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WAR DEPARTMENT

TECHNICAL MANUAL

POWER UNITS PE-95-G
AND
PE-95-H

September 3, 1943

WAR DEPARTMENT
WASHINGTON, D. C. September 3, 1943

This Technical Manual, TM 11-904H, published by O'Keefe & Merritt Company on orders 15030-PHILA-43, 20747-PHILA-43, 14889-SCGDL-43, 23408-PHILA-43, 26211-PHILA-43, 33041-PHILA-43, 36900-PHILA-43, and 3605-PHILA-44, covers Power Units PE-95-G and PE-95-H. All parts of these units are interchangeable with those listed in TM 11-904G, Technical Manual for Power Unit PE-95-G, except those specifically noted in the replacement parts list in this manual.

ADDENDA SHEET

SUBJECT: Change in Stator Winding Assembly
Part No. 7515, Ref. No. 583

The present stator winding assembly provides a no-load voltage of approximately 126 when operated at a frequency of 61 cycles. The normal full load voltage with this winding is approximately 118 at a frequency approximately one-half to one cycle below the no-load frequency.

A no-load voltage of 120 has been found desirable and is obtained with the present stator winding assembly by adjusting the engine governor. Final adjustment should be made after the power unit reaches normal operating temperature. At this reduced voltage the frequency meter will be inoperative because the frequency will be below 59 cycles.

A new winding with fewer turns (4-5-6 coil grouping instead of 5-5-6 coil grouping) has been designed and all new generators will have the revised stator winding assembly. This revised winding will provide a no-load voltage of 120 when operated at a frequency of approximately 61 cycles. When the engine governor is properly adjusted to provide a no-load voltage of 120 the corresponding voltage at one-half load (43 amps, 100 percent power factor) will be approximately 116, and the full-load (89 amps, 100 percent power factor) will be 112 volts. At 80 percent power factor half-load (59 amps), the voltage will be approximately 106.

The present and the revised stator winding assemblies are interchangeable, and the same part number will apply to each.

O'KEEFE & MERRITT CO.
Los Angeles, California
November 9, 1943

NOTE

All parts of Power Units PE-95-G and PE-95-H are interchangeable except the following:

Ref. No.	Name and Description	PE-95-G Part No.	PE-95-H Part No.
130	Crankshaft Bearing—Front—Upper	637724	637007
131	Crankshaft Bearing—Front—Lower	637725	637008
132	Crankshaft Bearing—Center—Upper	639237	638730
133	Crankshaft Bearing—Center—Lower	639238	638731
134	Crankshaft Bearing—Rear—Upper	639239	638732
135	Crankshaft Bearing—Rear—Lower	639240	638733
138	Crankshaft	637733	638121
156	Connecting Rod Bearing	116534	639862

Parts listed in column PE-95-G may be used only on Power Unit PE-95-G.
Parts listed in column PE-95-H may be used only on Power Unit PE-95-H.

TECHNICAL MANUAL
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WAR DEPARTMENT
WASHINGTON, SEPTEMBER 3, 1943

POWER UNIT PE-95-G AND PE-95-H

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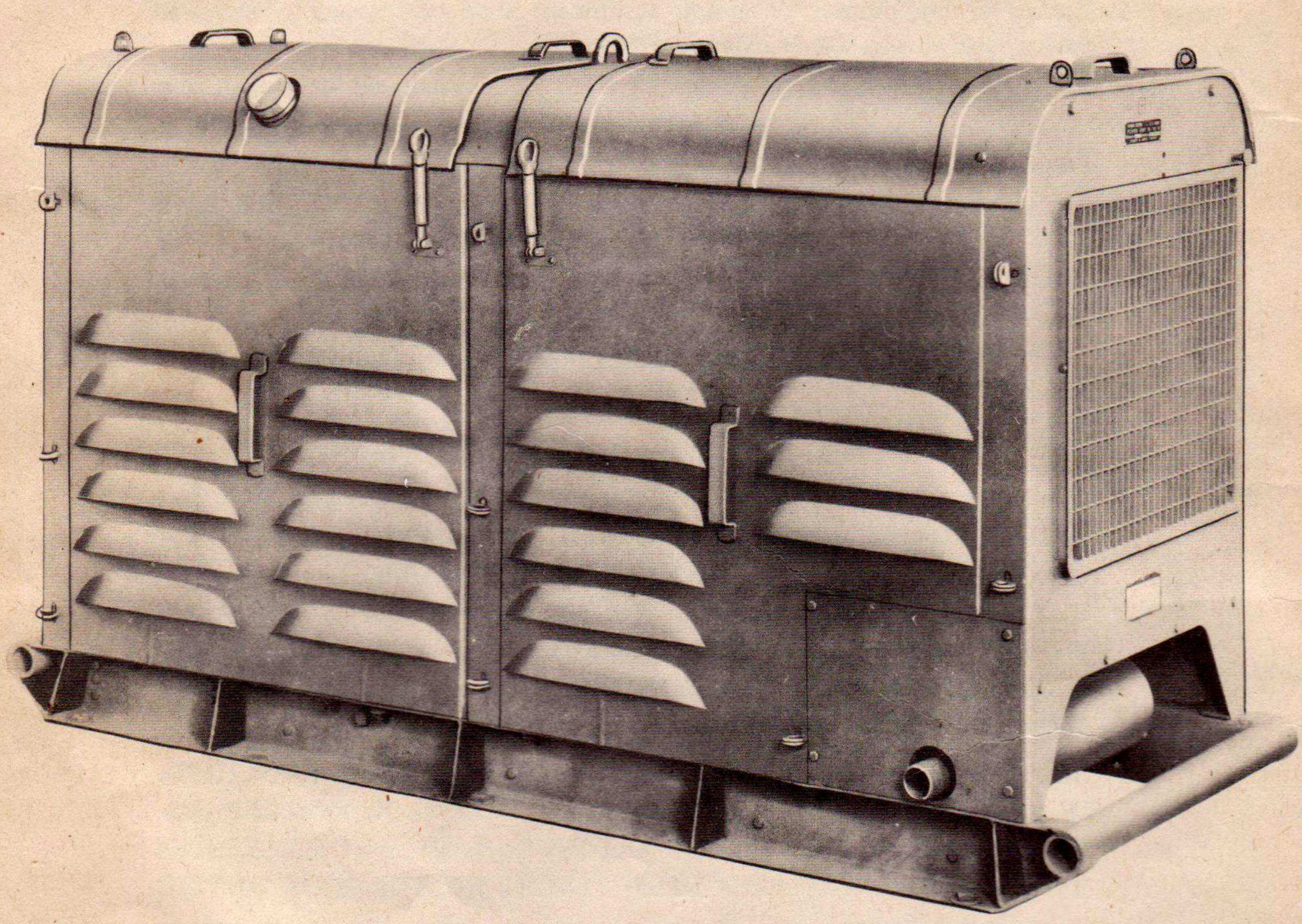
DESTRUCTION NOTICE

If capture of this equipment is imminent, destroy it by any or all of the following means, beyond any possibility of salvage, recognition or duplication:

1. Radio, Telephone and Telegraph equipment shall be thoroughly smashed with a sledge, axe, bar or other heavy object.
2. All wires, cables and internal wiring shall be slashed, cut or ripped out.
3. Castings such as engines and generators and teletypewriter parts shall be smashed with a sledge, axe or other heavy object.
4. All books, documents, wire and smashed equipment containing combustible parts shall be piled up, saturated with gasoline and burned.
5. Hand grenades or TNT may be used provided destruction of all parts of the equipment is thorough and complete.
6. Time permitting, smashed and burned equipment shall be buried or thrown into a stream.

SAFETY NOTICE

1. **DO NOT ATTEMPT ADJUSTMENTS OR CHANGES ON WIRING WHILE POWER UNIT PE-95-G IS IN OPERATION. THIS UNIT GENERATES HIGH VOLTAGE, SO THAT SEVERE AND POSSIBLY FATAL SHOCKS MAY BE ENCOUNTERED ESPECIALLY WHEN POWER UNIT IS OPERATING ON WET OR DAMP GROUND. ALWAYS DISCONNECT THE BATTERY BEFORE WORKING ON THE UNIT.**
2. **SUFFICIENT AND PROPER VENTILATION MUST BE PROVIDED, IF THE POWER UNIT IS OPERATED IN A CONFINED SPACE. EXHAUST GASES PRODUCED ARE POISONOUS, AND EXCESSIVE INHALATIONS MAY RESULT IN SEVERE SICKNESS OR DEATH.**
3. **DO NOT SERVICE WITH GASOLINE WHILE POWER UNIT IS RUNNING OR IF A RADIO TRANSMITTER IS OPERATING IN CLOSE PROXIMITY TO POWER UNIT. AVOID SPILLING GASOLINE ON A HOT ENGINE.**
4. **OPERATOR SHOULD OBSERVE EVERY STANDARD SAFETY REGULATION WHILE OPERATING THIS POWER UNIT.**



POWER UNIT PE-95-G AND PE-95-H

SECTION I
DESCRIPTION

1. General.—

a. Description.—Power Unit PE-95-G, (Figs. 1 and 2), is a complete electric generating plant. It consists of an engine and a generator with the necessary accessories and controls, all mounted in a metal housing with a skid base.

b. Output Rating.—Power Unit PE-95-G supplies single-phase, 60-cycle, alternating-current at either 120 volts or 240 volts. The rated capacity is 10 K.W. at unity power factor and 12.5 K.V.A. at 80% power factor.

c. Purpose.—Power Unit PE-95-G is used to furnish electricity to operate radios, signal systems, lights, motors, heating units and other appliances where power line service from a large power station is not available, or upon failure of such power line service.

2. List of Components.—

Quantity	Signal Corps Stock Number	Article	Width	Length	Height	Weight in Lbs.
1		Power Unit PE-95-G	28¼″	67½″	38½″	1556
1		Engine with accessories	22½″	27″	30½″	380
1		Generator with adapter ring.	19″	29¾″	19½″	640
1		Radiator assembly	8½″	20″	23½″	35
2		Battery	7″	10⅜″	8″	50
1		Fuel tank	12″	25¾″	19¾″	20
1		Control panel assembly	5½″	20″	16½″	25
1		Housing and skid base	28¼″	67½″	38½″	307

3. Engine.—

a. Design.—The engine (Fig. 5) is of the 4-cylinder, 4-cycle, L-head, water cooled, automotive type. It furnishes the power which drives the main generator to which it is direct-connected. It also drives certain necessary accessory equipment. It is designed to operate on regular gasoline of 70 to 80 octane.

b. Rating.—The engine is rated 35 horsepower at normal operating speed of 1800 r.p.m. The speed is controlled by a fly-weight mechanical governor which is driven by a V-belt from a pulley on the crankshaft.

c. Cooling system.—The water cooling system includes an automotive type radiator, fan and pump. The fan is mounted on the extended pump shaft and both fan and pump are driven by a V-belt from a pulley on the engine crankshaft. Cooling air is discharged forward through the radiator. A thermostat in the water outlet elbow at the top of the cylinder head controls water circulation.

d. Oiling System.—Main, connecting rod and camshaft bearings are lubricated by oil pressure supplied by a gear type oil pump. Other internal parts are spray lubricated. An oil filter is mounted on the left side of the engine. A bayonet type oil level gauge is mounted in the oil filler tube.

e. Fuel System.—The fuel supply system includes a 10½ gallon fuel tank mounted over the generator, a diaphragm type fuel pump, a downdraft type carburetor fitted with a combination oil-type air cleaner and silencer, and an automatic electric choke. A fuel filter screen, glass sediment bowl and shut-off valve are mounted under the fuel tank. A valve permits connecting an auxiliary fuel tank, if desired.

f. Ignition System.—A battery ignition system is used. An ignition unit is mounted on the left side of the engine, driven by a gear on the camshaft. This unit includes the breaker mechanism, condenser and high-tension distributor. A governor in the lower part of the distributor case advances the timing of the spark as the engine speed increases. The ignition coil is mounted near the distributor. Suppressors on the spark plug cables and on the center cable of the distributor reduce radio interference.

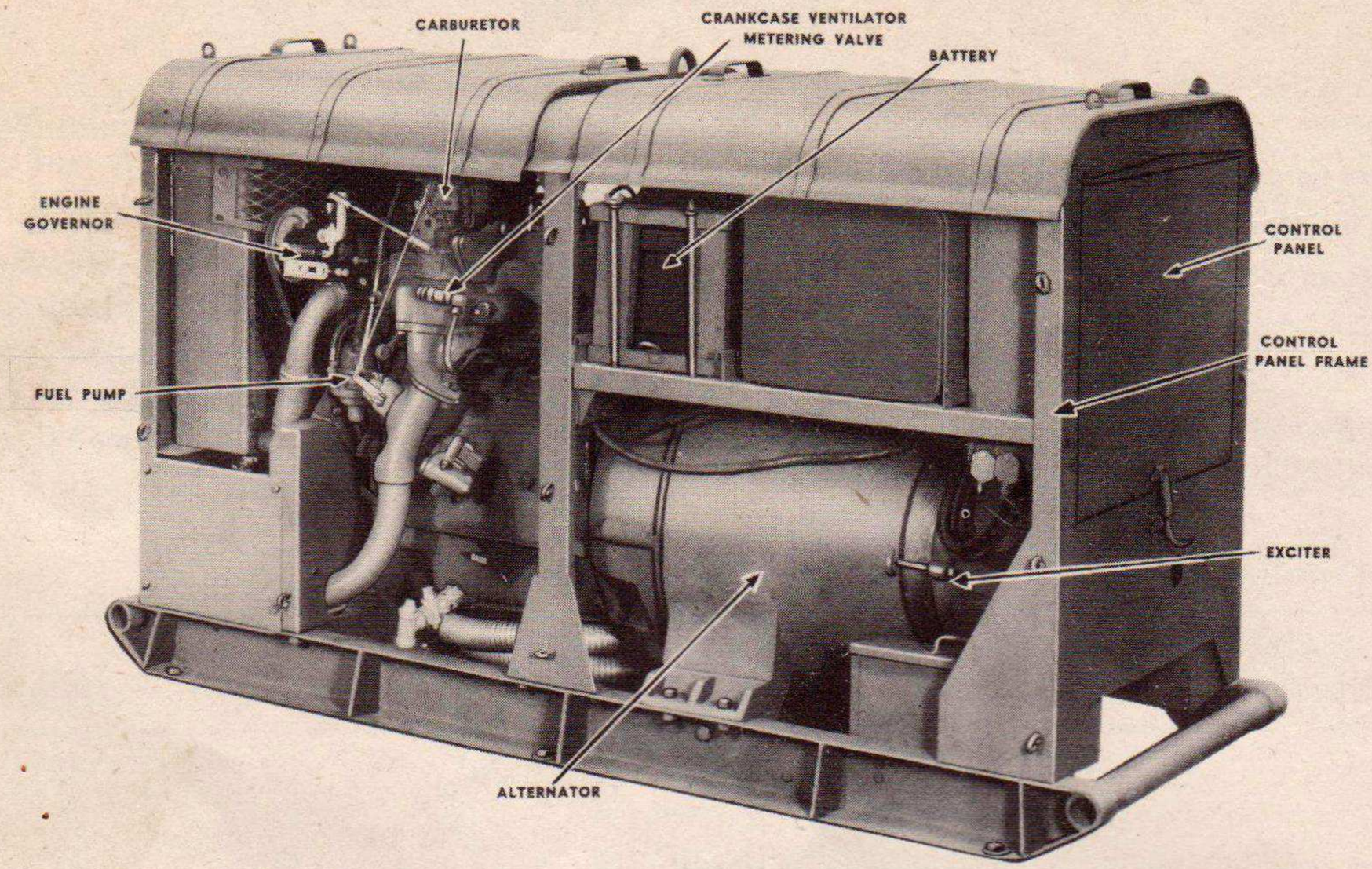


FIG. 1 POWER UNIT PE-95-G (RIGHT SIDE)

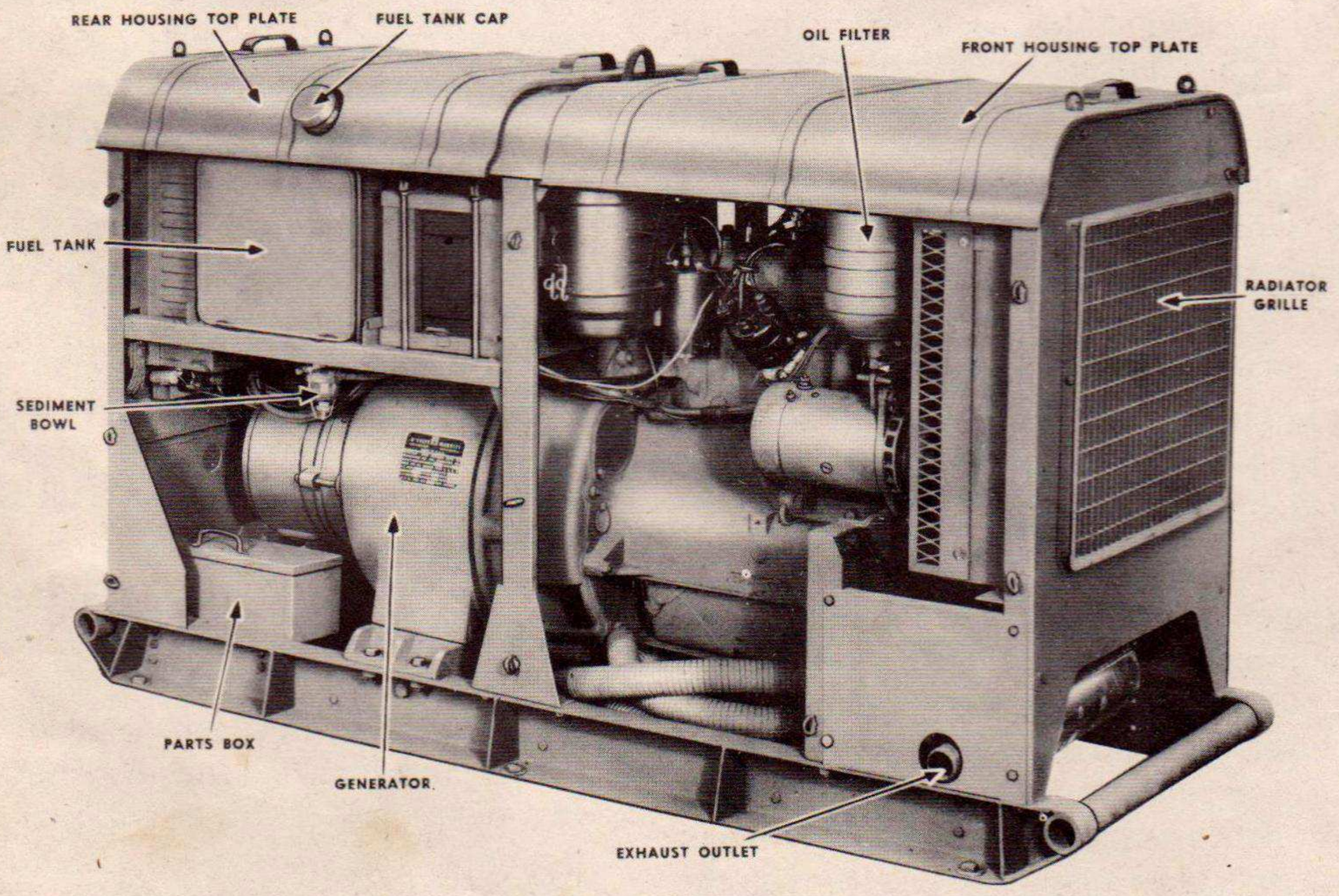


FIG. 2 POWER UNIT PE-95-G (LEFT SIDE)

g. 12-volt Battery System.—The 12-volt storage battery, consisting of two 6-volt automotive type batteries connected in series, is mounted in front of the fuel tank. The storage battery supplies power for electric cranking, automatic choking and for ignition during the starting period. It is recharged by current supplied by the exciting generator. The charging is controlled by the battery charging relay and the battery charging regulator and resistor group mounted on the rear of the control panel. The exciting generator has a special series field winding and operates as a motor for cranking the engine electrically.

4. Generator.—

a. Purpose.—The generator supplies the alternating-current power output of the power unit. This generator assembly really consists of two individual generators, the alternator and the exciter, (Fig. 2).

b. Alternator.—The alternator consists of two major parts, the revolving field and the stationary armature. It is in the two windings of the stationary armature that the alternating current is generated. These windings are connected directly to the terminal block on the control panel.

c. Exciter.—The exciter is attached to the outer end of the alternator and supplies the direct-current used to excite the revolving field. The exciter also supplies current for recharging the battery, for ignition and for operating certain controls while the engine is running. It operates as a motor for the purpose of cranking the engine electrically when starting the power unit.

d. Design.—The alternator frame is attached to, and supports, the rear end of the engine. The revolving field of the alternator and the revolving armature of the exciter are mounted on the same shaft. This shaft is driven by a steel disc connected to the shaft and to the engine flywheel. The rear end of the shaft is carried by a grease-sealed ball bearing. A flywheel blower circulates cooling air.

e. Rating.—The generator supplies single-phase alternating current at 60 cycles per second frequency. The voltage may be either 120 or 240, the change from one standard voltage to the other being made by changing jumper connections at the control panel terminal block. The generator is designed to operate with a full load temperature rise of less than 40° C. Rated capacity is 10 kw at unity power factor and 12.5 kva at 80% power factor.

f. Regulation.—

(1) *Voltage Regulation.*—The output voltage regulation of the generator after reaching normal operating temperature is within the limits of 126 volts at no load to 118 volts at full load at unity power factor, when a-c terminal jumpers are connected for 120 volts. When connected for 240 volts, the regulation is within the limits of 252 volts at no load to 236 volts at full load at unity power factor. Regulation is due to inherent characteristics obtained by strongly saturating certain parts of the magnetic circuit.

(2) *Frequency Regulation.*— Frequency regulation depends on the regulation of the engine speed, and is within the limits of 1 to 1¼ cycles per second, plus or minus, when adjusted for a no-load frequency below 63 cycles per second and a full-load frequency above 59 cycles per second.

5. Controls.—

a. Purpose.—Certain controls are used to start and stop the power unit. Others regulate it automatically under normal operating conditions and protect it against heavy overload, high water- temperature and low oil-pressure. Much of the control equipment is mounted on the control panel for convenient use. Other controls are necessarily located at different places on the power unit.

b. Control Panel Equipment.—The following pieces of equipment are mounted on the control panel. (See Figs. 3 and 4).

(1) *A.C. Voltmeter.*—0-300 volts scale, indicates the output voltage.

(2) *A.C. Ammeter.*—0-150 amperes scale, indicates the load amperes.

(3) *Fuel Gauge.*—Indicates the supply of fuel in the tank.

(4) *Battery Charge Rate Ammeter.* — Indicates the rate of battery charge and discharge.

(5) *Engine Oil Pressure Gauge.*—Indicates the operating pressure of the engine lubricating system.

(6) *Engine Water Temperature Gauge.* — Indicates the temperature within the engine water jacket.

(7) *Running-Time Meter.*—Shows the total operating hours.

(8) *Frequency Meter.*—Indicates the output frequency.

(9) *Circuit Breaker.* — Serves as the load switch, trips automatically when the power unit is heavily overloaded.

