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ABSTRACT

This packet of six learning modules on refrigeration is one of 20 such packets developed for apprenticeship training for stationary engineers. Introductory materials are a complete listing of all available modules and a supplementary reference list. Each module contains some or all of these components: goal, performance indicators, statement of purpose, objectives, learning activities (activities the student is expected to perform and their purpose), information summary, information sheets, worksheets, self-test, self-test answers, posttest, and posttest answers. The six training modules cover introduction to refrigeration; compressors; temperature controls; condensers and evaporation; purge, evacuate, recharge; and troubleshooting. (YLB)

ED254703

APPRENTICESHIP

STATIONARY ENGINEERS

RELATED TRAINING MODULES

9.1 - 9.6 REFRIGERATION

CE041979

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APPRENTICESHIP

STATIONARY ENGINEERS
RELATED TRAINING MODULES

COMPUTERS

1.1 Digital Language
1.2 Digital Logic
1.3 Computer Overview
1.4 Computer Software

SAFETY

2.1 General Safety
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4.2 Boring and Drilling Tools
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5.15 Switches and Relays
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6.3 Individual Strengths
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7.4 Multiplication and Division of Common Fractions and Whole and Mixed Numbers
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7.8 Ratio and Proportion
7.9 Perimeters, Areas and Volumes
7.10 Circumference and Wide Area of Circles
7.11 Area of Planes, Figures, and Volumes of Solid Figures
7.12 Graphs
7.13 Basic Trigonometry
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HYDRAULICS

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8.2 Hydraulics - Transmission of Force
8.3 Hydraulics - Symbols
8.4 Hydraulics - Basic Systems
8.5 Hydraulics - Pumps
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8.7 Hydraulics - Reservoirs
8.8 Hydraulics - Directional Control Valve
8.9 Hydraulics - Cylinders
8.10 Hydraulics - Forces, Area, Pressure
8.11 Hydraulics - Conductors and Connectors
8.12 Hydraulics - Troubleshooting
8.13 Hydraulics - Maintenance

STATIONARY ENGINEER
SUPPLEMENTARY REFERENCE DIRECTORY

Note: All reference packets are numbered on the upper right-hand corner of the respective cover page.

Supplementary Packet #	Description	Related Training Module
12.1	Correspondence Course, Lecture 1, Sec. 2, Steam Generators, Types of Boilers I, S.A.I.T., Calgary, Alberta, Canada	12.1 Boilers, Fire Tube Type
12.2	Correspondence Course, Lecture 2, Sec. 2, Steam Generators, Types of Boilers II, S.A.I.T., Calgary, Alberta, Canada	12.2 Boilers, Water Tube Type
12.3	Correspondence Course, Lecture 2, Sec. 2, Steam Generators, Boiler Construction & Erection, S.A.I.T., Calgary, Alberta, Canada	12.3 Boilers, Construction
12.4	Correspondence Course, Lecture 4, Sec. 2, Steam Generators, Boiler Fittings II, S.A.I.T., Calgary, Alberta, Canada	12.4 Boilers, Fittings
12.4	Corresondence Course, Lecture 4, Sec. 2, Steam Generators, Boiler Fitting I, S.A.I.T., Calgary, Alberta, Canada	12.4 Boilers, Fittings
12.5	Correspondence Course, Lecture 10, Sec. 2, Steam Generation, Boiler Operation, Maintenance, Inspection, S.A.I.T., Calgary, Alberta, Canada	12.5 Boilers, Operation
12.7	Correspondence Course, Lecture 3, Sec. 2, Steam Generation, Boiler Details, S.A.I.T., Calgary, Alberta, Canada	12.7 Boilers Heat Recovery Systems
12.8	Refer to reference packet 14.3/12.8	
		PUMPS
13.1 13.2 13.4 13.6 13.7	Correspondence Course, Lecture 9, Sec. 2, Steam Generator, Power Plant Pumps, S.A.I.T., Calgary, Alberta, Canada	13.1 Types & Classification 13.2 Applications 13.4 Calculating Heat & Flow 13.6 Monitoring & Troubleshooting 13.7 Maintenance
13.3 13.5	Correspondence Course, Lecture 6, Sec. 3, Steam Generators, Pumps, S.A.I.T., Calgary, Alberta, Canada	13.3 Construction 13.5 Operation

Supplementary Packet #	Description	Related Training Module
14.3 12.8	Correspondence Course, Lecture 6, Section 3, Steam Generators, Steam Generator Controls, S.A.I.T., Calgary, Alberta, Canada	14.3 Steam, Transport 12.8 Boilers, Instruments & Controls
14.4	Correspondence Course, Lecture 11, Section 2, Steam Generators, Piping II, S.A.I.T., Calgary, Alberta, Canada	14.4 Steam, Purification
15.1	Correspondence Course, Lecture 1, Sec. 4, Prime Movers & Auxiliaries, Steam Turbines, S.A.I.T., Calgary, Alberta, Canada	15.1 Steam Turbines, Types
15.2	Correspondence Course, Lecture 4, Sec. 3, Prime Movers, Steam Turbines I, S.A.I.T., Calgary, Alberta, Canada	15.2 Steam Turbines, Components
15.3	Correspondence Course, Lecture 2, Sec. 4, Prime Movers & Auxiliaries, Steam Turbine Auxiliaries, S.A.I.T., Calgary, Alberta, Canada	15.3 Steam Turbines, Auxiliaries
15.4	Correspondence Course, Lecture 6, Sec. 3, Prime Movers, Steam Turbine Operation & Maintenance, S.A.I.T., Calgary, Alberta, Canada	15.4 Steam Turbines, Operation & Maintenance
15.5	Correspondence Course, Lecture 8, Sec. 3, Prime Movers, Gas Turbines, S.A.I.T., Calgary, Alberta, Canada	15.5 Gas Turbines
16.2	Boilers Fired with Wood and Bark Residues, D.D. Junge, F.R.L., O.S.U. 1975	16.2 Combustion Types of Fuel
16.2	Correspondence Course, Lecture 5, Sec. 2, Steam Generators, Fuel Combustion, S.A.I.T., Calgary, Alberta, Canada	16.2 Combustion Types of Fuel
16.3	Correspondence Course, Lecture 5, Sec. 2, Plant Services, Fuel & Combustion, S.A.I.T., Calgary, Alberta, Canada	16.3 Combustion, Air & Fuel Gases
17.1	Correspondence Course, Lecture 12, Sec. 3, Steam Generation, Water Treatment, S.A.I.T., Calgary, Alberta, Canada	17.1 Feed Water, Types & Operation
17.2	Correspondence Course, Lecture 12, Sec. 2, Steam Generation, Water Treatment, S.A.I.T., Calgary, Alberta, Canada	17.2 Feed Water, Water Treatments

Supplementary Packet #	Description	Related Training Module
17.3	Correspondence Course, Lecture 7, Sec. 2, Steam Generators, Boiler Feed Water Treatment, S.A.I.T., Calgary, Alberta, Canada	17.3 Feed Water, Testing
18.1	Correspondence Course, Lecture 2, Sec. 5, Electricity, Direct Current Machines, S.A.I.T., Calgary, Alberta, Canada	18.1 Generators, Types & Construction
18.1 18.2	Correspondence Course, Lecture 4, Sec. 5, Electricity, Alternating Current Generators, S.A.I.T., Calgary, Alberta, Canada	18.1 Generators, Types & Construction 18.2 Generators, Operation
19.1	Corrspondence Course, Lecture 5, Sec. 4, Prime Movers & Auxiliaries, Air Compressor I, S.A.I.T., Calgary, Alberta, Canada	19.1 Air Compressors, Types
19.1 19.2	Correspondence Course, Lecture 6, Sec. 4, Prime Movers & Auxiliaries, Air Compressors II, S.A.I.T., Calgary, Alberta, Canada	19.1 Air Compressors, Types 19.2 Air Compressors, Operation & Maintenance
20.1	Basic Electronics, Power Transformers, EL-BE-51	20.1 Transformers
21.1	Correspondence Course, Lecture 7, Sec. 5, Electricity, Switchgear & Circuit, Protective Equipment, S.A.I.T., Calgary, Alberta, Canada	21.1 Circuit Protection
22.1	Correspondence Course, Lecture 10, Sec. 3, Prime Movers, Power Plant Erection & Installation, S.A.I.T., Calgary, Alberta, Canada	22.1 Installation Foundations

RECOMMENDATIONS FOR USING TRAINING MODULES

The following pages list modules and their corresponding numbers for this particular apprenticeship trade. As related training classroom hours vary for different reasons throughout the state, we recommend that the individual apprenticeship committees divide the total packets to fit their individual class schedules.

There are over 130 modules available. Apprentices can complete the whole set by the end of their indentured apprenticeships. Some apprentices may already have knowledge and skills that are covered in particular modules. In those cases, perhaps credit could be granted for those subjects, allowing apprentcies to advance to the remaining modules.

We suggest the the apprenticeship instructors assign the modules in numerical order to make this learning tool most effective.

SUPPLEMENTARY INFORMATION

ON CASSETTE TAPES

Tape 1: Fire Tube Boilers - Water Tube Boilers and Boiler Manholes and Safety Precautions

Tape 2: Boiler Fittings, Valves, Injectors, Pumps and Steam Traps

Tape 3: Combustion, Boiler Care and Heat Transfer and Feed Water Types

Tape 4: Boiler Safety and Steam Turbines

NOTE: The above cassette tapes are intended as additional reference material for the respective modules, as indicated, and not designated as a required assignment.

INSTRUCTIONAL LEARNING SYSTEMS

9.1

REFRIGERATION -- INTRODUCTION

Goal:

The apprentice will be able to describe a basic refrigeration system.

Performance Indicators:

1. Describe evaporation.
2. Describe refrigerants.
3. Describe basic refrigeration system.

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309-A Introduction to Refrigeration

Industrial Mechanics

309-A INTRODUCTION TO REFRIGERATION

As matter undergoes a change of state (from vapor to liquid, liquid to vapor) energy is gained or lost. This principle is the basis for operation of refrigeration equipment. Pressure differentials are used to move the refrigerant through the system making the use of a compressor a must. This package will provide the fundamentals of a typical refrigeration system.

REFRIGERATION

[redacted]

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OBJECTIVES

1. Given a pictorial view of the mechanical refrigeration system you will be able to determine where there is

   a. liquid - low pressure
   b. liquid - high pressure
   c. gas - low pressure
   d. gas - high pressure

2. Given a list of refrigeration parts, you will be able to explain in writing their function to 90% accuracy.

3. Upon completion of the package, be able to explain orally to the instructor the operation of the bellow's type temperature control in a refrigerator.

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LEARNING ACTIVITIES

ACTIVITIES	PURPOSE
Read: Information Summary	Tells you what this package covers.
Read: Information Sheet #1	To give you a good understanding of what refrigeration is.
Read: Information Sheet #2	To give you a good understanding of how gas flows through a mechanical system, and what changes occur in the state of the gas.
Read: Information Sheet #3	To give you a good understanding of the electrical components, necessary to a basic mechanical refrigeration system.
Do: **Worksheet #1**	Will give more background and explicit information on refrigeration.

INFORMATION SUMMARY

Having completed this package, you will know that "Refrigeration", means the removal of heat, and in order to remove heat you must have evaporation. When a liquid boils, its vapor carries off excess heat from whatever caused it to boil. In order to reuse the vapor, it must be condensed back into a liquid, by removing the heat that it carries. In a practical mechanical refrigeration system, you must use a refrigerant that has an extremely low boiling point. Therefore, you will know that Freon gas is best suited for this purpose in household appliances.

This package will also show that Freon gas is in a vapor state under low pressure while in the evaporator, and at the same time compresses it, forcing it into the condenser, where, giving up its heat to the air around the condenser, it condenses back into a liquid. It is then forced under high pressure back to the evaporator, where it is metered, to flow at an exact rate, into the evaporator, Since the metering device is the divider between high and low pressure, it allows the Freon gas to boil, and start the cycle anew.

