RESTRICTED

TM 11-929

WAR DEPARTMENT

TECHNICAL MANUAL
POWER UNIT PE-145-A

July 21, 1943

WAR DEPARTMENT

WASHINGTON, MAY 21, 1943

This Technical Manual, published by Le Roi Company on order no. 1870-PHILA-42, is furnished for the information and guidance of all concerned.

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TECHNICAL MANUAL

POWER UNIT PE-145-A

RESTRICTED

WAR DEPARTMENT, WASHINGTON, MAY 21, 1943

This Technical Manual covers Power Units PE-145-A supplied to the U. S. Signal Corps under the following orders.

LE ROI CO.	WESTERN ELECTRIC CO.	U. S. CONTRACT NO.	SERIAL NO. SPAN
18314	A-341736	W2124-SC-281	168619 and 168620
18742			168592 to 168618
18903			165750 to 166026

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SAFETY NOTICE

ELECTRIC SHOCK

WARNING: 110 VOLTS EXIST IN ELECTRICAL SYSTEM WHILE POWER UNIT IS IN OPERATION. Stop power unit before attempting any service work involving these parts.

ELECTRICAL SHOCK TREATMENT (See Appendix)

Start artificial respiration immediately, or as soon as the body is removed from contact where this is necessary.

Do not regard early rigidity or stiffening as a sign for ceasing artificial respiration. Resuscitation should be continued three or four hours even though there is no sign of revival.

After revival, treat any burns to guard against infection.

CARBON MONOXIDE

CAUTION: Never attempt to operate the engine in a small, unventilated room. Carbon monoxide gas, produced by all gasoline engines, is a deadly insidious poison when inhaled. Make certain exhaust gases are piped outside and all connections are gas-tight at all times.

CARBON MONOXIDE POISONING TREATMENT

The first thing to do is to get the patient into fresh air quickly.

If breathing has stopped, or is present only in occasional gasps, start artificial respiration at once and continue until normal breathing is resumed, or until rigor mortis has set in.

If the victim does not die in the gas, but is removed to the fresh air and given artificial respiration the carbon monoxide gradually leaves the blood. Some victims who are still breathing normally often cannot get the gas out of their blood fast enough to prevent their being very sick or even dying, afterward. Oxygen given to these patients helps to drive the carbon monoxide from the blood.

GUARDS — SHIELDS

The manufacturers of this equipment have taken every precaution to safeguard the operating personnel. All moving or operating parts have been adequately guarded or shielded to provide maximum protection.

IMPORTANT: Do not remove any guards, shields, screens, etc. to perform service or maintenance work while power unit is in operation. To do so removes the safety features provided for your protection.

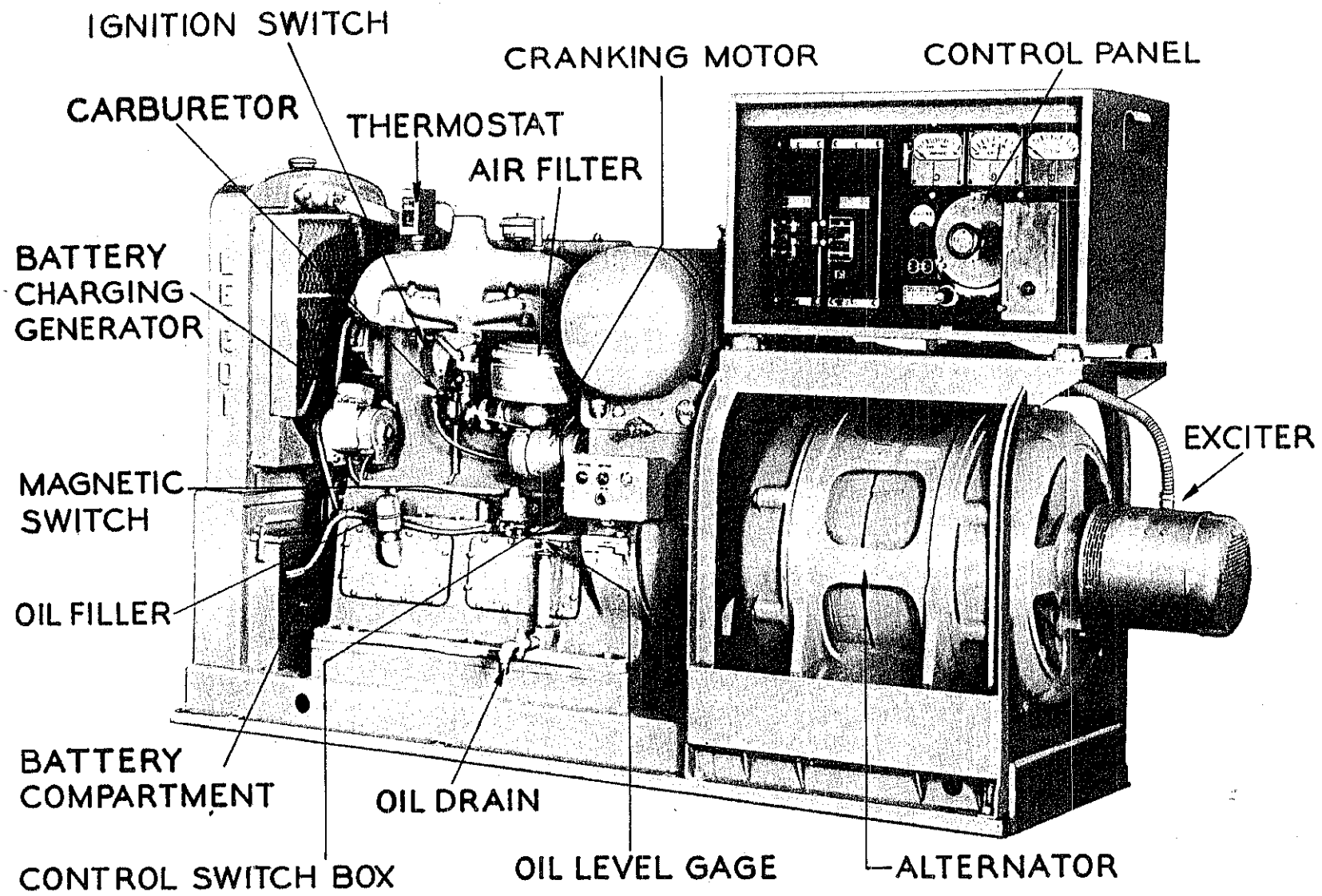

Fig. 1. Power Unit PE-145-A—Carburetor Side

SECTION I. DESCRIPTION

1. General Description of Power Unit.

a. Power Unit PE-145-A is a portable, self-contained, gasoline-electric power plant, consisting of a four-cylinder gasoline engine, directly connected through a full metallic coupling to an alternating current generator. The entire unit, including radiator, engine, alternator, and control panel, is mounted on an electrically welded steel bedplate. A 15-gallon gasoline tank is mounted over the flywheel housing. The engine is equipped with a fuel pump for supplying gasoline to the carburetor either from this tank or from drums of gasoline which may be placed alongside the power unit. A gear-type lubricating oil pump, equipped with a renewable cartridge-type oil filter, furnishes oil under pressure to all engine bearings. Carburetion is by means of a conventional-type carburetor with the air intake passing through an Air-Maze oil-bath air cleaner and backfire arrester.

b. Starting is accomplished by a heavy-duty 12-volt battery and electric starting motor, with ignition supplied by a Bosch magneto. Speed is regulated by a Woodward type SGX governor. The entire unit is completely radio shielded, even to the extent of shielding the battery-charging circuit and the use of bypass condensers on the battery-charging generator. A grounding lug is located on the bedplates near the left-hand front leg of the control cabinet support.

2. Engine

a. Cooling System.

The by-pass-type cooling system is thermostatically controlled. A positive centrifugal pump circulates the water through the engine block. The water temperature is controlled by the thermostat located in the engine outlet to the radiator, which does not allow water to flow through the radiator until the engine has reached the operating temperature. With the thermostat closed the water circulates only through the engine.

b. Air Cleaner.

The Air-Maze oil-bath air cleaner is attached to the side of the cylinder block by means of a cast-iron connection. Air passes through the intake opening down into the bowl of the cleaner through a bath of oil, and then through the filter element, where the oil is removed and returned into the oil bowl, allowing clean air to pass on into the engine. The oil drained back from the screen washes the dirt away. Proper functioning of the air cleaner is important in obtaining maximum power from the engine.

c. Manifolds.

Both intake and exhaust manifolds are combined in one casting. The manifold is equipped with a water jacket and is known as a water-cooled type.

d. Oil Filter.

The replaceable cartridge-type lubricating oil filter is located on the left side of the engine. A quantity of oil is bypassed from the main circulatory system through the filter element to the crankcase. Filter elements cannot be cleaned and should be replaced every time oil begins to get black and dirty.

e. Oil Pump.

The single-stage, gear-driven pump operates

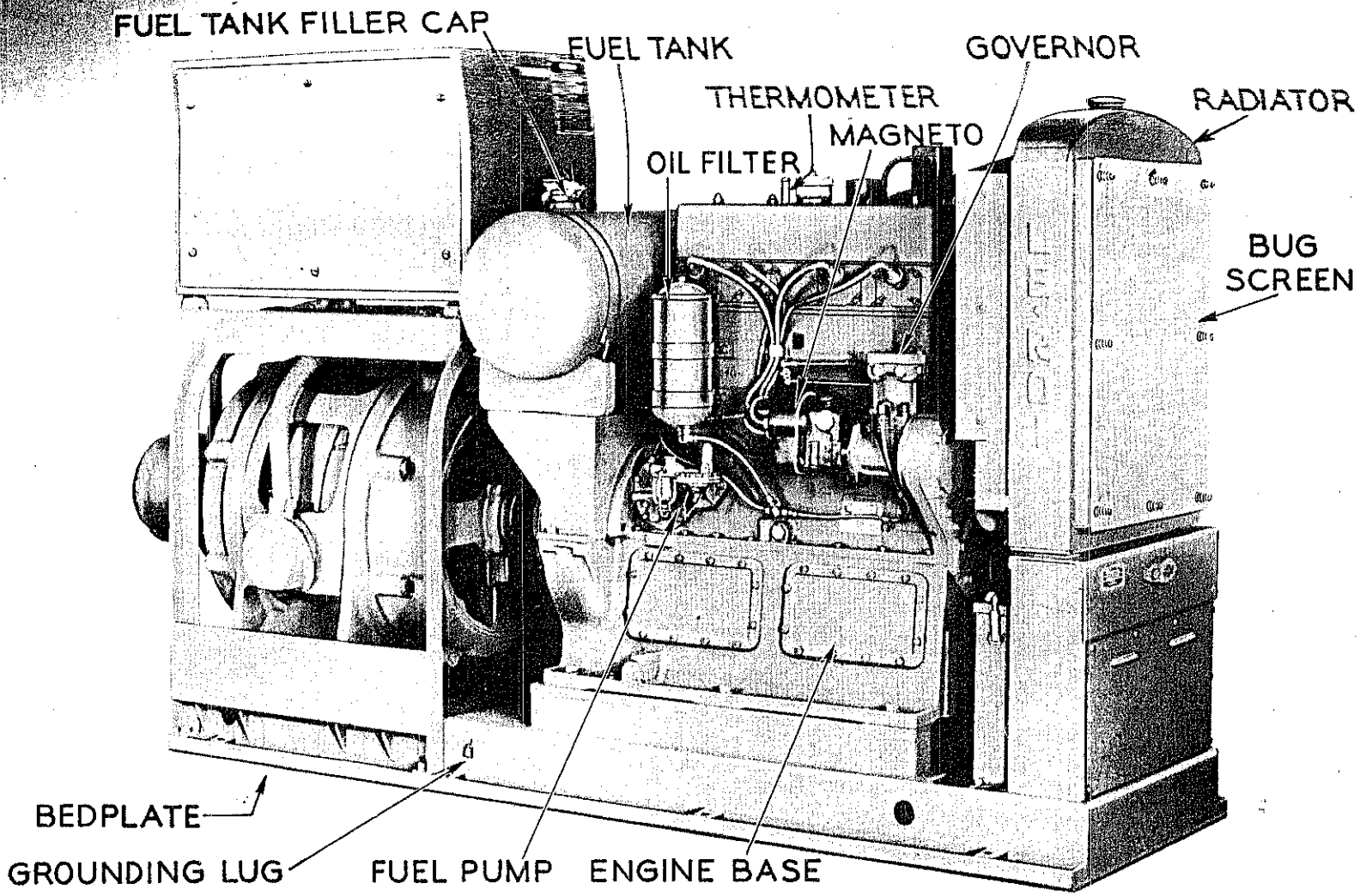

Fig. 2. Power Unit PE-145-A—Magneto Side

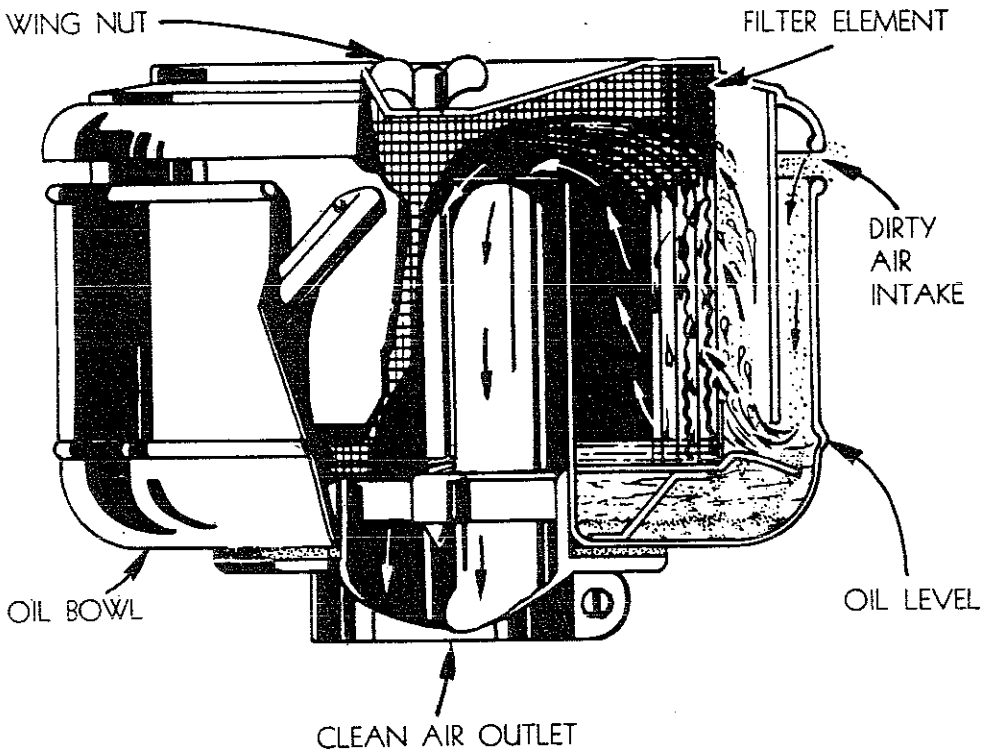

Fig. 3. Cross Section through Air Cleaner

off the camshaft, and is attached to the crankcase by cap screws. Oil travels through the screen, which strains out any large dirt particles, up through the pump body to the opening between the pump body and the crankcase, where it enters drilled passages in the crankcase. Both drive pinion and idler gear are keyed to their shafts. The upper drive gear, which meshes with the camshaft, is also keyed to the shaft.

f. Timing Gears.
The timing-gear train is accessible with the engine front cover removed. The camshaft gear operates directly off the crankshaft gear and drives the accessory shaft drive gear. These three gears must be in their proper places to have the engine timed properly.

g. Magneto.
The Bosch magneto (see Figs. 4 and 5) employs the induction principle of current generation. The coil windings (10) are stationary and the magnets (7) are rotated between laminated pole shoes (25). The condenser (24) and interrupter (27) are also stationary. Brush (14) and the rotating track combinations are confined solely to the high-tension distributor (16). Screened ventilators on either side of the housing (1) and the fan action of the magnet rotor (7) insure constant change of air throughout the interior of the magneto. A single casting (1), the open end of which is covered by the distributor plate (12) and the radio shield cover (13), incloses the magneto. The observation cover (18) on the radio shield cover (13) and the observation window (17) in the distributor plate (12), plus the arrow on the distributor motor (16), facilitate timing of the magneto to the engine.

h. Magnetic Switch.
The starting switch is of the magnetic type with the control switch mounted in the automatic safety control box below the instrument panel.

i. Control Switch Box.
The purpose of these controls is to shut down the engine if the oil pressure drops below

five pounds per square inch, or if the water temperature rises above 195 degrees Fahrenheit, while the engine is running.

The thermostat has a two-circuit single-throw switch which connects both of the terminals to the grounded side of the battery whenever the temperature of the water in the engine becomes too high. One of these terminals is connected to the magneto so that the magneto is shorted when the thermostat switch closes. The other terminal is connected to one side of the pilot light, which indicates that shutdown has been caused by high-water temperature. The other side of this pilot light is connected to the live side of the battery so that when the thermostat switch closes this pilot light will be lighted.

The oil pressure switch closes whenever the oil pressure drops to less than five pounds per square inch, and opens when the oil pressure rises above nine pounds per square inch.

j. Carburetor.