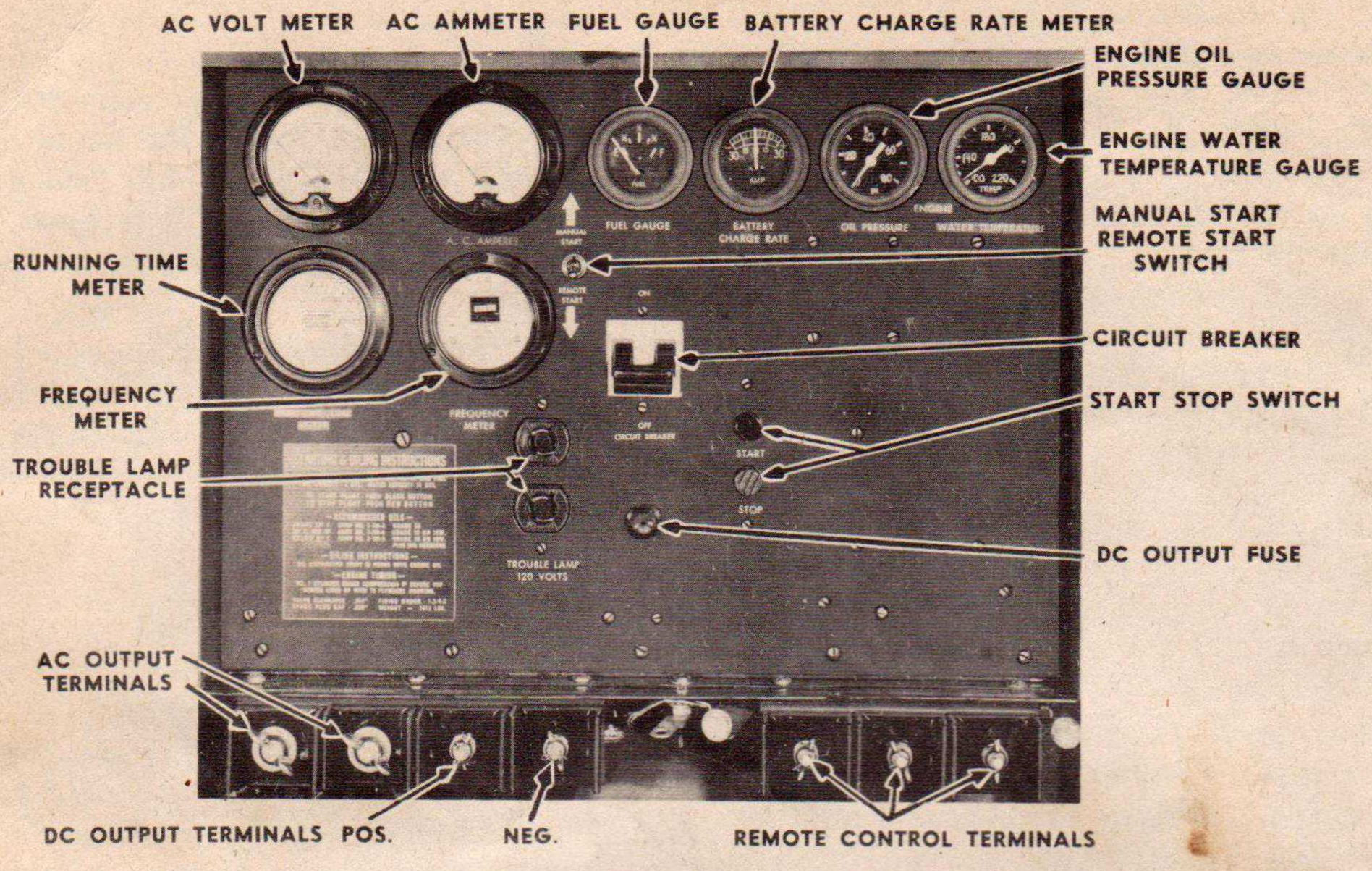


FIG. 3 CONTROL PANEL

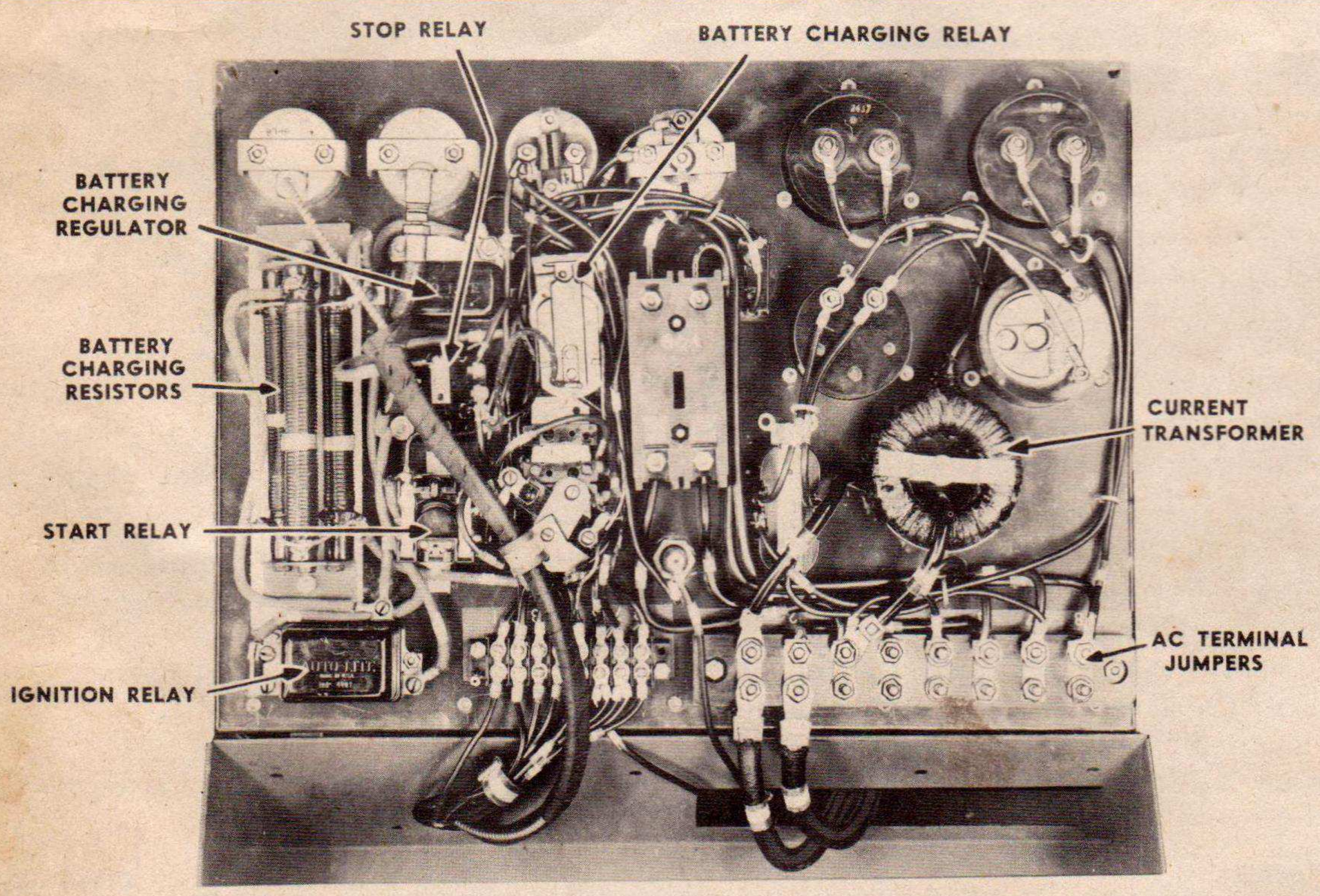


FIG. 4 CONTROL PANEL (REVERSE SIDE)

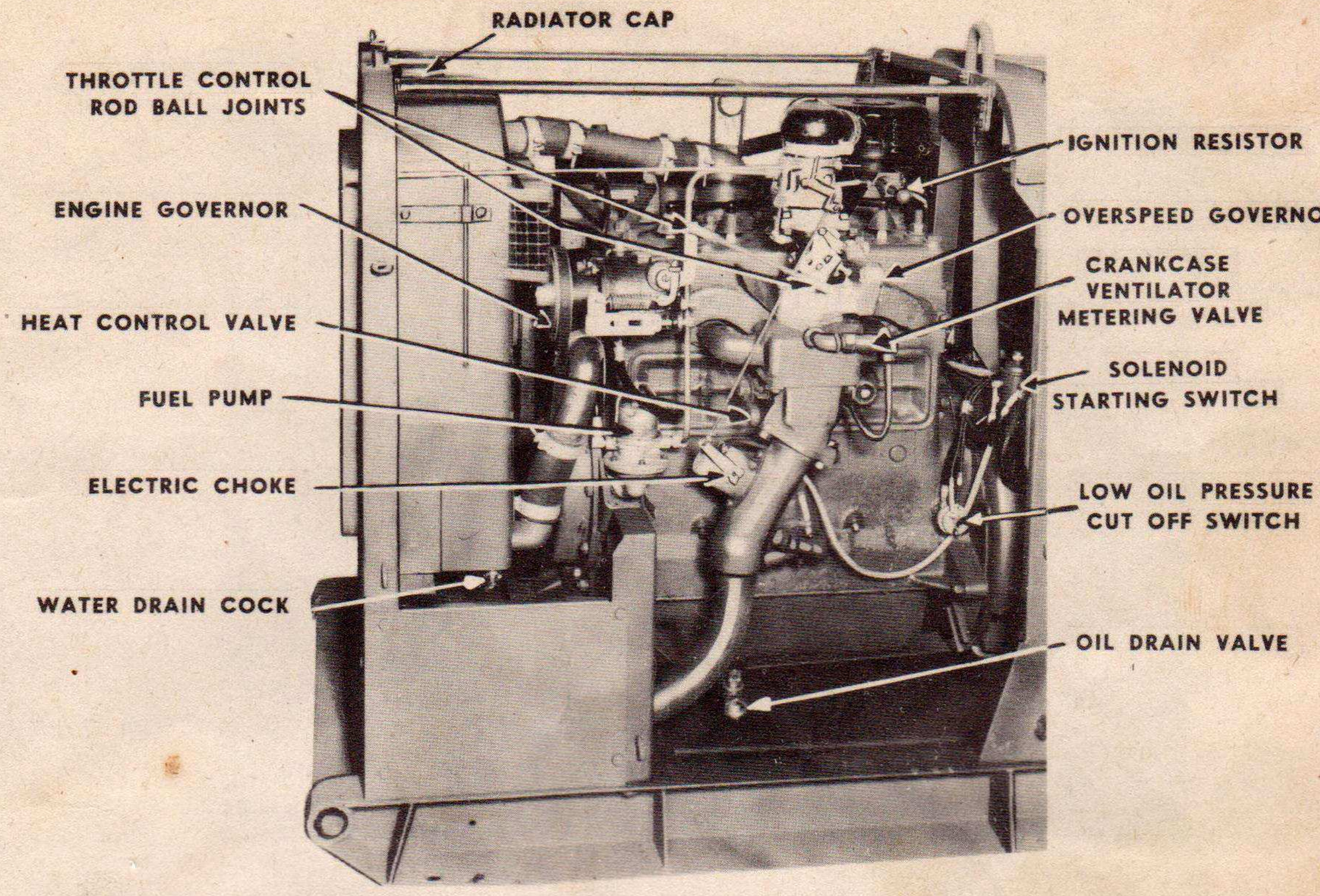


FIG. 5 RIGHT SIDE OF ENGINE

(10) *Trouble-Lamp Receptacles.*—Serve for connecting 120 Volt trouble lamps.

(11) *Start-Stop Switch.*—Serves to start and stop the power unit.

(12) *Manual Start-Remote Start Switch.*—Serves to switch the ignition circuit to Manual Start position as required for hand starting.

(13) *Relays.*—Control various circuits.

(14) *Battery Charging Regulator and Resistor Group.*—Regulates the battery charging rate.

(15) *A.C. Terminal Block and Jumpers.*—Serve to change the output voltage from 120 to 240 volts, or the reverse.

(16) *D.C. Output Fuse.*— Protects against short-circuit or severe overload on the D. C. OUTPUT circuit.

c. *Miscellaneous Control Equipment.*—The following control devices are located at different places on the power unit. (See Figs. 5 and 6).

(1) *Low Oil Pressure Cut-Off Switch.*—Stops the power unit if the oil pressure drops below 8 lbs. per sq. in. while the power unit is in operation.

(2) *High Water Temperature Cut-Off Switch.*—Stops the power unit if the water temperature rises above the value it is set at.

(3) *Electric Choke.*—Chokes the carburetor automatically when the engine is cranked electrically.

(4) *Engine Governor.*—Regulates the engine speed and the frequency of the a-c output.

(5) *Overspeed Governor.* — Limits the top speed of the engine if the main governor fails.

(6) *Heat Control Valve.*—Diverts hot exhaust gas to heat the intake manifold during the warm-up period.

(7) *Crankcase Ventilator Metering Valve.*—Controls the flow of ventilating air from valve spring chamber to the intake manifold.

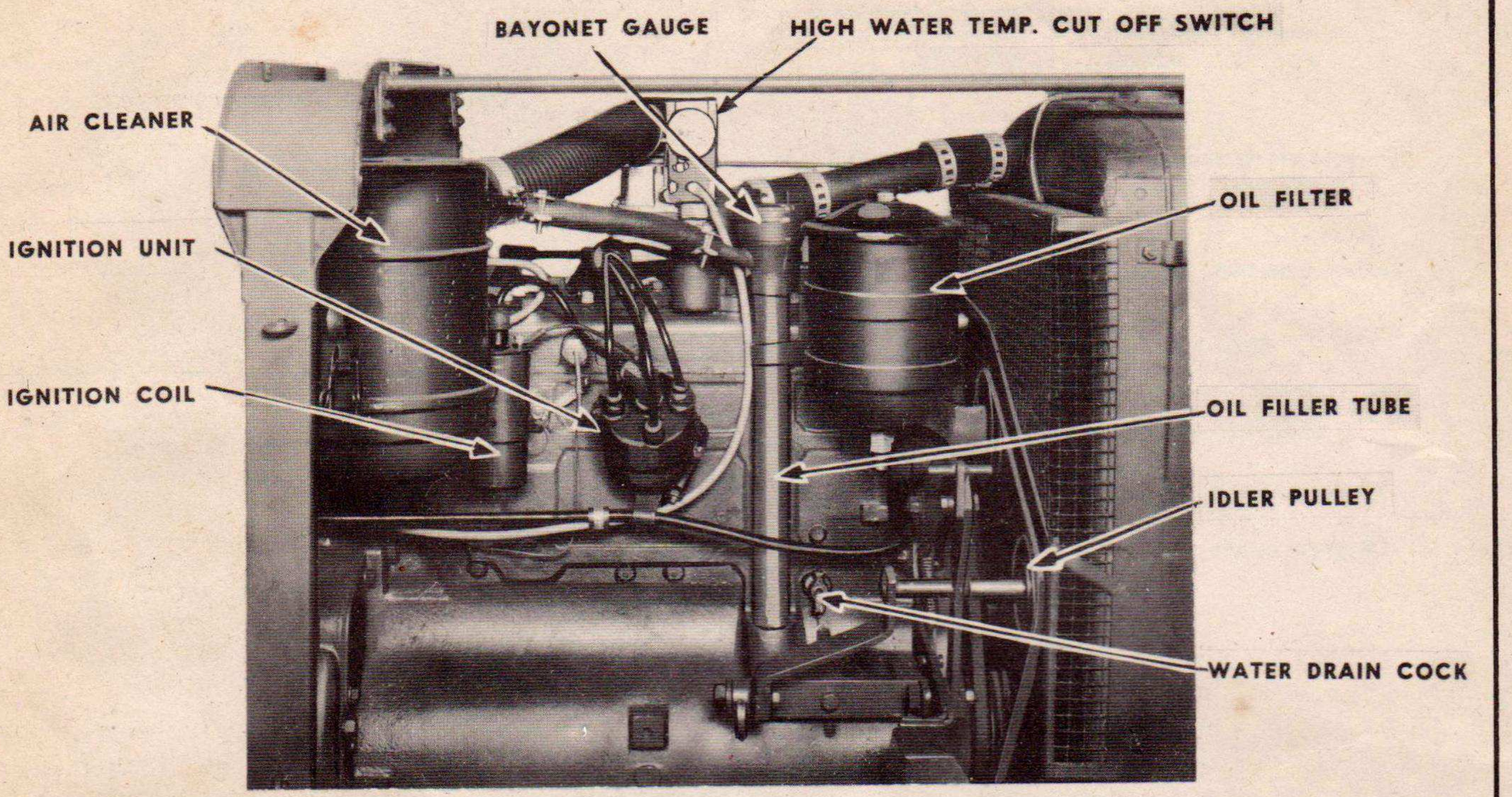


FIG. 6 LEFT SIDE OF ENGINE

6. Housing.—

The complete engine-generator unit with controls is mounted in a steel housing with steel skid base. The housing serves as radio shielding, helps direct cooling air currents and provides some protection against mechanical and other damage. Top and side panels are removable to permit inspecting and servicing the power unit. The fuel tank cap projects through the top of the housing. A grille at the front end protects the radiator and is provided with a grooved frame to which a canvas duct may be tied to convey heated air outside the room. The control panel is inset at the rear end of the housing and protected by a sliding door. Provision is made for inserting a starting crank and for manually operating the choke from the front end of the housing. Metal compartments for tools and parts are built into the housing. The inverted U-bolt of the lifting yoke extends through the top of the housing for accessibility in lifting the completely housed power unit.

SECTION II
INSTALLATION AND OPERATION

7. Installation.—

a. Handling the Uncrated Power Unit.—The skid base permits towing the power unit short distances over firm ground with truck or tractor. In very sandy or soft, muddy soil it may be necessary to lay down planks over which to skid it. Attach the tow rope or chain at one end of the skid base. Use a long hitch and go slowly. To hoist the power unit, attach a hoisting chain to the inverted U-bolt which extends above the top of the housing. Rollers may be used under the metal skid base.

b. Importance of Proper Installation.—Although Power Unit PE-95-G is built to rigid specifications and carefully tested and inspected before leaving the factory, it cannot function properly and give the best service unless the operating conditions are reasonably favorable. Many of these conditions depend entirely on the installation. The instructions which follow apply under usual conditions. When they cannot be followed exactly, use them as a guide and make the best installation that circumstances permit.

c. Choice of Location.—

(1) *Relation to Load.*—Locate the plant as near the center of the load as practicable. This assures lower line loss with a given size of wire and improves the control of voltage at the remote end of the lines. The size of line wires required depends largely upon the distance from the power unit to the load, the amount and kind of load and the permissible voltage drop between power unit and load. Be sure to use wire that is large enough for the purpose. If you do not know the proper size of wire, refer to the wiring tables in Section V of this manual.

(2) *Surrounding Conditions.*—The circumstances under which power units are used vary greatly, but for best results you must provide the most favorable operating conditions that circumstances permit. The housing on Power Unit PE-95-G protects it so that it can be operated out-of-doors, if necessary, but rain, snow, dust and grit and extremely cold weather are very unfavorable to satisfactory operation and long life. If circumstances permit, install the power unit inside a building or inside a mobile vehicle.

d. Indoor Installation.—

(1) *Space Required.*—If the power unit is to be permanently installed, provide an indoor location. This is particularly important in cold climates. Provide a floor space 9′ x 12′, or larger, in size. Install the power unit lengthwise in the space and at least 2½′ from the nearest wall or partition, to provide easy access for servicing. Usually the left side of the power unit, as viewed from the engine end, should be toward an outside wall so that the exhaust line can be extended outdoors conveniently. Provide ventilation, at least a door and a window on different sides of the room, so that the room temperature may be controlled. If necessary, in order to prevent too great a rise in room temperature, attach a canvas duct to the radiator grille and to a wall opening at least as large, so that the heated air will be conducted outside the room.

(2) *Foundation.*—Attach the power unit to a firm level base. The base must be strong enough to permanently support the weight of approximately 1800 pounds. It may be made of concrete or heavy timbers and should extend about 10 inches above the floor level for convenience. Shock absorbing material may be used between the plant and the base, if desired.

(3) *Exhaust.*—Exhaust gases are deadly poisonous. Pipe them outside the building. A 10′ length of flexible exhaust line is furnished with the power unit. Connect one end of this to the exhaust outlet located near the lower left front corner of the power unit. The exhaust pipe must extend outside the building by the most direct route practicable. If additional pipe is necessary, increase the size by one pipe size for each additional 10′ length. The additional pipe may be any suitable pipe of proper size. **Be sure that all connections are mechanically secure and gas tight.** Avoid unnecessary turns. Pitch the pipe downward from its connection at the power unit, if possible. If necessary to pitch the pipe upward, install a condensation trap in the line at the point where the upward pitch starts. This trap may be assembled of suitable pipe fittings. Its purpose is to catch water that condenses in the exhaust line and prevent its running into the muffler of the power unit. The trap must be drained periodically to perform this function. An exhaust line gets hot. If it passes through

an inflammable wall, partition or floor, install it in metal collars so as to separate it at least several inches from the inflammable material. Support the pipe securely at necessary points. If necessary, shield the pipe so nobody will get burned by contact with it.

(4) *Auxiliary Fuel Tank.*—Provision is made for connecting an auxiliary fuel tank, if desired. Use the 20′ length of flexible fuel line furnished. Install the fuel tank out-of-doors, if possible, but not farther from the power unit than the 20′ fuel line will permit. If a longer fuel line is used, the pump may fail to keep the carburetor supplied with fuel. The bottom of the fuel tank should not be more than 6′ below the fuel shut-off valve at the power unit. Be sure that the fuel line has a continuous downward pitch from power unit to tank. If the fuel line attaches to a fitting at the top of the auxiliary tank, there must be a suction tube inside the tank extending from the fitting to within an inch or two of the bottom of the tank so that the fuel may be drawn from the tank by the pump. Do not install the tank near the exhaust line. The tank must be vented.

(5) *Electrical Connections.*—Make sure that all electric wires entering the room and within the room are properly supported and insulated. Connect the load wires to the two A.C. OUTPUT terminals, (Fig. 3), beneath the control panel, one to each terminal. The size of insulated wire to use within the room for connecting the load to the power unit depends on the load amperes and the type of insulation on the wire. The following sizes are recommended as the smallest safe sizes for use within the room to carry the full load of the power unit; use No. 0 for 120-volt service, if the insulation contains rubber, or No. 2 if the insulation does not contain rubber; use No. 6 for 240-volt service if the insulation contains rubber, or No. 8 if the insulation does not contain rubber. Make sure that all connections are mechanically and electrically secure.

(6) *Remote Control.*—If it is desired to start and stop the power unit from one or more remote points, it will be necessary to install remote start and stop switches at each of the remote points and to connect them with the REMOTE CONTROL terminals, (Fig. 3), below the control panel of the power unit. Use 2-pole push button type switches, one for starting and one for stopping. Connect the insulated terminal of the starting switch to the REMOTE CONTROL terminal "Start". Connect the insulated terminal of the stopping switch to the REMOTE CONTROL terminal "Stop". Connect the REMOTE CONTROL terminal "Ground Return" through one wire to both remaining terminals of the two switches. No. 16 wires will serve for these connections up to 150 feet. Support them properly. These wires are connected with the 12-volt battery circuit.

e. Mobile Installation.—

(1) *Mounting.*—Attach the power unit securely to the floor or other supporting member of the vehicle in which it is installed. It should be so installed that it will set approximately level when in normal operation. Take full advantage of the available space in locating the power unit so as to provide proper ventilation and space for servicing. Use as much of the 10′ length of flexible exhaust tube as needed and pipe the exhaust gases outside the vehicle. Keep this pipe at least several inches from inflammable material and support it securely so that it will remain permanently in place. **This is important because exhaust gases are deadly poisonous.**

(2) *Caution.*—**Do not run the vehicle into a closed building and operate the power unit without carefully attaching an extension exhaust line that will carry all the exhaust gases outside the building.** The size of this extra piping should be increased one pipe size for each 10′ of length.

(3) *Ventilation.*—If the vehicle is a closed one, proper ventilation must be provided. This will require at least two openings, an inlet and an outlet, near opposite ends of the power unit. Several smaller openings will serve, if necessary, but there must be a total of at least 3½ square feet of opening for the inlet and a similar amount for the outlet. If necessary, connect a canvas duct to the radiator grille and the outlet opening in such manner that the heated air is forced outside the vehicle and thus prevented from recirculating.

(4) *Wiring.* — Support all permanent wiring within the vehicle so that vibration will not destroy the insulation or break the wires. Wiring is easily run in any direction. Do not let its location interfere with convenient servicing of the power unit. If power is taken off the power unit by flexible cable, provide a reel for the cable and store it in such location while in transit that it will not become damaged. Do not store other items on, or against, the power unit, or loosely within the compartment in such manner as to risk damaging the unit while in transit.

(5) *Leveling.*—If the power unit is to be operated for hours at a temporary location, locate the vehicle so that the power unit is reasonably level.

8. Preparation for Use.—

a. Procedure.—Comply with the following instructions in the order given:

(1) *Installation.*—Recheck to make sure that all instructions for installing the plant as given in paragraph 7 have been complied with.

(2) *Side Panels.*—Remove the side panels of the housing.

(3) *Manual Start-Remote Start Switch.*—Open the control panel door and make sure the MANUAL START - REMOTE START ignition switch is on the REMOTE START position. This switch must be on the REMOTE START position at all times except while starting the power unit by hand cranking and for emergency operation as explained in paragraph *9*.

(4) *Crank Manually.*—Crank the engine over a few times with the hand crank to make sure that the pistons are free and that the generator turns freely. You will find the hand crank attached in front of the engine oil pan inside the housing. Keep it there when not in use.

(5) *Battery.*—Prepare the battery for use.

(*a*) The battery is of the dry-charged type, shipped with plates in a partially charged condition. A card attached to the battery gives the manufacturer's instructions for preparing the battery for service.

(*b*) The electrolyte to be used is diluted sulphuric acid having a specific gravity of 1.265 at 80° F. It is packed in a separate container. In tropical climates, use electrolyte having a specific gravity of 1.200, produced by mixing 10 parts of the 1.265 electrolyte with 3 parts of water. Be sure to use distilled water, or other water known to be suitable for use in a lead-acid storage battery. Add the acid very slowly to the water. Never add the water to the acid.

(c) Remove the vent caps. Remove and destroy the Scotch tape or seals which covers the vent holes. Fill each cell with the correct electrolyte to a level 3/8 inch above the tops of the separators. Replace the vent caps and tighten securely. Be sure the seals have been removed.

(*d*) If the battery is filled with 1.200 electrolyte, for tropical use, stamp the numeral one (1) on the lead top connector at the positive cell for the information of anyone servicing the battery in the future. This number may be stamped with the end of a screwdriver or small chisel.

(*e*) If possible, allow the battery to stand from 4 to 12 hours after filling before placing in service. In an emergency, the battery may be placed in service 1 hour after it has been filled with proper electrolyte, however, this is not good practice.

(*f*) If possible, give the battery a freshening charge of from 16 to 20 hours at 6.0 amperes before placing in service. It will give satisfactory results without this charge if the battery temperature is above 50° F. If the battery temperature is below 50° F. it must be given a freshening charge in order to give satisfactory service. If temperatures are below 50° F. and no outside source for charging the battery is available, warm both the battery and the electrolyte to at least 50° F. before filling. Caution: Do not put cold electrolyte into a warm battery, or warm electrolyte into a cold battery, as severe damage will result.

(*g*) If the battery has been filled with 1.265 electrolyte, it may be considered fully charged when the specific gravity, corrected to 70° F., is between 1.270 and 1.285. If it has been filled with 1.200 electrolyte, it may be considered fully charged when the specific gravity, corrected to 70°. F, is between 1.210 and 1.225. At this point the terminal voltage of each cell should read not less than 2.5 volts while the battery is on charge at a 6.0 ampere rate.

