TM 11-925-B

WAR DEPARTMENT TECHNICAL MANUAL

POWER UNIT
PE-185-B

RESTRICTED. DISSEMINATION OF RESTRICTED MATTER
The information contained in restricted documents and the essential characteristics of restricted material may be given to any person known to be in the service of the United States and to persons of undoubted loyalty and discretion who are cooperating in Government work, but will not be communicated to the public or to the press except by authorized military public relations agencies. (See also par. 18b, AR 380-5, 28 September 1942.)

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5 AUGUST 1944

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WAR DEPARTMENT
WASHINGTON, 5 AUGUST, 1944

This Technical Manual, published on contract No. W 2279-sc-50, is furnished for the information and guidance of all concerned.

A. G. 062.11 (5-5-43)

By order of the Secretary of War:

G. C. MARSHALL,
Chief of Staff

Official:—

J. A. ULIO,
Major General,
The Adjutant General

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For explanation of symbols, see FM 21-6.

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SAFETY NOTICE

This unit generates voltage which may cause severe and possibly fatal shock. Always open the circuit breaker before changing load connections. Disconnect the battery and the remote control before working on the unit. Observe extra caution when working on wet or damp ground.

Provide ample ventilation when operating the unit in a confined space. Make sure that all exhaust connections are gas tight. When operating out-of-doors, locate the exhaust so that the wind will carry exhaust gases away from the personnel.

**EXHAUST GASES CONTAIN CARBON DIOXIDE,
WHICH MAY CAUSE SUFFOCATION**

Do not service the unit while it is running or is close to an operating radio transmitter.

REMEMBER THESE POINTS

1. Don't attempt repairs or adjustments to this unit unless you are sure what you're doing.
2. Watch your lubrication; check the oil level every 5 hours.
3. Don't take chances with exhaust gases; keep your exhaust line tight and be sure you have proper ventilation.
4. Be sure there is no dirt in your oil and fuel.
5. Keep your air filter clean. Watch this closely in dusty locations.
6. Keep the unit as clean as possible. Dirt on the cooling fins and in the air passages will cause overheating.
7. Don't expose your unit to rain or dampness. Electrical equipment and water do not mix.
8. Look out for shock. Don't touch exposed wires.
9. Go over your unit daily and tighten all screws and nuts.
10. Always warm up your unit before applying a load.
11. Study this book. Keep it handy. It will save you plenty of trouble.

DESTRUCTION NOTICE

WHY — To prevent the enemy from using or salvaging this equipment for his benefit.

WHEN — When ordered by your commander.

HOW — 1. Smash — Use sledges, axes, handaxes, pickaxes, hammers, crowbars, heavy tools, etc.

2. Cut — Use axes, handaxes, machetes, etc.

3. Burn — Use gasoline, kerosene, oil, flame throwers, incendiary grenades, etc.

4. Explosives — Use fire arms, grenades, TNT, etc.

5. Disposal — Bury in slit trenches, fox holes, other holes. Throw in streams. Scatter.

USE ANYTHING IMMEDIATELY AVAILABLE FOR DESTRUCTION OF THIS EQUIPMENT.

WHAT — 1. Smash — Radiator, battery, fuel tank, generator and exciter frame, oil filter, fuel pump, water pump, cylinder head, cylinder block, air cleaner, muffler, governor, manifolds, control panel instruments, voltage regulator, terminal panel, and batteries.

2. Cut — All cables, control panel wiring, fuel pipes, generator windings, exhaust tube, battery cables, radiator hose, and all other wires or cables used in or on the unit.

3. Bend and/or break — Unit housing, control cabinet, cable reels, tool and spare parts box and contents, and unit base.

4. Burn — Instruction books, other papers or documents, wire and cable, fuel, and oil.

5. Bury or scatter — Any or all of the above pieces after breaking.

DESTROY EVERYTHING

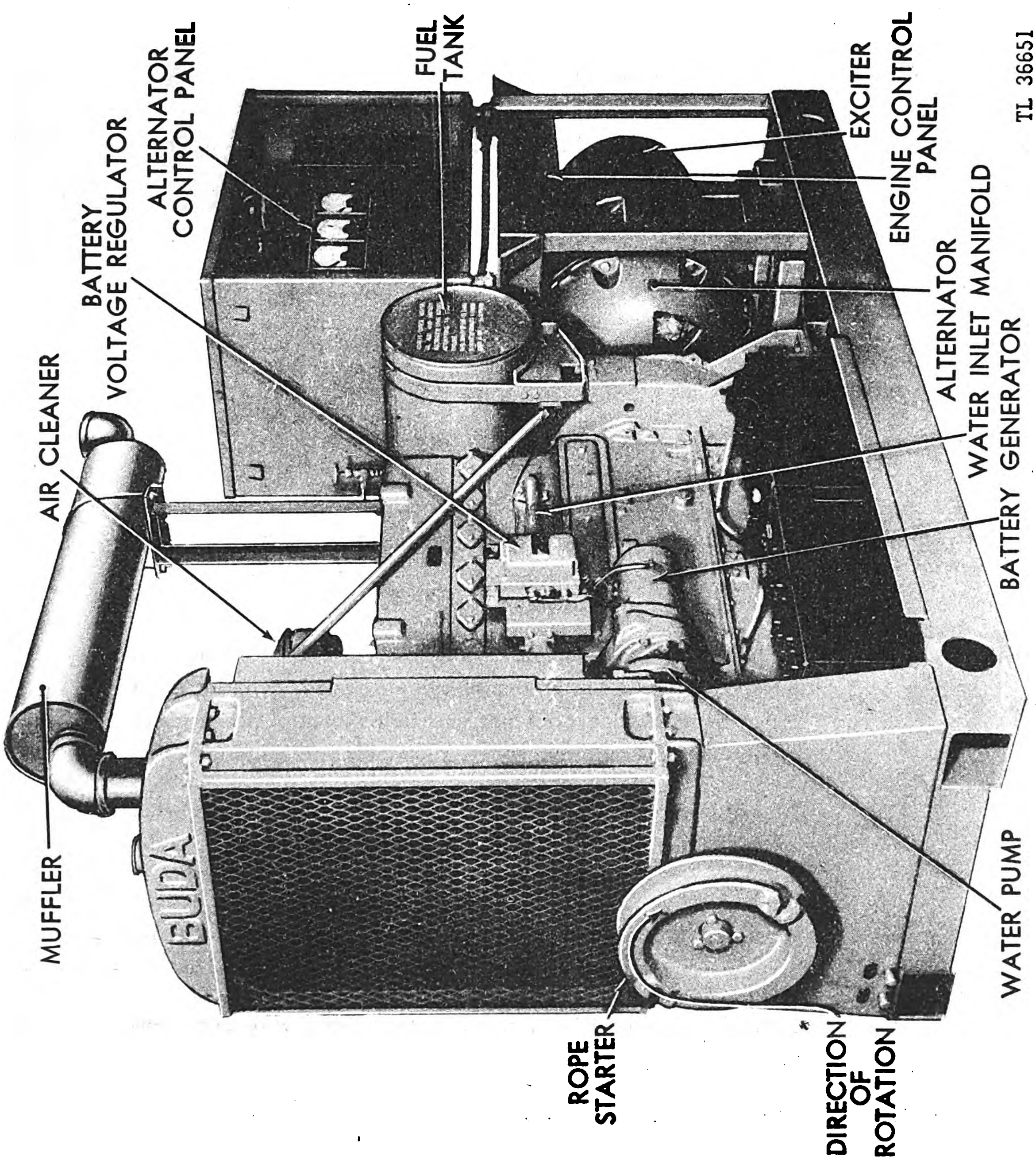

Fig. 1. Left Front of Power Unit PE-185-B

SECTION I
DESCRIPTION

1. **General.** Power Unit PE-185-B is intended to supply power for the operation of electrical equipment.

The power unit consists of a Diesel engine, and a generator (also called the alternator) to which the Diesel engine is directly connected. (See Figures 1 and 2.) The unit is shipped complete with tools, spare parts, muffler, fire extinguisher, fuel can, oil can, battery electrolyte, and technical instruction manual. Instructions for use of the fire extinguisher are given in paragraph 19. Before attempting to operate or service this power unit, read the manual carefully until you thoroughly understand the instructions.

The over-all dimensions of Power Unit PE-185-B are: length 119⁵⁄₁₆ inches, height 76¾ inches, and width 34¾ inches. The weight is 5,100 pounds.

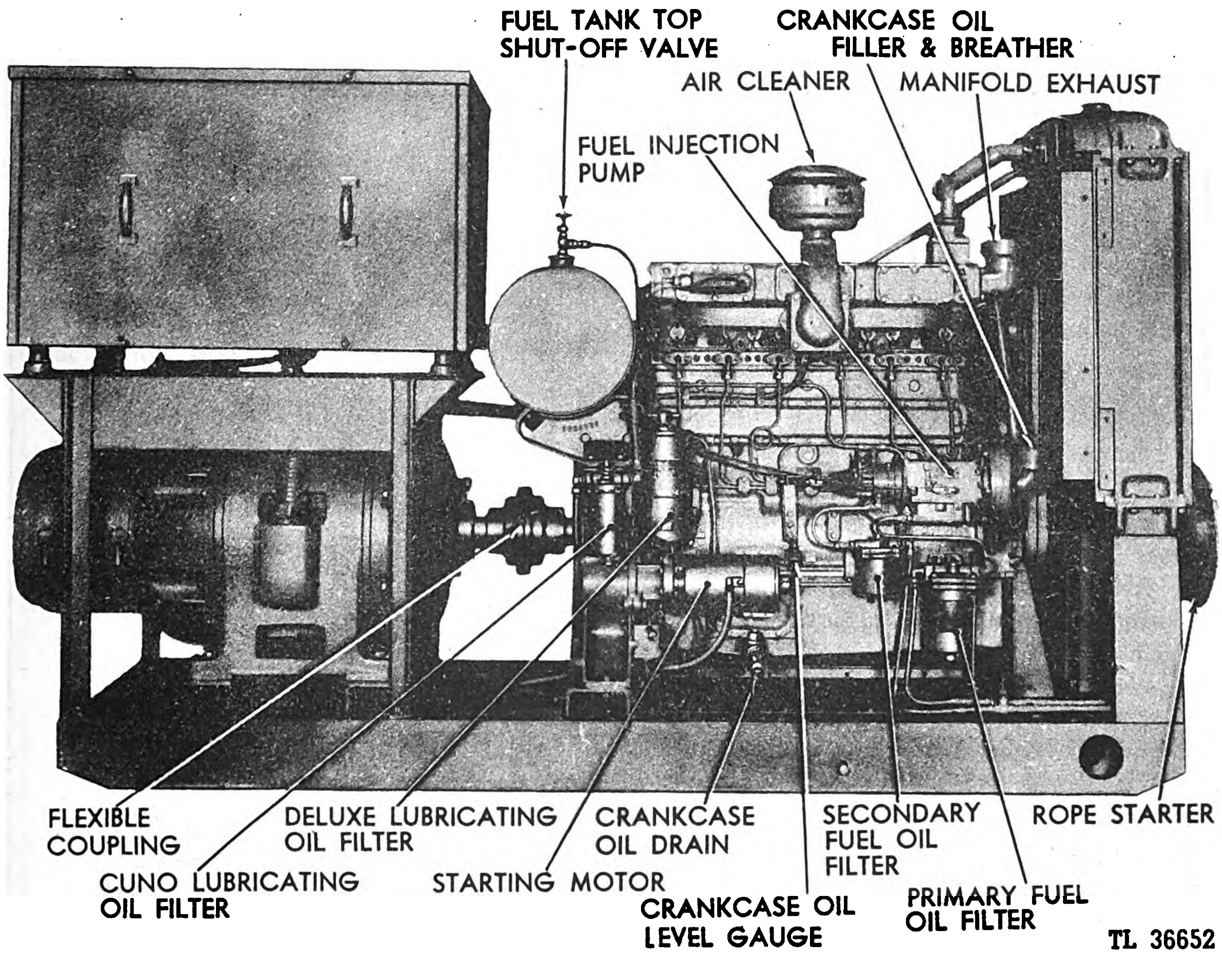

Fig. 2. Right Side of Power Unit PE-185-B

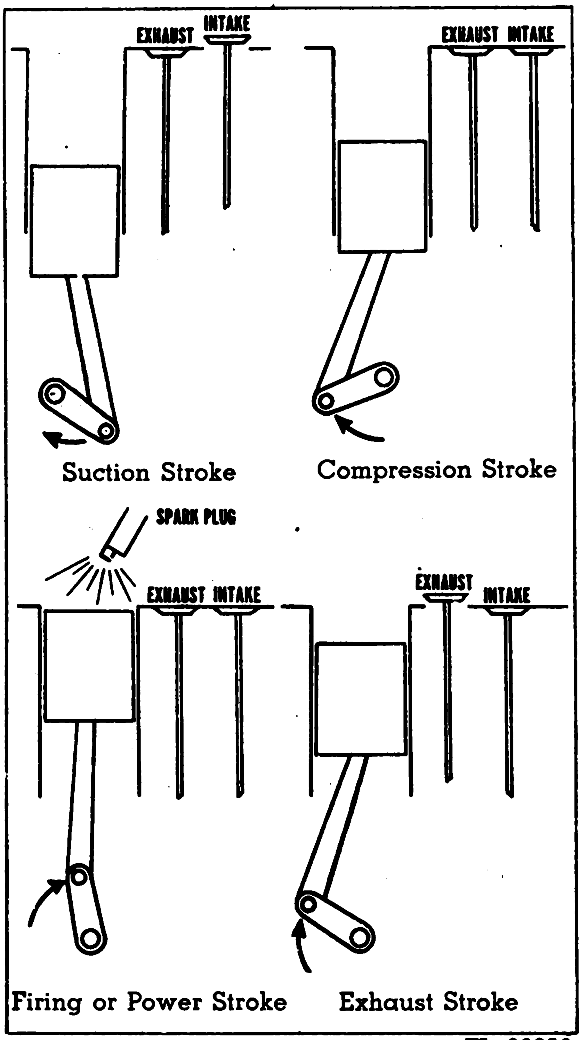

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Fig. 3. Four-Cycle Operation (Gasoline)

2. Engine. The Diesel engine is of the four-stroke cycle, full Diesel, solid injection type. By full Diesel is meant that the ignition is caused entirely by heat of compression, and that no hot bulb or plate is used to help ignite the atomized fuel. In the solid injection system the fuel is injected in the form of a spray, and other methods of breaking up the fuel and mixing it with the air are employed. Paragraph 4 describes the method of mixing the fuel and the air in the Buda-Lanova low pressure combustion system.

The equipment used in the operation of the engine consists of an air cleaner, batteries (two), fuel filter (primary), fuel filter (secondary), fuel injection pump, generator and charging battery, howler system, high water temperature switch, low oil pressure switch, governor, muffler, oil filter, starting motor, and voltage regulator (battery generator). (See Figures 1 and 2.)

3. Principle of Operation. In the four-stroke cycle Diesel engine the following series of actions take place: (a) inlet stroke, (b) compression stroke, (c) expansion or power stroke, (d) exhaust stroke. (See Figure 3A.) The fuel is ignited when it is injected into the heated air in the combustion chamber. This air is heated by rapidly compressing it after it is drawn in during the intake stroke.

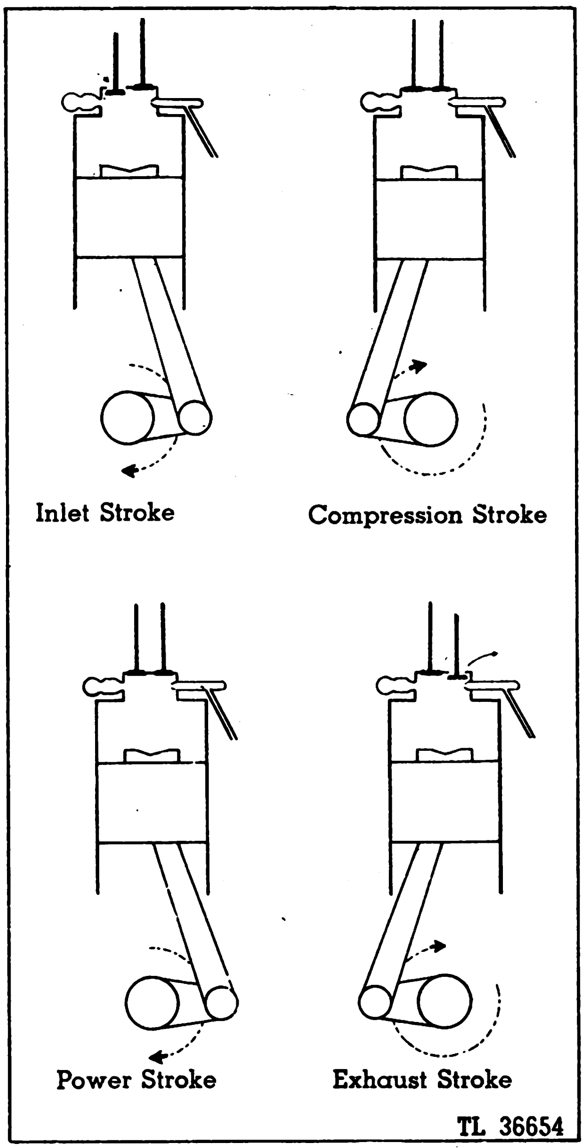


Fig. 3A. Four-Cycle Operation (Diesel)

The mechanism of the Diesel engine is similar to the more familiar gasoline engine in that the heat liberated by the combustion of fuel raises the temperature and pressure of the gases in a cylinder. 'hese gases then expand against a piston attached to a crank in such a manner as to produce a rotative effort. The sequence of actions, or cycle, of the two engines compare as follows: (See Figures 3 and 3A.)

a. Gasoline.

(1) On the first down stroke of the piston, the cylinder is filled with **a mixture** of atomized fuel and air.

(2) On the up stroke, the combustible mixture is compressed. Near the top of the stroke, the mixture is ignited by an electric spark.

(3) On the following down stroke, the piston is forced downward by the combustion.

(4) On the succeeding up stroke, the burned gases are forced out of the cylinder.

b. Diesel.

(1) On the first down stroke of the piston, the cylinder is filled with **fresh air only.**

(2) On the up stroke, the air is compressed. Near the top of the stroke, the fuel is injected and ignites as it mixes with the heated air.

(3) On the following down stroke, the burning of the fuel is regulated so that the combustion which forces the piston downward is controlled.

(4) On the succeeding up stroke, the burned gases are forced out of the cylinder.

The essential difference between the Diesel engine and the gasoline engine is that in the former the fuel is injected into hot, highly compressed air, at which time burning starts and combustion is controlled. In the gasoline engine the fuel enters and is compressed with the air; ignition is by an electric spark.

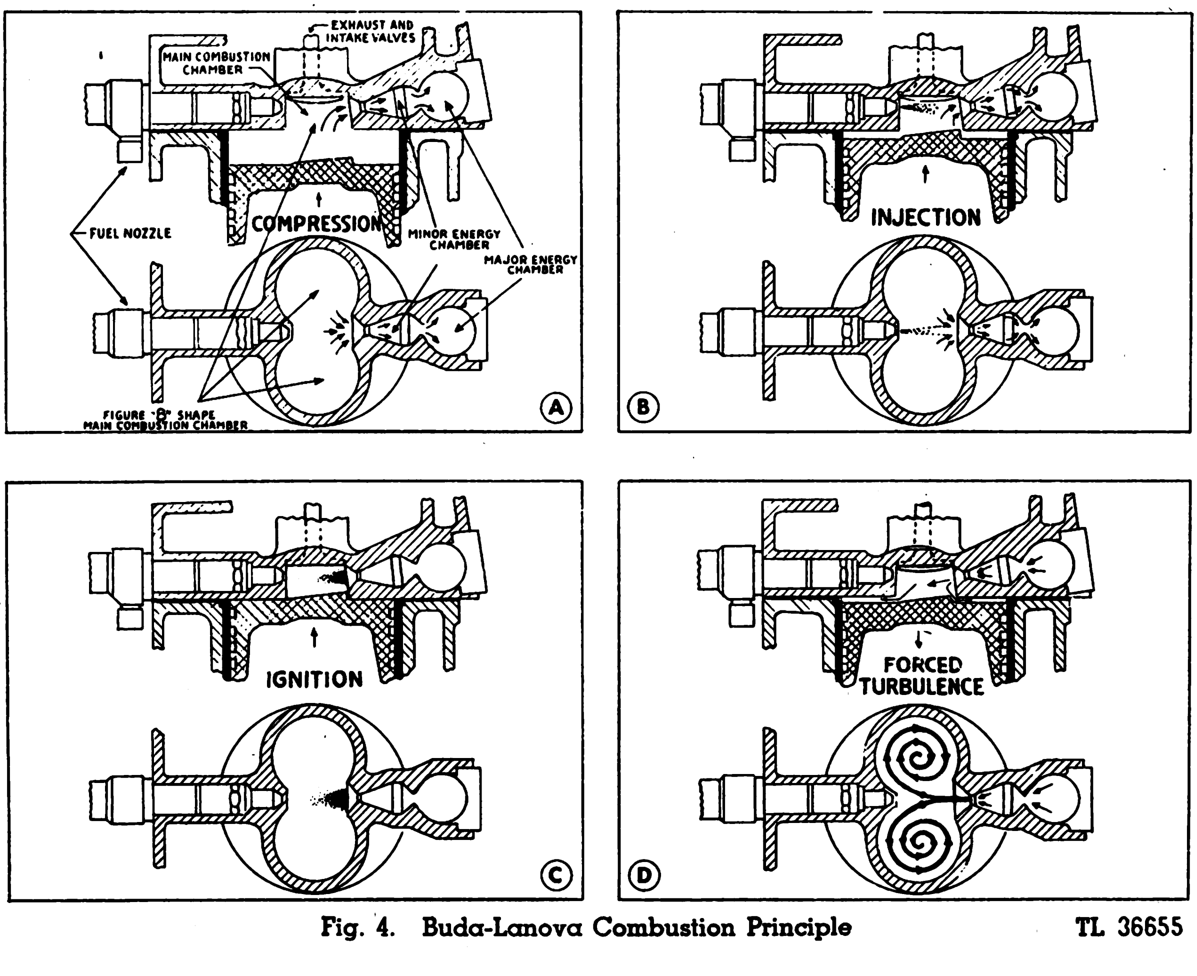


Fig. 4. Buda-Lanova Combustion Principle TL 36655

4. Low Pressure Combustion. In the Buda-Lanova combustion chamber, the clearance volume above the piston consists of three chambers. The main chamber is in the shape of a figure 8, which also forms the housing for the intake and exhaust valves. (See Figure 4.) The two auxiliary chambers of the energy cell are located directly opposite the injection nozzle. Beginning with the compression stroke and ending with the expansion or power stroke, four events or actions take place. These are designated as (a) compression period, (b) injection period, (c) ignition period, (d) controlled turbulence period. Figure 4, with the following explanation, illustrates the occurrences during each of these four periods.

a. Compression Period. Referring to Figure 4, illustration A, note that the air is compressed in the main chamber and also forced into the energy cell during the compression stroke. This energy cell is divided into a major and a minor cell. A predetermined portion of air is forced back into the minor and major energy cells as indicated by the arrow.

b. Injection Period. Just before the piston reaches top dead center (T.D.C.) while the air is being forced at high velocity through the opening which leads into the energy cell, the injection of the fuel begins. The atomized fuel rushes through the heated air of the main combustion chamber. No fuel strikes the piston. A predetermined portion of fuel enters the energy cell where it is intimately mixed with this inrushing air.

c. Ignition Period. Initial ignition takes place in the main combustion chamber where the compression (and consequently the temperature) is slightly higher. The fuel mixture burns very slowly here as it is not yet thoroughly mixed with the air. This delayed burning eliminates sudden combustion of the fuel and the resultant possible shock to the pistons, rods, and bearings.

d. Controlled Turbulence Period. In the energy cell, where the fuel is well mixed with the air, the burning is rapid. High pressure is developed quickly and a blast or backfire is sent out across the main combustion chamber. This blast breaks up the cloud of fuel in front of the cell and starts the "double swirl" in the main combustion chamber. This violent swirling, called turbulence, thoroughly mixes the fuel with the air in the main chamber and results in complete and controlled combustion, which also results in low peak pressures and temperatures.

5. Component Systems of the Engine. The component systems of the engine are: air induction, cooling, electrical, exhaust, fuel injection, howler or warning, and lubrication. Instructions for the overhaul of the various accessories of the component systems are given in paragraphs 61 to 93 inclusive.

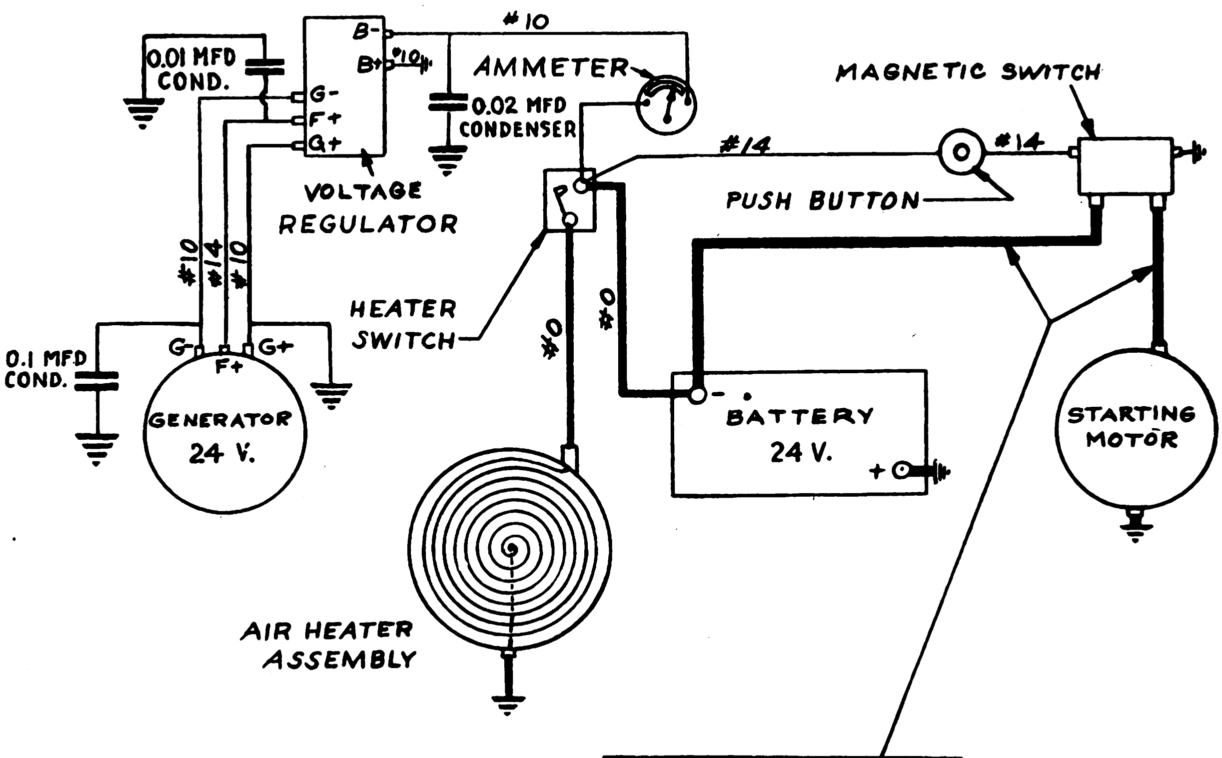
6. Air Induction System. Referring to Figures 3 and 3A, note that the piston is moving downward and the intake valve is open. This downward movement of the piston causes a pressure drop within the cylinder below atmospheric pressure. Atmospheric pressure, tending to equalize the pressure within the cylinder, causes a flow of air through the open intake port. Because it is important to efficient engine operation that only clean air enter the engine, an air cleaner is installed at the opening of the intake manifold through which the cleaned air is conducted to the various intake ports in the cylinder head. Dust is removed from the incoming air by the air cleaner which is of the oil-bath type. The indrawn air in striking the oil produces a fine mist, removing part of the dust and dirt. The dust remaining is removed by the filter element in the main body of the cleaner which the oil mist keeps moist. As oil mist collects in the cleaning element, drops form (draining into the oil cup where the sediment is deposited) to wash the filter element. Because abrasive dust is the chief cause of engine wear, it is important that the air cleaner be serviced after every eight hours of use, as recommended in the Maintenance Chart.

Since the fuel is ignited by the rise in temperature of the air caused by compression, as explained in paragraph 4, any means of increasing this temperature will aid starting. An air preheater is provided in the inlet manifold to increase the temperature of the inlet air to aid starting in cold weather. This preheater consists of an electric heater grid in the inlet passage which is connected directly across the battery terminals and operated by a switch. The switch should be used to operate the air heater prior to and during cranking operation. Do not use the switch continuously longer than 30 seconds. (See paragraph 73.)

7. Cooling System. The cooling system dissipates the excess heat from the engine and holds it to a temperature that makes for efficient engine operation. This temperature should be approximately 170 degrees Fahrenheit. A thermostat so controls the flow of water that when the engine is cool the water recirculates around the engine water jackets by a centrifugal pump without passing through the radiator. As the engine warms up, the thermostat opens, allowing the water to be circulated through the water jackets, around the exhaust manifold, and through the radiator where the cooling takes place. A fan creates a draft through the radiator to cool the water, the temperature of which is indicated by the gauge. The high water temperature switch will close automatically and cause the howler or warning system to sound if the water temperature exceeds 205 degrees Fahrenheit. (See paragraph 11.)

8. Electrical System. The engine electrical system primarily furnishes the electrical energy needed to crank the engine and to preheat the intake air. The system is radio shielded to prevent radio interference. Starting or cranking is done by means of a starting motor which receives its electrical energy from the storage battery. The electrical system is of 24 volts, consisting of two 12-volt batteries connected in series with a 24-volt starting motor and generator, and with a voltage regulator which automatically decreases or increases the rate of the current flowing to the batteries, depending upon the state of charge. If the batteries are in a low state of charge, the battery charging generator output is increased; if high, the output is decreased. (See paragraph 76d, and Engine Wiring Diagram, Figure 5.)

9. Exhaust System. The exhaust system consists of the exhaust manifold, exhaust pipes,



VOLTAGE	TOTAL LENGTH OF CIRCUIT	WIRE SIZE
24 V.	0-15 FEET	#00

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Fig. 5. Engine Wiring Diagram

and muffler. The purpose of the exhaust system is to carry away the burned gases as noiselessly as is possible. In order to aid the dissipation of the heat being carried away from the engine, the exhaust manifold is water cooled. Unlike the burned exhaust gases from a gasoline engine, which contain carbon monoxide and are poisonous, the exhaust fumes of a Diesel are not poisonous, but may produce suffocation. Therefore, if a Diesel engine is operated in an unventilated room, the exhaust gases should be piped outside the building in order to avoid the danger of suffocation. (See paragraph 23 (2).) If a person be overcome by exhaust gases, it is essential that he be rescued within five minutes from the space containing the gas. To revive a person so overcome, remove him to fresh air and apply artificial respiration as in the case of drowning.

10. Fuel Injection System. The fuel system cleans, prepares, controls, and times the flow of the fuel to the engine. (See Figure 6.) The fuel passes through the primary filter to the fuel transfer pump. From the fuel transfer pump, it passes through the second stage filter to the fuel injection pump, from which it is injected through the injection nozzles into the combustion chamber. A governor, built into the fuel injection pump, automatically regulates the speed of the engine. The engine speed is controlled by means of a mechanical centrifugal or flyball variable-speed-type governor, which will permit close regulation from idle to full load speeds.

The position of the rotor contained in the fuel pump determines the amount of fuel injected into the cylinder. This rotor is held in balance between a pair of weights and the governor spring. An increase in speed causes the weights to exert a greater force on the rotor, which in turn reduces the quantity of fuel injected; conversely, a reduction in speed causes the weights to exert lesser force, and thereby the governor spring moves the rotor position to increase the amount of fuel delivered. (See paragraph 81.)

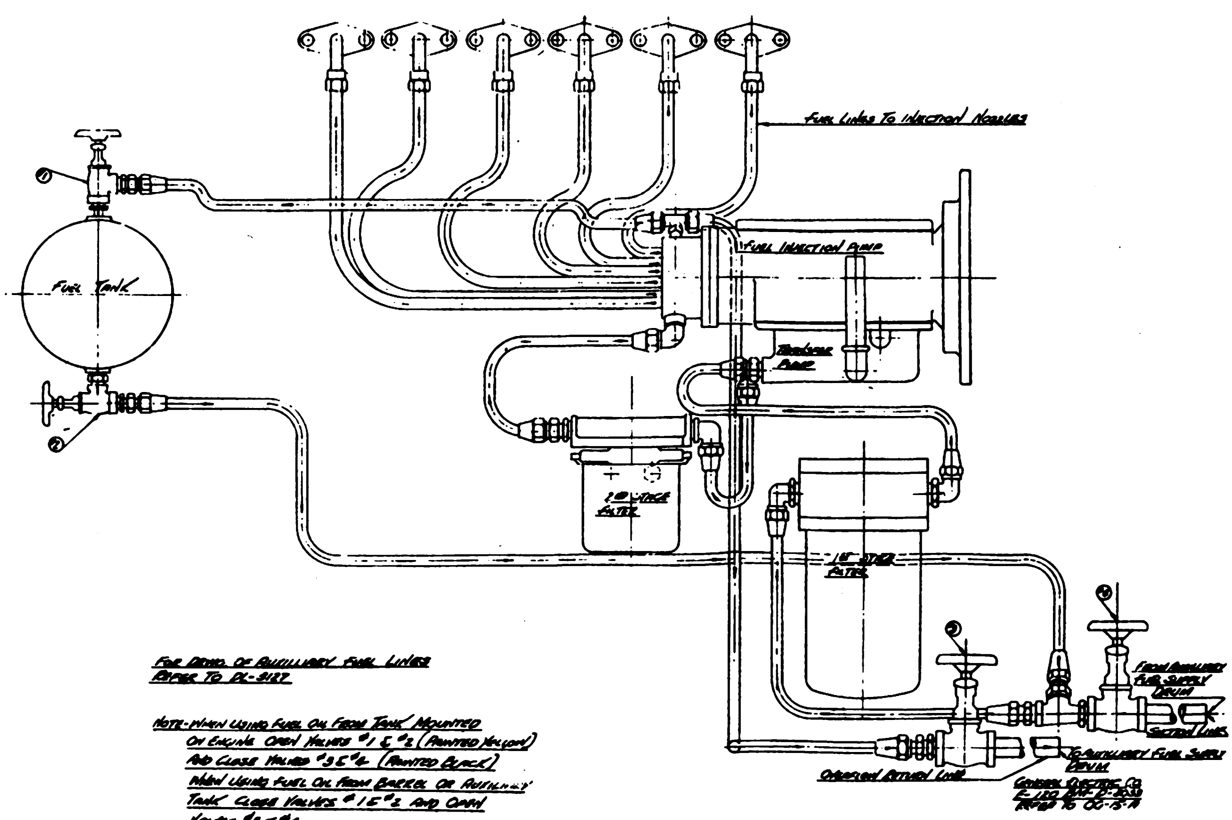

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Fig. 6. Fuel System

11. Howler System. The purpose of the howler system is to warn the operator when the water temperature is too high or the oil pressure is too low. If the oil pressure drops below 10 pounds or the water temperature exceeds 205 degrees Fahrenheit, the howler will sound and a warning light will go on. The yellow light indicates that the oil pressure is too low; the red light that the water temperature is too high; the green light that the system is operating properly. (See Figure 15A.)

Should the warning howl sound, try to discover the cause. If conditions permit, shut down the power temporarily. Move the circuit breaker to the OFF position and stop the engine by pulling out the stop control lever on the engine control panel. If power without interruption is needed, another power unit should be put into operation if possible. The wiring diagram of the howler system is shown in Figure 7. The howler switch controls the warning horn. The electrical energy needed to operate the howler system is received from the current being generated by the alternator. The receptacle fuse protects the howler system.

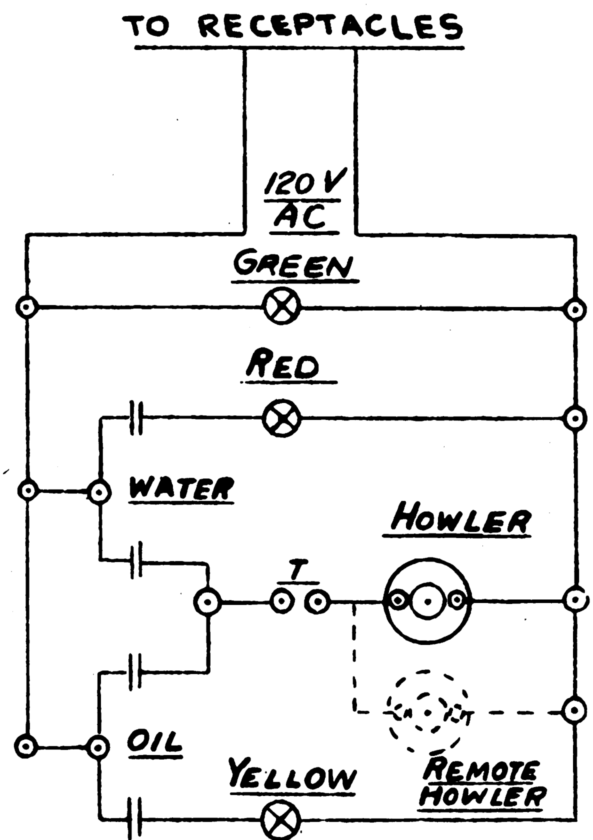

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Fig. 7. Howler Wiring Diagram

12. Lubricating System. A high speed oil pump sends the lubricating oil under pressure to the internal working parts of the engine. The oil is drawn from the pan through a suction screen and through drilled passages in the crankcase to the oil pump. From the pressure side of the pump the oil goes to the Cuno filter and a portion goes to the DeLuxe oil filter. From the DeLuxe filter it is returned to the oil pan. From the Cuno filter the oil goes to the main gallery line and to the oil pressure relief valve which limits the oil pressure to approximately 25 to 35 pounds when the oil is at normal temperature. From the main gallery line, side passages are drilled to the main bearings, the oil pressure gauge connection, and to the external connection to lubricate the rocker arm shaft and the Excello fuel injection pump. From the main bearings, the oil is delivered to the connecting rod bearings by means of the drilled crankshaft. After leaving the main bearings, the oil goes (1) through the rifle-drilled connecting rod to the piston pin, (2) through drilled passages in the crankcase to the camshaft bearings, (3) through a drilled passage to the idler gear stud. From the idler gear stud, oil is forced to the idler gear bearing from which it passes through drilled holes in the gear to lubricate the entire gear train. The cylinder walls are lubricated by the excess oil forced around the piston pin bearings and the splash from the connecting rods. (See Figure 8, Lubrication Diagram; also see paragraph 30.)

13. Alternator and Exciter. *General.* The weight of the a-c generator and exciter is 1,380 pounds. (See Figure 9.) It is designed for continuous operation in accordance with A. I. E. E. standards. The temperature rise of the generator at continuous full load, or at 25 per cent overload, for two hours at 55 degrees Centigrade ambient temperature, does not exceed the safe value for the class of insulation used, as tested in accordance with A. I. E. E. standards. (The ambient temperature is the temperature of the air which comes into contact with the heated parts of a machine

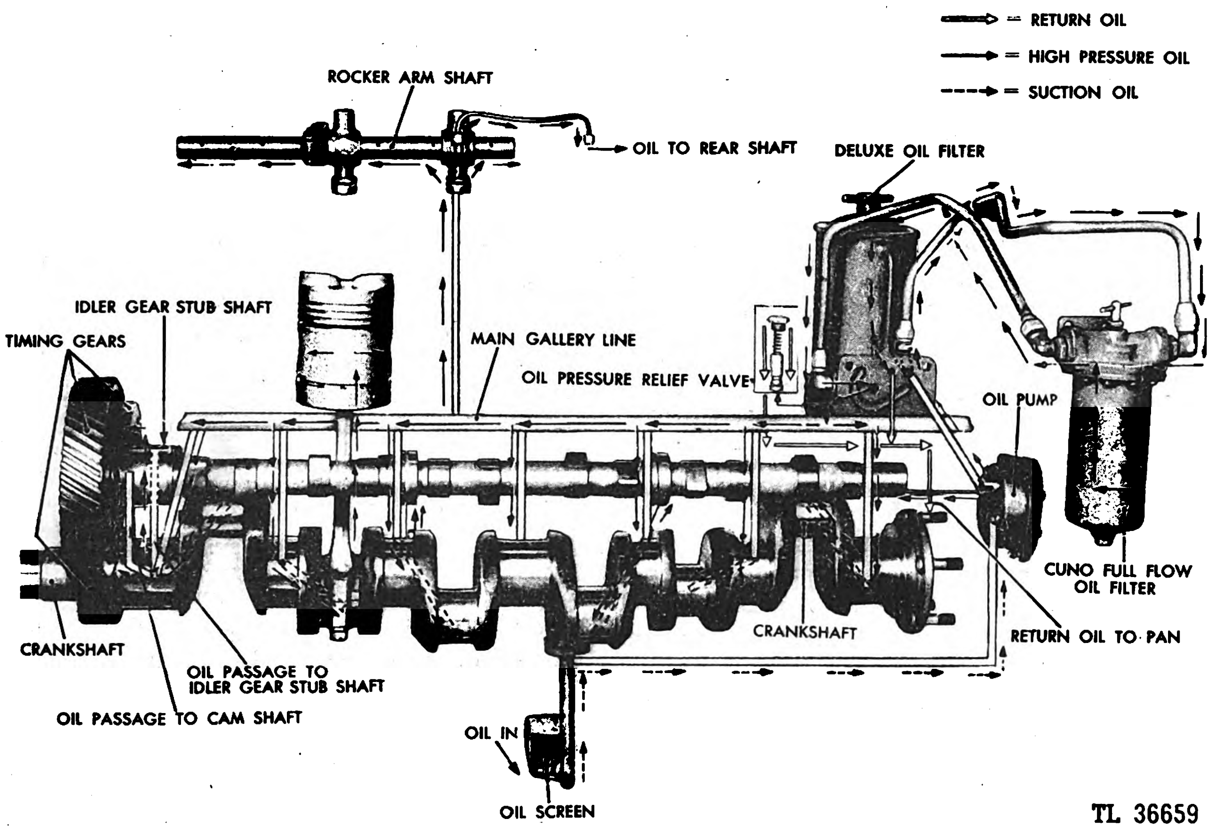

Fig. 8. Lubricating System (Engine)

and carries off its heat.) Both the alternator and exciter are self-cooled by means of fans attached to the armature shafts. The alternator and exciter are so designed and constructed as to eliminate radio interference through the radio frequency range between 550 kilocycles to 300 megacycles.

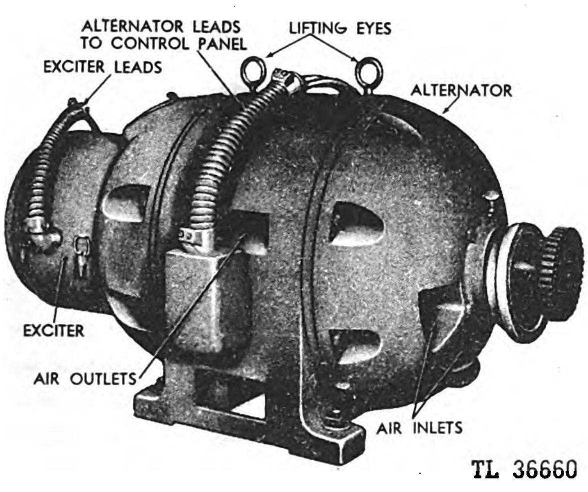

Fig. 9. Alternator and Exciter

14. **Alternator.** *a. Rating.* The main generator, or alternator which is the common term for an a-c generator, is directly connected to the engine and operates at engine speed, which is 1200 revolutions per minute. The excitation is supplied by a direct connected exciter which is located on the shaft extension of the alternator. The three-phase, four-wire, 60-cycle alternator is rated at 25 kw., 31.3 kva., 87 amperes, at 80 per cent power factor, 1200 r.p.m., 208/120 volts, at full load. The generator is provided with two ball bearings of such design that old grease is flushed out and forced into a reservoir when new grease is added.

b. Theory of Operation. The generator with its exciter transforms mechanical energy of the Diesel engine into electrical energy for operation of radio equipment, lights or motors. The Diesel engine rotates the exciter armature and generator rotor assembly. Residual magnetism in the exciter field poles sets up a magnetic flux which passes across the exciter air gap and into the exciter armature. As the armature conductors pass the poles, a voltage is generated in these conductors. Brushes on the commutator pick up the generated current at the most advantageous instant. This process is called commutation. Connections in the exciter are made so that a small portion of this current is diverted through the exciter field coils to increase the strength of the magnetic flux and in turn to generate a higher voltage until the requirements of the generator are met. The larger portion of this direct current flows through the windings of the generator field poles by the way of generator brushes and collector rings. As the poles pass the conductors in the stator, an alternating voltage is generated in these conductors. The value of this voltage is proportional to the speed of the rotor and the amount of current passing through the field windings. The amount of current in the stator winding varies according to the load on the generator.

c. *Construction.* The unit consists of the a-c generator with a direct connected d-c generator used as an exciter. The main parts of the a-c generator are a wound stator (Figure 10), two end shields, a rotor assembly (Figure 11), and a brush rigging with necessary parts. The wound stator consists of a cast-iron frame, in which is assembled a set of slotted punch-

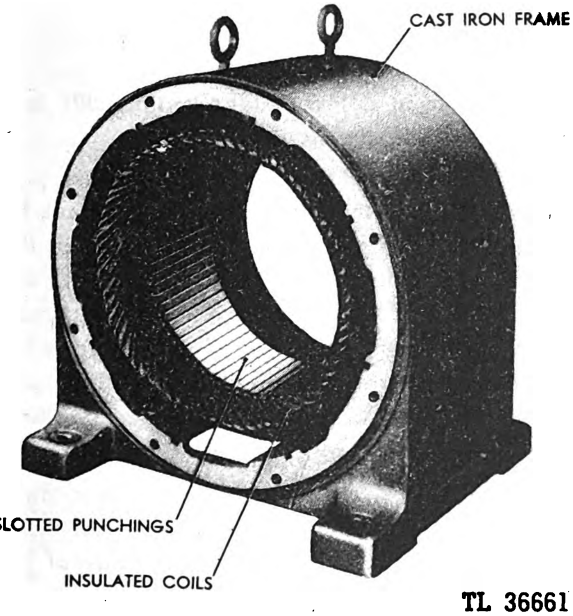

Fig. 10. Alternator Stator

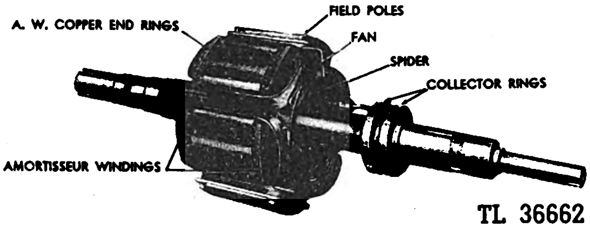

Fig. 11. Alternator Rotor

ings. Insulated coils are assembled in the slots and properly connected with four leads brought out for connections. A cast-iron end shield is bolted to the stator frame, engine end. A cast-iron end shield with a removable cover is bolted to the opposite end of the frame. The end shields, along with the bearings (Figures 12 and 13), support the rotor assembly and permit it to turn inside the stator. The bearings are pressed on the shaft and are held in place by a bearing nut and a bearing lockwasher. The rotor assembly consists of collector rings (Figure 11) and a spider pressed on the shaft, six ventilating fans bolted to the spider, and six field poles mounted securely on the spider. The brush rigging consists of four brush-holder assemblies, four brushes, four springs, four lever assemblies, and an insulated stud with a jam nut.

d. *Ventilation.* Ventilation of the machine is of the double-end radial type. The three ventilating fans, bolted to each end of the spider, draw air into the generator and exciter from both ends of the machine. The air inlets at the engine end are shown in Figure 9. An air baffle (Figure 12), which is bolted to the end shield at this end, directs the cooling air against the generator rotor poles, through and around the end loops of the stator coils at the engine end, and through the outlets (Figure 9) in the stator frame. The cooling air passes around the exciter field poles and across the exciter armature and then into the generator through openings in the generator end shield. An air bafflle (Figure 13) is bolted to the end shield. This baffle guides the air directly against the rotor poles, through and around the end loops of the stator coils at the exciter end, and through the outlets in the stator frame.

e. *Stator.* The slotted punchings (Figure 10) are assembled in dovetailed slots which are machined in the stator-reinforcing ribs.

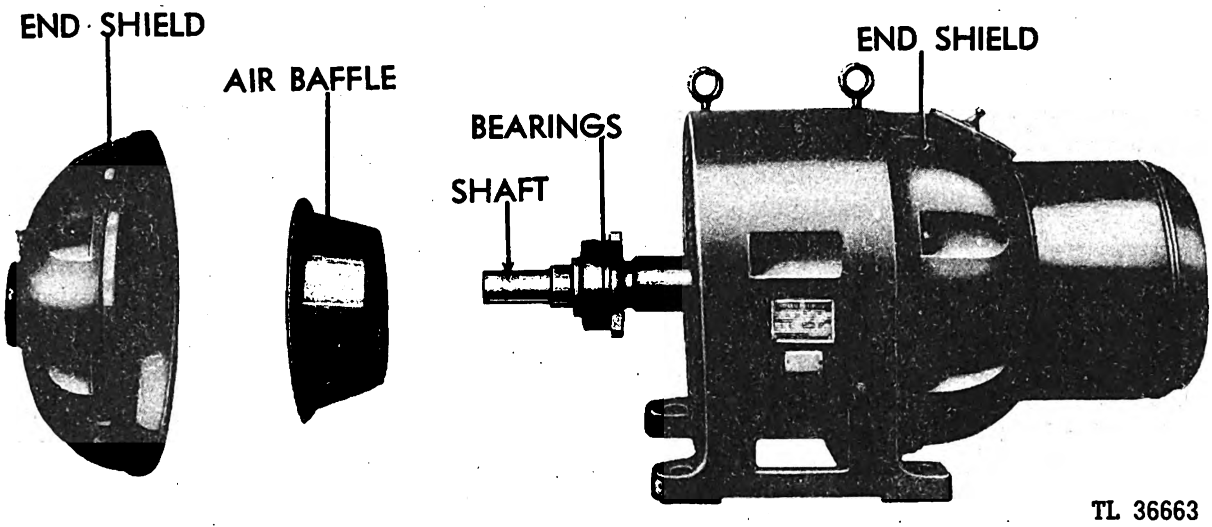

Fig. 12. Bearing Bracket and Air Deflector, Engine End

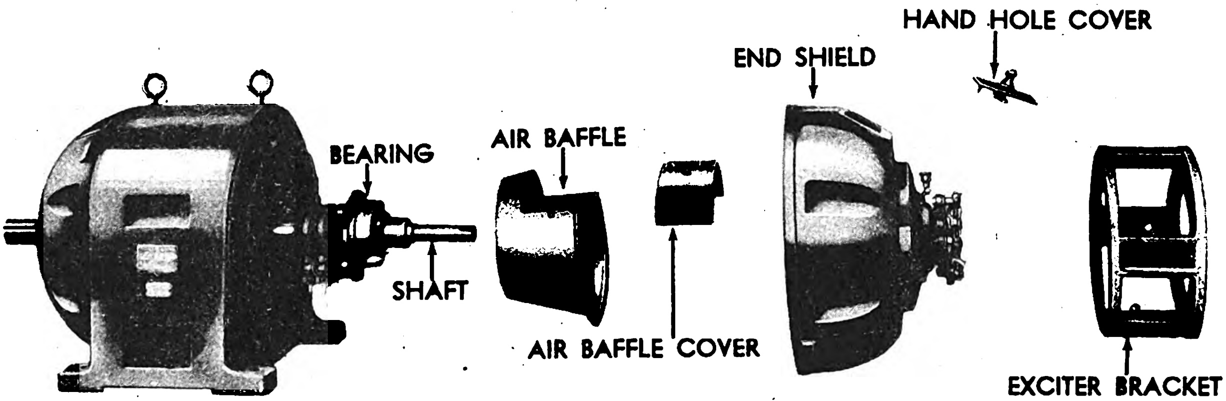

Fig. 13. Exploded View of Alternator, Exciter End

The punchings are held in place under pressure by heavy end flanges keyed to the stator frame. The punchings are high grade, non-aging silicon steel. The stator winding is of the random wound type, thoroughly insulated after assembly in the slots. The coils are wound of heavy, formex, cotton-covered wire. Slot tubes insulate the coils from the punchings. After the stator is wound, it is thoroughly impregnated with a varnish which is resistant to acid, oil, and moisture.

f. Rotor. The rotor is dynamically balanced so that the vibration measured by a vibrometer when the generator is standing on a solid bed plate is less than .003 inch. When the generator feet are resting on a level surface, the shaft is in a level plane within .007 inch to each foot of shaft length.

g. Amortisseur Windings. Each field pole has a copper armortisseur winding (Figure 11) located in the pole face. The bars of this winding are fitted into holes in the copper end rings and are silver-soldered to make permanent alloy joints. These windings improve the generator operation when connected in parallel with other units driven by a Diesel engine.

h. Determining Winding Temperatures. The temperatures of the windings are determined by the thermometer method and the resistance method. The temperature of windings of the rotor are determined by placing a thermometer on the windings.

i. Voltage Tests of Windings. The alternator and exciter are tested to withstand the high potential tests as prescribed in the latest revision of the A. I. E. E. standards; alternator field windings, 1500 volts; other windings, twice their rated voltage plus 1000 volts.

j. Collector Rings and Brush Holders. The collector rings are bronze and are machined free of cuts, flats, or any unevenness. Brush holders are of corrosion-resisting material so constructed as to prevent binding and to permit easy removal of the brushes. The collector ring brush holders are mounted so that the lower edge has a clearance of from $\frac{1}{8}$ inch to $\frac{5}{16}$ inch from the collector ring. The brush holders are located so that the brushes do not override the edges of the collector rings under normal operating conditions. Two covers provide access to the brush rigging for adjustment of springs and for brush replacement. The end shield at the exciter end of the machine has a handhole cover (Figure 13) and the air baffle has a cover made of sheet metal and attached with a pair of wing nuts. Access to the brush rigging may be gained through air vents in the bottom half of the end shield after the exciter cover has been removed (See paragraph 98.)

k. Minimum Air Gap. The minimum air gap for the generator is not less than 70 per cent of the normal gap. The air gap is the distance between the stator and outside of rotor —about $\frac{1}{8}$ inch.

l. Connections. The generator is connected three-phase star with a neutral lead brought out.

m. Insulation Resistance. The insulation resistance of the windings is usually measured with an instrument called a megger. The insulation resistance of machines in service should be checked periodically for possible deterioration of the windings.

This measurement gives an indication of the condition of the insulation, particularly in regard to moisture and dirt. The actual value of resistance varies greatly in different machines, depending on the size and voltage. The chief value of measurement, therefore, is in the relative values of the resistance of the same machine taken at various times. During the drying-out run, for example, the insulation resistance rises as the winding dries out, although it may fall appreciably at first. When measurements are made at regular intervals, with the machine at the same temperature as part of the maintenance routine, it is thus possible to detect an abnormal condition of the insulation and take steps to remedy it before a failure occurs. The insulation resistance of a new machine should be not less than one megohm.

15. Exciter. *a. Rating.* The exciter is rated at 1 kw., 125 volts, and 8 amperes, with a temperature rise not exceeding 40 degrees Centigrade above the ambient temperature for continuous operation.

b. Commutator. The commutator segments are of the best hard-drawn copper and are insulated from the shaft and from each other. The insulation between the bars is undercut. Commutator surfaces run true and are free from flaws, tool marks or other imperfections.

c. Brush Holders and Brushes. Brushes in the holders are connected electrically to their holders by copper pigtails. The brushes are held against the commutator by a coiled spring which may be adjusted to three possible positions by its lever. The exciter brushes are of high grade carbon.

16. Alternator Control Panel (Switchboard). The self-contained alternator control or switchboard is mounted on the engine base over the

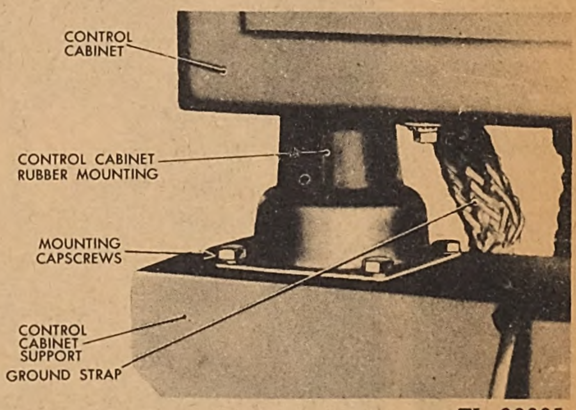

Fig. 14. Bonded Rubber, Anti-Vibration Mounting (Control Panel)

alternator. This control unit is of the cabinet type with a dead front construction. Access to the rear can be made by removing the cover plate. The entire enclosure is drip-proof and has been treated with rust-resistant paint to withstand salt moisture. The assembled switchboard on this control unit is mounted on the supporting frame by means of bonded rubber, anti-vibration shear mountings. (See Figure 14.) The switch cabinet, together with the supporting frame, may be removed from the unit and is self-supporting when placed elsewhere. It is the purpose of the alternator control panel, with its switch gear and instruments, to control the operation and output of the generator. The instruments and apparatus necessary to control the alternator output are given below. (See Figure 15.)

a. Main Breaker. The 100-ampere two-pole air circuit breaker serves the dual purpose of a circuit breaker and a disconnecting switch. A circuit breaker is a device constructed primarily for the interruption of a circuit under infrequent, abnormal conditions, overload, and short circuits. The circuit breaker on the PE-185-B Power Unit is automatic. The breaker is fully adjusted and does not have to be adjusted by the operator. In case an overload or short circuit occurs, the breaker will trip and the operating lever will move to the central position. In order to close the switch again, it is necessary **to move the operating lever to the OFF position and then move it to the ON position to again apply the load.** It is important, if such an overload exists, to remove the overload, or the cause, before further operation of the unit.

When the main breaker circuit is closed, the circuit is broken automatically if an overload or a short circuit condition exists. The heat caused by the overload or short circuit will cause a piece of metal in the circuit breaker to expand. This expansion moves a trigger which releases a latch, and, through spring action, this latch in turn breaks up the circuit. (See paragraph 105*g*.)

b. Voltmeter. The voltmeter shows the voltage between phases. With the voltage properly adjusted and the engine operating steadily, the voltage should be steady. The voltage regulator will automatically adjust the voltages to a value determined by the setting of the voltage adjusting rheostat on the front of the voltage regulator and by the setting of the exciter field rheostat. The generator

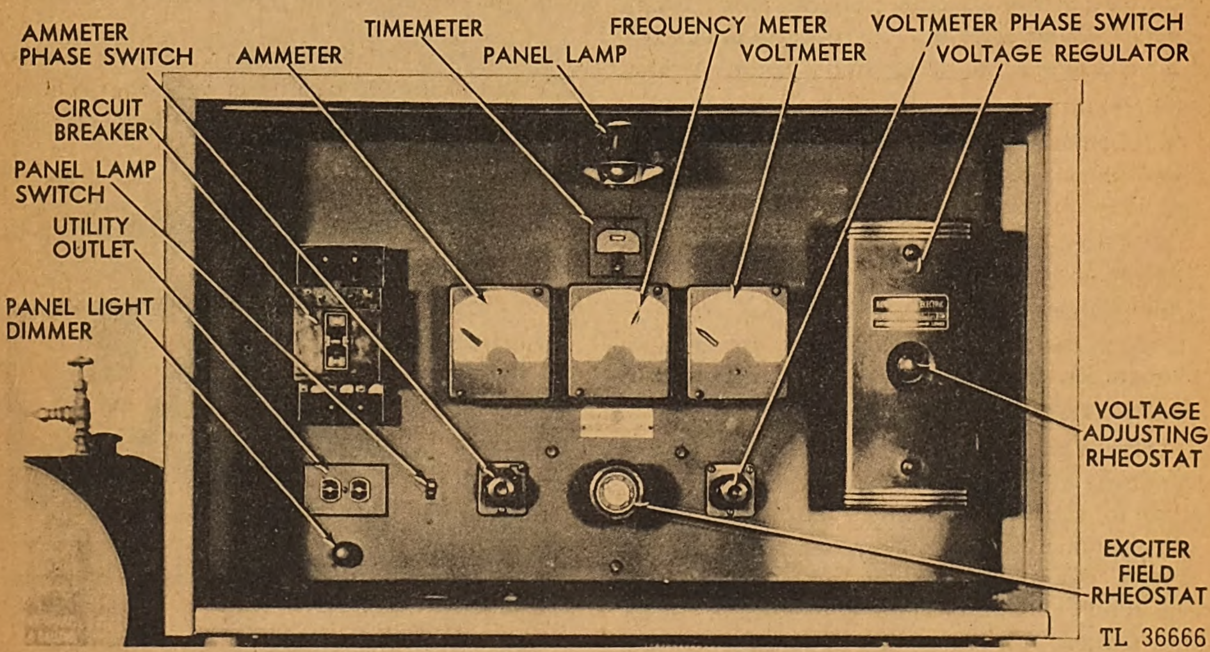

Fig. 15. Alternator Control Panel

voltage should indicate 208 volts, 60 cycles (1200 r.p.m.)

c. *Exciter Field Rheostat.* The rheostat is a resistor which is provided with means for readily varying its resistance. The rheostat is for the purpose of regulating the voltage in case the automatic regulator fails to function properly. The rheostat is connected in series with the voltage regulator and is not used as a voltage control when the regulator is in operation.

d. *Frequency Meter.* The frequency meter shows the proper frequency or speed of the generator. The generator should operate at approximately 60 cycles under full load conditions, and at 61.5 cycles at no load. No adjustments are provided for the frequency meter. **The pointer may rest at any position on the dial when the voltage is reduced on the generator. The pointer may not go back to the left** hand side of the scale when the unit is shut down.

e. *Ammeter.* The alternator ammeter operates as soon as the load is applied and shows the amount of current flowing through the circuit.

f. *Phase Switches.* Phase switches are provided in order to permit current or voltage readings in any of the three phases of the circuit. This may be done by turning the pointer on the respective phase switch to the number on the dial and reading the voltmeter or the ammeter, depending upon which phase switch is operated. If single-phase loads are applied to this unit, make sure that such loads are divided between the phases in order that the current in each line is the same. This permits better voltage regulation and operation of the machine.

g. *Voltage Regulator.* The voltage regulator automatically regulates the voltage when a change in load on the machine occurs. The regulator operates only when a correction in voltage is necessary. A small voltage adjusting rheostat is included in the regular assembly and provides a convenient means of setting the voltage to the value to which it is to be regulated.

The voltage regulator performs automatically the same operation as obtained by the hand manipulation of the field rheostat of a machine under manual control. As in the usual arrangement, an exciter is used to energize the field of the a-c generator. This exciter is a d-c generator having self-excited shunt field. Under manual control, the a-c generator voltage is determined by the setting of the exciter shunt field rheostat. Turning the rheostat in one direction lowers the a-c generator voltage. Turning the rheostat in the opposite direction raises the a-c generator voltage.

The voltage regulator achieves the same results automatically by varying a regulating resistance which is connected in the exciter shunt field circuit, in series with the usual exciter field rheostat. This regulating resistance is part of the voltage regulator. The regulator and the regulating resistance become effective when the exciter field rheostat is turned toward or near the resistance "all out" position. If the regulator becomes inoperative the exciter field rheostat can be used to regulate the alternator voltage.

h. *Elapsed-Time Meter.* The elapsed-time meter indicates the total hours the unit has been in operation. This time meter permits the operator to keep track of the periods of maintenance. These maintenance periods are given in paragraphs 35 to 43 inclusive. The elapsed-time meter cannot be reset readily.

i. *Receptacle or Utility Outlet.* There is a utility outlet which may be used to connect lights or any external loads up to approximately 20 amperes.

j. *Wiring Diagram.* A wiring diagram for PE-185-B Power Unit is shown in Figure 16.

17. **Engine Control Panel.** The engine control panel contains the necessary controls for starting and stopping the engine and the gauges that indicate the efficiency of engine operation, together with the howler switch and the indicating warning lights of the howler or warning system. (See Figure 15A.)

a. *Ammeter (Battery).* The engine ammeter, as distinguished from the generator or the alternator ammeter, indicates the rate of charge or discharge taking place in the battery circuit. The readings are from zero to —30, indicating discharge, and from zero to +30,

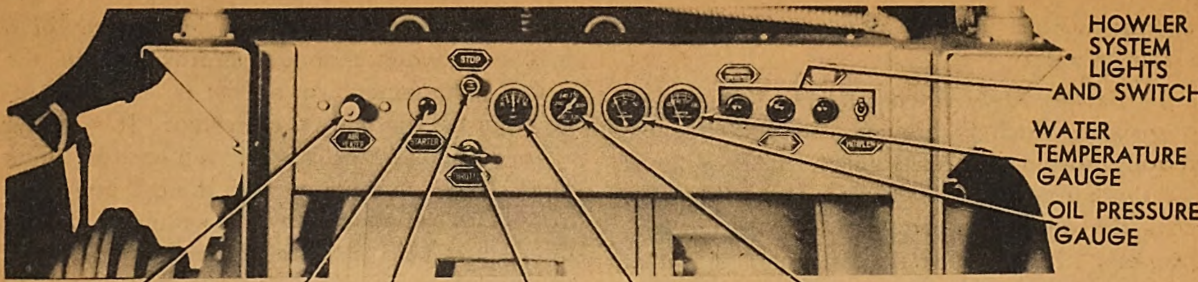

Fig. 15A. Engine Control Panel

indicating charge. Because the voltage regulator of the battery generator controls the rate of charge, it is common for the reading to be at zero or close to zero, with a normal battery condition. This indicates that the battery is fully charged or in a high state of charge. If high reading continues (over +10), trouble with the voltage regulator is indicated. A rundown battery, however, will take a higher rate of charge for a few hours. If the reading shows high on the discharge, there is a short circuit.

b. Water Temperature Gauge. Before operating the engine under load, the gauge should show a temperature between 120 degrees Fahrenheit and 145 degrees Fahrenheit. For continuous load the temperature should not be allowed to go below 165 degrees Fahrenheit and should not exceed 200 degrees Fahrenheit. If the temperature exceeds 205 degrees Fahrenheit, the warning system will howl and the red light will go on.

c. Oil Temperature Gauge. For normal operation, the oil temperature gauge should register between 140 degrees and 160 degrees Fahrenheit. It should not be allowed to exceed 220 degrees Fahrenheit. High oil temperatures usually indicate low oil pressure, excess blowby past the piston rings, weak or worn rings, loss of power, too heavy oil, too high water temperature, or overload.

d. Oil Pressure Gauge. The oil pressure gauge indicates whether or not the proper amount of oil pressure is being delivered to satisfactorily lubricate the internal working parts of the engine. It should indicate from 25 to 35 pounds per square inch under normal operating temperatures with oils of the recommended viscosities. If the pressure drops below 10 pounds, the warning system will howl when the yellow light glows.

e. Starter Button. The starter button is used to operate the magnetic switch which closes the circuit between the starting motor and the battery. This allows the electrical energy to turn the starting motor to crank the engine.

f. Engine Throttle. The throttle control is connected to the fuel injection pump on the engine. When the throttle is pushed all the way in, the engine will operate at the speed for which the governor is set. When it is pulled half way out, it will operate at half speed. When it is pulled all the way out, the engine will operate at idling position.

g. Stop Control. The stop control is connected directly to the engine governor. When it is pushed all the way in, it allows the engine to operate at the speed at which the throttle or the governor engine speed is set. When it is pulled all the way out, the flow of fuel through the fuel injection pump is shut off, causing the engine to stop.

h. Air Heater Switch. The air heater switch controls the air preheater in the inlet manifold. The switch should be used prior to and during the cranking operation. However, the switch should not be used continuously for longer than 30 seconds.

i. Howler Switch. The howler switch closes or opens only the circuit of the warning howler. The green light glows when the alternator rotates, indicating that the colored light warning system is in operation, as well as the howler, if the howler switch is closed.

18. Emergency Rope Starting. A rope starting system has been provided for use if electri-

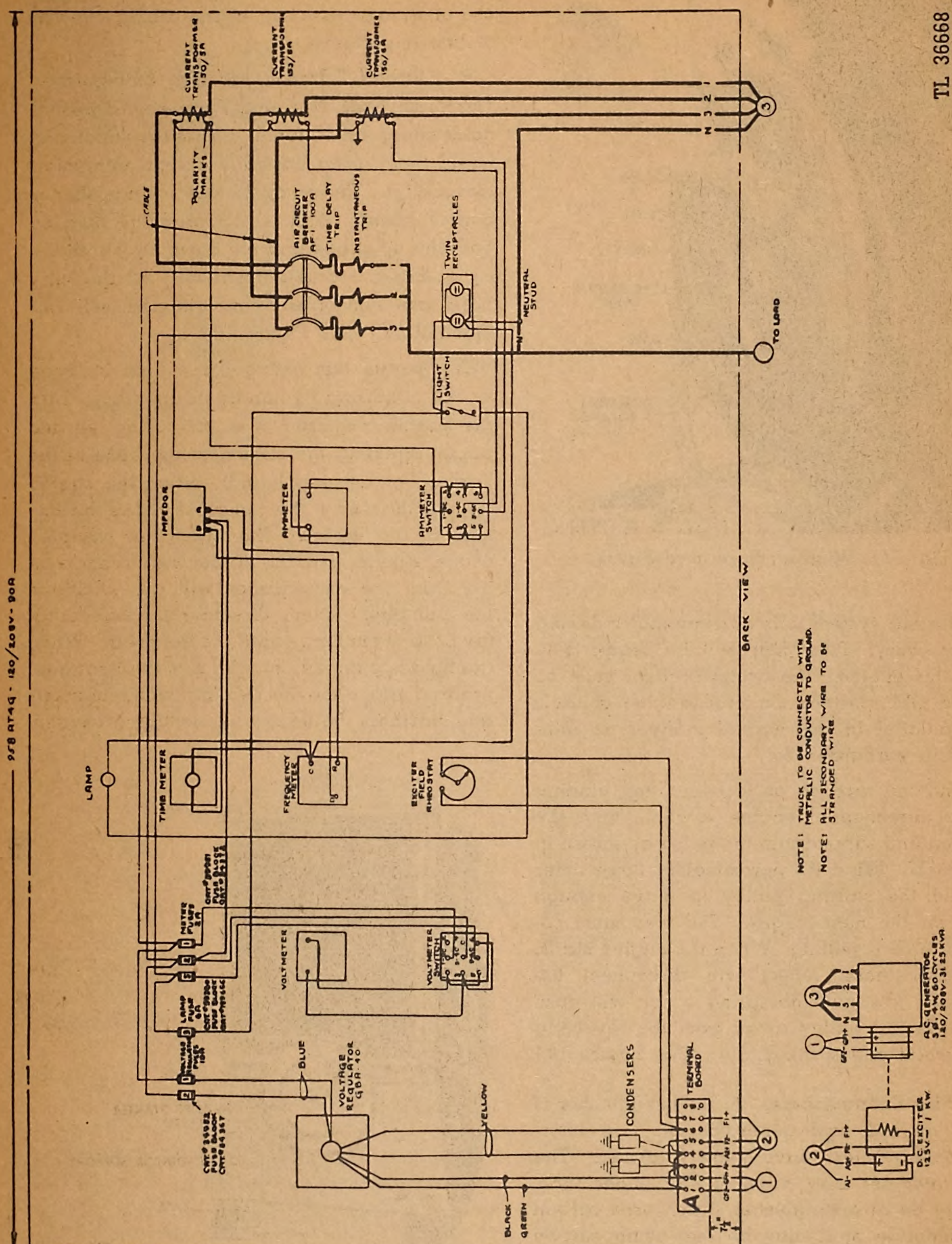

Fig. 16. Wiring Diagram Control Panel PE-185-B

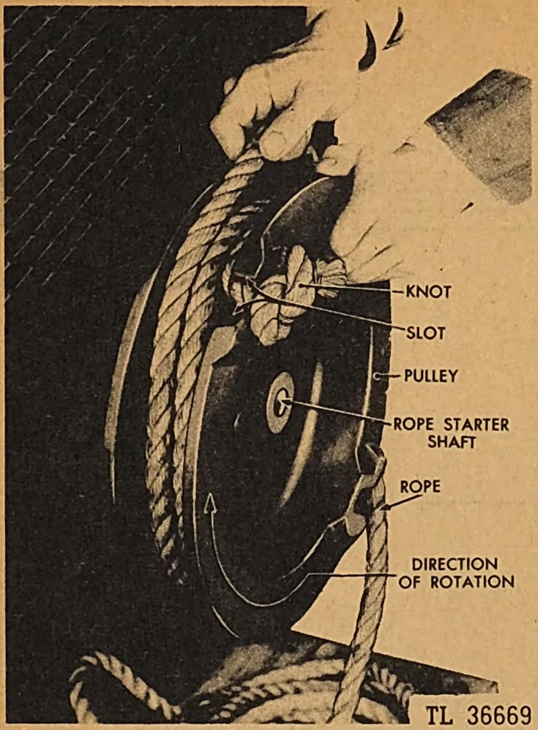

Fig. 17. Winding Rope and Starter

cal starting system fails or if manual cranking is necessary. Five men will be required to start this engine. The circuit breaker must be in the OFF position and the engine controls manipulated in the normal manner as indicated in paragraph 26.

Wind the rope so as to avoid any binding in the direction of engine rotation, with the knotted end slipped into the notch as shown in Figure 17. Wind it approximately three times around the starting pulley to leave enough rope for the men to grip. The men must coordinate their pulling. When the engine starts, the overrunning effect will disconnect the cranking jaw and the spring action will push the cranking pulley away from the revolving crankshaft and starting jaw. (See Figure 18.)

19. Fire Extinguishers. A fire extinguisher is provided with each generator set. Two different extinguishers have been furnished. The generator set may have one of either type. It may be an extinguisher which uses carbon tetrachloride or it may be one using carbon dioxide. Both of these extinguishers are recommended for fires of inflammable liquids and greases where a blanketing effect is essential, or for fires of electrical equipment where the use of a nonconducting extinguishing effect is of first importance.

a. Carbon Tetrachloride Fire Extinguisher. The small hand pumping Pyrene extinguisher holds one quart of liquid. It is of the vaporizing liquid type, using basically carbon tetrachloride (CCl_4). The pump in this extinguisher is double acting. That is, it expels the fluid on both the up stroke and the down stroke, thereby assuring a constant stream. All the vital parts are noncorrosive metals and will last indefinitely. (See Figure 19.)

To operate this extinguisher, hold its body in one hand and its handle in the other. Turn the handle a quarter of a turn to the left and pump, directing the stream at the base of the flame. For burning liquids, direct the stream against the side of the container above the surface of the liquids. The faster the pumping action is performed, the farther the stream coming from the extinguisher will go. Continue the pumping action, directing the stream at the base of the flame until the fire is out. When the fluid is pumped onto the fire, the heat generates a vapor heavier than air, which blankets and smothers the flames by excluding oxygen.

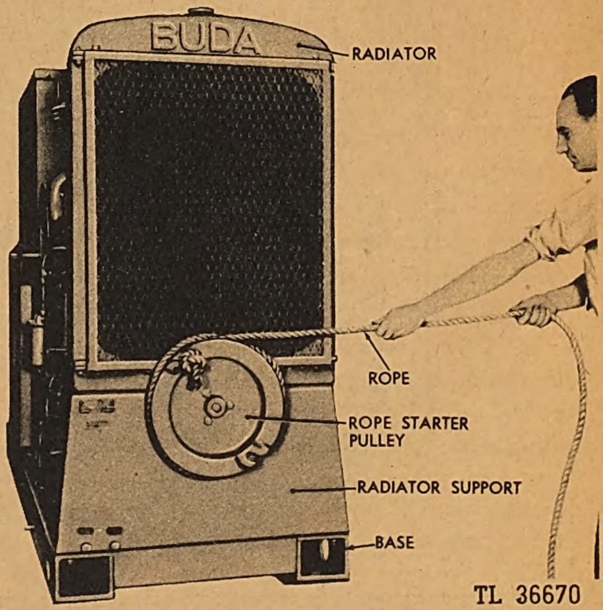

Fig. 18. Pulling Rope Starter

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Fig. 19. Carbon Tetrachloride Fire Extinguisher

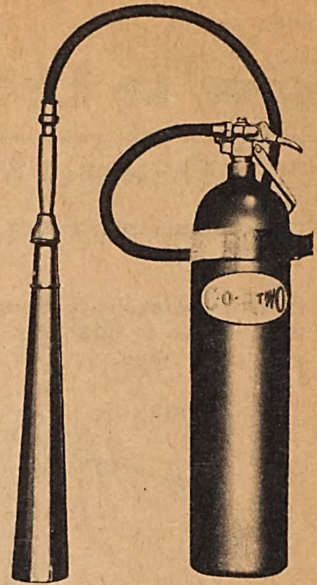

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Fig. 20. Carbon Dioxide Fire Extinguisher

Refill the extinguisher with the proper fluid immediately after using. Push the handle into the locking recess and give one-quarter turn to lock.

Every four months a part of the contents of the extinguisher must be discharged into a glass container. If the fluid is clean, pour it back through the filter hole in the cap. If it is excessively dirty, put new fluid in the extinguisher. This will check the amount and condition of the fluid, and will also check whether the pump on the extinguisher is operating satisfactorily and that the orifice of the nozzle is not clogged.

CAUTION: Under no circumstances must water be put into the extinguisher. The slightest amount of water in the fluid causes hydrochloric acid fumes, which are highly corrosive and cause damage to the internal parts of the extinguisher.

b. *CO_2 Fire Extinguisher.* The CO_2 fire extinguisher is a portable unit charged with four pounds (by weight) of carbon dioxide and equipped with a handle for carrying it to the scene of the fire. The cylinder is made of high quality steel, tested to withstand a hydrostatic pressure of 3,360 pounds. It is equipped with a squeeze-grip valve which retains the gas and controls the discharge when the trigger is squeezed. It has a discharge horn fastened to the valve for directing the discharge on the fire. (See Figure 20.)

Remove the extinguisher from the hanger bracket, carry it to the scene of the fire by the carrying handle and pull the locking pin from the disconnector, breaking the sealing wire. The cylinder must remain in an upright position. Squeeze the trigger and handle together and direct the discharge by raising or lowering the discharge horn. Direct the discharge at the base of the flame and work upward. When fighting floor fires, extinguish the nearest portion first. Then advance the discharge as the flames are extinguished. Do not haphazardly direct discharge over various sections of the fire; put out one portion completely before attacking other parts. Continue the discharge after the flames are out to coat the hot material with carbon dioxide snow. (See Figure 21.)

CAUTION: Thoroughly ventilate the space into which the gas has been discharged and make certain that all portions contain fresh air. Should it be necessary for a person to enter a space before it is thoroughly ventilated, he may do so for a short period by holding his breath. Should a person be overcome by carbon dioxide, it is essential that he be rescued within five minutes from the space

How to Use C-O-TWO Extinguishers

The RIGHT *Way*

1 **Carry extinguisher to fire THEN OPEN VALVE.**

2 **CARRY extinguisher with left hand. Hold nozzle at HOSE END of HANDLE with other hand.**

3 **Direct discharge CLOSE to fire.**

4 **Direct discharge FIRST at EDGE NEAREST OPERATOR or, if on vertical surface, at BOTTOM OF FIRE.**

5 **SLOWLY AND DELIBERATELY ADVANCE discharge as flame is extinguished. Be sure all flame is OUT in part of fire tackled before advancing.**

6 **Continue discharge after flames are out so as to COAT HOT MATERIAL WITH CARBON DIOXIDE SNOW.**

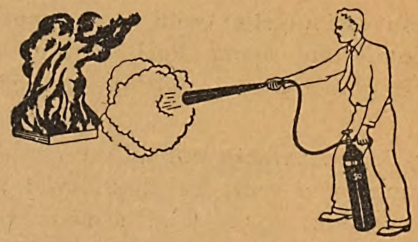
7 **Have extinguisher RECHARGED AS SOON AS POSSIBLE.**

The WRONG *Way*

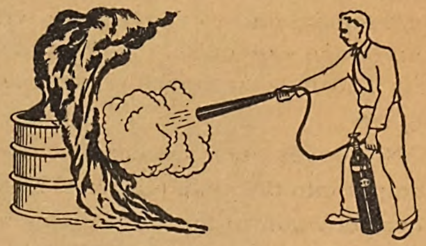
1 **DON'T OPEN VALVE BEFORE carrying extinguisher to fire.**

2 **DON'T stand extinguisher on the ground. DON'T hold nozzle near discharge end.**

3 **DON'T direct discharge at fire FROM FAR AWAY.**



4 **DON'T direct discharge at center of fire and then attempt to work to the edge.**



5 **DON'T HAPHAZARDLY direct discharge over various sections of fire. Put out one portion of fire completely before attacking other parts.**

6 **DON'T shut off extinguisher AS SOON AS flame is put out.**

7 **DON'T put used extinguisher aside and FORGET about recharging.**

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Fig. 21. How to Use Carbon Dioxide Fire Extinguishers

containing the gas. To revive a person so overcome, remove him to fresh air and apply artificial respiration as in the case of drowning. Replace used extinguisher with a fully charged one at once. Have the used extinguisher shipped to a charging station.

c. *Maintenance*. After long, rough trips or after combat, examine the cylinders in general for bad dents or breaks. Check condition of the valve, control heads, clamps, and the discharge horn. Tighten all connections and replace any broken or damaged parts. Any repairs or recharging of the cylinders must be done by the third or fourth echelon.

SECTION II
INSTALLATION AND OPERATION

20. Unpacking Generator Set. If the generator set is brought from cool surroundings into a warm room, it should be kept covered until its temperature has risen to room temperature, so as to prevent condensation on the sides and other parts.

(1) Remove the top of the crate first. Remove the ends and the sides of the crate.

(2) Remove sealed metallic bag. Then remove all padding and paper from the various parts of the generator set.

(3) Remove muffler and the fuel can and fire extinguisher which are fastened to the generator set.

(4) Remove silica-jell container.

(5) Remove the eight mounting bolt nuts and lift the generator off its skids. Remove the paper from instrument panel and the masking tape from the various fittings on the engine.

21. Preliminary Inspection. (1) First make a visual overall inspection of the generator set. Look for broken or loose electrical and hose connections. See that the air cleaner clamp is tight so that no dirt can be sucked in because of loose connections. (See Figure 1.)

(2) Check the fins and passages between the tubes of the radiator to be sure that they are free from dirt or foreign matter that might restrict the flow of air through the radiator tubes.

(3) See that no foreign objects are inside the generator. If there is foreign matter on the commutator and slip rings, smooth them up with very fine sandpaper after the unit has been started.

(4) See that the exciter brushes are in place in the brush holders with the springs giving the necessary tension.

(5) Remove the rear panel of the switchboard and inspect the wiring connections. (See Figure 30.)

22. Installation. Whether the foundation on which the generator set is to rest is of concrete or of wood, it must be strong enough to support 250 pounds per square foot. If a new foundation must be made, it is desirable that it be separate from the floor of the building. This will reduce the vibration transferred to the rest of the building when the generator is in operation.

If the foundation or floor on which the power unit is to rest is of concrete and already exists, it will be necessary to drill eight holes to take ⅞-inch diameter bolts or lagscrews. Install inserts into the holes (drilled with a star-drill) and secure the base to the foundation with lagscrews.

If the floor or foundation is of wood, the bolts securing the base to the foundation must be long enough to go through the entire planking.

a. Location. Make sure that the unit is placed in a location where it will be protected against moisture both before and after it is set up. Be sure that it is not touched by water or steam from leaking pipes, rain, snow, or any other atmospheric conditions. It is very important to keep the windings of the generator dry, since moisture lowers the resistance of the insulation and may cause the generator to break down.

Make sure that the machine is set up in a location where it will rest level. Also see that there is good ventilation, since overheating can cause serious damage to the generator. See Figure 23 for dimensions of the unit and as a guide for making installation.

b. Connections. (1) All the necessary connections between the switchboard and the generator with its exciter are made at the factory before each power unit is thoroughly tested. Nevertheless, it is suggested that these connections be checked at installation of the equipment. The exciter has four leads to the switchboard terminal block. They are labeled A1, A2, F1, and F2. The leads to the generator field are labeled GF1 and GF2. See Figure 25. The generator has four power leads, the terminals of which are stamped 1, 2, 3, and 0. See Figure 24. The 0 lead is the same lead which the switchboard diagram designates "N". Make certain that all connections are tight.

(2) Accessible internal connections should be checked. First remove the exciter wrap-around cover. Make certain that both capacitors mounted on the supporting bracket are connected as shown in Figure 25, and that the connections are tight. The exciter and generator are designed to keep radio interference at a minimum. Current variations which might cause radio interference are dampened by these capacitors which are connected to the A1 and A2 exciter leads. Be sure that tight connections are made between the capacitors and the supporting bracket.

c. *Grounding of the Power Unit.* It is recommended that the steel framework of the power unit be grounded in at least one spot, preferably in two. The grounding strap or cable should be securely connected to a rod driven into the ground (preferably moist). Use a braided copper strap or a cable having a cross-sectional area of approximately 105,000 circular mils. The length of the strap or cable should be short as possible.

23. Preparing Engine for Operation. (1) Install the muffler on the unit.

a. First, place the pipe nipple into the exhaust outlet elbow. (See Figure 22.)

b. Install one 90-degree, 3-inch elbow on the pipe nipple.

c. Now mount the muffler.

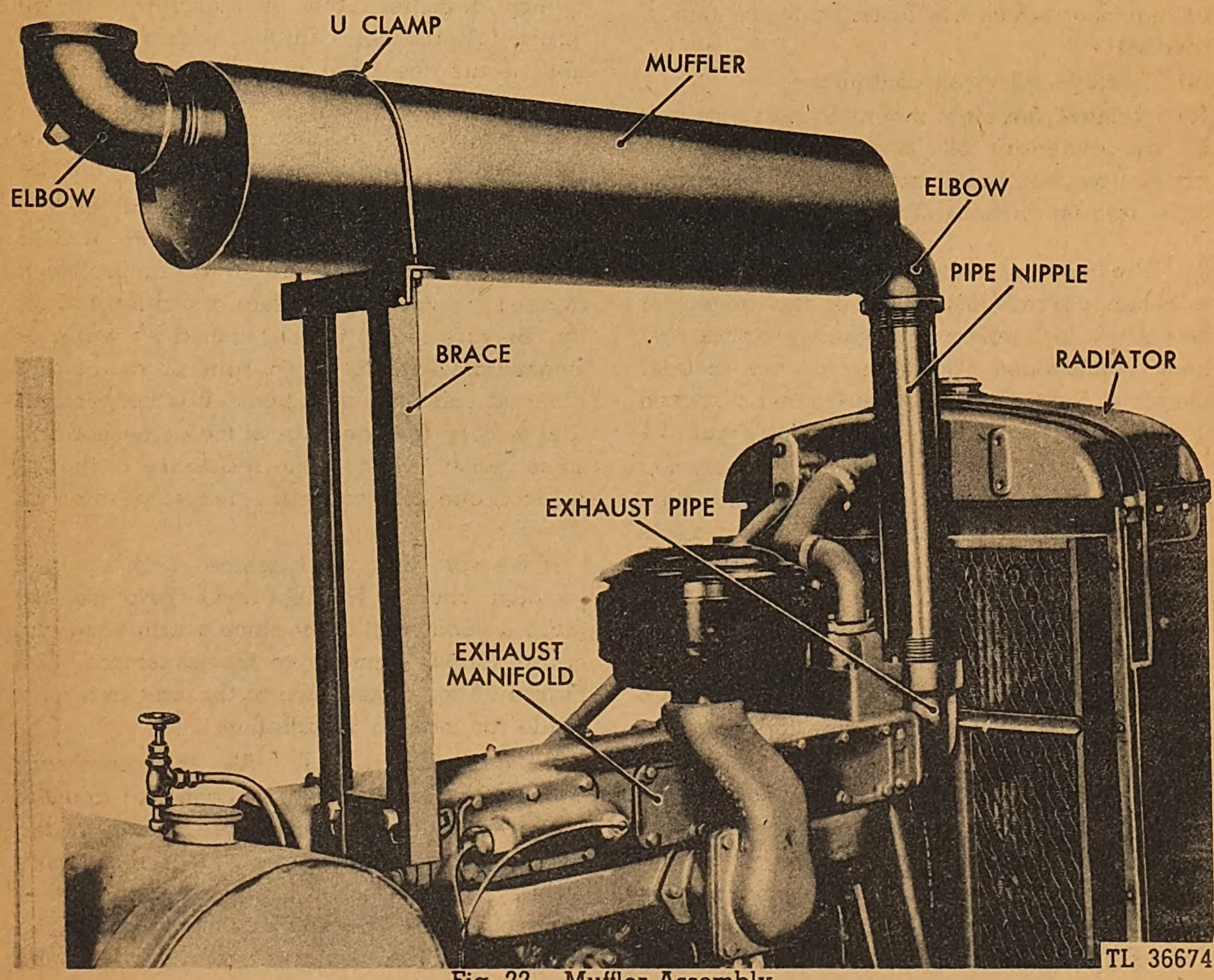

Fig. 22. Muffler Assembly

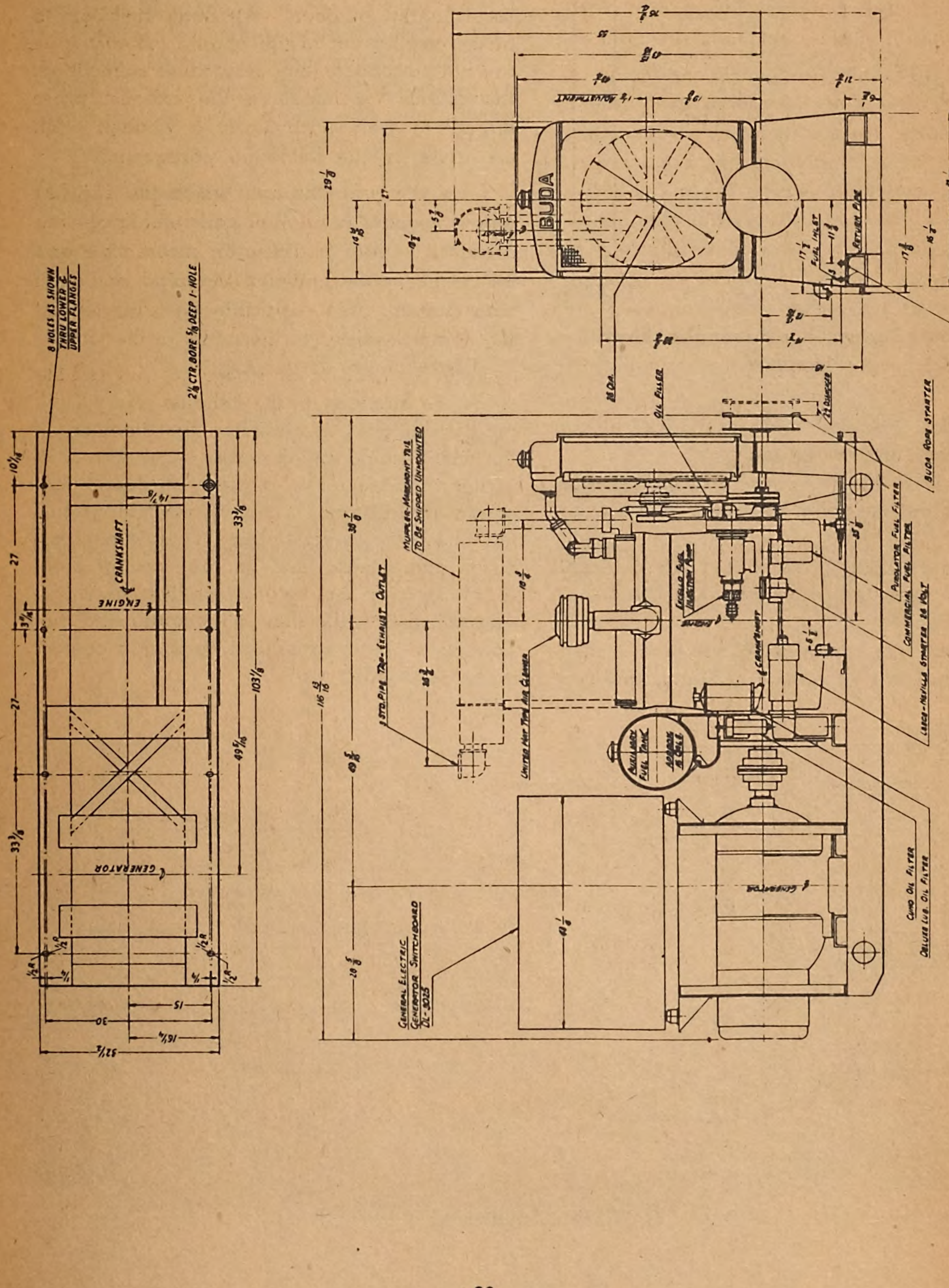

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Fig. 23. Installation Diagram (Structural Steel Base)

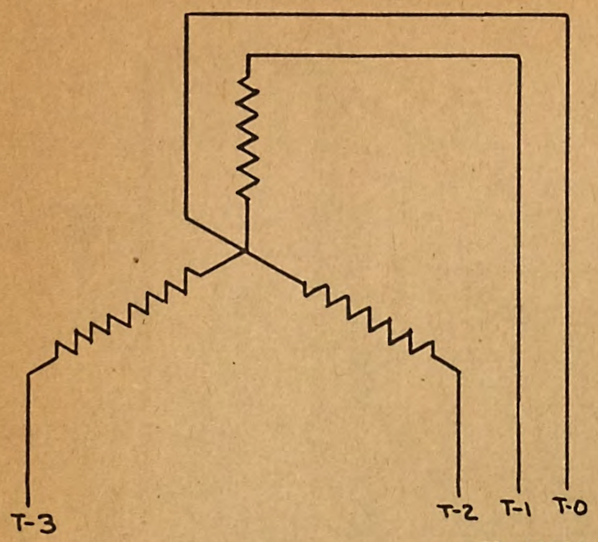

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Fig. 24. Connection Diagram for Main Generator

d. Install the other 90-degree, 3-inch elbow at the other end of the muffler.

e. Remove the two capscrews on the rear exhaust manifold cover and mount the muffler bracket.

f. Before mounting the muffler U-bolt, install two ¼-20 nuts and lockwashers in U-bolt before assembling.

g. Mount the muffler U-bolts in place. Then tighten with two additional ¼-20 nuts and two lockwashers directly below the bracket.

(2) Run the exhaust pipe outside of the building.

a. Whether the muffler is installed on the unit or is installed outside of the building, the exhaust gases should be carried out of the room to the outdoors. Although the burned gases coming out of the engine exhaust pipe are not poisonous, they may cause suffocation. Instructions for installing the exhaust pipes through a wall, particularly a wooden wall, are given in the following paragraphs.

b. If the wall through which the exhaust pipe is to pass is brick or concrete, knock out a hole 3 inches in diameter; insert pipe and fill in the space between the pipe and wall with cement. Use a flexible pipe to connect the engine exhaust to the outlet in the wall.

c. If the wall is of wood, cut out a hole twice the diameter of the exhaust pipe. If the pipe is 3 inches in diameter, the diameter of the hole should be 6 inches. Cut a hole 3 inches in diameter in a piece of steel 1 foot square and at least ⅛ inch thick. Through this hole insert the exhaust piping, flexible or otherwise, and secure this square foot of steel in place over the hole which has been cut through the wall, thus eliminating the fire hazards of the exhaust pipe coming in contact with the wooden wall.

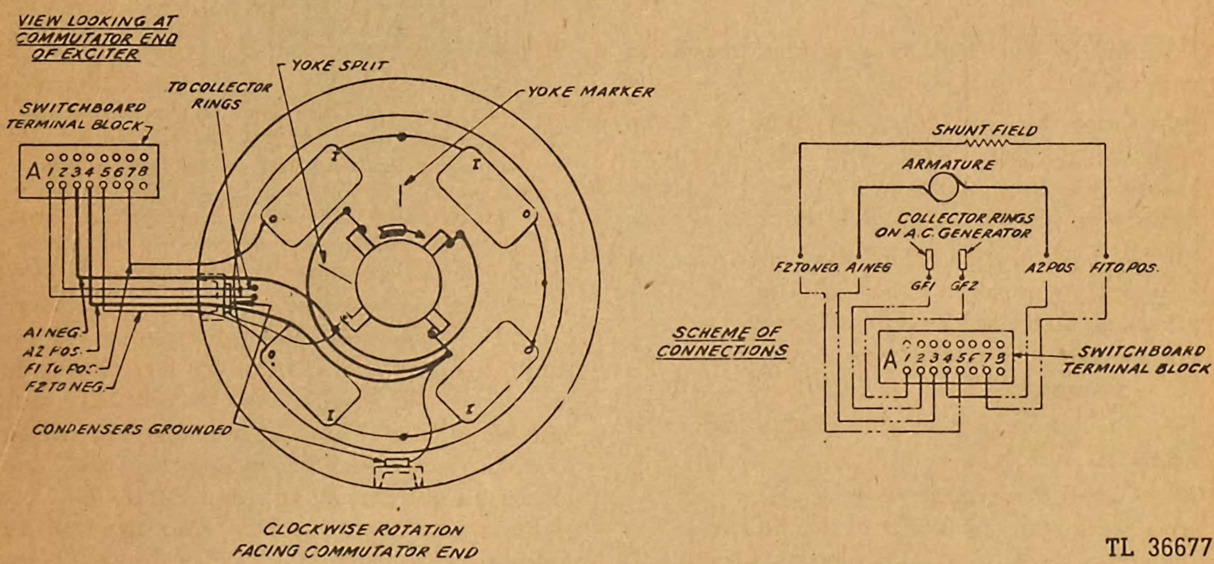

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Fig. 25. Diagram of Connections of Exciter

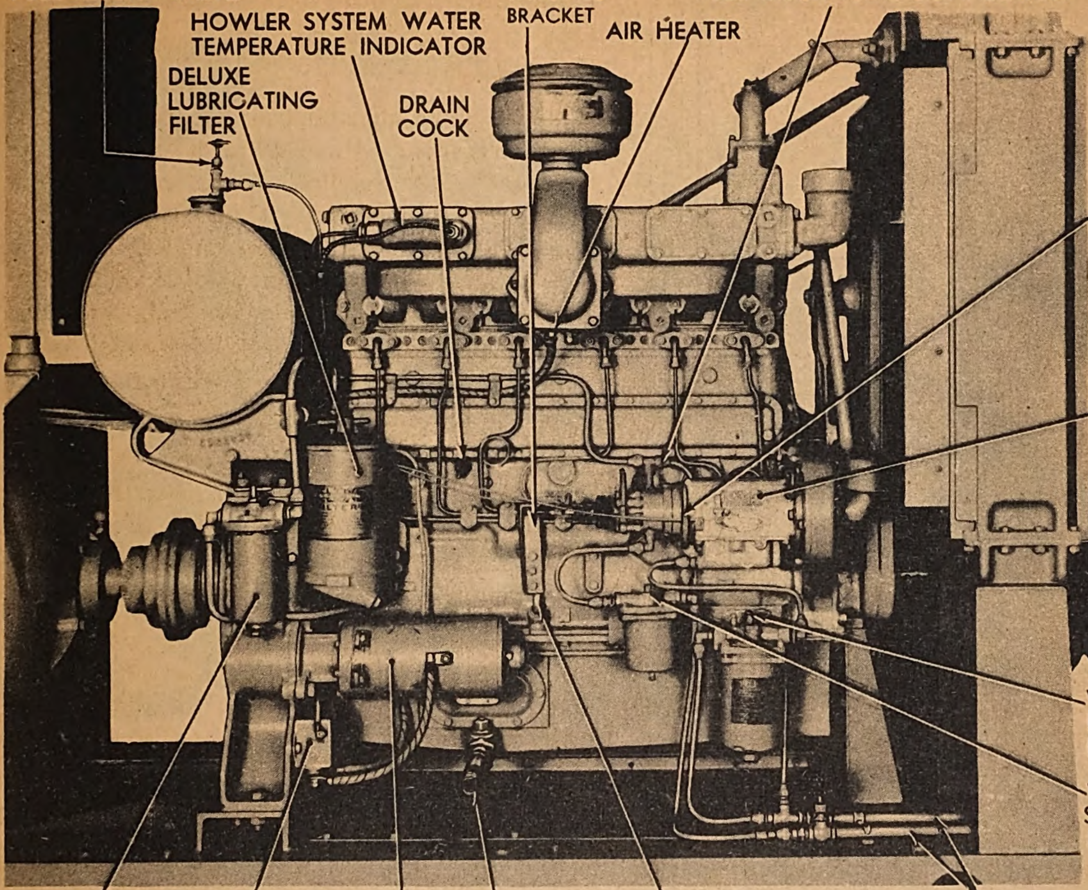


Fig. 26. Right Side of Buda Engine

(3) Fill the battery with electrolyte furnished with the unit.

(4) Close the crankcase and radiator drains with the plugs included with the unit. (See Figure 26.) Then fill the radiator with water or anti-freeze if necessary. (See paragraph 69c.)

(5) Remove the oil drain plug to drain out any rust preventive. (See Figure 26.) Replace the oil drain plug. Be sure that it is tight. Fill the crankcase with correct lubricating oil. (See paragraph 30.)

(6) Fill the air cleaner oil cup with engine oil up to the level mark.

(7) Crank the engine several times with the rope starter to see that it is free to turn.

(8) Connect the fuel lines to the auxiliary fuel tank. Fill both fuel tanks with recommended fuel oil. (See paragraph 29.)

NOTE: Before filling the engine tank, close the auxiliary tank shut-off valve. The auxiliary tank should be high enough so that the fuel lines will be gravity-fed. When using the engine tank, valves 1 and 2, painted yellow, must be open and valves 3 and 4, painted black, must be closed. When using the auxiliary tank, close the valves on the engine tank and open the valves painted black.

(9) Open the fuel feed and fuel return valves on the engine tank. The top valve is the return valve and the valve under the tank is the feed valve. Be sure to close the auxiliary tank shut-off valves. Loosen the air-vent screw located near the point where the fuel line enters the primary filter. (See Figure 27.) Let the fuel escape through the vent until the air bubbles stop coming out. Tighten the vent screw.

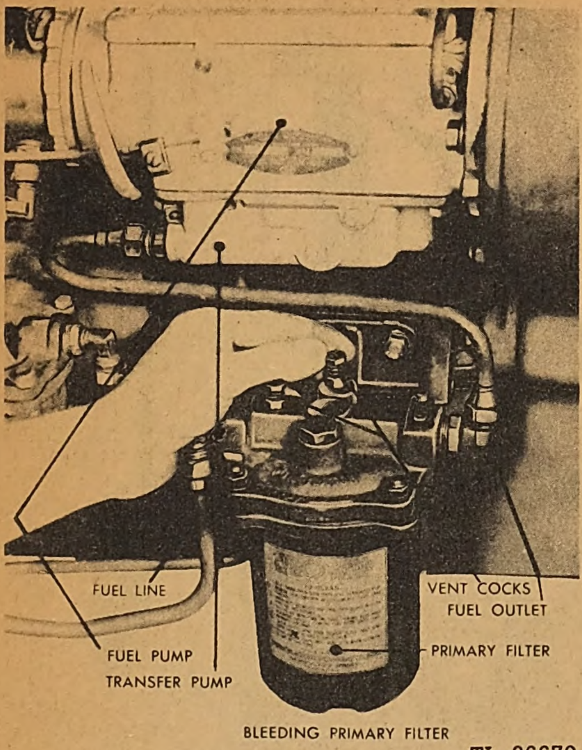


Fig. 27. Venting Primary Fuel Filter

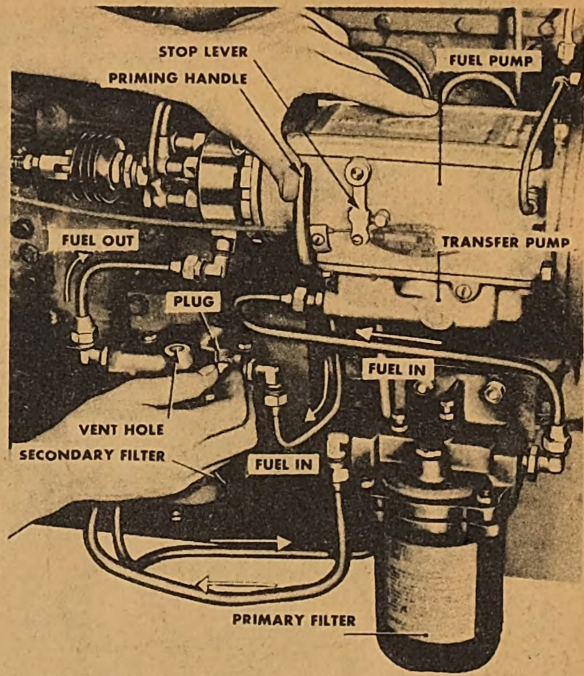


Fig. 28. Venting Secondary Fuel Filter

(10) To vent the auxiliary fuel line, shut off the engine mounted tank fuel feed and fuel return valves and open the auxiliary tank feed and return valves. Again let the fuel oil escape through the primary filter vent until the air bubbles stop coming out. Tighten the vent screw.

NOTE: If the auxiliary tank is not higher than the primary filter, it will be necessary to prime the fuel through the primary filter priming hole.

(11) Loosen the second vent screw on the primary filter and repeat Steps (9) and (10), being sure to keep the first vent screw closed.

(12) Remove the plug located on top of the secondary filter. (See Figure 28.) To vent the secondary filter, move the hand primer on the fuel injection pump back and forth until the fuel flows free of air bubbles. Replace and tighten the plugs.

(13) Remove the fuel return line at the injection pump and operate the hand primer again until the fuel flows free of air bubbles. (See Figure 29.) Replace the return line and tighten the connections.

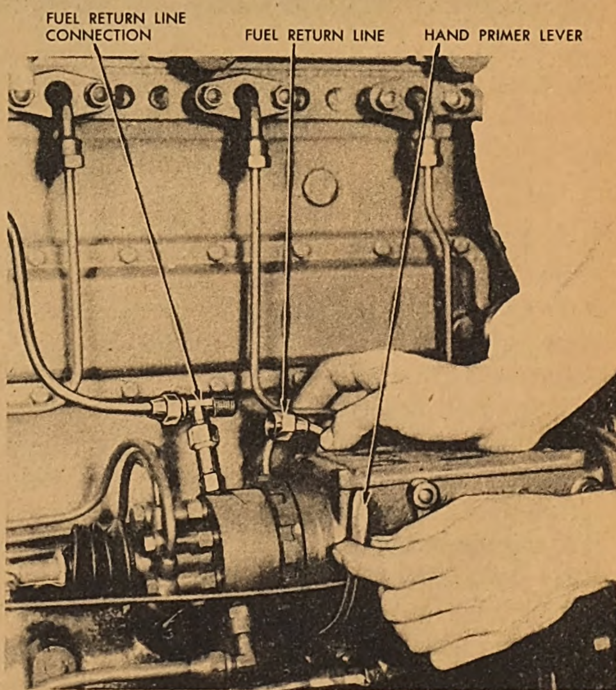


Fig. 29. Operating Primer to Free Hydraulic Unit of Air

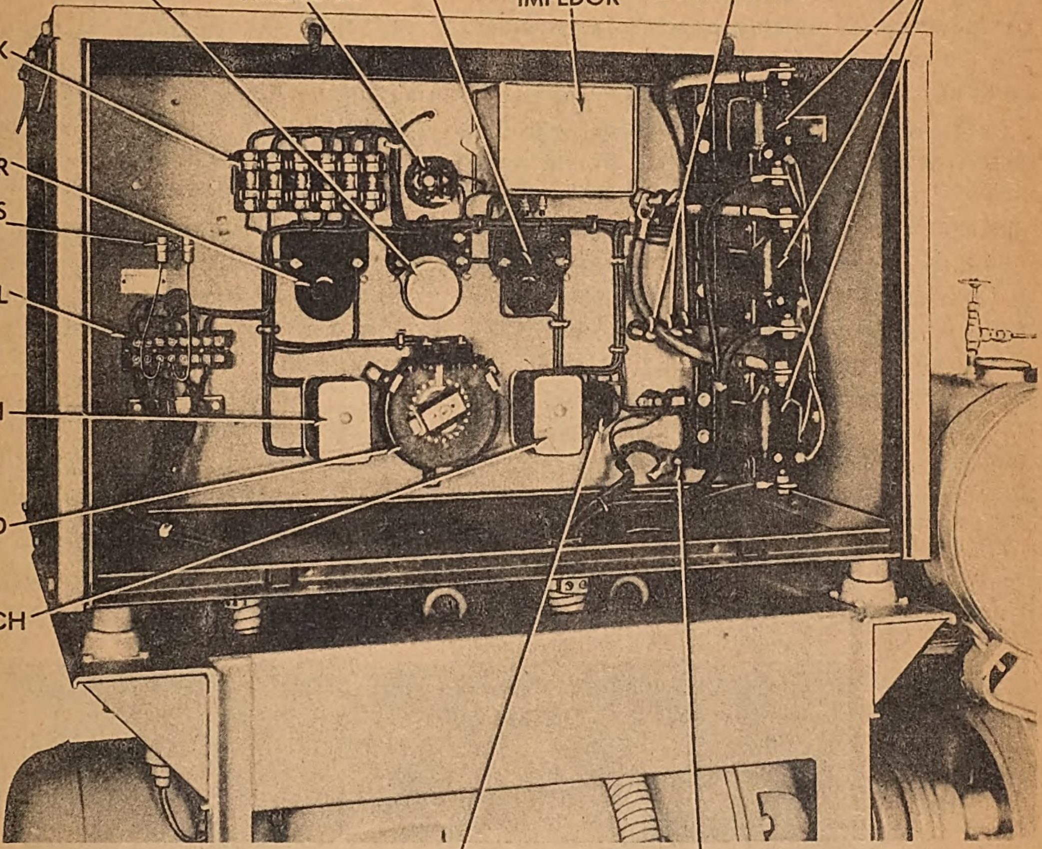


Fig. 30. Rear of Alternator Control Panel

24. Connecting Generator to Load. (1) Remove the back of the instrument panel and connect the load leads to the connections marked "L-1", "L-2", "L-3", and "L-O" or neutral (N). (See Figure 30.) The load leads should be #000 cable.

(2) Be sure that the circuit breaker is in the OFF position.

(3) Turn the exciter field rheostat all the way to the left, counterclockwise. (See Figure 32.)

25. Steps for Preparing Alternator and Exciter and Control Panel for Operation. (1) Remove the exciter cover and examine the interior of both the generator and the exciter for loose, foreign objects, such as bolts, nuts, wire, or small tools.

(2) Check all connections between the power unit and the switchboard.

(3) Check the accessible connections inside the generator and exciter. Make certain that pigtail connections to the brush holders are tight. Check to see that pigtails do not touch

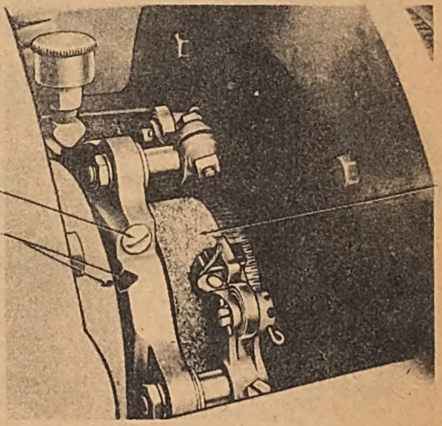


Fig. 31. Exciter Brush Yoke

each other or touch the frame.

(4) Check the exciter brush rigging for proper setting. Figure 31 shows the correct setting. The notches are exactly opposite each other. The clamp screw for the brush yoke should be tight.

(5) Check the clearance between adjacent sets of generator brush holders. At the same time check to see that the brushes ride on the approximate center of collector rings.

(6) Raise the brush springs for exciter brushes and the levers for generator brushes and move the brushes up and down in their holders. They should move freely, not bind.

(7) The commutator and collector ring surfaces should be clean. If not, wipe them with a clean cloth moistened in carbon tetrachloride or an equivalent. To clean them thoroughly, it may be necessary to polish them with #0000 sandpaper while the unit is operating after the initial start.

(8) Note the condition of the insulation. If the windings are wet or even damp, they should be dried before the power unit can be operated with a full load on the generator. Dry out the windings after initial start by operating the power unit with no more than one-fourth (25 amperes) normal load on the generator for at least two hours or until the windings are dry. Keep all covers on the exciter and the generator while operating the power unit.

26. Starting Engine. (1) Refer to Figure 32. Make sure that the breaker is in OFF position. Push the engine stop button all the way in and

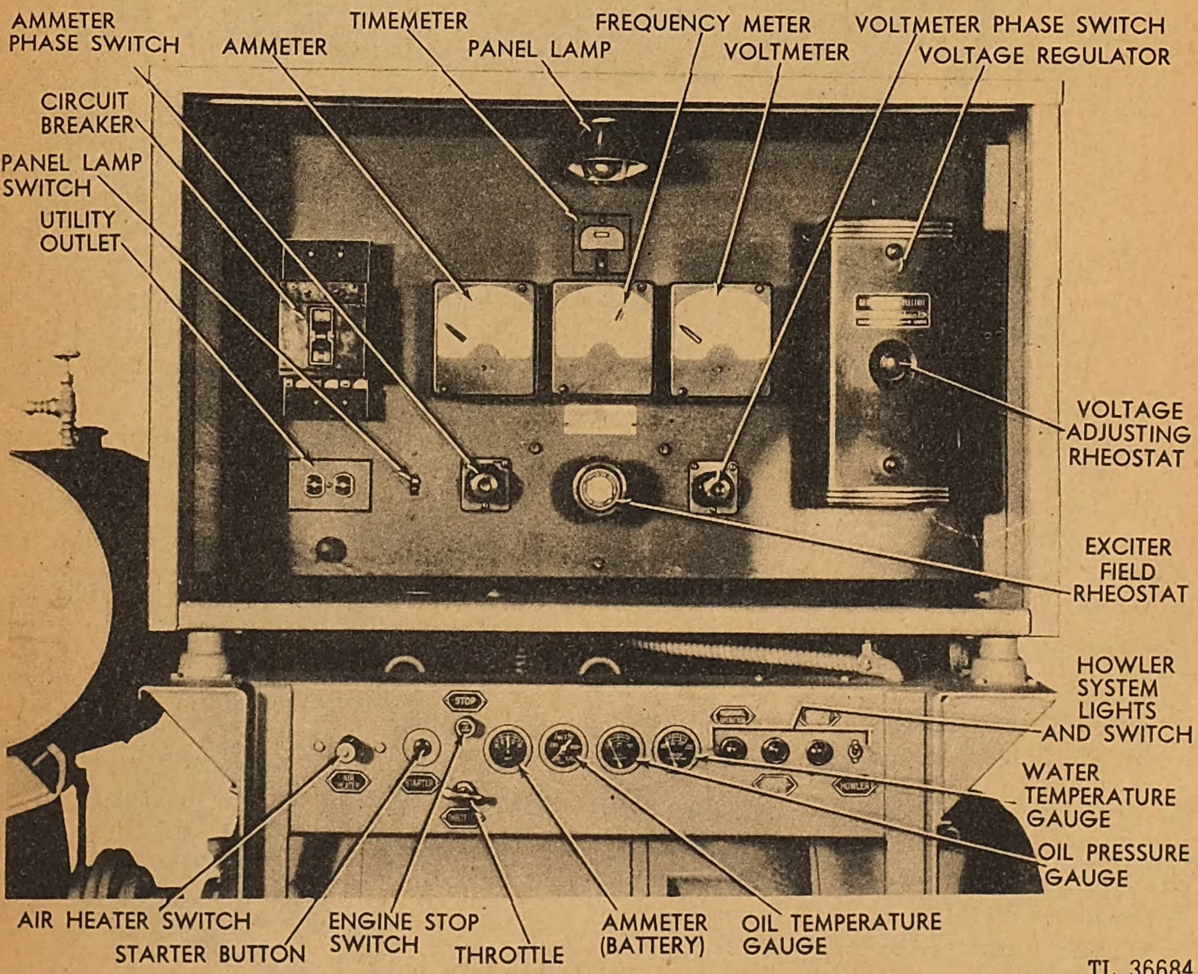


Fig. 32. Alternator and Engine Control Panels

hold in the depressed position until the engine fires.

NOTE: Holding the stop button down will depress the spring-loaded button in the shut-off lever, permitting a fuel quantity in excess of the normal maximum quantity to facilitate starting.

Pull the throttle control half way out and be sure that the howler switch is all the way in —OFF position.

(2) Press in the starter button. When the engine fires, release the button.

NOTE: In cool weather, push in the air heater button for about 30 seconds before depressing starter button. If the engine does not start the first time, it may be necessary to push in the heater button before depressing the starter button. Do not depress heater button continuously for more than 30 seconds.

(3) As soon as the engine starts running, check the oil pressure gauge. For normal operation the oil pressure gauge should read 20 to 35 pounds. Do not become alarmed if the pressure rises beyond 35 pounds if the engine is cool.

(4) Pull the howler switch out to put the howler in operation. Green glows if the warning system is working. (See Figure 32.)

(5) Run the engine without load at half speed until the water temperature rises to 140 degrees Fahrenheit.

27. Applying Load. (1) Push the throttle control all the way in. This brings the engine up to the required speed.

(2) For minimum generator voltage output, turn the switchboard rheostat until all the resistance is in the circuit.

(3) Adjust the exciter field rheostat slowly until the marking on the handwheel lines up with the marking on the switchboard panel or until the voltmeter indicates approximately 208 volts (three phase).

(4) In accordance with the voltage regulator instructions (see paragraph 16*g*), adjust the regulator for a generator output of 208 volts (three phase).

(5) Operate the power unit for a short time without load on the generator. Check the bearings for heating and watch for excessive vibration of the generator.

(6) Load the generator by closing the line circuit breaker. If the automatic trip opens the circuit breaker, decrease the load and close the circuit breaker again. The load should not exceed 87 amperes on the main line. Check the load on all three phases.

(7) Operate the power unit at least one-half hour.

(8) If the switchboard meters remain steady and the generator does not have excessive vibration, the operation of the generator and exciter is essentially normal and the unit is ready for use.

(9) If the switchboard instruments fluctuate widely when the unit is operating under constant load, refer to Troubles and Remedies (see paragraph 44). Also refer to the regulator instructions under adjustment and operation. (See paragraph 16*g*.)

(10) With the voltage properly adjusted and the engine operating steadily, the circuit breaker may be moved to the ON position, which applies the voltage to the load.

28. Stopping Engine. (1) Move the circuit breaker to the OFF position.

(2) Pull the throttle half way out to allow the engine to cool down gradually at half speed for approximately three minutes.

(3) Pull the stop button all the way out.

29. Diesel Fuel. Diesel engine fuel, 40 cetane number, will be supplied for use in equipment. Grade A for normal temperatures and grade X for extreme cold (10 degrees Fahrenheit).

The most important factor in the operation of a Diesel engine is clean fuel. Because the tolerances of the nozzle valves are measured in millionths of an inch, the finest dirt in the fuel will cause sticking nozzle valves. This siezure destroys timing and fuel atomization. **A single dust particle can destroy the valve seat.**

The delivery of fuel in barrels or drums should be avoided wherever possible. The more containers used in handling the fuel, the greater will be the chances of getting dirt into the fuel. The fuel should be transferred from the truck tank to the storage tank, or directly to the engine fuel tank, by pump and hose rather than buckets.

Where the use of barrels, or drums, or buckets, cannot be avoided, keep these clean and lint-free as possible Let the fuel in the drums stand undisturbed to permit the settling of rust or scale that may be present.

If the barrel pumps are not available, the drums should be laid on their sides with the back end lower than the front and with a faucet in place at the front end. After settling, the fuel can be poured without disturbing the solids and water which may have settled.

The drums should never be emptied by tilting. This always stirs up the dirt.

Keep the buckets, or fuel cans, and funnels, and the nozzles on the discharge hose under cover. Use a cap on the nozzle of the discharge hose. Wipe the spouts of the buckets clean before and after using.

30. Specifications and Symbols of Army Lubricants. The War Department Lubrication Program is designed to simplify procedure and reduce to a minimum the number of lubricants required for preventive maintenance of equipment. After considerable study, tests, and experiments, a minimum of types and grades have been provided for Army use, covering all lubricating needs and permitting uniformity in manufacture of lubricants by different refiners.

The Lubrication Program is based on the use of three oils, five greases, and two gear lubricants. These are designated by Army symbols and grades as shown. (See Lubrication Chart, page 33.)

Product Symbol	*Approved Nomenclature*
CG-0	Grease, general purpose, No. 0
CG-1	Grease, general purpose, No. 1
WB-2	Grease, general purpose. No. 2
WP	Grease, water pump
WB-3	Grease, wheel bearings, H. D.
GO-90	Lubricant, gear, universal SAE 90
GO-80	Lubricant, gear, universal SAE 80
OE-10	Oil, Engine, SAE 10
OE-30	Oil, Engine, SAE 30
OE-50	Oil, Engine, SAE 50

Engine Oil Recommendations

Crankcase	Capacity, 32 Quarts	Above +32° F.	+32° to 0° F.	Below 0° F.
		OE-30 (SAE 30)	OE-10 (SAE 10)	See Par. 34

OE—Oil, Engine; U. S. Army Specifications No. 2-104A. This oil is used in all automotive, gasoline, and Diesel engines. It is supplied in three viscosities designated as OE-10, OE-30 and OE-50.

OE is a refined petroleum product with or without additive agents and will provide satisfactory lubrication for high speed, automotive type gasoline, Diesel, or spark ignition fuel engines operating under all conditions of service.

The oil is noncorrosive to bearings and engine parts and will not cause piston ring sticking or clogging of oil channels. Figure 34 shows the points of lubrication.

Test	*Test Limits*		
	Grade OE-10	Grade OE-30	Grade OE-50
Viscosity, Saybolt Universal Seconds at 130° F.	90 to less than 120	185 to less than 225	....
Seconds at 210° F.	....	....	93 to less than 104
Viscosity Index, minimum	85	55	75
Pour Point, °F., maximum	0	10	15
Flash Point, °F., minimum	360	390	425

31. Alternator and Exciter Lubrication. Before leaving the factory, the generator bearings are packed with sufficient grease for approximately 1,024 hours of normal operation. For every 1,024 hours of operation thereafter, add about two ounces of grease to each bearing housing. Ordinary cup greases should not be used. A ball bearing grease, WB-2 or WB-3, is recommended. To grease the bearings, first remove the exciter cover and both drain plugs (Figures 34 and 35) on the bottom of the bearing housings. This prevents possible overlubrication. With the grease cup (Figures 34 and 35), add grease to both bearings while the power unit is operating at its normal rate of speed. Watch the drain plug opening and remove the excess grease, if any, before it drops and is drawn into the generator. After the lubricant has been added, replace the drain plugs and the exciter cover.

32. Coupling Lubrication. The Falk coupling is provided with Alemite flush-type grease fittings. The fittings are adaptable to the Alemite push-type guns equipped with flush-type nozzles. The recommended lubricant is WB-2 every 1,024 hours of operation. (See Figure 33.)

Fig. 33. Coupling Lubrication

33. High Temperature Lubrication. Engines operating in high temperatures and under heavy load conditions for long periods of time consume more oil. Hence, crankcase oil level should be checked and crankcase refilled more frequently than normally. If OE (SAE-50)* is available, it may be used. Always be sure to bring oil level to FULL mark on the gauge. Care must be exercised in using this heavy body (OE-50) oil, as the power loss caused by using an oil of this weight will result in an increase in oil pan temperature which will more than offset any possible gain in lubricating value.

NOTE: If unit is operated indoors, where temperature operation is usually higher, heavier oil will commonly be used.

34. Cold Weather Lubrication. When the unit is to be shut down for a prolonged period, and the temperature is below —20 degrees Fahrenheit, drain the oil from the engine crankcase at the end of the operation. Before renewing operation, the oil should be heated to 180 degrees Fahrenheit before pouring it back into the crankcase. No special preparation need be made for operating the main generator in cold weather. The greases recommended for the main generator are suitable for operation at below zero temperature. (See paragraph 35 and lubrication order.)

The intervals of the periods of lubrication, as shown in the Lubrication Chart, are based on actual hours of operation. The elapsed-time meter can be used to keep track of the periods of lubrication.

(For care of cooling system in freezing weather, see paragraph 69c.)

* OE (SAE-50) oil should be used only if OE-30 (SAE-30) is not available.

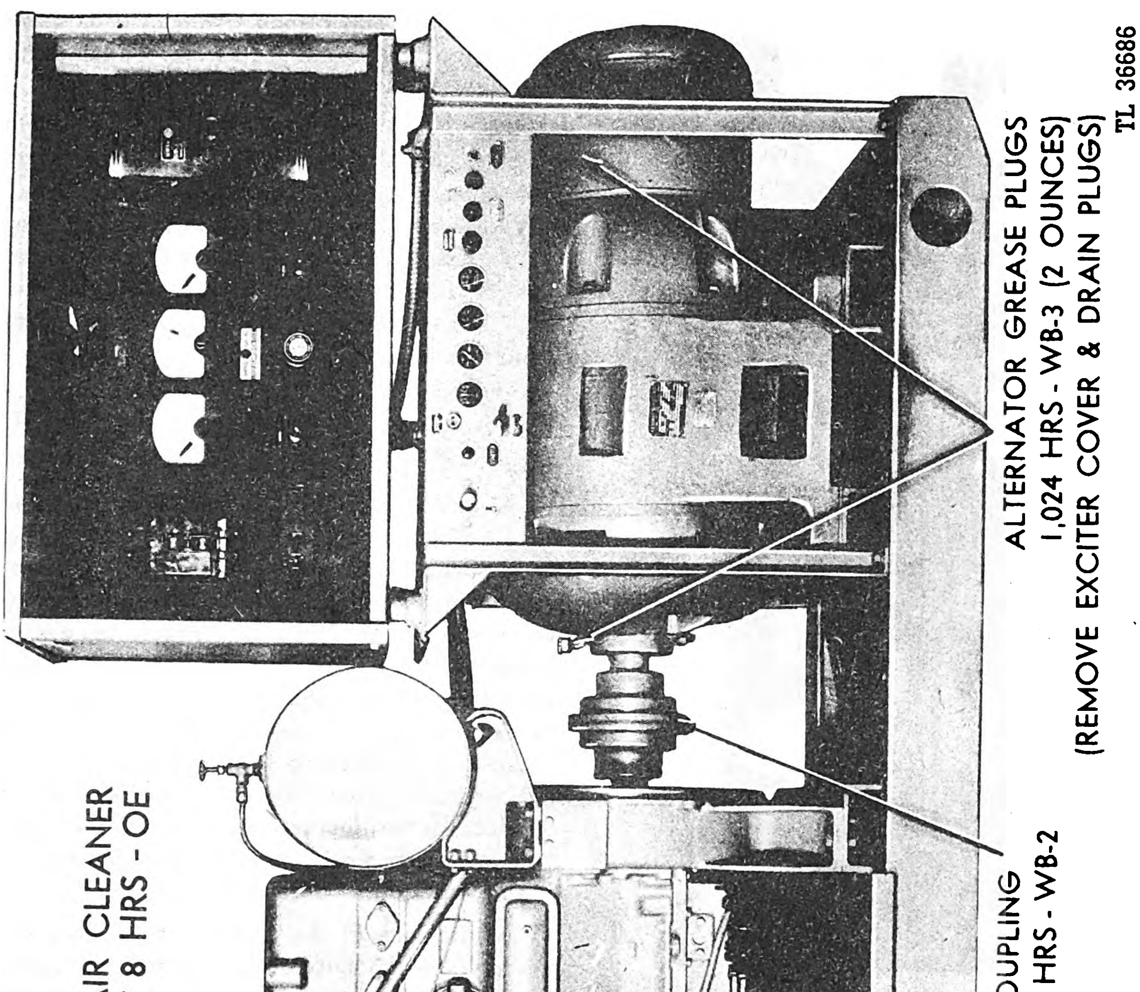


Fig. 34. Points of Lubrication

WAR DEPARTMENT LUBRICATION ORDER No. 3017

WAR DEPARTMENT, WASHINGTON 25, D. C., 29 JANUARY 1944

POWER UNIT PE-185-A & B

Operating Hours • Lubricant

64 *Oil Filter (Second Stage)*
Remove drain plug to drain sludge. Every 256 hours, drain, clean inside of filter body and renew element. Refill crankcase, run engine a few minutes and add OE to FULL mark on gage.

512 WB Fan Bearings
Remove plug, install fitting. Lubricate sparingly.

256 OE Crankcase Breather
Remove, wash, dry thoroughly, and saturate element with OE.

OE Crankcase Fill
(See Note)

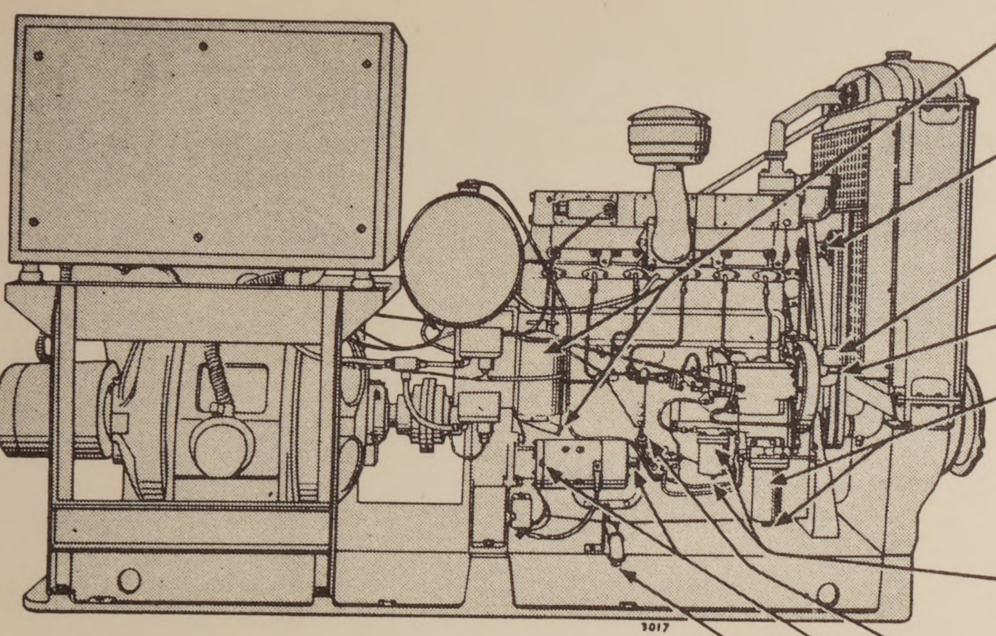
256 *Fuel Filter (Primary)*
Open housing vent and remove drain plug to drain sediment. Every 512 hours, remove filter housing and unscrew filter element. Remove cloth element from metal element. Clean metal element and filter housing and thoroughly flush out cloth element. Renew cloth element when it becomes worn or damaged. Before servicing, clean outside of housing and fuel lines to prevent dirt getting into fuel lines.

256 *Fuel Filter (Secondary)*
Open housing vent and remove drain plug to drain sediment. Every 512 hours, remove filter housing, clean and renew filter element. Before servicing, clean outside of housing and fuel lines to prevent dirt getting into fuel lines.

8 *Crankcase Level Gage*
Check level

128 OE Starting Motor Bearings
5 or 6 drops, each

128 *Crankcase Drain*
Drain and refill Cap. 32 qt. (See Note)



Lubricant • Operating Hours

Fuel Tank **1024**
Flush fuel tank and clean fuel lines. Keep fuel clean and vent in cap open. Cap. approx. 20 gal.

Air Cleaner **OE 8**
Check level and refill to level mark
Every 64 hours, drain, clean and refill.
Every 256 hours, remove and wash all parts.

Power Generator Drive Coupling **WB 1024**
Lubricate through two fittings

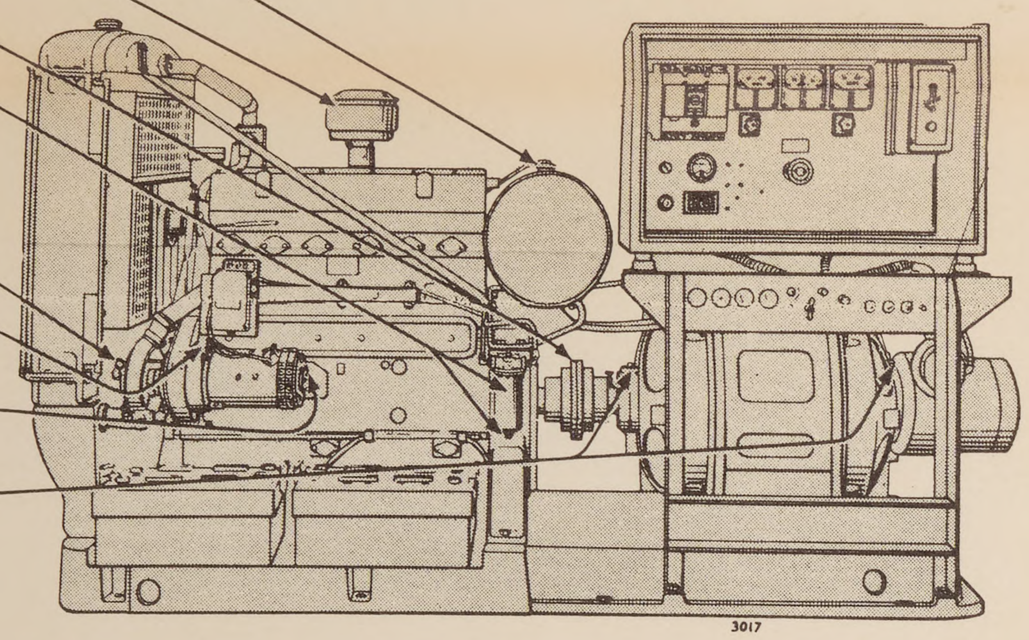
Oil Filter (First Stage) **8**
Turn handle 1 full turn. Every 64 hours, remove drain plug to drain sludge. Every 128 hours, remove metal filter cartridge and clean filter discs and blades. CAUTION: Do not damage discs or blades when cleaning

Water Pump **WP 8**
Turn cup ½ turn, refill as necessary

Charging Generator Front Bearing **CG 64**
(Some models) Turn cup ½ turn, refill as necessary (See Note)

Charging Generator Rear Bearing **OE 64**
5 or 6 drops

Power Generator Bearings **WB 1024**
Remove plug, install fitting (Some models) (See Note)



CRANKCASE—Drain only when hot. Refill to FULL mark on gage. Run engine a few minutes and recheck oil level. CAUTION: Be sure pressure gage indicates oil is circulating. Every 1024 hours, remove oil pan and thoroughly clean sludge from oil pan and oil pump suction screen.

CHARGING GENERATOR FRONT BEARING—Some models are equipped with an oil cup instead of a grease cup. Lubricate every 64 hours, through oil cup with 5 or 6 drops of OE.

POWER GENERATOR BEARINGS—On some models remove top plug, install fitting, lubricate sparingly; also, remove bearing sump drain plug. On other models, remove bearing housing vent plug, turn down grease cup until lubricant appears at vent plug opening. On all models, run generator until operating temperature is reached to expel excess lubricant. Remove fitting and re-install plugs.

COLD WEATHER—Below 0°F., drain crankcase. Refill crankcase with 75% OE SAE 10 and 25% gasoline thoroughly mixed. Check level more often. Maintain at FULL mark on gage by adding gasoline only. At end of each operating period check oil level; add gasoline to FULL mark if necessary. Start engine, run for 5 minutes before stopping. Reduce drain interval by one-half.

FITTINGS—Clean before applying lubricant.

HOURS—Reduce hours under severe operating conditions.

CLEAN parts with SOLVENT, dry-cleaning, or OIL, fuel, Diesel. Allow parts to dry thoroughly before lubricating.

OIL CAN POINTS—Every 64 hours, lubricate Rope Starter Shaft, Stop and Throttle Control Cables with OE.

DO NOT LUBRICATE—Fuel Injection Pump, Engine Governor, Exciter.

LUBRICATED BY MAINTENANCE PERSONNEL—Power Generator Bearing Housings, Starting Motor Bendix Drive.

REFERENCE—Technical Manual TM 11-925.

KEY

LUBRICANTS		LOWEST EXPECTED AIR TEMPERATURE		
		above +32°F.	+32°F. to 0°F.	below 0°F.
OE—	OIL, engine			
	Crankcase	OE SAE 30	OE SAE 10	See Cold Weather Note
	Except Crankcase	OE SAE 30	OE SAE 10	PS
CG—	GREASE, general purpose	CG No. 1	CG No. 0	CG No. 0
WP—	GREASE, water pump. All air temperatures			
WB—	GREASE, general purpose, No. 2. All air temperatures			
PS—	OIL, lubricating, preservative, special			

Copy of this Lubrication Order will remain with the equipment at all times. Instructions contained therein are mandatory and supersede all conflicting lubrication instructions dated prior to 29 January 1944.

BY ORDER OF THE SECRETARY OF WAR:

G. C. MARSHALL,
Chief of Staff.

OFFICIAL:
J. A. ULIO,
Major General,
The Adjutant General.

Requisition LUBRICATION ORDER from Lexington Signal Depot, Lexington, Ky., or Holabird Signal Depot, Baltimore, Md. by Signal Corps Stock No.

6D10113-17

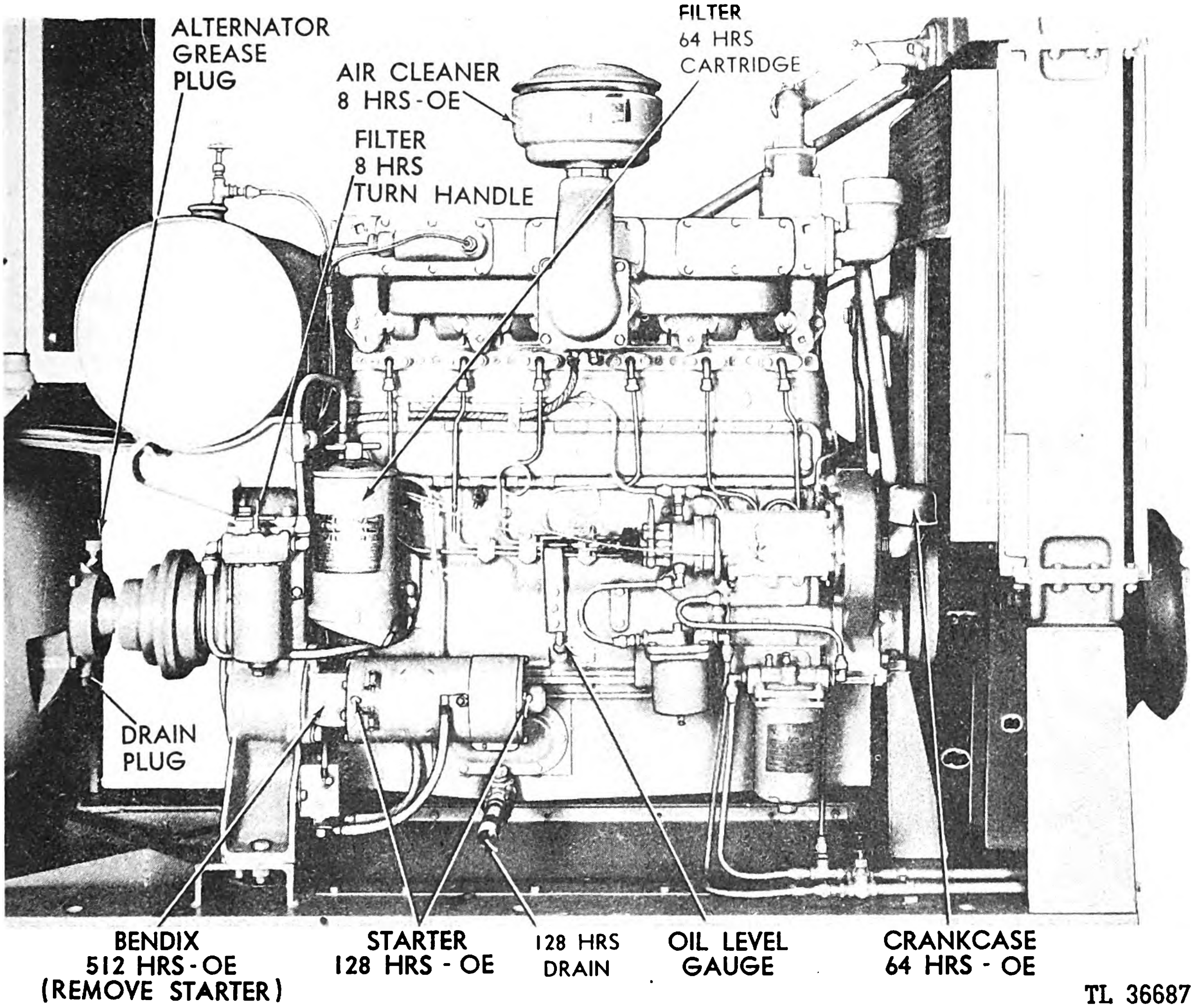


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Fig. 35. Points of Lubrication

LUBRICATION CHART

When to Lubricate	*What to Lubricate*	*Lubricant Required*
Every 8 Hours of Operation	1. Change Oil in Air Cleaner. 2. Water Pump Grease Cup (1/2 Turn).	1. OE 2. WP
Every 64 Hours of Operation	1. Check Lube Oil Filter Cartridge and Turn Lever on Cuno Filter. 2. Battery Charging Generator Oil Cups (2 Drops).	 2. OE
Every 128 Hours of Operation	1. Drain and Refill Crankcase. (32 Quarts.) 2. Starter (Fill Oil Cups). 3. Flex and Lubricate Stop Control and Throttle Cables. 4. Replace Oil Filter with Oil Change.	1. OE — for Prevailing Temperatures 2. OE 3. OE 4. OE
Every 512 Hours of Operation	1. Oil Bendix Drive Shaft. 2. Lubricate Fan.	1. OE-10 2. WB-3
Every 1,024 Hours of Operation	1. Alternator and Exciter. 2. Coupling.	1. WB-3 (See par. 31) 2. WB-2 (See par. 32)

SECTION III
MAINTENANCE

35. Preventive Maintenance. Because this power unit may be operated under climatic conditions which vary from extreme cold to hot, sandy or humid, the operating personnel must exercise judgment in following the intervals of preventive maintenance. These periods and servicings, indicated in the Maintenance Reference Chart, page 34, are based on continuous operation and take into consideration the over-all extreme climatic conditions, as well as heavy load demand. However, under certain circumstances the intervals of servicings may have to be shortened. Under other circumstances they may have to be lengthened. As a rule the intervals and servicings recommended in the Maintenance Reference Chart can safely be followed. Tools and other equipment necessary for servicings are included in engine tool box.

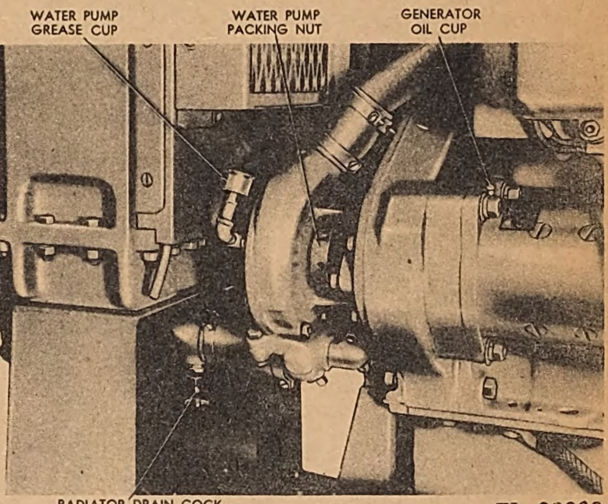

Fig. 37. Water Pump Packing Nut

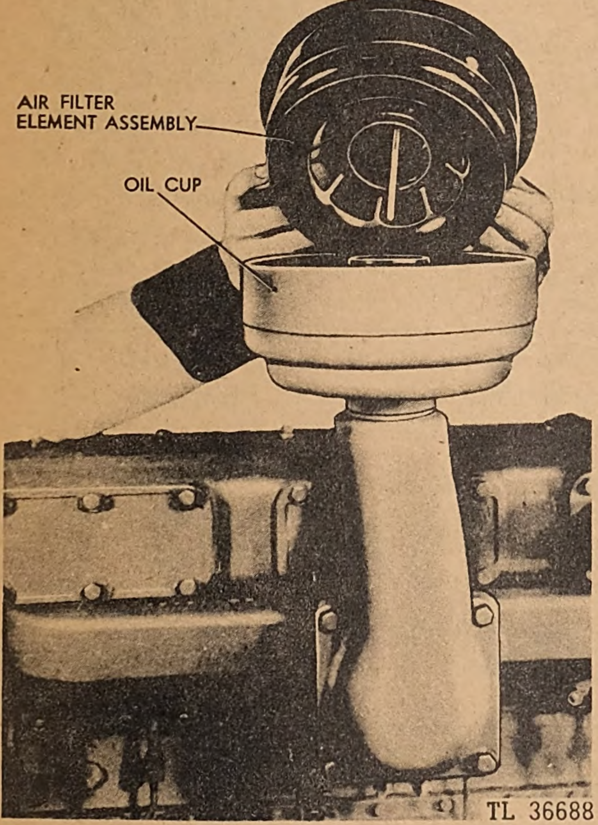

Fig. 36. Servicing Air Cleaner

36. Precautions. Because this equipment employs high voltages which are dangerous and may be fatal if contacted by the operating personnel, exercise extreme caution when working on the power unit. Besides observing the safety notices given in the forepart of this manual, the following rules should also be observed:

(1) Keep the engine and its accessories as well as the alternator, exciter, and the control unit clean.

