INSTRUCTION BOOK No. 1

INSTALLATION, CARE, AND OPERATION OF

25 Kw. GASOLINE-ELECTRIC GENERATING SETS

G. E. Co., TYPE GM-12

ENGINEER DEPARTMENT, UNITED STATES ARMY
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These Instruction Books are issued for the information and guidance of those charged with the installation, care, and operation of the 25 kw. sets described herein. They are to be accounted for on the Engineer Property Return. One copy should accompany each set, being kept in tool box or other equally accessible place; two copies should be in the possession of the Artillery Engineer, and two copies in the possession of the District Engineer Officer.

By order of the Secretary of War:

H. L. SCOTT,
Major General, Chief of Staff.

PREFACE.

1. This book covers the installation, operation, and general care of the 25-kw. gasoline-electric generating sets manufactured by the General Electric Co., and issued by the Engineer Department for fortification purposes. It supersedes instruction books Nos. 8367, 8402, 8557 (and supplements thereto) and Revised Memorandum previously issued by the Engineer Department.

2. For convenience of discussion, the subject matter of the book is divided into four parts:

I.—Description.
II.—Care and operation.
III.—Installation.
IV.—Part lists.

Changes in or additions to the text which may be rendered necessary from time to time will be issued in such form as to be readily pasted in portions of book to which they pertain.

3. The book is not intended to be a general treatise on the subject of gas-engine operation, and matters which are common to the operation of all gasoline engines are not included; it is assumed that the operator has a general knowledge of the operation of internal-combustion engines, such as can be obtained from experience or standard texts. **However, no attempt should be made to install or operate a set until this book has been thoroughly studied.**

INSTALLATION, CARE, AND OPERATION OF 25-KW. GASOLINE-ELECTRIC GENERATING SETS.

PART I.—DESCRIPTION.

TYPE AND FORM.

4. The 25-kw. gasoline-driven generating sets of the General Electric Co., which have been issued by the Engineer Department since 1908, are designated by the makers by type and form numbers. The type number designation has always been "Type G. M. 12." The form number has been changed from time to time coincident with changes in the details of the set. The distinguishing features of the form numbers are:

Form A1. First Government sets with manganese bronze base, gear pump and Eisemann A–8 magneto.

Form A2. Sets with cast iron base. Radical changes made in the oiling system. Both Eisemann A–8 and G. E. magnetos Type AY–105 have been furnished with the Form A2 engines.

Form A14. These engines were equipped with Eisemann magnetos and Kinney water pumps.

Form A20. Same as Form A14, except noise-reducing features were added.

Form A23. Same as Form A20, except that Splitdorf AX magneto was substituted for the Eisemann magneto.

CAPACITY.

5. The set consists of a vertical, four-cylinder, four-cycle, single-acting engine, direct-connected to a direct-current generator. The set is capable of being operated at rated load indefinitely and at 25 per cent overload for two hours, furnishing in each case 2 kw. additional for operating the radiator fan motor. With each set there are furnished a gasoline tank, a switchboard, a radiator with motor-driven fan, a muffler, a box of tools, and a box of spare parts.

FRAME.

6. This is a single piece casting, bored for the crank bearings. This construction maintains the generator and engine in proper alignment. The frame is provided with large handholes protected by cover plates. The latter are easily removed and provide means for adjustment and replacement of interior parts. The bottom portion of the frame is utilized as an oil reservoir for the lubricating system.

CYLINDERS.

7. Cylinders are made with water jackets cast in one piece. Suitable openings, provided with covers, are located on the water jackets for removal of sediment.

CRANK SHAFT.

8. The crank shaft is made in one piece. It is supported by two end bearings, one at the flywheel end and one at the generator end, and by three intermediate bearings. The end bearings are attached to the frame by studs. Through bolts in the frame perform the dual function of holding up the interior bearings and holding down the cylinders. Oil ducts are provided in the crank shaft. The oil ducts deliver oil, under pressure, from the crank-shaft bearings to the crank pins.

GEARS.

9. Located in an oil-tight gear case, at the flywheel end of the engine, is a chain of gears operated by a pinion keyed to the crank shaft. Immediately above the pinion and meshing therewith is the idler gear. To the left of the idler gear, in the order named, are the intake cam shaft gear and the pump gear. To the right of the idler gear, in the order named, are the exhaust cam shaft gear and the magneto gear. In the engines equipped with the "silencing features" the idler gears, pump gears, and magneto gears are of the cloth type. In all other engines the gears are made of steel.

PISTONS, CONNECTING RODS, ETC.

10. The pistons are machined, ground, and provided with four snap rings. Motion is transmitted from pistons to the crank shaft by means of wrist pins and connecting rods. An oil duct or tube, located on the connecting rod, delivers oil from the crank pin to the wrist pin.

CAM SHAFTS.

11. There are two sets of cams, one for operating the intake valves, the other for operating the exhaust valves. Cam shafts are made in one piece and are operated by their respective gears. The inlet cam shaft is provided with a bevel gear at the generator end for operation of the governor and oil pump. A lever is provided at the generator end of the exhaust cam shaft by means of which the exhaust cam may be shifted to relieve compression and thus facilitate starting. Throwing the lever inward, toward the engine, relieves compression; throwing the lever outward restores normal conditions. Shifting the exhaust cam shaft to relieve compression brings (in addition to main cams) an auxiliary set of cams into operation. These auxiliary cams open the exhaust valves during the later part of suction

stroke and hold them open during the greater part of following compression stroke.

BEARINGS.

12. Each bearing is adjustable and may be removed without disturbing the adjustment of other bearings or removing the shaft. The wrist pin bearing is one solid bushing. The main bearings are provided with removable linings.

VALVES.

13. Valves are provided with a removable stem guide and are free to rotate in their seats while in operation. In addition to the main valve spring, found on all engines, Form A–20 and subsequent engines are equipped with tappet rod springs. Cams on the cam shafts, coming in contact with the cam rollers, raise the rollers and cam roller forks which hold them. The stem of the fork passes through a guide attached to engine frame. Motion is transmitted from fork stem to valve stem through the medium of valve adjusting clamp—thus raising the valve from its seat. Valves are closed by the action of the main valve spring.

EXHAUST HEADER.

14. The exhaust header is a one-piece water jacketed casting, flange-connected to cylinders. Blind and threaded flanges (interchangeable in position) are provided at either end of the exhaust header.

MUFFLER.

15. The sound of the exhaust is deadened by a suitable muffler, which does not impair the efficiency of the operation of the engine. The arrow on the muffler indicates the proper direction for the passage of the exhaust gases.

FUEL SUPPLY SYSTEM.

16a. Pump.—A double plunger gasoline pump, attached to the engine frame, pumps gasoline (58° to 68° Baumé) from the supply tank to the carburetor. One plunger is provided with a lever for hand operation, the other is mechanically driven by an eccentric rod. The eccentric rod is operated by an eccentric on the water pump shaft, the latter being driven by the water pump gear. The hand-operated pump is used for starting or when the mechanically driven pump momentarily fails to function. The mechanically driven plunger supplies fuel when the engine is running. Suitable check valves keep the pump primed. The mechanically driven pump is of sufficient capacity for maximum load on the engine. For other than maximum load the excess gasoline returns to its source through the overflow pipe from the carburetor, the carburetor being of the constant level type.

16b. Carburetor.—At the side of the carburetor is an indicator glass through which the flow of gasoline may be observed at all times. Beneath the carburetor and attached thereto is an air-valve body with two inlets. The air valve is provided with a handle (*part 75, fig. 1*) by means of which the source of air supplied may be varied. When the handle is at "H" hot air only (from crank case) is supplied; when at "C" cold or room air is supplied. Between "H" and "C" both hot and room air are available—the proportions may be varied by changing the position of the handle. When at "S" the air supplied is entirely shut off. Between "C" and "S" partially throttled

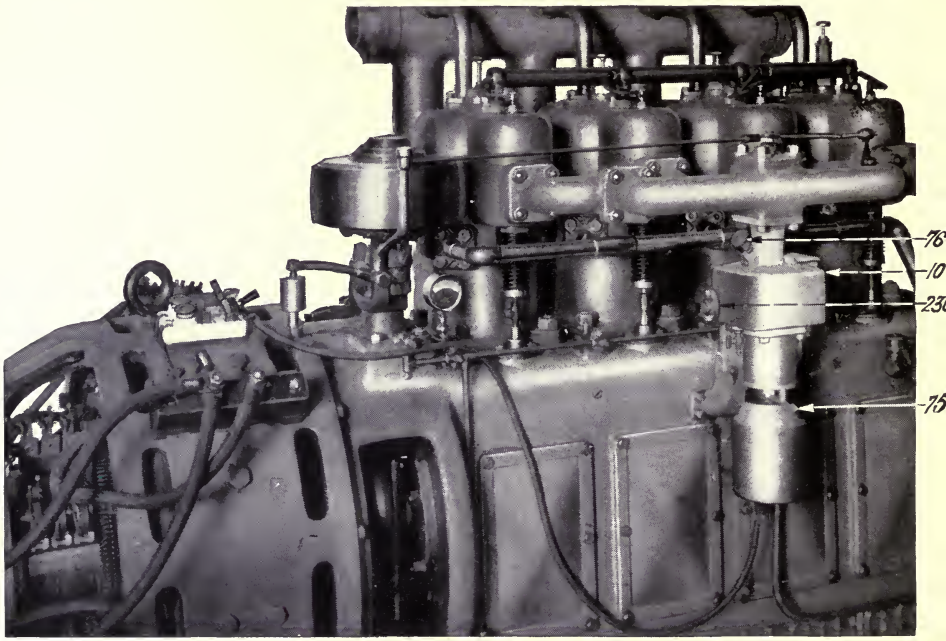


Fig. 1.—Carburetor, throttle valve and connections.

room air is supplied. The engine on the suction stroke draws a supply of air through the air valve and through a venturi tube in the carburetor. The high velocity of the air at the throat of the venturi tube causes the existence of static pressure sufficiently below atmospheric to draw a supply of vaporized gasoline from the carburetor reservoir. The gasoline is delivered to the venturi tube through a needle valve. This needle valve is provided with a notched disk handle (*part 76*), the notches of which are numbered. A spring index performs the dual function of holding the needle valves at a setting and indicating the amount of gasoline supplied. The mixture of air and gasoline passes through the throttle valve to the cylinders, where it is exploded by the ignition system.

16c. Air heater.—At the instant of starting in cold or damp weather the crank case air will be cold. In order to prevent formation of ice in the throttle opening, due to the moisture in the air, an electric heater is provided. This is a removable device attached to the air valve. A cutout switch on the generator puts the heater in or out of circuit. (*See fig. 1.*)

IGNITION SYSTEM.

17a. Component parts.—The ignition system consists of a low-tension magneto (G. E., Eisemann or Splitdorf), which is geared to the exhaust cam shaft of the engine, a nonvibrating step-up transformer coil, a set of dry cells and a switch with two sets of contacts ("M," magneto, and "B," battery, with an off position between). On the switch boxes furnished with Eisemann and G. E. magnetos there is an ignition plug which, when drawn from its socket, cuts out both the battery and magneto currents from the coil. This feature is not included in the Splitdorf magneto.

17b. Ignition switch "on magneto."—The essential features of the three types of magnetos are practically the same. When the

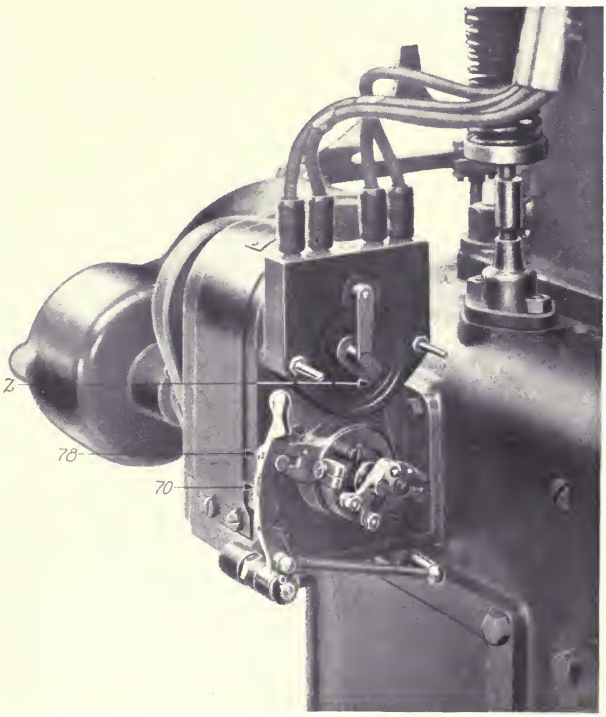


Fig. 2.—Exposed view of distributer and "make and break"—G. E. magneto.

ignition switch is at "M" the low-tension side of the circuit contains the armature of the magneto and the secondary, or low potential,

winding of the step-up transformer in series. The armature of the magneto supplies the transformer with low-tension alternating current. Short circuiting the armature, that is, in shunt with it, is the mechanically actuated "make and break" mechanism (*see fig. 2*). At "make" the armature is short circuited. At the instant the short-circuited current reaches its maximum value, the "break" occurs and the potential induced by the opening of the short circuit now discharges itself through the unbroken circuit of the transformer. This potential, which is higher than that which would normally be generated in magneto armature without the

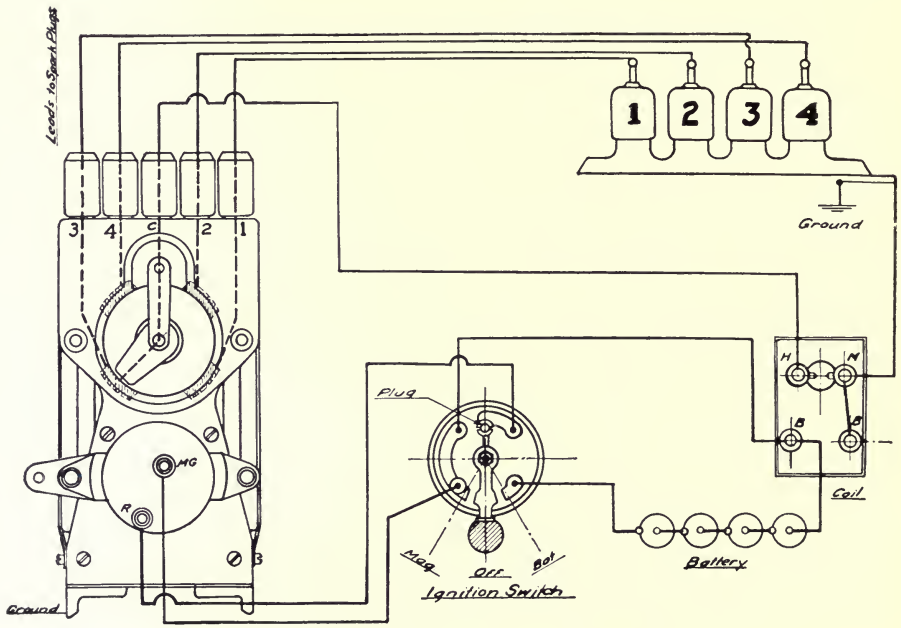


Fig. 3.—Wiring diagram, G. E. magneto.

"make and break" feature, induces a still higher potential in the primary of the transformer. This latter potential is sufficient to bridge the gap at the spark plugs of the cylinders—the discharge current passing through the high-tension distributer (*distributer finger shown at Z, fig. 2*), which directs the current to the proper cylinder in rotation. In the Eisemann magneto, the high-tension circuit is closed at the distributer, while in the G. E. magneto no actual contact is made. In the latter case the potential is high enough to bridge the small gap at the end of the distributer finger as well as as that at the spark plug.

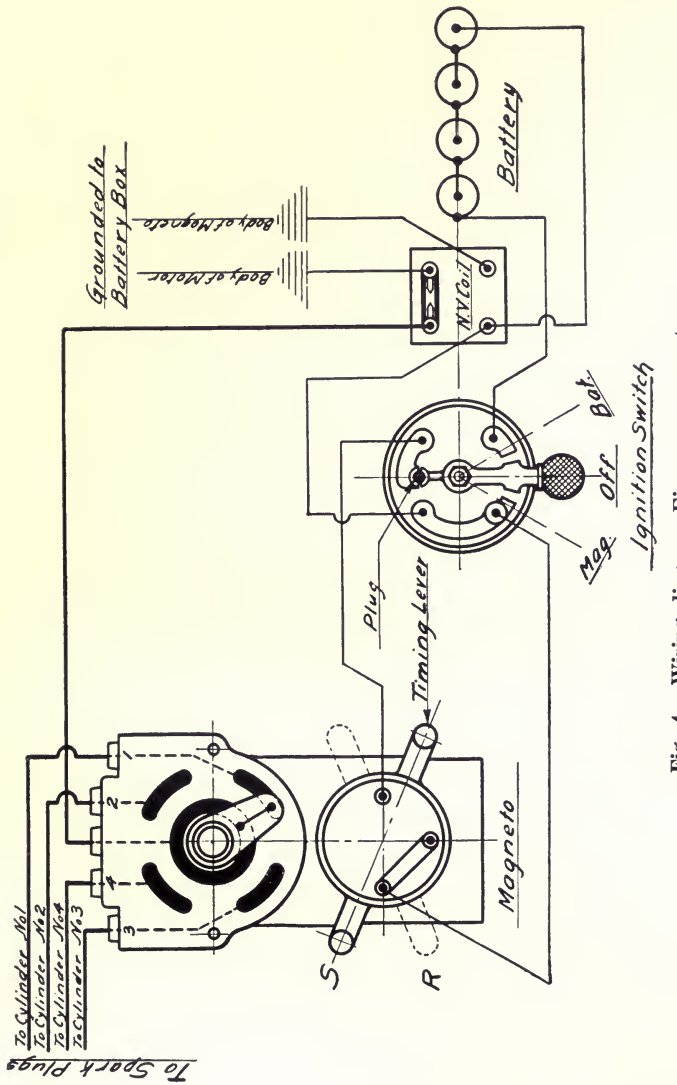


Fig. 4.—Wiring diagram, Eisemann magneto.

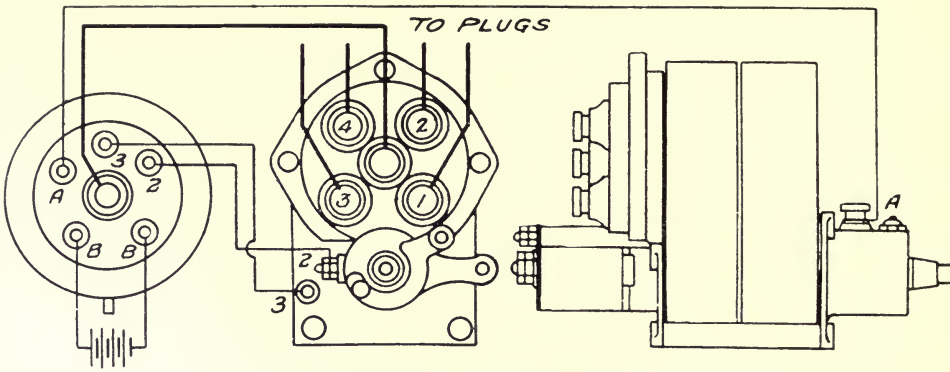


Fig. 5.—Wiring diagram, Splitdorf magneto.

17c. Ignition switch "on battery."—To supply the necessary current for starting, because the magneto circuit is useless until the magneto gets up to speed, a set of dry batteries is switched in series with the "make and break" mechanism and the transformer by placing the ignition switch at "B"—at the same time the armature of the magneto is disconnected. The action of the battery is the same as that of the magneto, except that the current is pulsating instead of alternating. As soon as the engine is up to speed, the battery is cut out and the magneto is switched on the operating circuit by moving the ignition switch from "B" to "M."

17d. High-tension cables.—The cables connecting the spark plugs are marked with numbered tags, indicating the spark plug to which they are connected. Under each terminal on the magneto is stamped a number showing to which cylinder it should be connected.

17e. Timing of spark.—The advance and retardation of the spark are obtained by movement of part commonly called the "timing lever" (*part 78, fig. 2. In G. E. magneto called "interrupter base," part 440, fig. 50; Eisemann, "bascual," part 906, fig. 49; Splitdorf, "breaker box," part 1021, fig. 47*). The adjusting lever (*part 70 or 959, fig. 52*) has two notches in it, one for starting (or retardation), marked "S," and the other the running position (or advance), marked "R."

17f. Safety spark gap.—A safety spark gap is located on the transformer. If the plug cables are fractured or broken away from the plugs or the distance between the electrodes of the plug or plugs is too great, the discharge takes place at the safety spark gap, thus protecting the insulation of the system. The safety spark gap is also utilized for testing the ignition system, as will be explained later.

SPEED REGULATION.

18. The governor is of the centrifugal weight type, mounted vertically on the engine frame and driven by means of a bevel gear keyed to the intake cam shaft. The main governor casing is a shal-

low cylindrical housing. The governor weights are mounted in the casing on a bell crank lever and are held in place by springs. A right and left hand screw, passing through the weights and springs, provides means for adjusting the speed. The engine is quantity governored. An increase in the speed of the engine raises the sliding collar on the governor shaft, exerts a pull on the throttle rod, and operates to close the throttle valve. The reverse is the case when the speed falls off. A dashpot is mounted between the governor lever and the bracket to prevent hunting of the governor. Fine adjustment, about 2 per cent of the speed of the engine, is provided for by means of a spring at the end of the throttle rod. The full load speed of the engine is 560 r. p. m. with 3 per cent variation from full load to no load. No-load speed (fan in operation) varies from 570 to 575 r. p. m.

LUBRICATING SYSTEM.

19. The crank case of the engine forms a reservoir for the lubricating oil, holding about 5 gallons. A sight oil gauge on the exhaust side of the engine shows the true level of the oil, but only when the engine is idle. From the reservoir oil is drawn through a strainer by the gear oil pump. This pump is driven from an extension from the governor shaft. The oil is forced by the pump through the main delivery pipe to seven branch pipes. A by-pass valve is located on the pressure side of the pump by means of which the pressure of the system is regulated. Five branch oil pipes[1] supply oil for the five main bearings. From each of these bearings oil is forced every revolution through a hole in the crank shaft to the crank-pin bearings, thence through a tube on the connecting rod to the wrist pin. All excess oil from the bearings is returned to the reservoir, the oil being thus circulated continuously. Two branch pipes, one to the governor bracket and the other[1] to the top of the gear case, are provided with adjustable needle valves. These needle valves are adjusted to give sufficient lubrication without throwing oil out from the bearings. Oil from the gear case travels along the eccentric shaft (part 80), is thrown out therefrom by centrifugal force, and collects in a pocket on the eccentric. From this pocket the oil is fed through a duct in the eccentric to the contact surface of the eccentric and eccentric strap. The cylinders and cam shafts are oiled by splash from the crank. The oil furnished through the pipes on the connecting rod lubricates the wrist pins. Air from the crank case carries oil in a fine divided state which assists in the lubrication of the cylinders and valve stems. Two pressure gauges, with stop-off cocks, are placed in the main distributing pipes. These gauges indicate the pressure of the system as a whole. Pressure is regulated by means of a hexagonal-headed screw in the by-pass valve.

[1] In Form A-1 engines ducts in the frame perform the functions of these oil pipes.

COOLING WATER SYSTEM.

20a. Water circulation.—The engine is water cooled, the system being inclosed to minimize evaporation. The water heated in the jackets, before it is used again, is cooled in an automobile type radiator through which a large volume of air is forced by a motor-driven fan. The motor used to circulate the air through the radiator is a standard type of inclosed G. E. direct-current motor, series wound, and is so connected between the generator and switchboard that it starts automatically when the set is started, without the use of a starting rheostat.[1] Two types of motors have been furnished in the past—types CQ. and C. V. C. The water is circulated by a gear pump (later engines are supplied with Kinney pumps). Water is forced through the cylinder jackets to the exhaust manifold; thence to the radiator. From the radiator the water is returned to the pump and is thus circulated continuously.

20b. Miscellaneous fittings.—The water outlet on the exhaust manifold may be turned in any one of four ways for convenience in attaching the water-outlet pipe. Special tubes for thermometers are provided near the water outlet fitting on the exhaust manifold and also on the pipe leading into the pump. There is a drainpipe immediately above the pump, in order that the jackets may be drained when necessary. A drain is also provided at the bottom of the radiator. Construction officers install a pressure gauge and waste cock in the outgoing water pipe near the engine. The waste cock is used in testing water circulation. There will shortly be available for issue and installation on all engines "sight-flow indicators," by means of which the flow of water may be observed by its action on a flap valve (*see par. 36d*).

CARTRIDGE-STARTER.

21. The engine may be started either by cranking or by the cartridge-starter. The cartridge-starter is a device attached to cylinder No. 1, by means of which the engine may be started in an emergency with an ordinary No. 10 gauge blank cartridge.

ENGINE CYCLE.

22a. Flywheel marking.—Cylinders are numbered from 1 to 4 consecutively beginning at the flywheel end of the engine. An index attached to the gear case marks the center line of the engine. On the circumference of the flywheel are drawn a number of lines,

[1] For the purpose of reducing the noise made by the fan of the radiator there is now included with all 25-kw. generating sets issued since June 1, 1914, a resistance unit which is used to reduce the speed of the fan from normal rated speed of 1,150 r. p. m. to about 950 r. p. m. The resistance is connected in the negative lead of the fan motor circuit and is shunted by a 50-ampere single-pole single-throw switch placed on the sub-base of the generator panel. With the switch open the current flows through the resistance in series with the motor and the voltage at the motor is reduced about 30 per cent. With the switch closed the resistance is short-circuited and the full generator voltage is impressed upon the motor.

each of which is stamped with its distinguishing mark or title. When the flywheel is turned so that these lines come opposite the index the positions of the various pistons are indicated as follows:

"Top of cylinders 1 and 4."—1 and 4 pistons are at top of stroke.

"Top of cylinders 2 and 3."—2 and 3 pistons are at top of stroke.

The other marks have exact significance only when considered in connection with the position of the indicator on the flywheel end of the intake cam shaft. Thus, when the indicator is pointing vertically upward and piston No. 1 is at top of stroke, then cylinder No. 1 is under compression. As the flywheel rotates in a clockwise direction "X. O. 1" (marked on flywheel) comes opposite the index, indicating that the exhaust valve of cylinder No. 1 has at that instant opened. Further rotation of the flywheel in a clockwise direction causes "I. O. 1" (also marked on flywheel) to come opposite the index. This indicates that the intake valve of cylinder No. 1 has opened and that the exhaust valve has closed.[1] When "I. C. 1" comes opposite the index the intake valve of cylinder No. 1 closes.

22b. Events; sequence of firing.—This being a four-cycle engine, pistons 1 and 4 move together, as do 2 and 3, but the same action is not taking place in the various cylinders at any instant. In a cycle there are four events—intake, compression, explosion, and exhaust—each occurring successively, thus requiring four strokes of the engine or two turns of the crank shaft for their completion. This will cause any of the lines (referred to in paragraph 22a above) to appear at the index twice during one cycle, once for each of the cylinders whose pistons move together. At any instant all of the above operations are taking place, one in each cylinder—e. g., No. 1, explosion; No. 2, compression; No. 3, exhaust; No. 4, intake. When the indicator is pointing to the right, No. 2 is under compression; down, No. 4; to the left, No. 3. The firing sequence is 1, 2, 4, and 3.

GENERATOR.

23a. Voltage.—The usual type of generator furnished with each set is a 115-volt commutating pole generator, designed to run at 560 r. p. m. In special cases 230-volt generators and also 230-115-volt, 3-wire generators are supplied. The no-load voltage is 115 volts and the generator is compounded for 115 volts at full load, an allowance being made for the 3 per cent drop in speed.

23b. Construction.—The magnet frame is of cast steel and is made in one piece, so constructed as to be bolted direct to the engine frame. The magnet cores are sheet-iron laminations of high permeability and are bolted to the generator frame. The commutating poles are

[1] Or has closed 5 degrees earlier, depending upon the design of the cam shaft.

of machine steel and are also bolted to generator frame. The armature core consists of sheet-iron laminations assembled on a spider of cast steel. The space blocks in the core form air ducts which communicate with the interior of the armature and insure thorough ventilation of the core windings. The armature winding is of the series drum barrel wound type.

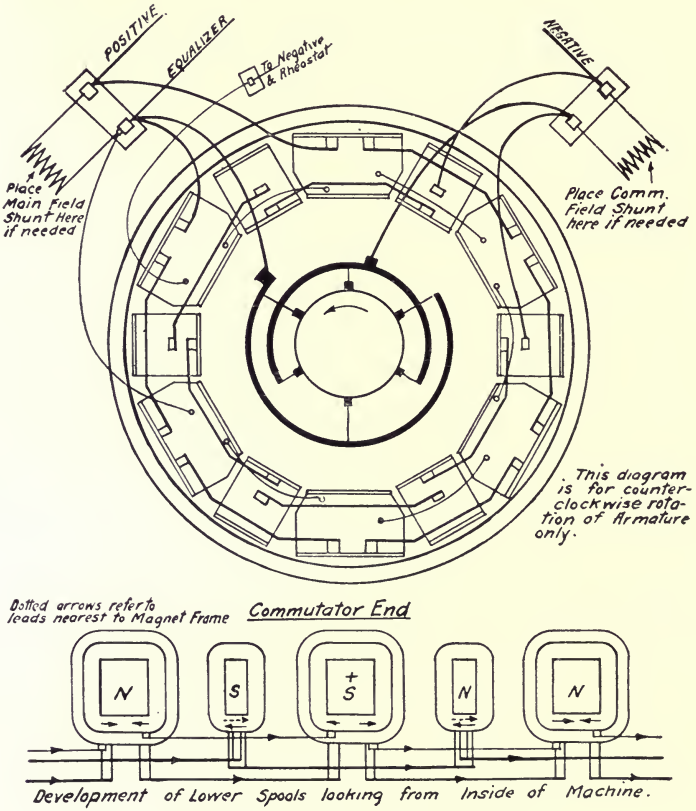


Fig. 6.—Generator connections.

23c. Connections.—Wiring diagram for generator connections is given in fig. 6.

PART II.—CARE AND OPERATION.

OUTLINE.

24. The subject matter of this section of the book will be discussed under the following headings:

STARTING AND STOPPING:
Methods of Starting (*par. 25a*).
Starting by Cranking (*par. 25b*).
Difficult Starting (*par. 25c*).
Starting with Cartridge Starter (*par. 25d*).
Loading Cartridge Starter (*par 25e*).
Shells: Reloading and Storage (*par. 25f*).
Stopping Engine (*par. 25g*).
COOLING WATER SYSTEM:
Filling Radiator (*par. 26a*).
Testing Water Circulation (*par. 26b*).
Temperature of Cooling Water (*par. 26c*).
Use of Fan Resistance (*par. 26d*).
Thermometers (*par. 26e*).
When Radiator is Not Used (*par. 26f*).
Draining Engine and Radiator in Freezing Weather (*par. 26g.*)
Non-Freezing Mixtures (*par. 26h*).
Heating Engine Room in Freezing Weather (*par. 26i*).
Additional Precautions in Freezing Weather (*par. 26j*).
Care of Water Pump (*par. 26k*).
LUBRICATION:
Quality of Oil (*par. 27a*).
Pressure of Oiling System (*par. 27b*).
Replenishing Oil (*par. 27c*).
Oiling of Camshafts (*par. 27d*).
Hand Lubrication (*par. 27e*).
Packing of Oil Pump (*par. 27f*).
FUEL SUPPLY SYSTEM:
Proper Mixture (*par. 28a*).
Quality of Gasoline (*par. 28b*).
Filling Carbureter (*par. 28c*).
Packing Gasoline Pump (*par. 28d*).
Gasoline Needle Valve (*par. 28e*).
Starting in Cold Weather (*par. 28f*).
Electric Air Heater (*par. 28g*).
IGNITION SYSTEM:
Disassembly of Magnetos (*par. 29a*).
To Replace a Magneto (*par. 29b*).
To Install a New Magneto (*par. 29c*).
Testing Ignition System (*par. 29d*).
Platinum Contacts (*par. 29e*).
Care and Maintenance of G. E. Magneto (*par 29f*).
Care and Maintenance of Eisemann Magneto (*par. 29g*).
Care and Maintenance of Splitdorf Magneto (*par. 29h*).

STARTING AND STOPPING.

25a. Methods of starting.—The engine may be started in either of two ways: First, by cranking in the usual manner, or, second, by

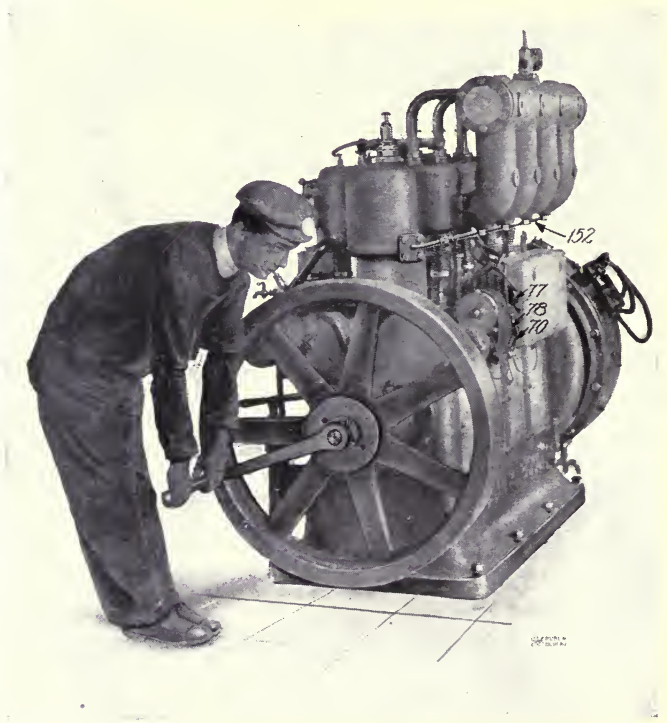


Fig. 7.—Correct method of cranking.

means of the cartridge starter. Cranking will generally occupy less time, all things considered, but when it is known that the engine will be needed for an emergency at some future time, the second method

may be used. In the latter case everything should be prepared beforehand so that when the time comes a single blow from the hand will start the engine.

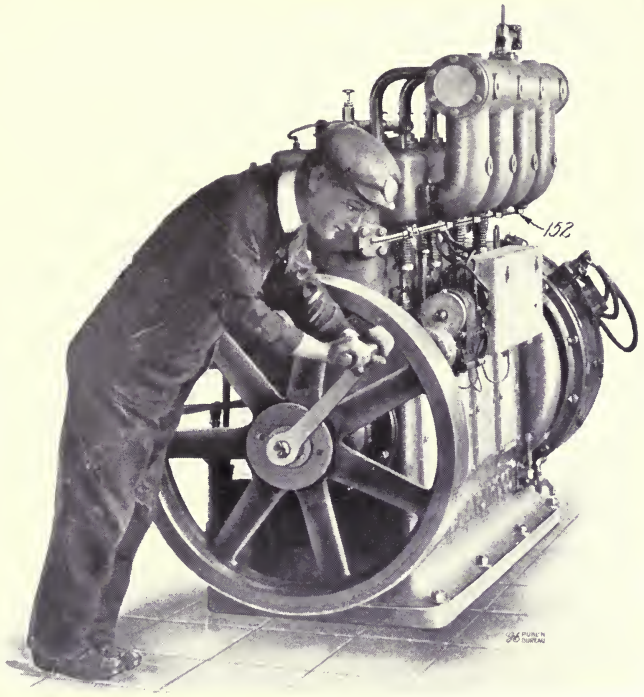


Fig. 8.—Incorrect method of cranking.