The general purpose of the carburetor is to discharge the desired amount of fuel into the air stream entering the engine, to atomize the fuel, and to make a homogeneous air-fuel mixture. The air-to-fuel ratio is not constant for all speeds and loads. The carburetor varies that ratio to give the best operating performance for all conditions. The carburetor has been calibrated to meter the correct amount of fuel for smooth operation throughout the operating range. The func-

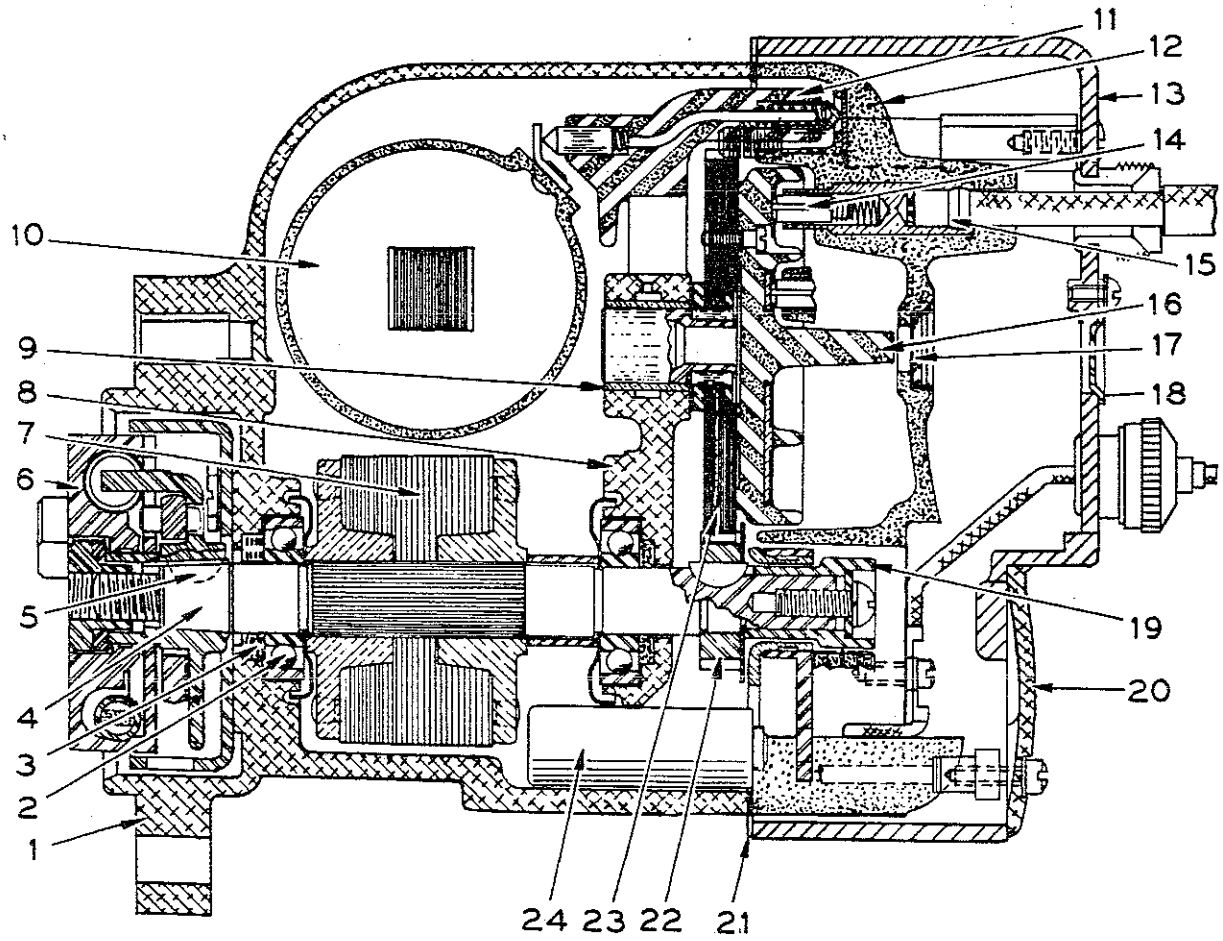

Fig. 4. Longitudinal Section through Magneto

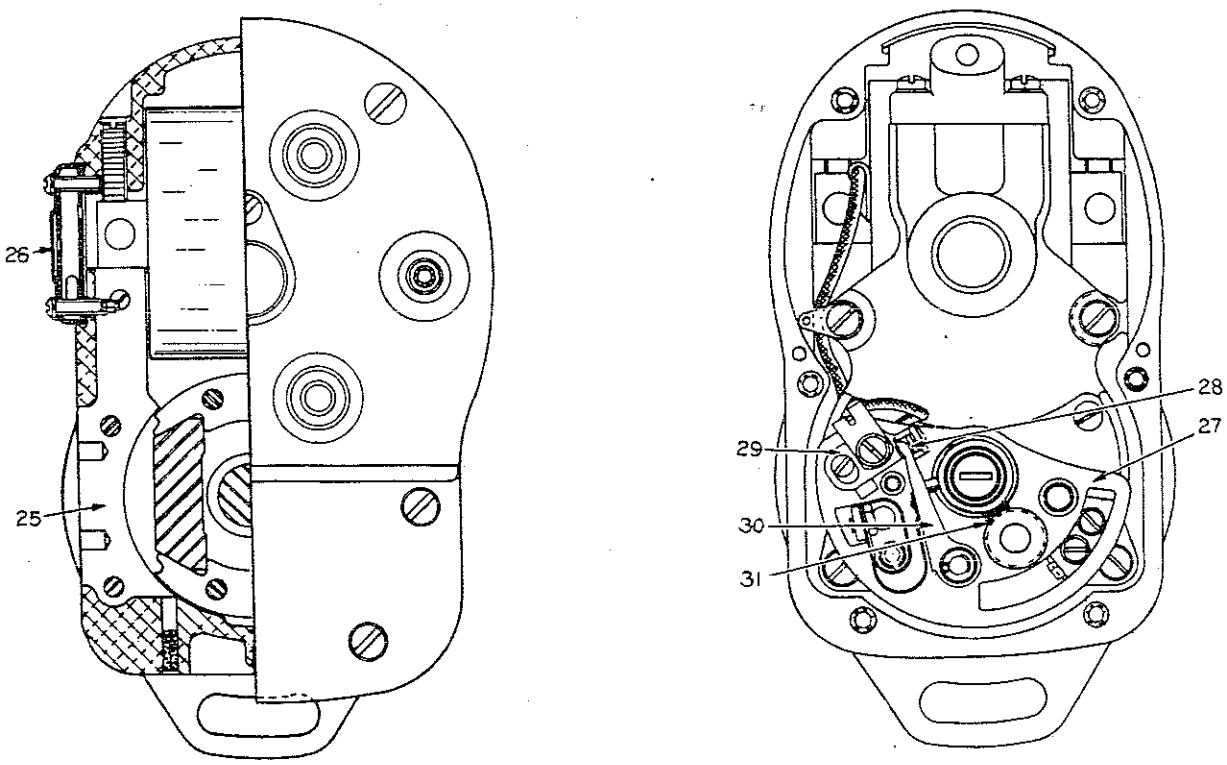

Fig. 5. Cross Section through Magneto

tion of the carburetor cannot extend beyond the proportionate mixing of fuel and air. The carburetor throttle is equipped with a hand lever, and has only two positions, STOP and RUN. In the STOP position, the carburetor lever makes contact with a switch which serves as the grounding means for the magneto.

k. Fuel Pump.

The fuel pump (see Fig. 6) is connected to the tank by a valve located beneath the tank and just behind the instrument panel. The valve which connects the fuel pump to an outside supply is located on the outside just below the instrument panel. Both of these valves should not be open at the same time, except momentarily, when shifting from one source of gasoline to the other.

l. Governor.

The governor (see Fig. 7) is of the hydraulic type, using engine lubricating oil under pressure, as an energy medium. It acts through oil pressure to increase fuel supply. It has a useful work capacity of about six inch-pounds over the full terminal shaft range of thirty degrees. A spring acting to cut off the fuel supply has been incorporated in the fuel control linkage. This spring should oppose the action of the governor with a total resistance of 12 inch-pounds of work for full terminal shaft travel.

3. Description of Generator.

a. General.

The alternating current generator is a single-phase, two-wire generator of the revolving field type, rated at 120 volts, 60 cycles, 900 rpm, 25 kva at 80 per cent power factor. A direct connected d-c exciter supplies direct current to the field windings of the alternator. Both the alternator and the exciter will carry the rated full load continuously with a temperaure rise not exceeding 72 degrees Fahrenheit above the ambient temperature. Temperatures can be measured by placing a thermometer on the hottest avail-

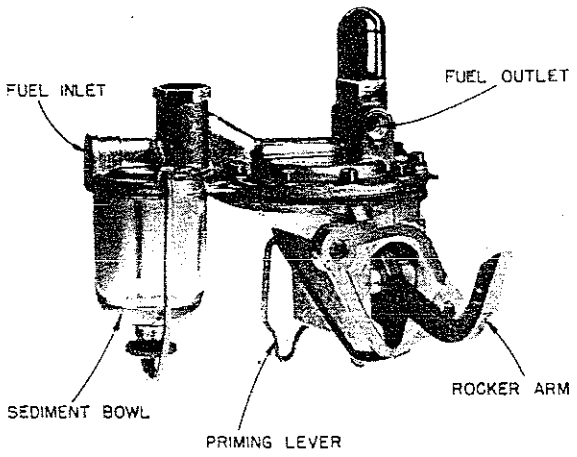

Fig. 6. AC Fuel Pump

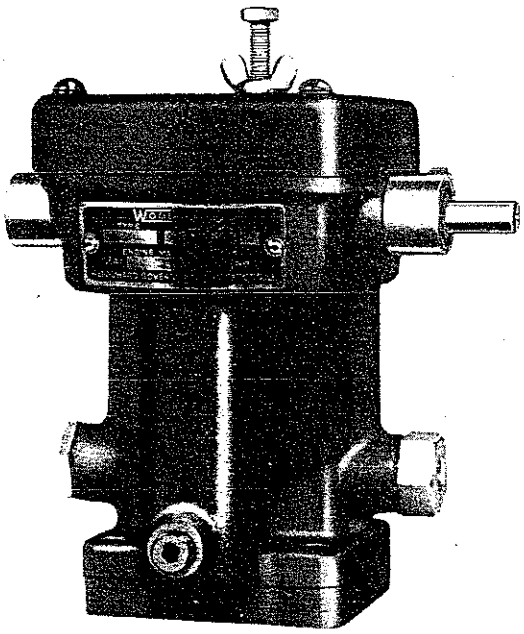

Fig. 7. Woodward Governor

able portion of the machine windings. Both the alternator and exciter were built and tested to withstand high-potential tests in accordance with AIEE standards. The generator field windings were tested at 1,500 volts and the other windings were tested at wice their normal rated voltages plus 1,000 volts.

The open type alternator frame is of a good grade, of cast iron and of rigid and rugged construction to withstand the vibration and jarring of transportation in a truck or trailer. The armature, of high grade laminated steel slotted to receive the stator coils, is held rigidly in place in the frame by end plates and keys. The windings are held in the slots by moisture-proof wedges. The coils are formed and insulated before winding into the slots. The wound stator is impregnated with an acid-, oil-, and moisture-resistant varnish which protects the entire winding from abrasive dust and oil, weak acid, and moisture.

The field coils are wound directly on the poles, each layer of the coil being well saturated with a bakelite varnish as it is wound and the final coil treated with moisture-resistant varnish. An amortisseur winding especially designed for use on single-phase generators is connected between poles.

The generator has two ball bearings designed so that adding new grease flushes out the old grease and forces it into an overflow

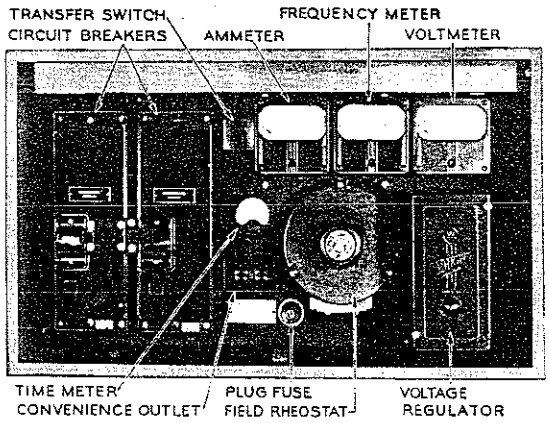

Fig. 8. Generator Control Panel—Front

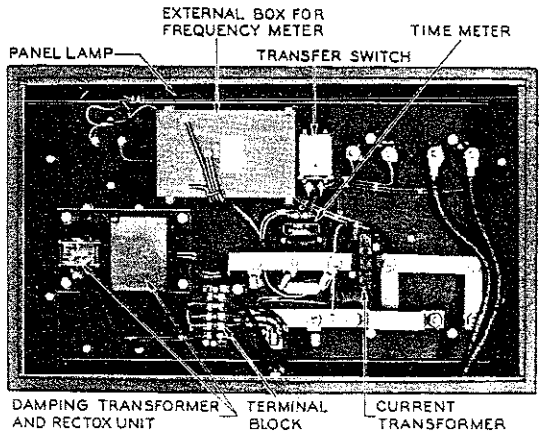

Fig. 9. Generator Control Panel—Rear

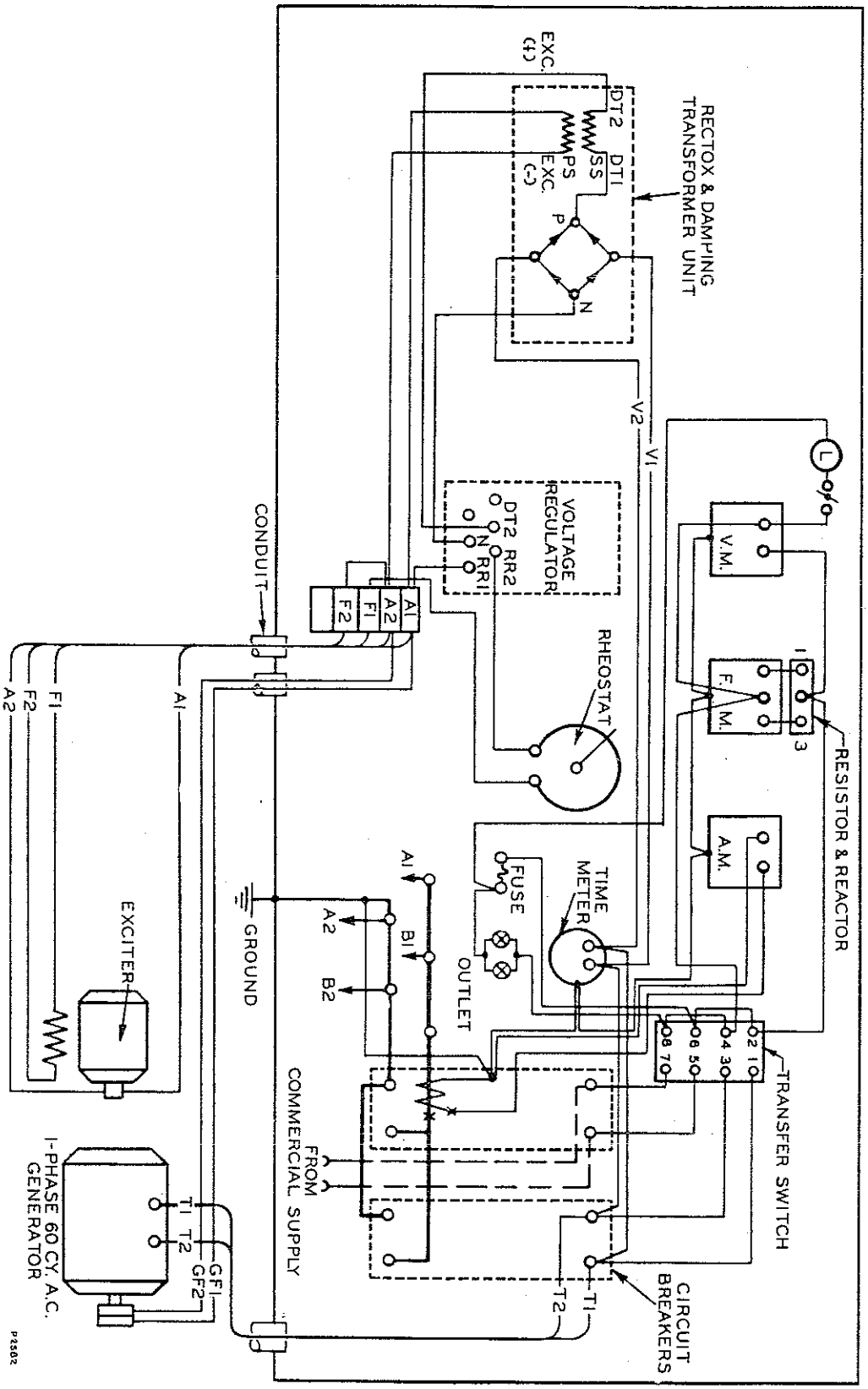

Fig. 10. Wiring Diagram—110 Volt System

reservoir. The bearings are suitable for coupled drive. The collector-ring brush holders, when assembled at the factory, are mounted so that the lower edge has a clearance of from one-eight to one-quarter of an inch from the collector rings. The brush holders the located so that the brushes do not override the edges of the collector rings under normal conditions (when the generator is coupled to the engine).