(*h*) Whenever charging the battery from an outside source, keep the temperature of the electrolyte below 120° F. If this temperature exceeds 120° F., reduce the charging rate until the temperature drops below that figure.

(*i*) Wash the top of the battery with water and tighten the vent plugs before placing in service.

(*j*) The negative battery cable is grounded to a rear cylinder-head stud. Connect this cable to the negative (—) post of the left-hand battery unit. Place this cable in such position that it will not interfere with removing a vent cap. Connect the positive (+) battery cable, which is attached to the left terminal of the solenoid starting switch, to the positive (+) post of the right-hand battery. The short connecting cable connects the positive (+) post of the left-hand battery unit to the negative (—) post of the right-hand battery unit. If it has been disconnected while servicing the battery, replace it. Place all the cable connectors well down around the battery posts and tighten the bolts securely.

(6) *Electrical Connections.*—Check all electrical connections to make sure they are tight and clean, including those of distributor and spark plugs.

(7) *Crankcase Lubrication.*—Fill the crankcase with oil to the FULL level, as indicated by the bayonet gauge. Use Army No. 2-104-A oil of proper S.A.E. number according to the lowest temperature to which the power unit will be exposed, as indicated in the following table:

Temperature	S.A.E. Number
Above 32° F.	S.A.E. No. 30
Between 0° F. and 32° F.	S.A.E. No. 10 or 10W
Below 0° F.	S.A.E. No. 10 or 10W diluted with 10% kerosene as instructed in paragraph 9 *i* (1) (c).

Caution: Do not put diluted oil into the engine until ready to start it, as it may separate if allowed to stand too long before use. Mix well just before pouring into the engine. Special instructions for preparing and using this mixture are given in paragraph 9*i* (1) (*a*) through (*g*). Refer to (Fig. 64) Lubrication Chart and Assembly Outline in connection with crankcase and other lubrication.

(8) *Air Cleaner.*—Remove the oil cup from the intake-air-cleaner and fill to the proper level as marked on the cup, with oil of the same grade as used in the crankcase. Replace the cup, making sure that the snaps hold it securely in place.

(9) *Throttle Control Rod Ball Joints.* — Place a drop of light cylinder oil in each ball joint of the throttle control rod and check to make sure the throttle mechanism moves freely.

(10) *Ignition Unit.*—Place 5 drops of light oil in the oil cup on the side of the ignition unit.

(11) *Water Drain Cocks.*—Close the water drain cock at the lower radiator connection and the water drain cock on the left side of the cylinder block.

(12) *Radiator.*—Fill the radiator to one inch below the bottom of the radiator neck with clean, alkali-free water. Distilled or rain water may be used. If there is danger of freezing use a standard anti-freeze solution in proper proportion. Carefully check all connections for water leaks, correcting any found. The capacity of the cooling system is 15½ quarts.

(13) *High Water Temperature Cut-Off Switch.*—Set the dial of the high water temperature cut-off switch to indicate a temperature several degrees Fahrenheit below the boiling point of the liquid used for cooling. For water, at sea level, the setting should be 208. This should be decreased 3 degrees for each 1000 feet above sea level.

(14) *Circuit-Breaker.*—Make sure that the CIRCUIT BREAKER handle is in the OFF position so that the load is not connected to the alternator.

(15) *Load Wires.*—Check the load wires for proper connections.

(16) *AC Terminal Jumpers.* — The terminal jumpers at the a-c terminal block on the rear of the control panel are connected properly for an output of 120 volts and will need no attention if that is the desired voltage. If an output of 240 volts is desired it will be necessary to change the jumper connections. Remove the three round-headed screws from the top edge of the control panel and tip the panel outward to an approximately horizontal position. Refer to the panel wiring diagram (Fig. 14). Remove the jumpers from terminals 3 and 4 and terminals 5 and 6. Connect both jumpers across terminals 4 and 5. Tighten all nuts securely. Tip the panel up into proper position, replace the screws and tighten securely.

(17) *Close Fuel Shut-Off Valve.*—Close the 2-way fuel shut-off valve located under the main fuel tank. The lever handle extends rearward when the valve is closed.

(18) *Fuel Tank.*—Fill the main or the auxiliary fuel tank, or both, with a good grade of gasoline, **observing the usual safety precautions in the handling of this fuel.**

(19) *Open Fuel Shut-Off Valves.*—Open the 2-way fuel shut-off valve to the position corresponding with the fuel tank which is to be used. The lever handle must extend down if the main tank is to be used; forward if the auxiliary tank is to be used. Make sure that the fuel shut-off valve at the top of the sediment bulb is open.

(20) *Fuel Pump.*—By means of the lever on the side of the fuel pump, (Fig. 5), pump the carburetor bowl full of fuel. If the engine camshaft sets so that the pump diaphragm is in its lowest position, the lever will not operate the pump. In that case insert the hand crank and crank the engine one complete revolution. Then the pump can be operated by the lever. Always push the lever down after pumping. If left up, the pump will not be operated by the engine. Examine the entire fuel system for leaks and correct any found.

9. Operation.—

a. Preliminary.—When the instructions for Installation and Preparation for Use, paragraphs 7 and 8, have been complied with, the power unit is ready for use and may be started. If the power unit was prepared for cold weather operation, the initial filling with diluted oil may have been left to be done immediately before starting the power unit. Check the oil level by means of the bayonet gauge. Make sure that the crankcase is filled with proper oil to the FULL mark on the gauge before attempting to start the power unit.

b. Starting the Power Unit Electrically.—

(1) *Circuit-Breaker.*—Make sure that the CIRCUIT BREAKER (Fig. 3) is in the OFF position.

(2) *Manual Start-Remote Start Switch.*—Make sure that the MANUAL START-REMOTE START switch is in the REMOTE START position.

(3) *Start Button.*—Press the START button firmly until the engine starts and builds up oil pressure, but not more than 10 or 15 seconds. Choking is automatic and the plant should start at once. If it fails to start, wait 10 seconds and then repeat the procedure. If the START button is released too soon the ignition will be cut off and the engine will stop. If the plant does not start after a few attempts, check the fuel supply and the ignition wires and then repeat the starting procedure. NOTE: **Oil was placed in the cylinders before shipping and in some cases it may be necessary to remove and clean the spark plugs before the engine will start the first time. This may be done by washing thoroughly in gasoline.**

c. Starting the Power Unit Manually. — In case the starting battery does not furnish sufficient cranking power, the plant may be started by hand cranking. However, the battery must furnish enough power for ignition. If it does not, it must be recharged from a separate source or replaced with a charged battery. To start the plant manually, proceed as follows:

(1) *Circuit-Breaker.* — Make sure that the CIRCUIT BREAKER is in the OFF position.

(2) *Manual Start-Remote Start Switch.*—Throw the MANUAL START-REMOTE START ignition switch to the MANUAL START position.

(3) *Cranking.*—Insert the hand crank and crank the engine. Do not spin or push down on the crank. Use a strong, quick, upward pull. Repeat as necessary.

(4) *Choking.*—Choke as necessary by means of the choke control at the front of the housing. Open the choke gradually as soon as the engine starts.

(5) *Manual Start-Remote Start Switch—Running Position.*—After the engine has been started, throw the MANUAL START-REMOTE START switch to the REMOTE START position.

d. Operation After the Engine Starts.—Check the oil pressure gauge immediately after starting the engine. Pressure will be high until the engine warms up. Observe the readings of gauges and meters on the control panel as a check on the normal operation of the power unit. Normal readings for the various instruments after the plant reaches normal operating temperature are given here.

(1) ENGINE WATER TEMPERATURE, about 175° F.

(2) ENGINE OIL PRESSURE, about 22 pounds.

(3) BATTERY CHARGE RATE, 2 to 10 amperes, depends on the state of charge of the battery and the amount of load connected to the D.C. OUTPUT terminals.

(4) FUEL GAUGE, indicates the supply of fuel in the fuel tank on the plant. Does not indicate the supply in the auxiliary fuel tank.

(5) A.C. VOLTMETER, indicates the voltage at the A.C. OUTPUT terminals which should be approximately 120 volts or approximately 240 volts, depending on the jumper connections on the back of the control panel. With a constant, unity power factor load, and after reaching normal operating temperature, the voltage should be between the limits of 118 to 126 or 236 to 252 volts.

(6) A.C. AMMETER, indicates the a-c output in amperes. The actual reading depends on the amount of load, the power factor of the load and the operating voltage. At 120 volts and a unity power factor load, the full load amperage is 83. At 120 volts and an 80% power factor load, the full load amperage is 104. At 240 volts, the corresponding full load amperages are just half the above values.

(7) RUNNING TIME METER, shows the total hours the power unit has been operated.

(8) FREQUENCY METER, indicates the output frequency.

e. Connecting the Load. — Throw the CIRCUIT-BREAKER control handle to the ON position to connect the load. The CIRCUIT-BREAKER will open and disconnect the load automatically if the power unit is heavily overloaded. Throw the control handle to the OFF position to disconnect the load when desired. A 12-volt D.C. load, not exceeding 10 amperes, may be connected to the D.C. OUTPUT terminals. Connect the positive load wire to POS. terminal. Connect the negative load wire to NEG. terminal. This load may consist of radio, battery-charging or a 12-volt trouble lamp. Caution: This load must not be so heavy and long continued that the storage battery on the power unit will not have enough charge to supply ignition current to permit starting the power unit manually.

f. Housing Side Panels and Top Plates.— Keep the side panels and top plates on the housing except while servicing. They help to direct the cooling air properly and to reduce radio interference.

g. Stopping the Power Unit.—To stop the power unit, press the STOP button on the control panel. The MANUAL START-REMOTE START switch must be in the REMOTE START position before the power unit can be stopped by means of the STOP button. It is good practice to disconnect the load by throwing the CIRCUIT-BREAKER control handle to the OFF position before stopping the power unit unless the power unit is to be controlled from a remote point.

h. Remote Control.—The remote-control push button switches which may have been installed at remote points perform the same functions as the START and STOP buttons on the control panel and are used in the same manner. The CIRCUIT-BREAKER must be left in the ON position if the plant is to be operated by remote control.

i. Abnormal Operating Conditions.—Temperatures below 0° F. require special attention in regard to lubrication and cooling liquids. Unusually dirty and dusty operating conditions, which sometimes cannot be avoided, require extra attention.

(1) *Lubrication.*—

(*a*) For temperatures below 0° F. use diluted oil in the crankcase to aid in starting and to assure proper lubrication.

(*b*) If the crankcase is filled with undiluted oil, run the engine until warm. Then drain the oil and close the drain valve.

(*c*) Thoroughly mix 1 pint of kerosene with 5 quarts of Army No. 2-104-A oil, SAE No. 10 or 10W. If kerosene is not available, use 1 pint of a good grade of distillate instead. Do not use heavier than S.A.E. No. 20 oil as it may separate when the engine is stopped, thus defeating the purpose and possibly causing damage.

(*d*) Fill the crankcase with the diluted oil to the FULL mark on the bayonet gauge.

(*e*) Run the engine 10 minutes to circulate the mixture throughout the lubricating system.

(*f*) Never add kerosene alone. Mix the kerosene with the oil before pouring into the crankcase. This applies also to the addition of diluted oil between changes.

(*g*) When using diluted oil, change the oil every 50 operating hours and check the level each night and morning, or more frequently if experience shows it to be necessary.

(2) *Cooling System.*—The liquid in the cooling system must be protected if there is any possibility of its freezing. Use any good anti-freeze prepared as directed by the manufacturer. Common ones are alcohol, glycerin, Prestone and Zerone. Never use kerosene or distillate in the cooling system.

(*a*) If the power unit has been used, drain and flush the cooling system with running water or a special flushing agent. Run the plant until warm before draining. Never flush a very cold plant with water or any solution which may freeze upon contact with the cold metal and cause damage.

(*b*) Close the drain cocks and fill the cooling system to a point one inch below the bottom of the radiator neck with water and anti-freeze in proper proportions, depending on the kind of anti-freeze and the degree of protection needed. **Do not fill to overflowing.**

(*c*) Check the cooling mixture often, both as to the amount and the degree of protection. Provide protection enough to take care of any unexpected drop in temperature.

(3) *Dust and Dirt.*—When the power unit is operated under dusty conditions it is necessary to check and service it more often.

(*a*) Keep the plant as clean as possible.

(*b*) Keep supplies of fuel and oil in air tight containers.

(*c*) Clean the air cleaner and refill the oil cup as often as is necessary. Check daily.

(*d*) Clean the generator commutator and brushes often. See that the brushes ride easily in their holders.

(4) *Engine Water Temperature.*—The normal Engine Water Temperature gauge reading after the power unit reaches operating temperature is about 175° F. Under very cold operating conditions, cover a lower portion of the radiator surface with cardboard, if necessary, in order to raise the engine water temperature to at least 160° F.

(5) *Emergency Operation.*—In case of failure of the start relay or the ignition relay to close the ignition circuit, the engine cannot be operated with the MANUAL START-REMOTE START switch in the REMOTE START position. Under this condition the power unit may be operated with the MANUAL START-REMOTE START switch in the MANUAL START position. It will be necessary to switch to the REMOTE START position before the engine can be stopped by pressing the STOP button. When operating with the switch in the MANUAL START position, the High Water Temperature Cut-Off switch and the Low Oil Pressure Cut-Off switch do not operate. Extra attention should be given to avoid overheating and low oil pressure.

10. Trouble and Remedy Chart.—

Symptom	Possible Cause	Check	Remedy
Exciter will not crank engine. May use hand crank until trouble corrected.	Discharged battery.	Hydrometer test.	Recharge or replace battery.
	Corroded terminals.	Battery terminals.	Clean and tighten terminals.
	Loose connections.	Cable connections.	Tighten connections.
	Defective solenoid switch.	Short across large terminals of switch.	Replace switch.
	Engine stuck.	Try with hand crank.	Return unit to depot for repairing.
	Defective start relay.	Start relay operation.	Clean contacts. Return unit to depot for replacement if necessary.
	Exciter will not operate as a motor.	Short across large terminals of solenoid switch.	Return unit to depot for repairing.
Engine cranks too slowly. May use hand crank until trouble corrected.	Too heavy oil in crankcase.	Inspect oil.	Drain, refill with lighter oil.
	Weak battery.	Hydrometer test.	Recharge or replace battery.
	Corroded terminal.	Battery terminals.	Clean and tighten terminals.
	Defective cable.	Battery cables.	Install new cable.
Engine is cranked electrically but will not start.	Battery too weak to supply ignition while cranking.	Hydrometer test.	Recharge or replace battery. Start by hand crank meanwhile.
	Faulty ignition.	Spark plugs.	Clean, adjust or replace plugs.
		Breaker contacts.	Resurface or replace contacts and adjust gap.
		Coils, cables, condenser.	Replace defective parts.
	Corroded start relay contacts.	Try with Manual Start-Remote Start switch in Manual Start position.	Clean the relay contacts. Return unit to depot for replacements if necessary.
	Lack of fuel or faulty carburetion.	Fuel tank empty.	Refill.
		Clogged fuel line.	Clean.
		Shut-off cock closed.	Open shut-off cock.
		Fuel screens.	Clean.
		Fuel pump.	Clean, repair or replace.
		Electric choke.	Replace, if defective.
		Cylinders flooded.	Crank few times with spark plugs removed.
		Poor fuel.	Drain, refill with good fuel.
		Dirt in carburetor.	Clean.
	Poor compression, usually because of leaking valves.	Hand crank with ignition off, noting whether compression uniformly good on all cylinders.	Tighten or replace head gasket. Tighten spark plugs. Adjust tappets. If still not corrected, return unit to depot for repairing.
	Wrong timing.	Spark timing.	Retime.

Symptom	Possible Cause	Check	Remedy
Engine runs but AC voltage does not build up.	Poor commutation.	Exciter brushes and commutator.	See that brushes seat well on commutator, are free in holders, are not worn shorter than ¾" and have good spring tension. If commutator is rough or badly grooved, return unit to depot for repair.
	Open circuit, short circuit or ground in generator.	No simple test, see paragraph 50h.	Return unit to depot for repairs.
	Poor seating of brushes on slip rings.	Slip rings and brushes.	Give slip ring brushes same attention as commutator brushes.
Voltage unsteady but engine not missing.	Poor commutation or poor brush contact at slip rings.	Exciter commutator and brushes.	See that brushes seat well on commutator, are free in holders are not worn shorter than ¾" and have good spring tension. If commutator is rough or badly grooved, return unit to depot for repairs. Tighten connections.
	Loose connections, especially in exciter circuits.	Check for loose connections.	
	Fluctuating load.	Check load. Some fluctuating loads, such as a motor driving a single action reciprocating pump, are normal conditions.	Correct any abnormal load condition causing trouble.
Generator overheating.	Overloaded.	Ammeter.	Reduce load.
Voltage drops under heavy load.	Engine lacks power.	See symptom of engine missing under heavy load.	See remedies for engine missing under heavy load.
		Crank with ignition off, noting whether compression uniformly good on all cylinders.	Tighten or replace head gasket. Tighten spark plugs. Adjust tappets. If still not corrected, return unit to depot for repairing.
		Carburetor.	Clean carburetor.
		Carburetor air cleaner.	Clean air cleaner.
		Choke.	See that it opens wide.
		Carbon in cylinders.	Remove carbon.
		Restricted exhaust line.	Clean or increase the size.
Engine misses at light load.	Carburetor idle adjustment set wrong or clogged.	Carburetor.	Adjust, clean if needed.
	Spark plug gaps too narrow.	Spark plugs.	Set at .030".
	Intake air leak.	Intake manifold.	Tighten or replace gaskets.
	Faulty ignition.	Breaker and coil.	Adjust or replace.
	Uneven compression.	Crank with ignition off noting whether compression uniformly good on all cylinders.	Tighten head gasket and spark plugs. Adjust tappets. If still not corrected return unit to depot for repairing.
Engine misses at heavy load.	Spark plugs defective.	Spark plugs.	Replace.
	Faulty ignition.	Breaker, coil and condenser.	Adjust or replace.
	Clogged carburetor jets.	Carburetor.	Clean.
	Clogged fuel screens.	All fuel screens.	Clean.
	Tappets adjusted too close.	Tappets.	Adjust.
	Defective high tension cables.	High tension cables.	Replace.
Engine misses at all speeds.	Fouled spark plug.	Spark plugs.	Clean and adjust.
	Defective or wrong spark plug.	Spark plugs.	Replace.
	Sticking valves.	Valves.	Return unit to depot for repairing.
	Broken valve spring.	Valve springs.	Replace.
	Defective ignition wires.	Ignition wiring.	Replace.
	Pitted or improperly adjusted breaker contacts.	Breaker contacts.	Adjust or replace.
	Defective ignition condenser.	See if breaker contacts sooty and spark weak and yellow.	If so, replace condenser.
	Tappets need adjusting.	Tappets.	Adjust.

Symptom	Possible Cause	Check	Remedy
Low oil pressure.	Oil too light.	Inspect oil.	Drain, refill with proper oil.
	Oil badly diluted.	Inspect oil.	Drain, refill with proper oil.
	Oil too low.	Oil level.	Add oil.
	Oil relief valve not seating.	Oil relief valve.	Remove and clean.
	Badly worn engine bearings.	Smoky exhaust, excessive oil consumption which cannot otherwise be accounted for.	Return unit to depot for repairing.
	Sludge on oil screen.	Must remove pan to check.	Return unit to depot for checking.
	Badly worn oil pump.	No simple check.	Return unit to depot for checking.
	Defective oil gauge.	No simple check.	Return unit to depot for checking.
High oil pressure.	Oil too heavy.	Inspect oil.	Drain, refill with proper oil.
	Clogged oil passage.	No simple test.	Return unit to depot for repairing.
	Oil relief valve stuck.	Oil relief valve.	Remove and clean.
	Defective oil pressure gauge.	Should read zero when unit not operating.	If not, install new oil pressure gauge.
Engine stops unexpectedly.	Fuel tank empty.	Fuel gauge.	Refill, or set fuel shut-off valve for other tank.
	Water temperature high.	Water in radiator.	Add water.
		Cardboard over radiator.	Remove cardboard.
		Unit overloaded.	Reduce load.
		Ventilation.	Increase ventilation.
		Fan belt.	Tighten, or install new one.
		Water not circulating freely due to sludge or defective hose.	Drain, flush and refill radiator, replace defective hose.
	High water temperature cut-off switch set too low temperature.	High water temperature cut-off switch.	Set dial to correct temperature.
	Low oil pressure, usually due to lack of oil.	Bayonet gauge.	Add oil to crankcase.
Engine backfires at carburetor.	Lean fuel mixture.	Carburetor.	Clean carburetor.
		Fuel screens.	Clean screens.
		Air leaks at intake manifold.	Replace gaskets, tighten.
	Poor fuel.	Fuel.	Drain, fill with good fuel.
	Spark too late.	Flywheel marks.	Retime ignition.
	Distributor wires crossed.	Distributor wires.	Install wires correctly.
	Intake valves leaking.	Hiss through carburetor when hand cranked with ignition off.	Adjust tappets. If this does not correct, return unit to depot for servicing.
Excessive oil consumption, light blue smoky exhaust.	Poor compression, usually due to leaking valves.	Hand crank with ignition off, noting whether compression uniformly good on all cylinders.	Tighten or replace head gasket. Tighten spark plugs. Adjust tappets. If still not corrected, return unit to depot for servicing.
	Oil leaks from oil pan or connections. This does not cause smoky exhaust.	Inspect visually for leaks.	Replace gaskets and leaking tubing. Tighten screws and connections.
	Oil too light or diluted.	Inspect oil.	Drain, refill with correct oil.
	Bearing clearance too great.	Oil pressure gauge registers low and this cannot otherwise be accounted for.	Return unit to depot for repairing.
	Oil pressure too high.	Oil pressure gauge.	Refer to symptom of high oil pressure for remedies.
	Engine misses firing.	Voltmeter reading unsteady and exhaust irregular.	Refer to symptoms of engine misses.
	Faulty ignition.	Spark plugs.	Clean, adjust or replace.
		Breaker contacts.	Resurface or replace contacts and adjust gap.
		Coils, cables, condenser.	Replace defective parts.
	Unit operated a great deal at light or no load.	Operating conditions.	No remedy needed.
	Too much oil.	Bayonet gauge.	Drain excess oil.

Symptom	Possible Cause	Check	Remedy
Black, smoky exhaust, excessive fuel consumption, fouling of spark plugs with black soot, possible lack of power under heavy load.	Fuel mixture too rich.	Carburetor float for leak and high level, needle valve for leak, jets and metering rod for wear or damage, gasket washers for leaks.	Install needed carburetor parts, adjust float level. Be sure all jet gaskets are in place and tight and needle valve gasket is in place and tight.
	Choke not open.	Choke.	See that choke opens properly.
	Dirty carburetor air cleaner.	Air cleaner.	Clean, refill to proper oil level.
Circuit breaker trips and disconnects load.	Load too great.	Ammeter.	Reduce load.
	Load line short circuited.	Ammeter.	Remove short circuit.
Lights dim at far end of line but bright near unit.	Too small line wire for load and distance.	Wire size, against load and distance.	Install larger or extra wires or reduce load.
Motors run too slowly and overheat at far end of line but OK near unit.	Too small line wire for load and distance.	Wire size, against load and distance.	Install larger or extra wires or reduce load.
Light pounding knock.	Loose connecting rod bearing.	Short out one spark plug at a time to locate.	Return unit to depot for repairing.
	Low oil supply.	Bayonet gauge.	Add oil.
	Low oil pressure.	Oil pressure gauge.	Refer to symptom of low oil pressure for remedies.
	Oil badly diluted.	Inspect oil.	Change oil.
Dull metallic thud, if not real bad may disappear after few minutes operation. If bad, increases with load.	Loose crankshaft bearing.	Accelerate under load.	Return unit to depot for repairing unless one of the next 3 remedies permanently corrects the trouble.
Sharp metallic thud, especially when cold plant first started.	Low oil supply.	Bayonet gauge.	Add oil.
	Low oil pressure.	Oil pressure gauge.	Refer to symptom of low pressure for remedies.
	Oil badly diluted.	Inspect oil.	Change oil.
Pinging sound when engine is rapidly accelerated or heavily loaded.	Carbon in cylinders.	Inspect through spark plug hole.	Remove carbon.
	Spark too early.	Flywheel marks.	Retime ignition.
	Wrong spark plugs.	Spark plugs.	Install Champion J-9 plugs.
	Spark plugs burned or carboned.	Spark plugs.	Install new plugs.
	Valves hot.	Tappet clearance.	Adjust tappets.
	Fuel stale or low octane.	Fuel.	Use good, fresh fuel.
	Lean fuel mixture.	Carburetor.	Clean.
Clicking sound.	Tappet clearance too great.	Tappet clearance.	Adjust tappets.
	Broken valve spring.	Valve springs.	Install new spring.
Hollow clicking sound with cool engine under load.	Loose pistons.	Put tablespoonful heavy oil in cylinder suspected. Crank engine with ignition off to lubricate piston. Then start engine. If noise not present, indicates loose piston or piston rings.	If noise only slight and disappears when engine warms up, no immediate attention needed. Otherwise return unit to depot for repairing.

SECTION III
FUNCTIONING OF PARTS

11. Engine.—

a. Four Stroke Cycle.—The engine, Figs. 2, 7 and 8, used in Power Unit PE-95-G is a conventional automotive type of internal-combustion, gasoline engine. Such engines develop their power by burning a mixture of gasoline and air under compression in the cylinders and applying the resulting expanding force on the heads of the pistons. The resulting downward motion of pistons is transmitted through connecting rods to the cranskshaft, resulting in rotary motion of the crankshaft. This engine operates on the usual four-stroke-cycle principle, the action of which may be considered as being a repetition of a cycle of four different strokes. The action of each cylinder is the same, but is 180° of crankshaft travel later than that of the preceding cylinder. Firing order is 1-3-4-2.