(2) Keep the fuel tanks clean. Water and dirt in the fuel oil causes more trouble and service interruptions than any other factor. Handle the fuel oil with extreme care. Do not depend entirely upon the fuel oil filters. The use of a funnel equipped with 200-mesh wire screen is the most satisfactory insurance

MAINTENANCE REFERENCE CHART

Period	*Servicings*	*References*
After 8 Hours of Operation (Daily)	1. Over-All Inspection.	Par. 37 (1)
	2. Check Radiator.	Par. 37 (2)
	3. Check Oil.	Par. 37 (3)
	4. Check Air Cleaner.	Par. 37 (4)
	5. Lubricate Water Pump.	Par. 37 (5)
	6. Turn Cuno Oil Filter Handle.	Par. 37 (6)
	7. Check Battery.	Par. 37 (7)
	8. Clean Alternator.	Par. 37 (8)
After Every 64 Hours of Operation	1. Drain DeLuxe Oil Filter.	
	2. Drain Cuno Oil Filter Sump.	See Figure 38
	3. Lubricate Generator (Battery).	Par. 37 (5)
After Every 128 Hours of Operation	1. Drain and Renew Oil.	Par. 39 (1)
	2. Check Battery Charge.	Par. 39 (2)
	3. Check Fan Belt Tension.	Par. 39 (4)
	4. Lubricate Starting Motor.	Par. 39 (5)
	5. Clean Cuno Lube Oil Filter.	Par. 93*d*
After Every 256 Hours of Operation	1. Check Battery Generator.	Par. 40 (1)
	2. Check Starting Motor.	Par. 40 (2)
	3. Check Voltage Regulator (Battery).	Par. 76*d*
	4. Check Tappet Clearance.	Par. 40 (4)
	5. Check Alternator.	Par. 40 (5), (6)
	6. Check Exciter.	Par. 40 (5), (7), (8)
	7. Drain and Bleed Fuel Filter Sumps.	Pars. 78, 79
	8. Clean Air Filter.	See Figure 35
	9. Renew Oil Filter (DeLuxe).	Par. 39 (1)
	10. Wash Crankcase Breather.	Par. 39 (3)
After Every 512 Hours of Operation	1. Clean Primary Fuel Filter.	Par. 41 (1)
	2. Install Element (Secondary Fuel Filter).	Par. 41 (2)
	3. Oil Bendix Drive.	Par. 41 (3)
	4. Lubricate Fan Bearing.	See Figure 35
After Every 1,024 Hours of Operation	1. Clean Out Oil Pan.	Par. 42 (2)
	2. Check Inside Engine.	Par. 42 (2)
	3. Flush Radiator.	Par. 69
	4. Check Battery Cables, Engine Wiring.	Par. 42 (4)
	5. Check Magnetic Starting Switch.	Par. 73*l*
	6. Lubricate Coupling.	Par. 32
After Every 2,048 Hours of Operation	1. Check Engine.	Section IV
	2. Check Engine Accessories.	Par. 61
	3. Lubricate Alternator.	Par. 31
	4. Grind Valves.	Par. 53*h*

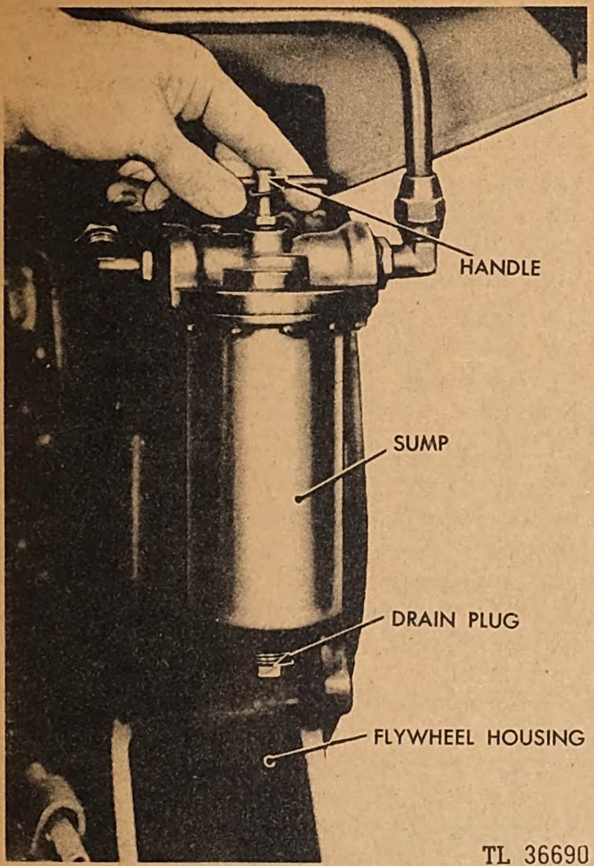

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Fig. 38. Servicing Cuno Oil Filter

against foreign material entering the fuel oil tank when filling tanks.

(3) Warm up the engine slowly. Never race a cold engine. Never add water to an overheated engine. Allow engine to cool before adding water. Never run the engine without water in the cooling system. Correct at once all minor troubles and troubles in the making.

37. Every 8 Hours of Operation, Daily. (1) Check for loose connections, oil, water and fuel line leaks; loose nuts, bolts, and capscrews; check the oil pressure gauge to see that the hand has returned to zero.

(2) Check the water level. The radiator must be full. Use only clean, soft water. If the water is hard, use a commercial water softener. Check the fins and passages between the radiator tubes to be sure that they are free from any foreign material and check the fins to see that they are not bent. Straighten the fins and remove any objects that may restrict the air flow.

(3) Check the crankcase oil level with the bayonet gauge, or dipstick. The level must be maintained at the full mark. Add oil of the recommended viscosity for the prevailing temperature.

(4) Check the air filter cup and refill with fresh crankcase oil to the level indicated inside the air cleaner oil cup. (See Figure 36.) The clamp between the air cleaner and the intake manifold must be airtight so that no dirt can be sucked in through loose joints.

(5) Turn the grease cup on the water pump one-half turn. (See Figures 37 and 35.) Keep the cup filled with WP grease. If the water pump leaks, tighten the packing nut with the spanner wrench as shown in Figure 37. Tighten the nut just beyond the point where the leaking stops and then back it up a little. If the packing nut is tightened too much, this will cause the shaft to wear.

(6) Turn the Cuno oil filter handle at least one complete turn. If the handle binds, keep turning it until only a slight drag remains. (See Figure 38.)

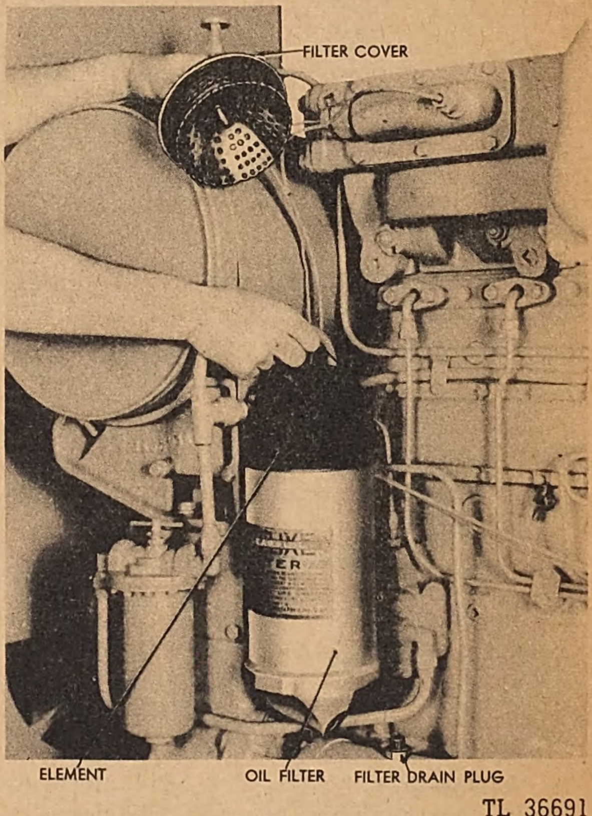

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Fig. 39. Renewing DeLuxe Oil Filter Element

(7) Check the battery water level. Use only distilled water in the battery. If there is corrosion present on the terminals, wash off the corrosion with a solution of baking soda and water. Thoroughly dry the terminals and cover them with grease to prevent further corrosion.

(8) Wipe the alternator and exciter with a rag slightly dampened with solvent or fuel oil. WARNING: Do not use solvent or fuel oil in or around the machine when it is in operation and be sure that all the parts that are cleaned are dried before operating the machine.

(9) Check the alternator for any dirt and dust. The sides must be kept clean, preferably by blowing with dry compressed air. If it is necessary to blow out the alternator, it is advisable to also blow out the exciter. Make certain that no moisture is in the compressed air lines. WARNING: Air pressure in excess of 25 pounds per square inch should not be used in blowing out the machine, since there is danger of lifting the insulation and damaging the windings.

NOTE: If, because of negligence, the exciter or alternator windings become so caked with grease or other substance that they cannot be removed with air, then disassemble and clean the windings thoroughly with a cloth dampened with solvent. See paragraph 95 for the alternator and exciter disassembly and paragraphs 45e and 45f for the use of solvents.

38. Every 64 Hours of Operation. (1) Drain Cuno oil filter sump while hot. (See Figure 38.)

(2) Drain sludge from DeLuxe oil filter while hot.

(3) Lubricate battery charging generator. (See Figure 35.)

(4) Lubricate rope starter shaft and stop and throttle control cables with engine oil.

(5) Drain, clean, and refill air cleaner oil cup.

39. Every 128 Hours of Operation. (1) Drain crankcase while oil is hot. Refill with 8 gallons of new oil of the recommended viscosity. (See Figure 35.) Run engine a few minutes, then check oil level.

(2) Disassemble the Cuno oil filter and thoroughly clean the entire filter with dry cleaning solvent or Diesel fuel oil. Be extremely careful not to damage disc when disassembling and cleaning. (See paragraph 93*d*.)

(3) Lubricate starting motor bearings. (See Figure 35.)

(4) Check the specific gravity of each battery cell with a hydrometer. A reading of 1.250 to 1.285 indicates approximately fully charged; 1.230, half charged; and 1.150, dead. Never take a reading shortly after adding water.

(5) Remove the crankcase breather and filler cover and wash the screen in gasoline. Next dip the screen in light engine oil and let it drain before installing it on the engine.

(6) Check the fan belt tension. It should be possible to pull the belts out of line from ½ to ¾ inch without excessive pulling. If it is necessary to adjust the fan belt tension, loosen the fan adjusting locknut as shown in Figure 40, and adjust the fan adjusting screws so that the fan belt will be at its proper tension.

40. Every 256 Hours of Operation. (1) Inspect the commutator and brushes of the battery charging generator by removing the cover band. Check for dirt and wear and also for high mica (the insulation material between the high bars) and for the commutator being

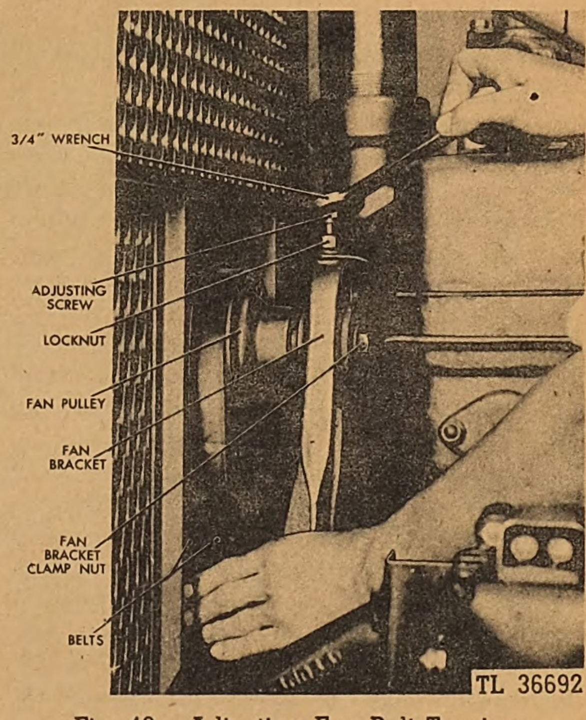

Fig. 40. Adjusting Fan Belt Tension

out of round. This latter can be determined by watching the brushes as the commutator revolves. If the brushes bob up and down, the commutator is out of round. If the commutator is out of round, or has high mica, it will be necessary to true the commutator in the lathe and undercut the mica. See paragraph 73f for instructions regarding trueing up the commutator and undercutting the mica. If the commutator is dirty, clean with #00 sandpaper. (See Figure 41.) Do not use emery cloth. If the brushes are worn or under improper tension, replace and adjust. Brushes that are worn to one-half their original length must be replaced. The brushes must also move freely in their holders. Do not fold or twist the brush

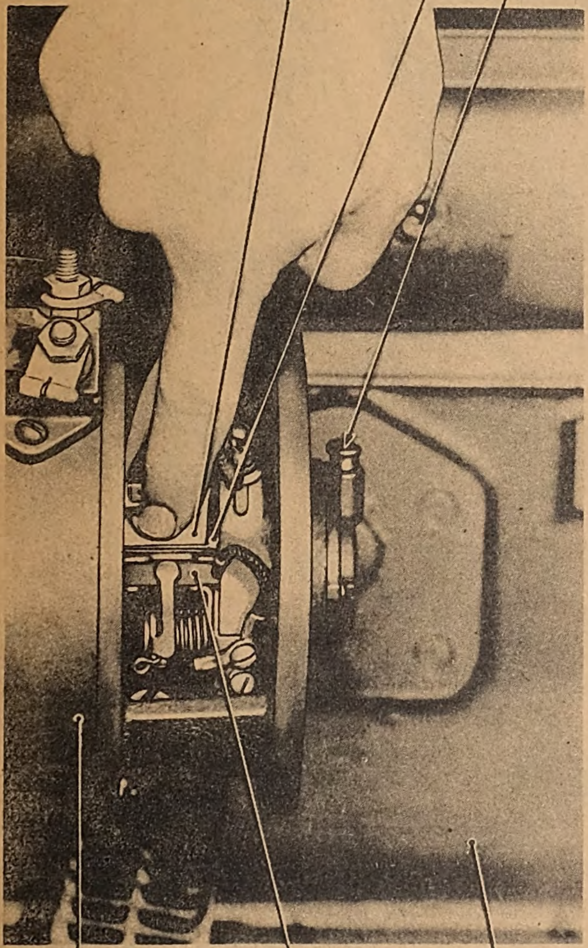

Fig. 41. Cleaning Commutator of Generator (Battery)

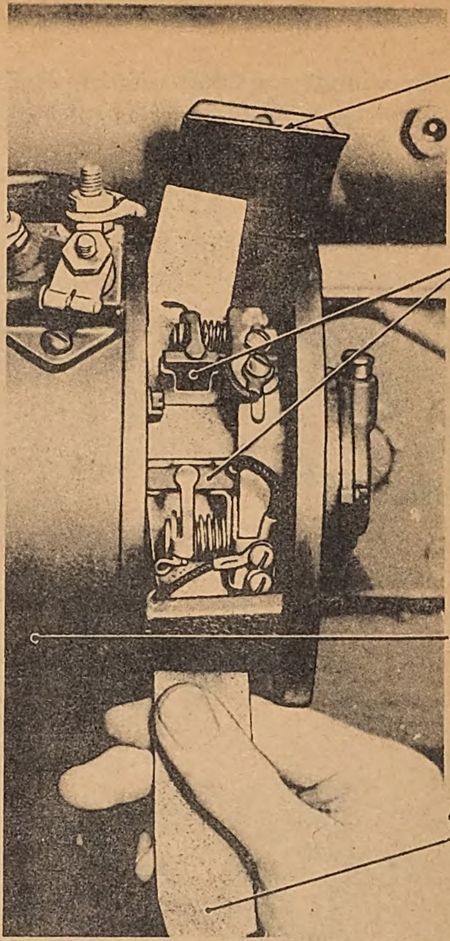

Fig. 42. Seating Generator Brush (Battery)

pigtails so that they prevent free brush movement. When installing a new brush, it must be seated with a strip of #00 sandpaper slightly wider than the brush. With the abrasive side of the sandpaper against the brush and the brush at its proper spring tension, draw the sandpaper upward or downward, making sure that the entire face of the brush is being ground. Do not grind excessively. Blow out the dust with dry compressed air or hand bellows. Check to see that both edges of the brush or brushes are touching the commutator properly. (See Figure 42.)

Before replacing the cover band, fold the brush pigtail wires down so that they will not touch the band or any other material except that of the brush holder. The screws attaching the brush pigtails to the holders must be tight.

(2) Inspect the commutator and brushes of

the starting motor in like manner to the instructions in (1).

(3) Check the voltage regulator contacts and the charging voltage. For the detailed instructions of checking, see paragraph 76*d*.

(4) Remove the rocker arm cover and check the valve tappet clearance. The recommended clearance between the rocker arm and the valve stem is as follows: for the intake, .009 inch; for the exhaust, .012 inch (engine hot). Insert the correct feeler gauge between the rocker arm and the valve stem. With the en-

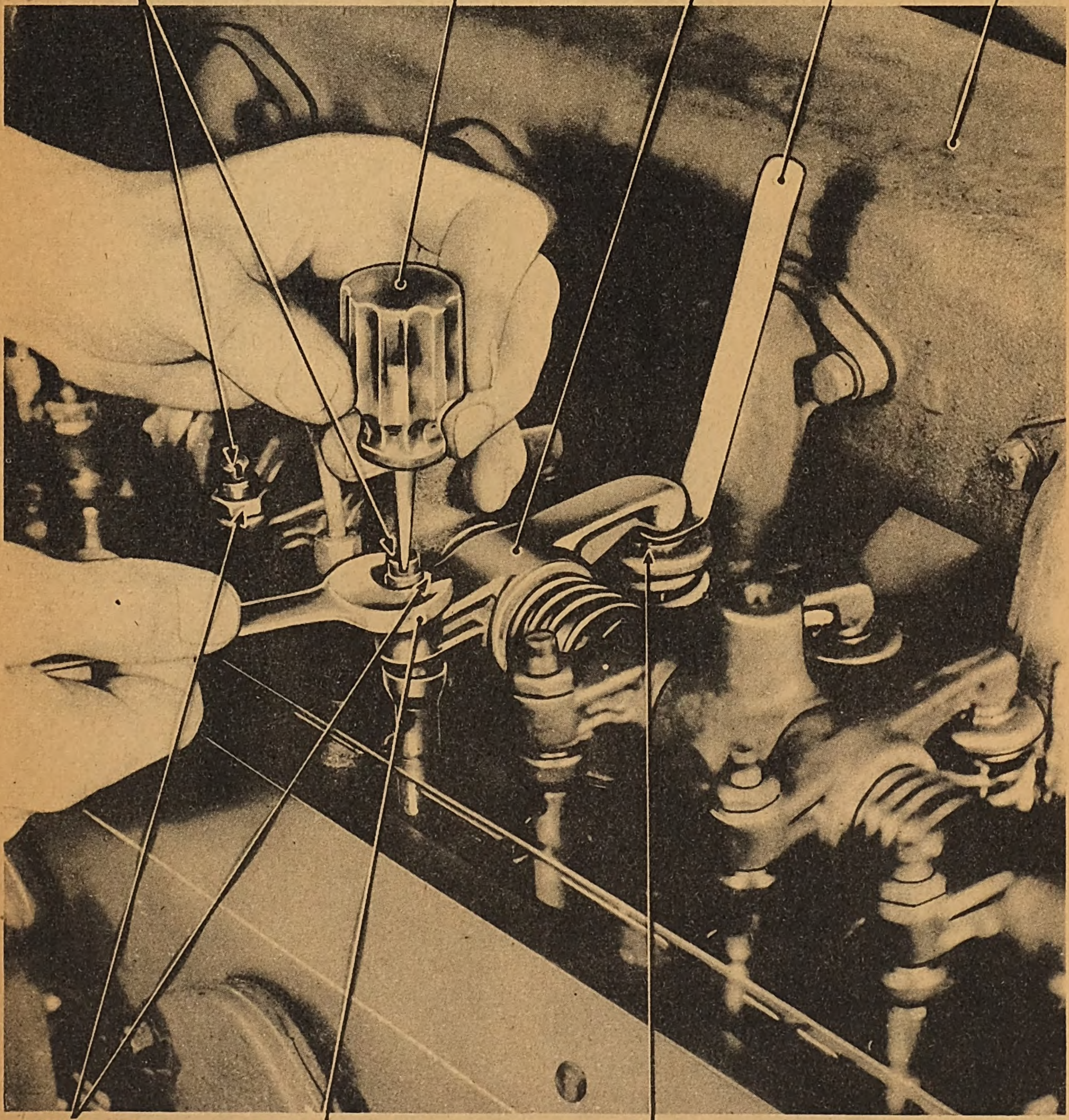

Fig. 43. Adjusting Valve Tappets

gine running slowly, move the feeler gauge back and forth. If the clearance is correct, the operator will note that there is just a slight drag, followed by binding which momentarily prevents him from moving the feeler gauge. If the clearance is not correct, this will be indicated by a continous binding which will not permit the feeler gauge to be moved without considerable drag. On the other hand, if the correct feeler gauge moves without any binding, the clearance is excessive. Recheck the clearance after tightening the locknuts to be sure the seating has not been changed. (See Figure 43.)

(5) Examine the exciter and alternator brush riggings. To do so, first remove the exciter cover, the handhole cover, and the sheet metal cover on the air baffle. Then check to see that all pigtails are securely fastened to the brush holders for good contact. Tighten those which are loose. Raise levers and springs so that the brushes can be moved up and down in their holders to check for binding. If any brush does not move freely in its holder, clean the dirt or foreign material out of the holder or off the brush. Adjust the spring tension according to brush wear. Alternator brushes are designed to have a wearing depth of approximately 3/4 inch. The lever assembly and spring are so designed that for each 1/4 inch of brush wear correct brush pressure can be maintained by moving the spring arm one notch toward the brush.

Brushes should be replaced before the lever assembly and the springs on exciter brushes rest on the brush holders instead of on the brushes. Broken, cracked, or severely chipped brushes should be replaced. Take out a worn brush by loosening the screw which holds the clip, pull out the clip, and remove the brush from its holder while the lever assembly (alternator) or spring (exciter) is raised as far as is necessary. With the spring or lever assembly raised as before, insert a new brush in the holder so that the brush fits the commutator or collector ring contour. Fasten the clip to the brush holder. Adjust the lever assembly to position of least tension.

Examine all brush holders for clearance between the commutator or the collector rings and the bottom of the holder. Exciter brush holders should be approximately 1/16 inch from the commutator surface. Alternator brush holders should be 1/8 inch from the collector rings. If the clearances are too large or too small, loosen the screws which clamp the brush holders to the stud. Adjust for correct clearance and tighten the screw.

(6) The slip rings must be kept clean and well polished with a piece of canvas or nonlinting material. Do not use vaseline or oil of any description on the brushes. When polishing the slip rings with a piece of nonlinting material, run the machine at its highest speed, being careful to polish one ring at a time and to have observed the safest position for the hands or fingers when doing this operation. If the slip rings are rough or pitted, smooth them by polishing with a piece of sandstone from which a segment has been cut having the same radius as the ring. If sandstone is not available, use sandpaper pressed against the surface of the slip ring, using a block of wood shaped like the sandstone mentioned previously. (See Figure 44.) Run the machine at its highest speed. If the rings are badly roughened or pitted, use coarse sandpaper or sandstone first; then follow up with a finer grade of sandpaper for the final polishing. Carefully clean the rings and brush holders in order to remove any grit or abrasive which might cut or scratch the slip rings.

Fig. 44. Smoothing Alternator Slip Rings

(7) Inspect the exciter commutator. Inspect the commutator to see if there is dirt or oil on the brush contact surfaces, high or low bars, or carbon deposits in the undercut grooves. A commutator in good condition will have an oily, glazed appearance, showing a light brown color. This condition is conducive to long commutator and brush life. If the commutator is rough, blackened, or pitted, polish it with #00 sandpaper. If there are high or low bars, the commutator must be trued up in a lathe. (See paragraph 99.)

If the commutator is rough, remove this roughness, using a piece of sandstone from which a segment has been cut having the same radius as the commutator. If sandstone is not available, use #00 sandpaper and, with the brushes lifted off the commutator, operate the unit at its highest speed and polish the commutator with the sandpaper.

Smooth the commutator. While smoothing the commutator, move the sandpaper sideways parallel to the shaft. Be sure that the brushes are lifted, for this will prevent unnecessary brush wear and keep particles of the abrasive from becoming imbedded in the brush.

Remove the carbon deposits from the undercutting grooves by using a small piece of hard wood shaped to the width of the grooves and used as a scraper. A piece of hack saw blade from which the set has been ground off can also be used for this purpose. When using the hack saw blade, however, be careful not to scratch the commutator.

(8) If the exciter brushes are stuck with dirt or other foreign material, remove the brushes and clean them. The brush holders and insulation supports should also be carefully cleaned. See that the brush pigtail connections are tight. Check the exciter brush spring tension, which should be approximately 13½ ounces. The exciter brush holder spring will maintain the correct tension indefinitely unless the brush pigtail circuit opens and permits the brush holder to carry the current. If the brushes of the exciter are worn to less than half their original length, they should be replaced. In fitting or seating the new brushes, place the brush and the brush holder under normal brush spring tension. Draw a strip of #0 or #00 sandpaper with the sanded side against the brush in the direction of rotation, following the contour of the exciter commutator or the alternator slip ring. (See Figure 31.) **CAUTION: Do not use emery cloth on the slip rings, the commutator, or the brushes. The final finish of the seating should be done with #0 or #00 sandpaper. Run the machine for a few minutes and inspect the brush contact surfaces for perfect seating. If not perfectly seated, repeat the foregoing operation with #0 or #00 sandpaper. The brushes of both the alternator and the exciter must be replaced by the same type and grade recommended by the manufacturer. (See parts listing.)**

(9) Drain and bleed the fuel oil filters. (See paragraph 23 (10), (11), (12) and (13).)

(10) Remove, drain, clean all parts, and refill air cleaner.

(11) Renew DeLuxe oil filter element. Clean filter thoroughly.

(12) Remove crankcase breather, clean thoroughly with solvent or fuel oil and saturate element with engine oil.

41. Every 512 Hours of Operation. (1) Before removing the primary fuel filter housing,

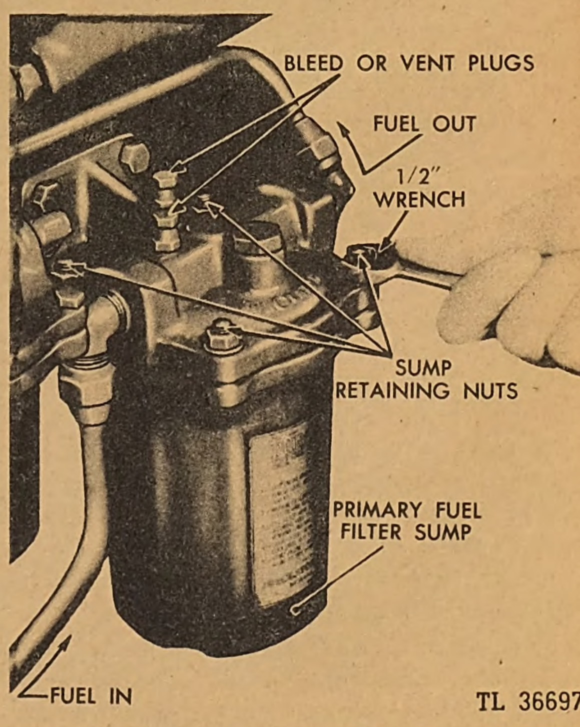

Fig. 45. Removing Primary Fuel Filter Housing

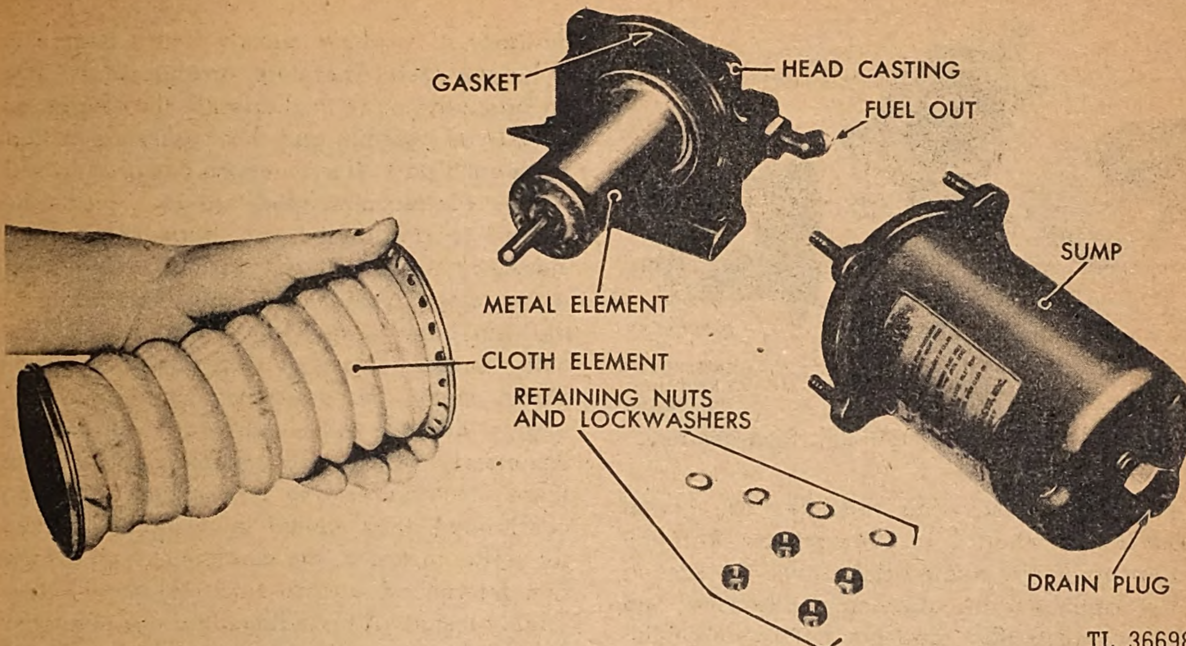

Fig. 46. Primary Fuel Filter Disassembled

wash the housing seats and tubes with fuel oil. (See Figure 45.) Then wash the filter element in clean fuel oil, making certain to remove any sludge. (See Figure 46.)

(2) Install a new element in the secondary filter, but first wash the outside of the filter housing seats and tubes before it is disassembled, to avoid getting dirt into the lines. Use clean fuel oil for washing. (See Figure 47.)

(3) Remove the starting motor from the flywheel housing and oil the Bendix pinion shaft. (See Figure 66.) Clean the Bendix assembly before oiling and reinstallation.

(4) Remove plug and install a grease fitting in fan assembly. Lubricate sparingly with WB and remove fitting.

42. Every 1,024 Hours of Operation. (1) Lubricate power generator drive coupling with WB-2. (See paragraph 32.)

(2) Remove the oil pan and wash out any sludge; also clean the oil pump suction screen. Inspect the inside of the engine, checking the cotter pins and locks in the connecting rods and main bearings. Make sure all connecting rod bolts, nuts, and main bearing capscrews are tight. Replace the oil pan gasket.

(3) Lubricate power generator bearings. (See Figure 35.)

(4) Flush the radiator with standard flushing compound. (See paragraph 69.)

(5) Inspect the battery cables and all the engine electrical wiring. Replace frayed, worn, or oil soaked wires with new ones of the same size.

(6) Check the magnetic starting switch. (See paragraph 73*l*.)

43. Every 2,048 Hours of Operation. (1) Check the engine and its component systems thoroughly. Because the power unit may be operated under conditions which vary, the maintenance personnel must exercise judgment in intervals of complete overhaul. If necessary, completely overhaul at 2,048 hours of operation.

44. Trouble Shooting. Over 90 per cent of engine trouble can be prevented by good periodical lubrication, inspection and maintenance, as already outlined in this manual. The time and energy consumed in so doing is only a fraction of what must be incurred when trouble ties up operations.

To remedy as quickly as possible the troubles that may come, the following list of

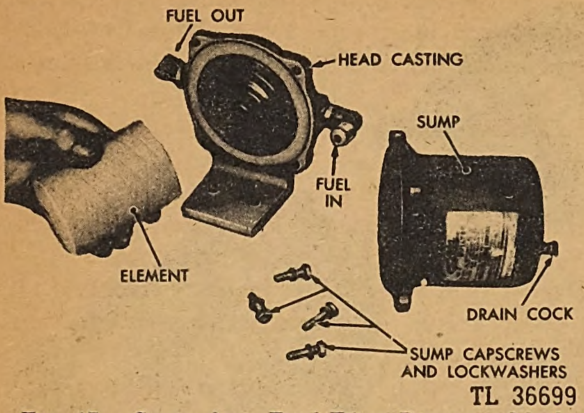

Fig. 47. Secondary Fuel Filter Disassembled

symptoms, causes and remedies are given. The trouble chart is in two sections. The first chart applies to engine difficulties; the second chart applies to the alternator and exciter and the control panel. (See pages 47 to 52 inclusive.) A special trouble chart pertaining to the fuel injection system is explained in paragraph 89.

45. Emergency Treatment and Storage. A generator set which has been filled with dirt due to dust storms or other unusual conditions, or has been submerged during a flood either in salt or fresh water and is clogged with mud and foreign matter, will require a thorough washing out, and this means a complete teardown of the entire unit.

a. Submerged Engine. A complete teardown of the engine is required, and, unfortunately, proper equipment for this operation is rarely available at the scene of submersion. This brings in the element of time. Therefore, means should be taken to prevent corrosion, in so far as possible, until the time when the engine is completely dismantled and each part cleaned. The action of the air creates the corrosion; therefore, all parts of the engine should be coated as thoroughly as possible with oil to prevent the air reaching them. It is so important that the air be kept from contacting the wet steel parts that, in cases where oil is not available, it is oftentimes better to allow the engine to remain under water until some slushing medium can be obtained, provided, of course, that this can be done within a reasonable length of time.

Too much stress cannot be given to the importance of working quickly if the engine is to be salvaged. Therefore, arrangements must be promptly made to dismantle the engine as quickly as possible and thoroughly clean and slush each part. If submersion occurred in salt water, it is recommended that, as soon as the engine is dismantled, all parts other than electrical equipment be washed in hot fresh water, dried, and slushed with lubricating oil that has been heated to 180 degrees Fahrenheit. Engine electrical accessories, such as starter motor and generator, should be thoroughly flushed with fresh water, dried and completely overhauled before using. When these electrical engine accessories are being overhauled, they should be visually checked for metal corrosion, the condition of all insulation determined, and all electrical circuits thoroughly tested. All windings that are otherwise serviceable should be baked in an oven at 140 degrees Fahrenheit for four hours before reassembly. All flexible conduits must be replaced.

A careful inspection must be made of each part salvaged to determine not only the extent of the damages caused by corrosion, but also other damage caused by the sudden cooling action of the water in cases where the engine was at operating temperature at the instant prior to submersion.

b. Submerged or Dust Filled Generator. Electrical apparatus which has been filled with dirt by dust storms or other unusual conditions or has been submerged during a flood and is clogged with mud and foreign matter will require a thorough washing out. In such cases, disassemble the apparatus and thoroughly wash all parts with water. Use an approved solvent to remove grease from the insulation. (See paragraph 45e and 45*f*.) If water is applied to insulated parts with a hose, the pressure should not exceed 25 pounds per square inch.

c. Cleaning. The method of cleaning insulation includes: wiping off the dirt with a clean, dry cloth, blowing it out with air pressure, drawing it out with suction apparatus, removing it in various ways with solvents, and washing it out with water—sometimes hot water and a solvent are needed. The method will, of course, depend upon the conditions involved.

d. Compressed Air. Blowing out dirt with air at about 25 pounds pressure is usually effective, particularly when the dirt has collected in places which cannot be reached with a cloth. Do not direct compressed air against insulation until certain that it is free from moisture that may have accumulated in the air line from condensation. Too great an air pressure may loosen binding tape and blow dirt under it. Dirt blown out of a machine is likely to be drawn into others that are in operation near it. Remember, the use of compressed air simply transfers the dirt from one location to another, and unless the final location is outside the operating room, very little good may be accomplished.

e. Using Solvents. If the accumulation of dirt contains oil or grease, a solvent will be required to remove it. There are three types of solvents in general for this purpose. These are petroleum distillates, such as benzine or gasoline (not benzene or benzol, which are extremely toxic), carbon tetrachloride, and a mixture of the two.

Benzine or gasoline has the least corrosive action on the insulation varnishes, and for that reason, where conditions permit, are preferable to the other solvents. Benzine, having a flash point of 100 degrees Fahrenheit or higher, is perhaps the most generally disirable. Solvents known commercially as Stoddard Solvents (described in U. S. Bureau of Standards as "Commercial Standard SC-3-28"), Cleaners' Naphtha, or Safety Type Solvents minimize the fire hazard and should be used in preference to gasoline or benzine, but ample precautions should be used to prevent fires or explosions. A mixture of 50 per cent carbon tetrachloride and 50 per cent benzine or 60 per cent carbon tetrachloride and 40 per cent gasoline is not inflammable, but the vapors mixed with the right proportion of air are explosive.

f. Applying Solvents. In cleaning a generator set, solvents are generally used by wiping the insulation with cloths moistened with the cleaning fluid. In such cases the solvent may be sprayed on the insulation or the insulated parts may be dipped into the solvent. **CAUTION: When petroleum distillates are used, guard carefully against fire and explosion.**

Both benzine and gasoline are very inflammable and their vapors are extremely explosive when mixed with the proper percentage of air.

Be sure there is good ventilation and minimum fire risk.

Do not allow the clothing to become saturated with the solvent. If the clothing should become saturated, it should be changed.

Always have a fire extinguisher handy.

Keep metal tools from striking metal parts of the generator set.

The mechanic's shoes should not have protruding nails.

If using a hose to spray either cleaning solution or varnish, make sure that the nozzle is grounded.

When using carbon tetrachloride, guard against breathing fumes.

Adequate ventilation should be provided when any type of solvent is used.

g. Drying. There are three general methods of drying the insulation of windings: external heat, internal heat, and a combination of both. An effective process, where possible is to dry the generator under vacuum while hot.

h. Drying with External Heat. Drying the insulation of the generator with electric heaters distributed under the ends of the winding is effective. Most convenient for this method are the space heaters. This type of heater is 3/16 inch thick, 1/2 inch wide, and, depending upon their capacity, are anywhere from 12 inches to 43 inches long.

i. Using Oven Heat. Oven drying is particularly recommended. A good temporary oven may be made of panels of heat insulating material secured to wooden frames, or they may be made of sheet iron, bricks, or concrete blocks lined with insulating material.

NOTE: The oven should be ventilated to provide air circulation and to remove moisture. Preheated air may be forced through the oven. Many kinds of heaters may be used if precautions are taken against fire and to keep the actual product of combustion out of the oven.

j. Drying with Internal Heat. The coil insulation may be dried by circulating current through the windings. In this way, internal heat can be developed without exposing the insulation to voltages that might damage it during drying. There is always danger, however, of serious injury to the windings when drying the insulation in this manner, since the heat generated in the inner parts is not readily dissipated; besides, coils containing moisture are most susceptible to injury from overheating. Gases and vapors generated within the insulation may develop such pressure that they are forced through the insulation, breaking the continuity of the layers or rupturing the material. Therefore, this means of drying should be carefully done.

Drying should be continued until the insulation resistance has dropped to a minimum and then has increased until at least one megohm for each 1,000 volts, operating voltage, is indicated, but in no case less than one megohm, regardless of voltage. It may then be desirable to maintain the temperature at from 15 to 25 degrees above the ambient until ready for operation.

In the alternating current generators, the internal heat method of drying can be done by the short-circuit method or low voltage from an external source. The short-circuit method means short-circuiting the armature windings and driving the generator and applying sufficient field excitation to give somewhat less than full load armature current. When the windings are provided with imbedded temperature detectors or when temperatures are determined by the increase of resistance method, the current may be adjusted to maintain an internal temperature of 85 degrees Centigrade from the beginning of the dryout run. If the temperature indications are obtained from thermometers located on the outside of the high-voltage coil insulation, several hours may elapse before maximum temperature under constant current, ventilation, and ambient temperature conditions are indicated. Since these temperatures may be from 2 degrees Centigrade to 25 degrees Centigrade lower than the temperature at the inside of the insulation, it follows, therefore, that the temperature by thermometer should not exceed 65 degrees Centigrade.

In the low-voltage method from an external source for drying the coil insulation, the current must be controlled so as not to exceed the full load current. When alternating current is supplied to the armature from an external source, the field windings should always be short-circuited.

k. Preparing Power Unit for Storage. If the power unit is to be stored, protective measures must be taken to prevent rusting, corrosion, or, more particularly, gumming of the precision parts of the fuel injection system. Corrosion of polished steel and copper is accelerated by fuel oil; therefore, the fuel oil must be removed. Care must be exercised in the selection of a proper nonrust medium, since many nonrust oils have properties which cause gumming and, finally, sticking of the fuel injection pump parts. Experience has indicated that Tectyl 506 GRI marketed by the Valvoline Oil Co., Cincinnati, Ohio, or its equivalent, is satisfactory as a rust-preventive compound. To prepare the power unit for storage, proceed as follows:

(1) Run the engine until the oil temperature registers at least 120 degrees Fahrenheit on the oil temperature gauge.

(2) Drain the crankcase oil and refill the crankcase with 50 per cent of engine oil and 50 per cent of rust preventive.

(3) Disconnect the auxiliary fuel tank. Drain the engine tank—turn the handle to the engine tank position. Disconnect the hydraulic unit return line at the three-way valve. Be sure to use a container to catch the fuel that will come out of the return line. Drain the fuel filter sumps. Pour about 1½ gallons of rust preventive in the engine tank. Bleed the fuel filters according to the instructions given in paragraph 23 (10), (11), (12) and (13). Operating the primer handle, pump at least one pint of rust preventive through the hydraulic unit. When you are sure that the whole system (primary and secondary filters and the fuel injection pump) is full of rust preventive, start the engine and let it operate at 500 r.p.m. for about ten minutes. Stop the engine.

(4) Take off the energy cell cover plates. (See Figure 79.) Then remove the energy cell plugs and pour one ounce of rust preventive into each cylinder. Crank the engine with the starting motor with the throttle wide open for a full twenty-five revolutions. Then reinstall the energy cell plugs and tighten the energy cell cover plates. Remove the fuel injection pump inspection plate. With a squirt can, put a small

amount of the rust preventive on the rotor drive and splines of the driver shaft, moving the rotor driver back and forth on the splines so that the compound is well distributed. Reinstall the inspection plate.

(5) Remove the rocker arm cover and "paint" the rocker arm assembly and valve springs with the rust preventive. Replace the rocker arm cover. Tape the air intake manifold and replace the air cleaner. The engine is now prepared for storage.

(6) Disconnect the storage batteries and store them separately so that they will be handily available. An unused or stored battery must be slightly recharged once a month. If the battery is allowed to stand in a discharged state, it will be ruined by sulphation.

(7) Drain water from engine and radiator.

(8) In storing the power unit, particularly the alternator and exciter, a safe and reliable heating system should be provided to protect the windings of the generator from alternate freezing and thawing if at all possible. An electric heater with a thermostatic control is recommended when such equipment is available. All the machine parts or surfaces should be slushed with the rust preventive* or "painted" before storage to prevent rusting. If the generator is to be stored for any length of time, those parts subject to rust should be inspected periodically, approximately every 30 days, to see that rusting has not started. Repaint and reslush parts if required. The alternator and exciter should be wrapped with waterproof paper. The unit must be protected from atmospheric conditions. See page 201, paragraph 106 for moisture proofing and fungi proofing of Power Unit.

ENGINE TROUBLE CHART

a. SUDDEN STOPPING

Probable Causes	*Remedy*
1. No fuel.	1. Refill fuel tank and bleed or vent the fuel injection system. Plugged line—Clean the fuel lines and examine for deterioration.
2. Insufficient flow of fuel.	2. Check for dirty filters, deteriorating flexible lines, insufficient fuel, and inoperative fuel transfer pump or air leak in suction line. Air traps—Bleed the fuel injection system of air.
3. Dirt in fuel.	3. Replace the secondary fuel filter element and wash the primary filter. Clean the tank and flush fuel and transfer pumps.
4. Water in fuel.	4. Drain the filters, the tank, and the fuel injection pump.
5. Overheating of engine.	5. Check the water and oil supply. Also check for clogged radiator, stuck thermostat, or other restrictions in the cooling system, loose or broken fan belts. Check for damaged water pump.
6. Low oil pressure.	6. Check for burned or worn bearings, dirt under the oil pressure relief valve, oil screen bracket for looseness, or loose oil lines and oil plugs, or diluted or light oil.
7. Fuel too heavy.	7. Drain the fuel filters and the fuel tank and refill with fuel of proper specifications. (See paragraph 29.)
8. Fuel injection pump inoperative.	8. See injection pump trouble chart, paragraph 89.

* AXS-673 compound, rust preventive, thin film.

ENGINE TROUBLE CHART (Cont'd)

b. LOSS OF POWER

Probable Causes	*Remedy*
1. Insufficient fuel.	1. Check fuel tank.
2. Air in fuel lines.	2. Vent or bleed the fuel injection system and check for air leaks.
3. Restrictions in fuel line.	3. See paragraphs 77 and 87.
4. Fuel too heavy.	4. See paragraph 29.
5. Weak or missing cylinders.	5. Check valve clearance. Injectors should be checked for atomization. NOTE: To discover which cylinder or cylinders are missing, loosen the nut of the injection line at the injector—no more than half a turn—so that the fuel leaks around the nut. If there is no appreciable change in the engine performance, that cylinder is not operating.
6. Sticking fuel injection pump plunger. Weak transfer pump. Governor out of adjustment.	6. See paragraph 90.
7. Sticking valves.	7. Paint the valve stems with kerosene, or remove valves and clean guides and stems.
8. Air cells carboned or burned.	8. Clean or replace cells. (See paragraph 53c.)
9. Low compression.	9. Check for pitted, burned, or warped valves, insufficient valve clearance, worn piston rings or stuck rings. (See paragraphs 53*g* and 58c.)
10. Clogged air cleaner.	10. Remove air cleaner and wash the air filtering element in gasoline. Wash out oil cup and refill with oil to the correct level.
11. Valve clearance out of adjustment.	11. Check rocker arm and adjust clearance. (See paragraph 40 (4).)
12. Faulty injectors. (Black exhaust.)	12. Replace.
13. Worn hydraulic unit or broken plunger springs.	13. Replace unit or springs. (See paragraph 85*b*.)
14. Fuel injection pump out of time.	14. Retime fuel injection pump. (See paragraph 59*v* (2), (3), (4).)

c. HARD STARTING

Probable Causes	*Remedy*
1. Insufficient fuel.	1. Add fuel. Check for restrictions.
2. Air traps.	2. Vent fuel lines.
3. Incorrect timing, either of valves or fuel pump.	3. Retime. (See paragraphs 59*t* and 59*v* (2), (3), (4).)
4. Worn rings—poor compression.	4. Replace rings. (See paragraph 58c.)
5. Pitted or warped valves.	5. Grind or replace valves. (See paragraphs 53*g* and 53*h*.)
6. Faulty injectors.	6. Replace. (See paragraph 90c.)

ENGINE TROUBLE CHART (Cont'd)

c. HARD STARTING (Cont'd)

Probable Causes	*Remedy*
7. Battery charge low.	7. Replace with fully charged batteries.
8. Valve clearance incorrect.	8. Adjust rocker arm clearance. (See paragraph 40 (4).)
9. Worn hydraulic unit.	9. Replace. (See paragraph 85*b*.)
10. Transfer pump faulty.	10. Replace transfer pump as a unit. (See paragraph 85c.)

d. OVERHEATING

Probable Causes	*Remedy*
1. Lack of cooling water.	1. Check water in radiator. CAUTION: Do not add cold water to an overheated engine.
2. Sediment or salt in water jackets, or clogged radiator.	2. Flush out cooling system.
3. Water pump damaged by ice or other substance.	3. Check water pump.
4. Fuel injection too late or too soon.	4. Pump should be retimed. (See paragraph 59*v* (2), (3), (4).)
5. Stuck thermostat.	5. Remove thermostat housing on the top of the exhaust manifold and free the thermostat.
6. Improper lubrication.	6. See Lubrication Specifications, paragraph 30.

e. KNOCKING

Knocks in the Diesel engine can be divided into fuel knocks and mechanical knocks which cannot be directly assigned to the injection process.

Knocks other than fuel are either from loose bearings, pistons, flywheel, improperly adjusted valve mechanism, or blow-by due to sticking piston rings.

Knocks could also be the result of a loose alternator coupling, or because the engine accessories are loose on their mountings.

Excessive fuel knocks are caused by too early injection of the fuel with the speed and load on the engine. This may be due to too great an advance of the injection or improper timing of the fuel pump in servicing.

Trouble from knocking, other than fuel knocks, can usually be found by sounding the knocks out under different load conditions and by cutting out one cylinder at a time. When the loose or incorrectly adjusted part is found, the remedy is usually obvious. These corrections should be made by an experienced mechanic.

f. EXCESSIVE SMOKING

This may be caused by sticking or worn nozzles, leaky inlet or exhaust valves, stuck or worn piston rings, or scored cylinders. Check the inlet and exhaust valve clearance and make sure that the valve is not sticking in the guide. Check for a dirty air cleaner. As a last resort, assume the trouble to be in the fuel injection pump. Too much load, stop-setting changed, or lever incorrectly set.

MAIN GENERATOR TROUBLE CHART

a. EXCESSIVE SPARKING AT EXCITER BRUSHES

Probable Causes	*Remedy*
1. Improper brush rigging setting.	1. Shift the brush rigging so that the notch in the yoke is exactly opposite the chisel mark on the end shield. (See Figure 31.)
2. Brush holders out of alignment.	2. Adjust the brush holders so that the brushes will ride on the commutator correctly and so that a clearance of $1/16$ inch is maintained between the holders and the commutator surface.
3. Binding brushes.	3. Raise springs and move brushes up and down to locate which brushes bind. Remove the obstruction from the holders.
4. Broken springs.	4. Replace broken springs.
5. Weak springs.	5. Compare spring tension of all the springs. Replace those which seem weaker than the others.
6. Improper brush fit.	6. Sand exciter brushes to fit the commutator curvature. (See paragraph 40 (8).)
7. Insufficient brush pressure.	7. Adjust spring tension one notch tighter.
8. Worn, cracked, severely chipped or broken brushes.	8. Replace defective brushes.
9. High mica between the commutator bars.	9. Undercut the mica.
10. Dirty or oily commutator.	10. Clean the commutator as described in paragraph 40 (7).
11. Rough commutator.	11. Stone or sandpaper the commutator as described in paragraph 40 (7).
12. Commutator out of round.	12. A small stick held firmly on a brush while the power unit is operating will show the eccentricity. Turn the commutator in a lathe.

b. EXCESSIVE SPARKING AT GENERATOR BRUSHES

Probable Causes	*Remedy*
1. Insufficient brush pressure.	1. Adjust spring tension one notch tighter.
2. Binding brushes.	2. Raise levers and move the brushes up and down to locate which brushes bind. Remove the dirt or foreign material from the brushes and their holders.
3. Brush holders out of alignment.	3. Adjust the brush holders so that brushes will ride on the approximate center of collector rings and so that a clearance of $1/8$ inch is maintained between the holders and the rings.
4. Broken springs.	4. Replace broken springs.
5. Weak springs.	5. Compare tension of all the springs. Replace those which seem weaker than the others.

MAIN GENERATOR TROUBLE CHART (Cont'd)

b. EXCESSIVE SPARKING AT GENERATOR BRUSHES (Cont'd)

Probable Causes	*Remedy*
6. Worn, cracked, severely chipped or broken brushes.	6. Replace defective brushes.
7. Dirty collector rings.	7. Clean with carbon tetrachloride or its equivalent.
8. Rough or eccentric collector rings.	8. A small stick held firmly on a brush while the power unit is operating will show the roughness or eccentricity. Turn the rings in a lathe.

c. LITTLE OR NO OUTPUT VOLTAGE

(Voltmeter on control panel does not register)

Probable Causes	*Remedy*
1. Low speed.	1. Check the speed of the Diesel engine and bring the power unit up to rated speed.
2. Loose connections.	2. Tighten all connections between generator, exciter, and switchboard.
3. Incorrect connections.	3. Use wiring diagrams to check connections. Connect leads to the correct terminal. (See Figure 16.)
4. Defective windings.	4. Test the windings with an ohmmeter, a Wheatstone bridge, or a Kelvin double bridge and replace the defective parts as directed below. a. Lift all brushes from the commutator and collector rings. b. Test across leads T_1 and T_2, then across T_2 and T_3, and finally across T_3 and T_1. (See Figure 24). These readings should be approximately .042 ohm at ordinary room temperatures. If the readings vary more than 10 or 12 per cent from the designated resistance, or if the readings vary widely from each other, replace the stator assembly. c. Test across the two collector rings. At ordinary room temperatures this reading should be between 13 and 15 ohms. If the reading is outside the limits, test the resistance of each coil to localize the defect and replace the defective wound pole. d. Check the exciter shunt field resistance between F_1 and F_2. The reading should be approximately 92 ohms. If the reading is not within 10 or 12 per cent of the designated resistance, check the resistance of each coil separately to localize the defect. Replace the shorted coil.

MAIN GENERATOR TROUBLE CHART (Cont'd)

c. LITTLE OR NO OUTPUT VOLTAGE (Cont'd)

Probable Causes	*Remedy*
	e. Check the exciter armature resistance. The reading (when checking between any first and the following twenty-fifth commutator bar) should be approximately 1 ohm. If a defect is indicated, replace the complete armature.
5. Voltmeter defective.	5. Replace voltmeter.

d. GENERATOR AND EXCITER OVERHEAT OR ARE NOISY

Probable Causes	*Remedy*
1. Ventilation openings clogged or blocked.	1. Clear the openings.
2. Generator overloaded.	2. Decrease the load on the generator until the switchboard ammeter reads not over 87 amperes on the highest line.
3. Generator load too unbalanced.	3. Distribute the load so that the switchboard ammeter readings are more nearly alike in all three phases.
4. Insufficient bearing lubrication.	4. Grease the bearings. (See paragraph 31.)
5. Defective or worn bearings.	5. Replace the bearings. (See paragraph 96c.)
6. Defective windings.	6. See preceding part c., (4).

e. CONTROL PANEL VOLTMETER REGISTERS LOW VOLTAGE

Probable Causes	*Remedy*
1. Exciter rheostat improperly set.	1. Turn exciter handle until voltage registers normal.
2. Defective voltage regulator.	2. Repair or replace. (See paragraph 105*d*.)
3. Alternator shunt field shorted or grounded.	3. Repair or replace. (See paragraph 95.)
4. Exciter shunt field shorted or grounded.	4. Repair or replace. (See paragraph 95.)
5. Exciter armature shorted or grounded.	5. Repair or replace. (See paragraph 95.)
6. Exciter commutator or alternator collector rings dirty or rough.	6. Clean and polish commutator and rings. (See paragraph 40 (6) and (7).)
7. Engine speed below normal 60-cycle speed—1200 R.P.M.	7. If ammeter on control panel does not indicate extreme overload, check the engine governor.
8. Alternator stator winding shorted or grounded.	8. Repair or replace. (See paragraph 95.)

SECTION IV
OVERHAUL AND REPAIRS

46. Power Unit. The instructions for complete overhaul of the PE-185-B Power Unit are based on actual field experience and good shop procedures. However, the success of the overhaul depends upon the mechanic's ability in following the rules of good overhaul procedures. These rules can be summed up as follows:

(1) Keep tools in efficient working order.

(2) Good housekeeping in the shop saves time.

(3) Never guess; always investigate the source of trouble.

(4) Use the proper measuring gauges and electrical testing meters.

(5) Every part, no matter how small, has a job to perform. Do not overlook the smallest detail.

(6) Carefully handle and store bearings and parts with machined surfaces so as to prevent damage either by scratching or by falling objects.

(7) Discard all old gaskets, oil seals, rubber oil stops, and felts, used cotter keys and safety wire. Always use new ones on reassembly.

(8) Provide clean boxes for small parts such as capscrews and bolts. Do not strew them on the bench or floor.

(9) Do not send a machine "back to work" until you are certain that every part is in good working order.

The tools and equipment necessary for overhauling this power unit are given in Section V. At the normal overhaul period of the engine, 2,048 hours, it will not be necessary to overhaul the alternator. At this period, under normal conditions, the alternator will be due for a greasing. The overhaul of the alternator and exciter will not be necessary under normal operation for many thousands of hours. There will be, of course, such minor servicings as brush replacement, cleaning commutator, and slip rings and so on.

NOTE: The mechanic must observe the conditions of the various parts and assemblies as he disassembles the power unit so that he can anticipate the necessary replacements and repairs; the steps of disassembly give the necessary checks that must be made, such as checking the crankshaft end play, camshaft bearing clearance, etc.

a. Disassembly of Power Unit. (1) Drain the water and the oil from the engine. Remove the oil drain pipe bracket. Disconnect the auxiliary fuel tank and lines, and drain the engine fuel tank.

(2) Remove the muffler supporting bracket U-clamp and the two capscrews holding the bracket to the muffler. Using the muffler body as a lever, unscrew the muffler from the exhaust pipe either from the manifold end or the

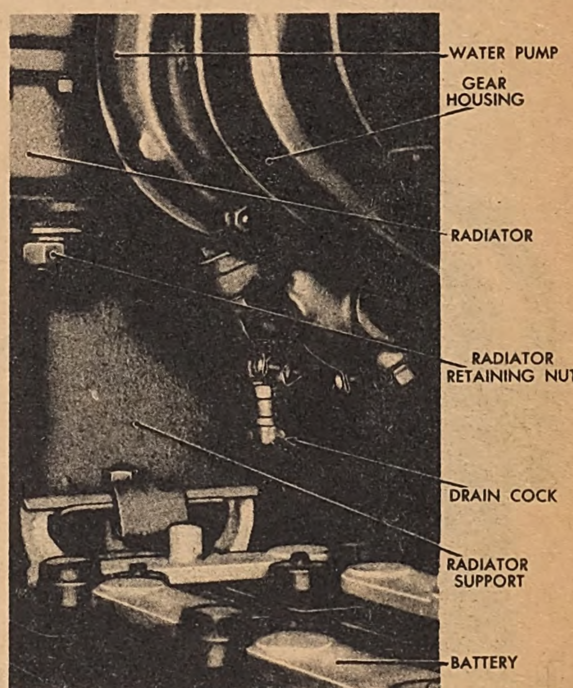

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Fig. 48. Radiator Support and Drain Cock

muffler end. If the muffler assembly is badly corroded or rusted, remove the four capscrews holding the exhaust manifold outlet elbow and remove the muffler assembly. (See Figure 22.)

(3) Disconnect the battery ground lead at the crankcase and disconnect the battery jumper lead. Remove the lead from the battery to the magnetic switch. Also remove the leads between the magnetic switch and engine control panel.

(4) Remove the radiator support rod. Remove the hose clamp and cut the hoses from the connections. Remove the fan guard, and remove the radiator retaining nuts (see Figure 48), and, with a chain hoist, lift the radiator off its supporting base and discard the rubber mounting pads which should be replaced with new ones during reassembly.

(5) Disconnect and remove the fuel lines from the tank and remove the engine fuel tank.

(6) Disconnect the engine controls and wires between the engine and engine control panel.

NOTE: The disconnections should be made at the engine.

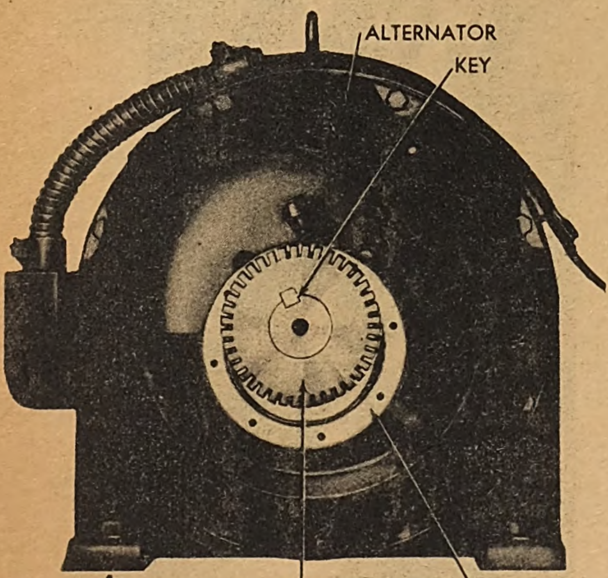
(7) Disconnect the coupling between the engine and alternator by first removing the coupling cover and pulling the two grids from the coupling. (Refer to Figure 55.)

(8) Remove the capscrews from the flywheel housing mounting pad and the two capscrews holding the front engine support. Remove the two threaded dowel pins which are used to locate the flywheel housing on the power unit base. These pins can be removed by screwing the nuts and adding extra washers under the nuts to lift dowel pins out of the dowel holes.

(9) Remove the cylinder head cover.

(10) Place a lifting eyebar on the cylinder head (see Figure 83), and, with the aid of a hoist, remove the engine from its base. For further engine disassembly, see paragraphs 47 and 48.

NOTE: If it is necessary to remove the alternator and exciter for overhaul, the control panel mounting frame can be lifted off the base after the leads running from the alternator to the control panel have been disconnected at the control panel. If the alternator is removed from the base, be sure to mark the shims under each generator frame pad so that they can be installed in their original position on reassembly.



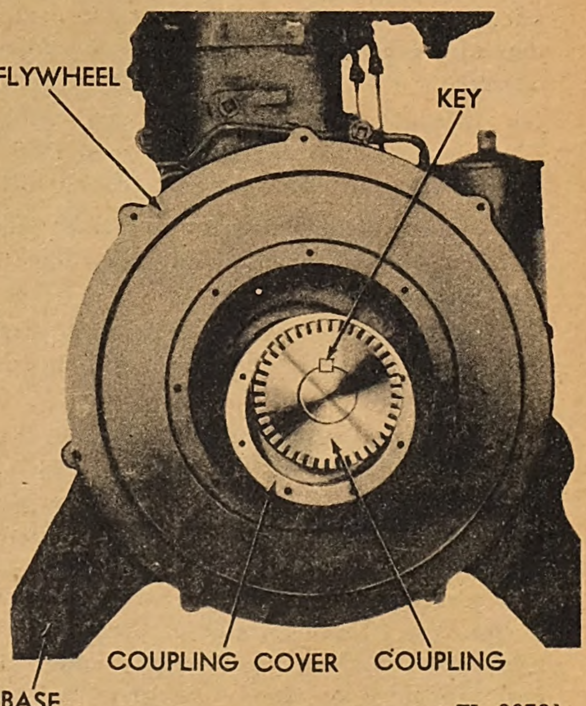


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Fig. 49. Flexible Coupling

Some difficulty may be experienced in removing the generator pad to base dowels. These can be removed by adding washers under the nut to pull the dowels from the pad.

b. Reassembly of Power Unit. The procedure for the reassembly of the power unit will depend on whether or not the alternator and exciter were removed from the base to be overhauled. If they were not removed, obviously, some of the following steps of reassembly are not necessary and can be eliminated.

(1) With a chain hoist, lift the engine on the base. Start the flywheel housing-to-base capscrews; drive in the flywheel housing to base dowels; tighten the flywheel housing and the front support capscrews and bolts.

(2) Install the radiator support.

(3) If the flexible couplings were removed from the flywheel stub shaft and the alternator shaft, place the covers of the couplings on the shaft before installing the couplings. Heat the hubs in oil to 400 degrees Fahrenheit and with tongs slip the hubs in place on their respective shafts so that the face of each hub is flush with the end of each shaft. (See Figure 49.)

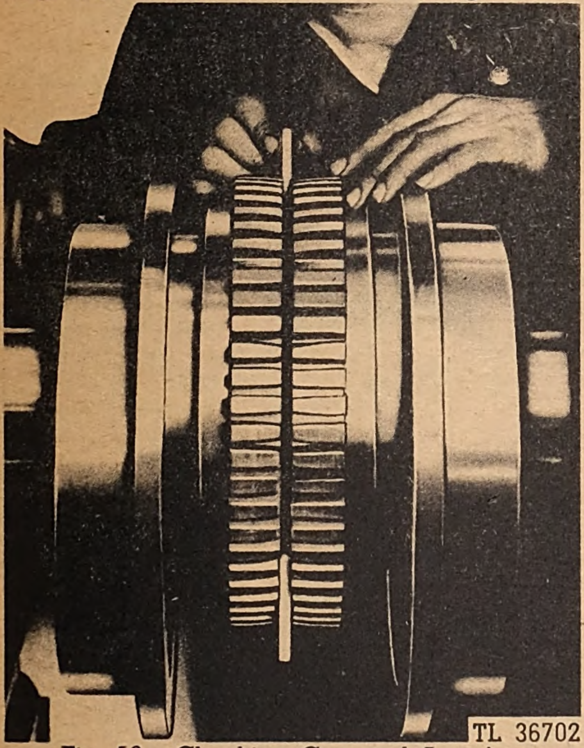

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Fig. 50. Checking Gap and Angular Alignment (Coupling)

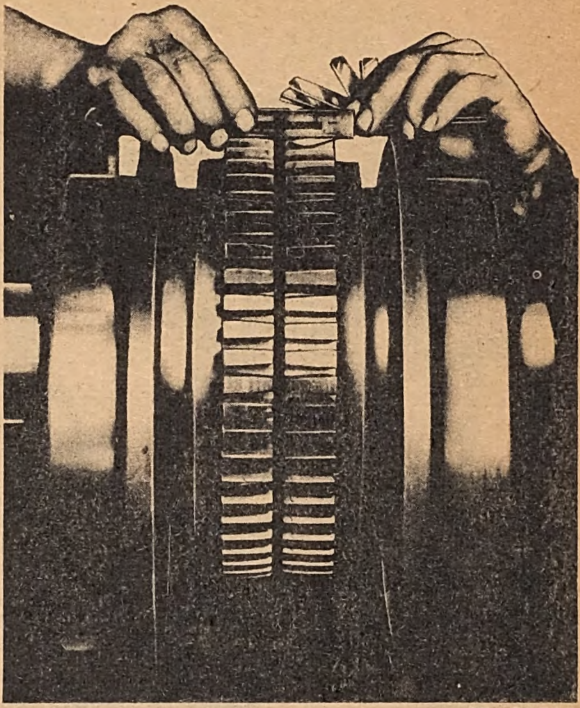

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Fig. 51. Checking Parallel Alignment

Line up the keyways and drive in the keys.

(4) Lift the alternator and exciter in place on the base; use the same shims that were removed on disassembly to assure correct alignment. Start the four generator pad to base capscrews. Drive the dowels in place and tighten the capscrews.

(5) Check the gap and the angular alignment of the coupling. The shafts must be lined up by using a spacer block and feelers in the gap between the coupling faces, checking at quarter points (90 degrees apart). (See Figure 50.) The minimum gap should not be less than $1/16$ inch; normal, $3/16$ inch; and maximum should not be more than $3/8$ inch. It is recommended that the coupling be set at the normal gap.

(6) Check the parallel alignment as shown in Figure 51. The flats are milled on the top of the teeth 90 degrees apart. Line up the shafts by using a straight edge over the top of these flats. Final checkup should be made after the foundation bolts are fastened. The

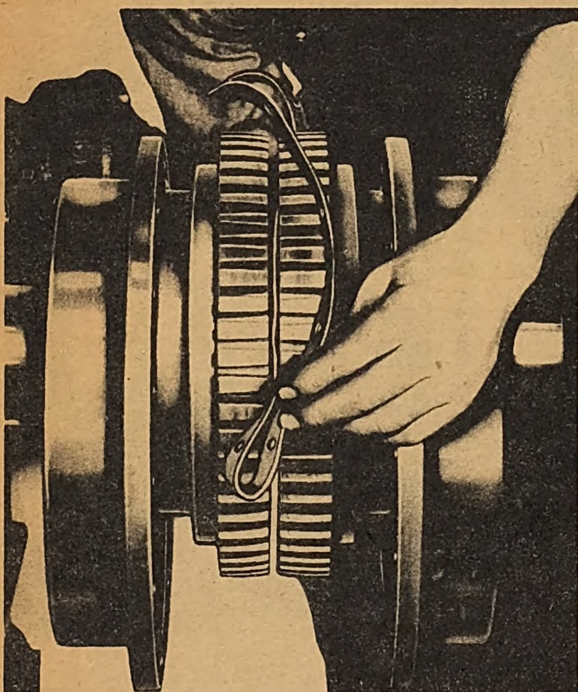

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Fig. 52. Inserting Gaskets

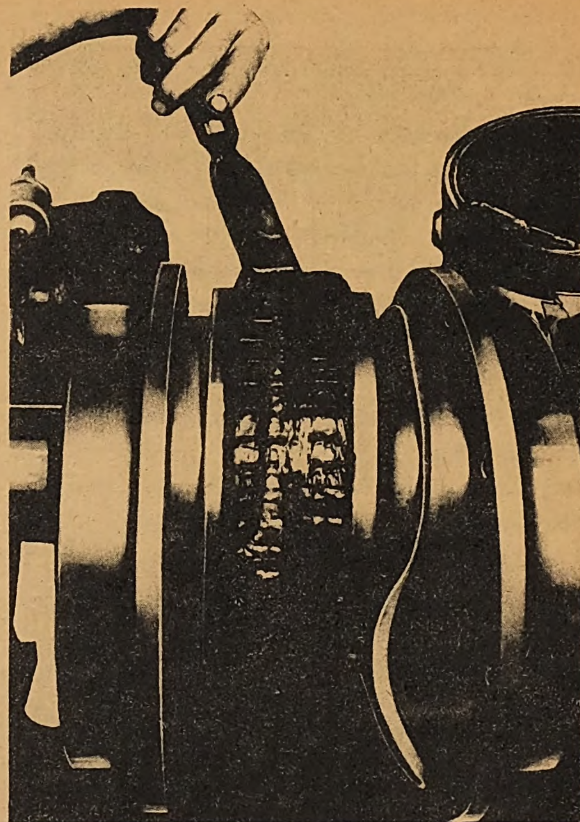

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Fig. 53. Filling with Grease

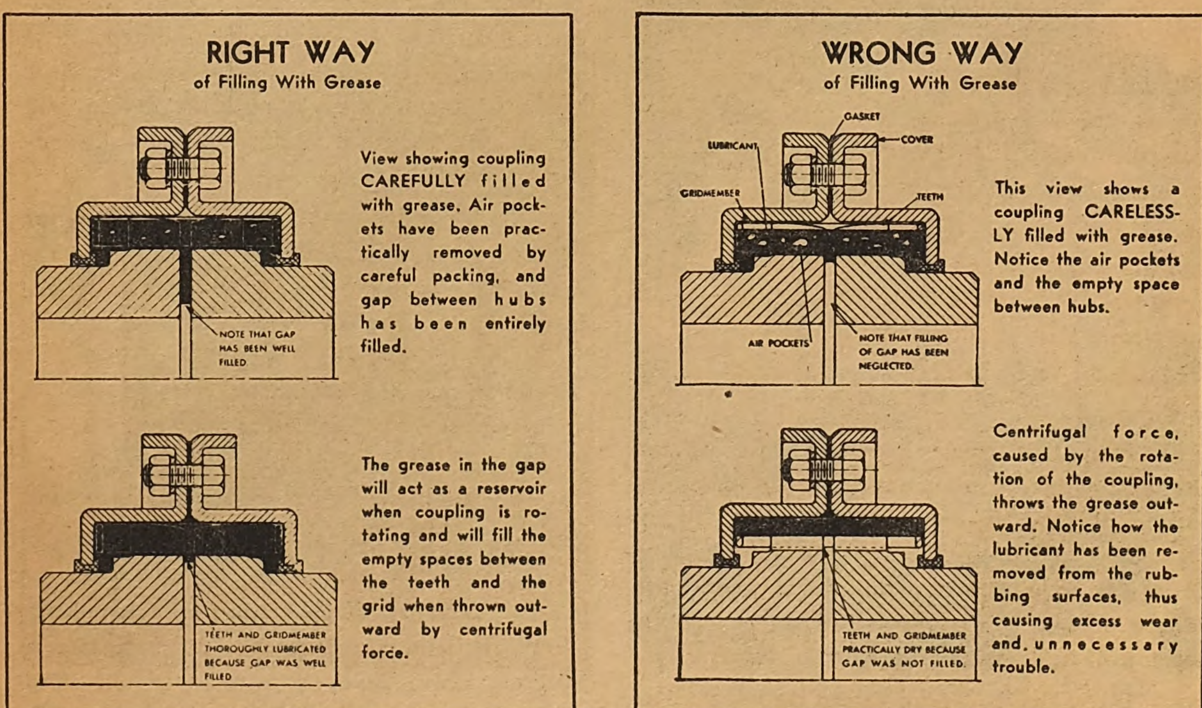

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Fig. 54. Right Way and Wrong Way of Filling with Grease

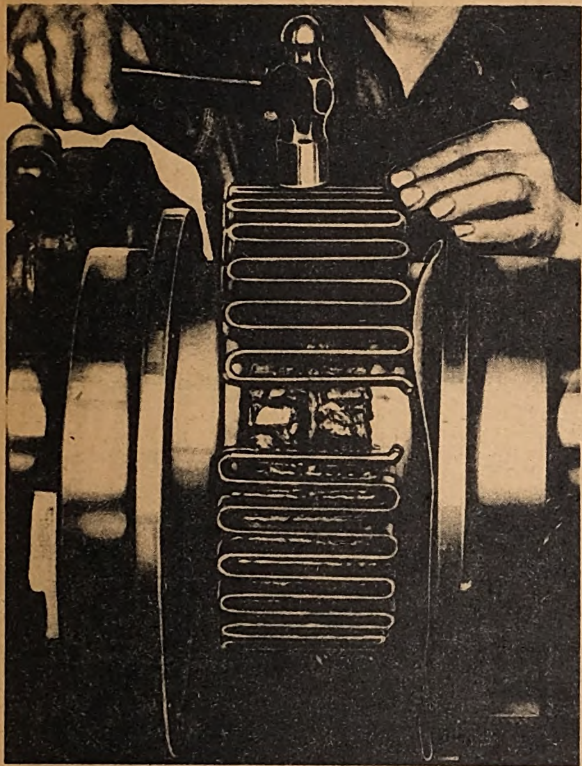

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Fig. 55. Inserting Grid Member

coupling alignment should be kept within .003 inch.

(7) After the coupling is aligned, insert the gasket, leaving it hang on either hub away from the teeth. (See Figure 52.) Care should be taken not to injure the gasket.

(8) Force as much grease as possible down into the gap between the coupling faces. (See Figure 53.) Figure 54 shows the right way and the wrong way of filling with grease.

(9) Insert the grid in the grooves as shown in Figure 55.

(10) Pack the spaces between and around the grid with as much lubricant as possible. Fill coupling to its absolute limit. (See Figure 56.) This is essential to proper functioning. Draw the covers up and pull them apart, and scrape or wipe up excess lubricant flush with the top of grid member; clean inside of cover.

(11) Draw the cover up again and fasten in place with bolts provided with the couplings. (See Figure 57.) Wipe off the coupling and add lubricant through the Alemite flush-type grease fittings, using an Alemite push-type gun equipped with flush-type nozzle. (See Figure 33.)

(12) Install the fuel tank brackets, fuel tank and fuel lines.

(13) Install the radiator, using rubber mounting pads between the radiator and radiator support. Brace the radiator with the brace rod which fastens on one end of the fuel tank bracket. (See Figure 1.)

(14) Install the alternator control panel mounting base and tighten the four capscrews. (See Figure 58.)

(15) Connect all the wires and controls between the engine and the engine control panel. (See Engine Wiring Diagram, Figure 5.)

(16) Mount the alternator control panel, making certain to ground the panel to the mounting base as shown in Figure 14.

(17) Connect the alternator and exciter wir-

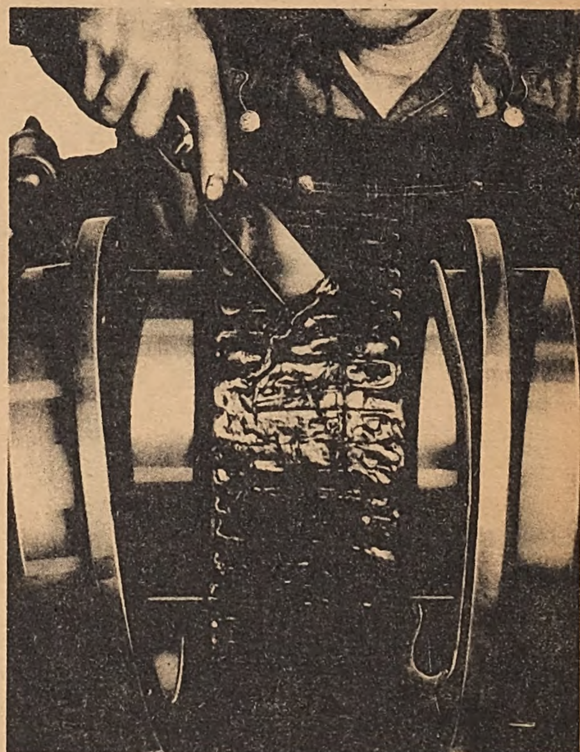

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Fig. 56. Packing Grease Over Grid and Teeth

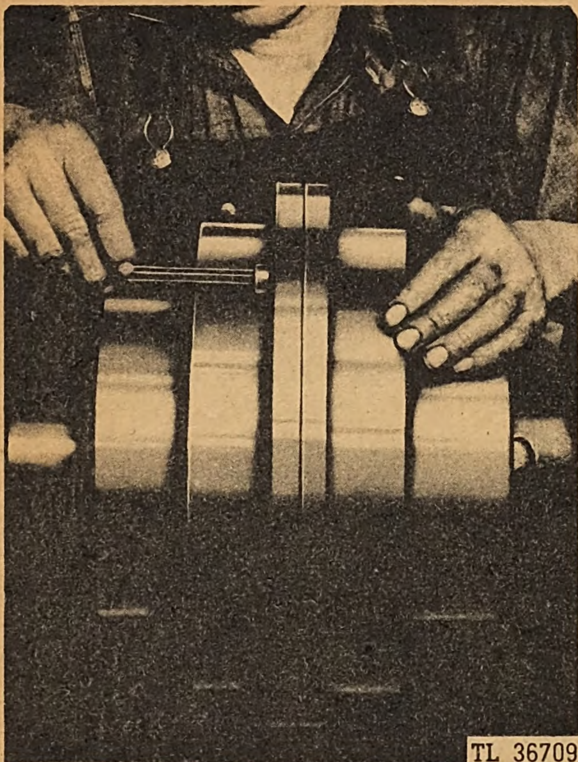

Fig. 57. Pulling On Cover

ing to the alternator control panel. See Wiring Diagram, Figure 16.

(18) Install the batteries.

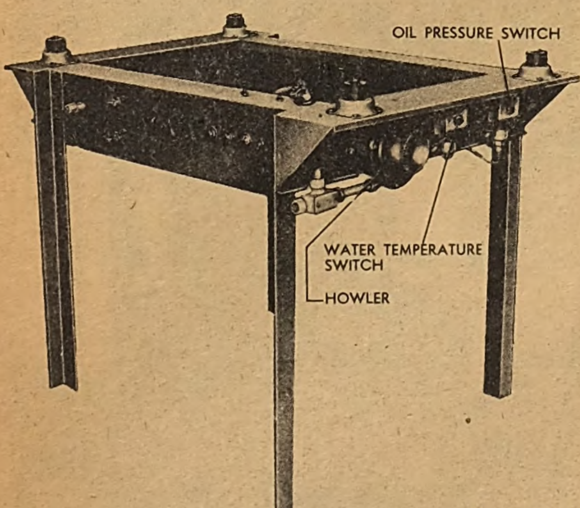

Fig. 58. Control Panel Mounting Base Assembly

The Power Unit is now assembled for test running, and for the checks and adjustments required. (See paragraph 60.)

47. Removing Engine Accessories. In removing the engine accessories, it is recommended that these accessories be removed according to the component system to which they belong. Therefore the following procedures give the removal of the accessories by systems.

a. Lubricating System. (1) Remove the two large external oil lines connecting the De Luxe oil filter to the Cuno oil filter. (See Figure 39.)

(2) Remove the DeLuxe oil filter from the engine crankcase. Do not lose the metal plate used between the filter and the crankcase. A $\frac{9}{16}$-inch universal socket is handy for the removal of the filter mounting capscrews, in particular the two between the filter and flywheel housing.

(3) Unscrew the two capscrews holding the Cuno oil filter bracket to the flywheel housing. (See Figure 1.)

b. Cooling System. (1) Loosen the fan bracket clamp nut and adjusting screw. Remove the two fan belts.

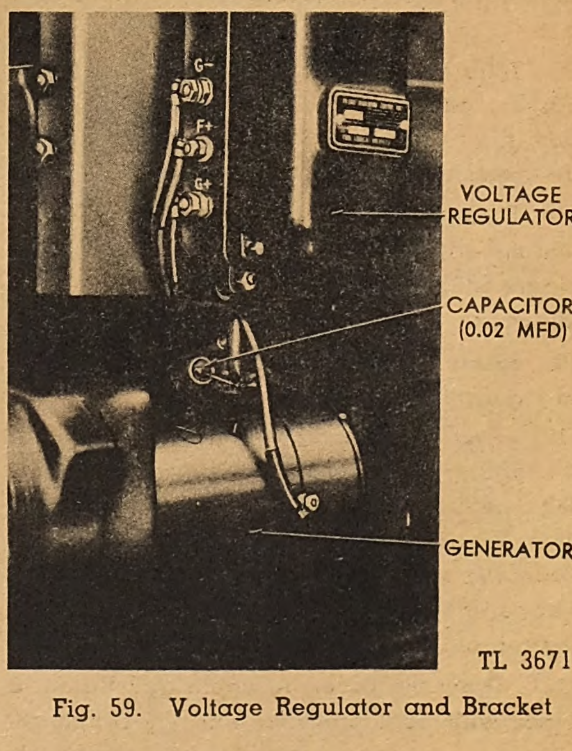

Fig. 59. Voltage Regulator and Bracket

(2) Separate the fan and pulley from the fan bracket. (See Figure 60.) Remove the two bolts holding the bracket to the gear cover.

(3) Disconnect the electrical connections at the generator and voltage regulator. Remove the voltage regulator and bracket from the water inlet manifold. (See Figure 59.) Loosen the hose clamps and unscrew the six capscrews holding the water inlet manifold to the cylinder block. Pull the three copper distributor tubes from the cylinder block. (See Figure 61.)

(4) Unscrew the four capscrews holding the thermostat housing to the exhaust manifold. Unscrew the two capscrews holding the by-pass line to the thermostat housing. Lift the thermostat housing off and remove the thermostat. (See Figure 62.)

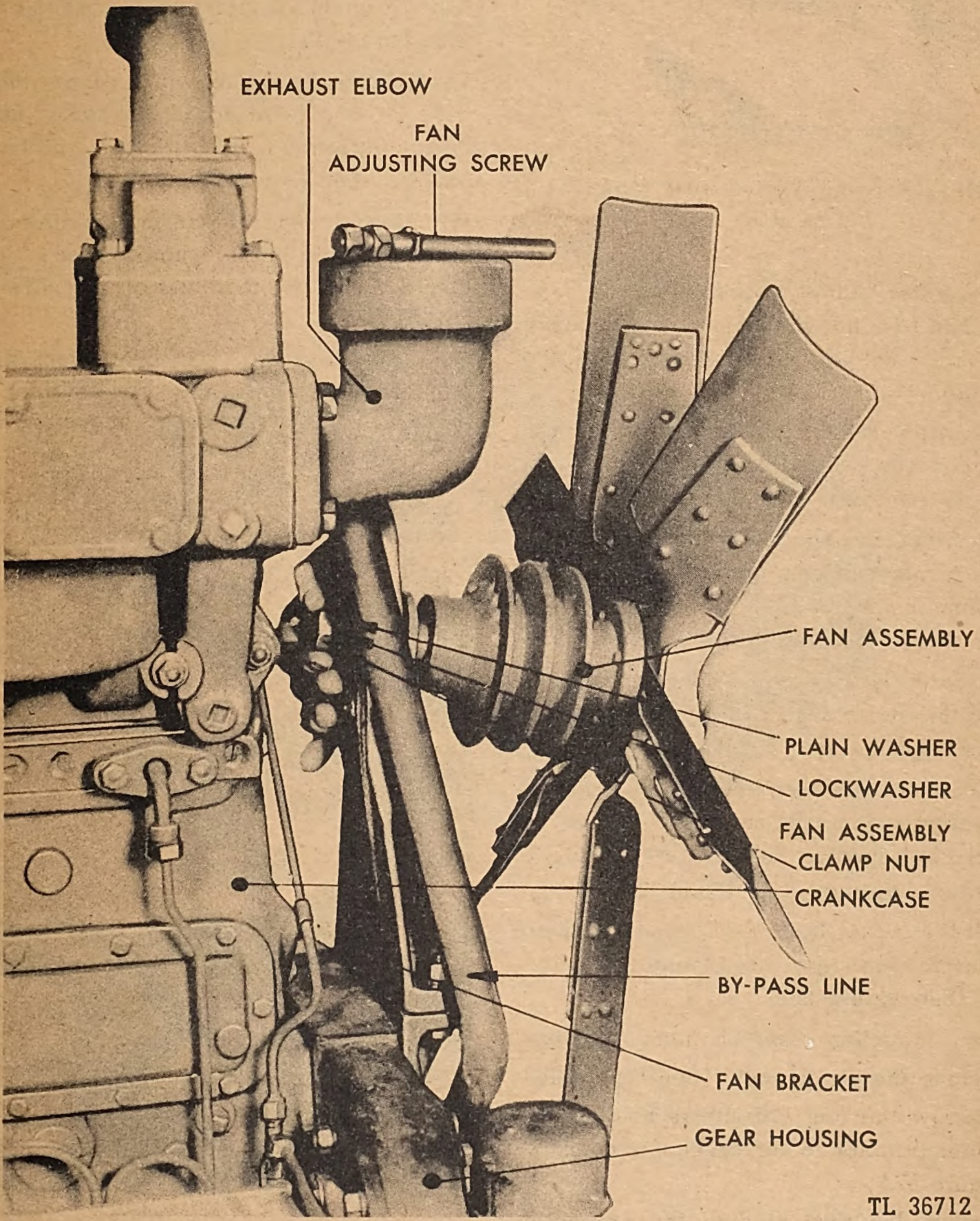

Fig. 60. Removing Fan Assembly

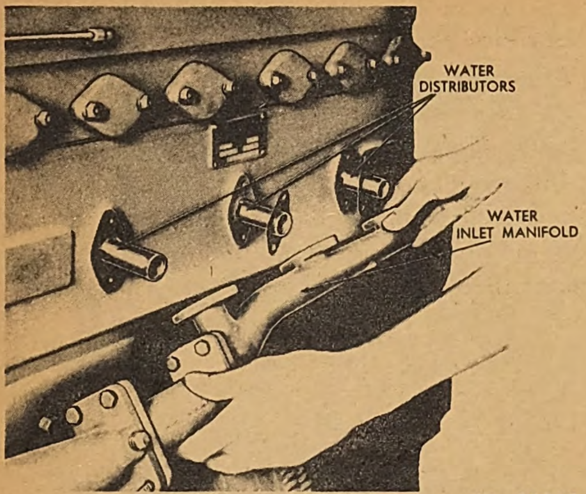

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Fig. 61. Removing Water Inlet Manifold Assembly

(5) The water pump by-pass line can now be detached from the water pump by removing the two bolts holding the by-pass line to the pump. (See Figure 63.)

(6) The water pump can be separated from the gear cover when three mounting capscrews are removed. (See Figure 64.)

c. *Electrical System.* (1) The voltage regulator was removed from the engine while disassembling the water inlet manifold from the cylinder block. (See paragraph 47*b* (3).)

(2) Unscrew the three nuts holding the generator to the gear housing and pull the generator from the housing. (See Figure 65.)

(3) Disconnect the electrical connections at the magnetic switch and starter. Unscrew the two capscrews holding the magnetic switch to the flywheel housing. (See Figure 26.)

(4) Pull the starter from the flywheel housing after unscrewing the three retaining capscrews. (See Figure 66.)

d. *Air Induction and Exhaust System.* (1) Remove the air cleaner. (See Figure 36.)

(2) Unscrew the four capscrews holding the air cleaner adaptor to air preheater housing. (See Figure 67.)

(3) Remove the nuts holding the preheater housing to the intake manifold. Examine the preheater element for poor insulation and burned element. (See Figure 67.)

(4) Unscrew the ten nuts holding the intake manifold to the cylinder head. Pull the manifold off the studs. (See Figure 68.)

(5) Remove the three water jacket plates from the exhaust manifold and examine the water passages for scale deposits. (See Figure 69.)

(6) Remove both ends of the exhaust manifold. Examine the manifold for carbon deposits. (See Figure 70.)

(7) Disconnect the six water connections from the cylinder head to the exhaust manifold. Each connection is held in place with four capscrews. (See Figure 71.)

(8) Unscrew the center nut holding the exhaust manifold to the cylinder head. (See Figure 68.) Pull the manifold off the studs. (See Figure 73.)

e. *Fuel System.* (1) Disconnect the fuel line connection from the primary filter to the fuel line, and the fuel return lines from the fuel

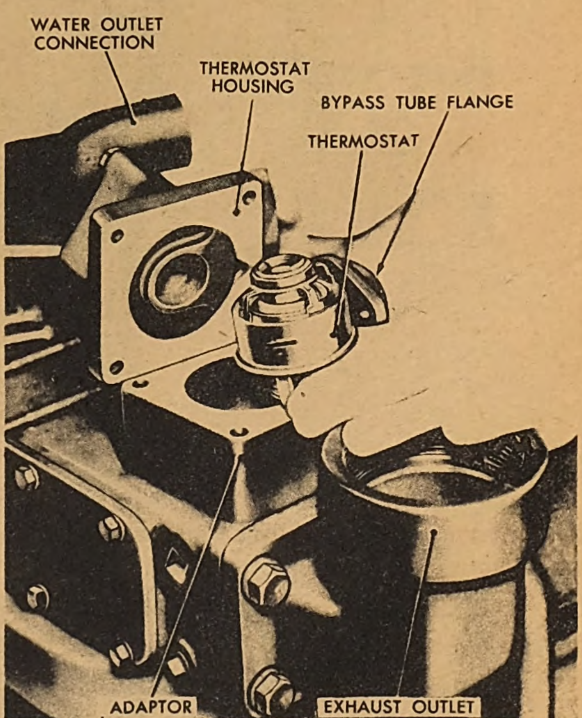

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Fig. 62. Thermostat and Housing

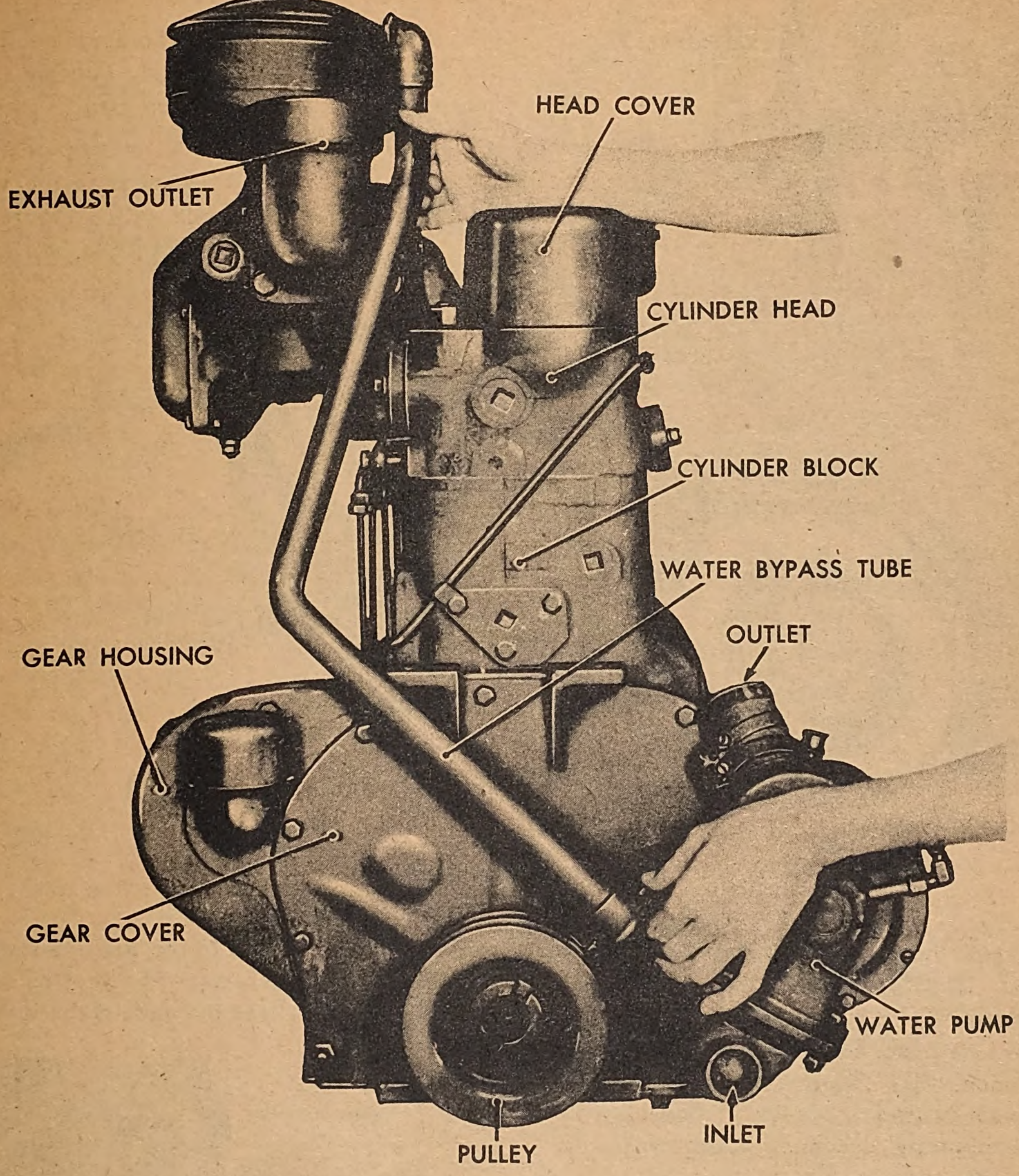

Fig. 63. Water By-Pass Line

pump to the engine fuel tank and the auxiliary tank return lines.

(2) Disconnect the fuel line from the primary filter to the transfer pump. The removal of the two mounting capscrews will drop the filter and bracket from the engine. (See Figure 72.)

(3) Disconnect both fuel lines from the secondary filter. Unscrew the one capscrew in the side of the block and the three capscrews through the oil pan mounting to remove the secondary filter. (The bracket that holds the secondary filter also holds the three-way fuel valve.) (See Figure 75.)

(4) Remove the bolt holding the throttle shaft clevis to the fuel pump. Unscrew the two capscrews holding the throttle bracket and remove

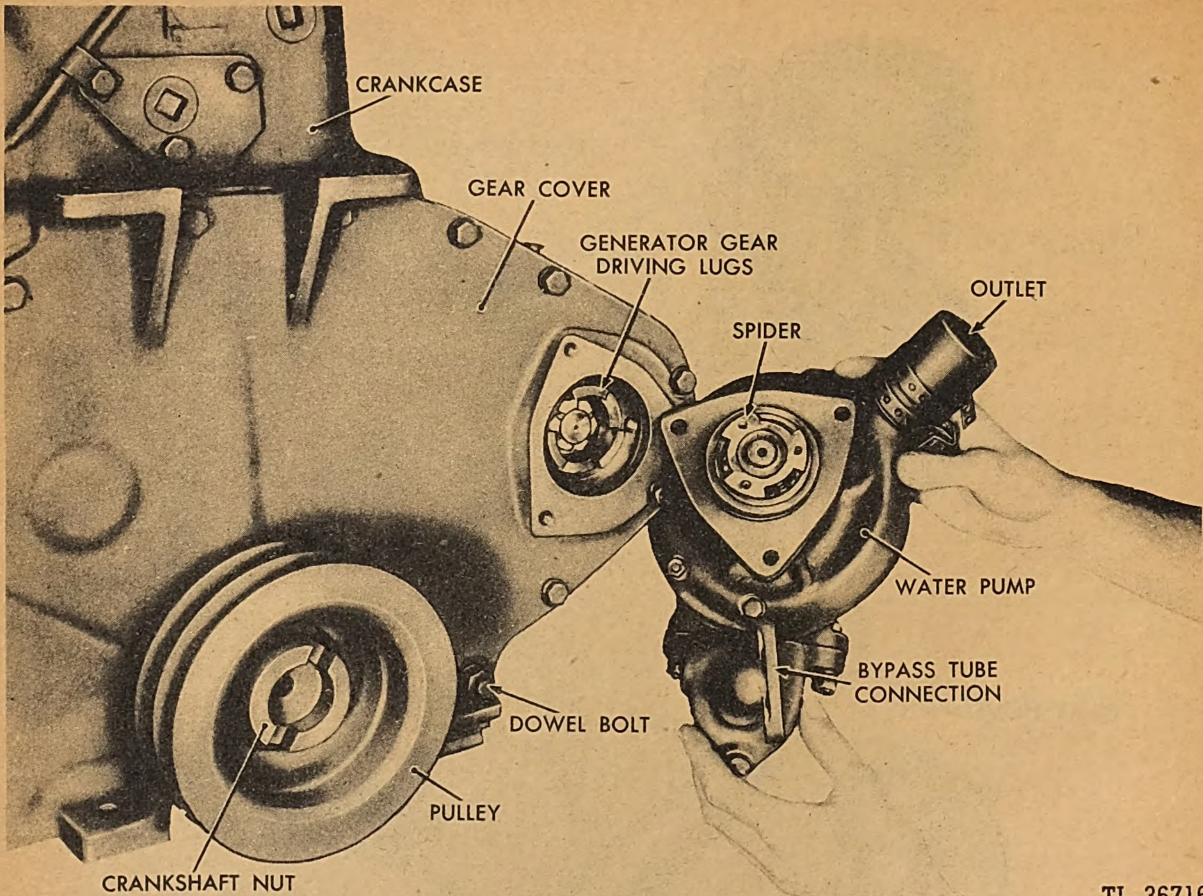

Fig. 64. Water Pump

the bracket, throttle shaft, clevis, and spring as a unit. (See Figure 20.)

(5) Remove the six high pressure fuel lines from the fuel pump hydraulic unit with a $\frac{9}{16}$-inch wrench. (See Figure 74.) A $\frac{5}{8}$-inch open end wrench is used to prevent the check valve from accidentally becoming unscrewed. Unscrew the injector end of the fuel lines with a $\frac{3}{4}$-inch wrench and remove the lines as a unit. (See Figure 76.) Close the ends of the injectors

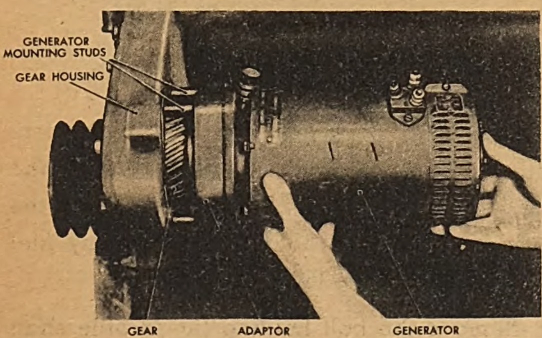

Fig. 65. Removing Generator

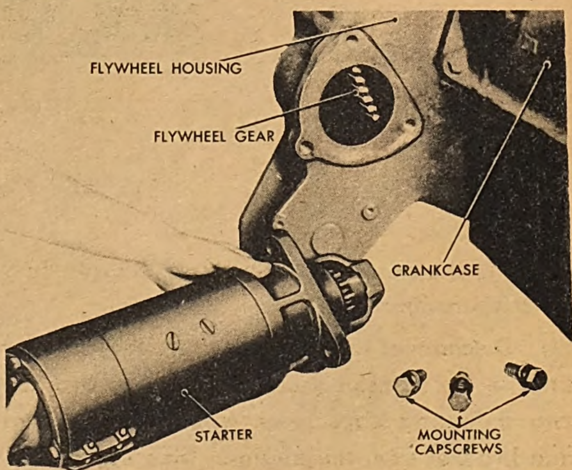

Fig. 66. Removing Starter

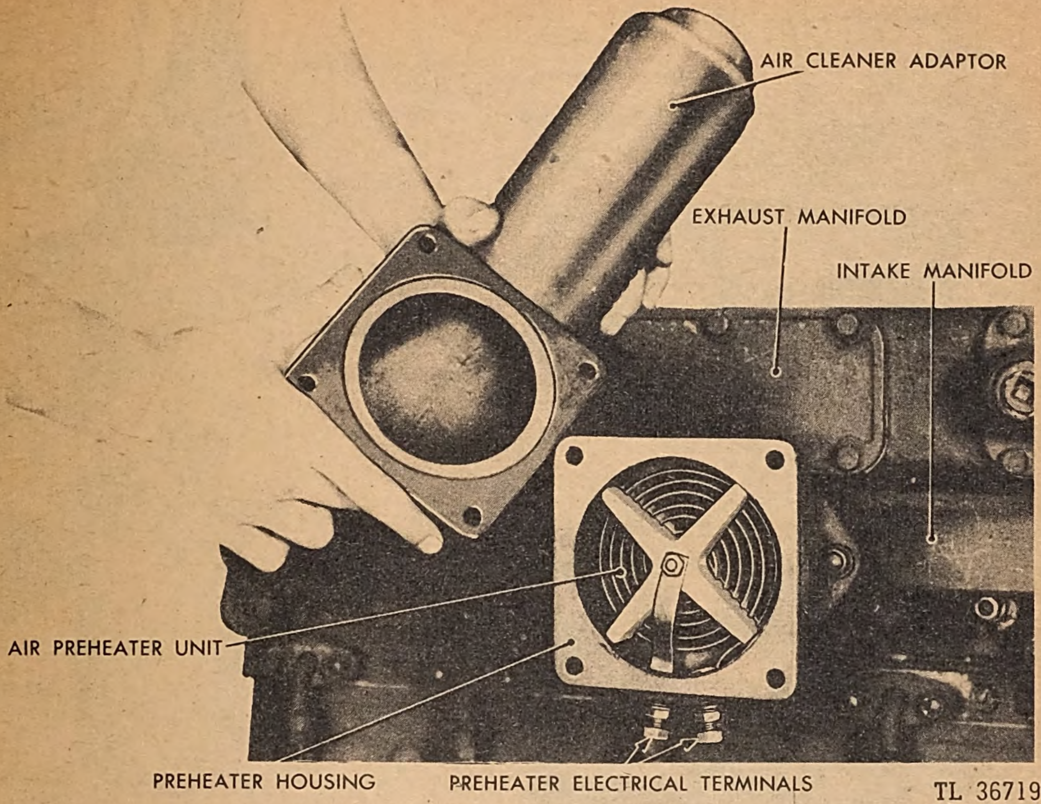

Fig. 67. Air Cleaner Adaptor

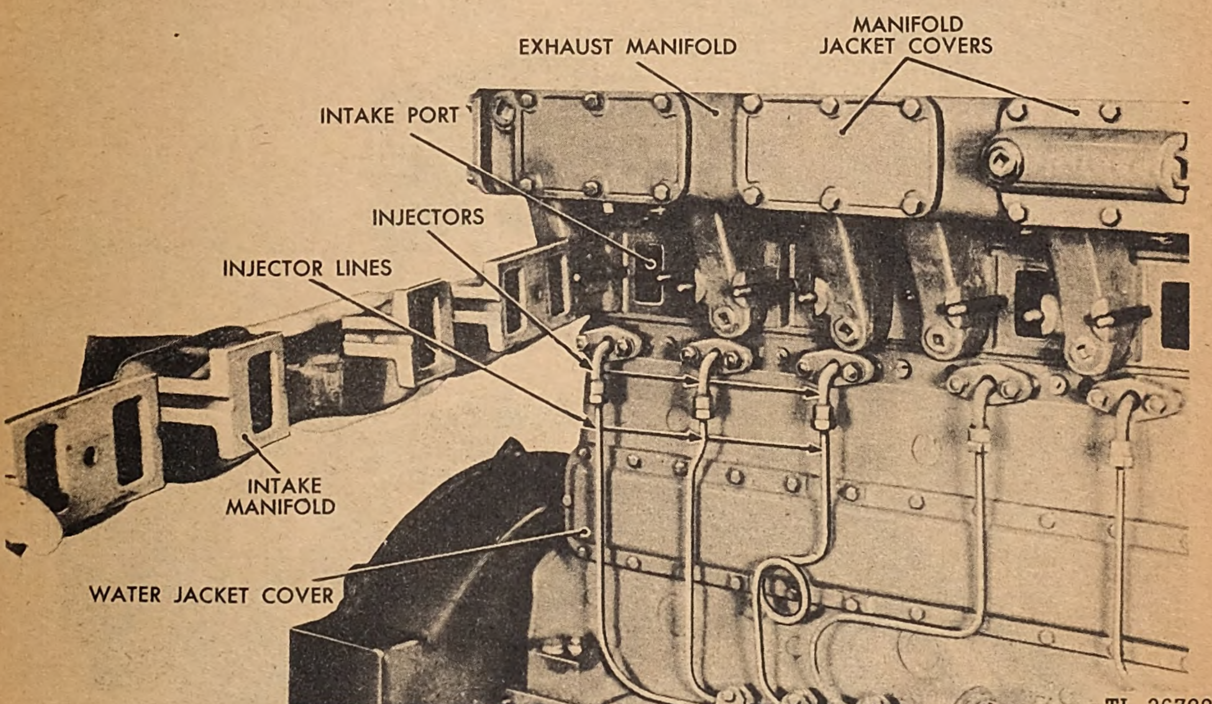

Fig. 68. Intake Manifold

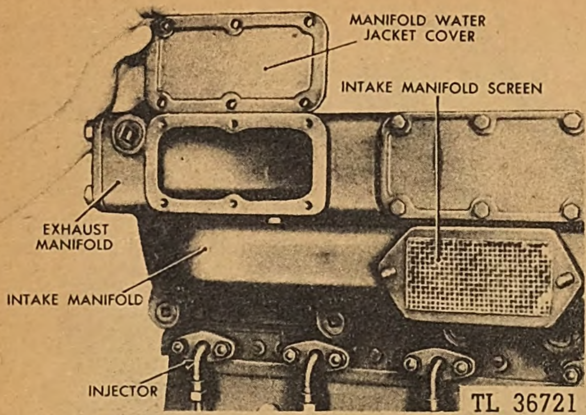

Fig. 69. Removing Water Jacket Plates

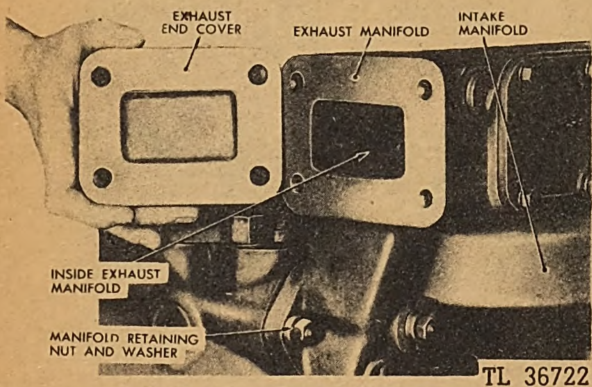

Fig. 70. Exhaust Manifold End Plate

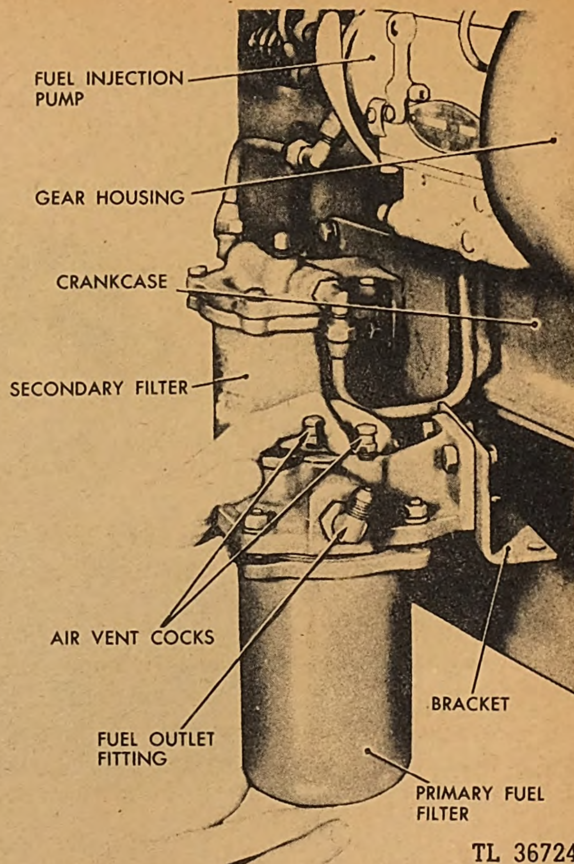

Fig. 72. Removing Primary Filter

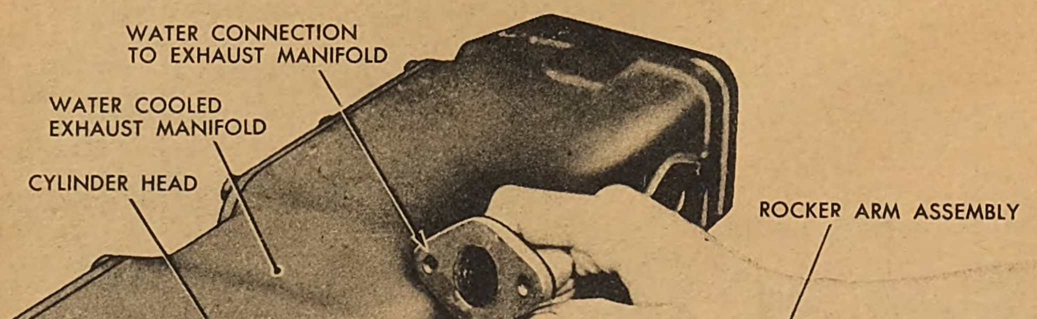

Fig. 71. Cylinder Head to Exhaust Manifold Water Connection

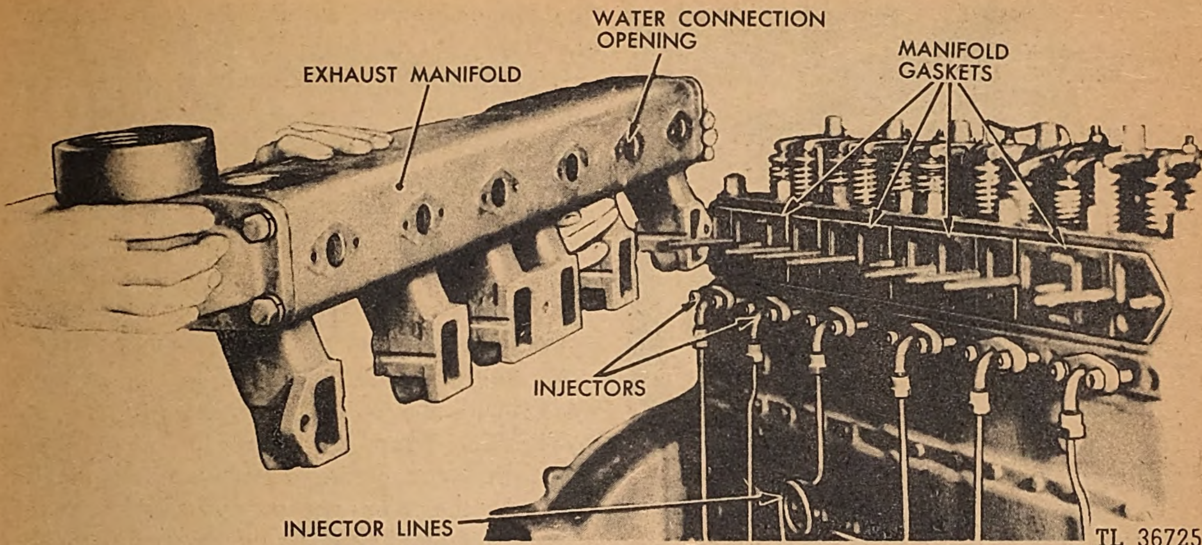

Fig. 73. Removing Exhaust Manifold

on the hydraulic unit and injector line openings with paper caps to prevent damage and entrance of dirt.

(6) Disconnect the lube oil pressure line to the fuel injection pump at the crankcase, the fuel pump, and at the cylinder head fittings. (See Figure 192.)

(7) Unscrew the nuts and lockwashers hold-

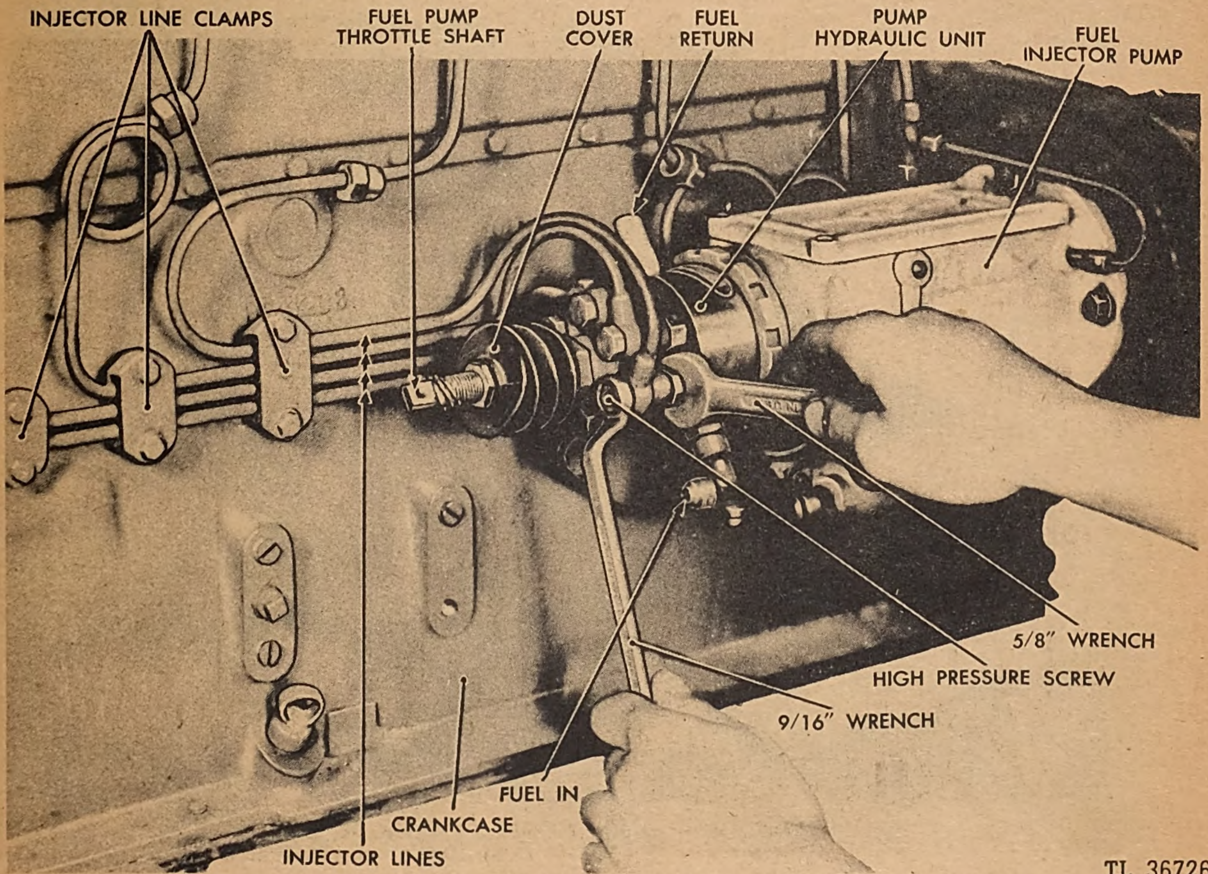

Fig. 74. Disconnecting High Pressure Lines from Hydraulic Unit

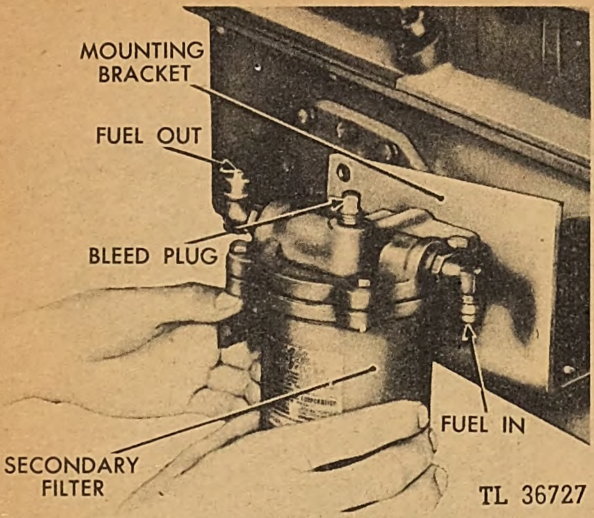

Fig. 75. Removing Secondary Filter

ing the injector flange to the cylinder head studs. Pull the injectors from the cylinder head. If the injectors are "carbonized" in the cylinder head, pry out as shown in Figure 77. Under no circumstances pry on the curved portion of the injector.

(8) Unscrew the nuts holding the air cell retaining flange to the cylinder head. Screw a ⅜-inch capscrew in the air cell plug and pry the plug from the head. (See Figure 78.) (The plug is ordinarily a sliding fit in the cylinder head, but a slight accumulation of carbon may necessitate the use of a pry as suggested.)

(9) Pull the energy cell from the cylinder head with the puller furnished with the engine. (See Figure 79.) To use the puller, screw the large end of the puller stud into the air cell, slip the yoke over the stud, and screw the nut on the stud. Turning the nut will draw the air cell from the head. (The air cell is ordinarily a sliding fit in the cylinder head, but a slight accumulation of carbon may necessitate

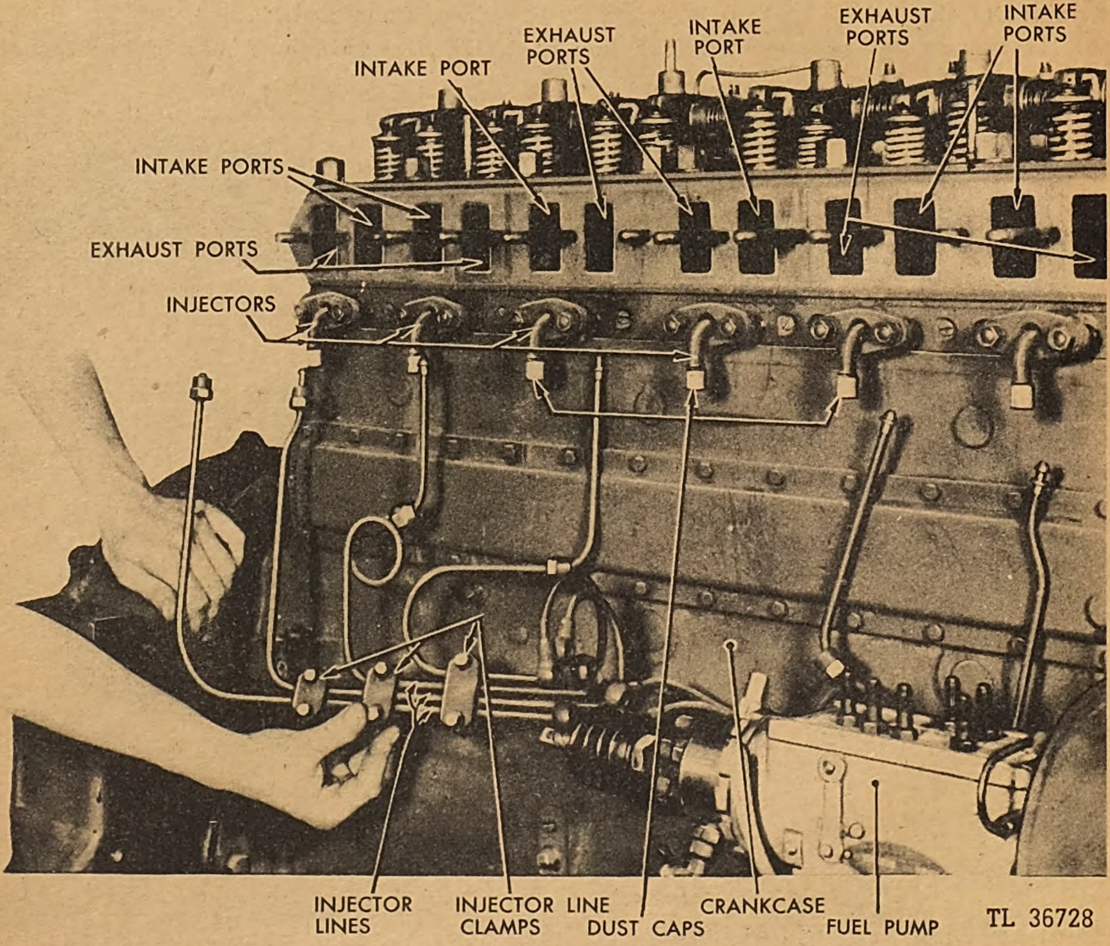

Fig. 76. Removing High Pressure Lines

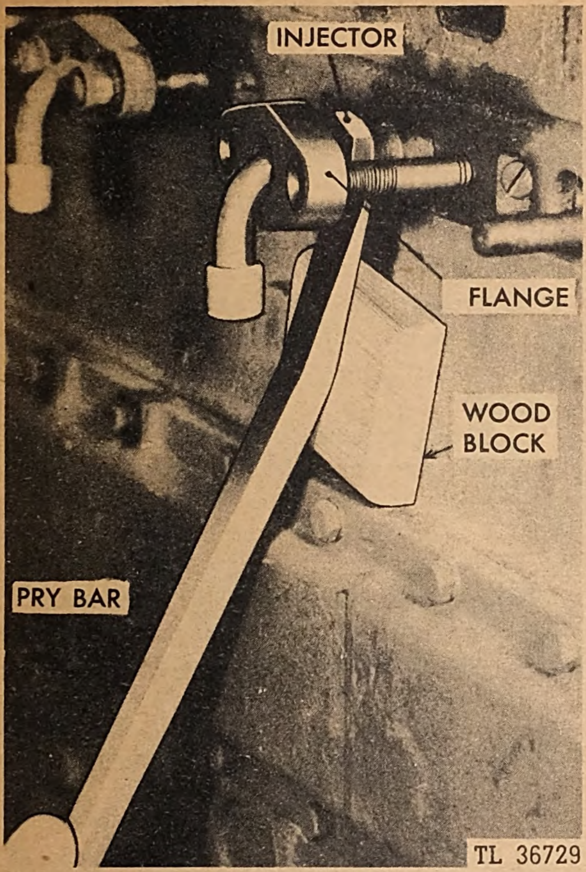

Fig. 77. Removing Fuel Injector

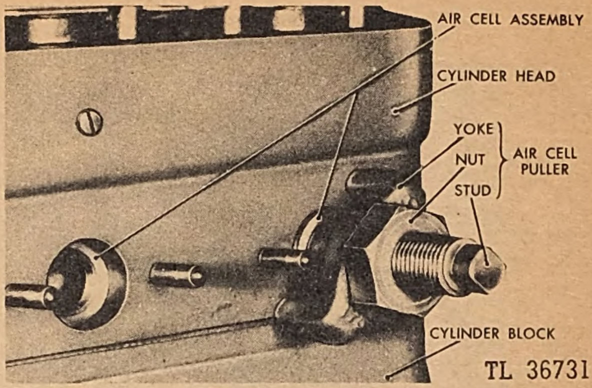

Fig. 79. Removing Energy Cell

the use of the puller.) Note the air cell condition; if any irregularities are present, check the cylinder number for future reference.

(10) Remove the acorn nut just back of the fuel injection pump as shown in Figure 80 before attempting to remove the pump. The pump is removed in Figure 80 so that the acorn nut position is clearly visible.

(11) Unscrew the five nuts and remove the one through bolt holding the fuel pump and adaptor to the gear housing. Pull the fuel pump and adaptor from the gear housing. (See Figure 81.)

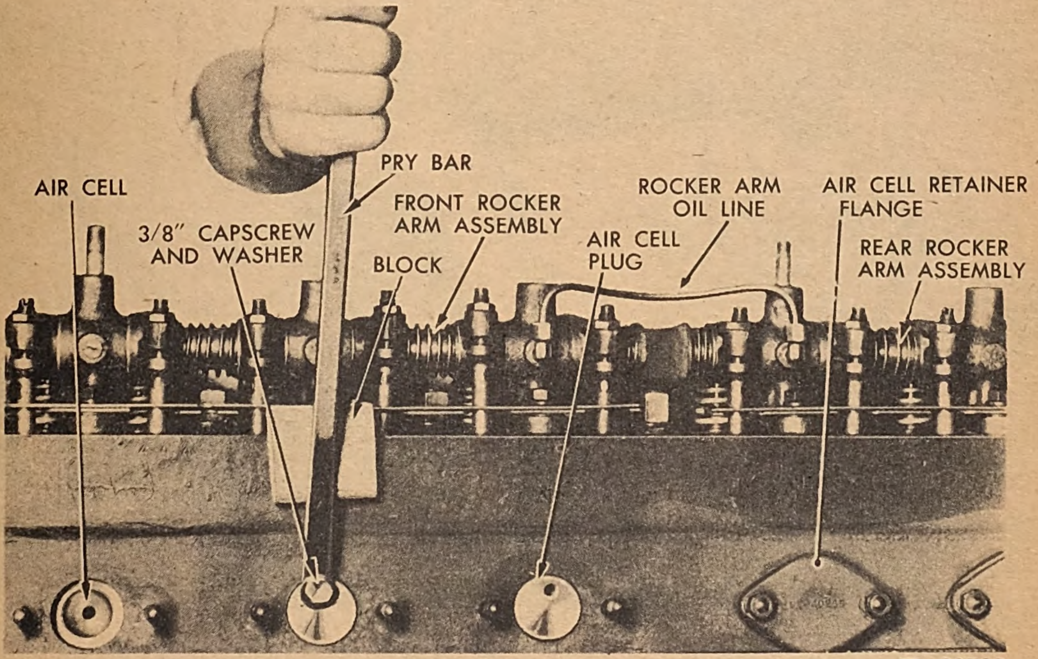

Fig. 78. Removing Energy Cell Plug

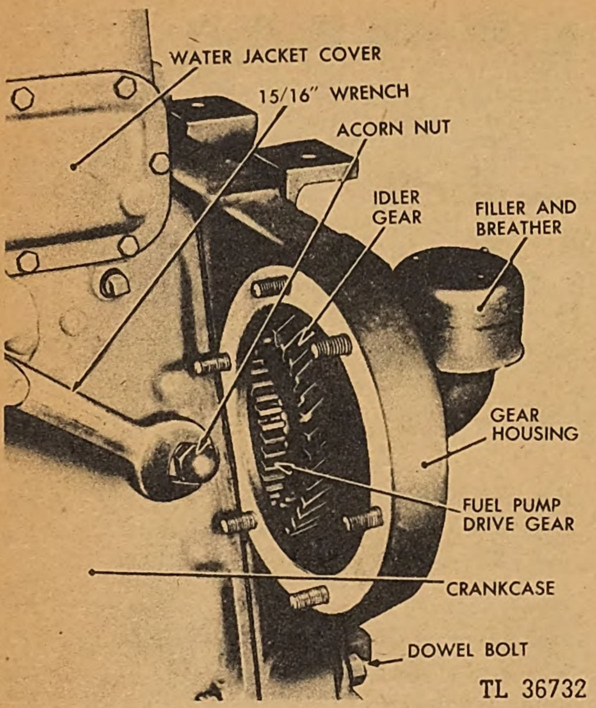

Fig. 80. Removing Idler Gear Stub Shaft Setscrew Acorn Locknut

48. Disassembly of Basic Engine. The engine has now been stripped of all its accessories. Instructions for the overhauling of these accessories and the component systems to which they belong begin with paragraph 61. The overhaul instructions for the alternator and exciter begin with paragraph 94. The disassembly of the basic engine begins with the following paragraph. Not only do these steps give the sequence of disassembly, but also the checks that are to be made in order to know what repairs and replacements are necessary.

a. Removing Rocker Arm Assembly. The cylinder head cover was removed when the engine was disassembled from the generator set. A lifting bracket was installed in place of the cover in order to provide a means of lifting the engine from the generator set. Disconnect the oil line connecting the two rocker arm assemblies. (See Figure 78.) Unscrew the six capscrews holding each rocker arm assembly to the cylinder head. Lift off the two push rod spacers for each rocker

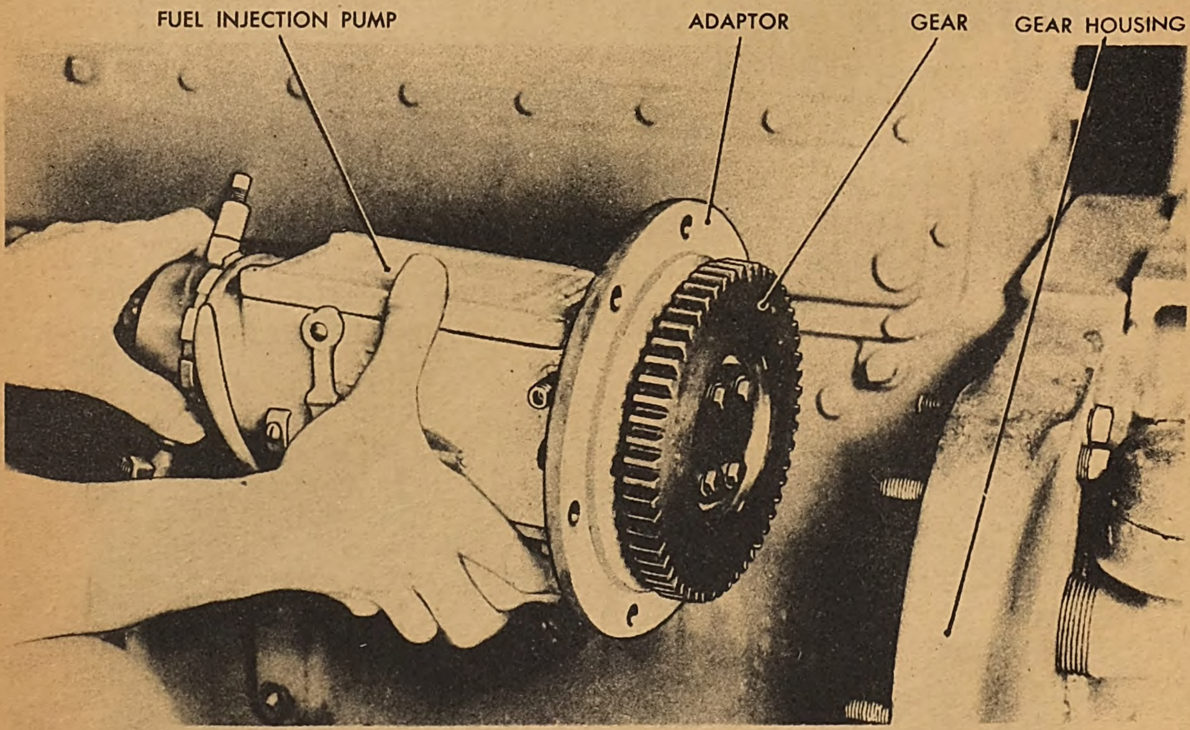

Fig. 81. Removing Fuel Pump

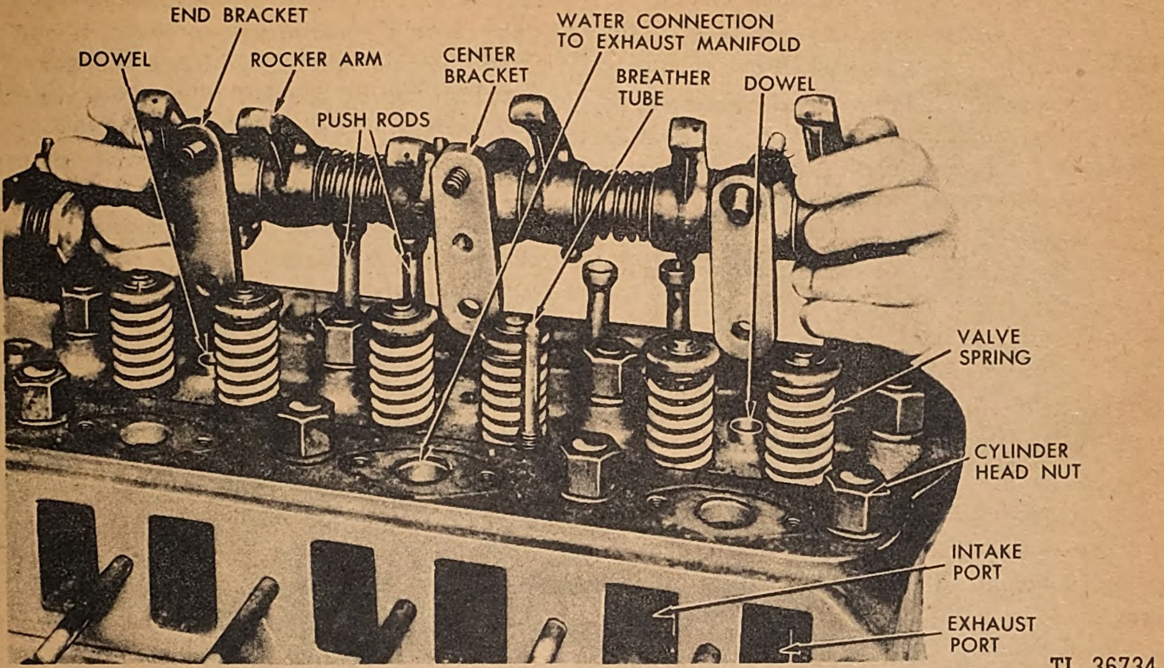

Fig. 82. Removing Rocker Arm Assembly

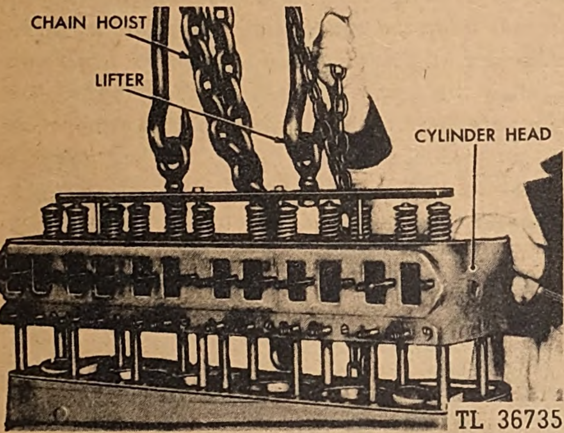

Fig. 83. Removing Cylinder Head

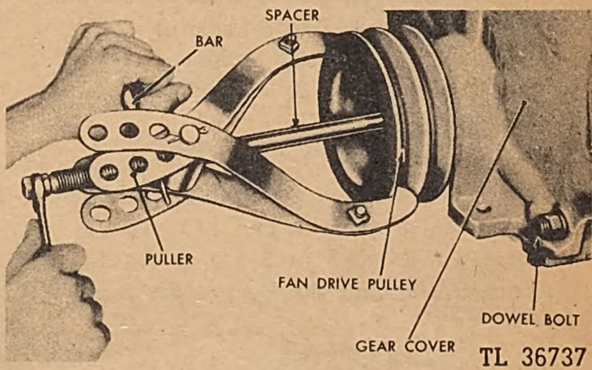

Fig. 85. Pulling Crankshaft Pulley

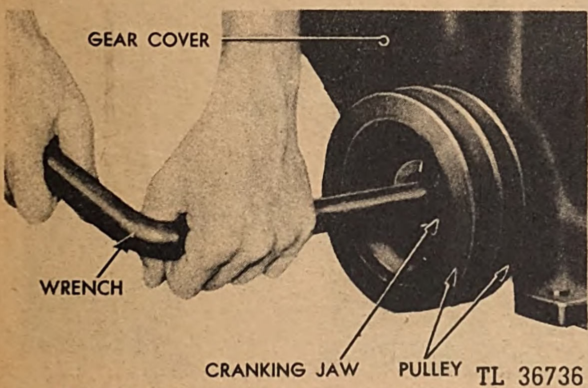

Fig. 84. Removing Crankshaft Pulley Nut Jaw

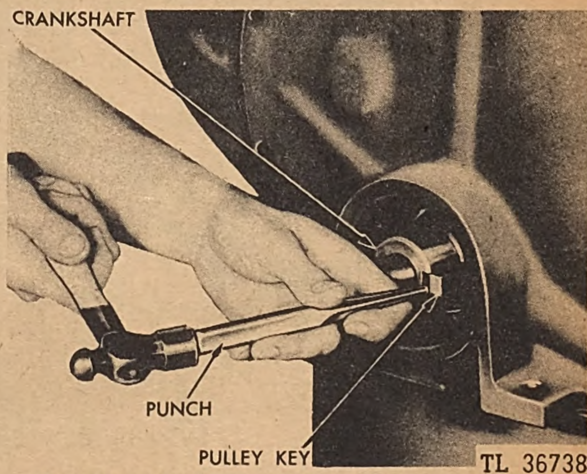

Fig. 86. Removing Crankshaft Pulley Key

arm assembly. (See Figure 186.) Lift the two rocker arm assemblies from the head. (See Figure 82.) Pull the push rods from the engine.

b. Removing Cylinder Head. Unscrew the fifteen nuts holding the head to the cylinder block and lift the head from the engine as shown in Figure 83. Discard gasket.

c. Removing Crankshaft Pulley. With a wrench shaped as shown in Figure 84, unscrew the crankshaft pulley nut. (The end of the wrench that fits into the nut must be similar to the same end of the rope starter shaft.)

(1) With a puller, pull the crankshaft pulley from the crankshaft. (See Figure 85.)

(2) Drive the pulley key from the crankshaft with a brass drift and hammer. (See Figure 86.)

d. Removing Gear Cover. Unscrew the fourteen capscrews (ten capscrews, gear cover to housing, and four capscrews, oil pan to gear cover) holding the gear cover to the housing. Unscrew the two dowel bolt nuts and drive the dowel bolts from the cover and housing with a brass drift and hammer. (See Figure 87.) Pull the gear cover from the housing. (See Figure 88.)

e. Checking Idler Gear Clearances. Check the idler gear end play and backlash before removing the gear. The end play should not be greater than .015 inch. (See Figure 89.) The backlash should not be greater than .012 inch. (See Figure 90.) Note that the camshaft gear is held stationary to prevent its moving while the idler gear backlash is checked. The backlash can be checked with a dial indicator as shown, or, if no indicator is available, insert thin feeler gauge strips between the two mating gear teeth at the point where an imaginary line would connect the gear centers until the clearance is taken up.

f. Removing Idler Gear. Unscrew the left-hand threaded capscrew holding the idler gear in place. Pull the idler gear from the shaft. (See Figure 174.)

g. Checking Camshaft Gear Backlash. Check the camshaft gear backlash similar to that shown in Figure 90 for the idler gear. Refer to paragraph 48e.

h. Removing Idler Gear Stub Shaft. Unscrew the setscrew revealed in Figure 80 when the acorn nut was removed. This setscrew securely holds the idler gear shaft in place.

With a pipe slightly larger in diameter and longer than the idler gear bearing surface installed over the shaft, pull the shaft from the case by tightening the original capscrew against the original washer. (See Figure 91.) (Be sure the washer slips over the dowel pin in the end of the shaft when the capscrew is tightened.) The addition of large washers to increase the length of the pipe will have to be made from time to time until the shaft is pulled all the way from the case.

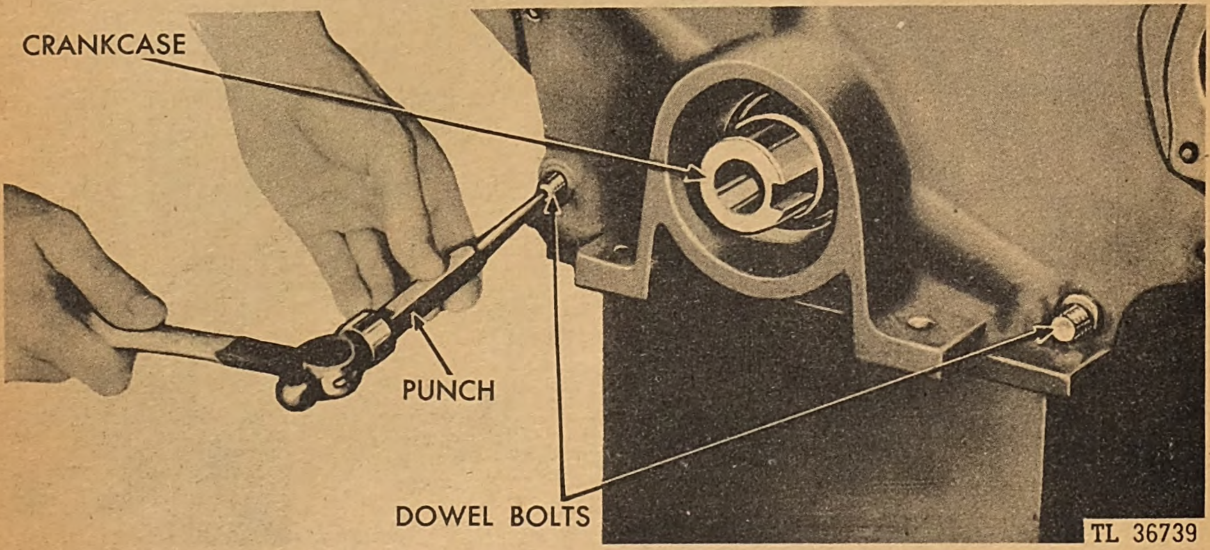

Fig. 87. Removing Gear Housing Cover Dowel Bolts

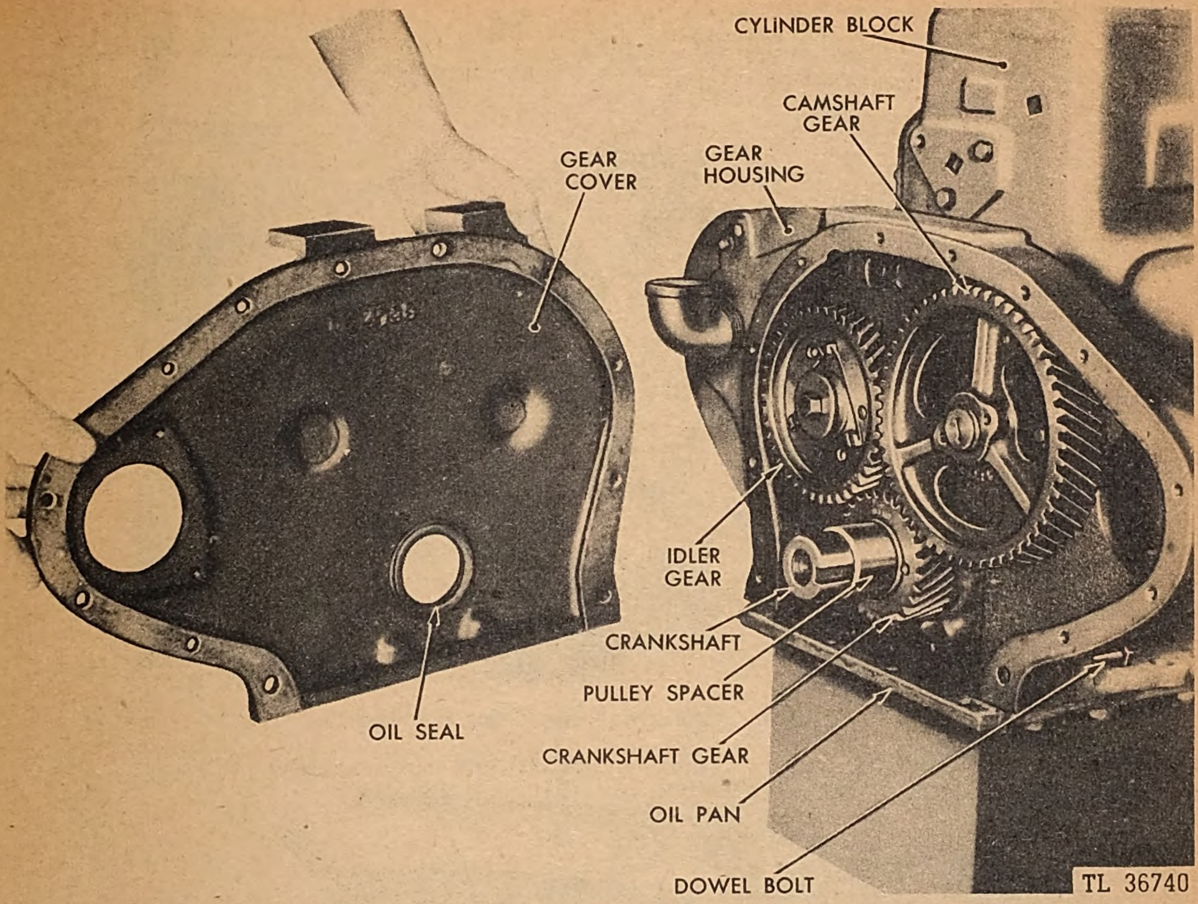

Fig. 88. Removing Gear Housing Cover

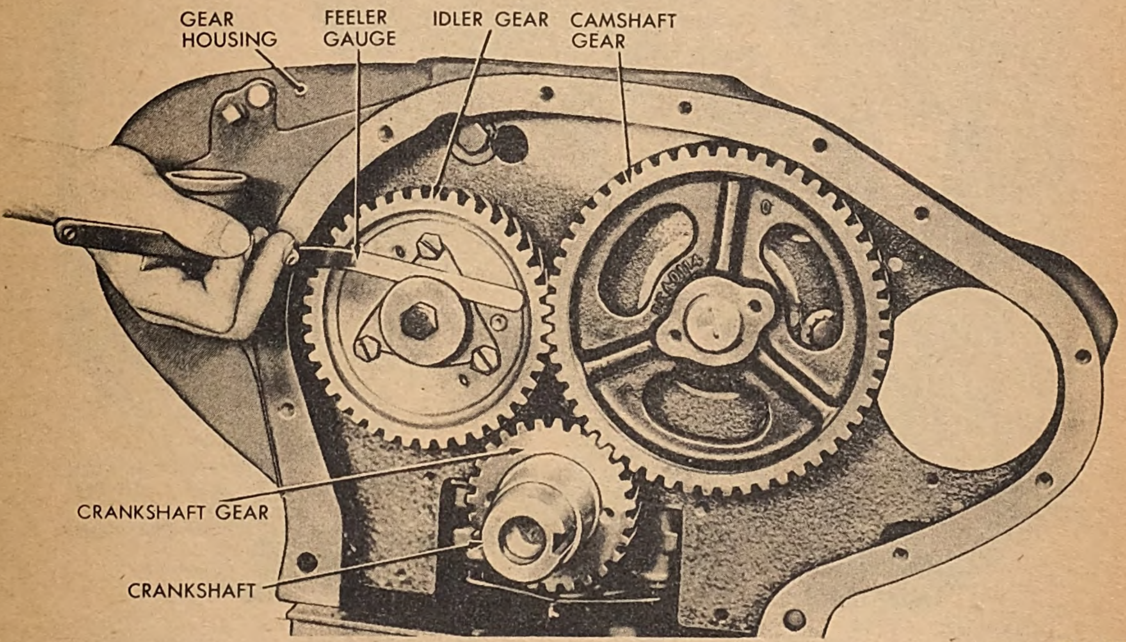

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Fig. 89. Checking Idler Gear End Play

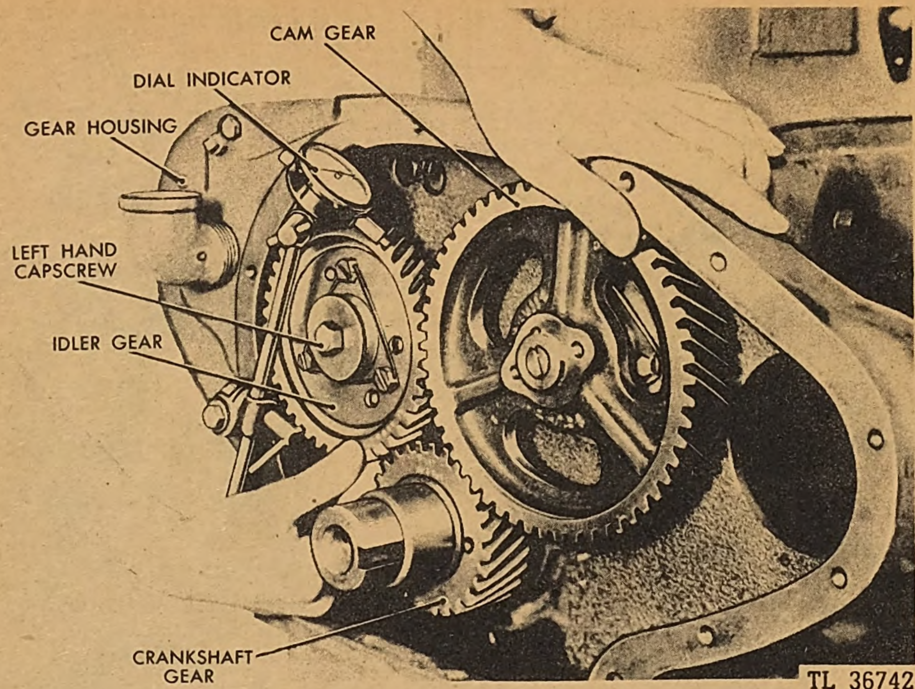

Fig. 90. Checking Idler Gear Backlash

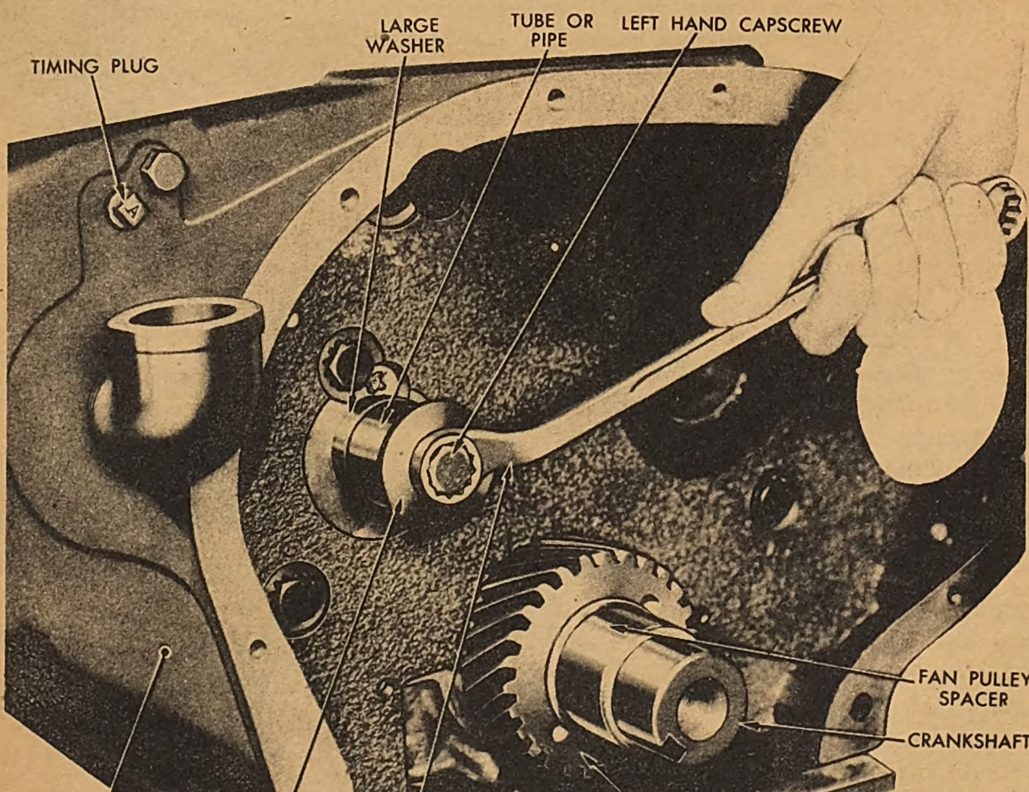

Fig. 91. Removing Idler Gear Stub Shaft

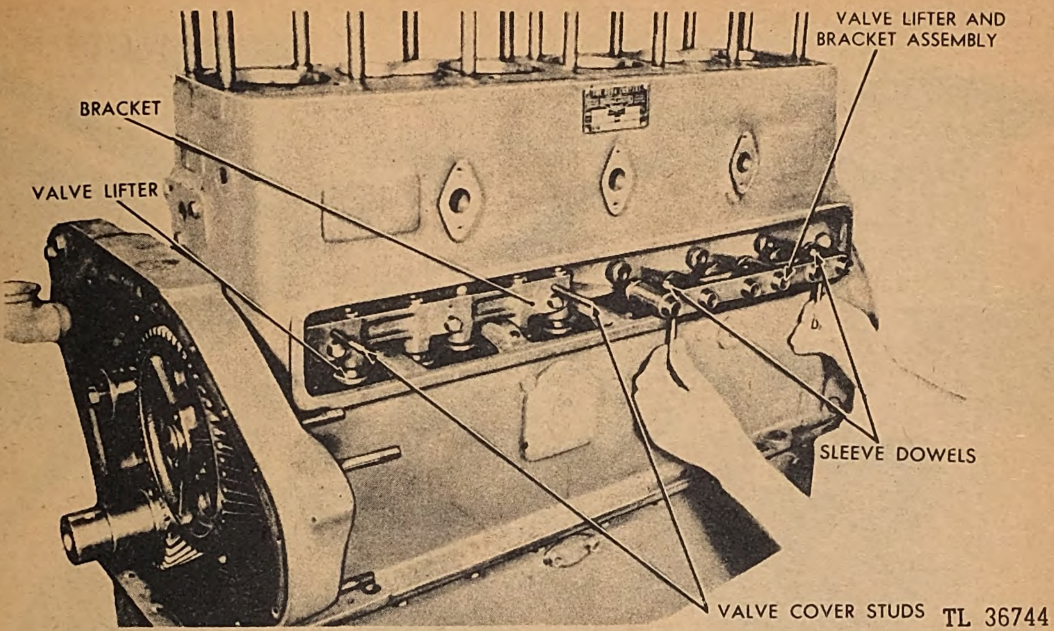

Fig. 92. Removing Valve Lifter and Bracket Assembly

i. Removing Valve Lifter and Bracket Assemblies. Remove the valve cover. Note that the valve cover nut closest to the gear housing is considerably longer than the other three nuts. Unscrew the valve lifter bracket bolts. Remove the brackets. (See Figure 92.) The capscrews holding the lifter brackets to the crankcase are of a specified length, 2 inches, and should be kept with the brackets to avoid loss or mixing with other length bolts. Longer capscrews will bend or break in the cylinder sleeves.

j. Checking Camshaft Clearances. (Removal). (1) Straighten the locking tabs on the camshaft retaining plate as shown in Figure 95. Unscrew the three retaining capscrews. An ordinary 7/16-inch open-end wrench, bent close to the head, will unscrew these capscrews. Consult Figure 173.