The rotor is dynamically balanced so that vibration, measured by a vibrometer is less than 0.003 inch when the generator is standing on a solid bedplate. When the alternator feet are resting on a level surface the shaft is on a level plane within 0.007 inch per foot of shaft length. The minimum air gap for the generator is not less than 70% of the nominal gap.

The brushes of the d-c exciter are mounted so that the lower edge has a clearance of one-sixteenth to one-eighth of an inch from the commutator surface. The commutator segments are of best quality hard drawn copper and are insulated from the shaft and from each other. The insulation between segments is undercut. All coils, leads, terminals and other connections are secured so that they cannot become damaged, displaced, or loosened by vibration. The leads from the alternator are brought to the control box and are enclosed in armored conduit. Access to the generator collector rings and to the exciter brushes can be gained through the openings in the end brackets and by removal of the exciter cover. All generator and exciter covers should be in their proper locations when the engine is being operated under load. The exciter cover is for the proper distribution of the exciter cooling air and to provide an effective shield against radio-frequency interference.

b. Control Panel.

The generator control panel contains the connections for the generator and all the accessory equipment necessary to the performance of the generator. It consists of a steel cabinet with the panel mounted in the front, an easily removable back, fixed top cover and knock-out holes in the bottom. The unit is supported on special vibration-proof fittings which, in turn, are supported by a steel frame that extends directly over the generator. All connections to external equipment are made through the knock-out holes in the bottom. The unit is shown in Figs. 8 and 9.

The front of the panel contains a voltmeter, an ammeter, a frequency meter, a time meter, generator-voltage regulator, two circuit breakers, and an exciter field rheostat. The purpose of selector switch is to transfer the voltmeter and frequency meter to the circuit breaker on that type of power (commercial or generator) that is in use. The circuit breakers are fully adjusted and tested at the factory and should require no further adjustments for operation. The frequency meter and ammeter must be level for accurate operation. Schematic diagrams are shown in Fig. 10

Each pole of the circuit breaker is equipped with nonadjustable thermal and instantaneous overcurrent tripping element. The thermal element provides overcurrent protection for the generator. The instantaneous element protects against short circuit.

The current transformer for the line ammeter is on the rear of the panel together with the thermal boards and the protective fuses. The current transformer has a 60:1 ratio with five-ampere secondary. The wiring diagram for the unit is located on the inside of the left rear side cover. A twin extension receptacle, a light switch, ground stud, and illumination light are also mounted on the front of the panel.

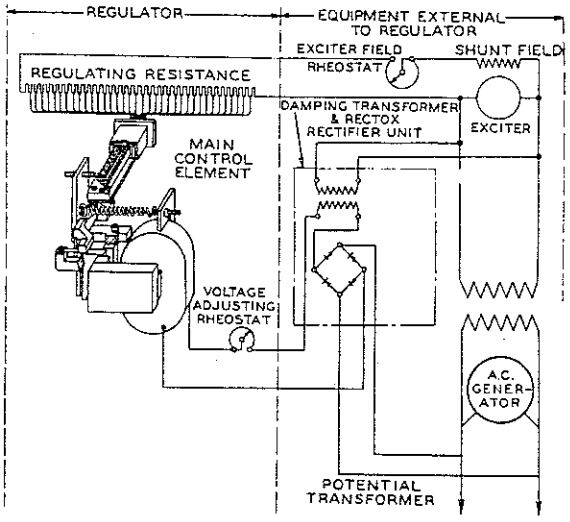

Fig. 11. Schematic Wiring Diagram of Voltage Regulator

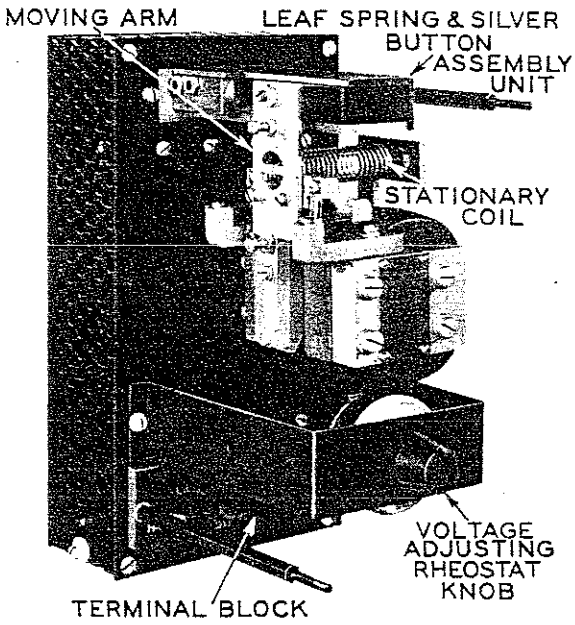

Fig. 12. Voltage Regulator with Front Cover Removed

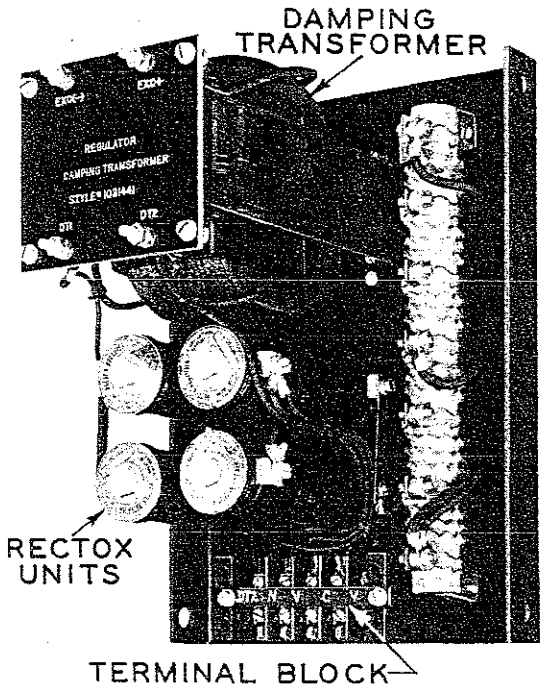

Fig. 13. Damping Transformer

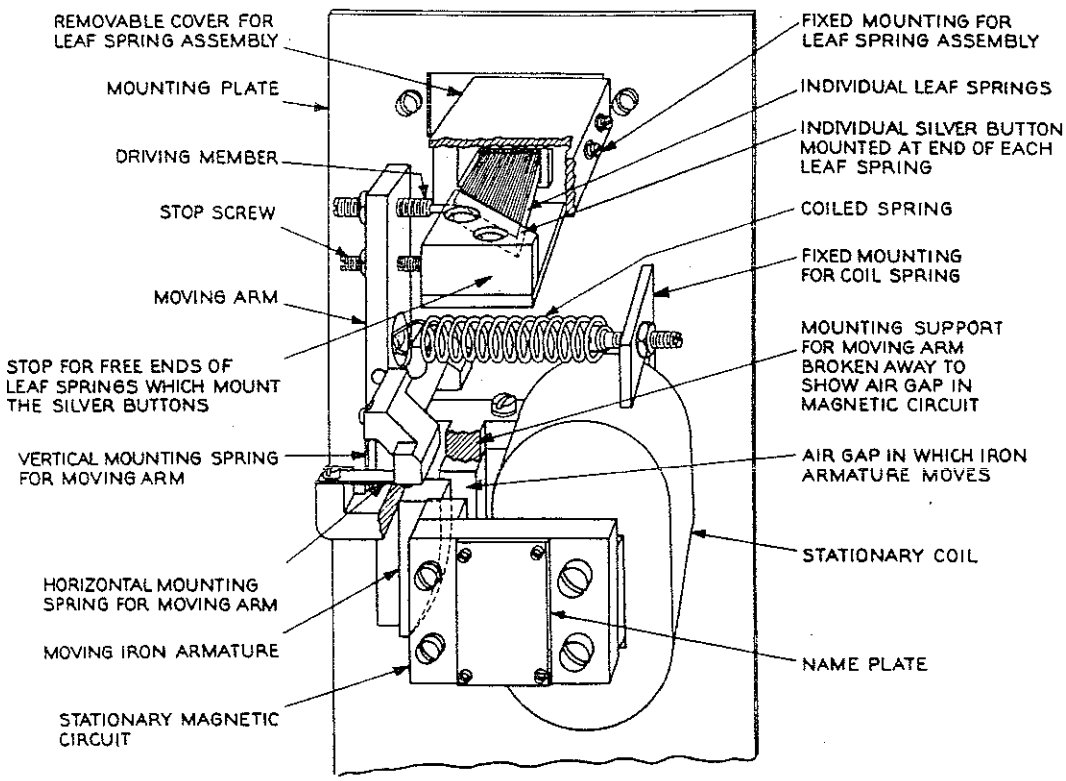

Fig. 14. Pictorial Diagram Showing Construction of Main Control Element in Voltage Regulator

c. Silverstat Voltage Regulator.
The Silverstat regulator is of the direct and quick acting rheostatic type, that is, correction of voltage is obtained by the regulator element varying directly the regulating resistance in the machine field circuit. The direct acting principle of operation employed keeps the regulating resistance automatically adjusted to the proper amount required to maintain the correct value of regulated voltage. The regulating resistance is entirely stationary, thus eliminating the complication involved where linkage and lever systems mechanically move the resistance assembly in order to vary its resistance, as necessary with some types of regulators.

The few moving parts used are supported by leaf type springs which provide a fixed and permanent axis that permits free action without the friction of pivots and bearings. This construction combined with light weight moving parts, whose maximum travel is only a fraction of an inch, practically eliminates the time lag due to the inertia and friction of these parts. This results in a sensitive device which functions quickly.

The type SRA a-c regulators control the voltage of an a-c generator by varying the resistance in the shunt field circuit of the exciter. In each case the regulating resistance in the field circuit is varied directly and automatically by the action of the regulator.

The control element of the regulator is a d-c operated device. A full wave Rectox (copper oxide) rectifier is interposed between the element and the a-c machine, to supply direct-current to the regulator element. Since the rectified d-c voltage is proportional to the a-c voltage, the d-c operated element of the regulator responds to changes in the a-c machine voltage.

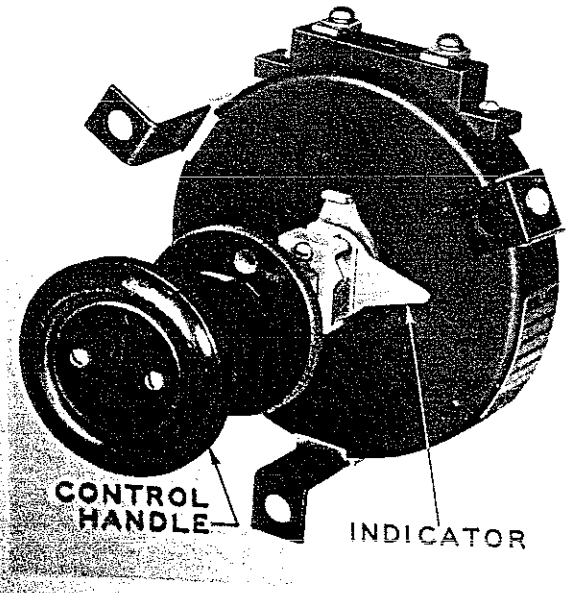

Fig. 15. Field Rheostat—Front

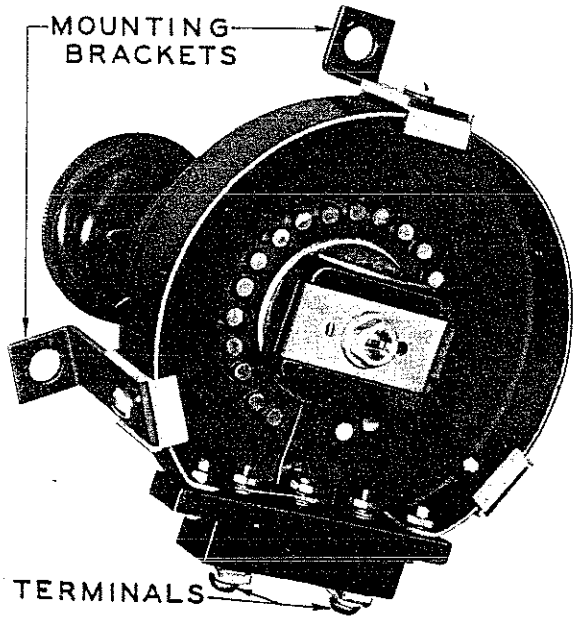

Fig. 16. Field Rheostat—Rear

SECTION II. INSTALLATION AND OPERATION

4. Installation and Preliminary Checks.

a. Extreme care should be taken in transporting and handling the power unit. The windings of the alternator especially are easily damaged. A blow on any part of the windings may be sufficient to injure the insulation and cause a coil to burn out. When the unit is unpacked, or whenever it arrives at a new site, it should be given a careful visual inspection for possible damage in transit and shipping.

b. The alternator must be protected against moisture both before and after installation. It is important that all windings be kept dry, since moisture lowers the insulation resistance and therefore increases the likelihood of a breakdown. If the unit is brought from cold surroundings to a warm room, the generator should be kept covered until its temperature has risen to room temperature. This will prevent condensation on the windings and other parts.

c. After installation of the power unit, turn the engine and generator over with the hand crank to make certain that the engine and the generator rotor turn freely. This should be done particularly if the unit is not put into service immediately after installation.

d. When the completely assembled unit is mounted in a truck or on a floor, place shims as required under each foundation bolt so that, when the bolts are tightened, the bedplate will not be distorted. If the unit is shipped in the installed position, check to see that all bolts are tight.

e. Make fuel connections to a drum of gasoline and make a good ground connection with a grounding peg. The generator connections and the connection for the d-c exciter are shown in Fig. 10.

f. Remove the muffler from its packed position and install it with the fittings supplied. These fittings may be found either mounted in place on the unit or packed in the spare parts box.

5. Checks Before Starting Engine.

a. Routine Checks.

Before attempting to start the engine, check **water, oil, gasoline,** and **battery electrolyte level.**

(1) The cooling system has a capacity of nine U. S. gallons and should be kept filled with clean water.

(2) The crankcase has an approximate capacity of seven U. S. gallons. The proper level can be checked by means of the dip stick gauge which stands out from the side of the engine below the starting motor. To check the oil level, remove the dip stick; wipe it clean; insert it slowly into the oil filler pipe (located on the carburetor side of the engine below the battery charging generator). Leave it there for two or three minutes before withdrawing it for a reading. The oil should reach the FULL mark.

(3) Gasoline is supplied from an external drum (capacity 55 U. S. gallons) and from a 15-gallon tank located just above the flywheel. Check these to see that there is a sufficient supply of gasoline for running the engine.

(4) Examine the battery to see that the level of the electrolyte is approximately one half inch over the top of the plates.

b. Additional Checks for New or Idle Engine.

(1) Remove the spark plugs and pour about two tablespoonfuls of a mixture of half oil and half gasoline into each cylinder to furnish lubrication to the pistons and cylinders.

(2) After connecting the fuel supply, prime the fuel pump and carburetor by manipulating the priming bail which will be found un-

FREEZING POINT		ANTI-FREEZE SOLUTIONS					
		METHYL ALCOHOL		ETHYL ALCOHOL		ETHYLENE GLYCOL	
CENT.	FAHR.	SPECIFIC GRAVITY	PER CENT BY VOLUME	SPECIFIC GRAVITY	PER CENT BY VOLUME	SPECIFIC GRAVITY	PER CENT BY VOLUME
-7°	20°	.9822	12.5%	.9796	16.5%	1.022	16.5%
-12°	10°	.9726	20.5%	.9704	25.5%	1.034	25.5%
-18°	0°	.9638	28%	.9611	33.5%	1.044	33.5%
-23°	-10°	.9560	34.5%	.9511	40.5%	1.051	39%
-29°	-20°	.9493	39%	.9392	47.5%	1.058	44%
-34°	-30°	.9421	44%	.9244	54.5%	1.062	47.5%
-40°	-40°	.9358	47.5%	.9068	63%	1.064	51.5%

Fig. 17. Anti-freeze Solution Chart

derneath the fuel pump. If the glass filter bowl on the fuel pump shows any amount of water and dirt, it should be removed, cleaned, and replaced, making sure that the edges of the bowl fit evenly and tightly against the cork gasket.

(3) Grease the water pump by turning down the grease cup.

c. Additional Checks before Starting in Cold Weather.

If the power unit is to be operated in temperatures of 32 degrees Fahrenheit or lower, observe the following precautions:

(1) Use only high-test winter-grade gasoline and keep the supply tightly covered so that the more volatile portion does not evaporate.

(2) At the end of each day's run, fill the gasoline tank to prevent moisture from collecting in the tank.

(3) Use the correct grade of lubricant in the crankcase and air cleaner. (See paragraph 38).

(4) Drain the cooling system of water at the end of each run, or use one of the recommended antifreeze solutions shown in Fig. 20. To drain the cooling system, open the drain cocks in the lower radiator connection, manifold, and cylinder block (located beneath the carburetor). See that drains are not plugged and that the water drains completely.

(5) During freezing weather, cover the entire radiator, fill with cooling solution, and start engine.

(6) If starting the engine is difficult in cold weather, it may be necessary to pour a small quantity of gasoline into each cylinder through the spark plug holes. Wait a few minutes, in order to vaporize the gasoline before turning on the switch which starts the engine.

