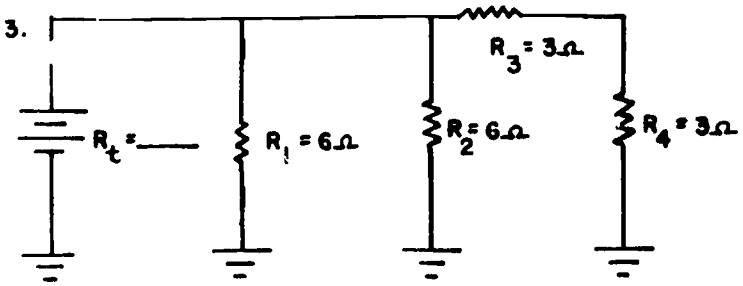
Frame 12 (Continued)

Using the resistive value over the number of like resistors formula solve for R_t in the circuit below. Write your answer(s) in the blanks provided.

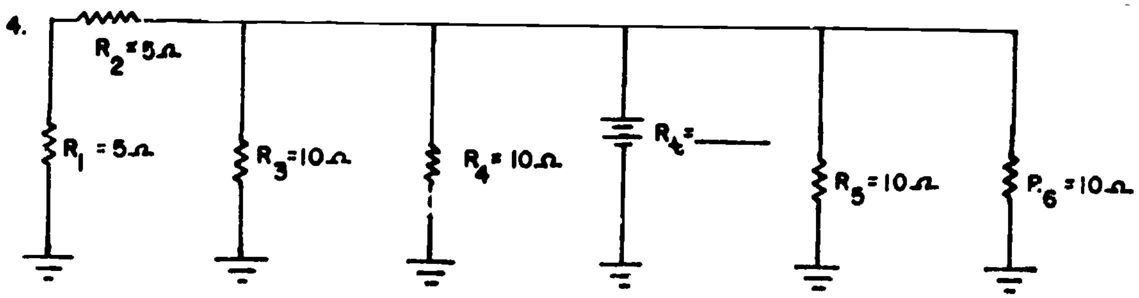


Note: Solve for the series circuit first.





Note: Solve for the series circuit first.



Note: Solve for the series circuit first.

Answers to Frame 12: 1. 1.33Ω 2. 1.0Ω 3. 2.0Ω 4. 2.0Ω

Frame 13

When determining the TOTAL values in a parallel circuit, you must decide whether the characteristic to use is the SUM, SAME, or SMALLER THAN THE SMALLEST.

In the space provided, write the characteristic beside the word it describes.

a. Voltage: ______________________________

b. Amperage: ______________________________

c. Resistance: ______________________________

Answers to Frame 13:

a. Voltage: s the same through the parallel circuit

b. Amperage: is the sum of all the amperages in the parallel circuit

c. Resistance: is smaller than the smallest resistor in the parallel circuit

Frame 14

SAME	________	(E)	________	VOLTAGE
SUM	________	(I)	________	CURRENT (INTENSITY)
SMALLER THAN THE SMALLEST	________	(R)	________	RESISTANCE

If you remember them in this order, it's much easier.

If you really understand these characteristics, there are several problems in frame 15 that will help you see how true those characteristics are. It will show you how far you have come in the field of electricity and electronics too!

You should be able to solve all the problems in frame 15 using Ohm's Law.

$E = I \times R$, $I = \frac{E}{R}$, $R = \frac{E}{I}$ and the characteristics of parallel and series circuits.

Characteristics of SERIES CIRCUITS:

SUM: total voltage is the sum in a series circuit.

SAME: total amperage is the same in a series circuit.

SUM: total resistance is the sum in a series circuit.

Characteristics of PARALLEL CIRCUITS:

SAME: total voltage is the same as any voltage in the circuit.

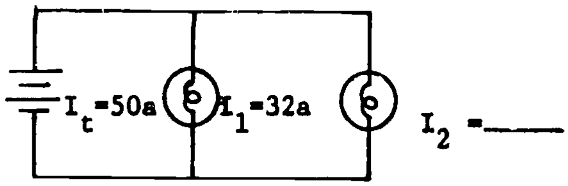
SUM: total amperage is the sum of all the amperages in the circuit.

SMALLER THAN THE SMALLEST: total resistance is less than the smallest resistor.

NO RESPONSE REQUIRED

Solve the following and write the answers in the blanks provided.

1.



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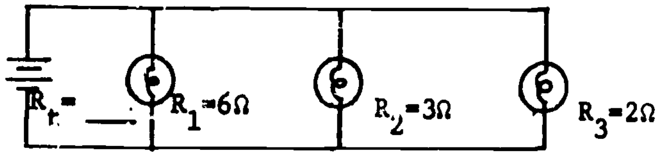

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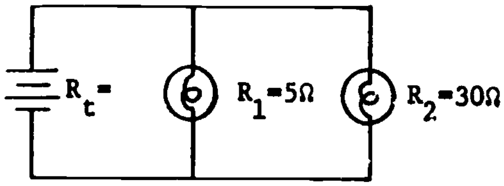

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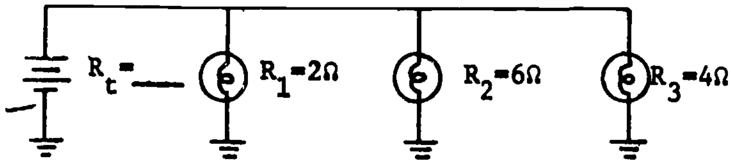

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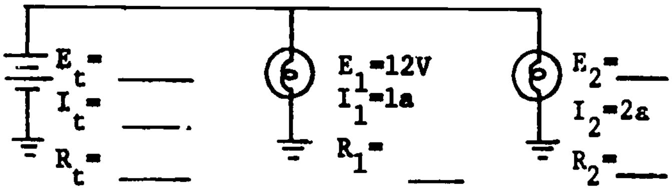

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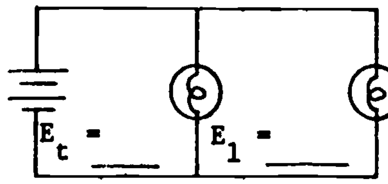

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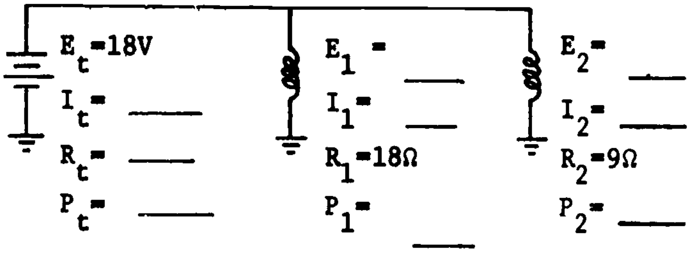

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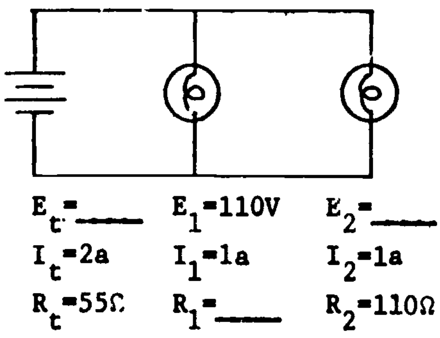

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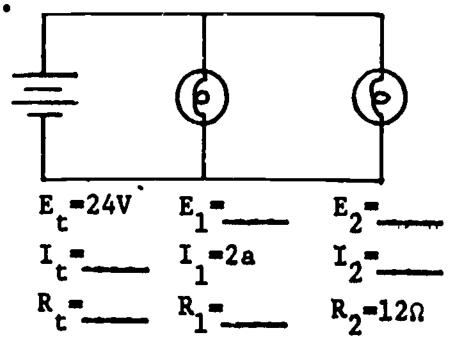

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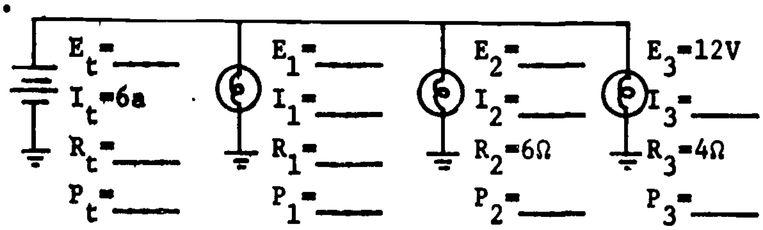
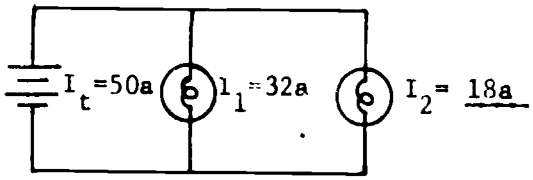
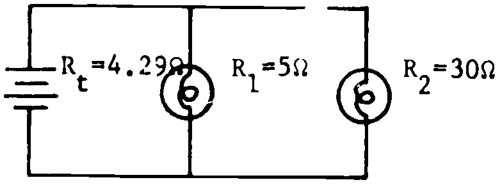


CORRECT RESPONSES FOR PARALLEL CIRCUITS in Frame 15:

1.



2.



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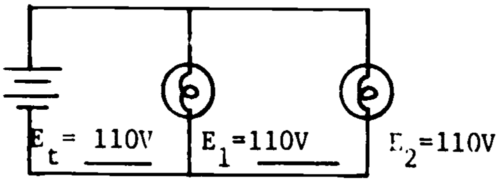

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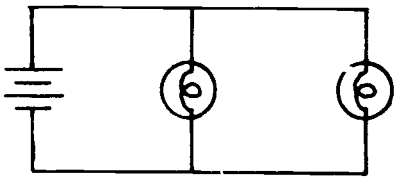
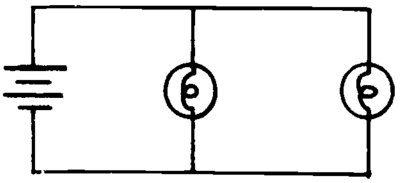


E_t=110V E_1=110V E_2=110V

I_t=2a I_1=1a I_2=1a

R_t=55Ω R_1=110Ω R_2=110Ω

5.

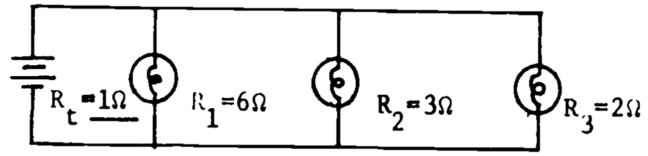


E_t=24V E_1=24V E_2=24V

I_t=4a I_1=2a I_2=2a

R_t=6Ω R_1=12Ω R_2=12Ω

6.



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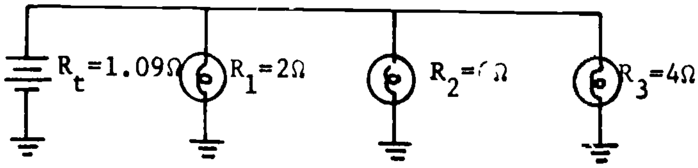

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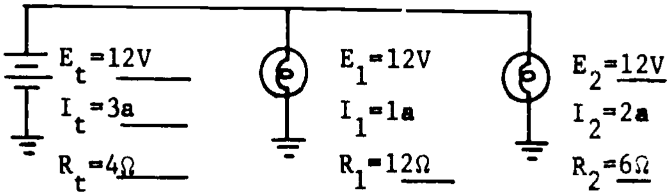

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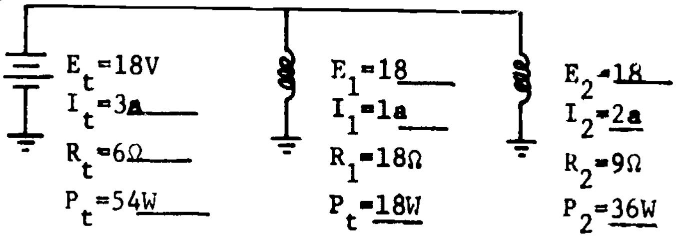
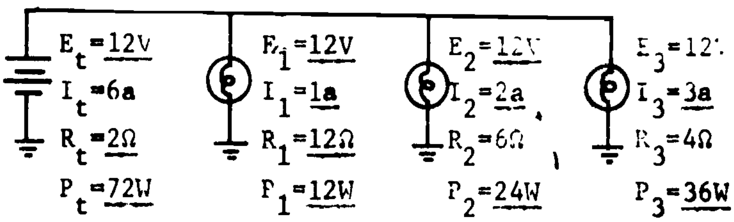
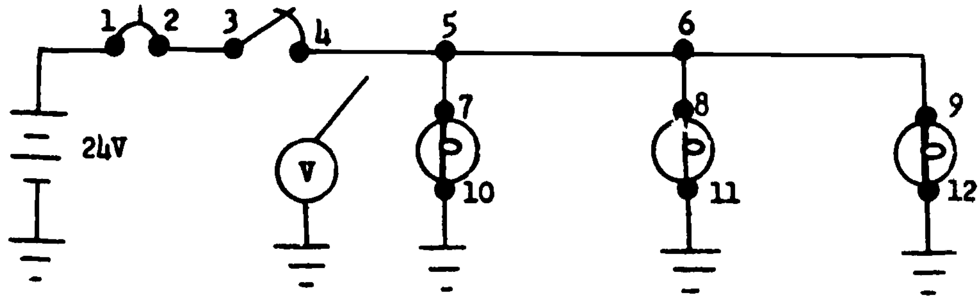


10.



In order to be able to troubleshoot a parallel circuit you must know what readings would indicate a normal circuit. In the circuit shown below, we have the negative lead of the voltmeter connected to ground. The positive lead was left free so it could be moved from one test point to another. What would the voltmeter read when connected to point 1? If you said 24V, you are correct. Let's see why. Trace a path from the negative terminal of the battery through the voltmeter and back to the positive terminal of the battery. The only resistance in this path is the voltmeter. Applying Kirchhoff's voltage law to this path, we have the voltage drop across the voltmeter equal to 24V. Thus, the voltmeter would read 24V. The voltmeter connected at point 2 would also read 24V. Since a circuit breaker is supposed to have practically 0 ohms of resistance, the only resistance in the path from the negative terminal of the battery through the voltmeter and circuit breaker and back to the positive terminal of the battery is the voltmeter. Thus, the voltmeter should read 24V when connected to point 2.



What should the voltmeter read when connected between each of these points and ground. Put your answer on the appropriate blank.

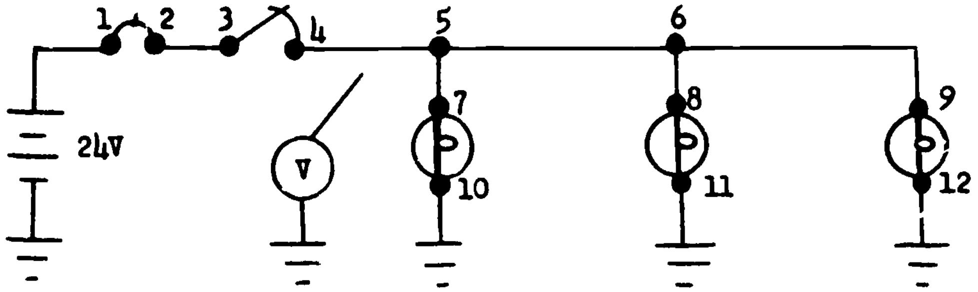
1. Point 3 __________

2. Point 4 __________

3. Point 5 __________

Frame 17

We are still using the same circuit that we used in the last frame. Let's connect the voltmeter to point 6. Trace a path from the negative terminal of the battery through the voltmeter connected at point 6, the switch, the circuit breaker, and back to the positive terminal of the battery. The only unit of resistance in this path is the voltmeter. Applying Kirchhoff's voltage law, we see that the voltmeter should be reading 24V. The voltmeter connected at points 7, 8, and 9 should also read 24V. If you don't see why, trace a complete path that includes the voltmeter and apply Kirchhoff's voltage law.



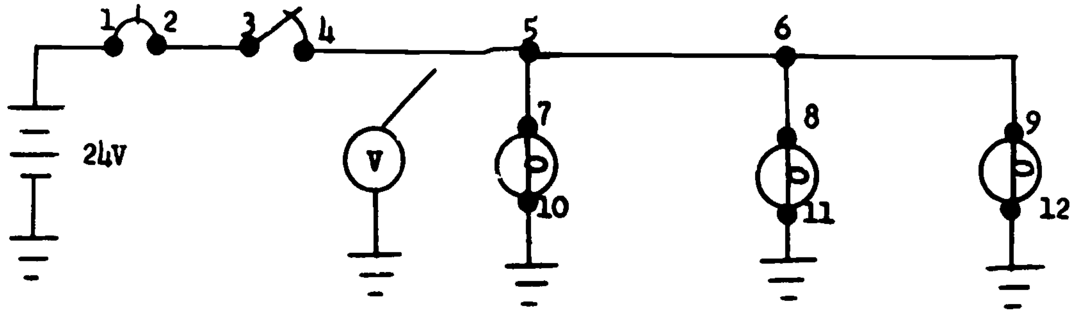
Check the true statements.

_____1. In the circuit above, each lamp has 24V applied to it.

_____2. A voltmeter connected from point 3 to ground should read 24V.

_____3. A voltmeter connected from point 9 to ground should read 0V.

We are still using the same circuit that we used in the last frame. What do you think the voltmeter should read when connected to point 10? If you said 0V, you are correct. Let's see why. The wire between point 10 and ground is providing a zero resistance path for the current to bypass the meter. Thus, all the current goes through the wire. With no current flowing through the meter, we have no needle deflection. The same explanation is true for points 11 and 12.



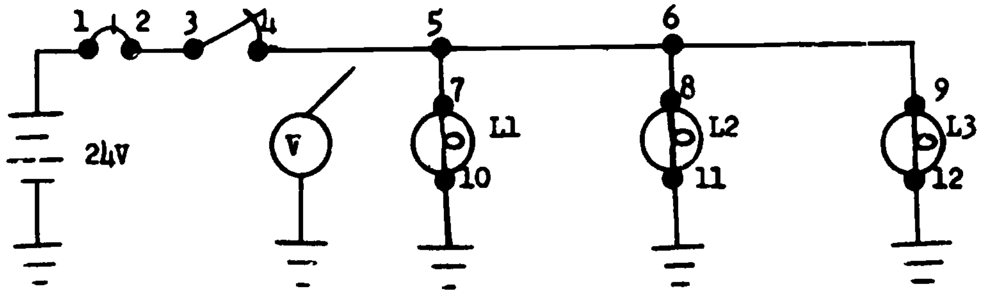
What should the voltmeter read when connected between each of these points and ground. Put your answer on the appropriate blank.

1. Point 2 ________
2. Point 9 ________
3. Point 11 ________
4. Point 8 ________
5. Point 5 ________
6. Point 12 ________

Answers to Frame 16: 1. 24V 2. 24V 3. 24V

Frame 19

An open was defined as an incomplete path for current flow. An open in a series circuit stopped all current flowing in the circuit. However, an open can happen in certain components in a parallel circuit and there can still be current flow in other parts of the circuit. Let's see how. Assume the wire between points 6 and 9 became open. When this happens, lamp L_3 will go out, but lamps L_1 and L_2 will continue burning. The reason lamps L_1 and L_2 continue burning is that there is still a complete path from the negative terminal of the battery through lamps L_1 and L_2 and back to the positive terminal of the battery.



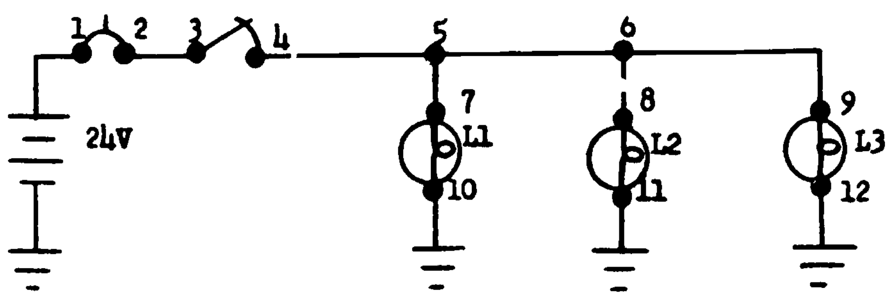
Check the true statements.

_____1. If the wire were cut between points 5 and 6, lamps L_1 and L_2 would continue burning.

_____2. If lamp L_2 burned out, lamps L_1 and L_3 would continue burning.

Answers to Frame 17: __✓__1. __✓__2. _____3.

In the circuit below, lamp L_2 will not light. Let's see what possible components could cause this malfunction. First of all, it can't be anything in the circuit from the battery to point 5. An open in this portion of the circuit would keep all three lamps from operating. What about the wire between points 5 and 6? It would keep both lamps L_2 and L_3 from operating. The wires between points 6 and 9 and between points 12 and ground will only affect lamp L_3. Likewise, the wires between points 5 and 7 and between 10 and ground will affect only lamp L_1. Thus, the only possibilities that would keep only lamp L_2 from operating are an open in the wires between 6 and 8, an open lamp L_2, or an open in the wires between point 11 and ground. Thus, it would be a waste of time and effort to take voltage readings at points 1, 2, 3, 4, 5, 7, 9, 10, and 12 in this situation. Before troubleshooting a circuit, get in the habit of analyzing the situation by listing all possibly faulty components.



For each of the following situations, list all possible faulty components that could cause the given indications. Assume that the battery is good.

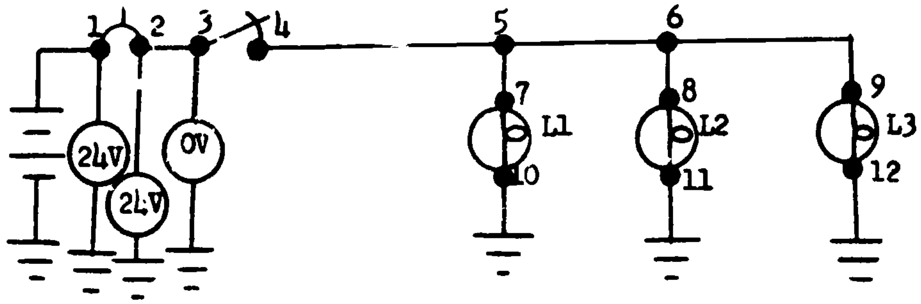
1. L3 is inoperative ______________________.
2. L1 is inoperative ______________________.
3. Lamps L2 and L3 are inoperative ______________.
4. All lamps are inoperative ________________

______________________________________.

Answers to Frame 18: 1. 24V 2. 24V 3. 0V 4. 24V 5. 24V 6. 0V

Frame 21

Let's take a look at the readings in a circuit that has an open in it. In the circuit below all lamps are inoperative. We have given you voltage readings at various points in the circuit. Since all lamps are inoperative, the only points that are necessary to check are 1, 2, 3, 4, and 5. The voltmeter readings at points 1 and 2 indicate that we have a complete path for current up to point 2. The voltmeter should also be reading 24V at point 3. However, the needle is not deflecting any when the meter is connected at this point. This indicates there is an open between points 2 and 3.



Check the true statements.

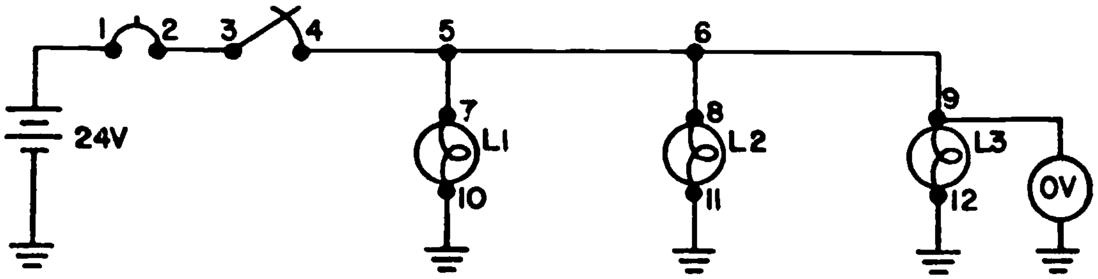
_____1. A voltmeter connected between points 2 and 3 would read 24V.

_____2. A voltmeter connected between points 1 and 2 would read 24V.

_____3. If the readings at points 1, 2, and 3 had all been 24V and the reading at point 4 0V, there would be an open between points 4 and 5.

Answers to Frame 19: _____1. __✓__2.

In the circuit below L_3 is inoperative. Since L_2 is operating, there must be voltage at point 6. Thus the only readings that we need to take in this problem are at points 9 and 12. The voltmeter connected at point 9 should be reading 24V which would indicate that there is a complete path up to point 9. However, the voltmeter connected at point 9 is reading 0V. Thus, there is an open between points 6 and 9.



L_3 is Inoperative.

Check the true statements.

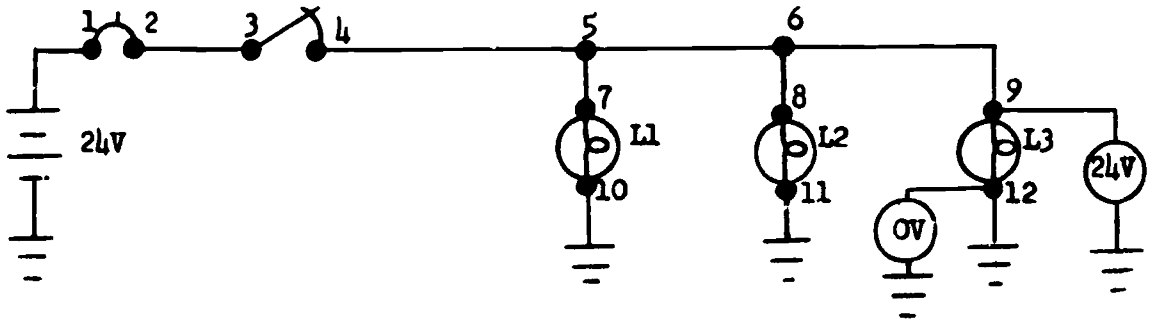
_____1. A voltmeter connected between point 6 and point 9 would read 24V.

_____2. A difference in potential of 24V across a wire in the circuit above would indicate that the wire was open.

Answers to Frame 20:
1. Open between 6 & 9, 9 & 12, or 12 & ground.
2. Open between 5 & 7, 7 & 10, or 10 & ground.
3. Open between 5 and 6.
4. Open between 1 & 2, 2 & 3, 3 & 4, or 4 & 5.

Frame 23

In the circuit below, lamp L_3 is again inoperative. The only readings that we need to take are at points 9 and 12. The voltmeter reading at point 9 of 24V indicates that there is a complete path up to point 9. We also have a normal reading of 0V at point 12. Lamp L_3 has 24V applied to it, but it is not operating. Thus, L_3 must be open.



Check the true statements.

_____1. A voltmeter connected around lamp L_2 would read 24V.

_____2. A voltmeter connected around lamp L_3 would read 24V.

_____3. A voltmeter connected around an open unit of resistance in a parallel circuit will read the same as when it is connected around a good unit of resistance.

Answers to Frame 21: __✓__1. _____2. _____3.

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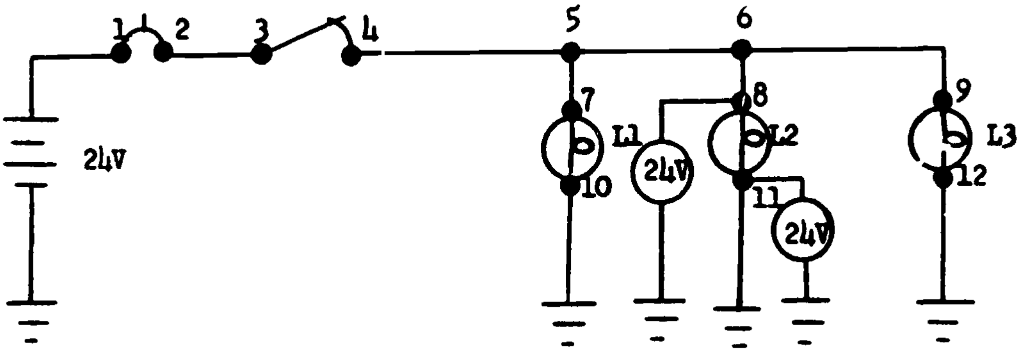
Let's take a look at one more parallel circuit that has an open in it. In the circuit below, lamp L_2 is inoperative. Since lamp L_3 is operating, we must have a complete path to point 6. Thus, the only readings that we need to take are at points 8 and 11. The 24V reading at point 8 indicates that the path is complete up to point 8. What does the 24V at point 11 indicate? If you said an open in the wire between point 11 and ground, you are correct. Let's see why. The 24V reading at point 11 indicates that there is a complete path up to point 11. Since this path is good up to point 11, the open must be between point 11 and ground.



Check the true statements.

_____1. A difference in potential of 24V between points 6 and 8 would indicate that there is an open in this section of wire.

_____2. A voltmeter connected around a wire should read 0V.

Answers to Frame 22: ✓ 1. ✓ 2.

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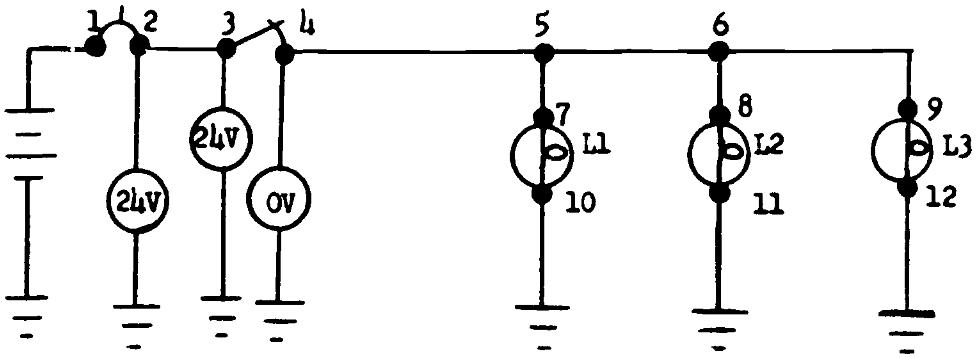
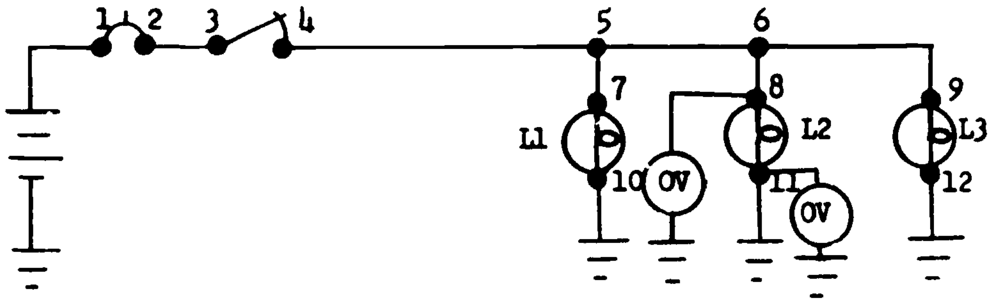
Frame 25

For each of the following problems, analyze the meter readings and the statements of operation of the circuits to determine the faulty component. On the blank provided by each circuit, list the type of trouble and the faulty component. The first one has been done for you.

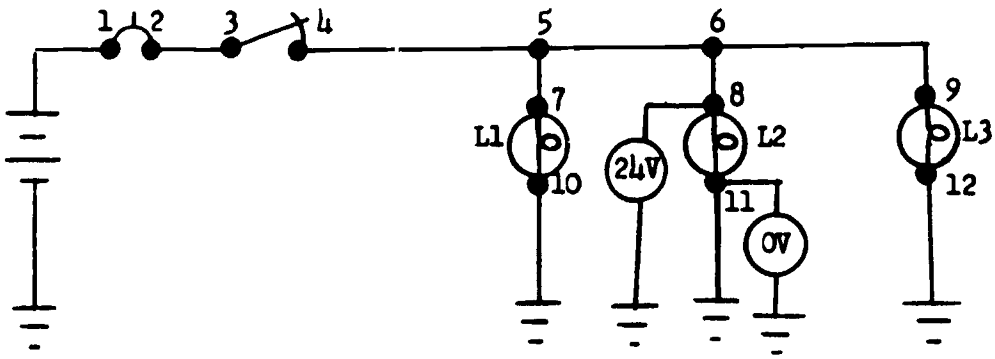
1. (All lamps are inoperative) OPEN Switch



2. (Lamp L2 is inoperative) ____________________



3. (Lamp L2 is inoperative) ____________________



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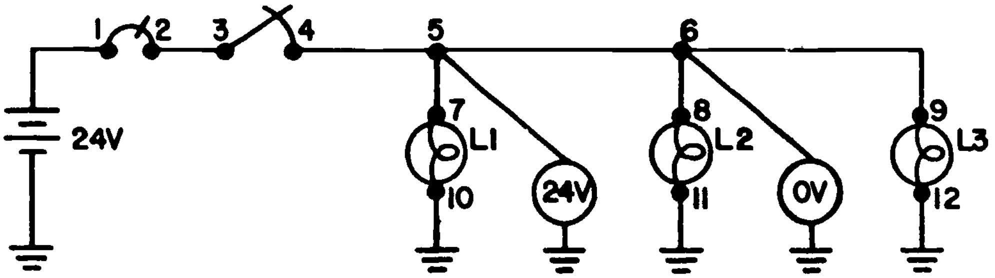
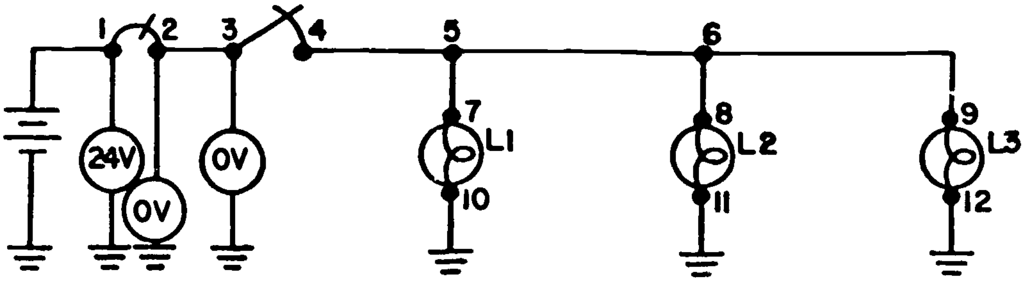
4. (Lamps L2 and L3 are inoperative) ______________________



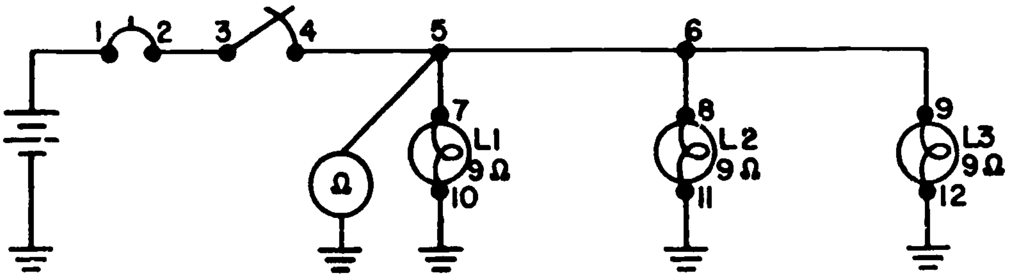
5. (All lamps are inoperative) ______________________



Answers to Frame 23: __✓__ 1. __✓__ 2. __✓__ 3.

Frame 26

An open can also be located with an ohmmeter. Remember, an ohmmeter has its own source of power and should never be used in a live circuit. Before using an ohmmeter for troubleshooting parallel circuits, let's see what readings an ohmmeter would indicate in a normal circuit. An ohmmeter connected at point 5 will read 3 ohms. Do you see why? An ohmmeter connected at point 5 does not only read the resistance of L_1, but will read the net effect of three 9 ohm lamps connected in parallel. Using the like resistor formula, $R_t = R/N = 9/3 = 3$ ohms. Since the lamps are in parallel, the ohmmeter forces current through each of the parallel legs. If you are still in doubt, trace three separate complete paths from one side of the ohmmeter to the other.



Check the true statements.

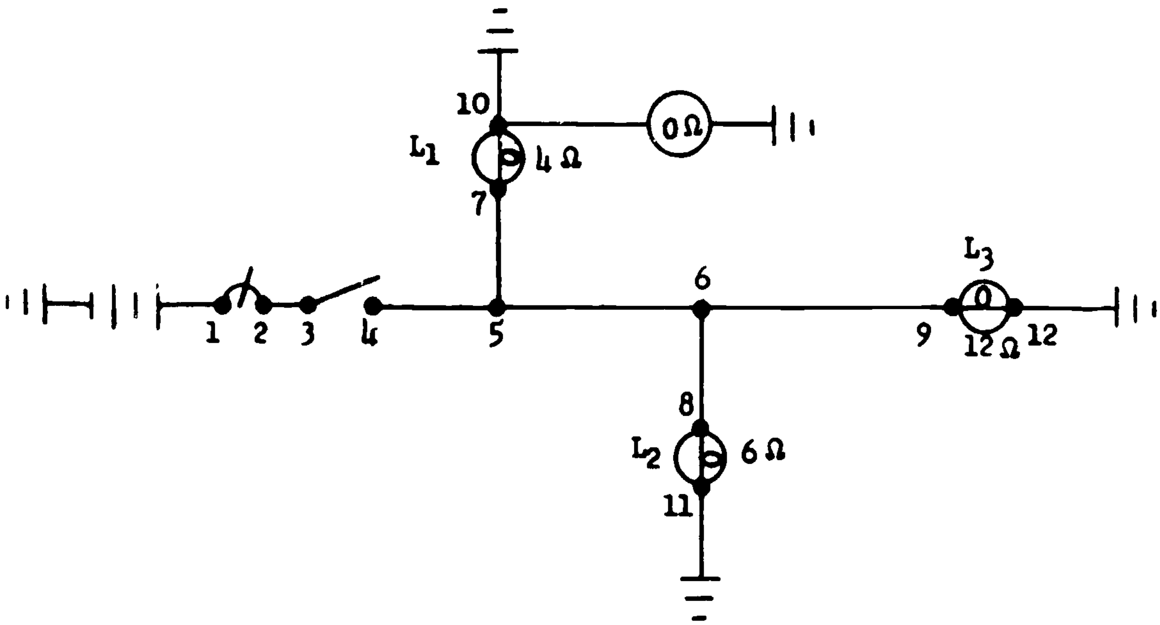
_____1. An ohmmeter connected from point 7 to ground would read 9 ohms.

_____2. An ohmmeter connected from point 9 to ground would read 3 ohms.

_____3. An ohmmeter connected from point 5 to ground would read the total resistance in the circuit.

Answers to Frame 24: __✓__1. __✓__2.

Let's look at the readings in another normal parallel circuit. Since the resistance of a wire is practically 0 ohms, an ohmmeter connected at point 10 should read 0 ohms. The same is true for points 11 and 12. An ohmmeter connected at points 4, 5, 6, 7, 8, or 9 should read the total resistance in the circuit.



What should the ohmmeter read when connected between each of these points and ground? Put your answer on the appropriate blank.

1. Point 9 ________ 4. Point 7 ________

2. Point 10 ________ 5. Point 6 ________

3. Point 12 ________ 6. Point 11 ________

Answers to Frame 25: 1. Open Switch 2. Open between 6 & 8
3. Open L2 4. Open between 5 & 6
5. Open circuit breaker

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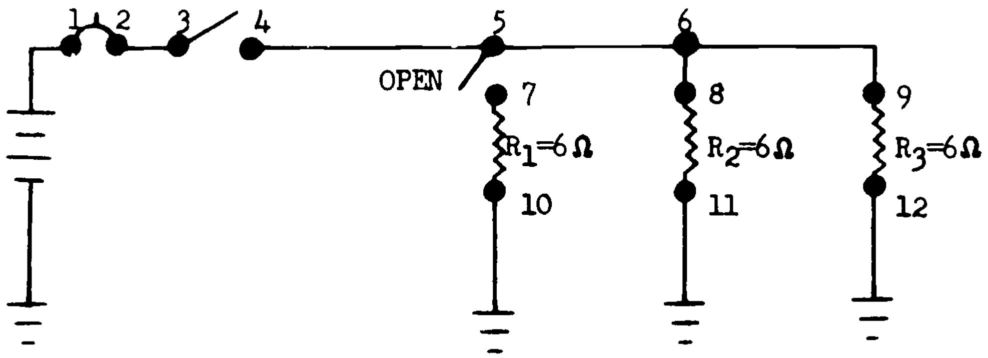
Frame 28

If we had an open in one of the parallel branches as shown in the circuit below, our ohmmeter readings would change. An ohmmeter connected at point 5 would now read 3 ohms. Let's find out why. The ohmmeter would now read through the second and third branch only (6/2 = 3 ohms). If the wire between points 6 and 8 had been open instead of between points 5 and 7, the ohmmeter would still read 3 ohms when connected to point 5. Now it is reading through the first and third branch only. For ease of troubleshooting at this point, we will modify the circuit. We'll discuss this in the next frame.



Check the true statements.

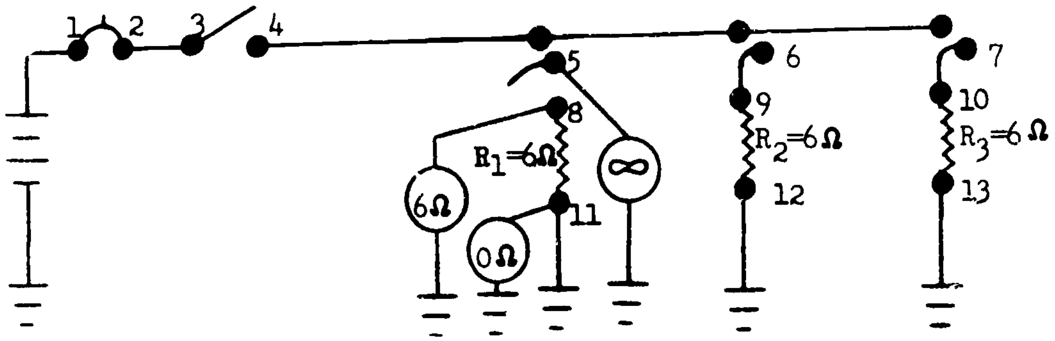
_____1. An ohmmeter reading of 3 ohms at point 6 indicates that R_2 is open.

_____2. An ohmmeter reading of 3 ohms at point 9 indicates that one of the branches is open.

_____3. If the circuit was normal, an ohmmeter connected at point 6 would read 2 ohms.

Answers to Frame 26: _____1. __✓__2. __✓__3.

In order to locate an open in a parallel circuit with an ohmmeter, you will modify the circuit by disconnecting each of the individual branches. This has been done in the circuit below. Let's assume that the wire is broken between points 5 and 8 and that the break cannot be spotted visually. Let's determine from the meter readings which component is open. An ohmmeter reading of 0 ohms at point 11 indicates that the ground wire is good. An ohmmeter reading of 6 ohms at point 8 indicates that R_1 is good. The ohmmeter reading of infinity (∞) at point 5 indicates that the wire between points 5 and 8 has an open in it. Remember an infinity (∞) reading indicates that no current is flowing through the meter movement. No current flow means an incomplete path for current flow which is an open.



Check the true statements.

_____1. An infinity reading at point 11 indicates that R_1 is open.

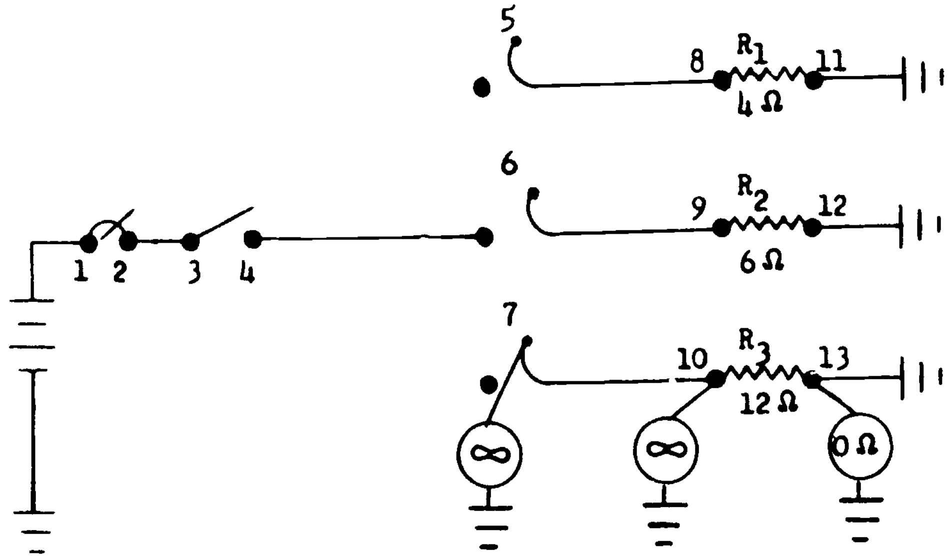
_____2. An infinity reading at point 12 indicates that the ground wire is open.

Answers to Frame 27: 1. <u>2 ohms</u> 2. <u>0 ohms</u> 3. <u>0 ohms</u>

4. <u>2 ohms</u> 5. <u>2 ohms</u> 6. <u>0 ohms</u>

Frame 30

Let's take a look at another parallel circuit with an open in it. We have disconnected the branch circuits in the circuit below. The reading of 0 ohms at point 13 indicates that the ground wire for R_3 is good. What does the infinity (∞) reading at point 10 indicate? If you said R_3 is open, you are correct. The reading at point 10 should be the resistance of R_3 which is 12 ohms. An infinity reading at point 10 indicates that there is not a complete path between point 10 and ground. Since the path was complete up to point 13, the open must be between points 10 and 13. An ohmmeter at point 7 is measuring the total resistance between point 7 and ground. Since there is an open between points 10 and 13, an ohmmeter at point 7 will also indicate ∞.



Check the true statements.

_____1. An ohmmeter connected between points 6 and ground should read 12 ohms.

_____2. An ohmmeter reading of ∞ at point 11 indicates that R_1 is open.

Answers to Frame 28: _____1. __✓__2. __✓__3.

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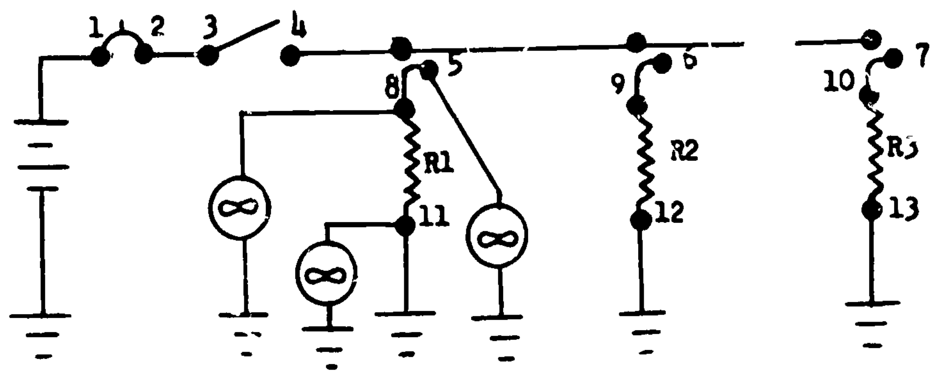
In the circuit below, we have given you ohmmeter readings at several points in the circuit. The infinity reading at point 11 indicates that the wire between point 11 and ground is open. Since the ground wire is open, the ohmmeter needle will not be able to deflect when the ohmmeter is connected at point 8 or at point 5. Thus, from the readings given you can't determine the condition of R_1 or the wire between points 5 and 8. For instance, in order to determine the condition of R_1 you would have to connect the ohmmeter between points 8 and 11. From this reading you could determine the condition of R_1.



Check the true statements.

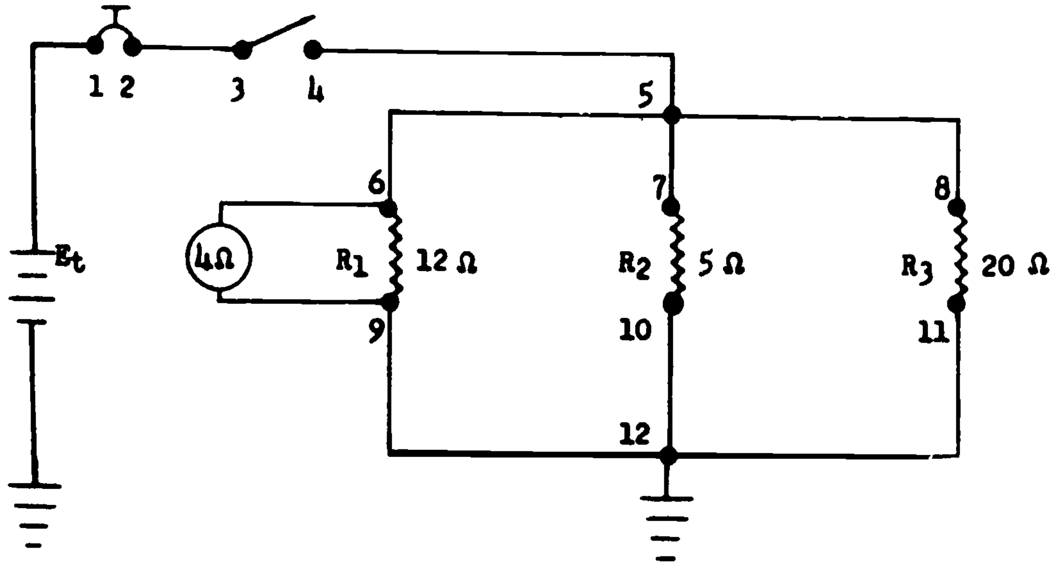
_____1. An ohmmeter reading of ∞ between points 9 and 12 indicates that R_2 is open.

_____2. An ohmmeter reading of ∞ ohms between point 13 and ground indicates that the ground wire is open.

Answers to Frame 29: _____1. __✓__2.

Frame 32

At times you may find it impractical or inconvenient to isolate completely the parallel branches of a circuit from each other. With a few ohmmeter readings this possible disadvantage may be overcome when troubleshooting opens. Let's look at the circuit below.



As we saw in frame 45, connecting an ohmmeter across the parallel circuit as shown, we should read the total parallel equivalent resistance. In this circuit the meter should be indicating 3 ohms because the parallel branches are not isolated from each other. The ohmmeter is indicating a total equivalent resistance of 4 ohms instead. What could be the malfunction? What is happening is that of the three normal paths that our ohmmeter current has for returning to its power source only two are complete. The current path through R_1 is not complete. We can prove this by computing the equivalent parallel resistance of R_2 and R_3 which is 4 ohms and the amount of resistance our ohmmeter is reading. R_1 must be open.

Check the true statements.

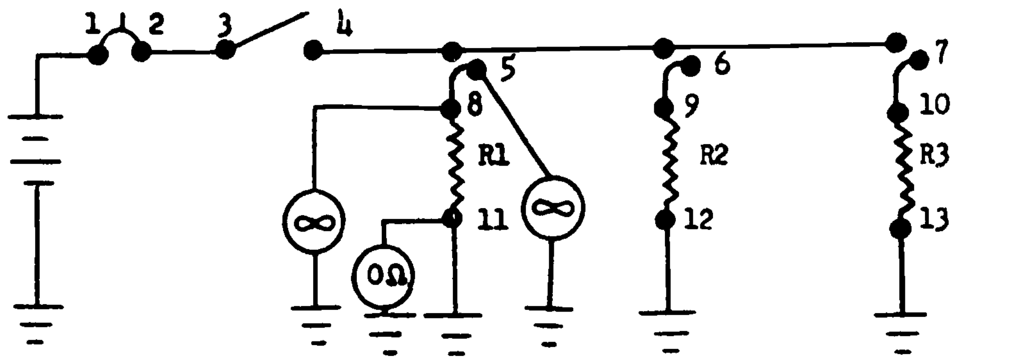
_____1. If the meter had indicated 3.5 ohms, the open would have been between points 5 and 8, 8 and 11, or 11 and 12.

_____2. If the meter were connected to points 8 and 11 and indicated 3 ohms, the trouble would be an open R_3.

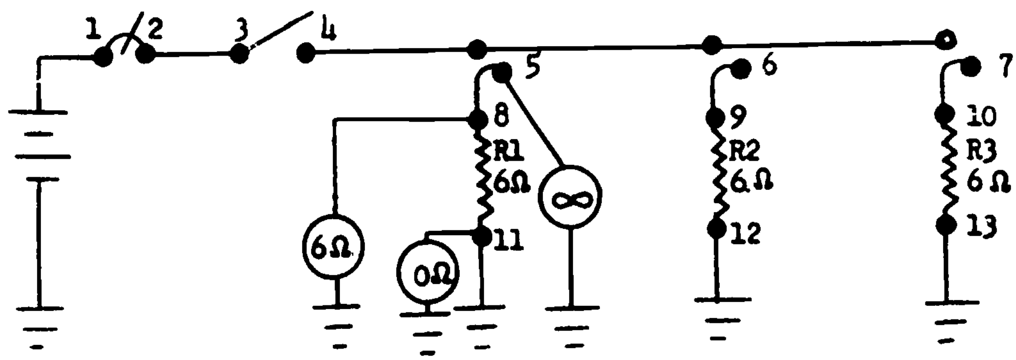
Answers to Frame 30: _____1. _____2.

Analyze the meter readings in each of the following circuits. On the blank provided by each circuit, list the type of trouble and the faulty component. The first one has been done for you.

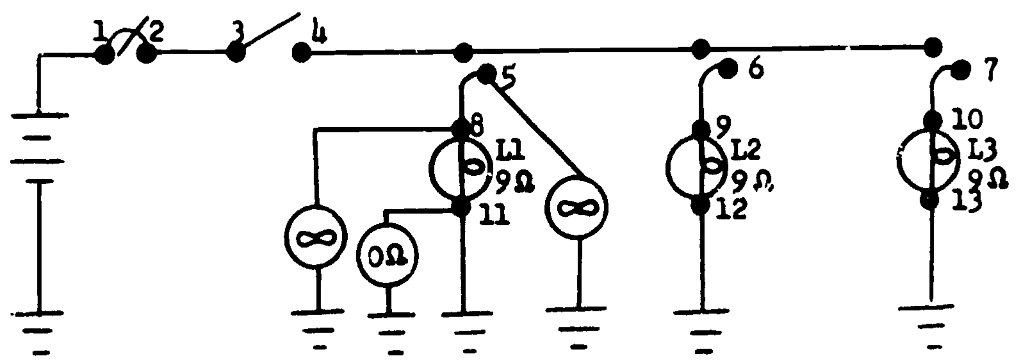
1. OPEN R1



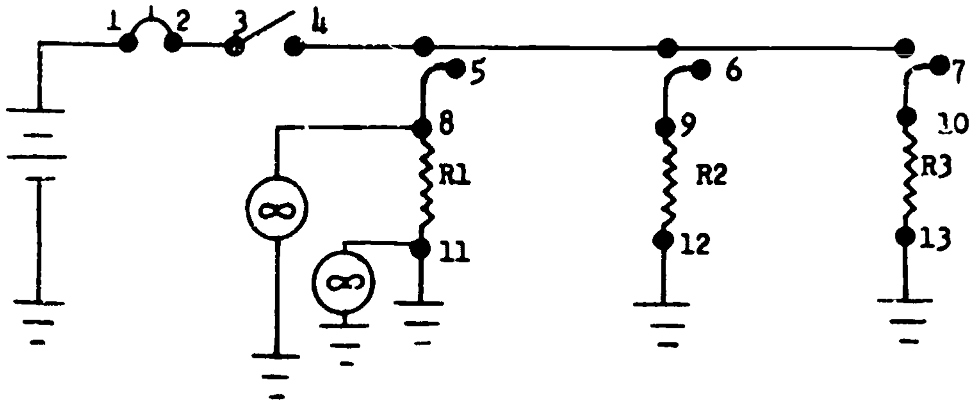
2. ______________________________



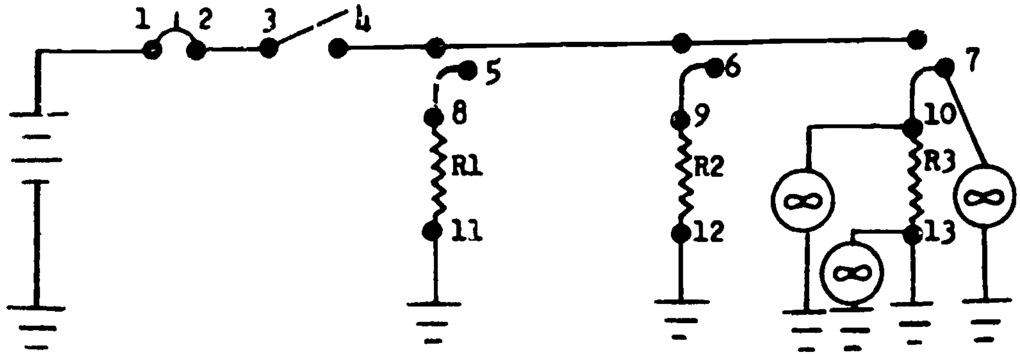
3. ______________________________



4. ____________________



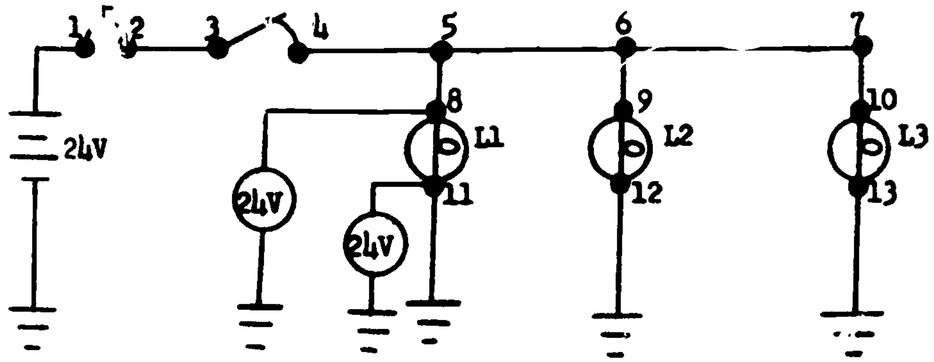
5. ____________________



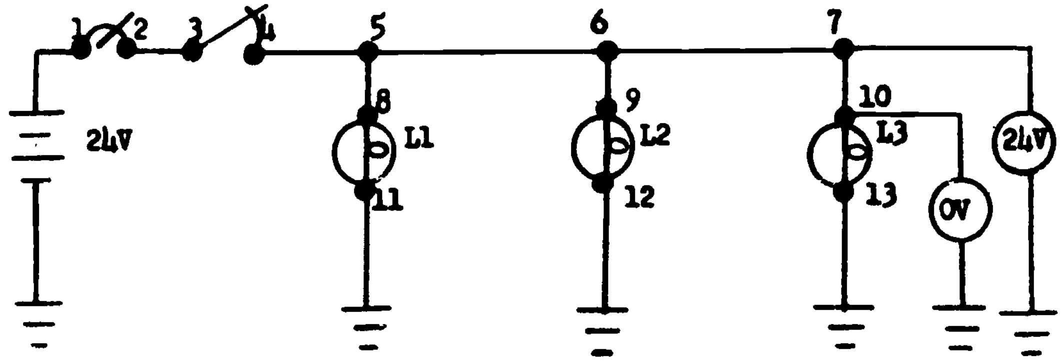
Answers to Frame 31: ✓ 1. ✓ 2.

Analyze the meter readings and circuit indications in each of the following circuits. On the blank provided by each circuit, list the type of trouble and the faulty component.

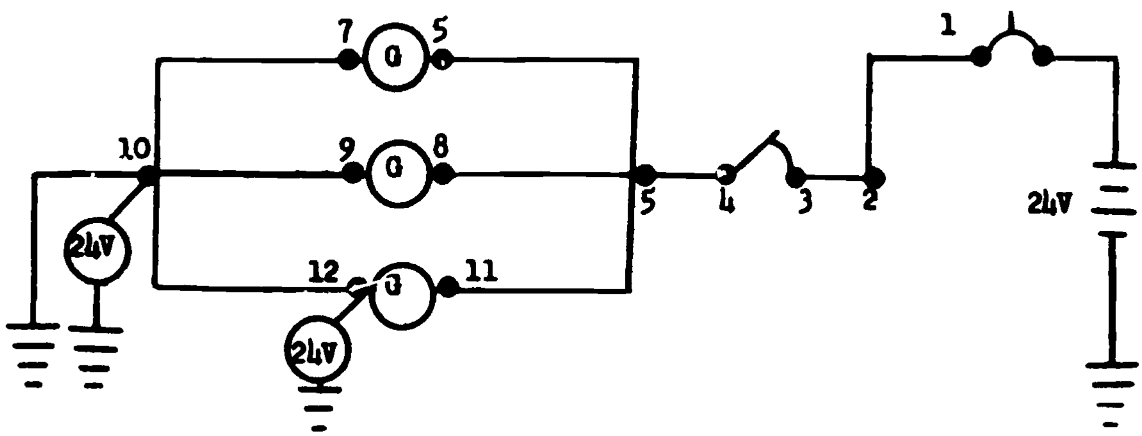
1. (Lamp L1 is inoperative.) ______________________



2. (Lamp L3 is inoperative.) ______________________

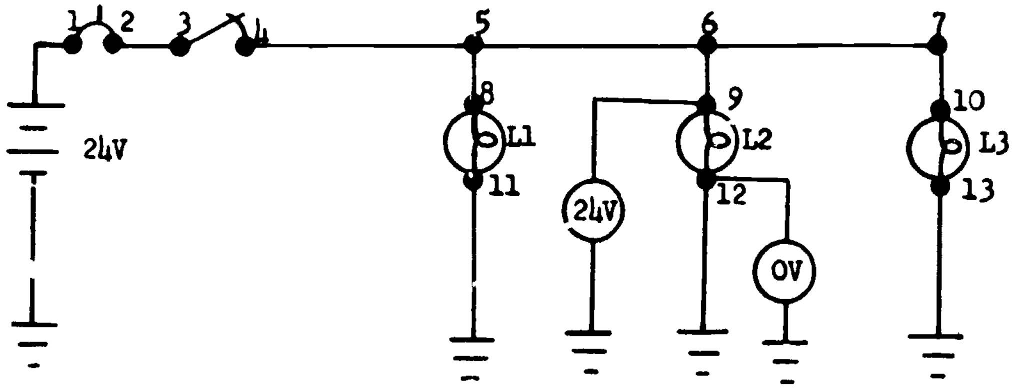


3. (All lamps are inoperative.) ______________________

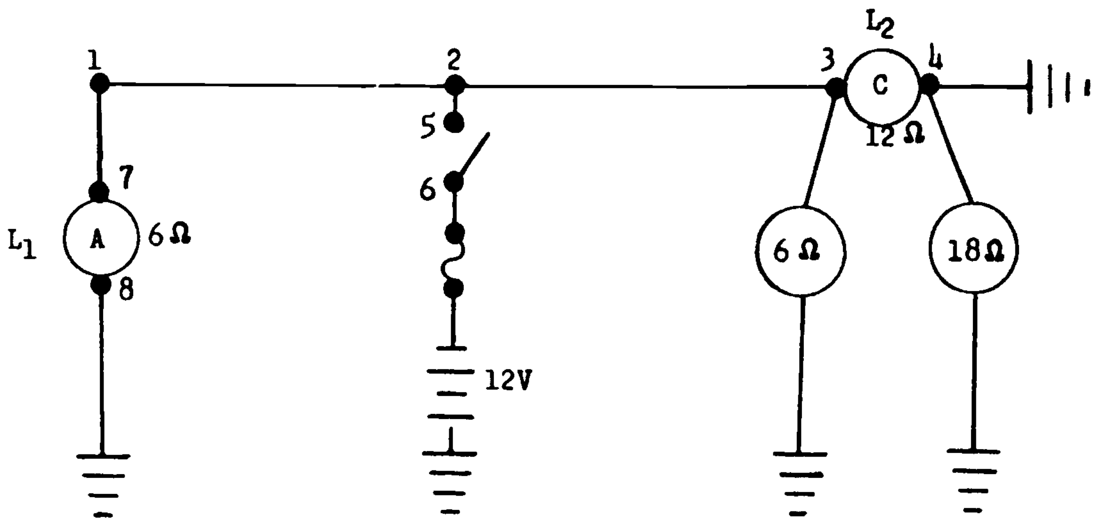


Frame 34 (Cont'd)

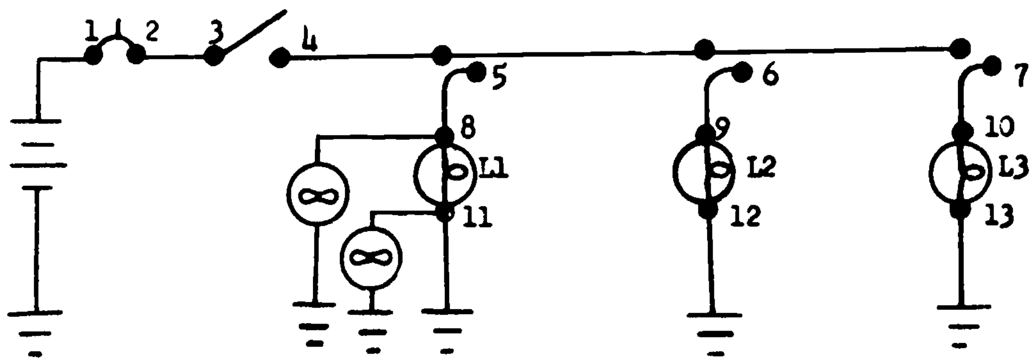
4. (Lamp L2 is inoperative.) ______________________



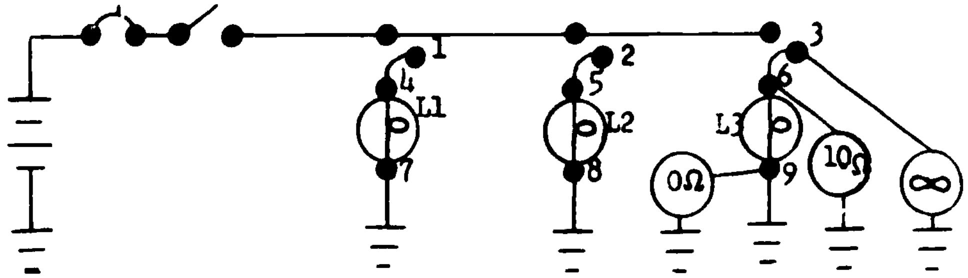
5. (Lamp L2 is inoperative.) ______________________



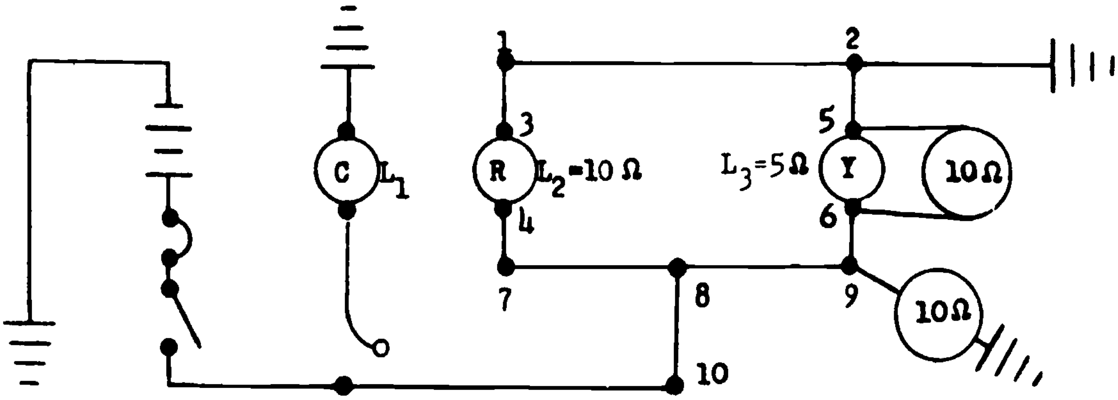
6. (Lamp L1 is inoperative.) ______________________



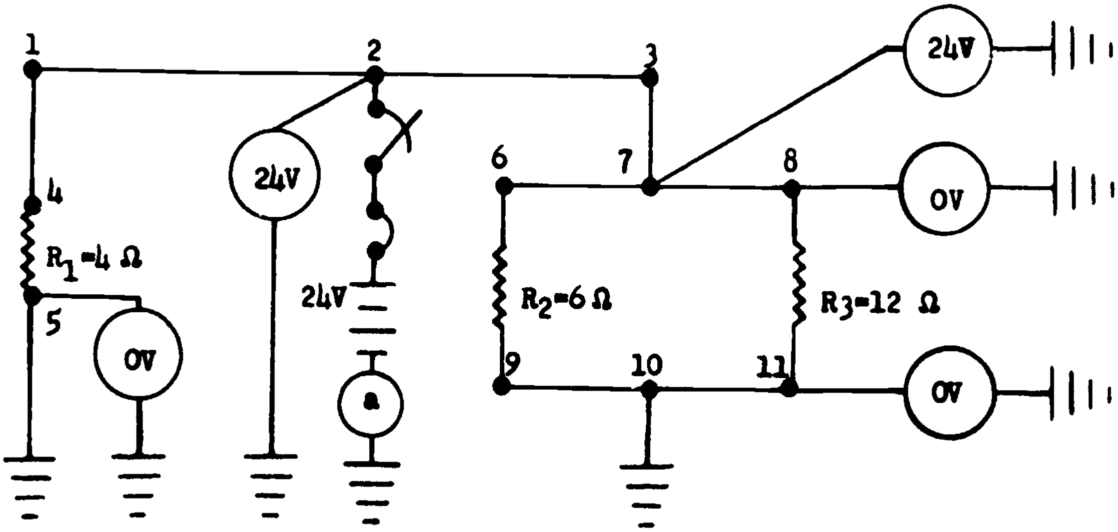
7. (Lamp L3 is inoperative.) ________________



8. (Lamp L3 is inoperative.) ________________



9. (When the switch is ON, the ammeter reads 10a.) ________



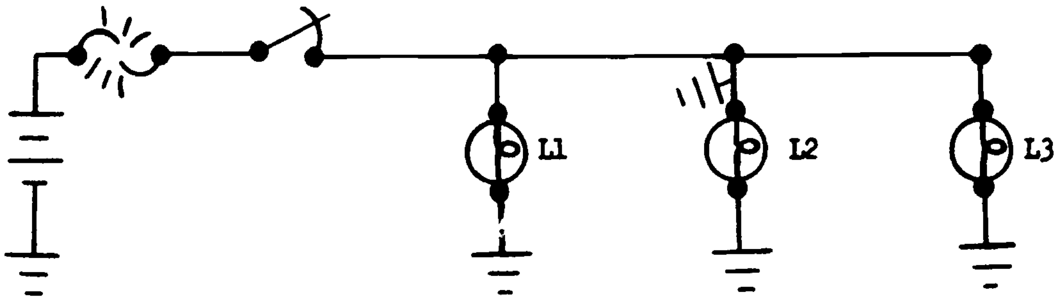
Have the instructor check your answers.

Instructor's Initials ________

Answers to Frame 32: __✓__ 1. ______ 2.

Frame 35

If we have a short in a parallel circuit, we will probably never get a chance to troubleshoot with a voltmeter. Let's see why! In the circuit below, the insulation on the posi ive lead to L_2 became worn off and the bare wire touched the aircraft frame. A direct short results. The current would become excessive causing the fuse to blow. With the fuse blown, the circuit would be open. With no power in the circuit, you could not use the voltmeter to troubleshoot. However, by making a few circuit modifications we can use an ohmmeter.



Check the true statements.

_____1. The fuse would also have blown if L_3 had become shorted.

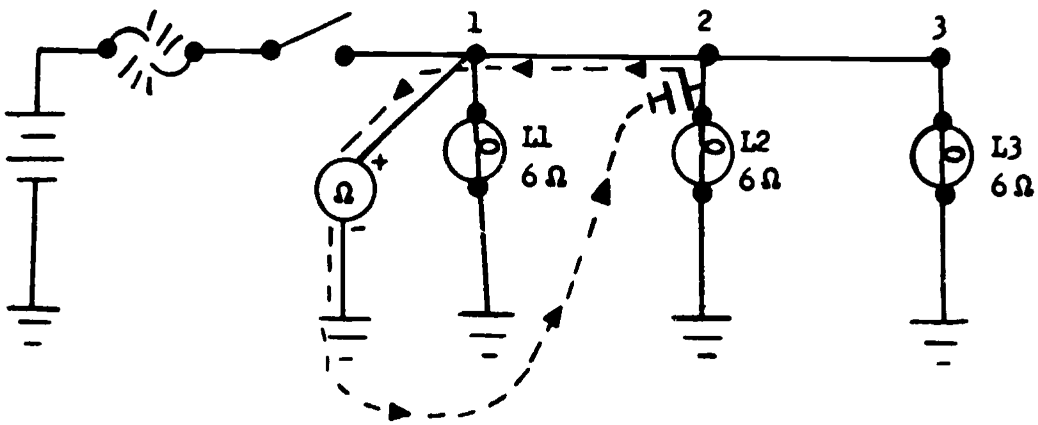
_____2. We could use a voltmeter to find the faulty component in the circuit above.

Answers to Frame 33: 1. Open R_1 2. Open between 5 and 8

3. Open L_1 4. Open between 11 and ground

5. Open between 13 and ground

We are using the same circuit that we used in the last frame. An ohmmeter connected at point 1 would read 0 ohms. To see this trace a path from the negative terminal of the ohmmeter through the wire that is connected to point 2 and back to the positive terminal of the ohmmeter. In this path, there are only conductors which have practically 0 ohms of resistance. Thus, the ohmmeter would read 0 ohms. The ohmmeter would also read 0 ohms when connected at point 2 and at point 3. Thus, to locate the trouble, we will need to isolate the circuit, or disconnect the units at points 1, 2, and 3 and then check across the units.



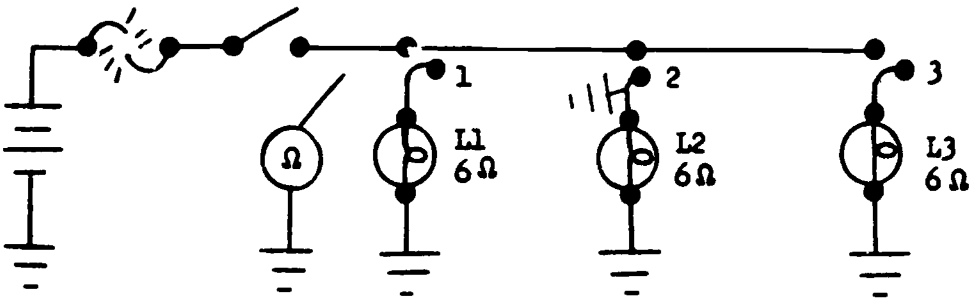
Check the true statements.

_____1. If the circuit above was functioning normally, the total resistance would be 18 ohms.

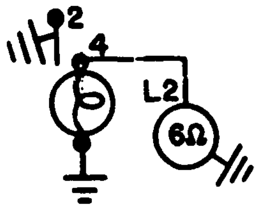
_____2. An ohmmeter connected between points 2 and 3 would read 0 ohms.

Frame 37

Let's isolate the circuit by disconnecting the branch circuits at points 1, 2, and 3. On the aircraft only one branch circuit is disconnected at a time. An ohmmeter at point 1 and point 3 would read 6 ohms. This indicates that these two branches are good. An ohmmeter at point 2 would read 0 ohms. This indicates that there is a short from point 2 to ground.



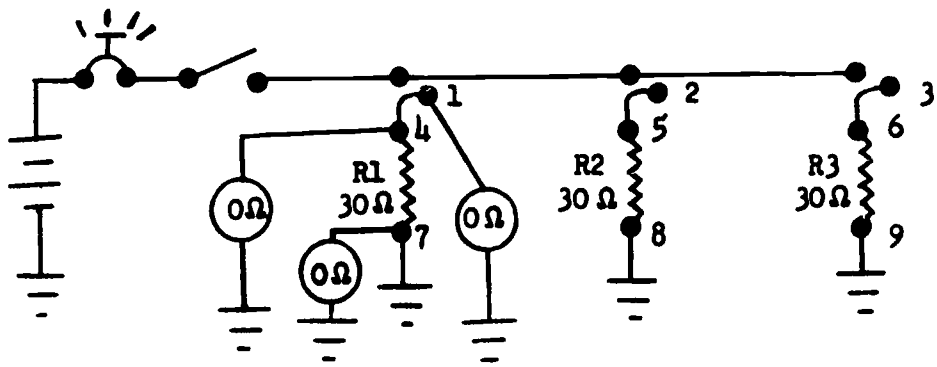
Now we need to determine the location of the short. To do this we will isolate the lamp. This is shown below. An ohmmeter reading of 6 ohms at point 4 would indicate that the lamp is good. A 0 ohm reading at point 2 would indicate that the wire at point 2 is shorted to ground.



No further response is required; proceed to the next frame.

Answers to Frame 35: __✓__1. _____2.

Now let's look at another circuit that has a short in it. The 0 ohm reading at point 7 indicates that the ground wire is good. What does the 0 ohm reading at point 4 indicate? If you said a short in R_1, you are correct. The reading at point 4 should be 30 ohms. Since the ohmmeter is reading 0 ohms at point 4, this indicates that R_1 is being bypassed by a zero resistance path. In other words, R_1 is shorted.



Check the true statements.

_____1. An ohmmeter at point 6 should read 30 ohms.

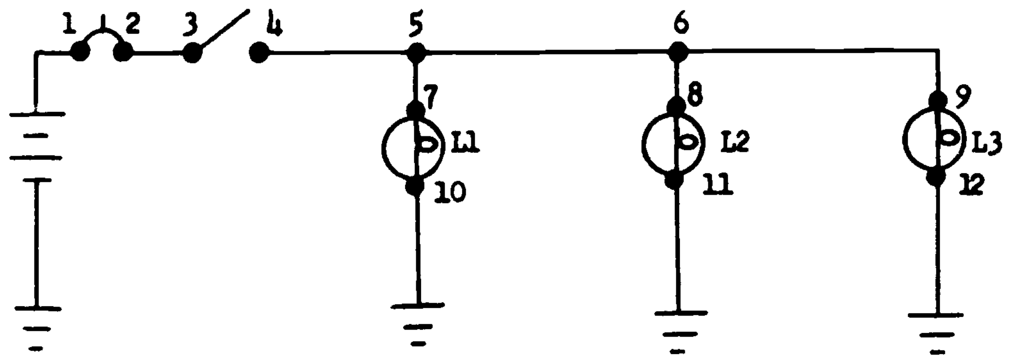
_____2. An ohmmeter at point 9 should read 30 ohms.

_____3. An ohmmeter reading of 0 ohms at point 5 indicates that R_2 is shorted.

Answers to Frame 36: _____1. __✓__2.

Frame 39

Let's discuss two possible shorts in the circuit below. Assume L_1 became shorted. Would lamps L_2 and L_3 continue burning? If you said no, you are correct. In a parallel circuit, the total resistance is always smaller in value than the resistance of any of the branches. Since L_1 is shorted, the resistance of the first branch is practically 0 ohms. Thus, R_t is practially 0 ohms and as a result the current would immediately become excessive causing the circuit breaker to pop. When the circuit breaker pops, all the lamps would go out. Now let's assume the lamps cannot be turned off. What could cause this indication? The only possibility would be a short between points 3 and 4. Therefore, even with the switch turned off, there is a complete path for the current flow through the circuit. Thus, the lamps burn when the switch is in the "OFF" position.



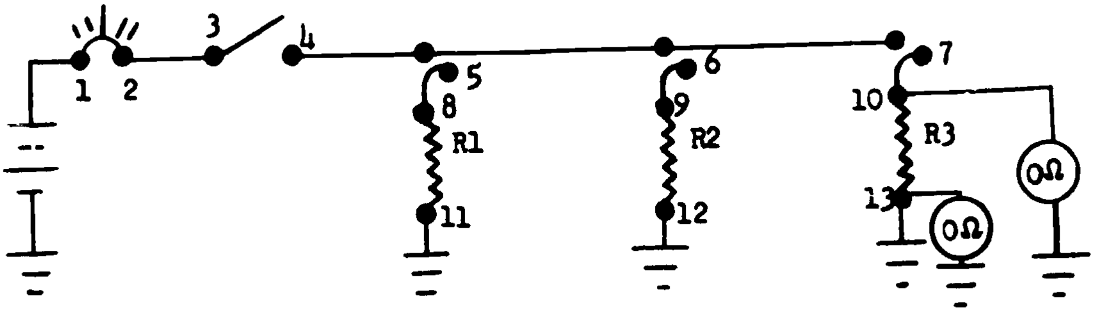
Check the true statements.

_____1. If L_2 became shorted, lamps L_1 and L_3 would continue burning.

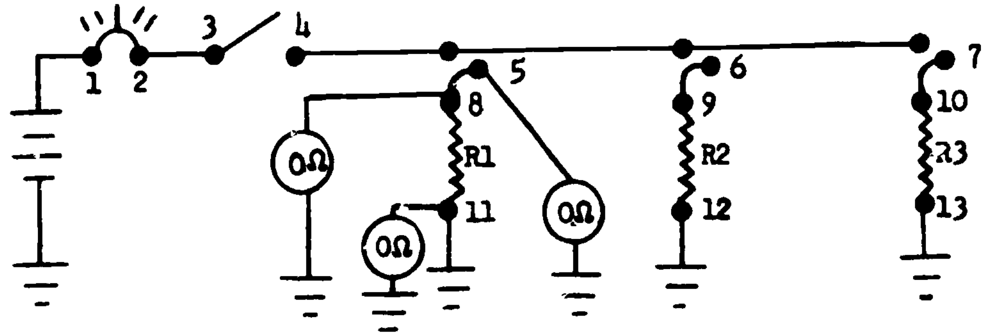
_____2. All lamps should be lit when the switch is closed.

Analyze the meter readings in each of the following circuits. On the blank provided by each circuit list the type of trouble and the faulty component.

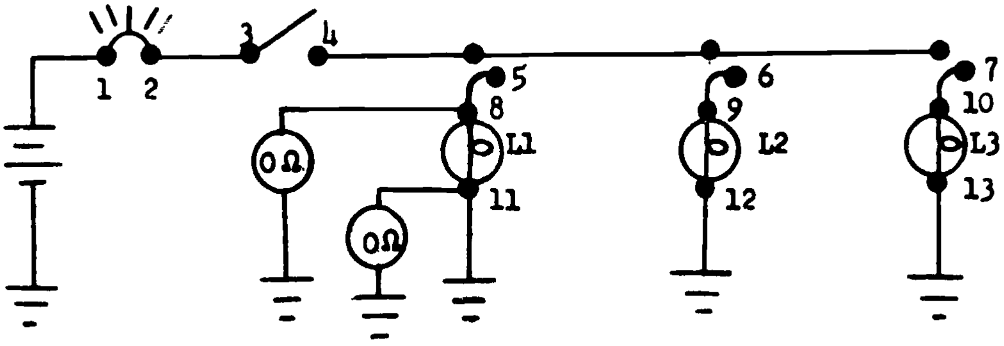
1. ____



2. ____



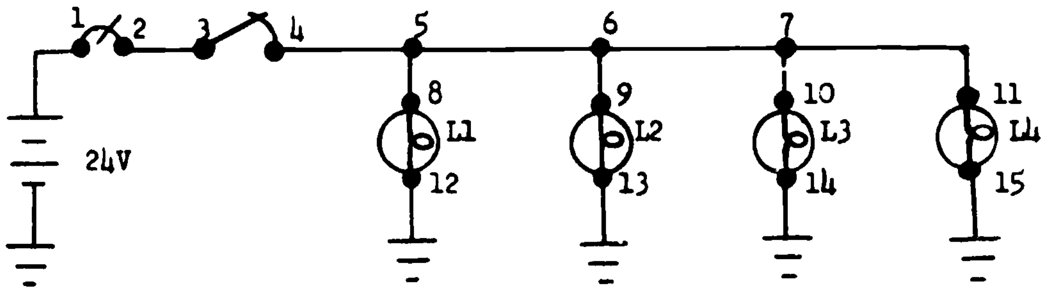
3. ____



Answers to Frame 38: _✓_ 1. ____ 2. _✓_ 3.

Frame 41

Using the circuit below, analyze the meter readings in each of the following problems. On the blank provided by each problem list the type of trouble and the faulty component.



1. All lamps are inoperative. A voltmeter connected from point 2 to ground reads 24V, 3 to ground 0V, and 4 to ground 0V.

____

2. Lamp L_3 is inoperative. A voltmeter connected from point 10 to ground reads 24V and 14 to ground 0V.

____

3. Lamps L_2, L_3, and L_4 are inoperative. A voltmeter connected from point 6 to ground reads 0V.

____

4. Lamp L_4 is inoperative. A voltmeter connected from point 11 to ground reads 24V and 15 to ground reads 24V.

____

5. Lamps cannot be turned off.

____

6. Lamp L_2 is inoperative. A voltmeter connected from point 9 to ground reads 0V.

____

Answers to Frame 39: _____1. __✓__2.

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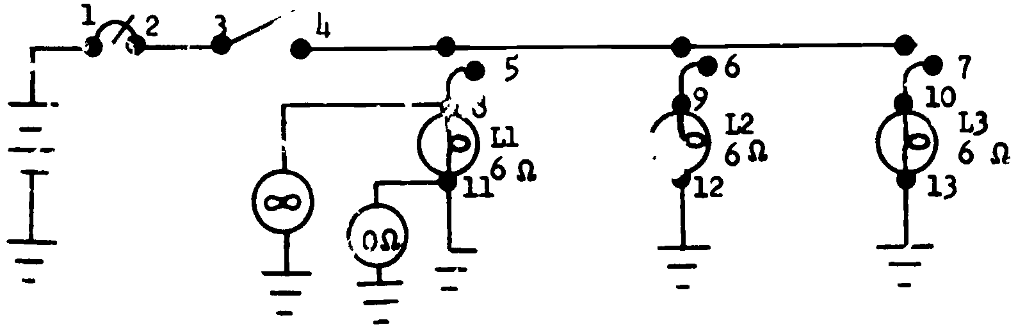
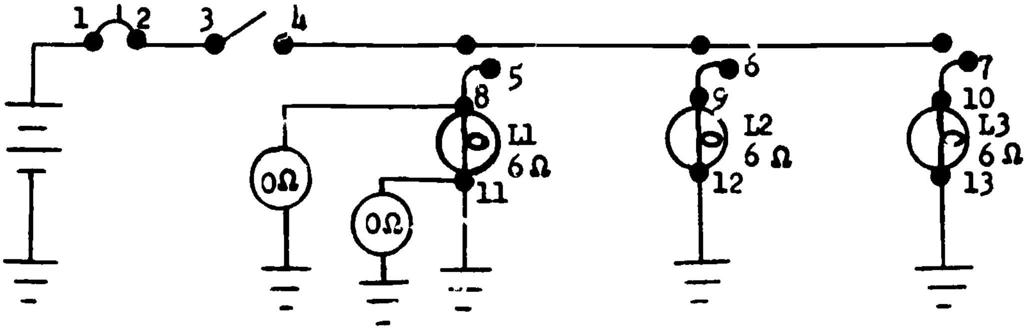
Analyze the ohmmeter readings in each of the following circuits. On the blank provided by each circuit, list the type of trouble and the faulty component. We are not showing the circuit breaker open even though there might be a short in the circuit.

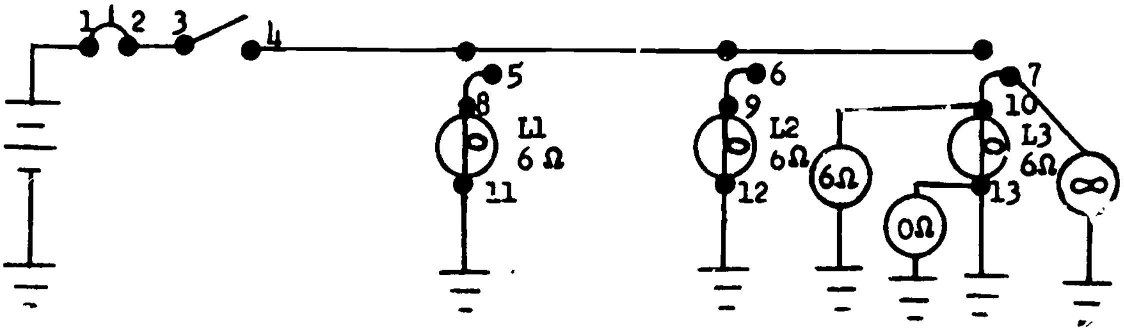
1. ______________________________



2. ______________________________

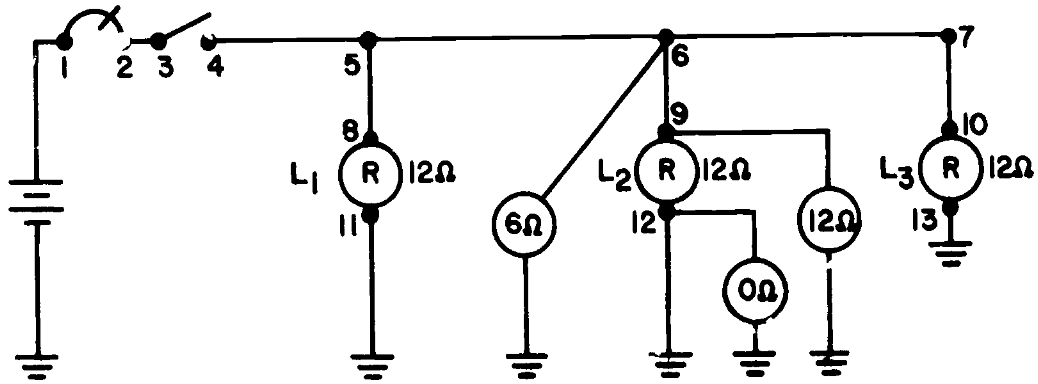


3. ______________________________

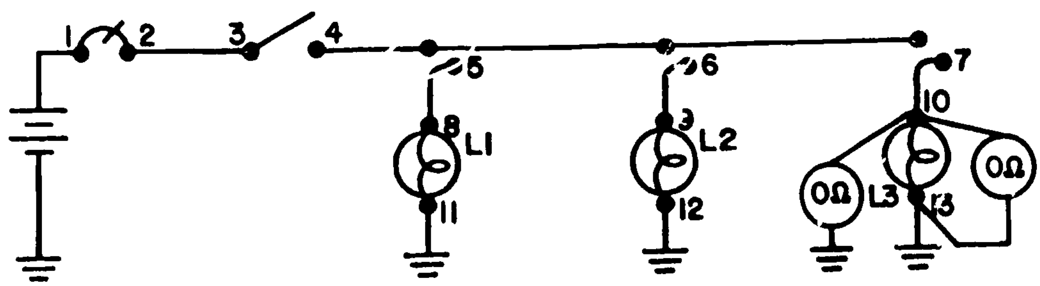


Frame 42 (Cont'd)

4. ____



5. ____



Answers to Frame 40: 1. Short R3 2. Short R1 3. Short L1

BASIC ENVIRONMENTAL SYSTEM TROUBLESHOOTING

Since all circuits are either series, parallel, or a combination of the two, it is important that you have a good understanding of them. By this time, you should be well equipped in this area. You should now be ready to apply some of this knowledge to help solve some basic problems in an environmetnal system.

Frame 43

The environmental systems mechanic needs more than just a toolkit to fix a malfunction. The most important thing in repair work is knowing what to repair. There are many aids in troubleshooting that take the guesswork out of the job. It costs time and money to change a part just to see if that will fix your problem.

Some common aids which every mechanic should learn to depend on are:

Tech Orders - These books tell you how the system should work.

Multimeters - These are one of the most useful tools in troubleshooting. The multimeter, when used correctly, will tell you if you are getting proper voltage to a unit and it can be used to detect open and shorted circuits.

Wiring Diagrams - While in school you will see many wiring diagrams. They break the system down and show you the path of current flow through the circuits. Use these like you would a road map to go across an unfamiliar city.

Working Schematics - Just as a machinist needs a blueprint to build a part, you need a schematic or working drawing of a system to see how it works.

Pressure Gauges - Tell you a lot about system workings and will sometimes put you on the correct trail to locate the malfunction.

Temp Gauges - These are used by the flight crew to decide whether to shut the system down or keep on flying.

Complete the following:

1. _______________ _______________ serve as a blueprint when trying to figure how a system works.

2. A _______________ is a measuring tool used to check proper voltage and detect open and shorts.

3. _______________ _______________ are drawings that show current paths through a circuit.

4. _______________ _______________ are books that contain step-by-step procedures telling how a system should work.

Answers to Frame 41: 1. Open 2-3 2. Open L3 3. Open 5-6 4. Open 15-ground 5. Short switch 6. Open 6-9

Frame 44

One of the first things you need to know (ask yourself) about troubleshooting is whether a problem actually exists. You must be familiar with the operation of a system to know what should work and when. By performing an operational check on the system you can see which part of the system is working and the parts that aren't. Sometimes the only problem is that the switch is not turned on. You should also check for the switch being in the proper position. Check all circuit breakers and fuses to see if an overload has occurred. The increased current flow from an overload (short) will blow the fuse or pop the circuit breaker.

Complete the following:

1. Use _______________ checks to determine if a system is working properly.

2. A _______________ causes fuses to blow and circuit breakers to pop.

Answers to Frame 42: 1. Open L1 2. Short L1 3. Open 7-10
4. Open 6-9 5. Short L3

In troubleshooting you will learn to recognize certain symptoms as being associated with specific components or system malfunctions. Here's an example: If the pilot places a demand for full cold air from the aircraft air conditioning system and receives full hot air, you know you have a system malfunction. Now you must use your past experience, job knowledge and technical data to solve this problem.

Let's look at some of the common problems associated with this malfunction:

1. The temperature control valve will not run to either the hot or cold position. Always look for the obvious first. Ask yourself these questions: Are the control switches for the system in the proper position? Has a circuit breaker been popped or pulled? This kind of logical thinking will save you many hours out on the flight line.

2. The temperature control valve will only run in one direction (HOT). The logical conclusion is that power has been interrupted to the cold side of the valve. Your first step would be to check the continuity of the cold circuit.

3. The temperature control valve runs backwards. This is more than likely a wiring problem. Using your multimeter, you would check to make sure that there are no crossed wires at either the valve control switch or the valve itself.

4. Many times you have a system that is operating properly in the manual mode of operation yet is malfunctioning in the automatic mode. In such cases a good wiring diagram and common sense will help you solve this problem. If the malfunction is in automatic only, you will naturally check only those circuits associated with automatic operation.

Check the true statements:

_____1. If a system does not run, first check switches, fuses and circuit breakers.

_____2. If the temperature control valve works only in the hot direction, it is necessary to first check the hot circuits.

_____3. To troubleshoot a temperature control valve that operates backwards, check the wiring with a multimeter.

SUMMARY

When troubleshooting, you will find that there is always a logical sequence to take when trying to solve a problem. By the process of elimination, common sense, and sound system knowledge you will be able to solve the most complicated problems you encounter.

Answers to Frame 43: 1. Working schematics 2. Multimeter 3. Wiring diagrams 4. Tech orders

Answers to Frame 44: 1. operational 2. short

Answers to Frame 45: ✓ 1. _____2. ✓ 3.

Technical Training

Aircraft Environmental Systems Mechanic

PARALLEL CIRCUITS PERFORMANCE

7 August 1979

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

PARALLEL CIRCUITS PERFORMANCE

OBJECTIVES

Using a DC Fundamentals trainer, construct a parallel circuit and measure electrical values with one instructor assist allowed for each task area.

EQUIPMENT

	Basis of Issue
Trainer P/N 521685 DC Fundamentals	1/student
Multimeter	1/student

SAFETY

Caution: Remove watches, rings, bracelets, etc., before starting any work on equipment. It is also good safety practice to work on the equipment with one hand. This practice reduces the chances of receiving an electrical shock to some vital body organ when working with electricity. Also remember that light bulbs, resistors, etc., do get hot and could burn the skin.

PROCEDURE

Pay close attention to all directions that you are given in the workbook. When performing in the workbook, such as answering questions or recording electrical measurements, if your response is <u>incorrect</u>, restudy the information with instructor assistance as needed. Do not hesitate to ask the instructor questions. You will be required to accomplish several exercises and have some of them checked by your instructor before you move to the next exercise. You will also find that many of the exercises have the correct answers on page 7 . After you have completed all the exercises you will satisfactorily complete the progress check assigned by your instructor. Pages 12 through 16 may be removed for your convenience.

When you leave your trainer for scheduled or unscheduled breaks, complete the following checklist before you go.

1. Insure the SPST switch is turned <u>off</u> in the circuit.

2. Insure the 28V DC bus bar has all the electrical leads removed from it.

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3. Insure the negative (black) bus bar has all the electrical leads removed from it.

4. Insure the multimeter is properly stored during this period.

a. Insure the controls are properly set for storage.

b. Leave the test leads attached to the meter.

c. Wrap the meter leads around the instrument.

d. Place the meter on the locker shelf.

5. When you return from break, take the same meter and go back to work.

Exercise 1. TRAINER PREPARATION

1. The metal plate on the right side of the trainer may be raised for your workbook to lay on.

2. Sign out a multimeter. See the lab instructor if assistance is needed.

3. Insure that the instructor has connected power to the trainer. You will do this by measuring the power with the multimeter at the positive (red) and negative (black) bus bars. These bus bars are located in the lower right and left hand corners of the trainer. If you don't read a voltage of $24 \pm 4V$ DC, see your instructor.

4. Insure that fuse wire is across the fuse holders of each of the three (3) ammeters on the trainer. This will protect the ammeter's internal circuit from an overload. If the fuse wire is burned in two or is missing, see your instructor for assistance.

5. Pull the circuit breaker out (open) and turn OFF (open) two (2) single pole single throw (SPST) switches.

6. Insure all leads in the drawer are in good condition with a plug at both ends. If you find any damaged leads, give them to the instructor.

7. Examine the electrical lead ends, and note how you may connect them together if one lead is too short. See your instructor for assistance if needed.

Exercise 2

Note: In this exercise you are required to build a parallel circuit with two (2) loads which will be light bulbs, both sharing one common ground wire. Follow the steps given following.

1. Using the electrical leads from the drawer, construct the circuit shown in figures 1 through 3, consisting of a circuit breaker, SPST switch, and two light bulbs.

Note: If an electrical lead to too short you may connect leads together to prevent stretching or breaking them.

2. Before applying power to your circuit, be sure you have one path for current flow from the negative bus bar to the lights. Tracing from negative to positive, electrons first go to the common side of both lamps and from there they can go two different paths. One is through the first lamp and the other is through the second lamp. The electrons (current) will rejoin again at the common positive side of the light that is closest to the SPST switch, and follow one path to the positive bus bar. (You have formed a parallel circuit at the lights.)

STOP and have your instructor check your work at this time.

3. After the instructor has checked the circuit and with the instructor present, do the following:

a. Push the circuit breaker.

b. Turn the single pole single throw (SPST) switch ON. The lamps should now light. If the lamps do not light, turn OFF the SPST switch and ask the instructor for assistance.

c. If the lamps light and everything appears OK, turn the SPST switch OFF.

STOP and have your instructor initial here before you proceed.

____

Exercise 3

1. Measuring and proving current flow is the sum in a parallel circuit.

a. You will use all three (3) ammeters on the trainer to prove current is the sum of all the currents in a parallel circuit. Refer to figure 3 for the circuit construction. As you can see, this is the same circuit you have previously done. Refer to figure 4 for the ammeter hookup.

b. Using figure 4 in the exercise, you should have done the following in hooking up the ammeter.

(1) Connect an ammeter between checkpoints 2 and 4 remembering the polarity of the + and - of the ammeter to the circuit. The positive lead of the ammeter will go to the most positive point and the negative ammeter lead will go to the most negative point.

(2) Connect an ammeter between points 3-5.

(3) Connect an ammeter between points 7-8.

(4) Insure the polarities on all three meters are correct.

(5) Turn on the power and record the ammeter readings in figure 4. If you do not get a reading on the ammeter and/or the circuit breaker pops, or the fuse wire burns in two, turn OFF the power. Do not touch the circuit wiring and see your instructor. Do not leave or turn the switch back on if you didn't get a reading the first time. This could prevent internal damage to the meter.

(6) Check your readings you have recorded from figure 4 and if they were correct, move on to the set of questions. If your readings were wrong, check with your instructor before going on.

Answer the following questions using the information given so far in this workbook.

1. A parallel circuit provides at least ________ paths of current flow in the circuit.

2. Total current flow in a parallel circuit is the ________.

3. An ammeter is hooked in ________ with the rest of the circuit.

See page 7 for answers.

If your answers to the last set of questions are correct, proceed on. Turn off the power to the circuit and put all the leads in the drawer if you fully understand the exercise. If any questions arise, be sure to ask the instructor for assistance.

Note: In the previous exercise you proved that total current in a parallel circuit is the sum of all the currents in the circuit. Also that current in a parallel circuit must have two or more paths to follow.

Exercise 4

1. Measuring and proving that an increase in the number of paths of current flow will increase the total current in the whole circuit.

a. Using figure 5 and three lights in parallel, construct and measure the current in a three load circuit.

b. Hook up the circuit in figure 5. Notice that the circuit is just about the same as figure 4, but you have connected in one more light and are now using only two ammeters.

(1) By hooking the ammeter between the circuit breaker and the switch, you are measuring the total circuit current. Also the second ammeter indicates the amperage in one light bulb which would be approximately the same for all the light bulbs.

(2) If you compare the two light bulb circuit in the previous exercise to the total reading in this exercise, you can see that by adding one more path of current flow (3rd light) the total current will increase

(3) Record the amperage readings on figure 5, and check your answers. Then proceed on to answer the following questions.

Note: If you have any questions up to this point, please ask your instructor.

Answer the following questions using the information given so far in this workbook.

1. The current in a parallel circuit is the same/sum __________.

2. Adding more paths in a circuit will increase/decrease the total circuit current. __________

3. An ammeter is hooked in parallel/series with the circuit being measured. __________

See page 7 for answers.

If you have any questions, please ask your instructor at this time.

Take apart the circuit and proceed to the next exercise.

Exercise 5

1. Measuring and proving voltage is the same in a parallel circuit.

a. Using figure 6 as a guide, construct the circuit indicated on the trainer and take the voltmeter readings at the points indicated.

b. Record your findings of the exercise and check your answers on page 7 . If you are having trouble connecting the circuit ask your instructor for assistance. After you have connected the voltmeter, take the readings at the indicated checkpoints and record your answers on figure 6. If you receive the correct readings, take the circuit apart, and proceed to the progress check, page 8 .

ANSWER SHEET

Exercise 3

1. two or more
2. sum
3. series

Figure 4

2 - 4	1.3 ± .5 amps
3 - 5	1.3 ± .5 amps
7 - 8	2.5 ± .8 amps

Exercise 4

1. sum
2. increase
3. series

Figure 5

4 - 6	1.3 ± .5 amps
9 - 10	4.2 ± .3 amps

Exercise 5

Figure 6

1 - 2	24 ± 4V DC
3 - 4	24 ± 4V DC

PROGRESS CHECK INSTRUCTIONS

This progress check will require you to correctly construct a parallel circuit and measure electrical values with one instructor assist allowed for each task area. Instructor assist for each task area is defined as an aid, such as technical direction or explanation, given a student who can proceed no further on his/her own. The instructor will initial your work after you have satisfactorily completed each task of the progress check. If you do not pass the progress check you will follow the instructions given by the instructor.

You will not communicate (talk, etc.) with other students during the progress check without your lab instructor's permission.

You will not use fellow students' work to solve the problems in this progress check.

You must satisfactorily complete this progress check before further progression to other lab progress checks.

Have your instructor select and initial on pages 9 or 10 the parallel circuit progress check you are to draw on figure 7. Using a lead pencil only, draw in the parallel circuit leads between the various symbols. Later you will construct this circuit on the trainer. After you have satisfactorily completed the progress check, you will follow the instructions on page 11.

_________ Instructor's Initials. Assigned progress check #1.

Complete each task listed below. <u>Do not</u> go on until the instructor has initialed your work for that task.

Task 1 Draw the circuit for a 10 ohm resistor in parallel with a light, with a circuit breaker and a SPST switch on figure 7.

_______ Instructor's Initials Task Initials _____ _____

Task 2 Construct the parallel circuit drawn on figure 7 on the trainer and complete an operational check for the instructor.

_______ Instructor's Initials Task Initials _____ _____

Task 3 Measure and record the electrical values required below.

The total current flow __________. (amps)

The voltage across the resistor ________. (volts)

The voltage across the light _________. (volts)

Task Initials _____ _____

_________ Instructor's Initials

Turn to page 11 for further instructions.

Note: If the instructor provides an instructor assist for a task, the instructor will initial behind the task initials (see objectives).

______ ______ Instructor's Initials. Assigned progress check #2.

After completion of each task listed below, <u>do not</u> progress until the instructor has initialed your work for that task.

Task 1 Draw the parallel circuit for two 10 ohm and one 500 ohm resistors. The circuit must also contain a SPST switch and a circuit breaker. Make your drawing on figure 7.

________ Instructor's Initials. Task Initials _____ _____

Task 2 Construct the parallel circuit drawn on figure 7 on the trainer and complete an operational check for the instructor.

________ Instructor's Initials. Task Initials _____ _____.

Task 3 Measure and record the electrical values required below.

The total current flow _______ amps.

The voltage across left resistor ______ volts.

The voltage across right resistor _______ volts.

The voltage across 500 ohm resistor ______ volts.

The total voltage _________ volts.

Task Initials _____ _____.

__________ Instructor's Initials

Turn to page 11 for further instructions.

Note: If the instructor provides an instructor assist for a task, the instructor will initial behind the task initials (see objectives).

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After you have satisfactorily completed the progress check you will do the following:

1. Put all the good leads in the drawer of the trainer.

2. Give the broken leads to the lab instructor with the parts.

3. Place the work table in the down position on the trainer.

4. Return the multimeter to its storage cabinet. Be sure the controls on the meter are set correctly for storage.

5. You will turn in your work to the lab instructor before you leave the lab area.

Note: You may review any part or all of this workbook if you wish, but your work will not leave the lab area without the lab instructor's permission.

Exercise 2, Figures 1 through 3.

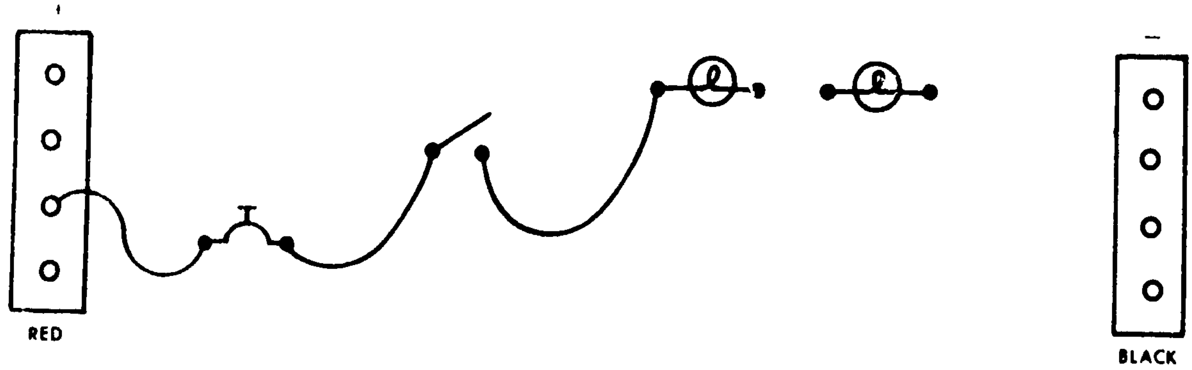


Figure 1.

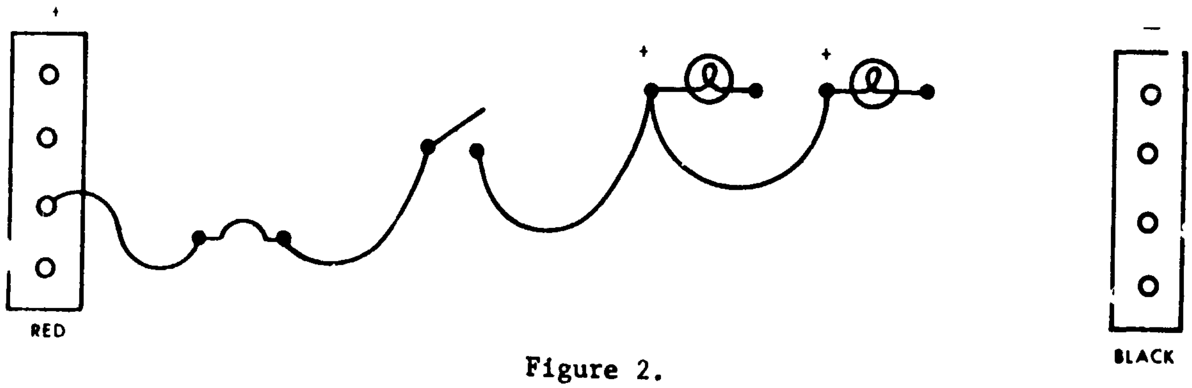


Figure 2.

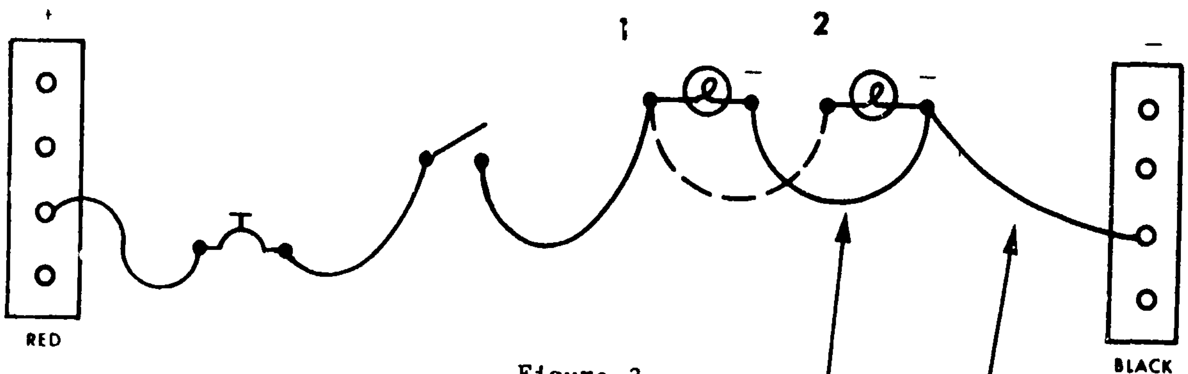


Figure 3.

Note: First light ground (negative side of load).

Second light ground (negative side of the load) and common ground for BOTH lights.

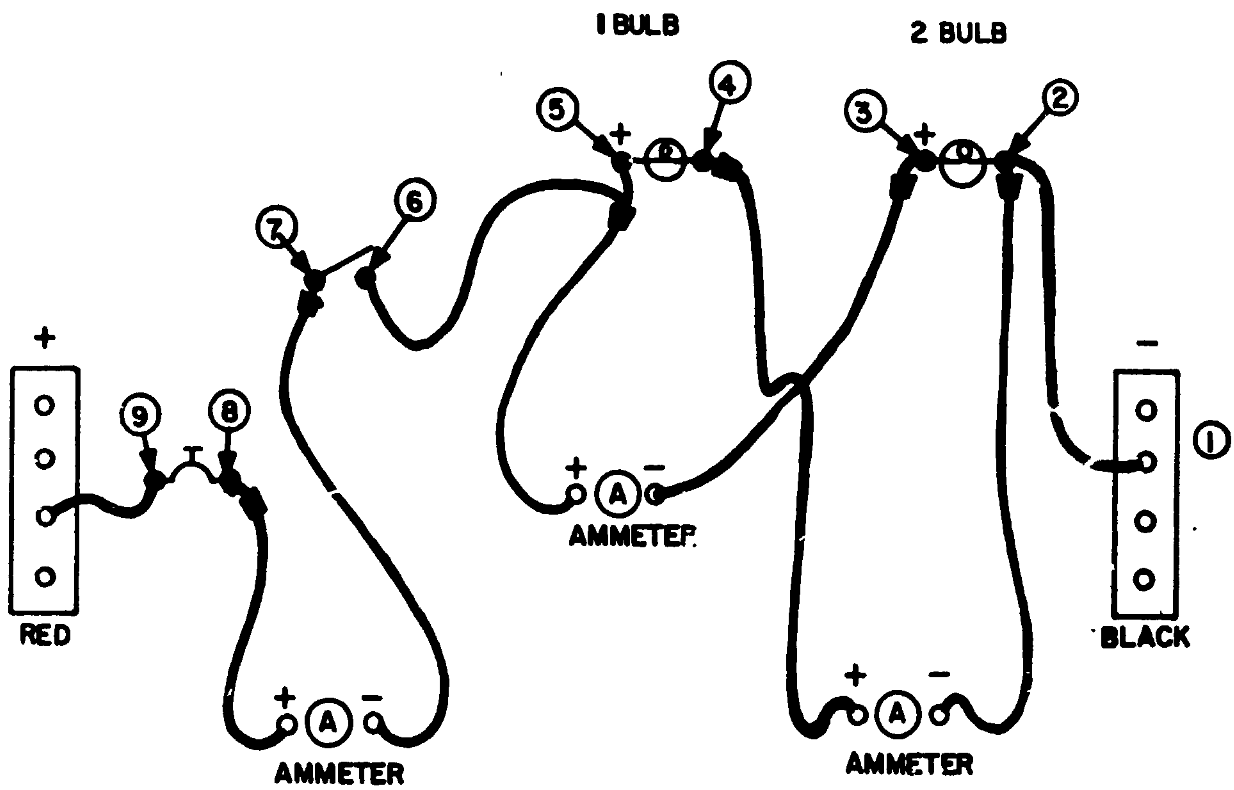


Figure 4.

CHECKPOINTS	AMPERAGE READINGS
2 - 4	________ amps
3 - 5	________ amps
7 - 8	________ amps (TOTAL)

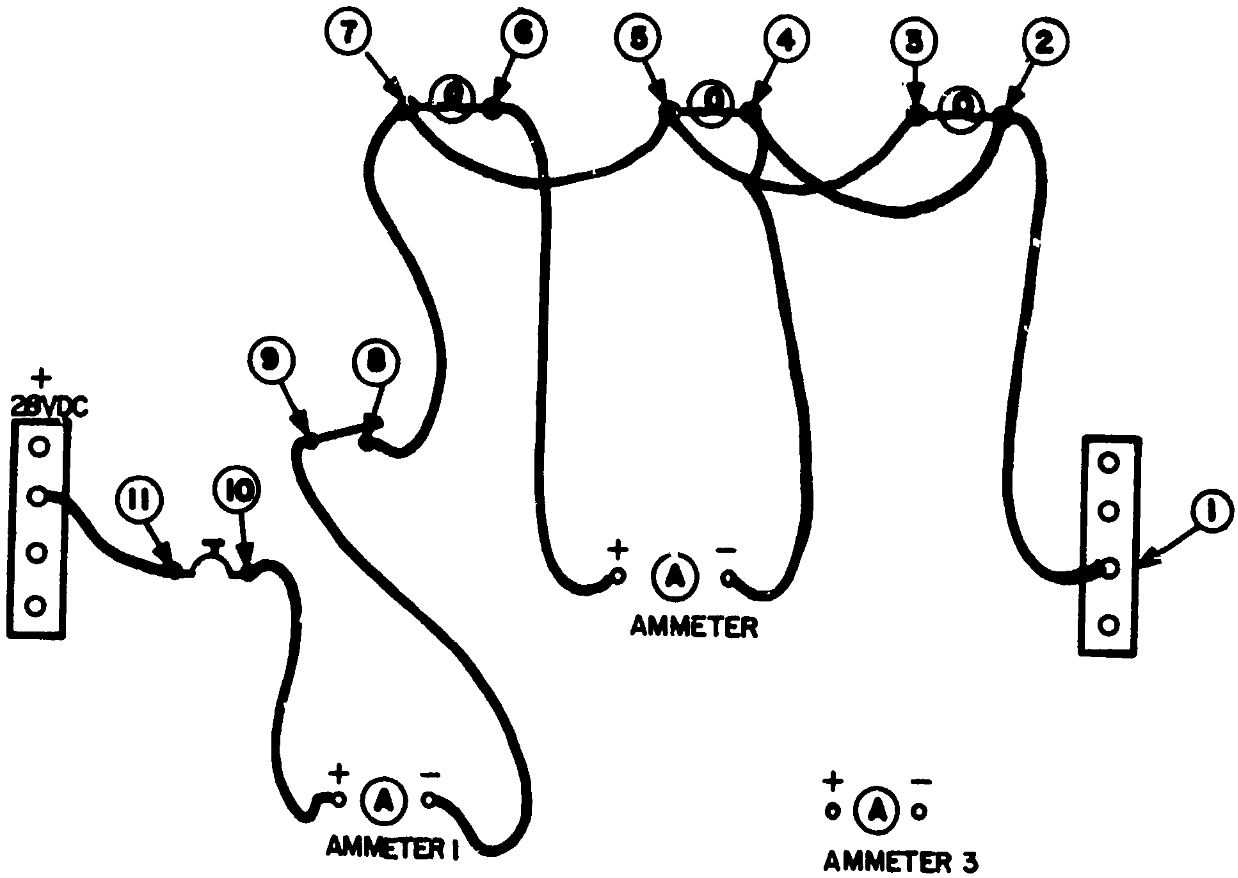


Figure 5.

CHECKPOINTS	AMPERAGE READINGS
4 - 6	______ amps
9 - 10	______ amps

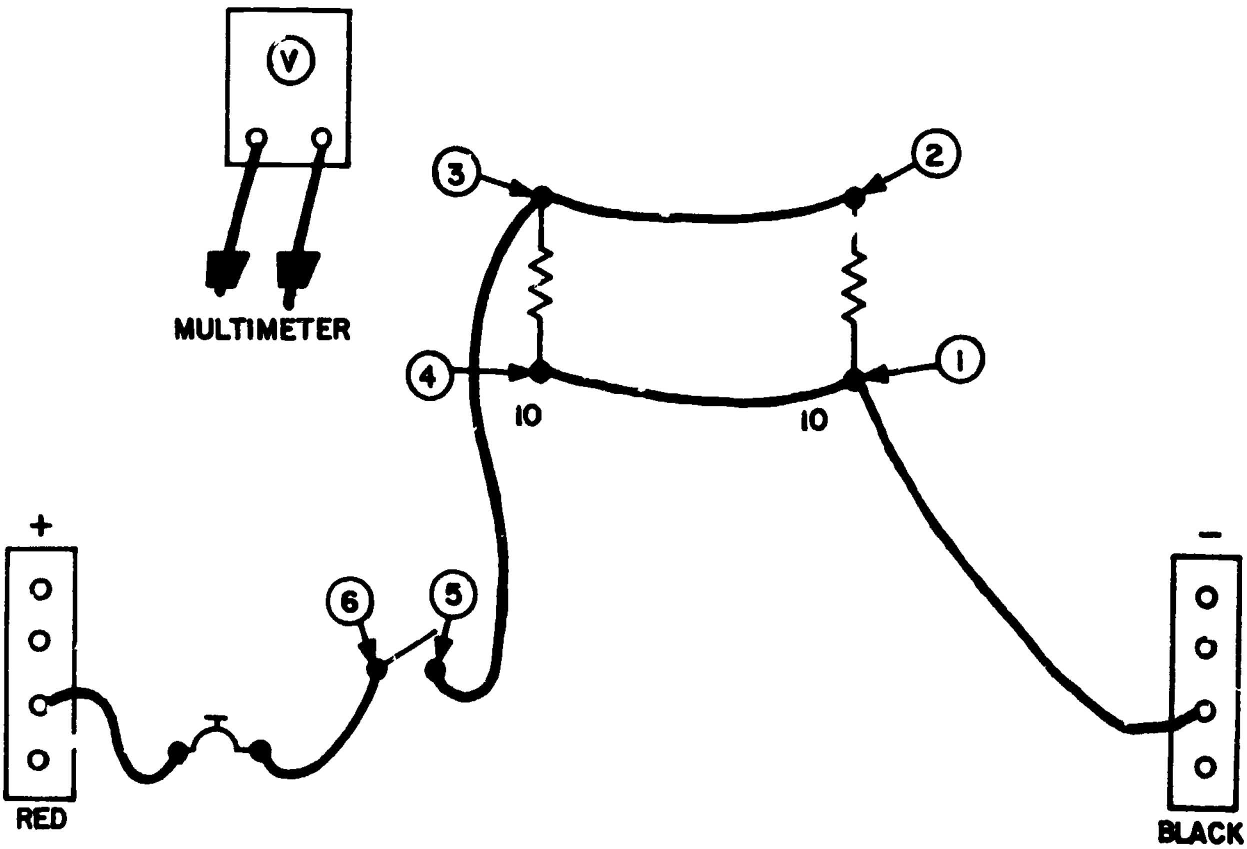
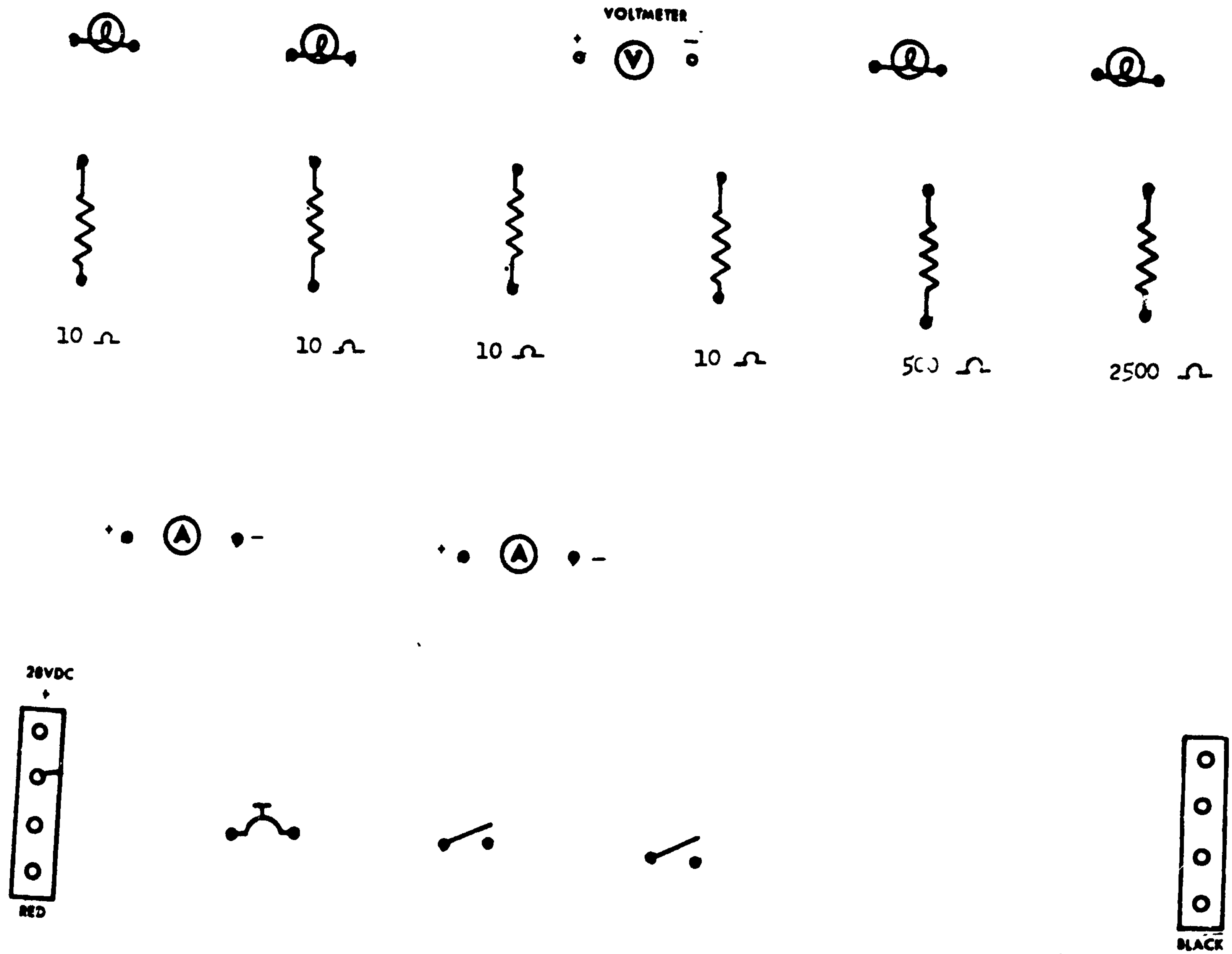


Figure 6.

CHECKPOINTS	VOLTAGE READINGS
1 - 2	________ volts
3 - 4	________ volts



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Figur

SERVICE TEST
HANDOUT

C3ABR42331-HO-118

Technical Training

Aircraft Environmental Systems Mechanic

PARALLEL CIRCUIT TROUBLESHOOTING

23 September 1983

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

Designed for ATC Course Use.

Do Not Use on the Job.

ATC FORM 214 (JAN 78) OBSOLETES ATC FORMS 214, MAY 69, 522, NOV 63 AND 523, MAY 71. STANDARD COVERSHEET

Parallel Circuit Troubleshooting

This handout is to be used with the Parallel Circuit programmed text. It will show you how to prepare and use a Power bench and a Parallel Circuit board to troubleshoot parallel circuits. Follow the instructions carefully and ask the instructor for assistance if you have difficulty.

PART 1

As you complete each of the following steps place a check on the blank by the number on that step.

____ 1. Insure that the powerbench's switches are in the following positions:

TRAINER POWER	OFF
28 VDC POWER	OFF
295 VAC POWER	OFF
DC RANGE	24v

____ 2. Insure that the four circuit switches on top of the Parallel Circuit board are in the 'OFF' position and that all troubleswitches on the back of the circuit board are in the 'OUT' position (down).

____ 3. Connect a DC power cord between the circuit board and the DC outlet on the powerbench.

____ 4. Observing Proper Polarity, connect three milliammeters to the points indicated on Circuit 3 (most positive on circuit to red on meter).

____ 5. Place the powerbench's trainer power and 28 VDC power switches in the 'ON' position.

____ 6. Turn on Circuit 3. The three milliammeters should read from 4 to 13 ma. Write in the readings in the blanks below.

Meter	
1	____
2	____
3	____
	____ Total

____ 7. Place Troubleswitch 2 (Circuit 3) in the 'IN' position. The milliammeter on the leg containing Resistor 3 should read zero.

Remember, this is a parallel circuit. It has more than one complete path to follow. Since the paths with Resistors 1 and 2 still show current flow they, along with the ground wire and the wire between test points 1 and 4, must be good. Threefore, the open must be between TP-4 and TP-15, or TP-15 and T -16, or TP-16 and TP-17.

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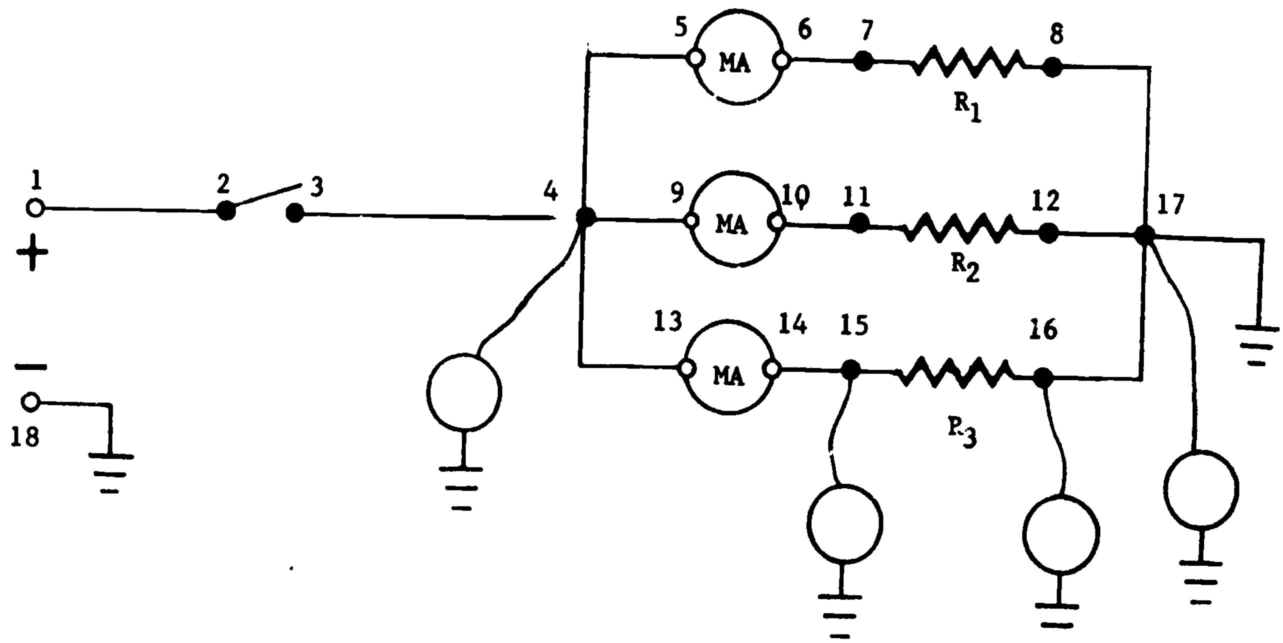
___ 8. Prepare the multimeter to read a maximum of 24 VDC.

___ 9. Take voltage readings at each of the test points indicated in the following circuit using TP-18 as ground. Fill in the meter readings as required.



___ 10. Check your answers at the end of this handout.

From the readings you can see that there is a complete path from TP-1 up to TP-16. Since there is zero voltage at TP-17 the open must be between TP-16 and TP-17.

___ 11. Place Troubleswitch 2 (Circuit 3) in the 'OUT' position and turn Circuit 3 off.

___ 12. Disconnect the milliammeters from Circuit 3.

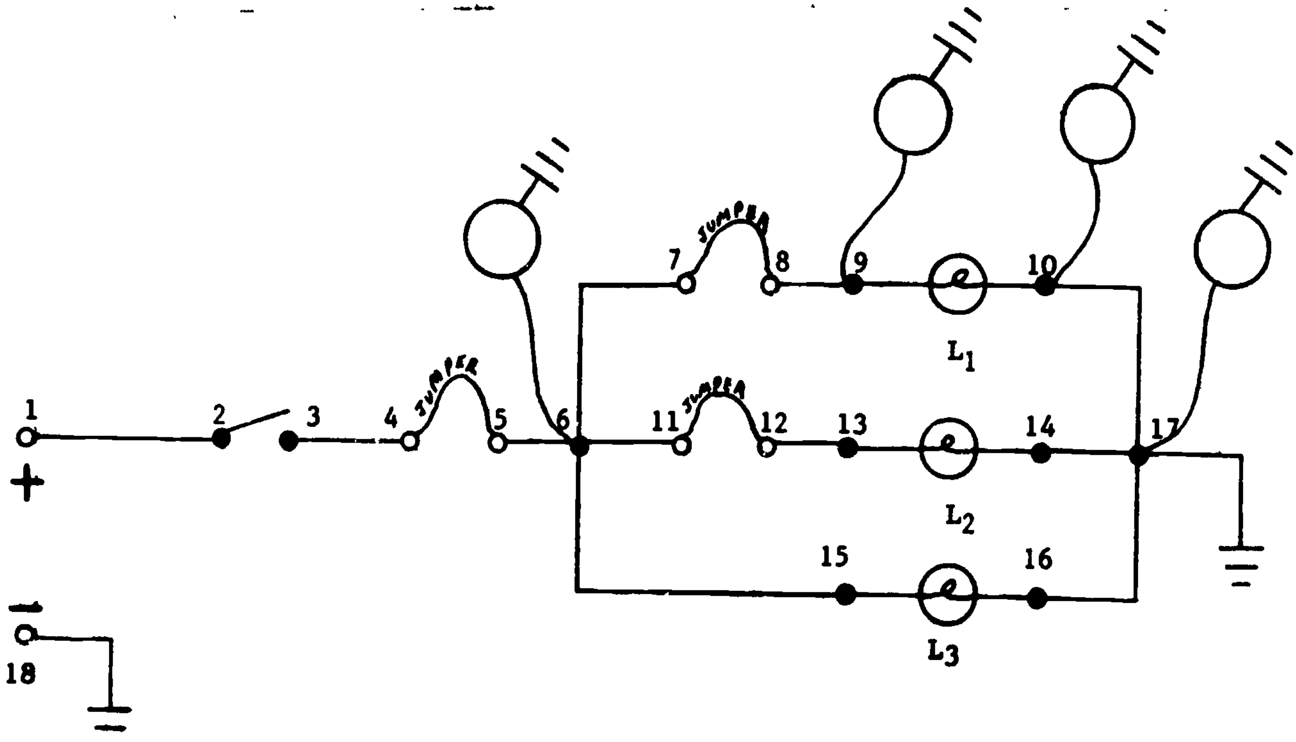
___ 13. Connect single jumper leads between TP-4 and TP-5, TP-7 and TP-8, and TP-11 and TP-12 on Circuit 4.

___ 14. Turn Circuit 4 on. All three lights should come on.

___ 15. Place Troubleswitch 3 (Circuit 4) in the 'IN' position. Light 1 goes out but Lights 2 and 3 stay on. Why?

As before, since parallel circuits have more than one path for current to follow, if one path is broken the others are not affected. Since only Light 1 went out the open must be between TP-6 and TP-9, or TP-9 and TR10, or TP-10 and TP-17.

___ 16. Take voltage readings at each of the test points indicated in the following figure using TP-18 as ground. Fill in the meter readings as required.



___ 17. Check your answers at the end of this handout.

From your readings you can see that there is a complete path between TP-1 and TP-10. Since there is no voltage at TP-17 the open must be between TP-10 and TP-17. No current will flow through Light 1 as a result of the open.

___ 18. Place Troubleswitch 3 (Circuit 4) in the 'OUT' position. All lights should be lit.

___ 19. Place Troubleswitch 5 (Circuit 4) in the 'IN' position. This time only Light 3 goes out.

Again, since only Light 3 is affected, the open must be between TP-6 and TP-15, or TP-15 and TP-16, or TP-16 and TP-17.

____ 20. Take voltage readings at each of the test points indicated below.

TP	Reading
6	______
15	______
16	______
17	______

The readings show a complete path between TP-1 and TP-6. Since there is no voltage at TP-15 the open must be between TP-6 and TP-15.

____ 21. Place Troubleswitch 5 (Circuit 4) in the 'OUT' position. All lights should be lit.

____ 22. Place Troubleswitch 6 (Circuit 4) in the 'IN' position.

What happened? ______________________________

What are the possibilities? ______________________________

What do your readings show? ______________________________

____ 23. Check your answers at the end of this handout.

____ 24. Place Troubleswitch 6 (Circuit 4) in the 'OUT' position and turn Circuit 4 off.

____ 25. Remove the jumper leads from Circuit 4.

____ 26. Turn the TRAINER POWER AND 28 VDC POWER switches off.

Continue with Frame 25 of the text

//

PART 2

When using an ohmmeter on a parallel circuit you must keep in mind that when the meter is connected across any two or more parallel paths, the current that leaves the meter's black lead will follow all of the possible paths to the meter's red lead. This will result in a 'total' resistance reading of the parallel paths. This is okay if it is what you want. But what if you only want to know how much resistance there is on one specific path? The answer is simple. You must 'ISOLATE' that path from the others by disconnecting it on one end. By doing this the current from the meter will have only one path to follow.

____ 1. Connect single jumper leads between TP-5 and TP-6, TP-9 and TP-10, and TP-13 and TP-14 of Circuit 3.

____ 2. Use the multimeter to take resistance readings at the test points shown below.

TP	READING
7 - 8	____
11 - 12	____
15 - 16	____
4 - 17	____

Each reading should be the same because, if you look closely, each time you connected the meter to the circuit there were three possible paths between the two leads for current to follow. Look again.

____ 3. Disconnect one end of each of the three jumper leads (to isolate the three paths) and take resistance readings across Resistors 1, 2 and 3. The readings should be: Resistor 1 = 6000 , Resistor 2 = 3000 , and Resistor 3 = 2000 . By using the resistance in parallel formula you can see that the total of the parallel is 1000 .

____ 4. Remove the jumper leads from Circuit 3 and connect them to TP-4 and TP-5, TP-7 and TP-8, and TP-11 and TP-12 of Circuit 4.

____ 5. Turn on the TRAINER POWER and 28 VDC POWER switches.

____ 6. Turn on Circuit 4. All three lights should come on.

____ 7. Place Troubleswitch 3 (Circuit 4) in the 'IN' position. Light 1 goes out.

Since only Light 1 went out, there must be an open either between TP-6 and TP-9, or TP-9 and TP-10, or TP-10 and TP-11. Let's use the ohmmeter to find it.

____ 8. Turn Circuit 4 off and isolate Light 1's leg by disconnecting one end of that paths jumper lead.

____ 9. Take resistance readings at the following test points.

TP	READING
9 - 10	____
10 - 17	____

Your readings should have shown resistance around Light 1 and infinity between Light 1 and TP-17. This means that the open is on the wire between Light 1 and TP-17.

____ 10. Place Troubleswitch 3 (Circuit 4) in the 'OUT' position and reconnect the jumper lead.

____ 11. Turn Circuit 4. All lights should come on.

____ 12. Place Troubleswitch 5 (Circuit .' in the IN' position.

What happened? ____________________

What are the possibilities? ____________________

____ 13. Turn Circuit 4 off.

____ 14. Isolate the path with the inoperative component.

____ 15. Take resistance readings to determine the trouble.

Your readings should show an open between TP-6 and TP-15.

____ 16. Turn the TRAINER POWER and 28 VDC POWER switches off.

____ 17. Disconnect the jumper leads and DC power cord. Put them in the drawer.

____ 18. Put the Parallel Circuit board away and sign in the multimeter.

____ 19. Have the instructor init the space below and then return to the classroom to finish the test.

____

//

ANSWERS

PART 1

CIRCUIT 3	TP	READING
	4	24v
	15	24v
	16	24v
	17	0v

CIRCUIT 4	TP	READING
	6	24v
	9	24v
	10	24v
	17	0v

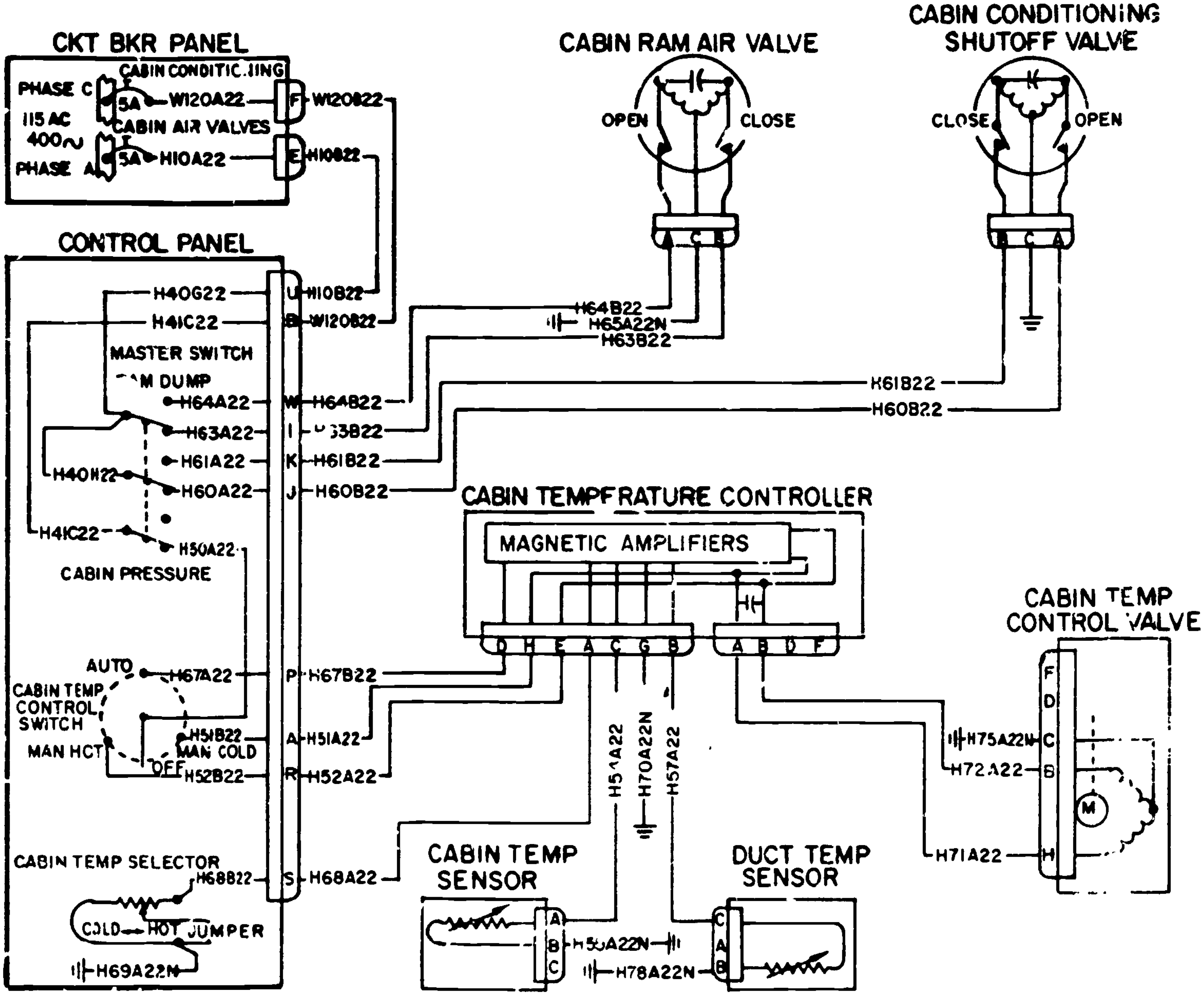
(Step 20)	TP	READING
	6	24v
	15	0v
	16	0v
	17	0v

(Step 22) Light 3 went out
An open between TP-6 and TP-15, or TP-15 and TP 16 and TP-17
Light 3 is open (burned out)

PART 2

Light 3 went out.
An open on Light 3's leg.

TRAINER AIR CONDITIONING SYSTEM WIRING DIAGRAM



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Supersedes AS/HO/C3ABR42331-127, 27 January 1984
OPR: 3370 TCHTG
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PROGRAMMED TEXT
3ABR42331-PT-119

Technical Training

Aircraft Environmental Systems Mechanic

SERIES-PARALLEL CIRCUITS

2 March 1981

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
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RGL: 9.3

OBJECTIVES

1. Using Kirchoff's current and voltage laws, Ohm's law, and power formula, solve for unknown values in series-parallel circuits. A minimum of 8 our of the 10 circuits must be correct.

2. Using schematic diagrams of electrical circuits, malfunction indications, and meter readings, specify the type of trouble for a minimum of 8 out of 10 indications.

INSTRUCTIONS

This programmed text presents information in small steps called frames. Carefully study the written material and/or schematic in each frame until you are satisfied you understand its contents. Each frame requires you to respond to the information in some way. For example, you may be required to select true statements, solve problems, etc. Specific instructions are provided in each frame. After you have made your response on the response sheet compare your answers with the answers given on the top of the next frame. If you are correct, go on to the next frame. If you are incorrect, study the frame again and correct your mistakes before continuing. If you still can't understand your mistakes, ask your instructor for assistance. Read carefully, select the correct answer(s) and DO NOT HURRY. DO NOT MARK IN THIS TEXT.

SPECIAL INSTRUCTIONS

As you complete this PT you should have a copy of the laws and formulas (3ABR42331-HO-101B) in front of you for easy reference.

There are a number of frames in this PT in which the answers are not given. In these frames you are told to have the instructor check your answers. These frames have been included in this PT for a distinct purpose. Do not proceed any further in the PT until you have had your answers checked. For example, frame 13 requires you to have the instructor check your answers. Do not proceed to frame 14 until your answers to frame 13 have been checked.

Supersedes 3ABR42331-PT-119, 15 September 1980.
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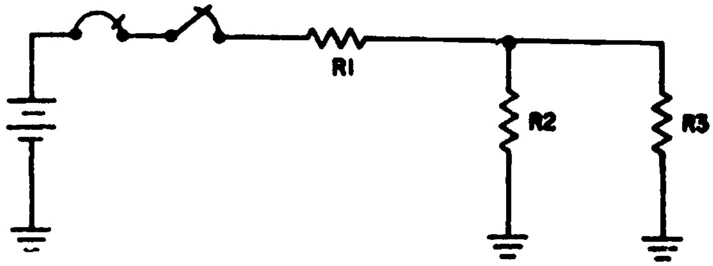
INTRODUCTION

You have just made a study of series and parallel circuits. Many circuits consist of both series and parallel units. A circuit of this type will be called a series-parallel circuit. No new formulas or laws are needed to solve for unknowns in series-parallel circuits. The only laws and formulas that you will need are in the handout that should be in front of you this time.

Frame 1

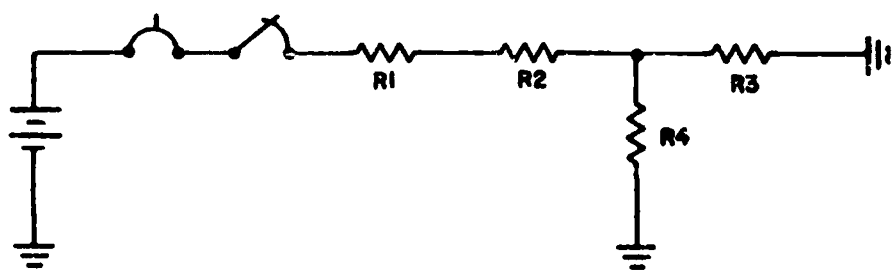
Do not start this frame unless you have a copy of the laws and formulas in front of you. See your instructor for them if necessary.

A series-parallel circuit is shown below. In this circuit R_2 and R_3 are connected in parallel with each other. R_1 is connected in series with the parallel combination of R_2 and R_3.



Mark the correct answer for each of the following questions. Use the circuit shown below.

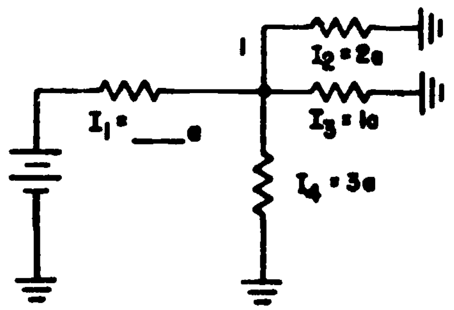
1. The two resistors which are in parallel with each other are
   a. R_3 and R_4.
   b. R_1 and R_2.
   c. R_2 and R_3.
   d. R_1 and R_4.
2. The circuit shown is a
   a. series circuit.
   b. parallel circuit.
   c. series-parallel circuit.



Answers to Frame 1: 1. <u>a</u> 2. <u>c</u>

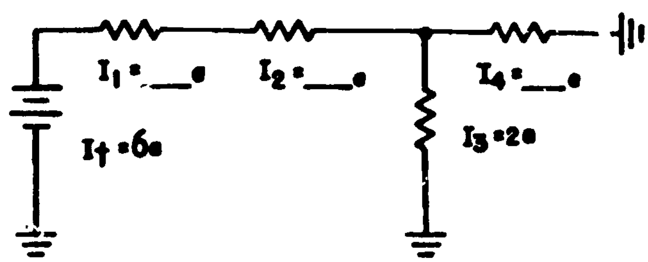
Frame 2

No new laws or formulas are needed to solve series-parallel circuits. In this PT we will review each of the laws and formulas with you. In the circuit shown below we want to find I_1. Applying Kirchhoff's current law to junction 1, the sum of the currents flowing into junction 1 is equal to 2 + 1 + 3 or 6a. Since 6a flows into junction 1, 6a must leave junction 1. Thus, I_1 = 6a.

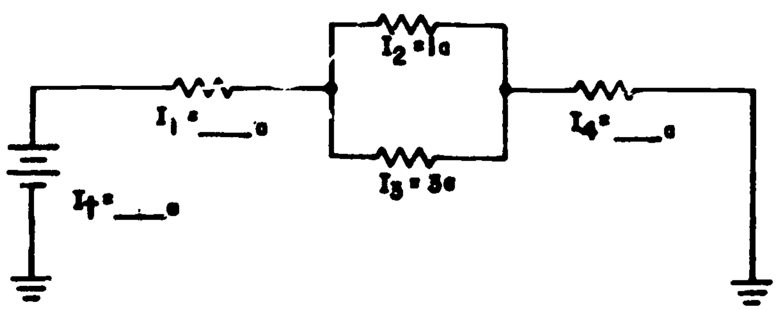


Using Kirchhoff's current law from your handout, solve for the unknown currents in each of the following circuits. Put your answers on the appropriate blanks.

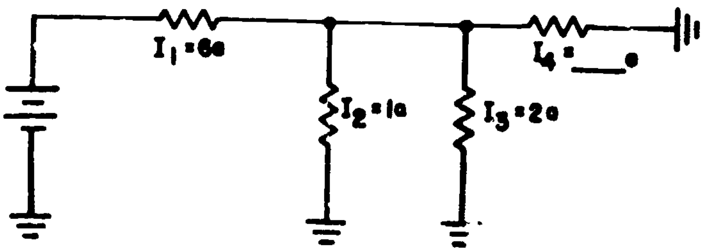
1.



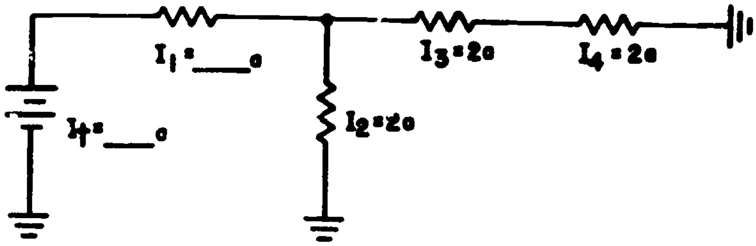
2.



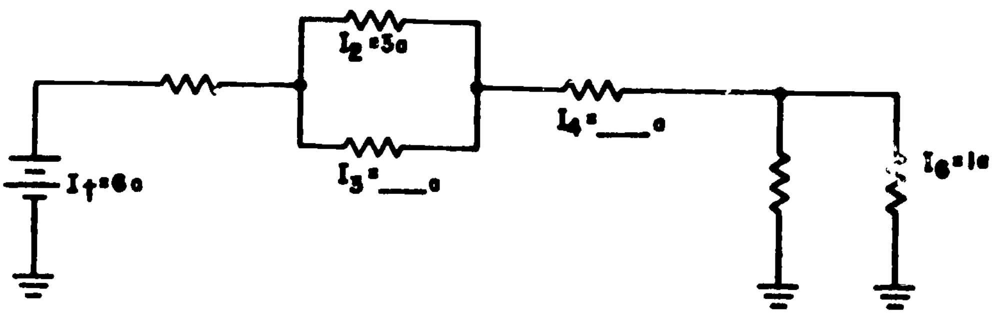
3.


$I_1 = 6a$
$I_2 = 1a$
$I_3 = 2a$
$I_4 = \_\_\_ a$

4.


$I_1 = \_\_\_ a$
$I_3 = 2a$
$I_4 = 2a$
$I_t = \_\_\_ a$
$I_2 = 2a$

5.


$I_2 = 3a$
$I_4 = \_\_\_ a$
$I_t = 6a$
$I_3 = \_\_\_ a$
$I_6 = 1a$

Answers to Frame 2: 1. I_1 = 6a 2. I_1 = 4a 3. I_4 = 3a 4. I_1 = 4a

I_2 = 6a I_4 = 4a I_t = 4a

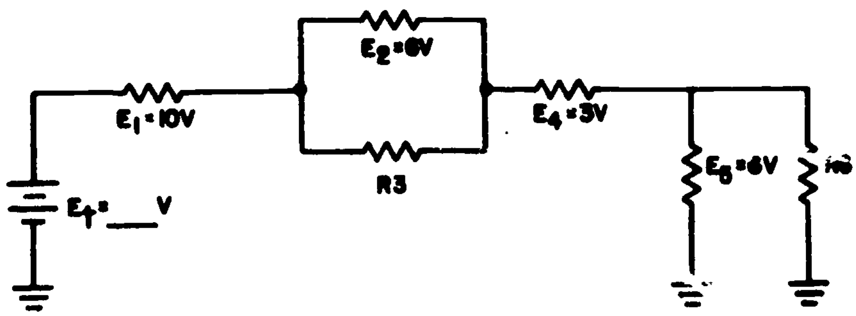
I_4 = 4a I_t = 4a

5. I_3 = 3a

I_4 = 6a

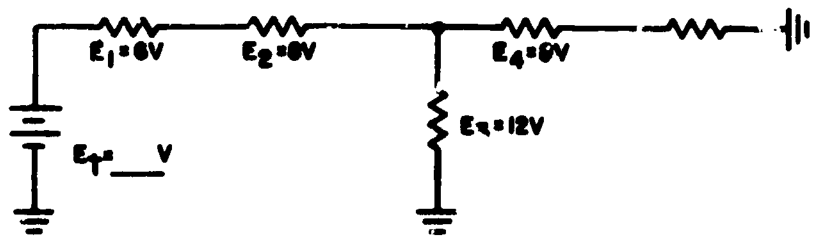
Frame 3

Kirchhoff's voltage law is also used to solve for unknowns in a series-parallel circuit. In the circuit shown below we want to find E_t. To find E_t we need to know all the voltage drops around a closed path. Since we do not know the voltage dropped on R_3 and R_6, we will not use the path in which they are located. Instead we will use the R_5, R_4, R_2, and R_1 path. Apply Kirchhoff's voltage law to this path. We have 6 + 3 + 6 + 10 = 25V. Thus, E_t = 25V.

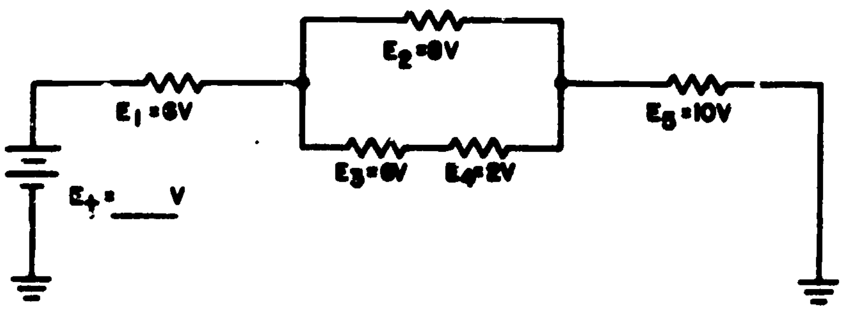


Using Kirchhoff's voltage law from your handout, solve for the unknown voltages in each of the following circuits. Put your answers on the appropriate blanks.

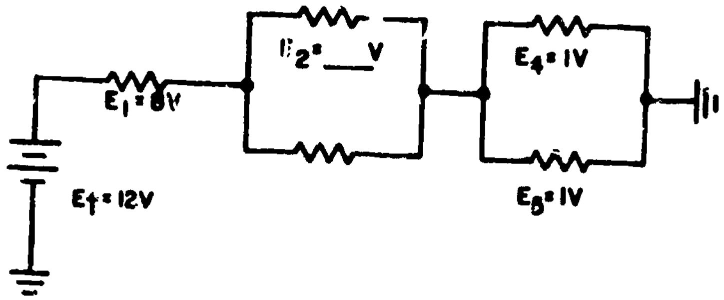
1.



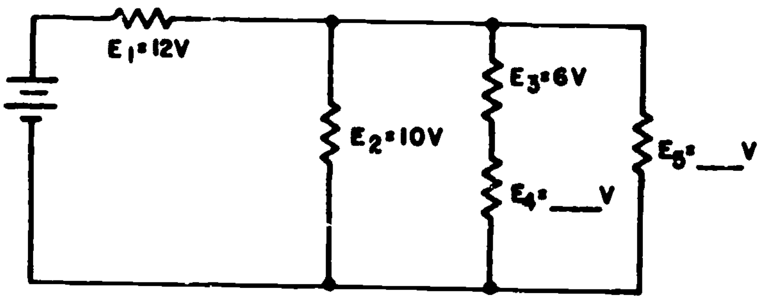
2.



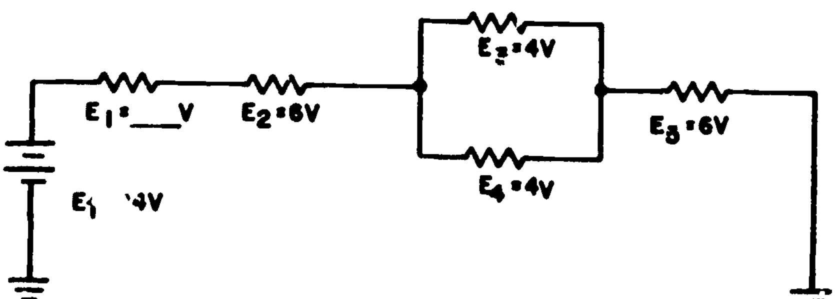
3.


E2= ___V
E1=8V
E4=1V
ET=12V
E5=1V

4.


E1=12V
E3=6V
E2=10V
E5= ___V
E4= ___V

5.

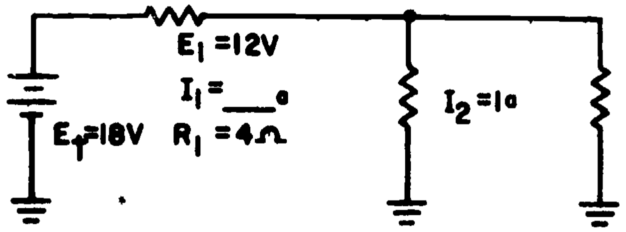

E3=4V
E1= ___V
E2=6V
E5=6V
E4=4V

Answers to Frame 3: 1. E_t = 26V, 2. E_t = 24V, 3. E_2 = 3V, 4. E_4 = 4V, E_5 = 10V

5. E_1 = 8V

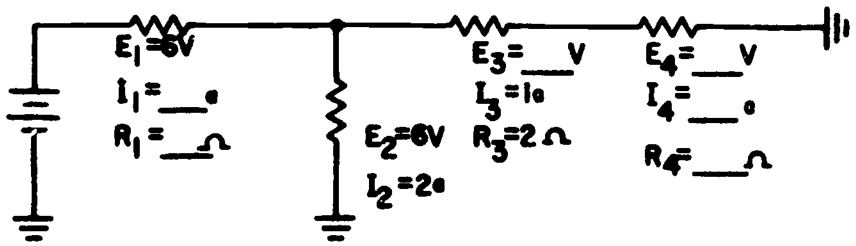
Frame 4

Ohm's law formulas are also used to find unknowns in serie -parallel circuits. In the circuit shown below we want to find I_1. When using Ohm's law formulas be sure that the values used are for the same component. For example, to find I_1 we would use E_1 and R_1. Thus, $I_1 = E_1/R_1 = 12/4 = 3a$.

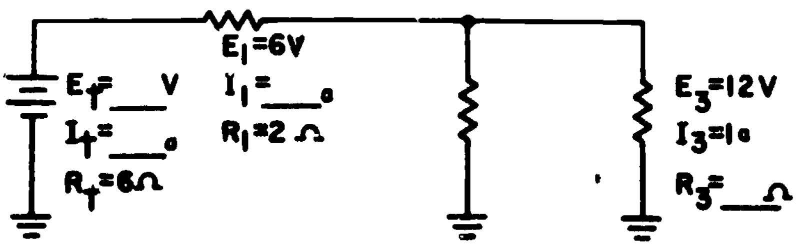


Using Kirchhoff's voltage and current law and Ohm's law formulas, solve for the indicated unknowns in each of the following problems. Write your answers on the appropriate blanks.

1.



2.



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Answers to Frame 4:

1. I_1 = 3a, E_3 = 2V, E_4 = 4V, 2. E_t = 18V, I_1 = 3a, R_3 = 12Ω

R_1 = 2Ω, I_4 = 1a I_t = 3a

R_4 = 4Ω

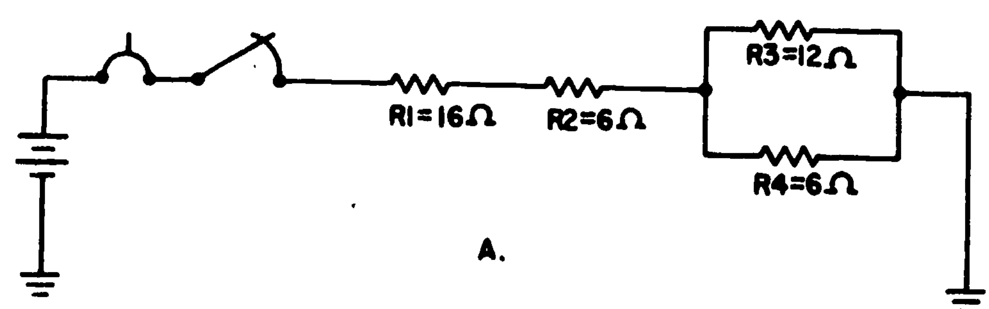
Frame 5

Now let's look at how to find the total resistance in a series-parallel circuit. Since R_3 and R_4 are in parallel with each other in circuit A, we can use either the "product over the sum formula" or the "reciprocal formula" to find the series equivalent resistance of R_3 and R_4. Using the "product over the sum formula" we have

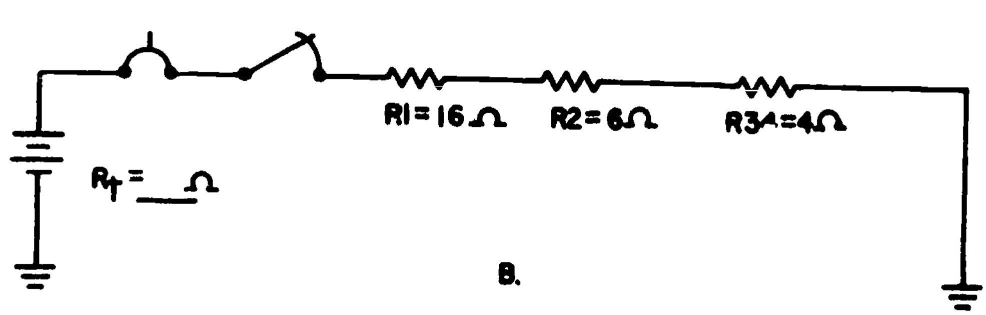
$$R_{34} = \frac{R_3 \times R_4}{R_3 + R_4} = \frac{12 \times 6}{12 + 6} = 72/18 = 4 \text{ ohms.}$$

Circuit B is the same as circuit A except we have replaced R_3 and R_4 by their series equivalent resistor R_{34}. Now we have a series circuit. In a series circuit the total resistance is equal to the sum of the individual resistances. Thus, R_t = 16 + 6 + 4 = 26 ohms.

Note: To find the total resistance of a series-parallel circuit, first find the series equivalent resistances of the parallel parts and then you just have a series circuit.



A.

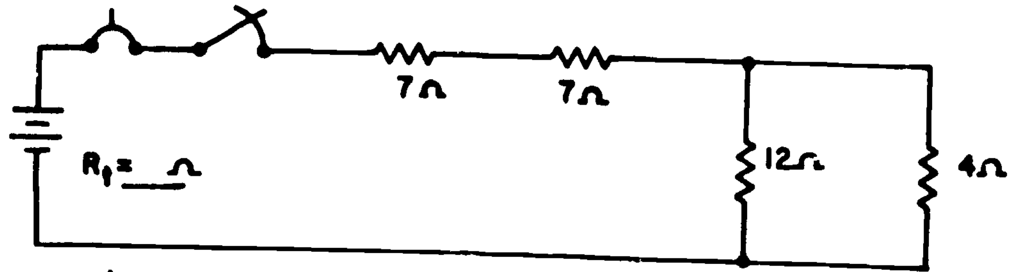


B.

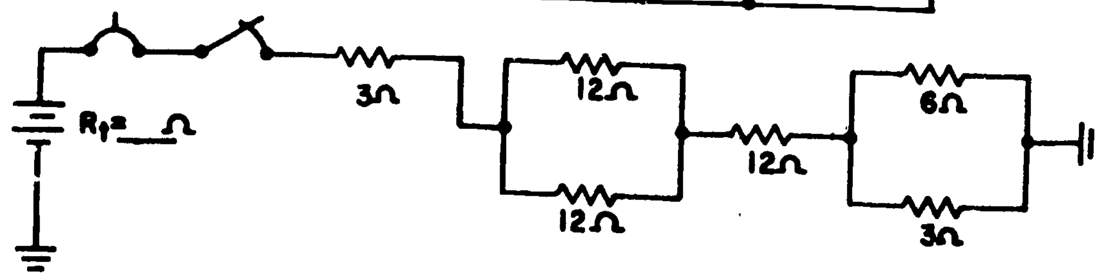
Frame 5 (Cont'd)

Find the total resistance in each of the following circuits and put your answers on the appropriate blank.

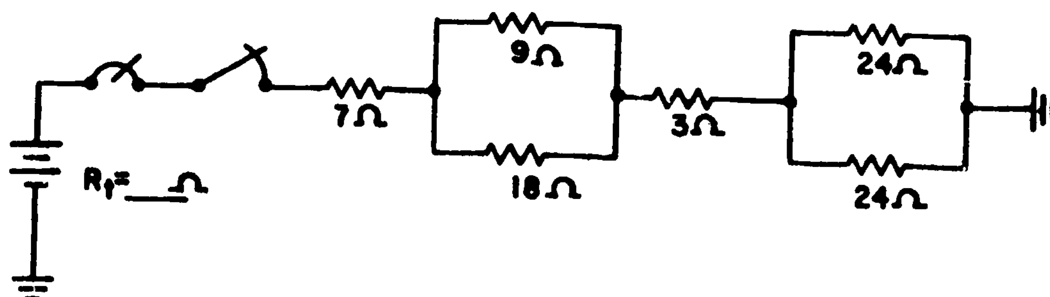
1.



2.



3.



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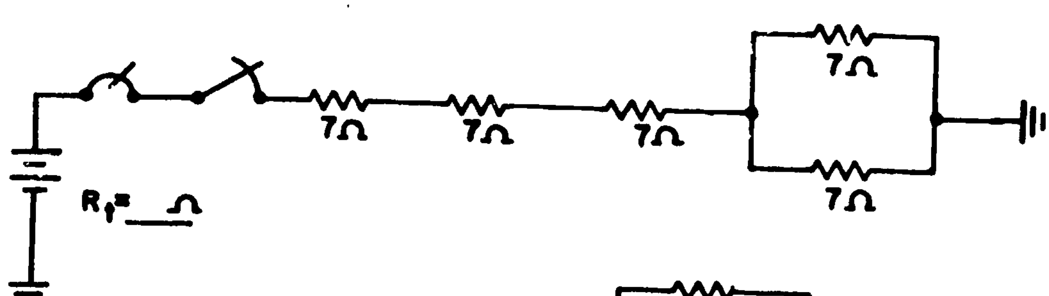
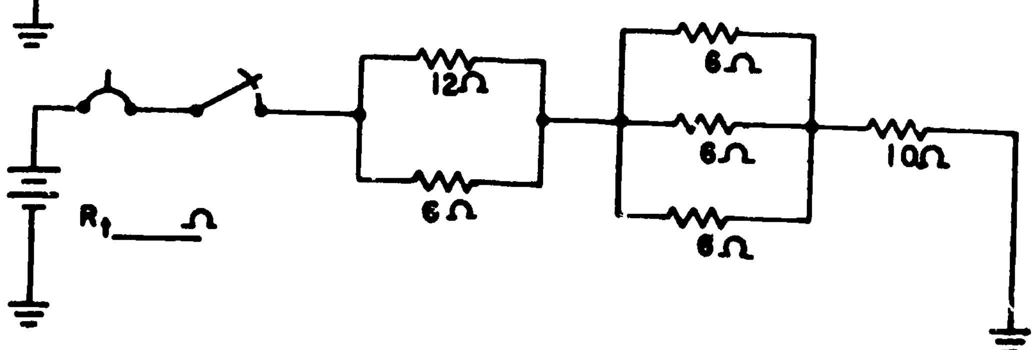


5.



Answers to Frame 5:

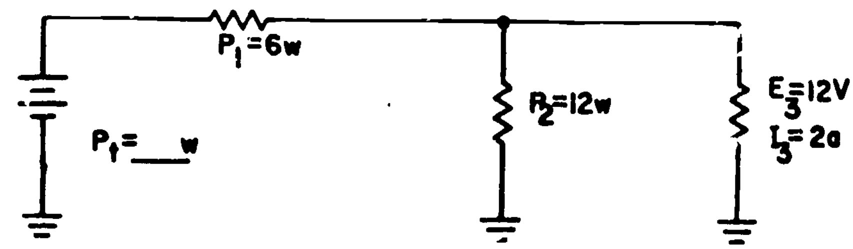
1. R_t = 17Ω, 2. R_t = 23Ω, 3. R_t = 28Ω, 4. R_t = 24.5Ω, 5. R_t = 16Ω

Frame 6

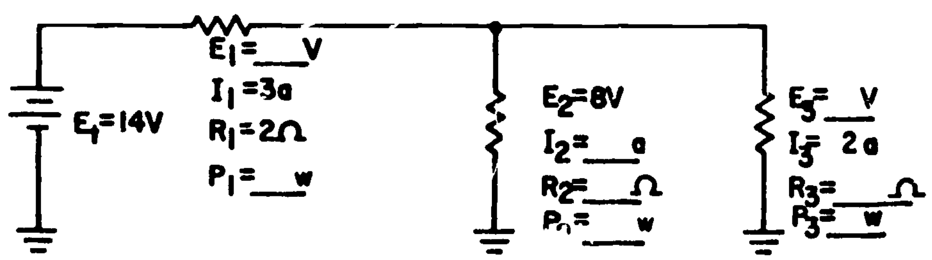
To find power you use the formula P = I X E. The total power in ANY circuit is equal to the sum of the powers used in the individual units. This can be expressed as a formula by $P_t = P_1 + P_2 + P_3$.

Solve for all indicated unknowns in the circuits shown below. Put your answers on the appropriate blanks.

1.



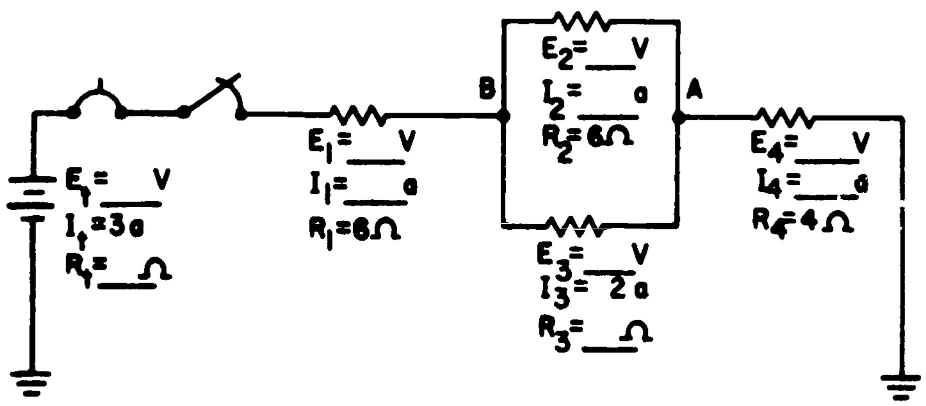
2.



Answers to Frame 6: 1. 42W, 2. E_1 = 6V, I_2 = 1a, E_3 = 8V
P_1 = 18W, R_2 = 8Ω, R_3 = 4Ω
P_2 = 8W P_3 = 16W

Frame 7

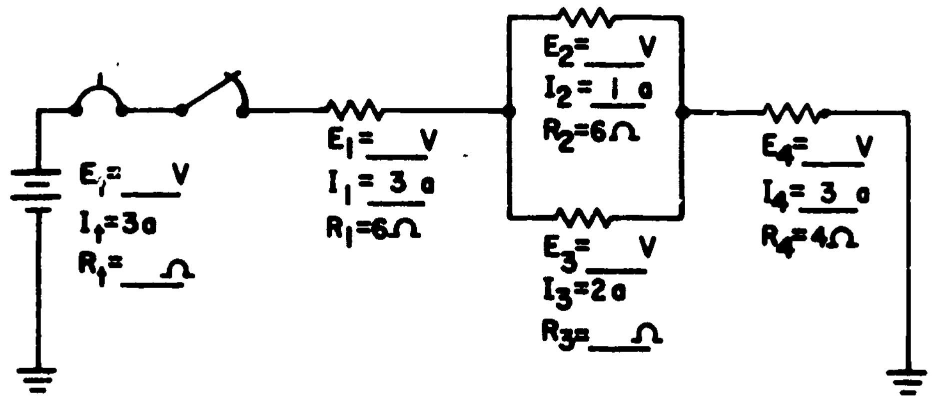
So far in this PT we have reviewed all the formulas and laws that are on your handout. We have seen how they are used to solve for unknowns in series-parallel circuits. Remember, if you can't apply one law to a particular circuit, try using a different one until you find one that can be used. In this and the next two frames we will solve the problem shown below step-by-step with you. Since we do not have any voltage readings we cannot use Kirchhoff's voltage law. However, we can use Kirchhoff's current law. Since there are 3a that leave the battery there must be a 3a that flow through R_4. Fill in 3a for I_4. Applying Kirchhoff's current law to junction A we have 3a flowing into junction A. Thus, there must be 3a leaving junction A. Since 2a flows through R_3, 1a must flow through R_2. Fill in 1a for I_2. The sum of the currents flowing into junction B ($I_2 + I_3$) is equal to the current leaving junction B. Thus, 3a leaves junction B and I_1 = 3a. Fill in 3a for I_1.



No further response required, proceed to the next frame.

This is the same circuit as in the last frame. The values for I_1, I_2, and I_4 that you found in frame 7 have been filled in for you. We still don't have enough information to use Kirchhoff's voltage law. However, we can use the Ohm's law formula E = I X R to find E_1, E_2, and E_4. $E_1 = I_1 \times R_1 = 3 \times 6 = 18V$. $E_2 = I_2 \times R_2 = 1 \times 6 = 6V$.

$E_4 = I_4 \times R_4 = 3 \times 4 = 12V$. Fill in these values on the appropriate blanks. We'll fini... problem in the next frame.

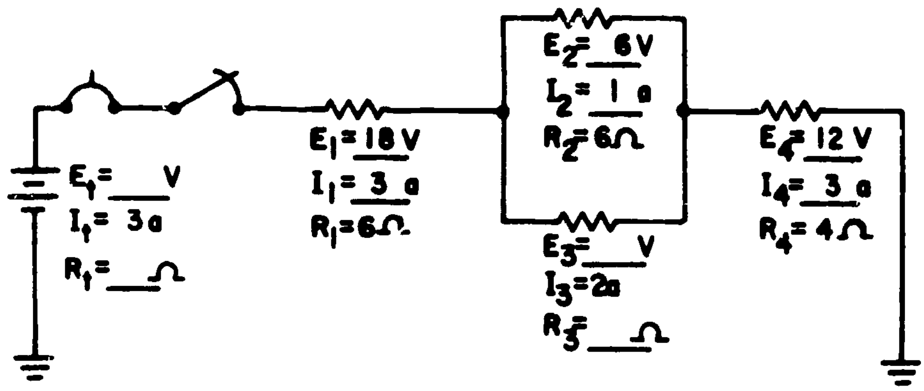


No further response required, proceed to the next frame.

Frame 9

We will finish the problem we started in frame 7. We have filled in the values that we have found so far. Now we can use Kirchhoff's voltage law. Applying Kirchhoff's voltage law to the path that contains R_4, R_2, and R_1, we have $E_t = E_4 + E_2 + E_1 = 12 + 6 + 18 = 36V$. Fill in 36V for E_t. We now can use Kirchhoff's voltage law to find E_3. Apply Kirchhoff's voltage law to the path that contains R_4, R_3, and R_1. We have $E_t = E_4 + E_3 + E_1$. Substituting we have $36 = 12 + E_3 + 18$. Subtracting 30 from 36 we have $E_3 = 6V$. Fill in 6V for E_3 on the appropriate blank below.

Now we can use Ohm's law formula $R = E/I$ to find R_t and R_3. $R_t = E_t/I_t = 36/3 = 12$ ohms. $R_3 = E_3/I_3 = 6/2 = 3$ ohms. Now the problem is solved.



No further response required, proceed to the next frame.

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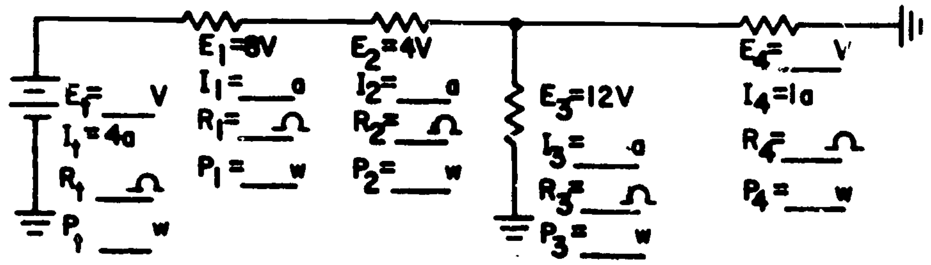
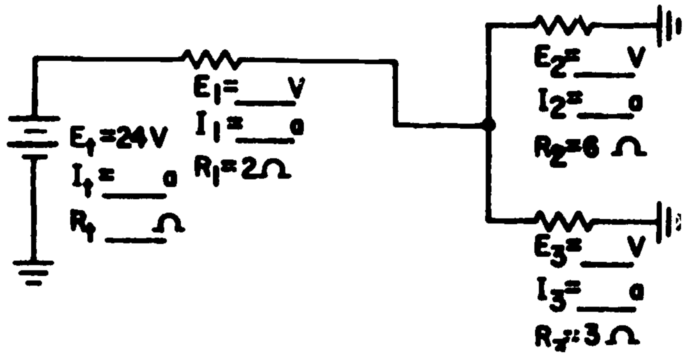
Solve each of the following problems for the indicated unknowns. Put your answers on the appropriate blanks.

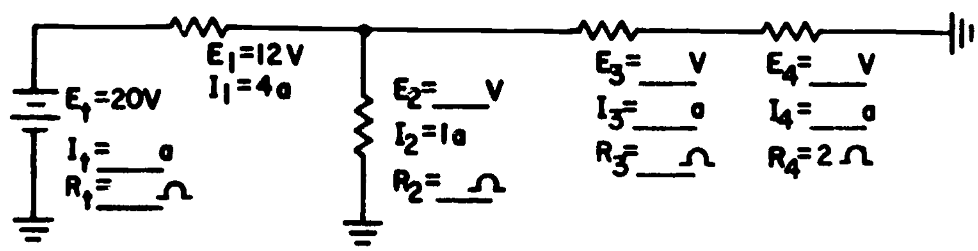
1.



2



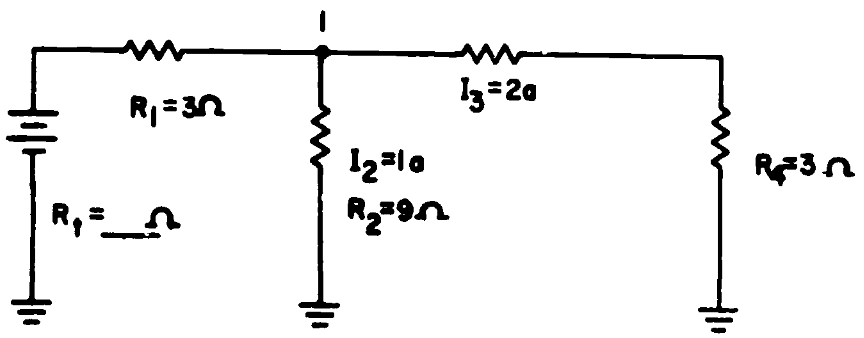
3.



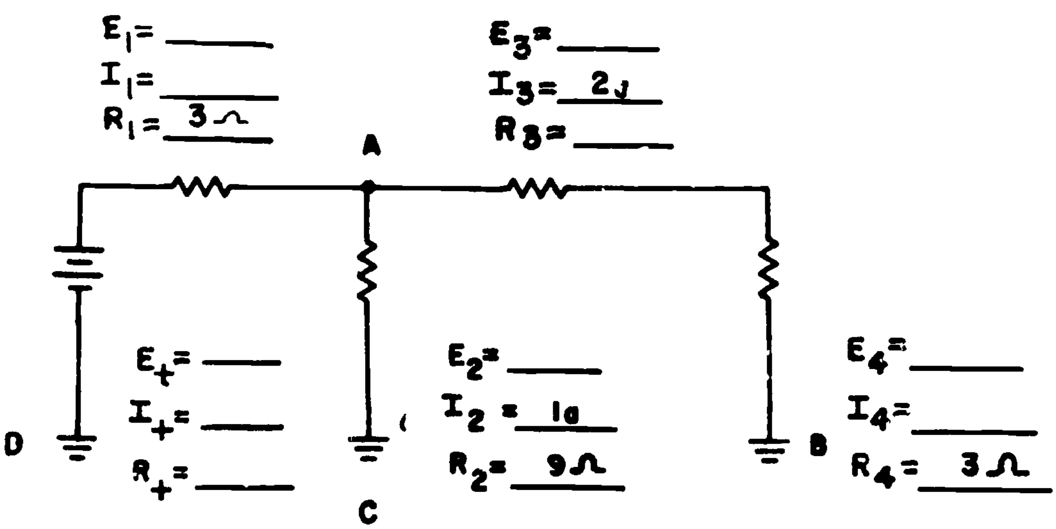
Answers to Frame 10: 1.	E_t = 24V	I_1 = 4a	I_2 = 4a	E_3 = 3a	E_4 = 12V
	R_t = 6Ω	R_1 = 2Ω	R_2 = 1Ω	R_3 = 4Ω	R_4 = 12Ω
	P_t = 96W	P_1 = 32W	P_2 = 16W	P_3 = 36W	P_4 = 12W
2.	I_t = 6a	E_1 = 12V	E_2 = 12V	E_3 = 12V	
	R_t = 4Ω	I_1 = 6a	I_2 = 2a	I_3 = 4a	
3.	I_t = 4a	E_2 = 8V	E_3 = 2V	E_4 = 6V	
	R_t = 5Ω	R_2 = 8Ω	I_3 = 3a	I_4 = 3a	
			R_3 = .66Ω		

Frame 11

In the circuit shown we want to find the value of R_t. To establish a procedure for solving series-parallel circuits we will work this problem step-by-step with you. As you complete each of the following steps place a check on the blank by the number of that step.



First draw the above circuit on scratch paper with all the E, I, R, known and unknowns, along with the letter for points A, B, C, and D as shown below.



_____ 1. Examining the circuit you can see the first step in this circuit should be to solve for E_2. Why? Because only Ohm's law is needed to solve for E_2. $R_2 \times I_2 = 9\Omega \times 1a = 9v = E_2$. Now you have the voltage at point A to point C. Because C and B are both ground points you will also have 9 volt from point A to point B. Remember A to C is in parallel with A to B, but A to B is a series circuit by itself.

_____ 2. Because Kirchhoff's current law states current flow in a series circuit is the same, I_4 must be equal to I_3 therefore, $I_4 = 2a$.

_____ 3. Now solve for E_4 by using Ohm's law. $I_4 \times R_4 = 2a \times 3\Omega = 6v = E_4$.

_____ 4. Now solve for E_3 by using Kirchhoff's voltage law. Subtract the voltage $E_4 = 6v$ from the total voltage (9v) across points A to B, which is 9v, $E_3 = 9v - 6v = 3v$. Now do you see how E_3 does equal 3v? If not, see Kirchhoff's voltage law and/or your instructor.

_____ 5. To solve for R_3 you must use Ohm's law.

$$R_3 = E_3/I_3 = 3v/2a = 1.5\Omega$$

_____ 6. Now you must find the total current. To do this you use Kirchhoff's current law. Add the current (2 amp) from circuit A and B to the current (1 amp) from A and C. This 3 amps will join at a point A, and will return to the positive point of the power sources. This means $I_1 = 3$ amp and also $I_t = 3$ amp.

_____ 7. Now that you know that $I_1 = 3a$ you can now apply Ohm's law and solve for E_1, $E_1 = I_1 \times R_1 = 3a \times 3\Omega = 9v$

_____ 8. Circuit A to B is in parallel with circuit A to C and the characteristic rules of a parallel circuit say that voltage is the same in a parallel circuit. To solve for E_t you must add the A to B voltage OR the A to C voltage to E_1 which will equal E_t, $E_t = 9v + 9v = 18v$.

_____ R_t Now to solve for R_t you must use Ohm's law.

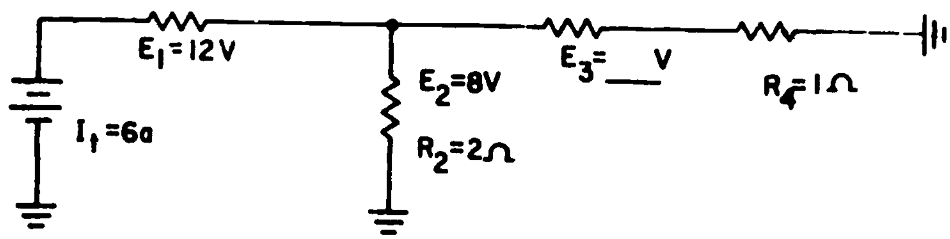
$$R_t = \frac{E_t}{I_t} = \frac{18v}{3a} = 6\Omega$$

Answers to Frame 11: R_t = 6 ohms

Frame 12

Solve each of the following problems for the indicated unknown. Put your answers on the appropriate blanks. Set up the problems, using the same procedures as in the last frame.

1.



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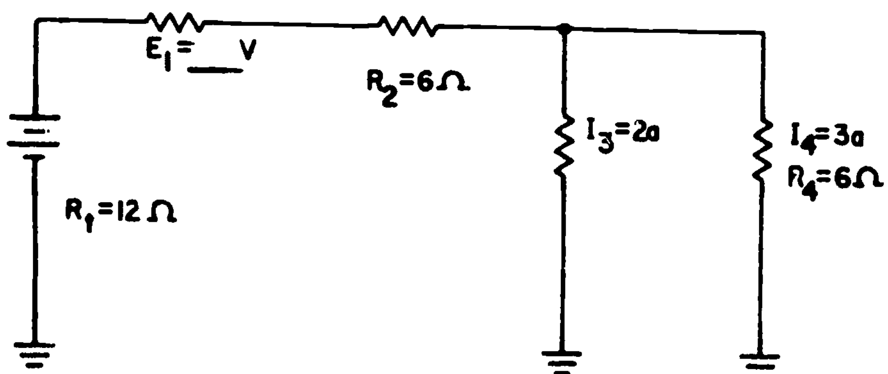
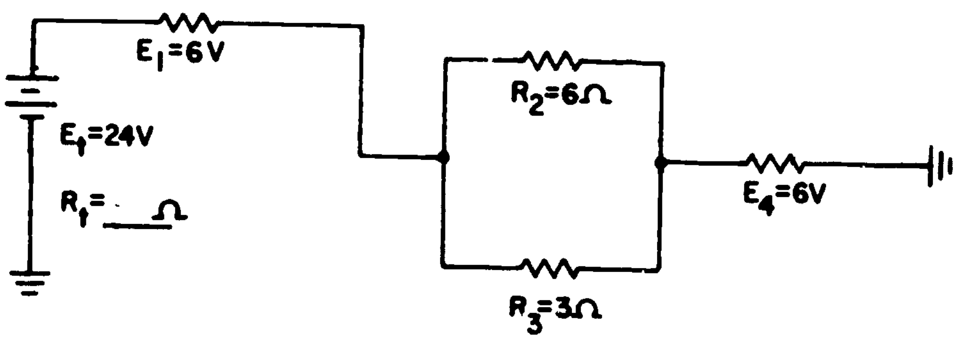
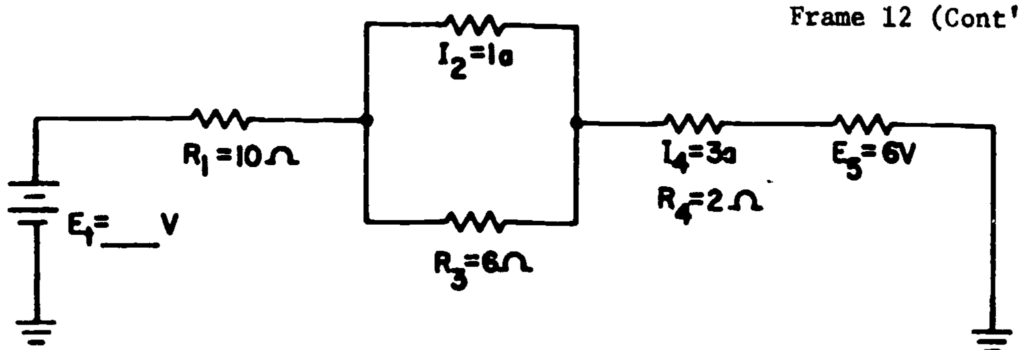


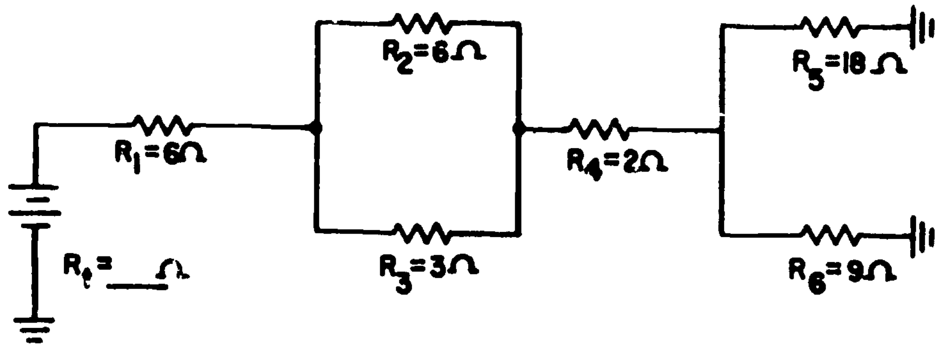
3



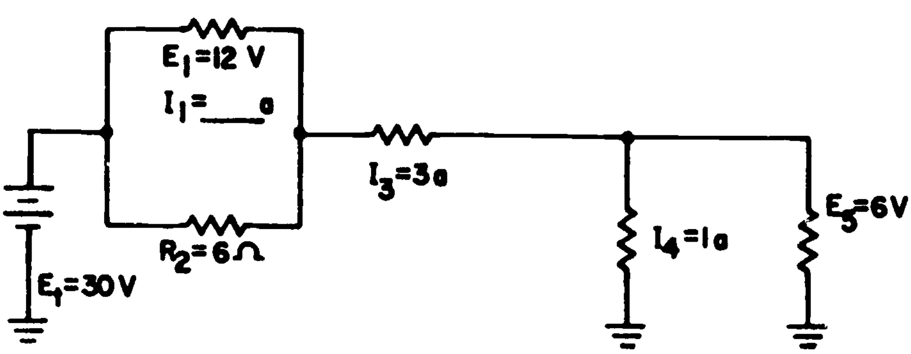
4.


I_2=1a
R_1=10Ω
I_4=3a
R_4=2Ω
E_5=6V
E_t=___V
R_3=6Ω

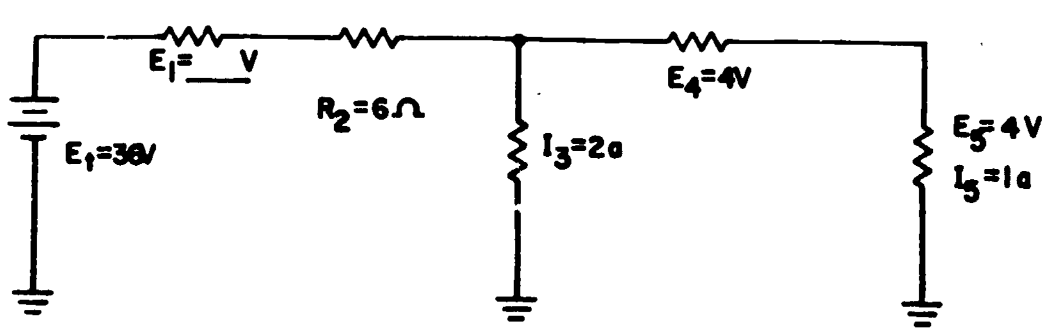
5.


R_2=6Ω
R_5=18Ω
R_1=6Ω
R_4=2Ω
R_t=___Ω
R_3=3Ω
R_6=9Ω

6.

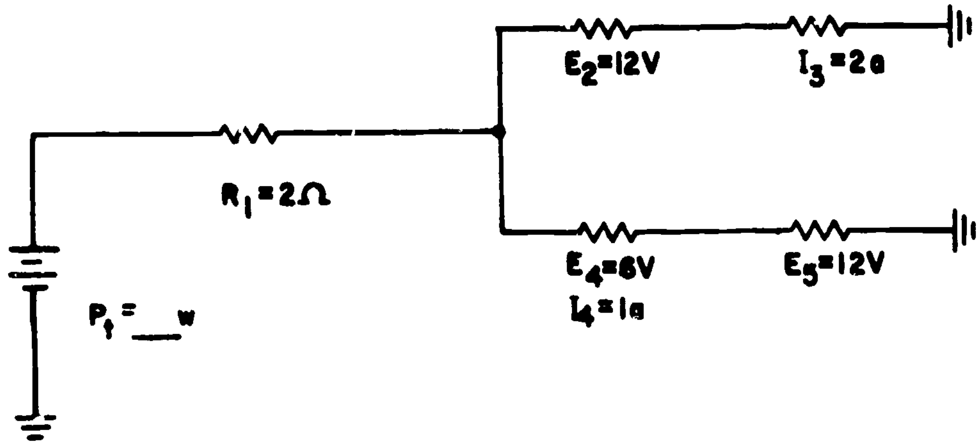

E_1=12 V
I_1=___a
I_3=3a
E_5=6V
I_4=1a
R_2=6Ω
E_t=30 V

7.

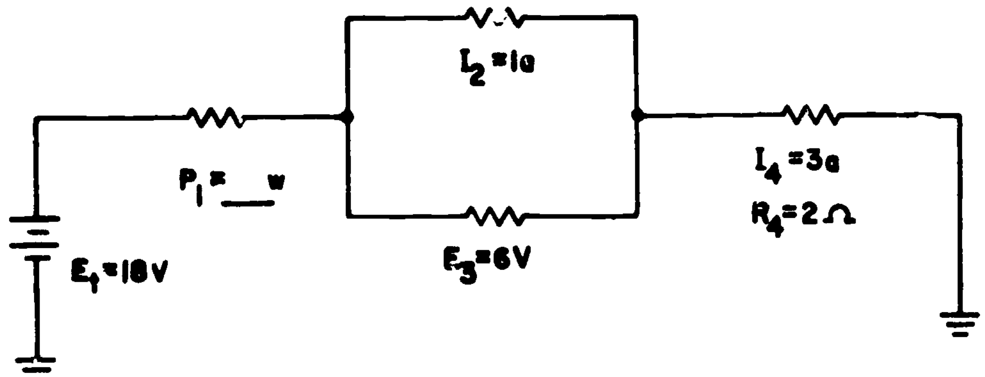

E_1=___V
R_2=6Ω
E_4=4V
E_5=4 V
I_5=1a
I_3=2a
E_t=36V

Frame 12 (cont'd)

8.



9.



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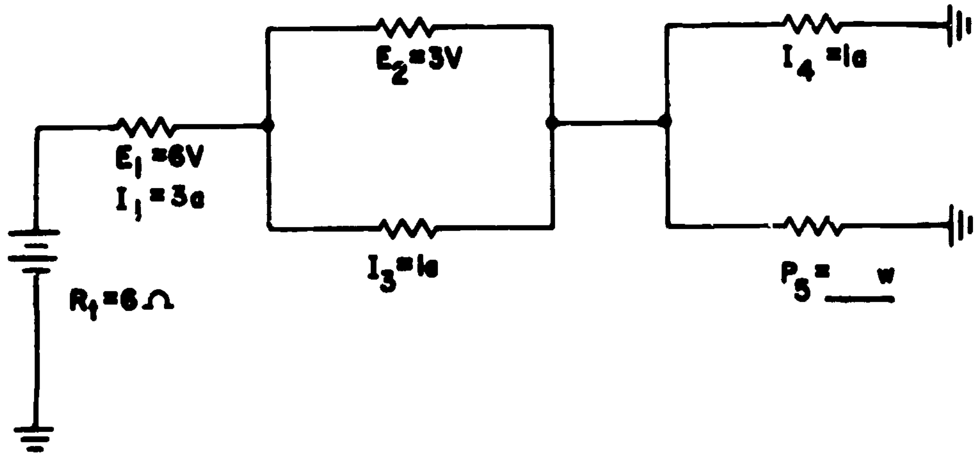

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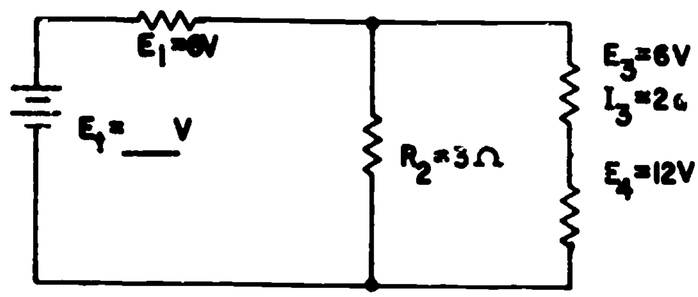
Answers to Frame 12: 1. 6v, 2. 12v, 3. 4 ohms, 4. 54V 5. 16 ohms, 6. 1a 7. 10v 8. 72W, 9. 18W, 10. 18W

Frame 13

Solve each of the following problems for the indicated unknown. Put your answers on the appropriate blanks.

1.



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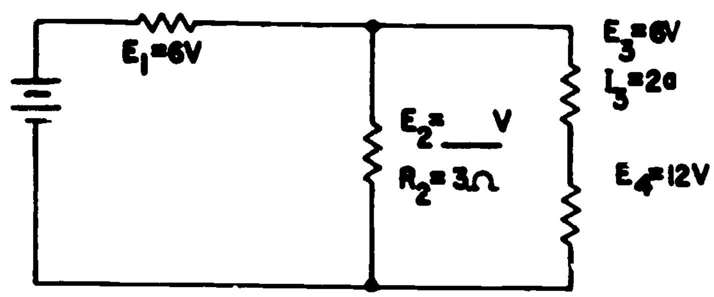

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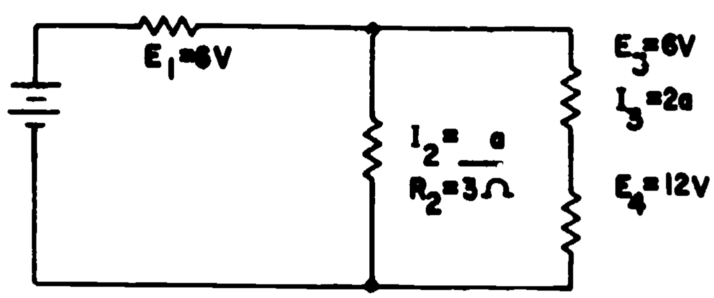

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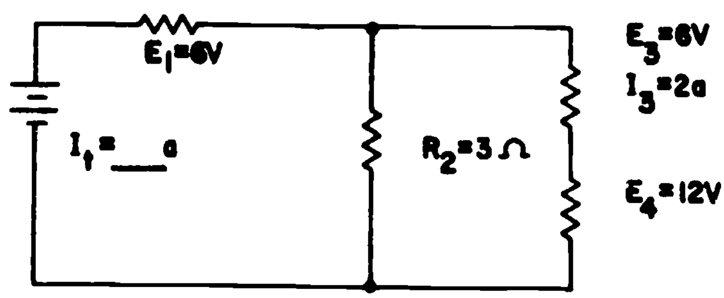
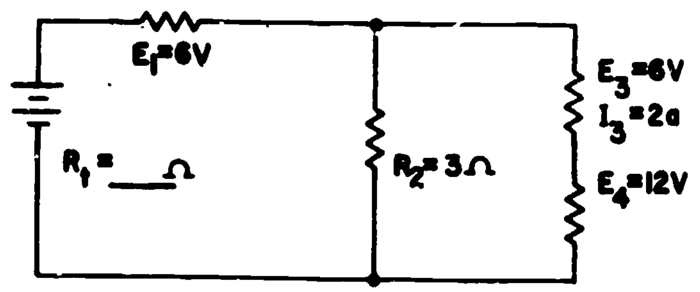
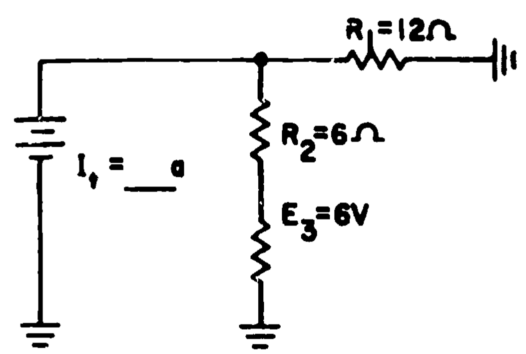


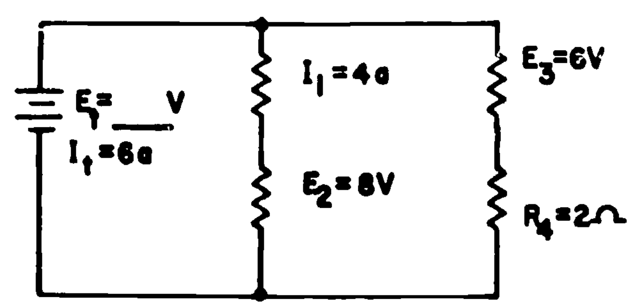
5.



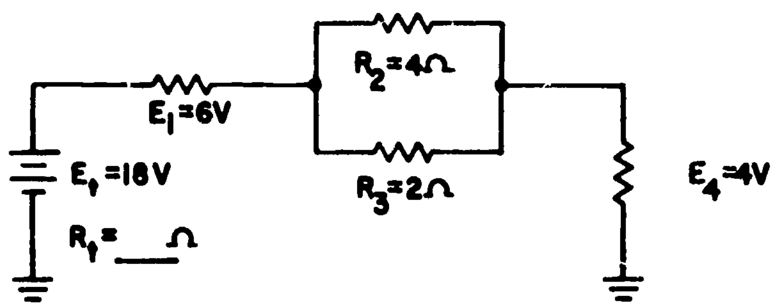
6.


E1 = 24V
R1=12Ω
R2=6Ω
E3=6V
It = ___ a

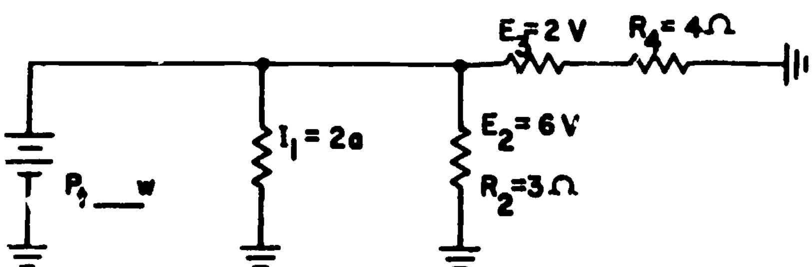
7.


Et= ___ V
It=6a
I1=4a
E2=8V
E3=6V
R4=2Ω

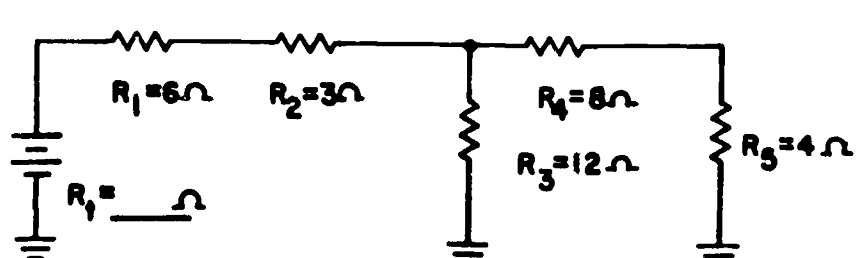
8.


E1=6V
R2=4Ω
R3=2Ω
Et=18V
Rt= ___ Ω
E4=4V

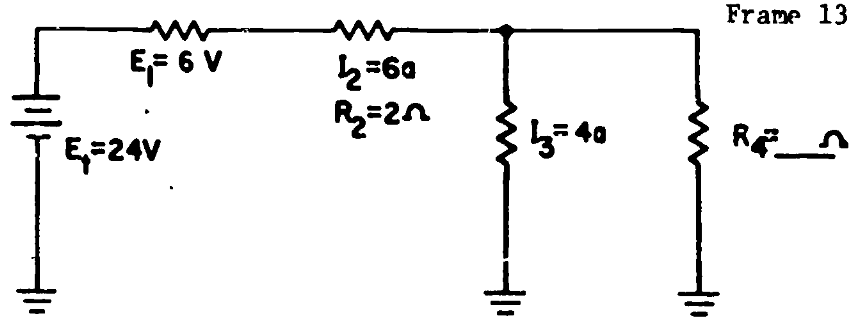
9.


E3=2 V
R4= 4Ω
I1= 2a
E2= 6 V
R2=3Ω
Pt ___ w

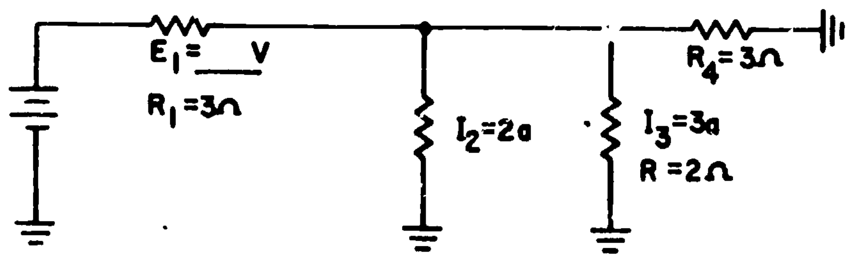
10.


R1=6Ω
R2=3Ω
R4=8Ω
R3=12Ω
R5=4Ω
Rt= ___ Ω

11.



12.



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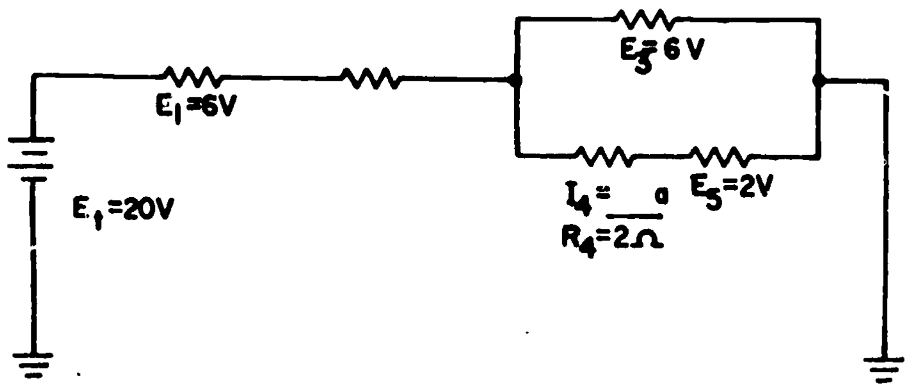
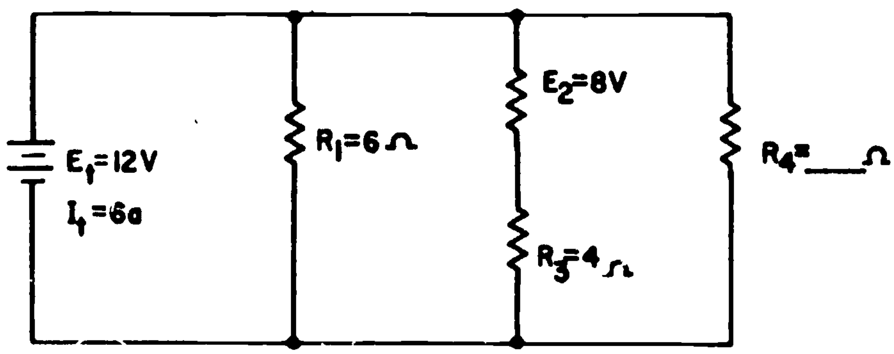
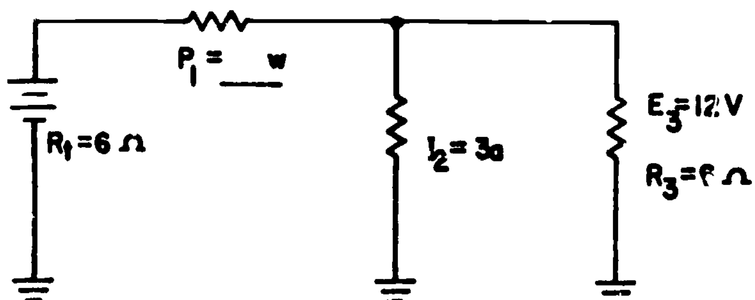


14.



15.



Have the instructor check your answers.

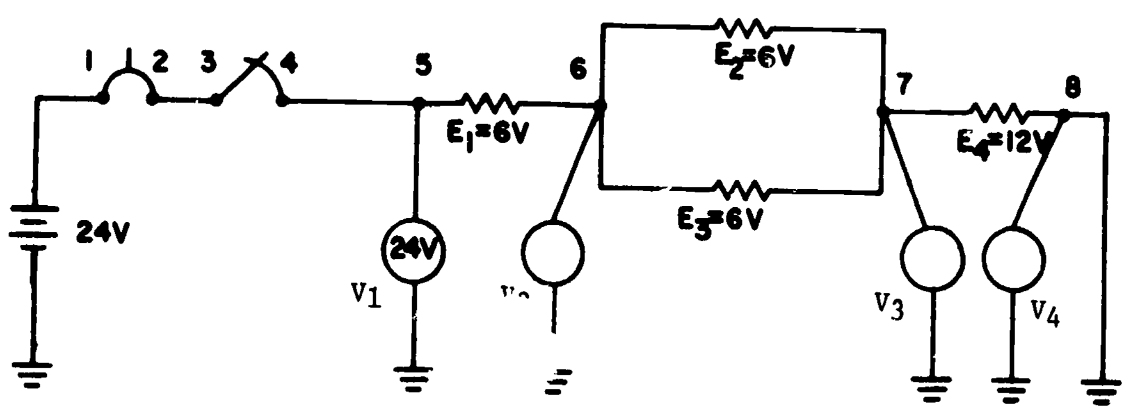
Instructor's Initials __________

Frame 14

The rest of this PT deals with troubleshooting. In order to troubleshoot you must know what the readings are in a good circuit. In the circuit shown the readings at points 1, 2, 3, 4, and 5 should all be 24V. Let's see why! For example, trace a path from the negative side of the battery through the voltmeter (V_1) at point 5 and back to the positive side of the battery. The only item in this path is the voltmeter (V_1). Thus, the voltmeter would read 24V. The same is true for points 1, 2, 3, and 4. Now trace a path from the negative side of the battery through the voltmeter (V_2) connected at point 6 and back to the positive side of the battery. In this path there are two items (the voltmeter and R_1). Since R_1 uses 6V, the voltmeter must read 18V. Fill in 18V for the voltmeter (V_2) at point 6 on the response sheet.

> Note: Voltage is a pressure that moves electrons through a resistance. The resistance will use up either all the voltage or part of it in doing its task in the circuit. In this circuit E, used 6 volts of the 24 volts with a remainder of 18 volts of pressure being applied between point 6 and the circuit ground.

Using Kirchhoff's voltage law determine what the meter would read at points 7 and 8. Fill in your answers in the circuit shown.

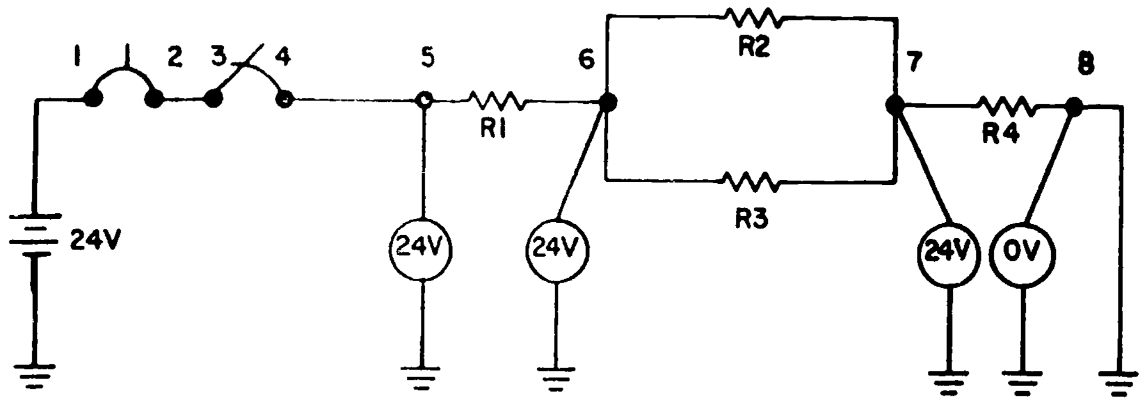


877

Answers to Frame 14: V_3 = 12V, V_4 = 0V

Frame 15

An open is an incomplete path for current to flow. In the circuit shown we have good readings at points 5 and 8. The readings at point 6 and 7 are abnormal. Even though the readings at points 6 and 7 are abnormal, we know that we have a complete path from the positive battery terminal to point 7 since the voltmeter needle is deflecting. The abnormal reading of 24V at point 7 indicates that the difference in potential across R_4 is 24V and there is an incomplete current path between here and ground. In this case R_4 is open.



Mark the following true statement(s) with a "T".

_____ 1. A voltmeter connected between points 5 and 6 would read 0V.

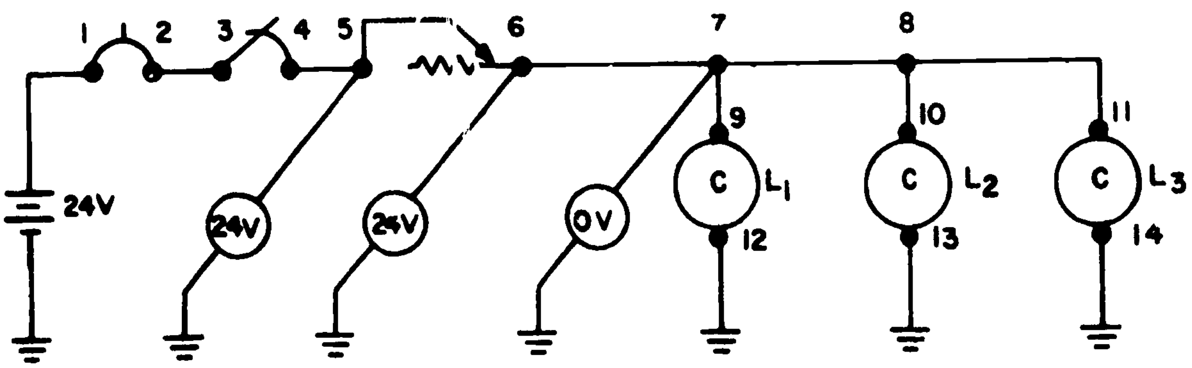
_____ 2. A voltmeter connected between points 6 and 7 would read 24V.

_____ 3. A voltmeter connected between points 7 and 8 would read 24V.

Answers to Frame 15: 1. T, 2. ___, 3. T

Frame 16

In the circuit shown all lamps* are inoperative. Since none of the lamps work, the open would be between points 1 and 7. If the open was anywhere else in the circuit, one or more of the lamps would be lit. The 24V reading at point 6 indicates that there is a complete path to point 6. The 0V reading at point 7 indicates that there is an open between points 6 and 7.



For each of the following malfunction indications, indicate on the blank the possible open components that could be the cause. Write your answers in the space provided. Number 1 has been done as an example.

1. L_1 is inoperative. 7 & 9, 9 & 12 (L_1), 12 & ground.
2. L_2 is inoperative. ____________________
3. L_3 is inoperative. ____________________
4. L_2 and L_3 are inoperative. ____________________

*Note: Lamps in this text are identified by the letters L_1, L_2, L_3, etc., or, by an applicable symbol. Those drawn as a simple circle with a letter inside denote its color; e.g., C for clear, R for red, etc.

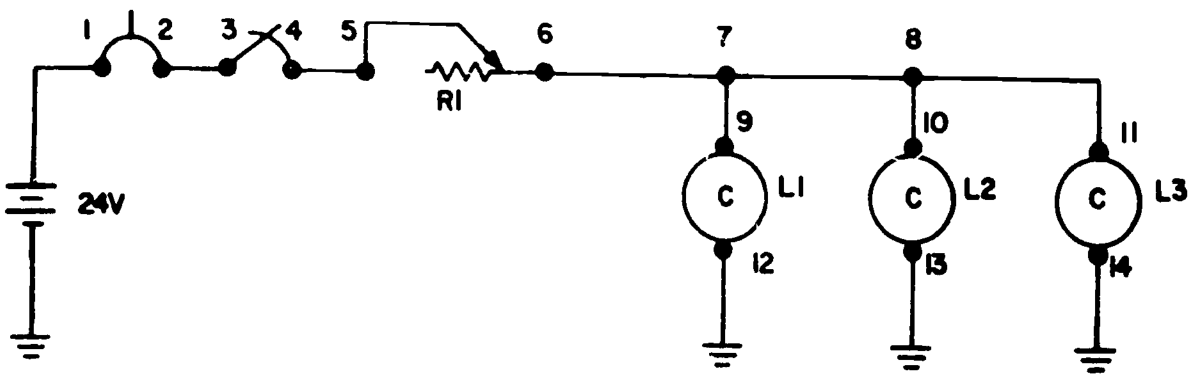
Answers to Frame 16: 2. 8 & 10, 10 & 13 (L_2), 13 & ground

3. 8 & 11, 11 & 14 (L_3), 14 & ground 4. 7 & 8

Frame 17

Before taking readings or analyzing readings in a circuit you should consider the possible components that could cause the circuit malfunction.

Using the circuit shown, determine the type of trouble and the faulty component for each of the following problems. Put your answers on the appropriate blanks. The first one has been done for you to show you how to do it.



1. L_1 is inoperative. A voltmeter connected between point 7 and ground reads 24V. A voltmeter connected between point 9 and ground reads 0V.
   Open 7 & 9

2. L_2 and L_3 are inoperative. A voltmeter connected from 8 to ground reads 0V.

   ____

3. All lamps are inoperative. A voltmeter connected from 5 to ground reads 24V. A voltmeter connected from 6 to ground reads 0V.

   ____

4. All lamps are inoperative. A voltmeter connected from points 1, 2, and 3 to ground reads 24V. A voltmeter connected from point 4 to ground reads 0V.

   ____

5. L_3 is inoperative. A voltmeter connected from 8, 11, and 14 to ground reads 24V.

   ____

Answers to Frame 17: 2. open 7 & 8, 3. open 5 & 6 (R_1), 4. open 3 & 4 5. open 14 & ground

Frame 18

The normal circuit readings are given in figure 1 below. From these readings should see that the voltage drop across R_1 is equal to 6V. (24 - 18 = 6V.) The drop across each lamp is 18V. (18 - 0 = 18V.)

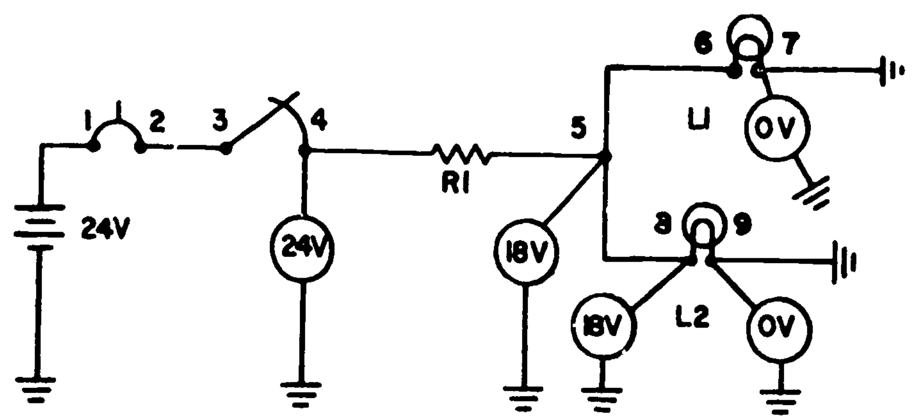


Figure 1.

Now let's see what the readings would be if L_2 burned out. This is shown in figure 2. Since there is still a complete path in the circuit, there will be current flowing through L1 and R_1. Since there is current flowing through R_1, there will be a voltage drop across it. Thus, even though L_2 is open, the difference in potential across it will not be equal to the applied voltage (24V). If you had not been told that L_2 was open, you could still determine this from the readings given. Since there is a difference in potential across the L2 and it is not lit, the lamp must be open.

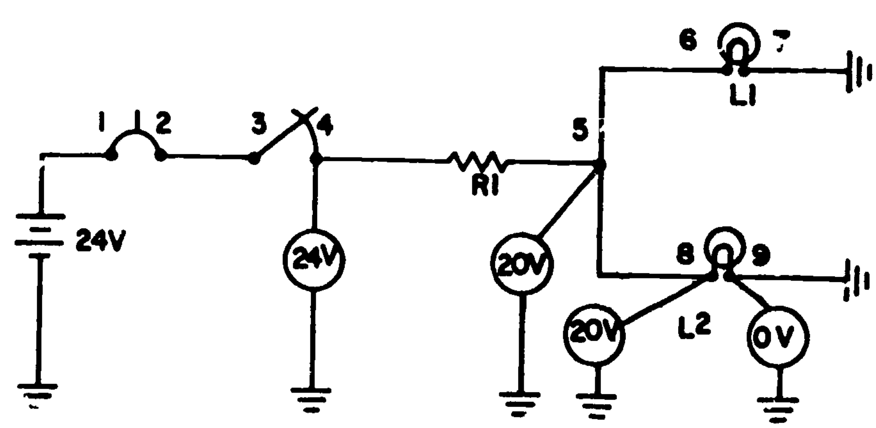


Figure 2.

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Mark the correct answer for each of the following questions.

_____ 1. If R_1 was open in figure 1, the voltmeter would read 0V at point

a. 1

b. 2

c. 3

d. 5

_____ 2. If the wire between points 5 and 8 was open in figure 1, the voltmeter would read 0V at point

a. 1

b. 3

c. 5

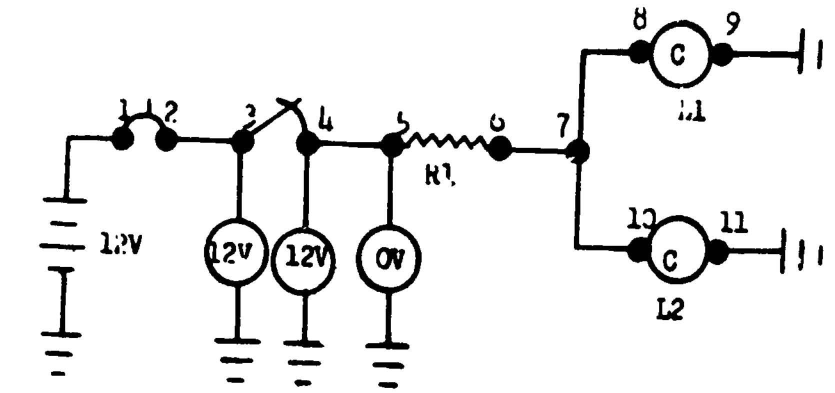
d. 8

Answers to Frame 18: 1. d, 2. d

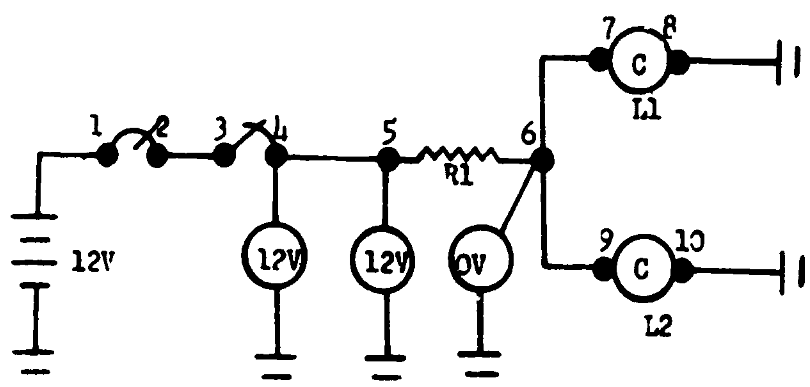
Frame 19

Analyze the meter readings and circuit indications in each of the following circuits. On the blank provided by each circuit list the type of trouble and the faulty component. The first one was done for you as an example.