25b. To start by cranking:

1. **Place ignition switch** (*part 77 Eisemann and G. E. magnetos, part 1038 Splitdorf magneto*) **in "off" position** (*see fig. 7; also par. 17*).
2. **Fill the radiator** (*see par. 26a*); or see that the water is circulating in cases where the cooling water is wasted (*see par. 26f*).
3. See that the level of the oil in the reservoir is at the correct height (*see par. 27c*).
4. Oil governor, pump parts, etc. (*see pars. 27d and 27e*).
5. See that the grease cups are full (*see par. 27e*).
6. Relieve compression by throwing lever (part 41) toward engine (*see par. 11*).
7. Fill carburetor by hand pump (*see par. 28c*).
8. Place gasoline needle valve (part 76) at "4."

9. Fill the priming receptacles (part 24) once or twice with gasoline; open the priming valves and close them immediately after gasoline has passed into the cylinders (*see par. 25c*).
10. **Place timing lever** (*parts 78, 440, 906, or 1021*) **at "S"** (*see par. 17e*).
11. Turn engine over by hand four or five times.
12. Place ignition switch on battery.
13. Move air valve handle five or six notches from "S" (*see par. 16b*).
14. Close switch for electric heater, if latter is to be used (*see pars. 16c and 28g*).
15. Engage crank as in fig. 7 **and pull up, never push down.** Repeat until engine starts (*see pars. 25c, 28e, 28f, and 29d*).
16. Place air valve handle between "H" and "C," if electric heater is not used; or at "C" if electric heater is used (*see pars. 28a and 28g*).
17. Throw compression lever outward.
18. Move ignition switch to "magneto."
19. Advance spark by placing timing lever at "R" (*see par. 17e*).
20. **Open waste cock beneath pressure gauge in outgoing water pipe** from exhaust manifold. When water squirts out freely, close the cock. **If water does not appear within 20 seconds from time of starting** (*see pars. 20b and 26b*) stop engine (*see par. 25g*). Note reading of pressure gauge on outgoing water pipe and examine sight flow indicator. (*See pars. 20b and 26b*).
21. **See that radiator is full** (*see par. 26a*) **and that fan is operating.**
22. Adjust mixture and spark to load (*see par. 28a*).
23. Oil parts requiring attention (*see par. 27e*).
24. **Examine pressure gauge** (*see par. 26b*) **and thermometer in outgoing water pipe** from time to time. If temperature exceeds 90° C,
    (a) **stop engine** (*see par. 25g*) *or*
    (b) close short circuit switch, shunting resistance in fan motor circuit (*see footnote par. 20a and par. 26d*). If temperature continues to rise **stop engine** (*see par. 25g*) and investigate (*see pars. 26b and 26c*) *or*
    (c) regulate temperature, if radiator is not used (*see par. 26f*).

25. Adjust oil pressure, if necessary (*see par. 27b*).
26. Open electric heater switch on generator (*see par. 28g*) and place air valve handle between "H" and "C."

25c. Difficult starting.—These sets have been and can be readily started by hand in temperatures varying from 34° to 95° F. If the instructions given in the book are carefully followed and there is difficulty in starting the set by hand, an examination of the batteries, connections, etc., should be made. If the conditions are found to be as they should be and the engine fails to start, after being primed through the priming valves, it may be cranked over four or five times with the air-valve handle a few notches from the extreme right position "S" (the ignition switch, of course, being "off"). This fills the throttle and manifold with gasoline vapor, and the engine will then start easily in the usual manner. **Do not crank the engine continuously unless the ignition switch is in mid or off position. Do not crank the engine with the magneto timing arm on "R." It must always be on "S" during cranking.**

25d. Starting with cartridge starter:

1. Perform operations 1 to 6, inclusive, par. 25b.
2. Turn flywheel so that "top of cylinders 1 and 4" is about 30° past the index (part 42) when indicator (part 33) is pointing upward (*see par. 22a*).
3. Remove, load, and replace cartridge starter (*see pars. 25e and 25f*).
4. Perform operations 7, 8, 9, 10, 12, 13, and 14, par. 25b.
5. Explode cartridge as shown in fig. 10.
6. Perform operations 15 to 26, inclusive, par. 25b.

25e. Loading cartridge starter.—New type (see figs. 9 and 10): With special wrench marked "cartridge starter" loosen part 250–A2 one turn and then completely unscrew part 256–A2 and remove wholly from cylinder; remove empty shell and replace with loaded one. Assemble all parts possible before allowing loaded shell to touch cylinder. **Never put loaded shell directly into part 256–A2 while this part remains on the cylinder.** An empty shell must always be kept in the cartridge-starting device and no attempt should be made to remove the shell when the engine is running. The shell forms a gasket which prevents the escape of gas fron the cylinder around the firing pin and thus keeps the firing pin from becoming clogged with carbon or otherwise damaged.

Fig. 9.—Removing and replacing cartridge starter (new type).

Fig. 10.—Method of firing cartridge starter (new type).

Old type (see figs. 11 and 12): To load this type of cartridge-starting device, pull out the locking pin with the left hand, fig. No. 11. With the right hand pull over and swing down the firing pin barrel

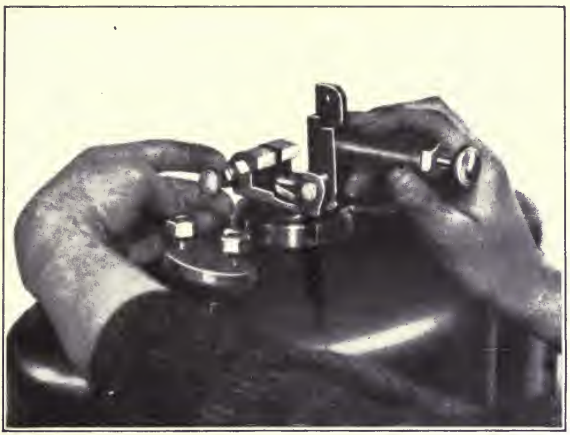


Fig. 11.—Method of extracting shell and reloading cartridge starter (old style).

into position shown; take out the empty shell which has automatically been lifted from its seat; insert a loaded shell into the breech block: push back the firing pin cylinder into place with the right hand while

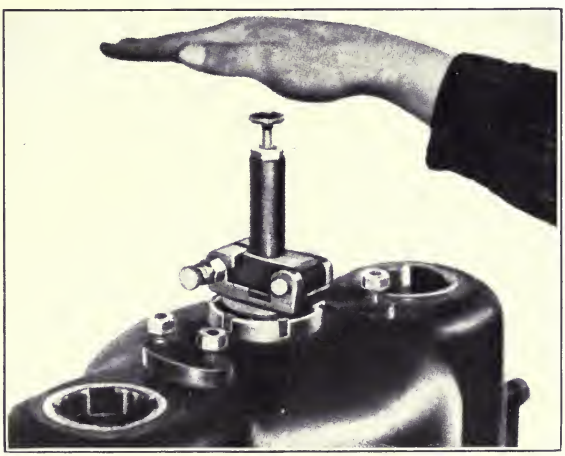


Fig. 12.—Method of firing cartridge starter (old style).

holding out the spring-return locking pin. When in place press the pin home, thus locking the breech block. The cartridge-starting device is then ready to fire. **Do not attempt to remove cartridge when engine is in operation.**

25f. Shells—Reloading and storage.—If it becomes necessary to reload the cartridge shells, which are furnished with the engine, they should be loaded with 300 to 325 grains of black powder (never

smokeless powder), using two felt wads of the usual kind, and standard caps of fulminate of mercury. To prevent corrosion, shells should be stored in a dry place and coated with vaseline or other inert water repellant.

25g. Stopping engine.—To stop engine:

1. Place ignition switch in "off" position.
2. If it is intended to use the engine within a few hours turn the air valve to "S" momentarily several times just before engine comes to rest.
3. If engine continues to fire, close needle valve (continued firing while ignition switch is "off" indicates carbon deposits). (*See par. 30c.*)
4. Relieve compression when engine stops.
5. Move timing lever to "S."
6. Drain cooling water system if necessary (*see par. 26g*).

COOLING WATER SYSTEM.

26a. Filling the radiator.—It never should be assumed that the radiator is full of water. If the radiator has been previously drained, it is evident that the water put into the radiator will rise to the pump but will not pass it until the engine is started. Starting the engine causes rotation of the pump—this fills the water jackets, and the water level in the radiator will therefore drop. The radiator must therefore be filled a second time, otherwise there will be insufficient water in the cooling system and cracked water jackets will be the result. **Fill the radiator until it overflows.**

26b. Testing water circulation.—In order to determine that the pump is working properly and that there is no stoppage in the water circulating system, the circulation must be tested immediately after starting the engine by opening the waste cock beneath the gauge in the water outlet from the exhaust manifold. This waste cock must be left open until water flows out of it freely. As stated above, this should occur within 20 seconds of the time of starting the engine. If the water does not flow out of the waste cock within this time, the engine must be stopped and an examination made to determine the cause. If there is ice in the suction pipe, the water flow may be stopped entirely. Ice in the pump may cause the pin, part 206, fastening the coupling to the end of the driving shaft of the pump, to shear, thus putting the pump out of commission. It is recommended that the water pump and especially the pin be examined occasionally even if no trouble is experienced. The normal pressure for the system in operation, as indicated by the pressure gauge in the outlet pipe near the exhaust manifold, should be determined by the operator. In case any variation from this normal pressure should occur—particularly a decrease in pressure—the engine must be stopped and the cause of the abnormal condition removed. The sight

flow indicator (*See par. 20b*) should be examined from time to time but its indications should not be accepted as final. The only safe and positive indication of proper circulation is that obtained by opening the waste cock as described above.

26c. Temperature of cooling water.—During acceptance tests, to simulate tropical conditions, the air entering the radiator is maintained at 35° C. (95° F.), this being assumed to be the most severe condition under which the engine must operate in service. With the air at this temperature and with the generator developing 25 kw. useful energy, the water leaves the jackets at approximately 80° C. and enters the jackets at about 10 degrees lower. That is, 10 degrees of heat are abstracted from the water by the radiator when the air enters at 35° C. The air which passes through the radiator under these conditions is raised about 26 degrees by lowering the water temperature the 10 degrees above mentioned. If the air enters the radiator at a temperature lower than 35° C., as is ordinarily the case, the cooling effect upon the jacket water is correspondingly increased. The maximum allowable temperature for the water leaving the jackets, 90° C., will be reached only under extremely severe conditions of operation—such, for instance, as obtain during acceptance tests, when a 25 per cent overload is placed on the generator for two hours immediately following an eight or ten hour run at full load—the air entering the radiator at 35° C. In other words, the radiator has sufficient cooling capacity for all ordinary and extraordinary conditions of operation, and any failure in this respect should be traced to some defect, such as impeded circulation, leaky fittings (which admit air on the suction side of the water pump), worn pump, or to a faulty adjustment of the time of ignition (a late spark will cause heating). If the temperature of the outgoing water exceeds 90° C., the switch short circuiting the fan resistance should be closed (if a fan resistance is installed). If the temperature of water continues to rise after switch has been closed, or if the temperature of water reaches 90° C., where no fan resistance has been installed, the engine must be stopped and cause for abnormal temperature removed.

26d. Fan resistance.—Experience has shown that at a speed of 950 r. p. m. the fan supplies sufficient air to maintain the temperature of the jacket water below 90° C., provided the useful output of the generator does not exceed full load—that is, 25 kilowatts. If the 25 per cent overload, which the set is designed to carry, is applied, the fan must operate at the maximum speed in order to keep the temperature of the jacket water within the above-mentioned limit, and this speed is obtained by closing the proper switch on switchboard, thereby cutting out the resistance. When the engines are new, there will be no difficulty in maintaining the temperature of the jacket water below 90° C. with the fan running at the low speed. However, it is possible that after the engine has been in use for some time the

cooling of the cylinders may not be so easily accomplished, and even at less than full load it may be necessary to operate the fan at full speed. **The temperature of the water leaving the engine therefore and not the load on the generator should be watched** as an indication when to increase the speed of the fan motor. A name plate is placed over short circuiting switch on switchboard which reads **"close when jacket water exceeds 90° C."**

26e. Thermometer.—Thermometer cups must be filled with oil. This serves to distribute the heat over the surface of the bulb. As a rule, one thermometer, and that at the exhaust water outlet, will give all the information as to temperature that is required, when the engine is acting normally. If the temperature of the jacket water is too high at the outlet, another thermometer at the inlet above the water pump may assist in localizing the trouble. To minimize breakage, thermometers should be carefully handled and used only for the purpose for which issued.

26f. When radiator is not used.—Just before starting up, the operator opens the cooling water supply valve sufficiently to create a continuous flow from the waste pipe. After the engine has been started and has run for a short time, if the temperature of the water at the outlet on exhaust manifold is too high, the valve in the supply pipe is opened slightly; if too low, it is closed a little. By thus regulating the valve a continuous flow of water at any temperature up to 90° C. can be obtained from the waste. This method of regulation permits the minimum amount of water being wasted and at the same time the temperature of the cylinders is maintained at the point giving the greatest economy. Normally the temperature should be maintained at 80° C. (*For description of piping see par. 36g and fig. 21*).

26g. Draining the engine and radiator.—The fact must not be overlooked that **it is necessary to drain off the circulating water immediately after the engine is stopped, whenever any part of the system is liable to be exposed to a temperature of 32° F. or lower** (*unless a nonfreezing mixture, see par. 26h, is used*), otherwise the water will freeze, especially in the radiator where the water is separated from the air by a very thin copper sheet. There is a drain at the bottom of the radiator for removing water therefrom. The engine jackets may be drained by the cock, part 26. Turn the engine over backward a few times after the cylinders have been drained in order to remove the water retained in the water pump.

26h. Nonfreezing mixtures.—Nonfreezing mixtures are not recommended for general use. However, if the engine is to be used intermittently during freezing weather and it is not practicable to drain and refill the circulating system each time, wood or denatured alcohol may be added to the water to lower the freezing point. But,

if alcohol is added, the fact that the boiling point is lowered as well as the freezing point should not be overlooked. Consequently, no more alcohol than is necessary to meet the requirements should be used. The freezing and boiling points for certain percentages of alcohol are as follows:

Alcohol.	Mixture freezes.		Mixture boils.	
	F.°	*C.°*	*F.°*	*C.°*
10 per cent	18	− 8	194	90
20 per cent	4	−16	181	83
30 per cent	− 9	−23	166	74

From a mixture of alcohol and water the alcohol evaporates more readily than the water, and in replacing losses due to evaporation from such a mixture, the percentage of alcohol in the added mixture should be at least double that of the original mixture.

26i. Heating the engine room.—Unless there is some other means of heating, an oil stove[1] should be placed in all engine rooms in which it is probable that the temperature will be below freezing at any time when the engine may have to be operated. The stove should be lighted a sufficient time before the engine is to be started to raise the temperature of the engine room, engine, radiator, piping, etc., above the freezing point, and sufficiently above freezing point as to permit the engine to be readily turned over by hand. In very cold weather it sometimes happens that it is difficult to turn engine over by hand, due to sluggishness of oil, pinching of pistons by cylinders, freezing of moisture in products of combustion, etc. When such a condition prevails, do not resort to the cartridge starter before the engine has warmed to such an extent as to permit easy cranking. If the radiator is in a separate room, this room should also be heated, because air at a temperature below freezing, if blown through the radiator in which the water is near the freezing point, will immediately freeze the water in the radiator tubes. As soon as the circulation is established, however, and the jackets begin to get warm, there will be no further trouble of freezing in the radiator, especially if a load is put on the engine immediately.

26j. Additional precautions in freezing weather.—If the precautions given in paragraphs 26g, 26h, and 26i are not observed, cracked water jackets will be the result. **Do not start the engine with the idea of warming it up slightly before allowing water to enter the system.** This method has been tried several times and always with the same result—cracked water jackets. The pro-

[1] [With an oil stove in operation in the engine room special care must be observed in handling gasoline. Properly used and cared for there is not the slightest danger from an oil stove. Extinguish the flame from the oil stove before pumping gasoline into the carburetor. Do not spill any gasoline in the room while the stove is burning. An operator should always be present when the oil stove is in use.]

cedure given in paragraphs 26a and 26b, in regard to filling the radiator and water jackets and testing circulation, should be followed at all times, but particularly in cold weather.

26k. Care of water pump.—The cylinder water jackets should be examined frequently for scale, sediment, etc. At least once in six months, or oftener if necessary, the flanges closing cylinder water jackets should be removed and jackets thoroughly cleaned. Otherwise this sediment will circulate through the system and eventually damage the water pump. Grease cups should be filled frequently (*see par. 27e*), otherwise there will be excessive wear on pump parts, as the hot circulating water causes the grease to wash out rapidly.

Packing for pumps should be renewed occasionally. This packing is in granular form and contained in cloth sacks. About 10 inches of packing are required for a complete renewal. The ends of the cloth container should be closed before the packing is put in place. After the packing has been firmly compressed always loosen the gland nut one turn.

LUBRICATION.

27a. Quality of oil.—Except in a great emergency the engine should not be run without proper lubricating oil. If the proper oil is not used the engine can be run only at risk of serious injury. Oil is furnished by the Engineer Department for sets used for fortification purposes. The issue of oil for sets used in connection with post lighting systems is governed by existing orders. **No oil should be placed in the crank case of 25 kw. sets unless it has been issued for that specific purpose.**

27b. Pressure of oiling system.—The exact pressure to which the system should be adjusted in order to obtain the best results must be ascertained by experiment. It will probably be between 10 and 15 pounds. The pressure can be regulated at the by-pass valve (*parts 110 and 110–A2*) by means of the spring adjusting screw. If the pressure is to be increased turn the screw to the right. The pressure may be reduced somewhat below 10 pounds without depriving the main bearings and other important parts of the system of sufficient lubrication. The pressure should not ordinarily exceed 18 pounds. The pressure gauge in the oiling system should be read occasionally in order that stoppages in supply pipe may not occur unnoticed. The proper amount of lubrication is indicated (with the proper fuel mixture) when, at full load, there is a faint blue haze issuing occasionally from the exhaust. If too much lubrication is given the cylinders the exhaust will be smoky; if not enough lubrication is given the exhaust will be perfectly clear. The latter looks well, but it is not a condition to be sought, and it indicates that the cylinders are too dry. Too much lubrication, on the other hand, not only causes smoke but will cause carbonization in the cylinders and spark plugs, and may result in preignition. The pressure at the governor and

gear case is adjusted by means of needle valves at those places, so as to give sufficient lubrication without throwing oil out of the bearings.

27c. Replenishing oil.—Lubricating oil may be filled into the crank case through the ventilating tube (part 81) or through the handhole openings. About 5 gallons are required for a complete refilling. The oil reservoir should normally be kept full of oil up to (not above) the level marked on the sight gauge (part 47–A). No attempt should be made to run the engine when the oil level is not visible through the sight gauge. **Remember that the true level is indicated only when the engine is idle.** As the oil in the lubricating system of the engine is used over and over again it eventually becomes used up and more or less filled with carbon. As a rule, the replacing of the oil which has burned up with new oil so as to keep the oil in the reservoir at a uniform height will be sufficient. Used in this way the engine may be run almost indefinitely without complete renewal at one time. Sediment can be extracted by removing the strainer (part 46) and cleaning same. When the engine is to be laid up for an indefinite time the reservoir, if the oil has been in use for a long time, should be drained (by drain cock, part 47) and thoroughly cleaned with kerosene. This is necessary because the lubricating oil, due to its continued use, will have become more or less carbonized and during an indefinite lay up the carbon will be deposited, forming a sticky mass difficult to remove. In filling the reservoir with new oil, after cleaning the strainer, etc., care should be taken to see that the suction pipe of the pump is filled with oil. This may be done by fully opening the adjustable by-pass so that the pump starts without any back pressure, thus freeing itself of any air which may exist on the suction side of the pump. If for any reason the suction pipe is removed from the engine it should be filled with oil before it is replaced. Be particularly careful to see that the joints on the lead gaskets are made perfectly tight. Leakage of air into the suction pipe will prevent the pump from developing its proper pressure and capacity.

27d. Oiling of cam shafts.—Cam shafts are lubricated by the oil which is splashed on them from the connecting rods, and the supply is ample under ordinary circumstances. However, when the engine has not been operated for some time or when first installed the bearings will be dry. As a result, when the engine is started, the bearings are liable to run hot before the splash lubrication is properly established. In such cases the handhole cover (part 14) should be removed and the cam shaft bearings should be thoroughly flooded with oil by hand previous to starting, otherwise there is danger of twisting the cam shafts due to binding at the bearings.

27e. Hand lubrication.—Parts not automatically lubricated and needing special attention are:

1. Generator bearing. The outboard bearing should be filled with the best grade of thin lubricating oil, care being taken not to allow

it to overflow. Oil throwing is usually due to excess of oil and can be avoided by care in filling the oil reservoir. This bearing should be examined at least once a day while the machine is in operation to see that the oil rings are turning properly and that there is sufficient oil in the reservoir. When it is necessary to renew the oil, draw the old oil out from the reservoir by means of the oil plug.

2. Collar, shoes, and pivots of governor; also bell connection of governor lever. Oil with squirt can once every 10 hours, or more often if necessary.

3. Gasoline pump. Put a few drops of oil around the plunger and eccentric once or twice every 10 hours.

4. Parts of compression relief lever (within engine frame) and valve stems. Oil with squirt can when necessary.

5. Water-pump grease cups (and grease cups for eccentric strap, form A1 engines only) should be filled once at least during each eight hours of continuous operation. Only No. 2 grease of the Vacuum Oil Co. should be used. This grease is furnished by the Engineer Department.

6. Governor dashpot. Do not use oil in the governor dashpot. From time to time, or if the governor has a tendency to stick, wipe out the dashpot and put a little powdered graphite therein, work the plunger a few times, and then remove and wipe both plunger and cylinder and replace.

7. Bearings of fan motor.

8. Magneto (*see pars. 29f, 29g, 29h*).

[*See also par. 27d on oiling of cam shafts.*]

27f. Packing oil pump.—Follow same procedure given in paragraph 28d. Use part 704 or 204 for packing.

FUEL SUPPLY.

28a. Proper mixture.—Under normal conditions, at full load, proper fuel mixture will be obtained when the air valve is approximately midway between "H" and "C" and the needle valve is between 3 and 6. However, conditions for proper mixture can only be determined by experiment. The engine should not be run continuously with the air valve at "H," both because crank case air is low in oxygen and also because such procedure may rob the middle cam-shaft bearings of the proper supply of oil.

28b. Quality of gasoline.—Commercial gasoline of 58° to 68° Baumé should be used. To test gasoline for water, pass the liquid through a piece of chamois; the gasoline will pass through but the water will be retained on the chamois. The storage tanks which are furnished with all engines are tested to 100 pounds hydraulic pressure and are water-tight at that pressure; therefore no water should leak into the gasoline from the tanks. However, sometimes water finds its way into the gasoline and gets into the carburetor where it

lodges. An occasional examination should therefore be made to ascertain the condition of the fuel. At least one case is on record where the engine failed to operate due to this cause and considerable time was wasted before the cause was ascertained.

28c. Filling the carburetor.—When starting the engine, the carburetor must be filled by means of the hand pump until gasoline overflows freely into the return pipe. This is necessary to prevent flooding of the carburetor, which may occur upon starting the engine, particularly when air pockets exist in the overflow pipe. As there is always a possibility that the engine may back-fire when starting cold, the consequences may be serious if back-firing occurs with the carburetor flooded. **The precaution of thus filling the carburetor by means of the hand pump until it overflows freely must be observed each time the engine is started.**

28d. Packing the gasoline pump.—In packing gasoline pump with metallic packing[1] the following method should be used (*see*

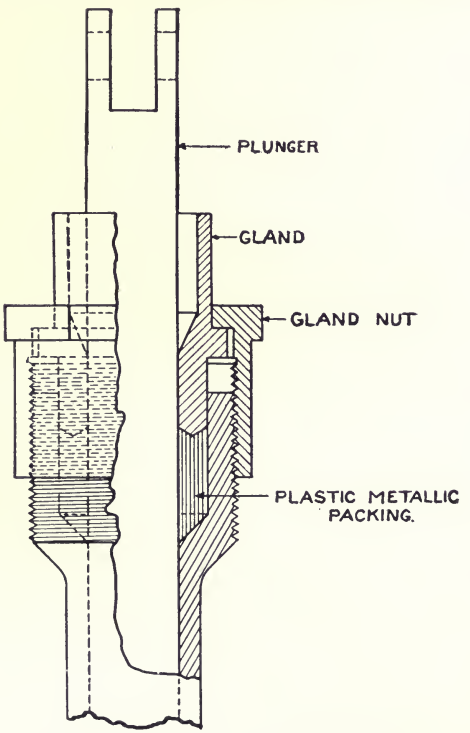


Fig. 13.—Packing of gasoline pump.

fig. 13): The pump body should be removed from the engine and held in a vise, the gland nut and gland removed, and the metallic

[1] Hemp packing is no longer issued for packing of gasoline pumps. However, hemp packing on hand should be used. This packing should be *first thoroughly soaked in glycerin* and then packed in place. When packing is properly compressed, the gland nut should be loosened one turn and the plunger lubricated with oil.

packing (parts 192 and 193) packed in place. Next the gland should be replaced and the packing compressed by driving the gland home by means of a hammer (**interposing a block of wood between the hammer and the gland**). When the desired amount of packing has been compressed in this manner, the pump may be reassembled on the engine and the packing nut well tightened up, and then backed off one turn. If necessary, after running the engine a day or so, the packing nut may be again tightened up and backed off one turn. **Do not start engine with gland nut screwed tight, as this will certainly score the plunger.**

28e. Gasoline needle valve.—A frequent cause of faulty operation, or failure to start, is clogging of the needle valve. To clean, remove adjusting needle (76) and pass a small straight wire through the nozzle into the gasoline chamber.

28f. Starting in cold weather.—If there is difficulty in starting in cold weather, a quantity of waste dipped in hot water and placed on the intake pipe (at either side of the throttle valve) will assist in vaporizing the gasoline and will generally facilitate starting. (*See par. 26i.*)

28g. Electric air heater.—An electric air-heating device is attached to all engines except those sent to localities south of San Francisco and Savannah. This device is so placed that the air drawn through the carburetor first passes through the heater. It should be kept in circuit only when necessary to keep the throttle valve from freezing, which, as a rule, will require its use only 20 to 30 minutes after starting. It should be used only when the air is damp and the room temperature is at or below 60° F. Failure to use it where conditions demand it may result in engine racing or slowing down due to freezing of throttle valve in open or closed position. The heater should be switched in only when necessary, as it uses a considerable amount of energy and, like any resistance, will burn out if continually used. As the air in the engine crank case is cold when the engine is started, the best results from the heater can be obtained by placing the air-valve lever on "C." In this position all the air will be drawn through the heater. As the engine heats up the lever may be advanced slowly until it is half way between "H" and "C." As soon as practicable thereafter the heater switch on the generator should be opened. If, after the heater has been switched off, the throttle still shows a tendency to freeze, the air-valve lever should be turned to the extreme left position "H," drawing all the air from the engine base. (*See par. 28a.*) If the air lever is intelligently used, there should be no trouble from throttle freezing nor should there be any necessity for continued use of the heater. Freedom of the throttle valve may be tested by moving the throttle-valve operating lever (part 216) back and forth slightly by hand to see that the governor acts properly when the lever is released.

IGNITION SYSTEM.

29a. Disassembly of magnetos.[1]—Magnetos are delicate pieces of apparatus and should be handled accordingly. Do not disassemble magnetos unless it is absolutely necessary. Manufacturers guarantee the proper performances of their magnetos, but once the magnets or armatures are removed their responsibility ceases. If troubles in the ignition system are traced to the magneto, it should be turned over to the Engineer Department for overhauling at the factory.

To remove interrupter covers:

1. G. E. magneto: Turn spring studs on cover 90°.
2. Eisemann magneto: Turn cover counter clock wise until released.
3. Splitdorf magneto: Evident on inspection of magneto.

To remove interrupter mechanism:

1. G. E. magneto: Pull outward spring-controlled limit pin on right side of interrupter base (part 440) and at same time turn interrupter base in a counter clockwise direction until released.
2. Eisemann magneto: Grasp the cylindrical portion of support containing part 891 and pull outward until mechanism is disengaged.
3. Splitdorf megneto: Pull the timing lever (part 1021) directly outward.

29b. To replace a magneto.—If the magneto is the one issued with the set and the gear setting is correct (as it will be if not disturbed, see par. 30f), it is only necessary to engage the driving and driven couplings (43 and 43–A2). This may result in the firing being either 90 or 180 degrees out of phase. To test, remove spark plugs, attach them to their respective high-tension terminals and ground them on their respective cylinders; then retard the spark; place ignition switch on battery; rotate the flywheel in the proper direction and watch the indicator (part 33). When it is pointing vertically upward, or nearly so, plug at cylinder No. 1 should spark, when pointing to the right No. 2, when pointing down No. 4, when pointing to the left No. 3. If the resulting fire is 4, 3, 1, 2, instead of 1, 2, 4, 3, as given above, change the coupling by 360 degrees. If the resulting firing is 2, 4, 3, 1 or 3, 1, 2, 4, instead of 1, 2, 4, 3, change coupling by 180 degrees in the proper direction. Always check the setting the second time.

[1] In an emergency it may be inexpedient to adhere to the procedure given in this paragraph in regard to repair of magnetos. In such cases observe the following precautions: Do not remove the armature from the mageto unless the magnets have been previously removed. When magnets are removed, they should be immediately short circuited with a piece of soft iron or laid on a flat surface so as to form a closed magnetic loop (south pole in contact with north pole). In replacing magnets be careful to replace them in their original positions. Do not strike magnets. If the precautions noted above are not observed, magnets may lose their magnetism and the magneto rendered useless. Should the gears and pinions be removed, see that the reference marks thereon register when gears are replaced.

29c. To install a new magneto.—The procedure is generally the same as given above. In this case, however, the adjusting lever (part 70 or 961) will be issued blank and it will be necessary for an experienced operator to determine the proper starting and running points and to notch them on the lever. The criteria by which the proper running point may be determined are quiet operation, speed, absence of preignition, etc.

29d. Testing ignition system.—Difficulty in starting and faulty operation are frequently due to causes outside of the ignition system, such as faulty carburetor, leaky valves, etc. Spark plugs should be frequently and thoroughly cleaned with gasoline and the carbon deposit scraped therefrom, if necessary. The distance between the electrodes of the spark plugs should be from $\frac{1}{32}$ to $\frac{1}{64}$ inch. If troubles develop which can not be located by a cursory examination, they may be located by performing the following operations in the sequence given:

(1) Inspect circuits for grounds, open circuits and short circuits. Make sure that all connections are clean and rigid.

(2) Place ignition switch on battery. Test sparking as explained for checking magneto installation given in paragraph 29b. Replace defective spark plugs. If this procedure does not correct faults then:

(3) Distributor cover and interrupter cover (or breaker-box cover of Splitdorf magneto) should be removed and all contact surfaces cleaned with gasoline. (*See paragraph 29e on adjustment of platinum contacts.*) After this procedure, repeat operation 2 above. If fault still exist then:

(4) Turn the engine over by hand until platinum contacts of the magneto close. Place ignition switch on battery. Remove one of the battery leads from the battery and rapidly make and break the battery circuit at the battery terminal. If no spark is observed the trouble is probably due to faults in the battery connections or to poor contact at platinum contacts (*see par. 29e*). If spark is observed, then:

(5a) G. E. and Eisemann magnetos: Disconnect middle lead from distributor, turn engine over by hand until platinum contacts close. Place ignition switch on battery. If a spark can not be produced at safety spark gap by rapidly switching the key between "battery" and "off" several times, the trouble must lie in the transformer coil; *or*

(5b) Splitdorf magneto: Turn engine over by hand until platinum contacts close. Place ignition switch on battery. Remove center lead from distributor and fix terminal so as to provide spark gap to ground (on engine or battery box, etc.) of one-fourth inch—not more—then lightly but rapidly tap the button on the ignition

switch. If no spark appears at the improvised spark gap, the trouble lies in the transformer coil.

(6) If the engine runs properly on battery but will not run properly on magneto and the faults are not apparent on careful examination, the magneto should be turned in to the engineer department for overhauling at the factory.

29e. Platinum contacts.—A gauge (small piece of sheet steel, part 329, 898, or 978) is furnished with each magneto for adjusting the gap between the platinum contacts. At maximum opening the gap should be adjusted sufficiently to accommodate the gauge. It should be observed that when any magneto part, the function of which is to operate the "make and break" mechanism, is changed, it will be necessary to readjust the gap between the contacts. The adjustment is not complete until the adjustable contact is locked by the set screw or nut provided. After long use the platinum contacts become worn, pitted, and fouled. When occasion demands, contact surfaces should be trued with a file or emery paper. After this procedure, see that full surface contact is obtained when the gap is closed.

29f. Care and maintenance of G. E. magneto.—Use good, light machine oil. Clean with gasoline and lubricate sparingly ball bearings, cam and interrupter lever, copper head on end of the armature and brush pressing against same, copper plate on distributor finger. Clean with gasoline cylindrical surface of distributor, brush in distributor finger. Lubricate gear and pinion through hole in top of gear guard and spring in back of interrupter base.

29g. Care and maintenance of Eisemann magneto.—Fill now and then with vaseline the small lubricator placed at the end of the distributor shaft in the center of the large gear, and the lubricator between magneto and gear cover. Lubricate with the best lubricating oil the wick oilers on the main bearings at the driving and collector ends (the latter being ball bearings), the shaft of the platinum contact lever and the cam which operates it. Clean frequently with gasoline the carbon brush on distributor finger, the platinum contact, the spring contact (part 891), and the metallic contact pieces on the distributor plate.

29h. Care and maintenance of Splitdorf magneto.—Lubricate gears with best lubricating oil through oil cups on back plate; lubricate distributor shaft bearing through oil well at top of front plate; and lubricate armature shaft bearing through oil ducts on side of front plate. Clean frequently with gasoline the carbon brushes on distributor cover and brass segment on distributor. Clean with gasoline and lubricate sparingly cam and interrupter lever.

ADJUSTMENT, MAINTENANCE, AND INSTALLATION OF PARTS OF ENGINE PROPER.

30a. Bearings.—Each bearing is supplied with five sets of shims on each side. Each set is made up of one shim 0.030 inch thick, one shim 0.015 inch thick, and three shims 0.005 inch thick, making a total thickness of 0.060 inch. When making adjustments for wear do not take out more than 0.005 inch on each side. Take out one shim 0.005 inch thick each time for the first, second, and third adjustments. Fourth adjustment, take out one 0.015-inch shim and put back two 0.005-inch shims. Fifth and sixth adjustments, take out one 0.005-inch shim each time. Seventh adjustment, take out one 0.030-inch shim and put back one 0.015-inch and two 0.005-inch shims. Eighth and ninth adjustments, take out one 0.005-inch shim each time. Tenth adjustment, take out one 0.015-inch shim and put back two 0.005-inch shims. Eleventh and twelfth adjustments, take out one 0.005-inch shim each time. Linings 130, 135, and 136 (*see list of parts*) are all made from the same drawing and have the same dimensions, but owing to unequal wear in operation (the lower lining wearing most) it is advisable to replace linings after disassembly in the same places in which they were found originally. This is particularly important on crank-shaft bearings to maintain proper shaft alignment. For this reason all linings, both in engine and furnished as spare parts, are marked with numbers on edge facing exhaust side of engine. Inside main crank-shaft linings are numbered 2, 3, 4, beginning with the flywheel side, and similarly connecting rod-head linings C1, C2, C3, C4. Figures must appear upright in the position they occupy in engine, so that upper linings will have figures near lower edge and lower linings will have figures near upper edge. In a similar manner main end bearing linings (293 and 294) are made from same drawing and marked 1 and 5, respectively. Each bearing stud or bolt is fitted with a standard hexagonal-head case-hardened nut and lock nut. After slacking off the lock nut one or two turns, tap the outer shell back, which will at once release the clamp on the inner shell, and the nut can then be taken off easily by hand. When tightening up connecting-rod head bolts, make sure the head is down in place and the flat on the bolt head fits with the corresponding flat on the connecting rod, so as to prevent turning. This also applies to the end bearing bolts and the cylinder holding-down bolts to middle bearings. When taking off or replacing the end bearing caps, it is necessary to hold up the bolts as high as possible on account of clearance. In making adjustments to bearings, take note that all parts are numbered on the exhaust side from 1 to 4, running in sequence from the flywheel end. They should be replaced accordingly.

