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AUTOMOTIVE DIESEL MAINTENANCE L. UNIT XII, PART I--MAINTAINING THE FUEL SYSTEM (PART II), CUMMINS DIESEL ENGINE, PART II--UNIT INSTALLATION (ENGINE).

HUMAN ENGINEERING INSTITUTE, CLEVELAND, OHIO

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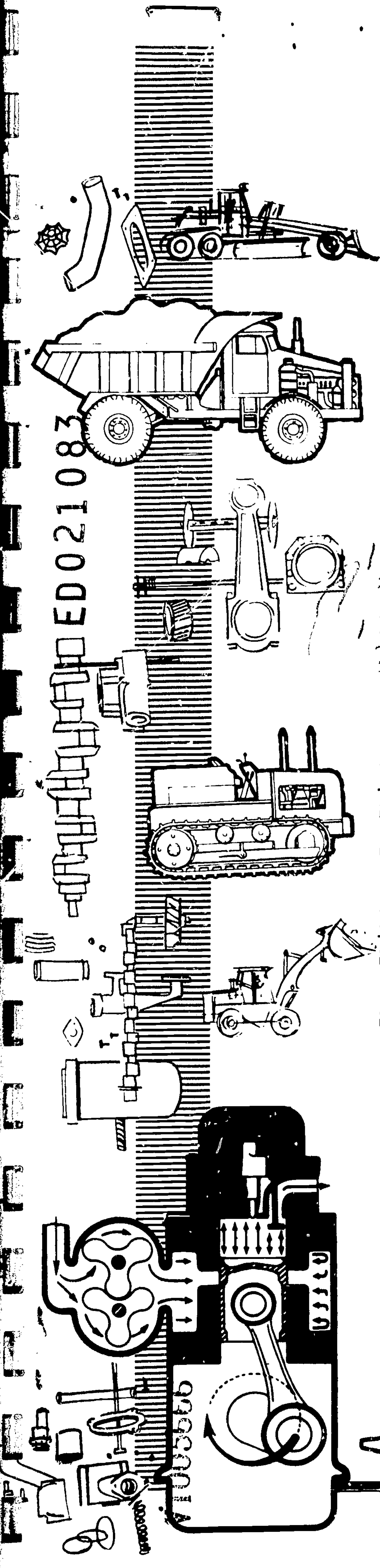
THIS MODULE OF A 30-MODULE COURSE IS DESIGNED TO DEVELOP AN UNDERSTANDING OF THE OPERATION AND MAINTENANCE OF THE DIESEL ENGINE FUEL SYSTEM AND THE PROCEDURES FOR DIESEL ENGINE INSTALLATION. TOPICS ARE FUEL FLOW CHARACTERISTICS, PTG FUEL PUMP, PREPARATION FOR INSTALLATION, AND INSTALLING ENGINE. THE MODULE CONSISTS OF A SELF-INSTRUCTIONAL BRANCH PROGRAMED TRAINING FILM "PRINCIPLES OF TORCH CUTTING" AND OTHER MATERIALS. SEE VT 005 655 FOR FURTHER INFORMATION. MODULES IN THIS SERIES ARE AVAILABLE AS VY 005 655 - VT 005 684. MODULES FOR "AUTOMOTIVE DIESEL MAINTENANCE 2" ARE AVAILABLE AS VT 005 685 - VT 005 709. THE 2-YEAR PROGRAM OUTLINE FOR "AUTOMOTIVE DIESEL MAINTENANCE 1 AND 2" IS AVAILABLE AS VT 006 006. THE NEXT MATERIAL, TRANSPARENCIES, PROGRAMED TRAINING FILM, AND THE ELECTRONIC TUTOR MAY BE RENTED (FOR $1.75 PER WEEK) OR PURCHASED FROM THE HUMAN ENGINEERING INSTITUTE, HEADQUARTERS AND DEVELOPMENT CENTER, 2341 CARNEGIE AVENUE, CLEVELAND, OHIO 44115. (HC)



STUDY AND READING MATERIALS

AUTOMOTIVE DIESEL MAINTENANCE 1

PART I - MAINTAINING THE FUEL SYSTEM (PART II) CUMMINS DIESEL ENGINE

PART II - UNIT INSTALLATION (ENGINE), UNIT XII

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HUMAN ENGINEERING INSTITUTE

I - MAINTAINING THE FUEL SYSTEM (PART II) CUMMINS DIESEL ENGINE

SECTION A -- FUEL FLOW CHARACTERISTICS

Before covering the various component parts of the Cummins fuel system in detail, let's review the fuel flow and some of the concepts about the system that are vital to its operation.

REQUIREMENTS OF AN INJECTION SYSTEM -- In delivering fuel to the cylinders, the fuel injection system must fulfill the following requirements:

1. Meter or measure the correct quantity of fuel injected.
2. Time the fuel injection.
3. Control the rate of fuel injection.
4. Atomize or break up the fuel into fine particles according to the type of combustion chamber, and properly distribute the injected fuel.

METERING -- Accurate metering or measuring of the fuel means that, for the same fuel control setting, the same quantity of fuel must be delivered to each cylinder for each power stroke of the engine. Only in this way can the engine operate at uniform speed with a uniform power output. Smooth engine operation and an even distribution of the load between the cylinders depend upon the same volume of fuel being admitted to a particular cylinder each time it fires; and upon equal volumes of fuel being delivered to all cylinders of the engine.

TIMING -- In addition to measuring the amount of fuel injected, the system must properly time the injection to ensure efficient combustion so that maximum energy can be obtained from the fuel. When the fuel is injected too early in the cycle, ignition may be delayed because the temperature of the air at this point is not high enough to ignite the fuel. An excessive delay, on the other hand, does not allow the atomized fuel to mix with the air, which in turn causes high cylinder pressures, incomplete burning and gives rough and noisy operation of the engine. It also permits some fuel to be lost due to the wetting of the cylinder walls and piston head. This, in turn, results in poor fuel economy, high exhaust gas temperature, and smoke in the exhaust. When fuel is injected too late in the cycle, all the fuel will not be burned until the piston has traveled well past top center. When this happens, the engine will not develop its maximum power, the exhaust will be smoky, and the fuel consumption will be high. Late injection can also result in burnt pistons and upper compression rings.

CONTROL OF RATE OF FUEL INJECTION -- A fuel system must also control the rate of injection. The rate at which fuel is injected determines the rate of combustion. The rate of injection at the start should be low enough so that excessive fuel does not accumulate in the cylinder during the initial ignition delay (before combustion begins). Injection should proceed at such a rate that the rise in combustion pressure is not excessive, yet the rate of injection must be such that fuel is introduced as rapidly as possible in order to obtain complete combustion.

An incorrect rate of injection will affect engine operation in the same way as improper timing. If the rate of injection is too high, the results will be similar to those caused by an excessively early injection; if the rate is too low, the results will be similar to those caused by an excessively late injection. The rate of injection is, in effect the rise and fall of pressure as a definite quantity of fuel is injected into the combustion chamber.

ATOMIZATION OF FUEL -- As used in connection with fuel injection, atomization means the breaking up of the fuel, as it enters the cylinder, into small particles which form a mist-like spray. Atomization of the fuel must meet the requirements of the type of combustion chamber in use. Some chambers require very fine atomization, others can function with a more coarse atomization. Proper atomization facilitates the starting of the burning process and ensure that each minute particle of fuel will be surrounded by particles of oxygen with which it can combine.

Atomization is generally obtained when the liquid fuel, under high pressure, passes through the small opening (or openings) in the injector or nozzel. As the fuel enters the combustion space, high velocity is developed because the pressure in the cylinder is lower than the fuel pressure. The created friction, resulting from the fuel passing through the air at high velocity, causes the fuel to break up into small particles.

DISTRIBUTION OF FUEL -- A fuel injection system must increase the fuel pressure sufficiently to overcome compression pressures and to ensure proper dispersion of the fuel injected into the combustion space. Proper dispersion is essential if the fuel is to mix thoroughly with the air and burn efficiently. While pressure is a prime contributing factor, the dispersion of the fuel is influenced, in part, by atomization and penetration of the fuel. (Penetration is the distance through which the fuel particles are carried by the kinetic energy imparted to them as they leave the injector or nozzle. Friction between the fuel and the air in the combustion space gradually absorbs this energy.)

If the atomization process reduces the size of the fuel particles too much they will lack penetration. Lack of sufficient penetration results in the small particles of fuel ignition before they have been properly distributed, or dispersed in the combustion space. Since penetration and atomization tend to oppose each other, a compromise in the degree of each is necessary in the design of fuel injection equipment, particularly if uniform distribution of fuel within the combustion changer is to be obtained. The pressure required for efficient injection and, in turn, proper dispersion is dependent upon the compression pressure in the cylinder, the size of the opening through which the fuel enters the combustion space, the shape of the combustion space, and the amount of turbulance created in the combustion space.

COMPONENTS OF THE CUMMINS FUEL SYSTEM -- The components that make up the Cummins fuel system vary with engine design and specific applications. Figure 1 shows the fuel flow through a V8 type engine. The components consist of a PTG fuel pump, eight injectors, a fuel filter, and piping with connections. The heart of this or any Cummins fuel system is the fuel pump which we will cover in this unit in detail.

As mentioned earlier, the PT (pressure time) system is based on simple hydraulic fundamentals. First, any pressure change in an oil-filled system is transmitted equally and immediately throughout the system. Secondly, if oil is pumped into an open system, the amount delivered at the open end will vary with pressure changes. Thirdly, the total amount delivered will vary with time, hence, the pressure time system.

A diagram of the PT system is shown in Figure 2. Fuel (shown by arrows) is supplied by the fuel pump to all injectors through a manifold at comparatively low pressures (120 psi) that are controlled by the governor and throttle valve located in the pump.

SECTION B -- PTG FUEL PUMP

FUEL PUMP ASSEMBLY -- Four items make up the fuel pump assembly: a supply pump, a governor assembly which controls the fuel pressure delivered by the pump in relation to engine speed, a throttle to control the fuel pressure delivered from the pump to the injectors, and a shut-down valve. Another system component (not part of the PTG fuel pump) is the PTB injector, a modification of the earlier types that meters, pressurizes and injects the fuel. These will be covered in detail in another unit.

Still another component (not part of the fuel pump) used exclusively on turbocharged engines is the ANEROID control. This control will be covered more thoroughly in a later unit. Briefly, this control overrides the fuel pump by limiting fuel pressure to the injectors during the period of