You will know that a cold control is used to maintain a given temperature in the evaporator, and that this control operates, by pressure from a gas filled tube. It is used to turn the compressor motor on or off.

The compressor motor is a split phase motor hermetically sealed in a case or dome, with the compressor, and this motor has no mechanical starting switch. The relay is used for starting the motor externally.

You will also know that the cold control and the relay are in series with each other, on one side of the supply line, and are connected to one side of the start winding and one side of the run winding.

In general, you will have a working knowledge of a basic mechanical refrigeration system, and the components necessary for its operation.

INFORMATION SHEET #1

The word "Refrigeration" means, the method by which heat is removed from any substance. Although many people think all refrigeration is a mechanical process, there is also the old fashioned method the "ice box".

The two most important things to consider in refrigeration, are the <u>removal</u> of heat from the substance that is to be cooled, and <u>disposing</u> of the heat after it has been removed from the substance.

Consider the simple ice box in figure 1. We put a piece of ice in the box and then place a piece of warm meat in the box with the ice. Remembering, that <u>heat always moves from hot to cooler temperatures</u>, the heat from the meat flows to the ice, causing the ice to melt. The water formed contains the heat, and it is generally drained off to a pan under the chest.

This system requires constant attention, such as, replacing the ice, and emptying the water in the pan. It is also limited in temperature range.

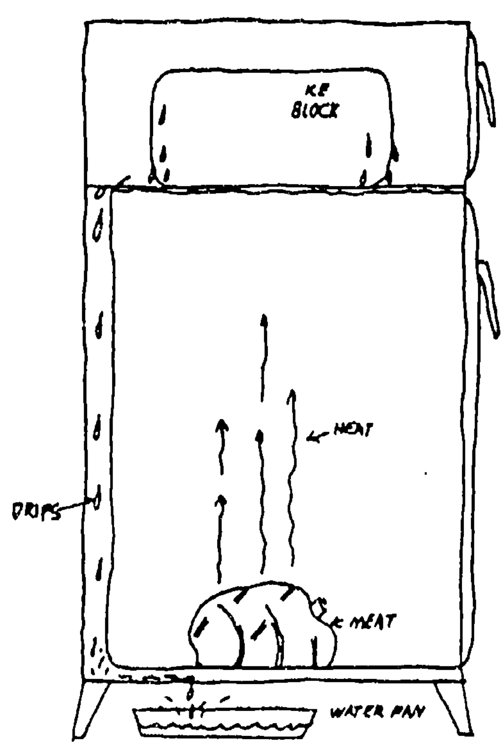


Fig. 1

ICE CHEST

3

Figure #2 shows a pan of water on a gas hot plate. The water is boiling due to the flame from the hot plate. Since flame is many times hotter than the water, and yet the water temperature will never rise above 212°, we may ask ourselves what happens to the excess heat being applied to the pan, by the flame? Answer, the excess heat is being carried off by the steam (vapor).

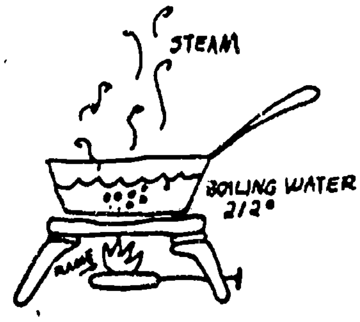


Fig. 2

As the steam rises into the cooler air above the stove, it condenses back into water again, and in doing so, it loses its heat to the air. If a means were provided, to trap this steam, condense it back to water, and return it to the pan, it could then be reused, to carry off more excess heat. This process is nothing more than evaporation. You might say, "the excess heat is carried off by the vapor." We have already stated that refrigeration is, "the removal of heat," therefore, we might also state that the process of refrigeration is "evaporation."

"Refrigerants" are gases. These gases are used in mechanical refrigeration. The state of these gases, (vapor or liquid) depends on the pressure to which they are subjected.

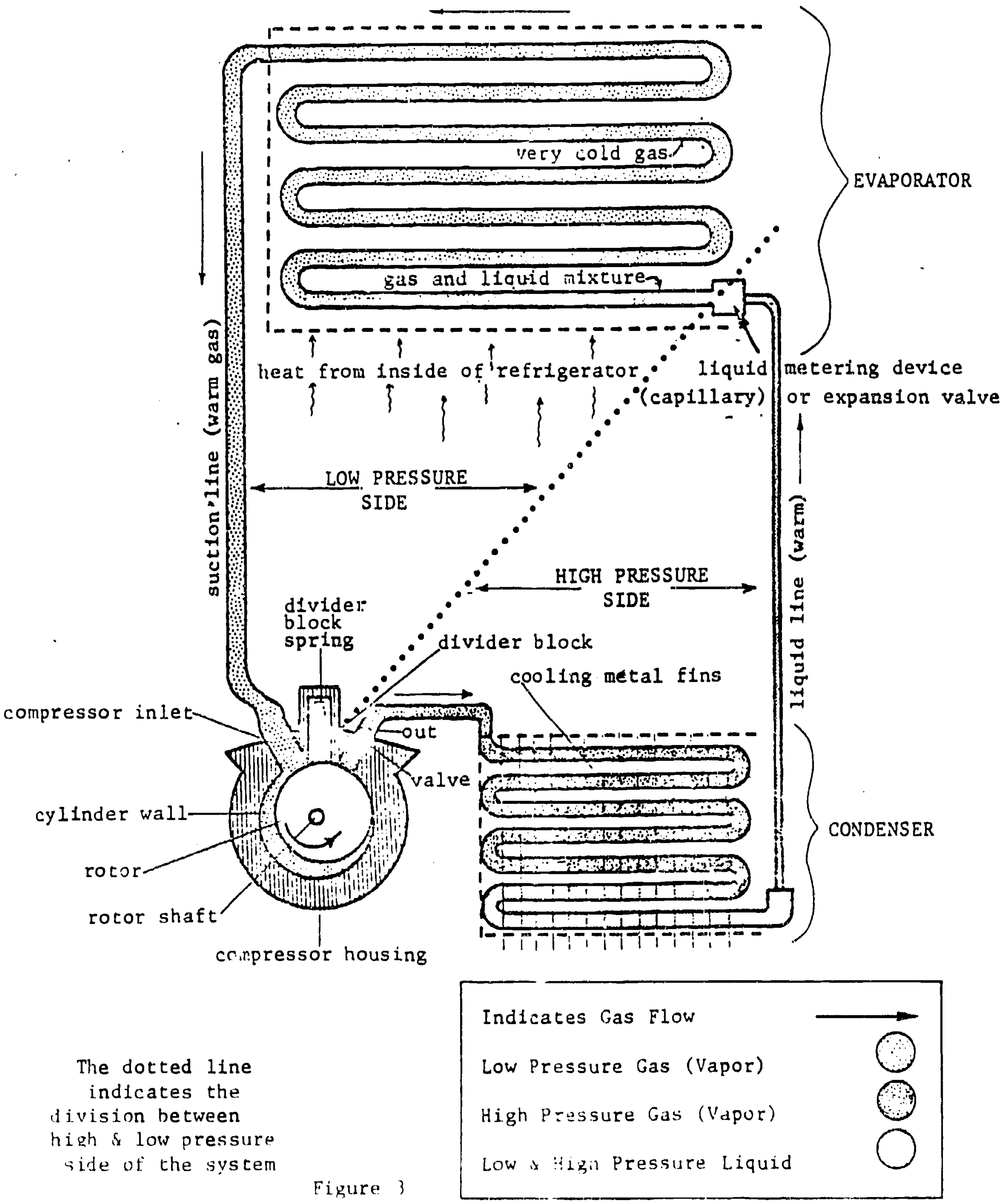
Freon is the most common gas used in household refrigeration systems, and therefore, will be the type discussed in this package. (Freon 12)

A practical refrigeration system must maintain a very low temperature, therefore, we need a gas that will have a very low boiling point. In other words, if a freezer is to maintain a temperature of 10° below zero, we must use a gas that will continue to boil at a temperature lower than 10° below zero. Freon 12 has a boiling point approximately 22° below zero, and therefore, is an excellent refrigerant. Hereafter refrigerant will ge referred to as "gas."

Note!! Freon gas has no odor, and at ordinary temperatures it is non-toxic. However, Freon gas will produce a poisonous gas when it contacts flame or red hot metal. A dull headache, dizziness, and nausea will occur. Fresh air is the best remedy.

Freon gas leaks are detected by a gas torch, known as a "Halide" torch. This torch uses alcohol, and when the normally blue flame of the torch encounters Freon gas, it will turn green. Large leaks may be detected by using liquid soap. The soap, when applied to a leak in a system, will bubble, due to the pressure of the gas escaping.

Flow Diagram of a Typical Refrigeration System:



The dotted line indicates the division between high & low pressure side of the system

Figure 3

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INFORMATION SHEET #2

Figure 3 is a diagram of a basic refrigeration system. This system has no electrical components, and therefore, you must assume that the rotor shaft of the compressor, is connected to an electric motor, and is turning in the direction indicated by the arrow on the rotor.

The rotor is eccentric, and as it turns, it is always touching the cylinder wall at one point or another. The divider block always presses against the rotor surface thus creating a division between high and low pressure. As the rotor turns, it squeezes the gas vapor ahead of it, thus forcing it out through the outlet on the high side of the system. The divider block prevents the gas from returning to the low side of the system.

Starting at the evaporator, we will proceed through the cycle a step at a time.

The liquid gas in the evaporator, is boiling due to the heat in the refrigerator. As the gas boils, its vapor is sucked through the suction line by the compressor. It is then forced into the condenser, by the rotor. The valve in the outlet side of the compressor, will open only one way, thereby holding the gas in the condenser, until the rotor returns with more gas.

As the gas (in vapor form) continues to increase in density as well as temperature, it becomes hotter than the air surrounding the condenser. The hot gas vapor then condenses back into a liquid, loosing its heat to the surrounding air, through the fins on the condenser.

The gas, now in liquid form and under high pressure, is forced through the liquid line, to the metering device, (capillary tube) where it is metered into the evaporator. The metering device is a division between high pressure and low pressure. Therefore, the evaporator is under low pressure, which allows the gas to vaporize (boil) and the cycle begins again. NOTE: The metering device (capillary tube) is engineered to allow only enough liquid into the evaporator, to keep the system in balance.

INFORMATION SHEET #3

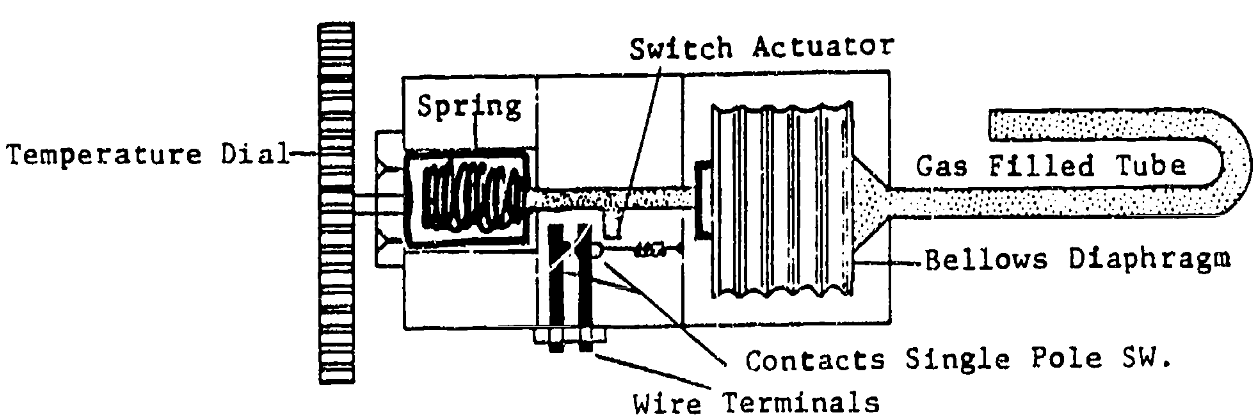


Figure 4

Figure 4 is a cold control. It is used to maintain, a near even temperature in the refrigeration system's evaporator (cooling chamber).