30b. Valves.—Do not grind in valves unnecessarily. Before attempting to grind in valves, make sure that they need it. In most cases cleaning the valve and valve seat thoroughly with gasoline will disclose the fact that no grinding is necessary. As further test, after cleaning, oil contact surface lightly and rotate the valve in its seat under pressure by means of a breast drill or brace. Upon withdrawing the valve from its seat, the necessity for grinding in will be apparent to an experienced operator. To grind in valves, lubricate valve contact surfaces and place a little flour of emery on the valve seat (use emery sparingly), rotate the valve with a slight pressure; examine and test surfaces from time to time as explained above. Cotton waste should be packed into cylinder passages in order to keep the emery out of cylinders. Remove all traces of emery from the valve before final assembly. The valve tool should be used sparingly or preferably not at all. It should be used only by experienced mechanics. It should not be used unless valve seat is badly pitted or burned while the valve itself is in good condition. Other than sparing use of the tool will result in ruining the cylinders. Before using the tool remove with gasoline or, if necessary, with a scraper, the hard scale which forms on the interior of the ports; otherwise this scale will prevent the tool from making a good surface on the valve seat. When valves are ground or when new valves are installed, it will be necessary to check the valve setting. To do this, turn the engine over by hand until the valve seats firmly. Then adjust, by means of the valve adjusting clamp (part 67), the distance between the valve stem and the tappet rod so that there is a clearance of $\frac{1}{32}$ inch between them when the parts are hot. **This clearance should be accurately measured.** If the valves are so adjusted that they do not seat properly, the hot gases will play through the opening and burn the valve stems.

30c. Cylinders, piston rings, etc.—The tendency of all internal combustion engines is to form a deposit of carbon on the inside of the cylinders and this tendency is increased when the engine is running under partial load. The tendency can be reduced when the engine is run under light load by throttling the gasoline so as to produce a leaner mixture. If the gasoline is throttled too much, however, there is liability of back-fire taking place (there is no danger from this source unless carbureter is flooded). Carbon in the cylinders causes the piston rings to stick and become inoperative, as well as to wear on the sides of the cylinders. Cylinders can be kept in perfect condition by the use of kerosene oil. Pour a small quantity of kerosene oil, enough to fill one cartridge shell (or two shells if the engine has been operated at or near full load for five or six hours) into each cylinder at the end of the run and while the engine is hot. Turn the engine over by hand two or three times so as to thoroughly

wash the sides of the cylinders with oil and to allow it to work in and around the piston rings, and leave it there until the next run. This should be done frequently; but it should not be done, however, when the set is to be laid up for an indefinite period, as kerosene in the cylinders will cause rust. Carbon can be completely removed from the cylinders by commercial acetone. Acetone should be used only when the cylinders are disassembled and it is impossible to remove the carbon in any other manner.

30d. Governor.—Trouble has been experienced with the engines when first installed, due to a slight bending of the lever of the governor (part 39), which caused the governor to stick and make the regulation of the engine poor. This lever is easily bent, and the bending may occur in the packing of the engine, in transportation, or in setting up. The free working of the governor dashpot (part 13) is absolutely essential to the proper operation of the governor. If the engine does not regulate properly, this part should be examined to see that it works freely. It has been found by experience that, after the graphite has been placed in the dashpot, it should be wiped out again, leaving merely a film on the inner surface of the dashpot. (*See par. 27e.*) The engines are adjusted, on acceptance test, to regulate properly. This adjustment is such that, upon throwing off full load of 25 kw. or instantly applying a full load of 25 kw., the voltage will return to the initial figure (stamped on the name plate of the generator) within five seconds; moreover, the fluctuation of voltage on constant load does not exceed one volt during long periods of operation. Therefore, because of these careful adjustments before shipment, it should be unnecessary to alter the governor in any manner after receipt of the engine. Any failure to regulate should be traced, if possible, to some other cause, and the governor, because of its intricate construction, should be left undisturbed. If, upon starting up, the speed at full load is not 560 r. p. m., a moderate increase or decrease may be obtained by increasing or decreasing the tension of the spring (part 57). The speed at no load (with only the fan for a load) may vary from 570 to 575 r. p. m.

30e. Flywheel.—The flywheel is held to the crank shaft with a key and taper fit, being securely clamped by a nut (part 106), in turn locked by set screws (part 146). To remove the flywheel, first drive out the cranking pin (part 73), loosen set screws and unscrew the clamping nut; a special wrench is provided for this nut. The flywheel should be slung so as to take its weight off the crank-shaft. A special tool, "flywheel puller" [1] (parts 311, 312, 313), is furnished for pulling the flywheel off the taper. Figure 14 shows method of dis-

[1] No flywheel pullers are furnished with Form A engines. A puller similar to that illustrated above can be readily fabricated if needed to remove flywheel hub.

assembly, turning the nuts (part 312) draws wheel off easily. In replacing the flywheel, push it on the shaft by hand as far as possible, forcing

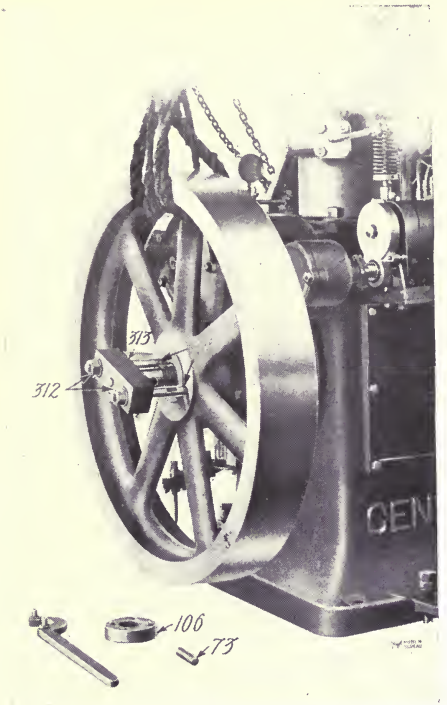


Fig. 14.—Removal of flywheel.

it finally in place by the clamping nut. Tighten the set screws and drive in the cranking pin.

30f. Gears.—It should be noted that when cloth gears are furnished the pump and magneto gears are interchangeable, but such is not the case, however, where steel gears are used throughout. If the gears are removed for any purpose, they should be replaced as indicated in figure 15. In the later engines gears are marked as indicated in the figure. If gears are not marked as indicated, observe that the reference line in all cases is the line through shaft center and the center of the key-way. After replacing gears, always test order of firing of cylinders as explained in paragraph 29b.

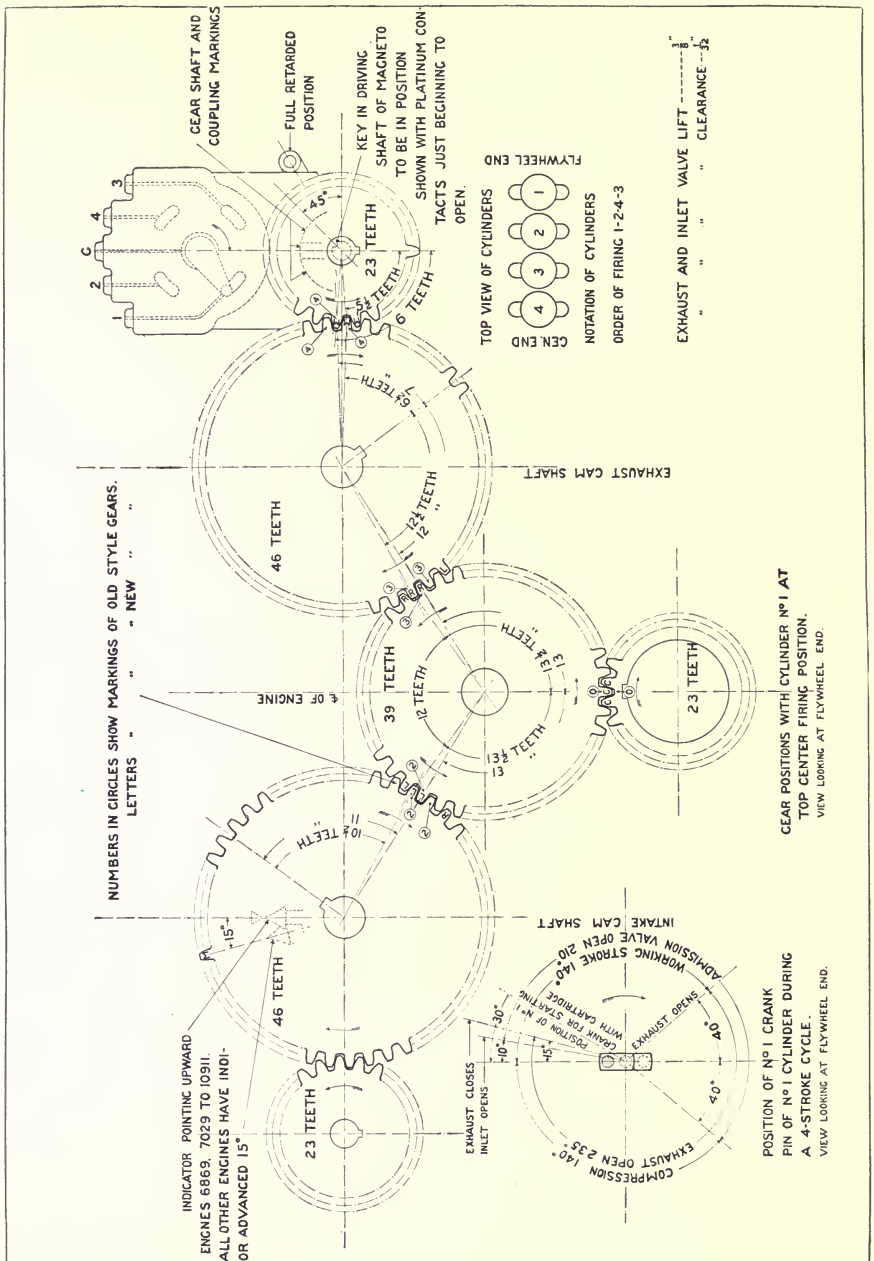

NUMBERS IN CIRCLES SHOW MARKINGS OF OLD STYLE GEARS.
LETTERS " " " NEW " "
INDICATOR POINTING UPWARD FOR ENGNES 6869, 7029 TO 10911. ALL OTHER ENGINES HAVE INDICATOR ADVANCED 15°
46 TEETH
23 TEETH
39 TEETH
12 TEETH
INTAKE CAM SHAFT
EXHAUST CAM SHAFT
CRANK SHAFT
CEAR SHAFT AND COUPLING MARKINGS
FULL RETARDED POSITION
KEY IN DRIVING SHAFT OF MAGNETO TO BE IN POSITION SHOWN WITH PLATINUM CONTACTS JUST BEGINNING TO OPEN.
6 TEETH
TOP VIEW OF CYLINDERS
CEN. END
FLYWHEEL END
NOTATION OF CYLINDERS
ORDER OF FIRING 1-2-4-3
EXHAUST AND INLET VALVE LIFT ---------
" " " " CLEARANCE ---
EXHAUST CLOSES
INLET OPENS
COMPRESSION 140°
EXHAUST OPEN 235°
WORKING STROKE 140°
ADMISSION VALVE OPEN 210°
EXHAUST OPENS
CRANK FOR STARTING
POSITION OF "A"
WITH CARTRIDGE
POSITION OF NO 1 CRANK PIN OF NO 1 CYLINDER DURING A 4-STROKE CYCLE.
VIEW LOOKING AT FLYWHEEL END.
GEAR POSITIONS WITH CYLINDER NO 1 AT TOP CENTER FIRING POSITION.
VIEW LOOKING AT FLYWHEEL END.

Fig. 15.

GENERATOR AND MOTOR.

31a. Field rheostat of generator.—Although the generator is flat compounded for 115 volts (or 230) at full load, it must be remembered that at loads intermediate between no load and full load the voltage is somewhat higher than the full or no load voltage. Therefore, the proper setting for field rheostat should be determined either at full load or no load. If field is adjusted to give 115 volts at half load, say, the generator will fail to hold the voltage properly at all other loads.

31b. Generator brush setting.—The direction of rotation of these machines is counter-clockwise when facing the commutator end

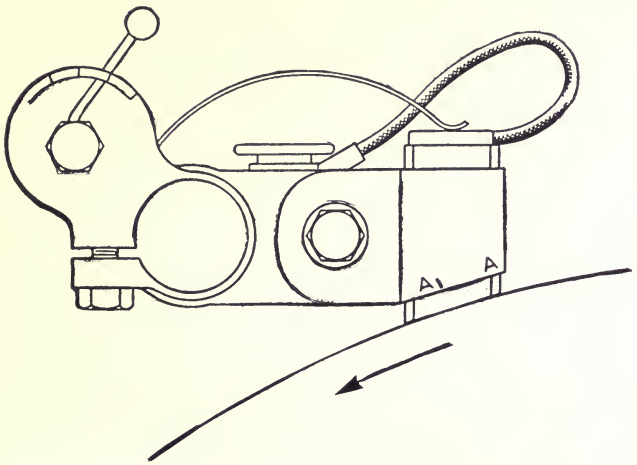


Fig. 16.—Brush and holder.

and the brushes are always arranged so that they trail with reference to the rotation of the commutator, figure 16. The nuts on the brush-holder studs should be tightened so that studs will be held rigidly, then clamp the body of the brush-holder firmly on the stud with the lower edge of the box $\frac{3}{32}$ inch from the surface of the commutator. Care should be taken to see that the lower side of the box (A–A1), figure 16, is parallel with the surface of the commutator; in other words, the distance of the point "A" from the commutator should be the same as that of the point "A1." Also be careful to see that the brush holders are staggered, so that the brushes on any one stud will not follow exactly behind those on the next stud ahead. The brushes should then be inserted in the boxes, properly sandpapered and fitted to the surface of the commutator.

The brushes should be properly spaced by placing a paper ring around the commutator marked with equal spaces to correspond to the number of poles. When the brushes are correctly set, across the brush-holder yoke is chisled a line, just under the arrow on the right-

hand side of the upper arm of the bearing bracket. This position will give correct commutation and compounding for all loads. The pressure of the brush should be from $1\frac{1}{2}$ to 2 pounds per square inch, and can easily be adjusted by placing the adjusting lever in one of the various notches. Nothing is gained by increasing the pressure per square inch on a carbon brush above 2 pounds, as the resistance per square inch beyond this point is practically not reduced, whereas the friction is increased in direct proportion to the pressure. Fit the carbon brushes carefully to the commutator by passing beneath them No. 0 sandpaper, with the rough side against the brush and the smooth side held down closely against the surface of the commutator. Move the sandpaper in the direction of rotation of the armature and draw it back for the next cut with brush raised to free it of sandpaper; then lower the brush and repeat the operation until a perfect fit is obtained. If the brush requires considerable sandpapering, No. 2 sandpaper may be used at first, but the final fitting should be done with No. 0. If an attempt be made to fit the brushes without raising them, while drawing the sandpaper back, it will in every case fail to give satisfactory results.

31c. Generator commutator.—The commutator, brushes and brush holders should at all times be kept perfectly clean and free from carbon or other dust. Wipe the commutator from time to time with a piece of canvas slightly soaked with vaseline; if vaseline is not at hand, use oil, but lubricant of any kind should be applied very sparingly. If the commutator, when running, begins to give trouble by roughness, with attendant sparking or excessive heating, it is necessary immediately to take measures to smooth the surface. Any delay will aggravate the trouble and eventually cause high temperatures, throwing of solder and possibly displacement of the segments. No. 0 sandpaper fitted to a segment of wood with a radius equal to that of the commutator, if applied in time to the surface when running at full speed (and if possible with brushes raised) and kept moving laterally back and forth on the commutator, will usually remedy the fault. If this does not suffice, it will then be necessary to take the armature out, tighten up the segments and turn them off true. A machine tool will not leave the surface smooth enough to give perfectly satisfactory results. It is always necessary, before putting on a load, after the commutator has been turned, carefully to smooth the surface with the finest sandpaper, thus removing all traces of the tool point.

31d. Generator connections.—The connections and manner of placing the spools are shown in fig. 6. Care should be taken to see that all connections both between the coils and on terminal boards are made as tight and rigid as possible, in order to reduce the contact resistance to a minimum.

31c. Fan motor.—Handhole covers on the fan motor should be removed and brushes and commutators examined from time to time. It must be remembered that it is occasionally necessary to replace carbon brushes. They should not be allowed to wear to such an extent as to permit the rivets of the pigtail attachment to come in contact with the commutator. The general remarks given in paragraphs 31b and 31c, relative to the care of commutator and brush settings, apply with equal force to the fan motor.

32. SYNOPSIS OF TROUBLES AND THEIR CAUSE.

Trouble.	Cause.
Hard to start	1. Dirty plug (*see par. 29d*).
	2. Spark gap in plug not properly adjusted—between 1/32 to 1/64 inch correct.
	3. Broken porcelain insulator at plugs or insulation of high-tension lead punctured.
	4. Wiring connections not rigid.
	5. Poor mixture.
	6. Cold weather (*see par. 27f*).
Knocking	1. Spark too far advanced for load.
	2. One cylinder not firing, the others being therefore overloaded.
	3. Pre-ignition, caused by too rich or too lean a mixture or by carbon in cylinders.
	4. Loose bearings.
Overheating	1. Water circulation faulty (*see par. 26b*).
	2. Fan stopped.
	3. Improper mixture (*see par. 28a*).
	4. Spark retarded too much.
Poor regulation	1. One or more cylinders not firing (this also manifests itself by periodic swing in the voltage).
	2. Sticky governor or dashpot (*see par. 27e*).
	4. Sticky or dirty throttle valve.
	4. Gasoline needle valve clogged (*see par. 28e*).

PART III.—INSTALLATION.

SHIPMENT:

33. Before shipment the exhaust header and the intake manifold are removed and replaced by two lifting bars by which the set may be safely lifted. The set, as a whole, should be lifted in this manner only. The sets when received will be found disassembled and packed in the following manner:

1. A crate containing the engine and the generator (minus the parts listed below).
2. A box containing the exhaust header.
3. A box containing the intake manifold, carburetor, hot-air intake, water-outlet pipes (from cylinders to exhaust header), field rheostat and electric air heater (if one be furnished).
4. A box containing the governor, governor bracket, and the throttle valve connecting rod.
5. A box containing the tool box and tools.
6. A box containing spare part box and spares.
7. A box containing foundation bolts. Foundation bolts, of type indicated in fig. 17, are shipped in advance of set proper and as early as practicable.
8. A crate containing the radiator, motor, motor pedestal, and sub-base.
9. A box containing fan motor rheostat.
10. A box containing 100 starting cartridges.
11. A box containing the muffler.

ASSEMBLY:

34. Each separate box or crate is marked with the serial number of the set, and only the component parts thus indicated should be comprised in a given installation (i. e., governors, radiators, etc., are not interchangeable). Where there is a likelihood of wrong assembly, the parts are marked to indicate their correct positions. Particular attention is invited to the fact that water-outlet pipes (parts 55, 613, 614, 615) are not interchangeable; the cylinders to which they belong are indicated by numbers on the pipes. When assembling iron to iron parts subject to heat (e. g., cylinders to exhaust manifold) the surfaces not gasketed should be coated with a mixture of oil and graphite. When installing keyed parts on shafts, the shafts and keys should be thoroughly oiled.

FOUNDATIONS:

35. Provide the sets with a suitable foundation, at least 2 feet thick and resting on hard earth. The foundation bolts should be set in pipes, allowing displacement in all directions until the engine is located over them. The customary way of insuring that the engine base will have an even bearing on the foundation, is to raise it about $\frac{3}{8}$ to $\frac{1}{2}$ inch on wedges or shims; level it and tighten holding nuts and then float the top of the foundation with concrete grout to a height slightly above the bottom of the engine base. The simplest way of leveling the engine consists in removing cylinder No. 4 and leveling the machined surface of its seat both longitudinally and laterally. Be sure that grout fills pipes for foundation bolts. The subbase, the radiator, and fan motor should be similarly installed on a concrete foundation of at least 6 inches thick. The district engineer officer must provide the necessary foundation bolts ($\frac{3}{4}$-inch diameter) for the radiator subbase. For typical sections of foundations see figs. 24 and 25. Sets will run without objectionable vibration or excessive noise only when foundations are properly constructed.

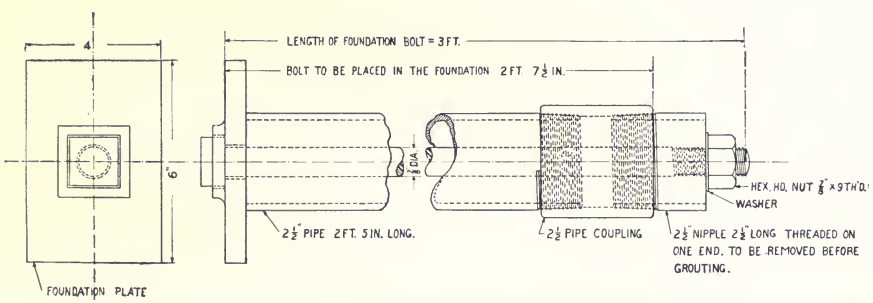


Fig. 17.—Foundation bolt for engine base.

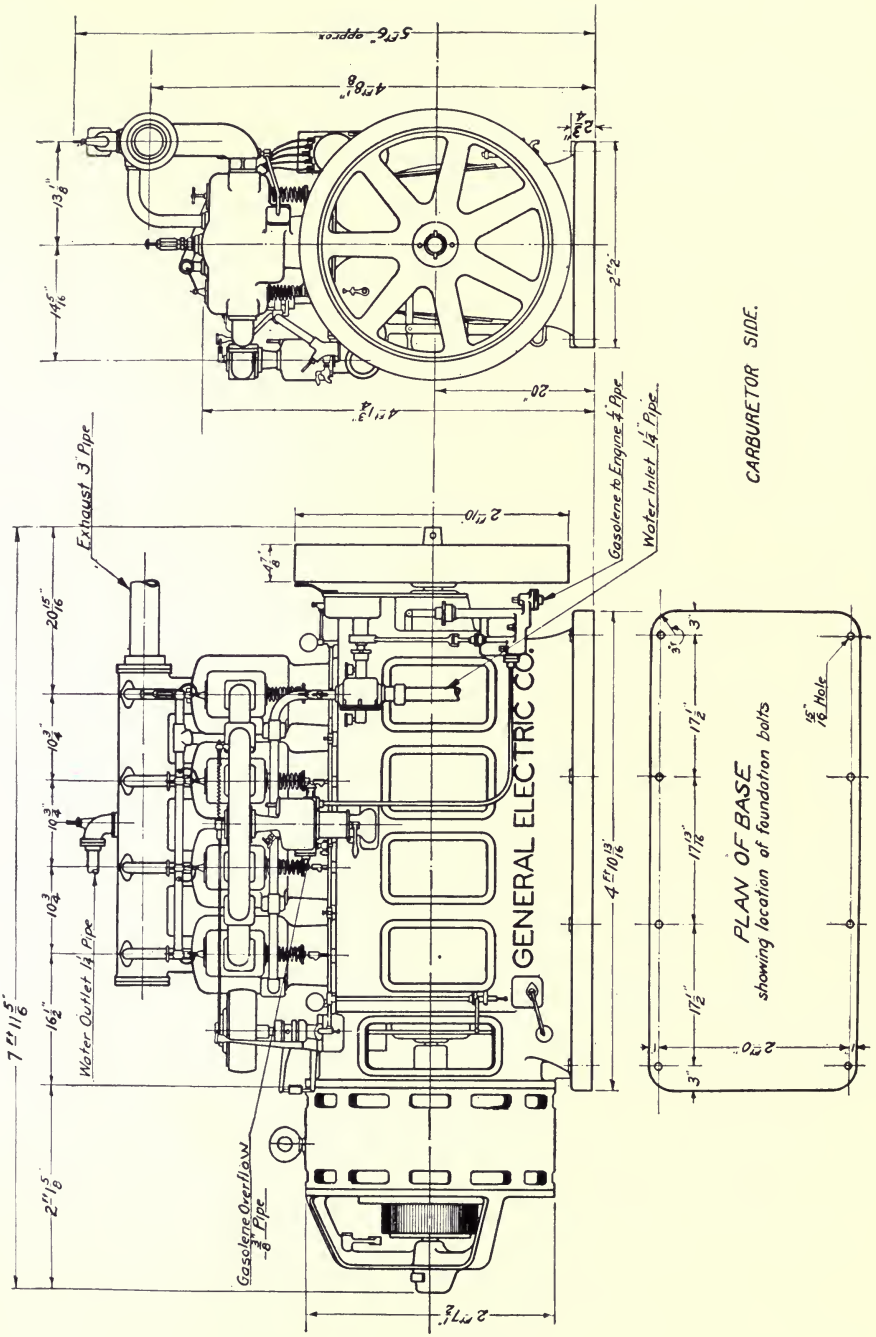


Fig. 18.—Outline dimensions of engine.

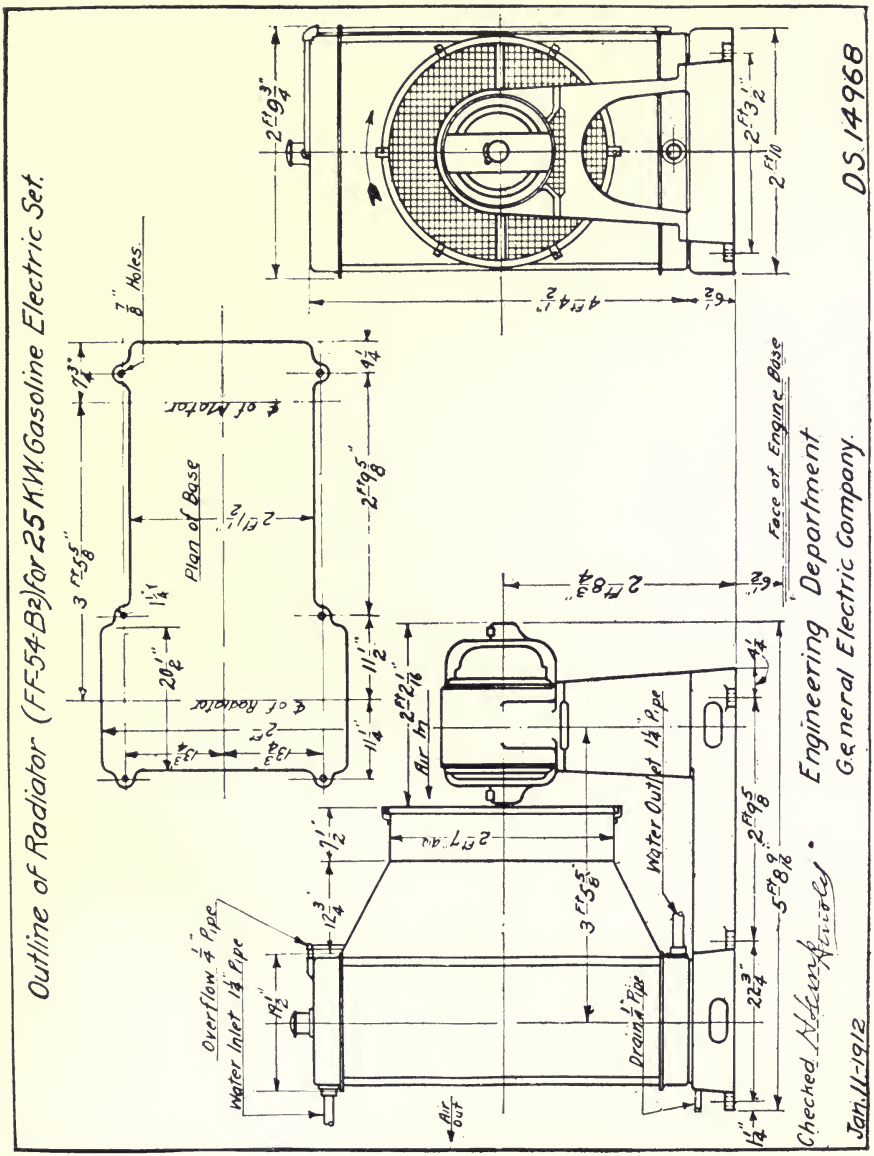


Fig. 19.—Outline dimensions of radiator.

WATER COOLING SYSTEM:

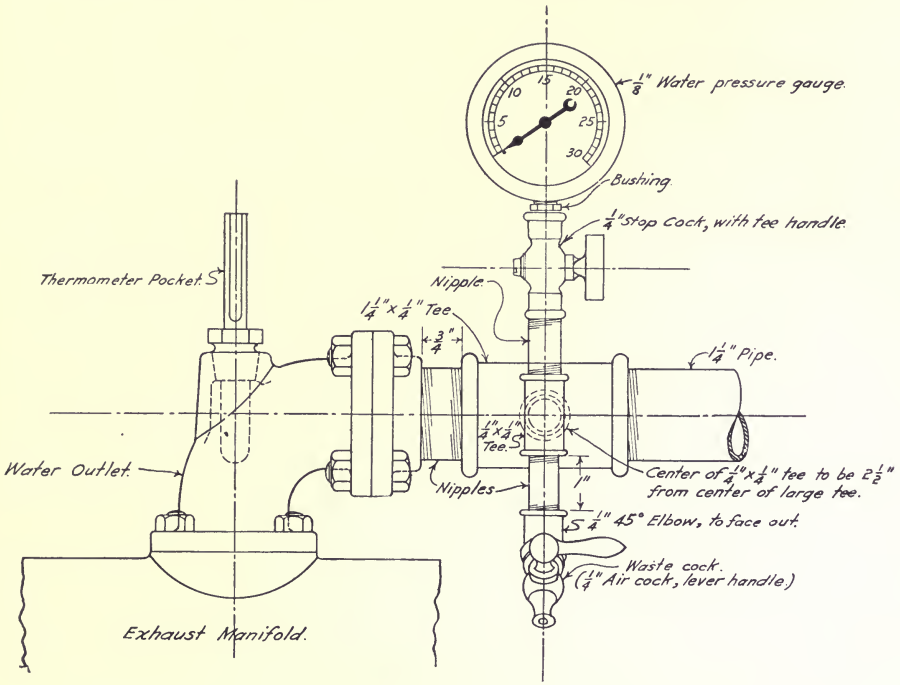
36a. General.—It is absolutely essential that the water-cooling system be carefully installed before any attempt is made to operate the sets. The amount of water required in the circulating system is small. The exact amount depends upon the installation, but in a general case it will not exceed 50 gallons.

36b. Valves.—No valves are to be placed in the main line of piping of the cooling system, either in the water outlet pipe (from exhaust manifold to radiator) or in the return pipe (from radiator to pump). Such a valve if installed might be left closed at starting with consequent disastrous results to the engine.

36c. Size of pipe.—The size of the water-pipe connections ($1\frac{1}{4}$-inch) on the engine and the radiator indicates the proper size of pipe to be used when the radiator is placed at a distance of not more than 30 feet from the engine. However, at greater distances the friction in $1\frac{1}{4}$-inch pipe would be too great. In such cases the size of the pipe should be increased to $1\frac{1}{2}$ inches or 2 inches, depending upon the distance at which the radiator is installed. With 2-inch pipe there should be no difficulty in operating the set with the radiator at a distance of 200 feet from the engine, but in such an installation care should be taken to avoid unnecessary bends and particularly inverted siphons in the return pipe. All fittings must be tight, particularly on the suction side of the pump, as a small air leak may materially reduce the volume of water circulated and cause overheating.

36d. Pressure gauge, waste cock, and sight-flow indicator.—A pressure gauge should be installed in the water system near the exhaust manifold. A gauge of the same size and interchangeable with the oil gauge (part 45) and having a range of 25 or 30 pounds should be used. The pressure gauge is attached by inserting a $1\frac{1}{4}$ by $\frac{1}{4}$ inch tee in the pipe leading from the top of the exhaust to the radiator and as near the exhaust outlet as practicable. To the $\frac{1}{4}$-inch opening of the $1\frac{1}{4}$-inch tee in the circulating pipe should be attached a $\frac{1}{4}$-inch tee by means of a nipple. To the top of this latter $\frac{1}{4}$-inch tee should be connected the pressure gauge by means of a nipple and $\frac{1}{4}$-inch tee handle stop cock. To the bottom of the $\frac{1}{4}$-inch tee should be connected, in the order named, a nipple, a 45° elbow, and $\frac{1}{4}$-inch air cock (waste cock) with lever handle. The installation should be such that water draining from the cock will clear the exhaust manifold of the engine. The cock immediately below the gauge is necessary to reduce the effect of the pulsations in the water pipe. The proper method of attaching the gauge and cocks is shown in fig. 20. The use of the waste cock when the engine is in operation is described in paragraph 26f. The gauge cocks and pipe fittings are supplied by the Engineer Depot, Washington Barracks. The sight-flow indicator should

be located immediately below the pump (below part 64) and in such a position that the flap will be horizontal when no water is flowing.



ARRANGEMENT OF WASTE COCK AND PRESSURE GAUGE IN WATER OUTLET PIPE OF 25 K. W. GAS MOTOR SETS ADOPTED IN NEW LONDON DISTRICT.

Revised 4-1-12.

Fig. 20.

36e. Proper method of piping.—The water supply should be led to a point conveniently near the radiator so as to permit the radiator being filled by hose through filling cap. The scheme of attaching the supply pipe direct to the exhaust-water outlet on the engine for the purpose of insuring that the jackets are full before the engine is started should be not resorted to generally. Successful operation with such an installation depends upon proper manipulation and functioning of valves. For example, if the supply valve should leak in cold weather after the engine had been drained, the water thus admitted to jackets might freeze and crack the cylinders. This type of installation is also subject to the objection of air binding.

36f. Loss of cooling water.—If the level of water in radiator at overflow is not at the highest point of the cooling water system there

may be a considerable waste of water after shutting down due to the difference in head between the highest point and the radiator overflow level. Thus, with 200 feet of 2-inch pipe higher than the radiator overflow level, the loss of water on shutting down would be considerable (approximately 30 gallons) and the advantages of the closed system would be lost, particularly where good cooling water is scarce. On the other hand, the amount of cooling water lost might, in some cases, be negligible. Nevertheless, if practicable, the radiator overflow level should be made the highest point in the water-cooling system. Cases may arise where this would entail expensive cutting of concrete above radiator in order to get necessary elevation, or would result in too great a reduction of head room near engine (in order to keep exhaust water outlet pipe below plane of radiator overflow level). The solution of the problem is a matter requiring good judgment on the part of the constructing officer. In extreme cases it may be necessary to have the highest point of the cooling water system in the overflow; to vent the overflow at this point; and to make the radiator cap water-tight by means of a suitable gasket.

36g. Where radiator is out of commission or not installed.—While in most cases it is best to adhere to the typical method of installing the radiator and fan to cool the jacket water and thereby avoid the waste of water and the occurrence of new complications, it is possible to conceive of an emergency arising under which it may be desirable or necessary to use water drawn from the city or post water system (for example, when the fan or radiator is damaged). The proper method of arranging the piping in such cases and the only one which is recommended is shown in figure 21. The suction of the pump is connected to the discharge above the manifold, thus completely by-passing the engine. The supply is led into this by-pass just below the pump. A valve is placed in the supply before it reaches the by-pass. The waste pipe of the system should be carried up a few feet, and then across the ceiling to the point of discharge, thus giving the necessary head room. The waste pipe should be high enough to give a static head greater than friction head of the by-pass; i. e., with the supply valve closed and by-pass full of water, no water should appear at the overflow when the engine is in operation.