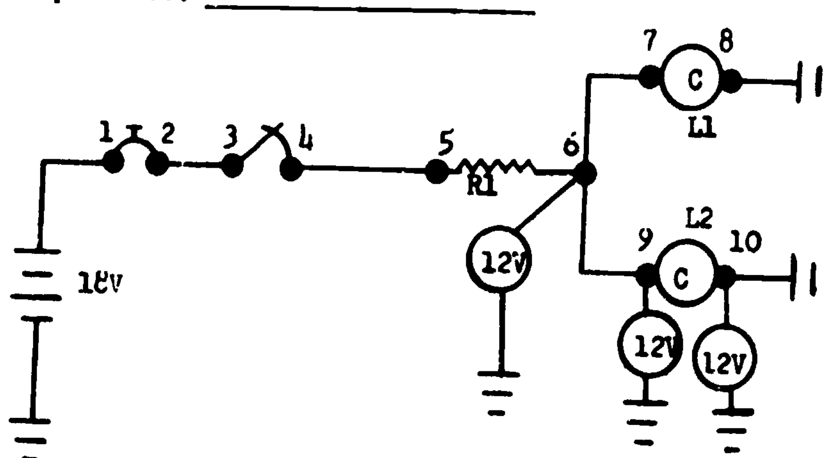
1. Both lamps inoperative. Open 4-5



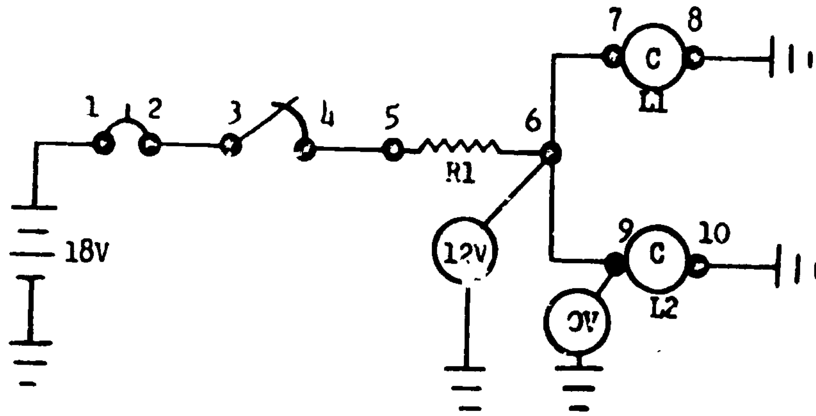
2. Both lamps inoperative ______________



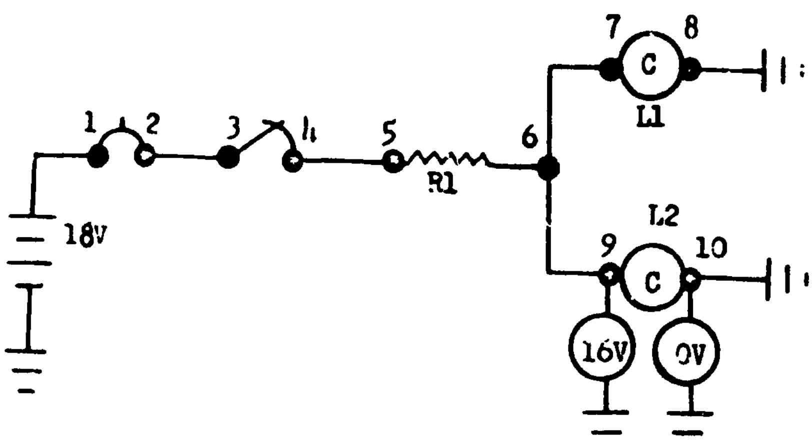
3. L_2 is inoperative. ______________



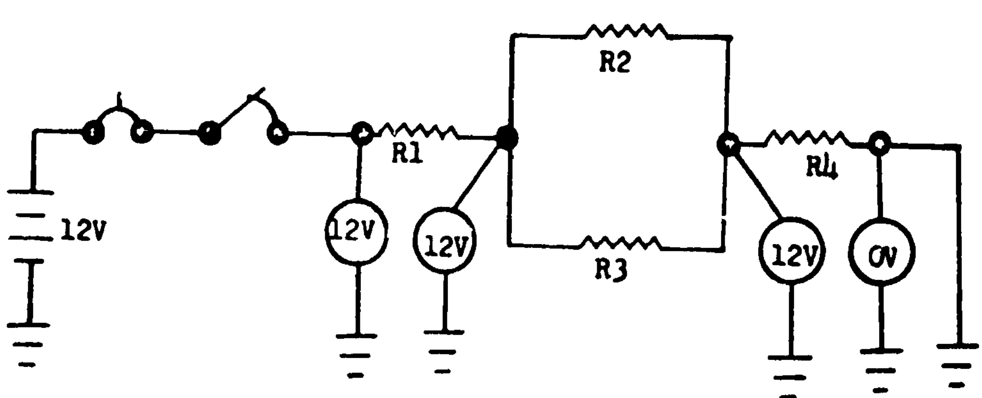
4. L_2 is inoperative. ______________________



5. L_2 is inoperative. ______________________



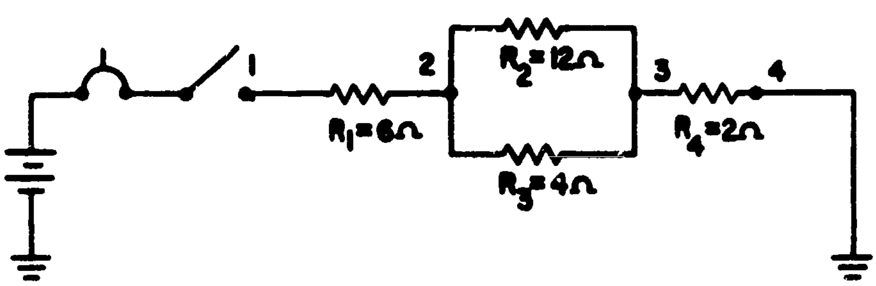
6. ______________________________________



Answers to Frame 19: 2. open 5-6 (R_1), 3. open 10 to ground, 4. open 6-9
5. open 9-10 (L_2) 6. open R_4

Frame 20

An open can also be located with an ohmmeter. The ohmmeter has its own source of power and should not be used in a live circuit. Before we use an ohmmeter for troubleshooting let's see what readings the ohmmeter would indicate in a normal circuit. We will use the circuit shown below. An ohmmeter connected from point 4 to ground should read 0 ohms because the resistance of the ground wire will be 0 ohms. An ohmmeter connected from point 3 to ground should read 2 ohms, the resistance of R_4. What should the ohmmeter read when connected at point 2? If you said 5 ohms, you are correct. When the ohmmeter is connected to point 2 it reads through R_2, R_3, and R_4. Since R_2 and R_3 are in parallel with each other we need to compute their series equivalent resistance. Using the product-over-the-sum formula we find this to be 3 ohms. Add this value to the value of R_4 and we find that the ohmmeter would read 5 ohms at point 2.



Mark the correct statement(s) below with a "T."

_____ 1. An ohmmeter connected from point 1 to ground would read 11 ohms.

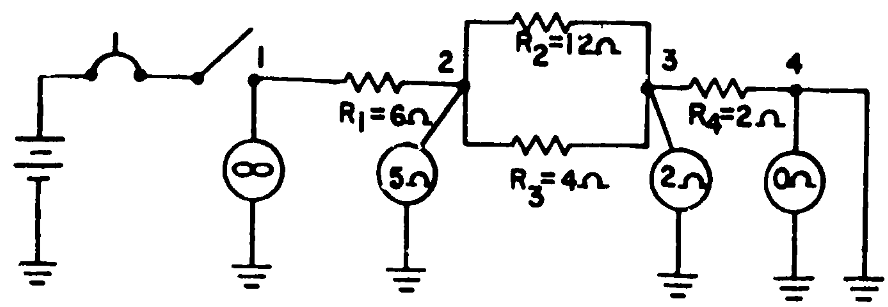
_____ 2. An ohmmeter connected from point 1 to point 2 would read 11 ohms.

_____ 3. An ohmmeter connected from point 2 to point 3 would read 16 ohms.

Answers to Frame 20: 1. T, 2. ___, 3. ___

Frame 21

Let's get some practice troubleshooting with an ohmmeter. In the circuit shown below we have given you ohmmeter readings at different points in the circuit. In order to have needle deflection, you must have current flowing through the movement. If no current is flowing through the movement, the needle will indicate infinity (∞). A reading of 0 ohms at point 4 indicates that the ground wire is good. The readings at point 3 and point 2 indicate that there is a complete path to point 2. When the ohmmeter is connected to point 1, the needle doesn't deflect. This indicates that no current is flowing through the ohmmeter when it is connected to point 1. Since we had a complete path up to point 2 and didn't have one up to point 1, there must be an open between points 1 and 2. In this case R_1 is open.



Mark the correct answer below for each of the following questions.

_____ 1. If an ohmmeter was connected around R_1 (points 1 and 2), the ohmmeter would read infinity (∞) indicating that R_1 is

a. closed.

b. open.

_____ 2. If R_4 was open, an ohmmeter connected from point 3 to point 4 would read

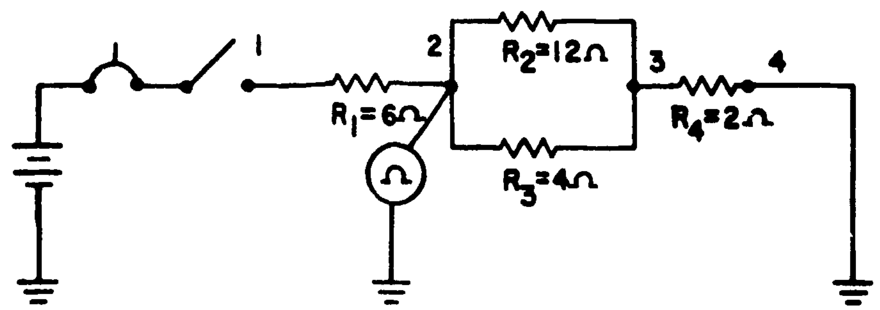
a. 0 ohm.

b. infinity.

Answers to Frame 21: 1. b, 2. b,

Frame 22

We will use the same circuit that we used in the last two frames. Let's see what the reading at point 2 would be if R_2 became open. With R_2 open, the ohmmeter would read through R_3 and R_4. Since R_2 is open, R_3 and R_4 are connected in series with each other and the ohmmeter will read 6 ohms (4 + 2).



Mark the following true statement(s) with a "T".

_____ 1. If R_3 had been open instead of R_2, the ohmmeter at point 2 would read 14 ohms.

_____ 2. If R_3 had been open instead of R_2, an ohmmeter at point 1 would read 6 ohms.

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Answers to Frame 22: 1. T, 2. ___

Frame 23

In some cases you will need to isolate the branches of the parallel part in order to determine the faulty component. For example, in the circuit shown below we have a 6 ohm reading at point 5. This indicates that the ohmmeter is reading through only one of the parallel branches and means one of the parallel branches has an open in it.

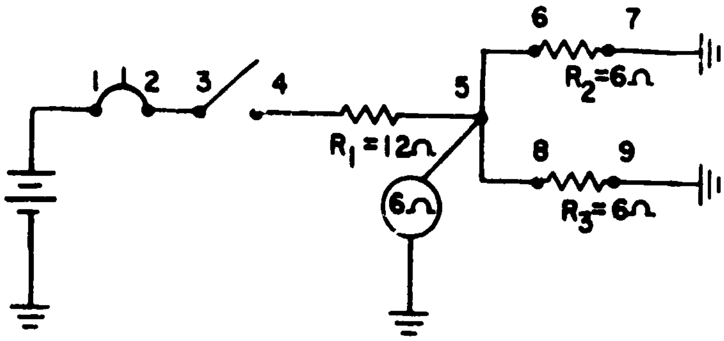


Figure 1.

To isolate the branches we would need to only disconnect one of the branches. This is shown below. We took readings at the points indicated. The ground wire for R_3 is good as indicated by the 0 ohm reading. The infinity reading at point 8 indicates that R_3 is open.

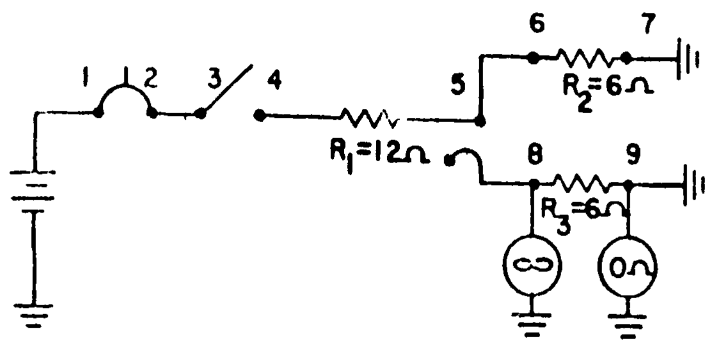


Figure 2.

Mark the following true statement(s) with a "T".

_____ 1. An ohmmeter connected around a good ground wire should read 0 ohms.

_____ 2. An ohmmeter connected around an open will read ∞.

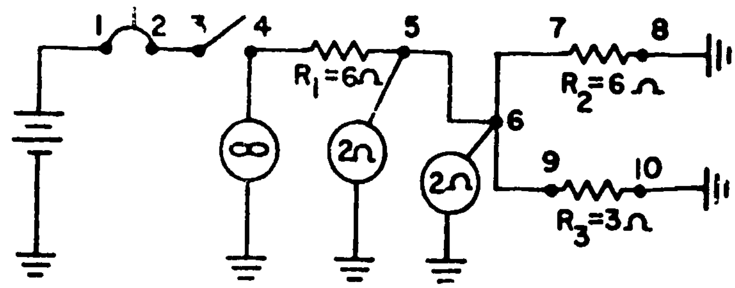
_____ 3. An ohmmeter connected at point 4 in figure 1 would read 12 ohms.

Answers to Frame 23: 1. T, 2. T, 3. ___

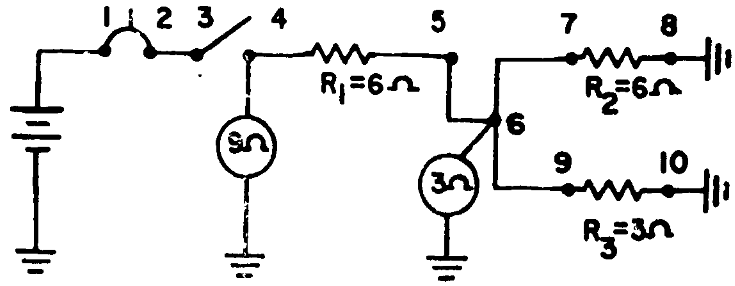
Frame 24

Analyze the meter readings in each of the following circuits. On the blanks provided by each circuit list the type of trouble and the faulty component. The first one has been done for you to show you how. Look at the answer and compare it to the meter readings.

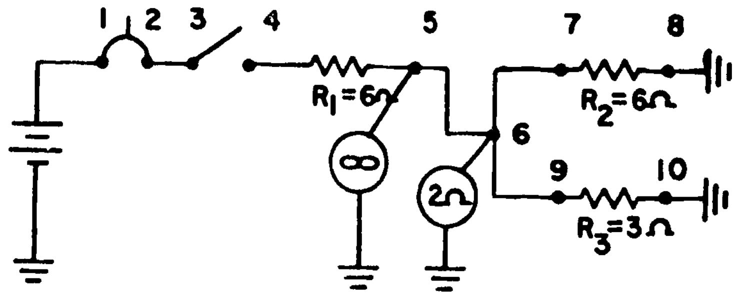
1. Open 4-5 (R_1)



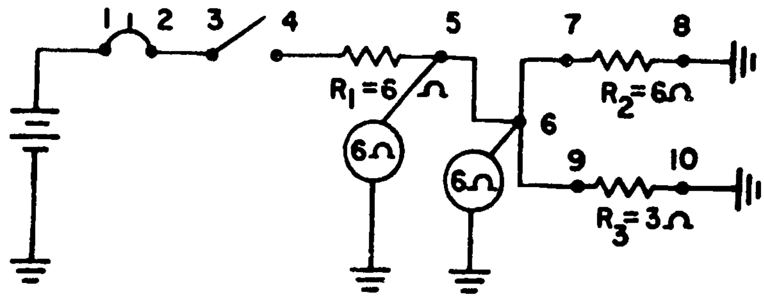
2. ______________________



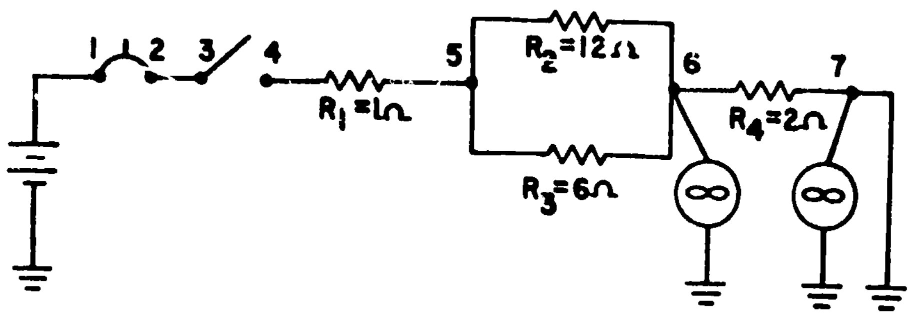
3. ______________________



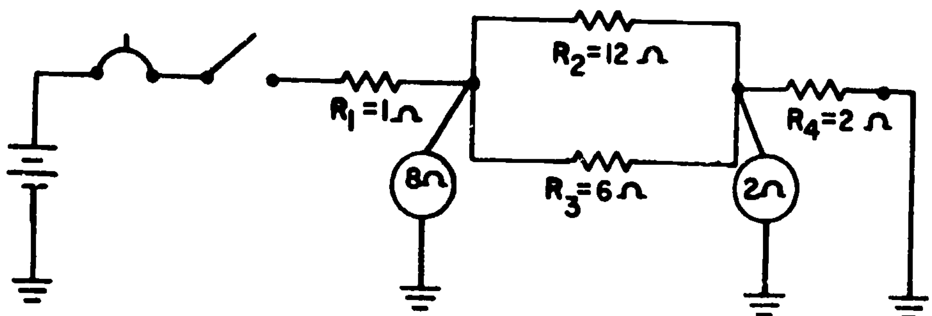
4. ______________________



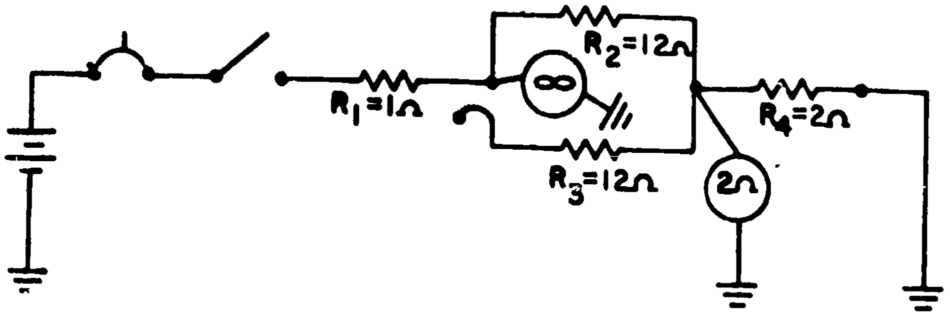
5. ______________________________


1
2
3
4
5
6
7
R_1=1Ω
R_2=12Ω
R_3=6Ω
R_4=2Ω
∞
∞

6. ______________________________


R_1=1Ω
R_2=12 Ω
R_3=6Ω
R_4=2 Ω
8Ω
2Ω

7. ______________________________

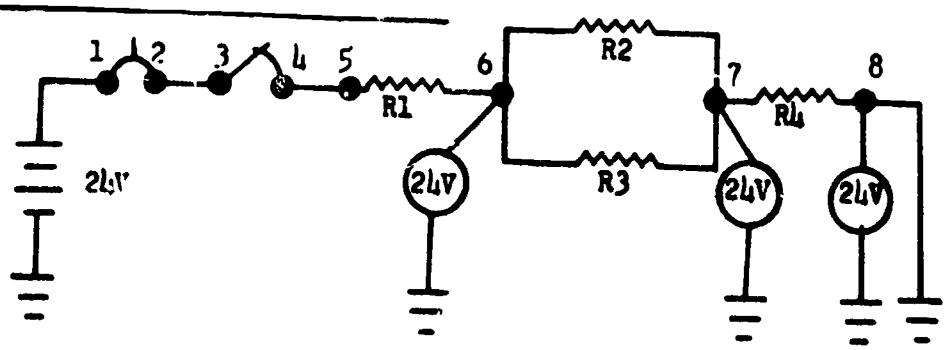

R_1=1Ω
R_2=12Ω
R_3=12Ω
R_4=2Ω
∞
2Ω

Answers to Frame 24: 2. open 6-7, 7-8, or 8 to ground, 3. open 5-6, 4. open 6-9, 9-10 or 10 to ground 5. open 7 to ground, 6. open R_2, 7. open R_2

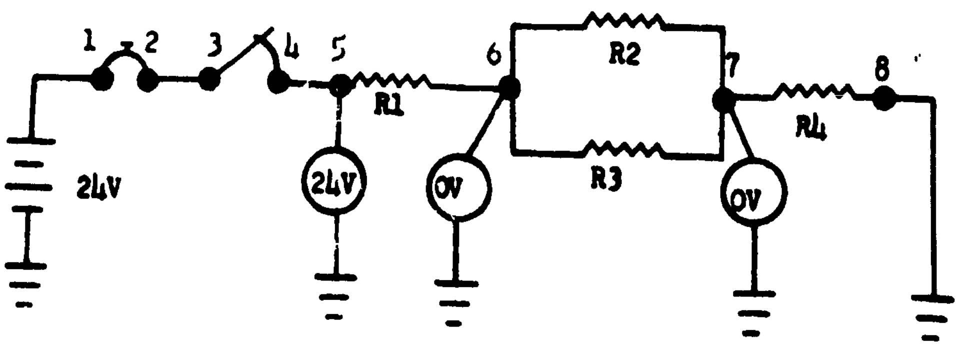
Frame 25

Analyze the meter readings and circuit indications in each of the following circuits. Using the blank provided by each circuit, list the type of trouble and faulty component. Have your instructor check your work when you have finished all nine problems.

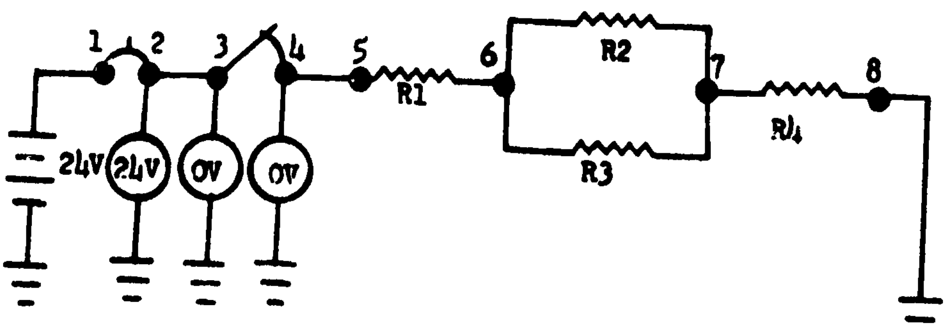
1. ______________________________



2. ______________________________



3. ______________________________



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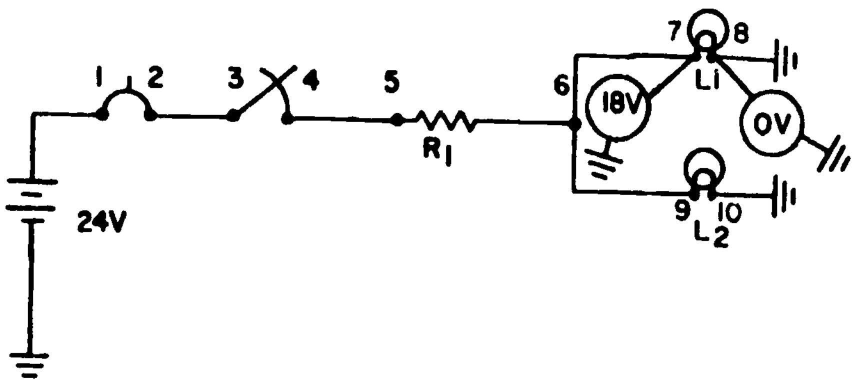
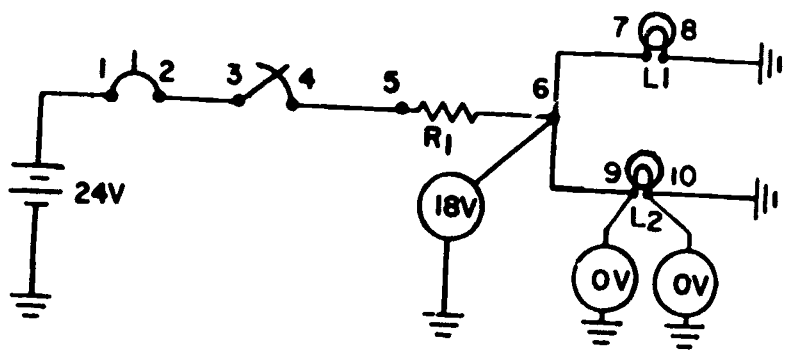
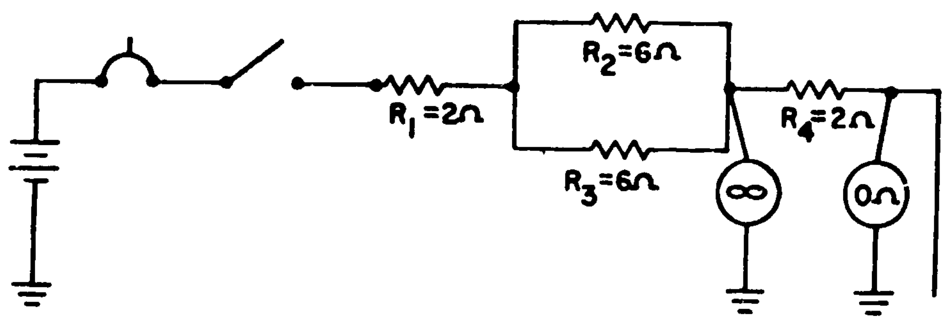
4. L_1 is inoperative. ______________



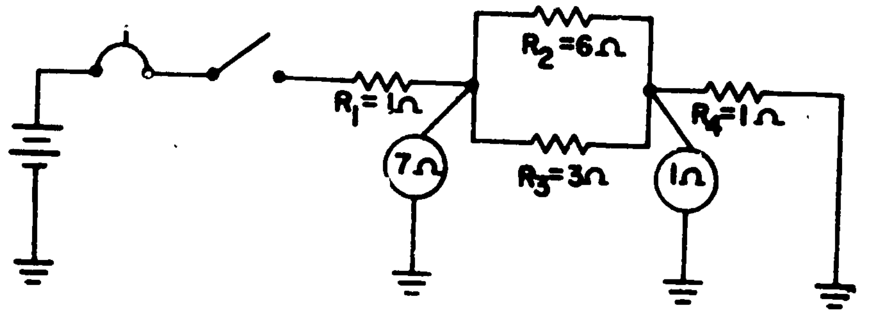
5. L_2 is inoperative. ______________



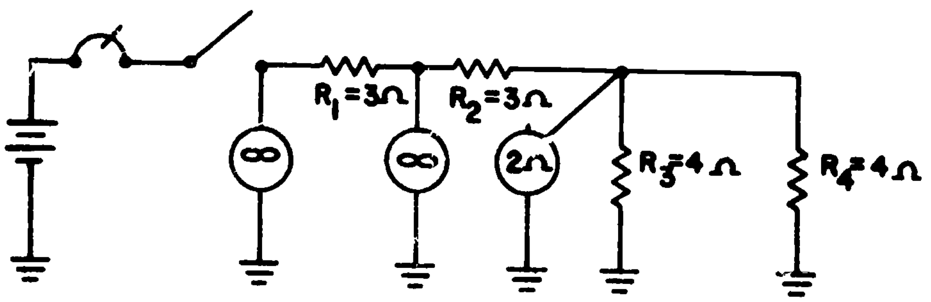
6. ______________ ______________



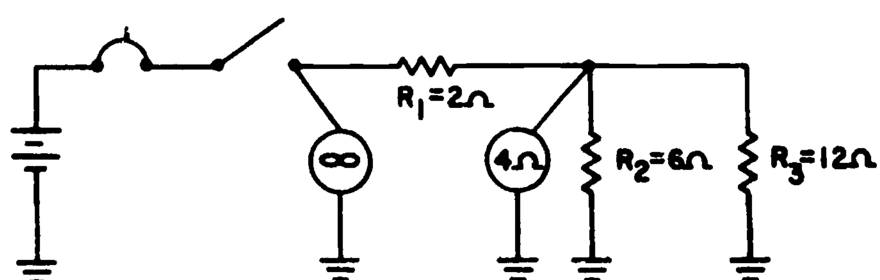
7. ______________________________



8. ______________________________



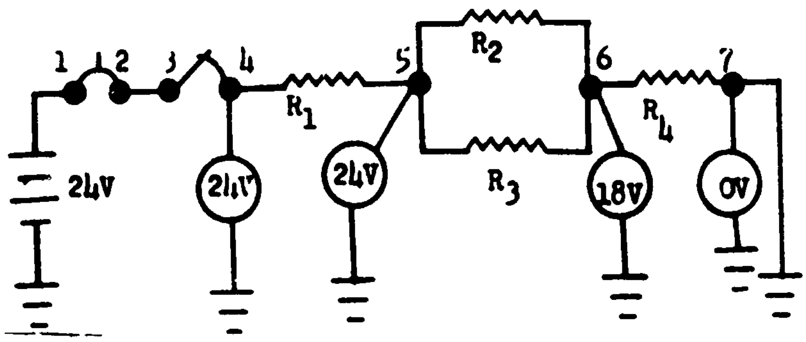
9. ______________________________



Have the instructor check your answers.

Instructor's Initials ____________

A short circuit is an accidental path of low resistance which passes an abnormal amount of current. Each load unit in a circuit should drop some of the applied voltage. If the load unit is shorted the current will bypass the load unit and flow through the low resistance path. With no current flowing through the load unit, it will not have any voltage dropped across it. In the circuit below we have given you readings at different points. Which resistor does not have a difference in potential across it? If you said R_1, you are correct. Let's see why! The potential at point 4 is 24V and the potential at point 5 is 24V. Thus, there is no difference in potential across R_1. Look at the rest of the circuit. R_2 and R_3 are dropping 6V. R_4 is dropping 18V. There is current flowing in the circuit. Since there is no difference in potential across R_1 and there is current flowing in the circuit, R_1 is shorted.



Mark the correct answer below for each of the following questions.

_____ 1. A voltmeter connected between points 4 and 5 would read

a. 0 volts.

b. 24 volts.

_____ 2. A voltmeter connected between points 5 and 6 would read

a. 24 volts.

b. 18 volts.

c. 6 volts.

_____ 3. The difference in potential across a shorted resistor is

a. 24 volts.

b. 18 volts.

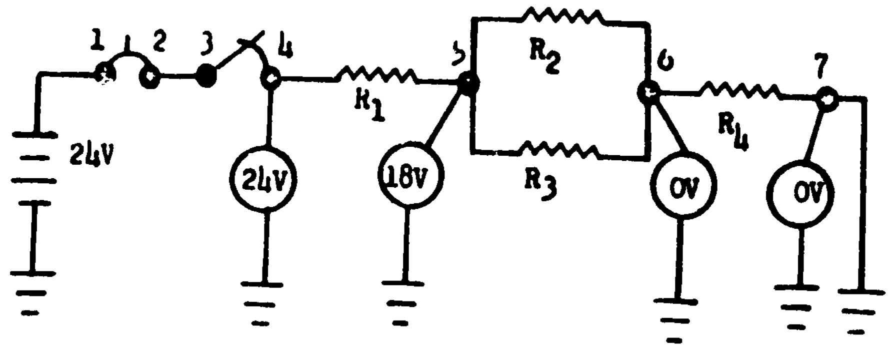
c. 6 volts.

d. 0 volts.

Answers to Frame 26: 1. a, 2. c, 3. d

Frame 27

In the circuit shown we have given you readings at different points. Let's find the faulty component. The difference in potential across R_1 is 6V. The difference in potential across the parallel part (R_2 and R_3) is 18V. The difference in potential across R_4 is 0V making the resistance of R_4 0 ohms. Since there is voltage dropped on R_1, R_2, and R_3, we know there is current flowing through them. Since there is current flowing in the circuit, but no voltage is dropped across R_4, R_4 must be shorted.



Mark the following true statement(s) with a "T".

_____ 1. The difference in potential across a shorted resistor is 0V.

_____ 2. A voltmeter connected between points 4 and 6 would read 24V.

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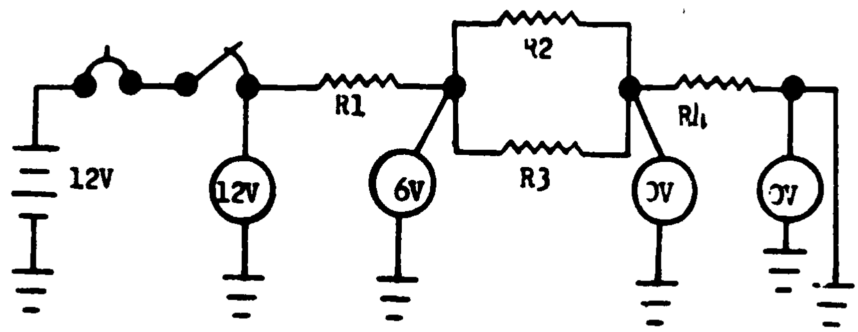
Answers to Frame 27: 1. T, 2. T

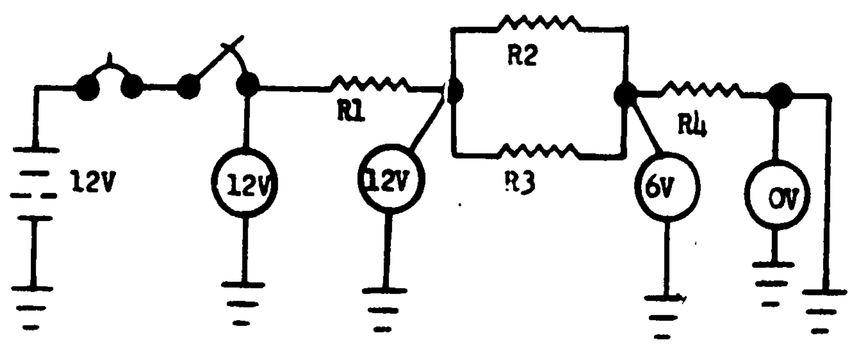
Frame 28

Analyze the meter readings in each of the following circuits. Using the blank on the response sheet provided for each circuit, list the type of trouble and the faulty component. The first one has been done for you to show how you should record your answer. Use the answer listed and determine why it is right by analyzing the meter readings.

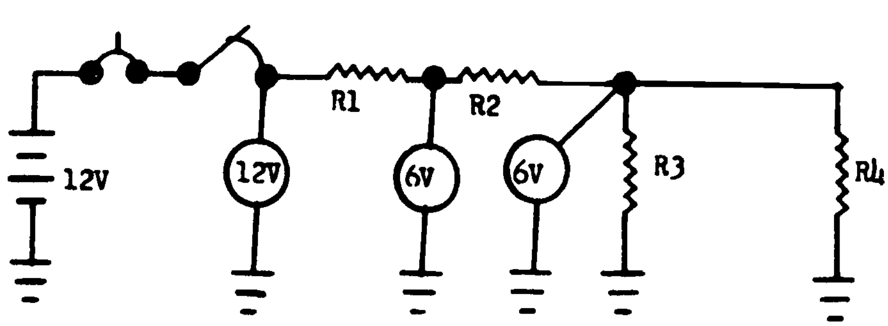
1. Short R_4



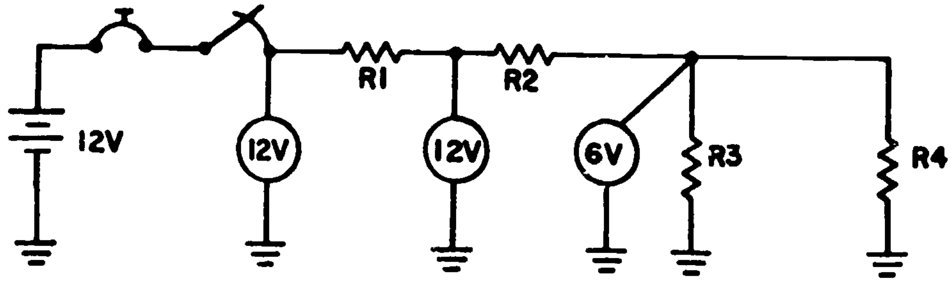
2. ______________________



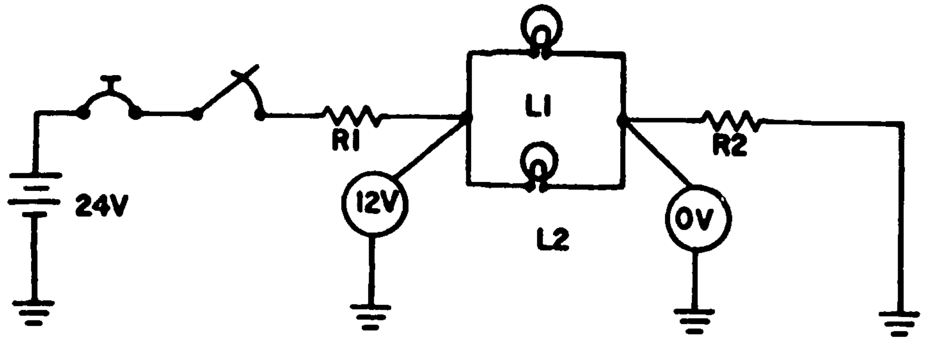
3. ______________________



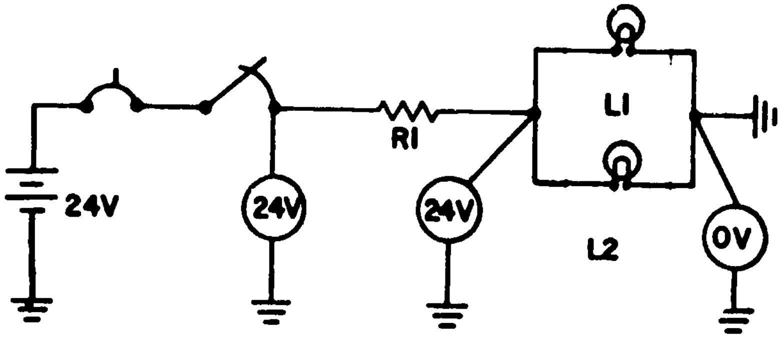
4. ____________________


12V
12V
12V
6V
R1
R2
R3
R4

5. ____________________


24V
R1
12V
L1
L2
R2
0V

6. ____________________


24V
24V
24V
R1
L1
L2
0V

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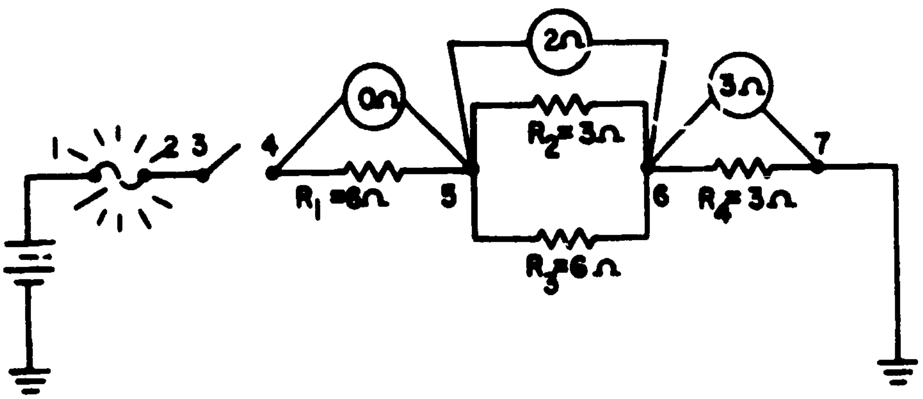
Answers to Frame 28: 2. short R_1, 3. short R_2, 4. short R_1, 5. short R_2, 6. short R_1

Frame 29

Many times a short circuit will cause the fuse to blow. When this happens you will need to use an ohmmeter to find the faulty component. Since a shorted resistor has a 0 ohm resistance path, an ohmmeter connected around a shorted resistor will read 0 ohms. In the circuit below we have taken ohmmeter readings across each resistor. Which resistor is shorted? R_1 is shorted since the ohmmeter connected around it reads 0 ohms.



Mark the following true statement(s) with a "T".

_____ 1. An ohmmeter connected from point 7 to ground should read 3 ohms.

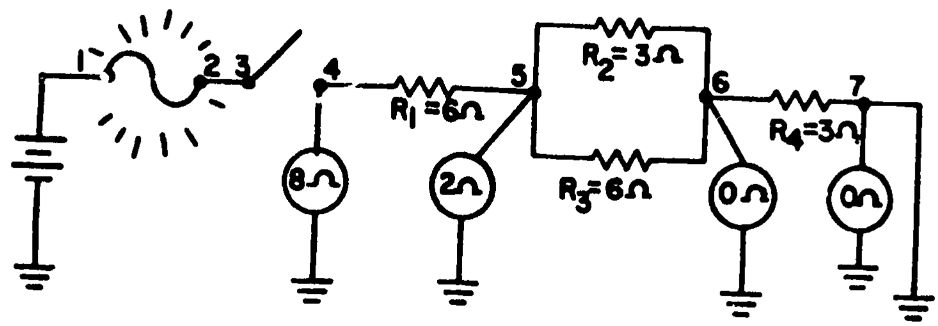
_____ 2. An ohmmeter connected from point 5 to ground should read 12 ohms.

_____ 3. An ohmmeter connected from point 4 to ground would read the same as one connected from point 5 to ground if R_1 was shorted.

Answers to Frame 29: 1. ___, 2. ___, 3. T

Frame 30

In the circuit shown we need to find why the fuse has blown. The reading at point 7 should be 0 ohms since we are just measuring the resistance of the ground wire. The reading at point 6 should be 3 ohms since we are just checking the resistance of the ground wire and R_4. However, the reading at point 6 is 0 ohms. This indicates that R_4 is shorted.



Mark the correct answer below for each of the following questions.

_____ 1. You probably have a short somewhere in the circuit if the

a. switch closes.

b. fuse blows.

c. ground opens.

_____ 2. An ohmmeter connected between points 4 and 5 read

a. 0 ohms.

b. 3 ohms.

c. 6 ohms.

_____ 3. An ohmmeter connected between points 5 and 6 read

a. 2 ohms.

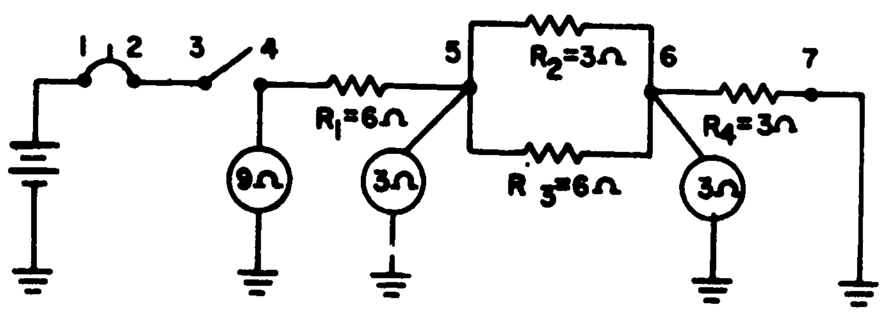
b. 3 ohms.

c. 6 ohms.

Answers to Frame 30: 1. b, 2. c, 3. a

Frame 31

The reading at point 6 indicates that R_4 is good. What does the reading of 3 ohms at point 5 indicate? If you said a short in R_2 or R_3, you are correct. Let's see why! If either R_2 or R_3 is shorted, they are in effect both shorted as the resistance of the parallel part would be 0Ω. In order to find which resistor is shorted, we would need to isolate R_2 and R_3.



Mark the following true statement(s) with a "T".

_____ 1. An ohmmeter connected between points 5 and 6 would read 0 ohms.

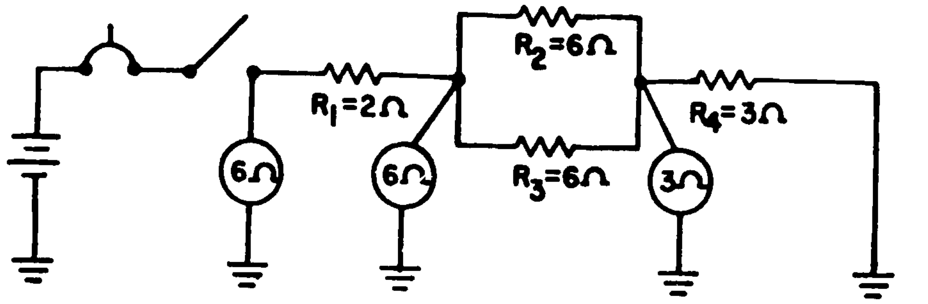
_____ 2. An ohmmeter connected from point 7 to ground should read 0 ohms.

Answers to Frame 31: 1. T 2. T

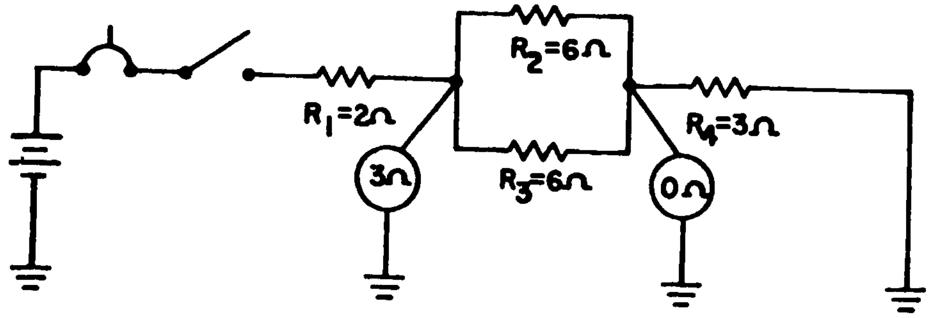
Frame 32

Analyze the meter readings in each of the following circuits. Using the blank provided for each circuit list the type of trouble and the faulty components. The first one has been done for you to show you how to record your answers.

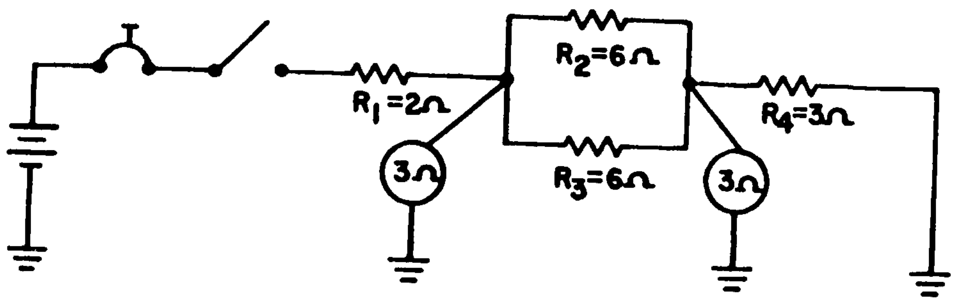
1. Short R_1



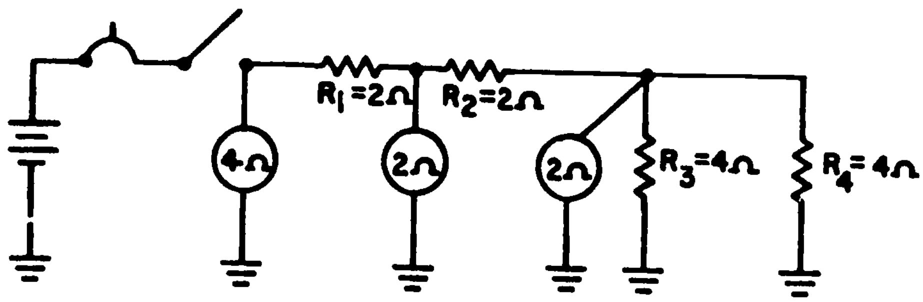
2. ____________________



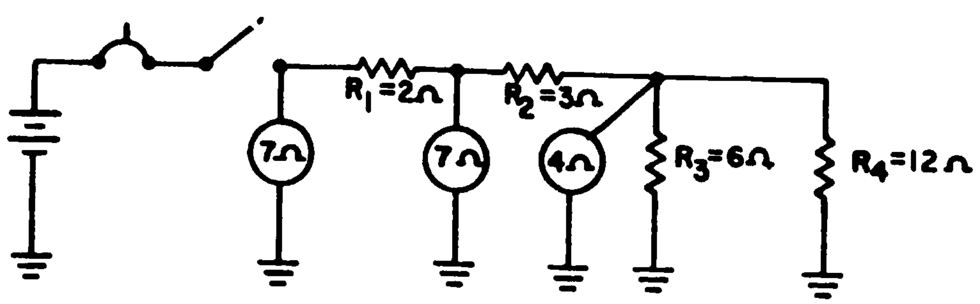
3. ____________________



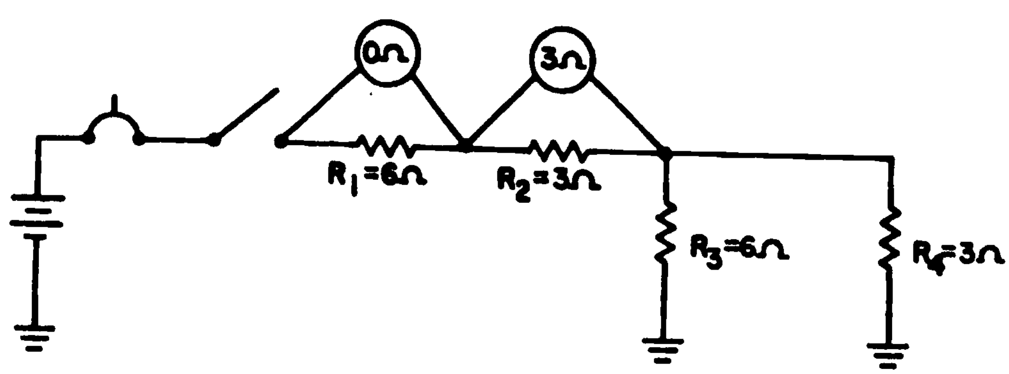
4. ______________________________


R$_1$=2Ω
R$_2$=2Ω
4Ω
2Ω
2Ω
R$_3$=4Ω
R$_4$=4Ω

5. ______________________________


R$_1$=2Ω
R$_2$=3Ω
7Ω
7Ω
4Ω
R$_3$=6Ω
R$_4$=12Ω

6. ______________________________

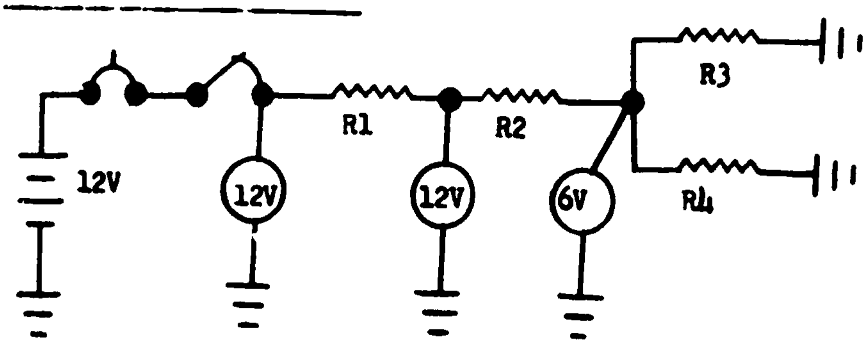

0Ω
3Ω
R$_1$=6Ω
R$_2$=3Ω
R$_3$=6Ω
R$_4$=3Ω

Answers to Frame 32: 2. short R_4, 3. short R_2 or R_3, 4. short R_2, 5. short R_1, 6. short R_1

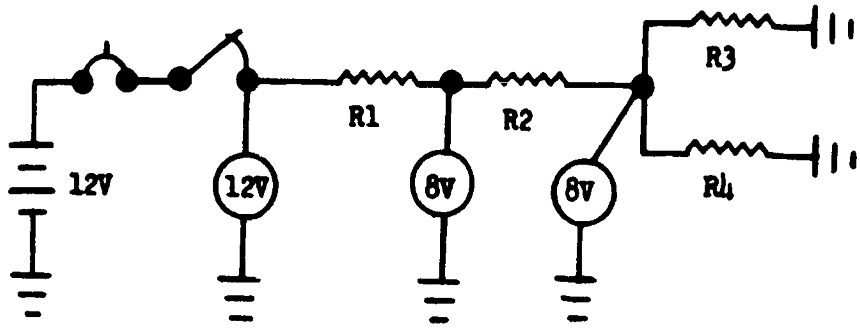
Frame 33

Analyze the meter readings in each of the following circuits. Using the blank provided for each circuit, list the type of trouble and the faulty component.

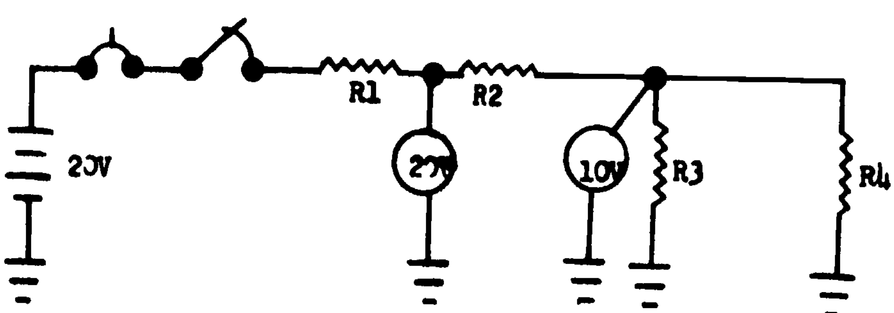
1. ____________________



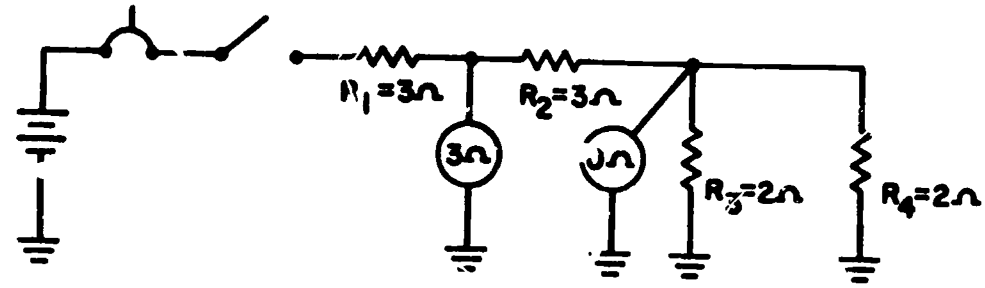
2. ____________________



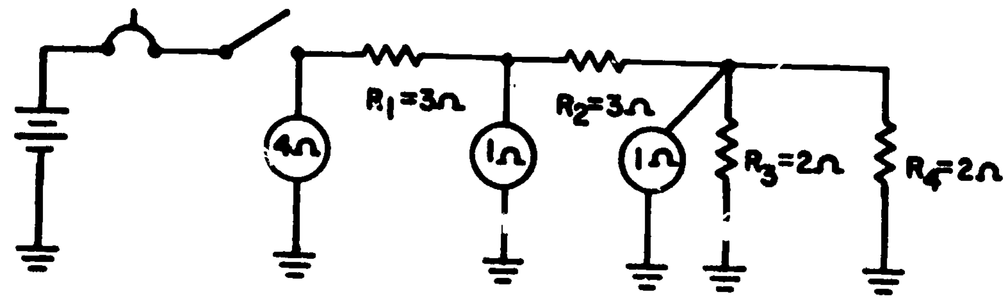
3. ____________________



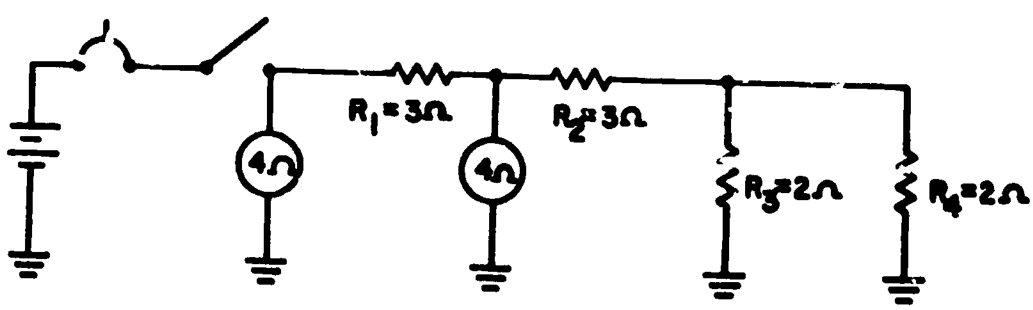
4. ______________________



5. ______________________



6. ______________________



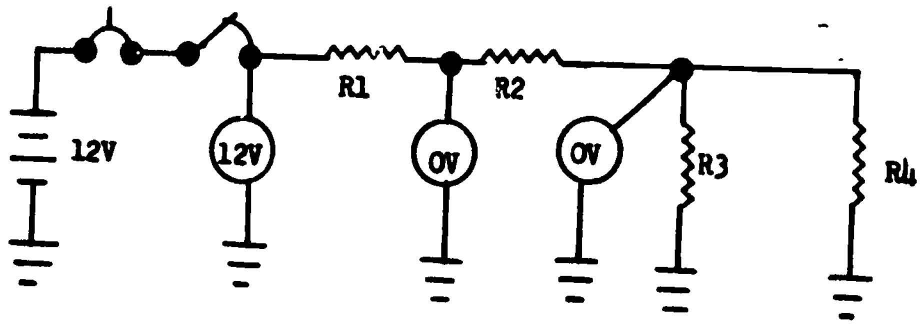
Have the instructor check your answers to this frame.

INSTRUCTOR's Initials ______________

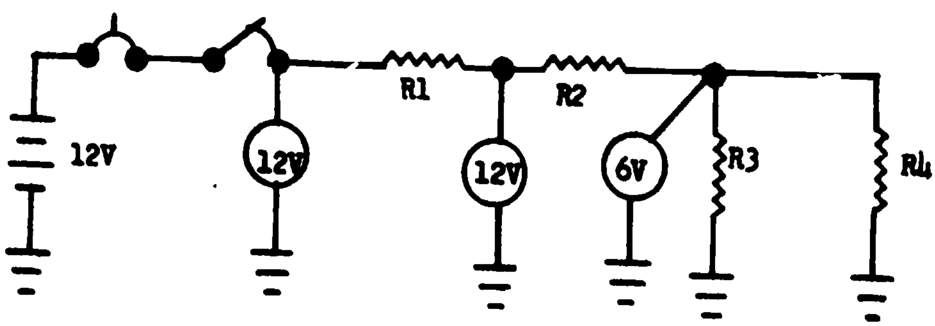
Frame 34

Analyze the meter readings in each of the following circuits. Using the blank provided for the circuit, list the type of trouble and the faulty component. The first one has been done to show you how to record your answers.

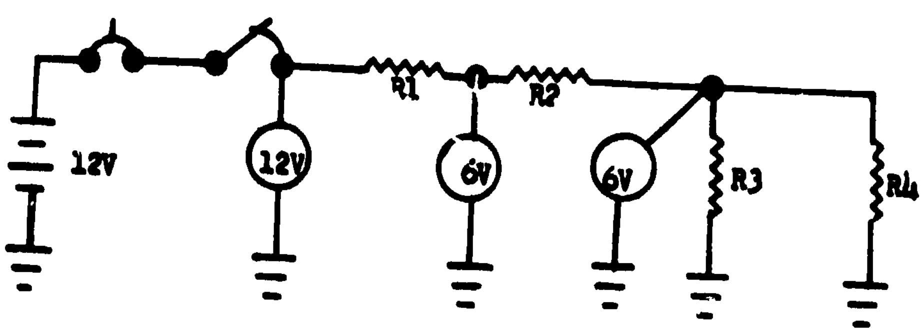
1. Open R_1 ______________________



2. ______________________

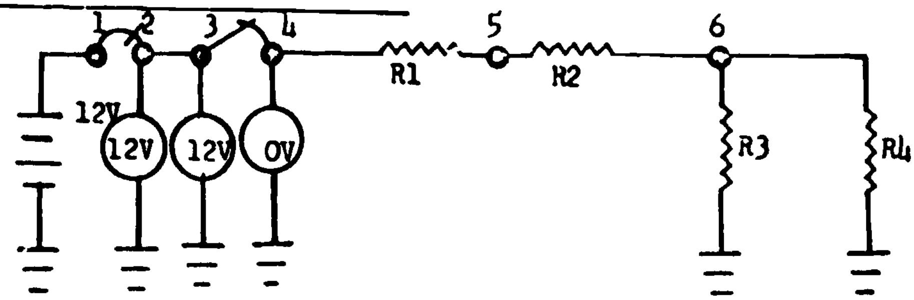


3. ______________________

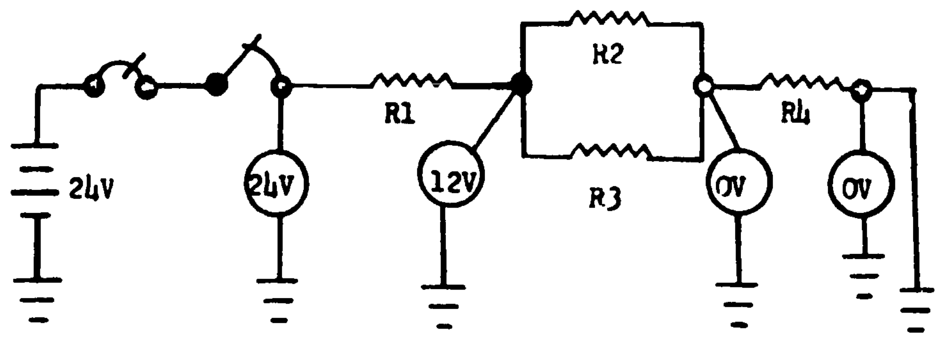


905

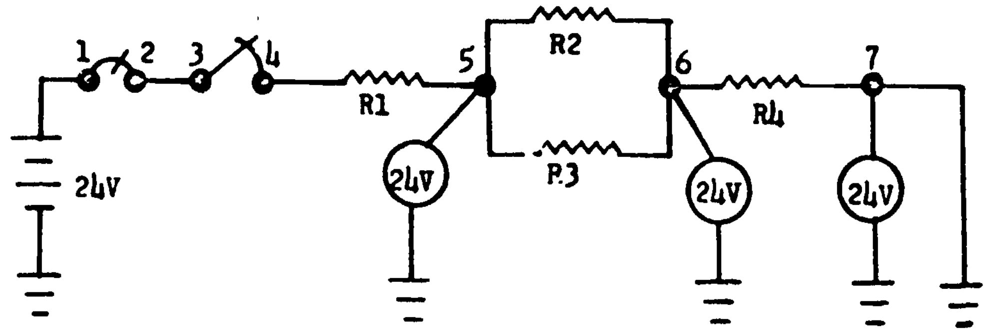
4. ______________________________


1
2
3
4
5
6
R1
R2
R3
R4
12V
12V
12V
OV

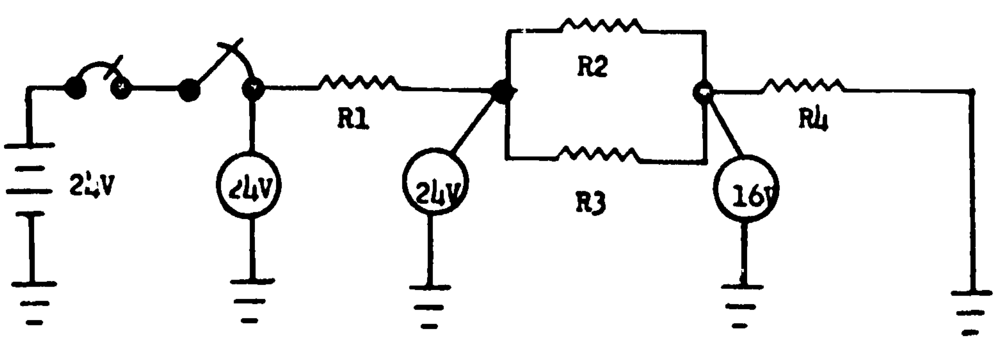
5. ______________________________


R1
R2
R3
R4
24V
24V
12V
OV
OV

6. ______________________________


1
2
3
4
5
6
7
R1
R2
R3
R4
24V
24V
24V
24V

7. ______________________________


R1
R2
R3
R4
24V
24V
24V
16V

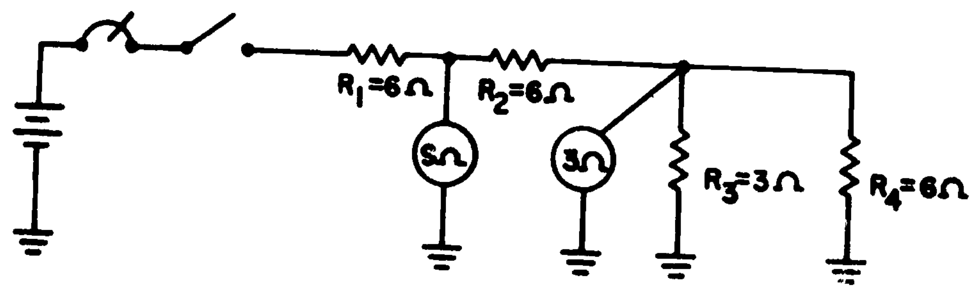
Answers to Frame 34: 2. short R_1, 3. short R_2, 4. open 3-4 switch

5. short R_4 6. open 7-ground 7. short R_1

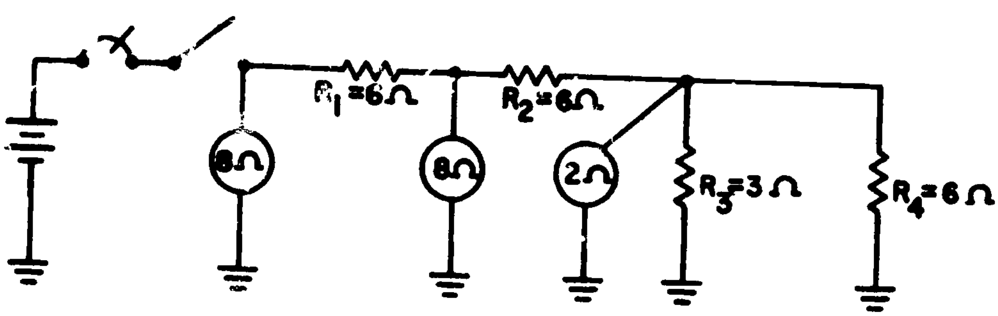
Frame 35

Analyze the meter readings in each of the following circuits. Using the blank provided for each circuit, list the type of trouble and the faulty component. The first one has been done to show you how to record your answers.

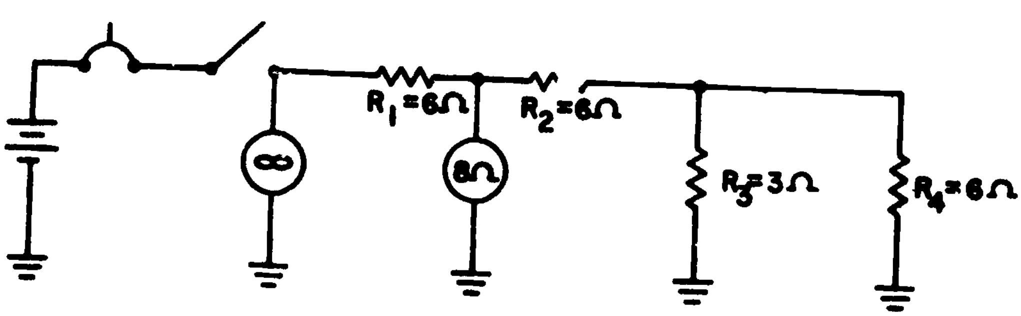
1. Open R_4



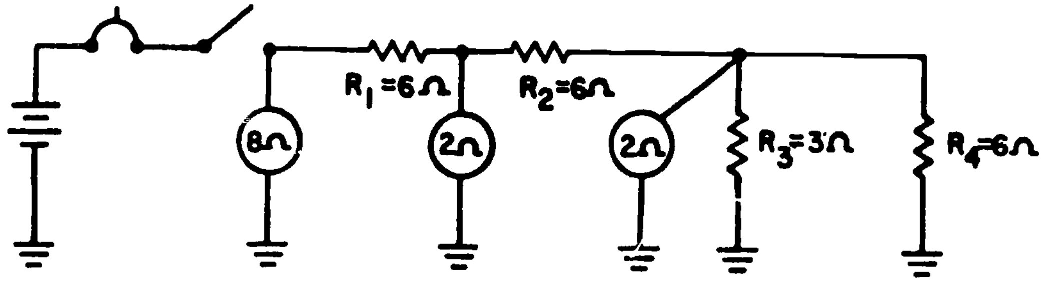
2. ____________



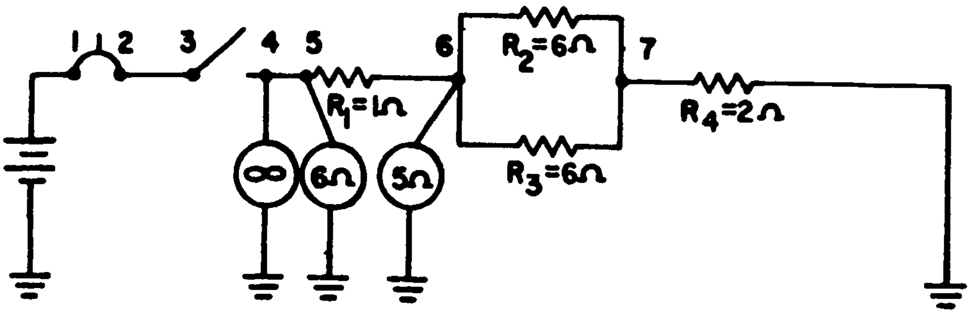
3. ____________



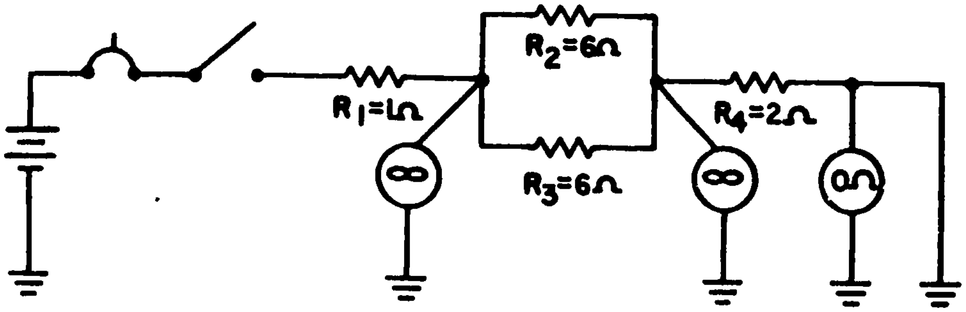
4. ____________________


R1=6Ω
R2=6Ω
R3=3Ω
R4=6Ω
8Ω
2Ω
2Ω

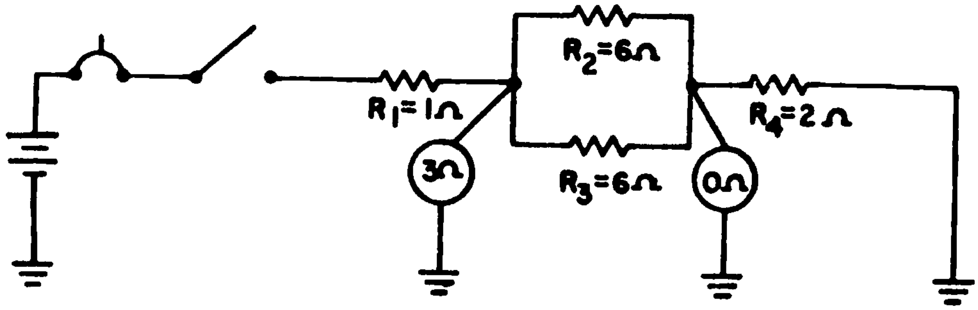
5. ____________________


1
2
3
4
5
6
7
R1=1Ω
R2=6Ω
R3=6Ω
R4=2Ω
∞
6Ω
5Ω

6. ____________________


R1=1Ω
R2=6Ω
R3=6Ω
R4=2Ω
∞
∞
0Ω

7. ____________________


R1=1Ω
R2=6Ω
R3=6Ω
R4=2Ω
3Ω
0Ω

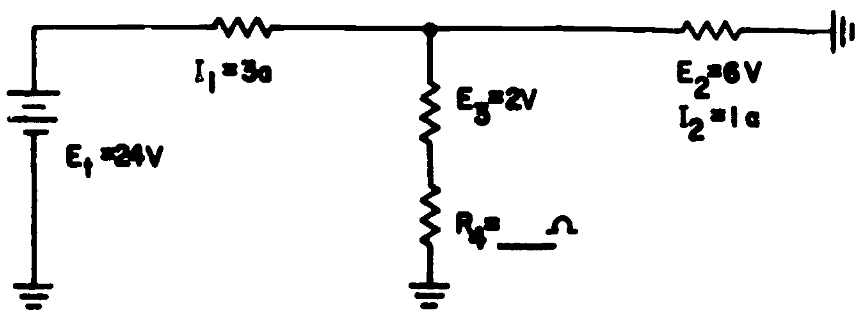
Answers to Frame 35: 2. short R_1, 3. open R_1, 4. short R_2,

5. open 4-5 6. open R_4, 7. short R_4

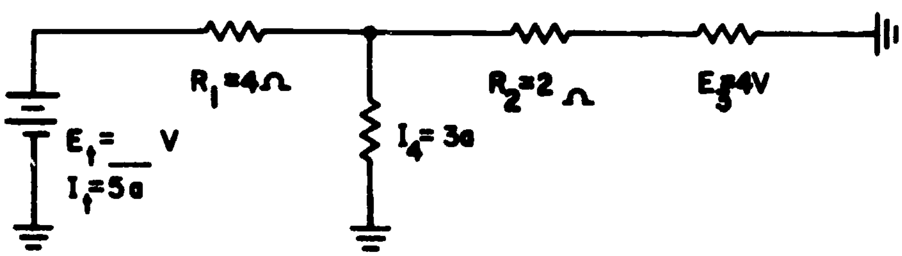
Frame 36

Solve each of the following problems for the indicated unknown. Put your answers o appropriate blanks.

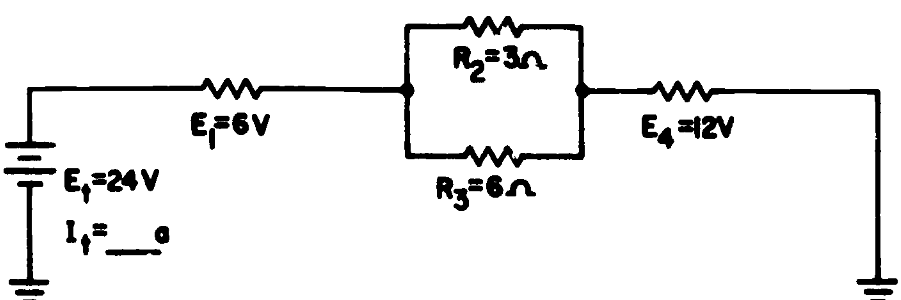
1.



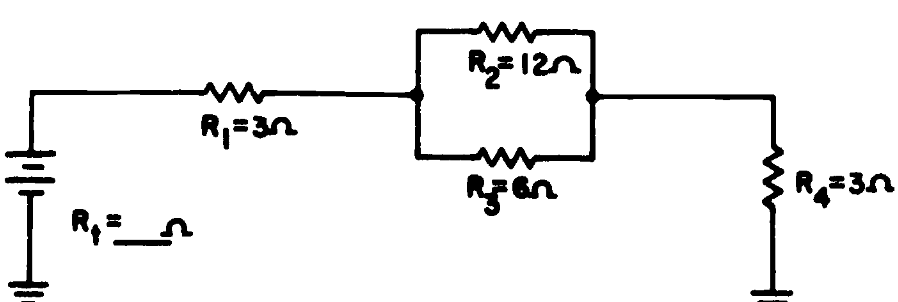
2.



3.

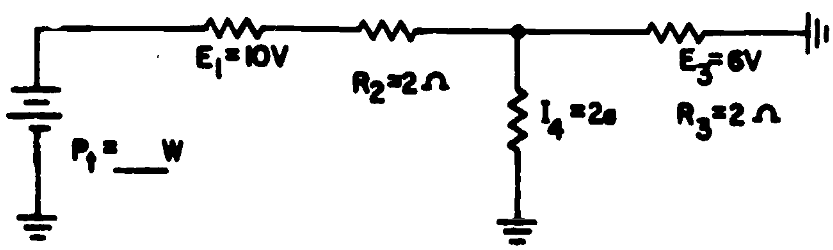


4.

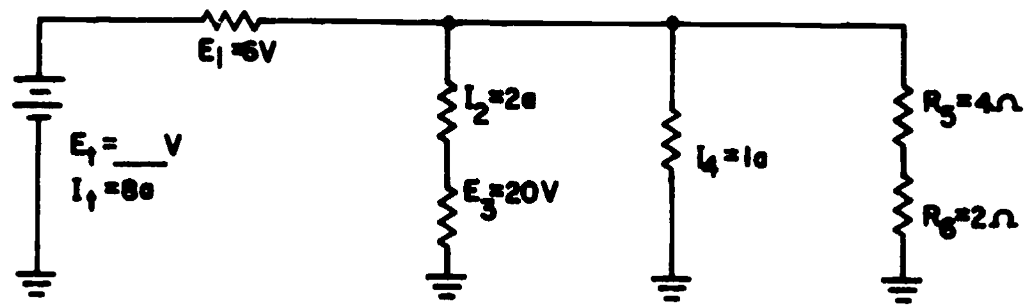


909

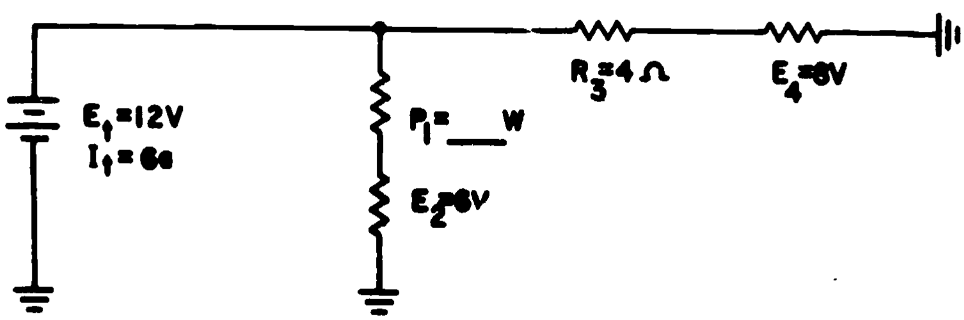
5.



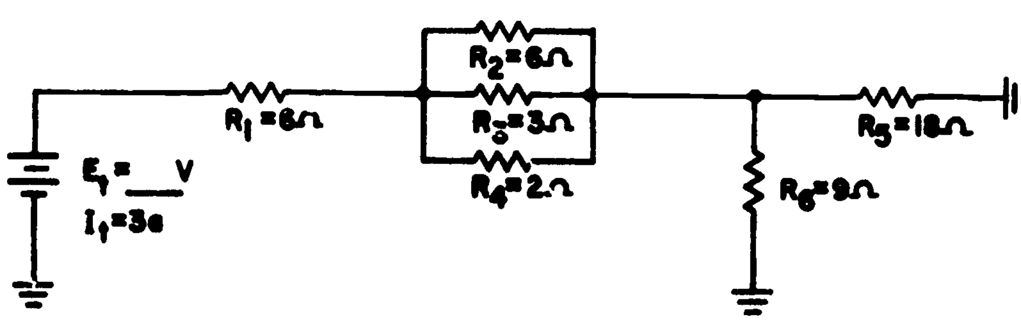
6.



7.



8.



Have the instructor check your answers and circle the next frame number which you are to do.

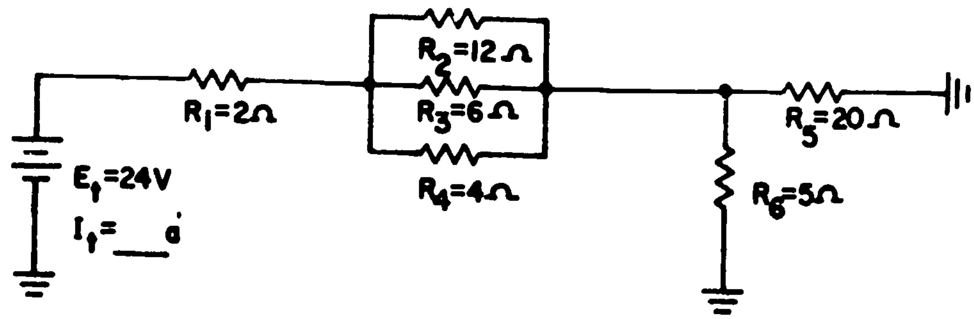
Instructor's Initials ____________

Note: If you need additional practice, you will be assigned the problems in Frame 37. If you don't need additional practice, the instructor will tell you to go to Frame 38.

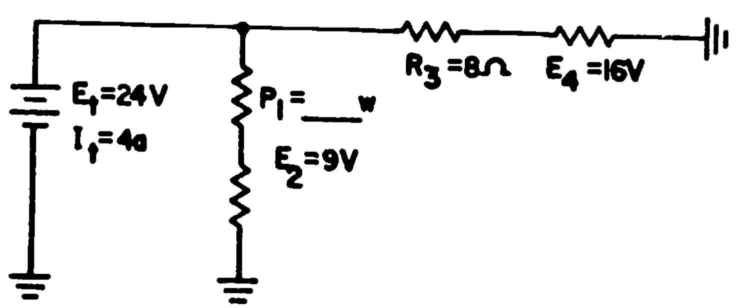
Frame 37

Before starting this frame, reread Frame 11. Frame 11 outlines the procedures for solving for unknowns in series-parallel circuits. Solve each of the following problems for the indicated unknown. Put your answers on the appropriate blanks.

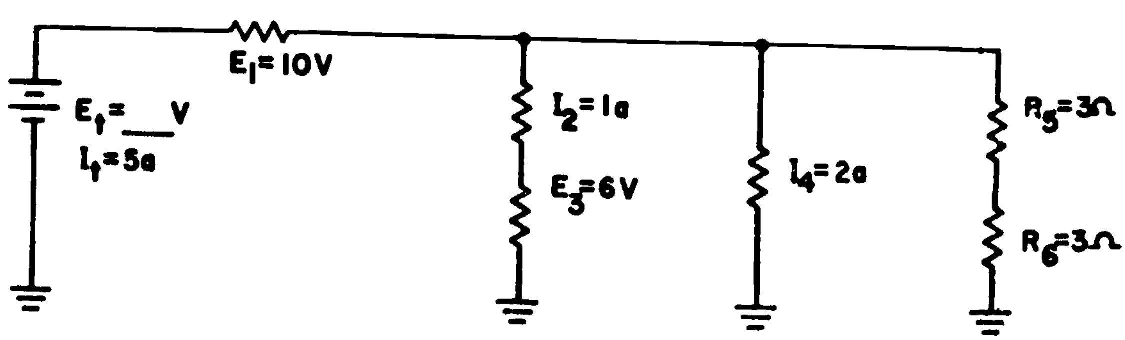
1.



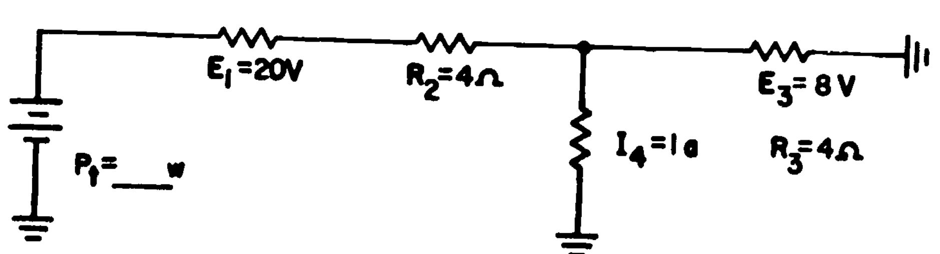
2.



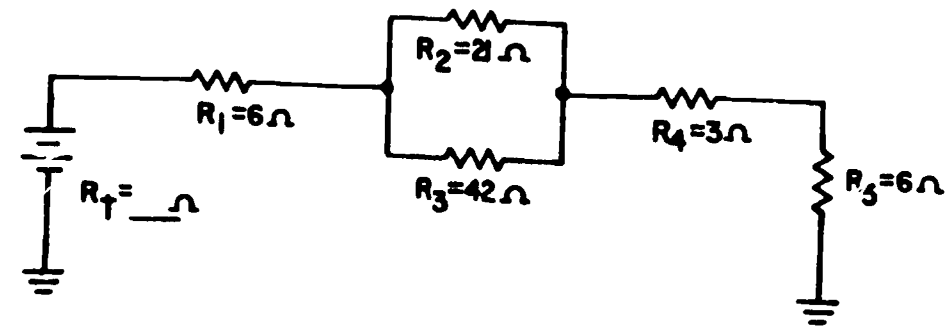
3.

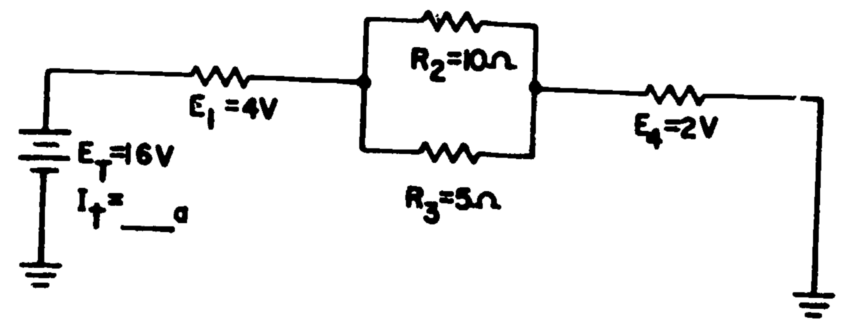


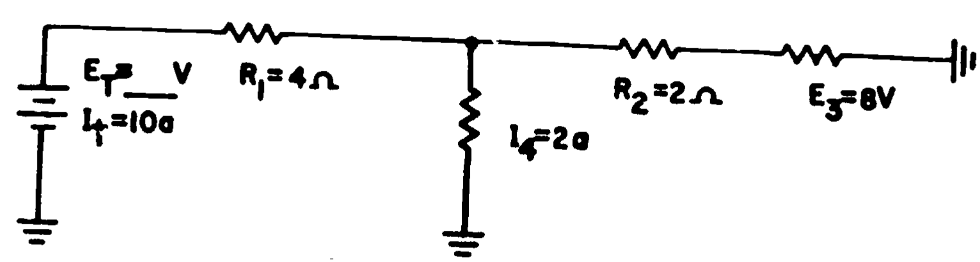
4.

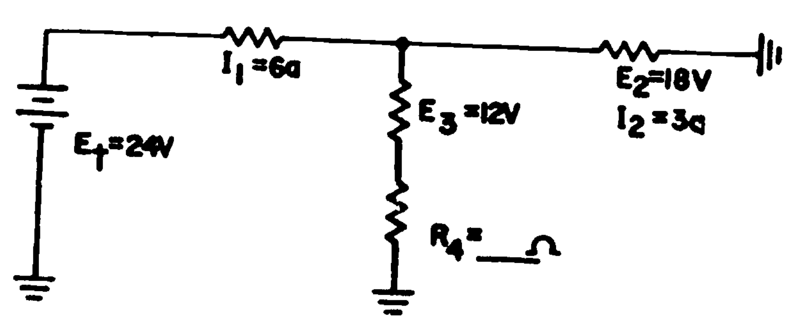


911

5. 

6. 

7. 

8. 

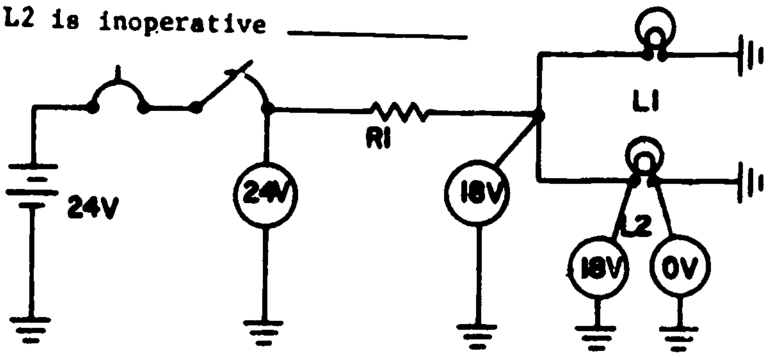
Have the instructor check your answers.

Instructor's Initials ________

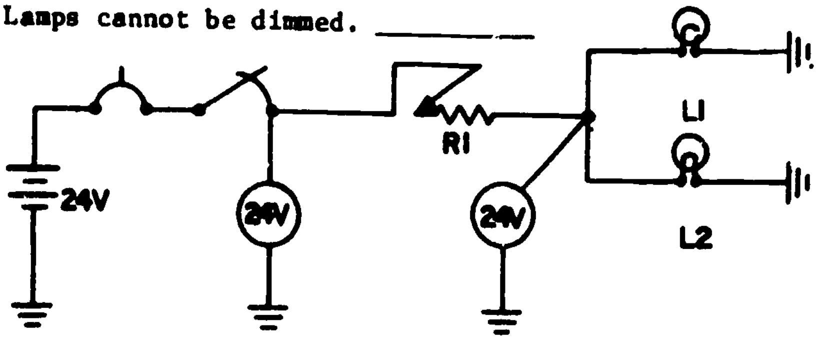
Frame 38

Analyze the meter readings and/or circuit indications in each of the following circuits. Using the blank provided for each circuit, list the type of trouble and the faulty component.

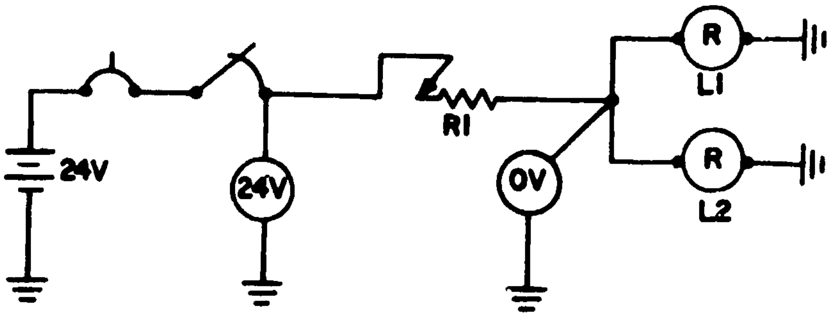
1. L2 is inoperative __________



2. Lamps cannot be dimmed. __________

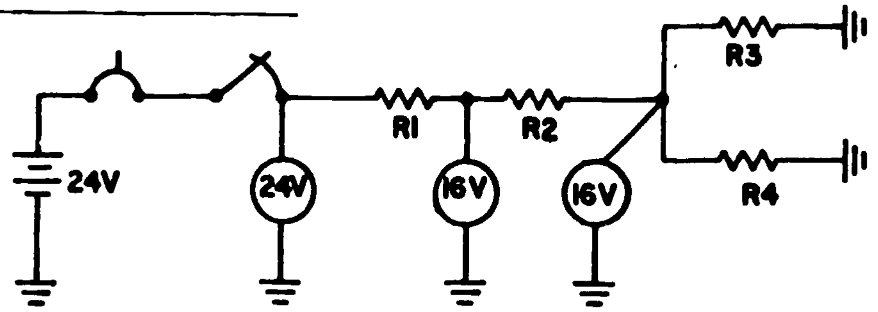


3. All lamps are inoperative. __________

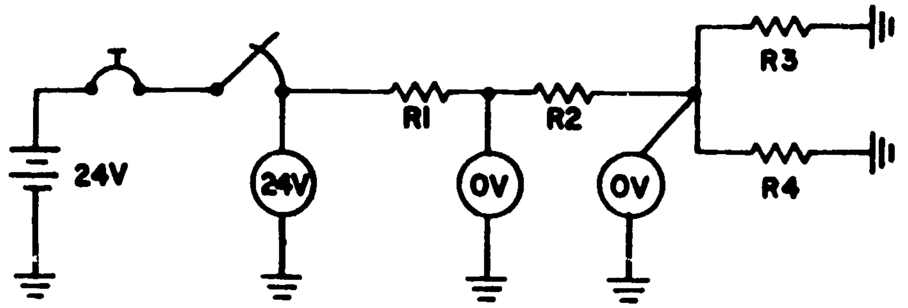


913

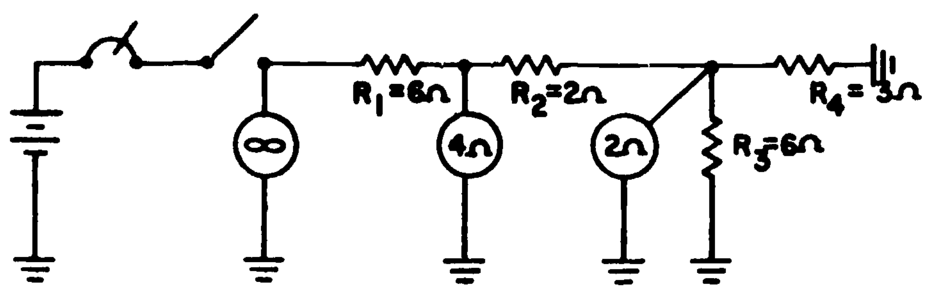
4. ______________


R3
R1
R2
24V
24V
16V
16V
R4

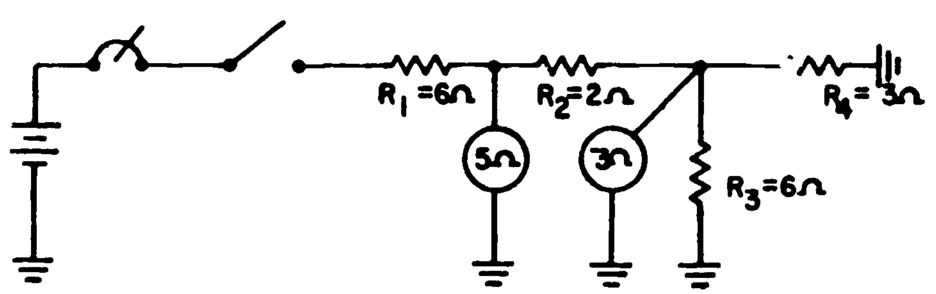
5. ______________


R3
R1
R2
24V
24V
0V
0V
R4

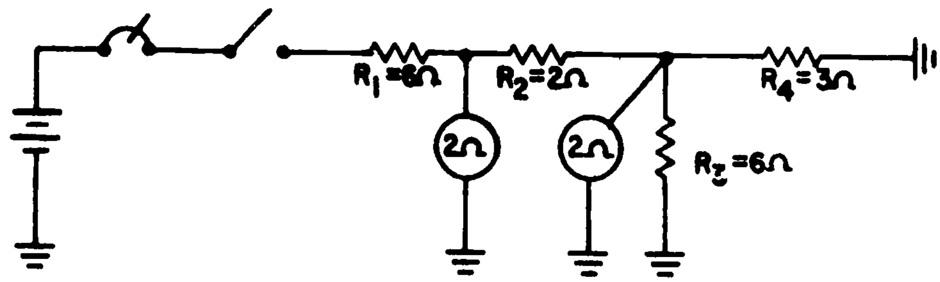
6. ______________


R_1=6Ω
R_2=2Ω
R_4= 3Ω
∞
4Ω
2Ω
R_3=6Ω

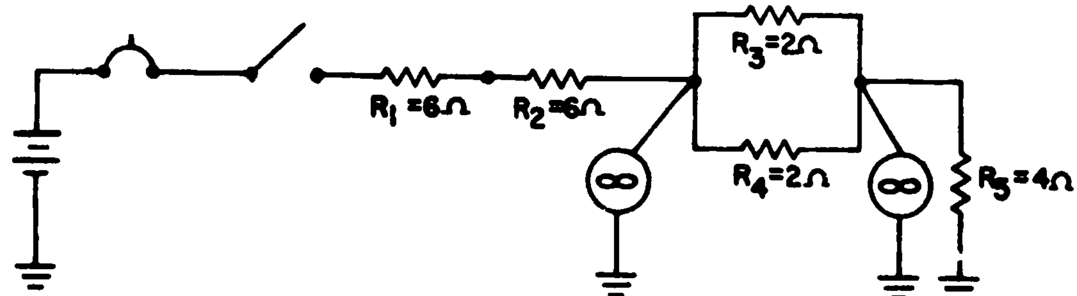
7. ______________


R_1 =6Ω
R_2=2Ω
R_4= 3Ω
5Ω
3Ω
R_3=6Ω

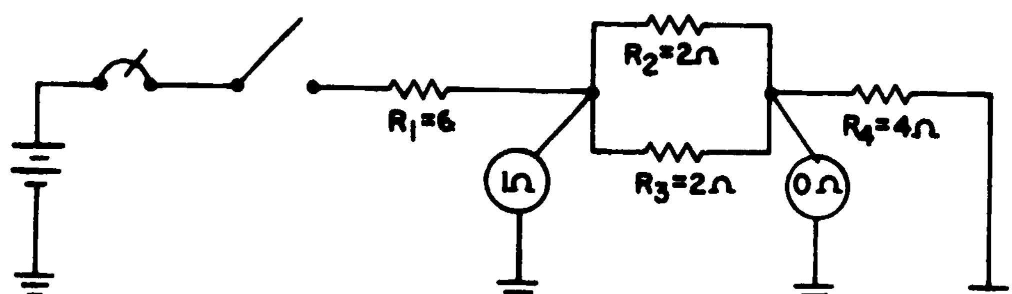
8. ____________________



9. ____________________



10. ____________________



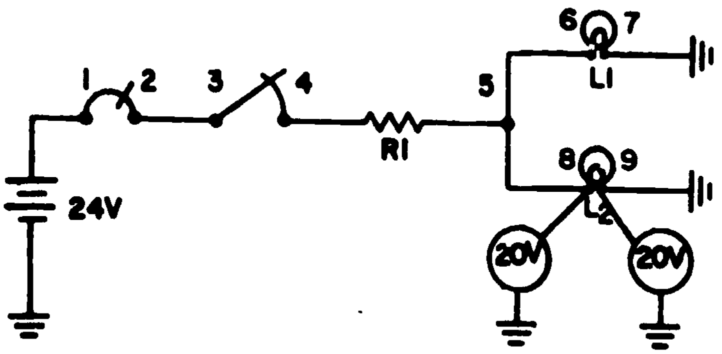
Have the instructor check your answers.

Instructor's Initials ____________

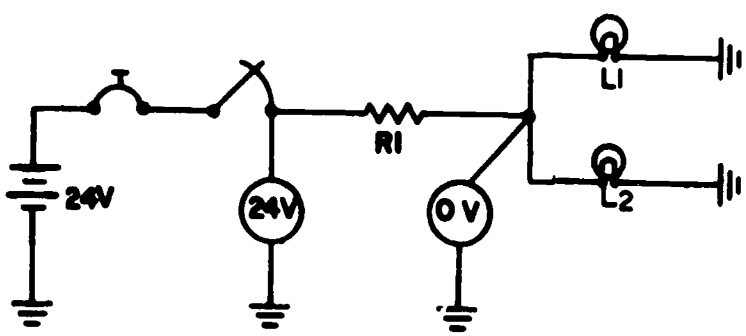
Note: If you need additional practice you will be assigned the problems in Frame 39. If you don't need additional practice you will see your instructor and ask to be given the appraisal for this text.

Analyze the meter readings and/or circuit indications in each of the following circuits. Using the blank provided for each circuit list the type of trouble and the faulty component.

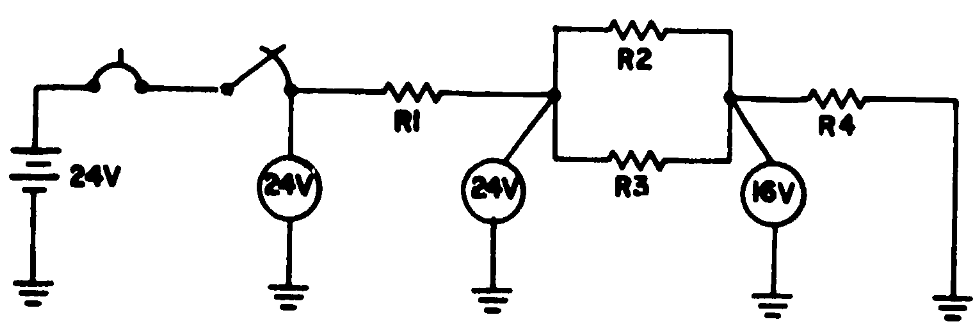
1. L_2 is inoperative. ______________________



2. Both lamps inoperative. ______________

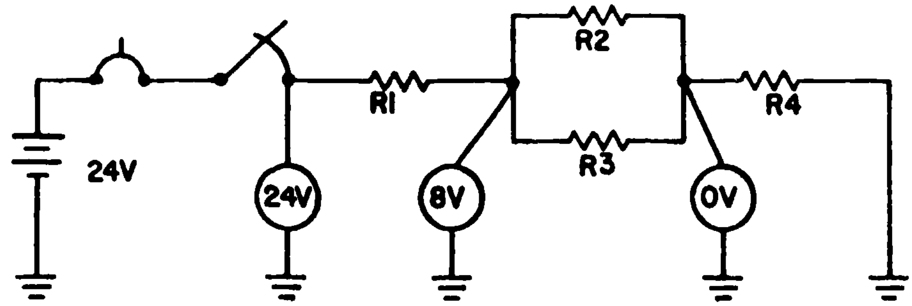


3. ______________

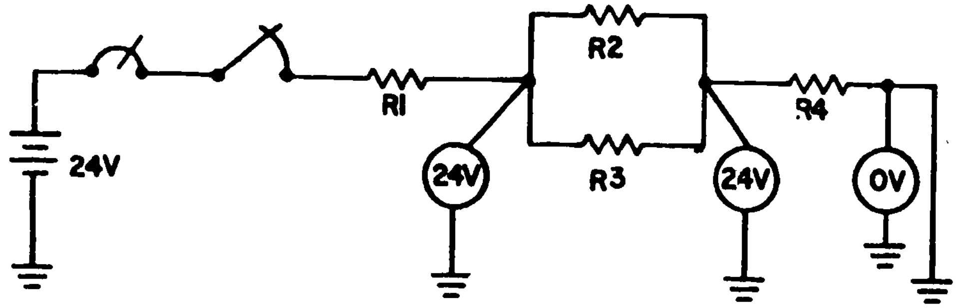


Frame 39 (Cont'd)

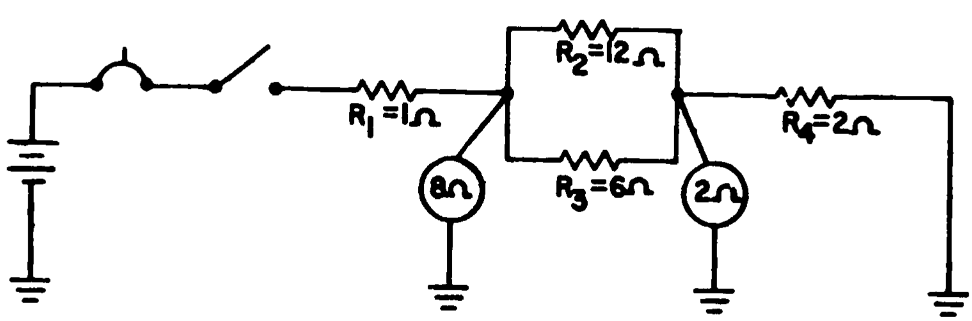
4. ____________



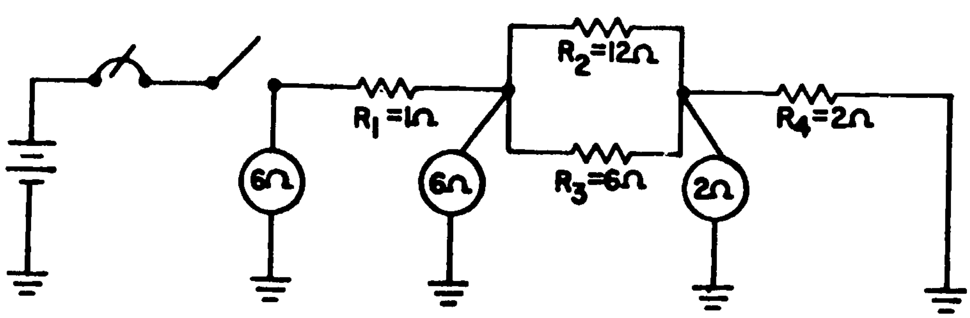
5. ____________



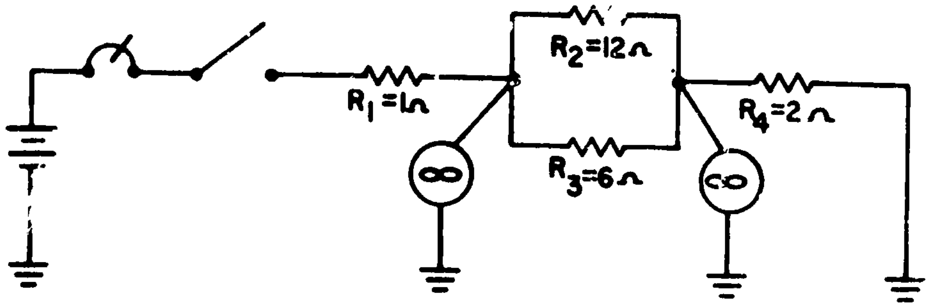
6. ____________



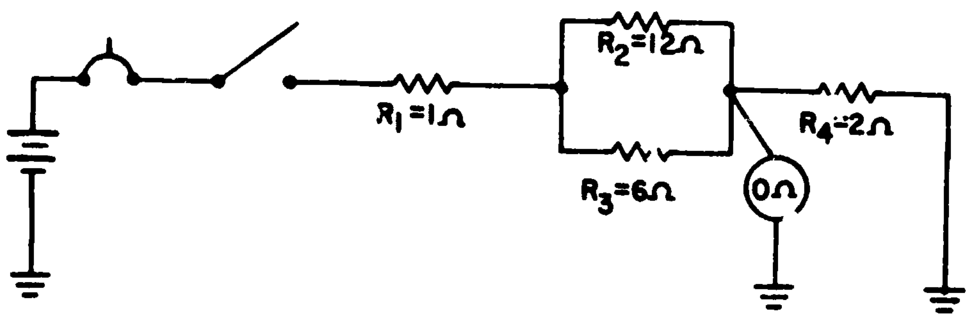
7. ____________



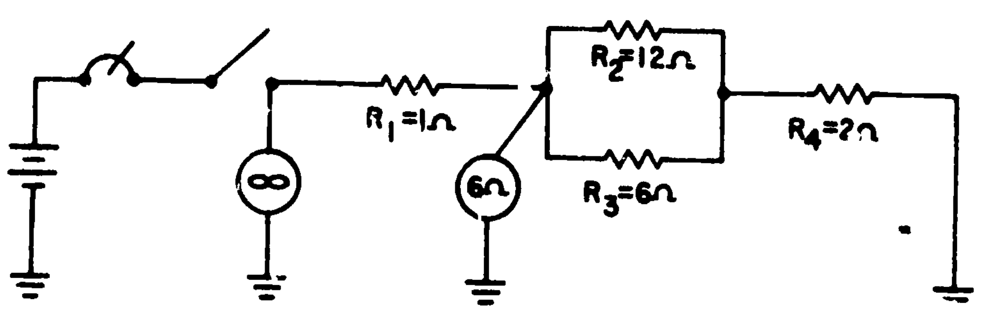
8. ______________



9. ______________



10. ______________



Have the instructor check your answers to this frame.

Instructor's Initials ____________

When you finish this frame see your instructor and ask to be given the appraisal for this text.

WORKBOOK
3ABR42331-WB-119

Technical Training

Aircraft Environmental Systems Mechanic

SERIES-PARALLEL CIRCUIT PERFORMANCE

7 August 1979

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

RCL : N/A

Environmental Pneudraulics Branch
Chanute AFB, Illinois

3ABR42331-WB-119

SERIES-PARALLEL CIRCUIT PERFORMANCE

OBJECTIVE

Using a DC fundamentals trainer, construct a series-parallel circuit and measure electrical values with one instructor assist allowed for each task area.

EQUIPMENT

	Basis of Issue
Trainer P/N 521685, DC Fundamentals	1/student
Multimeter	1/student

SAFETY

Caution: Remove watches, rings, bracelets, etc., before starting any work on the equipment. It is also a good safety practice to work on the equipment with one hand. This practice reduces the chances of receiving an electrical shock to some vital body organ when working with electricity. Also remember that light bulbs, resistors, etc., do get HOT and could burn the skin.

PROCEDURE

Pay close attention to all directions that you are given in the workbook. When performing in the workbook, such as answering questions or recording electrical measurements, if your response is incorrect, restudy the information with instructor assistance if needed. Do not hesitate to ask the instructor questions. You will find that many of the exercises have the correct answers on page 6. After you have completed all the exercises, you will satisfactorily complete the progress check assigned by the instructor. If you wish, pages 12 through 14 may be removed for your convenience.

Before you leave your trainer for scheduled or unscheduled breaks, make sure the following items are done.

1. Make sure the SPST switch is turned OFF in the circuit.

2. Make sure the 28V DC bus bar has all the electrical leads removed from it.

3. Make sure the negative (black) bus bar has all the electrical leads removed from it.

4. Make sure the multimeter is properly stored during this period.

   a. The controls on the meter must be properly set for storage.

Supersedes 3ABR42331-WB-119, 31 October 1978.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370TCHTG/TTGU-P - 300; TTVSA - 1

b. Leave the test leads attached to the meter.

c. Wrap the meter leads around the instrument.

d. Place the meter on the locker shelf.

5. When you return from the break, take the same meter and go back to work.

Exercise 1

1. Trainer preparation for exercises 2 and 3.

a. The metal plate on the right side of the trainer may be raised for the workbook to lay on.

b. Sign out a multimeter, see the lab instructor if assistance is needed.

c. Make sure that the instructor has connected power to the trainer. You will do this by measuring the power, with the multimeter, at the positive (red) and negative (black) bus bar. The bus bars are located in the lower right and left corners of the trainer. If you don't read a voltage (24V DC ± 4V DC), see your instructor.

d. Make sure that fuse wire is across the fuse holders of each of the three (3) ammeters on the trainer. This will protect the ammeter internal circuit from over load. If the fuse wire is burnt in two or is missing, see your instructor for assistance.

e. Pull the circuit breaker out (open) and turn OFF (open) two single pole single throw (SPST) switches.

f. Make sure all leads in the drawer are in good condition with a plug at both ends. If you find any damaged leads, give them to the instructor.

g. Examine the electrical lead ends, and note how you may connect them together if one lead is too short. See your instructor for assistance if needed.

Exercise 2

2. Build a series-parallel circuit. This circuit will be made up of two loads (light bulbs) in parallel with each other, and in series with one load (10 ohm resistor).

a. Using the electrical leads from the drawer, construct the series-parallel circuit shown in figure 1. This consists of a C/B (circuit breaker), SPST switch, two light bulbs in parallel with each other, and in series with a 10 ohm resistor.

Note: If an electrical lead is too short, you may connect leads together to prevent stretching or breaking them.

b. Before applying power to your series-parallel circuit, be sure you have a common ground for the two light bulbs in parallel; which are wired in series with a 10 ohm resistor.

c. If you study this series-parallel circuit in figure 1, you will find that IF power is applied, electrons will flow from point 1, the negative (-) bus bar, to point 2, then from point 2 they will divide and some will flow through the (right) light bulb to point 3 and on to point 5. Looking back at point 2 you will also find the electrons have another path to flow. They will flow through the wire to point 4 and on through the (left) light bulb to point 5. After the electrons, which have been divided into two paths through the light bulb's parallel circuit, regroup at point 5, they will enter the series portion of this circuit. The electrons will leave point 5, moving on to point 6 on through the resistor to point 7, then on through the remaining circuit to the positive (+) bus bar IF power is applied.

Exercise 3

3. Measuring electrical values in the series-parallel circuit constructed on the trainer from figure 1.

a. Make sure the circuit from figure 1 is correctly constructed on the trainer and them turn ON the power (SPST switch and C/B). Measure and record the voltage readings with the multimeter as required in figure 1.

(1) You should note that points 1, 2, 4 are all equally negative in the circuit. This is why-you can put the meters (-) negative black lead at either point to measure voltage applied across each bulb.

(2) You should also note that the total voltage applied can be measured at points 1 and 12. You may also add the reading of points 6 & 7 to the applied voltage across one of the bulbs.

b. Measure and record the total current flow in the circuit constructed as shown in figure 2.

c. Measure and record the voltage drop across the 10 ohm resistor at points 6 (-) to 7 (+) in figure 2.

Note: Leave the ammeter connected in the circuit until instructed to remove it.

d. Observe the ammeter in the circuit and do the following:

(1) Using a short lead from the drawer, you will connect it across the resistor from points 6 & 7 as shown in figure 3. This will simulate the effect a shorted resistor will have on a circuit.

(a) Note the light brightened because resistance decreased and note the current (amp) increased.

e. Measure and record the total current flow in the circuit with the shorted resistor (simulated) in figure 3.

f. Leaving the circuit connected as shown in figure 3, measure and record the voltage reading at points 6 and 7 in figure 3.

g. Answer the questions in figure 3.

h. Observe the ammeter in the circuit and do the following:

(1) Remove the short lead from points 6 and 7, the one across the resistor shown in figure 3 used to simulate a shorted resistor.

(2) Using the same short lead you will now connect it across either light bulb (load) in the parallel circuit part of this series-parallel circuit. Either across points 2 and 3 or points 4 and 5. We show it across points 4 and 5 in figure 4. Note the ammeter reading increased and the lights both go out.

(a) If you trace from point 1 to 12, you will find only the resistor is left in the circuit and carrying current flow. The current will flow from point 1 to 2 to 4 to 5 and on through the resistor to point 12. It flows around the light bulbs because there is less opposition to current flow in the wires from points 2 through 5 then in the bulbs.

i. Measure and record the total current flow in the circuit with the shorted bulb (simulated) in figure 4.

j. Leaving the circuit connected as shown in figure 4, measure and record the voltage reading with the multimeter as required in figure 4.

k. Answer the questions in figure 4.

l. Remove all the leads and store them in the drawer and report to your instructor for a progress check assignment.

CORRECT RESPONSES FOR FIGURES 1 through 4.

Figure 1

CHECKPOINTS		VOLTAGE READINGS
2 - 3 or 1 - 3		8.5 ± .5V DC
4 - 5 or 1 - 5		8.5 ± .5V DC
6 - 7		16 ± 1.0V DC
1 - 12	Total	26 ± 3.0V DC

Figure 2

CHECKPOINTS		READINGS
1 - 2	Total current	1.6 ± .4 amps
6 - 7	Voltage drop	16 ± 1.0 volts

Figure 3

Total current flow 3.0 ± .3 amps

Voltage points 6 and 7 0 volts

1. a

2. b

CHECKPOINTS	READINGS
4 - 5	0 volts
1 - 2	2.2 ± .2 amps

1. a

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PROGRESS CHECK INSTRUCTIONS

This progress check will require you to correctly construct a series-parallel circuit and measure electrical values with one instructor assist allowed for each task area. An instructor assist for each task area is defined as an aid, such as technical direction or explanation given to the student, who can proceed no further on his/her own. The instructor will initial your work after you satisfactorily completed each task of the progress check. If you do not pass the progress check, you will follow the instructions given by the instructor.

You <u>will not</u> communicate (talk, etc.) with other students during the progress check without your lab instructor's permission.

You <u>will not</u> use fellow student's work to solve the problems in this progress check.

You must satisfactorily complete this progress check before further progression to other lab progress checks.

Have your lab instructor select and initial on page 8 or 9 the series-parallel circuit progress check you are to draw on figure 5. Using a lead pencil only, draw in the series-parallel circuit leads between the various symbols. Later you will construct this circuit on the trainer. After you have satisfactorily completed the progress check, you will follow the instructions on page 11.

_________ Instructor's initials. Assigned progress check #1.

After completion of each task listed below, do not progress until the instructor has initialed your work for that task.

TASK 1 Draw the series-parallel circuit. This circuit will be made up of two loads (light bulb and 500 ohm resistor) in parallel with each other, and in series with one load (10 ohm resistor), SPST switch, and circuit breaker in figure 5.

_________ Instructor's initials. Task initials ______ ______

TASK 2 Construct the series-parallel circuit drawn in figure 5 on the trainer and demonstrate an operations check for the instructor.

_________ Instructor's initials. Task initials ______ ______

TASK 3 Measure and record the electrical values required below. Take these values from the circuit in figure 5 assigned.

Total current flow _________ amps.

Total voltage to the circuit _________.

Voltage drop across the bulb _________.

Voltage drop across the 500 ohm resistor _________.

Voltage drop across the 10 ohm resistor _________.

_________ Instructor's initials.

Turn to page 11 for further instructions.

Note: If the instructor provides an instructor assist for a task, the instructor will initial behind task initials (see objective).

_________ Instructor's initials. Assigned progress check #2.

After completion of each task listed below, do not progress until the instructor has initialed your work for that task.

TASK 1 Draw the series-parallel circuit. This circuit will be made up of two loads (light bulb and 10 ohm resistor) in parallel with each other, and in series with one load (10 ohm resistor), SPST switch, and circuit breaker in figure 5.

_________ Instructor's initials. Task initials ______ ______

TASK 2 Construct the series-parallel circuit drawn in figure 5 on the trainer and demonstrate an operations check for the instructor.

__________ Instructor's initials. Task initials _______ _______

TASK 3 Measure and record the electrical values required below. Take these values from the circuit in figure 5 assigned.

Total current flow __________ amps.

Total voltage to the circuit __________.

Voltage drop across the bulb __________.

Voltage drop across the 10 ohm resistor __________. In the parallel part of the circuit.

Voltage drop across the 10 ohms resistor __________. In the series part of the circuit.

__________ Instructor's initials.

Turn to page 11 for further instructions.

Note: If the instructor provides an instructor assist for a task, the instructor will initial behind task initials (see objectives).

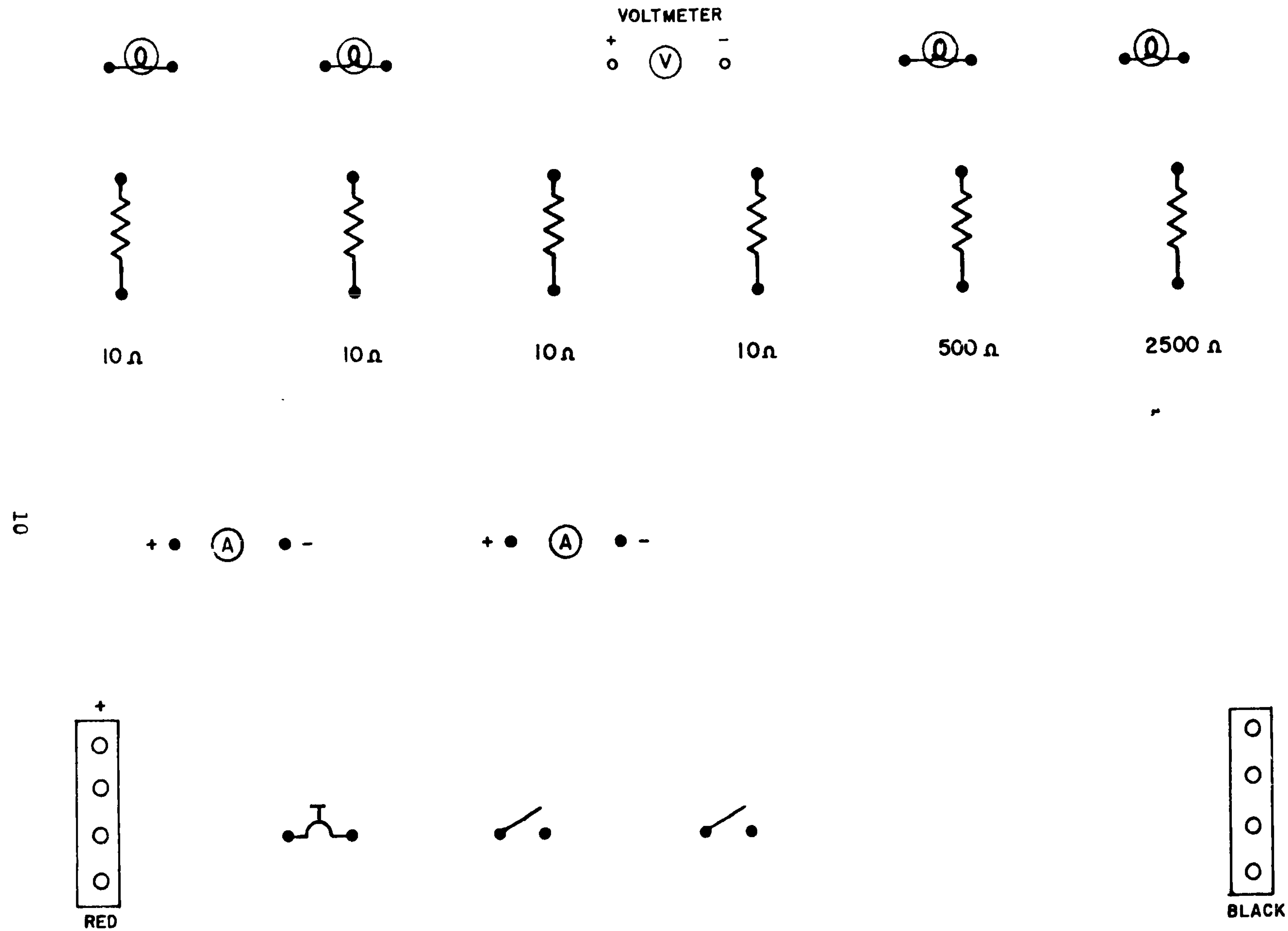

Figure 5.

After you have satisfactorily completed the progress check, you will do the following:

1. Put all the good leads in the drawer of the trainer.

2. Give all the broken leads to the lab instructor with the parts.

3. Place the work table in the down position on the trainer.

4. Return the multimeter to its storage cabinet. Be sure the controls on the meter are set correctly for storage.

5. You will turn in your work to the lab instructor before you leave the lab area.

Note: You may review any part or all of this workbook if you wish, but your work will not leave the lab area without the lab instructor's permission.

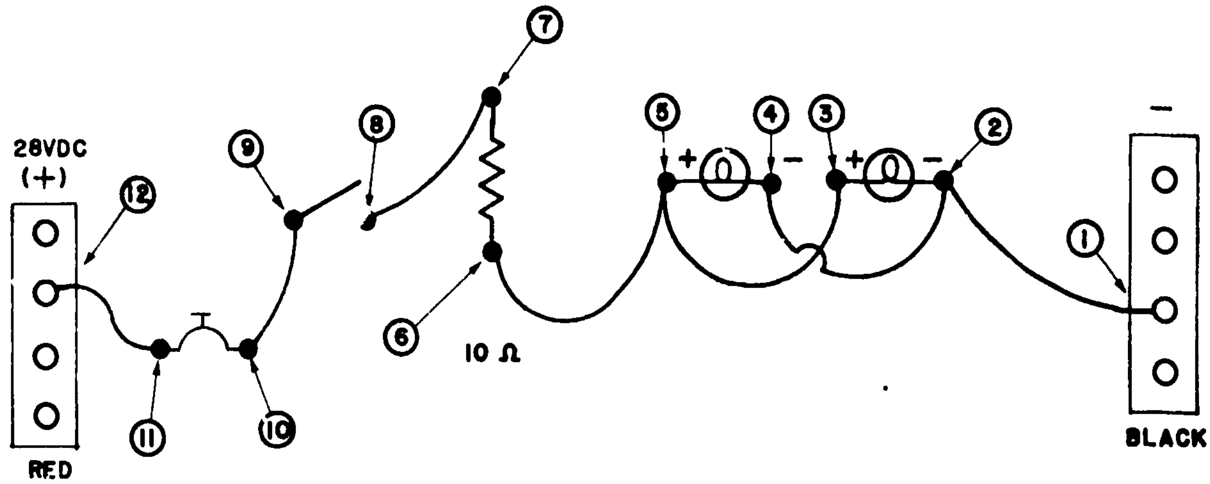

Figure 1.

CHECKPOINTS		VOLTAGE READINGS
2 - 3 or 1 - 3		________ volts
4 - 5 or 1 - 5		________ volts
6 - 7		________ volts
1 - 12	Total	________ volts

Correct answers are on page 6. Go to step "b" in exercise 3.

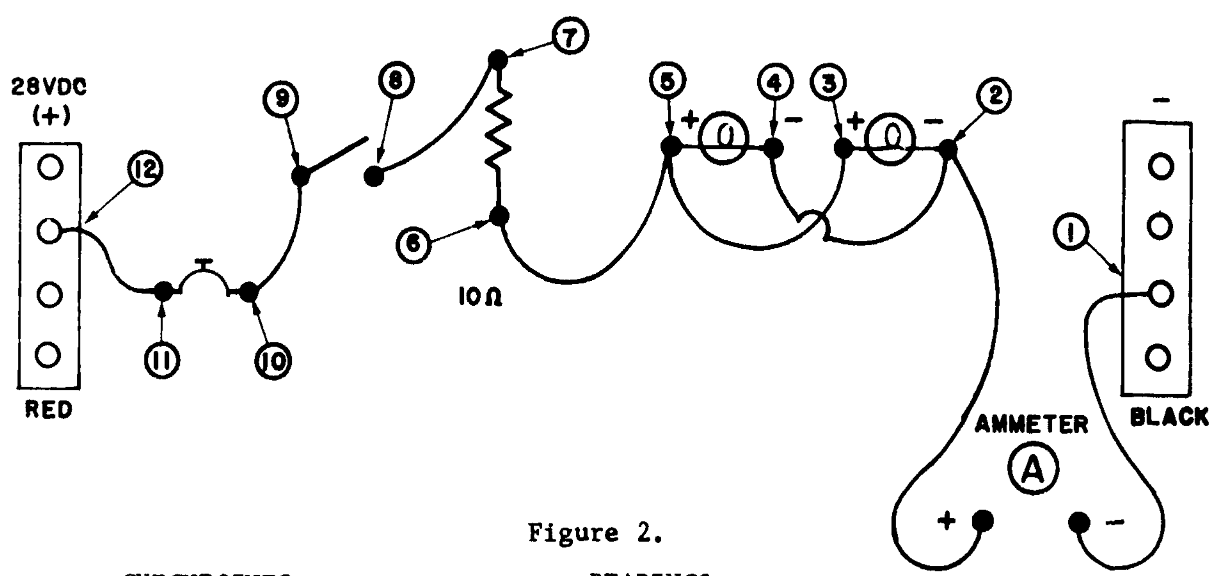

Figure 2.

CHECKPOINTS	READINGS
1 - 2	Total current ________ amps.
6 - 7	Voltage drop ________ volts.

Correct answers are on page 6.

Go to step "d" in exercise 3.

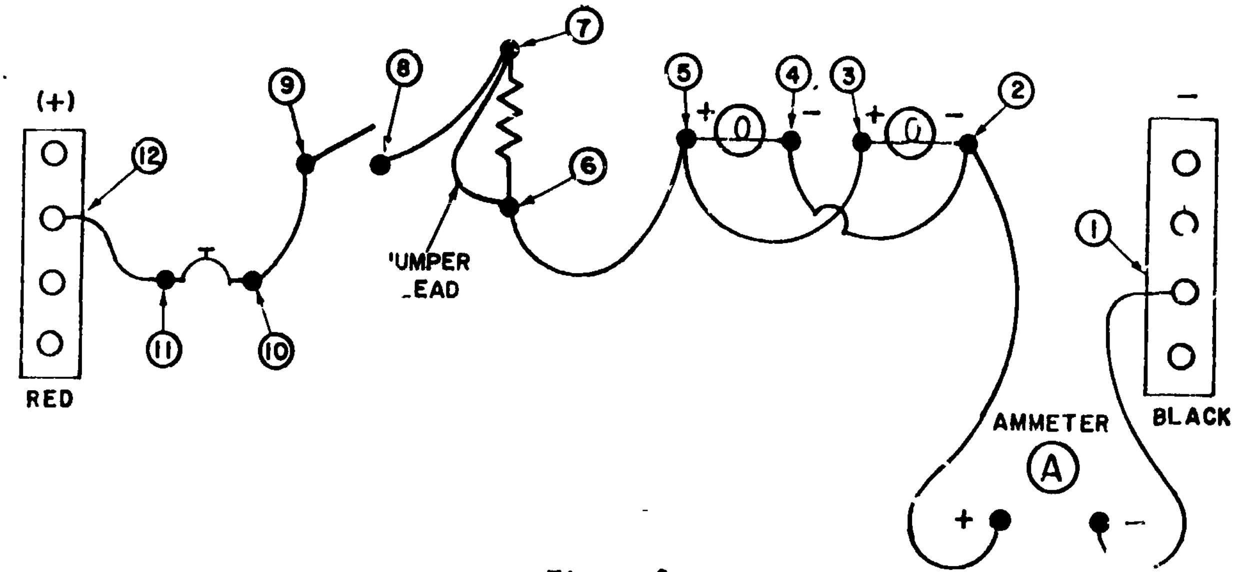

Figure 3.

Total c~~rrent flow __________ amps.

Voltage points 6 and 7 __________ volts.

1. The current flow increased

   a. because the total resistance in the series-parallel circuit decreased due to the simulated short in the resistor.

   b. because the total resistance in the series-parallel circuit increased due to the simulated open in the resistor.

2. The voltage drop across points 6 and 7

   a. increased.

   b. decreased.

Correct answers are on page 6.

Go to step "h" in exercise 3.

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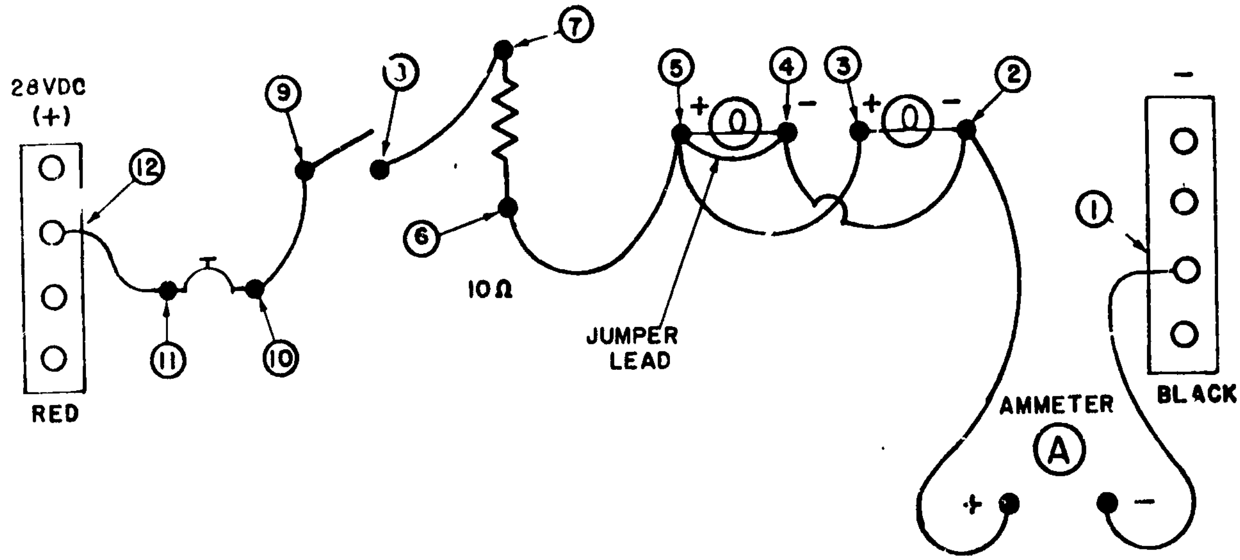

Figure 4.

CHECKPOINTS	READINGS
4 - 5	________ volts
1 - 2	________ amps

1. The current flow increased

   a. because the short caused the total resistance to decrease, allowing the current flow to bypass the parallel loads (bulbs) causing the lights to go out. Current flow is from point 1 to 2, not through the right light bulb, but around it over to point 4. From point 4 it goes around the left bulb through the jumper lead to point 5 and on through the resistor over to the positive bus bar.

   b. because the short caused the total resistance to decreased allowing the lights to go out and all of the current to flow through both light bulbs and not the resistor and on to the positive bus bar.

Correct answers are on page 6.

Go to step "1" in exercise 3.

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Technical Training

Aircraft Environmental Systems Mechanic

SERIES PARALLEL CIRCUITS

12 October 1984

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

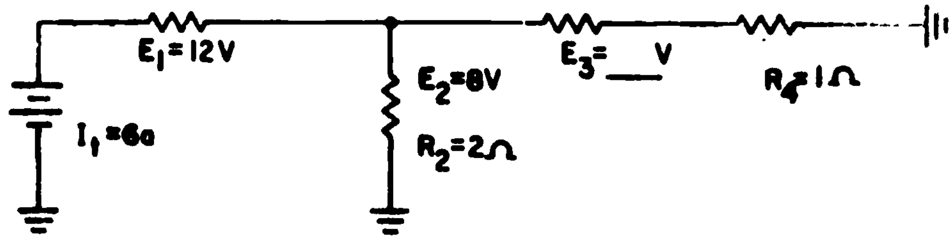
Designed for ATC Course Use.

Do Not Use on the Job.

SERIES-PARALLEL CIRCUITS

Solve each of the following problems for the indicated unknown. Put your answers on the appropriate blanks. Set up the problems, using the same procedures as in the last frame.

1.



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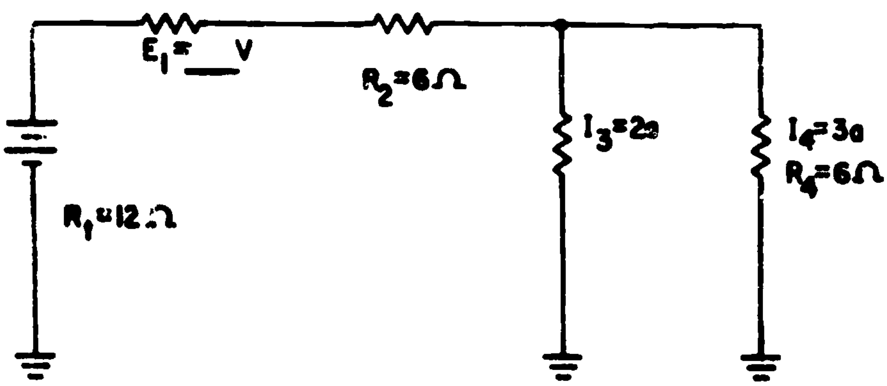
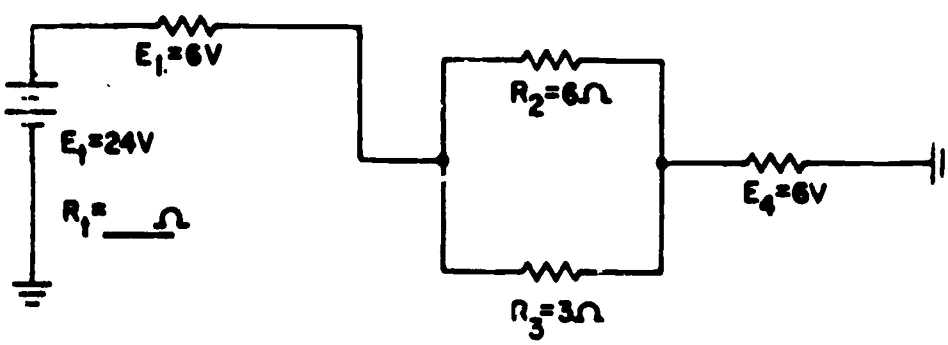
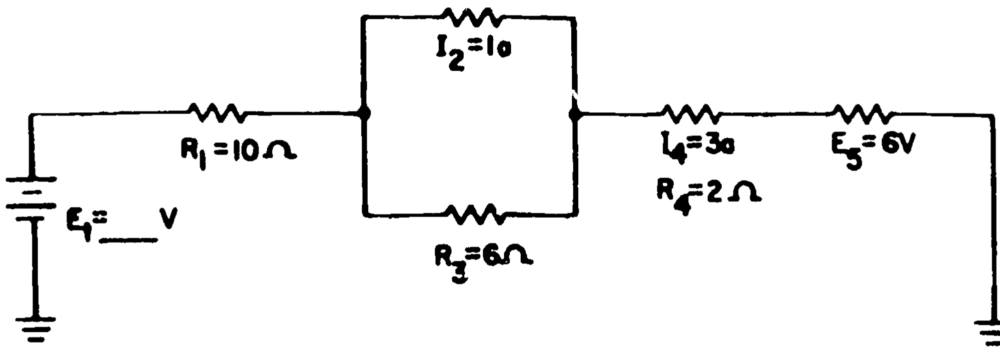


3.



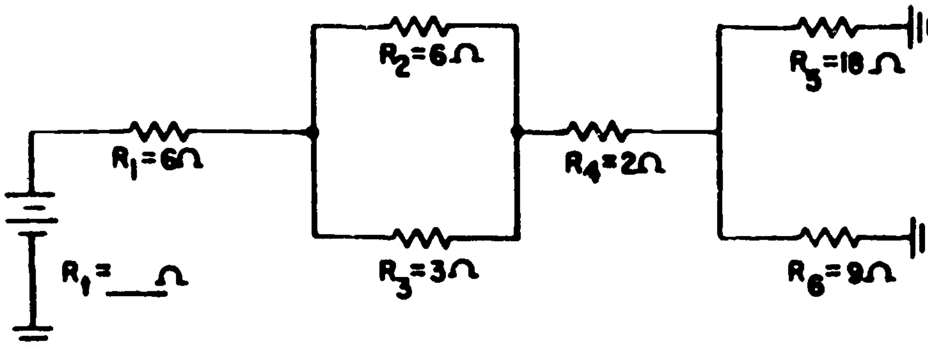
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 500; DAV - 1

4.



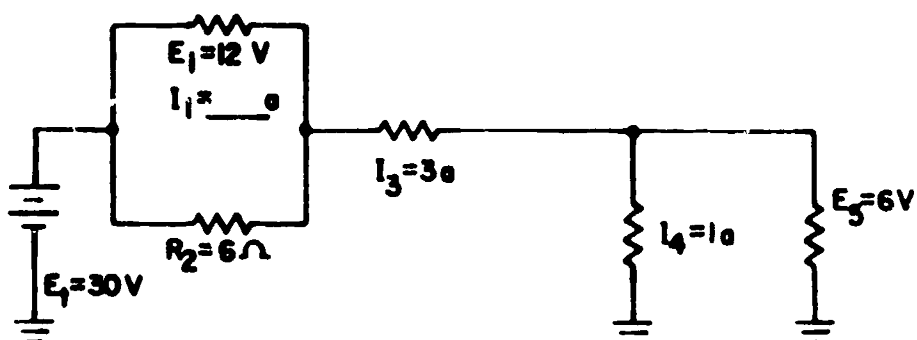
I_2=1a
R_1=10Ω
E_1=___V
R_3=6Ω
I_4=3a
R_4=2Ω
E_5=6V

5.



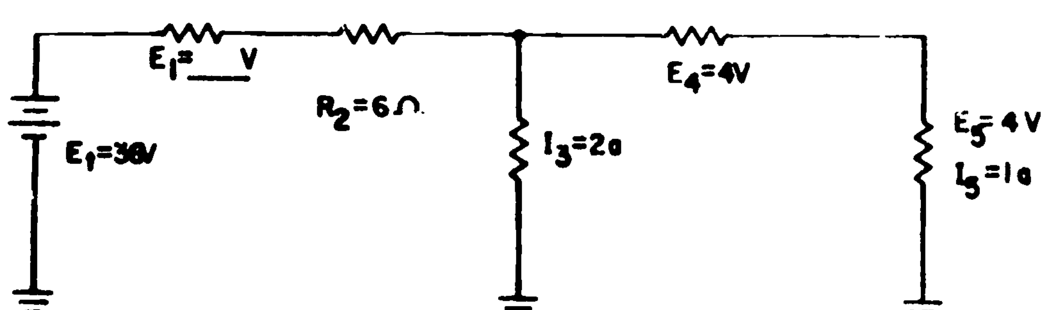
R_2=6Ω
R_1=6Ω
R_4=2Ω
R_5=18Ω
R_1=___Ω
R_3=3Ω
R_6=9Ω

6.



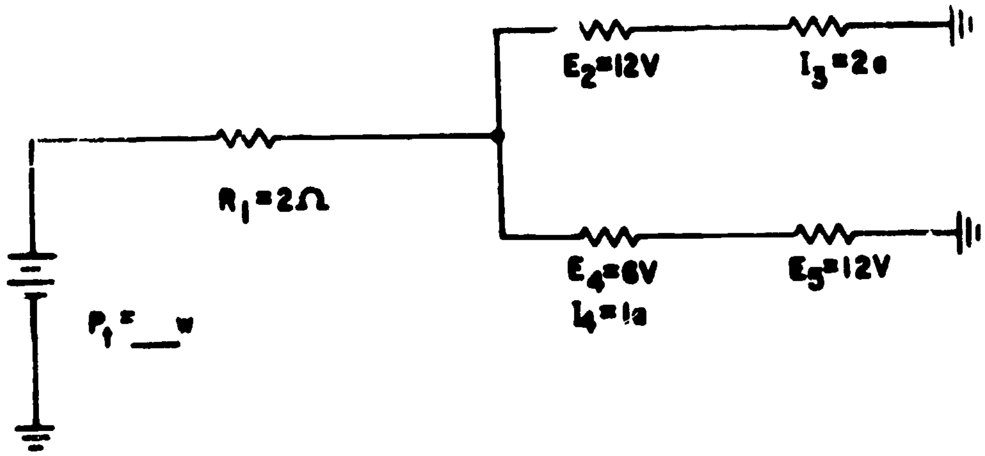
E_1=12 V
I_1=___a
I_3=3a
R_2=6Ω
E_1=30V
I_4=1a
E_5=6V

7.



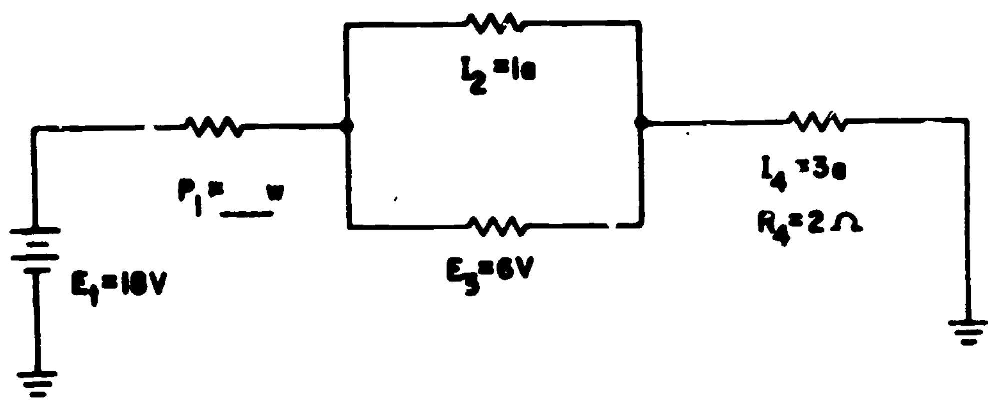
E_1=___V
R_2=6Ω
E_4=4V
E_1=36V
I_3=2a
E_5=4V
I_5=1a

8.



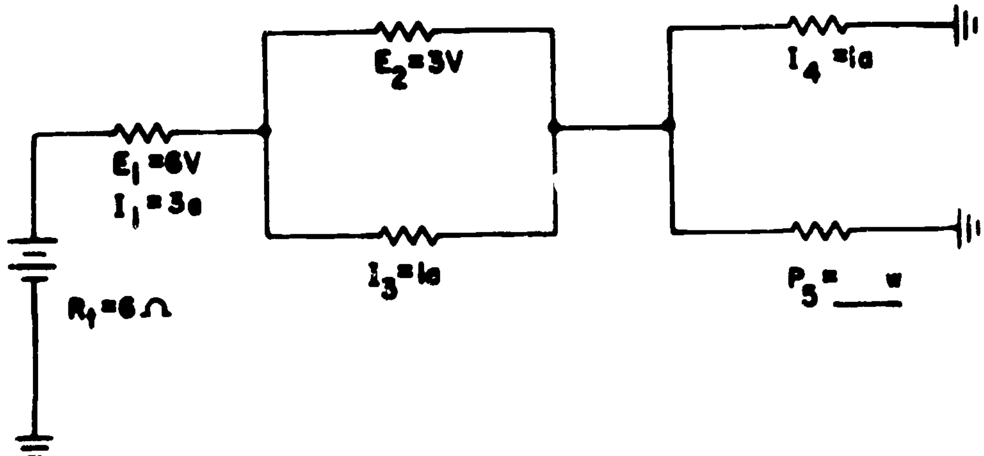
E_2=12V
I_3=2a
R_1=2Ω
E_4=6V
I_4=1a
E_5=12V
P_1=___w

9.



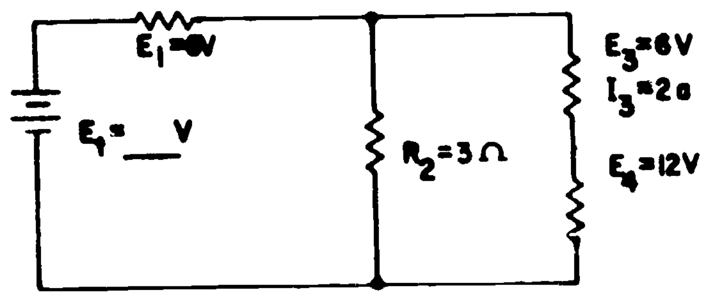
I_2=1a
P_1=___w
I_4=3a
R_4=2Ω
E_1=18V
E_3=6V

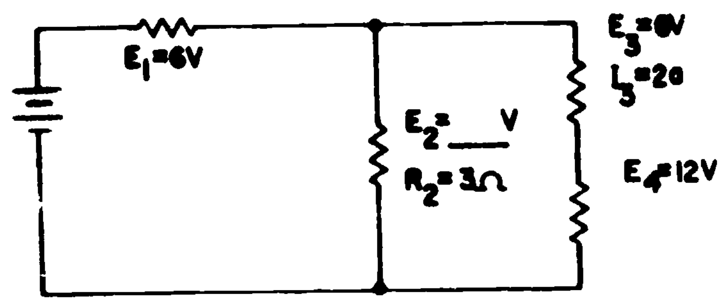
10.

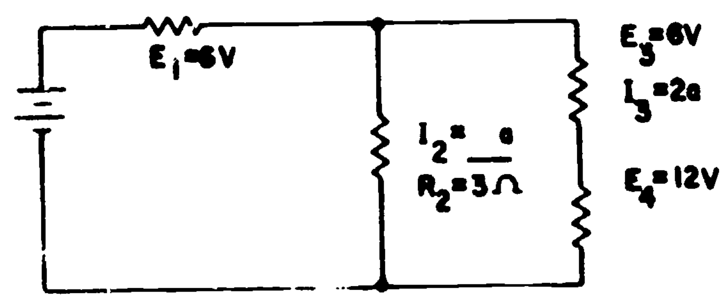


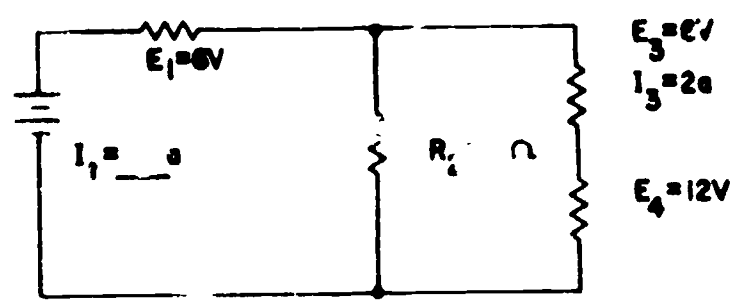
E_2=3V
I_4=1a
E_1=6V
I_1=3a
I_3=1a
R_1=6Ω
P_5=___w

Solve each of the following problems for the indicated unknown. Put your answers on the appropriate blanks.

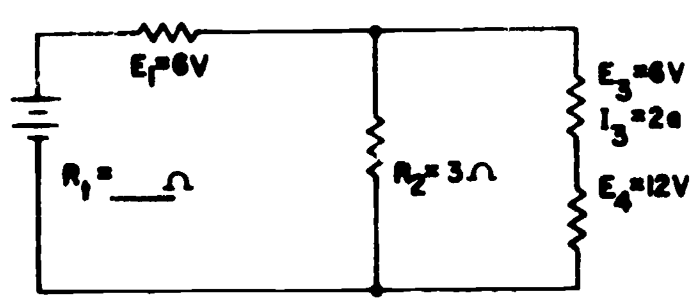




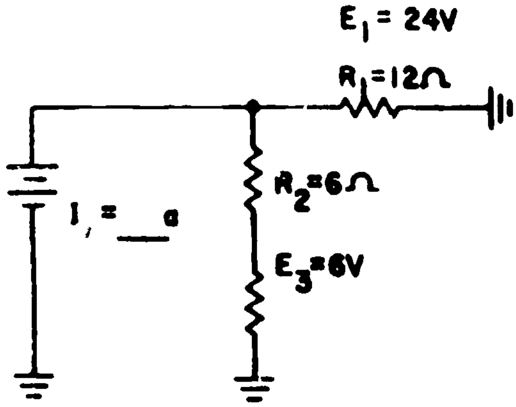




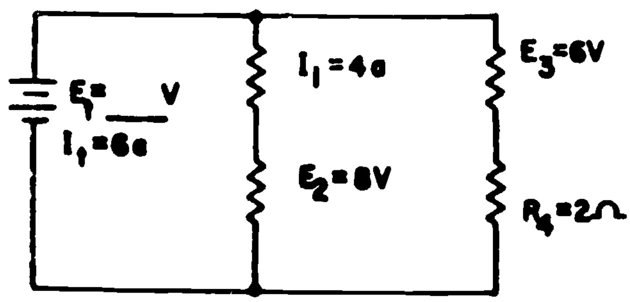
5.



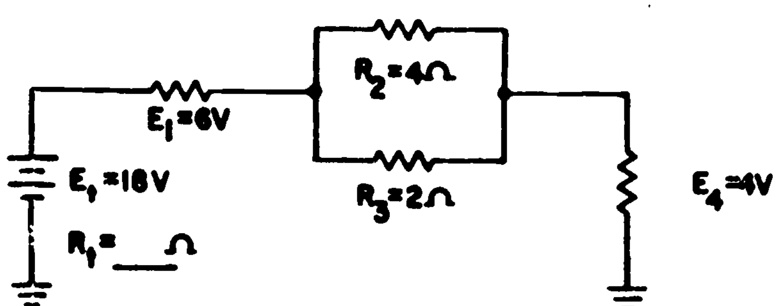
6.


E$_1$ = 24V
R$_1$=12Ω
R$_2$=6Ω
I$_1$ = ___a
E$_3$=6V

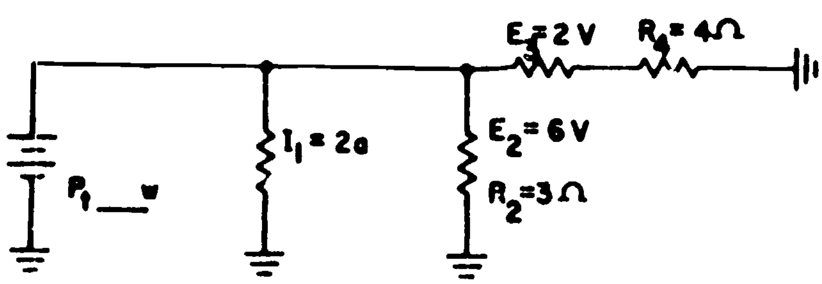
7.


E$_1$= ___V
I$_1$=6a
I$_1$=4a
E$_2$= 8V
E$_3$=6V
R$_4$=2Ω

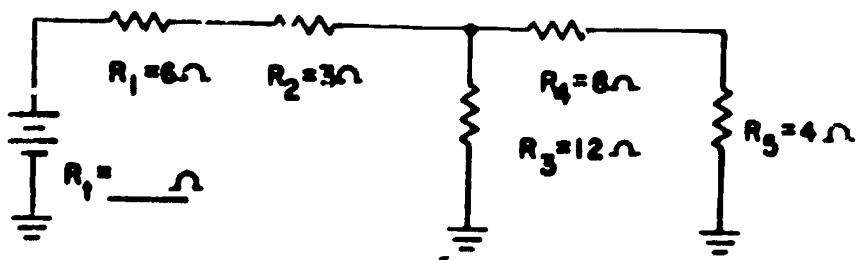
8.


E$_1$=6V
R$_2$=4Ω
R$_3$=2Ω
E$_t$=18V
R$_t$= ___Ω
E$_4$=4V

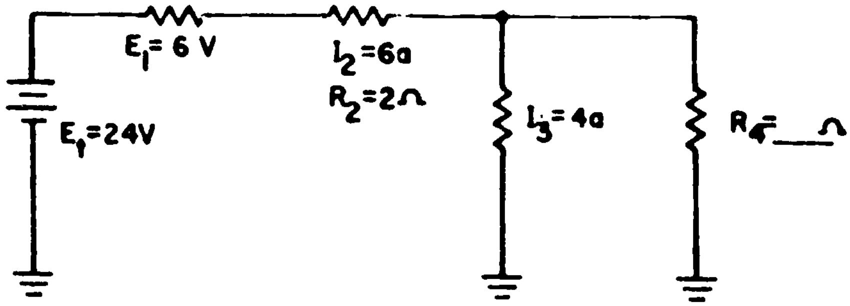
9.


E$_3$=2 V
R$_4$= 4Ω
I$_1$= 2a
E$_2$= 6 V
R$_2$=3Ω
P$_t$ ___w

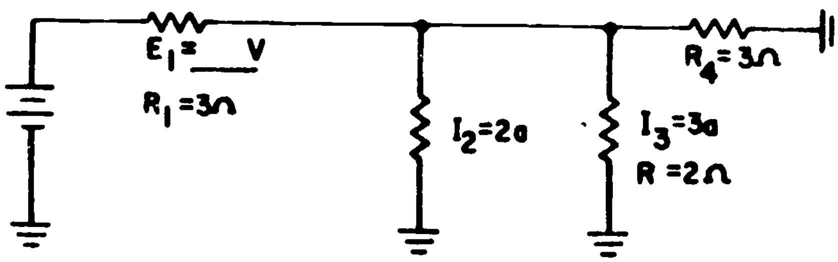
10.


R$_1$=6Ω
R$_2$=3Ω
R$_4$=8Ω
R$_3$=12Ω
R$_5$=4Ω
R$_t$= ___Ω

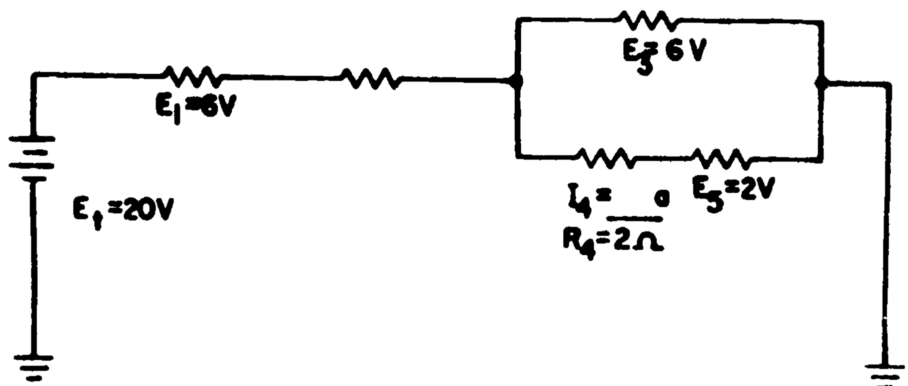
11.


E1= 6 V
I2 =6a
R2=2Ω
E1=24V
I3= 4a
R4=___Ω

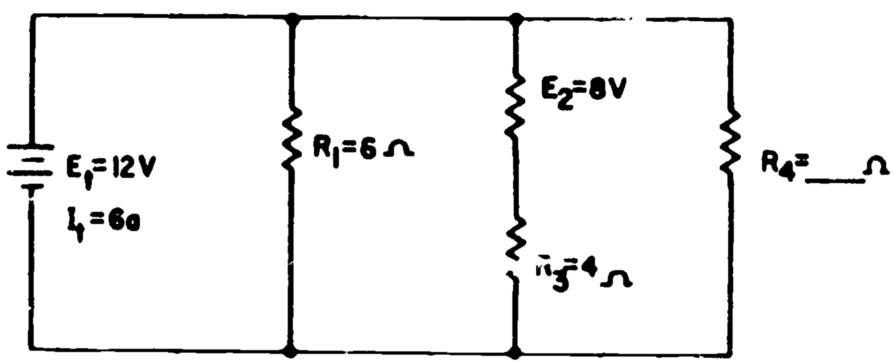
12.


E1 = ___V
R1 =3Ω
I2=2a
I3=3a
R =2Ω
R4= 3Ω

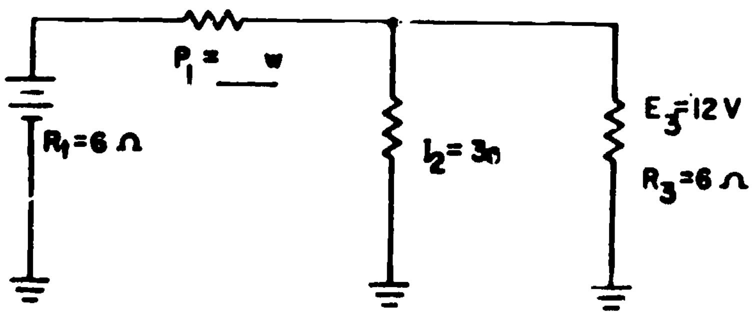
13.


E1=6V
E1=20V
E3= 6 V
I4= ___a
R4=2Ω
E5=2V

14.

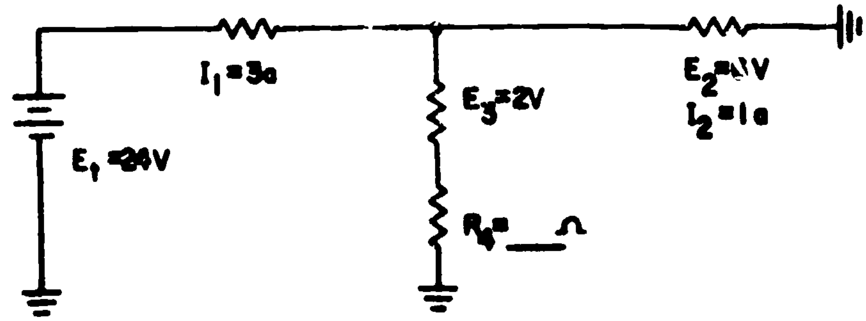

E1=12V
I1=6a
R1=6 Ω
E2=8V
R3=4Ω
R4=___Ω

15.

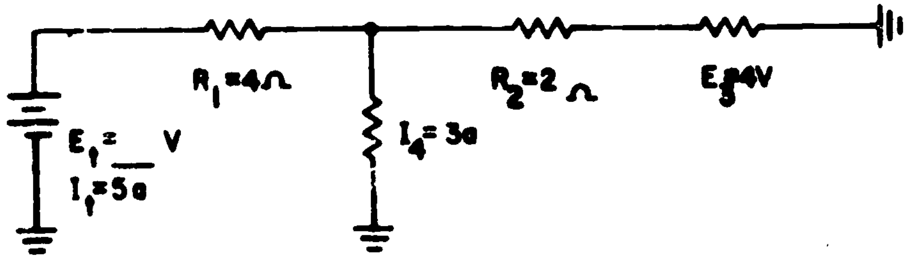

P1 = ___w
R1=6 Ω
I2= 3a
E3=12 V
R3=6 Ω

Solve each of the following problems for the indicated unknown. Put your answers on the appropriate blanks.

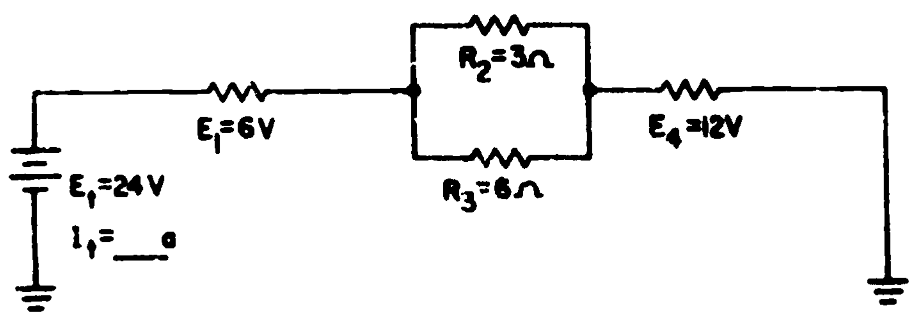
1.



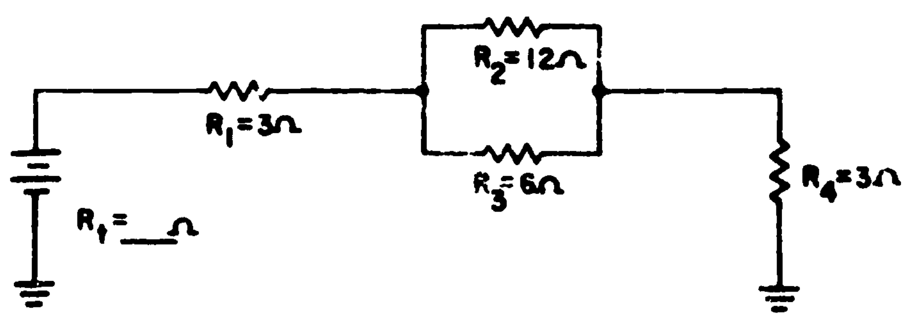
2.



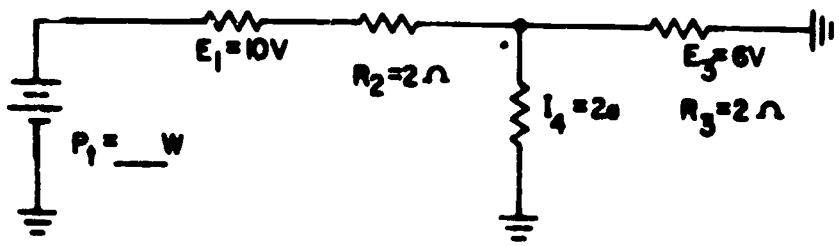
3.



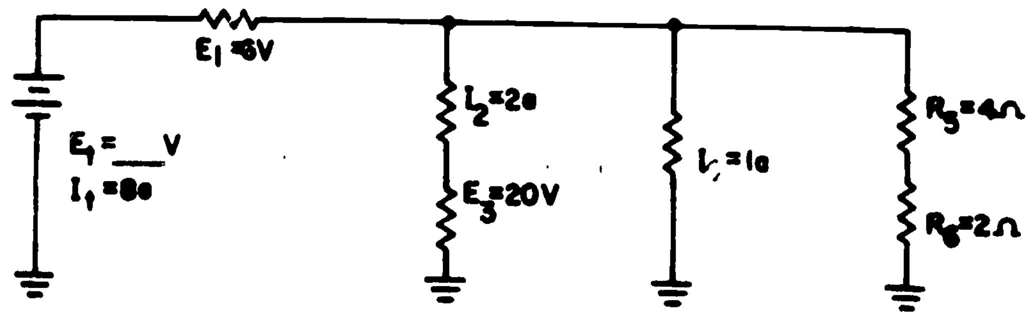
4.



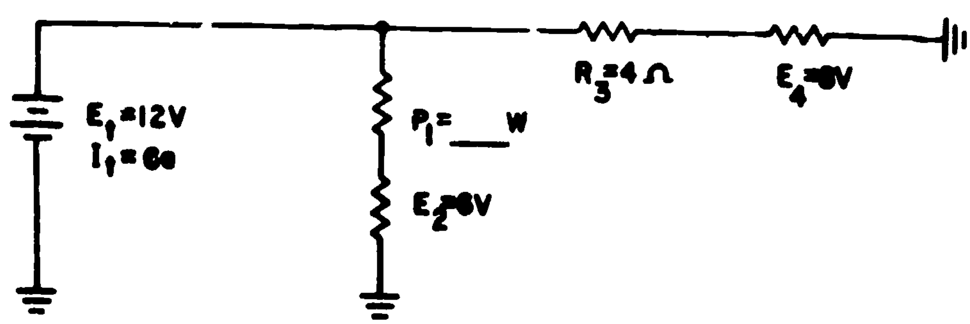
5.


E_1=10V
R_2=2Ω
I_4=2a
E_3=6V
R_3=2Ω
P_1=___W

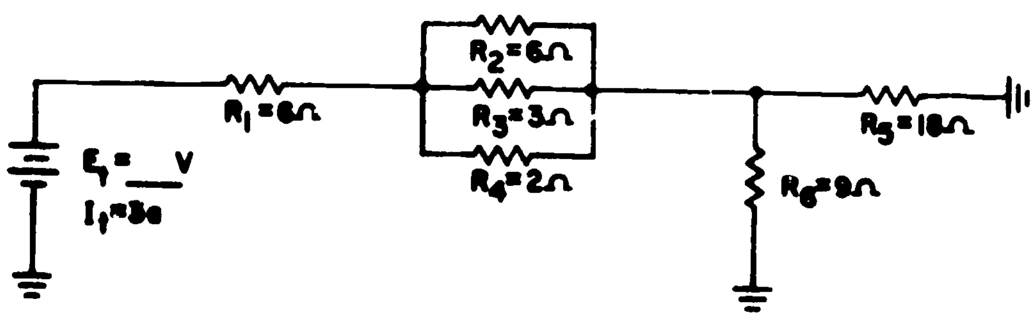
6.


E_1=6V
E_1=___V
I_1=8a
I_2=2a
E_3=20V
I_4=1a
R_5=4Ω
R_6=2Ω

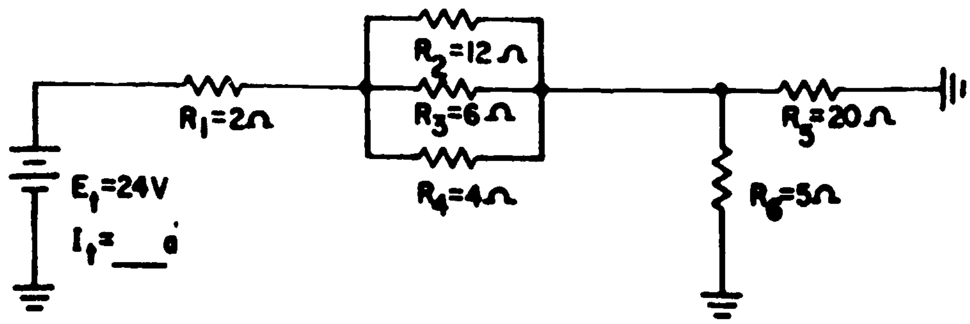
7.


E_1=12V
I_1=6a
P_1=___W
E_2=6V
R_3=4Ω
E_4=6V

8.

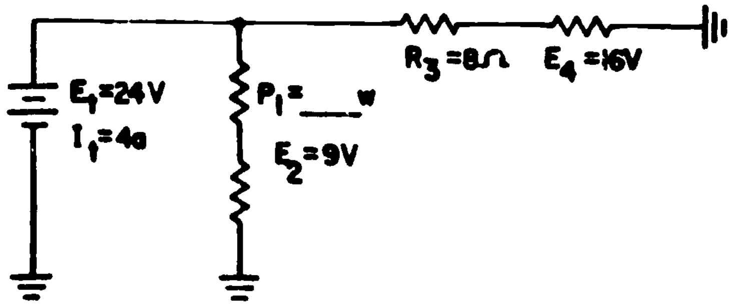

E_1=___V
I_1=3a
R_1=6Ω
R_2=6Ω
R_3=3Ω
R_4=2Ω
R_5=18Ω
R_6=9Ω

1.



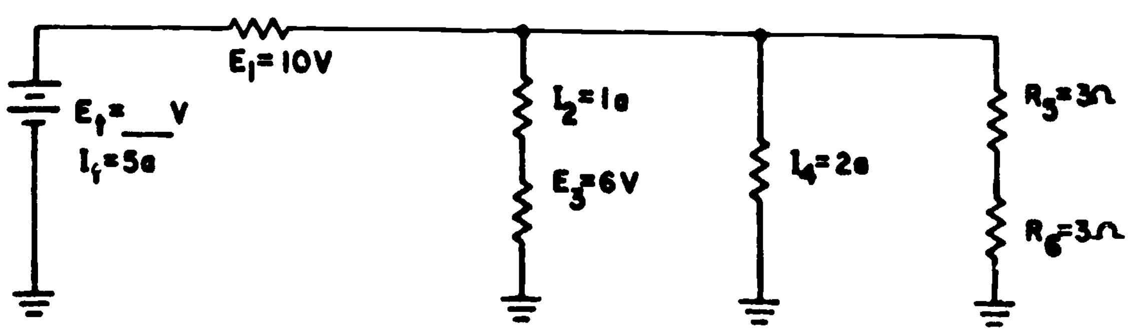
$R_2=12\Omega$
$R_1=2\Omega$
$R_3=6\Omega$
$R_5=20\Omega$
$E_t=24V$
$R_4=4\Omega$
$R_6=5\Omega$
$I_t=$___a

2.



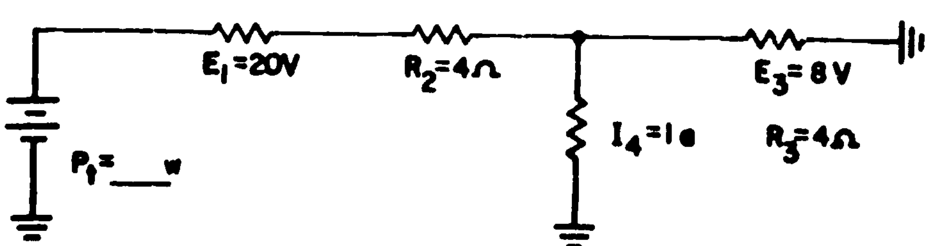
$R_3=8\Omega$
$E_4=16V$
$E_t=24V$
$P_1=$___w
$I_t=4a$
$E_2=9V$

3.



$E_1=10V$
$E_t=$___V
$I_2=1a$
$R_5=3\Omega$
$I_t=5a$
$I_4=2a$
$E_3=6V$
$R_6=3\Omega$

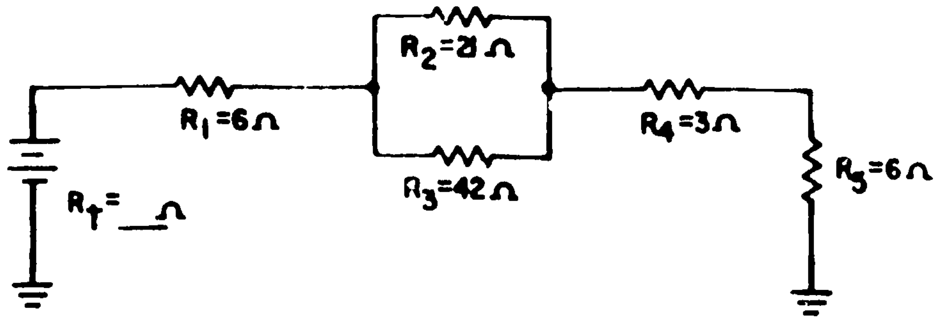
4.



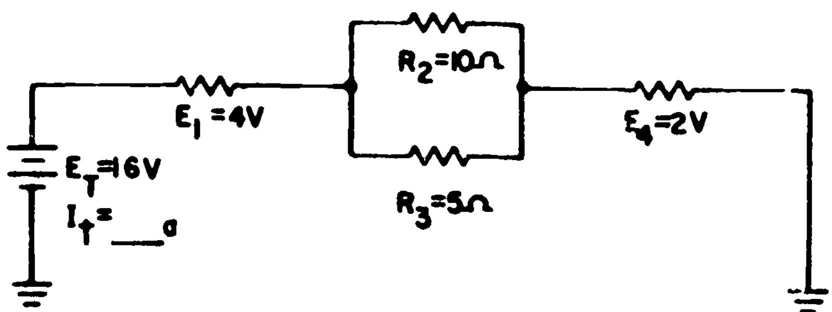
$E_1=20V$
$R_2=4\Omega$
$E_3=8V$
$I_4=1a$
$R_3=4\Omega$
$P_t=$___w

943

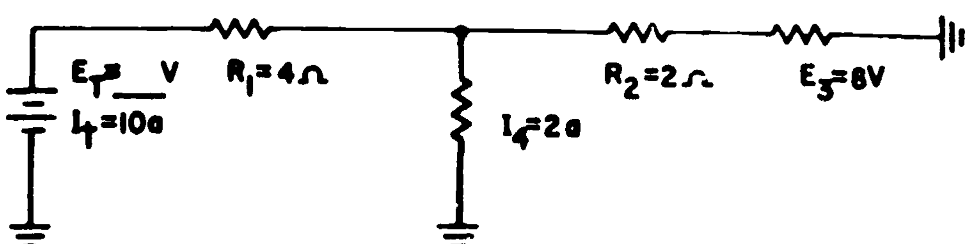
5.


R2=21Ω
R1=6Ω
R4=3Ω
R5=6Ω
R3=42Ω
RT=___Ω

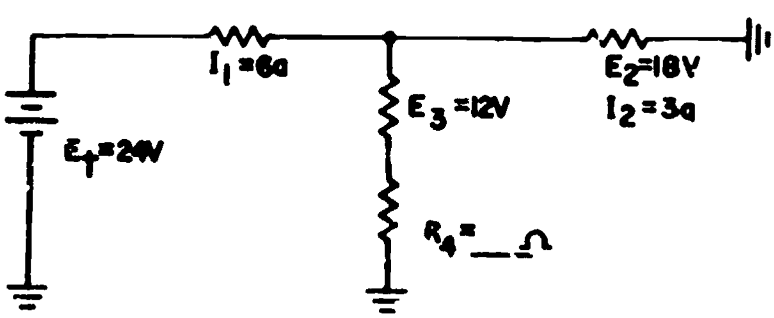
6.


R2=10Ω
E1=4V
E4=2V
ET=16V
IT=___a
R3=5Ω

7.


ET=___V
IT=10a
R1=4Ω
I4=2a
R2=2Ω
E3=8V

8.


I1=6a
E3=12V
E2=18V
I2=3a
ET=24V
R4=___Ω

Technical Training

Aircraft Environmental Systems Mechanic

INTRODUCTION TO RELAYS

20 February 1981

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

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RGL: 8.9

OBJECT'

Relate components of a relay sw... circuit to their purpose with a minimum of 80% accuracy.

INSTRUCTIONS

This program presents information in small steps called frames. After reading each frame, slide a mask (sheet of paper or cardboard) down the page until you see a short row of slashes (//////). Read the question; answer it and then slide the mask down until the correct answer is exposed. If you miss a correct answer, or you are not sure, restudy the appropriate frame.

Supersedes 3ABR42331-PI-120, 6 June 1980.
OPR: 3370 TCHGT
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 1000; TVSA - 1

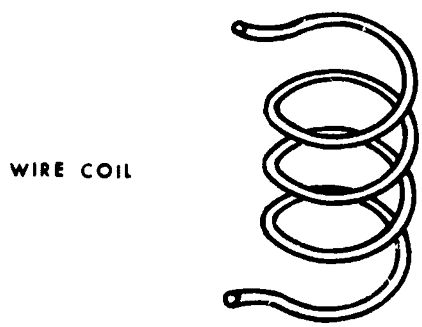
While aircraft and missiles are not really human, they are capable of doing some things that seem almost human. They can respond to orders just as we . Through the use of small electrical devices called "relays," they can transmit electrical orders to mechanical motors to operate vital parts of the aerospace vehicle.

///////////////

No response required

Frame 2

To better understand a relay, we will examine the "working parts." Below is a coil of wire that will be used as an electromagnet. Perhaps you recall that as current flows through the coil a magnetic field is built up around the coil. Like any magnet, it will attract any nearby metallic object that a magnet normally attracts.

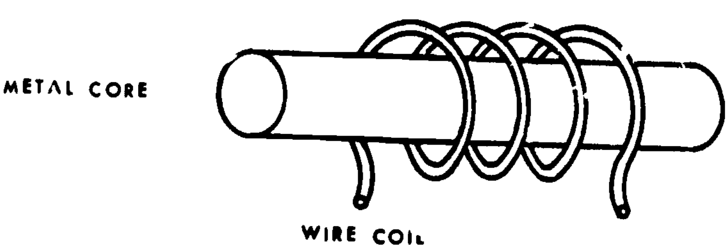


/////////////////

No response required

Frame 3

A soft iron core is put into the center of the coil. While this bar does not actually touch the coil of wire or have electrons flowing through it, it does make the magnetic field stronger by providing an easier path for the magnetic flux to travel.



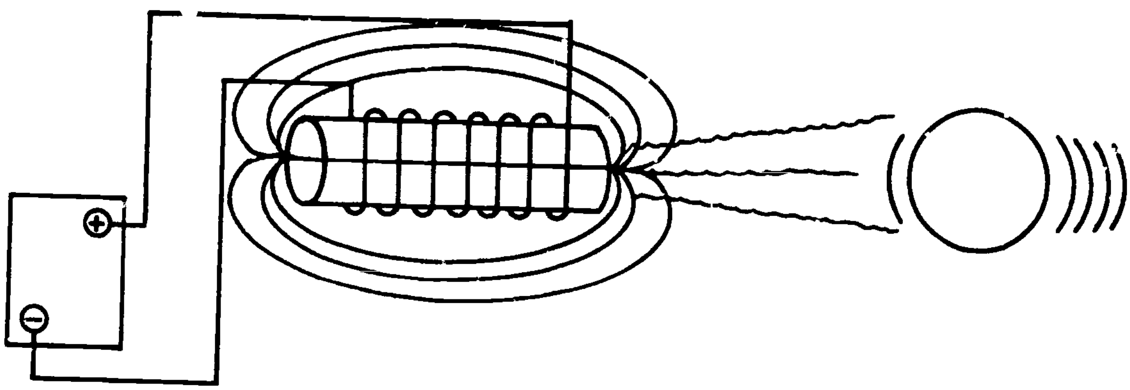
So far we have seen that a relay may be made up of a coil of ______________ and a soft iron______________.

////////////////

wire core

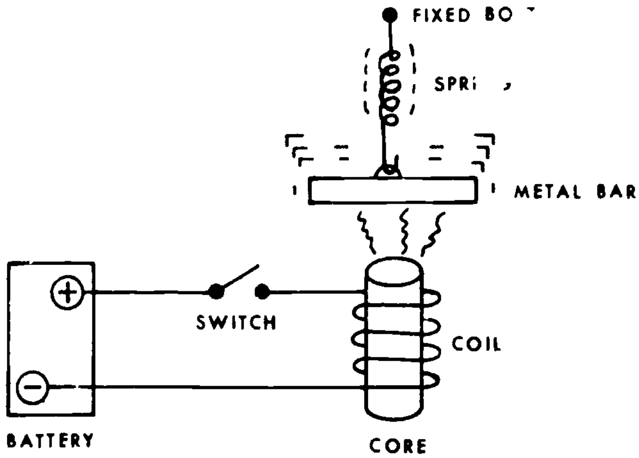
Frame 4

If the wire c·il is connected to a battery, a magnetic field will build up around the coil. The field will reach out to attract any object that is normally attracted by magnets.



////////,//////////
No Response Required

Because our electromagnet has the ability to attract certain metallic objects, we can make it do some uc.. ul work.



Study the illustration carefully and then complete the statements below by und rlining the correct word(s).

a. The CORE is actually a (soft-iron) (hard steel) bar.

b. A (battery) (switch) supplies current to the electromagnet.

c. Current flows through the (coil) (core).

d. A magnetic field flows through the (coil) (core).

e. The current is CONTROLLED by the (battery) (switch).

f. If the switch is turned on, the magnetic field will (attract) (repel) the metal bar.

g. The spring will pull the metal bar back to its original position if the switch is turned (on) (off).

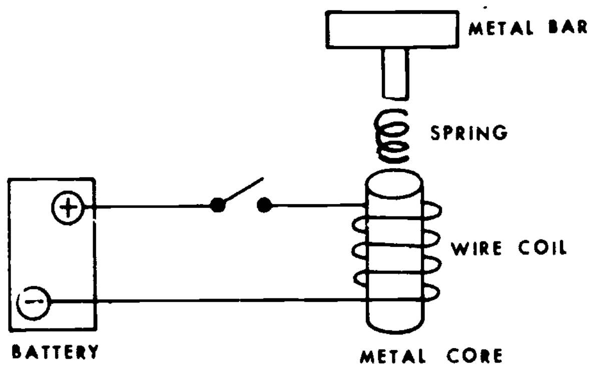
//////////////

a. soft iron. b. battery. c. coil. d. core.

e. switch. f. attract. g. off.

Frame 6

Study this illustration carefully and complete the statements that follow by underlining the correct word(s).



a. If the switch is closed, the metal bar will (compress) (stretch) the spring.

b. The battery supplies current to the (coil) (core).

c. The switch controls current through the (coil) (core).

d. The movable parts are the (coil) (coil and spring) (metal bar, coil and spring) (spring and metal bar).

e. The strength of the magnetic field is determined by the (spring) (current).

f. There (is) (is no) current flowing in the coil with the switch open.

g. There (is) (is no) current flowing in the upper metal bar.

h. The only purpose of the spring is to (pull the metal bar down) (push the metal bar away from the core).

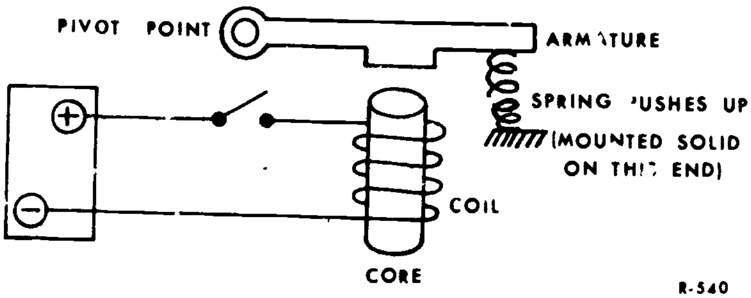
///////////////

a. compress. b. coil. c. coil d. spring and metal bar.

e. current. f. is no. g. is no.

h. push the metal bar away from the core.

Here is another way our electromagnet can be setup to pull on a metal bar (armature). Notice that the bar is pivoted (hinged) on one end. It can be pushed up by the spring and pulled down by the electromagnet. The proper name for this metal bar is the ARMATURE. Complete the statements below by underlining the correct word.



a. The battery sends current into the pivoted armature. (true) (false)

b. If the armature is hinged at the pivot point, the (right) (left) end of the armature will move down.

c. The spring will return the armature to its normal position anytime the switch is (open) (closed).

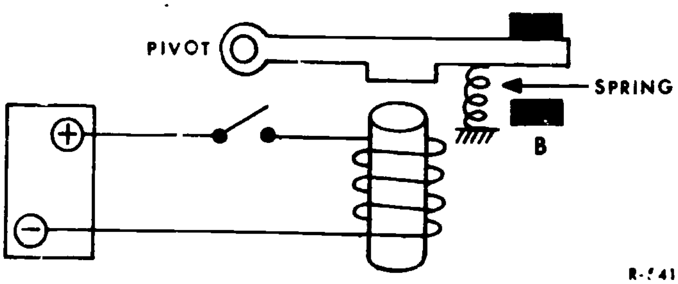
////////////////////

a. false. b. right.

c. open (if it is closed the magnetic field will pull the armature down).

Frame 8

In this illustration we have added something new. There are two contacts labeled "A" and "B." Underline the correct answer after you have carefully studied this illustration.



a. If the switch is open, the armature will be resting against contact (A) (B).

b. If the switch is closed, the armature will be drawn against contact (A) (B).

c. When the coil is turned OFF, the armature will normally rest against contact (A) (B).

d. Current from the battery will flow through the armature. (true) (false).

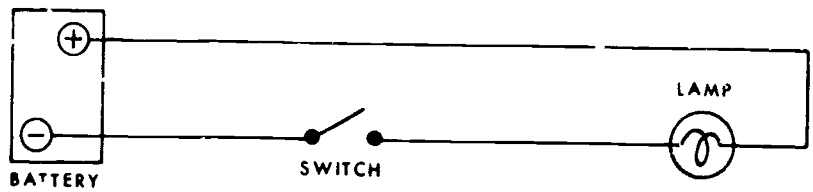
////////////////

a. A. b. B c. A

d. False (Current flows only through the coil).

952

For a moment, let's take a look at a simple circuit.



All we need to do is close the switch and the lamp will light. The battery supplies current to light the lamp when the switch is closed. The switch completes the path from the battery's negative terminal through the lamp, and back to the positive terminal.

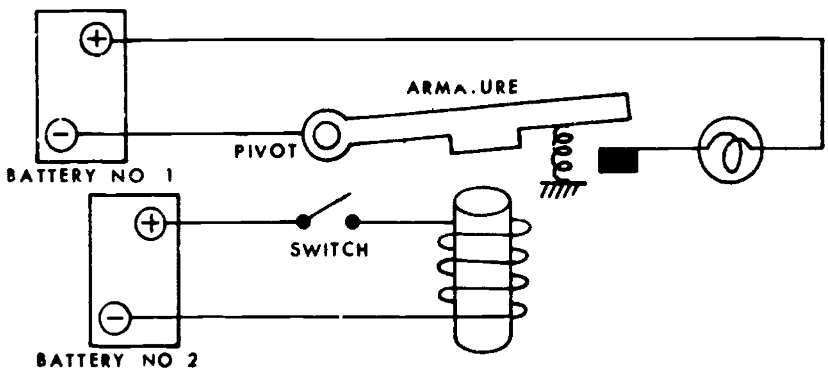
///////////////

No Response Required

Frame 10

Now we can put our electromagnet to work. Remember we normally turn a switch on and off with our fingers. What is to keep us from using our electromagnet to open and close the circuit between the battery and the lamp?

Look at this illustration and then underline the correct word in the statements below.



a. The switch controls current through the (coil) (lamp).

b. Current for the electromagnet's coil is supplied by battery (No. 1) (No. 2).

c. Current for the lamp is supplied by battery (No. 1) (No. 2).

d. Current will flow from battery No. 2 to the lamp. (true) (false)

e. The current that lights the lamp flows through the (coil) (core) (armature).

f. After the switch is OPENED, the lamp will go out because the spring pushes the armature away from the contact. (true) (false)

g. Current flows through the pivot, armature, and contact to get to the lamp. (true) (false)

//////;//////

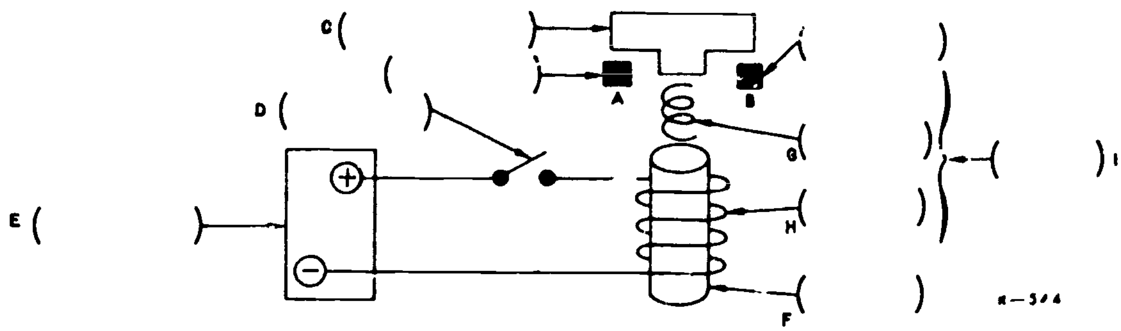
a. coil   b. No. 2   c. No. 1   d. false

e. armature   f. true   g. true

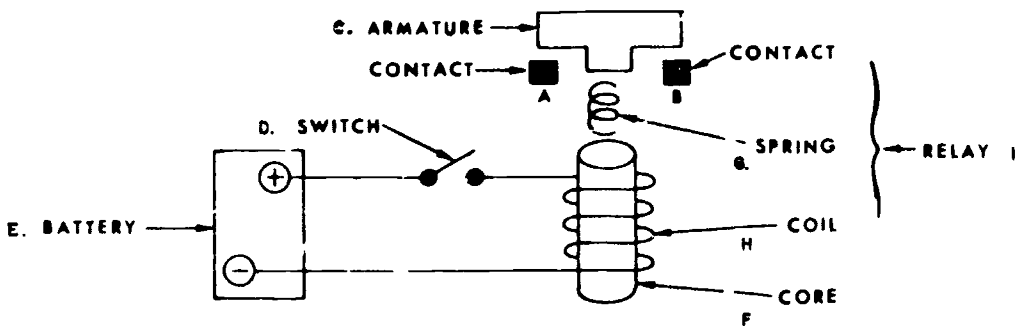
954

It's time to give our electromagnet and armature combination a name. From here on it will be referred to as a RELAY.

Label the parts in this illustration by writing the appropriate words in the spaces provided.

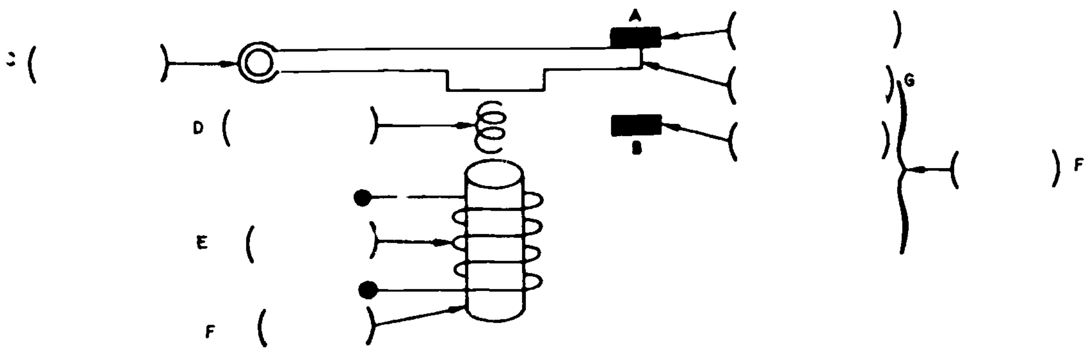


//////////////!!

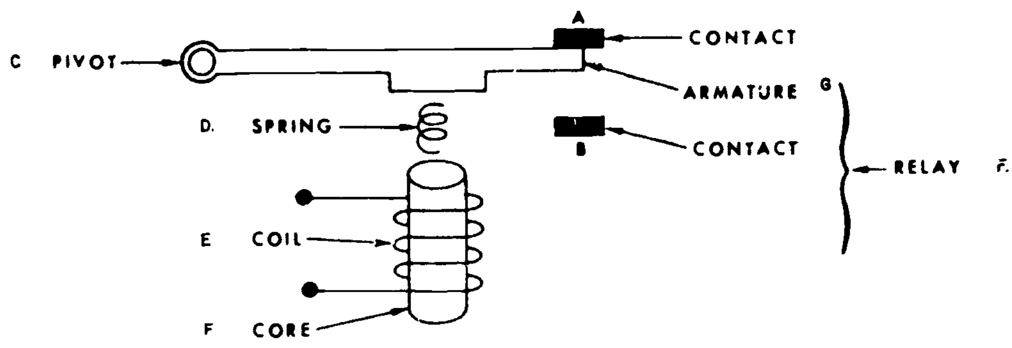


Frame 12

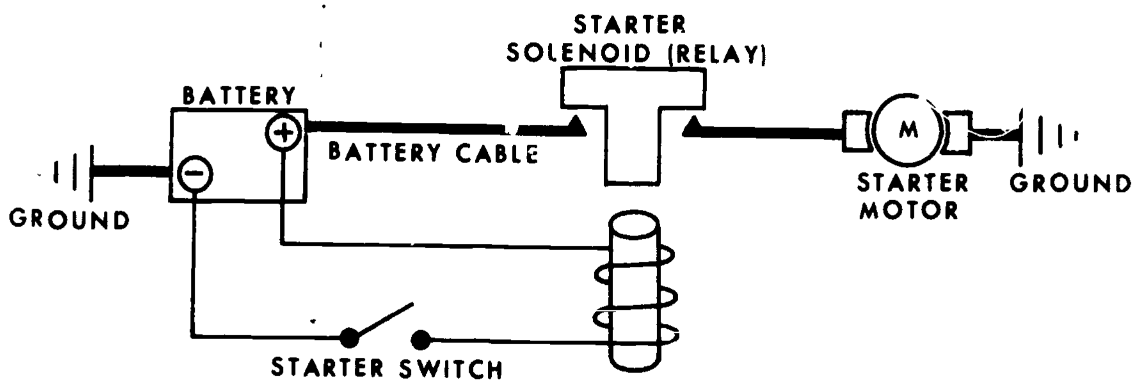
This is also an illustration of a relay. Label the parts by writing the appropriate word in the space provided.



///////////////



Relays are actually remotely controlled switches. An example of their use is the starter solenoid (relay) in your car. It takes a LOT of current to start a cold engine. If the battery cables are too long, they will reduce the amount of current the battery can deliver to the starter motor. The trick then is to keep the battery cables short and, yet not have to get out of the car and go beneath the hood just to close a switch between the battery and the starter motor. This is an illustration of one way in which it is done.



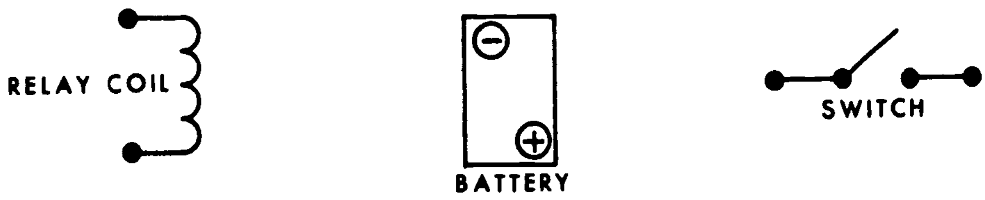
Close the starter switch and the magnetic field pulls the armature of the relay down. Now current can flow from the battery, through the starter motor and armature of the relay, then back to the battery. In this case, it is easy to see how a very small wire can come up to the starter switch inside the car. All the starter switch has to do is complete the circuit from the battery's negative terminal, through the relay coil and back to the battery's positive terminal (or to the chassis). No current goes from the relay coil to the relay armature. It is the magnetic field that pulls the armature down and closes the contacts.

//////////////

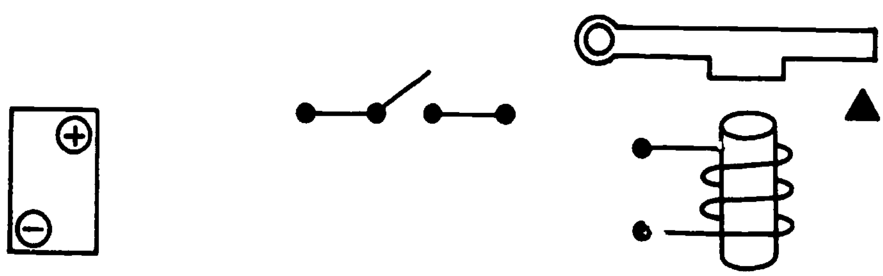
No Response Required

Frame 14

By now you have noticed that we have two electrical circuits in our relay diagrams. One of these is the CIRCUIT THAT CONTROLS THE RELAY causing it to turn on and off. The parts that make up the circuit that controls the relay are the -

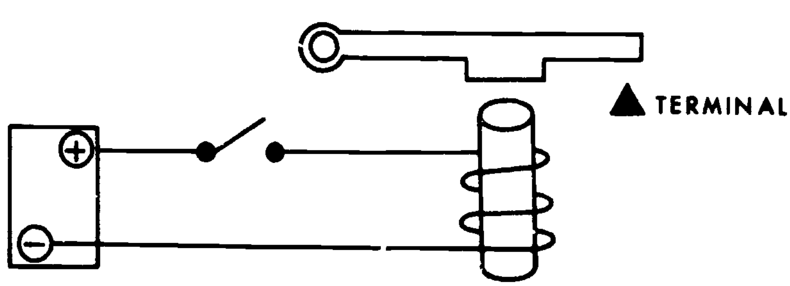


Below are some circuit components. Draw a line between them to show how YOU would wire them to make a circuit that CONTROLS just the relay.



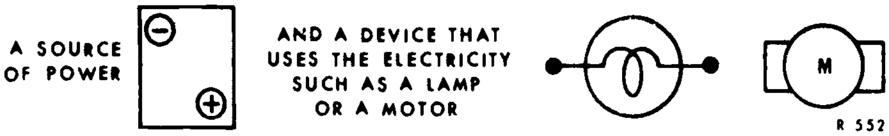
//////////////

Your answer should resemble this drawing.

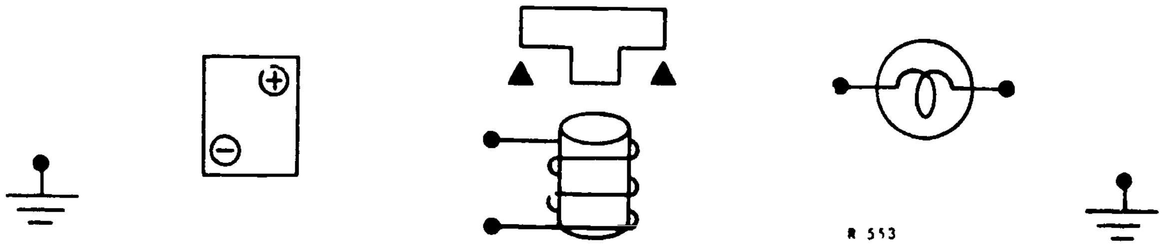


958

The second circuit we have illustrated is the CIRCUIT THAT IS CONTROLLED BY THE RELAY. It is usually made up of:

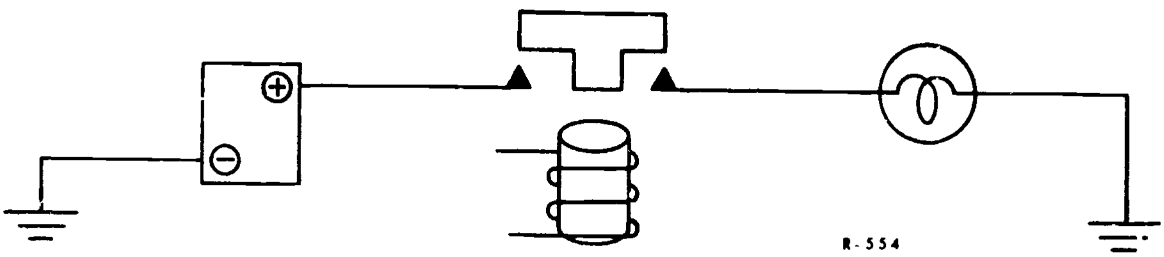


Draw a line between the components below to show how you would wire a CIRCUIT THAT IS CONTROLLED BY A RELAY.



///////////////////

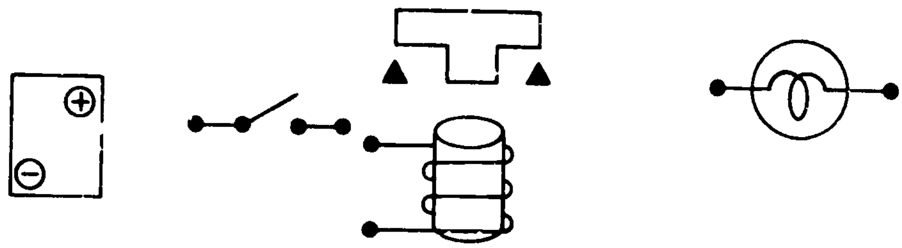
Since we provided the "grounds," your answer should resemble this.



Notice the relay coil is NOT wired because it is part of the circuit that CONTROLS THE RELAY.

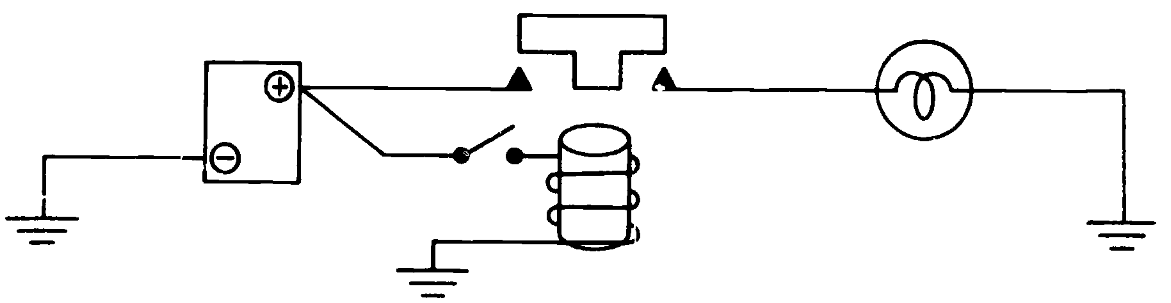
Frame 16

With the experience you have just gained in wiring a circuit that controls a relay and a circuit that is controlled by a relay, draw in the necessary wires to show how YOU would wire both a circuit that controls the relay, and the circuit that is controlled by the relay. YOU MAY USE ONLY ONE BATTERY.



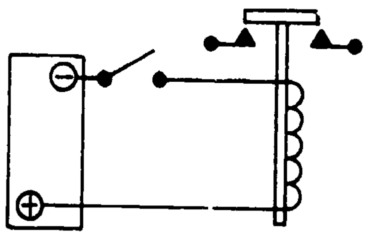
//////////////////

Your wiring should be similar to this - (if it is not, have your instructor explain what must be done to correct it).

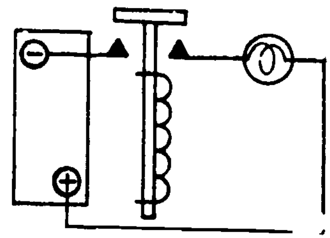


960

Below are several illustrations of electrical circuits. Look at them carefully and, when you are certain which kind they are, label them "Relay Control" for those circuits that simply turn the relay on and off, and "Controlled by a relay" for those circuits that are controlled by a relay. Write the correct answer in the space provided next to each illustration.

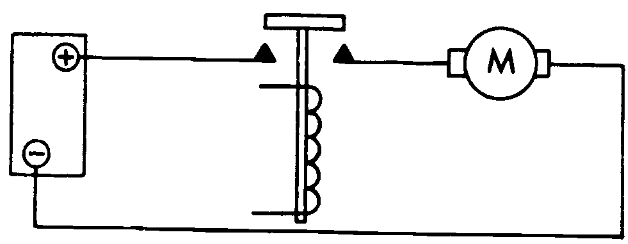


1. ____________________

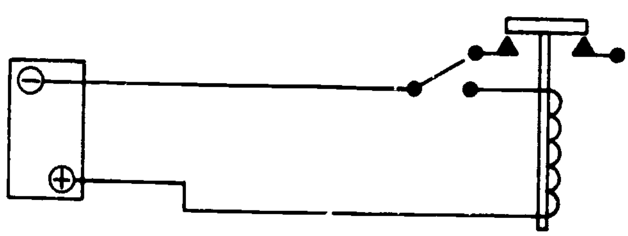


2. ____________________

R-557



3. ____________________



4. ____________________

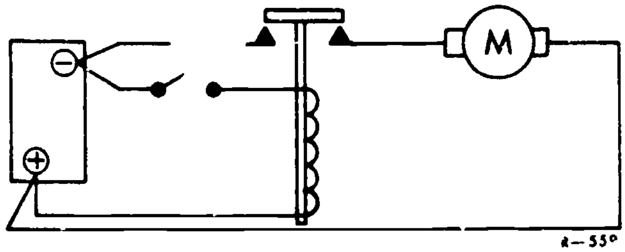
R-558

///////////////

1. relay control
2. controlled by a relay
3. controlled by a relay
4. relay control

Frame 18

You have learned that the circuits can be divided into two entirely different circuits. Study the circuit illustration below and underline the correct answer to the questions that follow.



a. The battery supplies energy for both circuits. (true) (false)

b. The switch is part of the circuit that is controlled by the relay. (true) (false)

c. The motor is part of the circuit that controls the relay. (true) (false)

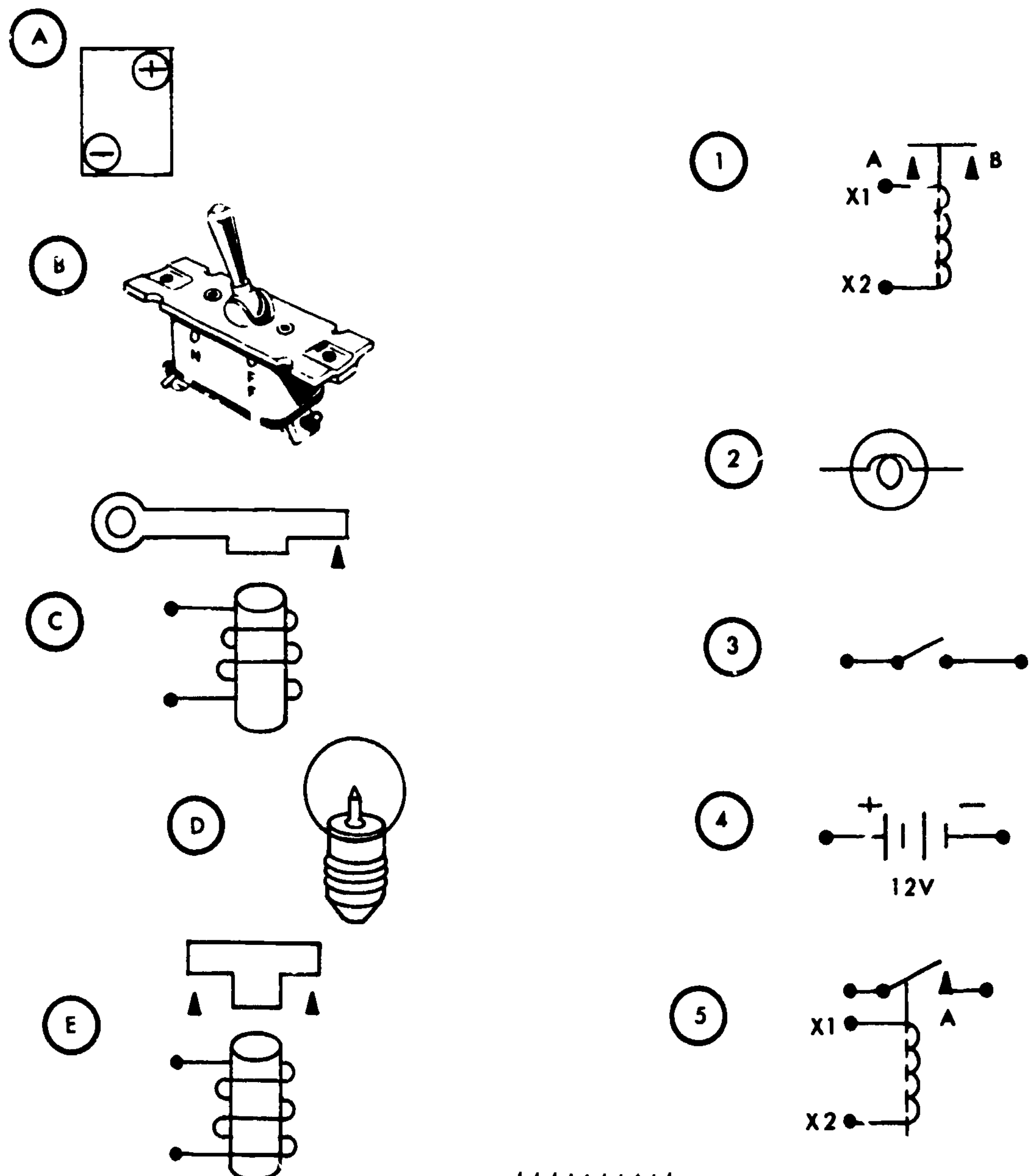
d. The relay coil is part of the circuit that controls the relay. (true) (false)

//////////////

a. true b. false c. false d. true

962

Symbols are used to represent the parts we have been working with so let's get acquainted with them. It saves a lot of time if you recognize the symbol and don't have to draw a picture of the battery, relay, etc. In the right column are the symbols for the units in the left column. Match them by drawing a line from the symbol to the device it represents.



//////////

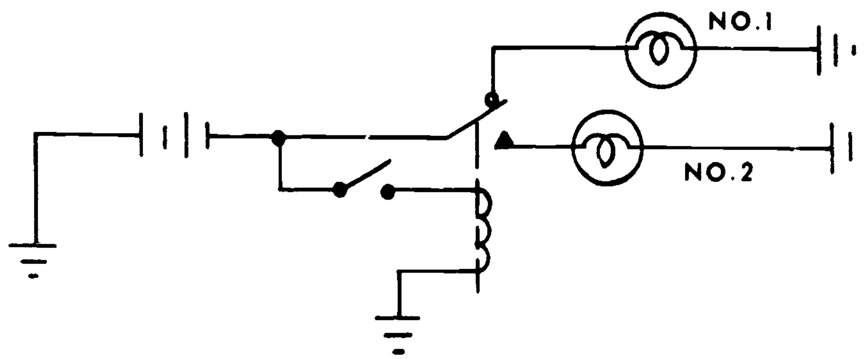
A → 4
B → 3
C → 5

D → 2
E → 1

963

Frame 20

A relay can be used to control more than one circuit. Study this circuit for a few minutes then underline the correct answer to the statements below.



a. With the switch in the position shown, (No. 1) (No. 2) (neither) lamp is lit.

b. If the switch is closed, (No. 1) (No. 2) (neither) lamp will light.

c. The switch lets current flow to both lamps if it is closed. (true) (false)

d. The switch controls current ONLY through the relay coil. (true) (false)

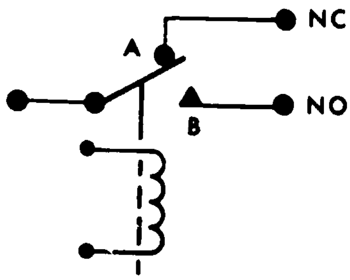
e. Which circuit is NORMALLY closed when the relay is not turned on? (No. 1) (No. 2)

////////////////

a. No. 1   b. No. 2   c. False   d. True   e. No. 1

964

You saw in frame 20 that the relay is at a certain position when it is NOT turned on.

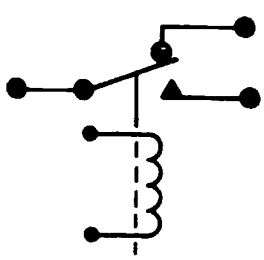


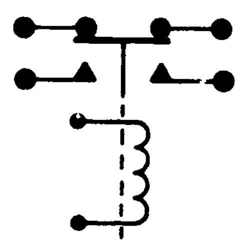
(NOT TURNED ON)

- so we labeled its upper contact (A) as NC - <u>No</u>rmally <u>C</u>losed.

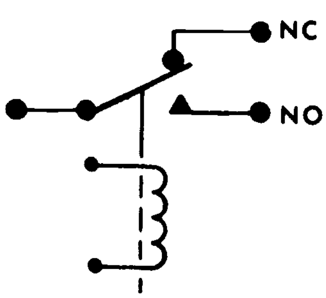
Contact B has been labeled as NO - Normally Open to show that circuit as being open when the relay is NOT turned on.

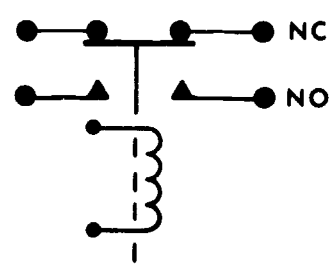
Label the contacts in the relay illustrations below to show their positions with the relay at rest (not turned on). You may abbreviate them NO and NC -





//////////////

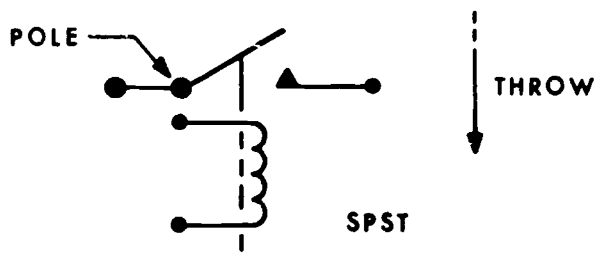




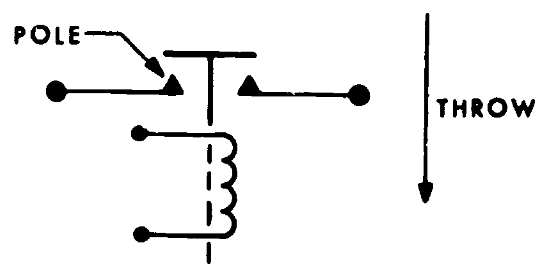
965

Frame 22

As with switches, relays are named according to their contact arrangements. This is called a "Single Pole, Single Throw" relay.



A "POLE" is the place where current enters the contacts and a "THROW" is the position the relay can be moved to in order to complete a circuit. The one shown above has a "Single Pole" and can be "thrown" (pulled down) to complete a path. Below is another SPST (single pole, single throw contact arrangement).

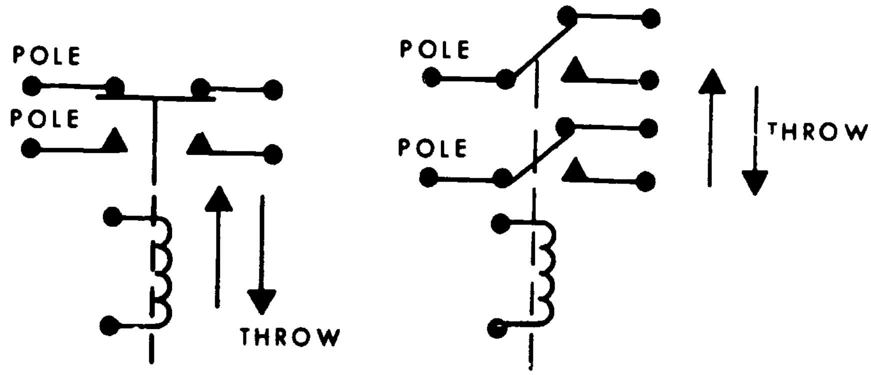


///////////////

No Response Required.

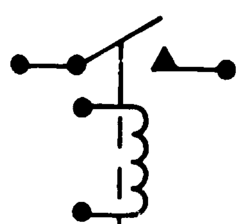
966

Study the illustration below and notice we have added a set of contacts.



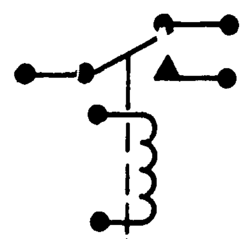
In this illustration each relay has TWO poles (places for current to enter the contacts) and TWO throws (positions to which the relay can be thrown to complete the circuits). If the relay is turned off, the spring moves the contacts to their original (up) resting position and certain circuits are completed. If the relay is turned on, the contacts are thrown down to complete different circuits. So, this relay would correctly be called a DPDT or double-pole, double-throw. Select the correct abbreviation for the contact arrangements below by underlining the correct answer.

A



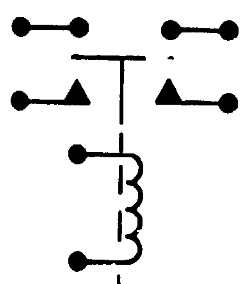
(SPST) (SPDT)
(DPST) (DPDT)

B



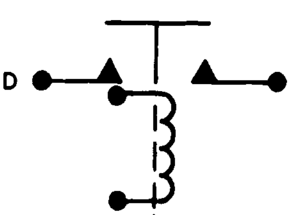
(SPST) (SPDT)
(DPST) (DPDT)

C



(SPST) (SPDT)
(DPST) (DPDT)

D



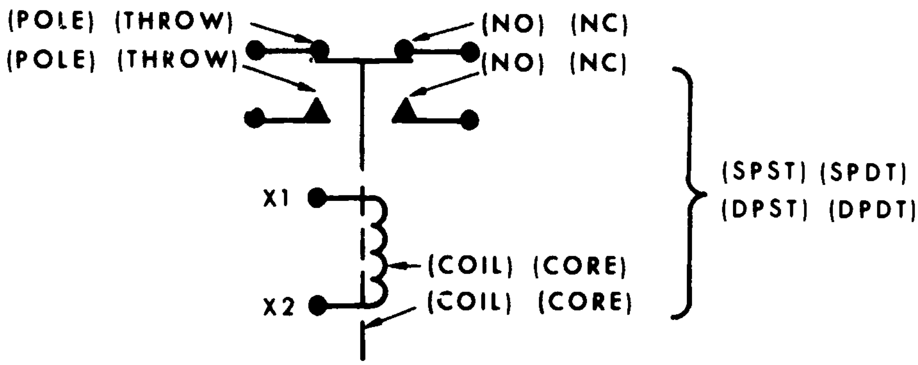
(SPST) (SPDT)
(DPST) (DPDT)

///////////////

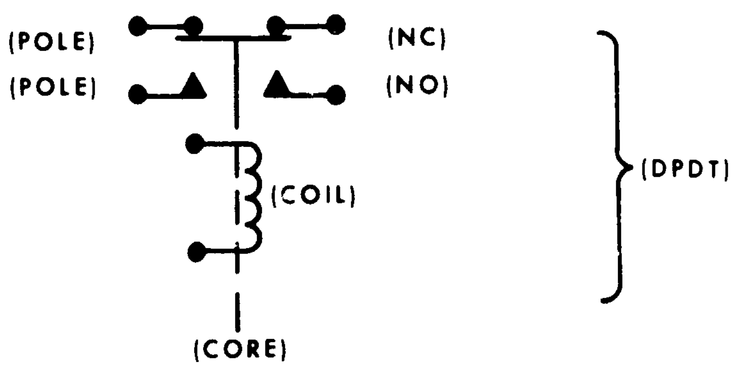
a SPST b. SPDT c. DPDT d. SPST

Frame 24

Did you identify figure "b" in frame 23 as a single pole, double throw relay? If you did, EXCELLENT! This shows you are capable of figuring out these arrangements by simply remembering that the contact where current enters is called a "POLE" and the positions it can be "thrown" to are called "throws." Perhaps you also noted that figure "b" had only one COMMON POLE so that any current entering this pole could be switched to either the upper (NC) contact or the lower (NO) contact depending upon which position the relay is thrown. Take another good look at the figure in frame 18 to see an example of this "common" pole of the single pole, single throw relay. Here is a problem to stimulate your memory. With the information you have learned so far and the illustration below, underline the word or words that correctly fit the piece being pointed to by the arrows.

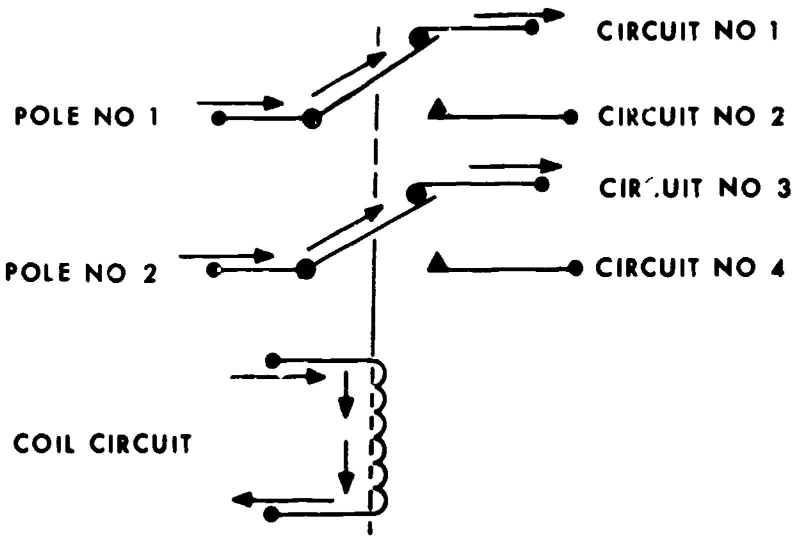


///////////////



968

Something far too important for us to overlook is how current travels across the relay's contacts. We have shown a DPDT relay in this figure, so you can see the path current flows.



No current travels from Pole No. 1 to circuits 3 and 4 at any time. Pole No. 1 carries current only to circuit 1 or 2. Pole No. 2 carries current ONLY to circuits 3 or 4, NEVER to circuits 1 and 2.

Incidentally, so you won't misunderstand, the actual contacts on a relay will be labeled according to the manufacturer's own desire. We labeled them as shown here so you would know which ones we are talking about in our explanations. It is necessary that you fully understand how current travels from a pole-out through the contacts. Actually, there is some type of insulator between the upper (No. 1) and lower (No. 2) armature poles so that current cannot possibly get from one armature pole to the other. Our relay is made this way so we can CONTROL TWO circuits at the same time with only one switch. Draw a relay circuit that controls two different light bulbs separately. You may use -

1. a switch.
2. a relay.
3. ONE battery.
4. Two lamps.
5. ONLY the CORRECT circuit symbols.

//////////////

Your circuit should closely resemble the illustration in frame 20.

This concludes our presentation of relay construction and operation. It is by no means all you can learn about these wonderful devices. It is enough to enable you to actually wire a relay into a circuit and observe its operation as it controls a lamp.

You will apply what you have learned in the relay PROJECT.

END OF TEXT.

970

WORKBOOK
3ABP42331-WB-120

Technical Training

Aircraft Environmental Systems Repairman

RELAY SWITCHING CIRCUIT PERFORMANCE

23 August 1978

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

RELAY SWITCHING CIRCUIT PERFORMANCE

OBJECTIVE

Using a DC fundamental trainer, construct a relay switching circuit and measure electrical values with one instructor assist allowed for each task area.

EQUIPMENT

	Basis of Issue
Trainer, P/N 521685	1/student
Multimeter	1/student

SAFETY

CAUTION: Remove watches, rings, bracelets, etc., before starting any work on the equipment. It is also a good safety practice to work on the equipment with one hand. This practice reduces the chances of receiving an electrical shock to some vital body organ when working with electricity. Also remember that light bulbs, resistors, etc., do get HOT and could burn the skin.

PROCEDURE

Pay close attention to all directions that you are given in the workbook. When performing in the workbook, such as answering questions or recording electrical measurements, if your response is <u>incorrect</u>, restudy the information with instructor assistance if needed. Do not hesitate to ask the instructor questions. You will find that many of the exercises have the correct answers on pages 5 and 6. After you have completed all the exercises you will satisfactorily complete the progress check assigned by the instructor. Pages 13 through 15 may, if you wish, be removed for your convenience.

When you leave your trainer for scheduled or unscheduled breaks insure the following are done before you go.

1. Insure the SPST switch is turned OFF in the circuit.

2. Insure the 28 VDC bus bar (red) has all the electrical leads removed from it.

3. Insure the negative (black) bus bar has all the electrical leads removed from it.

4. Insure the multimeter is properly stored during this period.

   a. Insure the controls on the meter are properly set for storage.

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b. Leave the test leads attached to the meter.

c. Wrap the meter leads around the instrument.

d. Place the meter on the locker shelf.

5. When you return from the break take the same mater and go back to work.

Exercise 1

1. Trainer preparation for Exercises 2 through 4.

a. The metal plate on the right side of the trainer may be raised for the workbook to lay on.

b. Sign out a multimeter, see the lab instructor if assistance is needed.

c. Insure that the instructor has connected power to the trainer. You will do this by measuring the power with the multimeter at the positive (red) and negative (black) bus bar. The bus bars are located in the lower right and left corners of the trainer. If you don't read a voltage (24 VDC $\pm$ 4 VDC) see your instructor.

d. Insure that fuse wire is across the fuse holders of each of the three (3) ammeters on the trainer. This will protect the ammeter internal circuit from overload. If the fuse wire is burned in half or is missing see your instructor for assistance.

e. Pull the circuit breaker out (open) and turn OFF (open) two (2) single pole single throw (SPST) switches.

f. Insure all leads in the drawer are in good condition with a plug at both ends. If you find any damaged leads, give them to the instructor.

g. Examine ctrical lead ends, and note how you may connect them if one lead is too short. See your instructor for assistance if needed.

Exercise 2

2. Build a circuit which controls the relay in a relay switching circuit. This circuit will be made up of one (1) load (the relay coil) with a SPST switch and a circuit breaker.

a. Using the electrical leads from the drawer construct the relay control circuit shown in figure 1 on page 13. This consists of a C/B, SPST switch, and the relay coil.

Note: If an electrical lead is too short you may connect leads together to prevent stretching or breaking them.

b. Before applying power to your circuit, constructed to control the relay, be sure you have the wires hooked up as shown in figure 1.

c. If you study this circuit you will find that the relay coil control circuit is nothing more than a series circuit with the coil as the load.

d. Answer the question below figure 1 on page 13.

Exercise 3

3. This exercise will help you build a circuit which is connected at the relays "NO" contacts. This circuit will be made up of two (2) loads (light bulbs) in parallel, wired through the relays "COM" and "NO" contacts and connected to the C/B.

a. Using the electrical leads from the drawer construct the circuit being controlled by the relay armature, as shown in figure 2 on page 14. This circuit consists of two (2) light bulbs, the relay armature with its contacts, and the C/B.

b. The wire between the "COM" point and the C/B will be connected to the negative side of the C/B. This is the side of the C/B which does not have the wire connected to the bus bar. This way, the C/B can protect all the circuits.

c. If you have correctly wired the circuit you will be able to turn on the lights by moving the SPST switch to ON. Remember, the SPST switch controls power to the relay coil, the current flow through the coil creates a magnetic field, the magnetic field pulls down the armature allowing current to flow through the bulbs.

d. When the SPST switch is opened (OFF), current is cut off to the relay coil, the magnetic field disappears, the armature is pulled up by a spring which cuts off the current flow through the bulbs.

e. Answer the questions below figure 2 on page 14.

Exercise 4

4. This exercise will help you build a circuit which is connected at the relays "NC" contacts. This circuit will be made up of two (2) loads (light bulbs) in series, wired through the relays "COM" and "NC" contacts and connected to the C/B.

a. Using the electrical leads from the drawer construct the series circuit being controlled by the relay armature, as shown in figure 3 on page 15. This circuit is connected to the "NC" contact of the relay and consists of two (2) light bulbs in series, the relay armature with its contacts and the C/B.

b. The wire between the "COM" and the C/B is the same wire you used in exercise 3. You now can see how it serves a dual purpose for the "NC" and the "NO" contacts of the relay. The C/B serves several circuits, the relay coil circuit, the light bulb parallel circuit on the "NO" contacts (exercise 3), and the light bulb series circuit on the "NC" contacts constructed in this exercise.

c. If you correctly wired the circuit in figure 3 you will be able to turn on the light bulbs in the parallel circuit by moving the SPST switch to the ON position, and if you move the SPST switch to the OFF position, you will turn OFF the parallel circuit and turn ON the light bulbs in the series circuit.

d. Also note that when power is applied to the relay coil the light bulbs connect to the "NO" circuit illuminate (light) and if power is cut off to the relay coil the light bulbs connected to the "NC" circuit illuminate.

e. Answer the questions below figure 3 on page 15.

f. If you have any questions about the exercises you have just completed, ask your instructor NOW.

g. Remove all the leads and store them in the drawer and report to your instructor for a progress check assignment.

Correct responses for figures 1 through 3.

FIGURE 1

Total applied voltage 24 VDC $\pm$ 4 VDC.

Voltage drop across the relay coil is 24 VDC $\pm$ 4 VDC.

1. a
2. a
3. b
4. b
5. b

FIGURE 2

Right lamp 24 FDC $\pm$ 4 VDC

Left lamp 24 VDC $\pm$ 4 VDC

Voltage drop across the relay coil is 24 VDC $\pm$ 4 VDC

Total current flow through only the light bulbs is 3 amp $\pm$ 0.4 amp.

1. b
2. a
3. a
4. b

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FIGURE 3

Right lamp 12 VDC $\pm$ 2 VDC

Left lamp 12 VDC $\pm$ 2 VDC

Total current flow in the light bulb series circuit is 1 amp $\pm$ 0.4 amp.

1. b
2. a

PROGRESS CHECK INSTRUCTIONS

This progress check will require you to correctly construct a relay-switching circuit and measure electrical values with one instructor assist allowed for each task area. Instructor assist for each task area is defined as an aid, such as technical direction or explanation given a student, who can proceed no further on his/her own. The instructor will initial your work after you satisfactorily complete each task of the progress check. If you do not pass the progress check you will follow the instructions given by the instructor.

You will not communicate (talk, etc) with other students during the progress check without your lab instructor's permission.

You will not use fellow students work to solve the problems in this progress check.

You must satisfactorily complete this progress check before further progression to other lab progress checks.

Have your lab instructor select and initial on page 6 or 8, the relay-switching circuit progress check you are to draw on the figure on page 10. Using a lead pencil only, draw in the relay-switching circuit leads between the various symbols. Later you will construct this circuit on the trainer. After you have satisfactorily completed the progress check you will follow the instructions on page 11.

_______ Instructor's initials. Assigned progress check 1.

STUDENT'S NAME ____
Last First MI

After completion of each task listed do not progress until the instructor has initialed your work for that task.

TASK 1 - Draw a relay control circuit in the figure on page 10. This circuit will be made up of a C/B, SPST switch, and relay coil.

_______ Instructor's initials for first instructor assist.

_______ Instructor's initials for second instructor assist which is failing.

_______ Instructor's initials for progression.

TASK 2 - Draw a parallel circuit controlled by the relay in the figure on page 10. This circuit will be made of two (2) loads (a light bulb and a 10 ohm resistor) in parallel, wired to the "NO" contact of the re. . Also draw in t[illegible] ver lead between the C/B and the "COM" of the relay. These two (2) loads will share a common ground wire.