(2) Carefully pull the camshaft out a few inches and check the camshaft end play as shown in Figure 94. The desired camshaft end play is .003 inch to .009 inch; permissible is .015 inch. Check the camshaft bushing clearance with a feeler gauge between each of the four bushings. (See Figure 93.) The clearance should be between .0014 inch to .004 inch; permissible .006 inch. If the clearance exceeds the permissible, replace the bushing.

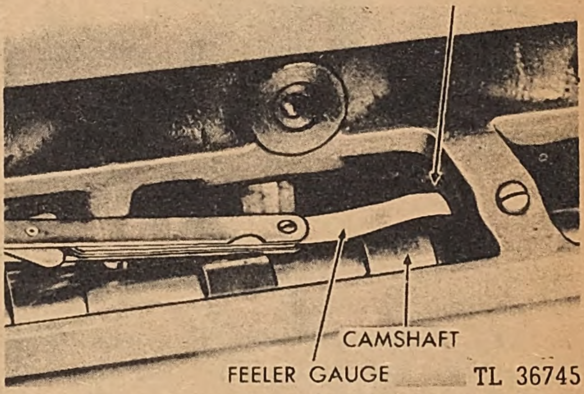

Fig. 93. Checking Camshaft to Bushing Clearance

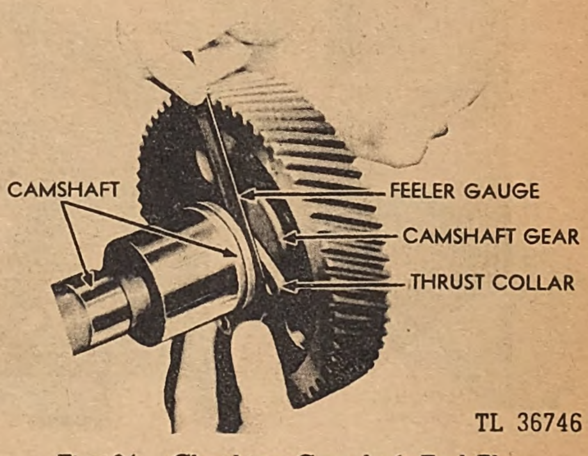

Fig. 94. Checking Camshaft End Play

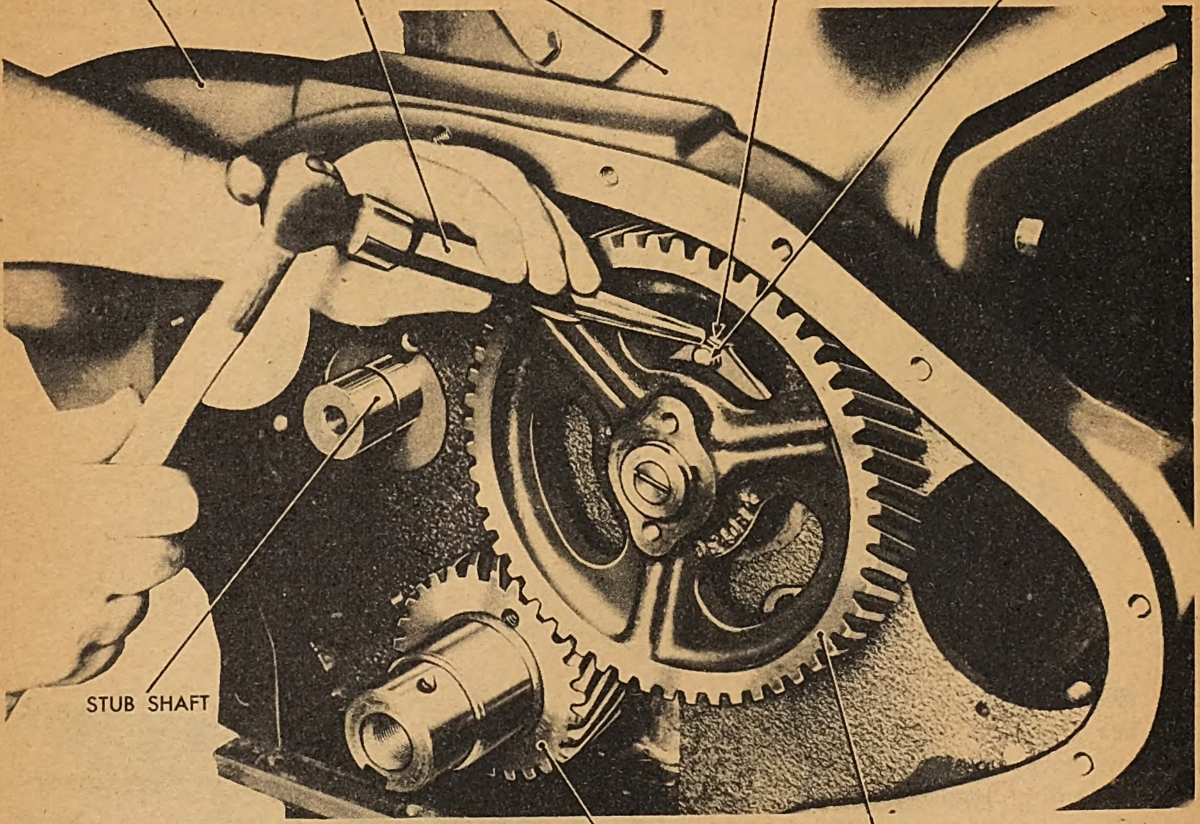

Fig. 95. Straightening Tabs on Cam Retaining Lock Plate

Consult paragraph 51e for camshaft bushing replacement.

(3) Pull the camshaft from the engine. (See Figure 171.) Be careful not to drag the cams through the bearing.

k. Removing Water Jacket Cover. Unscrew the 28 capscrews holding the water jacket cover to the cylinder block. Lift off the cover. (See Figure 96.) Check inside the block for scale formation.

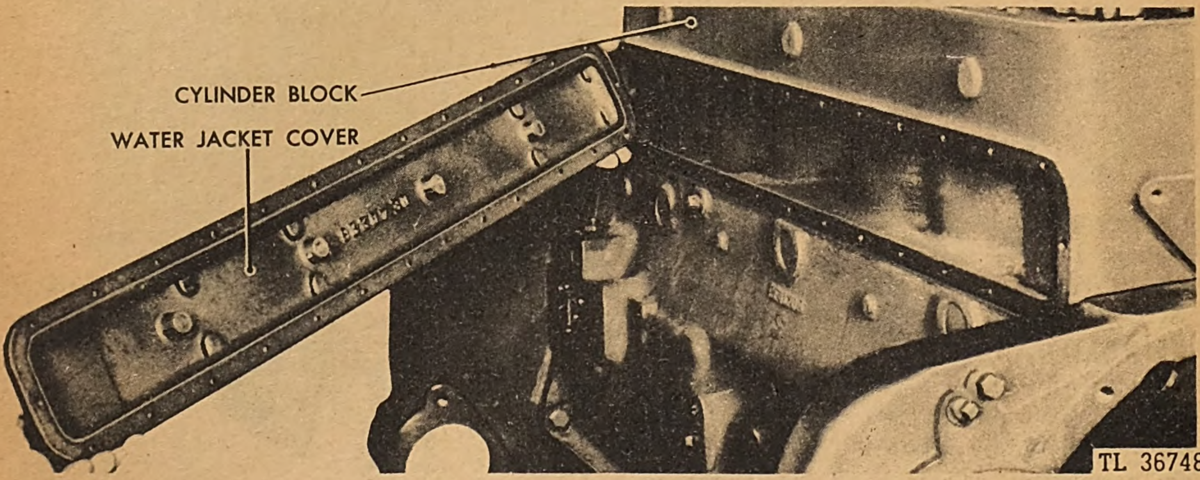

Fig. 96. Removing Water Jacket Cover

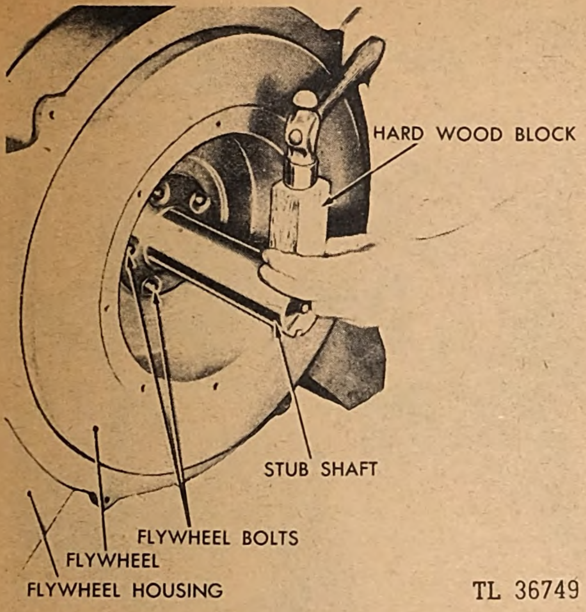

Fig. 97. Removing Stub Shaft

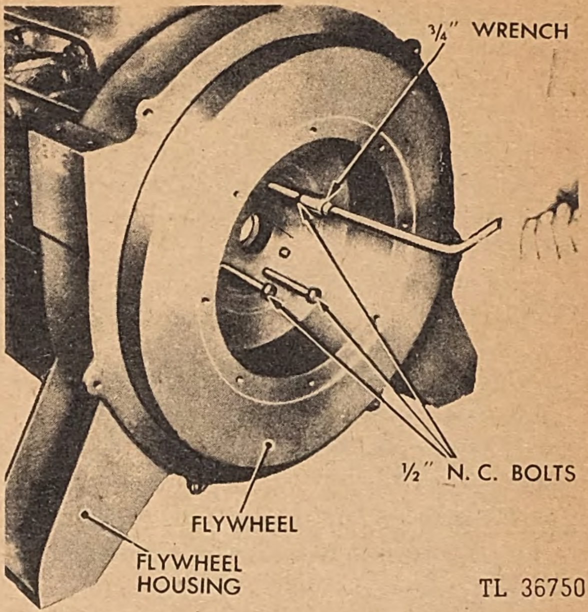

Fig. 98. Removing Flywheel

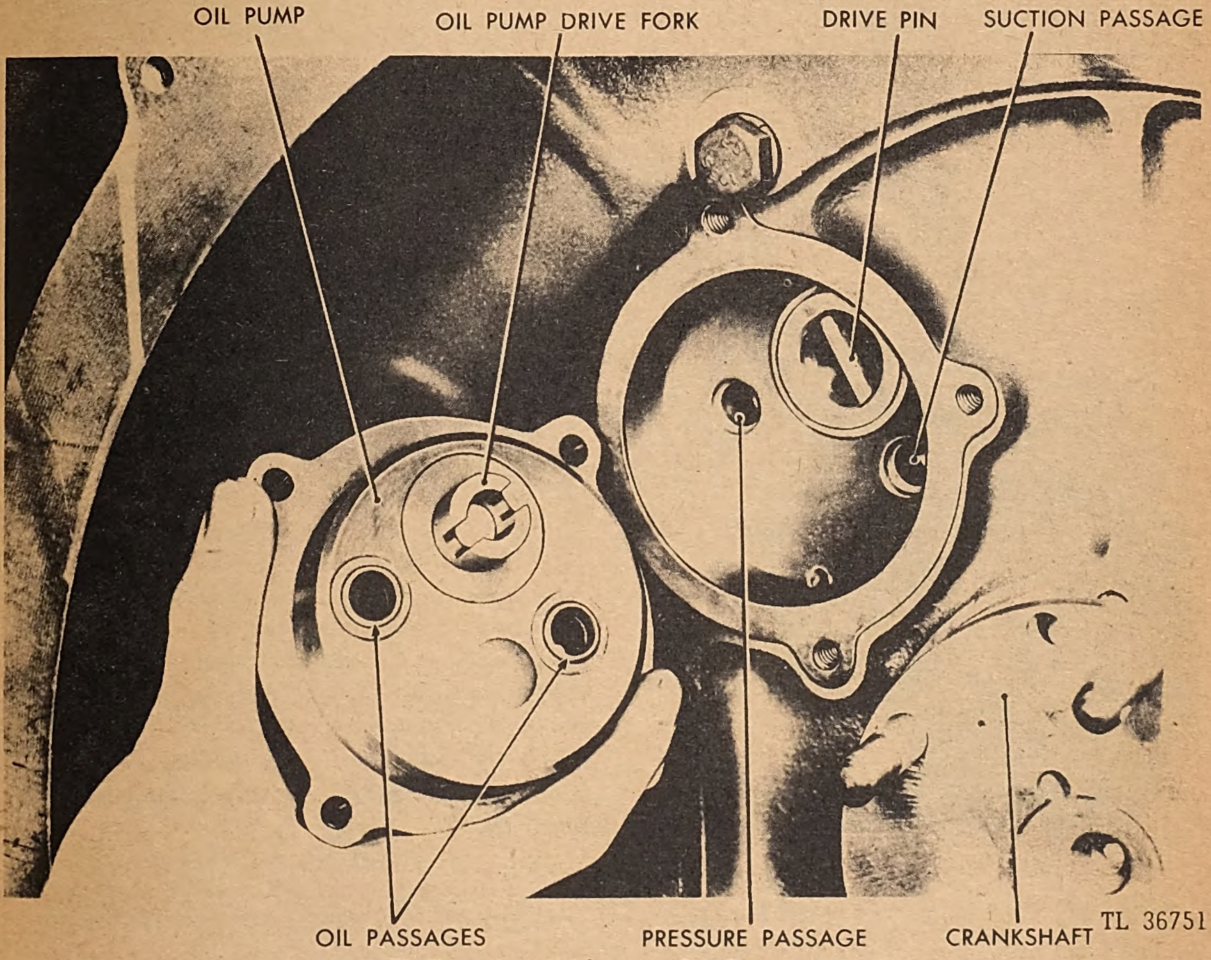

Fig. 99. Removing Oil Pump

l. Removing Flywheel and Stub Shaft. (1) Unscrew the five flywheel nuts holding the stub shaft and flywheel to the crankshaft. Tap the stub shaft with a hardwood block and hammer, tapping it around the shaft until the pilot on the end of the stub shaft has been worked out of the flywheel. (See Figure 97.)

If one-half of the drive coupling is still on the stub shaft, follow the same procedure as outlined above.

(2) Insert three ½-inch capscrews, N. C. (National Coarse) thread, which should be about 4 inches long, into the three tapped holes in the hub of the flywheel. Screw in the capscrews to push the flywheel off the crankshaft flange. Use the capscrews to lift the flywheel out of the housing. (See Figure 98.)

m. Removing Oil Pump. Unscrew the four oil pump retaining capscrews and pull out the oil pump. (See Figure 99.)

n. Removing Flywheel Housing. With a chain hoist, lay the engine on its left side. Unscrew the four capscrews and two dowel bolt nuts holding the flywheel housing to the crankcase and drive the two dowel bolts from the housing with a brass drift and hammer. Support the housing with a chain hoist. (See Figure 100.)

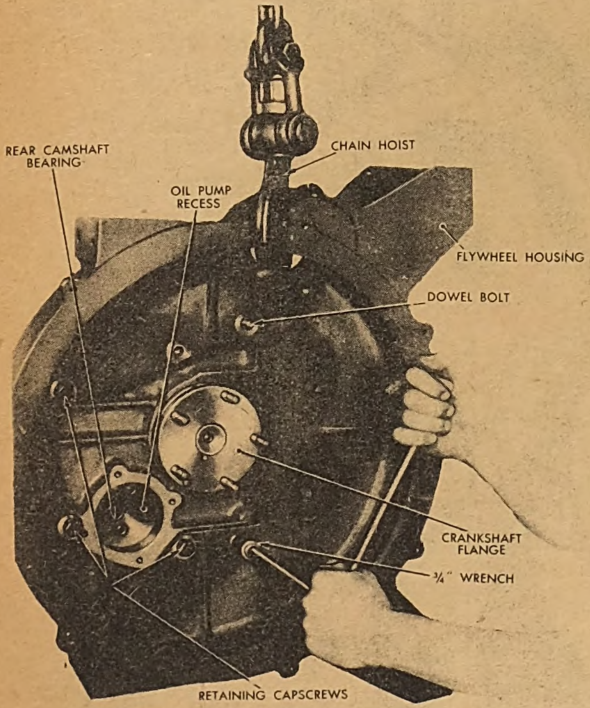

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Fig. 100. Removing Flywheel Housing

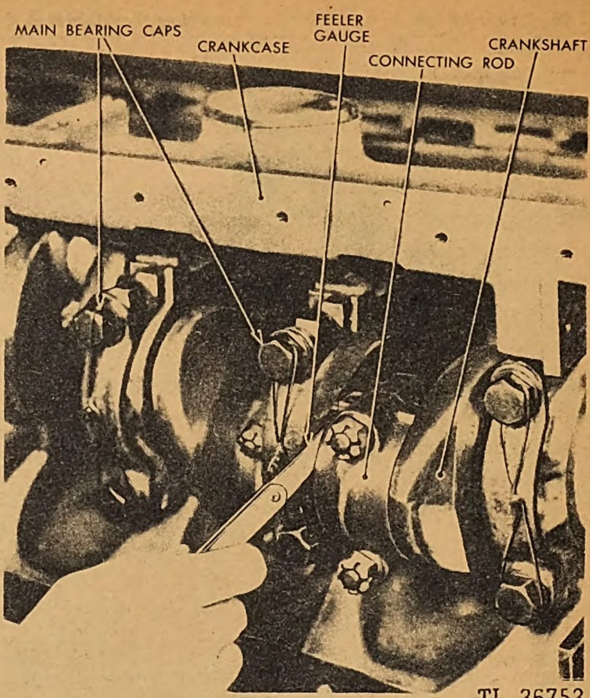

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Fig. 101. Checking Connecting Rod Side Clearance

o. Removing Oil Pan and Oil Screen. Remove the oil pan capscrews. Drop the oil pan. Remove the oil inlet screen bracket from the crankcase by unscrewing the two retaining capscrews. (See Figure 166.)

p. Checking Connecting Rod Side Clearance. Check the connecting rod side clearance with a feeler gauge inserted between the crankshaft throw and the connecting rod. (See Figure 101.) This clearance should not exceed .013 inch. If the clearance exceeds .013 inch, replace the connecting rod.

q. Removing Piston and Connecting Rod Assemblies. Remove and discard the cotter pins from the connecting rods. Remove the piston and connecting rod assemblies by pushing the assembly through the cylinder bore after removing the connecting rod nuts and cap. **CAUTION: Be careful not to mar the crankshaft bearing surface or the connecting rod bearings.**

NOTE: A good pilot tool for pushing off the pistons is a short wooden handle with a piece of copper tubing fitted over the connecting rod bolt. This tool acts as a pilot or guide and avoids damaging the bearing surfaces. (See Figure 102.) Replace the caps and nuts on their respective rods. The caps and connecting rods are all numbered for this purpose. **Do not reverse the position of the caps, for they must be replaced in their original positions.**

After the piston and rod assemblies are removed, avoid letting the piston rock against the connecting rod—there is danger of cracking the skirt.

r. *Removing Gear Housing.* Unscrew the six thin-headed capscrews holding the gear housing to the crankcase. Drive the dowel bolts through the gear housing with a brass drift and hammer. Remove the gear housing. (See Figure 103.)

s. *Checking Crankshaft End Play.* With a chain hoist, stand the crankcase on the cylinder head studs so that the crankshaft can conveniently be removed. The crankcase will have to be blocked in this position to prevent it from tipping over.

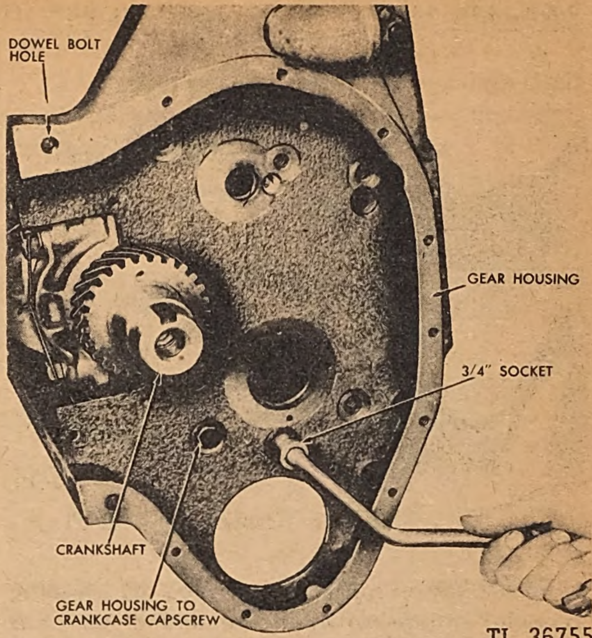


Fig. 103. Removing Gear Housing

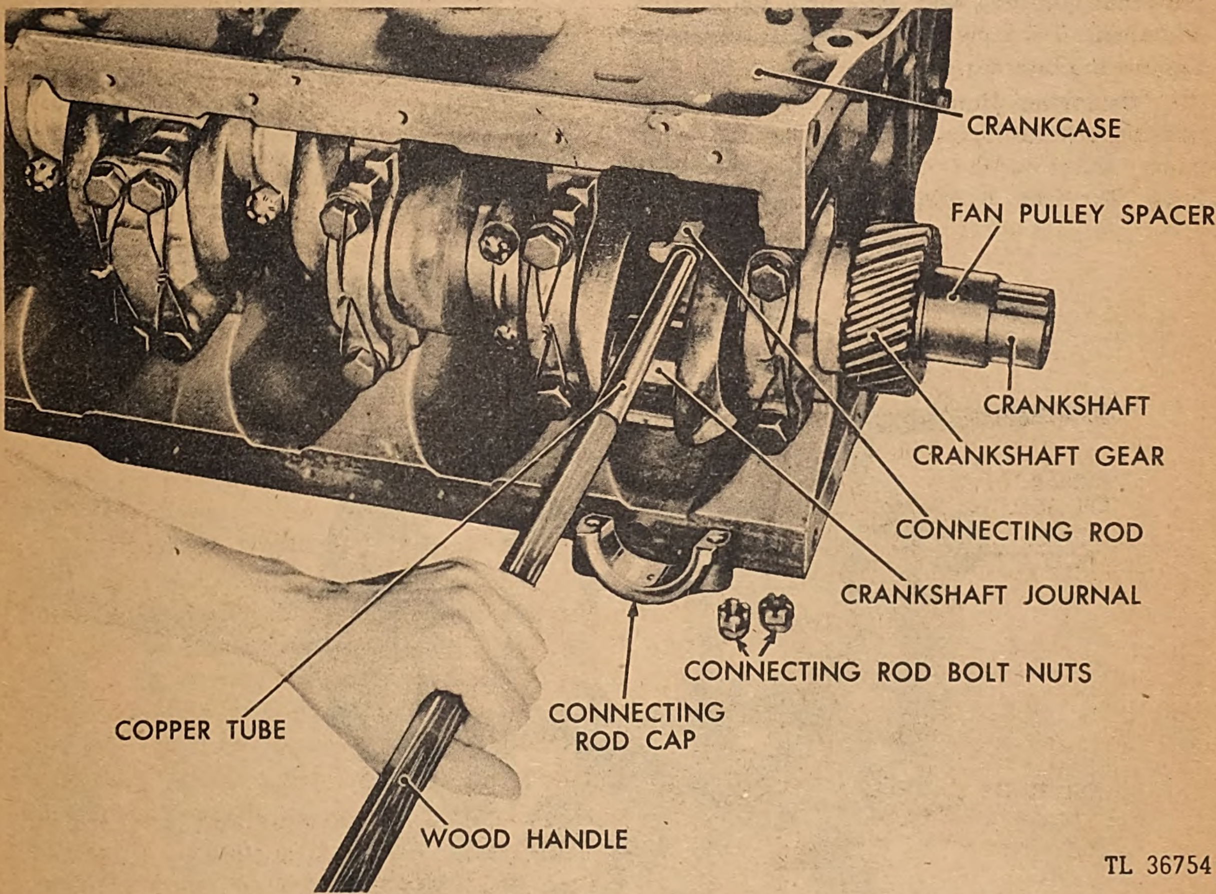


Fig. 102. Removing Connecting Rods

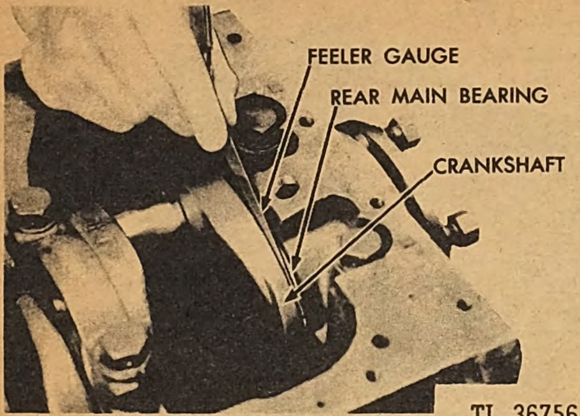


Fig. 104. Checking Crankshaft End Play

Check the crankshaft end play by slipping a feeler gauge between the end of the rear main bearing and the crankshaft as shown in Figure 104. The desired clearance should be between .003 inch and .007 inch; permissible .012 inch. If the clearance exceeds .012 inch, replace the bearing.

t. Removing Main Bearing Caps. Remove and discard the lockwires of the main bearing caps. Unscrew the cap bolts—remove the caps. The rear bearing cap with the lower half of the oil seal attached to it can be removed, as shown in Figure 105, with two pry bars, two blocks of wood, and two ⅜-inch N. C. (National Coarse) thread capscrews.

NOTE: The main bearing caps are numbered consecutively, starting at the front or fan end of the engine, 1 to 7 inclusive.

u. Removing Crankshaft. Carefully lift the crankshaft out of the crankcase, as shown in Figure 156, so as not to damage the bearing surfaces.

v. Removing the Upper Half of Oil Seal. Unscrew the three screws holding the upper half of the rear bearing oil seal, remove the oil seal, and discard the felt and gaskets. (See Figure 155.)

w. Removing Crankshaft Bearings. Remove the bearings from both the crankcase and the caps. Remove the rear bearing by tapping under the side of the bearing with a block of wood and hammer. (See Figure 106.)

NOTE: These bearings are not numbered. If the bearings do not need replacing they must be laid away just as removed, so that they can be placed back in their respective places exactly as they came out. Even their individual positions in the crankcase and the caps must not be reversed. If any one of the bearings is pitted or burned they should all be replaced.

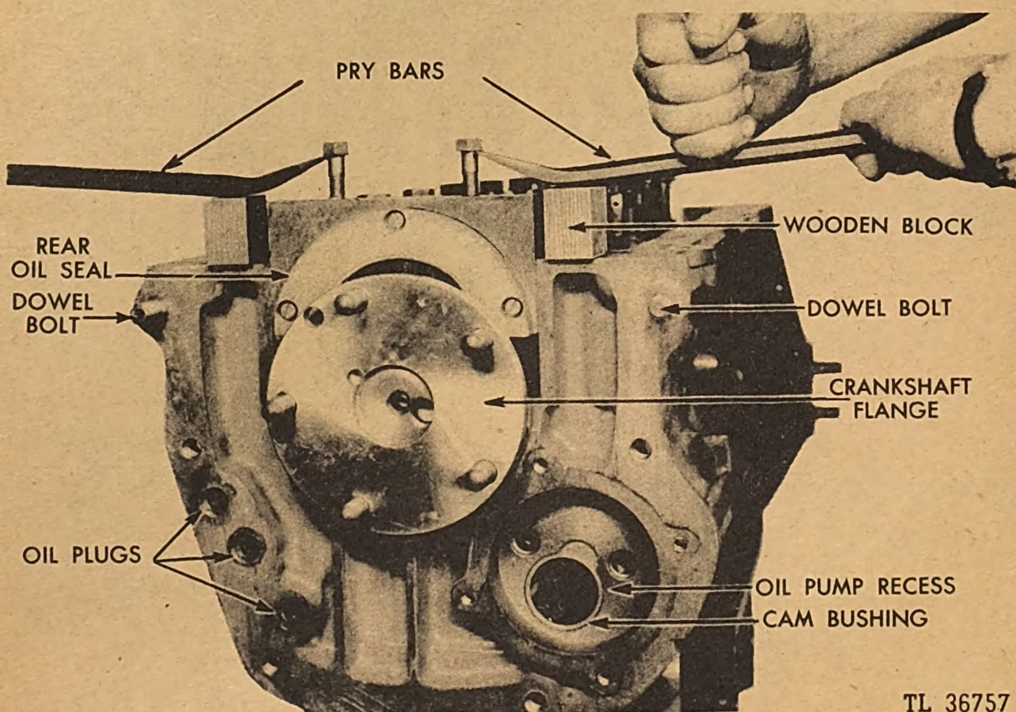


Fig. 105. Removing Rear Main Bearing Cap—Oil Seal

Fig. 106. Removing Main Bearing Shell from Cap

x. Removing Oil Line Pipe Plugs. Remove the oil line pipe plug at the front end of the crankcase and the three plugs at the rear end. (See Figures 107 and 108.)

y. Removing Oil Pressure Relief Valve. Remove the oil pressure relief valve and the oil line pipe plugs in the side of the block. (See Figure 168.)

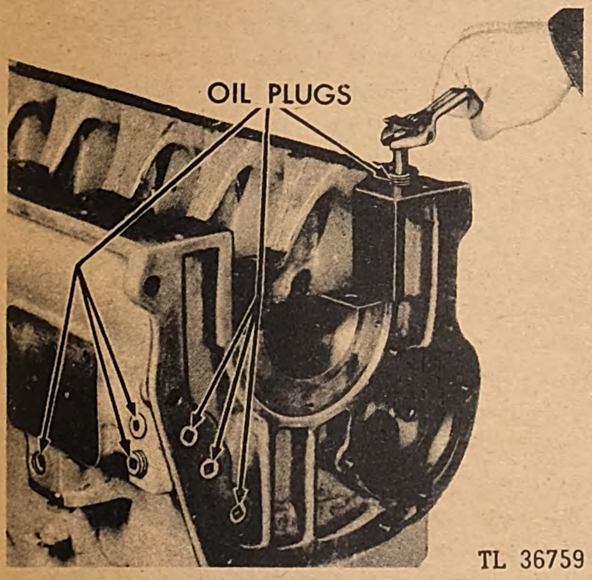


Fig. 107. Removing Oil Plugs

The engine is now completely disassembled except for the cylinder head assembly which is given in paragraph 53. The engine is now ready for complete inspection and repairs if needed, as given in paragraph 49. Inspection and repairs for the accessories, together with complete instructions for disassembly, testing, and reassembly, are given in paragraphs 61 to 93 inclusive.

49. Inspection and Replacement of Engine Parts. The instructions given here under Inspection and Replacement of Engine Parts take into consideration almost all repairs or replacements that can be made. It should not be assumed, however, that all of these repairs or replacements will be necessary or normal. For the most part, some of these replacements will be rare. Nevertheless, all these extreme conditions are given in order to aid the mechanic in doing a skilful job.

Also included in this section are such servicings which do not require a complete disassembly of the engine, such as replacing engine bearings, main bearings, grinding valves, replacing piston rings, etc. The assemblies or parts of the basic engine to be serviced, inspected, replaced or repaired are listed alphabetically.

NOTE: An accurate inspection can be made only if the parts are thoroughly cleaned both inside and outside. If no cleaning tank is available, washing the parts in kerosene is recommended.

50. Camshaft. The camshaft serves the purpose of opening and closing the valves at the

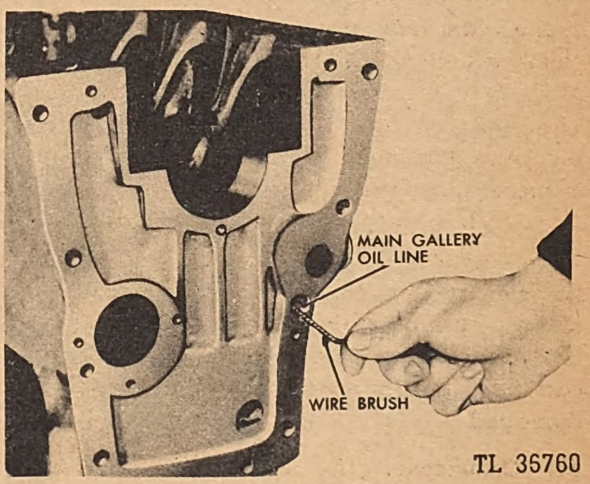


Fig. 108. Cleaning Main Gallery Oil Line

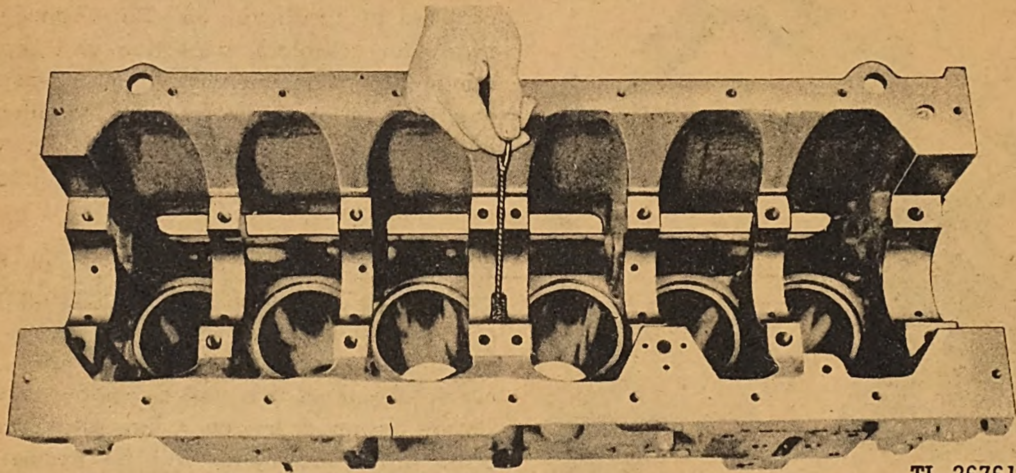


Fig. 109. Brushing Out Oil Channels to Cam Bearing

right time in relation to the engine cycle. The camshaft is of open-hearth steel, case-hardened, and runs in four bronze bushings which are pressed into the crankcase. The original camshaft bearing clearance is from .0014 inch to .004 inch. The camshaft, being case-hardened, will never have to be replaced because of too much clearance. The bushings will need replacement if the clearance is .006 inch or more. The instructions for the replacement of the bushings are given under crankcase instructions in paragraph 51e. The cams should show no appreciable wear. Bearing journals should be free from scores or mutilations. The oil holes in the camshaft bearings must be in line with the oil passages in the crankcase. The bearings must be tight in the crankcase.

The camshaft end play, which can be checked between the hub of the gear and the thrust collar, as shown in Figure 94, should be between .003 inch and .009 inch; maximum before replacement .015 inch. If the clearance is more, the thrust collar should be replaced.

Check the oil pump drive pin for wear. If worn, remove the pin from the shaft with a hammer and punch. After installing new pin, make certain that the riveted ends of the pin are ground slightly below the surface of the camshaft journal so the bearing will not be damaged.

51. Crankcase. The crankcase is a rigid structure supporting the crankshaft, camshaft, piston and connecting rod assemblies and other parts which serve to transmit reciprocating motion into rotary motion. The cylinder block and upper crankcase are a one-piece casting. The cylinder bores are completely surrounded by water jackets. The cylinder sleeves are finished by boring and honing to provide the proper piston clearance and a smooth finish. The cylinder sleeves are of the dry type.

Exercise care when handling the crankcase so as not to mar the face of the crankcase. This precaution cannot be stressed too strongly. In order to thoroughly clean the crankcase for inspection, all the oil plugs must be removed and the oil lines brushed out with a long wire brush, as shown in Figures 108 and 109, to remove any sediment or sludge. Blow out the lines with air.

a. Checking for Out of Round and Taper. Check each cylinder sleeve with an inside micrometer at the upper end of the ring travel.

First check in a position parallel to the crankshaft, and then in a position at right angles to the crankshaft, as shown in Figure 110. The difference between these two readings shows the amount the cylinder sleeve is out of round. To obtain the amount of each cylinder sleeve taper, measure in like manner the bottom of each cylinder by taking two readings, one position parallel to the crankshaft and the other at right angles to the crankshaft. Compare the top parallel reading with the bottom parallel reading, and the top right

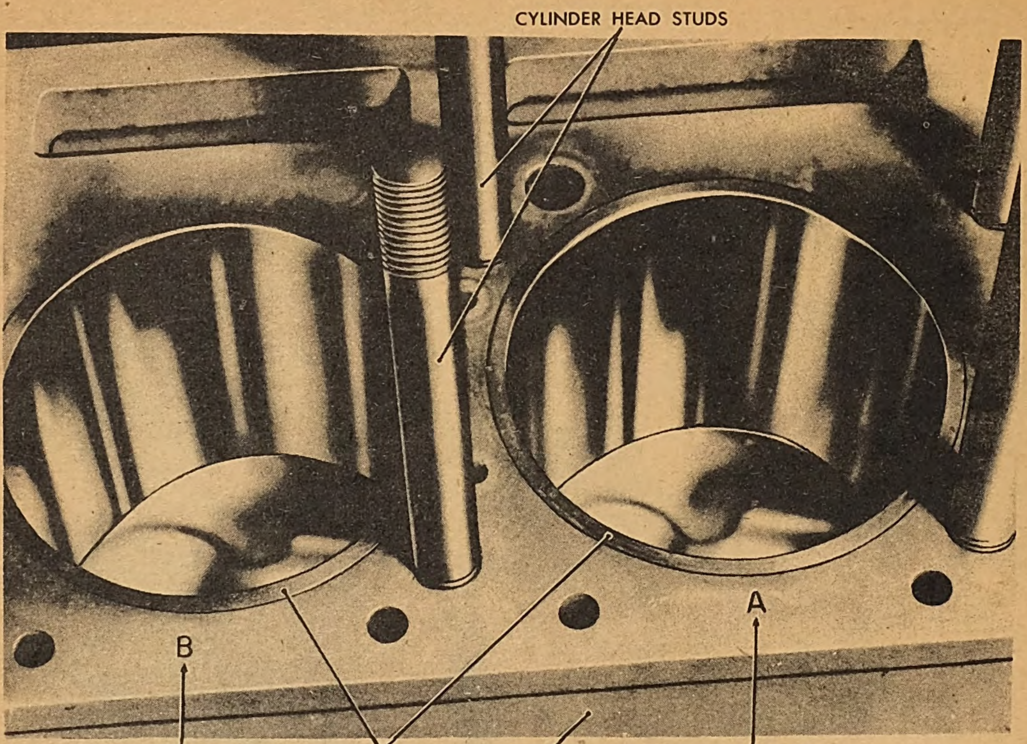
Fig. 110. "Miking" Cylinder Sleeve

angle reading with the bottom right angle reading, to obtain the taper. If the out of round and the taper is more than .005 inch, replace the cylinder sleeves and the pistons.

b. Replacing the Cylinder Sleeves. The cylinder sleeves can be removed and replaced with an ordinary screw-type pulling tool as shown in Figures 113 and 114. The bore of the block must be wiped clean and the sleeves dipped in light machine oil or fuel oil before inserting. Push in the new sleeve as far as possible by hand. Be sure that the new sleeve is entered squarely with the cylinder bore and is properly aligned before attaching the cross pin and pole screw of the sleeve pulling and installing tool, as shown in Figure 113.

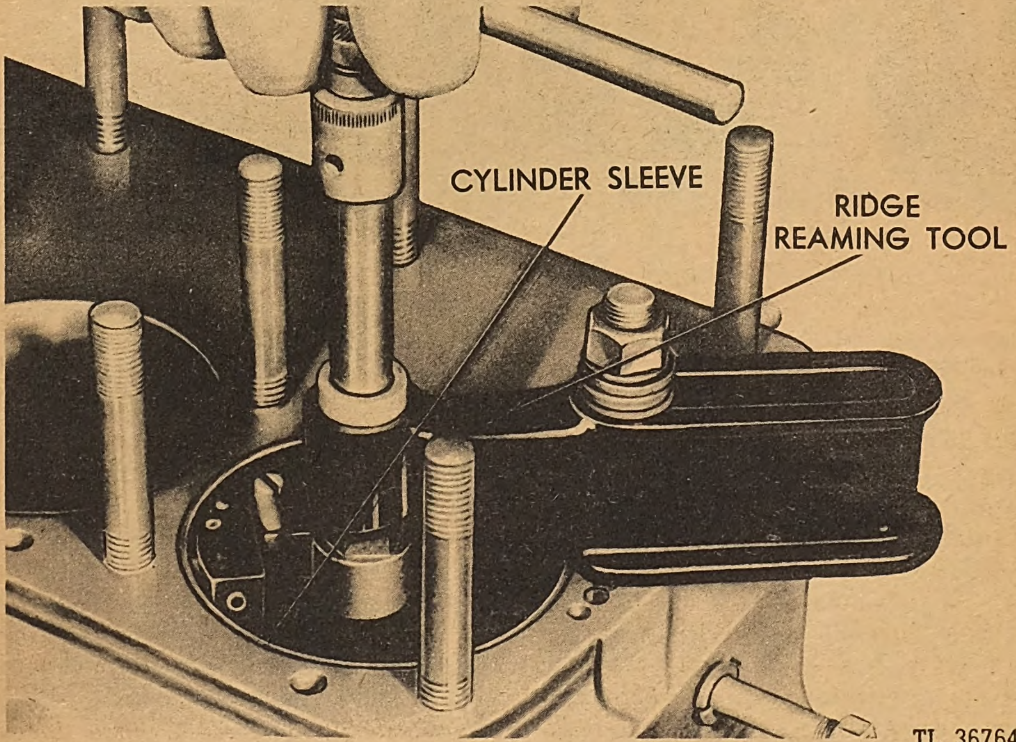
In order to secure absolute precision in outside diameter, the sleeves are selected on inspection for variations of thousandths of an inch, and the cylinder block and flange of the mating sleeve marked "A", "B", "C", or "AO", "BO", "CO". In ordering a new sleeve to fit a particular bore, be sure to state the "A", "B", "C" or "AO", "BO", "CO" marking found on the top of the cylinder block adjacent to the sleeve in question. (See Figure 111.) Also specify the engine serial number which will be found on the engine name plate. (See Figure 110.)

c. Reconditioning the Cylinder Sleeves. If the cylinder sleeves are within the limits specified in the preceding paragraph and are free



TL 36763

Fig. 111. Crankcase Sleeve Size Marking



TL 36764

Fig. 112. Cylinder Sleeve Ridge Reaming Tool

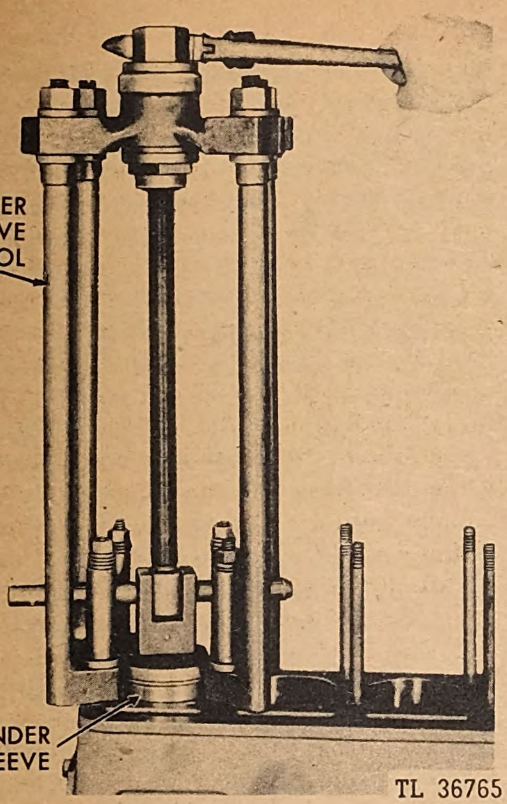


Fig. 113. Cylinder Sleeve Tool (Upper End)

from scores and scratches, remove the ring travel ridge at the top of the cylinders with a ridge reamer as shown in Figure 112. The removal of this ridge will forestall top ring breakage and unnecessary ring "clicking".

d. Checking Camshaft Bushings. The camshaft runs in four bronze bushings which are pressed in the crankcase. The desired camshaft bearing clearance is between .0014 inch and .004 inch and can be checked with a feeler gauge as shown in Figure 93. If the clearance exceeds .006 inch, the bearings must be replaced. The bearings are of the precision type and do not require reaming after being pressed into the case.

e. Removing and Installing Camshaft Bushings. With a hacksaw blade, carefully cut through the old camshaft bushing, being careful not to cut into the crankcase. With a cold chisel, break the bushing and knock it out. To install the bushing, use a tool similar to the one shown in Figure 115. Put the bushing in place and be careful to line up the oil holes in the bushing with the oil passage holes in the crankcase. With a driving bar, drive it in place, as shown in Figure 116.

If a tool as shown in Figure 115 is not available, use two washers slightly larger than the bushing and with holes in the center just large enough through which a bolt ½ inch in diameter and between 2 inches and 3 inches long can pass. Put one washer on one side of the crankcase with a bolt through the washer. Put the bushing into place and, with a washer and nut on the bolt, carefully turn the nut to pull the bushing into position. Be careful that the bushing is aligned with the hole in the crankcase before and during the process of pulling the bushing into place.

52. Crankshaft. The crankshaft changes the reciprocal motion transmitted by the connecting rod into rotary motion—the form in which it is utilized. The crankshaft has seven main bearing surfaces, one between each crankpin throw and at each end of the crankshaft. The crankshaft is balanced both statically and dynamically and is drilled to provide oil distribution to connecting rod and piston pin bearings.

a. Checking Crankshaft Wear. NOTE: Because of the number of micrometer readings necessary to find the taper and out of round of all the bearing surfaces of the crankshaft, as outlined in the following instructions, it is advisable that these readings be recorded in some such diagram as given in Figure 117.

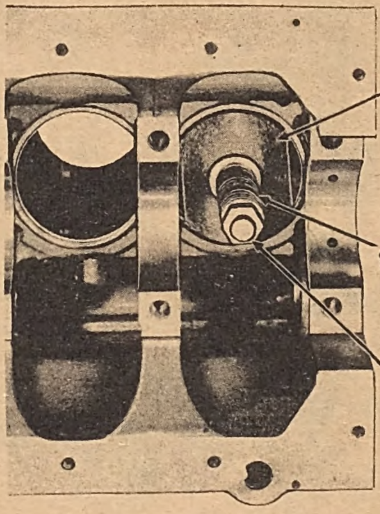


Fig. 114. Cylinder Sleeve Tool (Lower End)

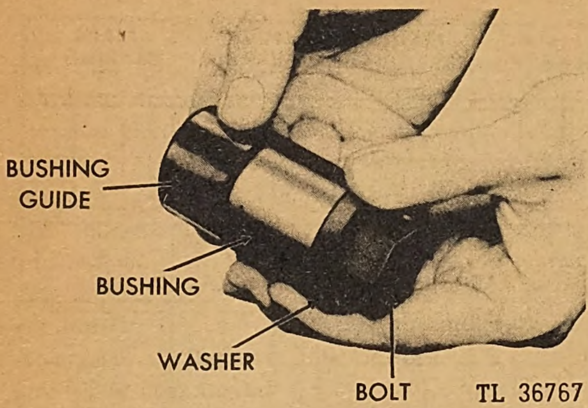


Fig. 115. Cam Bushing Installing Tool

Check the wear of each bearing surface, or journal, with a 2-inch to 3-inch outside micrometer. (See Figure 118.) Before recording, take readings all around one journal to find the lowest reading on the micrometer, or the smallest diameter of the bearing surface, which usually will be at one end. Using that small end as a starting point, take three readings in line, one at the small end, the second at the middle of the bearing surface, and the third at the other end. Record these readings. These three readings will give the amount of taper in this line of the journal. At a point 90 degrees or one-quarter of the way around the bearing surface, again take three readings in line, the first at one end, the second at the middle, the third at the other end. If the first three readings were horizontal, the second three readings must be vertical, or vice versa. The second three readings give the amount of taper in that plane, or the vertical position. For the amount of out of round, compare the first horizontal reading with the first vertical reading, the second horizontal reading with the second vertical reading, the third horizontal reading with the third vertical reading. Repeat this procedure on all the other bearing surfaces, both the main and connecting rod crankshaft bearing surfaces. The main bearing size is 2.999 to 3.0002 inches, and the bearing clearance is .002 inch to .0042 inch, which is taken off the staft. Therefore, the original size of the shaft is 2.996 inches to 2.997 inches. If the wear of the shaft is more than .0015 inch or measures less than 2.9945, the crankshaft should be re-

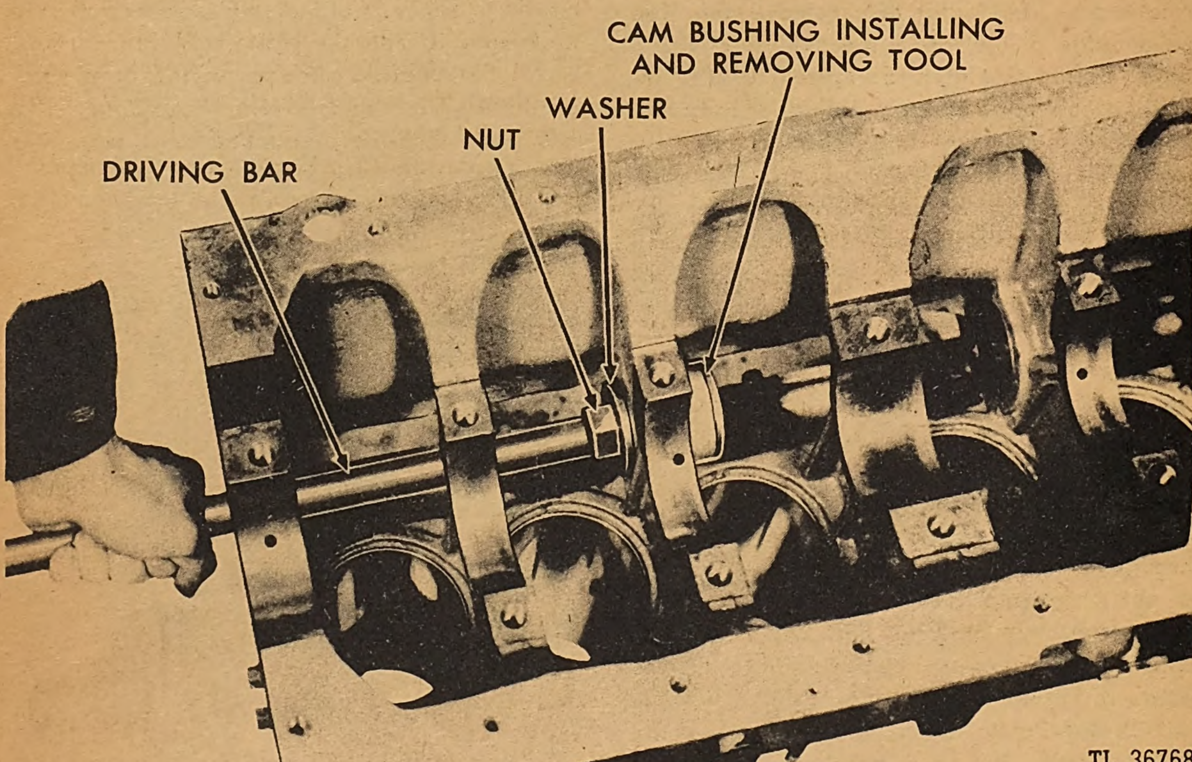


Fig. 116. Installing Cam Bushing

	MAIN BEARING #1			MAIN BEARING #2			MAIN BEARING #3			MAIN BEARING #4			MAIN BEARING #5			MAIN BEARING #6			MAIN BEARING #7		
HORIZONTAL																					
VERTICAL																					
	CONNECTING ROD BEARING #1			CONNECTING ROD BEARING #2			CONNECTING ROD BEARING #3			CONNECTING ROD BEARING #4			CONNECTING ROD BEARING #5			CONNECTING ROD BEARING #6					
HORIZONTAL																					
VERTICAL																					

Fig. 117. Chart for Micrometer Readings of Crankshaft TL 36769

ground to a standard undersize, .010 inch, .020 inch, .030 inch, or .040 inch.

The connecting rod bearings are 2.3755 to 2.3765 inches I.D.; and the bearing clearance is .002 inch to .004 inch. Therefore, the original size of the crankpin is 2.3725 inches to 2.3735 inches. If the wear of the crankpin is more than .0015 or measures less than 2.3710 inches, it should be reground to one of the undersizes already mentioned.

Check the crankshaft flange for nicks and smooth them if necessary. The flywheel bolts should be tight in the flange. Also check the oil slinger for burrs that might cut the oil retainer. If the oil slinger is bent, straighten it, being careful not to damage it. The oil holes in the shaft should be thoroughly cleaned out and blown dry with compressed air.

b. Checking Crankshaft Alignment. Check the crankshaft alignment by placing the front and rear main bearing surfaces on knife-edged rollers or V-blocks, with a dial indicator on the intermediate and center journals. The crankshaft journals should not run out more than .002 inch total indicator reading.

c. Checking Crankshaft Gear. Check the crankshaft gear for wear. If worn excessively, replace the gear with the same size as marked on the old gear, with due allowance for wear. See paragraph 55a. If the gear is replaced, and the replacement has no timing marks, be sure to transfer the timing marks from the old gear to the new gear. Refer to Figure 131.

d. Replacing Crankshaft Gear. To remove the old gear, use a gear puller as shown in Figure 119.

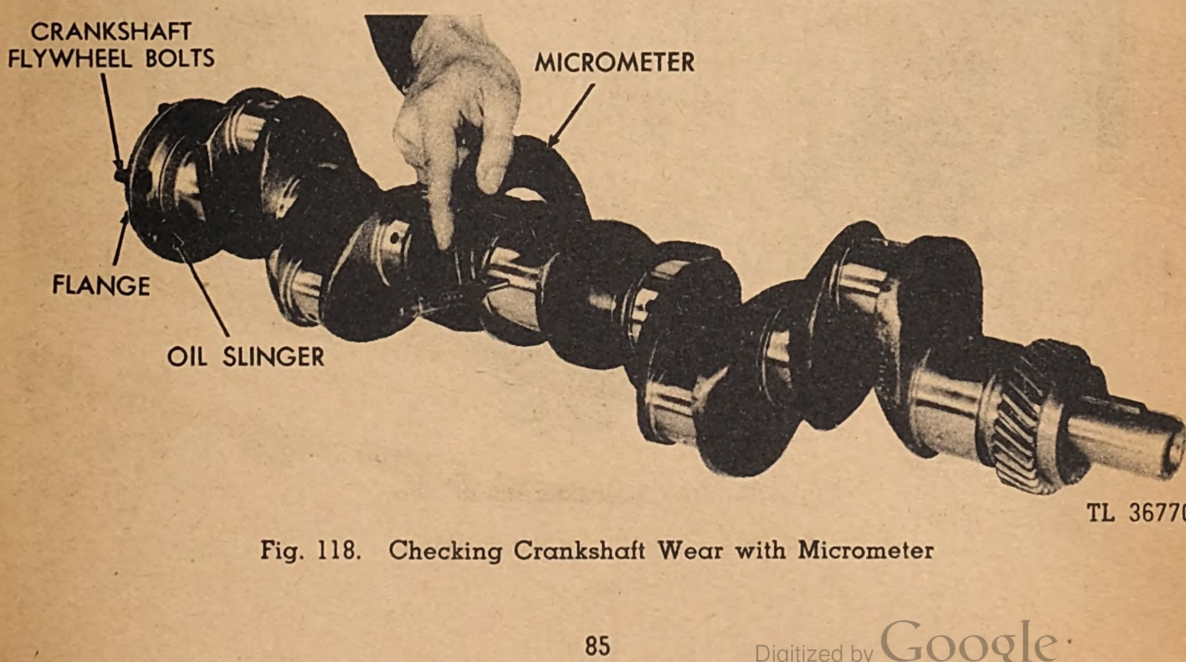


Fig. 118. Checking Crankshaft Wear with Micrometer

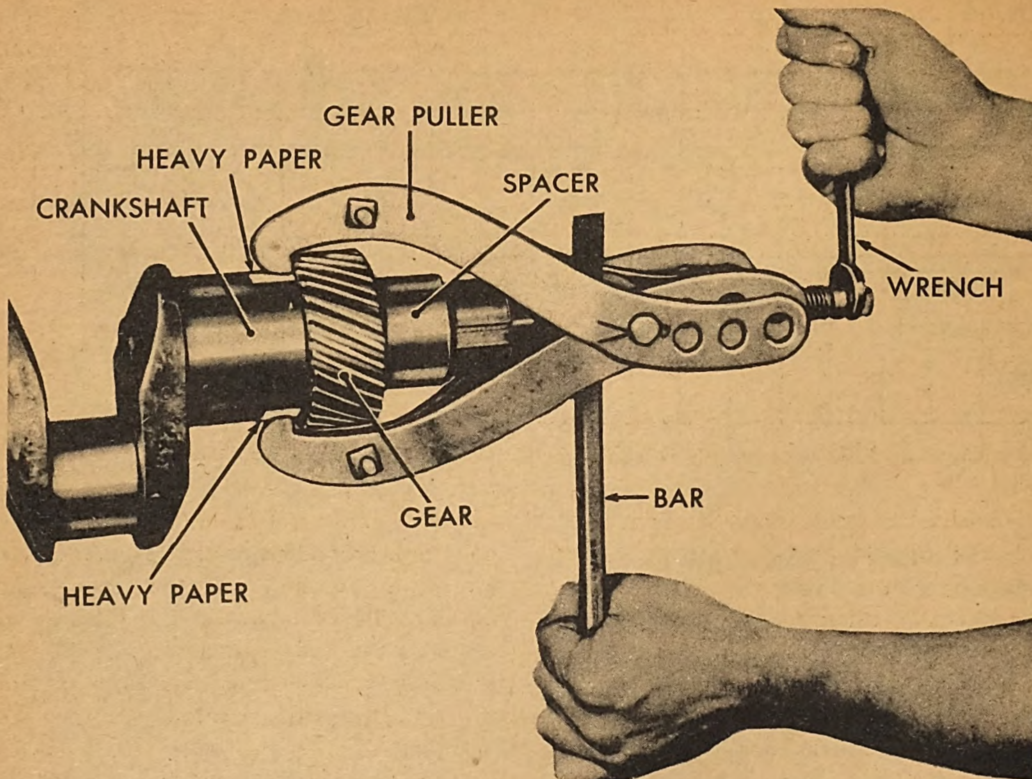


Fig. 119. Pulling Off Crankshaft Gear TL 36771

The bench method for installing a new crankshaft gear is to boil it in oil for approximately 15 minutes in order to expand the gear as much as possible. At the end of this time, pick up the gear with tongs or pliers and slip it onto the crankshaft. Be sure to align the key seat and the key. This method of heating the gear assures maximum expansion with no injury to the gear.

If the foregoing procedure is not feasible,

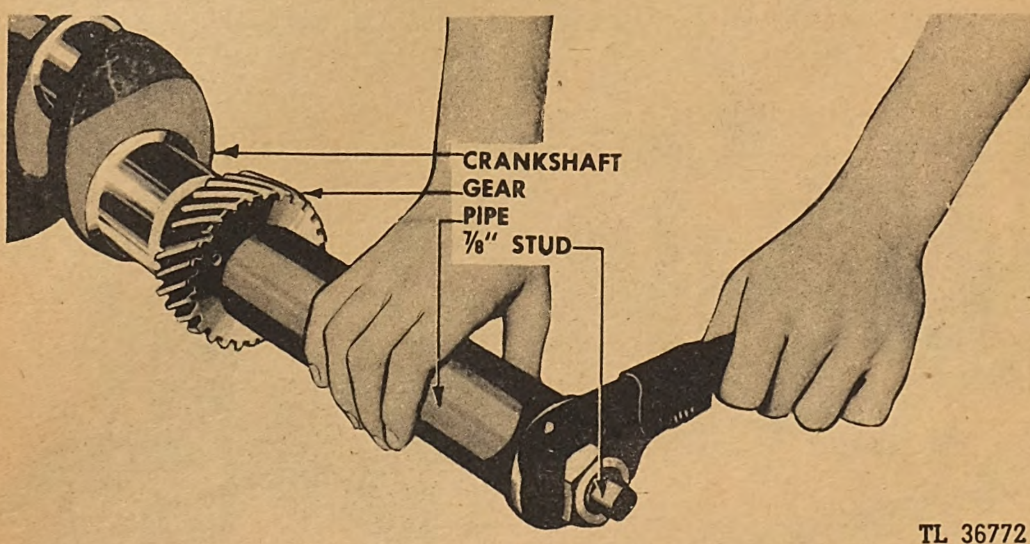


Fig. 120. Installing Crankshaft Gear

press on the gear as shown in Figure 120. For this method, a long 7/8-inch SAE stud, a pipe with the same outside diameter as the gear hub, washers to fit over the stud against the end of the pipe, and a nut to go on the end of the stud are needed.

First coat the crankshaft with white lead. Place the gear into position on the shaft with the keyway and the key in alignment. Screw the stud into the shaft. Place the pipe over the shaft with the washer in place and tighten the nut to press on the gear. Watch the key to be certain that it stays in position.

53. Cylinder Head Assembly. The cylinder head seals the end of the cylinders to form the top of the combustion chamber and contains the necessary passages to conduct the gases in and out of the combustion chamber, as well as the necessary water jackets through which the cooling liquid flows to prevent overheating. The cylinder head contains the valves, the rocker arm assemblies, and the air cell. To thoroughly service the cylinder head, it will be necessary to remove the valves and valve springs. (See paragraph 53*d*.)

a. Inspection. First thoroughly clean the cylinder head and all its ports, and remove all carbon deposits. Check the head for cracks. If cracked, the head should be replaced.

b. Cylinder Head Vent Tubes. Two small bleeder holes are drilled from the top of the cylinder head to the inlet port. Vent tubes are assembled above the holes. (See Figure 82.) This provides ventilation above the valves and draws off the combustion gases and prevents sludge and carbon formation, and also relieves excess crankcase pressure. It is important that these vents remain open. During the periodic valve grinding and general overhaul, these tubes should be carefully cleaned, making sure the holes leading to the inlet ports are open. Clogged holes may cause excess crankcase pressure, resulting in oil leaks at the various openings.

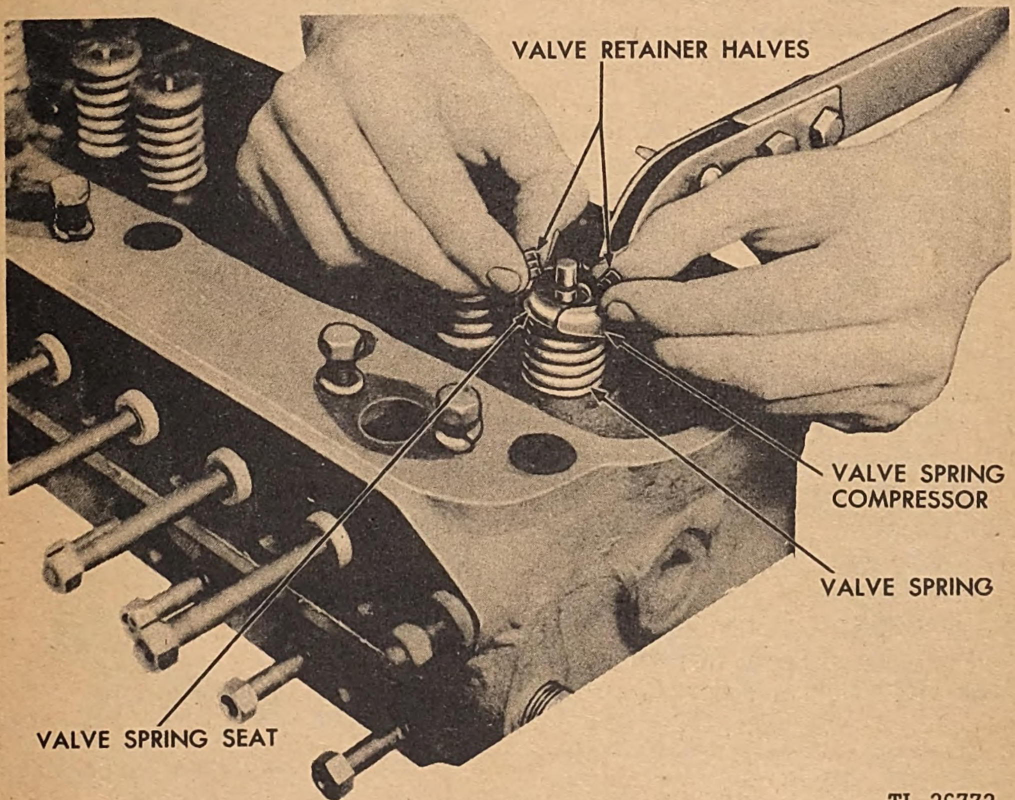


Fig. 121. Compressing Valve Spring

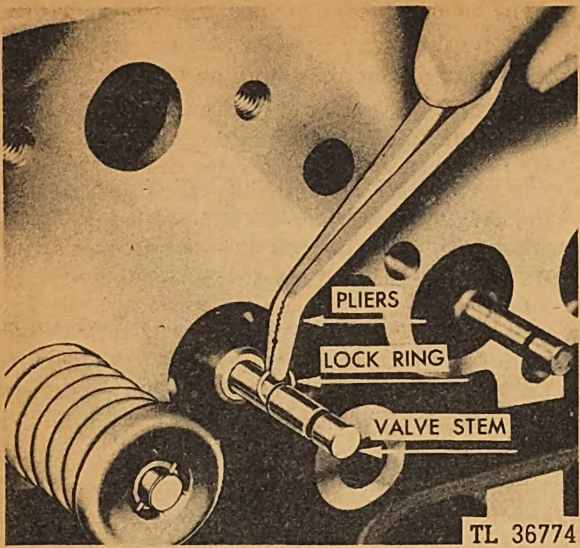


Fig. 122. Removing or Installing Valve Safety Clip

c. Checking and Replacing Air Cell. After the air cell retaining flange has been removed by taking out the two capscrews, the air cell plug can be removed by inserting a screw of ⅜-inch diameter with a washer, and pried out as shown in Figure 78. The air cell assembly can then be removed by a puller as shown in Figure 79.

If excessive carbon is present, the injector may be faulty, and, therefore, the injector should be carefully checked as noted in paragraph 90*d*. Inspect the air cell for burned spots, paying particular attention to the leading edge of the air cell which is directly opposite the injector when the air cell is in place in the cylinder head. Clean out any carbon deposits with a piece of hard wood. Do not use emery paper or any metal in removing the carbon. **CAUTION: Do not change the contour of the air cell in any manner. If burned internally, replace the air cell.**

d. Removing Valve Springs. Compress the valve spring with a compressor and remove the retainer halves as shown in Figure 121. Release the compressor tool and remove the valve spring, valve spring seat and valve safety clip. (See Figure 122.) The valve can now be removed.

NOTE: As a precaution, check the edges around the groove in which the safety clip seats to be certain that no burrs have been made when installing or removing the clip. The burr, or burrs, may scratch the guide when the valve is slipped out; therefore, remove the burrs with a hand stone before removing the valve if there is a burr on the stem.

e. Checking Valve Seats and Valve Guides. Inspect the exhaust and intake valve seats for burns, cracks, or pits. The exhaust valve seats can be replaced. The intake valve seats can be refinished with a valve seat refacer or grinder as shown in Figure 125. Check the valve guides for wear by inserting a valve and noting the amount of side play; maximum allowable clearance, intake to guide, .0055 inch; exhaust to guide, .0055 inch. If worn, remove the guide by driving it from the head with a driver. Press in new guides with an arbor press or drive in with a suitable driver. Ream guide so that clearance between new valve and guide will be between .002 inch—.0035 inch intake, .002 inch—.0035 inch exhaust.

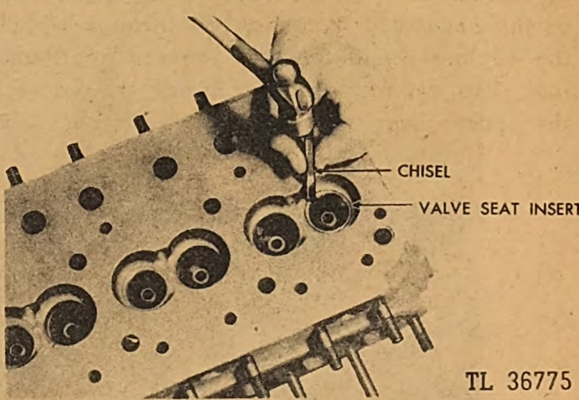


Fig. 123. Removing Exhaust Valve Seat Insert

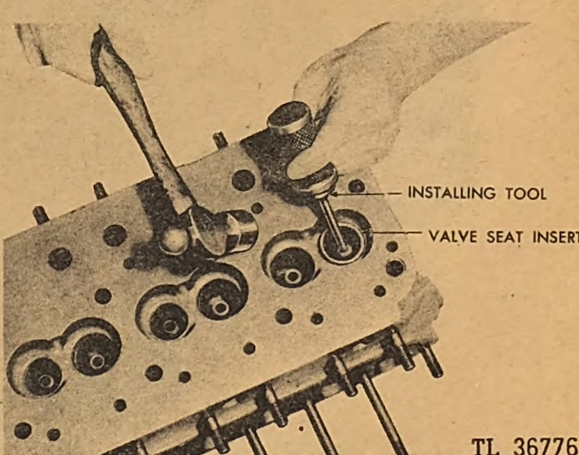


Fig. 124. Installing Exhaust Valve Seat Insert

f. *Replacing the Exhaust Valve Inserts.* The exhaust valve seat insert is held in place by a shrink fit. To remove the insert, center punch the insert and drill. Be careful not to drill through into the valve seat insert recess. With a small cold chisel, carefully break through the drilled holes and remove the insert. (See Figure 123.) Be careful not to mar the face of the cylinder head.

Remove all the burred edges around the hole and be sure the insert recess is clean. To install the new insert, chill it with dry ice and drive it in place with a driving tool as shown in Figure 124. Refinish the valve seat with a grinder. The same grinder can be used on the intake valve seat. (See Figure 125.)

NOTE: If no dry ice is available or climatic conditions are such that the foregoing procedures are not feasible, the following is recommended:

In hot climate, let the cylinder head stand in the sun until it gets as hot as the sun can heat it. Cool the valve seat insert as much as possible. Then drive the insert into the block as shown in Figure 124.

In cold climate, lay the valve insert on ice or let it remain outdoors until it is thoroughly chilled. Remove the chill from the cylinder head and fill the water jackets with boiling water. It may be necessary to change the water three or four times to warm

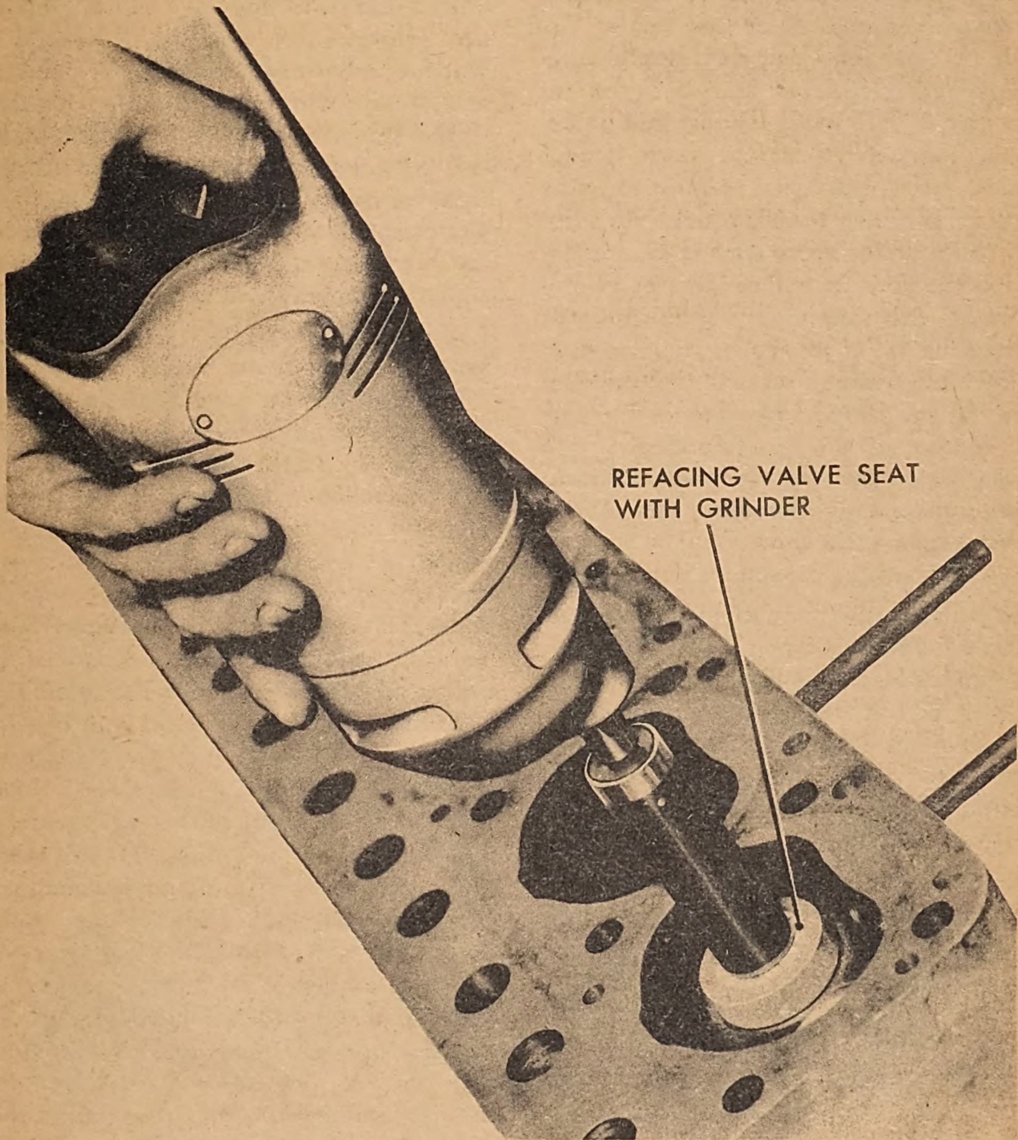


Fig. 125. Refacing Valve Seat

the cylinder head sufficiently. With the water still in the cylinder head to retain as much heat as possible, drive the valve seat insert in place as shown in Figure 124.

The intake valve seats should be 1/16 inch wide, and the exhaust valve seat should be 3/32 inch wide. As refacing broadens the seats, it will be necessary to narrow the seats with 20-degree and 70-degree stones. The above procedure is recommended only for the skilled mechanic.

g. Checking Valves for Grinding and Replacement. If the valves are warped, burned, or severely pitted, they must be replaced. If the valves are pitted slightly, reface the exhaust and intake valves at a 45-degree angle. Examine the valve stems for any appreciable wear; maximum clearance limit between intake and guide, .0055 inch; exhaust and guide, .0055 inch. Replace valve and guide if over these limits. New intake and exhaust to guide clearance is .002 inch to .0035 inch. Any appreciable wear on the valve stem is usually denoted by a shoulder near the valve head and one near the valve stem end, indicating the valve travel limits. If the valve stem is worn any appreciable amount, an accurate refacing operation on the valve face cannot be performed because of the irregularities of the valve stem which prevent the valve refacing chuck from accurately centering the valve. In this case replace the valve.

h. Grinding Valves. When necessary to grind the valves, use a good quality, water soluble valve grinding compound. This type of compound loses its cutting properties on contact with oil. A valve grinding tool like the one shown in Figure 126 or one similar is recommended. The difference between a good grinding and poor grinding job can be seen in Figure 127.

Thoroughly examine the valve stems and the valve guide clearance before grinding the valves. Do not mix the valves during the inspection, because the same valve must always go back into its original port. The intake and exhaust valves are made of different materials and if exchanged they will not give proper service.

The valve stems can be cleaned with gasoline and a cloth buffer. Do not, under any circumstances, use emery cloth or a wire brush on the stem, for the smooth glaze which is a normal result of engine operation will be destroyed. It is desirable to retain this glazed finish, since it prevents metal to metal contact. A wire brush may be used to free the valve heads of carbon.

Before beginning the actual grinding of the valves, all traces of carbon should be removed from the cylinder head and valve chambers, or ports. Do not scratch the valve seats or damage the metal in any way when removing the carbon.

It is not always necessary to reface the valves and recut the valve seats. Only if there are evidences of warping or serious pitting will the valve need refacing. A good method of detecting warping is to put each valve stem in the chuck of a valve lathe and slowly rotate the valve and grinding wheel. (The wheel must be set to the proper valve seat angle of 45 degrees.) Move the grinding wheel toward the valve until it almost touches the valve. Any slight eccentricity will be noticed immediately.

If there are deep pits or grooves on the valve seats, recut the seats to a 45-degree angle.

If the valve faces and seats are believed to be in sufficiently good condition to grind in properly without reconditioning, a final test with valve compound should be made. First place a circular piece of fine emery cloth which is slightly larger than the valve port over an old valve head or a valve seat reamer, so that the cloth will be between the valve and seat with the cutting side against the seat when the valve is placed in the cylinder. Pushing firmly on the valve head with the grinding tool, rotate the valve back and forth to remove the hard glaze from the valve seat. Unless this is done, a great amount of unnecessary grinding will be spent in cutting through this glaze.

To test the seat and valve condition with grinding compound, place a very little bit of compound on the valve face and grind against the seat in the usual manner. After a short time, remove the valve and clean both seat and valve of grinding compound. If both valve and seat show an even gray mark around their entire circumference, this proves that they are contacting fairly well and that grinding may be accomplished without refacing and recutting. If either valve or seat shows a mark around but part of its circumference, then re-

Fig. 126. Valve Grinding Tool

conditioning is necessary before a satisfactory grinding job can be accomplished.

When refacing valves, remove just enough to clean up the seat, and remove all evidence of pitting and grooving. Then put that particular valve in place, with a little grinding compound, and grind lightly. Then with the proper refacing angle stones (usually 20 degrees and 70 degrees), narrow the seat down until it is slightly narrower than the valve face. The width of the finished seat should be between 1/16 inch and 3/32 inch. Unless this is done it will be impossible to get a good valve seat no matter how long you grind.

To grind the valves, put a small quantity of valve grinding compound on the valves, just sufficient to cover the seating area. Grind the valves with a light but firm pressure, letting the spring lift the valve from the seat every two revolutions of the valve grinding tool crank. As soon as the "grinding feel" diminishes, wash the valve and seat in kerosene and examine the seat and valve. If the valve face or seat has lines or rings ground in it, this indicates that either the valve grinding compound was ground out, or too much pressure was applied, or the valve was not lifted off the seats often enough during the grinding operation. Therefore, the grinding must be done over.

If the valve and seat have the appearance of grey emery paper, apply a small amount of Prussian blue on the valve face. Wipe off the excess so **just a faint trace of blue** appears. Insert the valve and turn the valve on the seat one complete revolution under slight pressure. If the valve seat has a light blue ring completely around the seat, this indicates that the valve is seating properly. If the line is not complete, the valve and seat are not making complete contact and must be ground until they do. (See Figure 127.)

Be sure to wash off the compound when the job is finished and again check to see that all loose pieces of carbon around the valves and particularly between the piston head and cylinder walls are removed, for many well-done jobs of valve grinding are ruined by failing to remove small particles of carbon.

When grinding the valves, avoid scratching or marring the seats or stems. Be very careful to avoid grinding compound entering the valve guides, and all traces of compound must be cleaned away at intervals during the grinding to avoid excess amounts spilling onto valve stem.

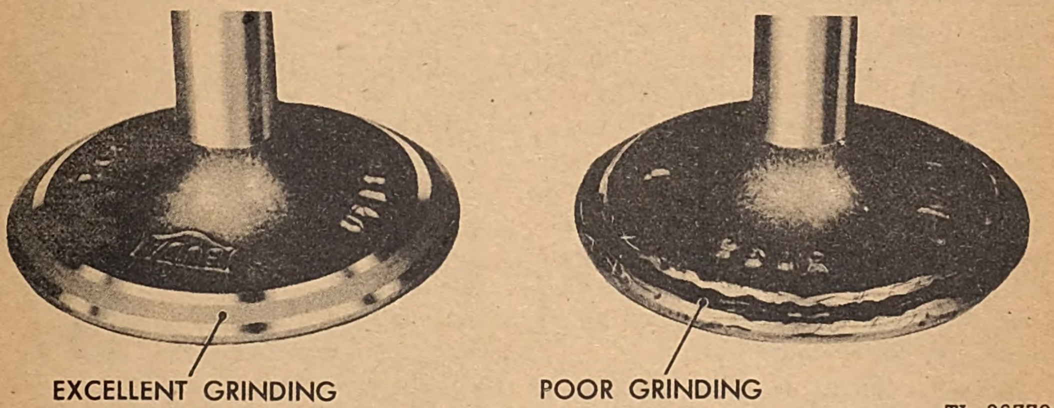


Fig. 127. Good and Bad Valve Grinding

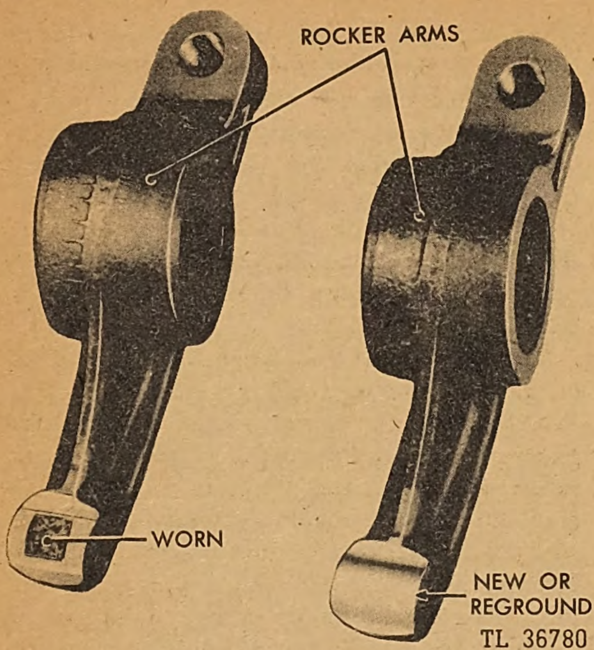


Fig. 128. Worn and Reground Rocker Arms

After valve grinding is completed, the parts should be thoroughly cleaned before reassembly, and the valve stems oiled.

i. Checking Valve Springs. Check the spring tension of each spring with a spring scale designed for this purpose. The tensions should all be equal. If the springs are weak, cracked, or broken, replace the spring.

NOTE: When the spring is compressed to the length of $2\frac{5}{16}$ inches, the scale should read 35 to 38 pounds, which is equivalent to the valve closed position. When the spring is compressed to the length of $1\frac{13}{16}$ inches, the reading should be 78 to 86 pounds, which is equivalent to the valve open position.

j. Checking Lifters and Brackets for Replacement. The lifter is of mushroom type and is made of grey iron with a chilled head. Check the lifter for cracks and replace if cracked. Check the lifter holes in the bracket by inserting a lifter in the hole. Lifters must be free fit in bracket without being "sloppy" or loose. Maximum clearance between lifter and bracket should not exceed .002 inch. Both the bracket and lifters must be replaced if worn beyond the limit specified. Each bracket contains two sleeve dowels to locate its position on reassembly. (See Figure 92.)

k. Retainers and Seats. Only because of loss or accident should it become necessary to replace the valve spring seats and retainers.

l. Valve Push Rods. Valve push rods should be inspected whenever removed. Rods should not be bent or twisted. They should be removed before the cylinder head is removed, and replaced after the cylinder head is installed to prevent damaging push rod. Examine the ball and cup ends of the rod for signs of undue wear; polish out any nicks or scores with a hand stone.

m. Valve Rocker Arms. Bushings in valve rocker arms are pressed in; oil holes are drilled after bushings are pressed in. Valve rocker arm bushings are broached to very close tolerances. When bushings have become worn, replace complete rocker arm. Rocker arms should be replaced when the clearance between the shaft and the arm exceeds .006 inch. Examine the rocker arm where it contacts the valve stem; if worn, either replace or regrind to the original contour. Figure 128 illustrates a worn rocker arm in comparison with a new rocker arm.

NOTE: When the rocker arm is worn as illustrated, it is impossible to secure accurate valve to rocker arm clearance (tappet adjustment.) Check the rocker arm wick; if hard, replace as shown in Figure 129. The rocker arm wick feeds the oil from the rocker arm shaft to the contact surface between the rocker arm and the valve stem.

Check the rocker arm shaft for wear; no shoulders should be in evidence indicating the rocker arm locations. Blow out all oil holes with compressed air. The rocker arm springs should show no broken or weak coils. Examine No. 2 rocker arm bracket, counting from the gear end of the engine; check the copper gasket in the mounting bracket; blow out the oil passage. Examine the rest of the brackets

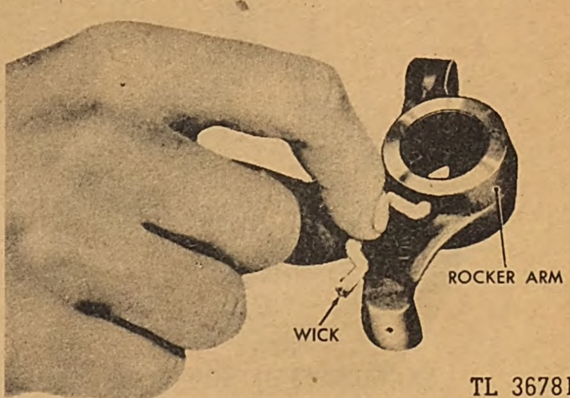


Fig. 129. Rocker Arm Wick

for cracks and presence of dowels, with the exception of No. 5 bracket which has no dowel. Check the rocker arm adjusting screw ball ends, and hone out any scratches or scores. Replace if worn severely.

n. Valve Cover. The cast-iron valve cover is held in place with two nuts and four special capscrews. Under each nut and capscrew a plain washer seals against the valve cover through a leather washer, thus preventing the valve mechanism from absorbing dust from the outside or leaking oil. The valve cover is sealed to the head with a cork gasket. Replace the gasket if cracked or broken. Wash the cover thoroughly, inspect for cracks and replace if necessary. Blow out the breather passages with compressed air.

o. Installing Valves. Insert the valve in its proper place. Make certain that the exhaust valves are in the exhaust ports and that the intake valves are in the intake ports. Install the safety clip in the groove on the valve stem, as shown in Figure 122. Compress the spring as shown in Figure 121 and install the retainer halves.

NOTE: Keep each valve in order so that it can go back in its original place.

54. Flywheel and Flywheel Housing. The flywheel stores the energy received from the power impulses of the crankshaft and returns this energy to the crankshaft between power strokes, thus maintaining an even rotary motion of the crankshaft. Inspect the flywheel ring gear for damaged teeth. If teeth are mutilated, replace with a new ring gear. Examine the bolt holes; if they are loose or worn, replace the flywheel and flywheel bolts. Inspect the bell housing for cracks; if cracked, replace the housing. Whenever flywheel is replaced, check timing marks on new flywheel with those on removed part.

a. Removing and Installing Ring Gear. To remove the old ring gear, lay the flywheel flat on the floor with the front or crankshaft side of the flywheel up. With a $\frac{3}{16}$-inch drill, drill two or more holes through the gear parallel with the teeth and in a line drawn from the center of the flywheel to the rim. Be careful

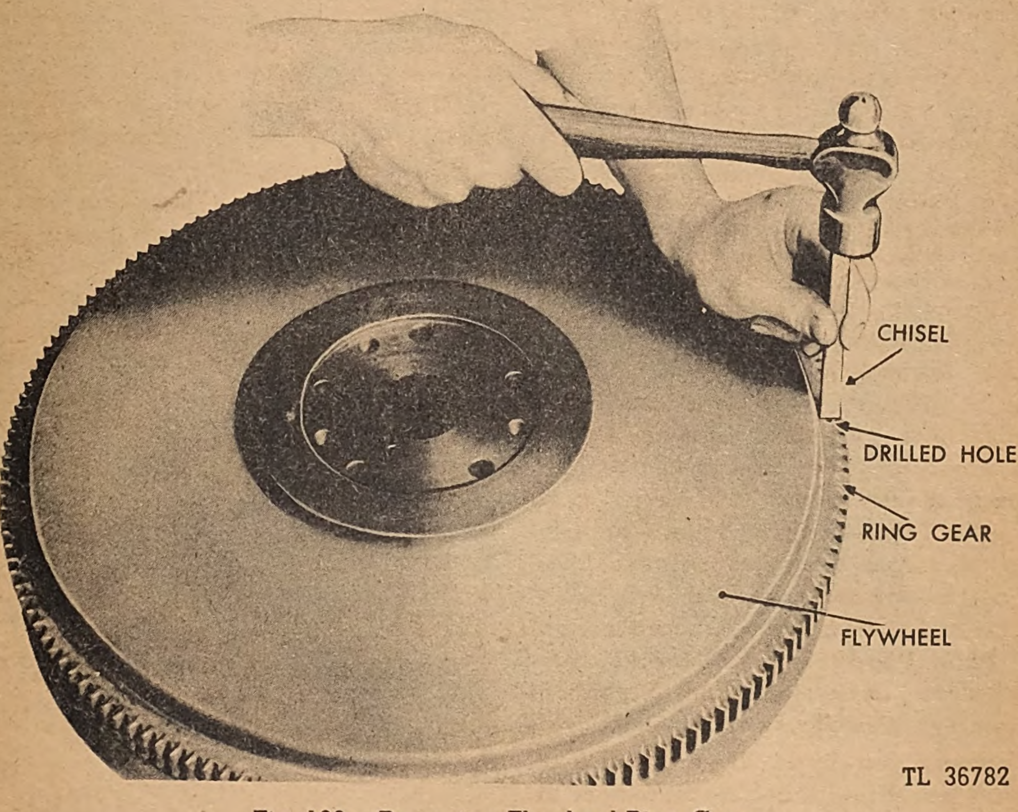


Fig. 130. Removing Flywheel Ring Gear

not to drill into the flywheel shoulder. With a cold chisel, cut the remaining metal between the holes to split the gear completely in two. (See Figure 130.) Drive off the ring with a punch and hammer. Boil the new ring gear in oil for 15 minutes, or heat evenly with a torch to expand the gear. With the flywheel flat on the floor, front side (crankshaft side) up, lay the heated ring gear in place with the bevel end of the teeth up. Be sure the ring gear is seated properly against the shoulder, then allow to cool.

55. Gears and Housing. The gears transmit the power necessary to turn the camshaft and accessories in order to co-ordinate the valve action and fuel injection, so that all the events necessary for the correct functioning of the engine are performed at the right time and in the proper order. The crankshaft gear drives the camshaft gear. The camshaft gear drives the fuel pump through a two-section idler gear imposed between the two. (See Figure 131.) The camshaft and fuel pump shaft turn in the opposite direction of the crankshaft. The gears are on fixed centers and adjustments are made by selecting oversize or undersize gears.

The idler gear rotates on a stub which is pressed into the crankcase. The shaft is secured by a lockscrew which screws into the right hand side of the case. (See Figure 132.) The crankshaft, idler and fuel pump gears are made of heat-treated steel, while the camshaft gear is made of alloy cast iron. This selected combination of metal assures long wear and quiet running of the timing gear train.

a. Checking Gears. The crankshaft, idler, camshaft and fuel pump gears should be fitted with .0005 to .0015 inch backlash; water pump gear maximum, .012 inch backlash. See Figure 131 for picture of the entire gear train. Refer to paragraphs 48*g* and 48e, and Figure 90, for method of checking the backlash of the gears.

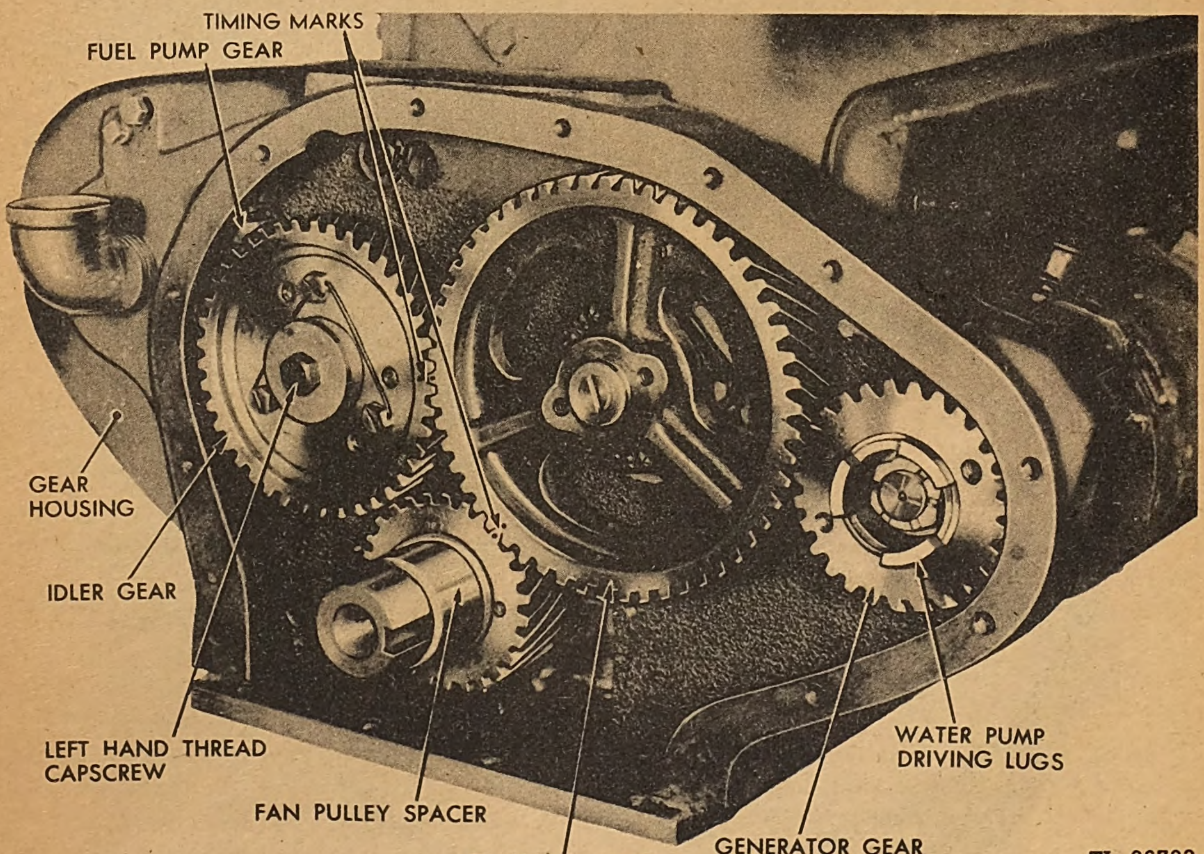


Fig. 131. Gear Train

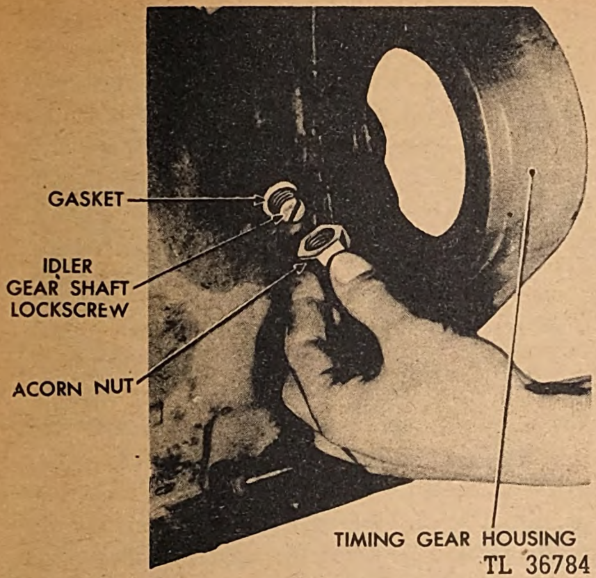


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Fig. 132. Idler Gear Stub Shaft Lockscrew

Normally, the gear train will not have to be renewed during the life of the engine. When one gear is worn more than others, it is recommended that the whole gear train be replaced. However, if replacing only one gear, use the old size marking. If timing marks are not on the new gears, be sure to transfer the timing marks from the old gears.

Each gear is marked with a number within either an O or a letter U, thus 3 or 2. The surrounding symbol denotes oversize (O) or undersize (U) respectively, and the number gives the deviation from the standard in thousandths of an inch. The letter S denotes standard size.

NOTE: The new gear, or gears, for replacement must correspond in size to the gear or gears replaced. Due allowance should be made for wear.

For example: Suppose the camshaft gear has .008-inch backlash against the crankshaft and idler gears, and it is stamped 3, which designates the gear as originally being .003 inch undersize. Replacing the gear with one stamped 2 will decrease the backlash to approximately .003 inch.

b. Replacing Idler Gear and Bushing. If the idler gear bushing to shaft clearance exceeds .004 inch, the bushing needs to be replaced.

NOTE: If the bushing is replaced, it must be bored in a lathe to a running fit on the stud. Hand reaming will not be straight and will cause the gear to run out. The new clearance between the idler gear bushing and shaft should be .0015 inch to .0025 inch. It is recommended that a new idler gear be installed rather than rebush the gear.

If it becomes necessary to separate the idler gear from the fuel pump drive gear, remove the three retaining capscrews. Using two of the capscrews in the threaded holes provided in the idler gear, push the two gears apart. (See Figure 133.)

c. Replacing Cam Gear. To replace the cam gear with the camshaft removed from the engine, remove the retaining clip from the end of the camshaft as shown in Figure 134. With an arbor press, press the camshaft out of the gear as shown in Figure 135.

Install the new gear and be careful to line up the gear keyway with the key and press in place as follows: With the thrust plate in position and a .003-inch feeler gauge between the plate and the gear, press on the gear until the .003-inch feeler gauge has a definite drag between the gear and the thrust plate or until the gear will go no farther. New clearance may be between .003 inch to .009 inch. Install gear retaining clip. (See Figures 94 and 134.)

d. Gear Housing. Inspect timing gear housing for cracks or mutilations. Barring accidents, it isn't likely the housing will ever need replacing during the engine's lifetime.

e. Gear Cover. Examine cover for cracks

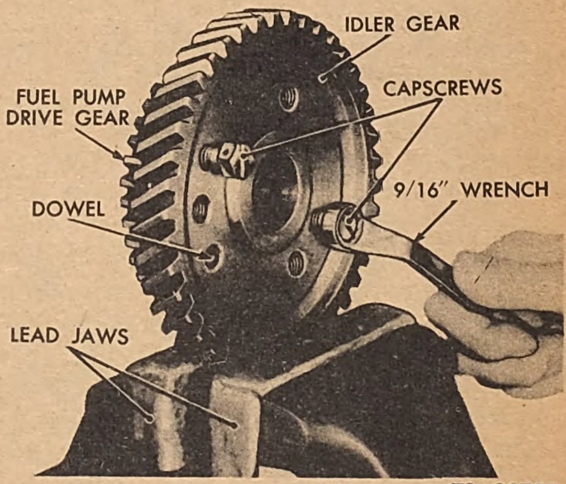

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Fig. 133. Separating Idler Gear and Fuel Pump Drive Gear

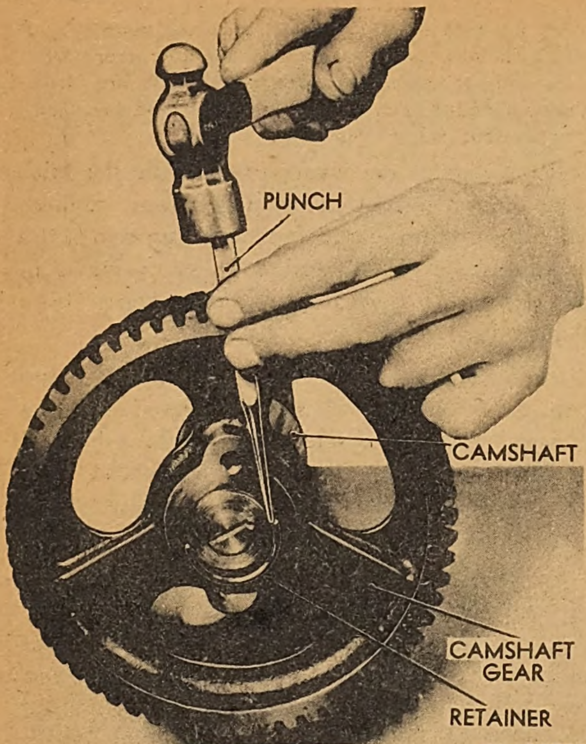

Fig. 134. Removing Cam Gear Retaining Clip

or mutilations. Remove old oil seal as shown in Figure 136. Install new oil seal as shown in Figure 137.

NOTE: The spring side or leather edge of the oil seal must be facing inward toward the gears when installed in the gear housing cover. (See Figure 138.) Check fan drive pulley spacer for worn groove from old oil seal. If groove is present, replace fan drive pulley spacer.

NOTE: The spacer can be removed only by pulling off the crankshaft gear. (See Figure 119.)

56. Main Bearings. Bearings locate and protect the contacting surfaces of the reciprocal or rotary parts when adequately lubricated. The main bearings are hard copper lead lined, steel backed, precision type. No scraping or fitting is required. Replacements can easily be made in the field. It is recommended that if one main bearing needs replacing, they should all be replaced. The upper shells are not doweled; the lower shells are doweled in the caps to hold them in place. No shims are required.

a. Inspection. Look for holes or cracks in the bearing surfaces and check the assembled bearings with an inside micrometer. It is necessary that the main bearings be in the case and the caps clamped on to obtain accurate measurement. If there are pin holes and cracks in the bearings and the crankshaft wear is less than .0015 inch, replace with new bearings of standard size.

NOTE: New main bearing standard size is 2.999 to 3.0002 inches. If the main bearing wear is more than .0015 inch and the crankshaft wear is negligible, replace them with bearings of standard size.

b. Replacement. Install upper halves of shells. (See Figure 154.) Make sure that the supports in the case are not marred and that there is no dirt or foreign matter between the shell and the case. Install the lower half in the cap so that the bearing fits over the dowel in the center of the cap. Do not file the

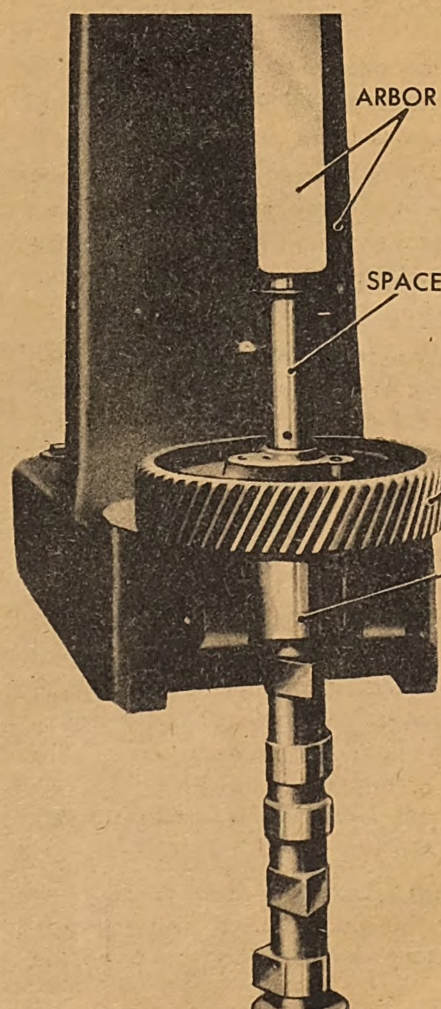

Fig. 135. Pressing Off Cam Gear from Shaft

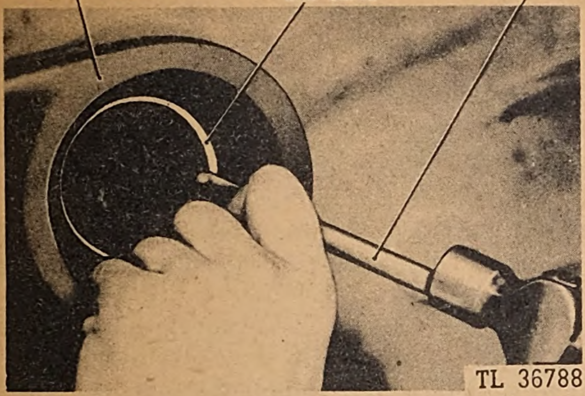

Fig. 136. Removing Gear Cover Oil Seal

face of the caps. If the crankshaft clearance is excessive (more than .0065 inch) when the caps are drawn down tightly, it will be necessary to install undersize bearings. If it should be necessary to install undersize bearings, the crankshaft journals should be reground.

c. *Rear Bearing Cap and Oil Seal.* Attached to the rear bearing cap is the rear bearing oil seal. Along the side of the rear bearing cap are oil stops which help to prevent oil leaks through the rear main bearing.

d. *Replacing Oil Stops.* Replace the rear main bearing cap oil stops during the overhaul. (See Figure 139.) If the standard oil stops are not available, the grooves can be packed with candlewick which can be firmly

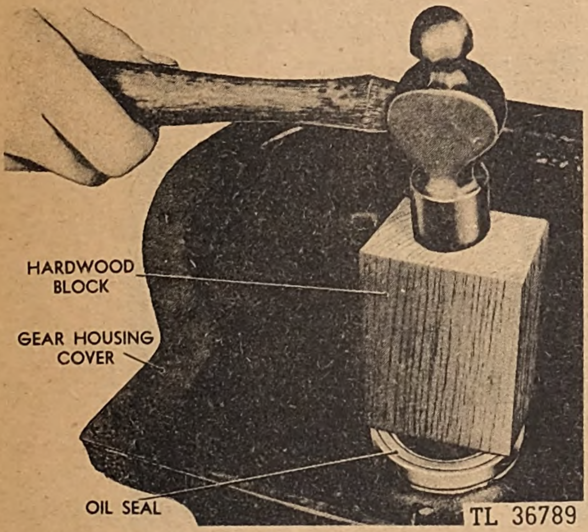

Fig. 137. Installing Oil Seal

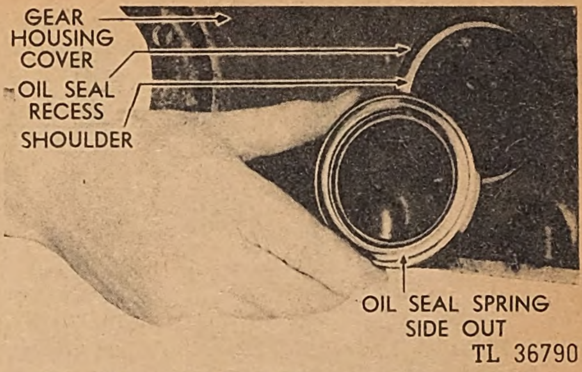

Fig. 138. Oil Seal Showing Spring Side

calked into place by means of a small tapered tool, or punch and hammer after the cap is assembled in place. Pound the candlewick gradually up to the grooves until they are packed full. Also replace the rear bearing oil seal felt during overhaul. To replace the rear bearing oil seal felt, remove the old felt from the oil seal groove with a knife, but do not cut away any of the metal. Coat one side of the new felt with shellac and calk the felt into the groove with the shellac side down, as shown in Figure 140. The shellac must not be allowed to penetrate through to the crankshaft side of the felt. Oil the surface of the felt with graphite grease to keep the felt from burning up when the engine is first started.

e. *Field Replacement of Main Bearings.* Replacement can be made in the field by simply pushing out the old shell as shown in Figure 141. This is best done by inserting into the oil hole in the crankshaft journal, a small bolt of practically the same diameter as the oil hole in the shaft; but with the head filed down to less than $^3/_{16}$ inch. Slowly turn the crankshaft

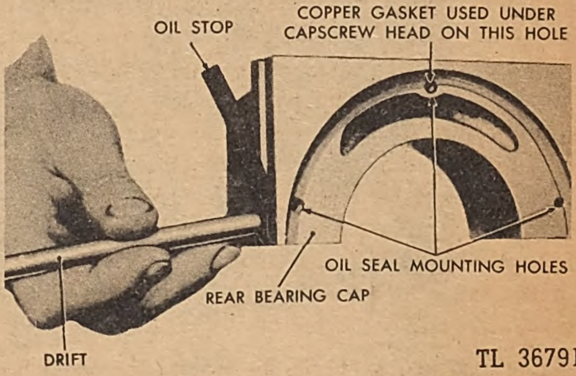

Fig. 139. Installing Oil Stops in Rear Cap

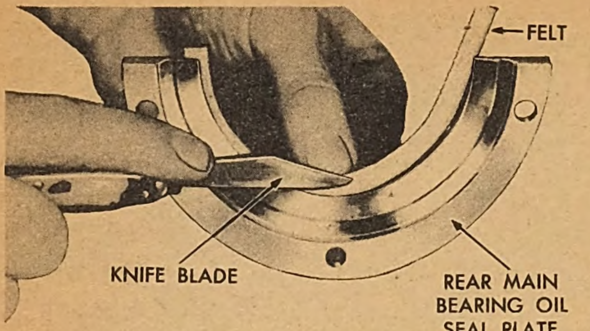

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Fig. 140. Installing Oil Seal Felt

by hand and push the old shell out. As mentioned in the fore part of paragraph 56, it is recommended that if one main bearing needs replacing, they should all be replaced. However, remove and install one set of bearings at a time. The crankshaft journals should be free from nicks and scores, and the clamping surfaces of the caps or the supports should not be marked. To install a new shell, start the shell into position by hand, being careful not to mar the bearings. After it is well started, insert the same bolt that was used to remove it, only this time allow the head to project over the bearing shell to keep it from raising up, as shown in Figure 142, as the crankshaft is slowly turned by hand. When almost in place, stop and back up the crankshaft to release the bolt from over the shell and insert a bolt of the same diameter, but with a higher head, and slowly push the shell into position by turning the crankshaft.

57. Manifolds, Intake and Exhaust. The manifolds serve as collectors for incoming or outgoing gases and connect the multiple ports to single openings or outlets. Check the manifolds for cracks and for warping.

Lay a straight edge, as shown in Figure 143, on the exhaust manifold. If warped, the manifold can be remachined—remove as little metal as possible. Check also the intake manifold in like manner with a straight edge for warping.

NOTE: If the manifolds are cracked, it is recommended that they be replaced rather than brazed.

Remove the water jacket covers on the water-cooled exhaust manifold and clean out any scale or rust that might be present. Install new gaskets under the covers. (See Figure 69.) Remove the exhaust manifold elbow and the exhaust manifold end plate—clean out any carbon deposits. (See Figure 70.)

58. Piston and Connecting Rod Assembly. The piston and connecting rod assembly, through reciprocating motion, transmits the work energy created by the expanding gases in the cylinder to the crankshaft, which changes this reciprocating motion into rotary motion, the form in which it is utilized.

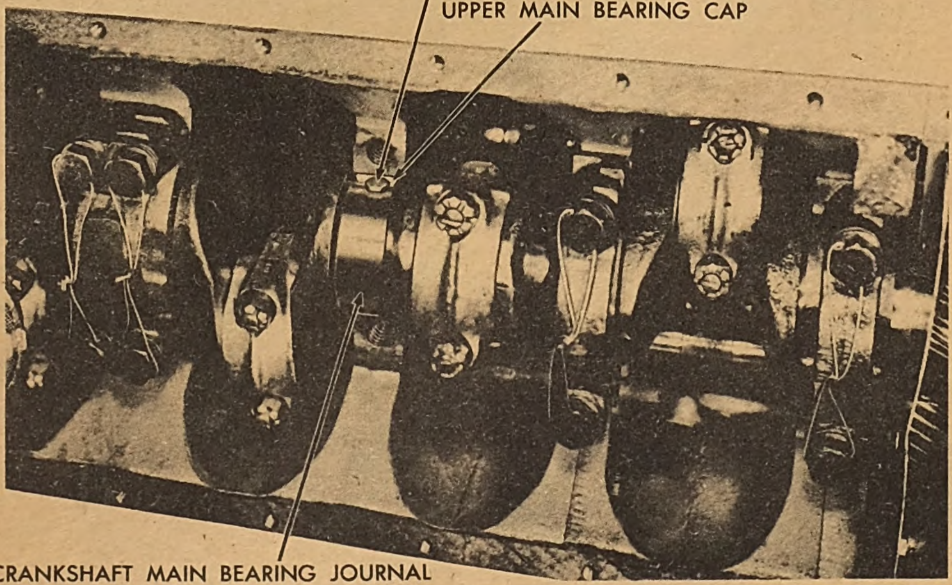

Fig. 141. Removing Upper Main Bearing Shell

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a. Pistons. The pistons are of aluminum alloy and have four rings above and one below the piston pin. The top three rings are compression rings; the lower rings are ventilated oil rings. If the cylinder sleeves are replaced, the pistons will also have to be replaced. After the piston and connecting rods have been disassembled and the piston rings removed, thoroughly clean the piston and inspect the grooves and ring lands for burns and cracks. Check also the head of the piston and skirt both inside and outside for cracks. Replace if necessary. The maximum clearance allowed between the piston and sleeve before replacement is necessary is .009 inch.

When new pistons and sleeves are installed, always replace the piston pin bushing in the connecting rods if the pin to bushing clearance exceeds .0015 inch, and realign the connecting rods. (See paragraph 58*g*.)

b. Checking and Replacing Piston Pin. The piston pins are full floating type and are made to rotate in either the piston or the connecting rod bushings. The pins are held in place by means of two snap rings which lock in grooves in the outer end of the piston pin bosses. These rings prevent the pin from coming in contact with the cylinder walls. If these grooves are worn so that the locks will not fit tightly in these piston grooves, the piston will have to be replaced.

The pins have the ends ground flat and polished to prevent their cutting through the lock ring. Replace the lock rings in the piston if any signs of wear on the rings are visible. The pin to piston is a .0000 inch to .0005 inch fit when new; maximum clearance before replacement, .0015 inch. The piston pin to connecting rod bushing is .001 inch to .0015 inch fit when new; maximum clearance before replacement, .0025 inch. The piston pin bushing should be reamed or honed to allow thumb push fit as shown in Figure 144.

If the piston pin to bushing clearance exceeds .0025 inch, replace the pin. Replace the piston and pin if the pin to piston clearance exceeds .0015 inch. No oversize piston pins are available. Field experience has proved that the piston pin will usually last the lifetime of the piston. When new pistons are installed, always replace the piston pin bushings if the clearance exceeds .0015 inch between the pin and bushing.

Particular care should be used when installing the snap rings or retainer rings. Use a pair of long nose pliers, as shown in Figure 145, and make sure that they fit snugly into the groove. Do not force the retainer rings into

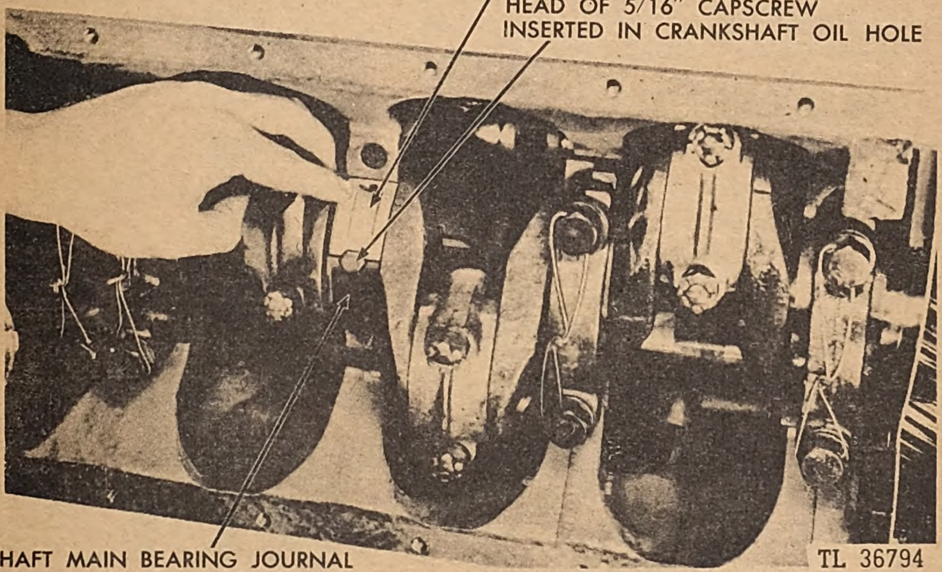

Fig. 142. Installing Upper Main Bearing Shell

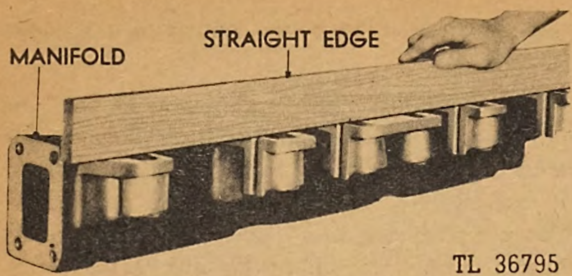

Fig. 143. Checking Manifold for Warping

or out of the grooves with a screwdriver. When these retainer rings are installed correctly, they cannot be readily turned with the fingers. If the piston pin bushing has to be replaced, it will be necessary to realign the connecting rod as given in paragraph 58*g*.

NOTE: To install the pin into the piston, allow the piston to stand in boiling water for about five minutes, after which install the pin. The reason for the heating is to allow the piston boss to expand so as to allow the pin to be installed. The pin to the connecting rod is a very light push fit.

c. Checking and Replacing Piston Rings. Always replace the rings during the overhaul, whether or not the cylinder sleeves have to be replaced.

NOTE: If at any time after 100 hours of operation a piston or pistons have to be removed from the engine, always replace the rings with new ones. This is recommended because it will be impossible to get the piston rings back into the same positions that they were in. Consequently, if they are not replaced, there is a possibility of the pistons pumping oil It is also recommended not to slip the new rings onto the pistons until they are ready to be put back into the engine.

Check the depth of the ring groove and check the groove clearance as shown in Figure 146. Fire ring to groove clearance is .003 inch to .005 inch; maximum before piston replacement, .007 inch. Compression ring to groove clearance is .0015 inch to .0035 inch; maximum before piston replacement, .005 inch. To check the ring gap, place the ring in the cylinder at the top above the ring travel. With the ring square with the cylinder walls (a piston can be used to straighten the ring in the cylinder), measure the gap between ends as shown in Figure 147. The fire ring gap should be .015 inch to .020 inch. The compression ring gap should be .007 inch to .012 inch. The oil ring gap should be .011 inch to .016 inch. If the gap is less than that specified above, remove the ring and dress the ends with a fine cut file until the proper clearance is obtained.

NOTE: The rings should be a selected fit to each individual bore and piston groove. When piston and ring assembly are installed in the cylinders, gaps in the rings should be staggered around the piston.

d. Connecting Rods and Bearings. With an inside micrometer, check the connecting rod bearing with caps in place. If worn more than .0015 inch, or the reading is more than 2.3765 inches, the bearings should be replaced with standard size, provided that the crankpin bearing surface wear is negligible and no regrinding of the crankshaft is necessary.

When it is necessary to remove the bearings

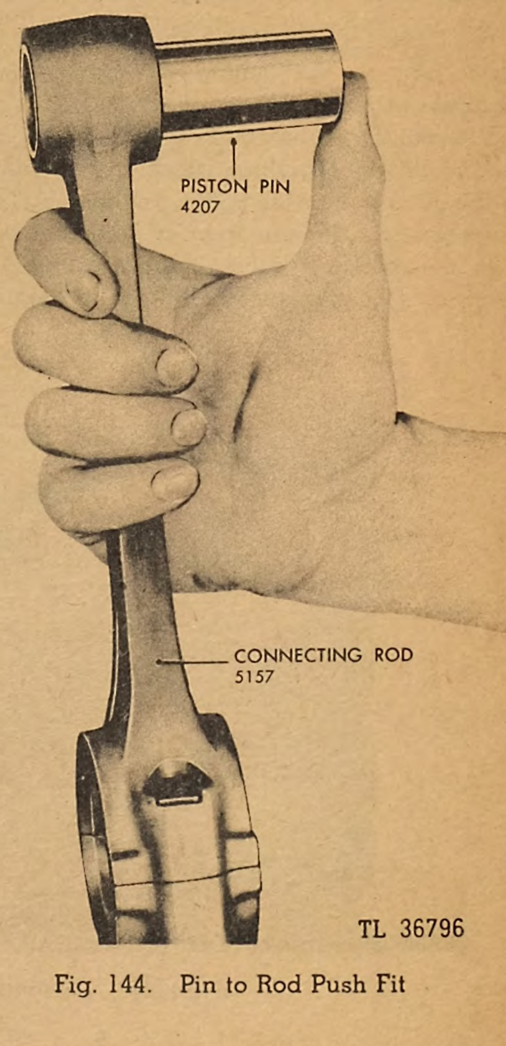

Fig. 144. Pin to Rod Push Fit

and replace them, remove and install one set of bearings at a time. Check the crankpins. They should be free from marks or scores. The clamping surfaces of the cap or rod should not be marred. To install the new bearings, proceed as follows:

(1) Place bearing halves in the connecting rod cap. Be sure that these bearings, as well as the rod and cap, are clean and free of metal burrs. Notch locks of the bearings must seat firmly in the similar locks of the rod and cap.

(2) Do not file the face of the caps. If the bearings do not fit when the caps are drawn down tightly, it will be necessary to install undersize bearings. The side clearance of the connecting rod between the side of the bearing and the crankshaft should be .004 inch to .009 inch; maximum permissible .013 inch.

e. Field Replacement of Connecting Rod Bearings. To replace a connecting rod bearing in the field, it will be necessary to drain the oil and remove the oil pan. Remove the cap and remove the old bearing by tapping lightly on the edge of the bearing cap. (See Figure 148.)

f. Inspecting and Replacing Connecting Rod. If the piston pin bushing is loose in the connecting rod, usually the entire rod must be replaced, otherwise even the new bushing would fit loosely. If the piston pin to bushing is more than .0025 inch, install new piston pin and bushing. If new pistons are installed, always install new piston pin bushings if the pin to bushing clearance exceeds .0015 inch. Whenever new piston pin bushings are installed, it will be necessary to check rod alignment. (See paragraph 58*g*.)

The new piston pin to connecting rod should be a thumb press fit as shown in Figure 144. Be sure that the new bearing oil hole aligns with the rifle-drilled connecting rod oil hole. To remove any foreign matter in this drilled hole, blow out the passage with compressed air.

g. Aligning Connecting Rods. (1) With piston and connecting rod assembly clamped

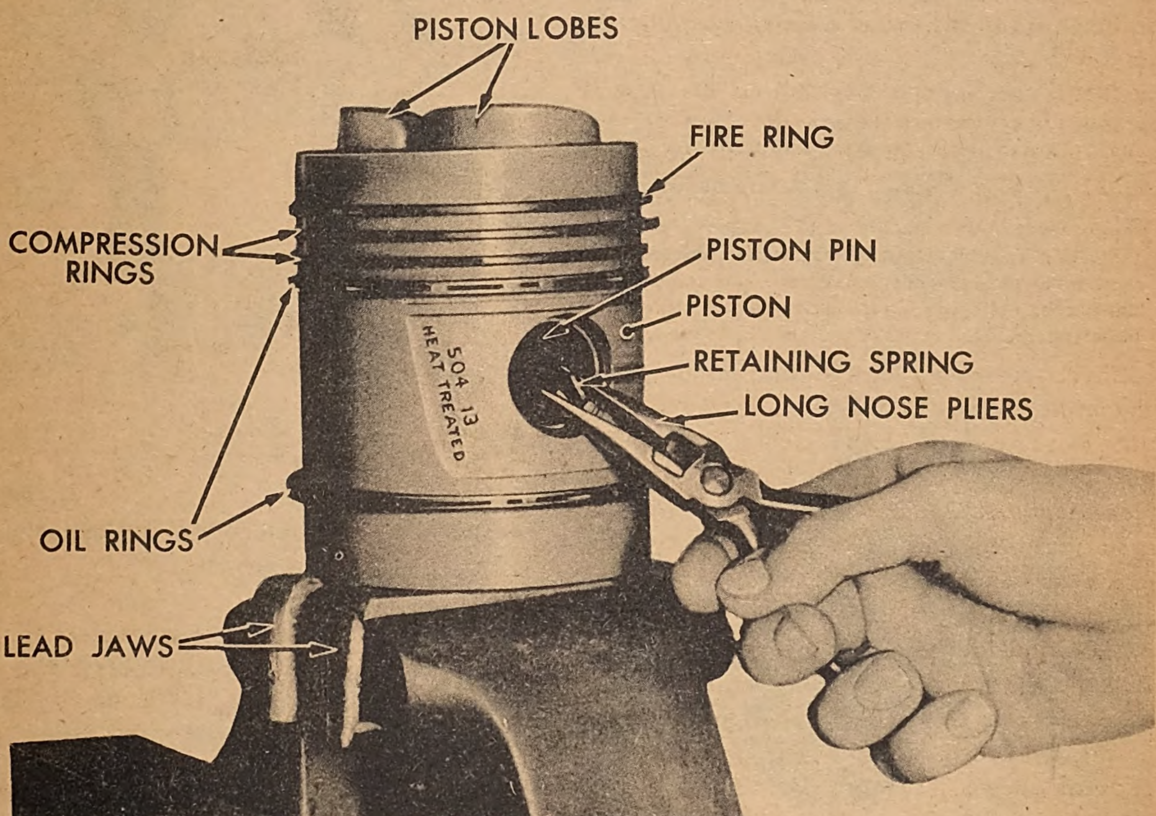

Fig. 145. Removing Piston Pin Snap Lock Ring

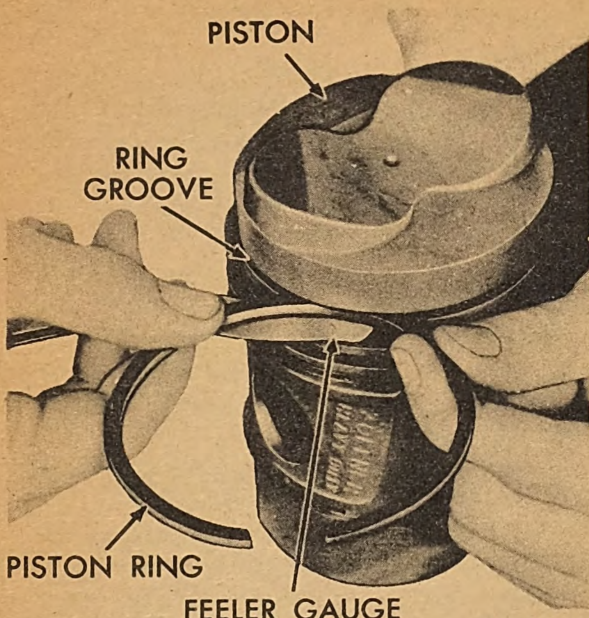

Fig. 146. Checking Ring to Groove Clearance

onto the mandrel of the aligning fixture, swing the rod into a horizontal position (parallel to the floor). With the piston held diagonally to the rod (piston head pointing to the floor), observe the space between the face of the fixture and the skirt of the piston as shown in Figure 149; if this space is not equidistant, the rod is twisted out of line.

NOTE: The ring lands at the top of the piston are smaller than the skirt; therefore, check the alignment of the rod along the full length of the skirt only. Twist the rod with a large wrench until space between the aligner and the piston is even. (See Figure 150.)

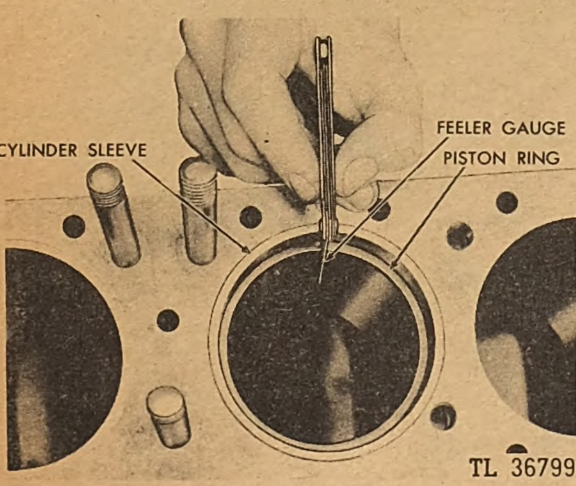

Fig. 147. Checking Piston Ring Gap

(2) Now check for a twist in the opposite direction by moving the piston into the opposite diagonal line to the rod (piston head pointing up). (See Figure 151.) Observe the space between the aligner face and piston skirt; if the space is uneven, twist the rod with a large wrench until true alignment is obtained.

(3) Check for a bent rod by moving the piston into a parallel position with the connecting rod (see Figure 152), and observe the space between the aligner face and the piston skirt; if the space is not even, the rod is bent. Straighten by carefully bending the rod with a large wrench. (See Figure 153.)

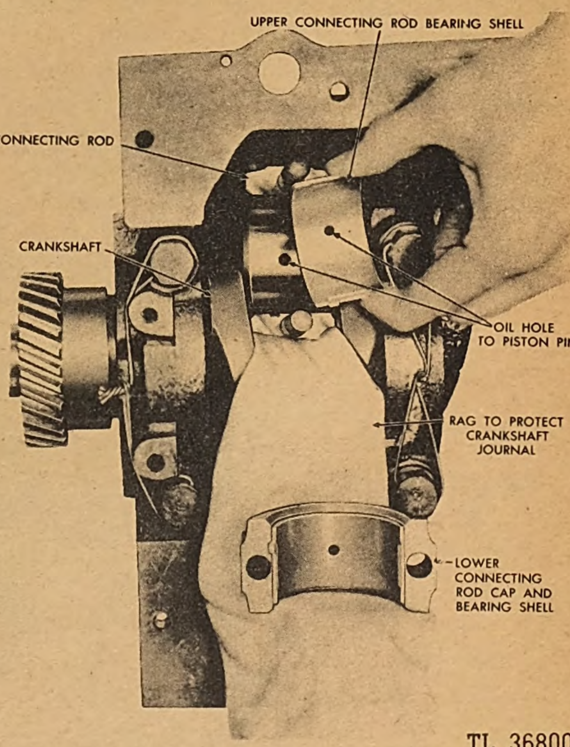

Fig. 148. Field Replacement of Connecting Rod Bearings

59. Steps of Engine Reassembly. At all times during the steps of reassembly of the engine, bear in mind that dirt is the engine's worst enemy. Therefore, the parts must be wiped clean and the lint must be removed. Do not use waste for wiping. Use a lint-free cloth. An air hose can be used to blow off any fine dirt or lint remaining on the parts after wiping.

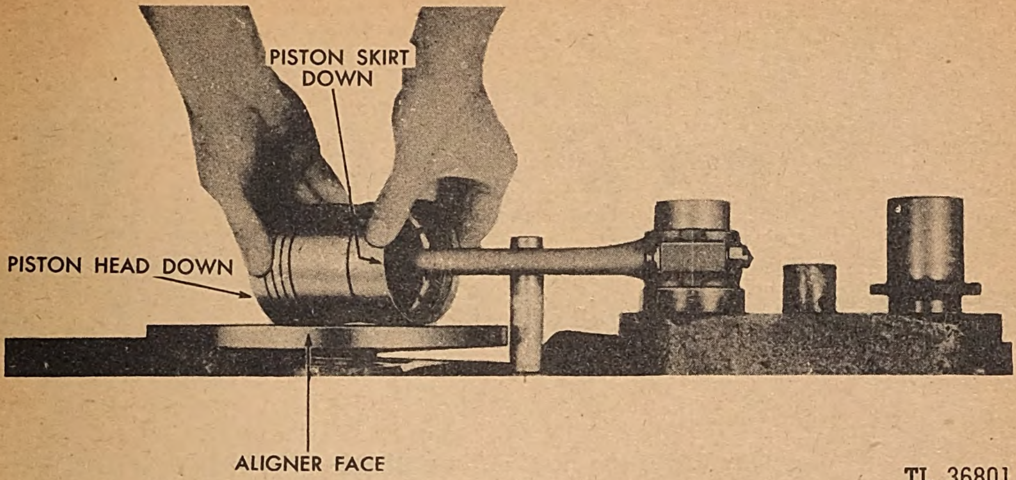

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Fig. 149. Checking Rod Alignment (Piston Head Down)

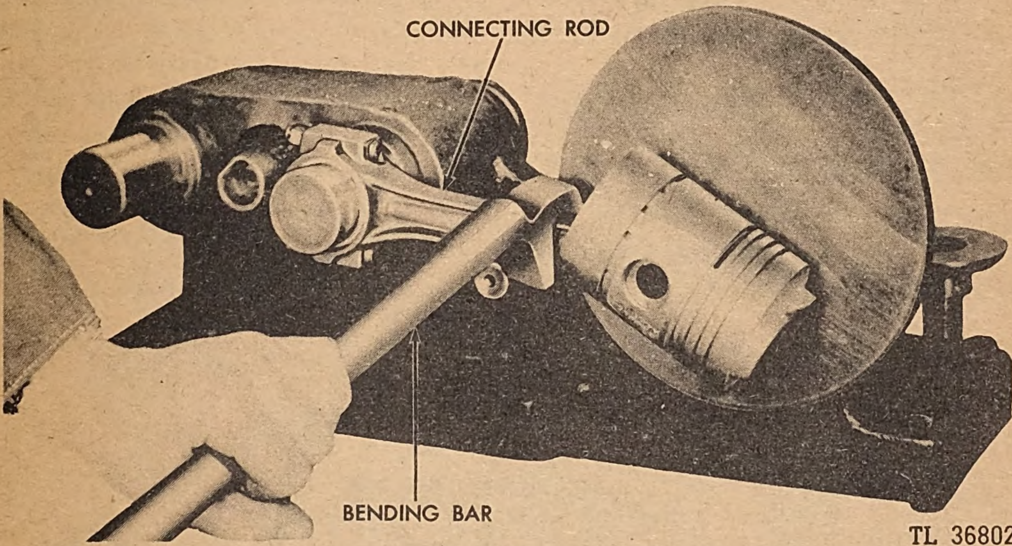

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Fig. 150. Straightening Twisted Connecting Rod

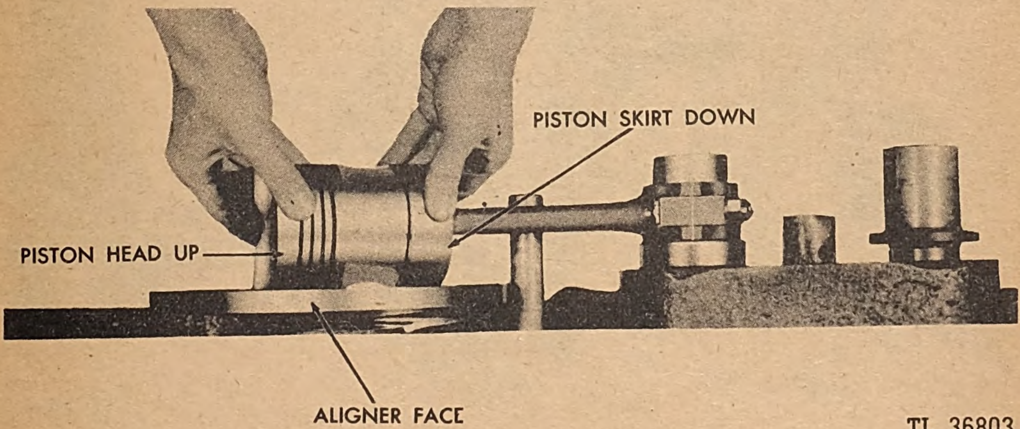

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Fig. 151. Checking Rod Alignment (Piston Head Up)

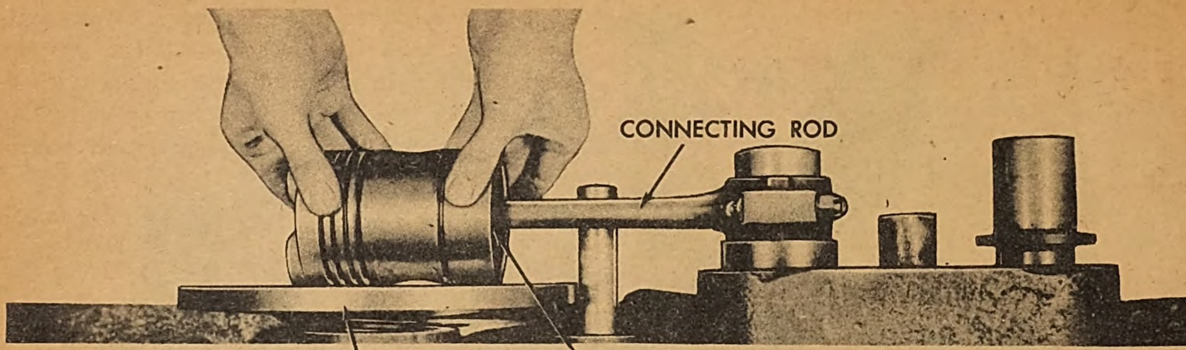


Fig. 152. Checking Rod Alignment (Piston Parallel)

Only clean, fresh oil must be used in oiling the parts as they are reassembled. Be sure to replace all gaskets, cotter keys, lockwire, oil seals and felts.

For convenience, the engine reassembly is given in two sections, basic engine assembly and assembly of the component system to the engine.

a. Assembling the Oil Plugs in the Crankcase. With the engine standing on its studs, as shown in Figure 107, install the oil passage plugs. Before installation, these oil passage plugs should be shellacked or Permatexed. Insert one plug in the front of the gallery oil line (see Figure 108), three at the rear end of the crankcase, one at the bottom side and two on the outside of the crankcase near the oil filter mounting pad. (See Figure 107.)

NOTE: The plugs at the front and rear ends must be screwed below the surface of the crankcase so as not to interfere with the surfaces of the flywheel housing and the timing gear housing.

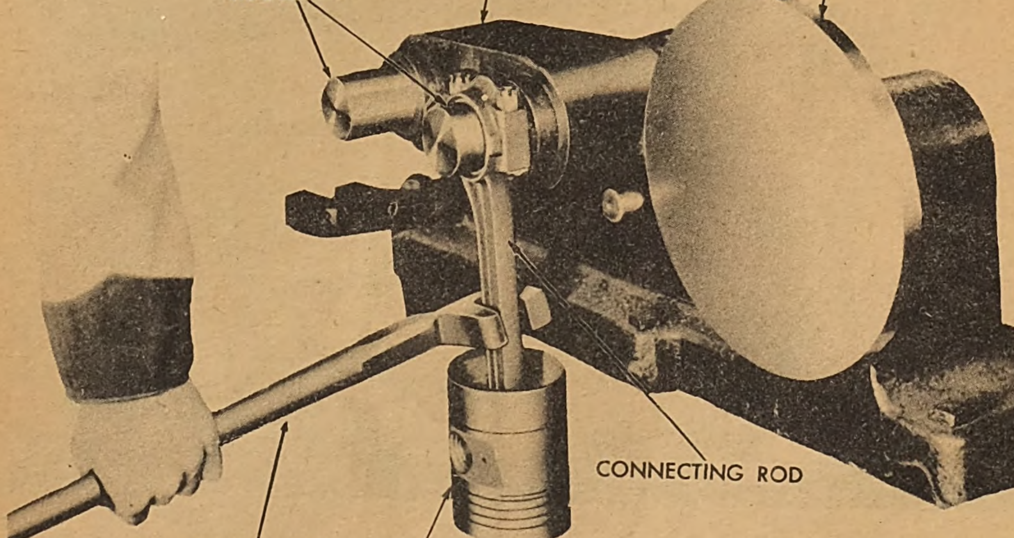


Fig. 153. Straightening Bent Rod .

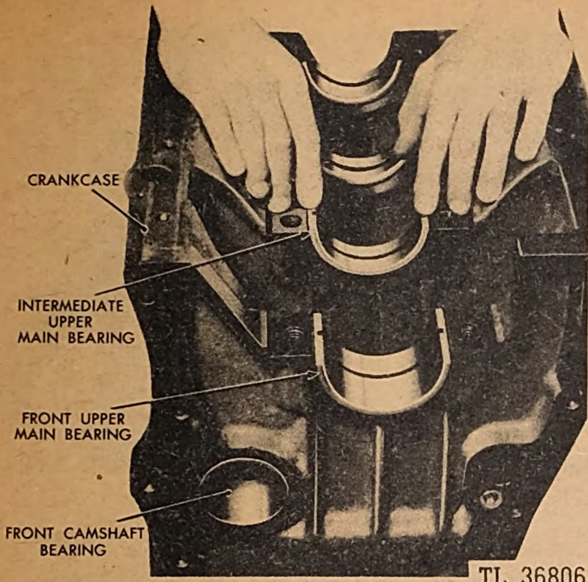


Fig. 154. Installing Main Bearings

b. Crankshaft Main Bearings, Caps and Oil Seal Assembly. (1) Install the upper main bearings in the crankcase support. (See Figure 154.) The rear main bearing may be lightly tapped into place with a wood block and hammer.

NOTE: Unless the main bearings are new, each must go back in that main bearing support from which it was taken. Their positions in the support must not be reversed.

(2) Install the upper half of the rear main bearing oil seal, using various size gaskets to locate the position of the oil seal, .010 inch to .012 inch, between the crankshaft oil slinger and the oil seal. (See Figure 155.)

NOTE: The accuracy of this position cannot be checked, however, until the crankshaft is laid in place.