The discharge should be in clear view of the operator so as to enable him to tell at a glance the amount of water that is wasting from the system. In places where the set may be subjected to freezing temperatures, a drain should be provided in the by-pass at its lowest point. A strainer should be interposed in the supply between the lower by-pass connection and the supply valve in order to prevent injurious substances from entering the pump. No valve except one in the supply pipe should be placed in the system. It

should be noted that a permanent installation of this type should be made only in cases where radiator is not installed. It is intended primarily as a temporary installation to be resorted to only when the radiator is out of commission.

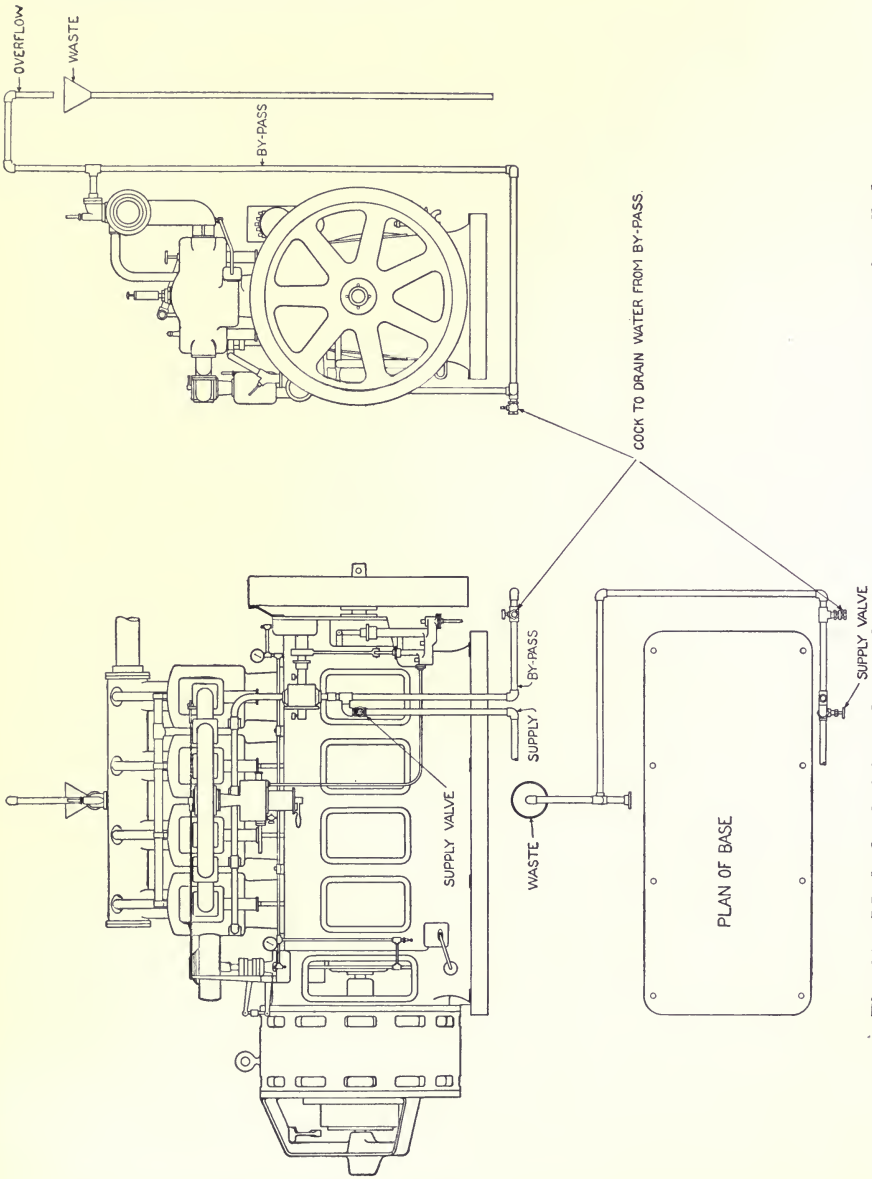


Fig. 21.—Method of piping when radiator is out of commission or not installed.

36h. Other methods of piping.—Other methods of piping than those given above will lead to more or less serious complications. For example, it has been found by actual experience that where the city or post water is piped directly into the engine, unequal cooling

in the cylinders results. This is due to the fact that the baffle plates in the water-outlet pipes from the cylinders are proportioned to the pressure created by the circulating pump. Any marked increase or decrease in this pressure will cause unequal distribution of water among the cylinders, and consequently unequal cooling.

FUEL SUPPLY:

37a. Gasoline tanks.—The 370-gallon gasoline tank (see fig. 22[1] for dimensions) should be buried outside the engine room below the level of the engine room floor. The bottom of the tank should not ordinarily be more than 5 feet below the level of the engine base and the tank should be placed as near the engine as is practicable. Before installing, the tank should be thoroughly cleaned inside and coated outside with tar. It should be set on a foundation of broken stone about 18 inches thick to insure good drainage, and back-filled with earth or small stone. Tanks should not ordinarily be installed so as to permit their use by more than one engine, as this requires use of valves in supply and overflow pipes. For the protection of the supply and return pipe where they enter the tank, it is suggested that a reinforced concrete box be built over the tank outlet. This box should be about 15 inches square inside and 6 inches deep in the middle, and should rest on the tank. A plate metal or reinforced concrete cover should also be provided. This arrangement being below ground will provide a well-protected means of access to the pipe in case of trouble. It also gives a minimum space for the accumulation of gasoline vapor in case of leakage. For these reasons it is to be preferred to a manhole accessible from the ground level.

37b. Overflow pipe.—It is absolutely essential that the return gasoline pipe carrying the overflow from the carburetor to the tank be installed without the slightest pocket in which air may collect. A gradual descent from the carburetor to the tank is imperative, otherwise when the engine is started the carburetor will flood. The engine when started cold is liable to backfire through the carburetor (as has happened on many occasions), and the results with a flooded carburetor are serious. **The necessity for a free overflow, therefore, can not be too strongly emphasized.** Under ordinary conditions a $\frac{1}{2}$-inch pipe (inside diameter) for the overflow is sufficient. However, if the tank is installed at a considerable distance from the engine or the grade of the overflow pipe is slight, it is advisable to install a $\frac{3}{4}$-inch pipe (inside diameter).

[1] Two types of tanks are furnished, as shown in fig. 22, one with both heads dished, the other with one head dished and one convex. The type depends upon the design used by manufacturer to whom contract is awarded.

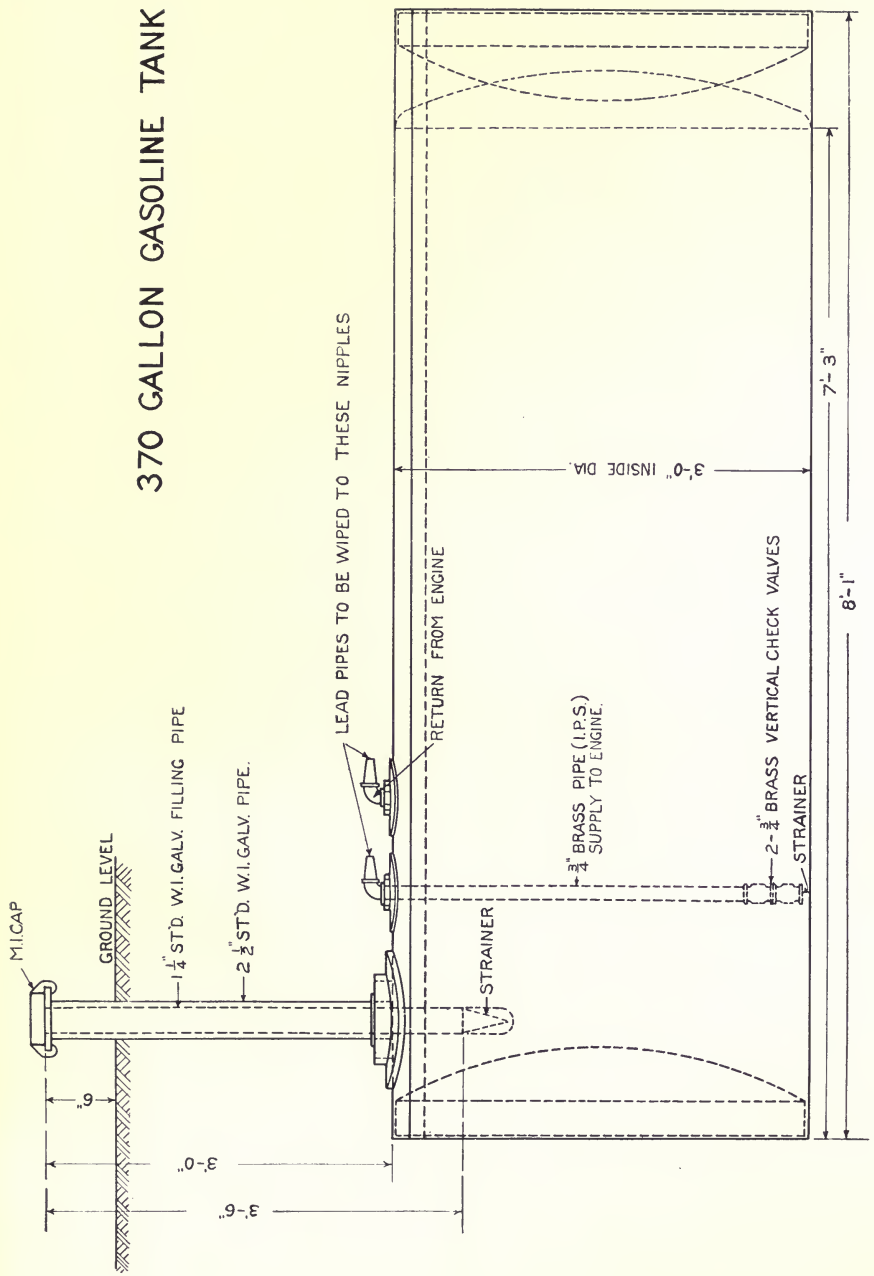

370 GALLON GASOLINE TANK
M.I. CAP
GROUND LEVEL
1¼" STD. W.I. GALV. FILLING PIPE
2½" STD. W.I. GALV. PIPE.
LEAD PIPES TO BE WIPED TO THESE NIPPLES
RETURN FROM ENGINE
¾" BRASS PIPE (I.P.S.) SUPPLY TO ENGINE.
STRAINER
2-¾" BRASS VERTICAL CHECK VALVES
STRAINER
3'-0" INSIDE DIA
7'-3"
8'-1"
6"
3'-0"
3'-6"

Fig. 22.

37c. Supply pipe.—The specifications under which the sets are purchased require the gasoline pump to lift the supply of gasoline 5 feet. The gasoline pump will easily meet this requirement under proper conditions and will generally lift the gasoline somewhat greater distances than specified (the lift of the pump depends very largely upon the temperature of the gasoline). The lift in all cases should be as small as possible, having due regard for the slope of the overflow pipe. As a general rule $\frac{3}{8}$-inch pipe (inside diameter) will be found satisfactory for supply pipe. If possible the supply pipe should be installed without foot valves (or check valves which are indicated in fig. 22) in order that all gasoline may drain back into the tank when the engine is stopped. If the lift does not exceed 6 feet and the supply line is not unusually long, the pump will lift the gasoline without a foot valve. Foot valves in the gasoline tank are likely to get out of order and they are difficult to repair on account of their location. It is recommended that the constructing officers experiment with their installations before deciding upon the use of check valves in the supply pipe.

37d. Piping in general.—Gasoline piping should be installed without screw or breakable joints between the carburetor or pump and the unions at the tank outlets. It is suggested that both the gasoline supply and return pipe be continuous lengths of lead pipe and that they be wiped to the nipples at tank outlets. Outside the emplacement the piping should be placed in ducts or large iron tubes. Gasoline pipes in the engine room floor should be installed in a trench covered by removable floor plates, thus permitting the piping to be inspected for leaks occasionally and giving easy access for repairs. Brass overflow and supply pipes should be dropped from the carburetor and the pump into the trench near the engine and wiped into the lead pipes in the trench. An exception to the general rule, that lead pipe shall be used for the gasoline supply and overflow may be made if there is probability that rats would gnaw the lead pipe. In some Coast Artillery installations, rats have caused considerable damage to lead-sheathed cable. If such a condition is anticipated, brass pipe should be installed and all joints should be soldered.

RADIATOR:

38a. General.—The fan throws a very large quantity of air through the radiator, approximately 10,000 cubic feet per minute, and a free circulation of cool air must therefore be provided. As a rule, the fan room should be separated from the engine room and provision should be made for taking the air either from the engine

room or from the outside as may be required. Avoid installing the radiator in such a manner that the same air will be used over again and again, as such installation will cause a rapid rise in temperature of the water. Radiators should be installed so that the radiator tubes (not the motor) will face the window or opening through which air is to be blown. It should be noted that a resistance is now provided on the switchboard for the radiator fan motor circuit. The purpose of this resistance is described in paragraphs 20a, footnote, and 26d.

38b. Ventilation of engine room by radiator.—In the average installation air is drawn from the fan room and discharged through an opening into the outside air. If it is desired in cold climates to use the hot air from the radiator to heat the engine and fan rooms, the fan motor leads should be reversed and the doors and windows properly manipulated so as not to obstruct the free passage of the hot air. In this manner the air is drawn from outside, heated by the radiator, and forced through the fan and engine rooms to the proper outlet. **A reversing switch should not be installed** in the fan motor circuit, as this might be left open at starting. The proper direction of rotation of the fan is counterclockwise (viewed through the radiator tubes). It should be noted that, due to propeller action of fan, there is a thrust from the fan hub to the motor shaft. Reversal of direction of rotation of fan will change this thrust to a pull and there will be a tendency for the fan to pull itself loose from the coupling and to pull the coupling from the motor shaft. Where reversal of the fan is contemplated, therefore, it is apparent that set screws and keys provided are not sufficient to resist this pull. In such cases the shaft and coupling should be drilled and additional set screws provided to properly bind the fan to the coupling and the coupling to the generator shaft.

38c. Use of radiator to heat battery room.—In cases where "condensation" troubles are likely to be met, provision should be made for the use of hot air from the radiator to heat the battery rooms. Fig. 24 shows a typical power installation in a modern mortar battery. When the door in air passage is in position *o–n*, the hot air from the radiator is discharged through the flue; when in position *o–p*, the hot air may be forced through the various battery rooms. To insure the proper circulation of air in the latter case, it may be necessary to place a damper in the flue. Fig. 23 show a convenient arrangement and the use of doors in 14-inch gun battery (2-story type) in cases where it is desirable to heat battery by hot air from the radiator. The radiator in this case discharges into the air passage. By closing the doors across passage *bb*, the hot air is

forced through passage *a;* similarly by closing doors across passage *a*, air may be forced through passage *bb*. The other door, shown in

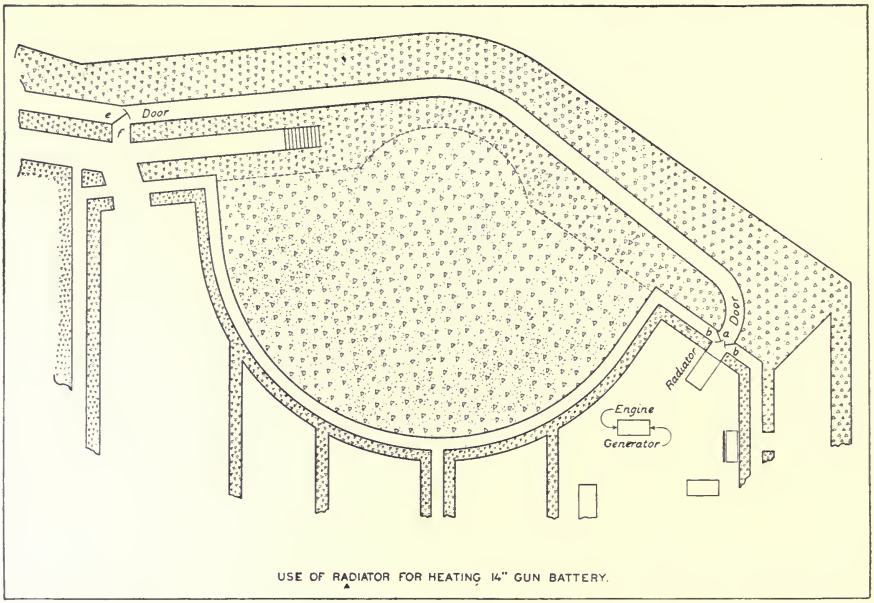


Fig. 23.

fig. 23, may be used as a deflector, dividing the air from the radiator between *e* and *f*.

EXHAUST CONNECTIONS:

39. The exhaust header is provided at either end with a blind and threaded flange. The exhaust connections may therefore be led from either end of the engine. The muffler has a red arrow painted thereon to indicate the proper direction of gas flow. Should the muffler or any portion of the exhaust pipe be placed vertically, provision must be made for draining all pockets. Standard 3-inch pipe should be used in the exhaust connections. The exhaust piping should be kept as free from elbows as is practicable. Too many elbows give an excessive back pressure on the engine and result in faulty operation. As a general rule, not more than four right-angle turns should occur; 45° bends should be used in preference to 90° bends wherever practicable.

SWITCHBOARDS:

40. A generator panel is issued with each set, and feeder panels where required. The panels should be installed about $2\frac{1}{2}$ feet from the wall and in front of an open manhole or trench (provided with a cover plate) from 1 to 4 feet deep, in which all the feeder cables and

generator leads can terminate. The generator leads should be preferably installed in three 2-inch pipes placed under the floor with long sweep elbows turning up under the generator frame and projecting about an inch above the floor. The other ends of the pipes should terminate in the manhole behind the switchboard. The field of generator must be so connected to the switchboard that opening of circuit breaker does not open the field current. In some cases where a feeder panel is installed a satisfactory method of wiring the sets is to terminate all feeder cables in the trench in rear of the switchboard, and connecting these cables to the feeder switches and circuit breakers by vertical risers of solid weatherproof wire (about No. 2 B. & S. gauge). These risers, because of their stiffness, can be shaped and squared up in a workmanlike manner. Feeder cable after leaving the switchboard should preferably be placed in ducts—if placed in trenches they should be hung on cable hangers on the walls of the trench so each individual cable may be readily identified at any place in the trench. The generator and power leads can be run directly to the generator switches and circuit breakers without employing vertical risers. A clear passage should be left in the rear of the board.

TESTING THE INSTALLATION:

41. Each set should be operated by the Engineer Department after it has been installed for a period sufficiently long to insure that the installation is complete and satisfactory. Before the engine is started, this entire instruction book should be carefully read by the Engineer Department employees in charge of the installation.

TYPE PLANS:

42. In the following pages will be found plans of typical installations in a modern mortar battery and in a detached power house, typical switchboard installations, and general outlines of power distribution systems.

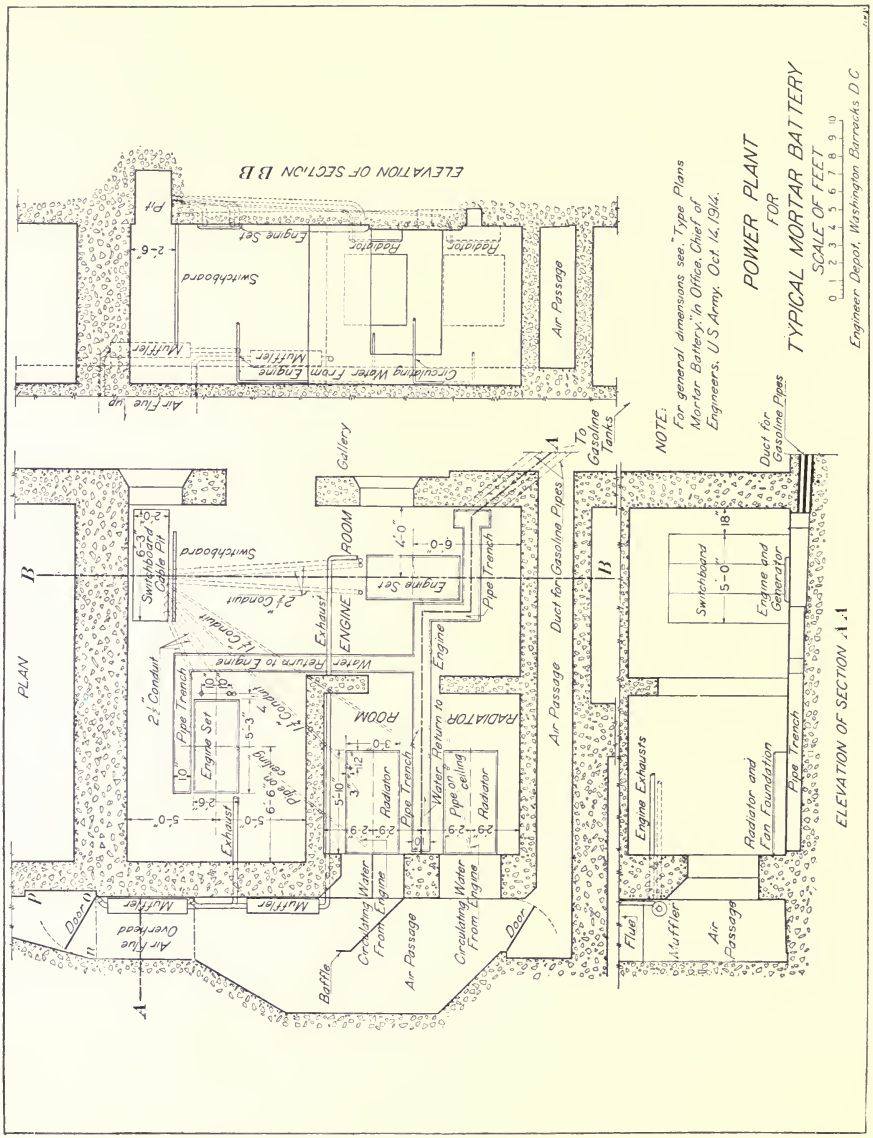

POWER PLANT
FOR
TYPICAL MORTAR BATTERY
SCALE OF FEET
0 1 2 3 4 5 6 7 8 9 10
Engineer Depot, Washington Barracks, D.C.
NOTE:
For general dimensions see "Type Plans Mortar Battery" in Office, Chief of Engineers, U.S. Army, Oct. 14, 1914.
PLAN
ELEVATION OF SECTION A-A
ELEVATION OF SECTION B-B
ENGINE ROOM
RADIATOR ROOM
Switchboard
Engine Set
Pipe Trench
Water Return to Engine
Exhaust
Gallery
Duct for Gasoline Pipes
To Gasoline Tanks
Air Passage
Circulating Water From Engine
Muffler
Flue
Air Flue up
Air Flue Overhead
Baffle
Door
Switchboard Cable Pit
Engine and Generator
Radiator and Fan Foundation

Fig. 24.

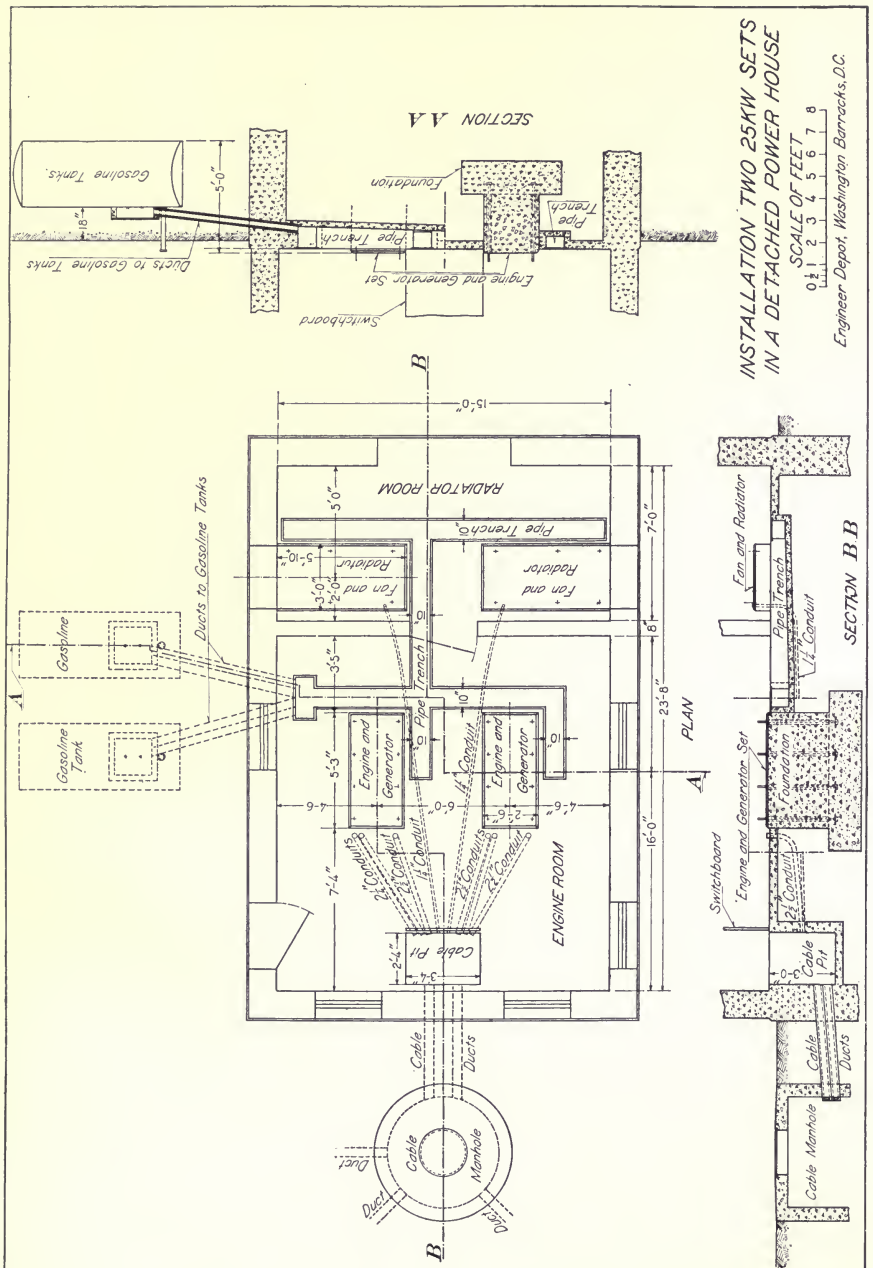

INSTALLATION TWO 25KW SETS
IN A DETACHED POWER HOUSE
SCALE OF FEET
0 1 2 3 4 5 6 7 8
Engineer Depot, Washington Barracks, D.C.
SECTION A A
Gasoline Tanks
Ducts to Gasoline Tanks
Foundation
Pipe Trench
Engine and Generator Set
Switchboard
PLAN
RADIATOR ROOM
ENGINE ROOM
Fan and Radiator
Pipe Trench
Engine and Generator
Cable Pit
Cable Manhole
Ducts
SECTION B B

Fig. 25.

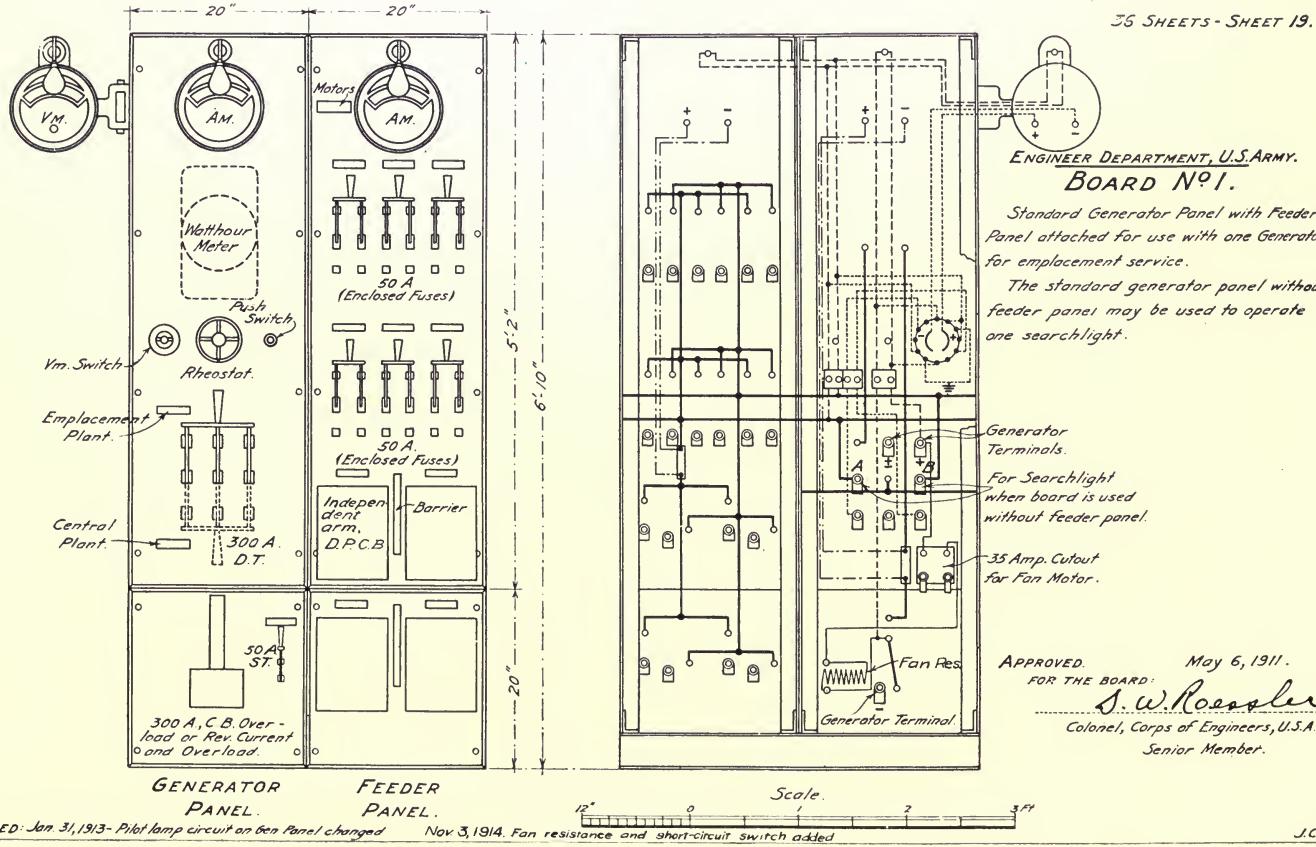
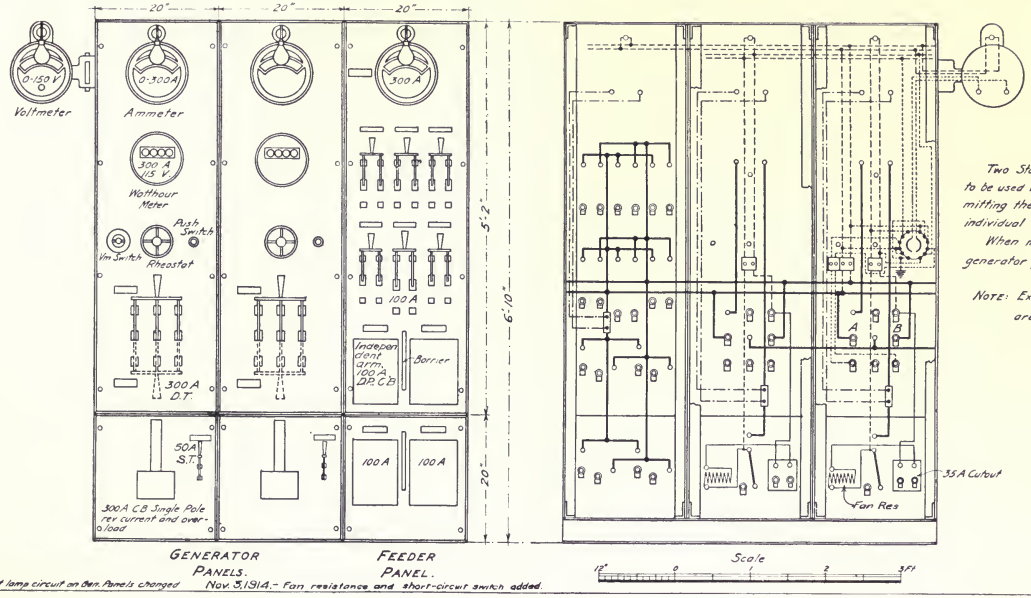

36 SHEETS - SHEET 19.
20"
20"
VM.
AM.
Motors
AM.
Watthour Meter
50 A (Enclosed Fuses)
Push Switch
Vm. Switch
Rheostat.
Emplacement Plant.
50 A. (Enclosed Fuses)
Central Plant
300 A. D.T.
Independent arm. D.P.C.B.
Barrier
50 A. S.T.
300 A, C.B. Over-load or Rev. Current and Overload.
5'-2"
6'-10"
20"
GENERATOR PANEL.
FEEDER PANEL.
Generator Terminals.
For Searchlight when board is used without feeder panel.
35 Amp. Cutout for Fan Motor.
Fan Res.
Generator Terminal.
ENGINEER DEPARTMENT, U.S. ARMY.
BOARD No. 1.
Standard Generator Panel with Feeder Panel attached for use with one Generator, for emplacement service.
The standard generator panel without feeder panel may be used to operate one searchlight.
APPROVED. May 6, 1911.
FOR THE BOARD:
J. W. Roessler
Colonel, Corps of Engineers, U.S.A.
Senior Member.
Scale.
12" 0 1 2 3 Ft
REVISED: Jan 31, 1913 - Pilot lamp circuit on Gen Panel changed. Nov 3, 1914. Fan resistance and short-circuit switch added
J.C.L.

Fig. 26.



36 SHEETS - SHEET 20.

ENGINEER DEPARTMENT, U.S. ARMY.

BOARD No 2.

Two Standard Generator Panels and one Feeder Panel, to be used when two generators are installed together permitting the parallel operation of both generators or the individual operation of either.

When more than two generators are installed additional generator panels may be added.

NOTE: Except where otherwise indicated, feeder switches are 50 Amp. capacity.

APPROVED May 6, 1911.
FOR THE BOARD:
S. W. Roessler
Colonel, Corps of Engineers, U.S.A.
Senior Member

REVISED: Jan 31, 1913 - Pilot lamp circuit on Gen. Panels changed. Nov. 3, 1914. - Fan resistance and short-circuit switch added.

J.C.L.

Fig. 27.