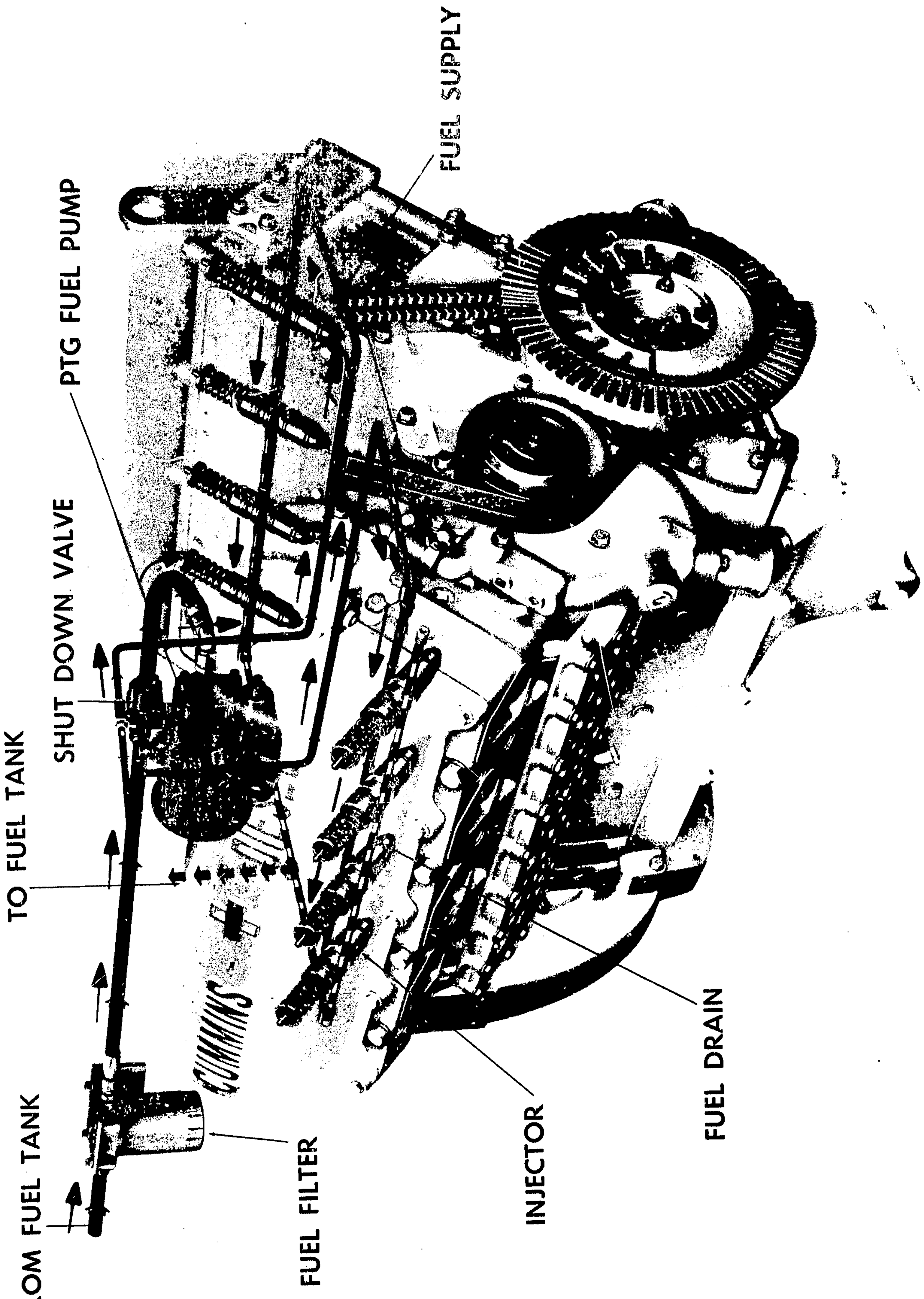

Figure 1

V6 (VIM)/V8 (VINE) FUEL OIL FLOW

CUMMINS

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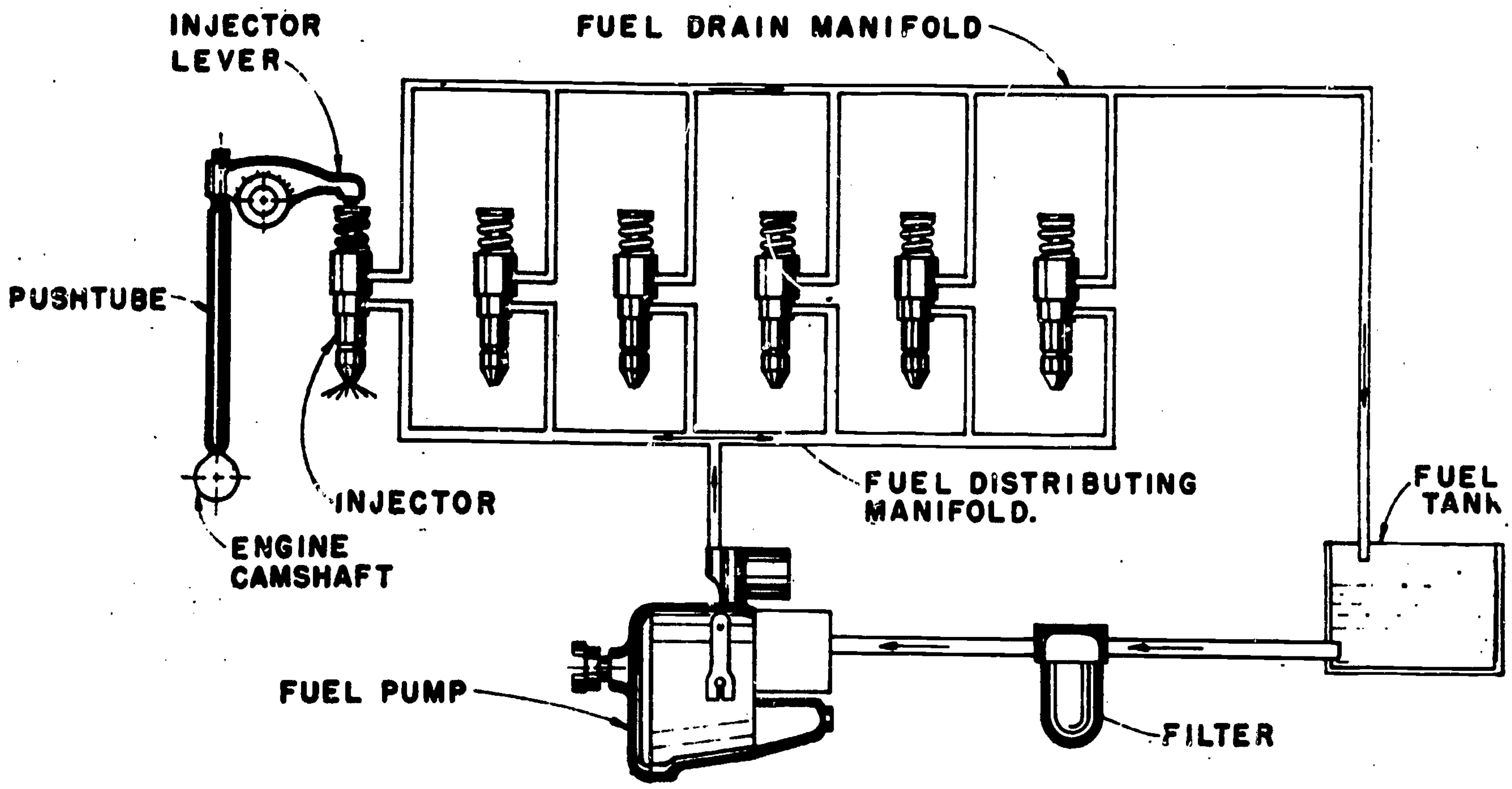
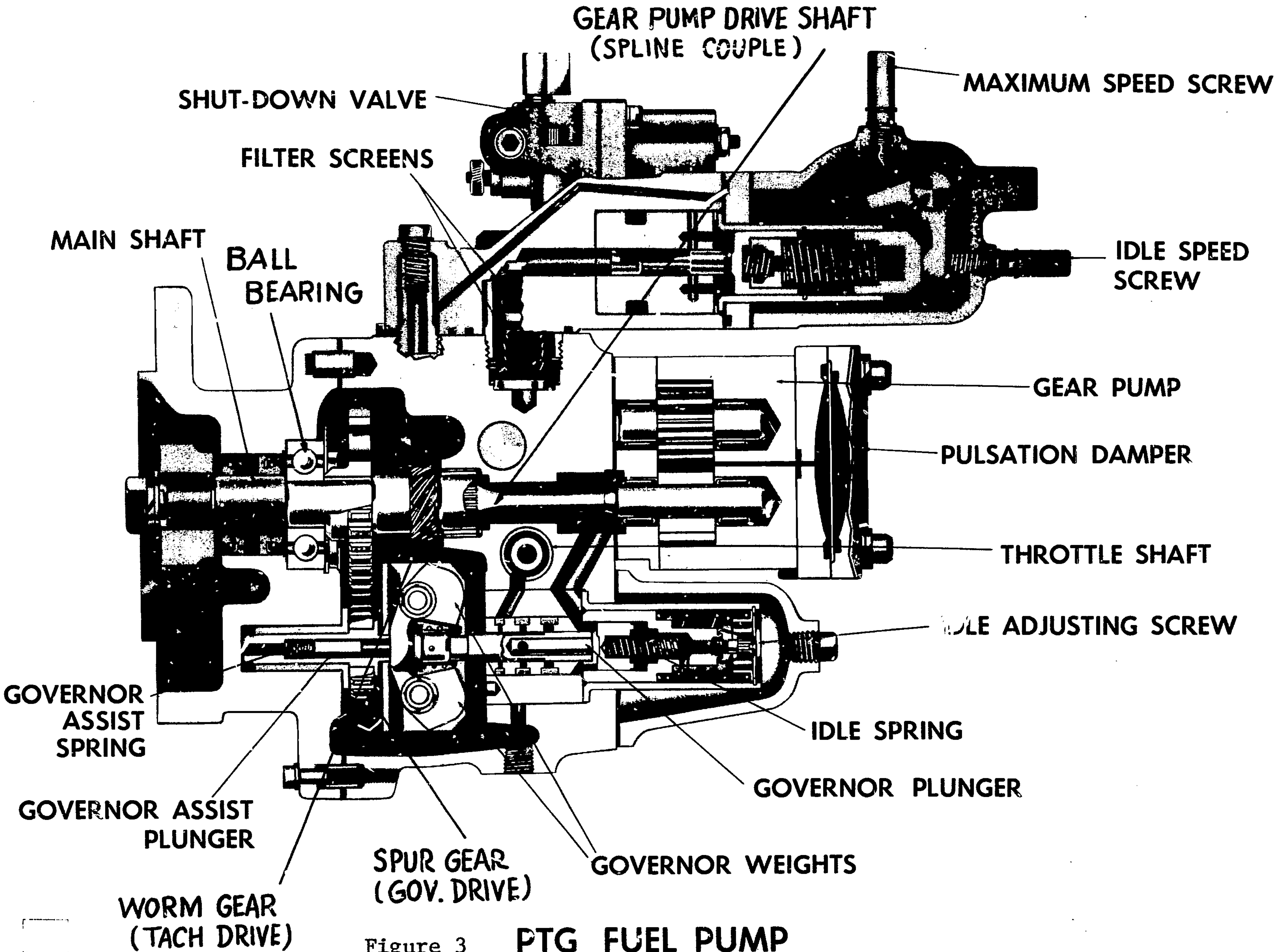


Fig. 2 Cummins fuel arrangement.

accelerating from speeds below normal operating speed range when manifold air pressure is not sufficient for complete combustion.

Figure 3 shows a cross-sectional view of the Cummins PTG fuel pump. We will be referring to Figure 3 continually during the remaining part of this unit.

FUNCTIONAL OPERATION -- Depending on the type of engine, the fuel pump is mounted either on the side or top of the engine. Figure 1 shows it mounted on the top, located at the rear of the engine. In this case it is gear driven by the gear train located at the rear of the engine. On other engine models, the pump is mounted directly behind the air compressor on the lower right side of the engine. The air compressor is belt driven. The pump's main shaft, (see Figure 3), is connected by means of a flange



CUMMINS

Figure 3 **PTG FUEL PUMP**

MECHANICAL VARIABLE SPEED GOVERNOR

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to the shaft of the air compressor. The shaft rotates in a ball bearing and two seals at the coupling end. A spur gear drives the governor, and a worm gear drives the tachometer shaft, (see Figure 3). Incidentally, a special adapter fitting is required to obtain a hand tachometer reading from the fuel pump at this point.

On top of the main housing is an electric solenoid shut-off valve which closes and stops fuel delivery to injectors whenever the solenoid switch is closed.

In Figure 3, notice the FILTER SCREENS. All fuel from the gear pump must go through and be strained by this filter assembly.

Figure 4 shows the filter assembly being removed for cleaning. The filter and screens should be cleaned with cleaning solvent and blown dry with compressed air every 1000 hours of operation (approximate). NOTE: Whenever an assembly is replaced, a new "O" ring must be used, and the assembly tightened to 20/25 foot pounds of torque.

The governor weight shaft rotates in a bronze bushing located at the front of the pump, (see Figure 3). A governor plunger -- guided by a barrel -- operates between the toes of the governor weights and the governor spring pack. The spring loaded governor assist plunger, sometimes called the low speed torque control spring, (see Figure 5), contacts one end of the governor plunger. During operation fuel is delivered to the fuel groove on the governor plunger, (see Figure 5). A fuel bypass circuit is provided from this fuel groove through an axial hole out the end of the plunger and back to the inlet pump. All fuel that is not delivered to the injectors is discharged from the gap between the end of the governor plunger and the button. Some fuel is bypassed under all operating conditions.