(3) Carefully lay the crankshaft in place so as not to mar the bearing surfaces. (See Fig-

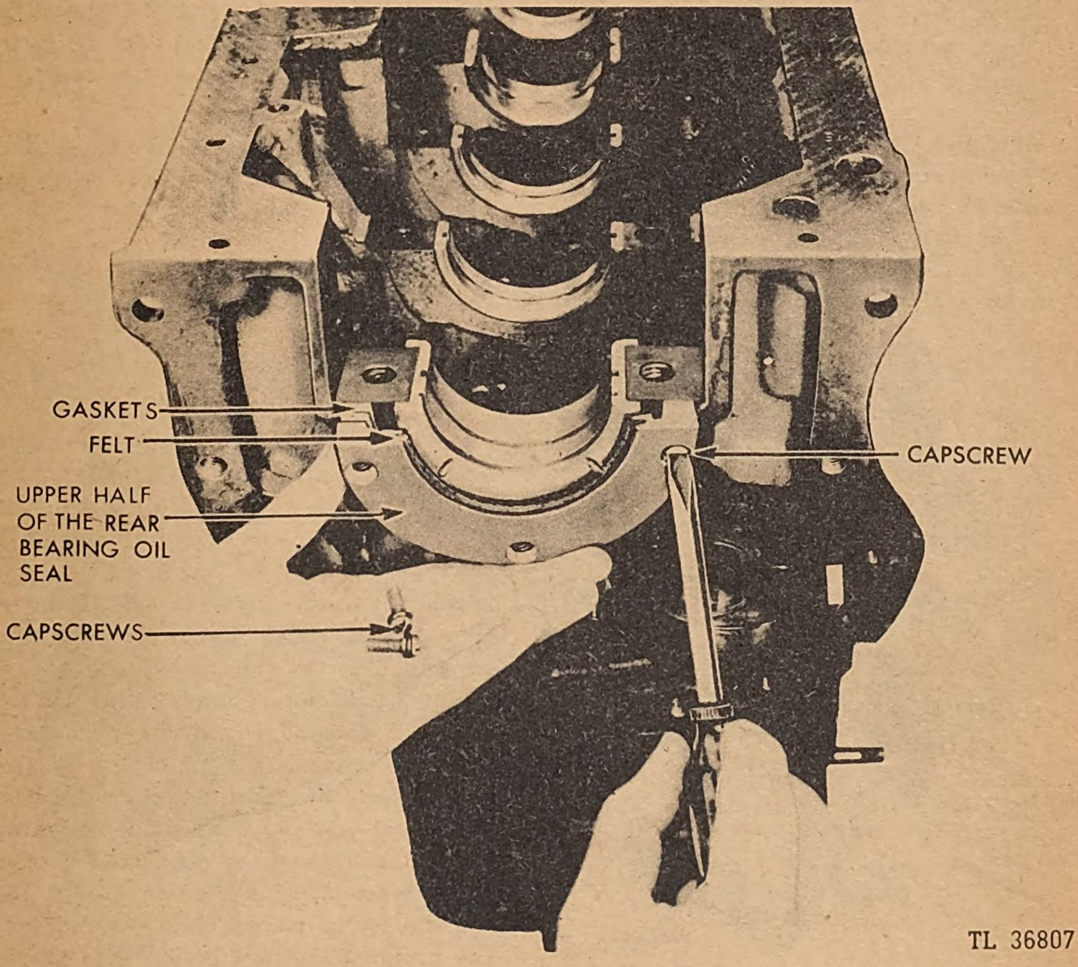


Fig. 155. Installing Upper Half Rear Bearing Oil Seal

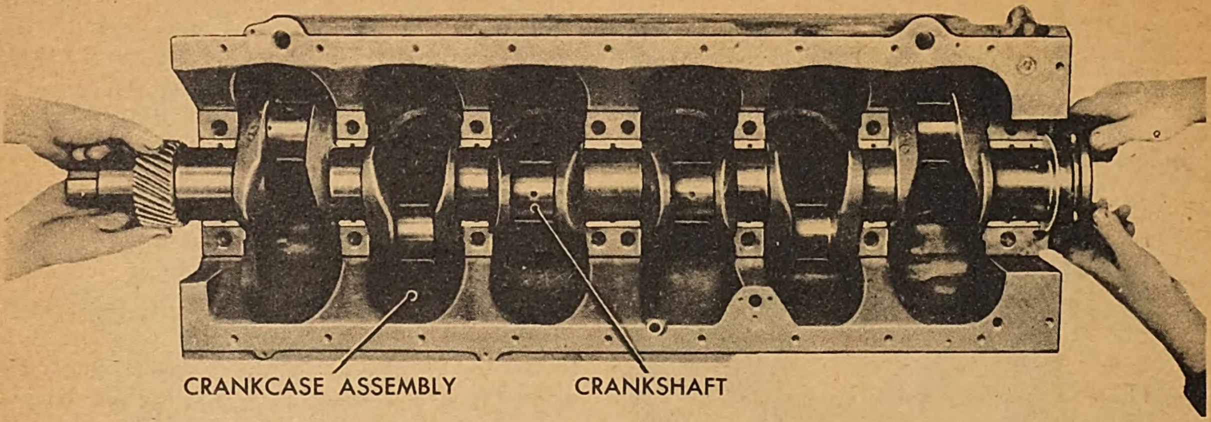
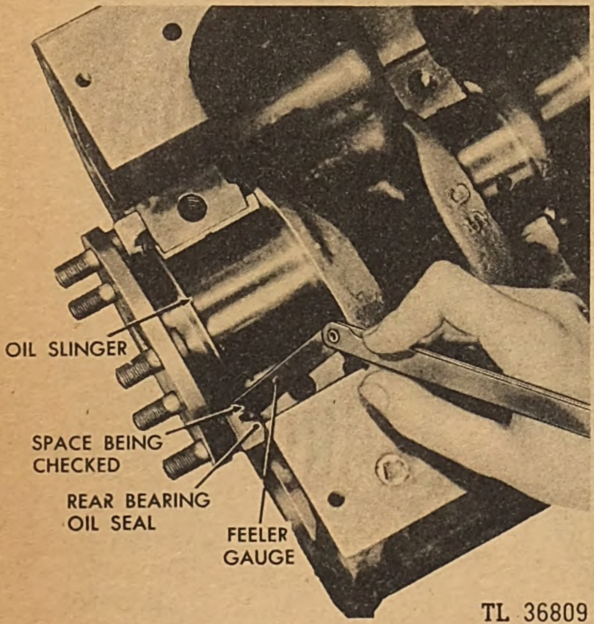


Fig. 156. Installing Crankshaft TL 36808

ure 156.) The flywheel bolts should be in place before installing the crankshaft. Note the extra hole in the crankshaft flange. This hole is for the purpose of getting at the fillister head screws in the rear bearing oil seal in order to remove the oil seal without having to take out the crankshaft. (See Figure 158.)

(4) Check the clearance between the slinger and the oil seal as shown in Figure 157. This clearance should be between .010 inch to .012 inch. If the clearance is not correct, lift out the crankshaft and add or remove one or more gaskets, whichever is necessary. The same



TL 36809

Fig. 157. Checking Oil Slinger Clearance

number and thicknesses of gaskets must be used in both the lower and upper halves of the oil seal.

(5) Assemble the lower half of the oil retainer seal onto the rear bearing cap. Be sure to put the copper gasket under the center fillister head screw.

NOTE: New oil stops should be installed in the cap. (See Figure 139.) These oil stops seal the sides of the cap to the crankcase and prevent oil from leaking through.

(6) Install the rear cap, being careful not to tear the oil stops when slipping the cap in place. After the cap is down in place, trim the ends of the oil stops flush with the top of the cap. (See Figure 158.)

(7) The main bearing caps are numbered from 1 to 7, starting from the timing gear housing on the front end. With the bearings in place, these caps should be installed in their respective places so that the single cast lobe is pointed to the camshaft side of the engine. (See Figure 159.) Tighten the main bearing capscrews with a torque wrench to a tension of 150 to 160 foot pounds. (See Figure 160.) The bolt threads should be dry and clean. Turn the crankshaft by hand to be sure it is free. Before installing the lockwires, check the crankshaft end play. Slip a feeler gauge between the ends of the rear main bearing and the crankshaft, as shown in Figure 104, and run the feeler gauge clear around the shaft. The proper clearance is .003 inch to .007 inch desired; permissible .012 inch.

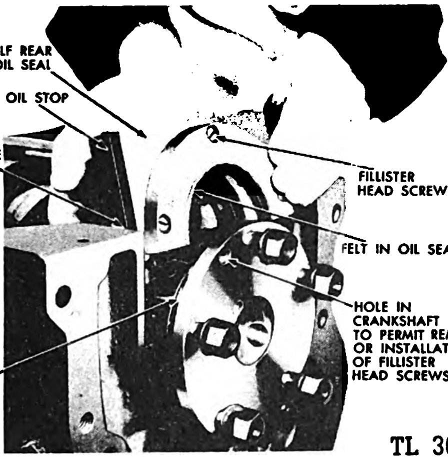


Fig. 158. Installing Lower Half Rear Bearing Oil Seal

(8) With the aid of a chain hoist, lay the engine on its left side.

If the crankshaft gear was removed and not replaced before assembly, press the gear onto the shaft. (See paragraph 52*d*.)

c. *Installing Piston and Rod Assemblies.* (1) Clamp the pistons and connecting rod assemblies in a vise with lead jaws so that the piston seats tightly against the top side of the jaws. With a narrow strip of clean cloth, clean out each ring groove. If the clearance between the ring lands and the ring has not been checked according to the instructions in paragraph 58c, the check should be made before installing the rings. Install the rings with a ring tool as shown in Figure 161 and space the gaps of the rings 90 degrees apart (a quarter of a circle). There should be no gaps over the piston pin. The top ring is a fire ring; the next two are compression rings, and the lower are ventilated oil rings.

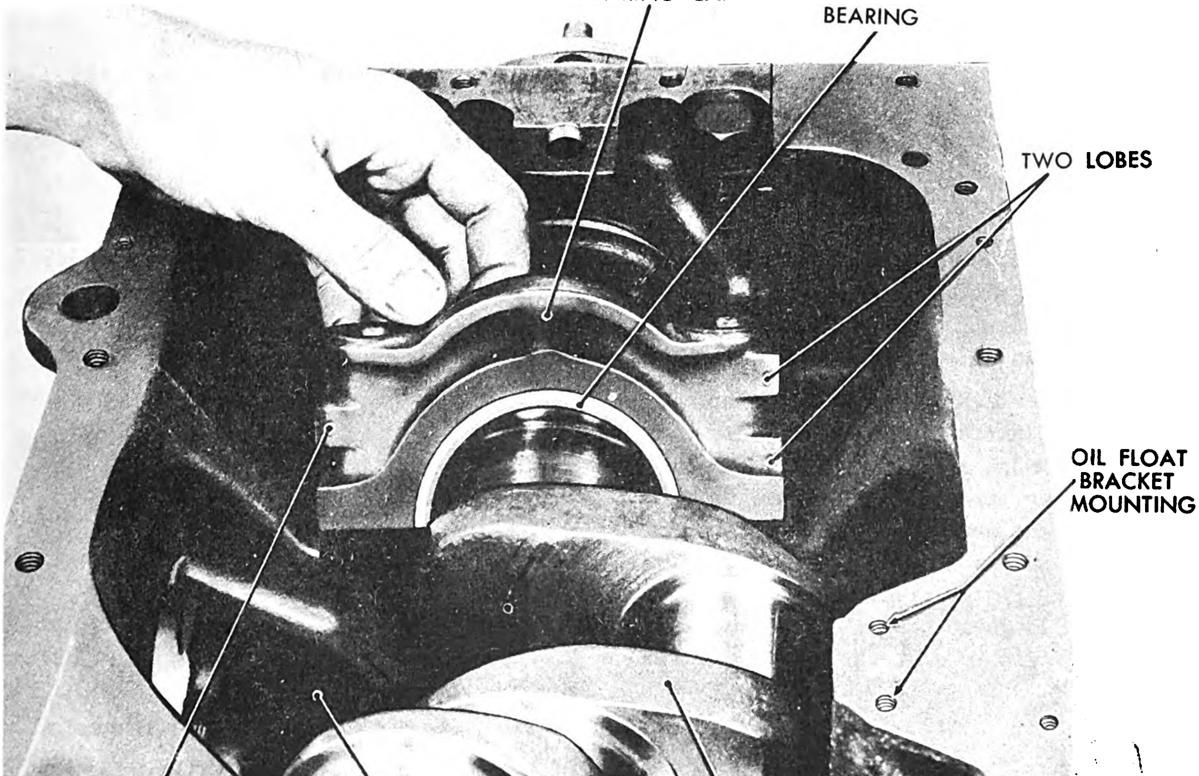


Fig. 159. Installing Bearing Caps

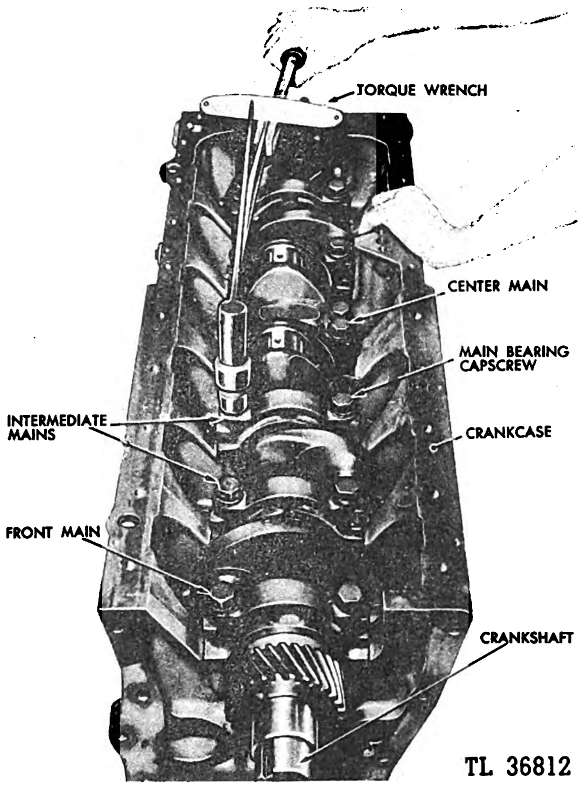


Fig. 160. "Torqueing" Main Bearing Capscrews

(2) When installing the piston and connecting rods into their respective cylinders, the arrow on the top of the piston should point to the injector side of the crankcase (the shallow side of the piston lobes). Place a ring compressor over the rings as shown in Figure 162.

Make certain that the rings are wholly in their grooves before tightening the ring compressor a little bit at a time, pausing to push the compressor sideways to be sure that the rings are free. Compress as much as possible. A pilot tool, or wooden guide, shown in Figure 102, should be placed over the upper connecting rod bolt to guide the rod into place without marring the bearing surfaces of the crankshaft.

NOTE: The piston and connecting rod assembly should be fitted into the proper cylinder, making certain that No. 1 piston is in No. 1 cylinder with the designating number facing the right side of the engine (opposite of the camshaft), and so on for each respective piston and cylinder. (See Figure 163.) With the handle of a hammer, lightly tap the piston and connecting rod assembly into the cylinder sleeve, as shown in Figure 162. Do not force the piston into the cylinder. If it does not move easily, either the rings are not compressed enough or the connecting rod is catching on the crankshaft. (The crankshaft throw should be in its bottom position for each piston and connecting rod installation.)

(3) Install the connecting rod cap and make sure that the number on the cap corresponds and lines up with the number on the connecting rod. (See Figure 163.) The caps are not interchangeable or reversible. Tighten each cap separately with a torque wrench. The torque should be between 95 to 105 foot pounds. (See Figure 164.) First torque each nut to its lowest value and then check to see

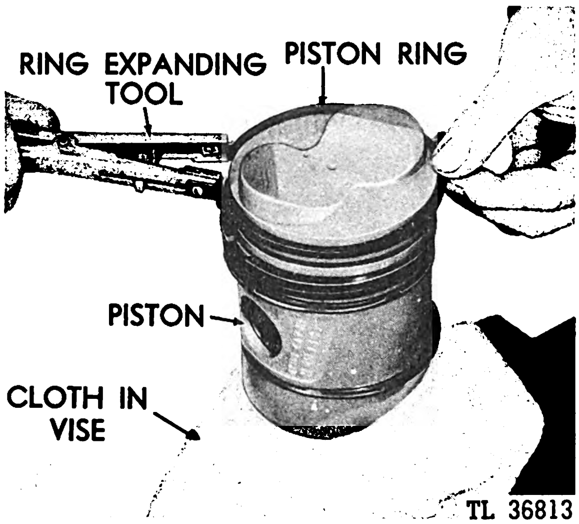


Fig. 161. Installing Piston Rings

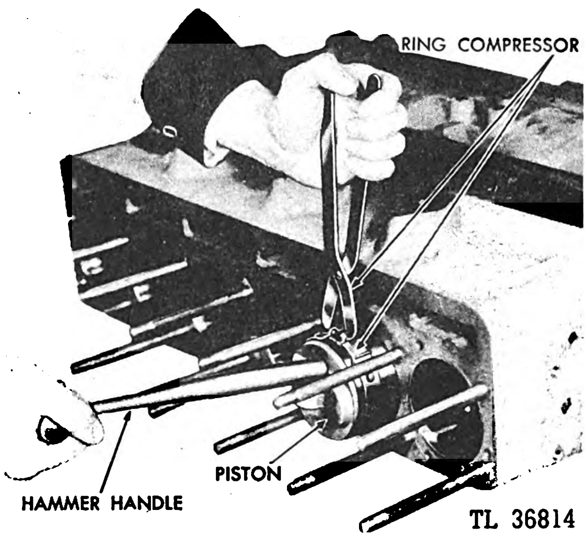


Fig. 162. Installing Piston in Cylinder

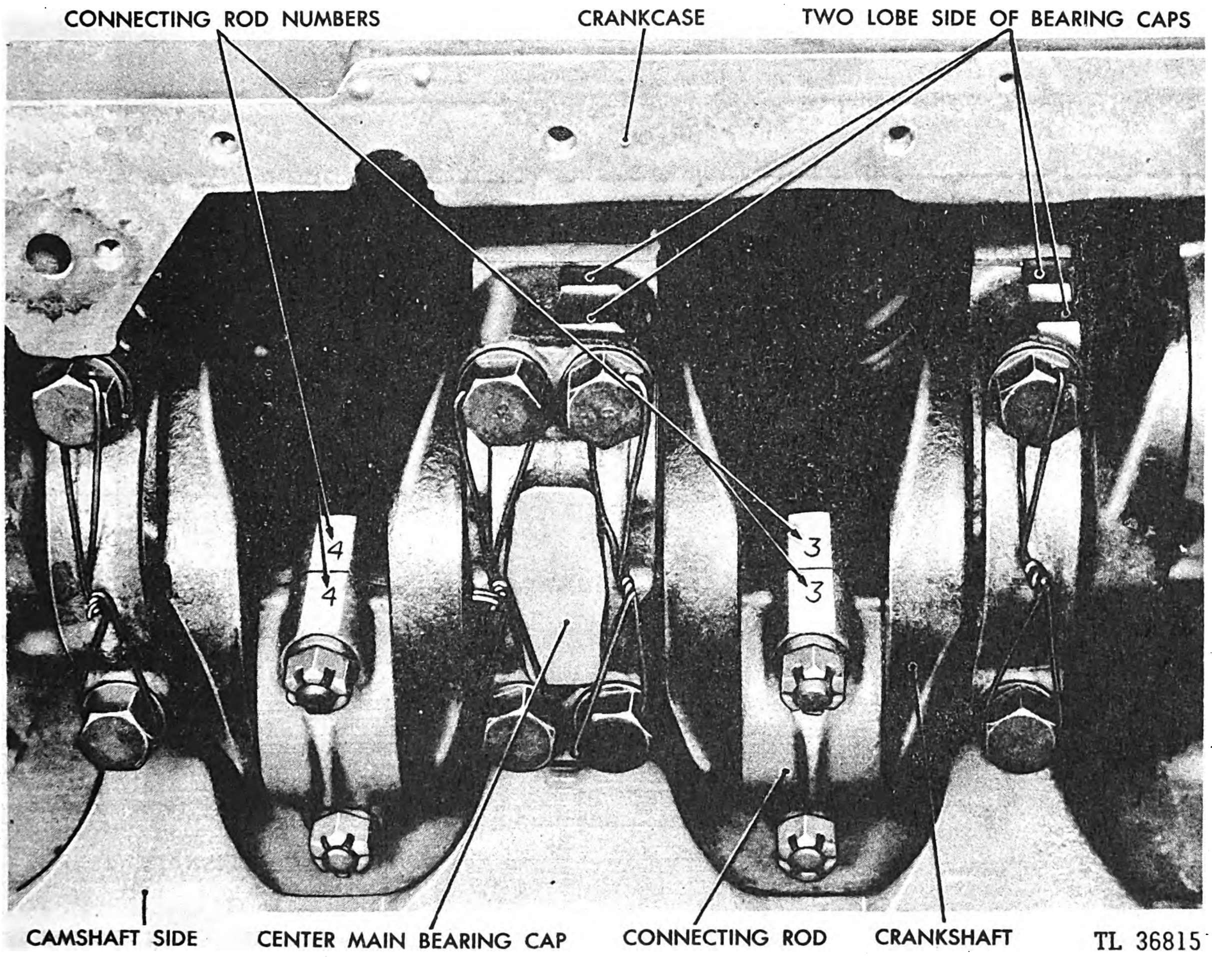


Fig. 163. Connecting Rod Numbers

if the cotter pin holes are lined up. If not, continue "torqueing" to a point somewhere between the highest and lowest torque values and again check to see if the cotter pin holes line up. After this, if there still remain some nuts that do not line up with the cotter pin hole in the bolt, exchange these nuts and continue the foregoing procedure until the cotter pin holes line up. But do not, at this point, insert the cotter pins. Check the side play of the connecting rods by tapping each cap lightly as shown in Figure 165. This side play should be from .004 inch to .009 inch desired; .013 inch permissible. This can be checked with a feeler gauge. (See Figure 101.) If the clearance exceeds .013 inch, replace the rod.

NOTE: If there is no side play, the piston and connecting rod must be removed and checked as follows:

Place the connecting rod cap on the crankshaft journal to see if it can be moved sideways. If not,

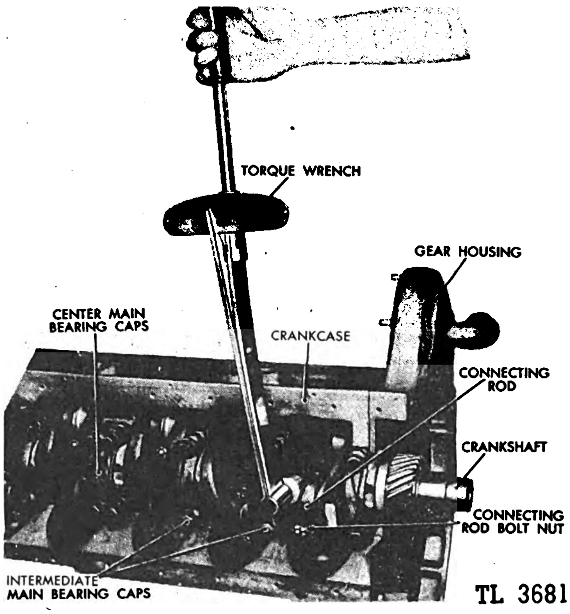


Fig. 164. "Torqueing" Connecting Rod Capscrews

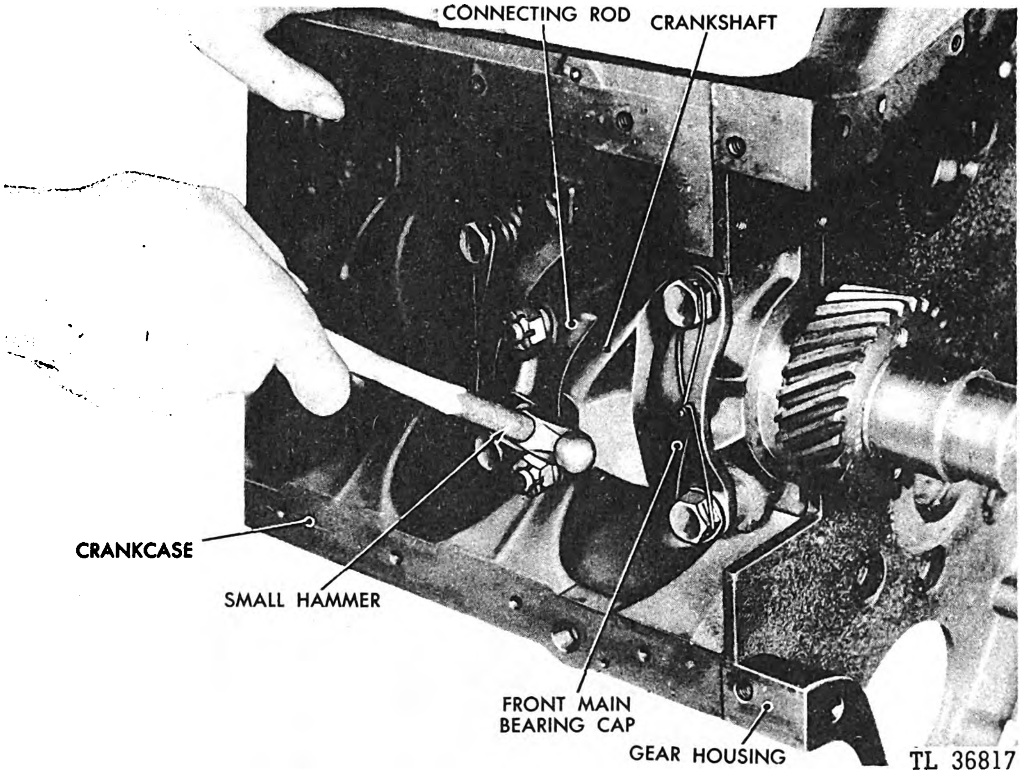


Fig. 165. Checking Connecting Rod Side Play

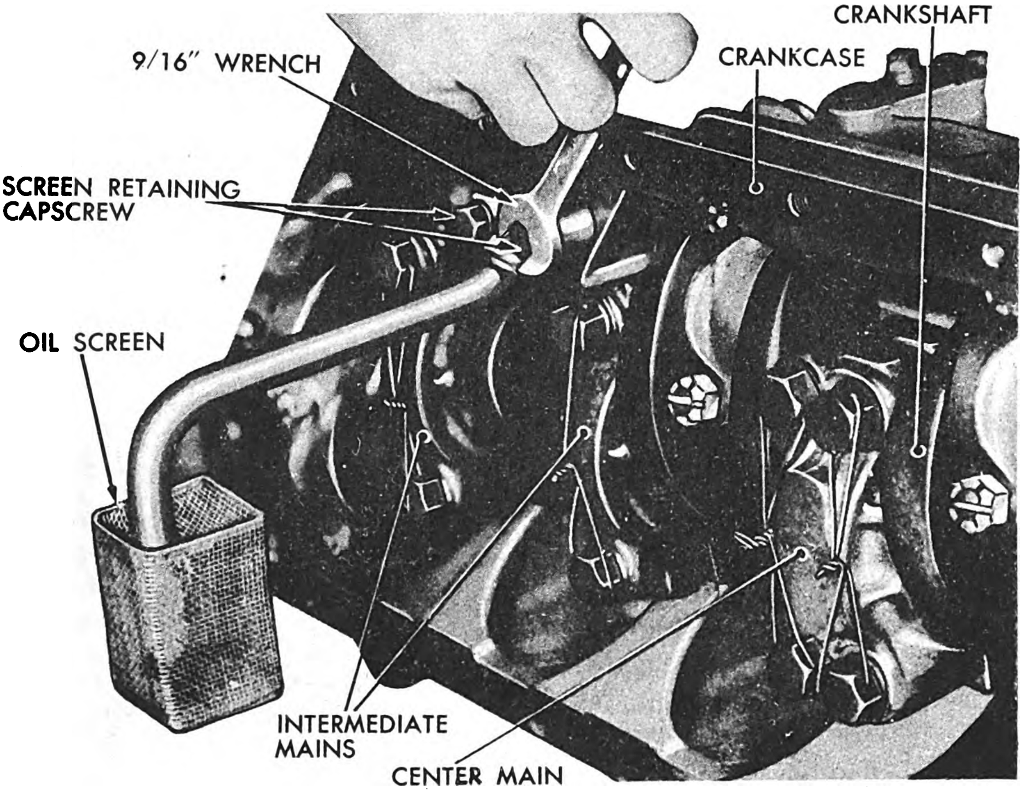


Fig. 166. Installing Oil Screen

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the cap and the rod must be filed together as a unit on one side. Usually a few strokes are sufficient to provide side clearance. If there is side play, but the movement is not free when tapping the cap and rod, there is either dirt on the bearing or the bearing is not the proper size. The connecting rod bearing clearance should be .002 inch to .004 inch desired; .0065 inch permissible.

(4) Insert the cotter pins of large enough diameter to make a snug fit in the hole. The cotter pins should extend from 3/8 inch to 1/2 inch to allow enough length for bending. If longer, cut off the excess length.

d. *Installing Oil Screen.* Install the oil screen to the crankcase. (See Figure 166.) Be sure the gasket between the screen bracket and crankcase is in place. Tighten the two capscrews.

e. *Installing Timing Gear Housing.* Shellac the gear housing gasket to the housing. Tap the two dowel bolts just through the crankcase. Set the gear housing in place. (See Figure 167.) Screw the six thin-headed capscrews with lockwashers loosely in place. Do not tighten the capscrews until the dowel bolts have been tapped through the dowel holes in the gear housing.

f. *Installing Flywheel Housing.* Tap the two flywheel housing dowel bolts through the crankcase. Using the dowel bolts as a guide,

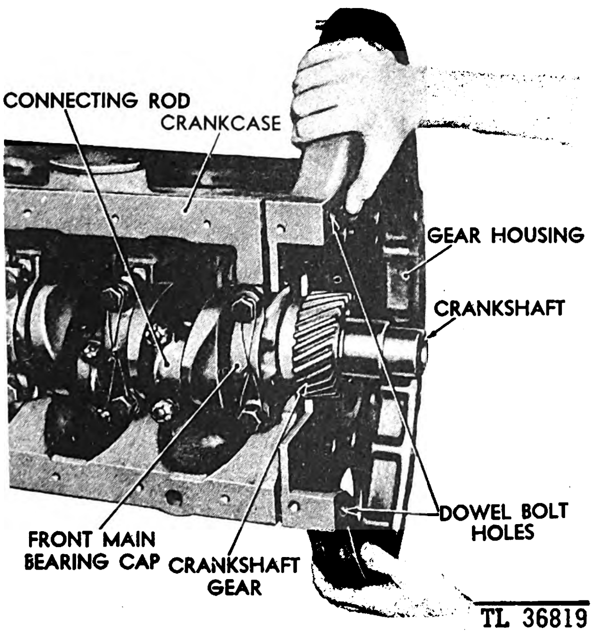

Fig. 167. Installing Gear Housing

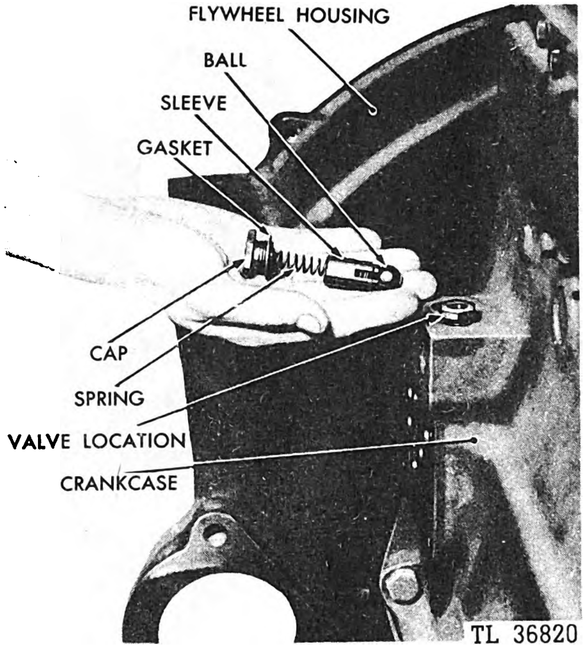

Fig. 168. Installing Oil Pressure Relief Valve

push the flywheel housing in place with the aid of a chain hoist. (See Figure 100.) Install the lockwashers, the four retaining capscrews and the two dowel bolt nuts.

g. *Installing Oil Pan.* Before installing the oil pan and gaskets, check the cotter keys in the connecting rods and the safety wires in the main bearing caps. Install the oil pan. Install the hand hole cover with a new gasket onto the oil pan.

h. *Installing Oil Pressure Relief Valve.* With a chain hoist, set the engine upright, blocking up the front end of the engine. Install the oil pressure relief valve. (See Figure 168.)

i. *Installing Idler Gear Shaft.* Drive in the idler gear shaft as shown in Figure 169. Be sure to line up the setscrew hole in the shaft with the setscrew hole in the crankcase. DO NOT MISTAKE THE OIL PASSAGE HOLE FOR THE SETSCREW HOLE.

Screw the idler gear stub shaft setscrew in place in the side of the block. (See Figure 170.) Do not install the acorn locknut until the fuel pump has been assembled to the engine.

j. *Installing Camshaft.* If the camshaft gear was removed and not replaced, press the gear onto the camshaft. (See paragraph 55c.) Install the camshaft and gear in the crankcase.

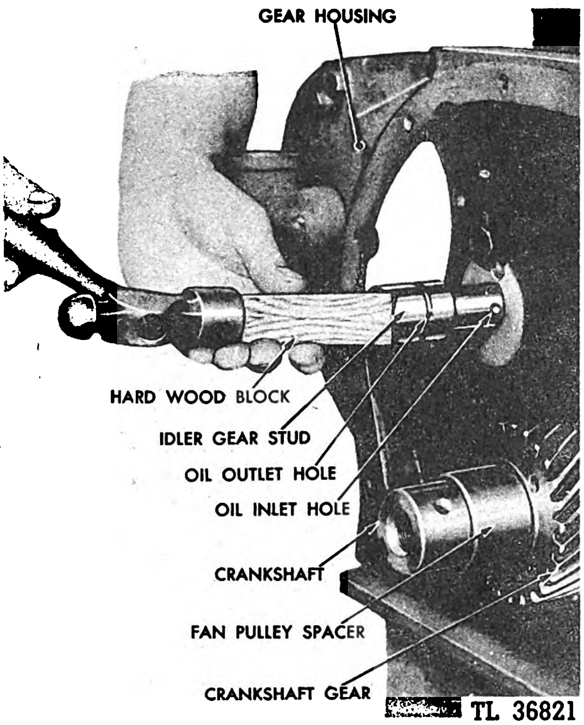

Fig. 169. Installing Idler Gear Stub Shaft

(See Figure 171.) Before meshing the camshaft gear and the crankshaft gear, align the marks on the two gears, as shown in Figure 131, and insert the camshaft thrust collar with lock plate and capscrews onto the camshaft. (See Figure 172.) The desired clearance between the thrust collar and camshaft should be .003 inch to .009 inch; permissible .015 inch. (See Figure 94.) Push the camshaft into position Tighten the three capscrews with a $\frac{7}{16}$-inch wrench, bent close to the head of the wrench. (See Figure 173.)

k. Installing Idler Gear. (1) Install the idler gear on the idler gear shaft with the larger gear (helical cut teeth) out. (See Figure 174.) If the idler gear was separated from the fuel pump drive gear and not reassembled, set the idler gear on the fuel pump drive gear so that the dowel hole matches with the dowel in the drive gear, and the center hole in the idler gear matches the pilot hub of the drive gear. Screw in the three capscrews and tighten the two gears together; safety wire the capscrews. (See Figure 131.)

(2) Screw the idler gear retaining washer and capscrew in place. This screw has a left-hand thread. Make certain that the washer is correctly started on the dowel pin.

(3) Check the idler gear end play, which should be .004 inch to .007 inch desired; .015 inch permissible. (See Figure 89.)

l. Installing Gear Cover. Shellac the gear cover gasket to the gear housing. A new oil seal should be in place in the gear cover. (See paragraph 55e.) Slip a thin steel cone over the crankshaft to protect the crankshaft oil seal when installing the cover, as shown in Figure 175. This thin steel cone is formed from rolling a thin piece of light steel so that the diameter of the one end is smalller than the end which slips over the fan pulley spacer.

m. Installing Crankshaft Pulley. Install the crankshaft pulley. Line up the key and keyway and drive it in, as shown in Figure 176, and screw on the crankshaft jaw.

n. Installing Valve Lifter and Bracket Assemblies. Install the valve lifter and bracket assemblies in the valve lifter chamber and tighten the six retaining capscrews as shown in Figure 92. The bracket assembly containing the short valve lifter cover stud should be installed toward the front or gear housing end of the engine. Be sure the sleeve dowels are in place in the brackets.

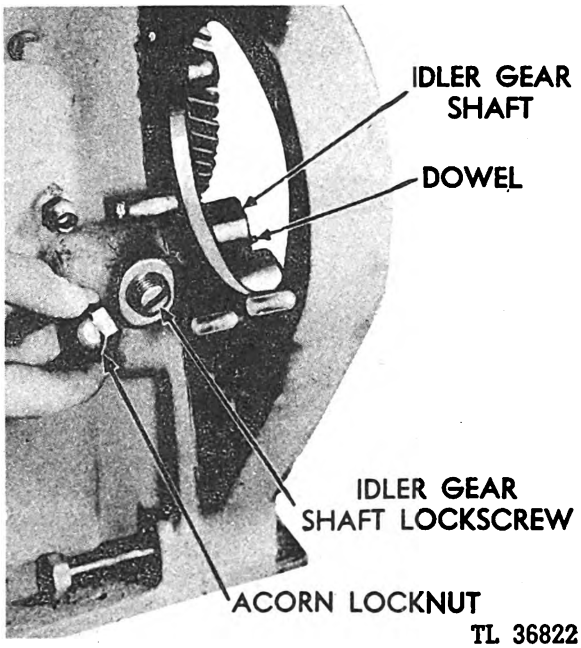

Fig. 170. Idler Gear Shaft Lockscrew

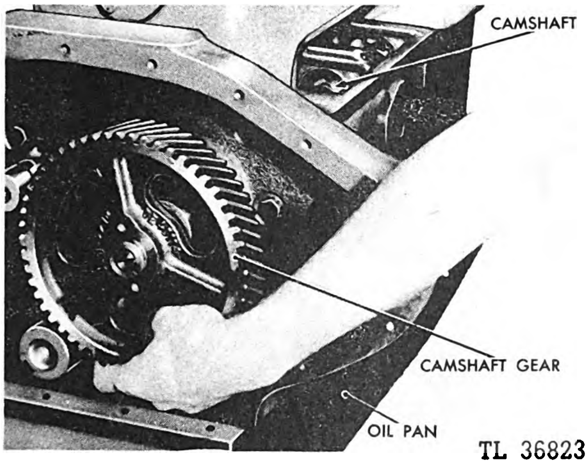

Fig. 171. Installing Camshaft

CAUTION: The holes for the capscrews holding the assemblies in place open directly onto the cylinder sleeves. If these capscrews are replaced, ones of identical length must be used; i. e. 2 inches. If longer ones are used, the sleeves will be dented or broken. Install the valve lifter chamber cover with the gasket in place and tighten the valve lifter cover nuts.

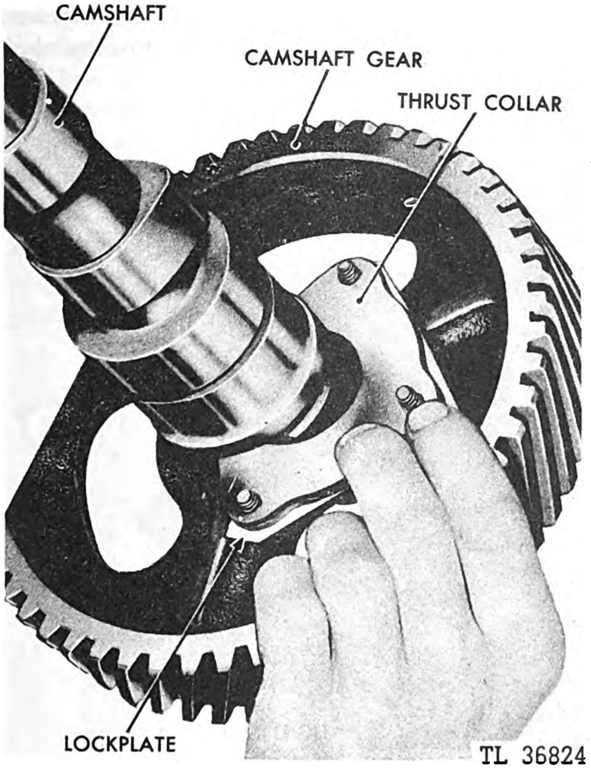

Fig. 172. Installing Thrust Collar on Camshaft

NOTE: The cover nut closest to the gear housing is considerably longer than the other three nuts.

o. *Installing Oil Pump.* Install the oil pump as shown in Figure 99. Be sure to use new copper gaskets on the dowel sleeves and see that they are properly in place. Make certain to line up the pin in the camshaft with the fork drive in the pump and tighten the four oil pump retaining capscrews.

p. *Installing Flywheel and Stub Shaft.* (1) Before installing the flywheel, make certain that all the dirt has been removed from the crankshaft flange and the crankshaft recess in the flywheel. Feel the surfaces for burrs and nicks. (See Figure 177.) Because of an offset bolt, the flywheel goes on in only one position. Turn the crankshaft so that No. 1 and No. 6 pistons are on top dead center. Turn the flywheel so that the T. D. C. mark on the flywheel lines up with inspection hole in flywheel housing. (See Figure 171.) Slip the flywheel onto the crankshaft bolts.

(2) Rotate the stub shaft until the holes in the shaft flange line up with the flywheel bolts. Push the stub shaft onto the flywheel bolts. Install the special thin lockwashers and retain-

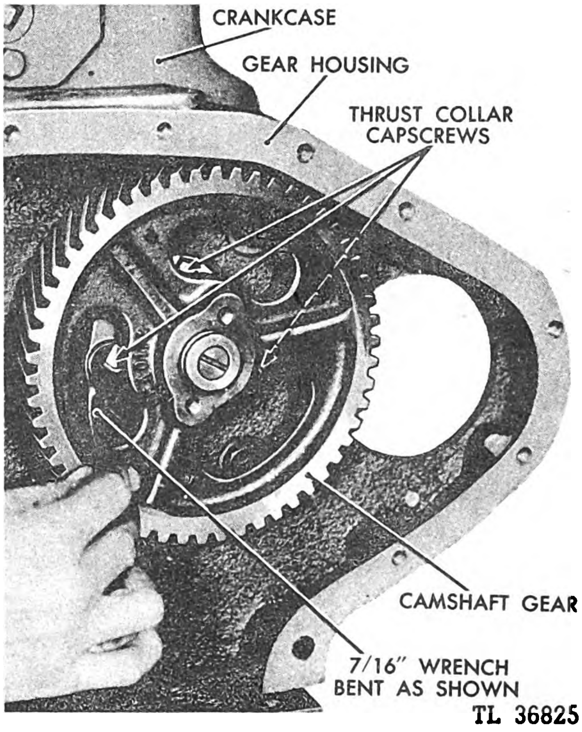

Fig. 173. Tightening Cam Lock Plate

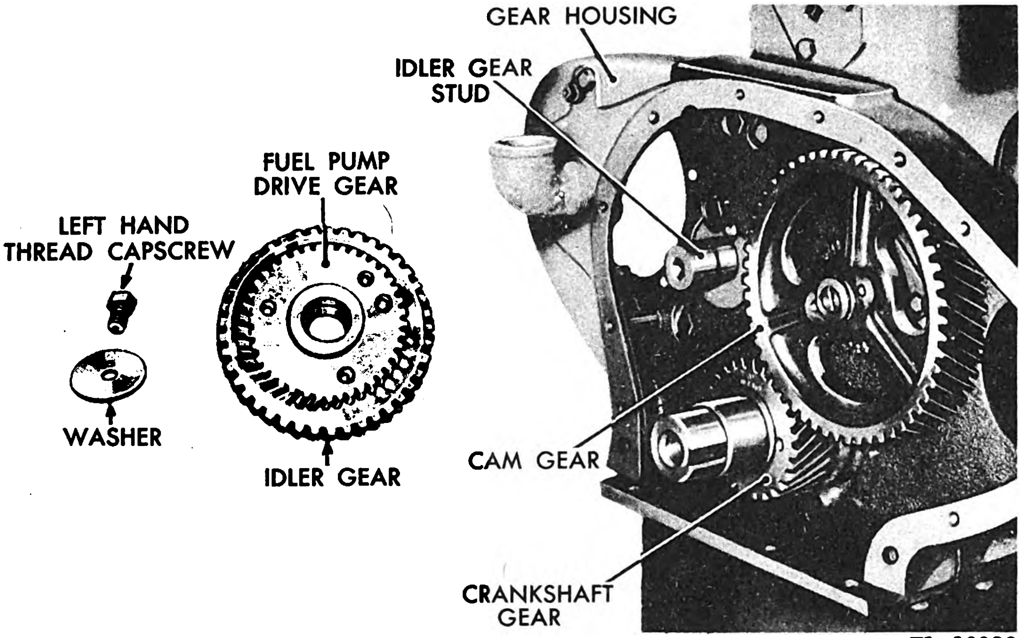

Fig. 174. Installing Idler and Pump Drive Gear Assembly TL 36826

ing nuts. Tighten the nuts slowly and evenly by tightening each second nut, going around several times until the nuts are tightened. Be sure the pilot on the end of the stub shaft is pushed into the flywheel hole when the nuts are tightened.

(3) Check flywheel runout with a dial indicator as shown in Figure 178. The maximum total indicator reading should not exceed .008 inch. Check the stub shaft runout with a dial indicator as shown in Figure 179. The reading should not exceed .003 inch. Be sure the shaft

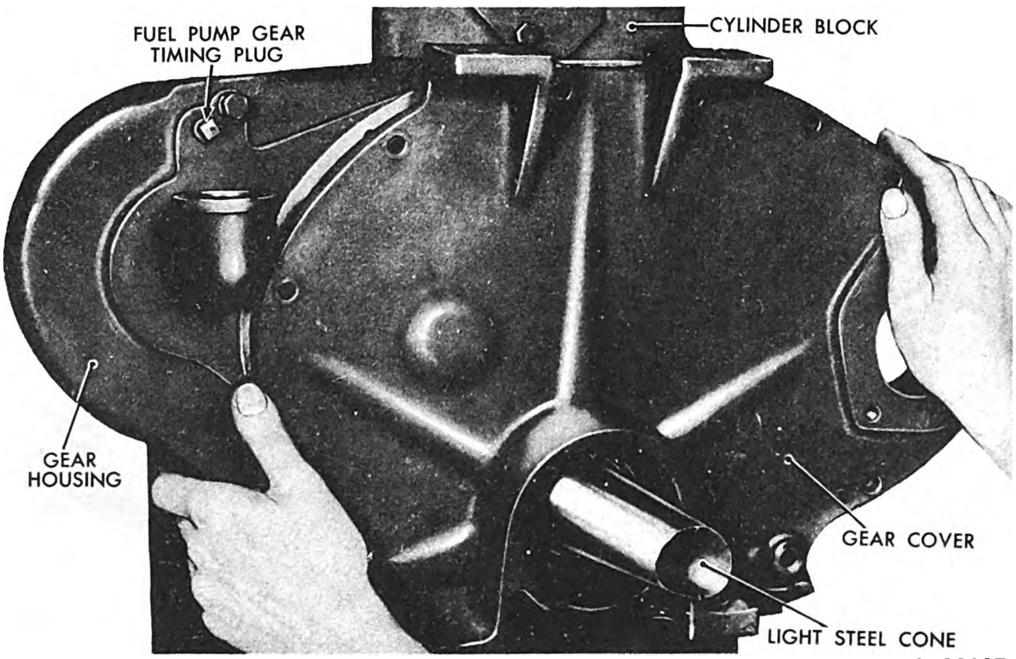

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Fig. 175. Installing Gear Housing Cover

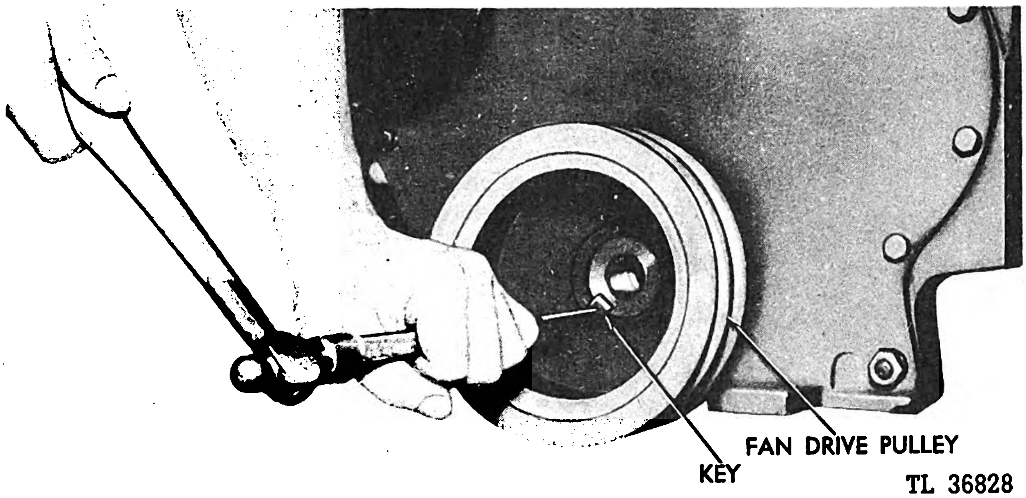

Fig. 176. Installing Crankshaft Fan Drive Pulley

is not turned completely around, since the dial indicator plunger will drop into the keyway and be broken off. If the coupling is on the stub shaft, check the runout with the dial indicator plunger against the coupling just back of the teeth. The runout should not exceed .003 inch. Also check the runout on the face of the coupling just inside the teeth. This runout should not exceed .002 inch. If the runout on the flywheel, stub shaft, or coupling is excessive, remove the stub shaft and flywheel and check for dirt, burrs, or nicks in the flywheel, crankshaft or stub shaft mounting surfaces.

q. Installing Cylinder Water Jacket Cover. Install the cylinder water jacket cover as shown in Figure 96. Be sure the gasket is in place between the cover and cylinder block.

r. Installing Cylinder Head. (1) Place the interlocking cylinder head gaskets in position and install the cylinder head. Make certain that the cylinder head is seating on the dowels in the cylinder blocks before tightening the stud nuts. (See Figure 180.) After the head is on the block, install the fan brace on the front

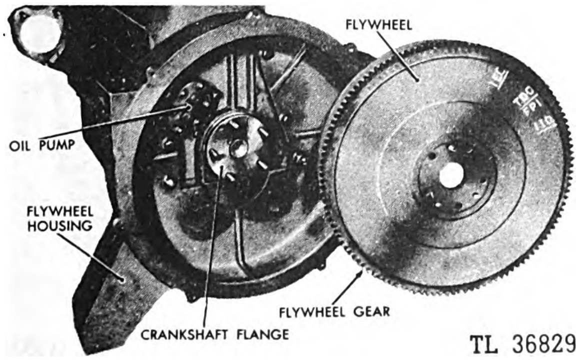

Fig. 177. Flywheel and Flywheel Housing

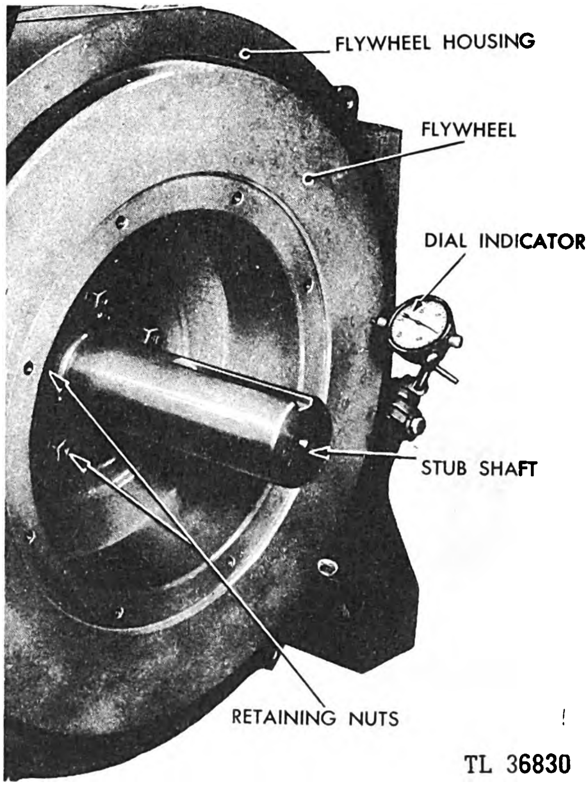

Fig. 178. Checking Flywheel Runout

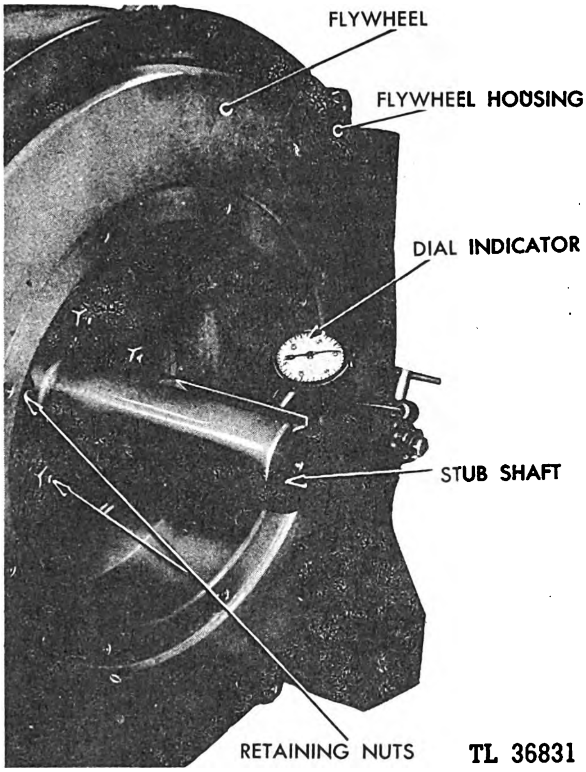

Fig. 179. Checking Stub Shaft Runout

cylinder head stud on the right side of the engine.

(2) The cylinder head studs should first be "snugged down" in the center, and then tightened alternately toward either end. See Figure 181 for proper sequence in tightening the cylinder head stud nuts. It will be necessary to repeat the procedure about three times, each time increasing the tension with the torque wrench until the third time when the torque value should be between 150 to 160 foot pounds.

s. Installing Rocker Arm Assembly. If the rocker arms need no servicing or replacements, the rocker arms can be installed as a unit after the push rods have been inserted. (See Figure 82.) If the rocker arm assemblies were disassembled, assemble and install as follows:

(1) Install the No. 1 rocker arm bracket. Just start the capscrew into the dowel end of the bracket. (See Figure 182.)

(2) Set the No. 2 rocker arm bracket on the head, making sure that the copper asbestos gasket is in place in the drilled oil passage in the bracket. (See Figure 183.) Start the capscrew on the spring side of the rocker arm bracket, but do not tighten.

(3) Install the No. 3 rocker arm bracket in the same manner as (1).

(4) Install the push rods.

(5) Install the rocker arm shaft, rocker arms, brass washers and springs as shown in Figure 184.

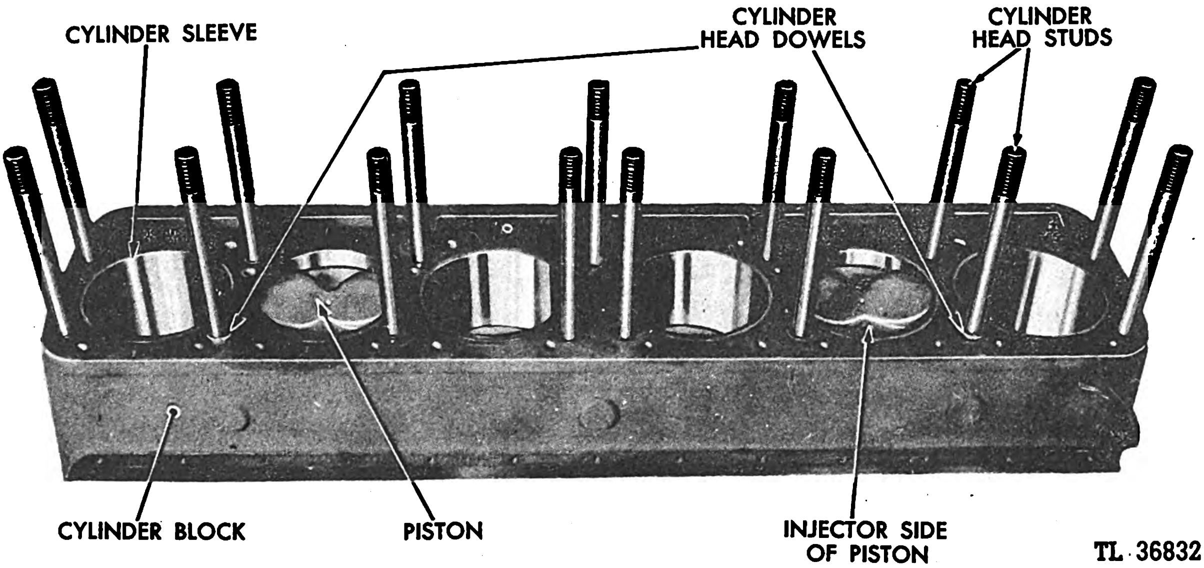

Fig. 180. Cylinder Head Dowels

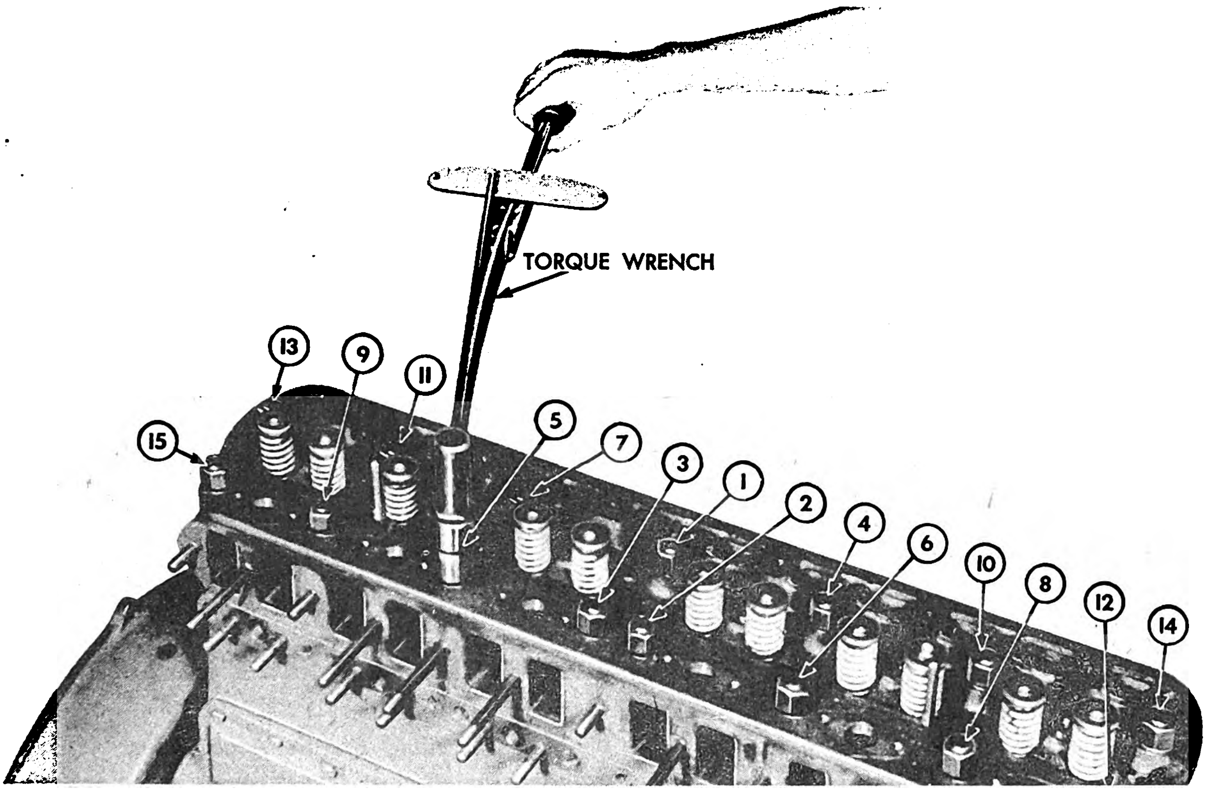

Fig. 181. Correct Sequence for Tightening Cylinder Head TL 36833

NOTE: There is a brass washer on each side of the rocker arms and one on each side of the spring. The word "front" is stamped on the front rocker arm shaft. Install the shaft so that the word "front" is visible between No. 2 and No. 3 rocker arms through the spring coil. (See Figure 185.)

NOTE: The pilot hole in the rocker arm is for the cylinder head cover stud pilot. This hole should line up with the tapped hole in the No. 1 bracket. (See Figure 184 and also Figure 185.) Install the cylinder head cover stud.

(6) Lay three 3/8-inch washers on the push rod side of the brackets for spacers and install the push rod spacer plates as shown in Figure 186. The rear push rod spacer plate has the mounting holes located in a different position than the front push rod spacer plate; that is, the holes in the rear plate are located closer to the rear edge to provide clearance between the rocker arm brackets and the plate. (See Figure 186.) Install the rest of the rocker arm bracket capscrews and tighten.

Repeat the same procedure for rear rocker arm assembly.

NOTE: On the rear rocker arm shaft, the word "rear" is stamped and should be visible through the coil spring between No. 4 and No. 5 rocker arm brackets. There is also a pilot hole for the cover stud pilot in No. 4 bracket.

Install the rocker arm shaft jumper oil line. (See Figure 78.)

t. Setting Valve Tappets. A temporary cold valve tappet adjustment can now be made. Turn the engine in the direction of rotation until No. 1 intake valve just closes. The No. 1 intake valve is the second valve from the front of the engine. Turn the engine one-half revolution to be certain that the cam is out from under the lifter. The piston is now approximately at top dead center and both the intake and exhaust valves are in position for checking or adjusting. With a feeler gauge, check the temporary clearances: For the intake valve, .012 inch; for the exhaust valve, .015 inch. Insert the correct feeler gauge between the rocker arm and the valve stem. Slowly move the feeler gauge back and forth. If the clearance is correct there will be a very slight drag on the feeler gauge when pulled from between the rocker arm and the valve stem.

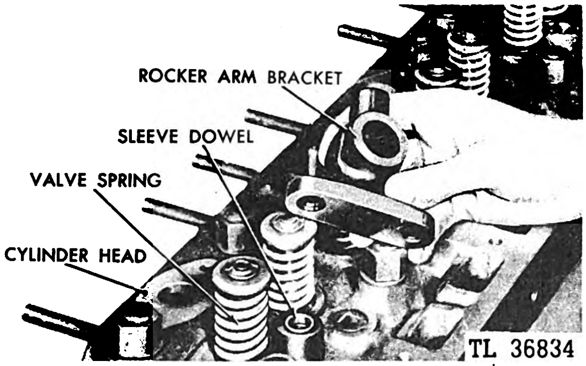

Fig. 182. Installing No. 1 Rocker Arm Bracket

To change the clearance, slack the tension on the locknut. Screwing the rocker arm adjusting screw out increases the clearance. Always recheck the clearance after tightening the locknut.

Repeat the tappet adjustment on the rest of the cylinders by first cranking the engine until the intake valve just closes on the particular cylinder being checked—then turn another half revolution before checking or adjusting the tappets. Refer to Figure 43.

The basic engine is now assembled and is ready for the component system.

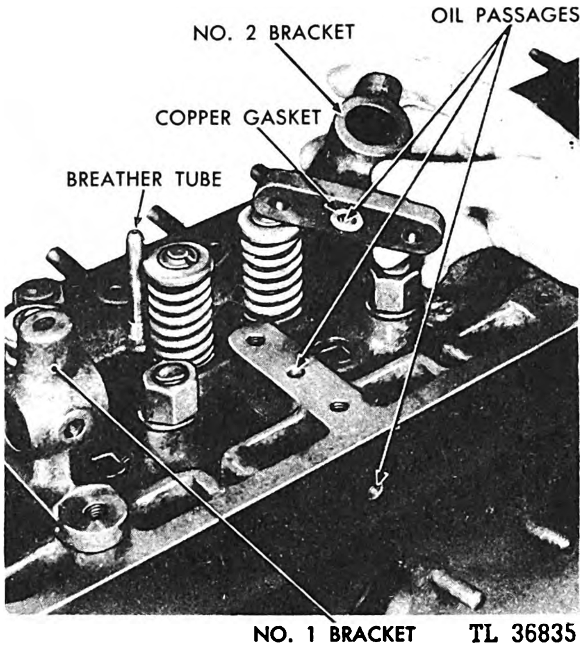

Fig. 183. Installing No. 2 Rocker Arm Bracket

u. *Installing Engine Accessories.* It is recommended that the accessories be installed on the engine according to the component systems to which the accessories belong,

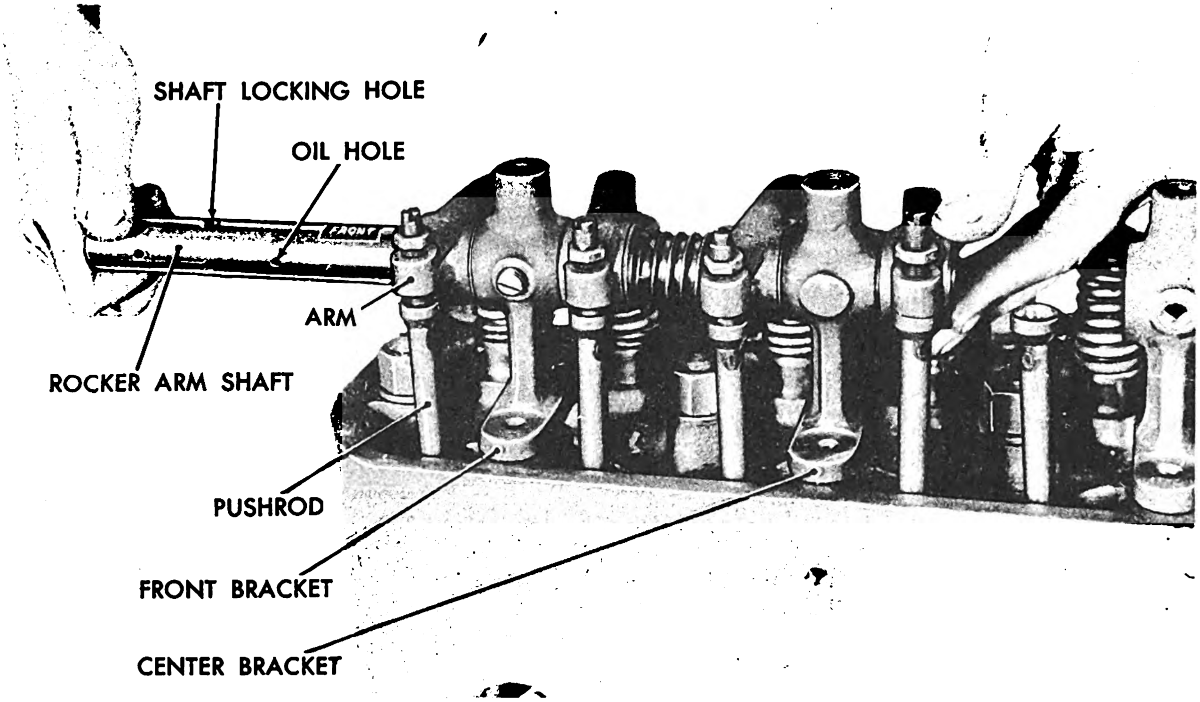

Fig. 184. Installing Rocker Arm Shaft, Brass Washers and Springs

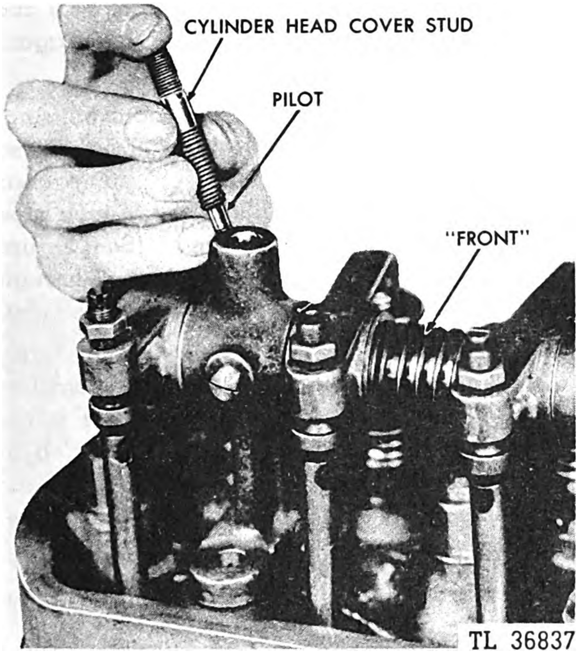

Fig. 185. Installing Cylinder Head Cover Stud

following the same procedure as in the steps of disassembly. By installing the accessories on one component system at a time, you can better understand the related functions of each of the members of a particular system and also make a better check of the thoroughness and correctness of your assembly job.

v. Assembling the Fuel System to Engine. (1) If the fuel pump, adaptor, and gear have been disassembled, shellac the fuel pump gasket to the adaptor plate and assemble to the fuel pump. (See Figure 187.) The capscrews holding the adaptor plate to the fuel pump have one star washer, one plain washer and one star washer under each head in that order. Be sure the cutaway section of the adaptor plate fits into the lower right hand corner of the fuel pump when facing the gear end of the pump. Slip the gear onto the fuel pump shaft with the mark in the gear tooth on the same side of the shaft as the 0 stamped in the end of the shaft. (See Figure 188.) Be sure the fuel pump weight pins are in place in the pump shaft when installing the gear.

NOTE: Do not force the gear onto the fuel pump; it should be a slip fit. Install the gear, lock plate and the four capscrews. Lock the capscrews by bending the tabs over the screw heads.

Shellac the adaptor gasket to the adaptor plate.

(2) Turn the engine crankshaft in the direction of rotation until the mark F. P. I. centers in the timing hole in the flywheel housing. (See Figure 189.) No. 1 cylinder should be

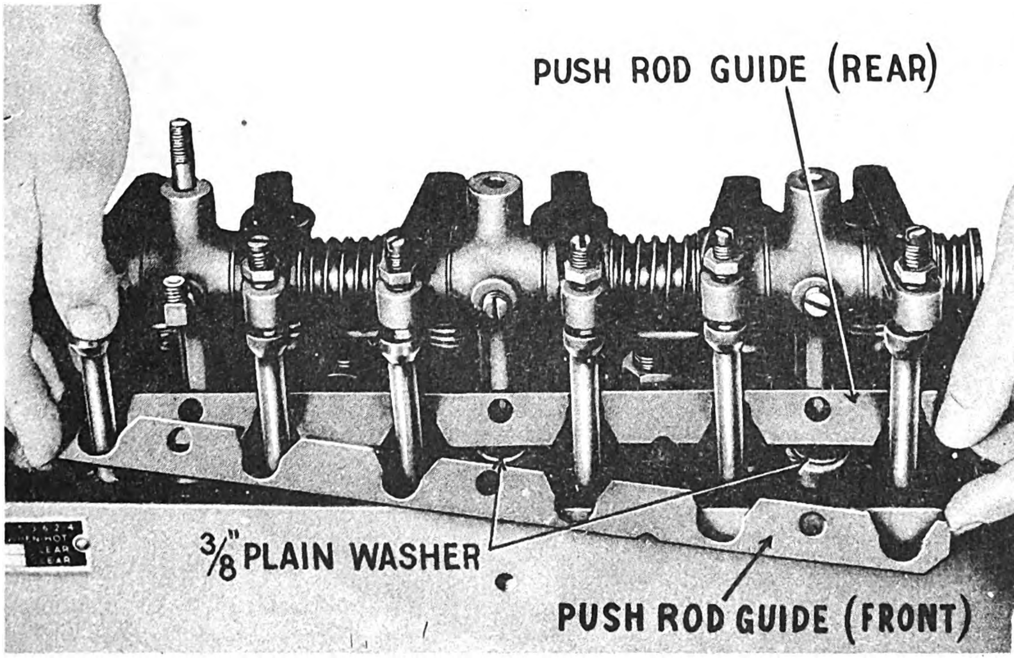

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Fig. 186. Installing Push Rod Spacer Plates

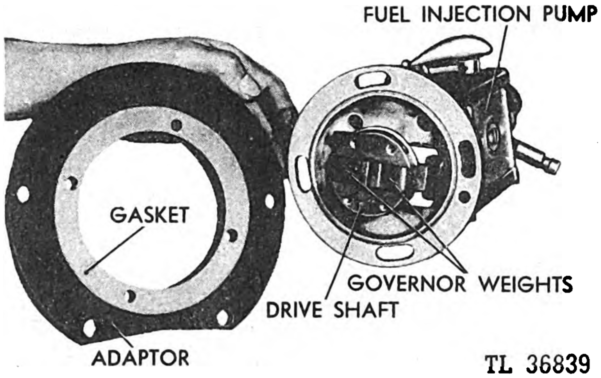

Fig. 187. Assembling Adaptor Plate to Fuel Pump

coming up on dead center compression stroke. Check this condition by feeling the rocker arms —if both No. 1 intake and exhaust valves are closed, the piston is in the correct position. If the exhaust valve is open, turn the engine one complete revolution until the F. P. I. mark again centers in the timing hole.

(3) Slip the fuel pump into the gear housing, as shown in Figure 81, meshing the gears so that the marked tooth of the fuel pump gear centers as close as possible in the $\frac{1}{4}$-inch pipe plug hole in the gear housing. (See Figure 190.) Tighten the five nuts and one through bolt holding the adaptor to the gear housing.

(4) Remove the fuel pump drive unit cover. (See Figure 191.) Slacken the four capscrews holding the fuel pump to the adaptor plate. Rotate the fuel pump in the slots provided in the mounting flange until the pointer aligns with the L mark on the pump swash plate.

Tighten the fuel pump to adaptor capscrews.

The fuel pump is now in time with the engine.

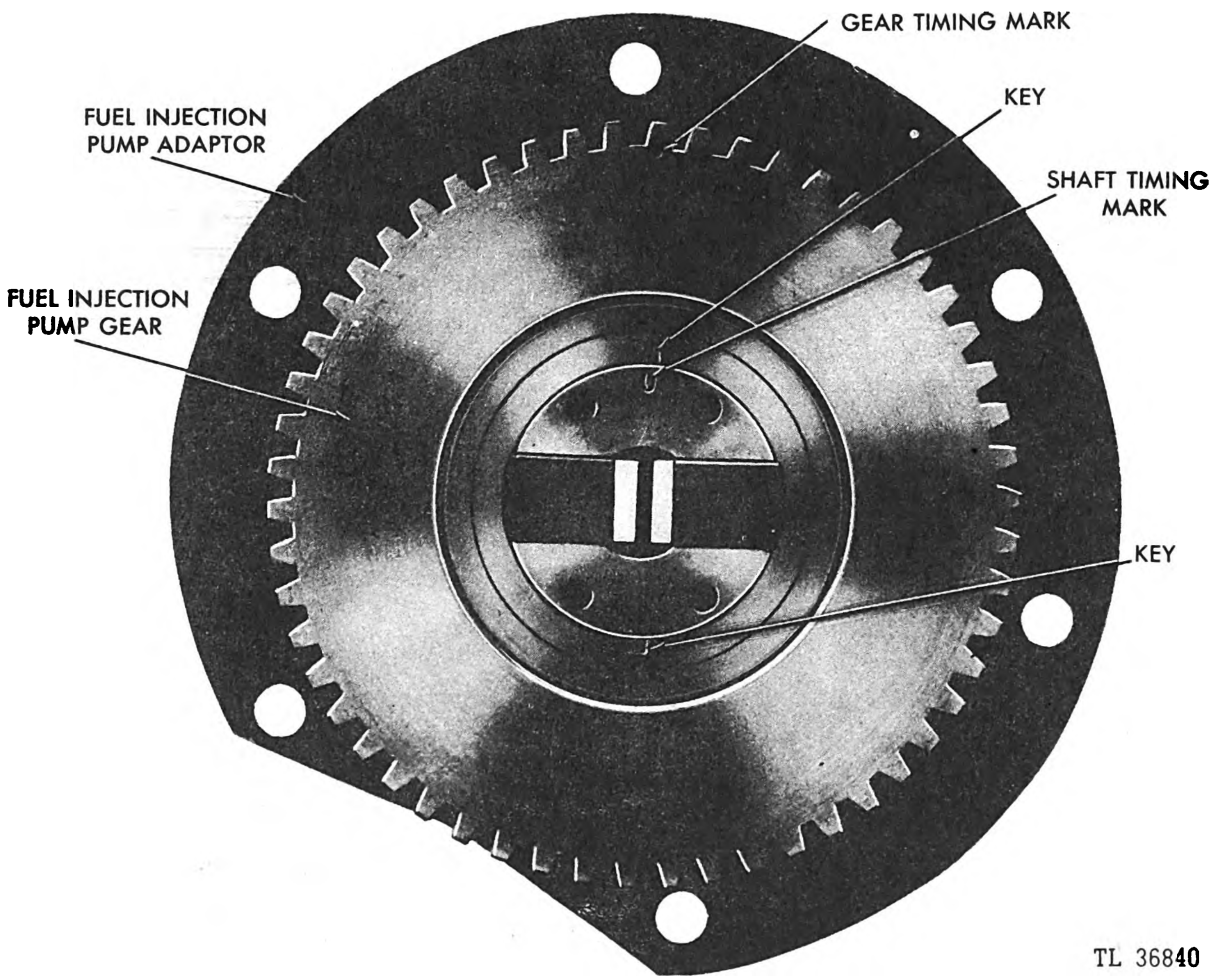

Fig. 188. Timing Marks on Fuel Pump Gear

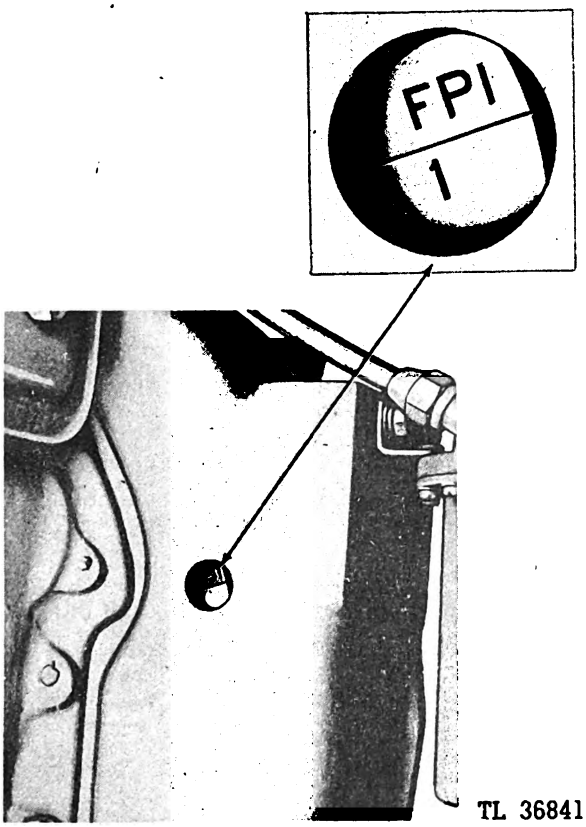

Fig. 189. Timing Mark in Flywheel Housing Timing Hole

(5) Install the acorn nut and copper gasket on the idler gear stud setscrew just back of the fuel pump. (See Figure 80.)

(6) Push the air cells into the cylinder head. Refer to Figure 79. Push the air cell plugs into position and install the retainer flanges, lockwashers and nuts. Refer to Figure 78. The air cells and plugs are of a slip fit in the cylinder head.

NOTE: The side of the retainer flange containing the rounded protrusion in the center should fit against the air cell plug.

(7) Clean the nozzle recess in the cylinder head if it was not cleaned at the time the head was reconditioned. Particular attention should be paid to the seating surfaces in order that no small particles of carbon will cause the assembly to be cocked or permit blow-by of the combustion gases. No hard or sharp tools should be used for this cleaning operation. A round piece of wood or brass is very effective.

Install new injector gaskets on the injectors. It is essential that there are no carbon flakes on the surfaces which the gasket seals.

Insert the injectors so that the nozzle tip does not strike against the recess wall. Install the injector retaining lockwashers and nuts.

NOTE: The injector retaining flange must be in place on the injector when the injector is inserted in the cylinder head; the triangular side of the retaining flange must bear against the injector.

(8) Install the injector lines. Install the injector line clamps. Be sure the injector lines are clean before installation. Refer to Figure 76. Do not bend the injector lines.

(9) Install the oil lines to the fuel injection pump and cylinder head. (See Figure 192.)

(10) Install the throttle bracket, spring, shaft and clevis. (See Figure 26.)

(11) Install the secondary fuel filter and bracket. (See Figure 74.) Connect the fuel lines from the secondary filter to the hydraulic unit and the transfer pump. (See Figure 26.)

(12) Set the primary fuel filter and bracket in position and screw in the two retaining capscrews. Connect the fuel line from the primary filter to the transfer pump. (See Figure 256.)

(13) Connect the fuel line from the primary fuel filter and return line from the hydraulic

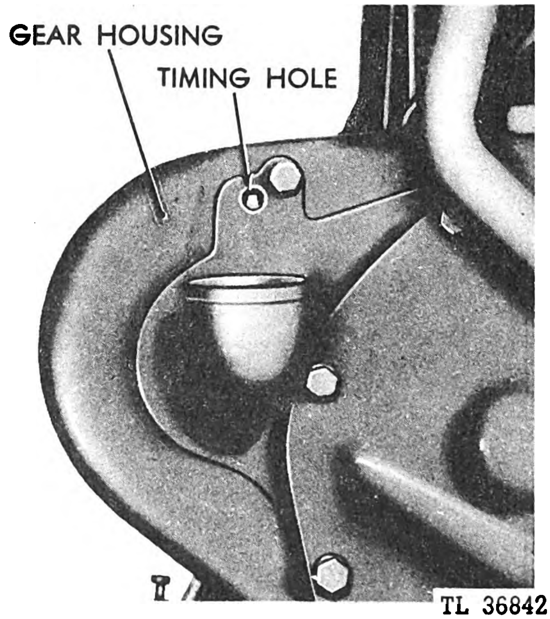

Fig. 190. Fuel Pump Gear Housing Timing Hole

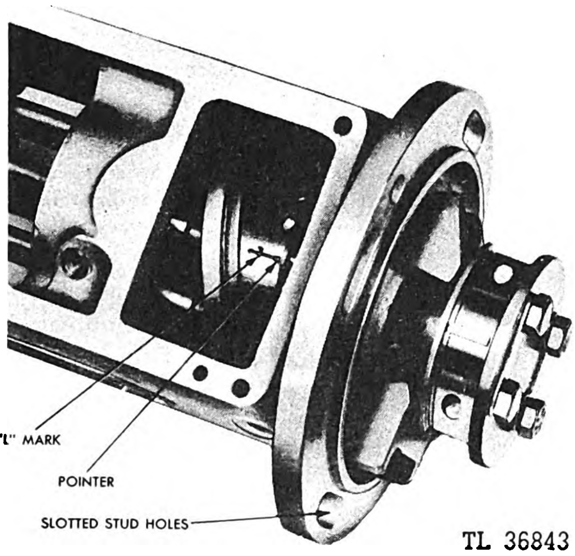

Fig. 191. Timing Marks—Fuel Injection Pump

unit to the "T" connections. (See Figure 256.) Install engine tank, and make connections.

w. Assembling Air Induction and Exhaust Systems to Engine. (1) Set the intake and exhaust manifold gaskets in place on the cylinder head studs. The rounded portion of each gasket should be installed away from the cylinder head. (See Figure 73.) Push the exhaust manifold onto the cylinder head studs. Hold in place by screwing on the center exhaust manifold nut. Do not tighten the nut. (See Figure 68.)

(2) Push the intake manifold onto the cylinder head. Screw the ten nuts and washers holding the intake and exhaust manifold in place. Tighten the nuts gradually and evenly.

(3) If the water jackets, end plate, and elbow

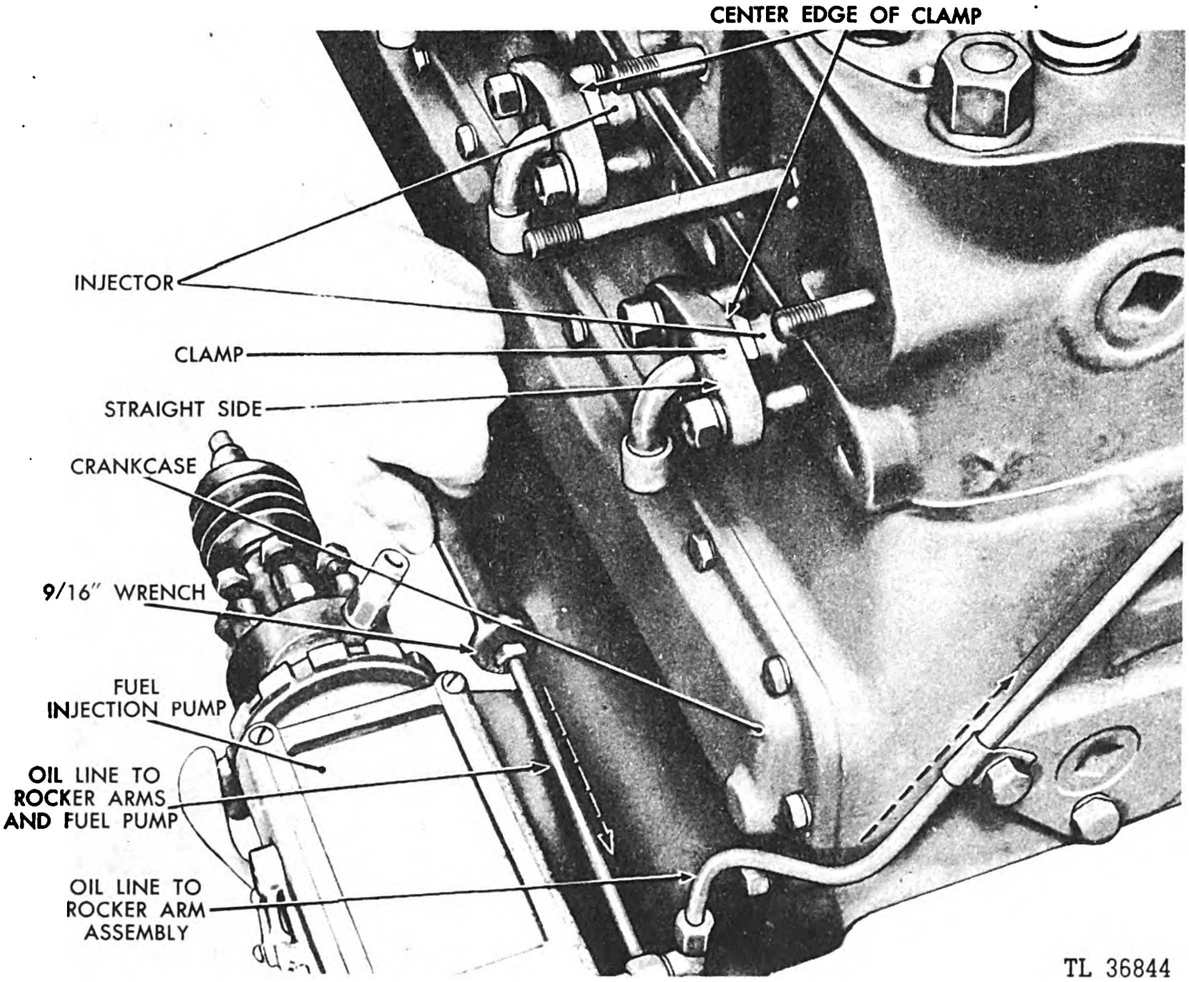

Fig. 192. Installing Fuel Pump Oil Line

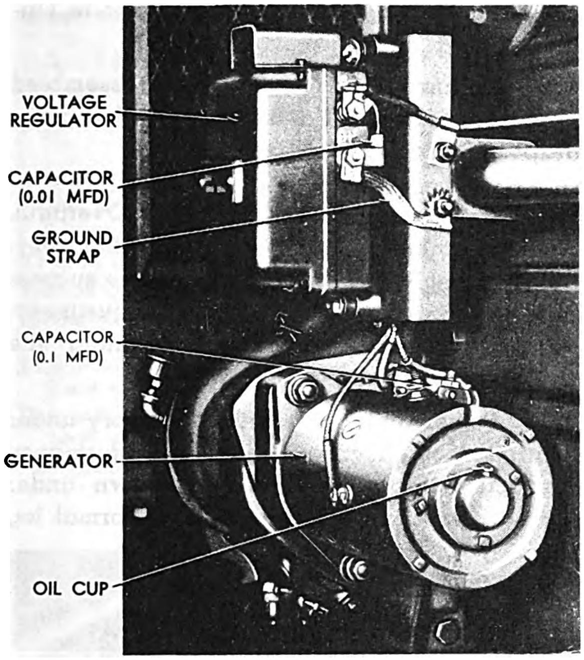

Fig. 193. Generator and Voltage Regulator

connection of the exhaust manifold have been removed, replace them. (See Figures 69 and 70.)

(4) Set the six water connections between the cylinder head and exhaust manifold in place with the gaskets shellacked to the connections. (See Figure 71.)

NOTE: Since the faces of the connections are at right angles, considerable care should be exercised in tightening the connections. The capscrews holding both faces of the connections should be drawn down lightly before the final tightening.

(5) Install the preheater assembly onto the intake manifold. Install the air cleaner adaptor. (See Figure 67.)

NOTE: Be sure the wire screen is replaced between the intake manifold and the preheater body when assembling the preheater to the intake manifold.

(6) Set the air cleaner in place. Be sure the gasket between the air cleaner and adaptor is in good condition.

x. Assembling Electrical System to Engine. (1) Push the starter into position in the flywheel housing. Tighten the capscrews. (See Figure 66.)

(2) Mount the magnetic switch onto the flywheel housing. Connect the electrical connection between the starter and magnetic switch. (See Figure 213.)

(3) Shellac the gear housing gasket to the adaptor. **Be sure the oil hole in the gasket lines up with the return oil hole in the adaptor.** To install generator, push the generator gear so that it will mesh with camshaft gear. Tighten the three nuts holding the generator to the housing. (See Figure 65.)

(4) Mount the voltage regulator to the bracket, using the rubber mountings between the bracket and the regulator. (See Figure 193.)

y. Assembling Cooling System to Engine. (1) Shellac the water pump gasket to the gear housing. Turn the spider on the water pump so that it will fit into the driving lugs of the generator gear. Slip the water pump in place and tighten the three retaining nuts. (See Figure 64.)

(2) Shellac the thermostat housing and adaptor gaskets in place. Install the adaptor, thermostat, housing, and water outlet connection on the exhaust manifold. (See Figure 62.) Be sure the thermostat housing is installed so that the water by-pass mounting boss is facing the water pump.

(3) Set the water by-pass line in place with the gaskets shellacked to the two mounting flanges. Tighten the two capscrews and the two bolts.

(4) Shellac the water inlet manifold gaskets to the cylinder block. Push the three copper distributor tubes in place. Install the water inlet manifold. (See Figure 61.) If the water inlet manifold spacer and spacer inlet connection have been disassembled from the inlet manifold, assemble to the manifold. Be sure to slip the water pump to manifold hose and clamps onto the inlet connections before assembling to the spacer and manifold. (See Figure 61.) Install the voltage regulator and bracket onto the inlet manifold spacer. (See Figure 193.) Connect the electrical leads between the regulator and generator, the G— of the regulator to the G— of the generator, etc. Ground the B— of the regulator to the bracket. (See Figures 66 and 193.)

(5) Mount the fan bracket to the gear cover. Install the fan and pulley assemblies to the bracket. (See Figure 59.) Slip the fan belts

in position on the pulleys and adjust the belt tension with the adjusting screw before tightening the fan bracket clamp nut.

z. *Assembling Lubricating System (External) to Engine.* (1) Install the Cuno filter and bracket to the flywheel housing. The bracket is held against the flywheel housing with two 3/8-inch capscrews. (See Figure 26.)

(2) Install the DeLuxe oil filter to the crankcase mounting pad as shown in Figure 194.

NOTE: The steel plate with a gasket on each side should be installed between the filter and crankcase. Be sure the oil holes in the plate and gaskets line up with the holes in the crankcase oil filter mounting and that the gasket with the circular slot is mounted between the plate and the oil filter.

(3) Connect the oil pressure lines between the DeLuxe and Cuno oil filters. Refer to Figures 26 and 35.)

The engine is now ready to be assembled to the generator unit and test run. (See paragraphs 46*b* and 60.)

60. Test Running Power Unit After Overhaul. The test running of the power unit after overhaul is for the purpose of checking the success of the overhaul and to make such adjustments as are necessary after reconditioning the engine and its component systems.

The Power Unit is tested at the factory under controlled conditions so that the performance characteristics of the unit are known under varied conditions. Figure 195 is a normal log

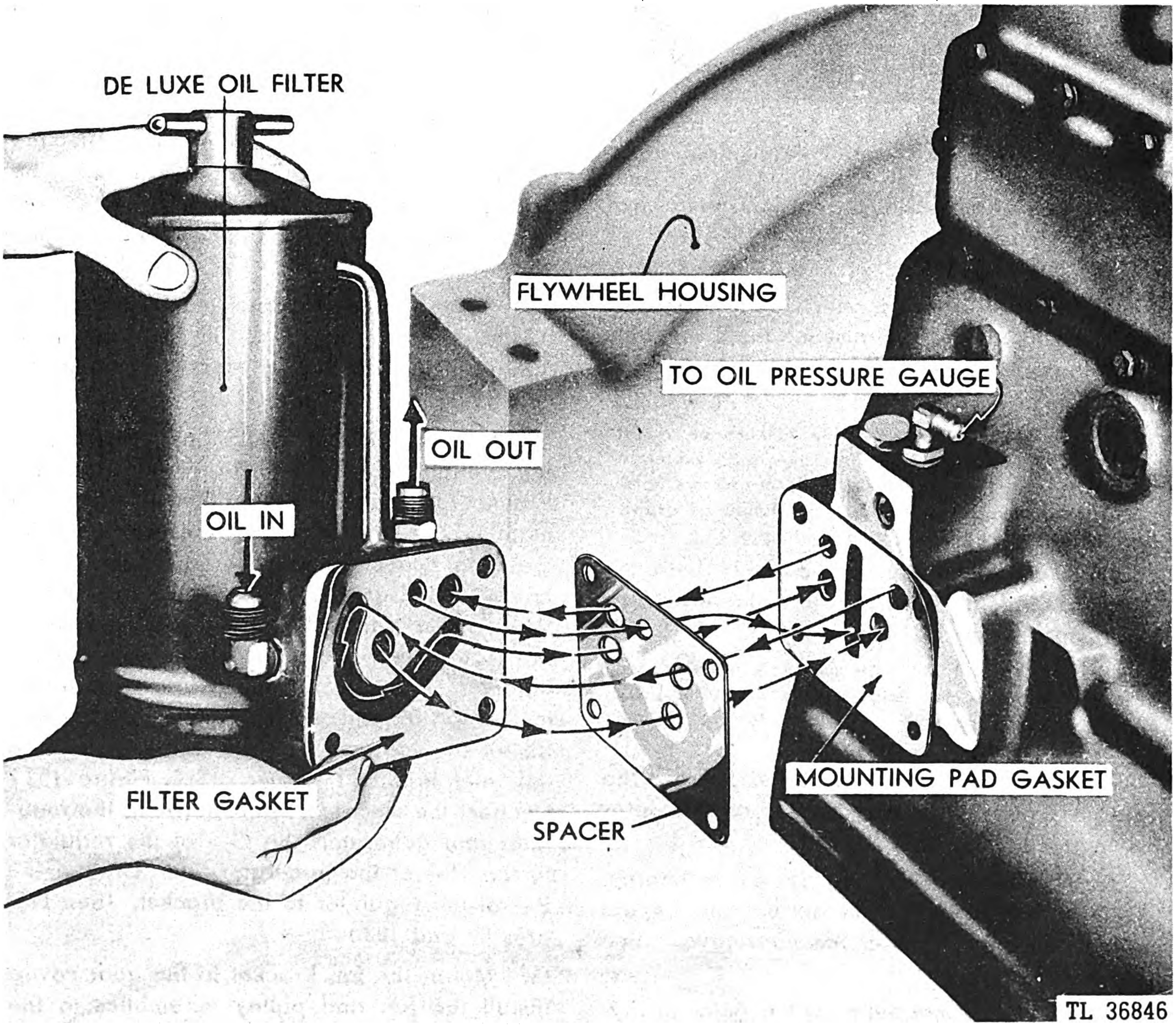

Fig. 194. Installing DeLuxe Oil Filter

sheet taken from the test run at the factory.

a. Performance Characteristics. The performance characteristics of PE-185-B Power Unit are as follows:

	Maximum	*Minimum*
Steady Load Frequency	.5 cycles	.1 cycles
Full Load Frequency	60.1 cycles	59.1 cycles
No Load Frequency	61.5 cycles	60.8 cycles
Voltage Overshoot (Load Off)	13.5 volts	12.6 volts
Voltage Undershoot (Load On)	120 to 116 volts	120 to 105 volts
Time to Recover Frequency When Load is Suddenly Applied	5 sec.	20 sec.
Time to Recover Frequency When Load is Suddenly Dumped	5 sec.	2 sec.
Fuel Consumption (per K.W.H.)	8 lbs.	.73 lbs.

b. Preparing Power Unit for Test Run. (1) Fill the crankcase with eight gallons of SAE 30 engine oil. (Army symbol OE-30.)

(2) Fill radiator with soft, clean water.

(3) Lubricate the engine according to the Lubrication Chart. (See paragraph 30.)

(4) Connect the fuel line and the fuel return line from the auxiliary tank and the engine tank. Vent the fuel system according to the instructions given in paragraph 23 (9), (10), (11), (12) and (13).

c. Test Run Checks. (1) Start the Power Unit according to the instructions given in paragraph 26. As soon as the engine starts,

ENGINE GENERATOR TEST
Unit No. 22
Engine No. 19157
Generator No. 6002073
Panel Board No. K6362802-210

Date Feb. 8, 1944
Generator Set PE-185-B
25 K.W., 80% P.F., 3 Phase
120/208 Volts, 60 Cycle,
1200 R.P.M.

	1/4	2/4	3/4	4/4	5/4	5/4	5/4	5/4	EQUIPMENT	
Time	10:00	10:15	10:30	10:45	11:00	11:15	11:30	11:45	Oil sw. lbs. 12 #	OK HFS
Volts— Ph. 1	209	209	208	208	208	208	208	208	Water sw. °F. 205	OK GMC
Ph. 2	209	209	208	208	208	208	208	208	Panel Lights	OK
Ph. 3	209	209	208	208	208	208	208	208	Howler & Sw.	OK
Amps.—Ph. 1	27	46	65	88	92	91	91	91	Switchboard	OK
Ph. 2	28	47	65	88	92	91	91	91	Eng. Controls	OK
Ph. 3	28	47	65	88	92	91	91	91	Fuel Valve	OK HFS
Freq. (Board)	60.7	60.5	60.3	60.0	59.7	59.8	59.8	59.8		
Time Meter	1	1	1	2	2	2	2	3		
Oil Pressure	46	43	41	37	36	35	33	32		
Oil °F.	150	155	160	175	175	180	185	190		
Water °F.	145	145	145	150	150	155	155	155		
Charge Amps.	3	3	3	3	3	3	3	3		
Air to Rad. °C.	22	23	27	29	29	30	30	30		
Intake Air °C.	21	22	26	28	28	29	29	29		
Rad. Top °C.	145	145	145	150	155	155	155	160	Fuel Consumption	
Air to Alt. °C.	25	26	26	29	30	30	31	31	C.C. 474	
Alt. Frame °C.	30	31	31	34	35	35	37	37	K.W. 26.0	
Std. Volts	121	121	120	120	120	120	120	120	Time 156 Sec.	
Std. Amps.	27	46	65	88	92	91	91	91	Lbs./K.W.H. .777	OK
K.W. (Chart)	7.6	13.6	19.2	26	32.6	31.8	31.8	31.8		
K.V.A. (Chart)	9.7	16.7	23.4	31.7	32.6	31.8	31.8	31.8		
P.F. (Calc.)	78%	81.5%	82%	82%	100%	100%	100%	100%		
Freq. (Chart)	60.6	60.5	60.4	60	59.7	59.8	59.8	59.8		
Chart Time	4:00	4:15	4:30	4:45	6:15	6:30	6:45	7:00		
Starting Test (seconds)	(1) 1.1	(2) 1.2	(3) 1.1	(4) 1	(5) 1	(6) 1.1			Tested by: H. F. Schomas	

This is to certify that the above data is a true copy of test made on equipment indicated.

Signed E. Gibbons
The Buda Company
Dieselight Division

Government Inspector's Approval Date Feb. 8, 1944

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Fig. 195. Log Sheet of Normal Performance

check the oil pressure. Allow the engine to run at half speed (approximately 600 R.P.M.) and check for oil, fuel or water leaks. Check the battery charging ammeter. Allow the engine to come up to normal operating temperature, which is between 120 and 170 degrees Fahrenheit.

(2) Remove the rocker arm assembly cover and adjust the valve tappets with a feeler gauge, the intake clearance to be .009 and the exhaust .012 inch. See instructions for adjusting the valve tappet clearances in paragraph 40 (4). Also see paragraph 82.

(3) Run the Power Unit for at least six hours, five of which should be run as follows: One hour at no load at 1000 R.P.M. (Revolutions Per Minute); one hour at no load at 1200 R.P.M.; one hour at half load at 1200 R.P.M.; one hour at three-quarters load at 1200 R.P.M.; and one hour at full load at 1200 R.P.M.

(4) Some time toward the completion of the test run, check the water temperature safety switch of the howler by raising the water temperature of the cooling system. This can be done by closing off the air circulation through the radiator. The howler should sound when the temperature reaches approximately 205 degrees Fahrenheit. If any adjustments are necessary, see paragraph 92*b*. Also, see paragraph 82. If the performance of the Power Unit is not normal, refer to paragraph 44; also check the Trouble Charts, pages 47 to 50 inclusive.

61. Foreword to Overhauling Component Systems. Exercise the same care and thoroughness in overhauling the engine component systems as you would in overhauling the basic engine. Only experienced mechanics should attempt to service the fuel injection equipment. Likewise, adjustments to the battery charging voltage regulator must be done by an experienced mechanic. Before attempting to service any one of the accessories, be sure you understand its related function in the system in which it operates as applied to your Buda 6-DTG-468 engine. The component systems are given alphabetically with functional descriptions and all the necessary information for a thorough and complete overhaul.

62. Air Induction System. The air induction system comprises the air cleaner, air cleaner adaptor, preheater, intake manifold, and the intake valves and ports. See paragraph 6 for a functional description of the system.

63. Air Cleaner. The air cleaner not only cleans the air to prevent the entrance of abrasive dust which is the major factor of engine wear, but also acts as an air silencer. The air cleaner is of the oil bath type. (See Figure 196.) No repairs or overhaul are necessary to the air cleaner. The only servicings required are those listed in Section III, paragraph 37, and in addition the following: Soak the air filter element and assembly in gasoline. Blow the element dry with compressed air, not to exceed 25 pounds pressure. The foregoing servicing must be done during the overhaul

Fig. 196. Air Cleaner (Exploded)

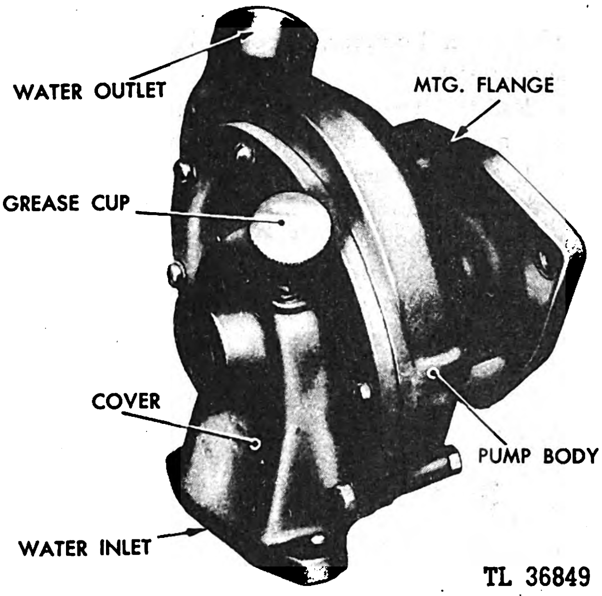

Fig. 197. Water Pump

and as often as the daily inspections might indicate.

The connections between the air cleaner and the intake manifold must be kept airtight at all times. Observe the condition of the air cleaner to adaptor gasket. Replace if faulty.

64. Preheater Element. Examine the metal ribbon element for oxidation. If the ribbon is severely pitted or corroded, replace the ribbon. Check the cross-shaped ribbon holders for disintegration, flaking, and broken arms. Examine the insulation around the electrical connections. If any of the foregoing conditions exist, replace the element. (See Figure 67.)

NOTE: The ribbon element should be tight in the ribbon holders. No section of the ribbon should touch another portion of the same ribbon.

65. Cooling System—Foreword to Overhaul. The efficient operation of the power unit depends a great deal upon maintaining the proper operating temperatures in the cooling system. The description of how the cooling system maintains the proper operating temperature is given in paragraph 7. During the general overhaul, check thoroughly the units of the cooling system and replace the rubber hose connections with new ones, as rubber deteriorates with age, releasing fine particles into the cooling system and lodging usually in the radiator tubes, thus impeding water circulation. The cooling system includes the water pump, fan, radiator, thermostats, by-pass line, intake and outlet water manifolds. A temperature gauge indicates the temperature of the water. If the operating temperature exceeds 205 degrees Fahrenheit, the howler system will give warning. The instructions for servicing the howler system are given in paragraph 92.

66. Water Pump. Positive water circulation is assured by an impeller-type water pump mounted on the gear housing and is driven by the generator drive gear through a coupling. (See Figure 37.) Tighten the packing nut (shown in Figure 37) just enough to stop leakage, then back off slightly to relieve the pressure. If this packing nut is kept too tight, the shaft will gall and the stuffing boxes will leak.

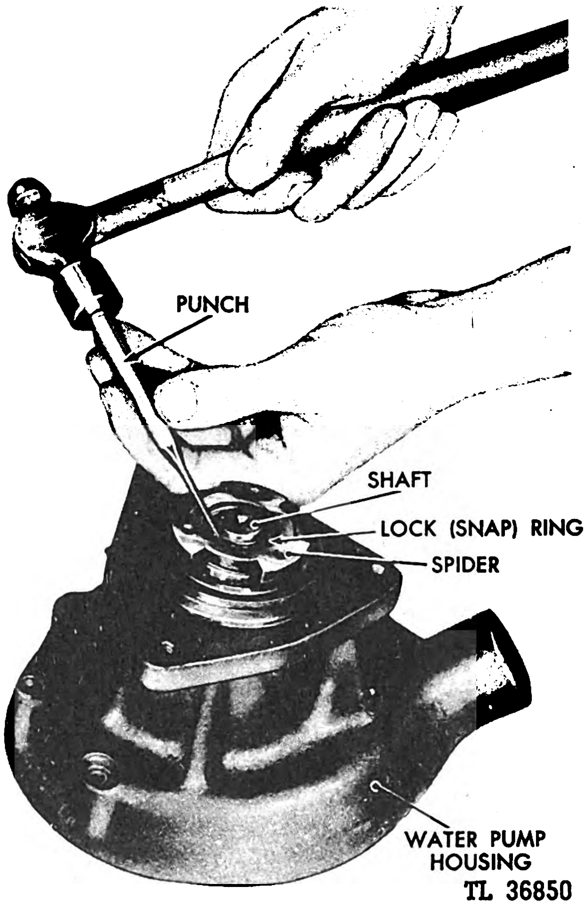

Fig. 198. Removing Clip from Water Pump Shaft

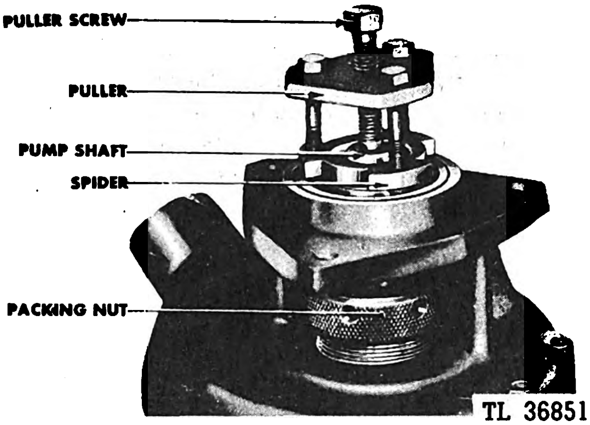

Fig. 199. Pulling Spider from Shaft

If frequent adjustments are necessary, this is an indication of worn bushings, worn shaft or misalignment, and corrective measures must be taken as indicated in the following paragraphs. The grease cup of the water pump should be kept filled with WP grease. See Lubrication Chart, page 33, and Figures 34 and 35. (Also see Figure 197.)

a. Disassembly. (1) Remove the clip and the spider from the water pump shaft. (See Figure 198.)

(2) Pull the spider and the ball bearings from the shaft with a wheel puller as indicated in Figure 199.

(3) Remove the water pump cover capscrews and bolt.

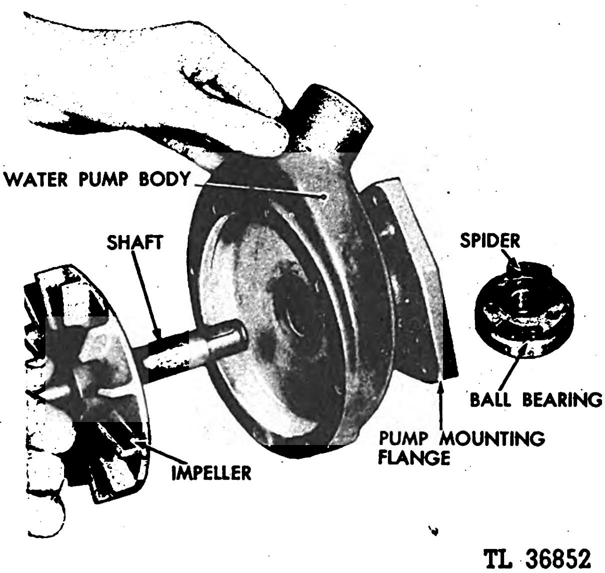

Fig. 200. Removing Impeller from Housing

(4) Tap the cover from the housing with a lead or soft hammer, tapping lightly on the water inlet boss.

(5) Pull the impeller from the shaft and water pump housing as shown in Figure 200.

(6) If the impeller or shaft needs to be replaced, the shaft can be removed from the impeller as shown in Figure 201. The shaft has an integral snap ring or machined collar which fits into a machined recess in the impeller; consequently, the shaft can only be pressed out one way; that is, the short end of the shaft must be pressed through the impeller. (See Figure 201.)

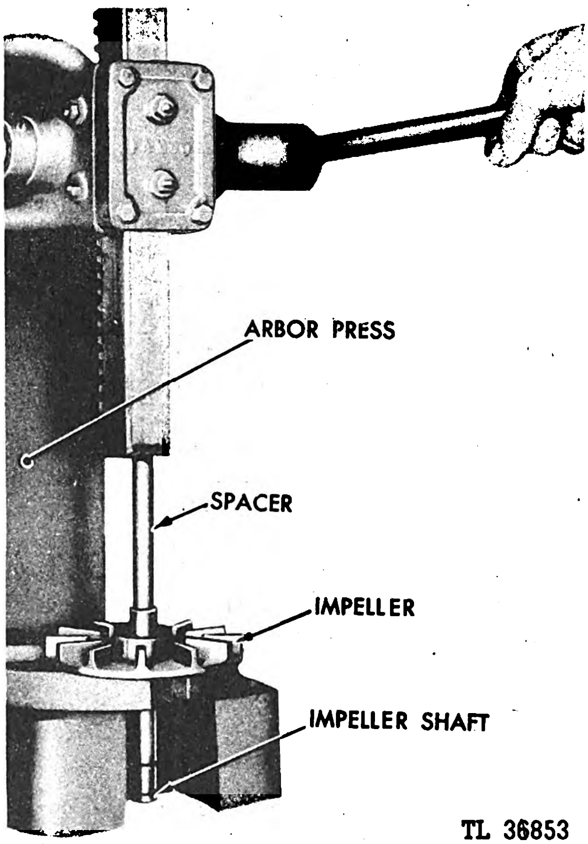

Fig. 201. Pressing Shaft Out of Impeller

(7) Unscrew the packing nut, remove the packing gland and pry out the old packing.

(8) Drive out the oil seal from the water pump body with a hard wooden block and hammer as shown in Figure 202.

(9) Do not remove the bearing from the spider unless the spider or bearing needs to be replaced, since the bearing will be of no further

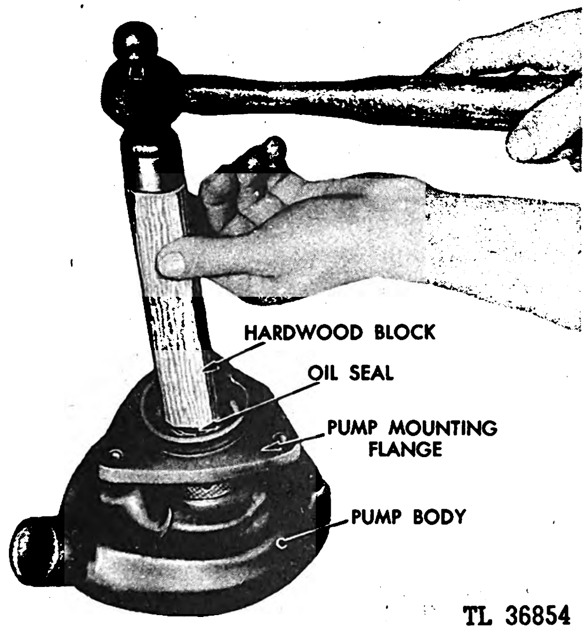

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Fig. 202. Driving Out Oil Seal

use after it is removed. If removal is necessary, press the bearing from the spider. The pump is now completely disassembled.

b. Inspection and Replacements. (1) Examine the shaft for wear on the plain bearing end and at the packing position. If the impeller was loose on the shaft at the time of removal, replace both the shaft and the collar.

(2) Check the impeller for cracks and corrosion. If the impeller was loose on the shaft, it is recommended that both the impeller and shaft be replaced.

(3) Examine the ball bearings and the spider for rough spots and excessive clearance. Do not remove the bearing from the spider unless the bearing needs replacement.

(4) Check the cover for cracks, clean the pump drain hole, and check the clearance between the shaft and the bushing and the cover. If this clearance exceeds .005 inch, replace the bushing. The shaft will not need to be replaced unless the bearing surface is ridged or scored. To replace the bushing, drive the expansion plug from the cover from the inside with a punch and hammer. The bushing can be easily pressed from the cover, as illustrated in Figure 203, using a spacer slightly less in diameter than the outside of the bushing. Be sure the grease passages are open from the grease cup to the bushing. In a like manner, press the new bushing in place. Ream the bushing to a running fit with the shaft.

(5) Examine the spider for excessive wear on the driving lugs. If the spider was loose on the shaft, replace both the spider and the shaft. If the spider needs replacement, replace both the spider and the ball bearings.

c. Reassembly. (1) Drive in the new oil seal in the water pump housing with a wooden block and hammer. The oil seal should be installed with the edge of the leather on the spider side of the housing. (See Figure 204.)

(2) Press the impeller on the shaft with the key in place.

NOTE: The collar or snap ring on the shaft must be positioned so that, when the shaft is pressed into the impeller, the collar or snap ring will fit into the recess.

(3) Temporarily push the shaft and impeller into the housing and install the new packing rings as shown in Figure 205.

(4) Press the spider and ball bearings on the shaft. Be sure the outer bearing recess is started straight into the housing. Push the clip

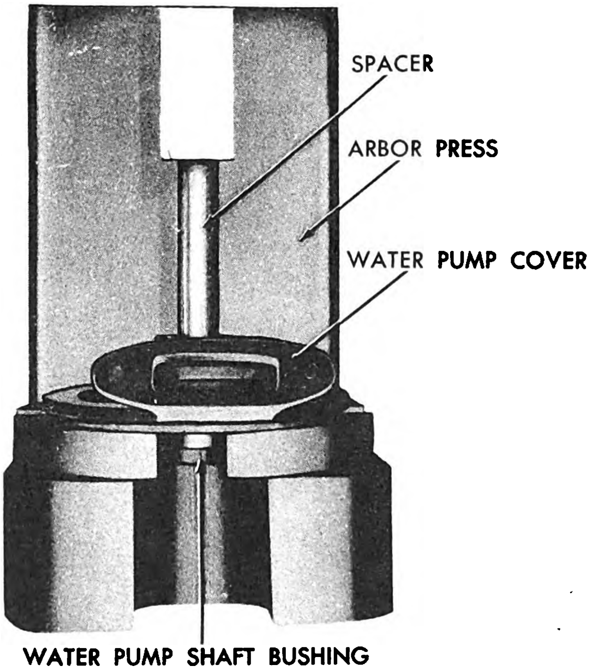

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Fig. 203. Pressing Bushing from Cover

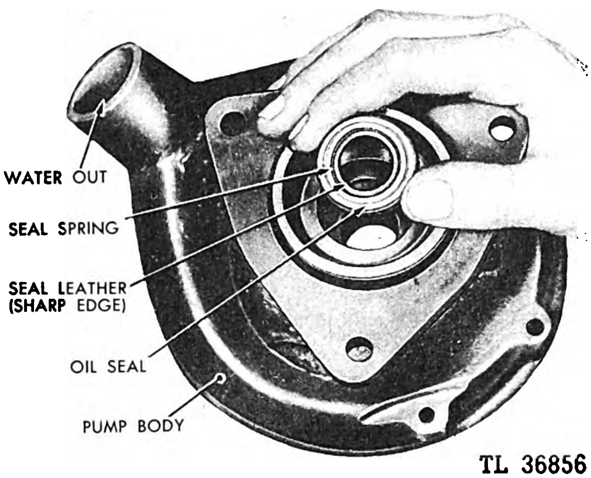


Fig. 204. Installing Oil Seal in Housing

or locking ring in the groove provided for it on the shaft. (See Figure 198.)

(5) Install the cover on the water pump, using a new gasket. Since the cover can be installed in two different positions, the cover must be installed so that the plane of the water inlet tube mounting surface is approximately perpendicular to a line drawn from the center of the shaft and the bottom water pump mounting hole. (See Figure 64.) Push the expansion plug into place and punch lightly in the center to tighten it in the cover.

(6) Fill the grease cup and turn it at least three times. Tighten the water pump packing nut and slack off until the nut is just snug. The pump and shaft must turn freely.

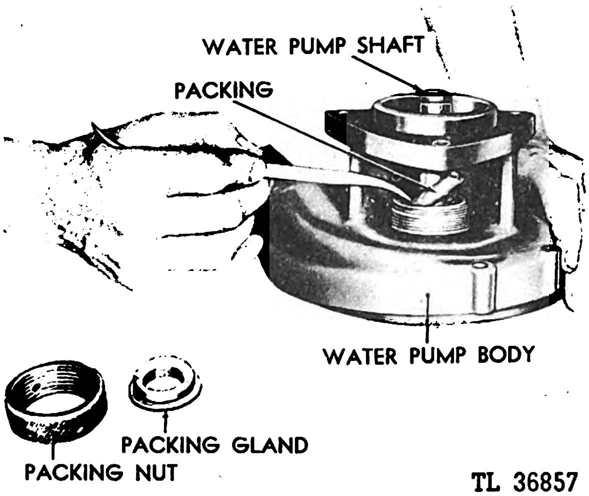


Fig. 205. Installing Pump Packing Ring

67. Fan and Belts. The fan is of the pusher type, blowing the air from the engine through the radiator. The fan is lubricated with wheel bearing grease, WB-3, every 512 hours of operation. At 2,048 hours of operation the fan should be disassembled, thoroughly cleaned and the parts checked for excessive wear. The fan belts are of the "V" type. "V"-type belts must run with some slack in order to avoid excessive wear. There must be just enough slack to prevent slippage—approximately 3/4 inch. When installing a new fan belt, always loosen the fan belt adjusting screw so as to allow the belt to be slipped in place without forcing. This will avoid any internal damage to the belt.

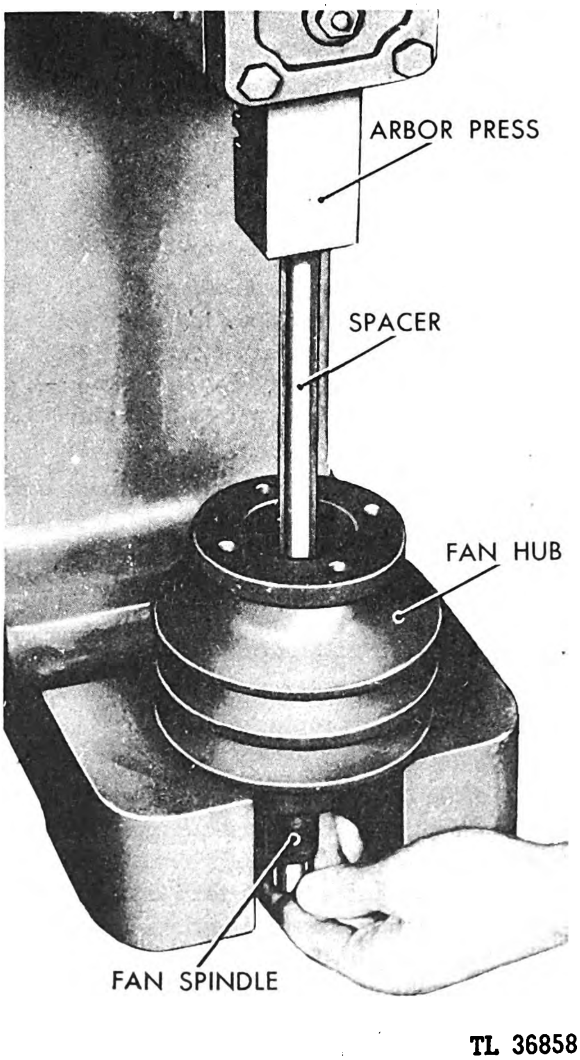


Fig. 206. Pressing Spindle from Hub

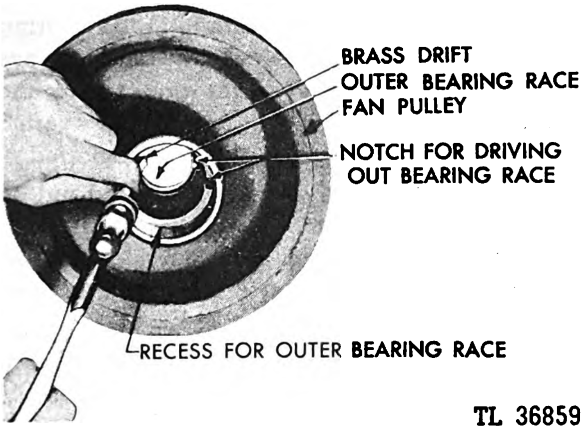


Fig. 207. Removing Outer Race from Fan Hub

a. Disassembly. (1) Unscrew the four capscrews holding the fan blade to the pulley hub and remove the blade assembly.

(2) Scrape out the old grease, remove the old cotter key, and unscrew the castellated nut in the fan end of the pulley hub. Remove the washer.

(3) With an arbor press and spacer as shown in Figure 206, press the spindle from the hub. Do not let the spindle fall to the floor when it is pressed out of the hub.

(4) Turn the pulley hub over and the front bearing (fan end) will fall out. **CAUTION: Do not let the bearing drop on the floor.**

(5) Under normal conditions it is not necessary to remove the outer bearing races from the hub. If a bearing is faulty, remove the outer race with a brass drift and hammer as shown in Figure 207. There are four cast openings in each end of the hub just back of the outer bearing race, which provides space for the drift to set against the outer race when driving it out.

(6) Pull the oil seal from the spindle. Discard the cork or felt washer in the oil seal.

(7) Do not press the rear bearing from the spindle unless either the bearing or the shaft is faulty. If it is necessary to separate the bearing from the spindle, use an arbor press as shown in Figure 208. **CAUTION: Be sure that the pressure is exerted on the inner race only and not on the rollers and bearing cage.**

b. Inspection and Replacements. (1) Examine the blade assembly for distorted blades, loose rivets, or cracks. Replace the blade assembly if it is cracked or if the blades are severely distorted or if there are loose rivets. The blades can be straightened if they are only slightly bent.

(2) Check the pulley hub for cracks, loose outer bearing races, loose oil seal retainer or stripped threads on the blade assembly retaining capscrews. Replace the hub if these faults are in evidence.

(3) Examine the bearing for pits and worn spots and for evidence of extreme wear. Replace the bearing if any pits or wear is present.

(4) Check the spindle for stripped threads and loose inner bearing races. If the races are loose on the shaft or threads are stripped, replace the spindle.

c. Reassembly. (1) If the outer bearing races were removed from the pulley hub, install each race in the hub with a hard wooden block and hammer as shown in Figure 209. Be sure the race is started in squarely and that the thick end of the race is toward the center of the hub.

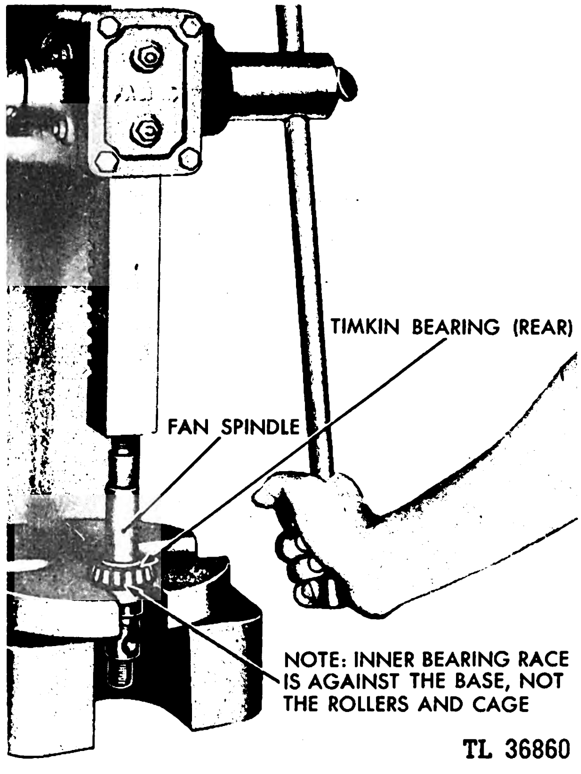


Fig. 208. Pressing Bearing from Fan Spindle Shaft

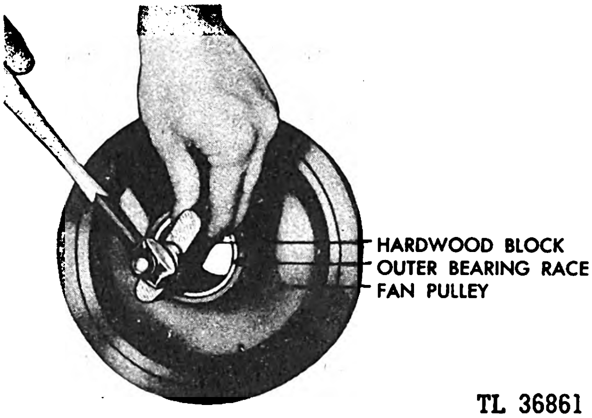


Fig. 209. Installing Outer Race in Fan Hub

(2) If the rear bearing is not on the spindle, press it in place with an arbor press as shown in Figure 210. **CAUTION: Be sure that the pressure exerted on the pipe spacer is transmitted to the inner race only and not on the cage or rollers.**

(3) Coat the spindle and bearing liberally with grease. Set the spindle and bearing in the pulley hub. Turn the hub over and pack the remaining space with grease.

(4) Push the front bearing in the hub. It may be necessary to tap the bearing on the spindle

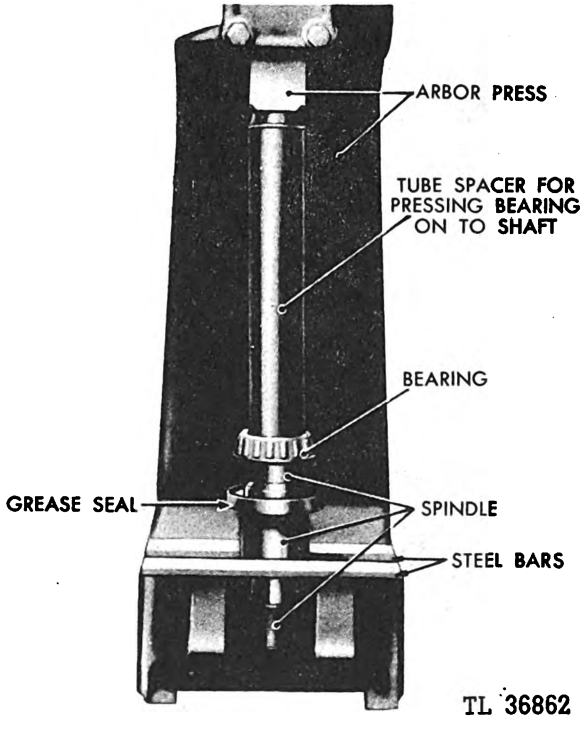


Fig. 210. Pressing Bearing on Fan Spindle

with a pipe spacer large enough to fit over the spindle, but not large enough to fit the bearing cage. When installing or removing bearings of this kind, always exert the pressure on the inner race, because if the pressure is exerted on the cage, the bearings will be damaged.

(5) Install the washer and castellated nut on the spindle. Tighten the nut until a definite bind is felt when turning the hub, slack off the nut one-quarter of a turn. Install the cotter key.

(6) Install the oil seal. (See Figure 211.) Insert the retainer washer against the bearing. With the cork or felt washer in the retainer, tap the pulley hub in place with a hard wooden block and hammer. The back of the retainer should be flush with the end of the pulley hub when it is in the right position.

(7) Install the fan blade assembly and new gasket on the pulley hub. Tighten the four capscrews evenly.

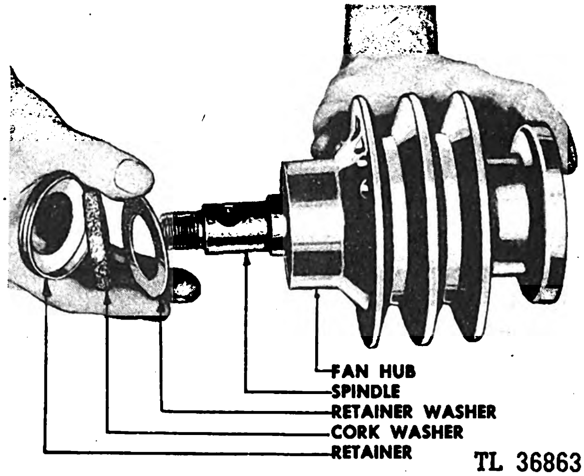


Fig. 211. Installing Oil Seal in Hub

68. Water Lines and Connections. The water circulating parts or lines and connections include the inlet and outlet water manifolds, water distributors, by-pass line, thermostat and housing, hose connections, and the radiator. The instructions for servicing the radiator are given in paragraph 69.

a. *Inlet and Outlet Water Manifolds.* Check these lines for any cracks and corrosion. Replace them if necessary. Check also the adaptor to which the generator bracket is attached.

b. *Water Distributors.* Check the distributors for any damage or corrosions. (See Figure 61.)

c. *Thermostat, Housing, and By-Pass Line.* The thermostat is of the bellows type and is installed in the water outlet connection. (See Figure 62.) Inspect the thermostat for freedom of movement and excessive corrosion. If it does not function or if it is corroded, replace it. Check the thermostat and by-pass lines for cracks or corrosion.

69. Radiator. The radiator core must be kept from corrosion and scale at all times. Use only clean, soft water in the cooling system. Where the use of hard water cannot be avoided, use a commercial water softener. With air pressure, blow out bugs or any leaves or lint, or any other obstructions that may have lodged between the fins in the core and the tubes. Straighten bent fins. (See Figure 212.)

a. *Servicing Clogged Radiator.* If the radiator is badly clogged, use cleaning compound, Federal stock No. 51-C-1568-500; and neutralizer, Federal stock No. 51-C-1600; specification ES-7346. Use one container of cleaning compound to every 4 gallons of water to fill the cooling system,—cooling system capacity, 8½ gallons. NEVER MIX THE WATER AND THE CLEANING COMPOUND BEFORE POURING THEM IN THE SYSTEM. DO NOT SPILL THE SOLUTION ON YOUR SKIN, CLOTHING, OR THE PAINTED PORTIONS OF THE ENGINE. Clean as follows:

(1) Run the engine until it reaches operating temperature. Stop the engine and drain the cooling system.

(2) Slowly pour in water till the system is half full. Add cleaning compound in the correct proportions. Complete filling with water.

(3) Replace radiator cap, run the engine at fast idling speed. Use a drain pan to catch the overflow from the radiator. Cover the radiator if necessary until the coolant reaches 180 degrees Fahrenheit but not over 200 degrees Fahrenheit. Constantly check water level.

(4) Stop the engine after it has run for thirty minutes at 180 degrees Fahrenheit but not over 200 degrees Fahrenheit. Drain the cooling system completely and allow engine to cool.

(5) Close drain cocks and pour water slowly until system is .alf full.

(6) Run the engine at idling speed. Add the neutralizer in the same proportions, one container to every four gallons of water. Complete filling the system with water. Allow the engine to idle for at least five minutes at operating temperature.

(7) Stop the engine and drain system completely. Allow the engine to cool.

(8) Pour water slowly into the radiator until the system is approximately half full. Run the engine at idle speed and fill the system completely with water. Run the engine until the coolant is heated to the normal operating temperature. Drain the system and repeat this flushing operation until the drain water is clean.

b. *Repairing a Leaky Radiator.* Do not use liquid solder or radiator compounds to stop leaks, as these tend to clog the radiator tubes. A leaky radiator should be tested under water with about 4 to 5 pounds of air pressure. Note the source of the air bubbles and solder the leaks. Be sure to wash off the acid after soldering, for many well-done jobs have been ruined by not washing off the acid which will eat into the tubes.

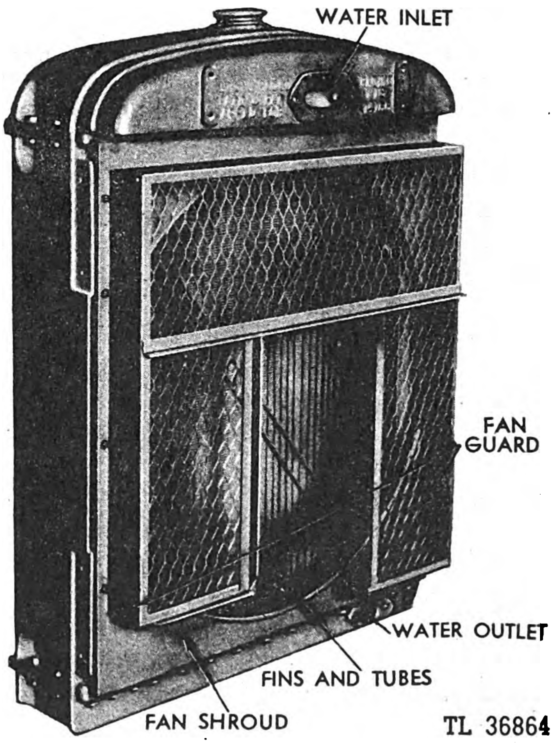


Fig. 212. Radiator

c. *Anti-Freeze.* The anti-freeze mixtures recommended are as follows:

Denatured Alcohol and Water

Freezing Temperature—Degrees Fahrenheit	Amount of Alcohol to Add to Each Gallon of Water
20	2 pts.
0	4 pts.
—20	6 pts.
—40	10 pts.
—60	19 pts.

For example, for each gallon of water placed in the radiator when the temperature draws near 20 degrees below zero, add 6 pints of denatured alcohol.

Ethylene Glycol (Prestone) and Water

Freezing Temperature—Degrees Fahrenheit	Amount of Ethylene Glycol to Add to Each Gallon of Water
16	2 pts.
0	4 pts.
—19	6 pts.
—34	8 pts.
—49	10 pts.
—62	12 pts

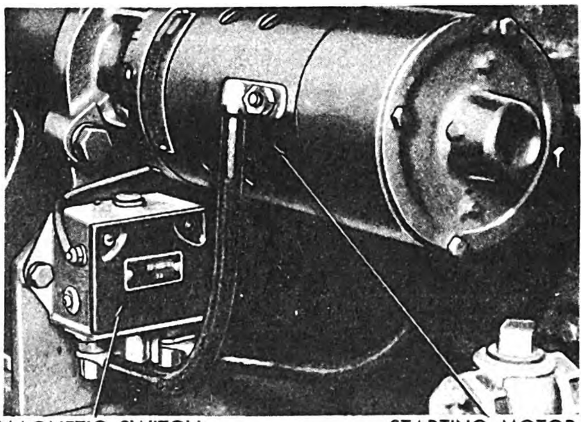
70. Water Temperature Gauge. The water temperature gauge indicates the water temperature as the water is leaving the cylinder head water jackets. Check the bulb for corrosion and the indicating hand of the gauge for false reading. If either the gauge or bulb is faulty, replace the entire unit.

71. Engine Electrical System. The engine electrical system includes the starting and the generating systems. (See the Wiring Diagram, Figure 5.) Although the howler system functions directly with the engine, the howler circuit does not receive its operating energy from the engine electrical system, but from the alternator. Instructions for servicing the howler system are given in paragraph 92. The engine electrical system is of 24 volts and employs the single-wire circuit which contains various size wires and connections by which all the electrical units are interconnected with the storage battery except the howler system. The engine and metal parts act as a ground for completing the circuit necessary for conducting the electrical energy to the different units.

The engine electrical system is radio shielded to prevent radio interference. One 0.1 MFD, one 0.01 MFD and one 0.02 MFD condensers are used. See Wiring Diagram, Figure 5.)

72. Starting System. The starting system includes the cranking motor, push button and magnetic switches, and the battery. Instructions for such servicings, which are necesssary for preventive maintenance to keep the cranking motor, switches and battery in efficient operating condition, are indicated in the Maintenance Reference Chart on Page 34 with further references to detailed instructions. The instructions that follow are for general overhaul and parts replacement.

73. Cranking Motor. The Leece - Neville 1236-M cranking motor is a series type, four-pole, four-brush motor. The current drawn by the motor is inversely proportional to the speed. Consequently, as the load drops off, the tendency is for the speed to increase. For this reason do not run the motor at the rated voltage without a load for any length of time, as it will tend to exceed the maximum allowable speed. (See Figure 213.)



TL 36865

Fig. 213. Cranking Motor

a. *Motor Characteristics.*

Dia. 5⅛"	Volts: 24	
Lock Torque	Ft. Lbs.	90
	Amps.	1320
	Volts	12.2
Max. H.P.	H.P.	9.6
	Amps.	640
	Volts	17.6
	R.P.M.	1600
	Ft. Lbs.	31.5
	Eff.	64%
Max. R.P.M.	R.P.M.	3600
	Amps.	280
	Volts	21.2
	H.P.	4.05
	Ft. Lbs.	5.9
	Eff.	51%

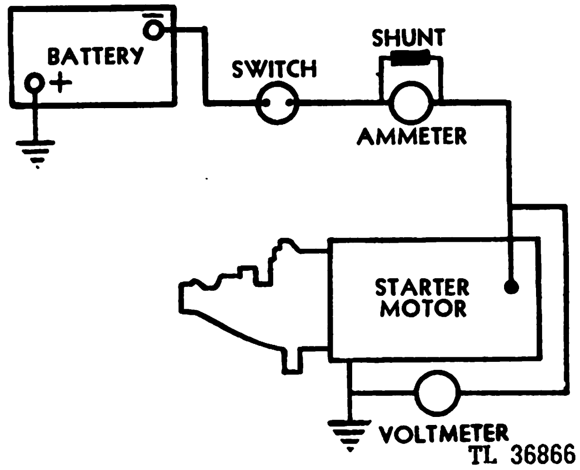


Fig. 214. Diagram—No-Load Test

b. No-Load Test. Connect the cranking motor in series with a battery of 24 volts and an ammeter capable of reading several hundred amperes. The armature r.p.m. can be checked with an r.p.m. counter. Figure 214 shows the hookup for the no-load test. The cranking motor should be fastened securely in a vise. At 3600 r.p.m. the ammeter should indicate 280 amperes and the voltmeter 21.8 volts.

c. Torque Test. For the torque test, a high-capacity ammeter, voltmeter, storage battery, torque arm, and a spring balance or spring scale are needed. (See Figure 215.) Fasten the torque arm securely to the cranking motor shaft. Clamp the motor to a work bench. Hook the spring scale to the torque arm exactly 12 inches from the center of the motor shaft. With the circuit closed, check the reading on the scale, the current draw on the ammeter, and the voltage on the voltmeter. These readings should indicate 90 foot pounds; 1320 amps., 12.2 volts, respectively.

d. Interpreting Results of No-Load and Torque Tests. (1) Rated torque, current draw and no-load speed indicate a normal condition of the cranking motor.

(2) Low free speed and high current draw with low developed torque may result from tight, dirty, or worn bearings, bent armature shaft, or loose field pole screws which would allow the armature to drag; shorted armature, grounded armature, or grounded field. This latter can be checked by raising the grounded brushes and insulating them from the commutator with cardboard and then checking with a test lamp between the insulating terminals and the frame. If the test lamp lights, raise the other brushes from the commutator and check

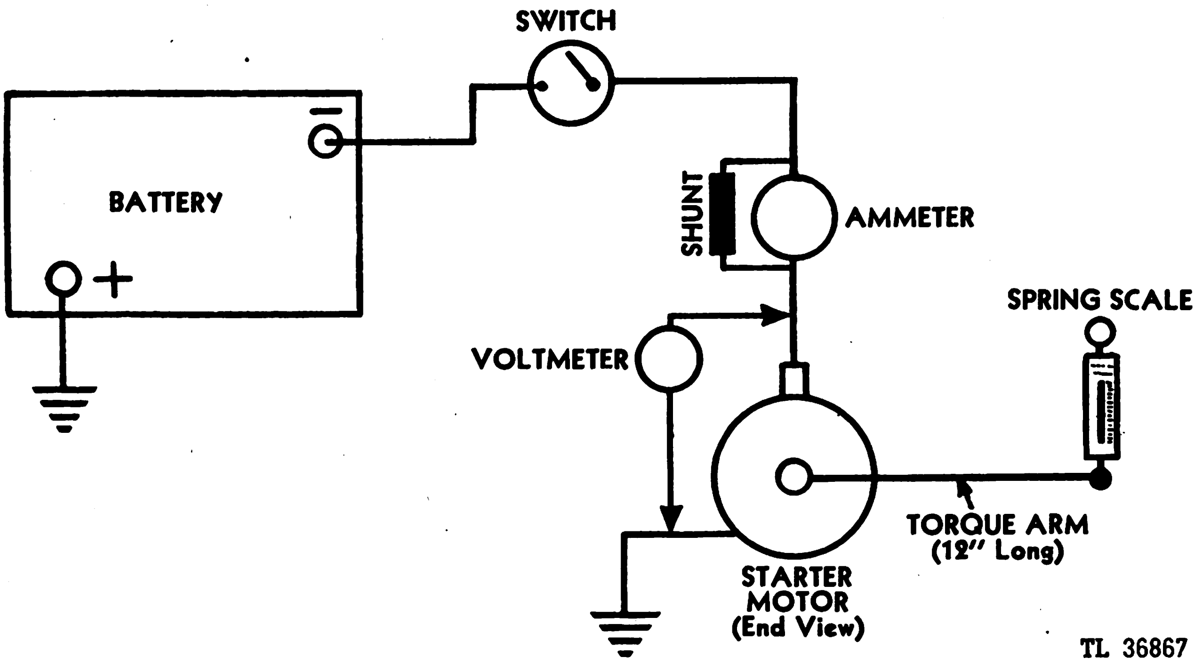


Fig. 215. Diagram for Torque Test

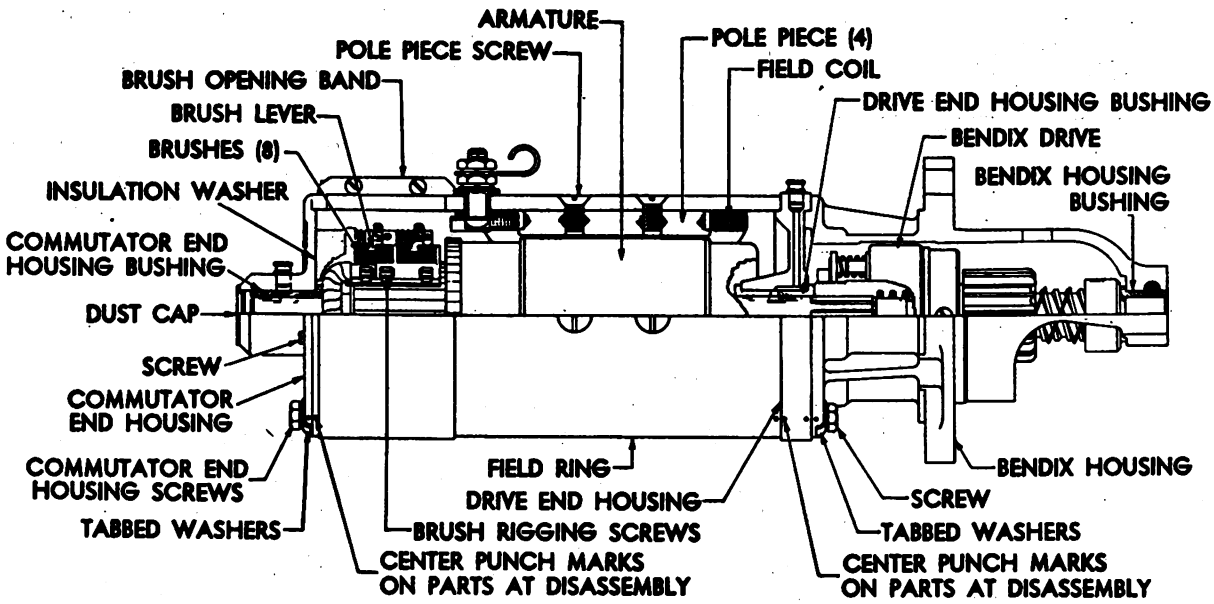


Fig. 216. Line Drawing of Cranking Motor TL 36868

the fields and commutator separately to determine whether it is the fields or the armature that is grounded.

(3) Failure to operate with high current draw indicates a direct ground in the switch, terminals, or fields; or frozen shaft bearings which prevent the armature from turning.

(4) Failure to operate with no current draw indicates an open field circuit, open armature coils, broken or weakened brush springs, worn brushes, high mica on the commutator, or dirty commutator.

(5) Low no-load speed, with low torque and low current draw indicates an open field winding, high internal resistance due to poor connections, defective leads, dirty commutator, or causes listed under item 4.

(6) High free speed with low developed torque and high current draw indicates shorted fields. There is no easy way to detect shorted fields, since the field resistance is already low. If shorted fields are suspected, replace the fields and check for improvement in performance.

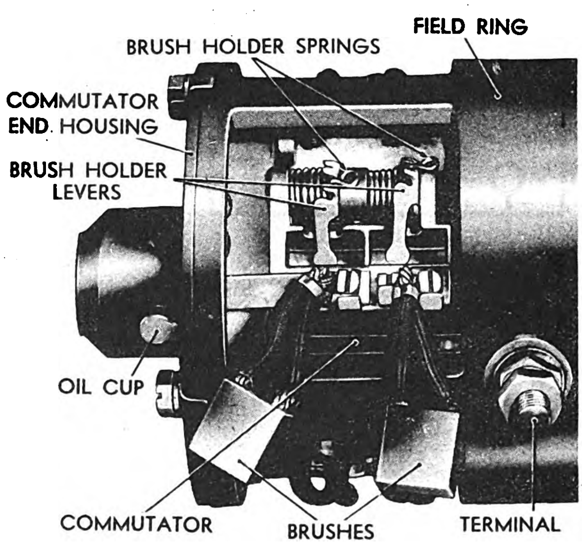
e. *Disassembly.* It is recommended that the motor be placed in a jaw-leaded vise for the following disassembly:

(1) Mark the field ring and all the three housings with the center punch marks so these marks may be lined up in reassembly. (See Figure 216.)