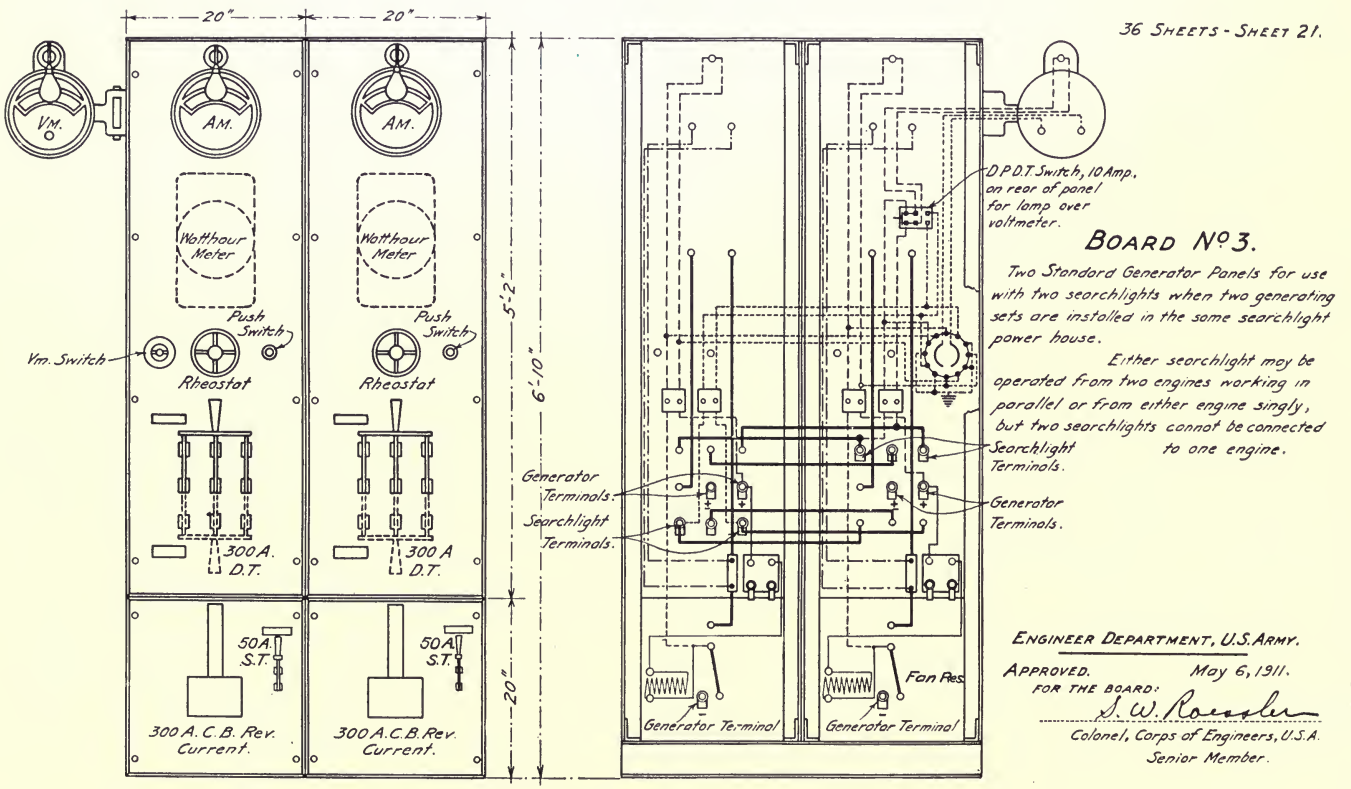
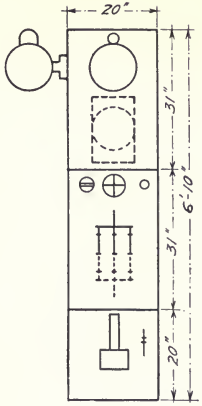
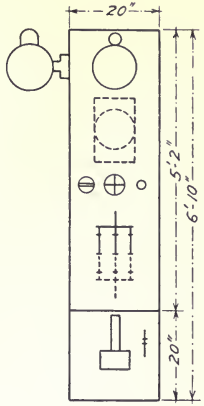

20"
20"
Vm.
O
A.M.
A.M.
Watthour Meter
Watthour Meter
Push Switch
Push Switch
Vm. Switch
Rheostat
Rheostat
300 A. D.T.
300 A D.T.
50 A. S.T.
50 A. S.T.
300 A. C. B. Rev. Current.
300 A. C. B. Rev. Current.
5'-2"
6'-10"
20"
Generator Terminals
Searchlight Terminals
D.P.D.T. Switch, 10 Amp, on rear of panel for lamp over voltmeter.
Searchlight Terminals.
Generator Terminals.
Fan Res.
Generator Terminal
Generator Terminal
36 SHEETS - SHEET 21.
BOARD No 3.
Two Standard Generator Panels for use with two searchlights when two generating sets are installed in the same searchlight power house.
Either searchlight may be operated from two engines working in parallel or from either engine singly, but two searchlights cannot be connected to one engine.
ENGINEER DEPARTMENT, U.S. ARMY.
APPROVED. May 6, 1911.
FOR THE BOARD:
S. W. Roessler
Colonel, Corps of Engineers, U.S.A.
Senior Member.
Scale.
12" 0 1 2 3 Ft.
REVISED: Jan. 31, 1913 - Pilot lamp circuit changed. Nov. 3, 1914. Fan resistance and short-circuit switch added.
J.C.L.

Fig. 28.



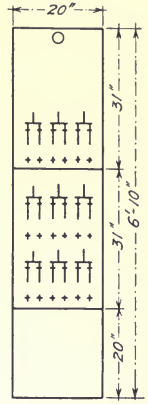
A.

Single Generator Panel for Insular Possessions (export), the board being in three sections to minimize breakage in transit; may be used without feeder panel for single searchlight.

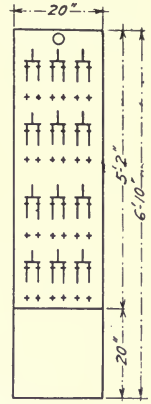


B.

Single Generator Panel for use in the United States (domestic), the board being in two sections; may be used without feeder panel for single searchlight.



C.



D.

Single Feeder Panels to be used in emplacements where generating sets have not been installed and where there are no motor circuits.

The boards have switches only and ammeters are not provided.

When a generating set is installed, a standard generator panel may be added to either of these feeder panels. Sketch C shows a three-section board for export.

ENGINEER DEPARTMENT, U.S. ARMY.

SWITCHBOARDS.

TYPES A, B, C & D.

APPROVED. May 6, 1911.

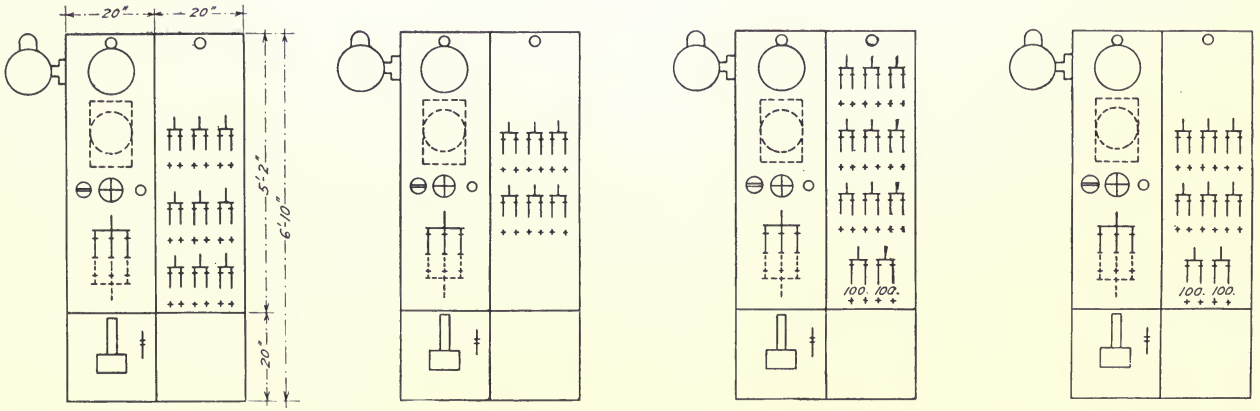
FOR THE BOARD:

J. W. Roessler

Colonel, Corps of Engineers, U.S.A.
Senior Member.

J.C.L.

Fig. 29.



E. F. G. H.

ENGINEER DEPARTMENT, U.S.ARMY.

SWITCHBOARDS.

TYPES E, F, G & H.

Single Generator Panels with Feeder Panels for use in emplacements where there are no motor circuits. Switches only are provided on the feeder panels, the size, number and arrangement varying with conditions.

Boards so arranged may be used in 6-inch or mortar batteries where there are no motor circuits.

APPPOVED. May 6, 1911.

FOR THE BOARD:

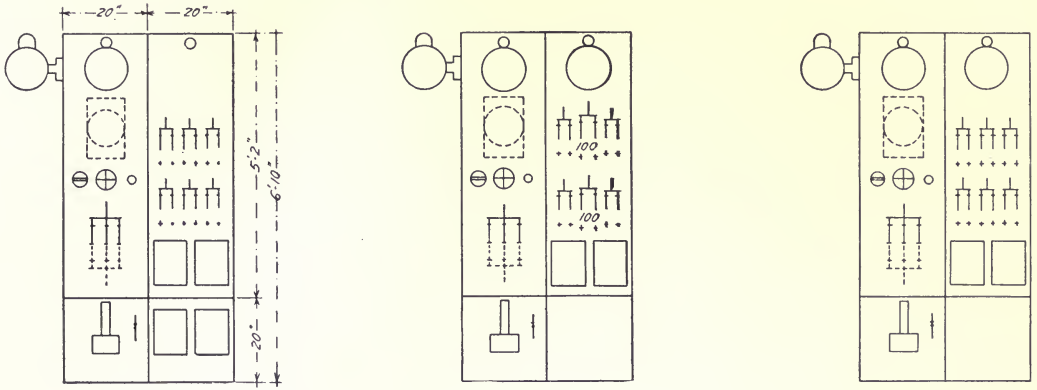
S. W. Roessler

Colonel, Corps of Engineers, U.S.A.
Senior Member.

J.C.L.

Fig. 30.

22066°—16——5



J. K. L.

SWITCHBOARDS.

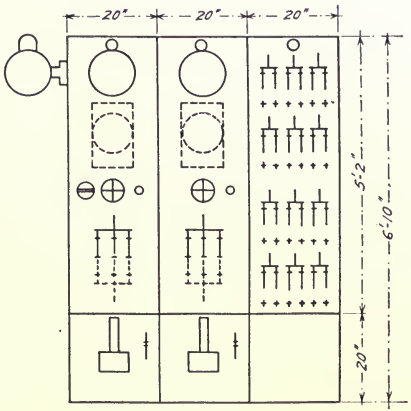
TYPES J, K & L.

Single Generator Panels and Feeder Panels with switches for lights and circuit breakers for motors
Boards K and L have ammeters on the feeder panel to measure the total motor load
Board J has four circuit breakers and may be installed in a two-gun battery with ammunition hoists (2 circuits) and with retracting motors on the gun carriages (2 circuits).
Boards K and L are used where there are only two motor circuits instead of four
The ammeter on the feeder panel is optional. Its omission provides space for three more 50-Amp switches

ENGINEER DEPARTMENT, U.S. ARMY.

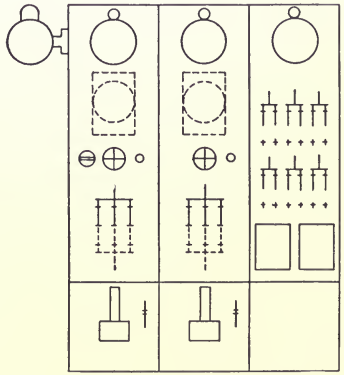
APPROVED. May 6, 1911.
FOR THE BOARD:
D. W. Ross
Colonel, Corps of Engineers, U.S.A.
Senior Member JCL

Fig. 31.



M.

Two Generator Panels and one Feeder Panel for lighting circuits only; for two generators operating in parallel.



N.

Two Generator Panels and one Feeder Panel supplying light, and power to motors; for two generators operating in parallel.

ENGINEER DEPARTMENT, U.S.ARMY.

SWITCHBOARDS.

TYPES M & N.

APPROVED. May 6, 1911.

FOR THE BOARD:

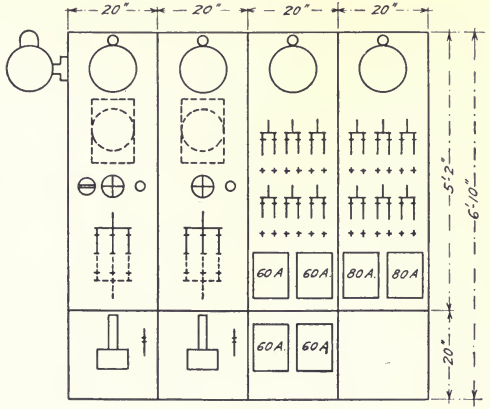
J. W. Roessler.

Colonel, Corps of Engineers, U.S.A.
Senior Member.

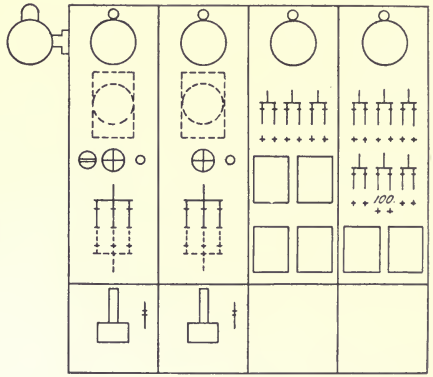
REVISED: Jan. 31, 1913.

J.C.L.

Fig. 32.



O.



P.

ENGINEER DEPARTMENT, U.S. ARMY.

SWITCHBOARDS.

TYPES O & P.

Two Generator and two Feeder Panels supplying light, and power to motors; for two generators operating in parallel.

This board may be installed in a three-gun battery where more than four motor circuits are required; one ammeter on one feeder panel may be used to indicate the current used by the retracting motors and the other to indicate the current used by the ammunition hoists.

APPROVED. May 6, 1911.

FOR THE BOARD:

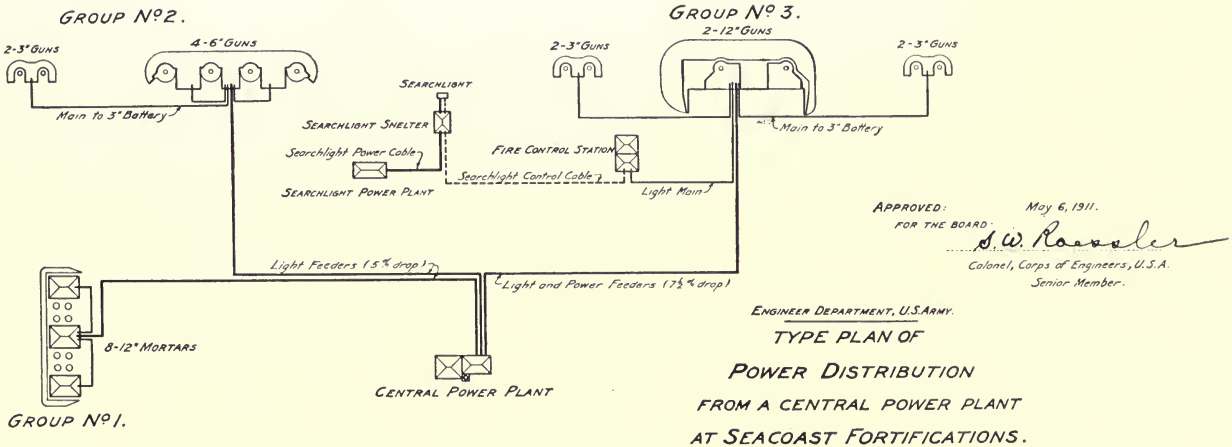
D. W. Ross

Colonel, Corps of Engineers, U.S.A.
Senior Member.

REVISED: Jan. 31, 1913.

J.C.L.

Fig. 33.



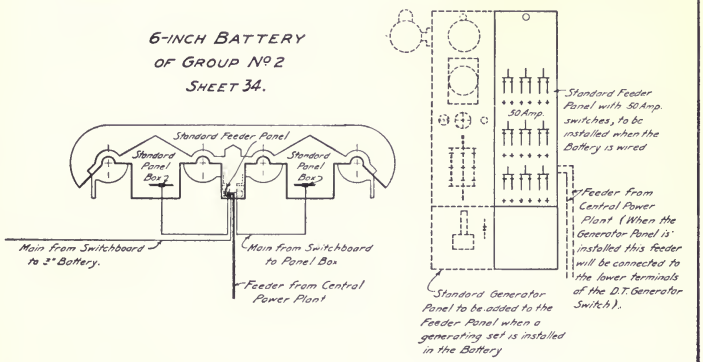
APPROVED: May 6, 1911.
FOR THE BOARD:
S. W. Roessler
Colonel, Corps of Engineers, U.S.A.
Senior Member.

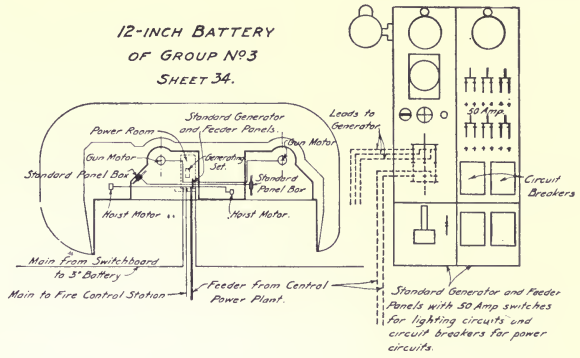
ENGINEER DEPARTMENT, U.S. ARMY.

TYPE PLAN OF POWER DISTRIBUTION FROM A CENTRAL POWER PLANT AT SEACOAST FORTIFICATIONS.

JCL

Fig. 34.





ENGINEER DEPARTMENT, U.S. ARMY.

TYPE PLANS SHOWING

DISTRIBUTION OF POWER FROM SWITCH-BOARDS IN SEACOAST BATTERIES.

APPROVED. May 6, 1911.

FOR THE BOARD:

D. W. Ronsler

Colonel, Corps of Engineers, U.S.A.
Senior Member.

J.C.L.

Fig. 35.

PART IV.—PART LISTS.

DIRECTIONS FOR ORDERING PARTS.

43. Requisitions for parts should be submitted through local district Engineer officer, except in cases where engines are operated by the Quartermaster Department in connection with post lighting systems. In the latter case requisitions are to be submitted through the Quartermaster Department, and in this connection attention is invited to Par. V of G. O. 48, 1913, and Par. III of G. O. 80, 1914. Requisitions should contain the following information:

(*a*) Part number and designation.

(*b*) Serial number of engine, generator, fan motor, magneto, heater, or switchboard for which the part is required.

(*c*) Application (whether to replace an unserviceable part, replenish spare part box, or as reserve, in excess of spare-part allowance, to cover future breakage).

(*d*) Shipping directions, to be furnished by District Engineer Officer.

SPARE PARTS.

44. The authorized allowances of spare parts are given in paragraph 59. These articles should be kept on hand as far as practicable at all times, but not in excess of quantities indicated. As soon as a spare part is renewed from the spare-part box and placed in service a new part should be requisitioned for. Spare cylinders are supplied as follows: One to each coast-defense command within the continental limits of the United States (in special cases one for each fort), and one for each engine in foreign possessions. The full number of cylinders should be maintained at all times, new cylinders being requisitioned for promptly as the spare cylinders are put into service.

SYNOPSIS OF PART LISTS:

45. The following outline shows the arrangement of part lists in the following pages:

METHOD OF USING PART LISTS.

46. In order to use part lists intelligently, it will be necessary to refer frequently to the outline given above. Under each heading or subheading, as given in the preceding paragraph, will be found all parts that may be logically associated with such heading or subheading. Thus, under the heading "Oiling system" are listed the oil pump and parts, oil pipes and flanges, all screws and studs for attaching parts to one another or to the engine frame. It has been impossible to show all of the many parts of the 25-kw. set in the cuts accompanying the part lists. However, all the parts considered essential have been listed whether shown in the cuts or not. Parts shown in cuts are arranged serially on page opposite cut or on consecutive pages. Parts not shown in cuts are listed under a part shown and with which they are closely associated. The fol-

lowing rules should be followed generally in determining part numbers for parts not shown in cuts:

(*a*) If contained in a part shown in the cut, they are listed immediately below the container (e. g., all parts contained in governor are listed under part 9, *see par. 48d.*

(*b*) If the part number of a support—as a bracket or stud, etc., or a means of attaching a part to another, as a cap screw, etc.—is desired, the part not shown in the cut will be found listed immediately below the part attached or supported (e. g., "573, stud on frame for part 29" is listed immediately below part 29, *see par. 48a.*

(*c*) In case a part suitable for only one type of auxiliary is shown in the cut the corresponding parts for other types of auxiliaries will be found listed immediately below the part shown (e. g., "959, locking lever for Splitdorf magneto" is shown in fig. 52; the corresponding part, 70, for Eisemann and G. E. magnetos is not shown, but is listed immediately below part 959 in part list, *see par. 49f.*

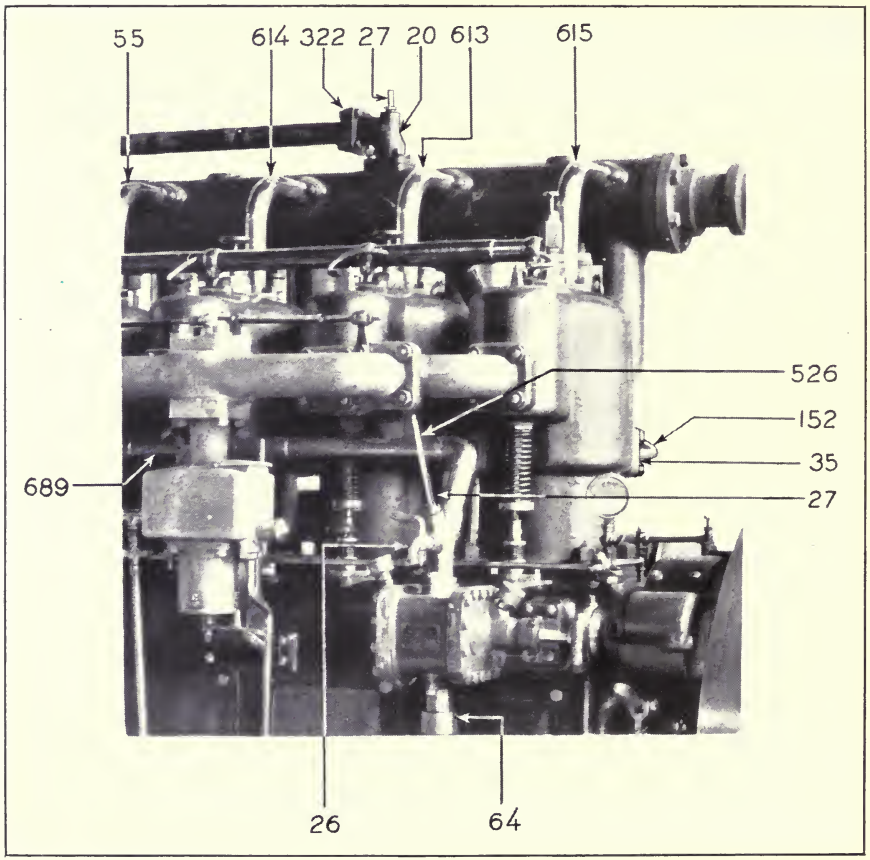


Fig. 36.

47a. Parts of cooling water system on engine, not including Pumps. (*See Fig. 36.*)

Part No.		Description.
Shown in figure.	Not indicated in figure.	
20	.....	Flanged elbow for water outlet at exhaust header.
	611	Studs to attach No. 20 to exhaust header.
	612	Nuts for No. 611.
	376	Gasket for No. 20 and exhaust header.
26	.....	Drain cock.
27	.....	Thermometer pocket.
35	.....	Flange connection at cylinder for No. 152.
	1383	Studs for No. 35.
	368	Nuts for No. 1383.
	377	Gasket for No. 35.
55	.....	Water outlet from cylinder No. 4 to exhaust manifold.
	717	Studs on cylinder for Nos. 55, 613, 614, and 615.
	706	Nuts for No. 717.
	608	Cap screws for Nos. 55, 613, 614, and 615.
	207	Gasket for Nos. 55, 613, 614, and 615.
64	.....	See pars. 47b and 47c.
152	.....	Drain pipe from exhaust manifold to cylinder.
322	.....	Pipe connection flange for No. 20.
	376	Gasket for No. 322.
	619	Cap screw to attach No. 322 to No. 20.
	620	Nut for No. 619.
526	.....	Thermometers, 100° C., 7 inches long.
613	.....	Water outlet from cylinder No. 2 to exhaust manifold.
614	.....	Water outlet from cylinder No. 3 to exhaust manifold.
615	.....	Water outlet from cylinder No. 1 to exhaust manifold.
	717	Studs on cylinders for Nos. 55, 613, 614, and 615.
	706	Nut for No. 717.
	608	Cap screw for Nos. 55, 613, 614, and 615.
	207	Gasket for Nos. 55, 613, 614, and 615.
689	.....	Water inlet pipe to cylinders for use with Kinney pump, less thermometer pocket and drain cock.
	17	Water inlet pipe to cylinders for use with gear pump, less thermometer pocket and drain cock.
	1383	Stud for No. 689 or No. 17 on cylinders.
	368	Nuts for No. 1383.
	377	Gasket for No. 689 or No. 17 at cylinders.
	208	Cap screw for No. 689 or No. 17 at pump.
	207	Gasket for No. 689 or No. 17 at pump.

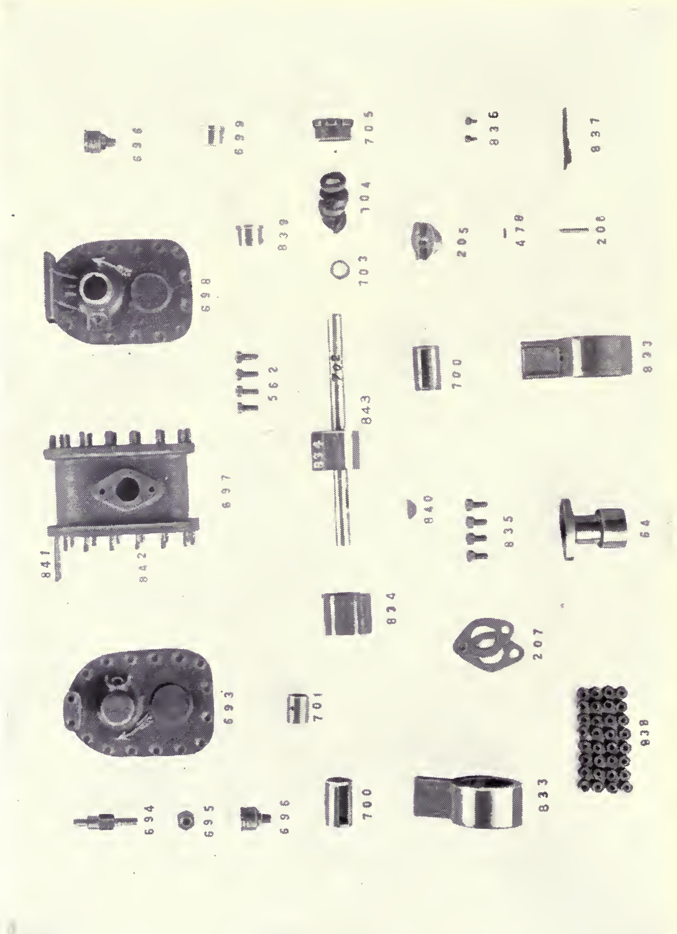


Fig. 37.

47b. Kinney water pump. (*See Fig. 37.*)

Part No.		Description.
Shown in figure.	Not indicated in figure.	
	692	Kinney pump, complete, with half coupling.
64	.....	Flange for water inlet connection.
205	.....	Coupling for water pump.
206	.....	Taper pin for No. 205.
207	.....	Gasket for No. 64.
478	.....	Cotter pin for No. 206.
562	.....	Cap screws to attach water pump to frame.
693	.....	Bearing head opposite coupling end.
694	.....	Stud for auxiliary support.
695	.....	Nut for No. 694.
696	.....	Ball check grease cup.
697	.....	Pump cylinder.
698	.....	Bearing head (coupling end).
699	.....	Bearing lining for No. 698.
700	.....	Slide pin.
701	.....	Bearing lining for No. 693.
702	.....	Pump shaft.
703	.....	Bottom ring for packing inside stuffing box.
704	.....	Plastic metallic packing ($\frac{3}{16}$ inch diameter, 10 inches long).
705	.....	Gland nut.
833	.....	Rotary piston and slide assembled.
834	.....	Piston cam.
835	.....	Cap screw to attach Nos. 64 and 689 to pump.
836	.....	Cap screw for lock of gland nut.
837	.....	Lock for gland nut.
838	.....	Nuts for Nos. 841 and 842.
839	.....	Gland.
840	.....	Woodruff key for No. 834 and shaft.
841	.....	Long stud for cylinder and head.
842	.....	Short stud for cylinder and head.
843	.....	Shaft assembled with piston cams.

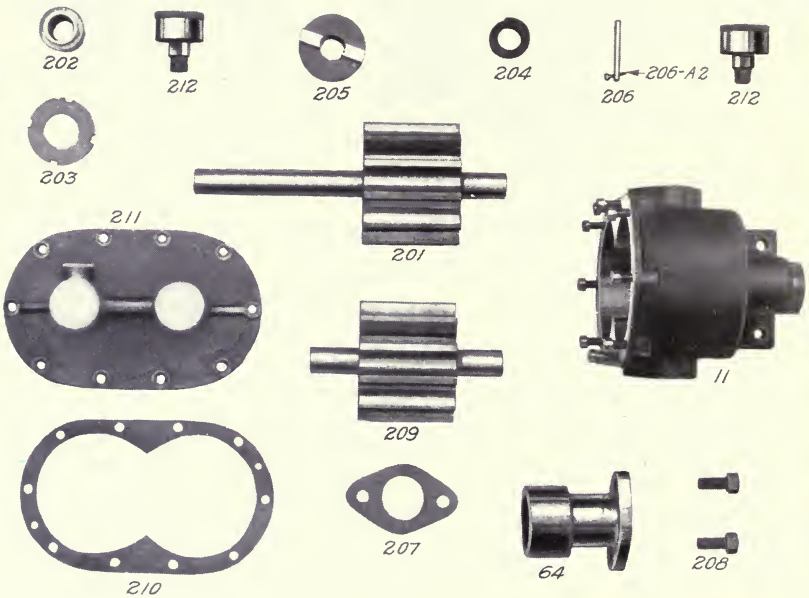


Fig. 38.

47c. Gear water pump. (*See Fig. 38.*)

Part No.		Description.
Shown in figure.	Not indicated in figure.	
11	.....	Gear water pump body.
	562	Cap screw to fasten water pump to frame.
64	.....	Flange for water inlet connection.
201	.....	Driving gear in water pump and shaft.
202	.....	Gland for No. 201.
203	.....	Nut for No. 202.
204	.....	Plastic metallic packing for No. 202 ($\frac{3}{16}$ inch diameter, 10 inches long).
205	.....	Coupling for No. 201.
206	.....	Taper pin for No. 205.
206A2	.....	Cotter pin for No. 206.
207	.....	Gasket for No. 64.
208	.....	Cap screws for No. 64.
209	.....	Driven gear in water pump and shaft.
210	.....	Gasket for water pump cover (No. 211).
211	.....	Water pump cover.
	563	Screw to attach water pump cover.
212	.....	Grease cup.

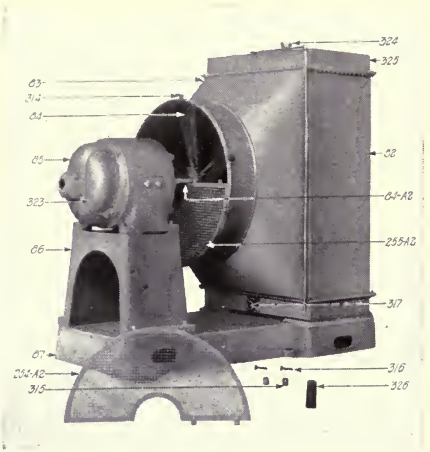


Fig. 39.

47d. Radiator (not including motor). *(See Fig. 39.)*

Part No.		Description.
Shown in figure.	Not indicated in figure.	
	525	Radiator complete, less motor and base.
	718	Stud to attach radiator to sub-base.
	654	Nut for No. 718.
82	.....	Radiator tubes.
83	.....	Air chute.
84	.....	Fan for radiator.
84A2	.....	Fan coupling for Type CQ radiator motor.
	862	Coupling for Type CVC radiator motor.
85	.....	See Nos. 85, 658, par. 47f; also 846, and 1141, par. 47e.
	655	Cap screw to attach motor to pedestal.
86	.....	Motor pedestal.
	656	Cap screws to attach pedestal to sub-base.
87	.....	Sub-base for radiator set.
254A2	.....	Radiator fan guard (upper half).
255A2	.....	Radiator fan guard (lower half).
314	.....	Block for fastening radiator screen.
315	.....	Clamp for radiator screen.
316	.....	Clamp screw for radiator screen.

47d. Radiator (not including motor). (*See Fig. 39.*)—Contd.

Part No.		Description.
Shown in figure.	Not indicated in figure.	
317	.....	Outlet or inlet pipe flange on radiator.
	717	Stud for No. 317.
	706	Nut for No. 717.
	709	Gasket for No. 317.
323	.....	See Nos. 323 and 863.
324	.....	Radiator filler cap.
	326	Radiator strainer.
325	.....	Radiator header. (State whether upper or lower is required.
	707	Short cap screw to attach header to No. 82.
	711	Long cap screw to attach header to No. 82.
	708	Nut for Nos. 707 and 711.
	718	Stud to attach radiator to sub-base.
	654	Nut for No. 718.
	710	Gasket for radiator headers.
	714	Nipple for overflow pipe.
	712	Elbow for overflow pipe.
	713	Horizontal section of overflow pipe.
	715	Vertical section of overflow pipe.
	716	Bottom support for No. 715.

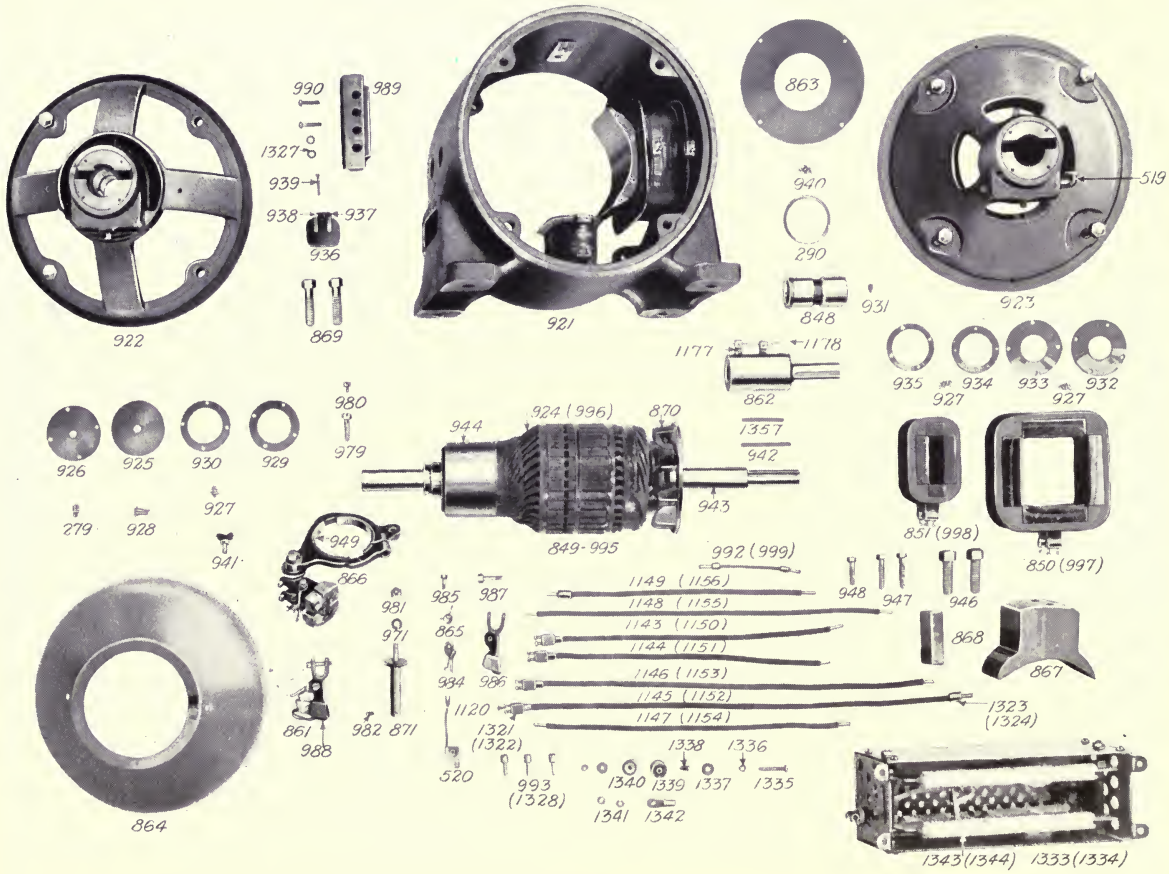

922
990
989
1327
939
938
937
936
869
921
863
940
290
848
931
923
519
1177
1178
862
935
927
934
933
927
932
926
925
930
929
980
979
944
924 (996)
870
1357
942
943
849-995
279
928
927
941
949
866
981
971
985
987
865
934
986
861
988
982
871
992 (999)
1149 (1156)
1148 (1155)
1143 (1150)
1144 (1151)
1146 (1153)
1145 (1152)
1147 (1154)
1120
1321
(1322)
520
993
(1328)
1340
1339
1337
1335
1338
1336
1341
1342
948
947
946
851 (998)
850 (997)
868
867
1323
(1324)
864
1343 (1344)
1333 (1334)

Fig. 40.