The gas filled tube is fastened to the side of the evaporator. When the temperature rises in the evaporator, the gas in the tube expands in volume, pushing the diaphragm towards the single pole switch, and closing the switch. This starts the compressor. The compressor will continue to run, until the temperature in the evaporator is cold enough to contract the gas in the tube of the cold control. This causes the diaphragm to retract, opening the switch, which in turn shuts off the compressor.

The dial is used to increase or decrease, the tension on the spring, which increases or decreases, the temperature in the evaporator.

This type of control is used on most household refrigerators and air conditioners.

Figure 5 is a diagram of a split phase motor and its taps. These motors are used in household refrigeration systems, and they are "Hermetically" sealed with the compressor in a dome shaped steel container. "Hermetic" applies to a compressor motor combination sealed by welding in a dome shaped container or case. When faults occur in either the compressor, or the motor, the complete unit must be replaced.

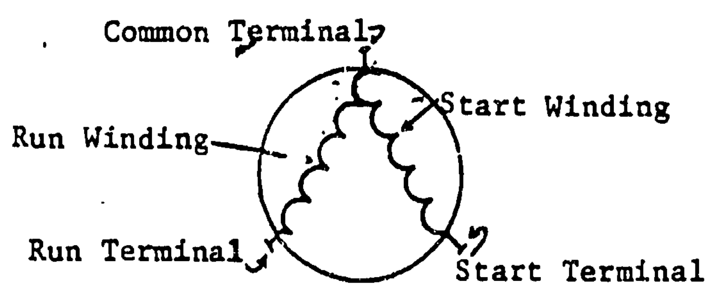


Figure 5

Figure 6 is a diagram of a split phase motor, with a relay for starting. Since the motor is sealed in a case, there is no way to install a mechanical starting switch. Therefore, the relay is used as a starting switch. It is used on all split phase motors that are Hermetically sealed.

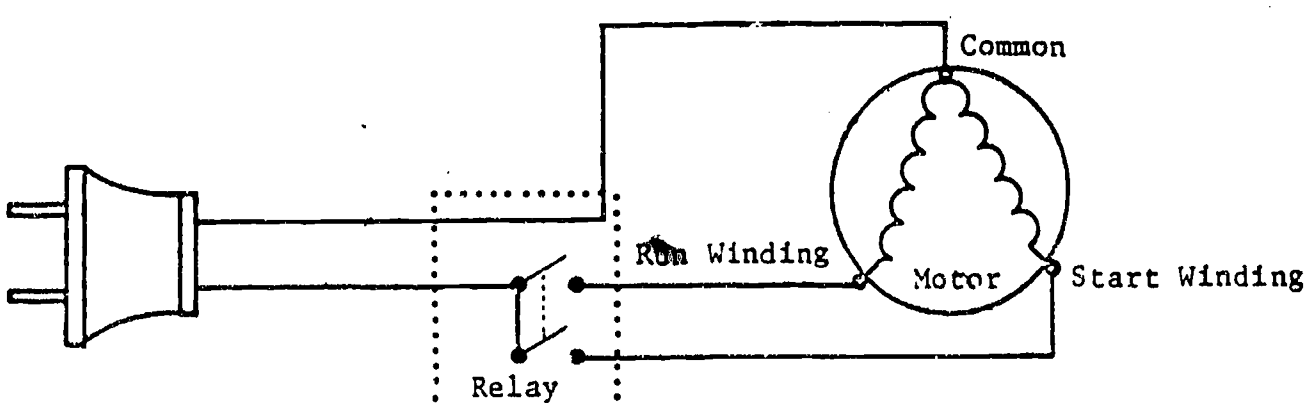


Figure 6

Figure 7 will show you the physical placement of the cold control, the relay and the compressor, as they relate to a common household refrigerator.

Information sheet #3 continued.

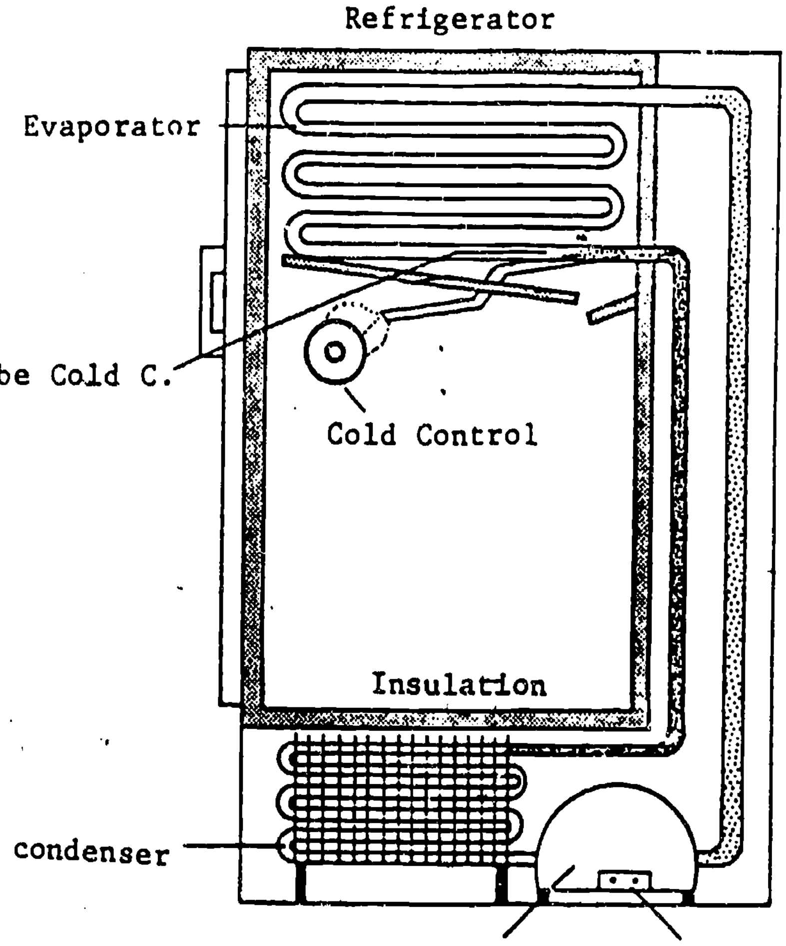


Figure 7

Figure 8 is the wiring diagram for a basic refrigeration system. This applies to household units, whether they be refrigerator, freezer, or air conditioner. There are other components found in most units, such as, lights, defrost timers, etc. However, a good understanding of the basic circuit will enable you to troubleshoot any circuit. Lights would be in parallel with the line, and a door switch would control them. Defrost timers, would be in series with the cold control, thus shutting machine off at a given time.

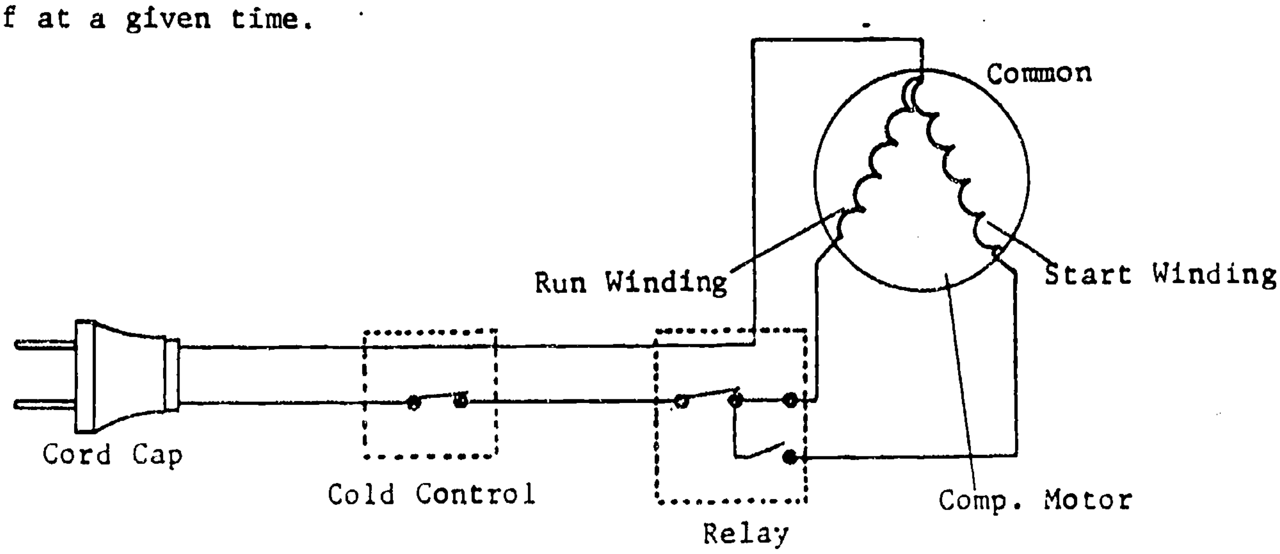


Figure 8

WORKSHEET #1

Define the following words or terms:

Refrigeration

Refrigerant

Hermetically sealed motors

Expansion cooling

Low pressure boiling points

Evaporator

Vaporization

SELF-TEST

Directions: Answer the following questions:

1. The gas in the evaporator is in what state?____________________
2. The condenser is on the high pressure or low pressure side of the system?

   ____
3. The cold control regulates the temperature in the____________________.
4. Motors used for household refrigeration systems are of the ________________ type.
5. The gas in the suction line is in what state?____________________

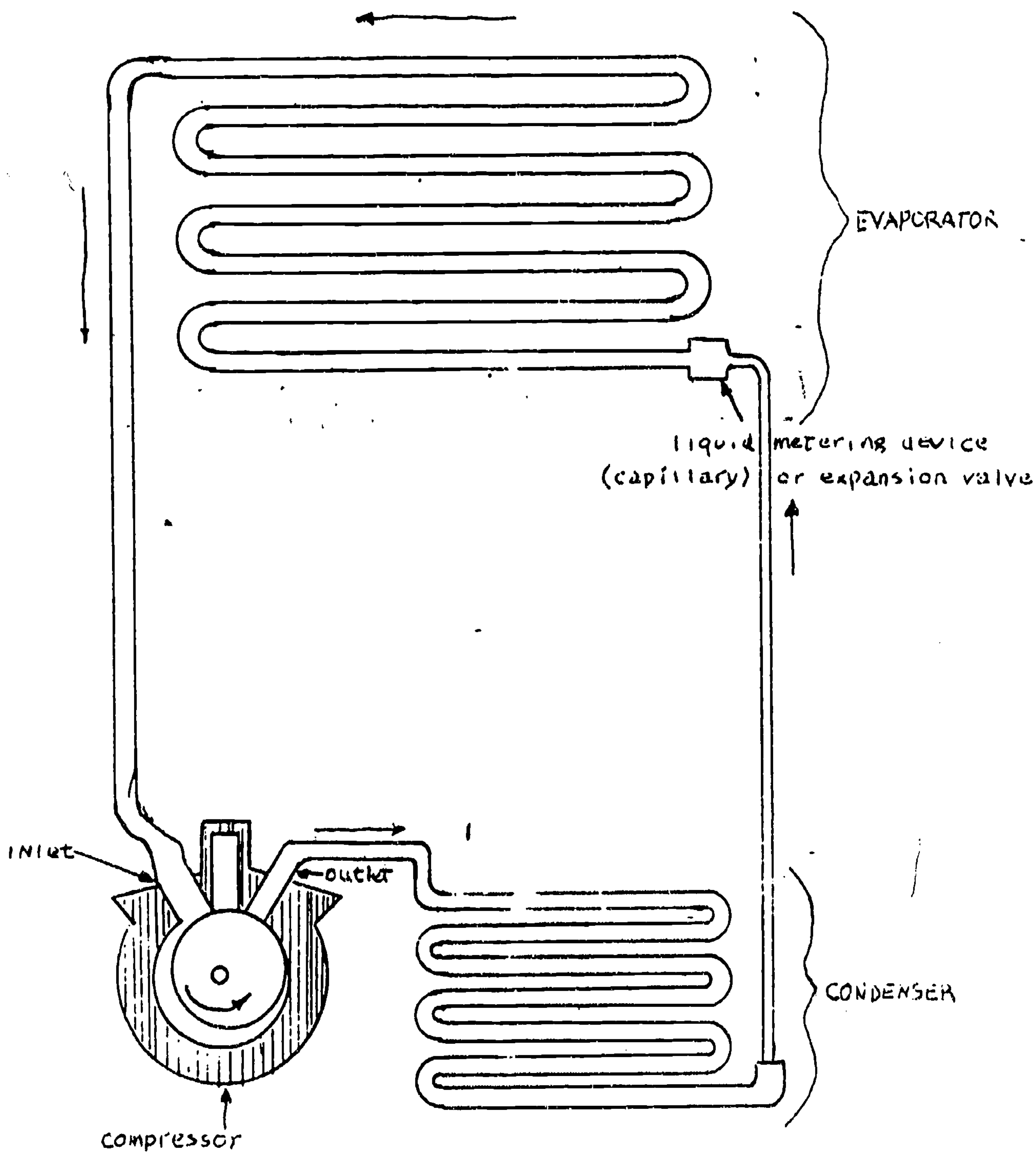
SELF-TEST ANSWERS

1. Liquid and vapor
2. High pressure side
3. Evaporator
4. Split phase
5. Vapor

POST-TEST ANSWERS

INTRODUCTION TO REFRIGERATION Package # 309 A

1. Removal of heat
2. Removal of heat - Disposing of heat
3. Hot to cooler temperatures
4. Freon
5. Used to maintain a near even temperature in the refrigeration system's evaporator (cooling system)