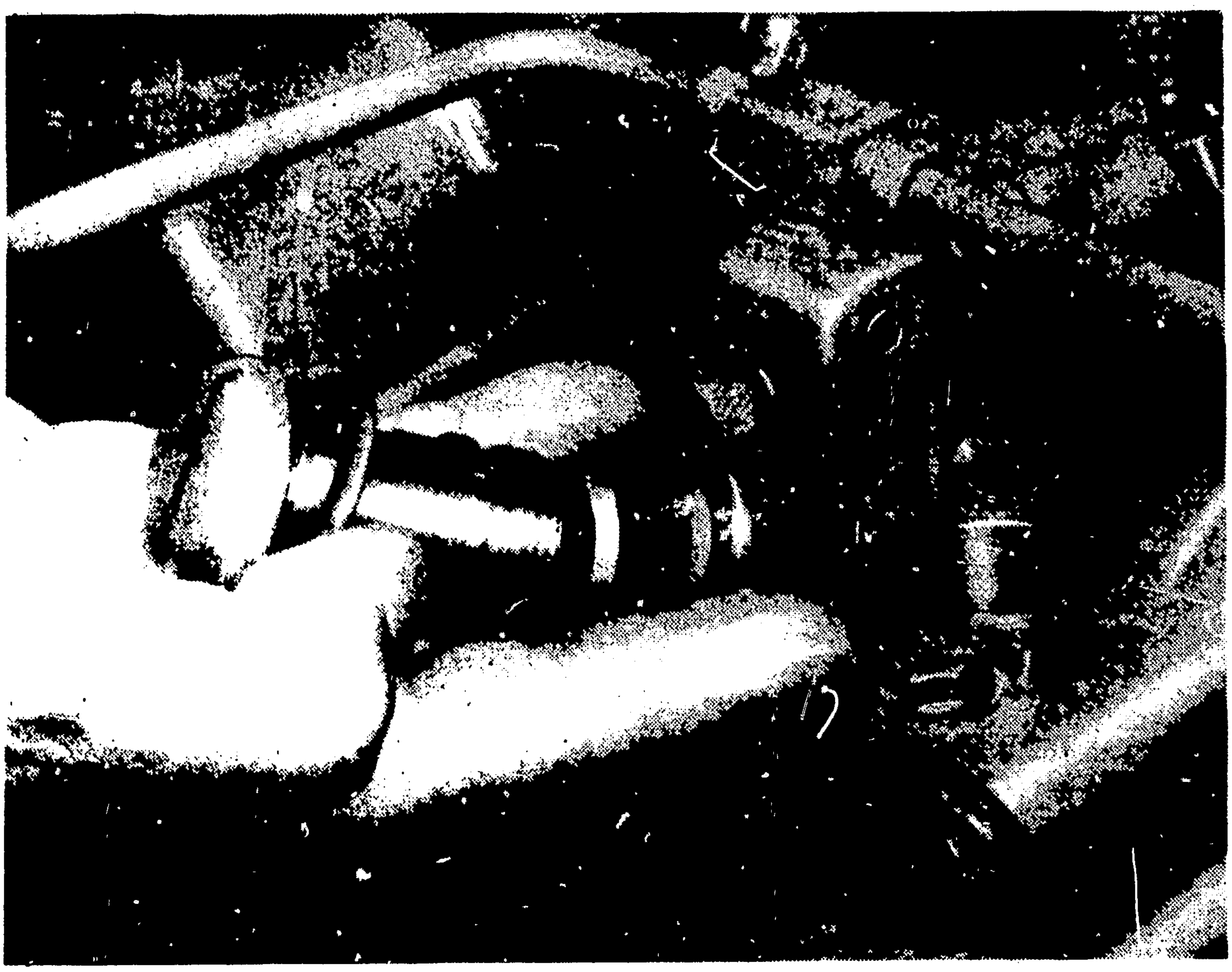


Fig. 4 Fuel pump screens.

The pressure delivered by the fuel pump is determined by the result of the governor and spring forces acting to close the gap between the end of the plunger and the pressure control button, (see Figure 5). This fuel pressure from the pump is independent of the throttle position, but is directly related to engine speed.

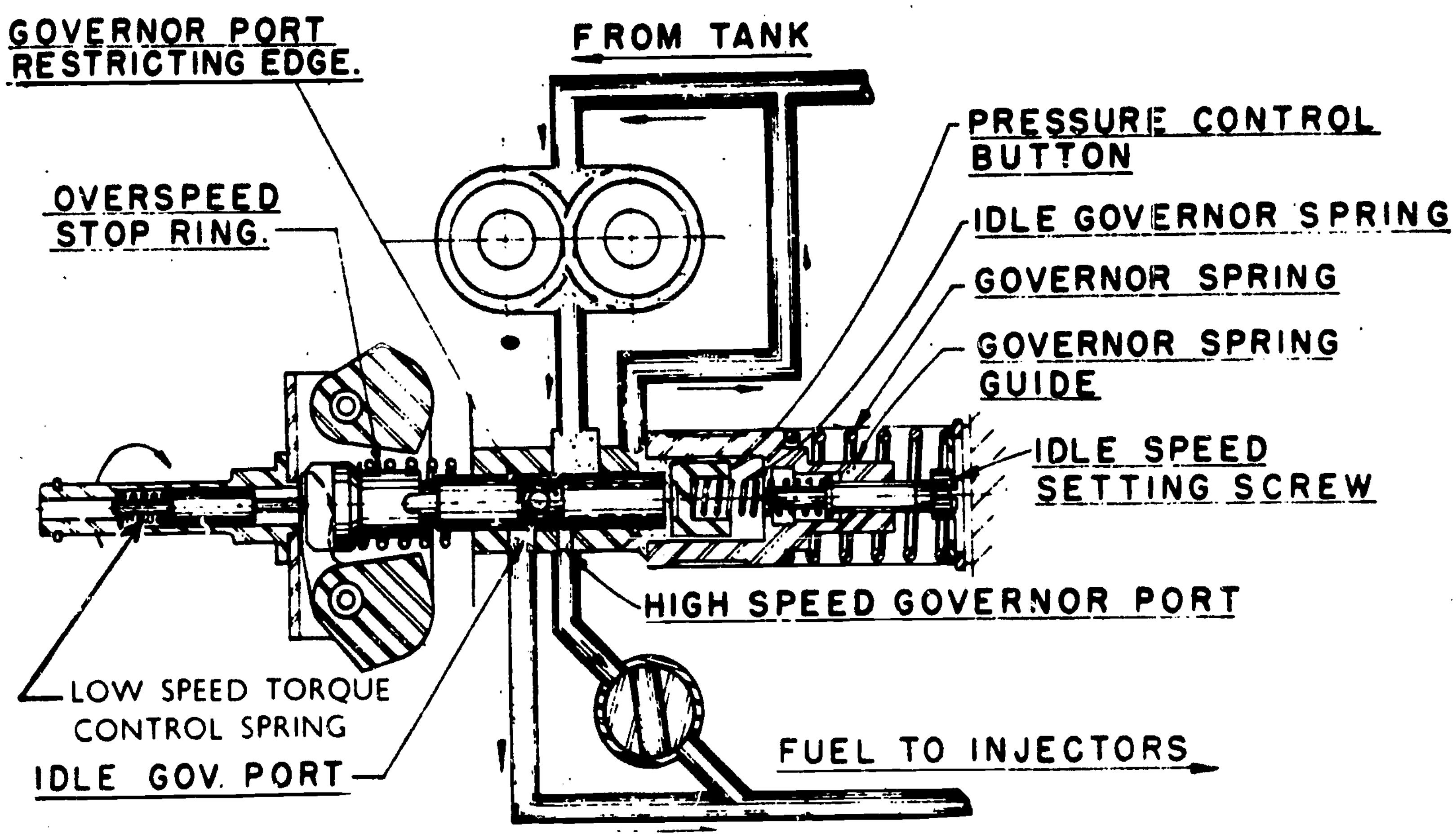


Fig. 5 Schematic flow diagram of Cummins fuel pump.

At idling speed, fuel passes through the idle governor port to the injectors. The throttle controls fuel flow in the range between idling and maximum governed speed. Above idling, fuel flows through the hole in the throttle shaft. By turning this shaft, the indexing of its hole with a fixed port is varied.

Throttle movement produces instantaneous response in fuel pressure at the injector. With wide-open throttle, maximum fuel manifold pressure ranges from 40 to 182 psi, depending upon the engine model. Pressures will be reduced as the throttle is closed and flow area decreased. Sensitive control of pressures is obtained which, combined with the time factor (a function of engine rpm), governs the amount of fuel delivered.

All fuel must pass the relief on the governor plunger on its way to the injectors. The governor regulates the fuel pressure and controls idling and maximum engine speeds. At idling, the throttle valve is closed and fuel is supplied through the idle governor port (see Figure 5). In case of overspeed at idling, the governor plunger moves to the right and shuts off the fuel at the idle governor port. If maximum engine speed is excessive, the plunger moves farther to the right, overcoming the force of the large governor spring, so that governor port restricting edge reduces fuel flow to the throttle at the high-speed governor port.

The use of the torque control spring, shown around the overspeed stop ring in Figure 5, provides increased engine torque as operating speed is decreased below rated rpm.

This completes the study of the internal parts of the mechanism for controlling fuel manifold pressure. However, as we know the PT system must be considered as a whole, including the injectors, because the final metering orifice is the injector. Injectors will be covered in the following unit.

II - UNIT INSTALLATION (ENGINE)

SECTION A -- PREPARATION FOR INSTALLATION

This portion of the unit will cover the steps the maintenance mechanic must know when he is installing rebuilt engines in Euclid 14 or 15 FFD trucks or MACK LYSW and M 45 trucks. Many of the procedures apply to other types of vehicles as well. Some maintenance and safety precautions will be inserted throughout this section.

Prior to mounting the rebuilt engine in the truck, there are three components that have to be installed. This can be accomplished while the engine is on the cart. These components are:

1. Steering booster pump.
2. Generator or alternator.
3. Air starter.

STEERING BOOSTER PUMP -- the steering booster pump is mounted as follows:

1. Attach pump with support bracket to the proper place on the engine housing.
2. Insert key into groove on pump drive shaft.
3. Press pulley onto the shaft. Tighten the join nut and pulley set screw.
4. Check V-belt for cracks and fraying before positioning on accessory drive pulley and pump pulley.
5. Tighten the adjusting screw join nut and adjusting screw until the pressure of the index finger depresses the belt as shown in Figure 1.

GENERATOR/ALTERNATOR -- The next step is installing the rebuilt generator or alternator. A note of caution here, be certain the generator or alternator is the same type and rating as the one that was removed, and that it matches the regulator on the truck.

Installation steps are as follows:

1. Mount unit to generator-to-motor mounting bracket (use shims if required). If bracket does not have the word "TOP" stamped on it, be sure to mount the unit so the top unit-to-bracket mounting holes are closer to the horizontal center line of the bracket. Failure to do so will place lubricating oil cup and oil passages out of position.
2. On gear driven generators, install the rubber buffer between the generator coupling and drive coupling; connect the two units. Mount generator and bracket assembly to the block.

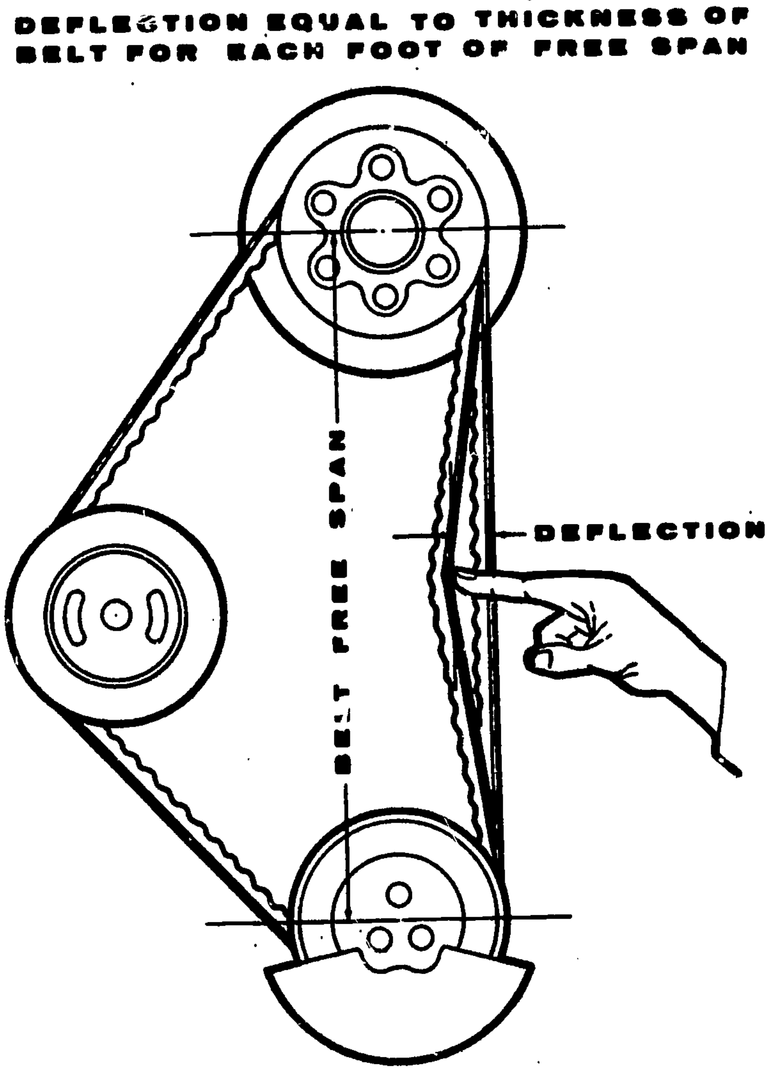


Fig. 1 Checking belt tension.

3. On belt driven generators, install belt(s) over drive pulley.

   Note: When two or more belts are used they must be replaced as a set.

   When installing belts, always shorten the distance between pulley centers so belt(s) can be installed without force. Never roll or tighten a belt over the pulley and never pry it on with a tool such as a screwdriver. Both of these methods will damage belts and cause early failure.

   Diagonal cuts on a failed belt indicate that the failure was caused by rolling a tight belt over the pulley. Cuts from prying a belt in place may be either diagonal or vertical. Again always replace pairs of belts in complete sets to prevent early failure and to provide efficient operation.

4. Adjust generator for proper belt tension, see Figure 1. Figure 2 shows the proper installation for a generator. Be sure not to over tighten belts - this can cause crankshaft failure.