(1) *Intake Stroke.*—The piston travels downward while the intake valve is open and the exhaust valve is closed. The resulting reduction in pressure within the cylinder allows air to rush in through the air cleaner, carburetor, intake manifold and intake valve port. As the air passes through the carburetor the proper proportion of gasoline is mixed with it.

(2) *Compression Stroke.*—The piston travels upward with both valves closed and compresses the fuel mixture in the combustion chamber at the upper part of the cylinder. As the piston reaches the top of the stroke a spark occurs at the spark plug and burning of the fuel mixture begins.

(3) *Power Stroke.*—Burning of the fuel mixture continues, developing great heat and pressure. Both valves are closed. The piston is forced downward, transmitting its power to the crankshaft.

(4) *Exhaust Stroke.*—The piston travels upward with exhaust valve open, intake valve closed, and forces the exhaust gases from the cylinder. These gases pass out through the exhaust port, exhaust manifold, exhaust pipe and muffler.

b. Power.—The amount of power developed by the engine, and hence its speed under a given load, is determined by the position of the throttle valve in the carburetor which regulates the amount of fuel mixture that enters the cylinders. The throttle valve is automatically controlled by the engine governor.

c. Valves and Camshaft.—The valves are operated in proper sequence and timing by tappets which ride on a series of cams on the camshaft. The camshaft is driven by a chain from a sprocket on the crankshaft and turns at just half the speed of the crankshaft. The valves are closed by spring action. A gear on the camshaft drives the oil pump and ignition unit.

d. Cooling.—Water is circulated around the cylinders, valve ports and combustion chambers to conduct heat away from the engine. The water flows from the outlet at the top of the cylinder head, to the radiator where it is cooled, then returned to the water jacket. Circulation is maintained by a centrifugal type water pump. Air circulation is maintained by a pusher type fan. A thermostat in the water outlet at the top of the cylinder head tends to maintain a uniform water jacket temperature under varying operating conditions by regulating the water circulation. The radiator cap is designed to maintain a pressure of four pounds per square inch before releasing vapor through the overflow pipe, thus to save water.

e. Lubrication.—Lubrication is provided within the engine by pumping oil from the oil pan to the main, connecting rod and camshaft bearings from which it sprays to other interior parts. The oil pressure registers on the ENGINE OIL PRESSURE gauge on the control panel and is regulated by a pressure relief valve in the pump body.

12. Oil Filter.—

The oil filter, (Fig. 6), on the left side of the engine filters particles of dust, carbon and other foreign material from the crankcase oil. Oil from the pressure lubricating system of the engine passes into the filter near the top, then through the filter and out at the bottom connection, from which it is conducted to the timing chain cover and returns to the crankcase. In service the filter element becomes filled with foreign material collected from the oil and no longer can perform its function. It must then be replaced with a new element. Only a portion of the oil leaving the pump passes through the oil filter, but all the oil in the crankcase passes through frequently enough to be kept in a clean condition if the filter element is changed often enough. As soon as the oil becomes dark, the element should be changed.

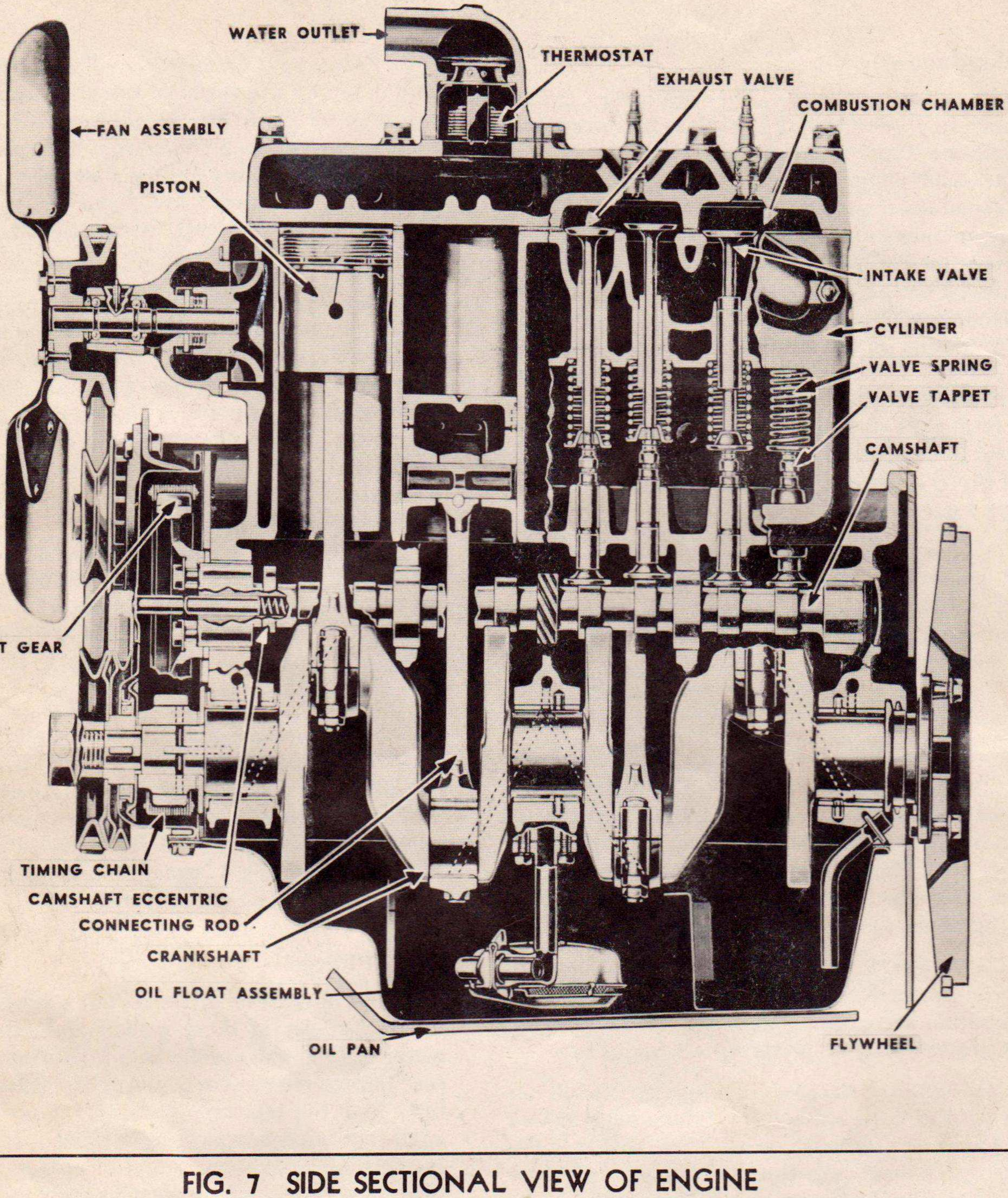


FIG. 7 SIDE SECTIONAL VIEW OF ENGINE

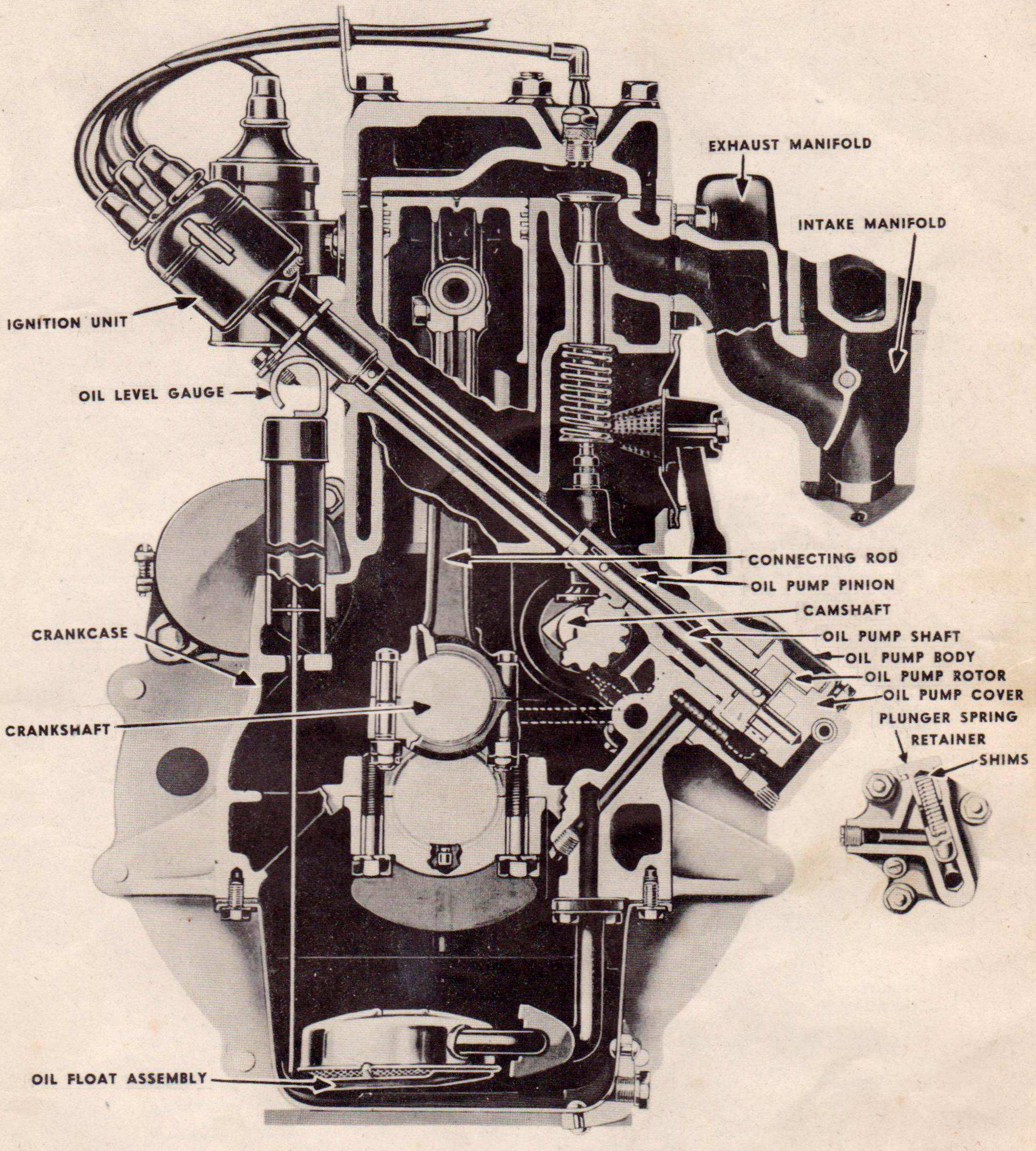


FIG. 8 FRONT SECTIONAL VIEW OF ENGINE

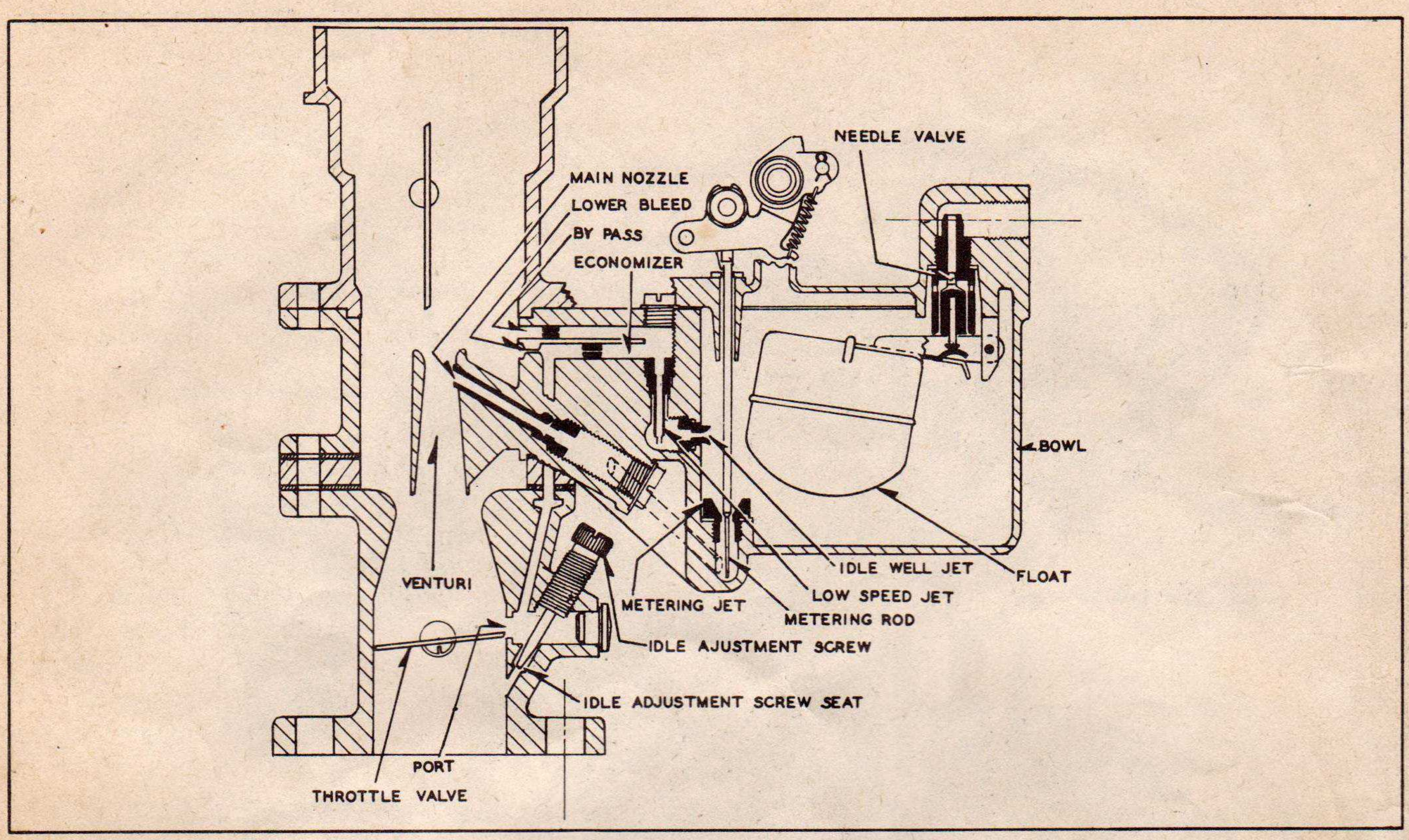


FIG. 9 CARBURETOR FUNCTIONING DIAGRAM

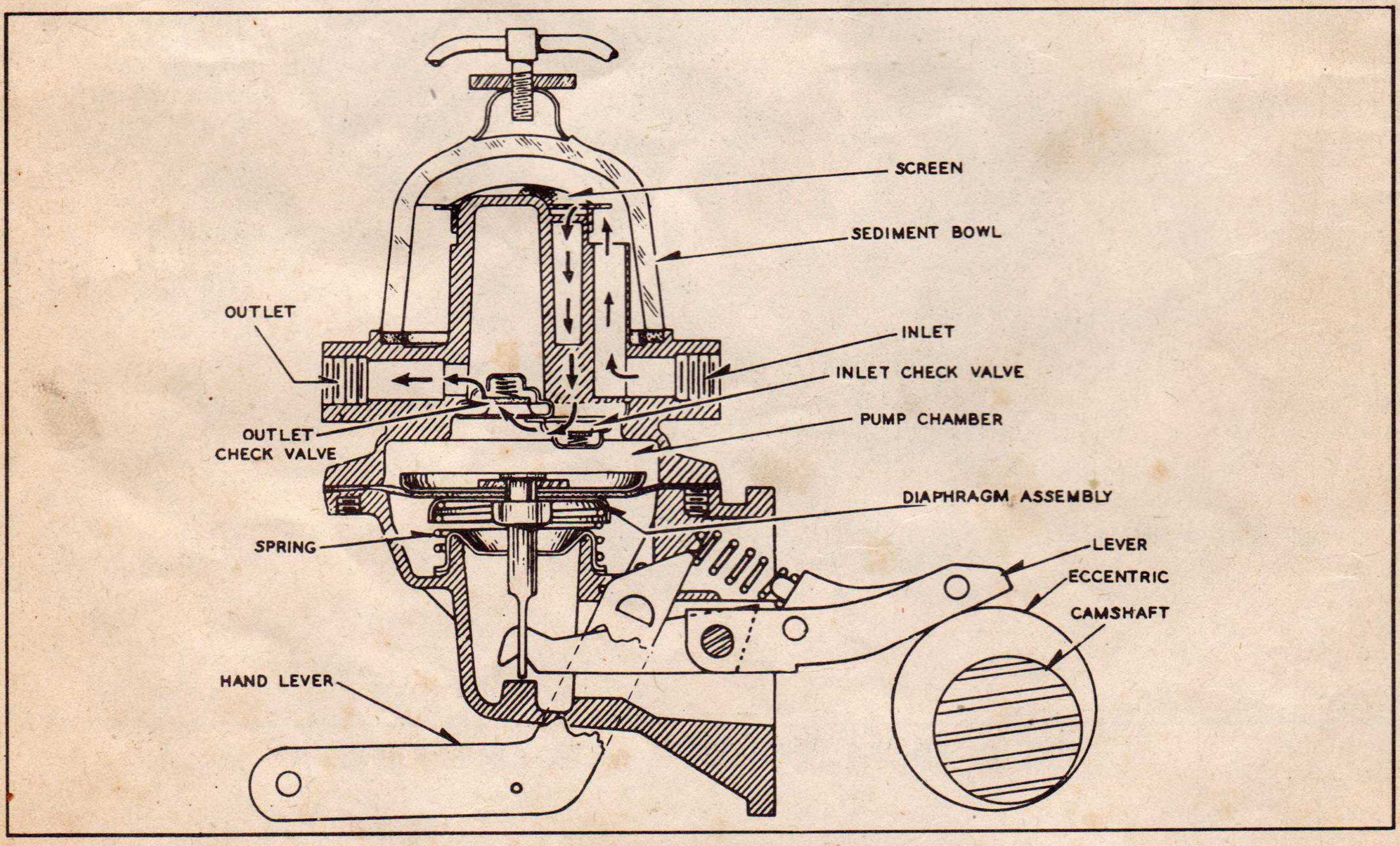


FIG. 10 FUEL PUMP FUNCTIONING DIAGRAM

13. Engine Governor.—

The engine governor, (Fig. 5), is of the conventional fly-weight type, driven by a V-belt from a pulley on the crankshaft. It controls the engine speed and, thus, the frequency of the alternating current generator. The governor arm is connected with the throttle arm of the carburetor and the action is such that an increase in engine speed tends to close the throttle, and vice versa. The engine speed may be adjusted by adjusting the spring tension. The governor is lubricated by oil from the pressure lubricating system of the engine.

14. Carburetor.—

This power unit is equipped with a Carter, No. 572 S, downdraft, metering jet type carburetor, Figs. 5, and 9, the prime function of which is to deliver a proper mixture of fuel and air to the engine under all load conditions.

a. Gasoline enters the carburetor bowl through the float-operated needle valve assembly, the level to which it rises in the bowl being controlled by the float.

b. When operating at very light load, the throttle valve is nearly closed and most of the gasoline enters the fuel mixture by way of the idle well jet, low speed jet, economizer, near which point it combines with streams of air from the by-pass and lower bleed, and then through passage to the port and the idle adjustment screw seat. This mixture is richer than required, but upon further mixing with air from the venturi provides a suitable mixture, the combined richness being adjustable by means of the idle adjustment screw.

c. At about 30% of full load the throttle valve opens so far that little fuel passes through the path just described. However, at this throttle position the reduction of air pressure at the tip of the main nozzle allows fuel to pass from the carburetor bowl through the metering jet, through the passage and the main nozzle, and into the main air stream. The amount of fuel through this path depends on the degree of reduction of pressure at the tip of the main nozzle below atmospheric pressure and upon the effective opening through the metering jet.

d. As the throttle valve opens further under increasing load, the pressure at the tip of the main nozzle is further reduced and the metering rod is raised by mechanical linkage with the throttle so as to increase the effective opening through the metering jet. The various parts are so proportioned as to provide a suitable mixture at all operating loads.

e. The pump with which the carburetor is equipped is not required and should be disconnected.

15. Fuel Pump.—

The diaphragm type fuel pump, Figs. 5 and 10, operates continuously while the plant is in operation and supplies fuel from the fuel tank to the carburetor. It is mounted on the right side of the engine and driven by an eccentric on the camshaft.

a. A special lever arrangement transmits motion to the diaphragm assembly. When the diaphragm assembly is drawn downward, the pressure within the pump chamber is reduced and fuel flows from the fuel tank, through the fuel line and into the pump inlet. It passes upward through the inverted sediment bowl, through the screen and inlet check valve into the pump chamber. Upward movement of the diaphragm forces fuel from the pump chamber through the outlet check valve and the pump outlet. From the pump outlet the fuel passes through a fuel line to the carburetor.

b. The diaphragm is pulled downward by the lever arrangement, but is returned upward by the action of the spring. After the carburetor bowl becomes filled with fuel, the diaphragm returns upward only as permitted by the flow of fuel through the needle valve of the carburetor.

c. A hand lever permits operating the pump manually for the initial filling of the carburetor bowl after it has been drained or has run dry because of an empty fuel tank.

16. Air Cleaner.—

The air cleaner, (Fig. 6), cleans the air which enters the carburetor intake. Air enters near the top of the cleaner, passes down and over or through a pool of oil in the cup at the bottom. Some oil is carried up and deposited in the metallic filter element. Surplus oil which does not adhere to the filter element runs back into the cup. Dust and foreign particles in the air adhere to the oily surface of the element and are constantly washed back into the cup where they settle to the bottom. Cleaning the cup and filter and filling to the proper level with clean oil when necessary keeps the cleaner in good functioning condition.

17. Ignition System.—

a. ***Purpose.***—The compressed gases of the fuel mixture in a cylinder are ignited by a spark which jumps the gap between the spark plug electrodes. The high voltage required to produce this spark is furnished by means of the ignition coil, (Fig. 6),

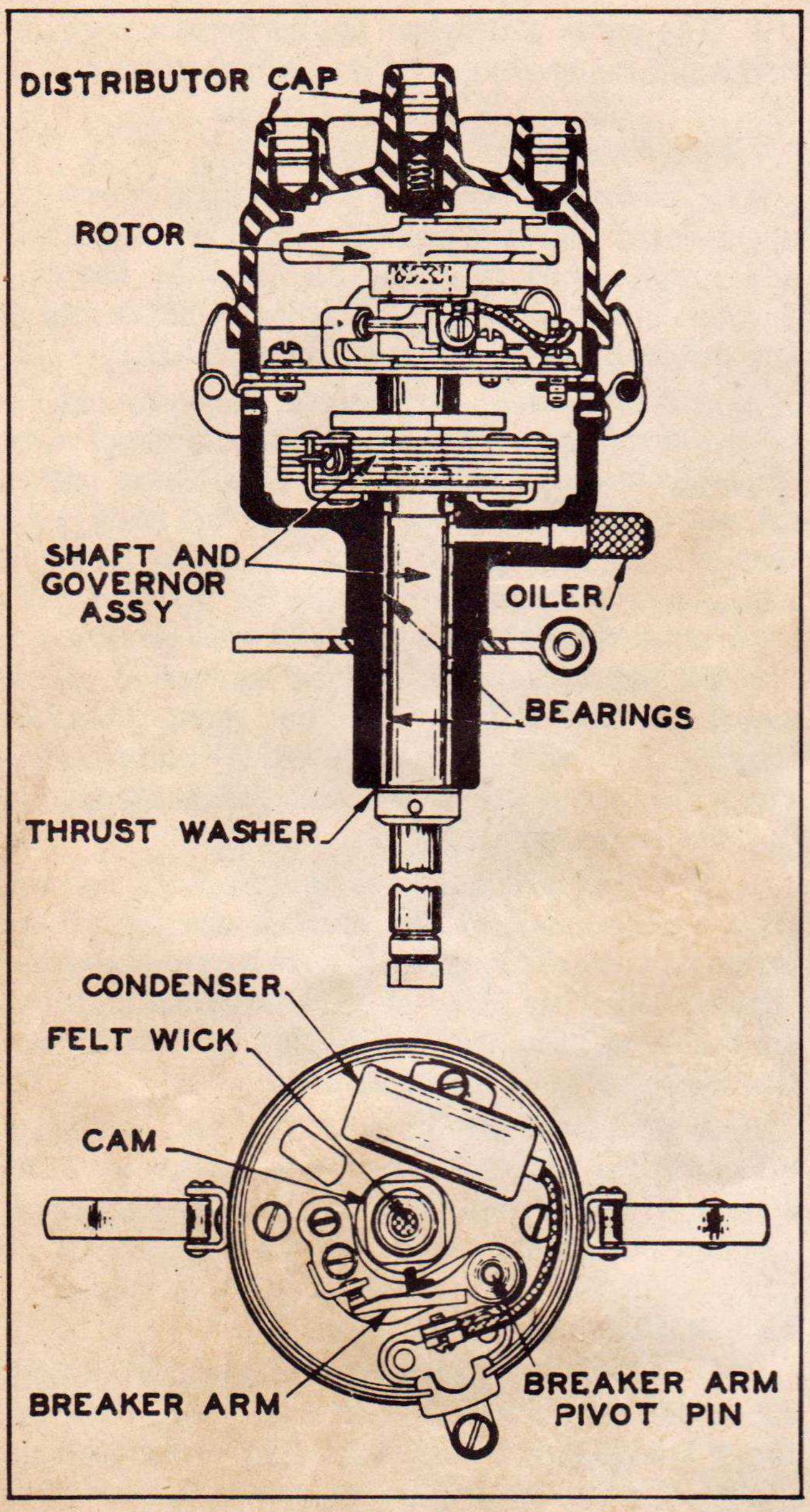


FIG. 11 IGNITION UNIT FUNCTIONING DIAGRAM

which obtains its electrical energy from the storage battery or from the exciter generator. The spark must occur at the proper time with respect to the upward travel of the piston near the top of its compression stroke and it must occur in each cylinder in its proper sequence of firing order, which is 1-3-4-2. The ignition unit, (Figs. 6 and 11), which regulates the timing of the spark and its distribution to the spark plugs in proper sequence, is mounted on the left side of the engine and driven by a gear on the camshaft.

b. Breaker Mechanism.—The breaker contacts are connected in series with the primary winding of the spark coil. The cam revolves at one-half the engine speed and opens the breaker contacts four times each revolution. Each time the breaker contacts open a spark is produced at a spark plug gap. The mechanism is properly timed so that the spark occurs when the piston has almost reached the top of its compression stroke. As the engine speed increases, the governor assembly in the lower part of the case automatically advances the timing with respect to piston position.

c. Condenser.—The condenser is connected in parallel with the breaker contacts. Its action is to greatly increase the intensity of the spark and to increase the life of the breaker contacts.

d. Ignition Resistor. — The ignition resistor mounted on the rear end of the cylinder head serves to limit the voltage applied to the 6-volt ignition coil from the 12-volt battery.

e. Distributor.—The high tension current travels from the spark coil to the spark plug by way of the distributor. It enters the distributor at the center tower, passes through the metal strip of the revolving rotor and out at the tower under which the metal strip is passing. Thus the sparks are distributed to the spark plugs, in proper sequence.