EVAPORATOR
liquid metering device
(capillary) or expansion valve
INlet
outlet
CONDENSER
compressor

POST—TEST

Package Number 309 A

Name ______________ Date ______________

INTRODUCTION TO REFRIGERATION

1. Define refrigeration.

2. What are the two most important things to consider in refrigeration?

3. Heat always moves from ______________ to ______________ temperatures.

4. ______________ is the most common gas used in household refrigeration systems.

5. What is the purpose of the cold control?

6. On the following diagram, draw in where

   a. there is low pressure gas
   b. there is high pressure gas
   c. low pressure liquid
   d. high pressure liquid

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9.2

REFRIGERATION -- COMPRESSORS

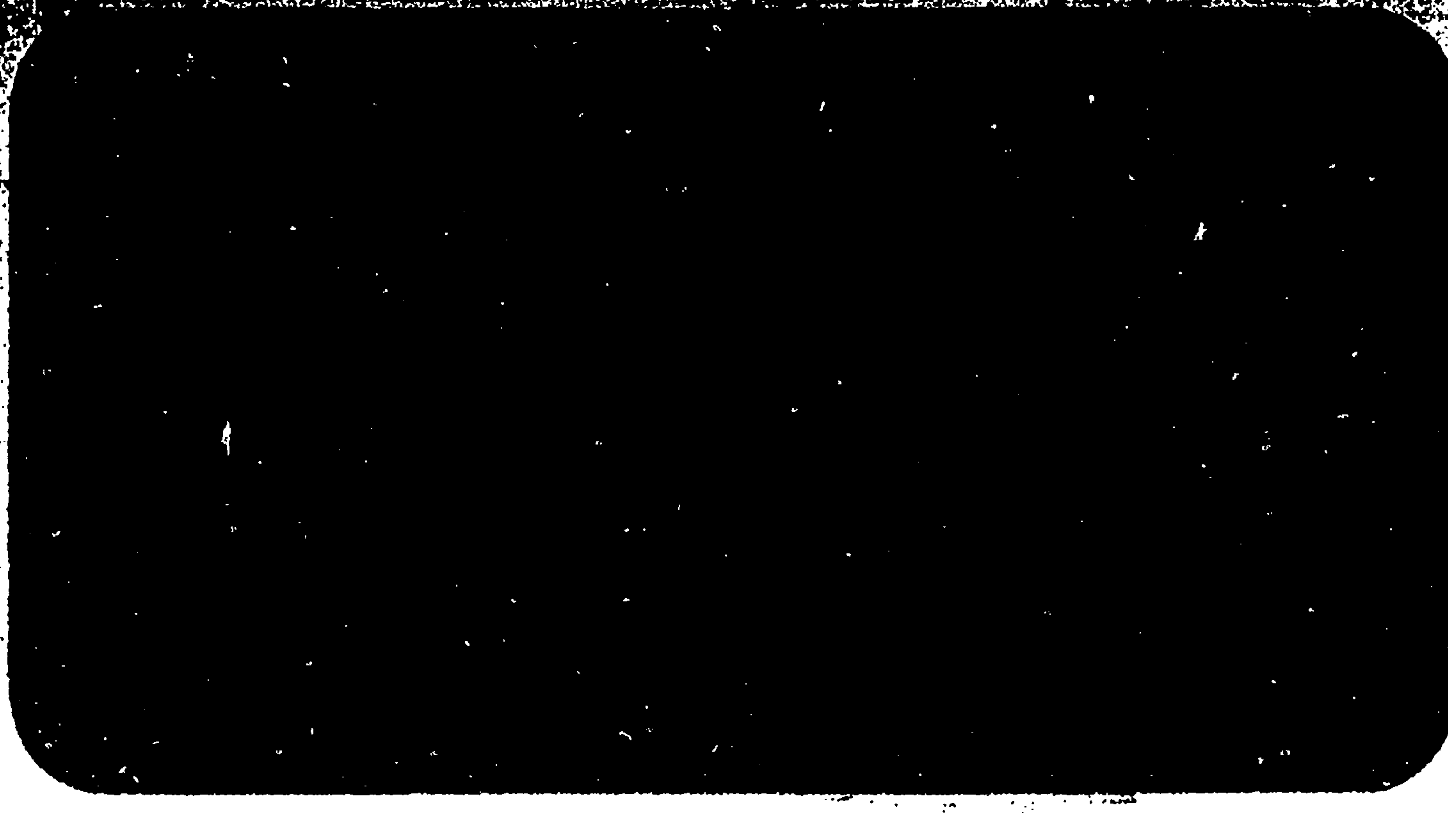
Goal:

The apprentice will be able to describe the use and types of compressors in refrigeration.

Performance Indicators:

1. Describe compressors.
2. Describe types of compressors.

309-B Refrigeration Compressors



Industrial Mechanics

309-B REFRIGERATION COMPRESSORS

This package gives you the technical knowledge necessary for understanding compressors. Compressors are very technical and the actual servicing of compressors is done by trained technicians.

REFRIGERATION

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OBJECTIVES

Upon completion of this package the student will be able to:

1. Upon completion of this package you will be able to explain the operating principles of three types of compressors in writing.

2. Given a compressor, be able to disassemble, inspect, and reassemble according to manufacturers recommendations.

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WRITERS:

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LEARNING ACTIVITIES

ACTIVITIES	PURPOSE
Read: Information Sheet #1	Gives technical knowledge about compressors.
Read: Section on Compressors in a Refrigeration Reference.	
Do: Worksheet #1	Gives practical experience and completes requirements of objective number 2.
Take self-test	Measures your learning.

INFORMATION SHEET #1

COMPRESSORS

The compressor is the heart of a refrigeration unit. The compressor has two functions:

1. To create flow through the system.

2. To cause low pressure on one side of the system and high pressure on the other side of the system.

The compressor has to have a prime mover to make it operate. Usually the prime mover is an electric motor, but in some instances it can be a fuel powered engine.

There are three types of compressors in common use today. They are:

1. Reciprocating compressor.
2. Rotary compressor.
3. Centrifugal compressor.

The reciprocating compressor is the most commonly used because it is durable, easy to manufacture and maintain.

Figure #1 shows a reciprocating compressor. As the piston travels down it creates low pressure on the intake side of the system or "The Lowside". As the piston travels upward it creates high pressure on the exhaust

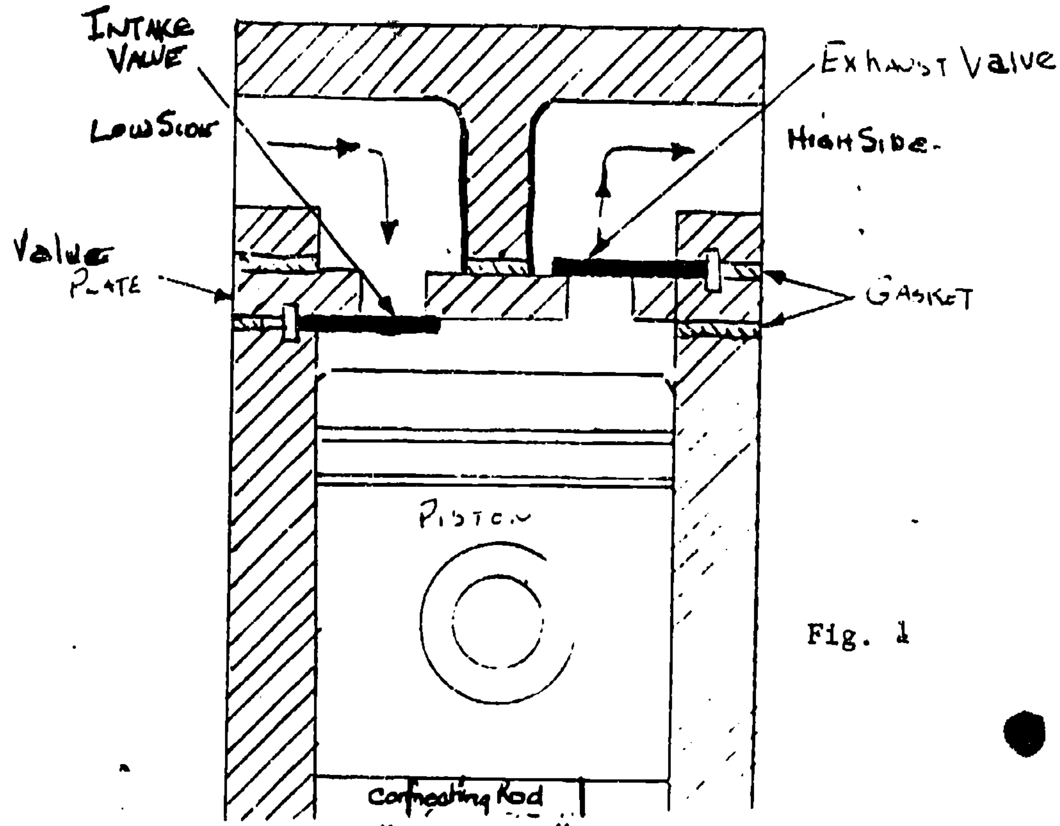

Fig. 1

side of the system on the "High Side".

Figure #2 shows a rotary compressor. In a Rotary compressor the rotor is off center to the cylinder. The blades maintain contact with the cylinder wall. As the rotor rotates the volume increases and decreases. On the intake the volume increases causing a decrease in pressure (suction) on the low side. On the exhaust stroke the volume decreases causing high pressure to the high side of the system. On this type compressor the rotor and blades also work as valves.