_______ Instructor's initials for first instructor assist.

_______ Instructor's initials for second instructor assist which is failing.

_______ Instructor's initials for progression.

TASK 3 - Draw a series circuit controlled by the relay in the figure on page 10. This circuit will be made up of two (2) loads (light bulbs) in series, wired to the "NC" contact of the relay. This series circuit will share the common ground wire used for the parallel circuit above.

_______ Instructor's initials for first instructor assist.

_______ Instructor's initials for second instructor assist which is failing.

_______ Instructor's initials for progression.

TASK 4 - Construct the relay-switching circuit drawn in the figure on the trainer and demonstrate an operations check for the instructor.

_______ Instructor's initials for first instructor assist.

_______ Instructor's initials for second instructor assist which is failing.

_______ Instructor's initials for progression.

TASK 5 - Measure and record the electrical values required below. Take these values from the circuit in the figure on page 10 assigned. Total current flow for only the circuit connected to the "NO" contact of the relay is _______ amps. Voltage drop across the resistor in the parallel circuit connected to the "NO" is _______ volts. Voltage drop across the left light in the series circuit connected to the "NC" is _______ volts.

_______ Instructor's initials for first instructor assist.

_______ Instructor's initials for second instructor assist which is failing.

_______ Instructor's initials for progression and satisfactory completion of this progress check.

Turn to page 11 for further instructions.

Note: If the instructor provides an instructor assist for a task, the instructor will initial as required.

_______ Instructor's initials. Assigned progress check 2.

STUDENT'S NAME ____
Last First MI

After completion of each task listed do not progress until the instructor has initialed your work for that task.

TASK 1 - Draw a relay control circuit the figure on page 10. This circuit will be made up of a C/B, SPST switch, and relay coil.

_______ Instructor's initials for first instructor assist.

_______ Instructor's initials for second instructor assist which is failing.

_______ Instructor's initials for progression.

TASK 2 - Draw a parallel circuit controlled by the relay in the figure on page 10. This circuit will be made up of two (2) loads (two (2) light bulbs) in parallel, wired to the "NO" contact of the relay. Also draw in the power lead between the C/B and the "COM" of the relay. These two (2) loads will share a common ground wire.

_______ Instructor's initials for first instructor assist.

_______ Instructor's initials for second instructor assist which is failing.

_______ Instructor's initials for progression.

TASK 3 - Draw a series circuit controlled by the relay in the figure on page 10. This circuit will be made up of two (2) loads (a light bulb and a 10 ohm resistor) in series, wired to the "NC" contact of the relay. This series circuit will share the common ground wire used for the parallel circuit above.

_______ Instructor's initials for first instructor assist.

_______ Instructor's initials for second instructor assist which is failing.

_______ Instructor's initials for progression.

TASK 4 - Construct the relay switching circuit drawn in figure on page 10, on the trainer and demonstrate an operation check for the instructor.

_______ Instructor's initials for first instructor assist.

_______ Instructor's initials for second instructor assist which is failing.

_______ Instructor's initials for progression.

TASK 5 - Measure and record the electrical values required below. Take these values from the circuit in figure on page 10 assigned. Total current flow for only the circuit connected to the "NC" contact of the relay is ______ amps.

Voltage drop across the resistor in the series circuit connected to the "NC" is ______ volts.

Voltage drop across the left light in the parallel circuit connected to the "NO" is ______ volts.

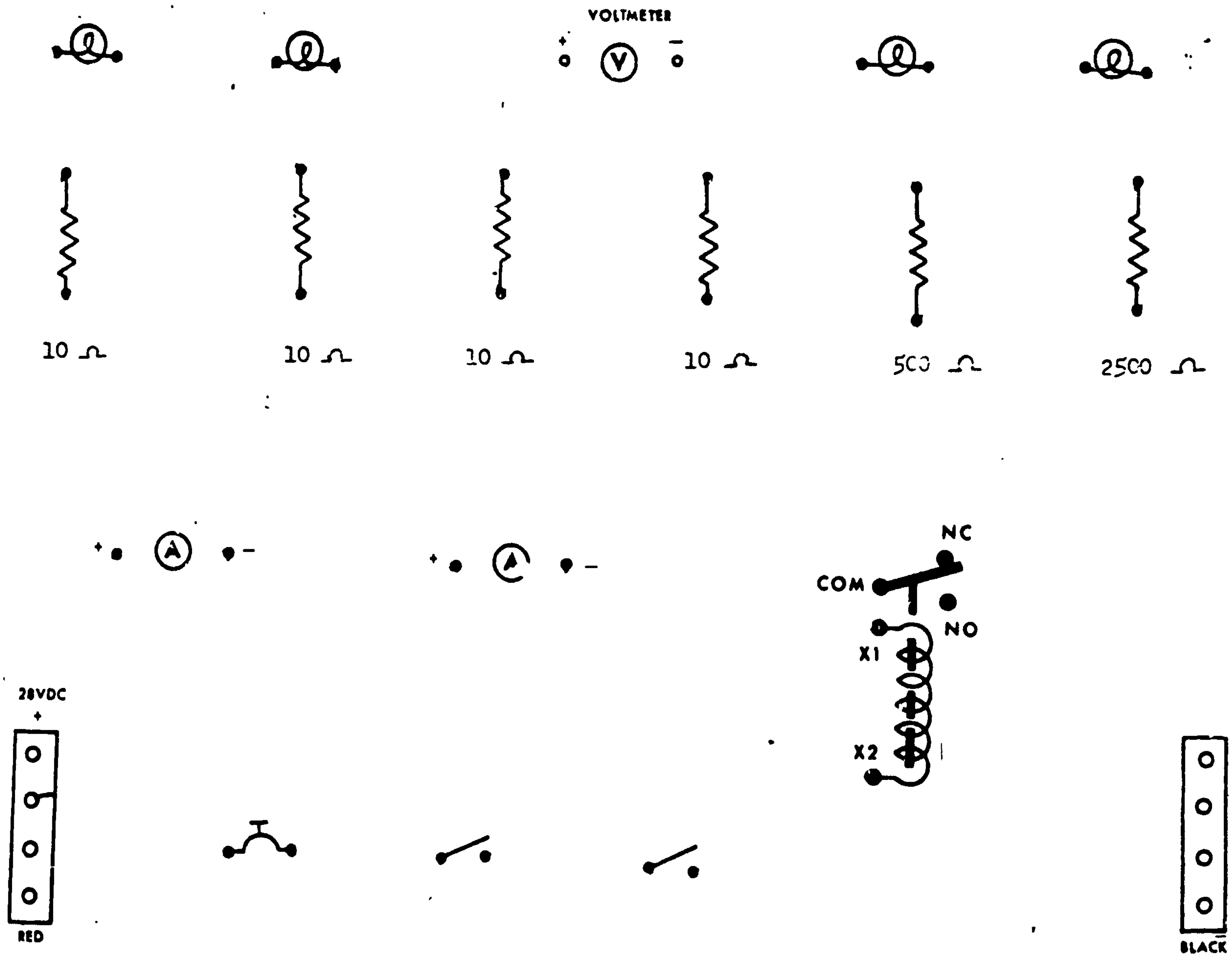
______ Instructor's initials for first instructor assist.

______ Instructor's initials for second instructor assist which is failing.

______ Instructor's initials for progression and satisfactory completion of this progress check.

Turn to page 11 for further instructions.

Note: If the instructor provides an instructor assist for a task, the instructor will initial as required.


VOLTMETER
10 Ω
10 Ω
10 Ω
10 Ω
500 Ω
2500 Ω
NC
COM
NO
X1
X2
28VDC
RED
BLACK

After you have satisfactorily completed the progress check you will do the following:

1. Put all the good leads in the drawer of the trainer.

2. Give all the broken leads to the lab instructor with the parts.

3. Place the work table in the down position on the trainer.

4. Return the multimeter to its storage cabinet. Be sure the controls on the meter are set correctly for storage.

5. You will turn in your work to the lab instructor before you leave the lab area.

Note: You may review any part of all of this workbook if you wish, but your work will not leave the lab area without the lab instructor's permission.

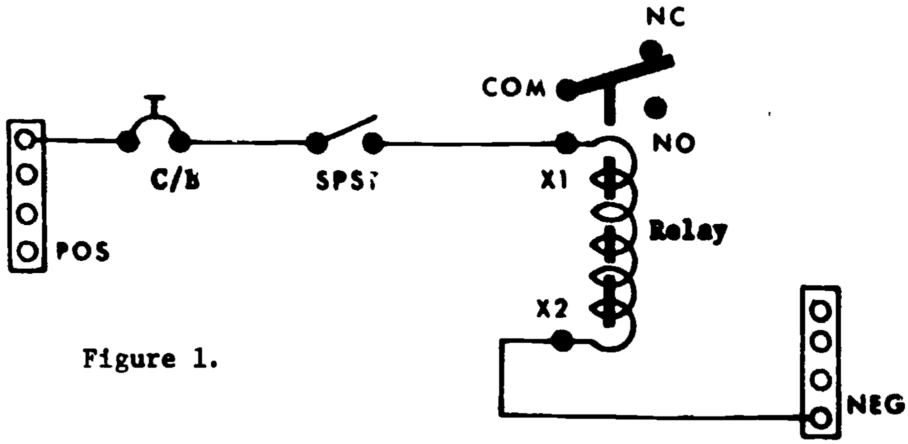


Figure 1.

Total applied voltage _______.

Voltage drop across the relay coil is _______ volts.

Circle the correct answer below.

1. The circuit you have constructed will magnetize the relay coil and cause its armature contacts to be pulled down.

   a. True

   b. False

2. For the relay to operate, BOTH the circuit breaker and the SPST switch must be

   a. closed.

   b. opened.

3. When the relay is turned ON the armature will complete the path between the "common" (COM) pole and the "normally open" (NO) and the "normally close" (NC) contacts.

   a. Yes

   b. No

4. The _______ pulls the armature down.

   a. SPST switch

   b. magnet field

5. The circuit breaker is provided to

   a. permit turning the relay on and off normally.

   b. open the circuit in case the circuit becomes shorted.

Correct answers on page 5.

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Go to exercise 3.

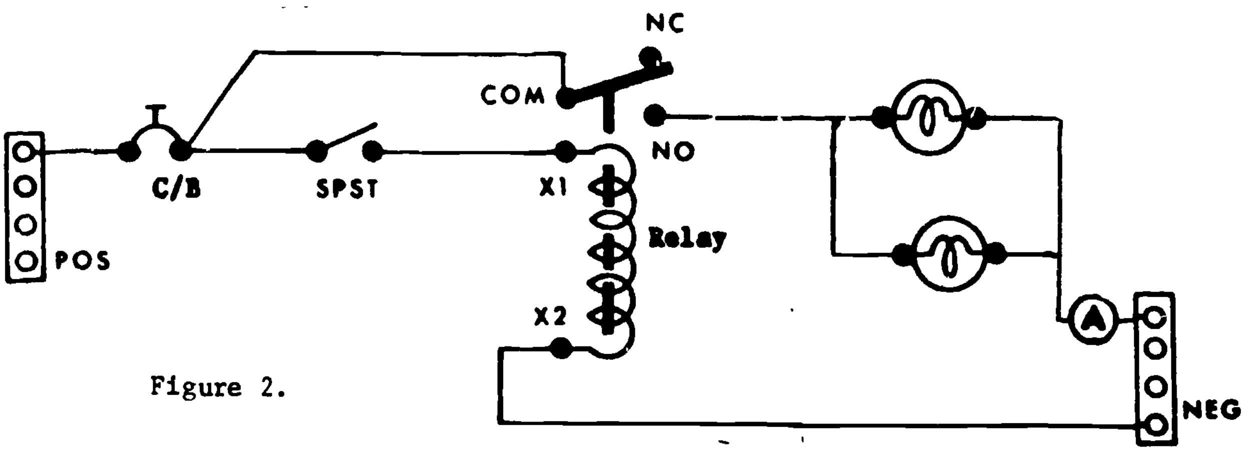

Figure 2.

Voltage drop across the lamps on the trainer. Right lamp _______ volts.

Left lamp _______ volts.

Voltage drop across the relay coil is _______ volts.

Total current flow through only the light bulbs is _______ amps.

1. The two light bulbs in parallel are directly controlled by the
   a. SPST switch.
   b. relay armature.
2. The relay armature is controlled by the
   a. magnetic field.
   b. SPST switch.
3. The magnetic field is controlled by the
   a. SPST switch.
   b. C/B.
4. The SPST switch is controlled by the
   a. C/B.
   b. circuit operator (you).

Correct answers on page 5.

Go to exercise 4.

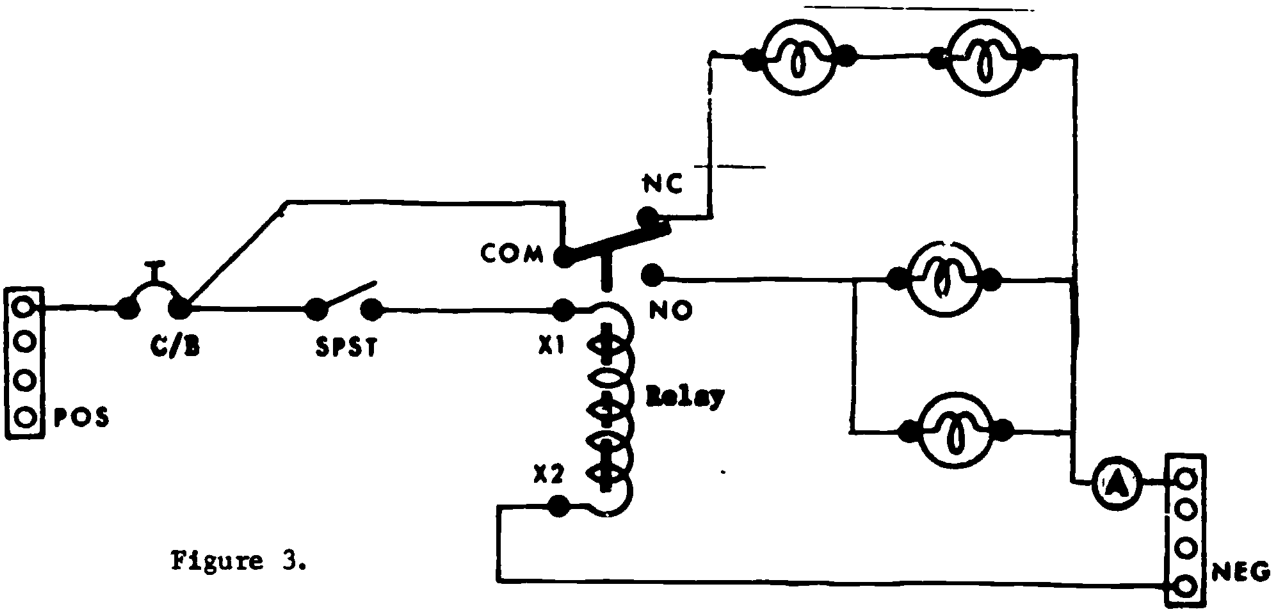

Figure 3.

Voltage drop across the lamps on the trainer in only the series circuit.

Right lamp _______ volts.

Left lamp _______ volts.

Total current flow in the light bulb series circuit is _______ amps.

1. When the SPST switch is in the ON position

   a. all four (4) lights are to light.

   b. only the lights in the parallel circuit will light.

2. The ammeter will show the total current flow in

   a. only the parallel circuit when the SPST switch is ON.

   b. both light bulb circuits and the relay coil circuit when the SPST switch is ON.

Correct answers on page 6.

Go to exercise 4, step "f".

985

Technical Training

Aircraft Environmental System Mechanic

DC MOTORS

20 July 1981

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

RGL: 9.2

OBJECTIVES

Specify basic facts relating to DC motors with a minimum of 80% accuracy.

INSTRUCTIONS

NOTE: BEFORE PROCEEDING, REMOVE THE RESPONSE SHEETS AT THE BACK OF THIS TEXT. THEN ENTER YOUR ANSWERS ON THE REMOVED SHEETS.

This programmed text presents information in small steps called "frames." After reading each frame, you are expected to respond by supplying a word or words, to complete a statement, choose either TRUE or FALSE, select the correct answer, or match terms to their proper meaning. DO NOT MARK IN THIS TEXT.

Use a piece of paper or card as a mask to cover the printed materials. Slide the paper or mask down the page until you expose the row of slashes (////////////////////). One small step is now exposed for you to read. Read the material presented, select your response to the question, and indicate your response on the response sheets. After you respond to the question, slide the mask down and compare your answer with the one given in the text. If you are correct, go on to the next frame. If your answer is wrong, read the frame again.

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DISTRIBUTION: X
3370 TCHTG/TTGU-P - 500; DAV - 1

Mechanical energy which has been converted from electrical energy is used in many different applications. You will be working on equipment that contains some form of energy conversion. Therefore, an understanding of the devices providing energy conversion are essential if you are to become good in your field.

There are many devices which convert energy. Our discussion will be limited to a device which changes electrical energy into mechanical energy, the motor. Motors are normally classified according to the voltage or current used, that is, AC or DC. In this text we will discuss the series and shunt DC motors.

//

No Response Required

As you have already learned, a magnetic field exists around any current-carrying conductor. The strength of this magnetic field depends upon the amount of current flowing in the conductor. When this current-carrying conductor is placed in a fixed magnetic field, the reaction of the two magnetic fields will cause the conductor to move out of the fixed field. The amount and direction of this force resulting from the interaction between the conductor's magnetic field and the fixed magnetic field determines the speed of the motor and its direction of rotation. All motors operate on the same fundamental principle, the force exerted on the current-carrying conductor when it is placed in a magnetic field.

Check the following statements that are TRUE.

1. A magnetic field exists around all current-carrying conductors.

2. The strength of the magnetic field around a current-carrying conductor depends upon the amount of current flow in the conductor.

3. The fundamental principle of operation of any motor is that force is exerted on a current-carrying conductor when placed in a magnetic field.

Answers to Frame 2: ✓ 1. ✓ 2. ✓ 3.

Frame 3

The force which acts on the current-carrying wire (conductor) when it is placed in the field of a magnet is at right angles to the wire. It is also at right angles to the magnetic field set up by the magnet. The action of this force upon the current-carrying conductor is shown below. The illustration shows a wire located between the magnet's poles. The lines of force in the magnetic field are from the north pole to the south pole (externally). When no current flows no force is exerted on the conductor.

WIRE WITHOUT CURRENT
LOCATED IN A MAGNETIC FIELD

Complete the following statements.

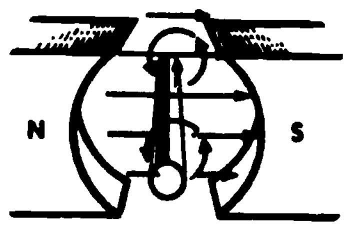
1. A ________________ field exists around any current-carrying conductor.

2. Unless current is flowing within a conductor, no ____________ is exerted upon it, even when in a magnetic field.

989

Frame 4

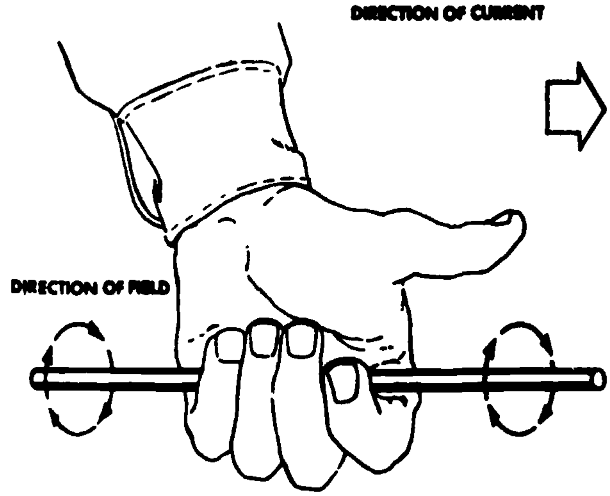
When current flows through the conductor, a magnetic field is set up about it, as is shown in the illustration.



WIRE WITH CURRENT
AND ACCOMPANYING FIELD

The direction of the field around the current-carrying conductor depends on the direction of current flow. Current in one direction creates a clockwise field about the conductor. Current in the other direction creates a counterclockwise field.

Do you remember the rule for determining direction of rotation of the magnetic field? The rule states "Grasp the conductor in the left hand. The thumb points in the direction of current flow. The fingers will point in the direction of the magnetic lines of force around the conductor."



LEFT HAND THUMB RULE

Study the diagram above and answer the following question.

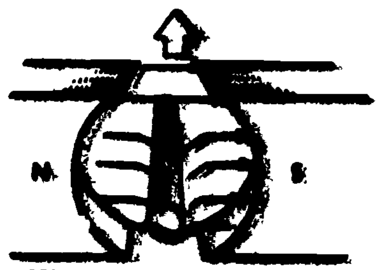
With current flowing through the conductor in the direction of the arrow, (you are standing at the left end of the conductor looking towards the right end) the magnetic field will rotate in a direction?

(Counterclockwise) (Clockwise)

Answer to Frame 4: Counterclockwise

Frame 5

The force which acts upon the current-carrying conductor when it is placed between the poles of the magnet will drive the conductor out of the field. The direction of this force is shown below. Note that the magnetic lines of force below the conductor are in the same direction as the lines of force around the conductor. These two forces add and strengthen the magnetic field below the conductor. The lines of force above the conductor oppose the magnet's lines of force. This action weakens the magnetic field above the conductor. The combination of the strong field below the conductor and the weak field above the conductor produces force which drives the conductor up. <u>The conductor is always pushed away from the side where the field is strongest.</u>



RESULTANT FIELD AND DIRECTION OF FORCE ON WIRE

Identify the following statements as true (T) or false (F).

1. A current carrying-conductor placed between the poles of a magnet is not affected by the magnetic field.

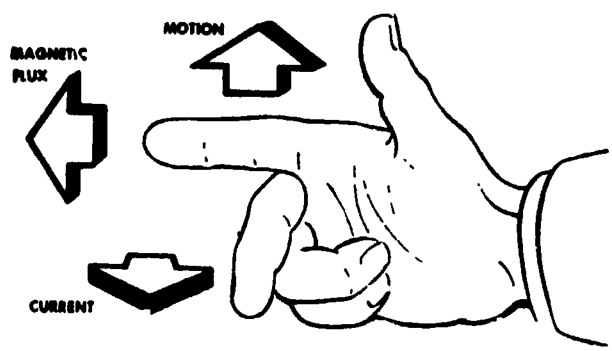
2. With current flowing as shown in the illustration, the conductor will be pushed up.

//

_F_ 1. _T_ 2.

Frame 6

If the current flow through the conductor were reversed in direction, the two fields would add at the top and subtract at the bottom. Since a conductor is always pushed away from the strong field, the conductor would be pushed down. The direction of motion can be determined easily as the following illustration shows. Don't confuse this rule with the left hand rule which is used to determine the polarity of a coil. This is called the Right Hand Motor Rule and states "Point the index finger of the right hand in the direction of the magnet's external magnetic field (N to S). The second finger pointed in the direction of current flow. The thumb will indicate the direction of motion."



Complete the following statement.

The Right Hand Rule is used to determine the direction of conductor ___________.

//

Motion

Frame 7

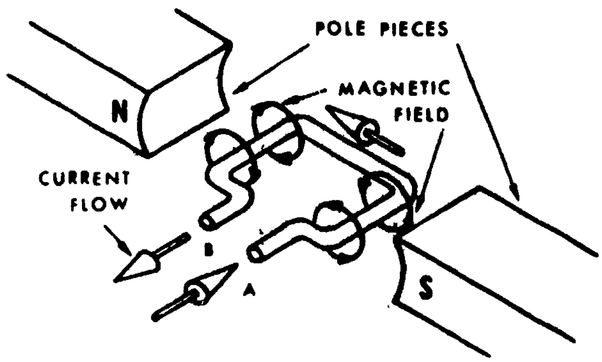
We now know how a current-carrying conductor moves in a magnetic field. Let's determine how this action is put to use in a motor. Although DC and AC motors operate on the principle just explained, they use different methods in obtaining a magnetic field and conductor current. For this reason let's discuss the basic DC motor before covering the basic AC motor.

//

No Response Required

Frame 8

If the single conductor is bent into a loop, the loop will tend to rotate in the field between the magnets. In the loop shown below, current flow is inward on side "A" and outward on side "B". The magnetic field about "B" is clockwise. The magnetic field about "A" is counterclockwise. With the single conductor, in which current flowed inward, a force will develop which pushes "B" downward. Current flow in the field of the magnet and the field about "A" is inward. The magnetic field will add at the bottom and subtract at the top. You can prove this by the Right Hand Motor Rule, "A" will move upward. The loop (A and B) will rotate until both sides are outside of the magnetic lines between the north and south poles of the magnet. In this position no torque (twisting force) is produced and the loop remains stationary instead of turning over.



Identify the correct words to complete the following statement.

With current flow as shown in the diagram above, the magnetic field will be (strongest) (weakest) above B and below A, causing the loop to rotate (clockwise) (counterclockwise).

//

strongest counterclockwise

Frame 9

Let's summarize what we've learned in the preceding frames by identifying the following statements as true (T) or false (F).

1. When current flows through any conductor, a magnetic field is set up about the conductor.

2. If a current-carrying conductor is placed between the poles of a magnet, the two magnetic fields cancel each other.

3. The direction of current flow within a conductor determines the direction of the magnetic field about it.

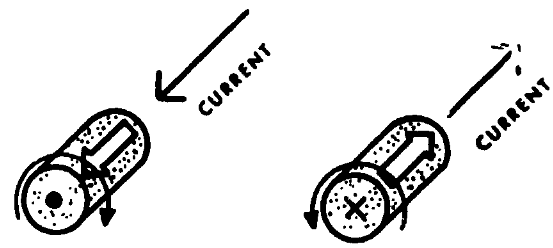
4. The direction in which a conductor is forced out of the magnetic field can be determined by using the Right Hand Motor Rule.

Answers to Frame 9: 1. T 2. F 3. T 4. T

Frame 10

It is general practice to draw a cross representing current flowing away from you in a conductor. A dot represents current flowing toward you.

Study the illustration to become familiar with this method of showing direction of current flow through a conductor.

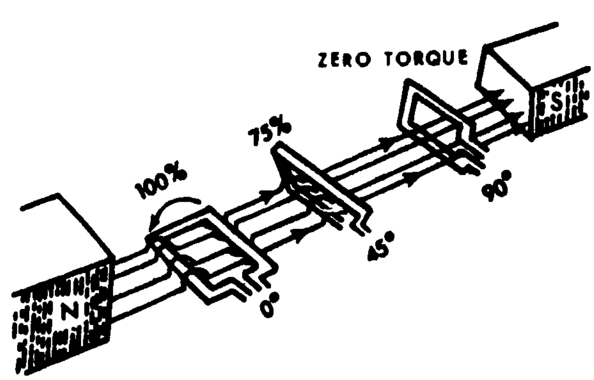


///

No Response Required

Frame 11

When the loop is parallel to the magnetic field as shown at 0° in the following illustration torque is maximum. Maximum torque occurs at this position. In this position the force acting upon the coil is in the same direction as coil movement. In any other position, however, only a portion of the force is in the direction of coil movement.



Complete the following statement.

Maximum torque occurs when the coil is in the position labeled ________.

(0°) (90°)

//////////////////////////////////

(0°)

Torque on a coil at various angles of rotation.

Frame 12

As the loop approaches the neutral plane of 90° (refer to frame 11), torque decreases. If the loop has sufficient "inertia," (a tendency to keep moving as a flywheel would) it will swing past the neutral plane, as shown in figure 1.

When loop side A swings to the right side, and loop side B swings to the left of the neutral plane, torque reverses. The loop will attempt to reverse its direction of rotation.

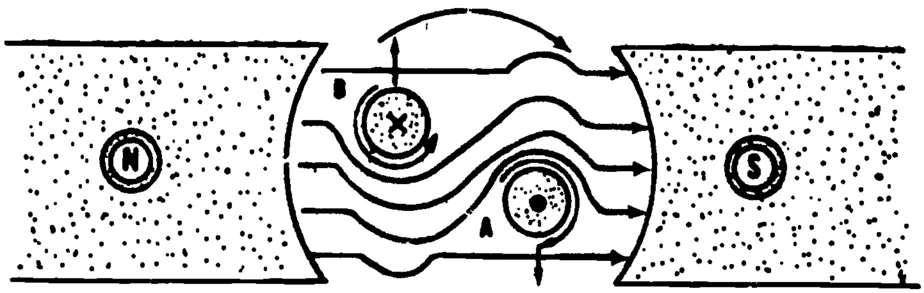


Figure 1.

Notice in figure 2, loop side A is to the left of the neutral plane. The current through it causes a counterclockwise torque. The current through loop side B to the right of the neutral plane is in the opposite direction. It also causes a counterclockwise torque. To keep torque in a counterclockwise direction, the current through the loop side to the left of the neutral plane must always flow out of the page (•). The current on the right of the neutral plane must always be into the page (x). To maintain continuous rotation some means must be provided which will reverse the direction of current through the loop as it rotates past the neutral plane.

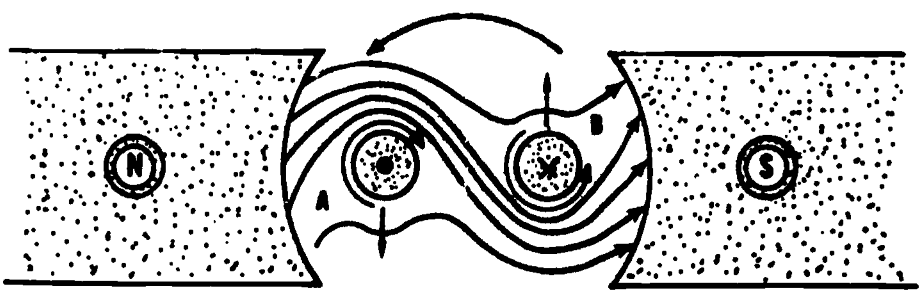


Figure 2.

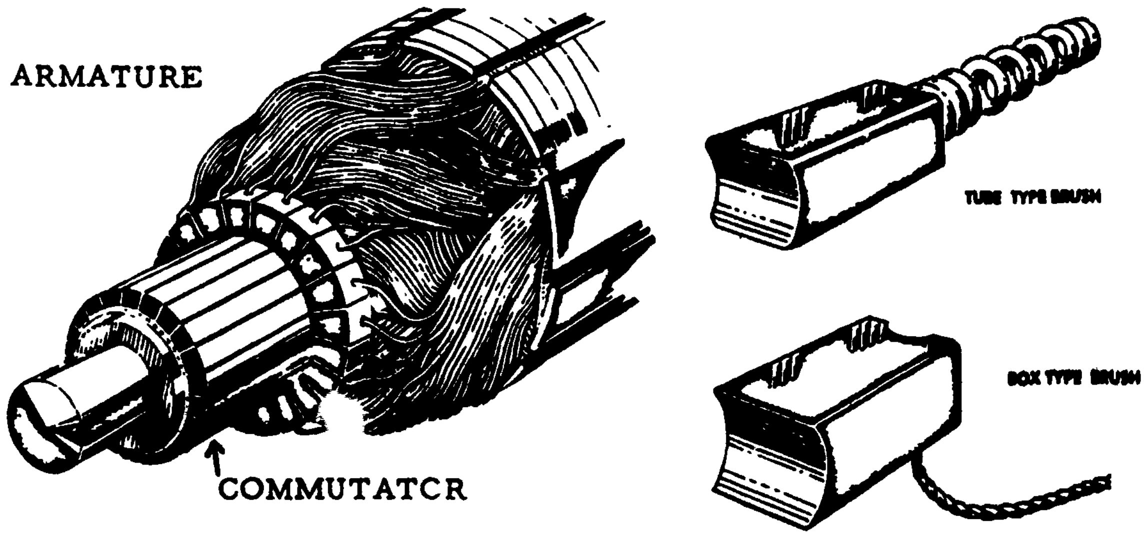
Is the following statement TRUE or FALSE?

In order for the loop to rotate counterclockwise, the current through both sides of the loop must be in the same direction.

//

False

This current reversal is accomplished by use of brushes and a commutator. A commutator is made up of a number of copper segments separated by insulating spacers. The number of segments depends upon the number of loops placed in the magnetic field, the type of coil winding used, and the voltage applied to the coils. Each segment is connected to a coil. The coils are wound so their sides are 180° apart.



Complete the following statement.

The procedure of reversing current is accomplished by using ___________ and a ________ ____________.

//

brushes commutator

Frame 14

Complete the following statements.

1. In a diagram showing current flow in a conductor, a dot (•) indicates that current flow is ________________ (into, out of) the page.

2. Maximum torque occurs when a coil is ________________________ (inside of) (outside of) the magnetic field.

3. In order to maintain continuous rotation of a coil, current flow must __________ (reverse-not reverse) in direction within the coil as it sweeps past the neutral plane.

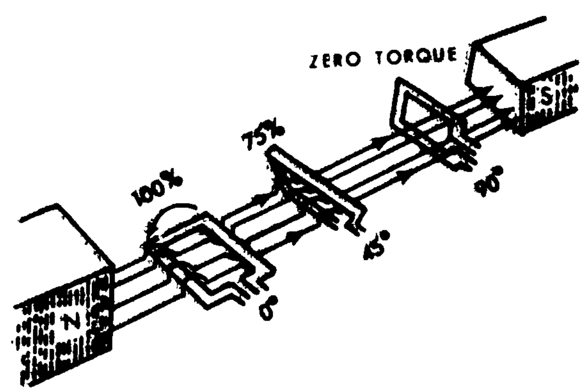
4. Each segment of a commutator is connected to a ________________ (coil-brush).

//

1. out of   2. inside of   3. reverse   4. coil

Frame 15

The amount of torque developed in a coil depends upon several factors--the strengths of the two reacting magnetic fields, and the position of the coil in the field. Let's take another look at the different positions of the coil (loop). In a coil carrying a steady current located in a uniform magnetic field, the torque will vary at different positions of rotation. When the coil is parallel to the lines of force, such as at 0°, the torque is maximum. When it is at 90°, the torque is at minimum. At other positions the torque ranges between zero and maximum.



Torque on a Coil at Various Angles of Rotation.

Study the illustration and answer the following question.

With current flow and force in the direction as shown, the conductor will rotate in a direction?

(clockwise) (counterclockwise)

//

Counterclockwise

When a loop (conductor) is rotated in a magnetic field, a voltage is induced in each side of the loop, see figure 1. During rotation, the two sides (A and B) of the loop cut the magnetic flux lines in opposite directions. Although the current flow is continuous in the loop, it moves in opposite directions with respect to the two sides A and B. To check this, apply the right hand rule, as shown in figure 2, to A and B in figure 1. Comparing wires A and B. When the loop rotates half a turn, the wires have exchanged positions. The induced EMF within each wire has reversed its direction. When two magnetic poles are used, the induced voltage reaches its peak value and reverses its direction twice per revolution. As a motor changes electrical energy to mechanical motion, it is at the same time generating a voltage (EMF) because it moves through the magnetic field.

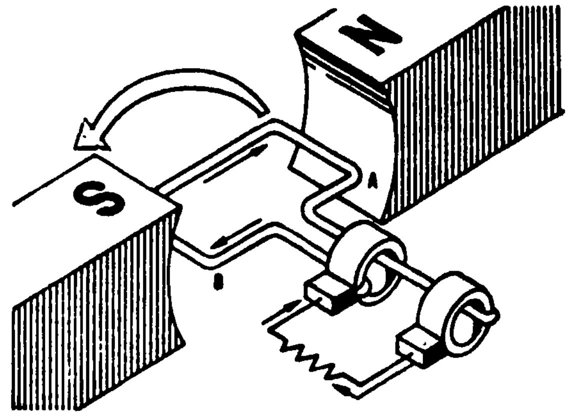


Figure 1. Voltage Induced in a Loop Conductor.

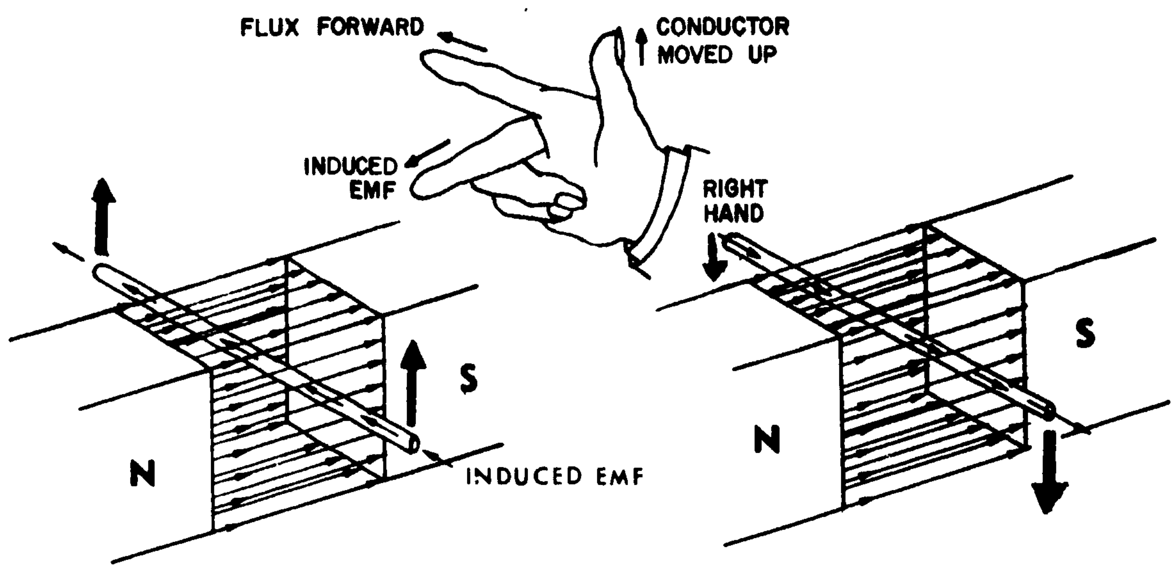


Figure 2. Left Hand Rule.

The action of the induced EMF will always oppose the applied EMF in a motor armature. This action called counterelectromotive force (CEMF). The CEMF tends to decrease the applied EMF on the armature. This in turn decreases the total armature current.

Is the following statement TRUE or FALSE?

Counterelectromotive force (CEMF) always has the same polarity as the applied EMF.

//

False

Frame 17

As the CEMF gets nearly as large as the applied armature voltage the armature current decreases. Very little current is required to keep a motor running without a load, just enough to overcome electrical losses and friction. If a greater load is put on the motor, the motor will slow down. This reduced speed causes the motor to <u>generate</u> less CEMF. Since there is now less CEMF (induced voltage) the <u>applied</u> current will be allowed to increase. The increase in current develops a greater torque to make up for the increased load. Since the applied voltage remains constant, there is a definite speed for each change of load. <u>The greater the load the lower the speed</u>. The CEMF is the controlling factor in speed and torque regulation of a motor.

Select either TRUE or FALSE for the following statements.

1. From our discussion of counterelectromotive force (CEMF) we can say that CEMF is induced voltage or current in the armature.

2. Counterelectromotive force is always opposite in polarity to the applied EMF.

3. CEMF is the controlling factor in the regulation of the speed of a motor.

//

T 1. T 2. T 3.

Frame 18

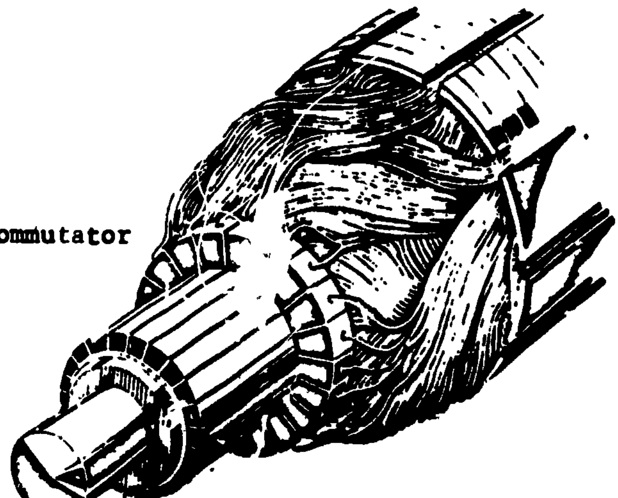
As we begin to discuss the different types of DC motors, let's first cover the major parts of a basic DC motor. These major parts are the armature assembly, the field assembly, the brush assembly, and the end frame.

These will be discussed separately in the following frames.

//

No Response Required

The armature assembly contains a laminated soft iron core, coils, and a commutator, al. mounted on a steel shaft. Laminations--layers of soft iron, insulated from each other--form the armature core. Solid iron is not used, since a solid iron core revolving in the magnetic field would heat and use energy needlessly. The armature windings are made of insulated copper wire. They are inserted in slots which are insulated to protect the windings. The ends of the windings are connected to the commutator segments. Wedges or steel bands hold the windings in place to prevent them from flying out of the slots when the armature is rotating at high speeds. The commutator is made up of an even number of copper segments insulated from each other and from the armature shaft by pieces of mica.



ARMATURE ASSEMBLY

Complete the following statements.

1. A soft iron core, coils, and a commutator make up the ________ assembly.

2. The ends of the windings are connected to the ________ ________.

3. The commutator is made up of an (even) (odd) number of copper segments.

//

1. armature 2. commutator segments 3. even

Frame 20

The field assembly consists of the field frame, the pole pieces, and the field coils. It contains laminated soft steel pole pieces on which the field coils are wound. A coil, consisting of several turns of insulated wire, fits over each pole piece. Together with the pole, it makes up a field pole. It is this field assembly that takes the place of a natural magnet such as we have used in previous illustrations. By winding the field pole we form an electromagnet.

Identify the parts that make up the field assembly.

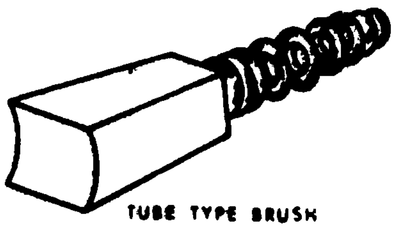
1. ________ 2. ________ 3. ________

//

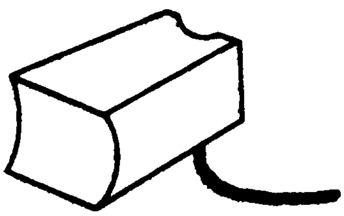
1. pole pieces 2. field coils 3. field frame

Frame 21

The brush assembly contains the brushes and their holders. The brushes are usually small blocks of carbon. This material lasts a long time and doesn't wear the commutator out as quickly as other materials might. The holders permit some play in the brushes so they can follow any irregularities in the surface of the commutator and thereby make good contact at all times. Springs hold the brushes firmly against the commutator.



TUBE TYPE BRUSH



BOX TYPE BRUSH

Complete the following statement.

Brushes are usually made of ______________ to reduce wear on the ______________.

carbon commutator

Frame 22

The end frame is the part of the motor on the opposite end from the commutator. The end frame is usually designed so that the motor can be geared on that end to the unit it will be turning. The bearing for the drive end is located in the end frame. Sometimes the end frame is made a part of the unit driven by the motor. When this is done, the bearing on the drive end may be located in any one of a number of places.

Select TRUE or FALSE for the statements.

____1. The bearing for the drive end is located in the end frame.

____2. The end frame is a part of the commutator.

____3. The motor is usually geared to the unit drive on the end frame.

T 1. F 2. T 3.

Match the units listed in the left hand column below to the major part of a DC motor to which they belong in the right hand column.

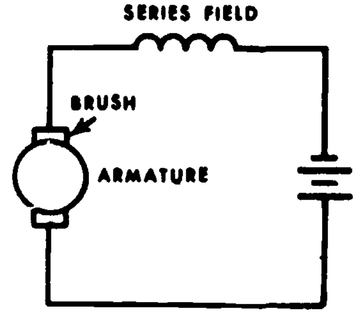
1. Coils, commutator, and soft iron core.
2. Brushes and brush holders.
3. Bearings.
4. Pole pieces, field coils and field frame.

a. End frame.
b. Field assembly.
c. Armature assembly.
d. Brush assembly.

//

1. c 2. d 3. a 4. b

The first type of DC motor which we shall discuss is the series motor. A series motor has its field winding connected in series with its armature. This method of connection makes it necessary for the field to be heavy enough to carry the armature current. Due to the series connection, the field winding is composed of relatively few turns of heavy wire in order to carry the relatively high armature current. The same current that flows through the field winding also flows through the armature winding. Therefore, any change in armature current is accompanied by a change in field strength.



SERIES MOTOR

Select the letter for the statement which completes the following statement.

In a series motor, the field winding

a. is connected in series with the commutator.

b. consists of a few turns of fine wire.

c. is connected in series with the armature winding.

d. has a separate power source.

//

c

Frame 25

When voltage is first applied to a series motor, a high starting current flows and a large starting torque is developed. The large starting current is due to the absence of CEMF, and the low resistance of the armature. As soon as the developed torque becomes great enough, the armature starts into motion. It accelerates toward its normal running speed.

Are the following statements TRUE or FALSE?

1. Because of the low resistance in the windings, the series motor draws a large current when starting.

2. In passing through both the field and armature windings, the starting current produces a high starting torque.

//

1. TRUE 2. TRUE

Frame 26

After getting started, armature current begins to decrease as an increasing CEMF is induced into the armature. This decrease in armature current also decreases motor field strength. This in turn attempts to decrease CEMF. Due to this action the series motor continues to accelerate in an attempt to maintain CEMF and limit armature current to a safe value. If the motor is not connected to a load, it attempts to operate at a very high speed which may result in motor damage. For this reason, series motors are never operated without a load.

From the foregoing statements, select either TRUE or FALSE for the following:

A series motor will run at high speed when it has a light load and at a low speed with a heavy load.

//

True

Frame 27

A series motor will slow down when its load is increased, due to the increased opposition to armature movement. The decreased CEMF caused by the decrease in motor speed results in an increase in armature current. The increased armature current provides the additional torque required by the increased load. A series motor, because its field strength depends upon armature current, requires a large variation in speed for a relatively small change in torque. Remember that an increase in armature current is the result of a decrease in speed This also increases field strength which tends to decrease speed.

Complete the following statement.

An __________ in armature current is the result of a decrease in armature_______________.

//

increase speed

Frame 28

Direction of rotation for a series motor may be changed in one of two ways:

1. Reversing current flow in the field winding. or
2. Reversing current flow in the armature.

When either of these currents is reversed, motor torque reverses and the direction of rotation reverses. Direction of rotation cannot be reversed by reversing the power source leads. This action would reverse current flow in both the armature and field windings. When both these currents are reversed, torque remains in the same direction and motor rotation remains unchanged.

An exception to this is the small motor with a permanent magnet for a main field. In this case reversing the power source leads only reverses current through the armature windings and not the main (permanent magnet) field.

Identify two ways by which direction of rotation may be changed.

1.

2.

//

1. Reversing direction of current flow in the field winding.
2. Reversing direction of current flow in the armature winding.

Frame 29

To review what has been covered in the last few frames, select either TRUE or FALSE where needed, or complete the statement.

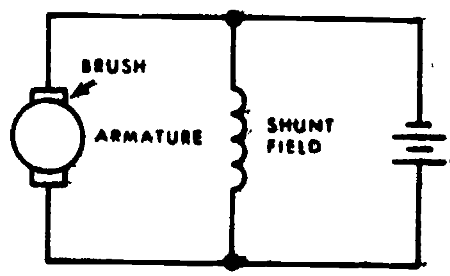
1. In a series motor, the field winding and the armature windings are connected in series.
2. The large starting current produces a high starting__________.
3. The heavier the load applied to the series motor, the faster the speed.
4. The field strength of a series motor depends upon armature and field__________.

//

1. T 2. torque 3. F 4. current

Frame 30

Another type of DC motor is the shunt motor. In this type of motor, the field winding is connected in parallel (shunt) with the armature winding. There are two circuits through the shunt motor—one through the armature and one through the field. The field coils are wound with relatively small wire and have a large number of turns. In this type of winding only a small flow current is necessary to maintain the magnetic field. Because ield is connected directly across power supply the magnetic field remains constant. Therefore, the torque of a shunt motor must vary with the current in the armature; that is, if the armature current doubles, the torque is also doubled. Since the field strength is constant, the motor speed will be constant from no load to full load. The shunt-wound motor is a <u>constant spee type</u>, but because of fixed field current, it does not have a starting torque as high as the series motor.



SHUNT MOTOR

Is the following statement TRUE or FALSE?

The shunt motor, like the series motor, has a high starting torque.

//

False

Frame 31

Small shunt motors may be started simply by connected voltage to them. The field current and field flux rise quickly to their full value. The armature current also rises rapidly since CEMF is zero when the armature is stationary. When the developed torque is great enough to overcome the friction and inertia of the armature and load, the armature starts into motion. CEMF proportional to motor speed is induced in the armature. The CEMF causes armature current to drop rapidly as the motor accelerates. Armature current becomes constant when motor speed becomes constant.

Complete the following statements.

1. The CEMF causes armature ____________ to drop rapidly as the motor speeds up.

2. A shunt motor has two circuits—one through the __________ and one through the ______________.

//

1. current 2. armature 3. field

The field strength of the shunt motor remains constant. The operating characteristics are quite different from those of the series motor. The shunt motor has:

1. Low starting torque.

2. Good speed regulation.

The low starting torque does not mean the shunt motor cannot be started with a load. Instead, it indicates that given a series and shunt motor of equal size and horsepower, the series motor produces greater starting torque.

1. Which type of motor, the series or shunt, produces the greater starting torque?

2. Which type of motor, the series or shunt, has the better speed regulation?

//

1. Series motor 2. Shunt motor

Frame 33

A shunt motor's direction of rotation is changed in the same manner as the series motor, which is:

1. Reversing current flow in the armature. <u>or</u>

2. Reversing current flow in the field winding.

//

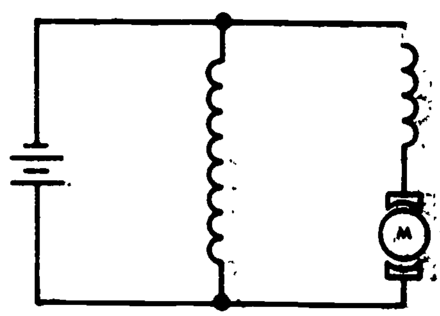
No Response Required

Frame 34

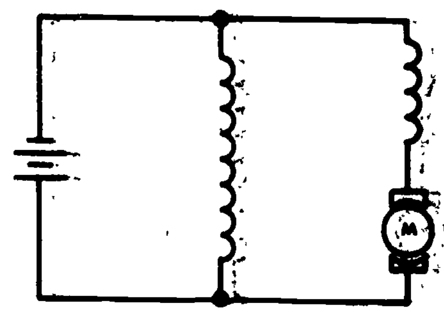
In addition to the series and shunt motors there are also compound motors. We won't go into a lengthy discussion of these motors other than to point out the different types of compound motors.

CUMULATIVE-compound motors have both a series and a shunt field which are connected so that the series windings aid the shunt field. This motor combines the characteristics of series and shunt motors. It is normally used when a starting torque greater than that of a shunt motor and a fairly constant speed are desired.

DIFFERENTIAL-compound motors are similar to cumulative-compound motors in all respects except the field windings. In this type of motor the fields are arranged so that the series fields oppose the main shunt field. This weakens the main field and tends to increase the speed of the motor as the load is increased. Due to this opposition, the field strength decreases as armature current increases.



DIFFERENTIAL—COMPOUND WOUND

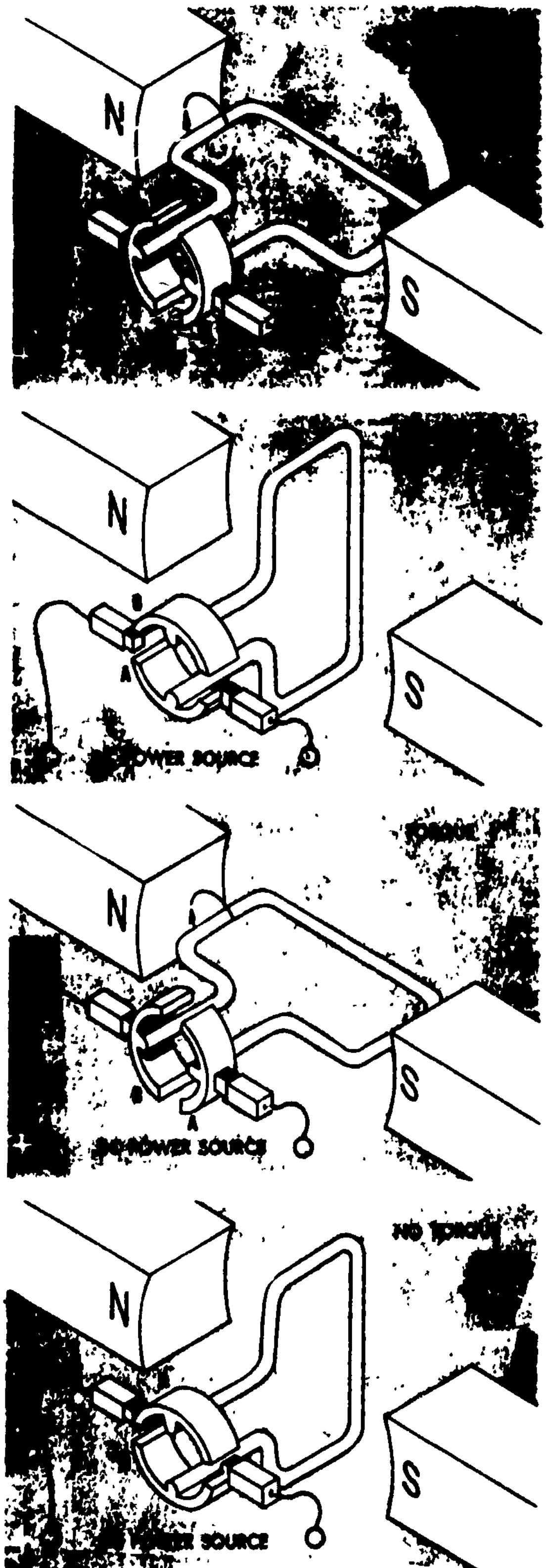


CUMULATIVE—COMPOUND WOUND

//

No Response Required

The accompanying diagrams show the operation of a typical DC motor. As you study these diagrams, recall the theory of operation as was explained in the preceding frames.



If any of these illustrations raise the slightest question, go back to the frames that explain the area in which you are having difficulty.

No Response Required

Frame 36

At this point you have learned some of the differences associated with the DC motors.

Match the letter of the motor types on the right with the DC motor characteristics on the left.

1. Field winding connected in parallel with the armature.
2. Field winding has only a few turns of heavy wire.
3. Poor speed regulation.
4. Torque varies with current in the armature.
5. Has low starting torque.
6. Has highest starting torque.
7. Good speed regulation.
8. Large current when starting.
9. Magnetic field remains constant.
10. Must operate under a load.

A. Series motor.

B. Shunt motor.

//

1. B 2. A 3. A 4. B 5. B 6. A 7. B 8. A 9. B 10. A

Technical Training

Aircraft Environmental Systems Mechanic

DC MOTOR AND VALVE ASSEMBLY CONTROL CIRCUIT WIRING DIAGRAMS

5 December 1980

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

Environmental Pneudraulics Branch
Chanute AFB, Illinois

3ABR42331-WB-121

DC MOTOR AND VALVE ASSEMBLY CONTROL CIRCUIT WIRING DIAGRAMS

OBJECTIVE

Using an electrical diagram, identify a minimum of 8 out of 10 circuit malfunctions when given the cause and the circuit condition.

EQUIPMENT

Color Pencils Set

INSTRUCTIONS

Pay close attention to all directions that you are given in the text. When performing in the test, such as tracing or answering questions, if your response is <u>incorrect</u>, restudy the information. At the end of this workbook, you will be given a performance test, which will be graded by your instructor. If you are ready to begin and have no questions, proceed with the lesson.

Exercise 1

Turn to figure 1 and familiarize yourself with the basic parts of a DC MOTOR VALVE ASSEMBLY. This sketch shows only the parts that concern us. Use this figure as you read the following.

Although this is a simple assembly, let's see how it works. When the motor armature #1 receives voltage it starts rotating. As the motor armature rotates it will turn the drive gears #2. As the drive gears rotate, they, in turn, rotate the valve shaft #3. This valve shaft has two jobs. First, it turns the valve butterfly #4 to either the open or closed position. This will stop or allow air flow through the valve housing #5. Second, it turns the cam lobe #6 which you can see is physically a part of the valve shaft. If you look on either side of the cam lobe, you will see two rectangular boxes. These are limit switches #7 and #8.

We will discuss the limit switches in more depth later. Stop at this time and locate these parts on the 28 volt DC Actuator and Valve Assembly trainer located in the lab. If you can not find or identify these parts on the trainer, ask your instructor.

In the next exercise you will trace the circuit and see how the voltage potential for the DC MOTOR VALVE ASSEMBLY is obtained.

Supersedes ST 3ABR42331-WB-121, 4 September 1980 and 3ABR42331-WB-121, 16 September 1980, which may be used until existing stocks are exhausted.
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3370 TCHTG/TTGU-P - 500; TTVSA - 1

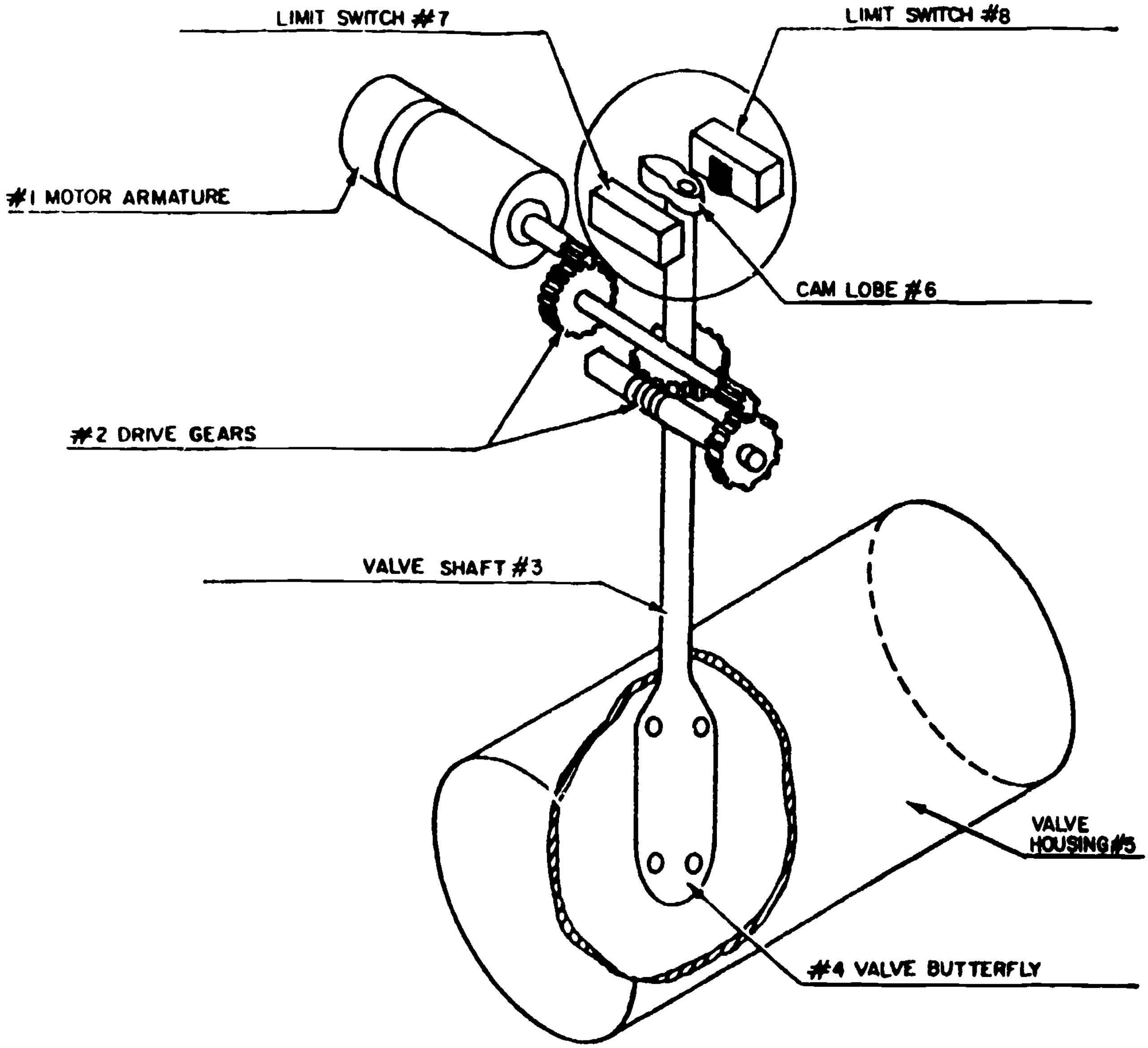


Figure 1.

Exercise 2

1. Remove the back page of this workbook and use a red pencil to trace the following voltage potentials on figure 2.

a. Start the trace from the 28 volt DC bus bar through the circuit breaker (CB No. 1) along wire H1A18 to A1 of the armature switch for relay 1. With the circuit breaker pushed in, there will be a voltage potential of 28 volts DC present at the armature switch (A1).

(1) Voltage stops at A1 because relay 1 has not been energized. The spring attached to the armature is holding it away from the contact A2 and this prevents this voltage from going any further at this time.

b. Trace from the bus bar through the circuit breaker (CB No. 2) along wire H5A18 to the pole of the control switch. With the circuit breaker closed, there will be a 28 volt DC potential up to the pole of the control switch.

(1) Voltage will stop at the pole unless the switch is moved to either the closed or open position.

c. Now trace from the bus bar through circuit breaker (CB No. 3) along wire H2A18 to A1 of the armature for relay 2. With the circuit breaker closed there will be a 28 volt DC potential up to A1 of the armature.

(1) Voltage stops at this point because relay 2 has not been energized. The spring attached to the armature contact is holding it away from the contact A2 and this prevents the voltage from going any further at this time.

d. Next trace through the circuit breaker (CB No. 4) across wire H7A18 to the pole of the transfer switch. With the circuit breaker closed and the transfer switch in the off position, there will be a voltage potential up to the pole of the switch.

e. You now have a 28 volt DC voltage potential through the four circuit breakers, to the armature of relays 1 and 2, and also to the poles of the control and transfer switches. Move now to exercise 3 and use this voltage potential that is at the control switch and at A1 of relay 1 to close the butterfly of motor valve #1.

Exercise 3

1. Using a blue pencil, trace motor valve #1 closed circuit. How this is done is explained in the following paragraphs:

a. Start the trace from the control switch. With the blue pencil, draw the control switch to the closed position. This will allow the voltage potential that is at the pole of the control switch to energize the relay. Trace from the closed position of the control switch along wire H5B18 to X2 of relay 1. Trace through the coil of relay 1 to point X1, and from X1 along wire H5D18N to the common ground point.

(1) You have now allowed the 28 volt DC voltage potential from exercise 2 to be applied to relay 1 and, with a good ground for the relay, the relay will become energized. From your previous study of relays, you know that when a relay is energized, it becomes a temporary magnet and this will pull the armature for relay 1 down and let it make contact with A2. This will complete the path for voltage from the circuit breaker (CB No. 1) to the close side of the motor.

b. Using the blue pencil again, draw the armature of relay 1 to the closed position (from A1 to A2).

(1) This will allow the path for the voltage at A1 to pass to A2 and on to check point B of the connector plug of motor #1.

c. Again use the blue pencil; trace from A2 of the armature along wire H1B18 to check point B of the connector plug. From B of the connector plug trace through the limit switch in the motor and down through the close field winding of the motor to check point E of the connector plug and along wire H6A18N to the common ground point.

(1) With voltage applied to the close winding of the motor valve and a good ground wire, the motor armature will rotate causing the valve shaft to turn and this will close the valve butterfly.

(2) In the next exercise we will explain the operation of the cam lobe and the limit switches.

Exercise 4

1. You will now learn exactly what a limit switch is, how it works, and why it is used.

a. A limit switch is a device which is used to limit or stop something from operating. When the valve butterfly goes to the full open or closed position, you do not want the motor to continue to operate. Simply stated, we could say that a butterfly in the valve assembly is like a door. Once it is opened, it is opened; once it is closed, it is closed; so why waste more energy trying to either open or close something when it has already traveled to its full position.

b. So we will use the limit switch in the motor valve assembly circuit to stop the motor you traced in the last exercise. Stopping the motor from running will, in turn, stop the valve butterfly from going past the fully closed position. The limit switch accomplishes this by removing power from the closed field winding of the motor. This is done by the use of the cam lobe.

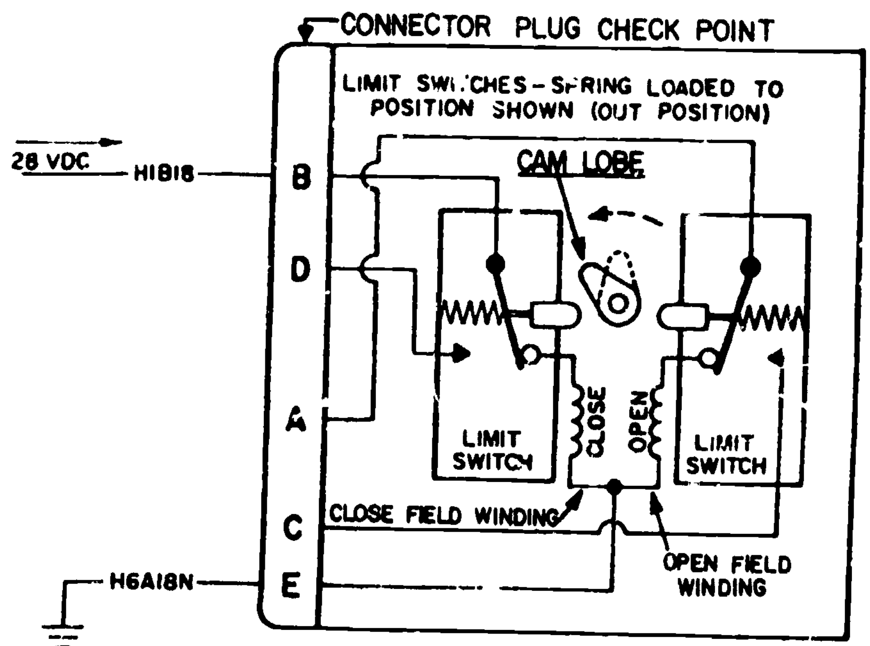


Figure 3.

2. Refer to figure 3 and locate wire H1B18. If we were to send 28 volts of power to check point B of the connector plug of the motor, it would go through the limit switch, continue across the close field winding

of the motor, and out of the connector plug at check point E to the ground. As the voltage energizes the close field winding of the motor, the motor will start rotating. This, in turn, will rotate the valve shaft and the valve butterfly, which is connected to one end of the shaft, will start to close. Connected to the other end of the shaft is the cam lobe that will also start to rotate. As the cam lobe leaves the neutral position (indicated by the arrow above the cam in figure 3) you will note that the cam is turning toward the limit switch that is on the close side of the motor. The cam lobe, that is indicated by the dotted line, is the position in which the cam was previously positioned.

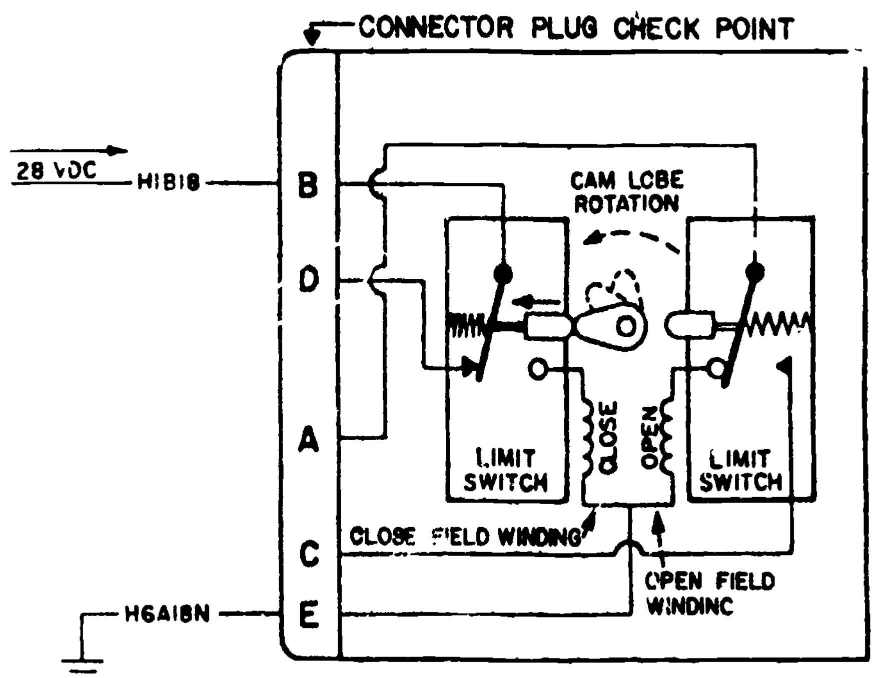


Figure 3a.

a. Refer to figure 3a and notice what happens to the cam lobe and the limit switch after the butterfly for motor #1 has traveled to the full closed position.

b. Notice that the cam lobe has rotated around and has depressed (pushed in) the limit switch button for the closed side of the motor. If you study figure 3a very closely, you will notice that the cam lobe has depressed the limit switch spring and has moved the pole of the switch. Through this action, the voltage has been removed from the closed field winding of the motor. As we stated previously, one of the purposes of the limit switch is to stop the valve from closing or opening too far. We do this simply by removing the power from the motor with the use of the limit switch and the cam lobe.

c. Look again at figure 3a and you will notice that since the limit switch button has been depressed, the 28 volts of power that was used to close the valve butterfly has now been rerouted to check point D of the connector plug. Later in this PT we will use this voltage to operate another motor. But remember, if motor #1 does not operate, the limit switch will not reroute the voltage.

d. Now you know why the limit switch is used. Its main purpose is to prevent our DC motor and valve assembly from running too far. Its secondary purpose is to reroute voltage to another motor circuit. Continue to the next exercise and see how this is done.

Exercise 5

Note: Look at figure 2 and refresh your memory on the voltage that started at circuit breaker #1 and went through the limit switch to the field winding of the motor and then to ground. This will now allow the valve to run to the fully closed position and the cam lobe to depress the limit switch.

1. Use a blue pencil once again to trace motor valve #2's open circuit on figure 2 as you read the following.

a. Draw the pole for the limit switch on the close side of the motor to the depressed position. Now trace from the limit switch contact to point D of the connector plug of motor #1.

b. Next trace from point D of the motor valve along wire H3A18 to A1 of relay #3.

c. At this point we must energize relay 3 before we can go any further. Proceed to exercise 6 and it will show how this is done.

Exercise 6

1. Using an orange pencil, trace the voltage needed to energize the transfer relay (relay #3) circuit on figure 2.

a. Start from the voltage potential which is on the pole of the transfer switch. Trace through the switch and across wire H7B18 to point X1 of relay #3. Continue through the coil of the relay to X2, then along wire H7C18N to the common ground point.

(1) Relay #3 is now energized. By the term "energized" we mean that the relay coil has become a temporary magnet. With the relay energized, the relay armatures between B1 to B2 and A1 to A2 will be pulled down toward the magnetized relay coil. The magnet is strong enough to overcome the spring tension that normally holds the armature away from contacts B2 and A2 of relay #3. Relay #3 is called the transfer relay.

Note: Remember that the dotted line going through the relay armature connects both armatures and, if the relay is de-energized or the transfer switch is turned off, both armature switches will be pulled back away from contacts B2 and A2 by the spring attached to the top armature. Proceed to exercise 7.

Exercise 7

1. In this exercise, we use the blue pencil once again to trace the DC motor valve #2's open circuit. This, in turn, will open the butterfly for this valve.

a. Trace across the contacts of relay #3 from both B1 and B2 and also from A1 and A2. This is because the transfer relay has been energized in the last exercise.

b. The voltage at A1 of relay #3 can now pass across the switch and go to the valve assembly. Trace from A2 along wire H3B18 to check point A of motor valve #2's connector plug.

c. Now trace from point A of the connector plug through the limit switch contacts and on through the open field winding of the motor. Trace from the field winding to check point E of the connector plug and from here along wire H6B18N to the common ground.

(1) Stop for a minute and examine what you have done thus far in the text.

(a) You have applied voltage to the circuit from the bus bar through the four circuit breakers. You have put this voltage to work by energizing relay #1 which, in turn, closed motor valve #1. If you examine your circuit, you will note that by closing motor valve #1 you have opened motor valve #2 through the use of the limit switch and the cam lobe of motor valve #1.

Note: In figure 4 you will find confirmation for exercises 2, 3, 5, 6 and 7. The heavy bold line identified with its color and exercise number should be the same as you have traced on figure 2. You may refer back to these exercises as needed. If your diagram was correct, continue to the next exercise. If not see your instructor at this time.

Exercise 8

1. This exercise will trace the open circuit for motor valve #1. Again use figure 2 and use a green pencil to trace this "open" circuit.

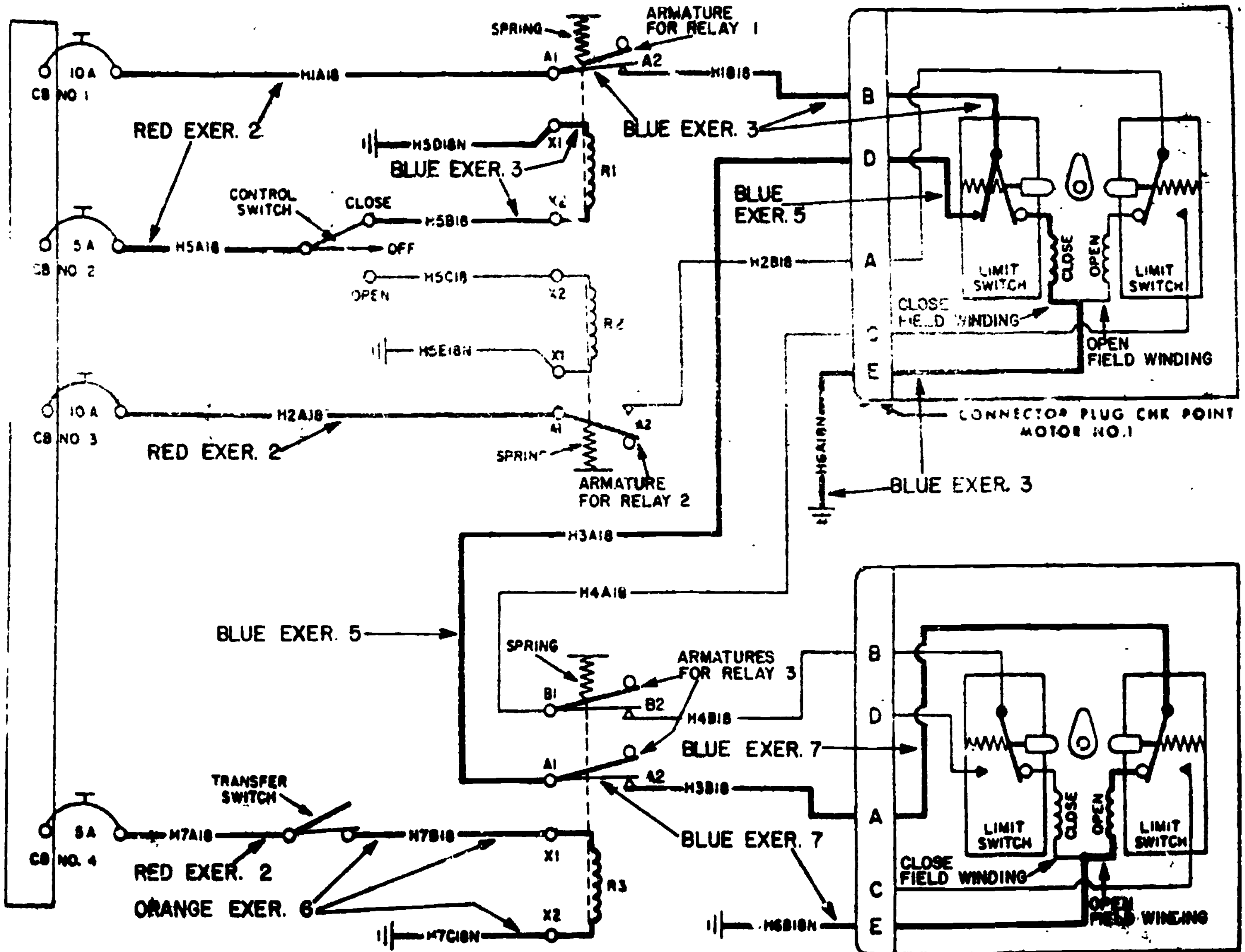
a. Trace from the control switch "off" position to the open contact of relay 2.

b. Trace from the open contact along wire H5C18 to X2 of relay 2, through the coil to X1. Trace from X1 along wire H5E18N to the common ground point.

c. Now that you have energized relay 2 the armature for this relay will make contact with A2. Use the green pencil and draw the armature of relay 2 to the "up" position (A1 to A2).

(1) As soon as the electrical path is made across A1 to A2 the voltage potential that comes from circuit breaker #3 can now travel from A1 to A2 and on to the motor valve. You will see how this is done as you start your next tracings.

Confirmation for exercises 2, 3, 5, 6 and 7. If your diagram was correct continue to the next exercise. If not see your instructor.



TRANSFER RELAY
DC REVERSIBLE MOTOR
Figure 4.

1018

1019

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d. Trace from point A2 along wire H2B18 to point A of the connector plug of motor #1, then through the limit switch and on through the open field winding of the motor armature. From here it goes on to check point E and along wire H6A18N to the common ground point.

(1) With voltage applied to the open field winding and a good ground, the motor armature will begin to rotate and open the valve butterfly.

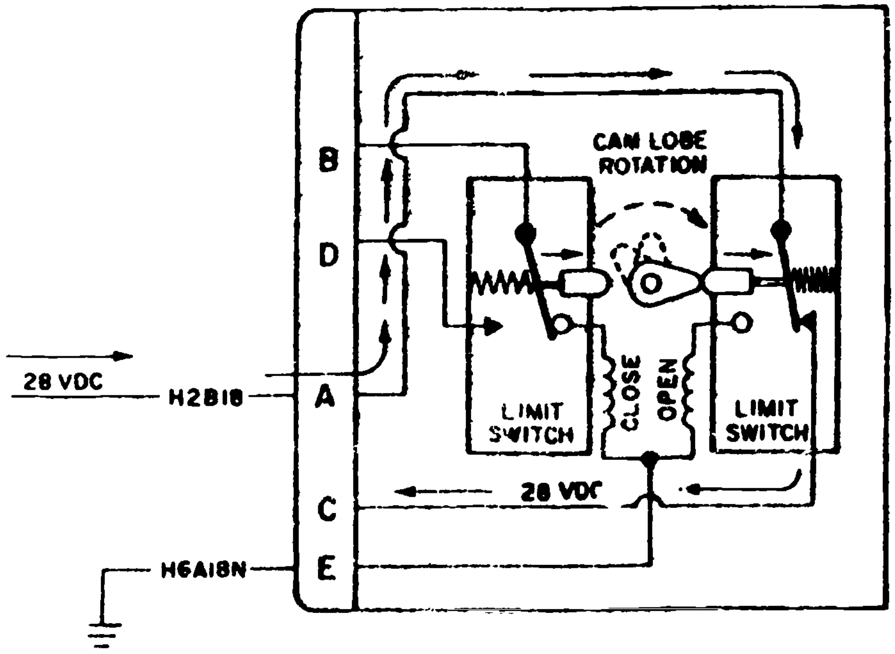


Figure 5.

(2) Look at figure 5 and note that as the motor armature starts to rotate toward open, the valve shaft and cam lobe start turning in the direction of the arrow above the cam lobe. The cam shown by the dotted lines indicates where the cam lobe was.

(3) Note that as the cam lobe is turned, the limit switch button for the closed side of motor 1 is released. Remember these switches are spring loaded. This action sets the close side of the motor valve up for operation again if the control switch was placed in the closed position.

(4) As the cam lobe reaches full travel (shown by the solid cam lobe), the limit switch button for the open circuit has been depressed and as a result voltage is removed from the open field winding. This voltage is now rerouted to check point C of the connector plug. In the following exercise, we will use this voltage to operate motor valve #2.

Exercise 9

1. You have already applied voltage to motor #1 on the open side in exercise 8. The valve butterfly has fully opened and the cam lobe has depressed the button of the limit switch.

2. Using a green pencil, trace motor #2's "close" circuit on figure 2.

a. Draw the armature of the limit switch for the open side of the motor valve to the depressed position. From the limit switch, trace to point C of the connector plug of motor valve #1.

b. Trace from check point C of motor #1 along wire H4A18 to point B1 of relay 3. In exercise 6 you have already energized relay 3, so the armatures of the relay are down.

c. Trace across the relay from B1 to B2.

d. Trace from B2 along wire H4B18 to check point B of the connector plug for motor #2.

e. Now trace from point B of the connector plug through the limit switch on through the closed field winding of the motor and out to check point E of the connector plug.

f. Trace from point E of the motor along wire H6B18N to the common ground point.

(1) Stop once again and examine what you have done.

(a) If you examine your circuit in figure 2, you can see that by placing the control switch to the open contact, you energize relay 2. This sends voltage from circuit breaker #3 to motor valve 1 and opens the valve butterfly. This also causes the cam lobe to depress the button on the limit switch and allows the voltage that was used to open motor valve 1 to be used to travel out point C and on to close motor valve 2.

Note: Use figure 6 for confirmation of exercises 8 and 9. The heavy bold line identified with its color and exercise number should be what you have traced on figure 2. You may refer back to these exercises as needed. If your diagram was correct, continue; if not, see your instructor at this time.

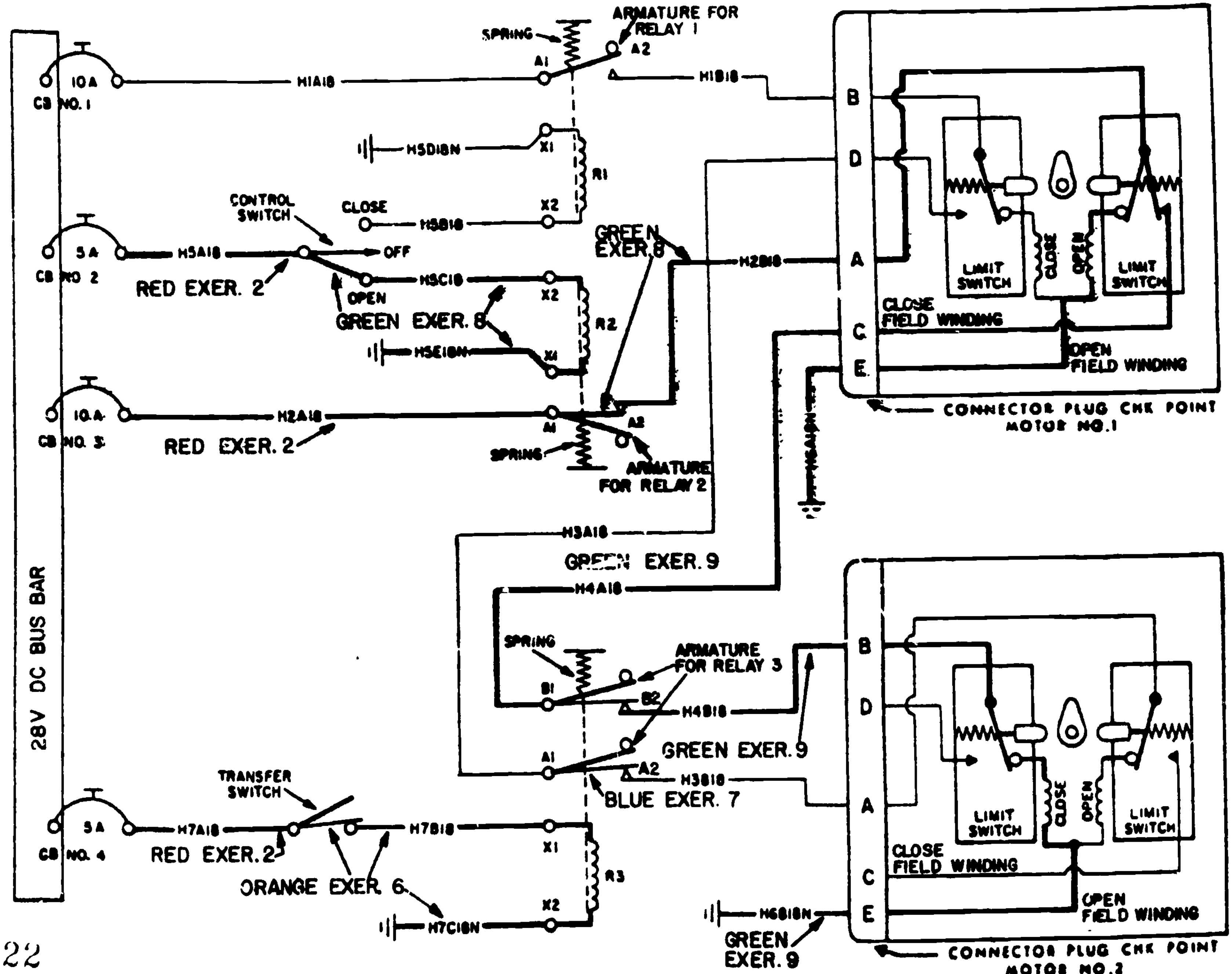
Before you start the practice problems for this workbook, there are a few items that you should know about the combined operation of these two DC motor valve assemblies. Again, refer to figure 2 as you read what these items are:

1. Motor valve #1 controls motor valve #2 with the use of the cam lobe and limit switches. The circuit drawn in blue shows how this is done on figure 2. By placing the control switch to the closed position, motor valve 1 closes. As the butterfly on this valve reaches its full closed position, the cam lobe pushes in on the limit switch pole and the voltage that was used to close this valve is sent out point D to be used to operate motor valve #2.

2. If for any reason motor valve #1 does not operate, there is no way that motor valve #2 will receive voltage. So you can see that this valve will not operate.

3. You may have also noticed that these two motors operate opposite of each other. By following the green trace on figure 2, you will see that by placing the control switch to open, you send voltage to the open field of motor valve #1. Once the motor opens, the cam lobe depresses the pole of

Confirmation for exercises 8 and 9. If your diagram was correct continue, if not see your instructor.



TRANSFER RELAY
DC REVERSIBLE MOTOR
Figure 6.

the limit switch and the voltage that was used to open motor valve #1 is now sent out check point C to the armature for relay #3. With this relay energized it continues across the armature to the closed field winding of the motor to close the butterfly of motor valve #2.

4. Following the blue lines on figure 2, you can see that by placing the control switch to close, motor valve #1 runs to the closed position and motor valve #2 runs to the open position.

5. You may also note that if motor valve 2 fails to open or close, it will in no way affect the operation of motor valve #1.

Note: If there is any doubt in your mind pertaining to the motor valve operation at this point, go back over all the preceding exercises. If not, you will now start your practice problem.

Using figures 7 and 8, you will identify the circuit malfunctions in the DC motor valve control circuit which are all caused by open circuits. You will place an "X" in the block which gives you the correct circuit malfunction. The first one (1) has been done for you. The next two you must do for practice and have them checked by your instructor before you progress to the problems in the performance test.

Practice Problem #1

1. Figure 7 gives you the location of the open circuit by number and an X for where the open occurs on the wire.

2. You will use figure 8 to record your answer. This has been done for you on the first problem.

3. To find how they got this answer look at figure 7 and find problem 1. You can see that it points to an open in the ground wire for motor valve #1 (H6A18N). Remember that all the problems given in this exercise are open circuits. An open circuit does not provide a complete path for voltage to pass.

4. Now look at figure 8. The numbers you find in the left column are the same numbers that are found on figure 7. The next column gives the circuit condition for each open circuit. An example of this is given in problem 1; the condition reads, control switch closed and transfer switch on. Using the circuit condition from figure 8 and the wiring diagram (figure 7), you can now find the circuit malfunction.

a. In figure 7 you have already found that for problem 1, wire H6A18N, the ground for motor #1, has an open. With an open here, it will now allow the electrons to flow through either the open or close field windings of this motor. You also know that if motor valve #1 fails to operate, motor valve #2 will also fail to operate. With this in mind, select the correct circuit malfunction given at the top of figure 8 and place an "X" in the correct block. This has already been done for you for practice problem #1.

b. The selection that was made is, "Motor Valve #1 and Motor Valve #2 Inoperative." This is the only complete and correct answer because the ground is for both the open and close winding of the motors, thus causing motor valve #1 to be completely inoperative. This in turn will make motor valve #2 inoperate because motor 1 supplies the voltage to operate motor #2.

Practice Problems #2 and #3

If you look at practice problem #2 on figure 8, you will find that the circuit condition for this problem is, "Control Switch CLOSED and transfer switch off." Now find problem #2 on figure 7. By placing the control switch to the closed position, you'll find that the open wire H5D18N will not allow the electrons to flow, thus affecting only the closed winding of motor #1. You may also note that Relay 3 is de-energized. This means there is no way that motor valve #2 will operate. With this in mind, select the correct circuit malfunction given at the top of figure 8 and place an "X" in the correct block for this practice problem. Go on now to practice problem #3 and after you have completed it, have the instructor grade your work. If the instructor initials your paper, you are to progress to the performance test.

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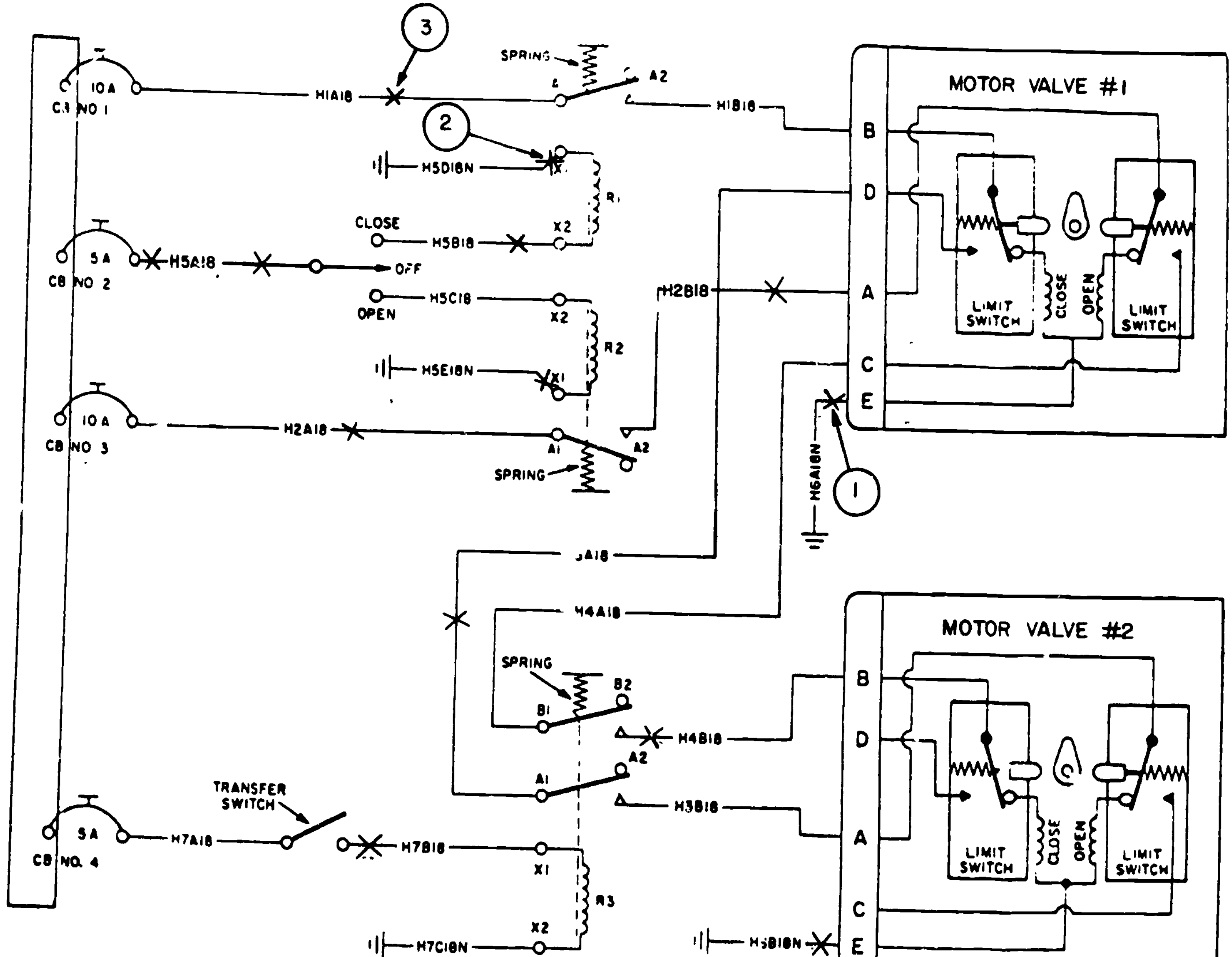

3
2
1
SPRING
A2
H1A18
H1B18
10A
CB NO 1
H5D18N
R1
CLOSE
X2
H5B18
5A
CB NO 2
H5A18
OFF
H5C18
OPEN
R2
H5E18N
X1
H2B18
10A
CB NO 3
H2A18
A1
MOTOR VALVE #1
B
D
A
C
E
LIMIT SWITCH
CLOSE
OPEN
H6A18N
H4A18
B1
B2
H4B18
H3B18
TRANSFER SWITCH
5A
CB NO. 4
H7A18
H7B18
R3
H7C18N
MOTOR VALVE #2

Figure 7.

Student completes the following, using the diagram in figure 7.

STUDENT NAME ______________________________ DATE STARTED __________

	These Numbers are Located on Figure 7	CIRCUIT CONDITION	CIRCUIT MALFUNCTION								
			Motor #1 will not CLOSE and Motor #2 will not OPEN	Motor #1 will not OPEN and Motor #2 will not CLOSE	Motor #1 will not CLOSE	Motor #2 will not CLOSE	Motor #1 will not OPEN	Motor #2 will not OPEN	Motor #1 and #2 inoperative	No or #1 inoperative	Motor #2 inoperative
Practice Problems	1	Control Switch CLOSED **and Transfer Switch ON**							X		
	2	Control Switch CLOSED and **Transfer Switch OFF**									
	3	Control Switch CLOSED and **Transfer Switch ON**									
INSTRUCTOR MUST INITIAL BEFORE STUDENT IS TO PROGRESS →											

Figure 8.

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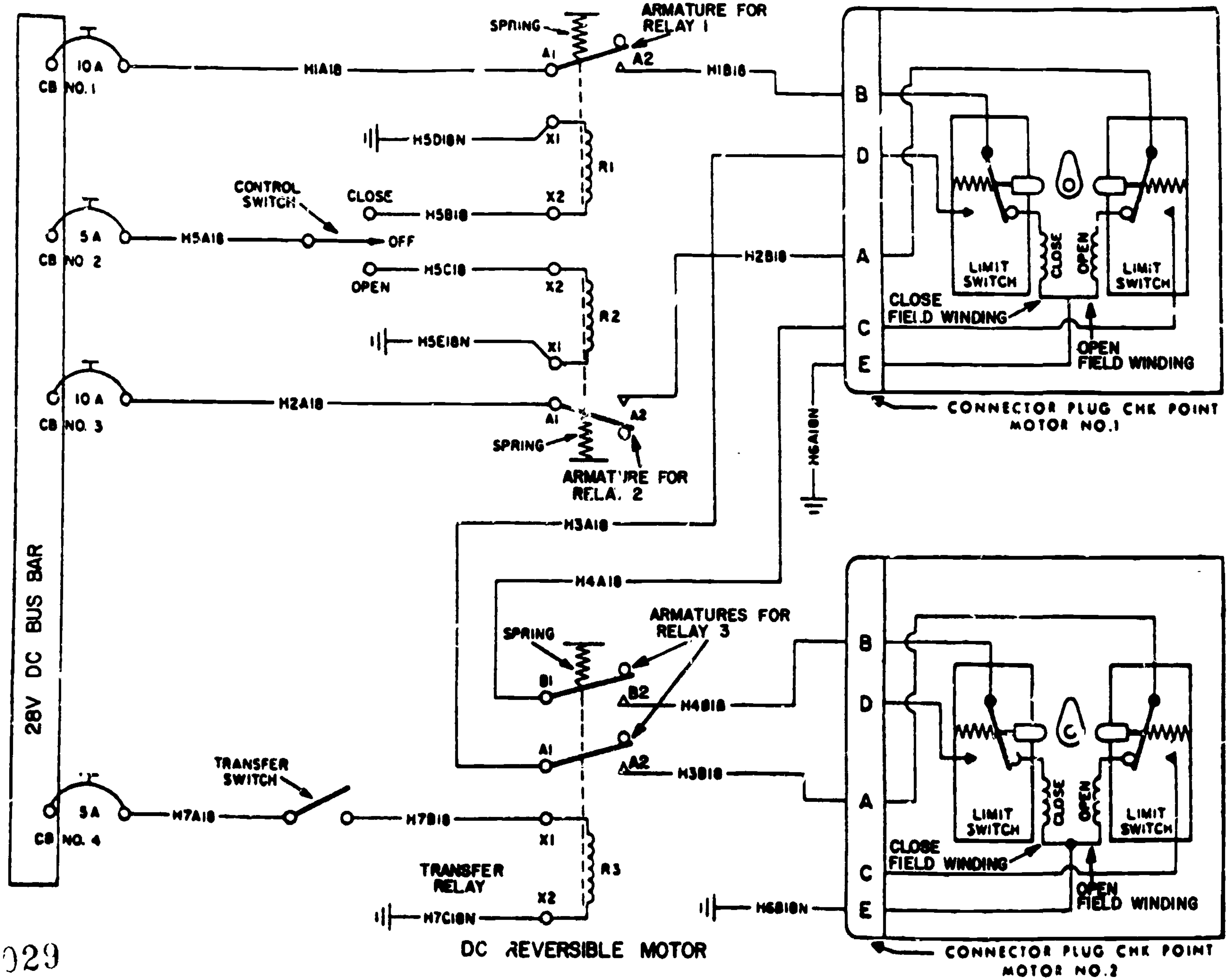
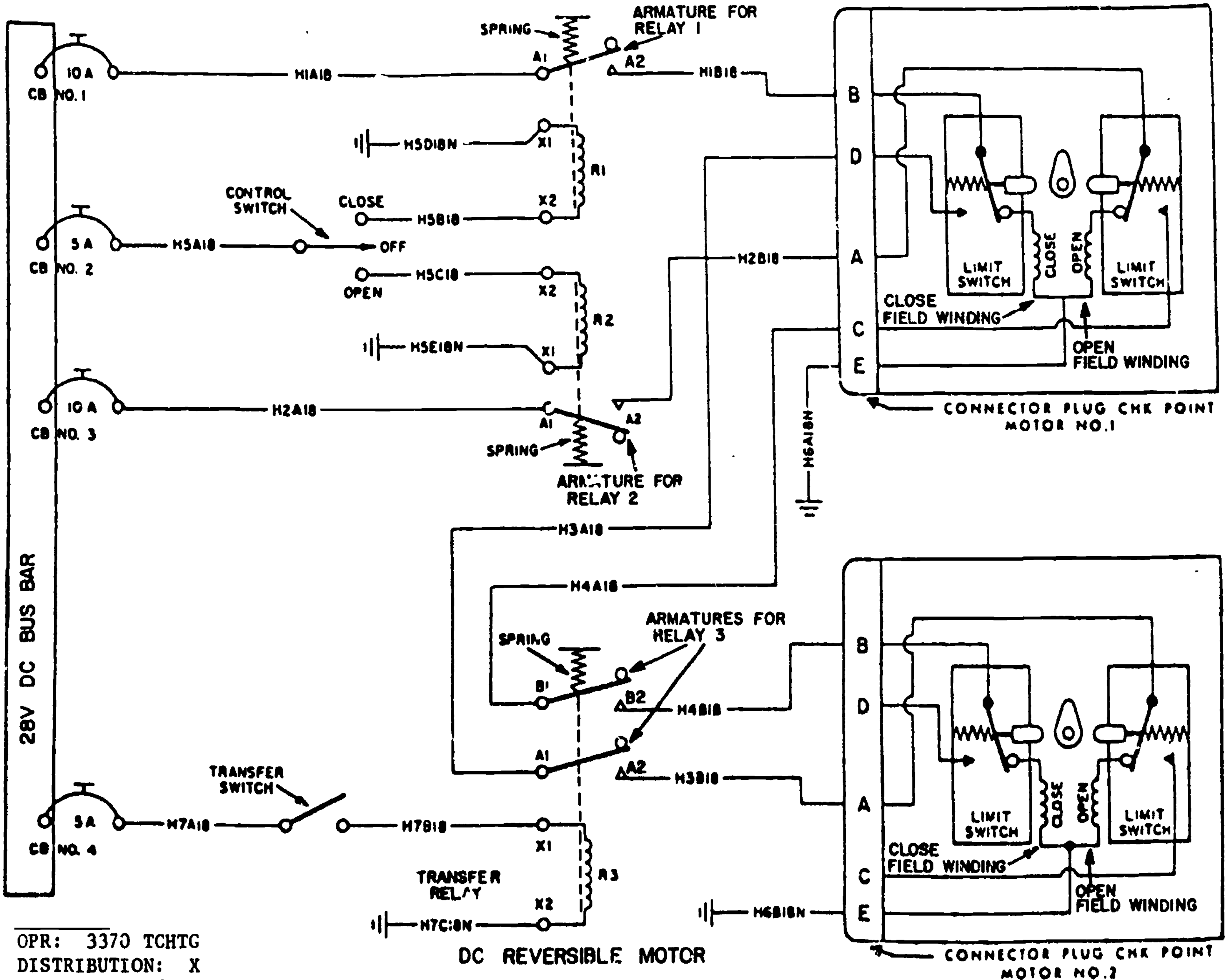


DC REVERSIBLE MOTOR

Figure 2.

DC MOTOR CONTROL CIRCUIT WIRING DIAGRAM



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Technical Training

Aircraft Environmental Systems Mechanic

DC MOTOR AND CONTROL CIRCUIT TROUBLESHOOTING

8 January 1981

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON T'? JOB

RGL: N/A

Environmental Pneudraulics Branch
Chanute AFB, Illinois

3ABR42331-WB-121A

DC MOTOR AND CONTROL CIRCUIT TROUBLESHOOTING

OBJECTIVE

Using a DC motor control circuit, electrical diagrams, and multimeter, troubleshoot five system problems. Four of the five problems must be accomplished with 100% accuracy.

EQUIPMENT

Trainer P/N 18501387, DC
  Reversible Motor System
Multimeter

CAUTION: Remove watches, rings, bracelets, etc., before starting any work on the equipment. It is also a good safety practice to work on the equipment with one hand. This practice reduces the chances of receiving an electrical shock to some vital body organ when working with electricity.

PROCEDURE

The first seven pages will be done without the trainer. They may be done in the lab and/or classroom at the descretion of the instructor(s). Page 8 on will be done in the lab. After you get to the lab ask the lab instructor to assign you a trainer to complete the workbook and performance test. You will also need a multimeter. Follow the procedures that are given in each exercise.

When you leave your trainer for a schedule' or unscheduled break, insure that the following procedures are done beiore you leave.

1. Place the CONTROL SWITCH to the OFF or center position.

2. Place the TRANSFER SWITCH to the OFF position.

3. Secure your multimeter during this pe- 4.

   a. Insure the controls on the meter are properly set for storage.

   b. Leave the test leads attached to the meter.

   c. Wrap the test leads around the meter.

   d. Place the meter on the locker shelf.

4. When you return from your break take the same meter from the locker and go back to work.

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OPR: 3370 TCHTG
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3370 TCHTG/TTGU-P - 400; TTVSA - 1

1. Before starting with the troubleshooting exercise, thoroughly refamiliarize yourself with the operation of the voltmeter.

a. In order for the multimeter to read voltage (AC or DC) there must be power applied to the circuit to have a voltage potential or a difference between a positive point and a negative point.

(1) To better understand what is meant by this, look at figure 1 below and continue reading.

(2) If the voltmeter leads were placed into the circuit as shown in figure 1, the meter would indicate a "0" (zero) voltage reading. The reason is because the wire between the two leads allows the same voltage (pressure) to exist at both ends of it. Because its the same at both ends, the meter cannot measure a difference.

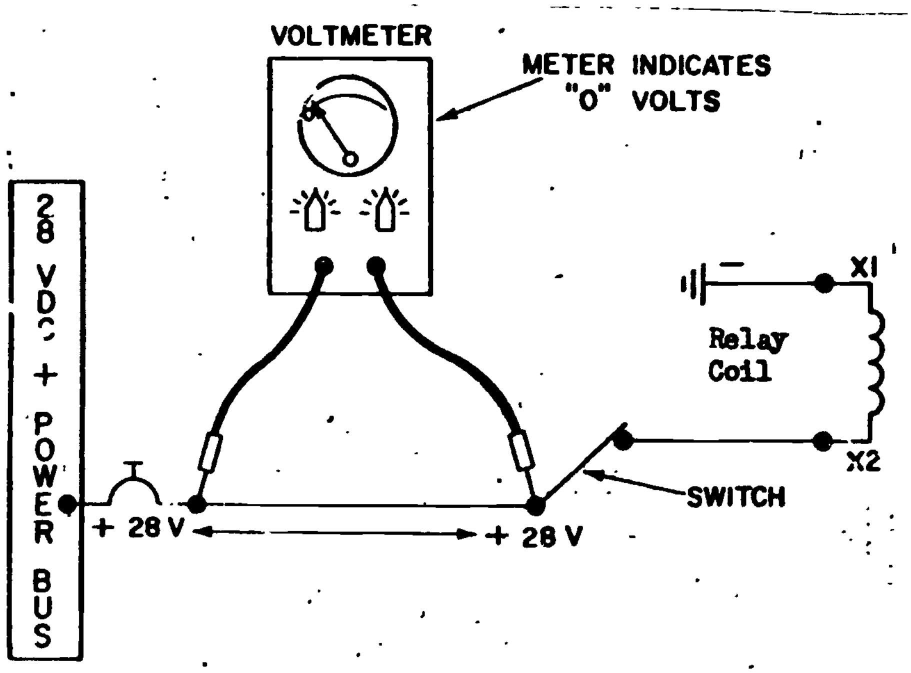


Figure 1.

Note: Always place the negative (black) lead at the most negative (-) point and the positive (red) lead at the most positive (+) point.

(3) In figure 1 locate the 28V DC bus (+) and note that the wire coming off the bus is merely an extension of the positive power source going through a protective device (CB). Therefore, the wire is as equally positive at the power bus as it is at the pole of the switch.

b. Now let's look at the negative side of the circuit. Refer to figure 2. If you were to place the meter leads in the circuit as shown, the meter also would give an indication of "0" volts.

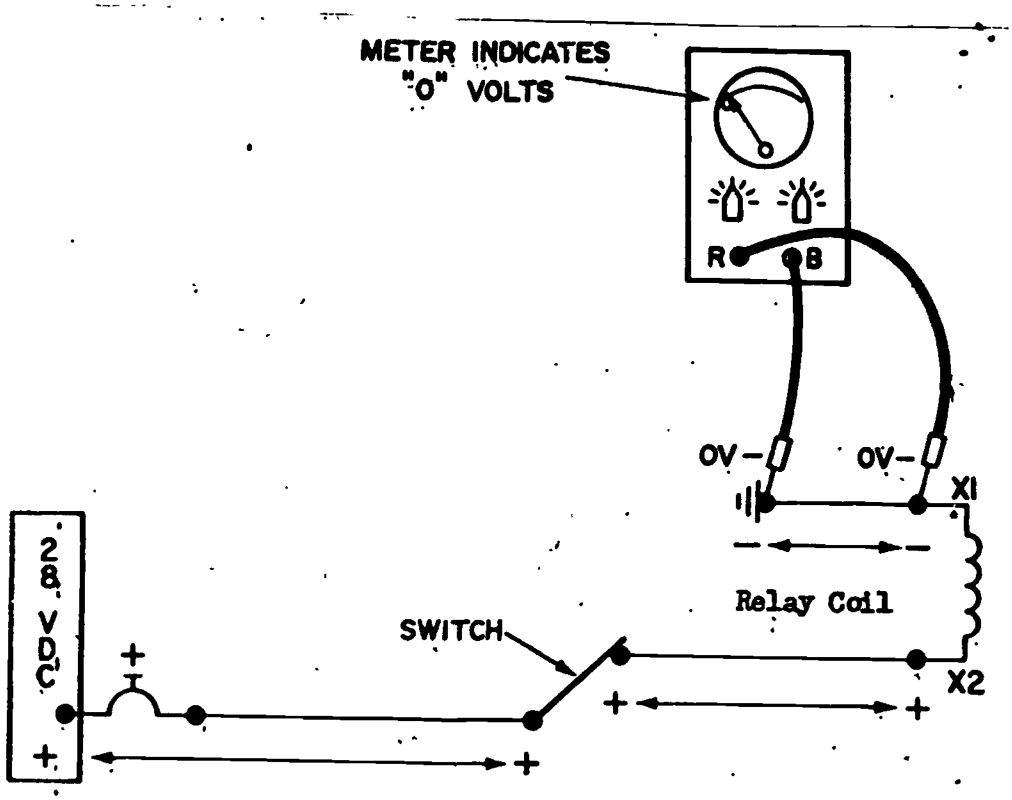


Figure 2.

(1) As you know there must be a voltage potential and/or drop in the circuit for the voltmeter to read. This normally caused by resistance (load) between the red and black leads when they are connected in a circuit.

(2) The ground wire is hooked from point X1 of the relay coil to the (‖——) ground point.

Note: Because of the reading of zero voltage in figures 1 and 2 these two wires are GOOD circuits WITHOUT opens.

c. IF you had a voltage reading on the negative side of the circuit in figure 2, which you should NOT have, it would stand to reason that something must be wrong with the circuit, but what?

(1) Refer to figures 2 and 3 and note in figure 3 that the ground wire for this circuit is broken (which will automatically make the circuit not work). Note the way the meter is connected in figure 3. The 28V DC reading is caused by the (high resistance) open wire in the ground circuit.

(a) There is a definite voltage difference in the ground circuit in figure 3.

(b) Only one side of the broken ground circuit in figure 3 is now physically connected to just the positive side (+) of the circuit. This is the part of the ground circuit connected to X2 of the relay coil.

(c) The other side of the broken ground circuit in figure 3 is physically connected to the negative side (–) ground point of the circuit.

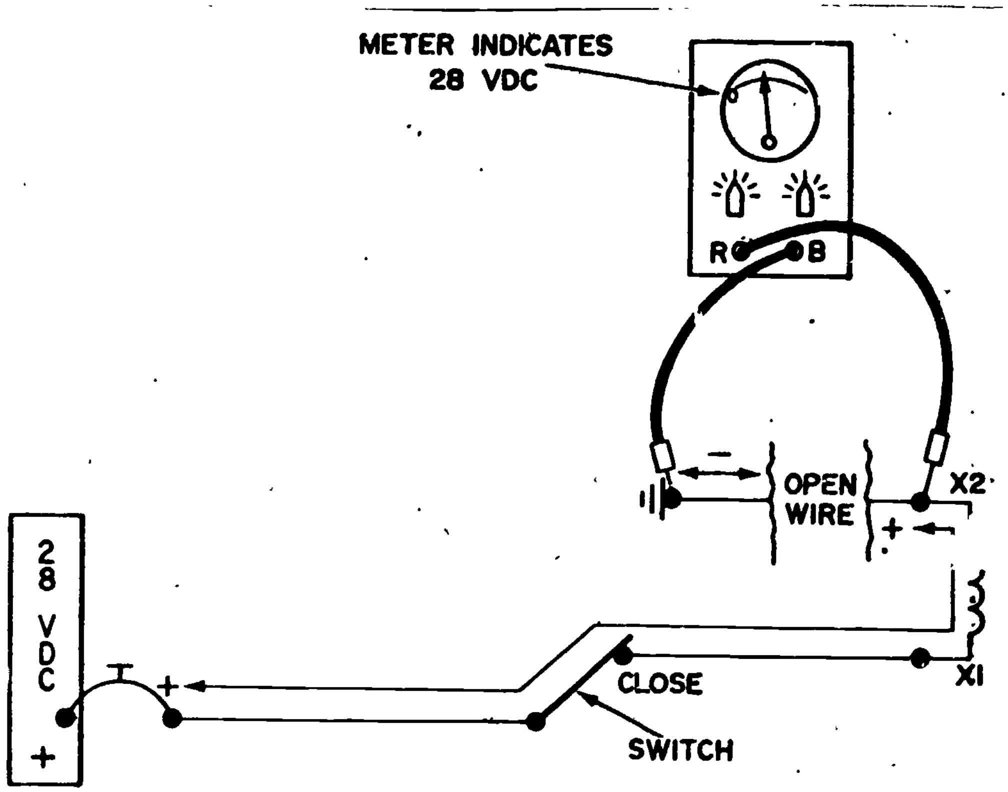


Figure 3.

(d) The black meter lead is connected to the negative side in figures 2 and 3.

(e) The red meter lead is connected to the positive side in figures 2 and 3.

1 The meter reads the difference between the two points (+ to -). This is because of the broken ground wire. If the wire was not broken you would have the conditions as shown in figure 2, a good circuit.

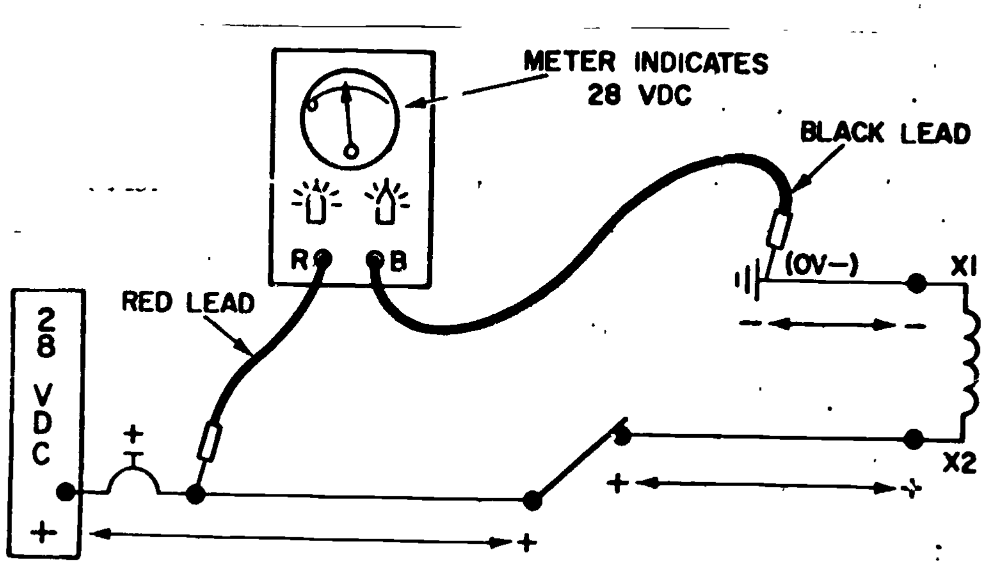


Figure 4.

d. Now let's see how the meter MUST be connected to the circuit to get a voltage reading. In figure 4 note that the black meter lead has been placed at the common ground point, further note that the RED meter lead is placed at the circuit breaker checkpoint.

(1) The voltmeter in figure 4 will now indicate a reading of 28V DC. Why? This is because of the distinct difference between the (+) and (-) points caused by the resistance (relay coil) between the two meter test points in the circuit. This voltage reading is obtained with power on.

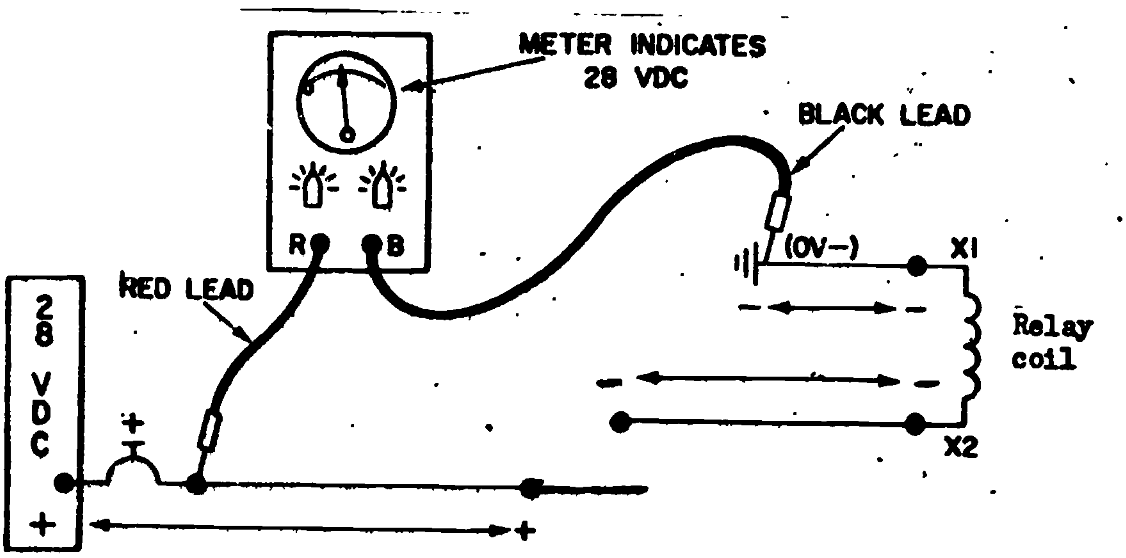


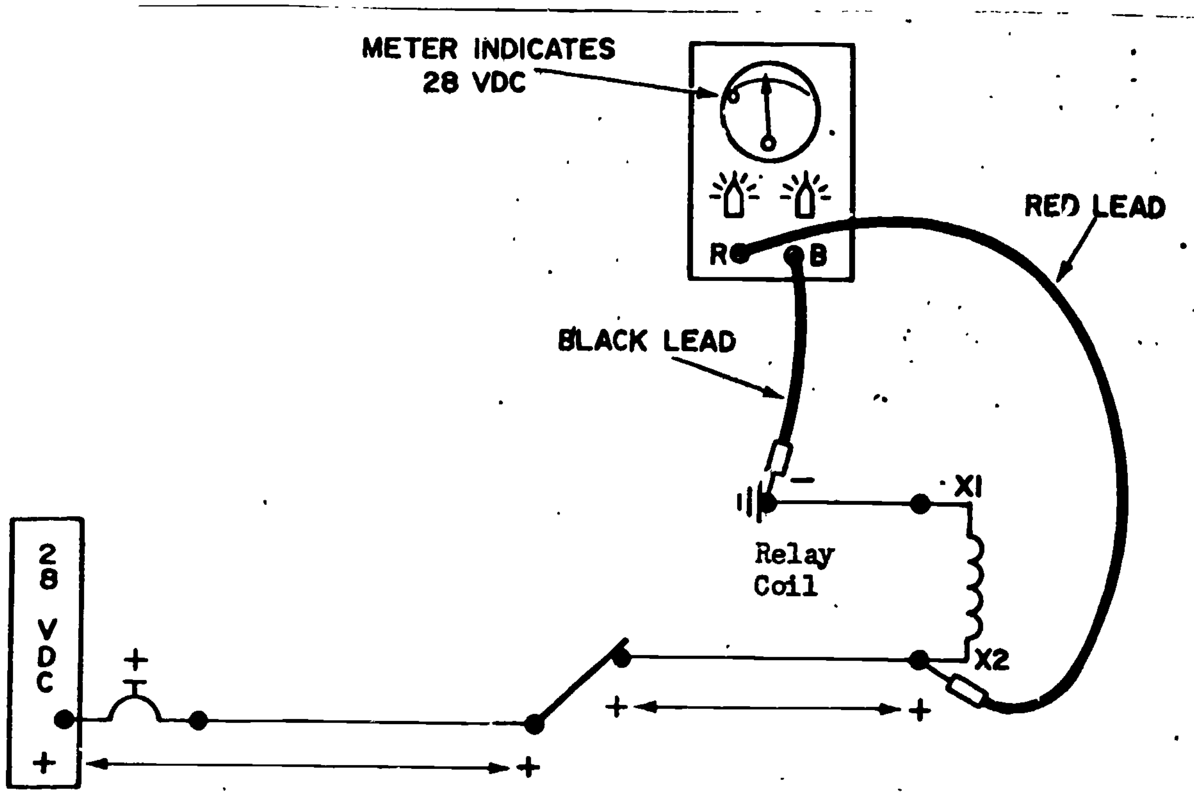
Figure 5.

(2) In figure 5 there is infinity resistance in the open contacts of the switch. The open in the switch is a NORMAL condition if the switch is turned to the OFF position. This causes the meter to read 28V DC as shown in figure 5. Remember back in figure 4 the meter also read 28V DC. This was with the switch closed and the reading was caused by the resistance of the load (relay coil).

Note: Compare the polarities (+) and (-) on X2 from figures 4 and 5. They changed because of the switch position.

e. Let's take another reading of this circuit in figure 6. Take a reading from X2 of the relay to the ground point. Note in figure 6 how the meter leads are connected. The black at the most negative (-) point and the RED at the most positive (+) point in the circuit being measured.

(1) Again the meter will indicate a reading of 28V DC. Because here again there is a difference in potential between the positive (+) and negative (-) sides of the circuit, which is the relay coil (load).



F'gure 6.

NOTE AND REMEMBER: In order for the multimeter to indicate voltage, there must be a voltage potential or a difference between positive (+) and negative (-) which is normally caused by a resistance (load, open, high resistance, etc.) between them. When you start to take a voltage reading, you should "automatically ground" your black meter lead.

Exercise 1

Caution: Remove watches, rings, bracelets, etc., before starting any work on the trainer. It is also a good safety practice to work on the trainer with only one hand. This practice reduces the chances of receiving an electrical shock to some vital body organ when working with voltage.

1. Trainer Troubleshooting: Before you can effectively troubleshoot the DC motor trainer, you must become thoroughly familiar with the normal operation of the system. An operational checkout MUST be performed prior to troubleshooting to determine the condition of the system and to help you locate exactly which portion of the system is defective. Knowing when and how the systems operate normally is the key to successful troubleshooting.

2. Follow the procedures below and perform an operational check of the system with relay R3 energized.

a. Insure all (4) circuit breakers are pulled out.

b. Place control switch in the OFF position.

c. Place transfer switch in the OFF position.

d. Place all trouble switches toggles to the OUT position. These are located on the back of the trainer.

e. Insure trainer is plugged in.

f. Push in all four (4) circuit breakers. This supplies 28V DC for the system.

g. Place the TRANSFER switch to the ON position. Leave the TRANSFER switch ON for exercise 1. When the TRANSFER switch is turned ON relay #3 will be energized.

Note: If you have any questions at this time see your lab instructor. As you perform each of the following steps, place an X in the blank that correctly indicates relay or motor position. You will observe the motor valve operation and also study the electrical diagram on the trainer to answer the questions.

h. Place the CONTROL switch to the CLOSE position and insure the TRANSFER switch is in the ON position.

(1) Which relay should and did energize?

_____(a) Relay #1 (close relay)

_____(b) Relay #2 (en relay)

(2) Which motor valve opened?

_____(a) Motor valve #1

_____(b) Motor valve #2

(3) Which motor valve closed?

_____(a) Motor valve #1

_____(b) Motor valve #2

(4) Should R3 be energized?

_____(a) No

_____(b) Yes

i. Place the CONTROL switch in the OPEN position and insure the TRANSFER switch is in the ON position.

(1) Which relay should and did energize?

_____(a) Relay #1 (close relay)

_____(b) Relay #2 (open relay)

(2) Which motor valve opened?

_____(a) Motor valve #1

_____(b) Motor valve #2

(3) Which motor valve closed?

_____(a) Motor valve #1

_____(b) Motor valve #2

(4) Should R3 be energized?

_____(a) No

_____(b) Yes

This completes the operational check procedures with R3 energized, now compare your answers to those given. This way you will know that the trainer is operating normally.

Correct responses to Exercise 1:

h. (1) a
(2) b
(3) a
(4) b

i. (1) b
(2)
(3)
(4)

If all of your answers agree with those given above, you are now ready to begin operational check with transfer switch OFF (R3 deenergized). If your answers do not agree, perform the operational check again or ask your instructor for assistance.

Exercise 2

1. Following the procedures below perform an operational check of the system with relay R3 deenergized.

a. Insure all circuit breakers are in and power is applied to the trainer.

b. Place the TRANSFER switch to the OFF position.

c. Place the CONTROL switch in the OFF position.

d. Insure all trouble switches toggles are to the OUT position. These are located on the back of the trainer.

Note: If you have any questions at this time see your lab instructor. As you perform each of the following steps, place an X in the blank that correctly indicates relay or motor position. You will observe the motor valve operation and also study the electrical diagram on the trainer to answer the questions.

e. Place the CONTROL switch to the CLOSE position, and insure the TRANSFER switch is in the OFF position.

(1) Which relay should and did energize?

_____(a) Relay #1 (close relay)

_____(b) Relay #2 (open relay)

_____(c) Relay #3 (transfer relay)

(2) Should motor valve #2 have opened?

_____(a) No

_____(b) Yes

(3) Should motor valve relay #2 have closed?

_____(a) No

_____(b) Yes

(4) Should motor valve #1 have opened?

_____(a) No

_____(b) Yes

(5) Did motor valve #1 close?

_____(a) No

_____(b) Yes

(6) Is relay R2 energized?

_____(a) No

_____(b) Yes

(7) Is relay R3 energized?

_____(a) No

_____(b) Yes

f. Place the CONTROL switch to the OPEN position, and insure the TRANSFER switch is in the OFF position.

(1) Which relay is energized?

_____(a) Relay #1 (close relay)

_____(b) Relay #2 (open relay)

_____(c) Relay #3 (transfer relay)

(2) Should motor #2 valve have opened?

_____(a) No

_____(b) Yes

(3) Should motor valve #2 have closed?

_____(a) No

_____(b) Yes

(4) Should motor #1 valve have opened?

_____(a) No

_____(b) Yes

(5) Should motor valve #1 have closed?

_____(a) No

_____(b) Yes

(6) Is relay R1 energized?

_____(a) No

_____(b) Yes

(7) Is relay R3 energized?

_____(a) No

_____(b) Yes

This completes the operational check procedures with R3 deenergized, now compare your answers to those given. This way you will know that the trainer is operating normally.

Correct responses to Exercise 2:

e.	(1)	a	f.	(1)	b
	(2)	a		(2)	a
	(3)	a		(3)	a
	(4)	a		(4)	b
	(5)	b		(5)	a
	(6)	a		(6)	a
	(7)	a		(7)	a

Exercise 3

If you are thoroughly familiar with the normal operation of the system you will now start with troubleshooting. If you are in doubt about the normal operation of the system, see your lab instructor.

1. Follow the procedures below to program a cause for a malfunction in the trainer.

a. Insure power is connected to the trainer. See your lab instructor if needed.

b. Insure the CONTROL switch is in the OFF or center position.

c. Insure TRANSFER switch is in the OFF position.

d. Insure the circuit breakers (CB) are pushed in.

e. Sign out a multimeter and insure it is properly set up and leads connected to the meter. Place the meter in the meter box on top of the trainer.

Note: As you can see on the wiring diagram, the bus bar has 28V DC and the multimeter must be set up for these values.

f. Insure that all the trouble switches on the back of the trainer are in the OUT position.

g. Now place trouble switch #2 on the back of the trainer to the IN position.

Exercise 4

1. Now you are ready for the operational check of the system. Remember you are now looking for a visual malfunction of the valve(s) during the operational check.

Note: You are going to use trouble switch #2 on the back of the trainer for the first practice malfunction. The trouble switch on the back of the trainer when placed to the "IN" position will place a trouble in the electrical control circuit giving a malfunction. Because the location of the cause for the malfunction is unknown to you in the circuit, you will need to perform a complete operational check and then troubleshoot the malfunctioning circuit with a multimeter. Once you have moved a trouble switch to the IN position you will leave it there until this workbook and/or instructor instructs you otherwise.

a. Place the CONTROL switch to the OPEN position.

(1) What has happened? Motor valve #1 should be in OR is going to the OPEN position. Is this normal operation? From your studies you know it is correct.

b. Place the TRANSFER switch to the ON position.

(1) What has happened? Motor valve #2 should be in OR is going to the CLOSE position. Is this normal operation? From your studies you know it is correct. (Motor valve #1 OPENS and then motor valve #2 CLOSES.)

Note: You can look through the clear plastic cover on motor valve #1 and observe the action of the armature shaft rotating the cam lobe toward the limit switch. On both motor valve assemblies you can observe the valve butterfly movement through the clear plastic covers.

c. Place the TRANSFER switch in the OFF position and CONTROL switch in the CLOSE position.

(1) What happened? Motor valve #1 should but did not CLOSE. The TRANSFER switch is in the OFF position which will not allow motor valve #2 to operate.

(2) Refer to the practice problem chart on page 17. Make the correct entry under the malfunction OFF column. The entries made will be one of the letters shown below in that chart which identifies the correct malfunction. Trouble switch #2 has already been completed. The letter G (motor valve #1 will not close) is entered in the OFF column. This is because the TRANSFER switch is in the OFF position.

d. Insure the control switch is in the CLOSE position and place the TRANSFER switch in the ON position.

(1) What happened? Motor valve #1 would be but is not CLOSED and motor valve #2 did not OPEN. This is the observable malfunction because you can see what DID NOT happen through the plastic covers on the motor valve assemblies. (Motor valve #1 will not CLOSE and motor valve #2 will not OPEN.)

(2) Refer to the practice chart on page 17. Make the correct entry under the malfunction ON column. The entry made will be one of the letter(s) shown below the chart which gives the correct malfunction. The letter A (motor valve #1 will not CLOSE and motor valve #2 will not OPEN) is entered in the ON column.

(3) This observable malfunction should tell you that the CAUSE of the malfunction is in the CLOSE control circuit for motor valve #1. As you know, motor valve #1 must complete an operation before motor valve #2 will operate.

Exercise 5

1. Now you are ready to troubleshoot the control circuit and to find the CAUSE for the observable malfunction (motor valve #1 will not CLOSE and motor #2 will not OPEN). You will use the voltage measuring method of troubleshooting. This procedure starts at the connector plug of the malfunctioning unit (load) or motor winding. <u>You will take the first voltage measurement on the positive side of the unit (load) which failed to function.</u> Having the correct amount of power in the positive circuit up to the malfunctioning unit (load) indicates that the positive circuit is OK. This first voltage check taken at the plug will tell you to continue troubleshooting the positive (close) control circuit or troubleshoot the ground circuit. IF the voltage reading is below the required value of 28V DC, you would continue troubleshooting in the positive (close) control circuit. IF the required value of 28V DC is measured you would then check out the ground circuit for the malfunctioning load.

Follow the following instructions to solve for the cause of the malfunction.

a. Connect the BLACK lead from the meter to the common ground point on the trainer. This point is located on the front of the trainer between the two motor valve units. The BLACK lead will stay there during the following voltage measurements.

(1) This is the common ground for all units (relays and motors) in the control circuit.

b. Use the RED lead and measure the applied voltage on the positive side of the malfunctioning unit (load).

(1) The failing unit (load) is the close winding in the motor #1.

(2) Because BOTH valve motors failed to operate as recorded in the practice problem chart, you must start troubleshooting with motor valve #1. This is because motor #1 must complete its function BEFORE motor valve #2 can operate.

(3) You will begin measuring on the positive side of the malfunctioning load. Use pin B on the connector plug of the motor valve #1 for this. Place the RED lead on pin B and read the meter. Pin B is connected to the motor winding on the positive side.

(4) The meter reading on point B on motor valve #1 is 0V DC (should be 28V DC) and this 0V DC indicates the positive (CLOSE) control circuit has failed. This means you will now troubleshoot only in the positive (CLOSE) control circuit for the CAUSE for the malfunction.

Note: IF at point B you had a normal voltage reading of 28V DC, this reading would indicate a good positive CLOSE control circuit and then you would check out the ground circuit (point E motor valve #1). You will check out the ground circuit ONLY IF the positive circuit is OK.

c. Because you now know the malfunction is in the positive CLOSE control circuit, you must move the RED lead to the next point (junction) A2 of R1. Remember because o the low voltage you are looking for the 28V DC power in the circuit You will have to follow wire H1B18 to junction A2. The meter reading at A2 is also 0V DC and this should tell you to move across the armature of the relay to A1.

Note: Why? Because the voltage comes from the bus bar and you will troubleshoot from the load to the power source, trying to find where the 28V DC power has stopped in the positive control circuit before it reaches the load. This location will help you identify the cause.

d. The next check point (junction) is A1 of R1. This meter reading on A1 of 28V DC indicates that from this point to the 10A circuit breaker is a good circuit, and you will not need to check the voltage at the circuit breaker.

Note: Remember voltage, power, current will not at anytime FLOW through OR in the dotted line in the relay symbol.

e. The power on one side of the relay armature, (point A1) but NOT on the other side (point A2) indicates the armature didn't CLOSE.

f. To find out why the relay armature didn't close you must now troubleshoot the positive relay control circuit. Being that the relay coil is a load on this circuit you will now troubleshoot by measuring with the RED lead at the positive side of the relay coil (load) connection, X2 of R1. The meter reading at point X2 of R1 is 28V DC. This indicates the positive circuit for the relay coil is functioning normally.

Note: Only IF point X2 of R1 was reading 0V DC would this indicate a failing positive circuit for the relay coil IF this was the case, you would continue troubleshooting further into the positive relay circuit, through the control switch to and through the circuit breaker IF needed. Remember, only IF both positive and negative circuits checked out OK for the relay coil, then the load (coil) itself may have failed internally and you would replace it.

g. You should have checked out the positive side of the circuit to the relay coil and found it is OK. Now, because the relay is still inoperative you must check out the negative circuit of the relay coil. This is done by measuring the voltage at X1 of R1. You should normally read 0V DC but you find an unwanted 28V DC power at this point, this indicates an open ground circuit for the relay coil. Remember, without the relay functioning correctly it will cause a malfunction on motor valve #1.

(1) Identify the malfunction by writing in the letter(s) which identifies the malfunction. Only one letter in each column is required. (These have already been done for you.)

(2) Complete the cause columns by writing in the (type of trouble) and (unit or wire number). These have already been done for you.

(3) See your lab instructor if you have any questions at this time.

h. Referring to the practice chart on page 17 and you will find all the required entries already made for trouble switch #2. Study the entries made to acquire knowledge on how to make the entries for the remaining trouble switches. You will also find that you have two (2) malfunction columns. You will complete both columns as needed.

Exercise 6

You have completed troubleshooting trouble #2. You should be able to troubleshoot a malfunction on your own at this time. You may ask for assistance from the lab instructor, if necessary.

1. Follow the procedures below to troubleshoot a malfunction in the trainer that you will do for practice.

a. Insure power is connected to the trainer. See your lab instructor if needed.

b. Insure CONTROL switch is in the OFF or center position.

c. Insure TRANSFER switch is in the OFF position.

d. Insure circuit breakers are pushed in.

e. Insure multimeter is properly set up and leads are connected to the meter.

f. Insure that all the TROUBLE switches on the back of the trainer are in the OUT position.

g. See the instructor to have a TROUBLE switch # entered in for the practice problem and performance test charts on page 17 and the performance test.

h. Now place the TROUBLE switch # entered on the practice problem chart to the IN position on the back of the trainer.

2. Perform an operational check.

3. Complete both malfunction columns transfer switch "ON" and "OFF" as required. (If there is an X in one of the blocks, no entry is required.)

4. Troubleshooting tne circuit(s) for the cause.

5. Complete both CAUSE columns.

6. Check the wire number against your entry in the malfunction columns for a recheck of your work. Note: Remember how you did your wiring diagr · workbook in the classroom, use that knowledge to cross check this work.

7. Have your instructor check and initial your work before progression. If your work is incorrect follow the instruction given by the instructor.

Practice Problems

Trouble Switch Number	Malfunction Transfer Switch ON	Malfunction Transfer Switch OFF	Cause: Type of trouble open, short, etc.	Cause: Unit or wire Number
?	A	G	open	H5D18N
		X		

A. Motor 1 will not close and motor 2 will not open.

B. Motor 1 will not open and motor 2 will not close.

C. Motor 1 and 2 inoperative.

D. Motor 2 will not open.

E. Motor 1 inoperative.

F. Motor 2 inoperative.

G. Motor 1 will not close.

H. Motor 1 will not open.

I. Motor 2 will not close.

Note: The circuit malfunction must describe exactly what is malfunctioning, nothing more or less. Always note the position of the control switch, transfer switch, and motor limit switch.

Instructor's Initials __________ Practice Problem Grade __________

If your lab instructor signs off your practice work, you will be assigned your progress check material.

Exerc ie 7

PROGRESS CHECK INSTRUCTIONS

This progress check will require you to correctly solve a minimum of 4 out of the 5 problems given. This should be accomplished in much the same manner as the practice problems. The instructor will check and initial your work after the 5 problems are graded and passed. If you have missed more than one (1) problem, you will follow the instructions of your lab instructor.

You will not communicate (talk, etc.) with other students during the progress check without your lab instructor's permission.

You will not use fellow students' work to solve the problems in this progress check.

You must satisfactorily complete this progress check before further progression to other lab troubleshooting projects.

Note: If any part of the answers (cause or malfunction) to the trouble switch # is wrong, the instructor will mark the whole trouble switch entry incorrect. This means YOU will have to find what part or parts of the cause or malfunction is incorrect for that trouble switch.

Students will please complete the following (print):

STUDENT'S NAME ______________________________
(Last) (First)

DATE PROGRESS CHECK STARTED ______________________

1050

PROGRESS CHECK						
Trouble Switch Number	Malfunction		Cause		Instructor Assist Initial	
	Transfer ON	Switch OFF	Type of trouble Open, short, etc.	Unit or wire Number	1st	2nd

A. Motor valve 1 will not close and motor valve 2 will not open.

B. Motor valve 1 will not open and motor valve 2 will not close.

C. Motor valve 1 and 2 inoperative.

D. Motor valve 2 will not open.

E. Motor valve 1 inoperative.

F. Motor valve 2 inoperative.

G. Motor valve 1 will not close.

H. Motor valve 1 will not open.

I. Motor valve 2 will not close.

Before you have your instructor check your work, recheck it yourself like you did in the practice problems.

Instructor's Initials __________ Complete Progress Check Grade __________

Whether you have failed or passed this progress check, you will follow the instructions given to you by the lab and/or classroom instructor.

If you have satisfactorily completed the progress check, store your multimeter and trainer in the following way:

1. Pull out all the circuit breakers (4) each.

2. Place the cont'ol switch in the OFF position.

3. Place the transfer switch in the OFF position.

4. Place all trouble switches toggles to the OUT position. These are located on the back of the trainer.

5. Insure all your training literature, pencils, etc, are taken with you when you leave the lab.

6. Insure your trainer and the area around it are clean before you leave the lab.

7. Properly store and sign in your multimeter before you leave the lab.

8. Check with the lab instructor before you leave the lab.

Note: Did you leave your multimeter set on OHM's? If you have to go back and change it.

PROGRAMMED TEXT
3ABR42331-PT-122

Technical Training

Aircraft Environmental Systems Mechanic

TEMPERATURE CONTROLLING BRIDGE CIRCUITS

10 April 1981

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

RGL: 10.6

OBJECTIVES

Using Kirchhoff's Current, Voltage and Ohm's Laws, solve for unknowns in temperature controlling bridge circuits. A minimum of 8 out of 10 unknowns must be correct.

INSTRUCTIONS

This programmed text presents information in small steps called "frames." After each step you are asked to respond to the information in some way. Do not mark in this text. Read the material and make your response on the response sheet as directed by the frame. After you have made your response, compare your answers with the correct answers on the following page or next even numbered page. If you find you are incorrect, reread the frame to get the correct information. If you are right, and you understand the information presented in that frame, proceed to the next.

Remember, you are not graded on how fast you go. Do not rush, but do not loaf. You will be required to take a test at the end of this text to determine what you have learned. Since your learning in every frame usually depends on what you have learned in the pre-ceding frame, DO NOT SKIP ANY FRAME.

Supersedes 3ABR42331-PT-122, 8 May 1980.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 1000; DAV - 1

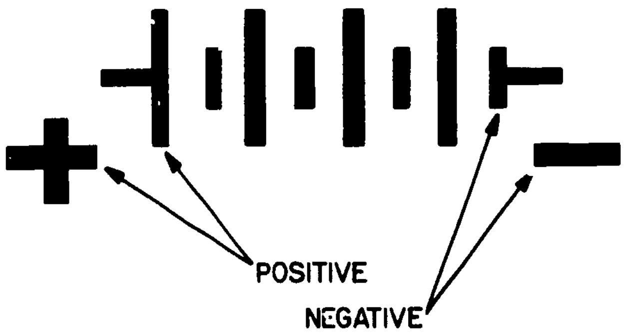
You are going to learn a circuit that is used extensively in aircraft environmental systems. It is called the automatic temperature control circuit. That's right--AUTOMATIC. It can actually decide the correct thing to do. Of course, we "program" its activity so it will make the right decisions.

If the pilot or a crew member wants to change the temperature in the cabin, he will simply turn a control knob. The system will automatically adjust to the temperature he selects. This system operates much like the heating and air conditioning system in your home. You simply set a thermostat to the temperature. Your furnace or air conditioner automatically maintains the temperature you select.

Do you recall the symbol for a battery? We thought it best if we presented the battery symbols again to refresh your memory.

A battery symbol is shown at the bottom of the page. Notice the symbol has long lines and short lines. The long lines indicate the POSITIVE terminals. The short lines indicate the NEGATIVE terminals of the battery.

Of course, the (+) sign indicates POSITIVE whi' the (-) sign indicates NEGATIVE



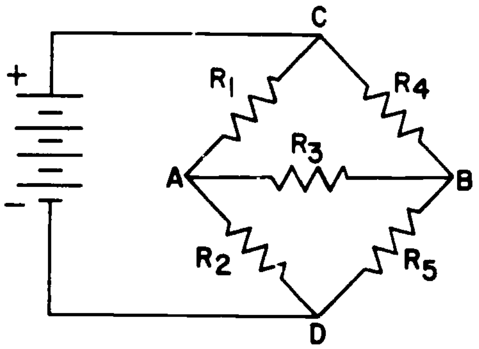
NO RESPONSE REQUIRED

CORRECT RESPONSES TO FRAME 1: No response required.

Frame 2

The circuit that you will be working with is called a DC bridge circuit. This "bridge" is used to automatically control the temperature in the aircraft. You must know the basic structure of the circuit to learn how it automatically controls the temperature. Notice, the circuit has five separate resistors and a source of EMF (voltage). Notice that between points A and B the circuit shows resistor R-3. This resistor bridges across the parallel circuit making it a bridge circuit.

The circuit operates on the principle of a voltage potential between different points of the circuit, A and B. Notice, at point C the circuit parallels into two branches. The left branch is made up of resistors R-1 and R-2. The right branch is made up of resistors R-4 and R-5. The parallel circuits become a bridge only when connected together by resistor R3.

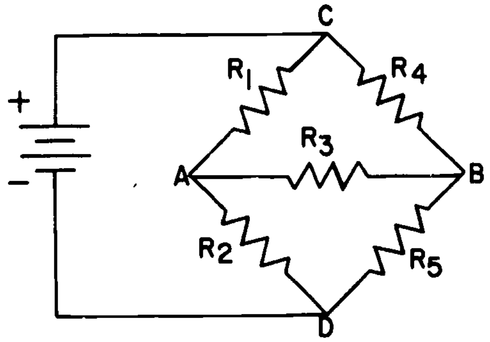


Complete the statements. Write your response on the response sheet.

1. The bridge circuit operates on the principle of a __________ of voltage between different points in the circuit.

2. The resistor that bridges the two parallel branches is resistor ______________.

For a current to flow, a difference of voltage potential must exist between two points. If point A has a higher potential than B, current will flow across resistor R3. Also, if B is higher than A, current will flow across resistor R3.



It is necessary to know operation of a bridge to understand aircraft temperature control. You must know the structure of the circuit and the function of its components. Also, how each part of the circuit affects operation of the bridge. The following frames will go through computation of bridge voltages.

Answer the statement true (T) or false (F) on the response sheet.

Current can flow either from points A to B or from points B to A.

CORRECT RESPONSES TO FRAME 2: 1. potential or balance 2. R-3

CORRECT RESPONSES TO FRAME 3: True

Frame 4

Refer to page 49. Locate the diamond shaped diagram; it looks similar to the circuit shown in frame 3. Locate the points of the diamond, A, B, C, and D. If a difference in voltage potential exists between points A and B, there will be a current flow across the coil between these two points. This will energize the temperature control valve. It will then operate in one direction or the other.

For example, assume that the voltages are unequal and current flows from point A to point B. As current flows across the coil (located between A and B) the coil becomes magnetized. The right hand end becomes the north pole. This pushes the contact down on the right side. The close side of the temperature control valve is energized. As a result, this valve closes farther and allows more cold air to enter the cockpit.

Assume that current flows across the bridge from point B to point A. In this case, the coil becomes magnetized in the opposite direction. The left side of the contact is pushed down. The open side of the temperature control valve is energized. This allows more hot air to enter the cockpit.

Complete the statements. Write your responses on the response sheet.

1. If voltages between points A and B are equal there will be ______________ across the bridge coil.

2. The temperature control valve is controlled by the __________ circuit.

3. If the voltages are unequal between points A and B, there will be ____________________ across the bridge.

The rest of the text describes the circuit function. To understand how the bridge operates you must compute voltages in series and parallel circuits. You must know how each point of the circuit relates to all other points. How to combine and compute series-parallel circuit voltages. Be able to determine how an unbalanced or balanced condition occurs.

Foldout #1 shows a bridge circuit controlling a temperature control valve. The valve gives either hot or cold air. The purpose of the bridge is to automatically control this valve. The valve, in turn, controls the aircraft temperature.

NO RESPONSE REQUIRED

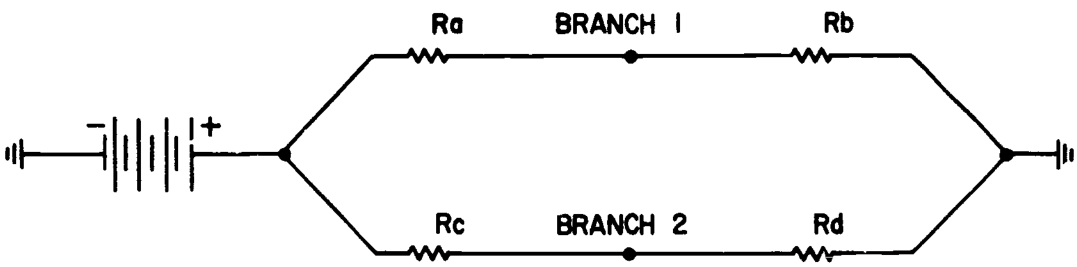
CORRECT RESPONSE TO FRAME 4: 1. no current 2. bridge

3. current flow.

CORRECT RESPONSE TO FRAME 5: No response required.

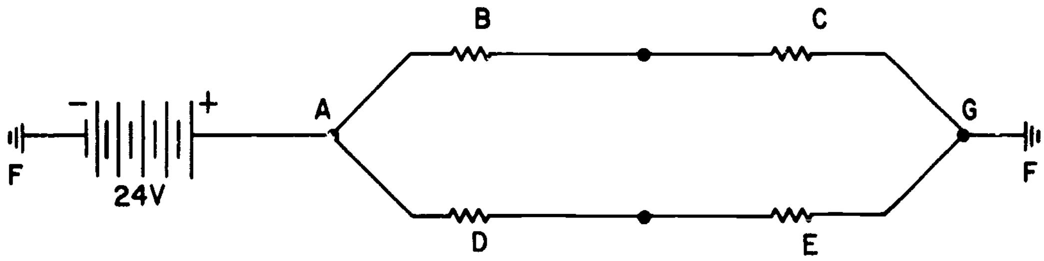
Frame 6

Previously, you studied series and parallel circuits. You observed the effects of current, voltage and amperage in these circuits. Before you can use these values you must determine which is a series or parallel circuit.



In the illustration above notice that resistors Ra and Rb are in series with each other. Resistors Rc and Rd are also in series with each other. Note that Ra and Rb make up Branch #1. Rc and Rd make up Branch #2. Notice that Branch #1 and Branch #2 are in parallel with each other.

Study the illustration below and answer the questions which follow.



Write the correct answers on the response sheet.

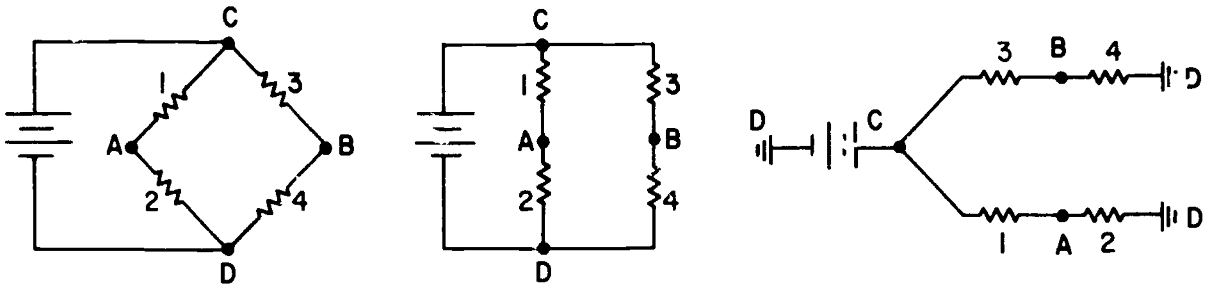
1. Points F are common (resistors) (grounds).

2. Resistors B and C are in (series) (parallel) with each other.

3. Resistors B and C are in (series) (parallel) with D and E.

4. Resistors D and E are in (series) (parallel) with each other.

Resistors are placed in a circuit in many different ways. When they have certain things in common, they form a series-parallel circuit. Illustrations A, B, and C are a few circuit arrangements.



A B C

We have assigned numbers and letters to different points in the circuits. This will assist you in locating the points being discussed. The reference points must be known before the circuit can be analyzed and computed. Use illustrations A, B, and C to answer the statements on your response sheet.

1. Point C is located between resistors (1-3) (2-4) and is connected to the (+) (-) battery terminal.

2. Point D is located between resistors (1-3) (2-4) and is connected to the (+) (-) battery terminal.

3. The most positive point in these circuits is point (A) (B) (C) (D).

4. The most negative point in these circuits is point (A) (B) (C) (D).

CORRECT RESPONSES TO FRAME 6: 1. grounds 2. series 3. parallel 4. series.

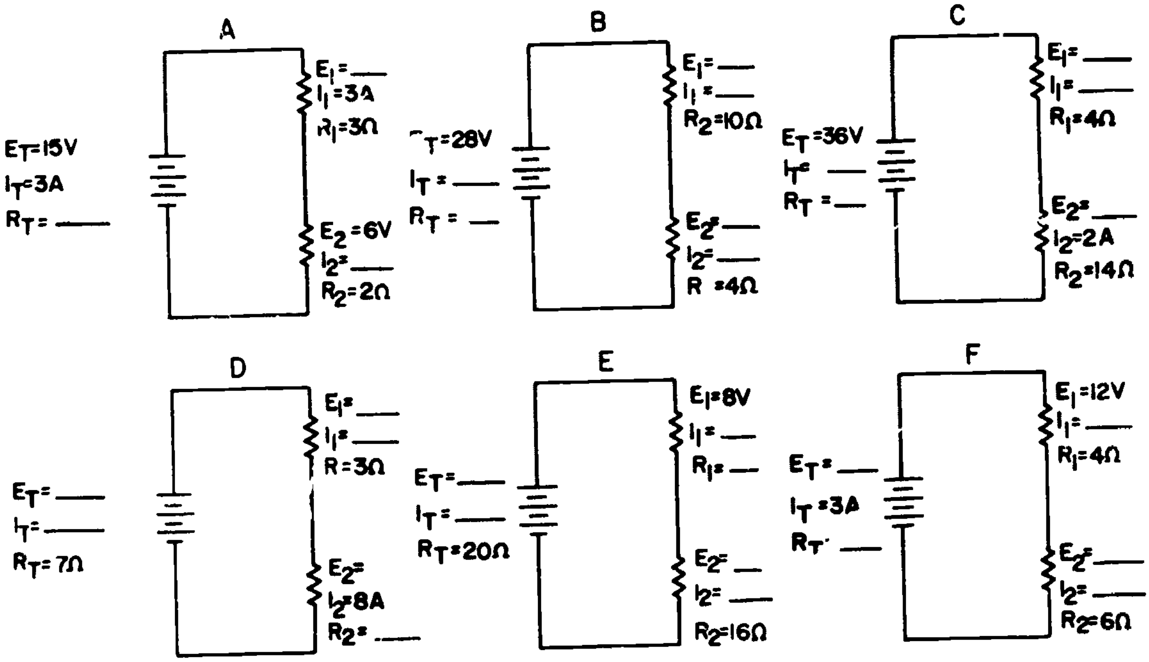
CORRECT RESPONSES TO FRAME 7: 1. (1-3) (+) 2. (2-4) (-) 3. (C) 4. (D)

Frame 8

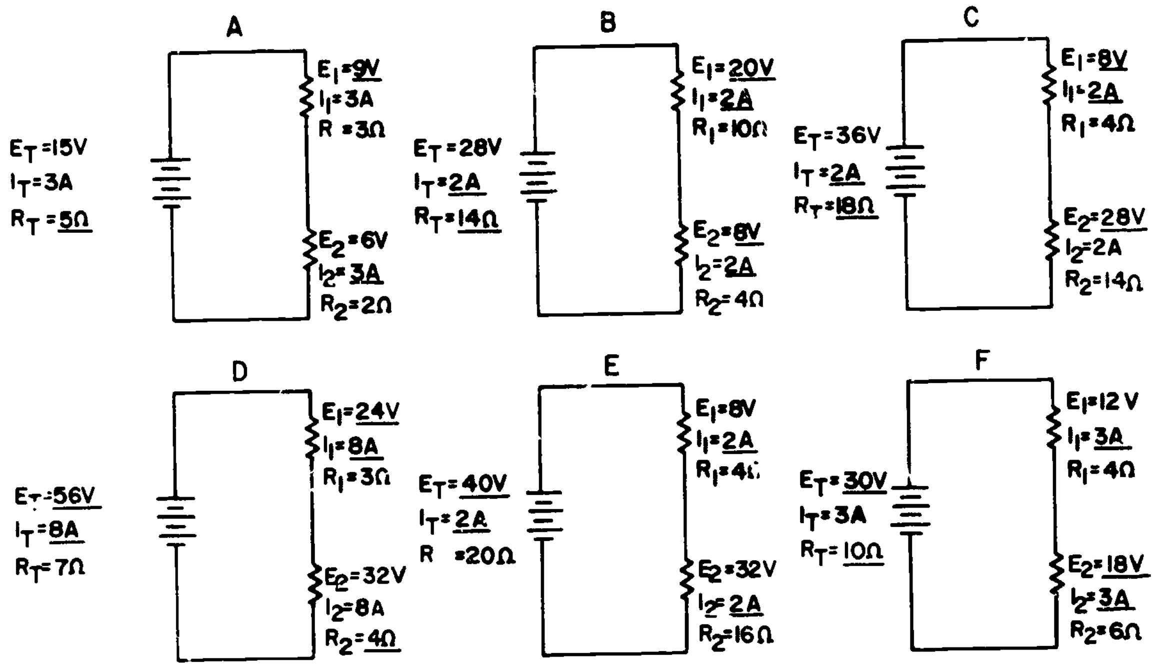
At this point let's have a quick review. Remember the rules for finding the totals of E, I, and R in a series circuit?

E_t = sum of voltages, I_t = same, and R_t = sum of all resistors in the circuits.

Apply Ohm's laws to solve the following series circuit problems. If you feel you need a review, refer to the text on series circuits, Kirchhoff's Current Law, Kirchhoff's Voltage Law and Ohm's Law as necessary. Use your response sheet to record your answers.

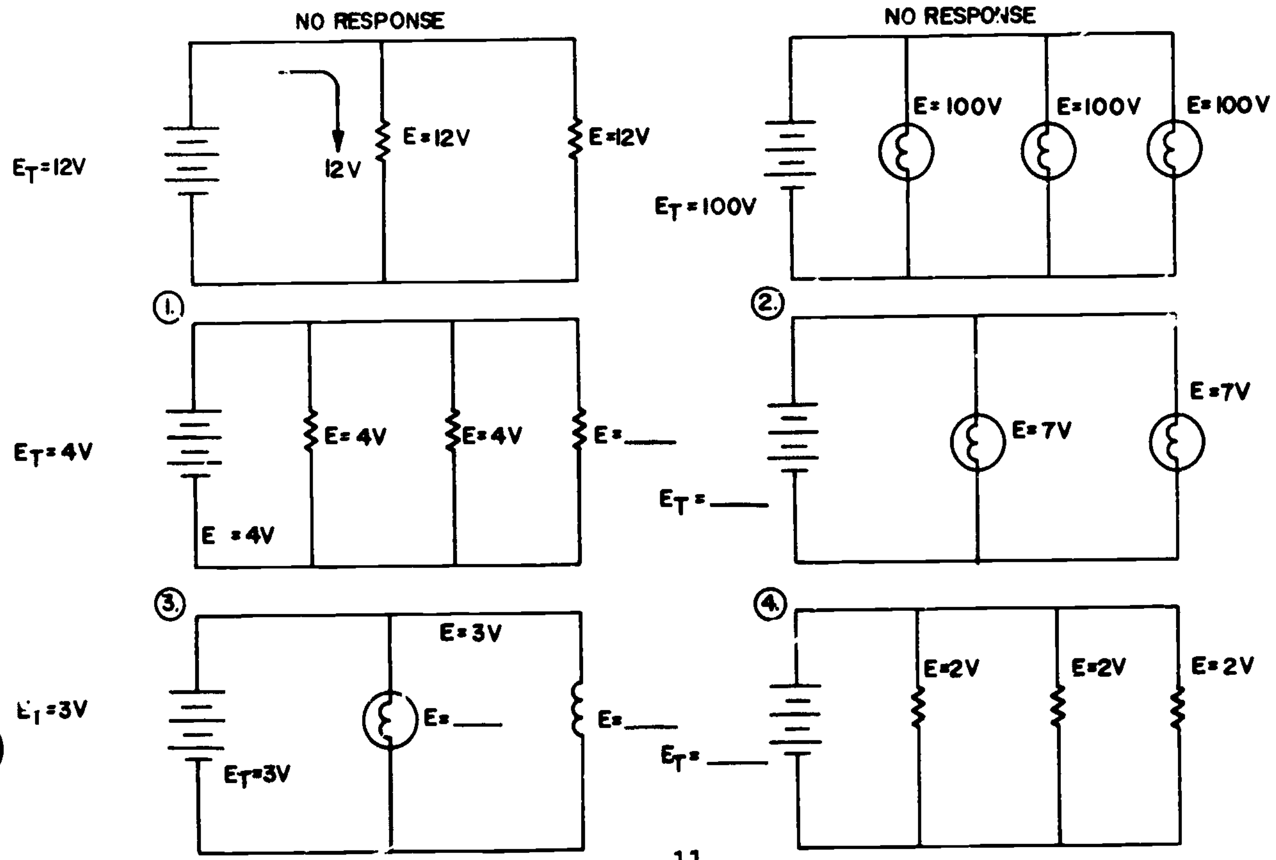


CORRECT RESPONSES TO FRAME 8:



Frame 9

When computing series-parallel circuit problems, the main application of Ohm's law you will be dealing with is voltage. Let's review the effect of voltage in a parallel circuit. In a parallel circuit voltage pushes with equal pressure across all branches. Or voltage has the same value in each branch of a parallel circuit. Solve the parallel circuit problems. Notice what happens to voltage.

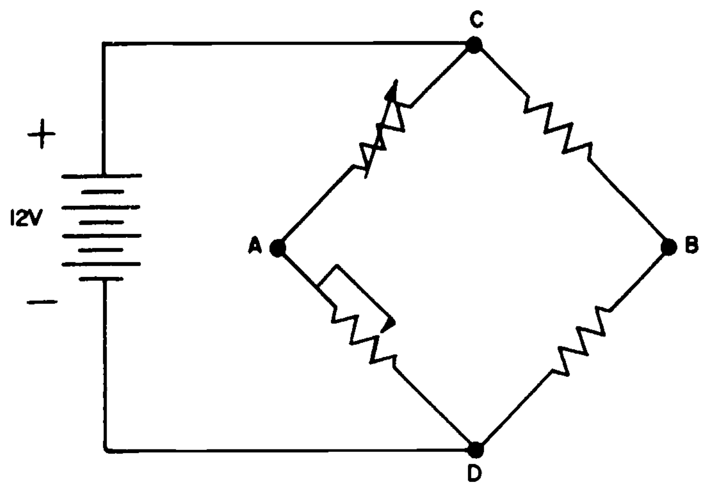


CORRECT RESPONSES TO FRAME 9: 1. $F = \underline{4v}$ 2. $E_t = \underline{7v}$ 3. $E = \underline{3v}$

4. $E_t = \underline{2v}$.

Frame 10

In a parallel circuit, remember that E_t = same, I_t = sum, and R_t = less than the least. In the figure below you will notice there is a 12 volt potential. This potential is at the positive (+) post of the battery. Also, 12 volts are impressed at point C of the circuit. Note, from the battery to point C there is only one path for voltage. Starting at point C you have two paths for voltage. The first path is from point C to point B to point D. One of the easiest ways to trace a voltage path is from the positive terminal of a power source to the negative point in a given circuit.



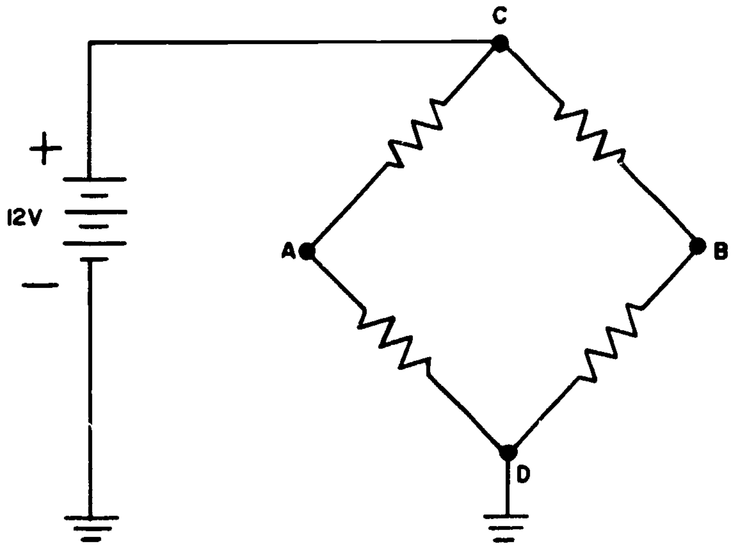
Write the correct answer for the statements below on the response sheet.

1. The easiest way to trace a voltage path in a circuit is from (negative to positive) (positive to negative).

2. Voltage drop (is the same) (differs) across all branches of a parallel circuit.

3. In the circuit above, there are 12 volts impressed at point (A) (B) (C) (D).

The circuit below is a series-parallel circuit. Study it closely. Remember that between points C and D the circuit divides into two series branches. When you see the two circuits, go on to Frame 12.



No Response Required

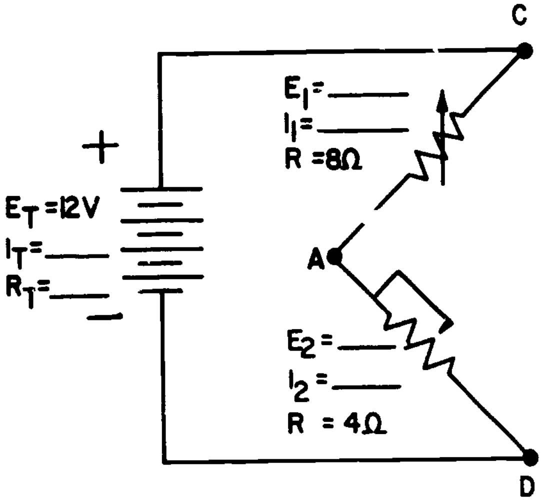
CORRECT RESPONSES TO FRAME 10: 1. positive to negative 2. is the same

3. c.

CORRECT RESPONSE TO FRAME 11: No response required.

Frame 12

To aid in computing the voltages and currents in a series-parallel circuit use a mask to cover the right side of the circuit. It would then appear as shown in the circuit below. You are now dealing with a series circuit. The circuit has two resistors in series with each other. Study the reading of the battery. The voltage total for the circuit is $E_t = 12$ volts.



Write your answers on the response sheet.

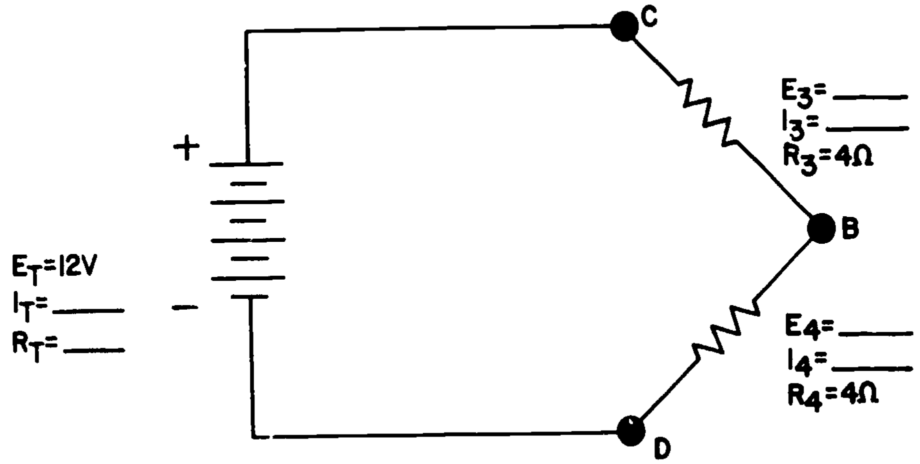
Look at resistors R_1 and R_2; you have been given the value of each resistor. If you add them together (R_1 and R_2), you can get the total resistance (R_t). Do so now and enter the resistance total on the response sheet.

You now have two complete values (E_t and R_t). Using Ohm's law find the rest of the totals. Use the formula

$$I_t = \frac{E_t}{R_t}.$$

When you have determined the current total (I_t) you have the key to the rest of the circuit. Remember the statement? "Throughout a series circuit, current flow remains the same." Simply stated; when one (1) amp of current flows through the first resistor, the same one (1) amp of current will flow through the rest of the resistors in series. Example: $I_1 = 1A$; $I_2 = 1A$. Find the rest of the values in the circuit.

The next step is to complete the right side of the series-parallel circuit. Follow the same procedures used in the preceding frame Cover the left branch of the circuit. Your circuit should appear as shown. Remember, you are not required to compute this circuit as a parallel circuit. The only computation that you must know of a parallel circuit is that voltage potential is equally applied across each branch of the circuit. From there, the two branches are separated and treated as two separate series circuits.



Write your answer on the response sheet.

Using the information learned so far, compute the right hand side of the circuit. The totals formula (E_t = , I_t = , R_t =) will not be entered on the rest of the circuits. It will be necessary for you to set up your own formulas. When you first look at a circuit from now on, you should automatically set up the formulas.

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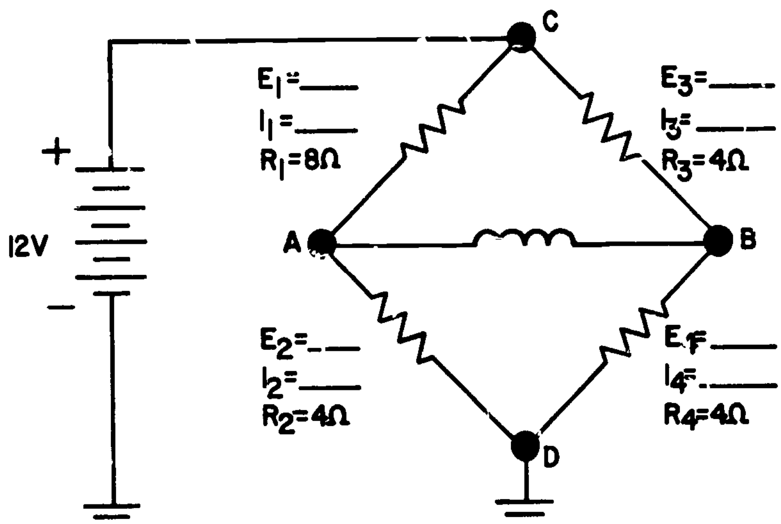
CORRECT RESPONSES TO FRAME 12: E_t = 12v, $I_t = 1_a$, R_t = 12; E_1 = 8v, I_1 = 1a, E_2 = 4v, I_2 = 1a.

CORRECT RESPONSES TO FRAME 13: E_t = 12v, I_t = 1.5a, R_t = 8, E_3 = 6v, I_3 = 1.5a, E_4 = 6v, I_t = 1.5a.

Frame 14

Let's combine what you know about a series and parallel circuit. Refer to the figure. Solve the following problems using Ohm's Law, Kirchhoff's Laws and the principles of series and parallel circuits on your response sheet.

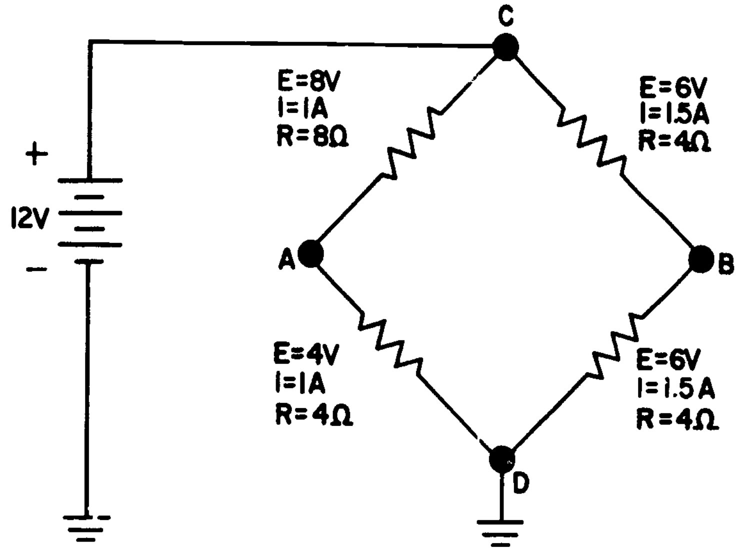
Note: Remember at point C, voltage is equally applied across each circuit. Read the bottom paragraph before computing the bridge.



Remember, from point C you are dealing with two series circuits. Take your mask and cover the right path of the circuit (R_3 and R_4).

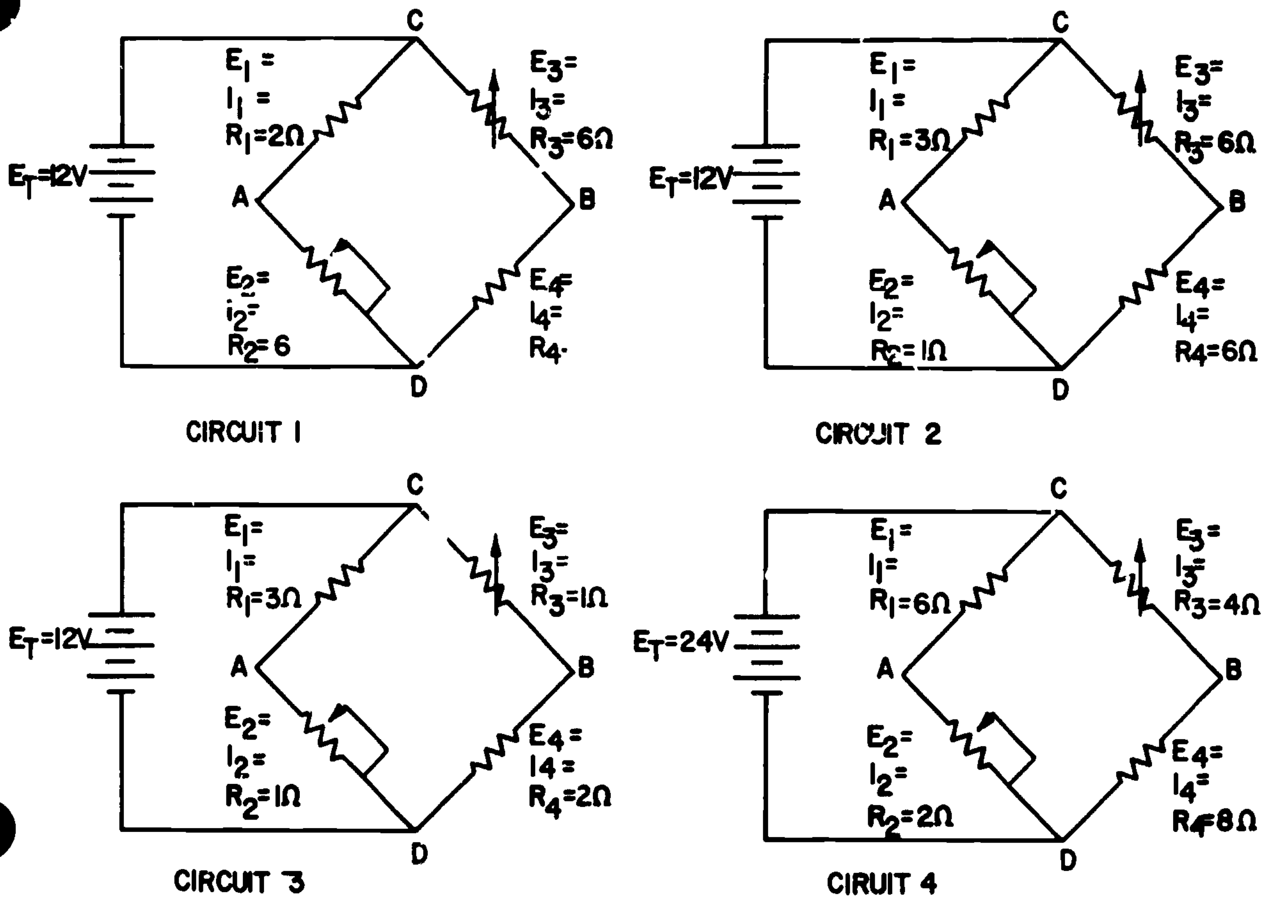
R_1 and R_2 now make up a series circuit. It must be computed as such. After completing the left path of the circuit, cover the left path and compute the right path. You now have resistors R_3 and R_4 in series. The circuit must be treated as such. You <u>do not</u> compute this circuit as a parallel circuit, except for the voltage factor being equally applied across each branch.

CORRECT RESPONSES TO FRAME 14:



Frame 15

To aid you further in computing series-parallel circuits, we have listed four more that you must complete. Using the principles learned thus far, Write your answers on your response sheet.



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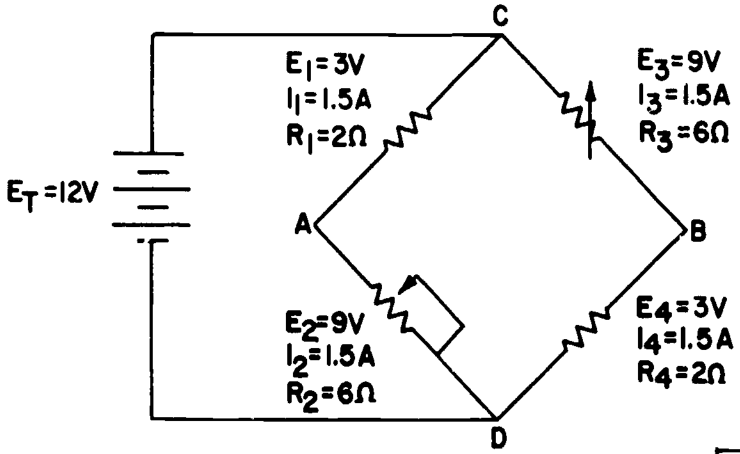
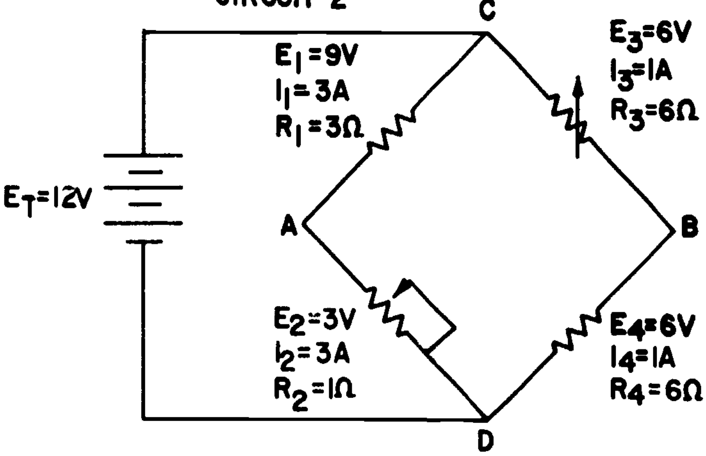
CORRECT RESPONSES TO FRAME 15:

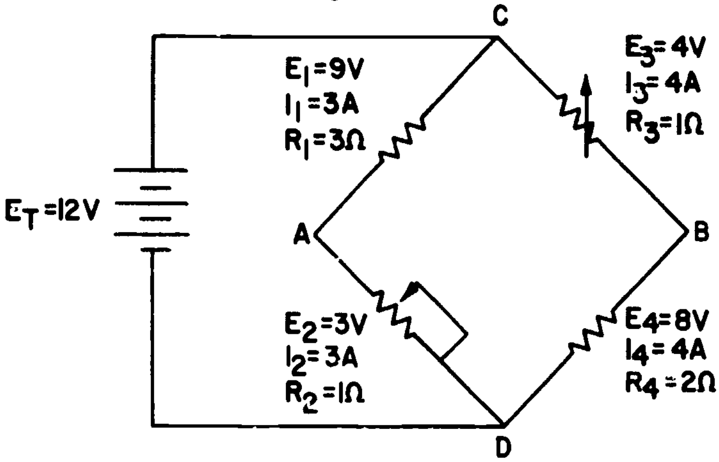
CIRCUIT 1



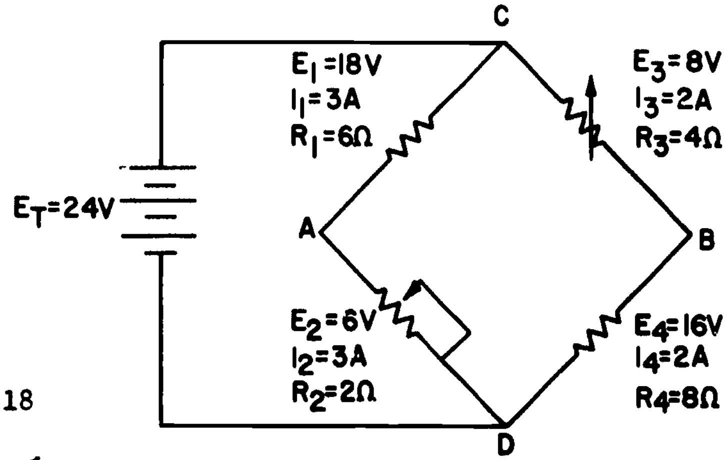
CIRCUIT 2



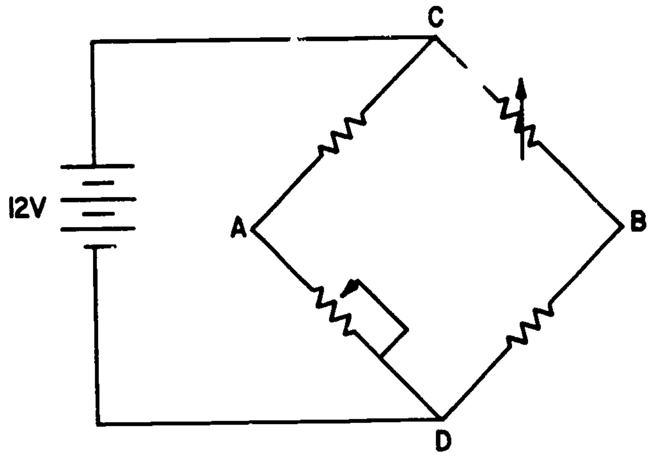
CIRCUIT 3



CIRCUIT 4



The next important step is defining voltage polarities at different points within the circuit. Remember, it was stated that point D is negative. It is connected to the negative terminal of the battery. In fact, point D is the most negative point in the circuit. Simply stated, if point D is most negative, nothing else could be more negative. If any other points are referenced to D they will always have to be positive. Read this information again; it will prove to be a key in determining bridge operation. Referring to the illustration, identify the correct polarity symbol in each statement. Write your answer on the response sheet.



1. C is (+) (-) in respect to point D.

2. D is (+) (-) in respect to point C.

3. B is (+) (-) in respect to point D.

4. A is (+) (-) in respect to point D.

5. D is the most (+) (-) point of the circuit.

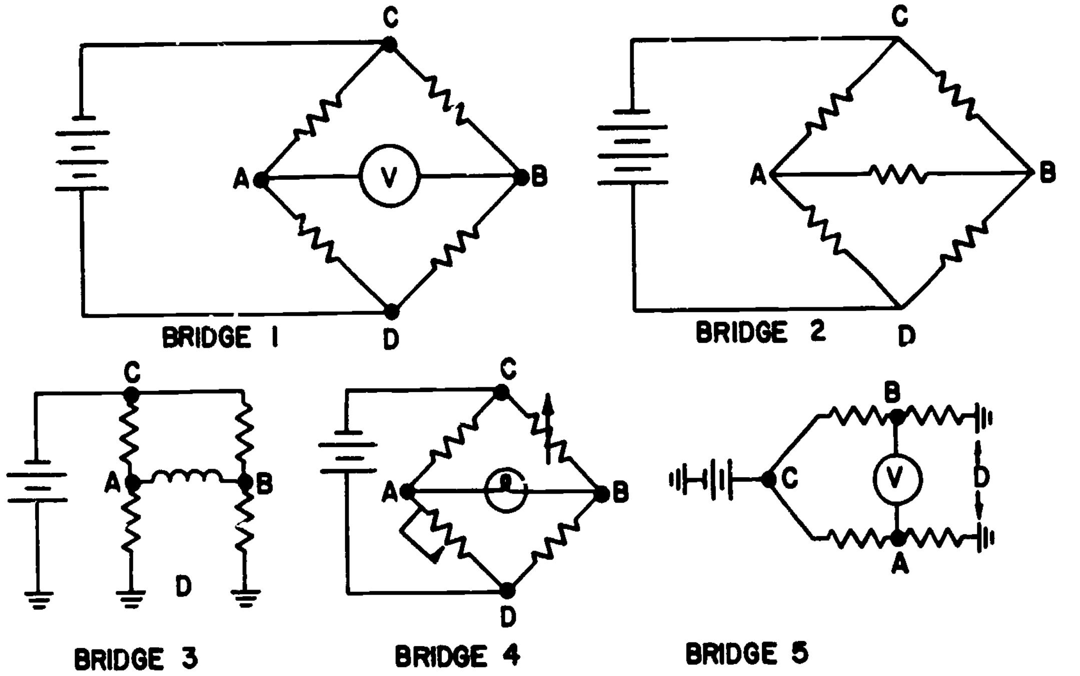
6. C is the most (+) (-) point of the circuit.

CORRECT RESPONSES TO FRAME 16: 1. <u>(+)</u> 2. <u>(-)</u> 3. <u>(+)</u> 4. <u>(+)</u> 5. <u>(-)</u>

6. <u>(+).</u>

Frame 17

Up to this point you have been dealing with series-parallel circuits. This type of circuit is necessary for a "bridge" circuit. What is a <u>bridge?</u> It is something that allows us to get from one point to another. An example is the Golden Gate Bridge. It allows you to get from one side of the Bay to the other without going around. Our bridge works on the same principle. We are going to <u>bridge</u> our circuits between points A and B. Below are some possible arrangements of <u>bridge</u> circuits. Notice, the paths that have been provided for current to flow from A to B or from B to A.



Did you notice that in bridge 1 we used a voltmeter, bridge 2, a resistor, bridge 3, a coil, bridge 4, a light bulb, and bridge 5, a voltmeter? Remember, to make a bridge, you can use various types of <u>bridging</u> devices.

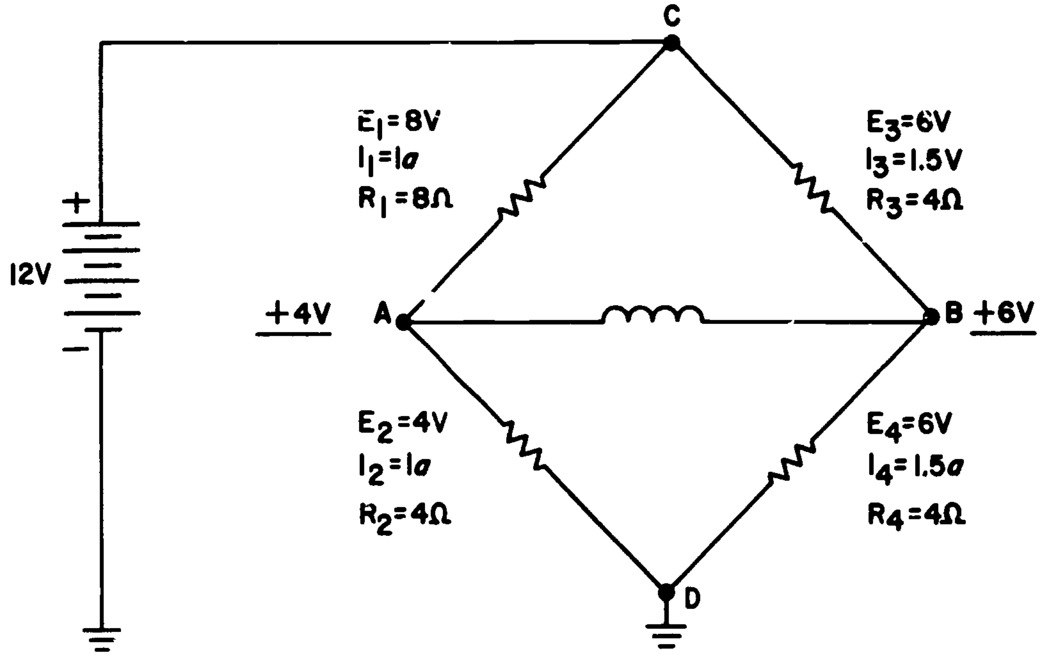
No Response Required

You have learned that voltage was "used up" in a circuit by pushing current through a resistance. Another term for the "using up" of voltage by a circuit is "voltage drop." Voltage drops in a series circuit are in proportion to the different resistances in the circuit. The total voltage drop is equal to the sum of the voltages. Voltage drop is determined by the resistance of the circuit.

In the circuit below, notice that resistor R_1 indicates 8 volts. What this means is, of the 12 volts available at point C, 8 volts are being used. The 8 volts will push 1 amp of current flow through this resistor. You have 4 volts remaining.

From resistor R_1 there is a wire to the top of resistor R_2. This wire offers very little resistance to current or voltage. The remaining 4 volts will not be used on this wire. The 4 volts will be used through resistor R_2.

It should be obvious at this point that no voltage is coming out of resistor R_2. The voltage difference between C and D is 12 volts. All the voltage is used by the circuit to push current through both resistors. A voltage reading to ground at point D is zero volts.



Using point D as reference in the diagram above, complete the following statements by writing your answer on the response sheet.

1. Voltage potential at point C is ____________ volts (+) (-).

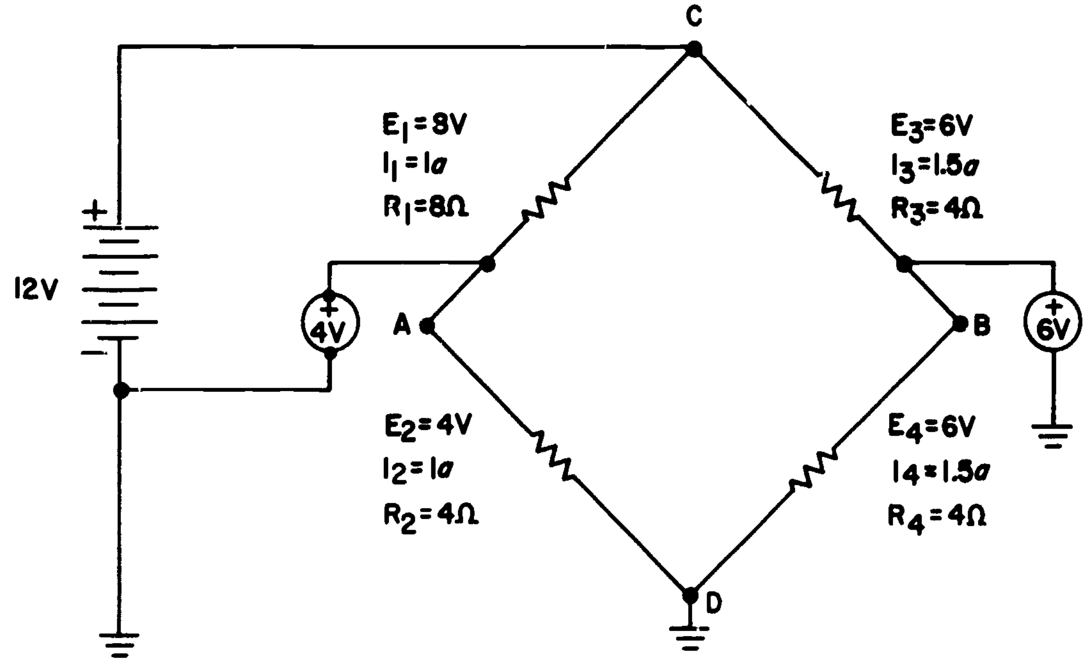
2. Voltage potential at point D is ____________ volts (+) (-).

3. Voltage potential at point B is ____________ volts (+) (-).

CORRECT RESPONSES TO FRAME 18: 1. 12v+, 2. 0v, 3. 6v+

Frame 19

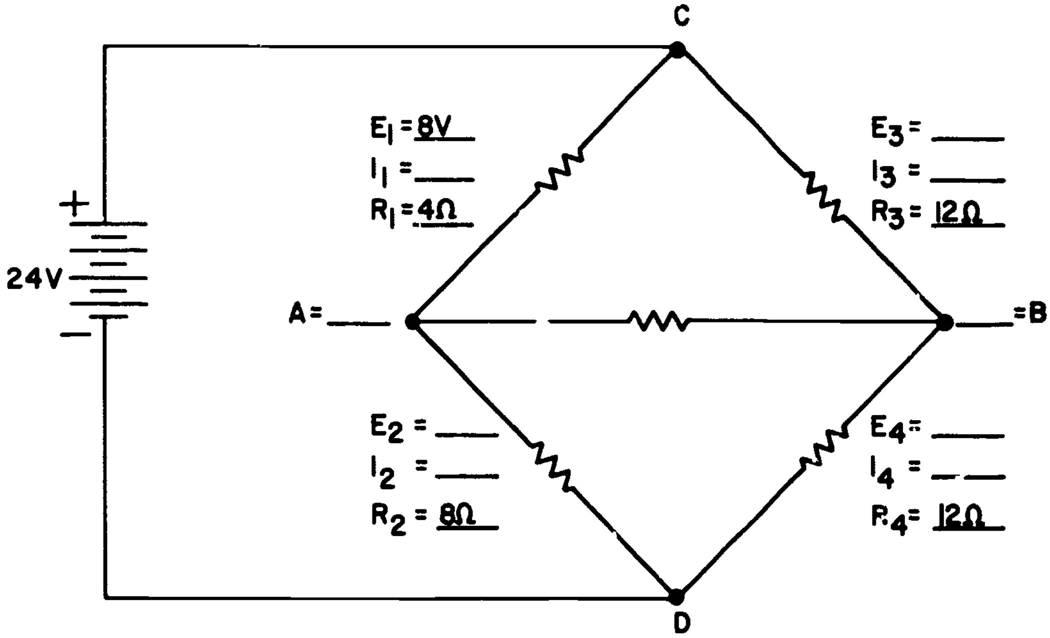
A bridge circuit has two legs; points CAD and points CBD. Look at the right leg (CBD) of the bridge circuit. It takes 6 volts (V) of the 12V potential at point C, to cause 1.5 amps to flow through R_3 to R_4. The remaining 6V can be found at any point on the wire between R_3 and R_4. Notice how the voltmeter is connected around point B. The voltmeter would indicate a + 6V potential at point B. Remember, current flows from positive (+) point C to negative (-) point D. The remaining 6V pushes the 1.5 amps through R_4. The potential of 12V at point C is used to force 1.5 amps through R_3 and R_4. The voltage potential at point D is zero. Another thing to consider; the voltage value of point B is -6V in relation to point C, and +6V in relation to point D. This is also true for the left leg (CAD) of the bridge circuit. Point A has a -8V in relation to Point C and + 4V in relation to point D. Point D is ground (-) and has a voltage relation of - 0V to point C. The voltage potential at point C is + 12V.



Complete the statements by writing your answer on the response sheet.

1. The voltage at point C is ________________.
2. The voltage drop across R_1 is ______________.
3. The voltage drop across R_2 is ______________.
4. The voltage drop across R_3 is ______________.
5. The voltage drop across R_4 is ______________.
6. The voltage drop across CAD is ____________.
7. The voltage drop across CBD is ____________.
8. The voltage at point D is ________________.

Solve for the missing value in the bridge circuit below and answer the questions which follow. Use point D as a reference point. Determine the voltages and polarities at points A and B. Write your answers on the response sheet.



Complete the statements.

1. I_1 and I_2 = ________________ amps.

2. Voltage at point A is ______________ volts and is (+) (-).

3. Point B is ______________ volts and is (+) (-).

4. Point __________ is the reference point of the bridge and all points in reference to it are (+) (-).

5. The difference between voltages at point A and B is ______ volts.

6. Point D should indicate a ______________ voltage reading on a voltmeter.

CORRECT RESPONSES TO FRAME 19: 1. 12v, 2. 8v, 3. 4v, 4. 6v, 5. 6v, 6. 12v, 7. 12v, 8. 0v

CORRECT RESPONSES TO FRAME 20: 1. 2 amps, 2. 16v (+), 3. 12v (+), 4. D (+), 5. 4v, 6. Zero (0).

Frame 21

Did you notice the difference between points A and B? You saw that point A was 16 volts positive and point B was 12 volts positive. There is 4 volts difference between the two voltages (16 - 12 = 4). The difference between the two voltages (points A and B) means that the circuit is unbalanced. If you have a difference between two voltages, current will flow if a path is provided. We have established a path between points A and B. Now we have to determine which way the current will flow.

To determine which way current will flow is a simple process. Both voltages are positive in respect to D. One is less positive than the other in respect to D. Study the scale below then read the paragraph.

(POSITIVE LINE IN REFERENCE TO D)

VOLTAGE LINE: 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

POINT D MOST NEGATIVE — POINT B — POINT A — MOST POSITIVE

Voltage Scale

Remember, point D is most negative. It is considered ground and therefore it has zero voltage. The two voltages obtained from frame 20 are (B = 12 volts and A = 16 volts) on the scale. It is apparent that 12 is closer to zero than is 16. Point B is more negative than point A. Furthermore, we know that current flows from a negative to a more positive point; hence, current flows across the bridge from point B to point A.

No Response Required

Frame 22

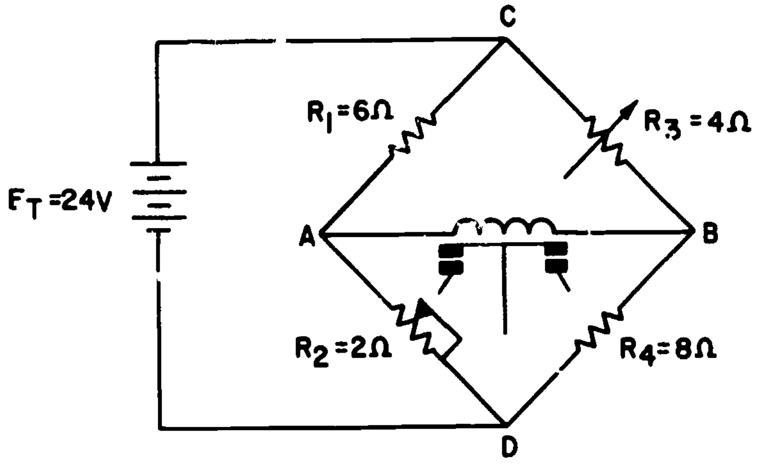


Figure 1.

Refer to figure 1, and answer the following questions on the response sheet.

1. What is the potential at point B in reference to point D? ______ volts (+) (-).

2. What is the potential at point A in reference to point D? ______ volts (+) (-).

3. What is the voltage drop between points A and B? ______ volts.

4. Current will flow across the coil fr point ___ to point ___.

5. Which of the two following circuits has the smallest total resistance to current flow? DABC or DBAC?

6. Which of the two following routes will the current flow take: DABC or DBAC?

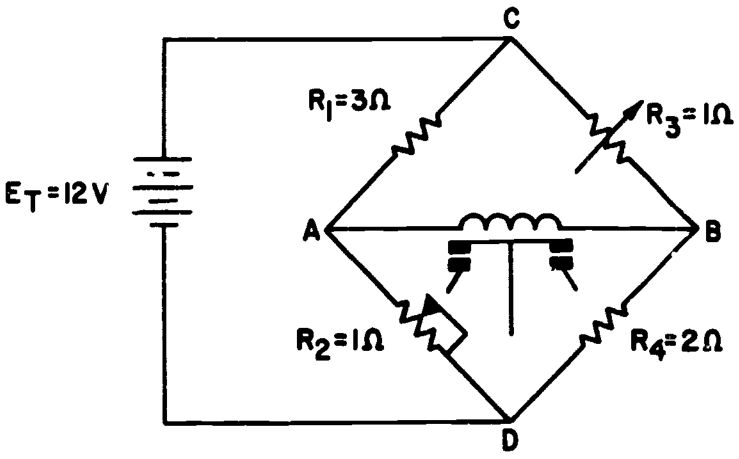


Figure 2.

Refer to figure 2, and answer the following questions on the response sheet.

1. What is the voltage potential at point A in respect to point D?

______ volts (+) (-).

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2. What is the voltage drop across R_2? _______ volts.

3. The voltage potential at point B in respect to D is _____ volts (+) (-).

4. Which way will current flow across the bridge? From ___________ to ___________.

5. Which of the two following circuits has the smallest total resistance to current flow: DABC or DBAC?

6. Which of the two following routes will the current flow take: DABC or DBAC?

CORRECT RESPONSE TO FRAME 21: No Response Required.

CORRECT RESPONSES TO FRAME 22: Figure 1: 1. 16v+, 2. 6v+, 3. 10v, 4. A to B, 5. DABC, 6. DABC

Figure 2: 1. 3v+, 2. 3v, 3. 8v+, 4. A to B, 5. DABC, 6. DABC.

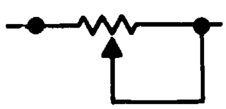
Frame 23

By modifying the AC bridge, it can be used to control aircraft temperatures automatically. Components used in the bridge are listed in the following frames. Fixed resistors have values which do not change. The fixed resistor is used in the bridge circuit to provide a constant resistance value. It can be identified in the schematic by the symbol shown below.

We may desire to adjust the resistance values in a circuit to allow for certain variations or to permit calibration. In this case we would use an ADJUSTABLE resistor. Its symbol is shown here.

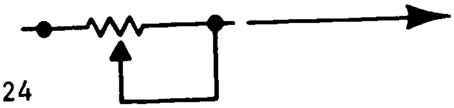
Select the adjustable resistor from the electrical display box. Obtain a display box from your instructor. Notice how the wire is wound around the ceramic cylinder and how the wiper contact is moved. Adjustment is accomplished by a specialist using a screwdriver to loosen a small screw. The contact is moved along until it is closer to the end that offers the right amount of resistance. The screw is then retightened.

Identify the symbol in Column A with its name in Column B on the response sheet.

COLUMN A		COLUMN B
1.		fixed resistor
2.		adjustable resistor

CORRECT RESPONSES TO FRAME 23:

1.  fixed resistor

2.  adjustable resistor

Frame 24

A rheostat is a resistor that has a moveable contact (wiper arm). Moving the contact changes its resistance. The contact is connected to a shaft that is turned by a knob (like the volume control on a radio).

The rheostat is in the bridge circuit to change the resistance on one side of the bridge. This automatically unbalances the circuit.

The pilot manually changes the resistance in the bridge circuit by rotating the rheostat knob. Shown below is the electrical symbol and a picture of the back side of a rheostat. Look in the electrical display box. Note how the resistance may be changed on the rheostat.

Draw its electrical symbol for each component on the response sheet.

1. ______________________________ Adjustable Resistor.

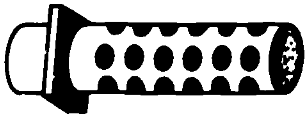
2. ______________________________ Fixed Resistor.

3. ______________________________ Rheostat.

CORRECT RESPONSES TO FRAME 24:

Frame 25

The component that "senses" the temperature of the air is called a temperature sensor. See the illustration below. Find the sensor in the electrical display box. This is one of the more common types in use.



This temperature sensor is a specially designed resistor. Its resistance changes any time the temperature of the air around it changes. The manner in which it changes resistance depends on its "temperature coefficient." That is: if the TEMPERATURE of the air across it increases and the RESISTANCE of the sensor also increases, the sensor has a POSITIVE TEMPERATURE COEFFICIENT OF RESISTANCE. It follows then that with a POSITIVE COEFFICIENT the resistance will decrease if the temperature of the air decreases. The point is, they increase together and decrease together. On the other hand, if the TEMPERATURE increases and the sensor's RESISTANCE decreases at the same time, it has a Negative Coefficient. This also means the sensor's resistance will increase as the temperature decreases. Below is a standard symbol for a sensor. Locate and identify the different types of sensors in the electrical display box.

Complete the statements by using the word increases or decreases on the response sheet.

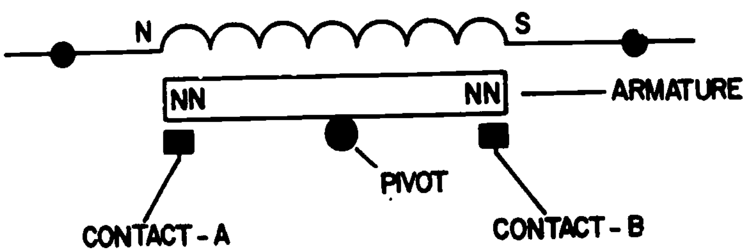
POSITIVE COEFFICIENT	NEGATIVE COEFFICIENT
1. If temperature increases, the resistance ____________.	3. If temperature increases, the resistance ____________.
2. If temperature decreases, the resistance ____________.	4. If temperature decreases, the resistance ____________.

CORRECT RESPONSES TO FRAME 25: 1. <u>increases</u>, 2. <u>decreases</u>, 3. <u>decreases</u>, 4. <u>increases</u>.

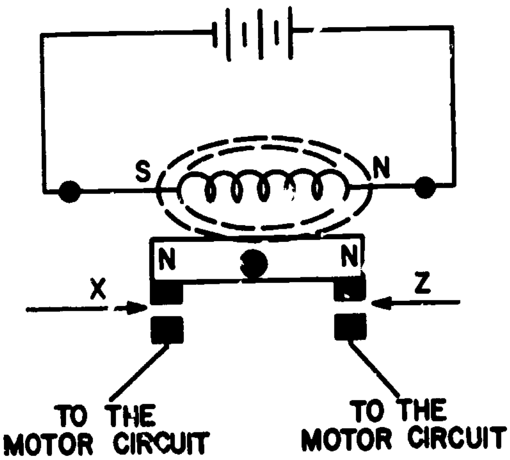
Frame 26

Changing an electrical bridge signal into useful motion, is done by a device called a MICROPOSITIONER. See the picture below. Find the actual component in the display box. Note the contact arrangement.

The micropositioner is a relay that can be tilted like a teeter-totter. It will tilt one way and close one set of contacts, or the opposite way and close a different set of contacts. How it does this can be seen in the simplified explanation that follows.



The armature (see above) of the micropositioner is <u>similar</u> to a magnet that has two <u>north ends</u>. (The south ends being unused.) A coil of wire is running alongside. If current flows through the coil, the coil will have a north and south pole. Remember the Law of Polarity; like poles repel and unlike poles attract. The armature will tilt around the pivot point and close the proper contact depending on the polarity of the coil and of the armature. (See arrows X and Z in the figure below). Since it is actually a relay, it will control a valve motor circuit. Check your understanding of the micropositioner's principle of operation by answering the questions on the response sheet.



1. Like poles (attract) (repel)

2. Unlike poles (attract) (repel)

3. Contact X will (open) (close)

4. Contact Z will (open) (close)

If the battery is reversed;

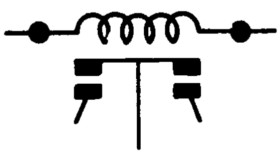
5. Contact X will (open) (close)

6. Contact Z will (open) (close)

CORRECT RESPONSES TO FRAME 26: 1. repel, 2. attract, 3. open, 4. close, 5. close, 6. open

Frame 27

Reversing the direction of current flow through the coil changes the coil's magnetic north and south poles to the opposite ends. The armature tilts to the opposite contact closing a different relay. You will recognize the micropositioner in a diagram by the symbol below. The micropositioner provides a path for current to flow if the bridge is unbalanced.



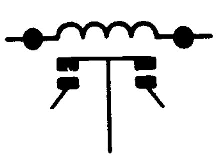
Identify each symbol by drawing them on the response sheet.

1.  ______________________

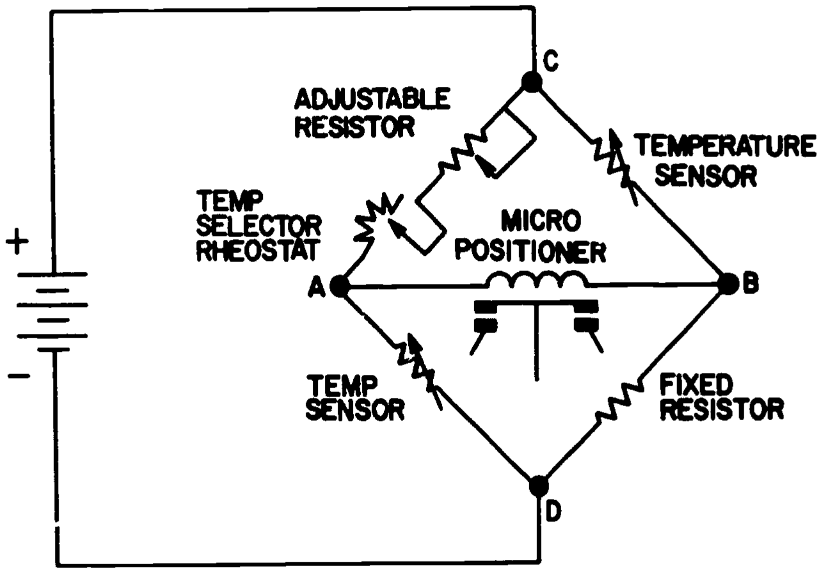
2.  ______________________

3.  ______________________

4.  ______________________

5.  ______________________

The figure below shows all of the components we have mentioned. Now let's go on to learn its operation as a bridge circuit.



You will see that the components are not always found in these positions. All of them may not be used or perhaps, as in some bridges, even more are added. Basically they will however, perform in much the same manner as these. The micropositioner, for instance, may be used in quite another way. We have used it here for one purpose and have already explained its principle of operation in a simplified manner.

No Response Required

CORRECT RESPONSES TO FRAME 27: 1. Fixed Resistor, 2. Rheostat,

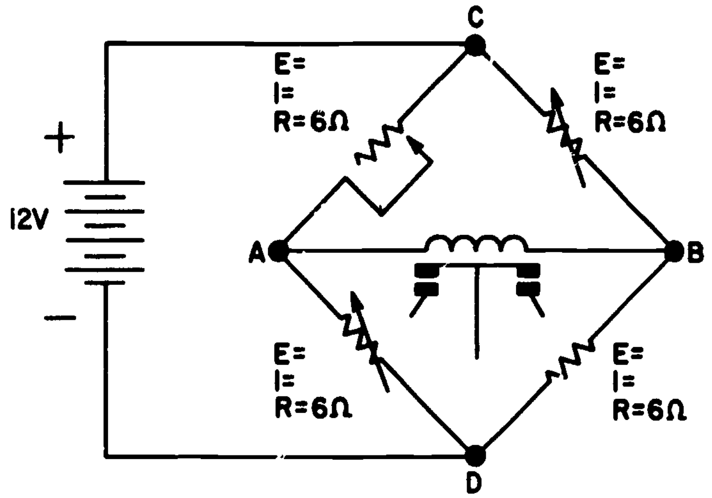
3. Temperature Sensor (or Variable Resistor), 4. Adjustable Resistor,

5. Micropositioner.

CORRECT RESPONSE TO FRAME 28: No Response Required.

Frame 29

Carefully solve the problems in the circuit below. Determine the polarities of points A and B. Use point D as reference.



Complete the following statements on the response sheet.

1. The most negative point in this circuit is (A) (B) (C) (D).

2. The most positive point in this circuit is (A) (B) (C) (D).

3. Point A is ______ volts (+) (-) with respect to point D.

4. Point B is ______ volts (+) (-) with respect to point D.

5. Point A is positive with respect to point B (true) (false).

6. Current will flow from (A to B) (B to A) (neither direction).

7. There is no difference in potential between A and B (true) (false).

8. The bridge is balanced (true) (false).

At this point it is necessary for you to understand the operation of an air conditioning system. Refer to foldout #1. This foldout shows just enough units to permit operation of the system. Air conditioning and completed circuits will be covered in later lessons.

Locate the two engines on the right hand side of the foldout. Remember the text material on Jet Engines? Recall the term engine bleed air? It was stated that the secondary purpose of the compressor section of a jet engine was to provide air for the air conditioning system. Now you will put this knowledge to use.

Locate the arrows coming from both engines. Arrows will indicate the direction of air flow. Follow the arrows from the engines. Notice that the air from both engines combines and enters the hot engine bleed air manifold. The manifold divides into two paths for the air to follow. One path is through the heat exchanger. The other is to the temperature control valve. Let's stop at this point and consider the temperature control valve. This valve has a butterfly-type gate. When open it allows hot engine bleed air to bypass the heat exchanger or closes to prevent bypassing air. Also, it can stop at any point between fully open or fully closed to allow a desired portion of hot air to bypass.

Complete the following sentences on the response sheet.

1. Air which is tapped from the engines is (hot), (warm), (cold).

2. Air is supplied by the ___________ section of a jet engine.

3. The temperature control valve allows a portion of the engine

   bleed air to be __________ around and through the heat exchanger.

CORRECT RESPONSES TO FRAME 29: 1. D, 2. C 3. 6(+), 4. 6(+), 5. false, 6. neither direction, 7. true, 8. true.

CORRECT RESPONSES TO FRAME 30: 1. (hot), 2. compressor, 3. bypassed.

Frame 31

Let's assume the temperature control valve is closed. No hot air is allowed to flow through. All the engine bleed air (EBA) is forced to go through the heat exchanger and cooling turbine. Through the combined action of these two units, the EBA temperature is greatly reduced. As a matter of fact, the air will become very cold. Note that airflow coming from the cooling units will go straight into the cabin through the conditioned air vents. At this stage, we are not controlling air temperature, are we? We are merely making the air very cold.

Answer the statements as true (T) or false (F) on the response sheet.

1. Air flowing through the heat exchanger will get hotter.

2. To get cold air to the cockpit, the temperature control valve is closed.

3. To warm up the cockpit we must open the temperature control valve.

Assume that the temperature control valve is fully opened. Air flow, like many other things, tends to follow the path of least resistance. Rather than going through the heat exchanger and cooling turbine, most of the air flows through the open valve. This hot air goes down to the hot and cold mixing section. Then to the conditioned air outlets into the cockpit. Under this condition the cockpit would get extremely hot. The air has bypassed the cooling units through the open temperature control valve. It would be desirable, then, to have a mixture of <u>hot</u> and <u>cold</u> air. This mixture can be obtained by positioning the temperature control valve in a partially open or closed position. Here is where our bridge circuit and micropositioner come into play. By rotating the temperature selector (rheostat) toward cold, we unbalance the bridge. This tilts the micropositioner. An electrical circuit is completed to close the temperature control valve. The pilot then, will receive the cold air he wants, merely by rotating the rheostat.

Refer to foldout 1; answer the following statements on the response sheet.

1. To get a mixture of hot and cold air, the temp control valve

   should be ______________________________.

2. If the temperature control valve is open, you will receive

   ______________ air in the cockpit.

3. If the temperature control valve is closed, you will receive

   ___________ air in the cockpit.

4. The cooling turbine (cools) (heats) the engine bleed air.

CORRECT RESPONSES TO FRAME 31: 1. F, 2. T, 3. T.

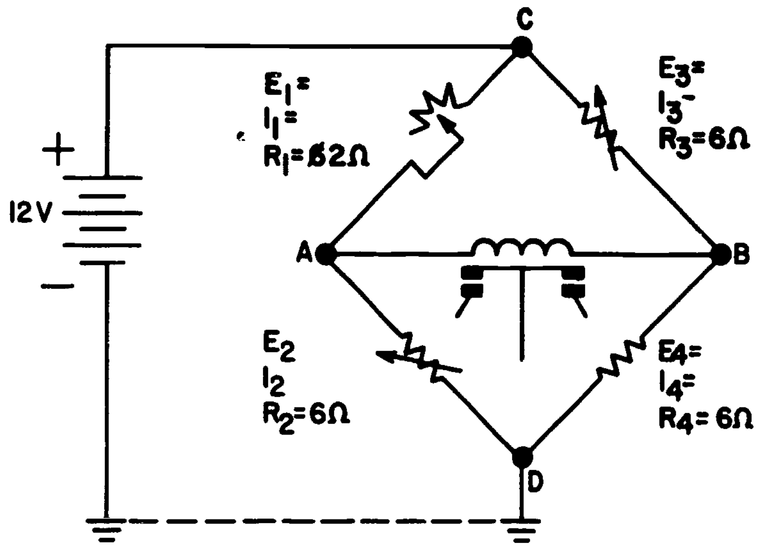
CORRECT RESPONSES TO FRAME 32: 1. partially open or closed. 2. hot

3. cold, 4. cools.

Frame 33

In frame 29 you saw a balanced bridge. Any time the potentials at points A and B are the same, there will be no current flow across the bridge. The coil of the micropositioner will not become magnetized. Therefore, the armature will not tilt either way. Both sets of contacts will stay open.

Refer to the circuit below and foldout 1. Let's see what happens when the temperature selector (rheostat) (R_1) is rotated. As each part is mentioned, locate it on both circuits. Remember that the rheostat is nothing more than a variable resistor. By rotating the rheostat, let us say we have manually decreased the resistance of the rheostat (R_1). You no longer have as much resistance on R_1 as you did in frame 29. As you can see from the circuit below, resistance has been decreased from 6 to 2 ohms. Now you have to recompute the bridge electrical values. After you complete computation, answer the following statements. Remember to use point D as reference.



Write your work on the response sheet.

1. The most negative point of the circuit is (C) (D).
2. Potential at point B is (+) (-) __________ volts.
3. Potential at point A is (+) (-) __________ volts.
4. Which point is most negative? (A) or (B).
5. Which way will current flow across the bridge? (A to B) (B to A).
6. Will the micropositioner tilt in a given direction? (Yes) (No).
7. This bridge circuit is (balanced) (unbalanced).

Refer to foldout 1. Locate resistor R_1 which is the temperature selector (rheostat) (variable resistor). Also locate resistor R_3 which is located in the hot and cold air mixing section. This resistor is a temperature sensing element. The sensing element changes its resistance whenever its temperature changes. Keep these two units in mind as you continue through this lesson.

By changing the resistance of the rheostat R_1 (refer to the figure in frame 33), you unbalanced the bridge circuit. Current flows across the bridge from points B to A. Using the left-hand rule for a coil and D as your reference point, identify the correct responses for the statements on the response sheet.

1. The micropositioner armature (will) (will not) tilt in a given direction.

2. The micropositioner armature (will) (will not) tilt to the (right) (left) (neither direction).

3. The rheostat has its resistance changed (automatically) (manually) (by temperature changes).

4. The temperature sensing elements' resistance is changed (automatically) (manually) (is not changed).

CORRECT RESPONSES TO FRAME 33: 1. D, 2. +6v, 3. 9V, 4. B,

5. B to A, 6. Yes, 7. unbalanced.

CORRECT RESPONSES TO FRAME 34: 1. will, 2. will, left,

3. manually, 4. automatically.

Frame 35

Refer to foldout 1. Locate the micropositioner armature. Assume it has tilted to the left. Locate the wire which carries 24V DC to the micropositioner armature. When the armature is tilted to the left, a circuit is completed. 24 volts is sent to the open side of the valve (electrical motor), running it to the open position. As the valve opens it allows more hot air to go to the mixing section. This increases the temperature in the cockpit area. Here is where the temperature sensing element plays a very important role.

Assume that the temperature sensing element has a negative coefficient. (If temperature goes up, the resistance of the element goes down and vise versa). The temperature increase is felt by the sensor as the air flows over it. As the temperature increases, the sensor resistance starts to decrease.

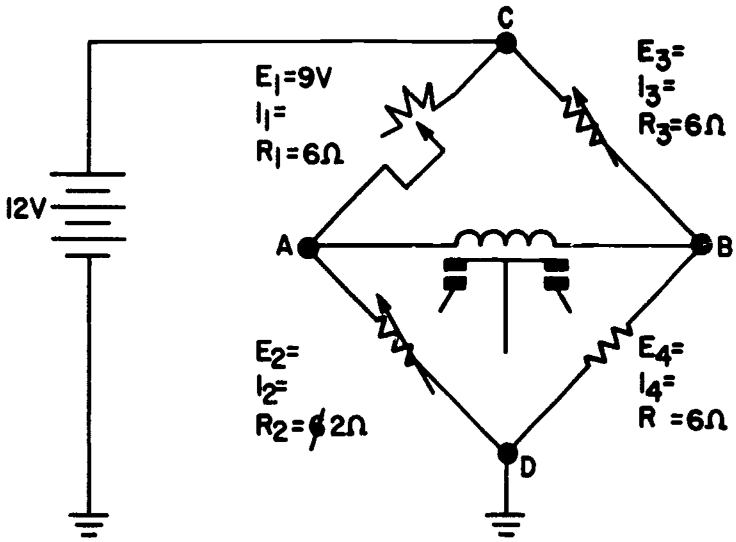
Complete the following statements on your response sheet.

1. The 24V DC applied to the micropositioner armature is the power used to open or close the ______ __________ ________.

2. Current flow from B to A in the bridge would call for ________ air.

3. The temperature control valve is operated by an electric ________.

Refer to the diagram below and foldout 1. Notice that the resistance of R_2 (temperature sensing element) has been decreased from 6 ohms to 2 ohms; this is indicated by the slash mark through the 6. This means that at the start it was 6 ohms (Frame 29) but doe to the rise in temperature, the sensor's resistance has decreased. Recompute the bridge's electrical values. Remember to use point D as your reference.



Complete the following statements on the response sheet.

1. Point A is ______________ volts and is (+) (-).
2. Point B is ______________ volts and is (+) (-).
3. Current will flow (from A to B) (from B to A) (neither direction).
4. The bridge is (balanced) (unbalanced).
5. The micropositioner armature is (tilted to left) (tilted to right) (not tilted).

This means the cabin air is increasing and this hot air flowing over (touching) R_2 in the cabin (refer to foldout 1) is driving the resistance down in R_2. This has lowered the resistance now causing current to flow from A to B the micropositioner will now begin to brake contact on the left side, which is to the open side of the temperature control valve.

CORRECT RESPONSES TO FRAME 35: 1. Temperature control valve

2. hot , 3. motor.

CORRECT RESPONSES TO FRAME 36: 1. 3v, (+) 2. 6v, (+)

3. A to B

4. unbalanced 5. tilted to right

Frame 37

Starting at frame 32, we manually unbalanced the bridge by rotating the temperature selector rheostat. By changing its resistance, we caused current to flow across the bridge from points A to B. This energized a motor circuit to allow a decrease in the temperature of the air entering the cockpit area.

Cooler air begins to flow across the temperature sensing element. The sensors resistance starts to increase. At that point the bridge starts to rebalance. That is, as soon as the sensors resistance again equaled the resistance of the rheostats new setting, current ceased to flow across the bridge.

With no current flowing across the bridge, the micropositioner deenergizes. Current ceases to flow through the motor circuit. When the circuit has balanced and the motor stops running, the system is said to be at its temperature control point.

It must be made clear that at times the temperature sensing element tends to overcorrect itself. Instead of stopping when the voltages are equal (at points A & B) the sensors resistance will continue to decrease or increase after the mixed air temperature has reached the temperature control point. This is due to a slight heat transfer lag between the air and sensor metal. This causes the sensor to be a little late in sending its final "balanced" signal to the bridge. The motor is late in shutting off and overruns. This causes the bridge to unbalance in the opposite direction. The bridge tries to "hunt" for its balanced condition. In other lessons you will study units which are put into the circuit to compensate for this problem. Remember the rheostat and the sensing elements are the units that unbalance and balance the bridge circuit.

Operating changes of the engines or air cooling units frequently change the temperature of the mixed air flowing past the temperature sensing element and into the cabin. When this happens the resistance of the sensor immediately changes, thereby, unbalancing the bridge. The bridge circuit will react to this in the same way as it does when the pilot turns the rheostat knob. Current will flow from A to B or from B to A. This causes the micropositoner to send the proper correction signal to the temperature control valve. This valve, in turn, opens or closes as required to restore the mixed air temperature to the temperature the rheostat is set for.

Complete the following statements on the response sheet.

1. When the bridge is balanced, the system is at its ____________ ____________ ____________.

2. An inaccurate temperature sensor could change the ____________ ____________ ____________.

3. When the bridge is unbalanced, current (will) (will not) flow across the bridge.

4. Whenever the resistance of the sensor differs from the resistance the rheostat is set on, the bridge will not rest until the two resistances are ____________.

CORRECT RESPONSES TO FRAME 37: 1. temperature control point

2. temperature control point

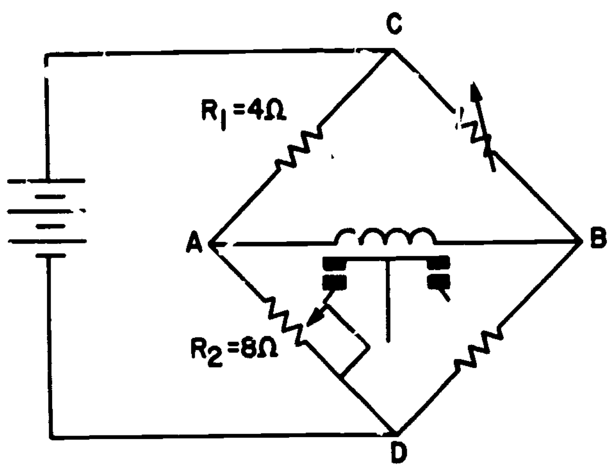
3. will 4. align

Frame 38

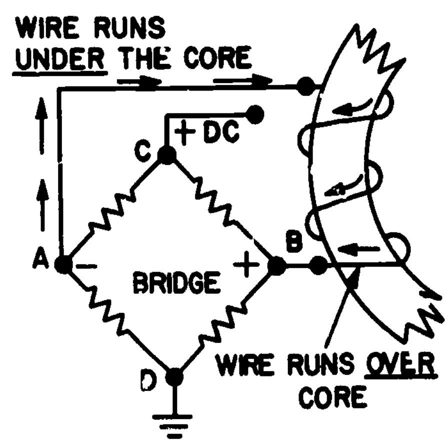
Refer to page 49. If the pilot wants colder air in the cockpit, all he needs to do is to increase the rheostats resistance. This will unbalance the circuit. Current will flow from points A to B, tilting the micropositioner armature to the right. 24V DC will flow to the close side of the temperature control valve.

By partially closing the valve, a greater portion of the air will be routed through the heat exchanger and cooling turbine. A greater proportion of cold air will be delivered to the cockpit.

The micropositioner connecting A to B on the preceding diagrams are not always built the same way. The wiring connections can be made on the outside of the circuit (figure B). Notice that point A is marked a negative potential (less positive). Point B is positive. Following the arrows (- to +) you will note that current flows from A to B on the outside of the diamond. Shown below are both types of circuits. Figure A shows wiring on the inside of the diamond. Figure B shows the wiring connections on the outside of the diamond.



A



B

NO RESPONSE REQUIRED

Complete the statements on the response sheet. If any of your responses are incorrect, review the appropriate frames to determine the correct response.

1. Increasing or decreasing one or more of the resistances will cause the bridge to become unbalanced. (True) (False)

2. A sensor may have a ____________ or a _____________ temperature coefficient.

3. A resistor that increases its resistance as the temperature around it increases has a ________________ temperature coefficient.

CORRECT RESPONSES TO FRAME 38: No Response Required.

CORRECT RESPONSES TO FRAME 39: 1. true 2. positive or negative

3. positive

Frame 40

As a final review of your ability to associate symbols and statements, draw the component symbol where the name of the component would normally fit on the response sheet.

1. A fixed ______________ has a value that normally does not change.

2. Temperature is "sensed" by a ____________________.

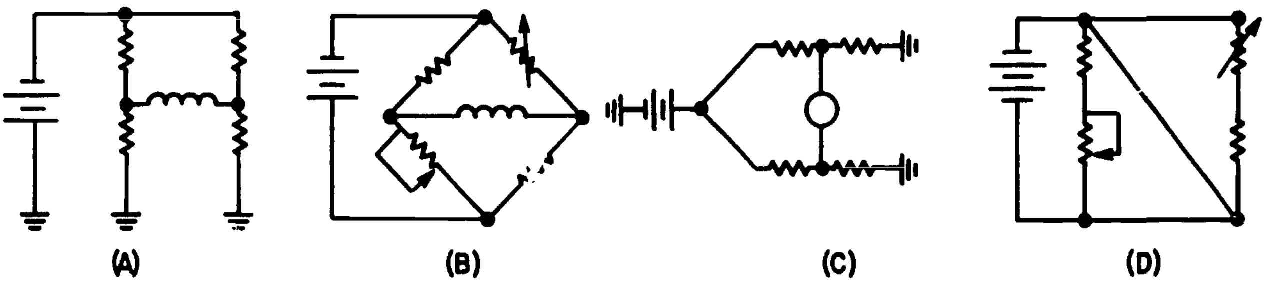
3. The pilot's temperature selector ________________ is turned by a knob.

4. A change in the direction of current across a bridge circuit

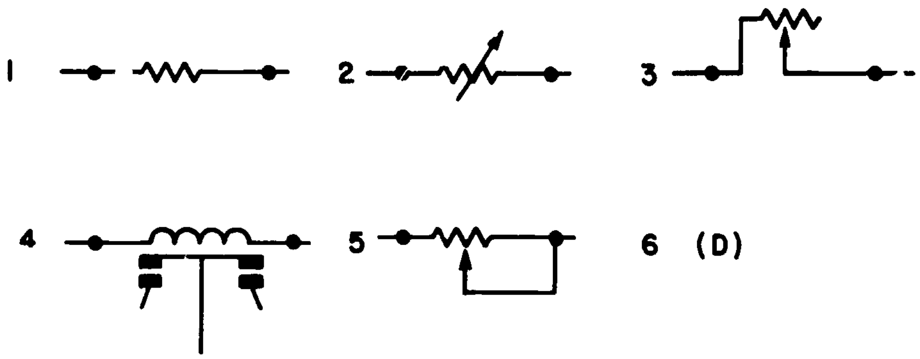
   can be sensed by a ____________________.