18. Spark Plugs.

The spark plugs, (Fig. 7), are important parts of the ignition system. Each consists of a center electrode highly insulated from the base which carries another electrode. The ignition spark jumps across the gap between the electrodes and it is quite important that this gap be kept adjusted at approximately .030". The original spark plugs are Champion, No. J5, and replacements should be of the same type.

19. Storage Battery.—

The 12-volt storage battery, (Fig. 1), consists of two 6-volt automotive type batteries connected in series. It supplies power for electric cranking, electric choking, ignition during the starting period and for operating certain controls. It is recharged automatically by the exciting generator while the power unit is in operation.

20. Battery Charging System.—

a. General.—The storage battery is recharged by current supplied by the 28-volt exciting generator while the power unit is in operation. Included in the battery charging system are the battery charging relay, the battery charging regulator with its group of resistors, and the BATTERY CHARGE RATE ammeter, (Figs. 3 and 4).

b. Battery Charging Relay. — The battery charging relay connects the battery to the exciter circuit while the power unit is in operation. The coil of this relay is connected across the exciter and the exciter voltage is impressed on it. As the exciter voltage rises, upon starting the engine, the magnetism set up by the coil of the battery charging relay overcomes the resistance of the spring and closes the relay contacts, thus connecting the battery to the exciter circuit. The contacts remain closed and the battery continues to receive charging current until the exciter voltage drops slightly below the battery voltage. Then the contacts open and disconnect the battery. This occurs when the power unit stops and prevents the discharge of the battery through the exciter while the power unit is not operating.

c. *Battery Charging Circuit.*—The closing of the battery charging relay contacts connects the storage battery across the exciter which then supplies charging current. See wiring diagram (Fig. 14). This current passes from the exciter to terminal 5, through the battery charging resistor and regulator group, through the battery charging relay contacts, through the BATTERY CHARGE RATE ammeter, to terminal 3, through the battery, through the frame of the power unit, to the exciter.

d. Battery Charging Regulator and Resistor Group.—The battery charging rate is regulated by the battery charging regulator and resistor group, (Fig. 4). The regulator coil is connected across the battery while the battery charging relay contacts are closed. When charge in battery is low the voltage across the coil is low and the regulator contacts remain closed. Charging current flows through all three resistors, providing the maximum charging rate of approximately 10 amperes. As the battery approaches a full charge, the voltage across the coil increases and the contacts are opened. This opens the circuit through the two 2-ohm resistors, and reduces the charging rate to approximately 2 amperes, which flows through the 2.5-ohm resistor. When load is connected to the D.C. OUTPUT terminals, the charging rate is reduced as a result. The amount of the reduction depends on the amount of such load. This extra load should not be so heavy, or so long continued that the storage battery on the power unit does not receive enough charge. Within the limits of the storage battery's capacity, load may be supplied from the D.C. OUTPUT terminals even though the power unit is not operating. Care must be taken to avoid discharging the storage battery so completely that it will not furnish ignition current for manual starting purposes.

21. Electric Choke Control.—

The electric choke control, (Fig. 5), is of the electromagnetic type with thermostatic compensator. The magnet coil is connected in parallel with the start solenoid circuit and thus the carburetor is choked automatically while engine is cranked electrically. Motion of the magnet armature is transmitted through a U-shaped bimetal thermostatic spring within the lower part of the case. The arrangement is such that when the engine is cold the choking is more forceful than when the engine is warm.

22. Generator.—

a. Purpose.—The generator, Figs. 11, 12 and 13, receives mechanical power from the engine and converts it to electrical power. It consists of a d-c exciting generator and a revolving field type of alternator.

b. Exciter.—

(1) Residual magnetism remains in the magnetic circuit of the exciter when not in operation. When the engine is started, the armature revolves and carries its conductors by the field poles. The cutting of magnetic lines of force by these conductors as they pass poles of alternate polarity induces alternating voltages in the conductors. The conductors are connected with commutator bars which revolve under, and in contact with, the exciter brushes. The various parts are so placed that the commutator bars in contact with any given brush always have the same polarity and direct current flows in the exciter circuits outside the armature.

(2) A small portion of this current passes through the exciter field winding and increases the field strength which, in turn, greatly increases the voltage induced in the conductors. The exciter voltage thus builds up to a maximum of approximately 28 volts at normal operating speed.

(3) The greater portion of the exciter output is used to excite the alternator revolving field, being connected with the alternator field windings by means of the brushes and slip rings.

(4) The exciter also operates as a starting motor and cranks the engine electrically. When the storage battery is properly connected to the exciter, strong magnetic fields are set up in the armature and field. and cause the armature to revolve, thus cranking the engine. The series field winding adds greatly to the strength of the magnetic field and to the cranking power. The battery is connected to the exciter by means of the solenoid starting switch which is controlled by the START button on the control panel.

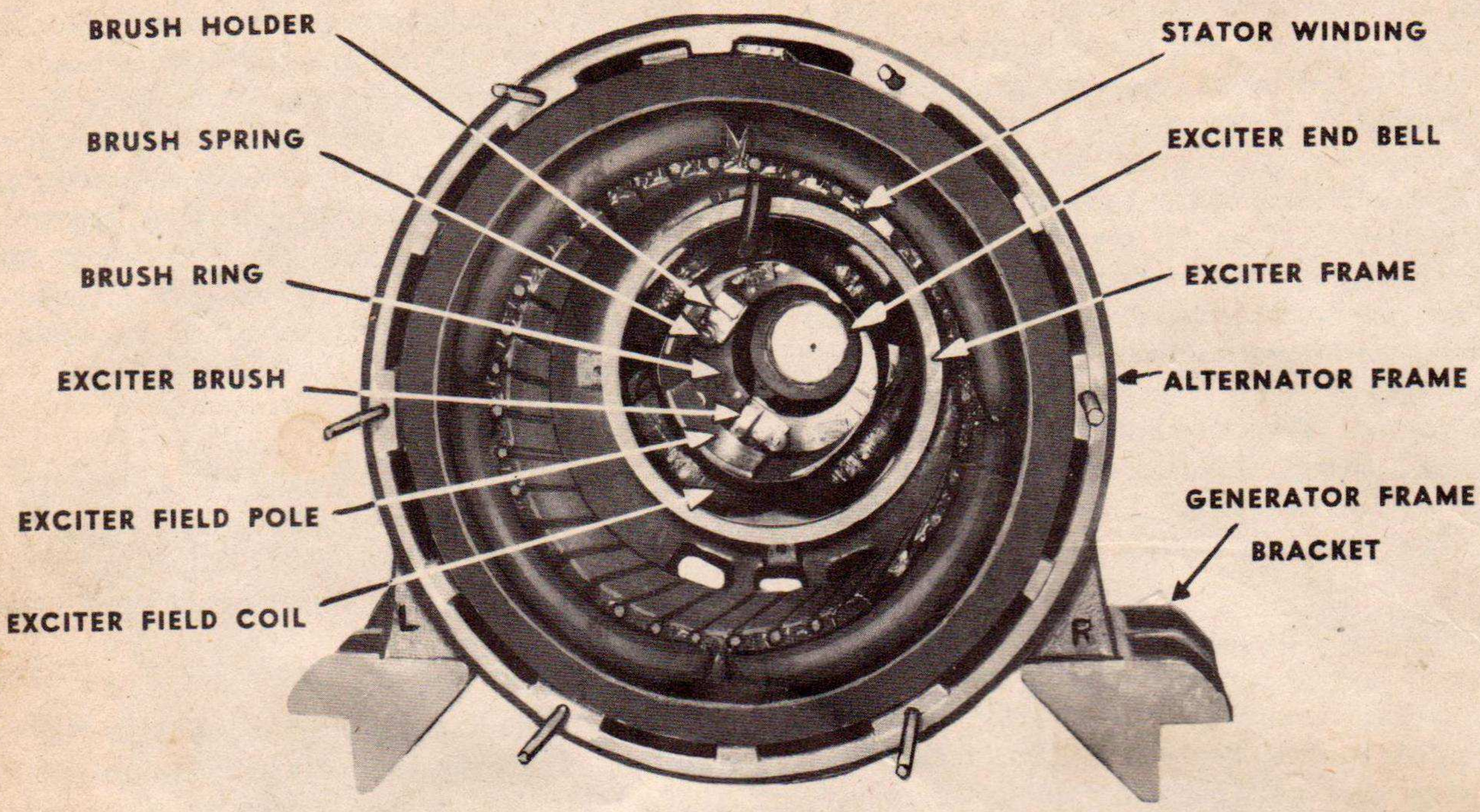


FIG. 12 GENERATOR FRAME ASSEMBLY

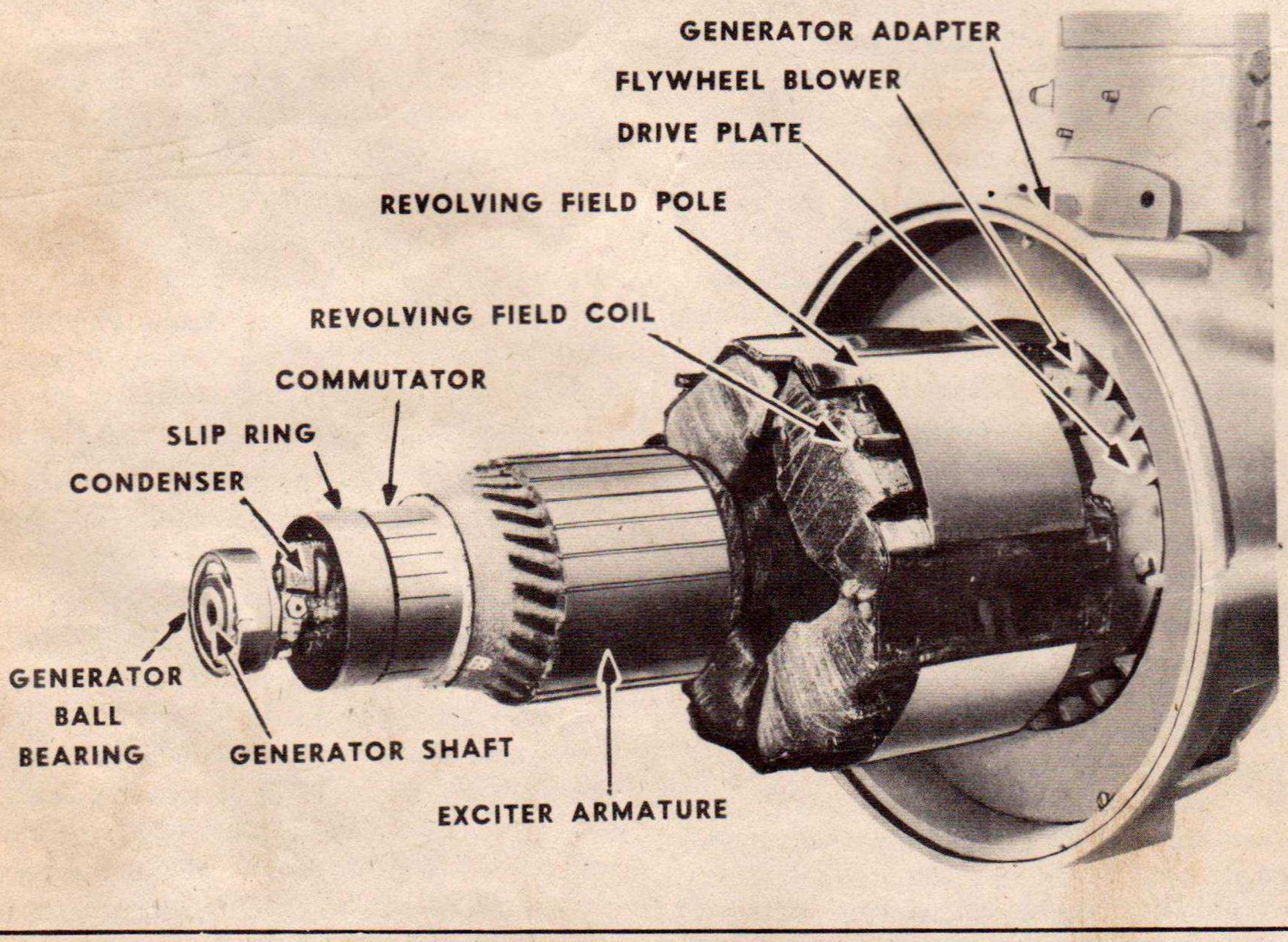


FIG. 13 ROTOR ASSEMBLY

c. Alternator.—The revolving field of the alternator is magnetized by direct current from the exciter. The field poles, of alternate polarity, revolve by the conductors of the stator and induce alternating voltages in them. Those conductors are connected in two groups and the groups are connected to the control panel. If the exterior circuit is complete, alternating current will flow in it. No collector rings and brushes are required in the a-c circuit.

d. Alternator Connections.—The two separate a-c windings of the alternator may be connected in parallel to produce 120-volts, or in series to produce 240 volts. These connections are made by means of jumpers at the a-c terminal block. See wiring diagram, (Fig. 14). The four leads from the two a-c windings of the alternator are connected directly to the a-c terminal block. The two-pole CIRCUIT BREAKER is connected in one side of each of the two a-c winding circuits, between the a-c terminal block and the A.C. OUTPUT terminals.

e. A.C. Voltage Regulation. — No means is provided for adjusting the voltage independent of the engine speed. At normal frequency, and after reaching normal operating temperature, the voltage is within the limits of 126 volts at no load to 118 volts at full load at unity power factor, when a-c terminal jumpers are connected for 120 volts. When connected for 240 volts the regulation is within corresponding limits of 252 volts to 236 volts. This voltage regulation is due to inherent characteristics obtained by strongly saturating parts of the magnetic circuit.

23. High Water Temperature Cut-Out Switch.—

a. Description.—The high water temperature cut-out switch, (Fig. 6), is electrically connected to the STOP button circuit. It automatically stops the engine if the temperature of the water in the engine water jacket rises higher than the temperature for which the dial is set. A temperature element extends down into the cooling liquid and contains a volatile liquid. This element is connected through a small tube to the diaphragm or bellows which operates the switch contacts. As the temperature within the water jacket rises, the liquid within the temperature element expands the bellows which closes the switch contacts, thus stopping the engine. The engine may be started again in the usual manner after the temperature drops about 10°. The cause of the high temperature should be determined and corrected before again starting the engine.

b. Adjustment.—The temperature at which the engine will be stopped may be adjusted by turning the dial so that the desired stopping temperature is exactly under the pointed indicator at the top of the dial. The dial should be set to stop the engine at a temperature at least several degrees below the boiling point of the cooling liquid. For water at sea level, the setting should be 208. This should be decreases 3° for each 1000 feet above sea level. Other cooling liquids may require different settings.

24. Low Oil Pressure Cut-Off Switch.—

The low oil pressure cut-off switch, (Fig. 5), is a small switch operated by oil pressure. When the oil pressure builds up to approximately 8 lbs. per sq. inch the switch contacts open. They are so connected with the control system that if the pressure drops below 8 lbs., the ignition is cut off and the engine stops.

25. Relays.—

On the back of the control panel are mounted the start, stop and ignition relays, (Fig. 4). Each relay includes a coil of insulated copper wire wound on a soft iron core. An iron armature is hinge-mounted near one end of the iron core and held away from the core by means of a spring. When electric current flows through the coil, the core becomes magnetized and the iron armature is attracted so strongly that it moves toward the core, thus opening or closing the relay contacts. When the circuit to the coil is opened and current no longer flows through it, the core loses most of its magnetism and the spring pulls the armature away from the coil, reversing the action of the contacts. All three relays are connected in the d-c control circuits.

26. Electrical Control System.—

a. Starting Cycle.—

(1) The storage battery supplies the power for electric starting. With the MANUAL START—REMOTE START ignition switch on Remote Start position the power unit is started by pressing the START button. This energizes the coil of the start relay and closes the two pairs of contacts on that relay. See (Figs. 3, 4, 14 and 15.)

(2) The closing of the start relay contacts (A) supplies current to the ignition coil, the current passing through the remote start contacts of the ignition switch and through the voltage dropping ignition resistor before reaching the ignition coil. It also supplies current to the coil of the ignition relay, closing its contacts (C). The current through the ignition relay coil passes through the stop relay contacts (D) and to ground.

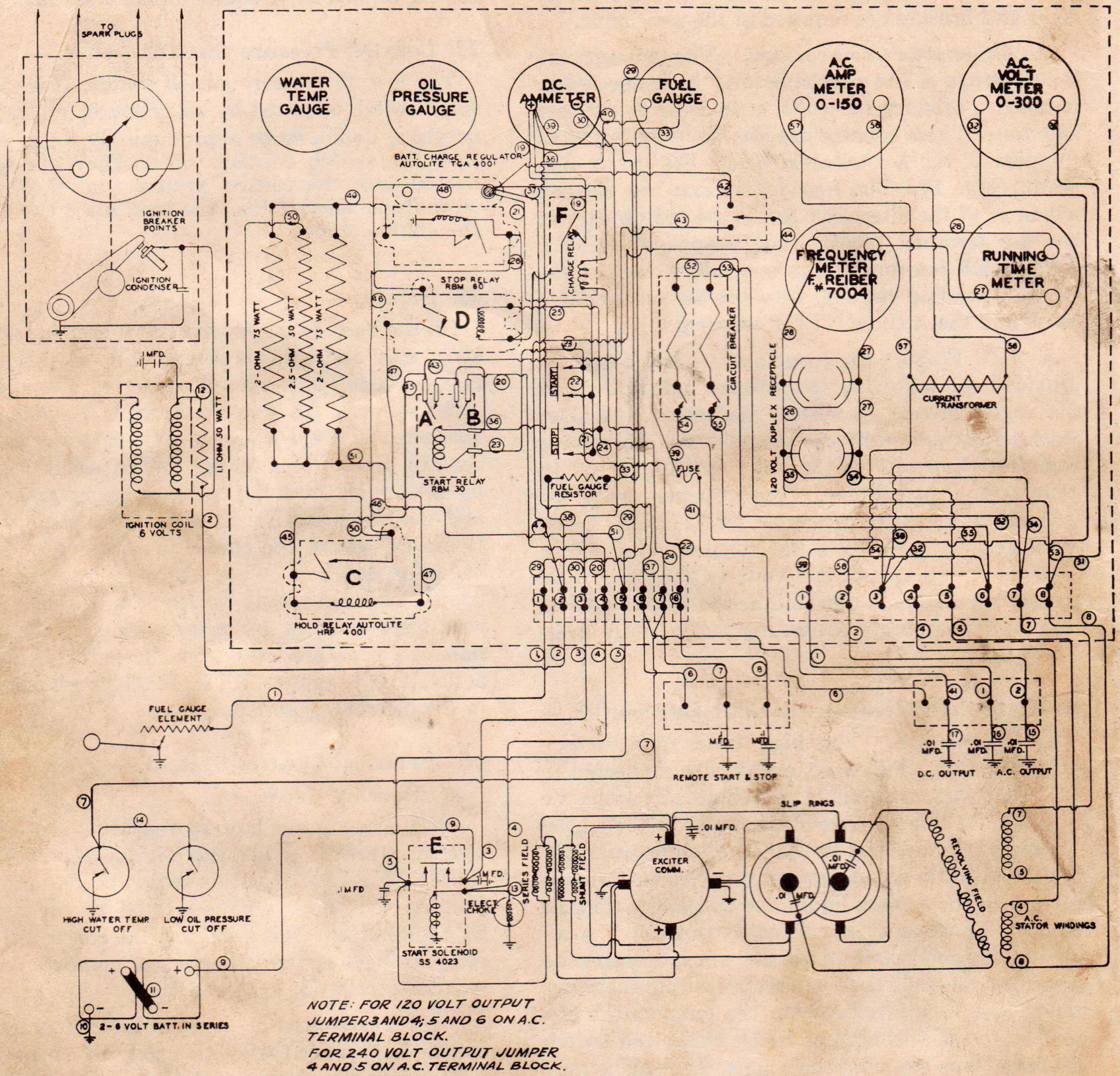


FIG. 14 PICTORIAL WIRING DIAGRAM

(3) The closing of the start relay contacts (B) supplies current to the electric choke, thus choking the carburetor, and to the start solenoid which closes the start switch contacts (E).

(4) The closing of the start switch contacts (E) supplies current to the exciter, passing through its series field winding, causing the exciter to operate as a motor and to crank the engine.

(5) At this stage of the starting cycle the ignition has been switched on, the carburetor is being choked and the engine is being cranked. The engine starts. The speed increases and the oil pump builds up pressure in the lubricating system. When this pressure rises to approximately 8 pounds, the contacts of the low oil pressure cut-off switch open. The exciter builds up voltage and supplies ignition current through another circuit. This current passes from terminal 5, through the battery charging resistor and regulator group, through the ignition relay contacts (C), to the remote start contacts of the ignition switch, through the ignition resistor, to the ignition coil.

(6) The START button is released. This opens the circuit to the start relay coil, and allows the contacts (A) and (B) to open.

(7) The opening of contacts (B) stops the electric choking and allows the start switch contacts to open, which opens the cranking circuit.

(8) The ignition current being supplied by the exciter does not pass through contacts (A) and, therefore, the engine does not stop when the contacts (A) open. However, if the contacts (A) open before the exciter voltage has built up high enough to supply proper ignition current, the engine will stop upon release of the START button. The engine will stop if the START button is released before the oil pump has built up enough pressure to open the contacts of the low oil pressure cut-off switch.

(9) The coil of the battery charging relay is connected across the exciter at all times and when the exciter voltage rises sufficiently the contacts (F) close, thus connecting the battery charging circuit.

(10) The FUEL GAUGE and the fuel gauge tank element are connected to the ignition switch in such manner that the gauge registers while the ignition system is supplied with current. If it is desired to have the gauge register while the engine is not operating, this may be done by switching the MANUAL START - REMOTE START ignition switch to the MANUAL START position. The switch should be returned to the REMOTE START position as soon as the FUEL GAUGE reading has been observed.

b. Operation.—While the power unit is in operation the exciter supplies current for ignition and for battery charging. The greater portion of the exciter output is used to excite the revolving field of the alternator. The two alternating-current windings of the exciter are connected direct to the a-c terminal block. There they may be connected by means of jumpers, as noted on the wiring diagram, to provide either 120 or 240-volts output. The 2-pole CIRCUIT-BREAKER serves as a load switch and disconnects the load automatically in case of severe overload. The A.C. VOLTMETER is connected in such a manner as to show the output voltage. The A.C. AMMETER shows the load amperage. Use is made of a current transformer in the ammeter circuit so that the heavy load current need not pass through the A.C. AMMETER. The RUNNING TIME METER, the FREQUENCY METER and the TROUBLE LAMP receptacles are connected across one a-c winding only. The D.C. OUTPUT terminals are connected to the battery charging circuit and serve for connecting a 12-volt d-c load of 10 amperes or less.

c. Stopping Circuit.—The engine is stopped by pressing the STOP button which energizes the stop relay and opens its contacts (D). The opening of these contacts de-energizes the ignition relay, allowing its contacts (C) to open, thus opening the ignition circuit and stopping the power unit. As the engine speed drops, the exciter voltage drops and allows the battery charging relay contacts (F) to open, thus preventing the discharge of the battery while the power unit is not operating.

d. Manual Start-Remote Start Ignition Switch.—When the MANUAL START-REMOTE START switch is in the MANUAL START position, ignition current is supplied direct from the battery to the ignition coil, thus by-passing all the relays and protective circuits. With the switch in this position the engine may be started by hand cranking. This makes it possible to use the power unit in an emergency when there may be trouble in a relay circuit. It will be necessary to throw this switch to the REMOTE START position before the engine can be stopped by means of the STOP button.

e. Remote Control.—Remote control circuits, if used, are merely extended circuits connected in parallel with the START and STOP button circuits on the control panel. Remote start and stop buttons are used in the same manner as the START and STOP buttons on the control panel.