5. Connect wiring leads to proper terminals.

AIR STARTER OR ELECTRIC CRANKING MOTOR -- The last item to be installed prior to removing the engine from the cart is the air starter or electric cranking motor whichever is applicable.

When installing the electric cranking motor, be certain it is of the same type and rating as the one that was removed. Cranking motors are designed with different type drives and must be used with a matching flywheel ring gear.

Next assemble the spacer to the cranking motor (if used).

Figure 3 shows the next step of mounting the cranking motors to the flywheel with capscrews.

The last step is to connect the wiring leads to the cranking motor terminals.

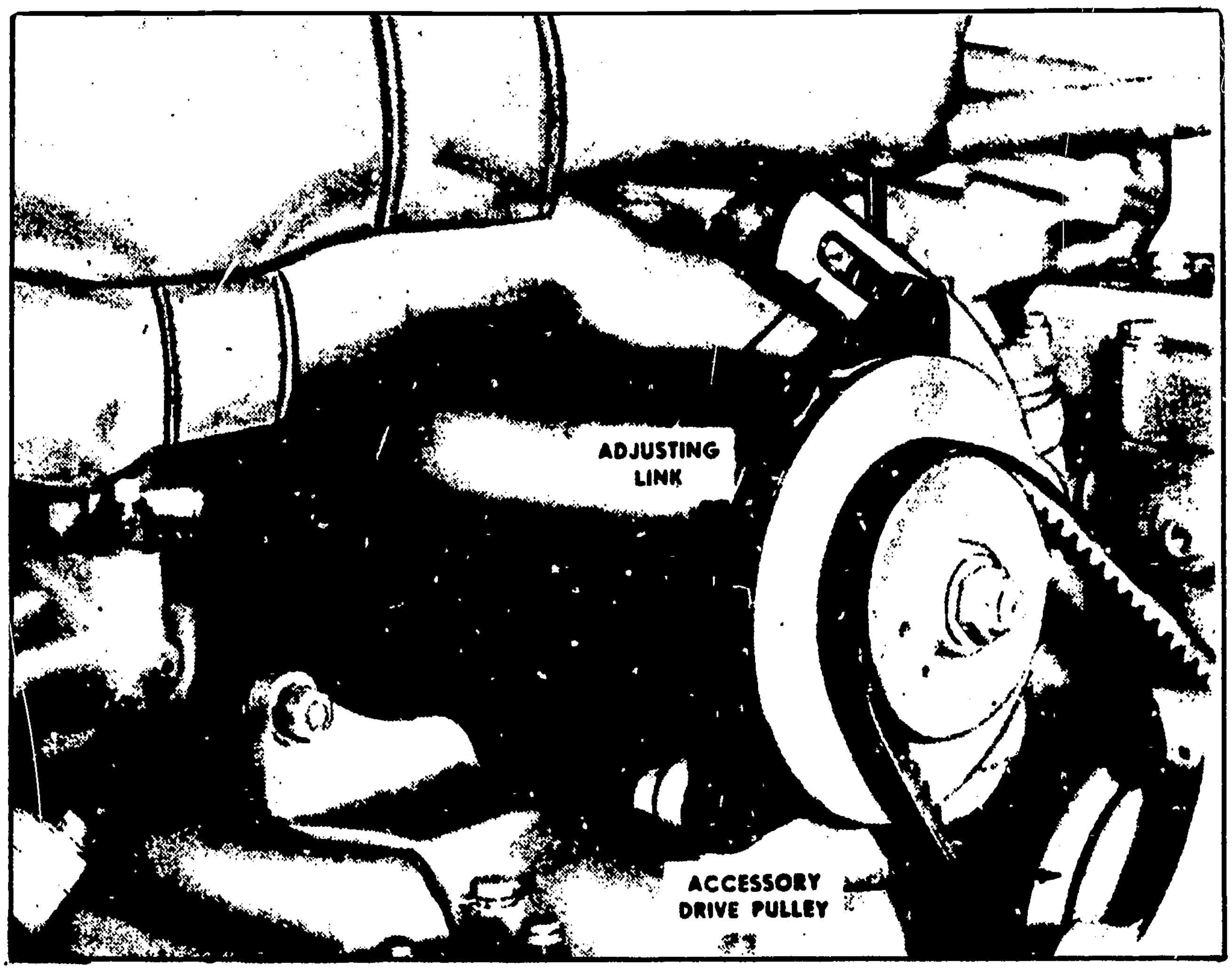
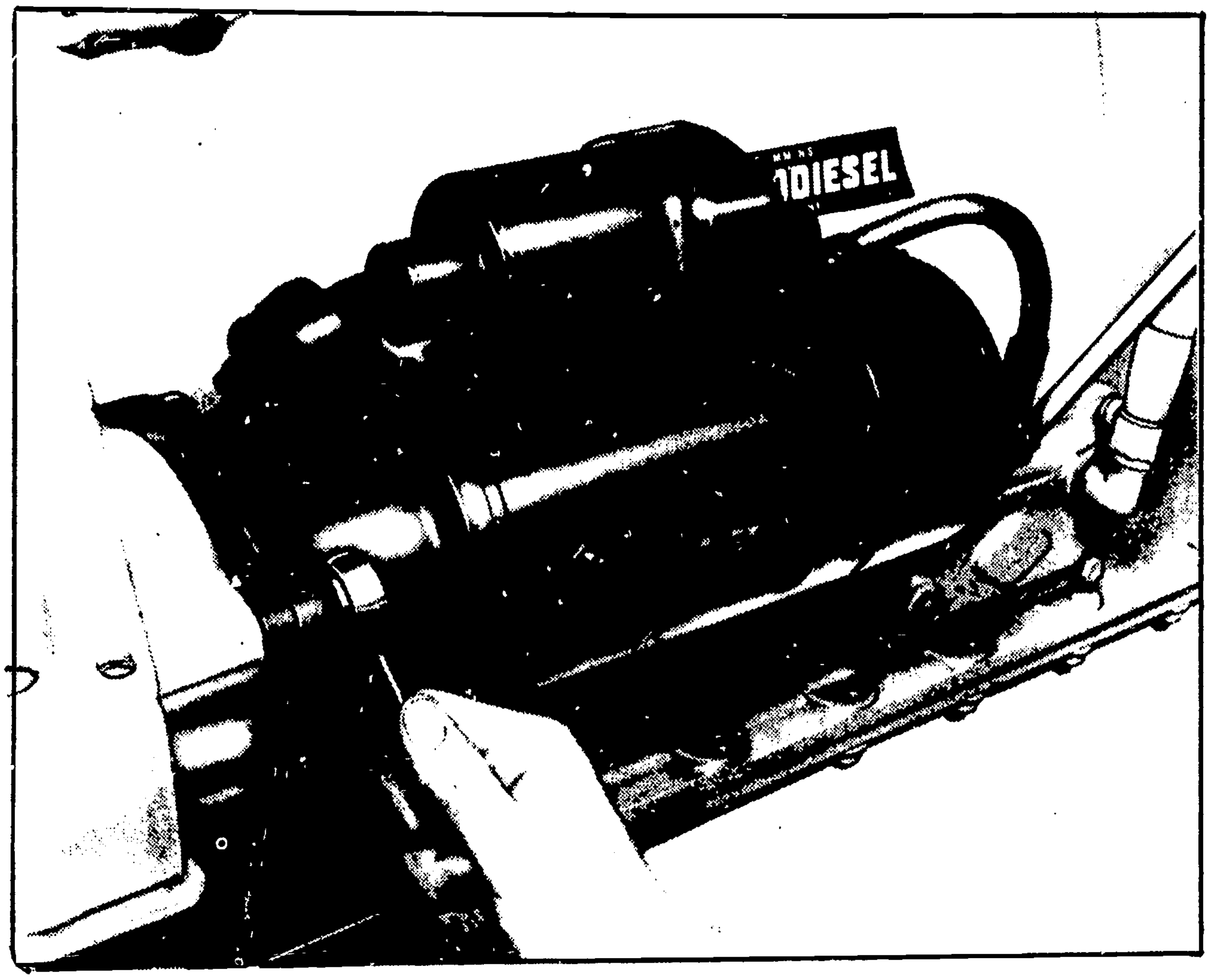


Fig. 2 Mounting generator.

On vehicles that use an air starting device, proceed with the installation as follows:

1. Put capscrews and lock washers in place in cranking motor mounting flange to furnish support during installation. In some applications, a spacer is used between the mounting flange and the flywheel housing.
2. Slide motor into opening in flywheel housing, clearing flywheel ring gear.
3. Tighten capscrews securely, see Figure 4.
4. Connect air supply line to starter.



<u>Fig. 3</u> Mounting electric cranking motor.

SECTION B -- INSTALLING ENGINE

After having installed the auxiliary components as mentioned above, the next step is to hoist the engine into position so it can be secured to the truck frame.

NOTE: Check engine lifting equipment to be certain it is absolutely safe. If any failings are discovered, such as a questionable switch, a sprung hook, frayed cables, or kinked chains, <u>do not use,</u> have it repaired first.

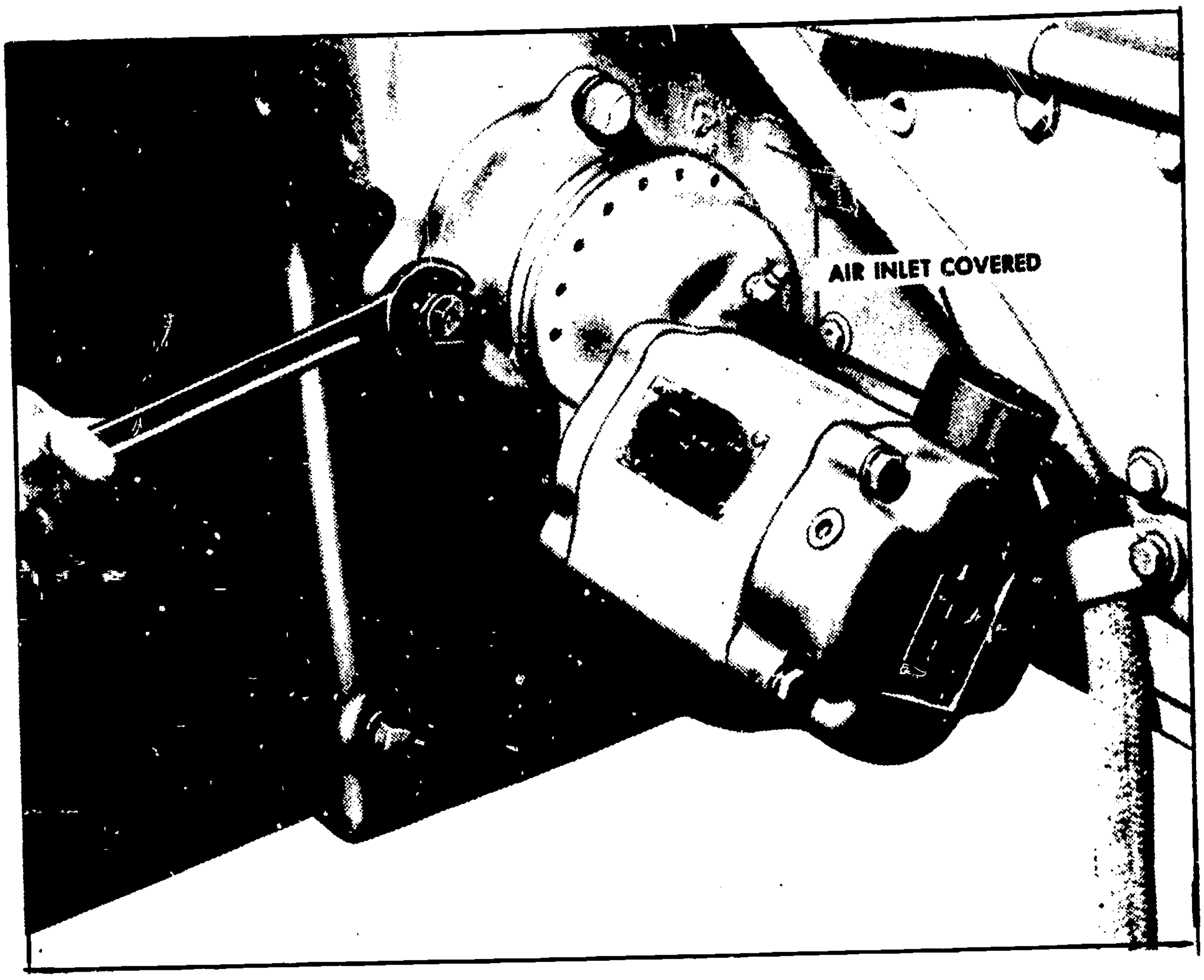


Fig. 4 Mounting air starter.

Attach the overhead crane with the four way spreader to the four lifting eyes or brackets on the engine. Lift the engine and position it correctly in the truck frame. Secure rear engine mount with eight capscrews and front engine mount with four capscrews.