5. Small adjustments can be made to a/an ____________ with a screwdriver.

6. Which of these is not really a bridge circuit?



CORRECT RESPONSES TO FRAME 40:



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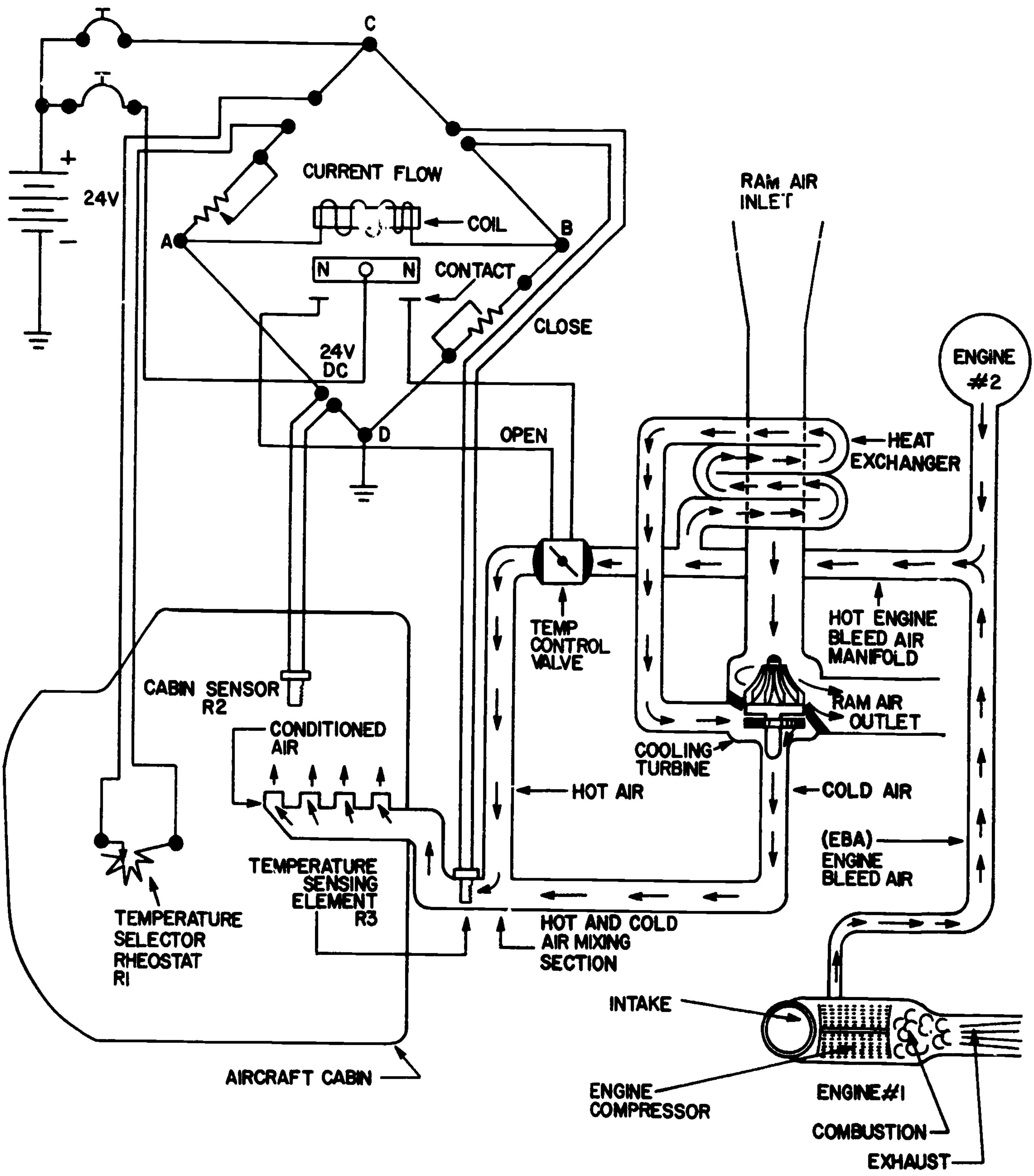


Foldout 1. Balanced Bridge.

71-16100

Technical Training

Aircraft Environmental Systems Mechanic

TEMPERATURE CONTROL CIRCUITS WIRING DIAGRAM

1 December 1980

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

RGL: N/A

TEMPERATURE CONTROL CIRCUITS WIRING DIAGRAM

OBJECTIVE

Using an electrical diagram, identify a minimum of 8 out of 10 circuit malfunctions, when given the cause and circuit condition.

EQUIPMENT

Colored Pencils
WB-116A

PROCEDURE

When you have acquired the above listed equipment, proceed according to the instructions for each project of the workbook. DO NOT change the color of the pencil you are using to trace each part of the circuit unless you are told to do so.

Project 1

In this project you will be tracing out three (3) different circuits, all controlling the same motor and valve assembly (only one circuit will be on at a time). One circuit will "automatically" control the temperature control valve. One circuit will "manually open" or close the temperature control valve assembly.

The MANUAL HOT & COLD circuits are used as a "back up" system in case the "automatic" circuit malfunctions.

INSTRUCTIONS

Using figure 17 from the back of the text and a set of colored pencils, trace the circuits in each of the following situations. Locate the various components that you will be working with; ie., the power bus, circuit fuse, temperature control switch, hot and cold relays, micro-positioner, and the temperature control valve. For ease of following the circuits, we will trace from the voltage source to ground, although in the actual circuit the current will flow from ground (-) to the voltage source (+).

Supersedes 3ABR42331-WB-122, 16 September 1980, which may be used until existing stocks are exhausted.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 500; TTVSA - 1

1. Using a red pencil, trace the following voltage source.

a. Trace from the 28V DC power bus along wire H28A18 to the five amp fuse, through this fuse along wire H29A18 to the temperature control switch. Stop at this point for a moment.

Note: This temperature control switch provides power to operate the AUTOMATIC, MANUAL COLD, and the MANUAL HOT circuits. To operate any of the three circuits from this point it is necessary to position the "switch" to the position that is desired. From the switch you will be using three different colors of pencil to show you the distinct separation of the three circuits even though they all control the same valve assembly.

If the power circuit you have just traced does not look like the completed portion of figure one, redo the previous step 1 or ask your instructor for assistance.

2. Using a green pencil place the temperature control switch to the "manual cold" position and trace the following voltage source.

a. Trace along wire H31A18 over to junction A2 of the "cold relay," from A2 along wire H31B18 through the close field winding of the temperature control valve, to junction "A" of the valve assembly. The symbol (M) represents the motors armature field, brushes or slip rings and end frame. Next trace from junction A to the motor, then from the motor along wire NMA18 to the ground point ( ).

(1) From your previous study of DC motors you should recall that if you apply voltage to the close field and armature windings of the valve, the armature and valve shaft begins to rotate, in turn rotating a unit or butterfly device of some type to a "closed" position.

(2) From the previous study of bridges you learned how the position of this temperature control valve butterfly affected the cockpit temperature. If you do not recall how this valve mixes the ratio of hot and cold air, then refer back to the text prior to this one that covers the bridge's operation in relation to the temperature control valve.

The manual cold circuit you have just traced, should look like the completed portion of figure 2. If not, redo step 2, or ask your instructor for assistance.

3. Using an orange pencil, trace the voltage source for the manual hot position.

a. Trace across the temperature control switch to the "hot" position along wire H30A18 to junction A2 of the hot relay. Now trace from junction A2 along wire H30B18 through the OPEN FIELD winding of the motor to junction A. Then trace on to the ground point, along the motor ground wire NMA18.

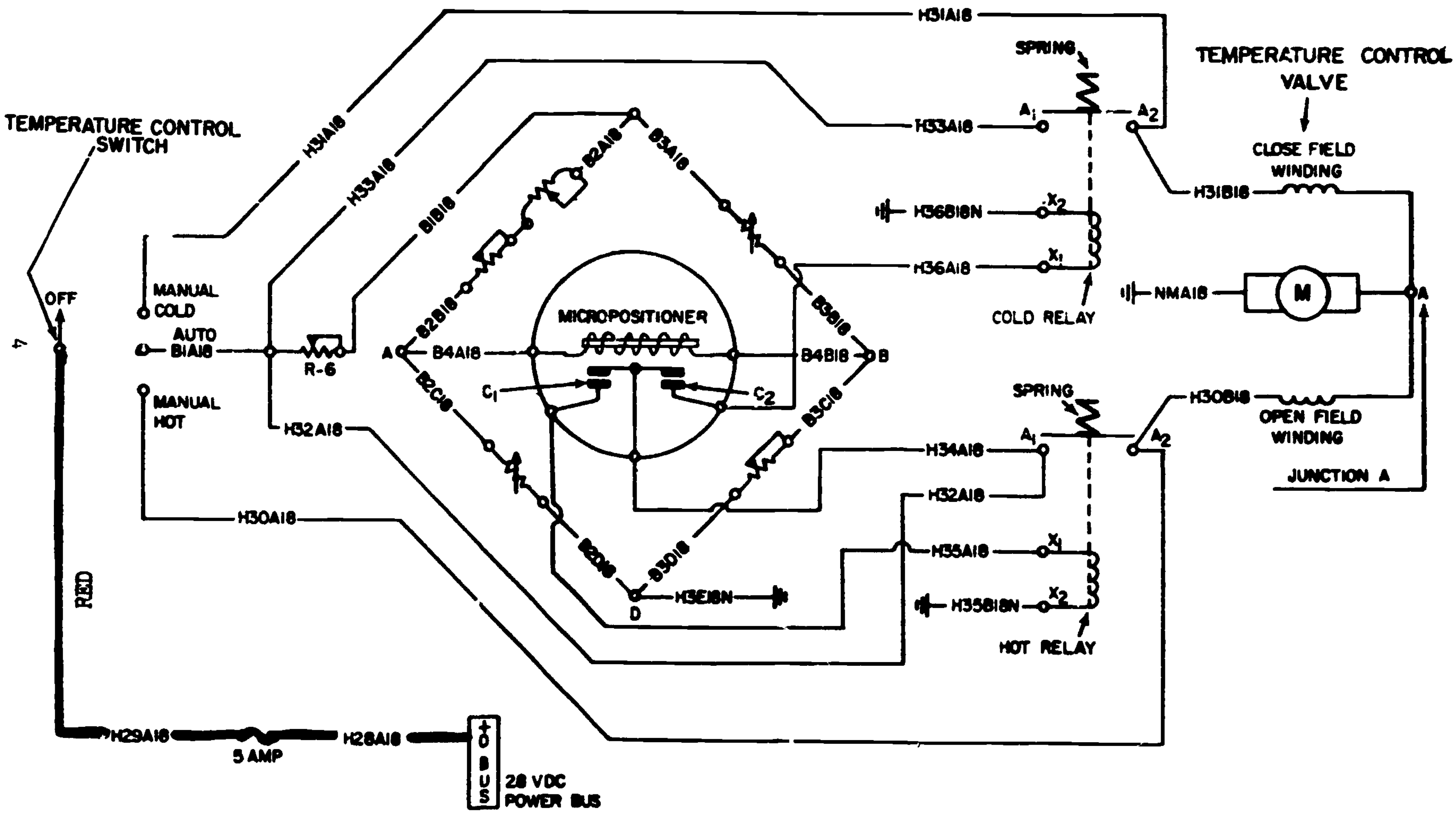

TEMPERATURE CONTROL SWITCH
OFF
MANUAL COLD
AUTO
MANUAL HOT
RED
H29A18
5 AMP
H28A18
+ D BUS
28 VDC POWER BUS
H31A18
H33A18
B1A18
R-6
B1B18
B2A18
B2B18
B2C18
B2D18
H32A18
H30A18
B3A18
B3B18
B3C18
B3D18
B4A18
B4B18
MICROPOSITIONER
C_1
C_2
A
B
D
H3E18N
SPRING
A_1
A_2
H36B18N
X_2
H36A18
X_1
COLD RELAY
H34A18
H35A18
H35B18N
HOT RELAY
TEMPERATURE CONTROL VALVE
CLOSE FIELD WINDING
H31B18
NMA18
M
H30B18
OPEN FIELD WINDING
JUNCTION A

Figure 1.

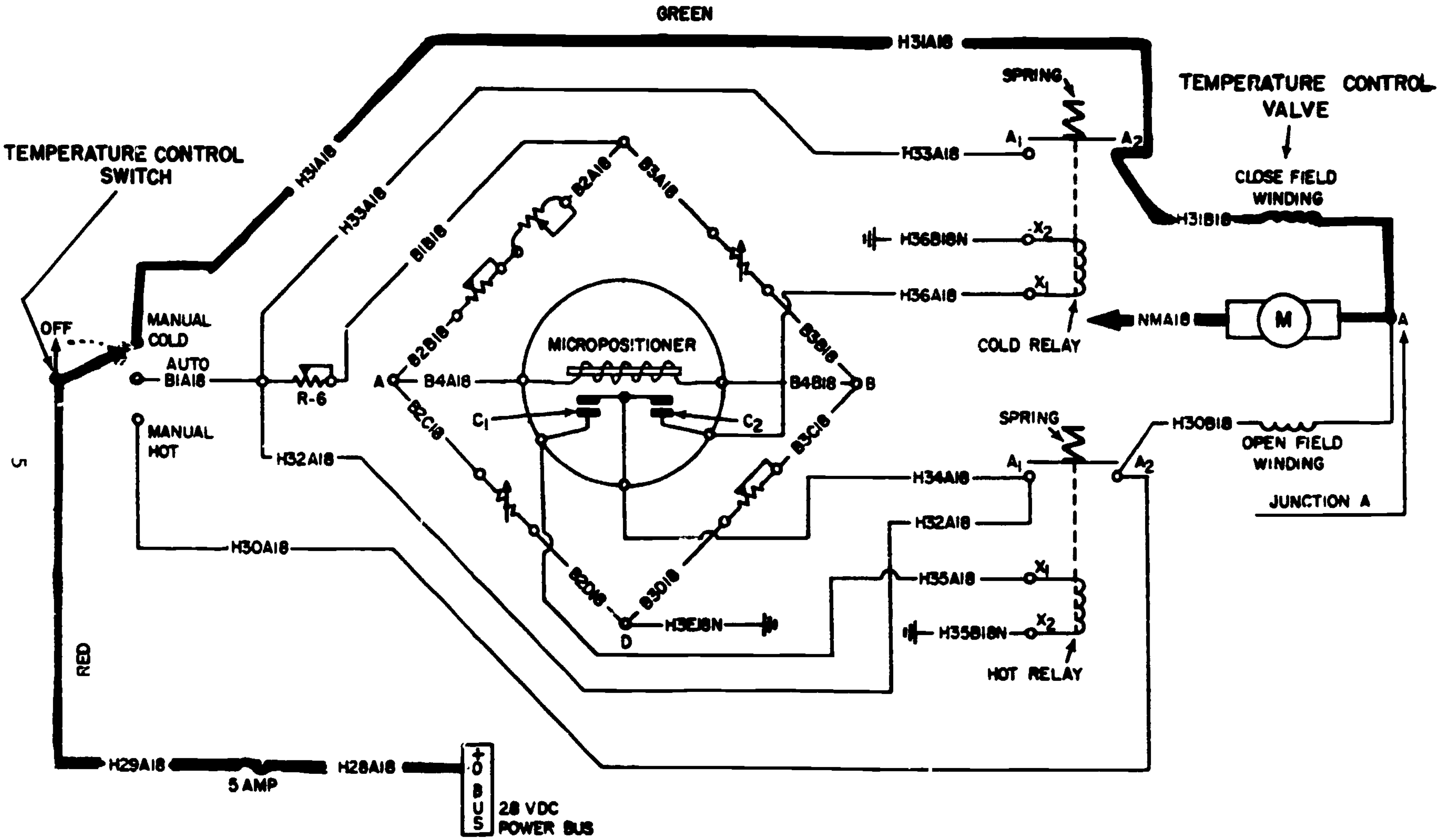


Figure 2.

1107

1106

(1) At this point the armature rotates and in turn will open the butterfly allowing hot air to enter the cockpit as long as the switch is left in this position.

The manual hot circuit you have just traced should look like the completed portion of figure 3. If not, redo step 3 or ask your instructor for assistance.

(2) From previous lessons you learned that you must get a ratio of hot and cold air to the cabin. In the manual range just explained, there must be a method so that you can momentarily position the temperature control switch to manual hot or cold and position the valve to the desired point where you want it; hot, warm, cool, or cold air.

b. If the switch is properly constructed this can easily be accomplished. Refer to the illustration below, then read the information that follows:

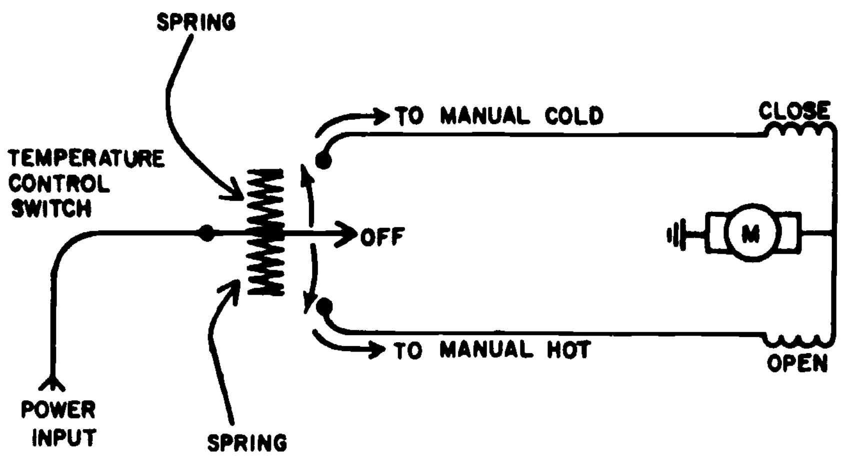
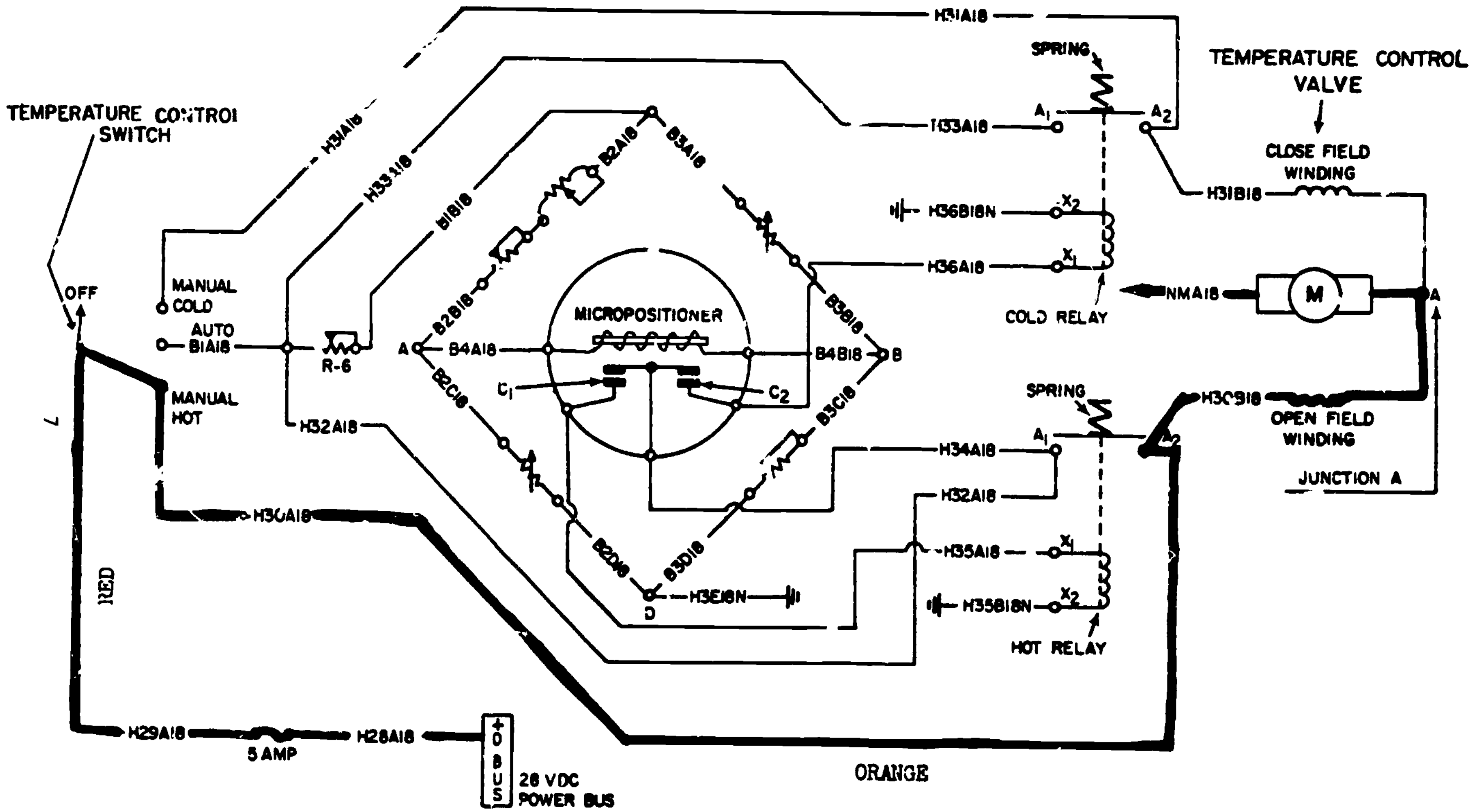


Figure 3.

(1) Note that there are two small springs connected to each side of the switch. If you were to hold the switch to the "manual cold" position and then release it, it in turn would spring back to the OFF position, thus removing power from the close (cold) side of the motor. By the same token if you placed the switch to "manual hot" and then released the switch, it would spring back to the OFF position.

(2) Simply in this manner you could send small blips of power to either side of the motor and position the valve to the exact point desired. Full open, partially open, partially closed or full closed until the desired cockpit temperature is reached.

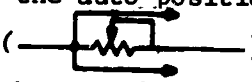
(a) Due to the varying altitudes and different throttle setting of the aircraft engines, creating temperature changes to the air conditioning system, the temperature would have to be continuously "monitored" in manual to maintain the proper temperatures in the cockpit. For this reason the automatic range was designed to give better temperature control, without having to constantly "monitor" the system.



TEMPERATURE CONTROL SWITCH
TEMPERATURE CONTROL VALVE
SPRING
H31A18
H33A18
A1
A2
CLOSE FIELD WINDING
H31B18
H36B18N
X2
H36A18
X1
COLD RELAY
NMA18
M
A
MANUAL COLD
AUTO B1A18
MANUAL HOT
OFF
R-6
B1B18
B2A18
B3A18
B2B18
B3B18
B4A18
B4B18
MICROPOSITIONER
C1
C2
B2C18
B3C18
B2D18
B3D18
H32A18
H34A18
H35A18
H35B18N
H3E18N
HOT RELAY
H30B18
OPEN FIELD WINDING
JUNCTION A
H30A18
RED
H29A18
5 AMP
H28A18
BUS
28 VDC POWER BUS
ORANGE

Figure 4.

4. Using a blue pencil, trace the following voltage sources in the "auto" position.

a. Draw the temp control switch in the auto position and trace across wire B1A18 to the 3 way junction (). Note at this point the circuit parallels into three paths.

(1) One along wire H33A18 to point A1 of the cold relay.

(2) One along wire H32A18 to A1 of the hot relay, then along wire H34A18 to the micropositioner armature contact.

(3) The other path through resistor R-6 along wire B1B18 to the "top" of the bridge.

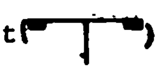
b. Let's take each path individually as you trace them out on the foldout.

(1) First trace along wire H33A18 to point A1 of the cold relay.

(a) Voltage would stop at this point because the cold relay <u>has not</u> been energized at this point. The spring attached to the armature contact is holding it up, therefore breaking the electrical circuit between points A1 to point A2 on the relay.

(2) Now trace along wire H32A18 to A1 of the hot relay.

(a) Again voltage would not be sent across from A1 to A2 of this relay; for at this point it is "deenergized."

(b) Trace from A1 along wire H34A18 to the micropositioner armature contact(). You now have a voltage potential on the contact. At this point with <u>no current</u> flow across the bridge, the contact is in its <u>neutral</u> position and neither relay is energized. Therefore, it should be of special interest to note if there is NO CURRENT across the bridge the system will not energize the hot or cold relays which feed power to the motor windings in automatic.

(3) Now trace across resistor R-6 at the three way junction, along wire B1B18 to the TOP of the bridge circuit.

Note: Resistor R-6 is a voltage dropping resistor to the bridge, simply the aircraft or trainer circuits would only require a small amount of voltage for actual operation. Therefore, this resistor is used to regulate voltage to the bridge.

(a) Notice that the circuit at this point is nothing more than a parallel circuit. One path down the left side, one path down the right side.

> Note: At this point you must assume that the bridge is in a balanced condition; that is voltage at points A and B are the same and NO current is flowing across the micro-positioner coil.

(b) Trace along wire B2A18 through the rheostat and variable resistor along wire B2B18 to point A. Continue on wire B2C18 through the temp sensing element ( ) along wire B2D18 to point D then to the ground point along wire [illegible] E18N.

(c) Go back to the top of the circuit and trace to the right along wire B3A18 through the sensing element ( ) along wire B3B18 to point B, continue on wire B3C18 through the variable resistor ( ) along wire B3D18 to the ground point along wire H3E18N.

The circuit you have just traced should look like figure 5. If your traced circuit does not, redo step 4 or ask your instructor for assistance.

> Note: At this point you have traced the manual cold circuit, the manual hot circuit, and the auto circuit under a balanced condition. In the next two steps you will unbalance the circuit and energize each relay in turn, the hot and cold relay circuits.

5. In this step you will create a difference in voltage potential by raising point A's voltage to a higher value than the voltage at point B.

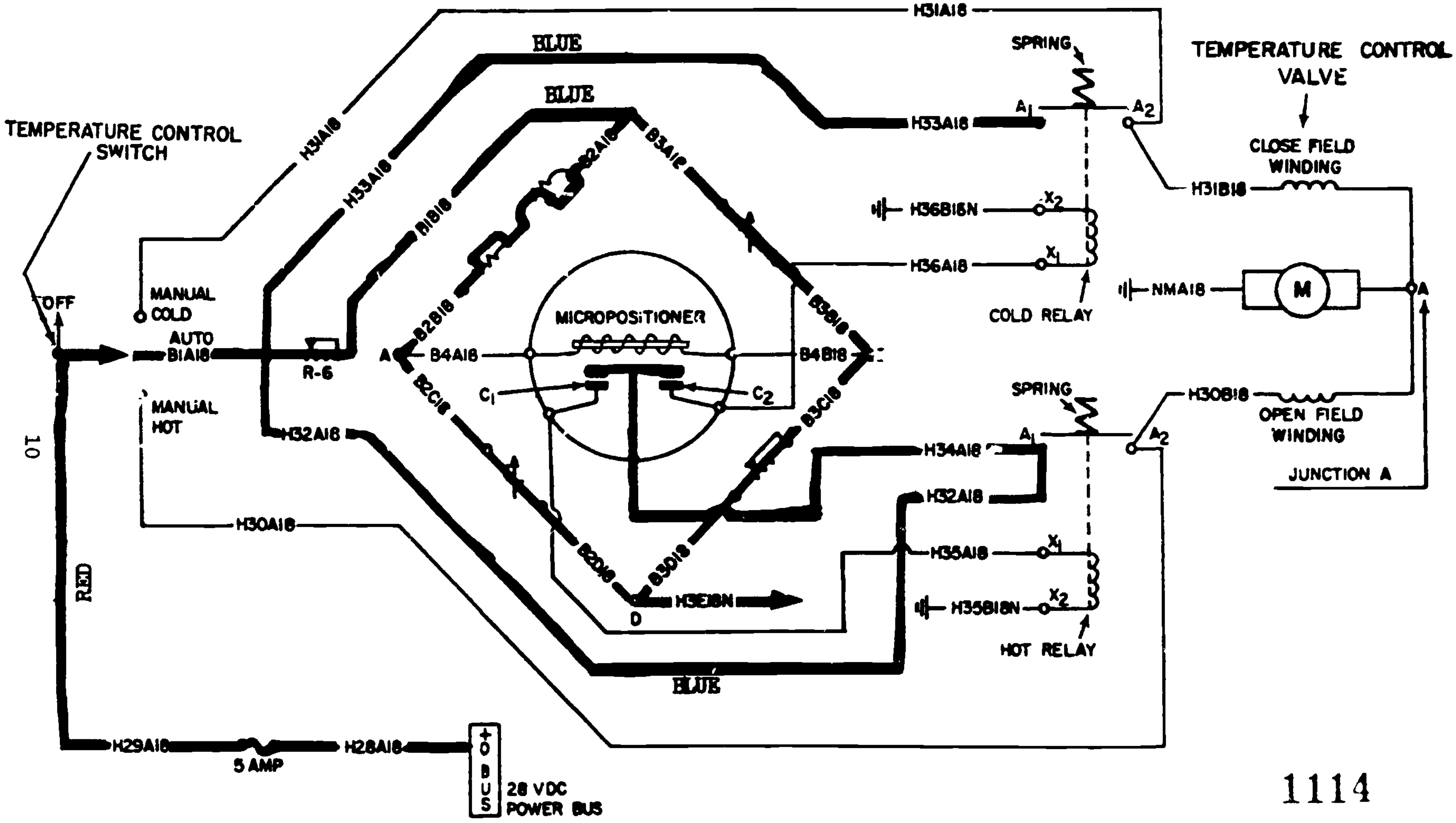
a. This can be accomplished in three ways.

(1) By the rheostat.

(2) By the variable resistor.

(3) By the temperature sensor on the left side of the bridge.

(a) If the rheostat's resistance is decreased, then less voltage would be used to get the current to flow through it; therefore, the voltage at point "A" would be higher. Remember, voltage drop or usage is in proportion to resistance in a series circuit. Simply if a resistor's value changes, the voltage requirement for that resistor or circuit automatically changes.



1113

1114

Figure 5.

(b) By the same token, the resistance of the variable resistor could be decreased also making a higher voltage for point A due to less voltage being required for it.

(c) On the sensing element, the resistance would have to be increased. By increasing this resistor's value, you would require a larger share of the voltage to get current to flow through it. Therefore, less voltage would be used through the other resistors, in turn impressing a higher voltage across point "A" to the sensing element.

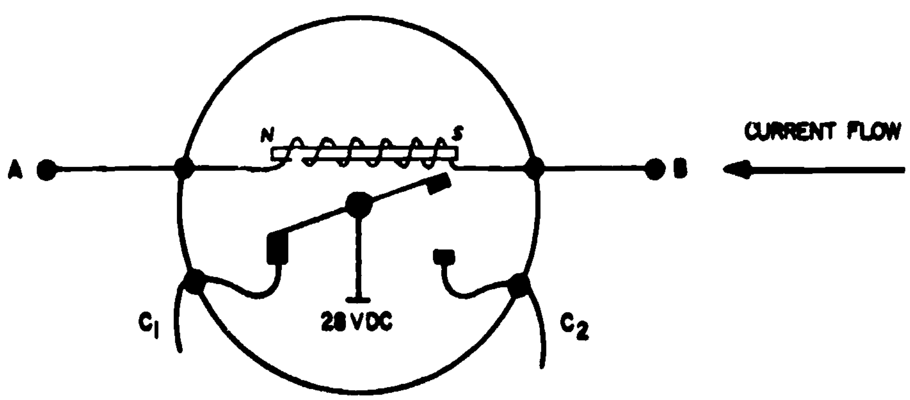
b. Now that a higher voltage has been established at point "A" than point "B", there would be current flow across the bridge.

Note: Always remember that if a resistor's value changes, for any reason, voltage will automatically be changed, either increasing or decreasing the voltage requirement for that unit or units.

(1) Using the orange pencil, again trace across the bridge from point "B" to point "A".

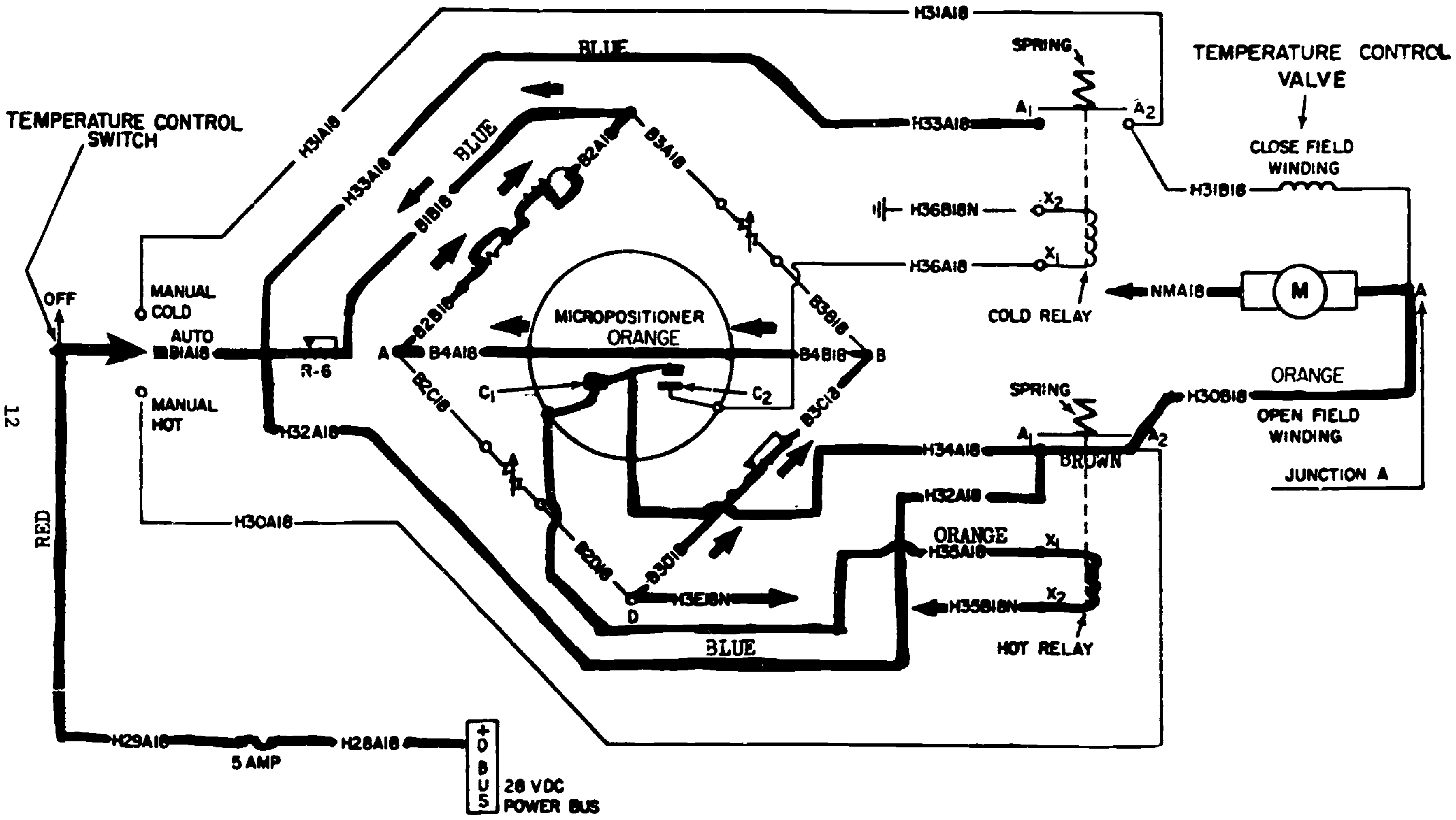
(a) Point B now has a low voltage. Point A has the higher voltage potential. Example: Point B = 6 volts, point A = 8 volts.

(b) From your previous study you should note that the micropositioner coil magnetizes and the armature is offset/tilted to the left. Note the illustration below.



REMEMBER to use the Left Hand Rule to find which side of the coil is north.

Figure 6.


TEMPERATURE CONTROL SWITCH
OFF
MANUAL COLD
AUTO
B1A18
MANUAL HOT
R-6
RED
H31A18
H33A18
H32A18
H30A18
H29A18
5 AMP
H28A18
+ D BUS
28 VDC POWER BUS
BLUE
B1B18
B2A18
B2B18
B2C18
B2D18
B3A18
B3B18
B3C18
B3D18
B4A18
B4B18
A
B
C
D
MICROPOSITIONER ORANGE
C_1
C_2
H3E18N
SPRING
A_1
A_2
H36B18N
H36A18
X_1
X_2
COLD RELAY
HOT RELAY
H34A18
BROWN
ORANGE
H35A18
H35B18N
TEMPERATURE CONTROL VALVE
CLOSE FIELD WINDING
H31B18
NMA18
M
H30B18
OPEN FIELD WINDING
JUNCTION A

12

Figure 7.

c. Using the orange pencil, trace from C1 to X1 of the hot relay through the coil to X2 to ground along wire H35B18N. The relay now becomes a temporary magnet and pulls the relay contact down, making a path for voltage from A1 to A2 of the hot relay. Use a brown pencil and trace across to A2 then on to the hot motor winding to ground.

Note: At A2 of the hot relay, auto hot and manual hot uses the same wire to get to the motor windings.

The circuit you have just traced should look like figure 7. If not, redo the previous section, or ask your instructor for assistance.

6. In this step, lower the voltage at point A. Assume that this voltage is now lower than point "B".

a. Again this can be done by changing any of the resistance values on the left side of the bridge. This could have easily been done on the right side of the circuit; however, the left side is merely being used as a point of reference.

b. Now that a lower voltage is established at point A, current will flow from A to B (left to right across the bridge).

(1) The micropositioner armature contact tilts/offsets to the right in turn energizing the contact to C2. Note the illustration below.

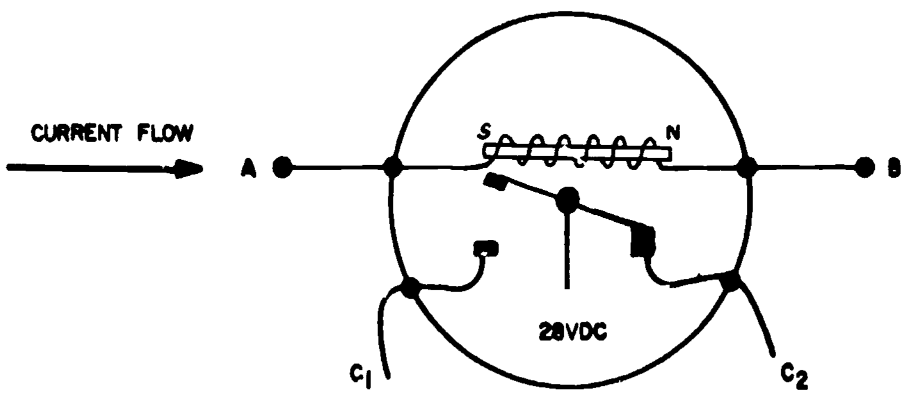
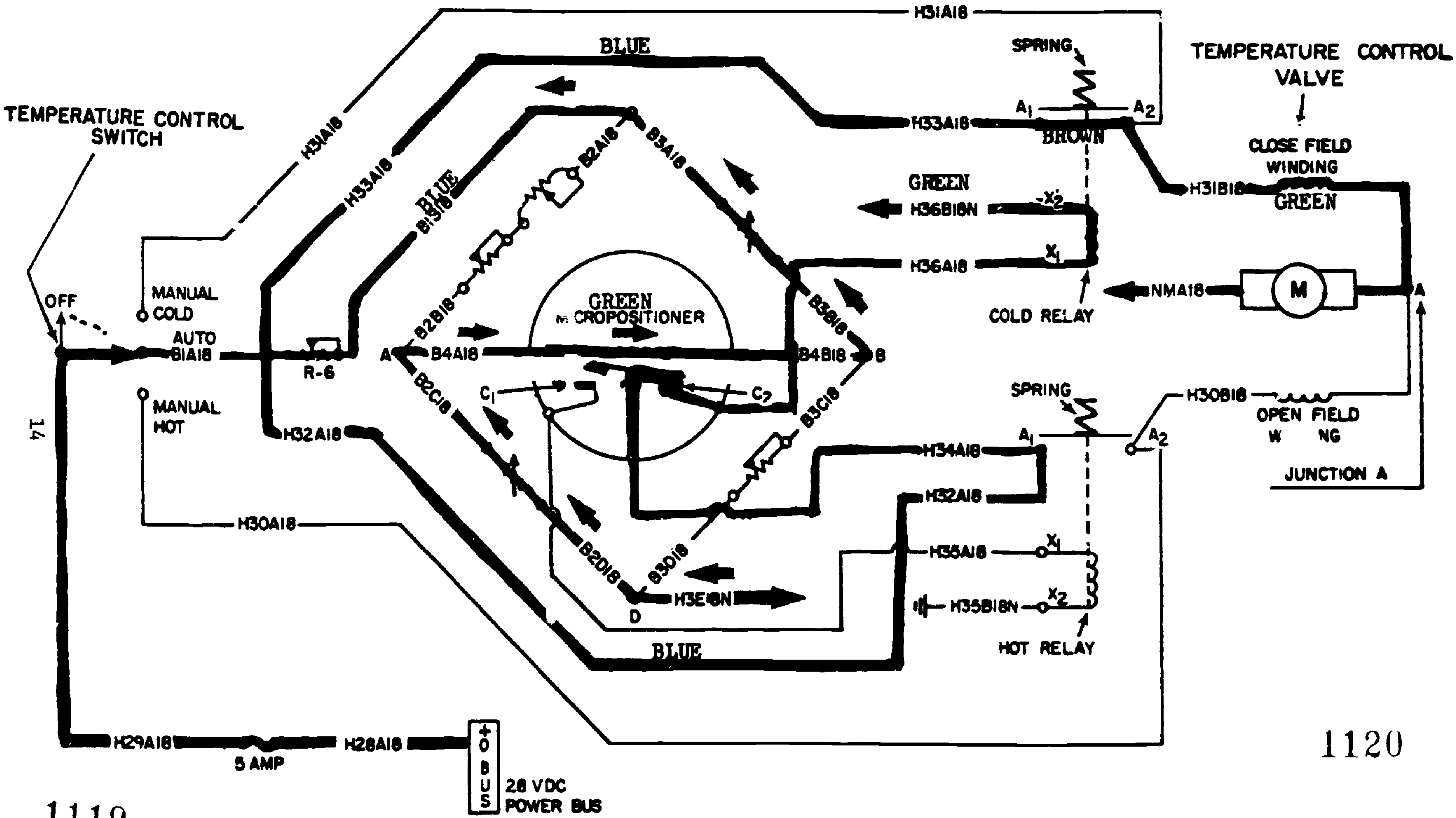


Figure 8.

c. Using a green pencil, trace current from point A across the micropositioner to point B. Trace out contact C2 to X1 of the cold relay through the coil to X2 to ground.

(1) This relay now becomes energized, the contact between A1 and A2 is pulled down and <u>makes</u> the electrical circuit.

d. Trace from A1 (using a brown pencil) to A2 through the close (cold) motor windings to the ground point along wire NMA18.



1120

1119

14

Figure 9.

Note at A2 of the cold relay that "auto cold" and "manual cold" use tha same wire at this point to transfer voltage to the motor windings.

This completes project 1. The figure you have just traced should look like figure 9. If you do not understand what you have done up to this point and why, then redo this project. If you still do not understand, then notify the instructor for aid.

Project 2

INSTRUCTIONS

Using figure 18, note the circles and squares with numbers at the various points on the circuit. The circled numbers (3) represent an OPEN wire at this point. The squares (4) indicate that the circuit is SHORTED at this point. REMEMBER! If for "any reason" a resistor's resistance is changed on either side of the circuit, vcltages at points A and/or B will be changed.

1. Using the illustrations below, see what happens when either side of the bridge resistance is changed. Illustration 1 indicates a normal circuit under a balanced condition (no current flow across the bridge). Illustration 2 shows the same circuit with resistor R-3 broken (open) and the circuit is shown in an ,balanced state.

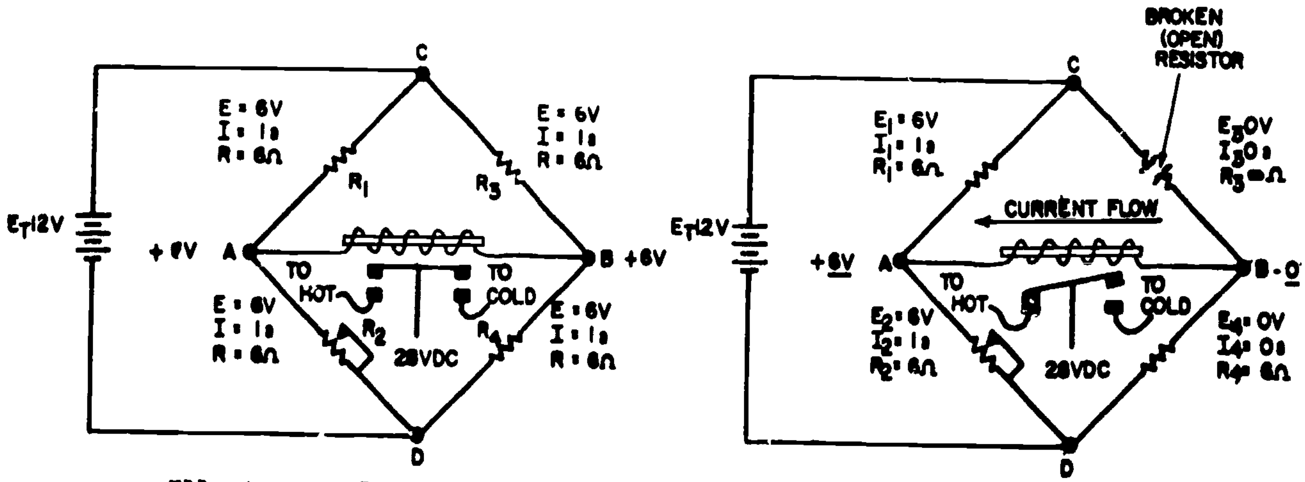


Illustration 1

Illustration 2

Figure 10.

a. Note that the left side of the bridge in illustration 2 is normal and still has a +6 volt potential at point A. Note further that with R-3 broken, that there is NO voltage across the break and the voltage potential at point B is at a zero (0) volt potential. From your previous studies you know that current would now flow from point B (- to point A (+). Keep in mind that point B could be 0, 1, 2, 3, 4, 5, 5.9 volts and current would still flow until B reaches the same voltage as point A, then the circuit would be balanced. With current flow from B to A, the micropositioner armature contact will tilt/offset to the left making contact with the wiring going to the hot relay.

(1) It is noteworthy to realize that at this point the resistor will remain broken until the aircraft returns from flight and you, the maintenance man, correct the malfunction.

(2) In turn the system would be demanding FULL HOT in AUTO at all times.

(3) The crew "must now" select the manual override ranges to control temperature.

2. As you may note, computing the different breaks or shorts on the bridge could become quite a math headache. However, there is a method for figuring out exactly which way current will flow when there is a malfunction on the diamond itself. Study the illustrations below as you read the information below them.

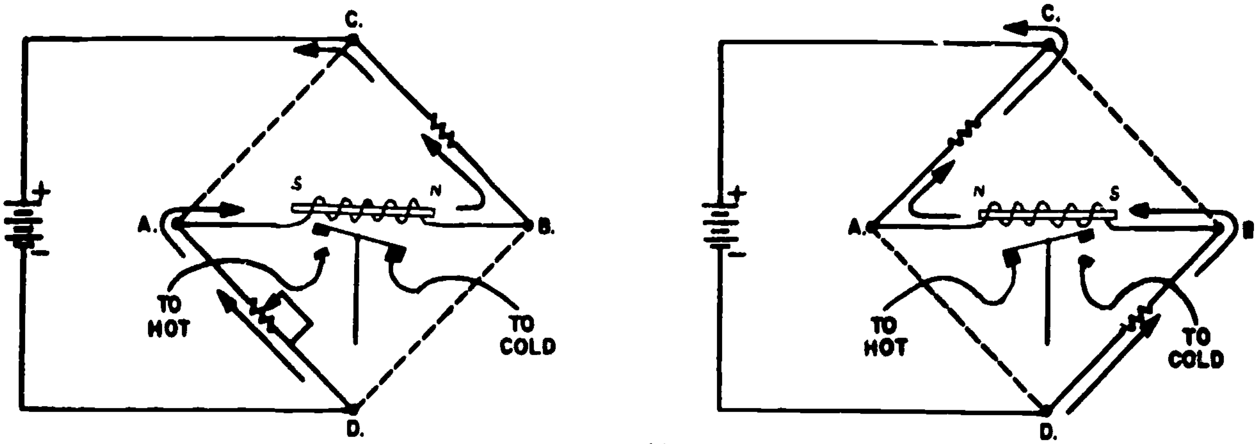


Figure 11.

a. If current were to flow ONLY in a lopsided Z pattern from point D of the circuit (note illustrations 1 and 2) and we used this method, we could readily identify the malfunction and determine which way current would flow across the bridge. Arrows indicate direction of Z, and current flow across the bridge.

(1) Remember this will only be a method used in aiding you to bypass having to mathematically compute voltages each time there is a short or open on the diamond. Keep these Z from D patterns in your head as you continue.

b. Using the illustration below, let's see exactly how this Z pattern will help in determining which way current will flow on the bridge.

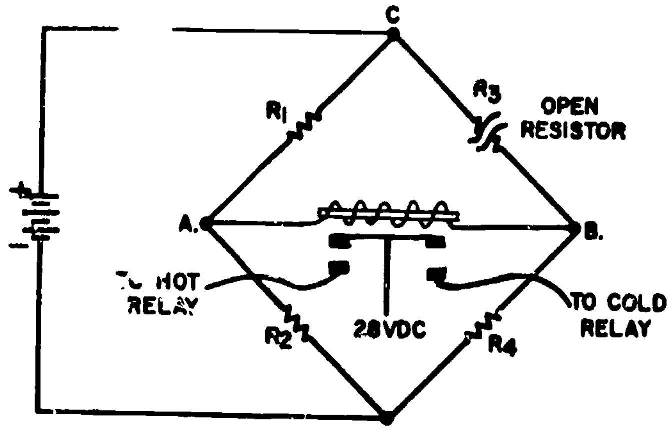


Figure 12.

(1) Using a green pencil and the Z pattern, trace from point D up to point A. So far the circuit looks ok., now trace across from point A to point B then up to the broken path (resistor R-3) of the circuit.

(2) At this point the circuit has an incomplete path and current could not flow on to point C or anywhere. (You must have a complete path for current to flow.) Seeing how you don't have a complete path from this point to C and on to positive, there NO ACTION on the micropositioner coil and it remains in the neutral position (neither relay on).

(3) So now you must go back to point D and start the Z pattern in the opposite direction. Use figure 13 shown below, in this procedure.

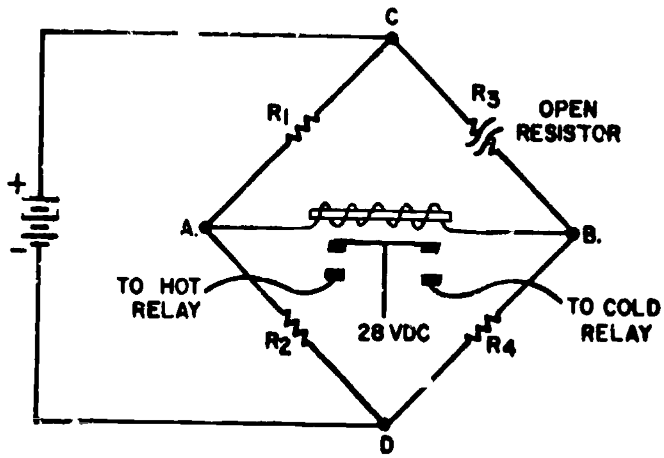


Figure 13.

(a) Using a green pencil, trace from D to point B across to point A, up to point C and to the positive bus. As you can see, the circuit is complete; the armature contact is tilted to the left, and the HOT circuit is energized. Trace the contact in its tilted position to the left in orange.

c. What if resistor R1 were shorted in the illustration below? Remember, if the bridge is unbalanced, the current will always take the Z pattern from the lowest voltage potential to the highest. In figure 14 below, use the green pencil to trace out your Z pattern, and then answer the questions about the circuit.

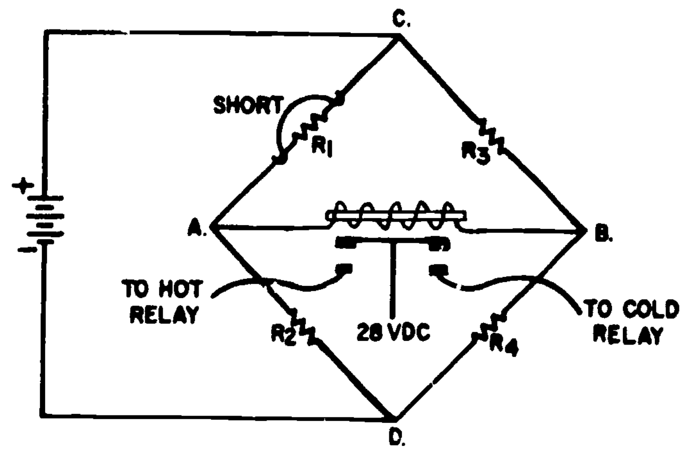


Figure 14.

Answer the following questions.

1. Current now flows across the bridge from __________ to

______________. (A to B, B to A)

2. This Z path has the least resistance _________________. (DBAC/DABC)

3. The micropositioner contact is (tilted/not tilted)

__________ to the (left/right/neither direction) _________________.

4. Current flow takes the path with the __________ (least/highest) resistance.

Check the following page for the correct answer to the illustration and questions. If your answers do not agree with these, then reread the information given.

Answers to illustration and questions 1 through 4 on page 18.

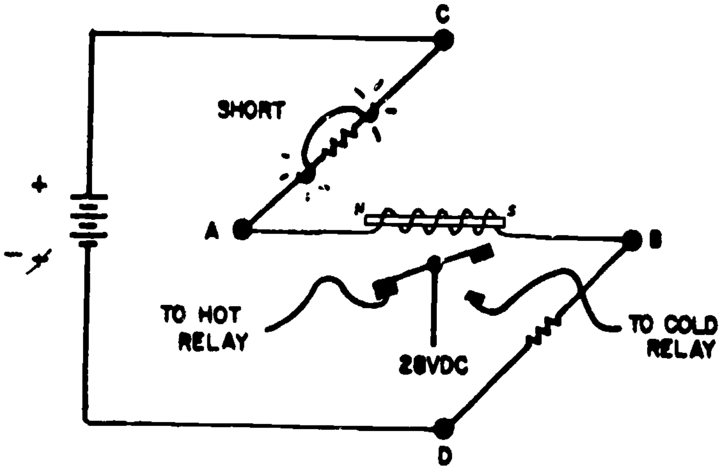


Figure 15.

c. Your circuit should appear as the one above. This is the portion of the circuit that you should have traced in green. From point D to B to A to C. Note the position of the micropositioner armature contact.

1. B to A.

2. DBAC.

3. tilted - left.

4. least.

(1) The system is still demanding full hot as was the previous circuit.

(2) The thing to remember is that current goes in the opposite direction of the <u>opens</u> and flows with the <u>shorts</u> when using the troubleshooting aid of "Z" from D.

d. As was stated previously, this "Z" from D is merely an aid in troubleshooting. If the circuit was to be mathematically computed in each case, you would find that this method proves correct in determining direction of current across the bridge.

Using figure 18 and figure 16, you will identify circuit malfunction(s) in the temperature control circuit which are caused by OPENS or SHORTS. You will place an "X" in the block which will give you the correct circuit malfunction. The first one has been done for you. Numbers 2, 3, 4 you must do for practice and have them checked by your lab instructor before you progress to the problems in the performance check.

First look at figure 16 and find practice problem 1, then using figure 18, look for problem 1 in the temperature control circuit. After you have found 1 on figure 18, you will see that it points to an OPEN in the power lead to the temperature control switch. You can identify an open in this figure 18 by the circle around the number of the cause, or you can also look on figure 16 under the cause column.

1. Figure 16 gives you the answer sheet for practice problem 1.

2. Figure 18 gives you the location of the OPEN circuit power lead.

3. The circuit condition column for the temperature control switch and rheostat in figure 16 will give you the position the controls will be in during an operational check when the given CAUSE is in the circuit.

a. How will the circuit malfunction when the temperature control switch is in the manual cold position? You're right; 1 is an open in the power circuit causing the power to be cut off to the temperature control switch. By tracing the circuit, you know this switch must have power to it for both the manual and auto circuit to operate or the whole system will fail. This can now be marked in figure 16 with an "X" under (NO OPERATION).

Remember, NO OPERATION means that the temperature control valve will not operate in manual hot, cold or automatic. This does not mean that the bridge will not control the micropositioner and the hot and cold relay.

The selection made is the CIRCUIT MALFUNCTION (NO OPERATION). This is the only complete and correct answer because the power has been cut off to the circuits. The above circuit malfunction will result regardless of the temperture control switch and rheostat position.

If you would have selected any of the other circuit malfunctions, your answer may be either half or all wrong.

Note: Be very CAREFUL in selection of the circuit malfunctions. They must describe exactly what is malfunctioning, nothing more or less. Also, always note the position of the temperature control switch and rheostat given in the circuit condition column in figure 16. Sometimes more than one answer could be correct.

PRACTICE PROBLEMS

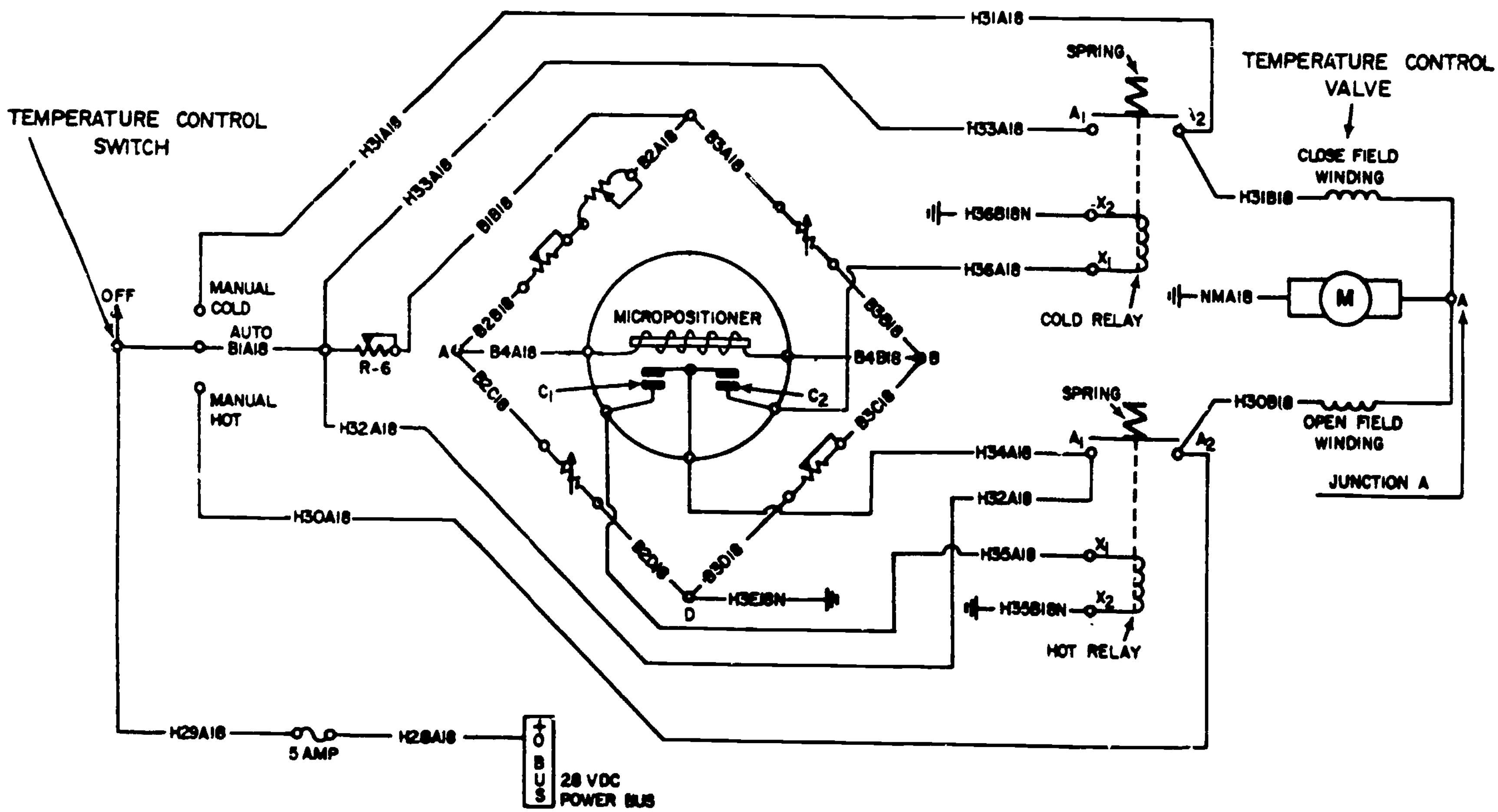
First look at figure 16 and find practice problems 2, 3, and 4, and then using foldout 2, look for problems 2, 3, and 4 in the temperature control circuit. After you have found 2, 3, and 4 on figure 18, select the correct circuit malfunction given at the top of figure 16 by placing an "X" in the correct block. Your instructor will grade your work and initial it if you are to progress to the performance test.

Student complete the following (print).

STUDENT NAME ____
(Last) (First)

CIRCUIT CONDITION					CAUSE	CIRCUIT MALFUNCTION(S)								
TEMPERATURE CONTROL SWITCH			RHEOSTAT											
MANUAL COLD	MANUAL HOT	AUTO	HOT (or)	COLD		No Manual Cold	No Manual Hot	No Auto Cold	No Auto Hot	Full Auto Cold	Full Auto Hot	No Operation	No Auto	Number on Foldout 2
X	X	X	X	X	OPEN							X		1
X					OPEN									2
		X	X	X	SHORT									3
		X	X	X	OPEN									4
INSTRUCTOR MUST INITIAL BEFORE STUDENT IS TO PROGRESS →														

Figu .6.



TEMPERATURE CONTROL SWITCH
OFF
MANUAL COLD
AUTO
B1A18
MANUAL HOT
R-6
H31A18
H33A18
B1B18
H32A18
H30A18
H29A18
5 AMP
H28A18
+ BUS
28 VDC POWER BUS
MICROPOSITIONER
B2A18
B3A18
B2B18
B3B18
B4A18
B4B18
B2C18
B3C18
B2D18
B3D18
C1
C2
A
B
D
H3E18N
SPRING
A1
A2
X1
X2
H36B18N
H36A18
COLD RELAY
H34A18
H35A18
H35B18N
HOT RELAY
TEMPERATURE CONTROL VALVE
CLOSE FIELD WINDING
H31B18
NMA18
M
H30B18
OPEN FIELD WINDING
JUNCTION A

Figure 17.

Technical Training

Aircraft Environmental Systems Mechanic

ALTERNATING CURRENT

26 March 1981

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

RGL: 9.6

OBJECTIVE

From various sine waves, specify peak voltage and effective voltage with a minimum of 80% accuracy.

INSTRUCTIONS

This package presents information in small steps called "frames." After reading the information in each frame, you are asked to select an answer or make an entry that shows you understand the "information" in that frame. You may write your answer in this booklet. You may check the accuracy of your answers by looking on the next page.

Supersedes 3ABR42331-PT-123, 9 May 1980.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 1000; DAV - 1

ALTERNATING CURRENT

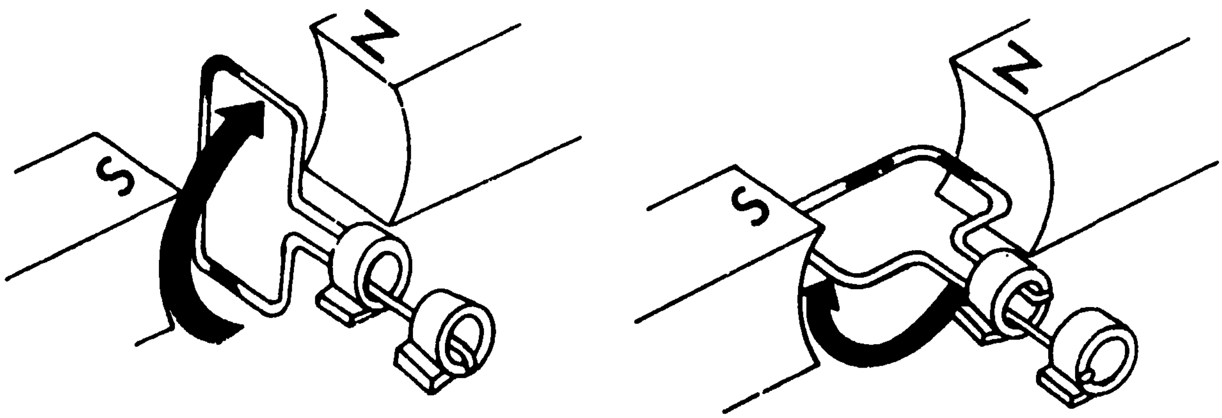
Alternating current and direct current are the two main forms of electrical power known to man today. You have already been introduced to direct current and to the method of producing it. In this unit of instruction we will deal almost exclusively with alternating current.

Alternating current is produced by the mechanical method. Both the alternating current generator and the direct current generator use the same principles of magnetism to produce a voltage. Both types of generators must have conductors, a magnetic field, and relative motion between the two. The difference in the type of output is controlled only by the internal parts of the generators.

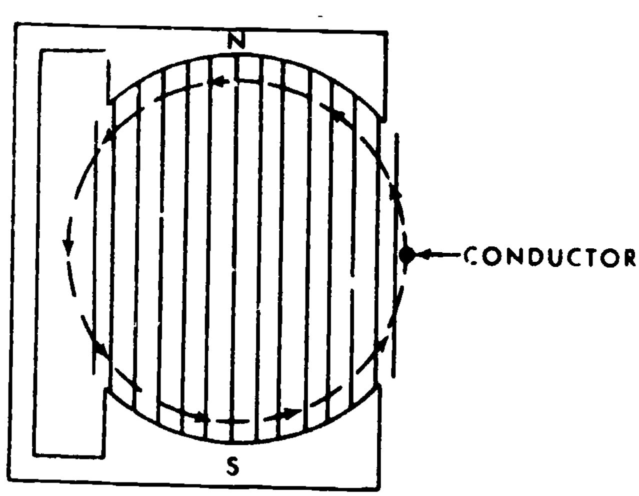
NO RESPONSE, GO TO THE NEXT PAGE

Frame 2

An AC generator has a conductor (actually many conductors) which rotates in a magnetic field. The diagram below shows a very basic AC generator, with a one wire conductor. Notice that the conductor is in the form of a loop, with a pivot point midway in the loop.



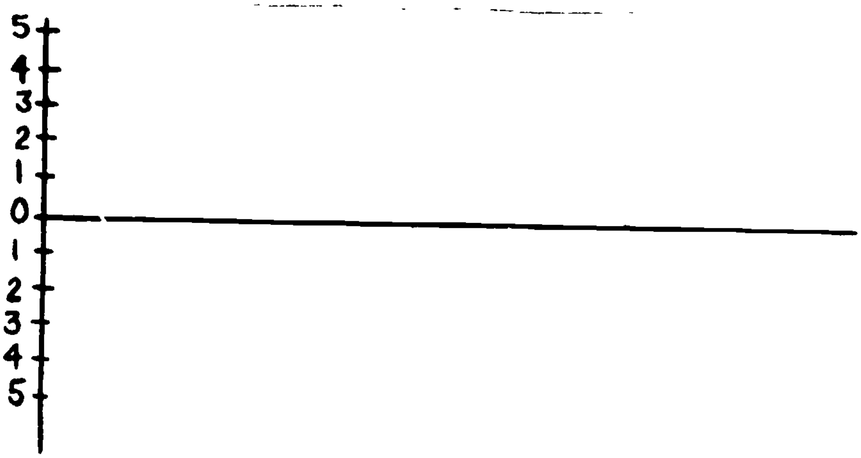
When one side of the loop is traveling up, the other side is moving down. The voltage buildup on one side of the loop always aids the voltage buildup on the other side. Since this is so, we will use only one of the conductors in the loop to explain how an AC voltage is produced. The diagram below represents this conductor in a magnetic field. (End view) If the conductor is rotated in a circle (represented by the dotted line) it will first cut across the magnetic lines of flux in one direction (right to left). Then it will cross the flux lines in the opposite direction (left to right). This causes current to flow first in one direction in the conductor, and then in the opposite direction.



NO RESPONSE, TURN TO THE NEXT PAGE

A sine wave is commonly used to represent this alterating current in a circuit. The next few pages in this program will teach you how this sine wave is developed and the terms used with it.

Let's start with the terms used when plotting a sine wave. The two solid lines in the diagram below are reference lines. In order to show how much voltage the generator is producing, the vertical line called an "amplitude" line is used. This line is sometimes marked with numbers to represent specific voltage or current values.



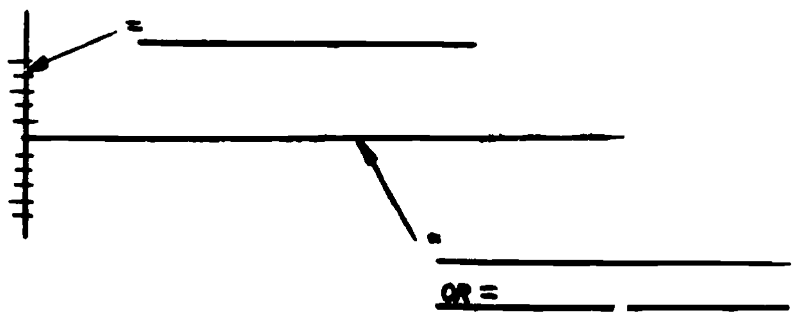
Draw an arrow pointing to the amplitude line in the diagram above.

Answer to Frame 3:

Frame 4

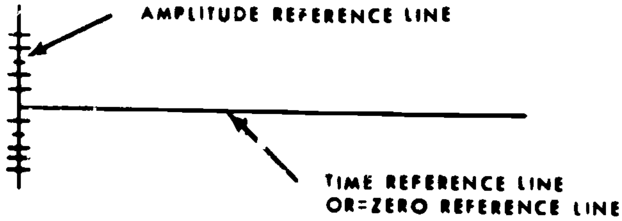
The horizontal reference line has two names. It can either be called a "0" (zero) reference line or a "time" reference line, for it represents both zero voltage and time.

Label the reference lines in the diagram below.



1138

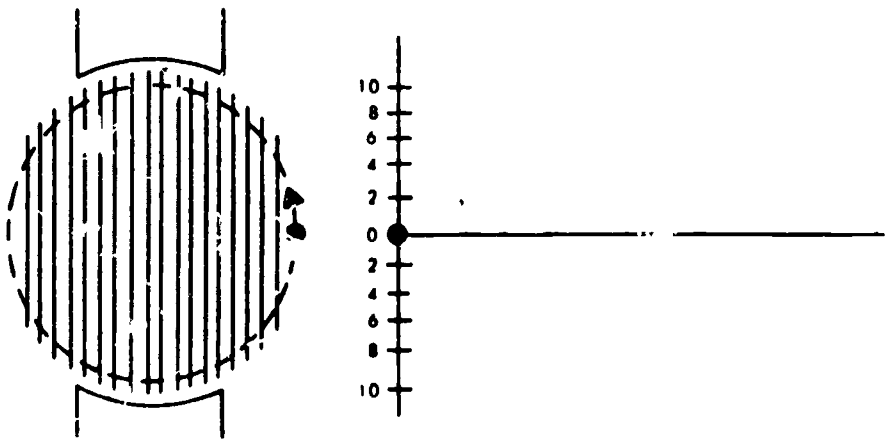
Answer to Frame 4:



Frame 5

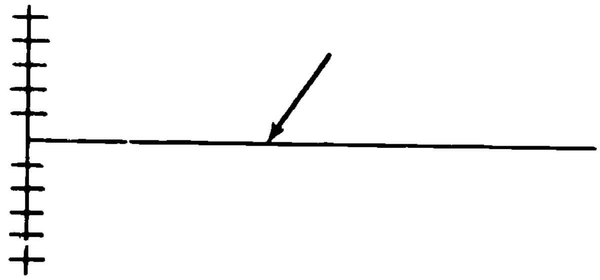
Now let's combine the basic generator (one conductor) and the reference lines to show how a sine wave is produced.

In the diagram below, the basic AC generator is producing no voltage. The conductor is moving parallel to the magnetic lines of flux at this instant, and, therefore, is not cutting across any lines. The "0" voltage produced at this time is represented by a dot on the zero reference line.



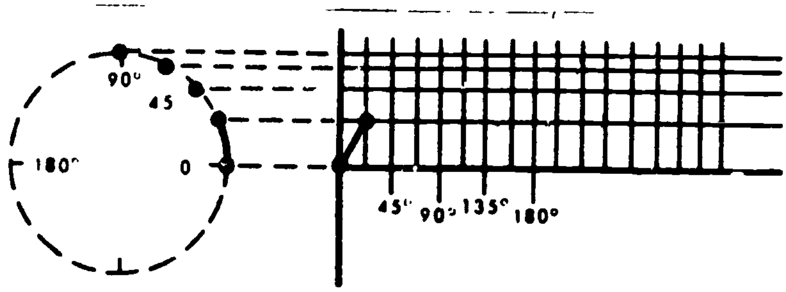
Draw an arrow to the "0" reference line in the diagram above.

Answer to Frame 5:

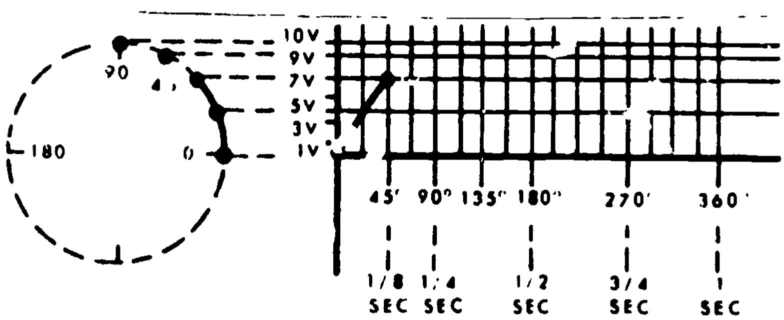


Frame 6

As the conductor rotates from the starting point through 22½° of a complete circle, it begins to cut across lines of magnetic flux.



This produces a voltage in the conductor. The amount of voltage at this time is small, but it is building toward the maximum voltage the generator will produce. This small amount of voltage is shown on our reference lines by a rising line. (The start of our sine wave.) As the conductor continues to rotate, it cuts across more lines of flux and produces a higher voltage.



In the diagram above, the conductor has traveled 45° of a circle, and the voltage shown on the reference line has risen higher.

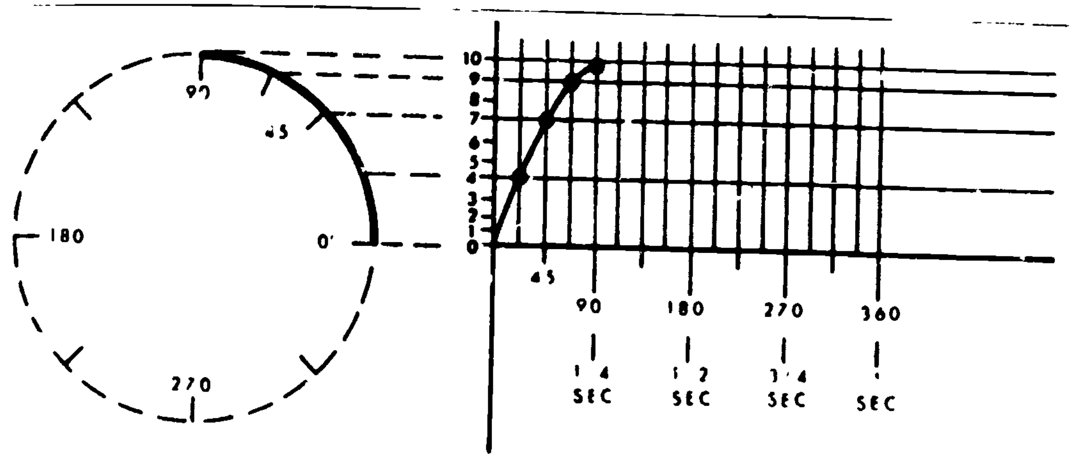
What is the voltage at this time? __________

How long has it taken for this voltage buildup? ______________

Answers to Frame 6: 7 volts
1/8 second

Frame 7

The conductor continues to rotate until it reaches 90°. (One quarter of a circle.) At this time the conductor is cutting a maximum number of flux lines and producing maximum voltage.



On the reference lines above, we have shown the voltage sine wave at its maximum height. Circle the letter before the correct answer.

1. What is the maximum voltage this generator is producing?
   a. 6 volts
   b. 8 volts
   c. 10 volts
   d. 12 volts

2. How long did it take to produce this peak (maximum) voltage?
   a. 1/8 second
   b. 1/4 second
   c. 1/2 second
   d. 3/8 second

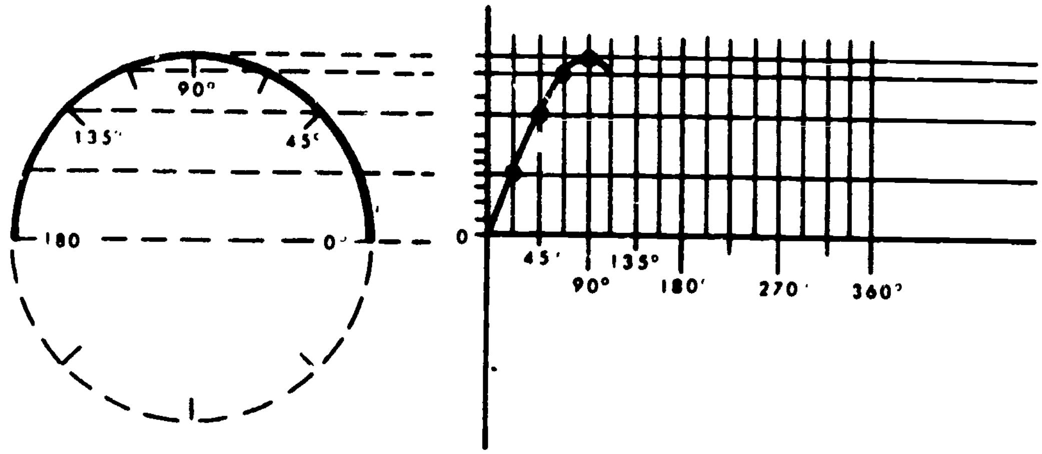
3. How many degrees did the conductor travel to produce this maximum voltage:
   a. 45°
   b. 90°
   c. 180°
   d. 270°

4. At what point on the time reference line is maximum voltage shown?
   a. 45°
   b. 90°
   c. 180°
   d. 270°

Answers to Frame 7: 1. c 2. b 3. b 4. b

Frame 8

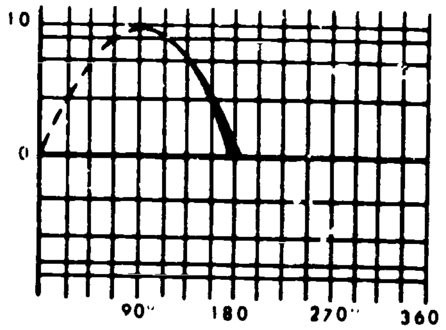
As the conductor continues to rotate to 180° of a circle, it cuts fewer and fewer flux lines, until it is finally traveling parallel with the flux lines again, cutting "0" lines of force, and producing zero voltage.



Complete the portion of the sine wave on the reference lines above to show the drop of voltage to zero volts at 180°.

1142

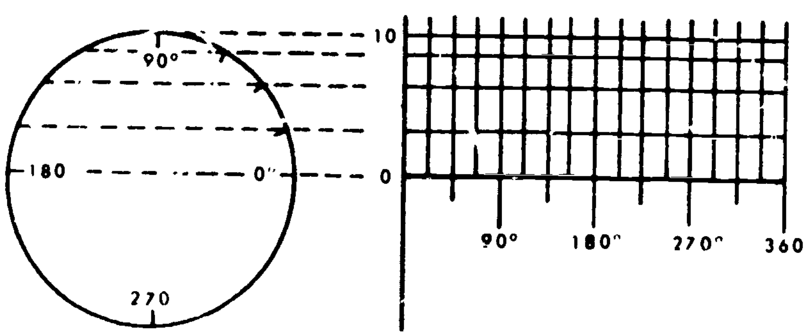
Answers to Frame 8:



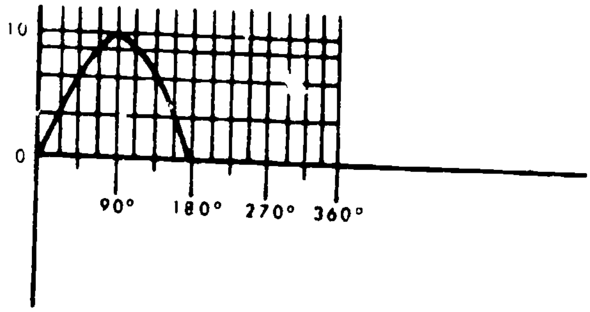
The sine wave must be drawn so that it covers the corners where the graph lines cross.

Frame 9

When the conductor has moved from 0° to 180° in a circle, it has completed one alternation (one rise and fall of voltage from zero to maximum and back to zero volts). When the sine wave for one alternation is drawn above the zero reference line, it always indicates a positive (+) alternation. Plot a sine wave on the reference lines below, showing one complete positive alternation of voltage.

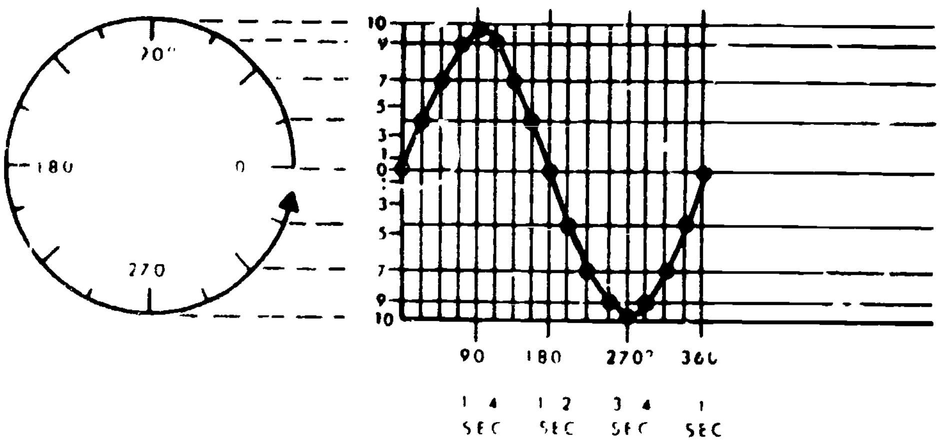


Answers to Frame 9:



Frame 10

When the rotating conductor completes the entire circle, it first moves through the flux ffield in one direction, (0° to 180°) and then cuts across the flux field in the opposite direction. (180° to 360°) This is one complete cycle (a complete sequence of events), for the conductor is now back at "0" degrees of the circle, and starting on the second cycle. The first half of this cycle produced a positive alternation. The last half of the cycle produces a negative alternation. (A reverse in the direction of induced EMF) This negative voltage buildup and collapse is always drawn below the zero reference line.



1. How long did it take for one complete cycle? ____________

2. How long did it take for one complete alternation? ____________

3. How many positive volts did the generator produce? ____________

4. How many negative volts did the generator produce? ____________

5. Would it be possible to produce more negative voltage than positive voltage with this generator? ____________

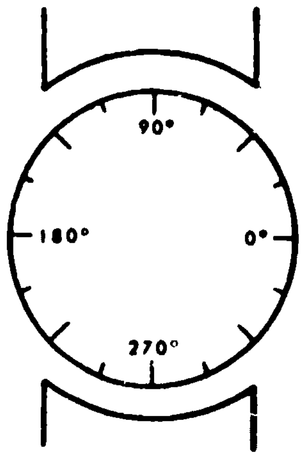
6. At what point on the graph is maximum negative voltage shown? ______°

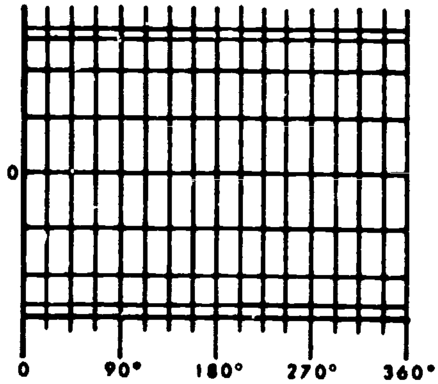
7. At what points on the graph are "0" voltages shown? ______° ______° and ______°

Answers to Frame 10: 1. 1 second 2. 1/2 second 3. 10V
4. 10V 5. no 6. 270°
7. 0 180 360

Frame 11

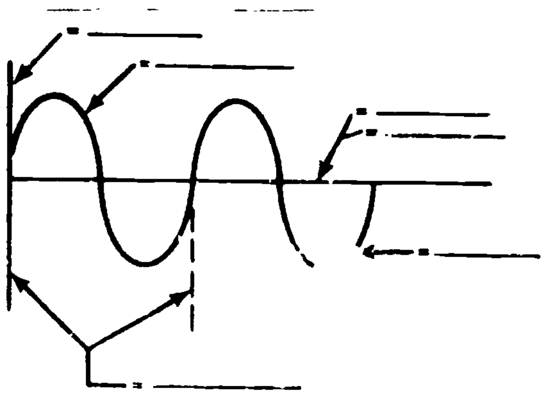
Plot a sine wave on the graph below, showing one complete cycle of AC voltage. Label each alternation as Positive or Negative.





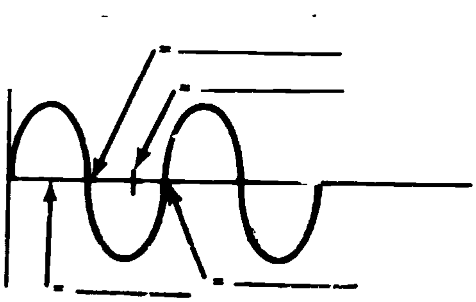
Label each of the following on the sine wave below.

Zero reference line
Time reference line
Amplitude reference line
One complete positive alternation
One complete negative alternation
One complete cycle

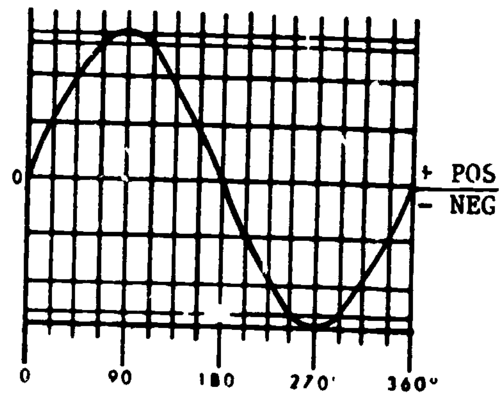


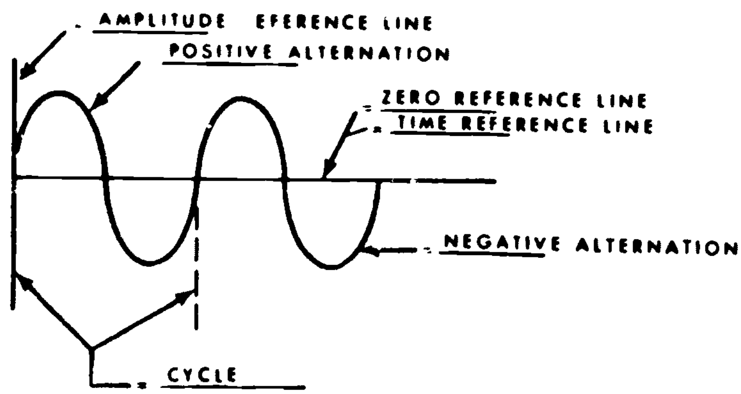
Label each of the following points on the sine wave below.

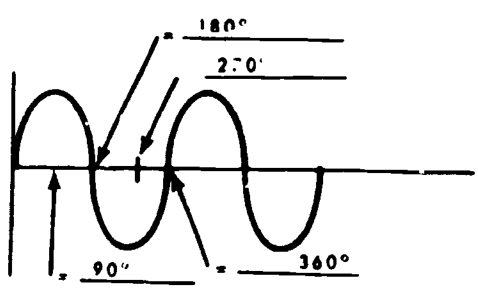
90°
180°
270°
360°



Answers tc Frame 11:





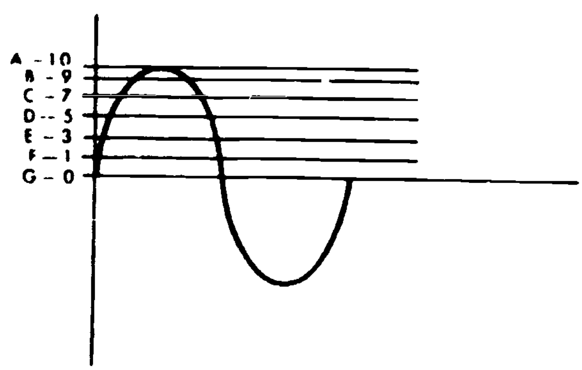


1146

As you have seen, the generation of an AC voltage produces a sine wave that is constantly changing in amplitude and periodically changing in direction. The voltage is always rising or falling and twice per cycle is at zero volts. Therefore, the amount of work a peak AC voltage can do is not equal to the amount of work an equivalent DC voltage can do. An AC voltage which reaches a maximum peak of 10 volts will do the same amount of work as 7.07 volts of DC.

Therefore, if we are referring to the effective voltage of an AC circuit it is only about 70% effective. It will only be .707 of the peak voltage.

Which of the lines across the positive alternation below represents effective voltage? (Circle the letter before the correct line)



Answer to Frame 12: c

Frame 13

Unless otherwise specified, all AC meters are calibrated to read the effective voltage of a circuit. The actual peak voltage will be higher than what your meter reads. There may be times when you will find it necessary to determine peak voltage. This can be done in one of two ways. Either divide the effective voltage by .707 or multiply by 1.414. Example:

```
          141.4               100
.707/ 100.000                   1.414
       707                      400
       2930                    100
       2828                   400
        1020                 100
         707                 141.4
        3130
```

You will find these numbers in almost any book on electricity, if you need them, so we don't expect you to memorize them.

1. AC meters (unless otherwise specified) are always calibrated to read

   a. amperage voltage.

   b. instantaneous voltage.

   c effective voltage.

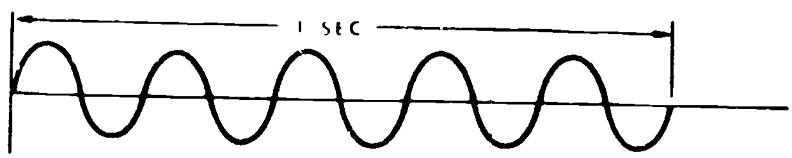
   d. peak voltage.

1148

Answer to Frame 13: c

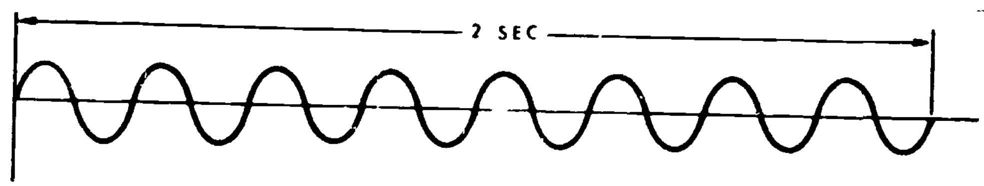
Frame 14

When our simple generator is turning at a speed of one revolution per second, it is producing one complete cycle per second (CPS). Another term for cycles per second (CPS) is Hertz. The number of cycles per second (Hertz) is called frequency. If the speed of the generator rotation were increased to 5 revolutions per second, the frequency of the output would then be 5 cps (Hertz). Frequency is always measured by the number of complete cycles in each second. The sine wave for 5 cps (Hertz) would look like this:



What is the frequency of the sine wave below?

a. 2 cps
b. 4 cps
c. 8 cps
d. 16 cps



Frequency is always measured in cycles per: (Circle the correct letter)

a. Microsecond.
b. Second.
c. Minute.
d. Hour.

Answers to Frame 14: 4 cps b

You have now completed this program. Please inform your instructor that you have completed the text.

Technical Training

Aircraft Environmental Systems Mechanic

CAPACITANCE

13 August 1982

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

RGL: 9.4

OBJECTIVE

Specify basic facts relating to capacitance with a minimum of 80% accuracy.

INSTRUCTIONS

This program presents information in small steps called "frames." After reading each frame, you are asked to select an answer or make an entry that shows that you understand the information in that frame; do so by writing your answer in the response sheet. Do not mark in this text. You may check the accuracy of your response by checking correct responses at the top of every even numbered page.

Supersedes 3ABR42331-PT-124, 9 January 1981.
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3370 TCHTG/TTGU-P - 500; DAV - 1

You have learned about electron flow in a previous text. At this point, lets see how a capacitor would effect this flow. To start with lets answer the question, "what is a capacitor?" A simple definition of a capacitor is: "an electrical device capable of storing electrical energy." It would be quite possible at this time to confuse this definition with the definition of a battery, however, there is a essential difference between the two. A battery is a chemical generator which produces electrical energy as a product of chemical activity. A capacitor is a storage device (not a generator) which stores electrons.

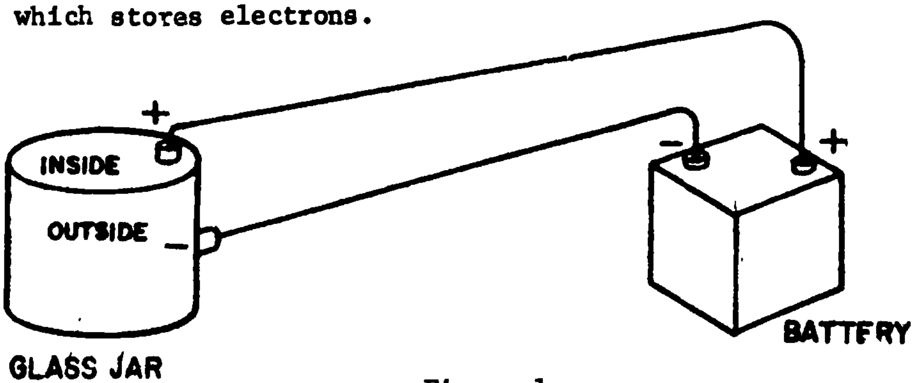


Figure 1.

Figure 1 above, illustrates a glass jar, two conductors and a battery. The inside and outside of the glass jar is wrapped with copper foil. The positive terminal of the battery is connected to the inside piece of foil. While the negative terminal is connected to the outside piece of foil. There is no connection between the two conductors as the glass jar separates them. It insulates the inside and outside copper foil from one another. We now have the three essential parts of any capacitor; two conductors, and an insulator. Each of these three parts has a specific name. The conductor (inside foil) connected to the positive post of the battery is called the <u>anode</u>. The conductor (outside foil) connected to the negative post, is called the <u>cathode</u>. The insulator (glass jar) is called the dielectric.

Answer each of the following statements either true (T) or false (F).

_____1. The insulating material in a capacitor is called a dielectric.

_____2. A capacitor is a electrical device capable of storing electrical energy.

_____3. The glass jar used in figure 1 would be an example of a conductor.

_____4. The foil used in figure 1 would be an example of a insulator.

CHECK YOUR RESPONSES AT THE TOP OF PAGE 4.

Correct Responses to Frame 1: 1. T, 2. T, 3. F, 4. F.

Frame 2

Now that we have established that there is no electrical connection between the two conductors, (or plates as they are sometimes called) lets see how the electrons flow. The electrons in the negative plate want to pass through the dielectric to the positive plate. Thus, we can say that a potential exists between the two plates. The electrons tend to accumulate on the negative plate (see figure 2A below). If we disconnect the battery, electrons will be trapped on the surface of the negative plate (see figure 2B below). Now if we touch thy leads connected to the plates, the electrons will have a way to reach the positive plate (see figure 2C below). Since electron movement will be virtually instantaneous, a spark will be produced.

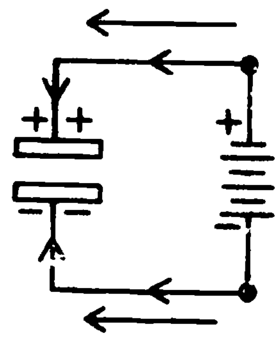


Figure 2A.

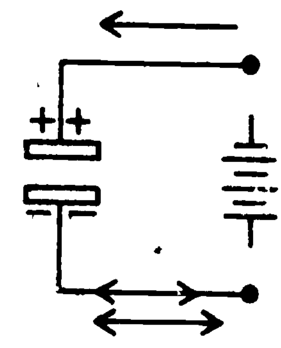


Figure 2B.

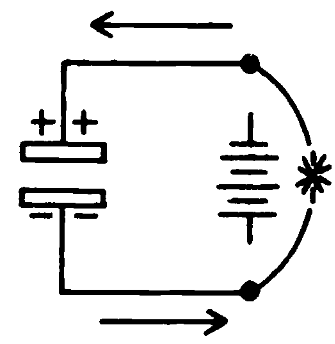


Figure 2C.

If the capacitor is removed from the circuit while still charged, we would have the equivalent of a small battery. It would not be a very useful battery however. For as soon as it was connected to a circuit, the electrons would leave the negative plate and attempt to reach the positive plate. Once this has occurred, the capacitor is discharged. Then the plates of the capacitor become two pieces of neutral metal. As the capacitor discharges through the circuit, it momentarily supplied a voltage. This voltage is almost as high as the original battery voltage due to the electron build up.

Indicate the letter of the correct response to each of the following statements.

1. When a charged capacitor is removed from a circuit, it will

   a. immediately charge.

   b. immediately discharge.

   c. retain its electrical charge.

2. A capacitor discharges with a voltage that is

   a. slightly higher than the applied voltage.

   b. slightly lower than the applied voltage.

   c. equal to the applied voltage.

SEE TOP OF PAGE 6 FOR CORRECT RESPONSES.

Correct Responses to Frame 2: 1. c, 2. b.

Frame 3

The amount of charge that a capacitor can hold depends upon how it is constructed. This capacity for storing energy in an electric field is called _capacitance_. Three separate physical properties determine the amount of ch[illegible] that any capacitor is capable of holding.

1. Plate Area - The larger the plate area, the more electrons it can hold; therefore, it has more capacitance.

2. Distance Between the Plates - When the distance between the plates is increased, the capacitance is decreased because the greater distance between the two plates reduces the attractive force between them.

3. Type of Dielectric - Electrons are easier to displace in some dielectric materials than they are in other dielectric materials. The type of dielectric, therefore, has a direct bearing on the capacitance of the capacitor.

Complete the following statement.

1. The three physical properties that determine the capacitance of a capacitor are:

   a. ______________________________.

   b. ______________________________.

   c. ______________________________.

CHECK YOUR RESPONSES AT THE TOP OF PAGE 8.

1155

Capacitors are effected more by temperature than by any other environmental conditions, except humidity. This is because capacitors are electrical devices and they store electrons. As the temperature increases, electron activity increases and as temperature decreases electron activity decreases. Therefore, when a circuit is designed to use a capacitor, the temperature factor must be taken into consideration.

NO RESPONSE REQUIRED

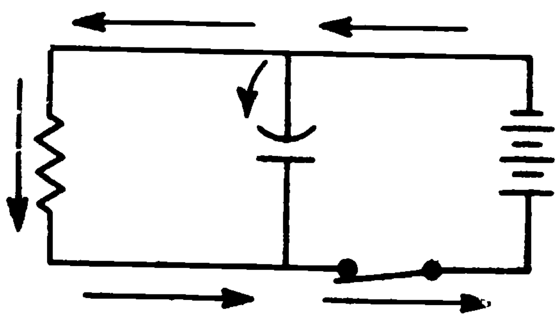
CHECK YOUR RESPONSE AT THE TOP OF PAGE 8.

Correct Responses to Frame 3: 1. a. plate area, b. distance between the plates, c. type of dielectric.

Correct Response to Frame 4: None Required.

Frame 5

A capacitor has the ability to oppose any change in voltage. To explain this more clearly, lets connect a capacitor in parallel with a resistor in a circuit. The symbol most commonly used to represent a capacitor is —|(— (Positive —| , Negative (—)



When the switch is closed in the circuit above, voltage causes current to flow through the resistor. Full voltage is applied across both the resistor and the capacitor. The capacitor is being charged at the same time that current starts flowing through the resistor. When the capacitor has been fully charged (to a voltage almost as high as the battery voltage), there will no longer be a flow of electrons to the negative plate of the capacitor. Now all the electron flow will be through the resistor. (This applies to a DC circuit only.)

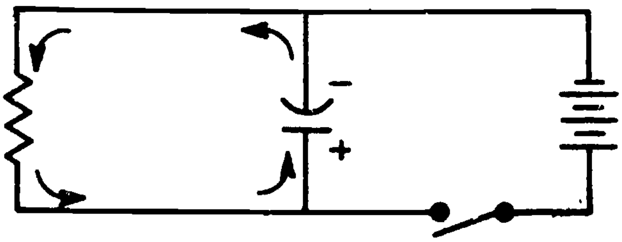
Indicate the letter of the correct response to each of the following statements.

1. A capacitor has the ability to oppose changes in
   a. current flow.
   b. voltage.
   c. frequency.
   d. resistance.

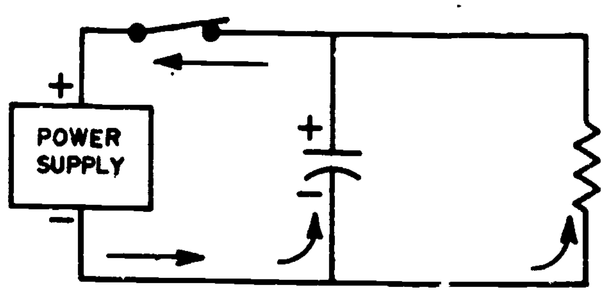
2. —|(— is the symbol for
   a. a capacitor.
   b. an inductor.
   c. reactance.
   d. impedance.

CHECK YOUR RESPONSES AT THE TOP OF PAGE 10.

When the switch in the circuit below is opened, after the capacitor has been charged, the battery voltage is removed from the circuit. Voltage across the resistor is not removed though, because of the charge on the capacitor. The capacitor discharges across the resistor keeping the voltage applied for a very short time. The capacitor acting like a battery, opposes the decrease (change) of voltage across the resistor. This circuit was used for demonstration purposes only. A capacitor is not needed to keep the voltage constant across the resistor because the battery voltage does not fluctuate.



Suppose we need a constant voltage across a resistor, and the power supply fluctuates from 100 volts to 110 volts. Would a capacitor in this type circuit help us obtain a steady voltage? It certainly would! As the voltage from the source rises from 100 to 110 volts, the capacitor would continue to charge to the higher voltage. Now when the applied voltage drops back to 100 volts, the capacitor discharges electrons through the resistor. This action helps stabilize the voltage across the resistor.



Answer each of the following statements either true (T) or false (F).

_____. The capacitor in the above circuit charges when the applied voltage increases.

_____2. The capacitor discharges through the resistor when the applied voltage decreases.

_____3. Fluctuations in applied voltage are not opposed by the capacitor.

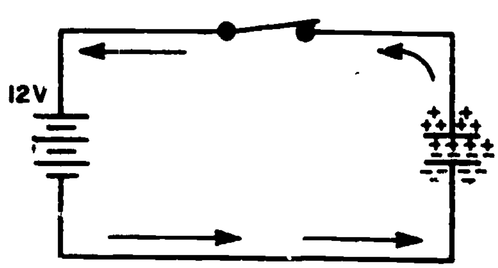
CHECK YOUR RESPONSES AT THE TOP OF PAGE 10.

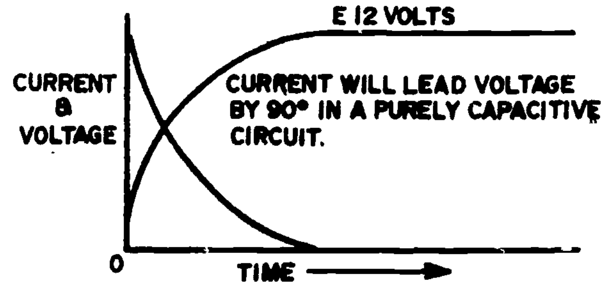
Correct Responses to Frame 5: 1. b, 2. a.

Correct Responses to Frame 6: 1. T, 2. T, 3. F.

Frame 7

A capacitor in a circuit causes current to lead the voltage. That is, the capacitor causes a shift in phasing between the current and voltage. This shifting action can be explained with the circuit and graph shown below.





VOLTAGE-CURRENT RELATIONSHIP DURING CHARGING OF A CAPACITOR.

Before the switch in this circuit is closed, the capacitor has a neutral charge. In other words, its voltage is zero. As soon as the switch is closed, the 12 volts from the battery causes a <u>maximum</u> flow of current. As the current flow continues, the voltage at the capacitor increases. As the charge of the capacitor builds up, the difference in potential between the battery and capacitor plates becomes less. This causes a progressively decreasing current flow. When the capacitor is fully charged (maximum voltage), the current flow will stop completely (minimum current).

The graph shows the voltage-current relationship at the capacitor during the charging time. The vertical line at the left of the graph represents the voltage-current condition in the capacitor at the instant the switch is closed. The current (electron) flow is at maximum, and the voltage is at minimum. As the voltage increases, the current flow decreases. When the voltage has reached maximum (near 12 volts), the current flow has dropped to zero. If we compare this action with one-half cycle in an AC circuit, we can see that the capacitor causes the current to lead the voltage.

Answer each of the following statements either true (T) or false (F).

_____1. At the time that the capacitor is fully charged (maximum voltage) the current flow is also maximum.

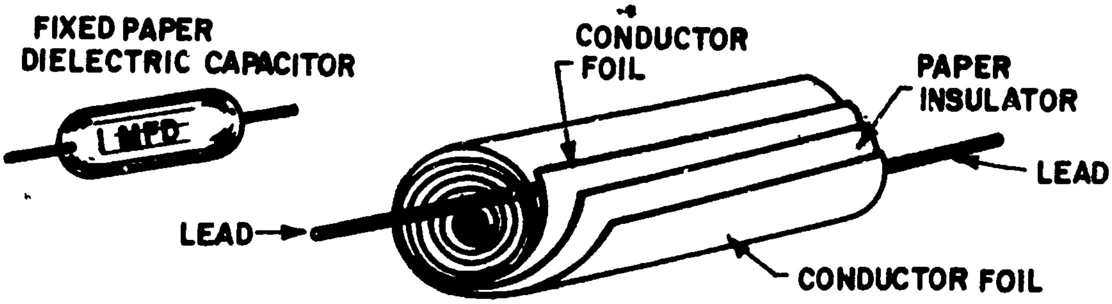
_____2. The capacitor causes current to lead the voltage in the circuit.

_____3. At the instant that the capacitor is starting to charge, the current will be at maximum.

CHECK YOUR RESPONSES AT THE TOP OF PAGE 12.

The unit of measurement for a capacitor is the farad. The letter "C" is the symbol of capacitance. If one coulomb (6.28×10^{18} electrons) will charge the capacitor to a one volt charge, the capacitor has one farad of capacitance. The farad itself is too large for practical use. Therefore, the unit of measurement actually used is microfarad. The microfarad is equal to one-millionth of a farad and is abbreviated mfd or µfd. The micromicrofarad is also used. It is equal to one-millionth of a microfarad and is abbreviated mmfd or pf.

Most capacitors also have a DC and an AC voltage rating stamped on them. This is to insure the capacitor will not be used in a circuit where its voltage limitations could be exceeded. Other capacitors may have color coding to designate the size and voltage rating.



Answer each of the following statements either true (T) or false (F).

_____1. The units of measurement for capacitance are the microfarad and the micromicrofarad.

_____2. An abbreviation for the microfarad is µfd.

_____3. The voltage ratings stamped on the capacitors should be observed when the capacitors are connected in circuits.

CHECK YOUR RESPONSES AT THE TOP OF PAGE 12.

Correct Responses to Frame 7: 1. F, 2. T, 3. T.

Correct Responses to Frame 8: 1. T, 2. T, 3. T.

Frame 9

There are many different types of capacitors. Let's briefly describe a few different types so that you will be familiar with them.

One common type of capacitor is made by placing a long, narrow sheet of oiled paper between two similar sheets of tinfoil. Then another sheet of oiled paper is placed against the outside surface of each tinfoil sheet. These layers of tinfoil and paper are then rolled up and sealed in a cardboard tube. Two terminals are connected to the tinfoil and one extended to the outside of the tube.

The amount of voltage that can be applied to such a capacitor depends upon the insulating ability of the paper (dielectric). In other words, the dielectric of a capacitor determines the highest voltage that the capacitor can withstand without breaking down. When the plates are charged, electrons attempt to move from the negative plate to the positive plate. But, the dielectric prevents this from happening. However, depending upon the applied voltage and the type of dielectric's own electrons may break loose and move to the positive plate. This reduces the efficiency of the capacitor. Therefore, it is desirable to use dielectrics with high "electron holding" characteristics. This electron-holding ability of a dielectric is indicated by a numerical value which is called the "dielectric constant." The dielectric constant value compares the electron-holding quality of a dielectric, to a comparable insulating layer of dry air. For example, a nonconductor with a dielectric constant of 6, would be 6 times as good a dielectric as a layer of air of equal thickness.

The higher the dielectric constant, the better the quality of the dielectric. The dielectric constant rating is so important that capacitors are classified by the kind of dielectric used. The general types of capacitors, classified by dielectric, are; air, compressed-gas, vacuum, mica, ceramic, glass, oil, oil-paper, caster oil paper, chlorinated diphenyl-paper, and wax paper. The castor oil paper type of capacitor is one of the better paper capacitors.

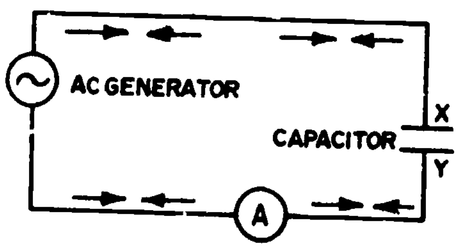
Answer each of the following statements either true (T) or false (F).

_____1. The dielectric of a capacitor determines the highest voltage the capacitor can withstand without breakdown.

_____2. Capacitors are distinguished by the type of dielectric they contain.

CHECK YOUR RESPONSES AT THE TOP OF PAGE 14.

We have previously stated that DC voltage, when applied to a capacitor, causes current to flow only until the capacitor is charged. However, if an alternating (AC) source of power is substituted the capacitor will act differently. We stated (in a previous text) that one AC cycle would be half positive and the other half negative. As shown, in the next figure, current flow from the AC source will alternate. On the first cycle, Y would be positively charged, while X would receive a negative charge. On the next cycle, X would receive the positive charge and Y the negative charge. This alternation will continue with each cycle. No current will flow through the insulator (dielectric) between the capacitor plates. However, current will flow in the remainder of the circuit in between cycles. The amount of current flow, within the circuit, will increase if one or more of the following occurs: (1) The amount of applied voltage is increased, (2) the capacitor is replaced by a larger capacitor, or (3) the frequency of the applied voltage is increased. A capacitor, for an AC circuit, must be carefully chosen. The capacitor chosen must change fast enough to store the needed energy. Yet, it must discharge fast enough to avoid bucking the next cycle of current.



Answer each of the following statements either true (T) or false (F).

____1. When a capacitor has AC applied to it, the charge on the capacitor constantly reverses.

____2. When DC voltage is applied to a capacitor, the charge on the capacitor constantly reverses.

____3. Current flow in the above circuit will change if the frequency of the applied voltage changes.

CHECK YOUR RESPONSES AT THE TOP OF PAGE 14.

Correct Responses to Frame 9: 1. T, 2. T.

Correct Responses to Frame 10: 1. T, 2. F, 3. T.

Frame 11

Capacitance may be compared to the elasticity, (springness) of a punching bag. Before the blow is delivered, the bag can be considered as being uncharged. Just as a capacitor is said to be uncharged before it has been connected across a power source.

Delivery of the boxer's punch causes the punching bag to move outward. The extent of movement depends upon the force exerted. Similarly, a capacitor accepts a charge. The strength of the charge is determined by the applied electrical energy.

The punching bag reaches the maximum distance it can move, in a given direction, because of the elasticity of its supports. This extreme distorted position represents stored energy, that flings the bag backward with almost equal force. This action may be compared to the action of the energy stored within a charged capacitor which is released when the capacitor is discharged.

Indicate the correct response to the following statements.

1. The strength of the capacitor's charge is determined by what?

   a. Magnetic field.

   b. Circuit resistance.

   c. Applied electrical energy.

   d. Current.

2. When is a capacitor said to be uncharged?

   a. After it has been connected to an emf.

   b. When it is gathering electrons.

   c. Before an emf is connected to it.

   d. When current is flowing.

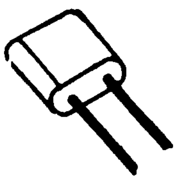
CHECK YOUR RESPONSES AT THE TOP OF PAGE 16.

1163

Below are shown some different types of capacitors that are used in various circuits. Study the illustrations and become familiar with these different types of capacitors.

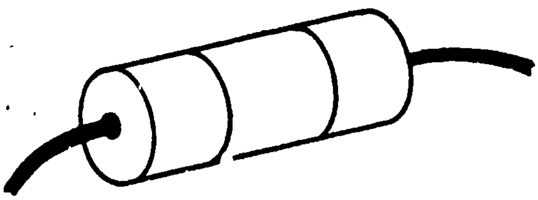
ELECTROLYTIC CAPACITOR

Most economical for AC motor starting circuits. Used with a centrifugal switch.



I MFD 100VOLT MINIATURE ELECTROLYTIC CAPACITOR

Most economical for AC motor starting circuits. Used with a centrifugal switch.



TUBULAR PAPER CAPACITOR

Has ability to withstand high voltages.

NO RESPONSE REQUIRED

CHECK YOUR RESPONSE AT THE TOP OF PAGE 16.

1164

Correct Responses to Frame 11: 1. c, 2. c.

Correct Response to Frame 12: None Required.

Frame 13

Answer each of the following statements either true (T) or false (F).

____1. The insulating material in a capacitor is called a dielectric.

____2. The size of the plates, the distance between the plates, and the type of dielectric determine the capacitance of a capacitor.

____3. Capacitance is measured in henries.

____4. When a charged capacitor is removed from a circuit, it immediately discharges.

____5. A capacitor has the ability to oppose any change in voltage.

____6. A capacitor causes current to lead the voltage.

____7. The voltage ratings on capacitors need not be observed when connecting the capacitors in AC circuits.

____8. Capacitors are distinguished by the type of dielectric they contain.

____9. When an AC voltage is applied to a capacitor, the charge on the capacitor constantly reverses.

____10. You should use caution when working with capacitors because of their ability to store an electrical charge.

CHECK YOUR RESPONSES AT THE TOP OF PAGE 17.

1165

Correct Responses to Frame 13: 1. T, 2. T, 3. F, 4. F, 5. T, 6. T, 7. F, 8. T, 9. T, 10. T.

1166

Technical Training

Aircraft Environmental Systems Mechanic

INDUCTANCE

9 January 1981

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

 RGL: 10.0

OBJECTIVE

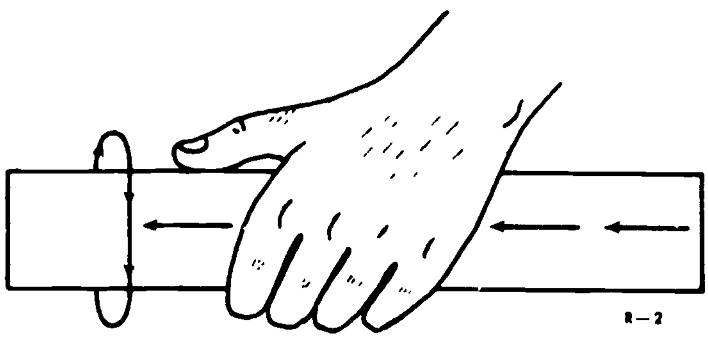
Identify basic facts, construction characteristics and principles relating to inductance with a minimum of 80% accuracy.

INSTRUCTIONS

This programmed text presents information in small steps called "frames." After reading each step, you are asked to complete a statement or respond as directed. Use a piece of paper or a card as a mask to cover the printed material. Slide this mask down the page until you expose the top of a short row of slashes (/////////////). One small step is now exposed for your viewing. Read the material presented and make your response in the space(s) provided. Slide the mask down and compare your answer with the correct one. If you are wrong, read the frame again; if you are correct, go on to the next frame.

Supersedes 3ABR42331-PT-125, 23 May 1980.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 1000; TTVSA - 1

When current flows through a conductor, a magnetic field is created around the conductor. If the current increases, the magnetic field expands. To determine the direction that the magnetic field is rotating around the conductor, the left hand rule is used. The left hand rule is demonstrated below.



LEFT HAND RULE

Thumb Points In Direction of Current Flow and
Fingers Show Direction of the Rotating Magnetic Field.

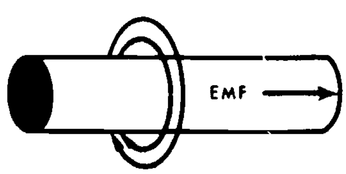
Whenever the direction of current is known, the direction of the rotating magnetic field can be found.

Whenever the direction of the magnetic field is known, the direction of the current flow can be found.

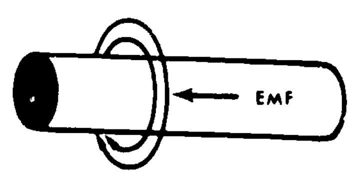
Circle the letter of the correct response to the following statements.

1. Which diagram below shows the correct direction of current flow?

a.

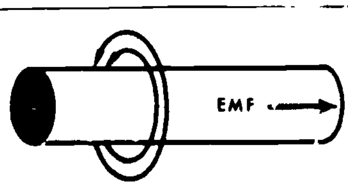


b.

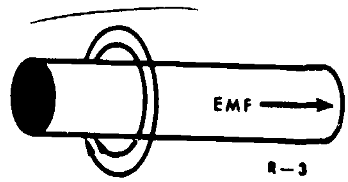


2. Which diagram below shows the correct direction of the rotating magnetic field?

a.



b.



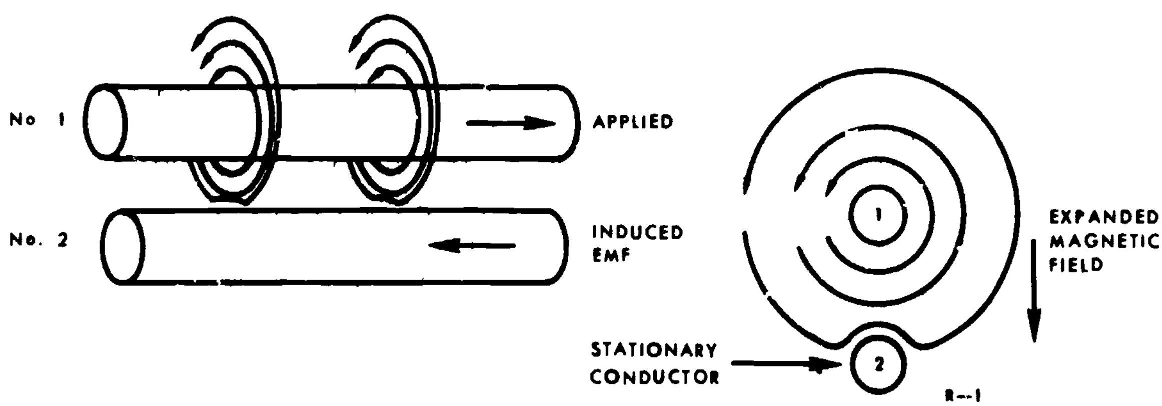
//////

Answers to Frame 1: 1. b. 2. a.

Frame 2

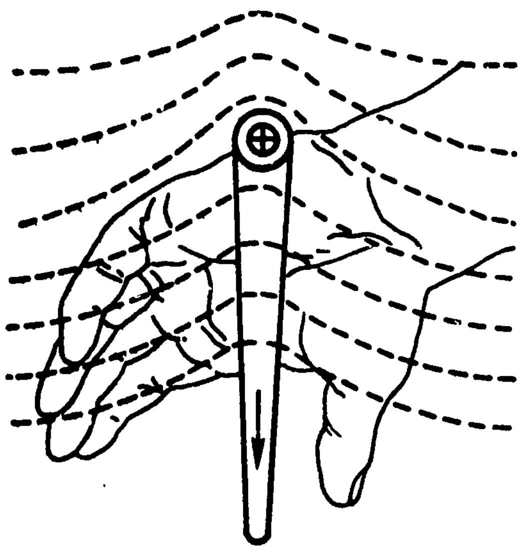
When two separate conductors are parallel to each other (adjacent) and one has current flowing through it, an electromotive force is induced in the adjacent conductor. Remember, to create an EMF, there must be a conductor, a magnetic field, and relative motion. The wires serve as conductors, as current flow increases through the first conductor an expanding magnetic field is created which cuts across the adjacent (No. 2) conductor, thereby producing an EMF. When current flow in one conductor produces an EMF in another conductor it is called mutual inductance. By using the left hand rule, we find that the EMF that is induced in the second (adjacent) conductor is in the opposite direction of the applied EMF.

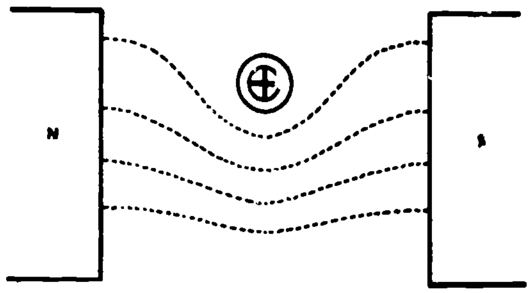
MUTUAL INDUCTANCE



Let's look at these same two conductors from an end view. Curving the fingers of the left hand around No. 2 conductor the way that the field is bent, you can see that the thumb of your left hand indicates the induced EMF to be in the opposite direction as the applied EMF in the No. 1 conductor.

Review the principle of operation of a basic generator as shown here. Follow the bent magnetic lines around the conductor with the fingers of your left hand and you see the current is flowing into the conductor away from you.





Current Flow in Wire Moving through a Magnetic Field

Notice that the conductor moves across the magnetic field in a generator, but isn't the result the same whether the conductor moves across the field or the field moves across a stationary conductor? Either way an EMF will be produced. Mark the following statements true (T) or false (F).

____1. When the conductor moves parallel with the magnetic field, no EMF will be produced.

____2. If a magnetic field moves across a conductor, an EMF will be produced.

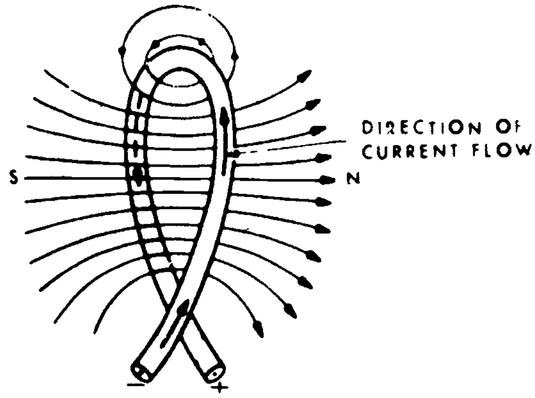
____3. The EMF that a conductor induces into another conductor is called mutual inductance.

//////

Answers to Frame 2: 1. T 2. T 3. T

Frame 3

A single conductor, when wound into loops, can induce an EMF within itself. When this occurs, it is called self-inductance. Also, when a conductor is wound into loops to form a coil, the strength of the overall magnetic field greatly increases. The amount of induced EMF therefore would be much greater.



Notice in the loop shown above, that the magnetic lines inside the loop aid each other to create a strong overall magnetic field. Consequently, when many loops form a coil, the self-inductance would be much greater. The letter symbol used to indicate inductance is "L." You may see the symbol ~~m~~ in diagrams to represent a coil (inductance). The unit of measurement for inductance is the "henry."

Circle the letter of the correct answer to the following statements.

1. Self-inductance is a voltage produced
   a. by a chemical method.
   b. in a conductor by current flow in the same conductor.
   c. in a conductor by current flow in a different conductor.
   d. by mechanical means.

2. The letter symbol used for inductance is
   a. V.
   b. A.
   c. L.
   d. I.

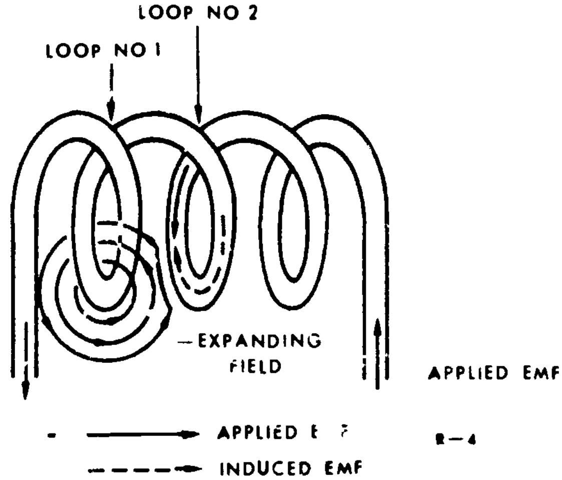
3. The amount of inductance in a single conductor can be greatly increased by
   a. forming the conductor into loops.
   b. increasing the length of the conductor.
   c. decreasing the length of the conductor.
   d. decreasing the applied EMF of the conductor.

4. The unit of measure for inductance is the
   a. henry.
   b. farad.
   c. ohm.
   d. amp.

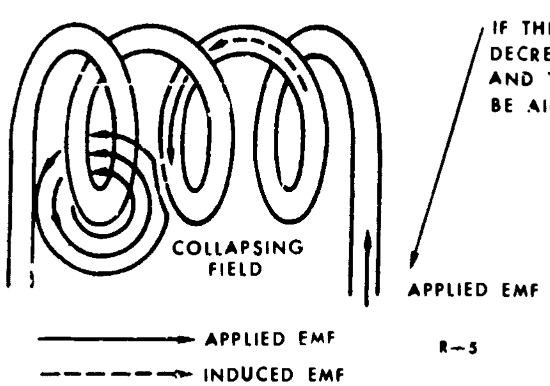
1172

Answers to Frame 3: 1. b 2. c 3. a 4. a

Frame 4



Looking at one expanding field as it cuts an adjacent conductor, (as shown above) we see that an induced EMF is produced which opposes the applied EMF. This action would be multiplied many times over if all the magnetic fields of all the loops were taken into consideration. Upon further examination, we can see that the induced EMF would also be created when the magnetic field collapses, but the induced EMF would now be in the opposite direction. A coil, therefore, has the ability to oppose any change in current flow. Notice that when current starts to increase in the coil, an expanding magnetic field produces an induced EMF which opposes the build up of current. If the current in the coil tends to decrease, (as shown below) the expanded field collapses and creates a counter EMF that would try to keep current flowing in the coil.



Mark the following statements true (T) or false (F).

_____1. A coil has the ability to oppose any change in current flow.

_____2. The property of a coil to produce an induced EMF is called inductance.

_____3. A coil will only oppose any change in current flow when its magnetic field is expanding.

_____4. Energy is stored in the magnetic field of a coil.

//////

Answers to Frame 4: 1. T 2. T 3. F 4. T

Frame 5

When an inductor is connected to a source of alternating voltage to form an inductive circuit, the current through the inductor lags the voltage across the inductor. This means that the current does not reach its maximum value until after the voltage has reached its maximum value. The current lags the voltage in a purely inductive circuit by 90°.

Mark the following statements true (T) or false (F).

____1. The current in an inductor does not reach its maximum value until after the applied voltage has reached maximum.

____2. In a pure inductive circuit, the current lags the voltage by 90°.

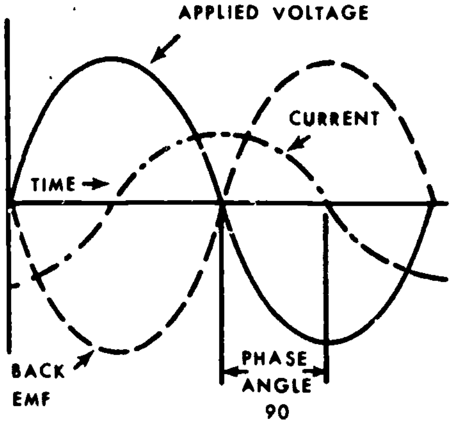
//////

1174

Answers to Frame 5: 1. T 2. T

Frame 6

Suppose that current is starting to flow through a coil. The current causes an expanding magnetic field which causes a back EMF to be induced in the coil. The polarity of the back EMF is opposite to the polarity of the applied voltage across the coil, and it, therefore, tends to oppose the increase in current. The result is that the rise in current flow is caused to lag behind the rise in voltage.



CURRENT LAGS VOLTAGE BY 90

R—7

The illustration above shows that the induced (back) EMF is always in opposition to the applied voltage, thereby causing current to be minimum when the applied voltage is at its maximum value. Notice that current in the coil does not reach its maximum value until the applied voltage has dropped to zero. You can clearly see that there is 90° difference between the applied EMF and current flow in the coil.

//////

No Response Required.

Frame 7

As current increases through the coil, energy is stored in the expanded magnetic field. When the applied voltage starts to decrease from maximum positive, the stored energy is returned to the circuit in the form of current flow. This current flow is actually greater than the current flow caused by the applied EMF alone.

When the negative portion of the applied voltage occurs, a similar action takes place and maximum current will flow in the reverse direction at the instant that the voltage has decreased to zero from its maximum negative direction.

Mark the following statements true (T) or false (F).

_____1. The applied voltage on a coil causes an induced EMF that is 180° out of phase with the applied voltage.

_____2. The energy stored in the magnetic field can cause a greater current to flow than the applied voltage does alone.

_____3. Current leads voltage by 90° in an inductor.

//////

1176

Answers to Frame 7: 1. T 2. T 3. F

Frame 8

Some of the main physical characteristics of a coil that determine the amount of its inductance are:

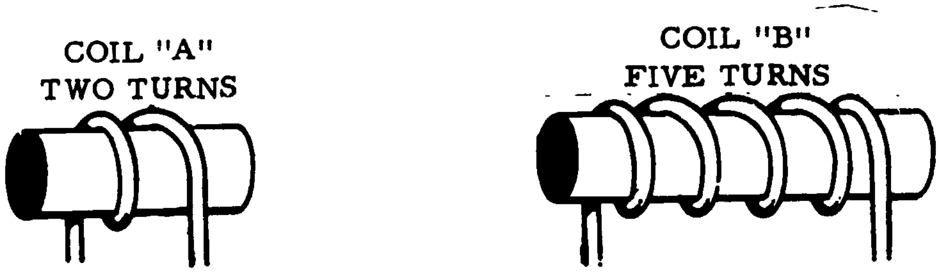
1 - number of turns (loops)

2 - spacing of the turns

3 - type of core

Let's first discuss the effect that the number of turns has on inductance.

Assume that a coil has a given number of turns and is carrying a definite amount of alternating current. If some turns are added to the original turns, the current flow through the total number of turns will create a stronger magnetic field. This stronger magnetic field will induce a greater back EMF in the original turns. In addition the stronger field also cuts the added turns. Both of these factors cause an increase in inductance. Look at the illustration below for a comparison of two coils with different numbers of turns.



Circle the letter of the correct response to the following statements.

1. If the amount of current flow is the same in the coils above, coil "B" has
   a. less inductance than coil "A."
   b. more inductance than coil "A."
   c. a weaker magnetic field than coil "A."
   d. the same strength magnetic field as coil "A."

2. The inductance of a coil can be increased by
   a. decreasing the current flow through it.
   b. increasing the current flow through it.
   c. adding more turns.
   d. decreasing the number of turns.

//////

Frame 7

As current increases through the coil, energy is stored in the expanded magnetic field. When the applied voltage starts to decrease from maximum positive, the stored energy is returned to the circuit in the form of current flow. This current flow is actually greater than the current flow caused by the applied EMF alone.

When the negative portion of the applied voltage occurs, a similar action takes place and maximum current will flow in the reverse direction at the instant that the voltage has decreased to zero from its maximum negative direction.

Mark the following statements true (T) or false (F).

____1. The applied voltage on a coil causes an induced EMF that is 180° out of phase with the applied voltage.

____2. The energy stored in the magnetic field can cause a greater current to flow than the applied voltage does alone.

____3. Current <u>leads</u> voltage by 90° in an inductor.

//////

1178

The third main factor that affects inductance is the type of core being used. The inductance of a coil is directly proportional to the permeability of the core. (Remember that permeability is the ease with which a material passes magnetic lines of force.) Typical nonmagnetic core coils are those that are wound on hollow porcelain cylinders and hollow cardboard cylinders. The core material in these coils is air. Magnetic-core coils are wound on cores of soft iron. Since the soft iron core is very permeable, it provides an easy path for the magnetic lines and allows a much stronger magnetic field to build up. A greater back EMF is induced in the iron core coil as compared to the air core coils.

Place the letter of the statement in Column A in the appropriate spaces of Column B.

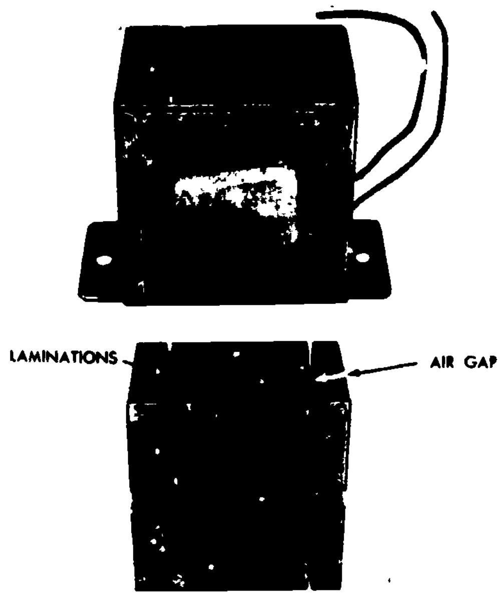
Column A		Column B
A - Increases inductance	____1.	Removing the iron core from a coil.
	____2.	Using close-winding method rather than space-winding.
B - Decreases inductance	____3.	Decreasing the number of turns of the coil.
	____4.	Winding the turns farther apart.
	____5.	Winding the turns in layers.
	____6.	Using a soft iron core instead of an air core.

//////

Answers to Frame 10: 1. B 2. A 3. B 4. B 5. A 6. A

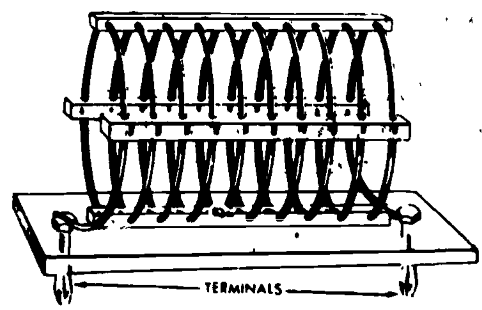
Frame 11

Familiarize yourself with the illustrations of various coils below. Sometimes the word "choke" is used interchangeably with the word "coil."

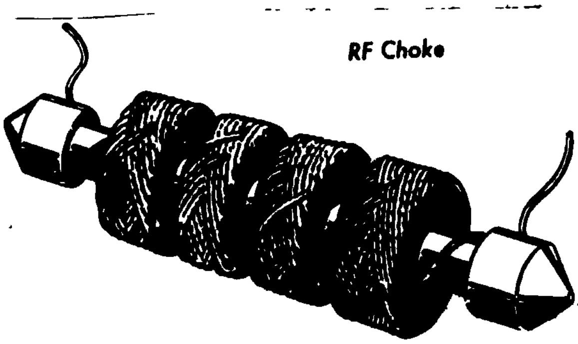


Laminated Iron-core Coil

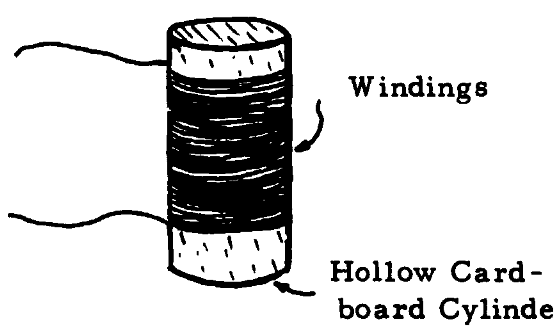
Fixed Tuning Coil



AIR CORE COIL



RADIO FREQUENCY COIL



COMMON TYPE AIR CORE COIL

//////

No Response Required.

Frame 12

Mark the following statements true (T) or false (F).

____1. The left hand rule can be used to determine the direction of a rotating magnetic field around a conductor if the direction of current flow is known.

____2. An inductor causes current to lag voltage by inducing a back EMF.

____3. The EMF that a coil induces within itself is called mutual inductance.

____4. A coil has the ability to oppose any change in current flow because it produces an induced EMF.

____5. The ability of a coil to produce an induced EMF is called capacitance.

____6. Inductance is measured in units called henries.

____7. In a pure inductive circuit, the current lags voltage by 90°.

____8. The current in a coil does not reach its maximum value until <u>after</u> the applied EMF has reached maximum.

____9. The amount of inductance of a coil is determined by its physical characteristics such as number of turns, spacing of turn, and type of core material.

____10. Energy is stored in the expanded magnetic field of a coil.

____11. Coils having soft iron cores provide less inductance than a comparable coil that has a core of air.

____12. When energy that is stored in the magnetic field of a coil is returned to the circuit, a greater current is caused to flow than can be caused by the applied EMF alone.

//////

Answers to Frame 12: 1. T 2. T 3. F 4. T 5. F

6. T 7. T 8. T 9. T 10. T

11. F 12. T

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Technical Training

Aircraft Environmental Systems

AC MOTORS

9 January 1981

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

RGL: 10.2

OBJECTIVE

Identify components of an AC motor when given their purpose with a minimum of 80% accuracy.

INSTRUCTIONS

NOTE: BEFORE PROCEEDING, REMOVE THE RESPONSE SHEET AT THE BACK OF THIS TEXT. ENTER YOUR ANSWERS ON THE REMOVED RESPONSE SHEET

This programmed text presents information in small steps called frames. Each frame is followed by some form of questioning. Immediately after reading each frame, you will make the required response in the response sheet. DO NOT MARK IN THE TEXT. Check your answer each time with the correct answer shown at the top of each even numbered page. If you have made the correct response go on to the next frame. If you have made an incorrect response, reread the frame before going on to the next frame. Be sure you understand the material presented in each frame before continuing. Do not hurry!

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Frame 1

Since alternating current (AC) is the most widely used form of power, most modern motors operate from an AC source. There are two general types of AC motors used on aircraft. They are called synchronous and induction motors. Either type of motor may use single or multiphase power. The induction motor is more often used because of its simple construction and reliability.

In the response sheet mark the following statements (T) true or (F) false.

1. Two types of AC motors are induction and synchronous.

2. Induction type AC motors use single phase power only.

3. The induction motor is often used.

CHECK YOUR RESPONSE AT THE TOP OF PAGE 4.

Frame 2

For the purpose of this text we will be primarily concerned with the two parts of an AC motor. The parts are the ROTOR and the STATOR. When assembled together inside a case they form an AC motor. It is the action of these two parts that cause the motor to operate.

NO RESPONSE REQUIRED

Frame 3

The stator is mounted in a fixed position inside the motor case. Although the stator doesn't move its purpose in an AC motor is to create a rotating magnetic field for motor operation. The stator consists of a laminated iron field pole assembly with insulated copper wire wound on the field poles. The Field pole assembly is installed in a housing. When power is applied to the STATOR windings the stator is said to be EXCITED.

In the response sheet mark the following statements (T) true or (F) false.

1. The stator of an AC motor does not move.

2. The stator creates a rotating magnetic field.

3. Th. stator consists of two copper poles and an iron housing.

CHECK YOUR RESPONSE AT THE TOP OF PAGE 4.

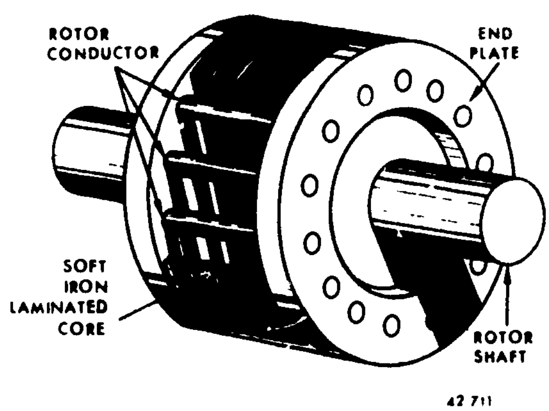
CORRECT RESPONSES TO FRAME 1: 1. T, 2. F, 3. T.

CORRECT RESPONSES TO FRAME 2: None Required.

CORRECT RESPONSES TO FRAME 3: 1. T, 2. T, 3. F.

Frame 4

The ROTOR is the portion of the AC motor that turns. There are two types of rotors used in AC motors. They are the SQUIRREL CAGE and the WOUND. The squirrel cage is more often used in environmental systems work so we will confine our discussion to it. (See illustration). The squirrel cage rotor has two end plates made of soft iron, a good conducting material. These plates are connected together by iron rods (rotor conductors). The iron rods are imbedded in the end plates to provide better conduction of the magnetic lines of force. The rotor of an induction motor does not have any electrical connections. The rotor has current flowing through it. Current flowing in the rotor is INDUCED current from the stator. The induced current in the rotor will create a magnetic field in the rotor. The magnetic field in the rotor follows the rotating magnetic field of the stator.



Fill in the missing information, in the response sheet, for the following statements.

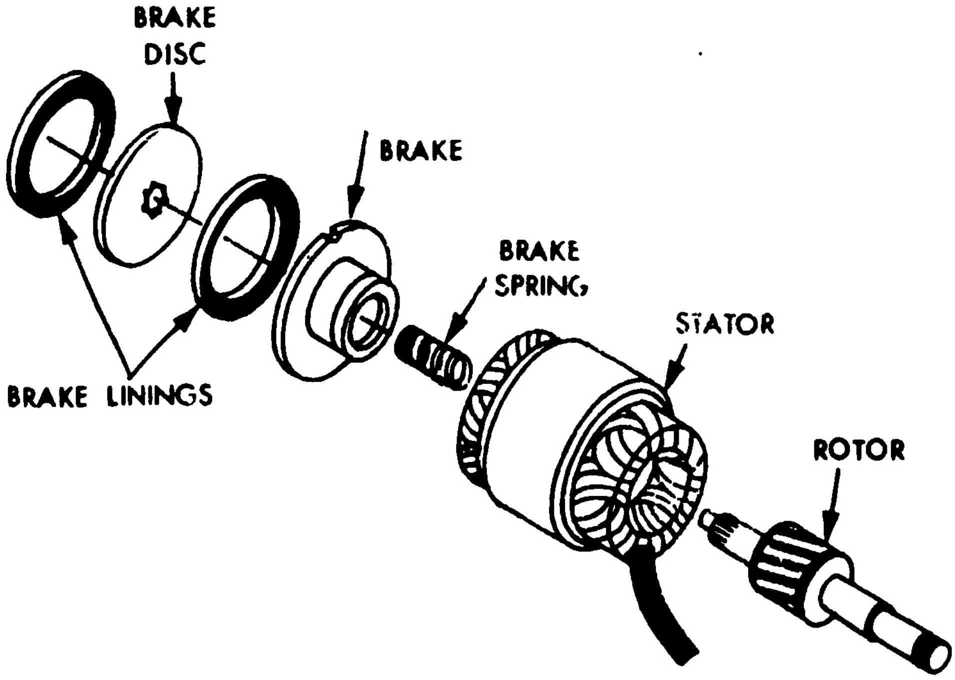
1. The current flowing in the rotor is ______________ current.

2. The rotating magnetic field of the ____________ will cause the ________ to turn.

3. The rotor of an induction motor doesn't have ___________ ________.

CHECK YOUR RESPONSES AT THE TOP OF PAGE 6.

Since induction motors used in environmental systems work are primarily reversible type, a brake assembly is sometimes used. The brake is designed to prevent overtravel (coasting) of a motor after current has been turned off. The brake is spring loaded ON and electrically disengaged. The illustration shows one type of brake with the rotor and stator. The unit uses the magnetic field of the rotor to disengage the brake. When power is applied the brake disengages and the motor turns. When power is stopped the spring pushes the brake against the brake disc stopping the motor. On AC motors that do not use a brake, a limit switch that you studied in the text on DC motors is used.



In the response sheet mark the following statements (T) true or (F) false.

1. Most AC motors used in environmental systems work are reversible.

2. The brake is spring loaded ON and electrically disengaged.

3. Some AC motors use limit switches to prevent overtravel.

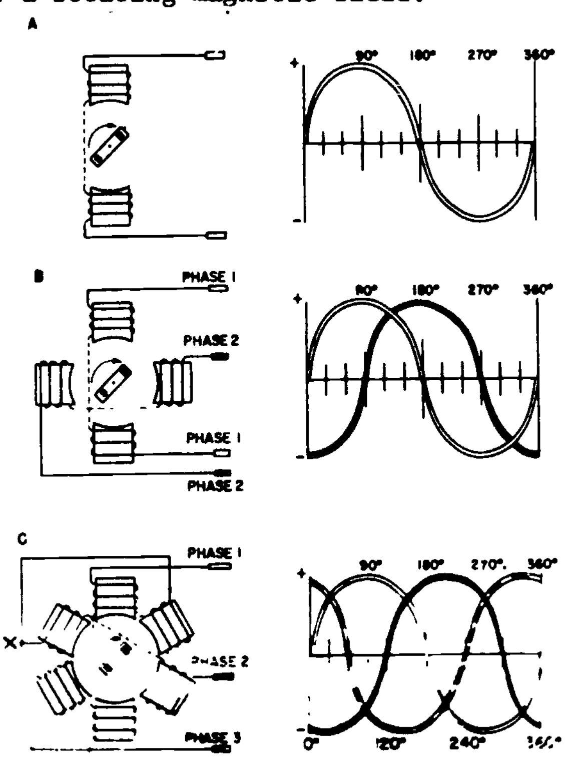
CHECK YOUR RESPONSES AT THE TOP OF PAGE 6.

CORRECT RESPONSES TO FRAME 4: 1. induced, 2. stator, rotor, 3. electrical connections.

CORRECT RESPONSES TO FRAME 5: 1. T, 2. T, 3. T.

Frame 6

To understand how an AC motor operates, an understanding of AC phase relationships is necessary. The illustration shows the sine waves for single, two- and three-phase power. Figure A shows the sine wave for single-phase power, you studied in an earlier text. Figure B shows the sine wave for two-phase AC power. Phase 1 is indicated by the white sine wave and phase 2 by the black sine wave. Phases 1 and 2 are two independent power supplies coming from the same source. These power supplies are 90 degrees out-of-phase. This means that by moving 90 degrees from the zero reference point phase 1 is at maximum value. At the same time phase 2 is at zero. Move 90 degrees further to the 180 degree point, phase 2 is at maximum. Phase 1 has dropped to zero. The phase changes occur in much the same manner in figure C except the three-phase power is 120 degrees out-of-phase. A study of the sine waves will show that each of the phases shown in figures B and C are at a different value at the same point in time. Because of this, each phase can be connected to different sets of poles in an AC motor to create a rotating magnetic field.



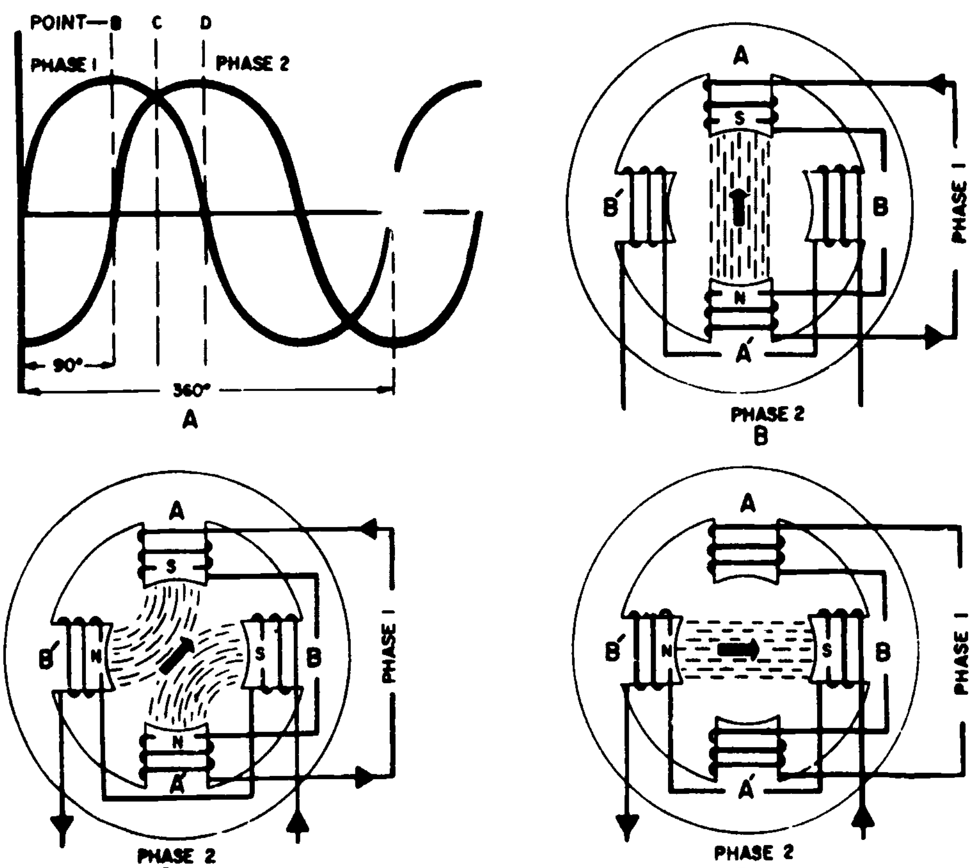
In the response sheet mark the following statements (T) true or (F) false.

1. Three-phase power has three independent power supplies with a common source.

2. Two-phase power is 90 degrees out-of-phase.

CHECK YOUR RESPONSES AT THE TOP OF PAGE 8.

The stator is excited by applying AC power to the windings around the stator poles. This will establish a rotating magnetic field for motor operation. The magnetic field moves from pole piece to pole piece as the applied AC power changes value. The illustration shows the rotating magnetic field of a 2-phase AC motor. Phase 1 is connected to the poles marked A and A'. Phase 2 is connected to the poles marked B and B'. The position of the magnetic field in relation to applied current values can be seen by comparing the sine waves in figure A with figures B, C and D. At point B of figure A phase 1 is at maximum value. At the same time phase 2 is at zero. The magnetic field will be as shown in figure B. Current flow will be in the direction as shown by the black arrow. At point C both phase 1 and 2 are NEAR maximum and the magnetic field moves clockwise. Indicated by the black arrow in the center of figure C. With current at the values of point D the magnetic field is as you see it in figure D.



A

B

C

D

Fill in the missing information in the response sheet for the following statements.

1. At point D of figure A phase 1 is at ________ and phase 2 is ________.
2. The stator is excited by applying AC power to the ________ around the ________ ________.
3. Phase 2 is connected to the poles marked ___ and ___.
4. The magnetic field moves in a ________ direction.

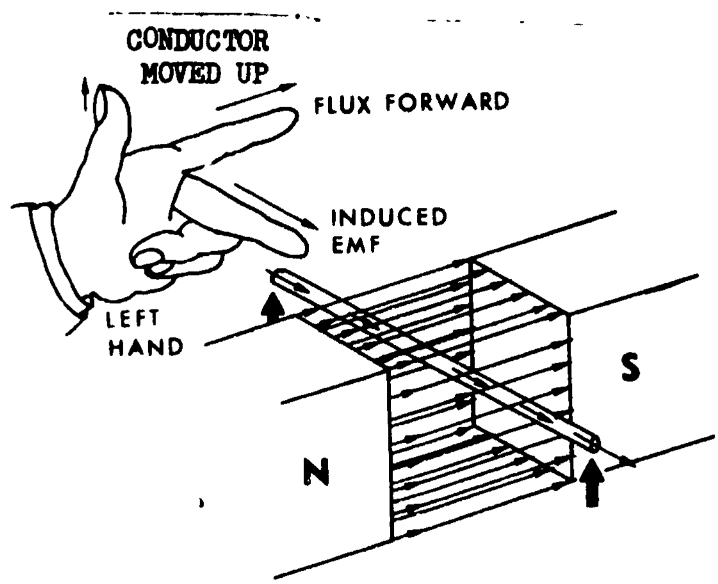
CHECK YOUR RESPONSES AT THE TOP OF PAGE 8.

CORRECT RESPONSES TO FRAME 6: 1. T, 2. T.

CORRECT RESPONSES TO FRAME 7: 1. zero maximum, 2. Windings, stator poles, 3. B-B', 4. clockwise.

Frame 8

Current flow is induced into the rotor by the magnetic field of the stator. You must know the direction of the induced current to determine which direction torque is applied to the rotor. The direction of induced current can be found IF the direction of conductor motion and the direction of the magnetic field are known. This is done by using the LEFT HAND GENERATOR RULE. The rule states "using your left hand, extend your thumb, index and middle fingers at right angles to one another. (See illustration). Position your hand with the thumb pointing in the direction of conductor motion. Point the index finger in the direction of magnetic lines of force (north to south). Your middle finger will point in the direction of induced current flow.



In the response sheet mark the following statements (T) true or (F) false.

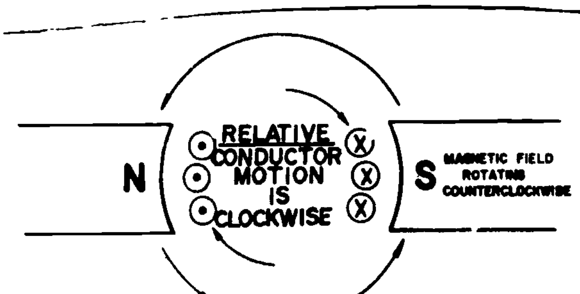
1. The left hand generator rule will give you the direction of conductor motion.

2. Current flow is induced into the rotor.

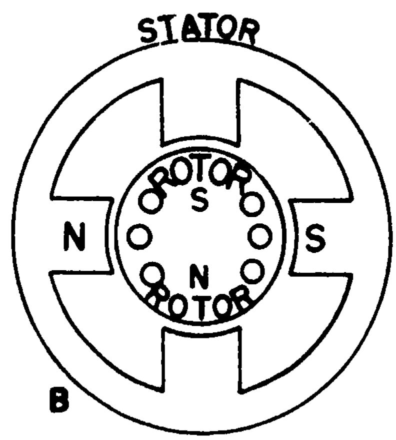
3. The direction of induced current can be found by using the left hand generator rule.

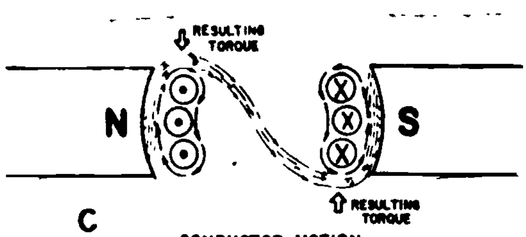
CHECK YOUR RESPONSES AT THE TOP OF PAGE 10.

The illustration shows you how current is induced into the rotor. The figures A, B, and C show the CONDUCTORS of the rotor between the north and south poles of the stator. The magnetic field of the stator is rotating counterclockwise. Remember the stator does notmove, the magnetic field moves. Motion of the rotor conductor RELATIVE to the stator field is CLOCKWISE (figure A). Use the left hand rule. The conductors on the LEFT are moving UP relative to the stator field. Point the thumb of your left hand toward the top of the page. Point the index finger in the direction of the stator field (north to south). Your middle finger will show that current flow in the LEFT conductors is toward you. Motion of the RIGHT conductors is toward the BOTTOM of the page. Point your left thumb toward the bottom of the page with the index finger pointing from north to south on the stator field. Your middle finger will show current flow into the page. Current flow in the rotor will cause the stator field to move as shown in figure C. Because the rotating magnetic field and torque are in the same direction the rotor will follow the rotating magnetic field of the stator.



A INDUCING A CURRENT INTO THE ROTOR CONDUCTORS





C

CONDUCTOR MOTION

In the response sheet mark each statement either (T) true or (F) false.

1. In figure A relative conductor motion is clockwise because the magnetic field is moving counterclockwise.

2. Torque is in the same direction as the rotating magnetic field.

3. Using the left hand generator rule the thumb is pointed in the direction of conductor motion.

4. The stator conductors turn between the poles of the rotor.

CHECK YOUR RESPONSES AT THE TOP OF PAGE 10.

CORRECT RESPONSES TO FRAME 8: 1. T, 2. T, 3. T.

CORRECT RESPONSES TO FRAME 9: 1. T, 2. T, 3. T, 4. F.

Frame 10

For induction to take place the rotating magnetic field must move faster than the rotor. This is because the magnetic field of the stator must pass through the rotor conductors to induce current. IF the rotor was turning at the same speed as the stator field the conductors and lines of force would be aligned and no induction could take place. The magnetic field of the stator always sweeps through the rotor conductors slightly faster than rotor speed. This induces current into the rotor which in turn develops torque. The difference between the speed of the rotating magnetic field and the speed of the rotor is called SLIP.

Fill in the missing information in the response sheet for the following statements.

1. The magnetic field of the stator must move ____________ than rotor speed.

2. Inducing current into the rotor produces ____________.

3. Difference between the speed of the stator field and rotor speed is called ____________.

4. Inducing current into the rotor the stator field must turn _____ than the __________.

CHECK YOUR RESPONSES AT THE TOP OF PAGE 12.

Frame 11

It was stated in earlier frames that AC induction motors may operate on single two- or three-phase power. Two- and three-phase motors have a rotating magnetic field, because the phases are connected to different sets of stator poles. Remember, each phase is an independent power source. The two-phase motor has power 90 degrees out-of-phase. The three-phase motor has power 120 degrees out-of-phase. What about single-phase motors? There is no phase difference with single-phase power. A motor which operates on single-phase power is not self starting. It DOES NOT have a rotating magnetic field. Operation of a single-phase motor is accomplished by connecting the internal wiring of the motor in different ways. How this is done will be discussed in the following frames.

In the response sheet mark the following statements (T) true or (F) false.

1. A single-phase motor is not self starting.

2. The phases of two-phase power are 90 degrees apart.

3. Single-phase power is phased 120 degrees apart.

4. Operation of a single-phase motor is by connecting the wiring of the motor in different ways.

CHECK YOUR RESPONSES AT THE TOP OF PAGE 12.

Review Frame 12

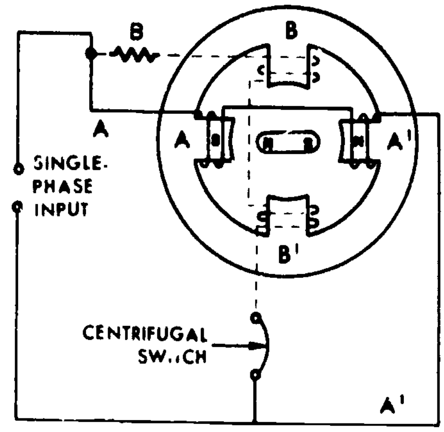
Match the items listed in column A with those listed in column B. Mark your answer in the response sheet.

Column A		Column B	
1.	Rotor	A.	Has no rotating magnetic field.
2.	Stator	B.	Has AC power applied.
3.	Single-phase motor	C.	Has AC power induced.
4.	Slip	D.	Difference in rotor and stator speed.
5.	Torque	E.	Is applied to the rotor.

CHECK YOUR RESPONSES AT THE TOP OF PAGE 12.

Frame 13

As stated in frame 11 a motor which operates on single-phase power is not self starting. Because of this a single-phase motor designed to operate like a two-phase motor. This is accomplished by co ecting an auxiliary (starting) winding in parallel with the main (running) winding. Look at the illustration. The main winding is labeled A and A1, the auxiliary winding is labeled B and B1. Dotted lines identify the auxiliary winding. Notice the centrifugal switch located in the motor starting circuit. A motor with this type of connection is called a split-phase motor. The auxiliary winding may be connected permanently or disconnected by the centrifugal switch, after the motor has started running. As stated in previous frames an out-of-phase condition is required to produce a rotating magnetic field. In a split-phase motor the out-of-phase condition is obtained in several ways. In the illustration the out-of-phase condition is obtained by placing high resistance in the auxiliary (starting) winding and high inductance in the main (running) winding. While the motor is starting both windings will have current flow. The centrifugal switch will disconnect the auxiliary winding at approximately 75% of motor speed. After the m - has started the force of the turning rotor will maintain motor operation.



Fill in the missing information for the following statements in the response sheet.

1. The auxiliary winding may be disconnected by a ________ _ _ ________.
2. The auxiliary winding may also be called a _____ _____ winding.
3. The main winding is sometimes called the __________ winding.
4. A motor connected in parallel is called a __________ __________ motor.

CHECK YOUR RESPONSES AT THE TOP OF PAGE 12.

CORRECT RESPONSES TO FRAME 10: 1. faster, 2. torque, 3. slip, 4. faster, rotor.

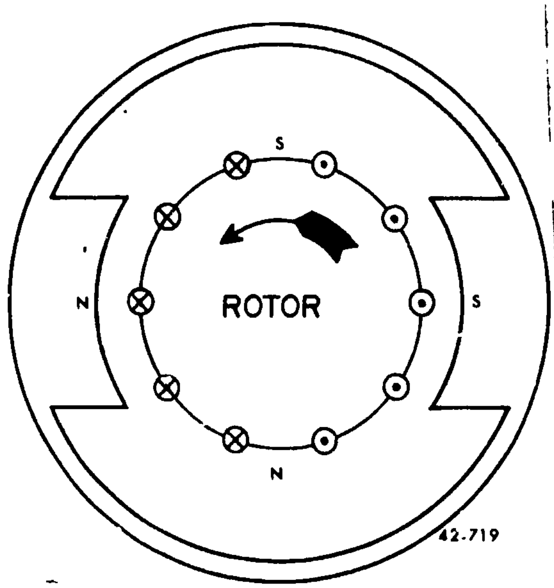
CORRECT RESPONSES TO FRAME 11: 1. T, 2. T, 3. F, 4. T.

CORRECT RESPONSES TO FRAME 12: 1. C, 2. B, 3. A, 4. D, 5. E.

CORRECT RESPONSES TO FRAME 13: 1. centrifugal switch, 2. starting, 3. running, 4. split phase.

Frame 14

In our discussion of AC motors, the rotor is moved by two forces. The force of the rotating magnetic field (frame 7) and the torqueing action as the magnetic field around the rotor conductors act on the stator field (frame 9). At this point we will discuss a THIRD force which will make the rotor turn. As stated earlier when the rotor turns it has current induced into it. This will cause the entire rotor to be magnetized. The magnetic field of the rotor will be in a position that will cause the rotor field to be attracted to the stator field. The illustration shows the magnetic field of the rotor with the south pole at the top and north at the bottom. The south pole of the rotor will be drawn to the north pole of the stator. The north pole of the rotor is pulled toward the south pole of the stator. The magnetic field of the rotor always remains in a fixed position. The rotor and stator poles will never become aligned. Although the poles will never align themselves the force which will cause them to try is present in the rotor.

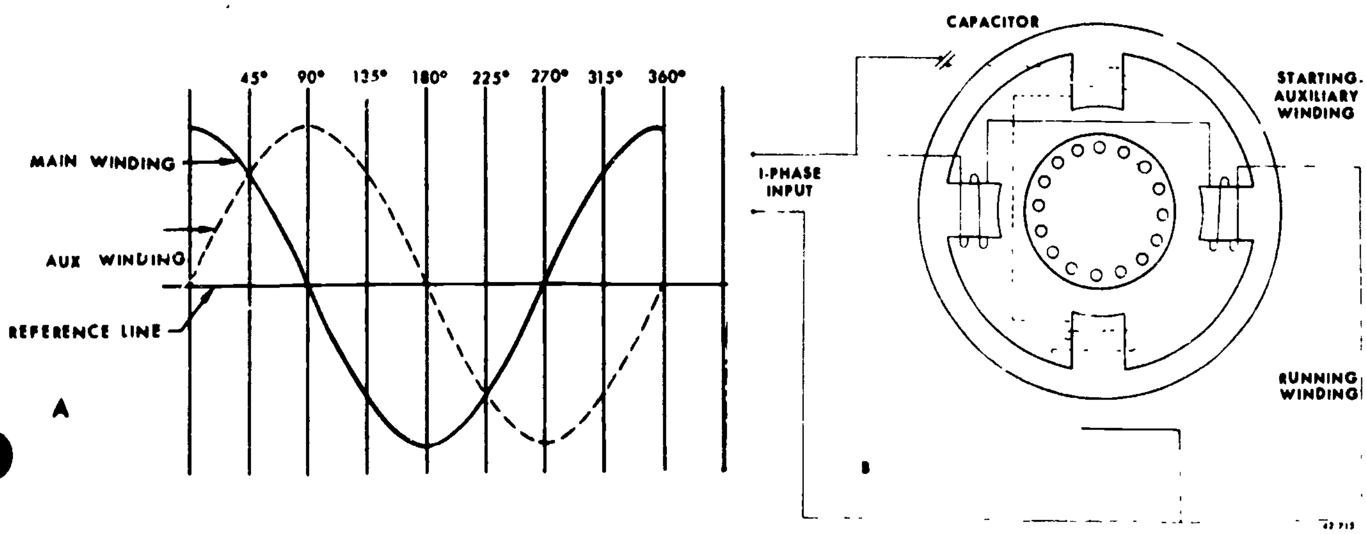


Mark the following statements (T) true or (F) false in the response sheet.

1. The rotor of AC motor will be magnetized.
2. The rotor field will be aligned with the stator field.
3. The rotor is acted upon by three forces.

CHECK YOUR RESPONSES AT THE TOP OF PAGE 14.

A motor with a resistance in the starting winding doesn't have a high starting torque. This is because the resistance does not create a very large phase difference between the current flow in the starting winding and current flow in the running winding. Where a higher starting torque is needed, a motor with a capacitor wired in the starting circuit is often used (figure B). This circuit arrangement will cause the current in the starting winding to lead the current in the running winding (figure A). As a result a two-phase EFFECT is achieved. There is more of a difference between the phases in this type of motor than one with resistance in the starting windings. Because of the phase difference a higher torque will result.



Fill in the missing information for the following statements in the response sheet.

1. More starting torque is obtained by connecting a ____________ in the starting winding.

2. A capacitor is connected in the motor to achieve higher ____________ ________.

3. In a split-phase AC motor a ________ phase effect is obtained.

CHECK YOUR RESPONSES AT THE TOP OF PAGE 14.

CORRECT RESPONSE TO FRAME 14: 1. T, 2. F, 3. T.

CORRECT RESPONSE TO FRAME 15: 1. capacitor, 2. starting torque,
3. two.

Frame 16

The AC motor most often used in environmental systems is the reversible AC motor. Reversible single-phase motors will be equipped with two stator windings. Supplying power to one winding will cause the motor to turn clockwise. Applying power to the other winding will turn the motor counter-clockwise. In the reversible type motor the centrifugal switch is not used and the starting and running windings are permanently connected.

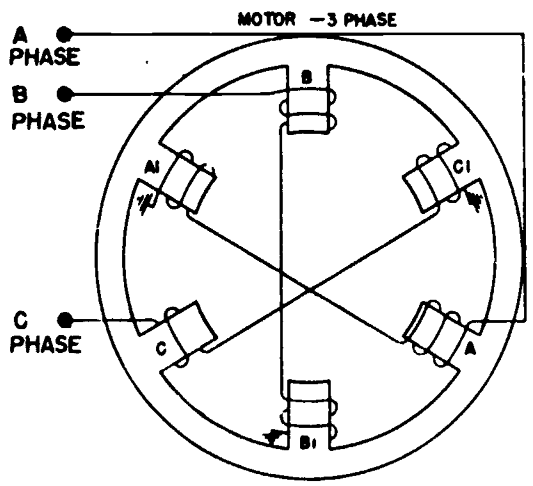
Mark the following statements (T) true or (F) false in the response sheet.

1. A reversible single-phase AC motor is equipped with two stator windings.

2. A reversible AC motor uses two centrifugal switches.

CHECK YOUR RESPONSES AT THE TOP OF PAGE 16.

In places where high starting torque and relatively quiet operation is needed a three-phase motor is used. The rotating magnetic field of a three-phase motor creates a more constant torque than the fields of split and two-phase motors. This is because more motor poles are receiving power at a given time. Other than that the operation of a three-phase motor is very much like a two-phase motor. The illustration will show you how a three-phase motor is connected electrically. Notice that there are three separate paths for current flow to three sets of motor poles.



NO RESPONSE REQUIRED

CORRECT RESPONSES TO FRAME 16: 1. T, 2. F.

CORRECT RESPONSES TO FRAME 17: None Required.

Frame 18

The illustration shows the rotating magnetic field of a three-phase AC motor. Figure 6 of t ustration shows phase A connected to poles A and A1, phase B to poles ... B1, and phase C to poles C and C1. Using figure 1 as a guide and comparing it to figures 2 through 5 the figures will show how a rotating magnetic field is achieved. Point 2 of figure 1 shows phases A and B at near maximum value while phase C is at zero. The magnetic lines of force are as shown in figure 2. The rotating magnetic field will be moving counterclockwise. Now move down the time line (figure 1) to point 3. At point 3, phase A is at zero and phases B and C are near maximum. This will cause the magnetic field to rotate counterclockwise to the position shown in figure 3. Compare points 4 and 5 (figure 1) and figures 4 and 5 and notice how the field continues to rotate counterclockwise. A check of points 2 and 5 (figure 1) and figures 2 and 5 will show that both current and the magnetic poles of the motor have changed polarity. Point 6 is the place where the motor will complete 360 degrees rotation. The current values of point 6 are the same as they were at point 2.

Mark the following statements (T) true or (F) false in the response sheet.

1. The current values at points two and six of figure 1 are the same.
2. The magnetic poles of the motor will change polarity as the current changes polarity.
3. From point two to point six the motor makes one complete turn.

CHECK YOUR RESPONSES AT THE TOP OF PAGE 18.

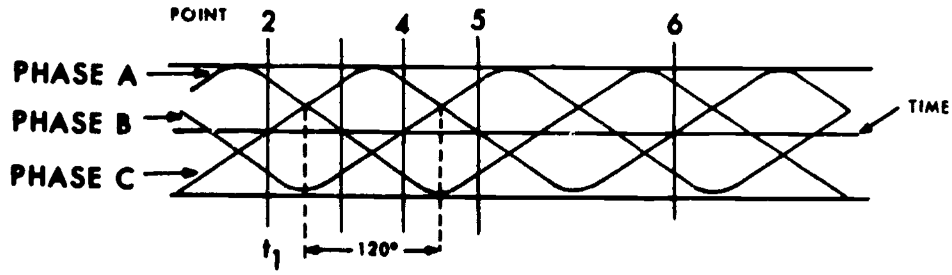


Figure 1.

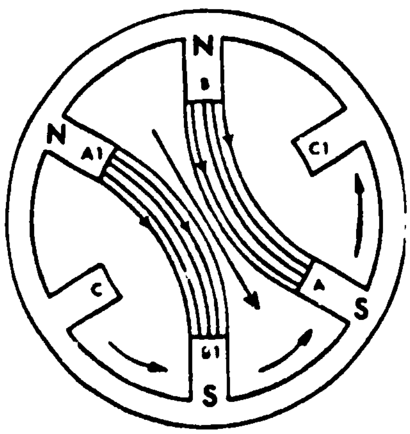


Figure 2.

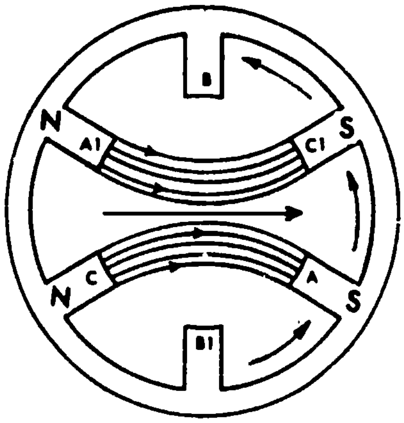


Figure 3.

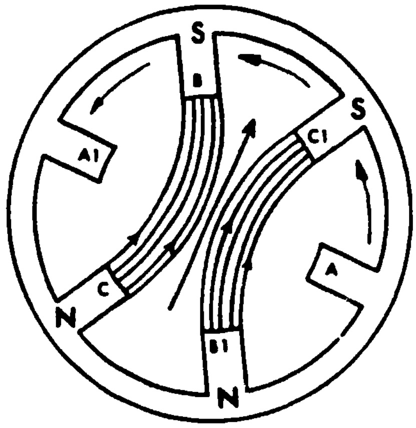


Figure 4.

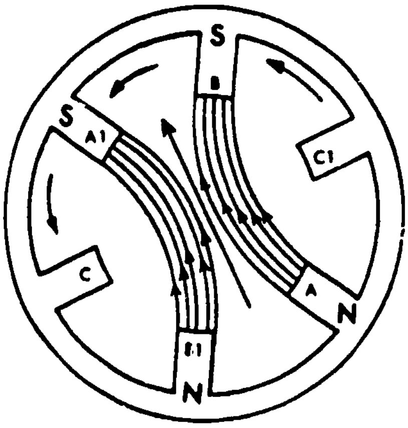


Figure 5.

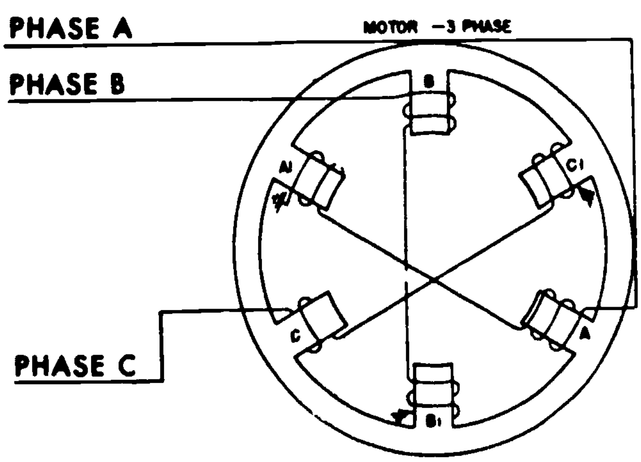
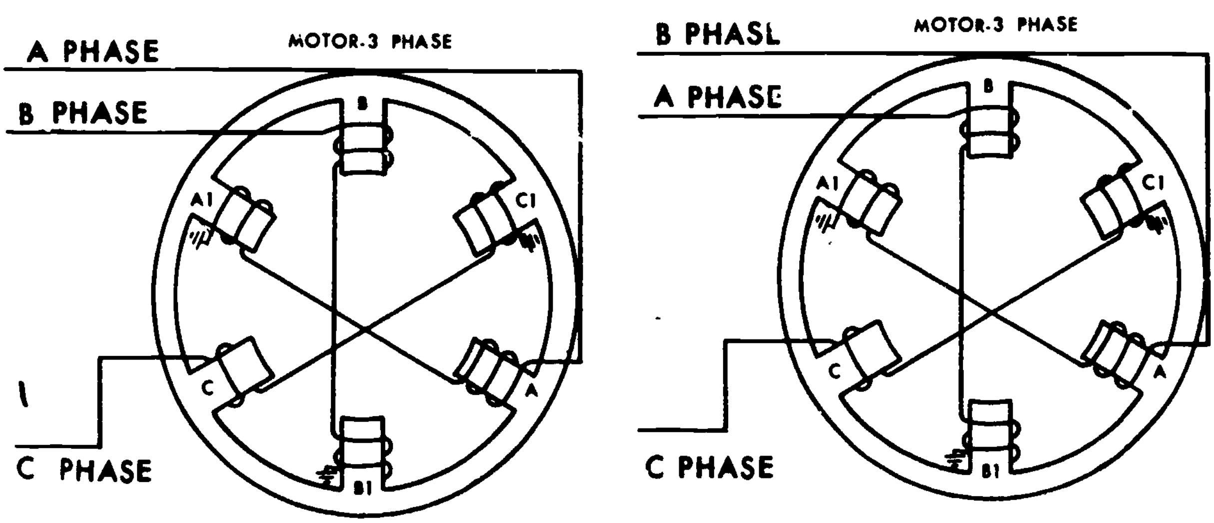


Figure 6.

CORRECT RESPONSE TO FRAME 18: 1. T, 2. T, 3. T.

Frame 19

A single-phase motor is reversed by sing two stator windings. Reversing a three-phase motor is done differently. The direction of rotation of a three-phase motor is reversed by reversing the connections on any two of the three phases. The illustration shows you two AC motors. These two motors will turn in opposite directions because A and B phases have been reversed on the right hand motor. Reversing the phases will reverse the direction of the rotating magnetic field and also motor direction. Reversing a three-phase motor is done using a relay circuit which you will study in your next text.



Fill in the missing information for the following statements in the response sheet.

1. Reversing two phases of a three-phase motor will change the direction of the __________ __________ field.

2. Reversing a three-phase motor can be done using a __________ circuit.

CHECK YOUR RESPONSES AT THE TOP OF PAGE 20.

1200

The rotor of an induction motor turns at a slower speed than the rotating magnetic field of the stator. The difference in speed is called SLIP. Slip is necessary in an induction type motor because if the rotor turned at the same speed as the rotating magnetic field no current would be induced. The speed of the rotating magnetic field is called SYNCHRONOUS SPEED. An AC motor which is designed to turn at the same speed as the rotating field of the stator is called a synchronous motor. A synchronous motor is used where exact speed regulation is necessary. The ROTOR of a synchronous motor is made of permanent magnets or is magnetized from an outside DC power source. Because the north and south poles of the rotor do not change the rotor will turn at synchronous speed. The speed of a synchronous motor is proportional to the AC frequency. The motor can be used to drive precision units if frequency is closely adjusted.

Mark the following statements (T) true or (F) false in the response sheet.

1. The difference between the speed of the rotor and the speed of the rotating magnetic field is called SLIP.

2. The rotor of a synchronous motor can be made of permanent magnets.

3. The speed of the rotating magnetic field is called induction.

CHECK YOUR RESPONSES AT THE TOP OF PAGE 20.

CORRECT RESPONSES TO FRAME 19: 1. rotating magnet, 2. relay.

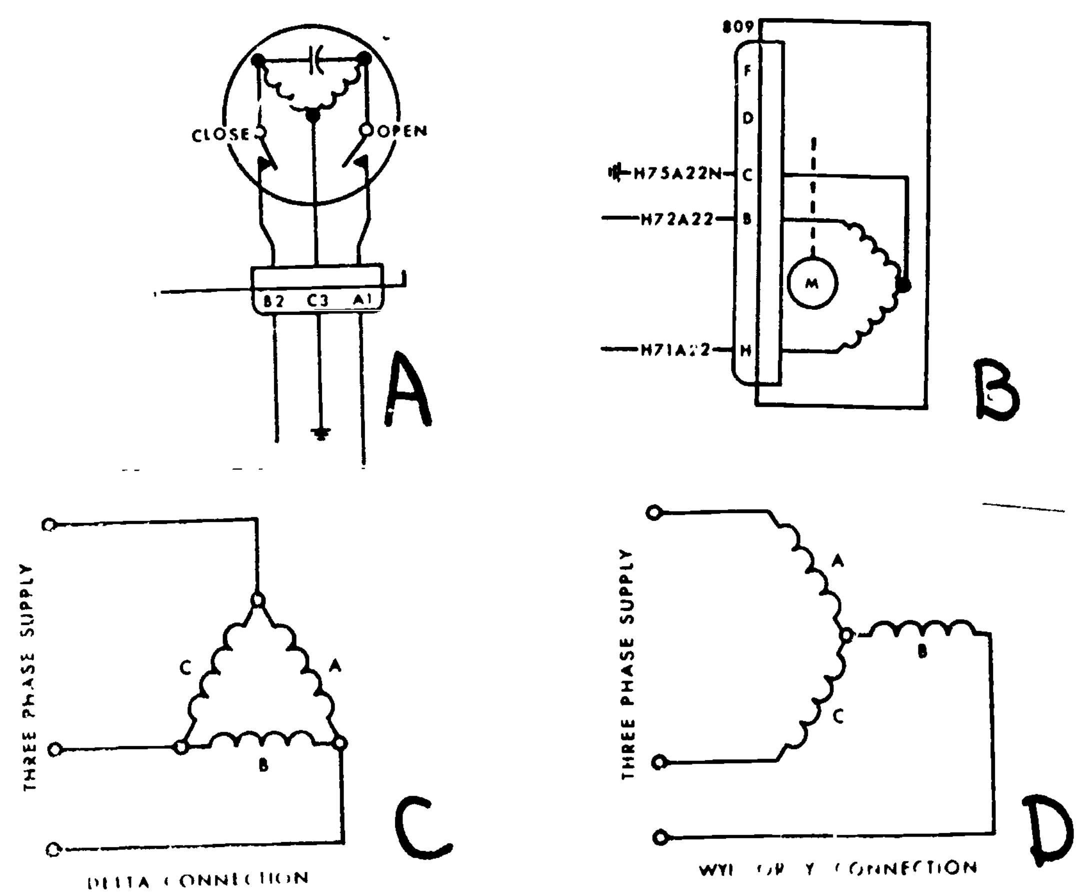
CORRECT RESPONSES TO FRAME 20: 1. T, 2. T, 3. F.

CORRECT RESPONSES TO FRAME 21: None Required.

Frame 21

The illustration will show you how several different types of AC motors will appear on a wiring diagram. Figure A shows a reversible single-phase motor. Figure B is a two-phase motor. The two figures marked C and D are two methods of wiring a three-phase motor. The three-phase motor is generally equipped with a ground wire to prevent electrical shocks but it is not necessary for motor operation.

NO RESPONSE REQUIRED



END OF TEXT

Technical Training

Aircraft Environmental Systems Mechanic

AC MOTORS AND CONTROL CIRCUITS WIRING DIAGRAM

28 July 1981

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

RGL: N/A

Environmental Pneudraulics Branch 3ABR42331-WB-116
Chanute AFB, Illinois

AC MOTORS AND CONTROL CIRCUITS WIRING DIAGRAM

OBJECTIVES

Using an electrical diagram, **specify** a minimum of 8 out of 10 circuit malfunctions, when given the cause and circuit conditions.

EQUIPMENT

Colored Pencil Set

PROCEDURE

Pay close attention to all directions that you are given in the workbook. When performing in the workbook, such as tracing or solving problems, if your response is incorrect, restudy the information. At the end of this workbook, you will have a progress check which will be graded by your instructor. If you are ready to begin and have no questions, proceed with the lesson.

In this section you will become familiar with an AC circuit as shown in figure 1, page 24 in Part 3 of this workbook. It is designed to operate and reverse the operati cf single phase and three phase motors. You will learn this by tracing the individual circuits which make up the entire cilcuit. Let us begin by discussing the system's switches.

The three (3) switches in the circuit which control the body crossover manifold valve and strut #3 bleed valve are the manifold valve switch, master switch and bleed selector switch. The two (2) switches in the circuit which control the open and close control relays, used to control the modulating valve, are the master switch and the manual switch. You will use this workbook, Parts 1, 2, and 3, to complete the lesson objectives

Part 1 consists of instructions and confirmations. Part 2 consists of figures. **Begin with Exercise 1.**

Note: You may remove Part 3 from Part 2 for ease of tracing if you so desire.

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PART 1

Exercise 1

In this exercise, we will trace power to the manifold valve switch. You will use a red pencil and figure 1 in Part 3 of this workbook.

1. Trace from Point A on the 118-205V, three phase, 400 Hertz AC bus bar, to the junction point of wires H200A20 and H400A20. Keep in mind that both wires use the same circuit breaker. For the time being we will trace only H200A20.

2. Trace up wire H200A20 to the manifold valve switch-pole A and the jumper wires to poles B and C. You have now applied power up to the manifold valve switch.

3. Turn to page 14 in Part 2 for confirmation. If you have traced this correctly, transfer what you have traced to foldout 1 in Part 3 of this workbook.

Exercise 2

In this exercise, we will trace the manifold valve switch in the open position. You will use a dark green pencil and figure 1 in Part 3 of this workbook.

1. Draw the manifold valve switch to the open position, by moving the armature of the switch down to Points 2 and 4. Notice the broken line between the two contacts. This indicates that the armatures are joined together by a single switch. If one armature moves, the other moves, in the same direction at the same time. This allows us to control two or more paths of current flow with a single switch.

2. Trace from Point 2, across wire H220A20 to Point 1 on the bleed selector switch.

3. Trace along wire H220B20 to pin B of the body crossover manifold valve connector plug. Remember this is a single phase AC motor. It has a capacitor start winding. In order to apply power to the motor correctly, we must trace it in the following manner.

4. Trace from pin B of the body crossover manifold valve connector plug, to the microswitch (open). Draw the microswitch closed.

5. Trace from the microswitch up to the capacitor.

6. Trace through and to the other side of the capacitor. You have now applied power to both windings.

7. Trace through both windings and out to Pin C of the valve.

8. Trace from Pin C down wires H310B20N, H310D20N and along H310E20N and on out to ground on the bus bar.

9. Go back to Point 4 of the manifold valve switch. Trace from this point along wire H240A20 to Point 4 of the bleed selector switch.

10. Trace from the bleed selector switch to Pin B of the strut #3 bleed valve connector plug.

11. Remember this is a single phase motor. You must trace it in the same manner as you did the body crossover manifold valve. Trace the capacitor and the windings and on out Pin C.

12. Trace from Pin C on out to ground at the bus bar. You will notice that wire H310D20N and H310E20N ground wires are shared by both single phase AC valves.

13. The body crossover manifold and strut #3 bleed valve are now open. Also, notice, with the manifold valve switch in the open position, the master switch and bleed selector have been bypassed. Turn to page 15 in Part 2 of this workbook for confirmation. If you have traced this correctly, transfer what you have traced to foldout 1 in Part 3.

Exercise 3

Now we will look at the manifold valve switch in the closed position. You will use a dark blue pencil and figure 2 in Part 3 of this workbook.

1. Draw the manifold valve switch armature(s) to the closed position.

2. Trace from Point 1 to pole A and stop.

3. Trace from Point 3 to pole B and stop.

4. With the manifold valve switch in the closed position, power is supplied to the master switch. This switch has two positions, RAM or up position and PRESSURE or down position. This switch is also made, so that if one armature moves, all three armatures move.

5. Trace the master switch in the RAM position as shown.

6. Trace from pole A to Points 1 and 2, and then over to Point 3 of the bleed selector switch.

7. Trace down and over to Pin A of the strut #3 bleed valve connector plug.

8. Trace through the microswitch (closed), windings, capacitor and on out Pin C of the valve.

9. Trace from Pin C to the ground on the bus bar. This valve will now close.

10. Trace from pole B of the master switch to Points 5 and 6 of the master switch.

11. Trace from Point 6 of the master switch to Point 2 of the bleed selector switch.

12. Trace from Point 2 of the bleed selector switch to Pin A of the body crossover manifold valve.

13. Trace through the valve, in the same manner as you did the strut #3 bleed valve, to Pin C of the body crossover manifold valve.

14. Trace from Pin C to ground on the bus bar. You will notice the H310D20N and H310E20N are again shared by both valves.

15. This valve is now closed. Remember, with the manifold valve switch in the closed position, the master switch in the RAM position, the bleed selector switch has been bypassed.

16. Turn to page 16 for confirmation in Part 2.

17. If you have traced this exercise correctly, transfer what you have traced to foldout 1 in Part 3 of this workbook.

Exercise 4

Let us see what will happen with the master switch in the PRESSURE position. You will use an orange pencil and figure 3 in Part 3 of this workbook.

1. Draw the manifold valve switch to the closed position.

2. Draw the armature of the master switch to the PRESSURE (down) position.

3. Trace from Point 1 of the manifold valve switch to the master switch pole A.

4. Trace through the master switch to the bleed selector switch.

5. Trace through the bleed selector switch to Pin B of the body crossover manifold valve.

6. Trace through the valve and windings to Pin C of the valve.

7. Trace from Pin C to ground on the bus bar.

8. Go back to Point 3 of the manifold valve switch and trace from there to the master switch.

9. Trace from the master switch to the bleed selector switch.

10. Trace through the bleed selector switch to Pin A of the strut #3 bleed valve.

11. Trace through the valve and windings, and out to ground on the bus bar.

12. You can see, with the master switch in the PRESSURE position, power is always applied to the close side of the strut #3 bleed valve, to insure that the valve stays closed.

13. Turn to page 17 for confirmation in Part 2.

14. If you have traced this exercise correctly, transfer what you have traced to foldout 1 in Part 3 of this workbook.

Exercise 5

The bleed selector switch in figure 4 in Part 3 of this workbook is shown in the normal position. Let us see what will happen when you place the bleed selector switch in the alternate position. You will use a light blue pencil and figure 4 in Part 3 of this workbook.

1. Trace the manifold valve switch in the closed position.

2. Trace the master switch to the PRESSURE position.

3. Trace the bleed selector switch to the alternate position.

4. Trace from Point 1 on the manifold valve switch to the master switch.

5. Trace through the master switch to the bleed selector switch.

6. Trace through the bleed selector switch to Pin A of the body crossover manifold valve connector plug.

7. Trace from Pin A through the valve and windings to Pin C of the valve.

8. Trace from Pin C to the ground on the bus bar.

9. Go back to Point 3 of the manifold valve switch and trace from there to the master switch.

10. Trace through the master switch to the bleed selector switch.

11. Trace through the bleed selector switch to Pin B of the strut #3 bleed valve connector plug.

12. Trace through the valve and windings and to Pin C of the valve.

13. Trace from Pin C out to the ground at the bus bar.

14. This will cause the body crossover manifold valve to close and the strut #3 bleed valve to open.

15. Turn to page 18 for confirmation in Part 2.

16. If you have traced this exercise correctly, transfer what you have traced to foldout 1 in Part 3 of this workbook.

Note: Before we continue, let's take a look at the ground wire for the body crossover manifold valve and the strut #3 bleed valve. If H310B20N is broken, only the body crossover manifold valve won't work. If H310C20N is broken, only the strut #3 bleed valve will not work. Each wire is common only to that valve. However, if H310D20N or H310E20N is broken, neither valve will work.

Exercise 6

You have learned that the master switch has three armatures. You have already traced wiring for two of these armatures. Let's now trace the wiring that is connected to the third armature. You will see that this armature allows 28V DC power to go to the manual switch, which in turn controls the relay(s) and the relay(s) control the 3 phase modulating valve. You will also learn where the power for the three phase motor comes from. For this exercise, you will use a brown and a red pencil and figure 4 in Part 3 of this workbook.

1. With a brown pencil, trace the master switch to the PRESSURE position. Remember all three armatures move down at the same time.

2. With a brown pencil, trace from the positive connection of the 28V DC bus bar to pole C of the master switch.

3. With a brown pencil, trace through the switch and down to the manual switch and stop.

4. Go back to the AC bus bar.

5. With a red pencil, trace from circuit breaker A to pole B2 of the open relay.

6. With a red pencil, trace through armature (B2-B3) to Point B3 of the close relay.

7. With a red pencil, trace from circuit breaker B of the bus bar to pole C2 of the open relay.

8. Trace through armature (C2-C3) to Point C3 of the close relay.

9. Trace from circuit breaker C to pole D2 of the open relay.

10. Trace through armature (D2-D3) to Point D3 of the closed relay.

11. Turn to page 19 for confirmation in Part 2.

12. If you have traced this exercise correctly, transfer what you have traced to foldout 1 in Part 3 of this workbook.

13. Let's go back and review what you have just traced. As you have already seen, the power for the manual switch is 28V DC. The manual switch controls the open and close relays, which in turn control the modulating valves three phase motor. Power for the three phase motor comes from the 3 phase AC bus bar. This 3 phase control circuit is now ready for a signal. This signal will cause the 3 phase modulating valve to open or close. The manual switch controls this signal.

Exercise 7

We are now going to trace the circuit that will close the modulating valve. You will use a light green pencil and figure 4 in Part 3 of this workbook.

1. Draw the manual switch to the closed position. Remember, in Exercise 6 you traced power to the manual switch in brown.

2. Trace from the manual switch to Pin F of the modulating valve.

3. Trace from Pin F, through the close limit switch, to Pin E of the modulating valve.

4. Trace from Pin E to X1 of the close relay.

5. Trace from X1 to X2 of the close relay coil.

6. Trace from X2 to ground on the negative point of the 28V DC bus bar.

7. Draw the three armatures of the close relay to the energized (down) position.

8. Trace phase A from Point B1 of the close relay to Pin A of the modulating valve connector plug.

9. Trace through the valves AØ (phase) winding to Pin H of the modulating valve.

10. Trace from Pin H to ground on the bus bar.

11. Go back to the relay and trace phase B from Point C1 to Pin B of the modulating valve.

12. Trace through the valves BØ winding and on out to ground at the bus bar.

13. Start again at the close relay and trace phase C from Point D1 to Pin G of the modulating valves connector plug.

14. Trace from Pin G through the valves CØ winding to Pin H and on out to the ground on the bus bar.

15. The modulating valve will now close, with all three phases of power applied.

16. Turn to page 20 for confirmation of what you have traced.

17. If you have completed this exercise correctly, transfer what you have traced to foldout 1 in Part 3 of this workbook.

Exercise 8

We will now see what will happen if the manual switch is in the open position. For this exercise, you will use a purple pencil and figure 5 in Part 3 of this workbook.

1. Draw the manual switch to the open position.

2. Trace from the manual switch to Pin D of the modulating valve.

3. Trace from Pin D of the modulating valve, through the open limit switch (insure that this limit switch had been traced to the closed position and the close limit switch to the open position) to Pin C of the modulating valve.

4. Trace from Pin C through the open relay coil to ground on the 28V DC bus bar.

5. The open relay is now energized.

6. Draw the armature of the open relay to the energized (down) position.

7. With this open relay energized, the close relay is de-energized. This is caused by the operation of the limit switches within the modulating valve. If you have forgotten limit switch operation, refer back to the wiring diagram on DC Motors workbook.

8. With the open relay energized, we can trace 3 phase power to the modulating valve. Trace phase A from Point B1 of the open relay to Point C1 on the close relay.

9. Trace from Point C1 of the close relay to Pin B of the modulating valve.

10. Trace through the motor BØ winding and out to the ground on the bus bar.

11. Go back to the open relay. Trace phase B from Point C1 to Point B1 of the close relay.

12. Trace from Point B1 of the relay to Pin A of the modulating valve.

13. Trace through the motor AØ winding and out to ground on the bus bar.

14. Go back to the open relay and trace phase C from Point D1 to Point D1 of the close relay.

15. Trace from Point D1 of the relay to Pin G of the modulating valve.

16. Trace through the motor CØ winding and out to ground on the bus bar.

17. The valve 3Ø motor will now go in the opposite direction and open. This is caused by reversing two phases of power to the motor windings. Phase A and B are reversed to the A and B phase motor windings on Pins A and B at the motor.

18. Notice the power direction when only the close relay is energized. The power leaves Point A of the AC bus bar and travels to Pin A of the modulating valve. The power that leaves Point B of the AC bus bar goes to Pin B of the modulating valve.

19. Also notice the direction of the power with only the open relay energized. The power that leaves circuit breaker A of the AC bus bar is now going to Pin B of the modulating valve, and the power from circuit breaker B is now going to Pin A of the valve. The CØ remains the same with either relay energized.

20. Turn to page 21 for confirmation of what you have traced in this exercise.

21. If you have traced this exercise correctly, transfer what you have traced to figure 6a in Part 3 of this workbook.

Note: Another point to remember is that the modulating valve is a three phase motor. If you will recall from your AC Motor programmed text, a three phase motor does not require an external ground for motor operation. This means that even though all three phases are connected to ground wire H310A20N and in turn H310E20N, an open in either or both of these wires will have no effect on the operation of the modulating valve.

Note: Wire H300C20N is a ground wire shared by both open and close relay ground.

Now that you have traced the individual circuits, you should be ready to solve some circuit malfunctions.

Using figures 6b and 7, you will identify the circuit malfunction(s) in the AC Motor Control Circuit which are all caused by open circuit(s). You will place one or more "X'x" in the block(s) which will give you the correct circuit malfunction. The first one has been done for you.

The second one you must do for practice and have it checked by your instructor before you proceed to the problems in the performance test. Keep in mind as you do each problem, you must mark <u>only</u> the malfunctions that <u>directly</u> relate to each problem.

PRACTICE PROBLEM 1

First look at figure 7 and find practice problem #1, then, using figure 6b, look for problem #1 in the AC Motor Control Circuit. After you have found #1 on figure 6b, you will see that it points to an open positive wire for both single phase valves. <u>Remember that all the problems given in this exercise are open circuits</u>.

1. Figure 7 gives you the answer sheet for practice problem #1.

2. Figure 6b gives you the location of the open circuit H200A20 the positive lead for both single phase motor valve assemblies.

Note: An "OPEN CIRCUIT" may be a condition of electrical circuit caused by the breaking of continuity of one or more of the conductors of the circuit; usually an undesired condition. It may also be a circuit which does not provide a complete path for current to flow.

3. Look at figure 6b and place the manifold valve switch, master switch, and the bleed selector switch in any combination of positions, you should then find that the body crossover manifold and strut number 3 bleed valve will not operate. You will also find that wire H200A20 is not used in any way to support the operation of the modulating valve. Now examine figure 7 and you will find how this problem number 1 has been marked for you.

If you have any questions on how this problem was marked, ask your instructor at this time.

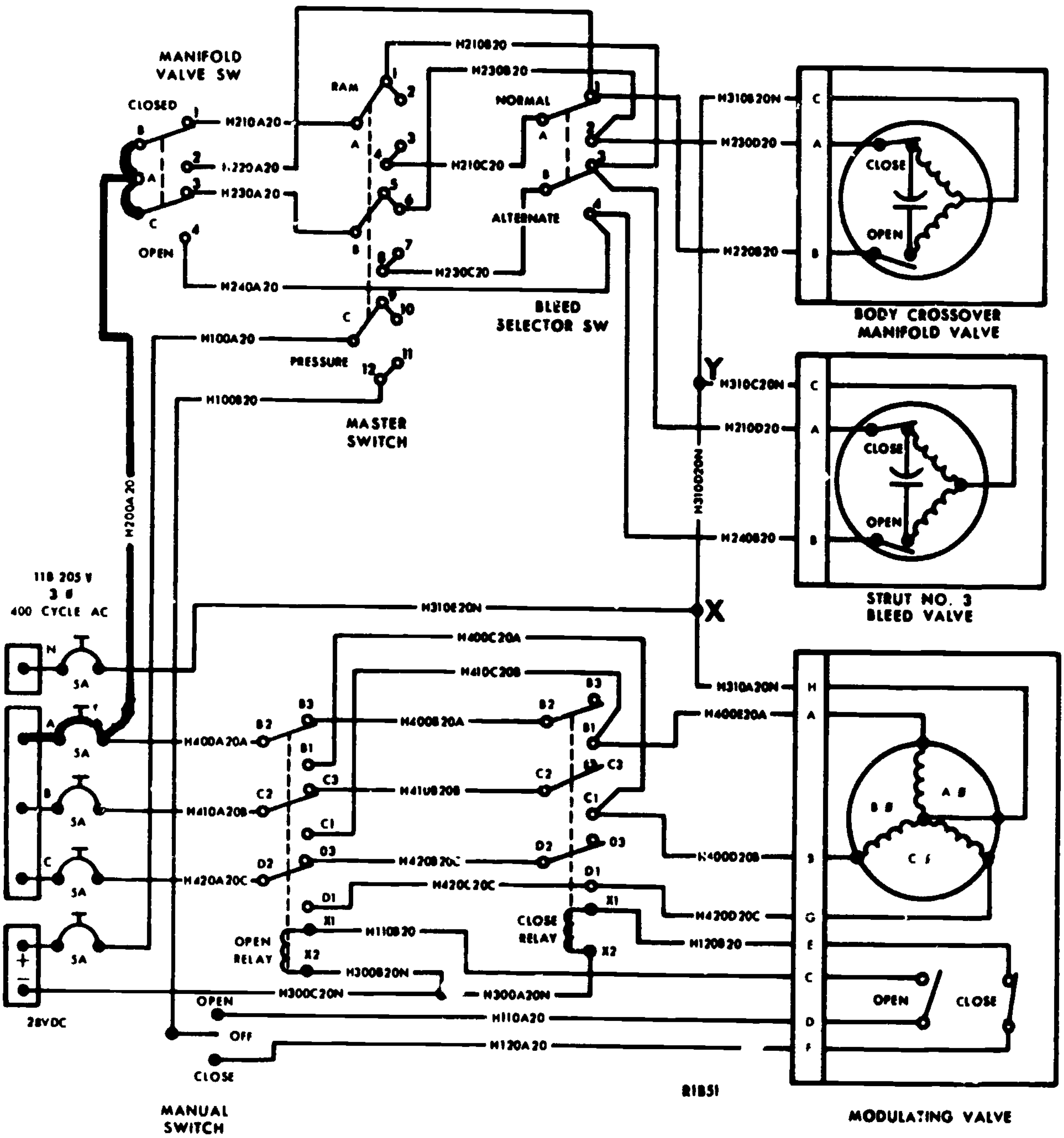
PRACTICE PROBLEM #2

You whould be able to complete this practice problem on your own using figures 6b and 7. If you are not sure, consult your instructor at this time.

When you finish the practice problems, have them checked and signed off by your instructor before you progress.

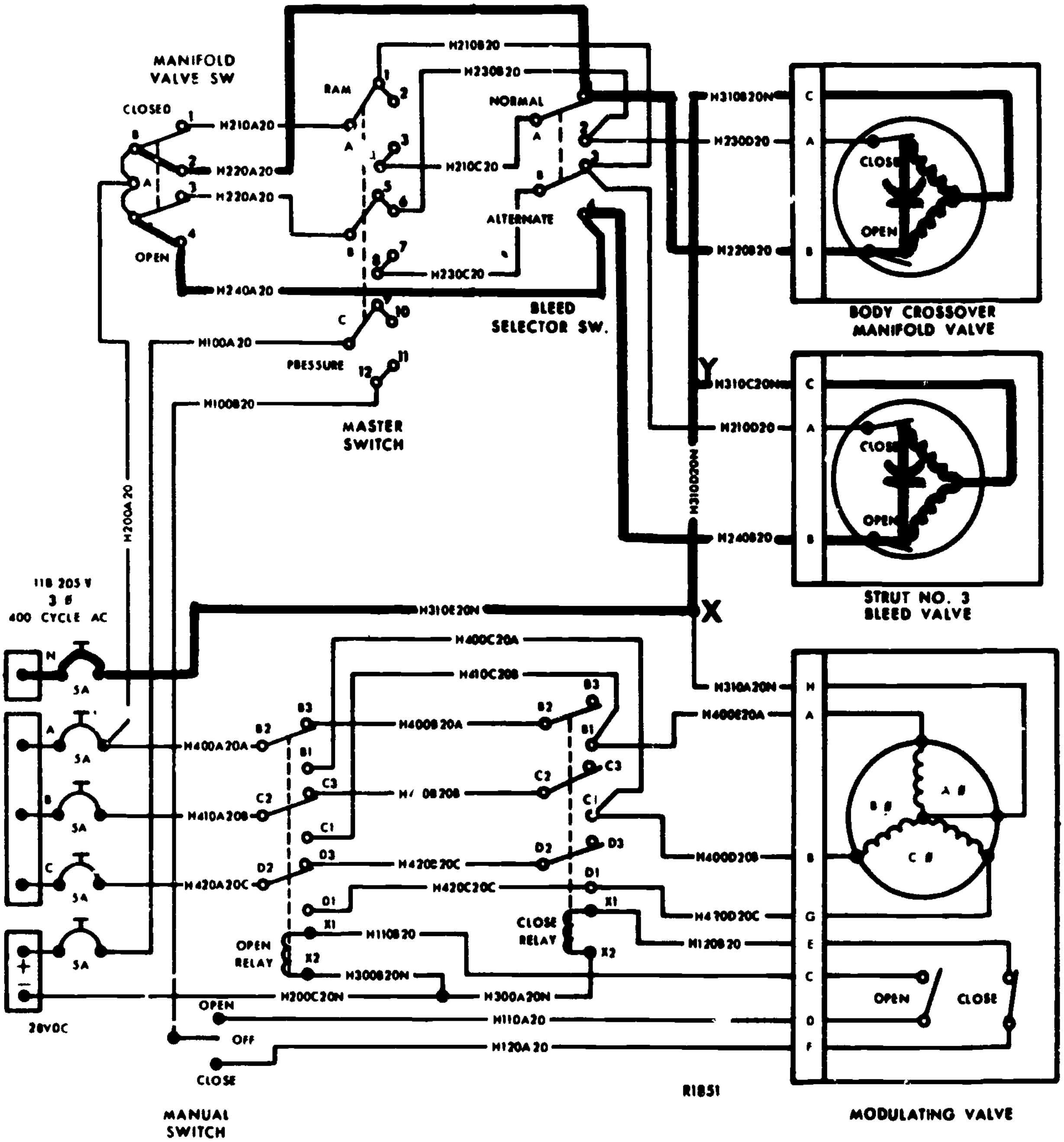
PART 2

Confirmation(s) for Exercises 1 through 8.



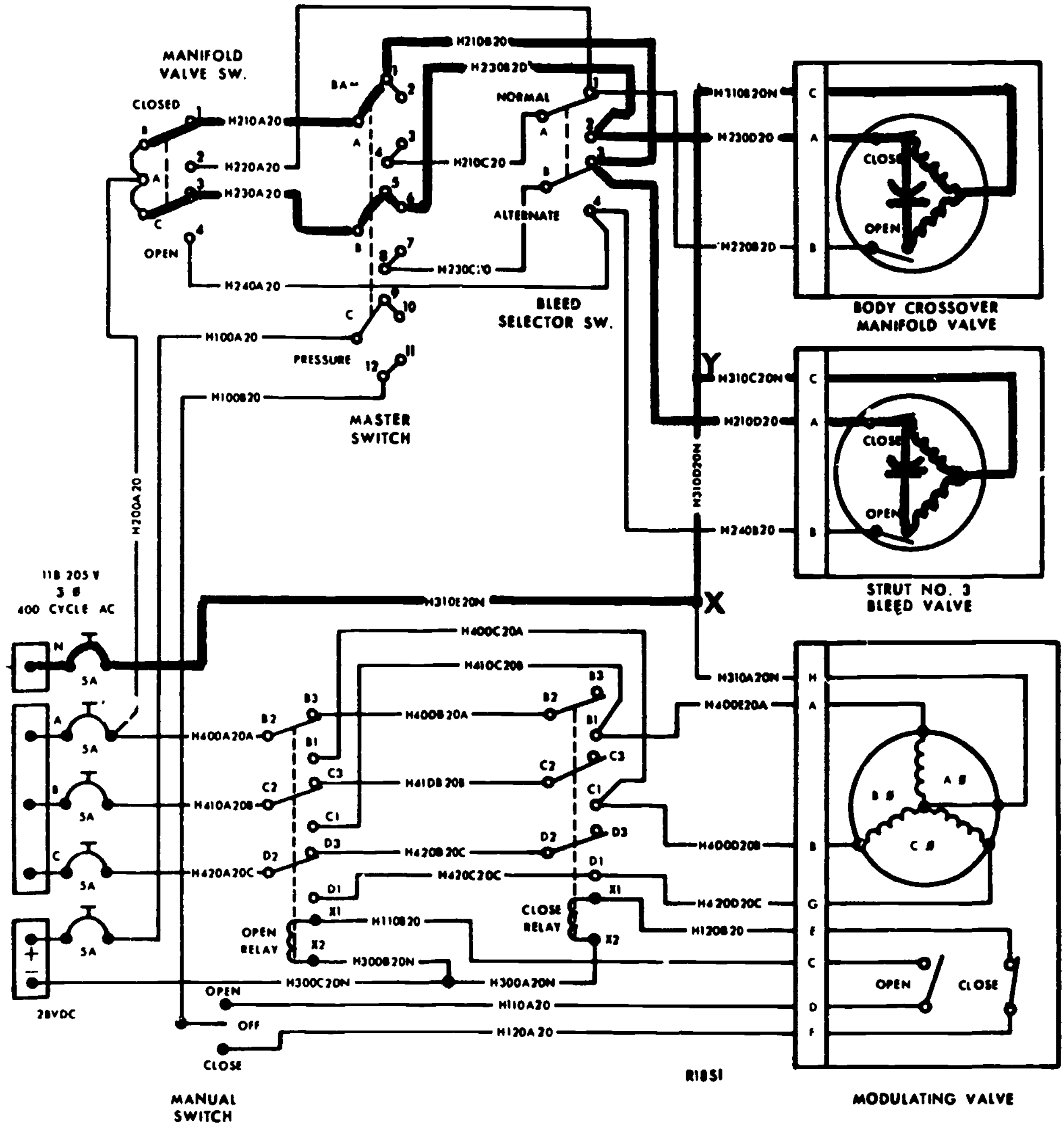
NOTE: The bold lines above are RED.

Part 2, Exercise 1 Confirmation.



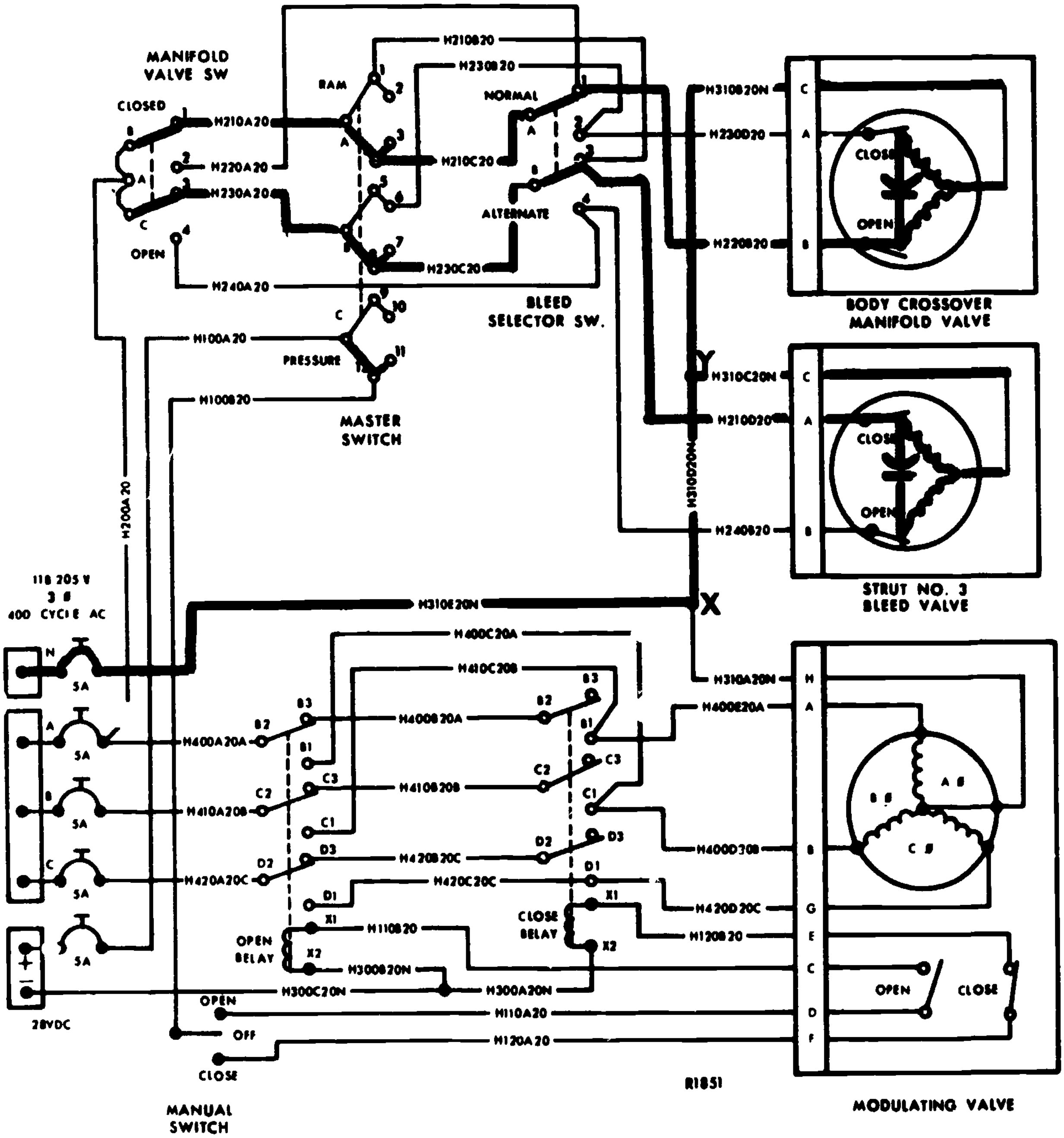
NOTE: The bold lines above are DARK GREEN.

Part 2, Exercise 2 Confirmation.



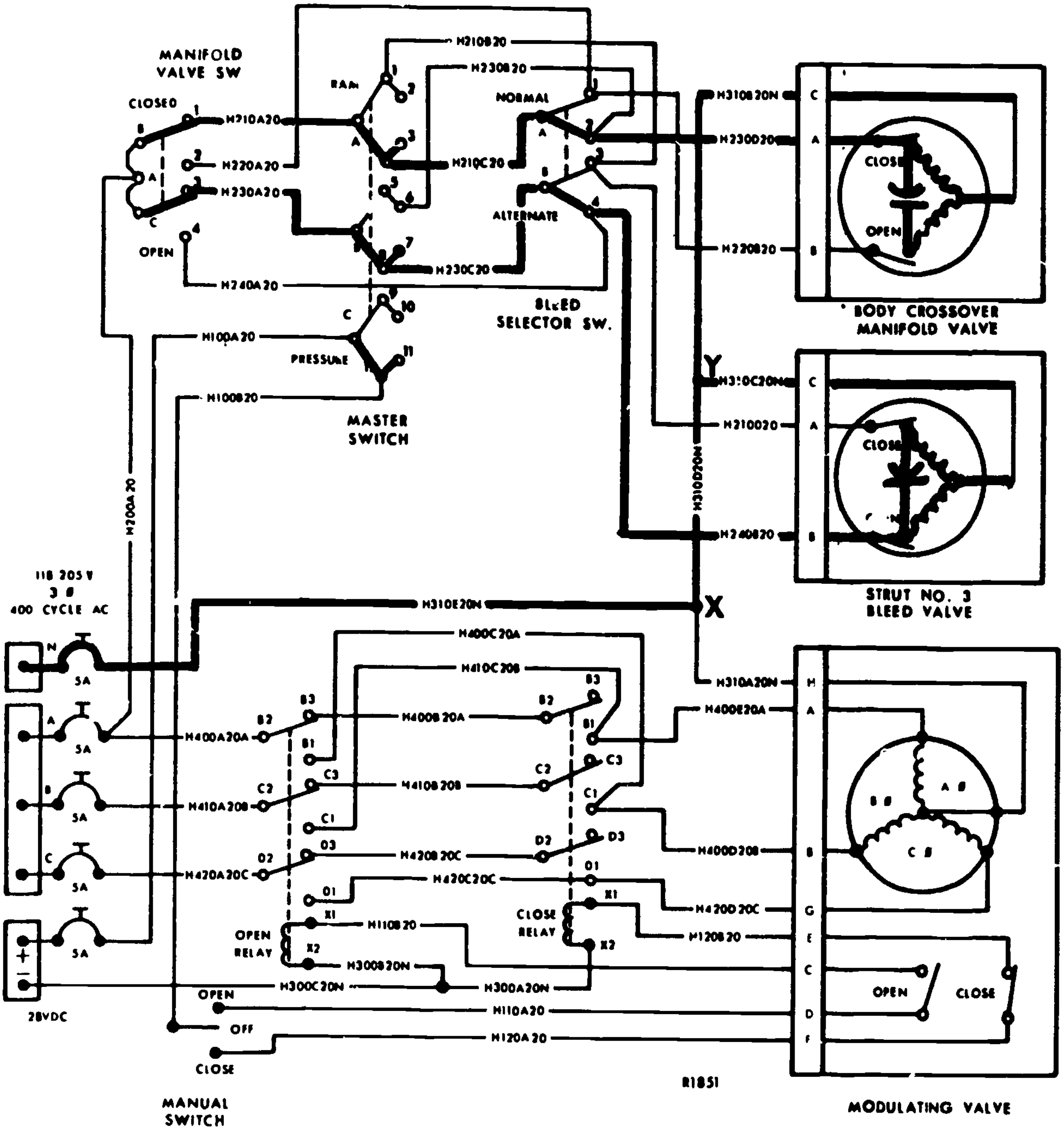
NOTE: The bold lines above are DARK BLUE.

Part 2, Exercise 3 Confirmation.



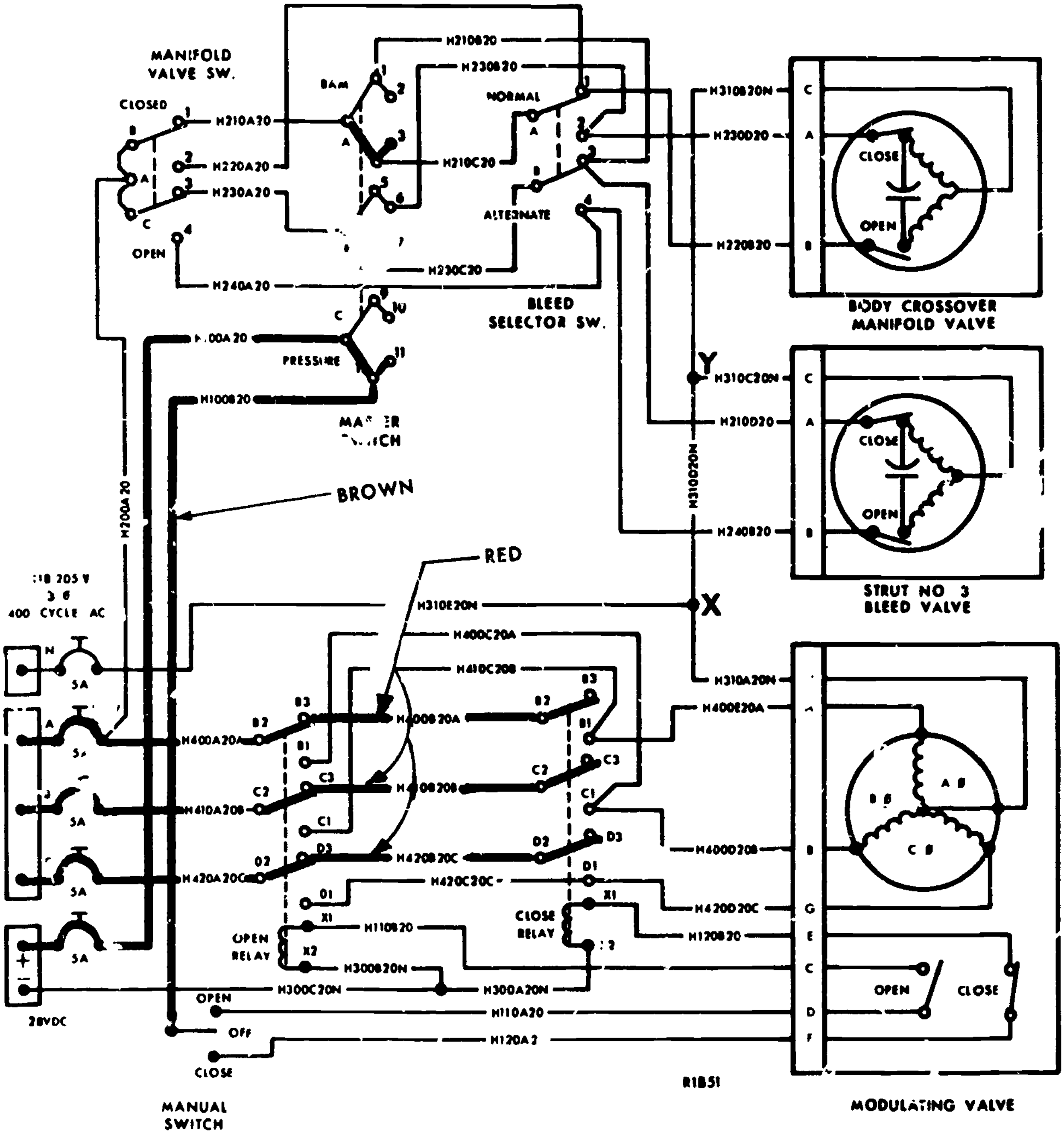
NOTE: The bold lines above are ORANGE.

Part 2, Exercise 4 Confirmation.



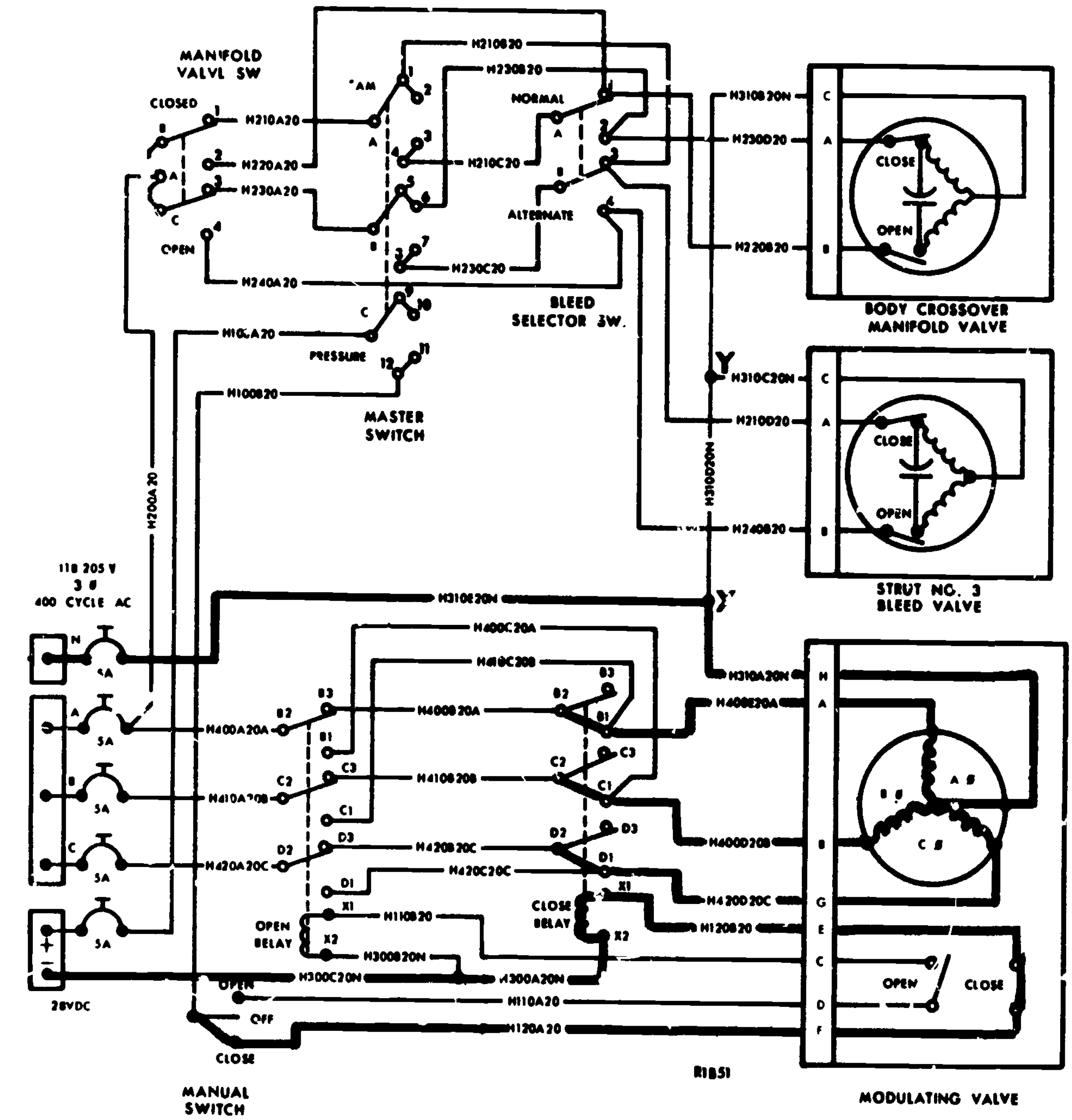
NOTE: The bold lines above are LIGHT BLUE.

Part 2, Exercise 5 Confirmation.



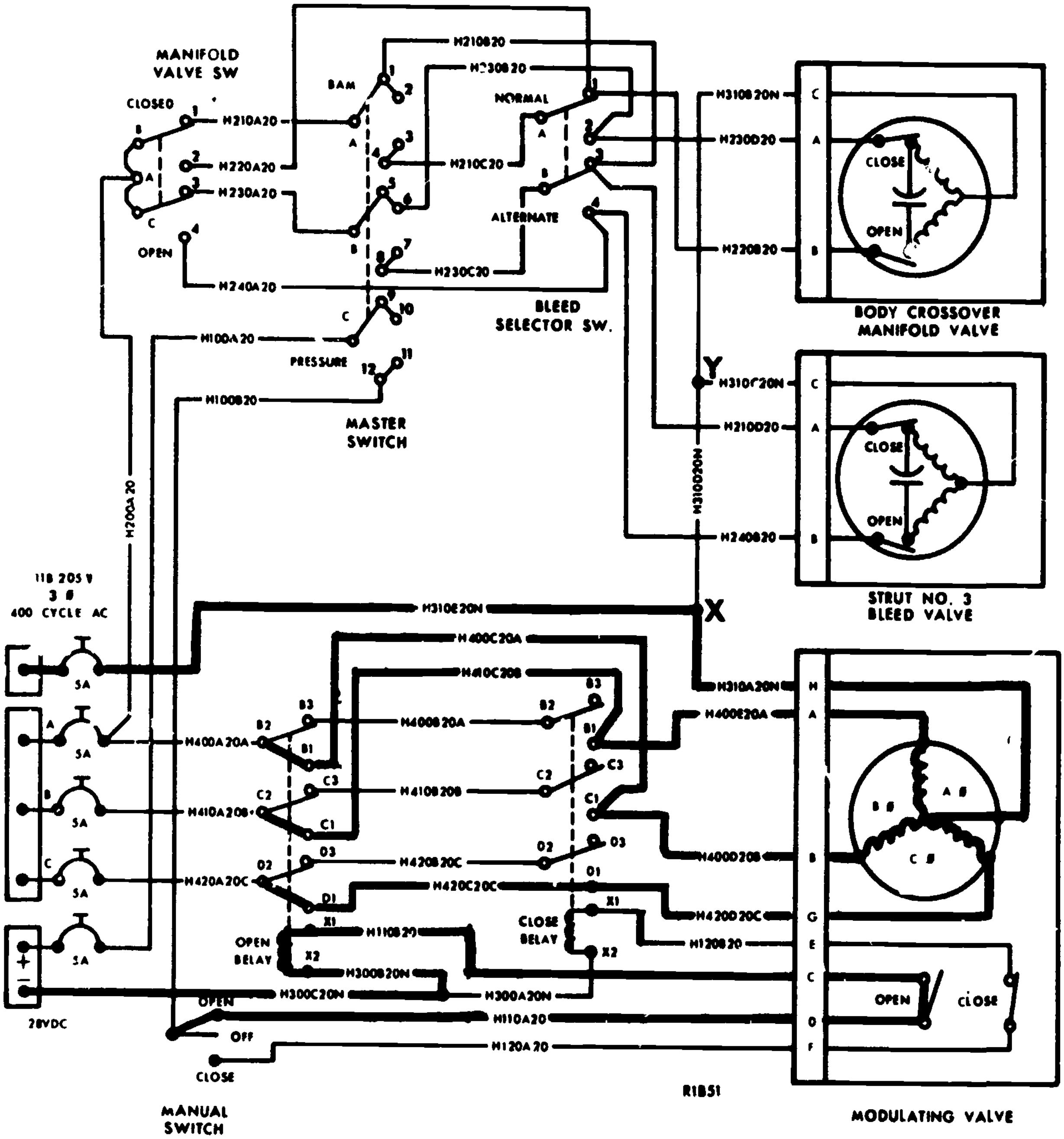
NOTE: The above bold lines are BROWN and RED.