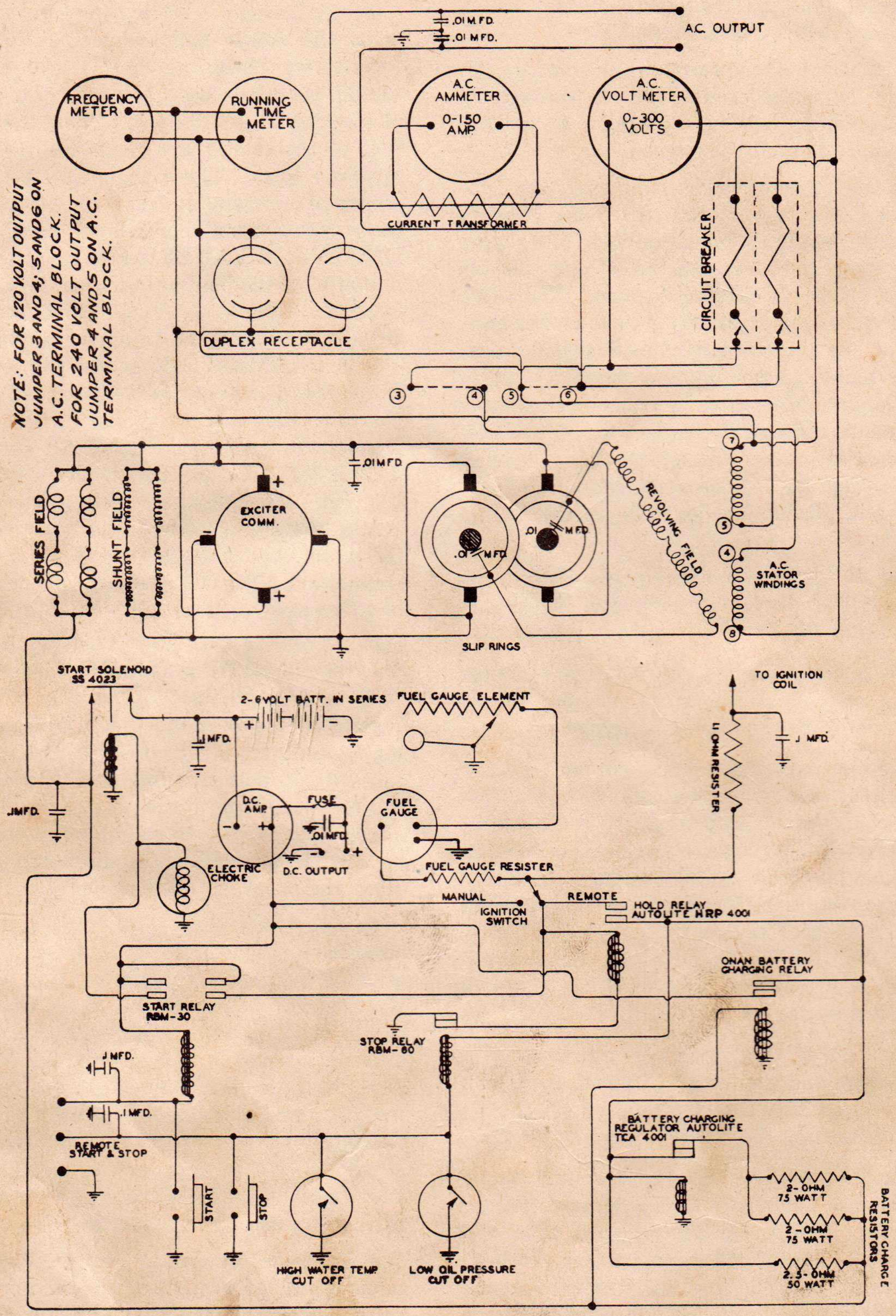


FIG. 15 SCHEMATIC WIRING DIAGRAM

SECTION IV
MAINTENANCE

27. Routine Attention.—

a. Important.—It is important to follow a definite schedule of inspection and service operations to maintain a high level of operating efficiency. The keeping of a log book as a continuous operating check is advised. A sample service log form is included in this manual.

b. Daily Service.—Check the following at least once a day:

(1) *Radiator.*—Check the cooling liquid level. Do not fill so high as to cause unnecessary loss of liquid through the overflow. Never allow the level to fall below the top of the upper hose. Under continuous use or in hot weather more frequent attention may be needed.

(2) *Oil Level.*—Check the crankcase oil level. Under continuous service check more frequently. Never operate the power unit when the oil level is near the EMPTY mark on the bayonet gauge. Fill to the FULL mark on the gauge with the proper oil as specified in paragraph 8 *a* (7) and 9 *i* (1).

(3) *Fuel Supply.*—Check supply of fuel, shown on the FUEL GAUGE on the instrument panel, as often as necessary to assure a sufficient supply in the tank at all times. The tank holds 10½ gallons. When operating at full load, the plant consumes about 2 gallons per hour. Check the supply of fuel in the auxiliary tank also, if such tank is connected to the power unit.

(4) *Control Panel.*—Check the various gauges frequently and take any corrective measures indicated. Normal readings are given in paragraph 9 *d*.

c. Weekly Service.—Check the following weekly, or every 50 operating hours, whichever occurs first:

(1) *Daily Check.*—Check all points mentioned above under Daily Service.

(2) *Crankcase Oil and Oil Filter.*—

(*a*) Lift out the bayonet oil gauge and examine the oil that adheres to it. If the oil is discolored, install a new oil filter element. If necessary on the basis of lubricating instructions contained in paragraph 9 *i* (1), change the oil. Drain the oil while the engine is warm. Close the drain valve securely and refill the crankcase to the FULL mark on the gauge with clean, fresh oil of proper kind and grade.

(*b*) To install a new filter element, remove the filter cover and the drain plug and drain the filter. Remove and discard the old filter element and clean all sludge and sediment from the filter body. Replace the drain plug and tighten securely. Install the new filter element and replace the filter cover, using a new gasket. Start the engine and check for leaks, correcting any found. After the engine has run about 10 minutes, stop it and check the oil level. The filter will have retained some oil. Add oil, if necessary, to again raise the level to the FULL mark on the gauge.

(3) *Ignition Unit.*—Place 5 drops of cylinder oil in the oil cup on the side of the ignition unit. Remove the distributor cap and rotor and place 1 drop of oil on the wick at the center of the shaft and 1 drop on the breaker arm post. Use the same kind and weight of oil as used in the crankcase. Wipe the cam clean and apply a very small amount of light grease to the rubbing surface.

(4) *Air Cleaner.*—

(*a*) If the power unit has been operated under dusty conditions, clean the oil type air cleaner. If the power unit has been operated only under clean air conditions, the servicing of the air cleaner may be included under Monthly Service.

(*b*) To clean the air cleaner, remove the cup and clean it thoroughly. Remove the filter element and clean it thoroughly by sloshing up and down in a suitable cleaning fluid or in gasoline. Allow it to dry or dry it by using an air hose. Fill the cup to the level mark with clean oil of the same grade as used in the engine crankcase. Reassemble the cleaner.

(5) *Battery.*—

(*a*) Test the battery by means of a hydrometer. All cells should test 1,250 or higher, unless they were filled with 1.200 electrolyte for tropical use. If filled with 1.200 electrolyte for tropical use, the numeral one (1), should appear on the lead top connector at the positive cell, near the battery type-number. See paragraph *8a* (5) (*b*) and (*d*). If filled with 1.200 electrolyte for tropical use, the cells should test 1.200, or higher. A test of approximately 1.100 indicates a discharged cell. A difference as great as 50 points between individual cell readings in a 6-volt unit probably indicates that the unit should be replaced with a new one to avoid a definite failure. The same is true when all cells of a unit test uniformly low, unless the low test can be accounted for by excessive starting in comparison with running hours, or by the power unit's not having been used for 2 or 3 weeks. In either case, check the battery unit daily for several days under normal use of at least several hours a day. If its condition does not improve, replace it.

(*b*) Fill the cells to 3/8″ above the tops of the separators, using distilled water or water known to be non-injurious to lead-acid batteries. Do not fill high enough to cause overflowing while charging.

(6) *Throttle Control Rod Ball Joints.*—Place a drop of oil in each ball joint of the throttle control rod and check to make sure the throttle mechanism moves freely.

d. Monthly Service. — Check the following monthly, or every 200 operating hours, whichever occurs first:

(1) *Weekly Check.*—Check all points mentioned under Weekly Service.

(2) *Spark Plugs.*—Remove the spark plugs. Clean them, if needed, and inspect for cracked or badly eroded porcelains. Discard any spark plugs not in good condition and replace with new ones of correct type. Adjust the gaps to .030″. When installing, make sure the gaskets are in place. Tighten securely.

(3) *Battery Terminals.*—Check the battery terminals, cleaning and tightening them if needed. Apply a coating of petroleum jelly. Replace the cables if not in good order.

(4) *Ignition Unit.*—Remove the distributor cap and wipe it clean, inside and outside. Inspect the breaker contacts. If badly pitted, replace with new ones. Turn the engine with the hand crank until the contacts are wide open. They should open .020″. Check with a wire gauge and adjust if necessary. If contacts are the least pitted, they should be resurfaced with a carborundum or similar hone before adjusting.

(5) *Ignition Timing.*—Check the ignition timing by using a neon timing light, if available, and make any adjustment needed. A small arm attached to the throttle shaft arm may be turned over and forward to a position that will hold the throttle at an idle position and cause the engine to operate at the moderate speed necessary for use of the neon timing light. If the neon timing light is not available, crank the engine very slowly by hand, stopping exactly when the breaker contacts separate at firing position for No. 1 cylinder. Then check the position of the IGN mark on the flywheel, (Fig. 16) as seen through the timing hole in the flywheel housing on the left side of the engine. Timing is cor rect if the IGN mark is at the center of the hole at the instant the points separate. Repeat the checks a time or two for accuracy. If necessary to adjust the timing, loosen the clamp bolt, turn the distributor body to the proper position and tighten the bolt. Then recheck to verify the correctness of the new setting.

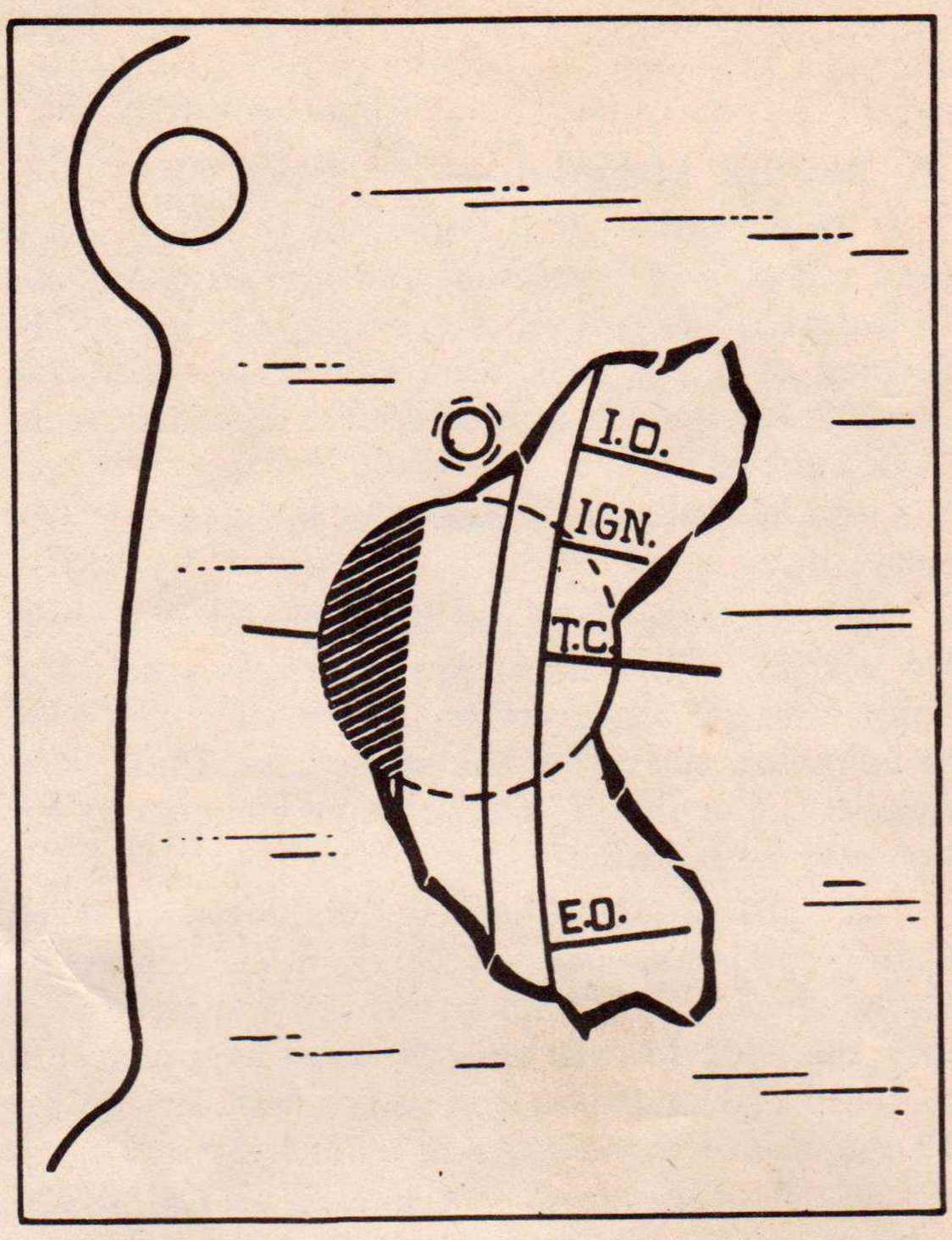


FIG. 16 TIMING MARKS (FLYWHEEL)

(6) *Valve Tappets.* — Disconnect the tubes from the valve spring cover, remove the cover screws and the cover. Crank the engine slowly by means of the hand crank and note when the intake valve of No. 1 cylinder begins to open. Then turn the crank one full revolution further. This places the camshaft in the correct position for checking or readjusting both tappets of No. 1 cylinder. Check the clearances with a feeler gauge, (Fig. 17). The

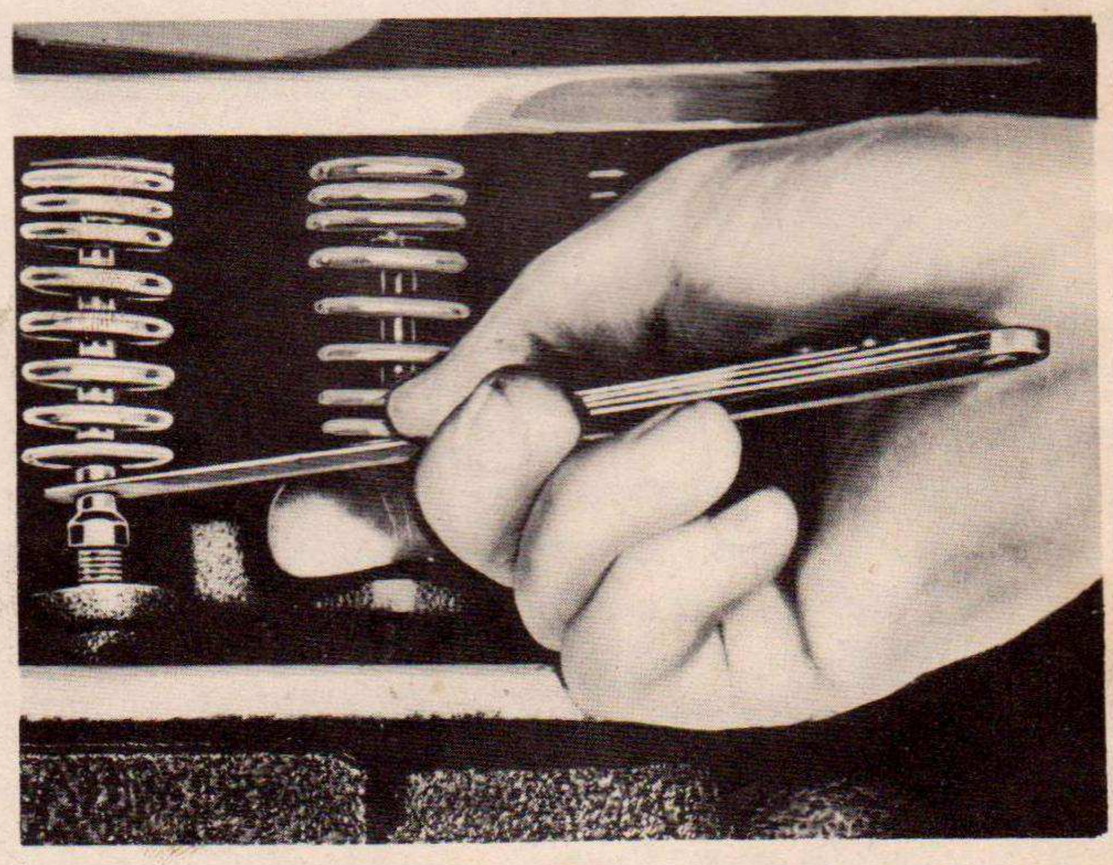


FIG. 17 VALVE TAPPETS AND SPRINGS

correct clearance is .014″ hot or cold. Adjust the tappets if necessary. Locate the correct positions for each of the remaining cylinders and check and adjust the remaining tappets. In locating the correct position for any cylinder, turn one revloution after the intake valve on that cylinder begins to open. See that the cover gasket is in good order, replace the cover, tighten the screws and connect the tubes.

(7) *Fuel Screens and Sediment Bowls.*—Close the 2-way fuel shot-off cock. Remove and clean the sediment bowl on the fuel pump and the one under the fuel tank. Clean the strainers if necessary. When replacing the bowls, make sure that gaskets are in good order and that the retaining nuts are tightened sufficiently to hold the bowls tightly on the gaskets. Remove the drain plug and strainer from the bowl of the carburetor. Clean and replace. Open the fuel shut-off cock. By means of the lever on the fuel pump, pump the carburetor bowl full of fuel. Examine the sediment bowls and the carburetor for leaks, correcting any found.

(8) *Fan and Governor Belts.*—Inspect the fan and governor belts. If not in good condition, replace with new ones. Adjust the belt tension so that the top side of the belt can be depressed about 1″. The fan belt is adjusted by loosening the clamp bolt in the slotted bracket at the idle pulley, moving the idle pulley to obtain proper tension, then tightening the bolt. Slotted holes in the governor bracket permit adjusting the governor belt in a similar manner. See (Fig. 18).

(9) *Exhaust System.*—Inspect all exhaust connections, replacing or tightening all parts requiring attention. Include the manifold connections and the flexible exhaust pipe. Permit no leaks that will allow gas to escape inside a building. If the exhaust system requires cleaning, clean it. Continued operation with excessive back pressure will eventually cause trouble even if not bad enough to noticeably affect the engine performance at the time of inspection.

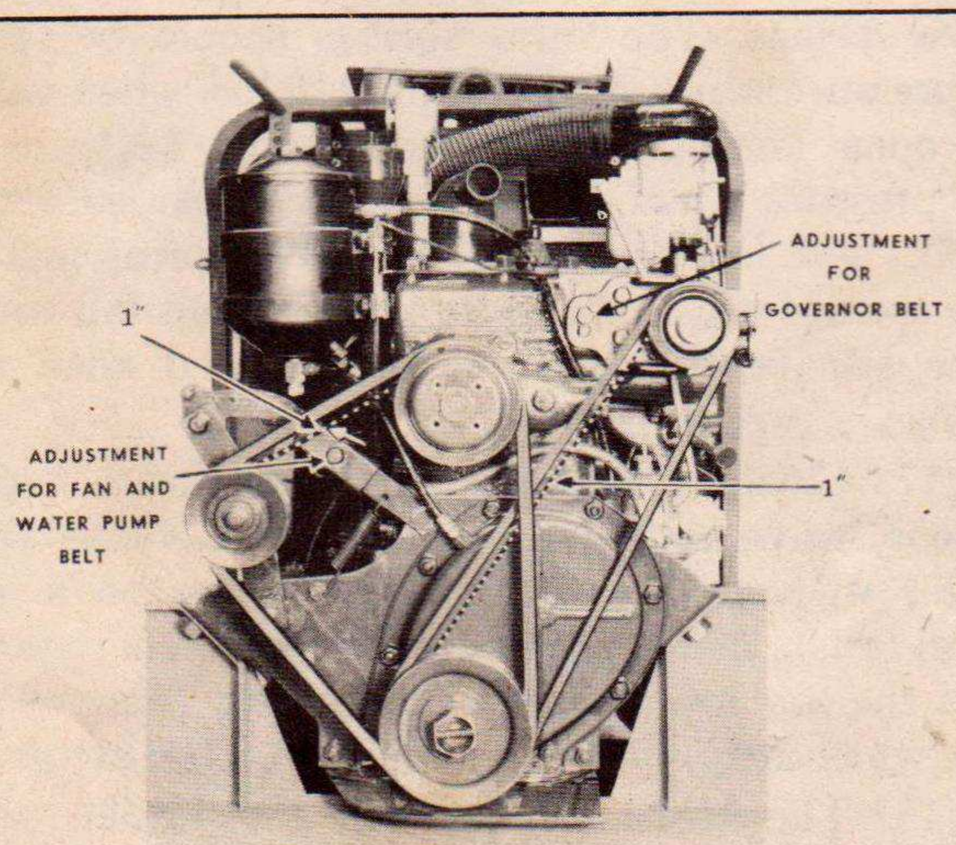


FIG. 18 FAN AND GOVERNOR BELT ADJUSTMENTS

(10) *Carburetor.*—With no load on the power unit, but with the engine at normal operating temperature, and with the throttle held so that the engine is operating at about half normal speed, adjust the idle adjustment screw so that the engine will idle smoothly.

(11) *Crankcase Ventilator Metering Valve.*—Disconnect the crankcase ventilator metering valve, open it, remove the plunger and clean all parts thoroughly in acetone. Reassemble and tighten all connections securely.

(12) *High Water Temperature Cut-Out Switch*—Check the operation of the high water temperature cut-out switch. With the power unit operating at normal temperature, turn the dial counter-clockwise (to left) very slowly and note the reading at which the switch stops the engine. Compare with the reading of the Engine Water Temperature Gauge. If the readings differ more than 5 degrees, check the accuracy of both switch and gauge as instructed in paragraph 46.

(13) *Crankcase Oil.*—Be sure to include an oil change in the monthly service. Drain the crankcase oil and refill to the FULL mark on the bayonet gauge with proper oil as indicated on the lubrication chart (Fig. 64) and as instructed in paragraph *8a*(7) and *9 i.*

(14) *Generator.*—Inspect the commutator and slip rings. Clean them, if needed, by holding a clean piece of canvas against them while the engine is operated slowly by holding the throttle partially closed. For safety attach the canvas over the square end of a narrow piece of dry wood to serve as a handle. In normal service, the commutator and collector rings acquire a mahogany-colored surface. If this surface is smooth, it requires no attention. Do not attempt to maintain a bright, newly-machined appearing surface. Check the brushes for good seating contact, free fit in holders and uniformly good spring tension. If brushes are worn to ¾″ length, or less, install new brushes. New brushes must be properly fitted. Refer to paragraph *50, a.* for instructions on fitting brushes.

(15) *General.*—Inspect the power unit thoroughly for leaks, loose electrical connections and other external items which may need attention. Make needed corrections.

28. Valve Servicing.—

a. When to Grind Valves.—

(1) Lack of power in an engine may be caused by poor seating of the valves in the valve seats, which allows the gases in the compression chamber to escape into the intake or exhaust manifold.

(2) By the use of a cylinder compression gauge one can readily determine which valves are not properly seating. Compression gauge readings should all be within 10 pounds of each other and not less than 70 pounds.

(3) If no gauge is available, turn the engine by the hand crank and note whether the compression is uniformly good on all cylinders. Compression should rock the crank backward forcibly if allowed to do so when well up on the compression stroke. Compressed gases leaking past an exhaust valve cause a hissing noise at the exhaust outlet. If leaking past an intake valve, a hissing noise may be heard through the carburetor. Disconnect the air cleaner horn at the carburetor and the exhaust line at the power unit and have someone crank the engine while you listen for these sounds, if you have reason to suspect that valves are leaking. Any valve leak present after the tappets are properly adjusted should be corrected by grinding all valves.

b. Grinding Valves.—Extreme care should be used whenever valves are ground to maintain factory limits and clearances, as only by maintaining these can one expect to get good engine performance. Proceed as follows:

(1) Drain radiator by opening drain cock at the bottom of the radiator.

(2) Disconnect governor oil supply line at governor.

(3) Remove oil filter and bracket by removing the nuts on the cylinder studs, and lay filter on idle pulley bracket.

(4) Remove fuel line from fuel pump to carburetor.

(5) Remove carburetor air cleaner horn and tube.

(6) Remove electric choke control rod. Disconnect throttle control rod at governor end and the manual choke wire at carburetor end.

(7) Remove nuts holding carburetor to manifold and remove carburetor.

(8) Disconnect the governor oil return tube and the crankcase air vent tube.

(9) Remove the cylinder head nuts which hold the governor bracket and remove the governor assembly.

(10) Remove nuts and bolt holding exhaust pipe to manifold.

(11) Remove manifold stud nuts and manifolds.