TRANSMISSION ALIGNMENT -- Align the transmission with the engine flywheel housing and install four capscrews to hold the transmission. Next install 12 capscrews to fasten flexiplate to flywheel.

NOTE: Torque flexiplate bolts to 100 foot pounds. Use caution when installing flexiplate bolts to prevent bolts from dropping into flywheel housing.

Install remaining capscrews that fasten transmission housing to flywheel housing. On the Allison CLBT-5960 or 6061, use a lock plate or wire capscrews to prevent them from loosening. If screw becomes loose and backout during operation, the transmission will fail.

Next connect throttle linkage and emergency stop cable. Be careful not to bend linkage. Handle with care.

AIR CLEANERS AND AIR CLEANER HOSES -- Next install the air cleaners after making sure they have been properly serviced for replacement. Install air cleaner hoses using two clamps on all hose connections. Check hose and fittings for wear or leaks. Replace as necessary. NOTE: Check oil level in cleaner (if oil bath type) and fill to oil level mark. Use some oil as used in engine. Install new elements for dry type cleaners. Check back pressure (after engine installation). Back pressure should not exceed 8 inches of water.

EXHAUST TUBING -- Next connect exhaust tubing to right and left exhaust manifolds using new exhaust gaskets. NOTE: Be sure all traces of the old gaskets are removed before assembling. Check maintenance manual for proper torque.

WIRING CONNECTIONS -- Connect the generator-fuel, solenoid-high temperature and low oil pressure switch wiring. After connection, check the signal alarms for proper operation.

ENGINE TO ACCESSORY ATTACHMENT CONNECTION -- Install steering booster hoses, cab heater hoses, lubrication oil line to pressure gauge, air line to air governor, copper air line to air compressor, and air line to starter and starter valve. NOTE: Clean all hoses and connections, replace all worn hoses.

RADIATOR INSTALLATION -- Attach a chain hoist and a suitable lifting hook (through the filter neck or otherwise) and position assembly on engine base. CAUTION: Use care in positioning radiator assembly as radiator parts can be damaged easily.

Attach radiator to engine mounts with bolts, nuts, and lock washers. Be sure radiator mounts are not cracked or chipped before installation.

Attach top and bottom radiator hoses and block heater hoses. Inspect hoses before installation for cracks and worn places. Use two clamps on all hose connections. NOTE: Do not gamble with hoses. If in doubt, replace with new hoses.

Mount shroud housing and fan assembly. NOTE: On some models, the fan and shroud housing assembly may have to be installed prior to installing the radiator.

COOLANT -- Fill radiator with a high boiling type anti-freeze or soft water. Do not use hard water as this will form scale and clog the core. Be sure to check entire assembly for leaks after filling. Check carefully to be sure air is bled from cooling system.

LUBRICATION -- Change all oil filters, water filters and conditioners, and fuel oil filters. NOTE: Consult the maintenance manual for proper grade and viscosity of oil. The following table is only a recommended guide.

AMBIENT TEMPERATURE	VISCOSITY GRADE
+30 and above	SAE 30W
+30° to 0° F	SAE 20 - 20W
0° to -20° F	SAE 10W

Remove both rocker covers and pour approximately one quart of engine oil over rocker arms and push rods of each cylinder head. Replace rocker covers and fill crankcase with oil to the proper dip stick level.

STARTING ENGINE -- Turn the engine over using the air starter until engine oil pressure is approximately 25 psi. When this pressure is attained, start engine and run at idle speed (about 800 rpm).

CAUTION: Observe the oil pressure gauge immediately after starting the engine. If there is no oil pressure indicated within 10 to 15 seconds, stop the engine and check the lubrication system. Consult maintenance manual for oil pressure at idle speed.

Check engine for air, water-fuel, oil, or lube oil for leaks. NOTE: Tighten hose connections where necessary to stop leaks. Check bleed line from water manifold to radiator for obstructions and purge air from cooling system.

Run engine at normal operating temperature and again check for leaks.

ROAD TEST -- Before road testing the vehicle,check oil pressure (pressure should not fall below 25 psi at 1200 rpm or 30 psi at 2100 rpm). Also check radiator for proper level and make any adjustments required. Clean up area and return tools to their proper storage racks. Road test the vehicle.

This has been a <u>very</u> brief presentation of installing a rebuilt motor and accessory components into a vehicle. Later on this procedure will be discussed in detail.

DIDACTOR PLATES FOR AM 1-12 D

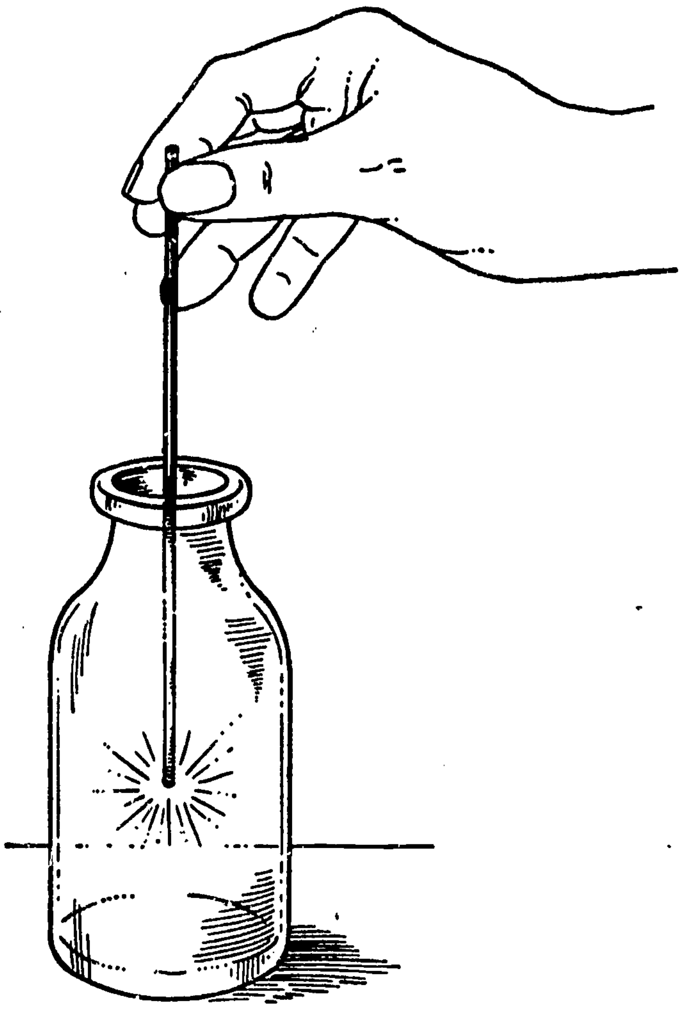


Plate I —If a thin piece of iron wire is heated red hot and then submerged in oxygen, the heated end will immediately burst into flame and burn vigorously. This reaction will continue until all the oxygen or all the iron wire is consumed.

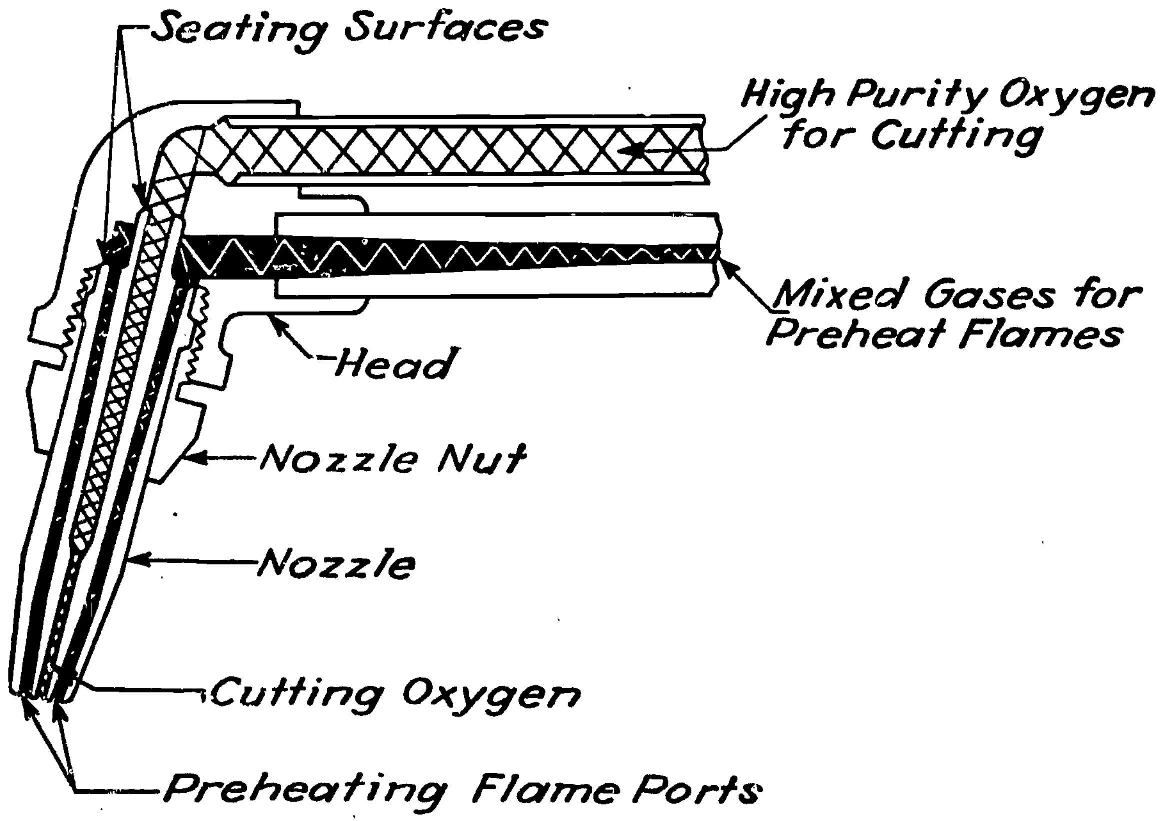
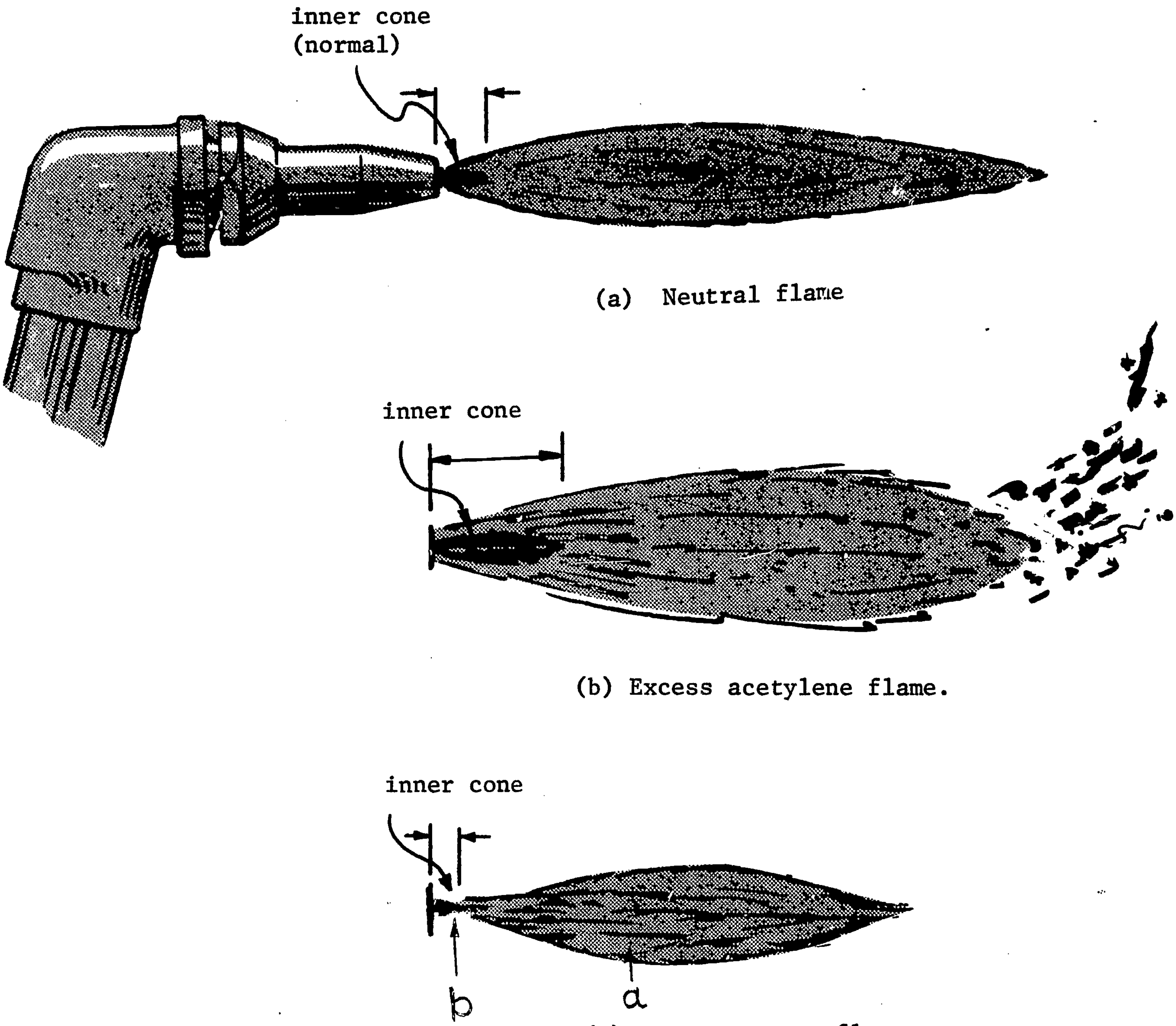


Plate II —An oxy-acetylene cutting blowpipe is designed to supply mixed acetylene and oxygen for the heating flames, and a stream of high purity oxygen to do the actual cutting.