Part 2, Exercise 6 Confirmation.



NOTE: The above lines are LIGHT GREEN.

Part 2, Exercise 7 Confirmation.



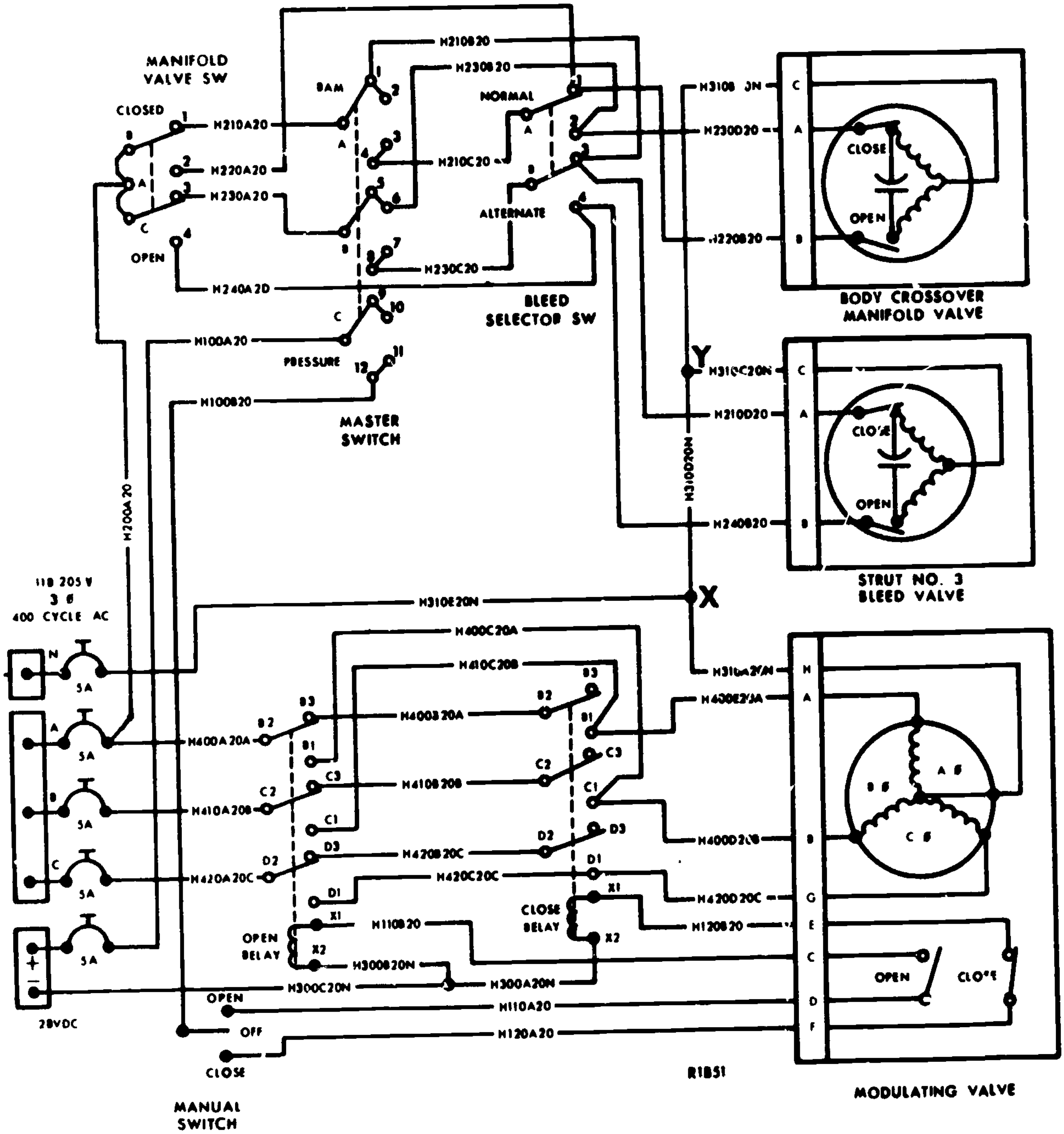
NOTE: The above bold lines are PURPLE.

Part 2, Exercise 8 Confirmation.

PART 3

Note: You may remove Part 3 from Part 2 for ease of tracing if you so desire.

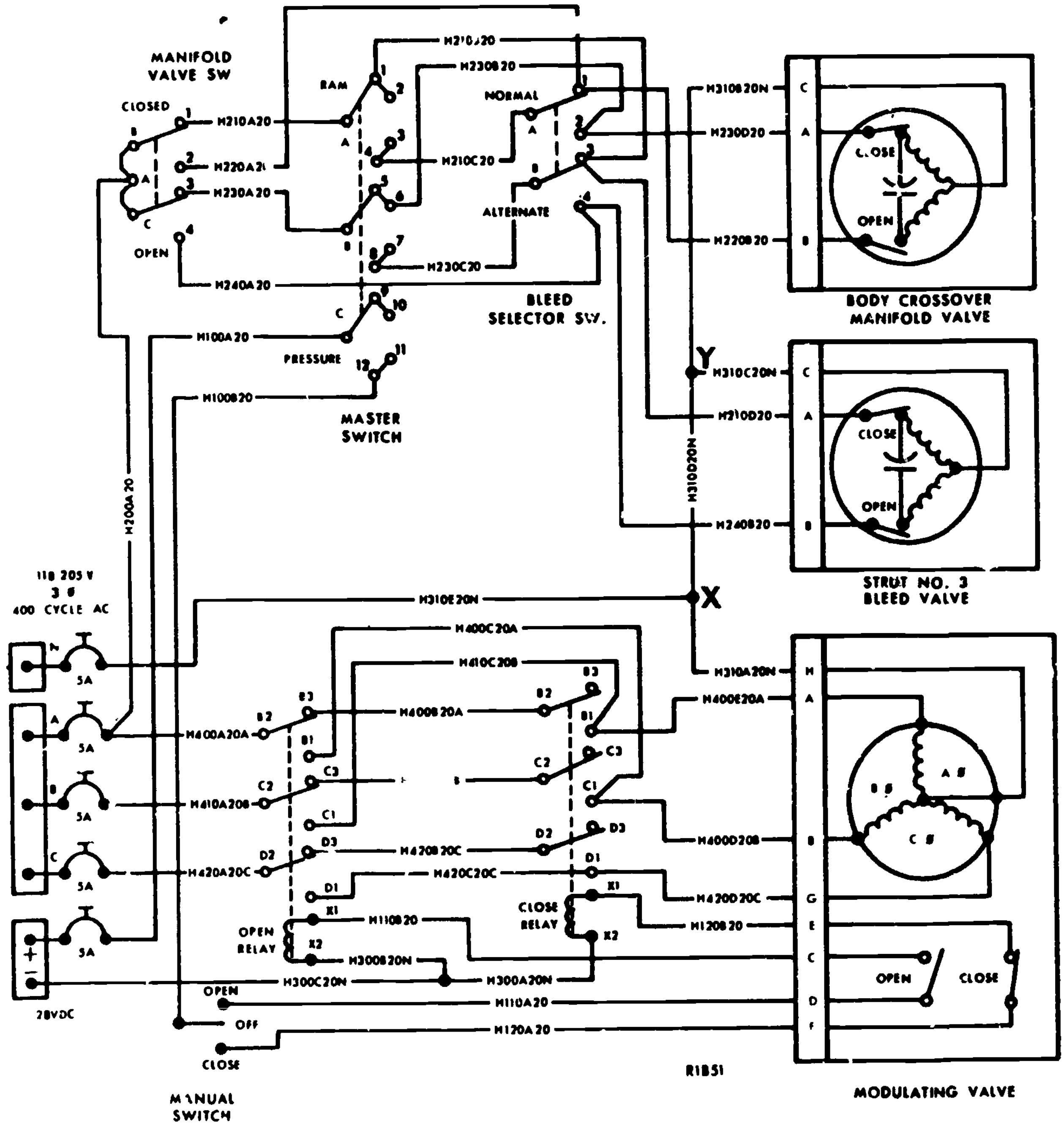
1224



Exercise 1 (red)

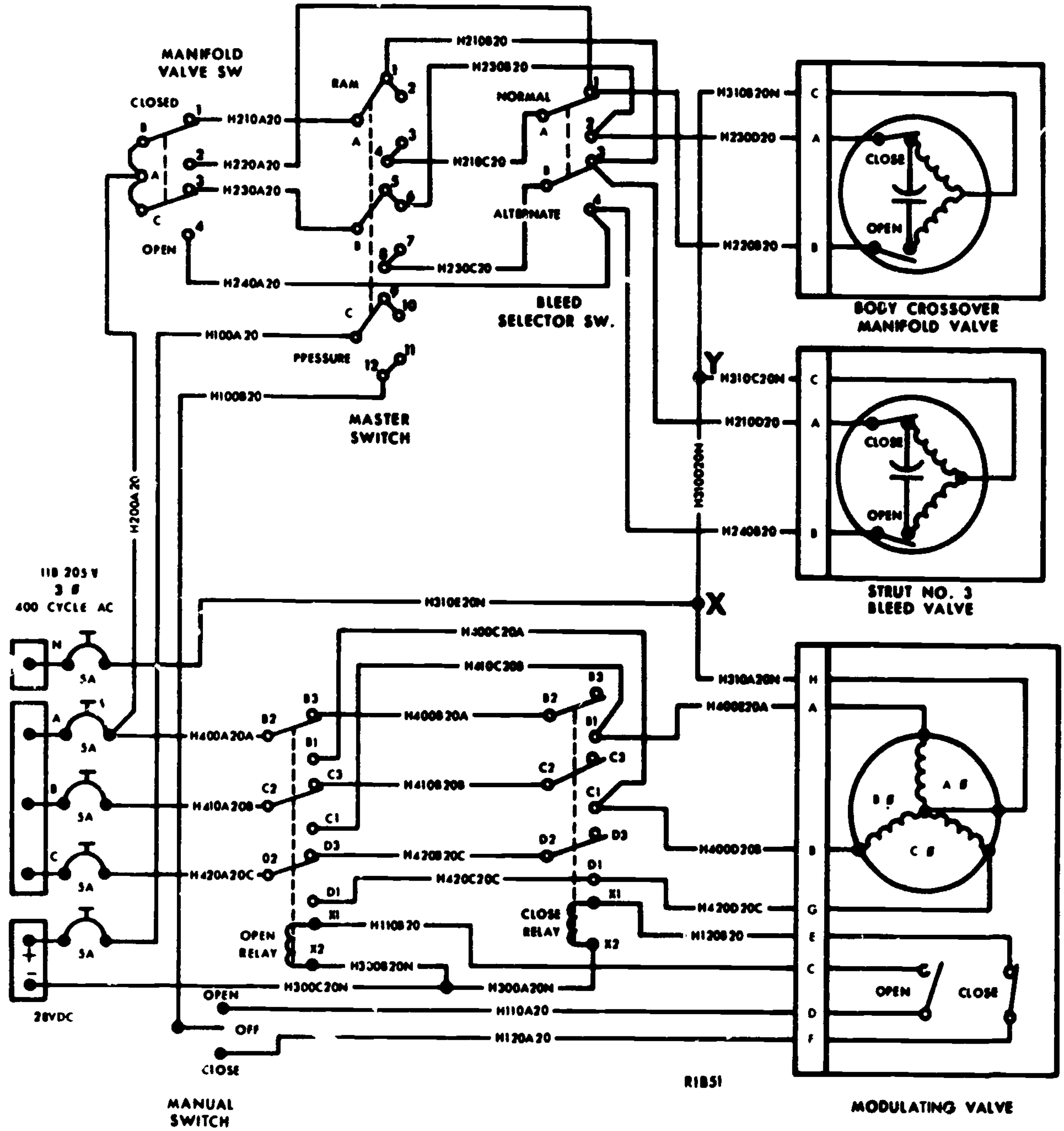
Exercise 2 (dark green)

Part 3, Figure 1.



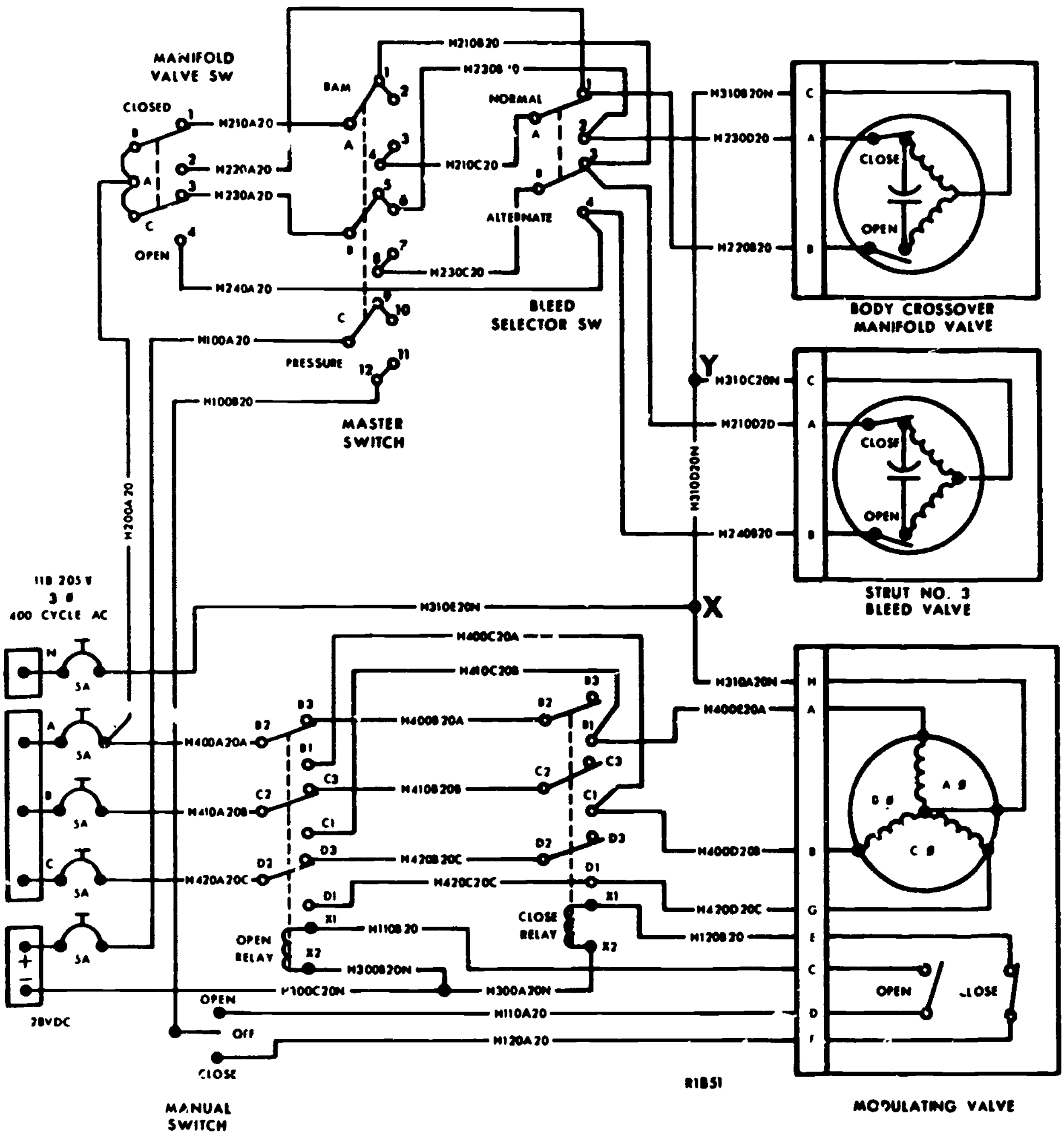
Exercise 3 (dark blue)

Part 3, .igure 2.



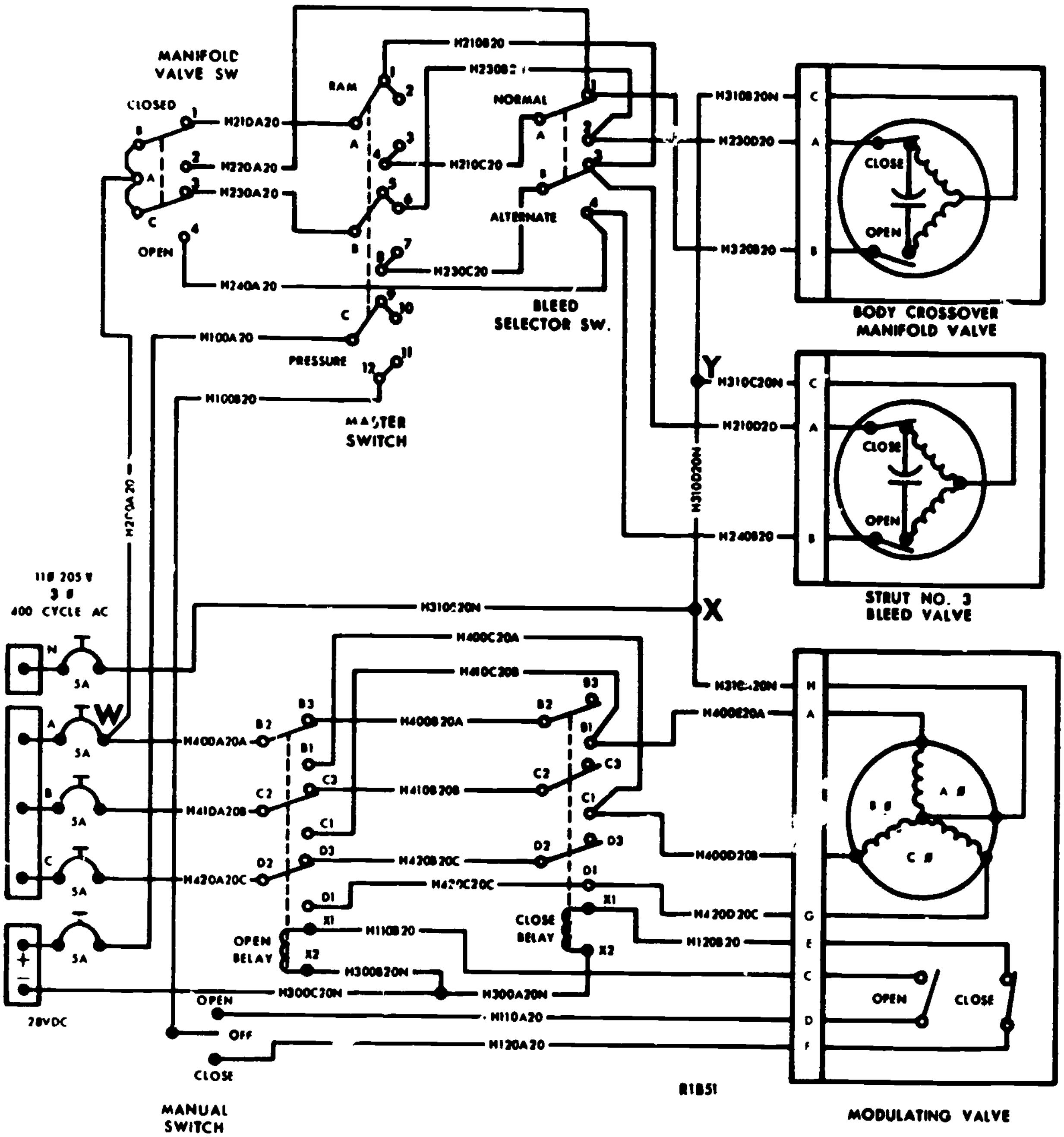
Exercise 4 (orange)

Part 3, Figure 3.



Exercise 5 (light blue)
Exercise 6 (brown and red)
Exercise 7 (light green)

Part 3, Figure 4.



Exercise 8 (purple)

Part 3, Figure 5.

1229

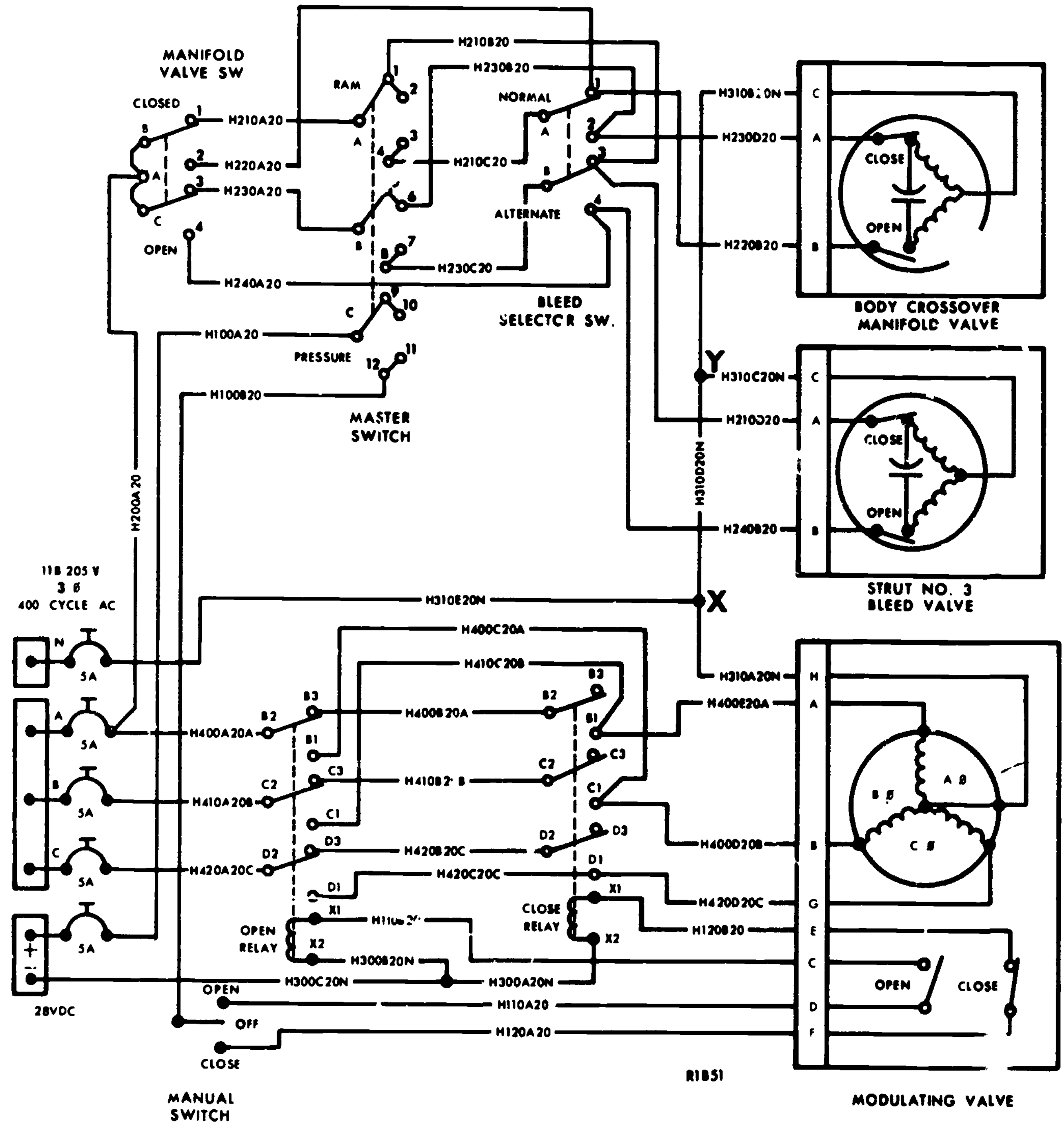

MANIFOLD VALVE SW
CLOSED
OPEN
H210A20
H220A20
H230A20
H240A20
RAM
NORMAL
ALTERNATE
PRESSURE
BLEED SELECTOR SW.
MASTER SWITCH
H210B20
H230B20
H210C20
H230C20
H100A20
H100B20
H200A20
BODY CROSSOVER MANIFOLD VALVE
STRUT NO. 3 BLEED VALVE
MODULATING VALVE
CLOSE
OPEN
H310C20N
H210D20
H240B20
H310D20N
H230D20
H220B20
H310E20N
H310A20N
H400E20A
H400D20B
H420D20C
H120B20
115 205 V
3 ø
400 CYCLE AC
5A
28VDC
H400A20A
H410A20B
H420A20C
H400B20A
H420B20C
H420C20C
H400C20A
H410C20B
OPEN RELAY
CLOSE RELAY
H300B20N
H300C20N
H300A20N
H110A20
H120A20
OPEN
OFF
CLOSE
MANUAL SWITCH
R1851

Figure 6a.

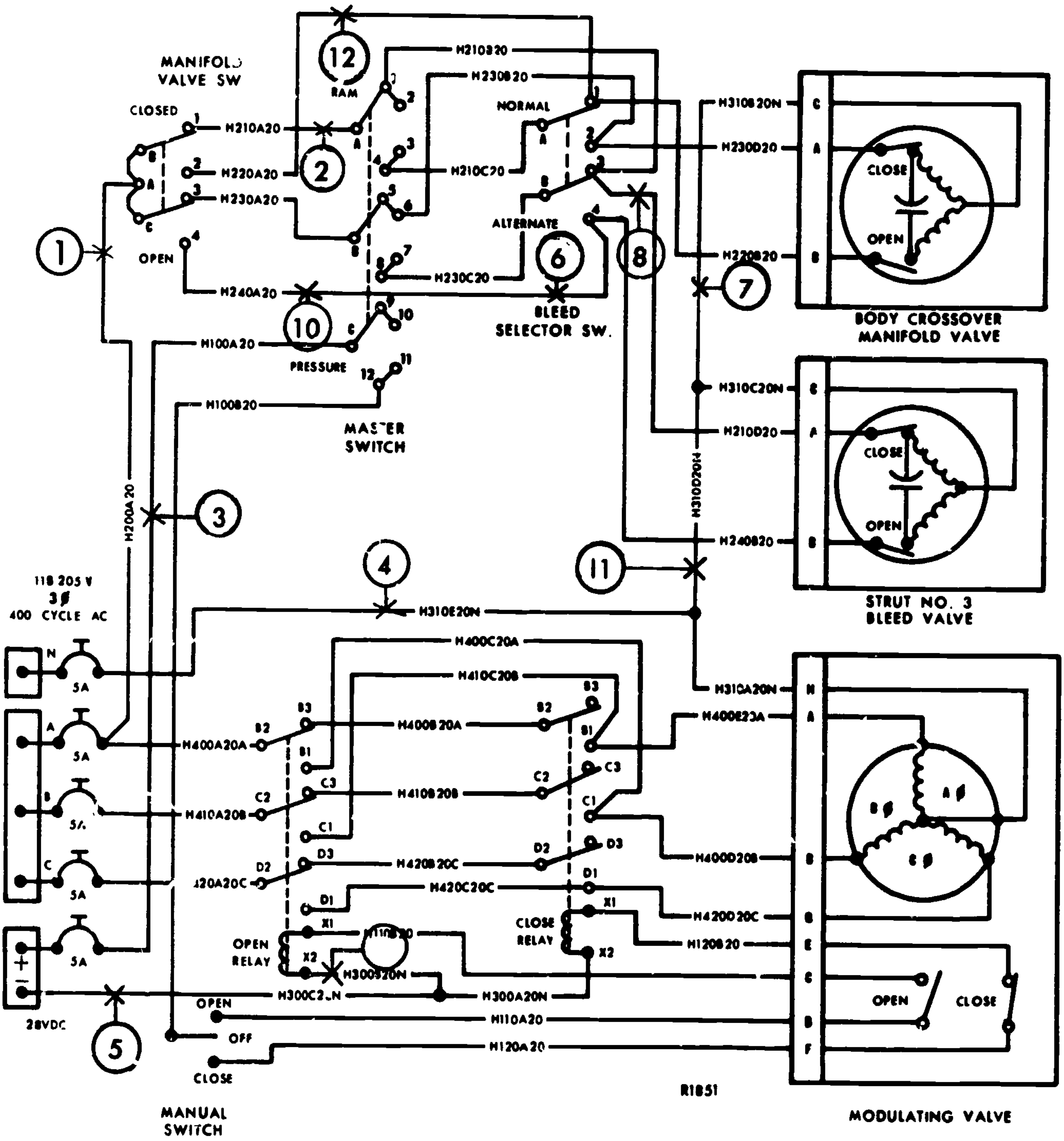

MANIFOLD VALVE SW
CLOSED
OPEN
H210A20
H220A20
H230A20
H240A20
H100A20
H100B20
H210B20
H230B20
H210C20
H230C20
RAM
PRESSURE
MASTER SWITCH
NORMAL
ALTERNATE
BLEED SELECTOR SW.
H310B20N
H230D20
H220B20
BODY CROSSOVER MANIFOLD VALVE
H310C20N
H210D20
H240B20
STRUT NO. 3 BLEED VALVE
H200A20
H310D20N
118 205 V
3 Ø
400 CYCLE AC
H310E20N
H400C20A
H410C20B
H400A20A
H410A20B
H400B20A
H410B20B
H420B20C
H420C20C
H310A20N
H400E23A
H400D20B
H420D20C
H120B20
OPEN RELAY
CLOSE RELAY
H300C20N
H300A20N
H110A20
H120A20
28VDC
OPEN
OFF
CLOSE
MANUAL SWITCH
R1851
MODULATING VALVE
CLOSE
OPEN
A Ø
B Ø
C Ø
5A

Figure 6b.

STUDENT'S NAME ________________________________
(last) (first)

PROBLEM NUMBERS (REFER TO FOLDOUT #2)	CIRCUIT INDICATIONS				CIRCUIT MALFUNCTIONS											
					BODY CROSSOVER MANIFOLD VALVE				STRUT #3 BLEED VALVE				MODULATING VALVE			
	MANIFOLD VALVE SWITCH	MASTER SWITCH	BLEED SELECTOR SWITCH	MANUAL SWITCH	NO EFFECT	INOPERATIVE	WON'T CLOSE	WON'T OPEN	NO EFFECT	INOPERATIVE	WON'T CLOSE	WON'T OPEN	NO EFFECT	INOPERATIVE	WON'T CLOSE	WON'T OPEN
1	CLOSE	RAM	ALT	OPEN		X				X			X			
2	OPEN	PRESS	NORM	CLOSE												

INSTRUCTOR MUST INITIAL BEFORE PROGRESSION ________

Figure 7.

71-18100

Technical Training

Aircraft Environmental Systems Mechanic

PRINCIPLES OF SOLID STATE DEVICES

26 March 1981

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

RGL: 10.7

OBJECTIVE

Specify basic facts relating to solid state devices with a minimum of 80% accuracy.

INSTRUCTIONS

This program text presents information in small steps called "frames." After each frame you are asked to complete a statement or match some statements. Read the material presented and make your response as directed. After you have made your response, compare your answer with the correct answer given on the page following each frame. If your answer is incorrect, restudy the frame to get the information correct. Write the correct answer next to your original response and then proceed to the next frame. If necessary, you may go back to check information previously given, but do not skip ahead.

INTRODUCTION

Solid state devices are miniature electronic components used to control or amplify current in an electronic circuit. The solid state devices that will be described in this text are PN junction diodes, Zener diodes, and transistors.

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OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 800; DAV - 1

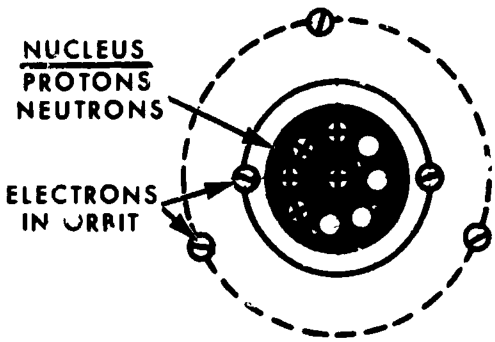
The PN junction diode is used in almost every temperature control circuit. This text will describe how the PN junction diode is constructed, how it reacts to changes in current flow, and its purpose in today's temperature control circuits.

The Zener diode is similar to the PN junction diode, except that its function in a circuit is different. This text will explain how the Zener diode is used as a control device and how it is used to regulate voltage.

The transistor also operates on the same principles as the PN junction diode. In this text you will be shown how the transistor operates and how it is used in a temperature control circuit.

Understanding the operating principles of these three devices is very important when studying the operation of temperature control systems.

To understand the principles of solid state devices, we must have a short review of electron theory. An atom is made up of PROTONS, NEUTRONS, and ELECTRONS. The protons and neutrons make up the center part of the atom which called the NUCLEUS. The electrons are held in orbit around the nucleus. This is shown in the sketch below. Electrons have a negative charge and protons have a positive charge. The neutrons are neutral, which means they have no electrical charge.



Fill in the blanks to complete the following statements.

1. Atoms are composed of __________, __________, and __________.
2. Electrons have a __________ charge.
3. Protons have a __________ charge.
4. Electrons orbit around the __________ of an atom.
5. Protons and neutrons make up the __________ of an atom.

Answers to frame 1: 1. protons neutrons electrons 2. negative

3. positive 4. nucleus 5. nucleus

FRAME 2

In some materials the atoms have many electrons orbiting around their nuclei. Some of these electrons are in orbits distant from the nucleus. This will make it easier to get the electrons to flow from one atom to another. These materials are said to have "free electrons." The atoms of other materials tend to resist the efforts toward electron flow. These materials are said to have almost no free electrons.

A material that has many free electrons is a conductor of electricity. Some examples of conductors are copper, silver, and gold. When a voltage is applied to a conductor, the free electrons can move with little or no resistance. This is called current flow. The materials that contain almost no free electrons are called insulators. Some examples of insulators are rubber, glass, and paper. These materials will oppose current flow.

Fill in the blanks to complete the following statements.

1. An insulator contains almost no ________ electrons.

2. Conductors contain many ___________ electrons.

3. Normally current will not flow through an __________.

4. Copper, gold, and silver are some examples of __________.

5. Current flow is the movement of __________ through a conductor.

Answers to frame 2: 1. <u>free</u> 2. <u>free</u> 3. <u>insulator</u> 4. <u>conductors</u>

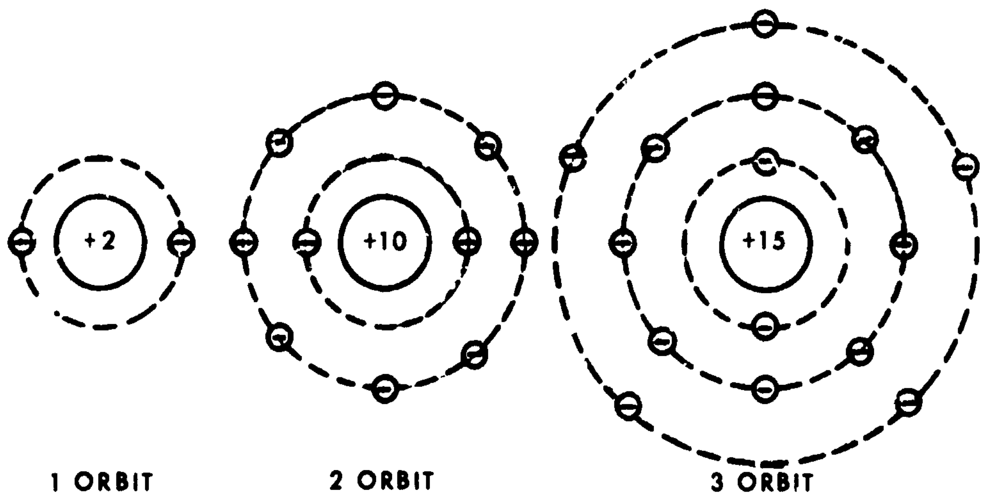
5. <u>electrons</u>

FRAME 3

Let's go on with our review of atomic structure and learn a new term. In each atom there are a specific number of electrons that orbit the nucleus. These electrons will be divided into a definite number of orbital paths. The actual number of electrons and the number of orbital paths will change with the types of material used. This fact in shown in the sketch in this frame. The number of orbits will depend on the number of electrons. In a balanced atom, the number of electrons will be equal to the number of protons. Note the number of electrons, protons and orbits in the sketch shown.

The electrons in the outermost orbit are called VALENCE electrons. As we explain the principles of solid state devices we will be concerned with these <u>valence electrons</u>. Remember this term and that these are the electrons in the <u>outermost orbit</u>.

A stable atom will have eight valence electrons. The <u>maximum</u> number of valence electrons in any atom is eight. Some atoms may have less than eight valence electrons but never more.



Fill in the blanks to complete the following statements.

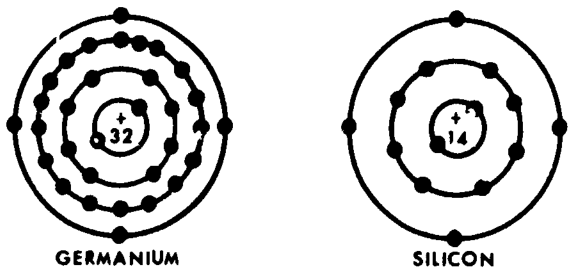
1. The electrons in the outermost orbit of an atom are called ____________ electrons.

2. The maximum number of electrons in the outermost orbit of an atom is ____________.

Answers to frame 3: 1. valence 2. eignt

FRAME 4

The two basic materials used in the construction of solid state devices are germanium and silicon. The electron structure of these atoms is shown below. Note that the germanium contains 32 electrons and silicon only 14 electrons. Now note the number of valence electrons in each of these atoms. They both have four. Our discussion on solid state devices will be based on this point. Because each of these materials have four valence electrons, their application to solid state devices is similar. For this reason we will use germanium in this text.



Fill in the blanks to complete the following statements.

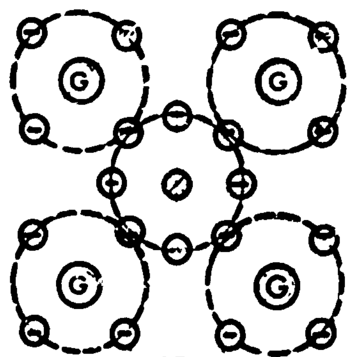
1. The two basic materials used in the construction of solid state devices are ____________ and ____________.

2. Germanium and silicon are similar because they both have four ____________ ____________.

Answers to frame 4: 1. germanium silicon 2. valence electrons

FRAME 5

In frame 3 it was stated that an atom is stable when it has eight valence electrons. A stable atom has no free electrons. When a group of germanium atoms are joined together to form a mass, the material will act as though the atoms are stable. This is because the valence electrons of one atom will join with the valence electrons of the atoms close to it. This makes each atom act as if it has eight valence electrons. This is shown in the sketch below.



Fill in the blanks to complete the following statements.

1. A stable germanium atom is one with __________ electrons in the valence orbit.

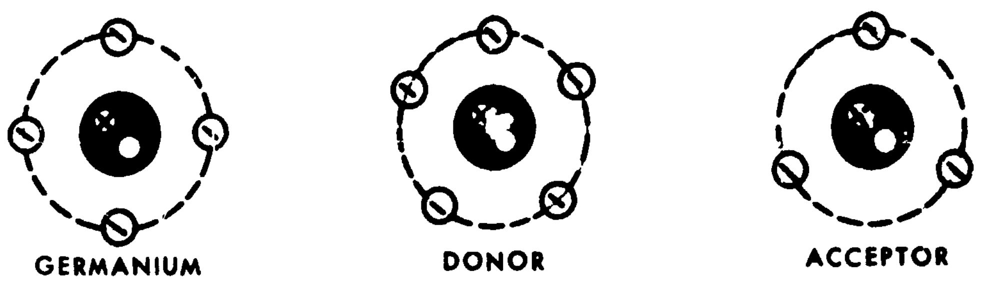
2. When a group of germanium atoms are joined, the material will react as if the atoms were __________.

Answers to frame 5: 1. eight 2. stable

FRAME 6

Solid state devices are made from materials known as semiconductors. A semiconductor is a man made substance. It is made by joining a material that has a different number of valence electrons with the germanium. The atoms that are joined with the germanium are called impurity atoms. The impurity atoms have either three or five valence electrons. In either case, when the impurity atoms are added to the germanium, the stable state of the germanium is changed.

An impurity that has three valence electrons is called an ACCEPTOR atom. Some examples are aluminum, indium, and gallium. An impurity that has five valence electrons is called a DONOR ATOM. Some examples are arsenic, phosphorous, and antimony. In the sketch below, compare the valence electrons of the donor and acceptor to the germanium atom.



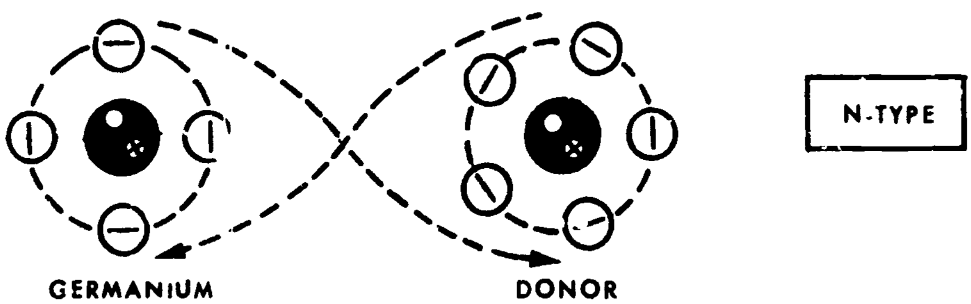
Fill in the blanks to complete the following statements.

1. Germanium can be altered by adding __________ atoms.
2. The number of valence electrons in a donor atom is ________.
3. The number of valence electrons in an acceptor atom is _______.

Answers to frame 6: 1. impurity 2. five 3. three

FRAME 7

Now let's see what change the donor has had on the germanium. When the donor atom is joined with a germanium atom, four of the electrons of the donor join the germanium atom. But since the donor atom has five valence electrons, one is left free to move in any direction. The material now has an excess electron which will give it a negative charge. Because of this, material containing a donor impurity is called N-type material. The sketch below shows the effect of joining a donor atom with a germanium atom.



4 + 5=9 ELECTRONS AVAILABLE
4→BEING JOINED BY←4= 8 ELECTRONS NEEDED

1 FREE ELECTRON

Fill in the blanks to complete the following statements.

1. N-type material consists of germanium combined with a ___________ atom.

2. N-type material contains a _______ charge.

3. A donor atom contains ____________ valence electrons.

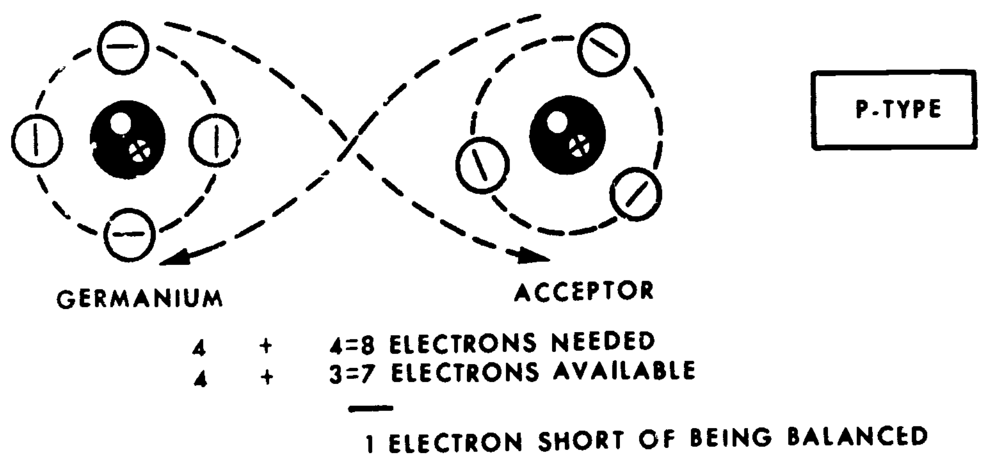
Answers to frame 7: 1. donor 2. negative 3. five

FRAME 8

Now, let's see how the germanium will change when an acceptor impurity is added to it. When the acceptor atom is joined with a germanium atom, the valence orbit will have seven electrons. Remember, to be stable, an atom needs eight valence electrons. When the acceptor atom is joined with the germanium, it leaves a space where one more electron can fit. This space is called a HOLE, and it can take on an electron.

The last frame stated that an atom that had an excess of electrons had a negative charge. In view of this, if an atom lacks an electron, it must have a positive charge. When an acceptor is joined to a germanium atom it becomes a positively charged atom. This positively charged atom (a material that has holes) is called P-type material.

The sketch below shows the effect of combining an acceptor atom with a germanium atom.



Fill in the blanks to complete the following statements.

1. An acceptor atom has __________ valence electrons.

2. P-type material has a ________ charge.

3. When an acceptor atom is joined with a germanium atom, it leaves a space called a _____________.

Answers to frame 8: 1. three 2. positive 3. hole

FRAME 9

Match the terms given in column B with the statements listed in column A. Place the letter that identifies the correct term in the blank provided. Column B has more responses than needed. Select only one for each question.

A	B
1. The number of valence electrons in a stable germanium atom is ________.	A. Nucleus
	B. Atom
2. The material used in solid state devices is called a ________.	C. Four
3. Electrons in the outermost orbit are called ________.	D. Semiconductor
	E. Electron
4. A material having many free electrons is a ________.	F. Eight
5. An impurity atom having three valence electrons is an ________ atom.	G. Valence electrons
	H. Conductor
6. An impurity atom having five valence electrons is a ________ atom.	I. Insulator
	J. Donor
7. The particle that orbits the nucleus of an atom is the ________.	K. Acceptor
	L. N-type
8. When germanium is combined with an acceptor atom it is called ________ material.	M. P-type

Answers to frame 9: 1. F 2. D 3. G 4. H 5. K 6. J
7. E 8. M

FRAME 10

Solia state devices are made of N-type and P-type materials joined together. When these materials are joined, as shown in figure A, a device is formed that is known as a PN JUNCTION. Because these two types of materials are joined, a "potential barrier" is formed as shown in figure B. This barrier will oppose electron flow until the right voltage potential is applied to the junction. This voltage is known as BIAS VOLTAGE. Bias voltage is usually DC, and is used to fix or set the current flow in a circuit. The two types of bias used are FORWARD and REVERSE.

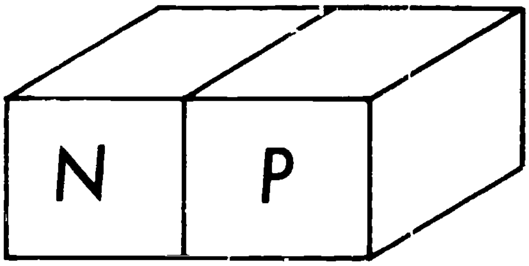


Figure A

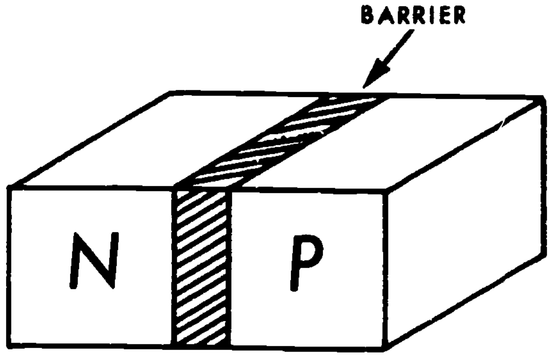


Figure B

Fill in the blanks to complete the following statements.

1. The voltage used to adjust the current flow through a PN junction is called __________ voltage.

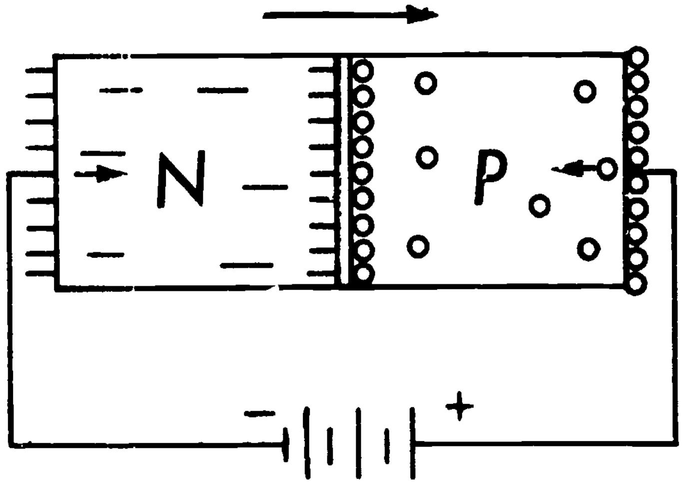
2. When P-type and N-type materials are joined, the unit formed is known as a ______________.

Answers to frame 10: 1. bias 2. PN junction

FRAME 11

Forward bias is a voltage placed on the PN junction in such a way that it aids current flow. The sketch below shows how forward bias is placed on a PN junction. Notice that the negative pole of the source voltage is put on the N-type material and the positive pole is put on the P-type material. This type of bias will cause the like charges to be repelled toward the center. The repelling action of the like charges will decrease the size of the potential barrier. When the barrier has been decreased enough current will flow across the junction.

CURRENT FLOW



FORWARD BIAS

Fill in the blanks to complete the following statements.

1. When applying forward bias, the positive pole of the power source is connected to the __________ (negative/positive) material.

2. When forward bias is applied, the width of the potential barrier __________.

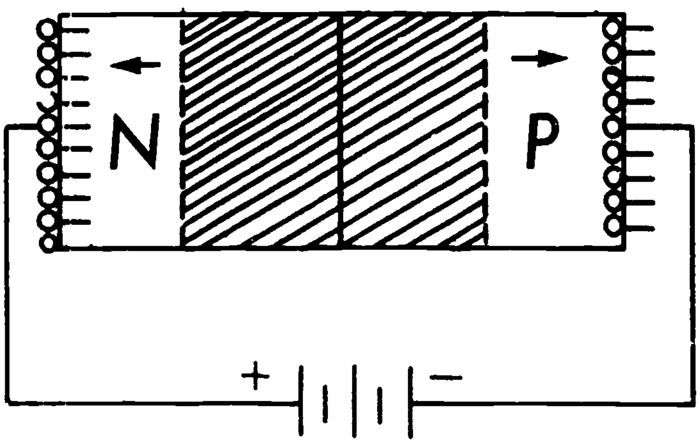
3. Current flows through a PN junction when _______ bias is applied.

Answers to frame 11: 1. positive 2. decreases 3. forward

FRAME 12

Reverse bias is a voltage applied to the PN junction in such a way that it opposes current flow. The drawing below shows how reverse bias is connected to a PN junction. Notice that the negative pole of the source voltage is connected to the P-type material, and the positive pole is connected to the N-type material. This type of connection causes the electrons in the N-type material to be attracted to the positive pole of the source, and the holes in the P-type material to be attracted to the negative pole of the source. This causes the potential barrier to increase in width and allow little or no current flow across the junction.

MININUM OR NO CURRENT FLOW



REVERSE BIAS

Fill in the blanks to complete the following statements.

1. The width of the potential barrier is increased when ________ bias is applied.

2. Reverse bias is connected to the PN junction so that it will ________ current flow.

3. When applying reverse bias, the negative pole of the power source is connected to the ____________ (negative/positive) material.

1247

Answers to frame 12: 1. reverse 2. oppose 3. positive

FRAME 13

When the PN junction is used in an electrical circuit it is called a DIODE. A diode is a two element unit, consisting of an EMITTER and a COLLECTOR. The emitter is the N-type material which emits electrons. The collector is the P-type material which accepts electrons. A diode is used in an electrical circuit to allow current flow in one direction only.

The electrical symbol for the diode is shown in figure A below. Current flow is always against the arrow. Figures B and C shows how bias effects current flow in the diode.

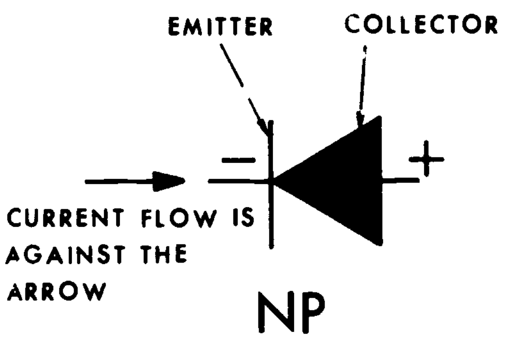


Figure A

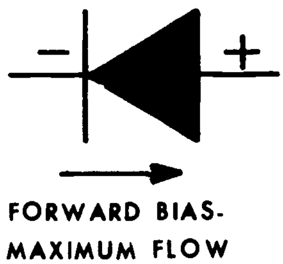


Figure B

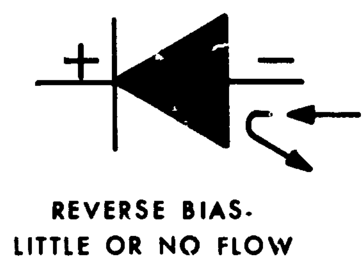


Figure C

Fill in the blanks to complete the following statements.

1. When a PN junction is used in an electrical circuit, it is called a __________.
2. The two elements of a diode are the emitter and __________.
3. A diode is used to allow current flow in __________ __________ only.
4. Current flow through a diode is always __________ the arrow.
5. The N-type material is the __________ (emitter/collector).
6. A diode will __________ current in one direction but will __________ current to flow in the other direction.

Answers to frame 13: 1. diode 2. collector 3. one direction

4. against 5. emitter 6. block, let or allow

FRAME 14

Changing alternating current to direct current is known as RECTIFICATION. When one diode is placed in an AC power supply circuit, it will let current flow on one half of the alternation only. This is called HALF WAVE rectification. For this reason, the diode is called a half wave rectifier.

Now let's trace the current flow in figure A to see how the diode rectifies it. On one half cycle (note arrow 1), the diode is forward biased. Current flow is from negative, through the load, through the diode, and back to positive. On the other half cycle (note arrow 2), the diode is reverse biased. Current will try to flow from the negative to the positive, but it cannot get through the diode. Remember, current only flows through a diode when it is forward biased. Therefore, the load (light) does not burn steadily, but will flash (pulsate) every half cycle. Note in figure B, the sine wave for the AC input as compared to the pulsating DC output.

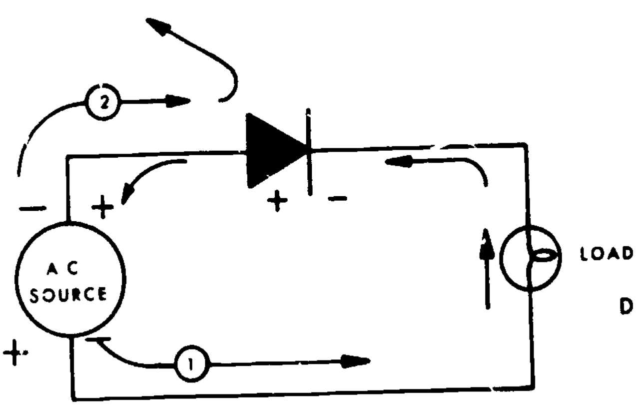


Figure A

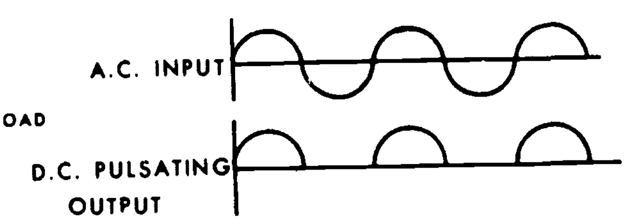


Figure B

Fill in the blanks to complete the following statements.

1. When one diode is used in an AC circuit, it is called a __________ wave rectifier.

2. A half wave rectifier changes alternating current to ______________ direct current.

Answers to frame 14: 1. half 2. pulsating

FRAME 15

To change AC to a continuous DC output requires a FULL WAVE rectifier. By using either two or four diodes, the alternating current can be rectified to provide an almost continuous direct current. Let's trace the path of current flow through the circuit in figure A. On one half cycle, diodes 1 and 2 are forward biased, while diodes 3 and 4 are reverse biased. When the source is negative at point A, the current flows through diode 1, then through the load, through diode 2, and back to the positive potential at the source. On the other half cycle, diodes 3 and 4 become forward biased and diodes 1 and 2 become reverse biased. Now current flows from the negative potential at point B, through diode 3, through the load, through diode 4, and back to the source.

With the full wave rectifier in figure A, there is a continuous flow of current through the load. Notice that this current flow is always in the same direction. Compare the sine waves of the AC input to the DC output shown in figure B. A filter network consisting of capacitors, coils and resistors would be used to smooth out the DC ripple effect of figure B. Note in figure C the output effect using capacitors, coils and resistor arrangement.

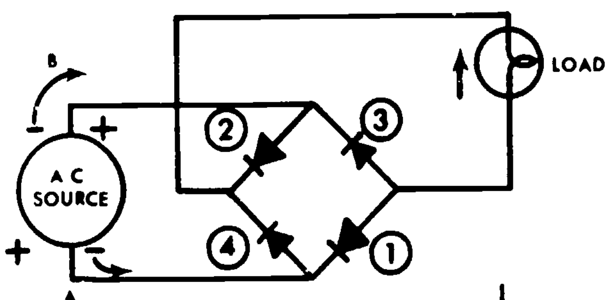


Figure A

Figure C

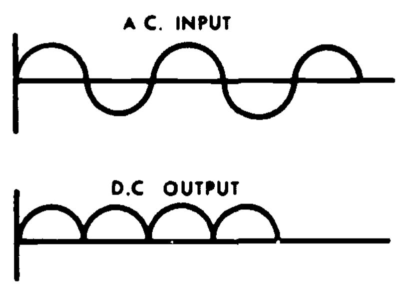


Figure B

Fill in the blanks to complete the following statements.

1. When four diodes are used in an AC circuit, it is called a ________ wave rectifier.

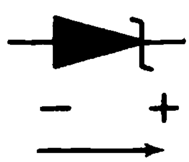
2. A full wave rectifier will allow current flow through the load during ___________ (one/both) half cycles.

3. When a full wave rectifier is used, the current flow through the load is in the ____________direction.

Answers to frame 1: full 2. both 3. same

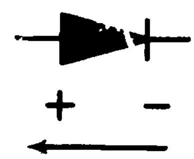
FRAME 16

A ZENER diode is a special kind of diode specifically designed for use as a voltage regulator. The schematic symbol for a Zener diode is shown in figure A below. On this illustration you will note that current flow is in the opposite direction to that of the normal diode as shown in figure B. Current flow in a Zener diode is [illegible] the arrow point. The Zener diode when hooked in a circuit will not allow [illegible] electrical circuit to be completed until it absorbs a certain preset voltage. By this token we say the Zener diode in reality is a voltage regulator.



Zener Diode
Current Flow

Figure A

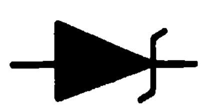


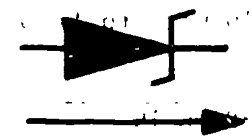
Normal Diode
Current Flow

Figure B

Fill in the blanks to complete the statements.

1. Zener diodes are used as _________ regulators.
2. Current flow in a Zener is (with/against) the arrow.
3. Draw an arrow under the schematic symbol which shows the direction of current flow.



Answers to frame 16: 1. voltage 2. with 3. 

FRAME 17

Match the terms given in column B with the statements listed in column A. Place the letter that identifies the correct term in the blank provided. Column B has more responses than needed. Select only one for each question.

A

1. The device used as a voltage regulator is a ________.
2. When reverse-bias is applied to a PN jucntion, it results in ________.
3. Biasing a PN junction effects the width of the ________.
4. A circuit that changes AC to pulsating DC is a _______ circuit.
5. To have current flowing through a diode requires ________.
6. The part (material) of the diode that serves as the collector is the ________.
7. When forward bias is applied to a diode, it results in ______.
8. The part (material) of the diode that serves as the emitter is the ________.

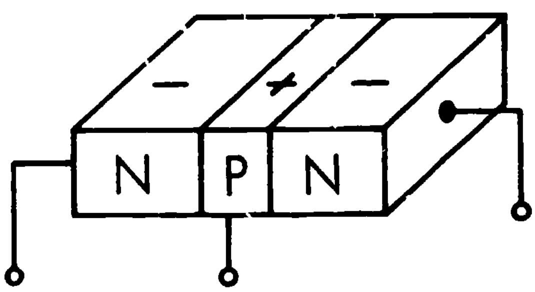
B

A. Rectifier
B. AC voltage
C. Reverse bias
D. Forward bias
E. Potential barrier
F. N-type material
G. P-type material
H. Zener diode
I. Maximum current flow
J. Minimum current flow

Answers to frame 17: 1. H 2. J 3. E 4. A 5. D 6. G 7. I 8. F

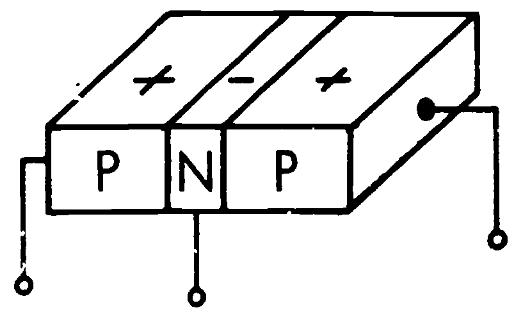
FRAME 18

Thus far the PN junction diodes have been described. These diodes consisted of P-type and an N-type material. When another N or P-type material is added to the diode, it becomes a triode (three element) TRANSISTOR. In modern day electronics, transistors are primarily used as amplifiers and relays. They are replacing vacuum tubes and conventional relays. The reason is that transistors are smaller and lighter than tubes or relays. They also have no moving parts to wear out from excessive use. Thus, the transistor's life span is longer. The two basic types of transistors are NPN and PNP. The block symbol for each is shown in figure A and B below.



Block Symbol for an NPN Transistor.

Figure A



Block Symbol for a PNP Transistor.

Figure B

Fill in the blanks to complete the following statements.

1. A combination of three N and P materials joined together forms a ________________.

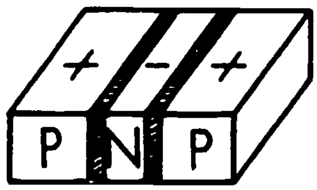
2. Transistors can be used as amplifiers or _________.

Answers to frame 18: 1. transistor 2. relays

FRAME 19

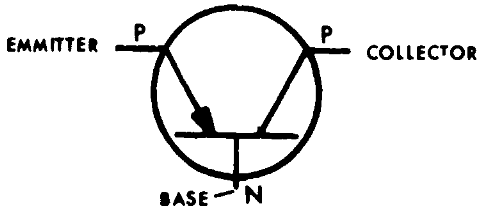
Both NPN and PNP transistors are used in temperature control systems. The PNP transistor consists of two end sections of P material and one center section of N material. These materials are bonded together to form one device. In this process we actually have two PN junctions. This also forms two potential barriers, a potential barrier between each of the PN junctions. Note the barrier regions in the block symbol shown in figure A below.

When a PNP transistor is used in an electrical circuit it is identified by the symbol shown in figure B.



BLOCK SYMBOL OF A PNP

Figure A



ELECTRICAL SYMBOL OF A PNP

Figure B

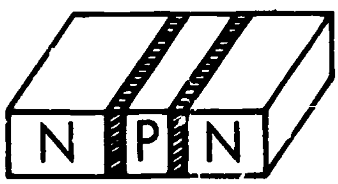
NO RESPONSE REQUIRED

FRAME 20

The NPN transistor consists of two end sections of N material and one center section of P material. This is shown in figure A. Note that this also forms two PN junctions and two potential barriers.

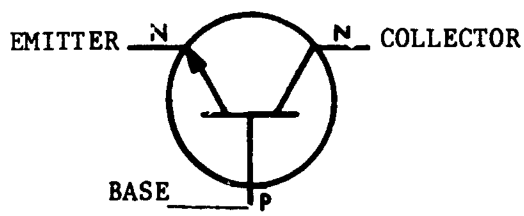
Figure A is the block symbol for an NPN transistor. However, when an NPN transistor is used in an electrical circuit, it is identified by the symbol shown in figure B.

The theory of operation of PNP and NPN transistors is basically the same. In the remainder of this text we will limit our discussion to the NPN transistor. The NPN transistor is the type used in most environmental system control circuits.



Block Symbol of an NPN.

Figure A

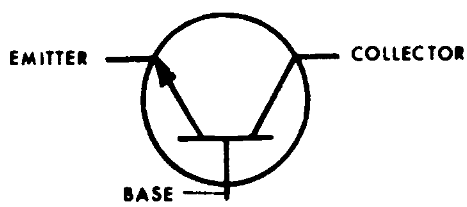


Electrical Symbol of an NPN.

Figure B

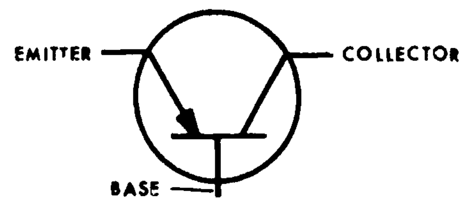
NO RESPONSE REQUIRED

Electrical diagrams of equipment using transistors will contain only the electrical symbol for transistors. The words or letters that identify the emitter, base, and collector are not used. Therefore, it's important that you can identify the sections of a transistor by the electrical symbol only. The arrow in the symbol is the key. The arrow always identifies the emitter. It also tells you whether it's an NPN or PNP. Notice in figure A (NPN transistor) that the arrow points out. Then notice in figure B (PNP transistor) the arrow points in. If the arrow is NOT POINTING IN, it's an NPN transistor. The center section is the BASE, and the remaining section is the COLLECTOR.



Electrical Symbol for an NPN Transistor.

Figure A



Electrical Symbol for a PNP Transistor.

Figure B

Fill in the blanks to complete the following statements.

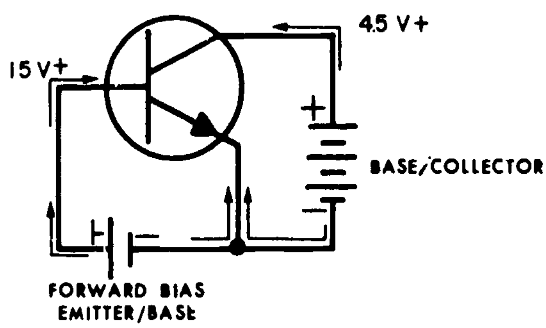
1. The three sections of a transistor are called ________, __________, and ___________.
2. The section of a transistor that controls the current flow through it is called the __________.
3. In the electrical symbol of a transistor, the emitter is signified by an _____________.
4. In an NPN transistor, the first N is the emitter and the second N is the ______________.

Answers to frame 21: 1. <u>base</u> <u>emitter</u> <u>collector</u> 2. <u>base</u> 3. <u>arrow</u>

4. <u>collector</u>

FRAME 22

Having learned that a transistor has an emitter, base, and collector, we can now talk about how it works. There must be a <u>positive signal put on the base, a negative signal put on the emitter, and a positive signal put on the collector</u>. These are shown in the sketch below. With these signals, the transistor is forward biased. As you recall from frame 10, bias is a voltage that is used to fix or set the current flow in a circuit. The sketch below shows the biasing of a transistor. Note that the emitter is pure negative while the base is 1.5 volts (+) positive. The collector circuit has a (+) positive voltage potential of 4.5 volts. It could be said that in order to forward bias the NPN transistor the emitter must be (-) negative, the base (+) positive and the collector at an even higher (+) positive potential.



For the transistor to conduct, forward bias is <u>always</u> applied between the emitter and base.

Fill in the blanks to complete the following statements.

1. Forward bias is always applied between the ________ and ________.

2. A transistor is forward biased when the positive signal is applied to the ____________.

Answers to frame 22: 1. emitter base 2. base

FRAME 23

The signal put between the base and emitter controls the load current flow that goes from the emitter to the collector. When the signal put on the base is more positive than the emitter, the transistor is forward biased. This will reduce the potential barrier and allow current to flow from the emitter to the collector. Figure A shows the transistor forward biased. Current flows from the negative emitter to the positive base. However, because the collector is always more positive than the base, most of the current flows through the base to the collector.

In figure B, the bias signal to the base is negative in respect to the emitter. This is a reverse bias. This negative signal (reverse bias between the base and emitter) will increase the potential barrier and stop current flow through the emitter-collector circuit. When biasing an NPN or PNP (forward or reverse) you bias the transistor between the emitter and base.

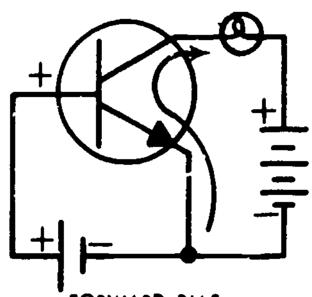


Figure A

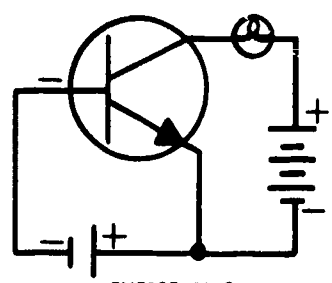


Figure B

Fill in the blanks to complete the following statements.

1. Current flows across a transistor only when the base is ________.

2. With a negative signal applied to the base, current flow across the transistor ________________.

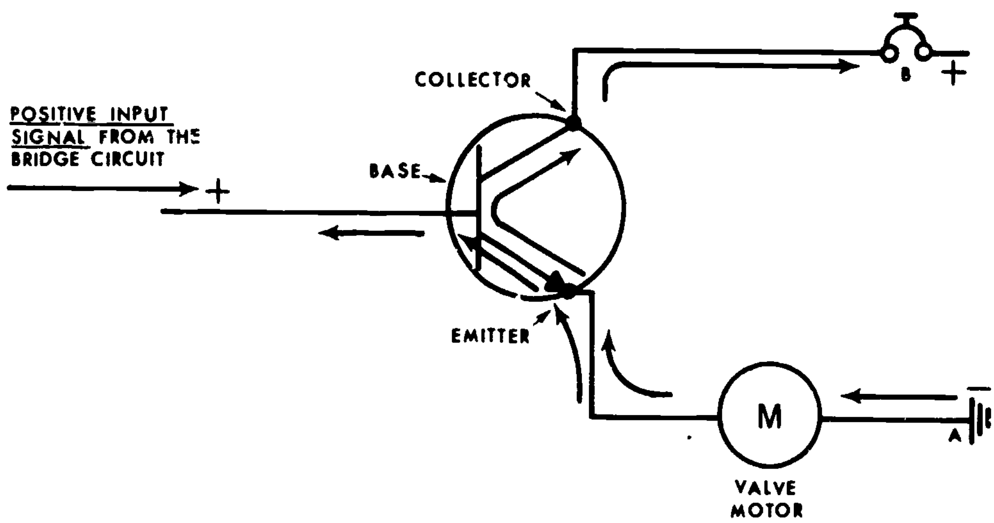
3. Current flow through a transistor is controlled by the signal applied between the emitter and ________.

4. When forward biasing an NPN transistor, you would bias it between the ________ and ________.

Answers to frame 23: 1. positive 2. stops 3. base
4. emitter and base

FRAME 24

This sketch shows how a transistor is used as a RELAY. The bridge circuit has put a positive signal on the base of the transistor. This will increase the forward bias of the emitter-base circuit. With this increase in forward bias, the transistor will conduct. With the transistor conducting, a circuit is completed between ground (point A) and the circuit breaker (point B). Current flows from ground, through the transistor, to the positive source at point B. When the transistor is conducting, the valve motor runs. When the bridge signal changes to negative, the base of the transistor also becomes negative. This will increase the reverse bias and the transistor will stop conducting. The current flow in the motor will now stop and the motor will no longer run. In this circuit, the transistor is used as a relay to control the operation of the motor.



Fill in the blanks to complete the following statements.

1. When the forward bias is increased the motor will __________.
2. The transistor will not conduct when the base is ___________.
3. When a transistor is used to control a motor circuit, it is being used as a ______________.

Answers to frame 24: 1. operate 2. negative 3. relay

FRAME 25

Match the terms given in column B with the statements listed in column A. Place the letter that identifies the correct term in the blank provided.

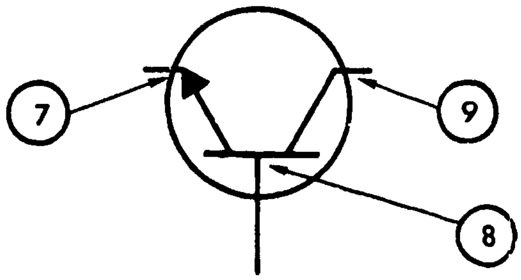
A	B
1. For current to flow through an NPN transistor, a positive signal must be applied to the ______.	A. Triode transistor
	B. NPN
2. A transistor can be used as a____.	C. Emitter
3. A transistor will conduct when there is ____ between the base and emitter.	D. Base
	E. Collector
4. When using an electrical symbol of a transistor, if the arrow is pointing away from the base, it is a/an _____ transistor.	F. Arrow
	G. Forward bias
	H. Reverse bias
5. The emitter of a transistor is identified on the electrical symbol by the _____.	I. Relay
6. The solid state device that contains three elements is a ______.	J. PNP

Name the sections of the transistor shown below:

7. ____________

8. ____________

9. ____________



10. The transistor shown in the above illustration is (a PNP/an NPN).

Answers to frame 25: 1. D 2. I 3. G 4. B 5. F

6. A 7. emitter 8. base 9. collector

10. NPN

Environmental Pneudraulic Branch
Chanute AFB, Illinois

SERVICE TEST
C3ABR42331-HO-127
1 February 1984

TRAINER AIRCRAFT. A/C SYSTEM TRAINER - OPERATIONAL CHECKOUT

BEST COPY AVAILABLE

PREPARATION

1. Place the TRAINER POWER switch in the 'ON' position.
2. Push in the CABIN AIR VALVES and CABIN CONDITIONING circuit breakers on the PEDESTAL COCKPIT circuit brearer panel.
3. Place the following switches in the position given

MASTER SWITCH	RAM DUMP
TEMPERATURE CONTROL SWITCH	OFF (center)
CABIN TEMPERATURE SELECTOR	70° (midposition)

OPERATIONAL CHECKOUT

Step	Control device and position	Operating valve(s)	Valve position
1	Place the MASTER switch in the CABIN PRESS position	Cabin Conditioning SOV Cabin Ram Air Valve	OPEN CLOSE
* 2	Hold the CABIN TEMPERATURE CONTROL switch in the MAN HOT position	Cabin Temperature Control valve	FULL OPEN
* 3	Hold the CABIN TEMPERATURE CONTROL switch in the MAN COLD position	Cabin Temperature Control valve	FULL CLOSE
4	Hold the CABIN TEMPERATURE CONTROL switch in the MAN HOT or MAN Cold posit on	Cabin Temperature Control valve	midposition
5	Place the CABIN [illegible] URE CONTROL switch in AUTO		
* 6	P cate the CABIN TEMPERATURE SELECTOR to 40°	Cabin Temperature Control valve	FULL CLOSE
* 7	Rotate the CABIN TEMPERATURE SELECTOR to 100°	Cabin Temperature Control valve	FULL OPEN
8	Place the CABIN TEMPERATURE CONTROL switch in the OFF position		
9	Place the MASTER switch in the RAM DUMP position	Cabin Conditioning SOV Cabin Ram Air Valve	CLOSE OPEN

*NOTE: Steps 2 and 3 and Steps 6 and 7 may be done in the reverse order.

OPR: 3370 TCHTG
TRIBUTION: X
370 TCHTG/TTGU-P - 200; DAV - 1

Designed for ATC Course Use. Do Not Use on the Job.

AUTOMATIC TEMPERATURE CONTROL COMPONENT TEST

NOTE: This test is to determine the condition of the Automatic Temperature Control circuit components (Cabin Temperature Sensor, Duct Temperature Sensor, and Cabin temperature Selector).

Step 1 Isolate the Temperature Control Bridge circuit components be disconnecting MS connector 188 from the Cabin Temperature Controller.

Step 2 Make a resistance check of the Duct Temperature Sensor and associated wiring. The resistance value of the sensor should fall between 16K and 47K ohms.

Step 3 Make a resistance check of the Cabin Temperature Sensor and associated wiring. The resistance value of the sensor should fall between 16K and 47K ohms.

Step 4 Make a resistance check of the Cabin Temperature Selector and associated wiring. The selector must be rotated to insure variable resistance values between 0 and 12K ohms.

SERVICE TEST
PROGRAMMED TEXT
C3ABR42331-PT-128

Technical Training

Aircraft Environmental Systems Mechanic

MAGNETIC AMPLIFIERS

19 November 1982

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

RGL: N/A

OBJECTIVES

Relate components of magnetic amplifier temperature control circuits to their purpose with a minimum of 80% accuracy.

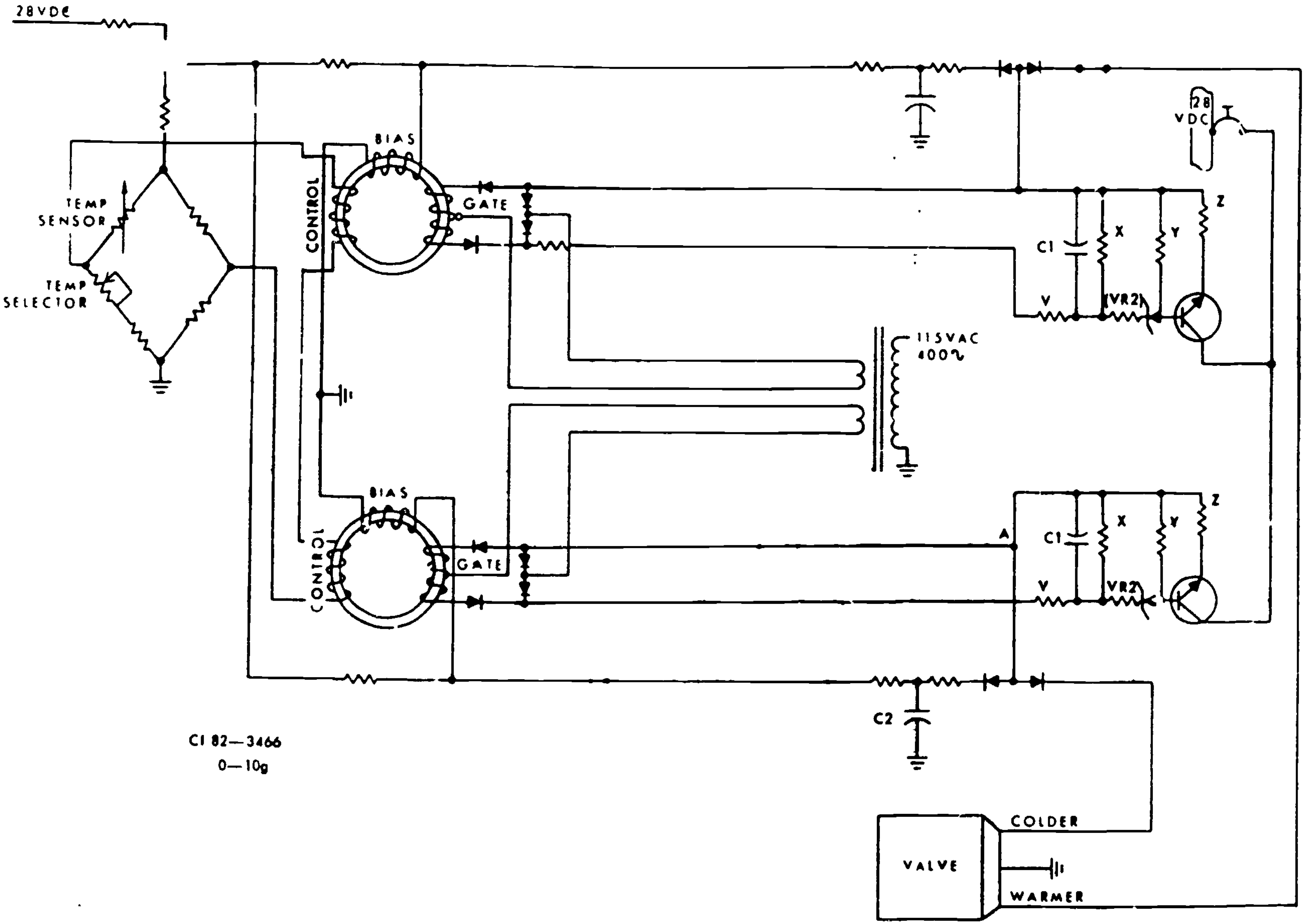
Specify how a signal from the bridge affects the components of magnetic amplifier temperature control circuits with a minimum of 80% accuracy.

INSTRUCTIONS

This programmed text presents information in small steps called frames. Carefully study the written material and/or schematic in each frame until you are satisfied you understand its contents. Each frame requires you to select true statements, solve problems, etc. Specific instructions are provided in each frame. After you have made your response, mark it in the space provided for it. Go to the back of the book to check your answers.

If you are correct, go on to the next frame. If you are incorrect, study the frame again and correct your mistakes before continuing. If you still can't understand your mistakes, ask your instructor for assistance. Read carefully, select the correct answer(s) and DO NOT HURRY.

Supersedes 3ABR42331-PT-128, 10 April 1981.
OPR: 3370 TCHTG
DISTRIBUTION:
3370 TCHTG/TTGU-P - 100; DAV - 1



CI 82—3466
0—10g

1266

1267

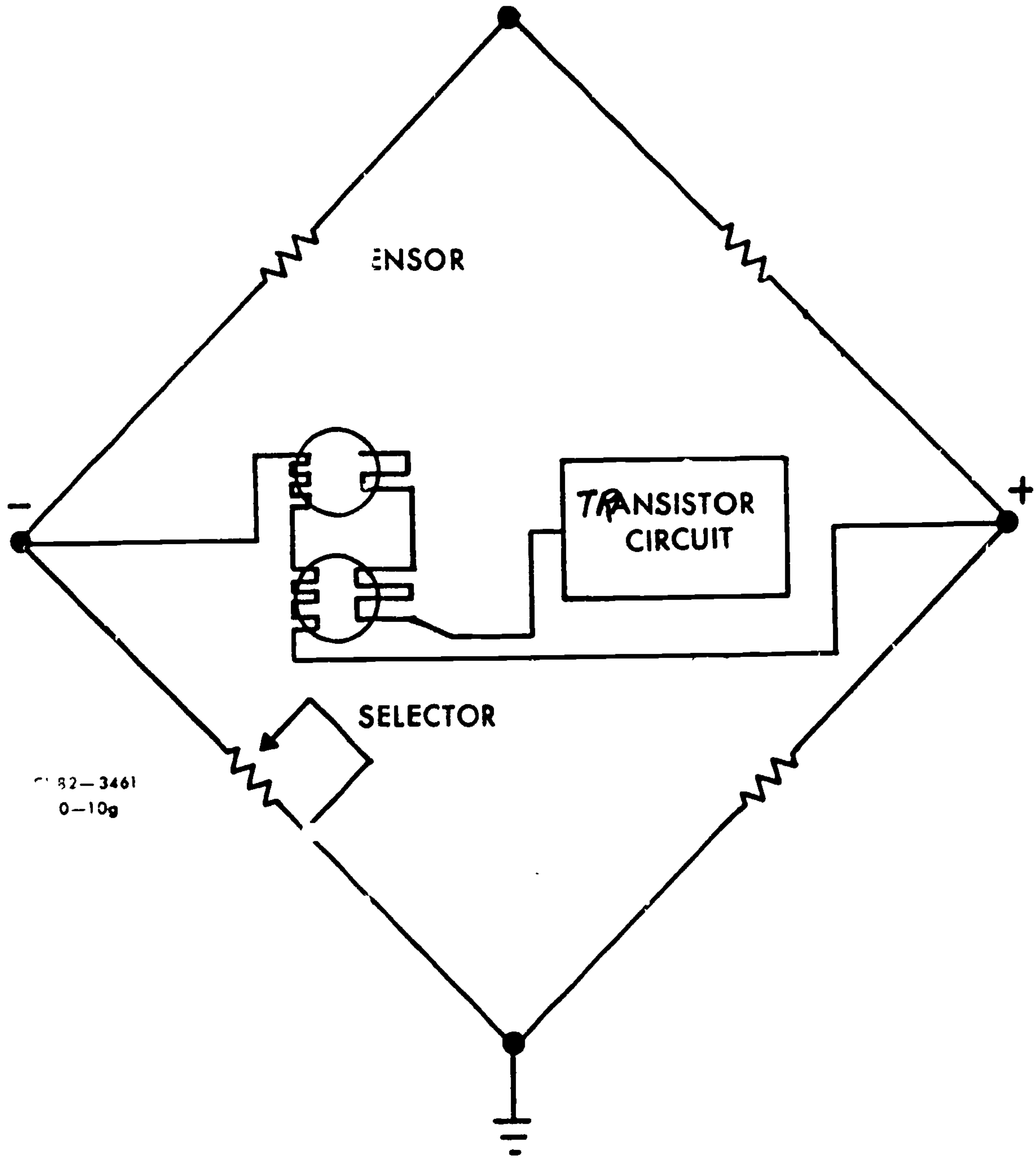
INTRODUCTION

In previous lessons on air conditioning systems, the automatic mode was controlled by a bridge circuit and micro-positioner. Now it will be controlled by a bridge and magnetic amplifier. Look at the diagram on page 5. You should notice that we've replaced the micro-positioner with a magnetic amplifier. In the diagram we have drawn the magnetic amplifier on the inside, so you would see how it replaces the micro-positioner. Throughout the rest of the text it will be drawn on the outside of the circuit.

Also in previous lessons you learned the valve that controlled the air was called the temperature control valve. Now it's called the turbine bypass valve. Its purpose is still the same; that is, it will direct the bleed air either into or around the turbine.

In the diagram on the previous page you will notice that the entire circuit is drawn for you. You will be able to refer to this diagram as you read the text.

1268


ENSOR
TRANSISTOR
CIRCUIT
SELECTOR
82—3461
0—10g
−
+

Frame 1

Before we begin there are some important words and terms that you must be familiar with. Using a dictionary or glossary of terms, define in your own words the terms and words below.

AMPLIFIER --

BIAS --

POLARITY --

OPPOSE --

THE LEFT-HAND RULE --

1270

Frame 2

You may be asking yourself why we use a magnetic amplifier instead of a micro-positioner. Some of the reasons are they are small, have no moving parts, give off very little heat, and are not effected by vibration or gravitational pull. So, you can see with today's aircraft the magnetic amplifier is very practical.

The purpose of the magnetic amplifier is to take the very small signal from the bridge and make it strong enough to operate the transistor circuit effectively.

Fill in the blanks to complete the following statements:

1. The purpose of a magnetic amplifier is to take a _________ signal and make it stronger.

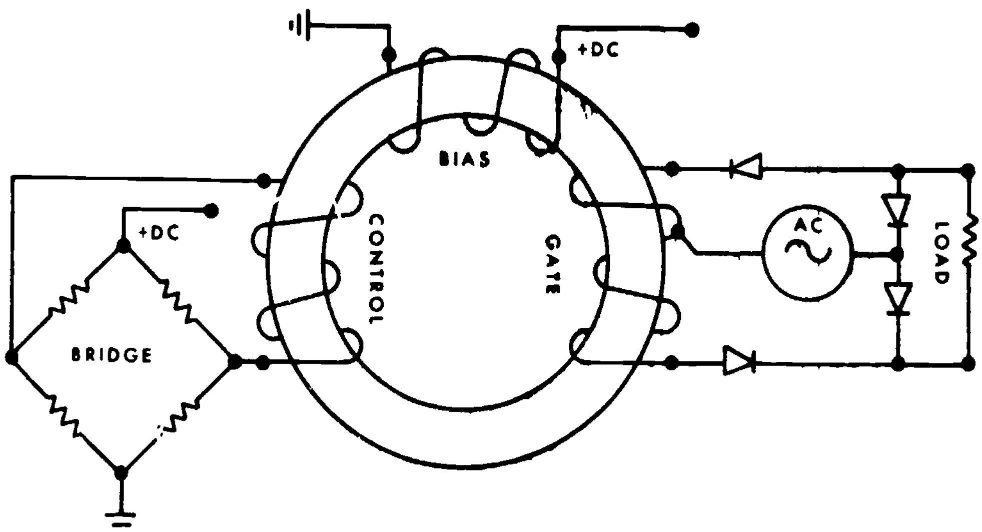
2. The magnetic amplifier receives the signal from the _________ circuit.

3. Advantages of the magnetic amplifier are: they are small, have no moving _________, and give off _________ _________ _________.

Frame 3

A basic magnetic amplifier contains a metal core, shaped like a donut, with wire coils wound around the core. The core is a material that can be easily magnetized. The core is circular (donut) shaped because this design provides a better magnetic field.

The diagram below illustrates a magnetic amplifier with three separate windings. These are the gate winding, the bias winding, and the control winding. Each of the windings has a specific function in the operation of the magnetic amplifier and in overall operation of the temperature controller. The direction that current flows through the windings is the controlling factor of the magnetic amplifier.



NO RESPONSE REQUIRED

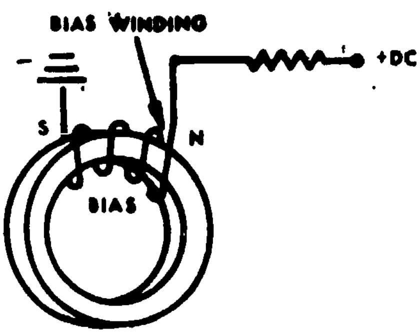
1272

Frame 4

BIAS WINDING

Before tracing the signal through the temperature controller, you need to know the purpose of each of the three windings, how they operate, and how each one affects the other. We'll begin with the bias winding.

The bias winding, illustrated at the right, uses direct current (DC) power. The polarity of the bias winding is shown in the illustration below. Since power for the bias winding is DC and it's always flowing in the same direction, then the magnetic polarity will always be the same. The purpose of the bias winding is to establish a fixed control point at which the gate winding can be triggered. That is, until the control winding is strong enough to aid the gate winding, the bias winding will overpower the control winding, keeping the system off.



Fill in the blanks to complete the following statements.

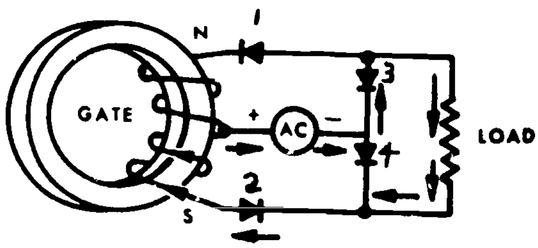
1. The windings in a magnetic amplifier are wound around a __________ core.

2. The bias winding operates on ______ (AC/DC) current.

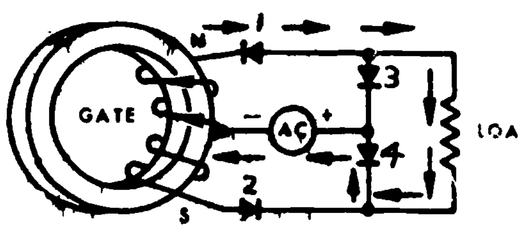
3. The __________ of the bias winding will always be the same because the __________ flow is always in the same direction.

Frame 5

The gate winding controls power from the amplifier to the load. The power supply for this winding is from an AC source. However, the current flow through the windings is DC. Let's see how that happens. The AC current from the power source is rectified, that is, changed from AC to DC by the system diodes. In order for you to understand how the diodes do this, let's follow the current flow through both cycles. In illustration A note the four diodes and how they are placed in the circuit. Arrows have been drawn on this diagram to illustrate the path of current flow. You must remember that current flows against the arrow of the diode. Starting at the negative side of the AC power source the current flows through diode 3, through the load, through diode 2, through the winding, and back to the positive side of the AC power source.



A



B

Illustration B shows the second alternation of the AC power source. Once again let's start at the negative side of the AC power source. Current travels through the winding, through diode 1, through the load, through diode 4, and back to the positive side of the AC power source. After following the current flow through both cycles, you should notice that current flows in one direction only, through the winding. This will also cause the polarity of the winding to always remain the same. You should notice the current flows in one direction through the load also.

Fill in the blanks to complete the following statements.

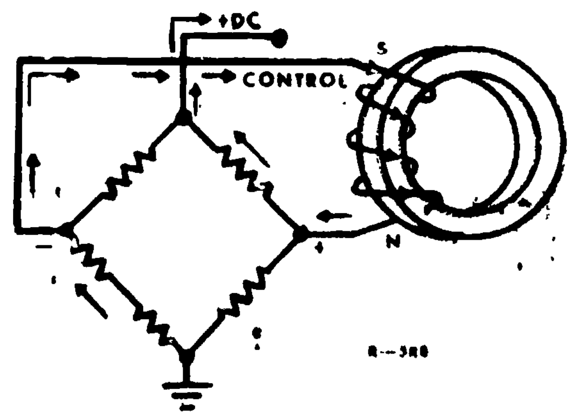
1. The __________ winding controls power from the amplifier to the load.

2. Diodes are used in the gate winding circuit to change __________ to __________.

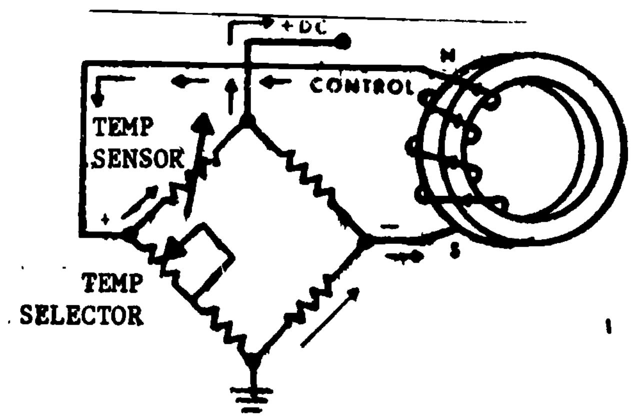
3. Current flow through the __________ winding and the load will be in the same __________.

1274

The control winding takes the signal from the bridge circuit and, using this signal, controls the gate winding. The polarity of the control winding will depend on the current flow through the bridge. The bridge will also determine the strength of the magnetic field of the control winding. The signal from the bridge is in the form of DC current. When the negative and positive points of the bridge are as shown in illustration A, current will flow through the control winding and cause the magnetic poles of the windings to be as illustrated.



A



B

However, should the resistance in one leg of the bridge change, the negative and positive points of the bridge will reverse as shown in illustration B. Now current will flow through the control winding in the opposite direction. Notice that the polarity will change. It will reverse. The resistance of the sensor or selector will determine the direction of current flow from the bridge. This will, in turn, determine the direction of current flow through the control winding. Remember the polarity of the winding depends on the direction of current flow.

Fill in the blanks to complete the following statements.

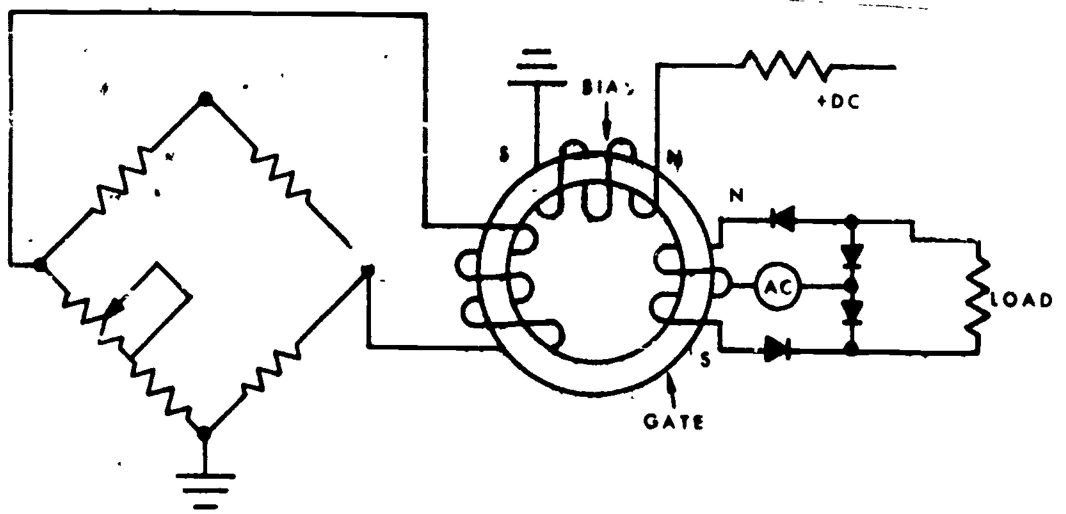
1. The control winding uses ______ (AC/DC) current.

2. The magnetic poles of the control winding are determined by the signal from the __________.

3. How strong the magnetic field of the control winding is depends on the signal from the ________________.

Frame 7

Now let's see how the polarities of one winding affects the other winding. Remember, the polarity in the bias winding is always the same and the polarity of the gate winding is always the same. Polarity of the control winding depends on the bridge circuit. Note in the illustration below that the bias winding and the gate winding have like poles. This means they will always oppose each other. The current flow through the bias winding will oppose current flow through the gate winding.



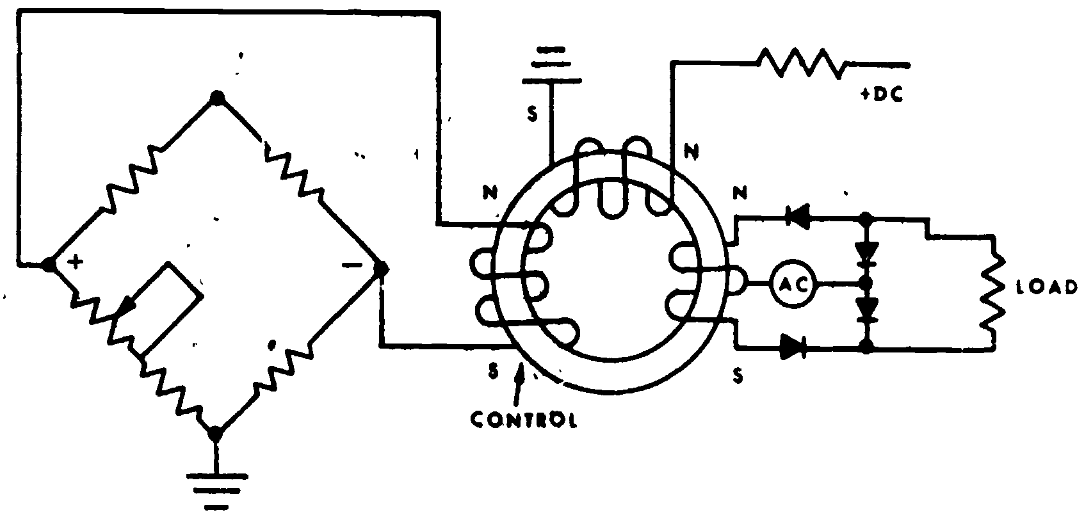
Fill in the blanks to complete the following statements.

1. The __________ winding and __________ windings have like magnetic poles.

2. The bias winding will always __________ current flow through the gate winding.

1276

Since the polarity of the control winding can change, depending on the direction of current flow from the bridge, it will either aid or oppose the gate winding. When the magnetic poles of the control winding are as illustrated below it will oppose current flow through the gate winding. Note that the poles are alike. When the magnetic poles are as illustrated, the bias winding and the control winding are both opposing the gate winding. This opposition will reduce current flow in the gate winding. This will prevent the load from operating.



Fill in the blanks to complete the following statements.

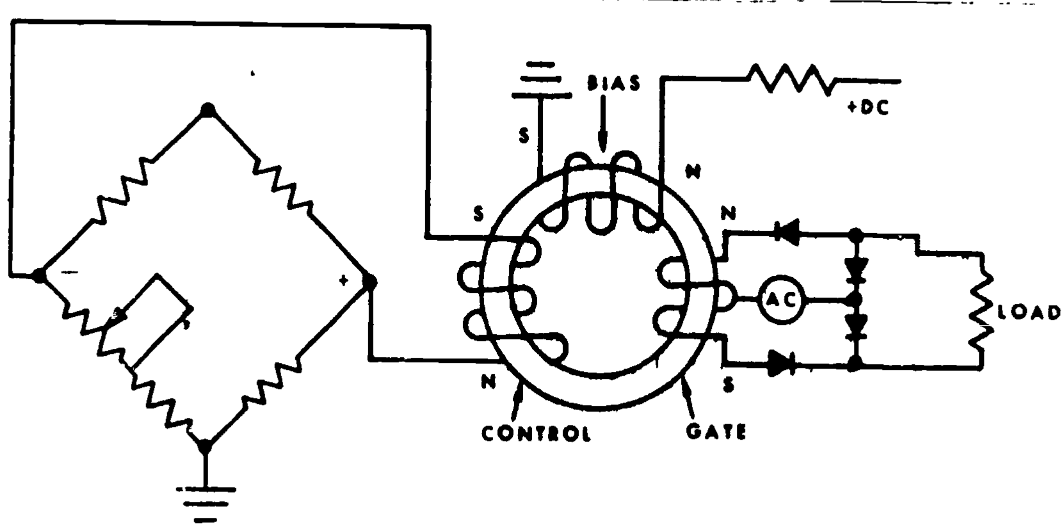
1. The control winding can either __________ or __________ the gate winding.

2. When the magnetic poles of the control and gate winding are alike, current flow through the gate will __________.

3. The signal from the bridge circuit determines the polarity of the __________ winding.

Frame 9

When the direction of current flow from the bridge changes, the direction of current flow through the control winding will also change. This will change the magnetic polarity of the control winding. When the magnetic poles of the windings are as illustrated below, the control winding will aid the gate winding. Notice the gate winding and control winding have unlike poles. Remember, unlike poles will aid each other. By aiding the gate winding it will allow current to flow. This will result in current flow through the load.



The gate winding controls the electrical signal that will cause the load to operate. If the gate winding is aided by the control winding the load will operate. If the gate winding is opposed by the control winding, the load will not operate.

Fill in the blanks to complete the following statements.

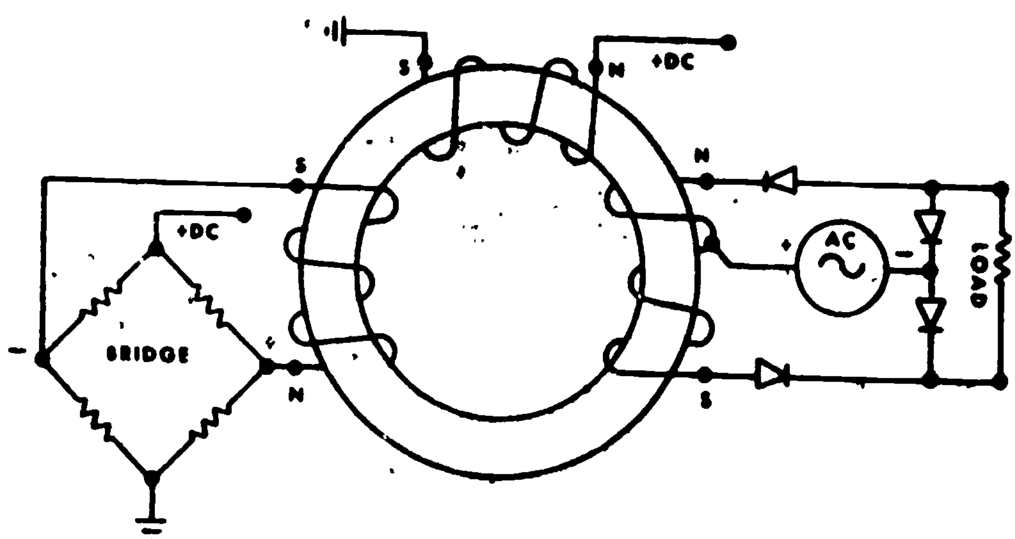
1. When the direction of current flow from the __________ changes, the magnetic poles of the __________ winding will also change.

2. Current will flow through the load when the control winding is __________ (aiding/opposing) the gate winding.

3. The control winding aids the gate winding when the magnetic poles are __________ (like/unlike).

1273

Let's see how the magnetic ampl'fier operates with a signal from the bridge. In the illustration below, the signal from the bridge, AC power source, and the magnetic poles have been drawn in. The North pole of the control winding is facing the South pole of the gate winding. The aid from the control winding is now stronger than the opposition from the bias winding. The rectified AC signal will flow through the gate winding to the load. Current flow through the gate winding will build up until it is strong enough to operate the load. The amount of current flow through the gate winding will depend on the strength of the signal from the bridge.



Fill in the blanks to complete the following statements.

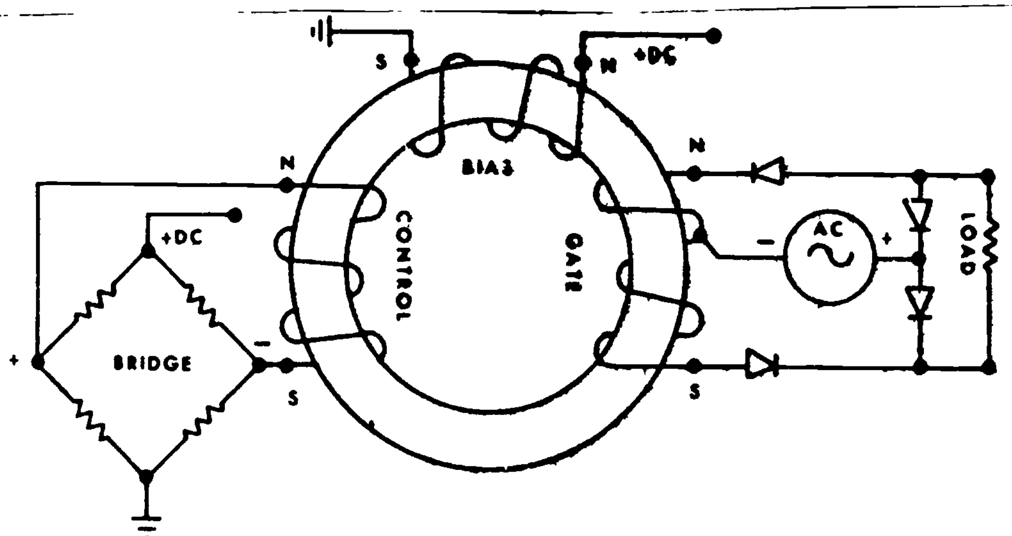
1. When the North pole of the control winding is facing the South pole of the gate winding, current __________ (will/will not) flow through the load.

2. In the circuit illustrated, the bias winding is __________ the gate winding and the control winding is __________ the gate winding.

Frame 11

Let's see what happens to the operation when the signal from the bridge changes to that shown in the illustration below. The control winding has changed magnetic poles because of the change in direction of current flow from the bridge. The South pole of the control winding is facing the South pole of the gate winding. These two poles are repelling each other or opposing current flow. The North pole of the bias winding is facing the North pole of the gate winding, and will also be opposing current flow in the gate winding.

With the control and bias winding both opposing the gate winding, there is very little current flow through the gate winding. With this condition, there will be no current flow through the load.



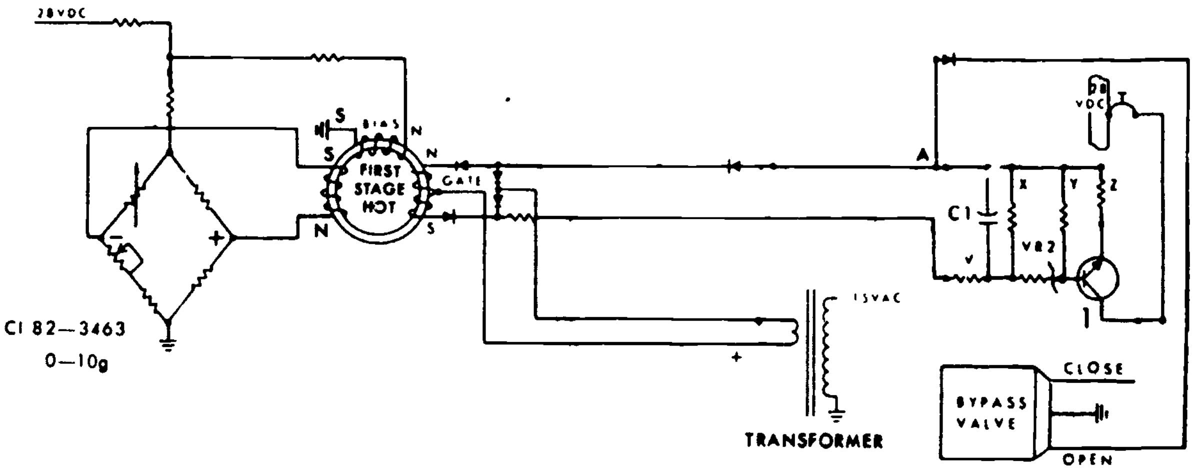
Fill in the blanks to complete the following statements.

1. When the South pole of the control winding is facing the South pole of the gate winding, current __________ (will/will not) flow through the load.

2. In the circuit illustrated, the bias winding is the gate winding and the control winding is __________ the gate winding.

1280

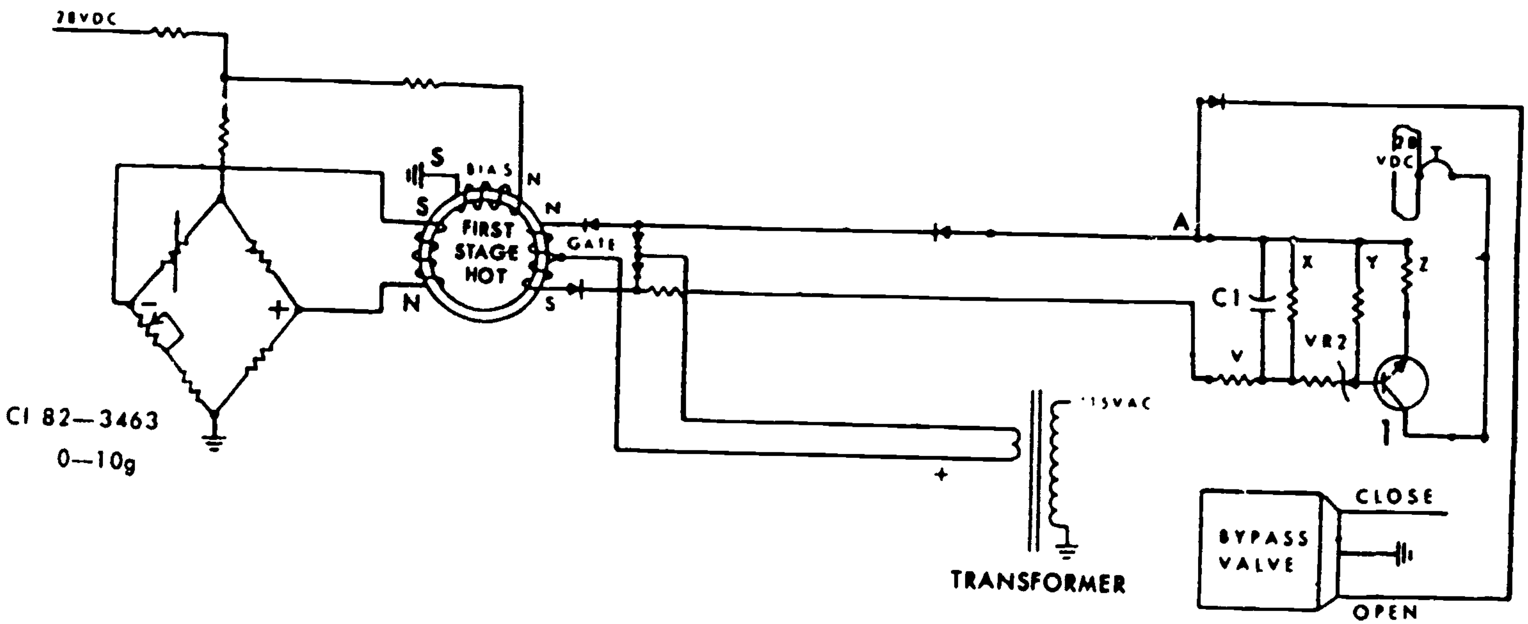
Let's see how the magnetic amplifier controls the turbine bypass valve. In the illustration below, we've added a transistor circuit and a bypass valve. The illustration shows only the circuit that the hot signal uses. You should notice that the bias winding and bridge have 28VDC constantly going to them. Also that the gate winding has 115VAC power source. Notice that the valve receives power from 28VDC bus bar on the right-hand side of the page. Remembering that the bridge sends the signal to the control winding and that the gate winding controls the load. The load is the transistor circuit.



Fill in the blanks to complete the following statements.

1. The power source for the bias winding and bridge will always rer`` the ________.

2. The gate winding controls the ________.


28VDC
S
BIAS
N
S
N
FIRST
STAGE
HOT
GATE
N
S
CI 82—3463
0—10g
115VAC
TRANSFORMER
A
VDC
C1
X
Y
Z
V
VR2
BYPASS
VALVE
CLOSE
OPEN

18

1283

1282

Let's trace the signal. Looking at the illustration on the preceding page, note the signal from the bridge. This signal causes the control winding to aid the gate winding. This, in turn, will allow current to flow from the AC power source. Current will now travel through the gate winding and down the wire to point A. From point A, it flow to and charges the capacitor (C1). At the same time it sets up a voltage potential at the three resistors marked X, Y and Z. Resistor X is the normal path the current flows until the Zener diode (VR2) breaks down.

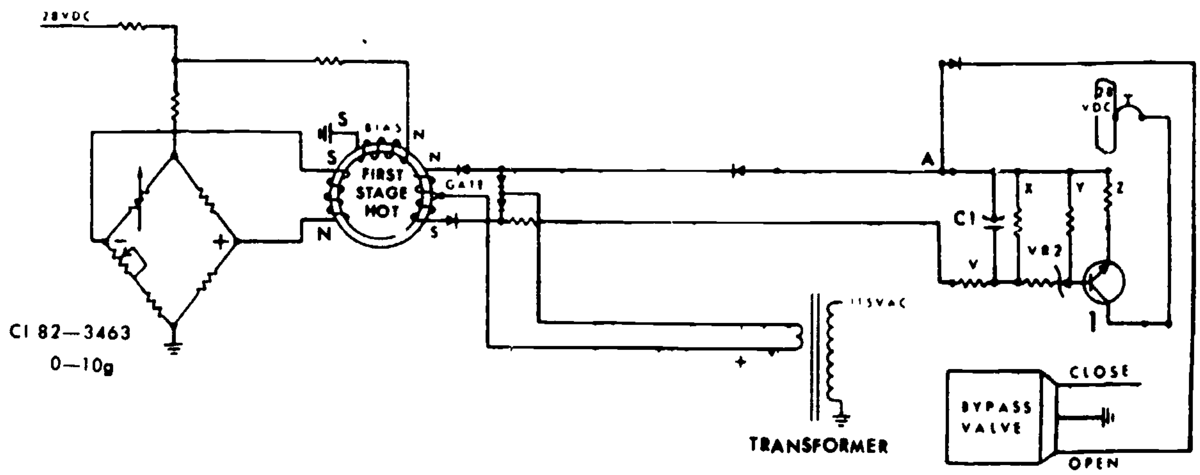
Follow this return path through resistor X, through resistor V, through the lower diode at the gate winding, then through the gate winding to the center connection and back to the positive potential at the transformer. Until the signal becomes strong enough to cause the Zener diode to break down, the transistor will not conduct.

NO RESPONSE REQUIRED

Frame 14

When the voltage increases enough across the Zener diode (VR2) it will force it to break down. When the Zener diode breaks down, current flows through resistor "Y," through the Zener diode, through the gate winding and to the positive side of the transformer.

The current flowing through the Zener diode causes the base of the transistor to become more positive than its emitter, causing it to conduct.



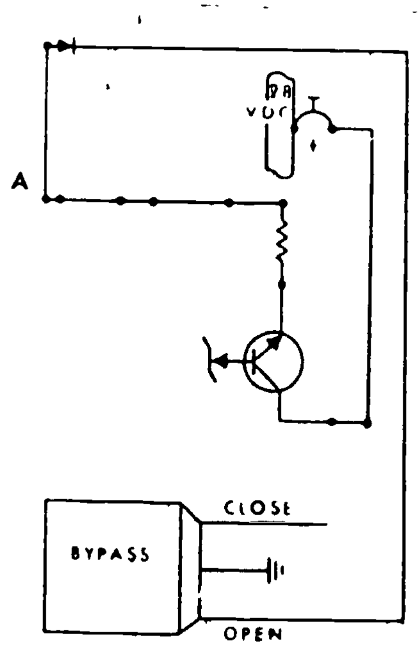
Fill in the blanks to complete the following statements.

1. The transistor is directly controlled by the __________ __________.

2. The strength of the potential at the Zener diode is a direct result of the signal from the __________ circuit.

1285

The transistor actually serves as a relay or switch for the bypass valve circuit. The transistor is forward biased when the Zener diode breaks down. This permits current flow from the emitter to the collector of the transistor. Note in the diagram how this will complete a circuit from the bypass valve ground to the 28VDC source. When the transistor conducts, current can flow from the bypass valve ground, through the valve motor winding (hot or open side), through the diode, then through the transistor to the positive potential at the 28VDC circuit breaker. This will operate the valve to the hot (open) position.



Fill in the blanks to complete the following statements.

1. The bypass valve circuit is controlled by the __________.

2. When hot air is demanded, the bypass valve will operate to the __________ position.

3. The transistor serves as a __________ or __________ for the valve circuit.

Figure 16

Operation of the transistor is controlled by the Zener diode. That is, when it breaks down it allows the transistor to reduce its internal resistance where it can operate the valve motor.

If we had used a cold signal from the bridge circuit, the signal would have aided the cold magnetic amplifiers. This would have caused the transistor in the cold circuit to conduct. The circuit would have been operated in the same manner, except it would cause the valve motor to operate in the opposite direction, providing cold air. Remember, the bridge circuit signal determines whether the hot or cold amplifiers operate.

Fill in the blanks to complete the following statements.

1. When cold air is demanded, the bypass valve will operate to the __________ position.

2. If the signal from the bridge causes the hot control winding to oppose the gate winding, and the cold control winding to aid the gate winding, the bypass valve will ____________ (open/close).

1287

We have seen how the hot signal from the bridge will run the bypass valve toward hot. But, with the circuit that we've traced, this hot signal could cause the valve to operate too far toward hot. This would cause the temperature to become too hot in the cockpit before the sensors could detect the temperature change and signal the valve to stop. This action would result in the bypass valve going first to hot then to cold and back to hot, always overshooting the exact position needed to deliver the selected temperature.

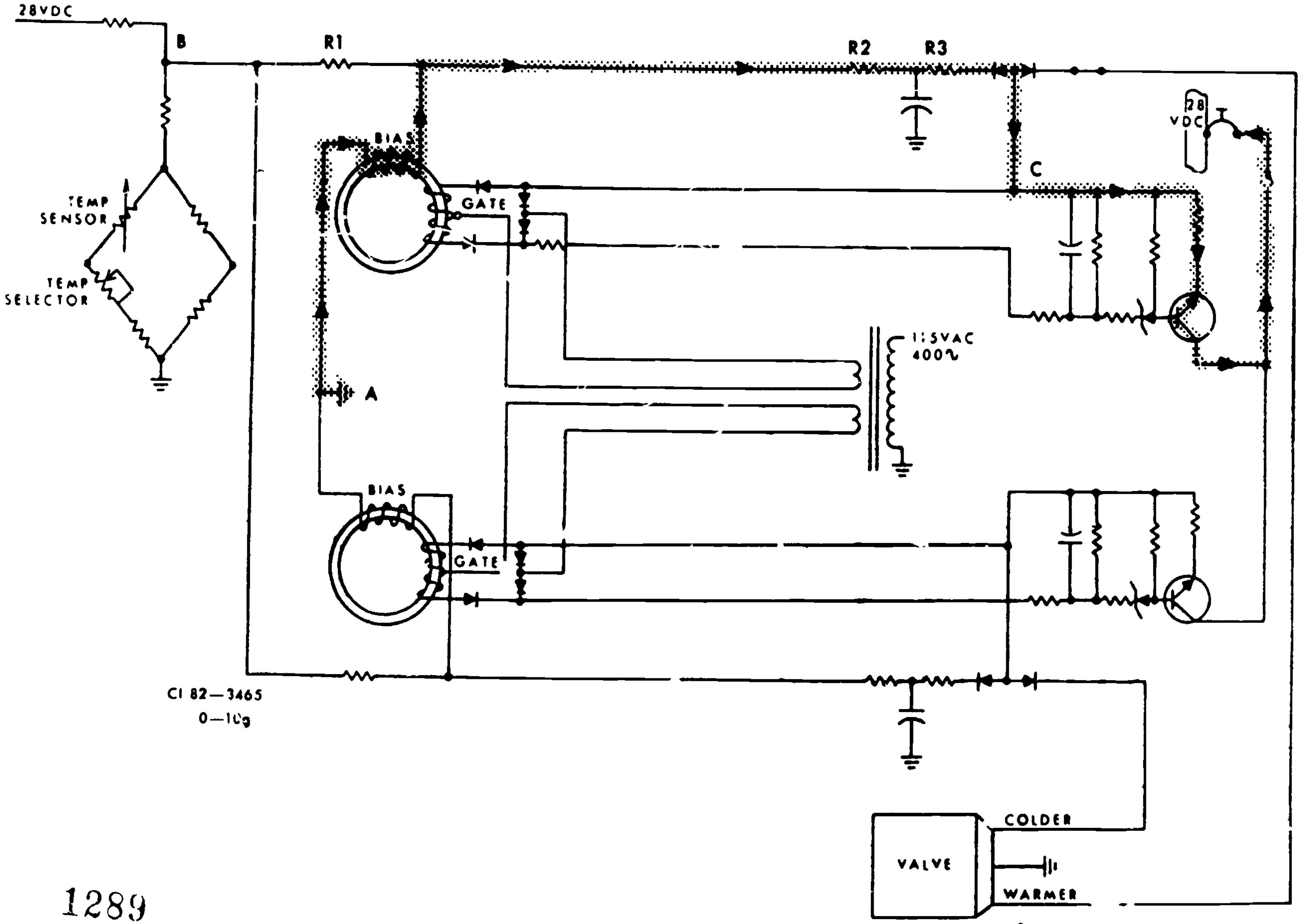
To prevent the valve from "hunting" or running continuously trying to maintain the temperature, a "feedback" circuit is used. The feedback circuit for both the hot and cold amplifiers is added to the diagram on the next page.

The feedback circuit will cause the bypass valve to "pulse" instead of running continuously. The pulsing action prevents a rapid change in the valve position. It also prevents a rapid change in air temperature coming from the air conditioning system. The rate of the pulsing action depends on the strength of the signal from the bridge. A strong signal causes the valve to pulse at a rapid rate. A weaker signal causes the valve to pulse at a slower rate.

Fill in the blanks to complete the following statements.

1. The purpose of the feedback circuit is to prevent the valve from __________ the exact position needed to deliver the selected temperature.

2. The pulsing action of the valve prevents __________ changes in air temperature.


28VDC
B
R1
R2
R3
C
28 VDC
BIAS
GATE
TEMP SENSOR
TEMP SELECTOR
115VAC 400~
A
BIAS
GATE
CI 82—3465
VALVE
COLDER
WARMER

1289

1290

Refer to previous page for diagram. Let's trade the feedback circuit to determine what controls the pulsing action. Starting at the ground for the bias winding, point "A," follow the current from point "A" up through the hot bias winding. From the hot bias winding, current can go in two directions. Current can go through resistor R1, to point "B" and back to the 28VDC source. The other path for current flow is through the feedback circuit. Current in the feedback circuit flows through resistors R2, R3, through the diode, then to point "C." From point "C" current flows through the transistor and up to the 28VDC circuit breaker. Now, notice that when the hot transistors start conducting they complete a path for current flow that operates the bypass valve and also a path for current from the first-stage hot bias winding. This increase in current flow through the winding will also increase the magnetic field of the bias winding. Remember, the magnetic field of the bias winding is opposing current flow in the gate winding.

Fill in the blanks to complete the following statements.

1. The feedback circuit will come on when the transistor is __________.

2. When the feedback circuit is in operation current flow through the bias winding is __________.

3. The bias winding will always oppose the __________ winding.

Frame 19

The increased current flow through the bias winding increases the opposition to current flow in the gate winding. This stops current flow in the gate winding, that is, it stops the magnetic amplifier from operating. When this happens the transistor will also stop conducting, and the end result is that the valve stops running and also stops current flow through the feedback circuit.

When current flow stops in the feedback circuit, there is no longer an increased opposition to current flow through the amplifier. This allows the signal to flow through the amplifier again, which allows the transistors to conduct. Of course the same sequence of events starts all over again. This causes the valve to pulsate until the temperature reaches a point to balance the bridge circuit.

We have taken a hot signal from the bridge and followed it through the complete automatic temperature control circuit. A signal for cold would operate the same as the hot signal, except we would have used the cold amplifier, transistor, feedback circuit, and cold side of the valve.

NO RESPONSE REQUIRED

1292

ANSWERS TO QUESTIONS AT THE END OF THE FRAMES:

Frame 2: 1. small, 2. bridge, 3. parts, very little heat

Frame 4: 1. metal, 2. DC, 3. same, current

Frame 5: 1. gate, 2. ACV, DCV, 3. gate, direction

Frame 6: 1. DC, 2. bridge, 3. bridge circuit

Frame 7: 1. bias, gate, 2. oppose

Frame 8: 1. aid, oppose, 2. stop, 3. control

Frame 9: 1. bridge, control, 2. aiding, 3. unlike

Frame 10: 1. will, 2. opposing, aiding

Frame 11: 1. will not, 2. opposing, opposing

Frame 12: 1. same, 2. load

Frame 14: 1. Zener diode, 2. bridge

Frame 15: 1. transistor, 2. open, 3. relay, switch

Frame 16: 1. closed, 2. close

Frame 17: 1. overshooting, 2. rapid

Frame 18: 1. conducting, 2. increased, 3. gate

1293

Technical Training

Aircraft Environmental Systems Mechanic

TRAINER AIRCRAFT AIR CONDITIONING SYSTEM TROUBLESHOOTING

15 July 1981

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

RGL: N/A

TRAINER AIRCRAFT AIR CONDITIONING SYSTEM TROUBLESHOOTING

OBJECTIVE

Using a trainer, electrical diagram, and multimeter, troubleshoot five system problems. Four of the five problems must be accomplished with 100% accuracy.

EQUIPMENT

Multimeter
Grease Pencil
Cloth Eraser
Trainer 3301, Air Conditioning System

PROCEDURE

1. REMOVE ALL JEWELRY. Report to the lab instructor and inform him or her of the lesson that you are working on. The instructor will provide you with the materials needed for this lesson.

2. Look at figure 1 on page 3. This figure shows the trainer that you will be working with and will help you to locate the various components. You must be able to locate and identify each component to correctly perform the performance test and troubleshooting. After you are familiar with the trainer you may continue with this lesson.

3. Also, when you leave your trainer for scheduled or unscheduled breaks insure the following steps have been done before you go.

a. Place the control switch to the off position and pull the two circuit breakers.

b. Secure your multimeter during this period.

(1) Insure the controls are set on the proper settings for storage.

(2) Leave the test leads attached to the meter.

(3) Wrap the leads around the meter.

(4) Place the meter on the locker shelf.

c. When you return from the break take the same meter and go back to work.

Supersedes 3ABR42331-WB-129A, 17 September 1980 which may be used until existing stocks are exhausted.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 1000; DAV - 1

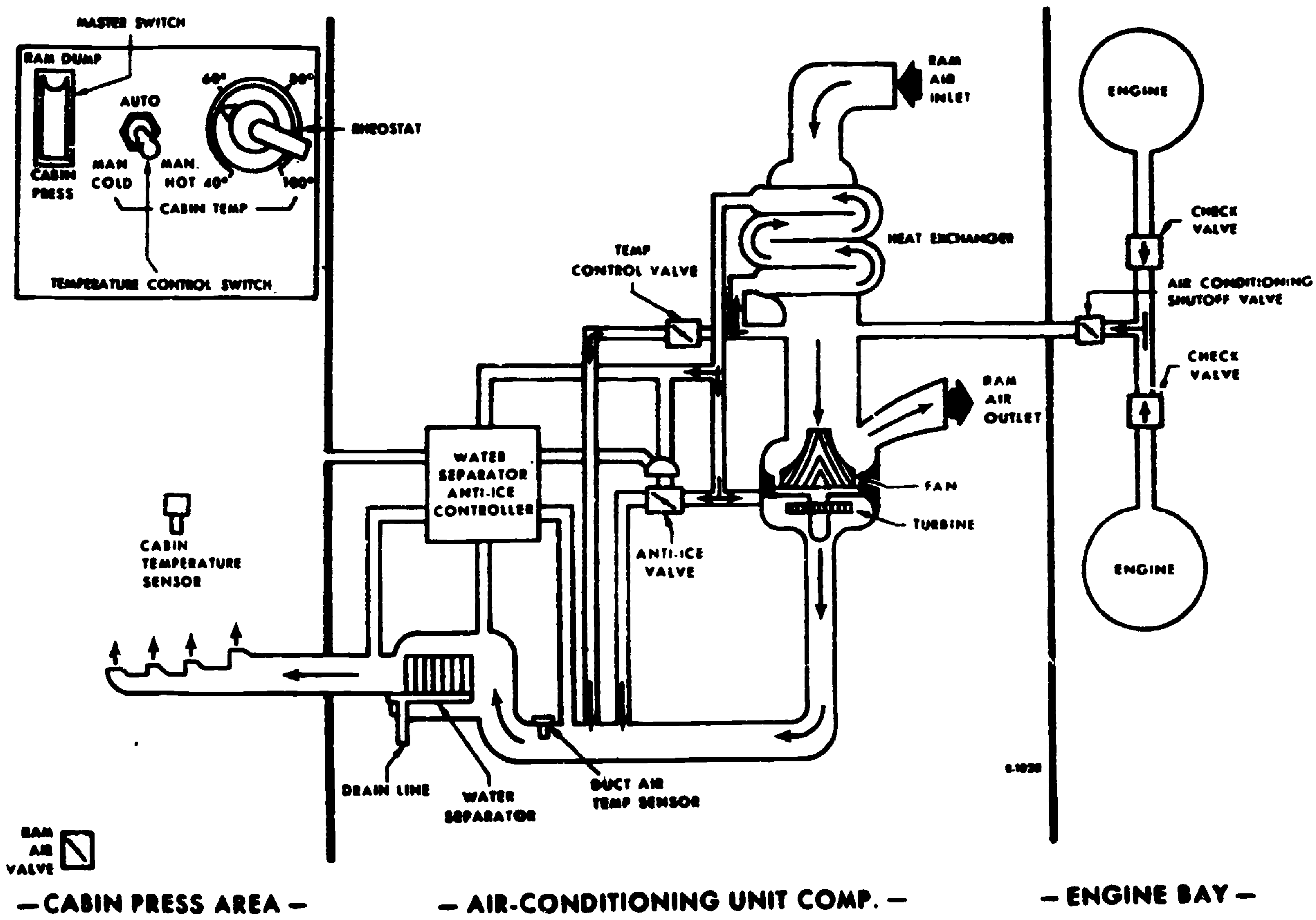


Figure 1. Air Conditioning System Trainer Layout.

PROJECT 1

Troubleshooting is the word used to describe a mechanic's locating mechanical and electrical failures. This workbook is designed to acquaint you with a basic approach to troubleshooting. It is highly unlikely that any two individuals will troubleshoot in exactly the same manner. You, as an Environmental Systems Specialist, will have to develop your own technique as you gain experience on the systems. But, regardless of the technique used, the problem must first be solved in the troubleshooter's mind; that is, all of the possibilities are thought out until the most likely one is determined.

When troubleshooting electrical failures, the multimeter is an essential tool. However, the multimeter does not do the actual troubleshooting. You must first analyse the system and determine the possible causes. Then use the meter to verify the actual cause.

Circle the number of each true statement below.

1. Troubleshooting is used to locate mechanical and electrical failures.

2. The multimeter does all of the troubleshooting for you.

3. Analyze the system for possible causes, then verify them with the multimeter.

Answers to Project 1: 1, 3

PROJECT 2

During this lesson you will be using the multimeter to test for voltage and resistance in the circuits and components. In previous lessons you were taught how to use the multimeter. The quiz below will help you recall how to use the multimeter.

Before completing the quiz, open the meter, and prepare it for use.

Using the meter as an aid, fill in the blanks to complete each of the following statements.

1. The Ohms scale is colored ______________.

2. The negative probe is colored ______________.

3. When checking for resistance, the trainer power must be turned ______________.

4. The multimeter is used for testing ______________ and resistance.

5. The aC volts scale is colored ______________.

6. When checking for resistance, the function selector must be set on __________ and the range selector to the desired ohms range.

7. To test a 115 volt AC circuit, the function selector must be set to __________ and the range selector to ______________.

8. If an accurate reading is to be obtained with the ohmmeter, it must be ______________.

Answers to Project 2: 1. green 2. black 3. off 4. voltage 5. black

6. ohms 7. AC, 250 volts scale 8. zeroed

PROJECT 3

Before we continue with the use of the multimeter, we need to learn how the trainer air conditioning system is operating. Let's do this by making an operational check.

OPERATIONAL CHECK PROCEDURES

1. Make sure all trouble switches at the left end of the trainer are in the OUT position, and the trainer power switch located in the upper left hand corner is placed to the OFF position.

2. Insure the trainer power cable is connected to an AC outlet, and make sure all circuit breakers on the trainer are pushed in.

3. Place the trainer power switch to the ON position.

4. Place the following switches to the positions listed below.

Master switch to CABIN PRESS position.

Temperature control switch to OFF (center) position

Temperature selector switch (potentiometer) to the 60° position.

Note: As you perform each of the following steps, place an X in the blank provided that correctly indicates the valve position.

5. Place the master switch to the RAM DUMP position.

a. Cabin ram air valve opened _________ closed _____________.

b. Cabin conditioning shutoff valve opened _______ closed _____.

6. Place the master switch to the CABIN PRESS position.

a. Cabin ram air valve opened ________ closed __________.

b. Cabin conditioning shutoff valve opened ______ closed _______.

7. With the master switch still in the CABIN PRESS position, hold the cabin temperature control switch to the MANUAL HOT position.

The temperature control valve is now moving open ________ close ___________.

8. Hold the cabin temperature control switch to the MANUAL COLD position.

The temperature control valve is now moving open _______ close __________.

9. Place the cabin temperature control switch to the AUTO position.

10. Rotate the temperature selector (potentiometer) to the HOT (100°) position.

The cabin temperature control valve is now moving open ______ close ___________.

11. Rotate the temperature selector to the COLD (40°) position.

The cabin temperature control valve is now moving open _______ close ____________.

12. Place the master switch to the RAM DUMP position.

The ram air valve opened _______ closed _________, and the cabin conditioning shutoff valve opened ________ closed ________.

13. With the master switch still in the RAM DUMP position, place the temperature control switch to each of the following positions and observe the temperature control valve.

MANUAL HOT position, MANUAL COLD position, and AUTO.

Did the cabin temperature control valve operate with the switch in any of the positions? Yes ______ No ______

This completes the operational check procedure, now compare your answers to those below. This way you will know that the trainer is operating normally.

Answers to Project 3:

5. a. opened
   b. closed

6. a. closed
   b. opened

7. open

8. close

10. open

11. close

12. opened, closed

13. no

If all of your answers agree with the ones given above, you are ready to begin troubleshooting. If you do not agree, perform the operational check again or ask your instructor for assistance.

PROJECT 4

In the previous lesson you learned about the sensors and the potentiometer and what happens if they malfunction. This knowledge is essential for you to do effective troubleshooting. Let's see what you remember.

Complete the following statements by filling in the blanks.

1. Only hot air is entering the cockpit in automatic. This would be an indication of an ___________ cabin sensor.

2. An open duct sensor will change the control point of the _________.

3. A shorted cabin sensor will cause the air entering the cockpit to be ___________.

4. Both sensors have a _______________ coefficient of resistance.

5. A shorted ________ ___________ will change the control point of the potentiometer.

6. An open in the potentiometer circuit would cause _________ air to enter the cabin.

1302

Answers to Project 4: 1. open 2. potentiometer 3. cold 4. negative

5. duct sensor 6. cold

PROJECT 5

You should recall from the previous lesson that the sensors and the potentiometer are variable resistors. To check then, we use the ohms portion of the meter.

Procedure for checking resistance of the sensors with a multimeter.

1. Place the trainer power switch to the OFF position.

2. Set the meter Function Selector to Ohms.

3. Set the range selector switch.

Note: The easiest part of the scale to read is near the center of the scale. Use the range setting that will place the needle near the center when reading the resistance according to the sensor resistance values.

4. Isolate the bridge circuit. You do this by disconnecting the cannon plug at the section marked 188 on the cabin temperature controller. This process is to disconnect all the components of the bridge for individual ohm check. You did this same type of exercise when you pulled out the junction pins on the bridge circuit trainer in the lab.

6. Locate the cabin sensor on the wiring diagram. Notice that the circuit coming from ground goes through pin B of the cabin sensor, out pin A, and then to pin C of the controller.

7. Now locate the cabin sensor on the trainer. Place one multimeter lead in plug 105, pin B, and the other lead in pin A. This circuit is illustrated below.

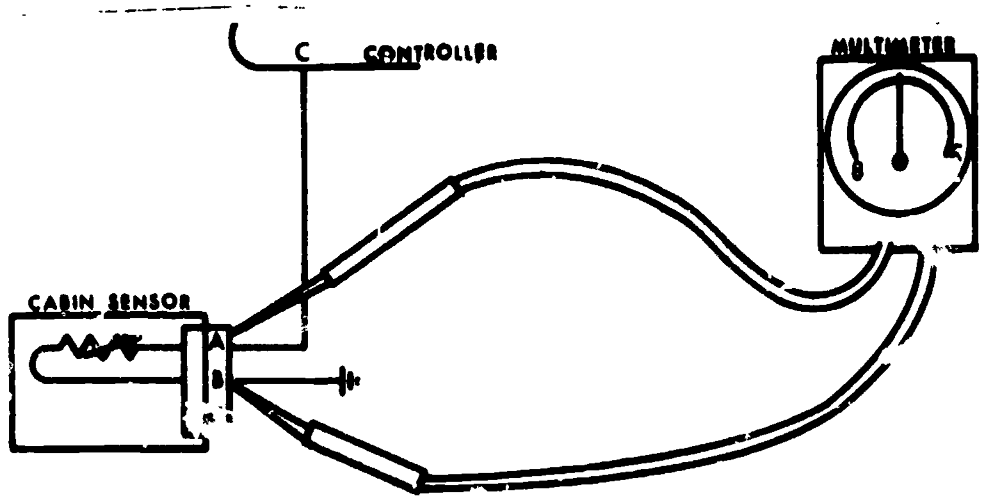


Figure 2. Checking Sensor Resistance.

8. Read the resistance and record it. ____________________

9. Now locate the duct sensor and measure its resistance.

Duct sensor resistance is ______________ ohms.

10. Both of these resistance values should be between 16,000 and 47,000 ohms. If the values you have recorded are not within this range, ask the instructor for assistance.

Now that you know the resistance of the sensors you can use this information during troubleshooting. When you check them again during troubleshooting they should have close to the same resistance values.

To check out the cabin temperature selector you must isolate the bridge circuit by disconnecting plug 188 and then ohm out the potentiometer. You must connect the meter leads at ground and either Pin S on plug 26 or Pin A on plug 188. The resistance should vary on the meter when the temperature selector is rotated. If it does not show any resistance you have a short in the potentiometer.

When troubleshooting, if you get a zero (0) reading on the meter, it means the sensor is shorted. If you get an infinity (∞) reading on the meter, it means the sensor is open.

Complete the following statements by filling in the blanks.

1. Trainer power should be turned ________ when using the ohmmeter.

2. If the meter indicates zero, it means the sensor is ___________.

3. If the meter indicates infinity, it means the sensor is _______.

4. When checking for ohms, the function selector must be set to

________________.

5. To check sensors and potentiometers, you should use the ____________ portion of the multimeter.

1304

Answers to Project 5: 1. off 2. shorted 3. open 4. ohms 5. ohms

PROJECT 6

Now let's find out how to check a wire for resistance. Normally a wire has extremely small resistance, and the ohmmeter should read zero.

Locate wire number H54A22 on the wiring diagram. This wire connects the cabin sensor to the controller. An open in this wire would be like having an open in the cabin sensor.

Check the resistance of wire number H54A22 by performing the following steps.

Note: Anytime you find a need to troubleshoot in the bridge circuit be sure to isolate the circuit with plug 188 and then ohm out the circuit.

1. Place the trainer power switch to the OFF position.
2. Set the function selector to OHMS.
3. Set the range selector to Ω x 100 and zero the meter.
4. Put one lead in pin "C" connection at the controller and the other lead in pin "A" connection at the cabin sensor. This test circuit is illustrated below.

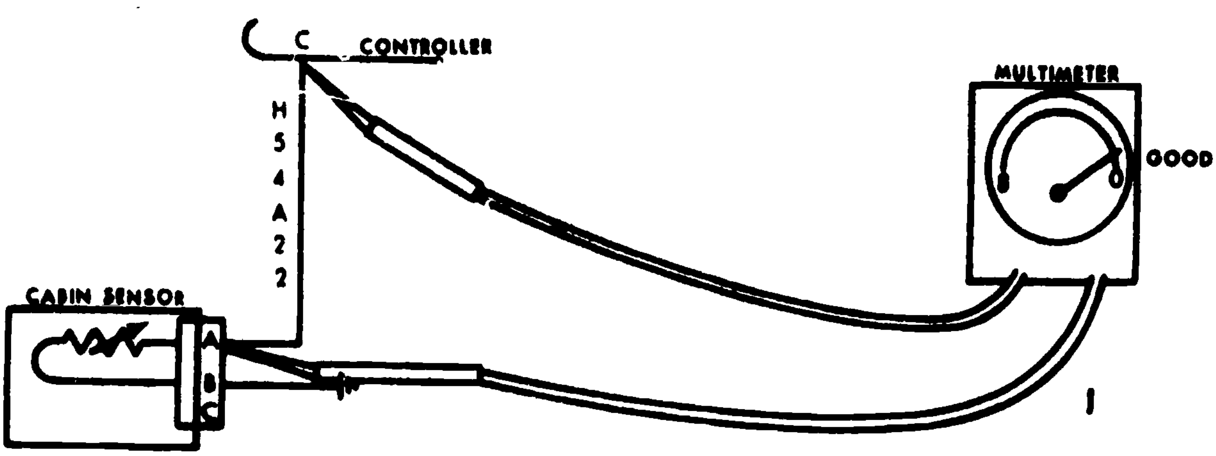


Figure 3. Checking Wire Resistance.

If the meter reads zero (0) the wire is good. If the meter reads other than zero, it either has an open or a high resistance.

Complete the following statements by filling in the blanks.

1. A good wire has _______________ resistance.
2. When using an ohmmeter, the power switch should be _______________ _______________.
3. When measuring the resistance of a wire, if the meter reads other than zero, the wire is ____________ or has a high ____________.

Answers to Project 6: 1. small (zero) 2. off 3. open, resistance

PROJECT 7

Most of your troubleshooting will be done using the voltmeter portion of the multimeter. The only time you should use the ohmmeter is for checking the sensors or potentiometer circuits (bridge circuit).

To illustrate this point, let's make a comparison. Locate the master switch on the trainer. This switch controls the air conditioning shutoff valve. Locate the shutoff valve. On the trainer it would be possible to check the wire from the master switch to the shutoff valve with an ohmmeter. But let's compare this to the same circuit on the T-38 aircraft by noting the illustration below. On the actual aircraft this valve is several feet from the switch. Imagine the difficulties one man would have in checking this same circuit from the cockpit to the shutoff valve with an ohmmeter.

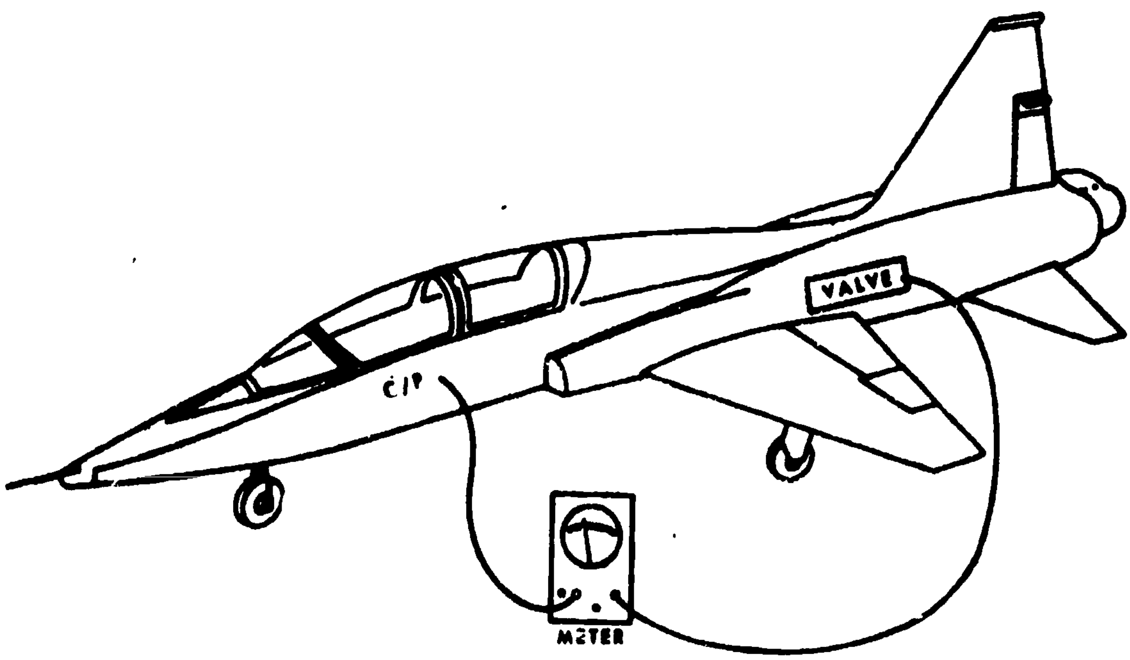


Figure 4. Voltmeter or Ohmmeter?

To prepare yourself for troubleshooting circuits on the aircraft, USE THE VOLTMETER FOR TROUBLESHOOTING THE TRAINER CIRCUITS. Use the ohmmeter for checking the sensor or rheostat circuits only

Complete the following statements by filling in the blanks.

1. To check the sensor and potentiometer circuits, you should use ______________.

2. For most of your troubleshooting, you should use the ______________.

3. An ohmmeter is always used to check ____________ and ______________.

4. The most practical meter used when troubleshooting is the ______________.

Answers to Project 7: 1. ohmmeter 2. voltmeter
3. sensors and potentiometer 4. voltmeter

PROJECT 8

Before using the multimeter to check voltage, let's see if you know how the system operates normally. Run through an operational check again. Start with the switches in the normal positions. Go back to project 3 for the procedure if necessary.

When you are sure you know how the system operates normally, perform the following steps.

1. Place trouble switch number 1 to the IN position.

2. Place the trainer power switch to the ON position.

3. Perform an operational check to determine which component does not operate properly.

Note: You should have found that the air conditioning shutoff valve did not open.

4. Using the grease pencil and the wiring diagram on the trainer, trace the circuit from the cabin air valves circuit breaker to the open side of the shutoff valve.

Note: The diagram below illustrates how the circuit should look when traced on the diagram.

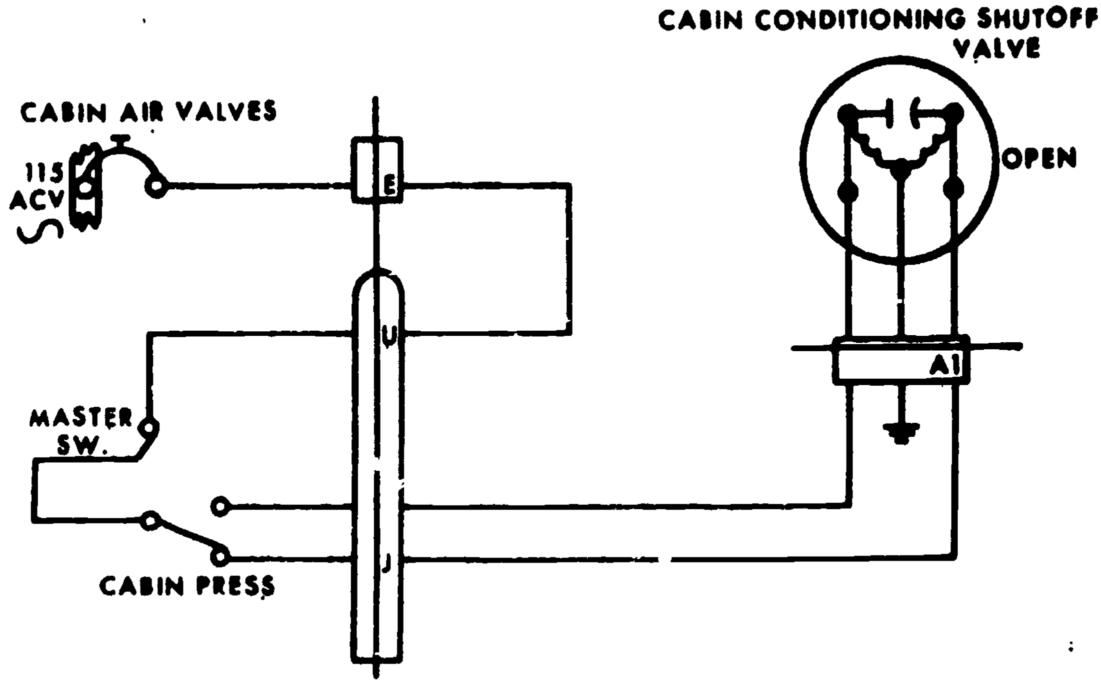


Figure 5. Circuit Tracing.

5. Analyze the circuit to determine why the valve didn't open. Ask yourself, where would an open be that might prevent the valve from opening.

Now let's use the voltmeter to see if you were right.

1. Leave the trainer power switch ON. Check the wiring diagram and determine the type of voltage you will be measuring. The voltage is indicated at the circuit breaker on the wiring diagram.

2. Set up the meter for checking this voltage.

3. When you are checking for voltage, the black lead (negative) is always connected to ground. Locate, on the trainer, the small metal strip marked AIRCRAFT GROUND. Place the black lead in this ground, and leave it there while checking for voltage. This metal strip represents the frame of the aircraft. When checking for voltage on the aircraft, the frame (metal) of the aircraft is ground.

4. Place the red lead (positive) in pin A1 of the shutoff valve.

Is there power at pin A1? Yes _____ No _____

You should have answered NO. There is no power at pin A1, <u>but there should be</u>.

5. Now trace the circuit back and find the next check point. This is pin "J" on control panel 26. Place the red lead in pin "J." Is there power at this point? Yes _____ No _____

You should have answered YES, there should be power at this point.

Complete the following statements by filling in the blanks.

1. There is an open in wire number ____________.

2. The voltage for the circuit checked is ________.

3. You had the function selector on ____________.

4. You had the range selector on ____________.

5. The color of the meter scale you used is ___________.

6. On the aircraft, any part of the frame can be used as an ________________.

7. When measuring voltage, the lead that goes to ground is the ___________ lead.

1308

Answers to Project 9: 1. H60B22 2. 110 - 120 volts AC 3. AC volts
4. 25C 5. black 6. ground 7. black (negative)

PROJECT 10

While performing the steps in projects 8 and 9, you have actually completed troubleshooting one malfunction. Let's review the steps you followed after placing the trouble in the system.

Step 1: Perform an operational check.

Step 2: Determine the malfunctioning component and how it malfunctioned (the valve wouldn't open).

Step 3: Trace the circuit on the wiring diagram.

Step 4: Analyze the circuit for possible causes (which wire could be open or which unit could be defective).

Step 5: Use the multimeter to verify the possible causes and determine the actual cause.

Performing the operational check is a step-by-step procedure used to cause all components to operate. This procedure is given to you in project 3. When working on an actual aircraft, this procedure is given in the technical order.

To determine the malfunctioning component you must know how each component is supposed to operate normally. Then you observe each component's operation to see if it does operate normally.

Tracing the circuit on the diagram helps you select the circuit or circuits that are involved in operating the malfunctioning component. This is the first step in isolating the problem.

Analyzing the circuit for the possible causes requires you to consider all of the available information (symptoms). Let's review the analysis for trouble switch number 1. Follow on the diagram as we analyze this problem. From the operational check we found that the air conditioning system shutoff valve would not open, but the ram air valve does open and close. With this information we know the circuit bringing power to the master switch is good. Since the problem is "the valve won't open," we can assume the close circuit to be good. This leaves our possibilities to be wire number H60B22, wire number H60A22, the ground wire, or a defective valve motor.

After determining the possible causes through analysis, the meter is used to determine where power is and find the actual cause.

PROJECT 11

Troubleshooting

Apply the five steps of troubleshooting to determine the cause for the trouble in each of the problems. You are to complete the remaining 3 practice problems, before you do your performance test. Each problem is placed into the trainer by one of the trouble switches. The trouble switches you are to use are not in numerical sequence - check the chart on the following page for the trouble switches to use.

Note: When troubleshooting the manual temperature control system, be sure you hold the temperature control switch in either the manual Hot or manual Cold position.

Note: Anytime you find a need to troubleshoot in the bridge circuit be sure to isolate the circuit with plug 188 and then ohm out the circuit.

Troubleshoot the system and determine the cause for the trouble in each of the problems. Place only one trouble switch to the IN position for each problem. Start with problem number written in by the instructor. After completing each problem, be sure to place the switch for that problem to the OUT position.

Record your findings for each problem on the chart. We have completed problem number 1 and the information has been filled out.

When you have completed the 3 practice problems, report to the instructor and the instructor will check your answers. If you are correct, you are ready for the progress check.

Note: When you find a HIGH RESISTANCE in a malfunctioning circuit, be sure that you have the circuit isolated that is showing the HIGH RESISTANCE. This may be done by disconnecting the unit electrical plug.

On the chart below list the following information.

In block A, name the unit that is malfunctioning.

In block B, state how the unit is malfunctioning - example: will not open, will not close, will not operate in automatic.

In block C, state the actual cause, giving the wire number or unit and whether it is an open or a short or high resistance.

After you go over the first problem which was done for you, do the next three practice problems and have the instructor check your work when you are done.

Note: Use only the trouble switch that is given by instructor for each problem.

PROBLEM NUMBER 1	TROUBLE SWITCH 1
A Air Conditioning System Shutoff Valve	
B Will Not Open	
C Wire #H60B22 Open	
PROBLEM NUMBER 2	TROUBLE SWITCH
A	
B	
C	
PROBLEM NUMBER 3	TROUBLE SWITCH
A	
B	
C	
PROBLEM NUMBER 4	TROUBLE SWITCH
A	
B	
C	

INSTRUCTOR'S INITIALS ________________ PRACTICE PROBLEMS GRADE ________

WORKBOOK

C3ABR42331-WB-200A

Technical Training

Aircraft Environmental Systems Mechanic

PROGRAMMING DECADE RESISTORS

28 June 1982

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

Designed for ATC Course Use.

Do Not Use on the Job.

RGL: N/A

Environmental Pneudraulic Branch
Chanute AFB, Illinois

C3ABR42331-WB-200A

PROGRAMMING DECADE RESISTORS

OBJECTIVES

Given a decade resistor and predetermined decades total ohms resistance, program the decade switch control settings properly under the proper decade switch designations. A minimum of 3 out of 4 decades total ohms resistance must be programmed correctly.

EQUIPMENT

Decade Resistors ZM-163/U

INSTRUCTIONS

Do not start this workbook unless you have satisfactorily completed the programmed material in WB-202 and have achieved the objective. You will only use a lead pencil to complete this workbook. When you are instructed to go to another page, figure, etc., be sure you follow the instructions.

You will be required to complete the exercises as given. After the exercises are properly completed, you will be assigned a performance test. You will be required to complete the performance test in accordance with instructions provided and meet the minimum performance standards given in the above objective.

If you do not understand the above objective, see your instructor at this time.

Caution: Remove watches, rings, bracelets, etc., before starting any work on the equipment. It is also a good safety practice to work on the equipment with one hand. This practice reduces the chances of receiving an electrical shock to some vital body organ when working with electricity.

When you leave your work area for a scheduled or unscheduled break, or anywhere else, make sure that the following procedures are done before you leave:

1. Insure you have complied with all the instructions given you by your instructor.

2. Insure your equipment is properly stored and secured before leaving the area.

3. When you return from your break, take the same equipment from the locker and go back to work.

4. If there is anything you do not understand about the procedures before, during or after break, be sure you ask your instructor.

Supersedes ST 3ABR42331-WB-202A, 1 October 1980.
OPR: 3370 TCHTG
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3370 TCHTG/TTGU-P - 600; DAV - 1

PERFORMANCE EXERCISE I

In this performance exercise you will be required to use a decade, program the decade to the ohm values given and then check them against the figures given of the decades in this book.

1. Set your decade to ----------- 400.0 ohms.

2. After you do step 1, turn to figure 1 and compare your decade settings to it. They must be the same. If they are not the same, you may ask your instructor for assistance.

3. If you believe you understand the above, continue with the following. If you don't understand, see your instructor NOW.

If you do understand the above, continue by using the ohm values given and program your decade for each of them. After you program each of them, check them against the correct figures given and then go on to the next one. If you have any problems, see your instructor.

Student will initial in the "STUDENT INITIALS" column, when he/she has done the work and believes he/she understands it.

DECADE TOTAL OHMS RESISTANCE	SEE FIGURE	STUDENT INITIALS
295.3 ohms	2	________
500.0 ohms	3	________
1100.0 ohms	4	________
500.0 ohms (See note below)	5	________

Note: The 500 ohms must be with the X-100 decade switch control set on 4 and then adjust the remaining to get the 500.0 ohms.

If you have any difficulty with this performance exercise, see your instructor immediately and do not progress to performance exercise 2.

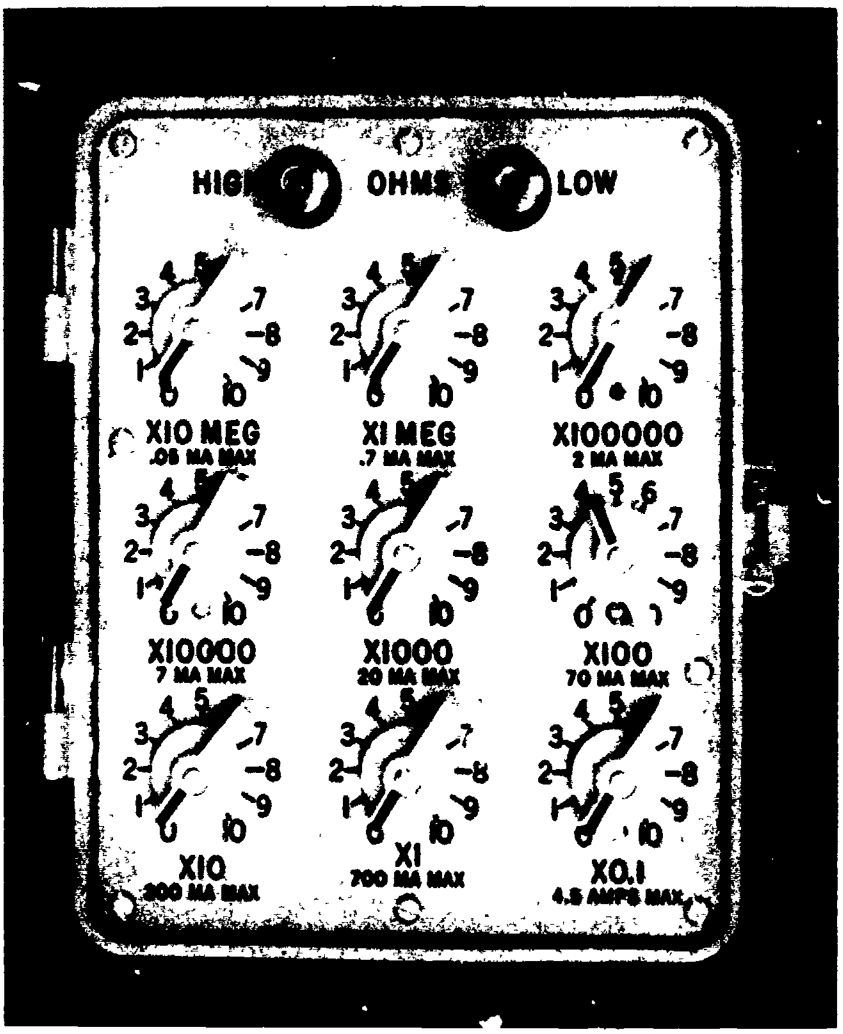

Figure 1.

1315

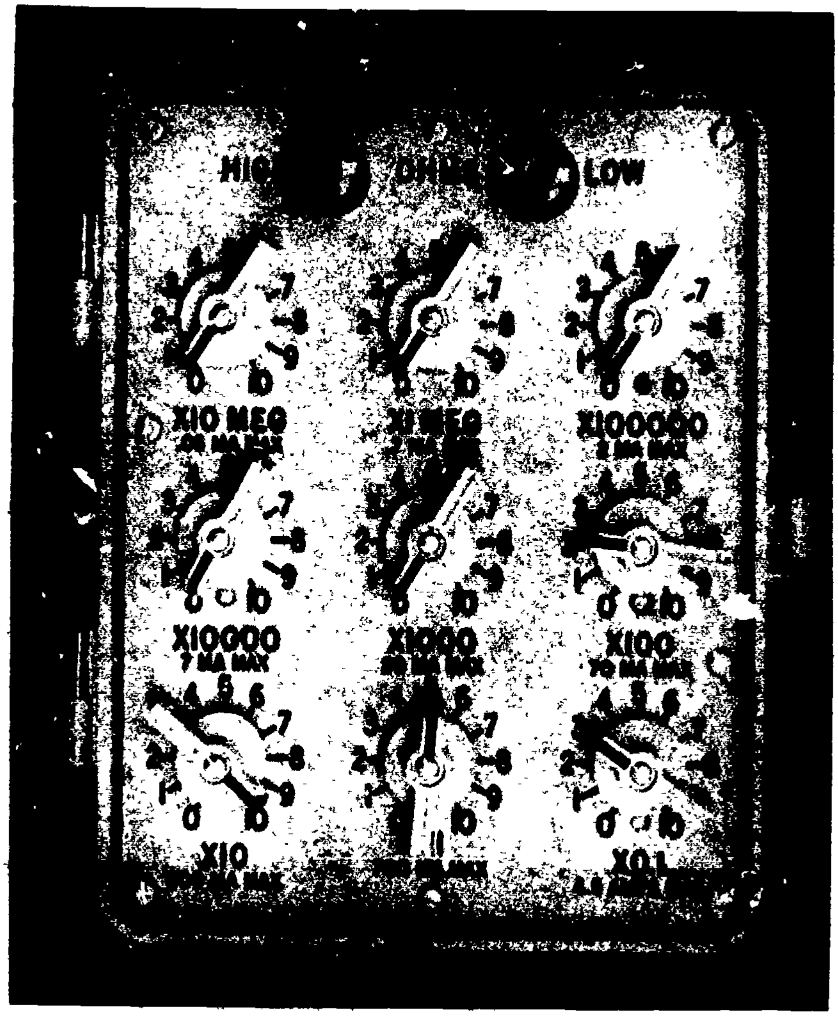

Figure 2.

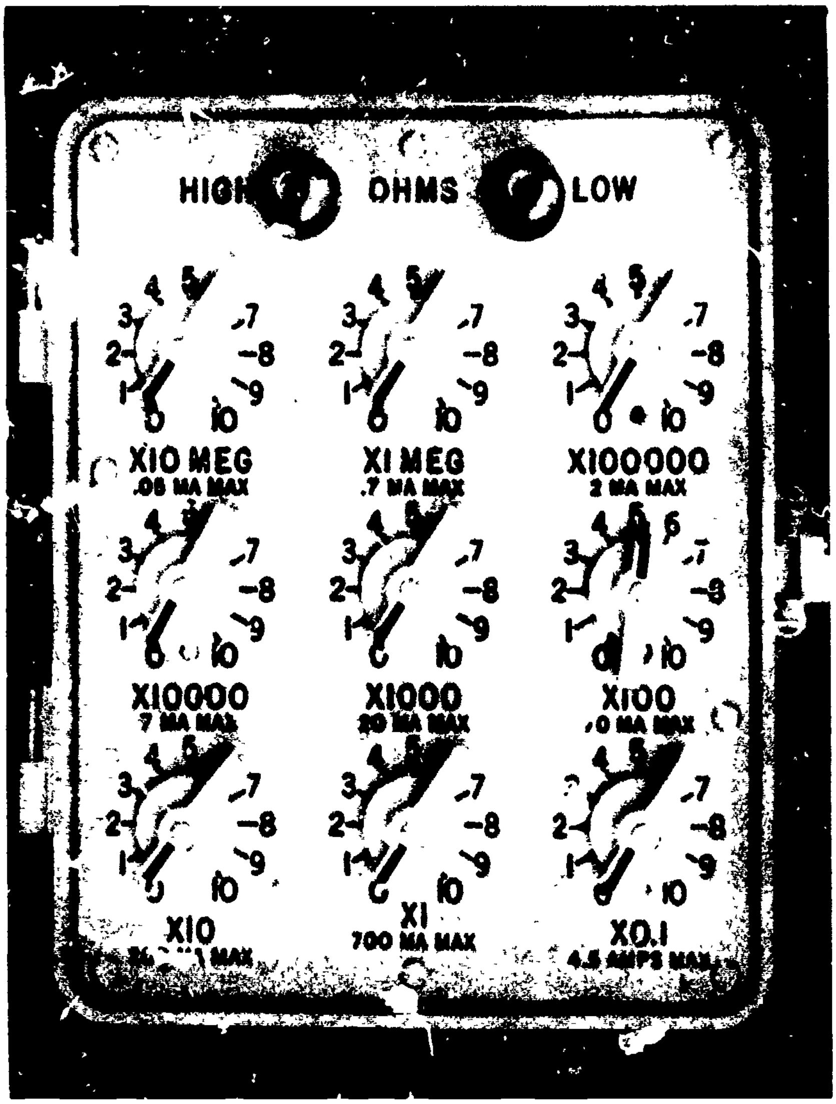
HIGH
OHMS
LOW
X10 MEG
.05 MA MAX
X1 MEG
.7 MA MAX
X100000
2 MA MAX
X10000
7 MA MAX
X1000
20 MA MAX
X100
X10
X1
700 MA MAX
X0.1
4.5 AMPS MAX

Figure 3.

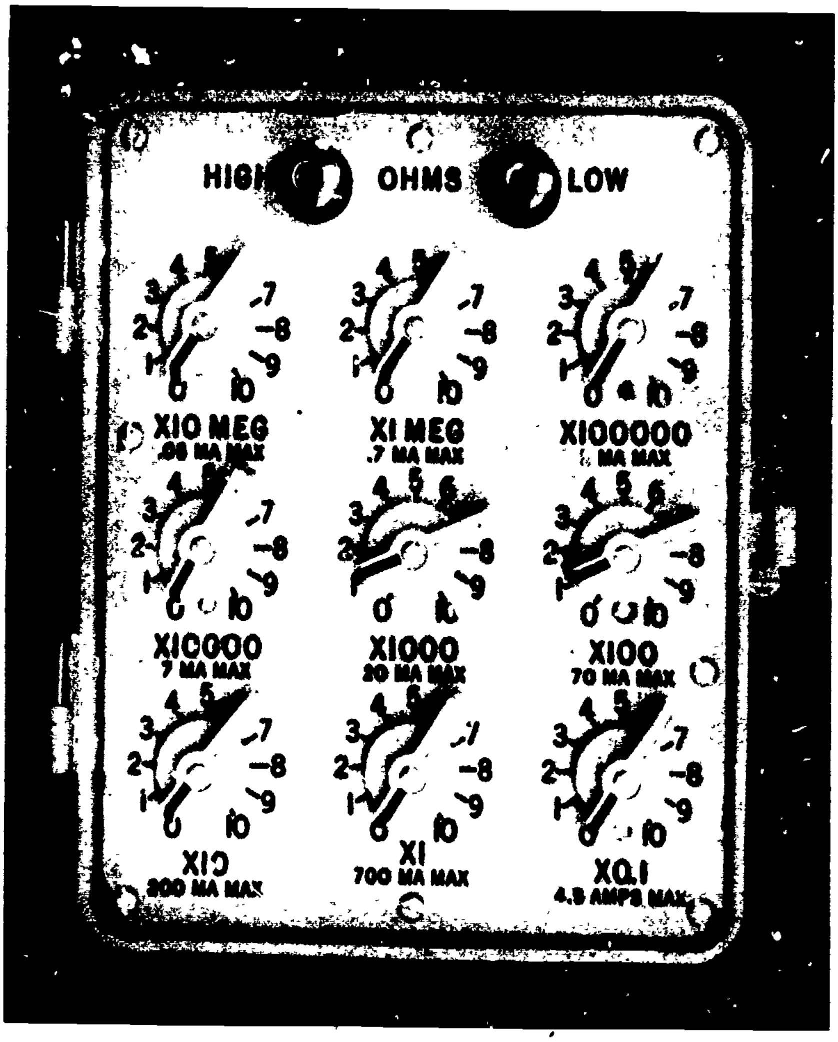
OHMS
LOW
X10 MEG
X1 MEG
.7 MA MAX
X100000
X10000
7 MA MAX
X1000
20 MA MAX
X100
70 MA MAX
X10
200 MA MAX
X1
700 MA MAX
X0.1
4.5 AMPS MAX

Figure 4.

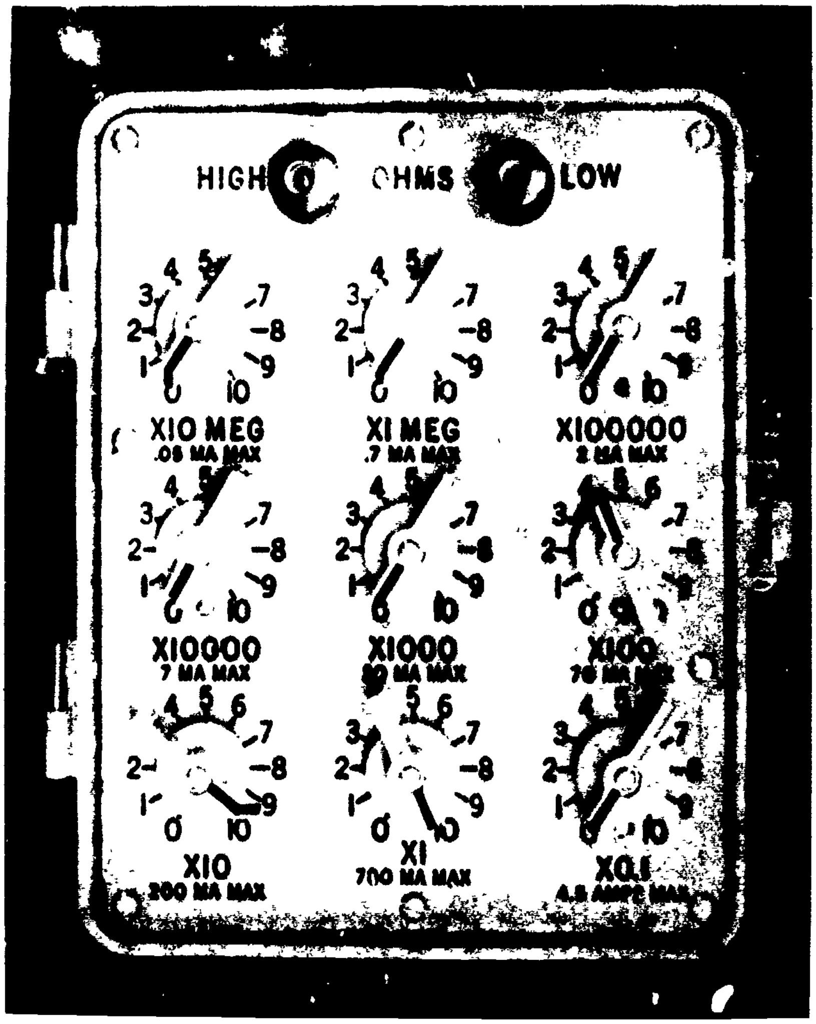
HIGH
OHMS
LOW
X10 MEG
.05 MA MAX
X1 MEG
.7 MA MAX
X100000
2 MA MAX
X10000
7 MA MAX
X1000
X100
X10
200 MA MAX
X1
700 MA MAX

Figure 5.

PERFORMANCE EXERCISE II

In this exercise, you will go from 505.0 ohms to a lower value. You will do this one ohm at a time. This may sound simple, but it can be very confusing unless you understand the procedure.

1. Using the decade provided, make each of the settings as the procedure is explained. We will start with 505.0 ohms and decrease only one ohm at a time to 490 ohms.

2. This procedure is shown by the 6 illustrations in figure 6.

a. Program the decade to obtain 505 ohms. Note Illustration A in figure 6.

b. To decrease resistance only one (1) ohm at a time, start by turning the decade switch X1 back toward zero, one ohm at a time, until it reads 0. You now have 500.0 ohms. Note Illustration B, figure 6.

c. Before you can decrease the resistance any further, you must change the resistance to read 500 ohms on a combination of other decade switch control settings that will allow you to continue decreasing by only one ohm at a time. This can be done by programming the decade switch on the X-100 decade switch back to 4. Now program the X-10 decade switch up to 9, and the X1 decade switch up to 10. Program the above on the decade. Note Illustration C in figure 6. Notice that with this combination you still have 500 ohms. (See figure 6, Illustration C.)

d. Now you can keep decreasing in one ohm steps by turning the X-1 decade switch back toward zero, only one ohm at a time, until it reads 0. This decreases the resistance to 490 ohms. (Note Illustration D, in figure 6.)

e. Should you be required to reduce to a lower ohm value, you could set the X-10 decade switch to 8 and X-1 decade switch to 10; this would still be 490 ohms. (Notice Illustration E in figure 6.) From this you could reduce one ohm at a time to 480 ohms. (Notice Illustration F in figure 6.) This process can be continued, allowing you to reduce resistance in one ohm at a time as desired. This procedure can be applied to any value.

PERFORMANCE EXERCISE III

In this exercise, you will go from 480 ohms to a higher value. You will do this only one ohm at a time. Again, like in Exercise II, this may sound simple, but it can be very confusing unless you understand the procedure. This procedure is similar to what you did in Exercise II. If you DON'T understand Exercise II or haven't completed it, don't start this exercise, but see your instructor at this time.

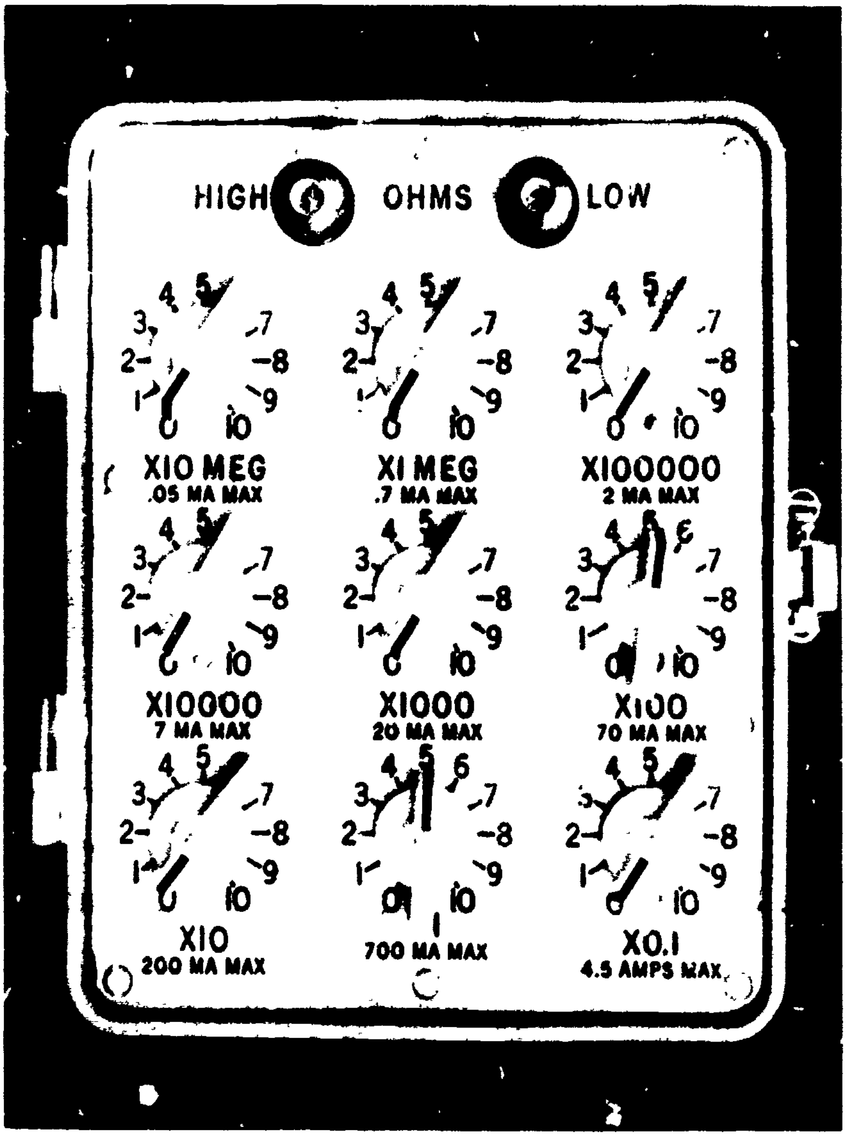

Figure 6A.

1321

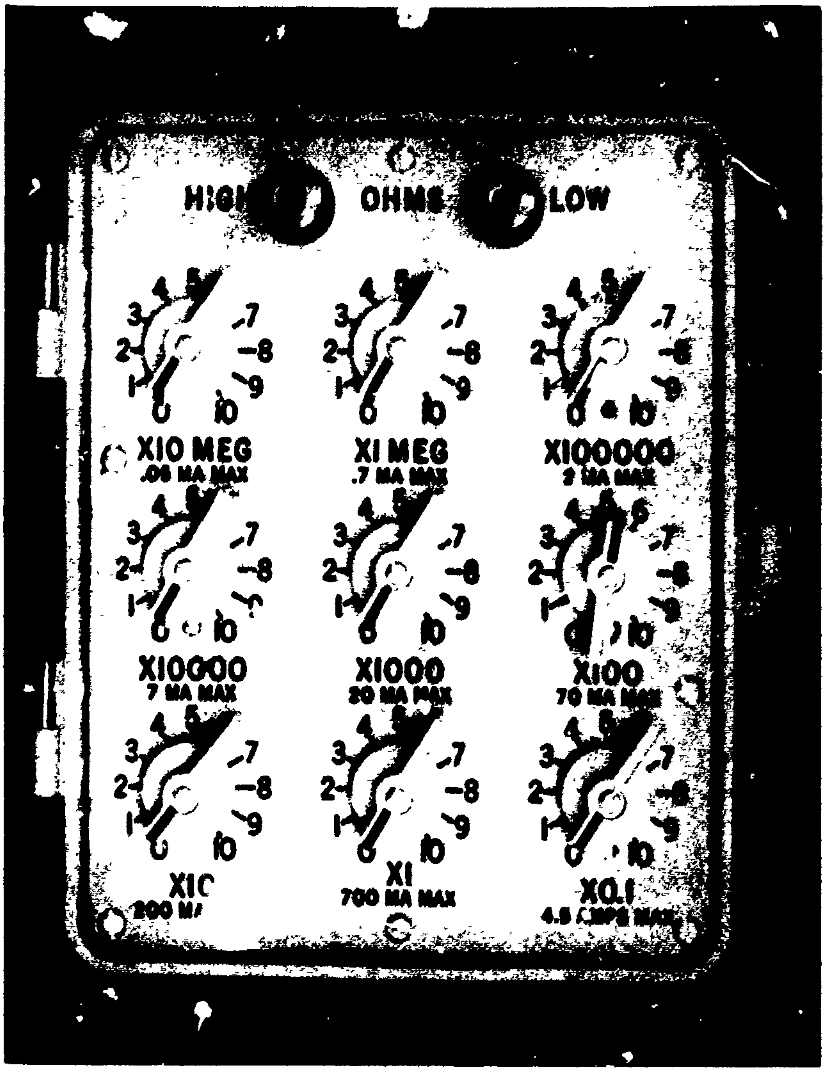

ILLUSTRATION B 500 Ω

Figure 6B.

1322

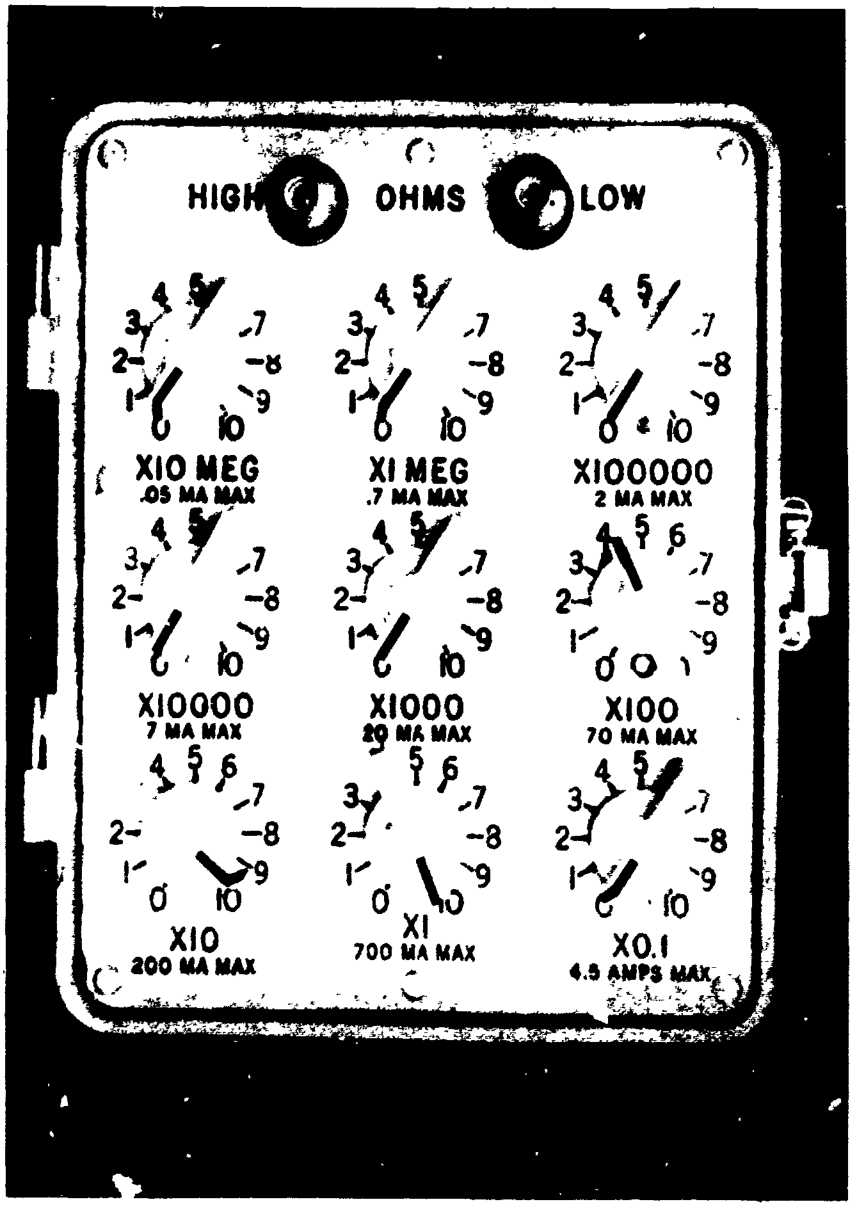

ILLUSTRATION C 500Ω

Figure 6C.

1323

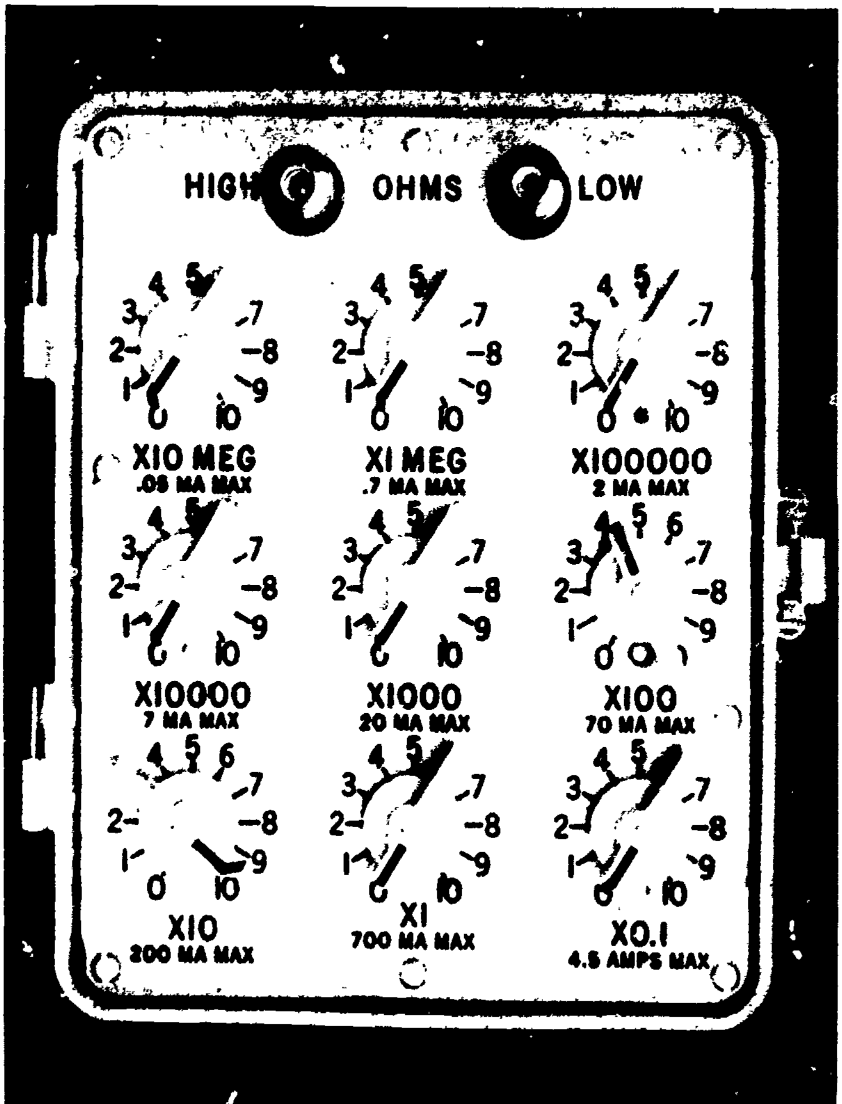

ILLUSTRATION D 490Ω

Figure 6D.

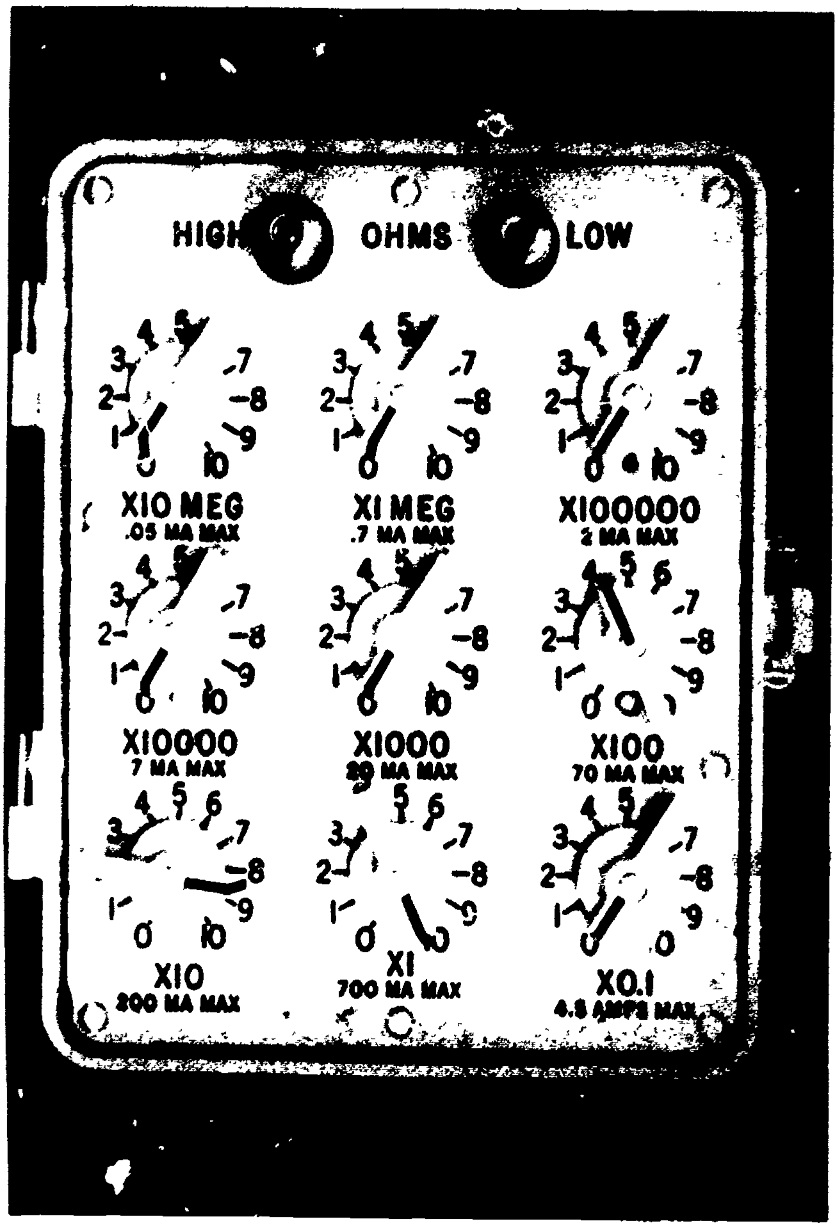

ILLUSTRATION E 490 Ω

Figure 6E.

1325

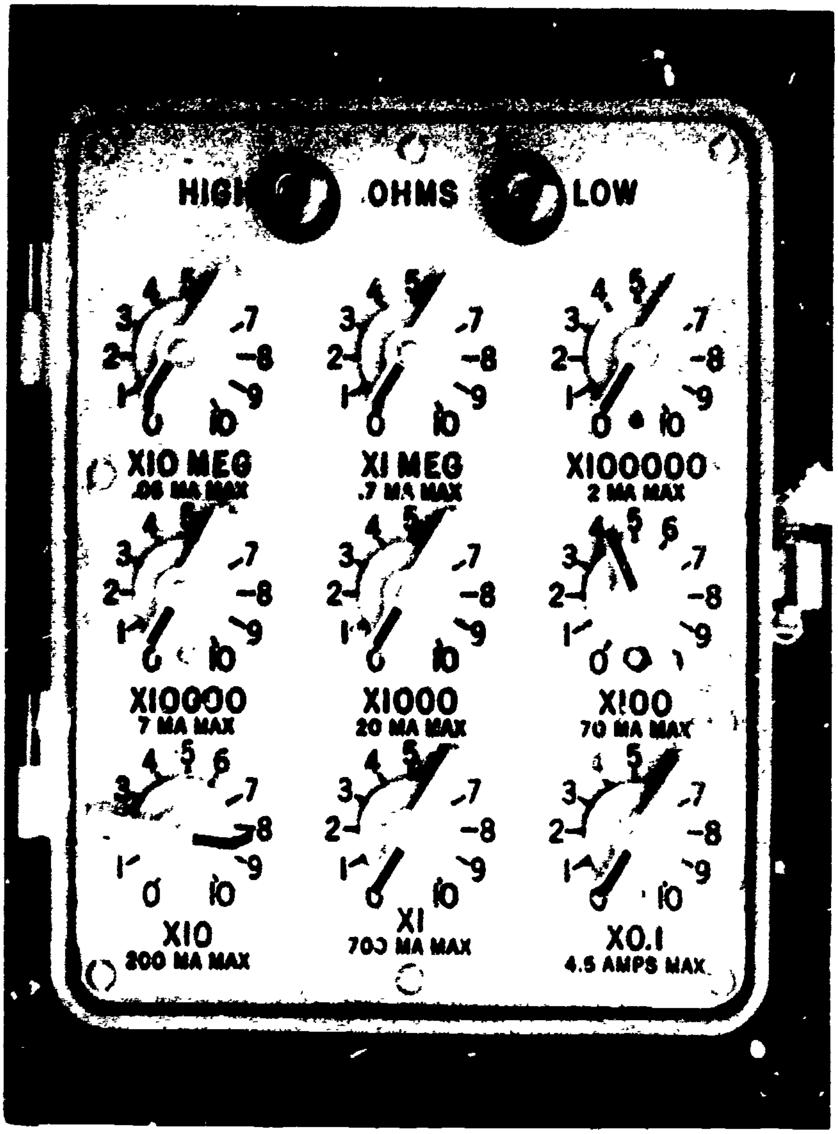

ILLUSTRATION F 480 Ω

Figure 6F.

1326

If you have satisfied the above, you may start with the following:

1. Using the decade provided, make each of the settings as the procedure is explained. For this exercise, we will start with the 480.0 ohm setting you have already set in Exercise II. (Note figure 6, Illustration F.) This setting will be increased only one ohm at a time up to 508.0 ohms.

2. This procedure is shown by the illustrations in figure 7.

a. Insure your decade is programmed at 480.0 ohms as given in Exercise II. (Note Illustration A in figure 7.)

b. To increase the resistance only one ohm at a time, start by turning the decade switch X1 only <u>one ohm at a time</u> up to 10, until it reads 10 x 1. You now have 490.0 ohms. (Note Illustration B, in figure 7.)

c. Before you can increase the resistance any further, you must change the resistance to read 490.0 ohms on a combination of other decade switch control settings that will allow you to continue increasing by only one ohm at a time using the X1 decade switch. This can be done by programming the X1 decade switch back to 0 and X10 decade switch up to 9 x 10. (Note Illustration C, figure 7.)

d. Now you can keep increasing in one ohm steps by turning the X1 decade switch toward 10, only one ohm at a time, until it reads 10. This increases the resistance to a 500 ohm value. (Note illustration D, figure 7.)

e. Before you can increase the resistance any further, you must change the 500 ohm resistance to read 500 ohms on a combination of other decade switch control settings. This allows you to continue increasing by only one ohm at a time, with the X1 decade switch. This can be done by programming the decade switch X1 back to zero, the X10 back to zero, and the X100 up to 5. This gives a total resistance value of 500 ohms. (Note Illustration E, figure 7.)

f. Now you can increase in one ohm steps by turning the X1 decade switch only one ohm at a time until you arrive at the 508 ohm value you are required to adjust to. (Note Illustration F, figure 7.)

Note: The time period between the one ohm settings may vary in length to allow the circuit to respond to the change. This is normally timed according to the technical data given with the circuit.

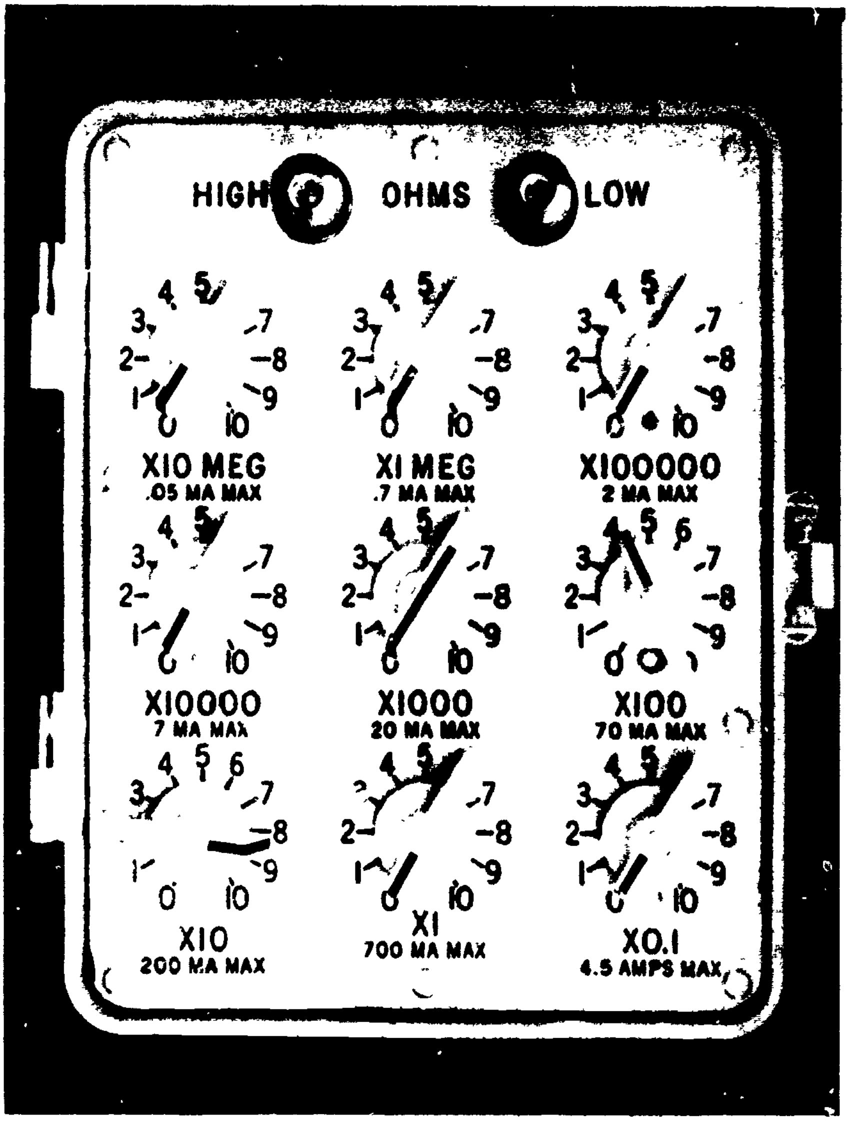

ILLUSTRATION A 480Ω

Figure 7A.

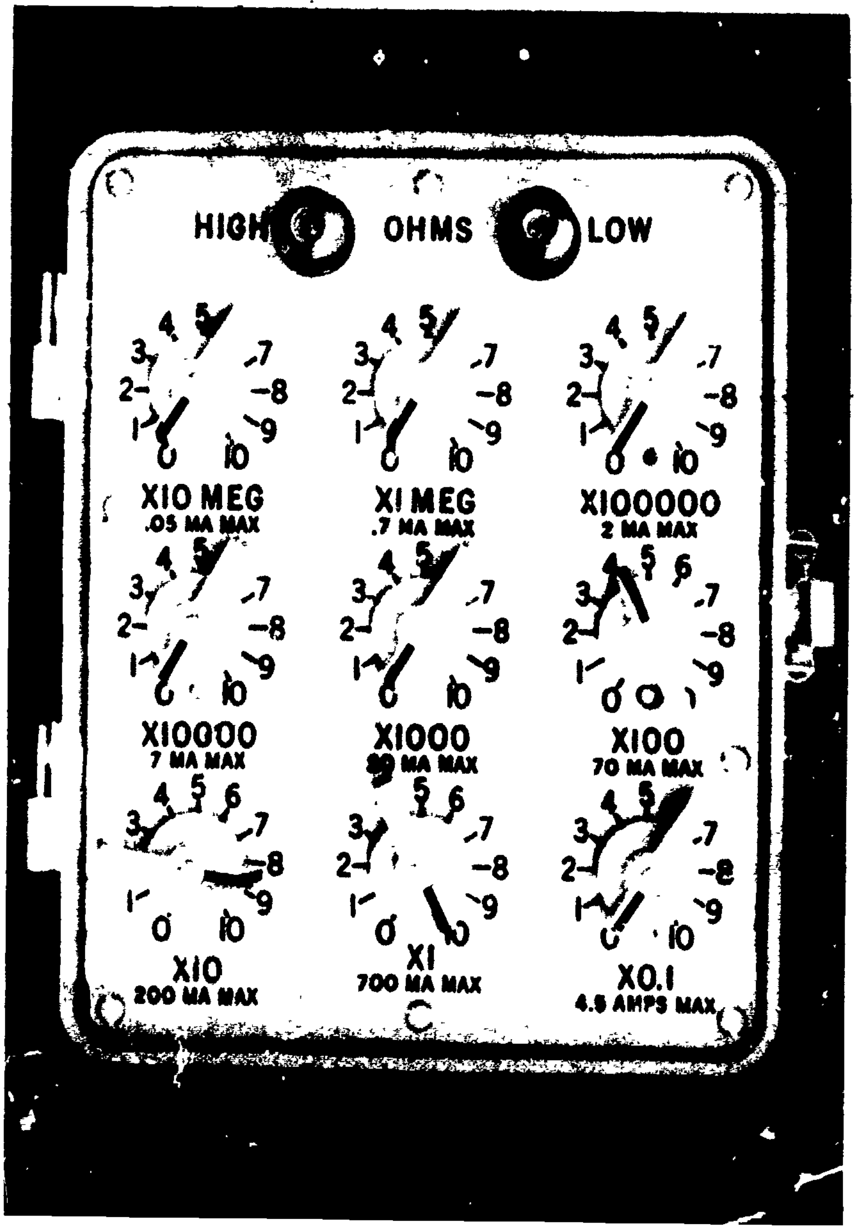

ILLUSTRATION B 490 Ω

F. ure 7B.

1329

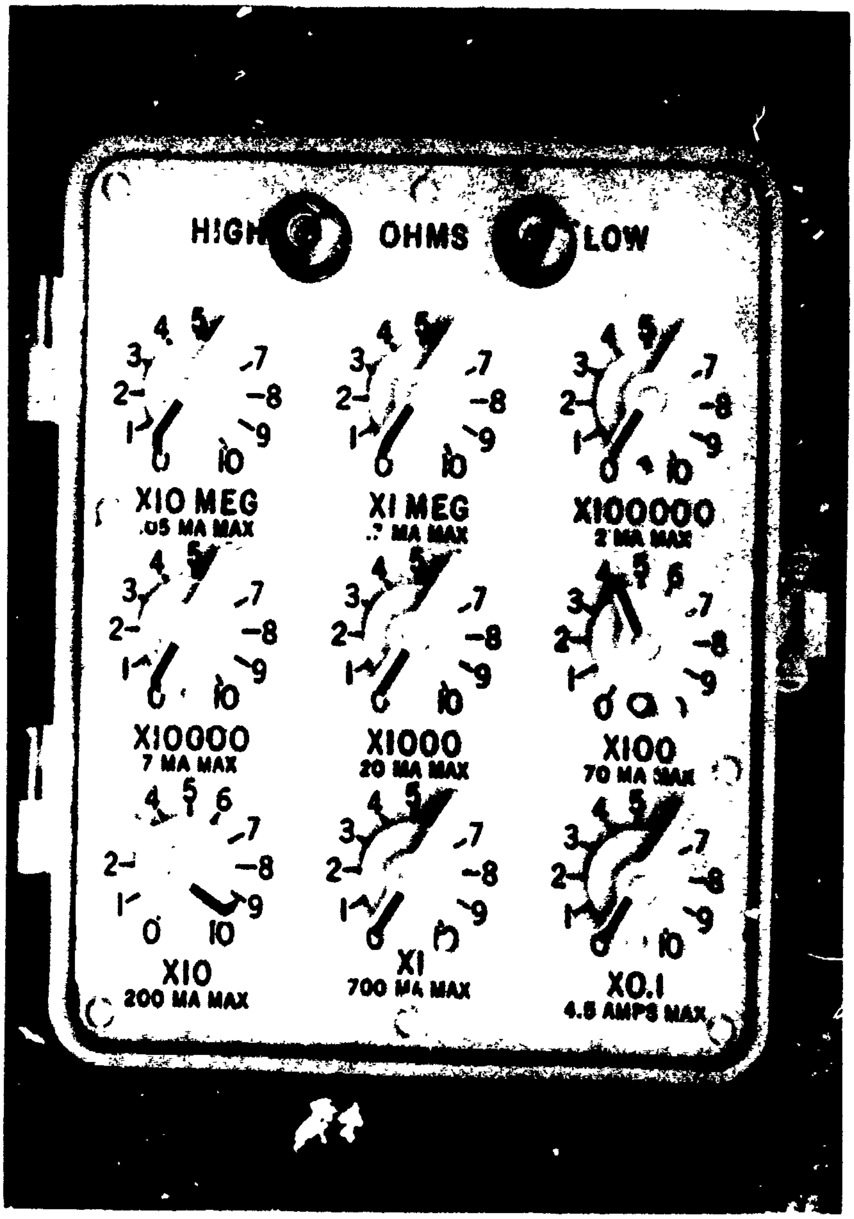

ILLUSTRATION C 490Ω

Figure 7C.

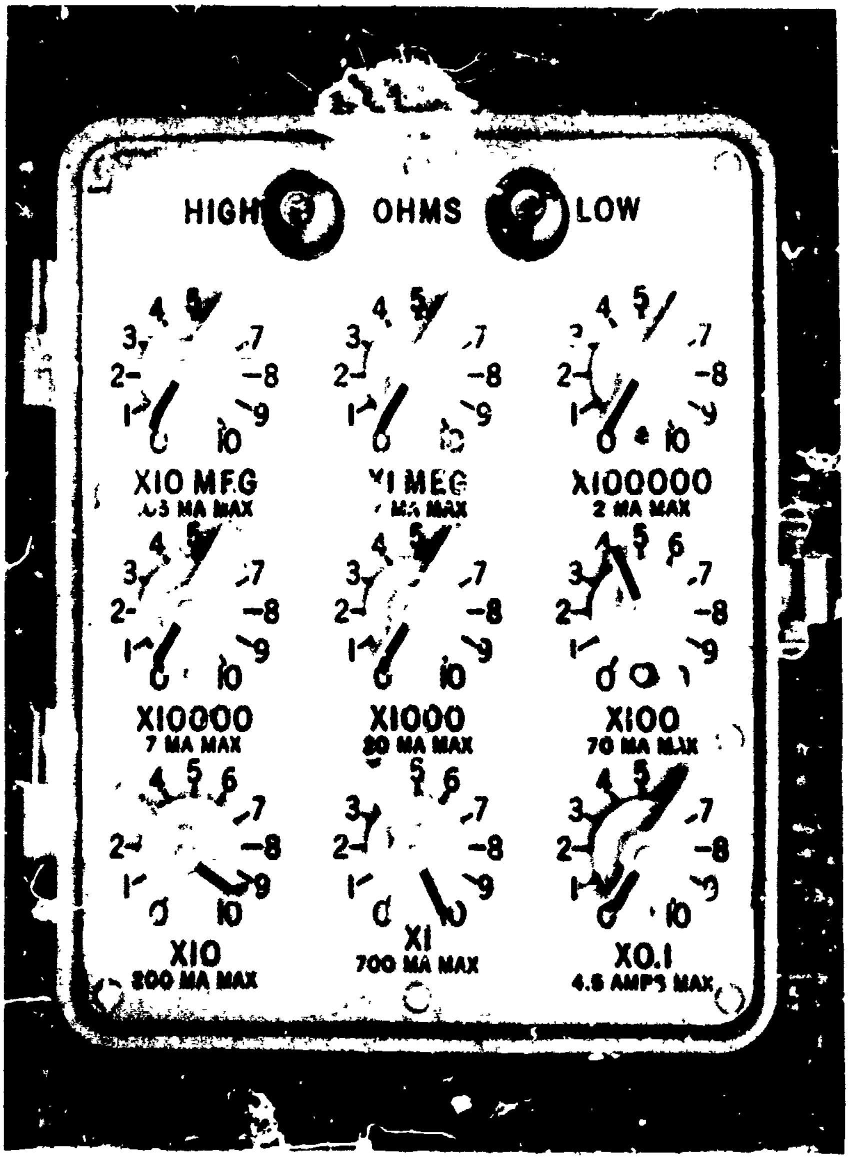

ILLUSTRATION D 500Ω

Figure 7D.

1331

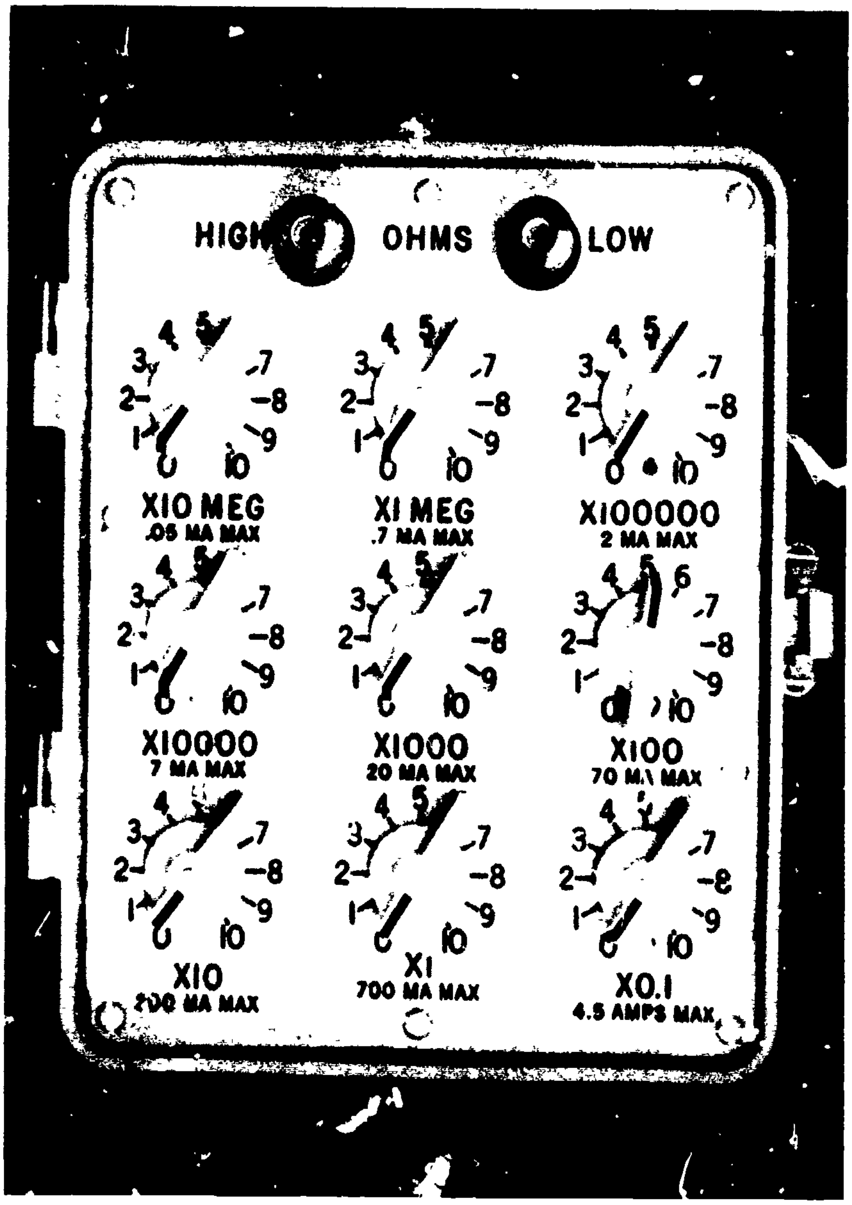

ILLUSTRATION E $\underline{500\,\Omega}$

Figure 7E.

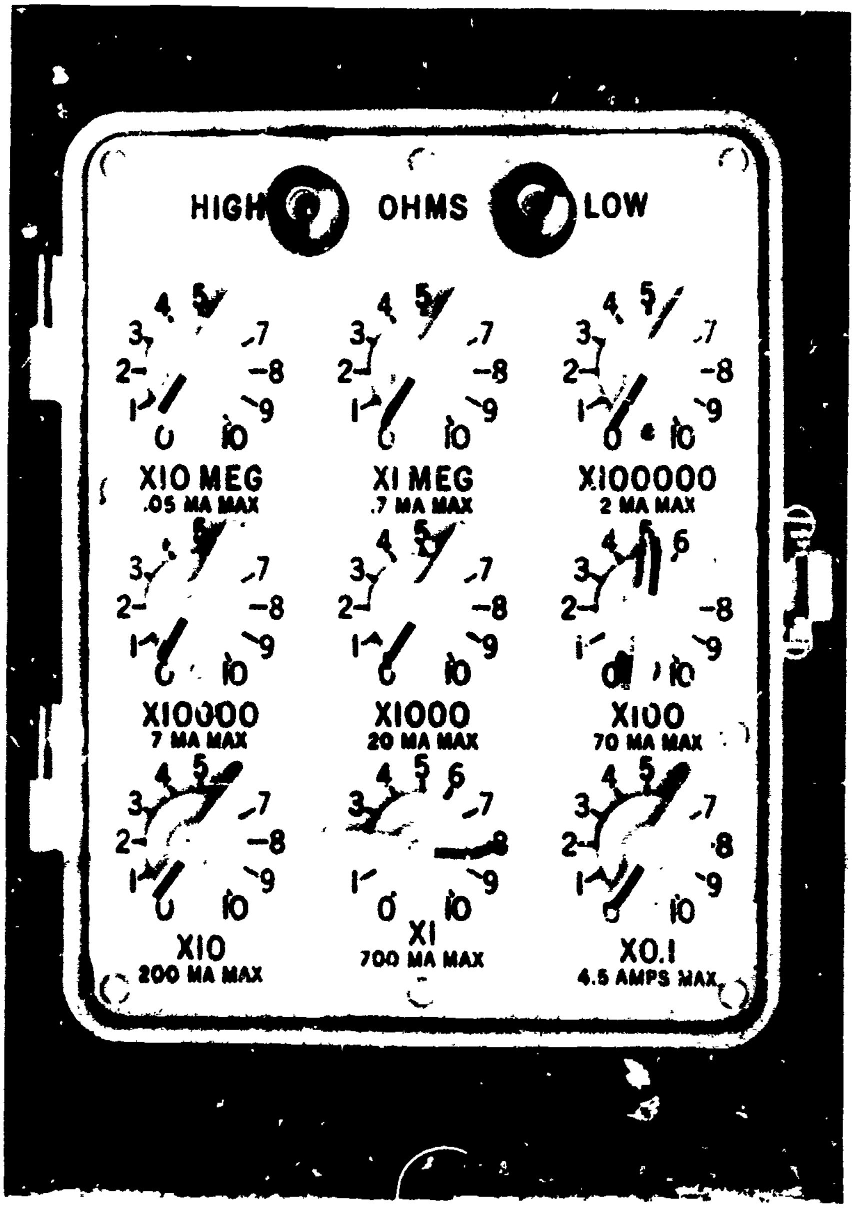

ILLUSTRATION F 508 Ω

Figure 1333

PERFORMANCE TEST INSTRUCTIONS

1. Remove this page.

2. After you have finished this workbook and its exercises, you will take the workbook to your instructor.

3. Insure your instructor has your daily records.

4. Read the performance test instructions provided by your instructor. If you have read all of them, and understand them,

initial here ____________________ and immediately ---------------

5. The student will ask the instructor to initial below so he/she may start the performance test given under the supervision of the instructor.

6. Instructor initials ______________ for you to start the performance test.

STUDENT'S NAME ____

NOTE: Items below completed by the instructor.

START TIME ______________________ and DATE ______________________

STOP TIME ______________________ and DATE ______________________

RETAKE - YES - NO

	PART 1	S	U
	PART 2	S	U
SATISFACTORILY = S	PART 3	S	U
UNSATISFACTORILY = U	PART 4	S	U

PROGRAMMED TEXT

3ABR42331-PT-201

Technical Training

Aircraft Environmental Systems Mechanic

FIGHTER BLEED AIR SYSTEM

6 March 1981

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

Designed for ATC Course Use.
Do Not Use on the Job.

RGL: 9.6

OBJECTIVES

Correctly identify system operation, safety procedures, and/or components of the bleed air system with a minimum of 80% accuracy.

INSTRUCTIONS

This text presents information in small steps called "frames." After each frame you are asked to respond by completing a statement. Read each frame carefully before responding. The answers to the statements for each frame are located on the top of the next frame. If you select the correct answers, continue to the next frame. If you are incorrect, read the material again and correct your answers before continuing.

Supersedes 3A3R42331-PT-201, 10 September 1980.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 1000; TTVSA - 1

In previous lessons you learned the trainer type aircraft air conditioning system. You should recall that the air used for air conditioning came from the jet engine.

Do you remember what to call the air that was tapped from the jet engines? Yes, it's called "engine bleed air."

You should keep in mind that engine bleed air is an extremely hot, high pressure air. The actual temperature and pressure will depend on the engine throttle setting and ambient air temperature.

The temperature can range from close to 500 F to 900 F and the pressure from close to 100 to 250 psi.

Engine bleed air as a rule is taken from the last stage of engine compression. Keep in mind, the number of stages of compression will vary with the different jet engines.

On the fighter aircraft that is used as an example in this lesson, the bleed air is tapped from the 17th stage of compression. This is the last stage of compression on this engine.

Fill in the blanks to complete the following statements.

1. The air tapped from the jet engine is called ___________ __ ______ air.

2. The pressure and temperature of the engine bleed air depends on the engine ______________ ________________.

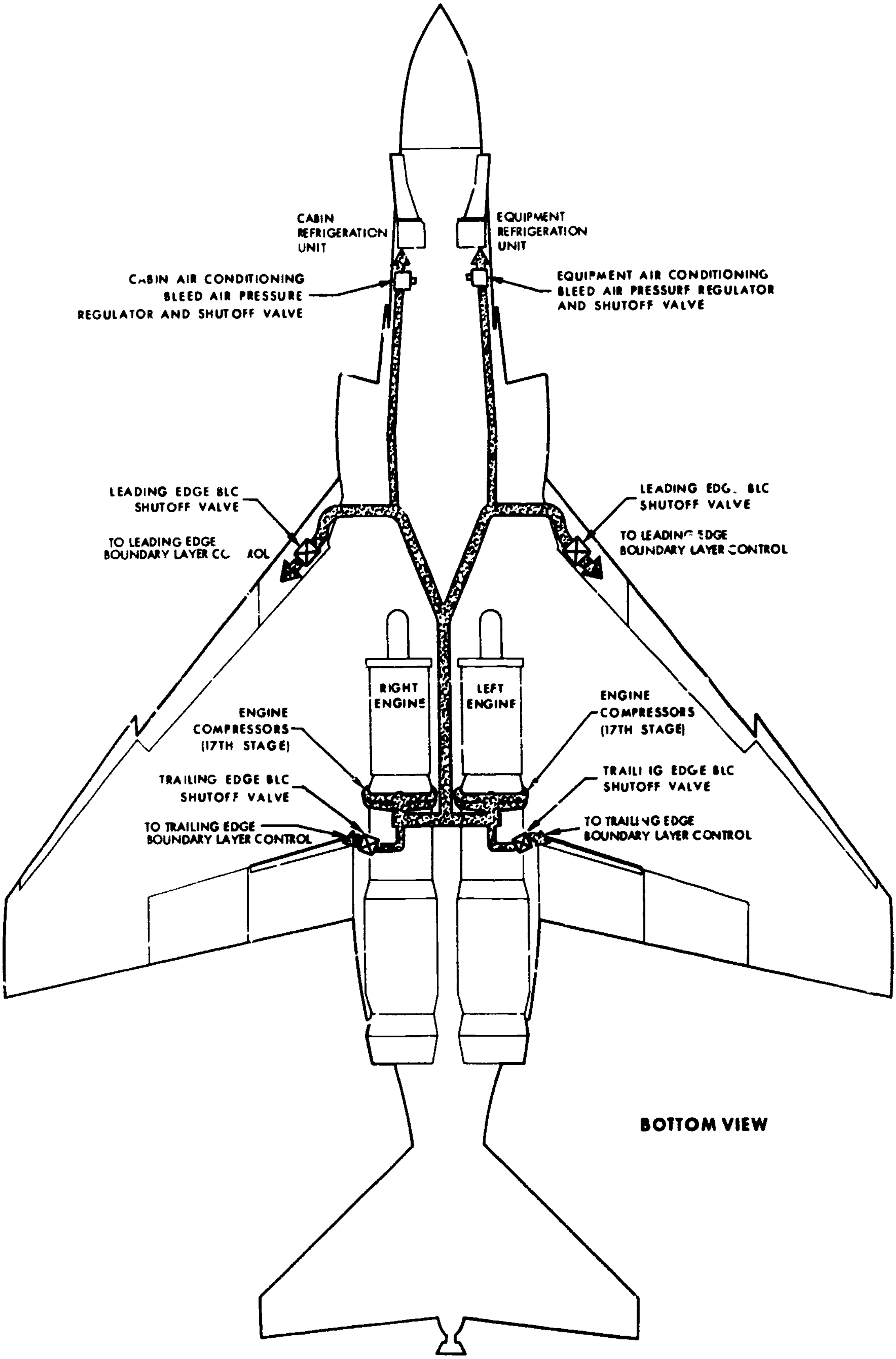

Figure 1. Bleed Air System.

Answers to Frame 1: 1. <u>engine bleed</u> 2. <u>throttle setting</u>

Frame 2

Engine bleed air is used for several purposes on the aircraft. It is used to air condition the cockpit, cool the electronic equipment, keep the windshield clear of rain, and aid in aircraft control through the boundary layer control system.

When the engines are running, bleed air is supplied to the cabin air conditioning system, equipment air conditioning system, and to the boundary layer control (BLC) system. Each of these systems has a shutoff valve to control the bleed air. You will learn how the bleed air is used in each of these systems in future lessons.

Figure 1 shows the bleed air system. The air is tapped from the 17th stage of compression on each of the two engines and is directed into one duct. From there it is distributed to each of the systems.

Follow the path of airflow in figure 1 from the engines.

Fill in the blanks to complete the following statements.

1. The air used for air conditioning is tapped from the _______ stage of engine compression.

2. The boundary layer control system receives air from the __________ ___________ _____ _____ system.

3. Engine bleed air is used for removing rain from the _______.

NOTES

1. COMPONENT OF BOUNDARY LAYER CONTROL SYSTEM.
2. COMPONENT OF ENGINE BLEED AIR SYSTEM

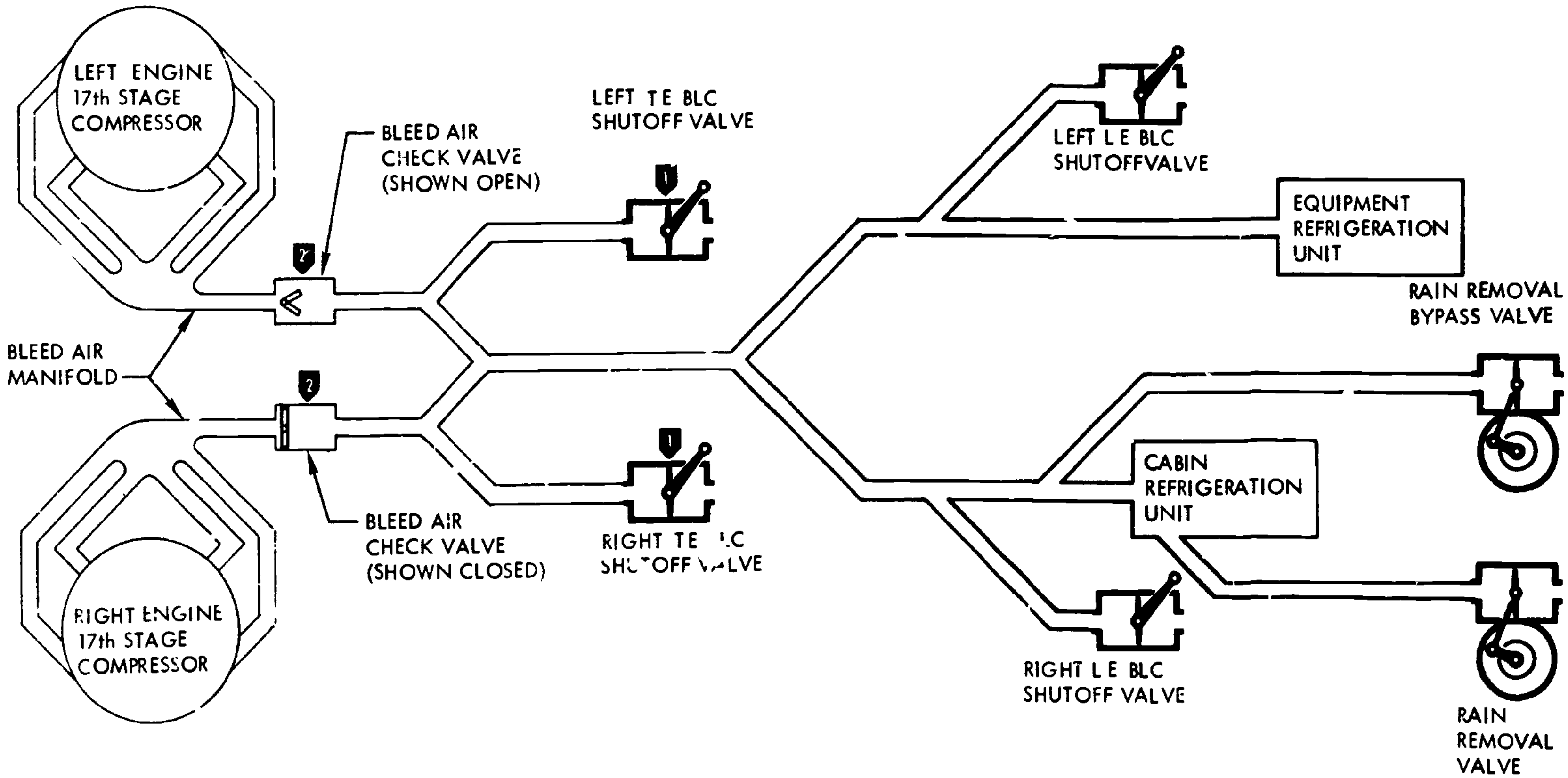

Figure 2. Bleed Air System Schematic. (Top View)

Answers to Frame 2: 1. 17th 2. engine bleed air 3. windshield

Frame 3

On this aircraft, bleed air is supplied by two engines. Check valves are used to prevent loss of bleed air if one of the engines is inoperative. Remember, check valves allow airflow in one direction only, or we can say, they prevent a reverse flow of air.

Notice the check valves in figure 2. In this system there is one check valve for each engine. These are flapper type check valves, similar to those used in the trainer aircraft air conditioning system.

Air flowing in one direction will open the flappers, but airflow in the opposite direction will force the flappers to close. Check valves normally have an arrow stamped on the body of the valve to indicate the direction of airflow.

Fill in the blanks to complete the following statements.

1. Loss of air through an inoperative engine is prevented by a ________ ________.

2. The check valves are opened by ________ ________.

Answers to Frame 3: 1. check valve 2. air pressure

Frame 4

Read each statement below then mark each one T (true) or F (false).

_____1. Engine bleed air is tapped off the 17th stage of compression on both the left and right engines.

_____2. Check valves allow bleed air to flow out of the engine compressor, and also prevent a reverse flow of air into an inoperative engine.

_____3. The arrows on the check valves indicate the direction of airflow.

_____4. The check valves are opened by spring tension.

_____5. The engine bleed air system supplies hot, high pressure air to the boundary layer control system, equipment refrigeration unit, and the cabin refrigeration unit.