(12) Disconnect wires from the ignition resistor, remove holding bolt and ignition resistor.

(13) Remove the upper radiator hose. Remove all spark plugs. Remove the cylinder head cap screws, stud nuts and the temperature gauge bulb, then lift head from engine block. Removal is made easy by using lifting hooks screwed in No. 1 and 4 spark plug holes. **Do not drive screw driver or any other sharp instrument in between the cylinder head and the block to break the head loose from the gasket.**

(14) Remove the valve spring cover screws and the cover. Care should be taken not to lose the copper gasket on each screw as well as the screen and gasket. Wad a piece of cloth or cotton waste over the three holes in the valve chambers to prevent the valve keys dropping into crankcase upon removal.

(15) With valve spring compressor inserted between valve tappet and spring retainer, raise springs on those valves which are in closed position and remove valve locks. Turn crankshaft with crank or by fan belt until those valves which are open become closed and repeat the operation.

(16) Remove valves and place them in a valve carrying board, so that they can be identified as to cylinders from which they were removed. Remove valve springs. The valve springs should be tested for pressure which should show 116 lbs. when valves are open (spring compressed, length 1¾″) or 50 lbs. pressure when closed (springs extended length 2$\frac{7}{64}$″). The free length of the valve spring is 2½″. Any springs which are distorted or do not fall within these specifications should be replaced with new springs.

(17) Clean carbon from cylinder head, top of pistons, valve seats and cylinder block. Clean valve guides with guide brush. Clean valves on a wire wheel brush, making sure that all carbon is removed from the top and bottom of the heads. Remove any gum which may have accumulated on the stems.

(18) The clearance between the intake valve stem and the valve guide is .0015″ to .00325″, the exhaust valve stem clearance to guide is .002″ to .00375″. Excessive clearance between the valve stem

and the valve guide will cause improper seating and burned valves. If there is too much clearance between the inlet valve stem and the valve guide, on the suction stroke there will be a tendency to draw oil vapors up the guide into the combustion chamber causing excessive oil consumption, fouled spark plugs and poor low speed performance. Check the wear of each valve guide by inserting a new valve in it and feeling the clearance by moving the valve stem back and forth. If the clearance is excessive, install a new valve guide as instructed in paragraph 28 c.

(19) Check the clearance of each valve in its guide and discard any having excessive clearance. Reface the usable ones to a 45° angle. Replace discarded valves with new ones. If seats in the block show excessive pitting, reface the seats.

(20) Then, by hand, touch up the valves to the seats with fine valve grinding compound.

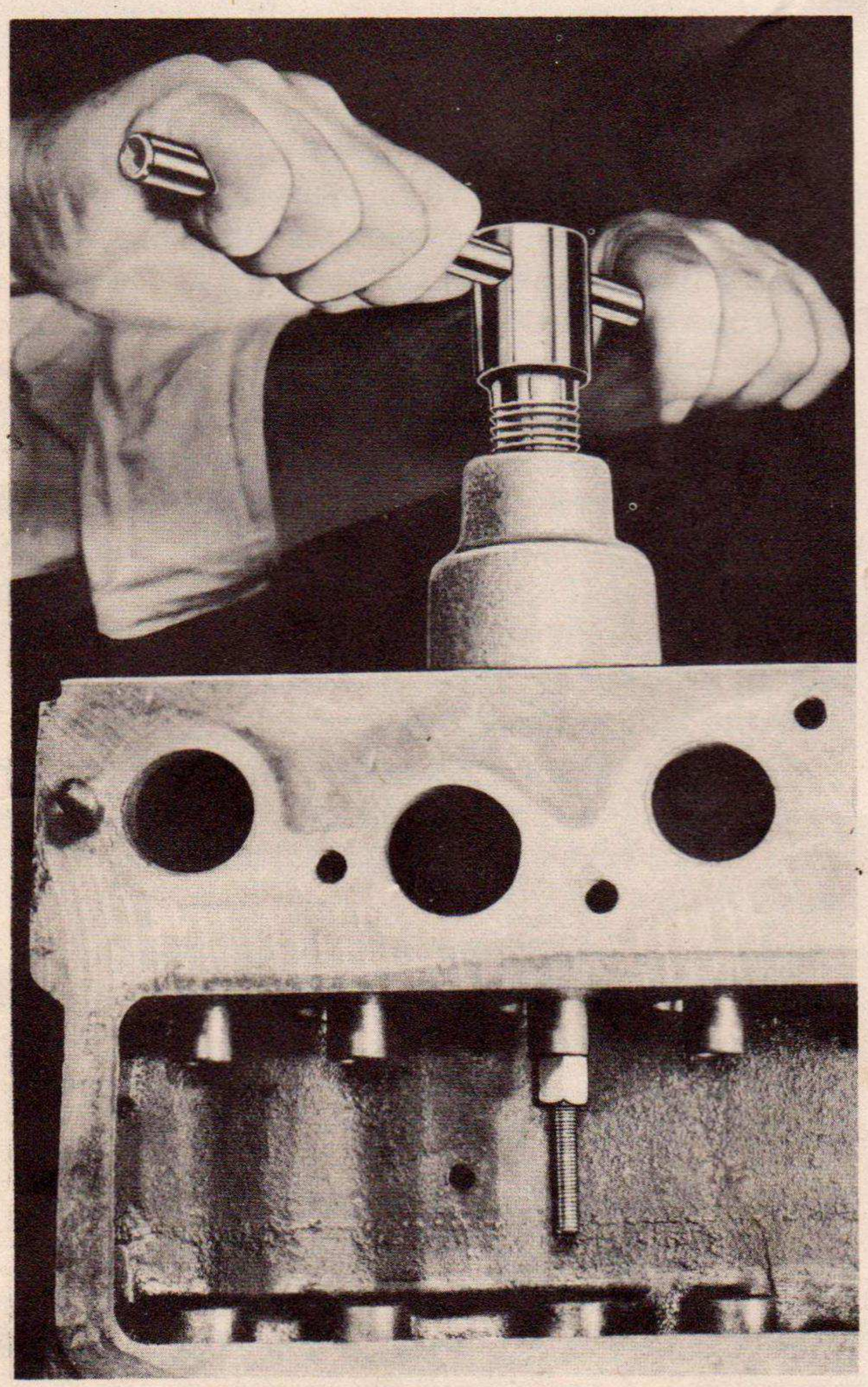


FIG. 19 REMOVING VALVE GUIDES

c. Removing and Replacing Valve Guides.—

(1) When removing the valve guides use a valve guide puller to prevent damage to cylinder block. See (Fig. 19). If a regular puller is not available, a suitable tool can be made from a 2″ pipe, 6″ long and a ⅜″ bolt 10″ to 12″ long with a long threaded end, a small hexagon nut which will pass through the hole in the cylinder block and a 2″ washer with a ⅜″ hole in it.

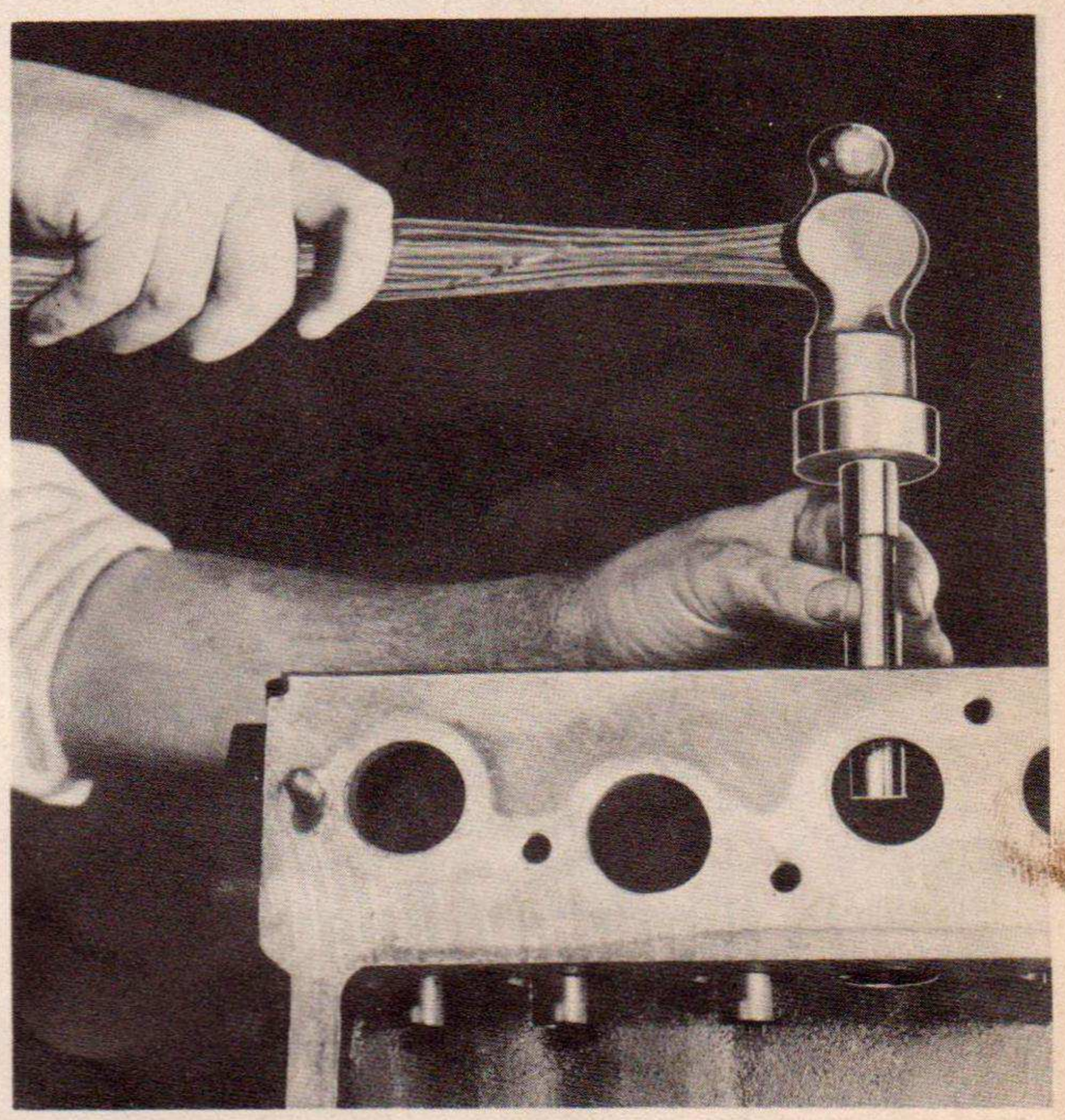


FIG. 20 INSTALLING VALVE GUIDES

(2) The valve guides are installed with a replacer or a driver as shown in (Fig. 20). Taking a piece of half-inch round stock 6″ long and turning down one end to ⅜″ diameter 2″ long will make a suitable driver.

(3) The exhaust valve guide is installed in the cylinder block so that there will be a distance of 1″ from the top of the guide to the top of the block. The intake valve guide is set at 1-5/16″ from the top of the valve guide to the top of the block, (Fig. 21).

(4) The valve tappet clearance in the guide should be .0005″ to .002″. It is advisable to check the clearance of the valve tappet by moving it back and forth in the guide. If the clearance seems to be excessive, it might be necessary to install a new valve tappet. This operation is covered in this section under paragraph 29.

d. Reassembling.—

(1) When assembling valve springs and retainers in engine make sure that the closed coils are

up against the cylinder block, (Fig. 17). Then install the valves, each in its proper seat. Using a valve spring compressor, raise the valve springs on those valves which are in closed position and insert the valve spring locks with a valve key inserting tool. If no key inserting tool is available, hold keys in place by sticking them to valve stem with grease. Crank engine until other valves are closed and install the remaining keys.

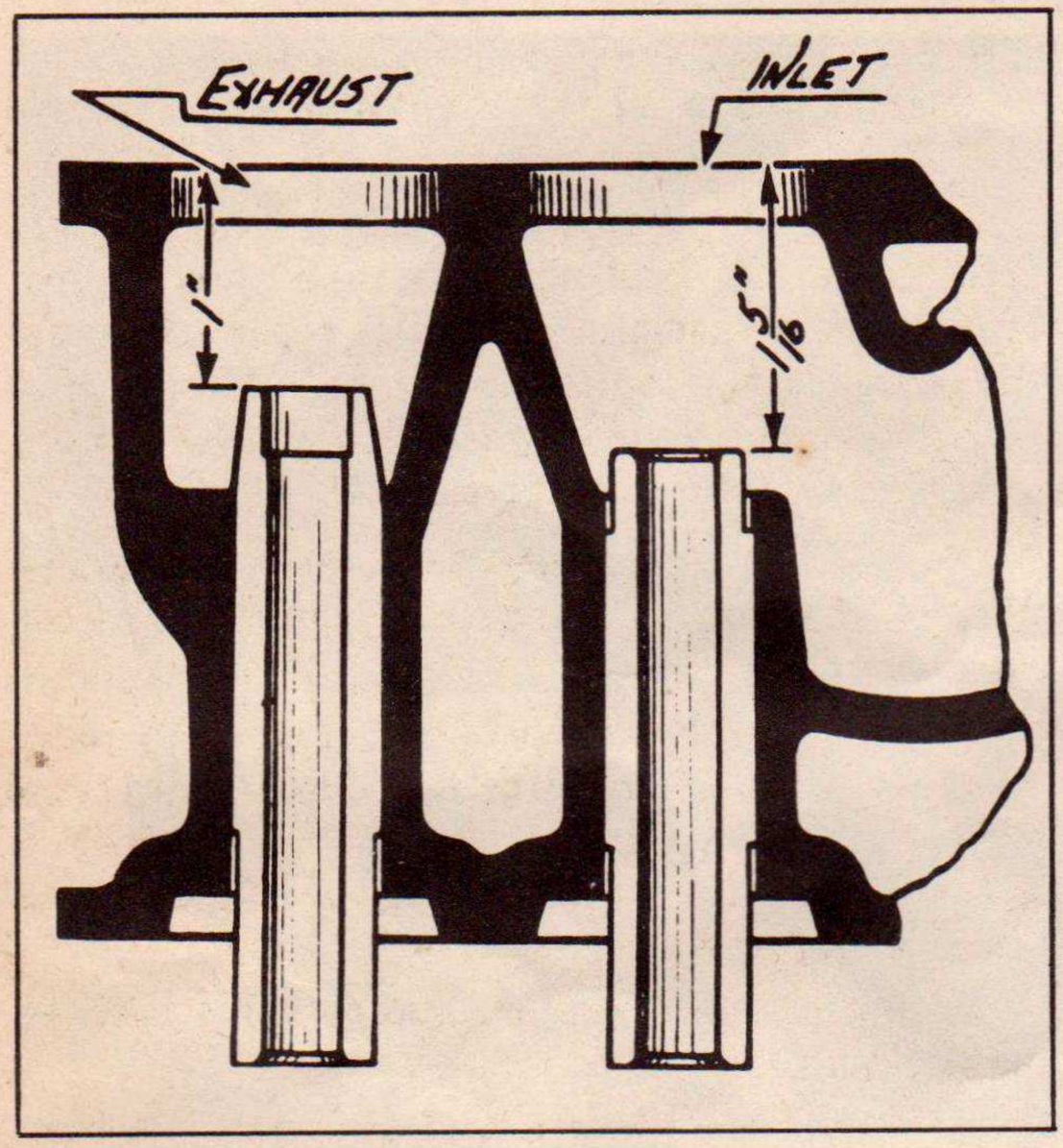


FIG. 21 POSITION OF VALVE GUIDES

(2) Adjust the valve tappet to valve stem clearance to .014", (Fig. 17). Remove cloth or waste from valve chamber.

(3) Clean top of block and pistons of all foreign matter and install cylinder head gasket. Clean carbon from cylinder head and wipe off all foreign matter, then install over studs on cylinder block. Install oil filter bracket. Install cylinder head cap screws and nuts bringing them down finger tight, then with a tension wrench tighten cylinder head screws and nuts in sequence as shown on (Fig. 22), tightening screws to 65 to 75 foot pounds or 780 to 900 inch pounds and the nuts to 60 to 65 foot pounds or 720 to 780 inch pounds.

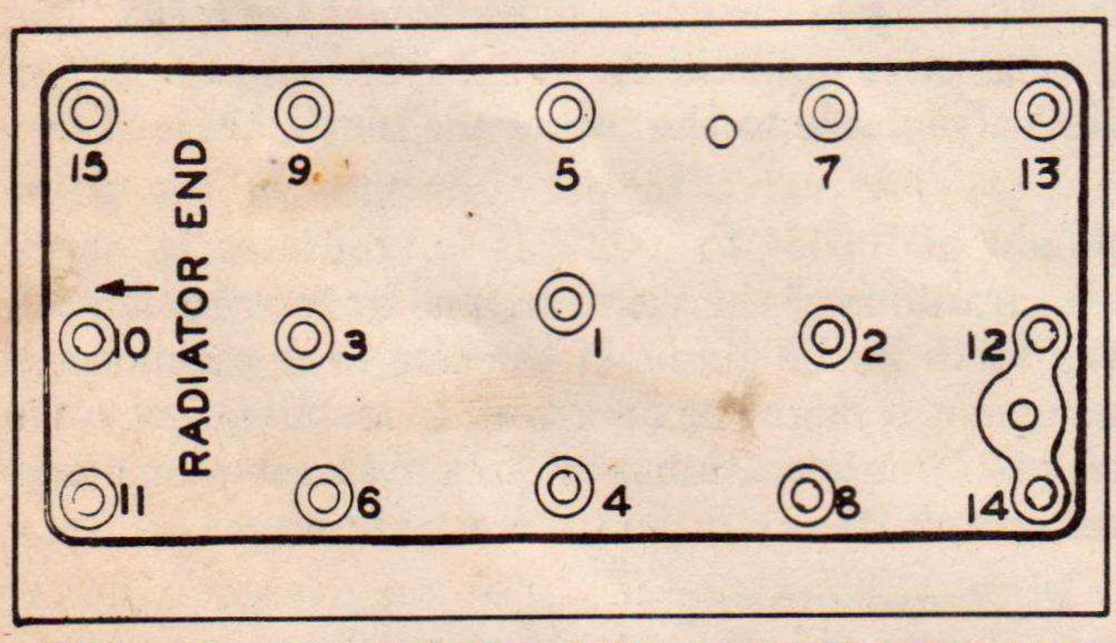


FIG. 22 CYLINDER HEAD TIGHTENING

(4) Clean and adjust spark plugs, setting the electrode gaps at .030". Install spark plugs in cylinder head to prevent any foreign matter from entering the combusion chamber during the remaining operations. Be sure to install spark plug gaskets.

(5) Install manifold with new gaskets. Install manifold clamp washers with convex surface toward manifold. Install manifold nuts drawing them up tight. Install exhaust pipe to manifold with new gasket.

(6) Install governor, adjust governor belt tension and connect governor oil supply line.

(7) Overhaul and recondition carburetor as per instructions given in paragraph 37. Install carburetor to manifold and attach controls. Install air cleaner horn and tube.

(8) Recondition ignition unit and set ignition timing in accordance with instructions given in paragraph 41. Make sure when installing distributor assembly in crankcase that it fits down in the crankcase properly. Install and connect ignition resistor.

(9) Install upper radiator hose, and all line connections. Close radiator drain cock and fill the radiator with water or anti-freeze solution as required. Arrange the end of the governor oil return tube so that returning oil will enter the crankcase through one of the three holes in the valve spring chamber. Start the engine and allow to run without load for five or ten minutes. Then stop it and recheck the tappet clearances.

(10) If necessary, install new valve spring cover gasket (shellac to cover). Install cover to engine block. Clean crankcase ventilator tube and screen and reinstall with gaskets.

(11) Install the governor oil return tube.

(12) Start the engine. After it reaches normal operating temperature, make any speed adjustment needed to provide correct frequency as shown by Frequency Meter.

29. Camshaft and Valve Tappets.—

a. Description.—

(1) The alloy steel camshaft rotates on four bearings which are lubricated under oil pressure through drilled passages in the crankcase. The front bearing carries the thrust and is a steel-backed

babbitt-lined shell. This bearing is staked in place to prevent rotation and endwise movement. See (Fig. 23).

(2) The valve tappets are lubricated through oil troughs cast in crankcase and drilled passages to valve tappet guides. The oil troughs are filled from oil spray holes at connecting rod bearing ends. A groove cut in center of valve tappet shank carries the oil up and down in the guides.

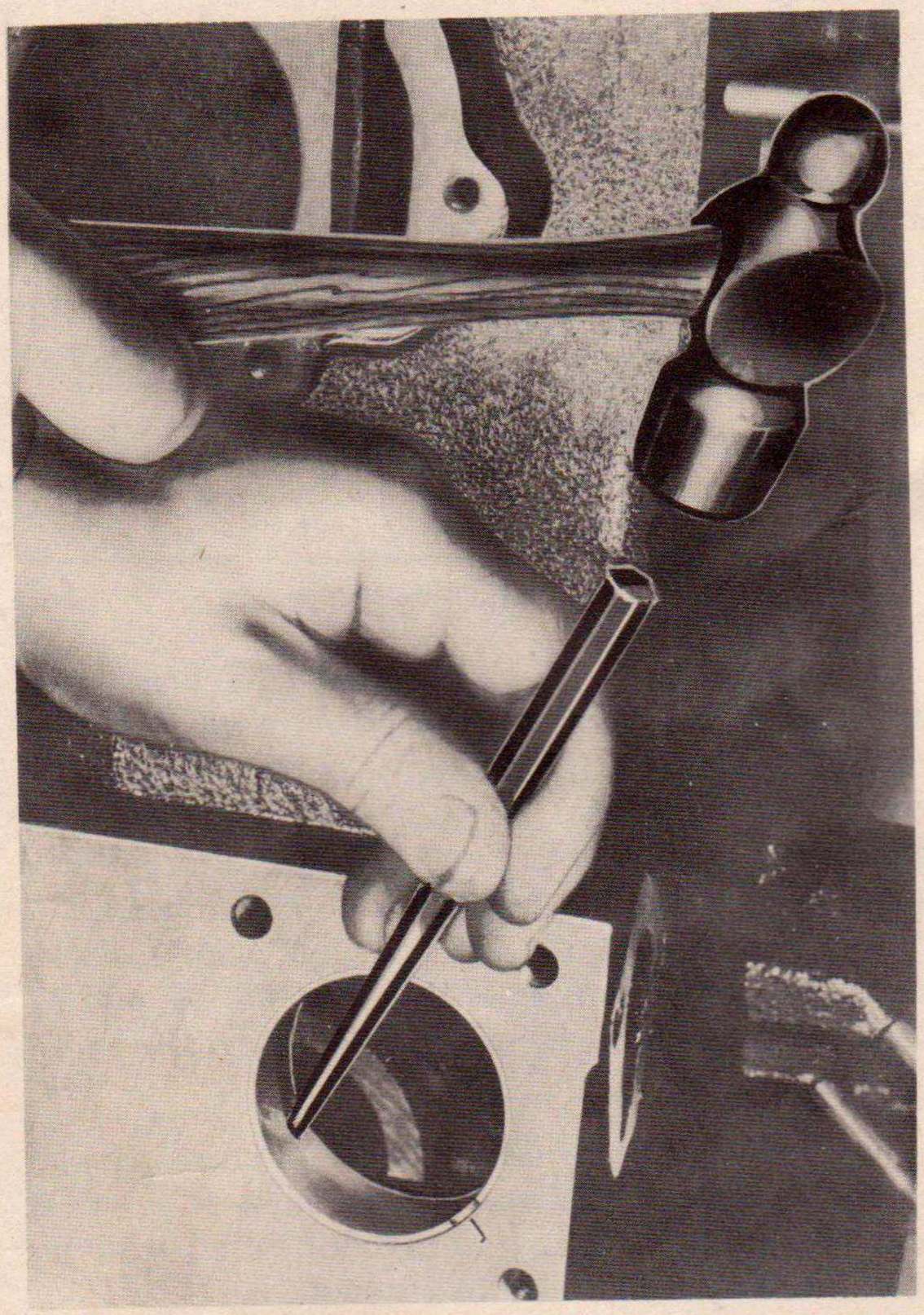


FIG. 23 STAKING CAMSHAFT BEARING

b. Removal of Camshaft or Valve Tappets.— To remove the camshaft or valve tappets, proceed as follows:

(1) Raise the power unit about 18 inches from the floor and support it securely in such manner that the oil pan may be removed later.

(2) Drain the water from the radiator. Remove the front housing top plate. Remove housing front end support and radiator assembly, See paragraph 39. Remove exhaust compartment top plate.

(3) Remove cylinder head, manifolds, valves and valve springs, following the instructions in paragraph 28.

(4) Remove oil pump and fuel pump assemblies.

(5) Drain the oil from the engine. Remove the bottom dust plate and the oil pan.

(6) Remove fan belt, fan blade assembly, governor belt and crankshaft pulley.

(7) Remove timing chain cover, camshaft sprocket screws and timing chain.

(8) Tie all valve tappets up with a string wrapped around heads of adjusting screws and attached to manifold studs.

(9) Remove sprocket from camshaft. Remove camshaft and valve tappets.

(10) Carefully inspect camshaft for scores, roughness of cams and bearings. Examine valve tappet faces where they contact cams and replace if found to be scored, rough or cracked. Check clearance of tappets to guides, renewing those which have worn excessively. Oversize available, .004".

c. Replacing Camshaft or Valve Tappets.— To install the camshaft and valve tappets, proceed as follows:

(1) Install valve tappets and tie up in place with string. Install camshaft. Install camshaft thrust washer.

(2) To set the valve timing, see instructions given in paragraph 30.