(2) Remove the cover or brush opening band.

(3) Lift up the brush levers and release the spring pressure. Be careful not to snap the brush levers, as this may damage the brushes. Remove all the brushes. (See Figure 217.) **CAUTION: Do not pull on the pigtails when removing the brushes.**

(4) Bend down the tabs on the lockwasher under all the housing screws. (See Figure 216.)



TL 36869

Fig. 217. Brushes Removed from Brush Holder

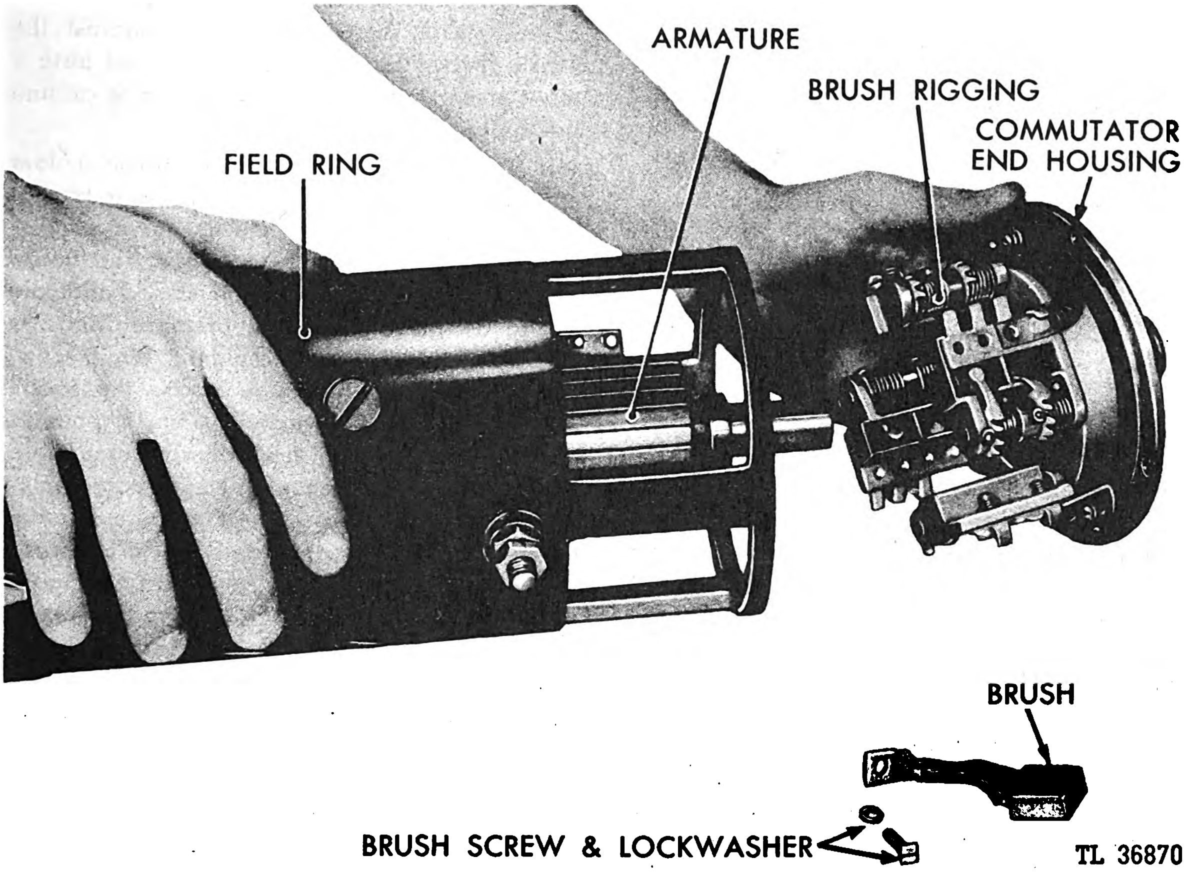


Fig. 218. Removing Commutator Housing

Remove the hex-headed housing screw.

(5) Pull away the Bendix housing and remove the Bendix drive. (See Figure 231.)

(6) Remove the twelve screws which attach the brush pigtails and field jumpers to the rigging.

(7) Remove the four hex-headed screws from the commutator end housing and remove the commutator end housing. (See Figure 218.) It may be necessary to tap the frame slightly in order to remove it.

(8) Remove the armature from the field frame. (See Figure 219.)

(9) Release the brush rigging from the commutator end frame by removing the two rigging attaching screws. (See Figure 229.)

(10) Pry off the dust cap from the commutator end frame.

(11) Disassembly of the subassemblies may be necessary if the inspection reveals parts which need replacing. Instructions for the further disassembly which may be necessary are given in the following paragraphs.

f. *Inspection and Replacements.* (1) Clean all parts thoroughly. Before using a

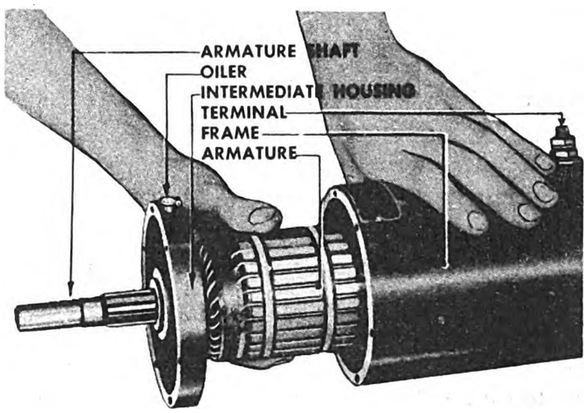


Fig. 219. Removing Armature from Field Frame

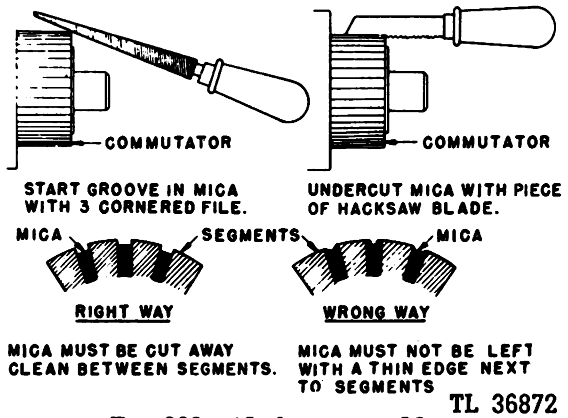


Fig. 220. Undercutting Mica

cleaning solution, with dry compressed air blow out the brush dust and dirt from the armature windings, field ring assembly, and brush rigging. Use either kerosene or unleaded gasoline for cleaning. Do not soak the armature or field ring assembly or brush rigging in the cleaning solution. Clean these assemblies with a cloth moistened with the cleaning solution. Thoroughly dry them for reassembly. **CAUTION: Do not use a cleaning solution on the bushings, as this may remove the graphite lubricant that is imbedded in the bearing surface. Wipe the bushings with a clean cloth dampened with lubricating oil.**

(2) Check the commutator. If it is rough, burned, or eccentric, resurface it in a lathe. Turn off only enough copper to leave a uniformly true surface. Do not turn off any copper from the commutator risers. After the commutator is turned, carefully undercut the mica insulation between the copper segments to a depth of .030 inch. (See Figure 220.) The sharp edges of the bearings should be removed with a hand scraper or knife. Smooth and polish the commutator surface with fine sandpaper, #00. Test the armature for short circuits or grounds. See paragraph 73*g*.

(3) Clean the brushes in unleaded gasoline, but do not soak them. Dry thoroughly before re-use. If the brushes are worn too short for the lever to hold them against the commutator or less than half their original length, replace the brushes. New brushes should be seated to the contour of the commutator. This can be done when the cranking motor is assembled. Fit the sandpaper to the contour of the commutator with the abrasive side against the brush. Draw the sandpaper back and forth a few times. Do not sand excessively or around the contact edges of the brush.

(4) Test the liveliness of the brush holder springs. Measure the spring liveliness by applying a small spring scale as shown in Figure 221. Place the spring end in the fourth notch of the brush holder. It should indicate 3½ to 3¾ pounds. If this pressure range is less, replace the brush holder. When new, the spring pressure range up to the fourth notch of the brush lever is 3½ to 3¾ pounds. However, this is not the actual pressure on new, full length brushes and may vary somewhat. If either the brush springs or holders are to be replaced, remove the brush or brush holders from the rigging as shown in Figure 222, and if it is necessary to replace the spring, remove the cross pin from the holder as shown in Figure 223.

(5) Check the bushings in the commutator

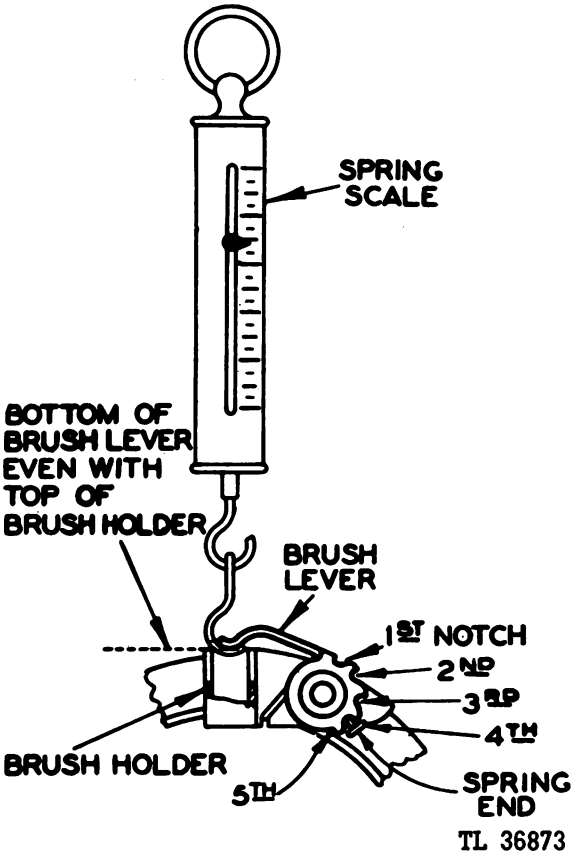


Fig. 221. Checking Brush Spring Tension

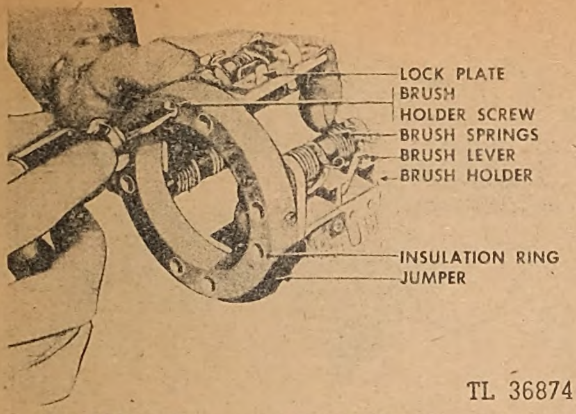


Fig. 222. Removing Brush Holders from Rigging

end housing, the drive end housing, and the Bendix housing. If replacement is necessary, press out the old bushings. New bushings can be pressed in the commutator or drive end housing or Bendix housing as shown in Figure 224. Make certain that the pilot diameter and the matching diameter on the housing and field ring are not nicked or burred. If they are, and these nicks and burrs are not removed, the alignment will not be true.

(6) Clean the Bendix assembly and check the movement of the Bendix drive gear. If the Bendix is in any way faulty, replace the entire assembly as a unit and return the faulty Bendix assembly to the factory.

(7) It is not necessary to disassemble the field and frame unless the tests given in paragraph 73*h* indicate that it is necessary that one or more of the coils need replacement. If this is necessary, remove the pole piece screws and remove the coils. (See Figure 225.) If the field coils are grounded and they cannot be reinsulated to eliminate the ground, replace the field coils.

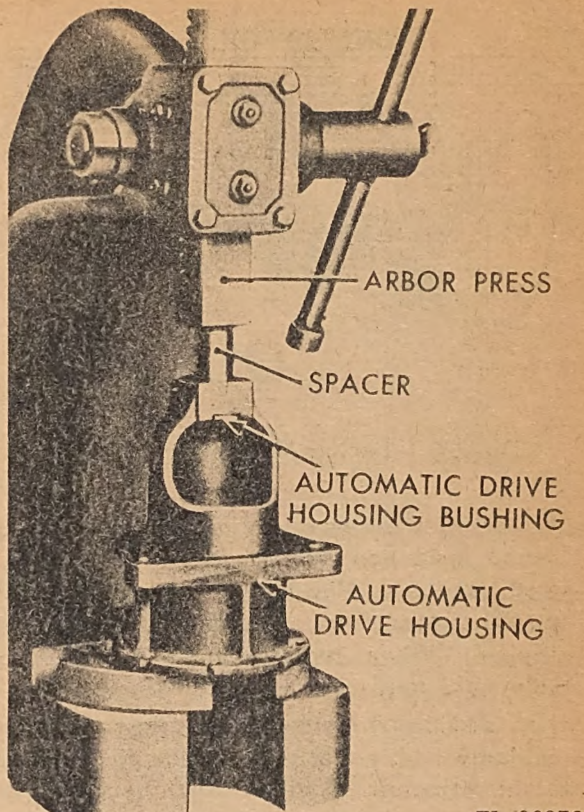


Fig. 224. Installing Bushing in Bendix Housing

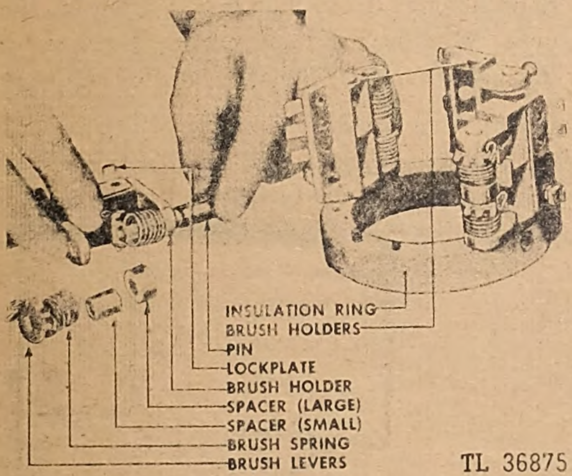


Fig. 223. Removing or Installing Spring Cross Pin

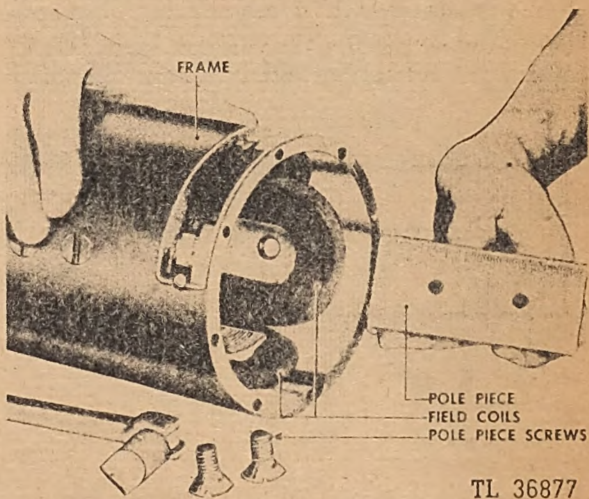


Fig. 225. Removing or Installing Pole Pieces

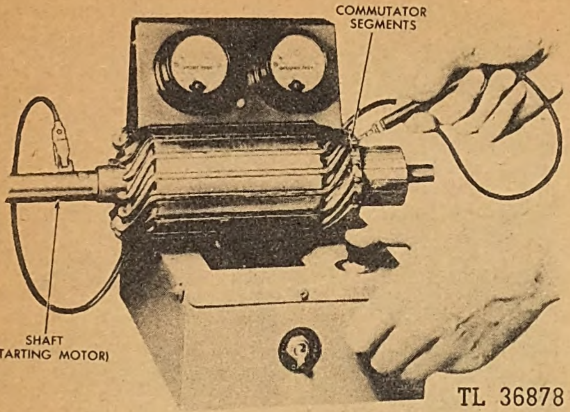


Fig. 226. Testing Armature for Ground

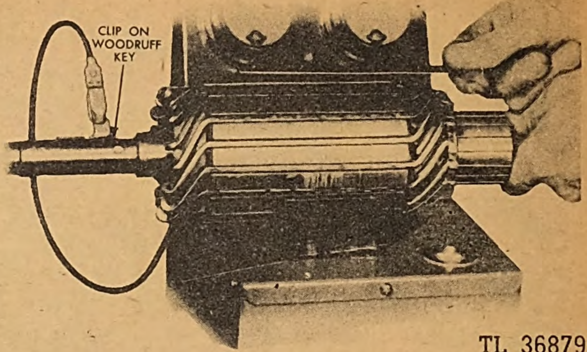


Fig. 227. Testing Armature for Shorts on Growler

(8) See that all the oil channels are open and clean. Insulation and insulators must be in good condition. Check the nuts, screws, and tapped holes to be sure that they are not stripped. When reassembling the cranking motor, use only new tab lockwashers.

g. Testing Armature. (1) Check with a test lamp and test points from the commutator to the armature shaft or lamination. If the lamp lights, indicating ground, and if the ground is not readily apparent and repairable, the armature must be replaced. (See Figure 226.)

(2) An open-circuited armature is often easy to detect, since this condition produces badly burned commutator bars. The open will usually be found at the commutator riser bars and is often a result of excessively long cranking periods, which overheat the units and cause the connections to become bad. Thrown solder is evidence of this condition. Repair is made by resoldering leads in riser bars (rosin flux) and turning down the commutator.

(3) A shorted armature may be detected on a growler. The growler is a strong electromagnet connected to a source of alternating current. When a shorted armature is placed on the growler and a hacksaw blade held above the shorted coils in the armature, the blade will be alternately attracted to and repelled from the armature, causing the blade to buzz against the armature. Before discarding a shorted armature, inspect the commutator slots carefully, since copper or brush dust sometimes collects in the slots and shorts adjacent bars. (See Figure 227.)

h. Field Coil Test. Test the field coil after drying thoroughly and it is certain that no deposits of cleaning fluid are in or on the field coils. With the test lamp probes, place one on the field ring and the other on the end of the

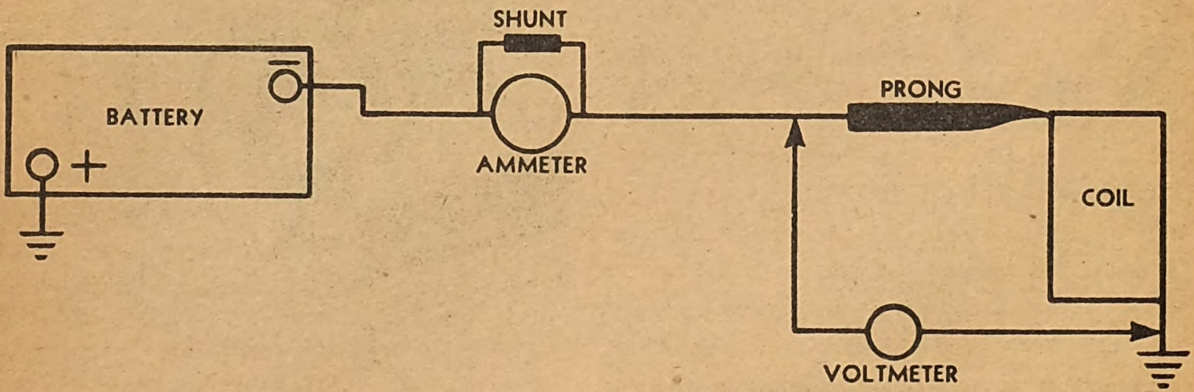


Fig. 228. Testing Field Coil TL 36880

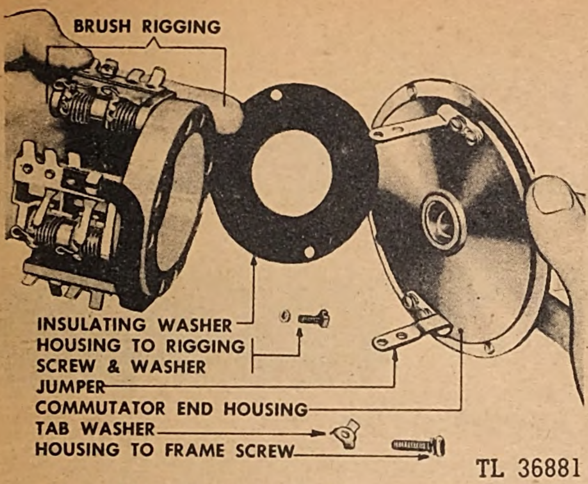


Fig. 229. Assembling Commutator End Housing and Brush Rigging

field winding. (See Figure 228.) Determine whether the winding is grounded to the field ring or to the pole pieces. If the field coils are grounded, they can be removed as described in paragraph 73*f*, item 7.

i. Bendix Drive. Do not attempt to disassemble the Bendix assembly. If faulty, replace the whole unit. Return the old one to the manufacturer.

j. Motor Reassembly. Be sure all the parts are clean before reassembling. Do not dip the Bendix unit in cleaning fluid, as the lubricant may be washed out.

(1) Attach the brush rigging to the commutator end housing. Be sure the insulator is inserted between the rigging and the housing. Do not put the brushes into the holders until the armature is in place. (See Figure 229.)

(2) Line up the center punch marks and attach the commutator end housing assembly to the field frame ring assembly. Be sure to use new spring lockwashers and new tab washers under the screws.

(3) Insert the armature into the drive end housing. Then place the armature in position.

(4) Insert the brushes in their holders. Connect all the brush pigtails, field leads, and terminal connectors according to the internal wiring diagram. (See Figure 230.)

(5) Assemble the Bendix drive to the armature shaft.

NOTE: Use graphite grease on the armature shaft. (See Figure 231.)

(6) Attach the Bendix housing to the drive end housing and field ring, using new spring lockwashers and new tab washers under the screws.

(7) Bend down the lockwasher tabs on all the housing screws. Install the commutator cover band.

k. Cranking Motor Tests and Adjustments After Overhaul. After reassembling the motor, it should be fastened securely in a bench vise. Check the Bendix drive by applying six volts of the battery to the terminals. The pinion should be thrown forward after the motor turns. When the battery is disconnected, the pinion should return freely to its normal position. With a 12-volt battery, connect the terminals to check the motor for commutation and for a rough check on speed. There should be no excessive sparking of the brushes, and the armature speed should be approximately 5000 revolutions per minute. New brushes must be seated in at this time. See paragraph 73*f*, item 3. **CAUTION: Never couple 24 or 32**

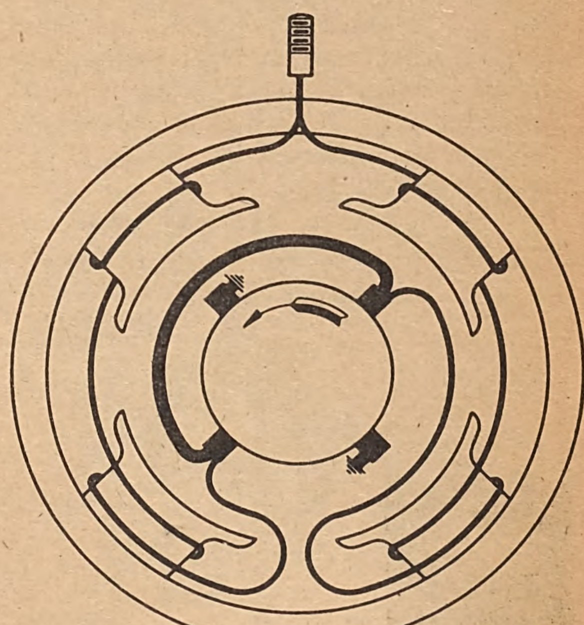
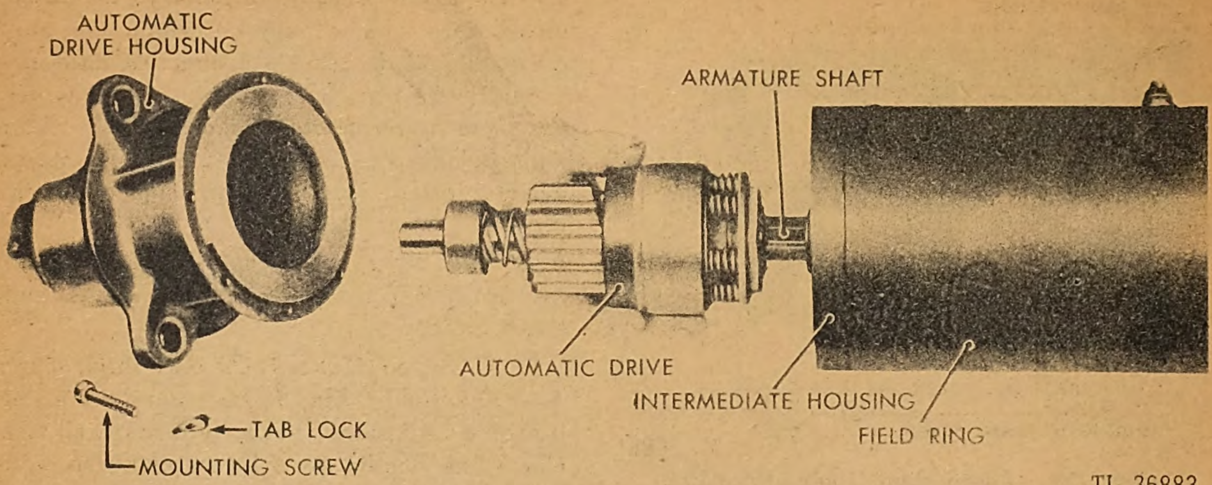


Fig. 230. Internal Wiring Diagram (Cranking Motor)



TL 36883

Fig. 231. Assembling Bendix to Armature

volts of battery to the motor unless the motor is under load. Check the cranking motor further for no-load test and torque test. See paragraph 73b, c, and d.

l. Magnetic Switch. The magnetic switch operates on the solenoid principle. The solenoid, when connected to a source of voltage, sets up a magnetic force, drawing the plunger toward the center of the coil. The magnetic circuit is completed through a yoke consisting of the top and the sides of the case, a lower bracket, and the plunger. The plunger draws one set of contacts, connected by a jumper, against the other set. The plunger is kept from contacting the yoke or coil by a brass tube. (See Figure 232.)

m. Disassembly of Magnetic Switch. (1) Remove the cover of the switch by loosening the screws and pulling the cover out from the top and up. This will expose the contacts, plunger, and coil. (See Figure 232.)

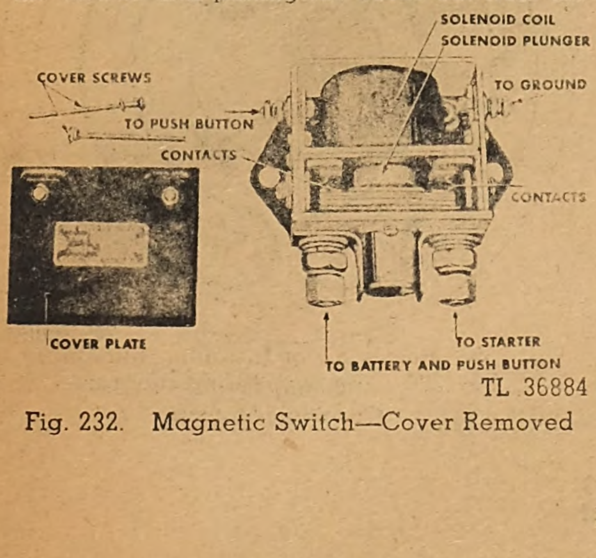
(2) Remove the large terminal nuts at the base and also the locknuts, washers and insulating pieces.

(3) Next, remove the round head screws securing the base and cap assembly. (See Figure 233.)

(4) The removal of the base and cap assembly now exposes the lower end of the plunger rod and retracting spring.

(5) Remove the insulators from the contact studs.

(6) Remove the plunger and contactor assemblies from the remainder of the unit. A slight rotation of the contactor will allow the parts to be taken out readily. (See Figure 234.)



TL 36884

Fig. 232. Magnetic Switch—Cover Removed

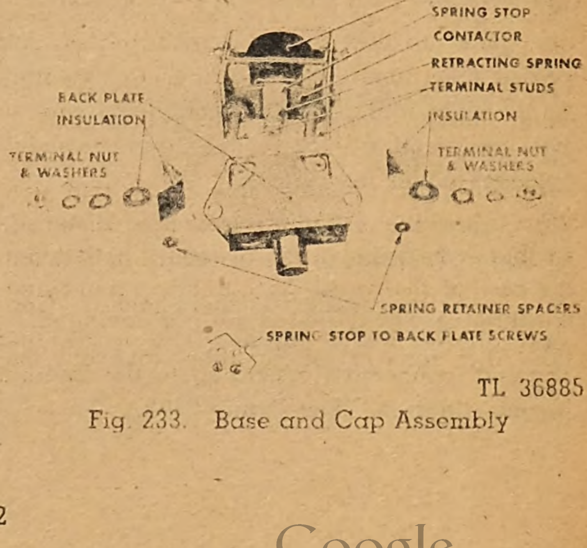


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Fig. 233. Base and Cap Assembly

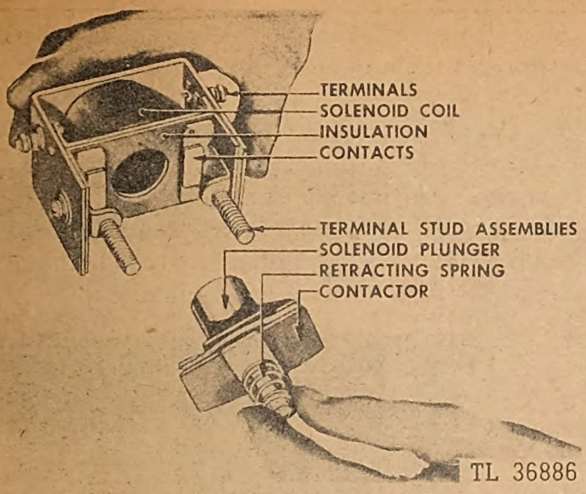

Fig. 234. Removing or Installing Plunger and Contacts Assembly

(7) If, because of excessive pitting or burning of the contacts, it is found necessary to resurface the faces or install a new contactor, the plunger may be unscrewed from the rod and the contactor removed. The resurfacing should be done on a grinder or with emery cloth held on a file. Exercise care to assure flat surface being maintained on the contact faces. A file may be used to remove slight surface irregularities or burning.

(8) Take out the round head screws on the sides to remove the stationary contacts. (See Figure 235.) These contacts may be resurfaced, if necessary, in the same manner as the movable contacts.

n. Inspection and Repairs. (1) Examine all insulators for burning or cracking and provisions made for removal.

(2) In case of a damaged coil, it may be removed by first taking out the pin assembly. This requires the use of a wrench to loosen the nut.

(3) Remove the nuts and washers on the small studs in order to free the coil leads.

(4) By tapping the yoke (frame) on a flat surface, the brass tube may be started out. When the tube extends a sufficient distance, so that it may be grasped easily, pull it out the rest of the way. Be careful in removing the tube so that the ends are not damaged.

(5) After removal of the tube, take out the coil.

o. Testing Magnetic Switch Coil. (1) Test the coil for shorts by obtaining the resistance. The value should be within the prescribed limits of 2.25 $\pm$ .1 ohms. Before reassembly, inspect the insulation carefully for any signs of overheating or damage.

(2) Check all insulators for breaks or cracks.

(3) Inspect and smooth off the contact surfaces.

p. Reassembly of Magnetic Switch. (1) Install the stationary contacts and insert the round-headed screws to secure the contacts on the base assembly. Be sure to use insulator washers, guard washers and lockwashers. (See Figure 235.)

(2) Install the plunger into the contactor assembly. (See Figure 234.)

(3) Install the cap assembly to the base assembly and fasten the cap assembly to the base assembly with the insulator in place next to the rod guard. (See Figure 233.)

(4) Install the terminal nuts at the base; also lockwashers and insulating pieces.

(5) Install the cover and tighten the fastening screws.

q. Push-Button Switch. The push-button switch is a complete unit in itself and cannot readily be taken apart. For this reason, if trouble is encountered, a new push-button should be installed, rather than attempt to repair the old one.

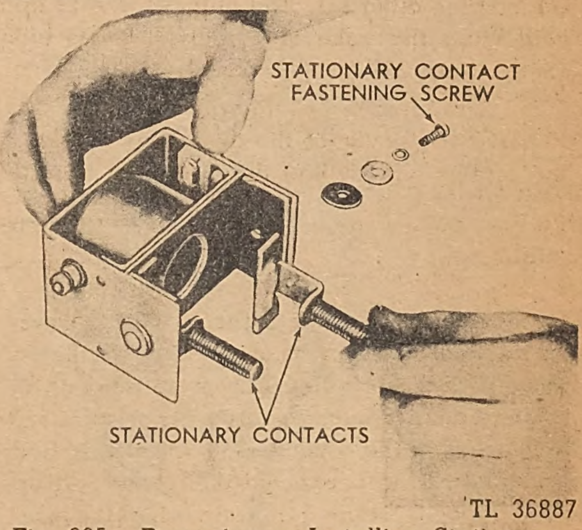

Fig. 235. Removing or Installing Stationary Contacts

74. Battery. Keep the terminals tight and clean. A loose battery connection will cause the voltage regulator to chatter; this may result in early failure of the regulator. If the terminals show a tendency to corrode, clean and apply a thin coat of vaseline to protect them from the acid. Keep the outside of the battery clean. Neutralize any electrolyte that may be on the metal surfaces, using a cloth saturated with ammonia or bicarbonate of soda solution (one pound of soda to one gallon of water), then wash off with water and dry.

a. Testing Battery. Test the specific gravity of each cell with a hydrometer. A reading of 1.270 to 1.285 indicates approximately fully charged; 1.230 indicates half charged; 1.150 indicates dead. Never take a reading just after adding water, for the reading will not be true. **CAUTION: Use only distilled water. Do not allow the battery to stand in a discharged state. It may become ruined by sulphation. A stored or unused battery should be given a slight charge once a month. A battery can sometimes be brought out of sulphation by a long and steady low charge.**

If the battery requires frequent addition of water and is gassing excessively, it is undoubtedly due to overcharging. The voltage regulator should be checked for faulty adjustment. If one or more cells continually require more water than others, it is an indication of a damaged cell.

b. Cold Weather Care. It is especially important in cold weather to test the specific gravity. A battery freezes between the temperatures 20 degrees above zero and 50 degrees below zero, depending on the state of its charge. Do not add water after shutting down for the night. It will freeze quickly. See that the battery gets a charge after adding water.

75. Generating System. The generating system includes the generator, voltage regulator, ammeter and the battery. It is the function of the generating system to restore to the battery the current withdrawn during cranking, and also to carry the connected electrical load up to the capacity of the generator when the generator is operating at a speed sufficient to produce the rate of output. (See the Wiring Diagram, Figure 5.) The system is radio shielded to prevent radio interference.

76. Generator and Voltage Regulator. The battery-charging generator is a device for changing mechanical energy into electrical energy which is stored in the battery. (See Figure 236.) The regulator is a combination circuit breaker and voltage regulator.

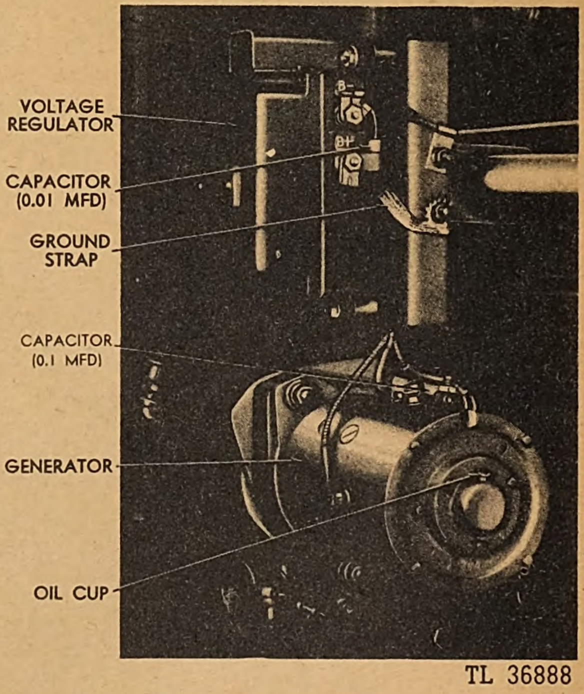

Fig. 236. Generator and Voltage Regulator

a. Generator Theory of Operation. The generator is a shunt-wound, four-poled, third-brush, reaction-type generator. The positive field terminal, F+, allows the field lead to be connected to the voltage regulator. The design of the generator is such that, as the speed of the armature increases from 0°, the current increases until a certain peak is reached, when connected to a battery. The output on this type of machine holds fairly constant over a comparatively wide range, but above a certain point tends to drop off as the speed increases. As the voltage increases to a certain point, relative to the increase in speed, greater current will flow between the main brushes. The increased armature current shifts the field flux away from the top of the leading pole, thus weakening the field excitation because of the

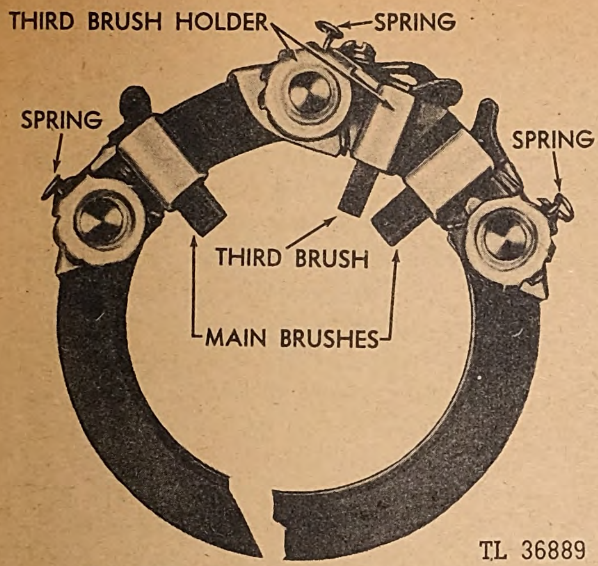

Fig. 237. Brushes and Brush Rigging

reduced voltage between one main brush and the third brush. As the field excitation decreases, there is a resulting decrease in flux for a corresponding increase of armature reaction. The field excitation is decreased by the action of the current flow in the armature coils, depending on the location of the third brush between the main brushes.

The shifting of the third brush greatly changes the speed-current characteristics because of the short circuit of elements of the armature and the consequent demagnetizing effect on the field. This is the reason for locking the third brush at the rated current. Any value above this tends to lower the voltage. Consequently, the current is reduced to bring the two into equilibrium at the maximum output. (See Figure 237.)

The voltage regulator reduces the generator output when the maximum is not needed, thus preventing high voltage and charged battery. When the battery is in a low charged state, the regulator automatically increases the generator output to its maximum. When the battery reaches a high state of charge, the regulator automatically decreases the rate of charge. The voltage regulator also contains a circuit breaker. The circuit breaker is an automatic switch that closes and opens the circuit between the generator and the storage battery. When the generator is not running, the contacts are open. When the generator is started, the contacts are automatically closed to connect the generator to the battery. When the generator loses speed and the voltage output drops below the battery terminal voltage, the contacts automatically open, thus preventing the battery from discharging back through the generator. See paragraph 76*b* for further discussion on how the regulator operates.

b. Regulator Theory of Operation. The regulator (24-volt Control Unit) used with the generator contains two elements in the same box—a voltage regulator and a cutout relay, together with control resistances which are mounted at the top of the box. This unit is designed to be mounted in a vertical position with its two mounting lugs at top and its single lug at the bottom. This places three terminals on the left and two on the right. (See Figure 238.)

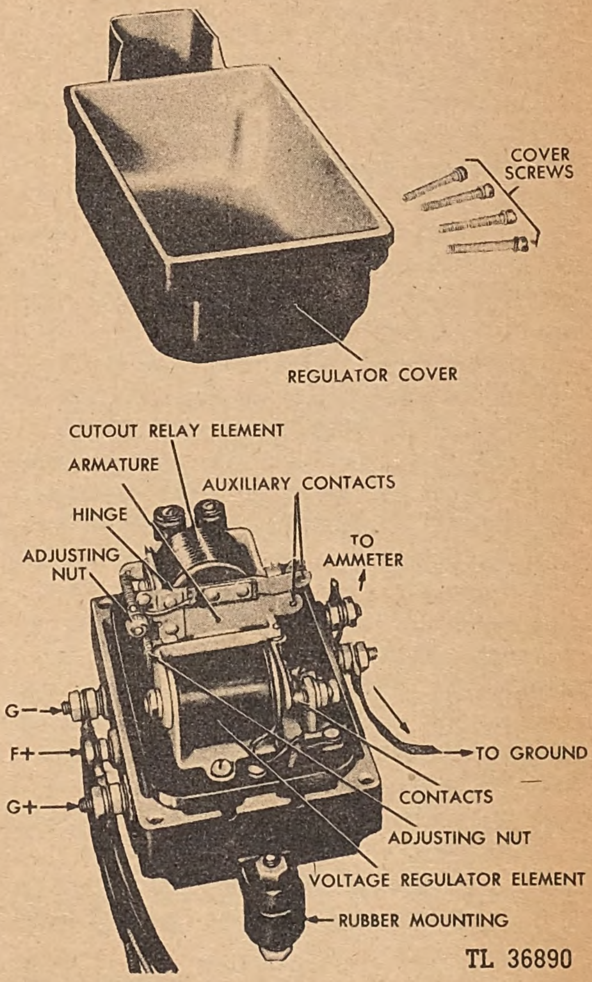

Fig. 238. Voltage Regulator

(1) *Voltage Regulator.* The voltage regulator is an electro magnetic relay of the vibrating type. The purpose of the voltage regulator is to automatically control and limit the generator voltage in order to properly charge a battery and to provide a source of controlled energy for other electrical units that may be connected.

The voltage regulator permits a comparatively high charging current to pass to the battery when it is in a discharged condition. It will also cause this current to gradually decrease as the battery becomes charged, thereby protecting the battery from possible damage by higher current. By means of voltage regulation, the charging current will be adjusted automatically to agree with the battery throughout the charging cycle.

This performance will indicate relatively high current when the battery is in a discharged condition, and as the battery is being charged the ammeter will indicate a gradual lowering of the current, so that by the time the battery is fully charged the ammeter will indicate a comparatively lower current than when the charging began. If this performance is noticed, do not assume that the generator is "going dead," but check the battery for state of charge, instead of making hasty and possible unnecessary adjustments.

(2) *Cutout Relay.* The cutout relay or reverse current cutout acts as an automatic switch between the generator and battery. This relay does not vibrate, because its contacts are normally either open or closed. When the generator speed and voltage have increased sufficiently to begin to charge the battery, the cutout relay contacts automatically close, thereby connecting the generator to the battery for charging. When the generator speed is not running, the cutout relay automatically disconnects the generator from the battery to prevent the battery from discharging back through the generator.

c. *Generator and Voltage Regulator Data.*

Generator:

Clockwise rotation, viewing drive end.

Field current draw, 10 amperes; 24-30 volts at 1500 r.p.m.

Balanced output O. C., 24 volts at 600 r.p.m.

Regulator:

Cutout Contact Gap:

(C3) .035 inch—.038 inch.

(C1) .070 inch—.075 inch.

(C5) Armature Core .018 inch—.025 inch.

Closing Voltage:

(C3) 22.0—22.3 volts.

(C1) 28.4—28.6 volts.

Voltage Regulator:

Contact Gap: .020 inch—.025 inch.

Armature Core: .050 inch—.055 inch.

Hinge Gap: .005 inch—.010 inch.

Voltage Setting: 28.4—28.6 volts.

d. *Testing Generator and Regulator.* Because the generator and regulator are to be operated together as a balanced system, they should be tested and adjustments made at the same time. Run the generator on a variable speed motor or on the engine to which it is attached. The speed range and revolutions per minute should be from idling speed to the governed top speed. The voltage regulator and generator should be hooked up according to the Wiring Diagram in Figure 5. The voltage regulator and cutout contact gaps must be set as closely as possible to the mechanical tolerances given in paragraph 76c. See also paragraph 76g. Run the engine at its top governed speed. With the battery disconnected from the B terminal, the generator should show a field current draw. Check the ammeter, which should show a field current draw of 10 amperes. If there is no output, this may be an indication that the brushes are sticking or the commutator is burned or gummed, or there is poor contact between the commutator and the brushes, or blown fuse. If the trouble is not readily apparent, use a test lamp and test points and check further. The test points are connected in series with the test lamp at a source of electricity on a 110-volt circuit. The test lamp can be used to detect short circuit, grounds or open circuit.

(1) *Ground Test.* Raise the grounded brush from the commutator and insulate it with a piece of paper or cardboard. See the Internal Wiring Diagram, Figure 253. Check with a test lamp from the G+ terminal lead with the F+ and G− terminals respectively, to locate the ground.

(2) *Open-Field Test.* Check for open-field circuit with test points from the F+ terminal to the third brush. If the lamp does not light, the field is open.

(3) Connect a battery and an ammeter in series with the F+ terminal to the third brush and note the current draw. The normal field current draw is 10 amperes at 24 volts. Proceed with care on this test, since a shorted field will draw a high current.

It may be necessary to disassemble the generator for further checks and servicings. See paragraph 76*i*.

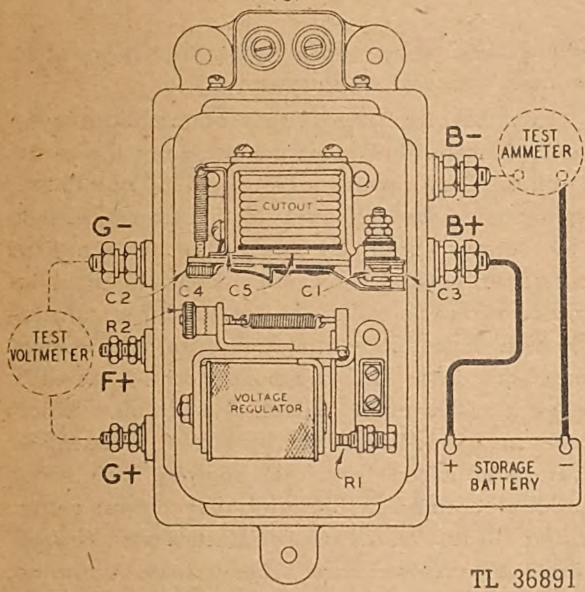

Fig. 239. Line Drawing Voltage Regulator

e. *Setting Voltage Regulator.* Turn the generator at 2000 r.p.m. and set the voltage regulator at 28.4 to 28.6 volts, open circuit. The battery should be disconnected from the B— terminal. Refer to Figure 239. Connect a voltmeter to the G— and G+ terminals of the regulator. Run the generator at slower speeds; then speed up to 1500 to 2000 r.p.m. The voltmeter should read 28.4 to 28.6. If not, turn the adjusting nut (R2) clockwise (see Figure 240) to raise the voltage, or counterclockwise to lower it. The contact (R1) should be open momentarily after each adjustment and allowed to close.

f. *Setting Cutout Relay.* For setting of the cutout relay, the generator should be operated

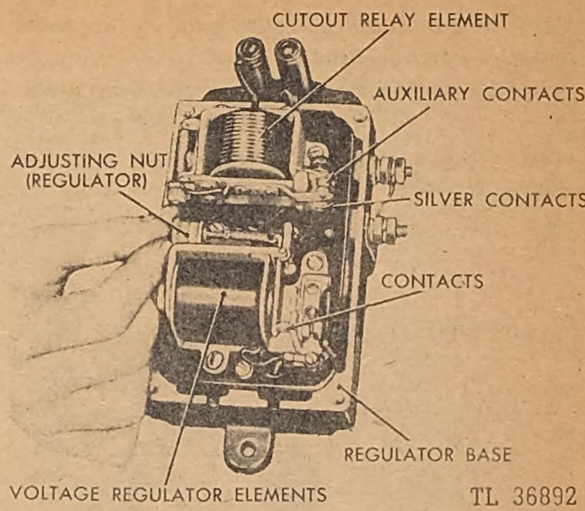

Fig. 240. Adjusting Voltage Regulator

in the same manner given in the foregoing paragraph.

From the low speed, where contacts C1 and C3 are open, gradually increase the generator speed until the contacts close. The contact C3 will come together first at 22.0 to 22.3 volts, then contact C1 will come together. The main contact C1 should close between 28.4 and 28.6 volts. If the voltage, as these contacts close, is not within the given values, the adjusting nut C2 (see Figure 241) should be turned clockwise to raise the voltage, or counterclockwise to lower the voltage, until the correct closed voltage is reached. From a point at which the contacts are closed, the speed should be lowered until the contacts open. The ampere discharge at this instant should read 0 to 10.

After each adjustment, the generator speed should be lowered until the cutout contacts

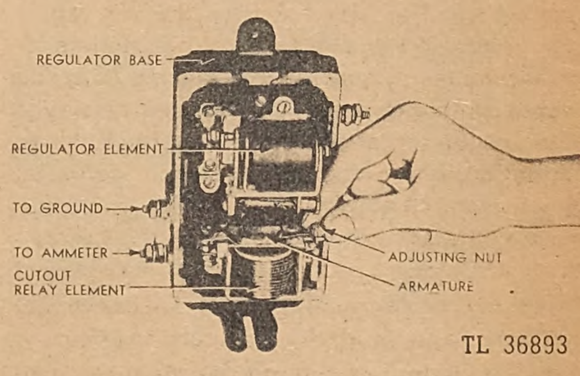

Fig. 241. Adjusting Cutout Relay

open, and then brought back up to the speed necessary to close them.

NOTE: The auxiliary contacts must close before the main contact, and open after the main contact. The arc is taken by the auxiliary contacts. Adjust the contact gaps by means of contact carrier arms and their stops. All settings of the voltage regulator should be made on open circuit, with one regulator lead not connected to the battery.

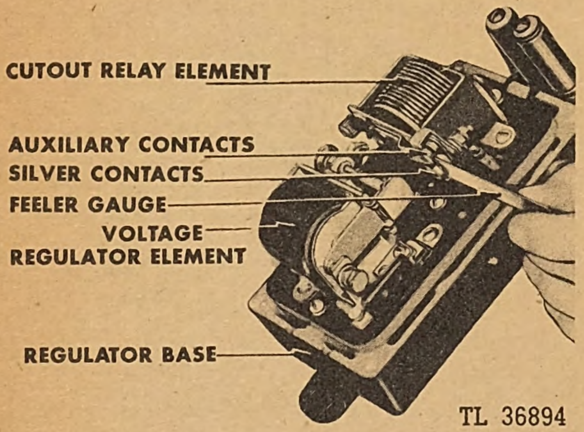

Fig. 242. Checking Main Contact Gaps

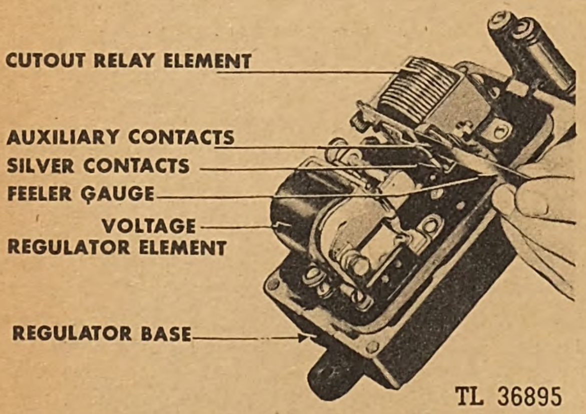

Fig. 243. Checking Auxiliary Contact Gap

g. Cleaning and Adjusting Voltage Regulator Contacts. Clean the contacts by drawing crocus cloth between them while being held together under slight pressure. Do not use emery paper or any other coarse abrasive. Blow away cleaning dust. Do not use a file except to remove projections or extreme roughness. Then only use a fine milled file. Do not leave lint or cleaning particles between the contacts. Snapping the contacts together or drawing clean, tough paper between the contacts may dislodge any loose particles. To

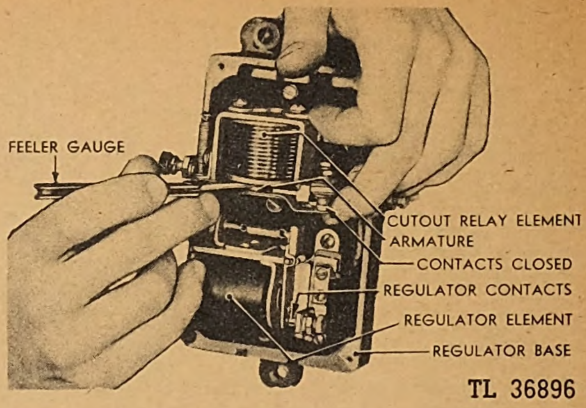

Fig. 244. Checking Cutout Relay Core Gap

check the contact gaps, core, and hinge terminals, proceed as follows:

To check the gap setting of the main contacts, insert a feeler gauge between the main contact C1 as shown in Figure 242. The dimension should be .070 inch to .075 inch. Adjust the contact gaps by means of the contact carrier arms and their stops, bending them in either direction. Check the auxiliary contact C3 with a feeler or thickness gauge as shown in Figure 243. This dimension should be .035 inch to .038 inch. Check the cutout armature core as shown in Figure 244. This tolerance should be from .018 inch to .025 inch. In like manner to checking the cutout relay contact gaps, check the regulator contact gaps and the armature core. The voltage regulator contact gap should be from .020 inch to .025 inch; clearance and voltage regulator armature core from .050 inch to .055 inch. Check the hinge gaps of the voltage regulator and

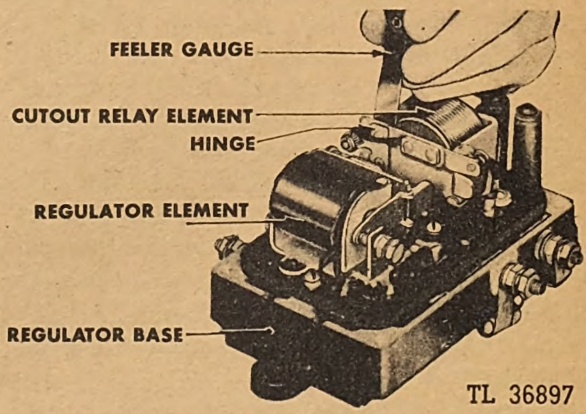

Fig. 245. Checking Cutout Hinge Gap

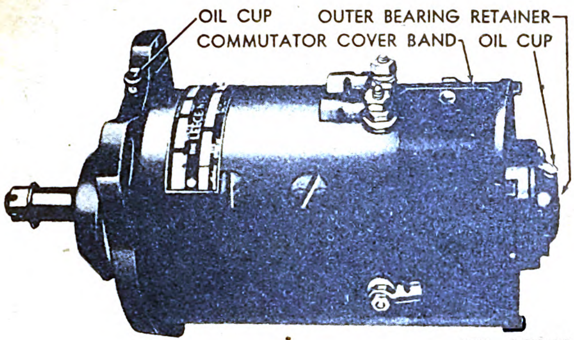

Fig. 246. Generator

the cutout relay with a thickness gauge as shown in Figure 245. This clearance should be from .005 inch to .010 inch. It should be noted that in setting the hinge gaps for either the regulator or cutout relay a narrow feeler gauge must be used, as the hinge spring rivets interfere with the proper measurement when too wide a gauge is used.

h. Generator Third Brush Adjustment. If the generator has been overhauled, the third brush should be set. Connect the ammeter to B— and to the battery line as shown on the Regulator Diagram, Figure 239. Run the generator over the entire speed range and the charging rate noted. The meter should never read over 10 amperes at any speed. Adjust the third brush to this maximum value and lock it at this point by means of the brush holder screws. Tests should be made with the battery at 1.200 to 1.225 specific gravity. The generator and regulator must be allowed to run at least 15 minutes at 1500 r.p.m. to make certain that they are sufficiently heated to insure the correct final setting.

i. Generator Disassembly. After the generator has been removed from the engine, the following procedure is recommended: (See Figure 246.)

(1) Remove the cotter pin, locking nut and washer from the drive shaft. The gear puller may then be attached to the driving gear by the two hex head screws and the gear removed from the shaft. (See Figure 247.)

(2) Make adjacent center punch marks on housings and field ring so that these marks can be lined up in assembly to locate the parts in their original position.

(3) Remove brush opening band.

(4) Lift up levers to relieve spring pressure, taking care not to snap them, which will damage the brushes.

(5) Now brushes may be removed from brush holders. Do not pull "pigtails" out of brushes.

(6) Remove screws, spring and tabbed lockwashers, and bearing retainer. Do not remove flat head screws.

(7) Remove drive end housing screws.

(8) With a brace rod held against exposed commutator end of armature shaft, drive the shaft out of ball bearing. (See Figure 248.)

(9) The armature with drive end housing assembly will now be free. (See Figure 251.)

(10) Place armature in a bench vise and remove screws, spring and tabbed lockwashers, and spacing collar. Do not remove flat head screws on drive end housing. (See Figure 249.)

(11) Press armature out of drive end ball bearing.

(12) Disconnect all internal connections from brush rigging.

(13) Remove screws, spring and tabbed lockwashers, and take away commutator end housing.

(14) Removal of two square head screws, through two arc-shaped slots in outer face of the commutator end housing, will release brush rigging. (See Figure 250.)

(15) Removal of flat head screws on the drive end housing will release the inner bearing retainers at the drive end and commutator end.

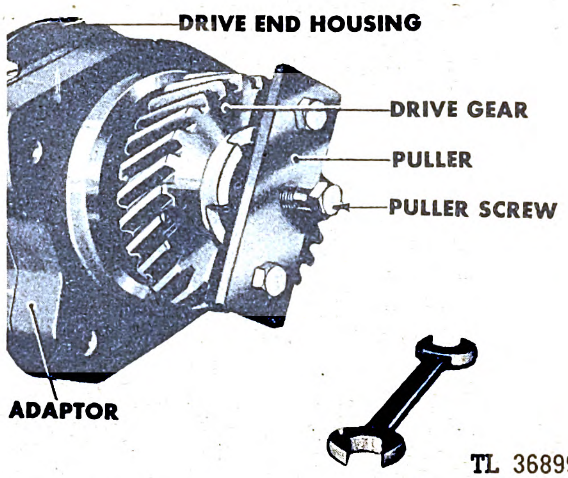

Fig. 247. Removing Generator Drive Gear

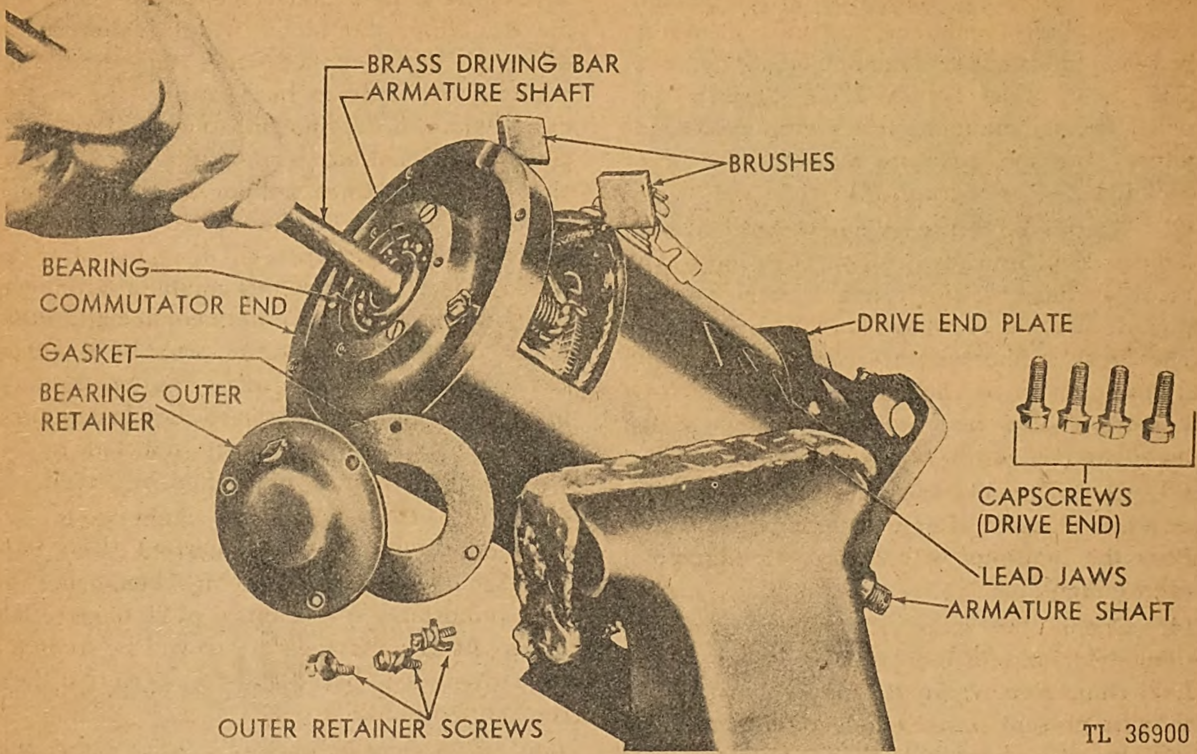

Fig. 248. Driving Out Armature Shaft

(16) Do not disassemble pole pieces and field coils from the field ring unless the field coils have to be replaced.

NOTE: If the field coils have to be replaced, terminal housing and terminal studs must be removed.

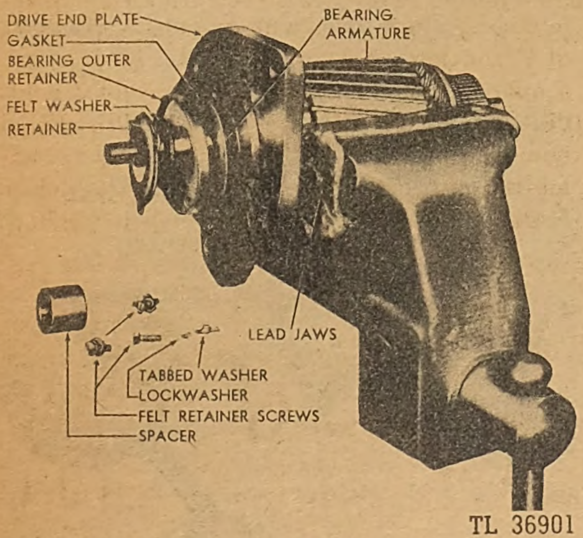

Fig. 249. Drive End Plate, Spacer and Retainers

j. Inspection and Repairs. Clean all parts thoroughly before inspection. Do not clean the armature or field coils by any degreasing methods, since this would damage the insulation and might ruin the windings. Before using a cleaning solution, blow out the brush dust and dirt from the armature windings, field ring assembly, and brush rigging with dry compressed air. Wipe them with a clean cloth, slightly dampened with carbon tetrachloride or a similar solvent.

(1) Allow to dry before inspecting or reassembly. Check the commutator. If it is rough, burned or eccentric, it must be resurfaced in a lathe. Turn only enough copper to leave a uniformly true surface. If a collett type lathe is available, it is recommended that the commutator end bearing diameter of the armature shaft be held in the collett at the lathe head stock, and the drive end of the shaft on center in the lathe tail stock. This permits turning the commutator true with the commutator end bearing. Do not turn off any copper from the commutator risers into which the armature

wires are soldered. After turning the commutator, carefully undercut the mica insulation between the copper segments to a depth of .030 inch. (See Figure 220.) Smooth and polish the commutator surface with #00 sandpaper. Test the armature for short circuits or grounds. See paragraph 76*k*.

(2) Discard the brushes when worn to $^{9}/_{16}$-inch length. New brushes are $^{13}/_{16}$ inch long. The brush spring pressure range is from 3 to $3\frac{1}{4}$ pounds up to the fourth notch of the brush lever. The brush spring pressure can be tested with a spring scale as shown in Figure 221. New brushes should be seated according to the instructions given in paragraph 40, item (1).

(3) Clean the bearings and check them for any pits or wear. Replace them if necessary. Pack the bearings with a high melting point grease, WB-3.

(4) Check the pilot diameters, matching diameters, and facings on the housings and field ring. Remove any nicks or burrs which may be present. If not removed, the alignment will be out. See that all oil channels and cavities are open and that old lubricants have been removed. All insulation and insulators must be in good condition. Replace if necessary. Be sure to discard the felt washers and replace them with new ones. Replace the tab lockwashers, because if used again they may break at the old bend.

k. Testing Armature. Check the armature for grounds with a set of test prodes consisting of a lamp in series and two points and connected to source of electricity. (See Figure 226.) Touch one prode to the armature shaft (not on the bearing surfaces) and touch the other prode to each commutator segment as shown in Figure 226. Do not touch the brush surfaces of the commutator, as an arc would mar the smooth finish. If an armature coil or commutator segment is grounded, the lamp will light. If the ground is accessible, it should be repaired. Otherwise, replace the grounded armature. The current for the test prodes should be an alternating 110-volt, 60-cycle. Check the commutator for shorts on a growler as shown in Figure 227. The growler is a strong electromagnet connected to a source of current, 110-volt, 60-cycle. When the shorted armature is placed on a growler and a hacksaw blade is held above the shorted coils on the armature, the blade will be alternately attracted and repelled from the armature, causing the blade to buzz against the armature. Before discarding an armature that indicates it is shorted, inspect the commutator slots carefully, since copper and brush dust sometimes collects in the slots and shorts the adjacent bars. An open-circuited armature is easily detectable, since this condition produces badly burned bars. The bars connected to the open coils on the armature soon burn, since every time they pass under the brush they interrupt a flow of current so that heavy arcing occurs. If the bars are not too badly burned, the armature may often be saved.

l. Field Coils. Test the field coils for grounding with alternating current. (See Figure 228.) The field coils are connected in series and have a resistance of 26 ohms ±0.5 ohms. At 24 volts, the current will be from .90 to .95 amperes. Replace the field coils if they are shorted or faulty.

m. Generator Reassembly. (1) Attach the inner bearing retainer to the commutator end housing with the flat head screws. (See Figure 250.) Do not attach the brush rigging with the two square head screws, but use a tab lockwasher. Do not install brushes at this time.

(2) Start straight and press or drive the ball bearing into the commutator housing. Hold the bearing in place with a temporary steel outer retainer, $\frac{1}{8}$ inch thick, with an outside diameter of $2\frac{5}{8}$ inches. A hole $1\frac{1}{8}$ inches in diameter should be punched in the center, and 3 holes drilled with a number 15 drill (.180), spaced equidistantly from each other on the circumference of a circle whose radius is $1\frac{1}{8}$ inches. Fasten this temporary steel outer retainer to

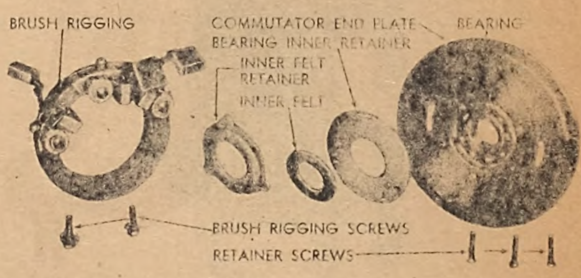

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Fig. 250. Commutator End Plate, Retainers and Brush Rigging

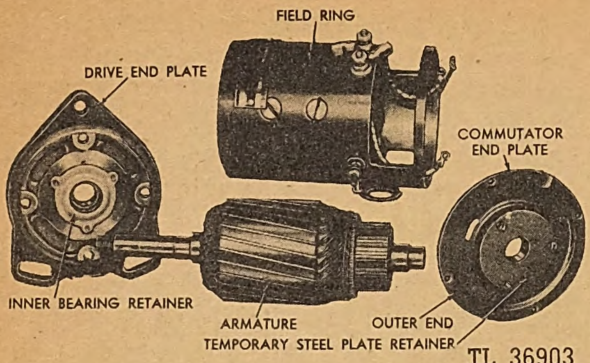

Fig. 251. Assembling Generator

the housing with the 3 retainer screws. (See Figure 251.)

(3) Fasten the commutator end housing assembly onto the field ring assembly and tighten the commutator end housing screws, using both the spring and tabbed lockwashers.

(4) Attach the oil saturated felt washer to the drive end housing with the flat head screws. Start straight and press the ball bearings in place into the drive end housing.

(5) Press the armature into the bearing and the drive end assembly, using a tubular drift against the inner race to prevent damaging the bearing. Slide the armature and drive end housing assembly into the field ring. (See Figure 252.) Drive the armature shaft in the ball bearing in the commutator end housing with a lead hammer, alternately hitting on the shaft and around the edge of the housing. Be sure that the pilot diameter of the drive end housing enters the field ring. Fasten the housing to the field ring, using both the spring and tabbed lockwashers with screws.

(6) Remove the temporary steel outer retainer from the commutator end housing and assemble the commutator end outer bearing retainer with the oil cup in place.

(7) Install the brushes and attach the pigtails according to the Wiring Diagram shown in Figure 253.

(8) Install the brush cover band. Press the drive gear onto the shaft. Install the castellated nut and cotter pin.

n. Regulator Overhaul. The regulator overhaul will ordinarily consist of cleaning the contacts and setting the gaps, inasmuch as there is no advantage in removing the parts. If it becomes necessary to check the resistance value of the coils, the leads may be discon-

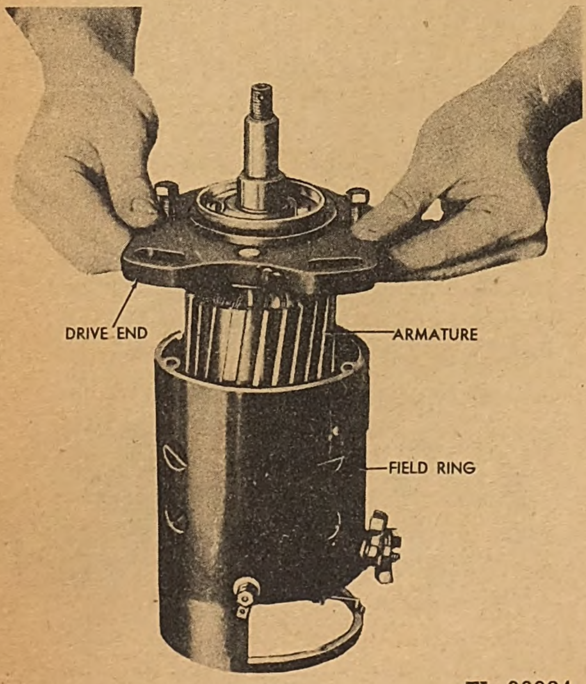

Fig. 252. Installing Armature Into Field Ring

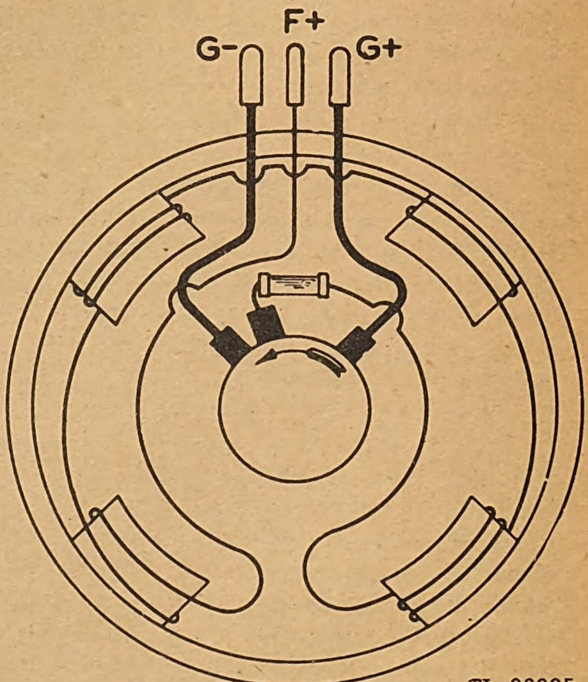

Fig. 253. Generator Internal Wiring Diagram

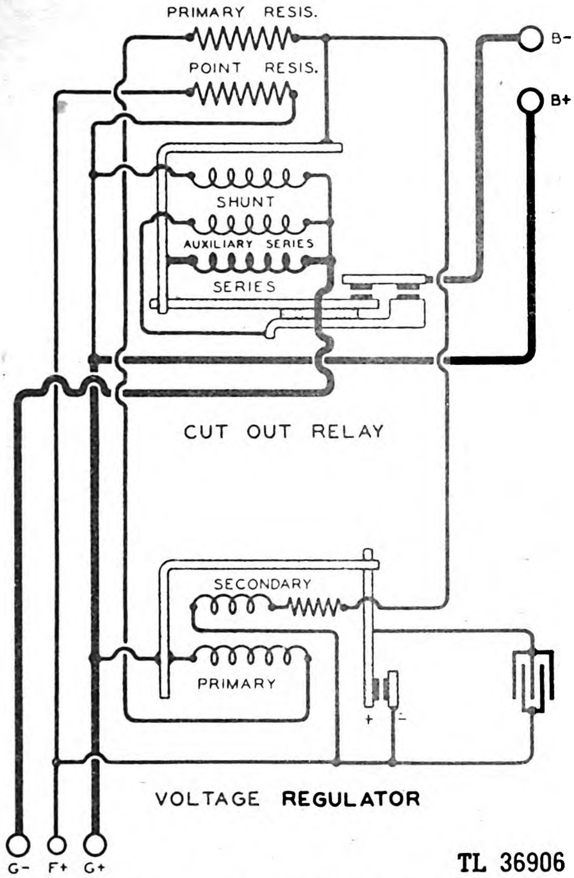

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Fig. 254. Regulator Internal Diagram

nected and the windings checked. (See Figure 254.

(1) The cutout relay coil consists of three windings: the shunt winding (green and red leads), the resistance of which should be 87 ± 3 ohms; the auxiliary windings (brown and black leads), the resistance of which is .75 to .85 ohms; and the resistance of the outer or series winding is about .035 ohms.

(2) The voltage regulator coil consists of two windings: the primary coil (fastened to core and red lead) should have a resistance of 15 ± 1 ohm; the secondary coil (brown and black leads) should have a resistance of 555 ohms.

(3) In the event that either of the coils have burned out or become otherwise damaged, the complete cutout coil and yoke assembly should be replaced. If the voltage regulator coil is faulty, it is only necessary to replace the element. Figure 255 shows the leads to the various terminals and will aid in replacing and hooking up the new elements. If new elements are installed, the voltage regulator should be checked according to the instructions given in paragraph 76*d*, *e*, *f* and *g*.

o. *Generator Preliminary Test After Overhaul.* For this test the generator must be unattached, so that its armature can turn freely. Connect a jumper from the generator terminals G+ to the generator terminal F+. Connect a wire from battery negative (—) to generator terminal G+. Momentarily touch the wire from the battery positive (+) to the generator terminal G+; the armature should rotate clockwise, viewing the drive end. If the armature does not rotate or its rotation is incorrect, check brush contacts on the commutator and the internal connections. (See Internal Wiring Diagram, Figure 253.) **CAUTION: If the jumper from terminal G+ to F+ is neglected, the test will be wrong. When this test is properly carried out, the generator will be polarized correctly for final test and operation with the control unit. The generator final test will be accomplished when the control unit and battery are connected as given in paragraph 76d.**

p. *Reinstallation Caution.* After the generator is reinstalled on the engine, or at any time after leads have been disconnected and then reconnected to the generator, connect a jumper lead momentarily between the BATTERY and ARMATURE terminals of the regulator **before starting the engine.** This allows a momentary surge of current from the battery to the generator, which correctly polarizes the generator with respect to the battery it is to charge.

77. Fuel System. The fuel system includes the fuel injection system, secondary fuel filter, primary fuel filter, fuel tank, and the fuel lines and tubing. (See paragraph 10.) Dirt and water are the two worst factors contributing to fuel system troubles. It is important, therefore, that care be exercised when handling and storing fuel. USE ONLY CLEAN CONTAINERS. It is also important that only fuel be used that conforms with the fuel oil specifications given in paragraph 28. Figure 256 is an illustration of the fuel system, tracing the flow of the fuel from the fuel tanks to the injectors.

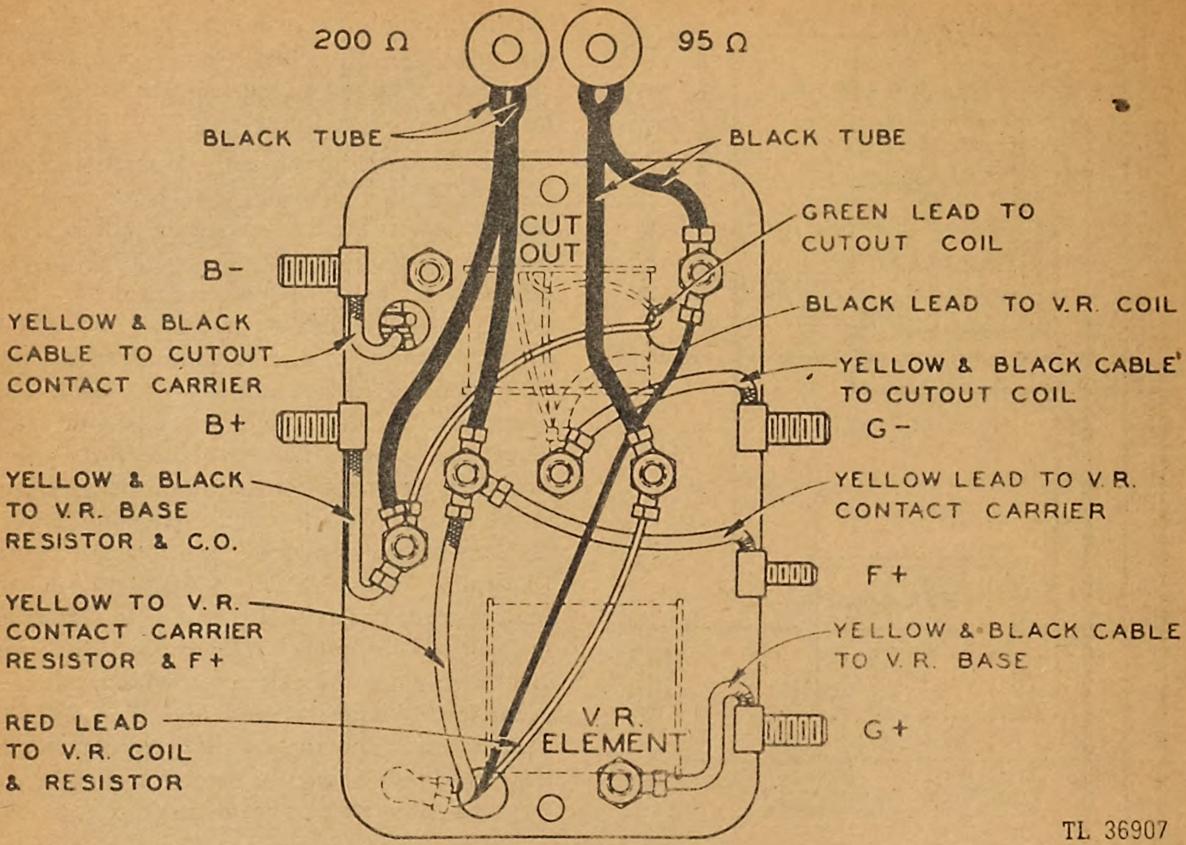

Fig. 255. Bottom View of Regulator Wiring

78. **Primary Fuel Filter.** Because fuel oils are less fine than gasoline, they contain more gum, fine abrasives and water. To prevent these from entering the engine and causing trouble, primary and secondary stages of filtration are employed. Not only should these filters be serviced as recommended, but the fuel line connections should be inspected during the overhaul period and replaced if there are any evidences that the fuel line is breaking down. Because of the construction of the filter, no overhaul is necessary because of wear, other than replacements that may be necessary due to accident. The primary stage fuel filter consists of two stages of filtration: the first through a specially woven wool fabric; the next through a spirally wound metal-edge filter. The fabric outer element removes small particles of dirt. The inner metal edge with a .0015-inch spacing removes any lint which may have been picked up while passing through the fabric element and acts as a safety in the event of the puncture of the fabric. The filter is installed in proper relation to the pump for preventing air locks.

a. Removing Sludge and Water. To remove sludge and water from the primary stage fuel filter, the engine must be stopped.

(1) Open both vent cocks, remove the drain plug and allow the fuel oil to drain out, taking with it any sludge or water that may be present.

(2) Install the drain plug. Remove the priming plug and fill the filter with clean fuel oil through the priming plug hole, allowing the fuel to flow to the fuel plug until the level remains constant. Tightly close the outlet vent cock, and close the inlet vent cock until it is just slightly open. Start the engine. Close the inlet vent cock when clean oil flows at this point.

b. Cleaning Filter Element. Before removing the filter housing, wash the housing, seats

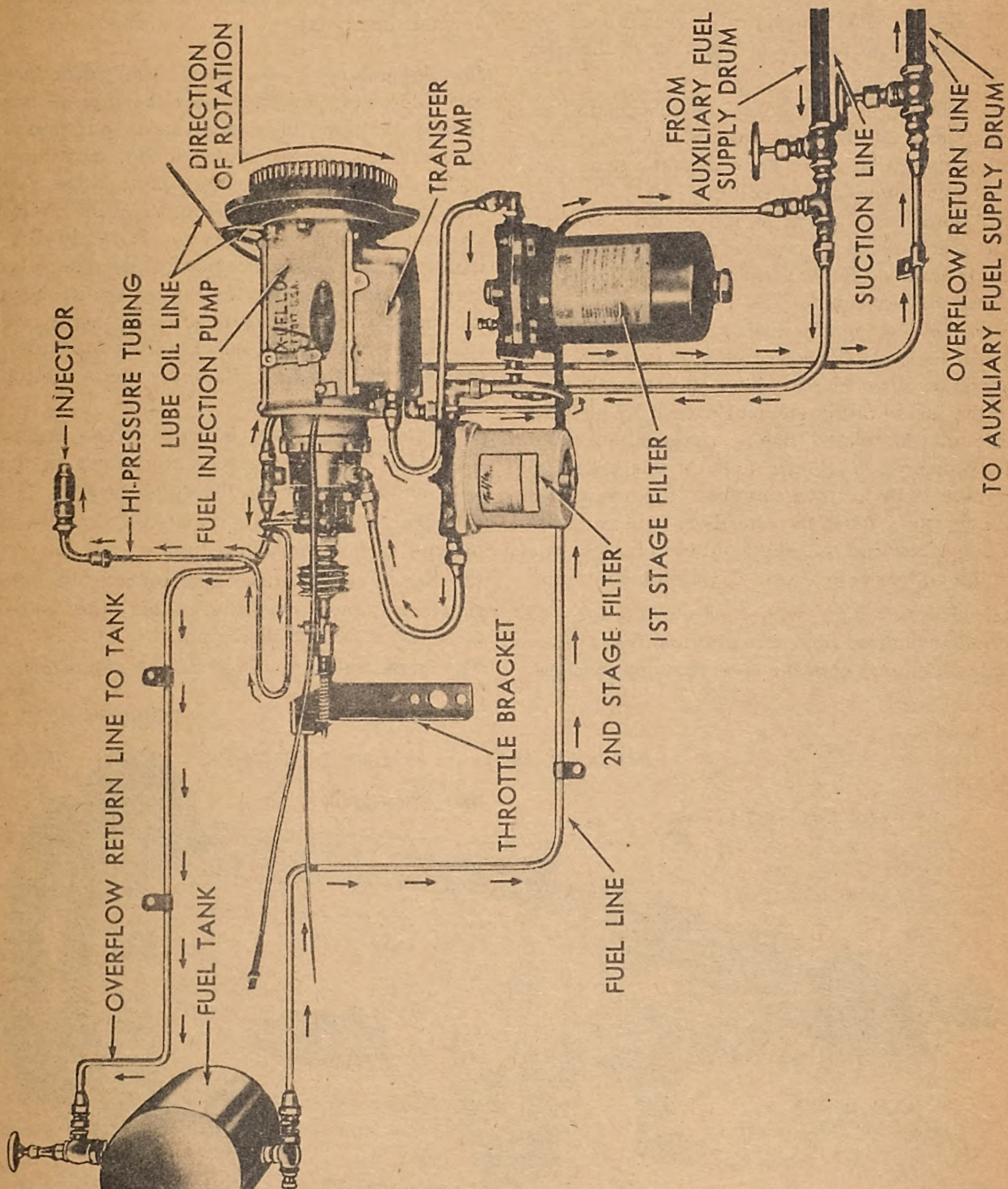

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Fig. 256. Fuel System Accessories

and tubes with fuel oil. (See Figure 45.) The engine must be stopped, then proceed as follows: (1) Open both vent cocks; remove the drain plug.

(2) Remove the housing or case and unscrew the element to remove it (right hand thread). (See Figure 46.)

(3) Wash the element and case thoroughly in clean fuel oil. Immerse the fabric unit in fuel oil or kerosene, place hand over the open end and push suddenly to collapse the unit. This will force the liquid on the outside through the cloth element, removing deposits on the outer surface. Repeat until the fabric is clean. Wash the outside of the fabric covering the filter unit by gently rinsing in a container of clean fuel oil. Do not scratch or perforate the fabric or allow any washing oil to find its way to the inside of the element except by filtering through the cloth. Before reassembly, carefully inspect the fabric unit. If this does not appear to be in good condition, replace it with a new unit. Wash the filter base and carefully clean all sludge and sediment from the pockets in the bottom of the base. Reassemble the unit.

(4) Fill the filter with fuel oil through the priming plug oil hole, allowing the fuel to flow to the fuel plug until the level remains constant.

(5) Tightly close the outlet vent; close the inlet vent cock until it is just slightly open.

(6) Start the engine.

(7) Close the inlet vent cock when clean oil flows at this point.

79. Secondary Fuel Filter. The secondary fuel filter filters the fuel after the fuel oil has passed through the fuel transfer pump and removes any foreign material that may have gotten by the primary stage filter. (See Figure 256.) Because of the construction of this unit, no overhaul is necessary. The only servicing will be the replacement of the filter element. Before replacing the filter element, wash the outside of the filter housing, seats and tubes before it is disassembled, to avoid getting dirt into the line. Use only clean fuel oil for washing.

a. Replacing Filter Element. (See Figure 47.) (1) Remove the four capscrews in the filter head and remove the sump or shell.

(2) Empty the shell of unfiltered liquid and dispose of the used filter tube.

(3) Insert a new tube. Be sure that the core sleeve is placed over the bottom core sleeve to center it for the shell ring.

(4) Reassemble the shell on the sump to the

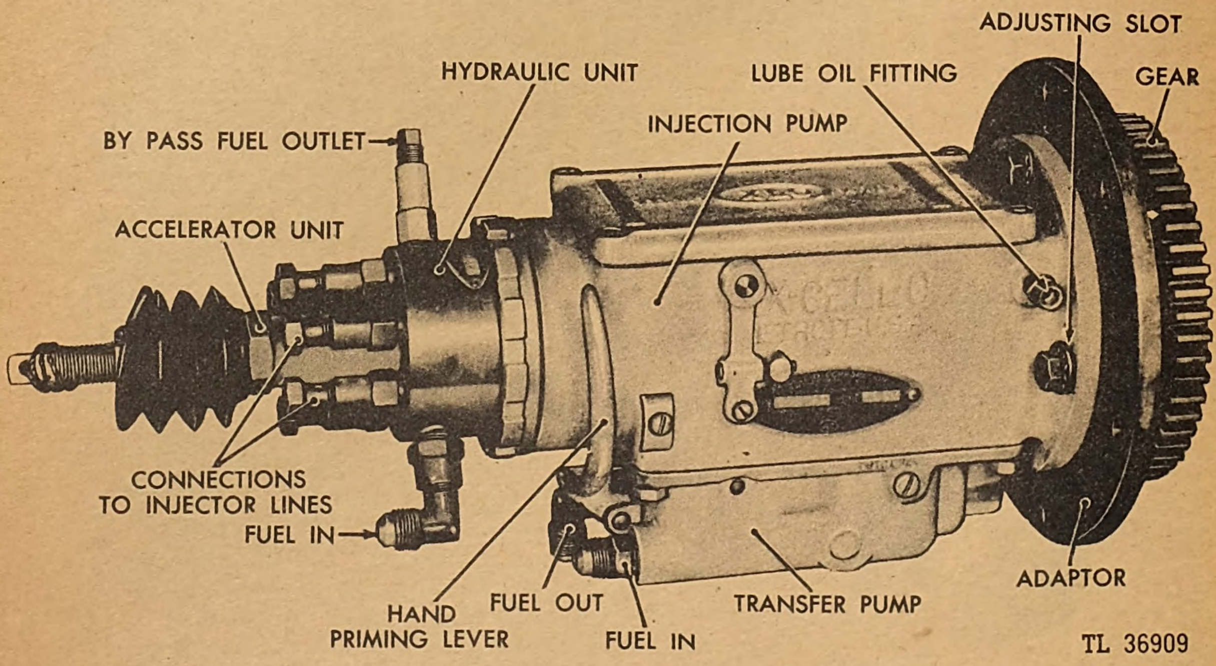

Fig. 257. Fuel Injection Pump

head so that the filter core at the top of the filter tube slips over the top core sleeve. Also be sure that the filter head engages the sump or shell evenly all around by tightening each diagonal pair of capscrews.

80. Fuel Injection System. The fuel injection system is composed of three components: the pump, the high pressure tubing, and the nozzles.

The purpose of the system is to transmit fuel from a supply tank to the engine under high pressure, at the correct time, and in the proper quantities, rate and form to provide complete and efficient combustion.

The pump provides the means for the transfer of fuel from the tank under low pressure to the injection nozzles at high pressure. It has major control of the quantity and the time at which the fuel is injected. The pump is a self-contained unit, composed of four replaceable and interchangeable units. These are: (see Figure 257) drive unit, hydraulic unit, accelerator unit, and fuel transfer pump. The hydraulic unit and fuel transfer pump are mounted on the drive unit, which, in turn, is flange-mounted on the engine. The accelerator unit screws into the end of the hydraulic unit.

a. Drive Unit. The drive unit is driven by a gear and supplies the energy and motion for operating the other units. It is lubricated directly from the engine supply system.

b. Hydraulic Unit. The hydraulic unit contains the precision parts of the pump which raise the fuel to a high pressure, and time and meter the fuel injection quantities.

c. Accelerator Unit. The accelerator unit contains the governor spring and the adjustments for controlling engine speed.

d. Transfer Pump. The transfer pump provides the means for the transfer of fuel from the supply tank to the hydraulic unit. It is equipped with a device for hand priming the system.

e. High Pressure Tubing. The high pressure tubing transmits the fuel from the hydraulic unit to the nozzle. This tubing must be of the same length to all the cylinders and of the same inside and outside diameter. This is to assure the same quantity of fuel to each cylinder.

f. Nozzles. The nozzles (see Figure 258) spray the fuel into the engine combustion chamber with the proper spray form, rate and degree of atomization. They consist essentially of a sealed nozzle tip assembly, assembled in the nozzle holder, designed for mounting in the engine head.

g. Nozzle Tip. The nozzle tip assembly contains all the working parts of the nozzle. It is not adjustable. The nozzle holder contains no moving parts and its principal function is to adapt the nozzle tip to the engine head.

81. Principle and Theory of Operation. *a. Drive Unit.* The power required to drive the pump is applied to a gear mounted on the hub of the drive shaft assembly (35). (See Figure 259.) Rotation of the drive shaft drives, through splines, a swash plate (33) by means of the splines. The rotation of the swash plate, in turn, through a shoe plate (31) imparts an axial motion to the tappets (30), which drive the spring loaded plungers (2) in the hydraulic unit.

Rotation of the drive shaft also turns, through a second set of splines on the end of the shaft, a rotor driver (29), which, by means of a tongue and groove connection, transmits this motion to the rotor (5) in the hydraulic unit. (See Figure 259.)

b. Transfer Pump. The bottom tappet (30) in the drive unit is slotted. A rocker (15) pinned in the transfer pump transmits the

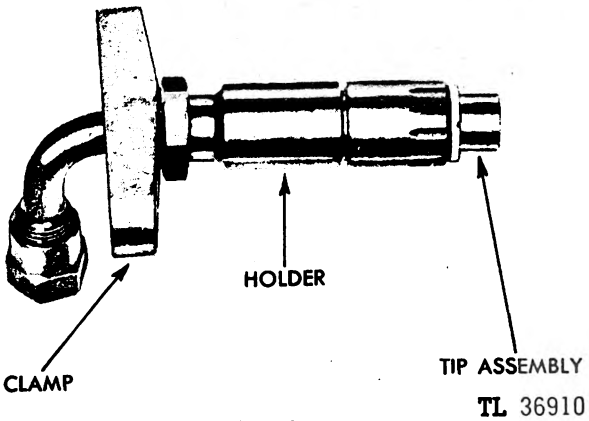

Fig. 258. Fuel Injection Nozzle

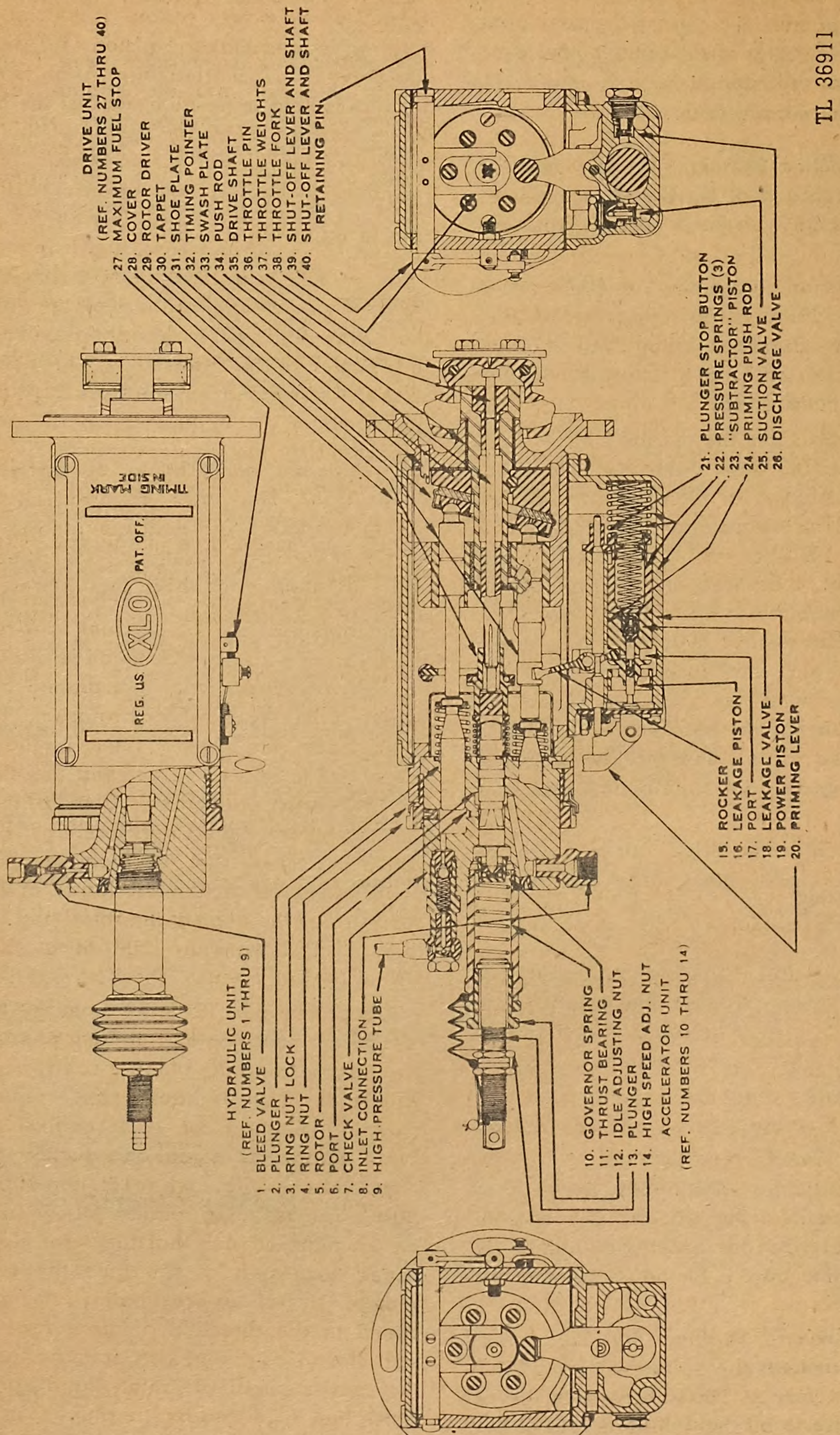

Fig. 259. Cross Section Assembly of Fuel Injection Pump

motion of the slotted tappet to the power piston (19), whose function is to draw the fuel from the supply tank and furnish it under low pressure to the hydraulic unit.

Fuel from the supply tank is drawn through the primary filter (see Figures 257 and 259), suction connection and suction valve (25) by the suction (leftward) stroke of the power piston. Motion of the power piston in the opposite direction raises the fuel pressure, which closes the suction valve and opens the discharge valve (26), forcing the fuel out of the transfer pump discharge connection through a secondary filter and into the inlet connection of the hydraulic unit (8). The transfer pump is of the type which automatically delivers the required varying volume of fuel under approximately a constant pressure, regardless of the load or speed at which the pump may be operated. The power piston has a constant stroke and, to allow the pump to deliver a variable volume of fuel, there is a spring-loaded "subtractor" piston (23) located in the same bore with the power piston. The movement of the "subtractor" piston is determined by the fuel pressure existing between this piston and the power piston; hence, at zero fuel delivery, the "subtractor" piston has a stroke equal to that of the power piston and at maximum delivery the stroke of the "subtractor" piston is zero. At any intermediate quantity of delivery the stroke of the "subtractor" piston accounts for a displacement volume, which represents the difference between the maximum possible quantiy of delivery and the quantity of fuel actually required. The pressure of the fuel delivery is controlled by the pressure of the springs (22) exerted on the "subtractor" piston.

The "subtractor" piston has a second function, in that manual operation of the priming lever (20) causes the "subtractor" piston to be stroked by means of the priming rod (24) and plunger stop button (21) independently of the operation of the power piston. The purpose is to manually prime or fill the system with fuel preparatory to starting the engine.

Another function of the transfer pump is to collect fuel which has leaked past the pistons in the transfer pump and from the hydraulic unit, and return this fuel to the system. This is accomplished by means of an auxiliary pump located in the power piston. It is composed of a spring-loaded leakage piston (16) and leakage valve (18). The leakage piston is stationary and is held in position against the housing of the transfer pump by means of the spring. Motion of the power piston which forms the cylinder of the leakage piston provides the effective pumping stroke. During the suction stroke of the power piston, fuel trapped in the cylinder, when the leakage piston closes the ports, is forced through the leakage valve into the normal fuel system described above. When the power piston moves on the discharge stroke, the vacuum created quickly draws in leakage fuel at the time the ports are again uncovered by the leakage piston.

c. *Hydraulic Unit.* From the fuel transfer pump, the fuel, under low pressure, passes through a secondary, final-type filter (see Figure 256) and then enters the hydraulic unit at the inlet connection (8). This connection and associated passage supply fuel to a recess in the hydraulic unit, which is made in part by a spool-like reduction in the diameter at the center of the rotary valve or rotor (5). The ends of the rotor are closely fitted in the central rotary valve bores and prevent the escape of the fuel endwise along the valve. In the spool-like reduction of the rotor, forming the recess, which is a small fuel reservoir, there is a triangular shaped section, or "land", of the same diameter as the ends of the rotor, and is, therefore, a close pressure-tight fit in the valve bores.

A separate port (6) leads from the recess or fuel reservoir to the end of each plunger bore. Through this port the plunger cavity is supplied with fuel. The hydraulic unit contains one pumping plunger for each engine cylinder. Each plunger is given one suction and discharge stroke with each revolution of the pump shaft. The angular relation of the rotor and swash plate is such that the rotor "land" will cover each port at the time the respective plunger is at approximately its maximum speed in the direction of discharge. Prior to port closure and after port opening (caused by the movement of the rotor "land" across the port), fuel displaced by the plunger in its pressure stroke flows back through the port into the

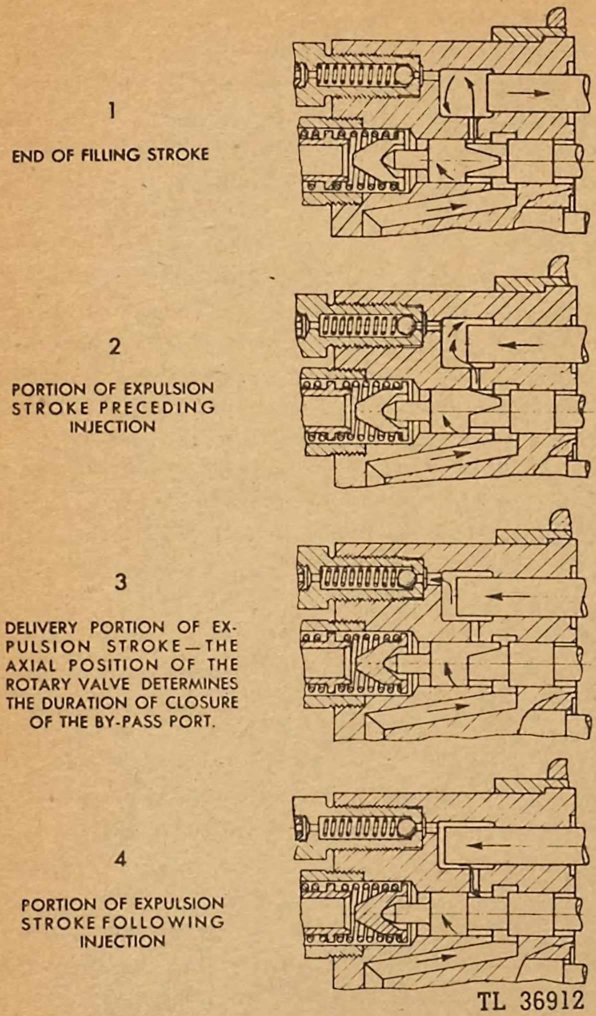

Fig. 260. Injection Cycle of Rotor Plunger

fuel reservoir. The fuel trapped in the plunger cavity when the port is closed is forced through a check valve (7) into the high pressure tubing (9). A check valve is located at the end of each plunger cavity. (See Figure 260.)

To obtain zero delivery, the rotor is moved endwise to a position where the ports are never closed by the "land." Stroking of the plungers then merely causes fuel to move in and out through the ports without building up a pressure sufficient to open delivery valves and cause injection. To cause the pump to deliver fuel, the rotor is moved endwise, so that, during rotation, the triangular shaped "land" closes the port when the plunger has its greatest velocity in the discharge direction. Further endwise movement of the rotor causes a wider portion of the triangular "land" to pass across the ports, thus increasing the duration of injection and quantity of fuel injected.

Connected with the fuel reservoir in the hydraulic unit is another passage leading to a bleed valve (1) (see Figure 259), which contains a ball check and an orifice. The purpose of the orifice is to bleed an approximate constant quantity of fuel, thus cooling the hydraulic unit and also providing a means for the escape of any air which may have entered the fuel system. The ball check is provided to maintain a fuel pressure in the hydraulic unit when the pump is not operated for facilitating engine starting. The bleed valve is connected with the auxiliary or main fuel tank through tubing.

d. Accelerator Unit. Governing of the engine is controlled by means of a mechanical centrifugal type governor. Since the axial position of the rotor (or width of rotor "land") determines the amount of fuel which will be injected, the rotor is held in axial balance between a pair of throttle weights (37) and a spring (10). The throttle weights mounted on trunnion pins impose their force on the rotor through a pin (36) and rod (34) assembled in the hollow drive shaft (35). The force of these weights is opposed by the governor spring (10) assembled in the accelerator unit. An increase in speed causes the throttle weights to exert a greater force, which moves the rotor (5) to the left, reducing the quantity of fuel injected; conversely, a reduction in speed causes the throttle weights to exert a lesser force, and the rotor is moved to the right, increasing the quantity of fuel delivered. As the force exerted by the governor spring (10) is controlled by the position of the accelerator plunger (13), the engine speed is under governor control throughout the entire range from idling to top speed. The rotor driver (29) is free to slide axially on the splines of the drive shaft extension; hence, the purpose of the splines which drive the rotor driver is then apparent, since they impart rotation to the rotor driver and rotor, but do not restrict axial movement of these parts necessary to engine governing.

To prevent overloading the engine, the maximum axial movement of the rotor in the direction of more fuel (to the right) must be restricted. The limit of this movement is determined by the maximum load at a given speed expected to be imposed on the engine. Restriction of the rotor is accomplished by means of a throttle control fork (38), which straddles the rotor driver (29). When the rotor has been moved to the position which gives the maximum quantity of fuel desired, a thrust bearing on the rotor driver makes contact with the toes of the throttle control fork, thus preventing any further axial movement.

The throttle control fork is attached to a shut-off lever and shaft assembly (39). Rotation of the shaft and fork (in a counterclockwise motion, facing the lever) is restricted by contact with an adjusting screw assembled in the maximum fuel stop (27) (also see Figure 261), thus positioning the throttle control fork and limiting the quantity of fuel which can be delivered. Assembled in the shut-off lever, at the point where the adjusting screw makes contact, is a spring-loaded button. A sufficient external force applied to the lever will compress this spring, allowing the throttle control fork and rotor to assume a position permitting a fuel quantity in excess of the normal maximum quantity for which the adjusting screw is set. The purpose of this device is to increase the normal fuel delivery at low-cranking speeds, thereby facilitating engine starting. Movement of the lever away from the fuel stop will move the throttle control fork and rotor to a position where no fuel will be injected and the engine will stop. The shut-off lever is designed for remote control.

e. *Nozzle (Injector)* Essentially, the nozzle, to which the pump delivers the fuel through the high pressure tubing, consists of seven parts or assemblies. These are (see Figure 262): (1) Sealed, replaceable tip assembly containing all the moving parts in the nozzle. (2) Nozzle holder body to which the tip assembly is attached and to which the injection lines connect. (3) Tip nut which holds the tip assembly in place on the holder body (4) Gaskets for sealing the nozzle in the engine. (5) Clamp for holding the nozzle assembly in place in the engine. (6) Tube nut for attaching the high pressure line to the holder body. (7) Tube nut sleeve which pilots the high pressure line in the tube nut and relieves the tube of high localized stress at the clamping point.

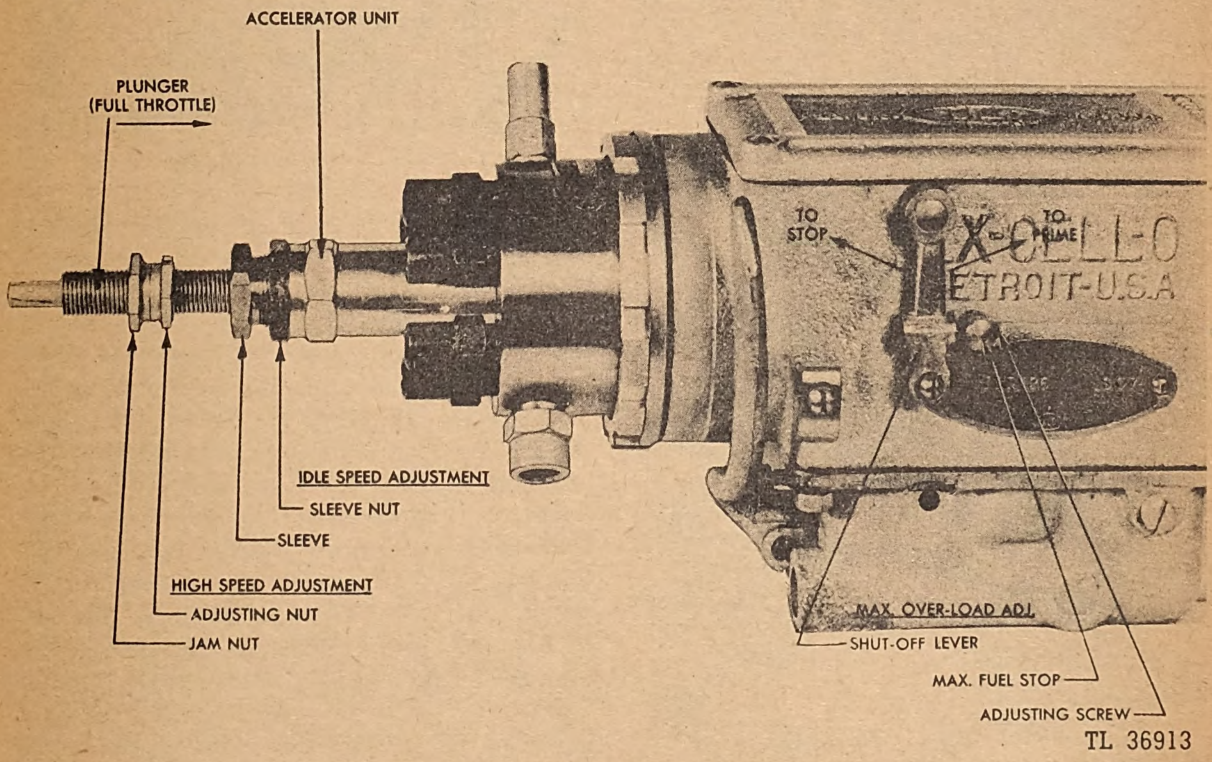

Fig. 261. Fuel Injection Pump Adjustments

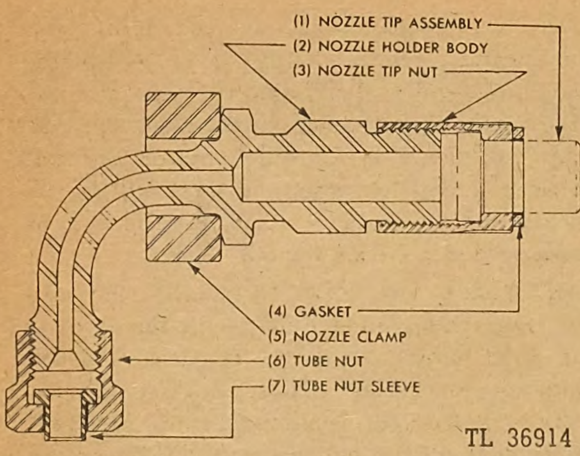

Fig. 262. Cross Section Assembly of Fuel Injection Nozzle

Fuel under high pressure from the injection pump acts on the seat area of the pintle, forcing it outward against a preloaded spring. (See Figure 263.) This spring, through its action on a spring hanger, also returns the pintle to its seat, sealing the nozzle against further injections or dribble when the line pressure is relieved at the pump. When the pintle moves outwardly, due to fuel pressure, an increasingly larger orifice area is opened around the flow angle of the pintle.

All of the working parts of the injection nozzle are adjusted and calibrated at the factory. These parts are sealed in the tip body

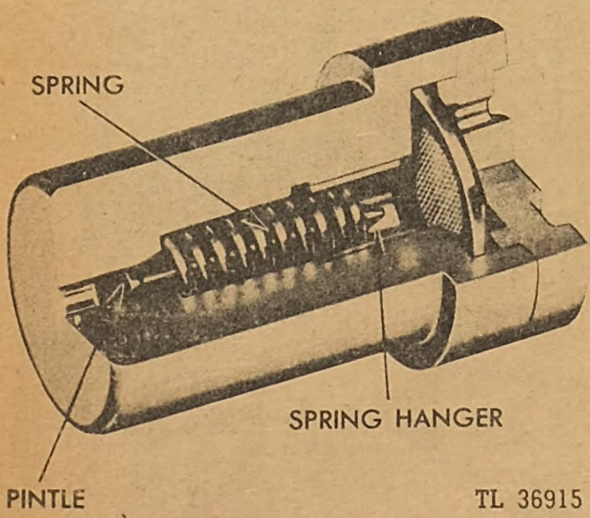

Fig. 263. Cut-Away View of Nozzle Tip Assembly

at final assembly and no field adjustment is required or possible.

82. Pump Adjustments. The only adjustments required or possible in the injection pump are speed adjustments (idle and maximum), and maximum fuel quantity adjustment for limiting the maximum power output of the engine. **Neither of the following adjustments should be attempted without first reading both instructions.** Before making any of the adjustments described in the following paragraph, it is important that the power unit shall have attained its normal operating temperature. Never make final adjustments on a cold engine.

a. Speed Adjustment. Two adjustments are provided in the accelerator unit for controlling engine speed—one for setting the idle speed, and one for setting the full-load speed.

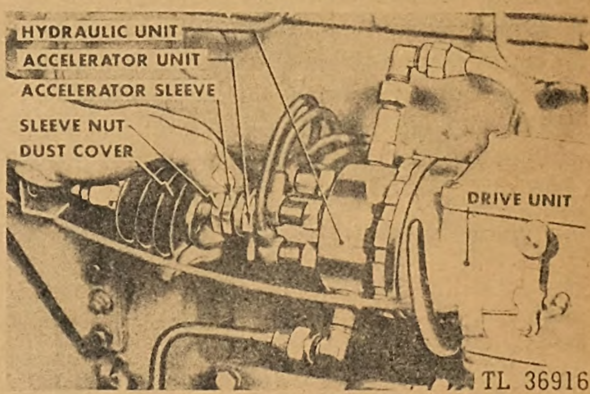

Fig. 264. Setting Idle Speed

The idle speed should always be set first. This is accomplished by loosening the sleeve nut and turning the accelerator sleeve. (See Figure 264.) This sleeve is provided with a right-hand thread. Screwing the sleeve into the accelerator body increases the pressure on the accelerator spring and raises the engine speed; screwing the sleeve out decreases the accelerator spring pressure and reduces engine speed. After securing the desired idle speed, the sleeve nut should be tightened securely.

When the idle speed has been set, the full-load speed can be adjusted. The accelerator plunger should be SLOWLY depressed into the body until the engine reaches the speed desired or the accelerator adjusting nut seats tightly against the accelerator sleeve, whichever occurs first. If the former occurs first, screw in the adjusting nut the remaining distance on the plunger until it touches the accelerator sleeve. Then, with full open throttle apply full-load to the engine. Before proceeding further with the speed adjustment, determine that the rotor driver has not made contact with the throttle control fork. This can be found by lightly moving the shut-off lever back and forth. If the lever is held in position against the maximum fuel stop by the accelerator spring, back out the adjusting screw until approximately $\frac{1}{16}$ inch of free movement is obtained. After loosening the jam nut, the plunger position, or hence accelerator spring pressure, can be varied by moving the adjusting nut, which will move the plunger in or out of the accelerator body. (See Figure 265.) Moving the plunger in increases the

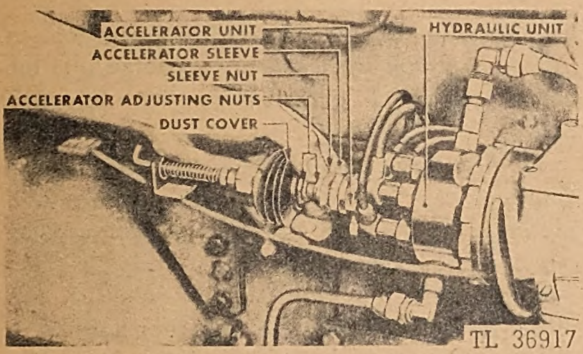

Fig. 265. Setting High Speed

engine speed; moving the plunger out decreases engine speed. After the desired speed has been obtained, tighten the jam nut. When adjusting the full-load speed, be sure that full load, or the desired load at which the speed is to be set, is maintained, because the load is subject to change with speed, unless the speed adjustments are fine. (See Figure 261.)

b. Maximum Over-Load Stop Adjustment. To adjust the maximum fuel stop, the speed adjustments described in paragraph 82a should first be made. Then, with the engine operating at full speed (accelerator plunger totally depressed), the maximum load (34 K.W.), should be imposed on the engine. If the desired load cannot be applied without losing excessive speed, the rotor driver has made contact with the throttle control fork, and the adjusting screw should be backed out so that the shut-

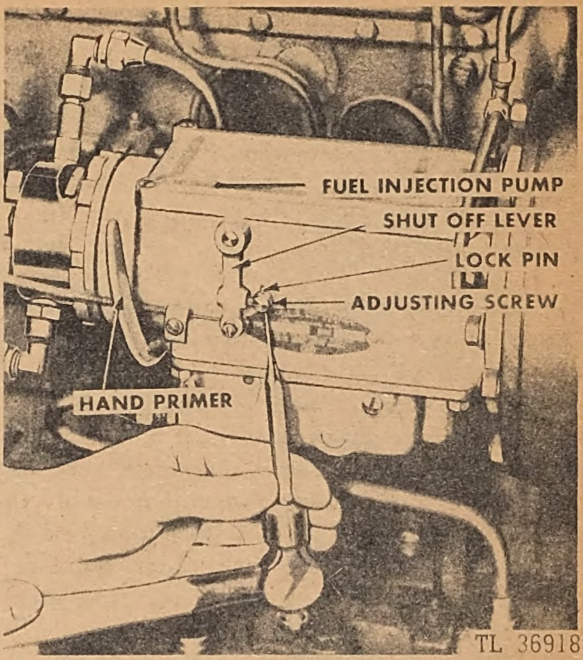

Fig. 266. Removing Overload Stop Lock Pin

off lever has a small amount of free movement. A lock pin is provided in the maximum fuel stop assembly to prevent turning of the adjusting screw. (See Figure 266.) After application of the load, screw in the adjusting screw to a position where free movement of the shut-off lever just ceases to exist. (See Figure 267.) During the adjustment of this screw, the speed

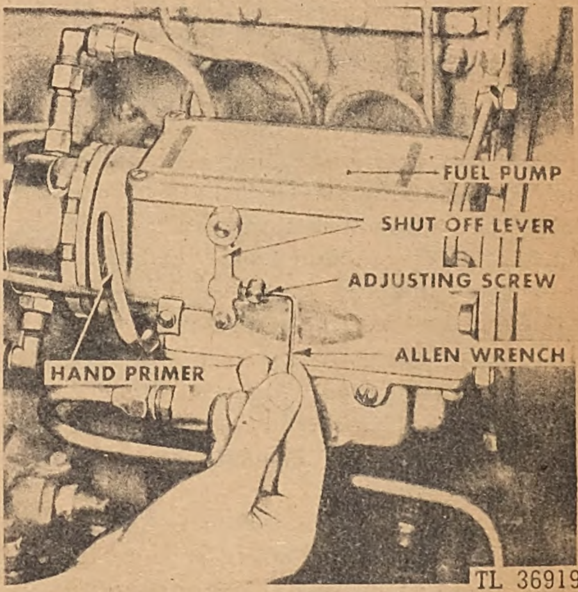

Fig. 267. Maximum Overload Stop Adjustment

will not be affected unless the screw has been turned in too far. After the adjustment has been made, replace the lock pin while holding the screw with a wrench so that it will not turn.

(If the adjusting screw is turned in too far, the rotor will assume a position where too little fuel is injected, and the engine will either stop or fail to start.)

83. Protection of the Fuel Injection Equipment. The fuel injection equipment is as foolproof as mechanical skill can make it. Lubrication is supplied by pressure from the engine lubricating system, and there is no part of the pump which requires any routine oiling, greasing or adjustment. The best care which can be given this equipment is to let it strictly alone, after making sure that the fuel oil strainer and filter are periodically cleaned strictly in accordance with the instructions of the manufacturer.

a. Filtration. The importance of adequate and careful attention to fuel filtration cannot be overemphasized, since the life of the fuel injection equipment is dependent almost entirely on whether the fuel used is properly filtered. All fuel oil contains dirt, ash and other abrasive particles of various sizes. The large particles, if not filtered out, will cause the precision parts to stick or score. The smaller particles, almost microscopic in size, cause the parts to wear, thus materially shortening their useful life. It is a comparatively easy matter to filter out the large dirt particles from the fuel. The finer abrasive material, however, presents more of a problem. Ample filtration is necessary. Frequent and careful cleaning of filter elements is essential. The life of the fuel injection equipment will be satisfactory if the proper filtration is employed, but like all other fuel injection equipment, it will be ruined in a short time by dirty fuel. Fuel which **LOOKS** clean may be ruinously dirty.

Do not abuse the fuel injection equipment —use recommended filtration—clean fuel strainers and filters regularly according to the intervals specified in the Maintenance Reference Chart on page 34.

b. Storage. If the injection equipment or unit in which it is assembled is to be stored or not operated for any period longer than a month, protective measures must be taken to prevent rusting, corrosion, or, more particularly, against gumming of the precision parts. Corrosion of polished steel and copper is accelerated in the presence of fuel oil; hence, to properly protect the equipment, the fuel oil must be removed. See paragraph 45*k*.

84. Overhaul—Foreword. Never attempt disassembly of the fuel pump until it is known exactly why such disassembly is necessary and what repairs are to be made. Familiarize yourself thoroughly with the principle and theory of operation in paragraph 81, and carefully read the instructions given in paragraphs 90 and 91, regarding trouble indications, probable causes, tests and remedies of fuel injection pump troubles. The fuel injection pump must be removed from the engine according to the instructions given in paragraph 47e.

85. Disassembly and Assembly. The following steps of disassembly are separated into the four units which compose the fuel injection pump:

a. Accelerator Unit. The accelerator unit contains the speed governing spring and plunger for varying the spring pressure by which speed adjustments are made. It is a self-contained unit, and screws into the end of the hydraulic unit. The governor springs in the thrust bearing are held in place by squeezing the end coils of the spring so that they will "snap" into position when assembled on the plunger and thrust bearing. An oilproof dust cover is provided for preventing the entrance of dirt or water into the sliding joint of the unit. If the dust cover becomes lost, torn or deteriorated, it must be replaced at once.

To disassemble this unit from the fuel pump, proceed as follows:

(1) Remove the dust cover.

(2) Unscrew the accelerator unit from the hydraulic unit as shown in Figure 268.

The accelerator unit is now removed. If further disassembly is necessary see Figure 259.

b. Hydraulic Unit. The hydraulic unit contains all of the precision parts of the pump. (See Figure 259.) It is held in position in the end of the drive unit with a ring nut, which is prevented from turning after assembly by

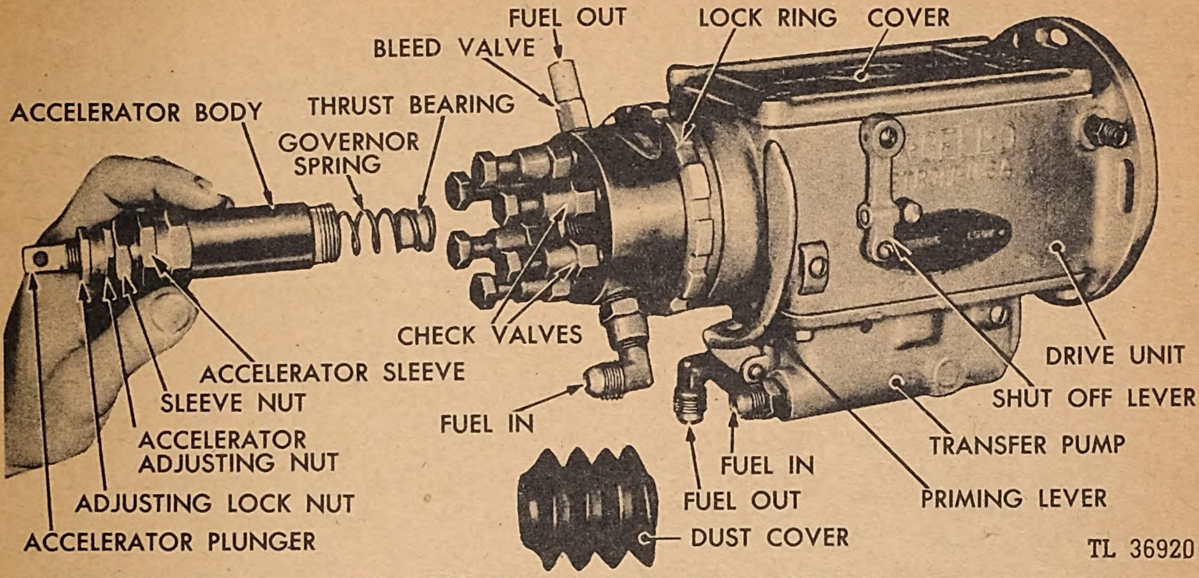

Fig. 268. Removing Accelerator Unit

a ring nut lock. The hydraulic unit is "indexed" in the drive unit body by a locating pin fastened in the hydraulic unit, which fits into a slot milled in the drive unit body. A tang on the nut lock also fits in this same slot, thereby preventing turning of the lock. (See Figure 269.) To remove the hydraulic unit from the pump and to replace it, proceed as follows:

(1) With a screwdriver, pry up the portion of the lock ring which is depressed into one of the spanner wrench slots of the large ring nut which locks the hydraulic unit in place.

(2) Unscrew the large retaining ring nut, using the spanner wrench provided with each pump for that purpose. DO NOT USE A HAMMER OR PUNCH.

(3) Remove the hydraulic unit from its socket. Make sure that the spline rotor driving member

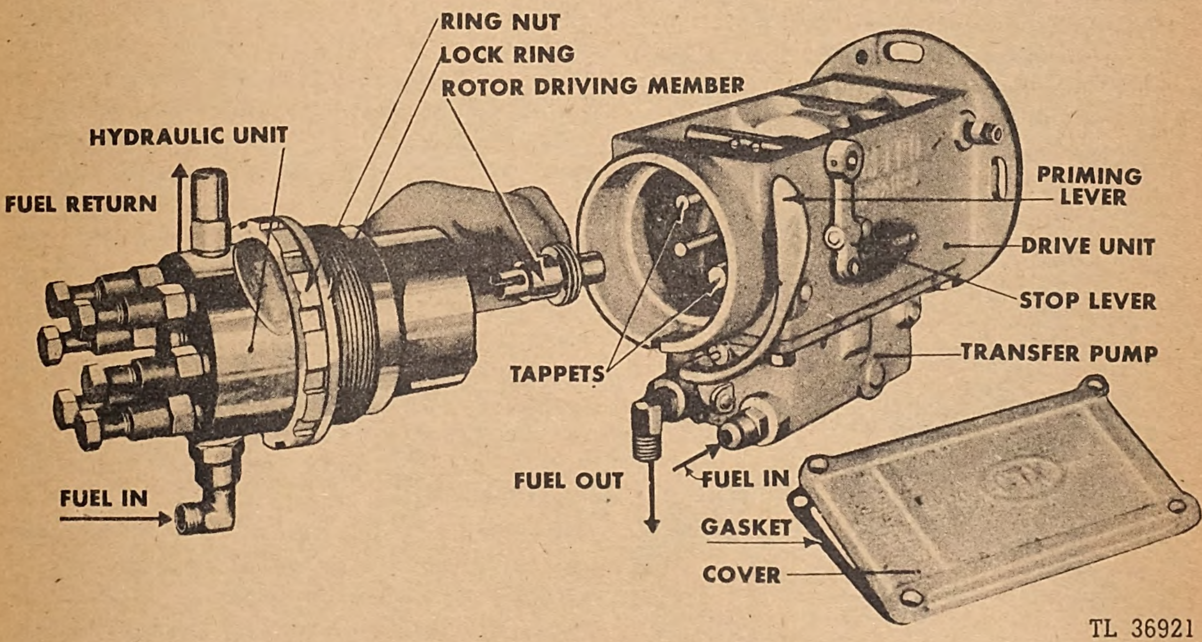

Fig. 269. Removing Hydraulic Unit

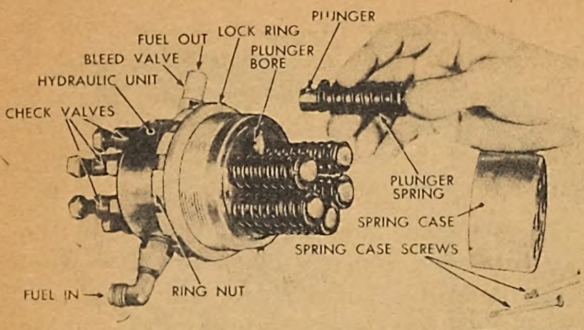

Fig. 270. Removing Plunger

is not lost. (See Figure 269.) If the hydraulic unit is not to be immediately replaced, cover the pump with a cloth to keep out dust and dirt. Do not unwrap the new hydraulic unit until you are ready to screw it in place. Should the unit come in contact with dirt, it should be rinsed with clean fuel, freshly drawn in a perfectly clean container.

(4) Access to the rotor, plungers and plunger springs is obtained by removing the spring case which is assembled on the unit with two round-head screws. (See Figures 270 and 271.) The plungers in the hydraulic unit are NOT INTERCHANGEABLE. They are numbered in a clockwise direction, starting with the plungers at the locating pin. Neither the plungers, rotary valve or bores should be touched with emery, crocus cloth or any abrasive or polishing compound. They may, however, be washed in clean fuel oil. The polished or highly finished parts should not be clicked, scraped or rattled together and should not be laid on anything but a clean paper or clean cloth.

NOTE: EXTREME CARE MUST BE TAKEN WHEN REASSEMBLING THE PARTS TO BE SURE THAT THEY ARE CLEAN. EACH PART SHOULD BE WASHED IN CLEAN FUEL OIL IMMEDIATELY BEFORE ASSEMBLY.

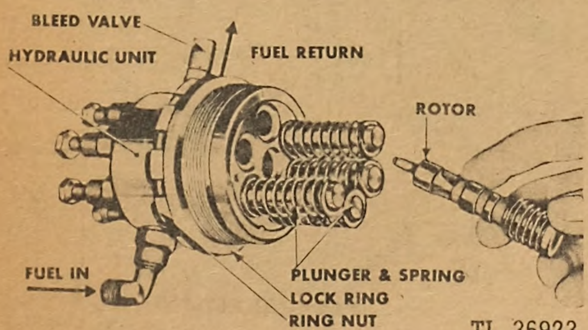

Fig. 271. Removing Rotor

The check valves are located in the end of the hydraulic unit and are screwed into position. Each hydraulic unit is calibrated for distribution with the check valves assembled in the unit. These valves should not be removed from the unit unless a failure of the valve occurs. (See Figure 287.)

The purpose of the bleed valve is to bleed fuel (and air) from the hydraulic unit, thus keeping it cool, and to retain fuel pressure in the unit during shutdowns, thereby facilitating engine starting. The bleed valve consists of an orifice and a spring-loaded ball valve. (See Figure 272.) The bleed valve can be disassembled for cleaning by removing the orifice detail which screws into the valve body. When reassembling, be careful to properly seat the spring on the orifice detail.

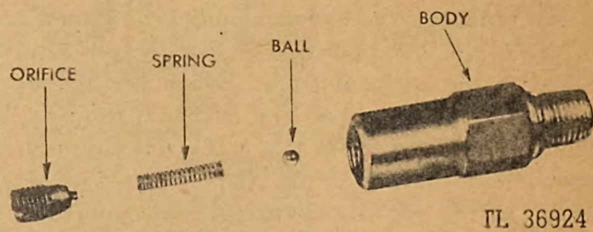

Fig. 272. Bleed Valve

(5) To install the hydraulic unit to the pump, remove one of the tappets which operate the plungers of the hydraulic unit. Look through the bore from which the tappet was removed and make sure the spherical end of the tappet, when replaced, will enter the cupped shoe of the shoe plate assembly. (See Figure 273.) However, if the hydraulic unit is replaced and the pump operated without the tappets properly entered in the cupped shoes, the tappets, shoe plate and other parts of the pump will be ruined. Additional warning of the error is given before any damage is done, as the hydraulic unit retaining ring nut will not screw into its normal location unless the tappets are properly entered.

(6) Make sure the splined bore of the rotor driving member is properly in place on the splined end of the drive shaft in the body of the pump. This will enter only one way (which is the right way).

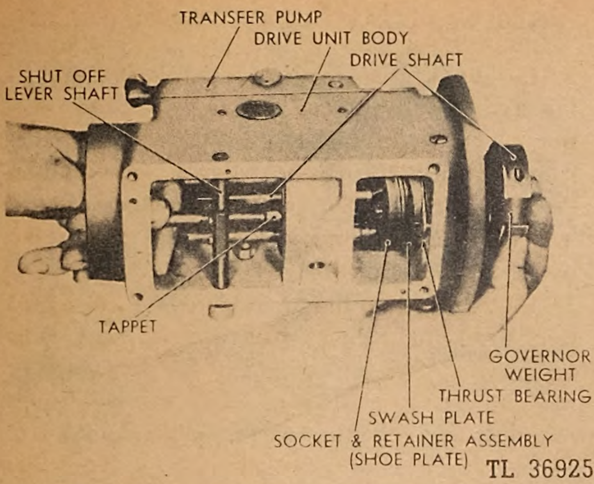

Fig. 273. Checking Tappet Fit Into Shoe Plate

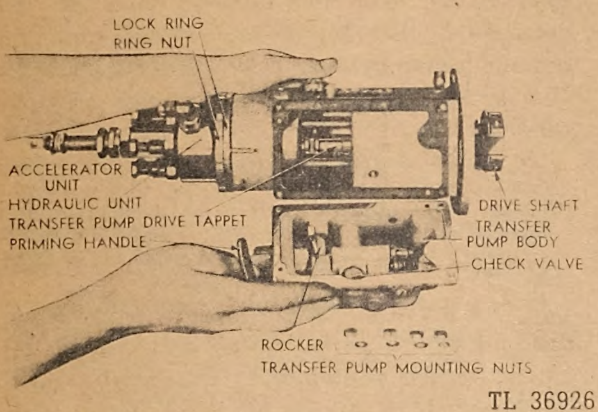

Fig. 274. Removing Transfer Pump

(7) Enter the hydraulic unit in place with the locating pin in the slot which is cut across the threads for the large ring locking nut in the bottom of the pump body. (See Figure 269.) The tail of the guard or lock for the large ring nut must also enter this slot.

(8) With one hand, press the hydraulic unit forward, and with the other, screw the large ring locking nut into place. (At the forward end of the rotor, is an offset rotor driving tang which enters an offset slot in the splined rotor driving member. If this tang does not enter the slot, no damage will be done, as the rotor return spring simply is compressed until the engine is cranked, at which time the tang will snap in place.) To press the hydraulic unit into the drive body recess and to turn the ring nut should require very little force or effort, until the nut draws the hydraulic unit into place close to the end of the thread. Then the nut should be tightened firmly by the special spanner wrench. DO NOT USE A PIPE OR A HAMMER ON THE WRENCH AND DO NOT USE A HAMMER AND A PUNCH FOR TIGHTENING THE NUT. When the nut is tight, a hammer and a punch should be used to depress a section of the lock ring into one of the spanner slots of the large ring nut, thus locking it against loosening.

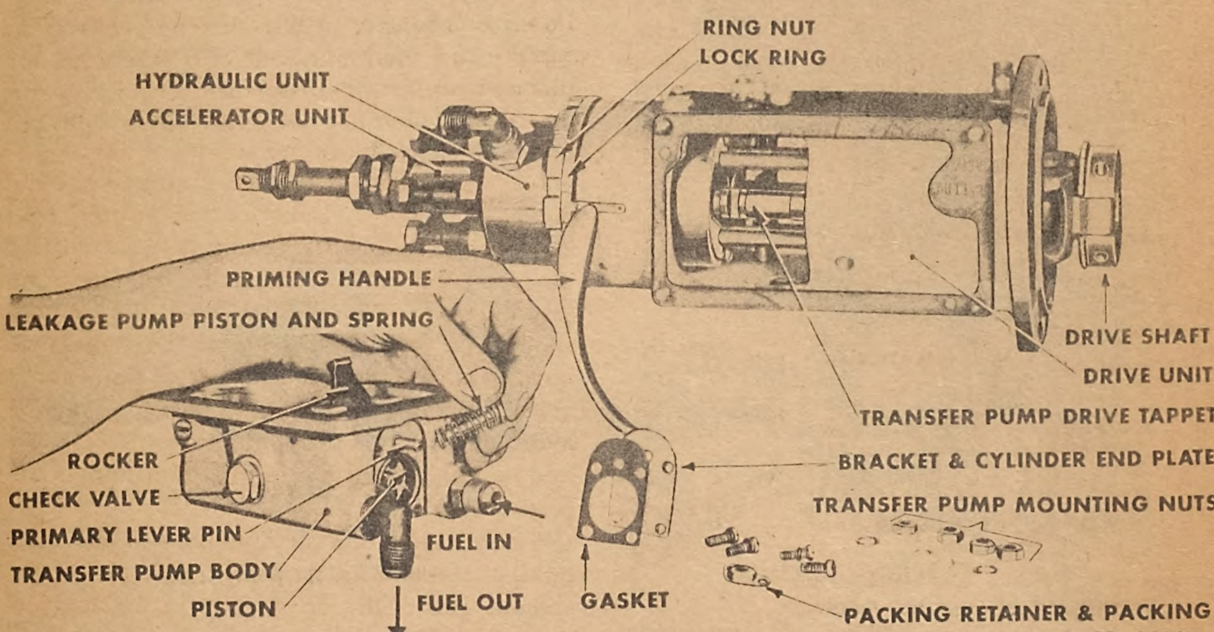

Fig. 275. Removing Leakage Pump Piston and Spring

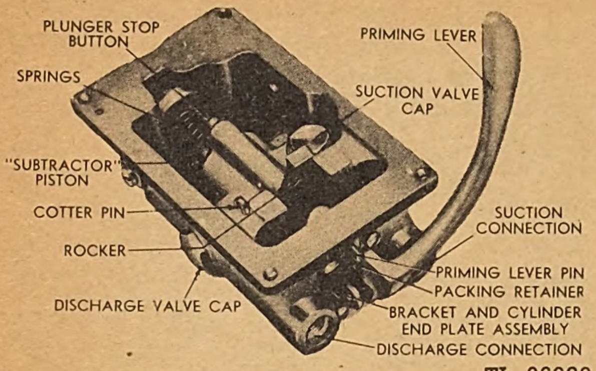

Fig. 276. Fuel Transfer Pump

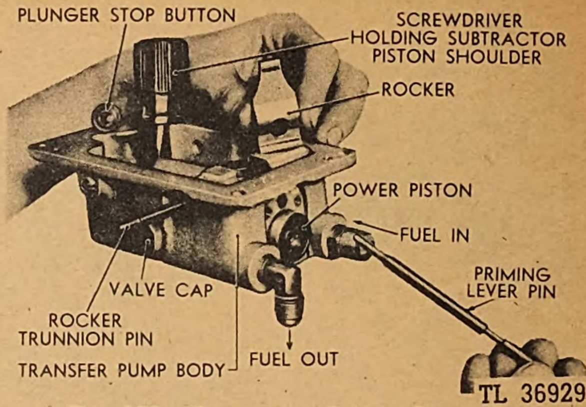

Fig. 277. Removing Primer Lever Pin

c. *Transfer Pump.* The transfer pump unit bolts up against the underside of the drive unit body. The unit can be removed from the pump by unscrewing the four hex nuts. (See Figure 274.) To disassemble and to reassemble the transfer pump, proceed as follows:

(1) Remove the bracket and cylinder end plate assembly held in position by four fillister head screws. Be careful that the packing retainer and packing around the priming lever pin are not lost. (See Figure 275.)

(2) The removal of the bracket and cylinder end plate assembly will expose the leakage pump piston and spring, which can be lifted out. (See Figure 275.)

(3) Remove the cotter pin and, with a punch or brass rod, drive out the rocker trunnion pin. (See Figures 276 and 277.)

(4) With a screwdriver inserted between the shoulder on the "subtractor" piston and the pump casting, or a soft brass rod inserted on top of the power piston, relieve the pressure exerted by the "subtractor" piston on the shoulder of the plunger stop button and pull out the priming lever pin. (See Figure 277.) The rocker and power piston can now be removed.

NOTE: If it is not necessary to remove the "subtractor" piston, the shoulder of the plunger stop button can be inserted between the shoulder of the "subtractor" piston and the pump casting, thus retaining the piston in the bore of the unit. (See Figure 277.)

(5) The leakage valve assembly screws into the end of the power piston and can be removed with a screwdriver. This valve cannot be reassembled if taken apart. When a leakage valve assembly is replaced in the piston, the new assembly should first be screwed in lightly, and then removed and inspected for full seal contact. Leakage will occur if a full seal is not obtained and the valve will not function. (See Figure 278.)

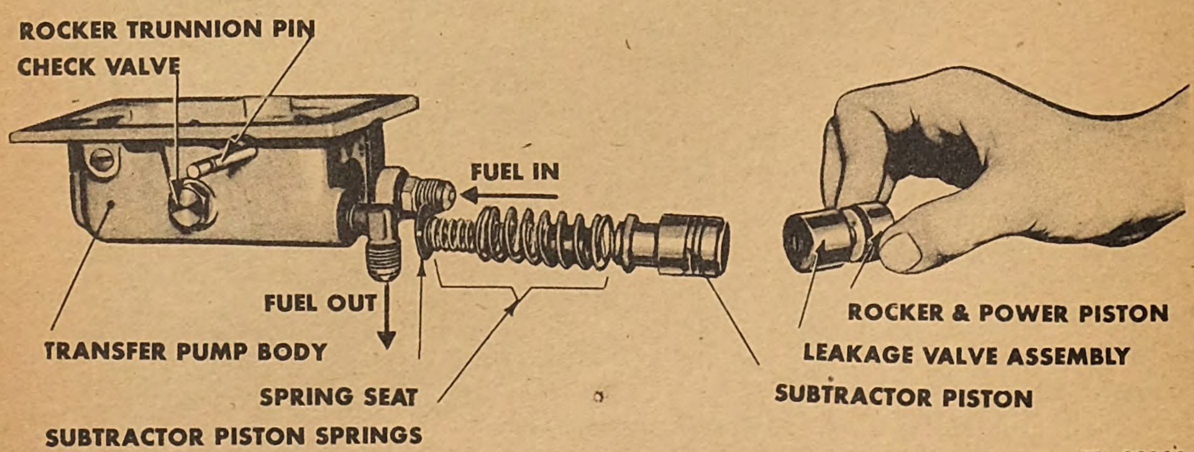

Fig. 278. Leakage Valve Assembly

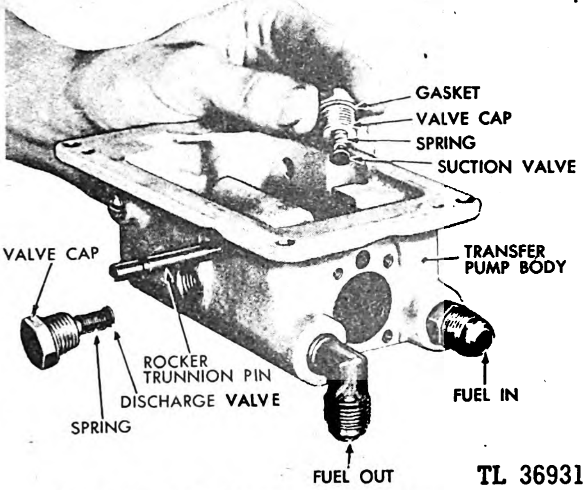

Fig. 279. Discharge and Suction Valves

(6) The suction and discharge valves of the transfer pump can be removed by unscrewing the valve assembly caps. The parts of these valves are alike and interchangeable, excepting the springs. The discharge valve spring is the heavier of the two. (See Figure 279.)

(7) The assembly of the transfer pump can be conducted in the direct reverse of the steps just outlined. Care should be exercised in the assembly and disassembly to keep all the parts clean and to prevent scraping or scoring of the pistons or piston bore. The pistons and bores are lapped fits; any mutilation of these surfaces may cause failure of the unit. When the transfer pump is assembled on the drive unit, it is important that the plunger drive rocker be engaged with the slot in the transfer pump drive tappet. If the rocker is not engaged in this slot, the face of the unit will not come up tight against the gasket of the drive unit body. Under no circumstances should it be forced or drawn up with the retaining nuts. The best procedure to follow for mounting the transfer pump is to turn the pump drive shaft until the bottom tappet is in its extreme position toward the hydraulic unit; then, with the rocker arm almost at the end of its travel, the rocker should engage with the slot when the transfer pump is mounted. (See Figure 274.) Always be sure that the unit can be pressed up firmly against the drive unit by hand before tightening the retaining nuts.

d. Drive Unit. The drive unit is the assembly upon which are mounted the hydraulic unit and transfer pump. The pump drive gear is a spur gear which has a slip fit on the pump drive shaft hub. (See Figure 257.) Torque from the gear is transmitted to the drive shaft through two diametrical Whitney keys located in the drive shaft hub. It is held in place on the drive shaft hub by an end plate and four hex head capscrews. (See Figure 280.) The gear hub is slightly longer (approximately $\frac{1}{64}$ inch) than the drive shaft hub, which provides a pinch on the gear when the end plate is assembled, preventing any movement of the gear on the shaft. Two screw locks with ears are provided, which, when bent firmly down on one of the flats of the hex head capscrews, secure the capscrews in position. When a drive gear is assembled on the drive shaft, it is important that a slip fit be maintained. If the gear is too loose, vibration may result, causing fatigue and failure of the drive shaft key. If the gear is too tight, a pinch action on the slotted hub takes place, which will cause a binding action on the throttle weights. It is important that these weights be perfectly free after the assembly of the drive gear, otherwise poor governing of the engine speed will result.

The tappets are interchangeable, with the

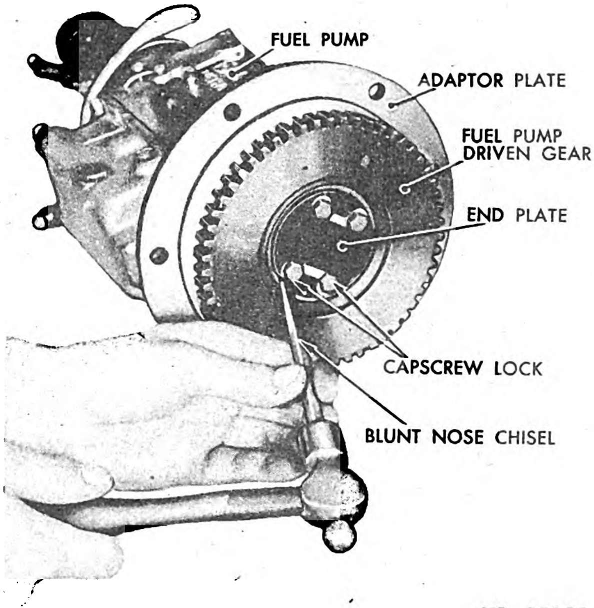

Fig. 280. Straightening End Plate Capscrew Locks

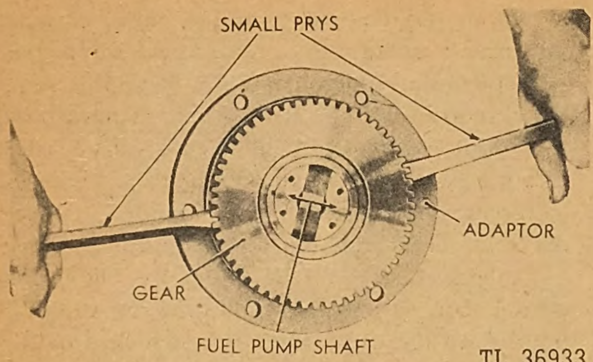

Fig. 281. Removing Fuel Injection Pump Gear

exception of the tranfer pump drive tappet. Rotor drivers are not interchangeable on the drive shaft. The shaft and rotor must be replaced as a unit, for each is carefully fitted for maximum freeness of movement with minimum backlash, both of which are essential for good governing. The rotor driver cannot be assembled on the drive shaft out of phase, since the design of the drive shaft includes the omission of one spline.

To disassemble or assemble the drive unit, proceed as follows:

(1) Straighten the tabs on the end plate retaining capscrews and remove the capscrews and plate. (See Figure 280.)

(2) Push the gear off the pump with two small prys. (See Figure 281.)