47e. Radiator motor, type CVC–112, and fan resistance. (*See Fig. 40.*)

Part No.				Description.
115-volt.		230-volt.		
Shown in figure.	Not indicated in figure.	Shown in figure.	Not indicated in figure.	
	846	.....	1141	Blower radiator motor.
279	.....	279	.....	¼-inch pipe plugs for oil wells and No. 926.
290	.....	290	.....	Oil ring used on 25 KW. generators and radiator motor bearings.
519	.....	519	.....	Overflow oil gage.
520	.....	521	.....	Carbon brush for radiator motor.
848	.....	848	.....	Motor bearing lining.
849	.....	995	.....	Armature for radiator motor.
850	.....	997	.....	Main field coil radiator motor.
851	.....	998	.....	Commutating field coil radiator motor.
861	.....	861	.....	Brush holder complete, less brush for radiator motor.
862	.....	862	.....	Coupling for radiator motor and fan.
863	.....	863	.....	Inclosing cover for fan end bearing head.
864	.....	864	.....	Inclosing cover for commutator end bearing head.
865	.....	865	.....	Brush-holder spring for radiator motor.
866	.....	866	.....	Brush-holder yoke with studs.
867	.....	867	.....	Main pole piece radiator motor.
868	.....	868	.....	Commutating pole piece radiator motor.
869	.....	869	.....	Cap screw for fastening bearing heads to radiator motor.
870	.....	870	.....	Ventilating fan on radiator motor armature.
	945	.....	945	Machine screws for fastening No. 870.
871	.....	871	.....	Brush-holder stud for radiator motor.
921	.....	921	.....	Radiator motor frame.
922	.....	922	.....	Motor bearing head, commutator end.

47e. Radiator motor, type CVC-112, and fan resistance—Con.

Part No.				Description.
115-volt.		230-volt.		
Shown in figure.	Not indicated in figure.	Shown in figure.	Not indicated in figure.	
923	.....	923	.....	Motor bearing head, fan end.
924	.....	996	.....	Armature coils for radiator motor.
925	.....	925	.....	Leather oil-retaining washer for outside commutator end bearing housing.
926	.....	926	.....	Steel cap for leather oil-retaining washer for outside bearing housing, commutator end.
927	.....	927	.....	Machine screws for oil-retaining washer, except outside commutator end.
928	.....	928	.....	Machine screws for oil-retaining washer, outside commutator end.
929	.....	929	.....	Leather oil-retaining washer for inside commutator end bearing housing.
930	.....	930	.....	Steel cap for leather oil-retaining washer inside commutator end.
931	.....	931	.....	Screw for holding bearing lining.
932	.....	932	.....	Leather oil-retaining washer for outside fan end.
933	.....	933	.....	Steel cap for leather oil-retaining washer outside fan end.
934	.....	934	.....	Leather oil-retaining washer for inside fan end bearing housing.
935	.....	935	.....	Steel cap for leather oil-retaining washer inside fan end.
936	.....	936	.....	Oil-well cover.
937	.....	937	.....	Pin for oil-well cover.
938	.....	938	.....	Hinge for oil-well cover.
939	.....	939	.....	Hinge screw for oil-well cover.
940	.....	940	.....	Machine screws for fastening fan end inclosing covers.
941	.....	941	.....	Wing screws for fastening commutator and inclosing covers.

47e. Radiator motor, type CVC-112, and fan resistance—Con.

Part No.				Description.
115-volt.		230-volt.		
Shown in figure.	Not indicated in figure.	Shown in figure.	Not indicated in figure.	
942	.....	942	.....	Key for armature shaft extension.
943	.....	943	.....	Shaft for radiator motor.
944	.....	944	.....	Commutator for radiator motor.
946	.....	946	.....	Cap screws for fastening main pole piece.
947	.....	947	.....	Cap screws for fastening upper commutating pole piece.
948	.....	948	.....	Cap screws for fastening lower commutating pole piece.
949	.....	949	.....	Brush-holder yoke.
971	.....	971	.....	Positive lock washer for radiator motor brush-holder stud.
979	.....	979	.....	Clamping screw for brush-holder yoke.
980	.....	980	.....	Locking screw for brush-holder yoke.
981	.....	981	.....	Nut for brush-holder stud.
982	.....	982	.....	Set screw for brush-holder stud and leads.
984	.....	984	.....	Lever and pressure finger for motor brush holder.
985	.....	985	.....	Screw for fastening pressure finger and brush-holder spring to brush-holder body.
986	.....	986	.....	Brush-holder body for radiator motor.
987	.....	987	.....	Clamping screw for brush-holder body.
988	.....	988	.....	Machine screw for fastening pigtail to brush-holder body.
989	.....	989	.....	Terminal board.
990	.....	990	.....	Machine screw for fastening terminal board.
992	.....	999	.....	External cross over lead.
993	.....	1328	.....	Terminals for outside line wires.
1120	.....	1120	.....	Machine screws for terminal board terminals.

47e. Radiator motor, type CVC-112, and fan resistance—Con.

Part No.				Description.
115-volt.		230-volt.		
Shown in figure.	Not indicated in figure.	Shown in figure.	Not indicated in figure.	
1143	.....	1150	.....	Lead between terminal board and lower commutating field coil.
1144	.....	1151	.....	Lead between terminal board and left-hand main field coil.
1145	.....	1152	.....	Lead between terminal board and left-hand brush-holder stud.
1146	.....	1153	.....	Lead between terminal board and right-hand main field coil.
1147	.....	1154	.....	Connecting lead between main field coils.
1148	.....	1155	.....	Connecting lead between commutating field coils.
1149	.....	1156	.....	Lead between top commutating coil and brush-holder stud.
1177	.....	1177	.....	Set screw for radiator motor coupling.
1178	.....	1178	.....	Locking wire for set screws.
1357	.....	1357	.....	Key for radiator motor coupling extension.
1321	.....	1322	.....	Terminal board terminals on connecting leads.
1323	.....	1324	.....	Inside end terminals for connecting leads.
1327	.....	1327	.....	Leather washer for machine screw and terminal board.
1333	.....	1334	.....	Series rheostat for radiator motor.
1335	.....	1335	.....	Machine screws for terminal of rheostat.
1336	.....	1336	.....	Washer for No. 1335.
1337	.....	1337	.....	Do.
1338	.....	1338	.....	Insulating bushing for No. 1335.
1339	.....	1339	.....	Mica insulating washer to go over No. 1338.
1340	.....	1340	.....	Mica insulating washer for end of No. 1338.

47e. Radiator motor, type CVC-112, and fan resistance—Con.

Part No.				Description.
115-volt.		230-volt.		
Shown in figure.	Not indicated in figure.	Shown in figure.	Not indicated in figure.	
1341	.....	1341	.....	Nuts for terminal.
1342	.....	1342	.....	Punched clip terminal.
1343	.....	1344	.....	Resistance unit for rheostat.

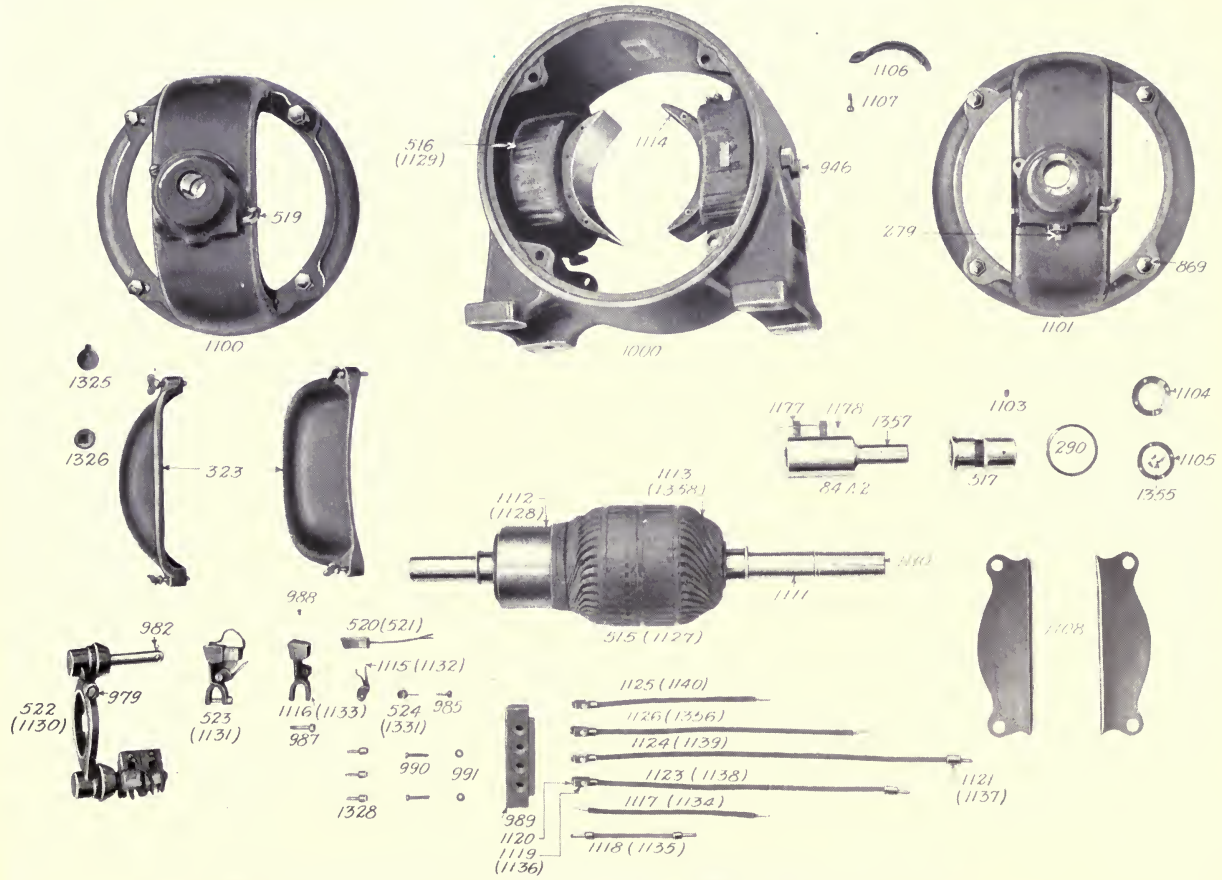

519
1100
516
(1129)
1114
946
1000
1106
1107
279
869
1101
1325
1326
323
988
1177
1178
1357
84 A 2
1103
517
290
1104
1105
1355
1112
(1128)
1113
(1358)
1111
515 (1127)
982
979
522
(1130)
523
(1131)
1116 (1133)
987
520(521)
1115 (1132)
524
(1331)
985
990
991
1328
1125 (1140)
1126 (1356)
1124 (1139)
1123 (1138)
1117 (1134)
1118 (1135)
1121
(1137)
989
1120
1119
(1136)
1108

Fig. 41.

47f. Radiator motor, type CQ–3. (*See Fig. 41; See Par. 47e for Fan Resistance Parts.*)

Part No.				Description.
115-volt.		230-volt.		
Shown in figure.	Not indicated in figure.	Shown in figure.	Not indicated in figure.	
	85	.....	658	Blower radiator motor.
1000	.....	1, 000	.....	Radiator motor frame.
84–A2	.....	84–A2	.....	Coupling for radiator motor and fan.
279	.....	279	.....	¼-inch pipe plugs for oil wells.
290	.....	290	.....	Oil ring used on 25 KW. generators and radiator motor bearings.
323	.....	323	.....	Enclosing cover for commutator end bearing head.
515	.....	1127	.....	Armature for radiator motor.
516	.....	1129	.....	Main field coil radiator motor.
517	.....	517	.....	Motor bearing lining.
519	.....	519	.....	Overflow oil gage.
520	.....	521	.....	Carbon brush for radiator motor.
522	.....	1130	.....	Brush holder yoke with studs.
523	.....	1131	.....	Brush holder complete less brush for radiator motor.
524	.....	1331	.....	Brush holder spring for radiator motor.
869	.....	869	.....	Cap screws for bearing heads.
946	.....	946	.....	Cap screws for fastening main pole piece.
979	.....	979	.....	Clamping screw for brush-holder yoke.
982	.....	982	.....	Set screw for brush-holder stud and leads.
985	.....	985	.....	Screw for fastening pressure finger and brush-holder spring to brush-holder body.
987	.....	987	.....	Clamping screw for brush-holder body.
988	.....	988	.....	Machine screw for fastening pigtail to brush-holder body.

47f. Radiator motor, type CQ-3—Continued.

Part No.				Description.
115-volt.		230-volt.		
Shown in figure.	Not indicated in figure.	Shown in figure.	Not indicated in figure.	
989	.....	989	.....	Terminal board.
990	.....	990	.....	Machine screw for fastening terminal board.
991	.....	991	.....	Leather washer for machine screw and terminal board.
1100	.....	1100	.....	Motor bearing head, commutator end.
1101	.....	1101	.....	Motor bearing head, fan end.
1103	.....	1103	.....	Screw for holding bearing lining.
1104	.....	1104	.....	Leather oil retaining washer for outside fan end bearing housing.
1105	.....	1105	.....	Steel cap for leather oil retaining washer outside fan end.
1106	.....	1106	.....	Oil well cover.
1107	.....	1107	.....	Hinge screw for oil well cover.
1108	.....	1108	.....	Inclosing cover for fan end bearing head.
	1109	.....	1109	Wing screws for fastening commutator and inclosing covers.
1110	.....	1110	.....	Key for armature shaft extension.
1111	.....	1111	.....	Shaft for radiator motor.
1112	.....	1128	.....	Commutator for radiator motor.
1113	.....	1358	.....	Armature coils for radiator motor.
1114	.....	1114	.....	Main pole piece radiator motor.
1115	.....	1132	.....	Lever and pressure finger for motor brush holder.
1116	.....	1133	.....	Brush-holder body for radiator motor.
1117	.....	1134	.....	Connecting lead between main field coils.
1118	.....	1135	.....	External cross over lead.

47f. Radiator motor, type CQ-3—Continued.

Part No.				Description.
115-volt.		230-volt.		
Shown in figure.	Not indicated in figure.	Shown in figure.	Not indicated in figure.	
1119	.....	1136	.....	Terminal board terminals on connecting leads.
1120	.....	1120	.....	Machine screws for terminal board terminals.
1121	.....	1137	.....	Inside end terminals for connecting leads.
1123	.....	1138	.....	Lead between terminal board and left hand brush-holder stud.
1124	.....	1139	.....	Lead between terminal board and right hand brush-holder stud.
1125	.....	1140	.....	Lead between terminal board and left hand main field coil.
1126	.....	1356	.....	Lead between terminal board and right hand main field coil.
1177	.....	1177	.....	Set screw for radiator motor coupling.
1178	.....	1178	.....	Locking wire for set screws.
1325	.....	1325	.....	Plug for commutator end bearing housing (punched type, old style).
1326	.....	1326	.....	Pipe plug for commutator end bearing (new style).
1328	.....	1328	.....	Terminals for outside line wires.
1355	.....	1355	.....	Machine screws for oil retaining washer, outside fan end.
1357	.....	1357	.....	Key for radiator motor coupling extension.

48a. Gasoline pump. (*See Fig. 42.*)

Part No.		Description.
Shown in figure.	Not indicated in figure.	
12	.....	Gasoline pump (body only; studded).
	569	Pad between No. 12 and frame.
	572	Stud to fasten gasoline pump to frame.
	574	Nut for No. 572.
29	.....	Lever for gasoline pump.
	571	Washer for No. 29.
	573	Stud on frame for No. 29.
	182	Cotter pin for No. 573.
30	.....	Plunger for hand pump.
54	.....	Eccentric rod for gasoline pump.
61	.....	Plunger for mechanically operated gasoline pump.
80	.....	Eccentric for gasoline pump.
	350	Key for No. 80.
147	.....	Gasoline pipe connecting pump to carburetor.
148	.....	Gasoline pipe flange.
	570	Stud for No. 148 at pump (see No. 195).
150	.....	Valve cap for gasoline pump.
151	.....	Ball valve for gasoline pump.
181	.....	Link for hand pump plunger (No. 30).
182	.....	Pin for No. 181 and No. 30.
183	.....	Washer for No. 182.
184	.....	Cotter pin for No. 182.
185	.....	Pin for No. 30.
186	.....	Cotter pin for No. 185.
187	.....	Large gland nut for hand pump.
188	.....	Large gland for hand pump.
189	.....	Small gland nut for mechanically operated pump.
190	.....	Small gland for mechanically operated pump.
191	.....	Bolt for eccentric strap (No. 200).
	663	Nut for No. 191.
	182	Cotter pin for No. 191.
192	.....	Metallic packing for mechanically operated gasoline pump (size $\frac{1}{4}$ by $9\frac{1}{2}$ inches).
193	.....	Metallic packing for hand operated gasoline pump (size $\frac{3}{8}$ by 18 inches).
194	.....	Lead gasket for gasoline pipe flanges.
195	.....	Nut for No. 570 and No. 148.
196	.....	Washer for No. 150.
197	.....	Pin for No. 61.

48a. Gasoline pump—Continued.

Shown in figure.	Not indicated in figure.	Description.
198	.....	Washer for No. 197.
199	.....	Cotter pin for No. 197.
200	.....	Eccentric strap.
	338	Pipe plug for eccentric strap.

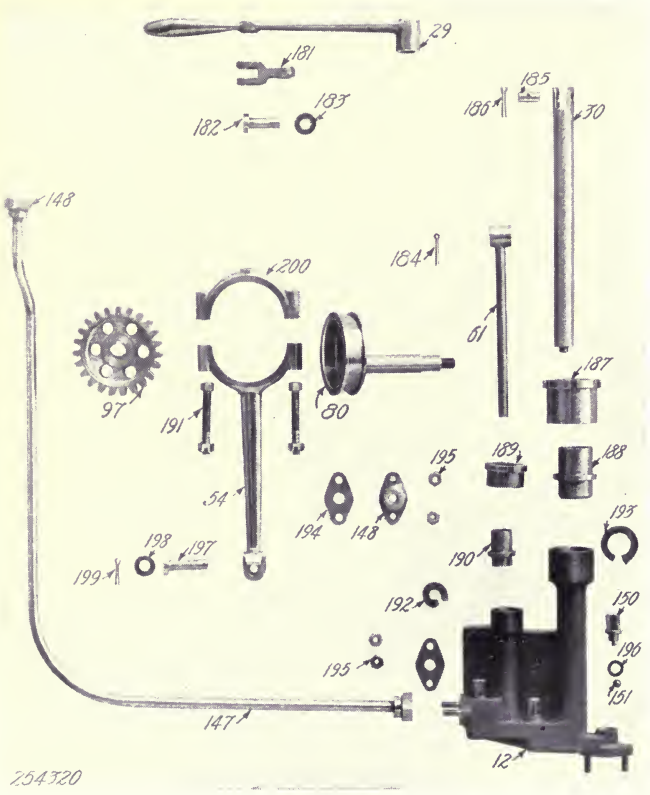


Fig. 42.

48b. Carburetor, throttle valve, air valve, hot-air intake, pipe connections, etc. (*See Fig. 43 and Fig. 44.*)

Part No.		Description.
Shown in figure.	Not indicated in figure.	
5	.....	Intake connection pipe with studs (state cylinders for which required).
	1384	Stud on cylinder to support No. 5.
	368	Nut for No. 1384.
6	.....	Intake pipe with studs.
	367	Short stud on No. 5 to support No. 6.
	1385	Long stud on No. 5 to support No. 6 and clip for governor spring.
	368	Nut for Nos. 367 and 1385.
10	.....	Carbureter, body only.
	367	Stud to attach No. 10 to No. 6.
	368	Nut for No. 367.
15	.....	Hot air intake pipe.
	626	Cap screw to attach No. 15 to frame.
	664	Gasket for No. 15.
58	.....	Carburetor drain cock.
74	.....	Air valve body (carburetor).
	369	Stud connecting No. 74 to No. 10.
	370	Nut for No. 369.
	625	Cap screw and nut to attach No. 74 to No. 15.
75	.....	Adjusting lever for air valve.
	363	Spring for Nos. 75 and 366.
	364	Taper pin for No. 75.
	366	Catch for No. 75.
76	.....	Gasoline needle valve.
213	.....	Cover and guide for throttle valve.
	367	Stud on No. 6 to attach No. 213.
	368	Nut for No. 367.
214	.....	Throttle valve and spindle.
	365	Shaft for No. 214.
	372	Dowel pin for Nos. 216 and 365.
215	.....	Washer for No. 214.
216	.....	Throttle valve operating lever.
	371	Clamping screw for No. 216.
	372	Dowel pin for Nos. 216 and 365.
217	.....	Gland nut for No. 218.
218	.....	Guide nut for No. 76.

48b. Carburetor, throttle valve, air valve, hot-air intake, pipe connections, etc.—Continued.

Part No.		Description.
Shown in figure.	Not indicated in figure.	
219	.....	Spring for No. 76.
220	.....	Screw for No. 219.
221	.....	Relief nozzle for No. 10.
222	.....	Baffle plate for carburetor.
223	.....	Gasket for No. 224.
224	.....	Indicator glass for No. 10.
	878	Brass substitute for No. 224.
225	.....	Screw cap for No. 224.
226	.....	Cover for carburetor.
227	.....	Gasoline nozzle for No. 10.
228	.....	Air valve.
229	.....	Lead gaskets for No. 230.
230	.....	Gasoline pipe flange.
	394	Stud connecting No. 230 to No. 10.
	531	Nut for No. 394.

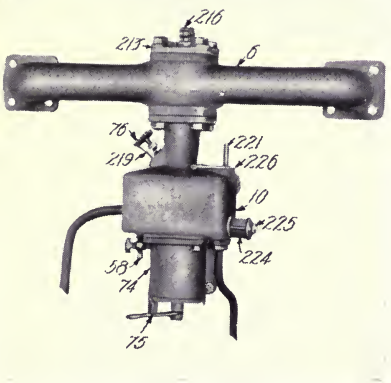


Fig. 43.

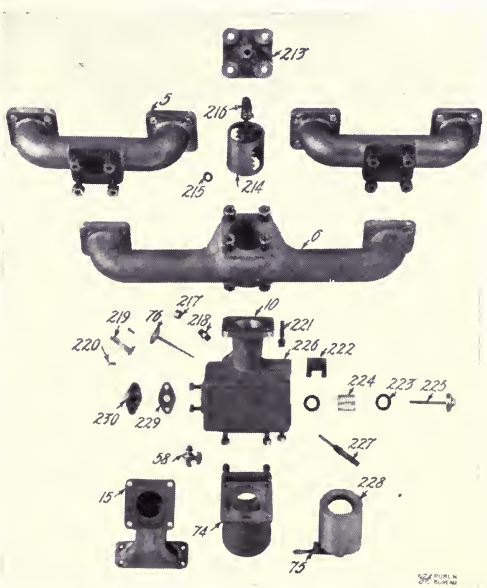


Fig. 44.

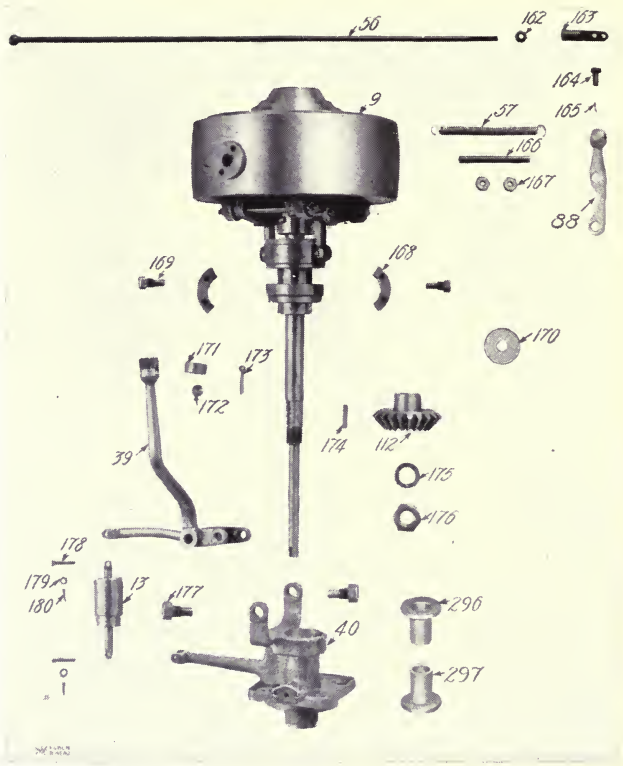

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Fig. 45.

48c. Governor. (*See Fig. 45.*)

Part No.		Description.
Shown in figure.	Not indicated in figure.	
9	.....	Governor complete.
	79	Governor shaft.
	505	Spring for governor (inside main casing).
	578	Cover for No. 580.
	579	Screw for No. 578.
	580	Governor casing.
	581	Governor weight.
	582	Adjusting nut for governor (shown in position on side of casing).
	583	Adjusting stud for governor (engages nut No. 582).
	585	Pin for No. 586 (to attach bell crank to governor casing).
	586	Bell crank lever for governor (transmits motion from weights to collar).
	587	Screw for attaching No. 590 to No. 588.
	588	Sliding collar on governor shaft.
	590	Link between No. 586 and No. 588.
	591	Key for No. 588.
	592	Pin connecting No. 586 and No. 590.
	593	Pin connecting No. 586 and No. 581.
	594	Washer for No. 585.
	595	Cotter pin for Nos. 585 and 592.
	596	Screw for securing key, No. 591, to sliding collar.
	597	Taper pin for attaching casing of governor to shaft.
	598	Cotter pin for No. 593.
	603	Cotter pin for governor shaft.
13	.....	Dashpot.
39	.....	Governor lever.
40	.....	Governor bracket.
	666	Stud to attach No. 40 to frame.
	667	Nut for No. 666.
	668	Lock washer for No. 667.

48c. Governor—Continued.

Part No.		Description.
Shown in figure.	Not indicated in figure.	
56	.....	Throttle rod.
57	.....	Spring for throttle rod, 4¼ inches long. (*See No. 500.*)
	500	Spring for throttle rod, 6¼ inches long.
88	.....	Clip for throttle valve spring.
112	.....	Bevel gear on governor shaft with key.
	111	Bevel gear on intake cam shaft operating governor, with key.
	59A2	Cover for governor gear box.
	60A2	Cap screw for No. 59A2.
162	.....	Nut for No. 56.
163	.....	Cross link for No. 56.
164	.....	Pin connecting Nos. 163 and 216.
	494	Washer for No. 164.
165	.....	Cotter pin for No. 164.
166	.....	Stud in No. 88.
167	.....	Nut for No. 166.
168	.....	Governor shoe.
169	.....	Screws for No. 168.
170	.....	Leather washer for governor shaft.
171	.....	Cap for lever, No. 39.
172	.....	Cap for No. 56.
173	.....	Cotter pin for No. 171.
174	.....	Key for No. 112.
175	.....	Lock washer for No. 176.
176	.....	Nut for governor shaft.
177	.....	Fulcrum screw for Nos. 39 and 40.
178	.....	Pins for No. 13.
179	.....	Washer for No. 178.
180	.....	Cotter pin for No. 178.
296	.....	Upper bushing for governor shaft.
297	.....	Lower bushing for governor shaft.

48d. Air heater (including parts on generator frame). (*See Fig. 46.*)

Part No.		Description.
Shown in figure.	Not indicated in figure.	
540	.....	Electric air heater, 115-volt.
	653	Electric air heater, 230-volt.
541	.....	Switch and cutout for use with heater.
542	.....	Cable for heater, less plug (No. 543).
543	.....	Connecting plug for heater cable.
544	.....	Long lead between No. 541 and line.
545	.....	Short lead between No. 541 and line.
546	.....	Cleat for Nos. 544 and 545.
547	.....	Screw for No. 546.
548	.....	Insulating washer for No. 541.
549	.....	Screw for attaching No. 541 to frame.
550	.....	Washer for No. 549.
551	.....	12-amp. fuse for No. 541 (115-volt heater).
	552	6-amp. fuse for No. 541 (230-volt heater).
787	.....	Terminal for Nos. 544 and 545.
788	.....	Terminal for No. 542.

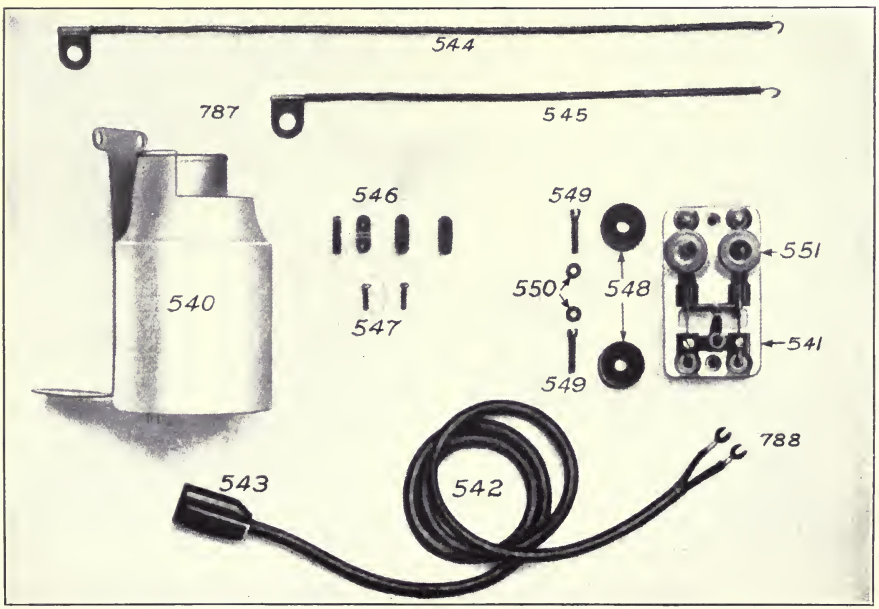

Fig. 46.

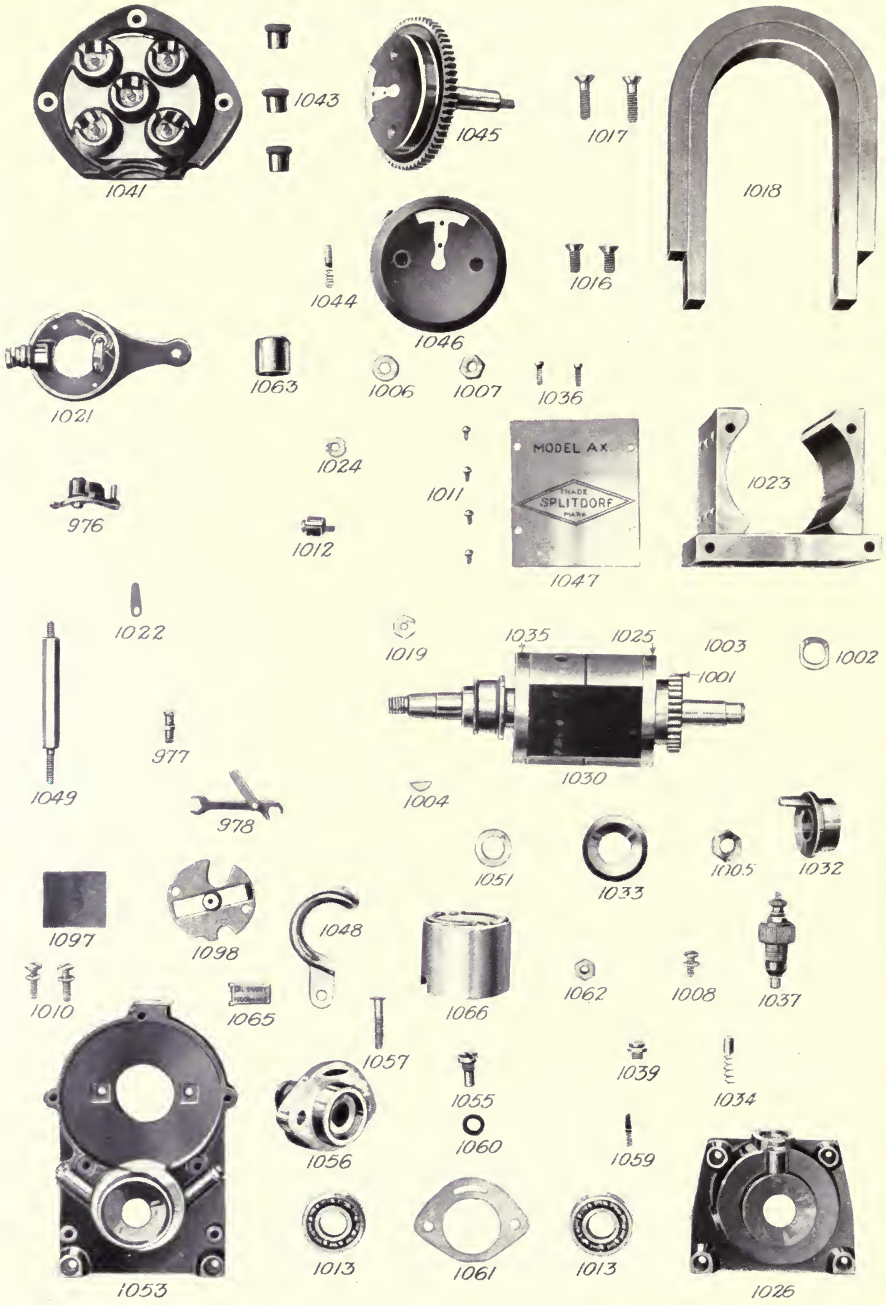
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Fig. 47.

49a. Splitdorf magneto, type AX. (*See Fig. 47.*)

Part No.		Description.
Shown in figure.	Not indicated in figure	
	966	Splitdorf, magneto, type AX.
976	.....	Breaker bar complete with platinum contact.
977	.....	Platinum contact screw with lock nuts.
978	.....	Combination wrench and gap gauge, L. T. .025.
1001	.....	Armature gear.
1002	.....	Cam nut.
1003	.....	Cam key.
1004	.....	Key for shaft, driving end.
1005	.....	Nut for shaft, driving end.
1006	.....	Washer for distributor gear shaft.
1007	.....	Nut for distributor gear shaft.
1008	.....	Short screws for front plate with lock washers.
1010	.....	Screws with washers for distributor cover.
1011	.....	Armature cover screws.
1012	.....	Breaker bar roller, screw, lock washer, and lock nut.
1013	.....	Standard annular bearing, 15 m/m, for armature shaft.
1016	.....	Magnet screws, short.
1017	.....	Magnet screws, long.
1018	.....	Magnets.
1019	.....	Brass hex nut for connection stud and No. 1021.
1021	.....	Breaker box less cover, breaker bar and platinum contact screw.
1022	.....	Breaker bar finger spring.
1023	.....	Cradle.