6. Starting the Power Unit.

a. See that the mechanism of the circuit breaker on the generator control panel operates freely by manually throwing the handle up and down a few times before starting the engine. The breaker is closed when the handle is inclined toward the ON marking. Throwing it toward the OFF marking will cause the operating mechanism to snap the contacts open. The engine should not be started under load. The circuit breaker must therefore be thrown to the OFF position before starting the engine.

b. Open the valve to the 15-gallon gasoline tank. Close the valve to the external drum.

c. Move the shaft lever on the carburetor to the RUN position.

d. Pull out the choke knob on the engine instrument panel.

e. Push the STARTER button on the safety control box until the engine fires. If the engine does not start immediately, push in the choke control and continue turning over

the engine with the starter until it fires. Do not operate the starter continuously for longer than thirty seconds without allowing the cranking motor to cool.

f. As the engine warms up, push the choke rod gradually in.

Caution. If the choke control rod is left out, an excess of raw fuel will be drawn into the cylinders, resulting in dilution of the crankcase oil, or possible stopping of the engine, owing to an over-rich mixture.

If the engine has been standing idle for some time, it may be necessary to push the control rod on the governor toward the radiator in order to hold the governor throttle partly open. The governor control rod will be found on the left side of the engine.

g. When the engine has started and is running at rated speed, observe all the engine instruments and general operating conditions to make sure that each element is performing its required function. (As soon as the oil from the engine builds up enough pressure to operate the governor, the governor regulates itself and maintains correct engine speed.)

h. After the engine warms up, switch from the 15-gallon tank to the external drum for fuel supply.

i. When the engine has warmed up sufficiently, turn the selector switch to GP and throw the circuit breaker on the generator control panel to the ON position. This connects the generator to the external load and the ammeter will read the load current, as load is applied.

When operating from commercial power, the engine need not be turned on. It is necessary only to turn the selector switch to CP and to throw the commercial power circuit breaker ON.

The breaker will trip automatically on overload or short circuit. When it opens, the handle moves to the midposition between OFF and ON. The breaker may be reset by moving the handle to the OFF position in order to reset the latch, and then moving it to the ON position in order to close the contacts. Overload tripping is initiated through a bimetallic thermal strip which deflects and actuates the trip mechanism when the strip is heated by the overcurrent. The breaker, also, has an instantaneous magnetic trip mechanism for rapid operation on short circuits.

7. Stopping the Power Unit.

a. Turn OFF the circuit breaker switch on the control panel.

b. Move the shaft lever on the carburetor to the STOP position. This cuts off the fuel supply to the carburetor and grounds the magneto.

c. If the power unit is to be left shut down for any length of time, shut off the fuel supply and drain the carburetor bowl. When the unit is to be moved to a new position, however, it is best to allow the fuel to remain in the carburetor.

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SECTION III. MAINTENANCE

8. General.

a. Daily (After 24 Hours' Service).

(1) See that only clean fuel is put into the tank from a clean container.
(2) Keep the radiator full of clean cooling liquid.
(3) Turn the water-pump grease cup down until it is snug. When it is empty, refill it with high-temperature ball-bearing grease.
(4) See that the oil is up to the FULL mark on the dip stick. Use oil as recommended.
(5) Keep the cylinder head and crankcase breathers free from dirt. When necessary, remove, wash in gasoline, and dry thoroughly and then replace.
(6) Check the air cleaner, and maintain the oil level to bead.

b. Weekly (After 150 Hours' Service).

(1) Check the spark plug and magneto point gaps. (See paragraph 25.)
(2) Lubricate all the accessories: battery charging generator, starting motor, etc.
(3) When the lubricating oil becomes badly discolored or diluted, it is an indication that the oil requires changing; the interval between oil changes depends entirely upon operating conditions and the quality of oil used. Renew oil-filter element.
(4) Valve adjustment should be checked to guard against low compression, which means loss of power. The clearance between the valve stems and the push-rod adjusting screws should be 0.015 inch when hot, and 0.018 inch when cold. Do not set too close, as this causes burned and warped valves.
(5) Check adjustment of the fan belt. The fan belt should be kept tight enough at all times to prevent slippage. (See paragraph 9.)
(6) Inspect and tighten any nuts that may have worked loose on the cylinder head and cylinder block.

c. Monthly (After 600 Hours' Service).

(1) Test the compression by cranking the engine over slowly on each compression stroke.
(2) Should the engine turn over easily on all cylinders, showing poor compression, the cylinder head should be removed and the valves reground. If one or two cylinders only lack compression, carefully inspect the valve and tappet clearances on these cylinders before removing the head. Insufficient valve clearance will cause burned valves and lack of compression.
(3) If valves are pitted, regrind them. (See paragraph 21.)
(4) The oil pan or sump should be thoroughly cleaned, removing all traces of sludge.
(5) Remove the oil-strainer screen from the oil pan and wash in gasoline.
(6) Remove coupling guard, check the coupling, and tighten nuts if necessary.

d. Semiannually (After 3,000 Hours' Service).

The entire engine should receive a thorough general inspection by a competent mechanic.

9. Cooling System.

a. Cleaning out Dirt and Sludge.

(1) Drain the cooling system by opening the drain cocks in the lower radiator connection, in the cylinder block, and in the manifold. Allow the system to drain and close the cocks.
(2) Fill the cooling system with a solution of two and one half pounds of ordinary washing soda mixed with nine U. S. gallons of water (cooling system capacity).

(3) Leave the radiator filler cap off and run the engine until the water is hot; then drain and flush the system with clean water.
(4) Refill with clean water.

b. Radiator Core.
Overheating is often caused by bent or clogged radiator fins. If the spaces between the fins become clogged, clean them with an air hose. When straightening bent fins, be careful not to injure the tubes or break the bond between the fins and tubes.

c. Adjusting the Belts.
Adjust the tension of the fan belt by changing the width of the groove in the fan pulley. To decrease the width of the pulley grooves loosen the lock screws and move the pulley flanges together; to increase the width, move the flanges apart. Retighten the lock screws after correct tension is obtained. To adjust the generator drive belt, loosen bracket, and move generator outward, away from the engine, until proper tension is secured. When

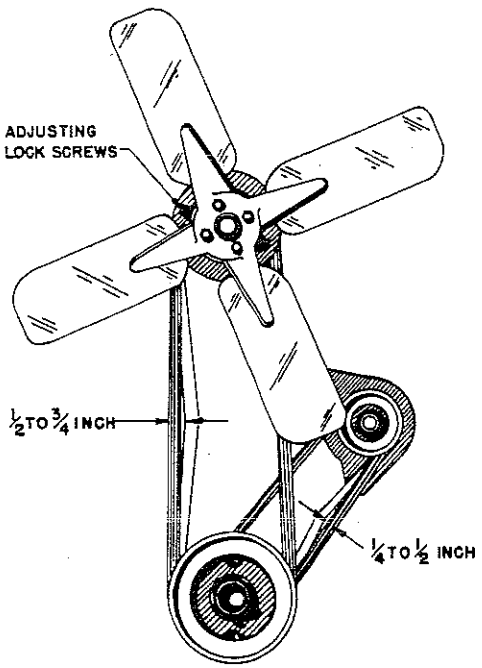

Fig. 18. Correct "V" Belt Tension

properly adjusted, belt must be slack enough to permit deflection by amount shown in Fig. 18 without appreciable pressure. Do not adjust the belt too tightly. After adjustment is obtained tighten the bracket securely.

d. Removing the Generator Belt.
To remove the generator belt, loosen the bracket and move the generator inward to engine until the belt can be slipped off the pulley. The fan belt must be removed before the generator belt can be removed.

e. Removing the Fan Belt.
To remove a fan belt, loosen the lock screws in the fan pulley hub and move the flange out as far as possible. Start the belt over the outer flange of the lower pulley and pry it out with a light bar or rod. Slowly crank the engine at the same time and the belt will work off the pulley.

f. Replacing Fan Belt.
The fan belt should be replaced with a new one when it becomes soaked with grease, or when it becomes so badly worn that it does not drive the fan at the proper speed. When replacing the belt, reverse the procedure outlined under paragraph 9e, above. The belt can be started on the lower pulley by hand, and will find its correct position if the engine is cranked slowly. Adjust to proper tension.

g. Water Pump. The water pump may leak, owing to wear after considerable use. If this occurs, it is necessary to replace the seal assembly, as there is no adjustment.

10. Air Cleaner.

The air cleaner is attached to the side of the cylinder block by means of a cast-iron connection. Air passes through the intake opening down into the bowl of the cleaner through a bath of oil and then passes through the filter element, where the oil is removed and returned into the oil bowl, allowing clean air to pass on into the engine. The oil drained back from the screen washes the dirt away.

The oil bowl should be removed daily and checked for dirt accumulation. Cleaning is accomplished by removing the oil bowl and dumping out the dirty oil. Rinse the bowl in fuel oil or gasoline, dry thoroughly, refill with clean oil to level of bead, and reassemble. It is important that the oil level be maintained at all times.

Periodically, depending upon operating conditions, the entire filter unit should be dismantled and cleaned thoroughly.

11. Manifolds.

Make certain that all connections and hold-down studs are tight at all times to prevent water leakage.

12. Oil Filter.

The oil filter is located on the left side of engine. A quantity of oil is bypassed from the main circulatory system through the filter element to the crankcase. Filter elements cannot be cleaned and should be replaced every time the oil begins to get black and dirty. Filter service operations are as follows:

a. Stop the engine.

b. Remove the drain plug and allow the filter to drain.

c. Remove the top cover assembly by unscrewing the bar handle capscrew.

d. Remove and discard the used refill cartridge. Inspect the bottom support plate and top of case. Clean thoroughly to insure complete seal when a new refill cartridge is inserted.

e. Flush the filter, using regular motor flushing oil or kerosene.

f. Replace the drain plug.

g. Place the new refill cartridge in the case.

h. Clean the hold-down plate and the gasket in top cover thoroughly. If the gasket has become hard, replace with a new gasket or place in hot water (200 degrees Fahrenheit) for ten minutes to restore resilience.

i. Replace the top cover assembly by placing the cover on the clarifier, and screw the bar-handle capscrew down tightly.

j. Check the oil level in engine crankcase.

k. Run the motor for at least ten minutes; then check all fittings and cover for leaks.

l. Add oil, if necessary, to bring crankcase up to the proper level.

13. Oil Pump.

The oil pump screen should be cleared of sludge and foreign particles whenever oil-pan handhole covers are removed.

14. Timing Gears.

For correct timing of the engine the three timing gears must be in their proper places. The timing gear is accessible with the front cover removed. The camshaft gear operates directly off the crankshaft gear and drives the accessory shaft drive gear. Before installing the camshaft gear, make certain that the timing marks are aligned as illustrated in Figure 19.

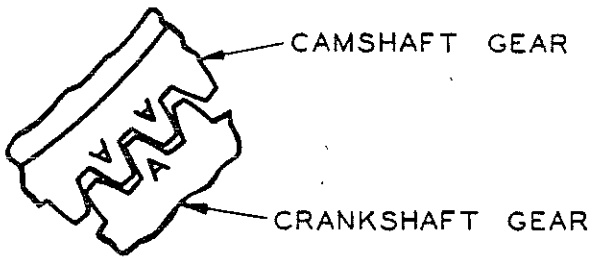

Fig. 19. Timing Gear Marks

Before meshing the accessory shaft drive gear it is necessary to turn the crankshaft until the impulse mark on the flywheel is aligned with the dead center mark on bell housing when the No. 1 cylinder is in firing position. To get the No. 1 cylinder into firing position turn the engine over until the No. 4 exhaust valve just closes, which will bring the flywheel markings (Fig. 20) into position. After the crankshaft is in position as described, move the accessory shaft-drive gear until No. 1 impulse fires; then move the gear back approximately one quarter turn and mesh the gears without further movement. After installation is made, it is best to check position by removing the No. 1 spark plug and reconnecting the wire. Ground the plug but do not install it in the cylinder head. Rotate the flywheel toward impulse position. The spark plug should fire as the flywheel is moved in the direction of rotation as impulse mark is reached. If the plug does

not fire in this position, the magneto will have to be rotated on its flange mountings. Make certain that the magneto flange capscrews are tightened securely after the proper setting is reached. If the proper setting cannot be obtained by flange adjustment, accessory shaft-gear position will have to be reset.

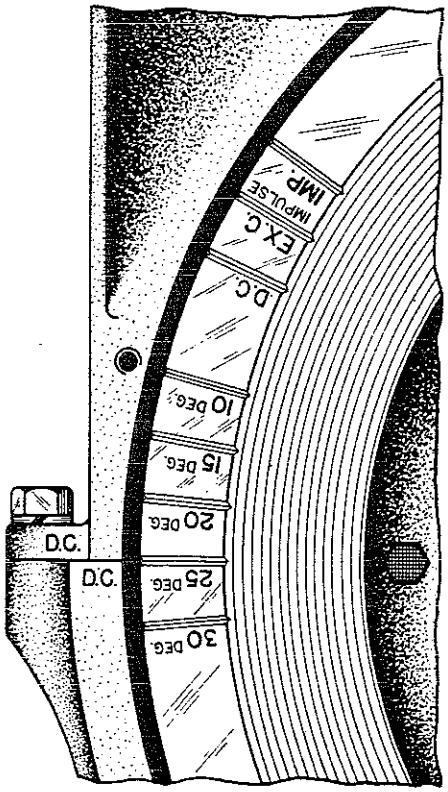

Fig. 20. Flywheel Timing Marks

The engine front gear cover can be removed, after taking off the cranking jaw and fan drive pulley. Care should be taken not to damage the oil seal when the cover is removed. In replacing the engine front cover make certain that the oil seal and gaskets are in good condition. If damaged in any way, replace. (See paragraph 19 b.)

15. Cylinder Sleeves.

Wet-type cylinder sleeves do not fit as tightly as dry-type sleeves, and can be driven out by using a block of hard wood and a hammer. The lower ends of the sleeves fit into rubber sealing rings. The cylinder block should be cleaned thoroughly at this point and the upper contact point before the sleeves are inserted. Clean the sleeves thoroughly at the contact points and place the rubber rings in position in the cylinder block, covering them with a thin coat of soft soap. Set the sleeve in the bore of the cylinder block with seal ring grooves down and drive the sleeve into position with a hard wooden block. To avoid damage to the rubber sealing rings, care should be taken to drive the sleeve down straight into the block. Carelessness might result in a water leak in the crankcase. When the cylinder sleeve is in place the top will project approximately 0.005 inch above the top surface of the cylinder block. This permits the cylinder head to clamp the cylinder-head gasket tightly against the top of the sleeve, holding it in place and sealing it at the upper end. Because of the removable sleeve construction of this engine, oversize pistons and rings are not necessary. When appreciable wear occurs, new standard-size parts should be installed.

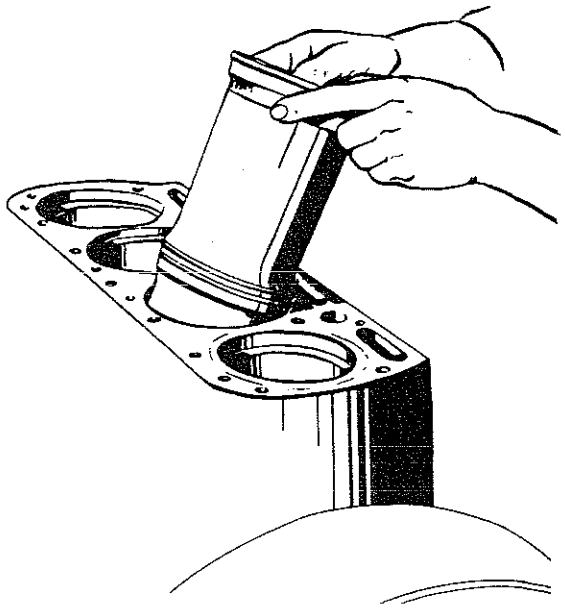

Fig. 21. Installing Cylinder Sleeves

16. Cylinder Head.

a. Removal.

Remove the water connections, manifold, cylinder head cover, oil lines, and rocker-arm mechanism. Disconnect spark-plug wires, carburetor and accessories. Withdraw the push rods and remove the cylinder head stud nuts and lift off the cylinder head. Valve seat inserts are standard for exhaust valve ports and minimize valve regrinding.

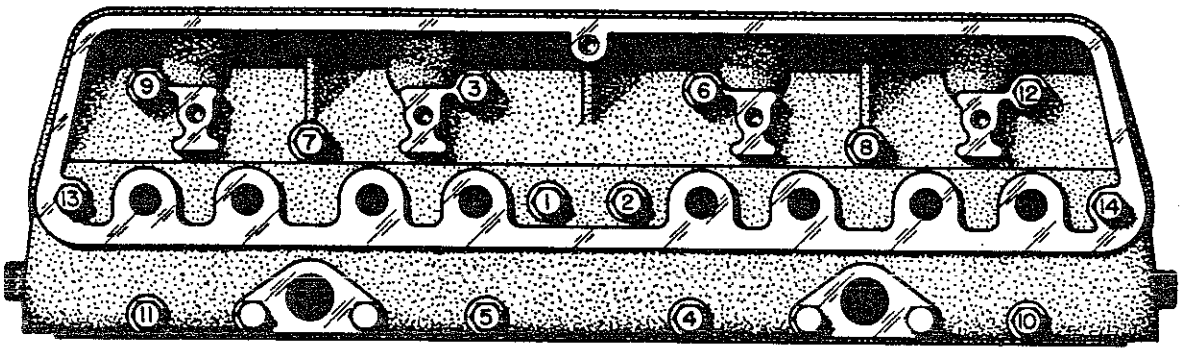

Fig. 22. Cylinder Stud Nut Tightening Sequence

b. Replacing.