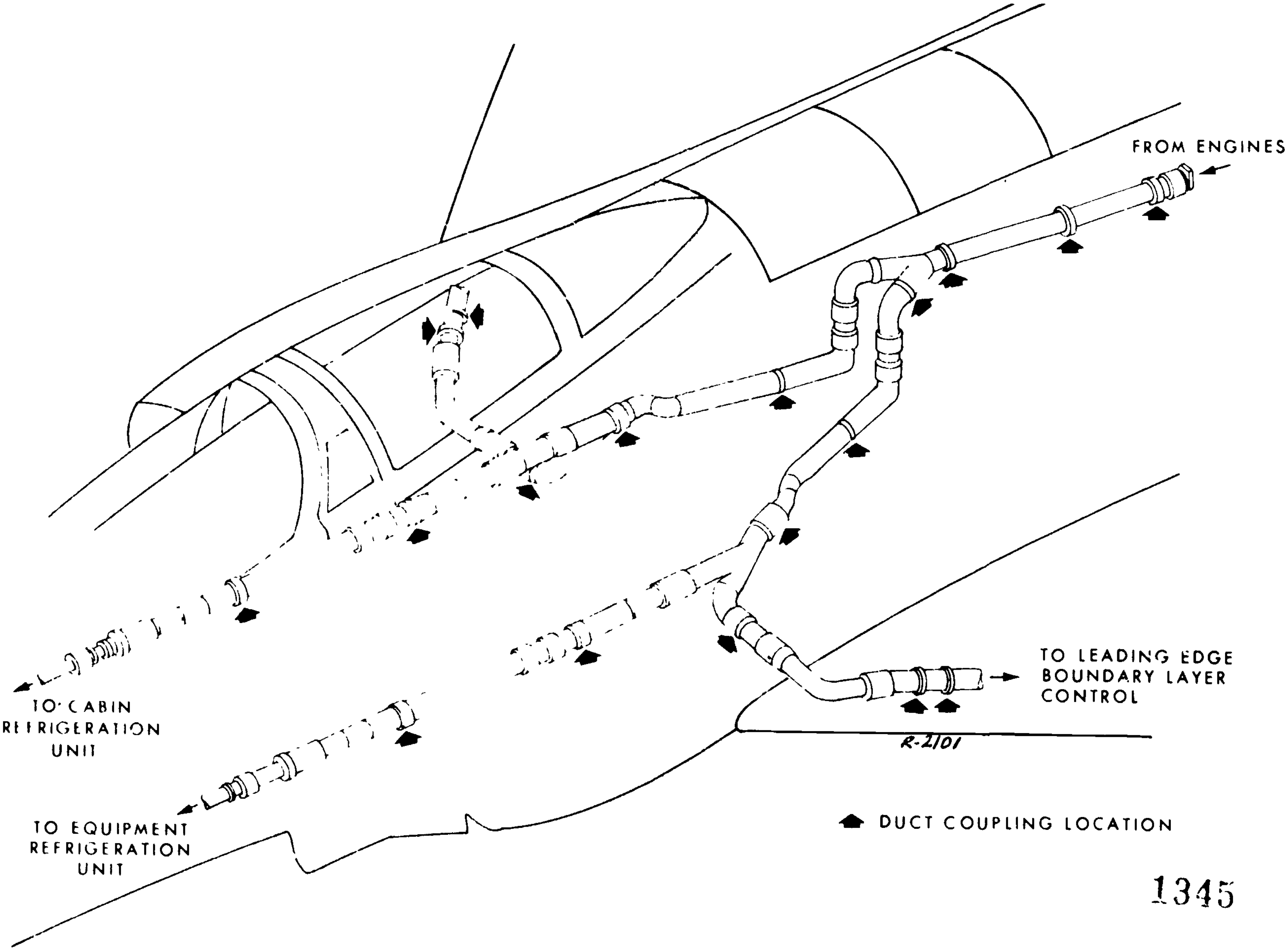

Figure 3. Bleed Air System.

Answers to Frame 4: T 1. T 2. T 3. F 4. T 5.

Frame 5

From the engines, the bleed air is routed through ducting to the different systems. The ducting is made up of short sections connected together with duct couplings.

Short sections of ducting are used to make it possible to remove and reinstall th. ·s for maintenance.

Figure 3 shows part of the bleed air ducting. The small arrows point to some of the many couplings used to hold the sections of ducting together.

The duct sections are made of a stainless steel alloy which can withstand extremely high temperatures.

The walls of the duct sections can be made very thin, thereby saving weight. For this reason they have to be handled with care. A dent or scratch will weaken the duct and can cause it to crack. This will result in a hot air leak, or rupture of the ducting.

Hot air leaks are very dangerous on aircraft as the hot air can burn the electrical wiring which can cause system failure, ignite flammable materials, or soften or burn through structural members. In some cases, total engine failure and loss of flight control has occurred.

Fill in the blanks to complete the following statements.

1. Duct sections are held together by ________ __________.

2. Engine bleed air ducting is made of _________ ________ alloy.

3. To make it possible to remove and reinstall engine bleed air ducting with ease, the ducting is made in ________ ________.

4. One precaution to observe when maintaining the bleed air system is to handle the ___________ with care.

Answers to Frame 5: 1. duct couplings 2. stainless steel
3. short sections 4. ducting

Frame 6

Most of the stainless steel duct sections are rigid. For this reason a means is needed which will allow for variations in duct length and for movement of the ducts.

The duct length will change with temperature changes. Increases in temperature will cause the duct to expand. This is called thermal expansion.

Thermal compensators are used to allow for duct movement caused by thermal expansion and contraction.

A thermal compensator is shown below. This part is made up of a flexible bellows that allows for linear (lengthwise) movement and a ball and swivel joint that allows for angular (sideways) movement.

The inner tube (2) is connected to the outer chamber (1) by the bellows (3). The duct is connected to the inner tube. If the duct moves due to expansion, the flexible bellows will allow the inner tube to move inside the compensator.

On the opposite end of the compensator, the duct is connected to the swivel joint. The swivel joint (4) allows the ducting to move angular (sideways) approximately 5 degrees.

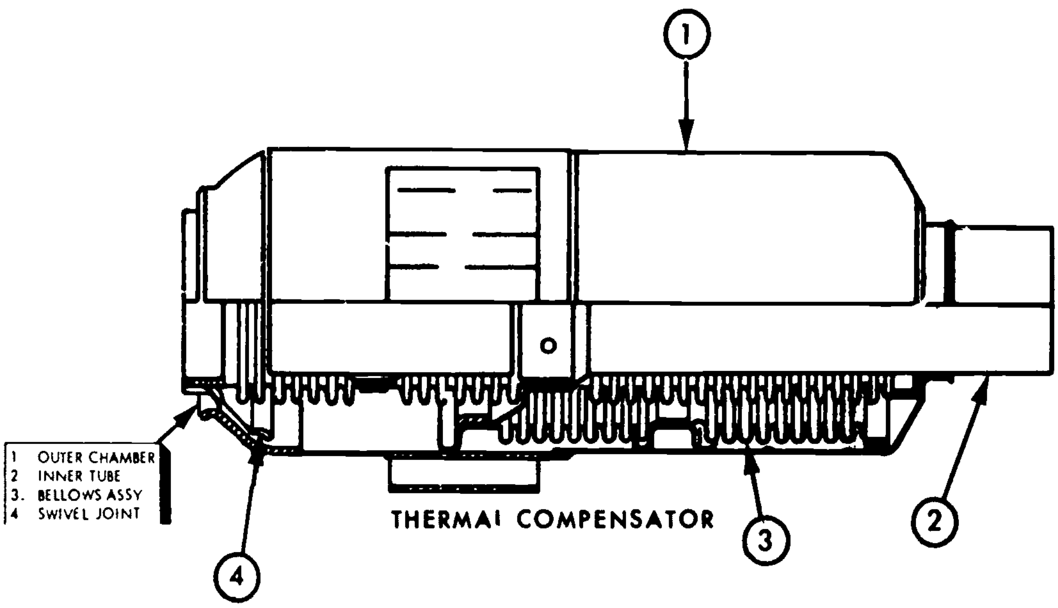

Figure 4. Thermal Compensators.

1347

Fill in the blanks to complete the following statements.

1. An increase in temperature will cause the ducting to ______.

2. Movement of the bleed air ducting due to thermal expansion or contraction is compensated for by the ____________ ____________.

3. The swivel joint allows for ________ __________ of the ducting.

Answers to Frame 6: 1. expand 2. thermal compensator
3. angular movement

Frame 7

When a duct section is removed during maintenance and a new section is installed, it's possible the ducting will not fit together the same as the old section did. Duct length may vary slightly.

Ambient (surrounding) temperature changes may cause variations in the aircraft structure and the bleed air ducting due to the difference in expansion rates of different metals. This can make it difficult to align the ducting and to insure a leak proof connection.

Tolerance compensators are installed in the system to compensate for variations in duct length.

The tolerance compensator is shown below. This unit consists of a bellows section for flexibility and a threaded section that allows the maintenance man to adjust the duct length. This is done by screwing the threaded section in to shorten the tolerance compensator, or out to make it longer.

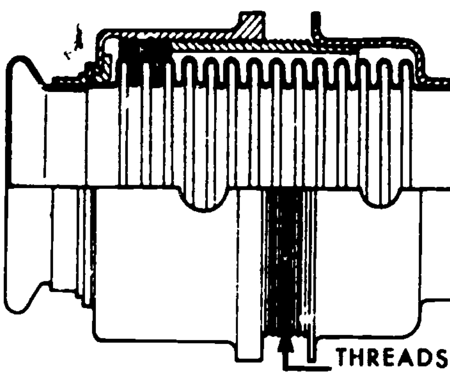

Figure 5. Tolerance Compensator.

Fill in the blanks to complete the following statements.

1. If the duct sections do not align properly, the maintenance technician should adjust the ______________ ____________.

2. The purpose of the tolerance compensator is to allow for ____________________ in duct length.

1349

Answers to Frame 7: 1. tolerance compensator 2. variations

Frame 8

There are several types of clamps and couplings used to join duct sections together and to attach the units such as compensators and control valves.

Four different couplings used in the bleed air system are shown below. They are the Marman V band, Marman Conoseal, Marman J11, and Janitrol couplings.

Notice that the Marman couplings use gaskets to make an air tight seal between the ducts, while the janitrol coupling does not.

The Janitrol coupling is designed to make the joint air tight by pulling the duct flanges together to form a metal to metal seal.

Care must be taken to insure the flanges on this coupling are not bent or nicked during maintenance, as a damaged flange will cause an air leak.

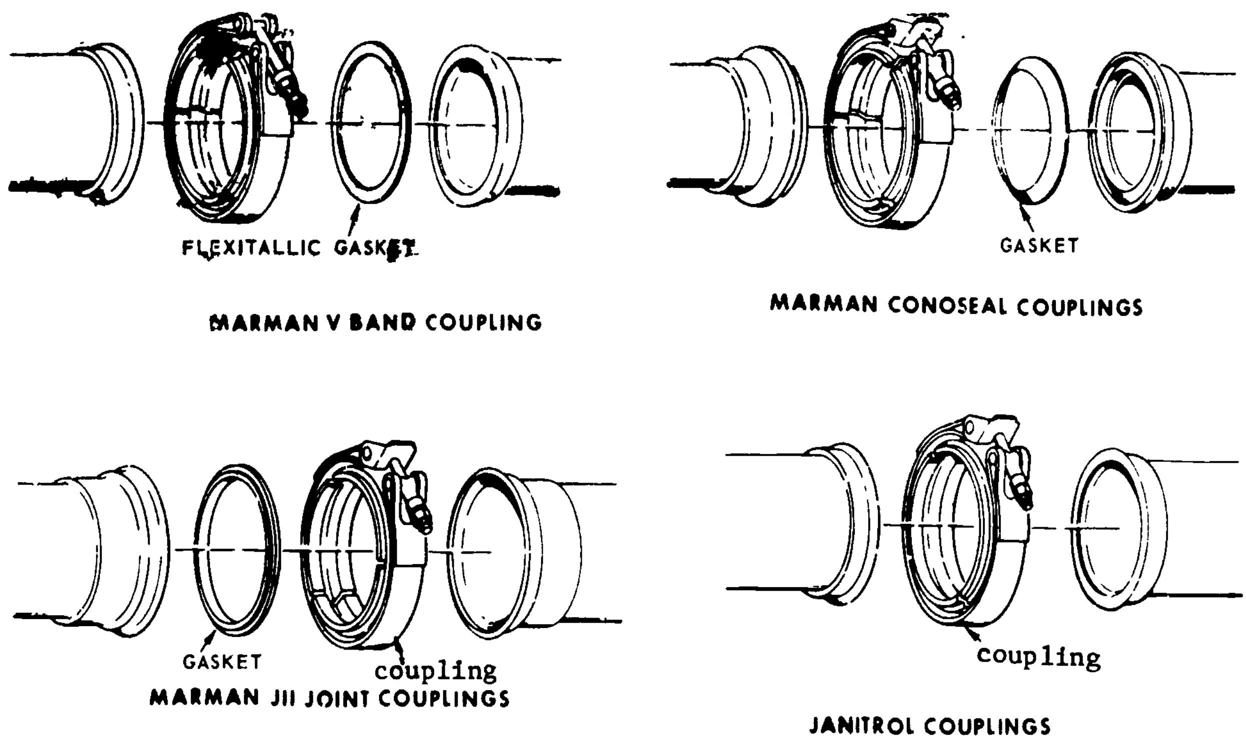

Figure 6. Duct Section Couplings.

Fill in the blanks to complete the following statements.

1. Duct sections are held together by __________ __________.
2. An air tight seal is formed in the Marman coupling by the __________.
3. An air tight seal is formed in the Janitrol coupling by the flanges forming a __________ to __________ seal.
4. A leak at a janitrol coupling could be caused by a damaged __________.

Answers to frame 8: 1. duct couplings 2. gaskets
3. metal to metal 4. flange

Frame 9

Each of the couplings shown in figure 6 will be referred to as a "V" (Vee) band coupling or clamp. This will be the general flight line terminology that you will encounter. They are called V-band couplings because of their V shape.

The sketch shown (figure 7) identifies some of the parts of a V-band coupling. Notice the "T" bolt and quick coupler latch. This permits disconnecting the coupling without complete removal of the nut.

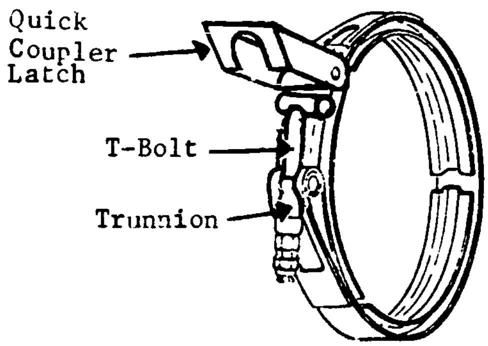

Figure 7. Components of a V-band Coupling.

The V-band couplings are normally used where the pressure and temperature are high, such as in the bleed air manifold ducting and the ducting leading to the air conditioning package.

Fill in the blanks to complete the following statements.

1. Couplings having a V shaped groove that fits over the duct flanges are normally called ____________ ____________ ____________.

2. Couplings used on the ducting carrying the bleed air to the equipment refrigeration unit would be of the ____________ ____________ type.

Answers to Frame 9: 1. V band couplings 2. V band

Frame 10

The gaskets used with the Marman V-band couplings are made of a metal wire molded into an asbestos material. These gaskets are called flexitallic gaskets.

The gaskets used with the Marman Conoseal couplings are cone shaped stainless steel gaskets.

The gaskets used with the Marman J11 are made of a copper alloy and are formed to fit machined grooves in the duct flanges.

Each of the gaskets are designed to fit a specific type of the duct connection and can not be interchanged.

When a duct connection is loosened, or removed and replaced, new gaskets must be installed.

To prevent damage to the gaskets they must be handled with care. Hot air leaks can take place at the couplings if the gasket is damaged or if the gasket is not put in properly.

Proper installation means having the duct flanges aligned so the flanges mate properly, insuring the coupling is on the connection straight, and torquing the coupling to the torque value specified by the applicable technical order.

Fill in the blanks to complete the following statements.

1. The material used in the gaskets for Marman V band couplings is metal and ____________________.

2. Whenever a duct connection is disconnected, a new __________ should be installed.

3. A leak at a Marman V-band coupling could be caused by a defective __________________.

Answers to Frame 10: 1. asbestos 2. gasket 3. gasket

Frame 11

The sketch below shows two additional types of couplings. These are the Marman Channel Band and Rubber Teck couplings. Couplings of this type are not used in the hot bleed air system. They are used in the air conditioning system where the pressure and temperature have been reduced.

To form an air tight seal, the rubber teck couplings uses a synthetic rubber seal. The Marman Channel Band coupling uses a fiberglas reinforced rubber sleeve. When installing these couplings the maintenance man must insure their proper alignment.

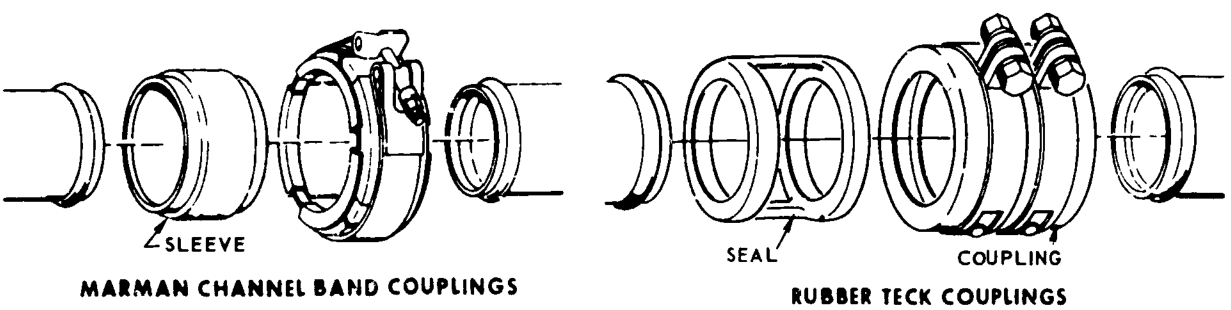

Figure 8. Air Conditioning System Couplings.

Fill in the blanks to complete the following statements.

1. The Marman Channel Band coupling is normally used where the pressure and ____________________ have been reduced.

2. An air tight seal is formed in the Rubber Teck coupling by a rubber _____________ and in the Marman Channel Band by a rubber _____________.

Answers to Frame 11: 1. <u>temperature</u> 2. <u>seal</u> <u>sleeve</u>

Frame 12

Some maintenance on the bleed air system requires you to take off and put on the duct sections of some parts. This means you will remove and install duct couplings.

When a duct coupling is put on it must be tightened to a specific value. How can you tell when it's tight enough? This is one place you must use a torque wrench.

The exact torque value to use will change with the type and size of the clamp or coupling. When torquing couplings, you <u>must</u> refer to the chart of torque values in the technical order for the aircraft on which you're working.

For example, on the F-4C aircraft, the torque value for a 4 inch Marman V band coupling is 35 to 40 inch pounds. A 4 inch Marman Conoseal coupling is torqued to 120 to 140 inch pounds.

To stop complete separation of the connection in case of a "T" bolt failure, the couplings are safety wired. The sketch shows a duct coupling with the safety wire installed.

Note: This is a double stranded, twisted safety wire.

When installing couplings, you will have to check the applicable technical order to determine specific procedures for safey wiring couplings.

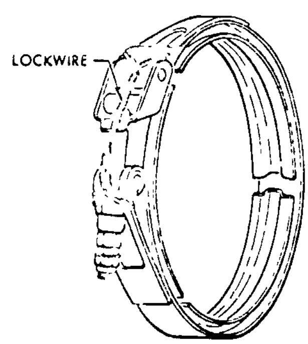

Figure 9. Coupling Safety Wired.

Fill in the blanks to complete the following statements.

1. When duct couplings are replaced, they must be tightened to a specific ______________ value.

2. To determine the proper torque value, you should refer to the ____________ ______________ in the technical order.

3. To determine if a coupling should be safety-wired you should check the applicable aircraft __________ __________.

Answers to Frame 12: 1. <u>torque</u> 2. <u>torque chart</u>
3. <u>technical order</u>

Frame 13

The following information gives some general guidelines that must be followed when working with ducting and couplings.

1. <u>Preinstallation checks</u>:

a. Exercise particular care during handling and installing ducts to ensure that flange faces are not scratched, distorted, or deformed.

b. Use protective flange caps on the ends of all ducts until the installation progresses to the point where removal of the cap is essential to the installation.

c. Clean the flange faces and inspect them every time a clamp is removed. Clean the flange faces by wiping with a clean cloth. Do not use a wire brush to remove dirt.

2. <u>Installation</u>:

a. Check the part number to ensure the proper coupling is being installed.

b. When reinstalling a used coupling, visually check it for spreading of the V section, broken spot welds, worn T-bolt threads, bent T-bolt, and freedom of movement of the latch and trunion.

c. When gaskets are used, use care to avoid nicks or burrs on the gasket surfaces. Whenever a joint is disassembled, a new gasket should be used when reassembling. Ensure the gasket is properly seated.

d. Determine the correct torque for the T-bolt by referring to the applicable technical order.

e. Tighten the nut to about 2/3 of the specified torque, then tap the coupling lightly with a plastic mallet. Continue alternately torquing and tapping until the torque wrench stabilizes at the specified value.

f. Safety wire the T-bolt as directed by the applicable technical manual.

NO RESPONSE REQUIRED

Read each statement below, then mark each one T (true) or F (false).

_____1. Angular movement and linear growth due to thermal expansion is compensated for by the thermal compensator.

_____2. The ball joint on the thermal compensator allows for angular movement.

_____3. The thermal compensator is used to adjust for variations in duct length during maintenance.

_____4. To align the ducts when installing a new section of ducting, the maintenance man can adjust the tolerance compensator.

_____5. The gaskets used with the Marman couplings must be replaced each time the connection is loosened.

_____6 A damaged gasket could cause an air leak in a Janitrol coupling.

_____7. Couplings are used to join duct sections and control units to the duct.

_____8. The Marman Channel Band couplings use a sleeve to form an air tight seal.

_____9. Marman Channel Band couplings are used in the hot, high-pressure bleed air system to attach units to the ducts.

_____10. When installing duct couplings, the maintenance man must tighten them with a torque wrench.

_____11. To determine the proper torque value for a duct coupling, you should refer to the technical order.

_____12. An air leak at the duct coupling could be the result of a damaged gasket, or an improperly torqued coupling.

Answers to Frame 14: T 1. T 2. F 3. T 4. T 5. F 6. T 7. T 8. F 9. T 10. T 11. T 12.

Frame 15

Since the air passing through the bleed air ducting is extremely hot, the heat from the duct can damage nearby equipment. If touched, the hot ducting can cause injury to maintenance personnel.

To stop damage to equipment and to protect the maintenance personnel the engine bleed air ducting is insulated.

Four different types of insulation are used; they are: fiberglas blankets, metal foil, fiberglas tape, and preformed fiberglas.

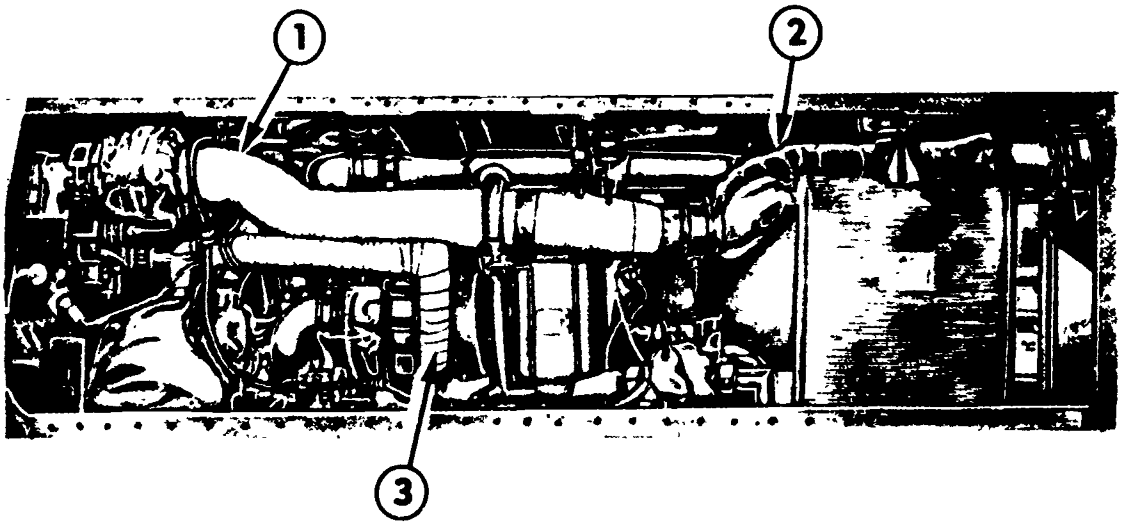

Figure 10. Bleed Air Duct Insulation.

The fiberglas blanket insulation is made up of fiberglas covered with a fabric material and sewn together with a fiberglas thread. The blankets are made to fit specific sections of ducting or valves. The ends are clamped to the duct with a metal band clamp.

The metal foil insulation is made up of fiberglas with a thin metal foil covering on each side. Each piece of this insulation is made to cover specific sections of ducting or certain units. There is also a piece of this metal foil insulation covering the refrigeration unit heat exchanger. This insulation is held in place with safety wire laced around small metal studs along joining edges.

The fiberglas tape is a material that is approximately 2 inches wide and is simply wrapped on the duct and held in place with a special thermosetting tape. This insulation is used on some of the smaller sections of ducting.

Fill in the blanks to complete the following statements.

1. To prevent heat damage to adjacent equipment and injury to personnel, the bleed air ducting is _________________.

2. The four types of insulation used on hot air ducts are fiberglas ______________, metal ______________, fiberglas ________________, and _____________ fiberglas.

3. Metal foil insulation is held in place with _____________ ______________________.

Answers to Frame 15: 1. insulated 2. blankets, foil, tape, preformed
3. safety wire

Frame 16

The illustration below shows insulation installed on a section of ducting. Number 1 points to the preformed fiberglas insulation (our fourth type) and number 2 points to metal foil insulation.

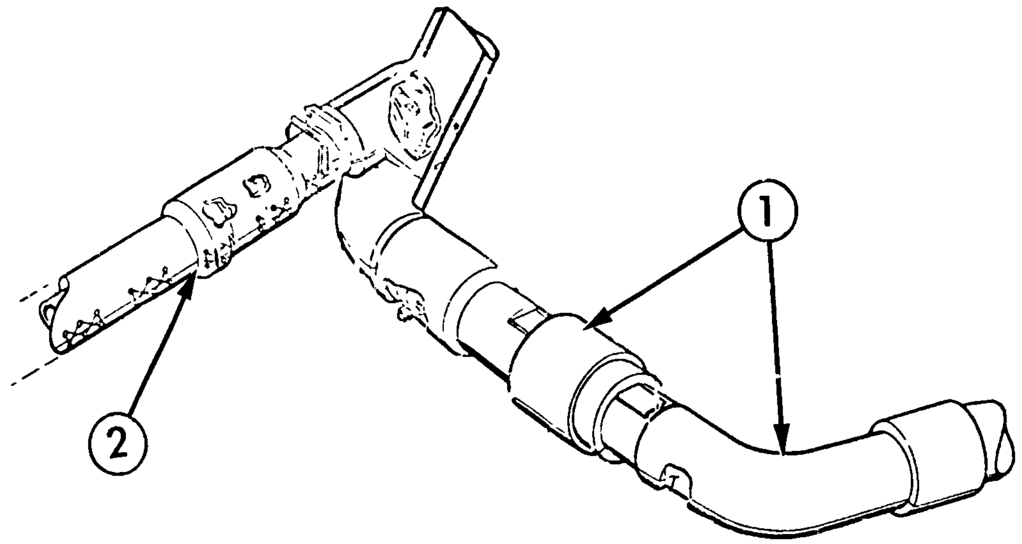

Figure 11. Duct Insulation.

The preformed fibe glas insulation (1) shown above, is a solid piece that is formed to fit specific installations such as around a duct or compensator. This insulation is usually made in two pieces (halves) and is held together on the duct by insulation c' ıps and thermosetting tape.

The metal foil insulation (2) above, is the same material as the metal foil explained in the previous frame. This sketch shows the insulation on a section of ducting. Notice how the safety wire is laced to hold the insulation in place.

The metal foil insulation is also used in the form of an insulation strap to cover duct couplings. The metal foil insulation strap is shown below. The insulation straps are held in place with safety wire. Notice in the sketch that the insulation strap is designed with a slotted area for the coupling bolt (T bolt) to fit through.

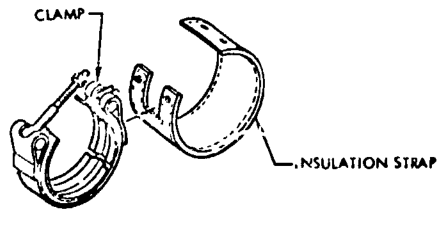

Figure 12. Insulation Strap.

In areas where the ducting or a coupling is not covered with insulation, the maintenance man must use caution to avoid getting burned. An exposed duct coupling can become extremely hot during operation of the system.

Fill in the blanks to complete the following statements.

1. The insulation used on bleed air ducting consists of ______ and ______________ foil materials.

2. Metal foil insulation straps are used to insulate duct ______________.

3. One precaution to observe when working on or near the bleed air ducting is to avoid touching an exposed section of a ______________ or an exposed duct ______________.

Answers to Frame 16: 1. fiberglas and metal 2. couplings
3. duct coupling

Frame 17

A leak c. must be made after completion of repairs or whenever leaks are thought to exist in the bleed air system.

A leak check on the bleed air system requires the use of special duct plugs, adapter, and a ground air compressor.

The plugs are put in at several points in the system to isolate the bleed air system from the refrigeration units, boundary layer control system, and the engines.

The adapter is put in at one of the engine tapoffs. Air from the air compressor is put through the adapter to pressurize the ducting.

Excessive leakage is found by pressurizing the system to a specified pressure, then monitoring the pressure drop over a set period of time.

As an example, the F-4 is pressurized to 250 psi, then the system is closed off. The pressure drop is timed and should not drop below 225 psi in five minutes. If the drop is greater, then the leakage is excessive. The point of leakage can be located by sound and by feel.

After this part of the leak check is performed, the duct plugs and adapters are removed, and the couplings reinstalled. These couplings must also be checked for leakage. This is done by running the engines and feeling each connection for leakage.

Actual performance of the leak test requires that you follow detailed procedures outlined in the technical order.

When performing the leak test you must avoid standing near or in line with any of the duct plugs while the system is pressurized. Severe injury may result if a plug is blown out.

Fill in the blanks to complete the following statements.

1. After you install a new section of ducting you must perform a ________________ ________________.

2. When performing a leak test of the bleed air system you should follow the procedures outlined in the ____________ ________________.

3. When performing a leak test, the bleed air system is isolated by using ____________ ______________.

4. Duct plugs are used to isolate the ___________ ___________ system for the leak testing.

5. Leakage in a bleed air system can be determined by timing the _____________ ________________.

6. One precaution to observe when performing a leak test is to avoid standing in line with _____________ _______________ while the system is pressurized.

Answers to Frame 17: 1. leak test 2. technical order
3. duct plugs 4. bleed air
5. pressure drop 6. duct plugs

Frame 18

There are several safety precautions that you must follow while working on the bleed air system. These precautions are to protect the equipment, to protect you and other maintenance personnel, and to insure the aircraft is safe to fly. Some of these precautions are listed below.

1. Extreme care should be used to avoid denting or scratching the ducts when these ducts are removed or installed. A dent or scratch could weaken the duct and cause the duct to rupture.

2. Use care when installing ducting with janitrol couplings to avoid damaging the flanges. A damaged flange will cause an air leak.

3. All coupling gaskets and seals should be handled with care. Damage to the gaskets or seals can result in a severe air leak which could damage the aircraft or adjacent equipment.

4. Always install a new gasket whenever a duct connection is loosened.

5. Torque each coupling to the value specified by the technical order.

6. Avoid touching or otherwise coming in contact with the exposed ducts and duct joints.

7. Do not stand near or in line with the bleed air duct plugs when performing a bleed air system leak test. You could get hurt if a plug blows out while under pressure.

Fill in the blanks to complete the following statements.

1. To determine the torque values for duct couplings, you should refer to the ____________ ____________.

2. When installing a new Marman coupling, you should install a new ____________________.

3. An air leak at a duct coupling could be caused by a damaged ________________ or an improperly __________ coupling.

4. Ducting should be handled with care to avoid ___________ or ________________.

5. Precautions to observe when maintaining the bleed air system require that you avoid ___________ the hot air ducts and standing in line with ____________ ______________.

Answers to Frame 18: 1. technical order 2. gasket
3. gasket torqued 4. denting or scratching
5. touching duct plugs

Frame 19

Read the following statements, then mark them T (true) or F (false).

_____1. The coupling shown in figure 13 is used to join sections of ducting in the bleed air system.

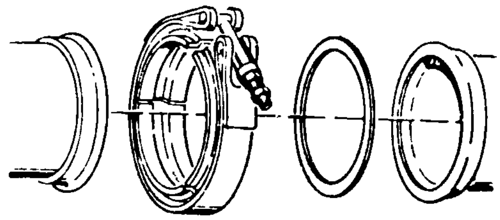

Figure 13.

_____2. The coupling shown in figure 14 is used to attach units to the ducts in the hot bleed air system.

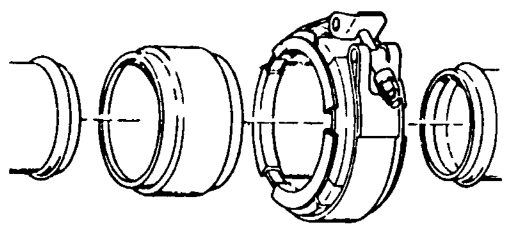

Figure 14.

_____3. To prevent possible air leaks, the gaskets used with the duct couplings should be replaced each time the coupling is loosened.

_____4. To prevent possible injury, maintenance personnel should avoid coming in contact with hot, exposed duct couplings.

_____5. All duct coupling seals and gaskets should be handled with care to prevent possible damage.

_____6. To prevent stripping the nut and bolt on the couplings, the nut is tightened only hand tight.

_____7. An air leak at the coupling could be caused by a gasket damaged during handling or an improperly installed gasket.

_____8. Couplings using a rubber seal or sleeve are designed for use on ducts carrying hot, high-pressure air.

_____9. All clamps must be tightened to technical order specification with a torque wrench.

_____10. Asbestos material is used to insulate all bleed air ducts.

Frame 19 (Continued)

____11. Duct couplings are insulated with a metal foil strap.

____12. The bleed air ducting is insulated to prevent heat damage to adjacent equipment.

____13. Metal foil and preformed fiberglas are two types of duct insulation.

Place the letter of the unit shown below in the blank space opposite the statement that identifies the purpose of the unit.

____14. Permits linear growth of a duct caused by thermal expansion and allows angular movement of the ducting.

____15. Permits the necessary adjustments during maintenance of the bleed air system.

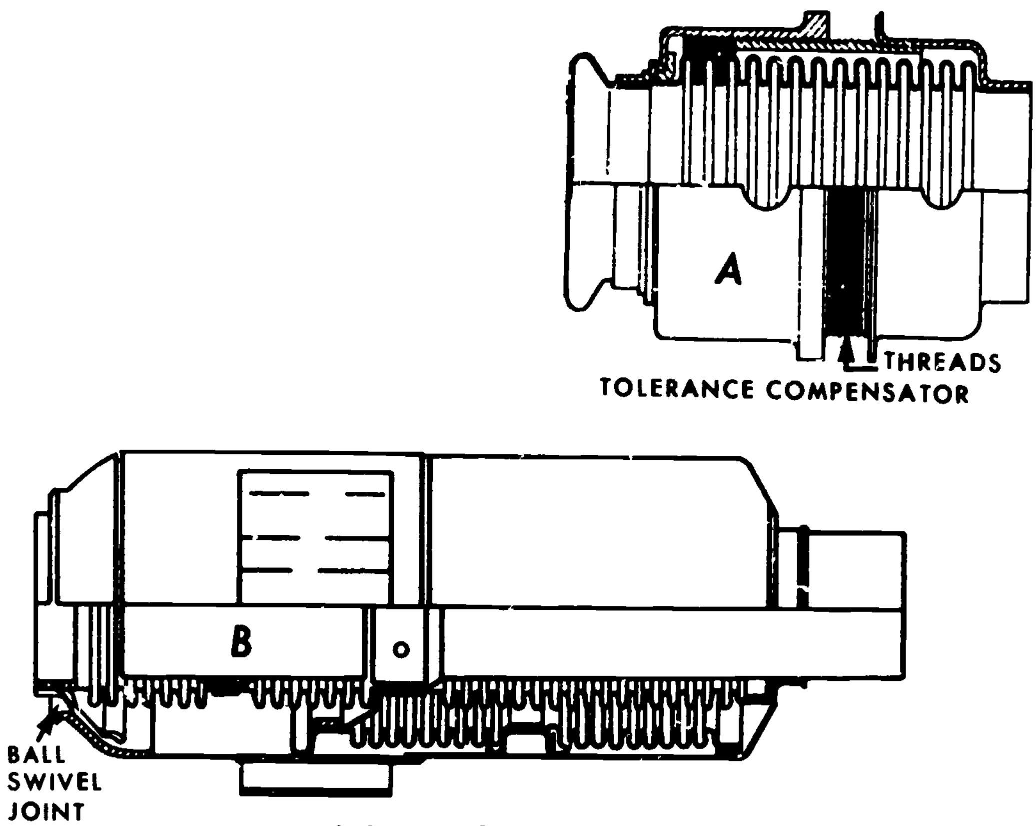

Figure 15.

Answers to Frame 19:

__T__ 1.

__F__ 2.

__T__ 3.

__T__ 4.

__T__ 5.

__F__ 6.

__T__ 7.

__F__ 8.

__T__ 9.

__F__ 10.

__T__ 11.

__T__ 12.

__T__ 13.

__B__ 14.

__A__ 15.

WORKBOOK
C3ABR42331-WB-201

Technical Training

Aircraft Environmental Systems Mechanic

DECADE RESISTORS

10 February 1984

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

DECADE RESISTORS

OBJECTIVES

Given an illustration of the panel face of the decade resistor with predetermined control settings, compute a minimum of 3 out of 4 decade switch control settings for designated switches into total ohm resistance.

INSTRUCTIONS

Do not start this workbook unless you have satisfactorily completed the programmed text PT-202 and have achieved the objective. You will only use a lead pencil to complete this workbook. Do not start this workbook without one.

You may separate the pages of this workbook if you desire. You will find definitions on this page of this workbook. Be sure yoy know these definitions.

When you go to another page, figure, etc., be sure you follow the instructions. You will be required to complete the exercises as given. After the exercises are properly completed, you will be assigned a performance test. You will be required to complete the performance test in accordance with instructions provided and meet the minimum performance standards given in the above objective. If you do not understand the above objective, see your instructor at this time.

DEFINITIONS

Read these definitions below so you will have a better understanding of the subject you are studying.

Decade Switch Control Setting - These are numbers you will find around the outside of each switch. These range from 0 through 10. See figure 1 on page 4.

Decade Switch Designation - This is written below each switch on the panel face. See figure 1, page 4.

Decade Switch Total Ohms - This is the total ohms value for only one switch.

Decade Total Ohms - This is the total resistance value which the decade box is set for.

MEG - This is the abbreviation for megohm. Megohm is one million ohms (1,000,000).

If you have any questions about the above definitions, see your instructor.

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In the following exercises you will be instructed on how to compute the decade switch designations and control settings into decades total ohms values. This will be achieved by using tne given illustrations of the decade panel face shown with predetermined control settings.

PERFORMANCE EXERCISE 1

You will find figure 1 decade switch control settings will also be shown in figure 2 beside each decade switch designation. Compare what you will find in figure 1 to figure 2. You will only study this exercise and not be required to make any entries.

The (X) in the decade switch designation in figure 2 and on the panel face of figure 1 means to multiply the decade switch control setting times the decade switch designation to find the decade switch total ohms. After you have found each decade switch total ohms you must add these totals to find the total decade value of 5,000,360.2 ohms.

Example for switch one (X0.1), figure 1. The decade switch control setting for (X0.1) from figure 1 was placed in its column in figure 2. Multiply times the decade switch designation (X0.1) for an answer of 0.2 ohms, for the decade switch total ohms. This same procedure is followed for the rest of the nine switches. Then all the decade switches total ohms are added for the decade total ohms of 5,000,360.2 ohms.

Study each one of the figures and if you understand the exercise, go on to Exercise 2. If you do not fully understand the information above and/or the two figures, see your instructor at this time.

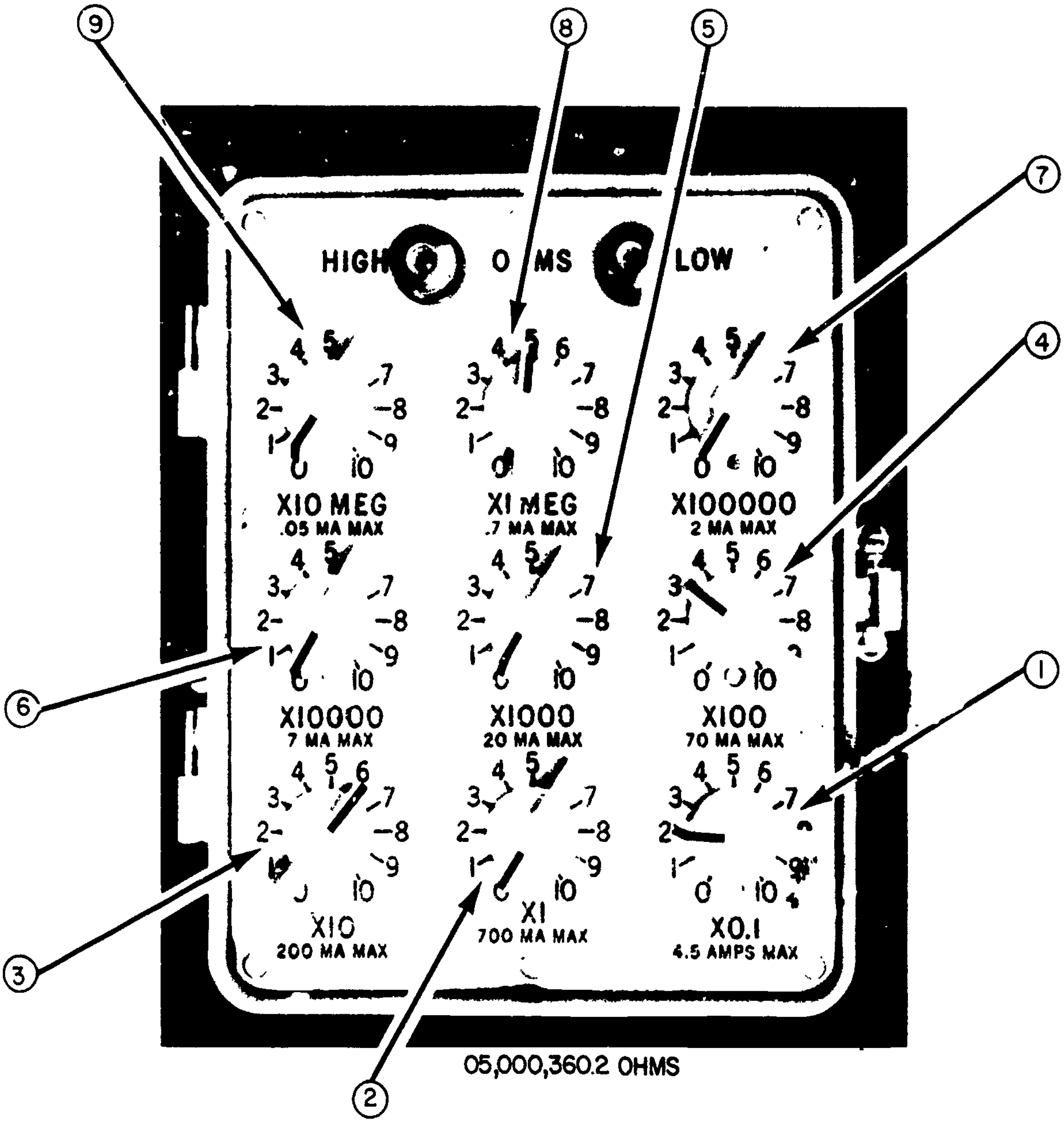

Figure 1. Panel Face.

1370

Decade Switch Control Setting	Decade Switch Designation	Decade Switch Total Ohms
0	X 10 MEG	0.0
5	X 1 MEG	5,000,000.0
0	X 100,000	0.0
0	X 10,000	0.0
0	X 1,000	0.0
3	X 100	300.0
6	X 10	60.0
0	X 1	0.0
2	X 0.1	0.2
Decades Total Ohms -----------------------		------5,000,360.2 Ohms

Figure 2

Note: Be sure you have all of the DECIMAL points in a straight column.

PERFORMANCE EXERCISE 2

This performance exercise will help you learn and practice how to compute the decade switch designations and control settings into decade total ohms. This will help you meet the minimum standards required in the objective to pass this performance test.

First you write the decade switch control setting found in figure 3 in the decade switch control setting column in figure 4 for all nine switches. Then in figure 4, multiply the decade switch control setting times the decade switch designation and write this answer in the decade switch total ohms column. Now add up all nine of the ohms and record it in figure 4.

Note: Be sure you have all of the decimal points in a straight column as shown in figure 2 for all your future work.

After you have completed figures 3 and 4, check your work against the correct answers given in this book on page 8. If your work is correct and you don't have any questions, you will start Exercise 3.

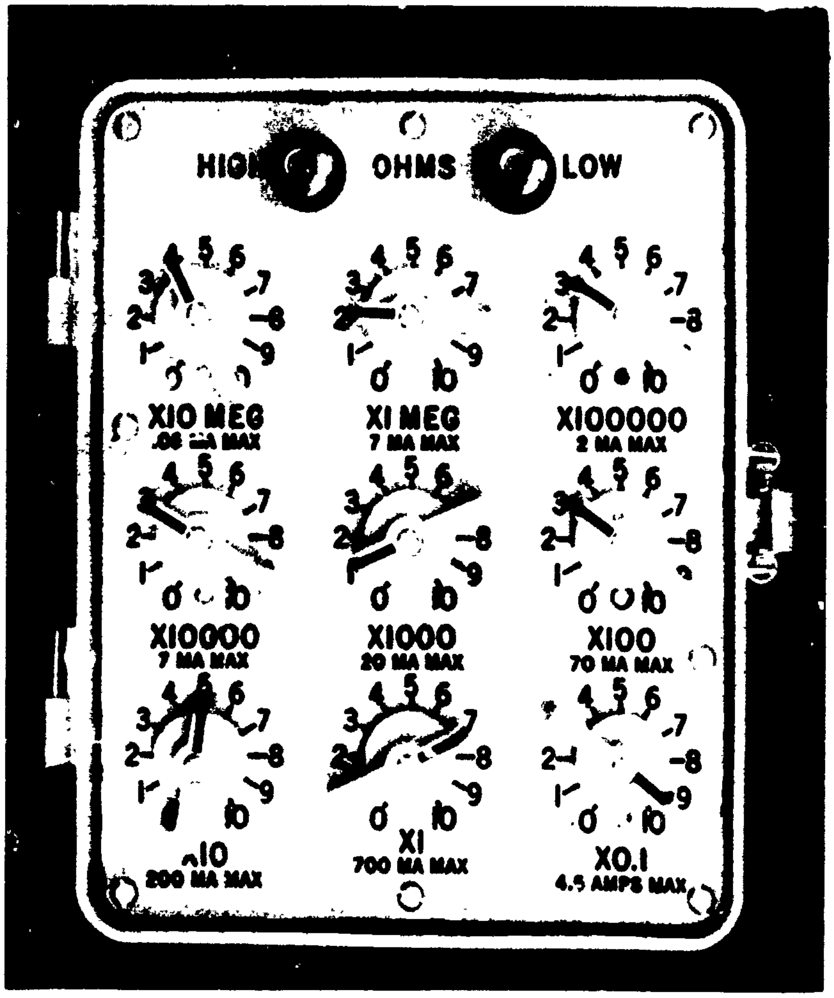

Figure 3.

Decade Switch Control Setting	Decade Switch Designation	Decade Switch Total Ohms
	X 10 MEG	.
	X 1 MEG	.
	X 100,000	.
	X 10,000	.
	X 1,000	.
	X 100	.
	X 10	.
	X 1	.
	X 0.1	.
Decade Total Ohms		.

Figure 4.

Correct answers to Exercise 2.

Decade Switch Control Setting	Decade Switch Designation	Decade Switch Total Ohms
4	X 10 MEG	40,000,000.0
2	X 1 MEG	2,000,000.0
3	X 100,000	300,000.0
3	X 10,000	30,000.0
1	X 1,000	1,000.0
3	X 100	300.0
5	X 10	50.0
7	X 1	7.0
9	X 0.1	.9
Decade Total Ohms		42,331,357.9 Ohms

PERFORMANCE EXERCISE 3

You must do this performance exercise in the order given. If you have any questions about the decade switch or the exercise, you should ask your instructor during this exercise.

You will be assigned at least three problems to do in this exercise. After you complete them, your instructor decides if you must complete an additional three before any further progress is assigned.

After you have completed the first three problems, given the completed workbook to your instructor for evaluation of your work. If the instructor determines you are ready for your performance test, you will be assigned to take the performance test when directed by the instructor.

If your instructor determines you need additional practice and training, the instructor may assign problems 4, 5, and 6 for you to complete. You will complete them only if directed by the instructor.

Start with problem 1 and complete all three problems.

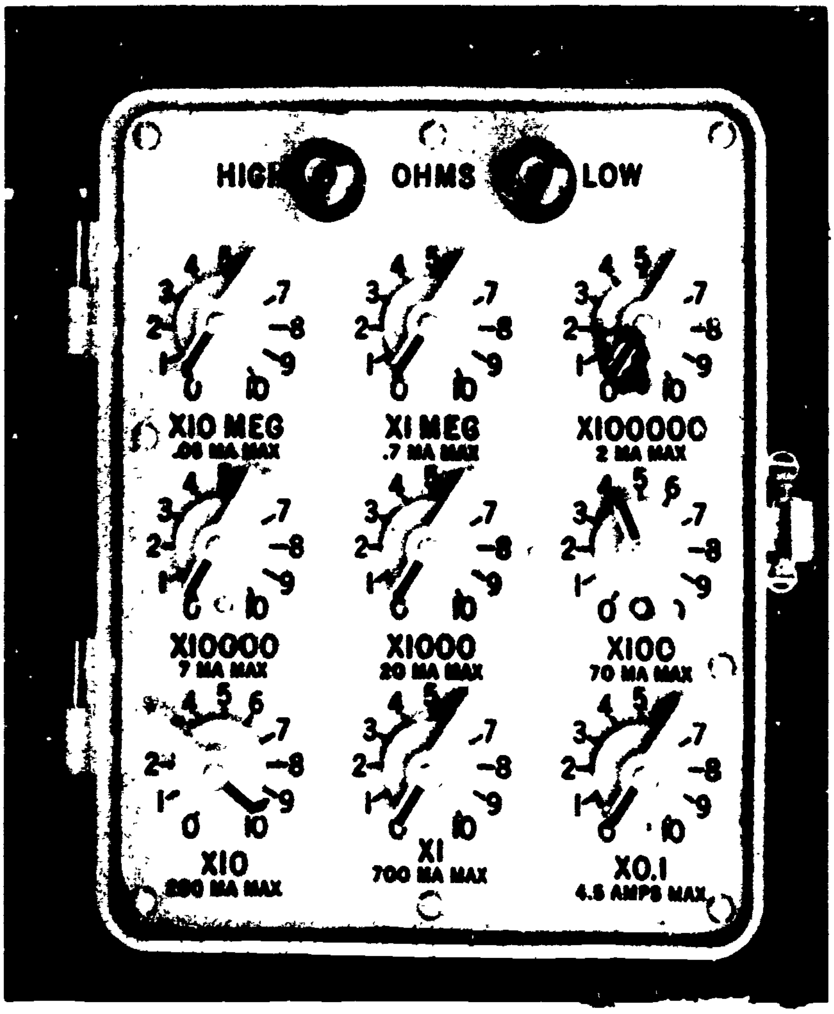

Figure 5.

Decade Switch Control Setting	Decade Switch Designation	Decade Switch Total Ohms
	X 10 MEG	.
	X 1 MEG	.
	X 100,000	.
	X 10,000	.
	X 1,000	.
	X 100	.
	X 10	.
	X 1	.
	X 0.1	.
Decade Total Ohms		.

Figure 6.

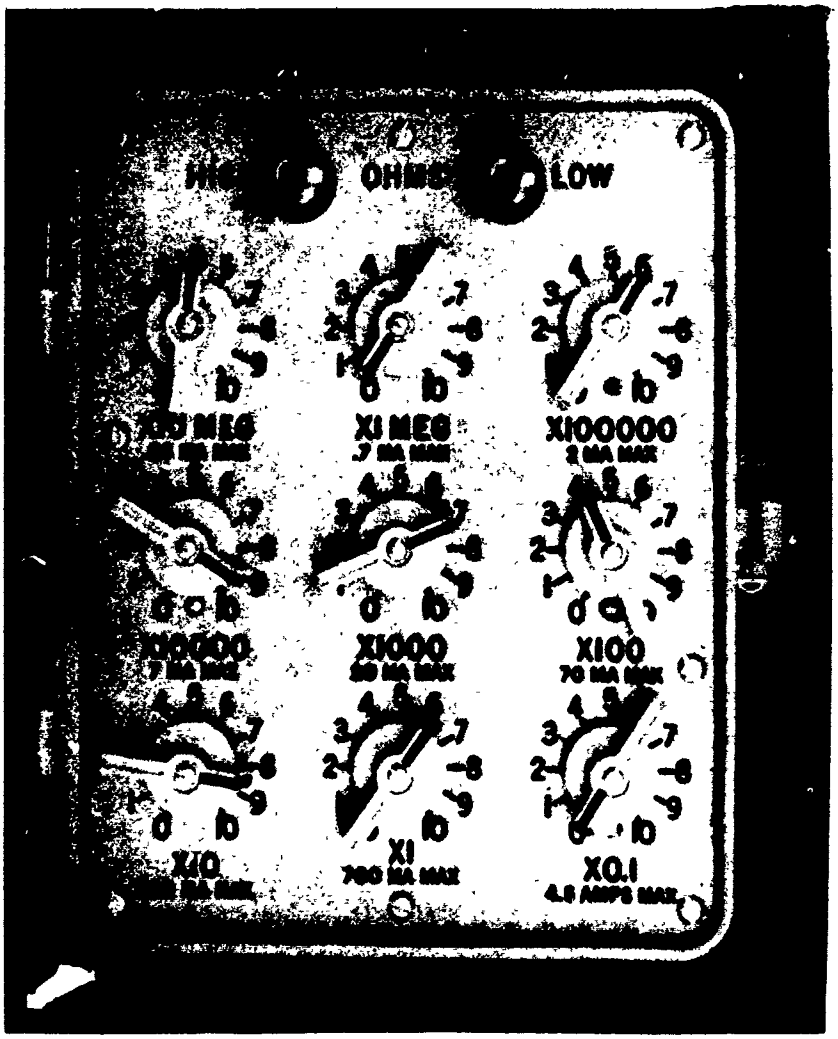

Figure 7.

Decade Switch Control Setting	Decade Switch Designation	Decade Switch Total Ohms Resistance
	X 10 MEG	.
	X 1 MEG	.
	X 100,000	.
	X 10,000	.
	X 1,000	.
	X 100	.
	X 10	.
	X 1	.
	X 0.1	.
Decade Total Ohms Resistance		.

Figure 8.

PROBLEM 3

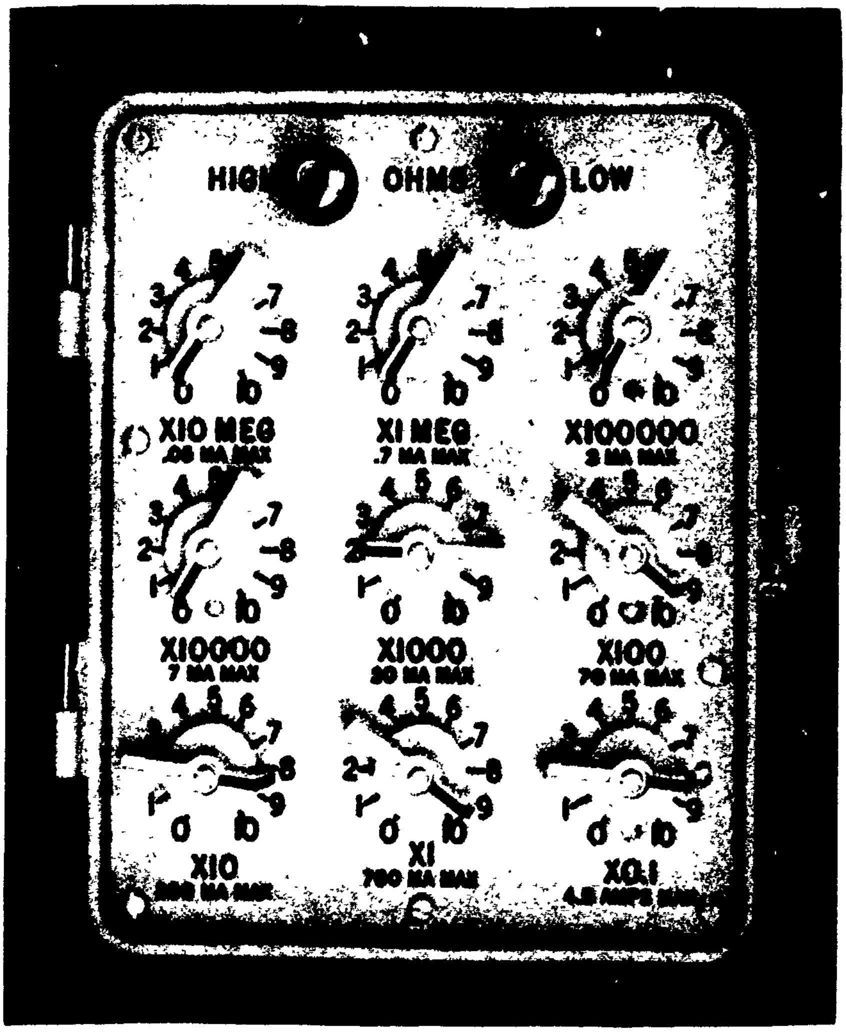

Figure 9.

Decade Switch Control Setting	Decade Switch Designation	Decade Switch Total Ohms
	X 10 MEG	.
	X 1 MEG	.
	X 100,000	.
	X 10,000	.
	X 1,000	.
	X 100	.
	X 10	.
	X 1	.
	X 0.1	.
Decade Total Ohms		.

Figure 10.

STOP!

After the three problems are completed, <u>show your work to your instructor</u>.

Your instructor will sign off one of the following for you to comply with.

Go to page 18 ________________

Do practice problems 4, 5, and 6 in the same way as you were instructed to do 1, 2, and 3 problems. ________________

Note: If you have any questions, see your instructor at this time.

PROBLEM 4

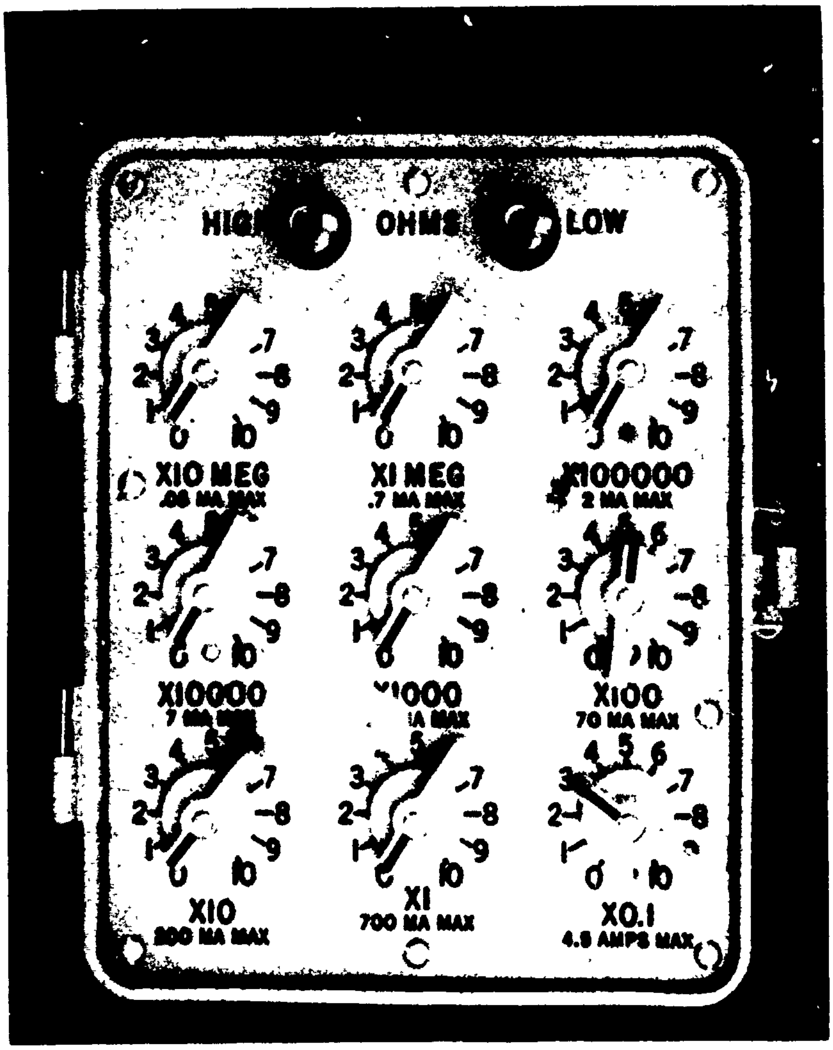

Figure 11.

Decade Switch Control Setting	Decade Switch Designation	Decade Switch Total Ohms
	X 10 MEG	.
	X 1 MEG	.
	X 100,000	.
	X 10,000	.
	X 1,000	.
	X 100	.
	X 10	.
	X 1	.
	X 0.1	.
Decade Total Ohms		.

Figure 12.

PROBLEM 5

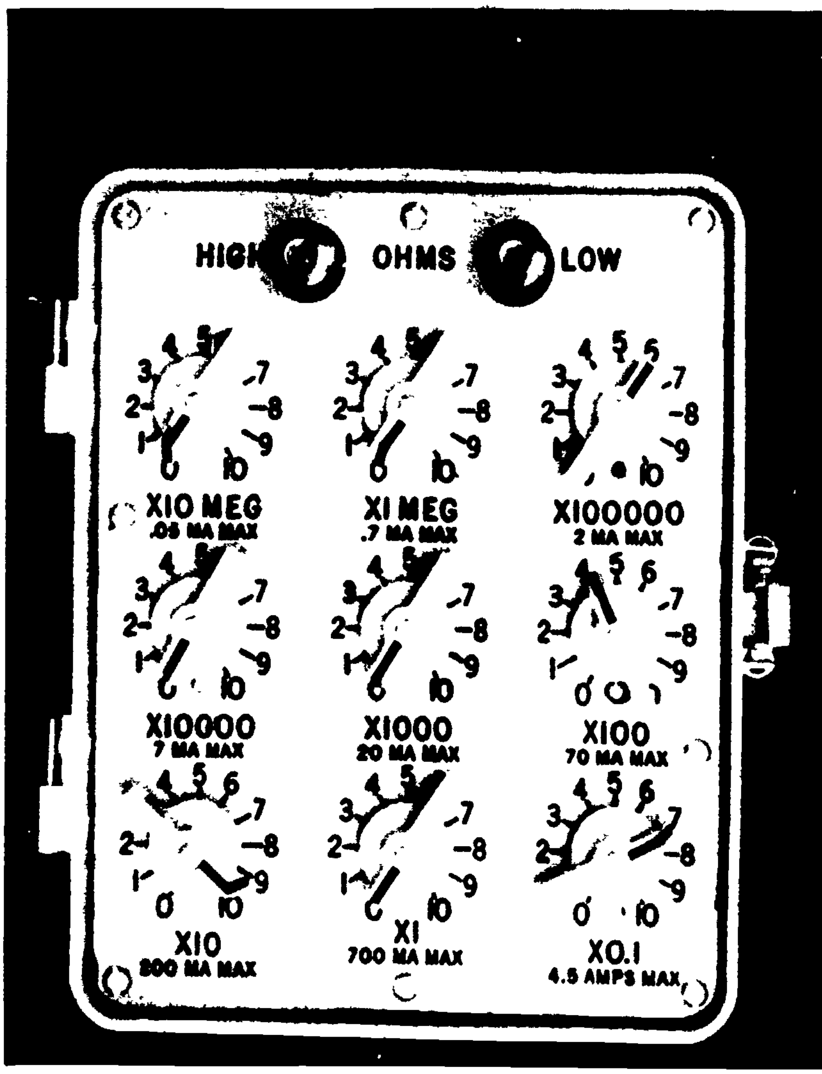

Figure 13.

Decade Switch Control Setting	Decade Switch Designation	Decade Switch Total Ohms
	X 10 MEG	.
	X 1 MEG	.
	X 100,000	.
	X 10,000	.
	X 1,000	.
	X 100	.
	X 10	.
	X 1	.
	X 0.1	.
Decade Total Ohms		.

Figure 14.

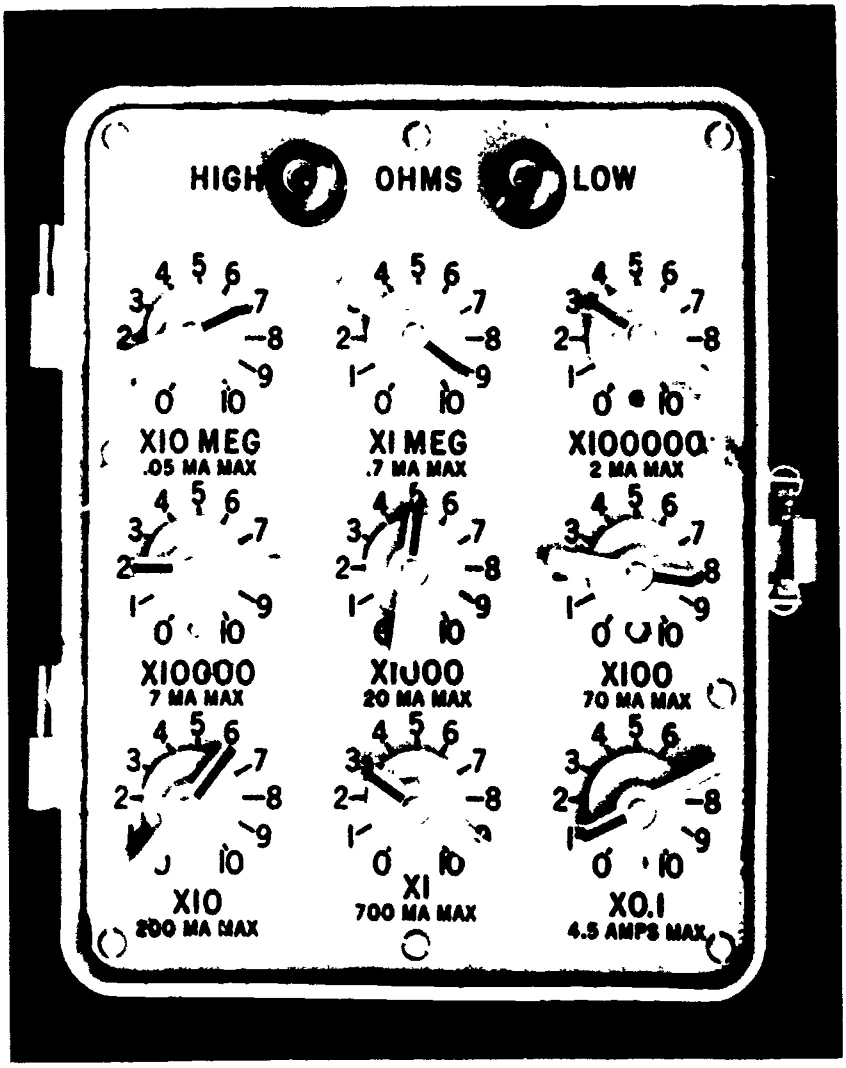

Figure 15.

Decade Switch Control Setting	Decade Switch Designation	Decade Switch Total Ohms
	X 10 MEG	.
	X 1 MEG	.
	X 100,000	.
	X 10,000	.
	X 1,000	.
	X 100	.
	X 10	.
	X 1	.
	X 0.1	.
Decade Total Ohms		.

Figure 16.

STOP!

After you have completed problems 4, 5, and 6, you must have them checked by the instructor.

The instructor may at this time allow you to progress to the performance test if the instructor has signed you off below.

Student is ready for performance test ______________________________.

Student is not ready for performance test and will follow instructions as given by the instructor ____.

PERFORMANCE TEST INSTRUCTIONS

1. Remove this page and the next page and write your name on them.
2. Take these two pages and all of your workbook to your instructor.
3. Insure your instructor has your daily record.
4. Read the performance test instructions provided for you by your instructor.

   If you have read all of them and understand them, initial here ____________________ and immediately-----

5. Ask the instructor to initial below so you may start the performance test. Do not start the performance test until the instructor has initialed 6 below and has also written the performance test number on the next page.
6. Instructor initials _______________ for you to start performance test.

Student's Name ______________________________ ____________ ___________

Note: Items below completed by the instructor.

START TIME ______________________ AND DATE ______________________

START TIME ______________________ AND DATE ______________________

SATISFACTORILY COMPLETED _______________

UNSATISFACTORILY COMPLETED _______________

RETAKE _____ YES _____ NO

PERFORMANCE TEST WORKSHEET

PERFORMANCE TEST NUMBER ________

PROBLEM ___1___

Decade Switch Control Setting	Decade Switch Designation	Decade Switch Total Ohms
	X 10 MEG	.
	X 1 MEG	.
	X 100,000	.
	X 10,000	.
	X 1,000	.
	X 100	.
	X 10	.
	X 1	.
	X 0.1	.
Decade Total Ohms		.

PROBLEM ___2___

Decade Switch Control Setting	Decade Switch Designation	Decade Switch Total Ohms
	X 10 MEG	.
	X 1 MEG	.
	X 100,000	.
	X 10,000	.
	X 1,000	.
	X 100	.
	X 10	.
	X 1	.
	X 0.1	.
Decade Total Ohms		.

STUDENT'S NAME ____________________________

PERFORMANCE TEST WORKSHEET

PERFORMANCE TEST NUMBER ____

PROBLEM 3

Decade Switch Control Setting	Decade Switch Designation	Decade Switch Total Ohms
	X 10 MEG	.
	X 1 MEG	.
	X 100,000	.
	X 10,000	.
	X 1,000	.
	X 100	.
	X 10	.
	X 1	.
	X 0.1	.
Decade Total Ohms		.

PROBLEM 4

Decade Switch Control Setting	Decade Switch Designation	Decade Switch Total Ohms
	X 10 MEG	.
	X 1 MEG	.
	X 100,000	.
	X 10,000	.
	X 1,000	.
	X 100	.
	X 10	.
	X 1	.
	X 0.1	.
Decade Total Ohms		.

STUDENT'S NAME ____________________

WORKBOOK
C3ABR42331-WB-201B

Technical Training

Aircraft Environmental Systems Mechanic

TEMPERATURE CONTROL PANEL MINIMUM PERFORMANCE TEST

9 September 1982

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

RGL: N/A

Environmental Pneudraulics Branch
Chanute AFB, Illinois

C3ABR42331-WB-201B

TEMPERATURE CONTROL PANEL MINIMUM PERFORMANCE TEST

OBJECTIVES

Given the minimum performance test procedures and related electrical/electronic test equipment, perform the minimum performance test and determine the serviceability of a temperature control panel, locating a minimum of two out of three troubles correctly.

EQUIPMENT

Power Bench P/N 18 79 4534
Power Bench UNIT-A
Temperature Control Panel
Multimeter
Decade Box

Caution: The student WILL NOT at any time turn ON any of the three (3) power switches found on the right side of the power bench.

Caution: DO NOT make any electrical connections until instructed to do so. DO NOT mix your leads, cables, etc., with your neighbor's equipment.

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DEFINITIONS

MINIMUM PERFORMANCE TEST - This is a test procedure required by the manufacture on all units prior to installation in the aircraft. This applies to all new units received from the manufacturer, to recently overhauled units, and to units which have been in storage. It is not necessary to dismantle the units in order to carry out this tes[illegible] [illegible]is is not done on the aircraft like the cabin refrigerati[illegible] function, but on a bench without the aircraft circuit. [illegible]his is to insure the temperature control panel will be serviceable before installation on the aircraft.

CONTROL CHARACTERISTICS - This is the relationship shown by a graph for the HOT and COLD signals giving the deadband, pulsing and full demands, figure 11.

UNIT - In this lesson UNIT is the same as TEMPERATURE CONTROL PANEL, see figures 6 and 8.

UNIT-A - Is the fighter air conditioning test set (UNIT-A), or air conditioning test set, see figures 1 and 7.

TEMPERATURE CONTROL PANEL - Same as: (Control, Temperature, Mag Amp), (Temperature Controller), (Temp Cont), (Temperature Control Panel), (Cabin Temperature Controller), see figures 6 and 8.

ADAPTER CABLE - The cable used to connect the temperature control panel to the fighter air conditioning test set (UNIT-A), see figure 3. This cable has the malfunction UNIT-A box permanently attached for training. The malfunction UNIT-A box would not be attached to the shops cable or found outside of a class environment.

AIR CONDITIONING TEST SET - Same as fighter air conditioning test set UNIT-A or fighter cabin air conditioning test set.

FIGHTER AIR CONDITIONING TEST SET - Same as air conditioning test set.

DEPICTED - To represent by a picture.

PARAMETERS - A measured value which expresses performance.

SIGNAL - Electrical (voltage) values sent to loads. (Example: DS lights, Motor windings (S-1).

ABNORMAL - Not normal, the position of the switch which places the circuit in a condition with a possible electrical defect.

NORMAL - The position of the switch which places the circuit in a condition with no electrical defects.

VALVE - Dual temperature mixing valve or temperature mixture valve motor.

THE FIGURES START ON PAGE 32.

Figure 6 - This figure is provided for reference when needed. You will find circuitry of the bridge inside and outside of the temperature control panel. The student may refer to the wiring diagram given in figure 6. This diagram will not be used during the evaluation unless the instructions allow it to be used.

Note: If at any time instructor's initials are required in the workbook, you will stop and request the instructor's initials.

In this workbook, you will find the minimum performance test procedures for the fighter temperature control panel. These procedures are similar to what you will be using on the flightline. The fighter temperature control panel (unit to be tested) is the same one used for the auto and manual operation of the dual temperature mixing valve on the aircraft shown in figure 5. On the flight line, the manufacturer recommends that the minimum performance test be carried out on all temperature control panels prior to installation in the aircraft.

The temperature control panel is shown in figure 8.

Place UNIT-A (Fighter Air Conditioning Test Set) in front of you on the power bench.

Remove the lid from UNIT-A, leave the wires inside UNIT-A, until instructed to remove them.

Section 1. FAMILIARIZATION

In figure 7, you will find a picture of the tester which is used to do the minimum performance test. This tester is called "Air Conditioning System Test Set" UNIT-A.

UNIT-A is made locally and for school use only, and not for flight line use. On the flight line you will use only the equipment authorized in the technical orders.

Figure 7 shows the top view of the fighter air conditioning test set (UNIT-A). UNIT-A has a control panel which has a storage area on its right and left. The adapter cable can be found in the left storage area, and power cables, test leads (red and black) in the right storage area.

Using figure 4, you will find two power switches, two circuit breakers, two power lights, one for 115V AC and one for 28V DC. The power switches will control power to the tester and temperature control panel under test.

The sensor (R-102) is where the decade box will be connected, see figure 4. The decade box is a means to control the resistance manually in place of the actual sensor.

The J1 Amplifier Control is the point on the tester where the adapter cable is connected later from the temperature control panel, see figures 3 and 4.

The defog/footheat simulator switch (S-105) in figure 4, is electrically the same switch as the defog switch, figures 6 and 12. As you recall this switch is in the bridge circuit as shown in the past wiring diagram. This is also the same switch which is controlled by the footheat and defog lever on the trainer in figure 5.

In figure 4, the DS-1 (cold) and DS-2 (hot) lights are used to give a visual indication if a voltage is leaving the temperature control panel. Sometimes the voltage is so small that the lamps are hard to see come on. If that happens a multimeter may need to be used at the TP points to check for small signals.

DS lights coming on indicates that motor windings on the Dual Temp Mix Valve are receiving the signal. Remember; the magnetic amplifier with its' feedback circuit creates and regulates the pulse voltages going to the valve motor, which in turn regulates the temperature of the air in the cabin.

In the right storage compartment of figure 7, is one black and red test lead used to connect the decade box to the sensor (R-102), the green jacks on the fighter air conditioning test set. This places the decade box in place of the cabin temperature sensor circuit during test. This will allow resistance to be manually programmed in place of the sensors resistance. Also, in the right storage compartment are two black power leads with plugs on them. One is for the 28V DC and the other for 115V AC 400 Hz power. These plugs will allow the tester to be connected to the power bench.

Section 2. CONTROL CHARACTERISTICS

PRELIMINARY

Before progression to Section 3, the following MUST be understood. The deadband as shown in figure 11, is between points C and A, this is also called the control point. This is the time when the bridge is normally balanced. During the deadband, the hot and cold transistors are off. Remember, the deadband occurs when the bridge is balanced, and this results in no power to the temperature mixture valve or during test no power to the DS lights.

Outside the deadband, signals are sent to the motor or DS lights.

Always perform the minimum performance test in the order stated, otherwise erroneous readings or indications may be obtained.

A unit passing the minimum performance test, which is free from obvious mechanical defects, may be put into service.

A unit failing the minimum performance test should be identified for repair.

Note: Calibration or repair will not be part of your training here. The various operations are changes in resistance in the bridge, resulting from changes made by programming the decade box as required.

Note: The decade resistance box is in place of the sensor during the test.

This is the same as if a decade box were connected in place of the sensor at points "A" and "B" of the cabin temperature sensor, see figure 6.

During a "Pulsing Demand" in figure 11, Part B either (A to B) or (C to D) will have many "Pulse Periods."

During a "Pulse Period," either the HOT or COLD transistor will be OFF and the other ON.

The transistors switches on and off repeatedly, sending a series of pulses to the DS lights on the tester. Remember, the DS lights are used in place of the motor windings during a minimum performance test.

The pulse period, figure 11, may vary in length of time as determined by the magnetic amplifier circuits.

The pulse period which is made of the TIME ON and the TIME OFF, may each vary in time.

For Example: Point A to B in figure 11, the bridge is unbalanced. At point A, the Time ON is very short compared to the Time OFF. As the resistance increases in the sensor or decaded, the <u>time on</u> becomes greater and <u>time off</u> becomes less near point B. This happens while passing through the pulsing demand area. After point B, the voltage normally goes to full 28V DC to drive the valve (Hot DS light On) to give a full hot.

During the pulsing hot demand, the cold transistor may turn on. This signal is normally not as strong as the hot signal. This is caused by the feedback circuit and aids to slow down the rate at which the valve moves to deliver hot air. This helps create the pulsing of the DS light(s) or on the aircraft makes the valve pulse.

See figure 11, Part B for the following:

FULL COLD DEMAND	When full 28V DC is applied to the auto cold circuit leaving the temperature control panel. The cold light during test will be on steady or in the aircraft the valve will run full cold. This is always caused by an unbalanced bridge. In this case the low resistance in the sensor circuit or during test, it's the decade resistance causing the unbalanced condition.
PULSING COLD DEMAND	This normally happens before FULL COLD demand. This is where the cold light will pulse, or in the aircraft the valve will pulse to the cold position. This results from the bridge being unbalanced, because the sensor or decade has decreased in resistance.
DEADBAND	When the bridge is balanced with both DS lights out during the test. If on the aircraft with a balanced bridge, the valve will not receive power.
PULSING HOT DEMAND	This normally happens before FULL HOT DEMAND. This is where the hot light will pulse or on the aircraft the valve will pulse to the hot position. This results from the bridge being unbalanced, because the sensor or decade has increased in resistance.
FULL HOT DEMAND	When full 28V DC is applied to the auto HOT circuit leaving the temperature control panel. The hot light, during the test, will be on steady or in the aircraft the valve will run full hot. This is always caused by an unbalanced bridge. In this case the high resistance in the sensor circuit or during test, it's the decade resistance causing the unbalanced condition.

Place a checkmark by the correct answer for the following questions or statements. You may refer to the past material if needed.

1. Failing of the (temperature control panel) to pass a minimum performance test may be caused by

_____a. calibration defects.

_____b. mechanical defects.

_____c. all the above.

2. When the bridge is balanced, it is also said to be in the

_____a. deadband.

_____b. control point.

_____c. all the above.

3. Full cold demand and full hot demand deliver the same temperature with the high resistance in the decade.

_____a. True

_____b. False

4. The DS-1 light is connected to the cold circuit from the temperature contr panel.

_____a. True

_____b. False

5. To get full cold, resistance in the sensor or decade must be

_____a. low.

_____b. high.

6. The hot and cold pulsing demand will constantly be the same.

_____a. True

_____b. False

7. The bridge circuit is balanced at B in figure 11.

_____a. True

_____b. False

For Exercise 1, instructors initiala below.
Progress Today ____________

ANSWERS ON PAGE 30.

NOTES

Section 3
TESTING
MINIMUM PERFORMANCE TEST

MINIMUM PERFORMANCE TEST

The following procedures and equipment provides a minimum check of the temperature control panel.

TOOLS AND EQUIPMENT

Power Bench with UNIT-A

Decade Box

Multimeter

Temperature Control Box

PREPARATION

1. Make sure the two power switches ON UNIT-A are off, see figure 4. Connect the AC and DC power cables from UNIT-A to the power bench outlets. These are found in front of you, under the cabinets, see figure 9.

2. Remove the malfunction UNIT-A with the adapter (figure 10), and place it as shown on the bench in figure 10. Remove the plastic dust covers two ea. , from its two plugs and store them in the LEFT storage compartment.

3. Remove the plastic cover from "J1 Amplifier Control" on UNIT-A and also place it in the LEFT storage compartment.

4. Remove the plastic cover from the electrical plug on the back of the temperature control panel (white box), figure 8, and place this one in the right storage compartment of UNIT-A.

5. Connect the two plugs of the adapter cable one (the male plug) to "J1 Amplifier Control" on UNIT-A and the other (the female plug) to the temperature control panel, see figure 10. Insure all nine abnormal/normal switches are in the normal position.

6. At this time a decade box and multimeter with leads, are needed from the storage area. Get one each and place them as shown in figure 10. Insure the decade is programmed to zero and the meter is set for 28V DC and connected to the tester.

7. Attach the decade red and black post to the sensor R-102 with the red and black leads provided in UNIT-A. The red/black leads may go in either green jacks on UNIT-A, see figures 4 and 10.

8. Set or verify simulator switch S-105 on UNIT-A is set to "Footheat" which means Defog Off.

9. The Cold DS-1 and Hot DS-2 bulbs need to be tested by pushing down on each of the DS lights to see if they have good bulbs in them. This is done by placing UNIT-A 28V DC power switch to on (DC only). This makes the red light just above it come on. With only the 28V DC power on, push down on the lens of each DS light to see if it comes on. This is where it says "PRESS TO TEST." If either one or both lamps fail to light under the press to test period notify the instructor.

1-CABIN SECTION - APPLYING POWER

a. Place 115V AC 400 Hz power switch "ON" found on the tester. The RED light above it should come on indicating power is at the tester and temperature control box.

b. Place the 28V DC power switch "ON" found on the tester. The RED light above it should come on indicating power is at the tester and temperature control box.

Explanation for the above

IMPORTANT Note: When the double line is seen in this workbook (like the above one), the material above it is the minimum performance steps. The material below it is provided to clarify the steps above the lines. Be sure the material below the line is studied carefully. This should be done before any attempt is made to accomplish the minimum performance steps above it on the following pages.

2-CABIN SECTION -- CONTROL POINTS

The cabin section has two control points, one in the cabin-defog off (S-105 in footheat) condition and the other in the cabin-defog on (S-105 in defog) condition. Reference to the appropriate electrical schematic figures 6 and 12. This shows it's accomplished on the aircraft by a remotely located switch (cabin defog sw). The control point is changed by switching appropriate resistance values (resistors) in or out of the bridge circuit. For test purposes, this is done by the FOOTHEAT-DEFOG SIMULATOR switch (S-105) on the tester.

a. The control point is not checked directly because there is no significant measurement that can be made at this point. The control point is the center of the deadband. The deadband is checked at two points A and C, that is where it breaks into the two pulsing bands for hot or cold, see figure 11.

Explanation for the above

When the above said "Two Control Points" (Deadbands) it means that with just a movement of the defog switch, the bridge will have different fixed resistor(s) in it, see figure 11. This will make the bridge have two different deadbands.

Figures 6 and 12 show R-6 and R-1b are part of the bridge with cabin defog OFF. In defog ON R-7 is in the bridge and not R-6 and R-1b. R-8, R-11 and R-12 are fixed resistors which are in the bridge for defog ON and OFF. The resistors are mounted in the temperature control panel.

Because of the two control points, both must be tested in the minimum performance test.

NOTE: For S-105: (Switch) FOOTHEAT = DEFOG - OFF DEFOG = DEFOG ON	Footheat is one of the deadbands and defog is the other deadband and each have their own values for the control points.

Turn the temperature selector to the Full hot position (full clockwise) on the temperature controller. Set the auto manual switch to AUTO on the temperature controller. Set S-105 switch to the footheat position on UNIT-A.

YOU WILL NOW BEGIN THE MINIMUM PERFORMANCE EXERCISE

---

3 - CABIN SECTION DEFOG-OFF - FINDING DEADBAND (Between C and A figures 13 or 18)

a. The control is in the deadband when both lamps DS-1 and DS-2 are off.

DS-1 is the COLD signal - GREEN

DS-2 is the HOT signal - RED

b. Decade resistor R-102 setting shall be between 1360 and 1660 ohms.

c. Record the decade resistance setting used in the deadband area (see notes below).

For performance exercises on figure 13 (all 9 abnormal/normal switches in normal).

For Performance Test Figure 18

Explanation for the above

For (b) above: NOTE: You may set decade anywhere between those settings, but about half way between them is ideal. This is about 1510 ohms.

Note: For the above and throughout this test, some time is required between each step. A fixed time period is not given because some units under test may not need the same time as the next. A reasonable time of 15 to 45 seconds may be a time to start with.

After setting decade to about 1510 ohms, measure the voltage at the TP points, with the black lead at either ground. Dropping to a lower scale on the meter may be necessary to check for lower voltage levels than 28V DC. Remember at this time voltage at both points should be zero and both DS lights should be out. If not, notify your instructor.

4 - CABIN SECTION DEFOG OFF - DETERMINATION OF POINT A (Figure 13 or 18)

a. Increase setting of decade resistor in one-ohm steps until the RED LAMP DS-2 (hot) just begins to pulse. This is Point A.

b. Record decade resistor setting as R102A1.

For Performance Exercises on figure 13.

For Performance Test - figure 18

Explanation for the above:

For (a) above: When the multimeter is connected at TP-2, it should begin to reflect a pulsing voltage and the range switch may have to be changed. When turning the knobs on the decade you may see the lights blink, disregard them while moving the knobs and also the meter may make a split second erratic movement which you may disregard.

For (b) above: R102A1 and Point A are the same in figure 13.

REMEMBER: When DS lights are on, the meter should show a voltage.

Note: The meter should be set on the 10 scale. Don't set it on the 2.5 scale if you don't understand why. Leave it on the 50 scale and see your instructor NOW.

5 - CABIN SECTION DEFOG OFF - DETERMINATION OF POINT B (Figure 13 or 18)

a. Increase of decade resistor to the point where RED LAMP DS-2 (hot) is FULL ON. This is point B.

b. Decade resistor R102 setting shall be between 3800 and 7000 ohms.

c. Record decade resistor setting as R102.

For Performance Exercises - on figure 13

For Performance Test - figure 18

Explanation for the above:

For (a) above: You will find that the voltage will increase to a steady value with this step, so set your meter for 28V DC BEFORE doing (a) above (see figure 11). If you don't understand, inform the instructor NOW during Exercise 1.

For (b) above: If the resistance is between the two values given, Point B is OK.

6 - CABIN DEFOG OFF - DETERMINATION OF POINT C (Figure 13 or 18)

a. Set decade resistor so that control is in deadband.

b. Decrease setting of decade resistor in one-ohm steps until the GREEN LAMP DS-1 just begins to pulse. This is point C.

c. Record decade resistor as R102C1.

For Performance Exercises on figure 13.

For Performance Test - figure 18.

Explanation for the above:

For (a) above: This deadband is from step 3, page 14.

For (b) above: Meter at TP-1 should also begin to reflect a pulsing and the range may have to be changed.

Note: R102C1 and Point C are the same in figure 13.

Note: Step 4 for Point A. Page 15 is almost the same as finding Point C, so review of it may be of value to you for the above.

7 - CABIN SECTION DEFOG OFF - DETERMINATION OF POINT D (Figure 13 or 18)

a. Decrease setting of decade resistor to the point where the GREEN LAMP DS-1 is FULL ON. This is Point D.

b. Decade resistor setting shall be between 300 and 600 ohms.

c. Record decade resistor setting for point D.

For Performance Exercises - on figure 13.

For Performance Test - figure 18.

Explanation for the above:

For (a) above: Going up the DS-1 range to Full Cold Demand (full on) will require the meter to be set to measure the higher voltage of 28V DC.

For (b) above: If the resistance is between the two values given, Point D is OK.

8 - CABIN SECTION DEFOG - LIMITS OF DEADBAND

a. Plot the readings recorded as R102A1 and R102C1 on graph shown.

For Performance Exercises - on figures 13 and 14.

For Performance Test - figure 19.

b. The intersection of the two points shall be within the shaded area.

Explanation for the above:

If you have difficulty with the graph, see your instructor. The two lines for R102A, and R102C, must intersect in the shaded area.

9 - CABIN SECTION DEFOG OFF - SELECTOR FUNCTION (Figure 15 or 20)

a. Set selector to COLD (full counterclockwise) position.

b. Increase decade resistor until control is in deadband. Decade resistor setting shall be approximately 25,000 ohms.

c. Record the deadband setting.

   For Performance Exercises - on figure 15.

   For Performance Test - figure 20.

d. Rotate selector slowly to HOT (fully clockwise) position.

e. The control shall pass through its HOT pulsing band and come FULL ON as indicated by LAMP DS-2. GREEN LAMP DS-1 shall NOT come on.

Explanation for the above:

For (a) above: The selector is on the temperature control panel.

For (b) above: Set decade for 25,000 ohms and measure the TP points and adjust the decade until you have zero voltage at both points. Adjustment may not be needed. (Be sure its setting is 25,000 and not 2,500).

For (c) above: If decade setting is not within 25,000 + or - 3,000 ohms STOP and see the instructor.

For (d) above: Be sure meter is on the 50 range if in TP-2 or disconnected from the tester.

For (e) above: Leave it in HOT.

1406

10 - CABIN SECTION DEFOG ON - FINDING DEADBAND (Between C and A figure 16 or 21)

a. Set simulator switch on the tester to defog. (Switch S-105).

b. Set selector on unit under test to HOT (full clockwise) position.

c. The control is in the deadband when both lamps DS-1 and DS-2 are off.

d. Decade resistor setting shall be between 245 and 294 ohms.

e. Record the decade resistor value for the deadband.

For Performance Exercises - on figure 16.

For Performance Test - figure 21.

Explanation for the above:

For (a) above: Before doing (a) insure if meter is connected and range is on 50.

For (b) above: Meter should be in TP-2 for 28V DC.

For (c) and (d) above: Should set decade to midway point of about 269 ohms and than measure the TP points and adjust the decade until you have zero voltage at both points. Adjustment may not be needed of the decade.

11 - CABIN SECTION DEFOG ON - DETERMINATION OF POINT A (on figure 16 or 21)

a. Increase setting of decade resistor in one ohm steps until DS-2 just begins to pulse. This is Point A.

b. Record decade resistor setting as R102A2.

For Performance Exercises - on figure 16.

For Performance Test - figure 21.

Explanation for the above.

For (a) above: Going from the deadband to Point A and the voltages will at first be low and the meter range needs to be set correctly.

1408

12 - CALIN SECTION DEFOG ON - DETERMINATION OF POINT C (figure 16 or 21)

a. Set decade resistor so that control is in deadband.

b. Decrease decade resistor in one-ohm steps until LAMP DS-1 just begins to pulse. This is Point C.

c. Recode decade resistor setting as R102C2.

For Performance Exercises - on figure 16.

For Performance Test - figure 21.

Explanation for the above:

For (a) above: Deadband same as in step 10.

For (b) above: This again is going from the deadband to point C at which the voltage value should be low, like going from deadband to point A.

Note: Disconnect or turn off meter from tester after completing the above.

13 - CABIN SECTION DEFOG ON - LIMITS OF DEADBAND

a. Plot the readings recorded as R102A2 and R102C2 on the graph shown.

For Performance Exercises - on figure 17 from figure 16.

For Performance Test - figure 22.

b. The intersection of the two points shall be within the shaded area.

Explanation for the above:

If you have difficulty with the graph, see your instructor. The two lines for R102A2 and R102C2 must intersect in the shaded area.

1410

14 - AUTO - MANUAL CONTROL FUNCTION

a. Set or verify SIMULATOR switch (S-105) on tester is set to FOOTHEAT.

b. Set or verify that selector on unit under t st is set to HOT (full clockwise) position.

c. Set decade resistor R-102 to 400 ohms.

d. Lamp DS-1 shall be full ON.

e. Set AUTO-MANUAL switch to manual hot DS-2 should be on..DS-1 should be off.

f. Set AUTO-MANUAL switch to AUTO.

g. Set decade resistor R-102 to 7000 ohms.

h. Lamp DS-2 shall be full ON.

i. Set AUTO-MANUAL switch to manual cold, DS-1 should be on. DS-2 should be off.

A meter is not needed for the above, so be sure it is disconnected before (a) is started.

It should be noted at the end of Exercise 1 that you have performed the minimum performance test and unit under test should be serviceable. (This is with all nine normal/abnormal switches in normal.)

Show figures 13 through 17 to your instructor and inform your instructor of anything you don't understand at this time.

Instructor's Initials
Here for Figure 13 through
Figure 17 ________________
Go to page 26 .

PERFORMANCE EXERCISE INSTRUCTIONS

STUDENT WILL NOT BEGIN PERFORMANCE EXERCISE UNLESS THE INSTRUCTOR HAS INITIALED PAGE 25.

This is the performance exercise (practice work) in which the requirement is to complete at least the first three assigned problems satisfactorily. In addition to the first three practice problems an additional 4 may be required. These additional problems are only required if the instructor determines additional exercise is needed. During the performance exercise, questions may be asked of the instructor within reason. The instructor will always reserve the right on how or if to respond to the question(s).

WORKSHEET INSTRUCTIONS FOR PAGE 27

The "ABNORMAL/NORMAL INDICATION SW NUMBER" column is the place where the instructor will place the switch numbers.

"STEP NUMBER" column, "RECORD TEST RESULT" column and "SERVICEABLE" column are the columns the student will place the correct responses as will be demonstrated later in the workbook for problem 1.

Below are test results from which you may pick the correct one for your problem. This is to be recorded under "RECORD TEST RESULT" column.

No Pulsing and No Full Hot Demand

No Pulsing and No Full Cold Demand

No Manual Hot

No Manual Cold

Full Hot Demand

Full Cold Demand

Out of Deadband Standards

Figures 13, 14, 15, 16 and 17 are to be used for problems 1 through 7. The answers may be erased on these figures after the assigned problem has been graded. This procedure will allow greater usage of these figures for the four additional practice problems as assigned.

PERFORMANCE EXERCISE INSTRUCTIONS (Cont)

The instructor should give you switch 1 for Problem Number 1. The following will take you through the general procedure on how to perform the Performance Exercise. All you know each time you test any unit is that the unit MAY OR MAY NOT be serviceable. Be sure you use the following time wisely. You must be able to use the general knowledge you gain here during the practice work to do the performance test.

Place the abnormal/normal indication switch as assigned, to the abnormal position and insure others remain in the normal position (figure 3, malfunction UNIT-A).

FIRST: Use Section 3 until defect is found.

SECOND: You should have found that procedure or step 4a, page 15 did <u>NOT</u> give a normal indication as required. DS-2 DIDN'T illuminate within the $R102A_1$ decades values in the graph in figure 19, which is an abnormal indication.

THIRD: Record the number "4a" "STEP NUMBER" on the PERFORMANCE EXERCISE WORKSHEET.

FOURTH: It was found in 4a the RED LAMP DS-2 did not come on as required which results in a "NO PULSING AND NO FULL HOT DEMAND." This is to be recorded under, "RECORD TEST RESULT" on the PERFORMANCE WORKSHEET!

FIFTH: On the worksheet, the student will mark if the unit under test is serviceable by placing a mark under "YES" for serviceable or "NO" for unserviceable.

DO	PROBLEM	ABNORMAL/ NORMAL INDICATION SW NUMBER	RECORD THE PROCEDURE OR STEP NUMBER	RECORD TEST RESULTS	SERVICEABLE	
					YES	NO
	1					
	DO STORAGE PROCEDURES					
	FOLLOW INSTRUCTIONS GIVEN BY INSTRUCTOR					
	2					
	DO STORAGE PROCEDURES					
	FOLLOW INSTRUCTIONS GIVEN BY INSTRUCTOR					
	3					
	DO ADDITIONAL PRACTICE PROBLEMS PAGE 28					
	DO PERFORMANCE TEST PAGE					

PERFORMANCE EXERCISE WORKSHEET

ADDITIONAL PRACTICE

Do additional practice problems 4 through 6, using pages 12 through 24.

DO	PROBLEM	ABNORMAL/ NORMAL INDICATION SW NUMBER	RECORD THE PROCEDURE OR STEP NUMBER	RECORD TEST RESULTS	SERVICEABLE	
					YES	NO
	4					
	5					
	6					

SEE YOUR INSTRUCTOR FOR THE PERFORMANCE TEST.

PERFORMANCE TEST

INSTRUCTIONS

This performance test will require the student to correctly record the responses for the three given problems. This should be accomplished by using the minimum performance test procedures, figures and worksheets, found in this workbook. The instructor will check your work as required. If you miss any part of the problems given, you will fail that problem. You must get two out of the three correct.

DO	PROBLEM	ABNORMAL/ NORMAL INDICATION SW NUMBER	RECORD THE PROCEDURE OR STEP NUMBER	RECORD TEST RESULTS	SERVICEABLE		GRADE	
					YES	NO	S	U
	1							
	DO STORAGE PROCEDURES							
	FOLLOW INSTRUCTIONS GIVEN BY INSTRUCTOR							
	2							
	FOLLOW INSTRUCTIONS GIVEN BY INSTRUCTOR							
	3							

PERFORMANCE TEST WORKSHEET

---Student will turn in ALL pages of this workbook to the instructor before leaving the area.

Figures 18 through 22 will be used for the performance test.

AFTER SATISFACTORY COMPLETION OF THIS WORKBOOK, COMPLETE THE STORAGE PROCEDURES ON THE FOLLOWING PAGE.

STORAGE PROCEDURE

1. Insure the two power switches are OFF on the Fighter Air Conditioning Test Set.

2. Insure the AC and DC power cables are disconnected from the power bench outlets and that cables are placed in the unit's storage area on the right side, see figures 4 and 7.

3. Insure the red and black leads for the decade are stored as in figures 4 and 7.

4. Insure the adapter cable with Malfunction UNIT-A box is stored as shown in figures 3, 4 and 7 with the plastic dust covers on its plugs (2 ea).

5. Insure the plastic dust cover is on the tester "J1 Amplifier Control."

6. Insure the plastic dust cover is on the temperature control panel (white box), see figure 8.

7. Insure the temperature control panel is turned OFF.

8. Ask your instructor to inspect your work at this time before you place the lid on the unit.

9. Install lid.

10. Place UNIT-A in storage cabinet.

11. Insure multimeter and/or decade is in its proper storage.

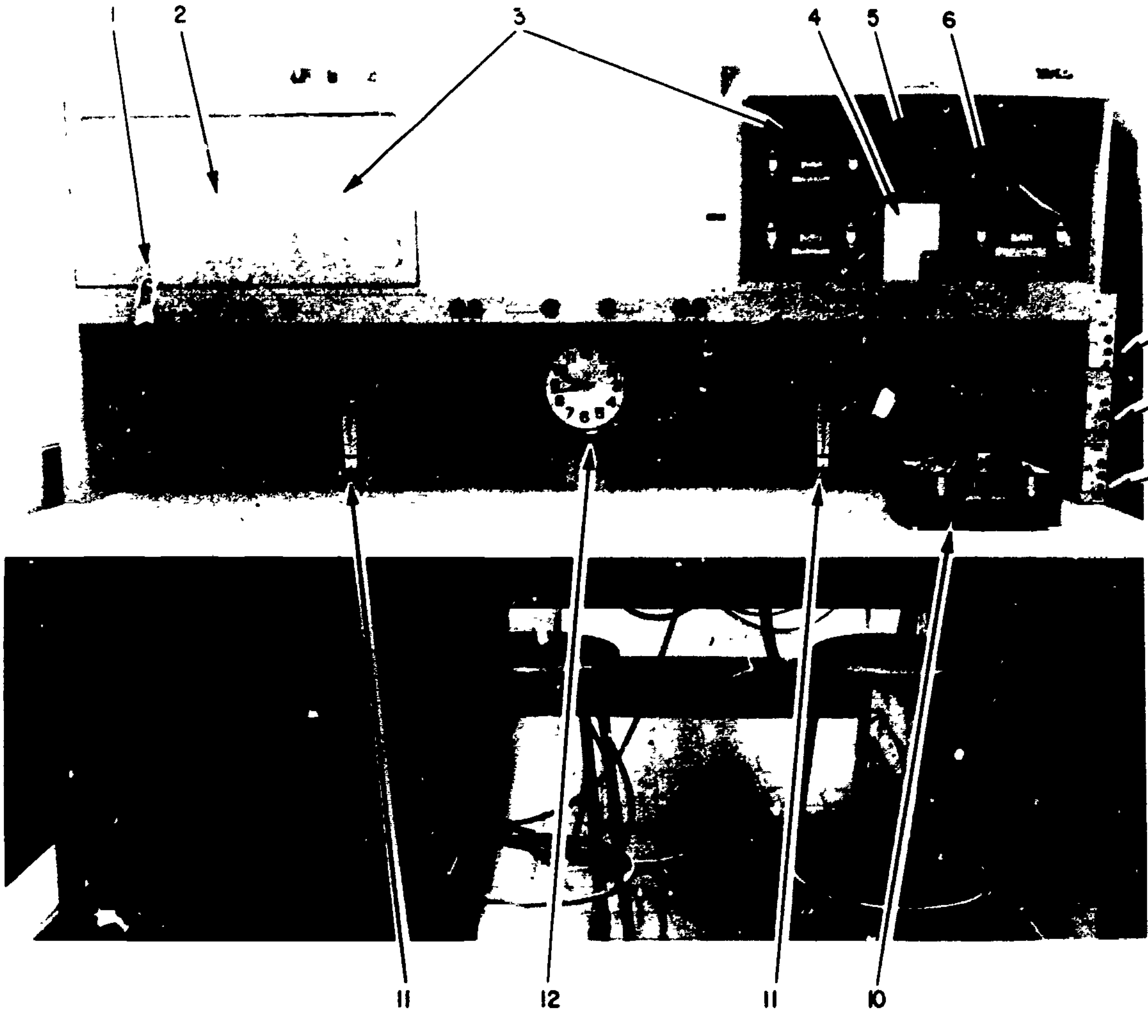
12. Insure the temperature control panel is in its proper storage area, see figure 1.

13. Clean your work area as needed.

14. Turn in this complete workbook to the instructor and wait for additional instructions.

Correct answers for page 9.

1. c
2. c
3. False
4. True
5. a
6. False
7. Fa[illegible]



1	DOOR CLOSED	7	60 HZ AC POWER 115V
2	DOOR CLOSED	8	28 VDC POWER
3	STORAGE CABINETS	9	400 HZ AC POWER 115V
4	TEMPERATURE CONTROL PANEL (WHITE BOX)	10	UNIT-A
5	DOOR OPEN	11	THERMOMETERS
6	LID FOR UNIT-A (ONE IN USE)	12	CLOCK

NOTE: THE THREE POWER SWITCHES (7, 8 and 9) WILL NOT BE TOUCHED BY STUDENTS

Figure 1. Power Bench with UNIT-A.

1417

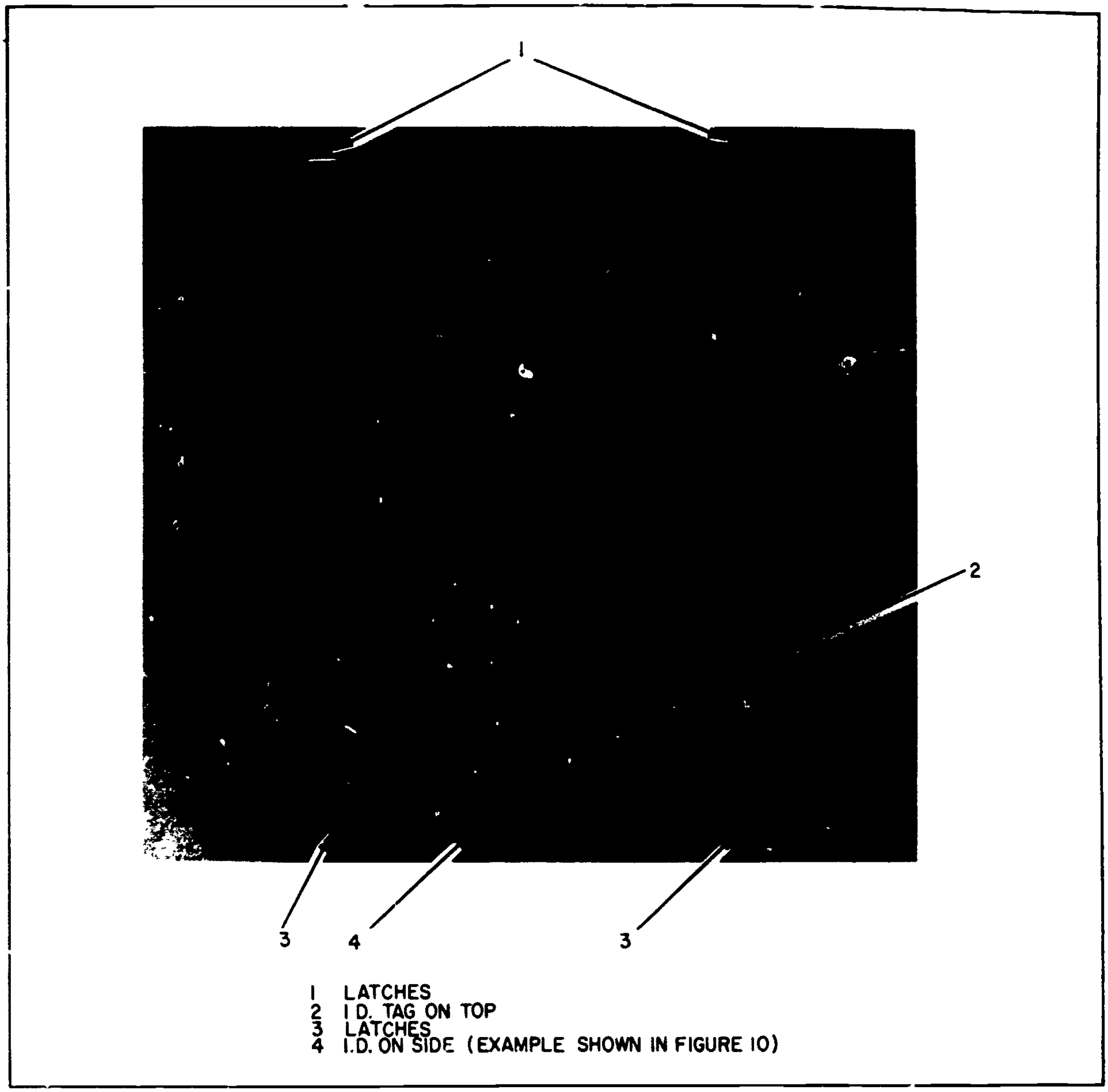
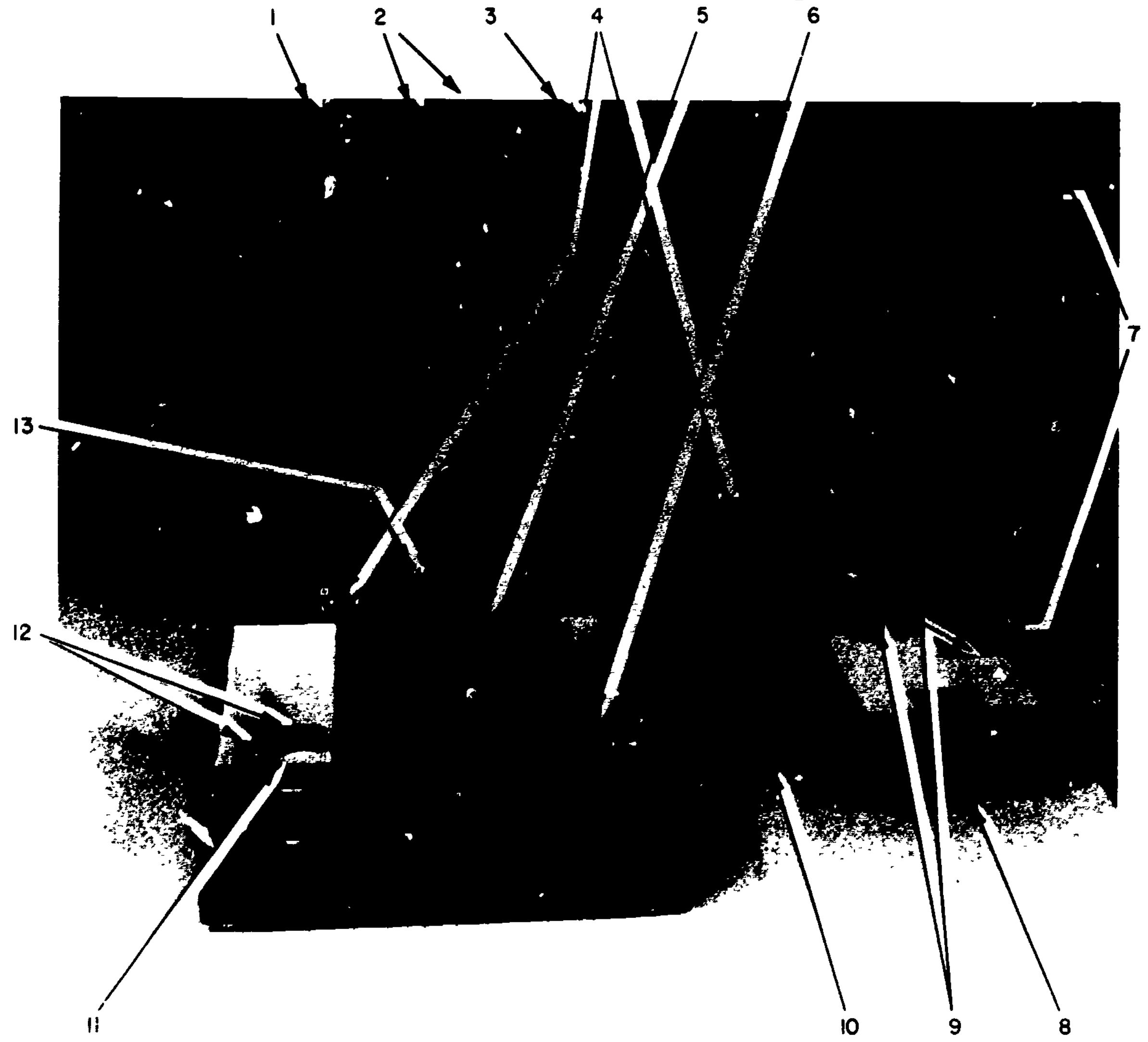
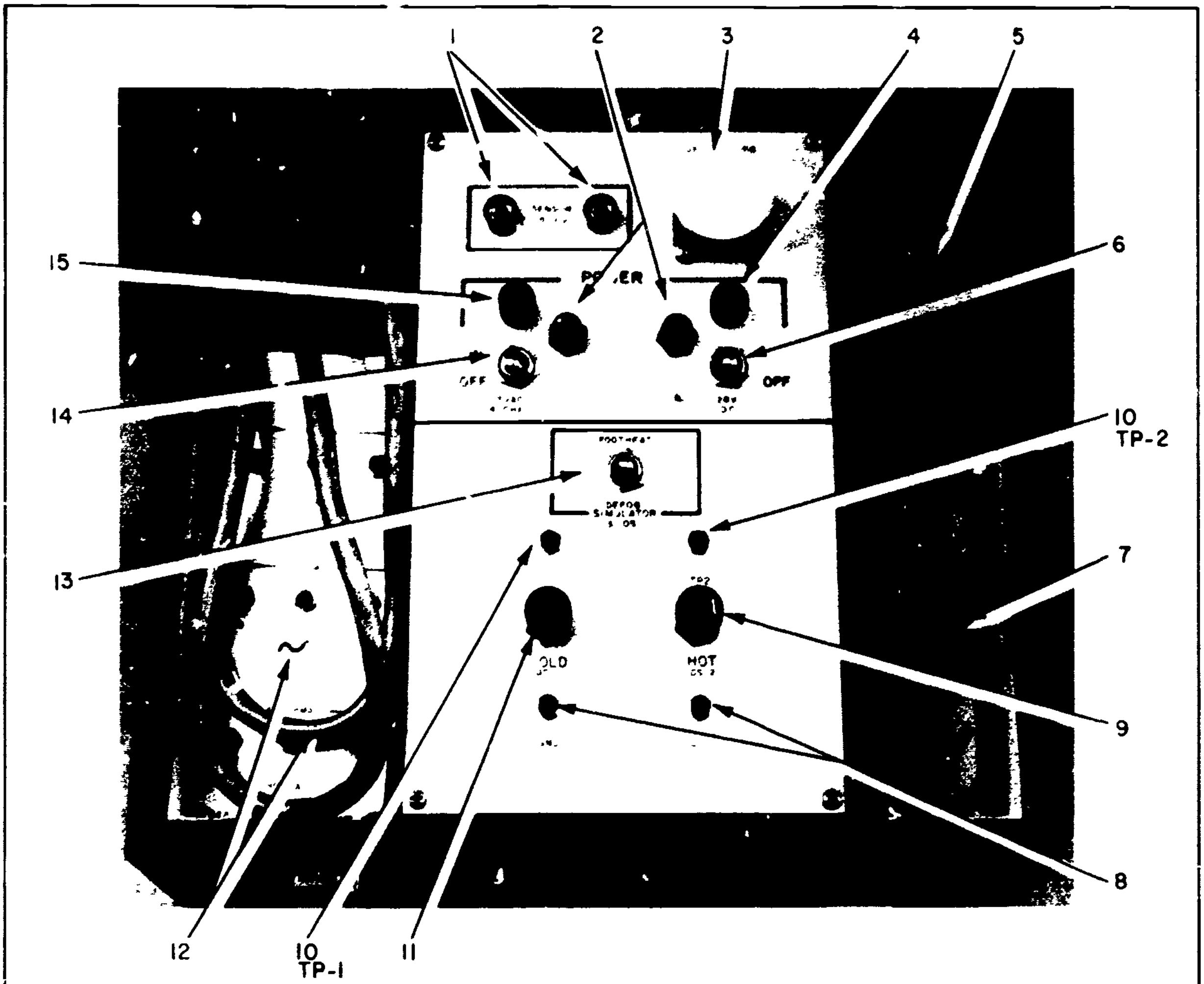


Figure 2. UNIT-A Top View with Lid On.



1 115VAC POWER 400Hz
2 115VAC POWER 60Hz
3 28 VDC POWER
4 ADAPTER CABLE
5 J-1 AMPLIFIER CONTROL JACK DUST COVER REMOVED
6 DUST COVER FROM BACK OF CONTROL COX
7 STUDENTS WILL NOT TOUCH THESE POWER SWITCHES
8 CONTROL BOX
9 DUST COVERS REMOVEC
10 MALFUNCTION UNIT-A IS PART OF ADAPTER CABLE
11 DUST COVER FOR J-1 AMPLIFIER JACK ON UNIT-A
12 STORAGE PLASTIC DUST COVERS FOR ADAPTER CABLE
13 DUST COVER REMOVED

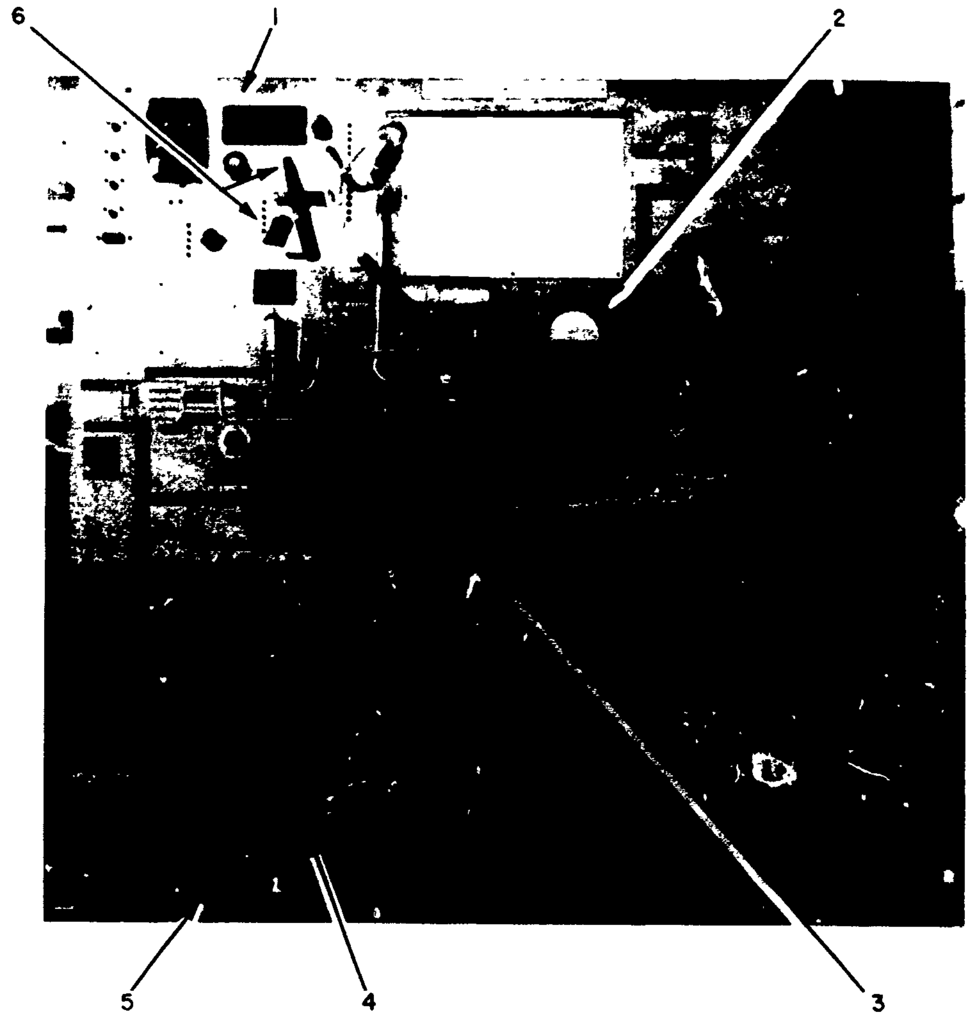
Figure 3. UNIT-A Fighter Cabin Air Conditioning Test Set.



1 SENSOR R-102
GREEN BANANA JACKS
2 CIRCUIT BREAKERS
3 J-1 AMPLIFIER CONTROL (PLUG)
4 28 VDC POWER LIGHT (RED)
5 AC AND DC POWER CABLE
6 POWER SWITCH 28 VDC
7 RED/BLACK TEST LEADS
FOR DECADE
8 GROUND COMMON FOR BOTH
TP-1 AND TP-2 (BLACK) PINJACKS

9 RED LIGHT DS-2
10 MULTIMETER RED LEAD
PIN JACKS
11 GREEN LIGHT DS-1
12 MALFUNCTION UNIT-A
WITH ADAPTER CABLE
13 FOOTHEAT/DEFOG SIMULATOR S-105
14 POWER SWITCH 115 VAC
15 115 VAC POWER LIGHT (RED)

Figure 4. UNIT-A.



1 TEMPERATURE CONTROL PANEL (WHITE BOX)
2 AN/PSM-37
3 CABIN DUAL TEMPERATURE MIXING VALVE
4 AN/PSM-21A
5 DUST COVERS FOR ELECTRICAL PLUG
6 AIRCRAFTS FOOTHEAT DEFOG LEVEF AND SWITCH

Figure 5. Fighter Air Conditioning System (A View of the Trainer).

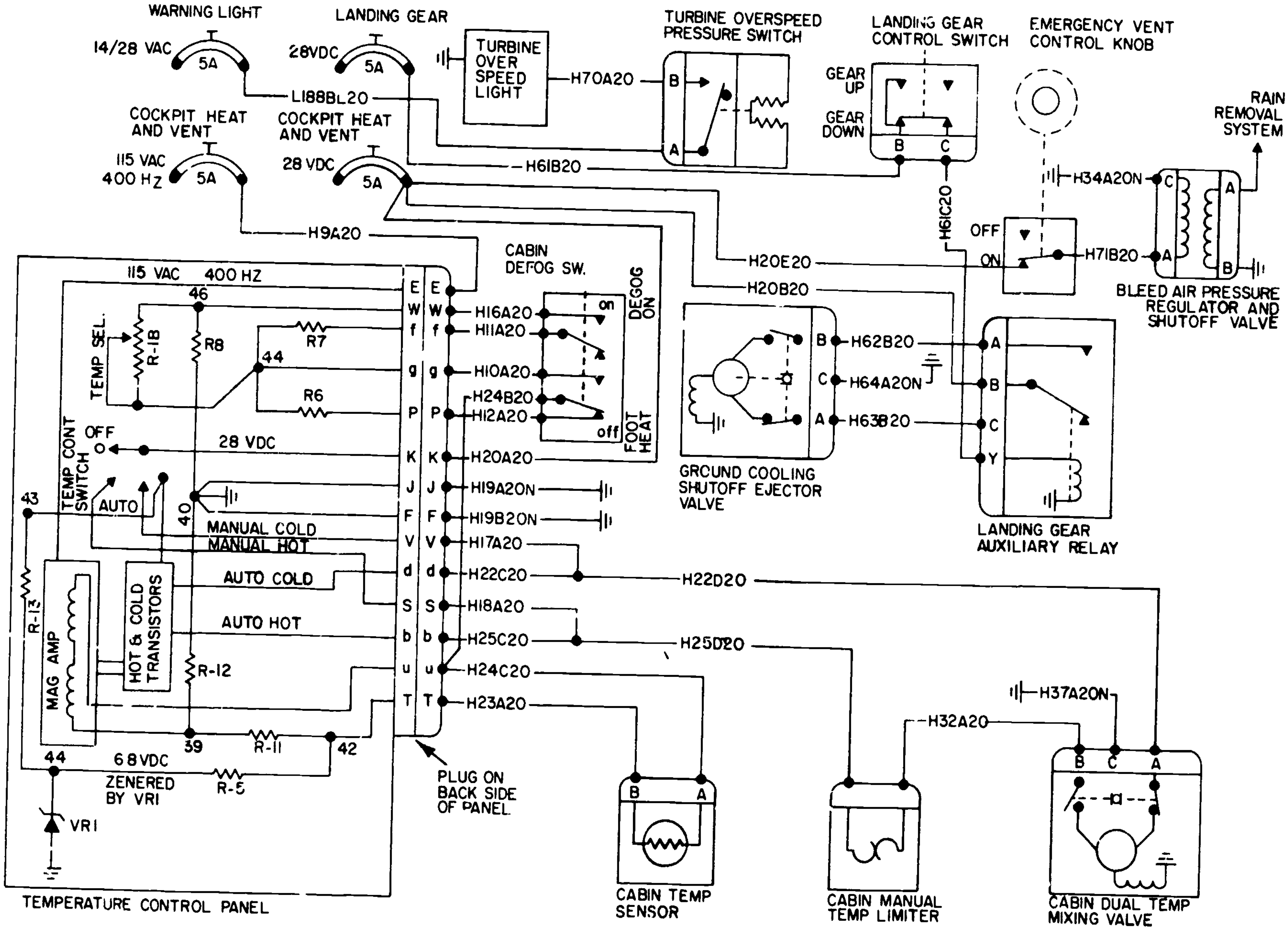
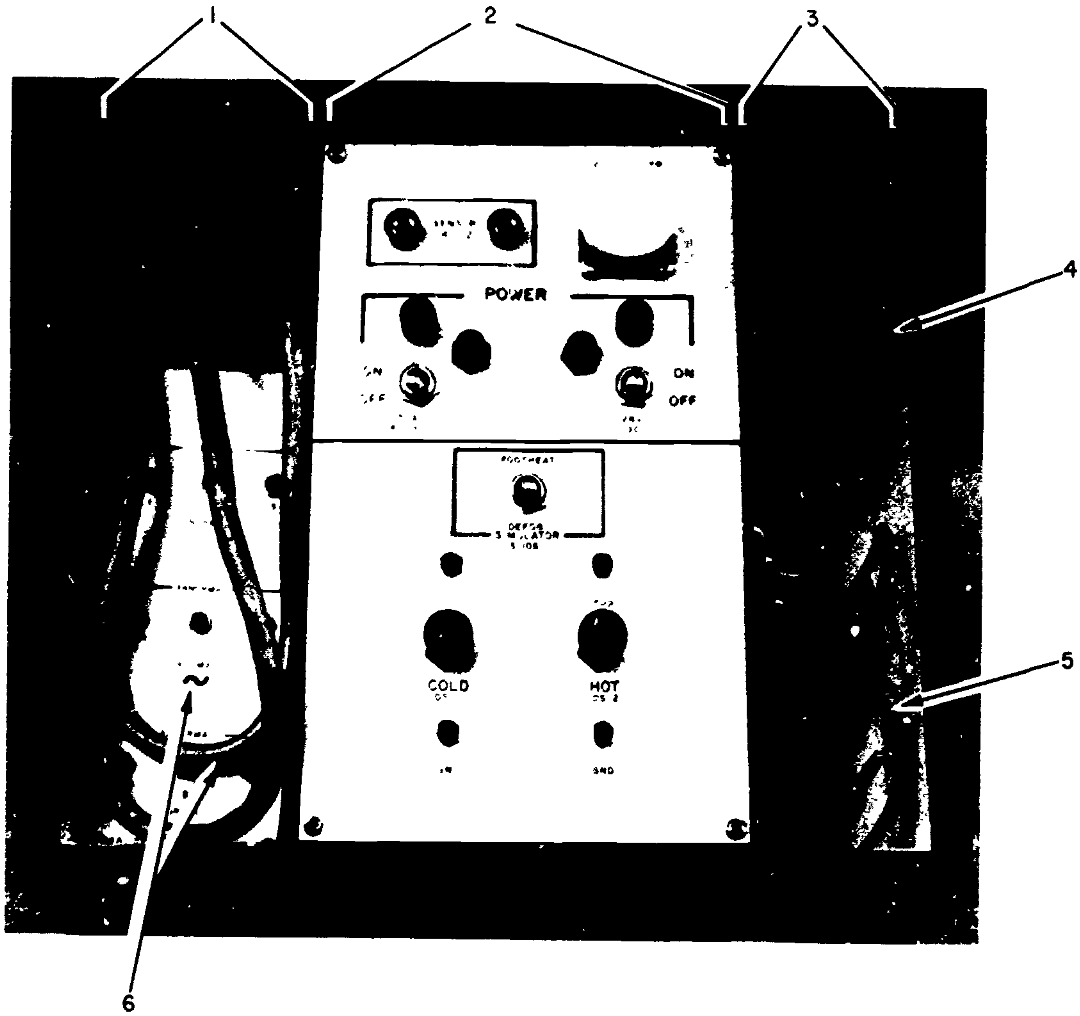


*Figure 6. Wiring Diagram Fighter Air Conditioning System.
*See definition page.



1 LEFT STORAGE AREA
2 CONTROL PANEL AREA
3 RIGHT STORAGE AREA
4 POWER CABLES
5 TEST LEADS RED AND BLACK
6 MALFUNCTION UNIT-A WITH ADAPTER CABLE

Figure 7. Air Conditioning System Test Set.

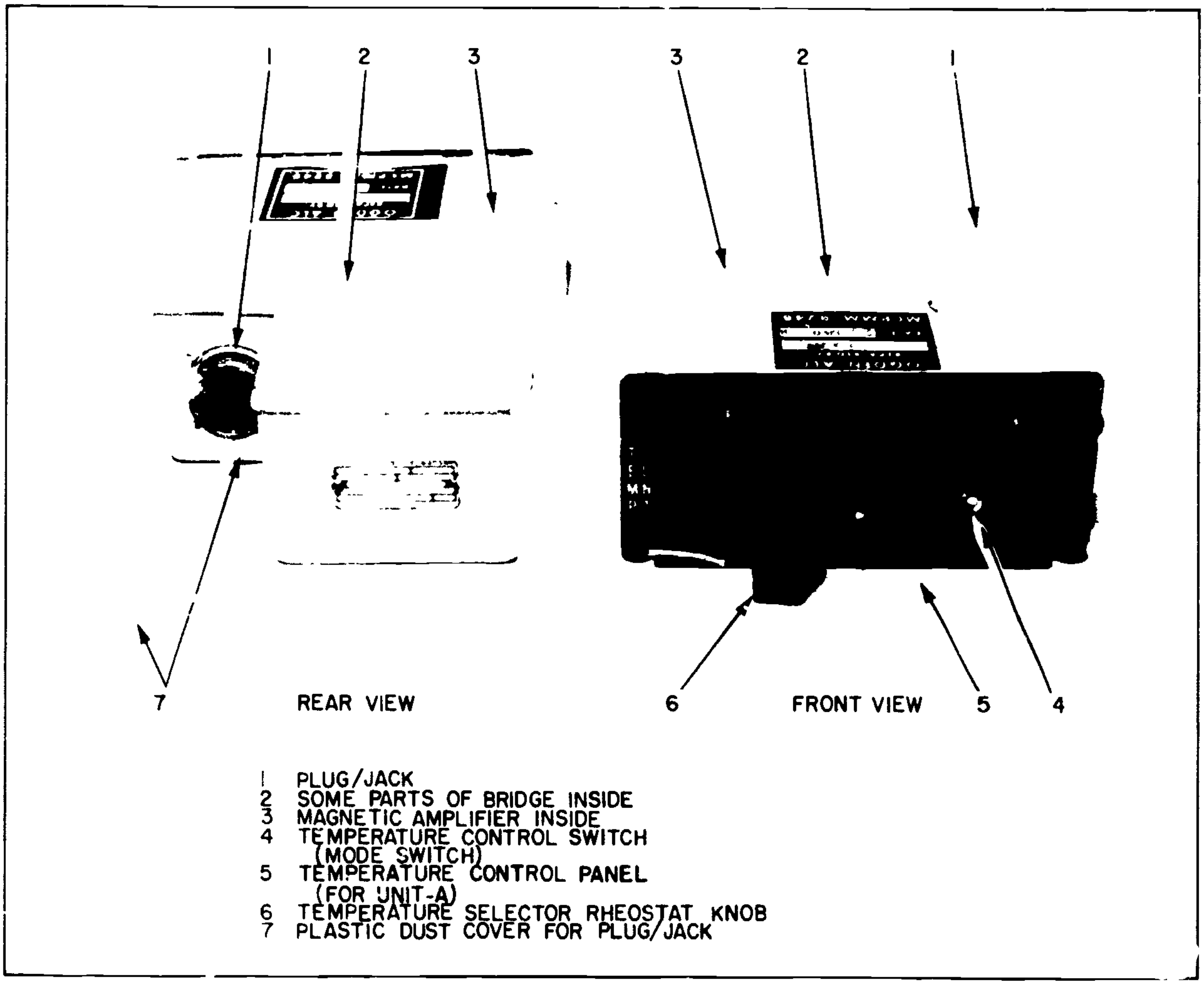
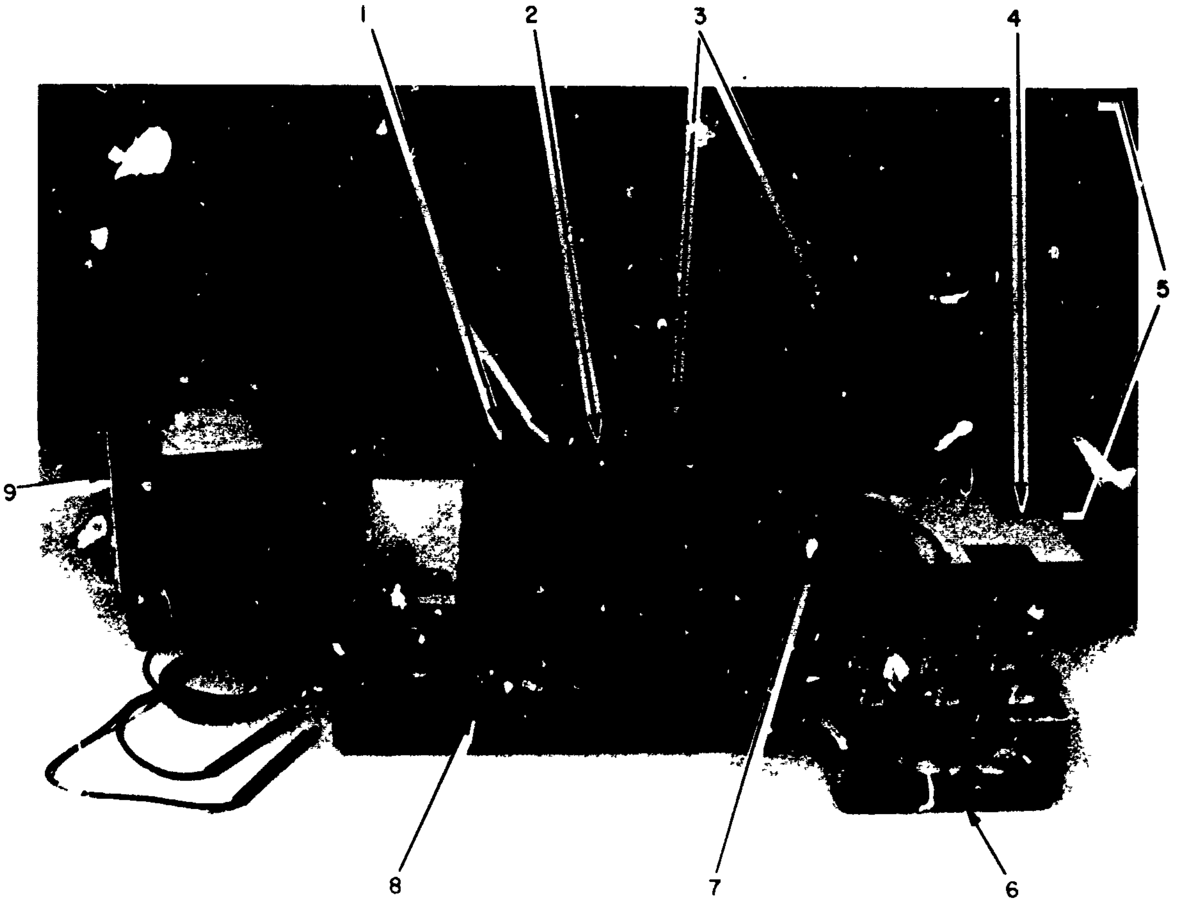


Figure 8. Temperature Control Panel.

1 AC PLUG- HAS (3) PINS AND FITS ONLY IN THE AC RECEPTACLE ON POWER BENCH
2 DC PLUG - HAS TWO PINS AND FITS ONLY IN THE DC RECEPTACLE ON THE BENCH
3 STUDENTS WILL NOT TOUC' THESE POWER SWITCHES

Figure 9.

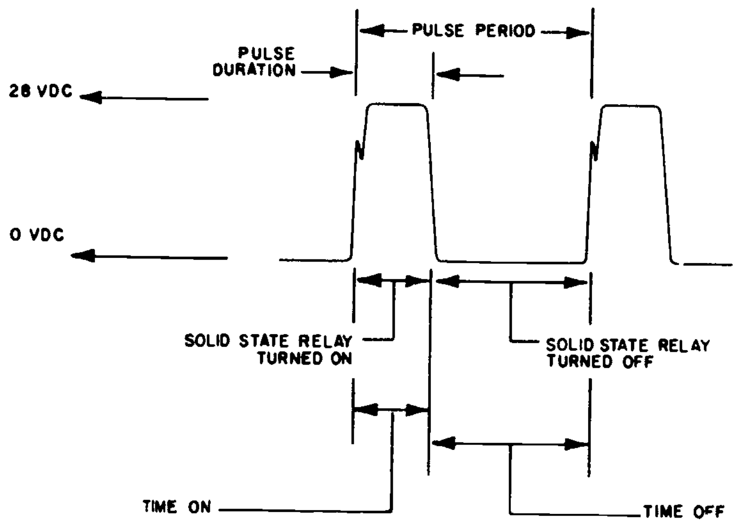


1 RED AND BLACK LEADS FOR DECADES
2 ADAPTER CABLE MALE PLUG
3 ADAPTER CABLE
4 ADAPTER CABLE FEMALE PLUG
5 STUDENTS WILL NOT TOUCH THESE POWER SWITCHES
6 DECADE
7 MALFUNCTION UNIT-A WITH ADAPTER CABLE
8 UNIT-A FIGHTER AIR CONDITIONER TEST SET
9 MULTIMETER AN/PSA-37

Figure 10.

CONTROL CHARACTERISTICS

PART A



PART B

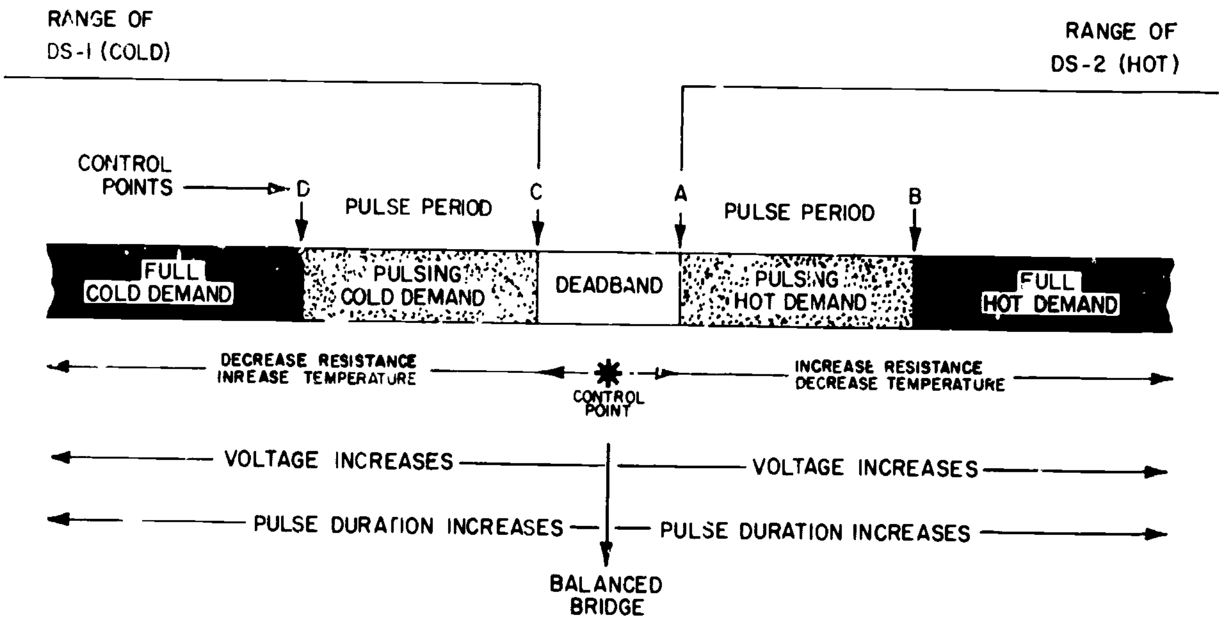


Figure 11.

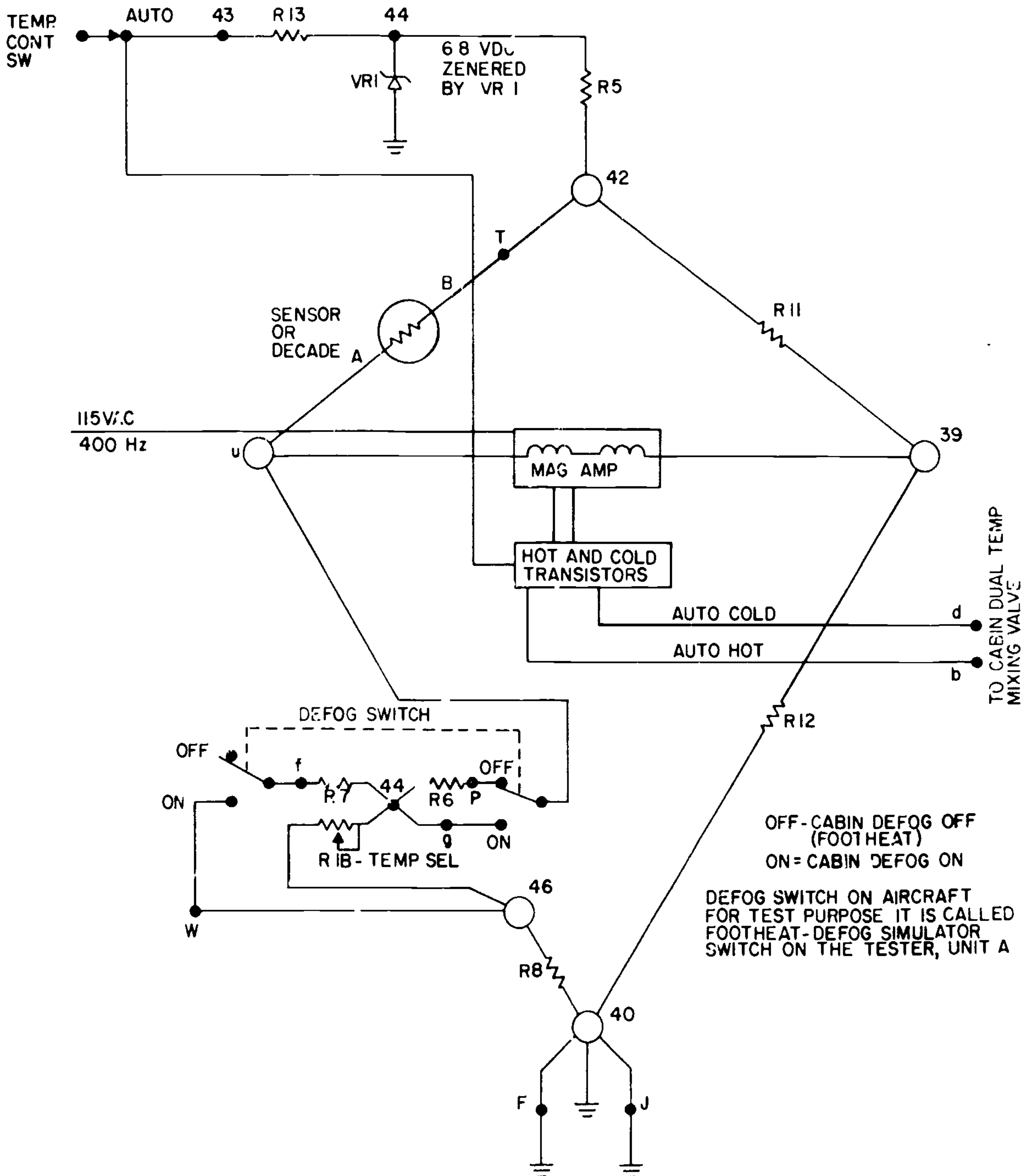
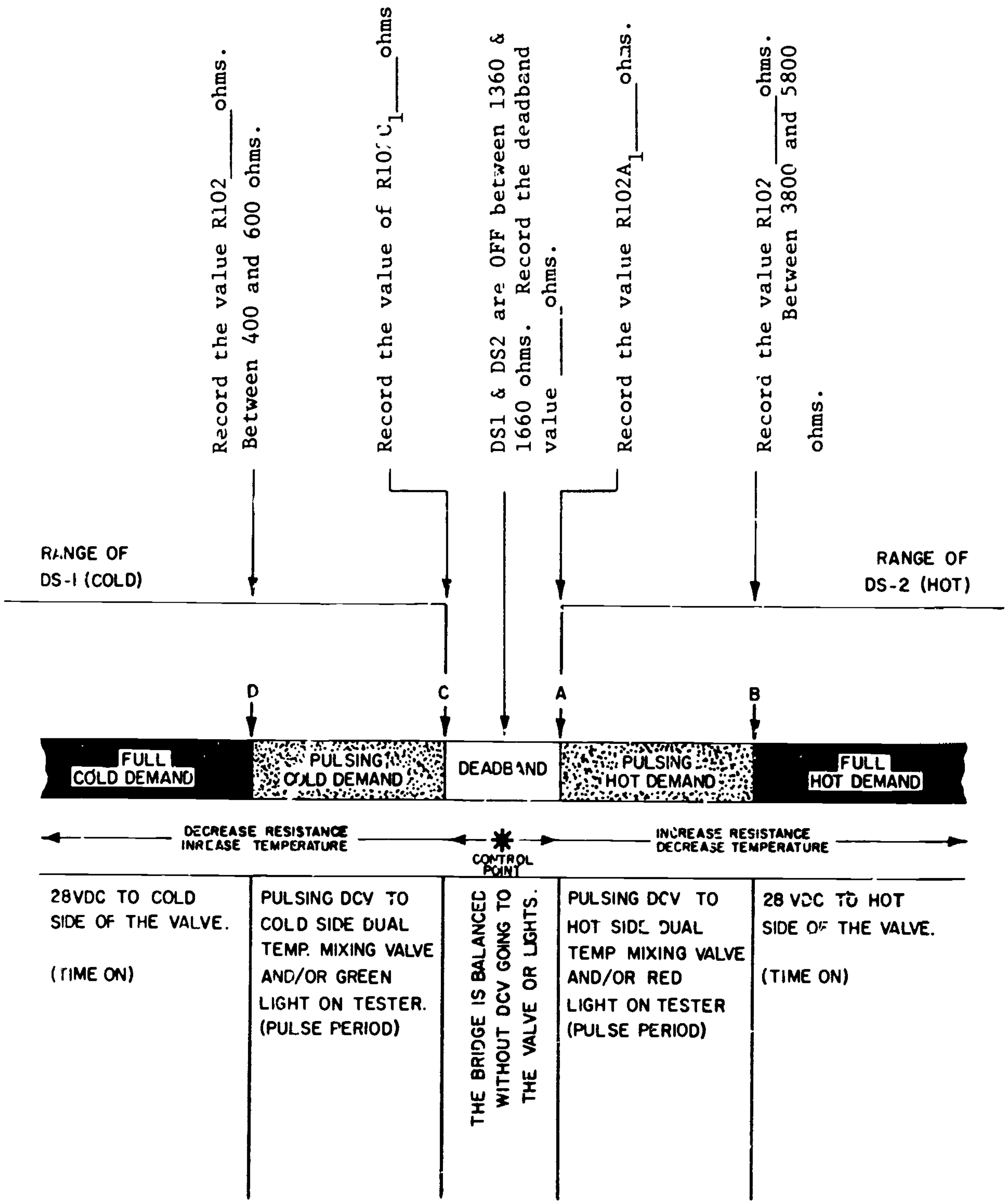
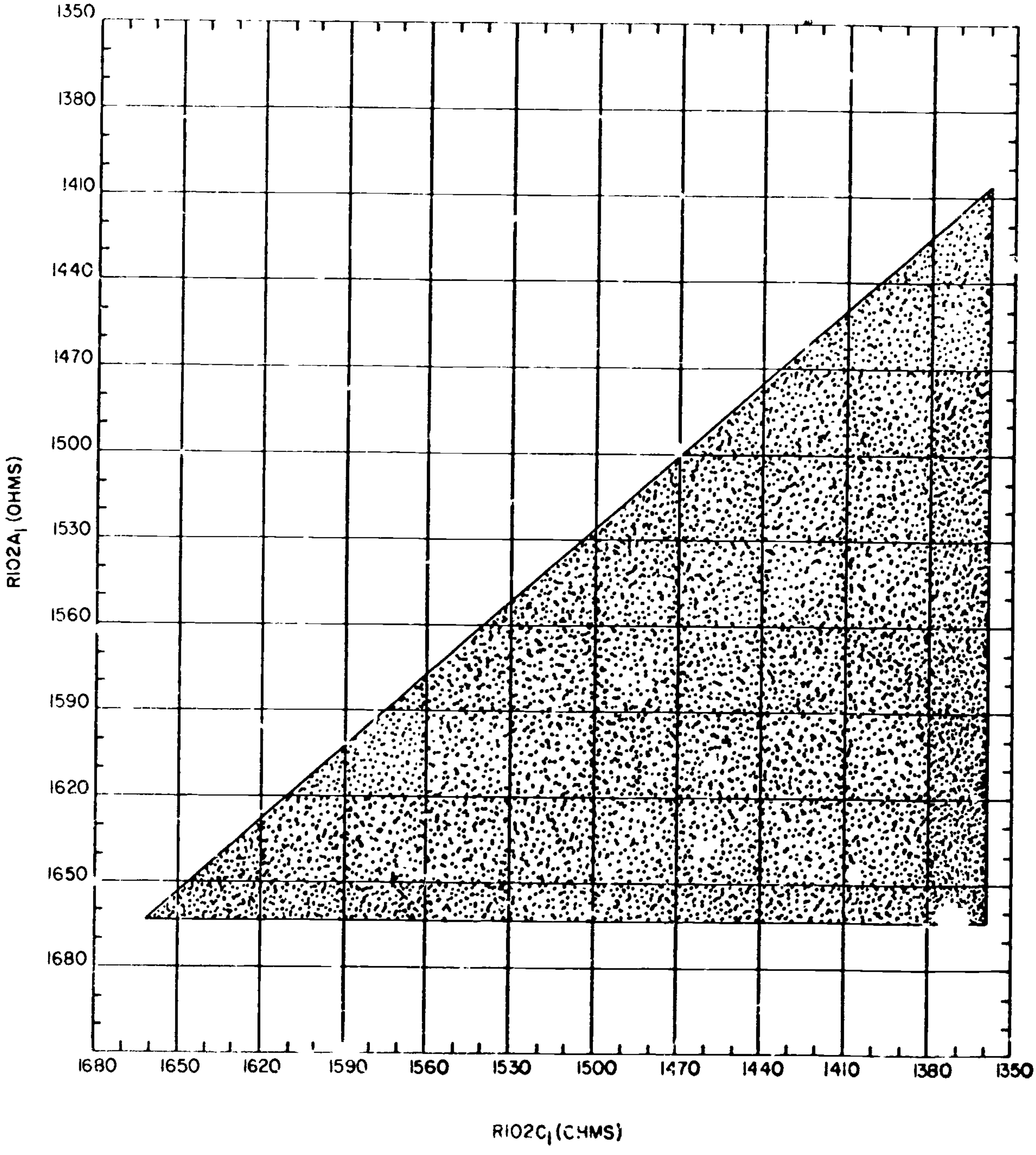


*Figure 12.
*See Definition Page.



Record the value R102 ____ ohms.
Between 400 and 600 ohms.
Record the value of R102C1 ____ ohms
DS1 & DS2 are OFF between 1360 & 1660 ohms. Record the deadband value ____ ohms.
Record the value R102A1 ____ ohms.
Record the value R102 ____ ohms.
Between 3800 and 5800 ohms.
RANGE OF DS-1 (COLD)
RANGE OF DS-2 (HOT)
D
C
A
B
FULL COLD DEMAND
PULSING COLD DEMAND
DEADBAND
PULSING HOT DEMAND
FULL HOT DEMAND
DECREASE RESISTANCE INRCASE TEMPERATURE
CONTROL POINT
INCREASE RESISTANCE DECREASE TEMPERATURE
28VDC TO COLD SIDE OF THE VALVE. (TIME ON)
PULSING DCV TO COLD SIDE DUAL TEMP. MIXING VALVE AND/OR GREEN LIGHT ON TESTER. (PULSE PERIOD)
THE BRIDGE IS BALANCED WITHOUT DCV GOING TO THE VALVE OR LIGHTS.
PULSING DCV TO HOT SIDE DUAL TEMP MIXING VALVE AND/OR RED LIGHT ON TESTER (PULSE PERIOD)
28 VDC TO HOT SIDE OF THE VALVE. (TIME ON)

Figure 13.



DEFOG OFF - LIMITS OF DEADBAND

Figure 14.

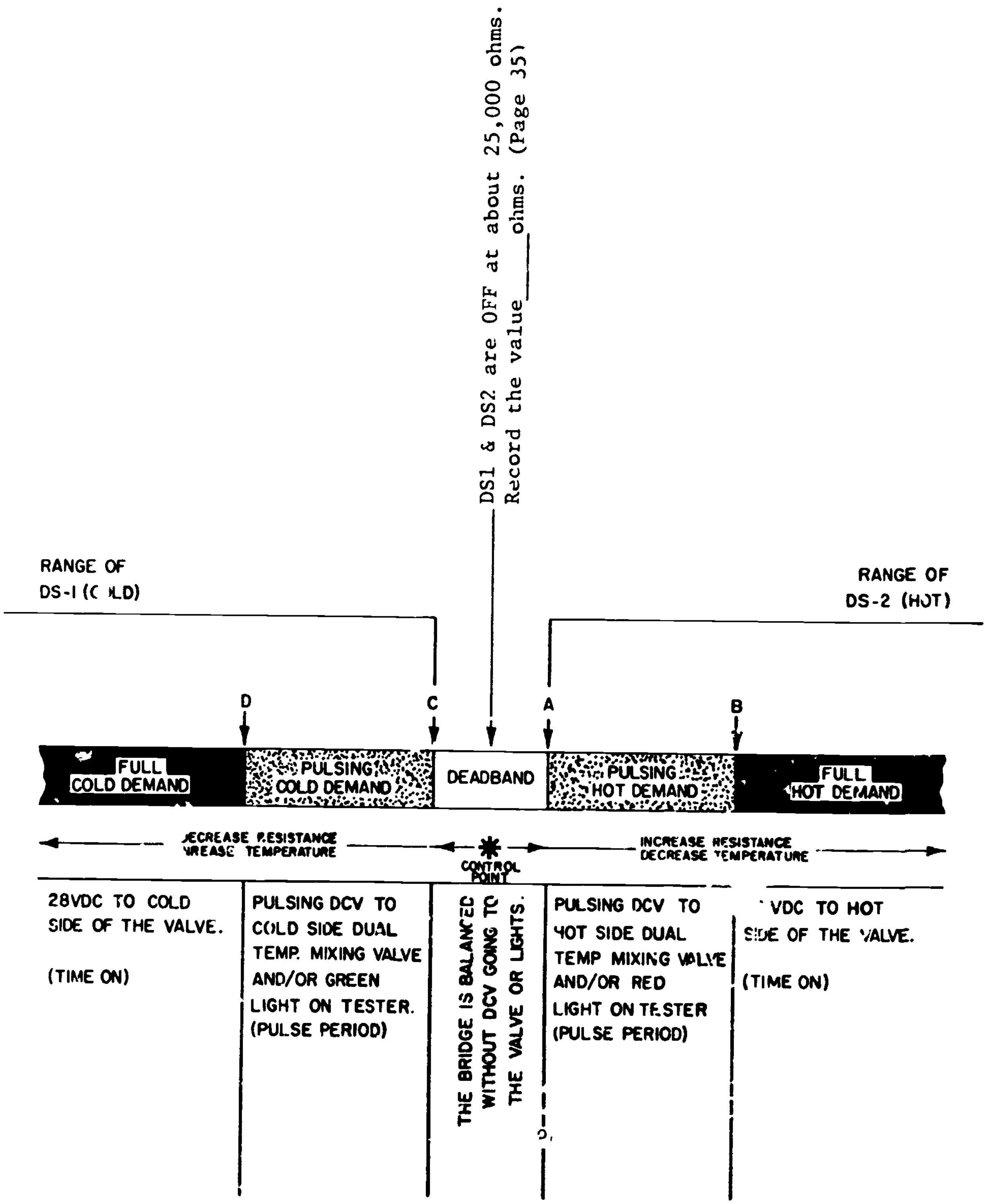

DS1 & DS2 are OFF at about 25,000 ohms.
Record the value____ohms. (Page 35)
RANGE OF DS-1 (COLD)
RANGE OF DS-2 (HOT)
D
C
A
B
FULL COLD DEMAND
PULSING COLD DEMAND
DEADBAND
PULSING HOT DEMAND
FULL HOT DEMAND
DECREASE RESISTANCE INCREASE TEMPERATURE
CONTROL POINT
INCREASE RESISTANCE DECREASE TEMPERATURE
28VDC TO COLD SIDE OF THE VALVE.
(TIME ON)
PULSING DCV TO COLD SIDE DUAL TEMP. MIXING VALVE AND/OR GREEN LIGHT ON TESTER.
(PULSE PERIOD)
THE BRIDGE IS BALANCED WITHOUT DCV GOING TO THE VALVE OR LIGHTS.
PULSING DCV TO HOT SIDE DUAL TEMP MIXING VALVE AND/OR RED LIGHT ON TESTER
(PULSE PERIOD)
VDC TO HOT SIDE OF THE VALVE.
(TIME ON)

Figure 15.

EXERCISE 1

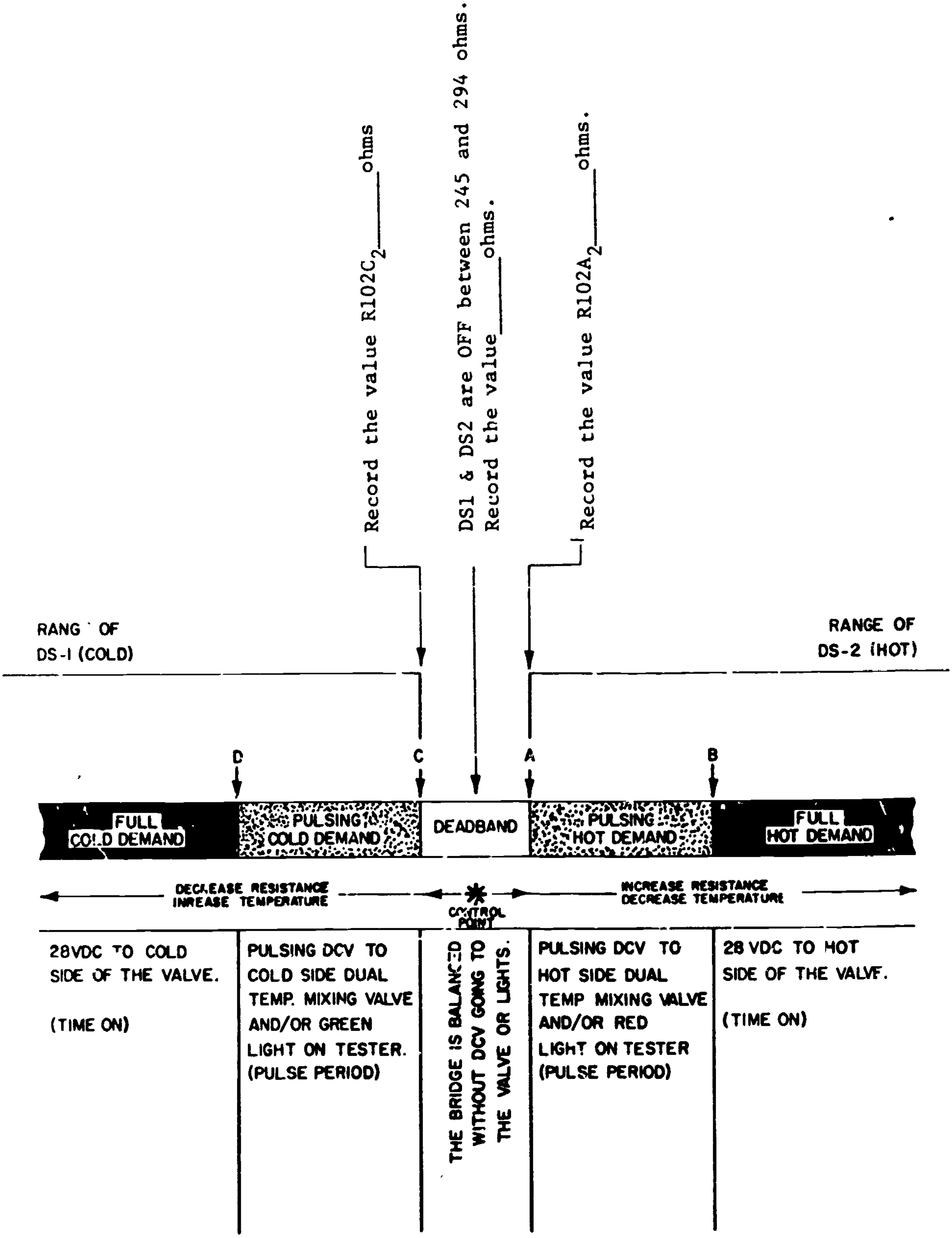
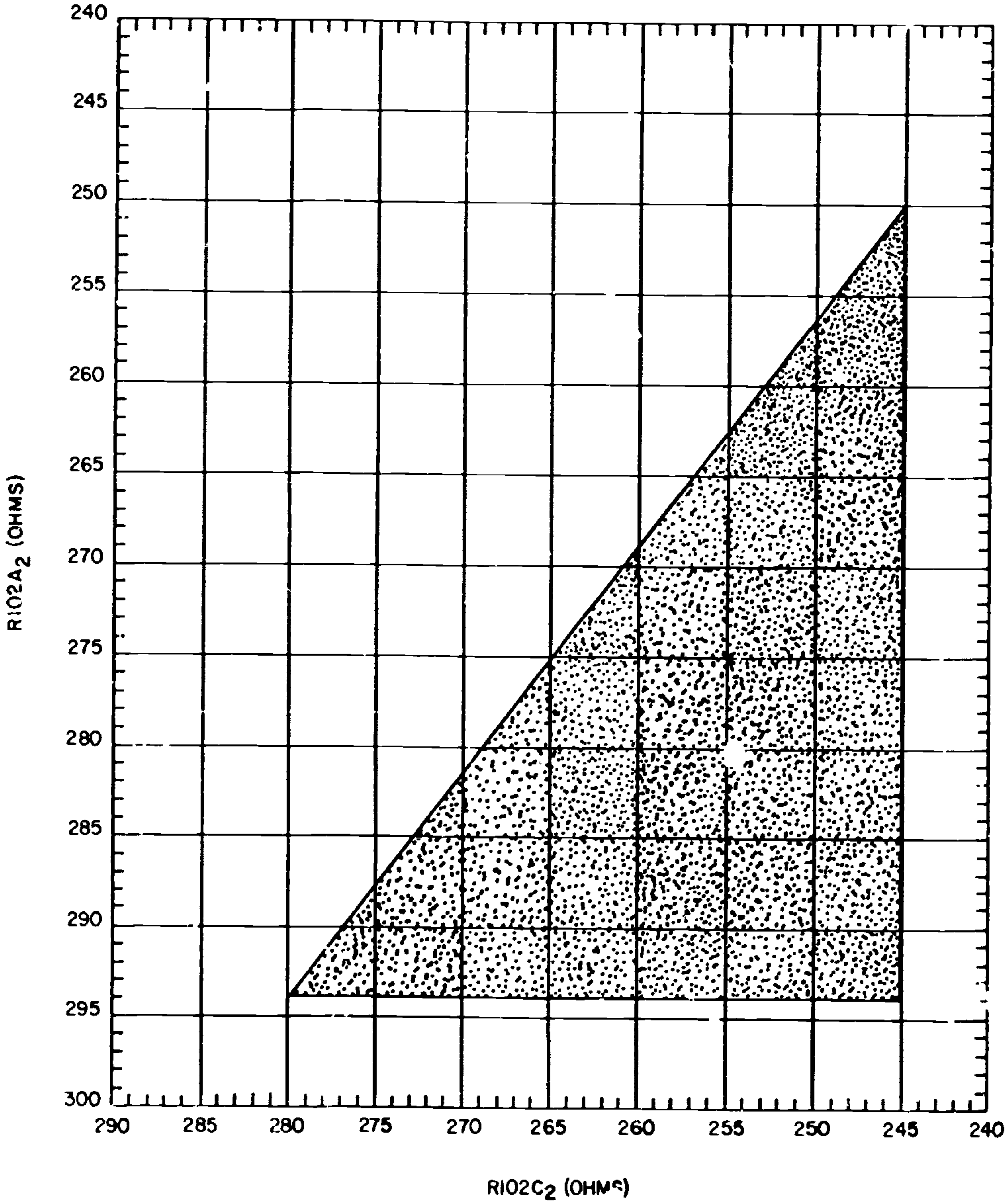


Figure 16.

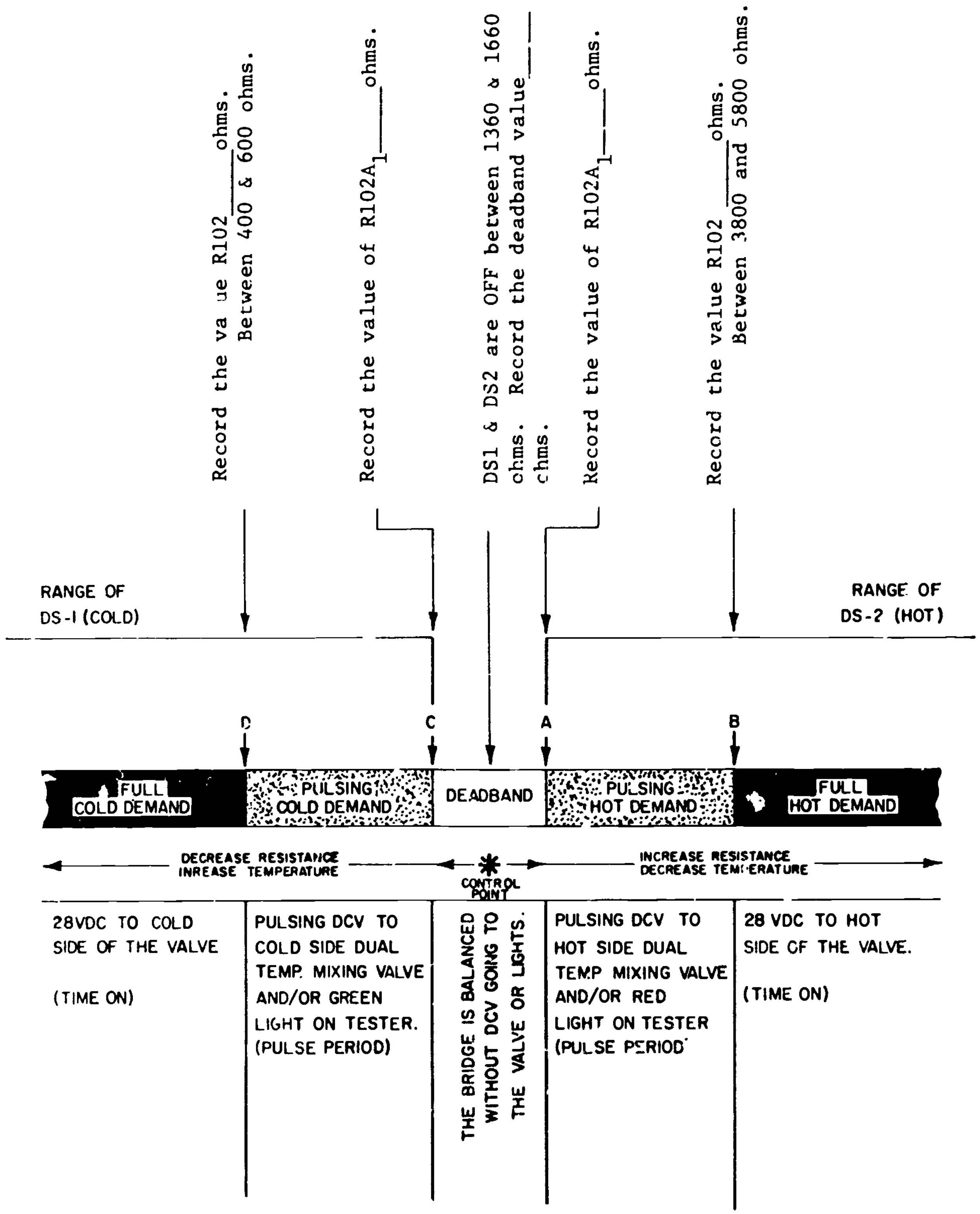


DEFOG ON - LIMITS OF DEADBAND

Figure [illegible].

PROBLEM 1

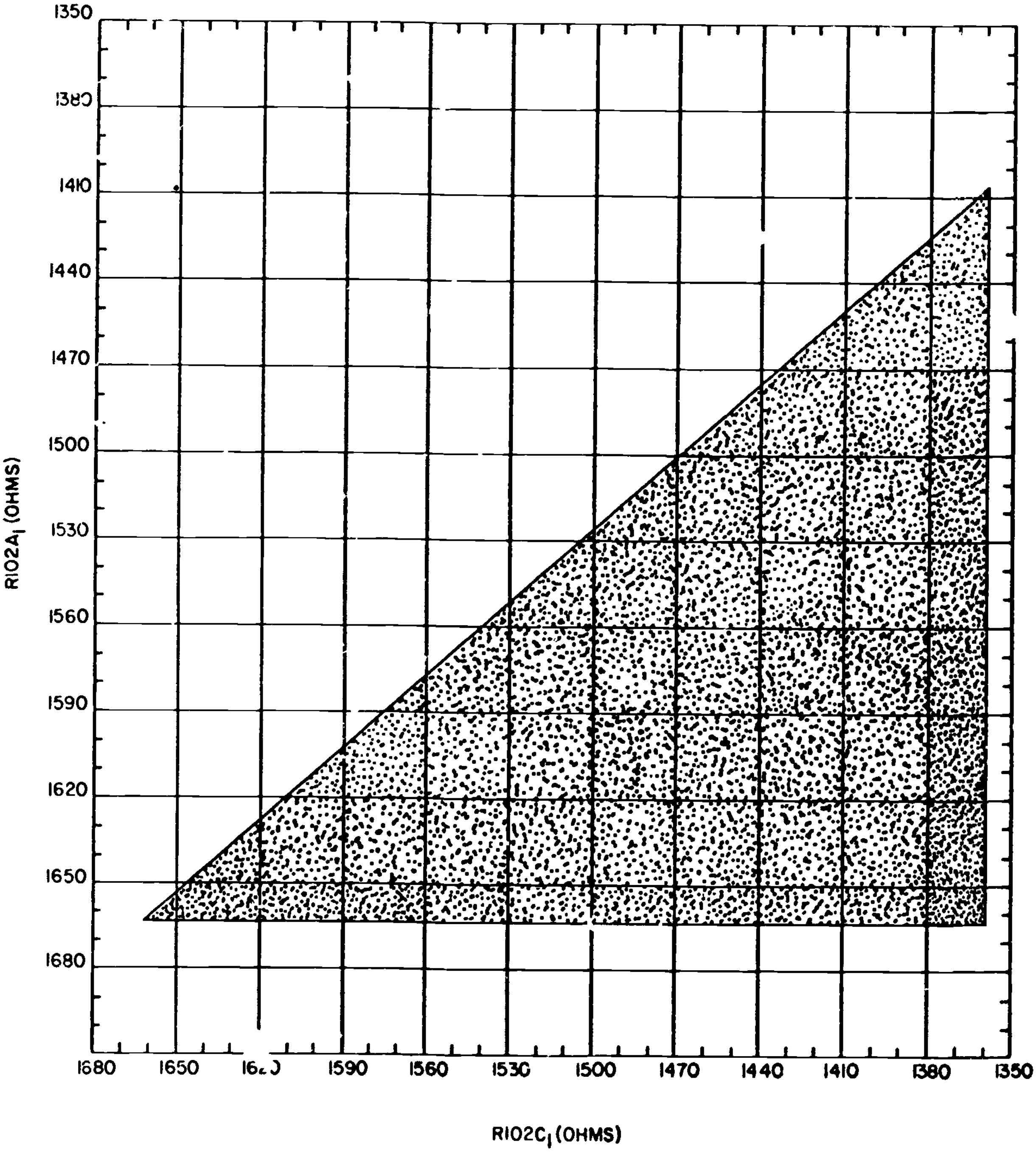
PERFORMANCE EXERCISE



1435

PROBLEM 1

PERFORMANCE EXERCISE



DEFOG OFF - LIMITS OF DEADBAND

Figure 19.

PROBLEM 1

PERFORMANCE EXERCISE

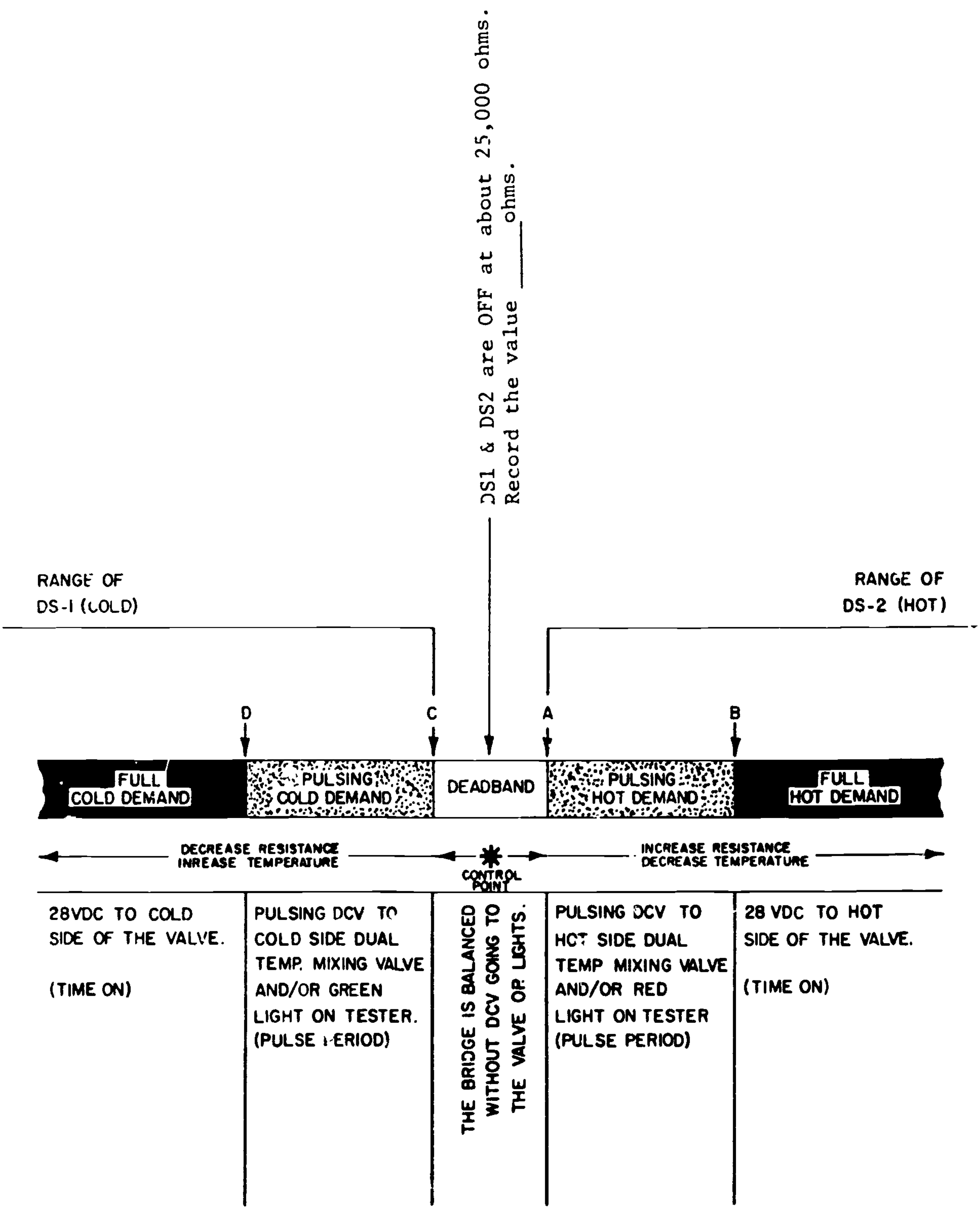


Figure 20.

1437

PROBLEM 1

PERFORMANCE EXERCISE

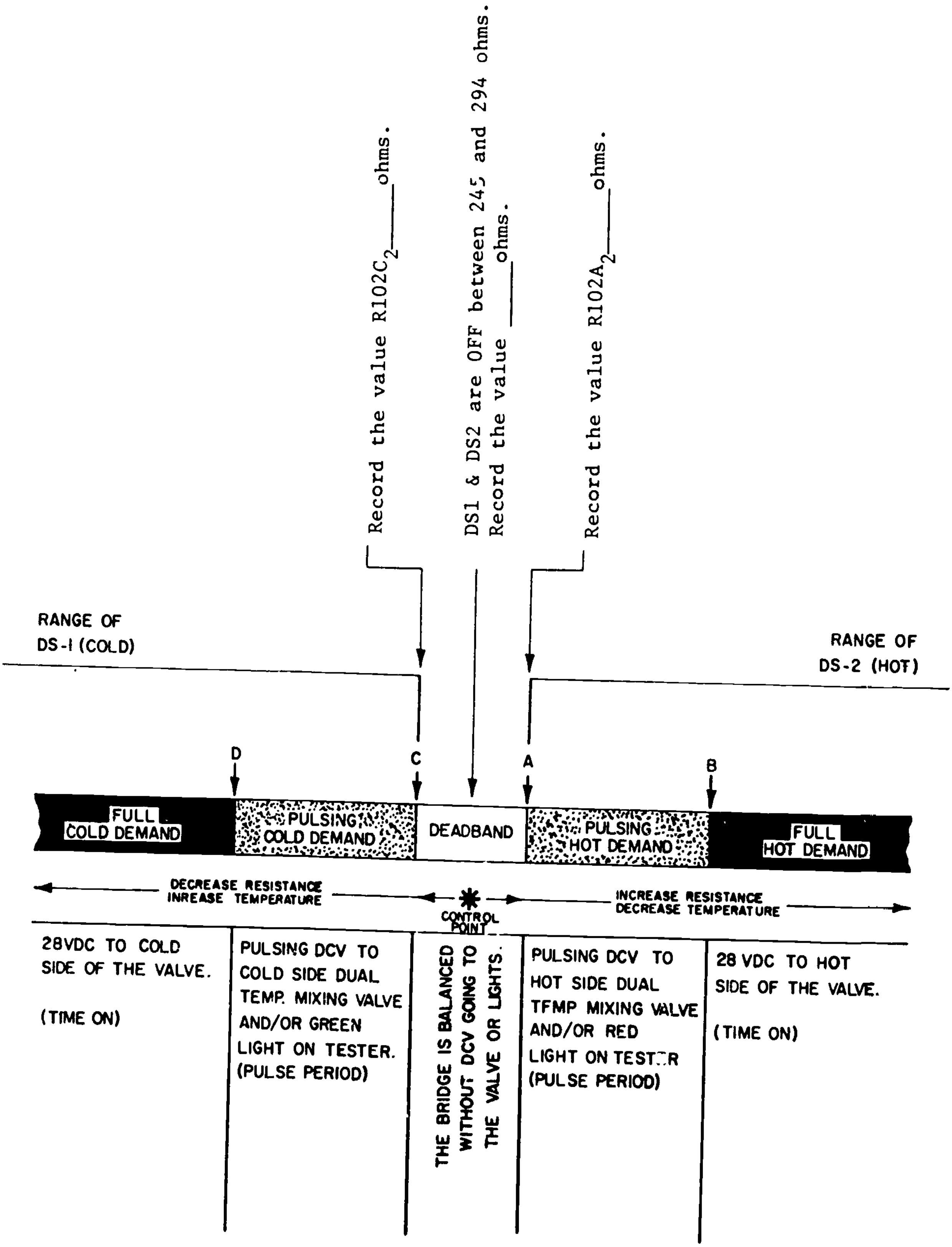
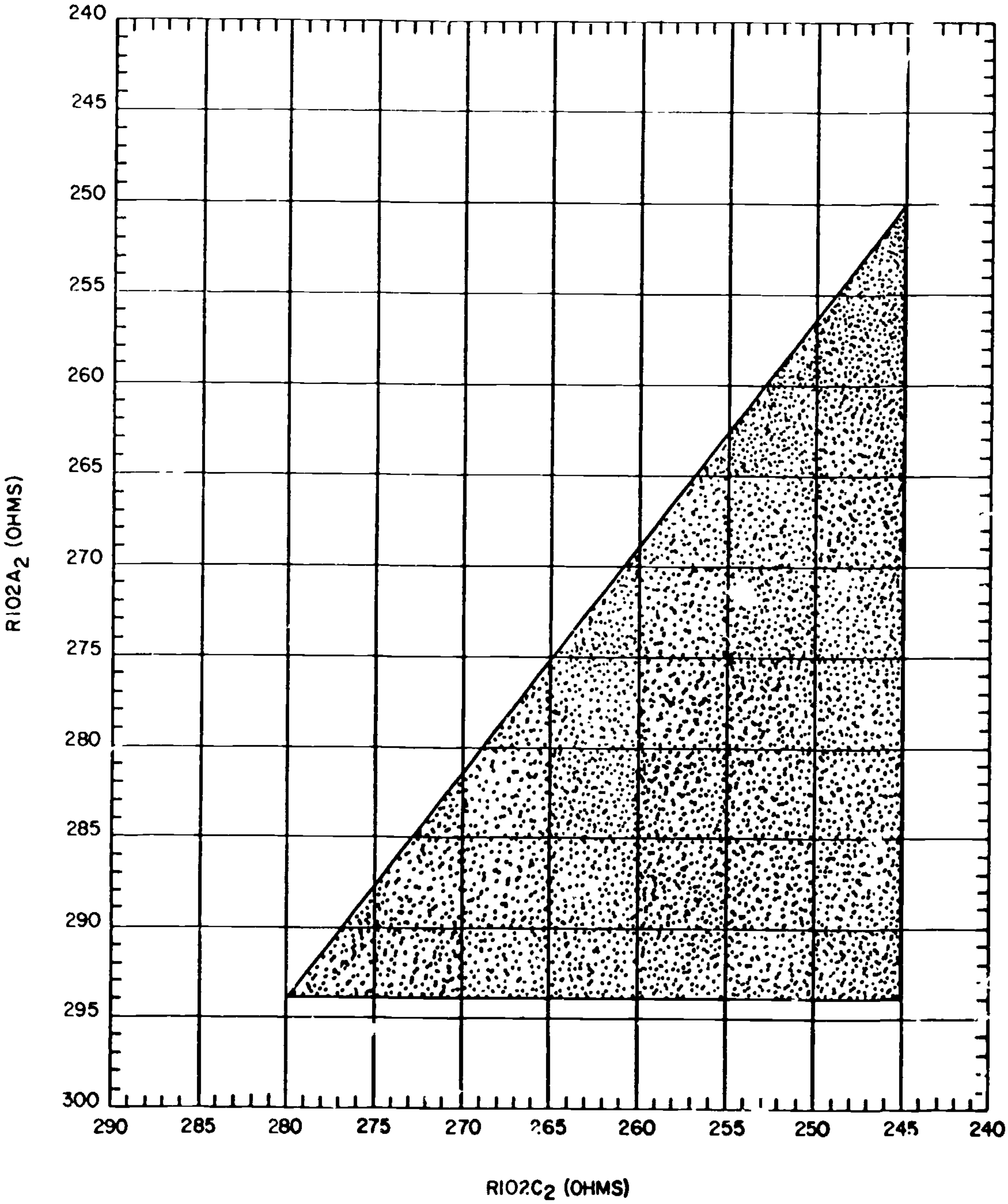


Figure 21.

1438

PROBLEM 1

PERFORMANCE EXERCISE



DEFOG ON - LIMITS OF DEADBAND

Figure 22.

Technical Training

Aircraft Environmental System Repairman

FIGHTER CABIN AIR CONDITIONING SYSTEM
WIRING DIAGRAM

30 January 1984

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

Designed for ATC Course Use.

Do Not Use on the Job. RCL: N/A

Environmental Pneudraulics Branch
Chanute AFB, Illinois

FIGHTER CABIN AIR CONDITIONING SYSTEM WIRING DIAGRAM

OBJECTIVE

Using a wiring diagram for the air conditioning system, specify causes for system troubles with a minimum score of 48 out of 60 total points.

EQUIPMENT

Colored pencils

INSTRUCTIONS

Pay close attention to all directions. After completing this lesson, you will be required to identify causes for system troubles with 80% accuracy on the attached diagram. If you are readv, and the instructor has already briefed you, begin.

FIGHTER CABIN AIR CONDITIONING WIRING DIAGRAM

INTRODUCTION

During this lesson, you will review the purpose of the system components and you will study the electrical circuity for the system operation, and troubleshooting various troubles. Be sure to read the instructions on this page before going further.

After the purpose of the components are explained, you will be required to respond in this workbook. If your response is incorrect, you should review the material or ask the classroom instructor for assistance.

At this time remove figure 5 from the back of the workbook and place it in front of you. You will be using this diagram throughout this lesson.

You will be required to troubleshoot this diagram at the completion of this lesson. If you have no questions turn to page 3 and begin.

Supersedes C3ABR42331-WB-202, 25 March 1983.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 200; DAV - 1

Locate the bleed air pressure regulator and shutoff valve in the upper right corner of the diagram. This valve serves as a shutoff valve and pressure regulator for the cabin air conditioning system. When closed, this valve shuts off the air flow. When open, it regulates air flow to the inlet side of the compressor turbine of the cabin air conditioning system. This valve is controlled by the emergency vent knob. Pushing the knob in, ies power to the solenoid and opens the valve, provided the eng leed air is available. When the knob is pulled out, power is remo d and the valve closes.

Frame 2

Locate the Landing Gear Auxiliary Relay, the Ground Cooling Ejector Shutoff Valve, and the Landing Gear Control Switch. The landing gear control switch is mounted on the landing gear handle and operates any time the gear handle is moved to the gear up or gear down position. The landing gear auxiliary relay is energized whenever the landing gear handle is placed in the gear down position. This pulls the relay armature down, completing the circuit, and applies 28V DC from pin C of the relay to pin A cr the open side of the ground cooling ejector shutoff valve motor.

Placing the landing gear handle in the gear up position deenergizes the landing gear auxiliary relay, moving the armature up, completing the circuit from pin A of the relay to pin B of the closed side of the ground cooling ejector shutoff valve motor.

Complete statements 1 through 6.

1. The bleed air pressure regulator and shutoff is controlled by the ____________ ____________ ____________.
2. When the emergency vent knob is pushed in, the bleed air pressure regulator is (energized/deenergized) ____________.
3. The bleed air pressure regulator controls airflow to the ____________ ____________ ____________ system.
4. The ground cooling ejector shutoff valve is actuated open when the landing gear handle is placed in the ____________ ____________ position.
5. The ground cooling ejector shutoff valve requires ________ ________ to operate.
6. The ground cooling ejector shutoff valve is actuated closed when the landing gear handle is placed in the ____________ ____________ position.

Refer back to figure 5.

Let's look at the temperature control system. The temperature control system includes the temperature controller, temperature sensor, cabin manual temperature limiter, and the cabin dual temperature mixing valve.

The temperature control system has an automatic and manual mode of operation. The temperature controller, located on the left side of the diagram, contains the magnetic amplifiers, the transistors, the temperature control switch, and the temperature selector rheostat.

The cabin temperature sensor, located in the bottom left center of the diagram, senses the temperature of the air entering the cabin. The sensor has a negative coefficient of resistance. This means that as the temperature goes up, the resistance of the sensor goes down; or, if the temperature goes down, the resistance will go up. This sensor forms one leg of the bridge circuit and is only used during the automatic mode of operation.

The cabin manual temperature limiter is located next to the cabin temperature sensor. It is a normally closed thermal switch and will open when the temperature of the air going to the cabin exceeds 220 degrees F.

When the switch opens, power is interrupted to the hot side of the Cabin Dual Temperature Mixing Valve. As the air temperature goes down, the switch closes again, and power can be resupplied to the hot side of the mixing valve.

Complete statements 7 through 13.

7. The temperature control system has an ________________ and ____________ mode of operation.

8. The magnetic amplifiers, transistors, temperature control switch, and temperature selector knob are located in the ____________ ____________.

9. If the resistance of the sensor goes down, the automatic control circuit will call for __________ air.

10. The cabin temperature sensor is used only when in the ______________ mode of temperature control.

11. The cabin temperature sensor makes up part of the ______________ circuit.

12. The cabin manual temperature limiter switch opens, the pilot is unable to select ____________ ____________ ____________ ______________.

13. The cabin manual temperature limiter is a normally ____________ (open/closed) thermoswitch.

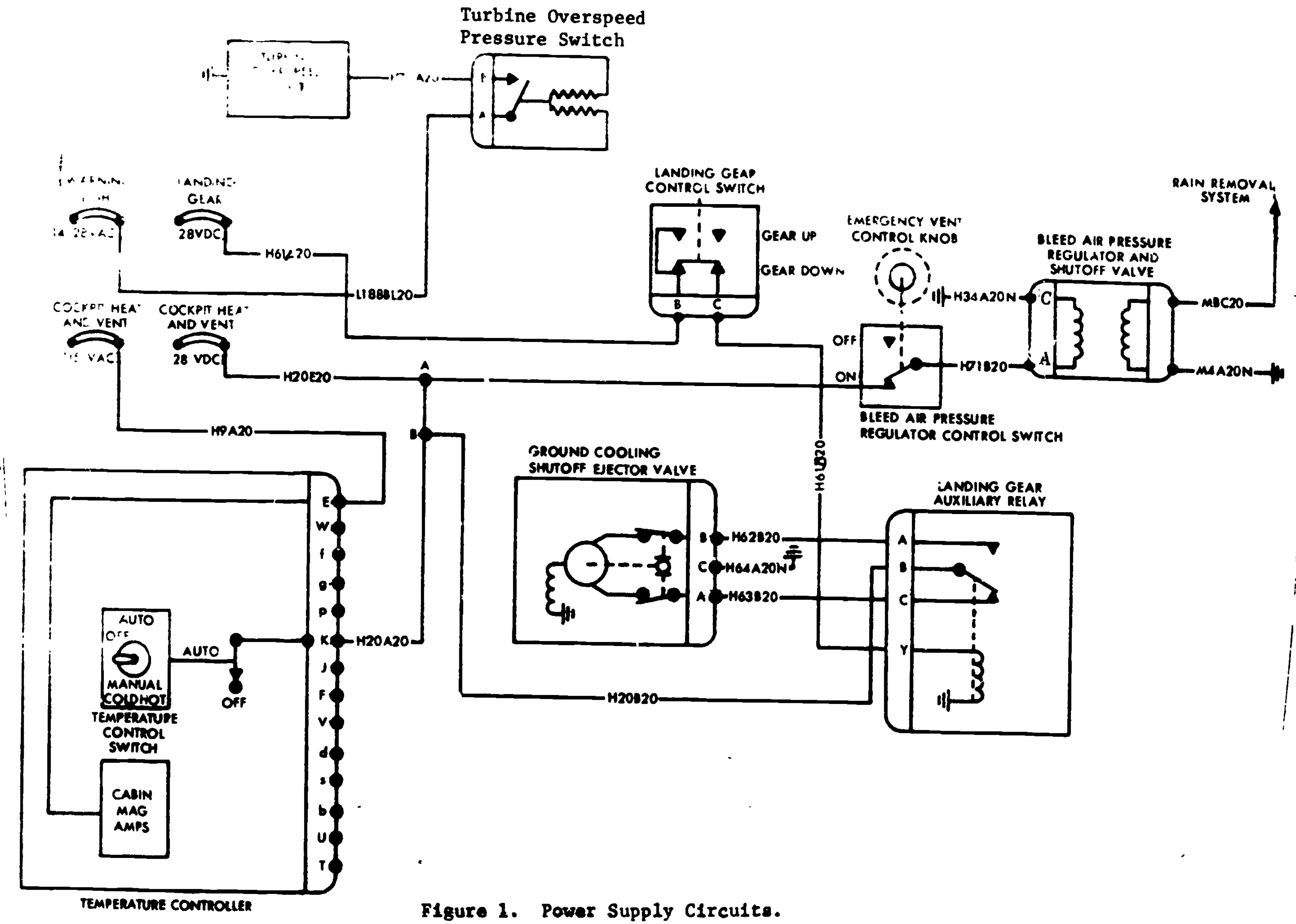


Figure 1. Power Supply Circuits.

BEST COPY AVAILABLE

You should now have an idea about the components of the complete system. Let's trace the individual circuits so that you can understand how each unit is controlled.

Turn to figure 1. This diagram contains the circuits that are energized when power is first applied to the aircraft. All switches are shown in their normal positions. Using your red pencil, trace from the 115 volt AC cockpit heat and vent circuit breaker to pin E to the temperature controller.

Now continue tracing the voltage from pin E to the cabin magnetic amplifiers. This power is used only when the temperature control system is operated in the automatic mode.

Locate the 28V DC cockpit heat and vent circuit breaker. Start at the circuit breaker and trace to the first junction marked A. Trace from junction A to the bleed air pressure control switch, through the switch, and to pin A of the pressure regulator and shutoff valve. Trace through the valve and out pin C to ground. This will energize the solenoid, which allows air pressure to open the valve. Since you are simulating the aircraft on the ground, you will also trace current to open the ground cooling ejector shutoff valve. Start at the 28V DC landing gear circuit breaker. Trace from this circuit breaker to pin B of the landing gear control switch, through the landing gear control switch, out pin C to pin Y of the landing gear auxiliary relay. Trace through the relay coil to ground. This will energize the relay, pulling the armature down. Now return to junction point A. Trace from this point to junction point B.

Now, go down and to the right until you reach pin B of the landing gear auxiliary relay. Since you have already energized this relay, current will flow through the relay armatures, out pin C to pin A on the ground cooling ejector shutoff valve. This valve will open and aid in drawing ram air across the heat exchanger.

Return to junction point A. Trace down to pin K of the temperature controller and to the center armature of the temperature control switch. This provides 28V DC power for the automatic and manual modes.

Locate the warning light circuit breaker. Trace from this circuit breaker to pin A of the turbine overspeed pressure switch. This puts a power potential to the pressure switch. If the pressure on the inlet side of the compression turbine exceeds 100 psi, the switch will close, turning the warning light on.

This completes the power supply circuits that are energized when the power is first applied to the system.

Frame 4 (Continued)

Complete statements 14 through 22.

14. AC power is needed only when using ________________ mode of temperature control.

15. The ground cooling ejector shutoff valve opens when the landing gear handle is in the ________ ________ position.

16. ____________ ______ __________ power is supplied to the temperature control switch.

17. If wire number H20A20 were open, it would cause the ____________ ____ ______ __________ to be inoperative.

18. If wire number H20B20 were open, it would affect the _________ ___________ _______ _____ __________ ______________.

19. If wire number H9A20 were open, it would affect the ______________ mode of operation.

20. The entire system is inoperative, the most probable cause will be an open in wire number ____________.

21. If wire number H71B20 were open, the bleed air pressure regulator and shutoff valve would ______________ (open/close).

22. If wire number H61B20 were open, the valve that would be affected is the ____________ ______________ ___ ___________ __________ and it would run ____________.

TRACE THE POWER CIRCUITS ON FIGURE 5.

When you complete this lesson, all circuits on figure 5 should be traced. Pay close attention to the switch positions and components that receive power. Before continuing with the lesson, be sure you have traced the power circuits on figure 5.

If any of your answers were incorrect, review the material or ask your instructor for assistance. Check the circuits to make sure you understand the information, if your answers were correct, continue on with the lesson.

The circuits that you have traced will provide power to open the pressure regulator and shutoff valve and to open the ground cooling ejector shutoff valve and to send power (AC and DC) to the temperature controller.

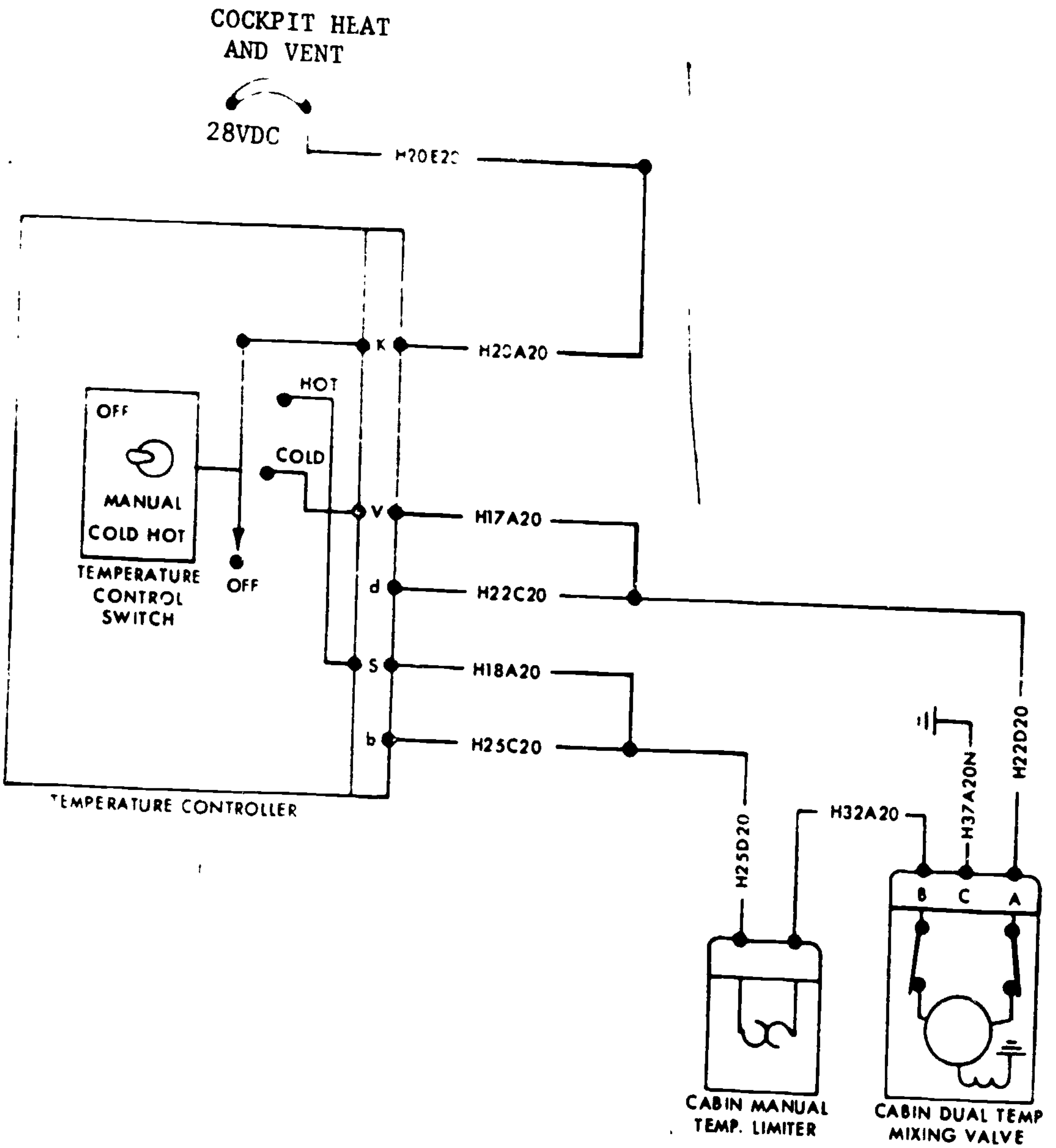


Figure 2. Cabin Mixing Valve, Manual Circuits.

Frame 5

Now turn to figure 2. The circuits for manual Hot and Cold have been added. Use a light green pencil to trace the manual Hot circuit. First, draw the temperature control switch to the manual Hot position. Trace from the switch, out pin S of the temperature controller, through the cabin manual temperature limiter, to pin B of the cabin dual temperature mixing valve out pin C to ground. This causes the valve to run to the hot position.

Remember, when the valve is in the hot position, the indicator on the valve will show "closed."

Now, return to the temperature control switch. Using a blue pencil, draw the switch to the manual cold position. Trace out pin V of the temperature controller to pin A of the cabin dual temperature mixing valve. This causes the valve to run to the cold position, the indicator will show "open."

Complete statements 23 through 27.

After completing the statements, go to figure 5 and trace the circuits that you have just traced on figure 2.

23. When the temperature control switch is placed in manual hot or cold,

    __________________ volts DC is supplied to the cabin dual temperature mixing valve.

24. If wire number H25D20 were open, the cabin dual temperature mixing

    valve could only be run to the _________ or _____________ position.

25. If wire number H22D20 were open, only auto and manual _____________ could be selected.

26. The cabin temperature limiter is a normally _____________ switch.

27. The cabin dual temperature mixing valve failed to open or close, one

    probable cause would be in wire number ____________ or ______________.

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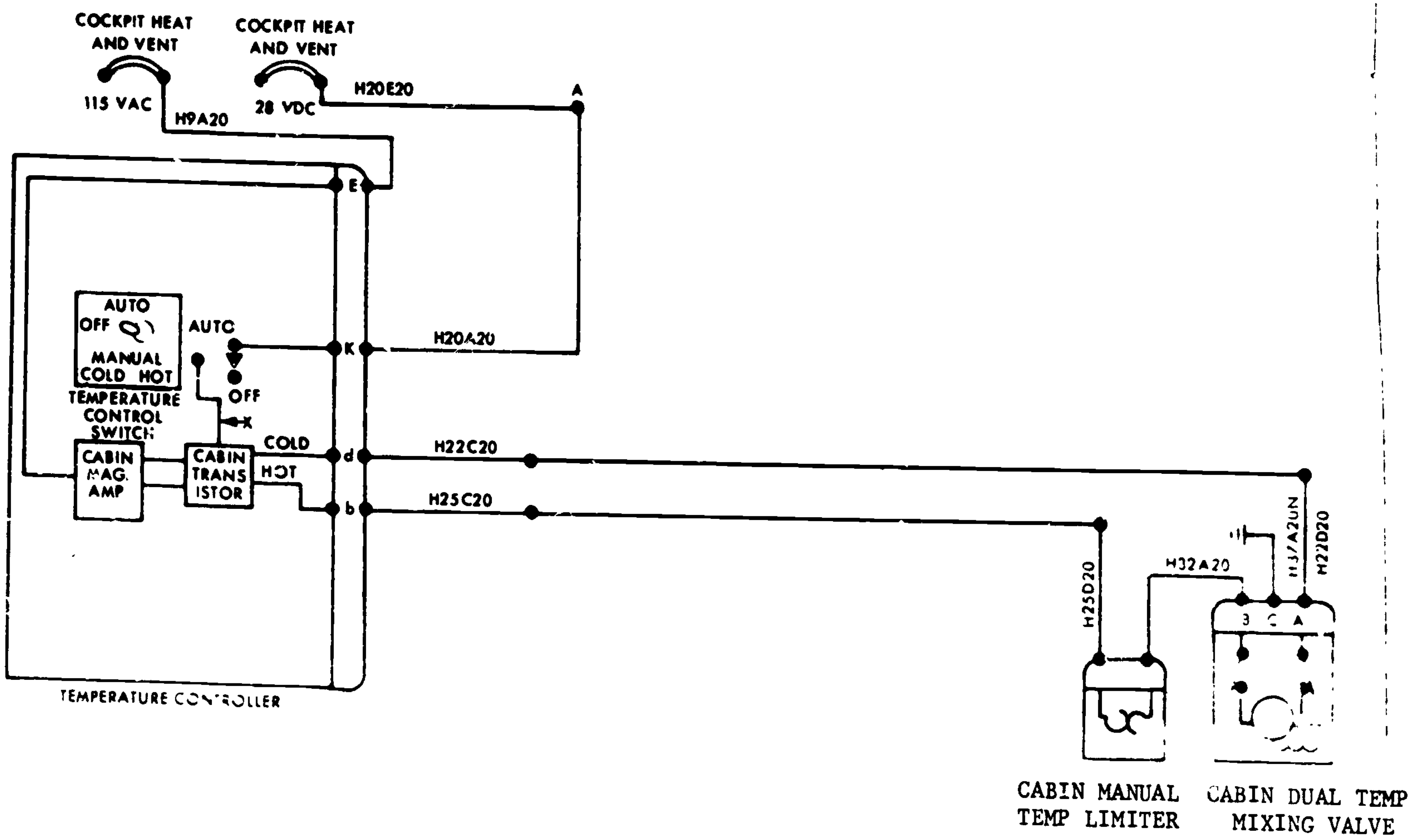

Figure 3. Cabin Mixing Valve, Automatic Circuits.

Frame 6

Turn to figure 3. Let's trace the circuits for the automatic operation of the cabin dual temperature mixing valve. Starting at the temperature control switch, use your orange pencil and draw the switch to the automatic position. Trace the circuit down to the cabin transistors. With power available to the cabin transistors from the magnetic amplifiers, the current can continue to the valve through one of the two circuits. Operation of the hot or cold transistors will direct the current flow. Let's trace the hot circuit first.

Start at the cabin transistor on the circuit marked "Hot." Using a dark green pencil, trace to pin b of the controller. Continue tracing to the cabin manual temperature limiter, through the limiter switch, to pin B of the cabin dual temperature mixing valve out pin c to ground will cause the valve to operate toward hot.

Return to the cabin transistors again. Using the purple pencil, trace the cold circuit to pin d on the temperature controller and to the cold side of the cabin dual temperature mixing valve. This will cause the valve to operate toward cold. The signal that determines if the hot or cold transistor will conduct comes from the bridge circuit which is covered later in the lesson.

Complete statements 28 through 34.

28. In automatic, the cabin temperature mixing valve receives power

when the ____________ transistors are conducting.

29. The cabin transistors receive DC power when the temperature control

switch is placed in ________________ position.

30. In order for the system to operate in automatic, 115V AC must be

applied to the ___________ ___ _______________ _______________.

31. If the cabin manual temperature limiter were open, the valve that

would be affected would be the _______________ __ _____________

_________________ ______________ ______________.

32. If wire number ___________ were open, automatic cold would be inoperative.

33. If the wire were open at junction point X, _________ temperature control would be inoperative.

34. The signal that determines if the hot or cold transistors will

conduct in the automatic modes comes from the ____________ circuit.

On figure 5, trace the operation of the cabin dual temperature mixing valve that you have just traced on figure 3.

If all of your answers are correct, continue with the lesson. Recheck the circuit if any of your answers are incorrect. The last circuit that you trace is the bridge circuit. Using figure 5 and a black pencil, trace the cabin bridge circuit by starting at the ground point of the cabin temperature selector. This is actually the ground end of resistor R8. Trace through R8, then through the temperature selector to junction point Y down through resistor R6 to pin P of the controller, then to the bottom of the footheat position. Trace through the switch to the cabin magnetic amplifiers. This circuit allows the pilot to select the desired temperature.

Go back to junction point Z. Trace from junction Z to pin A of the cabin temperature sensor, through the sensor, and out pin B. Then trace from pin B to pin T of the controller and into the cabin magnetic amplifiers. This circuit senses the air temperature entering the cabin and sends a signal to the cabin magnetic amplifiers.

Complete statements 35 through 38.

35. The pilot can automatically change the temperature in the cabin by

    changing the position of the __________ ________________

    _____________________.

36. The cabin temperature sensor senses the temperature of the air

    ____________ (entering/leaving) the cabin area.

37. An open in the sensor circuit will cause the system to call

    for ____________ air.

38. A short in the temperature sensor circuit will cause the system

    to call for ___________ air.

You have just completed tracing the Cabin Air Conditioning System Wiring Diagram. We will now do a Performance Exercise to check your knowledge, after completion of the performance exercise, see your instructor to start your performance test.

PERFORMANCE EXERCISE

Listed below are fifteen (15) questions pertaining to the wiring diagram you have just completed. Follow the directions for each part.

Place a T for True or an F for False in the blank provided for each statement.

_____1. The automatic and manual temperature control switch is used to select the desired temperature in automatic.

_____2. AC and DC power is required to operate the cabin temperature control system in the automatic mode.

_____3. Only DC power is required to operate the temperature control system in manual mode.

_____4. The cabin manual temperature limiter has a positive coefficient of resistance.

_____5. The ground cooling ejector valve helps draw ram air to flow across the heat exchanger when the aircraft is on the ground.

For questions 6 through 10 below, fill in the blanks.

6. A sensing element in which the resistance goes down when the temperature goes up is said to have a ______________________________ coefficient of resistance.

7. The cabin transistors will conduct when using the ____________________ mode.

8. The cabin temperature sensor has a _________________________ coefficient of resistance.

9. A short in a negative coefficient element would cause a ____________________________ resistance in the element. This would cause a demand for ________________________ air.

10. _____________________ and ________________________ _ power is needed for automatic operation of the cabin system.

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Select the description from column B and place the blank beside the component it best describes.

A		B
____11. Temperature control switch	a.	Contains the selectors and switches for operation of the cabin temperature control system.
____12. Landing gear control switch	b.	Controls the maximum temperature in the system.
____13. Temperature controller	c.	Supplies power to the cabin dual temp mixing valve.
____14. Cabin temperature sensor	d.	Controls the operation of the ground cooling ejector shutoff valve.
____15. Cabin manual temp limiter	e.	Controls the operation of the bleed air pressure regulator and shutoff valve.
	f.	Has a negative coefficient of resistance.

STOP: SEE YOUR INSTRUCTOR!!!!

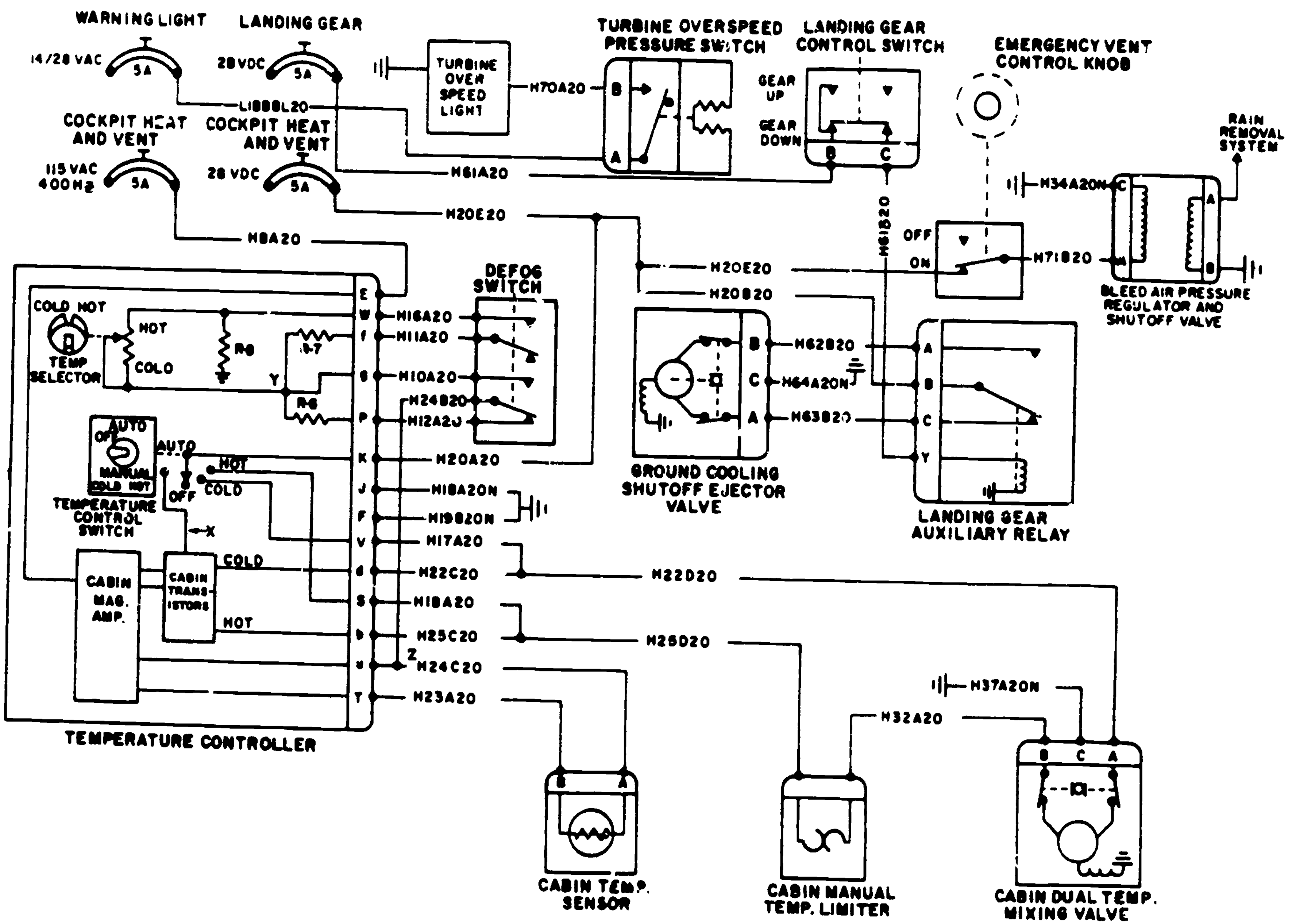
Instructor's Initials ______________________

Answers to WB-201

1. emergency vent knob
2. energized
3. cabin air conditioning
4. gear down
5. 28
6. gear up
7. manual and automatic
8. temperature controller
9. cold
10. automatic
11. bridge
12. automatic or manual hot
13. closed
14. automatic
15. gear down
16. 28 volts DC
17. automatic and manual
18. ground cooling ejector shutoff valve
19. automatic
20. H20E20
21. close
22. ground cooling ejector shutoff valve, closed
23. 28V DC
24. open or cold
25. hot
26. closed
27. H37A20N or H20A20
28. cabin
29. automatic
30. cabin magnetic amplifier
31. cabin dual temperature mixing valve
32. H22C20
33. automatic
34. bridge
35. cabin temperature selector
36. entering
37. hot
38. cold

Answers to Performance Exercise

1. F
2. T
3. T
4. F
5. T
6. negative
7. automatic
8. negative
9. low, cold
10. AC and DC
11. C
12. D
13. A
14. F
15. B



1458

Figure 4. Wiring Diagram Fighter Air Conditioning System.

18

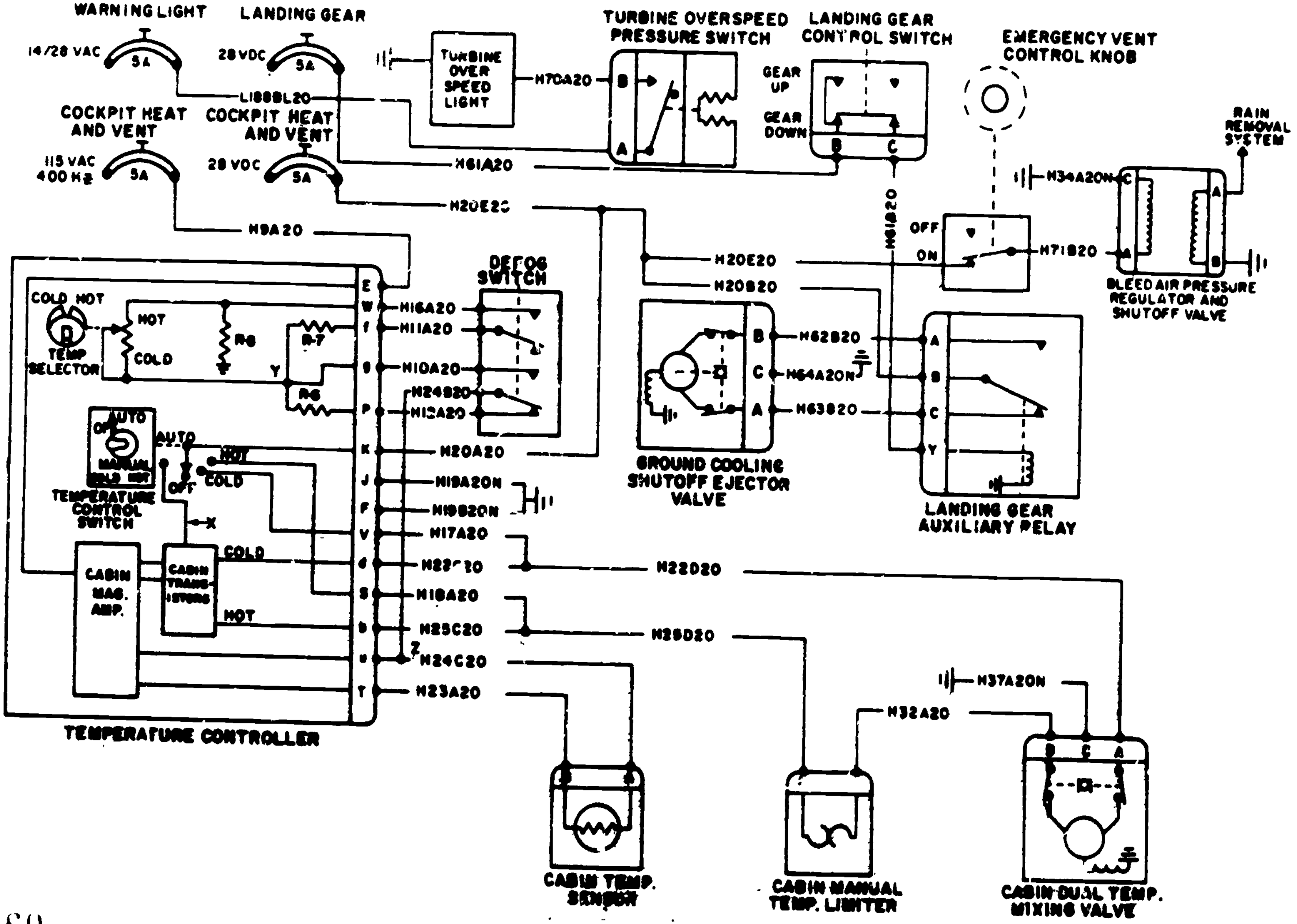


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Figure 5. Wiring Diagram Fighter Air Conditioning System.

BEST COPY AVAILABLE

Technical Training

Aircraft Environmental Systems Mechanic

FIGHTER CABIN AIR CONDITIONING SYSTEM

1 November 1983

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

RGL: 9.2

OBJECTIVE

After you complete this programmed text, you will be able to:

a. Relate a minimum of 8 out of 10 fighter cabin air conditioning system components to their operation.

b. Relate a minimum of 4 out of 5 defog system components to their operation.

INSTRUCTIONS

This programmed text presents information in small steps called "frames." After each frame you are asked to complete a statement or match some statements. Read the material presented and make your response as directed. After you have made your response, compare your answer with the correct answer given at the back of the text. If your answer is incorrect, restudy the frame to get the information correct. Write the answer next to your original response and then proceed to the next frame. If necessary, you may go back to check information previously given, but do not skip ahead.

This programmed text is divided into two sections. Have your instructor check your work after completing each section.

Supersedes C3ABR42331-PT-202A, 16 March 1983.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 300; DAV - 1

Frame 1

In your job as an Environmental System Mechanic, it is vital that you know how various types of aircraft air conditioning systems work. In one of your past lessons you learned about a trainer type aircraft air conditioning system. In this lesson, you will learn how a typical fighter aircraft air conditioning system works.

The fighter air conditioning system serves quite a few purposes. It will furnish conditioned air for crew comfort, windshield and canopy defrosting, and for cooling the electronic equipment found in the cockpit.

The fighter air conditioning system is similar to the trainer aircraft air conditioning system. That is, the fighter system will also get hot, high pressure bleed air from the engines and cool it through the use of a refrigeration unit. Look for and learn the differences in the parts used to control the airflow and temperature in this system. Remember, to do maintenance on an air conditioning system, you must first know how the system works.

Fill in the blanks to complete the following statements about the fighter air conditioning system.

1. It provides conditioned air for ____________________ and __________ defrosting.

2. It provides air for cooling the ______________ equipment located in the cockpit.

3. It provides conditioned air to the cockpit for __________ comfort.

4. It receives hot, high-pressure bleed air from the _______________.

Frame 2

In the fighter air conditioning system, the air conditioning components are grouped into an assembly called the "refrigeration unit." The two drawings on the opposite page are the front and back views of the refrigeration unit. The refrigeration unit consists of the following components, which are identified by corresponding numbers in the illustration.

1. Bleed air pressure regulator and shutoff valve.

2. Heat exchanger.

3. Ground cooling ejector shutoff valve.

4. Turbine overspeed pressure switch.

5. Flc limiting venturi.

6. Cabin dual temperature mixing valve.

7. Turbine assembly.

8. Water separator.

9. Anti-ice valve.

10. Anti-ice controller.

11. Lag chamber.

12. Engine bleed air duct.

13. Conditioned air outlet.

14. Ram air inlet.

15. Ram air outlet.

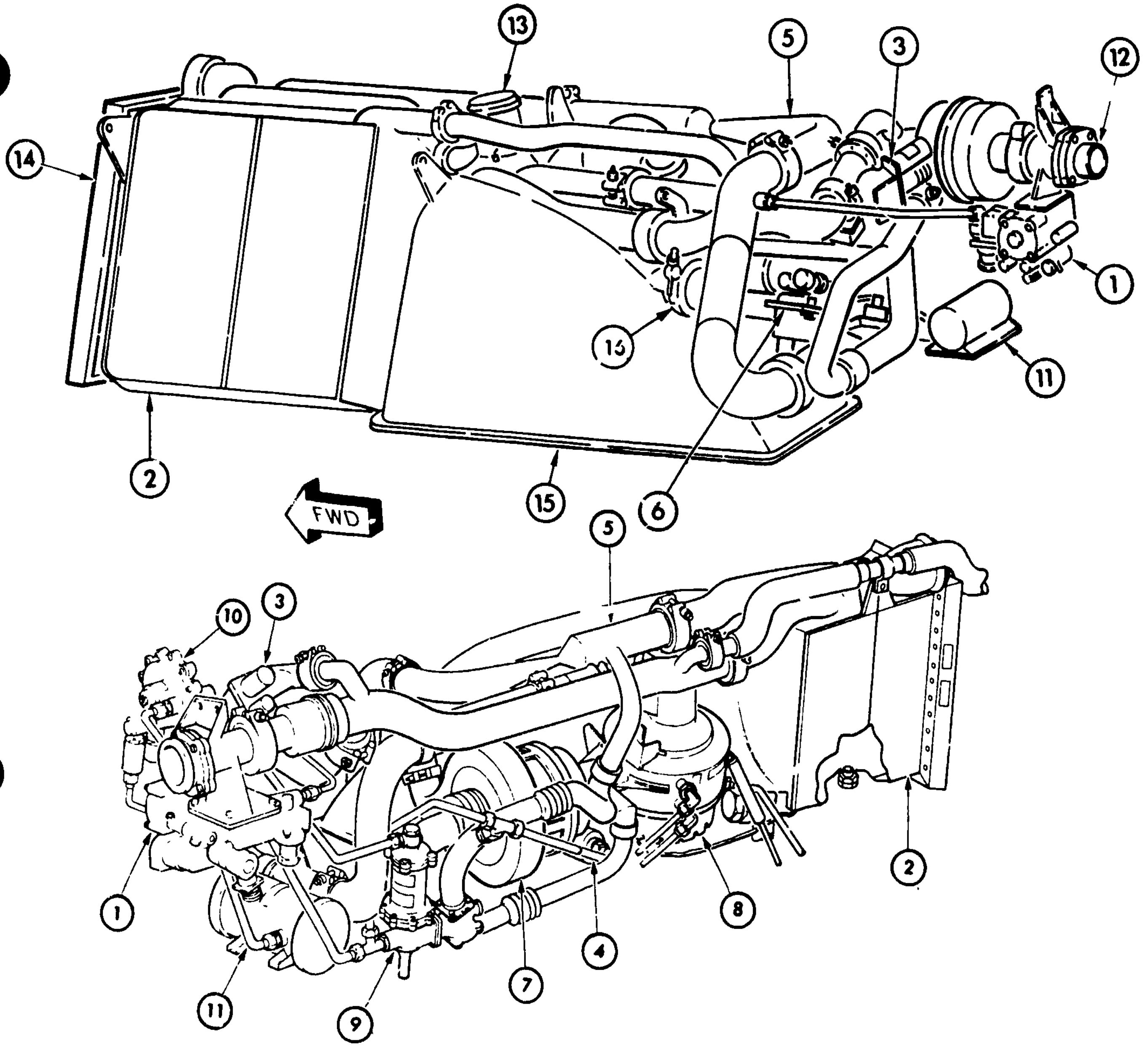
16. Rupture disc.

In the frames that follow, each of these components will be described. As each component is described, you should refer back to the illustrations of the refrigeration unit. This will help you see how each component makes up a part of this system.

The bleed air that enters inlet number 12 is from the bleed air manifold. Remember, this is hot, high-pressure air from the engine compressor.

NO RESPONSE REQUIRED

/ / / / / / / / / / / / / / / /



1. BLEED AIR PRESSURE REGULATOR AND SHUTOFF VALVE
2. HEAT EXCHANGER
3. GROUND COOLING EJECTOR SHUTOFF VALVE
4. TURBINE OVERSPEED PRESSURE SWITCH
5. FLOW LIMITING VENTURI
6. CABIN DUAL TEMPERATURE MIXING VALVE
7. COOLING TURBINE
8. WATER SEPARATOR
9. ANTI-ICE VALVE
10. ANTI-ICE CONTROLLER
11. LAG CHAMBER
12. ENGINE BLEED AIR INLET
13. CABIN AIR OUTLET DUCT
14. RAM AIR INLET DUCT
15. RAM AIR OUTLET DUCT
16. RUPTURE DISC

Frame 3

In a few of the following frames, small diagrams will be used to show you how the air flows through this system. These diagrams are simplified and will start by showing only part of the system. As you move on through this text, other parts will be added until the system is complete.