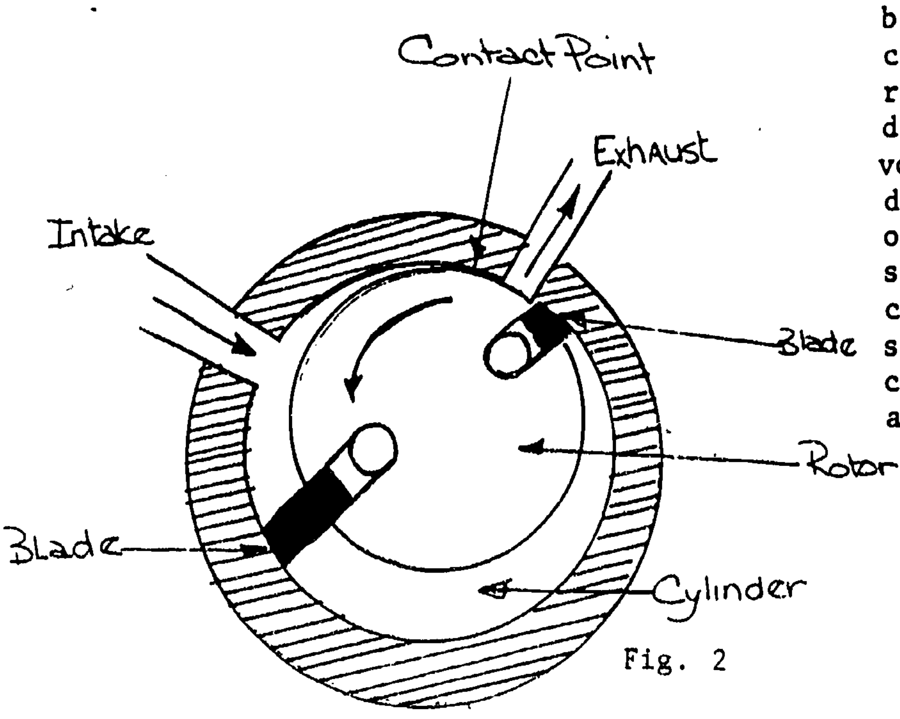

Fig. 2

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Figure #3 shows a centrifugal compressor. Centrifugal compressors are used in large refrigeration systems. With a centrifugal compressor the vapor is spun in a circular motion. The centrifugal force causes the pressures to rise. The moving of air through the intake causes low pressure on the low side. The centrifugal force causes high pressure on the high side.

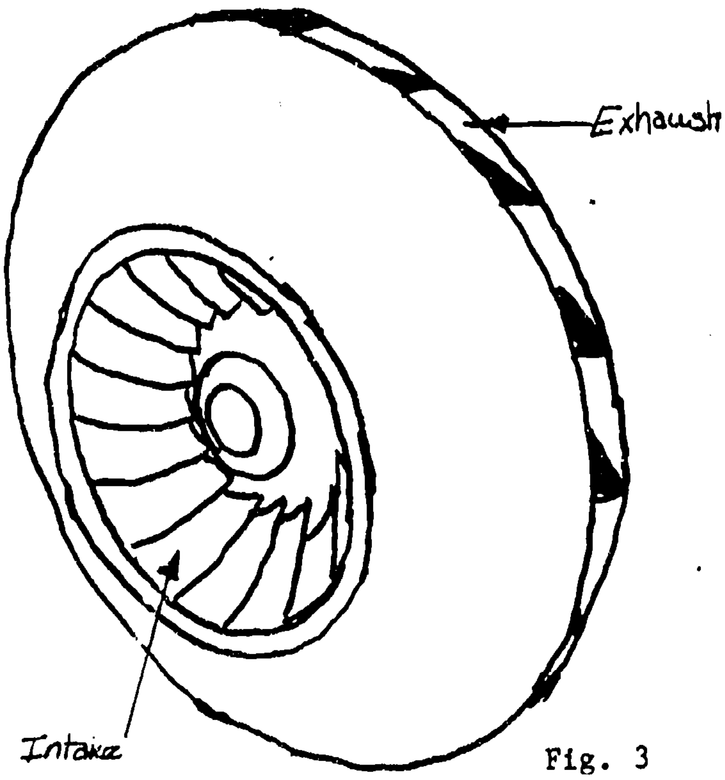

Fig. 3

SEALED UNIT COMPRESSORS

Sealed unit compressors are more commonly called "hermetic" motor compressors. A hermetically sealed unit contains both the motor and compressor in one sealed unit. These units are not generally serviceable except by replacement. The unit is normally mounted on springs or rubber mounts to absorb vibrations. Rotary type compressors are normally used in a seal unit.

WORKSHEET #1

1. Obtain a refrigeration compressor of any variety from your instructor and do the following.

   A. Obtain specification manual for your compressor.
   B. Disassemble as per manufacturers recommendation.
   C. Inspect for internal wear.
   D. List on the back of this page any problems you have found with the compressor.
   E. Reassemble following manufacturers recommended procedure.
   F. Locate the inlet and outlet side of compressor.
   G. Determine which way the compressor rotates.

CAUTION: Cleanliness is a must when doing compressor work because of the tight tolerances used.

SELF-TEST

1. What are the two functions of a compressor?

   a. ____________________
   b. ____________________

2. What is the most commonly used type of compressor?

   ____

3. Which type of compressor uses a piston or pistons to create pressures?

   ____

4. Which type of compressor uses blades to control leakage?

   ____

5. Where are centrifugal compressors used?

   ____

6. What is meant by a "Hermetically" sealed compressor motor?

   ____

2. Reciprocatin
3. Reciprocating
4. Rotary
5. Large refrigeration systems
6. Motor & compressor enclosed in one unit.

POST—TEST

Package Number 202-B

Name ____________ Date ____________

1. Explain the operating principles of a reciprocating refrigeration compressor.

2. Explain the operating principles of a rotary refrigeration compressor.

3. Explain the operating principles of a centrifugal refrigeration compressor.

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INSTRUCTIONAL LEARNING SYSTEMS

9.3

REFRIGERATION -- TEMPERATURE CONTROLS

Goal:

The apprentice will be able to describe temperature controls in refrigeration.

Performance Indicators:

1. Describe devices for temperature control.

309-C REFRIGERATION TEMPERATURE CONTROLS

Any refrigeration unit has to have a means of controlling the temperature of the unit. After all, who likes frozen beer!! This package will discuss the various types of refrigeration temperature controls.

Upon completion of this package, you will be able to do the following:

Given a refrigeration unit and an air conditioning unit, be able to determine the type of temperature control unit and explain its operation. The manufacturer's service manual may be used.

LEARNING ACTIVITIES

ACTIVITIES	PURPOSE
Read: Information Sheet #1	Give background necessary for completing objective.
Read: Section on temperature controls from any air conditioning refrigeration text or manual	
Do: Take Self-Test	Evaluates your progress

INFORMATION SHEET #1

To control the temperature in a refrigeration unit, you have to control the pressure in the evaporator. Most temperature control units work by shutting the compressor off when the evaporator pressure gets too low. When the evaporator pressure gets too high, the compressor starts again.

On home refrigeration units, an electrical temperature thermostat is used. This can be of two types. One is the bimetal thermostat and the other is a gas bulb type.

Figure 1 shows a bimetal thermostat.

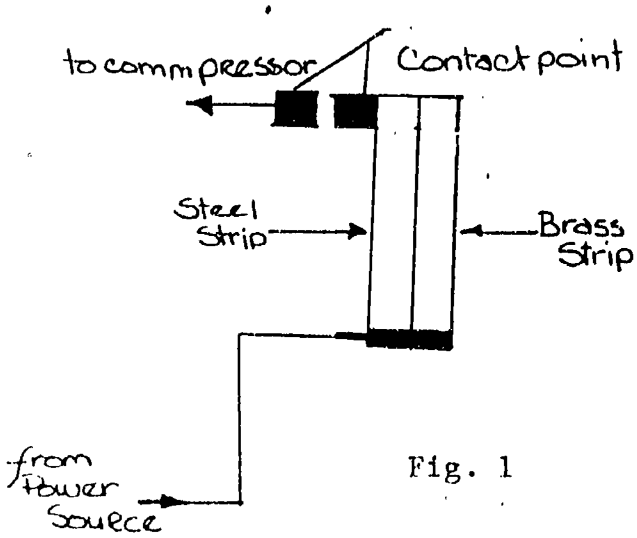

Fig. 1

A bimetal thermostat has two different kinds of metal strips fused to each other. The brass strip expands faster than the steel strip. When the evaporator gets too warm the bimetallic strips bend, the contact points close and the compressor starts. When the evaporator gets too cold the thermostat works opposite and the contacts open and the compressor stops.

Figure 2 shows a gas bulb thermostat.

A gas bulb thermostat has a gas filled bulb located next to the evaporator. As the evaporator warms up, the gas vapor expands in the bulb. The expanded gas transfers to the bellows. The bellows expand, the contact points close, completes the circuit, and the compressor starts. When the evaporator gets too cold, the return spring overcomes vapor pressure and breaks contact to stop the compressor.

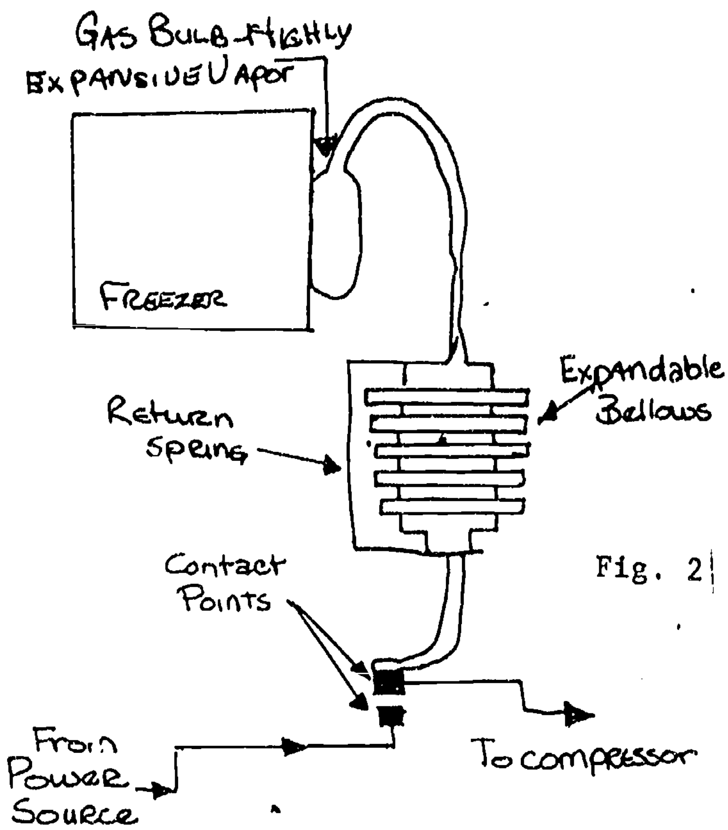

Fig. 2

Figure 3 shows an automatic expansion valve.

An automatic expansion valve controls the temperature of a refrigeration unit by directly controlling the pressure in the evaporator. As the temperature rises in the evaporator, the expansion valve lowers the evaporator pressure. The expansion valve is located on the inlet to the evaporator.

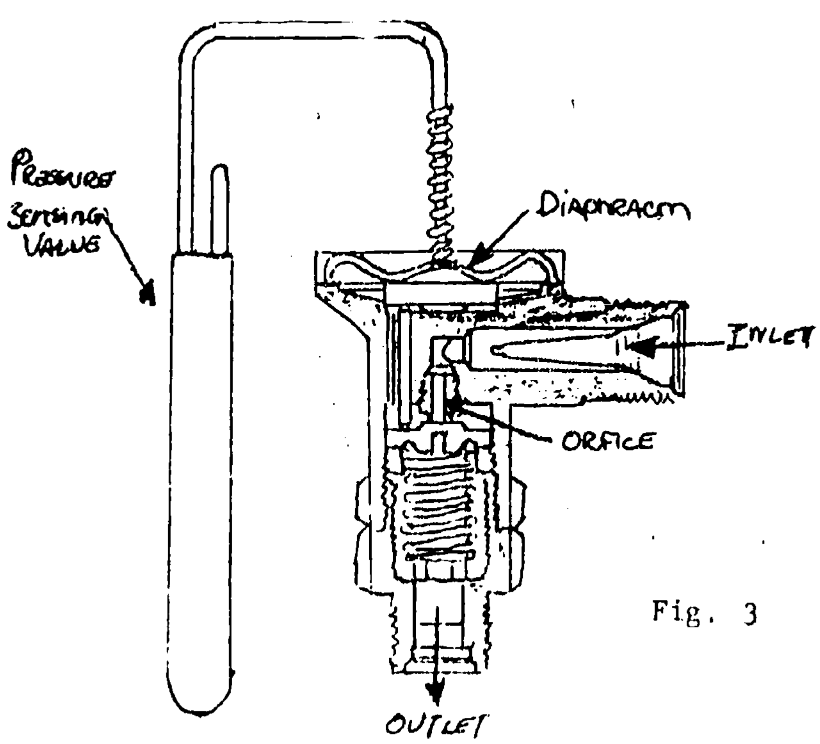

Fig. 3

SELF-TEST

Answer True or False

_______ 1. If you raise evaporator pressure, you lower the evaporator temperature.

_______ 2. If the evaporator pressure is lowered, the evaporator temperature is lowered.

_______ 3. A freezer unit would have lower evaporator pressure than an air conditioner.

_______ 4. A bimetal thermostat shuts off the evaporator when the evaporator gets too cold.

_______ 5. If the contact points were to stay closed on a gas bulb thermostat, the evaporator would not get down to the proper temperature.