Before replacing the cylinder head make certain that the surfaces of the cylinder block and head where the gasket rests are absolutely clean. It is important to tighten the cylinder head securely whenever it is replaced. This must be done carefully to prevent damage to the copper-asbestos gasket between the cylinder head and the cylinder block. When installing the cylinder-head gasket place it on the cylinder block with the beaded side up. For correct sequence in tightening cylinder head stud nuts, refer to the chart below. The cylinder-head stud nuts which are tightened when the engine is cold must be retightened when the engine is hot.

17. Piston Assemblies.

Piston Rings:	
Total required	4
Compression	3
Oil control	1
Width, compression	1/8"
Width, oil control	3/16"
Gap, compression	0.015" to 0.025"
Piston clearance	0.005" to 0.007"
Piston Pin:	
Length	3 15/16"
Diameter	1.500"
Clearance in bushing	0.0015" to 0.002"

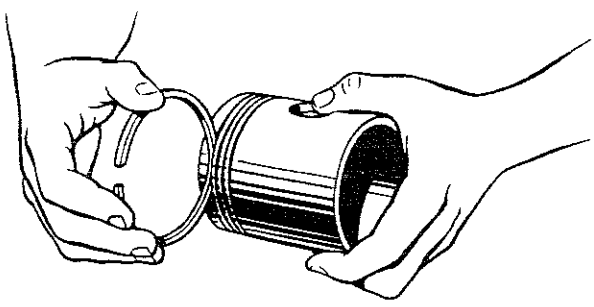

Fig. 23. Checking Piston Ring Fit to Piston

To fit the piston to the connecting rod, place the rod in the piston and slide the piston pin through the bushings. Tighten the clamp bolt in the connecting rod securely and lock in place. Fit the piston rings in the bore and assemble to the piston, making certain that the rings are free in the grooves and that the gaps are staggered. Oil the piston before replacing in engine. Pistons are numbered and should be reassembled into correct cylinders. (No. 1 starts at the front of the engine.)

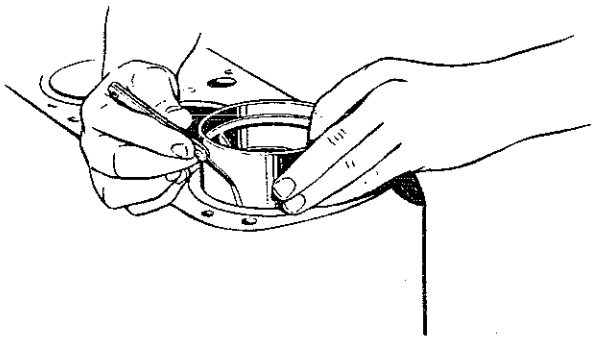

Fig. 24. Checking Piston Clearance in Cylinder

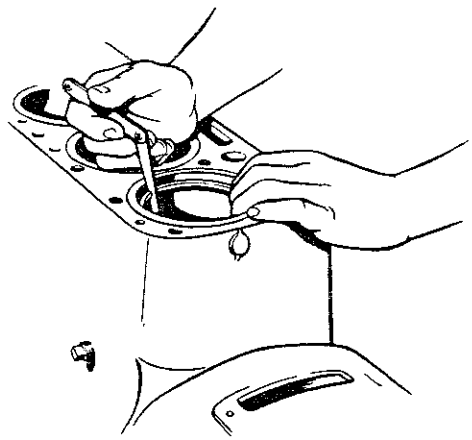

Fig. 25. Checking Piston Ring Clearance in Cylinder

18. Connecting Rods.

Connecting Rod Length, center to center	12½"
Crank pin diameter	2.875"
Bearing length, total	2.075"
Bearing running clearance	0.0025" to 0.004"
Bearing end clearance	0.012" to 0.20"
Bolts, size (special)	7/16" x 3 1/16"

The connecting rod bearings are of the babbitt-lined, steel-backed, precision type. They are not adjustable, and when clearance becomes excessive replacement is necessary. The connecting rods should be free from twist and parallel with the pistons. The connecting rods and caps are numbered with the number of the cylinder bore. Make certain that the proper cap is fitted to each rod and also that numbers correspond. No. 1 starts at the front of the engine. Place the numbered side away from the camshaft. When installing bearings be sure that the bearing backs and rod surfaces are absolutely clean, smooth, and free from oil. The bearings have a nib engaging a milled notch in rod and cap. Do not scrape the shell bearings and do not file the connecting rod nor the connecting rod cap-parting faces. Install the cap and turn the nuts down tightly, turning the engine over by hand to make sure that cap does not bind on the crank pin. Adjustment is correct when the nuts are tight and when the crankshaft may be rotated by hand with the starting crank. Replace all cotter pins and locking wires.

19. Crankshaft.

The crankshaft is drilled for pressure lubrication of the connecting rod and main bearings. Each bearing cap bears a number, which corresponds to a number stamped on the side of the crankcase.

a. Removal.

To remove crankshaft from engine it is necessary to remove entire crankcase assembly from base. The shaft is then easily removed. Remove bolts from flywheel and remove flywheel and bell housing. Remove engine front gear cover. Remove rear oil retainer assembly and disconnect connecting rods. Remove main bearing caps. The crankshaft can now be lifted out of the crankcase.

b. Replacing.

Before replacing the crankshaft be sure that the bearing caps, bearings, crankshaft journals and crankcase are all clean and absolutely dry, and oil the bearing surfaces.

(1) The front oil seal is located in the engine front gear cover with lip pointing inward, toward engine. Installation should be made by aid of a thin metal sleeve inserted inside of the seal. Slip the seal and sleeve over the crankshaft and remove the sleeve, making certain that the seal is not scratched or marred. The sleeve can be made of shim stock that can be bent into position. The rear oil seal is of the split type. To replace this the rear main bearing cap and rear oil retainer must be removed. If oil leaks behind the flywheel, check the fit of the welch plug at the rear of camshaft, replace the felt oil seal, and check the rear main bearing for excessive wear.

(2) The bearings are not adjustable. When clearance becomes excessive, replacement is necessary. The end thrust of the crankshaft is taken up by thrust washers on either side of the rear main bearing. The correct end clearance should be maintained from 0.002 inch to 0.012 inch. Bearings may be replaced without removing the crankshaft. To remove the upper half of the bearing shell, insert in the crankshaft-journal oil hole a cotter pin, or its equivalent, which has had its rounded head flattened to form a T. Then rotate the crankshaft to push out the bearing liner. The cap and bore are milled to receive a projection on the back of the bearing liner. The projection end is removed first. When replacing, rotate the shaft, and see that the projection end enters last. The bearing backs, crankcase bore, and cap bore should be absolutely clean and dry before the shells are replaced.

20. Camshaft.

Bearings, number	3
Bearing material	Bronze
Bearing journal diameter	2.250"
Running clearance	0.002" to 0.004"
Bearing length, front and center	3"
Bearing length, rear	2"
Thrust plate material	Bronze
End clearance	0.005" to 0.009"
Service bushings	Reamed to size
Camshaft drive	Helical gear
Number of teeth in gear	72

The camshaft rests in three bearings, reamed to size. To replace it, press these bearings into position. Make certain that oil holes are lined up with the holes in the crankcase. For sizes and running clearance, refer to the table above.

In order to complete the assembly of the camshaft, put the thrust plate onto the shaft, put the key into the shaft, and press the gear (72 teeth) on the shaft. Put on the lockwasher and the nut. The camshaft assembly is attached to the motor block with two capscrews (5/16 inch by 3/4 inch) with lockwashers accessible through holes in the flange of the gear. After assembly, the camshaft is put into place in the engine. To install the capscrew, it is necessary to rotate the gear slightly, either forward or backward.

The drilled holes in the camshaft center bearing journal supply metered oil to the valve rocker mechanism. Valve tappets may be removed and replaced when camshaft is removed.

When installing the camshaft make certain that the marked teeth on the gear mesh with the marked teeth on the crankshaft gear. (See Fig. 19.)

21. Valves.

Valve seat, width	3/32"
Valve seat, angle	45°
Valve seat, insert	Exhaust only
Valve stem guides (replaceable)	Grey iron
Valve stem, diameter	0.434"
Valve stem clearance in guide (intake)	0.0025" to 0.004"
Valve stem clearance in guide (exhaust)	0.0045" to 0.006"
Valve clearance, hot	0.015"
Valve clearance, cold	0.018"
Rocker arm shaft, diameter	0.998" to 0.999"
Rocker arm bushing, diameter	1.001" to 1.0015"

a. Intake Valves.

Head diameter	1 7/8"
Port diameter	1 11/16"
Valve opens	5° after top dead center
Valve closes	41° after bottom dead center

b. Exhaust Valves.

Head diameter	1 3/4"
Port diameter	1 11/16"
Valve opens	42.5° before bottom dead center
Valve closes	8.5° after top dead center

Valve stem guides are furnished as service parts but are not reamed to size. It is necessary to press them into place and ream them. After new valve guides are installed it is necessary to recut the valve seats.

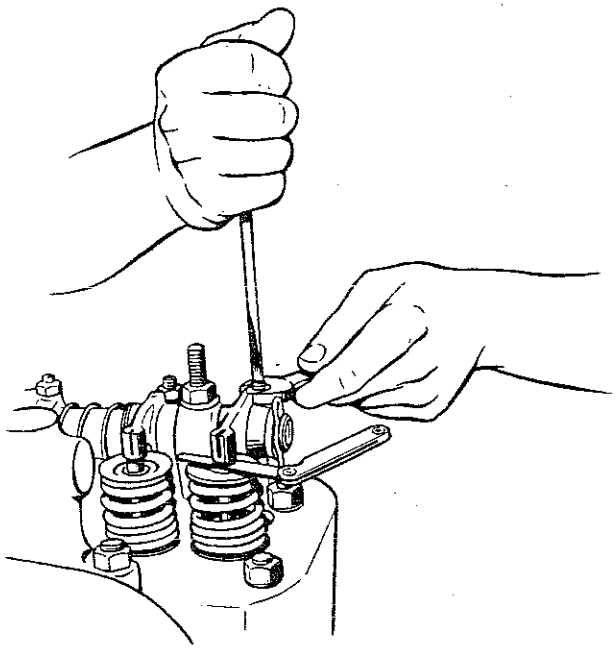

Fig. 26. Adjusting Valve Clearance

When service inserts are to be installed, it is necessary in most cases to use oversize inserts and to remachine the insert seat for a true fit. Allow approximately from 0.004 to 0.005 inch for press fit of insert. Do not drive the insert into place, as this will invariably cause trouble. A recommended practice is to pack the inserts in dry ice for approximately ten minutes before dropping them into position. Pliers should be used for handling. After the inserts reach atmospheric temperature, make certain that they are seated squarely. If a furling tool is available, it should be used. It is unnecessary to peen the head, since this does not insure a tight fit. Extreme care should be given in making this replacement. Rocker arms can be removed, as outlined for the cylinder head. Recheck valve tappet settings, after removing the rocker mechanism or head. Push rods are of tubular steel. Tappets are fitted into the crankcase, and are removable from the bottom after removing the camshaft. Lubrication to tappets is by splash and by returning oil from the rocker mechanism.

22. Engine and Alternator Alignment.

The engine and alternator are aligned accu-

rately on the bedplate by means of shims under the alternator. When the alternator is removed, the shims must be marked so that they can be replaced in the original manner. Alignment is maintained by dowels in the engine base and the alternator feet. These dowels must be removed before attempting to remove the engine or the alternator, and they must be replaced upon reassembly.

The engine and alternator are connected by full metallic coupling. In aligning, the alternator shaft is brought within 0.003 inch of concentricity with the inner bore of the engine flywheel, with the sub-base level and free of strains. When installing the completely assembled unit in a truck or on a floor, shims must be placed around each foundation bolt so that when the foundation bolts are tightened the bedplate will not be distorted.

23. Power Take Off.

The only field service required for the coupling is that involving the occasional replacement of disks. If the alignment is maintained and the nuts on the coupling bolts kept tight, there will be practically no service replacement of these items. The method of removal of disks for service is obvious upon examination of the coupling.

24. Trouble and Possible Causes.

a. Engine Hard to Start.

(1) Battery:
- (a) Battery not fully charged.
- (b) Loose battery terminals.
- (c) Electrolyte low.

(2) Magneto:
- (a) Worn brushes.
- (b) Oil or water soaked.
- (c) Coil damaged.
- (d) Brushes sticking.
- (e) Magnets weak.
- (f) Condenser faulty.
- (g) Points worn or pitted. See instructions herein.
- (h) Points sticking.

(3) Fuel system:
- (a) No fuel in tank.
- (b) Fuel flow obstructed.
- (c) Air vent in fuel tank filler cap clogged.
- (d) Fuel pump filter clogged.
- (e) Too much fuel. Carburetor flooded.
- (f) Water in fuel supply.
- (g) Improper fuel mixture.
- (h) Valves and jets clogged with gum from fuel.

(4) Miscellaneous:
- (a) Loose or defective wiring.
- (b) Spark plugs cracked or shorted by external dirt.
- (c) Spark plugs fouled.
- (d) Cables connected to wrong plugs or coated with paint.
- (e) Throttle or governor valves loose on shafts.
- (f) Intake manifolds or gaskets leaking.
- (g) Valves not seating properly.
- (h) Improper timing of ignition or valves.
- (i) Improper tappet clearance.
- (j) Muffler clogged.

b. Faulty Carburetion.

See carburetor instructions herein.

c. Excessive Smoke from Exhaust.

(1) Too much oil in crankcase.
(2) Carburetor needle valve open too far.
(3) Carburetor float sticking or leaking.
(4) Lubricating oil too thin to seal piston rings.
(5) Worn bearings, rings, cylinders and valve guides.

d. Explosion in Muffler.

(1) Spark retarded.
(2) Weak spark.
(3) Valves not seating or out of time.
(4) Exhaust valves warped.
(5) Missing on one or more cylinders.

e. Engine Overheating.

(1) Lack of water.
(2) Fan belt slipping.
(3) Water hose obstructed.
(4) Water hose collapsing.
(5) Carburetor choke control partially pulled out.
(6) Improper fuel mixture.
(7) Radiator clogged.
(8) Cylinders limed.
(9) Improper ignition timing.
(10) Valves leaking.
(11) Oil badly diluted.

(12) Lack of oil.

f. Engine Lacks Power.
(1) Valves warped or sticking.
(2) Valve seats worn.
(3) Cylinders or pistons badly worn or scored.
(4) Piston rings weak or worn.
(5) Piston rings sticking.
(6) Improper fuel mixture.
(7) Improper timing of ignition or valves.
(8) Muffler clogged.
(9) Governor or throttle levers loose on shafts.
(10) Oil badly diluted.
(11) Air cleaner requires cleaning.
(12) Fuel not suited to engine. Octane rating too low.

g. Engine Knocks.
(1) Excessive carbon deposits in combustion chambers.
(2) Loose main bearing.
(3) Loose connecting rod bearing.
(4) Valve tappet clearances too great.
(5) Valve not free in guides.
(6) Worn pistons, piston pins or cylinders.
(7) Engine overheated.
(8) Tight pistons or pins.
(9) Loose flywheel.
(10) Lack of oil or water.
(11) Worn timing gears.
(12) Spark advanced too much.
(13) Fuel not suited to engine. Octane rating too low.

h. Engine Missing.
(1) Spark plugs fouled.
(2) Spark plugs cracked or shorted by external dirt, or moisture.
(3) Improper spark plug gap.
(4) Defective wiring.
(5) Ignition breaker points sticking.
(6) Improper breaker point gap.
(7) Faulty condenser.
(8) Cylinder-head gasket leaking.
(9) Intake manifold or gaskets leaking.
(10) Valves warped or broken.
(11) Valves or tappets sticking.
(12) Valve tappets improperly adjusted.
(13) Valve springs weak or broken.
(14) Dirt or water in fuel system.

i. Explosion in Carburetor or Intake Manifold.
(1) Fuel mixture too lean. See carburetor instructions herein.
(2) Valves or tappets sticking.
(3) Intake valve springs weak or broken.
(4) Intake valves warped or broken.
(5) Intake tappets set too close.
(6) Incorrect timing of ignition or valves.
(7) Intake manifold or gaskets leaking.
(8) Cylinder head gasket leaking.

j. Poor Compression.
(1) Valves not seating properly.
(2) Valves or tappets sticking.
(3) Valve tappets set too close.
(4) Valves incorrectly timed.
(5) Weak valve springs.
(6) Piston rings sticking, weak or worn.
(7) Loose or cracked spark plugs.
(8) Cylinder head gasket leaking.
(9) Oil too thin to seal piston rings.
(10) Scored or worn pistons or cylinders.