(3) The pump drive shaft can be removed from the unit by first removing the tappets, rotor push rod, and the cotter pin which retains the swash plate pin. (See Figures 273 and 282.) Be careful not to disturb the location of the timing pointer. Rotate the driver shaft one-half turn until the swash plate pin lines up with and is perpendicular to the Welch plug assembled in the under side of the drive unit body. Then, with a punch, drive the pin down

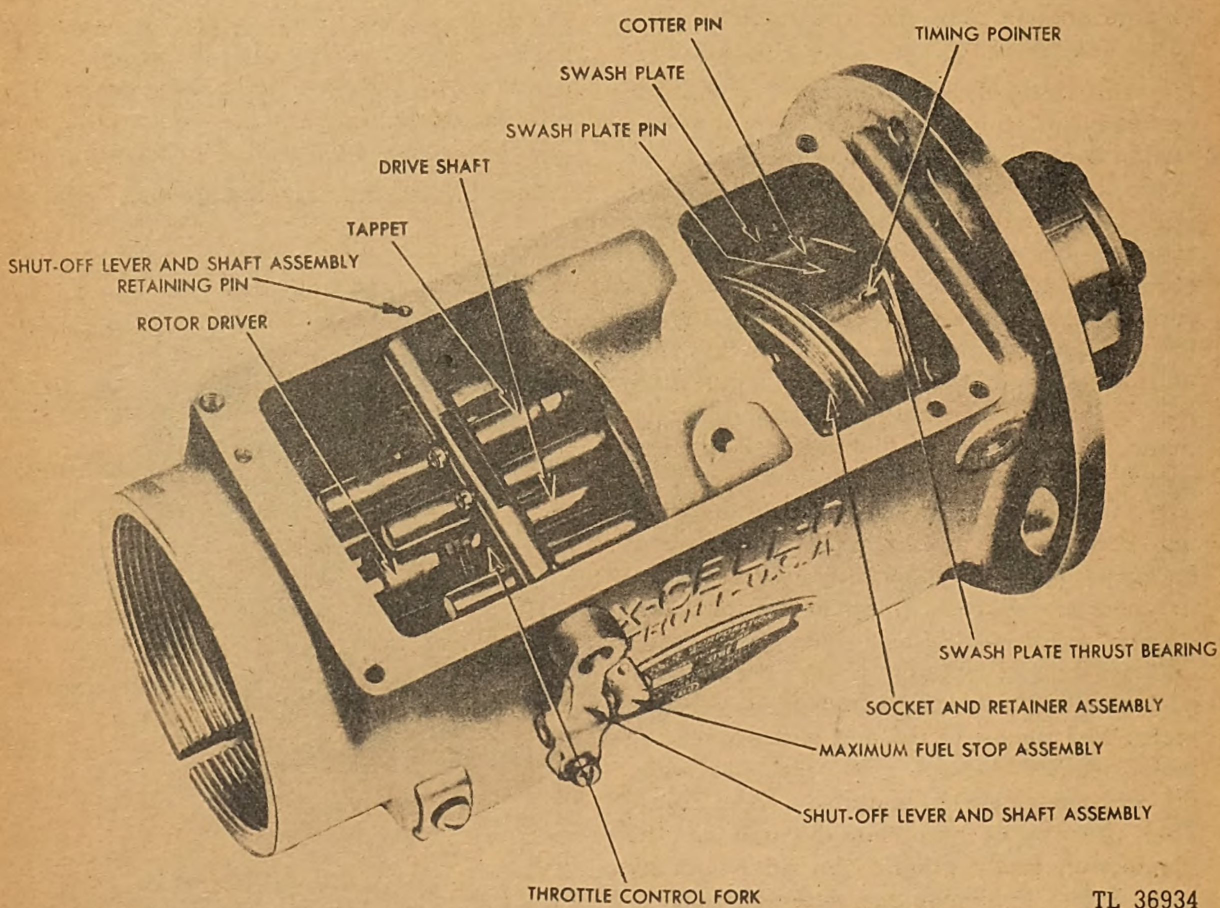

Fig. 282. Drive Unit

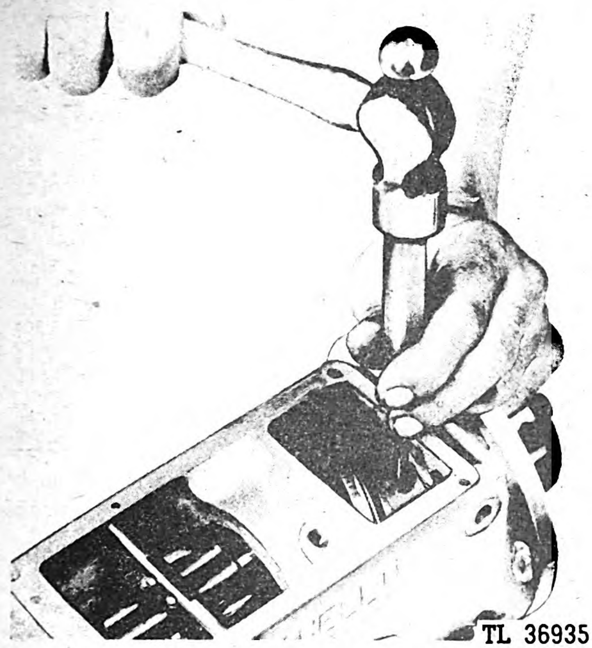

Fig. 283. Removing Drive Shaft

through the plug. (See Figure 283.) The drive shaft, socket, retainer assembly, swash plate and swash plate thrust bearing can now be removed. (See Figure 284.)

(4) The pinhole in the swash plate has two diameters. One diameter, slightly larger than the pin, extends approximately three-quarters of the distance through the swash plate; a second diameter, smaller than the pin, extends the remaining distance through the swash plate. Therefore, the pin can only be driven out from opposite the cotter pin end of the hole. After assembly of the swash plate on the drive shaft, the shaft should be turned so that it can be noted that the cotter pin does not interfere with the timing pointer. (See Figure 282.) Replace the Welch plug in the bottom of the drive unit, thus preventing leakage of the lubricating oil into the transfer pump.

(5) The swash plate thrust bearing is drilled for the communication of lubricating oil from the drilled passages in the body to the swash plate. (See Figure 284.) The timing pointer and dowel in the drive unit body serve as locating pins for the thrust bearing. The thrust bearing

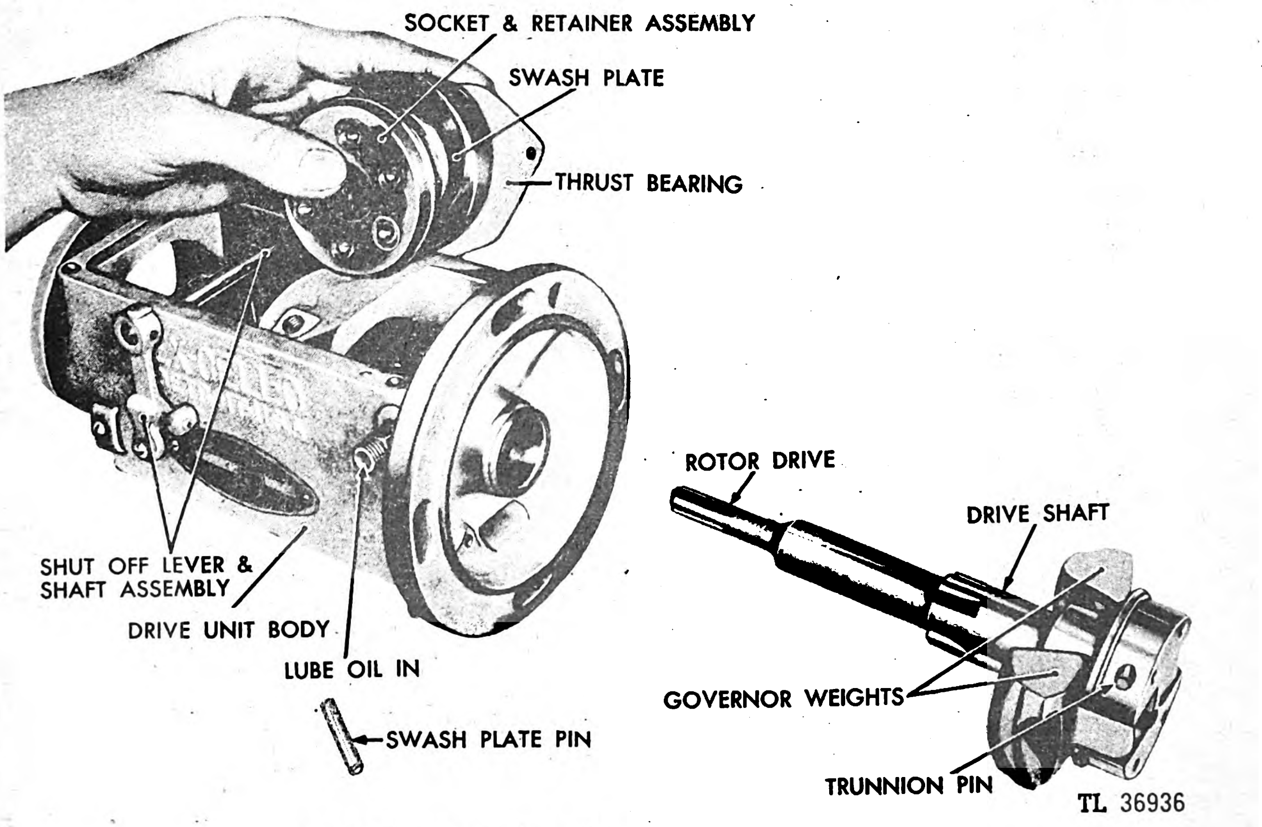

Fig. 284. Retainer and Swash Plate Assemblies

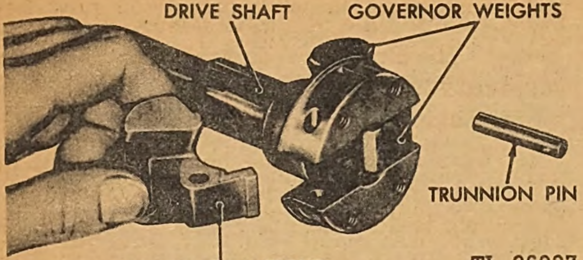

Fig. 285. Assembling Governor Weights

is a steel-backed bronze plate. Unless it is assembled correctly over both locating pins and with the bronze portion next to the swash plate, the lubricating oil passages will be blocked and failure of the pump will result.

(6) The governor weights are assembled in the drive shaft hub on trunnion pins. Care in the assembly or disassembly of the weights should be taken to prevent mutilation of the pinholes by the pin or punch, which cause the weight to bind, destroying governor action. (See Figure 285.)

(7) The shut-off lever and shaft assembly is retained in the unit by a loose-fitting pin (see Figure 286) extending down through the side of the drive unit body and engaging an angular undercut in the shaft. The pin is prevented from becoming disengaged with the shaft by the drive unit cover and gasket. To replace the shut-off lever and shaft assembly, the pin and throttle control fork must be removed. (See Figure 286.)

(8) The tappet body and drive shaft bushings should not be removed from the drive unit body. The bushings are burnished to a definite size after assembly in the body. The precision necessary on these parts can only be maintained at the factory.

86. Installation. To install a pump on the engine, it is simply necessary to mount the adaptor bracket on the pump, assemble the drive gear on the pump drive shaft hub, engage the gear with the timing gears of the engine, and bolt the adaptor bracket tightly against the engine housing. However, the pump must be correctly timed. The following instructions on timing should be carefully read before installing the pump.

a. Timing. To inject the fuel into the engine cylinder at the proper moment, a definite angular relation must be maintained between the pump rotor and the engine crankshaft. For the purpose of obtaining this definite relation, a timing pointer is installed in the drive unit body and an "L" timing mark is stamped on the swash plate. (See Figure 191.) WHEN THE POINTER IS IN LINE WITH THE "L" MARK AND THE #1 ENGINE CYLINDER CRANK IS 5 DEGREES BEFORE TOP CENTER ON THE COMPRESSION STROKE, THE ENGINE IS PROPERLY TIMED.

Since the timing pointer and "L" mark seldom line up exactly when the drive gear is engaged, slots are provided in the pump body flange for rotating the pump on the adaptor bracket studs. Therefore, when the adaptor bracket is assembled on the pump, the retaining nuts should not be drawn up tightly, but should be tightened only after the correct timing is obtained. To obtain the correct initial timing see paragraph 59*v*, items (2), (3) and (4).

b. Priming. The fuel injection pump must be primed when a new pump has been installed on an engine, or if the fuel lines to the transfer pump connections have been broken, or the system has been drained of fuel. To prevent excessive cranking of the engine to replenish this fuel, prime the system according to paragraph 23, steps 9, 10, 11, 12 and 13.

c. Adjustments. When a new pump is installed on an engine, it is often necessary to

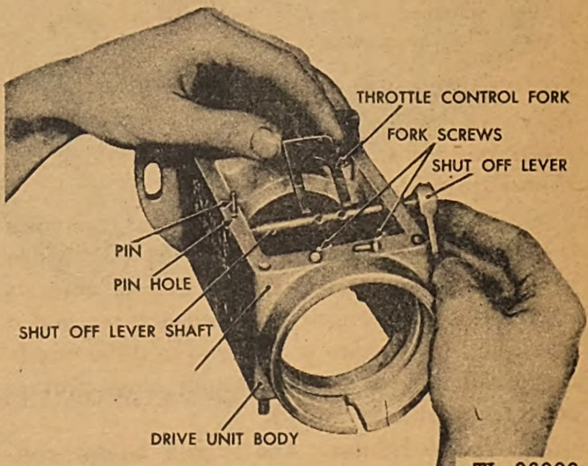

Fig. 286. Installing Shut Off Lever

make pump adjustments for speed and maximum load limitation. The adjustments required are given in paragraphs 82*a* and 82*b*.

87. High-Pressure Tubing. It is important that all high-pressure tubing, which transmits the fuel from the pump to the nozzles, be of the same inside diameter and outside diameter, and that all be of equal length, since the volume contained in the line and the elasticity of the line have a function in the injection characteristics. The high-pressure tubing should have a length of 29 inches, measured from the middle of the high-pressure pump connection to the end of the swaged nozzle connection. The inside diameter should be .094 inch; the outside diameter should be $\frac{1}{4}$ inch.

If a new line is prepared to replace one that is broken, the end of the line should be drilled with a $\frac{3}{32}$-inch drill after swaging—shaping the nipple to the tubing. The operation of swaging causes the line to collapse somewhat at the portion where the jaws of the tool hold the line; this, in turn, causes a restriction to the fuel flow. After the line has been prepared, the connection should be thoroughly cleaned and the line blown out with compressed air. If high-pressure air is not available, the line should be assembled on the pump. Before it is connected to the nozzle, the engine should be operated so that several injections of fuel pass through the line and into the atmosphere. Then connect the line to the nozzle.

NOTE: All high-pressure tubing should be securely clamped to prevent vibration—the principal reason for line breakage.

88. Fuel Injection Nozzles. The fuel injection nozzle is composed primarily of three units—the nozzle tip, nozzle holder and nozzle clamp. (See Figure 258.)

a. Nozzle Tip. The nozzle tip assembly contains all the working parts of the nozzle and is sealed at the factory. The tip consists of a body, pintle, spring, spring hanger and a filter. No field service is required and **the nozzle tip assembly should not under any circumstances be disassembled.**

b. Nozzle Holder. The nozzle holder contains no working parts and acts simply as a holder for the tip assembly. It consists of a body, tip nut, tube nut, tube sleeve, clamp and gasket. The tip nut is designed for a $\frac{3}{4}$-inch standard 12-point box wrench. No field service on the holder is required.

c. Nozzle Clamp. The nozzle clamp holds the nozzle in the cylinder head. One side of the clamp is flat; the other side is angled to a vertical edge at the center of the clamp. This edge should always be placed next to the nozzle (the flat side out) for the purpose of obtaining a centralized pressure on the nozzle holder, thus avoiding the introduction of possible stresses in the holder and tip if the clamp nuts are not tightened evenly.

d. Maintenance. No periodic field service on the nozzle is required or recommended. However, at the regular periods of engine overhaul, the nozzles may be removed and external carbon deposit wiped off the end of the tip with a SOFT CLOTH. NEVER USE A WIRE BRUSH TO REMOVE CARBON. The nozzle tip is sealed; under no circumstances should it be disassembled. If for any reason the nozzle tip is removed from the holder, care must be taken to protect the mating lapped surfaces of the tip and holder.

No definite periods or schedules can be set for nozzle replacement, since many varied circumstances, such as loads, temperatures, fuels and the conditions of operation in service, are the controlling factors. The nozzle should be left in the engine and operated until definite indication of faulty operation or failure is apparent. This indication cannot always be definitely determined on the hand test stand, because nozzles which squirt on the hand test stand will often operate an engine satisfactorily. Experience has shown that hand-stand tests are satisfactory to determine primarily only two things: (one) Valve opening pressure (V. O. P.) and (two) leakage past the pintle seat or mating surfaces in the tip and holder. To determine definitely that faulty operation exists, the suspected nozzle should be replaced with a nozzle known to be in good operating condition and engine performance noted. If improvement is observed, it may be concluded that the suspected nozzle is faulty. It should be replaced IF removal of the external carbon and several hard strokes on the hand stand do not remedy the fault.

89. Trouble Shooting (Fuel Injection Systems). These instructions outline engine indications of faults existing in the fuel injection equipment, the probable cause, and how, by simple tests, it can be determined whether any fault exists and the unit in which the fault exists.

YOU WILL SAVE TIME AND TROUBLE IF YOU MAKE SURE OF DOING THE RIGHT THING BEFORE THE INJECTION SYSTEM IS CHANGED IN ANY WAY. BEFORE ATTEMPTING ANY REPAIRS, READ CAREFULLY, "PRINCIPLE AND THEORY OF OPERATION," paragraph 81.

Before the fuel injection system is altered or adjusted in any way, and particularly before any parts are removed for inspection, carefully check the following points to be sure that the cause of the difficulty is really in the injection system. Too much stress cannot be laid on these instructions, as there is very little which can go wrong in the fuel pump. There is likewise little or nothing inside the pump which needs adjustment or to which adjustment is possible. Experience has shown that a high percentage of suspected troubles lie outside of the fuel pump. Tampering with the pump, in search of difficulties which are not there, is almost certain to cause trouble.

All possible fuel injection pump faults can be determined by tests which can be made without disassembling the pump. No part of the pump should be changed without knowing: First, the nature of the fault it is desired to remedy; second, the location and action of the parts that cause the fault; third, the proper procedure for correction of the fault.

Do not make any changes to the pump until the instructions in this manual pertaining to those changes have been studied thoroughly. If, after checking the following points, some part of the fuel injection system is found to be at fault, the changes should be made with this manual at hand, and the operations described should be performed in the order in which they are here named. (See 89*a* and 90.)

a. Index to Trouble Indications and Probable Causes.

1. Engine Stops or Fails to Start.

Probable Causes	*Reference*
(1) Lack of fuel.	Par. 28
(a) Shut-off lever in stop position.	
(b) Valve between tank and pump closed.	
(c) Fuel tank empty.	Par. 28
(d) Fuel system air-bound.	Par. 23 (9)
(e) Air leak in suction line between supply tank and fuel transfer pump.	
(f) Stoppage in fuel suction line from dirt or other foreign matter.	Pars. 85c, 90*a*
(g) Dirty or clogged filters.	Pars. 78, 90*a*
(h) Faulty transfer pump.	Par. 90*b*
(i) Seized hydraulic unit rotor.	Pars. 85*b*, 90c
(j) Worn hydraulic unit rotor.	Pars. 85*b*, 90c
(2) Engine out of time.	Par. 59*v*
(3) Improper maximum overload stop adjustment.	Par. 82*b*
(4) Water in fuel.	Par. 90e
(5) Ice in the fuel system.	
(6) Faulty nozzles.	Pars. 88, 90*d*

2. Engine Misses.

Probable Causes	*Reference*
(1) Seized hydraulic unit plunger.	Par. 90c (2)
(2) Faulty check valve.	Par. 90c (2)
(3) Seized fuel transfer pump power piston.	Par. 90*b* (2)
(4) Leaky high-pressure fuel line connection.	Par. 87
(5) Faulty nozzle.	Par. 90*d*

3. Excessive Smoke.

Probable Causes	*Reference*
(1) Engine out of time.	Par. 59*v* (2), (3), (4)
(2) Faulty check valve.	Par. 90*c* (2)
(3) Faulty nozzle.	Par. 90*d*
(4) Too much load on engine.	Par. 82*b*
(5) Change of fuel.	

4. Low Power.

Probable Causes	*Reference*
(1) Air leak in suction line between supply tank and fuel transfer pump.	Pars. 90, 90*a*
(2) Low fuel pressure.	Pars. 90, 90*a*
(3) Worn hydraulic unit rotor.	Pars. 85*b*, 90*c*
(4) Engine out of time.	Par. 59*v* (2), (3), (4)
(5) Engine missing.	Par. 89*a* (2)
(6) Improper pump adjustments.	Par. 82
(7) Faulty nozzle.	Par. 90*d*
(8) Change of fuel.	

5. Engine Knocks.

Probable Causes	*Reference*
(1) Engine out of time.	Par. 59*v* (2), (3), (4)
(2) Faulty nozzle.	Par. 90*d*
(3) Faulty check valve.	Par. 90*c* (2)
(4) Change of fuel.	

6. Poor Governing.

Probable Causes	*Reference*
(1) Throttle weight broken or sticking.	Par. 85*d*
(2) Rotor driver sticking on drive shaft splines.	Par. 85*b*
(3) Worn thrust bearing in accelerator unit.	Par. 81*d*
(4) Faulty nozzle.	Par. 90*d*

90. Tests to Determine Remedy and Fault. An installation of a fuel injection pump should include a pressure gauge installed in the line between the filter and the hydraulic unit, which will indicate the pressure of the fuel supply at the unit. The indication is the pressure built up by the fuel transfer pump, minus the loss of pressure caused by the passage of the fuel through the filter. First make sure the "STOP" control has been moved to the position for running.

a. Fuel Injection Pump. The most common cause for failure of the fuel injection system to inject fuel is an "air-bound" system. The most common cause for air binding is allowing the pump to run out of fuel, due to one of the following causes:

(1) Fuel tank allowed to become empty.

(2) Attempt to operate the engine with tank shut-off valve closed.

(3) Clogged fuel strainer or filters. Evidence of clogging will first appear when the engine is operating at top speed, full load. Usually sufficient fuel will flow through a filter, even when it is very dirty, to operate the engine at slow speed idling or at light load. If the fuel pressure gauge shows less than 20 pounds per square inch, clean strainer and filter at once.

(4) Air leak in the suction line between the tank and the fuel transfer pump (assuming that the supply is lower than the fuel transfer pump). Operators must realize that merely refilling of the fuel supply tank or reestablish-

ing the fuel supply after stoppage because of lack of fuel, will not remove the air which has filled the system. An air leak in the suction line will always be evidenced by the discharge of bubbles from a tube, one end of which is connected to the bleed valve on the hydraulic unit and the other end submerged in a container of fuel. However, after an engine which has been air-bound is started, the discharge of bubbles from the bleed valve is normal and will continue until all air has been expelled from the system. If the bubbles continue after a reasonable period of operation, a leaky suction line should be suspected.

(5) Fuel stoppage in suction line from dirt or foreign matter in the fuel tank.

The occurrence of any of the conditions just described will immediately be shown by loss of pressure on the fuel pressure gauge. Until the cause of this loss of pressure has been determined and remedied, it is useless to make any change to the fuel injection pump, as damage is likely to result.

When the engine is electrically started by storage batteries, it is important to save the charge in the storage battery by avoiding all needless use of the starter. Therefore, first make sure that there is fuel in the tank, that all necessary valves are open, that the filters are clear and there are no air leaks in the suction line.

Operation of the hand-priming pump should cause fuel pressure to show on the gauge; cranking the engine with the starter should cause an increase in pressure to 20 or 25 pounds. The pressure shown on the fuel pressure gauge should not drop any great amount between cranking periods. If this pressure does not appear on the fuel pressure gauge, it indicates that fuel is not reaching the fuel transfer pump, or that the cause of the difficulty is in the transfer pump. If the fuel transfer pump is suspected to be at fault, study the instructions below and remedy the cause of the trouble before changing other parts of the injection system.

If the engine does not start with fair promptness, do not waste the battery charge, but proceed to determine the cause. A Diesel engine that is getting fuel and yet fails to start, usually indicates this fact by the appearance of a bluish-white vapor resembling smoke from the exhaust pipe when the engine is being cranked. This vapor is unburned fuel and usually indicates that the temperature of the combustion chamber has not reached a point sufficiently high to ignite the fuel. Presence of such vapor is almost a sure indication that there is no difficulty in the pump or injection system (unless the pump has been removed and has been replaced "out of time").

b. Fuel Transfer Pump. (1) The first indication of any trouble with the fuel transfer pump will be a loss of pressure on the fuel pressure gauge. However, loss of pressure on this gauge does not necessarily indicate that the difficulty is in the fuel transfer pump. Before suspecting the fuel transfer pump, make sure that a thorough inspection has been made for the more simple causes outlined above. Also be sure the fuel pressure gauge is not stuck and is functioning properly.

If operation of the hand-priming lever does not cause a pressure indication on the pressure gauge, open the air-bleed vent at the top of the secondary filter; then operate the fuel transfer pump manual priming handle to see whether fuel under pressure is delivered from this vent. Quite a little pumping may be required, especially if the primary or secondary filters are empty of fuel, or nearly so.

To test the fuel transfer pump further, disconnect the supply and discharge tubing from the transfer pump. While operating the manual priming handle, note whether there is a suction at the inlet connection to the pump or a slight pressure build-up at the discharge exit from the transfer pump. This can be determined by placing the fingers lightly over these connections, or by temporarily fastening a short piece of copper tubing or rubber hose to the suction inlet to see if the pump will lift fuel from a container approximately two or three feet below the level of the pump when operating the manual priming handle.

If fuel is not discharged from the discharge connection or if there is no suction or pressure build-up at the connections of the fuel transfer pump, then the probable cause for failure is the lodging of some small foreign particle beneath one or both valves of the transfer pump. In this case the particle can often be removed by blowing into the suction inlet of the pump, preferably with a compressed air hose. This will lift both of the valves clear of their seats and usually will blow out the foreign particles. If compressed air is not available, remove the valves of the pump and inspect.

If the main or power-driven piston of the fuel transfer pump is stuck, it will probably cause the bottom tappet of the fuel injection pump to stop reciprocating, causing the engine to stop or at least to miss on the cylinder supplied by the bottom cylinder of the fuel injection pump. If fuel can be delivered by manual operation of the priming pump, it is evident that the valves of the fuel transfer pump are functioning properly and it is probable that the power piston of the fuel transfer pump is stuck. This latter condition may be checked by running the engine for a short time on fuel supplied by operation of the hand priming pump handle. If the engine misses on one cylinder, as just suggested, and especially if the engine runs out of fuel when ceasing to operate the hand priming pump, it may be concluded that the power operated piston of the transfer pump is stuck, in which case the fuel transfer pump should be replaced.

(2) Additional tests for the fuel transfer pump:

(a) If the "subtractor" piston operated by the hand priming lever is stuck, this can be determined by the behavior of the manual priming lever and the pressure gauge. It will either be impossible to move the priming lever through its normal working stroke or the lever will flop loosely through its entire stroke without moving the piston. In so doing, the manual operation of the fuel transfer pump will deliver no fuel. Seizure of the "subtractor" piston will also be evidenced by a high pressure on the gauge or a fluctuation in pressure if the piston is sticky.

(b) The fuel transfer pump contains an automatic drip pump which pumps the fuel drip from the hydraulic unit and fuel transfer pump back into the fuel delivery going to the hydraulic unit. If the leakage pump fails to operate for any reason, some fuel drip will come from the vent or overflow in the side of the drive unit. Except for the inconvenience of catching and otherwise disposing of this drip, no damage will be done. Such a transfer pump should, however, be returned for correction .

c. *Hydraulic Unit.* (1) If fuel under pressure and free of air or gases is supplied to the hydraulic unit and fuel seems not to be delivered to the nozzles when the speed control throttle is open and the stop control is in the "run" position, proceed as follows:

(a) Disconnect the linkage to the shut-off lever and slowly move this lever several times by hand throughout its range of travel. Particularly at and near the "stop" position, the pressure of the governor spring, acting through the rotary valve and the throttle control fork, should be felt against the stop control lever, especially if the accelerator plunger is fully depressed. If there is no such pressure and the stop control is free to "flop" without resistance from one position to another (especially near the "stop" position), it indicates the rotor has "seized" (most probably by dirt in the fuel) and the hydraulic unit must be removed and replaced.

A worn hydraulic unit usually becomes noticeable through requiring a high cranking speed to start, or failure of the engine to start, or tendency of the engine to stop when left running at slow idling speed. However, these symptoms may be caused by other conditions in the engine. Therefore, decision that the hydraulic unit is worn out can only positively be determined by the following tests:

(b) Disconnect all of the fuel injection tubes and remove the injection nozzles from the engine. Reconnect all the nozzles so that they will inject into the outside air.

(c) Next, turn the engine by hand, or by the electric starter, at a speed equal to the normal cranking speed of the engine. It is necessary that all other conditions for proper performance of the pump, as previously outlined, should first have been obtained. If the nozzles do not deliver fuel under normal cranking speed, and if they do deliver at a speed which is higher than the normal cranking speed, it may be concluded that the hydraulic unit is worn and should be replaced. Any peculiarity in the appearance of the spray from any of the injection nozzles should not be attributed to faults in the injection pump, as the nozzles themselves may be responsible for these peculiarities.

(2) Additional tests for the hydraulic unit:

(a) If the engine misses or fails to fire on any cylinder, this does not necessarily indicate that fault exists in the fuel injection system, as one of the engine valves may be holding open, or the engine compression may be insufficient for some other reason to permit the cylinder to fire. Before suspecting the fuel injection pump, the injection nozzle should be removed from the cylinder which fails to fire and reconnected to its injection tubing in such a way that the injections from the nozzle will be shot into the external air, where it can be observed by the operator while the engine is run on the remaining cylinders.

If no injection occurs from the nozzle in question, it should be replaced by another nozzle which is known to be in operating condition. If no injection occurs, a small particle of dirt (sometimes a small piece of copper from a gasket or scale from the fuel pump) may be holding a delivery valve from its seat. To determine if this is so, remove the delivery valve from the hydraulic unit, dry it carefully with a clean rag and blow in one end while the opposite end is submerged in a container of clean fuel. If you can cause air bubbles to come through the valve, blow compressed air through the valve at the seat end. If this does not remedy the condition, replace with a new valve. Do not attempt to disassemble the valve, as permanent distortion of the seat may result. If no injection then occurs, it is safe to assume that the associated plunger of the hydraulic unit has stuck or "hung up," possibly due to the presence of a small particle of dirt. Such an occurrence is unusual and the following should not be attempted until more probable difficulties have been checked.

However, a stuck or "hung up" plunger may often be permanently corrected by removing the delivery valve associated with that plunger (after first cleaning the end of the hydraulic unit). (See Figure 287.) After the valve is removed, the end of the plunger may be reached with a small piece of soft material, such as a short section of brass welding rod (after being carefully cleaned). Pressure applied to the end of the plunger or lightly tapping the rod will usually free the stuck plunger, after which, by motion of the rod when the engine is cranked, the operator will know that the plunger is moving in the normal manner. The

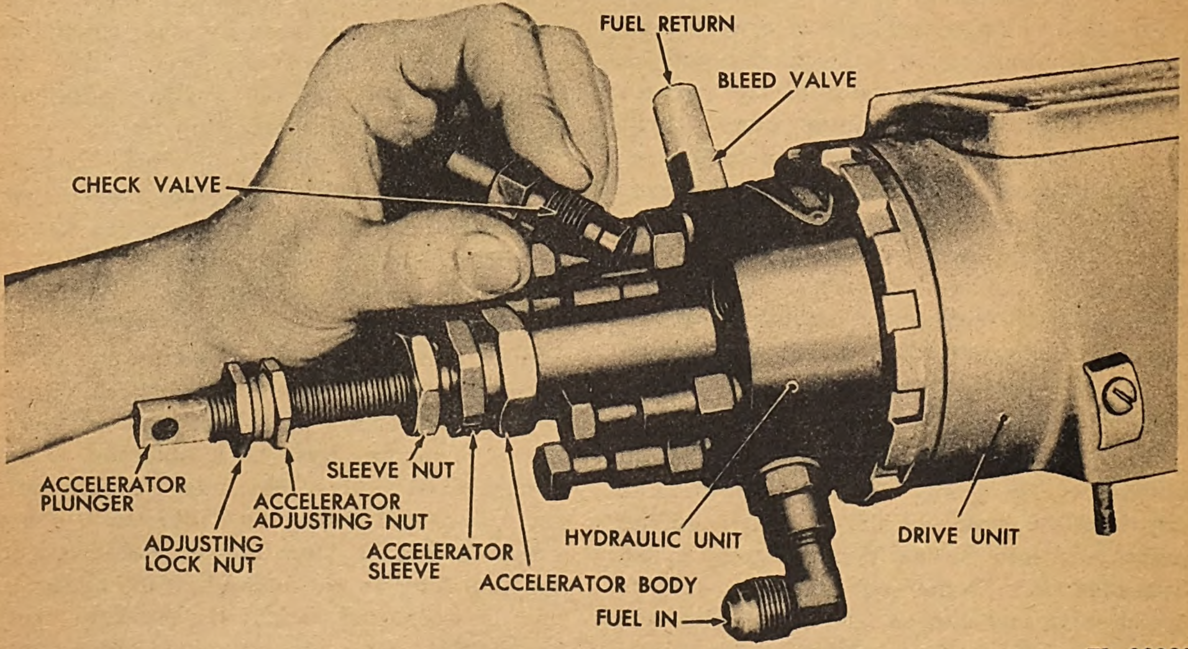

Fig. 287. Removing Check Valve

delivery valve may then be replaced and the nozzle again tried to see if it properly injects. If stuck plungers do not respond, the hydraulic unit must be changed. However, if the plunger which sticks is driven by the lowest tappet, which also operates the fuel transfer pump, before changing the hydraulic unit, read instructions in paragraph 85c pertaining to the fuel transfer pump.

There is no fault likely to occur in the hydraulic unit other than those just described. It is usually best to try the simple tests first, and even the test for a worn hydraulic unit need not be tried until the operator has reason to believe that the cause for hard starting is not in the engine. (Too low cranking speed or too cold an engine, or both, are most likely causes for hard starting.) However, if the test for a worn hydraulic unit shows that fuel is being delivered from the nozzles at normal cranking speed, and if it is known that the pump has not been removed from the engine since it was last operated, or, if removed, that the pump has been properly timed on its replacement, there is no further reason for questioning the fuel injection system. The cause of starting difficulties must then be looked for elsewhere.

(b) The bleed valve should maintain a back pressure of approximately 35 pounds per square inch of fuel. Failure to maintain this pressure in normal operation or when operating the manual priming pump may be due to a fault in the fuel transfer pump. If the fuel pressure gauge shows normal pressure when the engine is in operation, or when the manual priming lever is operated, this may usually be taken as sufficient indication that the fuel transfer pump is not at fault. If the pressure as shown on the pressure gauge drops quickly to zero upon stopping the engine, or immediately after ceasing to operate the fuel transfer pump, it may be suspected that the hydraulic unit bleed valve is leaking. Inspection of the parts of the valve will quickly show whether the valve, the seat and the spring are in proper relation. This unit has practically no wearing parts; if faulty, it should be replaced in its entirety.

d. *Fuel Injection Nozzles.* There is very little that can go wrong with the fuel injection nozzles and no repairs that can be made in the field except to clean the nozzles as described in paragraph 88*d*.

To inspect a nozzle suspected of faulty operation, remove the nozzle from the engine and test it on the Buda Nozzle Tester furnished with the engine. Use only clean Diesel fuel. Do not obstruct the oil spray as it leaves the nozzle. Keep your hands away from this spray. Complete directions are given with the nozzle tester. This method of checking the nozzle is preferable, since the valve opening pressure (V. O. P.), as well as spray pattern, valve action and seat leakage can be determined.

The effect of excessive nozzle seat leakage is exhaust smoke and the rapid accumulation of carbon deposits on the nozzle tip. However, the accumulation of carbon does not necessarily indicate excessive seat leakage, since the formation of some carbon is normal and to be expected.

The V. O. P. of the nozzle is set for 1400-1450 pounds pressure P S I at the factory. Many hours of operation will cause this pressure to be reduced, but not before other parts of the nozzle have become worn to such an extent that nozzle tip replacement is necessary. No minimum V. O. P. can be stated as a figure for tip replacement, since other factors must be considered.

If a nozzle is known to be faulty and another nozzle corrects the condition, and cleaning the nozzle in question does not restore its performance (measured as engine performance), then, only, should the faulty nozzle tip be discarded.

e. *Test for the Presence of Water.* In the handling of fuel oil while in transit or due to condensation which may occur in the fuel tank, water may have become mixed with the fuel and eventually may find its way into the fuel pump. This water is likely to set up corrosive action, so that the presence of water may be even more damaging than the presence of dirt.

It is recommended that the user obtain a supply of "gasoline water finder" paper for indicating the presence of water. This paper is used by attaching it by rubber bands to a rod or stick which can be lowered to the bottom of the barrel, tank or container. The paper is brown, as received, and if water is present in the bottom of the container, the portion of the paper which is touched by the water will turn white. This will be a warning to the user to carefully separate the water before filling the fuel tank from the container in question.

91. Fuel Tank and Fuel Lines. Because every precaution must be taken to keep dirt out of the fuel system, clean the fuel tank thoroughly during the overhaul period. Wash out any sediment which may be present. Check the fuel tank for leaks and make such repairs which may be necessary. If the paint is worn, repaint the outside of the tank. Be sure to remove any oil from the outside of the tank before painting. Check the fuel lines to and from the fuel tank. Look for breaks and for bad connections due to stripped or partially stripped threads. Replace any of these items if necessary.

92. Howler System. The howler system will automatically inform the operator by a warning sound of the howler if the operating temperature exceeds 205 degrees Fahrenheit or if the oil pressure drops below 10 pounds. See paragraph 11 for further description of operation. Because the howler system receives its electrical energy from the alternator, the green light, which indicates the system is in operation, will immediately light when the alternator revolves. The howler may sound when the engine is first started, and the red warning light of the oil pressure system will light. This should last only a few seconds, and the red light will go out when the oil pressure is built up beyond 17 pounds. The howler switch must be in the operating or closed position when the unit is started. (See Figure 15A.) This switch

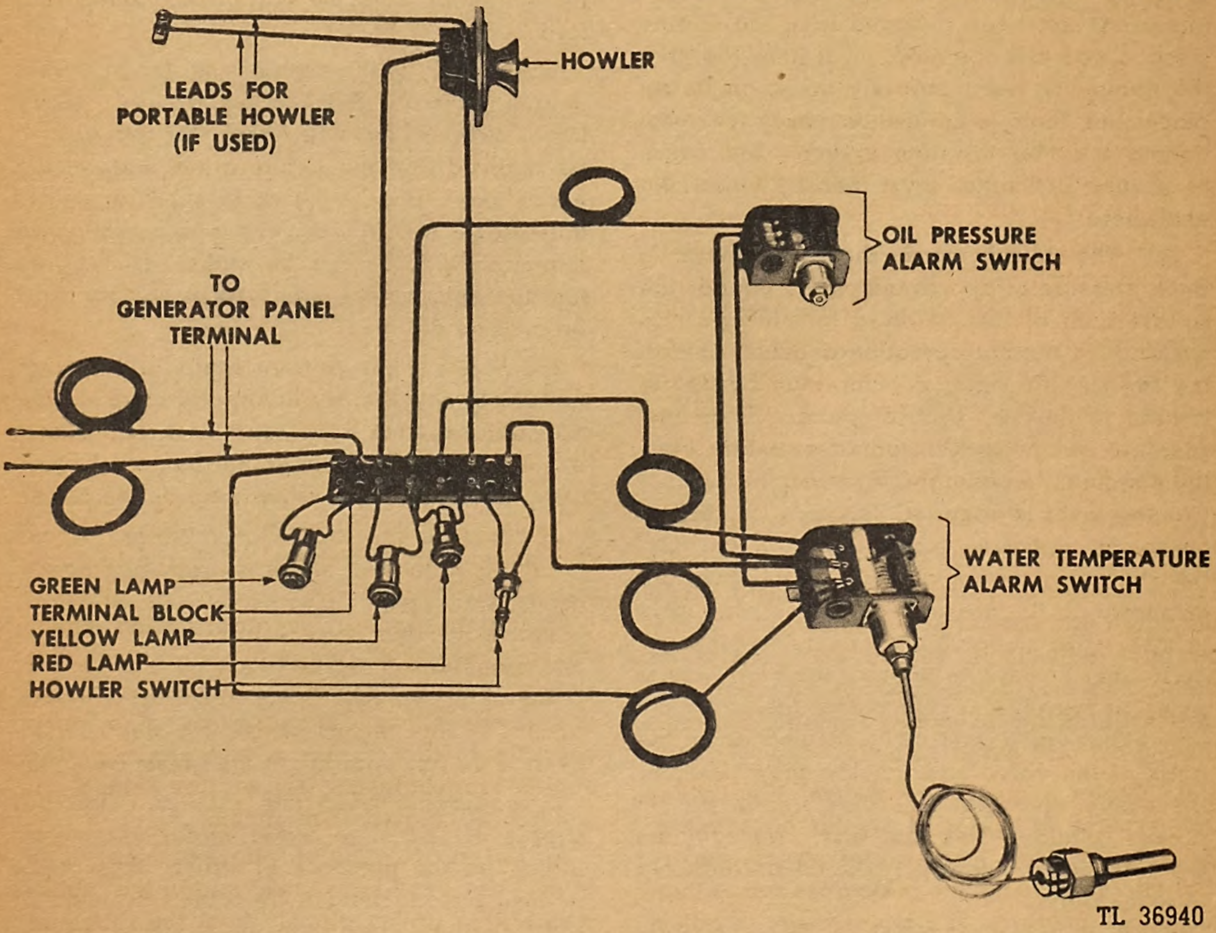

Fig. 288. Howler System

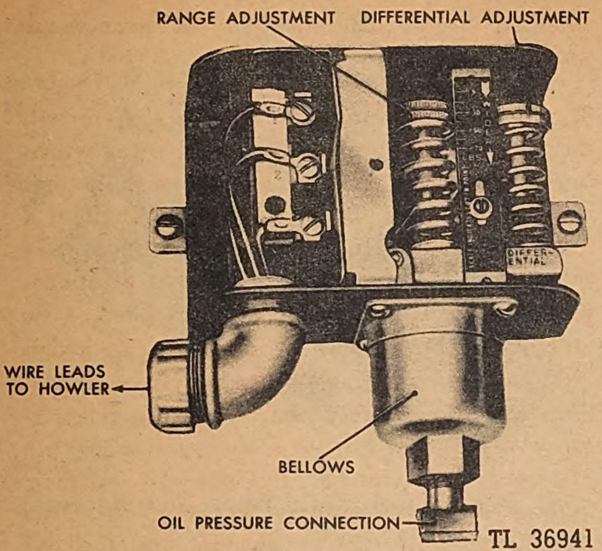

Fig. 289. Oil Pressure Switch

is merely used to break the circuit of the warning horn and does not affect the signal lights. (See Figure 288.)

a. Oil-Pressure Switch. The oil-pressure switch is all-metal construction. The springs, levers and pins are plated to resist rust and corrosion. The contacts are contained in a small bakelite case, made moistureproof by means of a tightly fitting, molded rubber cap and a flexible rubber seal on the contact-operating push rod. The low-pressure setting at which the switch should cause the howler to sound should be somewhere between 7 and 10 pounds. If this switch must be readjusted, proceed as follows, referring to Figure 289.

(1) Turn the differential adjustment (see Figure 289) to approximately 17 pounds.

(2) Place the range adjustment somewhere between 7 and 10 pounds.

The range adjustment raises or lowers both the cut-in and cut-out points similarly. The differential adjustment affects only the cut-in point. This provides a fixed cut-out point. The differential is approximately 7 pounds between the cut-out and cut-in values.

b. Water Temperature Switch. The water temperature switch is of similar construction to that of the oil temperature switch, except that the graduations are in degrees rather than in pounds pressure. If it is necessary to adjust the temperature switch, proceed as follows:

(1) Turn the range adjustment to approximately 205 degrees Fahrenheit.

(2) Adjust the differential to approximately 200 degrees Fahrenheit.

c. Wires and Switch. When connecting a switch into a circuit, it is good practice to place it in the hot side of line. When making connections, the armor should be removed from the BX for about 3 inches and the ends of the wires stripped for about ½ inch. Then form them into position so that the stripped ends of the wire can be quickly clamped under the screws. It is not necessary to form the wires into eyes to clamp securely under the screw heads. After tightening the terminal screws, tighten BX connector and bend the wires into position so they do not interfere with replacing the cover.

If rigid conduit is used, insert a short piece of flexible conduit between the control and the rigid conduit. The electrical rating and alternating current of the control switches are as follows:

110 Volts A. C.—15 Amps.; 220 Volts A. C.—10 Amps.

93. Lubricating System. The lubricating system is comprised of the following: oil pump, oil-pressure relief valve, full-flow oil filter (Cuno), and a DeLuxe oil filter. (See Figure 8, Lubrication Diagram.) For a detailed description of the lubricating system, see paragraph 12. Also see paragraphs 29 and 30 for lubrication specifications. The servicing of the lubricating system is primarily one of preventive maintenance, instructions for which are given in the Maintenance Reference Chart, Page 34. See also paragraph 37, items (3) and (6), paragraph 38, items (1), (2) and (3), and paragraph 39, item (1).

During the general overhaul period, check the oil pump, oil-pressure relief valve, oil screen and the external connections of the high-pressure lubricating system. The sump capacity of the crankcase is 8 gallons. The engine lubricating oil temperature should not exceed 220 degrees Fahrenheit.

a. Oil Pump. The oil pump assembly sets in the recess in the flywheel end of the crankcase and is driven directly from the rear end of the camshaft through a fork and pin connection. Connection with the pressure and suction passages in the crankcase is made by hollow dowels and sealed against oil leaks by copper asbestos gaskets. (See Figure 99.) The oil pump has a hydraulic relief in the casting. The oil which would otherwise be trapped between the teeth is allowed to return through the hydraulic relief to the pressure side of the pump. There are no movable parts in this type of relief. The idler gear and the drive gear of the pump have bushings which were machined in the gear blank before the teeth were cut. The gears and bushings should be replaced as a unit. An expansion plug is used as an oil seal at the end of the idle shaft in the pump body. This plug must not be removed from the oil pump body. The oil inlet and oil outlet passages go through the two locating sleeve dowels. To disassemble, inspect and reassemble the pump, proceed as follows:

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Fig. 290. Checking Oil Pump Gear Clearance to Case

(1). Remove the six capscrews and oil pump cover.

(2) Check the teeth and the bushings in the gear for wear. If either is worn, replace both the bushing and gear as a unit. Check the clearance between the teeth and the case. (See Figure 290.) If this clearance is more than .008 inch, replace with new gears and bushings.

NOTE: If the shaft is in place, the clearance should not be more than .004 inch.

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Fig. 291. Checking Oil Pump Gear Backlash

(3) Check the backlash of the gears as shown in Figure 291. If this backlash is more than .005 inch, replace the gears. If the ends of the gears are not flush with the case, replace the gears and bushings.

(4) Examine the studs on which the bushings run. If the studs are worn, replace the studs with new ones. Examine the case for cracks, and replace if necessary.

(5) In reassembling the pump, place the drive gear and idler gear in the housing. (See Figure 292.)

(6) Slip the gasket on the housing.

(7) Set the cover in place by starting the idler shaft in the idler gear and then slipping the drive gear shaft into the drive gear. (See Figure 293.) Be sure the holes of the gasket are in alignment with the cover and body cap-

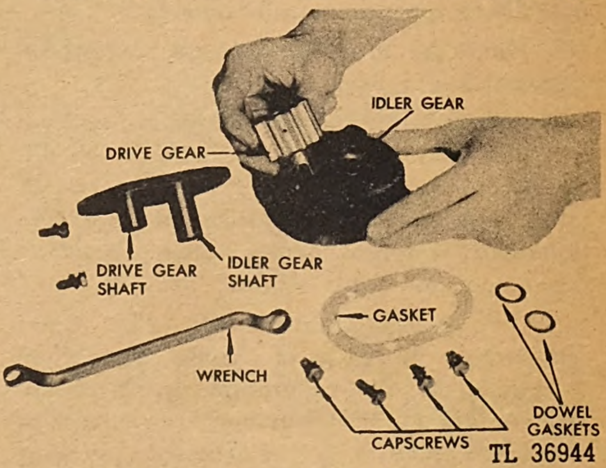

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Fig. 292. Installing Oil Pump Gear

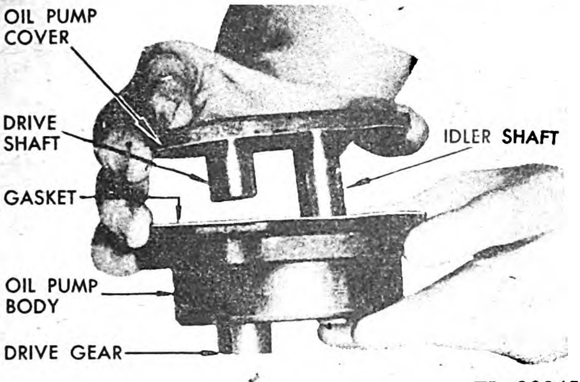

Fig. 293. Installing Oil Pump Gear Shaft

screw holes before installing and tightening the six capscrews. Also check the pump to be sure that the gears turn freely. To avoid having to prime the pump after it is installed on the engine, fill the pump with oil before installation.

(8) When installing the pump on the engine, be sure to use new dowel gaskets as shown in Figure 294.

b. Priming Oil Pump. If it becomes necessary to prime the oil pump, remove the oil plug from the side of the crankcase just back of the oil pressure gauge connection. If this plug is not accessible, connect a piece of tubing to the hole into which the oil temperature bulb is inserted and pour about a pint of oil into the tubing, thus forcing the oil into the suction passage while the engine is running. **CAUTION: Do not run the engine more than one minute without oil circulation.** As soon as the pressure comes up, the hole should be plugged immediately. If pressure is not obtained after this, examine the oil presure gauge and relief valve. If these are in good condition, it will be necessary to remove the oil pump and re-examine the drive pin and the end of the drive shaft; also the copper gaskets on the sleeve dowel.

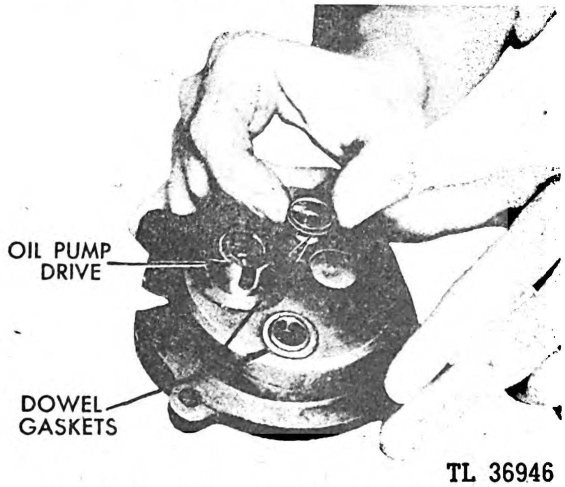

Fig. 294. Installing Dowel Gaskets

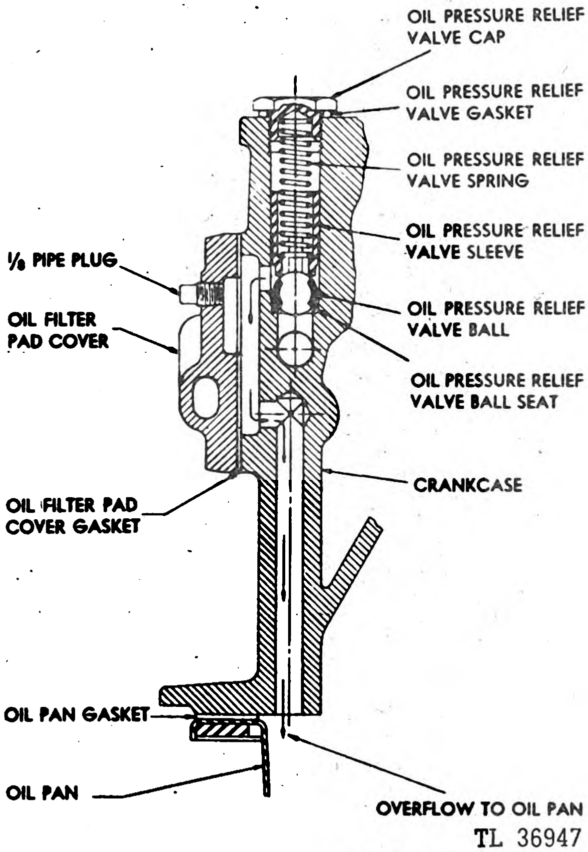

Fig. 295. Oil Pressure Relief Valve

c. Oil-Pressure Relief Valve. The oil-pressure relief valve is designed to maintain an operating pressure of approximately 30 pounds at normal speed and temperature. (See Figure 168.) No adjustment is provided. The free length of the spring is 2¾ inches; under 5¼ pounds pressure the length is $2\frac{13}{32}$ inches. Total number of coils is 16½. (See Figure 295.)

d. Full-Flow Cuno Oil Filter. In the full-flow filter, effective filtration is obtained by passing the oil between strips of metal separated by spacer pieces of certain thickness placed edgewise to the flow. Any foreign matter larger than the space between the strips cannot pass. This is known as edge filtration. In order to clean the edge-type filter without stopping the flow, the strips are wheel-shaped and are separated from each other by spacer pieces, which are in the form of spokes. The oil enters the filter from the right and fills the outer casing or sump, and passes through the space between the discs to the open passages between the spokes. Foreign matter too large to pass the space between the discs is retained on the outer edge of these discs. The central space within the stack of discs is connected to the filter outlet and provides a means of egress for the filtered fluid.

By turning the handle of the filter, the solids which have accumulated on the cartridge are removed as they reach the cleaner blades. Note the following points in servicing the Cuno filter:

(1) Note the "in" and "out" markings. Do not hook up backwards.

(2) Clean the filter element by giving the external handle one complete turn in either direction. This rotates the cartridge past the stationary cleaner blades which extend into the slots between discs, combing out all accumulated solids.

(3) There is no danger of turning the handle too often.

(4) If the handle turns hard, through failure to turn at sufficiently frequent intervals, rotate the cartridge back and forth until the cleaner blades free themselves and the handle can be easily turned through a complete revolution.

(5) Never use a wrench or other tool to turn a filter which has become plugged, or attempt to disassemble the cartridge.

(6) To free a plugged cartridge, remove it from the housing and wash the cartridge in a solvent until it turns freely.

(7) The sump should be drained during every oil change.

(8) Remove the cartridge every other oil change, and wash the element and housing thoroughly with a fuel oil or solvent.

e. DeLuxe Oil Filter. The DeLuxe oil filter, together with the Cuno full-flow filter, removes the metallic and carbon particles that may scratch the bearing and piston surfaces, and removes water and sludge which are the result of condensation. By also filtering out the water which combines with crankcase gases, the filter reduces acid erosion. In operation, from 5% to 10% of the oil pump capacity is fed to the DeLuxe oil filter, through its built-in metering hole. From there, it is forced through the porous filtering cartridge where the cotton fibres strain out large particles and absorb fine foreign particles. Finally, the oil reaches the top outlet and is returned to the crankcase. Since the oil pump delivers from 50% to 100% more oil than the bearings can take, the oil in the engine travels through the filter many times per hour. The DeLuxe filter element should be changed during every other oil change.

f. Oil Screen. Examine the oil screen. (See Figure 166.) Clean it with a solvent. Blow compressed air through the screen. No other servicing is necessary except replacement, should the screen or pipe be damaged in any way.

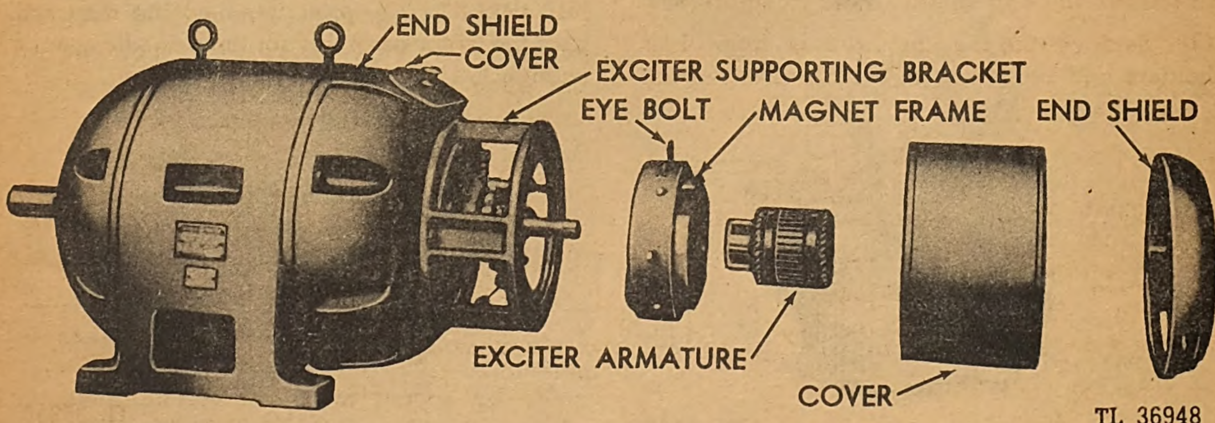

Fig. 296. Exciter End of Alternator Partially Exploded

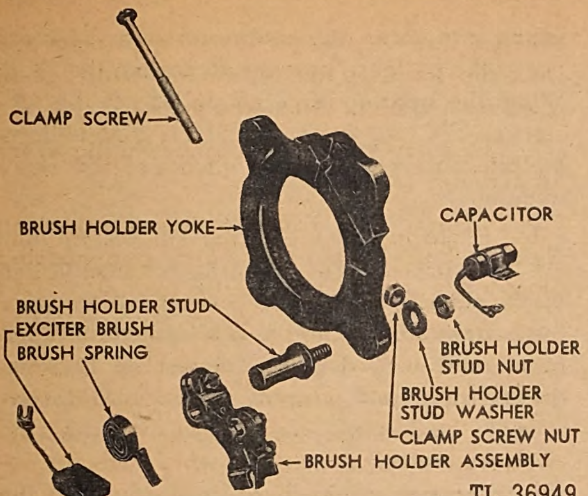

Fig. 297. Disassembled Brush Rigging

94. Overhaul and Repair of Alternator and Exciter. Because the instructions include detailed steps necessary for the complete overhaul of the alternator and exciter, this does not mean that a periodical teardown of the alternator and exciter is required. Only because of accident or because of neglect in performing the maintenance duties, as outlined in Section III, will it be necessary to teardown the alternator and exciter as completely as indicated in the following instructions.

95. Disassembly of Alternator and Exciter. For the removal of the alternator and exciter from the engine and base, see Paragraph 46*a*.

a. Exciter. (1) Remove the exciter wrap around cover. (See Figure 296.)

(2) Take out all the screws from the eye bolts to remove the end shield. Refer to Figure 296.

(3) Remove the exciter brushes from their holders and turn them to a crosswise position and insert them between the holders and springs. The pigtails need not be disconnected. (See Figure 297.)

(4) To remove the exciter armature a special tool is required. The dimensions of this tool are given in Figure 298. First, remove the capscrew from the extension shaft. Then insert the tool in the threaded hole which contained the capscrew and turn the tool to pull off the armature. **CAUTION: The removal of the armature without such a tool is not recommended.** (See Figure 299.)

b. Alternator. (1) At the engine end take out the screws which hold the grease cover to the end shield, and remove the screws which hold the end shield to the stator frame. (Refer to Figure 312.)

(2) Turn the rotor assembly to such a position that the face of the field pole will rest squarely on the stator punchings after the end shield has been removed. (See Figure 10.)

(3) Separate the end shield from the stator by driving against that part of the end shield which extends beyond the stator frame. (See Figure 12.) **CAUTION: The rotor will drop when the end shield is driven unless the end shield is lowered carefully.** Be sure that the coupling key has been removed. Then take the end shield away from the alternator. The bearing and grease cover will remain on the shaft.

(4) Remove the end shield from the opposite end of the machine in the same manner. (See Figure 13.) Note that two of the screws at this end shield are under the hand hole cover. IMPORTANT: The rotor need not be removed from the stator assembly for the periodic grease change.

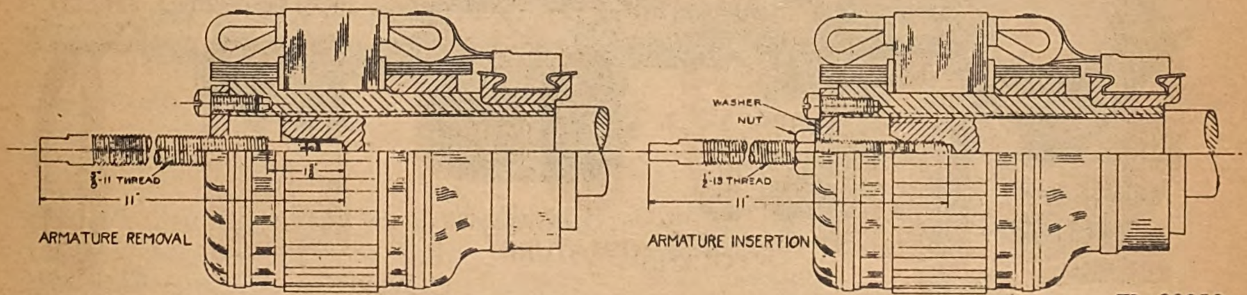

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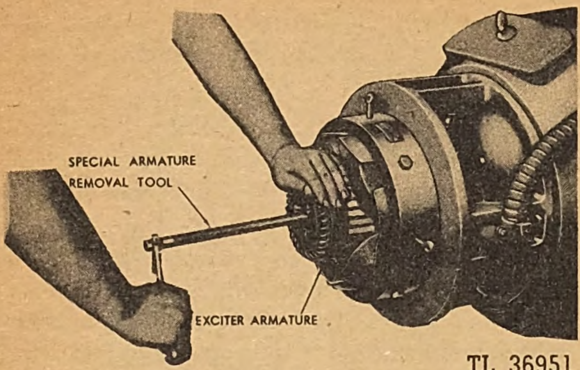
Fig. 298. Tool Dimensions for Armature Removal and Installation



TL 36951

Fig. 299. Removing Armature with Puller

96. Bearing Replacement. Once every two years, or every other engine overhaul, the grease in both bearings should be changed. If inspection shows the bearings are worn and noisy, it will be necessary to replace the bearings.

a. Removing Bearings. (1) Use a bearing puller like the one shown in Figure 300. (The dimensions of a puller which is suitable for removing both bearings are given in Figure 301.)

(2) Release the lockwasher shown in Figure 300.

(3) Remove the bearing nut and the lockwasher.

(4) Assemble the bearing puller with a soft piece of metal, like copper, between the shaft to the generator and alternator and the cross bar of the puller to prevent damaging the shaft. While the bearing is being pulled off, the tension on the two studs should be kept uniform by alternately tightening each nut the same amount.

b. Preparing New Bearing For Installation. (1) Prepare the new bearing for installation on the shaft by heating. It is recommended that the bearings be heated to a temperature of approximately 120 degrees Centigrade (248 degrees Fahrenheit) in an oven or similar device.

NOTE: The slushing oil should not be removed from the bearing.

(2). Thoroughly clean all grease from the grease cover and the grease shell for the bearing to be installed and put them back on the shaft.

c. Installing Bearings. Use a pipe or sleeve to press the new bearings onto the shaft. The sleeve should have a 3-inch inside diameter. The outside diameter should not be more than that of the inner race of the bearing. The pipe or sleeve must be clean and should be of such material that the metal will not flake when hit with a hammer or when pressed against the inner race of the bearing.

(1) Place the heated bearing on the shaft.

(2) Place one end of the pipe, or sleeve, against the inner race of the bearing, and hammer the other end of the pipe lightly until the

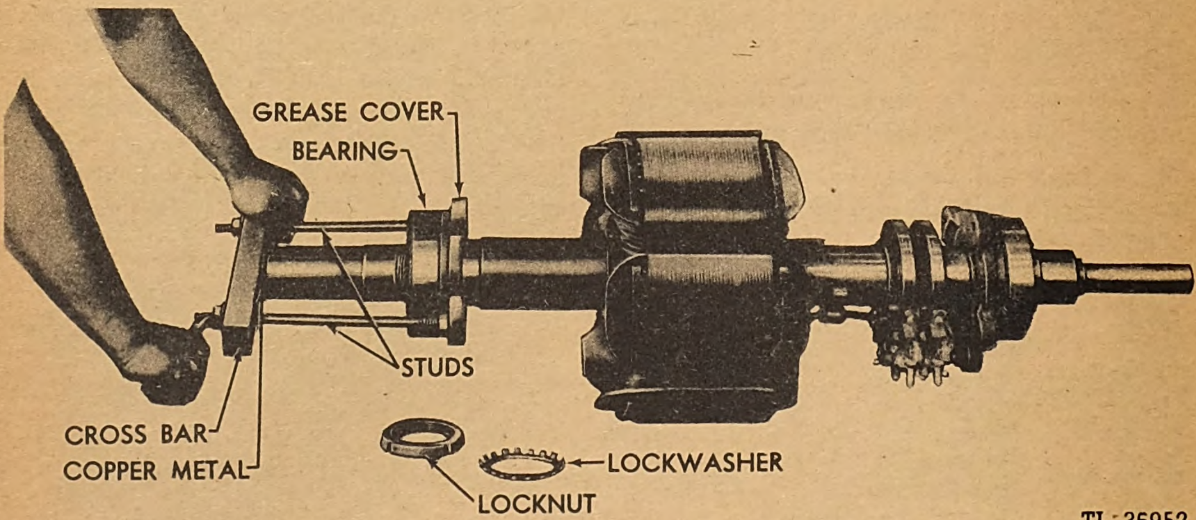


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Fig. 300. Removing Bearing from Rotor Shaft

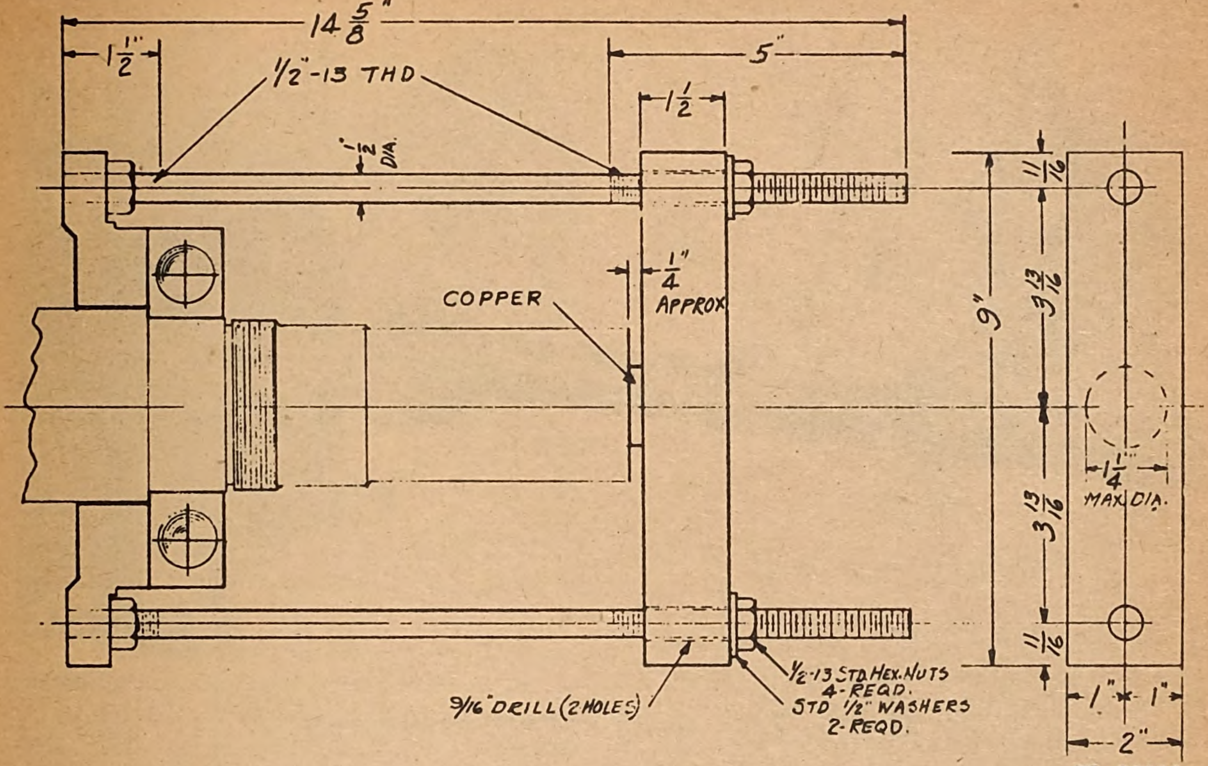


Fig. 301. Bearing Puller

bearing is in place. **CAUTION: Do not apply hammer blows directly on any part of the bearing.**

(3) After the bearing is installed, assemble the bearing lockwasher and locknut on the shaft. Do not use this locknut for driving on a new bearing. Damage to the bearing, the locknut or the threads on the shaft may result.

(4) Bend one of the lockwasher ears into one of the slots in the locknut.

(5) Fill the bearings with new grease only one-half full. Do not use ordinary cup grease. If GE electric low temperature grease, Catalog No. 214X6, which is recommended for satisfactory operation of the generator and ambient temperatures between 40 degrees Fahrenheit below 0 and 122 degrees Fahrenheit above 0, is not available use WB-2, or WB-3 for high ambient temperatures.

97. Rotor Pole Replacement. If a fieldpole or the rotor must be replaced, disassemble the generator and exciter as directed in paragraph 95, but do not take off the end shield at the exciter end. Take the generator brushes out of their holders and turn them to a crosswise position and slip them under the levers. (See Figure 302.)

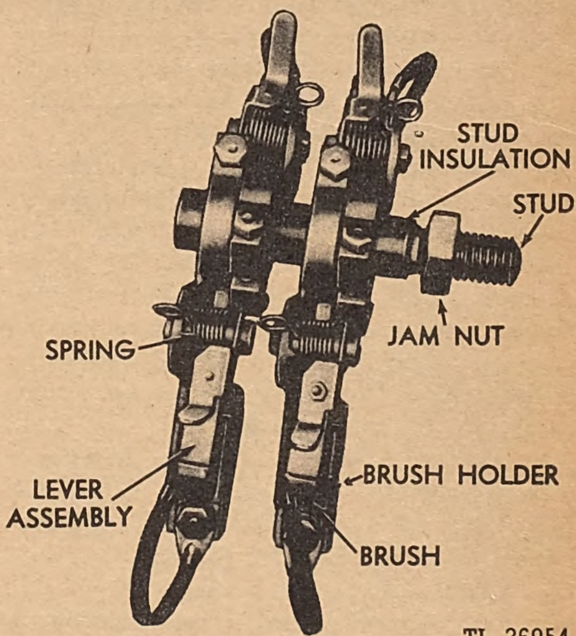


Fig. 302. Alternator Brush Rigging

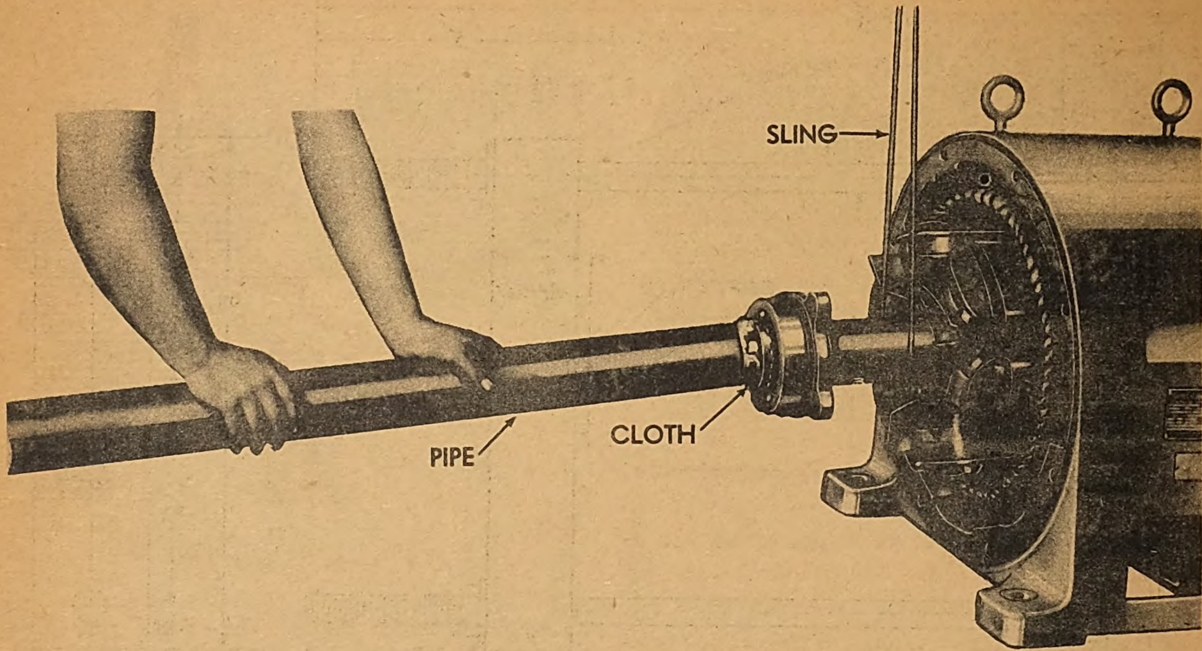


Fig. 303. Removing or Installing Rotor Assembly

a. Rotor Removal. To remove the rotor assembly from the generator, proceed as follows:

(1) The shaft extension should be wrapped with several layers of cloth over which a pipe with an inside diameter of approximately 3 inches will fit. (See Figure 303.) The length of the pipe should be about 5 feet.

(2) Support the rotor with an overhead crane and a sling which should be looped around the shaft as shown in Figure 303.

(3) Press down on the pipe to counter balance the weight of the rotor and pull the rotor out of the stator. **CAUTION: Be careful not to bruise or damage the windings.** To prevent damage to the collector rings or the brush holders, it is recommended that a second mechanic apply pressure on the opposite end of the shaft and also guide the collector rings away from the brush holders.

b. Removing Poles. (1) Place the rotor in a fixture similar to that shown in Figure 304. Note that both uprights are lined with thick leather to prevent bruising the shaft.

(2) Note that the pole to be removed is placed in a vertical position and is held rigid by an overhead pressure of at least 500 pounds capacity.

(3) Unsolder the connections between the defective coil and the adjacent coils. It may be necessary to take either one or two fans off the spider. Figure 304 shows one removed.

(4) Drive the pole key out from the engine end of the shaft. Use a hard steel drift with a cross sectional area of approximately ½ inch by 7/32 inch at the tip. When driving out the key, take care not to damage the collector rings.

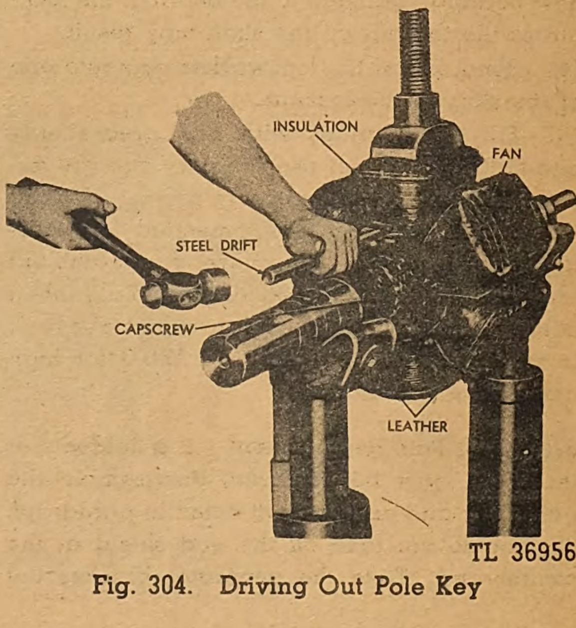
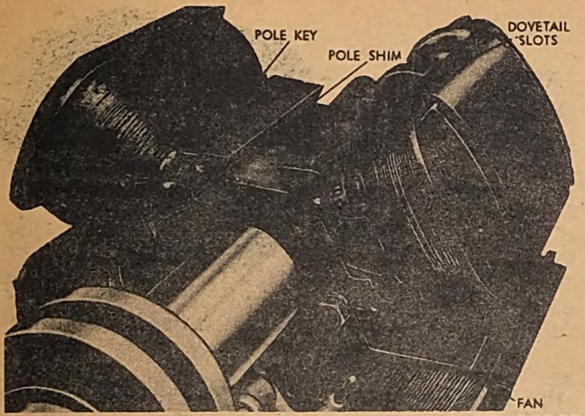


Fig. 304. Driving Out Pole Key



TL 36957
Fig. 305. Pole Removed from Rotor Assembly

(5) Slide the pole out of the dovetail slot in the spider. (See Figure 305.) Take away the shims. (See Figure 306.)

c. *Inserting New Wound Pole.* The new wound pole must be inserted so that the coil is in the same relative position as the other coils. One end of each coil has pieces of insulation protruding from it. (See Figures 304 and 305.) To insert the pole, proceed as follows:

(1) Insert the new pole so as to make the end of the coil face in the same direction as this end of all the other coils on the rotor.

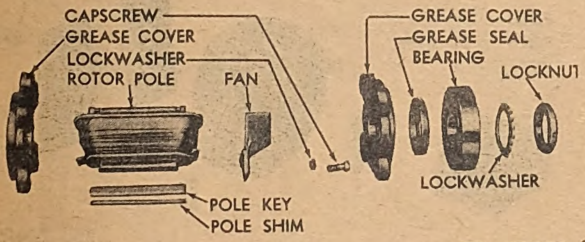
(2) Center the pole on the spider

(3) Put two new steel shims, .014 inch thick, in the slot. Figure 305 shows their position. Hold the pole rigid with the overhead press.

(4) Cover the new key with a coat of heavy lubricating oil and drive the key into place as illustrated in Figure 307. IMPORTANT: Note that the key is driven in from the coupling end of the shaft. The drift need not be of any special size.

(5) Solder the connectors to the new coil.

(6) Assemble the fans which were removed from the spider.



TL 36958
Fig. 306. Rotor Pole, Fan, Pole Key and Shim

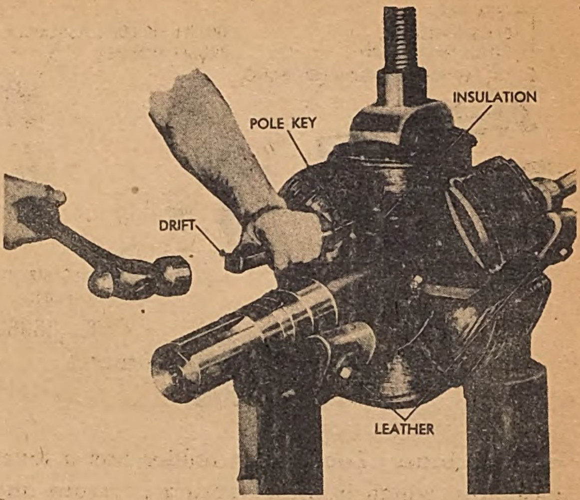


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Fig. 307. Driving in Pole Key

d. *Balancing Rotor.* The rotor assembly must be balanced after the new poles are installed. This may be done by cleaning the bearings of all grease, resting the assembly and bearings in a level position, and adding lead weights to the fans. Support the grease covers in such a way that they do not drag on the shaft. Add sufficient weights to balance the assembly if it always tends to rest in any one particular position when rotated. The lead weight should be poured into the recesses in the lower part of the fans which are on the right side. Remove the fans from the spider when pouring the weight.

98. Collector Rings and Brush Rigging. If the collector rings become grooved or are worn eccentric with the shaft, they must be trued up by placing the rotor assembly in a lathe and turning the collector rings to restore a smooth and true surface. After turning, the tools marks should be polished out with #0000 sandpaper.

The brush rigging is mounted on one of the grease covers by means of an insulated stud. (See Figure 302.) A jam nut locks the stud in position. Four brush holders are mounted on the stud end at which two slit bushings with corrugated surfaces are placed. The brush holders are clamped around the bushings and will maintain their correct position under considerable vibration of the generator. Note that the two brush holders are clamped around each bushing. The brush holders are made of

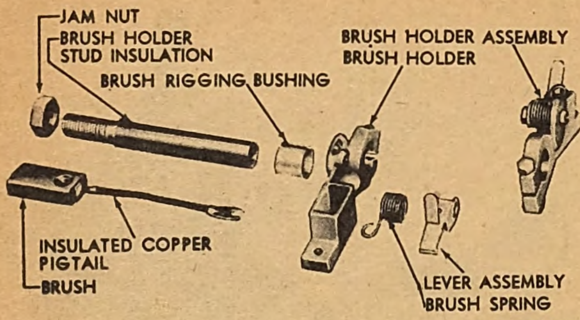

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Fig. 308. Disassembled Alternator Brush Rigging

die-cast brass. Each brush holder has a lever assembly which is under spring pressure and which rides in a metallic top in the carbon brush. Brush pressure may be adjusted by three possible spring positions. Each brush is provided with an insulated copper pigtail, the end of which is connected to the brush holder. Check the insulation, the brush spring pressure, and replace the brushes when worn to less than half their original length. Figure 308 shows the disassembled brush holder assembly.

99. Commutator. If the commutator is too rough or eccentric to be stoned down successfully by hand (See Figure 309), disassemble the alternator and exciter. The whole rotor assembly should be placed in a lathe and the commutator turned down to restore a smooth and true surface. (See Figure 310.) (The exciter should be installed on its own portion of

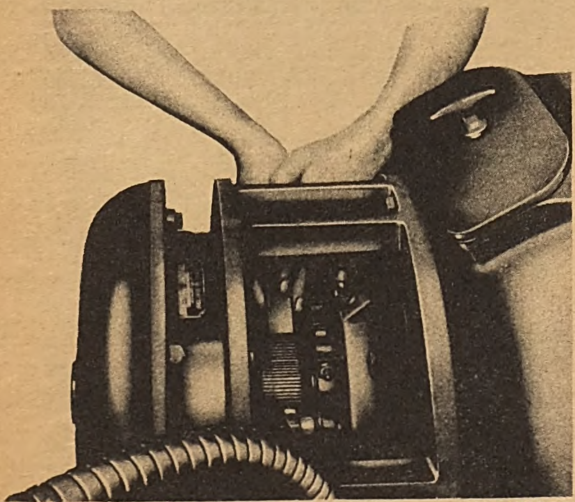

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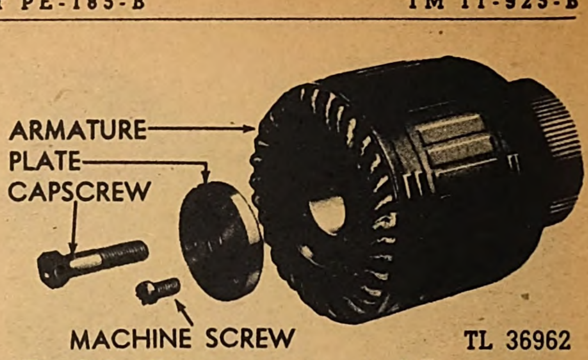
Fig. 309. Commutator Being Stoned



TL 36962

Fig. 310. Exciter Armature and Commutator

the rotor shaft.) Then polish the commutator with #0000 sandpaper. Do not use emery cloth. Undercut the mica approximately 1/32 inch below the commutator surface. This may be done with a piece of hacksaw blade or an equivalent placed in a suitable holder or handle. (See Figure 220.) Be careful not to scratch the commutator bars. Blow away all the mica and copper dust with dry compressed air of moderate pressure.

100. Exciter Field Coil Replacement. If the exciter field coil must be replaced, proceed as follows:

(1) Remove the connection clips from the coil to be replaced.

(2) Take out the capscrews which hold the pole to its magnet frame. The coils, shims, pads and pole piece may then be removed. Push the pole piece out of the coil and insert the pole piece into a new coil. (See Figure 311.)

(3) Put the pads back in place. Hold the assembly in position and partially insert the capscrew.

(4) Turn the coil so that its shape will fit the contour of the magnet frame. Note that the coil must be in such a position so as to allow proper connections to be made. Each coil lead

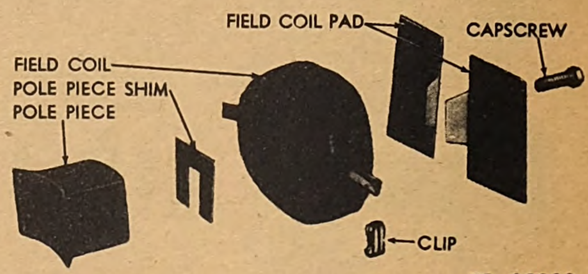


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Fig. 311. Exciter Main Field Pole and Coil

is stamped with an "I" or an "O". Connect the "I" lead of a coil to an "I" lead of the adjacent coil. Then connect the "O" lead of the new coil to the "O" lead of the adjacent coil.

(5) Slip the shims between the pole piece and the magnet frame. Tighten the capscrew.

101. Stator. In the event of damage to the stator assembly or shorts in the stator winding, replace the complete stator assembly. (See Figure 10.)

102. Reassembly of Alternator and Exciter. (See Figure 312.)

a. *Alternator.* The steps of reassembly for the alternator depends upon whether or not the rotor assembly was removed from the machine. In that event Steps 1 to 4 apply. If the rotor assembly was removed from the unit, Steps 4 to 9 apply.

(1) Reassemble the end shield at the exciter end.

(2) Lift the end shield with its air baffle and supporting bracket attached into position beside the stator frame.

(3) Insert the four screws which fasten the grease cover to the end shield. Then insert the eight end shield screws. Be sure that the rabbets of both the end shield and the stator are clean. Moving the end shield up and down

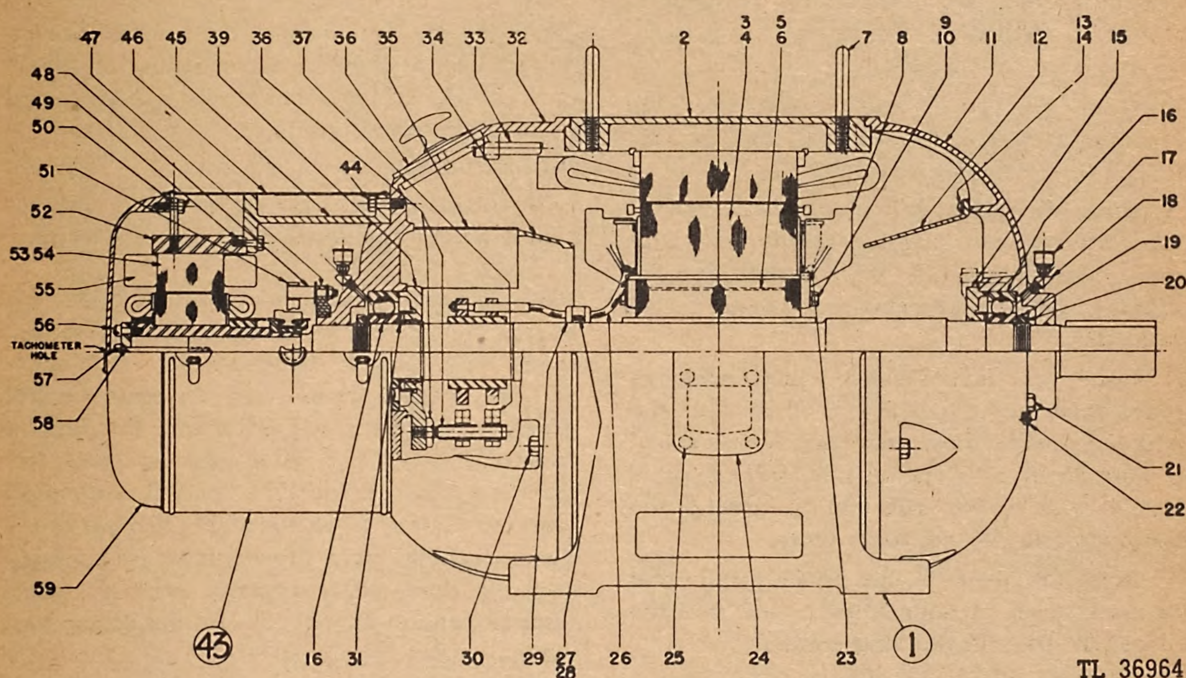

Fig. 312. Sectional Outline of Synchronous Generator

1. Generator
2. Assembly, Stator
3. Assembly, Rotor
4. Pole, Rotor
5. Key, Pole
6. Shim, Pole
7. Eyebolt, Stator
8. Fan
9. Capscrew
10. Washer, Lock
11. Shield, Engine End
12. Baffle
13. Screw, Machine
14. Washer, Lock
15. Cover, Grease
16. Bearing
17. Cup, Grease
18. Fitting, Angle (45°)
19. Washer, Lock
20. Nut, Lock
21. Capscrew
22. Plug, Bearing Housing
23. Connector, Coil to Coil
24. Box, Conduit
25. Capscrew
26. Lead, Rotor
27. Screw, Machine
28. Washer, Lock
29. Clamp, Rotor Lead
30. Capscrew
31. Seal, Grease
32. Shield, Exciter End
33. Capscrew
34. Baffle
35. Cover, Deflector
36. Cover
37. Assembly, Brush Holder
38. Stud and Insulation, Brush Holder with Jam Nut
39. Cover, Grease
43. Exciter
44. Capscrew
45. Bracket, Supporting
46. Cover, Exciter
47. Yoke, Brush Holder
48. Stud, Brush Holder
49. Capscrew
50. Eyebolt
51. Assembly, Brush Holder
52. Frame, Magnet
53. Piece, Pole
54. Capscrew
55. Field, Coil
56. Screw, Machine
57. Capscrew
58. Plate
59. Shield, End

or from side to side a small amount with a bar will aid in getting the screws started. **Do not force them.**

(4) If the rotor assembly was removed from the unit, it will be necessary, in order to install it, to suspend the assembly from an overhead crane with a steel cable or heavy rope looped around the shaft in such a manner so as to prevent injury to the windings. The shaft at the engine end should be wrapped with several layers of cloth over which a piece having an inside diameter of approximately 3 inches is placed. This pipe should be about 5 inches long. (See Figure 303.)

(5) Press down on the pipe to counter balance the weight of the rotor as it is pushed into the stator. WARNING: Be careful not to damage or bruise any winding.

(6) Insert the four screws which fasten the grease cover shield (exciter end). Be sure that the end shield screws are tight.

(7) Bring the other end shield with the air baffle attached into position beside the stator frame. (See Figure 12.) Make certain that the rabbets of both the end shield and stator frame are clean.

(8) Insert the four screws which hold the grease cover to the end shield. Then insert the eight end shield screws. Moving the end shield up and down or from side to side a small amount with a bar will aid in getting the screws started. **Do not force them.**

(9) Raise the levers on the brush rigging and slip the brushes in their holders. See that the brushes fit the collector ring contour.

b. Exciter. To reassemble the exciter to the alternator a special tool is required for inserting the exciter armature on the rotor shaft. The dimensions of this tool are shown in Figure 298.

(1) Place the tool in the armature and slide the armature on the shaft extension as far as possible.

(2) Tighten the nut on the tool as shown in Figure 313.

(3) After the armature is in position, remove the tool and insert the capscrew.

(4) Tighten this screw against the blade.

(5) Raise the springs on the exciter brush rigging and put the brushes in their holders.

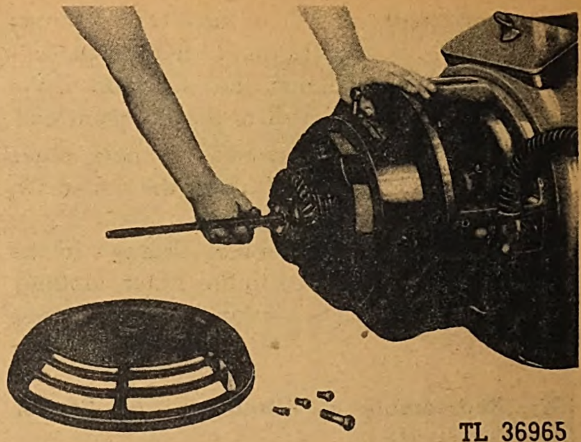

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Fig. 313. Installing Armature

IMPORTANT: Be sure that the brushes are inserted so that they fit the commutator curvature. Return the end shield to its position and tighten the screws firmly.

(6) Fasten the covers in place.

The alternator and exciter are now ready for reassembly to the power unit base and engine.

103. Alternator Control Panel. The generator control unit contains all the devices essential to the operation of the generator. It consists of a rigid steel frame with an open control panel in the front, set back into the unit, a fixed top cover and sides and an easily removable back cover. The unit is supported from the bottom by shock proof cushions to reduce vibration from the engine. All connections to the external equipment is made through conduit connections on the floor of the cabinet. (See Figure 30.)

The panel equipment consists of an ammeter, voltmeter, frequency meter, a time meter, generator-voltage regulator, an automatic air circuit breaker, ammeter and voltmeter phase switches, twin convenient receptacles, toggle switch, neutral ground stub, lamp bracket and shade, and a rheostat hand wheel. (See Figure 314.)

Within the unit are three current transformers for the line ammeter, the impeder box for the frequency meter, and the rheostat. (See Figure 30.)

104. Instruments. While the instruments will withstand a moderate amount of vibration and

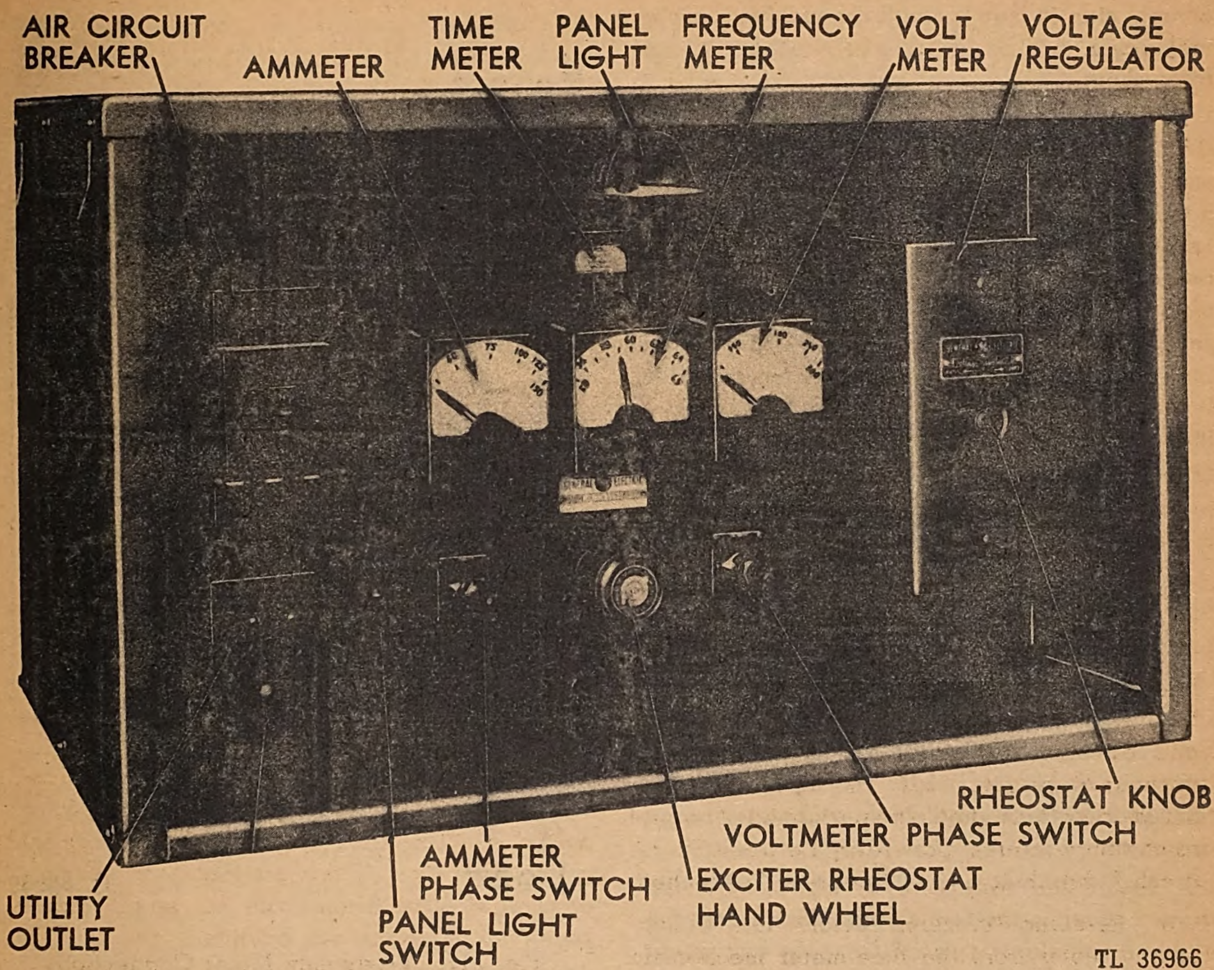

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Fig. 314. Alternator Control Panel

handling, shocks due to impact are likely to injure the bearings or other parts of the mechanism. Any treatment which subjects the instruments to this condition must, therefore, be avoided. The instruments should be carefully leveled.

a. Ammeter and Voltmeter. The ammeter and voltmeter are General Electric Type AD-6 and are made self contained up to and including 600 amperes. The rating of the ammeter is as follows: 5 amperes on the instrument indicates 150 amperes on the scale. Current transformers are provided in the load leads. Figure 315 shows the schematic arrangement of the ammeter. Figure 316 shows a schematic hookup of the voltmeter.

When there is no current through the instruments and they are properly leveled, the needles should indicate zero. Any deviation from the current should be corrected by the zero setter.

b. Frequency Meter. The type AD-6 frequency meter is a rectangular pattern switchboard instrument designed for surface mounting. A separate impeder is provided. Figure 317 shows the frequency meter connections, schematic, with the impeder. The needle may stand at any position on the scale when no current is flowing through the instrument since no control springs are used.

c. Time Meter. The time meter records the operating time of the generator. The meter is so constructed that the only servicing that will be necessary under normal conditions is reoiling which should be done every three years or every 6,144 hours. Before adding the new oil, the residue from the original oil should be

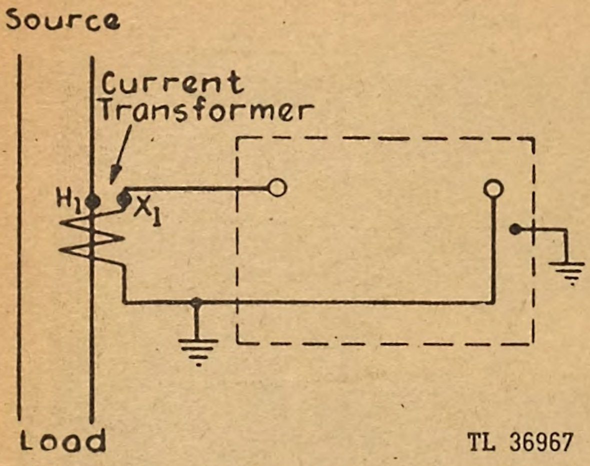

Fig. 315. A-C Ammeter with Current Transformer

removed in order to minimize possible contamination of the new oil. If the motor has not been serviced for a long time especially at high temperatures, the residue may be heavy and to remove it requires careful and thorough flushing of the rotor unit. The flushing and reoiling operations should be performed at normal room temperatures, preferably between 60 degrees Fahrenheit and 100 degrees Fahrenheit.

d. Re-oiling Telechron Motor. (1) Unfasten the motor from the time-meter mechanism and remove the rotor unit.

(2) Remove the re-oiling screw cap at the end of the rotor unit.

(3) Hold the open end of the rotor unit up

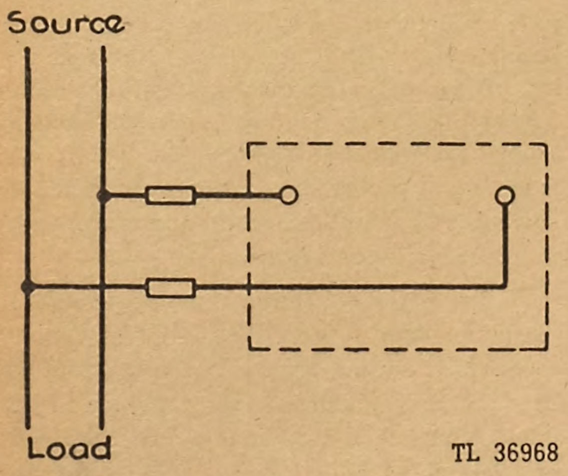

Fig. 316. A-C Voltmeter without Transformer

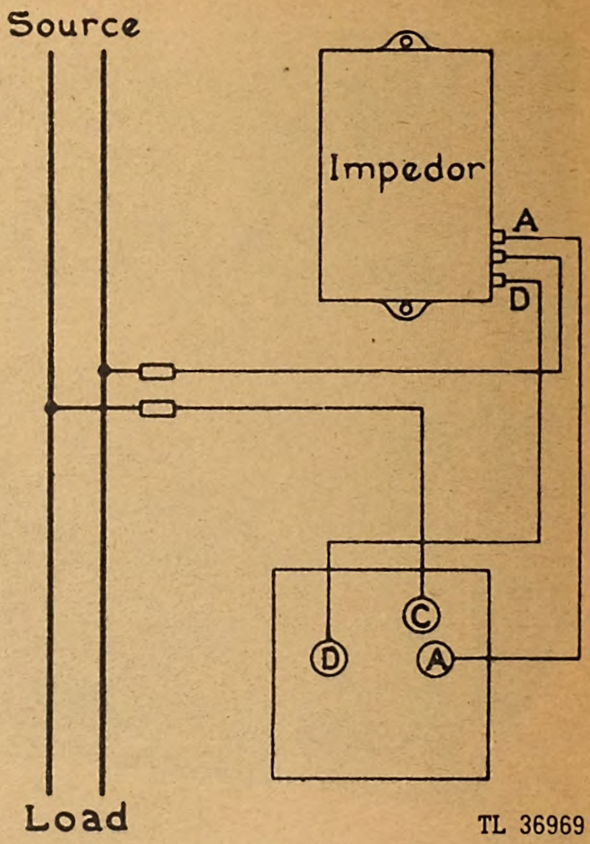

Fig. 317. Frequency Meter Connections without Transformer

and add sparingly some cleaning solution. about 5 cc of carbon tetrachloride.

(4) Replace the cap and shake the unit vigorously. Then place the unit in a rotor field and run with the shaft down for at least five minutes.

(5) Remove the screw cap and set the rotor on a rack with the open end directly downward and allow to drain for at least 15 minutes; then shake vigorously in a manner so as to remove by centrifugal force as much of the remaining solution and old oil as possible.

(6) Flush again by adding approximately 5 cc, or a few drops, of telechron motor oil and again shake vigorously to mix this oil with any remaining cleansing solution. Drain as described in the foregoing paragraph. This completes the flushing operation. Add the new oil. Lubricate by holding the open end of the rotor unit up

and add 1.8 cc of telechron motor oil. No further draining is necessary. After the proper amount of oil has been introduced in the unit, replace the screw cap and tighten firmly.

NOTE: The rotor should be replaced in the motor field so that the side of the unit marked top will be at the top when the complete motor is reassembled in the apparatus. The rotor unit must be assembed in the laminations on the same side from which it was removed. Otherwise, the motor will run backward.

e. Current Transformers. The three line current transformers are rated at 150 amps.; 30:1 ratio with a 5-ampere secondary.

f. Drying. Out Transformers. The transformers that have been subjected to submersion or have been stored for some time in a damp place should be dried out previous to installation. When drying out, it is necessary that the following method should be used:

(1) Allow the transformer to stand not less than 12 hours in a room of approximately room temperature.

(2) Measure the resistance of the windings and record the room temperature.

Short circuit the primary winding and apply voltage to the secondary winding through such controls that sufficient current will flow in the windings to raise the temperature to approximately 80 degrees Centigrade. This temperature should be maintained until the transformer is dry. To determine the temperature of the winding (approximately) assume that for each per cent increase in resistance the temperature rise of the winding is 2½ degrees Centigrade. Find the temperature rise and add this to the starting (room) temperature: the result will be the final temperature.

The amount of current necessary to obtain this temperature varies because of the variations in losses and copper densities in the different types of transformers. It is advisable to start with a current not greater than 5 amperes in the secondary of a current transformer and gradually raise this current until the proper heating is obtained. Increases of current should be made cautiously with regular observation of the rise of temperature of the winding. The rise of temperature should not exceed 6 degrees Centigrade per half hour.

When facilities for measuring the resistances are not available, the temperature may be taken by placing the bulb of a spirit thermometer on each coil as close to the winding as the insulation will permit. The bulb of the thermometer should be covered with clean dry cotton waste so that the bulb will have as nearly as possible the actual temperature of the coil. Do not use mercury thermometers.

g. Current Transformer Connections. The resistance of all primary and secondary joints should be kept as low as possible to prevent overheating at the contacts, and particularly in the secondary circuits of the current transformers, in order to prevent an increase in the secondary burden.

h. Current Transformer Maintenance. The transformers should need no care other than seeing that they are kept clean and dry.

NOTE: Always consider current transformers as a part of the circuit to which they are connected, and touch only the secondary leads, and such portions of the transformer as are properly grounded.

CAUTION: Do not open the secondary circuit of current transformers while the transformer is connected in a line circuit, since by so doing the core may be permanently magnetized, and voltages dangerous to human life are likely to be induced across the secondary terminals. To remove any device from the secondary circuit of a current transformer when the current is flowing through the primary, the secondary of the transformer should first be short-circuited, and care should be exercised not to disturb the ground connection of the secondary of the transformers.

i. Demagnetizing Current Transtormers. If by accident the current transformer becomes magnetized, it should be demagnetized in the following manner before being used for precision work:

(1) Connect at least 50-ohms resistance in series with the meters or instruments in the secondary circuit.

(2) Bring the primary current up to as near full load as possible and gradually reduce the secondary resistance by one-ohm steps until it reaches zero. WARNING: BE CAREFUL NOT TO OPEN THE SECONDARY CIRCUIT IN THE PROCESS.

j. Fuses. A 6-ampere, 120-volt fuse protects the howler system receptacle and panel light circuits. The voltage regulator is protected by a 10-ampere fuse, and three ampere

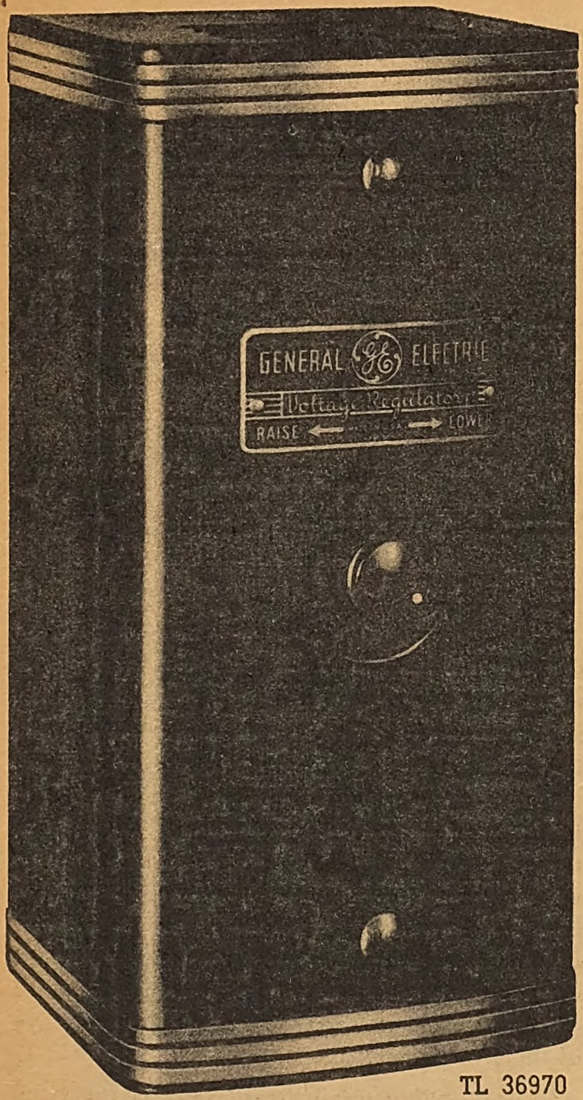

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Fig. 318. Generator Voltage Regulator

fuses protect the rest of the panel instrument circuits.

105. Controls.

a. Generator-Voltage Regulator. The 3GBA40A8 generator-voltage regulator controls the voltage of an alternating-current generator by working directly in the shunt field circuit of the exciter. By properly controlling the exciter excitation, the alternator voltage is maintained at the correct value over the full range of load.

These instructions cover the installation, operation, inspection, maintenance and test of subject equipment.

The 3GBA40A8 generator-voltage regulator (see Figures 318 and 319) consists of a voltage sensitive regulating element, a potential transformer, a stabilizer transformer, rectifier, series resistors and a rheostat, connected together as shown in Figure 320.

(1) The regulating unit consists of a set of tapped resistors wired to 24 contact fingers which normally rest on a silver shorting bar; a finger lifting mechanism, and a magnetic circuit energized by a pair of potential coils. The potential coils are energized from the alternator voltage through a transformer, series resistors and rectifier. Changes in this voltage control the position of the finger lifter and thus the amount of resistance in the exciter field circuit, since the finger lifter lifts the contact fingers from the silver shorting bar which introduces resistance in the circuit. The regulator operates in such a way that changes in voltage at the potential coils will cause a change in resistance in the exciter field circuit such that the alternator voltage will be restored to the proper value.

(2) The potential transformer has a primary winding suitable for the machine voltage and a 40-volt secondary which in combination with variable series resistors should furnish about 13.5 volts to the rectifier.

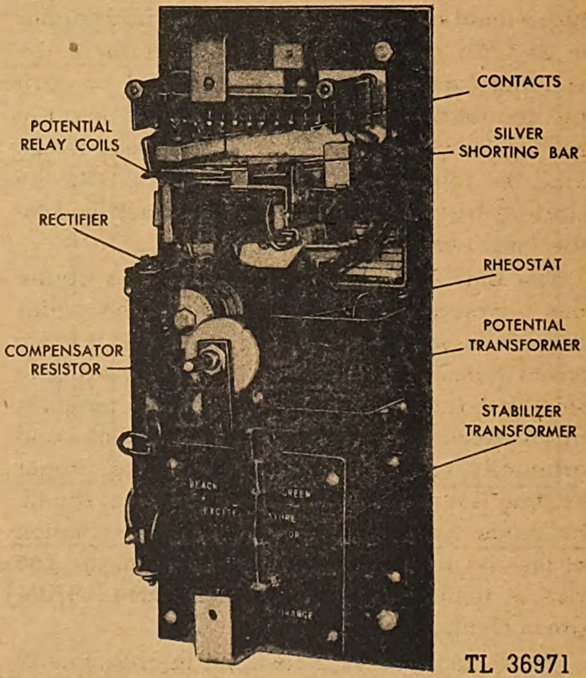

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Fig. 319. Voltage Regulator without Cover

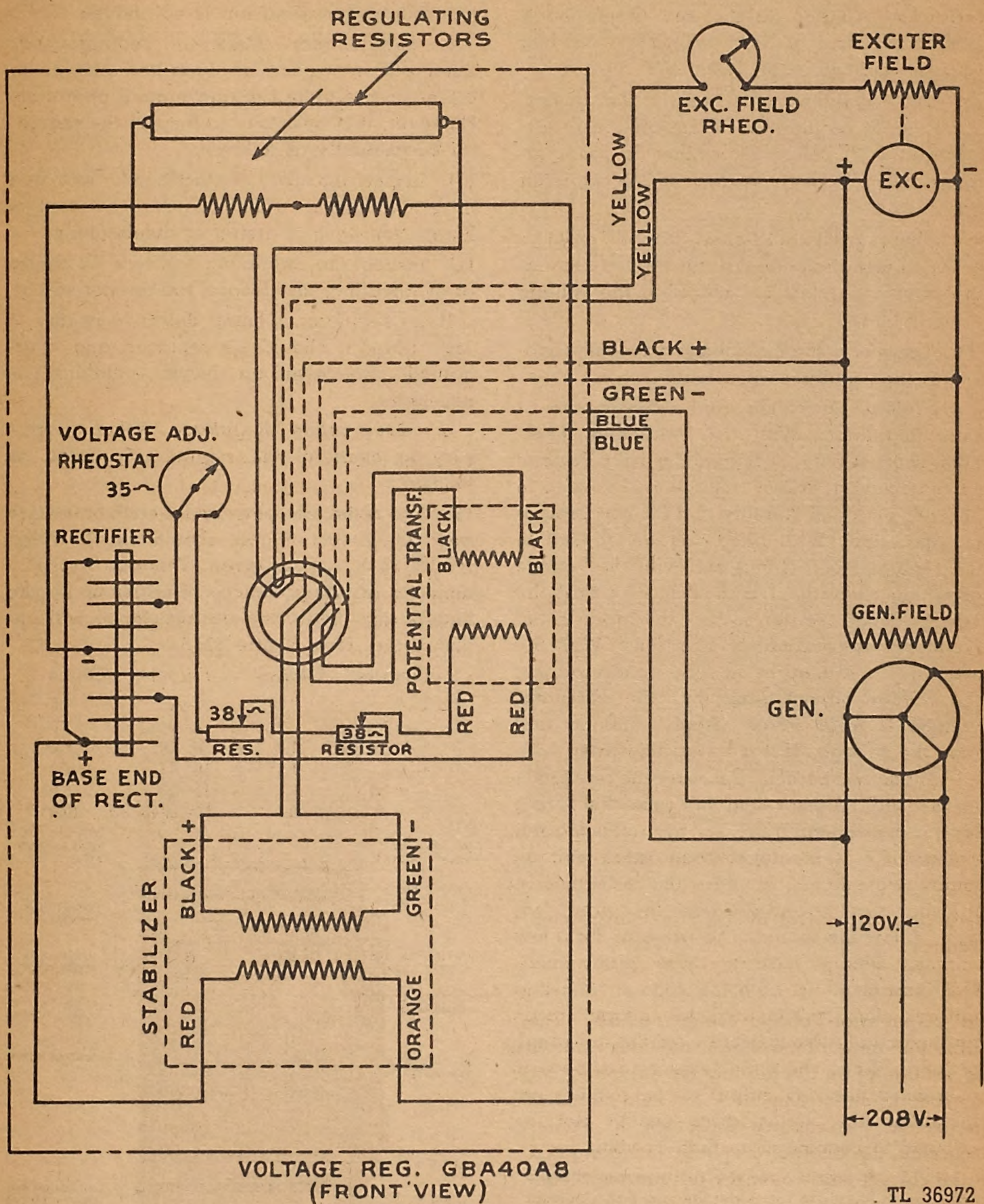

Fig. 320. Voltage Regulator Wiring Diagram

(3) The transformer is used in order to insure stable operation. It has two windings, a high resistance winding (black and green leads, 1200-ohms) and a low resistance winding (orange and red leads, 7.95-ohms).

(4) The regulating unit being a d-c. device, a rectifier is required in its application to a-c. apparatus. A selenium rectifier is used, arranged as a fullwave rectifier in the regulator coil circuit.

(5) There are two 38-ohm variable resistors in series with the potential transformer secondary for the puropse of controlling the voltage to the rectifier.

(6) There is a 35-ohm voltage-adjusting rheostat in the regulator coil circuit.

b. Initial Operation and Adjustments of New Regulator. With the regulating resistance shorted out, set the exciter field rheostat so that ceiling exciter voltage is 150-volts in order to get good stability and for best regulator operation. With rated voltage applied to the regulator coil circuit and with the voltage adjusting rheostat in mid position, adjust the variable slide resistor so that the input to the rectifier is approximately 13.5 volts. With the regulator operating at no-load conditions, set the voltage adjusting-nut until the alternator voltage is rated value. Apply full-load and note the voltage. If it is lower than rated voltage minus two percent, decrease the resistance in the slide resistor and increase the spring tension by changing the voltage adjusting nut position. If it is higher than rated voltage minus two percent, increase the resistance in the slide resistor and decrease the spring tension. Allow the regulator to warm up for a few minutes before making these adjustments. Continue to adjust both the voltage adjusting nut and slide resistor until the voltage droops approximately two percent over the full range of load. When the slide resistor resistance is decreased, the d-c. output of the rectifier not including the series discs should not be allowed to become more than 11-volts.

NOTE: A slightly drooping characteristic of rated voltage (no-load) to rated voltage minus two percent (full-load) is necessary to insure stable operation. It may be found necessary to have a greater droop than this.

If more voltage adjusting range than is obtainable in the rheostat is desired, the resistance in the slide resistor can be used provided the voltage adjusting nut is not moved.

c. Maintenance. Once the regulator has been put in service as described above, no attention is required during normal operation. However, it is desirable to inspect the regulator occasionally as follows:

(1) Inspect the silver contact bar for scorched or pitted points. Also, observe the contact fingers for signs of arcing or overheating.

(2) Inspect the regulating resistors for cracks or overheating; also inspect the resistor wiring.

If the regulator is found defective in any of the above, it should be replaced and overhauled, otherwise no further attention is necessary.

d. Overhauling Regulator. When necessary to overhaul the regulator, proceed as follows:

(1) The resistance per step for each of the two rows of contact fingers should check within $\pm 10\%$ of the values given. This can easily be done by inserting a piece of paper under the fingers and measuring the resistance with an ohmmeter. (See Figure 321.)

Fingers	*Ohms*	*Fingers*	*Ohms*
1—2	0.65	7—8	4.0
2—3	0.9	8—9	5.0
3—4	1.3	9—10	6.0
4—5	1.95	10—11	7.0
5—6	2.6	11—12	8.0
6—7	3.0	12—silver bar	10.0

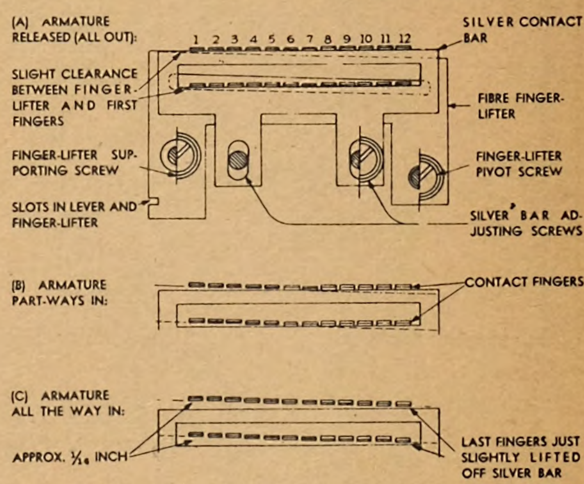

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Fig. 321. Voltage Regulator Contact Bar Adjustment

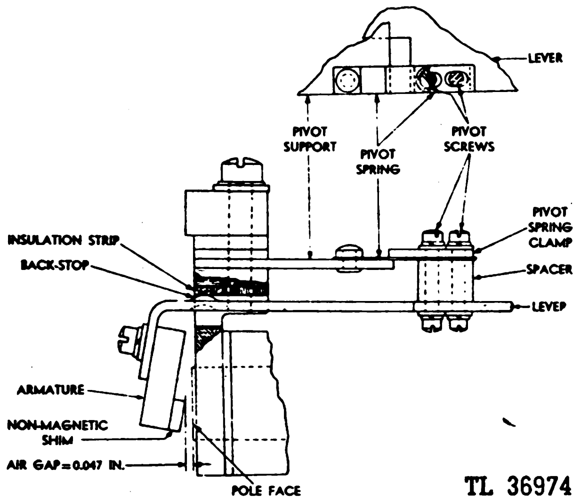

Fig. 322. Adjustment of Armature Air Gap and Pivots

(2) Check the air gap between armature and pole faces which should be about .047 inch. (See Figure 322.) Adjustment can be made by loosening the four pivot screws, inserting a .047 inch gauge block in the air gap, and tightening the screws while holding the armature tight against the gauge with back stop firmly against the top.

(3) See that the lever assembly moves freely. If it doesn't, check the clearance between the finger lifter and silver bar to see that they do not touch in any position of the lever. Check the pivots and pivot springs. Clamping plates should be straight and the springs should lie flat. The pivots should also be fairly well aligned with each other.

(4) The back stop on the lever should rest against the top when the lever is in the free position. If it doesn't, see that neither finger lifter nor lever rests on bakelite block (silver bar support) before or at end of travel.

(5) Check the adjustment of the silver bar. (See Figure 321.) It should be as follows: The first finger in front (the finger farthest from the base) should start lifting almost as soon as the armature starts moving in; but make sure that all fingers are touching the silver when the armature is released. The rest of the fingers should pick up in succession until the end of the armature travel, when the last fingers in back (the fingers nearest base) should be just slightly lifted off the silver bar. Adjustment can be made as follows: See that the slot in the edge of the finger lifter is approximately in line with the slot in the lever. Adjustment may be made by loosening the two supporting screws and moving the finger lifter on the left-hand side, where it has an oversized hole (right-hand side acts as a pivot). The silver bar has elongated holes on both sides. Loosen screws just enough to permit adjustment and set as described above. In the unit as a whole check the following.

(6) Inspect all wiring and soldered points.

(7) Check the condition of the rubber shock mountings suppporting the regulating unit.

(8) Check the following resistances:

	Ohms	*Tolerance*
Coil F-3190593	10.78	±5%
Coil F-3190594	6.93	±5%
Rheostat	35	±10%
Series Resistor (Adjustable)	38	±5%
Stabilizer transformer		
Black and green leads	1200	±5%
Orange and red leads	7.95	±5%

e. *Air Circuit Breaker.* The Type AF-1 air circuit breaker is fully adjusted and tested at the factory and needs no further adjustments for operation. It is a 100-ampere frame size.

f. *Operating Circuit Breaker.* (1) The breaker is closed when the handle is inclined towards the "ON" marking. The breaker is operated manually by moving the handle until it inclines toward the "OFF" position, which will cause the quick make operating mechanism to snap the contacts to the open position.

(2) The automatic tripping of the breaker is indicated when the handle moves to mid-position between "OFF" and "ON".

(3) The breakers are relatched by moving the handle to the "OFF" position to reset the latch, and then moving the handle to the "ON" position will close the contacts. Overcurrent is initiated through a bi-metallic thermal strip which when heated by the overcurrent deflects and actuates the trip mechanism.

g. *Circuit Breaker Maintenance.* No maintenance should be required through the normal life of the circuit breaker. The trip mechanism is part of the breaker assembly and should not be removed. If the unit becomes faulty, replace the entire air circuit breaker with one of the same type and design.

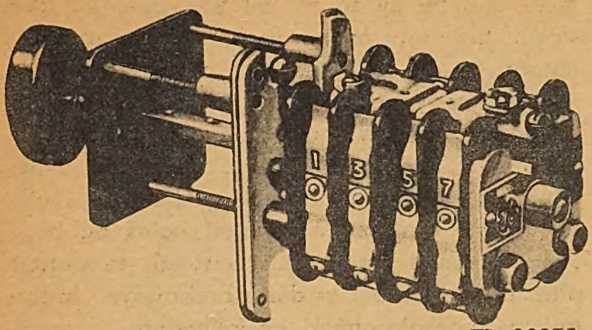

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Fig. 323. Instrument Switch

h. Phase Switch. The ammeter and voltmeter switches are provided in order to enable the operator to read the load in any one of the three phases. They are rotary switches operated by cams. Figure 323 shows that the moving contacts are marked with odd numbers on the left and even numbers on the right hand side of the switch, back view, starting with the stage next to the panel.

i. Phase Switch Maintenance. (1) To remove the moving contact, in case the contacts are burned and need replacement, first remove the screw and clamping washer holding the shunt to the terminal, as shown in Figure 324; then with the contact in the open position, press in on top and pull upwards to remove. The new contact is inserted by entering the end of the moving contact support under the shoe on the moving contact and sliding the contact down until the tongue engages the notch in the support. The shunt is then fastened to the terminal by means of the clamping washer and screw. Exercise care to avoid creasing or kinking the shunt.

(2) If a stationary contact requires replacements, a new contact unit should be installed by means of two round-head screws holding the stationary contact support to the front and rear supports of the switch.

(3) If it is necessary to replace cams, the switch must be disassembled. First remove the handle; then the fixed contact support; then loosen the tie rods through the switch but do not remove them. Slip the front support off the shaft, being careful not to pull the shaft out of the cams.

(4) Stand the switch up on the table, resting on the rear support with the tie rods and shaft extending up. Slide the shaft out just enough to remove the pin through the shaft which seats in the counter bore in the indent wheel or spring stretcher but do not slide the shaft out enough to lose the cams in the last stage.

(5) Push the shaft back and slip off the indent wheel or spring stretcher being careful to hold the shaft in so as not to misplace the cams. The first barrier may now be removed.

(6) Before removing the cams, compare their position with the cam arrangement. Each contact stage requires two or three cams depending on whether there are one or two contacts per stage. The cam arrangement is usually in vertical rows of three cams or two cams and one spacer. Under each vertical row are the contact numbers to which the cams apply. The horizontal rows are lettered A, B and C. The A cam is the one removed first, working from the front end of the switch, the B cam next and the C cam last.

(7) Reassemble the switch from the rear support. Put the tie rods through the rear support and place it on the table with the tie rods extending up.

(8) Put the shaft in the rear support in an angular position corresponding to the vertical switch position, or to agree with the cam arrangement on the drawing.

(9) Assemble the rear barrier and contacts. Place the C cams for the rear contacts on the shaft in the exact position shown in the cam arrangement, next the B cam and the A cam last.

(10) Continue with the next contact stage in

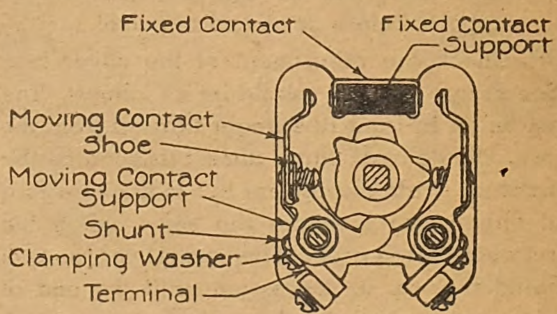

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Fig. 324. End Section of Instrument Switch

the same manner until all the stages are assembed.

(11) Assemble the indent wheel or spring stretcher and spring. Slide the shaft out just enough to replace the pin which seats in the counterbore of the indent wheel or spring stretcher.

(12) Assemble the front support and if it is a sustained contact switch, be sure the ball and spring which engage the notches in the indent wheel are assembled before pushing the front support home.

(13) Tighten the tie rods, first making sure the barriers are all properly nested.

j. Exciter Field Rheostat. The exciter field rheostat is connected in series with the exciter shunt field and voltage regulator resistance. If the exciter field rheostat is faulty, replace the entire unit. (See Figure 325.)

If it is necessary to transfer the generator to hand control of voltage from that normally supplied by the regulator while the generator is running, proceed as follows:

(1) Turn the exciter field rheostat slowly until the voltage, as indicated by the voltmeter, begins to fall.

(2) Turn the voltage adjusting rheostat to increase the resistance. The regulator will then be out of the circuit and the voltage may be controlled by the exciter field rheostat alone.

To return to regulator control, turn the voltage adjusting rheostat back slowly to its normal position and move the exciter rheostat, in turn, slowly back to its normal setting. After this operation, the regulator will again automatically regulate the exciter output.

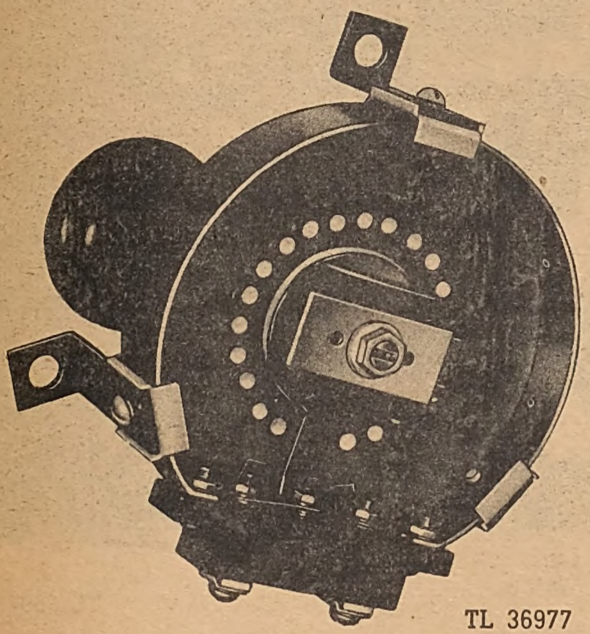

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Fig. 325. Exciter Field Rheostat

106. Moistureproofing and Fungiproofing.

a. General. The operation of Signal Corps equipment in tropical areas where temperature and relative humidity are extremely high requires special attention. The following items represent problems which may be encountered in operation:

(1) Resistors, capacitors, coils, chokes, transformer windings, etc., fail.

(2) Electrolytic action takes place in resistors, coils, chokes, transformer windings, etc., causing eventual break-down.

(3) Hook-up wire and cable insulation break down. Fungus growth accelerates deterioration.

(4) Moisture forms electrical leakage paths on terminal boards and insulating strips, causing flash-overs.

(5) Moisture provides leakage paths between battery terminals.

b. Treatment. A moistureproofing and fungiproofing treatment has been devised which, if properly applied, provides a reasonable degree of protection against fungus growth, insects, corrosion, salt spray, and moisture. The treatment involves the use of a moisture- and fungi-resistant varnish applied with a spray gun or brush. Refer to TB SIG 13, Moistureproofing and Fungiproofing Signal Corps Equipment, for a detailed description of the varnish-spray method of moistureproofing and fungiproofing.

CAUTION: Varnish spray may have toxic effects if inhaled. To avoid inhaling spray, use respirator if available; otherwise, fasten cheesecloth or other cloth material over nose and mouth.

c. Step-by-step Instructions for Treating Power Unit PE-185-B.

(1) Preparation.

(a) Make all repairs and adjustments necessary for proper operation of the equipment.

(b) Clean all dirt, dust, rust, fungus, oil, grease, etc., from the equipment to be processed.

(2) Disassembly.

(a) Remove rheostat knob from voltage regulator.

(b) Remove two thumb screws which hold cover to voltage regulator.

(c) Remove cover from voltage regulator (to be treated).

(d) Remove the four leads from frequency meter impedor box.

(e) Remove the two screws which hold frequency meter impedor box front cover.

(f) Remove the front cover from frequency meter impedor box.

(g) Remove the two nuts which hold impedor box to panel.

h) Remove the four screws which hold impedor box rear cover.

(i) Remove the rear cover including the felt pad (to be treated).

(j) Remove covers from volt and ammeter transfer switches (to be treated).

(3) Masking.

(a) Mask with tape all lugs on unfastened leads (Figure 326).

(b) Mask with tape all contacts on the voltmeter transfer switch.

(c) Mask with tape all contacts on the ammeter transfer switch.

(d) Mask with tape all contacts and contact arm of field rheostat.

(4) Drying.

(a) Use infra-red lamps to dry front and rear chambers of the control cabinet.

(b) Dry for 2 to 3 hours at 160 degrees Fahrenheit.

(c) Dry detached components for 2 to 3 hours at 160 degrees Fahrenheit.

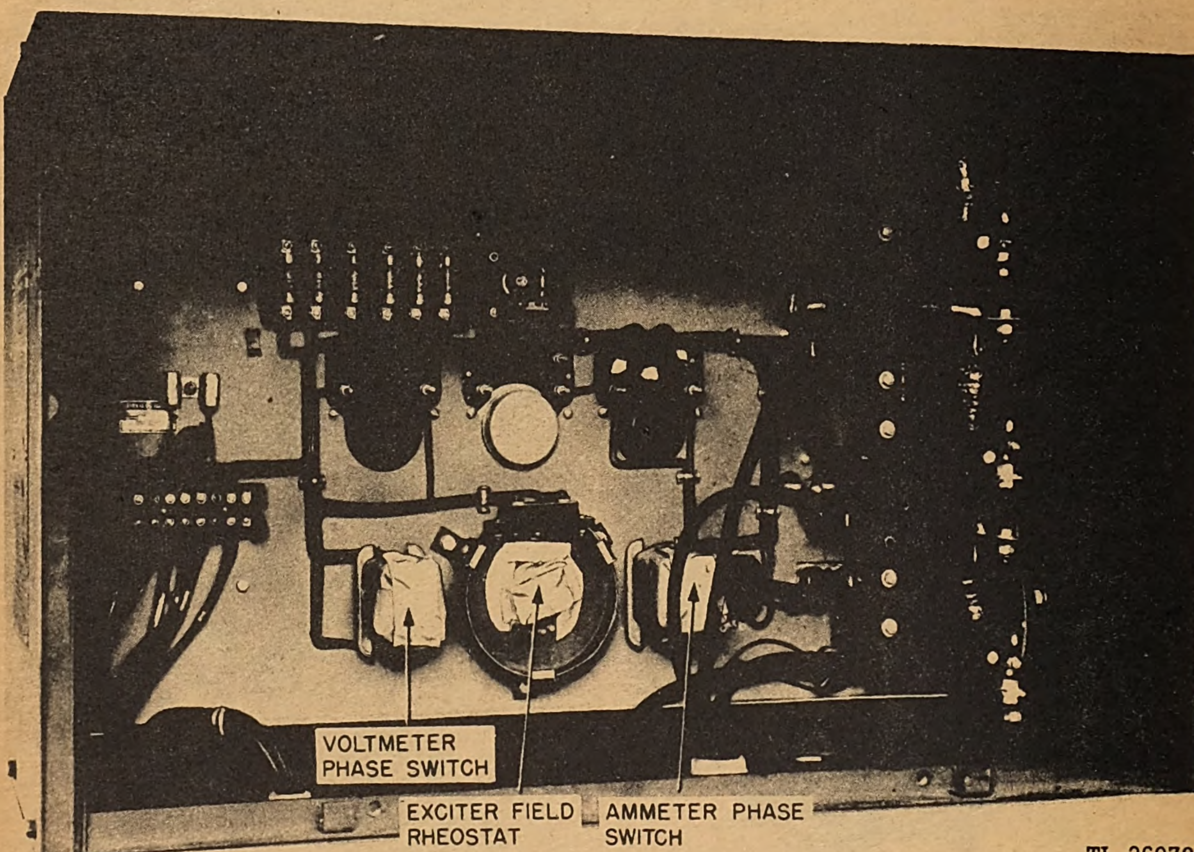


Fig. 326. Alternator Control panel masked ready for moistureproofing and fungiproofing

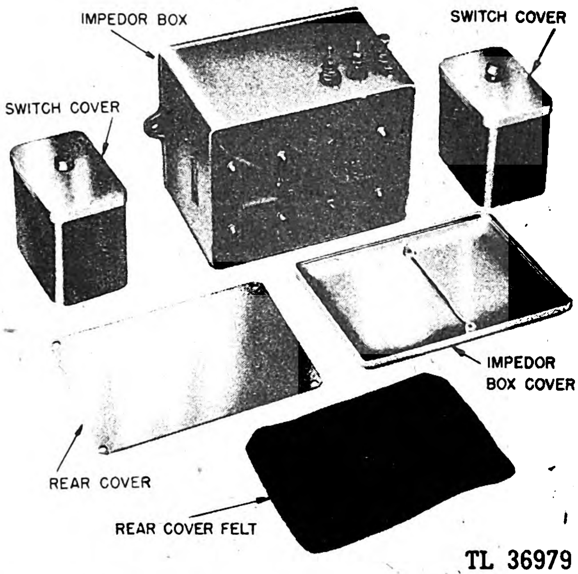


Fig. 327 Impedor Box and cover ready for fungiproofing and moistureproofing (front view)

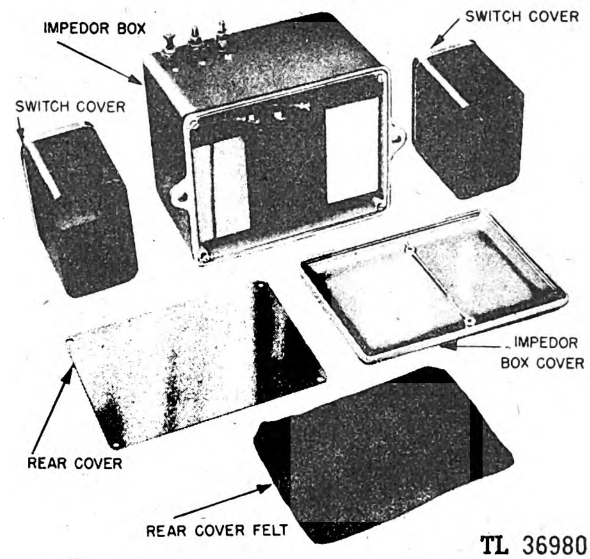


Fig. 328. Impedor Box and cover ready for fungiproofing and moistureproofing (rear view)

(5) Varnishing. Apply 3 coats of moistureproofing and fungiproofing varnish as follows:

(a) Spray reverse side of panel and all components remaining on panel (Figure 326).

(b) Spray inside of voltage regulator cover.

(c) Spray all components within the impedor box (Figures 327 and 328).

(d) Spray inside of volt and ammeter transfer switch covers.

(e) Varnish by brush all meter case seams, retaining screws, zero correction, and seams around window glass.

(f) Varnish by brush all wiring on complete power unit.

(g) Varnish by brush the voltage regulator coils and wiring.

CAUTION: Do not varnish contacts, such as rheostat, contact area of the adjustable resistors, and the assembly of the contact arms.

(6) Reassembly.

(a) Remove all masking tape.

(b) Clean all contacts with varnish remover, and burnish the contacts.

(c) Reassemble the set and test its operation.

(7) Marking. Mark the set with "MFP" and date of treatment. *Example:* MFP—8 June 1944.

SECTION V
SUPPLEMENTARY DATA

107. General. This section includes detailed specifications, tolerances, and tools and equipment needed for overhaul, together with a listing of all replaceable parts. Also, instructions for ordering repair parts are given in paragraph 110. A complete index of the power unit assemblies and accessories is given on page 207.

108. Service Data, Specifications and Tolerances.

a. Service Data.

ENGINE AND GENERATOR.

Model No. (Engine) 6-DTG-468
Type ....
Vertical in-line, 4 cycle, airless injection
No. of Cylinders 6
Bore .... 4¼"
Stroke .... 5½"
Piston Displacement 468.3
Firing Order 1-5-3-6-2-4
Rotation (Viewing Fan) ....
.... Clockwise (right hand)
Nozzle Opening Pressure ....
.... 1450 lbs. per square inch
Fuel Consumption at Rated Load (1200 R.P.M.) .... (Min.) .73 lbs. per K.W.H.; (Max.) .8 lbs. per K.W.H.
Cooling Capacity .... 42 quarts
Oil Capacity .... 32 quarts
Crankcase Oil Temperature Limit .. 220° F.
Oil Pressure (Normal Operating Temperatures) .....25 to 35 lbs. per square inch

SYNCHRONOUS GENERATOR

	Alternator	Exciter
Model	12G465	17G357
Type	ATI	BF
Frame	944-S	810
Kilowatts at .8 Power Factor	25	
Kilowatts		1
K.V.A.	31.3	
Volts	208/120	125
Amperes	87	8
R.P.M.	1200	1200
Phase	3	
Cycles	60	
Excitation Volts	125	
Excitation Amperes	5.7	

Temperature Rise not Exceeding 40° Centigrade (72° Fahrenheit) above Ambient.

Net Weight of Power Unit .... 5100 lbs.
Weight of Alternator and Exciter .... 1940 lbs.
Weight of Alternator Control Panel ... 355 lbs.
Over-all Length .... 119$\frac{5}{16}$"
Over-all Width .... 34¾"
Over-all Height .... 76¾"

b. Specifications and Tolerances (Engine).

The clearances listed as "desired" are maintained at the factory in new engines. The clearances listed as "permissible" are maximum permissible clearances before the various parts should be replaced. Therefore, judgment must be exercised when clearances do not exceed the maximum permissible, but are close thereto. If, in the opinion of the maintenance personnel, the wear will exceed the maximum permissible before the next overhaul period, the part or parts should be replaced.

CRANKCASE .... With block

CYLINDER SLEEVES

Type .... Dry
Bore Size .... 4.2535—4.2545
Bore-Out-of-Round .. Concentric within .002
Taper-Within ....
...... Not to exceed .0005 larger at top

CYLINDER HEAD

Torque Wrench Pull (Foot Pounds) . 150-160

CRANKSHAFT

No. of Bearings 7

Bearing Journal Diameter.
- No. 1 (Front) 2.996-2.997
- No. 2 (Front—Intermediate). 2.996-2.997
- No. 3 (Front—Intermediate). 2.996-2.997
- No. 4 (Center) 2.996-2.997
- No. 5 (Rear—Intermediate). 2.996-2.997
- No. 6 (Rear—Intermediate). 2.996-2.997
- No. 7 (Rear) 2.996-2.997

Connecting Rod Journal 2.3725-2.3735
Thrust Taken .... Rear
End Thrust (End Play)
- Desired .... .003-.007
- Permissible .... .012

Crank Pin Out-of-Round .... .001
Run-Out at
- Face of Crankshaft Flange and Flange Diameter .... .001-.002 indicator
- Gear Seat .... .0005-.001 indicator

CRANKSHAFT MAIN BEARINGS

Quantity 7
Undersize Available. .010-.020-.030-.040-.060
Bearing Clearance
- Desired .... .002-.0042
- Permissible .... .0065

Torque Wrench Pull (Foot Pounds) . 150-160

CRANKSHAFT BALANCER

Mounting .... None

CONNECTING ROD

Center to Center Length 11.002-10.998
Upper Bearing Ream in Place . 1.5030-1.5027
Lower Bearing in Place 2.3765-2.3755
Upper Bore for Bushing 1.6875-1.6870
Lower Bore for Bearing 2.5210-2.5205

CONNECTING ROD BEARING—UPPER

Bushing to Pin Clearance
- Desired .... .001-.0015
- Permissible .... .0025

CONNECTING ROD BEARING—LOWER

Bearing Clearance
- Desired .... .002-.004
- Permissible .... .0065

Connecting Rod Side Clearance
- Desired .... .004-.009
- Permissible .... .013

Undersize Bearings Available ....
.... .010-.020-.030-.040-.060
Torque Wrench Pull (Foot Pounds) .. 95-105

PISTON

Diameter of Piston at Ring Lands
- Top Land (A) 4.222-4.218
- 2nd Land (B) 4.227-4.223
- 3rd Land (C) 4.227-4.223
- 4th Land (D) 4.227-4.223

Clearance Between Piston and Cylinder
- Top of Skirt .... .0072
- Bottom of Skirt .... .0052

Ring Groove Width
- Fire .... .128-.127
- Compression .... .1265-.1255
- Oil .... .189-.188

PISTON PIN

Diameter—Grind 1.5015-1.5017
Diameter—Connecting Rod Bushings I.D. in Place .... 1.5030-1.5027 Ream
Diameter—Hole in Piston 1.5012-1.5015
Clearance Between
- Pin and Connecting Rod Bushing .... .001-.0015
- Pin and Piston Hole .... .0000-.0005

FIRE RING

Quantity (1 per Piston) 6
Type .... Plain—Butt Joint
Width .... .123-.124
Gap .... .007-.012
Ring and Groove Clearance
- Desired .... .003-.005
- Permissible .... .007

COMPRESSION RING

Quantity (2 per Piston) 12
Type .... Plain—Butt Joint
Width .... .123-.124
Gap .... .015-.020
Ring and Groove Clearance
- Desired .... .0015-.0035
- Permissible .... .005

OIL CONTROL RING

Quantity (2 per Piston) 12
Type ....CC-20 Butt Joint
Width .... .186-.1865
Gap .... .011-.016
Ring and Groove Clearance
- Desired .... .0015-.0035
- Permissible .... .005

CAMSHAFT

Number of Bearings 4
- Front 2.2475-2.2465
- Front—Intermediate 2.2475-2.2465
- Rear—Intermediate 2.2475-2.2465
- Rear 1.4975-1.4965

Bearing Clearance
- Desired .... .0014-.004
- Permissible .... .006

End Play (Thrust)
- Desired .... .003-.009
- Permissible .... .015

CAMSHAFT BEARING

Quantity 4
- Front 2.2534-2.2540
- Front—Intermediate 2.2534-2.2540
- Rear—Intermediate 2.2534-2.2540
- Rear 1.5034-1.5040

Bearing Clearance
- Desired .... .0014-.004
- Permissible .... .006

INTAKE VALVE

Lash-Hot (Tappet Adjustment) .... .009

Seat Angle .... 45°

Diameter Head 1.766-1.756

Length Overall .... 6¼"

Stem Diameter .... .3725-.3720

Guide Ream .... .3755-.3745

Stem to Guide Clearance
- Desired .... .002-.0035
- Permissible .... .0055

Intake Opens (No. 1) .... 17° B.T.C.

Intake Closes .... 39° A.B.C.

Intake Period .... 236°

EXHAUST VALVE

Lash-Hot (Tappet Adjustment) .... .012

Seat Angle .... 45°

Diameter Head 1.567-1.557

Length—Over-all 6.248

Stem—Diameter .... .3725-.3720

Guide Ream .... .3755-.3745

Stem to Guide Clearance
- Desired .... .002-.0035
- Permissible .... .0055

Exhaust Opens (No. 1) .... 43° B.B.C.

Exhaust Closes .... 13° A.T.C.

Exhaust Period .... 236°

VALVE LIFTER

Diameter .... .81175-.81225

Clearance—Block to Lifter
- Desired .... .00025-.00125
- Permissible .... .002

VALVE SPRING

Free Length .... (approx.) 2 23/32"

Pounds Pressure at 2 5/16 inches .... 35 to 38

Pounds Pressure at 1 13/16 inches ... 78 to 86

TIMING GEARS

Crank, Cam and Idler .... .0005-.0015

Backlash (Others)
- Desired .... .002-.004
- Permissible .... .012

Crankshaft Gear
- Material. . Heat treated, X-1335 bar steel
- Teeth .... 27 teeth, 8 pitch, helical gear

Camshaft Gear
- Material .... Alloyed cast iron
- Teeth .... 54 teeth, 8 pitch, helical gear

Idler Gear
- Material ...... Heat treated, SAE-414°
- Teeth .... 41 teeth, 8 pitch, helical gear

End Play
- Desired .... .003-.007
- Permissible .... .015

Gear to Stub Shaft Clearance
- Desired .... .0015-.0025
- Permissible .... .004

FUEL SYSTEM

Fuel Injection Pump .... Excello

Smoke Stop Setting .. 60 H.P. at 1200 R.P.M.

Overload Stop Adjustment .... 34 K.W.

Fuel Filter—Primary Purolator. D-21, WM-15

Fuel Filter—Secondary Commercial Filters .... Corp. Model AS-4

BATTERY CHARGING SYSTEM

Generator
- Field Current Draw
  - Amperes 10
  - Volts at 1500 R.P.M. 24-30
- Balanced Output (OC) .... 24 volts at 600 R.P.M.