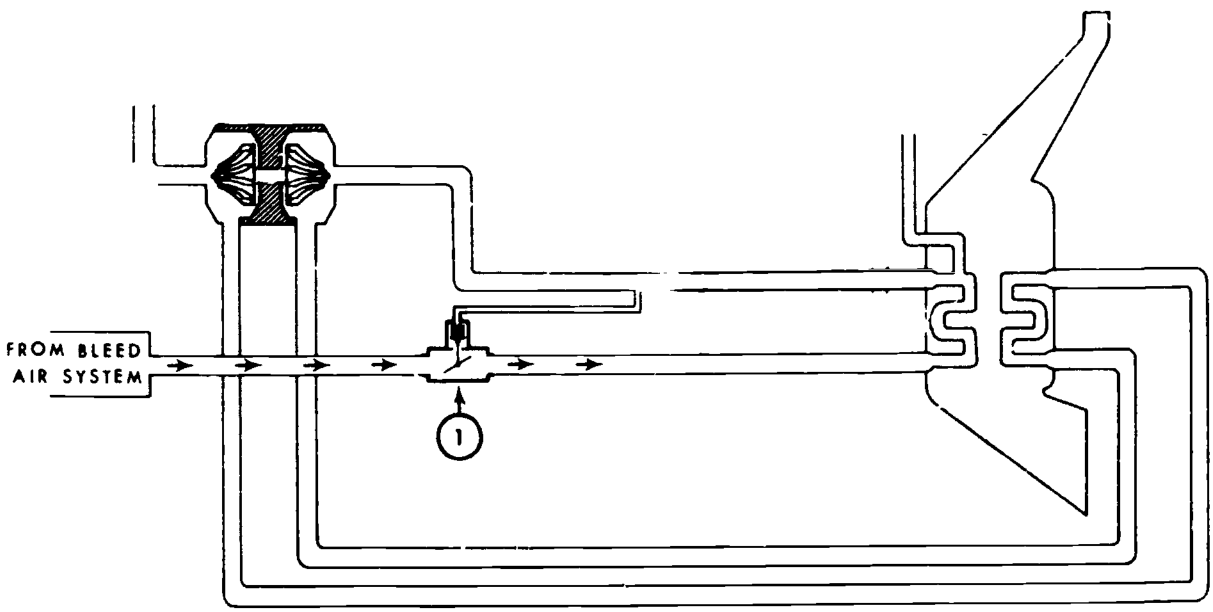
For example, the diagram below shows only the flow of air from the bleed air system to the turbine assembly. By following the airflow on these diagrams, it should make it easier for you to see how each part fits into this system.

From your studies of the trainer system, you should recall that the first part in the system was a shutoff valve. The fighter is similar; that is, it also has a valve to control the starting and stopping of airflow through the system.

The valve that does this task on the fighter system is the <u>bleed air pressure regulator and shutoff valve</u>.

Actually, as the name implies, this valve serves two purposes. It serves as a shutoff valve for the cockpit air conditioning system and it also serves to <u>regulate the air pressure</u> going through the air conditioning system.

During normal operation of the air conditioning system, this valve will regulate pressure at 62 psi. NOTE the location of this valve (number 1) in the schematic below.



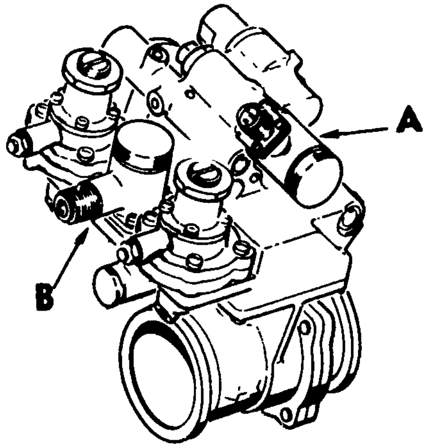
Fill in the blanks to complete the following statements.

1. The unit used to shutoff the air conditioning system is the bleed air pressure regulator and ____________ ______________.

2. The air going through the air conditioning system is regulated at 62 psi by the bleed air ______________ ____________ and shutoff valve.

The bleed air pressure regulator and shutoff valve is an air actuated, solenoid controlled valve. It is made up of a pneumatic actuator, butterfly valve, and two solenoids.

Engine bleed air that is used to operate the valve is taken upstream of the butterfly valve and led through the solenoid (marked "A" in the illustration) to the pneumatic actuator.



When this solenoid is de-energized, the air pressure is directed to close the valve. When the solenoid is energized, the air pressure is directed to open the valve. This will let airflow through the valve and to the air conditioning system.

The pressure of this airflow is regulated at 62 psi by the regulating portion of the valve.

The pressure in the duct is sensed by a sensing line before it enters the turbine assembly. When the pressure in the duct reaches 62 psi, the sensing line will allow this pressure to be applied to the regulating portion of the valve. This will cause the valve to adjust to a position (partially closed) that will maintain 62 psi in the system.

The second solenoid (marked "B" in the illustration) is used to reduce air conditioning system pressure to 40 psi when the rain removal system is operated. The rain removal system will be explained in a separate text.

Fill in the blanks to complete the following statements.

1. The bleed air pressure regulator and shutoff valve is controlled by a ______________.
2. The bleed air pressure regulator and shutoff valve is actuated by _________ ________________.
3. The bleed air pressure regulator and shutoff valve requires both __________ ____________ and ______________ power for operation.
4. The unit that controls air pressure for the air conditioning system is the bleed air ____________ ____________ and _________ ________.

Frame 5

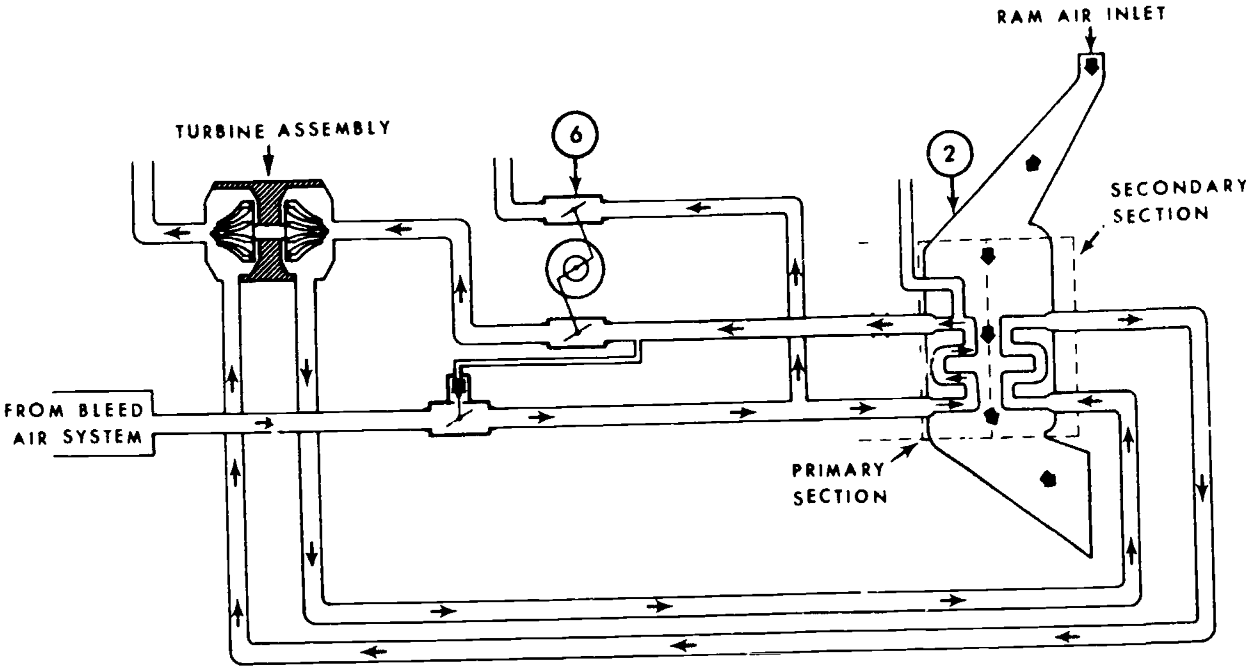
After the regulated bleed air flows through the pressure regulator and shutoff valve, it flows through the heat exchanger (number 2 in the illustration shown) and to the hot side of the temperature control valve (number 6 in the illustration).

On the illustration shown, note the path of airflow from the pressure regulator and shutoff valve to the heat exchanger and the path to the temperature control valve.

The heat exchanger is an air-to-air type and works on the same principle as the heat exchanger in the trainer aircraft air conditioning system. That is, it cools the engine bleed air by transferring heat from the bleed air to the ram air.

As shown in the illustration, this heat exchanger is divided into two sections; the primary, or hot bleed air section, and the secondary, or the compressor discharge section.

The hot engine bleed air is directed through the primary section for initial cooling. From there it flows through the turbine assembly and is then directed to the secondary section for additional cooling.



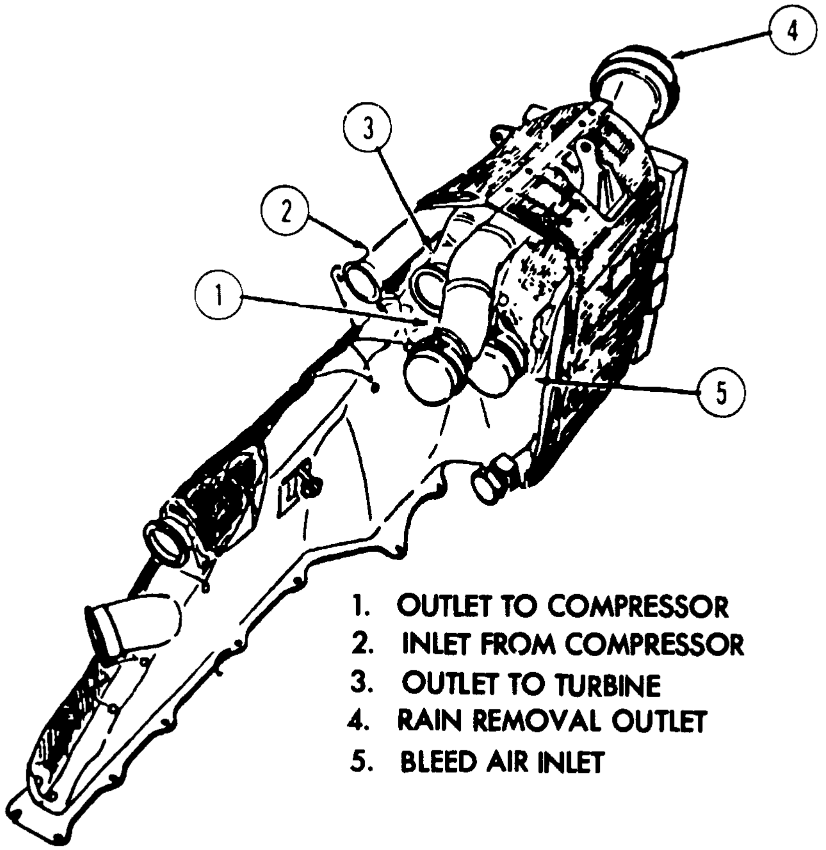
Fill in the blanks to complete the following statements.

1. The heat exchanger consists of the _______________ section and the ____________ section.

2. Initial cooling of the bleed air is accomplished by the ___________ section of the heat exchanger.

The illustration below shows the heat exchanger for the cockpit air conditioning and identifies the various connections. The engine bleed air from the pressure regulator and shutoff valve enters the primary air inlet (5), passes through the primary section of the heat exchanger and then to the compressor section of the turbine assembly (1). Air is also taken from the primary section of the heat exchanger for the rain removal system (4).

The air from the compressor section of the turbine assembly enters the secondary inlet (2), passes through the secondary section, and out to the expansion turbine through the secondary outlet (3).



Fill in the blanks to complete the following statements.

1. The primary section cools the air for the ____________ air conditioning system, and the ___________ removal system.

2. As the bleed air passes through the heat exchanger, the heat is transferred to the _________ air.

3. The air from the turbine assembly flows through the _____________ section of the heat exchanger.

Frame 7

In flight the forward movement of the aircraft gives plenty of ram air for the heat exchanger operation. But for ground operation, another means must be used to draw ram air across the heat exchanger.

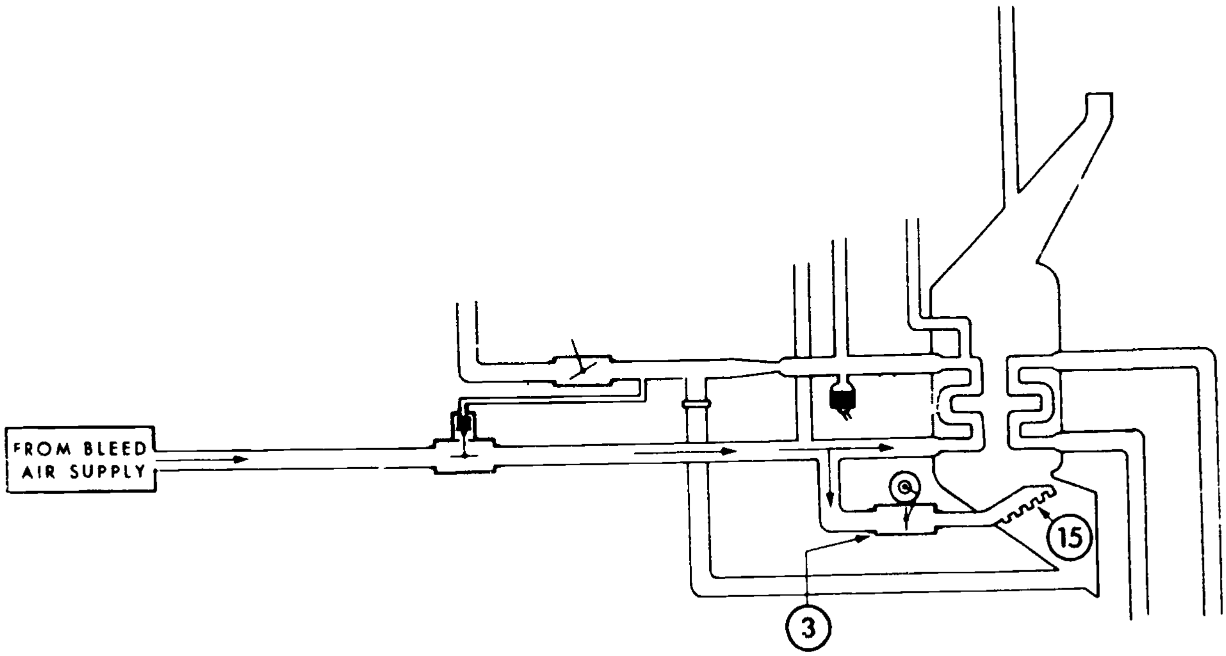
A ground cooling ejector assembly is used to boost the cooling efficiency of the heat exchanger while the aircraft is on the ground.

This assembly is made up of a ground cooling ejector shutoff valve (number 3 in the illustration) and the ejector nozzle (number 15). Find these two parts on the illustration shown.

Note that bleed air is tapped from the hot air duct before it goes in the primary section of the heat exchanger and is directed to the ground cooling ejector shutoff valve.

When this valve is open, engine bleed air is directed to the ejector nozzles. The ejector nozzles are located in the heat exchanger ram air outlet.

As the engine bleed air passes through the ejector nozzles it causes a low pressure area directly behind the nozzles. This low-pressure area helps to draw ram air across the heat exchanger. This will cause cooling (ram) air to flow over the heat exchanger, thereby increasing the cooling efficiency during ground operation.

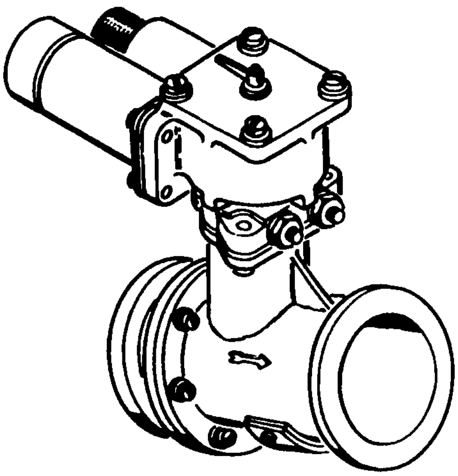


Fill in the blanks to complete the following statements.

1. During ground operation, ram airflow across the heat exchanger is caused by opening the ground cooling __________ __________ __________.

2. The ground cooling ejector assembly consists of a ground cooling ejector __________ __________ and an ejector ________.

The ground cooling ejector shutoff valve, shown below, is a motor operated, butterfly type of valve.



This valve controls the bleed air going to the ejector nozzles.

This valve is controlled by the landing gear auxiliary relay which receives its power from a switch on the landing gear handle. When the handle is in the gear down position, 28V DC power is directed to the landing gear auxiliary relay. This energizes the relay which will route power to the open side of the valve and move the valve to the open position. When the valve is open, bleed air flows through the ejector nozzles.

When the landing gear handle is in the gear up position, the landing gear auxiliary relay de-energizes and routes the power to the closed side of the valve. This will move the valve to the closed position and stop the air going to the ejector nozzles. In this way, the ejector assembly only operates when the landing gear handle is down, which is mainly during ground operation.

Fill in the blanks to complete the following statements.

1. The unit that controls the airflow to the ground cooling ejector

   nozzles is the ground cooling ___________ ___________ ___________.

2. The ground cooling ejector shutoff valve is controlled by the

   _______________________ _______________________.

3. For the ground cooling ejection system to operate, the landing gear

   handle must be _______________ (up/down).

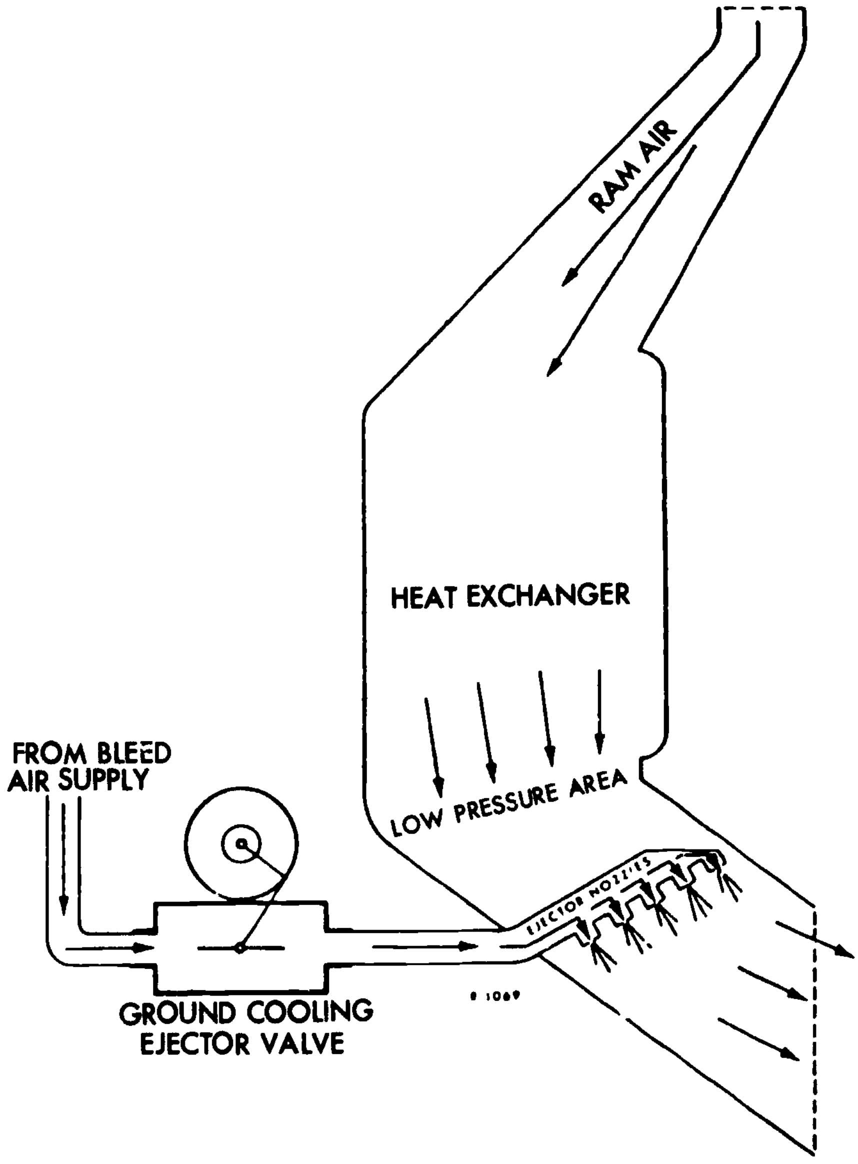
Frame 9

The principle of operation of the ejector nozzle is similar to a fan. A fan accelerates the movement of air by the design of the fan blades. As the fan moves the air it causes a low pressure vacuum area behind the fan. This causes more air to move toward the fan which results in a continuous movement of air behind the fan as well as in front of the fan.

The ejector nozzle assembly consists of several small air outlets (ejector nozzles). As the high-pressure air from the bleed air system is forced out through each of the ejector nozzles, it moves rapidly due to the high-pressure. This rapid movement of the air surrounds each of the nozzles.

The air movement causes a low pressure area behind the nozzles (similar to the operation of a fan). This causes the cooler outside air to move from the ram air inlet, across the heat exchanger, and be discharged at the ram air outlet.

Note the flow of air through the ejector and the heat exchanger in the illustration.



Fill in the blanks to complete the following statements.

1. Ram air is drawn across the heat exchanger by ejecting ___________ air through the ejector nozzles.

2. When bleed air is ejected through the ejector nozzles, it causes a ______ ____________ area behind the nozzles.

Frame 10

Match the units listed in Column "B" with the statements given in Column "A."

	Column A		Column B
1. _____	Directs engine bleed air to the ejector nozzles.	A.	Pressure Regulator and Shutoff Valve.
2. _____	Serves as a shutoff valve for the cabin air conditioning system.	B.	Heat Exchanger.
3. _____	Causes a low-pressure area in the heat exchanger ram air outlet.	C.	Ground Cooling Ejector Shutoff Valve.
4. _____	Opened only when the landing gear handle is in the gear down position.	D.	Ground Cooling Ejector Nozzles.
5. _____	Regulates system air pressure at 62 psi.		
6. _____	Transfers heat from t[illegible] bleed air to the ram air.		
7. _____	Actuated by air pressure and controlled by a solenoid.		

Complete the following statements.

8. When the solenoid of the bleed air pressure regulator and shutoff valve is energized, with air pressure available, the valve will ____________ (open/close).

9. The solenoid controls the pressure regulator and shutoff valve by controlling air pressure to the ________ ________ _____.

10. The pressure regulator and shutoff valve controls air ______________ in the air conditioning system, and also serves as a ______________ valve.

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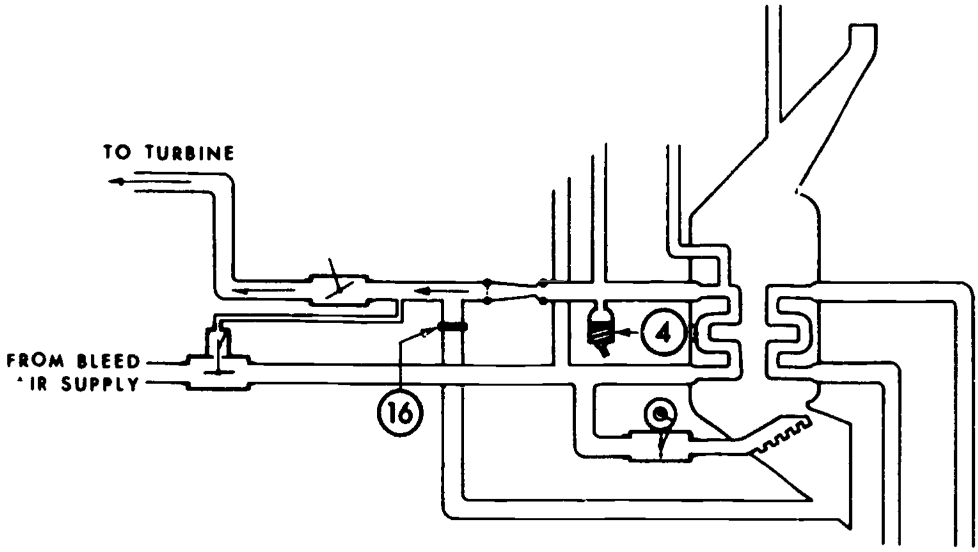
After the air is initially cooled by the primary section of the heat exchanger, it flows to the turbine assembly. The pressure of this air will be sensed by two safety devices which protect the system from damage caused by excessive pressure.

These two devices are the turbine overspeed pressure switch (number 4 in the illustration below) and the rupture disc (number 16). Notice the location of these two components in the illustration below.



The purpose of the turbine overspeed pressure switch is to alert the pilot of an excessive pressure condition by turning on a warning light in the cockpit. Should the pressure continue to build up, the rupture disc will blow out (rupture) and relieve the excessive pressure overboard.

Fill in the blanks to complete the following statements.

1. The two safety devices that are used to protect the system from damage caused by excessive pressure are the turbine overspeed __________ __________ and the __________ __________.

2. Should the pressure of the air going to the turbine become excessive, the turbine __________ __________ __________ will turn on a warning light.

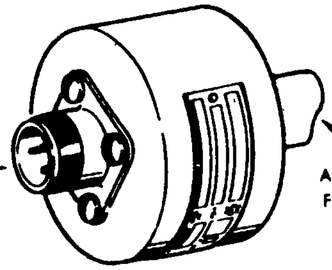
Frame 12

You should recall from frames 3 and 4 that the pressure regulator and shutoff valve is designed to keep pressure going to the turbine assembly at 62 psi. But, if this unit fails, the pressure could exceed 62 psi.

If the pressure gets too high it could cause the turbine to overspeed and cause damage to the heat exchanger or ducting. However, this pressure increase would be sensed by the turbine overspeed pressure switch.

The turbine overspeed pressure switch, shown below, is a sealed unit with electrical and air connections.

When the pressure reaches 100 psi, the pressure switch will complete an electrical circuit turning on the TURBINE OVERSPEED warning light in the cockpit. This will tell the pilot that the system pressure is too high.



The cause for the system pressure being too high could be a fault in the pressure regulating part of the pressure regulator and shutoff valve. It would not be regulating system pressure at 62 psi, but letting system pressure exceed 100 psi causing the switch to make contact, and thus, turning the warning light ON.

To prevent damage to the system, the pilot must do <u>one</u> of <u>two</u> things. He can reduce the engine throttle setting which will reduce the system pressure, or he can turn the air conditioning system off.

Remember, that the turbine overspeed pressure switch does not prevent the turbine from overspeeding, but it is used to alert the pilot of an overspeed condition.

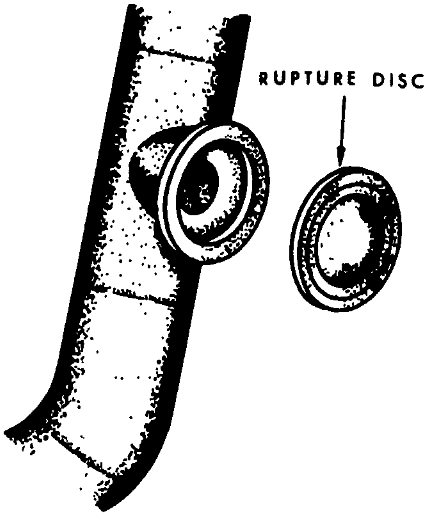
Fill in the blanks to complete the following statements.

1. When air pressure going to the turbine assembly reaches 100 psi, a warning light is turned ON by the ________ ____________ ________ __________.

2. If the turbine overspeed warning light comes ON, damage to the system is prevented by the __________ reducing the throttle setting.

3. The turbine overspeed warning light coming ON indicates a malfunctioning ________ ________ ________ ________ _____ ________ ________.

The rupture disc, illustrated below, is designed to rupture at 100 psi. During an overspeed condition if the system pressure is not reduce soon enough, or if it cannot be reduced for some reason, and pressure continues to build up, the rupture disc, will rupture at 100 psi and allow system pressure to bleed overboard thru the heat exchanger.



The pressure buildup would be caused by a malfunction in the regulating portion of the pressure regulator and shutoff valve.

This would require that you, as a maintenance man, to remove and replace the pressure regulator and shutoff valve and the rupture disc.

Note in the illustration in frame 11, that when the disc (16) ruptures, the system air will flow thru a duct and out thru the heat exchanger ram air outlet.

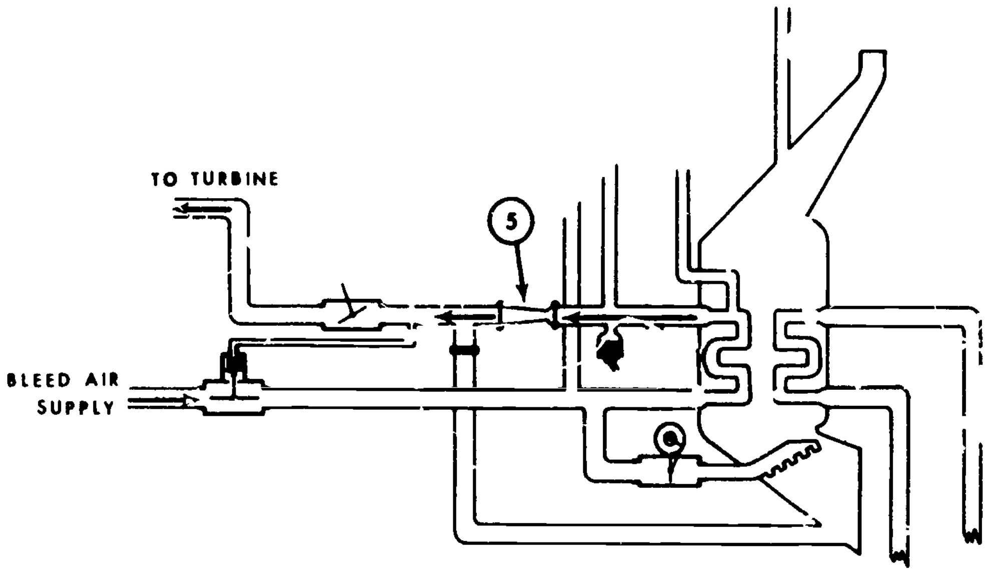
Fill in the blanks to complete the following statements.

1. If the pressure of the air going to the turbine should exceed 100 psi, the ____________ _________ will rupture.

2. If the rupture disc should rupture, the bleed air is discharged through the heat exchanger __________ __________ _____________.

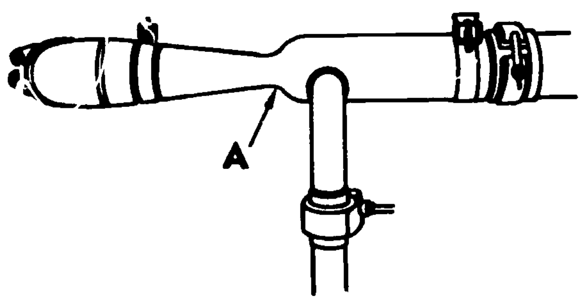
Frame 14

The air that flows from the heat exchanger to the turbine assembly passes through a flow limiting venturi (number 5 in the illustration shown).



The flow limiting venturi serves two roles in the system. First, the venturi stops surges from getting to the turbine assembly by smoothing out the airflow as it passes through the venturi. Second, it stops a complete loss of air pressure if the rupture disc should fail. This will insure some air pressure is available for operation of the auxiliary air systems.

The flow limiting venturi is shown below. It is similar to a section of ducting except that part of this unit is smaller (note the section where arrow "A" is pointing). This is called the throat of the venturi.



Because the throat is smaller, the venturi will curb (restrict) the amount of air that can pass through it. By limiting the airflow through it, it will smooth out any pressure surges.

Fill in the blanks to complete the following statements.

1. Pressure surges are prevented from reaching the turbine assembly by the flow ________ ________.

2. When the rupture disc ruptures, a complete loss of upstream pressure is prevented by the ________ ____ __ ______ ____.

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The partially cooled air from the primary section of the heat exchanger flows through the flow limiting venturi, then up to the cabin dual temperature mixing valve (number 6 in the illustration below).

The cabin dual temperature mixing valve controls the amount of hot and cold air going to the cockpit. Locate this valve in the illustration below.

Notice that this valve is a dual port valve; that is, it has two ports for air to flow through. Notice on the illustration that air can flow from the heat exchanger through one of the ports to the turbine assembly. This port is called the cold air port.

Also notice that airflow from a tapoff (marked A) on the hot air duct can flow through the opposite port. This port is called the hot air port.

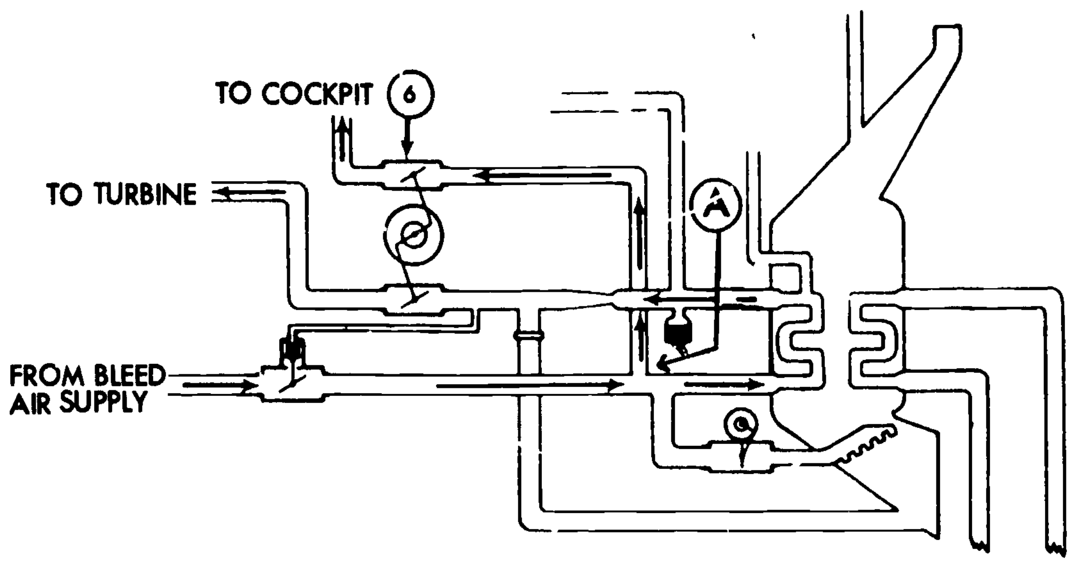
When the cold air port is closed and the hot air port is open, all of the airflow to the cockpit will bypass the heat exchanger and turbine assembly. This provides maximum hot air to the cockpit.

When the cold air port is open and the hot air port is closed, all of the airflow to the cockpit flows through the heat exchanger and turbine assembly. This provides maximum cold air to the cockpit.

When both ports are partially open a mixture of hot and cold air is delivered to the cockpit.

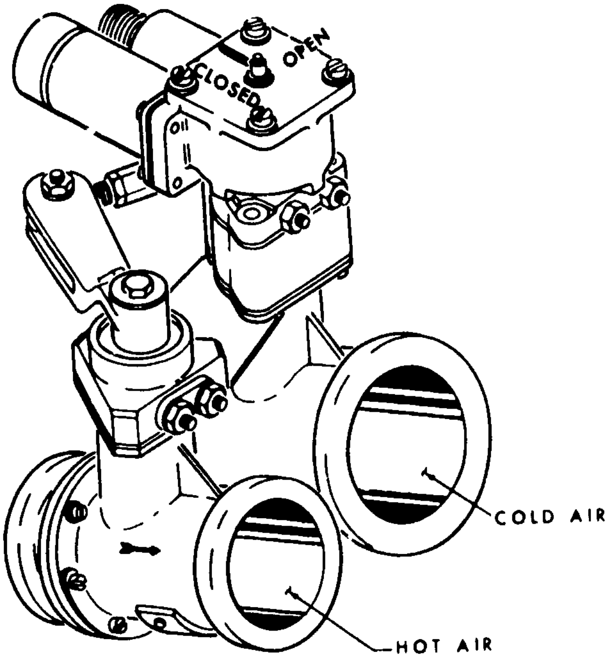
Fill in the blanks to complete the following statements.

1. The unit that mixes the hot and cold air to control cockpit temperature is the cabin ________ _______________ __________ _________.
2. To obtain maximum hot air for the cockpit, the cold air port is __________ (closed/open), and the hot air port is _________ (closed/open).



Frame 16

The cabin dual temperature mixing valve, illustrated below, is a dual butterfly, motor operated valve.



Note that both butterflies are actuated by the same motor.

The butterflies are connected together by a mechanical linkage.

When the cold air butterfly moves toward closed, the hot air butterfly moves toward open.

When the cold air butterfly moves toward open, the hot air butterfly moves toward closed.

This valve can be controlled by the temperature control switch or by the temperature selector. Actual control of this valve will be explained later in this text.

The indicator on the valve tells the mechanic only the position of the cold (larger) port.

If the indicator is "OPEN": the cold port is open allowing precooled air from the heat exchanger to enter the turbine, AND the hot port is closed stopping the hot airflow to the cabin.

If the indicator is "CLOSED": the cold port is closed stopping the precooled air from entering the turbine, AND the hot port is open allowing hot bleed air to enter the cabin.

If the indicator is BETWEEN open and closed: both hot and cold ports are open allowing hot and cold air to mix downstream of the valve.

Fill in the blanks to complete the following statements.

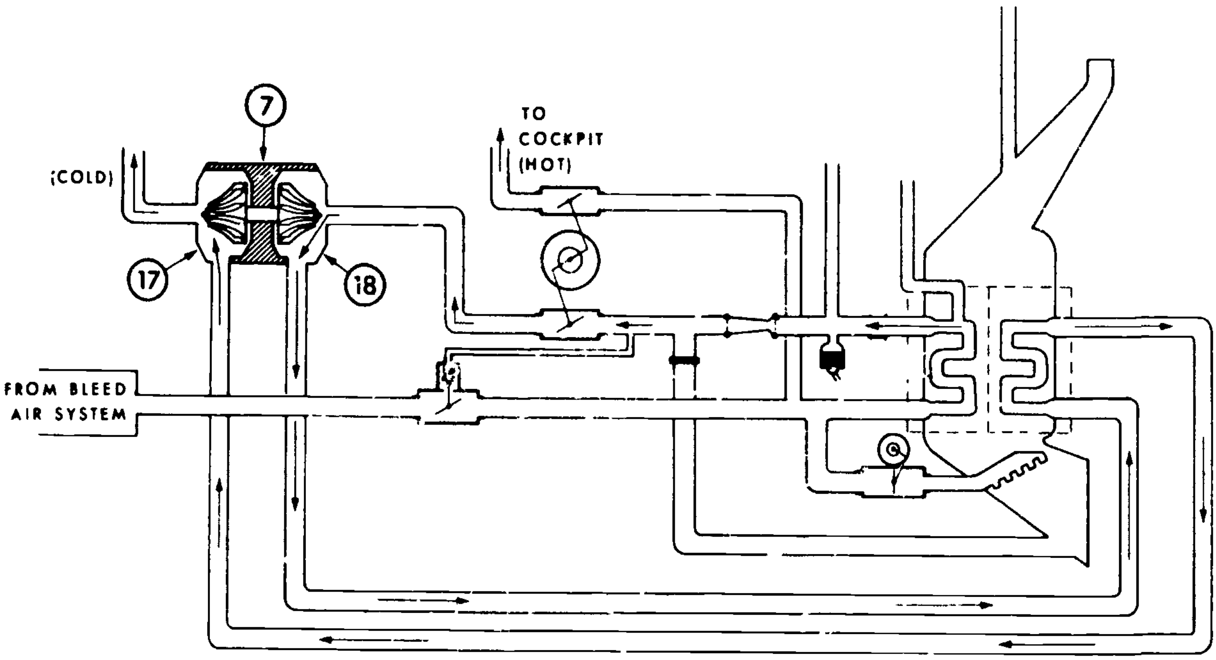
1. When both ports of the cabin dual temperature mixing valve are partially open, a mixture of _________ and __________ air will be delivered to the cockpit.

2. The cabin dual temperature mixing valve is actuated by an electric _______________.

3. The butterflies of the cabin dual temperature mixing valve are connected by a _________________ ____________________.

Frame 17

From the facts you gained on the trainer aircraft air conditioning system, you have no doubt guessed that the turbine assembly (number 7 in the illustration shown) is much the same as the turbine fan assembly.



This is half true. That is, it does cool air by rapid expansion and by converting heat energy to mechanical energy. But, instead of having a fan and a turbine, this assembly has <u>two</u> turbines. It has an expansion turbine (number 17) and a compressor turbine (num er 18).

Let's use the illustration shown to trace the airflow through the turbine assembly so that we can break down this unit's operation.

The air from the primary section of the heat exchanger flows through the compressor turbine where its pressure is increased. From the compressor turbine, the air flows to the secondary section of the heat exchanger, and from there to the expansion turbine.

Frame 17 continued

As the air flows through the expansion turbine, the pressure of the air will cause this turbine to rotate (turn). Since the expansion turbine and the compressor turbine are on a common shaft, the compressor turbine also rotates.

Fill in the blanks to complete the following statements.

1. The turbine assembly consists of a ____________ turbine and an ________________________ turbine.

2. The air flowing through the compressor turbine is from the ______________ section of the heat exchanger.

3. The air flowing through the expansion turbine is from the ________________ section of the heat exchanger.

Frame 18

It's important to note at this point that even though the air flows thru the compressor turbine first, this does <u>not</u> cause the turbine to turn. The air that flows through the expansion turbine compressor will cause the turbines to turn, or we can say the expansion turbine drives the compressor turbine.

For the expansion turbine to drive the compressor turbine, it must use energy. This energy is in the form of heat energy from the partially cooled bleed air.

In the course of driving the turbines, the heat energy is changed to mechanical energy.

By using the heat energy, the temperature of the air that flows through the expansion turbine is cut down.

In addition to using heat energy, the pressure of the air is rapidly decreased (expanded) which also helps to decrease the temperature.

Through this process of converting heat energy to mechanical energy, and rapidly expanding the air, the turbine assembly is able to deliver extremely cold air to the cockpit if it is needed.

Fill in the blanks to complete the following statements.

1. The compressor turbine is driven by the _________ _________________.

2. The turbine assembly cools the partially cooled bleed air by rapid __________________ and by converting _____________ energy to ____________________ energy.

The <u>compressor</u> <u>turbine</u> actually serves several purposes. It <u>compresses</u> the partially cooled air from the primary section of the heat exchanger. In doing so it puts a <u>workload</u> on the expansion turbine. The workload <u>uses</u> <u>the</u> <u>energy</u> from the bleed air and helps to <u>keep</u> <u>the</u> <u>turbines</u> <u>from</u> <u>overspeeding</u>.

The turbine assembly is illustrated below. This will help you to become familiar with the external appearance of this unit.

Fill in the blanks to complete the following statements.

1. The compressor turbine serves three purposes, they are;

   a. Helps to keep the turbine from ____________________.

   b. Uses energy from the bleed air by putting a _________________ on the expansion turbine.

   c. Serves to _________________ the partially cooled air.

Frame 20

You may be wondering why the compressor turbine is used to compress the air that was partially cooled by the primary section of the heat exchanger. Note on the illustration shown, that air from the primary section of the heat exchanger is also used for the rain removal system.

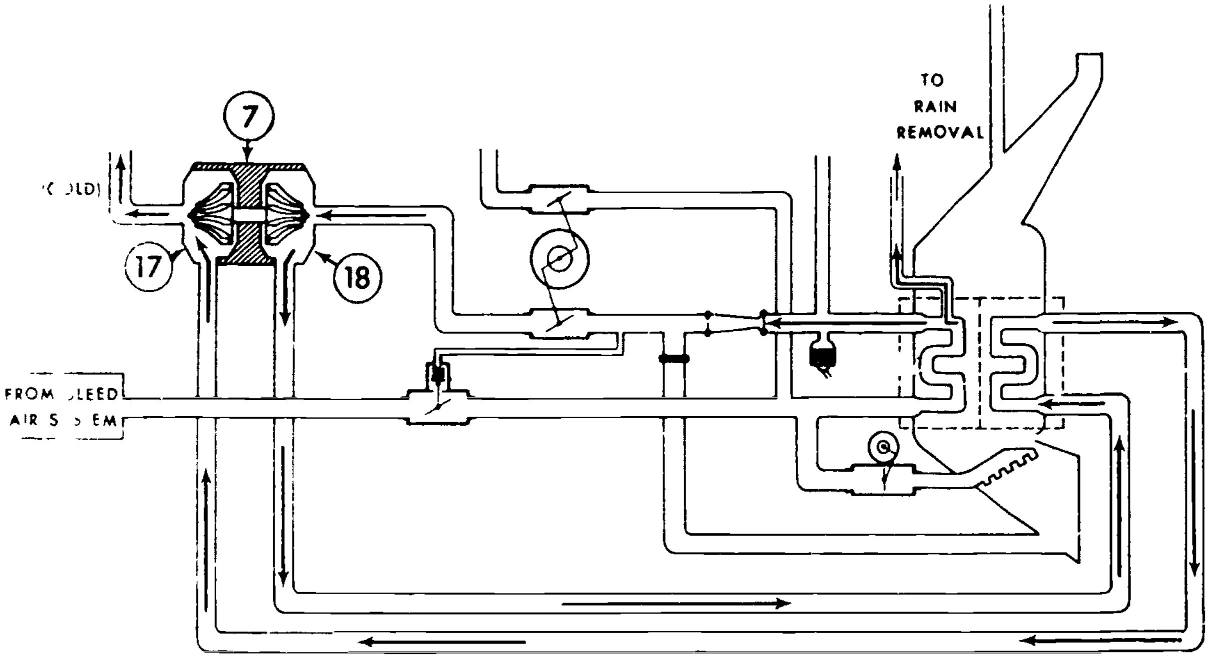
When the rain removal system is at work, it causes the pressure going to the turbine assembly to be cut down. Also, this aircraft is designed for operating at extremely high altitudes where the outside pressure is very low.

When the outside pressure is low, the air that comes from the bleed air system will also be low and could be less than the normal 62 psi.

For an expansion turbine to work efficiently, it needs air with enough pressure to turn it at very high RPMs. If the pressure should become too low this would not be possible. This is where the compressor turbine comes in. It increases the pressure so that the expansion turbine will operate efficiently.

Of course when the pressure is increased, the temperature is also increased. Notice that the air from the compressor turbine is routed to the secondary section of the heat exchanger where its partially cooled again.

From the secondary section of the heat exchanger it goes to the expansion turbine for final cooling.



Fill in the blanks to complete the following statements.

1. The bleed air from the bleed air system is first cooled by the ______________ section of the heat exchanger.

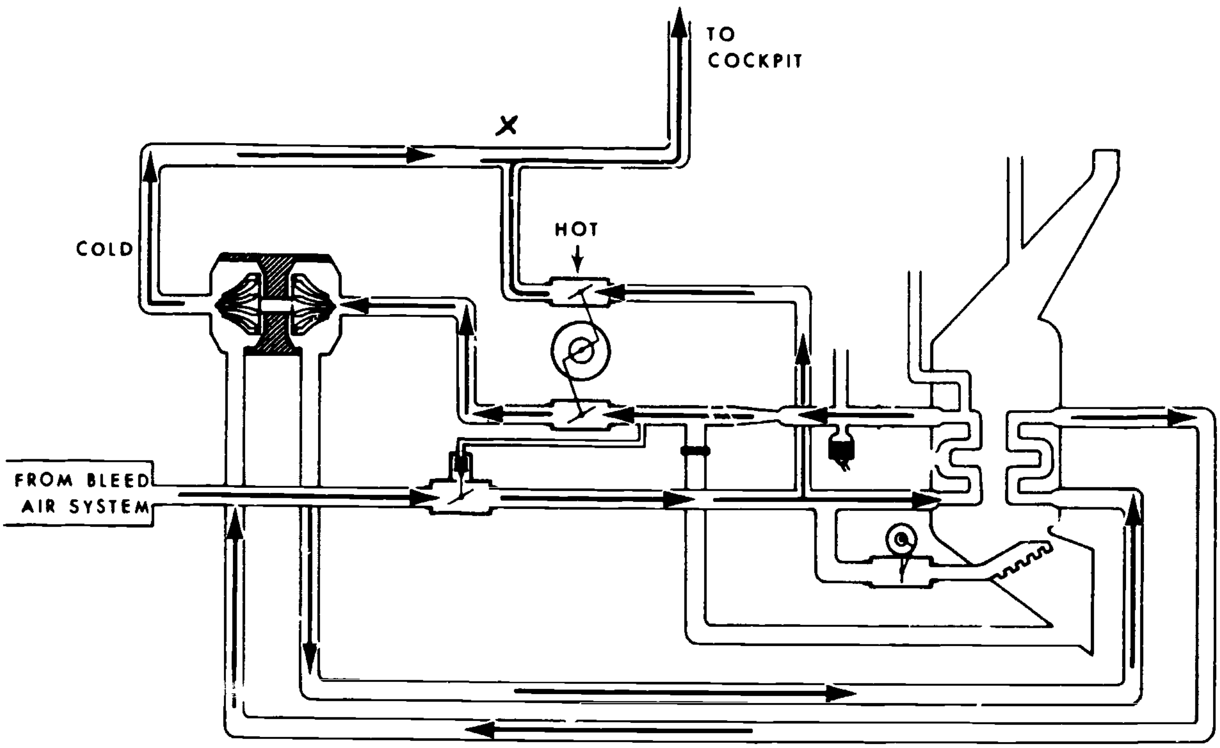
2. After the bleed air is cooled by the primary section of the heat exchanger it is compressed by the ____________ ____________.

3. The air from the compressor turbine is partially cooled by the ____________ section of the heat exchanger, and then further cooled by the ____________ ____________.

4. The reason for compressing the air with the compressor turbine is to increase the pressure so the ________________ turbine will operate more ________________.

Frame 21

The temperature of air in the cabin depends on the position of the cabin dual temperature mixing valve. Let's follow the airflow for the various temperature conditions on the illustration shown.



When maximum cold air is needed, the cold air port opens and the hot air port closes. This will cause all of the air to flow through the heat exchanger and turbine assembly before it goes to the cockpit. Note the path of air flow through the heat exchanger and turbine assembly on the illustration shown.

When maximum hot air is received, the cold air port is closed and the hot air port is open. This will cause all of the air to bypass the heat exchanger and turbine assembly. Note the path of airflow from the hot air duct, and through the hot air port of the dual temperature mixing valve.

When an intermediate temperature selection is needed, only part of the air will flow through the heat exchanger and turbine assembly. Part of the air bypasses these units. The hot and cold air then mixes at point "X," and flows from there to the cockpit. The arrows on the illustration above show the path of air to the point marked "X" where the air is being mixed.

NO RESPONSE REQUIRED

Frame 22

Match the units in Column "B" with the statements given in Column "A," by placing the letter from Column "B" in the blanks provided.

Column A	Column B
1. ____ Consists of an expansion turbine and a compressor turbine.	A. Turbine overspeed pressure switch.
2. ____ Motor operated dual butterfly valve.	B. Rupture disc.
3. ____ Smoothes out pressure surges.	C. Turbine assembly.
4. ____ A safety device to relieve excessive pressure.	D. Flow limiting venturi.
5. ____ Senses an overpressure condition and turns on a warning light.	E. Cabin dual temperature mixing valve.

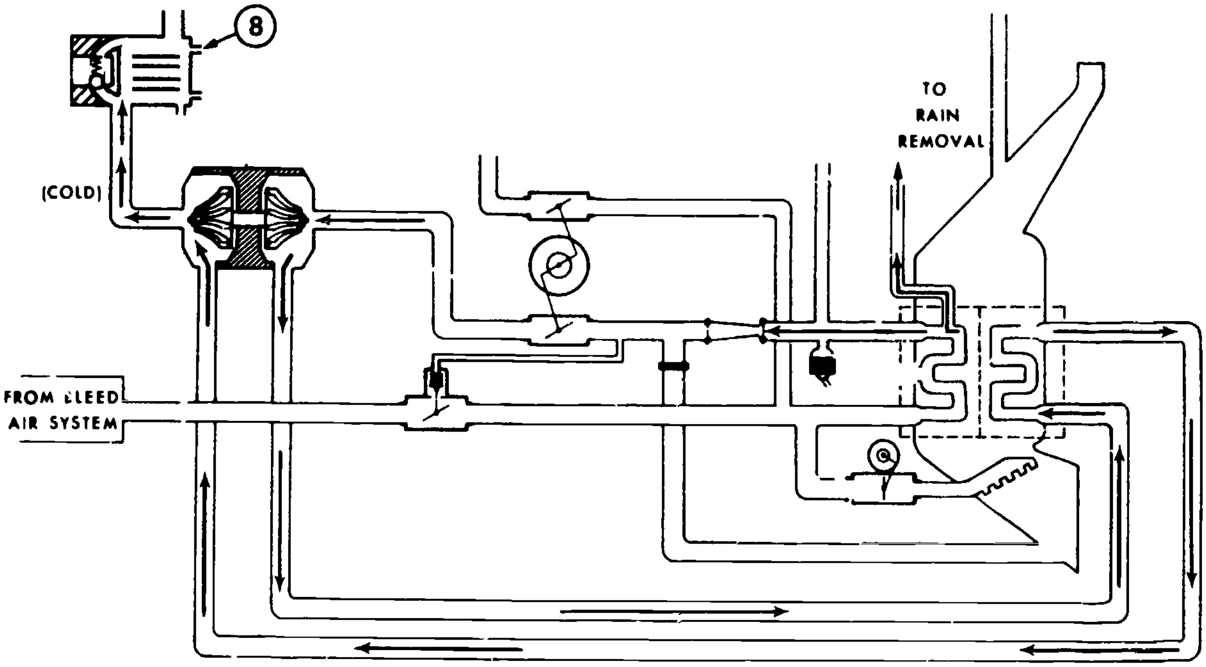
Circle the number of the true statements.

6. The turbine assembly cools air by rapid expansion and by converting heat energy to mechanical energy.
7. The compressor turbine drives the expansion turbine.
8. When the cold air port of the cabin dual temperature mixing valve is open, the hot air port is closed.
9. To receive maximum hot air in the cockpit, both the hot air port and the cold air port of the cabin dual temperature mixing valve will be open.
10. Before the air enters the expansion turbine, it must first pass through the primary section of the heat exchanger, the compressor turbine, and the secondary section of the heat exchanger.
11. The cabin dual temperature mixing valve is actuated by an electric motor.

The cold air flows from the expansion turbine to a water separator (number 8 in the illustration). The water separator removes any excess moisture.

You may be wondering, why is it necessary to remove the excess moisture. Cold air will not hold as much moisture as hot air. As a result, when air is cooled, the moisture will tend to condense.

This condensed moisture will appear as a mist or fog, or even as snow if the air is cooled close to the freezing point. Fog coming from the air conditioning outlets in an aircraft can be dangerous as it may be mistaken for smoke and it also would make it difficult for the pilot to see.



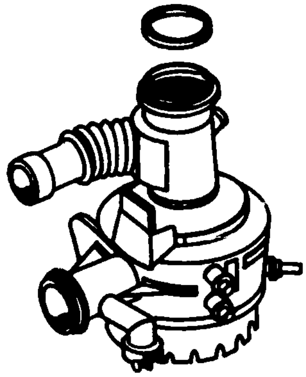
Fill in the blanks to complete the following statements.

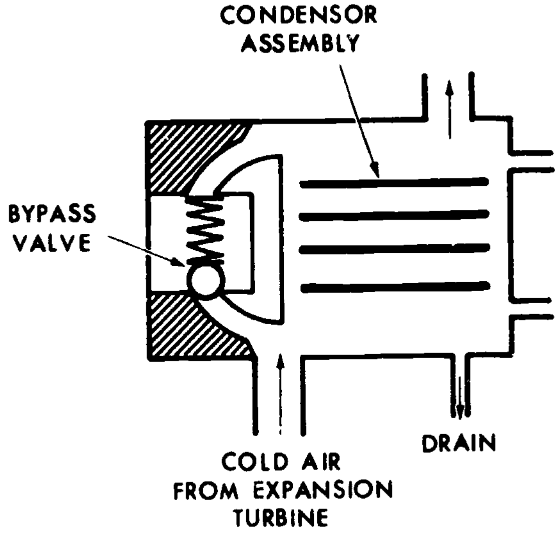
1. Excess moisture is removed by the __________ ______________.

2. The only air that passes through the water separator is the _______ air from the ____________ ______________.

Frame 24

The water separator is shown below. It contains a condensor assembly and a bypass valve. This is shown in the schematic in figure B, of the illustration.





The condensor assembly will cause the excess moisture to condense into water droplets within the water separator. The water is then drained overboard through the water separator drain.

The bypass valve will allow the air to bypass the condensor assembly in case the condensor become obstructed due to dirt or ice. The air that will pass through the water separator is cold, and can be below the freezing point of water. The water condenses on the condensor assembly, and if the air temperature is below freezing, ice will form on the condensor. Should this happen, the pressure on the inlet side will go up, overcoming the spring tension that's holding the bypass valve closed. This will open the bypass valve, permitting the air to bypass the condensor. This will insure a flow of conditioned air when the condensor becomes obstructed.

Fill in the blanks to complete the following statements.

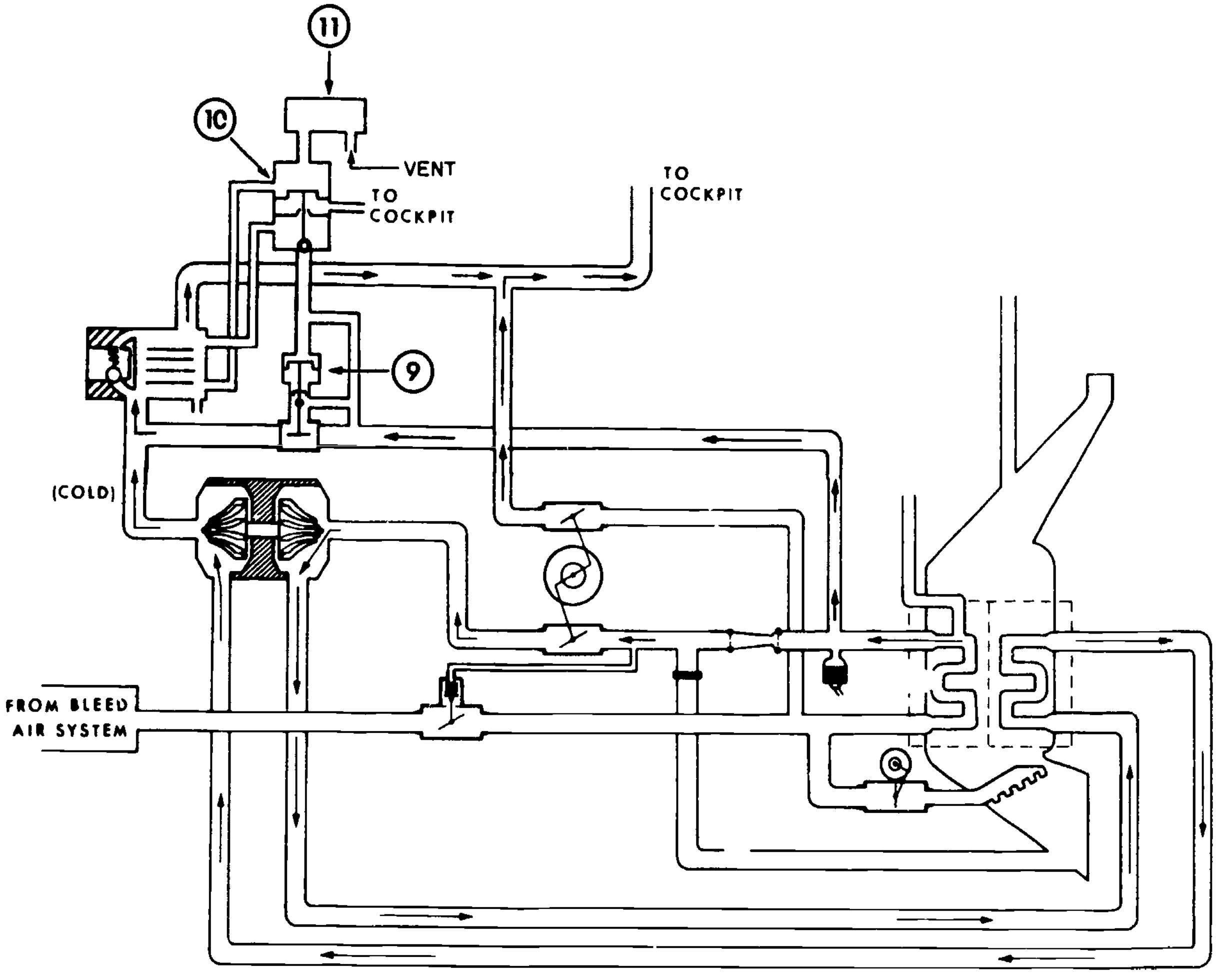
1. The water separator contains a ________________ assembly and a ____________ valve.

2. The water separator bypass valve is held closed by ___________ _______________.

3. The water separator bypass valve is opened by _______ ____________.

Under normal conditions, the bypass valve would stay closed as the water separator system incorporates an anti-icing system to prevent ice from clogging the condensor assembly.

The water separator anti-ice system is shown in the illustration below. This system includes an anti-ice valve (number 9), an anti-ice controller (number 10), and a lag chamber (number 11).



The anti-ice valve opens to allow some warm air to enter the water separator whenever ice starts to form on the water separator condensor. Notice the path of airflow through the anti-ice valve.

The anti-ice controller senses the icing condition and controls the opening and closing of the anti-ice valve.

The lag chamber aids in smoother operation of the anti-ice valve by absorbing rapid fluctuations in pressure.

Fill in the blanks to complete the following statements.

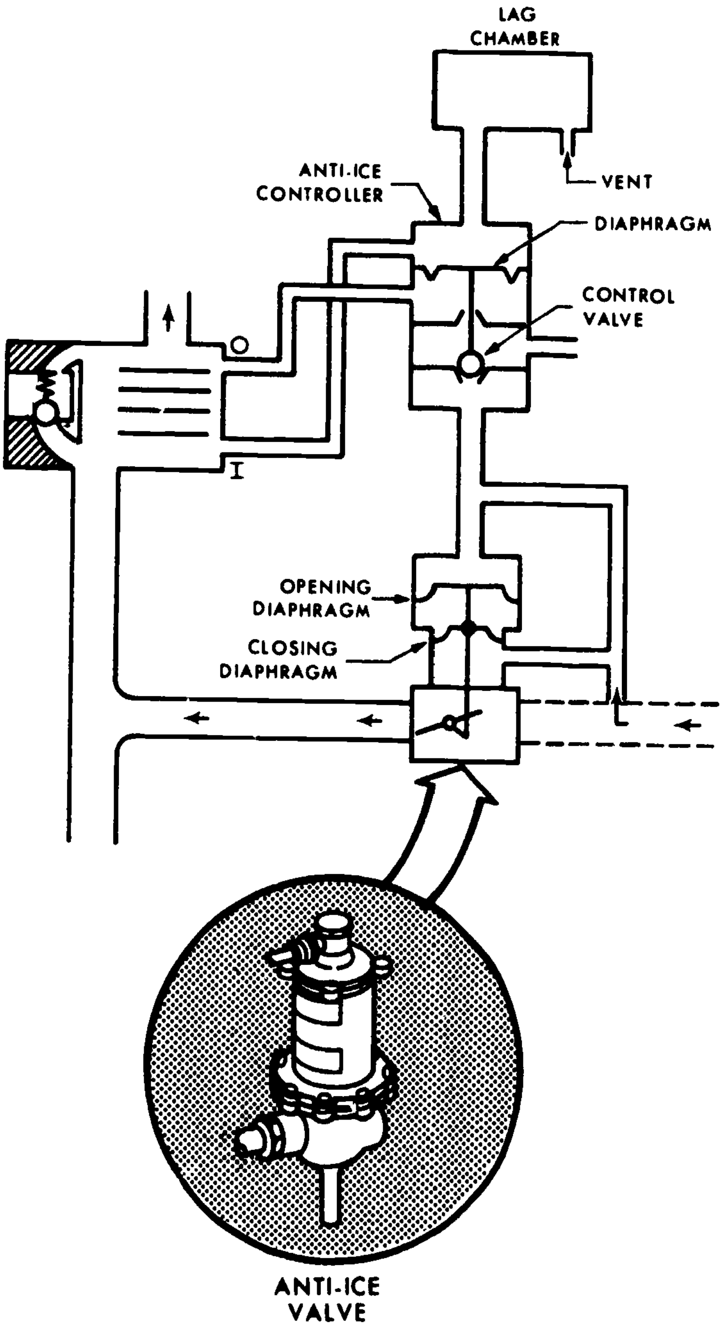
1. The water separator anti-ice system consists of an anti-ice ____________, and anti-ice ___________, and a lag chamber.

Frame 25 (Cont'd)

2. The anti-ice system prevents clogging of the water separator by allowing __________ air to enter the water separator.

3. The partially cooled (warm) air used for water separator anti-icing is taken from the ________________ section of the heat exchanger.

The illustration below shows the water separator and the anti-ice system. Note that this system is operated pneumatically. Now let's trace the airflow through the system to see how the anti-ice valve will be opened and closed.



The anti-ice valve actuator has two diaphragms, an opening diaphragm (top) and a closing diaphragm (bottom).

Frame 26 (Cont'd)

The opening diaphragm has a larger diameter than the closing diaphragm. This means it has a larger area.

Air pressure from the primary section of the heat exchanger goes in the actuator below the closing diaphragm and on the top of the opening diaphragm. This will place an equal pressure on both diaphragms. But, the opening diaphragm has a larger area, so the force that tries to open the valve will be greater than the force that tries to close the valve. This will cause the valve to open.

The opening and closing of the anti-ice valve is done by controlling the pressure on the opening diaphragm. This is done by the anti-ice controller.

Note the line from the anti-ice valve to the controller. If the control valve, in the controller is closed as shown, the pressure will buildup on the opening diaphragm of the anti-ice valve. This opens the valve.

If the control valve is open, the pressure going to the opening diaphragm will flow around the control valve and out the vent line to the cockpit. Under this condition, there will be no pressure buildup on the opening diaphragm and the anti-ice valve will stay closed.

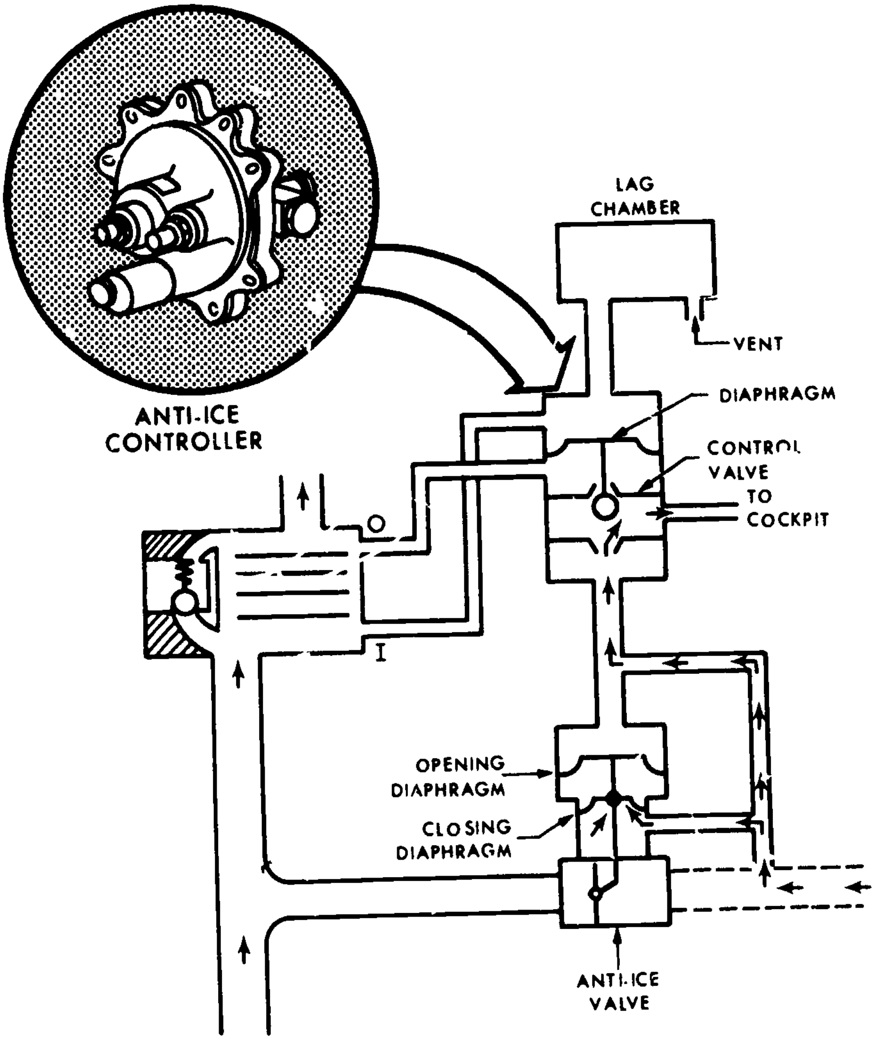
Fill in the blanks to complete the following statements.

1. The water separator anti-ice valve is operated ________________ (pneumatically/electrically).

2. The water separator anti-ice valve is controlled by the __________ ______________________.

3. If the control valve in the anti-ice controller is open, the anti-ice valve will be ____________ (open/closed).

Now let's see how the controller will sense ice to direct the opening and closing of the anti-ice valve. Note the points marked O and I on the water separator illustration shown. These are sensing lines.



The line marked I will sense inlet pressure and the line marked O will sense outlet pressure. If there is no restriction (no ice), the pressure in these two sensing lines will be the same.

Now look at the diaphragm inside the controller. The diaphragm controls the position of the control valve which, in turn, controls the pressure on the opening diaphragm of the anti-ice valve.

With the same pressure in the two sensing lines, the pressure that comes in the controller will also be the same on each side of the diaphragm. Now note that the inlet pressure also goes to the lag chamber.

The lag chamber has a small bleed port (vent) where the inlet pressure can vent overboard. This will result in a lower pressure on the top of the

Frame 27 (Cont'd)

controller diaphragm. The outlet pressure will force the diaphragm up holding the control valve open. This vents the pressure from the opening diaphragm, keeping the anti-ice valve closed.

Fill in the blanks to complete the following statements.

1. The anti-ice controller senses icing of the water separator by sensing a difference of ________________ in the water separator.

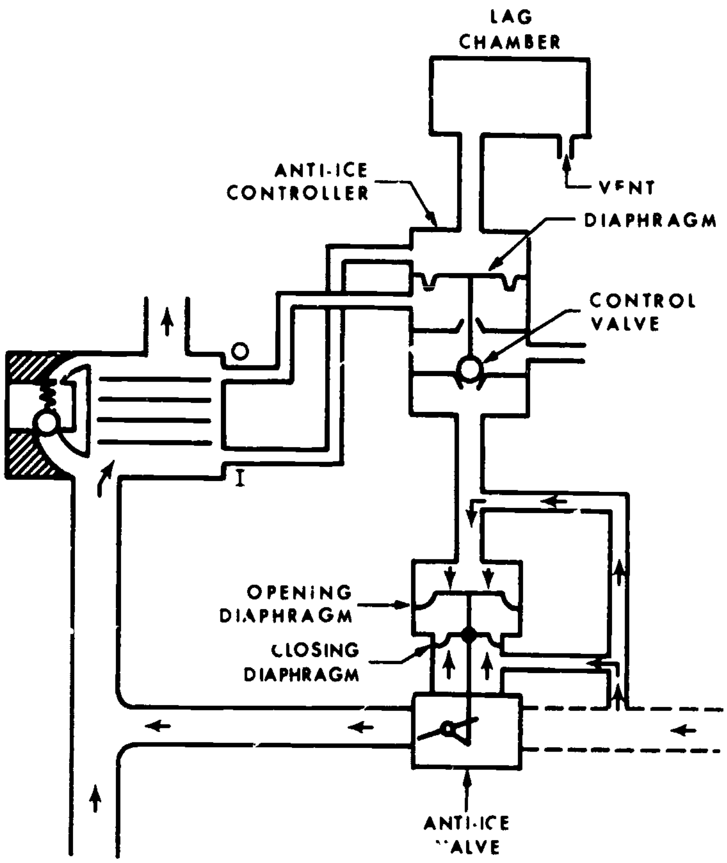
2. If the water separator inlet and outlet pressures are equal, the control valve in the anti-ice controller will be __________ (open/closed) and the anti-ice valve will be ___________ (open/closed).

When ice forms on the condensor, the flow of air through the water separator will be restricted. This will cause the inlet pressure to become greater than the outlet pressure.

The higher inlet pressure will force the controller diaphragm down which will move the control valve down. This stops the venting of air from the anti-ice valve opening diaphragm.

The pressure buildup on the opening diaphragm will open the anti-ice valve. The valve will stay open until the ice is removed and the pressure in the water separator equalizes.

The illustration below shows the anti-ice controller and anti-ice valve as it would be with ice on the water separator condensor.



Fill in the blanks to complete the following statements.

1. If the water separator inlet pressure is greater than the outlet pressure, it will cause the anti-ice valve to _______ (open/close).

2. During operation of the air conditioning system, when full cold is demanded, excessive moisture (fog and snow) comes from the air outlets. This indicates a defective anti-ice ________ or anti-ice ___________.

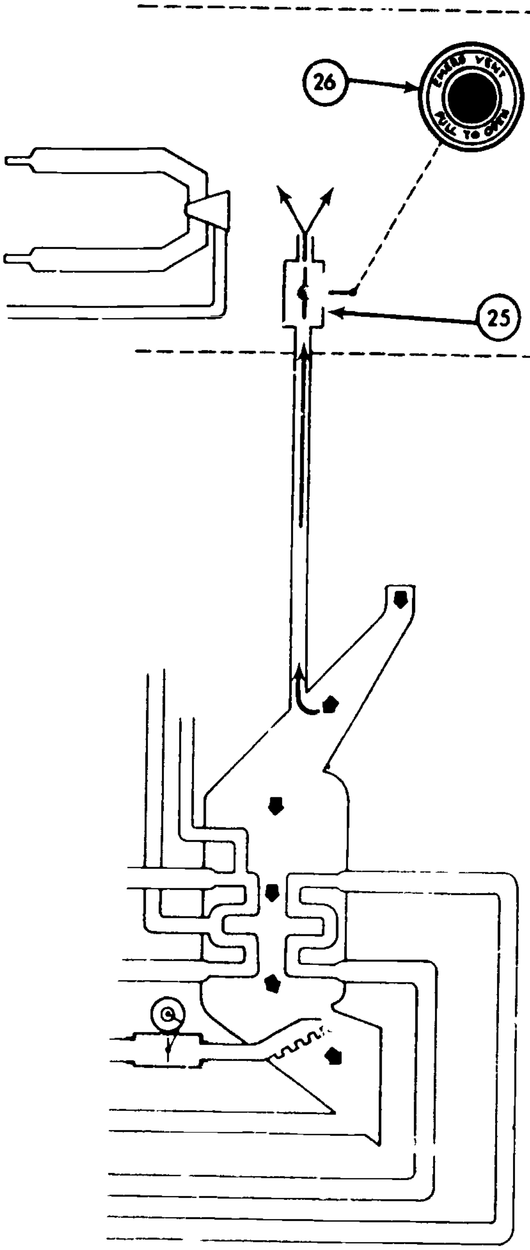
3. If the water separator anti-ice system fails to operate and allow ice to accumulate on the condensor, the ____________ valve will open to allow airflow to the cockpit.

Frame 2

If the air conditioning system fails to work while the aircraft is in flight, the pilot must have a means of receiving ventilating air.

It should be brought to mind that on the trainer aircraft air conditioning system a ram air valve was used for this purpose.

A ram air valve (number 25 in the illustration below) is also used on the fighter aircraft for this purpose.



Note in the illustration that air is tapped from the heat exchanger ram air inlet and ducted to the ram air valve in the cockpit.

When the ram air valve is open, the cabin air conditioning system is turned off. When the ram air valve is closed, the cabin air conditioning system is on.

The <u>emergency vent knob</u> (number 26) controls the ram air valve and also the on and off action of the cabin air conditioning system.

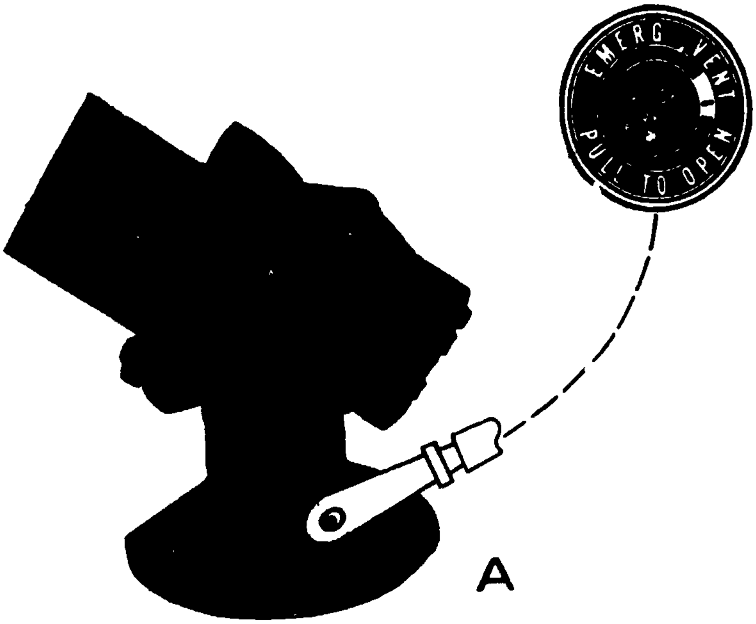
Fill in the blanks to complete the following statements.

1. When emergency ventilation of the cockpit is desired, the ________ ____________ valve can be opened.

2. The ram air valve is controlled by the ________ _________ ________.

Frame 30

Illustration "A" shows the ram air valve. This valve is actuated mechanically by a cable connected to the emergency vent knob.



A

B

When the emergency vent knob is pulled out, it opens the ram air valve and also actuates a switch which shuts off the cabin air conditioning system.

Illustration "B" shows the switch as it is installed on the valve. When the emergency vent knob is pushed in, the ram air valve closes. This also completes a circuit through the switch to operate the air conditioning system.

Fill in the blanks to complete the following statements.

1. The ram air valve is controlled by the ______________ ___________ _____________.

2. The switch on the ram air valve controls the ______ _________ ____ system.

3. When the emergency vent knob is pulled out, the air conditioning system will be _________ (on/off).

Frame 31

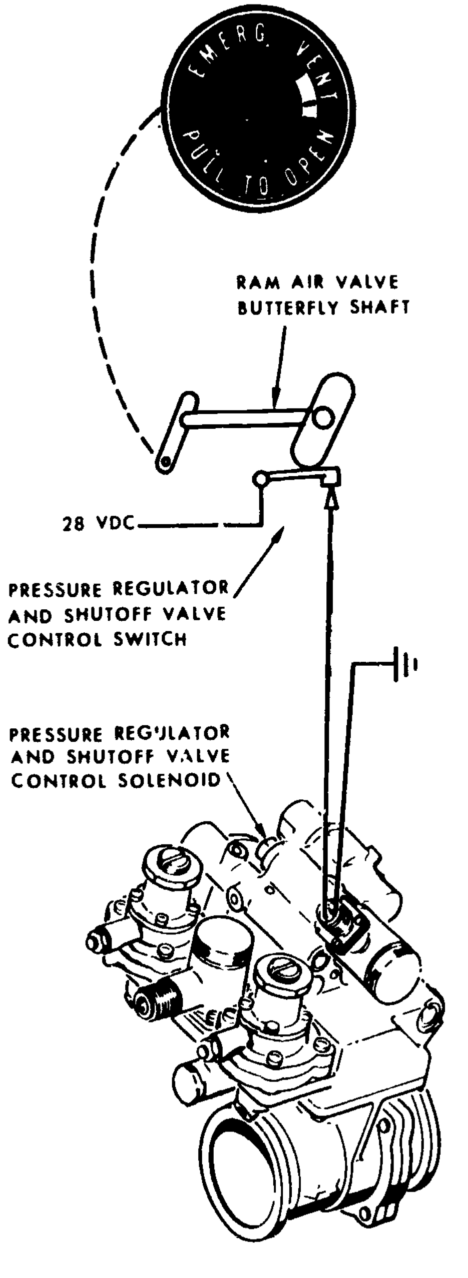
The emergency vent knob serves as the master control for the air conditioning and ventilation systems.

Recall from frame 4 that the pressure regulator and shutoff valve is controlled by a solenoid.

When the emergency vent knob is pushed in, the switch on the ram air valve directs 28-volts DC to energize this solenoid.

When the emergency vent knob is pulled out, the switch disconnects the electrical power from the solenoid.

Notice this control circuit in the illustration below.



Bleed Air Pressure Regulator
and Shutoff Valve

1571

Remember, when the solenoid is energized the pressure regulator and shutoff valve is open, and when the solenoid is de-energized, the valve closes.

Fill in the blanks to complete the following statements.

1. The switch on the ram air valve controls the air conditioning system by controlling the ______________ on the pressure regulator and shutoff valve.

2. With air pressure in the bleed air system and the emergency vent control knob pushed in, the bleed air pressure regulator and shutoff valve will be ______________________ (open/closed).

3. The solenoid on the bleed air pressure regulator and shutoff valve is controlled by a switch activated by the ___ __________ __________ ____________.

Frame 32

Match the units listed in Column "B" with the statements given in Column "A" by placing the letter from Column "B" in the blanks provided.

Column A		Column B	
1. _____	Controls the ram air valve and the pressure regulator and shut-off valve.	A.	Water separator
2. _____	Allows ram air to enter the cockpit for emergency ventilation.	B.	Anti-ice valve
3. _____	Senses an icing condition in the water separator.	C.	Anti-ice controller
4. _____	Opens to direct warm air to the water separator for ice removal.	D.	Emergency vent knob
5. _____	Removes excess moisture from the conditioned air.	E.	Ram air valve

The units described in the preceding frames were either used to condition the bleed air or to control the bleed airflow for some specific purpose. The cabin dual temperature mixing valve controls the mixing of hot and cold air. But, how does the pilot actually control this valve?

Under normal conditions the pilot only has to select the temperature he desires and the control system will automatically control the valve. However, there are provisions for the pilot to manually control the temperature should the automatic system fail.

Fill in the blanks to complete the following statements.

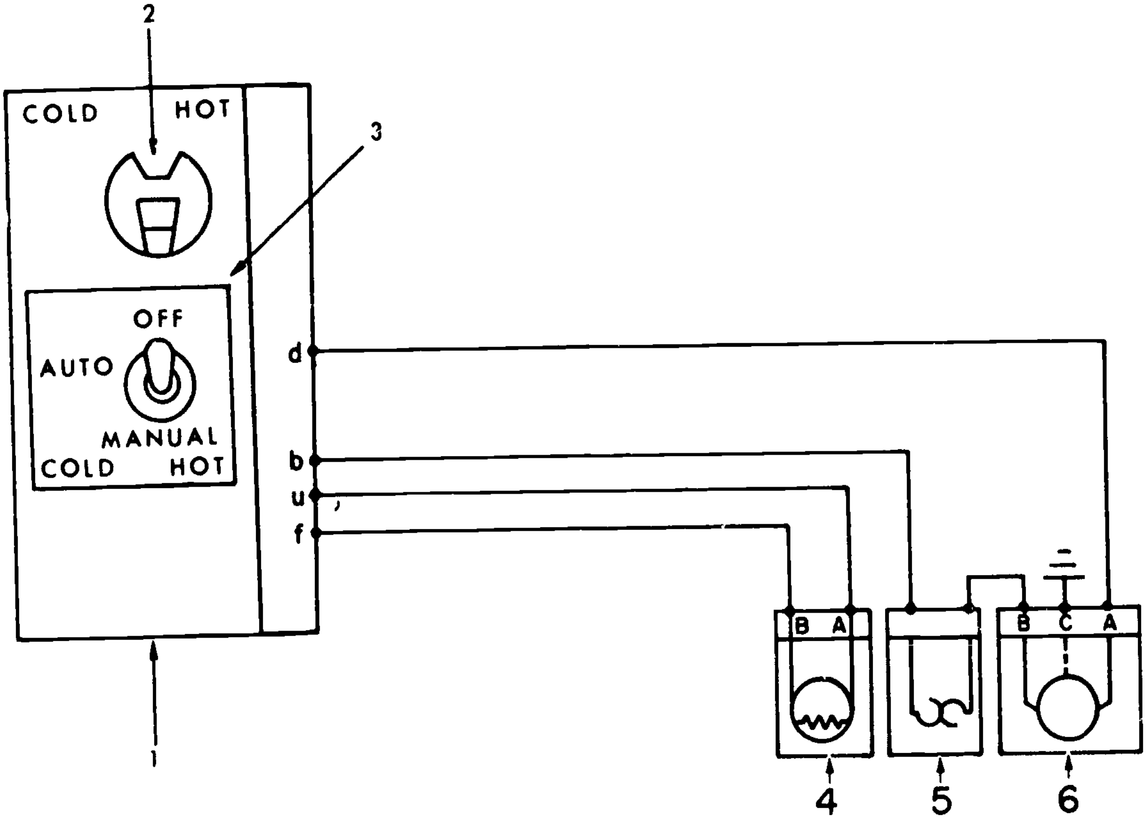
1. The temperature control valves control temperature by mixing ______ and ______________ air.

2. The two methods of controlling the temperature of the air entering the cockpit are _______________________ or ________________.

Frame 34

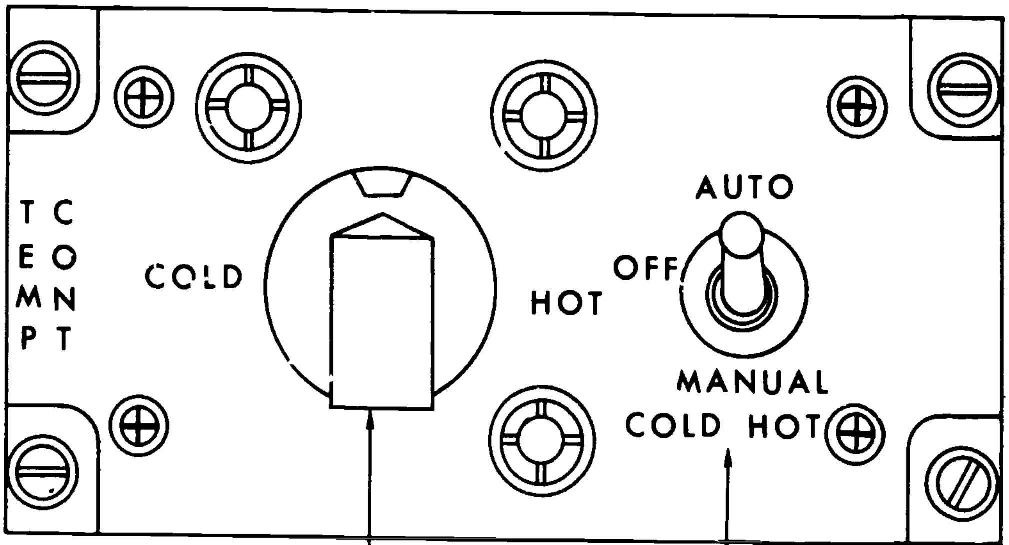
The illustration below shows a schematic diagram of the temperature control system. This system consists of the following components. The numbers correspond to the numbers on the diagram.

1. Temperature Control Panel
2. Temperature Selector (rheostat)
3. Temperature Control Switch
4. Cabin Temperature Sensor
5. Cabin Manual Temperature Limiter
6. Cabin Dual Temperature Mixing Valve



NO RESPONSE REQUIRED

The temperature control panel is the main controlling unit in this system. It controls the temperature of the air entering the cockpit. The temperature control panel shown contains the temperature control switch, temperature selector knob, and a magnetic amplifier type temperature controller. (The magnetic amplifier circuit is the same one you studied in the lesson on magnetic amplifiers.)



TEMPERATURE SELECTOR KNOB

TEMPERATURE CONTROL SWITCH

The temperature control switch is used to select the mode of operation. The modes of operation are AUTO and MANUAL. The switch has four positions; AUTO, MANUAL HOT, MANUAL COLD, and OFF. The temperature selector knob is used to select the desired temperature during automatic operation.

Fill in the blanks to complete the following statements.

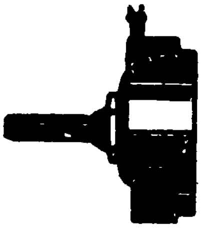
1. The temperature controller, temperature selector knob, and temperature control switch are each part of the ______________ ______________ ______________.

2. The temperature control panel controls the temperature for the ______________.

3. When the temperature control switch is in AUTO mode, the desired temperature can be selected by using the ______________ ______________ knob.

Frame 36

The temperature selector knob is used to select the temperature for the cockpit. Remember temperature selectors are actually variable resistors, and are frequently called "temperature control rheostats." This unit is illustrated below.



Fill in the blanks to complete the following statements.

1. The temperature selector consists of a ________________.

2. The temperature selector is used to select the temperature for the ______________________.

To control cockpit temperature automatically, requires a means of sensing the air temperature. This is the purpose of the cabin temperature sensor.

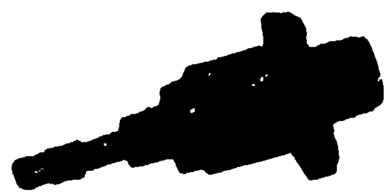
The sensor is located in the cabin air inlet valve (refer to frame 30). It senses the temperature of the air entering the cockpit.

The cabin temperature sensor and the cabin rheostat each form a part of the cabin temperature control bridge circuit.

The cabin sensor has a negative coefficient of resistance. An increase in air temperature causes a decrease in sensor resistance.

This, in turn, sets up a signal on the bridge circuit that will cause the temperature control panel to position the cabin dual temperature mixing valve for more cold air.

An increase in sensor resistance will call for hot air. The cabin sensor is shown in the illustration below.



Cabin Temperature Sensor

Fill in the blanks to complete the following statements.

1. A decrease in air temperature at the cabin air inlet valve will cause the cabin temperature sensor resistance to ______________.

2. When the temperature of the air entering the cockpit changes, the cabin __________________ ____________ sends a signal to the temperature control panel.

3. The cabin sensor has a _____________ coefficient of resistance.

Frame 38

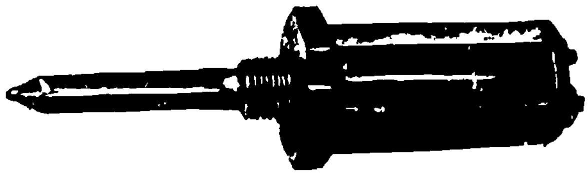
While in normal operation the cockpit temperature is controlled automatically. However, if the automatic system fails, the pilot can control the system manually.

In manual operation, if more cold air is needed, the pilot holds the temperature control switch to manual cold. This will cause the cabin dual temperature mixing valve to move toward open, as indicated by the valve position indicator.

If more hot air is needed, the pilot holds the temperature control switch in manual hot which will cause the cabin dual temperature mixing valve to move toward closed, as indicated by the valve position indicator.

When manual hot is used it is possible to cause an excessive amount of hot air to flow through the system. This in turn could cause damage within the system due to overheating.

A safety device is used to prevent this. This unit is the cabin manual temperature limiter. It is a normally closed thermoswitch. This part is shown below.



Cabin Manual Temperature Limiter.

The switch contacts are closed under all normal conditions. But, should the temperature of the air flowing through the air conditioning ducting exceed a preset temperature (220°F) $\pm$ 10°, then the switch contacts will open. This opens the electrical circuit going to the hot side of the cabin dual temperature mixing valve. This will stop the valve from going any further toward hot. The valve will only run toward the cold position.

Fill in the blanks to complete the following statements.

1. During manual operation, if more cold air is desired, the pilot must hold the ________________ ____________________ switch to MANUAL COLD.

2. The unit that prevents the system from becoming too hot during manual operation is the cabin _______________ _______________ ________________.

Match the units listed in Column "B" with the statements given in Column "A." Place the letter that corresponds to the unit in the blanks provided in Column "A."

Column A		Column B
1. _____	Used to select either AUTO or MANUAL modes for controlling temperature.	A. Temperature Control Panel
2. _____	Used to select the desired temperature during AUTO mode.	B. Temperature Selector Knob
3. _____	Contains a magnetic amplifier type temperature controller.	C. Temperature Control Switch
4. _____	Senses cockpit temperature during automatic operation.	D. Cabin Temperature Sensor
5. _____	Prevents the cabin air conditioning system from becoming too hot during manual operation.	E. Cabin Manual Temperature Limiter
6. _____	Controls the mixing of hot and cold air for cockpit temperature control.	F. Cabin Dual Temperature Mixing Valve

Frame 40

The preceding frames on temperature control have described the temperature control components and given their purpose. The electrical circuits for control of this system will be given in the next text.

As you work with the temperature control system you should be aware of the difference between the manual temperature control system and the automatic temperature control system.

What is this difference? The automatic temperature control system consists of the following components: Temperature control panel (temperature controller and rheostat), and the temperature sensor. These components control the cabin dual temperature mixing valve <u>only</u> during automatic operation.

When using manual mode, the temperature mixing valve is controlled directly by the temperature control switch. The cabin dual temperature mixing valve is the only common component to both the AUTO and MANUAL systems.

In other words, the automatic and manual systems work independently and problems in one system do not necessarily affect the other. This will be an important point to remember when you start performing system troubleshooting in your next lessons.

NO RESPONSE REQUIRED

Before continuing with this lesson, inform your instructor that you are going to the lab to look at the trainer. Now, report to the lab. Inform the lab instructor that you would like to look at trainer 3305, F-4C Environmental Systems. Using this trainer, perform the steps listed below.

1. Locate the following items.

   a. Bleed Air Pressure Regulator and Shutoff Valve.

   b. Ground Cooling Ejector Shutoff Valve.

   c. Turbine Overspeed Pressure Switch.

   d. Cabin Dual Temperature Mixing Valve.

   e. Foot Heat and Defog Valve.

   f. Emergency Vent Knob.

   g. Ram Air Valve (Emergency Vent Air Inlet Valve).

   h. Temperature Controller.

      (1) Temperature Control Switch.

      (2) Temperature Selector Knob.

   i. Cabin Temperature Sensor.

   j. Cabin Manual Temperature Limiter.

   k. Foot Heat and Defog Lever.

   Note: Were you able to locate each item? If not, ask the lab instructor for assistance.

2. Trace the airflow for cabin air conditioning.

   a. Start in the lower left corner and trace from the air source to the bleed air pressure regulator and shutoff valve. From the shutoff valve, trace the airflow to the ground cooling ejector shutoff valve and to the main heat exchanger.

   b. From the heat exchanger follow the orange line going to the pressure switch, through the flow limiting venturi, through the cabin dual temperature mixing valve and to the cooling turbine assembly. This air is entering the <u>compressor</u> turbine.

   c. From the compressor turbine follow the red line to the heat exchanger and the orange line back to the expansion turbine. This path provides cold air.

d. Go back to the pressure regulator and shutoff valve. Trace the dark red line going to the cabin dual temperature mixing valve hot air port. Trace airflow from the mixing valve to the point where the air from the hot air port and the air from the expansion turbine join (mix). The air flowing from this point, through the blue line, goes to the cabin. This is temperature controlled, conditioned air.

e. Trace the blue line to the cabin air inlet valve. From here the air can flow to the aft cockpit diffuser and to the forward cockpit foot heat outlets. If the foot heat and defog lever is positioned to the DEFOG position (right) the air will flow through the windshield and canopy defog ducts only.

4. Before answering the questions below, report back to your classroom.

Place a T (True) in the blanks to indicate which statements are True, and an F (False) to indicate a false statement.

_____ a. The ram air valve is actuated by the emergency vent knob.

_____ b. The switch located on the ram air valve controls the bleed air pressure regulator and shutoff valve solenoid.

_____ c. The pressure regulator and shutoff valve is actuated by a pneumatic actuator.

Using the illustration on foldout number 1, (attached to the back of this text), match the names of the components listed below with the components shown on the illustration. Place the letter that identifies the component in the blank space provided opposite the name.

1. _____ Ground Cooling Ejector Nozzle
2. _____ Turbine Overspeed Pressure Switch
3. _____ Cabin Dual Temperature Mixing Valve
4. _____ Pressure Regulator and Shutoff Valve
5. _____ Ground Cooling Ejector Valve
6. _____ Rupture Disc (location)
7. _____ Water Separator
8. _____ Anti-ice Controller
9. _____ Anti-ice Valve
10. _____ Compressor Turbine
11. _____ Expansion Turbine
12. _____ Ram Air Valve
13. _____ Lag Chamber
14. _____ Flow Limiting Venturi
15. _____ Heat Exchanger (primary section)
16. _____ Heat Exchanger (secondary section)
17. _____ Cabin Manual Temperature Limiter
18. _____ Cabin Temperature Sensor

Using foldout number 1, match the component with it's operation as given below. Place the letter that identifies the component in the blank space opposite the statements.

1. _____ Through the use of solenoids, and air pressure, it regulates air flow going to the air conditioning system at 62 psi.

2. _____ It has one motor that positions two butterflies in response to temperature changes thereby controlling the mixing of hot and cold air for cockpit use.

3. _____ A butterfly valve that is moved by mechanical linkage to the open position when emergency ventilating air is needed.

4. _____ Made up of several small outlets that will cause engine bleed air to create a low pressure area in the heat exchanger ram air exhaust and increase the ram air flow across the heat exchanger.

5. _____ Uses the principle of decreasing air pressure and increasing air velocity across it's throat to stop air surges going into the turbine and prevent a complete loss of air flow if the rupture disc cracked open.

6. _____ A butterfly valve controlled by diaphragms and operated by air pressure to the open position to prevent freezing of the water separator.

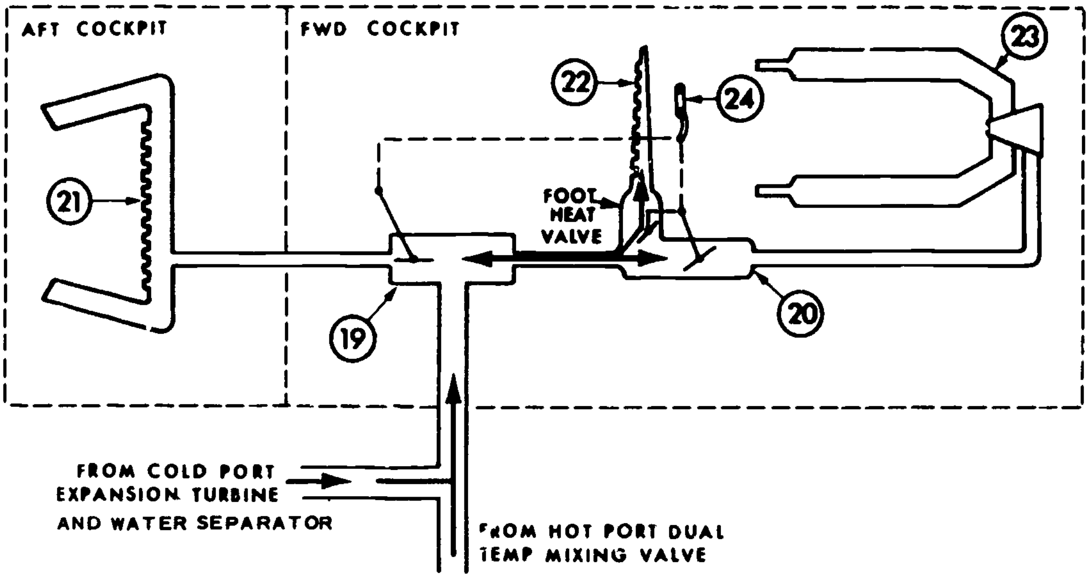
7. _____ A motor operated butterfly valve that will be opened when the landing gear are down to allow bleed air to flow through the ground ejector nozzles.

S T O P

Note: After completing this frame, stop and see your instructor.

Instructor's Initials ____________________

The cold air from the water separator will mix with hot air from the dual temperature mixing valve and then flow into the cockpit. The air that flows to the cockpit flows through a <u>Cabin Air Inlet Valve</u> (number 19 in the illustration shown) and a <u>Foot Heat and Defog Valve</u> (number 20).



These two valves are controlled by the <u>Foot Heat and Defog Lever</u> (number 24 in the illustration).

The cabin air inlet valve controls the amount of air going to the aft cockpit diffuser (number 21).

The foot heat and defog valve controls the air going either to the foot heat outlets (number 22) in the forward cockpit or to the windshield defogging tubes (number 23).

Find these parts in the illustration shown and note the path of airflow.

When windshield defogging is required, the cabin air inlet valve restricts the airflow going to the aft cockpit. The foot heat and defog valve directs the air to the windshield and, at the same time, reduces the airflow to the foot heat outlets.

Fill in the blanks to complete the following statements.

1. The unit that controls the amount of air going to the aft cockpit diffuser is the __________ __________ __________ valve.

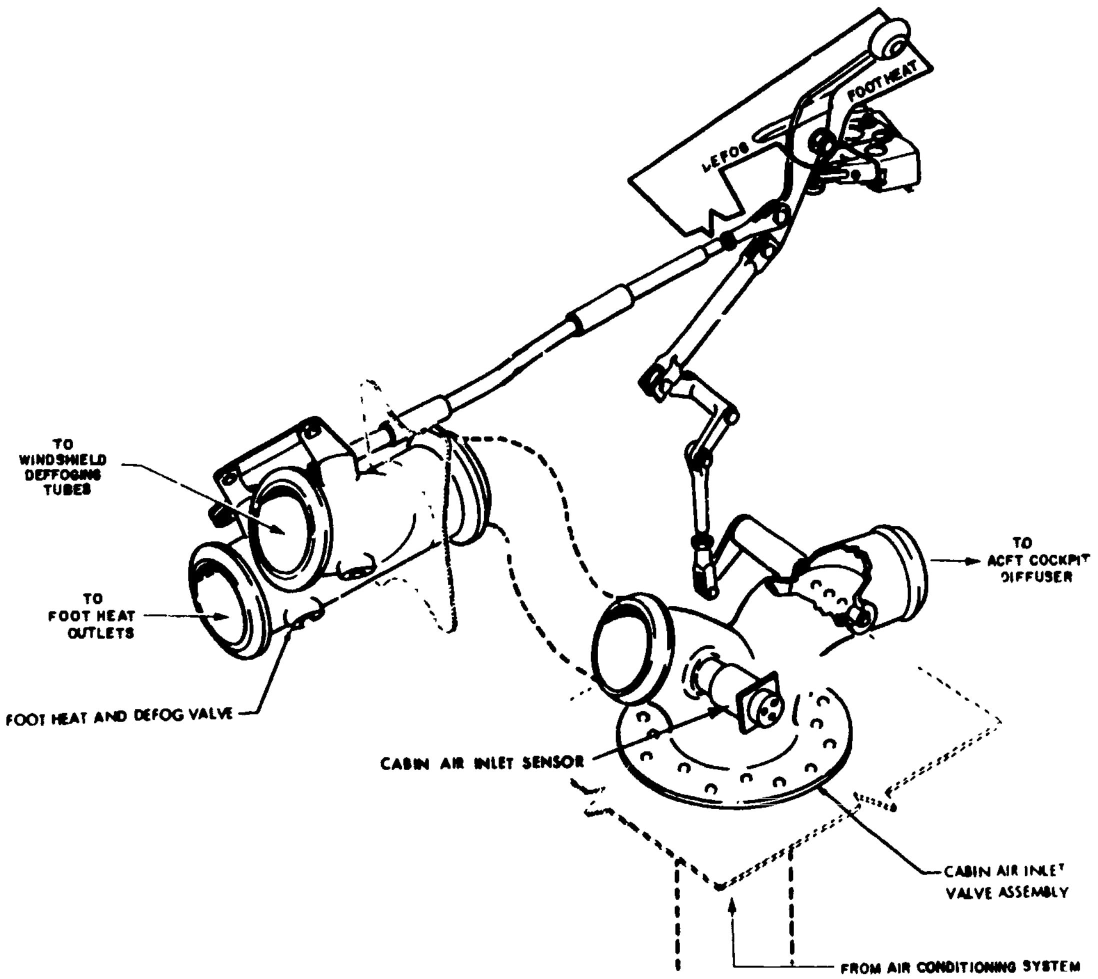
2. The unit that directs the air to either the foot heat outlets or the defogging tubes is the __________ __________ and __________ valve.

Frame 44

The cabin air inlet valve and the foot heat and defog valve are connected to one manual control lever by mechanical linkage. This lever is called the Foot Heat and Defog Lever.

The foot heat and defog lever has two positions; they are the FOOT HEAT position and the DEFOG position.

The illustration below shows the valves, lever, and mechanical linkage.

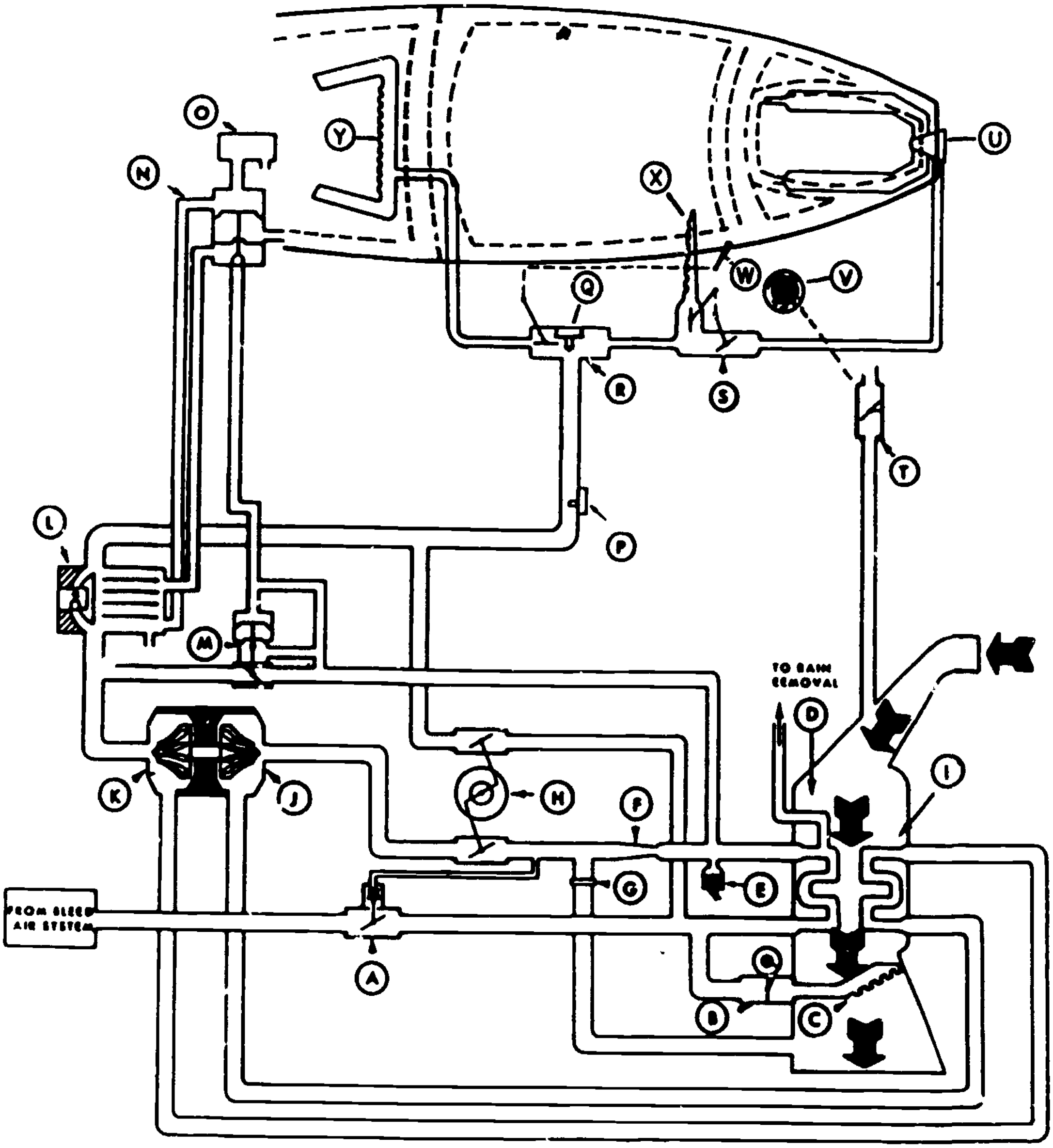


Fill in the blanks to complete the following statements.

1. The positions of the foot heat and defog control lever are ____________ and ____________.

2. The foot heat and defog valve and the cabin air inlet valve are connected to the same control ____________ by ____________ linkage.

3. The foot heat and defog control lever controls the foot heat and defog valve and the ________ ________ ________ valve.



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Foldout 1.

Correct Responses to the Frames

Frame 1
1. windshield, canopy
2. electronic
3. crew
4. engines

Frame 2 - No Response

Frame 3
1. shutoff valve
2. pressure regulator

Frame 4
1. solenoid
2. air pressure
3. air pressure, electrical
4. pressure regulator
   shutoff valve

Frame 5
1. primary, secondary
2. primary

Frame 6
1. cockpit, rain
2. ram
3. secondary

Frame 7
1. ejector shutoff valve
2. shutoff valve, nozzle

Frame 8
1. ejector shutoff valve
2. auxiliary relay
3. down

Frame 9
1. bleed
2. low pressure

Frame 10

1.	C	6.	B
2.	A	7.	A
3.	D	8.	open
4.	C	9.	pneumatic actuator
5.	A	10.	pressure, shutoff

Frame 11
1. pressure switch, rupture
   disk
2. overspeed pressure switch

Frame 12
1. turbine overspeed pressure
   switch
2. pilot
3. bleed air pressure regulator
   and shutoff valve

Frame 13
1. rupture disc
2. ram air outlet

Frame 14
1. limiting venturi
2. flow limiting venturi

Frame 15
1. dual temperature mixing valve
2. closed, open

Frame 16
1. hot, cold
2. motor
3. mechanical linkage

Frame 17
1. compressor, expansion
2. primary
3. secondary

Frame 18
1. expansion turbine
2. expansion, heat, mechanical

Frame 19
1. a. overspeeding
   b. workload
   c. compress

Frame 20
1. primary
2. compressor turbine
3. secondary, expansion turbine
4. expansion, efficiently

Frame 21 - No Response

Frame 22

1.	C	6.	T	11.	T
2.	E	7.	F		
3.	D	8.	T		
4.	B	9.	F		
5.	A	10.	T		

Frame 23
1. water separator
2. cold, expansion turbine

Frame 24
1. condensor, bypass
2. spring tension
3. air pressure

Frame 25
1. controller, valve
2. warm
3. primary

Frame 26
1. pneumatically
2. anti-ice controller
3. closed

Frame 27
1. pressure
2. open, closed

Frame 28
1. open
2. valve, controller
3. bypass

Frame 29
1. ram air
2. Emergency vent knob

Frame 30
1. Emergency vent knob
2. air conditioning
3. off

Frame 31
1. solenoid
2. open
3. emergency vent knob

Frame 32
1. D
2. E
3. C
4. B
5. A

Frame 33
1. hot, cold
2. automatically, manually

Frame 34 - No Response

Frame 35
1. temperature control panel
2. cockpit
3. temperature selector

Frame 36
1. rheostat
2. cockpit

Frame 37
1. increase
2. temperature sensor
3. negative

Frame 38
1. temperature control
2. manual temperature limiter

Frame 39
1. C 4. D
2. B 5. E
3. A 6. F

Frame 40 - No Response

Frame 41
1. T
2. T
3. T

Frame 42

Frame 41
1. T
2. T
3. T

Frame 42

1.	C	10.	J
2.	E	11.	K
3.	H	12.	T
4.	A	13.	O
5.	B	14.	F
6.	G	15.	D
7.	L	16.	I
8.	N	17.	P
9.	M	18.	Q

Frame 42 (Cont'd)

1.	A	5.	F
2.	H	6.	M
3.	I	7.	B
4.	[illegible]		

SECTION II

Frame 43
1. cabin air inlet
2. foot heat, defog

Frame 44
1. foot heat, defog
2. lever, mechanical
3. cabin air inlet

WORKBOOK

C3ABR42331-WB-202A

Technical Training

Aircraft Environmental Systems Mechanic

FIGHTER CABIN AIR CONDITIONING SYSTEM TROUBLESHOOTING

1 February 1984

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

Designed for ATC Course Use.

Do Not Use on the Job.

ATC FORM 214 (JAN 76) OBSOLETES ATC FORMS 214, MAY 69, 522, NOV 63 AND 521 [illegible] STANDARD COVERSHEET

Environmental Pneudraulics Branch
Chanute AFB, Illinois

C3ABR42331-WB-202A

FIGHTER CABIN AIR CONDITIONING SYSTEM TROUBLESHOOTING

OBJECTIVE

Using a multimeter and wiring diagram, troubleshoot the cabin air conditioning system trainer, locating 3 out of 4 troubles correctly.

EQUIPMENT

Trainer 3305, Fighter Air Conditioning
Multimeter AN/PSM-6

PROCEDURE

1. Remove all of your jewelry. Report to the lab instructor and inform him of the lesson on which you are working. The instructor will assign you to a trainer and provide the necessary materials.

2. This workbook is presented in two sections. Section 1 is to familiarize you with the components of the cabin air conditioning system and to prepare you for performing the operational check and troubleshooting. Section 2 contains the steps for operationally checking the system and the malfunctions that you are to troubleshoot. Perform each step as directed on the following pages.

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SECTION 1. CABIN AIR CONDITIONING SYSTEM COMPONENTS

1. Location and identification of system components.

a. Using the trainer and the illustration in figure 1, locate each of the numbered items. Write the name of each of these numbered items in the blank space. As you locate each component, notice the check point near the component that is used for checking the electrical circuitry.

(1) ______________________________

(2) ______________________________

(3) ______________________________

(4) ______________________________

(5) ______________________________

(6) ______________________________

(7) ______________________________

(8) ______________________________

(9) ______________________________

(10) ______________________________

COMPARE YOUR ANSWERS TO THOSE ON PAGE 5.

Figure 1. Fighter Air Conditioning Trainer.

Answers to location and identification step 1a.

(1) Bleed air pressure regulator and shutoff valve.

(2) Cabin dual temperature mixing valve.

(3) Ground cooling ejector shutoff valve.

(4) Cabin temperature sensor.

(5) Cabin manual temperature limiter.

(6) Turbine overspeed pressure switch.

(7) Emer air inlet valve.

(8) Water separater.

(9) Anti-ice valve.

(10) Anti-ice controller.

b. Using the trainer and figure 2, locate each of the numbered items. Write the names of each item in the blank space. As you locate the items notice the check points for checking the electrical circuit.

(1) ______________________________

(2) ______________________________

(3) ______________________________

(4) ______________________________

(5) ______________________________

(6) ______________________________

(7) ______________________________

(8) ______________________________

(9) ______________________________

(10) ______________________________

(11) ______________________________

(12) ______________________________

COMPARE YOUR ANSWERS TO THOSE ON PAGE 7.

Figure 2. Fighter Air Conditioning Trainer.

Answers to location and identification step 1b.

(1) Cockpit heat and vent circuit breaker; 115 VAC.

(2) Cockpit heat and vent circuit breaker; 28 VDC.

(3) Warning light circuit breaker.

(4) Landing gear circuit breaker.

(5) Emergency vent knob.

(6) Temperature control panel.

(7) Landing gear handle.

(8) Test point for the landing gear control switch.

(9) Footheat and defog lever.

(10) Defog switch.

(11) Cabin turbine overspeed warning light.

(12) Landing gear auxiliary relay.

2. Trainer preparation.

a. Place all trouble switches to the OUT position. These switches are located at the left end of the trainer.

b. Push in the following circuit breakers:

(1) Cockpit heat and vent; 115 VAC.

(2) Cockpit heat and vent; 28 VDC.

(3) Warning lights.

(4) Landing gear.

c. Place the switches to the NORMAL positions as listed below.

(1) Emergency vent knob ---------- Pushed in.

(2) Landing gear lever ----------- Down.

(3) Defog lever ------------------ Footheat.

(4) Temperature control switch --- Auto.

(5) Temperature selector --------- Cold.

d. Place the power switches to the ON position. These switches are located on the left side of the trainer.

3. Trainer Operation.

a. During the following steps you will operate each component of the cabin air conditioning system. When a switch or lever is actuated be sure to notice which of the valves operate and the valve position. Actuate each switch as directed. From your observation of the trainer operation, complete each of the statements by circling the correct word.

STEP 1. Bleed air pressure regulator and shutoff valve, and emer vent air inlet valve operation.

(1) Pull out the emergency vent knob.

(a) The bleed air pressure regulator and shutoff valve (opens/closes).

(b) T.. emer air inlet valve (opens/closes).

(2) Push in the emergency vent knob.

(a) The bleed air pressure regulator and shutoff valve (opens/closes).

(b) The emer air inlet valve (opens/closes).

(3) If the bleed air pressure regulator and shutoff valve fails to operate, it indicates a defective valve or an open electrical circuit.

STEP 2. Ground cooling ejector shutoff valve operation.

(1) Place the landing gear handle in the GEAR UP position. The ground cooling ejector shutoff valve (opens/closes).

(2) Move the landing gear handle to the GEAR DOWN position. The ground cooling ejector shutoff valve (opens/closes).

STEP 3. Cabin temperature control system; manual operation.

(1) Place the temperature control switch to MANUAL HOT. The cabin dual temperature mixing valve (opens/closes).

Note: This can be determined by observing the valve position indicator located on the valve body.

(2) Place the temperature control switch to MANUAL COLD. The cabin dual temp mixing valve (opens/closes).

(3) If the temperature control valve fails to operate it indicates that the valve is defective or there is an open in the 28 VDC electrical circuit.

STEP 4. Cabin temperature control system; automatic operation.

(1) Place the temperature control switch to AUTO, then rotate the temperature selector to HOT. The cabin dual temperature mixing valve moves toward (open/close).

(2) Rotate the temperature selector to COLD. The cabin dual temperature mixing valve moves toward (open/close).

(3) If the automatic temperature control system fails to operate, it indicaates an open in the 115-volt AC power circuit to the controller.

(4) If the temperature sensor or wiring to the sensor is SHORTED, the temperature mixing valve will go full (open/close).

(5) If the temperature sensor or wiring to the sensor is OPEN, the temperature mixing valve will go full (open/close).

STEP 5. Return all switches to the NORMAL position as indicated in paragraph 2d and place trainer power switches to OFF.

COMPARE THE ANSWERS THAT YOU HAVE SELECTED TO THOSE GIVEN BELOW.

STEP 1.	(1) (a) closes	(1) (b) opens		
	(2) (a) opens	(2) (b) closes		
STEP 2.	(1) closes	(2) opens		
STEP 3.	(1) closes	(2) opens		
STEP 4.	(1) close	(2) open	(4) open	(5) close

If your answers do not agree, check with the instructor. If your answers agree, then the trainer is operating correctly.

4. Sensor Resistance.

a. Prior to maintaining a temperature control system you should determine the normal resistance values of the sensors. This can be done by referring to the technical order or by measuring a known good sensor.

b. Measure the resistance of the cabin temperature sensor. To meausre resistance, the circuit must be isolated. To isolate the sensor on the trainer, disconnect the AN connector attached to the temperature control panel. With this disconnected you can measure the sensor resistance from the cabin temperature sensor check point. The resistance of the cabin sensor is ____________________.

c. Ask the instructor for the ambient temperature of the lab area ____________.

d. The graph illustrated in figure 3 shows the normal sensor resistance. This is the same type of graph you will use on the flight line. Determine the resistance range for the cabin sensor. Is the measured resistance of the sensor within the range given on the graph? (yes/no). If your answer was no, ask the instructor for assistance.

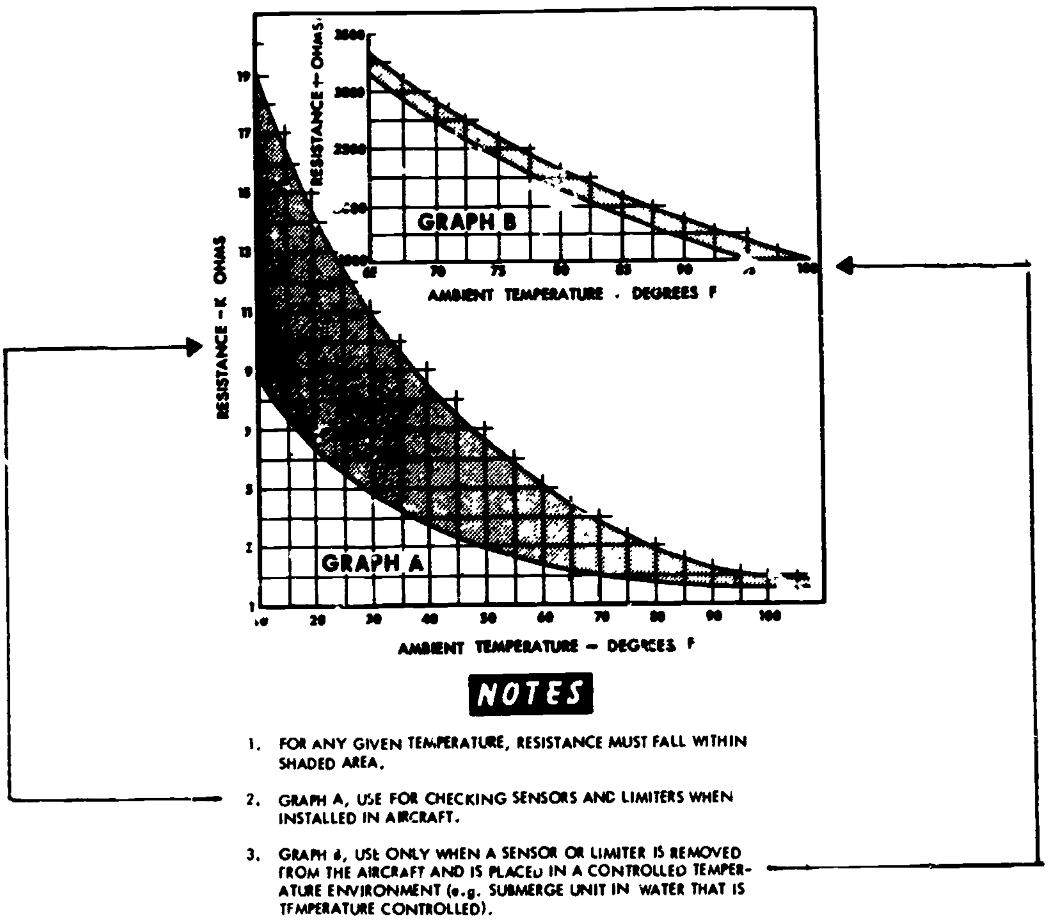

Figure 3. Temperature Sensor Resistance Graph.

Instructions for using the temperature sensor resistance graph.

On graph A, locate the vertical line for ambient temperature. Follow this line up to the shaded area, then follow the horizontal lines to the left to determine the range of the resis ance in "K" ohms. "K" = 1,000 ohms.

Example: If the temperature is 65°F, then the resistance range should be between 2200 ohms and 4500 ohms.

SECTION 2. CABIN AIR CONDITIONING SYSTEM
OPERATIONAL CHECK AND TROUBLESHOOTING

OPERATIONAL CHECK

1. The steps that you performed in paragraph 3a of Section 1 involved operating each component in the cabin air conditioning system. They determined if each component was operating properly and are called operational checks.

2. The chart below formalizes the procedure for performing operational checks in an outline form. To insure that you are familiar with this procedure, turn the trainer power switches ON and perform each of the steps. After you are sure you understand the operational check procedure, then continue to the troubleshooting part of this lesson.

Positioning the Control Devices	Operating Valve	Valve Position
Pull out the emergency vent knob	Bleed air pressure regulator and shutoff valve Emer Air inlet valve	CLOSED OPEN
Push in the emergency vent knob	Bleed air pressure regulator and shutoff valve Emer Air inlet valve	OPEN CLOSED
Move the landing gear handle to the GEAR UP position	Ground ejector valve	CLOSED
Move the landing gear handle to the GEAR DOWN position	Ground ejector valve	OPEN
Place the temperature control switch to MANUAL HOT	Cabin dual temperature mixing valve	CLOSED
Place the temperature control switch to MANUAL COLD	Cabin dual temperature mixing valve	OPEN
Place the temperature control switch to AUTO. Rotate the temperature selector to HOT.	Cabin dual temperature mixing valve	Travels toward CLOSED
Rotate the temperature selector to COLD	Cabin dual temperature mixing valve	Travels toward OPEN

Operational Check Procedure Chart

TROUBLESHOOTING

1. For each trouble, perform an operational check to determine the malfunctioning component; place a statement in the "discrepancy" block of the troubleshooting response sheet.

2. Using a wax pencil, trace the electrical circuit that operates or controls the malfunctioning component.

3. Use a multimeter to locate the cause of the trouble.

Note: When measuring voltage, be sure the meter is set to the correct voltage range. Make sure that you have the negative (black) lead to ground. Ground on the trainer is any connection with a ground (—|||) symbol. When checking the manual temperature control system, be sure to hold the temperature control switch to either hot or cold. When measuring resistance, be sure the trainer power switch is off, and the meter is set at OHMS. Use the OHM portion of the multimeter only to check sensors and their circuits.

4. Record the cause of the trouble in the "cause" block of the troubleshooting response sheet.

5. The trouble switch that you are to use for each problem is listed on the side of the discrepancy block. There are 12 problems for you to troubleshoot. We will go through trouble number 1 to show you how to arrive at the correct answer.

Trouble Switch #1

1. Place trouble switch #1 to the IN position.

2. Perform an operational check. Use the operational check chart, on page 11, if needed.

3. As you went through the operational check you found the cabin mixing valve would not operate in automatic. Make the following statement in the discrepancy block of the troubleshooting response sheet for trouble #1.

"Cabin mixing valve will not operate in automatic."

4. Since the cabin mixing valve will not operate in automatic hot or cold, what part of the circuit would affect automatic operation of the system?

5. If the problem were in the DC power supply, then the valve would not operate in manual. This leaves the AC power supply.

6. Trace the AC power supply from the 115V AC cockpit heat and vent circuit breaker to the temperature control panel.

Note: 28 volt DC supply is required to operate the valve. In auto and manual the 115V AC supply is required for operation of the cabin magnetic amplifiers. In automatic hot and cold only.

7. Check the AC power supply with the multimeter. Make sure your meter is set at the correct voltage. Check for voltage at pin "E" of the temperature control panel. You did not get a voltage indication, did you?

8. Now, check for voltage at the 115V AC cockpit heat and vent circuit breaker. There is voltage at this point. This means there must be an open in wire H9A20.

9. Record your findings in the "cause" block of trouble switch #1, on the troubleshooting response sheet.

"Open in wire H9A20."

10. You have completed trouble #1 so place that trouble switch to the <u>OUT</u> position and continue with troubles number 2 through 10. Be sure to record the malfunction in the "discrepancy" block and the cause of the malfunction in the "cause" block of the troubleshooting response sheet.

11. After you have completed, return this workbook to your lab instructor to have him grade it. If you did not locate the troubles correctly, your instructor will tell you where you made your error(s) and have you redo those troubles. Your instructor will now assign the test to meet the objective. You must locate 3 out of 4 troubles correctly.

TROUBLESHOOTING RESPONSE SHEET

TROUBLE SWITCH NUMBER	DISCREPANCY	CAUSE
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

WHEN COMPLETED, REPORT TO THE INSTRUCTOR.

Instructor's signature showing satisfactory completion of this objective:

____

PROGRAMMED TEXT

C3ABR42331-PT-203

Technical Training

Aircraft Environmental Systems Mechanic

RAIN REMOVAL SYSTEM

31 March 1983

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

Designed for ATC Course Use.

Do Not Use on the Job. RGL: 10.5

OBJECTIVE

Relate 8 out of 10 components of the rain removal system to their operation.

INSTRUCTIONS

The text presents this material in small steps called frames. After each frame you are asked to respond to questions in some manner. Read the material carefully and accomplish what each frame directs you to do. The correct answers are given at the top of the next frame or as specified. If you have answered each response correctly, continue on to the next frame. If you are incorrect, read the material again and correct your answers before continuing.

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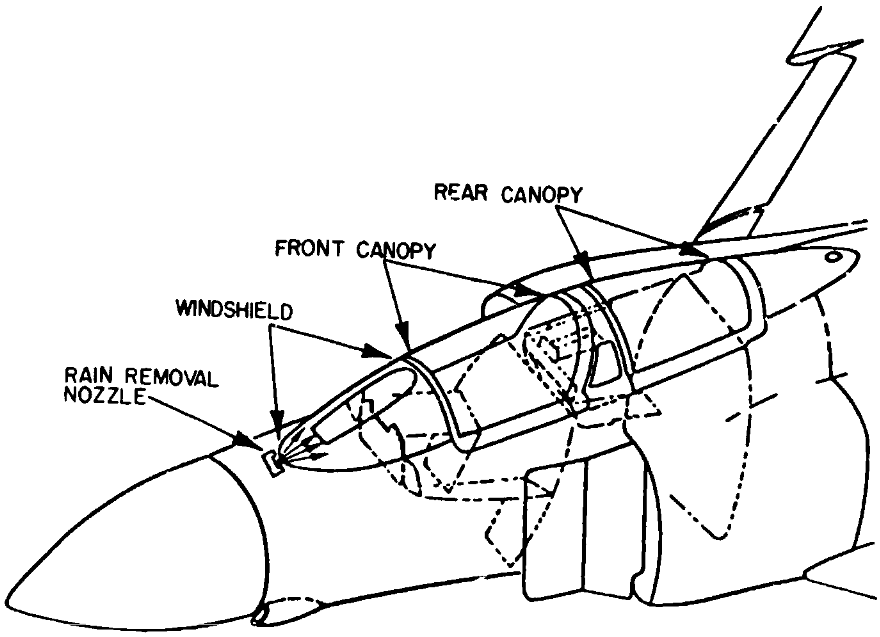
The purpose of the rain removal system is similar to the purpose of the windshield wipers on an automobile. The system keeps the windshield clear of rain. This is done by blowing a mixture of hot and partially cooled air over the windshield. The air will break up the rain particles and turn them away from the windshield.

During this lesson you wi[illegible] studying the system used on a fighter type aircraft. In the system th[illegible]ir for the rain removal is discharged through a nozzle (outlet). The nozzle is put at the base of the windshield. Notice the rain removal nozzle location below.



Complete the following statements.

1. The purpose of the rain removal system is to keep the ______________ clear of rain.

2. The rain removal system blows a mixture of ______ and ___________ ___________ bleed air over the windshield.

3. The rain removal nozzle directs air over the ___________________.

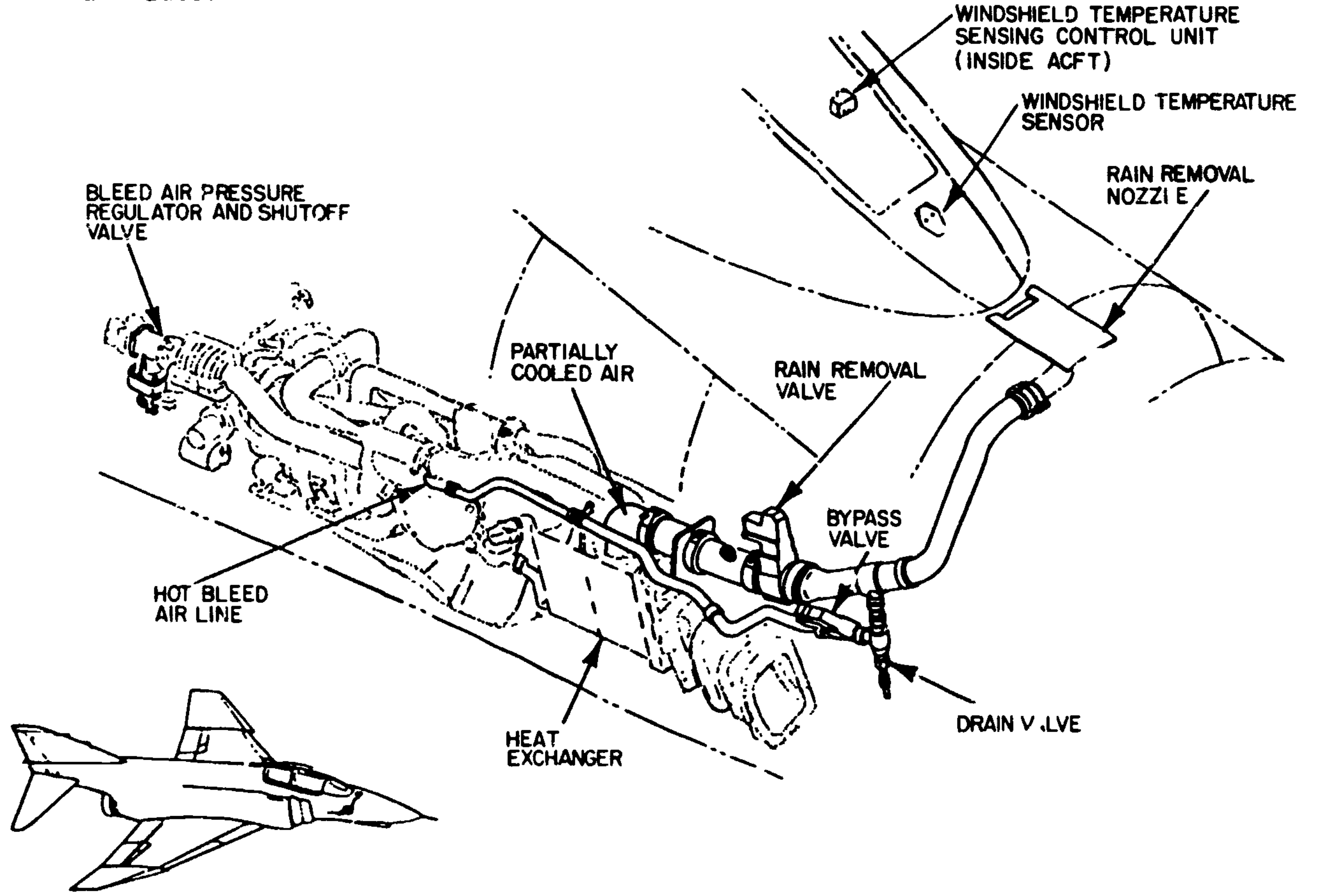
Answers to Frame 1: 1. windshield 2. hot, partially cooled 3. windshield

Frame 2

The air for the rain removal system is "tapped" from the cabin air conditioning system.

The partially cooled air is drawn from the primary section of the refrigeration unit heat exchanger. The hot bleed air is drawn from the unit's hot bleed air duct.

The dark lines in the sketch show the rain removal system. Note the large duct that carries the partially cooled air from the heat exchanger. The smaller duct takes the hot air from the refrigeration unit hot bleed air duct.



Fill in the blanks to complete the following statements.

1. The rain removal system receives partially cooled air from the

   ____________ __________________.

2. The air discharged from the rain removal nozzle is a mixture of partially _______________ and __________________ air.

3. The rain removal system receives hot bleed air from the refrigeration unit ______________ bleed air duct.

Answers to Frame 2: 1. heat exchanger 2. cooled, hot 3. hot

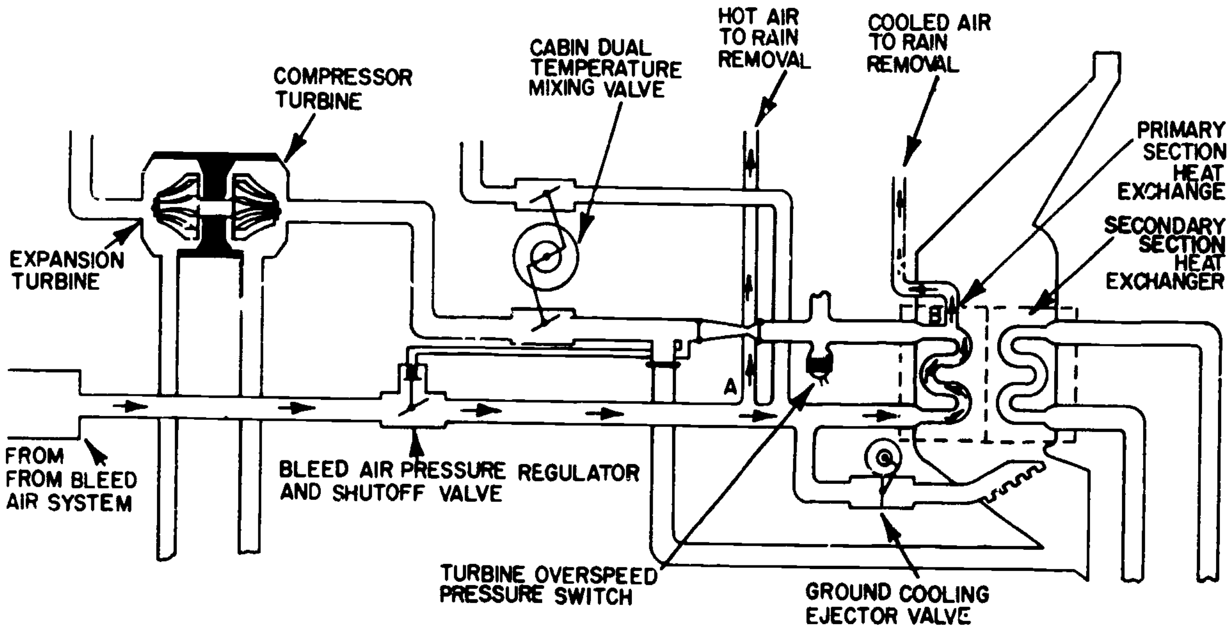
Frame 3

Remember the fighter cabin air conditioning system? Air flow through the cabin refrigeration unit is regulated by the bleed air pressure regulator and shutoff valve. This valve regulates the air pressure for both the cabin air conditioning system and the rain removal system.

Trace the airflow on the sketch below. Start at the point marked FROM BLEED AIR SYSTEM. Follow the arrows through the bleed air pressure regulator and shutoff valve.

Note the first tapoff, POINT A, going to the rain removal system. This is the hot bleed air tapoff.

Continue to follow the arrows through the primary section of the heat exchanger and note the second tapoff, POINT B, going to the rain removal system. This is the partially cooled air tapoff.



Fill in the blanks to complete the following statements.

1. The bleed air pressure regulator and shutoff valve must be ____________ for the rain removal system to operate.

2. The bleed air pressure regulator and shutoff valve is part of the cabin

____ ________ unit.

3. The partially cooled air used for rain removal is cooled by the

______________ section of the heat exchanger.

Answers to Frame 3: 1. regulating 2. refrigeration 3. primary

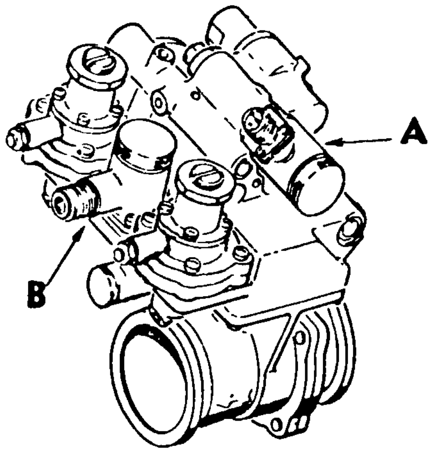
Frame 4

The bleed air pressure regulator and shutoff valve is a solenoid controlled, pneumatically (air) actuated valve. This valve has two solenoids: The main solenoid (A) and a low pressure solenoid (B). Both solenoids use 28 VDC power.

For normal cabin air conditioning operation, only the main solenoid is energized. This regulates the pressure of the air conditioning system to 62 psi. This will happen before the pilot turns the rain removal system on.

When the rain removal system is turned on, the low pressure solenoid will energize. This reduces the pressure of the bleed air (for both air conditioning and rain removal)to 35-45 psi.With the rain removal system on, both the main solenoid and the low pressure solenoid will be energized.

The bleed air for the rain removal system is tapped off downstream (beyond-past) of the pressure regulator and shutoff valve. This valve <u>must</u> be regulating (open) for rain removal operation.



Fill in the blanks to complete the following statements.

1. The bleed air pressure regulator and shutoff valve is actuated by

   ____________ pressure.

2. Opening and closing the pressure regulator and shutoff valve is

   controlled by the _________ (main solenoid/low pressure solenoid).

3. When the rain removal system is on, pressure to the air conditioning

   system is ___________ (reduced/increased).

4. When the rain removal system is on, the low pressure solenoid is

   (energized/deenergized) _____________________.

Answers to Frame 4: 1. air 2. main solenoid 3. reduced 4. energized

Frame 5

The sketch on this page is a simplified schematic of the rain removal system. The bleed air pressure regulator and shutoff valve and the heat exchanger are actually part of the cabin refrigeration unit. These are put in the system sketch. They are also related to the rain removal system as explained in the previous frames.

The rain removal system consists of the following four <u>components</u>:

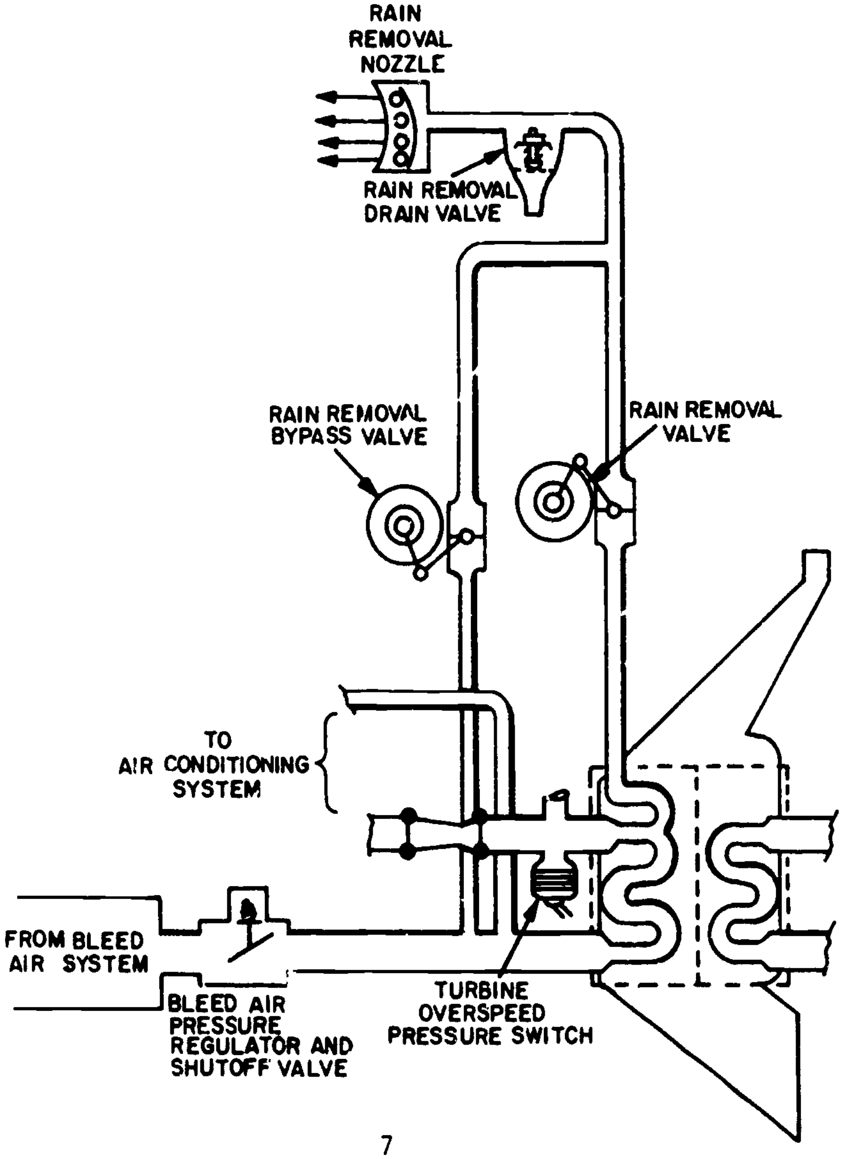
1. Rain removal valve

2. Rain removal bypass valve

3. Rain removal duct drain valve

4. Rain removal nozzle

Notice each of these components in the system illustration below.



Frame 6

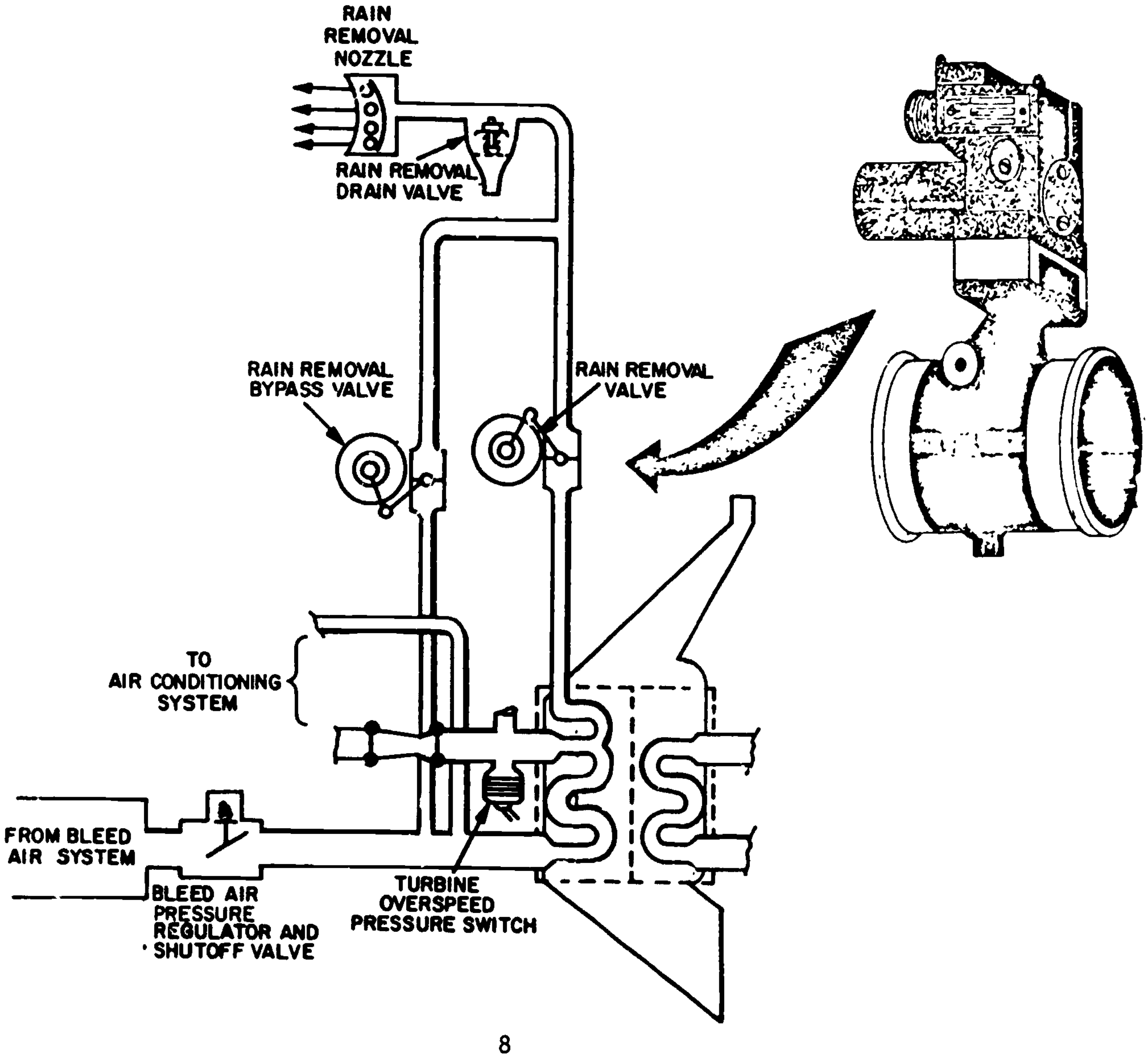
The rain removal valve, shown below, controls the flow of partially cooled bleed air from the heat exchanger to the rain removal nozzle. This is a butterfly type valve.

When the rain removal switch is placed to the ON position, 28 VDC power is directed to the rain removal valve motor. The valve then moves to the open position. This allows the partially cooled bleed air to flow through the valve and on to the nozzle.

NOTE: 1. The motor actuates the valve

2. Opening of the rain removal valve is controlled by the rain removal switch

3. Closing of the rain removal valve is controlled by the rain removal bypass valve limit switch



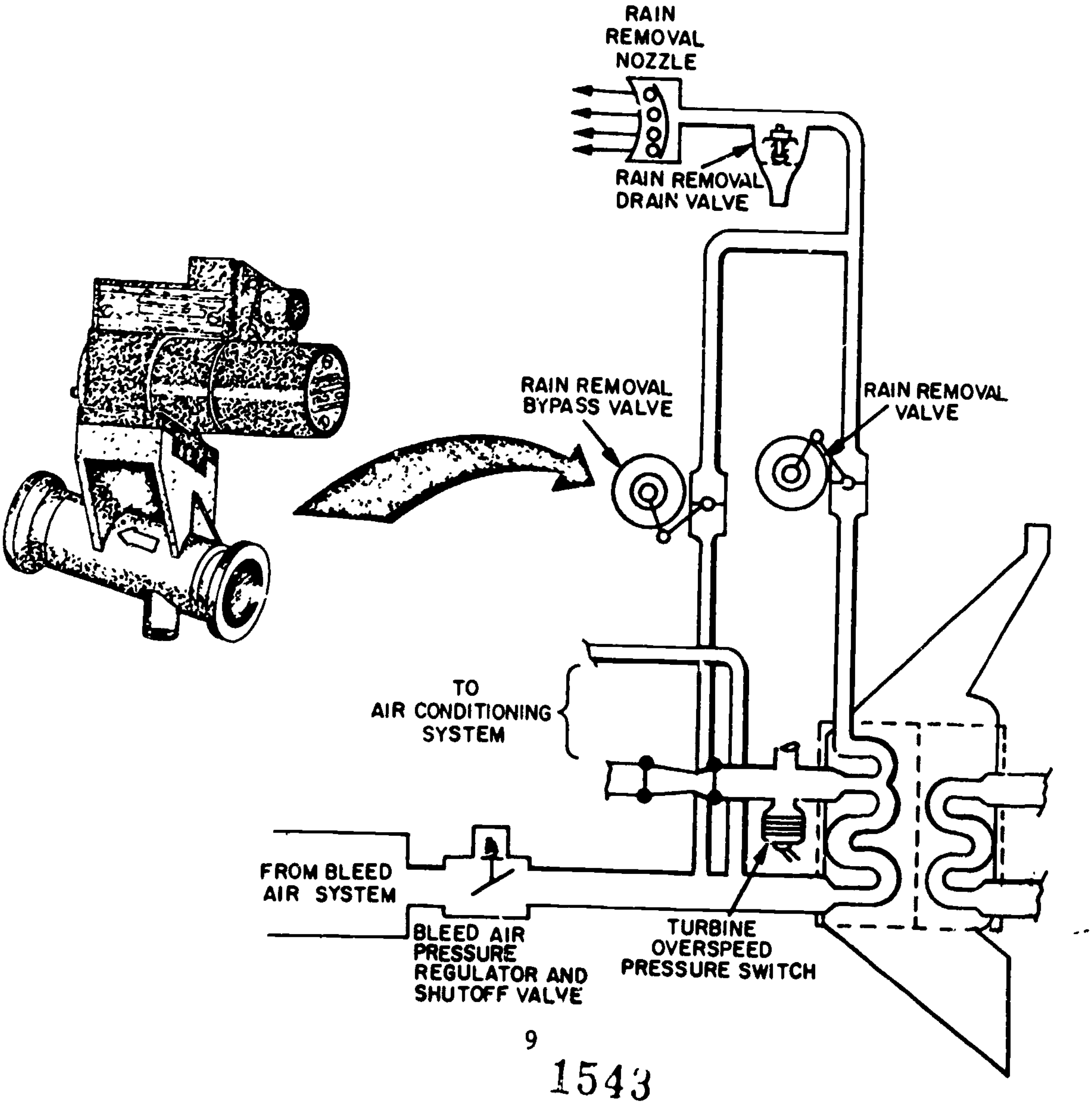
The rain removal bypass valve, shown below, controls the hot bleed air going to the rain removal nozzle from the hot bleed air duct. This is a butterfly type valve.

When the rain removal switch is placed to the ON position, 28 VDC power is directed to the rain removal valve motor. After this valve is fully open, a limit switch inside moves, opening the circuit within the motor. Then the 28 VDC power is directed to the rain removal bypass valve motor. The bypass valve then moves to the open position, allowing hot bleed air to flow to the mixing point. At this point, hot bleed air is mixed with the partially cooled air. The bypass valve increases the volume and temperature of the rain removal air.

NOTE: 1. The motor actuates the valve.

2. Opening of the rain removal bypass valve is controlled by the limit switch in the rain removal valve.

3. Closing of the rain removal bypass valve is controlled by the rain removal switch.



Frame 8

Fill in the blanks to complete the following statements.

1. The rain removal valve is actuated by a ______ ______ ______.

2. The hot bleed air going to the rain removal nozzle is controlled by the ______ ______ ______ valve.

3. The air flowing to the rain removal nozzle is a mixture of ______ ______ and ______ air.

4. The rain removal bypass valve is actuated by a ______ ______ ______.

5. The partially cooled bleed air going to the rain removal nozzle is controlled by the ______ ______ valve.

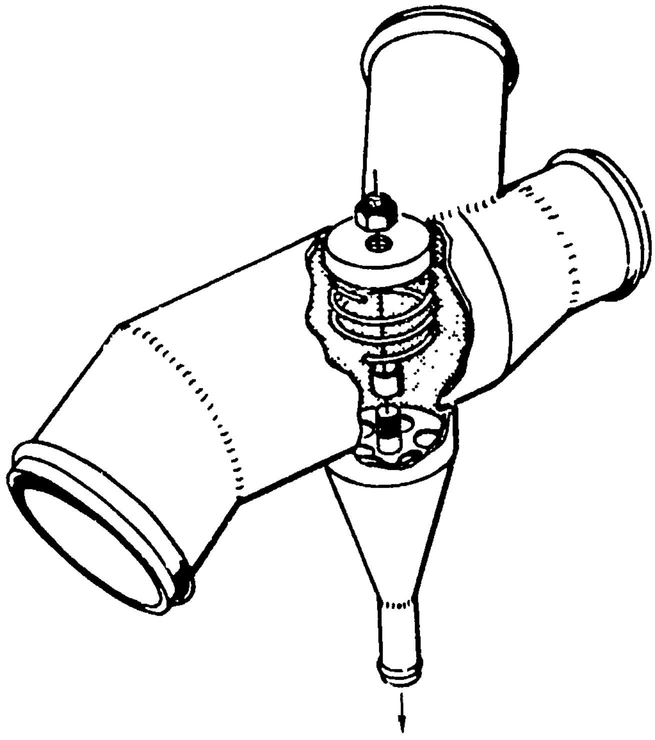
6. Opening of the rain removal valve is controlled by the ______ ______ ______.

Answers to Frame 8: 1. 28 VDC motor 2. rain removal bypass
3. partially cooled & hot 4. 28 VDC motor
5. rain removal 6. rain removal switch

Frame 9

When the rain removal system is OFF, the rain removal duct drain valve is held open by a spring. This allows the drain valve to drain water which accumulated while the aircraft was on the ground during periods of precipitation. The drain valve prevents water from being sprayed over the windshield when the rain removal system is turned on.

When the rain removal system is turned ON, air flowing through the rain removal ducts forces the rain removal duct drain valve to close. This also prevents a loss of air when the system is ON.



Fill in the blanks to complete the following statements.

1. The rain removal duct drain valve is opened by a ________________.

2. The rain removal duct drain valve is closed by ________________.

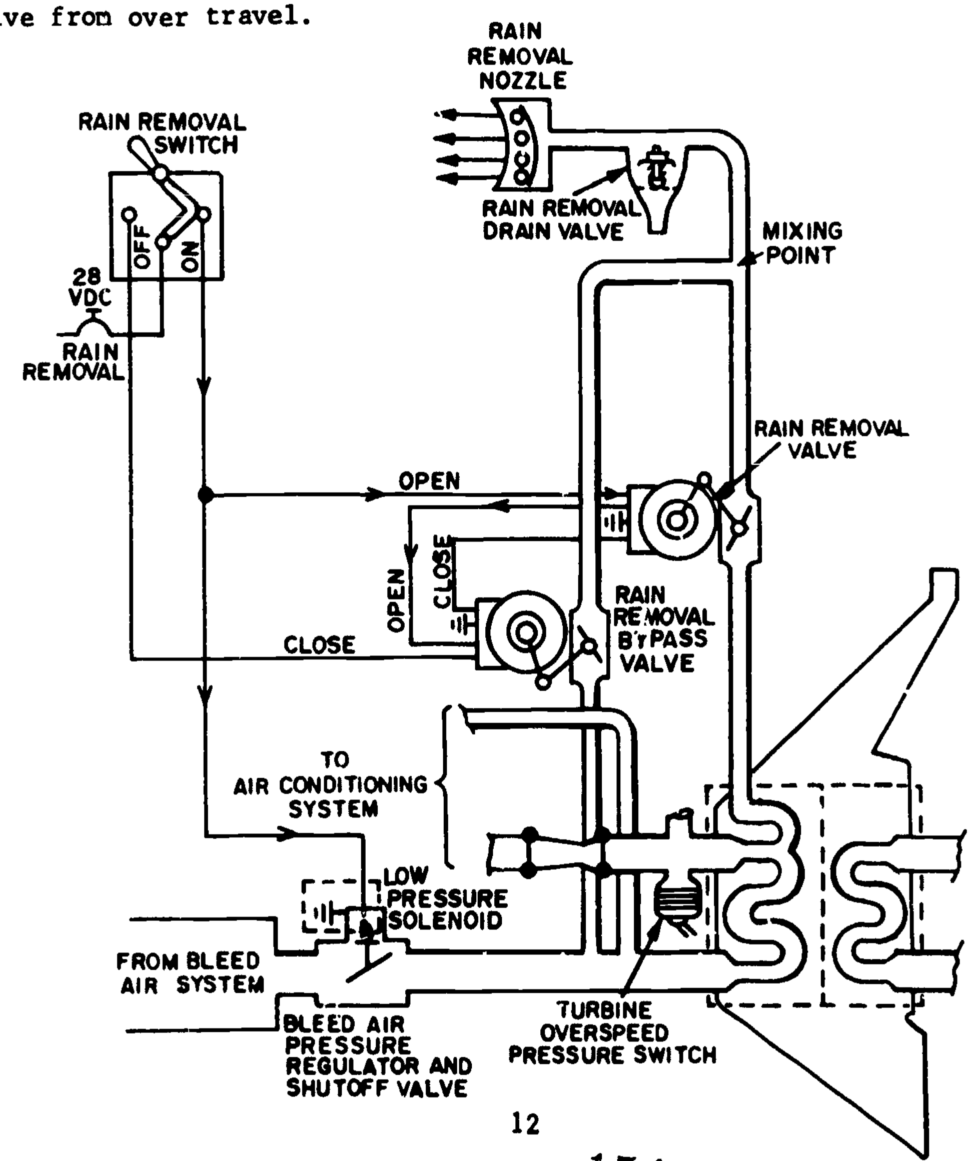
Answers to Frame 9: 1. spring 2. air pressure

Frame 10

The illustration below shows the complete airflow system with the rain removal switch in the ON position. A schematic of the electrical circuitry is also shown.

Trace the path for electrical current flow when the system is turned ON. Current flows from the circuit breaker, through the rain removal switch. From the switch current then flows to the low pressure solenoid on to the bleed air pressure regulator and shutoff valve. This reduces the air pressure going to the air conditioning system.

Current is also directed to the open winding of the rain removal valve motor. This operates the rain removal valve to the open position. When the valve reaches full open, it moves a limit switch to stop current flow to the rain removal valve motor windings. This limit switch then directs the current flow to the rain removal bypass valve motor. Current then flows through the open windings of the rain removal bypass valve motor, opening the valve. When the rain removal bypass valve reaches the full open position, it moves a limit switch to stop current flow to the rain removal bypass valve motor open windings, which prevent the valve from over travel.



Since the rain removal valve opens first, the partially cooled air will reach the rain removal nozzles first. Then the rain removal bypass valve will open allowing the hot bleed air to mix with the partially cooled air and flow on to the nozzles. The rain removal valves are sequenced this way to prevent a rapid temperature increase of the windshield, which could damage or distort the windshield.

Fill in the blanks to complete the following statements.

1. When the rain removal switch is ON, the low pressure solenoid will be

   ____________________.

2. When the rain removal switch is ON, the valve that opens first is

   the ____________ ____________ ______________.

3. The rain removal bypass valve will open only after the __________

   ____________ ______________ has fully opened.

4. When the rain removal switch is ON, the air pressure going to the

   air conditioning system is ___ ___________.

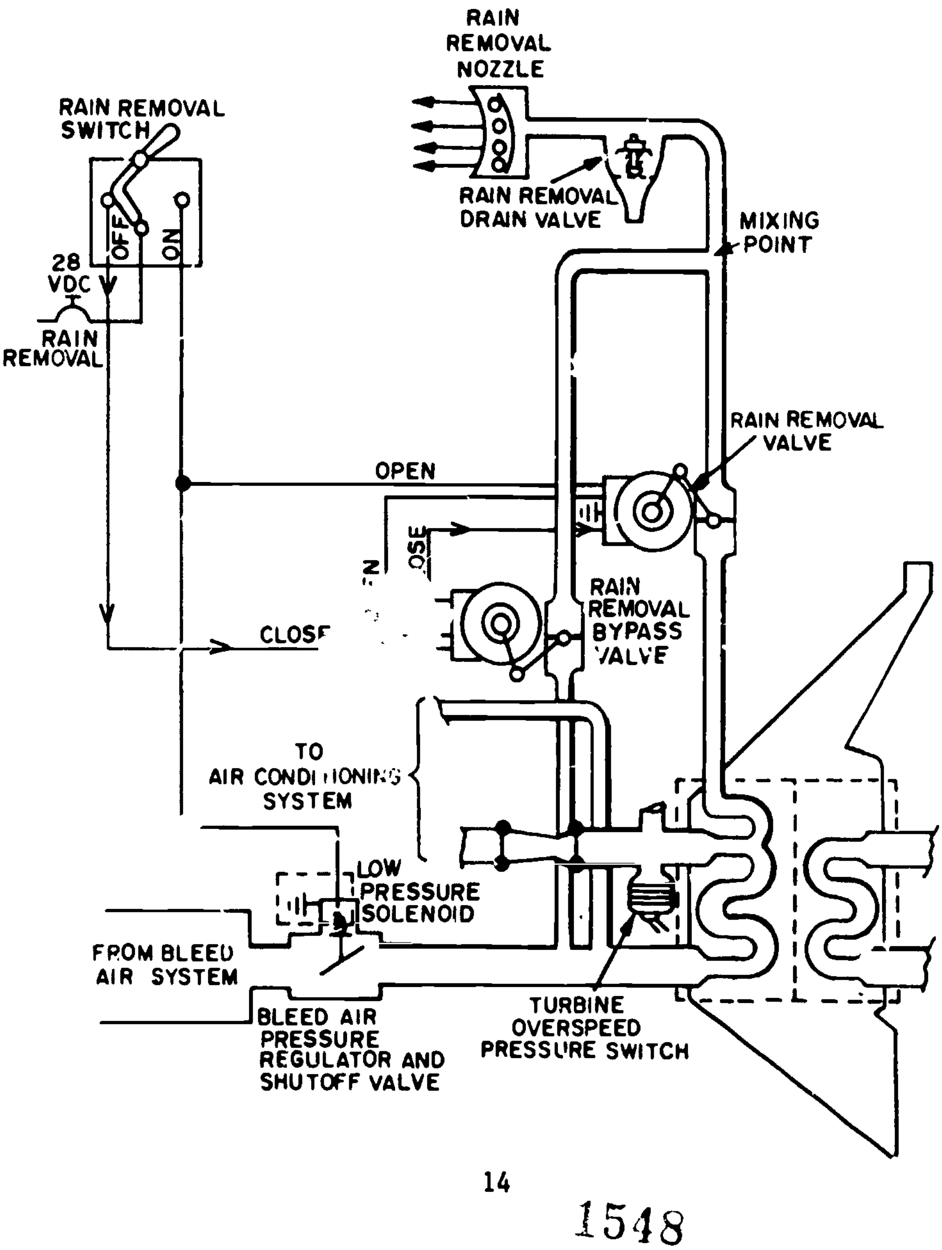
Answers to Frame 10: 1. energized 2. rain removal valve
3. rain removal valve 4. reduced

Frame 11

The illustration below shows the complete airflow system with the rain removal switch in the OFF position. A schematic of the electrical circuitry is also shown.

With the switch in the OFF position, the circuit will open going to the rain removal valve and the low pressure solenoid. This deenergizes the low pressure solenoid and allows the pressure regulator and shutoff valve to regulate pressure at 62 psi, for normal air conditioning.

Trace the path for electrical current flow when the system is turned OFF. Current flows from the circuit breaker, to the rain removal switch. From the switch current then flows to the close windings of the rain removal bypass valve motor, closing the valve.



When the valve reaches full closed, it moves a limit switch to stop current flow to the rain removal bypass valve motor windings. This limit switch then directs the current flow to the rain removal valve motor. Current then flows through the close windings of the rain removal valve, closing the valve. When the rain removal valve reaches the full close position, it moves a limit switch to stop current flow to the rain removal valve motor close windings, which prevents the valve from over travel.

Fill in the blanks to complete the following statements.

1. When the rain removal switch is placed to OFF, the low pressure solenoid is ______________________________.

2. Placing the rain removal switch to OFF, directs electrical power to close the ____________ ____________ ____________ valve first.

3. The rain removal valve closes only after the ___________ ___________ ___________ ___________ has been fully closed.

Answers to Frame 11: 1. deenergized 2. rain removal bypass
3. rain removal bypass valve

Frame 12

Answer the following statements true (T) or false (F).

_____ 1. The purpose of the rain removal system is to keep the canopy clear of rain.

_____ 2. The rain removal valve controls the flow of partially cooled air.

_____ 3. The partially cooled air for rain removal is tapped from the secondary section of the heat exchanger.

_____ 4. For the bleed air pressure regulator and shutoff valve to open, the emergency vent knob must be pushed in.

_____ 5. The volume and temperature of the rain removal air is increased when the rain removal bypass valve is opened.

_____ 6. The rain removal valve and bypass valve are both actuated by a 28 VDC motor.

_____ 7. The rain removal drain valve is held open by a spring and closed by air pressure.

_____ 8. For the rain removal bypass valve to open, the rain removal valve must be fully open.

_____ 9. The rain removal bypass valve closes after the rain removal valve has closed.

_____10. Opening of the rain removal valve and closing of the rain removal bypass valve are controlled by the rain removal switch.

_____11. Closing of the rain removal valve and opening of the rain removal bypass valve are controlled by the rain removal switch.

_____12. Closing of the rain removal valve is controlled by a limit switch on the rain removal bypass valve.

Answers to Frame 12: 1. F 2. T 3. F 4. T 5. T 6. T
7. T 8. T 9. F 10. T 11. T 12. T

Frame 13

The rain removal system does not have a way to control the air temperature automatically. So should an overheat condition occur, the pilot must turn the rain removal system off to reduce the temperature.

There is a system to warn the pilot when the windshield temperature reaches 260°F or above, where it could damage the windshield panel. This is the windshield temperature overheat warning circuit.

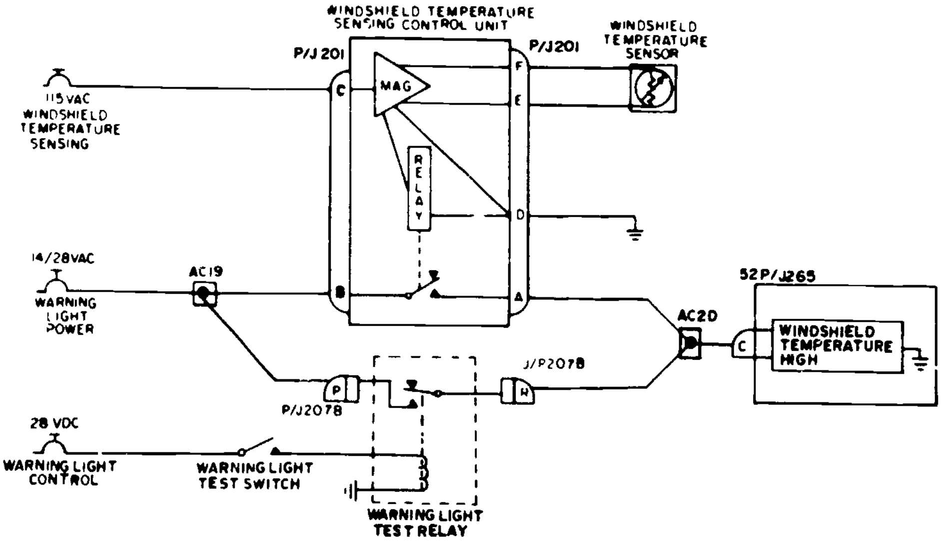
The windshield temperature overheat warning circuit consists of the following components:

1. Windshield Temperature Sensing Control Unit

2. Windshield Temperature (the warning light)

3. Windshield Temperature Sensor

Locate these components in the illustration shown below.



Fill in the blanks to complete the following statements.

1. The temperature of the rain removal air ______ (is/is not) controlled automatically.

2. Excessively hot air would probably ____________ the windshield.

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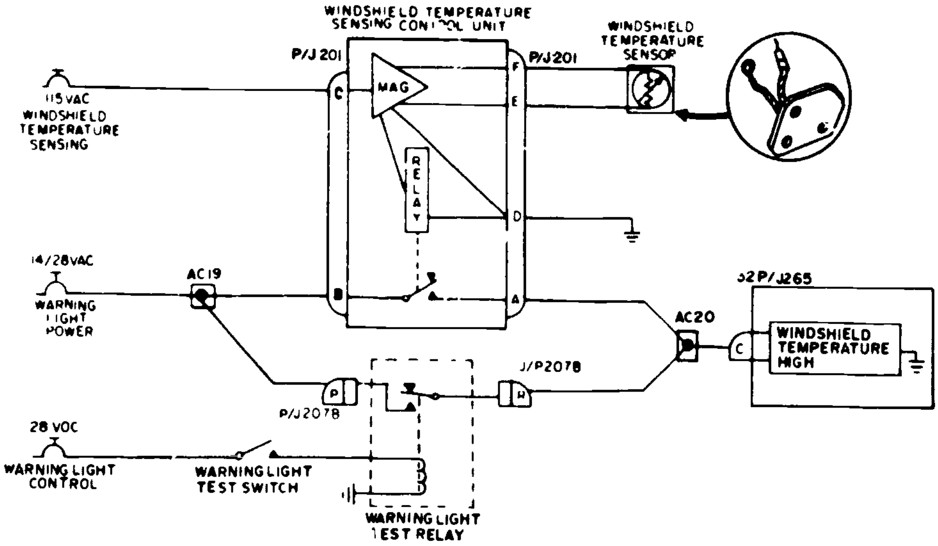
Answers to Frame 13: 1. is not 2. damage

Frame 14

The windshield temperature sensing element (also called the windshield temperature sensor) is mounted on the lower part of the windshield. The sensing element completes one leg of the temperature control unit circuitry.

The temperature sensing element has a positive coefficient of resistance. As the temperature increases, the resistance of the sensing element also increases. When the windshield temperature reaches 260°F, the increase in sensor resistance creates an unbalanced condition in the control unit and causes the WINDSHIELD TEMP HIGH warning light to come on.

The sketch shows the windshield temperature sensor. Also shown is the relationship of the sensor to the other units in the windshield temperature sensing circuit.



Fill in the blanks to complete the following statements.

1. The windshield temperature sensing element senses the temperature of the ______________________.

2. The windshield temperature sensing element has a _______________ coefficient of resistance.

3. When the windshield temperature decreases, the resistance of the sensing element ___________________. (increases/decreases)

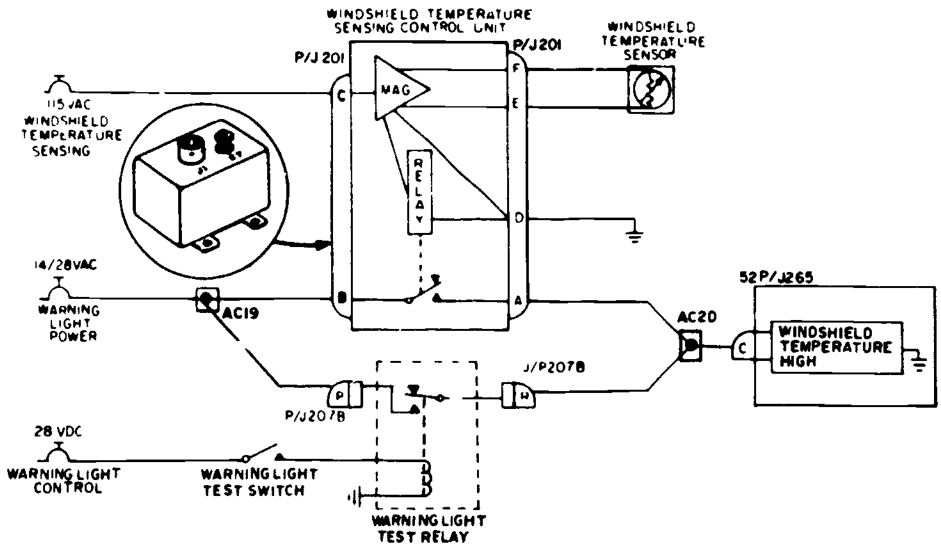
Answers to Frame 14: 1. windshield 2. positive 3. decreases

Frame 15

The windshield temperature sensing control unit, shown below, contains a magnetic amplifier, and a relay. The magnetic amplifier requires 115 VAC to operate and allow current to flow through the relay coil, energizing the relay. This keeps the relay contact open and the WINDSHIELD TEMP HIGH warning light off.

If there is a 115 VAC power loss to pin C of the windshield temperature sensing control unit (due to an open wire or pulled circuit breaker) the relay will deenergize. This closes the relay contacts, completing the warning light circuit and turning ON the WINDSHIELD TEMP HIGH warning light.

Should the windshield temperature reach 260°F or more, the signal from the sensor will stop the magnetic amplifier from energizing the relay. This closes the relay contacts, completing the warning light circuit and turning on the WINDSHIELD TEMP HIGH warning light.



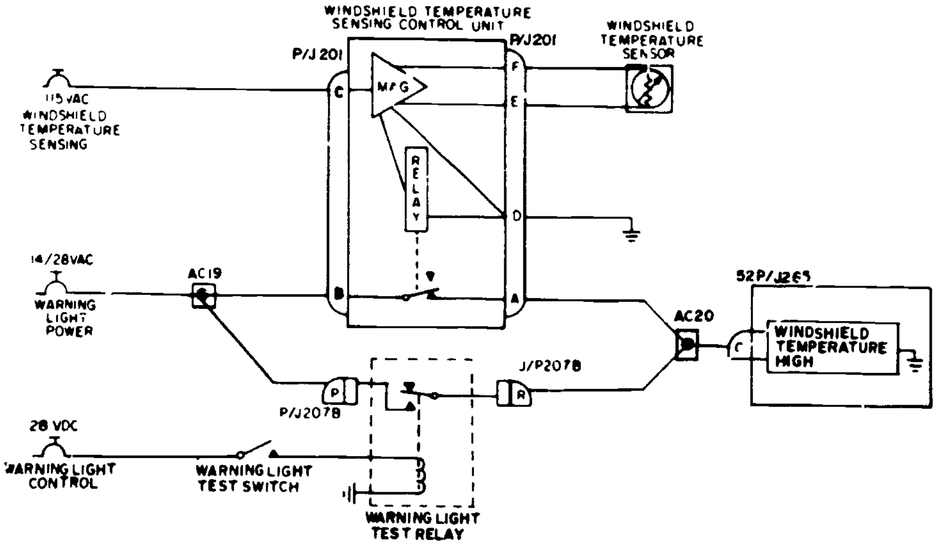
Frame 16

When the windshield temperature reaches 260°F, the WINDSHIELD TEMP HIGH warning light, comes on to warn the pilot of an overheat condition. When this happens, the pilot must turn off the rain removal system.

There is NO means for automatically controlling the rain removal temperature. The pilot must control the temperature manually. The windshield temperature warning system tells the pilot if the windshield temperature is too hot.

The sketch below shows the circuit with the warning light on (temperature is above 260°F). Notice the path of current flow from the warning light power circuit breaker to the light.

When the windshield temperature drops below 260°F, the windshield temperature sensing control unit will energize the relay, stopping current flow to the warning light.



Fill in the blanks to complete the following statements.

1. The rain removal temperature is controlled by the ______________.

2. The purpose of the windshield temperature overheat warning system is to warn the pilot when the ______________ is above 260°F.

3. When the WINDSHIELD TEMP HIGH warning light comes on, the pilot must turn off the ____________________.

Answers to Frame 16: 1. pilot 2. windshield temperature
3. rain removal system

Frame 17

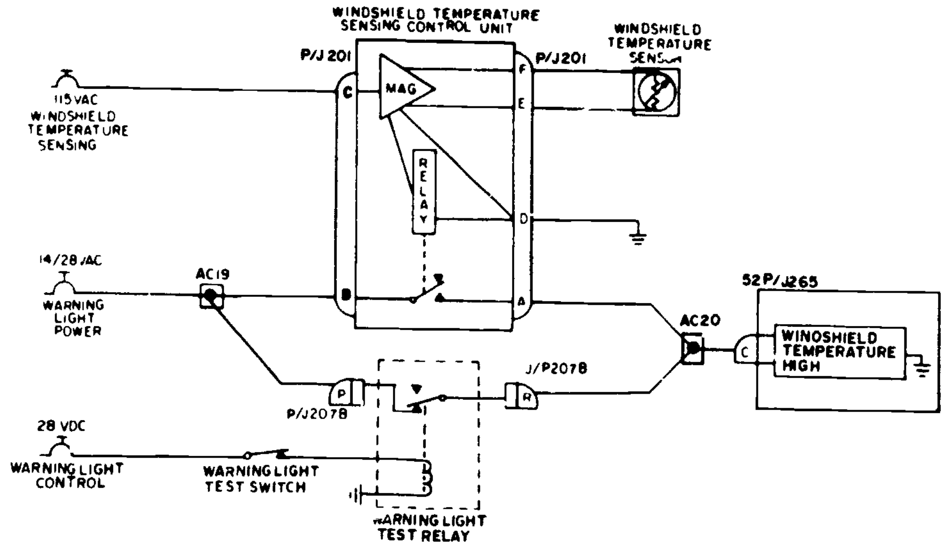
A warning light system is of no value unless we are sure it will work properly. The pilot can test the warning light system before each flight by using a warning light test switch.

The sketch below shows the warning light test circuit used to test the WINDSHIELD TEMP HIGH warning light.

When the warning light test switch is held in the test position, current can flow from the warning light control circuit breaker through the test switch and on to the warning light control unit. This energizes a relay in the control unit. With the relay energized, current flows from the warning light power circuit breaker, through the relay contacts and on to the light.

By holding the warning light test switch to the test position, the pilot knows power is available and the bulb is working properly if the warning light comes on. If the light does not come on, it indicates a burned out light bulb, or a loss of 14/28 VAC power.

The warning light test switch illustrated, shows testing of only one light. On the actual aircraft, this switch will test several warning light systems.



Fill in the blanks to complete the following statements.

1. The warning light test relay is used for __________ the warning light system.

2. When the warning light test relay is energized, the WINDSHIELD TEMP HIGH warning light is (on/off) ____________.

Answers to Frame 17: 1. testing 2. on

Frame 18

Match the units listed in column "B" with the statements given in column "A" by placing the letter from column "B" in the blanks provided.

COLUMN A	COLUMN B
____ 1. Allows the water to drain out when the system is off.	A. Rain removal bypass valve
____ 2. Senses the temperature of the windshield.	B. Low pressure solenoid
____ 3. Controls the flow of partially cooled air from the heat exchanger.	C. Windshield temperature sensing control unit
____ 4. Contains a magnetic amplifier and a relay which turns on the warning light	D. Rain removal duct drain valve
____ 5. Controls the hot bleed air going to the rain removal nozzle.	E. Windshield temperature sensor
____ 6. Used to reduce the pressure of the bleed air for both air conditioning and rain removal to 40 psi.	F. Pressure regulator and shutoff valve
____ 7. Warns the pilot that the windshield temperature is too high.	G. Rain removal valve
____ 8. Is an air actuated, solenoid controlled valve.	H. Windshield Temp High warning light
____ 9. This valve is held open by a spring, and closed by air pressure.	

Answers to Frame 18: 1. D 2. E 3. G 4. C 5. A 6. B
7. H 8. F 9. D

Frame 19

SUMMARY

The rain removal system, utilizing bleed air from the cabin air conditioning system, keeps the windshield clear when flying in rain by blowing hot air over the windsh'eld. This breaks up particles and diverts them over the glass.

When the pilot runs into rain he has to turn on the rain removal switch. This will energize the low pressure solenoid, and open the rain removal valve and the rain removal bypass valve. The rain removal bypass valve supplies hot bleed air to the rain removal nozzle. This mixture of partially cooled and hot bleed air goes over the windshield to keep the rain off the windshield. If the temperature on the windshield sensor reaches 260°F or above, the relay inside the windshield temperature sensing control unit will deenergize and turn on the WINDSHIELD TEMP HIGH warning light. When the light comes on, the pilot will have to manually turn off the rain removal system to prevent damage of the windshield. When the rain removal switch is placed to the OFF position, the rain removal bypass valve will close first, and then the rain removal valve will close. Once the valves are closed and the temperature drops below 260°F. the relay will energize and turn the light off. When the light has gone off, the pilot can turn the rain removal switch back to the ON position if need be.

Fill in the blanks to complete the following statements.

1. The rain removal nozzle directs air over the _______________.

2. The partially cooled air used for rain removal is cooled by the ____________ ____________ of the cabin refrigeration unit heat exchanger.

3. When the rain removal system is ON, the low pressure solenoid is (energized/deenergized) ________________.

4. The rain removal valve is actuated by a _______________.

5. The air flowing to the rain removal nozzle is a mixture of __________ air and _____________ air.

6. The rain removal duct drain valve is opened by a _____________.

7. When the rain removal switch is turned ON, the valve that opens first is the _______________.

8. The rain removal valve closes only after the rain removal bypass is fully _______________.

9. The windshield temperature sensor has a _______ coefficient of resistance.

Answers to Frame 19:

1. windshield
2. primary section
3. energized
4. 28 VDC motor
5. partially cooled, hot bleed
6. spring
7. rain removal valve
8. closed
9. positive

Technical Training

Aircraft Environmental System Mechanic

WINDSHIELD, TEMPERATURE CONTROL CIRCUIT FUNCTIONAL TEST PROCEDURES

25 June 1984

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE

DO NOT USE ON THE JOB

Environmental/Pneudraulic Branch
Chanute AFB, Illinois

C3ABR42331-WB-203B

WINDSHIELD TEMPERATURE CONTROL CIRCUIT
FUNCTIONAL TEST PROCEDURES

OBJECTIVE

Given functional test procedures for the windshield temperature control unit circuitry, the power bench with UNIT-B, and related test equipment, perform a functional test and record the correct procedure number and the remedy for abnormal indication for 2 given problems.

EQUIPMENT

Power Bench P/N 18-79-4534
Power Bench Unit B
Multimeter P/N AN/PSM-37
Decade Box

PROCEDURE

Caution: Remove watches, rings, bracelets, etc. before starting to work on the equipment. You will NOT, at anytime, turn ON any of the three power switches found on the right side of the power bench. ONLY the instructor will operate these three power switches. See figure 4. If you can't find these three power switches on the power bench, see your instructor at this time.

Note: Do NOT make any electrical connections until instructed to do so by the workbook or the instructor. Do NOT mix your leads, cables, etc. with your neighbor's equipment. When you leave your work area for any reason (break, etc.) make sure you do the following procedures before you leave:

1. Insure you have complied with all the instructions given by your instructor.

2. Insure your equipment is properly stored and secured before leaving the area. This includes:

   a. Multimeter.

   b. Decade (if it is not electrically connected to your work).

   c. Anything else the instructor may have instructed you to do.

3. When you return from your break, take the same equipment from the storage areas and go back to work.

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4. If there is anything you do not understand about the procedures before, during, or after break, be sure you ask your instructor.

5. Insure the power is turned OFF on your unit. If you are in question about the power, ask you instructor NOW! See figure 5.

Read and study the following definitions at this time.

DEFINITIONS

PROCEDURE - A series of steps which must follow in a regular definite order. This is required in order to achieve the objective.

NORMAL INDICATION - This is an indication which usually results from doing the correct procedure.

REMEDY FOR ABNORMAL INDICATION - A way to correct the abnormal indication.

WINDSHIELD AREA - This is the area on the aircraft around the windshield where the windshield temperature sensor is found. On the simulator aircraft, UNIT-B, there is a simulated Windshield Temperature Sensor. This is found in the top left hand corner under windshield area, where the black raised area is. See figure 5.

SIMULATION - This is written on the simulated aircraft in the top right hand corner of UNIT-B panel. This has a switch to allow the aircraft circuit to be programmed with either the aircraft's sensor or simulated sensor (Rheostat). The simulated position allows you to change the resistance as needed with a rheostat. The sensor position does not allow the use of the rheostat that you used when you had it in the simulated position. It does however use the internal resistance of the sensor circuit. See figure 5.

WINDSHIELD TEMP HIGH WARNING LIGHT - This is the light found in the lower left corner of the simulated aircraft (UNIT-B) which tells if an overheat condition exists. It is also called "Light," "Caution Light," or "Windshield Temp High Warning Light," and is found in the cockpit of the actual aircraft. See figure 5. HIGH is the same as HI.

- Same as "WSHLD TEMP HIGH"

- Same as "WINDSHIELD TEMP HI"

COCKPIT AREA - This is the area of UNIT-B which you would find similar to the actual aircraft. The panel given on UNIT-B has all the control devices needed for the circuit as found on an actual aircraft. (Simulation area is not found in the cockpit.) See figure 1.

WINDSHIELD TEMPERATURE SENSING CONTROL UNIT - It is found in the cockpit under the control panel of the real aircraft. On the simulated aircraft, (UNIT-B) it is found at the bottom of the cockpit area panel. It is for the WINDSHIELD TEMP HIGH CIRCUIT as you have studied in past material. See figure 5.

RELAY - It is below the cockpit area panel in UNIT-B. Its purpose is to test the WINDSHIELD TEMP HIGH light, NOT the automatic temperature circuit. See figure 5.

STEP NUMBER - In this workbook, step number and procedure are the same.

DIAGRAM 1 - This diagram is for your own use, unless otherwise instructed.

WINDSHIELD TEMPERATURE SENSING ELEMENT - Same as: "Temperature Sensor"

"Windshield Temperature Sensor"

"Sensor" in this workbook

UNIT-B - Fighter aircraft windshield temperature sensing control and sensing circuits.

- Windshield temperature control unit circuitry.

- Simulated aircraft.

Before you start with the following exercises be sure that you completely understand the past PTs and WBs of the rain removal system and circuits. If you have any questions about the system, see your instructor at this time and DON'T go to the next paragraph. If you know and understand the material on the rain removal system up to this point, you may progress.

In this workbook you will find checkout procedures which are similar to what you will be using on the flight line. Checkout procedures on the flight line are provided for use during established inspection periods or for performing troubleshooting. The items to be checked and scheduled frequencies for these checks are established by applicable inspection requirements manuals. Perform the procedures only in the sequence as outlined and given in this workbook or, if on the flight line, as the aircraft manual requires.

You may refer to the rain removal wiring diagram as you see fit during this workbook. It is found on page 34, diagram 1, at the back of this workbook. You will not be allowed to use the diagram during any evaluation, unless the evaluation instructions say you can.

If at any time in this workbook the instructor's initials are required, you will stop and ask the instructor for his/her initials.

From your past studies of the rain removal system on the fighter aircraft you should recall the following:

1. A caution light called WINDSHIELD TEMP HIGH is used to inform the pilot of an overheat condition on the windshield.

2. The caution light is in the windshield overheat circuitry and is controlled by the windshield temperature sensing control unit.

3. During NORMAL operation, the windshield high light will remain OFF. When a critical temperature period of 260°F or more is reached, the light will come on.

4. Power of 115 VAC is supplied to the amplifier in the temperature control unit.

5. The amplifier will NORMALLY keep the windshield temp sensing control relay energized as long as the sensor circuit resistance is low and within the shaded area shown in the graph in figure 9.

6. Low voltage 28 VAC power is supplied to the relays contacts in the windshield temperature sensing control unit. This relay controls low voltage 28 VAC power to the caution light.

7. When the temperature of the windshield rises to a critical temperature of over 260 degrees, the relay in the windshield temperature sensing control unit deenergizes, illuminating the warning light.

8. During normal temperature operation of the system, the relay in the windshield temperature sensing control unit is energized.

In figure 1 you will find a picture of UNIT-B. This is not a tester. It will be called a simulated aircraft because in it you find the fighter aircraft windshield temperature sensing control and sensing circuits. On each side of the cockpit area of UNIT-B, you will also find a storage area for the necessary wiring needed for this workbook. See figure 1.

You will find the left storage area and TEST CABLE shown in figure 1. The test cable has a box added to it which is not found on the flight line test cable. This is shown in figures 2 and 3. The box provides ABNORMAL/NORMAL indication switches (trouble switches used to simulate problems).

On the flight line, your shop will make their own test cable as shown in figure 2. Figure 2 is taken from the aircraft manual for you to examine. Note that figure 2, test cable does NOT have the box as the test cable used in the school does, shown in figure 3.

You must remember, UNIT-B is NOT a tester, it is a simulated aircraft for only the fighter aircraft windshield temperature sensing control and sensing circuits. Remember it is NOT a tester. Only the test cable, decade and multimeter may be considered by some to be in the same family as testers. This is because they are used to checkout the functioning of the circuits.

If you have any questions about the past materials, see your instructor at this time. If you don't have any questions, go to the next page.

PREPARATION

Note: DO NOT make any connections unless instructed to do so.

1. Insure you have complied with all safety requirements found in the beginning of this workbook, posted in the lab, and given by your instructor.

2. At the power bench, remove UNIT-B from one of the two cabinets in front of you. (See figure 4.) If they are locked or you have difficulty with them see your instructor at this time.

3. Place UNIT-B in front of you on the power bench (see figure 4).

4. Remove the lid from UNIT-B using the 4 latches and leave wires in UNIT-B until instructed to remove them.

5. Place the lid back in the cabinet (see figure 4).

6. Make sure the two power switches on UNIT-B (simulated aircraft) are OFF (see figure 5).

7. Insure the AC and DC power cables are connected to the power bench outlets in front of you under the cabinets (see figure 4). The power cables for the simulated aircraft are in the right storage area of UNIT-B.

8. Insure the simulated/sensor switch has the red cover down (see figure 5).

9. <u>Leave</u> the test cable with abnormal indication panel <u>in place</u> as shown in figure 1 on the left storage compartment.

10. <u>Leave</u> the RED and BLACK leads for the decade <u>in place</u> as shown in figure 1 on the right storage compartment.

If you don't have any questions at this time go on to Exercise 1.

If you don't have enough time to finish your workbook by lunch time or the end of the day, proceed to storage steps on page 18.

Exercise 1

WINDSHIELD TEMPERATURE SENSING CONTROL UNIT SYSTEM CHECK

You must have:

TOOLS AND EQUIPMENT

Power Bench with UNIT-B

Lead Pencil (No ink)

Do NOT progress in this exercise until the PREPARATION is completed on page 6.

Looking at the next page you will find 3 columns titled as follows:

1. PROCEDURE

2. NORMAL INDICATION

3. REMEDY FOR ABNORMAL INDICATION

See the definitions for the above on page 3.

If you find that a normal indication is provided in the column, but the indication resulting from the procedure is abnormal and there isn't a remedy provided for an abnormal indication, STOP and see your instructor.

Go to the next page.

WINDSHIELD TEMPERATURE SENSING CONTROL UNIT SYSTEM CHECK

PROCEDURE	NORMAL INDICATION	REMEDY FOR ABNORMAL INDICATION
1. Insure the two aircraft power switches are OFF, located on UNIT-B, the simulated acft.	All red lights out on simulated acft (UNIT-B)	
2. Insure the plug on the simulated aircraft is properly connected to the windshield temperature sensing control unit.	As shown in figure 5	
3. Insure the three circuit breakers are pushed in on UNIT-B	Circuit breakers should stay in.	

Note: At this time the instructor will insure the power switches on the right side of the power bench are set as required. Students will NOT turn these switches on!

4. Turn on the two power switches for AC and DC on the simulated acft.	The following RED lights should come on: 28 VDC 115 VAC 28 VAC	
5. Briefly hold the warning light test switch in test position. (See figure 5.)	WINDSHIELD TEMP HIGH comes on during the holding period of the switch.	

Note: The following steps make use of the SIMULATION area on UNIT-B. The simulated/sensor switch and rheostat for resistance changes with simulating temperature change are installed here only for training. They allow you to change resistance when you mentally simulate a temperature change. You will NOT find these on the actual aircraft on the flight line or in any of the rain removal systems wiring diagrams. The simulation switch when placed to simulation takes the Windshield Temperature Sensor out of the circuit and in its place puts the rheostat for simulation. (See figure 5.)

PROCEDURE	NORMAL INDICATION	REMEDY FOR ABNORMAL INDICATION
6. Place the simulated/ sensor switch to simulate. (Raise the red cover first.)	WINDSHIELD TEMP HIGH may OR may not come on.	
7. Rotate the rheostat clockwise to increase resistance with the simulated increase in temp.	WINDSHIELD TEMP HIGH light will come on at about 260° and 174 ohms. Do NOT measure these values.	
8. Rotate the rehostat counterclockwise to reduce resistance just far enough to turn OFF the Windshield Temp High light.	The Windshield Temp light goes out at 260°F and 174 ohms. Do NOT measure these values.	
9. Continue to rotate the simulated sensor counterclockwise until the Windshield Temp High light comes on.	Light comes on at about 70 ohms. Do NOT measure this value.	
10. Place the simulated/ windshield switch to sensor (red cover down).	Windshield Temp High light may or may not be out.	
11. Insure the two aircraft power switches are OFF. (Located on UNIT-B of the simulated acft.)	All red lights out on simulated aircraft (UNIT-B).	

If you want to do the above again, you may at this time.

GO TO THE NEXT PAGE

You have just completed the system check of the rain removal Warning Light Test when using the Warning Light Test switch. You have also just simulated high and low temperatures and then manually changed resistance with the rheostat so you could see the Windshield Temp High light come on and go OFF.

You must remember UNIT-B is NOT a tester. Later you will connect a test cable to the circuit and also use a decade box and/or multimeter to test the electrical quality and adjustment of this simulated aircraft.

You must remember that the simulated/sensor switch and the rheostat are not part of the real aircraft electrical circuit and you will not find them in the electrical wiring diagrams. They are for school use only, and you will not use them unless instructed by the instructor to do so in the remainder of the workbook.

If you should have any questions or don't understand something so far, see your instructor at this time.

Remember from your past training that the test switch does not check the sensor or the windshield temperature sensor control unit, but only the windshield temp high light.

After completing Exercise 1, progress on to Exercise 2.

Exercise 2

WINDSHIELD TEMPERATURE SENSOR FUNCTIONAL TEST

This procedure provides a detailed electrical check of the temperature sensor. You must have:

TOOLS AND EQUIPMENT

Power Bench with UNIT-B

Multimeter

Lead Pencil (No ink)

If you have done the storage steps on page 18 after Exercise 1, you must complete the preparation steps again on page 6 before beginning Exercise 2;

OR

If the storage steps were NOT done between Exercise 1 and 2, you should progress to Exercise 2;

OR

If you have just started the performance exercise or test, insure the preparation steps on page 6 are completed before beginning Exercise 2.

GO TO NEXT PAGE

WINDSHIELD TEMPERATURE SENSOR FUNCTIONAL TEST

PROCEDURE	NORMAL INDICATION	REMEDY FOR ABNORMAL INDICATION
1. Insure the two aircraft power switches are OFF, located on UNIT-B of the simulated acft.	All red lights out on the simulated aircraft UNIT-B.	
2. Insure the nine switches on the abnormal indication box are in normal.		
3. Insure the plug is disconnected from the Windshield Temperature Sensing Control Unit, or as connected in step 4.	See figures 5 and 6.	
4. Connect the cable with the abnormal indication box between the Wind-Shield Temperature Sensing Control Unit and the aircraft wiring.	See figure 6. Note: Disregard steps 2-4 when you are on your practice problems or progress check.	
5. Connect a multimeter to TP-1 and TP-2 and measure the sensor resistance and record the reading ______________.	See figure 7.	

Note: Insure Simulated/Sensor switch is in Sensor position with RED cover DOWN for step 5.

Note: The two plastic covers on the end of the test cable must be stored in left storage area.

6. Using the areas ambient temperature provided by your instructor (or found on the bench in front of you) and resistance you recorded above, plot this information on the graph in figure 9.	Resistance within tolerance shown. (This is the shaded area on the graph.)	a. If HIGH resistance, replace windshield temp sensor. b. If OPEN, replace windshield temp sensor. c. If LOW resistance, replace windshield temp sensor. d. If SHORT, replace windshield temp sensor.

If you want to do the above again you may at this time.

GO TO THE NEXT PAGE

You have just completed the Windshield Temperature Sensor Functional Test. This procedure provides a detailed electrical check of the temperature sensor only. It does <u>not</u> have anything to do with the rest of the circuit (which turns the Windshield Temp High light on or off).

If you should have any questions or don't understand something so far, see your instructor at this time.

Exercise 3

WINDSHIELD TEMPERATURE SENSING CONTROL UNIT FUNCTIONAL TEST

This procedure provides a detailed check of the electrical integrity and adjustment of the temperature sensing control unit. You must have:

TOOLS AND EQUIPMENT

Power Bench with UNIT-B

Decade

Lead Pencil (No ink)

Note: The multimeter is required for the Performance Exercise. Be sure that you have the multimeter disconnected from TP-1 and TP-2.

If you have done the storage steps after Exercise 2, you must complete the preparation steps on page 15, step 1, again before beginning Exercise 3;

OR

If the storage steps were not done between Exercise 2 and 3, you should progress to Exercise 3, step 8.

Exercise 3

WINDSHIELD TEMPERATURE SENSING CONTROL UNIT FUNCTIONAL TEST

PROCEDURE	NORMAL INDICATION	REMEDY FOR ABNORMAL INDICATION
1. Insure the two aircraft power switches are OFF on the simulated aircraft	All RED lights out on simulated acft UNIT-B figure 5.	
2. Insure the AC and DC power cables from the simulated aircraft are connected to the power bench shelf in front of you. See figure 4.	See figure 5.	
3. Insure the 3 circuit breakers are pushed in on simulated acft.	Circuit breakers should stay in.	
4. Insure the Sensor Simulated switch is in the sensor position with RED cover down. See figure 5.	RED cover down.	
5. Place the nine switches on the abnormal indication box to normal.	As shown in figure 6.	
6. Insure the plug is disconnected from the Windshield Temperature Sensing Control Unit, or as connected in Step 7.	See figures 5 and 6.	
7. Insure the cable with the abnormal indication box is connected between the Windshield Temperature Sensing Control Unit and acft wiring.	As shown in figure 6.	
8. Connect Simulated Sensor Decade 1 to the banana jacks at TP-3 and TP-4, which are the green jacks of the abnormal indication box.	See figure 8.	

PROCEDURE	NORMAL INDICATION	REMEDY FOR ABNORMAL INDICATION
9. Only after the instructor has initialed above, turn on the two power switches on the simulated aircraft.	Four lights come on for· 28 VDC Figure 5 115 VAC 28 VAC Windshield temp high light	
10. With only the 115 VAC circuit breaker pulled out, set decade 1 to 71 ohms.	Windshield Temp High light on. Figure 5.	Replace Windshield Temperature Sensing Control Unit.

Pulling out the circuit breaker cuts off 115 VAC power to the amplifier in the Windshield Temperature Sensing Unit. The relay in this control unit becomes deenergized and the contacts come together causing the Windshield Temp High light to come on. Study Diagram 1.

11. Set (push in) Windshield Sensing circuit breaker, 115 VAC.	Windshield Temp High light goes out.	Replace Windshield Temperature Sensing Control Unit.
12. Set resistance (decade) to 170 ohms	Light remains out.	Replace Windshield Temperature Sensing Control Unit.

Note: Throughout this workout, when the remedy for abnormal indication requires any kind of adjustments to resolve the abnormal indication you will NOT make the adjustment.

13. Slowly increase resistance (decade) in one (1) ohm increments, until Wshld Temp High light comes on. Record resistance ______ ohms.	Light comes on at 172.5 to 175.5 ohms.	Calibration (adjustment) required of Windshield Temperature Control Unit.
14. Increase resistance to 200 ohms.	Light remains on.	Replace Windshield Temperature Sensing Control Unit.

The next step <u>may</u> require resistance on the decade to be reduced to tenths to find the correct value.

15. Decrease resistance slowly until Wshld Temp High light goes out. Record resistance ____________ ohms.	Resistance not less than 1.5 ohms or more than 25 ohms below the resistance that light comes on in step 13.	Replace Windshield Temperature Sensing Control Unit.

PROCEDURE	NORMAL INDICATION	REMEDY FOR ABNORMAL INDICATION

Note: If you hear a hum, it is from the relay in the Windshield Temperature Sensing Control Unit and is due to inherent characteristics of the relay.

16. Set resistance to 80 ohms.		
17. Decrease resistance in one ohm increments until Wshld Temp High light comes ON.	Light comes on at 30 to 70 ohms and remains on at all values less than 30 ohms.	Replace Windshield Temperature Sensing Control Unit.
18. Increase resistance.	Light goes out at 30 to 70 ohms.	Replace Windshield Temperature Sensing Control Unit.
19. Set resistance at 80 ohms.	Light goes out.	If light does not operate per steps 19, 20, and 21 as specified, remove dust caps from R4 and/or R7 adjustment controls on the control unit. Adjust R4 and/or R7 so warning light comes on at a resistance setting of 172.5 to 175.5 ohms. Repeat steps 10-21. If test still fails, replace temperature sensing control unit.
20. Break resistance circuit. See Note 1.	Light goes on.	
21. Make resistance circuit. See Note 2.	Light goes out.	

Note 1: Break resistance means to replace an open in the simulated sensor decade 1 circuit. This can be done by removing one lead from the decade.

Note 2: This means to put the resistance back in the circuit. This must be done by placing the lead(s) back in the decade.

22. Turn OFF the two power switches on the simulated aircraft. See figure 5.	Three lights go out for 28 VDC 115 VAC 28 VAC	

Note: You may go back and redo or study the past material in this workbook at this time before you progress. If you don't understand or have any questions, now is the time to see your instructor.

See Your Instructor

STORAGE PROCEDURE

1. Insure the two power switches are OFF on the simulated aircraft and the three red lights should be out.

2. Insure the AC and DC power cables are disconnected from the power bench outlets in front of you and place the cables in the unit's storage area. See figure 1.

3. Insure the simulated/sensor switch has the red cover down.

4. Insure the test cable with the abnormal indication panel is disconnected from the simulated aircraft and stored on the left side of UNIT-B with switches to normal and with plastic covers installed on plugs. See figure 1.

5. Insure the aircraft plug to the windshield temperature sensing control unit is connected. See figure 5.

6. Insure the red and black leads for the decade are stored, as in figure 1.

7. Have your instructor inspect your work at this time before you place the lid on the unit.

8. Install lid.

9. Place UNIT-B in storage cabinet.

10. Insure multimeter and/or decade is in its proper storage.

11. Clean your work area as needed.

12. Turn in this complete workbook to the instructor and wait for additional instructions.

PRACTICE EXERCISE

This is your practice exercise (practice work). You are required to complete at least the first three assigned problems. In addition, you MAY also be required to complete some or all of the additional three problems. These additional problems are only required if the instructor determines you need additional practice. During the practice exercise you may ask any question you wish within reason. The instructor will always reserve the right on how or if to respond to your question(s).

The student will not be allowed to progress on to the progress check unless all the assigned practice exercises (practice work) are completed. The instructor will determine if your assigned practice exercise is completed and also when you are to progress to the progress check.

At this time go back and reread the objective in front of this workbook. If you have any questions about it, see your instructor now. If you don't have any questions with any of the past material and think you understand it, proceed with the following:

> Note: During the practice exercise, if you have anything you don't understand, inform your instructor, or if you have any questions during the exercise, that's the time to ask.

To start, place switch 1, on the Normal/abnormal indication box, to the Abnormal position. The following will take you through the general procedures on how to perform the practice exercise. Be sure you use this time wisely because you must be able to use the general knowledge you gain here to do the progress check and pass it.

Insure your preparation is complete and be sure your Normal/Abnormal switch remains in the Abnormal position until the problem you have been assigned is complete.

For each Abnormal/Normal switch placed to the Abnormal position you must do the following:

Exercise 2 - WINDSHIELD TEMPERATURE SENSOR FUNCTIONAL TEST
AND AS NEEDED

Exercise 3 - WINDSHIELD TEMPERATURE SENSING CONTROL UNIT FUCNTIONAL TEST

> Note: Remember it says, "AND AS NEEDED," above and that means since you start with Exercise 2 for each switch used you may or may not need to do Exercise 3 to find what the objective requires .

> Note: The reason Exercise 1 is not used at this time is because Exercise 1 was used to familiarize you with the operation of the windshield temperature sensing control unit.

Insure that you have switch 1 to the abnormal position and start Exercise 1 on page 11. After completion of Exercise 2 you should have found that the sensor reading was incorrect.

GO ON TO THE NEXT PAGE

Place the number 6 on the worksheet on page 21 under the Column, Record the Procedure or Step Number. This is the step that something malfunctioned.

Now write very neatly in lead pencil the Remedy for Abnormal Indication on page 21 under the Column, Record Remedy for Abnormal Indication.

You should have written "high resistance replace windshield temp sensor."

This is what you must do to record the information required by the objective.

Now stop and have the instructor initial before you proceed. The instructor reserves the right at this time and any other time to question you about the material, inform you, etc. The instructor will now assign additional practice problems.

After you have done the two practice problems on page 21, be sure you let your instructor check your work.

PRACTICE EXERCISE WORKSHEET GROUP ________			
PROBLEM	NORMAL/ABNORMAL INDICATION SW. NUMBER	RECORD THE PROCEDURE OR STEP NUMBER	RECORD REMEDY FOR ABNORMAL INDICATION
1			
STOP FOR INSTRUCTOR'S INITIALS TO PROCEED ________			
2			
3			

STOP FOR INSTRUCTOR'S INITIALS ________

PRACTICE EXERCISE WORKSHEET			GROUP ______
PROBLEM	NORMAL/ABNORMAL INDICATION SW. NUMBER	RECORD THE PROCEDURE OR STEP NUMBER	RECORD REMEDY FOR ABNORMAL INDICATION
4			
STOP FOR INSTRUCTOR'S INITIALS TO PROCEED ______			
5			
STOP FOR INSTRUCTOR'S INITIALS TO PROCEED ______			
6			
STOP FOR INSTRUCTOR'S INITIALS TO PROCEED ______			

PROGRESS CHECK

INSTRUCTIONS

Read the objective below:

OBJECTIVE

Given functional test procedures for the windshield temperature control unit circuitry, a power bench with UNIT-B, and related test equipment, perform a functional test and record the correct procedure number and the remedy for abnormal indication for 2 given problems.

If you have any questions about the objective, see your instructor at this time.

This progress check will require you to correctly record 2 step numbers with the abnormal indication from the functional test which prevent the windshield temperature control unit or windshield temperature sensor from passing the functional test. This should be accomplished by using Exercises 2 and 3 in much the same manner as the practice exercises (practice problems). The instructor will check your work as required. If you miss ANY PART of either problem given, you will fail. Then follow the instructions given you by your instructor.

You will <u>not</u> communicate (talk, etc.) with other students during the progress check without your instructor's permission. You will not use fellow student's work to solve the problems in the progress check. If you do communicate with other students without permission, the instructor may assume you are cheating and may fail you even though you may have not completed the work.

You will <u>not</u> have in your possession during this progress check any notes or other literature relating to this lesson without permission from your instructor. If you have any questions, now is the time to ask your instructor. After you start this progress check and you do ask a question, your instructor does <u>not</u> have to answer it.

Insure you have complied with all safety standards during the progress check. If you fail to follow the safety standards, the instructor may fail you on this progress check even though you have <u>not</u> finished. Insure you have a power bench with UNIT-B, multimeter, aircraft windshield temperature sensing control and sensing circuit. Do <u>not</u> start the progress check until told to do so by the instructor.

Have your instructor write the numbers for the Normal/Abnormal Indication Switch Numbers on page 24 of the progress check worksheet.

If you don't have any questions, ask your instructor to initial below for you to start your progress check.

PROGRESS CHECK WORKSHEET GROUP ________			
PROBLEM	NORMAL/ABNORMAL INDICATION SW. NUMBER	RECORD THE PROCEDURE OR STEP NUMBER	RECORD REMEDY FOR ABNORMAL INDICATION
1			
2			

After completing the above you will follow the instructions below and also have the instructor check your answers.

Student will turn in workbook to the instructor. The instructor will determine what pages to give the student.

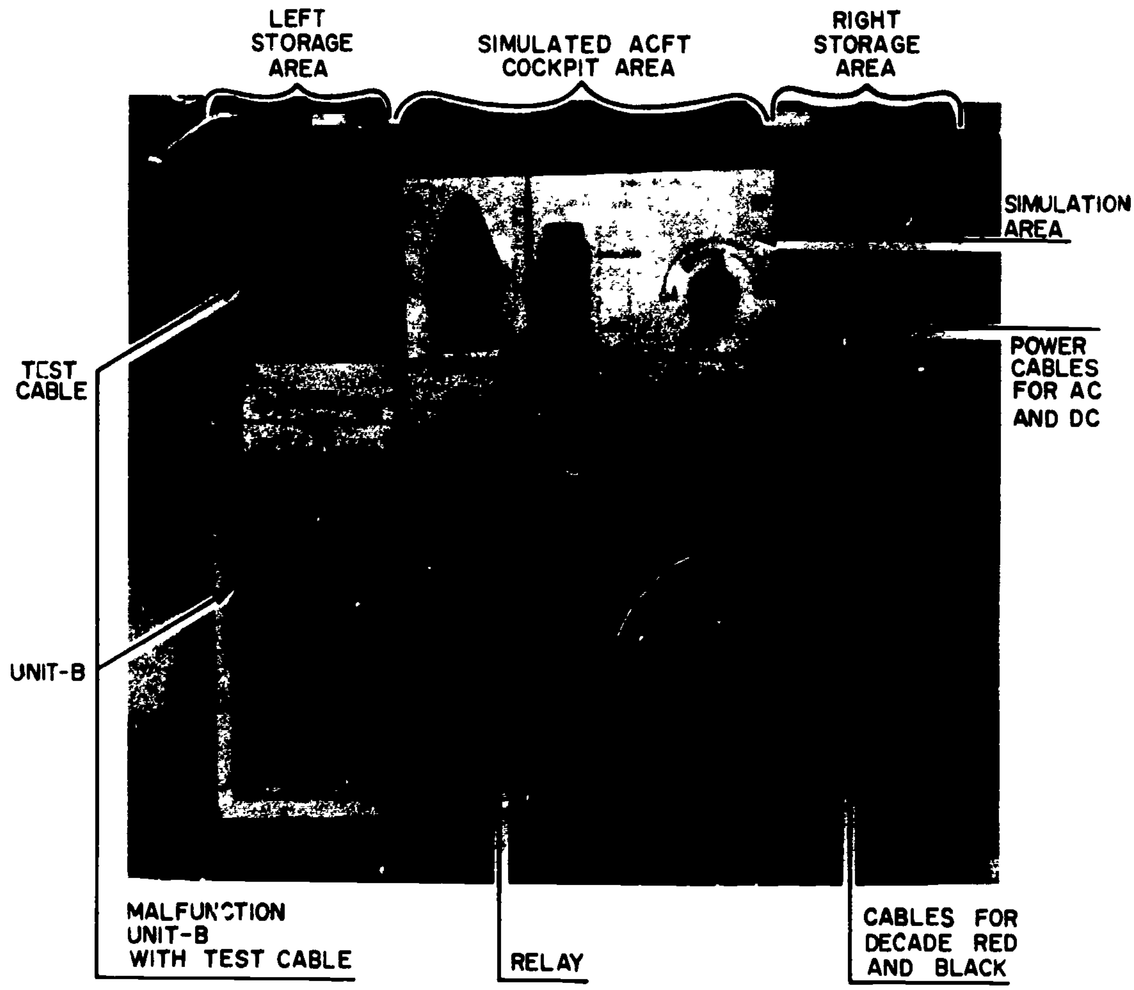

LEFT STORAGE AREA
SIMULATED ACFT COCKPIT AREA
RIGHT STORAGE AREA
SIMULATION AREA
TEST CABLE
POWER CABLES FOR AC AND DC
UNIT-B
MALFUNCTION UNIT-B WITH TEST CABLE
RELAY
CABLES FOR DECADE RED AND BLACK

Figure 1.

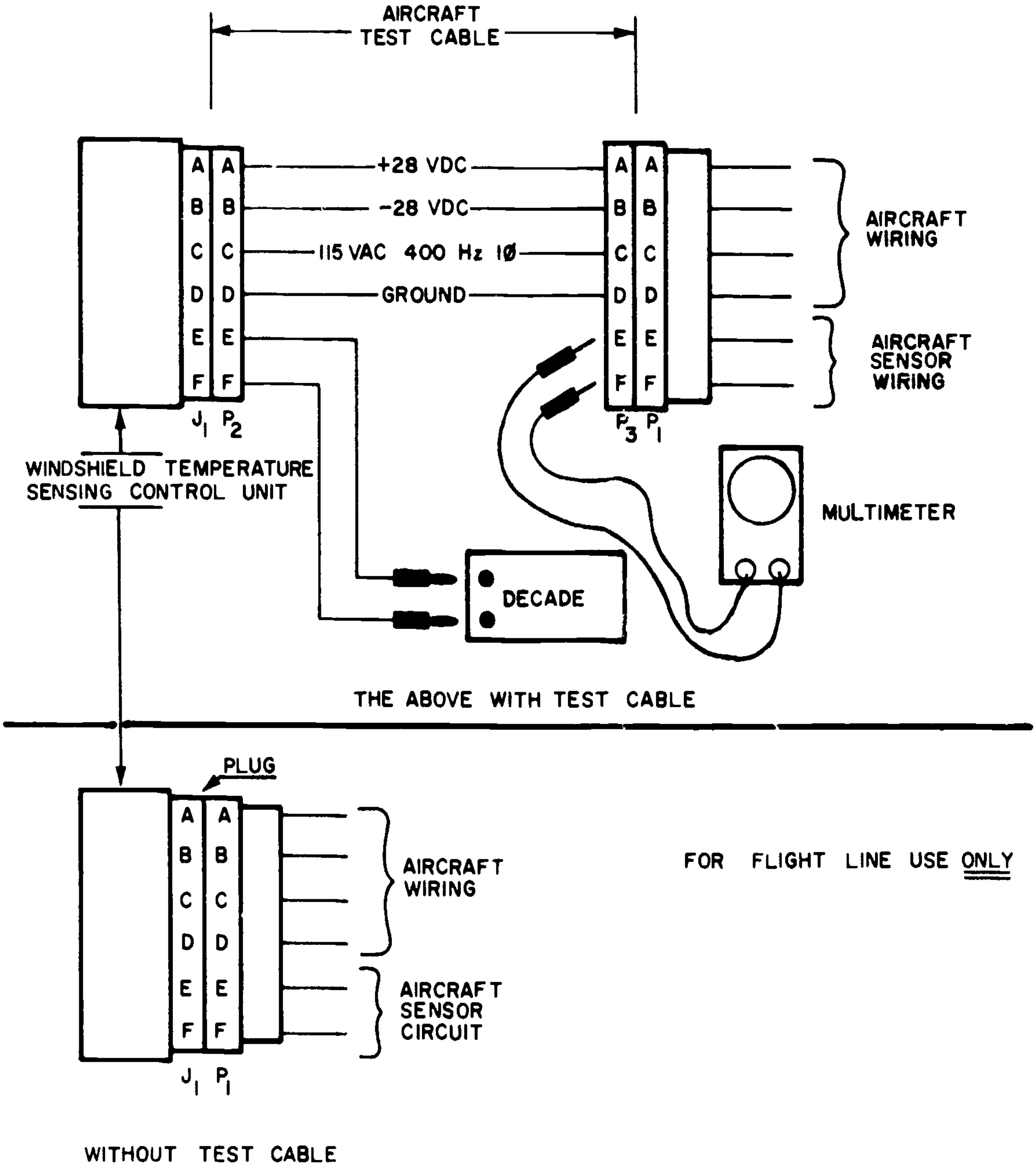


Figure 2.

1584

Explanation of Figure 3

At the top of figure 3 you will find it states "TEST CABLE." Note it is between the simulated aircraft wiring plug at "Point A" and "Point B" at the control unit. The center of the cablea wiring goes to the malfunction UNIT-B. Point B is where the test cable P_2 female plug and the windshield temperature sensing control unit junction J_1 connection. Point A is where the test cable male plug (P_3) connects to the aircraft wiring (P_1) female plug which was removed from the control unit J_1.

Shown in the figure is a decade and multimeter. The decade when attached is used to simulate the decade resistance for test purpose. The multimeter when attached is used only to measure the resistance of the aircraft sensor.

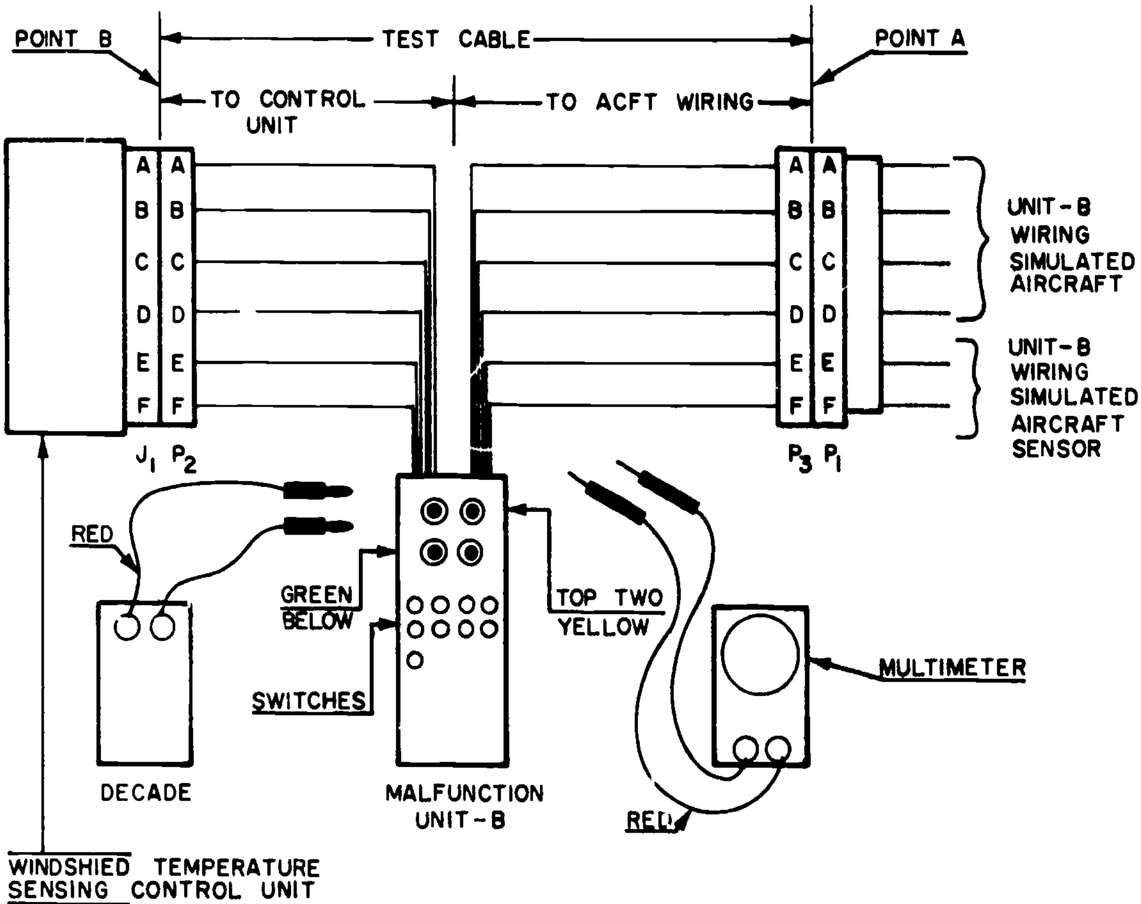
Note: The decade and multimeter are NOT attached to the malfunction UNIT-B at this time.

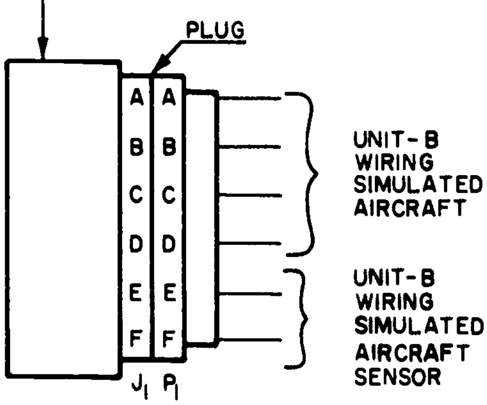
Because the multimeter and decade is used for the sensor resistive circuit it doesn't make any difference which way red and black leads are connected to the yellow or green contacts on the malfunction UNIT-B.

At the bottom of the figure 3 is the simulated aircraft wiring. Its male plug is connected to the temperature sensing control unit as found without the test cable attached. This is the way it would be for normal flight.

The letter "P" - Means plug which may be either female or male, for this system.

The letter "J" - Means junction which receives the plug "P."





THIS T T CABLE IS FOR SCHOOL USE ONLY BECAUSE IT HAS THE MALFUNCTION UNIT-B ATTACHED TO IT.

ON UNIT-B WITHOUT TEST CABLE

Figure 3.

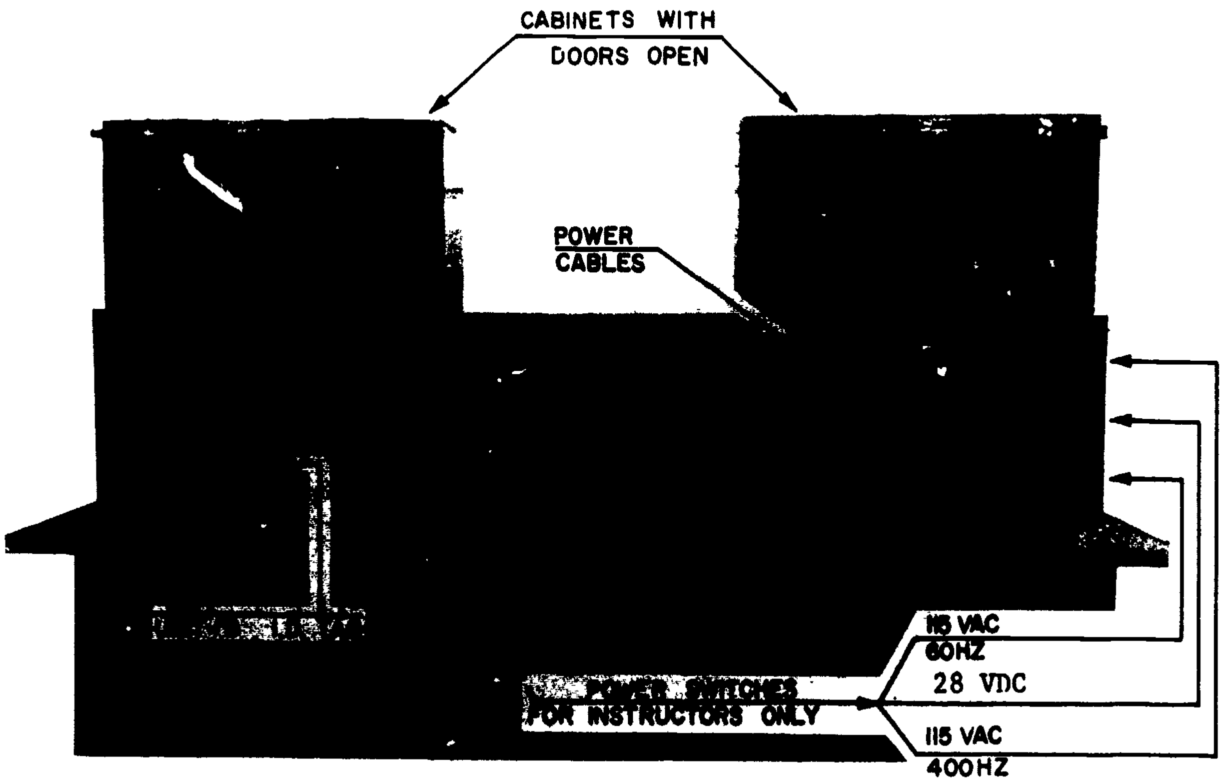

CABINETS WITH
DOORS OPEN
POWER
CABLES
115 VAC
60HZ
28 VDC
POWER SWITCHES
FOR INSTRUCTORS ONLY
115 VAC
400HZ

Figure 4.

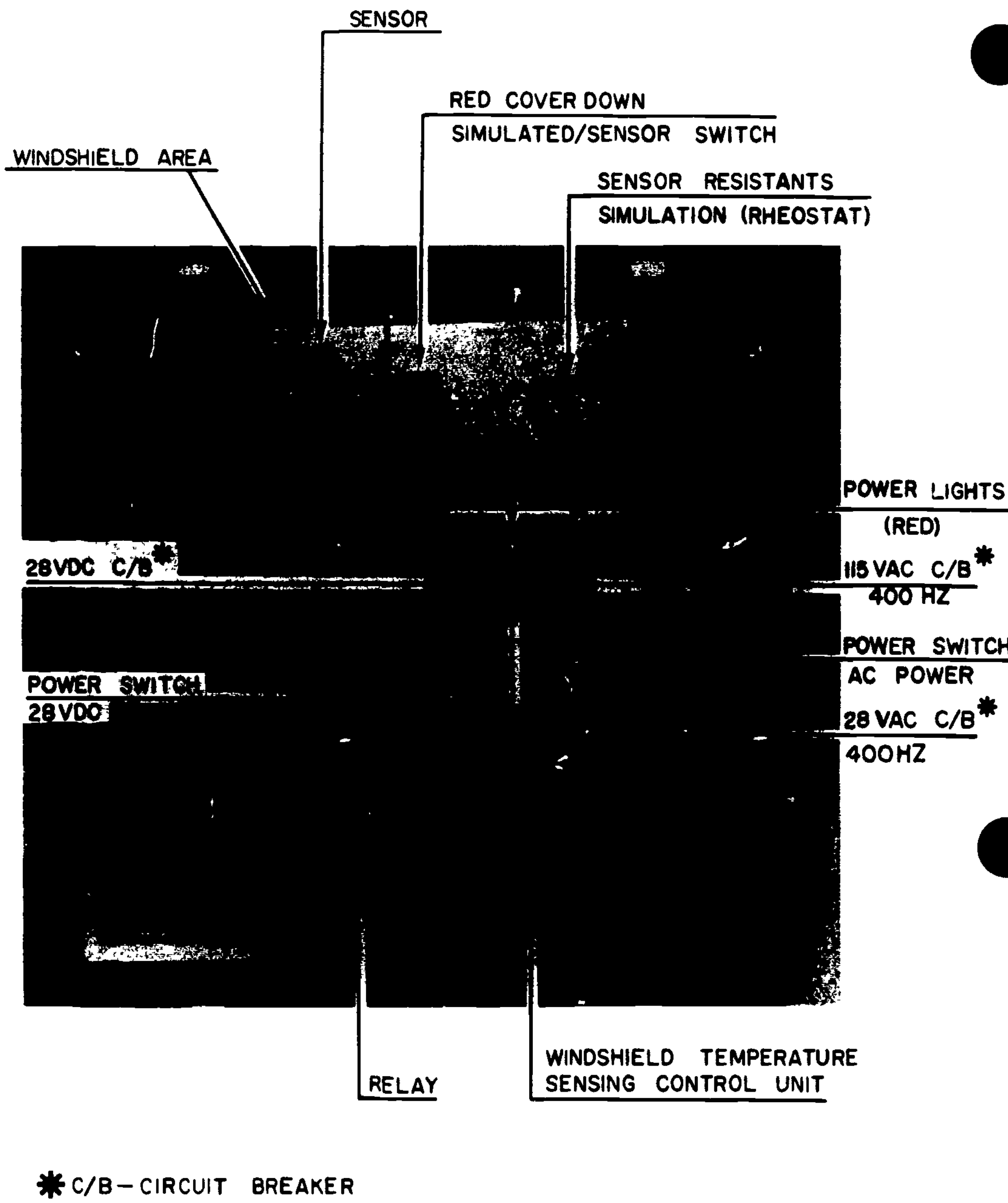

SENSOR
RED COVER DOWN
SIMULATED/SENSOR SWITCH
WINDSHIELD AREA
SENSOR RESISTANTS
SIMULATION (RHEOSTAT)
POWER LIGHTS
(RED)
28VDC C/B*
115 VAC C/B*
400 HZ
POWER SWITCH
AC POWER
POWER SWITCH
28VDC
28 VAC C/B*
400HZ
RELAY
WINDSHIELD TEMPERATURE
SENSING CONTROL UNIT
* C/B — CIRCUIT BREAKER

Figure 5.