25. Magneto.

ROTATION	Clockwise
SPARK	Fixed
COUPLING	1CA2A2
SETTING	33°

The magneto, which produces an ignition spark only at certain definite points in the rotation of the magnet rotor (7) (see Figs. 27 and 28), must be connected to the engine in such a manner that the spark is available always at the instant when required in the cylinder, i.e., about top dead center of compression stroke, with magneto set in retard position. The proper operating results are obtained by timing the engine and the magneto as follows (see Figs. 27 and 28). It is unnecessary to remove the distributor plate for this purpose.

a. How to Time the Magneto.
Remove the cap (20) from radio shield cover (13) (refer to Figs. 27 and 28). To prevent the engagement of coupling weights, rotate the impulse coupling (6) in the opposite direction to which magneto is to be driven, passing through the "contacts open" point to a position slightly beyond the point where

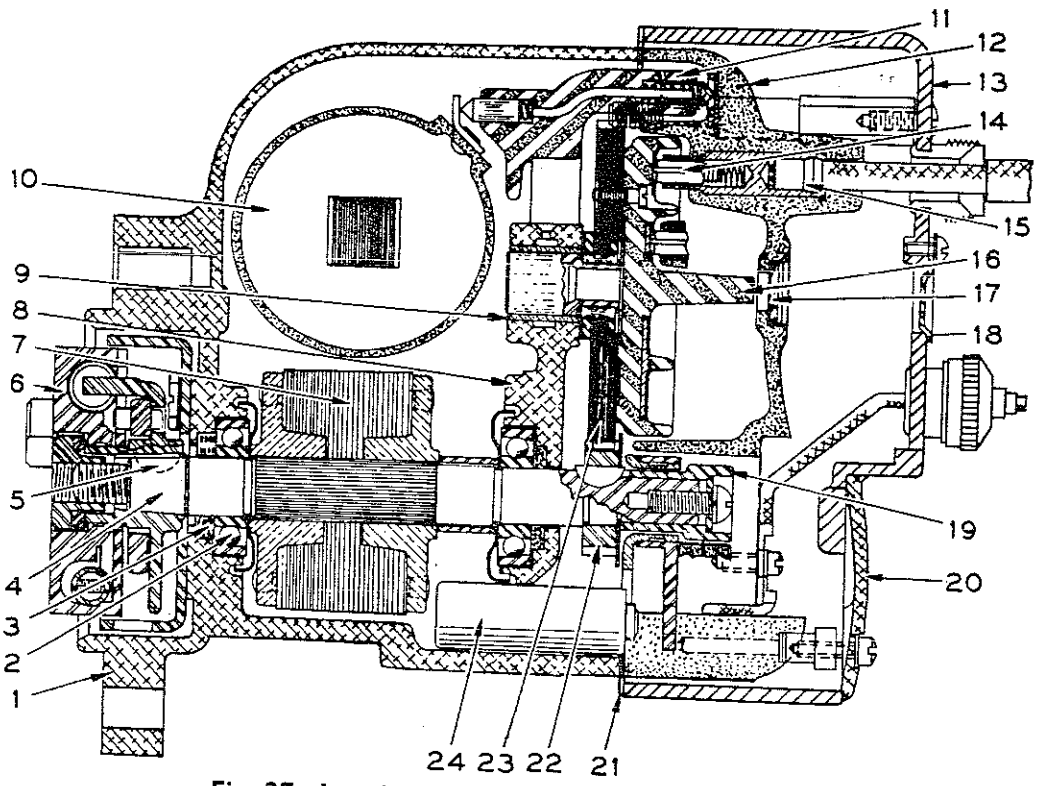

Fig. 27. Longitudinal Section through Magneto

the contacts (28) close. Then rotate coupling (6) in correct direction of rotation, until contacts (28) are just separating. With piston of No. 1 cylinder in firing position of compression stroke, both the engine and the magneto are in their correct relation for firing. Connect magneto drive to engine. The arrow visible through the observation cover (18) of the radio shield (13) and window (17) of the distributor plate (12) points to the cable outlet which is to be connected to No. 1 cylinder (that nearest the radiator). Complete the installation by connecting the remaining cables of the magneto to the spark plugs in the proper firing order (1-2-4-3). The firing sequence of the distributor, or high-tension end of the magneto, follows the opposite direction of rotation from that indicated by the arrow on the magneto nameplate, and must be taken into consideration when cables are connected to spark plugs. Replace the cap.

b. **Trouble Shooting.**

In case of defective ignition, it must first be determined whether the fault is in the magneto, or, as is more probable, elsewhere. Generally, when only one cylinder misfires, the fault is in the spark plug.

c. **Plug Gap.**

The distance between the electrodes of the spark plug varies according to the individuality of the engine, but, normally, this distance should not be less than 0.025 inch. On the other hand, too wide a gap increases the electrical resistance and interferes with the operation of the engine at low speed. Difficulty in starting an engine, and missing at low speed, are very often caused by the spark plug gaps being too wide, and as the spark will have a tendency to burn the electrodes and thereby gradually increase the gap, it is especially important that the plugs be examined occasionally to see that the gap is not too great; any difficulty of this nature may be overcome readily by readjusting the electrodes.

d. **Plug Short-circuited.**

This is usually caused by a cracked or porous insulator, or by fouling of the electrodes or insulator. Any of these conditions cause misfiring by permitting the current to stray from its intended path.

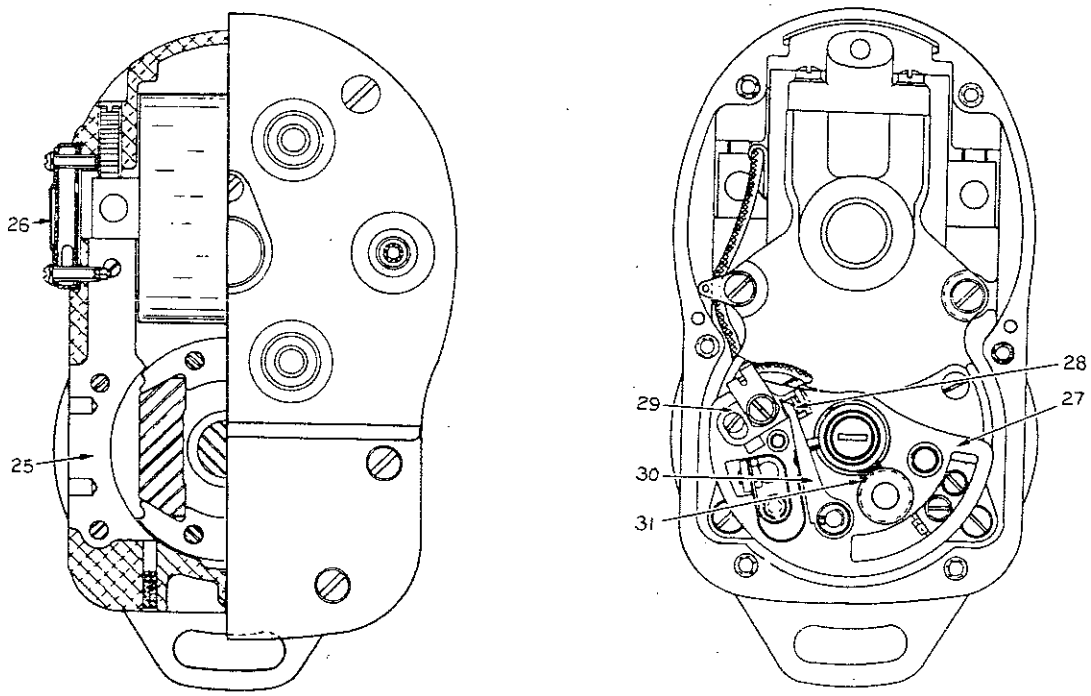

Fig. 28. Cross Section through Magneto

e. Cables.
Misfiring of one cylinder, either continuous or intermittent, may be caused by a chafed or broken cable or a loose cable connection. The metal terminals of the cables must not come into contact with any metal parts of the engine or the magneto, except those designated in the instructions.

f. Irregular Firing.
If the cables and plugs are in good condition and yet the ignition is irregular, the trouble is probably with the magneto, and the interrupter assembly (27) (see Fig. 28) should be carefully examined. It should be seen that the interrupter lever (30) moves freely and contacts (28) are clean and in correct alignment. (See paragraph 25 h below.)

g. Damaged Insulating Parts.
As it sometimes happens that distributor plate and control arm cap parts of the magneto are damaged through accident or carelessness, these parts should also be carefully examined for possible disarrangement or damage which might permit leakage of current.

h. Interrupter.
The interrupter contacts (28) should be adjusted to an opening of from 0.014 inch to 0.016 inch when the interrupter lever (30) fiber bumper rests on the top of the cam (19). This is done by means of the adjustable contact bracket (29) which can be shifted by an eccentric screw until the correct opening has been reached. After adjustment, the bracket (29) must be secured by means of its fastening screws. Contact points (28) must be free from oil or grease and be in proper alignment, so that the full surfaces of both contacts meet squarely. Pitted contacts (28) can be either filed flat or cleaned on a suitable stone. When point renewal becomes necessary, always replace both interrupter lever and contact bracket at the same time.

i. Spark Plugs.
Remove the spark plugs every 200 to 300 working hours, or oftener if necessary, for cleaning and checking the gaps between electrodes. A gap of from 0.025 inch to 0.030 inch

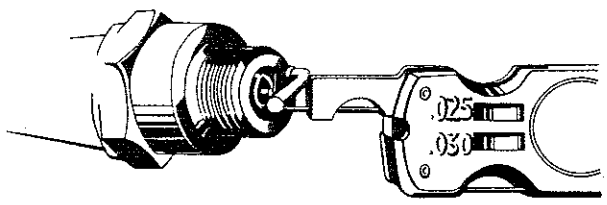

Fig. 29. Adjusting Spark Plug Gap

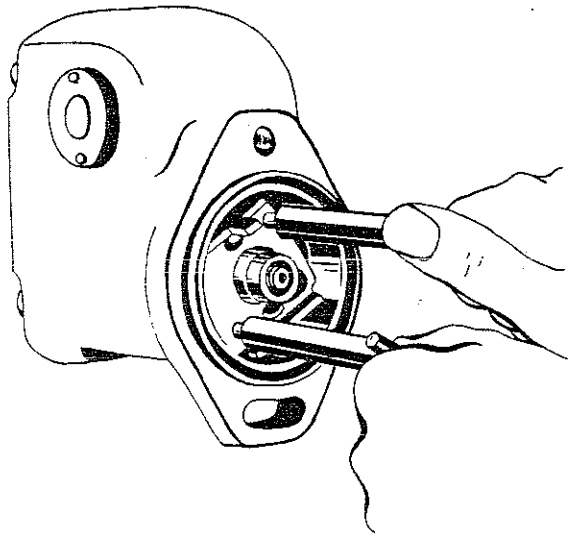

Fig. 30. Removing Impulse Coupling

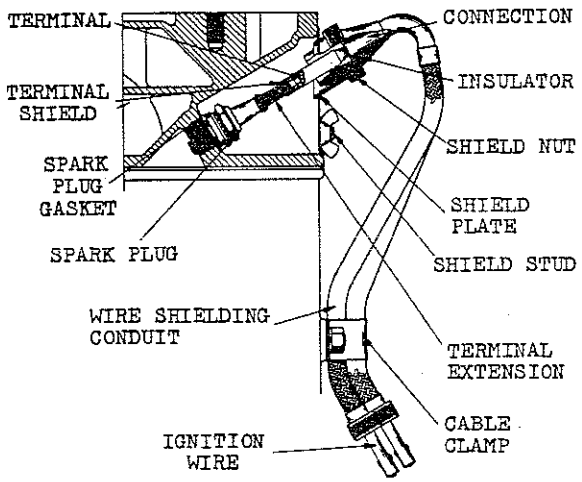

Fig. 31. Ignition Radio Shielding

should be maintained at all times. When making this adjustment, always bend the outer electrode. Never bend the center electrode, as this will damage the insulator. If the gap between electrodes is too great, because of improper setting or burning off of the ends, the engine will misfire and be hard to start, and may produce radio interference.

The recommended method of cleaning spark plugs is by sand-blasting. Never scrape or clean the insulator with anything that will scratch the porcelain, because scratched porcelain allows carbon and dirt to accumulate much faster.

j. Spark Plug Cables.

If the spark plug cables are removed for any reason, mark or tag the number of each cable

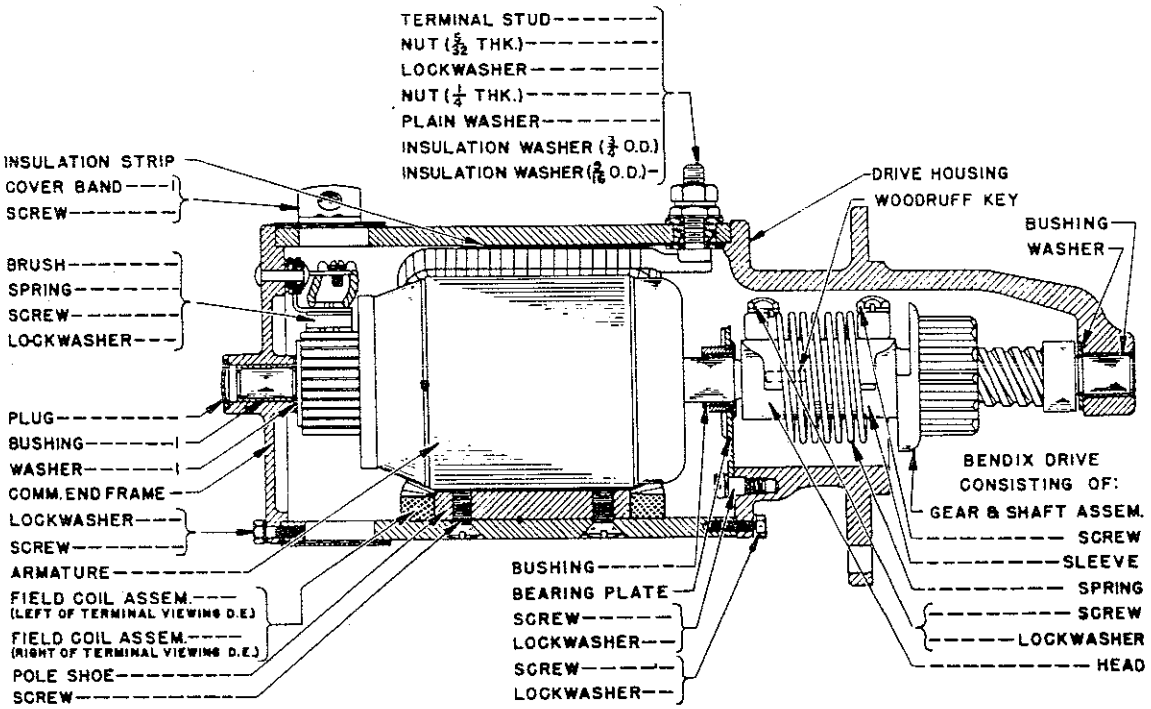

Fig. 32. Longitudinal Section through Cranking Motor

with reference to the magneto distributor cap. The wiring diagram in the appendix shows correct wiring.

26. Cranking Motor.

a. Service Instructions.

(1) No lubrication is required to service this motor, since all three bushings are of the oilless type. However, whenever the cranking motor is disassembled for cleaning, put a few drops of light engine oil in each bushing.

(2) Remove the cover band and inspect the commutator and brushes at regular intervals (approximately once every three months).

(3) If the commutator is dirty, clean with No. 00 sandpaper. **Never use emery cloth.**

(4) If the commutator is rough, out of round, or has high mica, turn it down in a lathe.

(5) Replace worn brushes. Check for high brush-spring tension, rough commutator or high mica if rapid brush wear is experienced.

(6) Burned commutator bars indicate open circuited armature coils. Inspect soldered connections at the riser bars, resolder if necessary and turn down commutator.

(7) The magnetic switch will require no servicing except to make sure that connections are tight and cover plug securely in place.

b. If Cranking Motor Does Not Operate Properly.

(1) Check battery, battery cables and connections.

(2) Remove cover plug from magnetic switch to make sure that the plunger is pulling in to close the cranking-motor-to-battery circuit when control switch is operated.

(3) Check commutator and brushes as above.

(4) Check for tight or dirty bushings, bent shaft or worn bushings which would allow the armature to drag on pole shoes.

(5) If the trouble has not yet been found, remove cranking motor, inspect Bendix drive, and check cranking motor specifications, which should be as follows:

Clockwise rotation viewing drive end.

Brush spring tension 36 to 40 ounces.

No load test—80 amperes at 11.2 volts at 4,500 rpm.

Stall torque test—670 amperes at 5.35 volts give 32 pound-feet torque.

Caution: Never operate the starter continuously for more than 30 seconds without pausing to permit the cranking motor to cool off. Excessively long cranking periods will cause the cranking motor to overheat and fail.

27. Magnetic Switch.

The magnetic switch requires no attention or lubrication. Check occasionally to make sure that mounting screws and electrical connections are clean and tight.

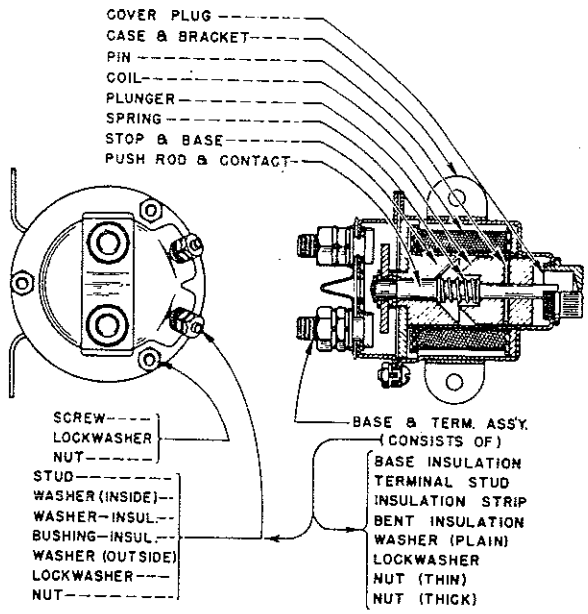

Fig. 33. Cross Section through Magnetic Switch

28. Generator.

The control unit consists of a cut-out relay which opens and closes the circuit between the generator and the battery, and a voltage control, which permits full generator output of from six to eight amperes (generator at operating temperature) until the battery becomes charged, at which time the voltage control operates and reduces the generator output to a small trickle charge of approximately two amperes—sufficient to maintain the battery in a charged condition without overcharging it.