SELF-TEST ANSWERS

1. F
2. T
3. T
4. F
5. F

POST—TEST

Package Number 309 C

Name ______________ Date ______________

REFRIGERATION TEMPERATURE CONTROLS

1. Locate an air conditioning unit. Determine the type of temperature control unit and explain the operation.

2. Locate a refrigerator or freezer unit. Determine the type of temperature control unit and explain the operation.

NOTE: You may have to use the manufacturer's service manual to complete this Post-Test.

INSTRUCTIONAL LEARNING SYSTEMS

9.4

REFRIGERATION -- CONDENSERS AND EVAPORATION

Goal:

The apprentice will be able to describe condensers and evaporators.

Performance Indicators:

1. Describe purpose of condensers.
2. Describe types of condensers.
3. Describe purpose of evaporators.
4. Describe types of evaporators.

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LEARNING ACTIVITIES

ACTIVITIES	PURPOSE
Read: Information Sheet #1	Gives the necessary information to complete the objective.
Read: Sections on condenser and evaporators in a refrigeration text or manual	
Do: Take Self Test	Measures your progress

INFORMATION SHEET #1

Condensers

The function of a condenser is to change the high pressure vapor coming out of the compressor into a high pressure liquid. This is done by the principle that heat travels from hot to cold.

The heat that is carried out of the evaporator is removed by the action of the condenser. The compressor raises the pressure of the vapor and, therefore, the temperature. The heat is then transferred out to the outside air and the vapor condenses back to a liquid inside the condenser. (Refer to VIP #309-A)

There are two general types of condensers, 1) Air cooled 2) Water cooled. First we will discuss the air cooled type of condenser.

The condenser is always located in a place so that when it discharges the heat it will not effect the area to be cooled.

Air Cooled Condenser

Air cooled condensers use the outside air to remove the heat and condense the vapor to a liquid. There are two types of air cooled condensers, 1) Ram air 2) Forced air.

Air cooled condensers look a great deal like automotive radiators and work on the same principle.

Ram air condensers can only be used on mobile equipment such as automobiles and trucks. A ram air condenser has to be located on the vehicle where there will be a great deal of air flow through the condenser.

A forced air condenser is the same construction as a ram air condenser. The only difference is that there is a fan or blower to blow air through the condenser.

Figure 1 shows an air cooled condenser.

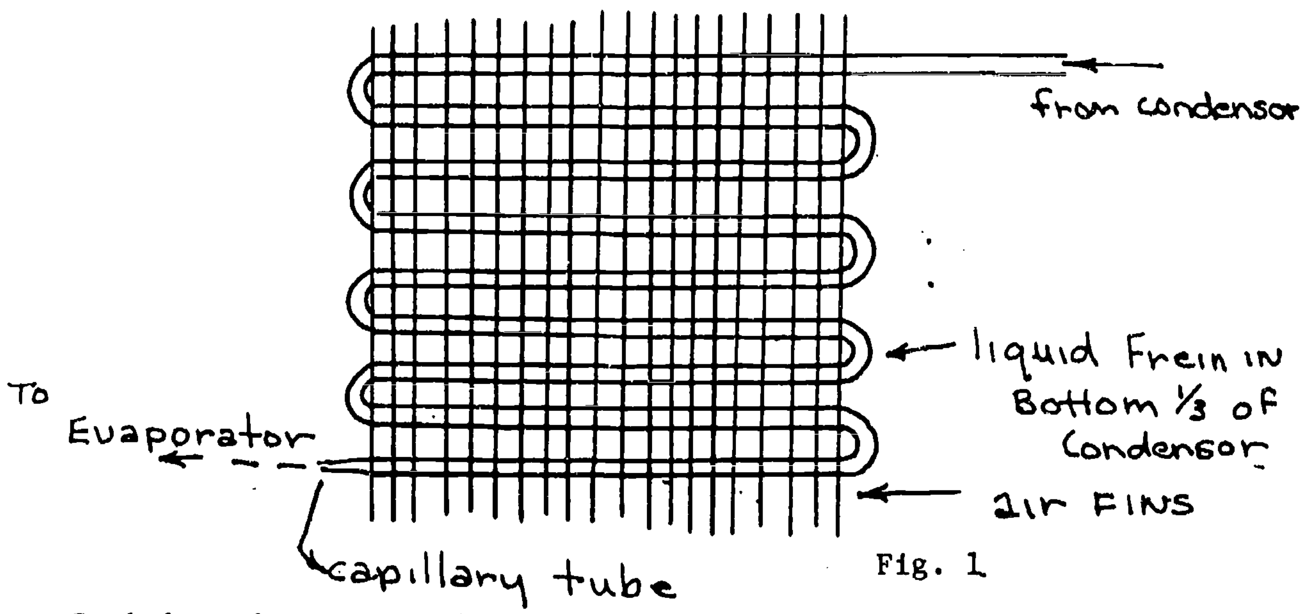

Fig. 1

Water Cooled Condensers

Water cooled condensers are usually found in large refrigeration units. This type of condenser is built in two styles.

1. Tube in a shell condenser
2. Tube in a tube condenser

Figure 2 shows a tube in a shell condenser.

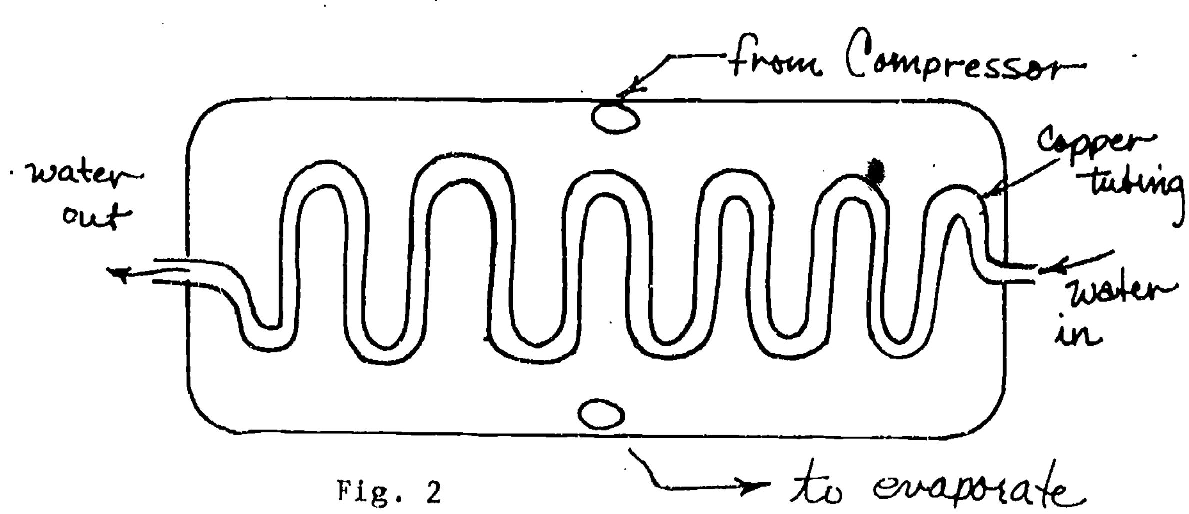

Fig. 2

The water flows through the copper tubing. The freon vapor coming through the container transfers its heat to the water coils. Once the heat is removed from the freon vapor, it condenses to a liquid and the liquid freon leaves the container at the bottom.

Figure 3 shows a tube in a tube condenser.

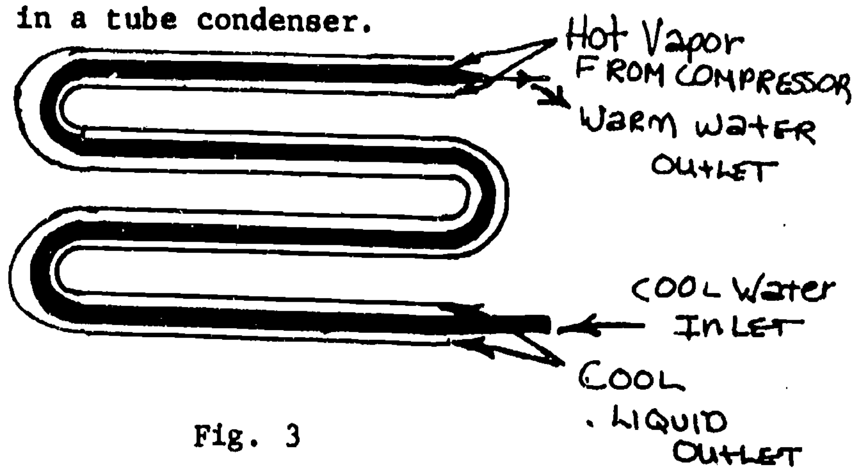

Fig. 3

A tube in a tube condenser has water running in a copper tube inside a tube of freon vapor. The heat of the vapor transfers through the tubing to the water and the vapor condenses to a liquid.

Evaporators

Most evaporators are used for cooling the air and the air in turn cools the contents of the cabinet.

Evaporators are of two principle types:

1. Forced convection evaporator coils

2. Natural convection evaporator coils

Forced convection evaporators use a fan or a blower behind the evaporator to blow air through the evaporator. Air conditioners use the forced convection type of evaporator.

Figure 4 shows a forced convection evaporator.

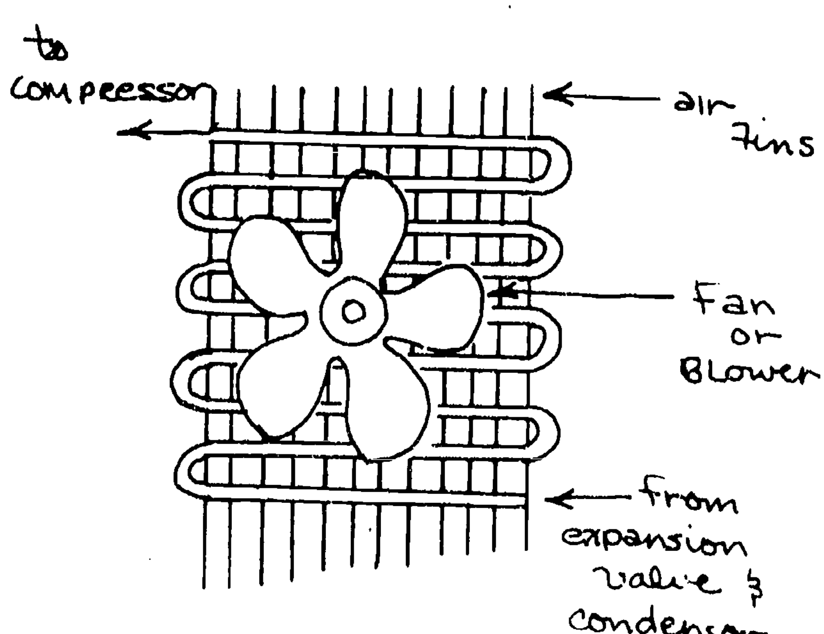

Fig. 4

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Natural convection evaporative coils come in three types:

1. Frosting type
2. Defrosting type
3. Nonfrosting type

The frosting type evaporator was used on older type refrigerators. The evaporator temperature on this type of evaporator is between 5^{o} and $25^{o}F$. The moisture in the air condenses on the evaporator and causes an ice build-up on the evaporator coils. This type of unit has to be defrosted by shutting the unit off periodically. Because the unit freezes the moisture in the air, a drying effect on the food to be frozen or cooled is obtained.