(a) Neutral flame

(b) Excess acetylene flame.

(c) Excess oxygen flame

Plate III

MM 1-13D and AM 1-12D
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PRINCIPLES OF TORCH CUTTING

Human Engineering Institute

Press A 1   Check to see that timer is OFF

1

Very often it is necessary for the mechanic, working on many kinds of mechanical equipment, to use torch cutting equipment, or, as it is referred to in engineering: oxy-acetylene cutting. This lesson is designed to acquaint a mechanic with the principles of torch cutting so he understand what happens when this equipment is used.

Press A 2

1

2

Oxy-acetylene cutting is a process for separating ferrous metals by using the rapid chemical reaction between heated iron and oxygen. When iron is heated red hot and exposed to high purity oxygen, an intense reaction takes place.

The iron burns fiercely, and so much heat is liberated that the oxide (rust) which is formed melts. Also, some of the unoxidized (unburned) steel or iron is heated enough that it too becomes a liquid.

What are the two ways in which an oxy-acetylene torch cuts ferrous metals?

A. (1) by melting (2) by turning them to a liquid 3
B. (1) by burning (2) by melting 4
C. (1) by turning red hot (2) by melting 3

1

3

You have made a mistake. The two ways in which an oxy-acetylene torch cuts ferrous metals are by burning and by melting.

There is a rapid chemical reaction between heated iron and oxygen. When iron is heated red hot and exposed to high purity oxygen, an intense reaction takes place.

The iron burns fiercely and so much heat is created that the oxide (rust) which is formed melts. Also, some of the unoxidized (unburned) steel or iron is heated enough that it becomes a liquid.

Press A 4

1

4

OK. The two ways in which an oxy-acetylene torch cuts ferrous metals are by burning and by melting.

For those who are not familiar with oxy-acetylene cutting, a discussion of the principles underlying this process will be of value.

Most iron and steel will oxidize when exposed to the air, regardless of the temperature, and form a layer of iron oxide (rust) on the surface.

Press A 5

1

5

With the so-called corrosion-resistant or stainless steels, this iron oxide forms a tight layer that prevents or retards further oxidation.

What is the common name for iron oxide?

A. Rust. 7
B. Corrosion. 6
C. Alum. 6

1

6

No. you have made an error. The common name for iron oxide is rust.

Most iron and steel will oxidize when exposed to the air, regardless of the temperature, to form a layer of iron oxide (rust) on the surface.

With the so-called corrosion-resistant or stainless steels, this iron oxide forms a tight layer that prevents or slows further oxidation.

Press A 7

1

7

OK. Rust is the common name for iron oxide.

With ordinary iron or steel, the oxide coating is loose and porous so that oxidation (rusting) continues unchecked. In time, the entire piece will be oxidized.

What slows or retards rusting in stainless steel?

A. Painting prevents or slows further oxidation. 8
B. Coating with oil prevents or slows further oxidation. 8
C. The iron oxide forms a tight layer that prevents or slows further oxidation. 9

1

8

Sorry, you misunderstood the question.

You were asked: What slows or retards rusting in stainless steel?

The iron oxide or rust of stainless steel forms a tight layer that prevents or slows further oxidation.

However, the practice which you mentioned is a good maintenance practice.

Press A 9

1

9

OK. The oxide of stainless steel forms a tight layer that slows or prevents further oxidation. However, the oxide of ordinary iron or steel is loose and porous and allows further rusting to continue unchecked.

When the temperature of the iron or steel is raised until the metal is white hot, and a stream of pure oxygen from a cutting blowpipe is directed against the white hot spot, the metal can be seen to burn rapidly.

Press A 10

1

10

The reaction between the oxygen and the white hot iron causes a considerable amount of heat to be given off. Under the influence of this heat, the oxide formed is melted and flows or is blown away, exposing more metal to the action of the oxygen.

When the temperature of iron or steel is raised until the metal is white hot and a stream of pure oxygen from a cutting blowpipe is directed against the white hot spot, the metal ____________________.

A. glows slightly. 11
B. turns a dull red. 11
C. burns rapidly. 12

1

11

Your answer is not quite right.

When the temperature of iron or steel is raised until the metal is white hot and a stream of pure oxygen from a cutting blowpipe is directed against the white hot spot, the metal burns rapidly.

Press A 12

1

12

OK. The white hot metal burns rapidly when a stream of pure oxygen is directed against it.

The heat resulting from this reaction is not enough to keep the reaction (and cutting) going, because of the chilling effect of the surrounding metal and the stream of cutting oxygen.

What else happens to the iron or steel (as well as the rust) under the influence of the high heat?

A. It melts. 14
B. It cools. 13
C. It is purified. 13

1

13

Your answer is wrong. The iron or steel (as well as the rust) melts under the influence of the high heat.

The reaction between the oxygen and the white hot iron causes a considerable amount of heat to be given off. Under the influence of this heat, the oxide formed is melted and flows or is blown away, exposing more metal to the action of the oxygen.

Press A 14

1

14

OK. The high heat causes the metal to melt and flow.

(Plate I shows the reaction between hot iron and oxygen).

The flow of heat to the colder parts of the metal will cause the oxide formed to solidify, protecting the metal underneath from the action of the oxygen stream.

Therefore, it is necessary to supply acetylene as well as oxygen to the point of cutting in order to keep the cutting reaction going. This is called a preheat flame; see Plate II

Press A 15

1

15

Oxy-acetylene blowpipes are constructed so that they will provide one or more small oxy-acetylene flames for preheating and to supply heat to the point of cutting during the cutting operation. In addition, a stream of high purity oxygen is provided.

What will happen to the cutting action if the flow of acetylene is stopped?

A. The iron will burn even more rapidly.
B. The iron will cool and cutting will stop.
C. The iron will be so hot that even the oxide will melt.

1

16

Your answer is incorrect. If the flow of acetylene is stopped during cutting, the iron will usually cool and stop the cutting. The flow of heat to the colder parts of the metal will cause the oxide formed to solidify, protecting the metal underneath from the action of the oxygen stream.

Press A 17

1

17

OK. The iron will cool and cutting will stop unless acetylene is fed into the flame.

The heat from the burning iron and acetylene burns and melts its way through the metal, making a hole. As the blowpipe is moved, the hole is widened to a slot. By using the proper blowpipe nozzle, it is possible to cut even heavy steel sections and have only a narrow slot where cutting or burning took place.

In order to keep a cut going, both oxygen and some acetylene must be applied to the hot metal in a ________.

A. molten metal. 18
B. hot melted iron. 18
C. preheat flame. 19

1

18

You have made a mistake. In order to keep a cut going, both oxygen and some acetylene must be applied to the hot metal in a preheat flame.

The flow of heat to the colder parts of the metal will cause the oxide formed to solidify, protecting the metal underneath from the actio of the oxygen stream.

Therefore, it usually is necessary to supply acetylene, as well as oxygen, to the point of cutting in order to keep the cutting reaction going with a preheat flame.

Press A 19

1

19

Right, both oxygen and acetylene must be supplied to the cut in a preheat flame.

Let's summarize now and go on to the next part. Oxy-acetylene cutting is done with a blowpipe and nozzle that will supply an oxy-acetylene flame for heating a spot on a piece of iron or steel. When the metal is hot enough, high purity oxygen under pressure, will burn and melt a slit entirely through it.

A preheat flame is used to maintain a cut by overcoming the effects of chilling.

Press A 21

XC → 20

1

20

OK. Let's review this first part to be sure we have it before moving on. But first, let's summarize.

Oxy-acetylene cutting is done with a blowpipe and ~~nozzle that~~ supplies an oxy-acetylene flame for heating a spot on a piece of iron or steel. When the metal is hot enough, high purity oxygen under pressure will burn and melt a slit entirely through it.

A preheat flame is used to maintain a cut by overcoming the effects of chilling.

Press A
→ 1

1

21

In principle, the cutting blowpipe needs only one preheat flame. However, this would make it hard to change the direction of the cut because preheating must always take place ahead of cutting.

Cutting nozzles are therefore made with a ring of openings, usually four or more, surrounding the cutting oxygen hole. This supplies several smaller flames, giving better heat and making it easier to change directions. See Plate II.

Press A 22

2

22

The cutting blowpipe has two valves to regulate the quantities of oxygen and acetylene that are mixed together for the preheat flame. It also has a third valve, usually operated by a lever, to control the cutting oxygen stream.

This film will not move until you answer the question below correctly.

The preheat flame holes are in a ring around the cutting-oxygen hole in order to ___(1)___ and ___(2)___.

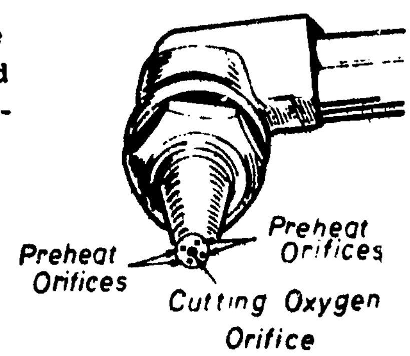
A. (1) save oxygen (2) save acetylene — 23
B. (1) save oxygen (2) keep the cut cool ××
C. (1) give better heat (2) make it easier to change directions × ✓

2

23

Right, to give better heat and to make it easier to change directions.

Note in this figure, how the heating flames are provided in a ring around the cutting-oxygen orifice (hole) in the center, thus giving the most desirable balance of heat input to the base metal. See Plate II.



Press A 24

2

24

It may seem obvious, but it is important to realize that the "tool" of the oxy-acetylene process is not the welding blowpipe but the flame.

There are three distinct types of oxy-acetylene flames, depending upon the ratio of the amounts of oxygen and acetylene supplied through the blowpipe. These flames are the neutral flame, the excess acetylene flame, and the excess oxygen flame.

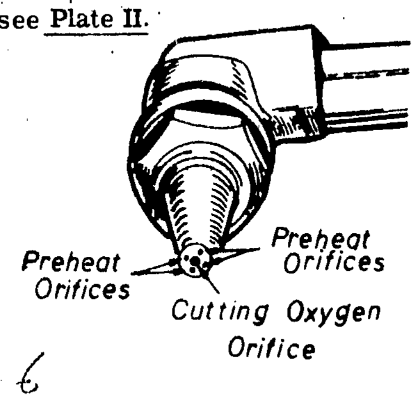
What kind(s) of hole(s) or orifice(s) are there on a cutting nozzle?

A. Preheat orifice or hole. 25
B. Cutting-oxygen orifice and cutting acetylene orifice. 25
C. Cutting-oxygen orifice (hole) and preheat orifices (holes). 26

2

25

Your answer is wrong. There are two kinds of orifices on a cutting nozzle: the cutting-oxygen orifice and the preheat orifices. See the figure in this frame. Also see Plate II.

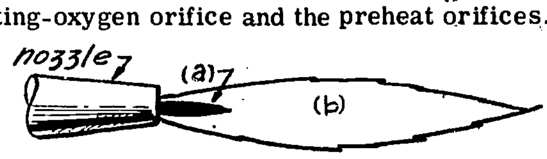


Press A 26

2

26

OK. The two kinds of holes on a cutting nozzle are the cutting-oxygen orifice and the preheat orifices.



An oxy-acetylene flame has two main parts: the inner cone (a) and the outer envelope (b), see Plate III.

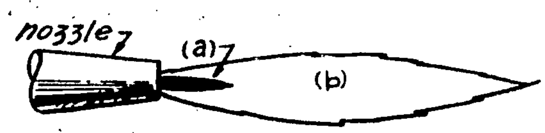
Name the three distinct types of oxy-acetylene flames. (The film will not move until you answer correctly).

A. Neutral flame, excess oxygen, and excess acetylene. 27
B. Neutral flame, welding flame, and cutting flame. XX
C. Hot flame, medium flame, and cold flame. XX

2

27

Right. The three distinct types of flame are the neutral flame, the excess oxygen flame, and the excess acetylene flame.



The neutral flame is obtained by burning approximately a one-to-one mixture of acetylene and oxygen. The pale blue core of the flame is known as the inner core (a). The oxygen required for the combustion of the carbon monoxide and hydrogen in the outer envelope (b) of the flame is supplied from the air. See Plate III (a).