(1) Add from eight to ten drops of light engine oil to each hinge cap oiler every 128 hours of operation.

(2) Remove the cover band and inspect the

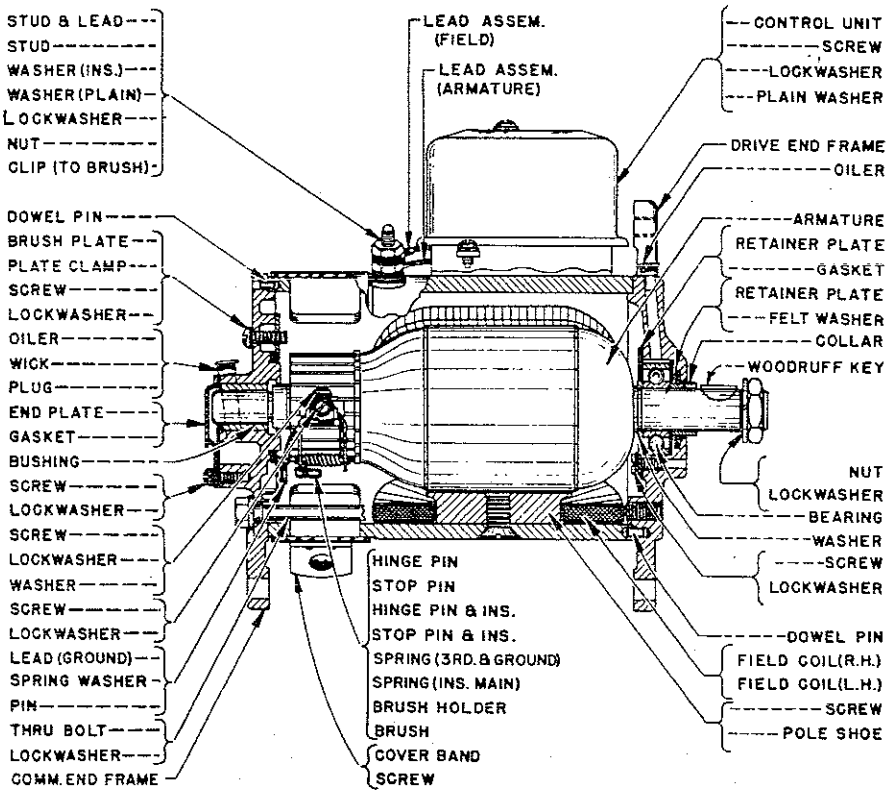

Fig. 34. Longitudinal Section through 12 Volt Generator

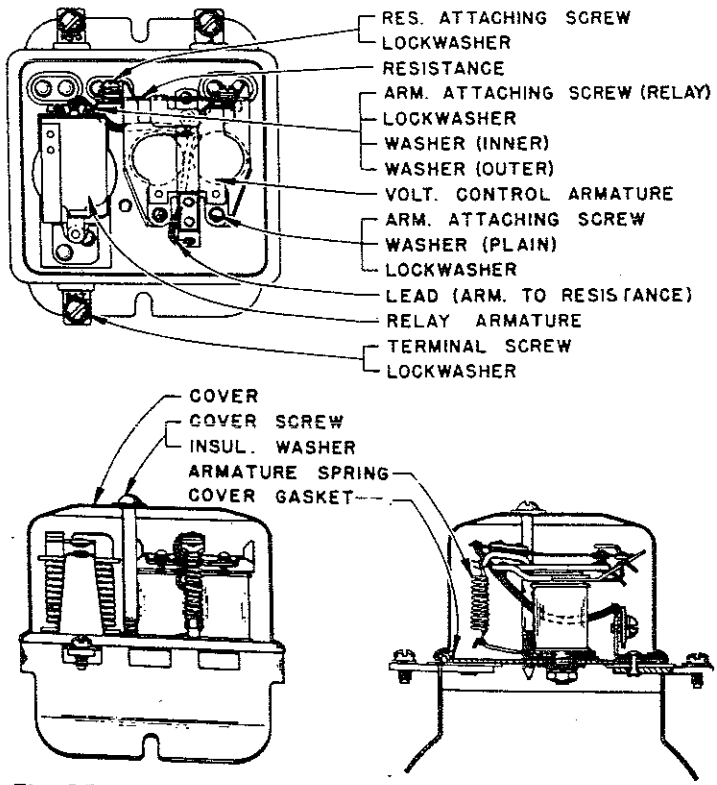

Fig. 35. Cross Section through 12 Volt Voltage Regulator

commutator and brushes at regular intervals (approximately once every three months).
(3) If the commutator is dirty, clean with No. 000 sandpaper. **Never use emery cloth.**
(4) If the commutator is rough, out of round, or has high mica, turn it down in a lathe, and undercut the mica.
(5) Replace worn brushes. Check for high brush-spring tension, rough commutator or high mica, if rapid brush wear is experienced.
(6) Burned commutator bars indicate open-circuited armature coils. Inspect the soldered connections at the riser bars, resolder if necessary, then turn down the commutator and undercut the mica.
(7) Be sure all leads are in good condition and all connections are tight. Generator specifications are as follows:

Clockwise rotation viewing drive end.
Brush spring tension—16 ounces.
Output at operating temperatures—6-8 amperes at 14.1-14.5 volts at 2400 rpm.

Voltage control specifications are as follows:

Cut-out relay closes—12.9-13.9 volts.
Voltage control points open (to cut down generator output)—14.1-14.7 volts.
Voltage control points close (to permit output to increase)—12.0 volts maximum.

NOTE: No attempt should be made to test or adjust any part of the generator circuit without the proper testing equipment.

Never operate the generator on open circuit (circuit between the generator and battery disconnected). To do so will cause damage to the generator. It is possible to operate with the circuit open between the generator and battery if the lead is disconnected from the F terminal of the generator.

29. Storage Battery.

a. Electrolyte.

To prevent failure of battery it is important that the electrolyte be kept at the proper level at all times.

b. Care of Battery.

Keep the vent hole in the battery filler caps open.

Inspect the battery once a week or oftener to keep the water at the correct level and to maintain the correct specific gravity. The specific gravity reading of about 1.250, corrected to 80 degrees Fahrenheit, should be maintained. (See Battery Testing Chart following.) **Caution: If water is added to the battery when the temperature is near the freezing point (32 degrees Fahrenheit) always run the engine long enough to mix the water and the electrolyte so that the water will not freeze.**

Acid or electrolyte should never be added except by a skilled battery man. Under no circumstances should any special "dopes," solutions, or powders be added.

The electrolyte in each cell should be approximately one-half inch above the plates. When the electrolyte is below this level, pure **distilled water** should be added. Never use hydrant water, or any water which has been in a metal receptacle. Keep on hand a glass jar of pure distilled water for battery use only. Use a clean syringe to put water in a cell.

The battery cable terminals must be clean and tight. Use hot water to remove any terminal corrosion, and also for cleaning the top of the battery. Brighten the terminal contact surfaces with wire wool, apply a light coat of vaseline and reassemble. Be sure that the terminals are clamped tightly and that the battery is clamped securely in place.

c. Battery Testing Chart.

Condition	*Cause*	*Procedure*	*Remedy*
1. Hydrometer test shows all cells over 1.250 specific gravity and readings practically equal (within 10 or 15 points).	Battery is probably in good condition.	Battery does not require a recharge in summer months, but may require a boosting charge in cold weather.	Examine battery terminals to see that they are tight and clean; ascertain charging rate of generator.

c. Battery Testing Chart (continued)

Condition	*Cause*	*Procedure*	*Remedy*
2. Hydrometer test shows all cells reading 1.250 or less and readings practically equal (within 10 or 15 points).	Demand from battery greater than input from generator.	Recharge battery.	Make a thorough check on electrical system for short circuits, loose connections, and charging rate of generator. Recommend an increase in charging rate to suit.
3. Cells unequal (20 or more points variation) and highest reading over 1.225 specific gravity.	a. Short circuit in low cell or cells. b. Evaporation caused by overcharging. c. Unnecessary addition of acid. d. Loss of electrolyte by leakage.	Make momentary high rate test on each cell.	If high rate test shows that all cells are within from 1 to 10 volts of each other, recharge battery until gravity of electrolyte remains constant for 4 hours. Adjust gravity of all cells by adding water or small amount of acid (1.400 specific gravity or less).
4. Cells unequal (20 or more points variation) and highest cell reading 1.225 or less.	a. Short circuit in low cell or cells. b. Evaporation caused by overcharging. c. Unnecessary addition of acid. d. Loss of electrolyte by leakage.	Recharge battery if possible, and then make momentary high rate discharge test on each cell.	If battery takes a recharge and high rate test shows all cells within from 1 to 10 volts, adjust gravity of all cells by adding water or small amount of acid (1.400 specific gravity or less).
5. Hydrometer tests show cells with gravity readings over 1,300 at 80 degrees Fahrenheit.	a. Unnecessary addition of acid to cells.	a. If battery has not been operated for a long period or at an excessively high gravity, this condition may be remedied by careful treatment.	a. Drain out all solution from cells. Refill with dilute (1.000 specific gravity) electrolyte and charge at a low rate of current until gravity of electrolyte remains constant for 4 hours. Then drain cells again and refill with 1.285 specific gravity electrolyte and after 3 hours charging adjust gravity to 1.285. Continue charge until the gravity of all cells is constant for a period of 2 hours.
	b. Addition of battery compounds commonly known as battery "dope" solutions.	b. No positive assurance can be given that conditions arising from the use of battery compounds can be remedied. A number of battery manufacturers construe the use of battery "dope" solutions as grounds for cancelling their warranty.	b. Treat as in preceding paragraph (a). Under no circumstances should battery compound be introduced into a battery.

c. Battery Testing Chart (concluded)

Condition	*Cause*	*Procedure*	*Remedy*
6. Battery is fully charged but hydrometer tests show gravity to be 1.265 or less at 80 degrees Fahrenheit.	Excessive evaporation usually caused by overcharging.	Adjust gravity of electrolyte to proper limits by adding small amounts of acid (1.400 specific gravity or less).	Ascertain charging rate of generator and reduce the rate if necessary.
7. Frequent additions of water to all cells of battery.	Excessive overcharging.		Reduce charging rate of generator.
8. Container cracked, causing frequent additions of water to one cell of battery.	a. Loose installation. b. Stone bruise c. Frozen battery.		Replace with new container.
9. Bulge in battery container.	Excessive temperature, probably caused by overcharging.	Same as for condition 3 or 4.	If high rate test indicates any weak cells, the battery probably is beyond repair. In all cases, ascertain charging rate and reduce the rate if necessary.
10. Corrosion on battery terminals.	a. Excessive charging rate causing spray of acid on terminals. b. Lead coating destroyed on terminals.	Remove terminals from posts. Clean posts and terminals thoroughly. Replace terminal cable if corroded excessively.	Grease terminals and posts thoroughly to prevent access of acid to terminals, bolts and nuts. Ascertain charging rate and reduce rate if necessary.
11. Broken terminal posts.	a. Loose battery installation. b. Terminal cable too short.	Remove battery and build up new terminal post.	Replace terminal cable with one of proper length; tighten battery in carrier and also battery terminals on posts.

d. Tools.

To diagnose the conditions stated in the foregoing paragraphs the battery station must have the following tools:

(1) A good, accurate hydrometer graduated to read from 1.100 to 1.325 with divisions to indicate differences in gravities within ten points.

(2) A good, accurate thermometer graduated to read as high as 115 degrees Fahrenheit. Many batteries are damaged because of high temperatures; this condition can be determined only by means of a thermometer.

(3) A good, single-cell-type voltmeter, having a three-volt scale with division showing one tenth of a volt (possibly an additional scale reading 15 volts to read total battery voltage).

(4) A good, high-rate discharge tester; this instrument may be either a single-cell tester

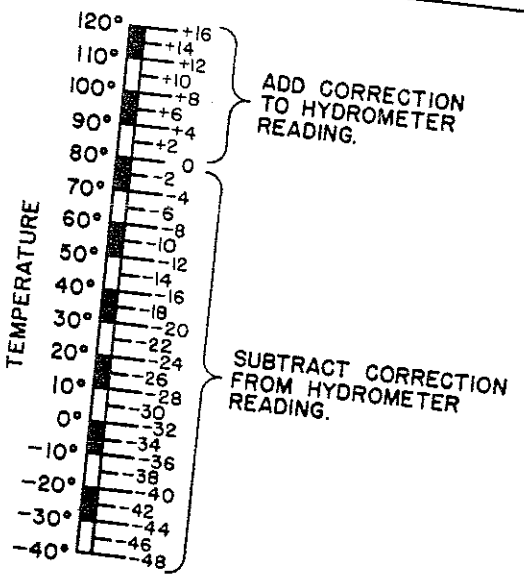

Fig. 36. Hydrometer Reading Correction Chart

or a more elaborate type adapted to test the complete battery.

e. **Charging Instructions.**

Regular starting and lighting batteries should be charged at a current rate not exceeding one ampere per positive plate. A rate of four or five amperes is usually suitable for the majority of batteries. During the charge, a thermometer should be used to check the temperature of the electrolyte in the cells. If the temperature exceeds 110 degrees Fahrenheit, reduce the charging rate immediately, or else discontinue the charge until the battery temperature is less than 90 degrees Fahrenheit. Charge the battery until all cells gas freely and the specific gravity of electrolyte remains constant for four hours. Adjust the gravity of cells at end of charge to proper limits if necessary. The specific gravity of a fully charged battery should be between 1.275 and 1.295 at a temperature of 80 degrees Fahrenheit.

f. **Conditions Within the Battery.**

No battery should be returned to the manufacturer, nor should it be opened for inspection before its condition is diagnosed in accordance with the procedure given in this chart. When readings obtained with the high-rate test differ considerably more than one tenth of a volt, it is proper to open the battery. The separators may be found to be worn thin in places, or broken, or split. If the plates are in good condition, however, the separators may be replaced and the battery recharged. If the positive plates are badly buckled or the positive grids are broken, the battery is not in condition for further service. Such a battery either was badly overcharged or else may have been in service for a long period of time.

Example: A battery cell has a hydrometer reading of 1.245 at ten degrees Fahrenheit. What is specific gravity at 80 degrees Fahrenheit?

From the correction scale, illustrated in Fig. 36, we find that the correction is minus 28 points in gravity. Subtracting 28 points from hydrometer reading gives the correct specific gravity of the battery, 1.217 at 80 degrees Fahrenheit.

30. Control Switch Box.

The purpose of these controls is to shut down the engine when the oil pressure drops below five pounds per square inch, or when the water temperature rises above 195 degrees Fahrenheit, while the engine is running.

The thermostat has a two-circuit single-throw switch which connects both of the terminals to the grounded side of the battery whenever the temperature of the water in the engine exceeds 195 degrees Fahrenheit. One of these terminals is connected to the magneto so that the magneto is shorted when the thermostat switch closes. The other terminal is connected to one side of the pilot light, which indicates when shutdown is caused by high water temperature. The other side of this pilot light is connected to the live side of the battery so that it will light when the thermostat switch closes. After the switch has closed, it will not reopen automatically, no matter how cool the water in the engine. The reset button on the top of the thermostat cabinet must be pressed before it will open, turning out the pilot light and removing the short from the magneto so that the engine can be restarted. When it is necessary to start the engine immediately after it has been shut down because of too high water temperature, the radiator should be filled and the reset button held down while the start button is pushed. The reset button should be held down until the cooler water has been circulated to reach the thermostat bulb. It may then be released and the engine will continue to run.

The oil pressure switch closes whenever the oil pressure drops to less than five pounds per square inch, and opens when the oil pressure rises above nine pounds per square inch. Whenever the engine stops, the oil pressure will drop to zero; the oil pressure switch therefore cannot be used to light the indicating pilot as with the thermostat since oil failure would then be indicated whenever the engine was not running. Hence it is necessary to add a relay which will close whenever the oil pressure drops too low while the engine is running, but will not close when the drop in oil pressure is caused by the engine slowing down. This selective action is accomplished by connecting the relay coil across the

generator which charges the storage battery. Whenever the engine is running at nearly normal speed, the generator will be charging the battery and its voltage will be enough to close the relay whenever low oil pressure causes the switch to close. However, when the engine slows down (stopped manually) the generator voltage drops until the automatic cutout opens, disconnecting it from the battery, and the generator voltage continues to drop as the speed decreases. The oil pressure drops more slowly so that when the oil pressure switch finally closes, the generator voltage is not sufficient to close the relay and therefore oil failure will not be indicated.