49a. Splitdorf magneto, type AX—Continued.

Part No.		Description.
Shown in figure.	Not indicated in figure.	
1024	.....	Special nut for connection stud.
1025	.....	Armature, cam end.
1026	.....	Back plate with oiler.
1030	.....	Armature complete with gear and shaft.
1032	.....	Collector spool.
1033	.....	Collector spool washer.
1034	.....	Collector brush with spring.
1035	.....	Armature, drive end only.
1036	.....	Distributor disk screws.
1037	.....	Collector brush holder.
1037–A	.....	Thumb nut for No. 1037.
1039	.....	Oil cup complete.
1040	.....	Transformer coils complete.
1041	.....	Distributor cover.
1043	.....	Distributor block thumb nuts, hard rubber.
1044	.....	Carbon brushes for distributor.
1045	.....	Distributor gear with shaft, disk, and segment.
1046	.....	Distributor disk with segment.
1047	.....	Armature cover.
1048	.....	Breaker-box cover spring.
	1020	Hexagonal nut to attach No. 1048 to stud No. 1049.
1049	.....	Stud for breaker-box cover spring.
1050	.....	Distributor block thumb nuts, brass.
1051	.....	Cam.

49a. Splitdorf magneto, type AX—Continued.

Part No.		Description.
Shown in figure.	Not indicated in figure.	
1053	.....	Front plate with ground stud and oiler.
1055	.....	Distributor shaft bearing wick holder.
1056	.....	Distributor shaft bearing.
	1064	Distributor shaft bearing felt washer.
1057	.....	Stud for distributor shaft bearing.
1059	.....	Distributor shaft bearing wick.
	1058	Spring for No. 1059.
1060	.....	Gasket for wick holder of distributor shaft bearing.
1061	.....	Gasket for distributor shaft bearing.
1062	.....	Nuts for distributor shaft-bearing stud.
	1052	Lock washer for No. 1062.
1063	.....	Distributor shaft-bearing dust cap.
1065	.....	Oil-well cover with pin and spring.
1066	.....	Breaker-box cover with condenser.
1097	.....	Condenser.
1098	.....	Copper brush, spring, and base in breaker-box cover.

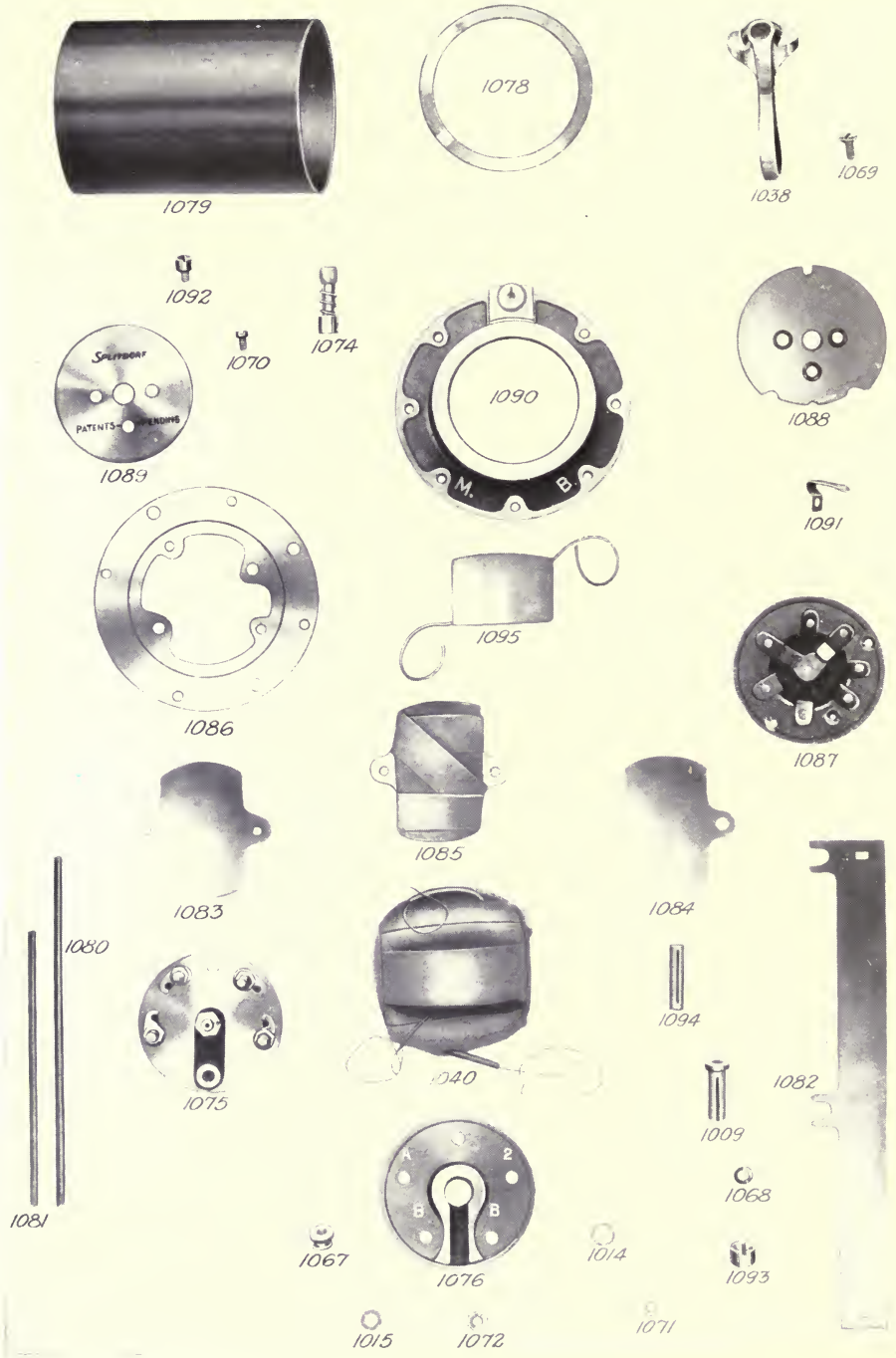
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Fig. 48.

49b. Splitdorf transformer coil, type T. S. B. (*See Fig. 48.*)

Part No.		Description.
Shown in figure.	Not indicated in figure.	
	958	Splitdorf transformer coil, type T. S. B.
1009	.....	Stud bushing
1014	.....	Washer for stud bushing.
1015	.....	Washer for No. 1072.
1038	.....	Switch handle with push button.
1067	.....	Thumb nut.
1068	.....	Lock washers.
1069	.....	Plate screws.
1070	.....	Cover screws.
1071	.....	Hexagonal nut $\frac{5}{16}$ inch.
1072	.....	Hexagonal nut $\frac{3}{8}$ inch.
1074	.....	Push button and spring.
1075	.....	Bottom block, rubber.
1076	.....	Stud plate.
1077	.....	Stud-plate cover.
1078	.....	Bottom ring.
1079	.....	Tube.
1080	.....	Long core stud.
1081	.....	Short core stud.
1082	.....	Core strip.
1083	.....	Condenser clamp.
1084	.....	Condenser clamp insulation.
1085	.....	Condenser clamp insulation pad.
1086	.....	Switch ring.
1087	.....	Switch bottom.
1088	.....	Switch disk.
1089	.....	Switch disk plate.
1090	.....	Switch cover.
1091	.....	Stop spring.
1092	.....	Stop screw.
1093	.....	Connection nut.
1094	.....	Core pillar.
1095	.....	Condenser with silk insulation.

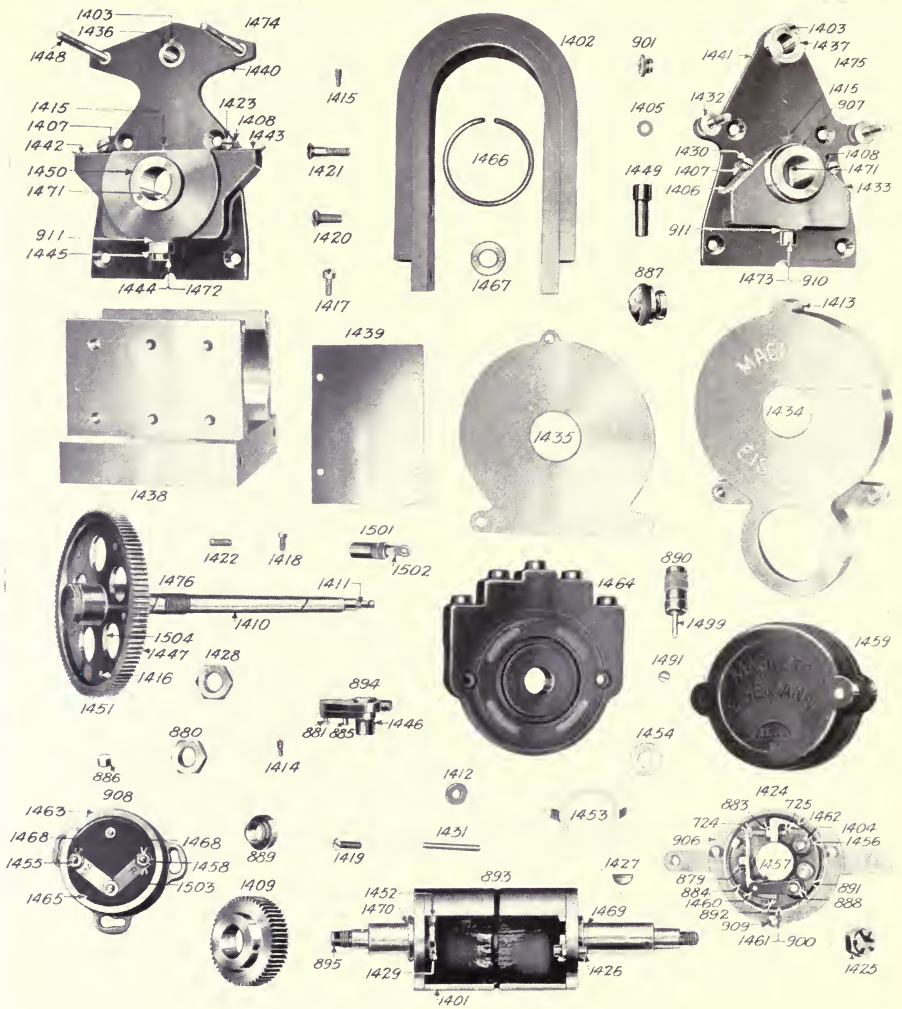
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Fig. 49.

49c. Eisemann magneto. (*See Fig. 49; for Eisemann transformer coil and switch see Par. 49e.*)

Part No.		Description.
Shown in figure.	Not indicated in figure.	
	527	Eisemann magneto, type A8.
724	.....	Platinum contact screw on lever.
725	.....	Adjustable platinum contact screw.
879	.....	Contact-breaker lever with fiber piece, but without platinum contact.
880	.....	Nut for locking cam.
881	.....	Steel brush with spring for distributor finger.
882	.....	High-tension distributor cover.
883	.....	Lock nut for platinum contact screw.
884	.....	Flat spring for breaker lever.
885	.....	Carbon brush with spring for distributor finger.
886	.....	Low-tension carbon brush.
	899	Spring support with holder for low-tension carbon brush.
887	.....	Grease cup for distributor shaft, complete.
888	.....	5 m/m nut for breaker mechanism.
889	.....	Steel cam.
890	.....	High-tension terminals complete, hard rubber.
891	.....	Support for platinum contact with spring contact button.
892	.....	Screw fastening spring to contact breaker lever.
893	.....	Armature, complete with shaft.
894	.....	Distributor finger complete.
895	.....	Low-tension collector on armature.
900	.....	Make-and-break mechanism complete.
901	.....	Knurled nuts for distributor plate cover.
904	.....	Low-tension terminal complete.
906	.....	Bascual, with spring studs for cover.
907	.....	Armature shaft bearing driving end.
908	.....	Make-and-break cover complete.
	899	Spring support with holder for low-tension carbon brush.
909	.....	Spring studs of bascual.
910	.....	Oil-wick screw, driving end.
911	.....	Packing washer, leather, for oil-wick screws.
1401	.....	Armature.
1402	.....	Magnet.
1403	.....	Set screw for distributor shaft bearing.
1404	.....	Brass washer on platinum contact support.
1405	.....	Brass washer for No. 901.
1406	.....	Oil-hole cover on left side, driving end.
1407	.....	Oil-hole-cover spring, right-hand wound.

49c. Eisemann magneto—Continued.

Part No.		Description.
Shown in figure.	Not indicated in figure.	
1408	.....	Oil-hole-cover spring, left-hand wound.
1409	.....	Small gear on armature shaft, 54 teeth.
1410	.....	Distributor shaft.
1411	.....	Key for distributor shaft.
1412	.....	Brass washer in front of distributor finger.
1413	.....	Bolt for gear-casing cover.
1414	.....	Screw for pinion.
1415	.....	Set screw for armature bearing.
1417	.....	Fastening screw for dust cover.
1418	.....	Connection screw for armature winding.
1419	.....	Fastening screw for armature flanges.
1420	.....	Screws for end plate and magnets.
1421	.....	Long screws for magnets.
1422	.....	Screw for fastening large gear to shaft.
1423	.....	Oil-hole-cover screw, cam end.
1424	.....	Bascual with make-and-break mechanism complete.
1425	.....	Hexagon nut for armature shaft, driving end.
1426	.....	Ground carbon with spring for armature shaft.
1427	.....	Woodruff key for coupling (armature-shaft extension).
1429	.....	Hexagon nut for low-tension collector No. 895.
1430	.....	Oil-hole-cover screw, driving end
1431	.....	Taper pin for pinion.
1432	.....	Gear-cover-holding stud.
1433	.....	Oil-hole cover on right-hand side, driving end.
1434	.....	Gear casing with bolt and nut.
1435	.....	Gear-casing cover.
1436	.....	Bronze bearing for distributor shaft, cam end.
1437	.....	Bronze bearing for distributor shaft, driving end.
1438	.....	Base plate with pole pieces.
1439	.....	Dust cover for pole casing.
1440	.....	End plate only, cam end.
1441	.....	End plate only, driving end.
1442	.....	Oil hole cover on left side, cam end.
1443	.....	Oil hole cover on right side, cam end.
1444	.....	Oil wick screw only on cam end.
1445	.....	Brass stop for bascual.
1446	.....	Distributor finger alone.
1447	.....	Fiber rim for distributor gear.
1448	.....	Studs holding distributor cover.

49c. Eisemann magneto—Continued.

Part No.		Description.
Shown in figure.	Not indicated in figure.	
1449	.....	Insulation bushing for stud No. 1448.
1450	.....	End plate bearing, cam end.
1451	.....	Distributor gear without shaft or grease cup.
1452	.....	Insulating disk for collector No. 895.
1454	.....	Washer for armature shaft, driving end.
1455	.....	Stud for end cap.
1456	.....	Insulating bushing on platinum contact support.
1457	.....	Steel washer on contact breaker lever stud.
1458	.....	Connection stud for end cap.
1459	.....	Distributor plate cover.
1460	.....	Retaining spring for contact breaker lever.
1461	.....	Disk of make and break mechanism with studs.
1462	.....	Insulating plate for platinum contact support.
1463	.....	End cap without fiber plate.
1464	.....	Distributor plate complete.
1465	.....	Fiber disk complete for make and break cover.
	899	Spring support with holder for low-tension carbon brush.
1466	.....	Spring ring for make and break cover.
1467	.....	Brass washer for steel cam.
1468	.....	Hexagon nut for make and break cover.
1469	.....	Armature shaft and flange complete, driving end, counter clockwise.
1470	.....	Armature shaft and flange complete, cam end, counter clockwise.
1471	.....	Oil wick with spring complete.
	902	Spring for oil wick.
	903	Oil wick.
1472	.....	Oil wick screw with wick complete, cam end.
1473	.....	Oil wick screw with wick complete, driving end.
1474	.....	End plate, cam end, complete.
1475	.....	End plate, driving end, complete.
1476	.....	Distributor gear with axle complete.
1491	.....	Inside cable connection screw for all hard rubber terminals.
1499	.....	Terminal piece for No. 890.
1501	.....	Complete hard rubber terminal for low tension cable on make and break cover.
1502	.....	Terminal piece for No. 1501.
1503	.....	Washer for Nos. 1458 and 1468.
1504	.....	Hub for distributor gear, fiber rim style.

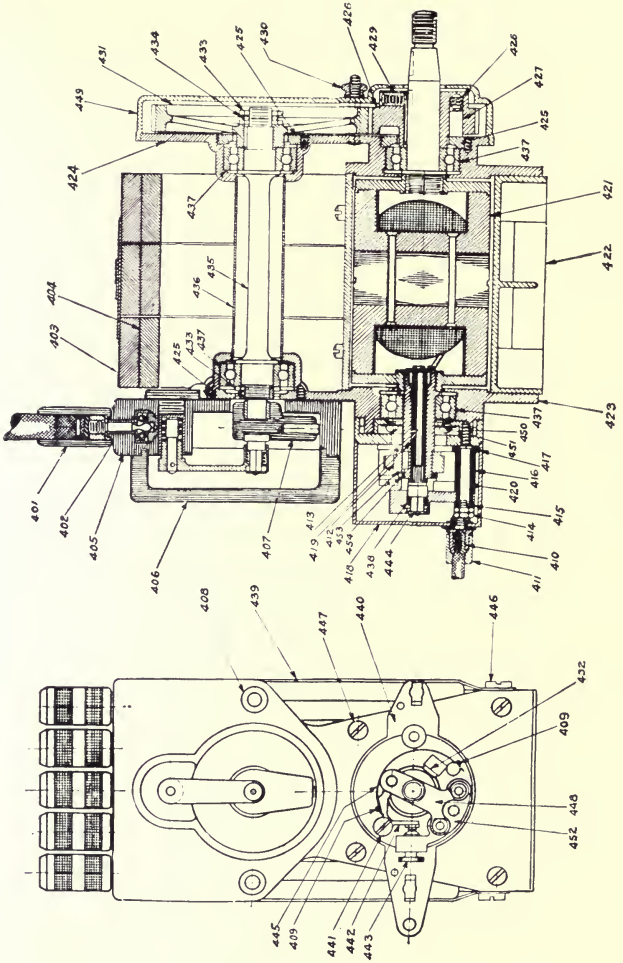
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Fig. 50.

49d. G. E. magneto. (*See Fig. 50; for G. E. Transformer Coil see Par. 49e.*)

Part No.		Description.
Shown in figure.	Not indicated in figure.	
	23	G. E. Magneto.
401	.....	Distributor plug.
402	.....	Plug spindle.
403	.....	Outer magnet.
404	.....	Inner magnet.
405	.....	Distributor plate.
406	.....	Distributor cover.
407	.....	Distributor finger.
408	.....	Nut for distributor cover.
409	.....	Screw for interrupter spring.
410	.....	Low tension terminal.
411	.....	Nut and bushing for No. 410.
412	.....	Cam.
413	.....	Collector pin.
414	.....	Nut for stud No. 420.
415	.....	Insulator for interrupter block.
416	.....	Insulator for contact block.
417	.....	Insulator washer.
418	.....	Interrupter cover.
419	.....	Insulation for collector pin.
420	.....	Stud for interrupter.
421	.....	Armature complete.
422	.....	Field complete, less magnets.
423	.....	Bearing, interrupter end.
424	.....	Bearing, driving end.
425	.....	Oil baffle plate.
426	.....	Pinion, less set screws.
427	.....	Ground brush.
428	.....	Spring for No. 427.
429	.....	Set screw for pinion.
430	.....	Nut for gear guard.
431	.....	Distributor gear.
432	.....	Oiler for cam.
433	.....	Nut for distributor shaft.
434	.....	Lock spring for No. 433.
435	.....	Distributor shaft.
436	.....	Tube for shaft.
437	.....	Ball bearing complete.

49d. G. E. magneto—Continued.

Part No.		Description.
Shown in figure.	Not indicated in figure.	
438	.....	Spring for No. 444.
439	.....	Magnet strap.
440	.....	Interrupter base.
	536	Pin on No. 440 (engages in notches of No. 70, adjusting lever).
441	.....	Screw for interrupter lever.
442	.....	Interrupter lever.
443	.....	Interrupter contact screw.
444	.....	Collector brush.
445	.....	Interrupter spring.
446	.....	Screw for magnet band.
447	.....	Screw for bearing head.
448	.....	Interrupter block.
449	.....	Gear guard.
450	.....	Oil retainer.
451	.....	Spring for interrupter base.
452	.....	Contact block.
453	.....	Lock washer for cam.
454	.....	Nut for cam.

49e. G. E. and Eisemann transformer ignition coils. (*See Fig. 51.*)

Part No.		
Eisemann magneto, shown in figure.	G. E. magneto, not indicated in figure.	
8	.....	Transformer ignition coil for Eisemann A8 magneto.
77	.....	Ignition switch for Eisemann A8 magneto.
919	920	Plug for ignition switch.
1482	1386	Knurled terminal nut.
1483	.....	Hexagon nut for terminal screw No. 1489.
1484	.....	Round nut for terminal screw No. 1489.
1485	.....	Switch plate "Bat."
1486	.....	Switch plate "B."
1487	.....	Switch plate "M."
1488	.....	Fastening screw for switch plates and No. 1495/6.
1489	.....	Terminal screw.

49e. G. E. and Eisemann transformer ignition coils—Con.

Part No.		
Eisemann magneto, shown in figure.	G. E. magneto, not indicated in figure.	
1490	.....	Switch cover.
1492	.....	Fastening screw for cover.
1493	.....	Insulating plate for switch plate "M."
1494	.....	Washer for terminal screw No. 1489.
1495	.....	Handle with supporting block.
1496	.....	Switch block "R."
1497	.....	Switch casing.
1498	.....	Washer for connection screw No. 1500.
1500	.....	Connection screw.

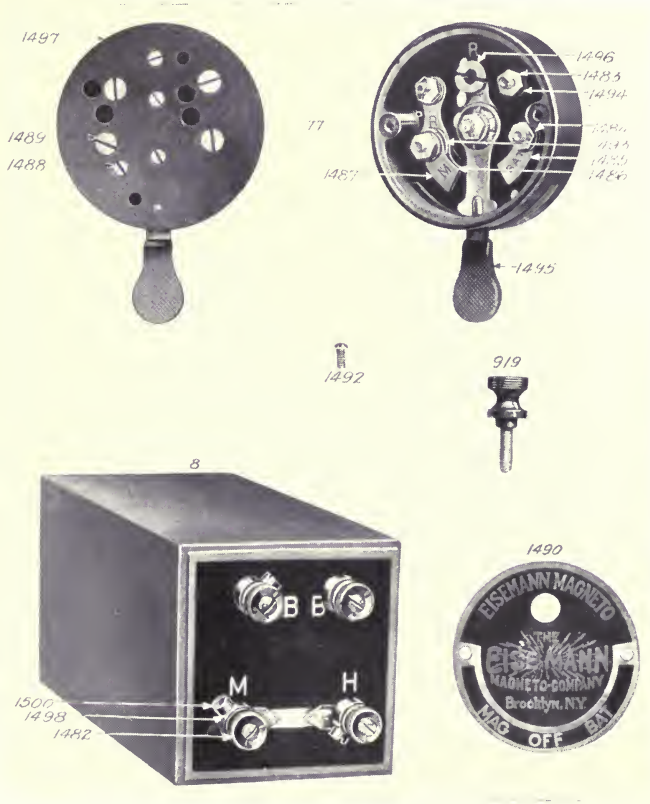

Fig. 51.

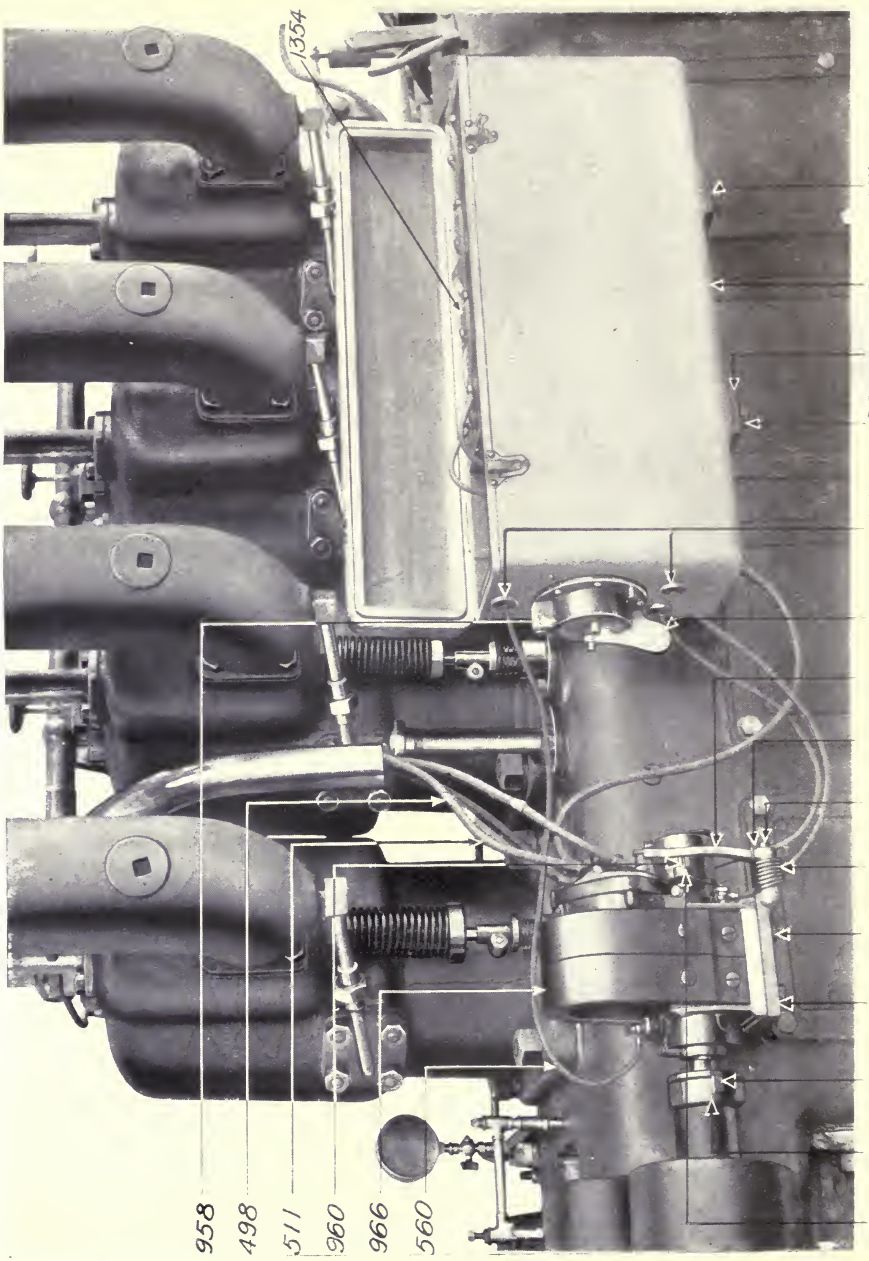
1354
971
970
44
620
715
1038
359
353
961
963
936
965
967
43
1021
958
498
511
960
966
560

Fig. 52,

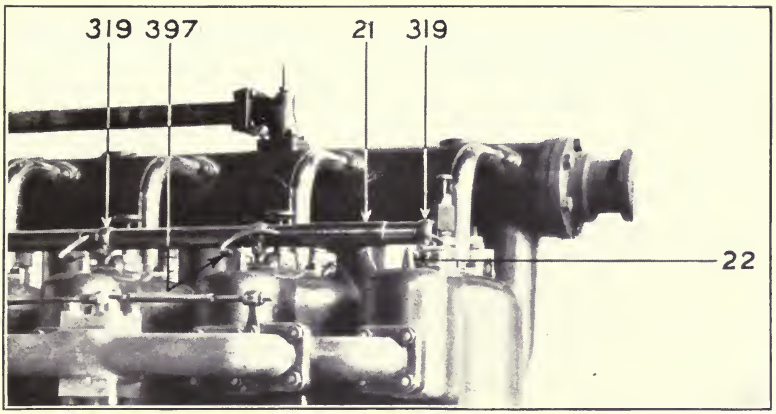

Fig. 53.

49f. Parts of ignition system not included in pars. 49a to 49e, inclusive. (*See Figs. 52 and 53.*)

Part No.		Description.
Shown in figure.	Not indicated in figure.	
21	.....	Conduit for leads.
22	.....	Spark plug.
43	.....	Driving magneto coupling with gear shaft and key.
44	.....	Bracket for battery box.
319	.....	Support for No. 21.
	501	Cap screws for No. 319.
	717	Stud to attach No. 319 to cylinder.
	706	Nut for No. 717.
397	.....	Rajah terminal at spark plug for No. 511.
498	.....	Tay for leads.
511	.....	High tension cable. (Specify number of feet wanted.)
560	.....	Low tension cable. (Specify number of feet wanted.)
620	.....	Nut for battery box stud.
775	.....	Bushing for low tension leads.

49f. Parts of ignition system not included in pars. 49a to 49e, inclusive—Continued.

Part No.		Description.
Shown in figure.	Not indicated in figure.	
	773	Bushing for high tension leads.
953	.....	Cotter pin for use with Splitdorf magneto.
	535	Cotter pin for use with GE and Eisemann magnetos.
956	.....	Cap screw to attach Splitdorf magneto to bracket.
	537	Cap screw to attach Eisemann and GE magneto to bracket.
958	.....	See corresponding number, par. 49b; also par. 49e.
959	.....	Locking lever, for use with Splitdorf magneto only.
	70	Locking lever for Eisemann and G. E. magnetos.
960	.....	Pin for Splitdorf magneto timing arm.
	536	Pin for timing arm of G. E. and Eisemann magnetos.
961	.....	Pivot pin for No. 959.
	128–A2	Pivot stud for locking lever No. 70.
	962	Washer for No. 961.
	534	Washer for No. 128–A2.
963	.....	Torsional spring for No. 959, Splitdorf magneto only.
	533	Spiral spring for locking lever No. 70, Eisemann and G. E. magnetos only.
965	.....	Bracket for Splitdorf magneto.
	69	Bracket for Eisemann and G. E. magnetos.
	504	Cap screws to attach magneto bracket to frame.
966	.....	Splitdorf magneto, Type AX.
	23	G. E. magneto.
	527	Eisemann magneto, Type A8.

49f. Parts of ignition system not included in pars. 49a to 49e, inclusive—Continued.

Part No.		Description.
Shown in figure.	Not indicated in figure.	
967	.....	Driven coupling for Splitdorf magneto.
	43–A2	Driven coupling for Eisemann and G. E. magnetos.
	968	Buffer for couplings.
970	.....	Battery box for use with Splitdorf transformer coil.
	18	Battery box for use with Eisemann and G. E. transformer coils.
	774	Stud to attach battery box to bracket.
971	.....	Lock washer for No. 620.
1021	.....	See No. 1021, par 49a.
1038	.....	See 1038, par. 49b; also par. 49e.
1354	.....	Columbia multiple battery.

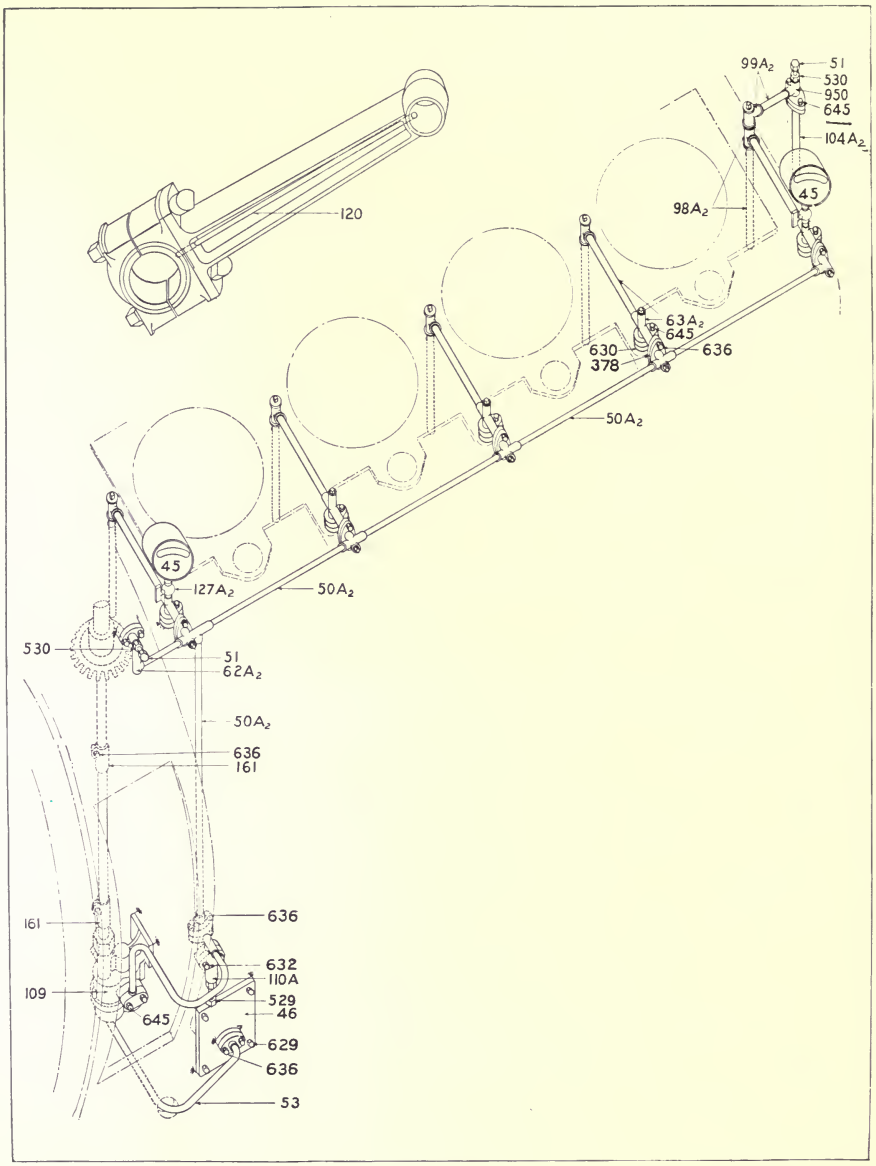
99A2
51
530
950
645
104A2
120
98A2
45
63A2
645
630
378
636
50A2
45
127A2
50A2
530
51
62A2
50A2
636
161
161
636
632
110A
109
529
46
645
629
636
53

Fig. 54.

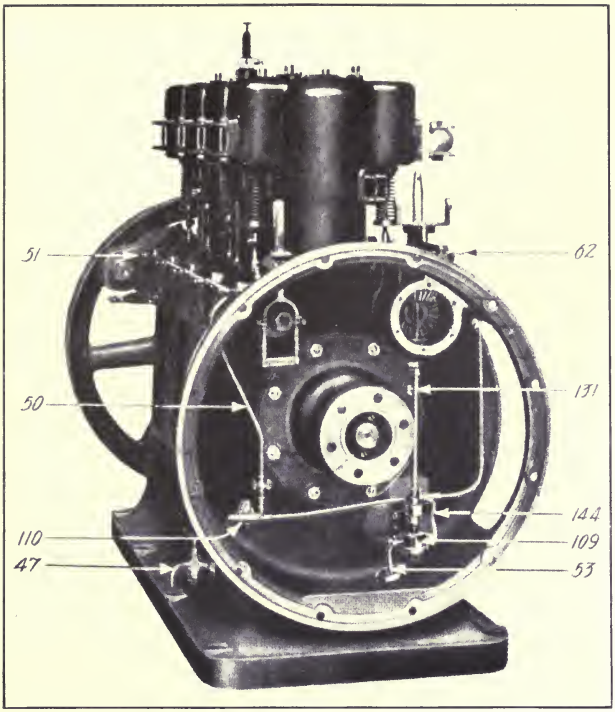

Fig. 55.