(3) For installation of oil pump see instructions in paragraph 34.

(4) Install the plunger and spring in the front end of camshaft with round end out. Inspect pin in timing chain cover to see that it stands perpendicular to the cover face. Put a light smear of cup grease on end of pin and on the end of plunger, then assemble cover to the engine.

(5) Complete the assembly by reversing the operations used for removal of the camshaft.

30. Valve Timing.—

a. Timing Chain and Sprockets.—

(1) The timing chain is non-adjustable. The lubrication is positive through drilled passages in the crankshaft and sprocket from the front main bearing. These should be checked whenever the chain or sprockets are replaced.

(2) To replace timing chain, it is necessary to remove radiator, fan blades, fan belt, crankshaft pulley and timing case cover. See paragraphs 29 and 39 *d* (2). Remove screws holding camshaft sprocket to camshaft and remove chain.

(3) When chain has been removed it will be necessary to give due attention to the valve timing when chain is replaced.

b. Timing.—

(1) To set the valve timing, turn the crankshaft so that No. 1 and No. 4 pistons are at top dead center. Top dead center is indicated by a mark TC on the flywheel which is visible through a hole in the flywheel housing, (Fig. 16).

(2) Place the camshaft sprocket on the camshaft and line up the holes for the capscrews. Screw all four capscrews in by hand. Rotate the camshaft so that the punch mark on the face of the sprocket is in line with the punch mark on the crankshaft sprocket, (Fig. 24).

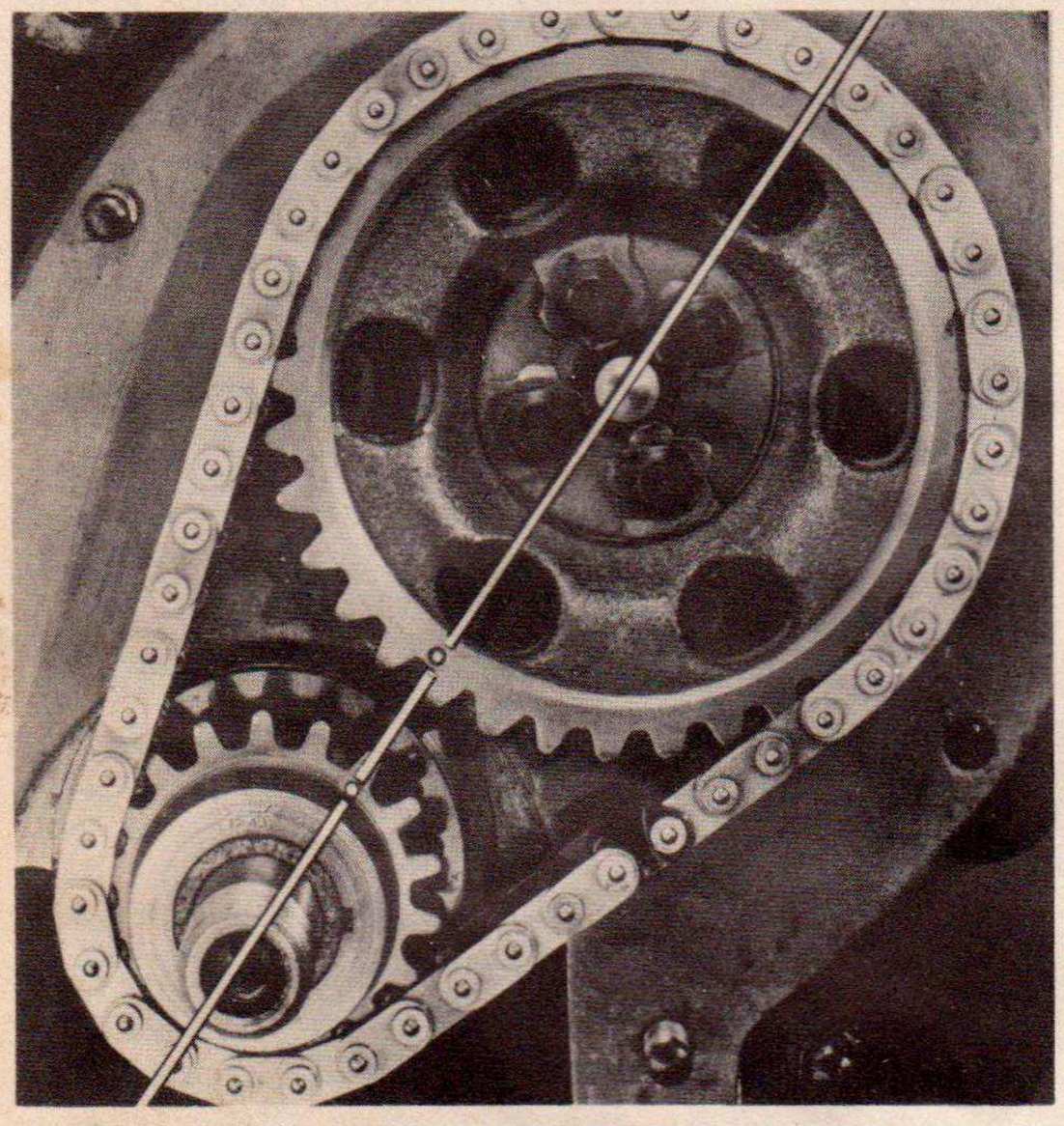


FIG. 24 TIMING SPROCKETS

(3) Remove the camshaft sprocket and install the timing chain. Change the position of the camshaft sprocket, within the chain, until all four capscrew holes are matched. Unless the position of the camshaft has been changed, the punch marks on the camshaft and crankshaft sprockets will now be in line as shown in (Fig. 24). Make sure the camshaft thrust washer is in place, replace the capscrews and again check the lineup of the punch marks. Timing is correct when a straight line between sprocket centers cuts through the punch marks on both sprockets as shown in (Fig. 24). In this position No. 4 cylinder is at top of compression stroke and the distributor arm should be under the segment for that cylinder.

(4) Tighten capscrews and lock with the special washers.

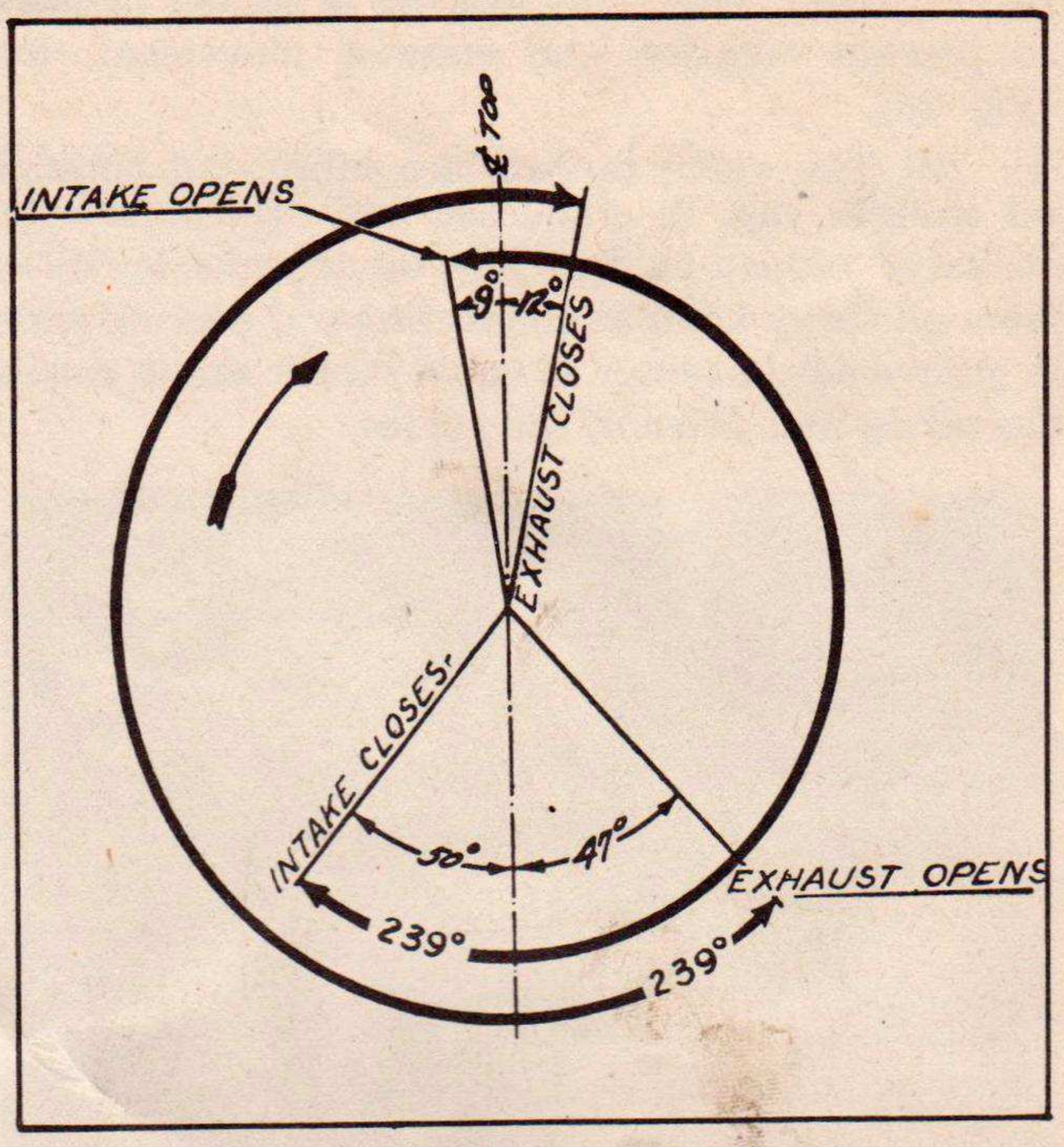


FIG. 25 VALVE TIMING

(5) Inlet valve opens 9° before top center measured on flywheel or .039″ piston travel from top center. To check valve timing, (Fig. 25), adjust inlet valve tappet of No. 1 cylinder to .020″. Rotate crankshaft clockwise until piston in No. 1 cylinder is ready for the intake stroke, at which time the tappet should just be tight against end of valve stem and mark on flywheel I.O. in center of timing hole in flywheel housing on right side of engine, (Fig. 16).

c. Timing Chain Cover Seal.—The crankshaft oil seal is woven asbestos impregnated with graphite and oil. When necessary to install new oil seal, the steel retainer should also be renewed.

31. Crankshaft.—

a. Description.—The crankshaft rotates in three steel-backed babbitt-lined bearings, the front bearing taking the thrust. Packing at the rear bearing, (Fig. 26), prevents the escape of oil. The main bearing journal diameter and length dimensions are: Front, 2.3340″—1.920″; Center, 2.3340″—1.8125″; Rear, 2.3340″—1.75″.

b. Servicing.—

(1) The steel-backed babbitt-lined bearings are made to size and are interchangeable without line reaming. The running tolerance of the bearing is established at .001″ to .0025″. No adjustment is

provided on the main bearing. Should they require attention they should be replaced to maintain proper control of oil. Main bearing cap screw torque wrench reading 65-70 foot lbs. If new crankshaft bearings are installed, care should be taken to see that the drilled passages line up with drilled passages in the crankcase, and that the bearings set snugly over the dowel pins. Undersize main bearings are available in .010"; .020" and .030".

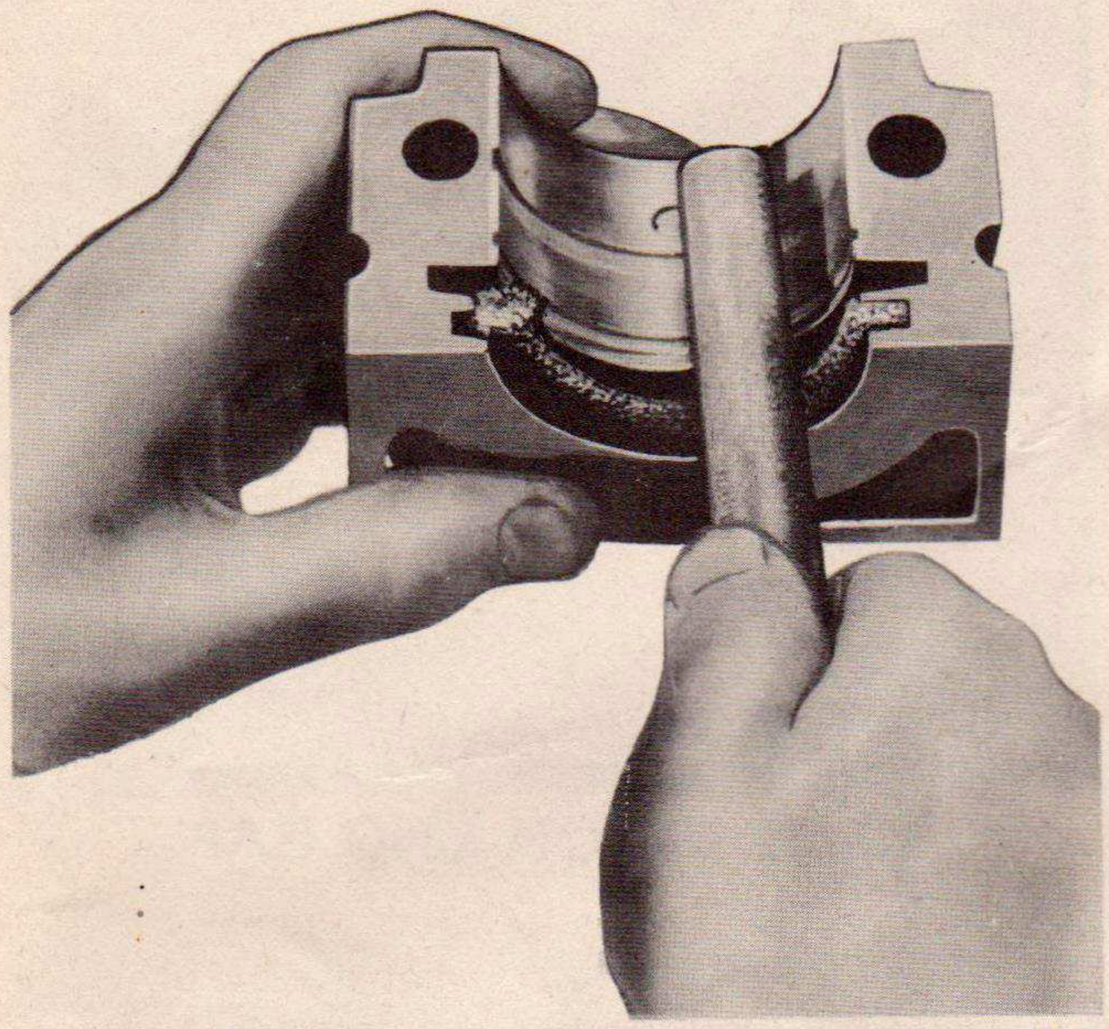


FIG. 26 REAR MAIN BEARING PACKING

(2) The end play of the crankshaft is .004" to .006" and adjusted by shims between the crankshaft sprocket thrust washer and end of main bearing. To adjust end play, the crankshaft sprocket must be removed with gear puller.

(3) Whenever it is necessary to remove the crankshaft or install new crankshaft bearings, the engine has to be removed from the housing. See instructions under Flywheel in paragraph 35.

c. *Rear Bearing Seal.*—

(1) The rear main bearing is sealed by a wick type packing, installed in grooves machined in the crankcase and rear main bearing cap, (Fig. 26).

(2) To install a new seal at the rear main bearing cap, insert the packing in the groove with the fingers. Then using a round piece of wood or steel, roll the packing into the groove. When rolling the packing, start at one end and roll the packing to the center of the groove. Then starting from the other

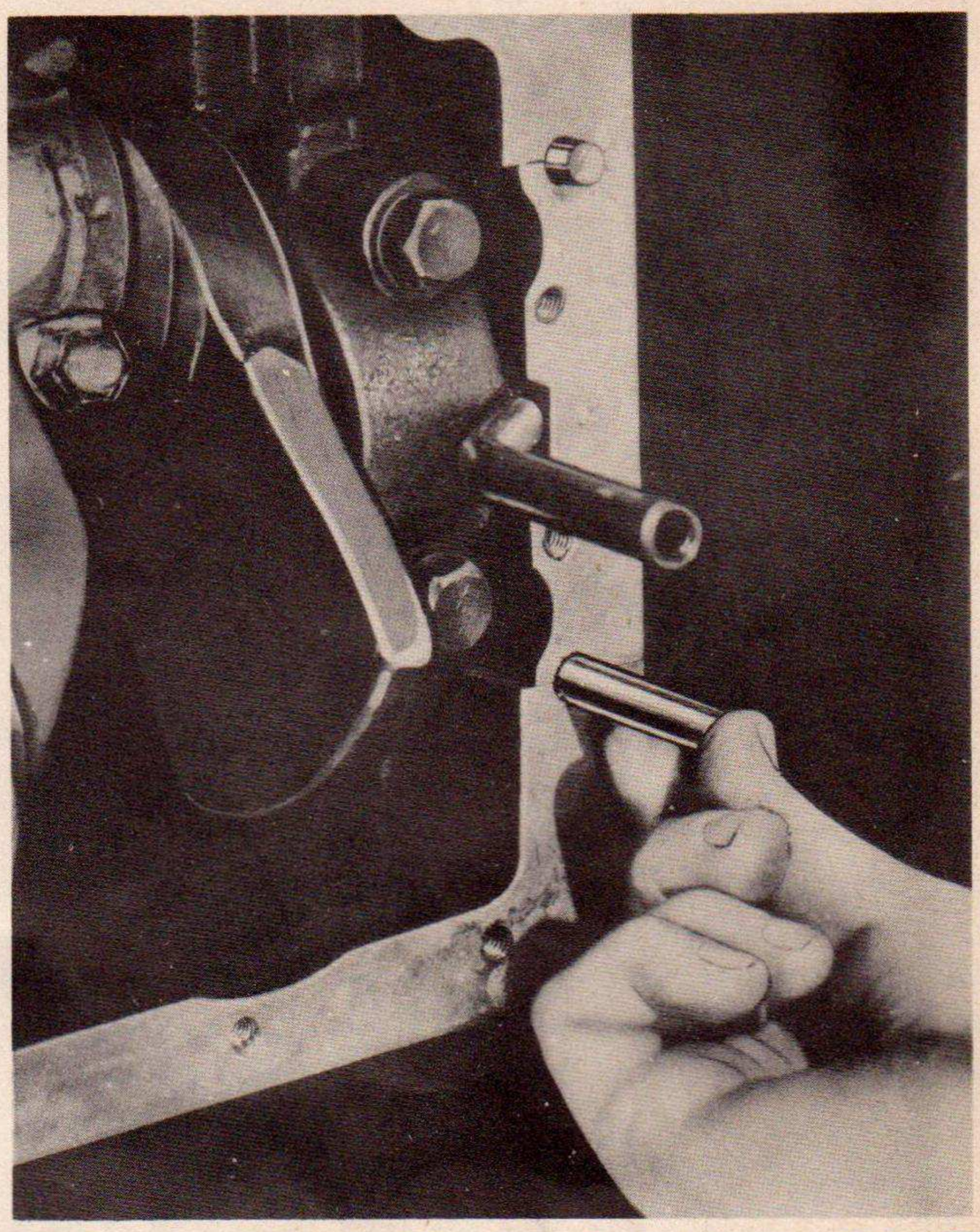


FIG. 27 REAR BEARING CAP PACKING

end again roll toward the center. By following the above procedure you are sure that the wick is firmly pressed into the bottom of the groove. The small portion of the packing which protrudes from the groove at each end should be cut flush with the surface of the bearing cap. To prevent the possibility of pulling the packing out of the groove while cutting off the ends it is recommended that a round block of wood, the same diameter as the crankshaft be used to hold the packing firmly in position while the ends are being cut off.

(3) Should it be necessary to install a new seal in the crankcase, it will require the removal of the engine from the housing and the removal of the crankshaft. The same procedure should be followed when installing a crankcase seal as when installing a seal in the bearing cap.

(4) When installing rear main bearing cap to case, a little sealer should be put on the faces of the cap where it fits against the case. The rubber seal packing that goes between the main bearing cap and the case is cut to a given length and will protrude down from the case approximately ¼". When the oil pan is installed it will force this seal tightly into the holes and prevent any oil from leaking from the engine into the generator adapter. See (Fig. 27).

32. Connecting Rod and Piston Assembly.—

a. Connecting Rod.—The connecting rods are drop forged. The babbitt bearings are of the replaceable type, steel-backed, babbitt-lined, precision cut to size and no fitting is required. Clearance on crankshaft .0005″ to .0025″. Total side clearance .005″ to .009″. Undersize rod bearings are available in .010″, .020″ and .030″.

b. Piston.—

(1) The piston is aluminum alloy, T slotted, cam ground, tin plated and with a heat insulation groove above top ring. Pistons are available in the following over-sizes: 010″; .020″ and .030″ and semi-finished .030″.

(2) The clearance of the piston in the cylinder bore is .003″. Check clearance with .003″ feeler gauge ¾″ wide; feeler gauge should have from 5 to 10 lbs. pull when being removed. The gauge should extend the entire length of the piston on the thrust side which is the opposite side from the T slot in the skirt. If it is ever found necessary to install an over-size piston, the cylinder bore must be honed with a regular cylinder honing tool and the manufacturer's instructions should be carefully followed to get a true straight cylinder. **Do not try to lap in a new piston using compound because it will ruin the tin plating on the piston and cause a scoring or wiping condition of both the piston and cylinder walls. See Checking Cylinder Bores and Cylinder Boring, paragraph 33.**

c. Piston Rings.—

(1) Width of compression rings 3/32″. Width of oil control ring 3/16″. The upper compression ring is installed with the inside beveled edge up. The face of the lower compression ring is tapered .005″. The letters "T-O-P" on the upper edge of the ring indicate how the ring is installed, (Fig. 28).

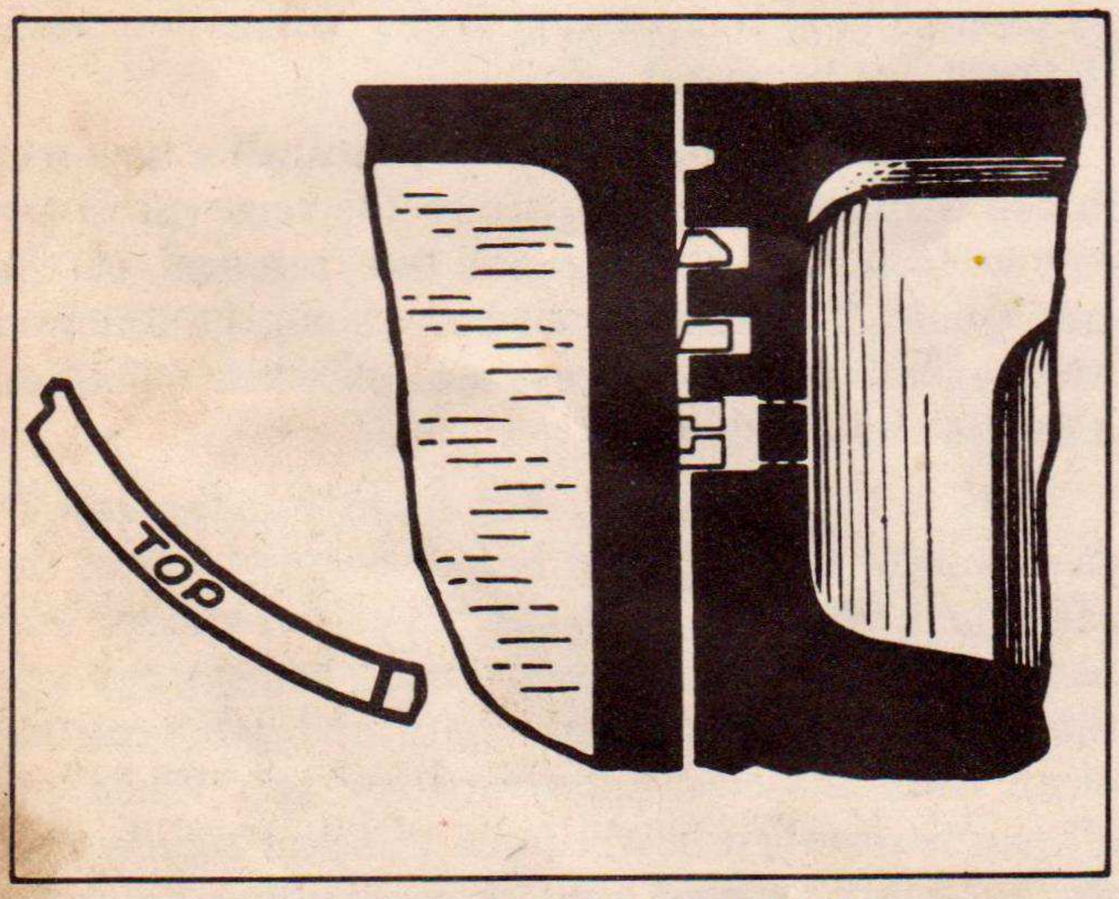


FIG. 28 PISTON RINGS

FIG. 29 PISTON RING GAP

FIG. 30 COMPRESSION RING FITTING

(2) When fitting the rings to the cylinder bores, the end gap is .008″—.013″. (Fig. 29). When fitting piston rings to grooves, (Figs. 30 and 31), give them the following clearances: Compression rings, .0005″—.001″; oil rings, .001″—.0015″. Oversize rings are available in the following sizes: .010″; .020″; .030″. Use standard rings up to .010″ oversize cylinder bores.