The defrosting type evaporator works at the same temperatures as the frosting type, but there is a thermostat that causes the evaporator to warm up when the evaporator temperature gets too cold. This defrosts the evaporator. The ice melts off and drains to a drain pan. The water that drains into the drain pan usually evaporates as fast as the water comes into the pan.

Nonfrosting evaporators work at a temperature high enough to not allow frost to build up on the evaporator. This type of evaporator is not suitable for a freezer unit. They are most suited for air conditioners.

Evaporators are also classified as to their construction design. The two most popular designs are:

1. Tube and fin
2. Plate type

The tube and fin type looks like an automotive radiator or a condenser. The plate type is made by fusing two pieces of flat steel with grooves. The tube and fin type of evaporator is used on air conditioning units and the plate type is used generally for refrigerator units.

SELF-TEST

Fill in the blanks.

1. The function of a condenser is to change high pressure ______________ to a high pressure ____________________.

2. A ram air condenser uses a ____________________ to move air through the condenser.

3. Forced air condensers are used on ____________________ equipment.

4. The change of state of the freon take place in the bottom_______________ of the condenser.

5. Air conditioning units have_______________convection evaporator coils.

6. Refrigerators normally use_______________convection evaporator coils.

7. A frosting evaporator needs to be _______________periodically.

8. A defrosting type of evaporator _______________the evaporator to defrost.

9. Air conditioners use _______________and_______________constructed evaporators.

10. Refrigerators use _______________ _______________constructed evaporators.

SELF-TEST ANSWERS

1. vapor/liquid
2. fan or blower
3. mobile
4. 1/3
5. forced convection
6. natural convection
7. defrosted
8. warms
9. tube/fin
10. plate type

POST-TEST ANSWERS

CONDENSERS AND EVAPORATORS   Package # 309 D

1. Condenser: Ram air - air cooled

   Evaporator: Forced convection - tube and fin - nonfrosting

2. Condenser: Air cooled - forced air

   Evaporator: Forced convection - tube and fin - nonfrosting

3. Condenser: Air cooled - forced air

   Evaporator: Natural convection - plate type - defrosting type

4. Condenser: Water cooled - either type

   Evaporator: Forced convection - tube and fin - frosting

5. Condenser: Air cooled - forced air

   Evaporator: Forced convection - tube and fin - frosting

POST—TEST

Package Number 309 D

Name ______ Date ______

CONDENSERS AND EVAPORATORS

Give the type and design of condensers and evaporators for the following application:

1. Automotive air conditioner

2. Home air conditioner

3. Home refrigerator

4. Industrial freezer

5. Ice maker

INSTRUCTIONAL LEARNING SYSTEMS

9.5

REFRIGERATION -- PURGE, EVACUATE, RECHARGE

Goal:

The apprentice will be able to describe the procedures for purging, evacuation and recharging of a refrigeration unit.

Performance Indicators:

1. Describe purging of refrigeration unit.
2. Describe evacuation of refrigeration unit.
3. Describe recharging of a refrigeration unit.

1003-A PURGE, EVACUATE, AND RECHARGE REFRIGERATION SYSTEM

Most refrigeration units need little service
but periodically a recharging is necessary.
This package will help you learn this procedure.

Upon completion of this package, you will be able to:

1. Given a basic refrigeration unit, purge, evacuate and recharge the sealed system to manufacturer's specifications.

LEARNING ACTIVITIES

ACTIVITIES	PURPOSE
Read: Instruction Sheet #1	1. Gives you the necessary information for completing the first objective. 2. To further acquaint you with the terms of refrigeration.
Do: Take Self Test	1. Clerify important terms

INFORMATION SUMMARY

Having completed this package, you will know the following information.

Repair of aluminum components in a refrigeration system is not practical, they should be replaced.

Piercing valves are most commonly used for tapping a hermetically sealed unit. They are always installed in the suction line, which is on the low side of the unit, so that after the unit has been evacuated, the gas can be replaced in a vapor, with the unit running. While running, the unit draws the vapor from the top of the gas drum.

Some hermetically sealed units have charging valves. If this be the case, gas may be installed in liquid form from a metering device. The unit must not be running. The liquid will be drawn into the unit by the vacuum that was created while evacuating the system with the vacuum pump.

When charging the unit, always open the valve on the gas drum first. Allow the gas to flow up to the charging valve, and before opening the charging valve, loosen the hose fitting, allowing the gas to escape for a short period of time. This will force all of the moisture laden air out of the hose. After tightening the hose, then open the charging valve.

When pulling a vacuum on a refrigeration unit, allow the vacuum pump to run for at least one half hour. After shutting down the pump, wait for at least one half hour to make sure the vacuum holds before charging the unit.

A clean shop, tools and equipment are most important to a successful repair job on refrigeration units.

INFORMATION SHEET #1

Figure 1 shows a manifold with gauges and hoses. For the purpose of this package, the black scale (outside scale) will be used on each gauge. (Colors not indicated in Figure) The low pressure gauge ranges from 30 inches of vacuum to 250 psi. The high pressure gauge ranges from 0 - psi, to 500 psi. The low pressure gauge will be the only one used in this package.

Note: psi = pounds per square inch

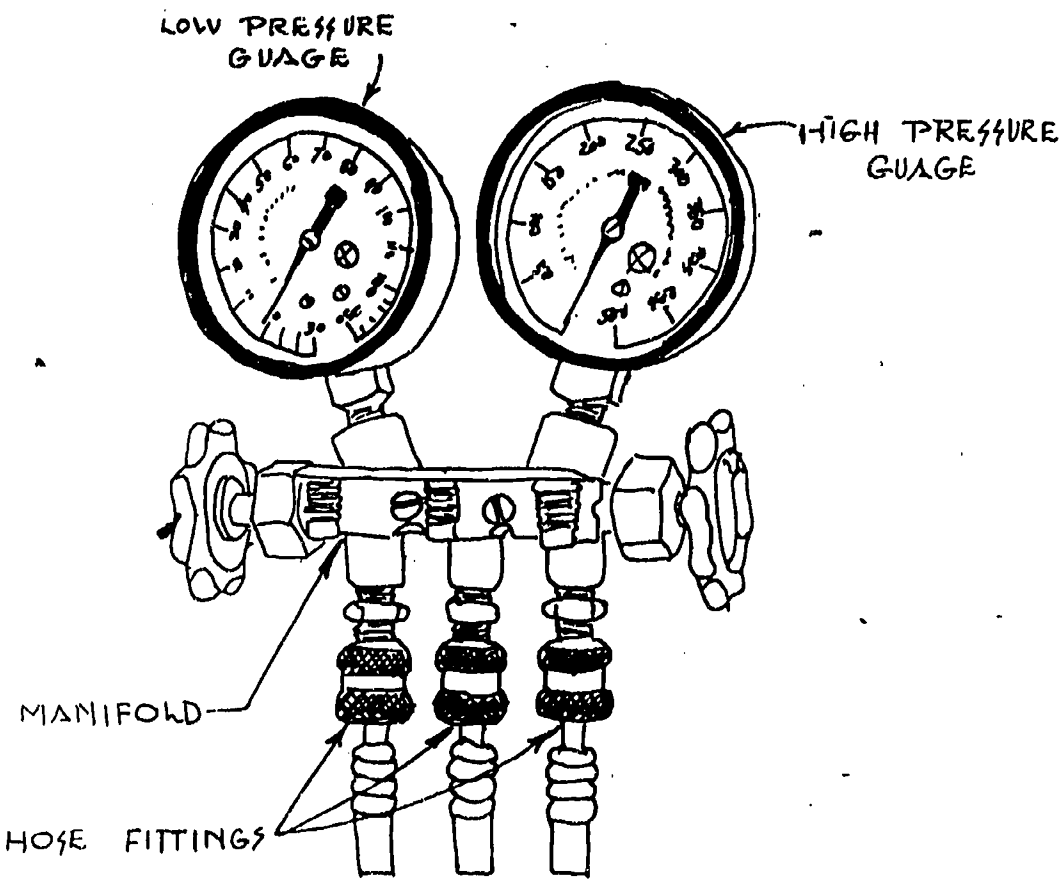

Fig. 1

Figure 2 shows a piercing valve fixed to a copper tube. Once this valve is installed, it will be left on the unit. Figure 3 shows another type of piercing valve.

The method of installing these valves will be obvious to the user upon close inspection. Always install piercing valve in the suction line and where it will be easy to work on.

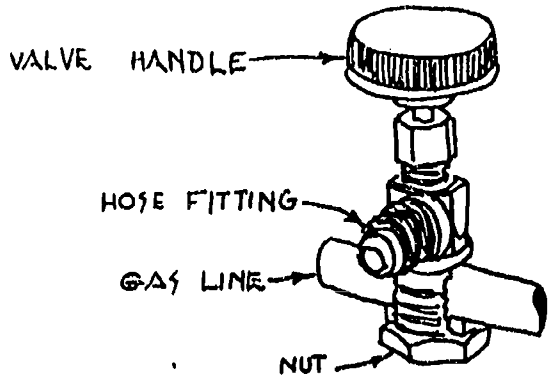

Fig. 2

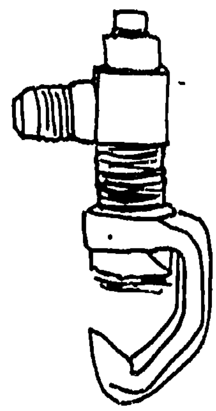

Fig. 3

Figure 4 shows the hook-up for purging, evacuating and charging a refrigeration unit.

Step 1: Install piercing valve on low side line to compressor. Close valve.

2: Hook up manifold as shown in Figure 4, with all valves in the closed position. Do not hook up vacuum pump at this time.

3: Open piercing valve. With the compressor running open the low side valve slowly. EYE PROTECTION MUST BE WORN AT THIS TIME. Caution: If the low side valve is opened too much the compressor oil will be drained with the freon. Purge the system until the low side guage reads zero.

4: Turn off compressor, hook-up vacuum pump. Run the vacuum pump for 1/2 hour.

5: Close low pressure valve and turn off vacuum pump. Wait another 1/2 hour, if vacuum holds proceed to step #6. If the vacuum drops there is a leak in the system and further repair is needed.

6: Open valve on freon tank, loosen fitting of tank, loosen fitting of tank hose at manifold and allow a small amount of freon to escape, then tighten hose fitting.

7: Start compressor, open high pressure valve, meter gas in by turning high pressure valve off and on.