Regulator
- Cutout Contact Gap (C1) .... .070-.075
- Cutout Contact Gap (C3) .... .035-.038

Closing Voltage (C3) .... 22.0-22.3 volts
Closing Voltage (C1) .... 28.4-28.6 volts

Voltage Regulator
Contact Gap .... .020-.025
Armature Core .... .050-.055
Hinge Gap .... .005-.010
Voltage Setting .... 28.4-28.6 volts

Battery
Capacity, Ampere Hours at 20-Hour Rate 204
Plates .... 2 batteries, 12 volt, required, 25 per battery
Size (Battery) .. $21\frac{1}{8}'' \times 10\frac{15}{16}'' \times 10\frac{1}{2}''$
Terminal Ground .... Positive (+)

STARTING MOTOR

Starter .... 24 volts
Lock Torque
Foot Pounds 90
Amperes 1320
Volts 12.2
Maximum H.P.
H.P. 9.6
Amperes 640
Volts 17.6

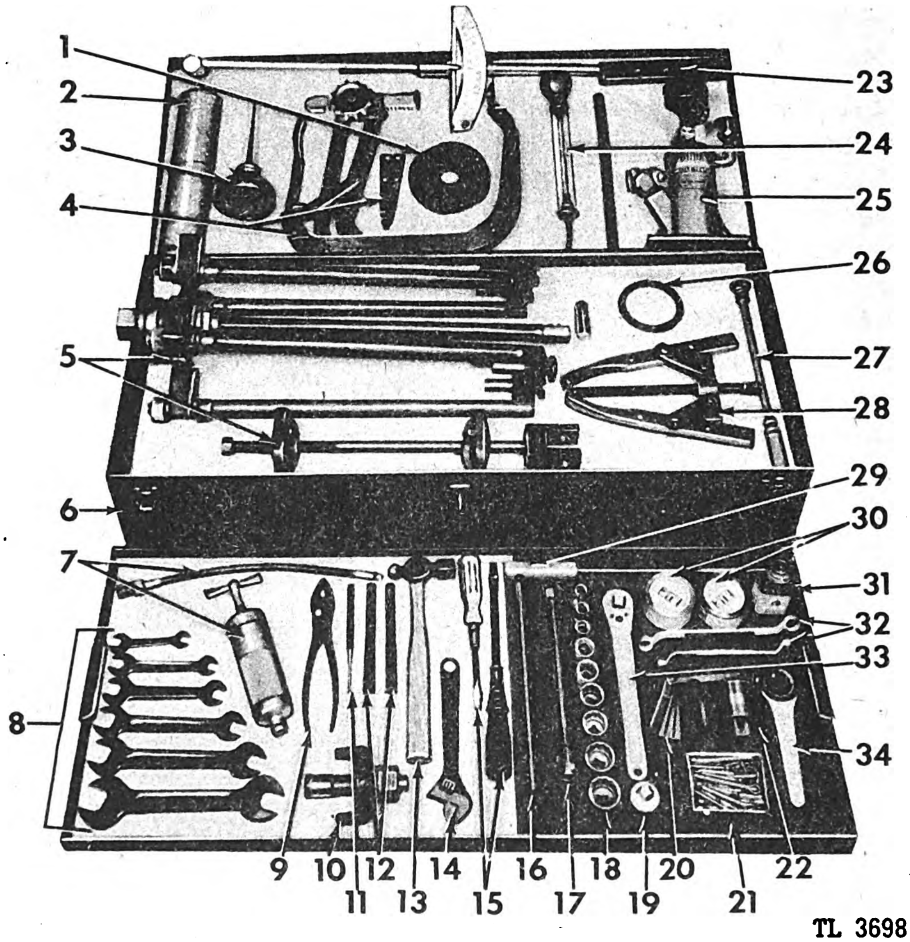


Fig. 329. Tools Furnished with Engine

1. Friction Tape
2. #00 Sandpaper
3. Oil Can
4. Valve Spring Depressor
5. Sleeve Puller
6. Metal Tool Box
7. Grease Gun and Hose
8. Open End Wrenches
9. Combination Pliers
10. Air Cell Puller
11. Pin Punch
12. Cold Chisels
13. Ball Peen Hammer
14. Adjustable Crescent Wrench
15. Screwdrivers
16. Handle Bar
17. Extension Bar
18. Double Hex Sockets
19. Double Hex Socket
20. Feeler Gauge
21. Cotter Keys
22. Piston Ring Compressor
23. Torque Wrench
24. Hydrometer
25. Nozzle Tester
26. Steel Wire
27. Valve Grinder
28. Wheel Puller
29. Hinged Offset Handle
30. Grinding Compound
31. Gasket Shellac
32. Box Wrenches
33. Reversible Ratchet
34. Spanner Wrench

R.P.M. 1600
Foot Pounds 31.5
Efficiency 64%

Maximum R.P.M.

R.P.M. 3600
Amperes 280
Volts 21.2
H.P. 4.05
Foot Pounds 5.9
Efficiency 51%

109. Tools and Equipment. The tools furnished with every two engines are illustrated in Figure 313.

In addition to the tools furnished with the engine, it is recommended that the following equipment and instruments be made available for general overhaul:

AMMETERS—Test
One, range 0 to 600 amperes
One, range 0 to 50 amperes

CHAIN HOIST
3-ton

CONNECTING ROD ALIGNER

DIAL INDICATOR—One

LATHE
At least 9" swing

MICROMETERS
Outside, 1" to 2", 2" to 3", 3" to 4"
Inside, ½" to 6"

PISTON PIN REAMER, OR HONE

TACHOMETER—Test
Range 50 to 2000 R.P.M.

VALVE REFACER

VALVE SEAT REFACER

VOLTMETER—Test
One, 0 to 50 volts

WORK BENCH AND VISE

110. Ordering Repair Parts. When ordering parts, do not order by reference numbers shown in the illustrations. Order by the Signal Corps stock number, together with the name and description of the part. Refer to the Maintenance Parts List, paragraph 154, page 286.

Also, when ordering parts, give the engine serial number, together with the B/M number on the engine on which such parts are to be used. The engine serial number and the B/M number are on the engine name plate attached to the left side of the crankcase.

Facsimile of the Engine Name Plate

When ordering one gear for replacement, specify the size marking of the old gear. Each gear is marked with a number within either a circle or letter "U", as 1 or 3, denoting oversize or undersize. The number within gives the deviation from the standard in thousandths of an inch.

In ordering a new sleeve to fit a particular bore, be sure to state the A, B, C, or AO, BO, CO marking found on the top of the cylinder block alongside the sleeve in question.

All main bearings are furnished in pairs to fit a standard size or .020", .030" or .040" undersize crankshaft. Unless the order states otherwise standard bearings will be furnished.

111. Engine Accessory Manufacturers' Parts List

Description	*Buda Part No.*	*Manufacturer*	*Manufacturers' Model No.*	*Weight in Pounds*
Air Cleaner	DE-55602	United Specialties Company Chicago, Illinois	H-95-8361	5
Batteries (2)	DL-3193	Globe Union Co. Milwaukee, Wisconsin	12 volt	135 each
Fuel Filter (Primary)	DE-42622	Purolator Products Corp. Newark, New Jersey	Type D21-15	7 3/16
Fuel Filter (Secondary)	DE-61560	Commercial Filters Corporation Boston, Massachusetts	AS4-3/8-BDV-1/4"	4 1/8
Fuel Injection Pump	DE-42492	Excello Corporation Detroit, Michigan	Model BBD126 Style LS074	30 3/8
Generator (Battery Charging)	DE-42830	Leece-Neville Company Cleveland, Ohio	LN-2286-G	47 1/4
Howler System				
High Water Temperature Switch	DE-42590	Detroit Lubricating Co. Detroit, Michigan	Series D423 Type G961802	2 3/4
Low Oil Pressure Switch	DE-42588	Detroit Lubricating Co. Detroit, Michigan	Series D423 Model PL Type 1B4	2 1/4
Governor	Integral with fuel injection pump			
Muffler	DP-2698	Maremont Auto Products Chicago, Illinois	7212	30
Oil Filter	DE-40817	DeLuxe Products Corp. LaPorte, Indiana	Model SSD-502	17 1/8
Oil Filter (Cuno)	DE-56590	Cuno Engineering Corp. Meriden, Connecticut	11769	5
Starter Motor	DE-50921	Leece-Neville Company Cleveland, Ohio	LN-1236-M	52 1/4
Voltage Regulator	DE-42831	Leece-Neville Company	LN-2286-R	4 5/8

a. Manufacturers Code. A code is provided to identify the original manufacturer of the engine parts, accessories, alternator and control panel assemblies. The code used is from the Ordnance Standard Nomenclature list. The manufacturers and their codes are as follows:

Code	*Name*	*Address*
BE	The Buda Company	Harvey, Illinois
CMF	Commercial Filters Corp.	Boston, Massachusetts
CU	Cuno Engineering Corp.	Meriden, Connecticut
DX	DeLuxe Products Corp. (The)	LaPorte, Indiana
EX	Ex-Cell-O Corporation	Detroit, Michigan
FK	Falk Corporation	Milwaukee, Wisconsin
GE	General Electric Co.	Schenectady, New York
GLU	Globe Union Co.	Milwaukee, Wisconsin
LN	Leece-Neville Company	Cleveland, Ohio
MAR	Maremont Automotive Products, Inc.	Chicago, Illinois
PRX	Perfex Corporation	Milwaukee, Wisconsin
PU	Purolator Products, Inc.	Newark, New Jersey
SZ	Schwitzer-Cummins Co.	Indianapolis, Indiana
UTS	United Specialties Company	Chicago, Illinois

112. **Apparatus Parts Legend, Illustrated.**

NOTE: Part reference numbers prefixed by X indicate Standard Hardware.

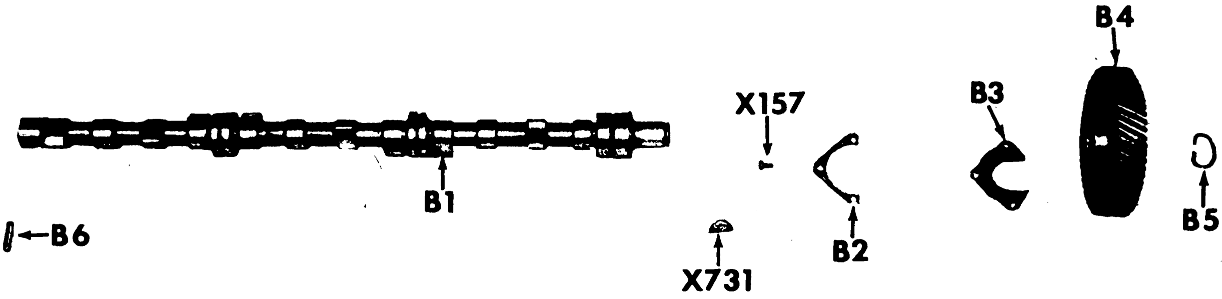


Fig. 330. Camshaft and Component Parts

113. Camshaft Assembly

Ref. No.	*Quantity*	*Description*	*Mfr.*	*Symbol*
B 1	1	CAMSHAFT	BE	DE-40067
B 2	1	LOCK PLATE, Camshaft Thrust Collar	BE	1341
B 3	1	COLLAR, Camshaft Thrust	BE	DE-55995
B 4	1	GEAR, Camshaft	BE	DE-40114
B 5	1	RETAINER, Camshaft Gear	BE	1307
B 6	1	PIN, Camshaft Oil Pump Drive	BE	1308
X 157	3	SCREW $\frac{1}{4}$"—20 x $\frac{1}{2}$", Camshaft Thrust Collar Lock Plate	BE	106972
X 731	1	KEY, Camshaft Gear Woodruff #15	BE	113782

Note: Camshaft Bearings are listed with Crankcase Assembly.

114. Cranking Devices (Manual)

C 1	1	FLANGE, Rope Starting Support	BE	DE-42715
C 2	1	SHAFT, Rope Starting	BE	DE-42546
C 3	1	SPRING, Rope Starting	BE	DE-42547
C 4	1	FLANGE, Rope Starting Pulley	BE	DE-42548
C 5	1	PIN, Starting Shaft	BE	1112
C 6	1	PULLEY, Rope Starting	BE	DE-42545
X 127	3	CAPSCREW, Rope Starting Pulley Flange	BE	100159
X 128	3	CAPSCREW, Rope Support Flange	BE	100160
X 504	3	LOCKWASHER, Rope Starting Pulley Flange	BE	103323
X 504	3	LOCKWASHER, Rope Support Flange	BE	103323
X 560	1	WASHER, Plain	BE	106270
X 628	1	PIN, Rope Starting Shaft Cotter	BE	103408
X 659	1	PIN, Rope Starting Shaft	BE	103792
.....	1	* ROPE, Starting	BE	DP-2962
.....	3	NUT, Rope Support Flange Capscrew	BE	117064

* Not Illustrated.

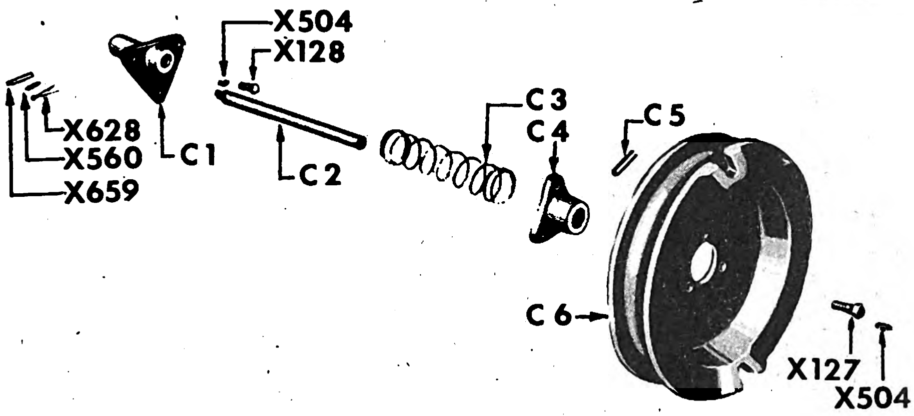


Fig. 331. Rope Starting Assembly TL 36983

115. Crankshaft Assembly

Ref. No.	Quantity	Description	Mfr.	Symbol
D 1	1	JAW, Starting Crank	BE	DE-41314
D 2	1	PULLEY, Fan Drive	BE	K-40273
D 3	1	SPACER, Crankshaft Fan Pulley	BE	DE-41303
D 4	1	GEAR, Crankshaft	BE	DE-4033
D 5	1	KEY, Crankshaft Fan Pulley	BE	DE-41320
D 6	1	CRANKSHAFT	BE	DE-41342
D 7	1 pr.	† BEARING, Main—Upper and Lower Front	BE	DE-41363
D 8	4 pr.	† BEARING, Main—Intermediate Upper and Lower	BE	DE-41365
D 9	1 pr.	† BEARING, Main—Center Upper and Lower	BE	DE-41367
D 10	1 pr.	BEARING, Main—Rear Upper and Lower.	BE	DE-41369
D 11 *	1 pr.	† BEARING, Main Rear—Upper and Lower.	BE	DE-42691
D 12 *	4	FLANGE, Rear Main Bearing Thrust	BE	DE-56731
D 13 *	4	PIN, Rear Main Bearing Thrust Flange ..	BE	141360
X 732	1	KEY, Crankshaft Gear	BE	113879

† Available in standard size, or .020, .030, .040 undersize, sold in pairs only.
* Replaces D10.

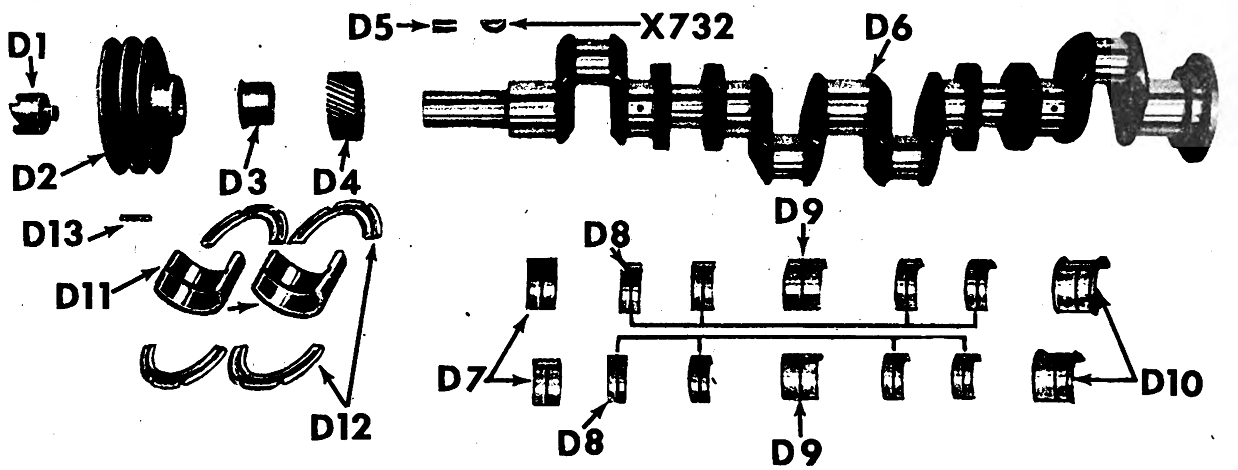
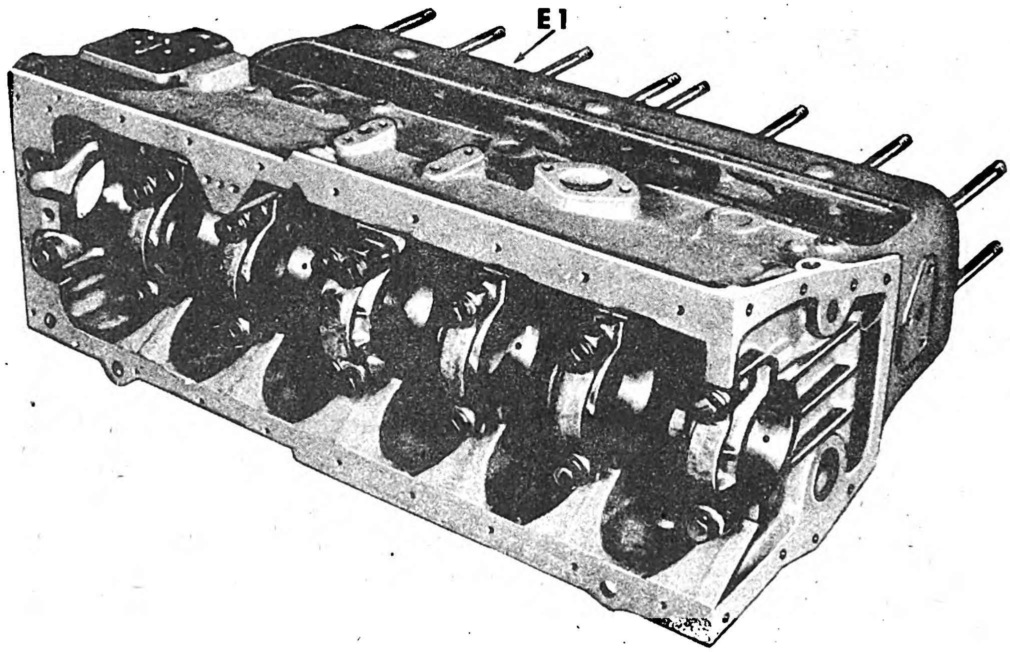


Fig. 332. Crankshaft and Main Bearing Assemblies



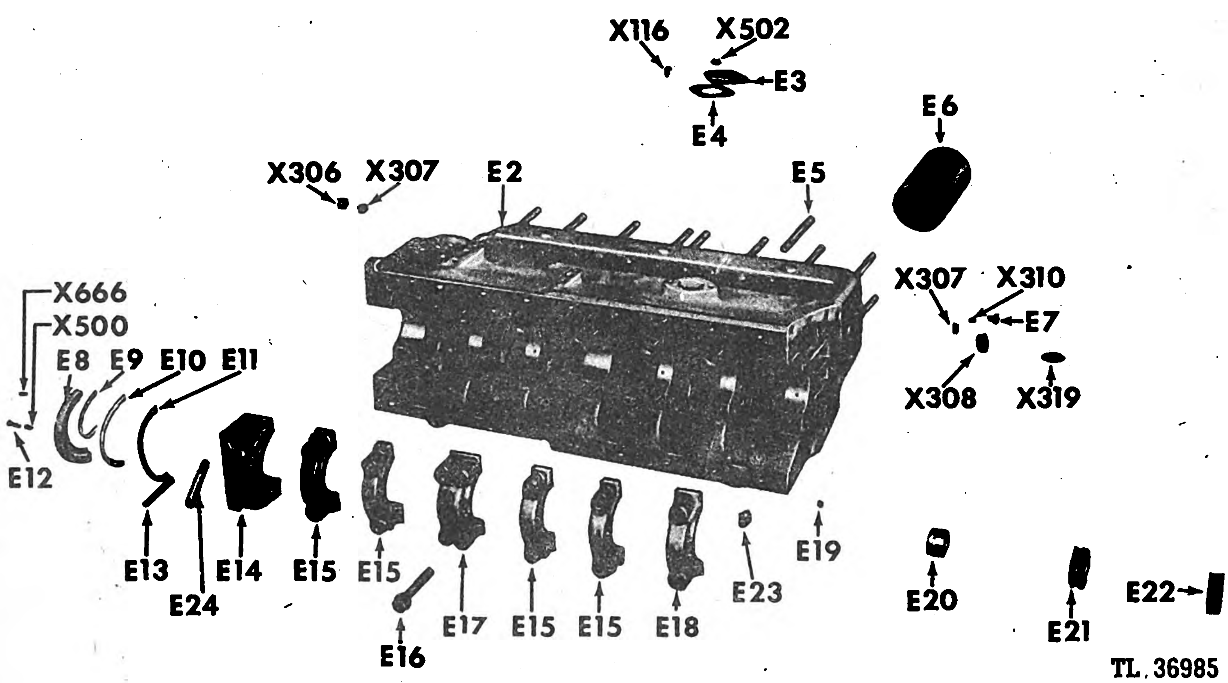


Fig. 333. Crankcase and Cylinder Block Assembly

116. Crankcase and Cylinder Block Assembly

Ref. No.	Quantity	Description	Mfr.	Symbol
E 1	1	• ASSEMBLY, Cylinder and Crankcase	BE	DE-41228
E 2 •	1	CRANKCASE	BE	DE-41208
E 3 •	1	PLATE, Oil Filler Pad Cover	BE	4578
E 4 •	1	GASKET, Oil Filler Pad Cover Plate	BE	DE-4153
E 5 •	15	STUD, Cylinder Head	BE	DE-40012
E 6 •	6	SLEEVE, Cylinder	BE	DE-41182
E 7	5	PLUG, Cylinder and Crankcase Oil Line .	BE	DE-4870
E 8	2	SEAL, Rear Main Bearing Oil—(Upper and Lower)	BE	DE-56131
E 9	2	FELT, Rear Main Bearing Oil Seal	BE	DE-56165
E 10	1	GASKET, Rear Main Bearing Oil Seal ...	BE	1438
E 11	1	GASKET, Rear Main Bearing Oil Seal ...	BE	1561
E 12	6	SCREW, Rear Main Bearing Oil Seal	BE	1560
E 13	2	STOP, Rear Main Bearing Oil—(Short) ..	BE	H-12289
E 14 •	1	CAP, Rear Main Bearing	BE	K-40574
E 15 •	4	CAP, Intermediate Main Bearing	BE	4012
E 16 •	14	CAPSCREW, Main Bearing	BE	4015
E 17 •	1	CAP, Center Main Bearing	BE	5379
E 18 •	1	CAP, Front Main Bearing	BE	4013
E 19 •	2	PLUG, Crankcase Oil Hole ¼"	BE	DE-40282
E 20 •	1	BEARING, Camshaft Rear	BE	DE-41504
E 21 •	2	BEARING, Camshaft Intermediate	BE	DE-41386
E 22 •	1	BEARING, Camshaft Front	BE	DE-41417
E 23	7	DOWEL, Lower Main Bearing	BE	1030
E 24	1	TUBE, Rear Main Bearing Drain	BE	DE-56727
X 116 •	2	CAPSCREW, Oil Filler Pad Cover Plate ..	BE	114670
X 306 •	6	PLUG ⅜" Countersunk, Crankcase Pipe .	BE	103873
X 307 •	2	PLUG, ½" Pipe Thread, Oil Line	BE	103874
X 308 •	6	PLUG ¾" Headless, Pipe	BE	103875
X 310 •	1	PLUG, ⅛" Square Head, Oil	BE	103877
X 319 •	1	PLUG, 1½", Welch Expansion	BE	103896
X 500	6	LOCKWASHER, Rear Main Bearing Oil Seal Screw	BE	103319
X 502 •	2	LOCKWASHER, ⅜", Oil Filter Pad Cover Plate Capscrew	BE	103321
X 666 •	2	PIN 3/32" x ⅜", Rear Main Dowel	BE	141065
* •	7	LOCKWIRE, Bearing Cap Bolts	BE	DE-5476
* •	2	STOP, Rear Bearing Oil Cap	BE	H-11950
*	1	BUSHING, Oil Pressure Connection	BE	127875
*	1	COCK, Water Jacket Drain	BE	4045
* •	1	PLUG, Pipe ⅛" Slotted	BE	103883
* •	2	PLUG, Welch Expansion 1¼"	BE	103895
* •	10	PLUG, Welch Expansion ½"	BE	103890
* •	1	PLUG, Welch Expansion 1⅛"	BE	106517

Note: Crankshaft Main Bearings are listed with Crankshaft Assembly.

• Included in assembly DE-41228, reference number E 1.

* Not Illustrated.

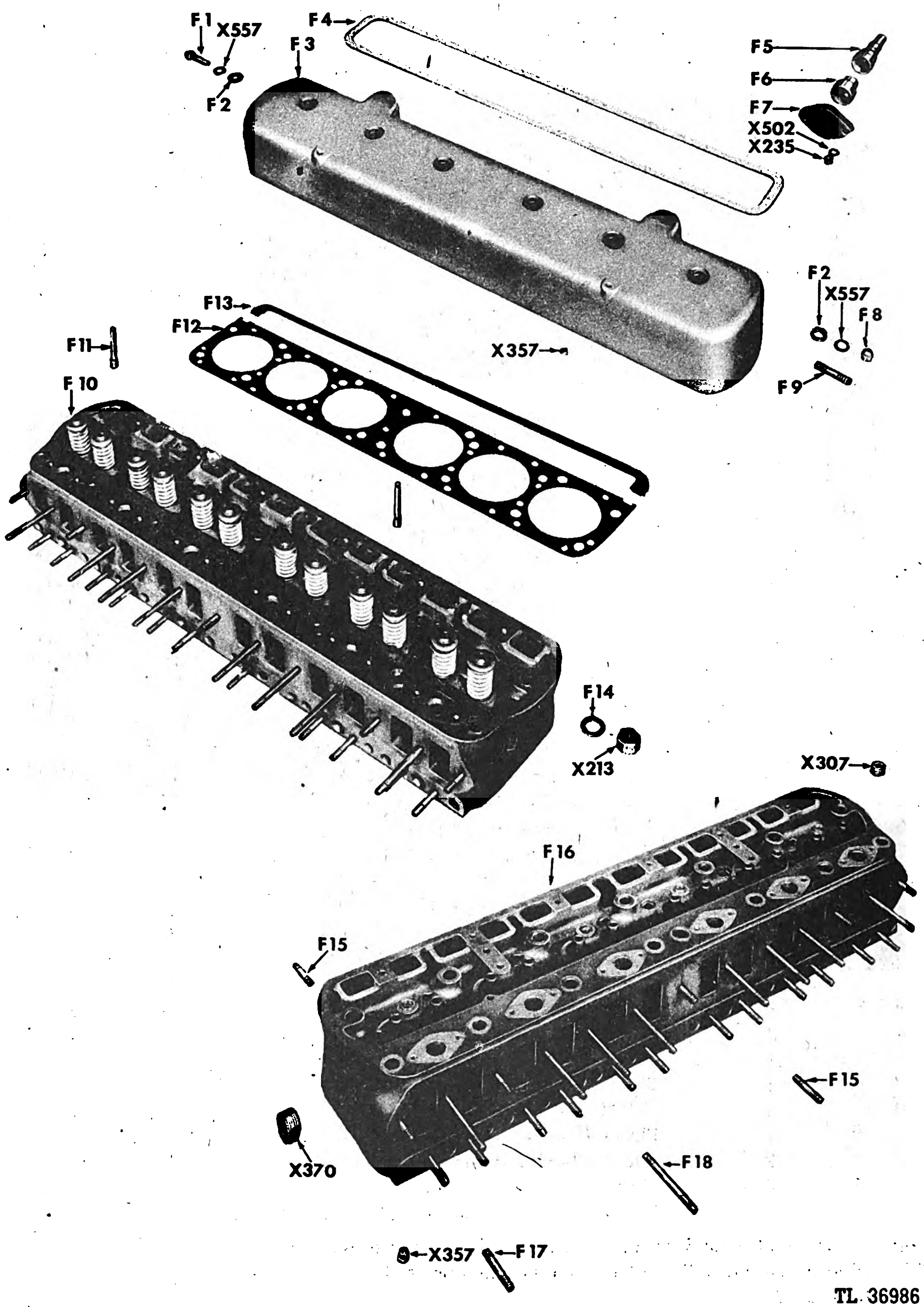


Fig. 334. Cylinder Head Assembly

117. Cylinder Head Assembly

Ref. No.	Quantity	Description	Mfr.	Symbol
F 1	4	STUD, Cylinder Head Cover	BE	DE-55119
F 2	6	WASHER, Cylinder Head Cover Stud	BE	5493
F 3	1	COVER, Cylinder Head	BE	DE-42147
F 4	1	GASKET, Cylinder Head Cover	BE	DE-4057
F 5 ●	6	ASSEMBLY, Air Cell	BE	DE-41050
F 6 ●	6	PLUG, Air Cell	BE	DE-41047
F 7 ●	6	RETAINER, Air Cell	BE	DE-40255
F 8	6	NUT, Cylinder Head Cover Stud	BE	DE-41286
F 9	2	STUD, Cylinder Head Cover	BE	DE-40069
*	1 ●	ASSEMBLY, Cylinder Head	BE	DE-40943
F 10	1	ASSEMBLY, Cylinder Head (Includes Valves)	BE	DE-40943-B
*	2	DOWEL, Cylinder Head	BE	DE-4684
F 11	2	TUBE, Cylinder Head Breather	BE	DE-41192
F 12	1	GASKET, Cylinder Head—Major—Thick	BE	DE-42458
*	1	GASKET, Cylinder Head—Major—Thin	BE	DE-42455
F 13	1	GASKET, Cylinder Head—Minor—Thick	BE	DE-41013
*	1	GASKET, Cylinder Head—Minor—Thin	BE	DE-41012
F 14	15	WASHER, Cylinder Head Stud	BE	KE-184
F 15 ● # $	12	STUD, Air Cell Retainer	BE	DE-40190
F 15 ● # $	5	STUD, Intake and Exhaust Manifolds—Short	BE	DE-40190
F 16	1	ASSEMBLY, Cylinder Head	BE	DE-40943-A
F 17 ● # $	12	STUD, Injector Nozzle Holder	BE	1361
F 18 ● # $	8	STUD, Intake and Exhaust Manifolds—Long	BE	DE-40164
X 213	8	NUT, Cylinder Head Stud—Thick	BE	106640
X 235	12	NUT, Air Cell	BE	102635
X 307 ● # $	6	PLUG ½", Cylinder Head Pipe	BE	103874
X 357 ● # $	12	PLUG ⅛", Cylinder Head Pipe	BE	118831
*	4	PLUG, ⅛" Cylinder Head Cover Pipe	BE	118831
X 370 ● # $	2	PLUG, Cylinder Head Pipe—1"	BE	103876
X 502	12	LOCKWASHER, Air Cell	BE	103321
X 557	6	WASHER, Cylinder Head Cover Stud	BE	106263
*	7	NUT, Cylinder Head Stud—Thin	BE	103030

* Not Illustrated.

● Included in Assembly DE-40943—*.

Included in Assembly DE-40943-B (F 10).

$ Included in Assembly DE-40943-A (F 16).

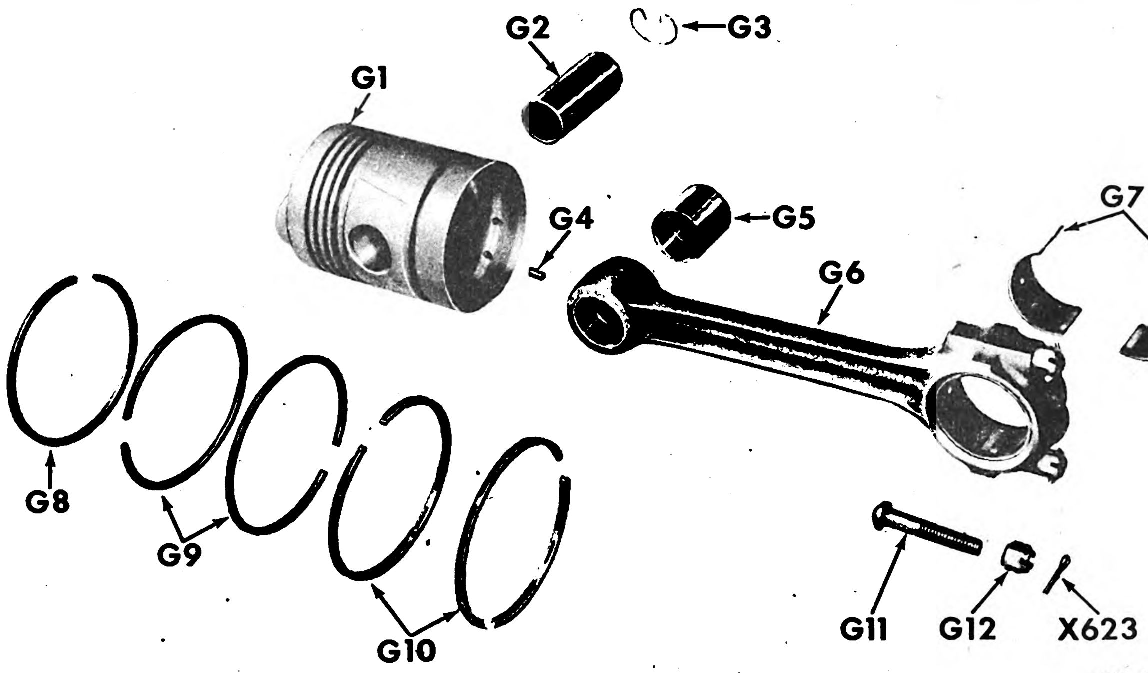


Fig. 335. Piston and Connecting Rod Assemblies

118. Piston and Connecting Rod Assemblies

Ref. No.	*Quantity*	*Description*	*Mfr.*	*Symbol*
G 1	6	PISTON	ZN	DE-41245
G 2	6	PIN, Piston	BE	DE-4706
G 3	12	SPRING, Piston Pin Retainer	BE	DE-4699
G 4	6	DOWEL, Connecting Rod Bushing	BE	DE-4866
G 5	6	BUSHING, Connecting Rod	BE	DE-40081
G 6	6	ASSEMBLY, Connecting Rod (Includes G5, G6, G7, G11, G12)	BE	DE-41372
G 7	6	# BEARING, Connecting Rod (pairs)	BE	DE-41371
G 8	6	RING, Piston—Top	BE	DE-41084
G 9	12	RING, Piston—2nd and 3rd	BE	DE-41355
G 10	12	RING, Piston—Oil Control	BE	DE-41086
G 11	12	BOLT, Connecting Rod	BE	DE-4217
G 12	12	NUT, Connecting Rod Bolt	BE	DE-4218
X 623	12	PIN, Connecting Rod Cotter	BE	103374

Available in .010, .020, .030, .040 and .060 undersize.

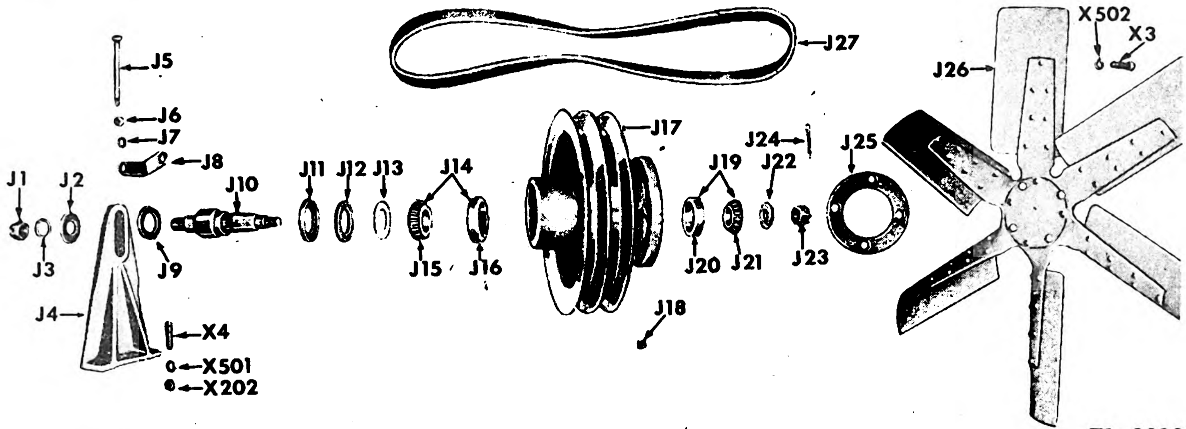


Fig. 336. Fan Assembly (DE-41873) 26" 6 Blade Pusher

119. Fan Assembly

Ref. No.	Quantity	Description	Mfr.	Symbol
J 1 ●	1	NUT—Hex (not slotted) Rear, Fan Spindle	SEP	SP-645-D
J 2 ●	1	WASHER, Rear, Fan Spindle Clamp	SEP	SP-3369-D
J 3 ●	1	LOCKWASHER—Rear, ¾", Fan Spindle .	BE	103326
J 4	1	BRACKET, Fan	BE	4607
J 5	1	SCREW, Fan Adjusting	SEP	SP-2247-D
J 6	1	NUT; Fan Adjusting Screw	BE	103028
J 7	1	LOCKWASHER ½", Fan Adjusting Screw	BE	103323
J 8	1	BRACE, Fan Bracket	BE	DE-41720
J 9 ●	1	WASHER, Front, Fan Spindle Clamp	SEP	SP-3368-D
J 10 ●	1	SPINDLE, Fan	SEP	SP-3366-D
J 11 ●	1	CUP, Fan Spindle Felt Retainer	SEP	SP-1008-D
J 12 ●	1	WASHER, Fan Spindle Felt	SEP	SP-995-D
J 13 ●	1	WASHER, Fan Spindle Felt Retainer	SEP	SP-1000-D
J 14 ●	1	BEARING—Rear, Fan Spindle	SEP	1533-D
J 15 ●	1	CONE—Timken, Fan Spindle Bearing ...	SEP	250048 §
J 16 ●	1	CUP—Timken, Fan Spindle Bearing	SEP	250048 §
J 17 ●	1	HUB (Casting only), Fan	SEP	3367-LD
J 18 ●	1	PLUG, Fan Hub Oil	SEP	SP-467-D
J 19 ●	1	BEARING—Front, Fan Spindle	SEP	2133-D
J 20 ●	1	CUP—Timken, Fan Spindle Bearing	SEP	250051 †
J 21 ●	1	CONE—Timken, Fan Spindle Bearing ...	SEP	250050 †
J 22 ●	1	WASHER, Fan Spindle	SEP	SP-1202-D
J 23 ●	1	NUT—Slotted (Hub End) Fan Spindle ...	SEP	SP-1221-D
J 24 ●	1	PIN, Cotter	SEP	SP-1848
J 25 ●	1	GASKET, Fan Blade Cork	SEP	SP-3304-D
J 26 ●	1	ASSEMBLY, Fan Blade	SEP	K-40623
J 27	2	FAN BELT	BE	DE-41321
X 3	4	CAPSCREW, Fan Blade	BE	100134
X 4	2	BOLT—Hex Head, Fan Bracket	BE	100161
X 202	2	NUT, Fan Bracket Bolt	BE	102637

● Included in Fan Assembly DE-41873 (SP-4402-L).
§ Included in Fan Assembly 1533-D.
† Included in Fan Assembly 2133-D.

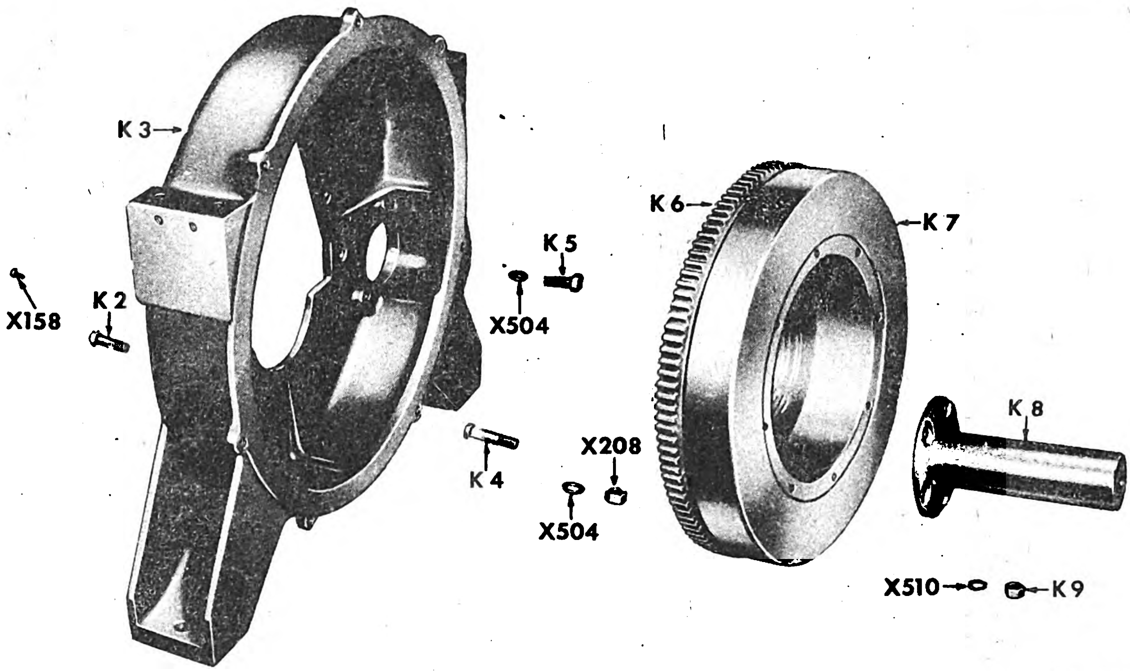


Fig. 337. Flywheel and Housing Assembly

120. Flywheel and Housing Assembly

Ref. No.	Quantity	Description	Mfr.	Symbol
K 2	2	BOLT, Flywheel Housing Dowel	BE	4053
K 3	1	HOUSING, Flywheel	BE	DE-42503
K 4	5	BOLT, Crankshaft to Flywheel	BE	H-12112
K 5	4	CAPSCREW, Flywheel Housing	BE	2074
K 6	1	GEAR, Flywheel Ring	BE	DE-3694
K 7	1	FLYWHEEL, (without Ring Gear)	BE	DE-42501
K 8	1	SHAFT, Stub	BE	AP-6732
K 9	5	NUT, Flywheel Bolt	BE	CUE-763
*	2	PIN, Flywheel Housing Dowel—1	BE	DL-3158
*	2	PIN, Flywheel Housing Taper—Threaded End	BE	DP-2944
*	1	KEY, Stub Shaft Square (⅝ x ⅝ x 3¾") ..	BE	DP-2799
X 158	2	CAPSCREW, Dust Plate	BE	106974
X 208	2	NUT, Flywheel Housing Dowel Bolt	BE	103028
*	2	NUT, Flywheel Taper Pin	BE	103029
X 504	2	LOCKWASHER, Flywheel Housing	BE	103323
X 504	4	LOCKWASHER, Flywheel Housing Capscrew	BE	103323
X 510	5	LOCKWASHER, Flywheel Bolt	BE	106500
*	1	PLUG, Flywheel Housing Pipe 1"	BE	103876

* Not Illustrated.

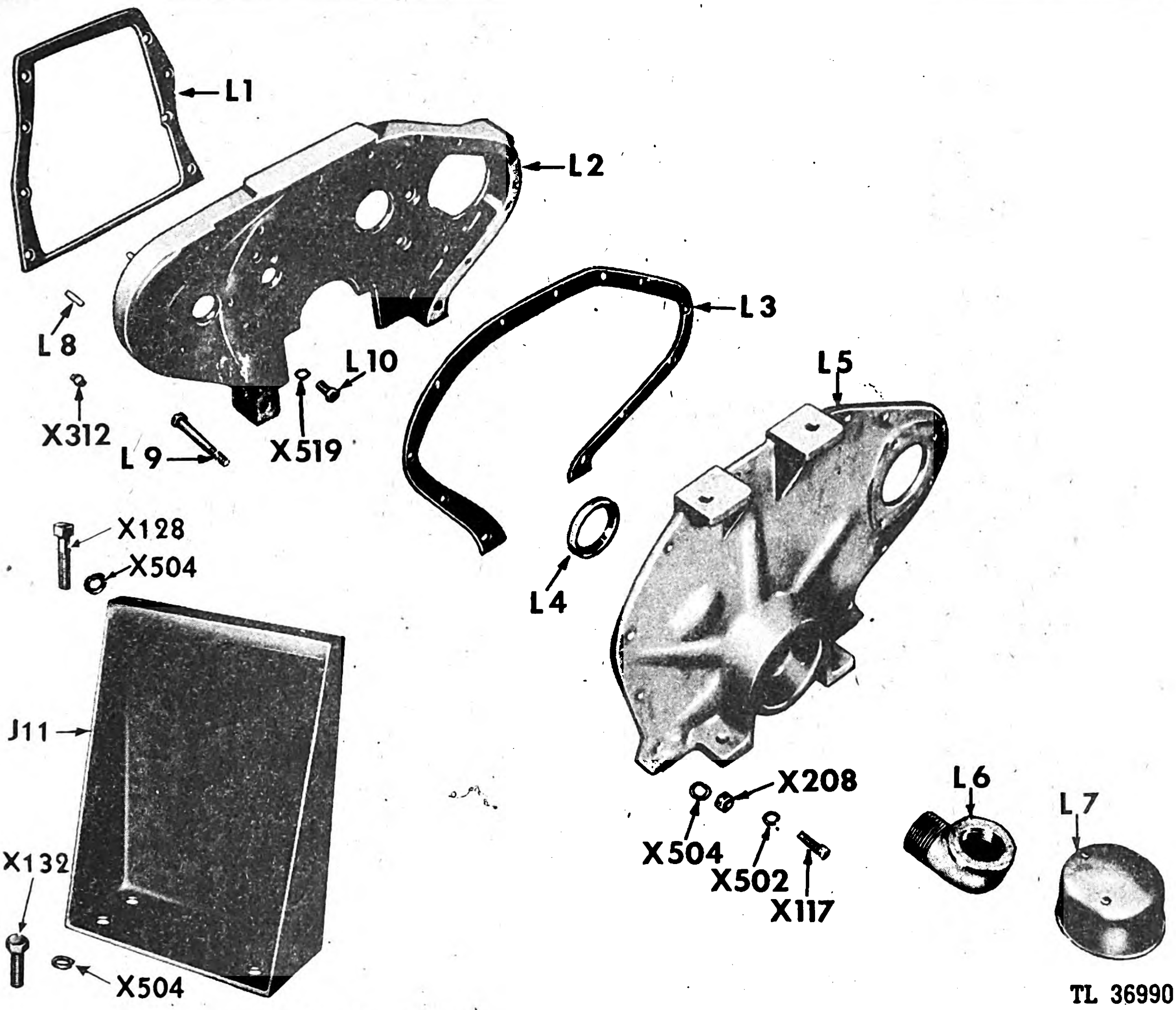


Fig. 338. Gear Housing Cover and Front Support Assembly

121. Gear Housing Cover and Front Support Assembly

Ref. No.	*Quantity*	*Description*	*Mfr.*	*Symbol*
L 1	1	GASKET, Front End Gear Housing	BE	5044
L 2	1	HOUSING, Front End Gear	BE	DE-42504
L 3	1	GASKET, Front End Gear Housing Cover.	BE	DE-4065
L 4	1	SEAL, Gear Housing Cover Oil	BE	PA-117
L 5	1	COVER, Front End Gear Housing	BE	DE-4739
*	1	PLATE, Gear Housing Baffle	BE	4447
L 6	1	FILLER, Oil—Same as Q9	BE	DP-445
L 7	1	ASSEMBLY, Oil Filler Cap—Same as Q10	BE	GE-1074
L 8	5	STUD, Fuel Injection Pump Adaptor	BE	....
L 9	2	BOLT, Gear Housing Dowel	BE	4052
L 10	6	CAPSCREW, Gear Housing	BE	4054
L 11	1	SUPPORT, Front Engine	BE	DL-3069
*	1	SHIM, Front Engine Support	BE	DL-3214

* Not Illustrated.

121. Gear Housing Cover and Front Support Assembly (Cont'd)

Ref. No.	Quantity	Description	Mfr.	Symbol
X 117	10	CAPSCREW, Gear Housing Cover	BE	100135
X 128	2	CAPSCREW ½"—13 x 1½", Front Support to Engine	BE	100160
X 132	4	CAPSCREW ½"—13 x 1½", Front Support to Base	BE	100159
X 208	2	NUT, Gear Housing Dowel Bolt	BE	103028
X 312	1	PLUG ¼" Slotted, Gear Housing Pipe ...	BE	103884
X 501	2	LOCKWASHER ½", Front Support Capscrew to Engine	BE	
X 502	10	LOCKWASHER, ⅜" Gear Housing Cover Capscrew	BE	103321
X 504	6	LOCKWASHER	BE	103323
X 519	6	LOCKWASHER, Gear Housing Capscrew	BE	115551
*	4	NUT, Front Support Capscrew	BE	102637

122. Idler Gear Assembly

Ref. No.	Quantity	Description	Mfr.	Symbol
*	1	ASSEMBLY, Idler Gear—Serviced as an Assembly only	BE	DE-40942
M 1	1	CAPSCREW, Idler Gear Thrust Washer ..	BE	1458
M 2	1	WASHER, Idler Gear Thrust	BE	3432
M 3 ●	3	CAPSCREW, Fuel Pump Drive Gear	BE	DE-4980
M 4 ●	1	GEAR, Idler	BE	DE-4808
M 5 ●	1	GEAR, Fuel Pump Drive (Included with M 4)	BE	DE-4809
M 6	1	NUT, Idler Gear Lockscrew Shaft	BE	DE-55136
M 7	1	LOCKSCREW, Idler Gear	BE	DE-4134
M 8	1	SHAFT, Idler Gear	BE	4452
*	1	BUSHING, Idler Gear	BE	4220
X 656	1	PIN $\frac{3}{16}$" x ½", Idler Gear Lockscrew	BE	103720
X 672 ●	1	DOWEL, Fuel Pump Drive Gear	BE	141244
X 691	1	GASKET, Idler Gear Lockscrew	BE	105453

● These Parts make up ASSEMBLY DE-40942.
* Not Illustrated.

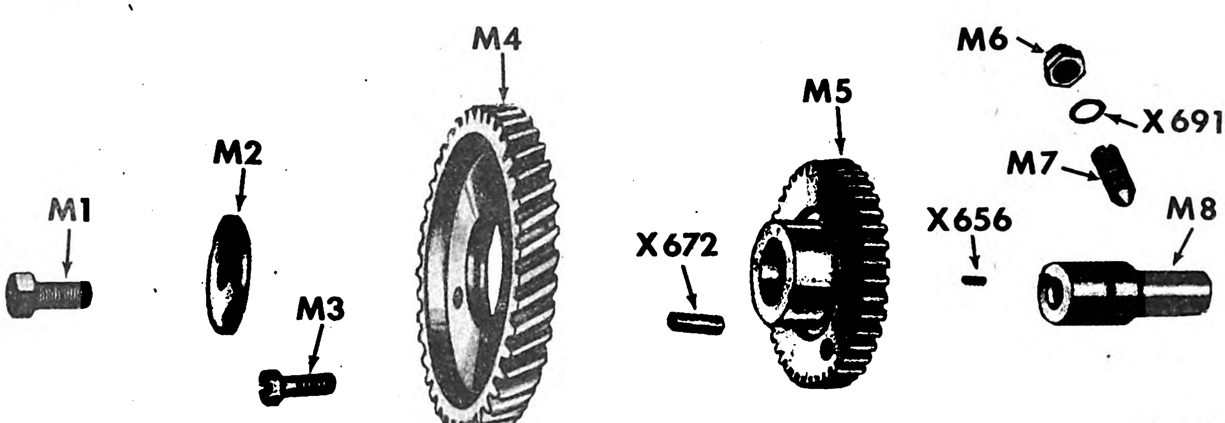
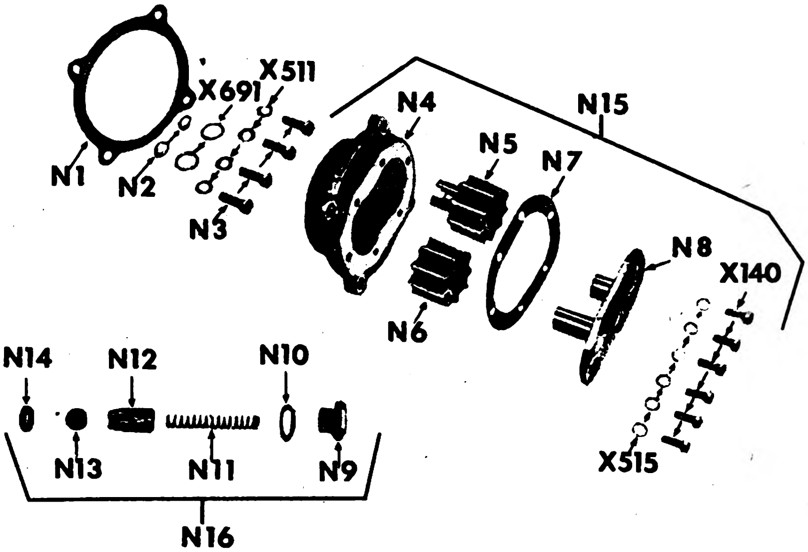


Fig. 339. Idler Gear and Stub Shaft Assembly



TL 36992

Fig. 340. Oil Pump and Oil Pressure Relief Valve Assemblies

123. Lubricating System

Ref. No.	*Quantity*	*Description*	*Mfr.*	*Symbol*
N 1	1	GASKET, Oil Pump (To Case)	BE	1546
N 2	2	DOWEL, Oil Pump (To Case)	BE	1547
N 3	4	CAPSCREW, Oil Pump	BE	2516
N 4 ●	1	BODY, Oil Pump	BE	5896
* ●	1	PIN, Oil Pump Body	BE	1535
N 5 ●	1	GEAR, Oil Pump Drive with Bushing	BE	5879-S
* ●	1	BUSHING, Oil Pump Drive Gear	BE	1563
N 6 ●	1	GEAR, Oil Pump Idler with Bushing	BE	5880-S
* ●	1	BUSHING, Oil Pump Idler Gear	BE	1562
N 7 ●	1	GASKET, Oil Pump Body Cover	BE	1508
N 8 ●	1	ASSEMBLY, Oil Pump Body Cover	BE	5899
N 9	1	CAP, Oil Pressure Relief Valve	BE	5529
N 10	1	GASKET, Oil Pressure Relief Valve Cap .	BE	1530
N 11	1	SPRING, Oil Pressure Relief Valve	BE	3547
N 12	1	SLEEVE, Oil Pressure Relief Valve	BE	DE-40317
N 13	1	BALL, Oil Pressure Relief Valve	BE	104924
N 14	1	SEAT, Oil Pressure Relief Valve	BE	DE-40318
N 15	1	ASSEMBLY, Oil Pump	BE	5895
X 140 ●	6	CAPSCREW ¼"—20 x ⅝", Oil Pump Body Cover	BE	106319
X 511	4	LOCKWASHER, Oil Pump Capscrew	BE	108579
X 515 ●	6	WASHER ¼", Oil Pump Capscrew	BE	114604
X 691	2	GASKET, Oil Pump Dowel	BE	105453
* ●	1	PLUG, Oil Pump Body Welch	BE	103892

● Included in Assembly 5895 (N 15).

* Not Illustrated.

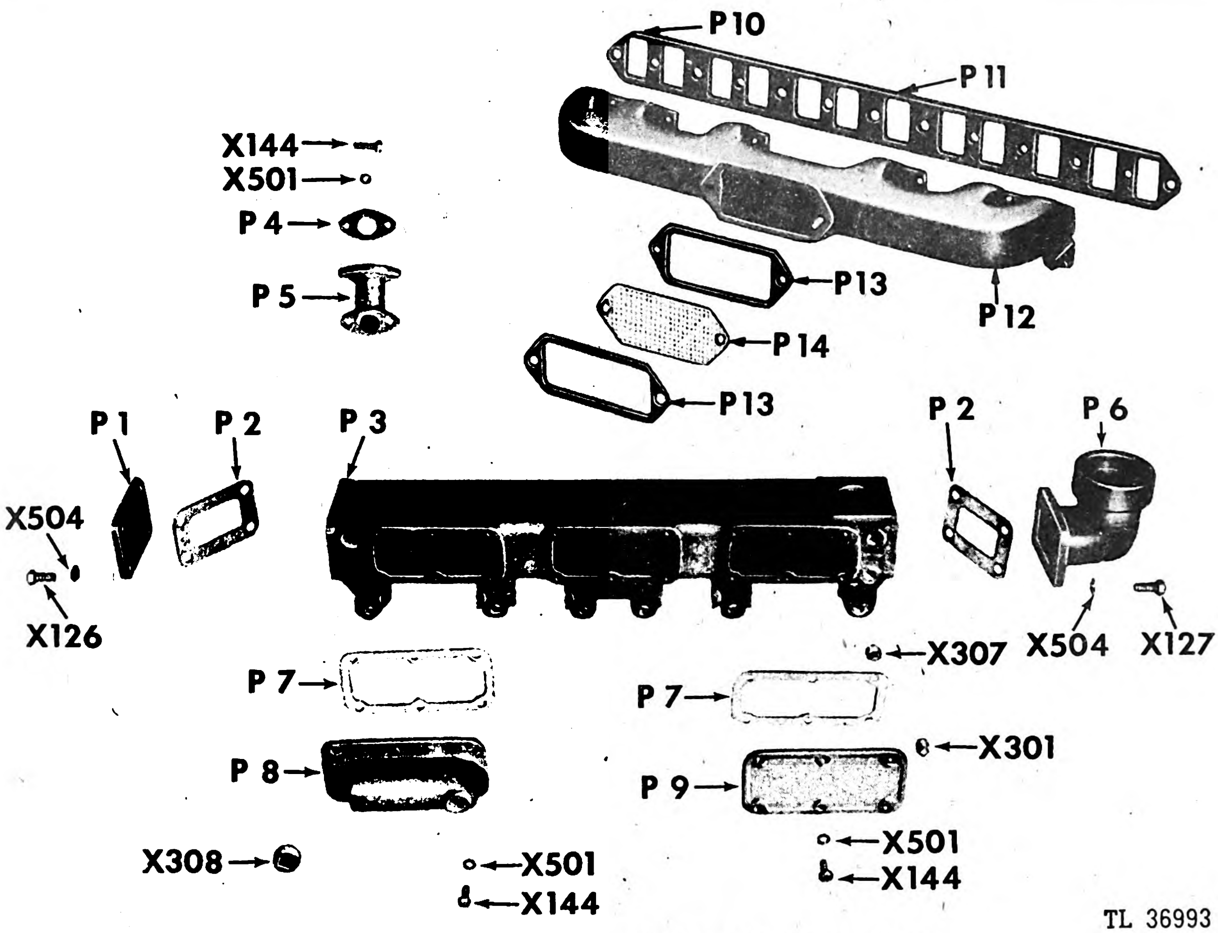


Fig. 341. Intake and Exhaust Manifold Assemblies

124. Manifold (Intake and Exhaust) Assemblies

Ref. No.	Quantity	Description	Mfr.	Symbol
P 1	1	FLANGE, Exhaust Manifold Blind	BE	DE-4014
P 2	1	GASKET, Exhaust Manifold Blind Flange	BE	DE-4058
P 2	1	GASKET, Exhaust Manifold Elbow	BE	DE-4058
P 3	1	MANIFOLD, Exhaust (Water Cooled)	BE	DE-42578
P 4	12	GASKET, Water Connection	BE	MA-265
P 5	6	CONNECTION, Water	BE	DE-40094
P 6	1	ELBOW, Exhaust Manifold	BE	DE-40991
P 7	3	GASKET, Exhaust Manifold Cover Plate	BE	DE-4016
P 8	1	HOUSING, Exhaust Manifold Cover and Temperature Bulb	BE	DE-42579
P 9	2	PLATE, Exhaust Manifold Cover	BE	DE-4013
P 10	2	GASKET, Intake and Exhaust Manifolds—End	BE	DE-41189

124. Manifold (Intake and Exhaust) Assemblies (Cont'd)

Ref. No.	Quantity	Description	Mfr.	Symbol
P 11	2	GASKET, Intake and Exhaust Manifolds—Intermediate	BE	DE-41188
P 12	1	MANIFOLD, Intake	BE	DE-40061
P 13	2	GASKET, Air Heater Housing	BE	DE-40371
P 14	1	SCREEN, Air Heater Housing	BE	DE-40938
*	2	STUD, Air Heater to Intake Manifold	BE	RE-106
X 126	4	CAPSCREW, Exhaust Manifold Blind Flange	BE	100158
X 127	4	CAPSCREW, Exhaust Manifold Elbow	BE	100159
X 144	24	CAPSCREW, Exhaust Manifold to Plate	BE	106325
X 144	18	CAPSCREW, Exhaust Manifold Cover and Temperature Bulb Housing	BE	106325
*	1	PLUG, Exhaust Manifold Water Drain	BE	103866
X 301	1	PLUG ¾" Countersunk, Exhaust Manifold Water Drain	BE	103875
X 307	1	PLUG ½" Countersunk, Exhaust Manifold Pipe	BE	103874
X 308	2	PLUG, Exhaust Manifold	BE	106642
X 501	18	LOCKWASHER, Exhaust Manifold Cover and Temperature Bulb Housing Capscrew	BE	103320
X 501	24	LOCKWASHER, Water Connection Capscrew	BE	103320
X 504	4	LOCKWASHER, Exhaust Manifold Elbow	BE	103323
X 504	18	LOCKWASHER, Exhaust Manifold Cover Plate	BE	103323
X 504	4	LOCKWASHER, Exhaust Manifold Blind Flange	BE	103323
*	13	NUT, Manifold Stud	BE	121932
*	13	WASHER, Manifold Stud	BE	DE-40036

* Not Illustrated.

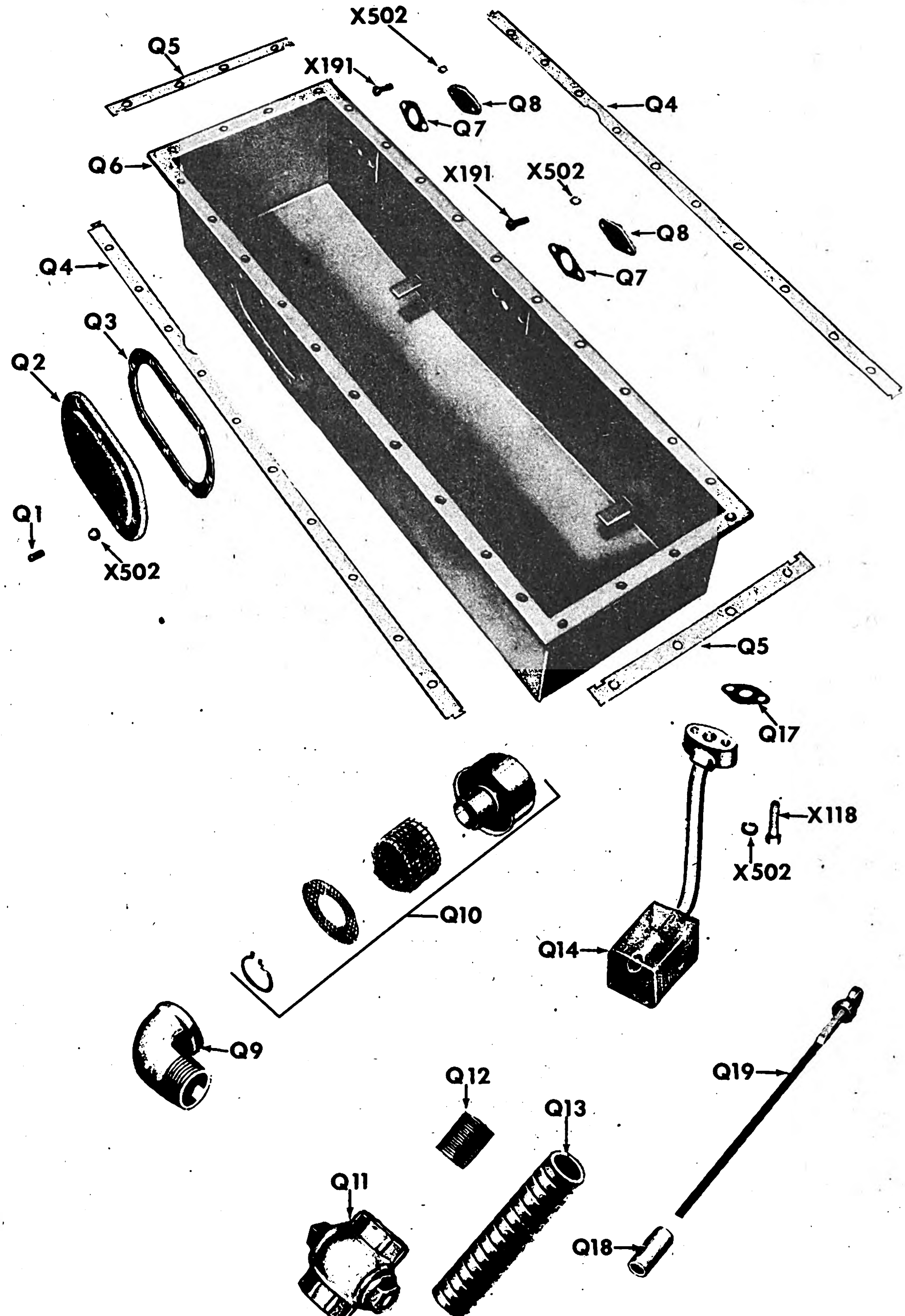


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Fig. 342. Oil Pan, Breather and Screen

125. Oil Pan and Breather Assemblies

Ref. No.	Quantity	Description	Mfr.	Symbol
Q 1	8	STUD, Oil Pan Handhole Cover (Replaces Capscrew)	BE	4040
Q 2	1	COVER, Oil Pan Handhole	BE	M-60507
Q 3	1	GASKET, Oil Pan Handhole Cover	BE	M-60508
Q 4	2	GASKET, Oil Pan—Sides	BE	4539
Q 5	2	GASKET, Oil Pan—Ends	BE	4541
Q 6	1	PAN, Oil—Special Deep—Assembly	BE	DE-42534
Q 7	2	GASKET, Oil Pan Hole Cover	BE	M-60576
Q 8	2	COVER, Oil Pan Hole	BE	DE-42699
Q 9	1	FILLER, Oil (same as L6)	BE	DP-445
Q 10	1	ASSEMBLY, Oil Filler Cap (same as L7)	BE	GE-1074
Q 11	1	COCK, Oil Pan Drain Stop	BE	PA-437
Q 12	1	§ NIPPLE, Oil Pan, 1" x 2½" long	BE	PA-447
Q 13	1	TUBING, Oil Pan Flexible, 1" I.D. x 6¼"	BE	PA-438
Q 14	1	ASSEMBLY, Screen	BE	DE-42603
Q 17	1	GASKET, Oil Pump Suction Flange	BE	5526
Q 18	1	TUBE, Oil Level Gauge Assembly	BE	DE-42934
Q 19	1	GAUGE, Oil Level	BE	DE-42535
X 118	2	CAPSCREW, Oil Pump Suction Flange	BE	100136
X 191	4	CAPSCREW ⅜"—16 x 1", Oil Pan Hole Cover	BE	100134
X 207	8	NUT, Oil Pan Handhole Cover Stud (not illustrated)	BE	103026
X 502	4	LOCKWASHER ⅜", Oil Pan Hole Cover Capscrew	BE	103321
X 502	2	LOCKWASHER, Oil Pump Suction Flange	BE	103321
X 502	8	LOCKWASHER, Oil Pan Handhole Cover Stud	BE	103321
*	23	CAPSCREWS, Oil Pan to Case	BE	100134
*	28	LOCKWASHERS, Oil Pan to Case Capscrews	BE	103321
*	1	LUG, Oil Pan Ground	BE	DE-55547

* Not Illustrated.

§ Replaces Old Style Oil Pan Drain Pipe Assembly.

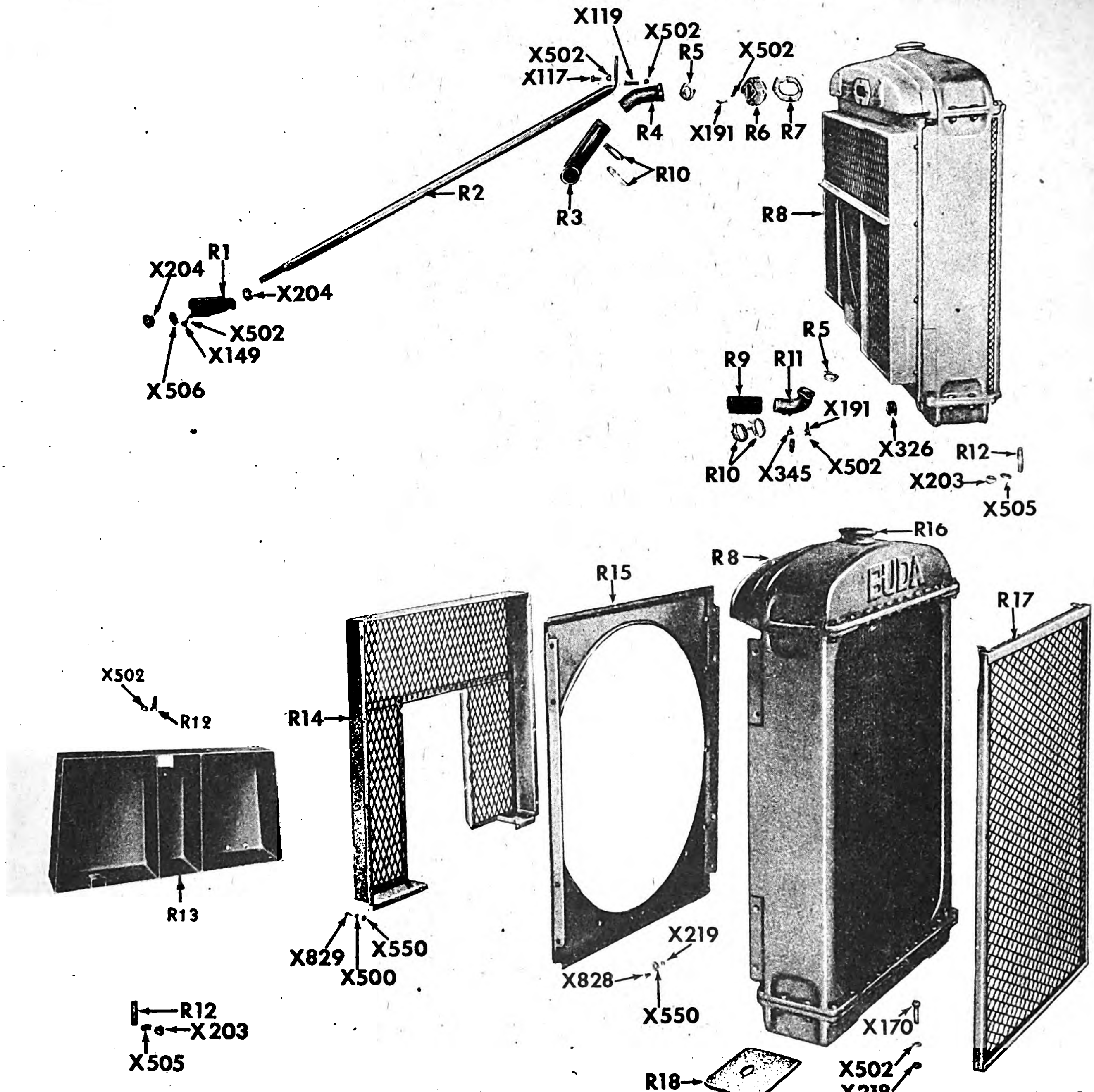

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Fig. 343. Radiator Assembly and Support

126. Radiator Assembly

Ref. No.	*Quantity*	*Description*	*Mfr.*	*Symbol*
R 1	1	ASSEMBLY, Radiator Tie Rod Bracket ...	BE	DE-42712
R 2	1	ASSEMBLY, Radiator Tie Rod	BE	DP-2710
R 3	1	HOSE, Inlet	BE	DP-2752
R 4	1	INLET, Radiator	BE	DP-2746
R 5	1	GASKET, Outlet	BE	1645

126. Radiator Assembly (Cont'd)

Ref. No.	Quantity	Description	Mfr.	Symbol
R 5	1	GASKET, Inlet	BE	1645
R 6	1	ADAPTOR, Radiator Inlet	YR	DP-436
R 7	1	GASKET, Adaptor	YR	DP-437
R 8	1	RADIATOR (Perfex—R6233)	PRX	DL-3023
R 9	1	HOSE, Radiator Outlet	BE	DP-528
R 10	2	CLAMP, Outlet Hose	BE	AP-6081
R 10	2	CLAMP, Inlet Hose	BE	AP-6081
R 11	1	PIPE, Radiator Outlet	BE	DP-964
R 12	2	CAPSCREW, Radiator Mounting	BE	100183
R 13	1	SUPPORT, Assembly Radiator	BE	DL-3066
R 14 ●	1	GUARD, Radiator	PRX	A11-69
R 15 ●	1	SHROUD, Radiator	PRX	A6-84
R 16 ●	1	CAP, Radiator	PRX	G-13500
R 17 ●	1	SCREEN, Radiator	PRX	A12-74
R 18	2	PAD, Radiator Shim		AP-3163
X 117	2	CAPSCREW, Inlet Pipe and Tie Support	BE	100135
*	1	CAPSCREW, Radiator Support to Base	BE	100159
X 119	1	CAPSCREW, Radiator Inlet	BE	100136
X 149	3	CAPSCREW 3/8"—16 x 1 1/8"	BE	106331
X 191	2	CAPSCREW, Radiator Outlet	BE	100134
X 191	3	CAPSCREW, Radiator Inlet Adaptor	BE	100134
X 204	2	NUT, Radiator Tie Rod 3/4" I.D.	BE	102640
X 219	8	NUT 1/4"—20 Hex Head, Shroud Capscrew	BE	114378
X 243	1	NUT, Radiator Support Capscrew	BE	117062
X 502	3	LOCKWASHER, Capscrew Radiator Inlet Adaptor	BE	103321
X 502	2	LOCKWASHER, Outlet Capscrew	BE	103321
X 502	1	LOCKWASHER, Inlet Capscrew Radiator.	BE	103321
X 502	2	LOCKWASHER, Capscrew Inlet Pipe and Tie Support	BE	103321
X 502	4	LOCKWASHER, 3/8", Radiator Tie Rod Bracket Capscrew	BE	103321
*	5	LOCKWASHER, Support Capscrew	BE	103323
X 505	2	LOCKWASHER, Radiator Stud	BE	103325
X 506	2	LOCKWASHER, Radiator Tie Rod Nut 3/4"	BE	103326
*	1	REDUCER, Radiator Drain Cock	BE	PA-52
*	1	COCK, Drain 1/4"	BE	4045
*	2	CAPSCREW, Radiator Tie Rod Bracket	BE	100146
*	3	NUT, Radiator Tie Rod Bracket	BE	103026
*	2	LOCKWASHER, Radiator Tie Rod Capscrew	BE	103322
*	1	WASHER, Plain 5/8" Tie Rod	BE	106267

● Included in DL-3023, reference number R 8.

* Not Illustrated.

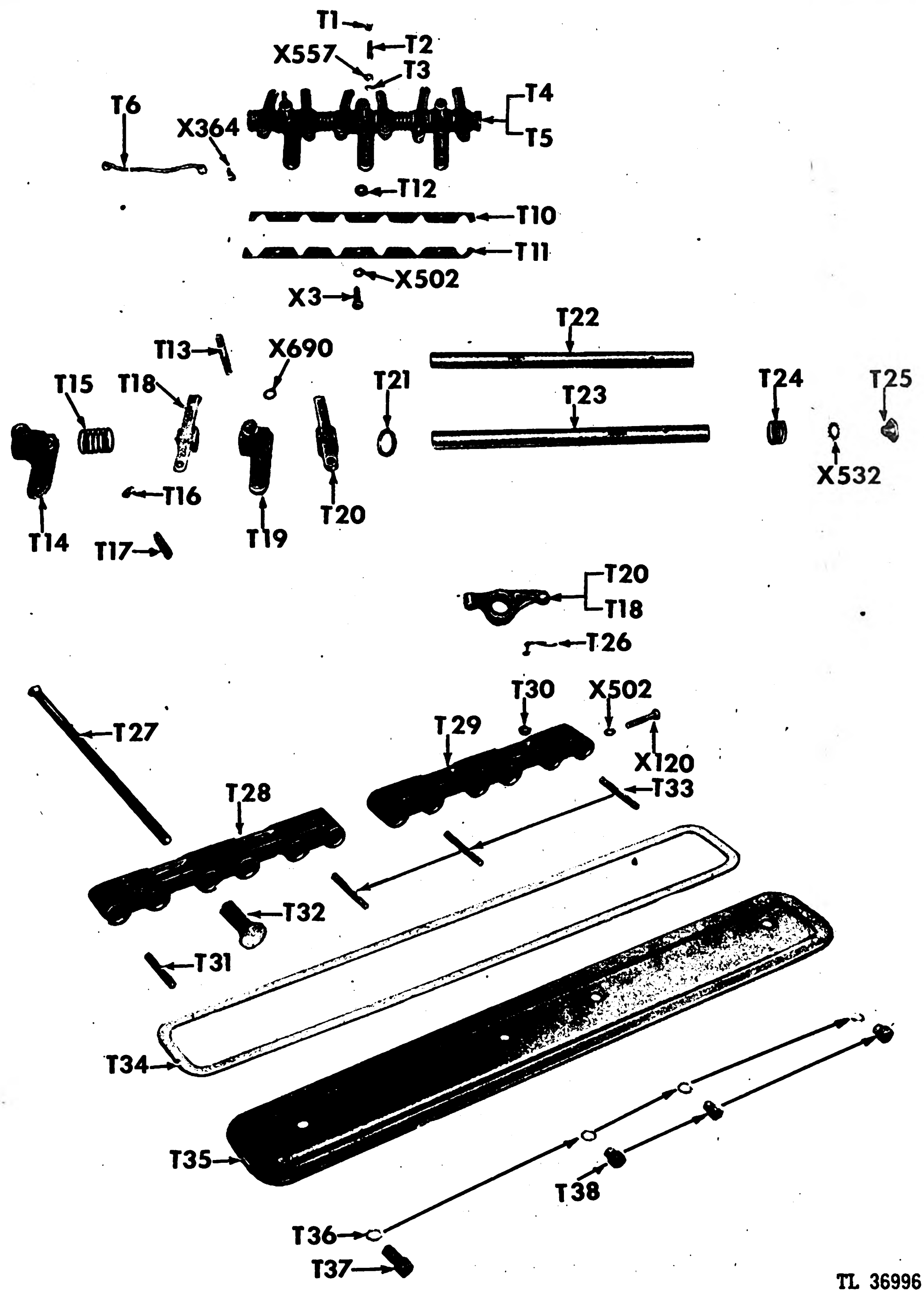

Fig. 344. Rocker Arm Push Rod and Lifter Assemblies

127. Rocker Arm and Lifter Assembly

Ref. No.	Quantity	Description	Mfr.	Symbol
T 1	6	NUT, Rocker Arm Assembly Stud	BE	DE-41286
T 2	4	STUD, Rocker Arm Assembly and Cylinder Head Cover	BE	DE-55119
T 3	6	WASHER, Rocker Arm Assembly Stud ...	BE	5493
T 4	1	ASSEMBLY, Rocker Arm—Front Not Serviced as an Assembly		
T 5	1	ASSEMBLY, Rocker Arm—Rear Not Serviced as an Assembly		
T 6	1	ASSEMBLY, Oil Line—Front Rocker Arm Shaft to Rear Rocker Arm Shaft	BE	DE-41603
T 10, T 11	4	GUIDE, Push Rod Plate	BE	5981
T 12	4	DOWEL, Rocker Arm Bracket	BE	DE-5284
T 13	2	LOCKSCREW, Rocker Arm Assembly and Cylinder Head Cover Stud	BE	DE-40069
T 14	4	BRACKET, Rocker Arm—Front and Rear .	BE	DE-40009
T 15	4	SPRING, Rocker Arm Shaft Spacer—Intermediate	BE	DE-40963
T 16	12	NUT, Rocker Arm Adjusting Screw	BE	1304
T 17	12	SCREW, Rocker Arm Adjusting	BE	DE-4051
T 18	6	ARM, Rocker—Left Hand with Bushing ..	BE	5507-S
T 19	2	BRACKET, Rocker Arm—Center	BE	5412
T 20	6	ARM, Rocker—Right Hand with Bushing .	BE	5506
T 21	28	WASHER, Rocker Arm Shaft—Bronze	BE	5940
T 22	1	SHAFT, Rocker Arm—Rear	BE	5532
T 23	1	SHAFT, Rocker Arm—Front	BE	5533
T 24	4	SPRING, Rocker Arm Shaft Spacer—End .	BE	5405
T 25	4	PLUG, Rocker Arm Shaft—End	BE	DE-40962
T 26	12	WICK, Rocker Arm	BE	5510
T 27	12	ASSEMBLY, Valve Push Rod	BE	DE-40955
T 28	1	BRACKET, Valve Lifter—Rear (R.H.)	BE	DE-40010
T 29	1	BRACKET, Valve Lifter—Front (L.H.)	BE	DE-40018
T 30	6	DOWEL, Valve Lifter Bracket	BE	1305
T 31	1	STUD, Valve Cover Plate—Front	BE	1357
T 32	12	LIFTER, Valve	BE	DE-40954
T 33	3	STUD, Valve Cover Plate	BE	4357
T 34	1	GASKET, Valve Cover Plate	BE	4033
T 35	1	PLATE, Valve Cover	BE	4070
T 36	4	GASKET, Valve Cover Plate Stud	BE	1359
T 37	1	NUT, Valve Cover Plate Stud—Front	BE	DE-40209
T 38	3	NUT, Valve Cover Plate Stud	BE	2065
*	12	BUSHING, Rocker Arm	BE	DE-4024

* Not Illustrated.

127. Rocker Arm and Lifter Assembly (Cont'd)

Ref. No.	Quantity	Description	Mfr.	Symbol
X 3	12	CAPSCREW, Push Rod Guide-Plate and Rocker Arm Bracket	BE	100134
X 120	6	CAPSCREW, Valve Lifter Bracket	BE	100138
X 364	2	ELBOW, Oil Line Assembly	BE	121370
X 502	6	LOCKWASHER, Valve Lifter Bracket Capscrew	BE	103321
X 502	12	LOCKWASHER 3/8", Rocker Arm Bracket Capscrew	BE	103321
X 532	4	LOCKWASHER, Rocker Arm Shaft End Plug	BE	114756
X 557	6	WASHER, Rocker Arm Assembly Stud (Cylinder Head Cover)	BE	106263
X 690	2	GASKET, Center Rocker Arm Bracket to Cylinder Head	BE	105451
*	1	NUT, Rocker Arm Shaft Oil Line 3/16" Tube	BE	120487
*	1	SLEEVE, Rocker Arm Shaft Oil Line 3/16" Tube	BE	120488

128. Valve Assembly

Ref. No.	Quantity	Description	Mfr.	Symbol
V 1 ● #	12	CUP, Valve Spring Retainer	BE	1313
V 2 ● #	12	SPRING, Valve	BE	DE-40025
V 3 ● # §	12	GUIDE, Valve Stem	BE	5984
V 4 ● #	6	VALVE, Intake	BE	DE-41531
V 5 ● #·§	6	INSERT, Exhaust Valve	BE	DE-40462
V 6 ● #	12	RING, Valve Retaining	BE	5987
V 7 ● #	12 prs.	LOCK, Valve Spring Retainer	BE	H-12280
V 8 ● #	6	VALVE, Exhaust	BE	DE-41536

* Not Illustrated.
● Included in Assembly DE-40943—See page 217.
Included in Assembly DE-40943-B—see page 217.
§ Included in Assembly DE-40943-A—see page 217.

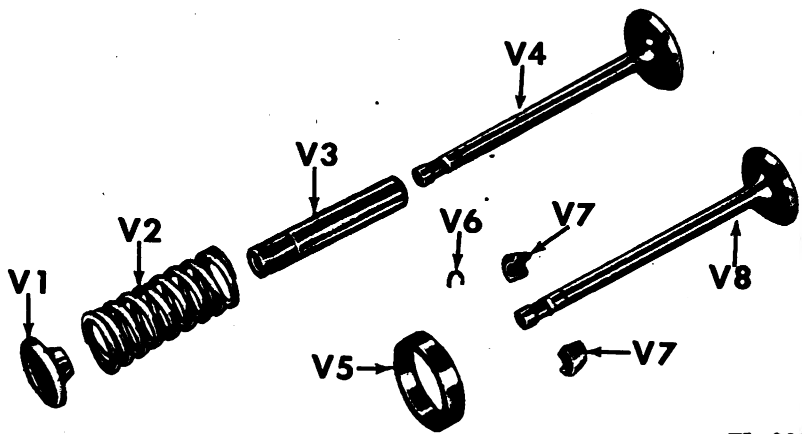

Fig. 345. Intake and Exhaust Valve Assembly

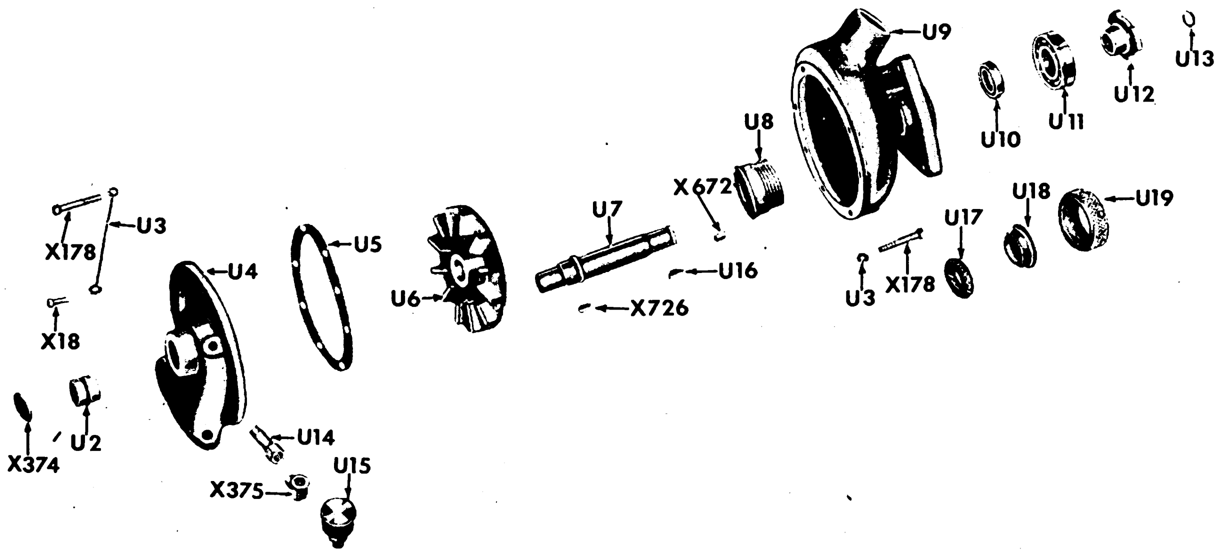

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Fig. 346. Exploded View—Water Pump

129. Water Pump Assembly

Ref. No.	*Quantity*	*Description*	*Mfr.*	*Symbol*
U 1	1	ASSEMBLY, Water Pump (Figure 347) ...	BE	DE-42217
U 2	1	BUSHING, Water Pump Cover	BE	DE-50468
U 3	8	GASKET, Water Pump Cover Capscrew .	BE	DE-233
U 4	1	COVER, Water Pump	BE	DE-5356
U 5	1	GASKET, Water Pump Cover	BE	DE-5358
U 6	1	IMPELLER, Water Pump	BE	DE-5361
U 7	1	SHAFT, Water Pump	BE	DE-42729
U 8	1	RETAINER, Water Pump Body Packing ..	BE	DE-55305
U 9	1	BODY, Water Pump	BE	DE-5355
U 10	1	SEAL, Water Pump Oil	BE	DE-4084
U 11	1	BEARING, Water Pump Drive (Gurney 206-C)	BE	PA-1
U 12	1	SPIDER, Water Pump Drive	BE	DE-5362
U 13	1	LOCKWIRE, Water Pump Drive Spider ..	BE	DE-5363
U 14	1	PIPE, Water Pump Grease Cup Extension.	BE	....
U 15	1	CUP, Water Pump Grease	BE	DE-5482
U 16	1	KEY, Water Pump Impeller	BE	1654
U 17	1	PACKING, Water Pump	BE	2687
U 18	1	GLAND, Water Pump Packing	BE	2692
U 19	1	NUT, Water Pump Packing Gland	BE	2691
X 18	6	CAPSCREW, Water Pump Cover	BE	114354
X 178	2	CAPSCREW, Water Pump Cover	BE	100113
X 374	1	PLUG, Water Pump Expansion 1⅛"	BE	106517
X 375	1	ELBOW, Water Pump Grease Cup, Street	BE	PA-74
X 672	1	DOWEL, Water Pump Body	BE	141342
X 726	1	KEY, Water Pump Drive Spider	BE	106750
*	1	NUT, Water Pump Cover Capscrew	BE	109084
*	1	RING, Water Pump Shaft Impeller Snap .	BE	K-40314

* Not Illustrated.

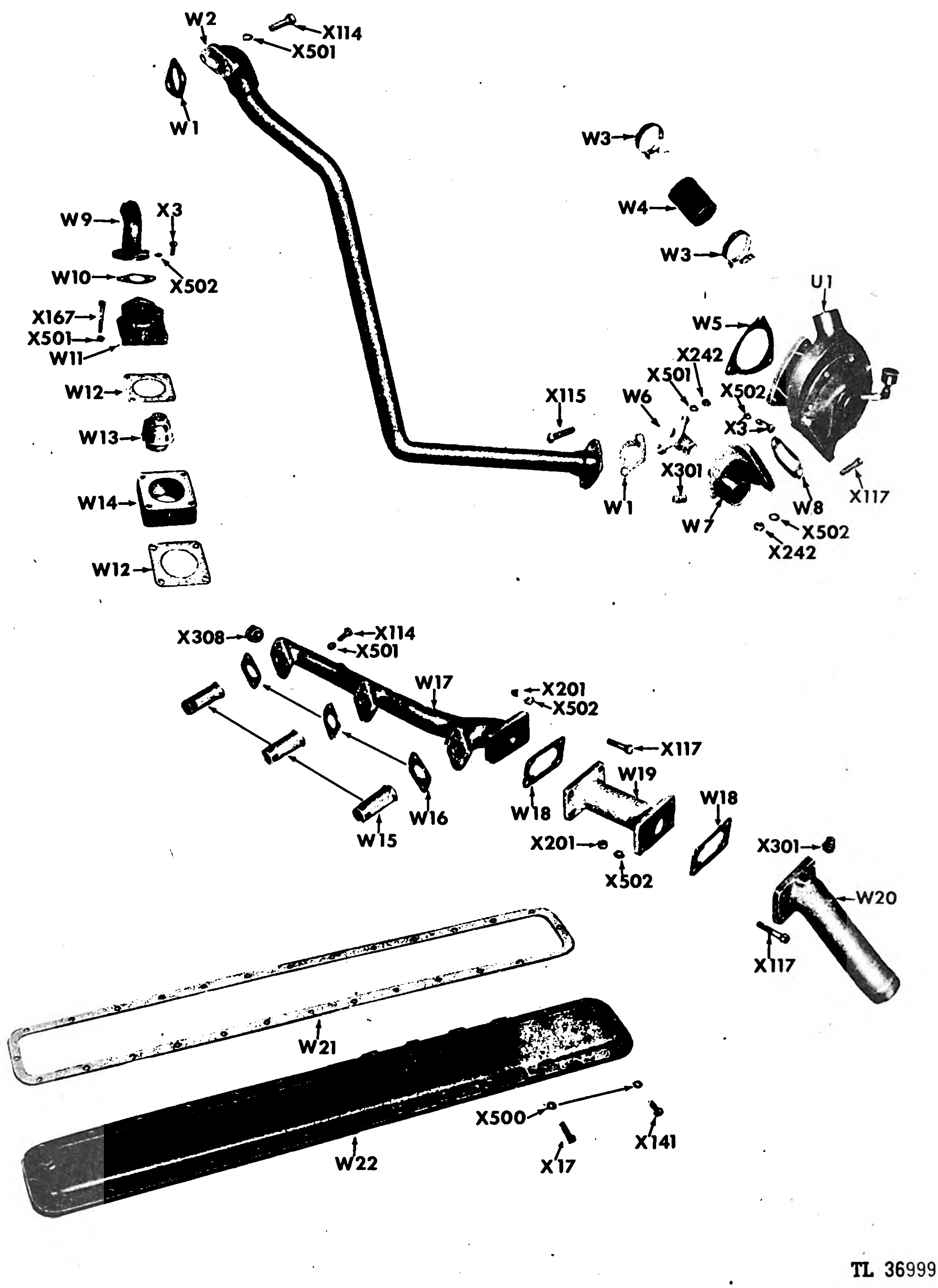

Fig. 347. Water Distributing Parts

130. Water Distributing Parts

Ref. No.	Quantity	Description	Mfr.	Symbol
W 1	2	GASKET, By-Pass Line	BE	MA-265
W 2	1	LINE, Water Pump By-Pass	BE	DE-42540
W 3	2	CLAMP, Water Pump Outlet Hose	BE	AP-6081
W 4	1	HOSE, Water Pump Outlet	BE	DE-4215
W 5	1	GASKET, Water Pump to Engine	BE	DE-4087
W 6	1	ELBOW, Water Inlet Connection	BE	H-12227
W 7	1	CONNECTION, Water Pump Inlet	BE	DE-50373
W 8	1	GASKET, Water Inlet Connection	BE	DE-5365
W 9	1	PIPE, Water Outlet	BE	DP-1563
W 10	1	GASKET, Water Outlet Pipe	BE	1645
W 11	1	HOUSING, Thermostat	BE	DE-55080
W 12	2	GASKET, Thermostat Housing Adaptor	BE	DE-50333
W 13	1	THERMOSTAT	BE	DE-50299
W 14	1	ADAPTOR, Thermostat Housing	BE	DE-51556
W 15	3	DISTRIBUTOR, Cylinder Water Inlet Manifold	BE	DE-40727
W 16	3	GASKET, Cylinder Water Inlet Manifold	BE	MA-265
W 17	1	MANIFOLD, Cylinder Water Inlet	BE	DE-40045
W 18	2	GASKET, Cylinder Water Inlet Manifold Adaptor	BE	DE-4070
W 19	1	ADAPTOR, Cylinder Water Inlet Manifold	BE	DE-40221
W 20	1	CONNECTION, Cylinder Water Inlet Manifold	BE	DE-40044
W 21	1	GASKET, Cylinder Water Jacket Cover	BE	4058
W 22	1	COVER, Cylinder Water Jacket	BE	DE-40263
X 3	5	CAPSCREW, Water Pump to Engine	BE	100134
X 17	8	CAPSCREW ¼"—20 x 1⅛", Cylinder Water Jacket Cover	BE	106321
X 114	2	CAPSCREW, By-Pass Line	BE	100122
X 114	6	CAPSCREW, Cylinder Water Inlet Manifold	BE	100122
X 115	2	CAPSCREW, By-Pass Line	BE	100123
X 117	2	CAPSCREW, Water Inlet Connection	BE	100135
X 117	4	CAPSCREW ⅜"—16 x 1¼", Cylinder Water Inlet Manifold Connection	BE	100135
X 117	4	CAPSCREW, Cylinder Water Inlet Manifold Adaptor	BE	100135
X 141	20	CAPSCREW ¼"—20 x ⅞", Cylinder Water Jacket Cover	BE	106320
X 167	4	CAPSCREW, Thermostat Housing	BE	108617
X 201	4	NUT, Cylinder Water Inlet Manifold Adaptor Capscrew	BE	102635
X 201	4	NUT, Cylinder Water Inlet Manifold Connection	BE	102635
X 242	2	NUT, Water Inlet Connection	BE	117061

130. Water Distributing Parts (Cont'd)

Ref. No.	Quantity	Description	Mfr.	Symbol
*	2	NUT, By-Pass Line Capscrew	BE	103866
X 301	1	PLUG, 1/4" Cylinder Water Inlet Manifold Connection	BE	103866
X 308	1	PLUG 3/4", Water Manifold End	BE	103875
X 500	28	LOCKWASHER 1/4", Cylinder Water Jacket Cover Capscrew	BE	103319
X 501	10	LOCKWASHER, Cylinder Water Inlet Manifold Capscrew	BE	103320
X 501	4	LOCKWASHER, By-Pass Line	BE	103320
X 502	4	LOCKWASHER, Water Inlet Connection	BE	103321
X 502	3	LOCKWASHER, Water Pump to Engine	BE	103321
X 502	4	LOCKWASHER, Cylinder Water Inlet Manifold Connection Capscrew	BE	103321
X 502	4	LOCKWASHER, Cylinder Water Inlet Manifold Adaptor Capscrew	BE	103321

131. Air Intake System

Ref. No.	Quantity	Description	Mfr.	Symbol
AA 1	1	STUD, Air Cleaner	UTS	US-A-7322
AA 2	1	ASSEMBLY, Air Cleaner (Upper Half)	UTS	US-8453
AA 3	1	ASSEMBLY, Air Cleaner (Lower Half)	UTS	US-B-7351
AA 4	1	GASKET, Air Cleaner	UTS	US-A-7156
AA 5	1	SLEEVE, Air Cleaner Detachable (less Clamp Assembly)	UTS	US-A-10874
AA 6	1	CLAMP, Air Cleaner Sleeve	UTS	US-A-10743
AA 7	1	CONNECTION, Air Cleaner Inlet	BE	DE-42563
AA 8	1	GASKET, Air Cleaner Inlet Connection	BE	DE-40372
AA 9	2	BUSHING, Air Heater Terminal Capscrew	BE	DE-50776
AA 10	1	FRAME, Air Heater Section (Left Hand)	BE	DE-40758
AA 11	1	RIBBON, Air Heater Element	BE	DE-55480
AA 12	1	FRAME, Air Heater Section (Right Hand)	BE	DE-40757
AA 13	1	LOCKWASHER, Air Heater Terminal—1/4"	BE	DE-50779
AA 14	1	CAPSCREW, Air Heater Terminal—1/4"—20 x 1 7/8"	BE	DE-50777
AA 15	1	HOUSING, Air Heater	BE	DE-40648
AA 16	4	WASHER, Air Heater Bolt Terminal (Copper)	BE	DE-40903
AA 17	4	WASHER, Air Heater Bolt Terminal (Mica)	BE	DE-40236
AA 18	2	BUSHING, Air Heater Bolt Terminal (Mica)	BE	DE-40258
AA 19	2	BOLT, Air Heater Terminal	BE	DE-40895
AA 20	1	CONNECTOR, Air Heater Terminal	BE	DE-40896
AA 21	2	CAPSCREW, Air Heater Bolt Terminal	BE	DE-40897
AA 22	2	CONNECTION, Air Heater Terminal Bolt	BE	DE-50781
AA 23	1	SWITCH, Air Heater	BE	1715
AA 24	1	ASSEMBLY, Air Cleaner (H95-83615)	UTS	DE-55602

* Not Illustrated.

131. Air Intake System (Cont'd)

Ref. No.	*Quantity*	*Description*	*Mfr.*	*Symbol*
AA 25	1	ASSEMBLY, Air Heater	BE	DE-42832
X 110	2	CAPSCREW, Air Heater Switch		106972
X 201	4	NUT 3/8"—16, Air Cleaner Inlet Connection Capscrew	BE	102635
X 207	2	NUT, Air Heater Housing Stud	BE	103026
X 214	2	NUT, Air Heater Switch Capscrew		117060
X 220	1	NUT 1/4"—20, Air Heater Terminal Capscrew	BE	114379
X 257	4	NUT, Air Heater Bolt Terminal	BE	122006
X 500	2	LOCKWASHER, Air Heater Switch Capscrew		103319
X 502	2	LOCKWASHER, Air Heater Housing Stud.	BE	103321
X 502	4	LOCKWASHER, 3/8", Air Cleaner Inlet Connector Capscrew	BE	103321
*	1	ASSEMBLY, Air Heater Element	BE	DE-56334
*	4	CAPSCREW, Air Heater Inlet Connection.	BE	100134
*	2	BOLT, Air Cleaner Strap	BE	108616
*	2	NUT, Air Cleaner Strap Bolt	BE	109084
*	2	LOCKWASHER, Air Cleaner Strap Bolt ..	BE	103319

* Not Illustrated.

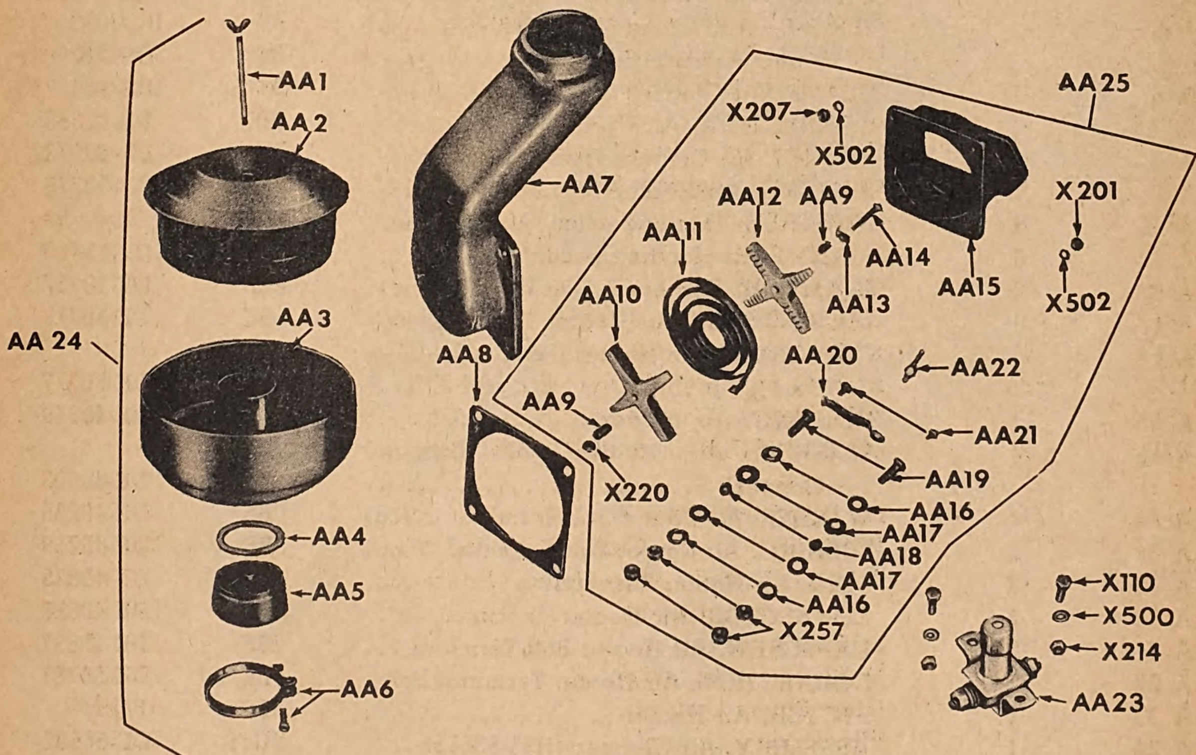

Fig. 348. Air Cleaner Adaptor and Preheater Assemblies

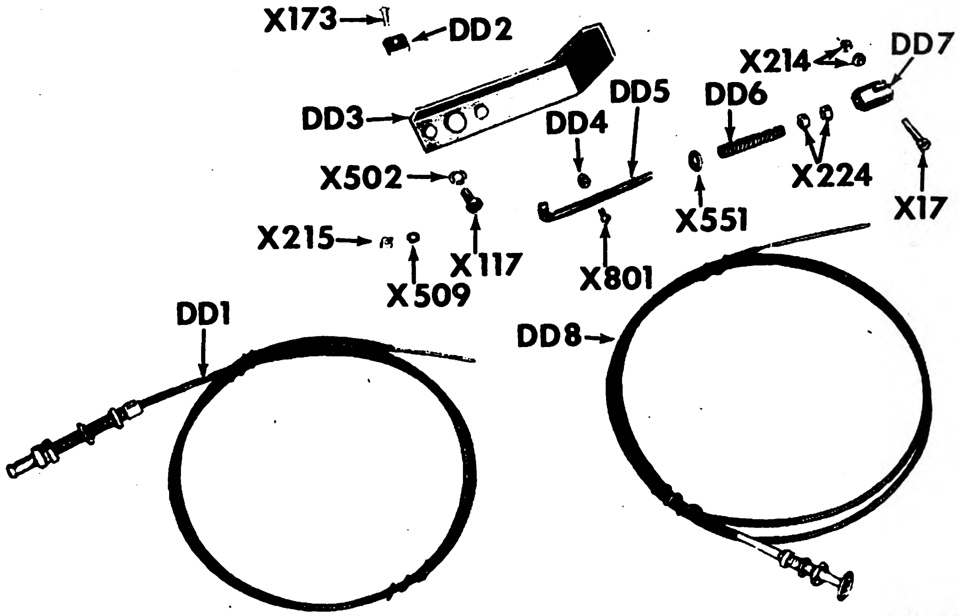

Fig. 349. Engine Controls

132. Engine Controls and Cables

Ref. No.	*Quantity*	*Description*	*Mfr.*	*Symbol*
DD 1	1	CONTROL, Engine Throttle Wire	BE	DP-2101
DD 2	2	CLIP, Throttle Control Cable	BE	AP-6034
DD 3	1	BRACKET, Throttle Control Assembly	BE	DL-3053
DD 4	1	COLLAR, Throttle Cable	BE	AP-4782
DD 5	1	ROD, Throttle Connecting	BE	DL-3154
DD 6	1	SPRING, Throttle Control Rod	BE	3545
DD 7	1	COUPLING, Throttle Control	BE	DE-42707
DD 8	1	CONTROL, Governor Stop	BE	DL-3153
X 17	1	CAPSCREW, Throttle Control Coupling, ¼"—20 x 1⅛" Hex Head	BE	106321
X 117	2	CAPSCREW, Bracket, ⅜"—16 x ⅞"	BE	106330
X 173	1	CAPSCREW, No. 10—24 x ¾" Round Head	BE	110501
X 214	1	NUT, Coupling Capscrew..............	BE	110633
X 215	2	NUT, Coupling Capscrew, No. 10—24 ...	BE	110633
X 224	2	NUT, Throttle Control Rod, 5/16"—8 Hex ..	BE	114502
X 502	2	LOCKWASHER, Throttle Control Bracket Capscrew ⅜"	BE	103321
X 509	1	LOCKWASHER, No. 10	BE	106497
X 551	2	WASHER, Throttle Connecting Rod, 5/16"	BE	103340
X 801	1	SCREW, Throttle Wire Collar—No. 8—32 x ⅜" Round Head	BE	100750
*	1	LOCKWASHER, Throttle Control	BE	106260
*	1	WASHER, Throttle Control	BE	103338
*	3	CLIP, Safety Control	BE	AP-3094
*	1	PIN, Throttle Control	BE	DL-3079
*	1	LOCKWASHER, Safety Control Clip, ¼"	BE	103319

* Not Illustrated.

133. Exhaust System

Ref. No.	*Quantity*	*Description*	*Mfr.*	*Symbol*
EE 1	2	ELBOW, Muffler—3" Pipe 90°	BE	PA-412
EE 2	1	MUFFLER, (Maremont)	MAR	DP-2698
EE 3	1	BOLT, Muffler Bracket "U"	BE	DE-42900
EE 4	1	ASSEMBLY, Muffler Bracket	BE	DE-42901
EE 5	1	PIPE, Nipple, 3"—19	BE	PA-413
X 126	2	CAPSCREW, Muffler Bracket and Exhaust Blind Flange	BE	100158
X 241	4	NUT, Muffler Bracket "U" Bolt	BE	117060
X 500	4	LOCKWASHER, Muffler Bracket "U" Bolt	BE	103319
X 504	2	LOCKWASHER, Muffler Bracket and Exhaust Blind Flange Capscrew	BE	103323
*	4	GASKET, Muffler End Flange, Copper ...	BE	PA-18
*	1	SCREEN, Exhaust	BE	DL-3220

* Not Illustrated.

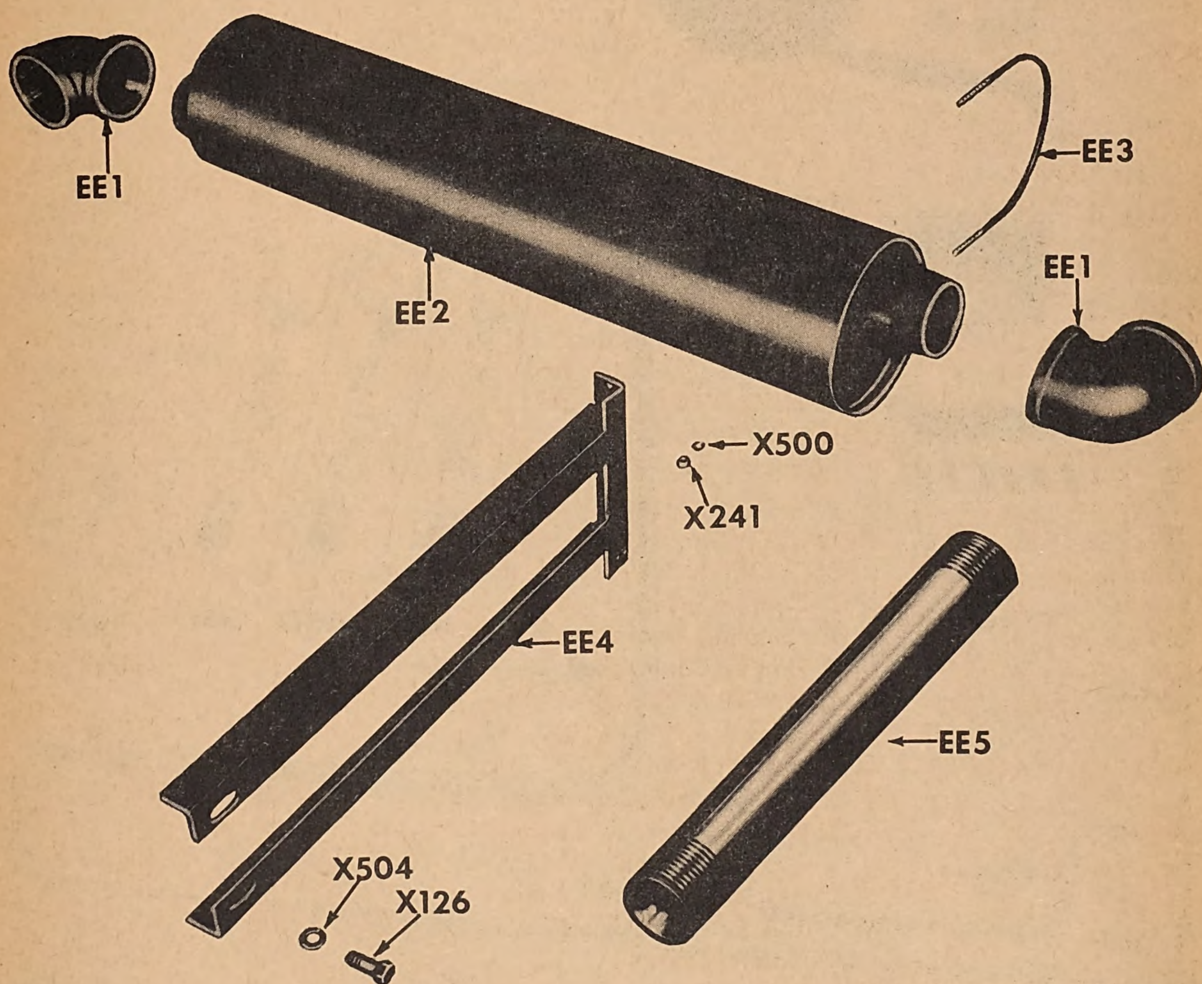

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Fig. 350. Muffler Assembly and Mounting Bracket

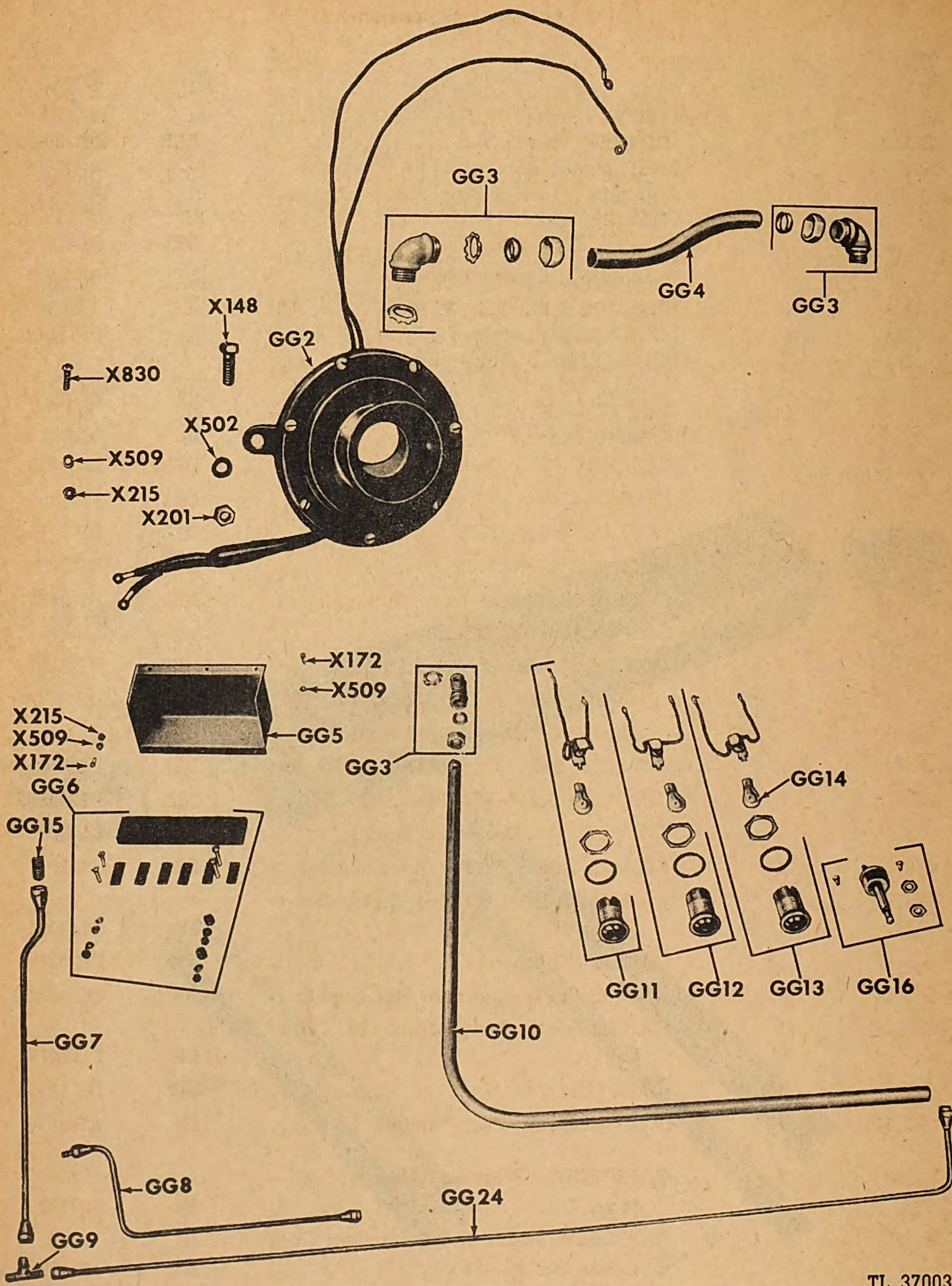

Fig. 351. Warning Howler System

134. Gauges and Instruments

Ref. No.	Quantity	Description	Mfr.	Symbol
GG 2	1	HOWLER, Warning	DEL	DE-42590
GG 3	5	ELBOW, Conduit	DEL	DP-2764
GG 4	1	CONDUIT, ½" x 4¼" Long	DEL	DL-3097
GG 5	1	COVER, Terminal Block	DEL	DL-3179
GG 6	1	ASSEMBLY, Terminal Block	DEL	DL-3108
GG 7	1	ASSEMBLY, Oil Line (3 Way Tee to Oil Pressure Gauge)	BE	DL-3088
GG 8	1	ASSEMBLY, Oil Line (Control Switch to 3 Way Tee)	BE	DL-3090
GG 9	1	TEE, Oil Line 3 Way	BE	118805
GG 10	1	CONDUIT, ½" to Control Cabinet	DEL	DP-2800
GG 11	1	LENS, Bull's-Eye (Green)	DEL	DP-2754
GG 12	1	LENS, Bull's-Eye (Red)	DEL	DP-2755
GG 13	1	LENS, Bull's-Eye (Yellow)	DEL	DP-2756
GG 14	3	LAMP, Bull's-Eye—6 Watt, 110 Volt	DEL	DP-2786
GG 15	2	CONNECTOR, Oil Line	BE	118748
GG 16	1	SWITCH, Howler	DEL	DL-3107
GG 17	1	CONDULET, ½" Tee (to Panel)	DEL	DP-2763
GG 18	1	CONDUIT, ½", Developed Length 5⅜" ..	DEL	DL-3111
GG 19	2	BRACKET, Safety Control Oil Line Support	DEL	DL-3195
GG 20	1	CONTROL, Safety (Oil Pressure)	DEL	DE-42588
GG 22	1	CONDUIT, ½", Developed Length 9½" ..	DEL	DL-3096
GG 23	1	SWITCH, Safety (Water Temperature) ..	DEL	DL-3073
GG 24	1	ASSEMBLY, Lube Oil Line (3 Way Tee to Block)	BE	DL-3092
GG 27	1	GAUGE, Oil Pressure	SW	DE-52196
GG 28	1	GAUGE, Oil Temperature (48" Capillary)	SW	DL-3074
GG 29	1	GAUGE, Water Temperature (90" Capillary)	SW	DL-3075
GG 30	1	AMMETER	SW	DE-52194
GG 31	1	SWITCH, Starter Push Button	LN	AP-3696
X 148	2	CAPSCREW, Warning Howler, ⅜"—16 x ¾"	BE	100133
X 172	4	CAPSCREW, Round Head, Terminal Block Cover, No. 10—24 x ⅝"	BE	100499
X 201	2	NUT, Warning Howler Capscrew, ⅜"—16	BE	102635

134. **Gauges and Instruments (Cont'd)**

Ref. No.	*Quantity*	*Description*	*Mfr.*	*Symbol*
X 215	4	NUT, Oil Line Clamp Screw No. 10—32 ..	BE	110633
X 350	1	ELBOW, 1/8" Oil Line	BE	118753
X 502	2	LOCKWASHER, Warning Howler Capscrew, 3/8"	BE	103321
X 509	4	LOCKWASHER, Terminal Block Cover Capscrew, No. 10	BE	106497
X 509	4	LOCKWASHER, Safety Control Screw, No. 10	BE	106497
X 803	4	SCREW, Round Head, Safety Control, No. 10—24 x 1/2"	BE	110487
X 811 *	2	SCREW, Round Head Machine Screw No. 10—24 x 7/8"	BE	110503
*	1	GROMMET, Warning Howler Rubber ...	BE	DL-3219
*	2	CONNECTOR, Conduit-Control Cabinet .	BE	PA-331
*	1	CONDUIT, 1/2" Developed Length 4 5/8" ...	BE	DL-3110
*	1	TEE, Conduit, 1/2"		DP-2763
*	1	CONDUIT, 1/2" Developed Length 11 1/4" ..	BE	DL-3095
*	1	BUSHING, Conduit Capped	BE	DL-3118
*	1	COUPLING, Safety Control Oil Line Pipe 1/2"	BE	250255
*	1	CLAMP, Safety Control Oil Line	BE	AP-6034
*	1	ADAPTOR, Water Temperature Gauge ..	BE	DE-51443
*	2	CLIP, Howler Capillary	BE	TC-57
*	20	CLIP, Wire and Tube Tie	BE	DE-42726
*	2	NUT, Hex Machine Screw No. 10—24	BE	110633
*	2	NUT, Safety Control Oil Line Clamp Screw No. 10—32	BE	103088
*	1	BUSHING, Safety Control Oil Line, 3/8" x 1/8"	BE	119933
*	2	LOCKWASHER, Machine Screw No. 10 ..	BE	106497
*	2	WASHER, Machine Screw, Plain No. 10 ..	BE	103338
*	2	SCREW, Safety Control Oil Line Clamp, Round Head No. 10—32 x 1/2"	BE	100764

* Not Illustrated.

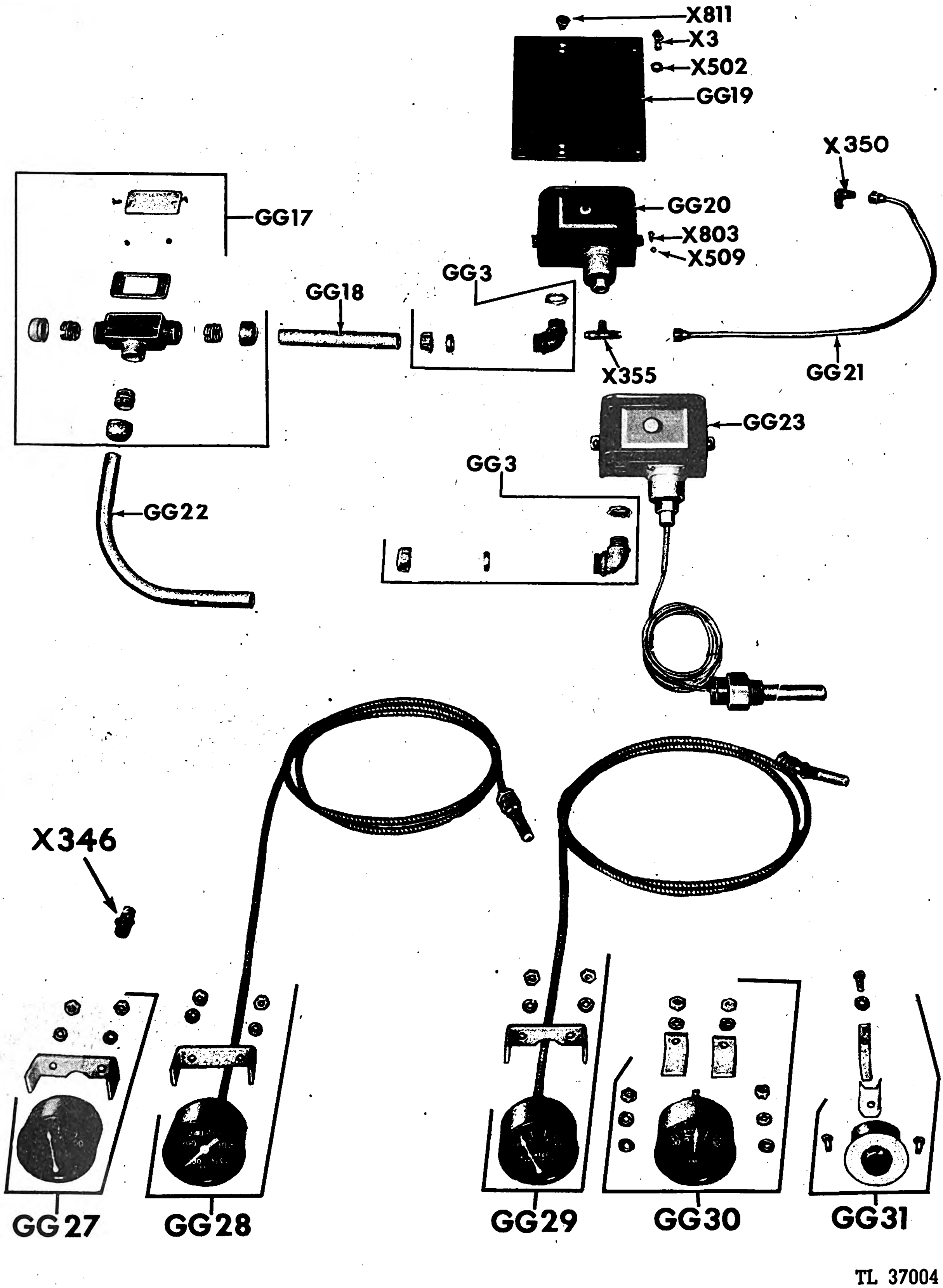

Fig. 351A. Howler Switches and Engine Instruments

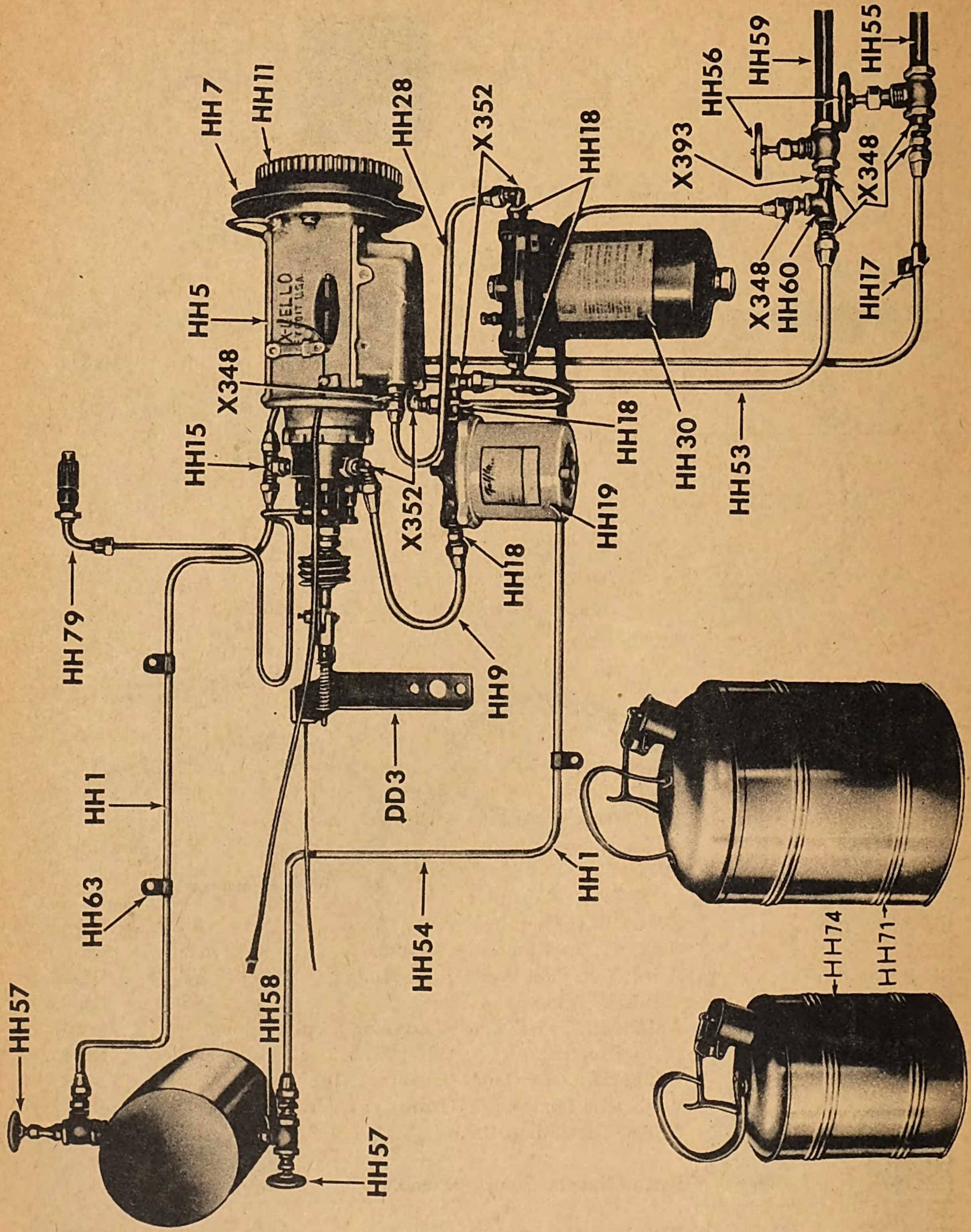

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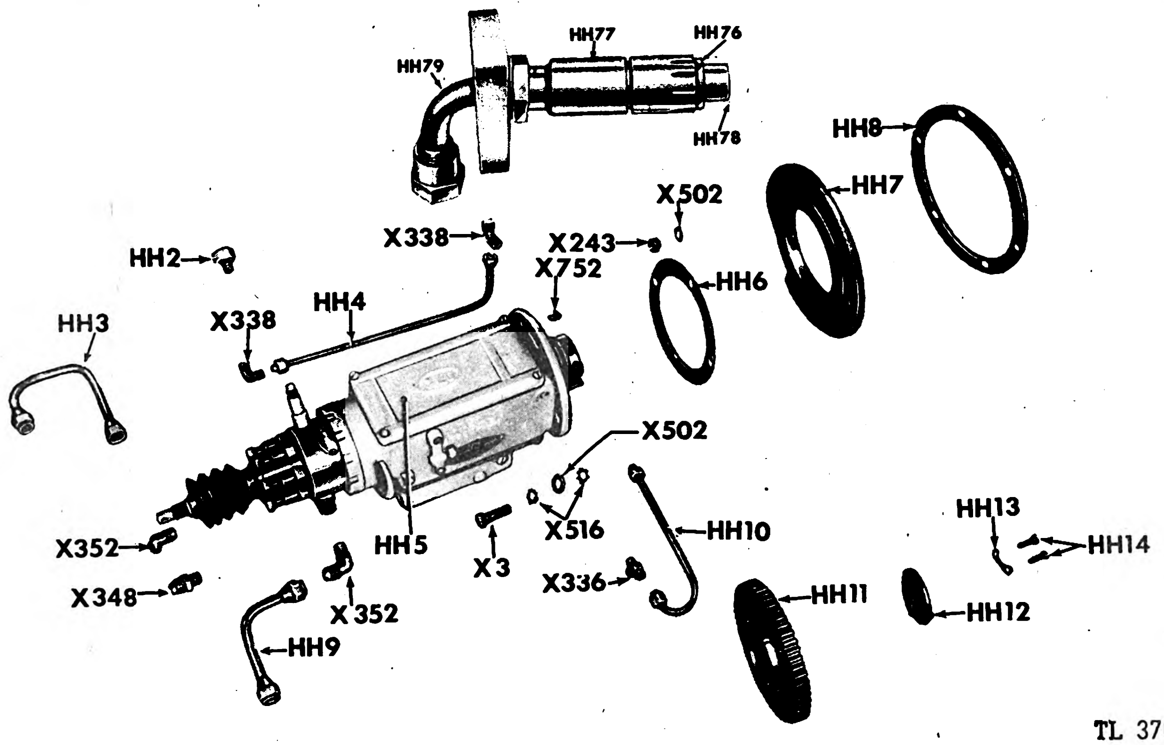
Fig. 352. Fuel Injection System Accessories



TL 37006

Fig. 352A. Fuel Injection Pump Adaptor and Gear

135. Fuel System

Ref. No.	Quantity	Description	Mfr.	Symbol
HH 1	2	ASSEMBLY, Fuel Line to Engine Tank ...	BE	DP-2801
HH 2	1	ADAPTOR, Fuel Return Line	BE	PA-320
HH 3	1	ASSEMBLY, Fuel Line (Transfer Pump to 2nd Stage Filter)	BE	DE-42584
HH 4	1	LINE, Oil (Cylinder Block to Governor Tee), 1/4" Tube	BE	DE-42692
HH 5	1	PUMP, Fuel (Excello)	EX	DE-42492
HH 6	1	GASKET, Fuel Pump to Adaptor	BE	DE-50427
HH 7	1	ADAPTOR, Fuel Pump	BE	DE-42010
HH 8	1	GASKET, Adaptor to Case	BE	DE-4063
HH 9	1	ASSEMBLY, Fuel Line (2nd Stage Filter to Fuel Pump)	BE	DE-42582
HH 10	1	ASSEMBLY, Oil Line (Governor Tee to Excello Pump), 1 1/4" Tube	BE	DE-42694
HH 11	1	GEAR, Fuel Pump Driven	EX	DE-42011
HH 12		Part of Excello Pump Assembly	EX	....
HH 13		Part of Excello Pump Assembly	EX	....
HH 14		Part of Excello Pump Assembly	EX	....
HH 15	1	TEE, Fuel Line, 2 Way	BE	118760
HH 16	1	ASSEMBLY, Tee to Cylinder Head Oil Line	BE	DE-42695
HH 17	1	CLIP, Fuel Line	BE	PA-54
HH 18	2	REDUCER, Fuel Line	BE	PA-52

135. Fuel System (Cont'd)

Ref. No.	Quantity	Description	Mfr.	Symbol
HH 19	1	FILTER, Fuel (2nd Stage) (AS-4-3/8" BVD 1/4")	CMF	DE-61560
HH 20	1	PLUG, Fuel Filter Head Vent	CMF	CL-X-13246
HH 21	4	CAPSCREW, Fuel Filter	CMF	100110
HH 22	4	LOCKWASHER, Fuel Filter Capscrew	CMF	CL-W-934
HH 23	1	ASSEMBLY, Fuel Filter Head	CMF	CL-F-913
HH 24	1	GASKET, Fuel Filter	CMF	DE-62640
HH 25	1	CARTRIDGE, Fuel Filter	CMF	DE-42543
HH 26	1	ASSEMBLY, Fuel Filter Shell	CMF	CL-F-9812-A
HH 27	1	PLUG, Fuel Filter Drain	CMF	CL-L-9817
HH 28	1	ASSEMBLY, Fuel Line (1st Stage to Transfer Pump)	BE	DE-42580
HH 29	1	BRACKET, Fuel Filter First Stage	BE	DL-3049
HH 30	1	ASSEMBLY, Fuel Filter First Stage	PU	DE-42622
HH 31	1	PLUG, Fuel Filter Filler	PU	PR-7335
HH 32	1	GASKET, Fuel Filter Filler Plug	PU	PR-7494
HH 33	1	PLUG, Fuel Filter Drain	PU	PR-11216
HH 34	1	GASKET, Fuel Filter Drain Plug	PU	PR-11217
HH 35	2	VALVE, Fuel Filter Vent	PU	PR-15002
HH 36	1	HEAD, Fuel Filter	PU	PR-15648

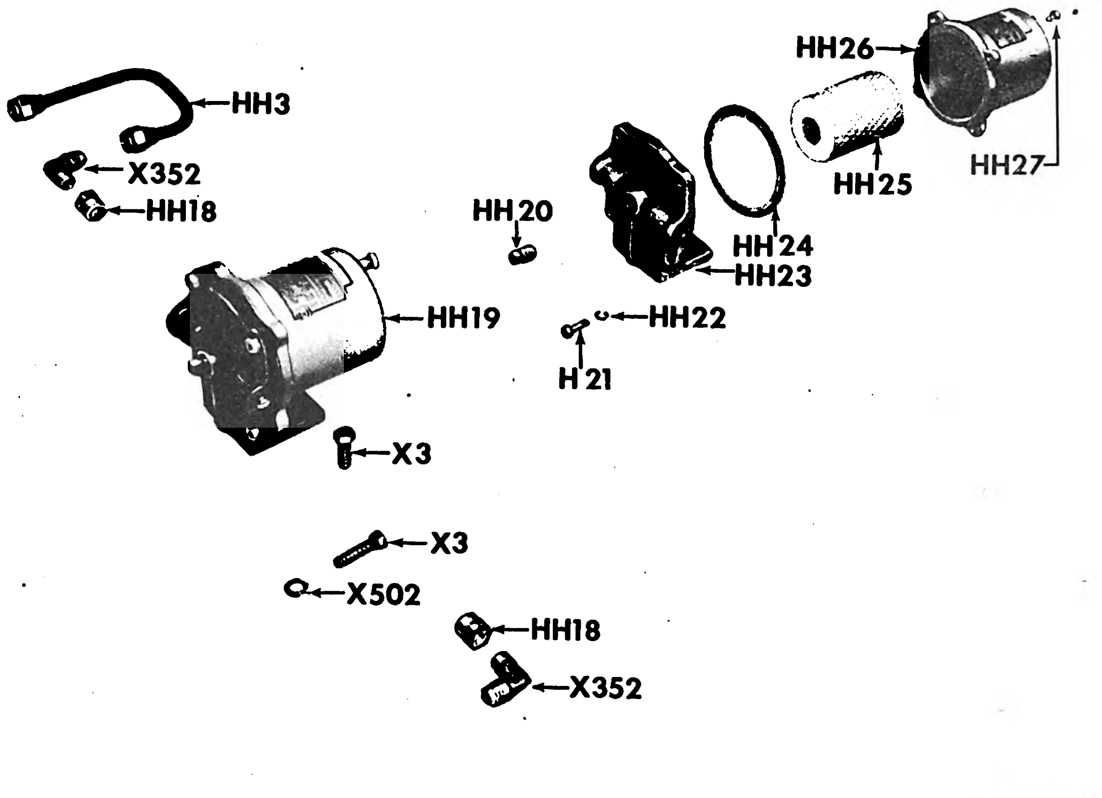


Fig. 352B. Secondary Filter and Mounting Bracket

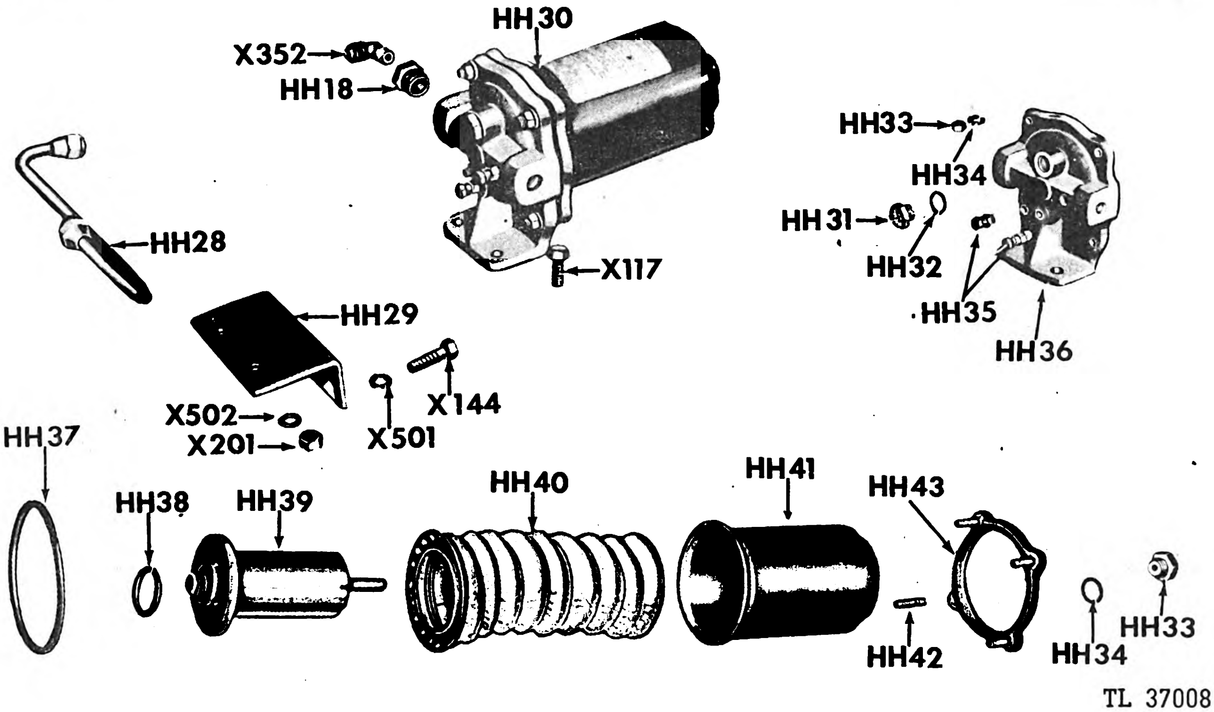


Fig. 352C. Primary Filter and Mounting Bracket

135. Fuel System (Cont'd)

Ref. No.	Quantity	Description	Mfr.	Symbol
HH 37	1	GASKET, Fuel Filter Clamping Ring	PU	PR-14796
HH 38	1	GASKET, Fuel Filter Vent Chamber	PU	15696
HH 39	1	ELEMENT, Fuel Filter Metal	PU	18155
HH 40	1	ELEMENT, Fuel Filter Fabric	PU	DE-10742
HH 41	1	CASE, Fuel Filter	PU	13326
HH 42	1	STUD, Fuel Filter	PU	14795
HH 43	1	ASSEMBLY, Fuel Filter Clamping Ring ..	PU	14797
HH 44	1	ASSEMBLY, Fuel Line (Cylinder No. 1) ..	BE	DE-42034
HH 45	1	ASSEMBLY, Fuel Line (Cylinder No. 2) ..	BE	DE-42035
HH 46	1	ASSEMBLY, Fuel Line (Cylinder No. 3) ..	BE	DE-42036
HH 47	1	ASSEMBLY, Fuel Line (Cylinder No. 4) ..	BE	DE-42037
HH 48	1	ASSEMBLY, Fuel Line (Cylinder No. 5) ..	BE	DE-42038
HH 49	1	ASSEMBLY, Fuel Line (Cylinder No. 6) ..	BE	DE-42039
HH 50	1	CLAMP, Fuel Line, 1 and 2; 5 and 6	BE	DE-50532
HH 51	1	CLAMP, Fuel Line, 4, 5 and 6	BE	DE-40735
HH 52	1	CLAMP, Fuel Line, 3, 4, 5 and 6	BE	DE-3573
HH 53	1	ASSEMBLY, Fuel Line (Tee to 1st Stage Filter)	BE	DL-3080
HH 54	1	ASSEMBLY, Fuel Line (Bleeder to Valve).	BE	DL-3082
HH 55	1	LINE, Fuel Assembly Return to Auxiliary Tank	BE	DL-3061
HH 56	2	VALVE, Line to Auxiliary Tank	BE	DL-3103
HH 57	2	VALVE, Fuel Line to Engine	BE	DL-3104

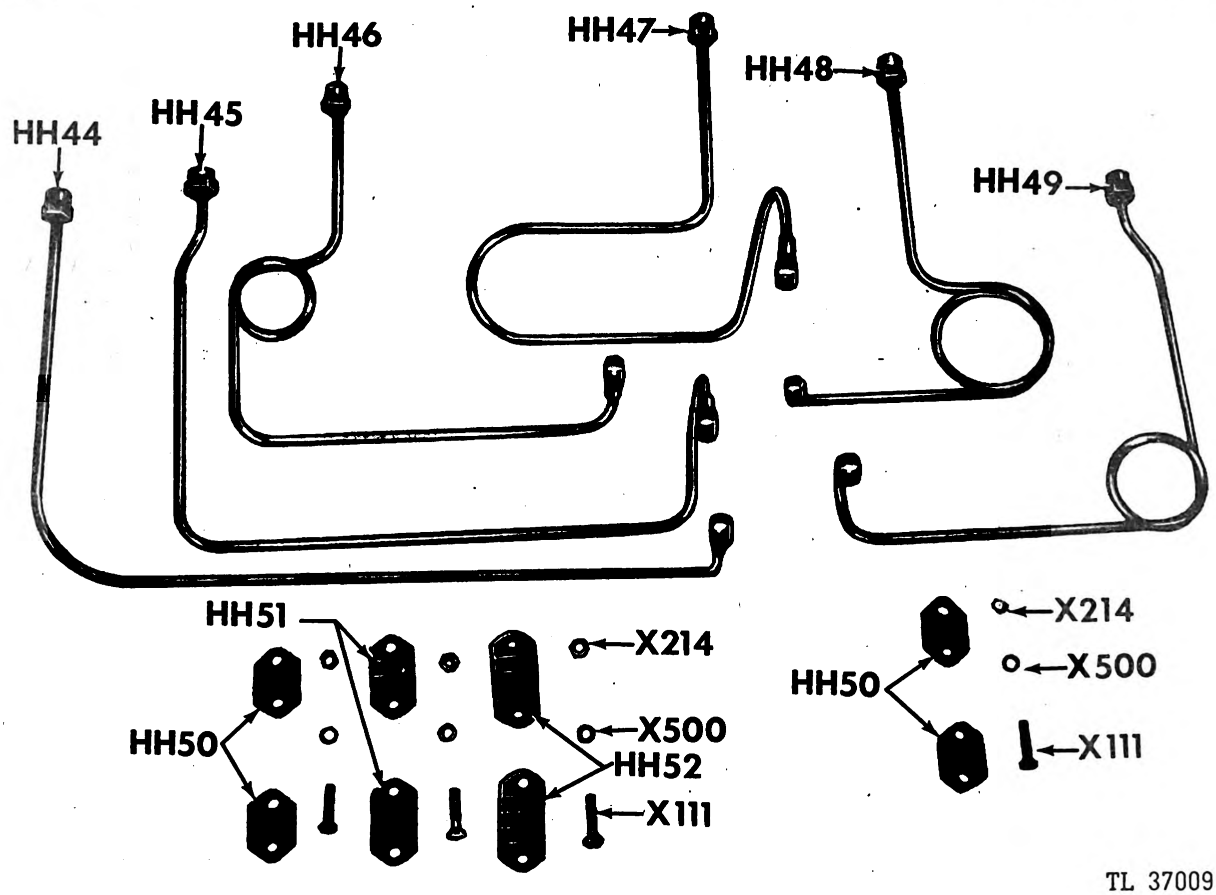


Fig. 352D. High-Pressure Lines

135. Fuel System (Cont'd)

Ref. No.	*Quantity*	*Description*	*Mfr.*	*Symbol*
HH 58	1	NIPPLE, Angle Valve	BE	DL-3106
HH 59	1	LINE, Fuel Line from Tee to Tank	BE	DL-3086
HH 60	1	TEE, Fuel Line	BE	PA-355
HH 62	1	NUT, Packing Fuel Line	BE	2808
HH 63	3	CLIP, Fuel Line	BE	DL-3103
HH 64	1	BUSHING, Fuel Line Packing	BE	DL-3129
HH 65	1	PIPE, Fuel Suction	BE	DP-2806
HH 66	2	ASSEMBLY, Fuel Line (Drum to Valve ½" O.D. x 20 ft.)	BE	DP-2801
HH 67	2	STRAP, Fuel Tank	BE	DP-2614
HH 68	1	CAP, Fuel Tank	BE	....
HH 69	1	TANK, Fuel	BE	DL-3197
HH 70	2	BRACKET, Fuel Tank	BE	DE-42552
HH 71	1	CAN, Fuel Oil (5 Gal.)	BE	DP-2768
HH 72	2	UNION, Inverted Flared Tube (Weatherhead)	BE	137417
HH 73	2	LINE, Flexible Fuel (Weatherhead)	BE	DL-3128
HH 74	1	CAN, Fuel Oil (2 Gal.)	BE	DP-2767
HH 75		LINE, Tee to Cylinder Head Oil	BE	DE-42695

135. Fuel System (Cont'd)

Ref. No.	Quantity	Description	Mfr.	Symbol
HH 76	6	GASKET, Fuel Injection Nozzle	BE	DE-31198
HH 77	6	HOLDER, Fuel Injection Nozzle Holder ...	EX	DE-43007
HH 78	6	TIP, Fuel Injection	EX	DE-56745
HH 79	6	NOZZLE, Fuel Injection Nozzle and Holder Assembly (Includes HH 77 and 78) ...	EX	DE-42646
X 3	15	CAPSCREW, 3/8"—16 x 1"	BE	100134
X 111	3	CAPSCREW, Fuel Line Pipe Support, 1/4"—20 x 1"	BE	100110
X 116	4	CAPSCREW, Fuel Tank Bracket, 3/8"—16 x 3/4"	BE	100133
X 117	2	CAPSCREW, Fuel Filter Bracket	BE	100135

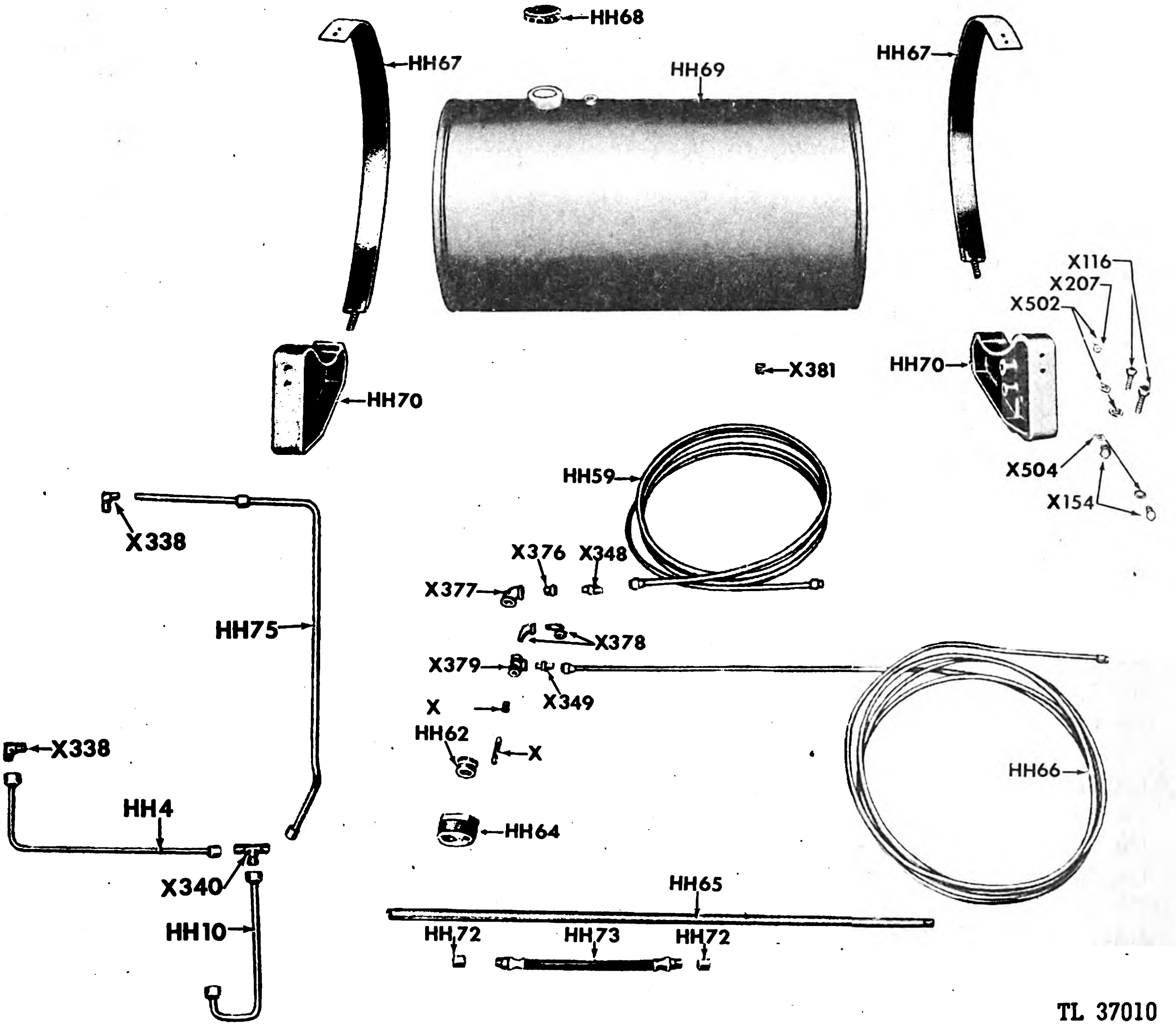


Fig. 352E. Fuel Tank, Fuel Lines and Lube Oil Lines

135. Fuel System (Cont'd)

Ref. No.	Quantity	Description	Mfr.	Symbol
X 154	4	CAPSCREW, Fuel Tank Strap, ½"—13 x 1⅜"	BE	106342
X 201	2	NUT, Fuel Tank Strap	BE	102635
X 207	12	NUT, Fuel Injection Nozzle Stud	BE	103026
X 214	5	NUT, Fuel Line Clamp Capscrew, ¼"—20	BE	109084
X 243	6	NUT, Fuel Filter Bracket	BE	117062
X 336	1	CONNECTOR, Oil Line to Excello Pump, ¼" Tube	BE	114626
X 338	2	ELBOW, ¼"	BE	114632
X 340	1	TEE, Three Way Oil Line	BE	114635
X 348	7	CONNECTOR, Flared ⅜" Tube, Fuel Line	BE	118750
X 349	2	CONNECTOR, Flared ½" Tube	BE	118752
X 352	6	ELBOW	BE	118755
X 376	2	BUSHING, Pipe, ⅜" x ½"	BE	120322
X 377	2	ELBOW, Pipe, ½"	BE	144130
X 379	1	TEE, Pipe, ¼"	BE	114635
X 380	1	NIPPLE, Pipe, ⅛" x 2"	BE	114794
X 381	1	PLUG, Square Head Brass Fuel Tank Drain, ⅜"	BE	112304
X 393	4	BUSHING, Reducing ⅜" x ¼"	BE	119928
X 500	9	LOCKWASHER, Fuel Line Clamp, ¼"	BE	103319
X 502	33	LOCKWASHER, ⅜"	BE	103321
X 504	4	LOCKWASHER, Strap Capscrew, ½"	BE	103323
X 752	2	KEY, Fuel Pump Driven Gear, No. 3—⅛" x ½"	BE	106749
*	2	CLAMP, Fuel Line Pipe	BE	DL-3194
*	1	CLIP, Fuel Line	BE	PA-335
*	1	VALVE, Fuel Filter (1st Stage)	PU	PR-7381
*	1	GASKET, Fuel Filter Head (1st Stage)	PU	PR-13291
*	1	GASKET, Fuel Filter Adapter (1st Stage)	PU	PR-18157
*	1	SUPPORT, Oil Line	BE	DL-3205
*	8	PLUG, Oil Line Cork	BE	DL-3252
*	1	RESTRICTOR, Tee to Excello Oil Line Connector	BE	DE-5577
*	1	RESTRICTOR, Tee to Cylinder Head Oil Line	BE	DE-56030
*	1	CLIP, Tee to Cylinder Head Oil Line	BE	RSE-289
*	1	NUT, Tee to Cylinder Head Oil Line	BE	114627
*	1	SLEEVE, Tee to Cylinder Head Oil Line	BE	114628
*	2	BUSHING, Reducing, Fuel Line ⅜" Standard x 16" Long	BE	120322
*	1	SUPPORT, Fuel Line Pipe	BE	DL-3050
*	4	BUSHING, Reducing ⅜" x ¼"	BE	119928
*	1	BUSHING, Reducing ½" x ⅛"	BE	144050
*	1	TEE, 2 Way, Return Line to Fuel Tank	BE	118760
*	1	NIPPLE, Close, ¼" Brass	BE	144591

* Not Illustrated.