Press A 28

2

28

Turn to Plate III.

Identify the inner cone and the outer envelope of Plate III (c). (The film will move only when you press the correct answer).

A. (a) inner cone (b) outer envelope XX
B. (a) outer envelope (b) inner cone 29

2

29

Right, (a) is the outer envelope and (b) is the inner cone.

What is the ratio of oxygen to acetylene in the neutral flame?

A. Two-to-one. 30
B. One-to-two. 30
C. One-to-one. 31

2

30

You have made a mistake.

The neutral flame is made by burning approximately a one-to-one mixture of acetylene and oxygen. The pale blue core of the flame is known as the inner core; see Plate III (a). The oxygen required for the combustion of the carbon monoxide and hydrogen in the outer envelope of the flame is supplied from the air.

Press A 31

2

31

OK., one-to-one.

Excess acetylene. This flame adjustment is one in which there is excess acetylene over the ratio required for a neutral flame.

As you can see in Plate III (b), the excess acetylene flame has a third cone between the inner cone and the outer envelope, known as the excess acetylene feather. This "feather" is white and contains white hot carbon particles, some of which, during welding, are dissolved in the molten metal.

Press A 32

2

32

As we just said, the excess acetylene feather contains white hot carbon particles, some of which, during welding, are dissolved by the molten metal. For this reason, the flame adjustment is frequently known as a "carburizing" flame.

What is meant by an excess acetylene flame?

A. The flame is very long. 33
B. The flame is adjusted to contain more oxygen than acetylene. 33
C. The flame is adjusted to contain more acetylene than oxygen. 34

2

33

Your answer is wrong. The excess acetylene flame adjustment is one in which there is more acetylene than is required for a neutral flame, that is, more than one-to-one.

Press A 34

2

34

OK., more acetylene than oxygen.

During the welding of iron and steel, the excess acetylene or carburizing flame acts as a "reducing" flame. "Reduce" is a chemical term which means to remove the oxygen from metal; see Plate III (b).

Why do we call the excess acetylene feather the "carburizing" flame?

A. It turns the metal to carbon. 35
B. Carbon particles from the feather become dissolved in the molten metal. 36
C. The oxygen in the flame completely consumes the carbon. 35

2

35

You've made a mistake. Carburizing flame means that carbon particles from the feather become dissolved in the molten metal.

The excess acetylene feather contains white-hot carbon particles, some of which, during welding, are dissolved by the molten iron or steel.

Press A 36

2

36

OK. Carburizing means carbon becomes dissolved in the metal.

Excess oxygen means that more oxygen is contained in the flame than would be required for the neutral flame.

What do we mean by "reducing" flame?

A. It tends to remove the oxygen from iron oxides which may be present. 38
B. It tends to make the metal smaller. 37
C. It tends to make a smaller flame. 37

2

37

Your answer is incorrect. "Reducing" is a chemical term which means to remove the oxygen from metal.

During the welding of iron and steel, the excess acetylene or carburizing flame will tend to remove the oxygen from iron oxides which may be present.

Press A 38

2

38

OK. It means to remove oxygen from metals; see Plate III.

If there is more oxygen present in the mixed gases than is required for a one-to-one mixture, there will be oxygen left over after the primary combustion in the inner cone. This is the excess oxygen flame; see Plate III (c).

The whole flame will be smaller, and hotter, than the other two flame adjustments.

The three distinct kinds of flame adjustment are the (1) excess oxygen, the ____(2)____, and the ____(3)____.

A. (2) the cool flame (3) the hot flame 39
B. (2) the oxygen flame (3) the acetylene flame 39
C. (2) the neutral flame (3) the excess acetylene flame 40

2

39

Your answer is incorrect.

The three distinct types of oxy-acetylene flame adjustment are: the excess oxygen flame, the neutral flame, and the excess acetylene flame; see Plate III.

These distinctions are based on the ratio of oxygen to acetylene in the flame. The excess oxygen flame has more oxygen. The excess acetylene flame has more acetylene. The neutral flame has equal amounts of oxygen and acetylene.

Press A 40

2

40

OK., the neutral flame and the excess acetylene flame. When oxygen is in excess, the flame has only two zones like the neutral flame. However, the inner cone is different than the inner cone of the neutral flame. It is shorter, is necked on the sides, and has a purplish tinge. See Plate III (c).

Compare the excess oxygen flame to the other two flames:

A. It is smaller, but not as hot as the other two flames. 41
B. It is hotter, but not as small as the other two flames. 41
C. It is smaller and hotter than the other two flames. 42

2

41

Your answer is wrong. The whole excess oxygen flame is smaller and hotter than the other two flames.

Because there is excess oxygen, the acetylene will be more easily burned than is possible with the other types of flame adjustment.

Press A 41

2

42

OK., smaller and hotter.

The products of the excess oxygen flame are strong "oxidizing" agents. This means that these products cause metals to combine with oxygen.

For example, a highly oxidizing flame can turn sponge iron to the highest oxides.

The inner cone of the excess oxygen flame is shorter than the neutral flame, ___(1)___ and ___(2)___.

A. (1) whiter (2) fatter on the sides
B. (1) necked on the sides (2) purplish
C. (1) lighter blue (2) wider on the sides

2

43

No, you have made an error. The inner cone of the excess oxygen flame is shorter, is necked on the sides, and has a purplish tinge; see Plate III (c).

Press A 44

2

44

OK., necked on the sides and purplish.

A "slightly excess oxygen flame" is a flame adjustment which is used when it is felt that a slight excess of acetylene might have a harmful effect on the metal being welded.

This is to avoid the possibility of any slight change in the oxygen or acetylene flow through the blowpipe which could cause the flame to become slightly acetylene.

What do we mean by oxidizing agent?

A. Causes the oxygen to be taken out of a metal. 45
B. Causes the acetylene to be taken out of a metal. 45
C. Causes the oxygen to be put into or combined with the metal. 46

2

45

Your answer is incorrect. An oxidizing agent is a material that causes oxygen to be put into or combine with the metal.

The excess oxygen flame is an oxidizing agent because in the cutting process, it oxidizes the metal to form iron oxide (combines with the metal in the form of rust) as it burns and melts its way through the metal.

Press A 46

2

46

OK. An oxidizing agent causes oxygen to combine with the metal.

In order to make the acetylene burn completely, we must use 2 1/2 times more oxygen by volume than acetylene. Some of this extra oxygen comes from the oxygen storage tank and much of it comes from the air around the blowpipe and flame.

When would we use a "slightly oxidizing flame"?

A. When a slight excess of acetylene might harm the metal. 48
B. When we want to reduce the metal slightly. 47
C. When we want to save oxygen. 47

2

47

Your answer is wrong. We would use a "slightly oxidizing flame" when a slight excess of acetylene might harm the metal.

This is to avoid the possibility of a slight change in the oxygen or acetylene flow in the blowpipe which could cause the flame to become slightly acetylene.

Press A 48

2

48

OK., when a slight excess of acetylene might harm the metal.

In the same way, a slight excess of acetylene is specified for those metals on which a slight excess of oxygen would be harmful.

How much oxygen is needed to make the acetylene burn completely?

A. A one-to-one ratio is needed. 49
B. Two and one-half times more oxygen, by volume, is needed. 50
C. Five times more acetylene by volume is needed. 45

2

45

You have made a mistake. Two and one-half times more oxygen by volume is needed.

In order to make the acetylene burn completely, we must use 2 1/2 times more oxygen by volume than acetylene. Some of this extra oxygen comes from the oxygen storage tank and much of it comes from the air around the blowpipe and flame.

Press A 50

2

50

OK., 2 1/2 times more oxygen than acetylene is needed.

The sole purpose of the various items of equipment used in the operation is to produce the basic tool of the oxy-acetylene process. This equipment is designed to give the operator more control over the basic tool and to give the equipment longer life.

What is the basic tool of the oxy-acetylene process?

A. The flame. 52
B. The oxygen and acetylene gas. 51
C. The blowpipe. 51

2

51

You have made a mistake. The basic tool of the oxy-acetylene process is the flame.

The sole purpose of the various items of equipment used in the oxy-acetylene process is to enable the operator to produce an oxy-acetylene flame best suited for the work he is doing.

Press A 52

2

52

OK. The oxy-acetylene flame is the basic tool of this process.

The factors within a given oxy-acetylene welding blowpipe governing the flame are the size and shape of the orifice in the welding head, the pressures of oxygen and acetylene, and the ratios and amounts of oxygen and acetylene in the mixture of gases which burn at the blowpipe tip.

When would we use a slightly acetylene flame?

A. To give us a good long flame. 53
B. When an excess oxygen flame might harm the metal. 54
C. To avoid carburizing the metal. 53

2

53

No, your answer is only partly right. We would use a slightly acetylene flame when a slightly or excess oxygen flame might harm the metal.

Press A 54

2

54

OK.. when an excess oxygen flame might harm the metal.

The flame is governed by the ____(1)____, the ____(2)____, and the ratios and amounts of oxygen and acetylene in the mixture of gases which burn at the blowpipe tip.

A.	(1) kind of metal being welded,	(2) kind of metal being cut,	55
B.	(1) distance of the metal from the blowpipe,	(2) kind of safety glasses worn,	55
C.	(1) size and shape of the holes in the welding head,	(2) pressures of oxygen and acetylene,	56

2

55

Your answer is only partly right.

The flame is governed by the size and shape of the holes in the welding head, the pressures of oxygen and acetylene and the ratios and amounts of oxygen and acetylene in the mixture of gases which burn at the blowpipe end.

Press A 56

2

56

A cutting blowpipe has two types of holes. It has preheat holes and cutting holes. Mixed acetylene and oxygen comes out of the preheat holes and pure oxygen comes out of the cutting-oxygen orifice; see Plate II.

Although in theory, the cutting blowpipe needs only one preheat flame, in practice, it has several to make it easier to change the direction of a cut.

Let's summarize what's been covered in this last sequence of material, then review it before going on to new material.

Press A 57

X C →

2

57

SUMMARY -- There are three distinct kinds of flame: the neutral flame, the excess oxygen flame, and the excess acetylene flame.

The character of the flame is important because the flame is the real tool of the oxy-acetylene process. The equipment only provides the operator with a flame.

The excess acetylene flame is the only one with an acetylene feather. It is also known as the carburizing or reducing flame.

Let's review now. Read carefully and take your time in answering the questions. All right answers will advance you to the next section.

Press A → 21

2

58

Right. You have completed the section on the oxy-acetylene flame.

Now, let's discuss the cuttability of metals.

Since oxy-acetylene cutting is an oxidation process, it may seem strange that its successful application is limited to ferrous metals. After all, metals other than iron and steel oxidize; some even more rapidly.

Press A 59

3

59

There are some very good reasons why oxy-acetylene cutting is limited to ferrous metals. Other metals do not form an oxide that melts at a lower temperature than the base metal (the main metal in an alloy). For instance, a flux is needed when welding some metals, to make it possible to float the oxide out of the weld.

Press A 60

3

60

Another example is the metal which has a tight film on its surface that prevents further oxidation. If this film also melts at a higher temperature than the base metal, the protection of the base metal from oxidation continues until the base metal melts.

What is base metal?

A. The oxide substance of a metal. 61
B. The main metal in an alloy. 62
C. A low quality, low grade metal that is worthless. 61

3

61

You have made a mistake. A base metal is the main metal in an alloy.

Non-ferrous metals simply do not form an oxide that melts at a lower temperature than the base metal.

Press A 62

3

62

OK., a base metal is the main metal in an alloy.

Furthermore, all ferrous metals do not cut with equal ease. Some are more resistant to oxidation than others, while in some cases the metal possesses certain other physical properties that hinder the cutting action.

What problems are created in cutting and welding when the oxide melts at about the same temperature as the base metal?

A. None really. 63
B. The oxide mixes with the base metal and it is necessary to use a flux to float the oxide out of the cut or weld. 64
C. The flame is much, much too hot for such a metal. 63

3

63

You have made a mistake.

There is a problem when the oxide melts at about the same temperature as the base metal. The oxide mixes with the base metal and it is necessary to use a flux to float the oxide out of the cut or weld.

Press A 64

3

64

OK., it's difficult to separate the oxide and the base metal.

Theoretically, it requires 4.58 cu. ft. of oxygen to **oxidize 1 lb. of iron completely. Actually,** in the cutting of ordinary steel, the consumption **varies** from 2 to 6 cu. ft. of oxygen per lb. of iron removed from the cut.

What problem is created when the base metal melts at a lower temperature than the oxide (when the oxide forms as a tight film on the metal)?

A. The base metal melts too easily.
B. The film protects the base metal from oxidation until the base metal melts. 66
C. There is danger of fire from the oxidized film.

3

65

Your **answer is wrong. The base metal won't** oxidize **until it melts.**

This is the problem that is created when the oxide film coating the base metal is tight and melts at a higher temperature than the base metal.

Press A

3

66

OK. The film protects the base metal from oxidation until the base metal melts.