In case of generator failure, the engine can still be run, but the low-oil-pressure safety feature will not be working. If it is important to retain the low-oil-pressure safety feature, it will be necessary, whenever the engine is run, to connect terminal 1 of the pressure switch directly to the battery for as long as the generator is not working. With this connection, oil failure will be indicated each time the engine stops, but the engine will be stopped whenever the oil pressure fails. The start button can be touched to turn out the oil-failure pilot light when the engine is stopped.

The sequence of operation is as follows: If the water-temperature pilot is lighted, the thermostat-reset button should be pressed, and, if necessary, held down while starting. Pressing the start button will drop out the relay and turn out the oil-pressure pilot light if it is on. The start button must be held in until the oil pressure builds up. There is no danger of holding the start button in too long, since once engine is running the Bendix drive automatically disconnects the starter when the engine is started.

Caution: If the engine fails to start do not hold starting button in for more than 30 seconds without allowing the cranking motor to cool.

If the oil pressure pilot lights when the start button is released, the oil level should be checked. This light could be caused, however, by the oil being so cold that the pump cannot build up pressure, or by the oil in the pipe leading to the oil-pressure switch having been solidified by the cold so that it will not transmit the pressure. This condition will correct itself after the engine reaches operating temperature.

After the engine is running, if the oil pressure drops until the oil-pressure switch closes, the relay coil is connected across the generator and the relay closes. When the relay is closed, the coil is connected directly across the battery and remains closed until the start button is touched. This opens the coil circuit so that the relay drops out and the circuit cannot be closed again until oil pressure fails while the engine is running. Closing of the relay also makes a connection from the magneto to ground, shorting the magneto and stopping the engine.

31. Carburetor.

In servicing the carburetor, refer to Figs. 37 and 38.

a. Main Jet System.

The main or high-speed jet (2) exerts its principal influence at the higher engine speeds. Fuel from the bowl is metered through the main jet and discharged into the

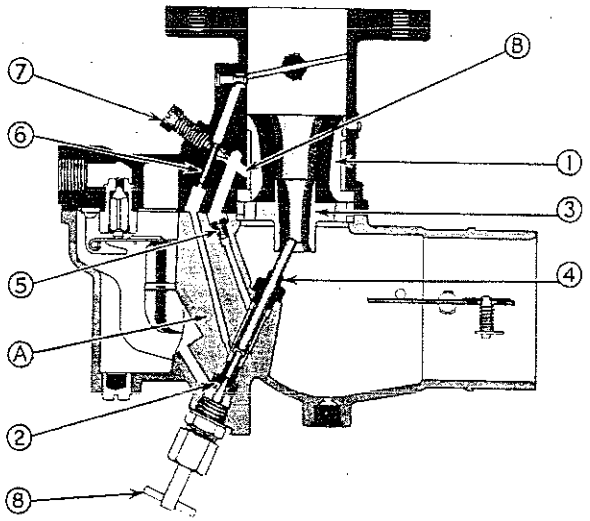

Fig. 37. Cross Section through Carburetor

air stream at the point of greatest suction, in the secondary venturi (3) through the main discharge jet (4).

The main jet determines the maximum amount of fuel to be obtained for high-speed

operations. The main-jet adjustment (8) reduces this amount if it is turned toward its seat. Ordinarily the main-jet adjustment has no effect after it is two turns open.

To set this adjustment, retard the spark and move the throttle to approximately one-quarter open. Turn the adjustment clockwise, shutting off the fuel until the engine speed is decreased by the lean mixture. Open the adjustment until the engine speed is decreased by excess fuel. The adjustment should be set at a position halfway between these two extremes.

b. Compensating System.

The compensating system consists of the main discharge jet and the well vent (5). The flow of fuel from the main jet is controlled by the size of the well vent and the size of the main discharge jet. The mixture delivered through the main discharge jet may be made richer either by increasing the size of main discharge jet or by decreasing the size of the well vent. Conversely, the mixture may be made leaner by reversing this procedure.

c. Idling System.

The idling system consists of the idling jet (6) and the idle adjusting needle (7). The idling jet receives its fuel from the main jet through channel (A). The fuel is metered through the idling jet and is mixed with air which is admitted from behind the venturi (1) through channel (b). The idle-adjusting needle controls the amount of air which is admitted to the idling system, which functions only at idling and low speeds. At these speeds, the throttle plate is almost closed and there is a very strong suction past the edge of the throttle plate. This suction draws the mixture of fuel and air from the idling jet which discharges into the air stream through the priming plug.

d. Removal.

Removal of the carburetor may be accomplished in the following manner.

(1) Disconnect the air cleaner and connection from the carburetor.

(2) Disconnect the choke wire and remove the lever from the end of the governor operating cross shaft.

(3) Disconnect the fuel inlet line.

(4) Take out the carburetor-to-manifold capscrews and remove the carburetor by pulling away from the engine, using caution not to damage cross shaft or bushings.

e. Replacement.

The carburetor may be replaced by reversing the order of removal. Make certain that the gasket is in good condition and that the connections are tight.

f. Disassembly.

To repair the carburetor properly, follow the routine below.

(1) Loosen the clamp screw and remove the throttle lever.

(2) Remove idling adjusting screw (7) and spring.

(3) Remove assembly screws, using a screwdriver or a $\frac{5}{16}$-inch wrench.

(4) Raise the throttle body slightly and loosen the gasket from the bowl assembly.

(5) Lift the throttle body and gasket clear of the bowl without damaging the float.

(6) Turn the throttle body upside down on the bench.

(7) Remove the body-to-bowl gasket.

(8) Remove the float axle, pushing it from the slotted end of the float-hinge bracket with a small screwdriver, and using the fingers to remove it the rest of the way.

(9) Remove the float and the fuel valve needle.

(10) Remove the fuel valve seat and gasket, using C161-85 service tool.

(11) Remove the secondary venturi (3) and the main venturi (1) as a unit.

(12) Remove the idling jet (6), using a small screwdriver with $\frac{3}{16}$-inch blade.

(13) Remove the economizer jet and gasket, using a screwdriver. (This jet is located in the lower face of the throttle body, directly under one of the throttle shaft bearings.)

(14) **Before removing the throttle plate, refer to paragraph 31h.** Then proceed as directed and remove throttle-plate screws, plate and shaft.

(15) Remove the throttle stop-lever taper pin, using a small punch and a light hammer.

(16) Drive the throttle shaft out of the stop-

lever hub, using a small drift and a light hammer.
(17) Remove throttle-shaft packing retainers and packings, using a screwdriver to pry out the retainers. (See paragraph 31k.)
NOTE: Do not remove the identification disk which is riveted to the bowl cover, the throttle stop, the venturi locating pin, the priming plug, the float hinge bracket, nor the channel plugs.
(18) Remove the well vent (5), using a small screwdriver.
(19) Remove the main discharge jet (4) and gasket, using C-161-9 service tool.
(20) Remove lower plug (or main-jet adjustment (8), using a one-half-inch open end wrench.
(21) Remove the main jet (2) and gasket, using C161-1 service tool (or suitable screwdriver).
(22) Remove air-shutter lever retainer nut, using a 5/16-inch wrench.
(23) Remove air-shutter lever.
(24) Remove air-shutter bracket retainer screw and bracket, using a one-half-inch wrench.
(25) Remove air-shutter screws and lockwashers.
(26) Remove air-shutter and shaft.
(27) Remove air-shutter shaft hole plug, using a one-half-inch wrench.
(28) Remove air-shutter shaft packing retainers and packings.
NOTE: Do not remove air-shutter stop pin, bowl-vent channel plug, or drip plug.
(29) Clean the bowl and throttle body castings in gasoline or other solvent and blow through each channel with compressed air to make sure all channels are clean.
(30) Refer to paragraph for list of parts recommended for replacing when overhauling this type of carburetor.

g. Reassembly.
(1) Install air-shutter shaft packings and packing retainers.
(2) Install air-shutter shaft and air shutter. (See paragraph 31j.) Be sure the air-shutter valve is correctly located and that air shutter is properly centered before tightening the screws and lockwashers securely.
(3) Install air-shutter shaft-hole plug and gasket, using a one-half-inch wrench.
(4) Hold air-shutter bracket in position and install retainer screw, using a one-half-inch wrench.
(5) Install air-shutter lever with retainer nut and lockwasher, using a 5/16-inch wrench.
(6) Check for complete closing and full opening of air shutter and change position of the lever on the shaft, if necessary, to obtain correct operation.
(7) Replace main jet (2) and new gasket, using C161-1 service tool.
(8) Install lower plug (or main-jet adjustment) and new gasket, using a one-half-inch open-end wrench.
(9) Replace main discharge jet (4) and new gasket, using C161-9 service tool.
(10) Replace well vent (5), using a small screwdriver (no gasket required).
(11) Place new throttle shaft packings in retainers.
(12) Install throttle-shaft packing retainers (with packings), using a light hammer.
(13) Install new throttle shaft and throttle plate as described in paragraph 31h. Be sure the shaft is installed so that the economizer valve milling on the shaft coincides with economizer channels in the casting. Use new throttle-plate screws.
(14) Set throttle stop-screw to hold throttle slightly open, as a preliminary adjustment.
(15) Install stop-lever assembly on the shaft so that the stop lever is resting against the stop pin when the throttle plate is wide open (straight up and down in the barrel).
(16) Drill and pin stop-lever hub to shaft, using a No. 45 drill and CT63-2 taper pin.
(17) Replace economizer jet and new gasket, using a small screwdriver (one-quarter-inch blade).
(18) Replace idling jet (6), using small screwdriver (3/16-inch blade). No gasket is required.
(19) Place main venturi (1) in position with locating groove on the locating pin.
(20) Place secondary venturi (3) in slots provided in main venturi.
(21) Replace fuel valve seat and new gasket, using C161-85 service tool.
(22) Replace fuel valve needle.
(23) Replace float assembly and float axle, using the handle end of a screwdriver to drive the float axle into the slotted end of the float-hinge bracket.

(24) Check position of float assembly for correct fuel level. As shown in Figure 38, the A dimension should be $1^{39}/_{64}$ inches plus or minus $^{3}/_{64}$ inch. Float should move freely on its axle.
(25) Place a new bowl-to-body gasket in position on the throttle body. Be sure that the economizer channel in throttle body coincides with hole in gasket.
(26) Place bowl assembly in position on the throttle body, being careful to avoid damaging the float.

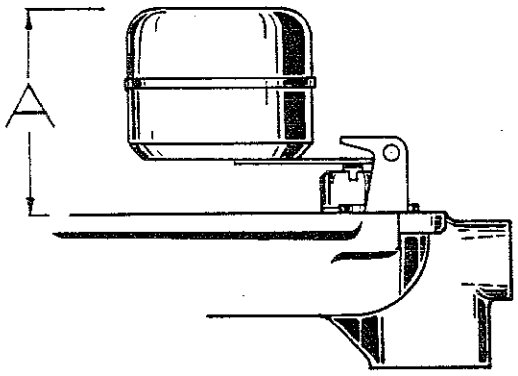

Fig. 38. Float Level Adjustment Diagram

(27) Install assembly screws and lockwashers. Be sure to tighten screws evenly and securely, using a screwdriver or a $^{5}/_{16}$-inch wrench.
(28) Install idling adjusting screw (7) and spring. Adjust to one full turn open as a preliminary adjustment.
(29) Install throttle lever and tighten clamp screw.

h. Throttle Replacements.
The location of the priming-hole plug in relation to the throttle plate is extremely important for uniform idling and part-throttle operation. To maintain a uniform relation between the priming-hole plug and the throttle plate, the throttle shaft and plate are assembled in the throttle body before drilling the body for the priming-hole plug, locating the hole in a definite relation to the throttle plate in each case. It is readily apparent from the foregoing that throttle plates and throttle bodies cannot be interchanged indiscriminately. When it becomes necessary to replace the throttle shaft or throttle plate, follow the routine below:

(1) Unscrew the throttle stop screw to permit closing of the throttle plate.
(2) Hold throttle in tightly closed position and mark the inside of the throttle body close to the throttle plate with a steel scriber.
(3) Using this scribed line as a guide, replace the throttle shaft or plate. If new plate used shows a noticeable variation from old one, select another new plate that fits very close to the scribed line when installed.
(4) If throttle body has to be replaced, it is advisable to obtain a complete throttle body assembly, including shaft, plate, and priming-hole plug, built to the outline number which appears on the identification tag on the bowl cover.

i. Ordering Special Parts.
A round identification tag riveted to the carburetor bowl cover specifies the assembly outline number to which the carburetor was originally built. When ordering special parts, such as the throttle bodies, throttle lever and stop lever assemblies, throttle plates or throttle shafts, be sure to specify outline number of the carburetor to prevent errors in selecting parts required.

j. Bracket and Lever Assemblies.
The air-shutter bracket and lever assemblies can be installed on either side of the air inlet. Be sure to assemble on same side and in same position as when received for overhaul.

k. Rebushing Throttle Shaft Bearings.
This operation should not be attempted unless the shop is properly equipped for such work. Bushings must be lined reamed after installation. If facilities for this are not available, replace entire throttle body assembly.

l. Tool List.
The following tools are recommended for servicing the carburetor:

Main Jet Wrench C161-1
Main Discharge Jet Wrench C161-9
Fuel Valve Seat Wrench C161-85

32. Fuel Pump.

a. Operation.
The rotation of the camshaft eccentric actuates the rocker arm, which pulls the link,

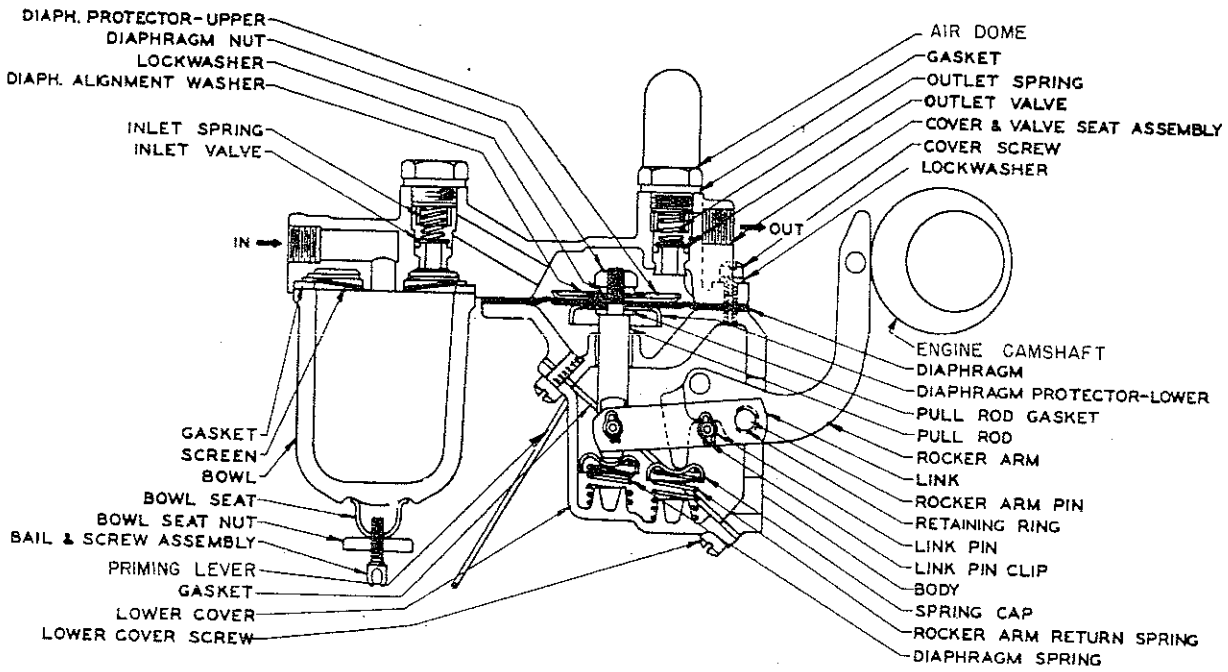

Fig. 39. Cross Section through Fuel Pump

diaphragm, and pull rod assembly downward against the diaphragm spring pressure, creating a vacuum in the pump chamber.

On the suction stroke of the pump, fuel from the tank enters through the inlet into the sediment bowl, passes through the screen and on through the inlet valve into the pump chamber.

On the return stroke, the diaphragm-spring pressure pushes the diaphragm upward, forcing fuel from the pump chamber through the outlet valve and out through the outlet to the carburetor.

When the carburetor bowl is filled, the float in the carburetor will shut off the needle valve, thus creating a pressure in the pump chamber. This pressure will hold the diaphragm downward against the spring pressure, where it will remain inoperative in the downward position until the carburetor requires further fuel and the needle valve opens. The rocker-arm spring is merely for the purpose of keeping the rocker arm in constant contact with the camshaft.

b. Service Instructions. Fuel pump repairs are divided into two classifications:
(1) Repairs made without disturbing pump installation.

If there is evidence of a lack of fuel in the carburetor or if the carburetor is flooding, check the float and needle valve for proper functioning. Examine the gas line for leaks, kinks, or obstructions.

Lack of Fuel at the Carburetor

Check as follows:

CAUSE	REMEDY
Gasoline tank empty.	Refill.
Leaky tubing or connections.	Replace tubing and tighten all pipe connections at the fuel pump and gasoline tank.
Loose valve plug.	Tighten valve plug securely, replacing valve plug gasket if necessary.
Bent or kinked tubing.	Replace tubing.
Dirty screen.	Clean the screen. Make certain that cork gasket is properly seated when reassembling.