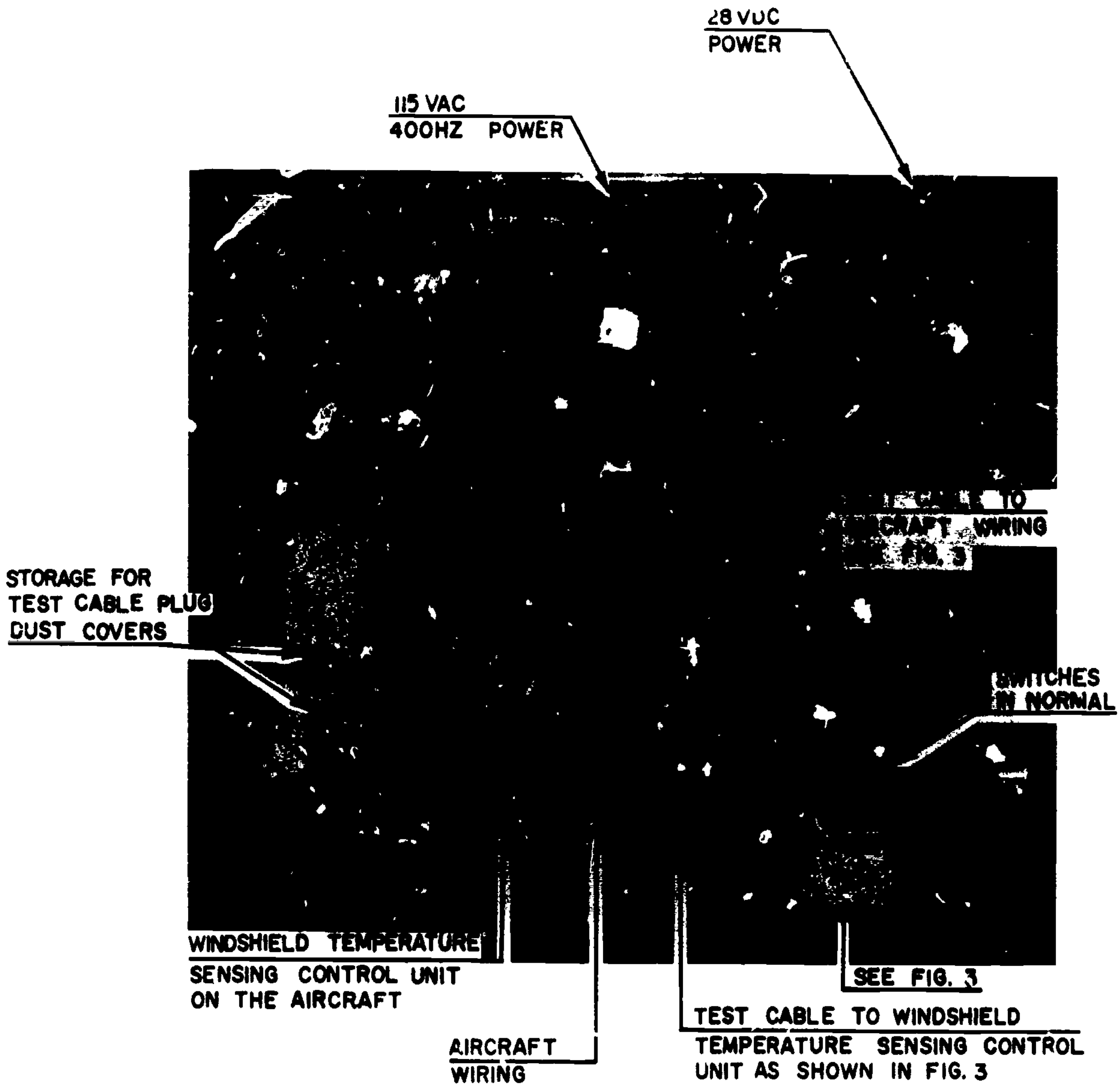

28 VDC
POWER
115 VAC
400HZ POWER
STORAGE FOR
TEST CABLE PLUG
DUST COVERS
IN NORMAL
WINDSHIELD TEMPERATURE
SENSING CONTROL UNIT
ON THE AIRCRAFT
AIRCRAFT
WIRING
SEE FIG. 3
TEST CABLE TO WINDSHIELD
TEMPERATURE SENSING CONTROL
UNIT AS SHOWN IN FIG. 3

Figure 6.

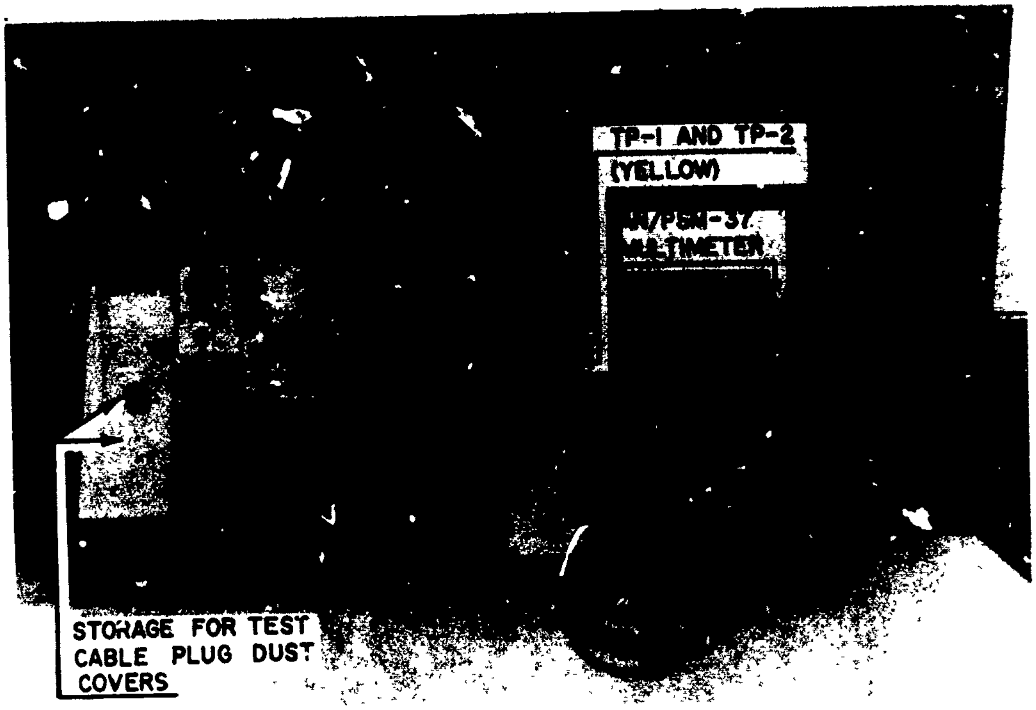


Figure 7.

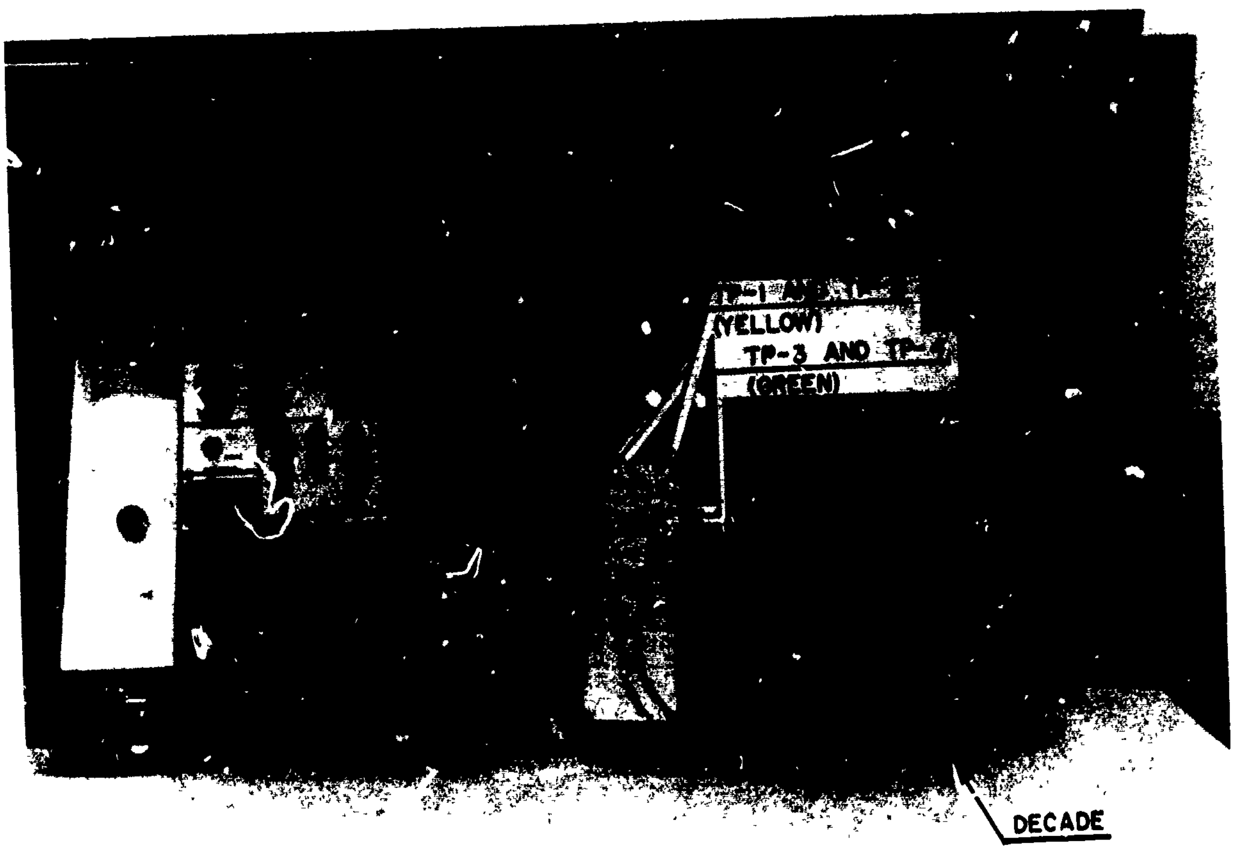


Figure 8.

CAUTION

DO NOT APPLY VOLTAGE IN EXCESS OF 8 VOLTS TO THE SENSOR.

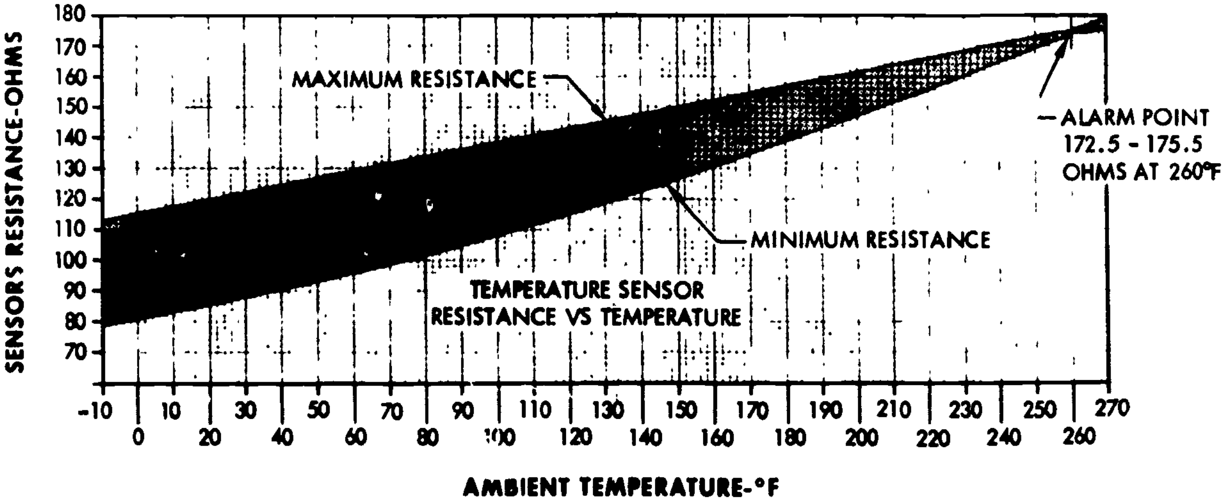


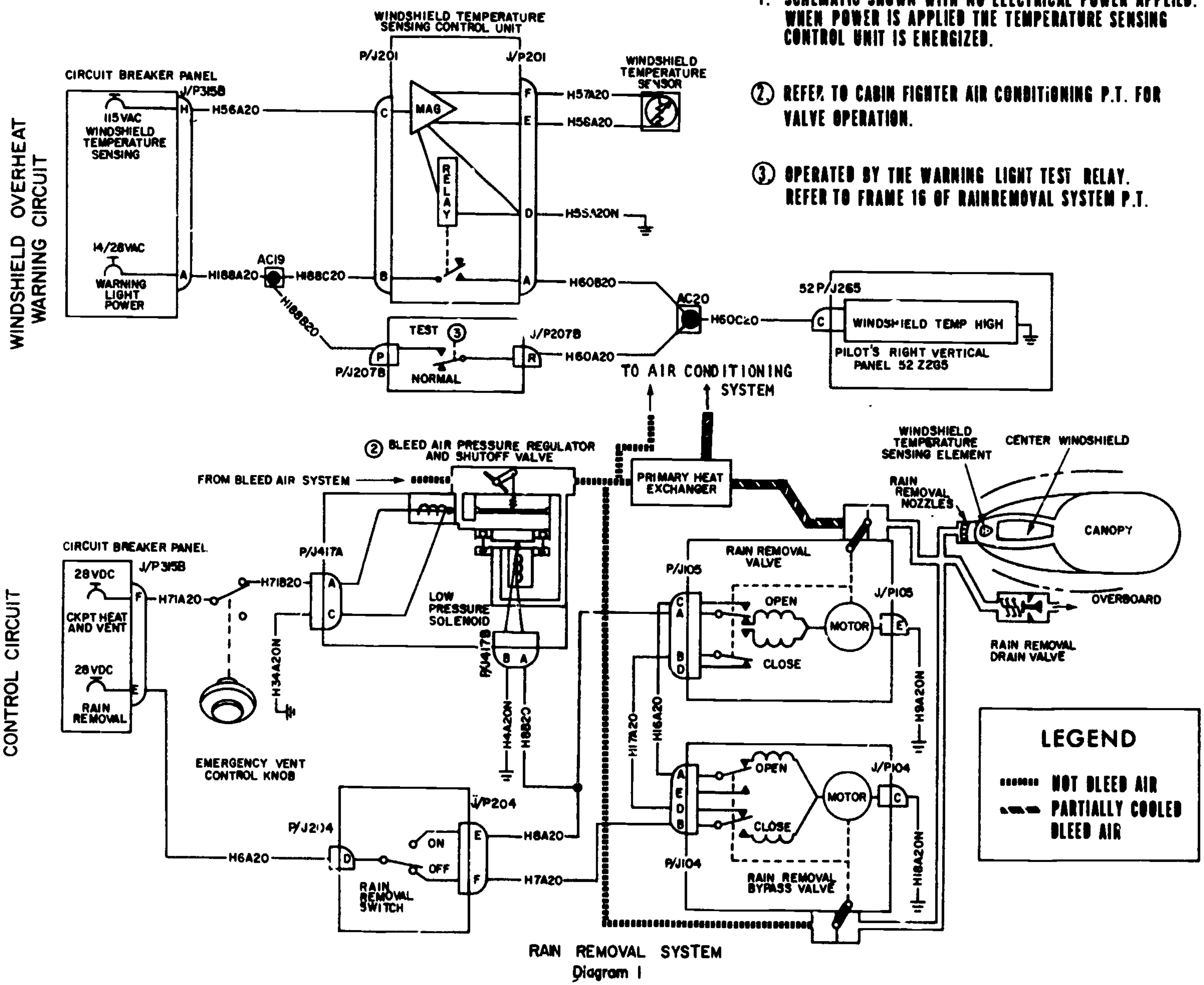
Figure 9.

NOTE

1. SCHEMATIC SHOWN WITH NO ELECTRICAL POWER APPLIED. WHEN POWER IS APPLIED THE TEMPERATURE SENSING CONTROL UNIT IS ENERGIZED.

2. REFER TO CABIN FIGHTER AIR CONDITIONING P.T. FOR VALVE OPERATION.

3. OPERATED BY THE WARNING LIGHT TEST RELAY. REFER TO FRAME 16 OF RAINREMOVAL SYSTEM P.T.



RAIN REMOVAL SYSTEM
Diagram I

Diagram 1.

Technical Training

Aircraft Environmental Systems Mechanic

RAIN REMOVAL SYSTEM

29 June 1984

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

Designed for ATC Course Use.

Do Not Use on the Job.

OBJECTIVE

Relate 8 out of 10 components of the rain removal system to their operation.

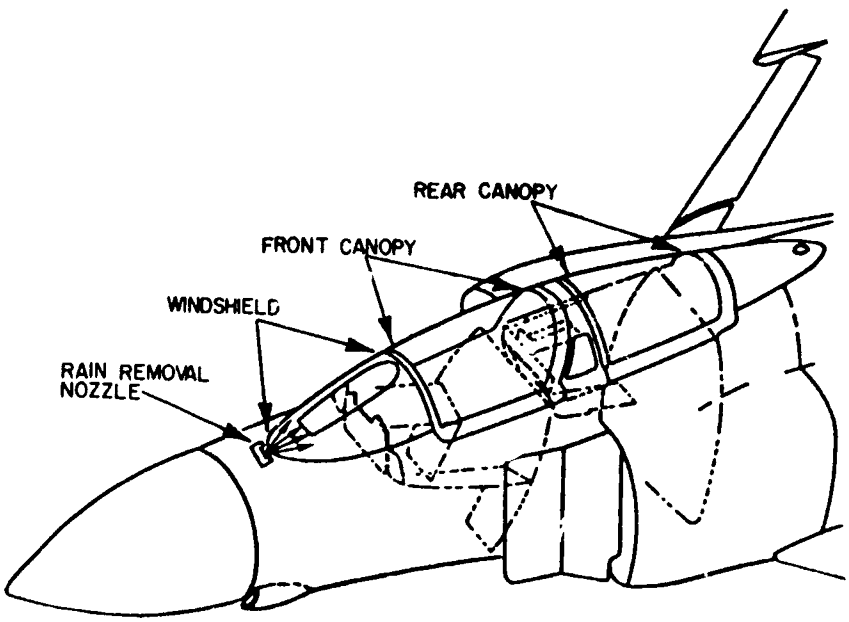
INTRODUCTION

The Rain removal system is one auxiliary system that is of highest priority. Have you ever driven without windshield wipers? Needless to say you can understand its importance. This study guide is to acquaint you with the system and the components.

Supersedes C3ABR42331-SG-203, 20 March 1984.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 500; DAV - 1

The purpose of the rain removal system is similar to the purpose of the windshield wipers on an automobile. The system keeps the windshield clear of rain. This is done by blowing a mixture of hot and partially cooled air over the windshield. The air will break up the rain particles and turn them away from the windshield.

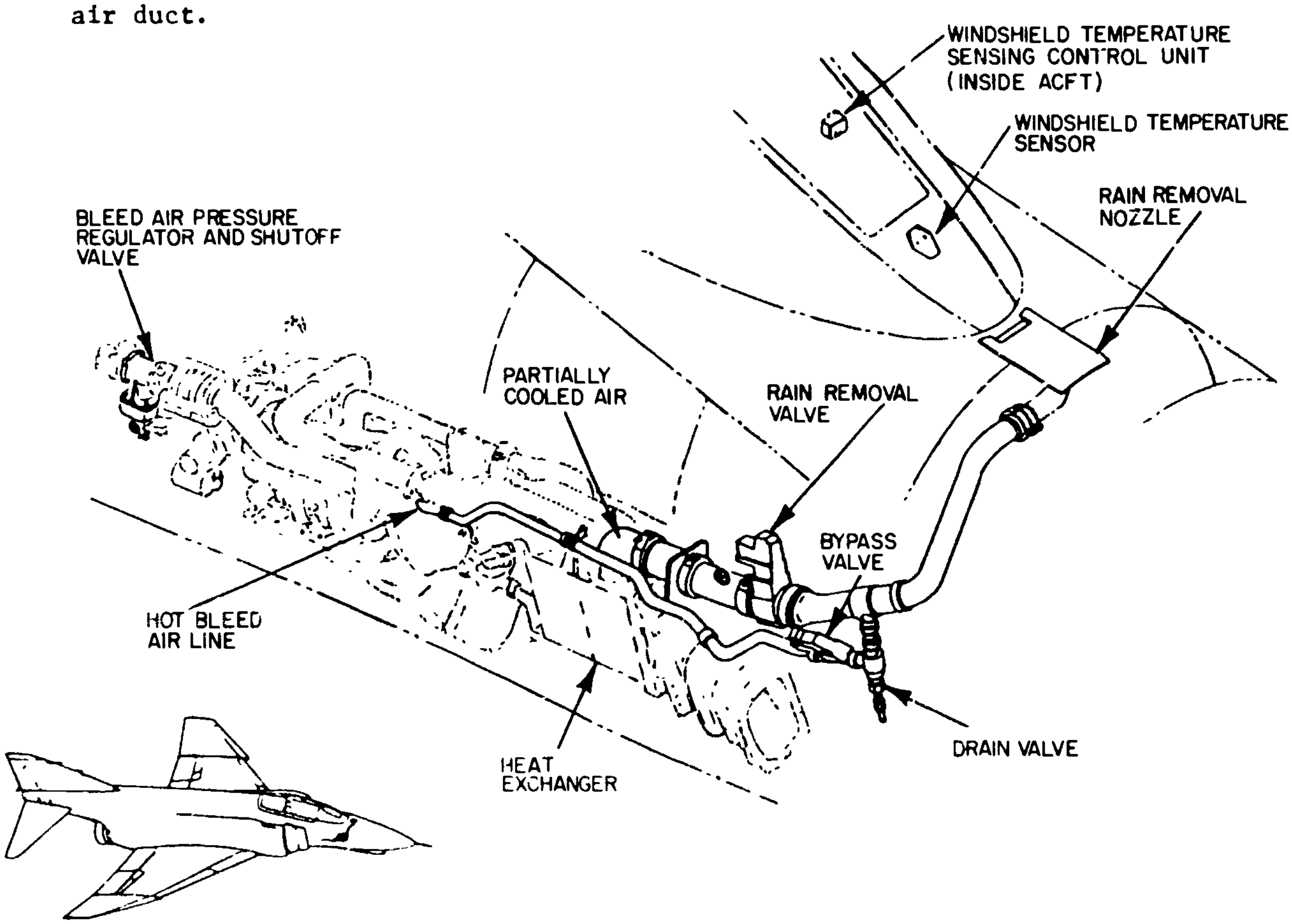
During this lesson you will be studying the system used on a fighter type aircraft. In the system the air for the rain removal is discharged through a nozzle (outlet). The nozzle is put at the base of the windshield. Notice the rain removal nozzle location below.



The air for the rain removal system is "tapped" from the cabin air conditioning system.

The partially cooled air is drawn from the primary section of the refrigeration unit heat exchanger. The hot bleed air is drawn from the unit's hot bleed air duct.

The dark lines in the sketch show the rain removal system. Note the large duct that carries the partially cooled air from the heat exchanger. The smaller duct takes the hot air from the refrigeration unit hot bleed air duct.

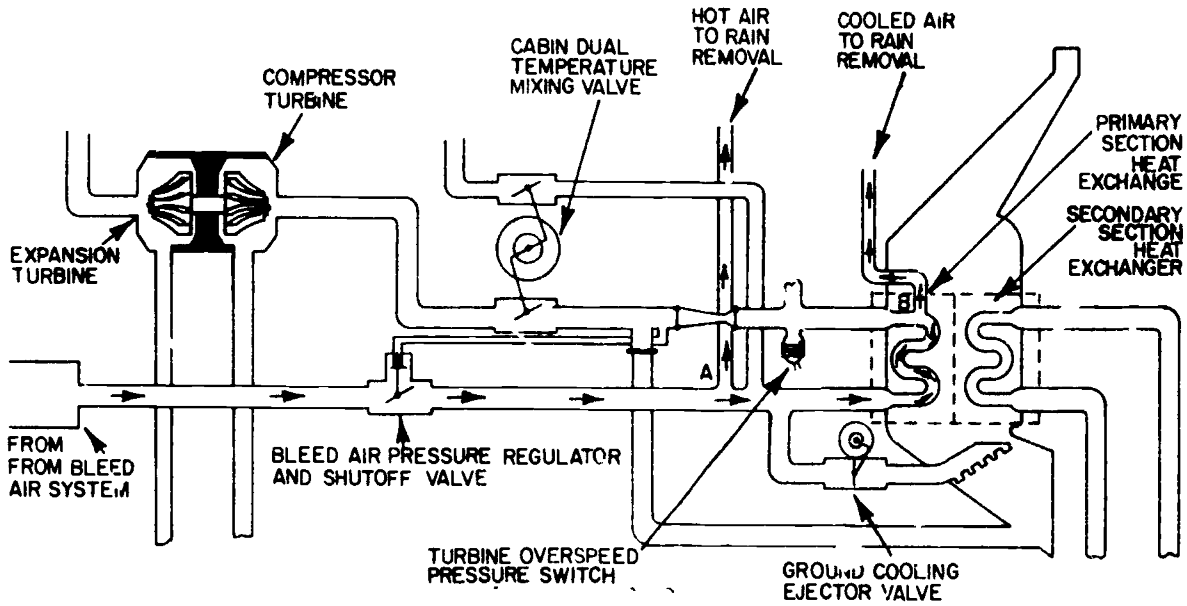


Remember the fighter cabin air conditioning system? Air flow through the cabin refrigeration unit is regulated by the bleed air pressure regulator and shutoff valve. This valve regulates the air pressure for both the cabin air conditioning system and the rain removal system.

Trace the airflow on the sketch below. Start at the point marked FROM BLEED AIR SYSTEM. Follow the arrows through the bleed air pressure regulator and shutoff valve.

Note the first tapoff, POINT A, going to the rain removal system. This is the hot bleed air tapoff.

Continue to follow the arrows through the primary section of the heat exchanger and note the second tapoff, POINT B, going to the rain removal system. This is the partially cooled air tapoff.

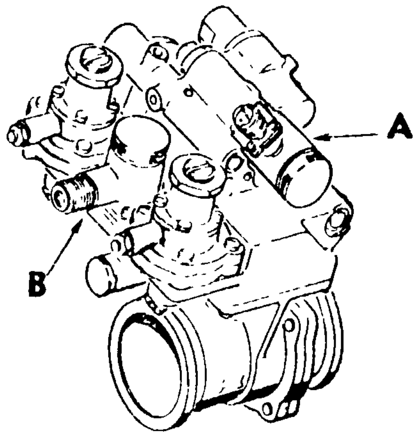


The bleed air pressure regulator and shutoff valve is a solenoid controlled, pneumatically (air) actuated valve. This valve has two solenoids: The main solenoid (A) and a low pressure solenoid (B). Both solenoids use 28 VDC power

For normal cabin air conditioning operation, only the main solenoid is energized. This regulates the pressure of the air conditioning system to 62 psi. This will happen before the pilot turns the rain removal system on.

When the rain removal system is turned on, the low pressure solenoid will energize. This reduces the pressure of the bleed air (for both air conditioning and rain removal)to 35-45 psi.With the rain removal system on, both the main solenoid and the low pressure solenoid will be energized.

The bleed air for the rain removal system is tapped off downstream (beyond-past) of the pressure regulator and shutoff valve. This valve must be regulating (open) for rain removal operation.



The sketch on this page is a simplified schematic of the rain removal system. The bleed air pressure regulator and shutoff valve and the heat exchanger are actually part of the cabin refrigeration unit. These are put in the system sketch. They are also related to the rain removal system as explained in the previous frames.

The rain removal system consists of the following four components:

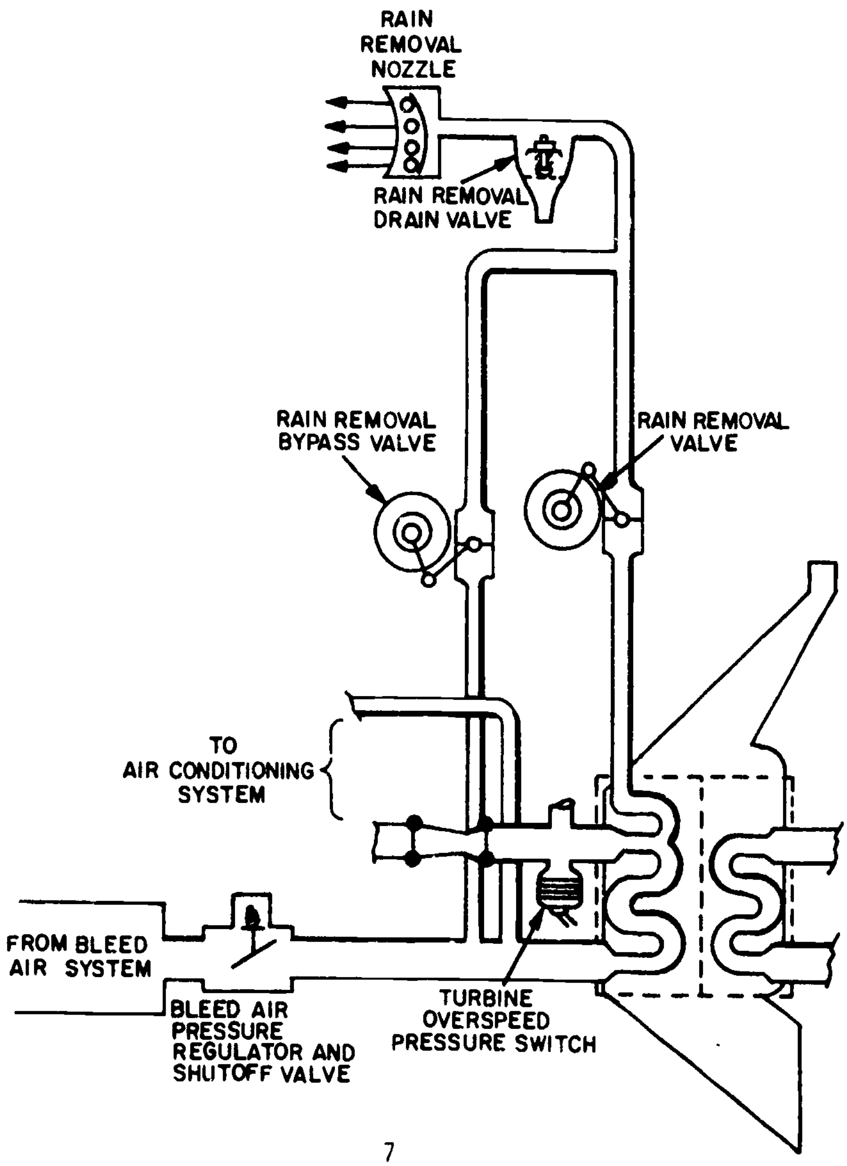
1. Rain removal valve

2. Rain removal bypass valve

3. Rain removal duct drain valve

4. Rain removal nozzle

Notice each of these components in the system illustration below.



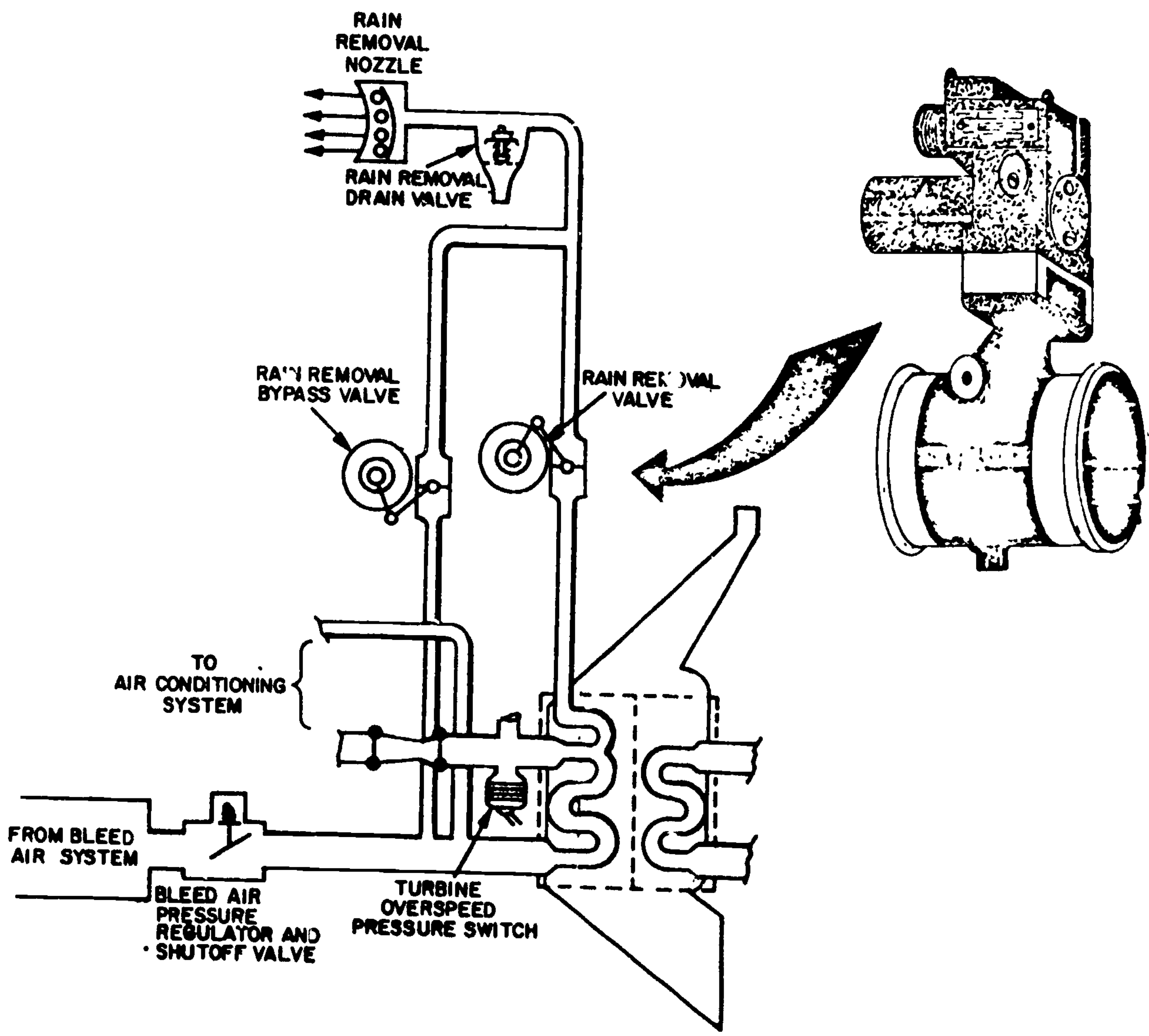
The rain removal valve, shown below, controls the flow of partially cooled bleed air from the heat exchanger to the rain removal nozzle. This is a butterfly type valve.

When the rain removal switch is placed to the ON position, 28 VDC power is directed to the rain removal valve motor. The valve then moves to the open position. This allows the partially cooled bleed air to flow through the valve and on to the nozzle.

NOTE: 1. The motor actuates the valve

2. Opening of the rain removal valve is controlled by the rain removal switch

3. Closing of the rain removal valve is controlled by the rain removal bypass valve limit switch



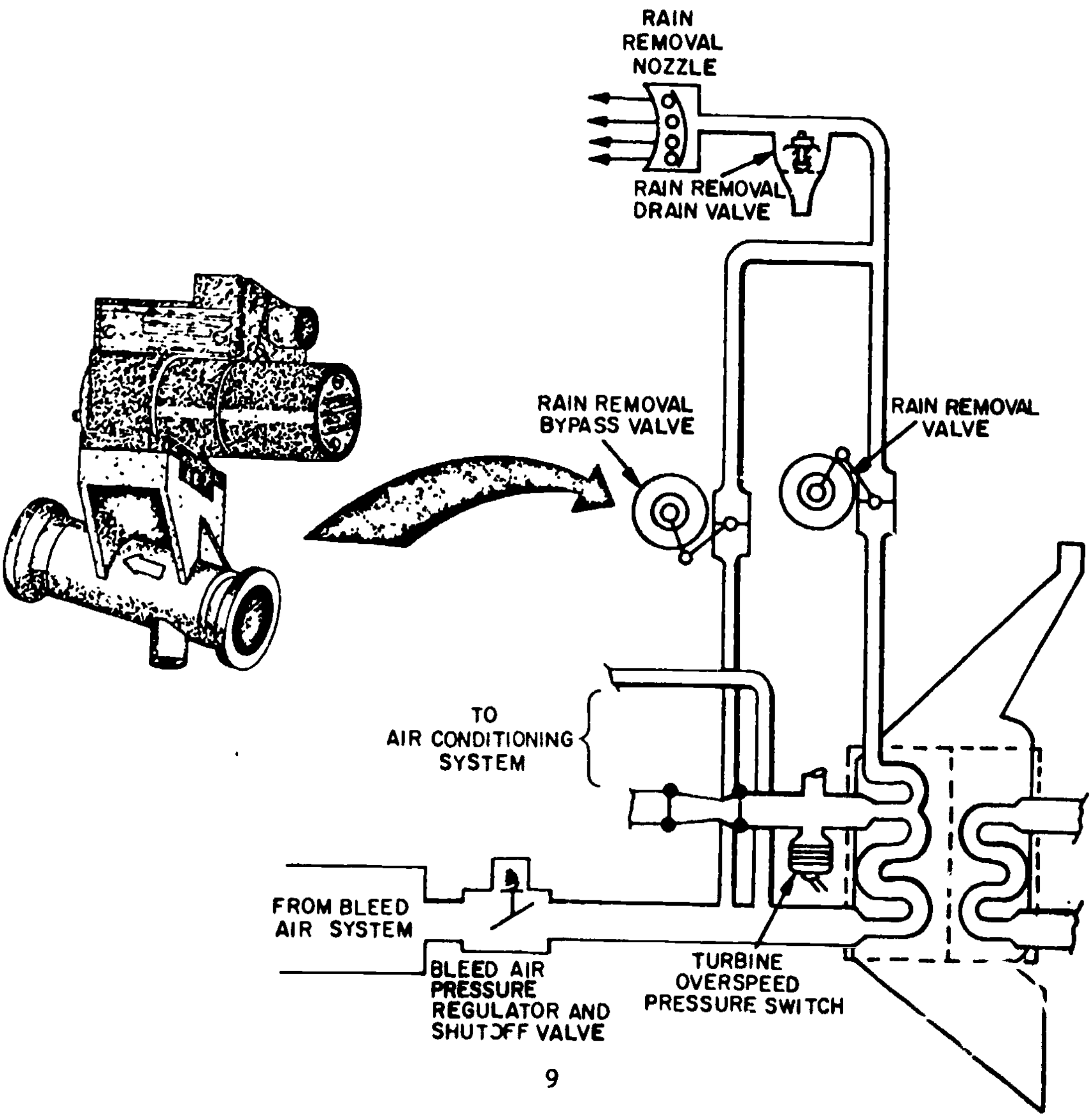
The rain removal bypass valve, shown below, controls the hot bleed air going to the rain removal nozzle from the hot bleed air duct. This is a butterfly type valve.

When the rain removal switch is placed to the ON position, 28 VDC power is directed to the rain removal valve motor. After this valve is fully open, a limit switch inside moves, opening the circuit within the motor. Then the 28 VDC power is directed to the rain removal bypass valve motor. The bypass valve then moves to the open position, allowing hot bleed air to flow to the mixing point. At this point, hot bleed air is mixed with the partially cooled air. The bypass valve <u>increases</u> the <u>volume</u> and <u>temperature</u> of the rain removal air.

NOTE: 1. The motor <u>actuates</u> the valve.

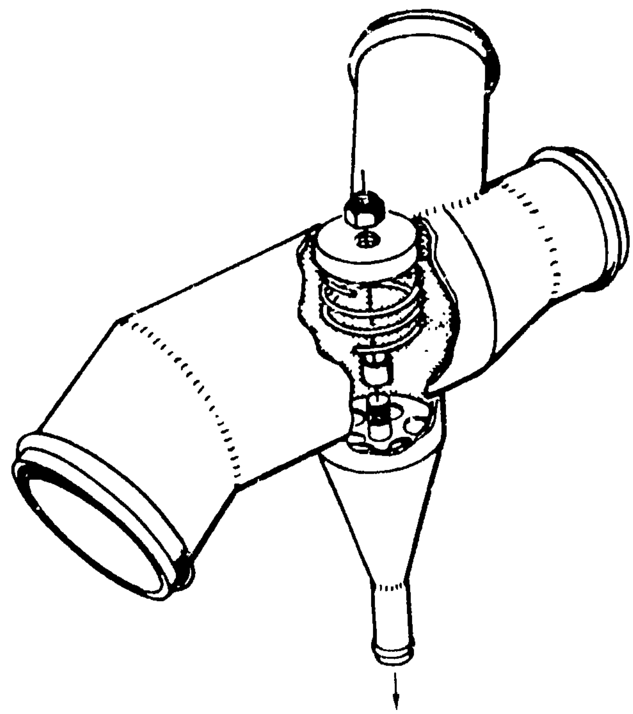
2. Opening of the rain removal bypass valve is <u>controlled</u> by the limit switch in the rain removal valve.

3. Closing of the rain removal bypass valve is <u>controlled</u> by the rain removal switch.



When the rain removal system is OFF, the rain removal duct drain valve is held open by a spring. This allows the drain valve to drain water which accumulated while the aircraft was on the ground during periods of precipitation. The drain valve prevents water from being sprayed over the windshield when the rain removal system is turned on.

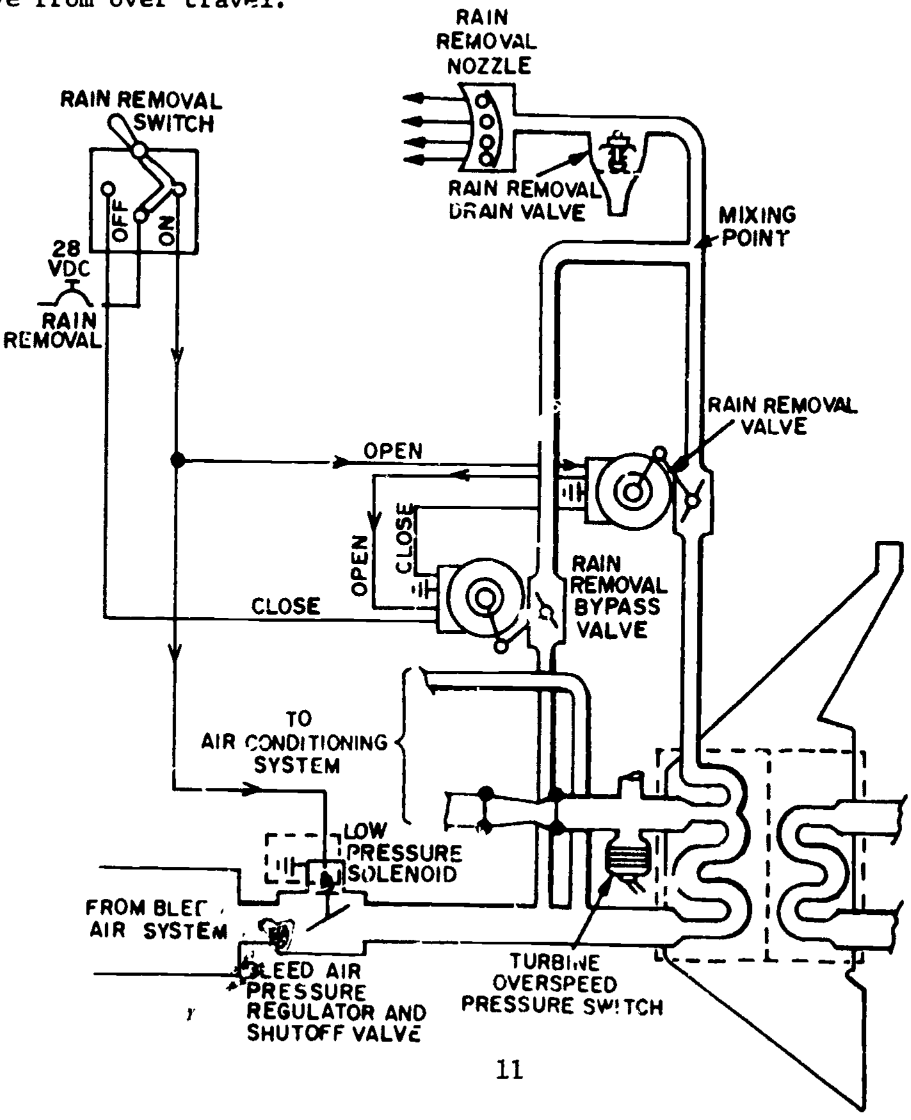
When the rain removal system is turned ON, air flowing through the rain removal ducts forces the rain removal duct drain valve to close. This also prevents a loss of air when the system is ON.



The illustration below shows the complete airflow system with the rain removal switch in the ON position. A schematic of the electrical circuitry is also shown.

Trace the path for electrical current flow when the system is turned ON. Current flows from the circuit breaker, through the rain removal switch. From the switch current then flows to the low pressure solenoid on to the bleed air pressure regulator and shutoff valve. This reduces the air pressure going to the air conditioning system.

Current is also directed to the open winding of the rain removal valve motor. This operates the rain removal valve to the open position. When the valve reaches full open, it moves a limit switch to stop current flow to the rain removal valve motor windings. This limit switch then directs the current flow to the rain removal bypass valve motor. Current then flows through the open windings of the rain removal bypass valve motor, opening the valve. When the rain removal bypass valve reaches the full open position, it moves a limit switch to stop current flow to the rain removal bypass valve motor open windings which prevent the valve from over travel.

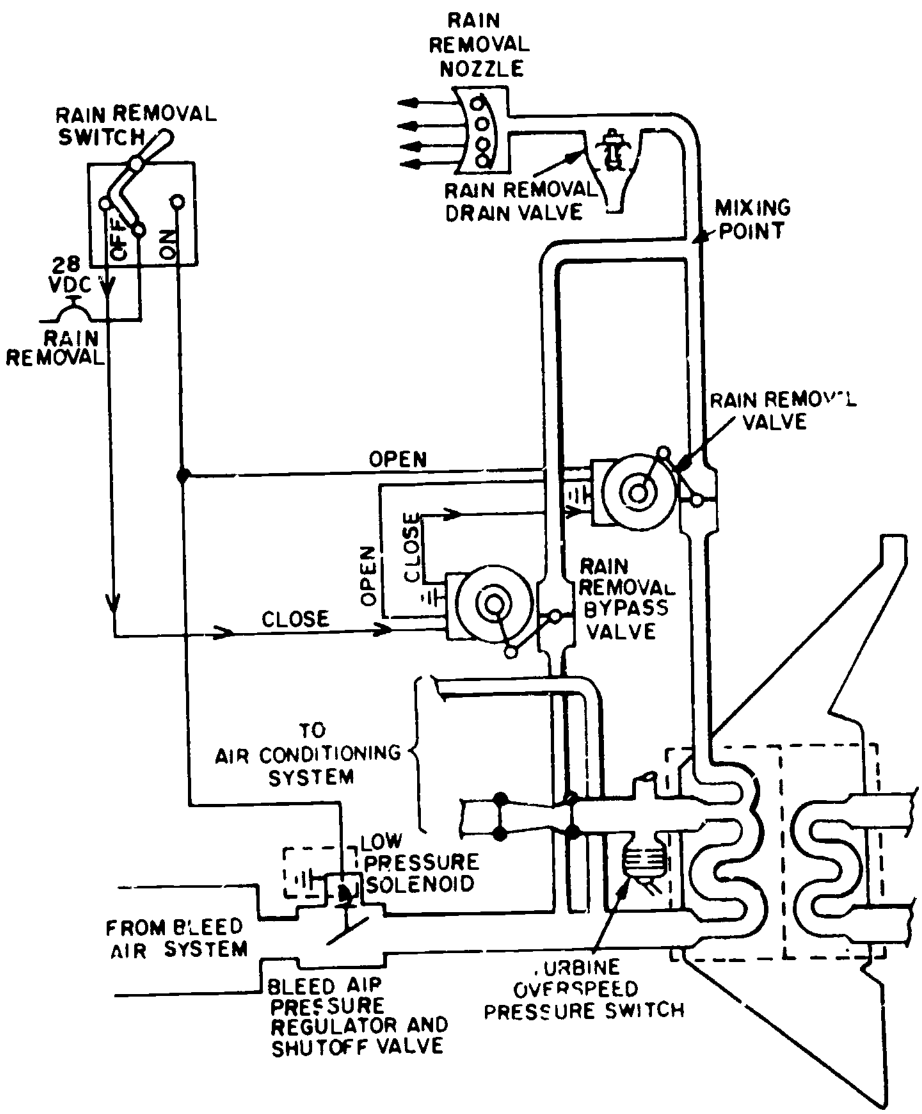


Since the rain removal valve opens first, the partially cooled air will reach the rain removal nozzles first. Then the rain removal bypass valve will open allowing the hot bleed air to mix with the partially cooled air and flow on to the nozzles. The rain removal valves are sequenced this way to prevent a rapid temperature increase of the windshield, which could damage or distort the windshield.

The illustration below shows the complete airflow system with the rain removal switch in the OFF position. A schematic of the electrical circuitry is also shown.

With the switch in the OFF position, the circuit will open going to the rain removal valve and the low pressure solenoid. This deenergizes the low pressure solenoid and allows the pressure regulator and shutoff valve to regulate pressure at 62 psi, for normal air conditioning.

Trace the path for electrical current flow when the system is turned OFF. Current flows from the circuit breaker, to the rain removal switch. From the switch current then flows to the close windings of the rain removal bypass valve motor, closing the valve.



When the valve reaches full closed, it moves a limit switch to stop current flow to the rain removal bypass valve motor windings. This limit switch then directs the current flow to the rain removal valve motor. Current then flows through the close windings of the rain removal valve, closing the valve. When the rain removal valve reaches the full close position, it moves a limit switch to stop current flow to the rain removal valve motor close windings, which prevents the valve from over travel.

The rain removal system does not have a way to control the air temperature automatically. So should an overheat condition occur, the pilot must turn the rain removal system off to reduce the temperature.

There is a system to warn the pilot when the windshield temperature reaches 260°F or above, where it could damage the windshield panel. This is the windshield temperature overheat warning circuit.

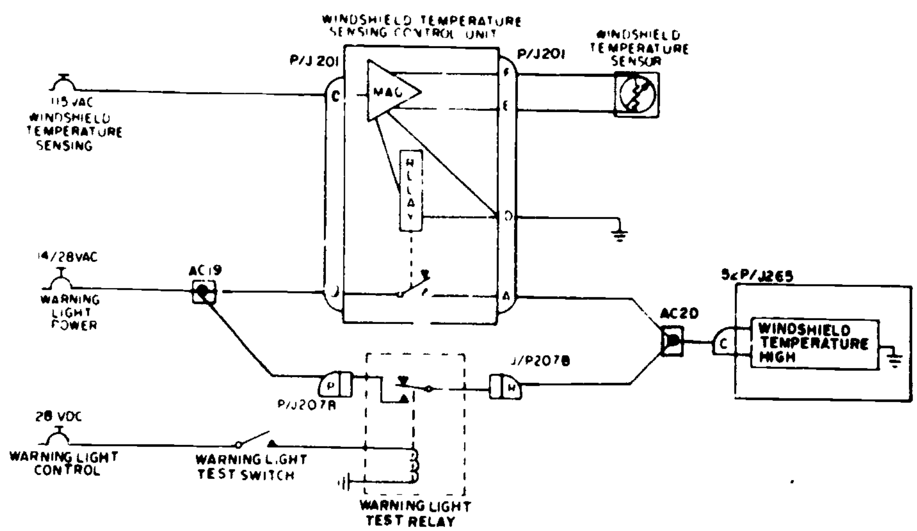
The windshield temperature overheat warning circuit consists of the following components:

1. Windshield Temperature Sensing Control Unit

2. Windshield Temperature (the warning light)

3. Windshield Temperature Sensor

Locate these components in the illustration shown below.



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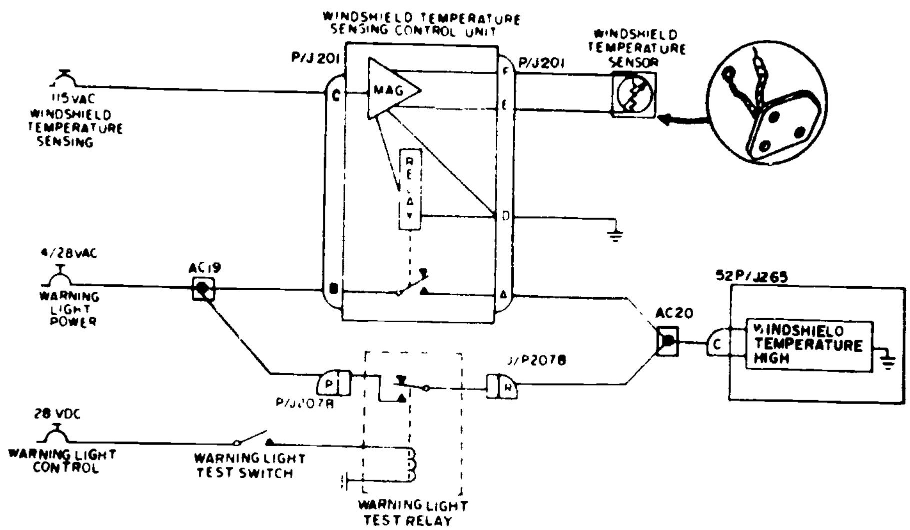
The windshield temperature sensing element (also called the windshield temperature sensor) is mounted on the lower part of the windshield. The sensing element completes one leg of the temperature control unit circuitry.

The temperature sensing element has a positive coefficient of resistance. As the temperature increases, the resistance of the sensing element also increases. When the windshield temperature reaches 260°F, the increase in sensor resistance creates an unbalanced condition in the control unit and causes the WINDSHIELD TEMP HIGH warning light to come on.

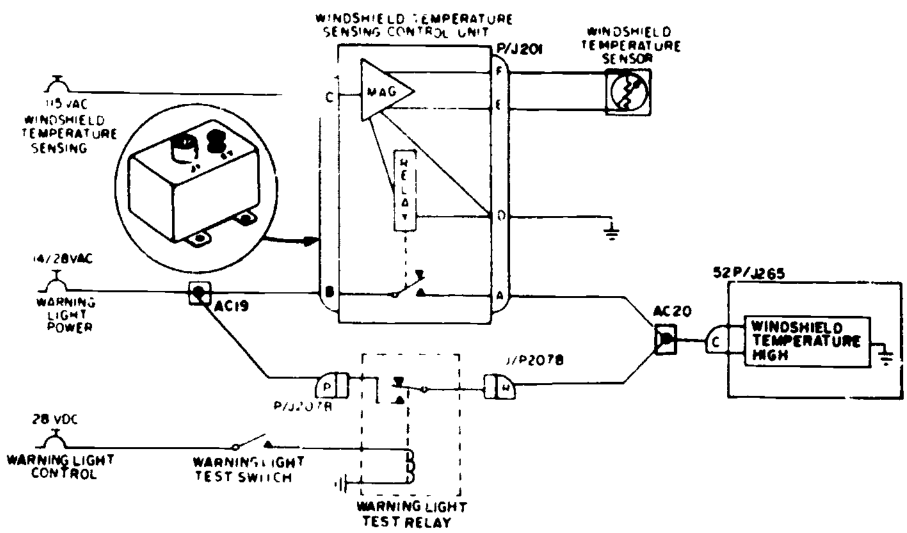
The sketch shows the windshield temperature sensor. Also shown is the relationship of the sensor to the other units in the windshield temperature sensing circuit.



The windshield temperature sensing control unit, shown below, contains a magnetic amplifier, and a relay. The magnetic amplifier requires 115 VAC to operate and allow current to flow through the relay coil, energizing the relay. This keeps the relay contact open and the WINDSHIELD TEMP HIGH warning light off.

If there is a 115 VAC power loss to pin C of the windshield temperature sensing control unit (due to an open wire or pulled circuit breaker) the relay will deenergize. This closes the relay contacts, completing the warning light circuit and turning ON the WINDSHIELD TEMP HIGH warning light.

Should the windshield temperature reach 260°F or more, the signal from the sensor will stop the magnetic amplifier from energizing the relay. This closes the relay contacts, completing the warning light circuit and turning on the WINDSHIELD TEMP HIGH warning light.



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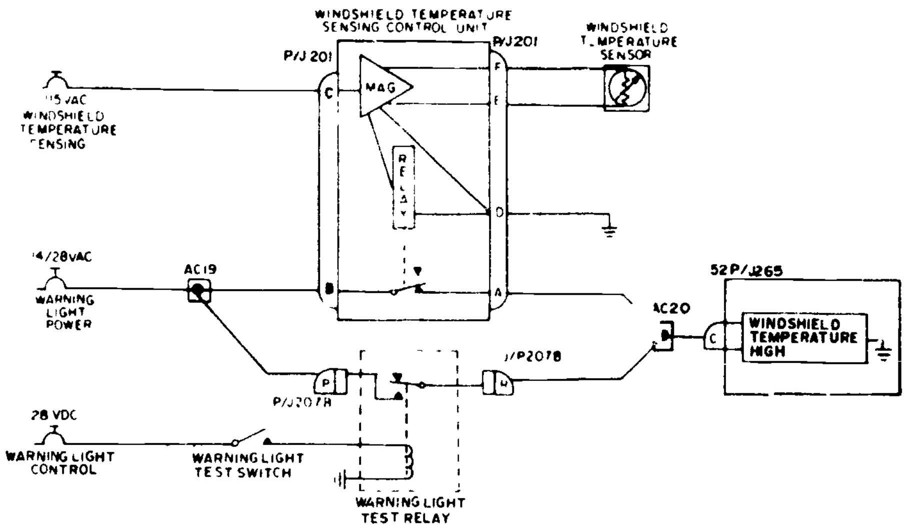
When the windshield temperature reaches 260°F, the WINDSHIELD TEMP HIGH warning light, comes on to warn the pilot of an overheat condition. When this happens, the pilot must turn off the rain removal system.

There is NO means for automatically controlling the rain removal temperature. The pilot must control the temperature manually. The windshield temperature warning system tells the pilot if the windshield temperature is too hot.

The sketch below shows the circuit with the warning light on (temperature is above 260°F). Notice the path of current flow from the warning light power circuit breaker to the light.

When the windshield temperature drops below 260°F, the windshield temperature sensing control unit will energize the relay, stopping current flow to the warning light.



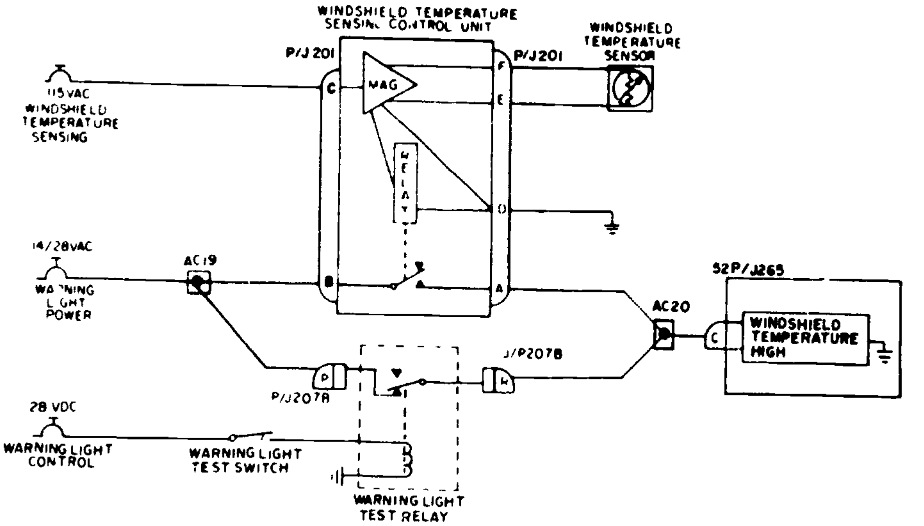
A warning light system is of no value unless we are sure it will work properly. The pilot can test the warning light system before each flight by using a warning light test switch.

The sketch below shows the warning light test circuit used to test the WINDSHIELD TEMP HIGH warning light.

When the warning light test switch is held in the test position, current can flow from the warning light control circuit breaker through the test switch and on to the warning light control unit. This energizes a relay in the control unit. With the relay energized, current flows from the warning light power circuit breaker, through the relay contacts and on to the light.

By holding the warning light test switch to the test position, the pilot knows power is available and the bulb is working properly if the warning light comes on. If the light does not come on, it indicates a burned out light bulb, or a loss of 14/28 VAC power.

The warning light test switch illustrated, shows testing of only one light. On the actual aircraft, this switch will test several warning light systems.



The rain removal systems, utilizing bleed air from the cabin air conditioning system, keeps the windshield clear when flying in rain by blowing hot air over the windshield. This breaks up particles and diverts them over the glass.

When the pilot runs into rain he has to turn on the rain removal switch. This will energize the low pressure solenoid, and open the rain removal valve and the rain removal bypass valve. The rain removal bypass valve supplies hot bleed air to the rain removal nozzle. This mixture of partially cooled and hot bleed air goes over the windshield to keep the rain off the windshield. If the temperature on the windshield sensor reaches 260°F or above, the relay inside the windshield temperature sensing control unit will deenergize and turn on the WINDSHIELD TEMP HIGH warning light. When the light comes on, the pilot will have to manually turn off the rain removal system to prevent damage of the windshield. When the rain removal switch is placed to the OFF position, the rain removal bypass valve will close first, and then the rain removal valve will close. Once the valves are closed and the temperature drops below 260°F, the relay will energize and turn the light off. When the light has gone off, the pilot can turn the rain removal switch back to the ON position if need be.

Complete the following statements.

1. The purpose of the rain removal system is to keep the ____________ clear of rain.
2. The rain removal system blows a mixture of ______ and __________ __________ bleed air over the windshield.
3. When the rain removal system is on, the pressure to the air conditioning system ____________ (reduced / increased)
4. When the rain removal system is on, the low pressure solenoid is (energized/ deenergized)
5. The rain removal valve and rain removal bypass valve are actuated by a _____ _________ _________.
6. The hot bleed air going to the rain removal nozzle is controlled by the __________ ________ ____________ valve.
7. The partially cooled bleed air going to the rain removal nozzle is controlled by the __________ ___________ valve.
8. The rain removal duct drain valve is opened by a ______________ and closed by ____________________.
9. The windshield temperature sensing element has a ________________ coefficient of resistance.
10. The purpose of the windshield temperature overheat warning system is to warn the pilot when the windshield temperature is above _________.

Match the units listed in column "B" with the statements given in column "A" by placing the letter from column "B" in the blanks provided.

COLUMN A	COLUMN B
____ 1. Allows the water to drain out when the system is off.	A. Rain removal bypass valve
____ 2. Senses the temperature of the windshield.	B. Low pressure solenoid
____ 3. Controls the flow of partially cooled air from the heat exchanger.	C. Windshield temperature sensing control unit
____ 4. Contains a magnetic amplifier and a relay which turns on the warning light	D. Rain removal duct drain valve
____ 5. Controls the hot bleed air going to the rain removal nozzle.	E. Windshield temperature sensor
____ 6. Used to reduce the pressure of the bleed air for both air conditioning and rain removal to 40 psi.	F. Pressure regulator and shutoff valve
____ 7. Warns the pilot that the windshield temperature is too high.	G. Rain removal valve
____ 8. Is an air actuated, solenoid controlled valve.	H. Windshield Temp High warning light
____ 9. This valve is held open by a spring, and closed by air pressure.	

WORKBOOK
C3ABR42331-WB-203

Technical Training

Aircraft Environmental Systems Mechanic

RAIN REMOVAL SYSTEM WIRING DIAGRAM

2 February 1984

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

RAIN REMOVAL SYSTEM WIRING DIAGRAM

OBJECTIVE

Using an electrical diagram, identify and record the causes for given discrepancies achieving a minimum of 32 out of 40 total points.

EQUIPMENT

Color pencil sets

INSTRUCTIONS

Pay close attention to all directions that you are given in this text. When you do such things as tracing or answering questions, if your response is incorrect and/or you don't understand, restudy the information and/or check with the instructor. At the end of this workbook, you will first be given a performance exercise (practice problems). After the workbook is complete with the assigned practice problems and the instructor determines you are ready for the performance test, it will be assigned.

In this diagram you will be tracing voltage from the circuit breakers to the component's ground. This is the easiest way to understand the wiring diagram.

EXAMPLE:

Note: Look at the rain removal switch on diagram 1. P/J204 and J/P204 are written on it to identify the plug (P) and jack (J). On this diagram if the P of the P/J204 is on your left this means the plug is on the left and the jack is on the right. If the J of the J/P204 is on your left this means the jack is on the left.

Example: In your home, the electrical outlet in the wall should be called the jack (J). The item on your desk lamp cord should be called the (P) plug which you connect to the (J) jack in the wall.

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3370 TCHTG/TTGU-P - 300; DAV - 1

EXERCISE 1 - POWER CIRCUIT

EXPLANATION - Control circuit (bleed air pressure regulator and shutoff valve at 62 psi). Closing the CKPT HEAT AND VENT circuit breaker will place a positive potential on the single pole of the emergency vent control knob switch.

DRAW IN RED - With the red pencil, start coloring at the circuit breaker through pin F of J/P 315B, over wire H71A20, and up to the single pole of the emergency vent control knob switch. The voltage will stop here because the emergency vent knob is pulled out.

EXPLANATION - Regulator circuit (62 psi). To turn on the bleed air pressure regulator and shutoff valve for 62 psi, the armature for the emergency vent control knob switch must be pushed in. This will energize the bleed air pressure regulator and shutoff valve solenoid allowing the system to regulate air pressure at 62 psi.

DRAW IN BLUE - Draw the emergency vent knob contact to the up position, continue tracing over wire H71B20 to point A of P/J 317A, up to the pressure regulator and shutoff valve solenoid and back to point C of P/J 417A. From point C trace across ground wire H34A20N. The bleed air pressure regulator and shutoff valve solenoid is now energized and the system will receive bleed air regulated at 62 psi, when bleed air is applied to the system.

EXERCISE 2 - POWER CIRCUIT

EXPLANATION - Power to the rain removal switch. Closing the rain removal 28VDC circuit breaker will place a positive potential on the single pole of the rain removal switch.

DRAW IN RED - Start at the 28VDC rain removal circuit breaker and trace to point E on J/P 315B, then across wire H6A20 to point D of P/J 204 and to the rain removal switch.

EXPLANATION - Rain removal system turned on. To turn on the rain removal system, the armature of the rain removal switch must be in the ON position. In this position a positive potential is placed to the low pressure solenoid and the rain removal valve. After the rain removal valve is completely open, the positive potential will then be directed to the rain removal bypass valve. With the low pressure solenoid energized and both valves open the rain removal system will be operating, when bleed air is applied to the system.

DRAW IN BROWN - Draw the armature of the rain removal switch to the on position and continue on through pin E of J/P 204, and to the junction point. At this point voltage will go two ways. First, trace across wire H8B20 to point A on P/J 417B through the low pressure solenoid and to point B then continue out ground wire H34A20N. This circuit will energize the low pressure solenoid and drop bleed air pressure from 62 psi to 40 psi. Now continue from the junction point. Trace from the junction point to point A on P/J 105. Continue tracing from point A across the open motor winding to point E on J/P 105 out ground wire H9A20N. This will allow the rain removal valve to open allowing partially cooled bleed air into the system.

Part 2 - Opening of the Rain Removal Bypass Valve

EXPLANATION - Only after the rain removal valve has reached the full open position will the following occur. After the rain removal has reached its full open position, the open limit switch armature of the rain removal valve will move to the opposite position. This closes the circuit between pins A and C of P/J 105. This armature movement cuts off power to the open winding, and closes the circuit to the closed motor winding. The limit switches in each valve are mechanically linked, when one switch moves the other switch in that valve will also move to the same position. Since the limit switch moved to the up position, voltage can now continue to the rain removal bypass valve. Remember this is only after the rain removal valve is completely open. Once voltage is established through the open winding of the rain removal bypass valve, it opens. Then the limit switches of the rain removal bypass valve will move to the opposite position.

DRAW IN ORANGE - To show that the rain removal valve is completely open, draw both of its limit switch armatures up. Starting at the rain removal valve single pole open limit switch, draw over the armature through pin C of P/J 105, over H16A20, through pin A of P/J 104 to the single pole of the open limit switch on the rain removal bypass valve. Continue tracing across the open motor windings to point C of J/P 104 out ground wire H18A20N. This completes the circuit and will allow the rain removal bypass valve to open. After the valve opens, its limit switches will move to the opposite position. After both rain removal valves are open, air will be applied to the windshield.

EXERCISE 3 - AIR FLOW THROUGH THE SYSTEM

EXPLANATION - Air Flow - Rain Removal Switch ON

After both valves are open, air for rain removal will be applied to the center windshield. This air comes through the bleed air pressure regulator and shutoff valve and then divides into two routes. One route goes through the primary heat exchanger, through the rain removal valve, rain removal nozzle, on over the windshield temperature sensing element and then over the center windshield. The other path is a bypass of the primary heat exchanger. This air is at a higher temperature and goes through the rain removal bypass valve, rain removal nozzle on over the center windshield temperature sensing element and over the center windshield. As shown, the two air paths mix together by the nozzle to pass over the windshield and the air should not exceed 260°F.

DRAW IN ORANGE - Hot bleed air

In orange draw a solid line for air flow starting where it says "from bleed air system" through the bleed air pressure regulator and shutoff valve UP TO but NOT through the primary heat exchanger.

DRAW IN DARK GREEN - Partially cold air

To show a drop in temperature after (on right side) the primary heat exchanger, use the dark green pencil to draw through the rain removal valve (butterfly symbol) on through the rain removal nozzle and over the windshield temperature sensing element and center windshield. This is partially cold bleed air.

DRAW IN ORANGE - Hot bleed air (bypass)

The other path will be HOT bleed air drawn in orange starting at the point between the regulator and heat exchanger. From this point, draw down through the rain removal bypass valve (butterfly symbol), through the rain removal nozzle mixing with the other path then over the windshield temperature sensing element and center windshield. This air leaving the nozzle is mixed and should not be over 260°F.

Note: Once the rain removal valve is open the rain removal drain valves closes from the air pressure placed on it.

EXERCISE 4 - WINDSHIELD OVERHEAT WARNING CIRCUIT

Part 1 - Power

EXPLANATION - Power 115VAC

After the 115VAC windshield temperature sensing circuit breaker is pushed in, a positive potential is placed on the MAG. This power is used by the MAG and changes it to a desirable voltage for the sensor circuit and its relay coil. The voltage for the sensor circuit and relay coil is NOT to be measured and is NOT available. The relay, like the MAG, is inside a sealed container, the windshield temperature sensing control unit. But, if a measurement of its circuit is needed, it must be isolated and the circuit resistance must be measured.

DRAW IN RED

With a red pencil starting at the 115VAC windshield temperature sensing circuit breaker, draw through pin H of J/P315B over H56A20, through pin C of P/J201, through the MAG, to point D on J/P201 and out ground wire H55A20N. This supplies power to the MAG.

EXPLANATION - Power 14/28VAC

After the 14/28VAC warning light power circuit breaker is pushed in, a positive potential is placed on the single pole of the relay in the windshield temperature sensing control unit and on the normally open throw of warning light test relay.

DRAW IN RED

With a red pencil starting at the 14/28VAC warning light power circuit breaker, draw through pin A of J/P315B, over H188A20, through AC19 over H188C20, through pin B of P/J201 up to the single pole of the relay in the windshield temperature sensing control unit. Going back and starting at AC19, draw over H188B20 through pin P of P/J207B up to the normally open throw of the warning light test relay.

Note: The voltage in the warning light circuit is AC power (14/28VAC) and NOT DC power (28VDC).

Part 2 - Under 260°F (light out)

EXPLANATION - As the temperature of the air passing over the windshield temperature sensing element (sensor) changes the resistance of the sensor will change. Air less than 260°F cause the sensor to reach a resistance which creates a condition in the windshield temperature sensing circuit and control unit, causing its relay to be energized. This relay receives power from the MAG's transistor only when the MAG and sensor circuit allows it. With the relay energized the windshield temperature high light will be out. This tells the pilot a safe air temperature is passing over the windshield.

DRAW IN VIOLET

This color indicates the current flow to and from the MAG through the sensor is such that the MAG has energized the relay. This results in the windshield temp high light staying out. Draw in violet from the MAG through the sensor and back to the MAG in either direction. Then trace from the MAG, through the relay to point D on J/P201 and out ground wire H55A20N. This circuit will energize the relay keeping the warning light off.

Note: The sensor's wires are for turning the light on or off. One of the wires is not just for turning the light on or off.

Note: Remember the relay uses H55A20N only under 260°F when it is energized.

Part 3 - Test Circuit

EXPLANATION - Power Circuit

With the 28VDC warning light control circuit breaker set, power will be applied to the warning light test switch.

DRAW IN RED

Trace from the 28VDC warning light control circuit breaker to point C on J/P 315B, continue across wire [illegible]0A20 to the warning light test switch.

EXPLANATION - Warning light test relay energized, warning light on. When the warning light test switch is placed to test, power is directed to the warning light test relay. This will energize the relay pulling the armature down. This will allow 14/28VAC to continue to the windshield temp warning light turning it on.

DRAW IN DARK GREEN

Draw the warning light test switch to the test position. Continue tracing across wire L[illegible]0A20 to junction FC1, across wire L50B20 to point B on P/J207B. Trace through the relay to point A on P/J207B and out ground wire LB2A20N. This will energize the relay pulling the contact down. Continue with the dark green pencil. Draw the warning light test relay contact down, continue to point [illegible] on J/P207P across wire H60A20 to junction AC20. From junction AC20, continue across wire H60C20 through point C on 52P/J265, through the light to ground. The warning light will come on telling the pilot the light is good.

Note: After the spring loaded test switch is released the test light will deenergize and the windshield temp high light will go out.

Part 4 - Over 260°F (overheat light on)

EXPLANATION - As the temperature of the air passing over the windshield temperature sensing element (sensor) changes, the resistance of the sensor will change. Air OVER 260°F causes the sensor to reach a resistance which creates a condition in the windshield temperature sensing control unit causing the relay to deenergize. The relay coil will not receive power from the MAG's transistor when the sensor circuit resistance is such that it is causing the MAG transistor to cut power to the relay. With the relay deenergized, the windshield temperature high light will be on. This tells the pilot an unsafe air temperature is passing over the windshield. At this time the pilot must place the rain removal switch to OFF!

DRAW IN YELLOW

This color reflects the current flow to and from the MAG through the sensor is such that the MAG has allowed the relay to deenergize. This results in the windshield temperature high light to come on. Draw in yellow from the MAG through the sensor and back to the MAG. DO NOT draw in yellow the wire from the MAG to relay because the relay will not receive power. The relay must be deenergized for temperatures over 260°F to turn on the windshield temperature high lamp.

With an overheat at the windshield temperature sensor, the resistance will increase to the point (over 260 degrees) where the MAG will cause the relay to deenergize. This causes the armature to fall and complete the circuit to the light.

Note: H55A20N is the AC ground for the AC power.

Pin B and A of P/J201 are for AC power (low voltage 14/28VAC) and NOT DC power 28VDC.

The windshield temperature high lamp uses AC power 14/28VAC.

DRAW IN YELLOW

In yellow draw the relay armature close connecting B to A of P/J201. Draw in yellow, starting at the single pole of the relay through pin A of J/P201 over H60B20 through AC20, over H60C20 up to pin C of 52P/J265, through the light and out ground. Beside the windshield temperature high light write in yellow, "light on over 260°F."

Note: It's AC and NOT DC power that turn on the light.

EXERCISE 5 - RAIN REMOVAL VALVES CONTROL CIRCUIT (CLOSE/OFF)

Part 1 - Low pressure solenoid deenergized and rain removal bypass valve close.

EXPLANATION - Rain Removal System OFF

If the rain removal air over the center windshield is not wanted, both rain removal valves must be closed. The pilot closes them by placing the rain removal switch to the OFF position. In this position, the positive potential is removed from pin A of P/J417B deenergizing the low pressure solenoid. This allows the regulator to again regulate at 62 psi for air conditioning with the high pressure solenoid energized. Also in this position a positive potential is applied to pin B of the rain removal bypass valve. After this valve closes completely, a positive potential will be placed on pin B of the rain removal valve for it to close.

Note: The rain removal bypass valve closed first to make a reduction in temperature and then the rain removal valve will make the final cutoff of air to the windshield. With both rain remova valves closed the rain removal drain valve will open the spring inside it.

DRAW IN BLACK

The rain removal bypass valve is open and the limit switches inside it will be found in the down position. In this position power was cut off through the open windings earlier. This will allow electron flow through the close windings to let the valve close. Insure the limit switch armatures are in the down position by drawing them this way with a light green pencil.

Draw in light green the armature of the rain removal switch to the OFF position and continue on through pin F of J/P204 over H7A20 through pin B up to the single pole of the close limit switch in the rain removal bypass valve. Continue through the close motor windings to pin C of J/P104 and out ground wire 18A20N.

Part 2 - Rain Removal Valve Close

EXPLANATION - Rain Removal System OFF (Cont'd)

AFTER the rain removal bypass valve has closed, reaching its full close position, the close limit switch armature will close the electrical path between pin B and D of P/J104. The open limit switch armature will be in a position to connect pin A of P/J105 to the open winding. Power from the rain removal bypass valve will then continue to the rain removal valve, closing it. This will then shut off all airflow across the windshield.

DRAW IN BLACK

Insure the limit switch armatures in the rain removal valve are drawn in the UP position indicating the valve is open. With the rain removal bypass valve completely closed, draw with the black pencil both limit switches armature up. Starting at the single pole of the close limit switch, draw in black over the armature through pin D of P/J10', over H17A20, through pin B of P/J105 to the single pole of the rain removal valve, across the close motor windings to point E of J/P105 and out ground wire H9A20N. After the valve closes all the way, the limit switches will return to their original position.

Part 3 - Air Flow, Off

EXPLANATION - With both valves now closed and low pressure solenoid deenergized, the system air flow over the windshield will stop and the air conditioning pressure will increase. With the loss of this air, the rain removal drain valve will open with its spring.

PRACTICE EXERCISE INSTRUCTIONS

This is the practice exercise (practice work) in which the requirement is to complete at least the first three assigned problems satisfactorily. In addition to the first three practice problems an additional amount may be required. These additional problems are only required if the instructor determines additional exercise is needed. During the practice exercise, questions may be asked of the instructor within reason. The instructor will always reserve the right on how or if to respond to the question(s).

The student will NOT be allowed to progress to the progress check unless all of the assigned practice exercises are complete. The instructor determines if the assigned practice exercise is completed satisfactorily and when progression to the progress check will be.

At this time, go back and reread the objective in the front of this workbook. If you have any questions about it, see the instructor NOW. If you don't have any questions about the past material and think you understand it, proceed with the following.

Note: During the practice exercise, if you have anything you don't understand, inform your instructor. Also, if you have questions during the exercise, that's the time to speak with the instructor.

All of the entries made for each cause must be correct. Partial credit cannot and will not be given during progress check.

PRACTICE PROBLEM 1

Diagram 1 at the back of this workbook must be used in conjunction with the practice exercise page(s) in this workbook.

FIRST - Read the discrepancy given. Study it along with diagram 1 to the point that you completely understand the discrepancy. You should understand it so you feel as though you have actually written the discrepancy.

SECOND - Study diagram 1 and make personal notes somewhere on diagram 1 of all the possible causes for the discrepancies.

THIRD - Under the possible cause column on page 11 you will find the recording area for one or more of the required causes. Remember, you will not be required to record page 11 all the possible causes for each discrepancy. You should have done this in step 2 above, on the diagram.

The following information and guidance are provided to help you understand how to meet the objective.

Read the discrepancy as given for problem 1 on page 11. You need to study the discrepancy so you feel as though you have actually written it. At the same time you may refer to diagram 1 in the back of this workbook. After you fully understand it, use diagram 1 to help identify the possible causes for the given discrepancy.

The discrepancy says "Air flow from the rain removal nozzle has stopped," this means the valves must both be closed. The statement, "with the rain removal switch on," means the valves should be open. "And the air conditioning pressure does not drop," means that the solenoid didn't energize.

If the motors don't drive the valves open and the solenoid is deenergized, the circuitry which is in COMMON to or SHARED by all three loads (solenoid and two motors) must be considered first.

Examining diagram 1, you will find the following wires and components are shared by all three loads when the system is turned on.

1. Wire H8A20

2. Wire H6A20

3. Rain removal switch

4. Rain removal circuit breaker

These four items should be the ones you should have identified as possible causes on diagram 1 for the discrepancy. This should be marked by placing a very light checkmark by each one of them on the diagram. Each problem's checkmarks can be erased after the problem is complete.

As indicated by the answer column, the cause is marked <u>wire</u> numbers and two open spaces, and the discrepancy is "Airflow from the Rain Removal nozzle has stopped, with the rain removal switch 'ON' and the Air Conditioning Pressure does not drop," and in the cause column they want two wires. Out of the four items you checked there are two wires, write these two wires in the two spaces given.

Don't forget that any of the areas you have marked could have been the cause. But, as you can see, only one cause is asked for. You will not always be required to give all the possible causes for grading. You should however, always mark all possible causes on the diagrams before actual troubleshooting. This should save you time and it should prevent you from possibly straying into circuits which are in no way related, during actual troubleshooting with test equipment.

PRACTICE EXERCISE

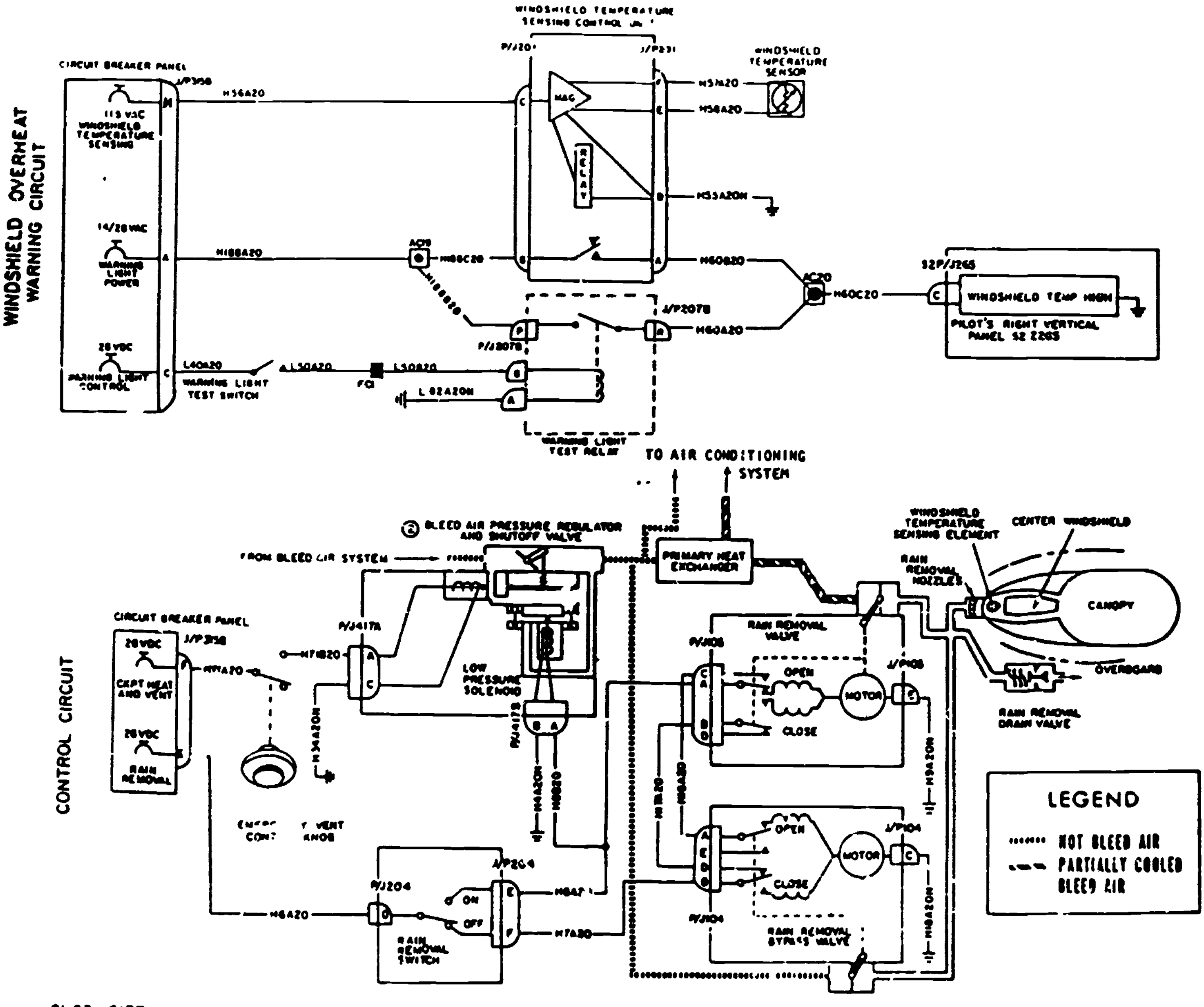
(Practice Work)

DISCREPANCIES		CAUSE
1.	With the rain removal switch "ON" air conditioning pressure does not drop and air does not flow across the windshield.	Open wire numbers ________, ________.
2.	During an overhead condition the "Windshield temp high" warning lamp failed to come on. The lamp worked normally during the test procedure.	Open wire numbers ________, and ________.
3.	Both valves remain open with the switch in the "OFF" position. The valves did open normally.	Open wire number ________.

See your instructor to have the three practice problems evaluated at this time.

If you have anything you don't understand or have questions, now is the time to ask. What you may ask during the progress check is limited.

STOP!! Inform your instructor you are ready to start the progress check.



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RAIN REMOVAL SYSTEM

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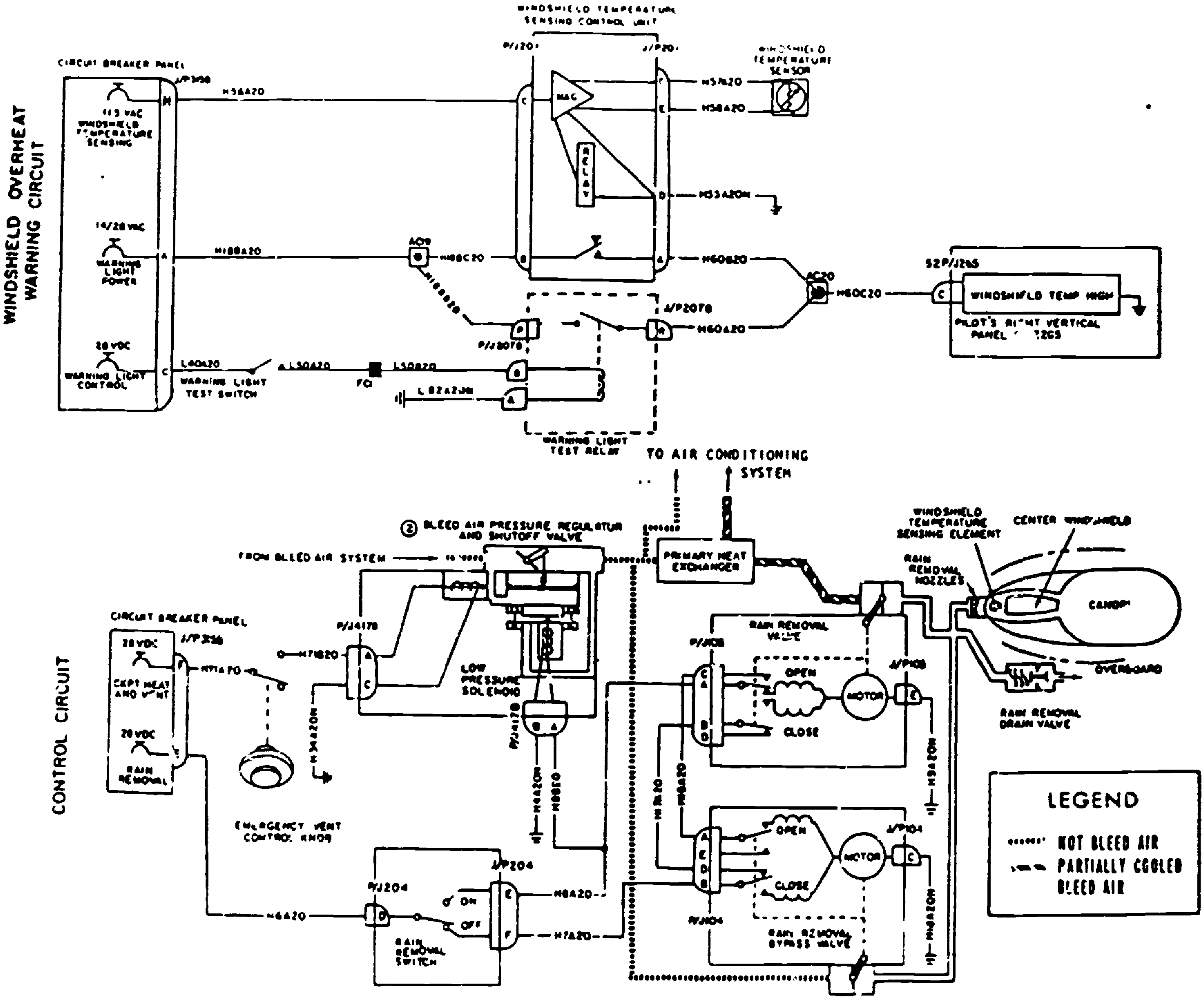

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RAIN REMOVAL SYSTEM

SERVICE TEST
STUDY GUIDE

C3ABR42331-SG-203

Technical Training

Aircraft Environmental System Mechanic

FIGHTER REFRIGERATION SYSTEM

26 April 1984

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

Designed for ATC Course Use.

Do Not Use on the Job.

Environmental/Pneudraulics Branch
Chanute AFB, Illinois

SERVICE TEST
C3ABR42331-SG-203

FIGHTER REFRIGERATION SYSTEM

OBJECTIVE

Relate a minimum of 8 out of 10 refrigeration components to their operation.

INFORMATION

The refrigeration system can actually be broken down into two sections - hot and cold air - cold air to the equipment compartment and a mixture of hot and cold air to the cockpit. Also included in the refrigeration system is the servo air system.

The purpose of the servo air system is to supply air pressure to the valves in the ECS. This air pressure is used for valve activation (movement). Partially cooled bleed air (air that has passed through the heat exchanger but not the cooling turbine) from the inlet side of the compressor turbine is the source of the air for the servo air system.

The servo air is then routed to the water trap where excess moisture is removed from the air. The water trap is designed to collect moisture from the servo air and then force this water out through a drain hole (vent) in the bottom of the filter. This water is allowed to evaporate in the refrigeration bay.

After passing through the water trap, the air is sent through the servo air filter. This filter is a disposable wire mesh unit which insures that relatively clean, dry air is being used in the servo air system.

After being cleaned by the filter, the servo air must be regulated. This is accomplished by the servo air regulator which takes 30 psi air pressure and regulates it down to 18 ± 2 psi. The servo air regulator also has an overpressure relief setting of 25 psi.

Now that we know how the valves are actuated open and closed, let's discuss one of the sections mentioned earlier - the hot air system.

The Hot Air Control Valve - You should recall from the bleed air section that the three primary valves (7th, 13th stage bleed valves and the variable pressure regulator (VPR)) all control PRESSURE but not TEMPERATURE. The hot air control valve DOES control temperature.

Working in conjunction with the hot air sensor/controller, the hot air control valve maintains a duct temperature of 320°F. This set functions as a source of hot air to be mixed with cool refrigerated air to maintain the desired temperature range in the cockpit, as well as providing a warm air source for the water separator anti-icing control set.

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Hot air for W/S anti-icing is taken downstream of the VPR. The warm (partially cooled) air consists of bleed air which has passed through the primary section of the heat exchanger, but has not yet passed through the ECS cooling turbine. These two air sources (hot bleed air and partially cooled air) combine in the warm air duct at a point between the hot air sensor/controller and the hot air control valve. The sensor controller is a device that is used to help the control valve maintain the 320°F duct temperature. The duct temperature is also monitored by the hot air bypass thermostat. If the hot air control valve or the hot air sensor/controller should malfunction and allow duct temperature to rise to a temperature of 450°F, the hot air bypass thermostat would shut the system down. (Remember this from the bleed air section.)

The hot air control valve is spring-loaded closed and pneumatically actuated open. It also has a push-to-test button for testing the operation (open/close movement) of the valve. With the button pushed half-way i the valve will bleed off control pressure and close. With the button pushed all the way in the valve will open.

This completes the hot air section, so let's continue on with the cold air section.

First, we shall talk about the component that gives the pilot cold air, the cooling turbine. The cooling turbine consists of an oil sump, a compressor turbine and an expansion turbine. We will discuss each of these parts separately.

First, the oil sump, located at the bottom of the turbine, is used to lubricate the bearings. This is done through two oil wicks which hang down in the oil sump. These two wicks will soak up oil and distribute it on to the bearing. Servicing of the oil sump should be done on the aircraft according to the applicable TO. After servicing, the turbine should be allowed to sit for a period of time (time is designated by the TO) to allow for adequate lubrication.

The compressor and expansion "wheels" of the turbine will be discussed together. To understand the proper operation of the two, you must first understand what effect the bleed air has as it strikes the "blades" on the wheel.

Look the bleed air schematic and notice that after the air passes through the primary section of the heat exchanger, it flows to the compressor side of the turbine. After going through the compressor side of the turbine, it flows back through the secondary section of the heat exchanger to receive additional cooling from the ram air flowing through the heat exchanger, and then it is routed to the expansion side of the turbine.

Now to better explain this, let's go back to the starting point. The hot hi-press bleed air receives its initial cooling as it passes through the primary section of the heat exchanger. The bleed air is then routed to the compressor side of the turbine. Now to explain the what, why and how of the compressor wheel.

What: What is the compressor turbine? This is the part of the turbine that will take bleed air and do <u>exactly</u> as the name implies - it will COMPRESS the bleed air.

Why: Why does it compress the bleed air? It compresses the bleed air because if the turbine is going to produce cool air it must work efficiently. For the turbine to work efficiently, the bleed air must be hi-press. If you study the schematic you will notice that the bleed air is "tapped" off for uses other than air conditioning. These "tap offs" cause the pressure to drop. The pressure must be brought back up to an efficient working pressure. To do this, the bleed air is routed to the compressor.

How: How is the air compressed? Once again, study the bleed air schematic and you will notice that the bleed air enters the compressor turbine by going straight into the blades. At this point two things are taking place. First, you are taking a large volume of air and forcing it into a small area. This is, of course, going to cause the air to compress. Secondly, by the way the air is entering the compressor, (straight into the blades) it is going to cause the compressor to put a load on the expansion turbine. (This will be discussed in more depth when we talk about the expansion side.) After going through the compressor, the bleed air is going to be hot hi-pressure bleed air again. Because you increased the pressure, you also increased the temperature. Now it must be sent through the secondary section of the heat exchanger to remove the increased temperature.

After the bleed air passes through the secondary section of the heat exchanger, it goes through the regenerative heat exchanger for additional cooling (this will be discussed later). After passing through the regeneration heat exchanger, the bleed air goes into the expansion side of the turbine.

What is the expansion turbine? This is the part of the turbine where the "super" cooling of the bleed air takes place. This is also considered the final stage of cooling. This is accomplished by what is known as rapid expansion. Rapid expansion is the taking of the compressed bleed air (molecules that have been compressed together) and causing them to expand very rapidly (molecules are thrown apart). This will create the cold air.

Because of the fact that the hot air is being expanded, it is also referred to as taking heat energy and turning it into mechanical energy. This means you are taking hot air and expanding it, which causes the expansion turbine to turn. By doing this, the expansion turbine is considered the "driving" force of the cooling turbine assembly. Even though the bleed air passes through the compressor turbine before it gets to the expansion turbine, the expansion side is still the "driving force." It causes the turbine to spin (turn) while the compressor turbine puts a "load" on the expansion side to prevent it from overspeeding. By studying the bleed air schematic you should also have noticed that the two turbine wheels are connected by a common shaft, so when the expansion turbine starts to turn, so does the compressor side.

All right! Now we have cooled the air going into the cockpit. How about precooling before it gets to the turbine assembly?

You probably remember sending the bleed air through the heat exchanger before routing it through the turbine! The heat exchanger is the unit that will "precool" the hot bleed air before it goes to the cooling turbine. Locate the heat exchanger on the bleed air schematic and note that it is comprised of two sections - the primary section and the secondary section.

The heat exchanger is an air-to-air type heat exchanger. This means that you have hot bleed air passing through the heat exchanger and ram air passing around it to transfer the heat from the bleed air to the ram air. Depending on the throttle setting, the temperature of the bleed air entering the heat exchanger can range from 400°F to 1100°F. After passing through the primary section of the heat exchanger the temperature of the bleed air will be approximately 300°F or below. The air then goes to the compression side of the cooling turbine. You should remember that the pressure and temperature are increased at this point. You should also remember that after going through the compression side of the cooling turbine, the bleed air goes back to the heat exchanger, the secondary section of the heat exchanger. The temperature of the bleed air will generally be below 350°F after passing through the secondary section of the heat exchanger. Pressure at this point will vary between 65 and 145 psig.

Now you know how the bleed air is precooled before it gets to the cooling turbine. The heat exchanger can be considered the first stage of cooling for bleed air. The second stage of cooling is the regenerative heat exchanger. Locate the heat exchanger on the bleed air schematic.

The regenerative heat exchanger provides additional cooling of the high-pressure bleed air that is discharged from the secondary section of the air-to-air heat exchanger. Because it uses the water drail-off from the water separator, the regenerative heat exchanger is most efficient under high moisture content conditions (low altitude).

The regenerative heat exchanger has two small lines going to it. One from the water separator and the other from partially cooled air manifold. The partially cooled air enters the regenerative heat exchanger at the top. At the end of this line is a venturi. At the throat of the venturi is the other line. The venturi will create a low pressure at the throat, which will suck the moisture out of the water separator. This moisture is then blown over the tubing that carries the partially cooled air in the regenerative heat exchanger, providing additional cooling. Because the air temperature and ram air inlet temperature are high at low altitude and high speed, the primary heat exchanger is not very efficient. At low altitude there is more moisture in the air which will make the regenerative heat exchanger more efficient to help the primary air-to-air heat exchanger.

Once the air is discharged from the regenerative heat exchanger, it flows through the expansion turbine. You should recall that the air is "super" cooled at this point. At low altitudes the air coming out of the expansion turbine has a lot of water (moisture). If this moisture is allowed to go into the cockpit, it would cause a fogging effect which could cause a visibility problem for the pilot. Also, if this moisture is allowed to enter the equipment compartment, it could cause damage to the equipment.

To prevent the fogging effect and equipment damage, the water must be removed from the air. This is accomplished by the water separator which is installed downstream of the cooling turbine.

The water separator consists of a by-pass valve and a cooleser.

The by-pass valve is set to open at 7 psig. It allows air to flow through the water separator in the event of an ice blockage.

The cooleser is designed to collect moisture from the air and turn it into water droplets. The cooleser also caus s the air to swirl around in the water separator creating a centrifugal force which will "throw" the water droplets to the outside wall where they drop down into the bottom of the water separator and are sucked into the regenerative heat exchanger to increase the cooling efficiency of the air-to-air heat exchanger. Because of the low temperature of the air coming out of the expansion turbine and entering the water separator, it sometimes causes the moisture in the water separator to freeze up. If this occurs, airflow going into the cockpit and equipment compartment is blocked. At this point, the by-pass valve will open (7 psi), allowing some air-flow into the cockpit/equipment compartment.

To try and prevent this from happening, there has to be a way to keep air temperatures above freezing. To do this, a water separator anti-ice system has been incorporated into the system.

This system consists of a water separator anti-ice valve and a water separator anti-ice sensor/controller.

The water separator anti-ice valve is an electrically controlled, pneumatically actuated valve. It is spring-loaded closed. Opening of the anti-ice valve is controlled by the sensor/controller. Let's look at an example to better understand the proper operation of the anti-ice valve. The altitude of the aircraft will determine the output temperature of the air coming out of the water separator. At an altitude of less then 27,000 ft, the water separator output should be 35° $\pm$2°F. At altitudes above 27,000 ft the output temperature will drop to 0° $\pm$2°F. Now - lets look at an example! The aircraft altitude is below 27,000 ft. Output temperature should be 35° $\pm$2°F. Now, lets say the temperature drops to 30°F, that is below freezing, so the temperature must be brought back up to 35° $\pm$2°F or we face the problem of a water separator freezing up. The sensor/controller, located in the output duct of the water separator does just what the name implies; it senses the temperature of the air coming out of the water separator and controls the temperature to 35° $\pm$2°F. So, if the temperature has dropped from 35° to 30°, the sensor portion of the controller will sense this temperature drop and send a signal to the controller portion of the unit. The controller in turn will increase current flow to the anti-ice valve motor. When this happens servo air will open the anti-ice valve, allowing hot air to be mixed with turbine discharge air. With a warmer mixture of air flowing into the water separator, the output temperature will increase, bringing the temperature back to 35° ±2°F. This action is a continual cycle to keep the proper water separator output temperature. The anti-ice valve should always be open a little.

RAM AIR SYSTEM

During ram air operation, part of the ram air that is normally routed to the air-to-air heat exchanger is diverted to the cold air supply ducting.

The ram air system is activated by selecting RAM on the air source selector switch. This will cause the shutoff solenoids on the 7th & 13th stage regulators and the variable pressure regulator to energize and the dump solenoid on the cabin safety dump valve to energize. This action will stop airflow into the system and allow pressure to be dumped overboard. At the same time, the emergency ram air valve is deenergized to the open position. The emergency ram air valve is electrically controlled and pneumatically operated. Loss of electrical power and/or servo air will cause the valve to move to the open position. A split flapper-type check valve is installed downstream of the ram air valve to prevent loss of cooling air during normal system operation should the ram air valve fail.

WATER SEPARATOR, ANTI-ICE

The anti-ice control switch has several positions which we will take up individually:

Valve Return "Norm" - Allows you to read voltage from water separator anti-ice valve. Depending on the position of the anti-ice valve, voltage readings will range from 19 VDC (full open) to 28 VDC (full closed). Normal readings should be about 25 VDC, indicating a slightly open valve.

Valve Return High Temp - When placing the tester ANTI-ICE CONTROL switch in the VALVE RETURN - HI TEMP position, you are checking operation of the water separator anti-ice sensor/controller and the water separator anti-ice valve. This is accomplished by causing an imbalance in the bridge circuit of the sensor/controller. The sensor/controller contains a negative coefficient bridge circuit The imbalance will cause the sensor/controller to think that the W/S discharge temperature is too cold, therefore sending a signal to the anti-ice valve causing it to open, sending warm air into the W/S. Normal voltage display on the meter should be 19 to 22 VDC, indicating a nearly full open valve. The temperature display in the AVIONICS or CABIN position should increase to 85°F ±10°F. (75° - 95°F)

Control High Temp Test - This test will check the opening of the water separator anti-ice valve, increasing the temperature output of the anti-ice valve to 85°F, just as it did in the HIGH TEMP test. The voltage display will indicate the transistor voltage is zero indicating valve closed and 2.5 VDC indicating valve open. Normal voltage reading should be greater than 2.0 volts.

Control Mode Shift - This test will do three things. First, it will read the voltage controlling the transistor in the water separator anti-ice sensor/controller. Secondly, it will increase the resistance of this sensor, causing it to think that the water separator discharge air is too cold and opening the water separator anti-ice valve to allow warm air into the water separator. Thirdly, it will check the ability of the sensor to respond to mode shift. The mode-shift will lower the temperature of the air from 85°F to 50°F.

WORKBOOK

C3ABR42331-WB-203A

Technical Training

Aircraft Environmental Systems Mechanic

RAIN REMOVAL SYSTEM AND TROUBLESHOOTING

1 November 1983

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE

DO NOT USE ON THE JOB

RAIN REMOVAL SYSTEM AND TROUBLESHOOTING

OBJECTIVE

Using a multimeter and wiring diagram, troubleshoot the rain removal system trainer, locating three out of four troubles correctly.

EQUIPMENT

Trainer 3336, Rain Removal System
Multimeter, AN/PSM-37

PROCEDURE

1. Remove all of your jewelry. Report to the lab instructor and inform him of the lesson on which you are working. The instructor will assign you to a trainer and provide the necessary equipment.

2. This workbook is presented in two sections. Section 1 is to familiarize you with the components of the rain removal system trainer. Section 2 contains the steps for operationally checking the systems and the malfunctions that you are to troubleshoot. Perform each step as directed on the following pages. If you do not understand any part be sure to ask the instructor for assistance.

SECTION 1. RAIN REMOVAL SYSTEM TRAINER COMPONENTS

1. Locate each of the following items on the trainer. The names of the items are listed near each component.

a. Bleed air pressure regulator and shutoff valve.

Note 1: This is the pressure regulator and shutoff valve that controls air for cabin air conditioning. The controls that energize the main solenoid are not on this trainer. Since we are only concerned with the rain removal system, the only part of this regulator that will operate is the low pressure solenoid.

b. Rain removal shutoff valve.

c. Rain removal bypass valve.

Supersedes C3ABR42331-WB-202A, 13 October 1982.
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3370 TCHTG/TTGU-P - 300; DAV - 1

d. Windshield temperature sensor.

e. Windshield temperature sensing amplifier.

f. Warning lt cont 28V DC circuit breaker.

g. Warning lt pwr 14/28V AC circuit breaker.

h. Rain removal 28V DC circuit breaker.

i. Windshield temp sensing 115V AC circuit breaker.

j. Rain removal switch.

k. Warning light test switch.

l. Overheat simulator switch.

Note 2: This switch is used to simulate a temperature rise above 260°F When the switch is placed in the simulated overheat position it increases the resistance in the sensor circuit causing the windshield temperature sensing amplifier to turn on the warning light.

2. Trainer preparation.

a. Place all trouble switches to the OUT position. These switches are located on the right end of the trainer.

b. Push in all circuit breakers.

c. Place the rain removal switch to the OFF position.

d. Place the trainer power switches to the ON position. These switches are located on the left end of the trainer.

3. Trainer operation.

During each of the following steps you will operate each component of the rain removal and windshield temperature warning systems. When a switch is actuated be sure to notice which of the valves operate and the valve position. Actuate each switch as directed. From your observation of the trainer operation, complete each of the following statements by circling the correct word.

STEP 1. Rain removal system operation.

(1) Place the rain removal switch to ON.
The rain removal valve (opens/closes).
The rain removal bypass valve (opens/closes).
The pressure regulator and shutoff valve low pressure solenoid (energizes/deenergizes).

Note 3: Since we do not have airflow through the system you cannot observe the decrease in flow to determine whether or not the low pressure solenoid is operating. However, you can check to determine if the solenoid is energizing as follows: Remove the AN electrical connector by unscrewing it from the solenoid valve at P417B and J417B. As you remove the connector you should hear an audible click as the solenoid deenergizes. Then replace the electrical connector, listening closely as you do so. You should hear the click as the solenoid is energized. Try this several times to be sure you recognize the audible sound of the solenoid energizing and deenergizing.

(2) Place the rain removal switch to OFF.
The rain removal bypass valve (opens/closes).
The rain removal shutoff valve (opens/closes).

STEP 2. Windshield temperature overheat warning system operation.

(1) Hold the windshield temperature sensor simulated overheat switch to simulated overheat position.

The WINDSHIELD TEMP HI warning light is (on/off).

(2) Release the simulated overheat switch.

The WINDSHIELD TEMP HI warning light is (on/off).

STEP 3. WINDSHIELD TEMP HI warning light test circuit operation.

(1) Hold the warning light test switch to TEST.

The WINDSHIELD TEMP HI warning light is (on/off).

(2) Release the warning light test switch.

The WINDSHIELD TEMP HI warning light is (on/off).

STEP 4. Place the trainer power switches to OFF.

COMPARE THE ANSWERS THAT YOU HAVE SELECTED TO THOSE GIVEN BELOW.

Answers to trainer operation statements.

STEP 1. (1) opens.
opens.
energizes.

(2) closes.
closes.

STEP 2. (1) on.
(2) off.

STEP 3. (1) on.
(2) off.

If your answers do not agree, check with the instructor. If your answers agree, then the trainer is operating correctly.

4. Sensor resistance.

a. Knowing the normal resistance value of the sensor will be helpful when troubleshooting the system.

b. To measure the resistance of the sensor, the circuit must be isolated. To isolate the sensor circuit, disconnect the AN connector from the windshield temperature sensing amplifier. With this disconnected you can measure the sensor resistance from the check point, pins E and F at the temperature sensing amplifier. Using the multimeter, measure the resistance of the sensor.

The sensor resistance is ________________________.

c. Ask the instructor for the ambient temperature in the lab area.

Temperature is ________________________________ .

d. The graph, illustrated in figure 1 below, shows the normal sensor resistance. Using the graph, determine the resistance range for the sensor at the present ambient temperature in the lab. Is the measured resistance of the sensor within the range given on the graph? (Yes/No).

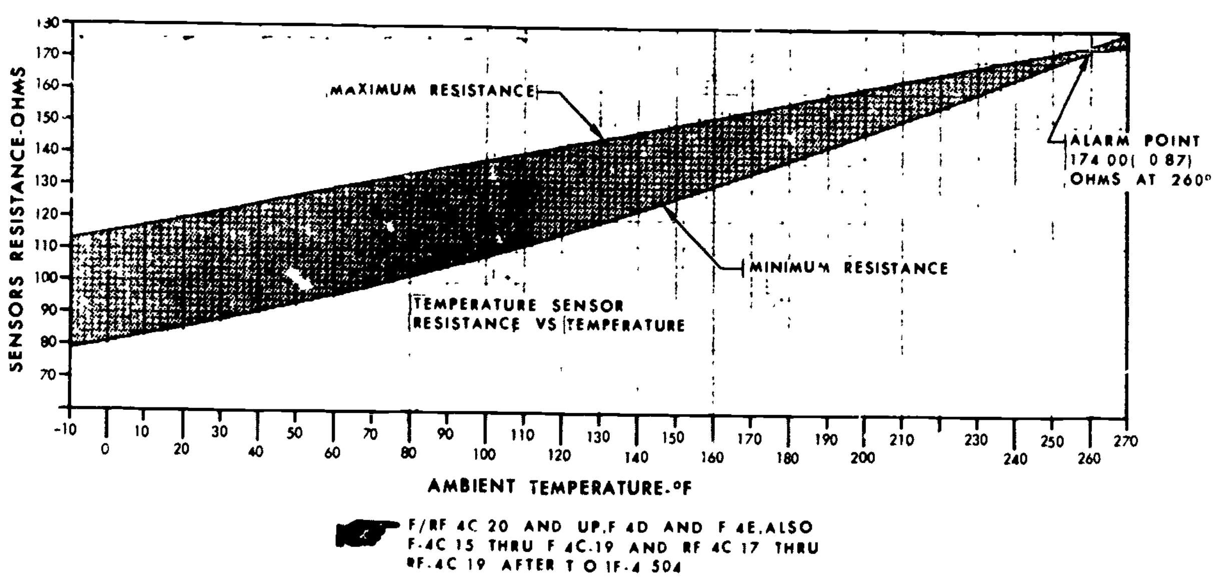

Figure 1. Windshield Temperature Sensor Resistance Graph.

Instructions for using the temperature sensor resistance graph.

Locate the vertical line for the ambient temperature. Follow this line up to the shaded area, then follow the horizontal lines to the left to determine the resistance range in ohms. The measured resistance should be within this range.

Example: If the temperature is 120°F, then the resistance should be between 112 and 142 ohms.

SECTION 2. OPERATION AND TROUBLESHOOTING

OPERATIONAL CHECK

1. The steps that you performed in paragraph 3a of Section 1 involved operating each component in the rain removal and windshield temperature overheat warning systems. They determine if each component was operating properly and are called operational checks.

2. The chart below formalizes the operational check procedures in an outline form. With troubleshooting, you will be required to perform an operational check for each trouble. To insure that you are familiar with the procedure, turn on the trainer power switches and perform an operational check using the outline below. After you have completed the operational checks, continue with the troubleshooting part of this lesson.

Switch Positioning	Operating Valve or Light	Valve Position and Light Indication
Place the rain removal switch to ON.	Rain removal shutoff valve Rain removal bypass valve Low pressure solenoid WINDSHIELD TEMP HI Light	OPEN OPEN Energized* OFF
Place the rain removal switch to OFF.	Rain removal bypass valve Rain removal shutoff valve Low pressure solenoid WINDSHIELD TEMP HI light	CLOSED CLOSED Deenergized* OFF
Place the windshield temperature sensor simulating switch to simulated overheat. Hold in position.	WINDSHIELD TEMP HI light	ON
Release the sensor simulating switch.	WINDSHIELD TEMP HI light	OFF
Place the warning light test switch to TEST. Hold in position.	WINDSHIELD TEMP HI Light	ON
Release the warning light test switch.	WINDSHIELD TEMP HI light	OFF

*See Note 3

TROUBLESHOOTING

1. Perform an operational check for each trouble to determine the malfunctioning component or components.

2. Using a waxed pencil, trace the electrical circuits that operate or control the malfunctioning component.

3. Use the multimeter to locate the cause of the trouble.

Note 4: When measuring voltage, be sure the meter is set to the correct voltage range. Make sure you have the negative (black) lead to ground. This trainer does not have a common ground point, use any one of the valves for ground. Be sure the trainer power switches are OFF and the meter is set at OHMS when checking resistance.

4. Some of the troubles in this system are located inside of the component. For these troubles you should determine exactly which part of the internal circuit is causing the trouble. On the rain removal shutoff valve, rain removal bypass valve, and the low pressure solenoid there is a "J" section and a "P" section on the AN connector. The "P" section is for checking circuits coming to the component. The "J" section is used for checking the internal condition of the valve.

5. Use the trouble switches indicated on the troubleshooting answer sheet provided on the last page of this worksheet. The troubleshooting answer sheet has three columns. The first column contains the trouble switch numbers. The second column, marked discrepancy, is for you to record the malfunction. In this column state the name of the component and the condition, such as: "shutoff valve won't open." In the third column, marked cause, state if it is an open or short in the circuit and the location (wire number or between two certain pins), such as: "open between pins B and E of the shutoff valve."

6. We will go through trouble number 3 to show you how to arrive at the correct answer.

a. Place trouble switch number 3 to the IN position.

b. Perform an operational check. Use the operational check procedure chart, figure 2.

c. During the operational check you found the rain removal shutoff valve would not open and also the rain removal bypass valve would not open. Make the following statement in the discrepancy column for trouble switch number 3.

"Rain removal system inoperative, valves will not open."

d. When you performed the operational check you should have also noticed the low pressure solenoid on the bleed air pressure regulator and shutoff valve is energizing when the rain removal switch is ON. Knowing this is very helpful in our trouble analysis process.

e. Since there is power to the solenoid, this tells us that we do have 28-volts DC through the rain removal switch to the solenoid. Our problem must be in the circuit after the junction of wires M8A20 and M8C20. Trace the circuit from the junction to pin A of the rain removal shutoff valve (wire number M8C20), through the open side of the motor, to pin E, and through wire number M9A20N to ground.

f. Since the rain removal shutoff valve will not open, the trouble must be in the circuit traced. But why doesn't the rain removal bypass valve open? ... Remember the rain removal shutoff valve has to open all the way before the bypass valve will open.

g. Use the multimeter and check for 28-volts DC at pin A of the rain removal shutoff valve. You should read voltage at this point. Since we do have power to the valve, the trouble must be in the ground circuit or internally in the valve. Use the ohmmeter to verify this conclusion.

Caution: Do not remove the AN connector from any of the three valves on the trainer. You will use the connectors for each valve as they are required. They are located beside each valve on the trainer.

h. Turn the power switches OFF, and disconnect the AN connector from the rain removal shutoff valve. Check for continuity from pin E to ground. You should read continuity (zero resistance). Since this circuit is good, the trouble must be in the valve.

i. Check for continuity between pins A and E of the valve motor. Be sure to check the circuit going through the valve motor. This is done by using check point J103. If this circuit is good you should read continuity, but it will be something greater than zero because of the resistance of the motor windings. If the circuit is open the meter will read infinity. What indication did you receive? You should have an infinity reading. There is an open in this circuit. Make the following statement in the cause column of the answer sheet.

"Open between pins A and E of the rain removal valve."

j. You have completed trouble number 3. Replace the AN connector to the rain removal shutoff valve, and place trouble switch 3 to the OUT position. Place trouble switch number 1 to the IN position, perform an operational check and continue with the troubleshooting. Be sure to record your findings for each problem.

TROUBLESHOOTING ANSWER SHEET

TROUBLE SWITCH NUMBER	DISCREPANCY	CAUSE
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

Note: When using trouble switch #10, use 1KΩV on the AN/PSM-37 function switch.

WORKBOOK
C3ABR42331-WB-204

Technical Training

Aircraft Environmental Systems Mechanic

EQUIPMENT AIR CONDITIONING SYSTEM WIRING DIAGRAM

8 March 1984

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

RGL: N/A

Environmental Pneudraulics Branch
Chanute AFB, Illinois

C3ABR42331-WB-204

EQUIPMENT AIR CONDITIONING SYSTEM WIRING DIAGRAM

OBJECTIVE

Using a wiring diagram specify causes for equipment air conditioning system troubles with a minimum score of 80 out of 100 total points.

EQUIPMENT

Colored pencils

INSTRUCTIONS

Pay close attention to all directions. After completing this lesson, you will be required to identify causes for system troubles with 80% accuracy on the attached diagram. If you are ready, and the instructor has already briefed you, begin.

EQUIPMENT AIR CONDITIONING WIRING DIAGRAM

INTRODUCTION

During this lesson, you will review the purpose of the system components and you will study the electrical circuitry for the system operation, and troubleshooting various troubles. Be sure to read the instructions on this page before going any further.

You will be using diagram 1 in the back of your workbook. You will use this diagram throughout the lesson.

You will be required to troubleshoot this diagram at the completion of this lesson. Open your book to this diagram; also open the workbook to page 3.

After the purpose of the components are explained, you will be required to respond in this workbook. If your response is incorrect, you should review the material or ask the classroom instructor for assistance.

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Section 1. PURPOSE OF COMPONENTS

Let's start by locating the Pressure Regulator and Shutoff Valve in the right center of Diagram 1. This valve serves as a shutoff valve and a pressure regulator. When closed, it stops airflow, and when open, it regulates air pressure (at 106 psi) going through the equipment air conditioning system. The solenoid on this valve is energized automatically whenever electrical power and air pressure are applied to the aircraft. Any time the system goes into an overheat condition, this valve is automatically closed by the temperature limiter switch.

On the top center to the right of Diagram 1, locate the landing gear control switch, the ground cooling ejector shutoff valve, and the landing gear auxiliary relay. You should recall that the ground cooling ejector shutoff valve opens to allow bleed air to flow through the ground cooling ejector nozzles when the aircraft is on the ground.

Look at the landing gear control switch, this is mounted on the landing gear handle. When the landing gear handle is placed to the gear do position, the landing gear control switch completes a circuit to the landing auxiliary relay, pulling the contacts down and opening the ground cooling ejector valve. When the landing gear handle is placed to the gear up position, the landing gear control switch breaks the circuit, and deenergizes the landing gear auxiliary relay, moving the contacts up and the ground cooling ejector shutoff valve will close.

Complete statements 1 through 6. Purpose of components.

Using the Diagram at the back of the workbook and the information given, fill in the blanks to complete the following statements.

1. When electrical power is applied to the aircraft, the bleed air pressure regulator and shutoff valve solenoid is ______________________ (energized/deenergized).

2. The solenoid on the bleed air pressure regulator and shutoff valve requires ____________ volts DC for operation.

3. The ground cooling ejector shutoff valve will open when the landing gear handle is in the ____________ ____________ position.

4. The landing gear control switch is mounted on the ____________ ____________ ____________.

5. The ground cooling ejector shutoff valve requires ____________ volts DC to operate.

6. The landing gear auxiliary relay is energized when the landing gear handle is in the ____________ ____________ position.

On Diagram 1, locate the temperature control assembly, the turbine bypass valve, and the inlet air temperature sensor. These units function together to automatically control the conditioned air temperature. When the temperature of the negative coefficient sensor changes, it directs a signal to the temperature control assembly, the temperature control assembly then directs a 28 volt DC signal to the open or closed side of the turbine bypass valve.

Locate the altitude pressure switch. This unit senses a difference of atmospheric pressure between two altitudes, above 25,000 feet, and below 25,000 feet. Whenever the aircraft is below 25,000 feet, the temperature is increased to 85 degrees F to prevent moisture from accumulating on the equipment. Whenever the aircraft is above 25,000 feet the temperature is decreased to 40 degrees F because there is less moisture content in the atmosphere.

Complete statements 7 thru 15.

7. The temperature sensor has a ________________ (negative/positive) coefficient of resistance.

8. An increase in air temperature will cause the temperature sensor resistance to ________________.

9. The turbine bypass valve is operated by a ______________ volt DC motor.

10. The voltage requirements for operation of the temperature control assembly are ______________ and ________________.

11. The temperature control assembly contains ________________ amplifiers and transistors.

12. The resistanc ıal from the temperature sensor is sent to the ____________ ________________ ____________________.

13. When the aircraft goes above 25,000 feet, the equipment system temperature is ______________ by the ______________ ________________ switch.

14. The reason that a higher temperature is maintained in the equipment compartments below 25,000 feet is due to the ____________ in the air.

15. The altitude pressure switch senses ____________________ pressure.

On Diagram 1, locate the temperature limiter switch, the inlet air temperature limiter, and the radar CNI cooling off lights. The inlet air temperature limiter and the temperature limiter switch work together to shutoff the air conditioning system by deenergizing the pressure regulator and shutoff valve solenoid, and to warn the pilots in case of an overheat condition by turning on the CNI cooling off warning lights. Also locate the pilot's reset switches. These switches are used to reset the system after an overheat condition.

Look at the temperature limiter switch. The temperature limiter switch is a latch type relay with a latching coil and a reset coil. The inlet air temperature limiter is a normally open thermoswitch that closes at 150 degrees F. When the inlet air temperature limiter closes due to an overheat condition at 150 degrees F, it completes the circuit to energize the latch coil, thus pulling the contacts down. When the temperature drops below 150 degrees F, the latch coil relay will deenergize. The system must be reset manually by the reset switches. Pressing the reset switches will energize the reset coil; when the top or reset coil is energized, it sets up an opposing magnetic field which forces the contacts up. When the coils are deenergized, the contact levers are held in there position by an over-center spring. This means that when the contacts are pulled to one position they stay in that position until the opposing magnetic field forces it to the opposite position.

Note: The reset coil must be deenergized before the latch coil can force the contacts down. Also the latch must be deenergized before the reset coil can force the contact levers up.

Complete statements 16 thru 19.

16. When the latch coil is energized, the temperature limiter switch causes

    the pressure regulator and shutoff valve solenoid to ________________ (energize/deenergize).

17. The units that make up the overheat warning circuits are the temperature

    ____________, temperature ____________ ______________ and the

    ____________ ____________ ______________ ______________ warning lights.

18. After an overheat condition has occurred, it is necessary to press one

    of the __________________ switches in order to restart the air conditioning system.

19. The inlet air temperature limiter is a normally __________________ thermoswitch.

Statements 20 thru 29 in the workbook pertains to all of the components on the diagram. This is your chance to check your understanding of the system. Complete statements 20 thru 29.

20. When electrical power is applied to the aircraft, the solenoid on the pressure regulator and shutoff valve is ________________.

21. The ground cooling ejector shutoff valve is controlled by the ____________ ____ ________ ______________ ____________.

22. When the aircraft is below 2? 000 feet, the temperature is maintained at ____________ degrees F.

23. The conditioned air temperature is sensed by the ______________ ____________ ____________ ______________.

24. The two different temperature ranges are controlled by the ______________ ____________ ______________.

25. When the temperature ________________ the sensor resistance will decrease.

26. During flight, if the equipment system conditioned air temperature exceeds 150 degrees F, (overheats), the pressure regulator and shutoff valve will be ____________________.

27. The purpose of the RADAR CNI COOL OFF lights is to inform the pilot of an ____________ ______________.

28. An overheat condition is detected by the ______________ ____________ __________ ___ ____________________.

29. The latch coil of the inlet air temperature limiter is energized when the system ________________.

HAVE YOUR INSTRUCTOR CHECK YOUR ANSWERS.

1646

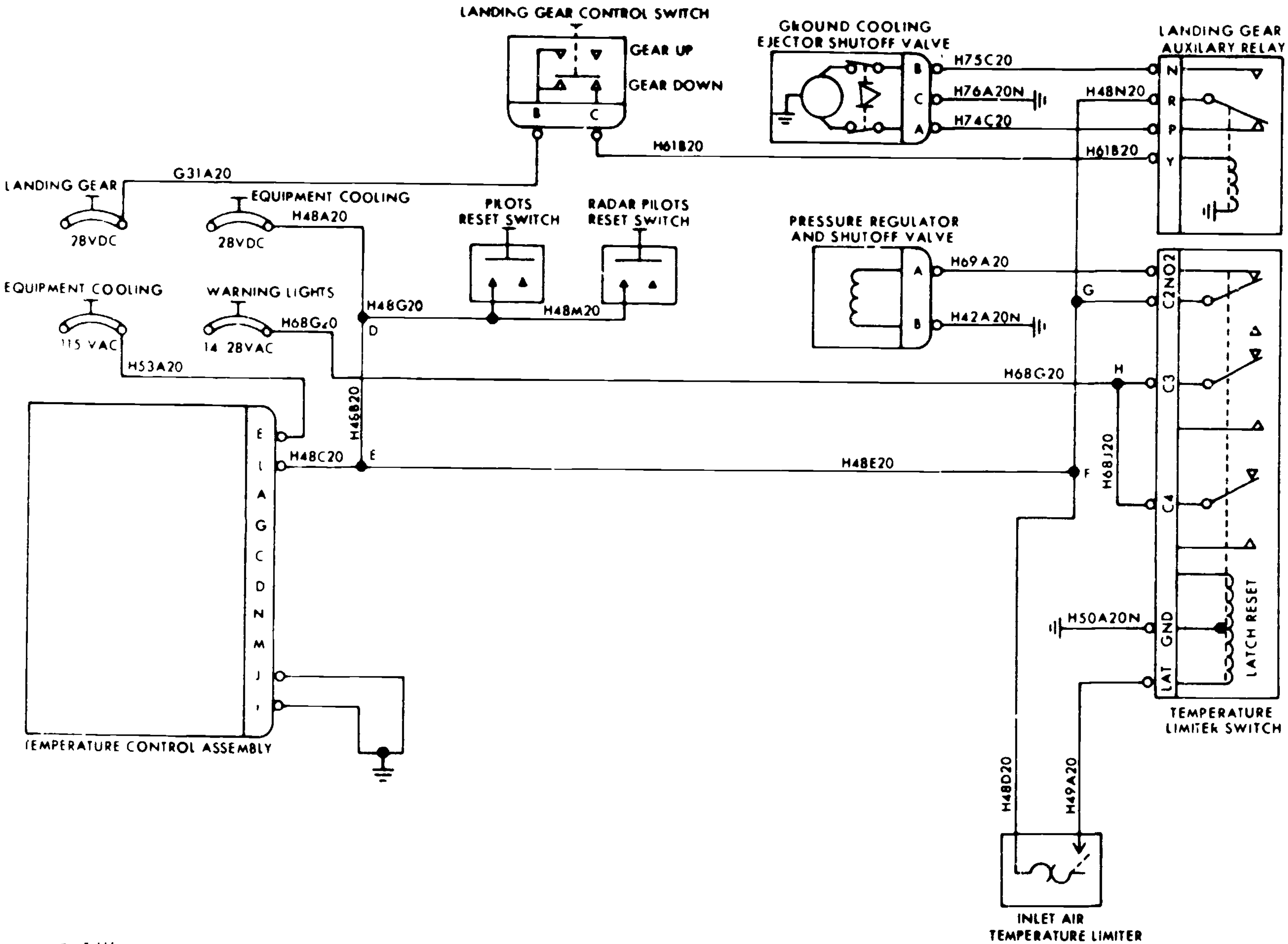

LANDING GEAR CONTROL SWITCH
GEAR UP
GEAR DOWN
GROUND COOLING EJECTOR SHUTOFF VALVE
LANDING GEAR AUXILARY RELAY
H75C20
H76A20N
H74C20
H48N20
H61B20
G31A20
LANDING GEAR
28VDC
EQUIPMENT COOLING
H48A20
28VDC
PILOTS RESET SWITCH
RADAR PILOTS RESET SWITCH
PRESSURE REGULATOR AND SHUTOFF VALVE
H69A20
H42A20N
EQUIPMENT COOLING
115 VAC
WARNING LIGHTS
14 28VAC
H68G20
H48G20
H48M20
H53A20
H46B20
H48C20
H48E20
H68J20
H50A20N
LATCH RESET
TEMPERATURE LIMITER SWITCH
TEMPERATURE CONTROL ASSEMBLY
H48D20
H49A20
INLET AIR TEMPERATURE LIMITER

Figure 1.

Section 2. SYSTEM OPERATION

At this point, you will start tracing the electrical circuits used for operation of the equipment air conditioning system. You will start by tracing the power circuits, the landing gear circuits, then continue to the overheat circuit, reset circuit, and then to the temperature control circuit. You will trace each of these circuits on a small diagram such as shown in figure 1. Then you will be required to complete several statements pertaining to that circuit. After completion of the lesson, you should have all circuits traced on Diagram 1.

When tracing circuits to the components, we will trace from the circuit breaker to the components ground. This is not necessarily the way current flows, but it is the easiest way to follow the path of current flow. As you trace each circuit, be sure to consider the effect that an open or short would have on the system, as you will be required to accomplish the performance exercise at the end of the lesson.

The diagram in figure 1 contains the circuits that are energized when power is applied to the aircraft. Use your red pencil and trace from the 115V AC equipment cooling circuit breaker to pin E of the temperature control assembly. This provides AC power to the magnetic amplifier.

Locate the 28V DC Landing Gear circuit breaker. Trace from this circuit breaker to pin B of the landing gear control switch. If we have the aircraft on the ground, the contacts will be in the gear down position. Trace through the switch, out pin C to pin Y of the landing gear auxiliary relay, then trace through the relay to ground. This energizes the relay, pulling the contacts down. If the aircraft is in the gear up position, you will have power up to pin B of the landing gear control switch; but with the contact broken, there will be no current flow to pin Y of the landing gear auxiliary relay. This allows the contact lever to go up and the ground cooling ejector shutoff valve will close. Go back to the 28V DC equipment cooling circuit breaker. Trace from this circuit breaker to junction point D. Then trace the circuit to the right and put a voltage potential at the pilot's reset switches. Return to junction D and trace to junction E. Trace the circuit to the left, to pin L on the temperature control assembly. <u>This supplies DC power to the HOT and COLD transistors</u>.

Now trace to the right to point F. From this point, trace down to the contacts of the inlet air temperature limiter. Current cannot go through the temperature limiter because it is a normally open thermoswitch. Here we have only a voltage potential. Return to point F and trace up to point G then to contact C2 of the temperature limiter switch. Trace through the contact and out No 2 to pin A of the pressure regulator and shutoff valve. Trace through the solenoid to ground. This energizes the solenoid and the valve will open.

Go back to point G and trace up to pin R of the landing gear auxiliary relay. As you remember, when the gear is up the contact of the landing gear auxiliary relay is up, and this allows the current to flow to the closed side of the valve; when the gear is down this energizes the landing gear auxiliary relay, and pulls the contact down allowing the current to flow to the open side of the valve. This will allow bleed air to flow through the ejector nozzles for more efficient ground cooling. Since we have the landing gear relay energized and the contact levers down, trace from pin R to pin P and out to pin A of the ground cooling ejector valve and out to ground.

Locate the warning light circuit breaker. Trace from here to point H then to the temperature limiter switch to C3. Trace into the switch contacts and stop. Go back to point H and trace down to pin C4 and into the contacts. This puts a voltage potential to the contacts of the temperature limiter switch. When an overheat condition occurs, current will flow from these contacts to the overheat warning lights.

Circle the correct answers to statement 1 thru 4, then referring to Diagram 1, complete statements 5 thru 7. After completing the statements, trace the power circuits on Diagram 1, with the aircraft on the ground.

1. Ground cooling ejector shutoff valve (open/closed).

2. Landing gear auxiliary relay (energized/deenergized).

3. Pressure regulator and shutoff valve solenoid (energized/deenergized).

4. Temperature limiter switch (energized/deenergized).

Refer to Diagram 1, to complete statements 5 thru 7.

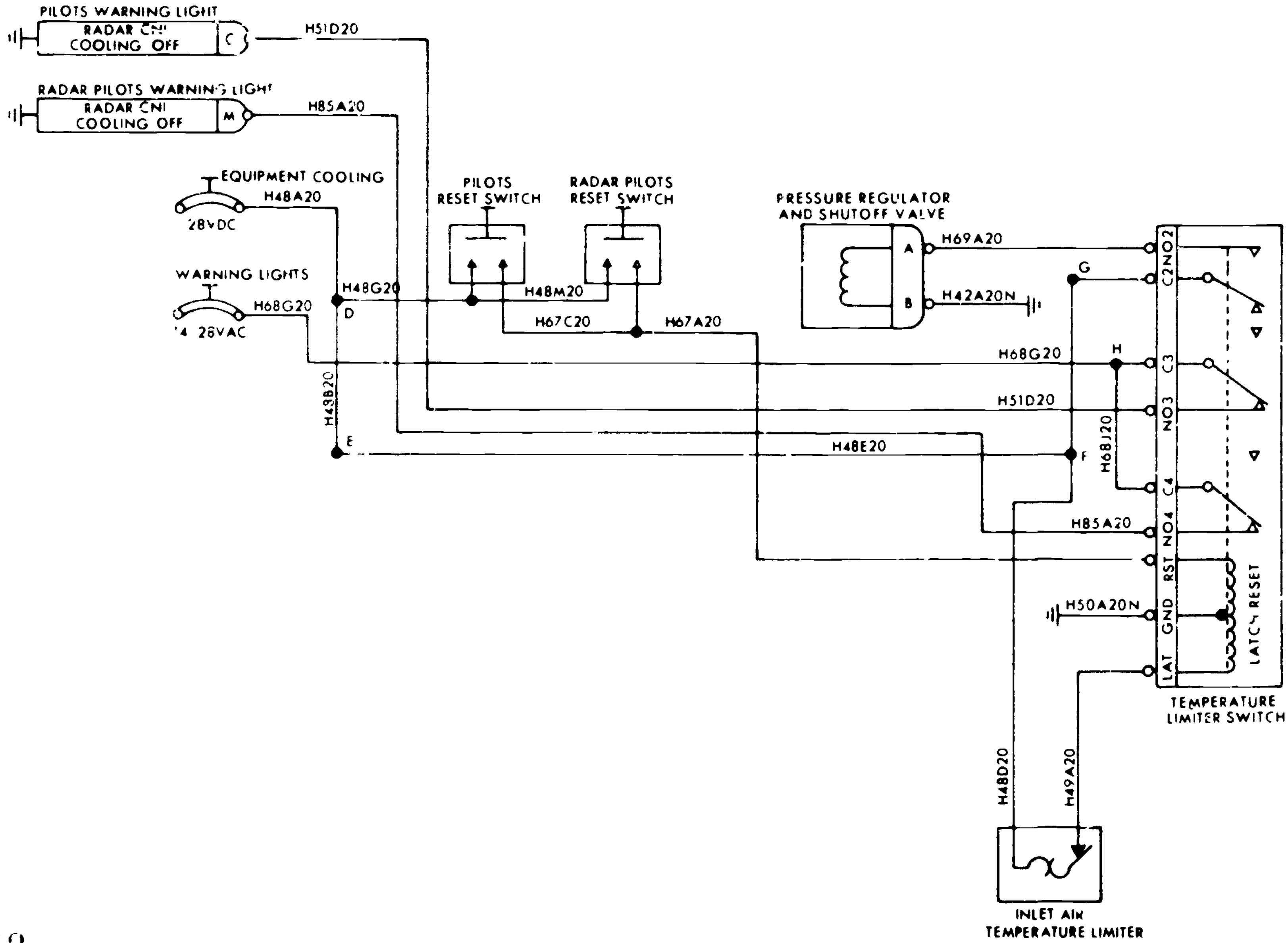
5. An open in wire H53 `0 will cause th ____________ __________ ____________ to be inoperative.

6. An open in wire number G31A20 will cause the _____________ ______________ _______________ _____________ _______________ to stay closed.

7. An open in wire number H48E20 will cause the __________________________ ___________ ________________ _______________ valve to be inoperative and also the ground cooling ejector shutoff valve to be _________.

On Diagram 1, use your red pencil and trace in all of the circuits that you just traced on figure 1.

1651



11

1652

Figure 2.

1653

Refer to figure 2 on page 11. This diagram shows the overheat circuit. Remember, if the temperature of the air going to the equipment compartments exceed 150 degrees F, the overheat circuit will turn off the air conditioning system and turn on the warning lights.

When tracing the power circuits on figure 1, you traced power up to the inlet air temperature limiter. In an overheat condition, the contacts of the inlet air temperature limiter will close. The contacts are drawn closed on figure 2. With the contacts closed, current can flow up to the latch coil, of the temperature limiter switch.

Using a purple pencil, trace this circuit. Current flow through this circuit will energize the latch coil, bringing the contacts down. These contacts are drawn down. Notice that this opens the circuit to the pressure regulator and shutoff valve solenoid and also completes the circuits to the warning lights.

When tracing the power circuits on figure 2, you also traced power up to the contacts at pins C3, and C4 of the temperature limiter switch. Starting at pin C3, trace through the contact point and out pin NO3 to the pilot's warning light. Go back to the temperature limter switch at pin C4 and trace through the contact, out pin NO4, and up to the radar pilot's warning light. This turns on the warning lights to inform both pilot's of the overheat condition.

Complete statements 8 through 12.

8. The inlet air temperature limiter is a normally ____________ thermoswitch.

9. The inlet air temperature limiter (closes/opens) at ___________ degrees F.

10. When the inlet air temperature limiter closes, it energizes the

    ____________ coil of the temperature limiter switch.

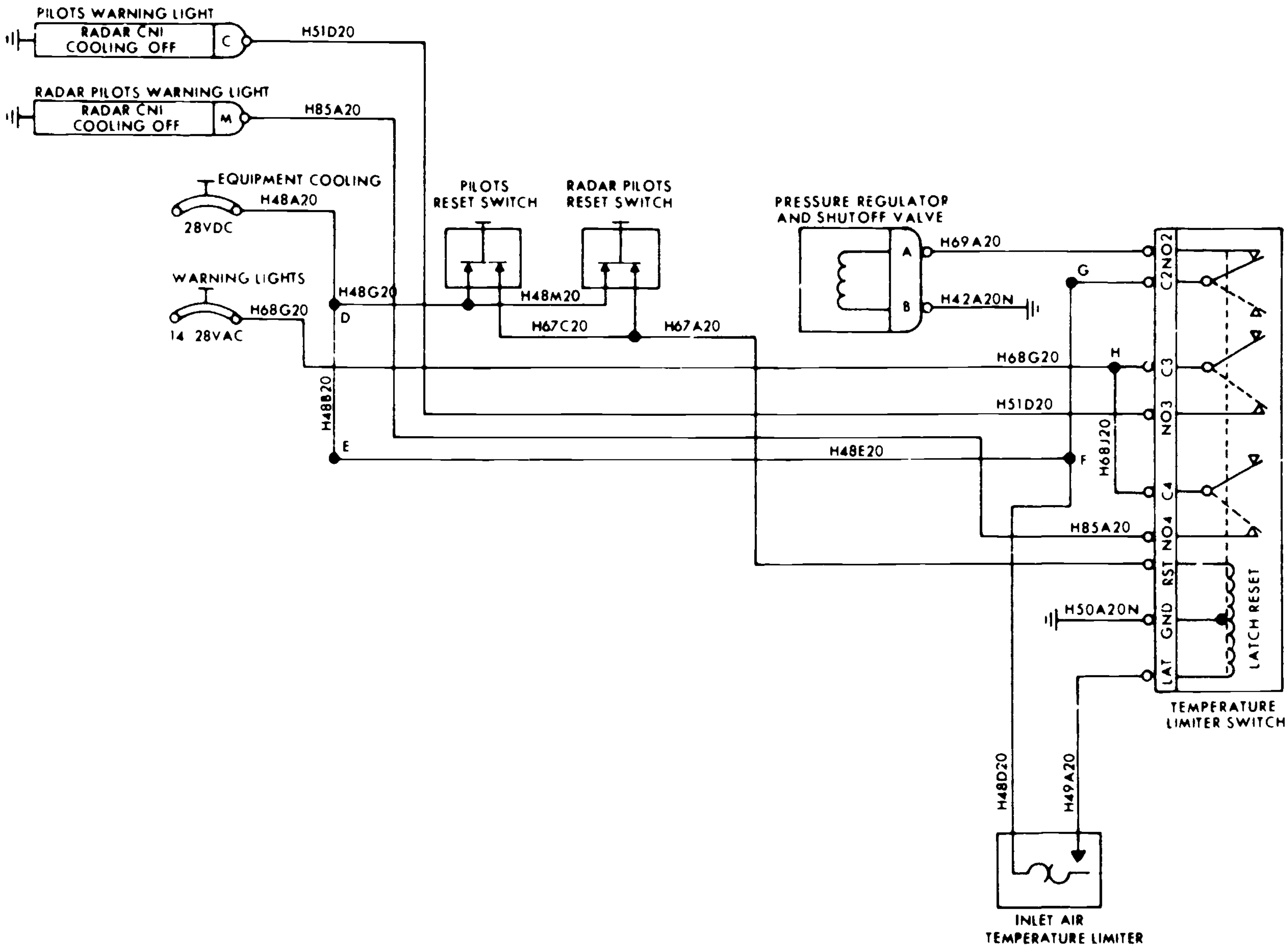
11. An open wire number H68G20 will cause the ________ __________ to be inoperative.

12. If the air conditioning system is inoperative and both warning lights

    remain on, the trouble is in the ____________ _______________

    ____________ __________ or an open in wire number __________

    or ______________.



13

1655

Figure 3.

When the latch coil is energized, it pulls the contacts down. The contacts will stay in this position until they are pushed back up by the reset coil. Notice in figure 1, that you have previously traced power to the pilot's reset switches.

On figure 3, you will notice that when the reset switches are pressed, the inlet air temperature limiter is deenergized (the system has cooled below 150 degrees F) but the contacts are still down.

Let's see how we reset the system. The reset switches are drawn down on figure 3. Using a purple pencil, trace voltage through either of the reset switches (wire numbers H67C20 or H67A20) to the pin marked RST on the temperature limiter switch and through the reset coil to ground.

Current flow through this circuit will energize the reset coil, throwing the contacts up. This turns off the warning lights and completes the circuit to energize the pressure regulator and shutoff valve solenoid. This opens the pressure regulator and shutoff valve and also closes the ram air valve.

Complete statements 13 and 14.

Refer to figure 3 to complete statements 13 and 14.

13. After an overheat condition, a __________ ____________ must be pressed in order to restart the equipment air conditioning system.

14. When either reset switch is pressed, it energizes the __________ coil of the temperature limiter switch.

On Diagram 1, use your purple pencil and trace all of the circuits that you have just traced on figure 3.

HAVE YOUR INSTRUCTOR CHECK YOUR ANSWERS.

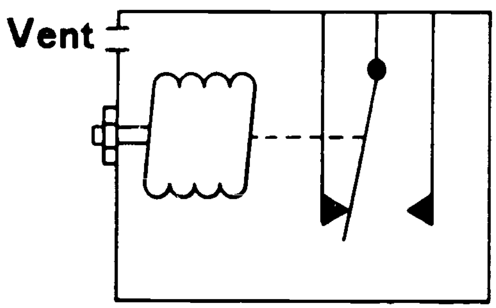
1657

86	↑	↓	↓	Cold Air Called For Until 85° Is Reached
85	Balanced Bridge			System Temperature Achieved
84	↓	↑	↑	Hot Air Called For Until 85° Is Reached
Equip. Compt. Temp.		Sensor Resistance	System Temp.	Air From System

A Below 25,000 Feet

41	↑	↓	↓	Cold Air Called For Until 40° Is Reached
40	Balanced Bridge			System Temperature Achieved
39	↓	↑	↑	Hot Air Called For Until 40° Is Reached
Equip. Compt. Temp.		Sensor Resistance	System Temp.	Air From System

B Above 25,000 Feet



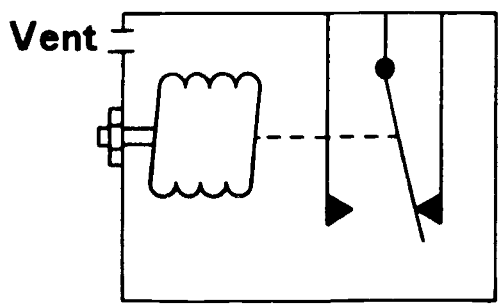


Figure 4. Coefficient Chart.

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Section 3. BRIDGE CIRCUIT OPERATION

Let's go over our coefficient chart, figure 4, and see what happens above and below 25,000 feet.

Below 25,000 feet, our system is to maintain 85 degrees F, air to the equipment bays and radar package (see figure 4, section A). At 85 degrees F, we have a balanced bridge so the system is at its proper temperature and no air is called for from the system.

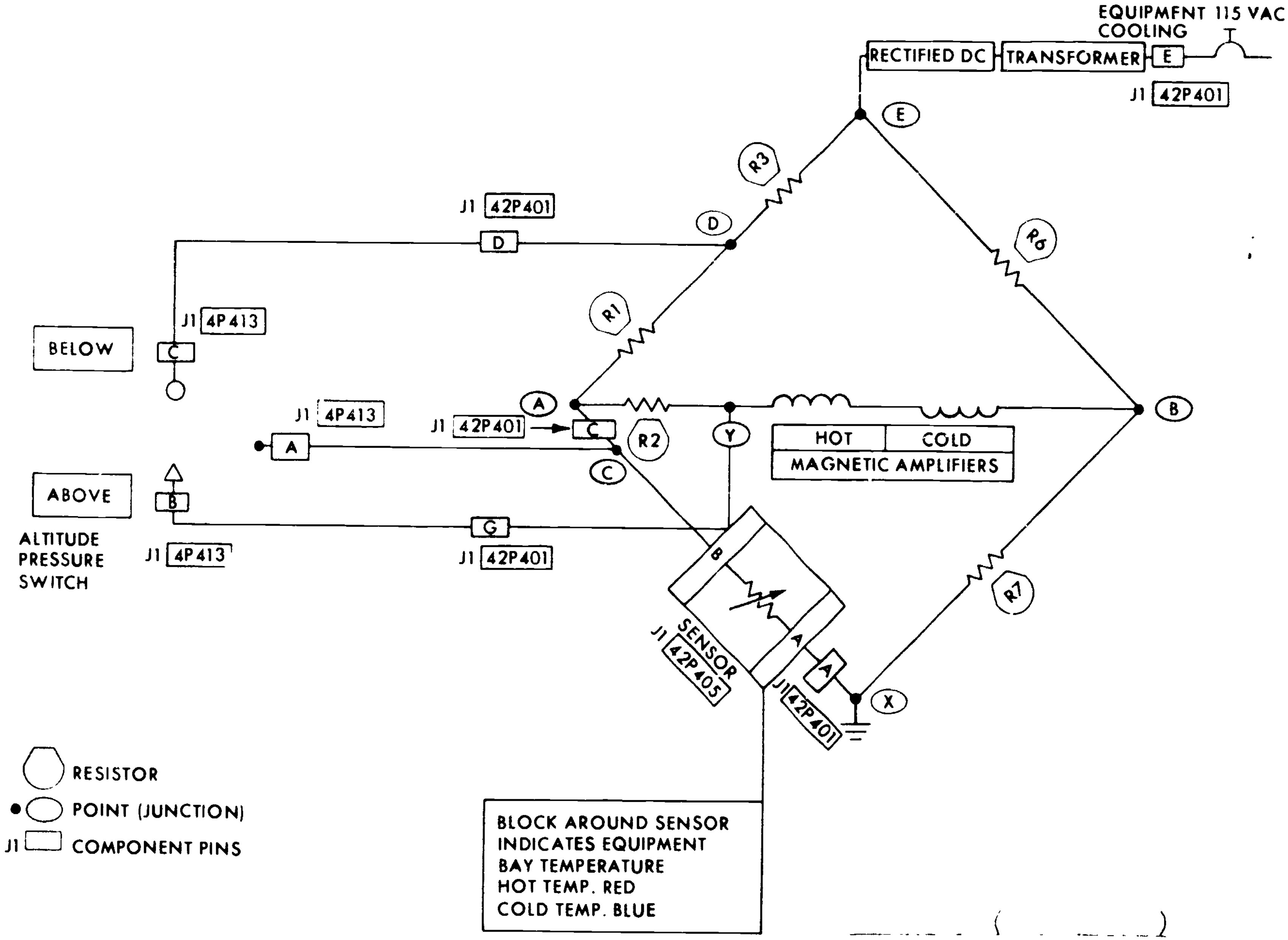
What happens if the temperature increases in the equipment compartments? If the temperature increases, we can see that the resistance decreases, unbalancing the bridge circuit and calling for cold air until 85 degrees F is reached and the system will balance. If there were a decrease in equipment temperature, the sensor resistance would unbalance, but in the opposite way that it did when the temperature increased. The air conditioning system would send air to the equipment bays until 85 degrees F was achieved and once again the bridge would balance.

The equipment air conditioning system works the same above 25,000 feet, but instead of maintaining 85 degree air we would maintain 40 degree air (see figure 4, section B).

1660

Let's look at how the Technical Manual explains the Temperature Control Assembly.

The Temperature Control Assembly is a magnetic type amplifier. Changes in resistance due to changes in temperature of the temperature sensor unbalance a resistance bridge electrical circuit. This unbalance in the resistance bridge results in changes in the bridge voltage and this difference is amplified by the magnetic amplifier. The amplified signal causes a solid state relay (transistor) to "Turn ON" for a duration dependent upon the error signal and applies electrical power to the turbine bypass valve.



13

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Figure 5.

During this section, while tracing all diagrams, refer to the coefficien diagram, figure 4, section A for below 25,000 feet and section B for above 25,000 feet.

We will start with figure 5. Turn to this diagram in your workbook.

On the blank line, write in balanced bridge and in the parentheses write in Above and Below.

The block around the sensor indicates the equipment bay temperature. With your colored pencils color half of the block red and half the block blue to indicate a proper mixture of temperature. As you know, with the proper temperature around the sensor, we have a balanced bridge circuit.

Let's follow current flow in a balanced bridge circuit and see what happens. Draw the Altitude Pressure Switch to the below 25,000 feet position.

Using an orange pencil, start at the ground, junction point X. Current will flow equally in two directions, we will go up to the left first. Trace from ground to pin A, 42P401 to pin A of the sensor, through the sensor and out pin B, continue to junction point C to the left to pin A, 4P413 of the Altitude Pressure Switch through the Pressure Switch and out pin C to pin D, 42P401 then to junction point D, up through Resistor R3 to point E to the rectifier circuit.

Return to point X, trace up to and through Resistor R7 to point B, then through Resistor R6 to point E, then to the rectifier circuit

With the circuit drawn as shown, we have equal voltage at the junction points A & B of the bridge, this means there will be no current flowing through the magnetic amplifiers and they will not conduct.

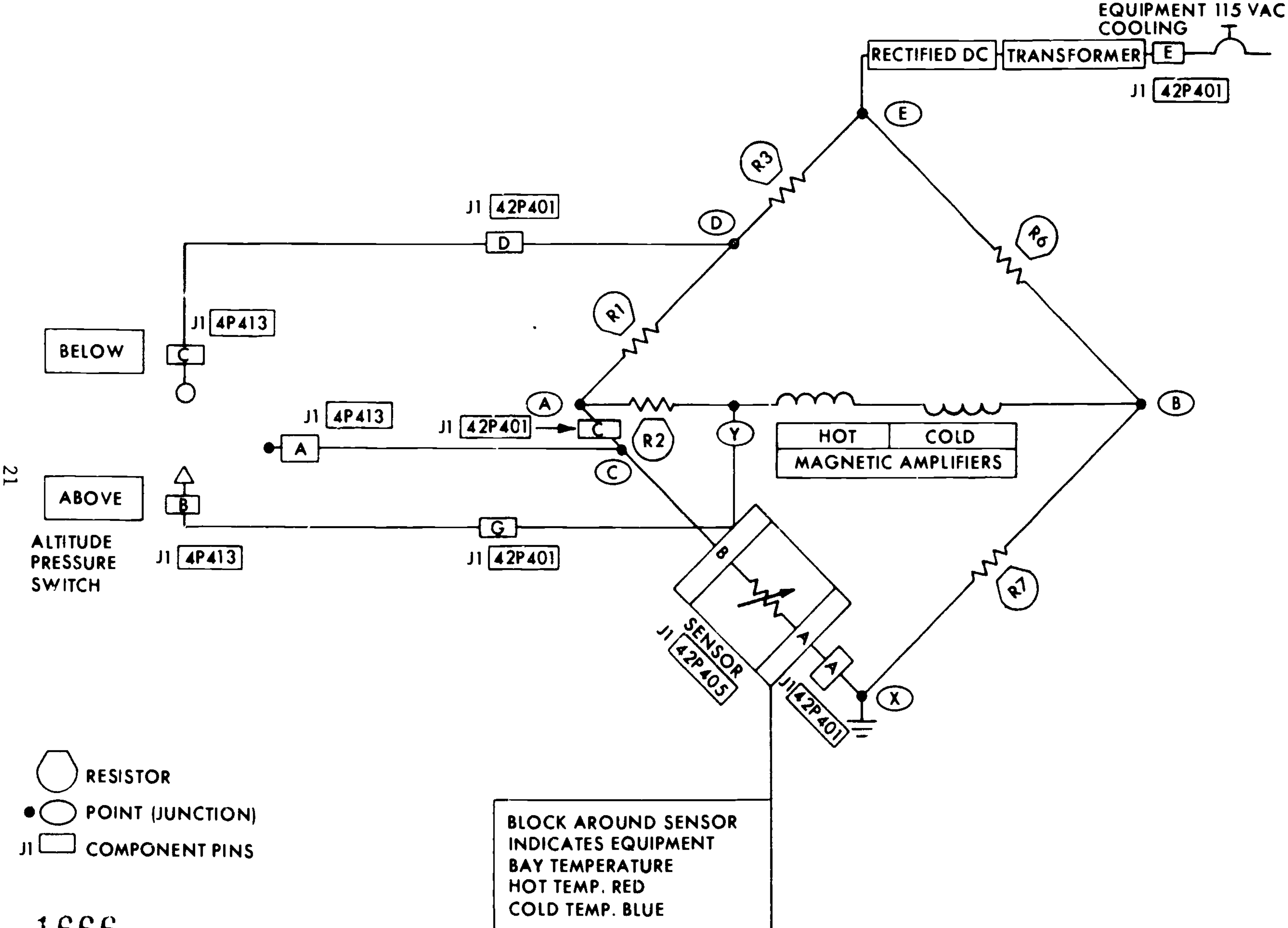
Through this action, the system will maintain 85 degree temperature.

Using the same figure 5, and the coefficient diagram, figure 4, we will trace current flow through this circuit above 25,000 feet. Draw the Altitude Pressure Switch to above 25,000 feet. Using a yellow pencil, start at point X and up to pin A, 42P401 and up to pin A, through the sensor and out pin B. Trace up to junction point C to pin C 42P401 to junction point A of the bridge. Now trace upward through resistor R1 to junction point D then through resistor R3 to point E to power.

Return to ground and trace up through resistor R7 to point B and then up through resistor R6 to point E to power.

Again with equal voltage at junctions A & B of the bridge, we will have no current flow through the Magnetic Amplifiers and again neither amplifiers will conduct.

With the Altitude Pressure Switch in the Above position we will maintain 40 degrees temperature.



21

1666

Figure 6.

1667

We will now look at what happens when the temperature in the equipment compartments increases below 25,000 feet.

Using figure 6, on the blank line write in "COLD SIGNAL" and in the parentheses write in "BELOW" in the block around the sensor, indicating the temperature in the equipment compartment, using your red pencil color in the block.

Again using your coefficient chart Section A, we see that the temperature has increased and the resistance in the sensor has decreased. Since current takes the path of least resistance, it will flow through the sensor. Let's trace this circuit.

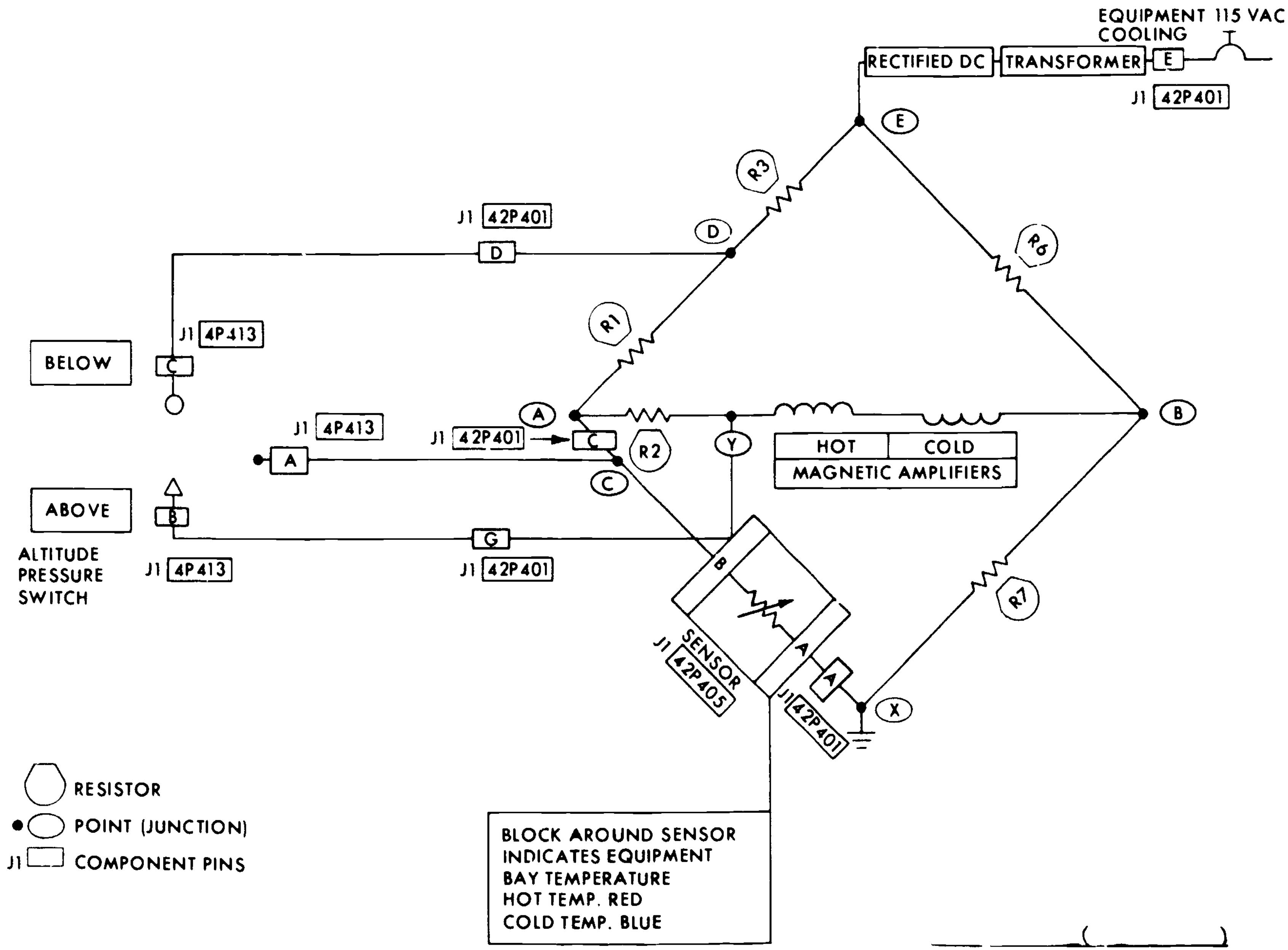
One thing to remember when tracing the remaining circuits, as current flows through the Magnetic Amplifiers, the first one traced is not energized (it turns off) and the second one you trace through is energized (turned on).

Using your blue pencil, start at ground point X and trace to pin A, 42P401 to pin A of the sensor, trace through the sensor and out pin B to point C to pin C 42P401 to point A of the bridge. Now trace to the right through resistor R2 through point Y to the Hot Magnetic Amplifier. Again remember this is the first Magnetic Amplifier we will trace through so it will "Turn OFF;" trace from this to the cold Magnetic Amplifier. The Cold Magnetic Amplifier is the second Magnetic Amplifier we will trace through so it will "Turn ON."

This will allow the system to decrease in temperature until 85 degrees is reached.

Trace to point B of the bridge and up through Resistor R6 to point E to power.

1668



23

1669

Figure 7.

We have traced a balanced bridge and a cold signal below 25,000 feet. Let's look at how current flows for a hot signal below 25,000 feet.

Look at your coefficient chart, and using figure 7 on the blank line write in HOT SIGNAL and in the parentheses, write in BELOW. We now have a low temperature in the equipment bay, so color the block around the sensor Blue to indicate this temperature.

Let's trace this circuit.

Using a green pencil, start at point X. Again, because of the high sensor resistance, current will flow up to the right through resistor R7 to point B, from here it will flow to the left, first through the Cold Magnetic Amplifier (turning it OFF) then through the Hot Magnetic Amplifier (Turning it ON) to point Y, from point Y through resistor R2 to point A, down to pin C of 42P401 to point C to the left to pin A of the Altitude Pressure Switch. Since we are below 25,000 feet, draw the contact to the below position to pin C of 4P413. Continue to trace through to pin D of 42P401 and continue on to point D, then up through resistor R3 to point E to power.

Since we turned the Hot Magnetic Amplifier ON, we will get hot air from the system until we reach 85 degrees F, once again balancing the bridge.

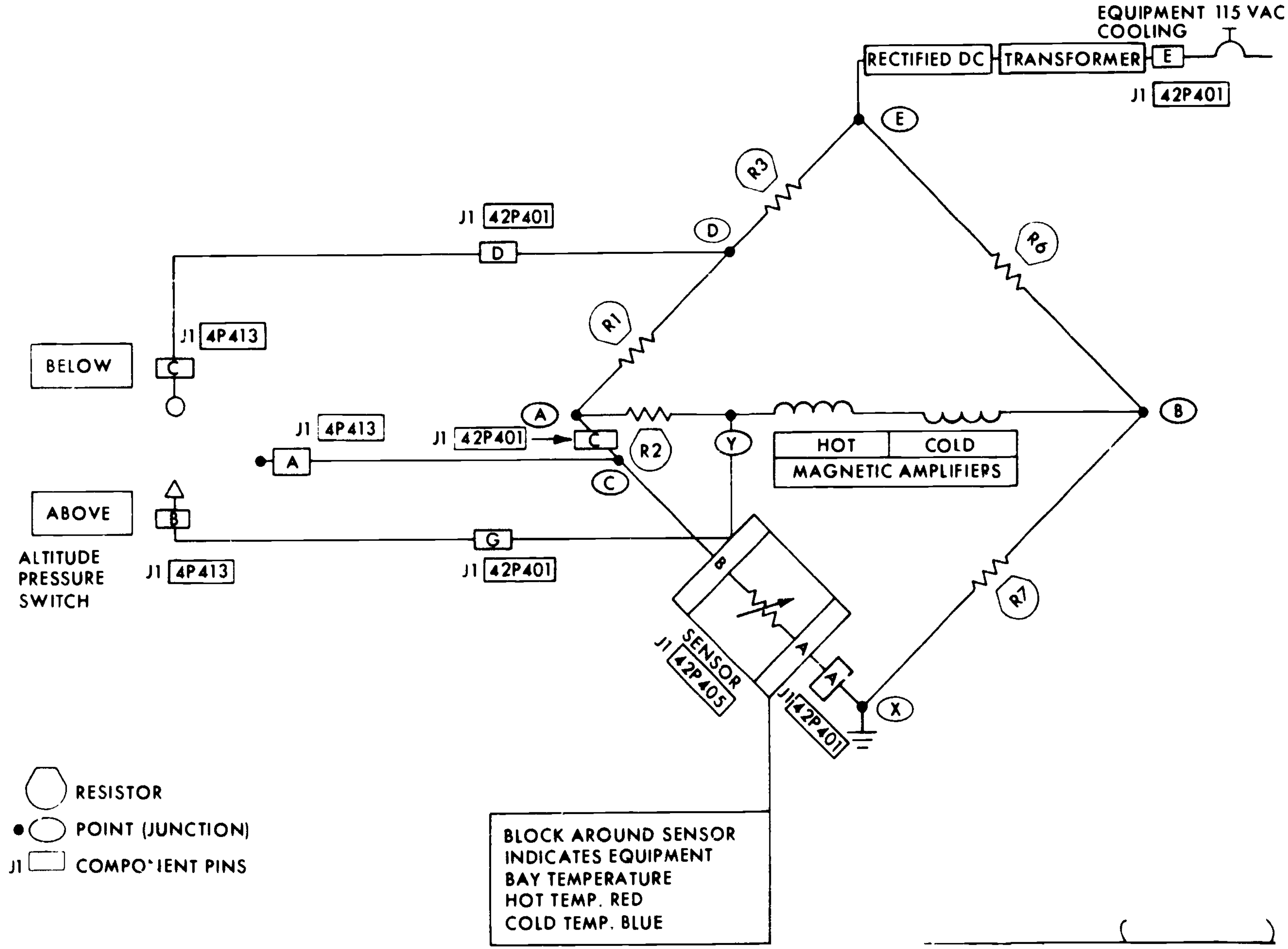
1671

We have seen how current flows when the bridge is balanced in the above or below position. We have also traced current flow for our Hot and Cold signals in the below 25,000 feet position and saw how we maintain 85 degrees F air.

We also know that while tracing current flow in the automatic equipment temperature control bridge that the first magnetic amplifier we trace through will "Turn OFF" and the second one we trace through will "Turn ON." Another item to remember is if the resistance in the sensor decreases, current will flow through the sensor, and if the resistance in the sensor increases, current will not flow through the sensor.

We are now going to look at what happens when the aircraft ascends above 25,000 feet. From our previous text we know that we maintain a 40 degree F temperature because of the moisture factor.

Let's see how our system responds above 25,000 feet.



1673

Figure 8.

1674

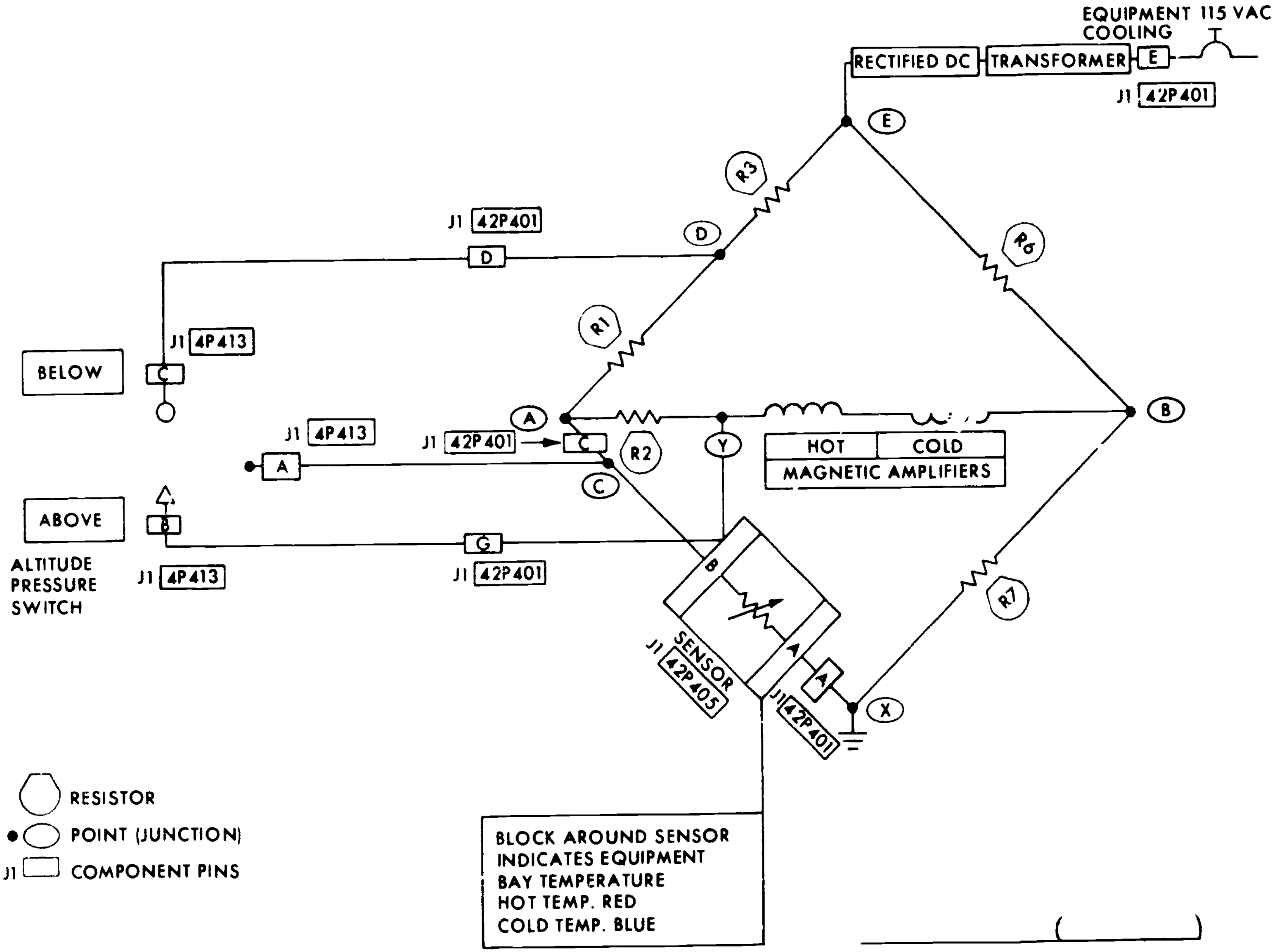
Using figure 8 and section B of your coefficient chart, figure 4, let's trace current flow for a Cold signal, above 25,000 feet.

First, on the blank line, write in "Cold Signal" and in the parentheses write in "Above."

Using your red pencil, color the box around the sensor to indicate an increase in equipment bay temperature which gives us a low sensor resistance.

Now using your blue colored pencil, start at point X (ground), trace to pin A of 42P401 to pin A of the sensor, trace through the sensor and out to pin B, to point C. Trace to the left to pin A of 4P413 of the Altitude Pressure Switch. Draw the contact to the Above position. Continue tracing through the Altitude Pressure Switch, out pin B to pin G of 42P401 and on to point Y. Now to the right to the Hot Magnetic Amplifier (Turning it OFF) then to the Cold Magnetic Amplifier (Turning it ON). Trace on to point B, up to and through resistor R6 to point E to power.

When the Cold Magnetic Amplifier conducts, it allows the turbine bypass valve to run cold until we reach a temperature of 40 degrees F and balancing the bridge.



28

1676

Figure 9.

1677

This will be the last of our Basic Bridge circuits.

Using figure 9 and section B of your coefficient chart, figure 4, let's trace current flow for a Hot Signal, Above 25,000 feet.

First, on the blank line write in "Hot Signal" and in the parentheses write in "Above."

Using your blue pencil, color in the block around the sensor to indicate a decrease in equipment bay temperature, which gives us a high sensor resistance. (Now remember, with a high resistance, current <u>will not flow</u> through the sensor.)

Now, using your green pencil, start at point X, trace up through resistor R7 to point B, then to the left through the Cold Magnetic Amplifier (Turning if OFF) then through the Hot Magnetic Amplifier (Turning it ON) then to point Y. Now trace down and to the left to pin G of 42P401 to pin B of the Altitude Pressure Switch and up to pin A. Now trace to point C, and up to pin C of 42P401 to point A. Continue through resistors R1 and R3 to point E up to power.

When the Hot Magnetic Amplifier conducts, this allows the Turbine Bypass Valve to run Hot until we reach a 40 degree temperature, and once again balancing the bridge.

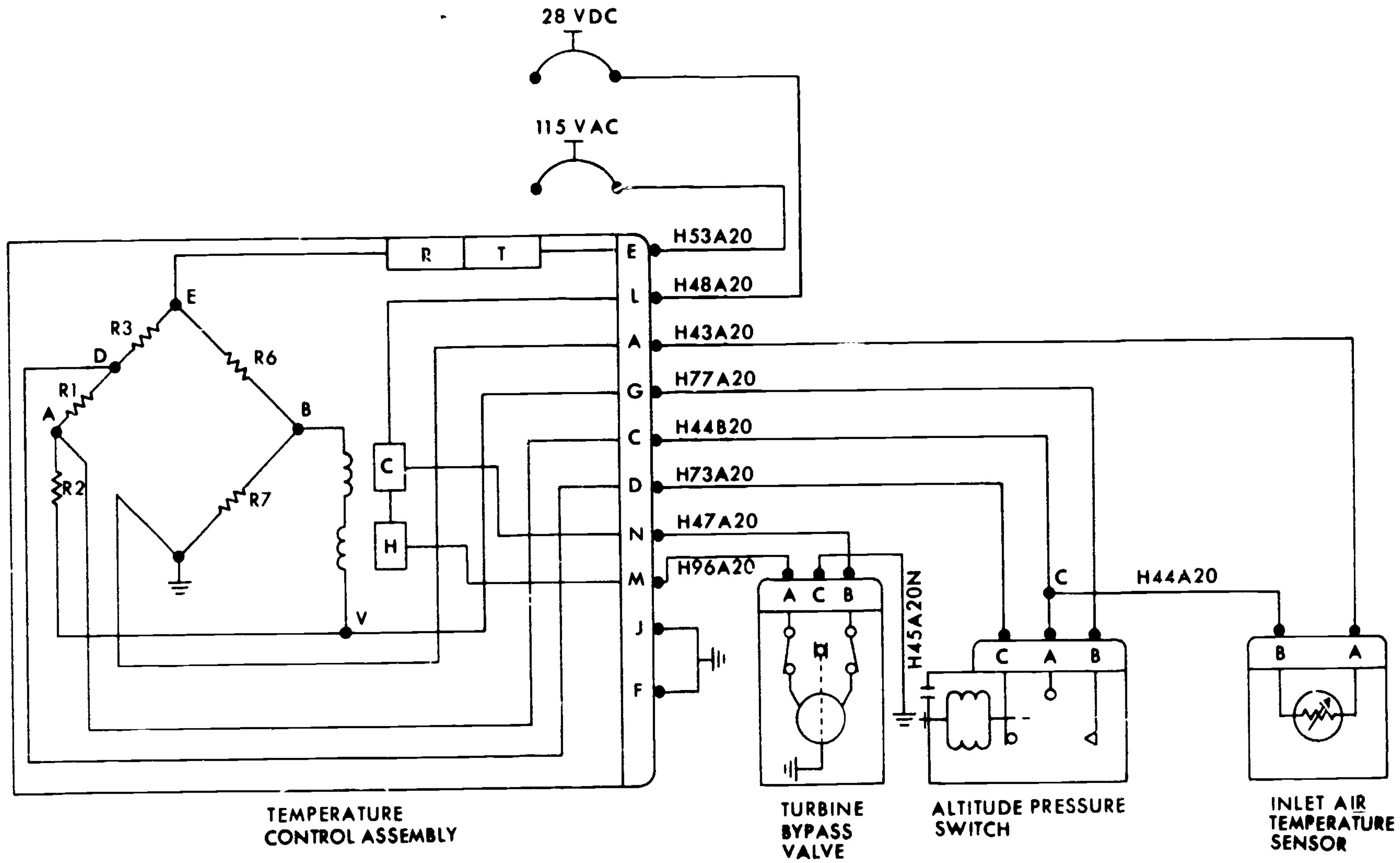

28 VDC
115 VAC
H53A20
H48A20
H43A20
H77A20
H44B20
H73A20
H47A20
H96A20
H45A20N
H44A20
R
T
E
L
A
G
C
D
N
M
J
F
R1
R2
R3
R6
R7
V
H
TEMPERATURE CONTROL ASSEMBLY
TURBINE BYPASS VALVE
ALTITUDE PRESSURE SWITCH
INLET AIR TEMPERATURE SENSOR

Figure 10.

We have seen how our basic bridge circuit works in the Above and Below 25,000 feet position with both our Hot and Cold signals.

Turn now to figure 10 on page 30.

As you can see on this diagram, we have basically the same diagram that we have already traced, with the addition of the Hot and Cold transistors, next to the respective Magnetic Amplifier, we have also included the turbine bypass valve.

You can also see that when using any one of the basic bridge diagrams, current flow will energize either the Hot or Cold Magnetic Amplifiers. When the Magnetic Amplifier is "Turn ON" it will in turn "Turn ON" the respective transistor. For example, look back to figure 8, (you can do this with any of the basic bridge diagrams). You remember, that as temperature goes up, resistance goes down. Current will now flow through the sensor and through the magnetic amplifiers, energizing the Cold

With this magnetic amplifier energized, this allows the Cold transistor to conduct. Remember that both the Hot and Cold transistors have 28V DC waiting to be used. Now with the Cold transistor conducting, this allows that 28V DC to flow to the Cold side of the turbine bypass valve. The valve will run to the Cold position until the proper temperature is achieved.

We have traced the landing gear, reset, overheat, and the automatic temperature control circuits.

We have already traced normal system operation. We, as Aircraft Environmental System Mechanics not only must know how a system works but also how to detect malfunctions and their causes.

In this section, we will analyze the malfunctioning system and isolate the problem for repair. We will take one problem per system (landing gear, reset, etc) and after we go through the troubles, you will be required to do the performance exercises at the end of each frame.

After completion of the Performance Exercises, you will be required to do the performance test at the back of the workbook.

PERFORMANCE EXERCISE

Listed on pages 33 through 40 are 14 questions pertaining to the wiring diagram you have just completed. Follow the directions for each part.

If we put the landing gear handle in the gear down position, and the ground cooling ejector shutoff valve remained in the closed position, what would be the probable cause?

We know that when the landing gear handle is in the gear down position, it allows power to the landing gear auxiliary relay which pulls the contact lever down and the ground cooling ejector shutoff valve opens for ground cooling.

If wire #G31A20 were open, see Diagram 1, we can see that we would not have any voltage potential at the landing gear auxiliary relay. With no power at the relay, the contact lever would remain up. This would allow the valve to stay in the closed position.

Complete statements 1 and 2.

1. An open in wire #H61B20 would cause the ground cooling ejector shutoff valve to (open/close).

2. If the landing gear control switch were shorted, the ground cooling ejector shutoff valve would be (open/closed).

We know that when the equipment air conditioning system overheats, the temperature limiter makes contact and energizes the latch relay. This in turn pulls the three contact levers down in the temperature limiter switch.

You can see that a malfunction in the overheat circuit would have serious consequences.

If we had an open in wire number H48D20, see diagram 1, we can see that we would not get power through the temperature limiter even in an overheat condition. With an open in this wire, the system would overheat, the limiter would latch, but the latch coil in the temperature limiter switch would not energize and the contacts would stay in the up position. With this, the pressure regulator and shutoff valve would not deenergize, the warning lights would not come on and the system would continue to overheat. We could damage the equipment (radar, air data computers, etc) due to high temperature.

Complete statements 3 and 4.

3. If the equipment air conditioning system shows an overheat condition when power is applied to the aircraft, the probable cause could be an

(open/shorted) ________________ inlet air temperature limiter.

4. The equipment air conditioning system overheats, but the latch relay does not engergize. Which three wires could cause this indication?

(Wires __________ ______________ or ______________)

1684

We now know that when the equipment air conditioning system overheats, the system shuts down and the warning lights come on. After an overheat condition, the pilot or radar pilot must be able to reset the system to continue his mission, but he cannot continue his mission if the equipment system will not reset.

Let's look at an open wire in the reset system and what affect it would have on the system.

We know that after an overheat, the pilot or radar pilot must press a reset button. This allows power to flow from the equipment cooling 28V DC circuit breaker, through the reset switches (either one) to the reset relay to ground.

If we had an open in wire number H67A20, we can see that this would not allow power to the reset relay and would not allow the system to reset.

If the pilot or the radar pilot cannot reset the system, there will be no air going to the equipment air conditioning system because there would be no power to the pressure regulator and shutoff valve and it would be deenergized closed.

Complete statements 5 and 6.

5. If we had an open in wire number H48B20, which reset switch(s) would be inoperative? (Pilot's/Radar Pilot's/Both)

6. If we had an open in wire number H67C20, which reset switch(s) would be inoperative? (Pilot's/Radar Pilot's/Both)

We have looked at how we can detect malfunctions in the ground cooling, overheat and reset circuits, but what about the temperature control circuits?

The temperature control on the equipment air conditioning system is, as we know fully automatic. We also know that to make this system work correctly, we must have a proper resistance/temperature ratio.

You have to understand that in our bridge circuit we have a balance or an imbalance of resistance to maintain our required temperature. For example, a balanced bridge circuit would be one with a proper resistance/temperature ratio (85 degree F or 40 degree F above).

If the temperature increases around the sensor, (see figure 6) the resistance in that sensor would decrease; we now have a high temperature-low resistance or an imbalance in the bridge. With this imbalance, the cold magnetic amplifier will conduct and we will receive cold air from the turbine bypass valve until we achieve the proper temperature and resistance desired (85 below or 40 above). The equipment air conditioning system is constantly balancing or unbalancing to maintain our temperature.

Complete statements 7 and 8.

Circle correct answer.

7. With the aircraft below 25,000 feet and an equipment bay temperature of 85 degrees F, we will have a (balance/unbalance) in our bridge circuit.

8. With the aircraft below 25,000 feet, an equipment bay temperature of 86 degrees F and the turbine bypass valve running cold, we will have a (balance/unbalance), in our bridge circuit.

1686

In our equipment air conditioning system, we can see that it takes a constant balance or imbalance to keep our system functioning at its proper temperature.

What happens if we have a constant imbalance in the system?

Let's look at what will happen to our system when we have an open in one of our wires to or from the sensor or in the sensor itself, (see figure 11).

We know that if we have an open in a circuit we will have a constant high resistance, (it will read infinity on the multimeter). With this constant high resistance, current will flow as indicated by the heavy line (in figure 11). The bridge circuit will be at a constant imbalance. We can see from the diagram that if we have a high resistance in the sensor circuit it will cause the hot magnetic amplifier to conduct. We know that when the magnetic amplifier conducts it will allow voltage to flow through the corresponding transistor, which in turn allows the valve to run hot.

If we have a Full High resistance, it will conduct the hot magnetic amplifier All Of The Time and the valve will run Full Hot!

Complete statements 9 and 10.

Circle the correct answer.

9. An open in any circuit will read (high/low) resistance on a multimeter.

10. An open in a wire to the sensor will cause the turbine bypass valve to travel full (hot/cold).

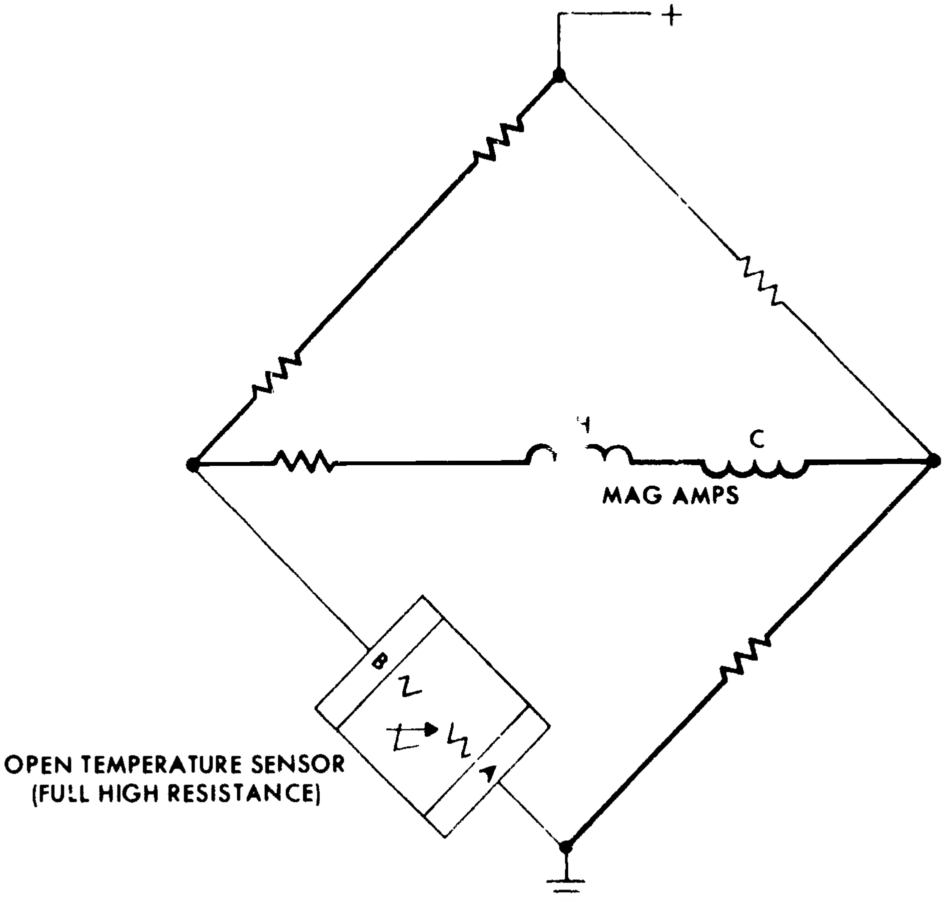


Figure 11.

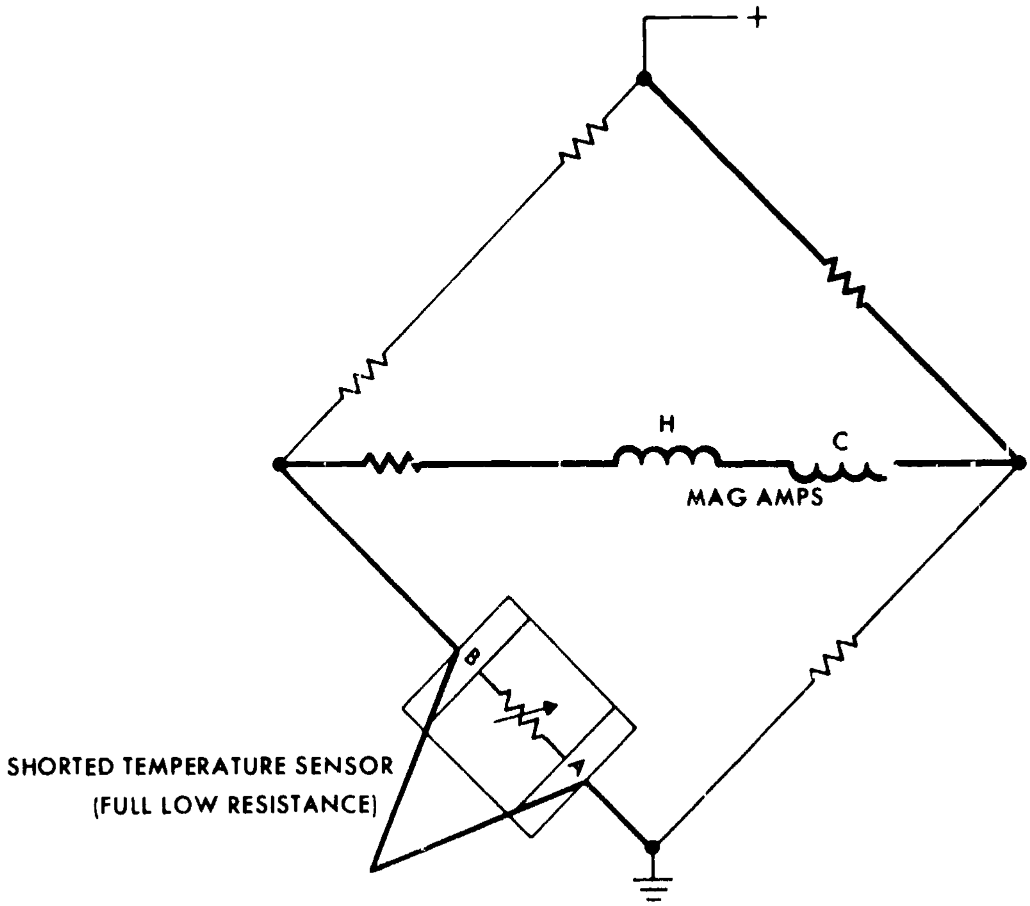


Figure 12.

We know that an open in our sensor circuit will cause a full hot, but what happens with a shorted sensor?

Remember that with a short, we will have a constant low resistance (it will read 0 on the multimeter). With this constant low resistance, current will flow as indicated by the heavy line (figure 12), the bridge circuit will be at a constant imbalance, but this time it will unbalance in the opposite direction. We can see from the diagram that if we have a low resistance in the sensor circuit it will cause the cold magnetic amplifier to conduct. We know that when the magnetic amplifiers conduct they allow current to flow through the corresponding transistor, which in turn allows the valve to run cold.

If we have a <u>Full Low</u> resistance it will conduct the cold magnetic amplifier <u>ALL OF THE TIME</u> and the turbine bypass valve will run <u>FULL COLD</u>.

Complete statements 11 and 12.

Circle the correct answer.

11. A short in any circuit will read a (low/high) resistance on a multimeter.

12. A short in the wires to the sensor will cause the turbine bypass valve to travel full (hot/cold).

We now know that with a Full High or Low resistance we will get a Full Hot or Full Cold signal (respectively) to the Turbine Bypass Valve.

What would happen if the Hot or Cold Magnetic Amplifier conducted but the valve did not open or close? This would be a NO HOT or NO COLD.

This could be caused by an open between the Hot or Cold Transistors and the Turbine Bypass Valve. See Diagram 1.

NOTE TO REMEMBER

Keep in mind, there is a distinct difference between a FULL hot and a NO cold or a FULL cold and a NO hot.

Remember, any time you have a Full Hot or a Full Cold you will have an open or a short (respectively) in the bridge circuit (Sensor, Controller, or the wires connecting the two).

Any time you have a NO Hot or a NO Cold, you will have an open in the valve or the wires to the valve.

Complete statements 13 through 14. Circle the correct answer.

13. An open in the sensor would give the system (Full/NO) (Hot/Cold).

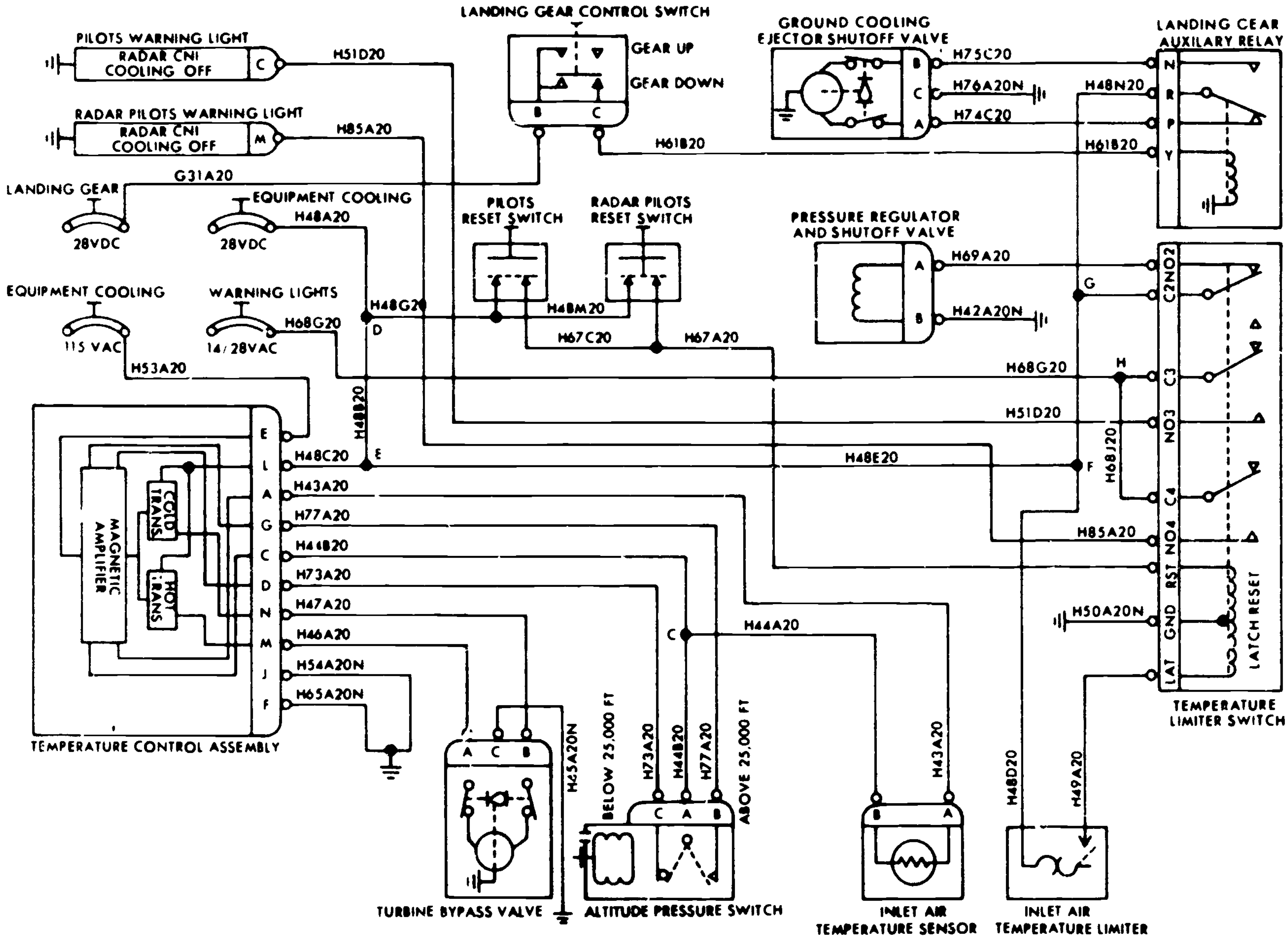
14. A shorted sensor would give the system a (Full/NO) (Hot/Cold).

HAVE YOUR INSTRUCTOR CHECK YOUR ANSWERS.

PERFORMANCE TEST

Note: Use Diagram 1 to complete the responses for the 10 discrepancies listed below. You must achieve 80 of the 100 points. Each answer is worth 4 points.

#	TROUBLE	CAUSE
1.	When the Landing Gear Handle in the GEAR DOWN position, the ground cooling ejector valve will not open, but will close.	Open wire numbers, ________, ________. ________.
2.	When the equipment air conditioning system temperature exceeds 150°F, the pressure regulator and shutoff valve closes, but the warning lights do not come on.	Open wire number ________.
3.	The turbine bypass valve is inoperative, the pressure regulator and shutoff valve operates normally.	Open wire numbers ________, ________. ________.
4.	After an overheat condition the system cannot be reset, by the pilot.	Open wire numbers ________.
5.	With the engines operating there is no airflow through the equipment air conditioning system. All other valves operate normally.	Open wire numbers ________, ________.
6.	The turbine bypass valve runs to the Full Hot position.	Sensor (Open/Shorted) (Open/Shorted) wires ________, ________ ________.
7.	The turbine bypass valve runs to the Full Cold position.	Sensor (Open/Shorted) (Open/Shorted) wires ________, ________ ________.
8.	The turbine bypass valve will not go Hot.	Open wire number ________.
9.	The equipment air conditioning temperature exceeds 150°F, but the pressure regulator and shutoff valve will not deenergize and the warning lights do not come on.	Open wire numbers ________, ________, ________ ________.
10.	The turbine bypass valve will not go Cold.	Open wire number ________.


LANDING GEAR CONTROL SWITCH
GEAR UP
GEAR DOWN
GROUND COOLING
EJECTOR SHUTOFF VALVE
LANDING GEAR
AUXILARY RELAY
PILOTS WARNING LIGHT
RADAR CNI
COOLING OFF
H51D20
RADAR PILOTS WARNING LIGHT
RADAR CNI
COOLING OFF
H85A20
H75C20
H76A20N
H74C20
H48N20
H61B20
G31A20
LANDING GEAR
EQUIPMENT COOLING
28VDC
28VDC
H48A20
PILOTS
RESET SWITCH
RADAR PILOTS
RESET SWITCH
PRESSURE REGULATOR
AND SHUTOFF VALVE
H69A20
H42A20N
EQUIPMENT COOLING
WARNING LIGHTS
115 VAC
14/28VAC
H68G20
H48G20
H48M20
H67C20
H67A20
H53A20
H48B20
H68G20
H51D20
H48C20
H48E20
H68J20
H43A20
H77A20
H44B20
H73A20
H47A20
H46A20
H54A20N
H65A20N
H85A20
H50A20N
H44A20
MAGNETIC
AMPLIFIER
COLD
TRANS
HOT
TRANS
TEMPERATURE CONTROL ASSEMBLY
H45A20N
BELOW 25,000 FT
H73A20
H44B20
H77A20
ABOVE 25,000 FT
H43A20
H48D20
H49A20
LATCH RESET
TEMPERATURE
LIMITER SWITCH
TURBINE BYPASS VALVE
ALTITUDE PRESSURE SWITCH
INLET AIR
TEMPERATURE SENSOR
INLET AIR
TEMPERATURE LIMITER

Diagr m 1.

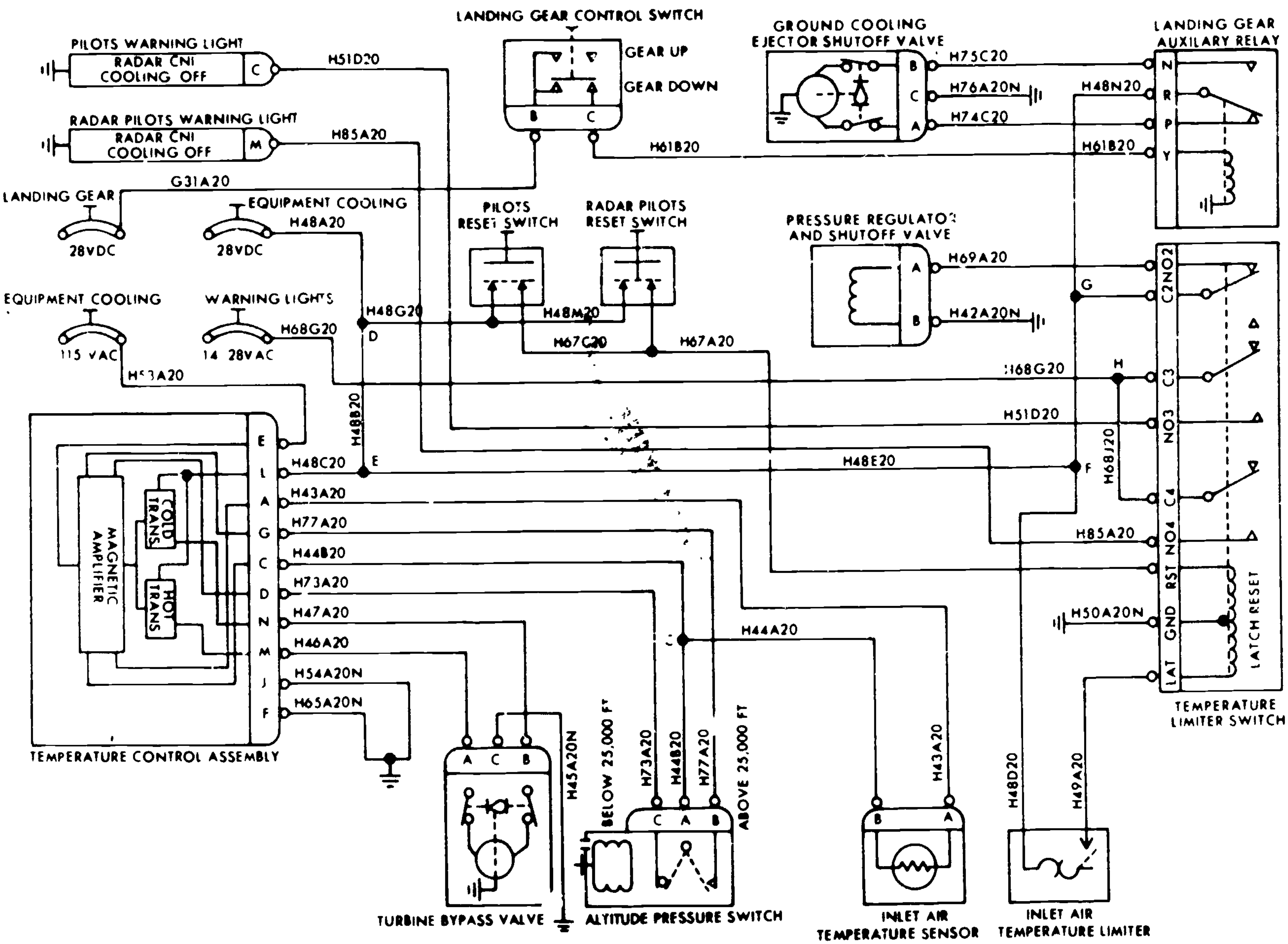


Diagram 1.

43

83-70316

SERVICE TEST
C3ABR42331-SG-204
26 April 1984

FIGHTER EQUIPMENT COOLING SYSTEM

OBJECTIVE

Relate a minimum of 8 out of 10 equipment cooling system components to their operation.

INFORMATION

The equipment cooling system is used for just what the name implies - cooling equipment. This is accomplished either by free convection or by forced air cooling. Let's talk about the forced air method first.

Some components generate excessive amounts of heat during operation. These components must be forced air cooled. Forced air cooling is accomplished by forcing cold air through ducts leading directly into the components. This air will range in temperatures of 0°F to 35°F.

The size of the component will determine the amount of air going into the component. With a temperature of 35°F going into the component, and with the amount of heat generated by this component, discharge temperature of the air coming out of the component should be maintained at 140°F. This is a 105° temperature increase.

A temperature of 140°F is maintained by the electronic cooling sensor/controller and the electronic cooling modulating valve. (This valve is controlled by the sensor/controller.) The electronic sensor/controller is mounted to the cooling air supply duct and receives a "sample" portion of the cooling air going through the duct. Inside the sensor controller is a heating element, valve control sensor, low flow sensor, and an overheat sensor. As the "sample" portion of the air goes into the sensor/controller it is heated by the heating element. This heating element simulates the heat load of the equipment. After being heated, the air passes over the two sensors.

The valve control sensor senses the temperature of the heated air. Remember, we are trying to maintain a discharge temperature of 140°F. If the discharge temperature is too high (over 140°F) the valve control sensor will sense the higher temperature and send a signal to the electronic cooling modulating valve. This will cause the modulating valve to open a few degrees. By opening the valve a few degrees, you are going to increase the flow of air through the cooling air supply duct. This will also increase the amount of air going across the heating element. With an increase in the air flow across the heating element, the temperature of the discharge air will decrease.

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DISTRIBUTION: X
3370 TCHTG/TTGU-P - 350; DAV - 1

Now what happens if the temperature decreases too much (below 140°F)? If this happens, the valve control sensor will sense the decrease and once again send a signal to the modulating valve. This signal will cause the valve to close a few degrees.

By closing the modulating valve a few degrees, you are going to decrease the amount of air flow going through the supply duct and also decrease the amount of air going across the heating element.

With a decrease in the flow of air going across the heating element, the discharge temperature will increase.

Remember, the valve control sensor controls the opening and closing of the valve.

After the "sample" portion of the cooling air supply has passed over the heating element and the valve control sensor, it goes over the low flow sensor.

The low flow sensor senses the temperature of the discharge air also. Its purpose is to detect a low flow of air going through the supply duct. Don't forget, the sensor/controller senses a "sample" portion of the same air that is going through the cooling air duct. The more air flow going through the duct, the more air flow goes through the sensor/controller.

So, if the low flow sensor detects a low flow of air, what is going to happen to the temperature of the air going through the sensor controller.

The slower the air flow going across the heating element, the more time it will have to heat up the air.

Now, if the temperature of the air goes above 140°F, the modulating valve is supposed to open. This will increase the flow of air going across the heating element. By increasing the flow of air across the heating element, you should decrease the discharge temperature of the air.

But what if the discharge temperature continued to increase? The discharge temperature is supposed to be maintained at 140°F.

If the temperature of the discharge air rises to 155°F or more, you have an overheat situation.

This overheat is basically saying that you do not have enough air going through the system (low flow).

If the temperature does reach a 155°F, the low flow sensor will send a signal to energize the environmental control relay. This will pull an armature down, completing a power circuit to the "equipment hot" light.

You should keep in mind that there are only two ways to get an overheat light.

1. Excessive temperature
2. Insufficient airflow

1697

Anytime an equipment hot light comes on, there are several things the pilot can do.

1. He can increase engine power setting, which will increase the air source volume and pressure.

2. He can turn off all nonessential equipment. This will reduce the equipment heat load.

3. The pilot can position the defog lever to the 3/4 forward position. Because of the size of the defog nozzle a back pressure will be created, making more air available to the equipment.

One of the biggest uses of cooling air is the radar. Anytime an equipment hot light comes on, power to the radar transmitter is automatically cut.

Now, lets talk about the free convection method of cooling.

This method is used where there is not as much heat generated among the components.

Cold air for the free convection method of cooling is tapped off of the cooling turbine (expansion side).

After being tapped off of the turbine, it travels up to the cold air shutoff valve.

The cold air shutoff valve is controlled by the cold air thermostatic valve.

The cold air thermostatic valve is a liquid-charged bellows type thermostat. The bellows will expand or contract depending upon the temperature.

At a temperature of 140°F to 150°F, at 14.7 psia the bellows will expand, opening the servo airport and sending air to the open side of the shutoff valve.

At an atmospheric pressure of 1.69 psia, (this is equivalent to 50,000 ft altitude) the bellows will open at a temperature of 90°-100°F.

The reason for the low temperature (90°-100°F) at this altitude is that the bellows has already expanded due to low outside temperature and pressure. So it will not take as much temperature to expand the bellows at high altitudes.

Also, on the cold air thermostat you will find a "press-to-test" button. This provides a way for you to test the operation of the cold air shutoff valve (open/close movement).

By pushing the button, you will be sending servo air straight to the cold air shutoff valve, causing it to open. Remember, it is spring-loaded closed.

Releasing the button will stop the servo air, allowing the valve to close.

EQUIPMENT COOLING TESTER INTERFACE

To properly troubleshoot the equipment cooling system, you must first know how to use the ECS tester.

The TO will, of course, explain step-by-step procedures for troubleshooting the equipment system. It will also tell you what operational test you must perform and how to set up the tester.

But, even if you can set up the tester as specified by the TO, do you know what is taking place?

Let's go over some of the different tests and find out what is taking place.

First, the avionic cooling knob.

By placing the avionic cooling knob in the "Norm" position, you will be taking a voltage reading from the equipment cooling control valve (voltage going into the valve). This reading will be displayed on the multimeter display on the tester.

The controller output will vary from zero volts (valve full open) to 25 ma (valve full closed). During normal ground operation the valve should be near full open. This would give a multimeter display reading of from zero to 8 volts.

Another position of the avionic cooling knob is the "Hi-temp" position.

In the hi-temp position you will once again be taking a reading of the voltage going to the valve motor of the equipment cooling control valve.

At the same time it will tie a 17 Kohen resistor into the water separator anti-ice circuit. This resistor will create a high resistance, making the water separator anti-ice sensor/controller think the system too cold. The sensor/controller will signal for hot air. By signaling for hot air, the temperature of the air going to the equipment will increase. Voltage to the equipment cooling valve will decrease as the valve spring-loads open, increasing the flow of air into the system.

The avionic cooling knob can also be placed in the "open" or "closed" position. (Both positions will be discussed separately.)

First, we will talk about the "close" position.

When in the "close" position, you are checking the closing of the equipment cooling modulating valve and also the overheat circuit.

By placing the avionic cooling knob in the "close" position, and by holding the valve close switch in the "avionic clg" position you will complete a circuit going to the equipment cooling modulating valve. This will send 28 VDC power to the valve causing it to go to the almost full close position. (It will never fully close.)

By nearly fully closing the valve, you will decrease the amount of air flow going through the cooling air supply duct. What is going to happen when air flow decreases? Is this going to have any effect on the discharge temperature of the "sample" air going through the electronic cooling sensor/controller? You should remember from the equipment cooling section that when air flow through the cooling air duct decreases, then the air flow through the sensor/controller is going to slow down. That means the heating element will be able to increase the amount of air that it can heat. This, of course, will increase the temperature of the discharge air.

Approximately 15-50 seconds after the equipment cooling valve closes, the equipment hot light on the pilot caution light panel and the equipment hot light on the tester should come on indicating an overheat (155°F). You should also notice a pressure drop at T.P. 50 because of the equipment cooling valve going to the near full close position.

In the "open" position you are basically checking the <u>opening</u> of the equipment cooling valve.

This is done by placing the avionic cooling knob in the "open" position.

When the avionic knob is placed in the "open" position, you are completing a circuit from the sensor/controller going directly to a ground.

This will allow power to take the path of least resistance, instead of power going from the sensor/controller to the valve, it will go directly to the ground. This will allow the valve to spring-load to the open position, increasing air flow and pressure into the system. This can be confirmed by monitoring the pressure readout of T.P. 50.

WORKBOOK

C3ABR42331-WB-204A

Technical Training

Aircraft Environmental Systems Mechanic

EQUIPMENT AIR CONDITIONING SYSTEM TROUBLESHOOTING

30 January 1984

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

Designed for ATC Course Use.

Do Not Use on the Job.

EQUIPMENT AIR CONDITIONING SYSTEM TROUBLESHOOTING

OBJECTIVE

Using a multimeter and wiring diagram, troubleshoot the equipment air conditioning system trainer, locating 3 out of 4 troubles correctly.

EQUIPMENT

Trainer 3305, Fighter Air Conditioning
Multimeter, AN/PSM 37A

PROCEDURE

1. Be sure all your jewelry is removed. Report to the lab instructor. Tell him the lesson on which you are working. The instructor will assign you to a trainer and give you the necessary materials.

2. This workbook is in two sections. Section 1 is to familiarize you with the location and operation of the components of the equipment air conditioning system. Section 2 gives the steps you will use to make an operational check of the system and also lists the malfunctions that you are to troubleshoot. Do each step as directed.

Section 1. EQUIPMENT AIR CONDITIONING SYSTEM COMPONENTS

1. Location and Identification of the System Components.

a. Use figure 1 to locate each of the numbered items on the trainer. Write the name of each of the numbered components in the spaces following. As you locate each item, notice the electrical checkpoints next to them. These checkpoints are used for checking the electrical circuitry when troubleshooting.

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(1) ____________________

(2) ____________________

(3) ____________________

(4) ____________________

(5) ____________________

(6) ____________________

(7) ____________________

(8) ____________________

(9) ____________________

Check your responses with the answers on page 11.

b. Locate the following items on the trainer.

(1) Radar cooling reset buttons.

(2) Radar CNI COOLING OFF lights.

(3) Warning light circuit breaker.

(4) Landing gear circuit breaker.

(5) Equipment cooling 115V AC circuit breaker.

(6) Equipment cooling 28V DC circuit breaker.

(7) Temperature sensor simulator rheostat.

(8) Temperature limiter simulat r switch.

(9) Altitude pressure switch simulator.

Note: On the trainer Simulator Control Panel there is a guarded switch next to a rheostat. You will use this switch and a multimeter when checking the resistance of the sensor.

When the switch is in the NORMAL position, the temperature sensor is in the circuit and is controlling system temperature. During troubleshooting if you want to check the actual sensor circuit, you must have this switch in the NORMAL position.

When the switch is in the TEST position, the temperature sensor is not in the circuit; the simulating rheostat is i the circuit. It is used to simulate sensor resistance changes for checking the proper operation of the temperature control assembly and the turbine bypass valve.

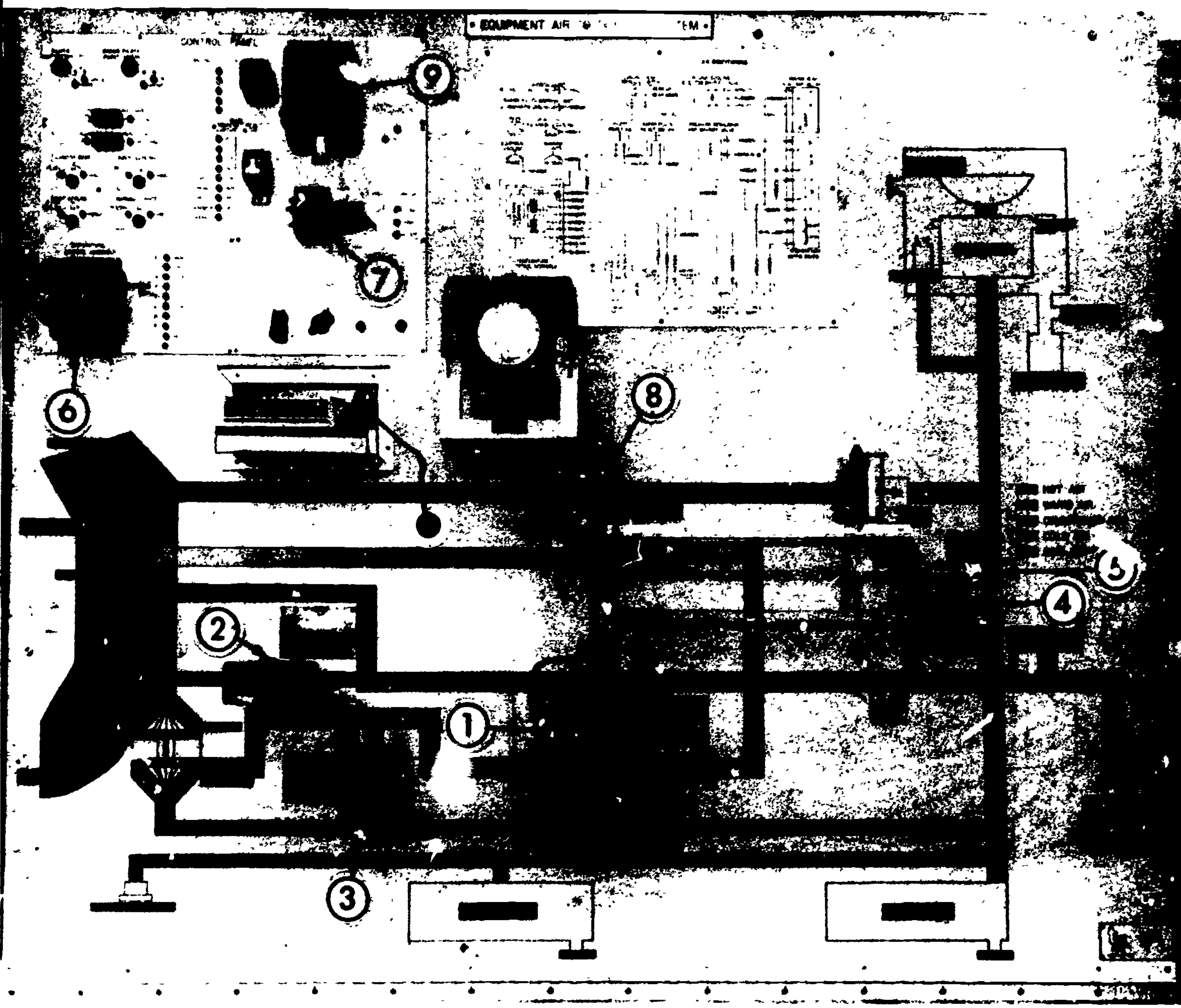

Figure 1.

2. Trainer Preparation.

a. Place all trouble switches to the OUT position. These switches are located at the left side of the trainer.

b. Push in the following circuit breakers:

(1) Landing Gear 28V DC.

(2) Equipment Cooling 28V DC.

(3) Equipment Cooling 115V AC 400 Hz.

(4) Warning Lights 14/28V AC.

c. Place the landing gear handle in the GEAR DOWN position.

d. Place the sensor simulator switch to the NORMAL position.

e. Ensure that the altitude pressure switch is set to above 25,000 feet.

f. Place the trainer power switches to the ON position. These switches are located on the left side of the trainer.

3. Trainer Operation.

By following the steps listed below, you will operate each component of the equipment air conditioning system. Whenever a switch or lever is used, be sure to notice which of the valves operated and position of the valve after it has stopped. From your observation of the trainer operation, complete each of the statements by circling the correct word.

STEP 1. Bleed air pressure regulator and shutoff valve and ram air valve operation.

a. Pull the equipment cooling 28V DC circuit breaker <u>out</u>.

(1) The pressure regu[illegible]r and shutoff valve (opens/closes).

(2) The ram air valve (opens/closes).

b. Push the equipment cooling 28V DC circuit breaker <u>in</u>.

(1) The pressure regulator and shutoff valve (opens/closes).

(2) The ram air valve (opens/closes).

STEP 2. Ground cooling ejector shutoff valve operation.

a. Place the landing gear handle in the GEAR UP position.

(1) The ground cooling ejector shutoff valve (opens/closes).

b. Place the landing gear handle in the GEAR DOWN position.

(1) The ground cooling ejector shutoff valve (opens/closes).

STEP 3. Temperature control system (turbine bypass valve) operation.

a. Since this system is completely automatic, you will have to simulate temperature changes in the duct. This is done by using the sensor simulating rheostat. Turn the sensor simulating rheostat clockwise to the full cold position. Place the guarded selector switch to the TEST position.

(1) The turbine bypass valve (opens/closes).

b. Turn the sensor rheostat counterclockwise to the full Hot position.

(1) The turbine bypass valve (opens/closes).

c. Return switch to normal position.

STEP 4. Temperature limiter operation.

a. Place the temperature limiter simulator switch to the OVERHEAT position.

(1) The pressure regulator and shutoff valve (opens/closes).

(2) The ram air valve (opens/closes).

(3) The CNI COOLING OFF warning lights are (on/off).

b. Place the temperature limiter simulator switch to the normal position. Did the pressure regulator and shutoff valve or the ram air valve operate? (Yes/No).

c. Press either reset button.

(1) The pressure regulator and shutoff valve (opens/closes).

(2) The ram air valve (opens/closes).

(3) The CNI COOLING OFF lights are (on/off).

d. Check your responses with answers on page 11.

4. Sensor Resistance.

Caution: All power to trainer must be off before you use the multimeter as an ohmmeter to check a circuit. Only use the ohm portion of the multimeter to check the sensor and the sensor circuit.

a. Before you can make an operational check or troubleshoot the system, the normal resistance value of the sensor must be determined. To make this resistance measurement, the sensor circuit must be isolated. To isolate the sensor circuit, disconnect the AN connector attached to the temperature control assembly. With the connector disconnected you will measure only the sensor resistance at the sensor checkpoints. The checkpoints are lettered A and C on the temperature control assembly test panel.

Note: The sensor simulating selector switch must be in the NORMAL position.

b. The resistance of the sensor is ____________________. The resistance value should be between 1500 and 3000 ohms.

Section 2. OPERATION AND TROUBLESHOOTING

Operation

1. By following the steps in Section 1, you became familiar with the operation of each component in the system.

2. Before you can troubleshoot you must know what is and what is not working properly in the system. To do this you must perform an operational check. The operational check procedure chart (figure 2), lists the planned steps that are used to make an operational check of the system. Use this chart to become familiar with each step. After you are sure you can make an operational check, continue to the troubleshooting section. Remember, you will need to make an operational check for each trouble. DO NOT depend on your memory. Use the checklist to be 100% sure.

Note: The equipment air conditioning temperature control system is fully automatic. This makes it necessary to simulate the operation of the equipment sensor circuit, when you make an operational check or troubleshooting the system on the trainer. This must be done before the sensor resistance is checked.

3. Another step that you must check when performing an operational check of the Equipment Air Conditioning System that is not on the operational check procedure chart is listed below.

"When performing an operational check of the Equipment Air Conditioning System, after you return the sensor simulating switch to the NORMAL position, place the altitude pressure switch to the "ABOVE 25,000 FT" position and the turbine bypass valve should close. Then return the switch to the "BELOW 25,000 FT" position and the turbine bypass valve should open."

POSITIONING CONTROL DEVICE	OPERATING VALVE OR LIGHT	VALVE POSITION
Pull out the equipment cooling 28V DC circuit breaker	Pressure Regulator and Shutoff Valve Ram Air Valve	Closed Open
Push in the equipment cooling 28V DC circuit breaker	Pressure Regulator and Shutoff Valve Ram Air Valve	Open Closed
Move the landing gear handle to the GEAR UP position	Ground Ejector Valve	Closed
Move the landing gear handle to the GEAR DOWN position	Ground Ejector Valve	Open
Place the sensor simulator switch to test. Rotate the sensor simulator rheostat to full counterclockwise	Turbine Bypass Valve	Open
Rotate the sensor simulator rheostat to full clockwise	Turbine Bypass Valve	Closed
Place sensor simulator switch to NORMAL and altitude pressure switch to below 25,000 FT	Turbine Bypass Valve	Open
Place altitude pressure switch to above 25,000 FT	Turbine Bypass Valve	Closed
Place the altitude pressure switch to below 25,000 FT	Turbine Bypass Valve	Open
Place temperature limiter simulator switch to overheat	Pressure Regulator and Shutoff Valve Ram Air Valve CNI Cool Off Light	Closed Open On
Place temperature limiter simulator switch to NORMAL	No Valve Action	
Press either reset button	Pressure Regulator and Shutoff Valve Ram Air Valve CNI Cool Off Light	Open Closed Off

Figure 2. Operational Check Procedure Chart.

Troubleshooting

1. Before going through an actual trouble, let's check the turbine bypass valve circuits to see the normal indications and to learn the procedure for troubleshooting the system.

a. Use the wiring diagram mounted on the trainer to trace the circuits required to operate the temperature control assembly. Trace from the equipment cooling 28V DC circuit breaker to pin L of the temperature control assembly. Trace from the equipment cooling 115V AC circuit breaker to pin E of the temperature control assembly. Trace from pins J and F of the temperature control assembly to ground. This circuit provides the necessary power for operation of the temperature control assembly.

b. Place the sensor simulator switch to the TEST position.

c. Turn the sensor simulator rheostat full CLOCKWISE. This simulates an increase in air temperature. A signal is sent by the rheostat to the control assembly demanding cold air. This will cause the COLD transistors to conduct.

d. Use the trainer diagram to trace the COLD CIRCUIT from pin N of the temperature control assembly to pin B of the turbine bypass valve.

e. Use the multimeter to check the voltage at pin B of the turbine bypass valve checkpoint. The voltage should be 24 to 28 volts. Did you get the correct voltage reading? ____________

> Note: When measuring voltage, be sure the meter is set to the correct voltage range. Make sure that you have the negative (black) lead to ground. Ground on the trainer is any point
>
> marked with a ground ( ) symbol.

f. Turn the sensor simulator rheostat full COUNTERCLOCKWISE. This simulates a decrease in air temperature. A signal is sent by the rheostat to the temperature control assembly demanding hot air. This will cause the HOT transistors to conduct.

g. Use the trainer diagram to trace the HOT circuit from pin M of the temperature control assembly to pin A of the bypass valve.

h. Check the voltage at pin A of the turbine bypass valve checkpoint. The voltage should be between 24 to 28 volts. Did you get the correct voltage reading? ________________

i. Return sensor simulator to normal position.

2. There are 12 malfunctions for you to troubleshoot. The trouble switch you are to use for each problem is identified on the Troubleshooting Response Sheet.

3. For each problem, perform an operational check to find out which component is malfunctioning. Enter a description of the malfunction in the discrepancy block of the troubleshooting response sheet.

4. Trace the electrical circuits that operate or control the malfunctioning component.

5. Use the multimeter to locate the cause of the trouble.

6. Enter in the discrepancy block of the Troubleshooting Response Sheet a description of the cause of the malfunction.

7. The first trouble will be analyzed and solved with you. You will do the rest of the troubles on your own.

a. Place trouble switch number 1 to the IN position.

b. Perform an operational check using the chart in figure 2.

c. As you went through the operational check, you should have found that the turbine bypass valve did not operate.

d. Make the following statement in the discrepancy block of the Troubleshooting Response Sheet for Trouble Switch Number 1 NOW.

"Turbine bypass valve did not operate"

e. Since the bypass valve will not operate to either position, the trouble must be in a wire or component that is common to both the hot and cold circuits. Which electrical circuit would cause this problem? --- The DC and AC power supply circuits. --- Use the trainer diagram to trace the AC and DC power supply circuits from the circuit breaker to the temperature control assembly.

f. Check the DC power supply circuit with the multimeter. You should get a voltage reading.

g. Check the AC power supply circuit. You did not get a reading, did you? This means there is an open in wire H53A20.

h. Make the following statement in the malfunction cause block of the Troubleshooting Response Sheet for Trouble Switch Number 1 NOW.

"Open in wire H53A20"

i. Place trouble switch number 1 to the OUT position and continue with the assigned problems. Use the Troubleshooting Response Sheet to record the malfunction and malfunction cause for each problem.

8. The lab instructor will constantly be evaluating your progress. After you have completed this troubleshooting section check your answers with the lab instructor.

The correct responses to the location and identification of system components:

(1) Bleed Air Pressure Regulator and Shutoff Valve.
(2) Ground Cooling Ejector Shutoff Valve.
(3) Turbine Bypass Valve.
(4) Temperature Sensor.
(5) Temperature Limiter.
(6) Temperature Control Assembly.
(7) Altitude Pressure Switch.
(8) Ram Air Valve.
(9) Landing Gear Handle.

The correct responses to Trainer Operation.

STEP 1.

a.(1) closes
(2) opens
b.(1) opens
(2) closes

STEP 2.

a. closes
b. opens

STEP 3.

a. closes
b. opens

STEP 4.

a.(1) closes
(2) opens
(3) on
b. no
c.(1) opens
(2) closes
(3) off

If your answers do not agree, check with your instructor. If your answers agree, then the trainer is operating properly.

TROUBLESHOOTING RESPONSE SHEET

TROUBLE SWITCH NUMBER	DISCREPANCY	CAUSE
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

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