136. Lubricating System (External) *

Ref. No.	Quantity	Description	Mfr.	Symbol
LL 1	1	HANDLE, Lube Oil Filter	CU	CU-F-136
LL 2	1	NUT, Lube Oil Filter Gland	CU	CU-F-1258
LL 3	1	PACKING, Lube Oil Filter Gland	CU	CU-1334-8
LL 4	1	FOLLOWER, Lube Oil Filter Gland	CU	CU-F-745
LL 5	1	PLUG, Lube Oil Filter Vent	CU	103883
LL 6	2	NUT, Lube Oil Filter Bracket	CU	113106
LL 7	1	BRACKET, Lube Oil Filter	CU	1212
LL 8	1	HEAD, Lube Oil Filter	CU	CU-7001
LL 9	1	GASKET, Lube Oil Filter Head	CU	CU-8262
LL 10	1	ASSEMBLY, Lube Oil Filter Cartridge ...	CU	DE-5690
LL 11	2	WASHER, Lube Oil Filter Cartridge Screw	CU	CU-B-112
LL 12	2	SCREW, Lube Oil Filter Cartridge	CU	101076
LL 13	1	SUMP, Lube Oil Filter	CU	CU-6944-U
LL 14	2	LOCKWASHER, Filter Bracket Screw	CU	106498
LL 15	2	SCREW, Lube Oil Filter Bracket	CU	100677
LL 16	8	SCREW, Lube Oil Filter Sump	CU	CU-5055
LL 17	1	FILTER, Lube Oil (Cuno)	CU	DE-56590
LL 18	2	REDUCER, Lube Oil Line	BE	PA-110
LL 19	1	ASSEMBLY, Oil Line (Cuno to DeLuxe) ..	BE	DL-3051
LL 20	1	ASSEMBLY, Oil Line (DeLuxe to Cuno) ..	BE	DL-3054
LL 21	1	GASKET Lube Oil Filter Case Side	BE	DE-40835
LL 22	1	SPACER, Lube Oil Filter	BE	DE-40867
LL 23	1	GASKET, Lube Oil Filter (Filter Side)	BE	DE-40834
LL 24	1	ASSEMBLY, Lube Oil Filter (DeLuxe)	DX	DE-40817
LL 25	1	ASSEMBLY, Lube Oil Filter Relief Valve .	DX	DX-JCUS-32-34
LL 26	1	GASKET, Lube Oil Filter Metal	DX	DX-JCUS-31
LL 27	1	COVER, Lube Oil Filter	DX	DX-SD-21
LL 28	1	GASKET, Lube Oil Filter Cover	DX	DE-51710
LL 29	1	CAP, Lube Oil Filter Perforated	DX	DX-SD-24
LL 30	1	LOCKNUT, Lube Oil Filter Perforated Cap	DX	DX-JCUS-41
LL 31	1	ASSEMBLY, Lube Oil Filter Cartridge ...	DX	DE-51305
LL 32	1	TUBE, Center Assembly	DX	DX-SS-36-37
LL 33	1	GASKET, Center Tube	DX	DX-CS-51
LL 34	1	ASSEMBLY, Lube Oil Filter Body and Base	DX	DX-SSB-42-38
LL 35	1	GASKET, Base Drain Plug	DX	DX-CS-52
LL 36	1	PLUG, Base Drain	DX	DX-CS-50
LL 37	1	PIPE, Lube Oil Filler	BE	DL-3117
LL 38	1	ADAPTOR, Temperature Gauge	BE	DE-51443
LL 39	1	CONNECTOR, Lube Oil Line	BE	128141
X 120	4	CAPSCREW, Lube Oil Filter	BE	100138
X 147	2	CAPSCREW, Lube Oil Filter, 3/8"—16 x 3/4"	BE	106329
X 303	1	PLUG, Lube Oil Filter Sump Drain, 1/2" ..	BE	103868
X 349	1	CONNECTOR, Lube Oil Line	BE	118752
X 352	3	ELBOW, Lube Oil Line	BE	118757
X 502	6	LOCKWASHER, Filter Capscrew, 3/8"	BE	103321

* See Page 249 for External Line to Fuel Pump and Rocker Arms.

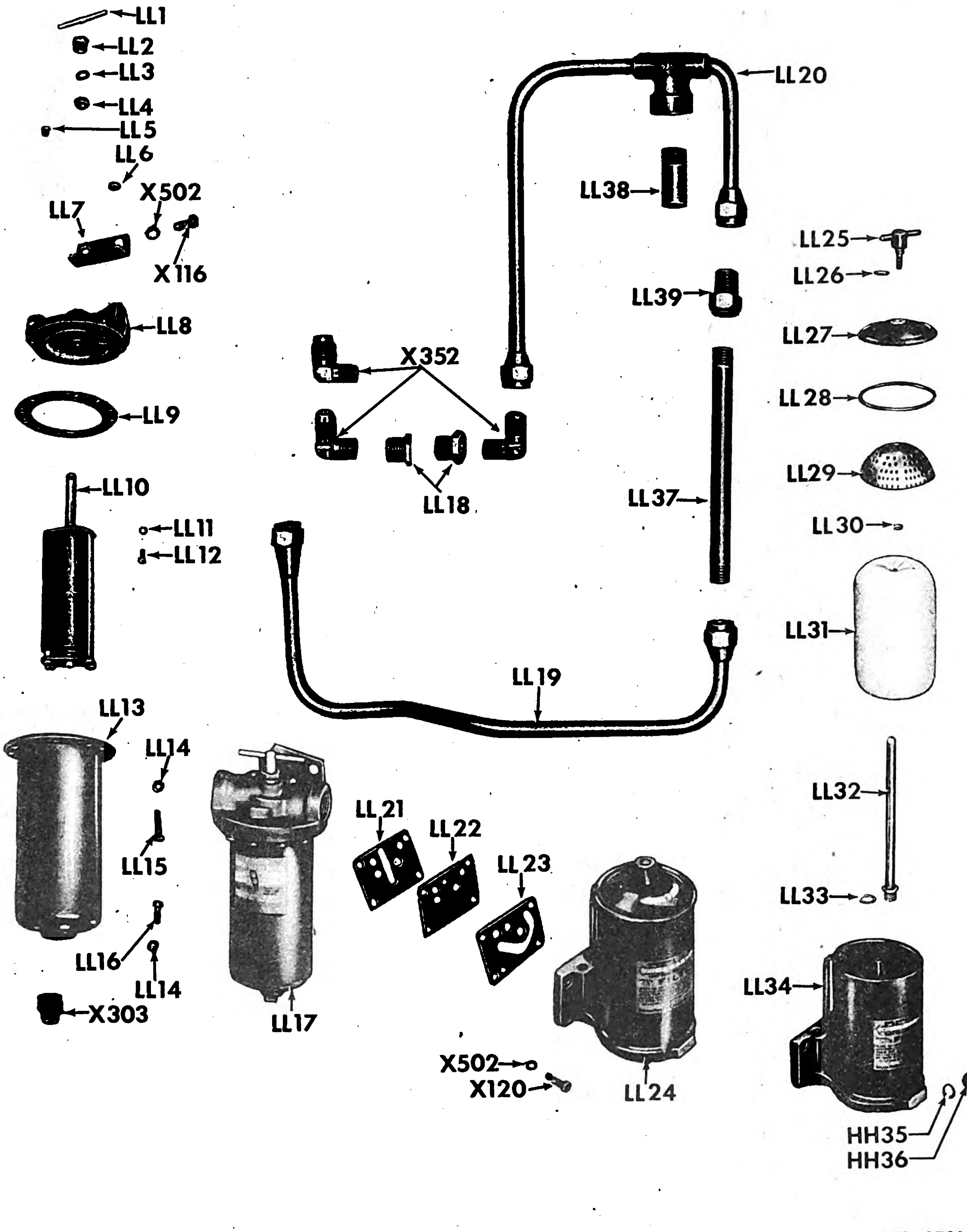


Fig. 353. Lube Oil Filters

137. Battery and Wiring Harness Assembly

Ref. No.	Quantity	Description	Mfr.	Symbol
PP 1	1	BOLT, Battery Clamp Carriage, 3/8"—16 x 11"	BE	119405
PP 2	1	CLAMP, Battery Hold Down End—Center.	BE	DP-2749
PP 3	2	BATTERY (Includes PP 9)	GLU	DL-3193
PP 4	2	ASSEMBLY, Battery Hold Down Clamp—Ends	BE	DL-3102
PP 5	2	SPACER, Battery Hold Down Clamp	BE	DP-2923
PP 6	2	BOLT, Battery Clamp Carriage, 3/8"—16 x 10"	BE	119400
PP 7	6	SPACER, Battery Box	BE	DP-2626
*	2	CLIP, Battery Carriage	BE	DE-42479
PP 8	1	LEDGE, Battery Side	BE	DL-3150
PP 9	1	ASSEMBLY, Wiring Harness (Battery) (Includes next 3 Items)	BE	DL-3151
PP 10	1	CABLE, Magnetic Switch to Starter—No. 0 with Terminal	BE	DP-2863
PP 11	1	CABLE, Battery Jumper—No. 0 with Terminals	BE	DP-2862
PP 12	1	CABLE, Battery Ground—No. 0 with Terminals	BE	DP-2864
PP 13	1	ASSEMBLY, Wiring Harness (Includes next 59 items)	BE	DL-3148
PP 14	1	CABLE, Ammeter to Voltage Regulator Terminal—No. 12 x 82" Armored	BE	DL-3136
*	1	TERMINAL, Ammeter to Voltage Regulator	BE	PA-302
*	1	TERMINAL, Ammeter to Voltage Regulator	BE	PA-301
*	2	SLEEVE, Ammeter to Voltage Regulator Terminal Cable Rubber	BE	DL-3139
PP 15	1	CABLE, Magnetic Switch to Starter—No. 0 x 13"	BE	DP-2975
*	1	TERMINAL, Magnetic Switch to Starter Cable	BE	DE-55547
*	1	TERMINAL, Magnetic Switch to Starter Cable	BE	PA-458
PP 16	1	CABLE, Heater Switch to Starter Switch—No. 12 x 5 1/4" Armored	BE	DL-3137
*	1	TERMINAL, Heater Switch to Starter Switch Cable	BE	PA-301
*	1	TERMINAL, Heater Switch to Starter Switch Cable	BE	PA-303
*	2	SLEEVE, Heater Switch to Starter Switch Cable Terminal Rubber	BE	DL-3139
PP 17	1	CABLE, Magnetic Switch to Ground—No. 12 x 5" Armored	BE	DL-3138

* Not Illustrated.

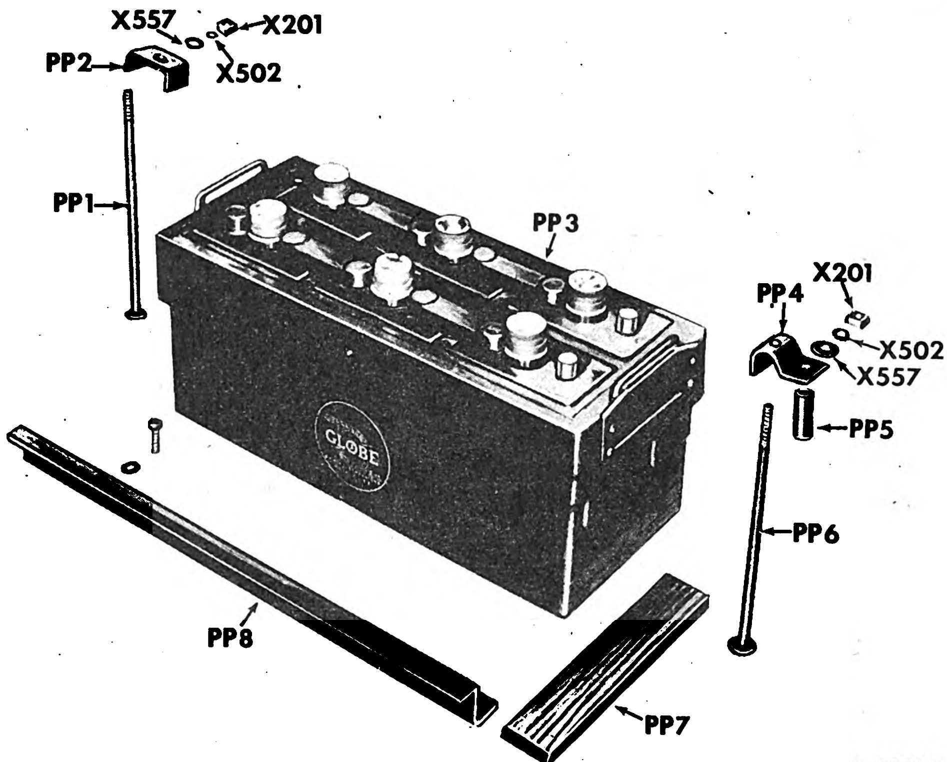


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Fig. 354. Battery and Mounting Frame

137. Battery and Wiring Harness Assembly (Cont'd)

Ref. No.	*Quantity*	*Description*	*Mfr.*	*Symbol*
*	1	TERMINAL, Magnetic Switch to Ground Cable	BE	PA-301
*	1	TERMINAL, Magnetic Switch to Ground Cable	BE	PA-303
*	2	SLEEVE, Magnetic Switch to Ground Cable Terminal Rubber	BE	DL-3139
PP 18	1	WIRE, Voltage Regulator + Terminal to Ground Band—3/8" x 4" Radio Shield	BE	DP-2916
*	2	TERMINAL, Voltage Regulator + Terminal to Ground Band	BE	PA-302
PP 19	1	ASSEMBLY, Voltage Regulator to Generator Wiring (Includes next 10 items)	BE	DL-3147
PP 20	1	CABLE, Voltage Regulator to Generator F+ Terminal No. 12 x 8" Armored	BE	DL-3132
*	2	TERMINAL, Voltage Regulator to Generator F+ Terminal Cable	BE	PA-302
*	2	SLEEVE, Voltage Regulator to Generator F+ Terminal Cable Terminal Rubber	BE	DL-3139
PP 21	1	CABLE, Voltage Regulator to Generator G+ Terminal No. 12 x 10" Armored	BE	DL-3133

* Not Illustrated.

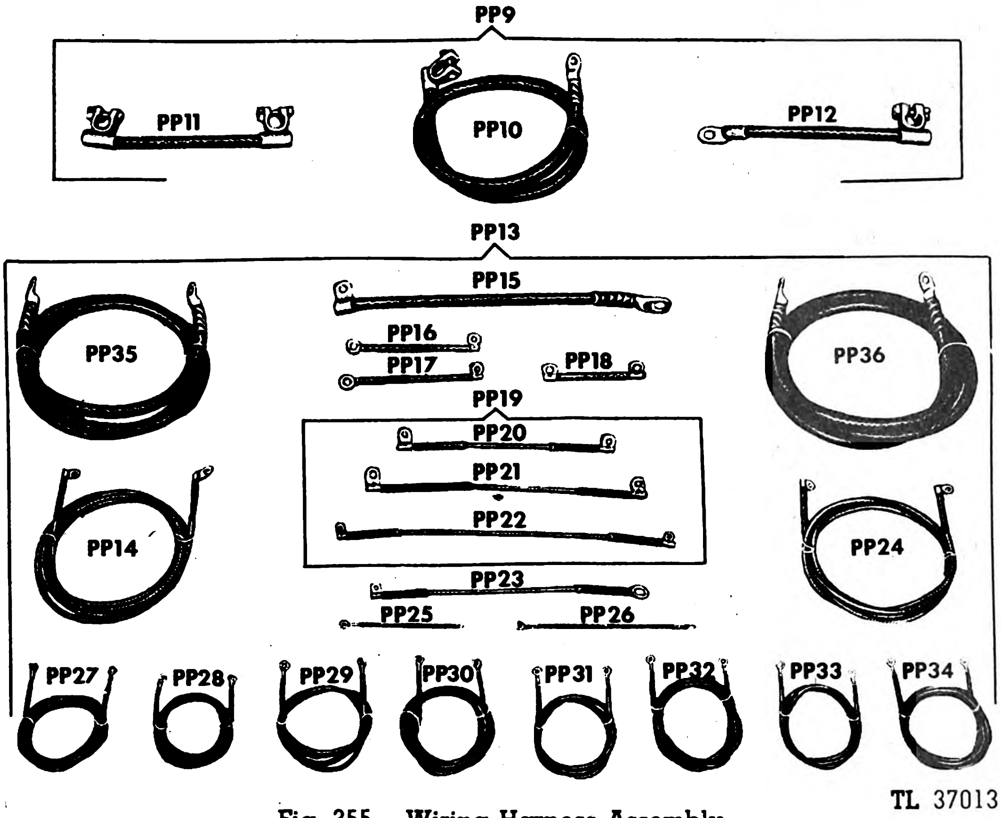

Fig. 355. Wiring Harness Assembly

137. Battery and Wiring Harness Assembly (Cont'd)

Ref. No.	*Quantity*	*Description*	*Mfr.*	*Symbol*
*	2	TERMINAL, Voltage Regulator to Generator G+ Terminal Cable	BE	PA-302
*	2	SLEEVE, Voltage Regulator to Generator G— Terminal Rubber	BE	DL-3139
PP 22	1	CABLE, Voltage Regulator to Generator G+ Terminal No. 12 x 12" Armored	BE	DL-3134
*	2	TERMINAL, Voltage Regulator to Generator G— Terminal Cable	BE	PA-301
*	2	SLEEVE, Voltage Regulator to Generator G— Terminal Cable Rubber ..	BE	DL-3139
*	1	CLIP, Voltage Regulator to Generator Wire Support	BE	DL-3196
PP 23	1	CABLE, Heater Switch to Ammeter—No. 12 x 10" Armored	BE	DL-3204
*	1	TERMINAL, Heater Switch to Ammeter Cable	BE	PA-301
*	1	TERMINAL, Heater Switch to Ammeter Cable	BE	PA-302
*	2	SWITCH, Heater Switch to Ammeter Cable Terminal Rubber	BE	DL-3139

* Not Illustrated.

137. Battery and Wiring Harness Assembly (Cont'd)

Ref. No.	Quantity	Description	Mfr.	Symbol
PP 24	1	CABLE, Starting Switch to Magnetic Switch—12 x 65" Armored	BE	DL-3135
*	2	TERMINAL, Starting Switch to Magnetic Switch Cable	BE	PA-301
*	2	SLEEVE, Starting Switch to Magnetic Switch Cable Terminal Rubber	BE	DL-3139
PP 25	5	WIRE, Terminal Block to Light Socket—No. 14 x 4" Stranded	BE	DL-3141
*	5	TERMINAL, Terminal Block to Light Socket Wire	BE	DP-2791
PP 26	1	WIRE, Terminal Block to Light Socket—No. 14 x 6" Stranded	BE	DL-3140
*	1	TERMINAL, Terminal Block to Light Socket Wire	BE	DP-2791
PP 27	1	WIRE, Terminal Block No. 3 to Water Temperature Gauge Terminal No. 1—No. 14 x 36" Stranded	BE	DL-3145
*	2	TERMINAL, for above	BE	DP-2791
PP 28	1	WIRE, Terminal Block No. 6 to Water Temperature Gauge Terminal No. 3—No. 14 x 36" Stranded	BE	DL-3146
*	2	TERMINAL, for above	BE	DP-2791
PP 29	1	WIRE, Jumper from Oil Pressure to Water Temperature Gauge Terminal No. 3—No. 14 x 26" Stranded	BE	DL-3203
*	2	TERMINAL, for above	BE	DP-2791
PP 30	2	WIRE, Terminal Block No. 5 and No. 6 to Generator Panel—No. 14 x 50" Stranded	BE	DL-3144
*	4	TERMINAL, for above	BE	DP-2791
PP 31	1	WIRE, Jumper Oil Pressure Gauge to Water Temperature Gauge No. 2 Terminal—No. 14 x 26" Stranded	BE	DL-3143
*	2	TERMINAL, for above	BE	DP-2791
PP 32	1	WIRE, Terminal Block No. 1 Terminal to Oil Pressure Gauge Terminal No. 2—No. 14 x 36" Stranded	BE	DL-3201
*	2	TERMINAL, for above	BE	DP-2791
PP 33	2	WIRE, Howler to Terminal Block No. 2 and No. 5—No. 14 x 30" Stranded	BE	DL-3142
*	4	TERMINAL, Howler to Terminal Block No. 2 and No. 5 Wire	BE	DP-2791
PP34	1	WIRE, Terminal Block No. 4 to Oil Pressure Gauge Terminal No. 1—No. 14 x 36" Stranded	BE	DL-3202
*	2	TERMINAL, for above	BE	DP-2791

* Not Illustrated.

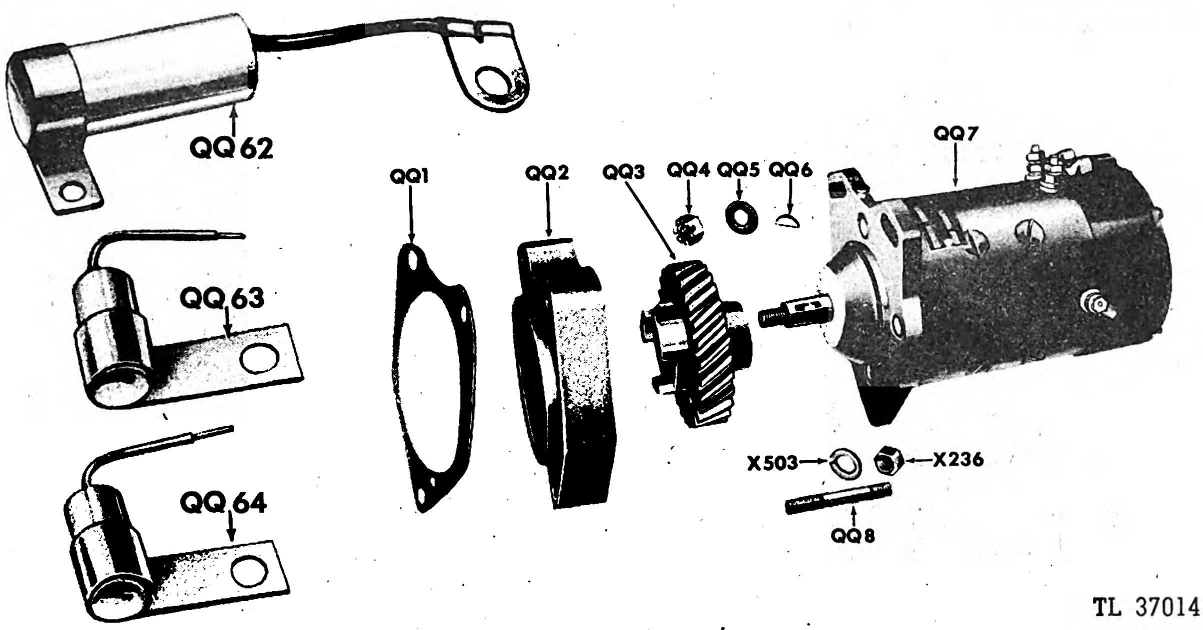

Fig. 356. Battery Charging Generator

138. Battery Generating System

Ref. No.	Quantity	Description	Mfr.	Symbol
QQ 1	2	GASKET, Generator and Adaptor	BE	DE-4923
QQ 2	1	ADAPTOR, Generator	BE	DE-4041
QQ 3	1	GEAR, Generator Drive	BE	DE-4062
QQ 4	1	NUT, Generator Drive Shaft Gear	BE	LN-3133
QQ 5	1	WASHER, Generator Gear	BE	LN-3249
QQ 6	1	KEY, Generator Gear	BE	LN-6399
QQ 7	1	GENERATOR (LN-2286-G), 24-volt	LN	DE-42830
QQ 8	3	STUD, Generator Adaptor	BE	DE-4064
QQ 9	3	SCREW, Generator Bearing—Commutator End	LN	LN-6637
QQ 10	1	RETAINER, Generator Bearing—Commutator End (Outer)	LN	LN-25895
QQ 11	1	GASKET, Generator Bearing Retainer—Commutator End (Outer)		(No Symbol)
QQ 12	1	HOUSING, Generator—Commutator End.	LN	LN-12340
QQ 13	1	ASSEMBLY, Generator Brush (Not serviced as Assembly)		(No Symbol)
QQ 14	1	SCREW, Generator Brush Opening Band .	LN	LN-3255
QQ 15	1	NUT, Generator Brush Opening Band Screw	LN	LN-5955
QQ 16	1	BAND, Generator Brush Opening	LN	LN-5510
QQ 17	1	RING, Generator Field	LN	LN-26116
QQ 18	1	HOUSING, Generator—Drive End	LN	LN-5840
QQ 19	1	GASKET, Generator Bearing Retainer ...	LN	LN-2290
QQ 20	4	GASKET, Generator Housing Screw—Drive End	LN	LN-6539

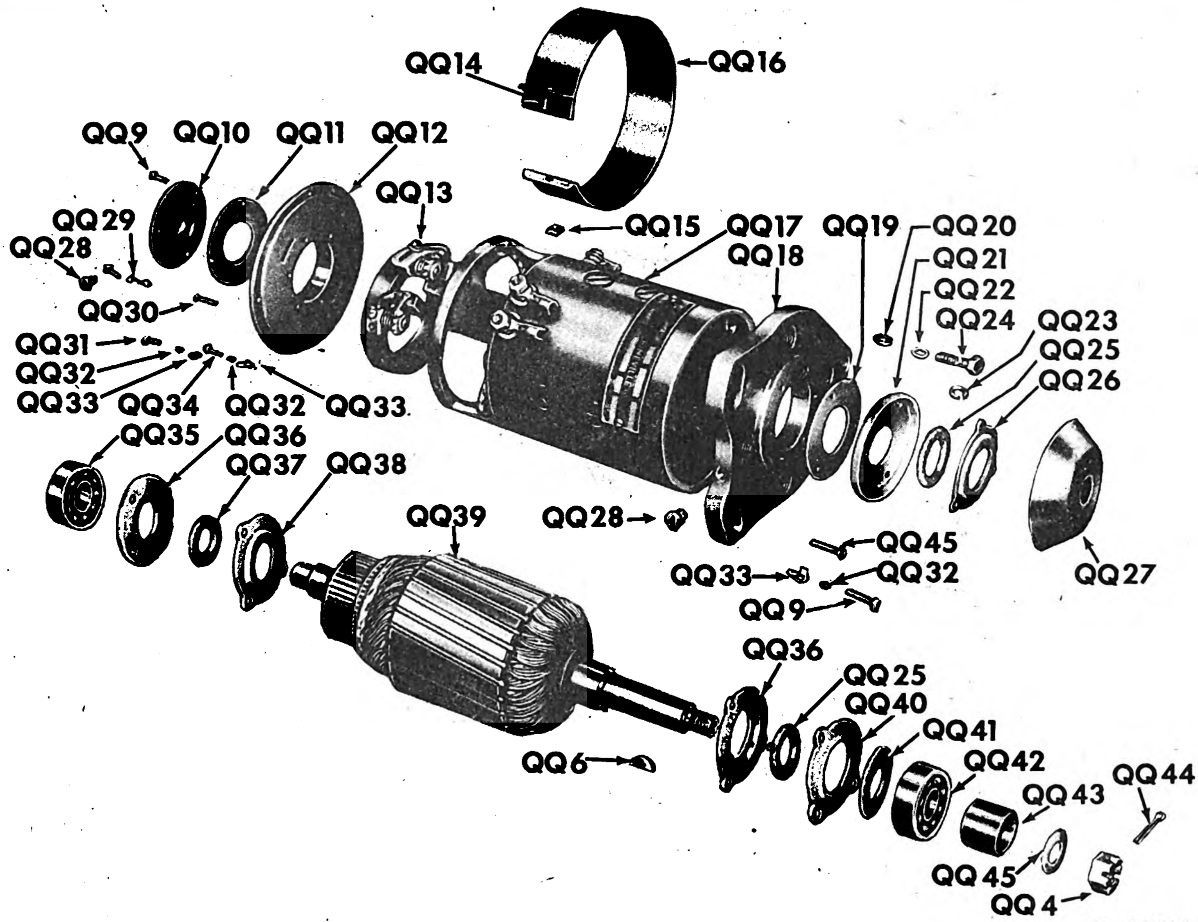

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Fig. 357. Generator Exploded

138. Battery Generating System (Cont'd)

Ref. No.	*Quantity*	*Description*	*Mfr.*	*Symbol*
*	4	LUG, Generator Housing	LN	LN-6020
QQ 21	1	RETAINER, Generator Bearing	LN	LN-6436
QQ 22	4	WASHER, Generator Housing Screw Guard—Drive End	LN	LN-2336
QQ 23	4	LOCKWASHER, Generator Housing Screw —Drive End	LN	LN-3231
QQ 24	4	SCREW, Generator Housing—Drive End .	LN	LN-4229
QQ 25	1	WASHER, Generator Bearing Retainer Felt	LN	LN-5498
QQ 26	1	RETAINER, Generator Bearing Retainer Felt	LN	LN-5906
QQ 27	1	THROW, Generator Bearing Oil	LN	LN-6437
QQ 28	1	OILER, Generator—Commutator End	LN	LN-5458
QQ 28	1	OILER, Generator—Drive End		(No Symbol)
QQ 29	1	WIRE, Generator Jumper	LN	LN-6419

* Not Illustrated.

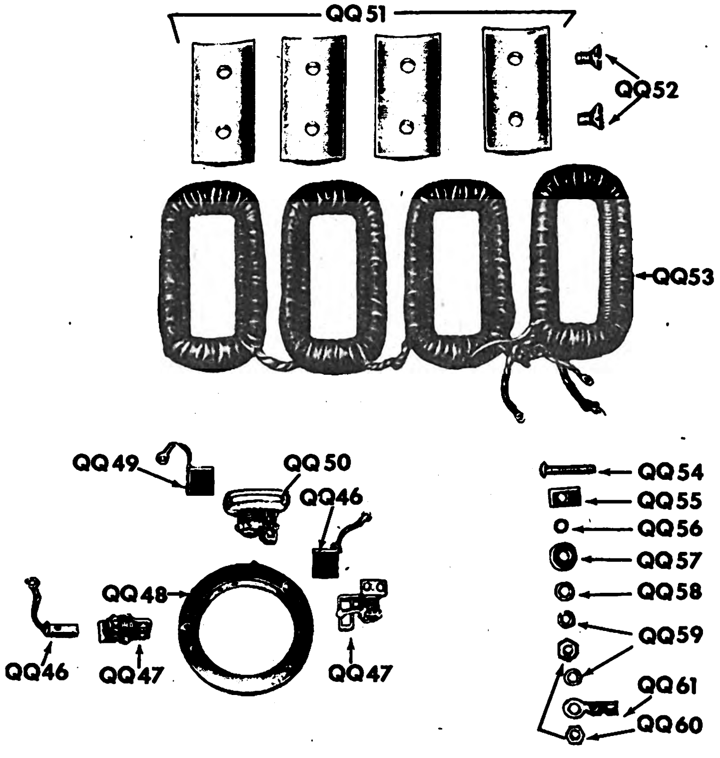

Fig. 358. Field Coil and Brush Rigging

138. Battery Generating System (Cont'd)

Ref. No.	Quantity	Description	Mfr.	Symbol
QQ 30	3	SCREW, Generator Bearing Retainer—Commutator End (Inner)	LN	LN-5579
QQ 31	2	SCREW, Generator Brush Holder Bracket	LN	LN-8414
QQ 32	2	LOCKWASHER, Generator Brush Holder Bracket Screw	LN	LN-2435
QQ 33	2	WASHER, Generator Brush Holder Bracket Screw Tabbed	LN	LN-6814
QQ 34	4	SCREW, Generator Housing—Commutator End	LN	LN-5983
QQ 35	1	BEARING, Generator—Commutator End	LN	LN-2344
QQ 36	1	RETAINER, Generator Bearing Retainer Felt—Commutator End	LN	LN-5894
QQ 37	1	WASHER, Generator Bearing Retainer Felt—Commutator End	LN	LN-6775
QQ 38	1	RETAINER, Generator Bearing—Commutator End (Inner)	LN	LN-7540
QQ 39	1	ARMATURE, Generator	LN	LN-GA16166
QQ 40	1	RETAINER, Generator Bearing Retainer Felt Washer	LN	LN-5862
QQ 41	1	GASKET, Generator Bearing Retainer	LN	LN-7149
QQ 42	1	BEARING, Generator—Drive End	LN	LN-3640

138. Battery Generating System (Cont'd)

Ref. No.	Quantity	Description	Mfr.	Symbol
QQ 43	1	COLLAR, Generator Shaft	LN	LN-6042
QQ 44	1	COTTER, Generator Shaft Gear Nut		(No Symbol)
QQ 45	3	SCREW, Generator Bearing Retainer—Drive End (Inner)	LN	LN-2376
QQ 46	1	HOLDER, Generator Brush—Left	LN	LN-6592
QQ 47	1	HOLDER, Generator Brush Holder—Right	LN	LN-6591
QQ 48	1	BRACKET, Generator Brush Holder	LN	LN-6555
QQ 49	1	BRUSH, Generator—Third	LN	LN-7904
QQ 50	1	HOLDER, Generator Brush —Third	LN	LN-6646
QQ 51	4	POLE PIECE, Generator	LN	LN-12052
QQ 52	8	SCREW, Generator Pole Piece	LN	LN-6050
QQ 53	1 set	COIL, Generator Field	LN	LN-16165
QQ 54	2	SCREW, Generator Terminal	LN	LN-2770
QQ 55	2	INSULATOR, Generator Terminal Screw .	LN	LN-5351
QQ 56	2	BUSHING, Generator Terminal Screw Insulating	LN	LN-2330
QQ 57	2	WASHER, Generator Terminal Screw Insulating	LN	LN-2772
QQ 58	4	WASHER, Generator Terminal Screw Guard	LN	LN-2524
QQ 59	4	LOCKWASHER, Generator Terminal Screw Nut	LN	LN-2523
QQ 60	4	NUT, Generator Terminal Screw	LN	LN-2771
QQ 61	2	TERMINAL, Generator	LN	(No Symbol)
QQ 62	1	CONDENSER, .02 M.F.D.	BE	DL-3198
QQ 63	1	CONDENSER, .01 M.F.D.	BE	DL-3199
QQ 64	1	CONDENSER, .1 M.F.D.	BE	DL-3200
QQ 68	1	RESISTANCE, 95-Ohm	LN	LN-12285
QQ 69	2	SCREW	LN	LN-6846
QQ 70	2	WASHER, Guard	LN	LN-5291
QQ 71	2	WASHER, Insulating	LN	LN-5896
QQ 72	2	WASHER, Insulating	LN	LN-4471
QQ 73	2	NUT	LN	LN-1867
QQ 74	1	BASE	LN	LN-12277
QQ 75	4	SCREW	LN	LN-6123
QQ 76	4	LOCKWASHER	LN	LN-2434
QQ 77	1	BRACKET	LN	LN-7865
QQ 78	1	SPRING, Adjusting	LN	LN-8469
QQ 79	1	SCREW, Adjusting	LN	LN-8336
QQ 80	1	NUT, Adjusting	LN	LN-8465
QQ 81	1	ASSEMBLY, Lead	LN	LN-12283
QQ 82	1	NUT, Adjusting	LN	LN-6826
QQ 83	1	SCREW, Adjusting	LN	LN-6835
QQ 84	1	ASSEMBLY, Lead	LN	LN-12288
QQ 85	2	NUT	LN	LN-4340

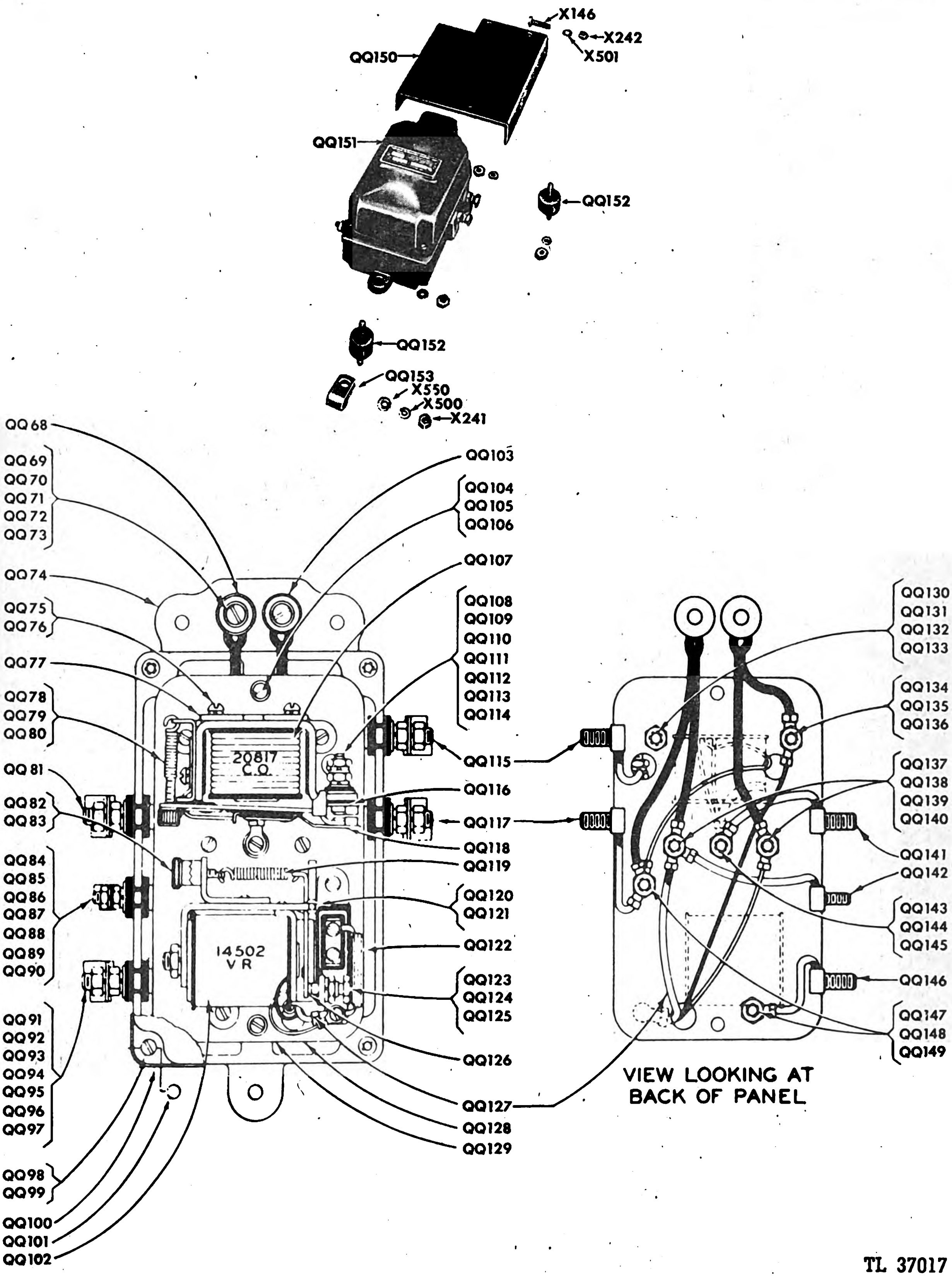

Fig. 359. Voltage Regulator (Battery)

138. Battery Generating System (Cont'd)

Ref. No.	Quantity	Description	Mfr.	Symbol
QQ 86	2	LOCKWASHER	LN	LN-2434
QQ 87	1	WASHER, Guard	LN	LN-5291
QQ 88	1	WASHER, Insulating	LN	LN-4471
QQ 89	1	BUSHING, Insulating	LN	LN-8342
QQ 90	1	INSULATOR	LN	LN-18763
QQ 91	1	ASSEMBLY, Lead	LN	LN-12283
QQ 92	8	NUT	LN	LN-2771
QQ 93	8	LOCKWASHER	LN	LN-2523
QQ 94	4	WASHER, Guard	LN	LN-2524
QQ 95	4	WASHER, Insulating	LN	LN-4474
QQ 96	4	BUSHING, Insulating	LN	LN-4488
QQ 97	4	INSULATOR	LN	LN-18484
QQ 98	4	SCREW	LN	LN-13944
QQ 99	4	LOCKWASHER	LN	LN-2435
QQ 100	1	COVER	LN	LN-7860
QQ 101	1	SEAL	LN	LN-6977
QQ 102	1	ASSEMBLY, Coil	LN	LN-14503
QQ 103	1	RESISTANCE, 200-Ohm	LN	LN-12284
QQ 104	2	SCREW	LN	LN-6138
QQ 105	2	LOCKWASHER	LN	LN-2435
QQ 106	2	WASHER, Guard	LN	LN-9700
QQ 107	1	ASSEMBLY, Coil and Yoke	LN	LN-19737
QQ 108	1	ASSEMBLY, Screw	LN	LN-6992
QQ 109	2	NUT	LN	LN-2525
QQ 110	2	LOCKWASHER	LN	LN-2435
QQ 111	1	WASHER, Guard	LN	LN-13624
QQ 112	1	WASHER, Insulating	LN	LN-6113
QQ 113	1	BUSHING, Insulating	LN	LN-6112
QQ 114	1	BUSHING, Insulating	LN	LN-7749
QQ 115	1	ASSEMBLY, Lead	LN	LN-12283
QQ 116	1	ASSEMBLY, Contact	LN	LN-19738
QQ 117	1	ASSEMBLY, Lead	LN	LN-12283
QQ 118	1	ASSEMBLY, Armature	LN	LN-19743
QQ 119	1	SPRING, Adjusting	LN	LN-1241
QQ 120	1	PIN	LN	LN-8079
QQ 121	2	WASHER	LN	LN-7493
QQ 122	1	CONDENSER	LN	LN-10072
QQ 123	1	ASSEMBLY, Screw	LN	LN-7507
QQ 124	1	NUT	LN	LN-7107
QQ 125	1	LOCKWASHER	LN	LN-2523
QQ 126	1	ASSEMBLY, Armature	LN	LN-6902
QQ 127	1	ASSEMBLY, Lead	LN	LN-8333
QQ 128	1	ASSEMBLY, Panel	LN	LN-20816
QQ 129	1	PANEL	LN	LN-7970
QQ 130	1	SCREW	LN	LN-6138
QQ 131	2	LOCKWASHER	LN	LN-2435
QQ 132	1	WASHER, Guard	LN	LN-9700

138. Battery Generating System (Cont'd)

Ref. No.	Quantity	Description	Mfr.	Symbol
QQ 133	1	NUT	LN	LN-2525
QQ 134	1	SCREW	LN	LN-6138
QQ 135	1	LOCKWASHER	LN	LN-2435
QQ 136	2	NUT	LN	LN-2525
QQ 137	2	SCREW	LN	LN-6138
QQ 138	2	LOCKWASHER	LN	LN-2435
QQ 139	2	WASHER, Guard	LN	LN-9700
QQ 140	4	NUT	LN	LN-2525
QQ 141	1	ASSEMBLY, Lead	LN	LN-12283
QQ 142	1	ASSEMBLY, Lead	LN	LN-12288
QQ 143	1	SCREW	LN	LN-6138
QQ 144	1	WASHER, Guard	LN	LN-9700
QQ 145	2	NUT	LN	LN-2525
QQ 146	1	ASSEMBLY, Lead	LN	LN-12283
QQ 147	2	SCREW	LN	LN-6138
QQ 148	2	LOCKWASHER	LN	LN-2435
QQ 149	4	NUT	LN	LN-2525
QQ 150	1	BRACKET, Voltage Regulator	BE	DE-42602
QQ 151	1	REGULATOR, Voltage (LN-2286R)	LN	DE-42831
QQ 152	3	DAMPENER, Voltage Regulator Vibration	LN	DL-1151
QQ 153	1	CLIP, Generator Wire Tube	LN	DE-62056
X 146	4	CAPSCREW, Bracket, $\frac{5}{16}$"—18 x $1\frac{3}{8}$"	BE	106327
X 236	3	NUT, Generator Stud	BE	117050
X 241	6	NUT, Voltage Regulator Dampener	BE	117060
X 242	4	NUT, Bracket, $\frac{5}{16}$"—18	BE	117061
X 500	6	LOCKWASHER, Dampener Capscrew	BE	103319
X 501	4	LOCKWASHER, Bracket, $\frac{5}{16}$"	BE	103320
X 503	3	LOCKWASHER, Generator Stud	BE	103322
X 550	1	WASHER, Regulator Wire Clip Flat	BE	103339
*	4	LUG, Generator Housing Screw Field—Drive End	LN	LN-6020
*	3	LOCKWASHER, Voltage Regulator	BE	103119
*	3	CAPSCREW, Voltage Regulator	BE	106320
*	3	NUT, Voltage Regulator	BE	109084

* Not Illustrated.

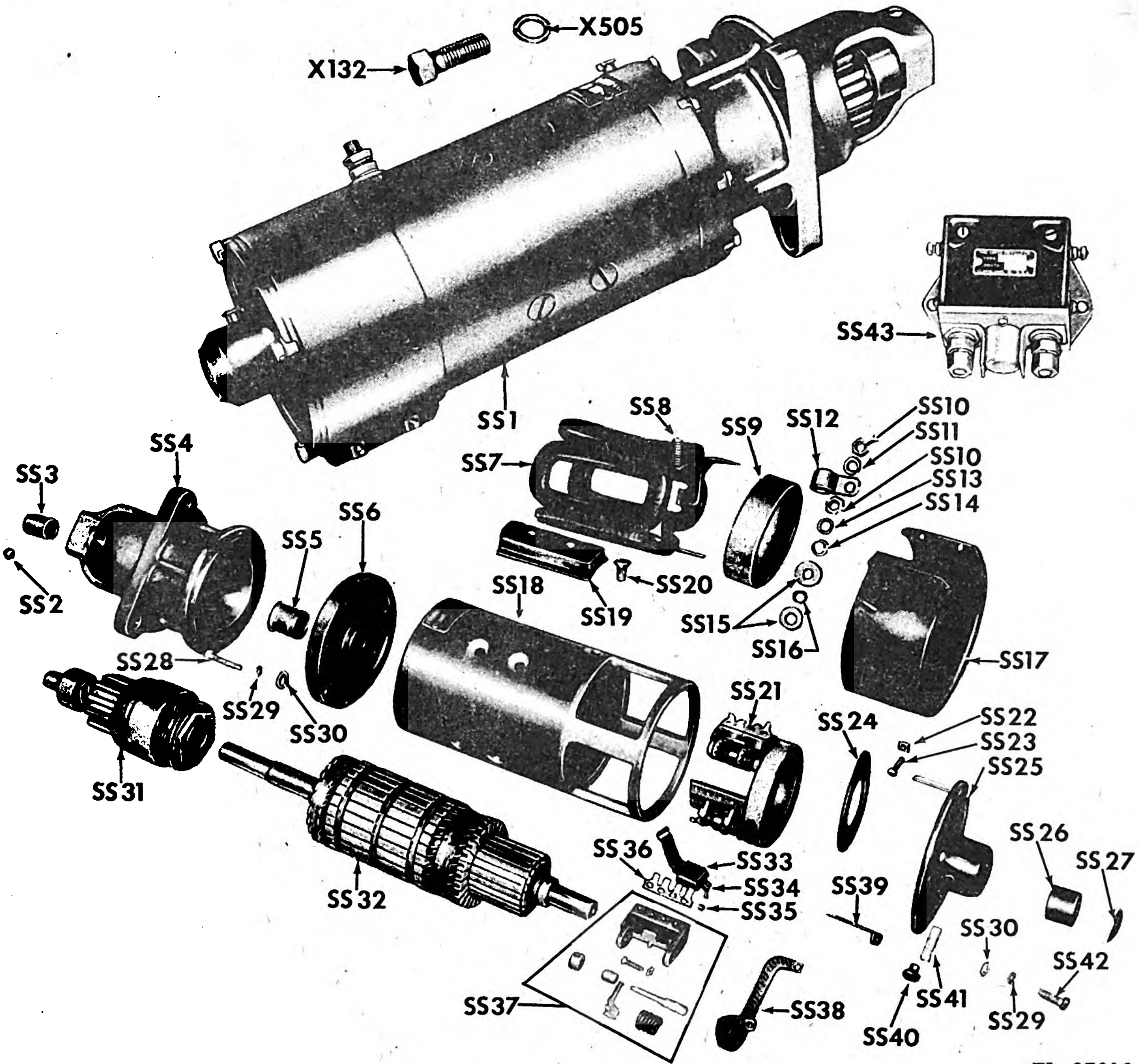

Fig. 360. Starting Motor and Magnetic Switch with Starting Motor Exploded

139. Starting System

Ref. No.	Quantity	Description	Mfr.	Symbol
SS 1	1	ASSEMBLY, Starting Motor	LN	DE-50921
SS 2	2	PLUG, Starter Housing (Bendix Drive End)	LN	LN-3730
SS 3	1	BUSHING, Starter Housing (Bendix Drive End)	LN	LN-16592
SS 4	1	HOUSING, Starter Bendix (with Bushing)	LN	LN-19561
SS 5	1	BUSHING, Starter Housing (Drive End) ..	LN	LN-16259
SS 6	1	HOUSING, Starter Drive End	LN	LN-16253
SS 7	1	ASSEMBLY, Starter Field Coil	LN	LN-16262
SS 8	1	SCREW, Starter Terminal	LN	LN-5204

139. Starting System (Cont'd)

Ref. No.	Quantity	Description	Mfr.	Symbol
SS 9	1	INSULATION	LN	....
SS 10	2	NUT, Starter Terminal Screw	LN	LN-5289
SS 11	2	LOCKWASHER, Starter Terminal Screw	LN	LN-2433
SS 12	1	TERMINAL, Starter	LN	LN-6110
SS 13	1	WASHER, Starter Terminal Guard	LN	LN-3852
SS 14	1	WASHER, Starter Terminal Insulating	LN	LN-13728
SS 15	2	INSULATOR, Starter Terminal Screw	LN	LN-5354
SS 16	1	BUSHING, Starter Terminal Screw	LN	LN-5230
SS 17	1	BAND, Starter Brush Opening	LN	LN-16291
SS 18	1	RING, Starter Field (not sold separately)	LN	....
SS 19	4	PIECE, Starter Pole (not sold separately)	LN	....
SS 20	8	SCREW, Pole Piece	LN	LN-7092
SS 21	1	RIGGING, Starter Brush (complete less Brushes)	LN	LN-16255
SS 22	2	NUT, Starter Brush Opening Band Screw	LN	LN-5955
SS 23	2	SCREW, Starter Brush Opening Band	LN	LN-3255
SS 24	1	WASHER, Starter Brush Rigging Insulation	LN	LN-13731
SS 25	1	HOUSING, Starter with Bushing (Commutator End)	LN	LN-19083
SS 26	1	BUSHING, Starter Housing (Commutator End)	LN	LN-12335
SS 27	1	CAP, Starter Dust (Commutator End)	LN	LN-18256
SS 28	8	SCREW, Starter Housing (Drive End)	LN	LN-13743
SS 29	8	LOCKWASHER, Starter Housing Screw (Drive End)	LN	LN-2523
SS 30	8	WASHER, Starter Housing Screw Tabbed (Drive End)	LN	LN-7506
SS 31	1	ASSEMBLY, Bendix Drive Starter	LN	LN-12834
SS 32	1	ARMATURE, Starter	LN	LN-MA-20046
SS 33	8	BRUSH, Starter	LN	LN-16238
SS 34	16	SCREW, Starter Brush Rigging Lock Plate	LN	LN-5983
SS 35	16	LOCKWASHER, Starter Brush Rigging Lock Plate Screw	LN	LN-2435
SS 36	4	LOCK PLATE, Starter Brush Rigging	LN	LN-19858
SS 37	4	ASSEMBLY, Starter Brush Holder	LN	LN-18866
SS 38	1	JUMPER, Starter Brush Holder	LN	LN-16281
SS 39	1	JUMPER, Starter Grounding	LN	LN-19086
SS 40	1	CUP, Commutator End Oil	LN	....
SS 41	1	WICK, Starter Oil Felt	LN	LN-19586
SS 42	4	SCREW, Starter Housing (Commutator End)	LN	LN-2675
SS 43	1	SWITCH, Magnetic (27-MS-24)	LN	DE-50922
SS 44	1	CORE	LN	LN-12346
SS 45	1	COIL	LN	LN-5767
SS 46	2	INSULATOR, Lock	LN	LN-6150
SS 47	2	INSULATOR	LN	LN-6149

139. Starting System (Cont'd)

Ref. No.	Quantity	Description	Mfr.	Symbol
SS 48	2	TERMINAL, Wire	LN	LN-1931
SS 49	2	SCREW, Terminal	LN	LN-6126
SS 50	4	NUT	LN	LN-4340
SS 51	4	LOCKWASHER	LN	LN-2434
SS 52	2	WASHER, Guard	LN	LN-2385
SS 53	2	WASHER, Insulating	LN	LN-5896

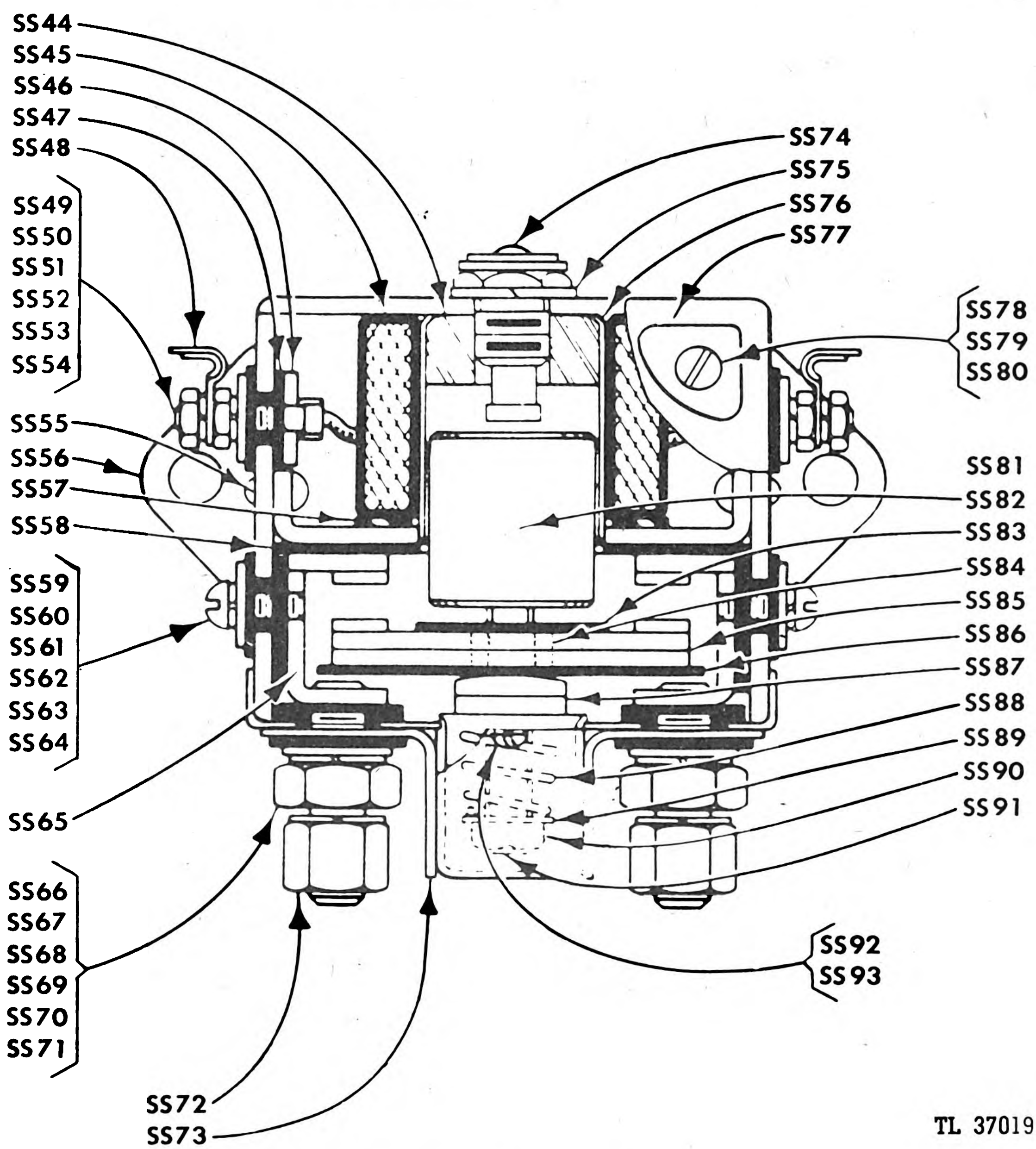

Fig. 361. Magnetic Switch

139. Starting System (Cont'd)

Ref. No.	Quantity	Description	Mfr.	Symbol
SS 54	4	BUSHING	LN	LN-3675
SS 55	1	BOX	LN	LN-19158
SS 56	1	BASE	LN	LN-19153
SS 57	2	WEDGE, Coil	LN	LN-5771
SS 58	1	INSULATOR	LN	LN-19170
SS 59	2	SCREW	LN	LN-5179
SS 60	2	LOCKWASHER	LN	LN-2434
SS 61	2	WASHER, Guard	LN	LN-26141
SS 62	2	WASHER, Insulating	LN	LN-13951
SS 63	2	BUSHING	LN	LN-22000
SS 64	2	INSULATOR	LN	LN-19169
SS 65	2	ASSEMBLY, Contact	LN	LN-19154
SS 66	2	NUT	LN	LN-5205
SS 67	4	LOCKWASHER	LN	LN-2433
SS 68	2	WASHER, Guard	LN	LN-5295
SS 69	2	WASHER, Insulating	LN	LN-13728
SS 70	2	BUSHING	LN	LN-5461
SS 71	2	WASHER, Insulating	LN	LN-2858
SS 72	2	NUT	LN	LN-13961
SS 73	2	INSULATOR	LN	LN-24784
SS 74	1	PIN, Release	LN	LN-19767
SS 75	1	LOCKWASHER	LN	LN-1613
SS 76	1	TUBE, Plunger	LN	LN-5279
SS 77	1	COVER	LN	LN-5273
SS 78	2	SCREW	LN	LN-5370
SS 79	2	LOCKWASHER	LN	LN-2434
SS 80	2	NUT	LN	LN-4340
SS 81	1	ASSEMBLY, Plunger	LN	LN-19707
SS 82	1	PLUNGER	LN	LN-19164
SS 83	1	INSULATOR	LN	LN-19168
SS 84	1	INSULATOR	LN	LN-19166
SS 85	1	ASSEMBLY, Contact	LN	LN-19152
SS 86	1	INSULATOR	LN	LN-19167
SS 87	1	STOP, Spring	LN	LN-19171
SS 88	1	SPRING	LN	LN-19163
SS 89	1	WASHER	LN	LN-5358
SS 90	1	NUT	LN	LN-22162
SS 91	1	ASSEMBLY, Rod	LN	LN-19710
SS 92	2	SCREW	LN	LN-2383
SS 93	2	LOCKWASHER	LN	LN-2435
X 132	3	CAPSCREW, Starter Mounting	BE	100184
X 505	3	LOCKWASHER, Starter Mounting	BE	103325

140. Alternator and Exciter Assembly

Ref. No.	Figure No.	Description	Mfr.	Symbol
1	363	GENERATOR, Type-ATI, Frame-994-S . . .	GE	12G565
2	362	ASSEMBLY, Stator	GE	8101451AJG1
3	363	ASSEMBLY, Rotor	GE	8139884G1
4	368	POLE, Rotor	GE	8103572AKG1
5	368	KEY, Pole	GE	5836914
6	368	SHIM, Pole, .014 x ½" x 6⅞" Long	GE	
7	362	EYEBOLT, Stator, ⅝"—11	GE	
8	368	FAN	GE	8139237P1
9	368	CAPSCREW, Hex Head 1½" Long, ½"—13	GE	9887
10	368	LOCKWASHER, 11/64" x ⅛"	GE	
11	362	SHIELD, Engine End	GE	8115744ABP1
12	363	BAFFLE		5887336P1
13	363	SCREW, Machine, Round Head 1" Long, 5/16"—18	GE	
14	363	LOCKWASHER, ⅛" x 3/32"	GE	
15	368	COVER, Grease	GE	8066014P1
16	368	BEARING, SKF No.-6315	SKF	3666784P16
17	362	CUP, Grease, Gits No. 7004, Style GA, Size 00, ⅛"—I.P.S.	GTS	

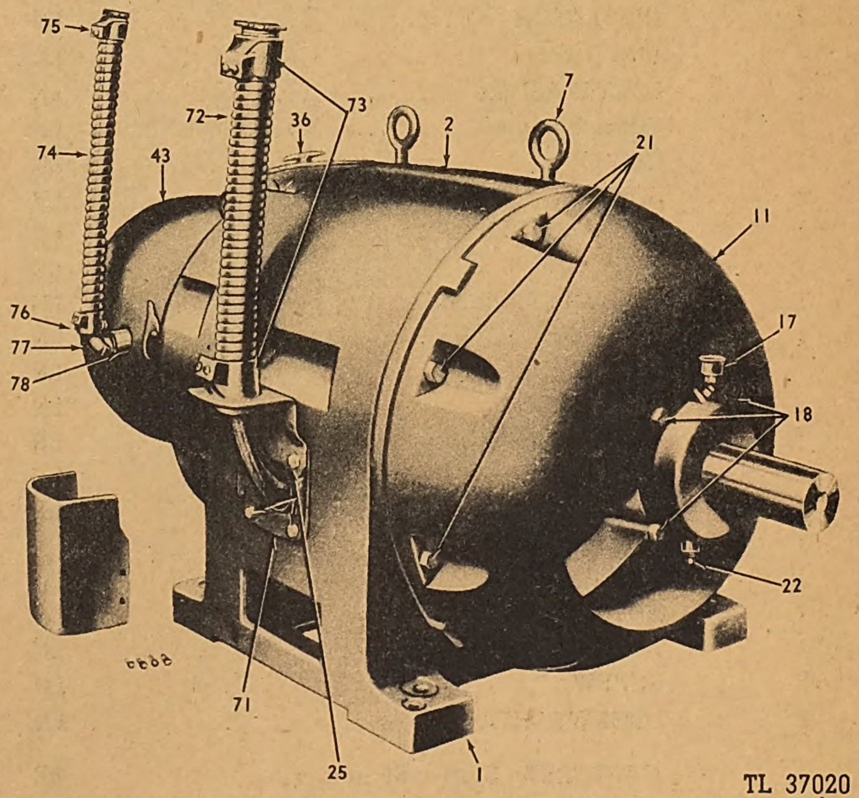

Fig. 362. Alternator and Exciter

140. Alternator and Exciter Assembly (Cont'd)

Ref. No.	*Figure No.*	*Description*	*Mfr.*	*Symbol*
18	362	FITTING, Angle (45°), Gits No.-8155, Style F	GTS	
19	368	LOCKWASHER, SKF No. W-15	SKF	
20	368	LOCKNUT, SKF No. AN-15	SKF	
21	362	CAPSCREW, Hex Head 3½" Long, ½"—13	GE	
22	362	PLUG, Bearing Housing, Square Head, ¼"		
23	363	CONNECTOR, Coil to Coil, Copper Wire, No. 6 (.162"), 4½" Long	GE	
24	363	BOX, Conduit	GE	5983484G1
25	362	CAPSCREW, Hex Head ¾" Long, ⅜"—16		
26	363	LEAD, Rotor	GE	5856427G4
27	363	SCREW, Machine, Round Head, ½" Long, ¼"—20	GE	167816
28	363	LOCKWASHER, ⅛" x 1/16"	GE	
29	363	CLAMP, Rotor Lead	GE	50807683G3
30	363	CAPSCREW, Hex Head 2½" Long, ⅝"—11	GE	
31	368	SEAL, Grease	GE	2478336
32	363	SHIELD, Exciter End	GE	8115741ACP1
33	363	CAPSCREW, Allen Hex Socket Head 5" Long, ⅝"—11	GE	
34	363	BAFFLE	GE	5887695P1
35	363	COVER, Deflector	GE	5887352G1

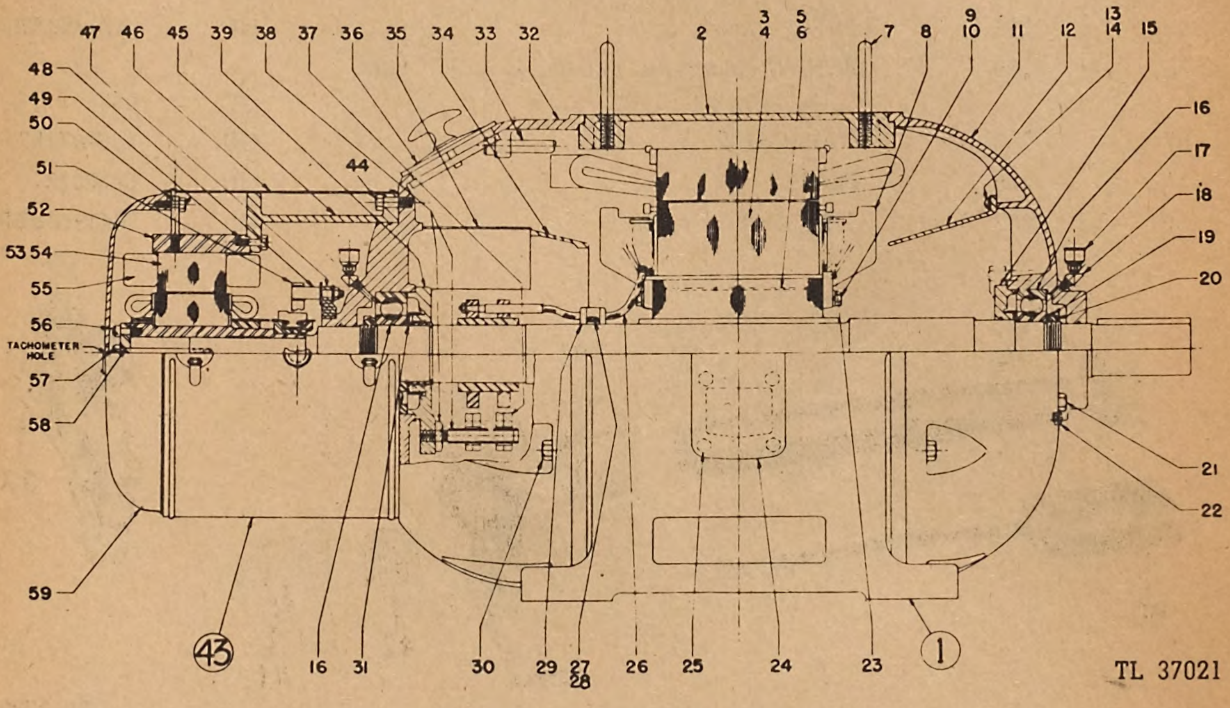

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Fig. 363. Sectional Outline

140. Alternator and Exciter Assembly (Cont'd)

Ref. No.	*Figure No.*	*Description*	*Mfr.*	*Symbol*
36	362	COVER	GE	8126864G1
37	364	ASSEMBLY, Brush Holder	GE	5844427ABG1
38	364	STUD, Brush Holder with Insulation and Jam Nut	GE	5823467ADG7
39	368	COVER, Grease	GE	5887335P1
40	364	BRUSH	GE	5804490
41	364	ASSEMBLY, Lever	GE	1846460G1
42	364	SPRING	GE	243928
43	362	EXCITER, Type BF, Frame 810	GE	17G357
44	363	CAPSCREW, Hex Head 1½" Long, ½"—13	GE	
45	363	BRACKET, Supporting	GE	5843917AFP2
46	363	COVER, Exciter	GE	5848462APG2
47	367	YOKE, Brush Holder	GE	5822519P1
48	367	STUD, Brush Holder	GE	5822520G2
49	363	CAPSCREW, Hex Head 1" Long, ⅜"—16	GE	308
50	363	EYEBOLT	GE	5838561
51	367	ASSEMBLY, Brush Holder	GE	4813380G13
52	363	FRAME, Magnet	GE	8134617P1
53	365	PIECE, Pole	GE	1792901ACG1
54	365	CAPSCREW, Hex Head 1¾" Long, ½"—13	GE	5150
55	365	FIELD, Coil	GE	8134358ABG1
56	366	SCREW, Machine, Fillister Head 1" Long ⅜"—16	GE	9831
57	366	CAPSCREW	GE	5867872P7
58	366	PLATE	GE	5890522
59	363	SHIELD, End	GE	5843918ABP2

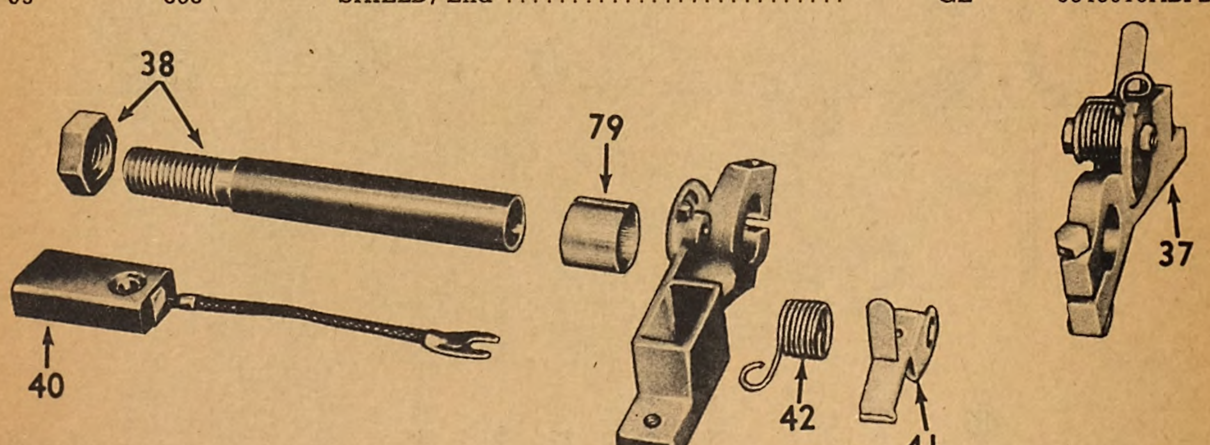

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Fig. 364. Alternator Brush Rigging

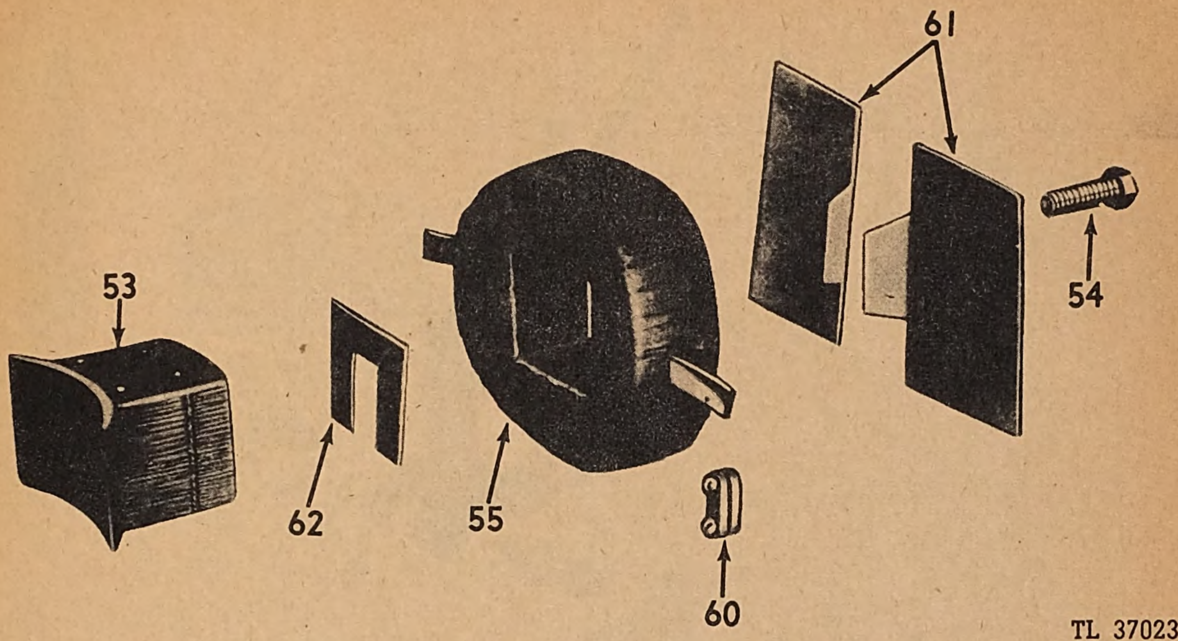

Fig. 365. Exciter Main Field Coil and Pole Piece Exploded

140. Alternator and Exciter Assembly (Cont'd)

Ref. No.	*Figure No.*	*Description*	*Mfr.*	*Symbol*
60	365	CLIP	GE	1743528G1
61	365	PAD, Field Coil	GE	5874085
62	365	SHIM, Pole Piece	GE	5874086
63	366	ARMATURE, Exciter (Complete)	GE	8134741G1
64	367	BRUSH	GE	5804490
65	367	SPRING	GE	3794709
66	367	SCREW, Clamp, Round Head 4" Long 5/16"—18	GE	284X63

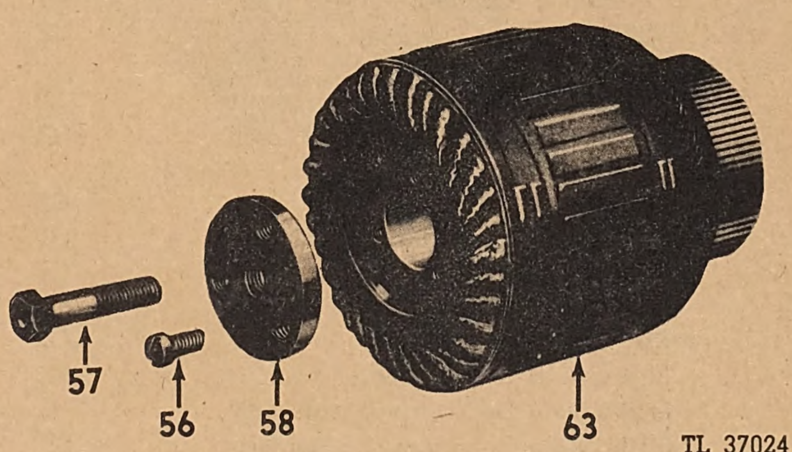

Fig. 366. Exciter Armature

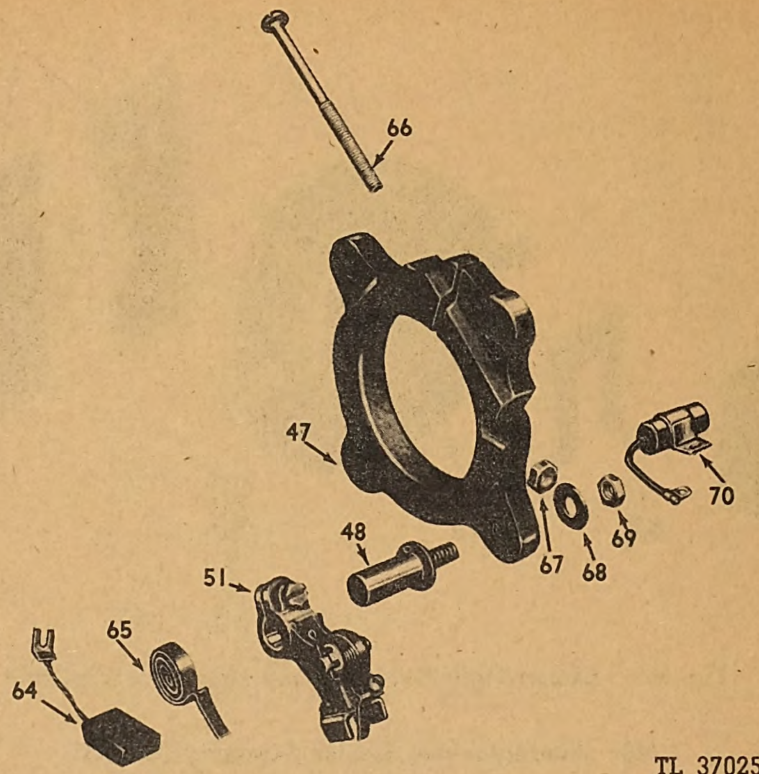

Fig. 367. Exciter Brush Rigging Exploded

140. Alternator and Exciter Assembly (Cont'd)

Ref. No.	*Figure No.*	*Description*	*Mfr.*	*Symbol*
67	367	NUT, Clamp Screw, $\frac{5}{16}$"—18, Hex	GE	47346
68	367	WASHER, Brush Holder Stud, .062" Thick, $\frac{3}{4}$" O.D., $\frac{13}{32}$" I.D.	GE	414729
69	367	NUT, Brush Holder Stud, Hex $\frac{3}{8}$"—16	GE	47347
70	367	CAPACITOR, .25 M.F.D., Electric Auto-Lite Catalog IGB-1025J	AL	
71	362	PLATE, Conduit Box	GE	5873760
72	362	CONDUIT, Flexible, $17\frac{1}{2}$" Long, $1\frac{1}{2}$" Single Strip	GE	
73	362	FITTING, Conduit, Straight, "Tite-Bite" ..	GE	SP5310
74	362	CONDUIT, Flexible, $17\frac{1}{2}$" Long, 1" Single Strip	GE	
75	362	FITTING, Conduit, Straight, "Tite-Bite" ...	GE	SP5306
76	362	FITTING, Conduit, 90° Angle, "Tite-Bite" .	GE	SP5326
77	362	COUPLING, Conduit, 1"	GE	
78	362	NIPPLE, Conduit, Close 1"	GE	
79	364	BUSHING, Brush Rigging	GE	2435212
*		SHIM, Main Generator (8 required)	BE	DP-2891
*		SHIM, Main Generator (8 required)	BE	DP-2894

* Not Illustrated.

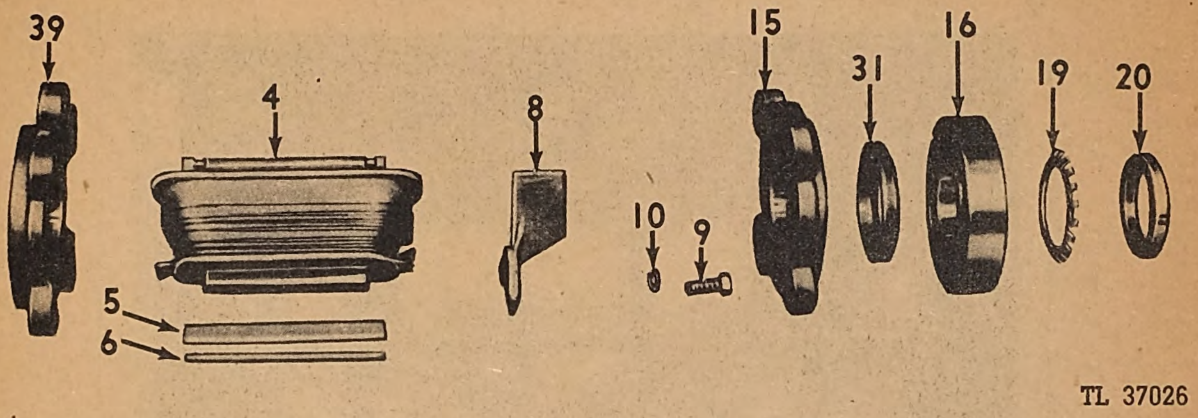

Fig. 368. Rotor Pole, Fan, Pole Key, and Pole Shim

141. Flexible Coupling

Ref. No.	*Quantity*	*Description*	*Mfr.*	*Symbol*
RR 1	1	COUPLING, Engine to Generator, 11-FAS	FK	DP-2648
RR 2	1	KEY, $\frac{5}{8}$" x $\frac{5}{16}$"	BE	....

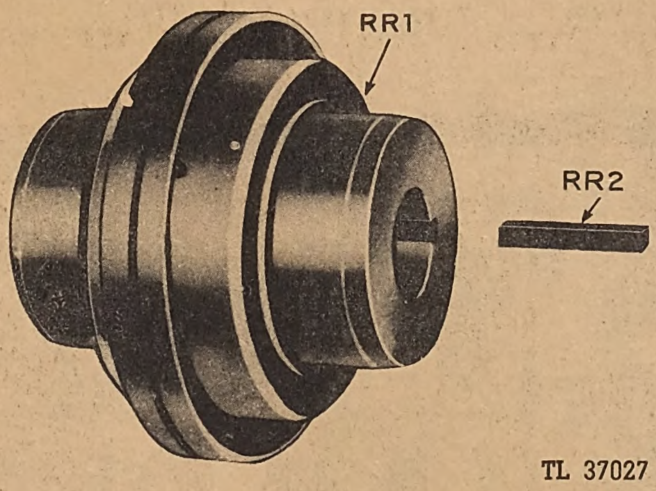

Fig. 369. Coupling

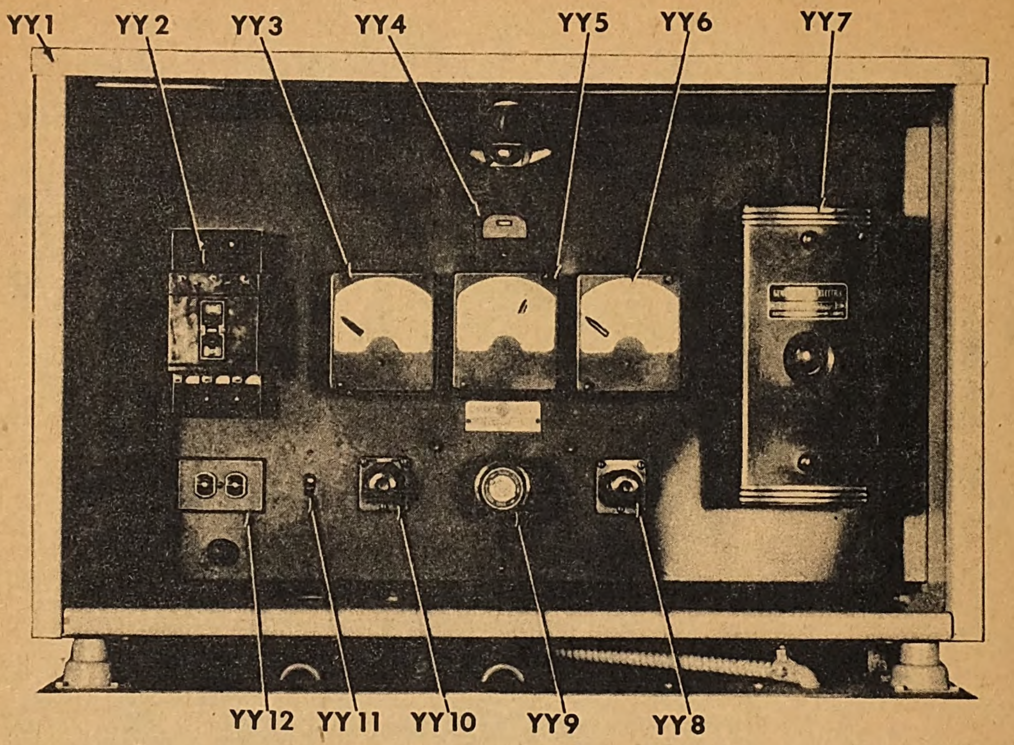

Fig. 370. Alternator Control Panel (Front)

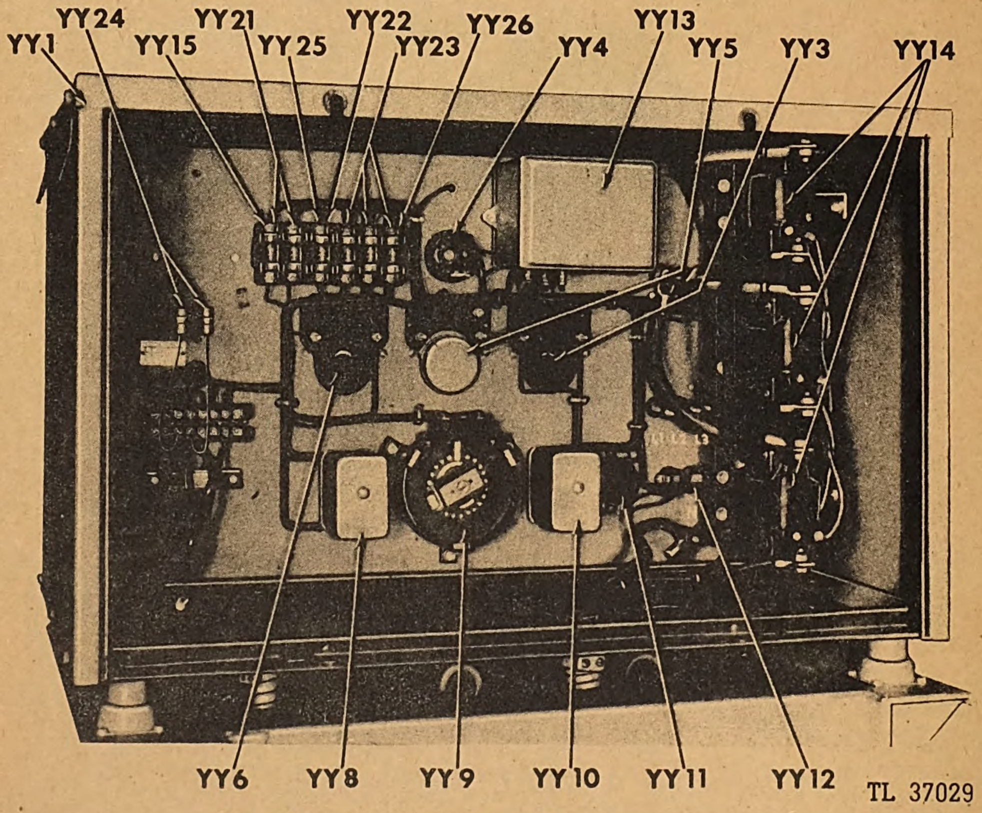

Fig. 371. Alternator Control Panel (Rear)

142. Alternator Control Panel and Mounting Frame

Ref. No.	Quantity	Description	Mfr.	Symbol
YY 1	1	CABINET, Generator Control	GE	DL-3025
YY 2	1	BREAKER, Circuit	GE	AF-1-TPST
YY 3	1	AMMETER, 150—5 amp.	GE	8AD6ABZ37
YY 4	1	METER, Time	GE	8KT8
YY 5	1	METER, Frequency (AD-6)	GE	8AD6FAA8
YY 6	1	VOLTMETER, 300-volt	GE	8AD6VBD
YY 7	1	REGULATOR, Voltage, Type GBA40	GE	3GBA40A4
YY 8	1	SWITCH, Voltmeter Phase	GE	16SB1CF1
YY 9	1	RHEOSTAT, Cat. No. SPEC—Ward-Lanord		1942-4235-08
YY 10	1	SWITCH, Ammeter	GE	16SPICE-24
YY 11	1	SWITCH, Snap	GE	GE-2842

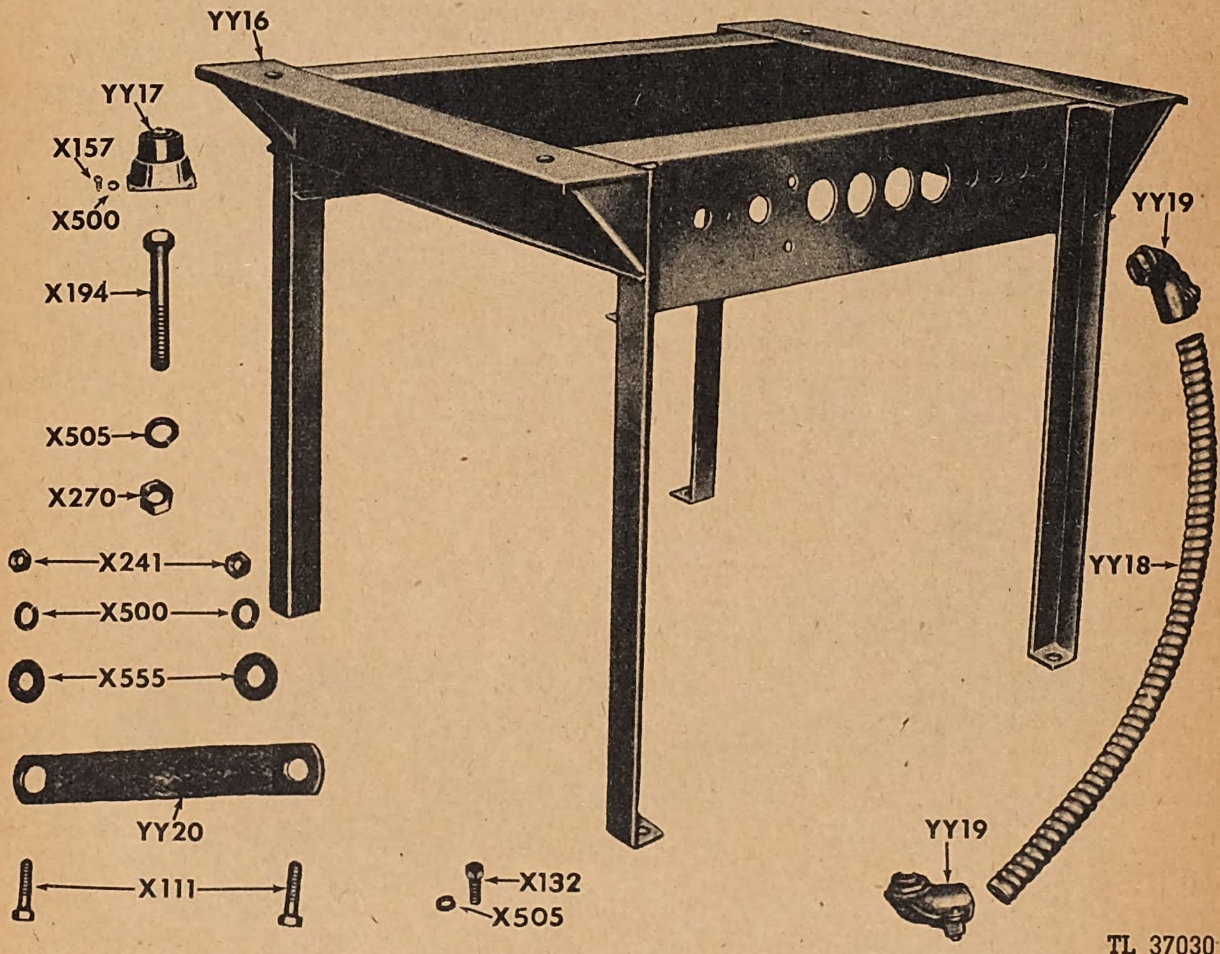

Fig. 372. Alternator Control Mounting Frame

142. Alternator Control Panel and Mounting Frame (Cont'd)

Ref. No.	*Quantity*	*Description*	*Mfr.*	*Symbol*
YY 12	1	RECEPTACLE, Duplex, 10—250 amp.; 15—125 amp.	GE	....
YY 13	1	IMPEDOR, for 8AD6FAA8	GE	1432789
YY 14	1	TRANSFORMER, Current 150—5 amp.	GE	JY755
YY 15	1	BLOCK, Fuse	GE	Cat. No. 34367
YY 16	1	ASSEMBLY, Generator Conduit Cabinet Support	BE	DP-2700
YY 17	4	MOUNTING, Generator Control Cabinet Rubber	BE	PA-295
YY 18	1	CONDUIT, Main Generator to Control Cabinet	BE	DP-2800
YY 19	2	CONNECTOR, Main Generator to Control Cabinet Conduit	BE	PA-331
YY 20	1	STRAP, Alternator Control Panel to Frame	BE	DE-42727
YY 21	2	FUSE, 10 amp.	GE	34952
YY 22	1	FUSE, 6 amp.	GE	59380
YY 23	3	FUSE, 2 amp.	GE	59951
YY 24	2	CAPACITOR, .1 MFD		....
YY 25		BLOCK, Fuse	GE	Cat. No. 189664
YY 26		BLOCK, Fuse	GE	Cat. No. 34372

143. Base and Drip Pan Assembly

Ref. No.	*Quantity*	*Description*	*Mfr.*	*Symbol*
ZZ 1	1	PAN, Drip	BE	DL-3057
ZZ 2	1	CAP, Drip Pan Drain Pipe, $\frac{3}{8}$"	BE	110675
ZZ 3	1	PIPE, Drip Pan Drain, $\frac{3}{8}$"—14" Long	BE	DL-3112
ZZ 4	1	ELBOW, Drip Pan, $\frac{3}{8}$"—90° Strut	BE	120063
ZZ 5	1	ASSEMBLY, Engine Sub Base	BE	DL-3022
X 37	6	CAPSCREW, $\frac{5}{16}$"—18—$\frac{3}{8}$"	BE	106963
X 144	6	CAPSCREW, $\frac{5}{16}$"—18—$\frac{7}{8}$"	BE	106325
X 501	12	LOCKWASHERS, $\frac{5}{16}$"	BE	103320
*	6	NUT, $\frac{5}{16}$"—18	BE	102634

* Not Illustrated.

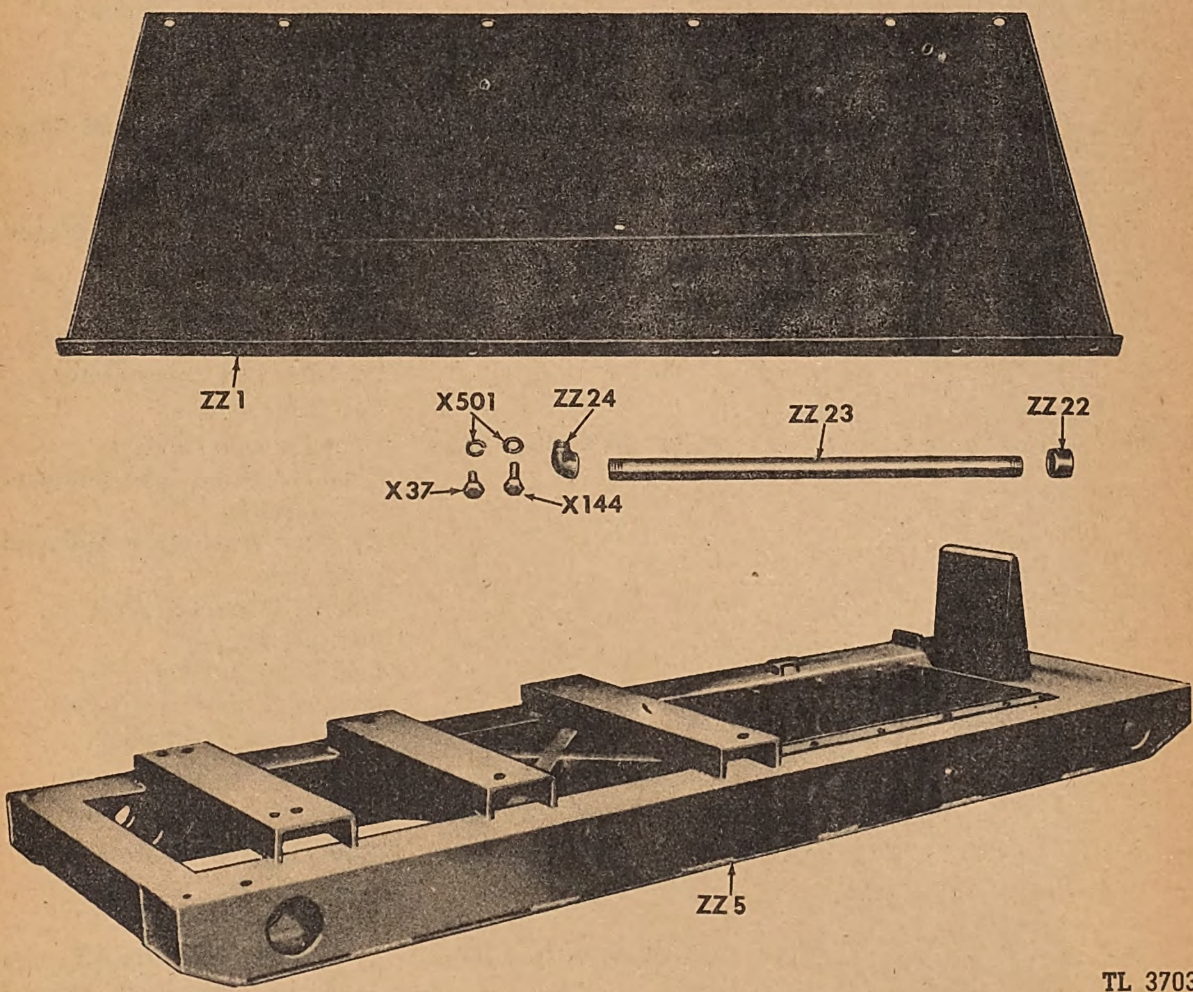

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Fig. 373. Base and Drip Pan Assembly

144. Bolts and Capscrews

Quantity	Size	Length	Thread	Description	Where Used
24	3/8"	1"	16	CAPSCREW, Hex Head..	Fuel Pump to Adaptor Fuel Pump Adaptor Fan Blade Safety Control Switch Bracket Water Pump to Engine Fuel Filter Bracket and Connector Block Assembly 2nd Stage Filter to Bracket
3	3/8"	1½"	16	CAPSCREW, Hex Head..	Spacer Capscrew for 2nd Stage Filter Bracket Fan Bracket Battery Carriage
1	½"	13"	13	BOLT, Round Head......	Battery Carriage
2	7/16"	1¾"	14	BOLT, Round Head......	Carriage
9	¼"	1⅛"	20	CAPSCREW, Hex Head..	Cylinder Water Jacket Cover Throttle Control Coupling
7	¼"	5/8"	20	CAPSCREW, Slotted.....	Water Pump Cover
4	¼"	¾"	20	CAPSCREW, Hex Head..	Air Heater Switch
5	¼"	1"	20	CAPSCREW, Hex Head..	Main Generator Ground Strap Fuel Line Clamp
8	5/16"	1"	18	CAPSCREW, Hex Head..	By-Pass Line Cylinder Water Inlet Manifold
2	5/16"	1¼"	18	CAPSCREW, Hex Head..	By-Pass Line
9	3/8"	¾"	16	CAPSCREW, Hex Head..	Magnetic Switch Lube Oil Filter Oil Filler Pad Cover Plate Fuel Tank Bracket
27	3/8"	1¼"	16	CAPSCREW, Hex Head..	Gear Housing Cover Cylinder Water Inlet Manifold Connection Cylinder Water Inlet Manifold Adaptor Throttle Control Bracket Radiator Support Fuel Filter Bracket Inlet Pipe and Tie Support Water Inlet Connection
2	3/8"	1½"	16	CAPSCREW, Hex Head ..	Oil Pump Suction Flange
1	3/8"	1¼"	16	CAPSCREW, Hex Head..	Radiator Inlet
12	3/8"	1¾"	16	CAPSCREW, Hex Head..	Lube Oil Filter Gasket Lube Oil Filter Valve Lifter Bracket
6	½"	1"	13	CAPSCREW, Hex Head..	Exhaust Manifold Blind Flange Muffler Bracket and Exhaust Blind Flange

144. Bolts and Capscrews (Cont'd)

Quantity	*Size*	*Length*	*Thread*	*Description*	*Where Used*
7	½"	1¼"	13	CAPSCREW, Hex Head..	Rope Starter Pulley Flange Exhaust Manifold Elbow
6	½"	1½"	13	CAPSCREW, Hex Head..	Front Support Rope Support Flange Front Support to Engine
12	⅝"	1½"	11	CAPSCREW, Hex Head..	Front Support to Base Starting Motor Control Cabinet Support Hose Cabinet Support Hose
7	¼"	⅝"	20	CAPSCREW, Hex Head..	Fuel Line Clamp Oil Pump Body Cover
20	¼"	⅞"	20	CAPSCREW, Hex Head..	Cylinder Water Jacket Cover
22	5/16"	⅞"	18	CAPSCREW, Hex Head ..	Exhaust Manifold Cover and Temperature Bulb Housing Exhaust Manifold Cover Plate Three-Way Block to Bracket Fuel Filter Bracket
4	5/16"	1⅜"	18	CAPSCREW, Hex Head..	Bracket
2	⅜"	⅞"	16	CAPSCREW, Hex Head..	Warning Howler
4	⅜"	1⅛"	16	CAPSCREW, Hex Head..	Radiator Tie Rod Bracket
4	½"	1⅜"	13	CAPSCREW, Hex Head..	Fuel Tank Strap
20	¼"	½"	20	CAPSCREW, Hex Head..	Rubber Mounting Camshaft Gear Thrust Collar Lock Plate
2	5/16"	1½"	18	CAPSCREW, Hex Head..	Dust Plate
4	5/16"	2¾"	18	CAPSCREW, Hex Head..	Thermostat Housing
4	⅜"	1½"	16	CAPSCREW, Hex Head..	Radiator Screen
6	No. 10	⅝"	24	CAPSCREW, Round Head	Terminal Block and Socket Cover
1	No. 10	¾"	24	CAPSCREW, Round Head	Throttle Control Clip
2	¼"	1¾"	20	CAPSCREW, Fillister Head Slotted.........	Water Pump Cover
12	¼"	⅝"	20	CAPSCREW, Round Head	Radiator Guard
36	⅜"	1"	16	CAPSCREW, Hex Head,.	Fuel Pump Oil Pan Hole Cover Thermostat Water Outlet Pipe Throttle Control Bracket Outlet Radiator Inlet Adaptor Safety Control Switch Bracket Fuel Pump to Adaptor Fuel Pump Adaptor Fuel Filter Bracket and Connector Block Bracket Assembly 2nd Stage Filter to Bracket

145. Lockwashers

Quantity	Size	Length	Thread	Description	Where Used
96	1/4"			LOCKWASHER	Voltage Regulator Voltage Regulator Vibration Dampener Main Generator Ground Strap Rear Main Bearing Oil Seal Screw Radiator Shroud Capscrew Radiator Guard Capscrew Muffler Bracket "U" Bolt Rubber Mounting Fuel Line Clamp Capscrew Air Heater Switch Fuel Line Clamp Cylinder Water Jacket Cover Capscrew
36	1/2"			LOCKWASHER	Front Support Capscrew to Engine Dust Plate Exhaust Manifold Cover and Temperature Bulb Housing Capscrew Three-Way Block to Bracket Bracket Fuel Filter Bracket Thermostat Housing Capscrew Cylinder Water Inlet Manifold Capscrew By-Pass Line Fan Bracket Bolt
136	3/8"			LOCKWASHER	Gear Housing Cover Capscrew Fuel Pump Capscrew Air Cell Magnetic Switch Lube Oil Filter Gasket Capscrew Lube Oil Filter Capscrew Oil Filler Pad Cover Plate Capscrew Oil Pump Suction Flange Oil Pan Hole Cover Capscrew Oil Pan Handhole Cover Stud Valve Lifter Bracket Capscrew Thermostat Water Outlet Pipe Water Pump to Engine Cylinder Water Inlet Manifold Connection Capscrew Cylinder Water Inlet Manifold Adaptor Capscrew

145. Lockwashers (Cont'd)

Quantity	*Size*	*Length*	*Thread*	*Description*	*Where Used*
				LOCKWASHER	Throttle Control Bracket Capscrew
					Radiator Screen Capscrew
					Radiator Support Capscrew
					Radiator Tie Rod Bracket Capscrew
					Rocker Arm Bracket Capscrew
					Inlet Capscrew
					Outlet Capscrew
					Water Inlet Connection
					Safety Control Switch Bracket Capscrew
					Warning Howler Capscrew
					Air Cleaner Inlet Connection Capscrew
					Air Heater Housing
					Fuel Filter Bracket
					Fuel Pump to Adaptor Capscrew
					Fuel Pump Adaptor
					Fuel Tank Bracket Capscrew
					2nd Stage Filter to Bracket Capscrew
					Fuel Filter Bracket and Connector Block Assembly Capscrew
					Fuel Tank Strap Nut
					Spacer Capscrew for 2nd Stage Filter
					Fan Blade Capscrew
3	7/16"			LOCKWASHER	Generator Adaptor Stud
					Generator Stud
50	1/2"			LOCKWASHER	Gear Housing Dowel Bolt
					Flywheel Housing Dowel Bolt
					Flywheel Housing
					Fylwheel Housing Capscrew
					Rope Starter Pulley Flange
					Rope Support Flange
					Fuel Tank Strap Capscrew
					Exhaust Manifold Blind Flange
					Exhaust Manifold Cover Plate
					Exhaust Manifold Elbow
					Muffler Bracket and Exhaust Blind Flange Capscrew
					Battery Carriage Bolt
					Gear Housing Dowel Bolt

145. Lockwashers (Cont'd)

Quantity	*Size*	*Length*	*Thread*	*Description*	*Where Used*
36	5/8"			LOCKWASHER	Front Support Capscrew to Base Radiator Stud Starting Motor Capscrew Control Cabinet Support Hose Cabinet Support Hose Front Support Capscrew to Engine
2	3/4"			LOCKWASHER	Radiator Tie Rod Nut
12	No. 10			LOCKWASHER	Terminal Block and Socket Cover Capscrew Safety Control Screw Terminal Block Screw
5	1/2"			LOCKWASHER	Flywheel Bolt
6	1/4"			LOCKWASHER	Oil Pump Body Cover Capscrew
8	3/8"			LOCKWASHER	Fuel Pump to Adaptor Capscrew
12	1/2"			LOCKWASHER	Gear Housing Cover Gear Housing Capscrew
4	9/16"			LOCKWASHER	Rocker Arm Shaft End Plug

146. Nuts

18	3/8"		16	NUT, Hex	Cylinder Water Inlet Manifold Adaptor Capscrew Cylinder Water Inlet Manifold Connection Warning Howler Capscrew Fuel Filter Bracket Air Cleaner Inlet Connector Capscrew 2nd Stage Filter to Bracket Capscrew
2	1/2"		13	NUT, Hex	Fan Bracket Bolt
2	5/8"		11	NUT, Hex	Radiator Stud
2	3/4"		10	NUT, Hex	Radiator Tie Rod
16	3/8"		24	NUT, Hex	Oil Pan Handhole Cover Stud Air Heater Housing Stud Fuel Tank Strap
4	1/2"		20	NUT, Hex	Gear Housing Dowel Bolt Flywheel Housing Dowel Bolt
8	5/8"		18	NUT, Hex	Cylinder Head Stud—Thick

146. Nuts (Cont'd)

Quantity	Size	Length	Thread	Description	Where Used
36	¼"		20	NUT, Hex	Throttle Control Coupling Capscrew Terminal Block and Socket Cover Capscrew Terminal Block Screw
28	No. 10		24	NUT, Hex	Terminal Block Screw
4	⅜"		16	NUT, Hex	Radiator Screen Capscrew
8	¼"		20	NUT, Hex	Radiator Shroud Capscrew
1	½"		20	NUT, Hex	Air Heater Terminal Capscrew
2	5/16"		18	NUT, Thin Hex	Throttle Control Rod
12	⅜"		24	NUT, Hex	Air Cell
3	7/16"		20	NUT, Hex	Generator Adaptor Stud Generator Stud
12	¼"		20	NUT, Hex	Voltage Regulator Voltage Regulator Vibration Dampener Main Generator Ground Strap Muffler Bracket "U" Bolt Fuel Line Clamp
9	5/16"		18	NUT, Hex	Bracket Three-Way Block to Bracket Water Inlet Connection
12	⅜"		16	NUT, Hex	Oil Pan Hole Cover Capscrew Radiator Support Capscrew Fuel Pump Adaptor Stud
3	½"		13	NUT, Hex	Battery Carriage Bolt
4	⅜"		24	NUT, Hex Brass	Air Heater Bolt Terminal

147. Pipe Fittings and Plugs

Quantity	Size	Length	Thread	Description	Where Used
3	¾"			PLUG, Square Head	Cylinder Water Inlet Manifold Connection Water Pump Inlet Connection Exhaust Manifold Water Drain
1	½"			PLUG, Square Head	Lube Oil Filter Sump Drain
6	⅜"			PLUG, Countersunk	Cylinder and Crankcase Pipe
11	½"			PLUG, Countersunk	Cylinder Head Pipe Exhaust Manifold Pipe Cylinder and Crankcase Oil Line Cylinder and Crankcase Pipe

147. Pipe Fittings and Plugs (Cont'd)

Quantity	*Size*	*Length*	*Thread*	*Description*	*Where Used*
4	¾"			PLUG, Headless Countersunk	Exhaust Manifold Water Drain Cylinder and Crankcase Pipe Water Manifold End
1	1"			PLUG, Headless Countersunk	Cylinder Head Pipe
1	⅛"			PLUG, Square Head Steel	Cylinder and Crankcase Oil
1	¼"			PLUG, Headless Slotted	Gear Housing Pipe
1	1½"			PLUG, Welsh Expansion	Cylinder and Crankcase
1	1¼"			PLUG, Square Head	Pipe
1	¼"	⅛"		BUSHING	Pipe Reducer
1	¼" Tube			CONNECTION	Oil Line to Excello Pump
1	¼" Tube		⅛" Pipe	ELBOW	Oil Line with Nut and Sleeve
1	⅜"			COCK	Drain
1	¼" Tube		⅛" Pipe	CONNECTION	Lube Oil Line to Gauge
2	⅜" Tube		¼" Pipe	CONNECTOR	Fuel Line—2nd Stage Filter to Fuel Pump Flared Tube
2	½" Tube		⅜" Pipe	CONNECTOR	Flared Tube Lube Oil Line
1	¼" Tube		⅛" Pipe	ELBOW	Oil Line—Flared Tubing
10	⅜" Tube		¼" Pipe	ELBOW	Fuel Line Assembly—Bleeder Valve to Three-Way Block Fuel Line Assembly—2nd Stage Filter to Fuel Pump Fuel Line—2nd Stage Filter Lube Oil Line Fuel Line
2	½" Tube		⅜" Pipe	ELBOW	Lube Oil Line Fuel Line—Connecting Block to 1st Stage Filter
1	¼" Tube		⅛" Pipe	TEE	Oil Line (Two-Way)—Flared Tubing
12	⅛"		⅛" Pipe	PLUG, Headless Slotted	Cylinder Head Pipe
2	3/16"		⅛" Pipe	ELBOW	Oil Line Assembly
1	1⅛"			PLUG, Steel	Water Pump Expansion
1	⅛" Tube		⅛" Pipe	ELBOW	Bronze
1	⅜"	½"		BUSHING	Pipe
1	½" Tube		½" Pipe	ELBOW, Brass 90°	Pipe
2	¼"		¼" Pipe	ELBOW, Brass	Pipe—Street 90°
1	¼"		¼" Pipe	TEE, Brass	Pipe
1	⅛"	2"		NIPPLE	Pipe
1	⅜"			PLUG, Square Head	Fuel Tank Drain—Brass

148. Washers—Plain and Flat

Quantity	*Size*	*Length*	*Thread*	*Description*	*Where Used*
3	1/4"			WASHER, Flat Small	Radiator Guard Capscrew Flat Voltage Regulator Wire Clip
2	5/16"			WASHER, Flat Small	Throttle Connecting Rod
2	1/4"			WASHER, Flat Large	Main Generator Ground Strap
12	3/8"			WASHER, Flat Large	Cylinder Head Cover Stud Rocker Arm Assembly Stud
1	1"			WASHER, Flat Large	Base
40	No. 10			WASHER, Flat Small Brass	Terminal Block Screw

149. Cotters

12	3/32"	1"		PIN	Connecting Rod Cotter
1	3/16"	1 1/4"		PIN	Rope Starter Shaft Cotter

150. Dowels (Pins)

1	3/16"	1/2"		PIN	Idler Gear Lockscrew
1	1/2"	2"		PIN	Rope Starter Shaft
2	3/32"	3/8"		PIN	Rear Main Bearing Dowel
2	3/8"	1"		DOWEL	Fuel Pump Drive Gear Water Pump Body

151. Gaskets

8	3/8"			GASKET, Annular	Oil Pan Hole Cover Cap Center Rocker Arm Bracket to Cylinder Head
4	5/8"			GASKET, Annular	Idler Gear Idler Gear Lockscrew Oil Pump Dowel

152. Keys

1	5/32"x5/8"			KEY, Woodruff No. 6	Water Pump Driver Spider
2	1/4"x1"			KEY, Woodruff No. 15 ...	Generator Driven Gear Camshaft Gear
1	5/16"	1 1/4"		KEY, Woodruff No. D	Crankshaft Gear
2	1/8"	1/2"		KEY, Woodruff No. 3	Fuel Pump Driven Gear

153. Screws

2	No. 8	3/8"	32	SCREW, Round Head	Throttle Wire Collar
4	No. 10	3/8"	24	SCREW, Round Head	Safety Control
12	No. 10	1"	24	SCREW, Round Head	Terminal Block
4	No. 10	1 1/2"	24	SCREW, Round Head	Terminal Block
2	3/8"	3/4"	16	SCREW, Flat Head	Safety Control Switch Bracket
8	1/4"	3/4"	20	SCREW, Flat Head	Radiator Shroud
2	1/4"	5/8"	20	SCREW, Round Head Machine	Radiator Guard
12	No. 10	3/4"	24	SCREW, Round Head	Terminal Block

154. Maintenance Parts List For Power Unit PE-185-B

Ref symbol	Signal Corps stock No.	Name of part and description	Quan per unit	Orgn stock 1st ech	Orgn stock 2d ech	3d ech	4th ech	Depot stock
	3H1911-1	ENGINE: 60 hp; 4 cyc; 1,200 rpm; Buda model 6 DTG-468 ..	1					*
		AIR CLEANER GROUP						
AA 24	3H1911-1/C15	CLEANER ASSEMBLY, air: Buda DE-55602	1					*
		AIR HEATER GROUP						
AA 25		HEATER ASSEMBLY, air: 24v; Buda DE-42832	1					*
AA 23		SWITCH: air heater; Buda 1715	1					*
		BATTERY GROUP						
PP 3		BATTERY, storage: 12v; Globe Union DL-3193	2					*
		CAMSHAFT GROUP						
E 20	3H1911-1/B2	BEARING, camshaft: spcl; 1.7525" OD x 1.5034" ID x 1.482" wd; Buda DE-41504	1				*	*
E 22	3H1911-1/B3	BEARING, camshaft: spcl; front; bronze; 2.236" ID x 2.5025" OD x 1.748" wd; Buda DE-41417	1				*	*
E 21	3H1911-1/B4	BEARING, camshaft: spcl; intermediate; bronze; 2.5025" OD x 2.236" ID x 7/8" wd; Buda DE-41386; p/o Buda engine ...	2				*	*
B 1	3H1911-1/C10	CAMSHAFT: Buda DE-40067	1					*
B 3	3H1911-1/C21	COLLAR: camshaft thrust; Buda DE-55995	1					*
B 4	3H1911-1/G15	GEAR: camshaft; spcl; 8.0761" OD x 1½" wd; 1.2500" bore; Buda DE-40114	1					*
X 731	3H1911-1/K11	KEY: camshaft gear; Buda 113782	1					*
B 2	3H1911-1/P15	PLATE, lock: special; Buda 1341	1					*
B 5	3H1911-1/R5	RETAINER: camshaft gear; spcl; Buda 1307	1					*
		CONTROL GROUP						
YY 3	3F1150-10	AMMETER: a-c; 0-150 amp; GE type AD-6, dwg No. 8AD6ABZ 37	1					*
YY 2	3H900-100-1	CIRCUIT BREAKER: 100 amp; 125v; GE AF-1	1					*

* Indicates stock available.

Ref symbol	Signal Corps stock No.	Name of part and description	Quan per unit	Orgn stock 1st ech	Orgn stock 2d ech	3d ech	4th ech	Depot stock
YY 5	3F2787	FREQUENCY METER: 55-65 cyc; GE type AD6	1					*
YY 23	3Z1903-2	FUSE: 2 amp, 250v; Fed Spec W-F-791	2		*	*	*	*
YY 22	3Z2606.8	FUSE: 6 amp, 250v; Chase Shawmut D-1003	2	*	*	*	*	*
YY 21	3Z1931	FUSE FU-31: 10 amp, 250v; Superlag	2	*	*	*	*	*
	3Z3006	FUSE LINK: 6 amp, 250v; Fed Spec W-F-803	2		*	*	*	*
	3Z3010	FUSE LINK M-195: 10 amp, 250v; Econ Fuse R-210 or Bryant Elec 7156	2		*	*	*	*
	3H4860-4	RECTIFIER, selenium: GE model 6RS5A6V	1					*
YY 7	3H4992-1	REGULATOR, voltage: complete; 125 amp, 208v; 60 cyc; GE dwg 3GBA-40A4M	1					*
		RESISTOR: vitreous; WL type; GE dwg 1133045	1					*
YY 9	3Z7130	RHEOSTAT: 130 ohm; 525w; Wemco 874472	1					*
YY 14	2Z9900.9	TRANSFORMER: current; GE JY-755AA2; dwg K4147218	1					*
YY 6	3F8300-34	VOLTMETER: a-c; 0-300v; GE type AD6; dwg 8AD6VBD	1					*
		CYL BLOCK & GEAR COVER GROUP						
D 9	3H1911-1/B7	BEARING: center main; spcl; upper, Buda DE-41367; lower, Buda DE-41368	1				*	*
D 7	3H1911-1/B9	BEARING: front main; spcl; upper, Buda DE-41363; lower, Buda DE-41364	1				*	*
D 8	3H1911-1/B8	BEARING: intermediate main; spcl; upper, Buda DE-41365; lower, Buda DE-41366	4				*	*
D 11		BEARING: rear main; Buda DE-42691	1				*	*
	3H1911-1/P32	PLUG: expansion; 1" x 1/4"; Buda 103895	1	*			*	*
	3H1911-1/P33	PLUG: expansion; 1" x 1/2"; Buda 103896	1	*			*	*
E 16	6L4910-62H	SCREW: cap; main bearing; steel; hex head; 5/8"—11 x 3 7/8"; Buda 4015	14				*	*
E 12	3H1911-1/S50	SCREW: cap; oil seal; Budd 1560	3				*	*
E 8	3H1911-1/S6	SEAL: oil; rear bearing; Buda DE-56131	2				*	*
E 6	3H1911-1/S21	SLEEVE: spool; cyl; steel; 9 15/16" lg x 4.5005" OD x 4.2535" ID; Buda DE-41182	6				*	*

* Indicates stock available.

154. Maintenance Parts List For Power Unit PE-185-B (Cont'd)

Ref symbol	Signal Corps stock No.	Name of part and description	Quan per unit	Orgn stock 1st ech	Orgn stock 2d ech	3d ech	4th ech	Depot stock
		CYL BLOCK & GEAR COVER GROUP (Cont'd)						
T 32	3H1911-1/T1	TAPPET: valve lifter; Buda DE-40954	12				*	*
	3H1911-1/W2	WICK: main bearing oil stop; Buda 1031	2				*	*
		CYL HEAD & VALVE GROUP						
F 5	3H1911-1/A1	AIRCELL ASSEMBLY: spcl; steel; Buda DE-41050	6	*			*	*
T 18		ARM, rocker: left-hand; w/bushing; Buda 5507-S	6				*	*
T 20		ARM, rocker: right-hand; w/bushing; Buda 5506-S	6				*	*
	3H1911-1/C8	COCK, drain: $\frac{1}{4}$" pipe thd; Buda 4045	1				*	*
V 1	3H1911-1/C35	CUP: spcl; valve spring; Buda 1313	12				*	*
F 10	3H1911-1/C50	CYLINDER HEAD: w/valves, springs, retainers, washers, studs; Buda DE-40943-B	1				*	*
	3H1911-1/G71	GASKET: No. 1 thin; cyl head, major; Buda DE-42455	1	*		*	*	*
	3H1911-1/G70	GASKET: cyl head, minor; Buda 41012	1	*		*	*	*
F 4	3H1911-1/G13	GASKET: cyl head cover; Buda DE-4057	1	*		*	*	*
T 34	3H1911-2/G5	GASKET, cork: $\frac{3}{32}$" thk; valve inclosure cover; Buda 4033	1		*	*	*	*
W 1	3H1911-3/G46	GASKET, fiber: cyl head water outlet pipe; Buda MA-265	12				*	*
W 21	3H1911-2/G15	GASKET, fiber: material; approx 30" lg x $3\frac{1}{2}$" wd; Buda 4058	1				*	*
T 36	3H1911-1/G5	GASKET: valve cover stud nut; $\frac{1}{2}$" ID x $\frac{5}{8}$" OD; Buda 1359	4			*	*	*
V 3	3H1911-1/G35	GUIDE: valve; $3\frac{7}{16}$" lg x 0.626" OD x 0.3755" ID; Buda 5984	12				*	*
	6L2010-18JS	NUT: cyl head stud nut; $\frac{5}{8}$"—18; thin; Buda 103030	15	*				*
X 213	6L3510-18	NUT: cyl head stud; $\frac{5}{8}$"—18; thick; Buda 106640	15	*				*
T 16	3H1917/N12	NUT: screw, rocker arm adjusting; LeRoi 1304; Buda 1304	12	*			*	*
F 6	3H1911-1/P28	PLUG: aircell; $1\frac{5}{8}$" lg x 1.516" thk; Buda DE-41047	3				*	*
F 7	3H1911-1/R6	RETAINER: aircell; Buda DE-40255	3				*	*
V 6	3H1911-1/R21	RING: snap; 0.043" thk x 0.325" ID; Buda 5987	12	*			*	*
V 7	3H1911-1/R7	RETAINER: valve spring cup; Buda H-12280	24	*			*	*

* Indicates stock available.

Ref symbol	Signal Corps stock No.	Name of part and description	Quan per unit	Orgn stock 1st ech	Orgn stock 2d ech	3d ech	4th ech	Depot stock
T 17	6L7966-25.31S	SCREW: set; steel; Buda DE-4051; $\frac{3}{8}$"—24, $1\frac{9}{16}$" lg; headless; cup-point; screwdriver slot $\frac{3}{32}$"; thd lg $1\frac{3}{16}$", 0.368" OD, thread one end; RH	1	*			*	*
V 2	3H1911/S31	SPRING: valve; $2\frac{23}{32}$" lg x $1\frac{3}{16}$" OD; Buda DE-40025	12	*			*	*
E 5	6L31185	STUD: cyl head, steel; Buda DE-4-40012	15				*	*
	3H1911-1/C30	STUD: valve cover; Buda 4357	3	*			*	*
T 27	3H1911-1/T31	TUBE ASSEMBLY: push rod; Buda DE-40955	12	*			*	*
V 8	3H1911-1/V1	VALVE: exhaust, 45° valve seat; Buda DE-41536	6	*			*	*
V 4	3H1911-1/V2	VALVE: intake; 45° valve seat; Buda DE-41531	6	*			*	*
	6L58032	WASHER: cyl head stud; Buda KE184	15	*				*
T 21	3H1911-1/W11	WASHER: rocker arm; Buda 5940	24				*	*
		FAN GROUP						
J 27	3H1911-1/B15	BELT: fan; 46°; 58" OD x $\frac{1}{2}$" thk; V-type; Buda DE-41321	2	*		*	*	*
Fig. 336	3H1911-2/F1	FAN: 26"; 6 blade; pusher type; Buda DE-41873	1					*
		FUEL FILTER GROUP						
HH 25	3H1911-1/C2	CARTRIDGE: 2d stage fuel filter; Buda DE-42543	1		*	*	*	*
HH 30	3H1911-1/F10	FILTER, fuel: 1st stage; Buda DE-42622	1					*
	3H1911-1/E12	ELEMENT: filter; 1st stage; Purolator 18155	1	*	*	*	*	*
HH 9	3H1911-1/L8	LINE: fuel; filter; 2d stage filter to fuel pump; Buda DE-42582	1				*	*
HH 73		LINE: flexible; fuel; (Weatherhead) Buda DL-3128	1				*	*
HH 59		ASSEMBLY: fuel line; incl tank to 3-way tee; Buda DL-3086	1				*	*
HH 53		LINE: fuel; tee to 1st stage filter; Buda DL-3080	1				*	*
HH 73		LINE: flexible; fuel; (Weatherhead) Buda DL-3128	1				*	*
		FUEL INJECTOR GROUP						
HH 8	3H1911-1/G9	GASKET: gear housing; adapter; fuel injection pump; Buda DE-4063	1			*	*	*
HH 76		GASKET: fuel injection pump nozzle; Buda DE-31198	6	*		*	*	*
HH 6	3H1911-1/G8	GASKET: fuel injection pump to adapter; Buda DE-50427	1			*	*	*
HH 44	3H1911-1/L16	LINE ASSEMBLY: No. 1 fuel injection; Buda DE-42034	1				*	*

* Indicates stock available.

154. Maintenance Parts List For Power Unit PE-185-B (Cont'd)

Ref symbol	Signal Corps stock No.	Name of part and description	Quan per unit	Orgn stock 1st ech	Orgn stock 2d ech	3d ech	4th ech	Depot stock
		FUEL INJECTOR GROUP (Cont'd)						
HH 45	3H1911-1/L17	LINE ASSEMBLY: No. 2 fuel injection; Buda DE-42035	1				*	*
HH 46	3H1911-1/L18	LINE ASSEMBLY: No. 3 fuel injection; Buda 42036	1				*	*
HH 47	3H1911-1/L19	LINE ASSEMBLY: No. 4 fuel injection; Buda DE-42037	1				*	*
HH 48	3H1911-1/L20	LINE ASSEMBLY: No. 5 fuel injection; Buda DE-42038	1				*	*
HH 49	3H1911-1/L21	LINE ASSEMBLY: No. 6 fuel injection; Buda 42039	1				*	*
HH 79	3H1911-1/N11	NOZZLE, fuel injection: Buda DE-42646; Excello Corp 39-TH-019-028	6	*	*	*	*	*
	6L31161	STUD: steel; Buda DE-10121 (injector mtg)	12	*				*
HH 78		TIP ASSEMBLY, nozzle: fuel injection; Buda DE-56745	6	*	*	*	*	*
		FUEL INJECTION PUMP GROUP						
HH 5	3H1911-1/P35	PUMP ASSEMBLY: spcl; fuel; Excello Corp model B; Buda DE-42492	1					*
		FLYWHEEL GROUP						
K 9	6L3508-20-12	NUT: steel; hex; Buda CUE763	5				*	*
K 4	6L7920-8-35S	SCREW, machine: steel; Buda H-12112	5				*	*
X 510	3H1911-1/W10	WASHER, lock: flywheel; spcl; Buda 106500	5				*	*
		GENERATOR GROUP (BATTERY CHARGING)						
	3H2460/B10	BRUSH, charging gen: main Leece-Neville 2286G	2	*				*
QQ 49	3H4585A/640	BRUSH, charging gen: 3d; Leece-Neville 7904	1	*				*
QQ 1	3H1911-1/G74	GASKET: generator adapter; Buda DE-4923	2					*
QQ 7	3H2460L	GENERATOR: charging; 24v; Leece-Neville 2286G; Buda 42830	1					*
QQ 151		REGULATOR, voltage: 24v; Leece-Neville (2286-R); Buda DE-42831	1					*

* Indicates stock available.

Ref symbol	Signal Corps stock No.	Name of part and description	Quan per unit	Orgn stock 1st ech	Orgn stock 2d ech	3d ech	4th ech	Depot stock
		GENERATOR GROUP						
16	3H4574/B7	BEARING: ball; BCA No. 1315 and No. 315; Ahlberg No. 6315; Fafnir No. 315w and No. 315K; Fed No. 1315M and No. 1315; Hoover No. 315; MRC No. 315R, No. 315M and 315S; McGill No. 315; ND No. 1315 and No. 3315; Norma-Hoff No. 315; SKF No. 6315; LeRoi No. 21-234; GE No. 60X440	2					*
	3H5170-50-/B10	BRUSH ASSEMBLY: GE dwg K-5804446 (exciter brushes) ..	4	*		*	*	*
64	3H2405-1/B20	BRUSH, carbon: GE 5804490 (AC generator)	4	*		*	*	*
1	3H2411-14	GENERATOR: 120/208v, 3 ph, 60 cyc; 1,200 rpm; 25 kw; 0.8070 pf; Buda DL-3020; GE dwg M5888952	1					*
		IDLER GEAR GROUP						
X 691	3H1911-2/G3	GASKET: idler gear shaft lockscrew; Buda 105453	1					*
M 4	3H1911-1/G17	GEAR: idler; spcl; 6.1900" OD; x 7/8" thk; Buda DE-40942 ...	1					*
M 6	6L2810-11S	NUT, acorn: hex; steel; Buda DE-55136	1					*
M 7	6L7940-21.35S	SCREW: set; headless; steel; Buda DE-4134	1					*
M 1	6L7920-8-15.81S	SCREW, machine: steel; hex head; 3/4"; Buda 1458	1					*
M 8	3H1911-1/S12	SHAFT: idler gear; 3 7/8" lg; Buda 4452	1					*
X 656	3H1911-2/P30	PIN: shaft; idler gear; Buda 103720	1					*
M 2	3H1911-2/W1	WASHER: thrust; idler gear shaft; Buda 3432	1					*
		LUBRICATING OIL FILTER GROUP						
LL 10	3H1911-1/C3	CARTRIDGE: lube filter unit; Cuno 10652-15-U; Buda DE-56900	1				*	*
LL 31	3H1911-1/C1	CARTRIDGE: oil filter; Buda DE-51305	1		*	*	*	*
LL 17	3H1911-1/F11	FILTER ASSEMBLY: lube oil; Cuno 11769; Buda DE-56590 ..	1				*	*
LL 19		LINE ASSEMBLY: Cuno to Deluxe filter; Buda DL-3051	1				*	*
HH 16	3H1911-1/L9	LINE ASSEMBLY: gov tee to cyl head; Buda DE-42695	1				*	*
LL 20		LINE ASSEMBLY: Deluxe to Cuno filter; Buda DL-3054	1				*	*

* Indicates stock available.

154. Maintenance Parts List For Power Unit PE-185-B (Cont'd)

Ref symbol	Signal Corps stock No.	Name of part and description	Quan per unit	Orgn stock 1st ech	Orgn stock 2d ech	3d ech	4th ech	Depot stock
		MANIFOLD GROUP						
P 10	3H1911-1/G10	GASKET: end; intake and exhaust manifold; Buda DE-41189	2	*		*	*	*
P 11	3H1911-1/G11	GASKET: inner; intake and exhaust manifold; Buda D-41188	2	*		*	*	*
P 3	3H1911-1/M1	MANIFOLD, exhaust: Buda DE-42578	1					*
P 12	3H1911-1/M2	MANIFOLD, intake: Buda DE-40061	1					*
	6Z6820-19	LAMP, incandescent: 120v; 40w; Mazda inside frosted; std screw base	1	*				*
		MUFFLER GROUP						
EE 2	3H1911-1/M10	MUFFLER: Maremont 7212; Buda DP-2698	1					*
		OIL PRESSURE GROUP						
N 13	3H1911-1/B1	BALL: steel; $\frac{5}{8}$" diam; GM 104924	1				*	*
N 10	3H1911-2/G27	GASKET: oil-pressure relief valve cap; Buda 1530	1				*	*
N 14	3H1911-2/S21	SEAT: oil-pressure relief valve; Buda DE-40318	1				*	*
N 12	3H1911-1/S22	SLEEVE: oil-pressure relief valve; Buda DE-40317	1				*	*
N 11		SPRING: oil-pressure relief valve; Buda 3547	1				*	*
		OIL PUMP GROUP						
Q 5	3H1911-2/G7	GASKET: end; cork; 1" wd x 12" lg; Buda 4541	2				*	*
Q 17	3H1911-1/G73	GASKET: float; oil pan; Buda 5526	1				*	*
Q 4	3H1911-2/G9	GASKET: side; cork; 1" wd approx x 30" lg; Buda 4539	2				*	*
HH 28	3H1911-1/L13	LINE ASSEMBLY: fuel-transfer pump to 1st stage filter; Buda DE-42580	1					*
HH 3	3H1911-1/L14	LINE ASSEMBLY: fuel-transfer pump to 2d stage filter; Buda DE-42584	1					*
N 15	3H1911-1/P37	PUMP ASSEMBLY: oil; consists of body, pin, driver gear, 2 bushings, idler gear, drive shaft, idler shaft, plug, cover, gasket, 6 screws $\frac{1}{4}$"—20 x $\frac{5}{8}$", 6 washers; Buda 5895	1				*	*
Q 14	3H1911-1/S3	SCREEN: oil pan float assembly; Buda DE-42603	1				*	*

* Indicates stock available.

Ref symbol	Signal Corps stock No.	Name of part and description	Quan per unit	Orgn stock 1st ech	Orgn stock 2d ech	3d ech	4th ech	Depot stock
		PISTON GROUP						
G 7	3H1911-1/B5	BEARING: spcl, crank pin 2.3725" diam x 2.321" OD x 1.481" wd; Buda DE-41371 (connecting rod bearing)	12				*	*
G 11	3H1911-1/B25	BOLT: connecting rod; Buda DE-4217	6				*	*
G 5	3H1911-1/B30	BUSHING: spcl; 1.495" ID x 1.691" OD x 1⅝" wd; Buda DE-40081 (piston pin bushing)	6				*	*
G 12	6L3508-20-13	NUT: steel; hex; Buda DE-4218	12				*	*
	3H1911-1/P20	PISTON & PIN ASSEMBLY: Buda DE-42929	6				*	*
G 8	3H1911-1/R20	RING: top; piston; 4.250" OD x 0.124" wd x 0.170" thk; Buda DE-41084; Sealed Power Corp BB884	6				*	*
G 9	3H1911-1/R18	RING: piston; 4.250" OD x 0.124" wd x 0.155" thk; Sealed Power Corp BB900; Buda DE-41355	12				*	*
G 10	3H1911-1/R19	RING: piston; 4.250" OD x 0.186" wd x 0.167" thk; Sealed Power Corp BB885; Buda DE-41086	12			*	*	*
G 6	3H1911-1/R30	ROD ASSEMBLY: connecting; special; steel bronze and hard copper lead; Buda DE-41372	6				*	*
G 3	3H1911-1/S34	SPRING, retaining: piston pin; Buda DE-4699	12				*	*
		POWER PANEL GROUP & SAFETY GROUP						
GG 30	3F1030-16	AMMETER: DC; 30-0-30 amp; Stewart Warner 94245	1					*
GG 27	3H1911-1/G26	GAUGE, oil pressure: Buda DE-52196	1					*
GG 28		GAUGE, oil temp: Buda DL-3074	1					*
G 29		GAUGE, water temp: Buda DL-3075	1					*
	6Z6050-1	HOWLER: warning; Benjamin Elec 191506D	1				*	*
GG 11	2Z5884-35	LAMP ASSEMBLY: green; Allied Radio 52500; Buda DP-2754; Signal Indicator Corp 75CF	1				*	*
GG 12	2Z5884-37	LAMP ASSEMBLY: red; Allied 52501; Buda DP-2755; Signal Indicator Corp 75CF	1				*	*
GG 13	2Z5884-36	LAMP ASSEMBLY: yellow; Allied 52502; Buda DP-2756; Signal Indicator Corp 75CF	1				*	*
GG 24		LINE ASSEMBLY: lube oil; 3-way tee to block; Buda DL-3092	1					*

* Indicates stock available.

154. Maintenance Parts List For Power Unit PE-185-B (Cont'd)

Ref symbol	Signal Corps stock No.	Name of part and description	Quan per unit	Orgn stock 1st ech	Orgn stock 2d ech	3d ech	4th ech	Depot stock
		POWER PANEL GROUP & SAFETY GROUP (Cont'd)						
GG 23		SWITCH: high water temp; Buda DL-3073	1					*
GG 23		SWITCH: high water temp; Buda DL-3073	1					*
GG 16		SWITCH: howler; Buda DL-3107	1					*
GG 20	3H1911-1/S61	SWITCH: low oil pressure; Detroit Lubricating Co Series D-423, Model P1, type 1B4; Buda DE-42588	1				*	*
GG 31	3H4567B/292	SWITCH, push button: $1\frac{5}{16}$" diam x $1\frac{1}{2}$" h; Climax 92348; Leece-Neville 103-SS	1				*	*
		FITTING, brass: gasoline; $\frac{1}{4}$"; $\frac{1}{8}$" pipe thd; Weatherhead W200X4	1				*	*
		RADIATOR AND SUPPORT GROUP						
R 10	3H1911-1/C6	CLAMP, hose: adjustable up to $2\frac{1}{2}$"; Buda AP-6081	6	*		*	*	*
R 3	3H1911-1/E6	ELBOW: special; $1\frac{3}{4}$" ID; Buda DP-2752	1			*	*	*
R 5	3H1911-2/G26	GASKET, fiber: approx $2\frac{1}{2}$" diam; Buda 1645 (for water pump inlet)	2				*	*
R 9	3H1911-1/H5	HOSE: $1\frac{3}{4}$" ID x $3\frac{3}{32}$" OD x $5\frac{1}{2}$" lg; Buda DP-528	1			*	*	*
R 8		RADIATOR ASSEMBLY: Perfex RL-771; Buda DL-3023	1					*
		SPECIAL HARDWARE						
	3H1911-1/C26	CONNECTOR: brass; $\frac{1}{2}$"; flared; Buda 118752	1				*	*
	3H1911-1/C27	CONNECTOR: flared; brass; tube; Buda 118750	1				*	*
	3H1911-1/E8	ELBOW: brass; flared; $\frac{1}{4}$"; Buda 118755	1				*	*
	3Z9859-30	SWITCH, toggle: Wemco GE2842	6					*
	6Z8860-5	UNION: brass; $\frac{1}{2}$" tube size; Weatherhead 302X8	2				*	*
		STARTING MOTOR GROUP						
SS 31	3H1911-1/B20	BENDIX DRIVE: starting; Buda LN-12834	1			*	*	*
SS 33	3H4585A/350/47	BRUSH: Leece-Neville 16238	8	*	*	*	*	*
SS 1	3H3114-16	MOTOR: starting; 24v; Leece-Neville 1236-M; Buda DE-50921	1					*
SS 43	3H3114-16/S30	SWITCH: starting motor; magnetic; Leece-Neville 27MS24; Buda DE-50922	1	*			*	*

* Indicates stock available.

Ref symbol	Signal Corps stock No.	Name of part and description	Quan per unit	Orgn stock 1st ech	Orgn stock 2d ech	3d ech	4th ech	Depot stock
		THERMOSTAT GROUP						
W 10	3H1911-2/G26	GASKET, fiber: approx 2½" diam; Buda 1645 (for water pump inlet)	1				*	*
W 1	3H1911-3/G46	GASKET, fiber: cyl head water outlet pipe; Buda MA-265	3				*	*
W 12	3H1911-1/G75	GASKET: thermostat housing; Buda DE-50333	1				*	*
W 2	3H1911-1/L25	LINE ASSEMBLY: thermostat bypass; Buda DE-42540	1				*	*
W 13	3H1911-1/T15	THERMOSTAT: valve closed 150°F, open 180°F; Buda 50299	1	*			*	*
		TIMING GEAR HOUSING AND SUPPORT GROUP						
L 3	3H1911-1/G76	GASKET: timing gear cover; Buda DE-4065	1				*	*
L 4	3H1911-1/S5	SEAL, oil: timing gear cover; Buda PA-117	1				*	*
		WATER MANIFOLD GROUP						
F 15	6L31142	STUD: intake and exhaust manifold; steel; Buda DE-40190	5	*				*
F 18	6L31156	STUD: intake and exhaust manifold; steel; Buda DE-40184	8	*				*
		MISCELLANEOUS GROUP						
	3H1911-1/G6	GASKET SET: complete; Buda DE-41296	1				*	*
W 18	3H1911-1/G72	GASKET: manifold water inlet adapter; Buda DE-4070	2				*	*
W 4	3H1911-1/H6	HOSE, rubber: special; 1¾" ID x $2\frac{3}{32}$" OD x 3" lg; Buda DE-4215	1	*			*	*
		WATER PUMP GROUP						
U 11	3H1911-1/B11	BEARING: water pump; Buda BB-206C; Buda PA-1	1				*	*
U 15	3H1911-1/C36	CUP: water pump grease; Buda DE-5482	1				*	*
U 5	3H1911-1/G79	GASKET: water pump body cover; Buda DE-5358	1				*	*
W 5	3H1911-1/G78	GASKET: water pump to engine; Buda DE-4087	1				*	*
W 8	3H1911-1/G77	GASKET: water pump inlet connection; Buda DE-5365	1				*	*
U 10	3H1911-1/S8	SEAL: water pump oil; Buda DE-4084	1				*	*
U 18	3H1911-2/G85	GLAND, packing: water pump; Buda 2692	1				*	*
U 17	3H1911-1/P1	PACKING: ¼" x 4"; hemp and graphite; Buda 2687	1		*	*	*	*
U 1	3H1911-1/P36	PUMP ASSEMBLY: water; Buda DE-42217	1				*	*

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