Theoretically it requires 4.58 cu. ft. of oxygen to oxidize 1 lb. of iron completely.

How many cubic feet of oxygen are actually needed to oxidize a pound of ordinary steel during a cut?

A. 2 to 6 cu. ft. 68
B. 26 cu. ft. 67
C. 2 cu. ft. 67

3

67

Your answer is incorrect. It can actually take from 2 to 6 cu. ft. of oxygen to remove a pound of iron from a cut.

Theoretically it requires 4.58 cu. ft. of oxygen to oxidize 1 lb. of iron completely.

Press A 68

3

68

OK., from 2 to 6 cu. ft. of oxygen are required.

Consumption can be as low as about 2 cu. ft. because in addition to the iron oxidized during cutting, some iron is removed by melting and by the erosion or scrubbing effect of the oxygen and the iron oxide flowing from the cut.

Theoretically, how much oxygen is needed to oxidize one pound of iron completely?

A. 26 cu. ft. 69
B. 6.2 cu. ft. 69
C. 4.58 cu. ft. 70

3

69

No, you have made an error. Theoretically, it requires 4.58 cu. ft. of oxygen to oxidize one pound of iron completely.

Actually, in the cutting of ordinary steel, the consumption varies from 2 to 6 cu. ft. of oxygen per lb. of iron removed from the cut.

Press A 70

3

70

OK., 4.58.

We know that some metallurgical change takes place in the metal next to the cut, since this area is raised nearly to the same temperature as the melting point.

What is the lowest amount of oxygen that we would expect to use to remove a pound of iron from a cut?

A. 2 cu. ft. 72
B. 4.8 cu. ft. 71
C. 5 cu. ft. 71

3

71

You have made a mistake. Two cu. ft. is the lowest amount of oxygen that we would expect to use to remove a pound of iron or steel from a cut.

Consumption can be as low as 2 cu. ft. because in addition to the iron oxidized during cutting, some iron is removed by melting and by the erosion or scrubbing effect of the oxygen and the iron oxide flowing from the cut.

Press A 72

3

72

OK., 2.0 cu. ft.

The effects of the heat from the cut can be put to good use, however, using the heat often requires more control over the heating and cooling process than we can give during cutting and welding.

Therefore we should use the blowpipe carefully and avoid hardening or softening adjacent metal parts.

Some metallurgical change ____________ takes place next to the cut.

A. sometimes 73
B. never 73
C. always 74

3

73

You have made a mistake. Some metallurgical change always takes place next to the cut.

We know that some metallurgical change must take place in the metal next to the cut, since this area is raised almost to the same temperature as the melting point.

Press A 74

3

74

OK., some change always takes place.

When those steels which have air-hardening properties are flame cut, there is a tendency for hardened zones and perhaps even tiny cracks to form in the area immediately adjacent to the cut.

How easy is it to control the effects of the heat on the metal?

A. It is not easy. It is difficult. 76
B. Easy. 75
C. Very easy. 75

3

75

Your answer is wrong. It is not easy to control the effects of the heat on the metal.

The effects of the heat from the cut can be put to good use. However, using the heat often requires more control over the heating and cooling process than we can give during cutting and welding.

Press A 76

3

76

OK. It is difficult to control the effects of the heat on the metal.

Steels which harden or crack easily can be flame cut by preheating, postheating, or both, when necessary. This treatment serves to slow the rate of cooling after cutting.

Which steels did we say would harden or crack after flame cutting? Steels which have ________________ properties.

A. air-softening 77
B. air-hardening 78
C. air-quenching 77

3

77

No, you have made an error.

When steels which have air-hardening properties are flame cut, there is a tendency for hardened zones, and perhaps even tiny cracks, to form in the area next to the cut.

Press A 78

3

78

OK., steels with air-hardening properties.

As in welding, the heat of cutting causes an expansion of the metal in the area being cut, followed by contraction as it cools. This usually produces a distortion of the part in the form of a concave bow.

How can we avoid hardening or cracking when cutting steel with air-hardening properties?

A. Quenching with water. 79
B. Preheat, postheat, or both. 80
C. Quenching with cold water. 79

3

79

Your answer is incorrect. We can avoid hardening or cracking when cutting steel with air-hardening properties by preheating, postheating, or both.

Steels which harden or crack easily can be flame cut by preheating, postheating, or both when necessary. This treatment serves to slow the rate of cooling after cutting.

Press A 80

3

80

OK., by preheating, postheating, or both

As in welding, the heat of cutting causes an expansion of the metal in the area being cut, followed by contraction as it cools.

What form of distortion does this produce?

A. A very smooth, straight edge. 81
B. A large bulge in the metal. 81
C. A concave bow. 82

3

81

You have made an error. Cooling of the metal after welding produces a concave bow.

As in welding, the heat of cutting causes an expansion of the metal in the area being cut, followed by contraction as it cools.

This usually produces a distortion of the part, in the form of a concave bow.

Press A 82

3

82

Right, a distortion in the form of a concave bow.

You have now completed this film on the technology of oxy-acetylene cutting.

We have reviewed the properties of the basic oxy-acetylene flames: the neutral flame, the excess oxygen flame and the excess acetylene flame. In doing this, we have learned the properties and uses of each flame.

We have also reviewed properties of ferrous metals and discussed some of the problems in cutting them.

Please REWIND this film and turn off the machine.

X C → 83

3

83

OK. The distortion takes the form of a concave bow.

This is the last section of this film.

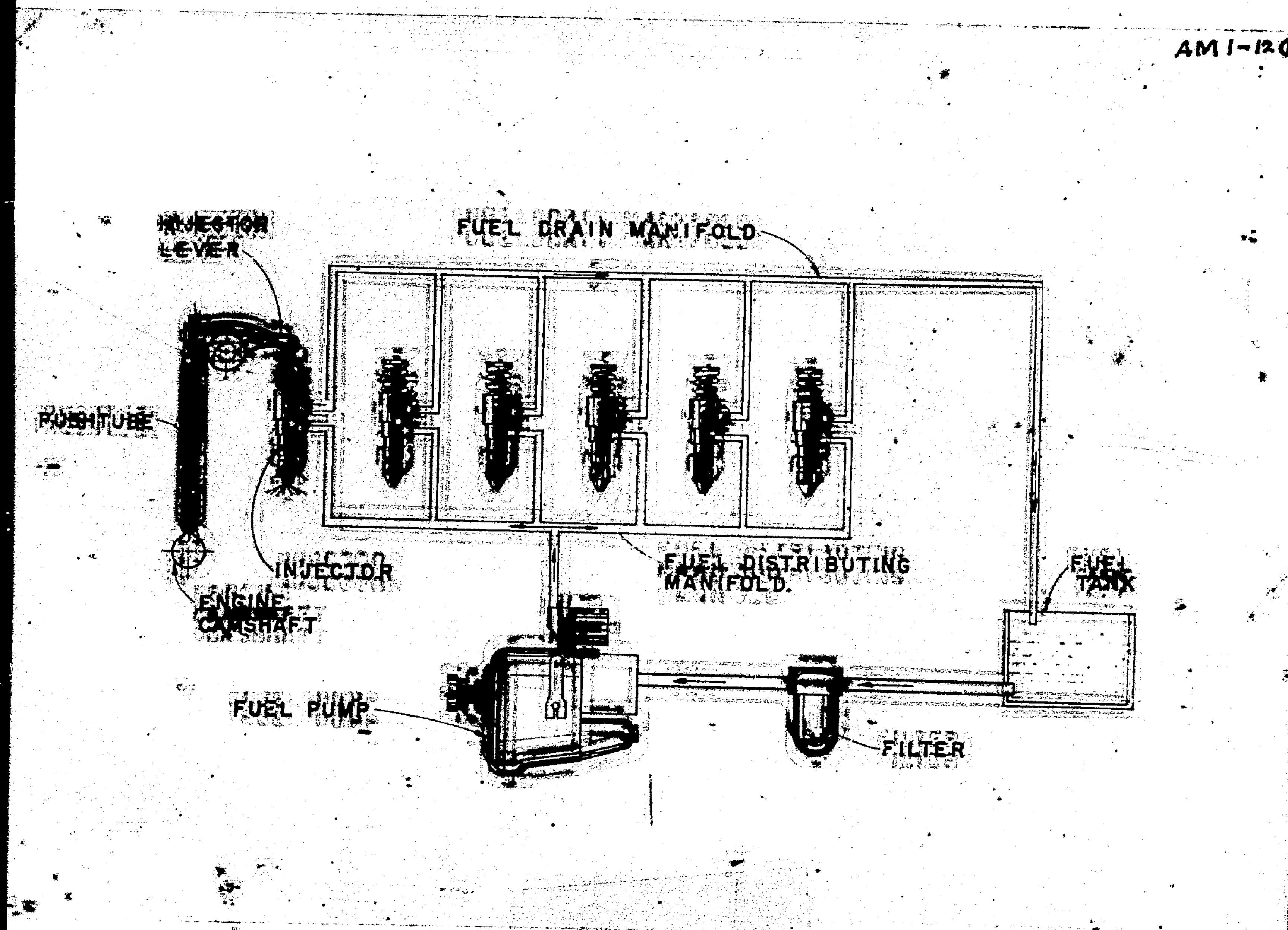
We have discussed the kinds of metals that can be cut with an oxy-acetylene flame.

We have also discussed some of the problems in flame cutting.

You have made some mistakes in this section so it will be best to review and establish it well in your mind. Read carefully and think before answering the questions.

Press A 55

3



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INSTRUCTOR'S GUIDE

Title of Unit: Part I - Maintaining the Fuel System (Part II) Cummins Diesel Engines

Part II - Unit Installation (Engine)

Code: AM 1-12

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FIRST: Be sure all questions have been answered that students might have on home study units.

OBJECTIVES : By the end of class, each student should know:

Part I

1. What any fuel system (Diesel) requires to function properly.
2. How to define the terms: meter, time, fuel rate, and atomize.
3. What metering does for the diesel engine.
4. What timing does for the diesel engine.
5. What is meant by controlling the fuel rate in an engine.
6. When atomization of the fuel occurs.
7. Why turbulence is important in the combustion chamber.
8. How the Cummins fuel system components differ from the GM, and where they are similar.
9. How to briefly discuss the pressure-time principle.
10. Be able to trace the fuel flow in the Cummins system.
11. Know what the four main parts of the fuel pump are.
12. Be able to describe the principle of the Aneroid control.
13. How the pump is driven and where it is mounted on the engine.
14. Briefly what the flow of fuel is through the pump.
15. What part the throttle plays in the control of fuel.

Part II

1. What parts must be installed prior to placing the engine in the vehicle.
2. What to look for when installing a rebuilt generator.
3. The rules to follow when installing and tightening fan belts.
4. What is meant by proper fan belt tension.
5. That torque is important when installing an engine.
6. The rules to follow when filling the crankcase with new oil.
7. How to start an engine and what rules to follow.

Instructor's Guide for AM 1-12

LEARNING AIDS suggested:

WALL CHARTS:

1. Bulletin #983474, V8-350/VT8-430 FUEL FLOW
2. Bulletin #983475, PTG FUEL PUMP FLOW
3. Bulletin #983477, PTG FUEL PUMP (Mechanical Variable Speed Governor).

VUE CELLS:

1. AM 1-11 (1) (PTG Fuel Pump-Mechanical Variable Speed Governor)
2. AM 1-11 (2) (V8-350/VT8-430 Fuel Flow)
3. AM 1-11 (5) (PTG Fuel Pump Flow)
4. AM 1-12 (1) (Cummins Fuel System Arrangement)

MAINTENANCE MANUALS:

CUMMINS - V12 Series Operator's Manual
CUMMINS - V12 Series Shop Manual

FILM STRIPS:

1. Theory of the PTG Fuel System -- Film #985509
2. Principles of a Mechanical Governor -- Film #985511
3. Operations and Adjustments of the PTG Fuel Pump -- Film #985512

NOTE: Records are available to accompany the above films.

CUTAWAYS:

PTG Fuel Pump or obtain one from the shop and tear it down in class.

QUESTIONS FOR DISCUSSION AND GROUP PARTICIPATION:

Part I

1. What component in the Cummins fuel system does the metering of fuel?
2. Is it possible for an engine to run smoothly if different quantities of fuel are being delivered to each cylinder? Explain.
3. What happens when fuel is delivered too early to the cylinder?
4. What components determine when the fuel will reach the combustion chamber at the correct time?

Questions for Discussion and Group Participation continued

5. Why is complete atomization of the fuel vital to good combustion?
6. How does the fuel help to cool the injectors?
7. Could a Cummins engine operate without an Aneroid control?
8. What purpose has the electric shut-off valve located on top of the fuel pump?

Part II

1. How can one tell if a fan belt is too loose or too tight?
2. What is meant by the word "shims"?
3. Why is it advisable to replace belts in pairs when there is more than one?
4. Why use two clamps on all radiator hoses?
5. Why pour cil down the rocker arms and push rods when the crankcase is full of oil?