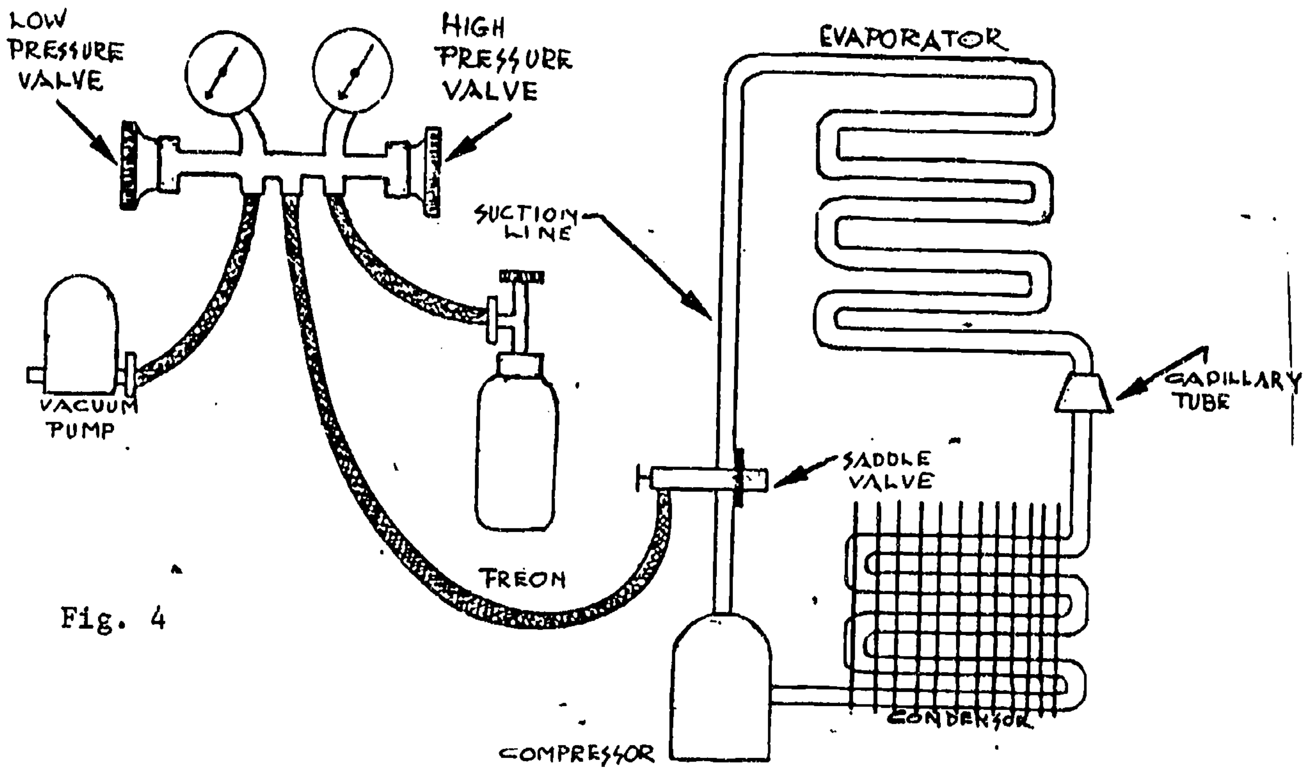

Fig. 4

Figure 5 is a dispensing valve for small cans of freon. Many times you will use these small cans because they are much easier to handle due to their weight. They hold 1 pound of gas, and may be disposed of after use.

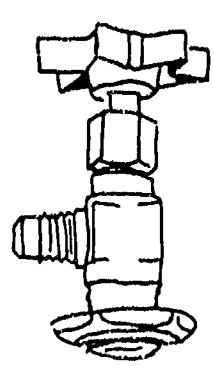

Fig. 5

Figure 6 shows the valve fixed to a small can of gas. The valve may be used many times.

Depending on materials available to the instructor, you may use oı may not use this valve and the small cans of gas.

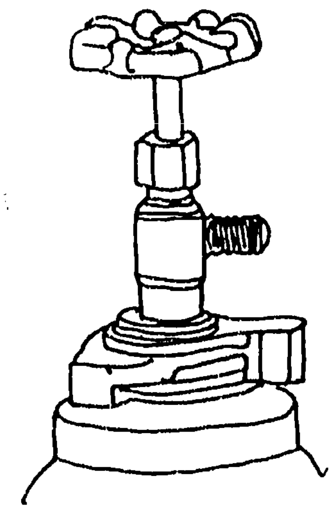

Fig. 6

Self-Test:

Look up key index words.

1. manifold
2. piercing valve
3. flaring tool
4. tube cutter
5. vacuum
6. purge

POST—TEST

Package Number 1003 A

PURGE, EVACUATE AND RECHARGE REFRIGERATION SYSTEM

Name ______________ Date ______________

Obtain a refrigeration or air conditioning unit and purge, evacuate and recharge the sealed system.

INSTRUCTIONAL LEARNING SYSTEMS

9.6

REFRIGERATION -- TROUBLESHOOTING

Goal:

The apprentice will be able to describe basic troubleshooting procedures in refrigeration.

Performance Indicators:

1. Describe common symptoms of refrigeration problems.
2. Describe common problems that require troubleshooting.

1002-D REFRIGERATION TROUBLESHOOTING

Before condemning the sealed system in a refrigerator, the electrical system should be checked. This package explains trouble-shooting procedures in refrigeration.

1. Given a refrigeration unit with an electrical problem, and the necessary tools, you will be able to determine the problem and describe it to the instructor.

2. Given a refrigeration unit with a mechanical problem, and the necessary tools, you will be able to determine the problem and describe it to the instructor.

LEARNING ACTIVITIES

ACTIVITIES	PURPOSE
Read: Information Sheet #1	
Read: Information Sheet #2	Give troubleshooting for electrical and mechanical refrigeration problems.
Read: Information Summary	
Do: Take Self Test	To further your understanding.

Information Sheet #1

REFRIGERATION TROUBLESHOOTING

Much time is used in troubleshooting, and in business time is money. Therefore, a complete knowledge of the theory of operation, and the construction of the system is essential to a repairman. You may refer to the package on Refrigeration Theory, while doing this package.

Figures 1 and 2 will be used to show the steps to follow for troubleshooting the electrical system.

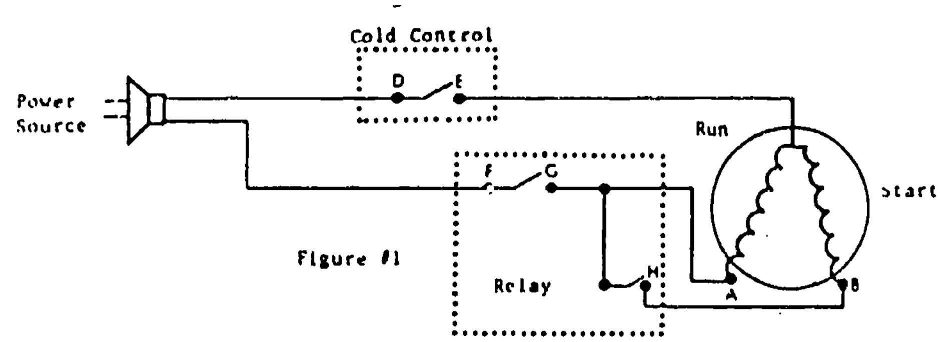

Figure #1

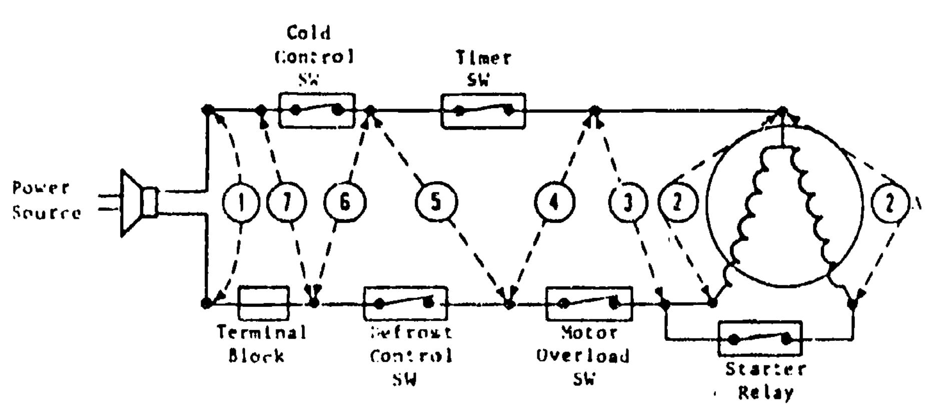

Figure #2

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All troubles fall into two groups. Either the unit does not run, or it does not run properly.

PROBLEM 1. Does not run.

a. Check power cord and fuse or breaker.
b. Check cold control thermostat with unit disconnected from power source, using a continuity tester.
c. Check for power at motor terminals AB & C. Lack of power on either starting or running terminals means circuit trouble. Use Figure 1 for reference.
d. Test power between relay terminals F & C. Power between F & A or F & B. Use Figure 1.
e. A test between C & G, also between C & H is the next step. Lack of power between either of these poin*s means faulty relay use Figure 1.
f. Figure 2 shows a step by st method, to check for power as they would be made. The dotted lines ow where to place the leads of the voltmeter. Unit must be plugged into ower source for this test. If all switches are closed, voltage across any pair of the 7 numbered points would indicate no trouble between the power source and the points being tested. A no voltage reading would indicate trouble in the control, somewhere between the two points being tested and the power supply. NOTE: A jumper wire could be used across the control switch in doubt to double check it.

PROBLEM 2. Motor hums, but will not start.

Step #2 in Figure 2 would show voltage for a short period of time, and then no voltage; this would be intermittent, and would indicate that the compressor is stuck, and must be replaced. Test 2A, Figure 2 would indicate the same thing.

The reason for intermittent voltage is the cutting in and out, of the motor's overload protective device.

NOTE: In most cases, cold controls, and relays can not be repaired; they must be replaced. Defrost timers can be repaired. Usually it means replacing the timer motor.

Information Sheet #2

REFRIGERATION TROUBLESHOOTING

Having covered the electrical problems, we will not assume, that the unit is electrically in good condition.

PROBLEM: Unit runs but will not get cold.

1. First check the gas filled temperature sensing bulb or tube on the cold control. Be sure it is clamped securely to its bracket. Too much frost surrounding this tube will cause it to malfunction. Also make sure the cold control tube is not broken, if so replace complete cold control unit.

2. Check the condenser! If air passages or surfaces of the condenser are dirty, the unit cannot dispose of its heat, and will continue to run. Clean condenser thoroughly.

3. Check the evaporator! If you can see that only a portion of the evaporator is icing up, you will know one of two things. Either the unit has lost some of its gas, through a leak or there is a restriction in the system. The restriction, will normally be found in the capillary tube, (liquid line). If leak is found, repair leak and recharge unit. If a restriction is located, you will have to replace the evaporator, which has the liquid line (capillary) and the suction line assembled at the factory. Instructions for this will be found in another package.

4. If, when checking the evaporator, you find no ice whatsoever, one of two things are possible. Either the unit has lost most of its gas, through a leak, or the divider block is stuck in the compressor. Check for leaks, if no leaks are found, you must replace the compressor. Instructions for this will be found in another package.

PROBLEM. Unit runs, and gets too cold.

This problem can only be the cold control. If it checks out electrically, (i.e. the switch is not stuck closed) and the gas filled tube is secure in its bracket, the complete control must be replaced.

PROBLEM. Too much moisture in box.

Check the seal on the door. A loose fitting door (poor seal) will allow warm moist air to enter the box. This moisture in the air condenses to liquid, and causes frost build up on the evaporator, and will drip into the storage section of the unit. This applies to refrigerators and freezers only.

INFORMATION SUMMARY

Having read this package you will know the following.

Cold controls can do no more than start and stop the compressor motor, to control the temperature in the evaporator.

Condensors conduct heat from the refrigerant to the surrounding temperature, they have no control of the amount of heat carried by the refrigerant.

Evaporators only conduct heat from their surrounding temperatures, to the refrigerant within them.

Liquid metering devices (capillaries) can only regulate the flow of liquid into the evaporator, providing there is liquid under pressure.

Two things are very important. Each component has its function. #1 The component is responsible for its particular function. #2 No other component can cause that particular malfunction.

SELF-TEST-Answer the following questions

1. The refrigerator is running continuously, and getting too cold. What is the problem?

2. The refrigerator will not run. What is the first thing to check?

3. Water is dripping inside the refrigerator box, what is the most likely cause?

4. Frost is covering only a small portion of the evaporator, what two things can cause this problem?

SELF-TEST ANSWERS

1. Malfunction of the cold control.

2. The power source

3. Door gasket is not fitting properly, allowing air to enter the box.

4. The unit is low on gas, or there is a restriction in the line.

POST—TEST

Package Number 1002 D

Name ____________ Date ____________

REFRIGERATION TROUBLE SHOOTING

Obtain a refrigerator or air conditioner, with trouble in the electrical and/or the mechanical system. You will locate this trouble and describe it to the instructor.