50. Oiling system. (*See Figs. 54 and 55, p. 118.*)

Part No.		Description.
Shown in figure.	Not indicated in figure.	
45	.....	Oil pressure gage.
46	.....	Oil strainer complete.
	375	Gasket for 46.
47	.....	Drain cock for oil reservoir.
	47A	Sight oil gauge for reservoir.
	375	Gasket for No. 634.
	634	Flange for 47.
	912	Glass tube for 47A.
	918	Packing washer for 912.
50	.....	Horizontal and vertical sections of main oil pipe (*Form A1 engines only*).
	59	Blind flange to cover oil passages (*Form A1 engines only*).

50. Oiling system — Continued.

Part No.		Description.
Shown in figure.	Not indicated in figure.	
50–A2	.....	Horizontal and vertical sections of main oil pipe (*Form A2 and subsequent engines only*).
51	.....	Needle valve screw, with nut and leather washer (*for No. 62–A2 and No. 99–A2*).
53	.....	Oil pipe between strainer and pump.
62	.....	Oil pipe connection from No. 144 to governor (*Form A1 engines only*).
62–A2	.....	Needle valve, elbow complete, governor oil pipe (*Form A2 and subsequent engines only*).
63–A2	.....	Horizontal section of branch oil pipe to main bearings (*Form A2 and subsequent engines only*).
98–A2	.....	Vertical section of branch oil pipe to main bearings (*Form A2 and subsequent engines only*).
99–A2	.....	Horizontal section of branch oil pipe to gear case complete (*Form A2 and subsequent engines only*).
104–A2	.....	Vertical section of branch oil pipe to gear case (*Form A2 and subsequent engines only*).
109	.....	Oil pump.
	673	Stud to attach No. 109 to frame.
	674	Nut for No. 673.
	623	Lock for oil pump gland nut.
	704	Packing for oil pump. (*Same as No. 204.*)
	1387	Cotter pin for lock of oil-pump gland nut.
110	.....	By-pass valve and pipe connection to No. 144 (*Form A1 engines only*).
110–A2	.....	By-pass valve body and pipe connection to pump (*Form A2 and subsequent engines only*).
	633	Gasket between by-pass valve and frame.
120	.....	Oil pipe on connecting rod.
127–A2	.....	Shut-off cock for oil pressure gauge.
131	.....	Governor shaft extension.
144	.....	Oil pipe connection to pump, pressure side (*Form A1 engines only*).

50. Oiling system—Continued.

Part No.		Description.
Shown in figure.	Not indicated in figure.	
161	.....	Coupling for governor shaft extension.
378	.....	Gasket for oil pipe flanges.
529	.....	Adjusting screw for oil by-pass valve (not including nuts or washers).
530	.....	Lock nut for oil by-pass valve and needle valve screw, No. 51.
629	.....	Cap screw for oil reservoir flanges at strainer and drain cock.
630	.....	Distance piece between No. 63–A2 and frame.
632	.....	Cap screws for by-pass valve and frame.
636	.....	Screw for all oil pipe flanges (*except flanges at distance pieces, pump, and gear case*) and 161.
637	.....	Nut for No. 645 at gear case.
645	.....	Screw for oil pipe flanges at pump, distance piece, and gear case.
950	.....	Needle valve body at gear case.

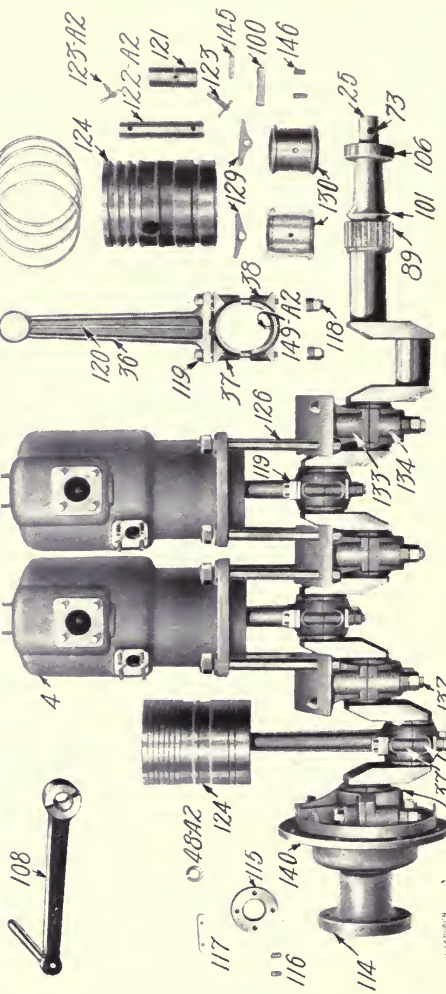
125
123-A2
122-A2
121
124
123
145
100
146
129
130
25
73
106
101
89
120
36
119
37
38
149-A2
118
126
119
133
134
4
48A2
124
137
118
38
37
141
108
117
116
115
140
114

Fig. 56.

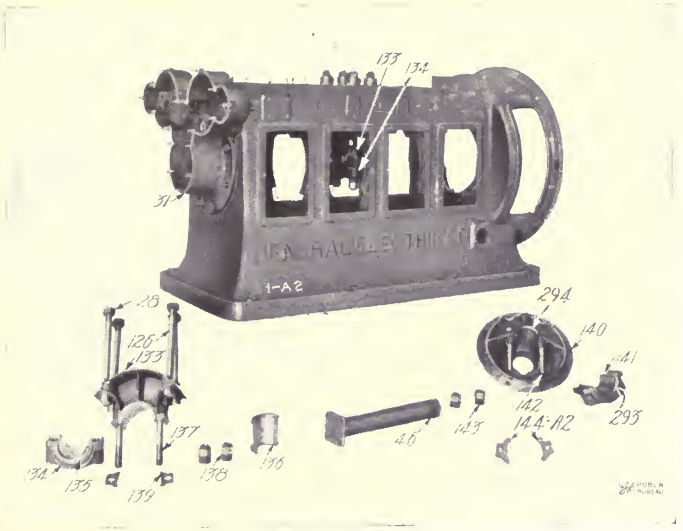

Fig. 57.

51. Cylinders, pistons, crank shaft, connecting rods, bearings, etc. (*See Figs. 56 and 57.*)

Part No.		Description.
Shown in figure.	Not indicated in figure.	
1-A2	.....	Engine frame (Form A2 and subsequent engines only).
	1	Engine frame (Form A engines only).
4	.....	Cylinder.
	659	Studs for fastening 1 and 4 cylinders to frame (*see No. 28 et seq.*).
25	.....	Crank shaft, less couplings.
28	.....	Nut for fastening down cylinders.
	568	Positive lock washer for No. 28.
31	.....	Gear case and end bearing (studded; without bushings).
	300	Nuts for No. 301.
	301	Outside stud on frame for No. 31.
	669	Lower inside stud for gear case.
	670	Cotter pin for Nos. 669 and 671.
	671	Upper inside stud for gear case.
	672	Nut for Nos. 669 and 671.
36	.....	Connecting rod.

51. Cylinders, pistons, crank shaft, connecting rods, bearings, etc.—Continued.

Part No.		Description.
Shown in figure.	Not indicated in figure.	
37	.....	Connecting rod head, upper half.
38	.....	Connecting rod head, lower half.
46	.....	Oil strainer complete (*for screws, etc., see par. 50*).
73	.....	Cranking pin.
	876	Guard for cranking pin.
	877	Cap screw for No. 876.
89	.....	Crank shaft pinion, for use with steel gears. (*See also No. 872.*)
	872	Crank shaft pinion, for use with cloth gears. (*See also No. 89.*)
100	.....	Key for shaft and flywheel.
101	.....	Oil collar, flywheel end of crank shaft.
106	.....	Nut to fasten flywheel (or flywheel coupling of Form A engines) to crank shaft.
	32	Cover for No. 106 (*Form A engines only*).
	146	Set screws to lock No. 106.
108	.....	Starting crank.
114	.....	Crank shaft coupling for armature.
115	.....	Clamping nut for No. 114.
116	.....	Set screw for locking nut No. 115.
117	.....	Key for armature coupling.
118	.....	Nut and lock nut for No. 119.
119	.....	Bolts for connecting rod head.
120	.....	Oil pipe on connecting rod.
121	.....	Wrist pin bushing.
122–A2	.....	Wrist pin.
123	.....	Set screw for holding wrist pin in piston.

51. Cylinders, pistons, crank shaft, connecting rods, bearings, etc.—Continued.

Part No.		Description.
Shown in figure.	Not indicated in figure.	
123–A2	.....	Safety screw for wrist pin.
124	.....	Piston.
125	.....	Piston ring.
126	.....	Bolts for holding down cylinders and up crank bearings.
129	.....	Shim for connecting rod head.
130	.....	Lining for connecting rod head.
133	.....	Upper part of inside bearing of crank shaft.
134	.....	Lower cap of inside bearing of crank shaft.
135	.....	Lower lining of inside bearing of crank shaft.
136	.....	Upper lining of inside bearing of crank shaft.
137	.....	Stud for holding up lower cap of inside bearing of crank shaft.
138	.....	Nut and lock nut for stud No. 137.
139	.....	Shim for inside bearing of crank shaft.
140	.....	Upper crank shaft bearing, generator end.
	396	Oil collar for crank shaft, generator end.
141	.....	End bearing cap.
142	.....	Bolts for end bearing.
143	.....	Nut and lock nut for bolt No. 142.
144–A2	.....	Shim for end bearing of crank shaft.
145	.....	Key to fasten pinion No. 89 (also No. 872) to crank shaft.
146	.....	Set screw for lock nut No. 106.
149–A2	.....	Dowel pin for Nos. 130 and 38.
293	.....	Lower lining for end bearing of crank shaft.
294	.....	Upper lining for end bearing of crank shaft.

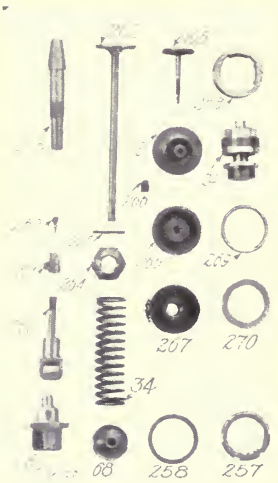

Fig. 58.

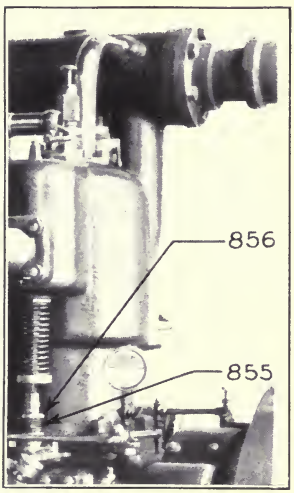

Fig. 59.

52. Intake and exhaust valves and their operating parts; priming and relief valves; cylinder plugs, etc. (*See Figs. 58 and 59.*)

Part No.		Description.
Shown in figure.	Not indicated in figure.	
19	.....	Relief cock and primer for cylinder No. 1, body only.
24	.....	Relief cock and primer for cylinders Nos. 2, 3, and 4, body only.
34	.....	Main valve spring.
65	.....	Guide for cam roller fork.
	661	Stud to attach No. 65 to frame.
	662	Nut for No. 661.
67	.....	Valve-adjusting clamp.
68	.....	Seat for main valve spring.
105	.....	Relief cock and primer valve.
257	.....	Clamping ring nut for Nos. 16, 16A2, and 24.
258	.....	Brass packing ring for Nos. 16, 16A2, and 24.
259	.....	Valve guide for No. 262.
260	.....	Clamping screw for No. 67.
261	.....	Cam roller and fork.
	682	Cam roller fork and guide complete (engines prior to A20).
	858	Assembled cam roller fork and guide complete with spring (A20 and subsequent engines only).
262	.....	Intake and exhaust valve.
263	.....	Key for No. 262.
264	.....	Nut for valve guide.
265	.....	Plug for exhaust chambers of cylinders Nos. 2, 3, and 4.
266	.....	Pipe plug for No. 265.
267	.....	Plug for intake chamber.
268	.....	Clamping ring nut for Nos. 19, 265, and 267.
269	.....	Copper asbestos gasket for Nos. 16, 16–A2, and 24.
270	.....	Tauril gasket for Nos. 16, 16–A2, and 24.
855	.....	Spring for No. 261 (A20 and subsequent engines only).
856	.....	Cap for No. 855.

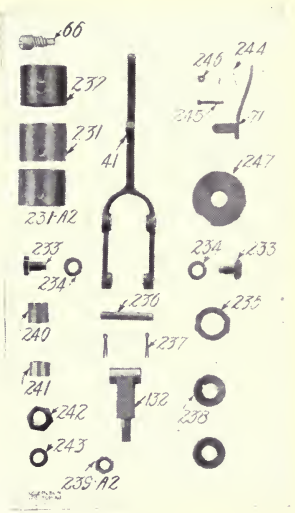
66
237
231
231-A2
41
246
244
245
71
247
233
234
236
240
237
241
242
132
238
243
239-A2

Fig. 60.

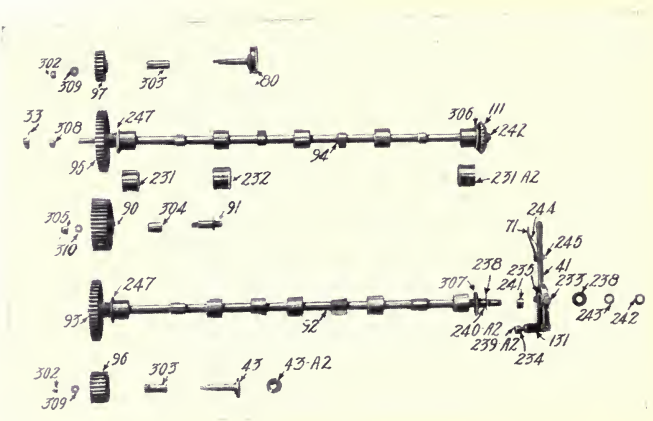
302
309
97
303
80
33
308
247
306
111
242
95
94
231
232
231 A2
305
90
304
91
310
244
71
245
238
235
41
233
238
307
241
247
93
92
240-A2
239 A2
131
234
243
242
302
309
96
303
43
43-A2

Fig. 61.

53. Intake and exhaust cam shafts, shifting lever, magneto and pump gears, etc. (*See Figs. 60 and 61.*)

Part No.		Description.
Shown in figure.	Not indicated in figure.	
33	.....	Indicator.
	726	Screw for No. 33 and cam shaft.
	728	Clamping screw for No. 33.
41	.....	Cam shaft shifting lever.
	72	Locking plate for No. 41.
	575	Cap screw for No. 72.
43	.....	Driving magneto coupling and gear shaft, with key.
43–A2	.....	Driven magneto coupling.
66	.....	Set screw for cam shaft bushing.
71	.....	Catch for cam shaft lever.
80	.....	Eccentric of gasoline pump.
90	.....	Idler gear with bushing (for use with steel gears).
	852	Idler gear, cloth.
91	.....	Idler gear stud.
92	.....	Exhaust cam shaft (all engines except A–20 and subsequent engines).
	875	Exhaust cam shaft (Form A–20 and subsequent engines only). (*See also No. 92.*)
93	.....	Exhaust cam shaft gear with key.
94	.....	Intake cam shaft (all engines except A–20 and subsequent engines). (*See also No. 873.*)
	873	Intake cam shaft (Form A–20 and subsequent engines only). (*See also No. 94.*)
95	.....	Intake cam shaft gear with key.
96	.....	Gear operating magneto, steel. (*See also No. 859.*)
97	.....	Gear operating gasoline and water pumps, steel. (*See also No. 859*).
	859	Driving gear for magneto and pumps, cloth. (*See also Nos. 96 and 97*).
111	.....	Bevel gear on intake cam shaft with key.
132	.....	Support for No. 41.
231	.....	Bushing for cam shaft, flywheel end.
231A2	.....	Bushing for cam shaft, generator end.
232	.....	Middle bushing for cam shaft.
233	.....	Screw to fasten No. 235 to No. 41.
234	.....	Positive lock washer for No. 233 and No. 239–A2.

53. Intake and exhaust cam shafts, shifting lever, magneto and pump gears, etc.—Continued.

Part No.		Description.
Shown in figure.	Not indicated in figure.	
235	.....	Shifting sleeve.
236	.....	Pin connecting No. 41 and No. 132.
237	.....	Cotter pin for No. 236.
238	.....	Washer for shifting sleeve.
239	.....	Lock nut for No. 132. (Order Nos. 239–A2 and 234).
239A2	.....	Nut for No. 132.
240	.....	Long spacing sleeve for No. 92.
241	.....	Short spacing sleeve for No. 92.
242	.....	Nut for Nos. 92, 94, 874, and 875, to attach bevel gear to intake cam shaft.
243	.....	Positive lock washer for No. 242.
244	.....	Flat spring for No. 71.
245	.....	Pin for No. 71.
246	.....	Washer for No. 245.
247	.....	Washer for cam shafts, flywheel end. (For all engines except Form A–20 and subsequent engines.) (*See also No. 874.*)
	874	Washer for cam shafts, flywheel end. (Form A–20 and subsequent engines only.)
302	.....	Lock nut to fasten No. 97 to No. 80, also No. 96 to No. 43.
303	.....	Bushings for Nos. 43 and 80.
304	.....	Bushing for idler gear.
305	.....	Lock nut for No. 90.
306	.....	Thrust washer for No. 94, generator end.
307	.....	Thrust washer for No. 92, generator end.
308	.....	Bushing in gear case cover for No. 94.
309	.....	Washer for No. 302.
310	.....	Washer for No. 305.

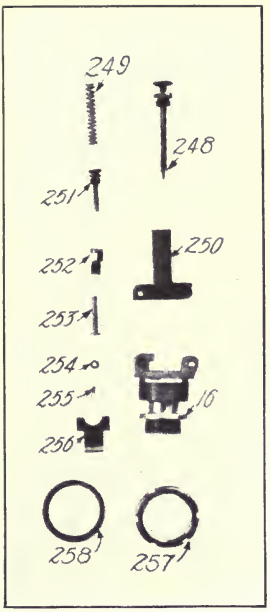

Fig. 62.

54a. Cartridge starter, old type. (*See Fig. 62.*)

Part No.		Description.
Shown in figure.	Not indicated in figure.	
16	.....	Breechblock.
248	.....	Firing pin for breechblock.
249	.....	Spring for No. 248.
250	.....	Breechblock, upper part.
251	.....	Locking pin for No. 250.
252	.....	Guide block for No. 251.
253	.....	Pin for No. 250.
254	.....	Washer for No. 253.
255	.....	Cotter pin for No. 253.
256	.....	Shell ejector for No. 16.
257	.....	Ring nut for Nos. 16 and 24.
258	.....	Brass packing ring for Nos. 16 and 24.

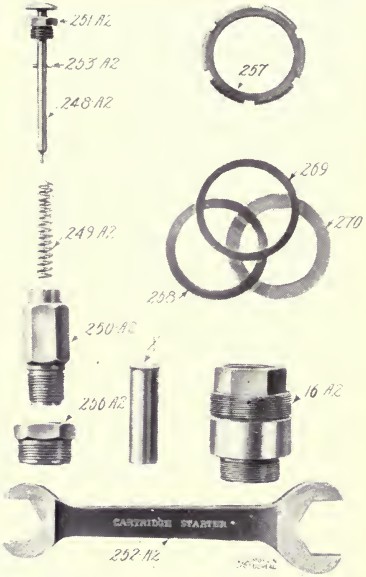
251 A2
253 A2
248 A2
257
269
270
249 A2
258 A
250 A2
256 A2
16 A2
CARTRIDGE STARTER
252 A2

Fig. 63.

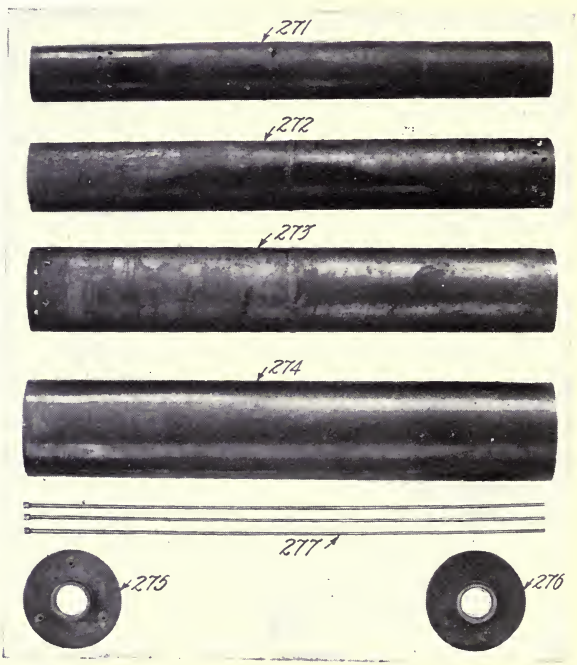
271
272
273
274
277
275
276

Fig. 64.

54b. Cartridge starter, new type. (*See Fig. 63.*)

Part No.		Description.
Shown in figure.	Not indicated in figure.	
16–A2	.....	Cartridge starter (body only).
248–A2	.....	Firing pin for cartridge starter.
249–A2	.....	Spring for No. 248–A2.
250–A2	.....	Clamp for No. 256–A2.
251–A2	.....	Guide nut for No. 248–A2.
252–A2	.....	Wrench for cartridge starter.
253–A2	.....	Limit pin for No. 248–A2.
256–A2	.....	Shell holder for No. 16–A2.
257	.....	Ring nut for No. 16–A2.
258	.....	Brass packing ring for No. 16–A2.
269	.....	Copper-asbestos packing for No. 16–A2.
270	.....	Tauril packing for No. 16–A2.
	510	No. 10 gauge blank cartridge.
	528	Cartridge starter complete.

55. Exhaust muffler. (*See Fig. 64.*)

113	.....	Muffler.
271	.....	First expansion chamber of No. 113.
272	.....	Second expansion chamber of No. 113.
273	.....	Third expansion chamber of No. 113.
274	.....	Fourth expansion chamber of No. 113.
275	.....	Inlet head of No. 113.
276	.....	Outlet head of No. 113.
	493	Packing ring for muffler heads.
277	.....	Through bolts of No. 113.

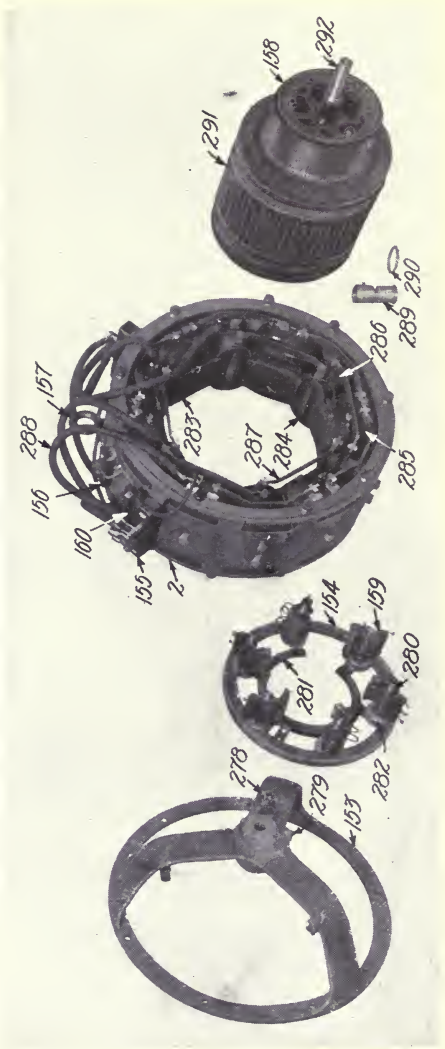
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Fig. 65.

56a. Generator frame and parts thereon, not including terminal boards or pole pieces. (*See Fig. 65.*)

Part No.				Description.
115-volt generator.		230-volt generator.	3-wire generator.	
Shown in figure.	Not indicated in figure.	Not indicated in figure.	Not indicated in figure.	
2	.....	791	791	Frame for generator.
	301	792	792	Stud for generator frame.
	1158	1158	1158	Nut for stud for generator frame.
	1160	1160	1160	Machine screw for name plate.
157	.....	157	157	Eyebolt for generator frame.

56b. Generator bearing bracket and parts thereon. (*See Fig. 65.*)

153	.....	153	796	Bearing bracket for generator.
	1157	1157	1157	Bolt for fastening generator bearing bracket.
278	.....	278	278	Drip cock for oil gauge.
	107	107	107	Sight oil gauge complete.
	1163	1163	1163	Oil tube for sight oil gauge.
	1164	1164	1164	Sight tube for generator oil gauge.
	1165	1165	1165	Cover for sight tube.
	1166	1166	1166	Cotter pin for sight oil gauge cover.
	1167	1167	1167	Glass tube for sight oil gauge.
	1168	1168	1168	Cork washer for bottom of sight tube.
	1169	1169	1169	Brass washer for bottom of glass tube.
	1170	1170	1170	Cork washer for glass tube.
	1171	1171	1171	Nipple for top of sight tube.
279	.....	279	279	¼-inch drain plug for generator bearing.
	973	973	973	⅜-inch pipe plugs for generator bearing.
289	.....	289	289	Lining for generator bearing.
	1159	1159	1159	Screw for holding bearing lining.
290	.....	290	290	Oil ring for generator bearing.
	1161	1161	1262	Oil-well cover for generator bearing.
	1162	1162	1162	Hinge screw for oil-well cover.

56c. Generator armature, commutator, shaft, etc. (*See Fig. 65.*)

Part No.				Description.
115-volt generator.		230-volt generator.	3-wire generator.	
Shown in figure.	Not indicated in figure.	Not indicated in figure.	Not indicated in figure.	
158	.....	807	798	Commutator.
	1226	1259	1259	Key for commutator.
291	.....	1255	1291	Armature for generator.
	1227	1260	1260	Armature bar winding.
	1228	1261	1261	Connecting clips for armature winding opposite commutator end.
	1229	1360	1293	Connecting clips for armature winding commutator end.
		1256	.....	Armature for generator (Panama insulation).
292	.....	1257	1292	Armature shaft and key.
	1225	1258	1258	Key for armature spider.

56d. Generator pole pieces and field coils. (*See Fig. 65, p. 132.*)

283	.....	1230	1230	Main pole piece for generator.
	1186	1232	1232	Bolt for generator main pole piece.
284	.....	1231	1231	Commutating pole piece for generator.
	1187	1233	1233	Bolt for generator commutating pole piece.
285	.....	1234	1275	Main field coil for generator.
		1235	.....	Main field coil for generator (Panama insulation).
286	.....	1236	1276	Commutating field coil for generator.
		1237	.....	Commutating field coil for generator (Panama insulation).

56e. Connecting leads between field coils of generator. (*See Fig. 65, p. 132.*)

Part No.				Description.
115-volt generator.		230-volt generator.	3-wire generator.	
Shown in figure.	Not indicated in figure.	Not indicated in figure.	Not indicated in figure.	
287	.....	1242	.....	Inside connecting lead for generator commutating field coils.
	1320	1241	.....	Outside connecting lead for generator commutating field coils.
	1175	1239	1239	Bolt for commutating field connecting strips.
	1194	1240	1240	Nut for commutator field connection strip.
	1195	594	.....	Washer for commutating field connection strip bolt.
	1190	1238	.....	Connecting strips for generator series field coils.
	1192	1239	1239	Bolt for series field connecting strips.
	1191	1240	1240	Nut for series field connecting strip bolt.
	594	594	.....	Washer for series field connecting strip bolt.
	1196	1243	1243	Connection leads for generator shunt field coils.
			1277	Series connecting lead for 3-wire generator main-field coils.
			1280	Series connecting lead between commutating and main coils.

56f. Connecting leads between field coils and terminal boards of generator. *(See Fig. 65, p. 132.)*

Part No.				Description.
115-volt generator.		230-volt generator.	3-wire generator.	
Shown in figure.	Not indicated in figure.	Not indicated in figure.	Not indicated in figure.	
288	.....	.....	.....	Cables. (Order by numbers given below.)
	1198	1197	.....	Negative terminal lead from commutating coil.
	1199	1244	.....	Lead for right-hand commutating coil to negative terminal board.
	1200	1245	.....	Lead from inside bus ring to negative terminal board.
	1201	1244	.....	Positive terminal lead from top series coil to positive terminal board.
	1202	1197	.....	Equalizer lead from generator series coil to terminal board.
	1203	1245	.....	Equalizer lead from outside bus ring.
	1204	1246	1246	Equalizer lead from shunt field.
	1205	1247	1247	Lead from shunt field to shunt terminal board.
	1207	1207	.....	Cap screw for terminal leads and bus rings.
			1281	Series line lead from No. 1 main coil to left-hand terminal board.
			1244	Tap from No. 5 main coil for left-hand series field shunt.
			1282	Series line lead from No. 6 main coil to right-hand terminal board.
			1197	Tap for No. 2 main coil for right-hand series field coil.
			1283	Series lead from bus rings to right and left hand commutating coils.
			1284	Lead from collector rings to right and left hand terminal boards.

56g. Generator brushes, brush-holder yoke and parts. (*See Fig. 65, p. 132.*)

Part No.				Description.
115-volt generator.		230-volt generator.	3-wire generator.	
Shown in figure.	Not indicated in figure.	Not indicated in figure.	Not indicated in figure.	
154	.....	154	1263	Brush-holder yoke for generator.
	1174	1174	1264	Clamp for generator brush-holder yoke.
	1175	1175	1175	Bolts for generator brush-holder yoke clamp.
159	.....	805	805	Brush-holder complete, less brush for generator.
	1179	1180	1180	Brush-holder body for generator.
	854	854	854	Clamping screw for generator brush holder and stud.
	1181	1181	1181	Spring holder for generator brush holder.
	1182	1182	1182	Machine screw for fastening spring holder to brush-holder body.
	514	514	514	Brush-holder spring.
	1183	1183	1183	Brush-holder spring lever.
	1184	1184	1184	Bolt for brush-holder spring and spring holder.
	206–A2	206–A2	206–A2	Cotter pin for brush-holder bolt.
	1185	1185	1185	Thumb screw for fastening pigtail to brush-holder body.
			1266	Collector brush holder complete, less brush.
			1267	Collector brush-holder body.
			1268	Clamping screw for collector brush holder and stud.
			1269	Spring holder for collector brush-holder spring.
			1270	Brush-holder spring for collector brush holder.
			1272	Bolt for brush-holder spring.
			1273	Cotter pin for brush-holder spring bolt.
			1274	Thumbscrew for fastening pigtail to collector brush holder.
280	.....	280	802	Brush-holder studs for generator.
			801	Brush-holder studs for generator collector brushes.

56g. Generator brushes, brush-holder yoke and parts—Con.

Part No.				Description.
115-volt generator.		230-volt generator.	3-wire generator.	
Shown in figure.	Not indicated in figure.	Not indicated in figure.	Not indicated in figure.	
	627	627	627	Brass washer for generator brush-holder studs.
	589	589	589	Nuts for generator brush-holder studs.
	584	584	584	Insulation bushing for generator brush-holder studs and yoke.
281	.....	281	803	Inside bus ring for generator.
	1206	1206	804	Outside bus ring for generator.
282	.....	282	282	Fiber washer for generator brush-holder stud and yoke.
	512	513	.....	Carbon brush with pigtail for generator commutator.
			1265	Carbon brush with pigtail for 3-wire generator collector.

56h. Generator terminal boards. (*See Fig. 65, p. 132.*)

155	.....	1248	1285	Block for generator terminal boards.
	951	951	951	Bracket for series terminal boards.
	1208	1208	1208	Spacer for bracket and terminal board.
	1209	1209	1209	Cap screw for fastening terminal boards to generator.
	594	594	594	Washer for terminal board cap screws.
	1210	1249	1249	Cap screws for terminal board terminals.
	198	594	.....	Washer for cap screws.
	1211	1240	.....	Nut for Nos. 1210 and 1249.
	1212	1250	1250	Space block for generator terminal leads.
	1213	1251	1251	Space block for generator terminal board.
	1214	.....	.....	Space block for equalizer connection.
	1215	1249	.....	Cap screw for equalizer connection.
156	.....	156	156	Shunt terminal board complete.
	1216	1252	1252	Cap screw for fastening shunt terminal board.
	825	825	825	Washer for terminal board cap screw.
	1217	1217	1217	Base for shunt terminal board.
	1218	1218	1218	Binding plate for shunt terminal board.

56h. Generator terminal boards—Continued.

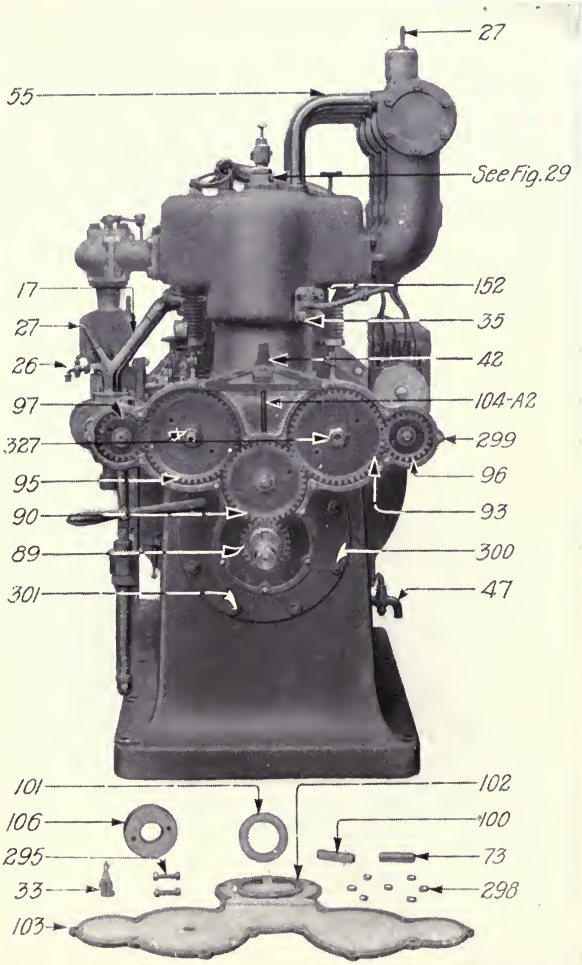
Part No.				Description.
115-volt generator.		230-volt generator.	3-wire generator.	
Shown in figure.	Not indicated in figure.	Not indicated in figure.	Not indicated in figure.	
	1219	1219	1219	Binding screws for shunt terminal board.
	1220	1220	1220	Nut for shunt terminal board binding screw.
	1221	1221	1221	Washer for shunt terminal board binding screw.

56i. Generator shunts. (*See Fig. 65, p. 132.*)

160	.....	1253	.....	German silver shunt for main field.
			1289	German silver shunt for main field, left hand.
			1290	German silver shunt for main field, right hand.
	1223	1254	.....	German silver shunt for commutating field.

56j. Collector rings and parts, 3-wire generator.

Part No.		Description.
Shown in figure.	Not indicated in figure.	
	128	Key for collector rings.
	617	Nut for collector-ring stud.
	800	Collector ring.
	1294	Connecting clips for collector-ring leads.
	1295	Collector-ring assembly.
	1296	Supporting spacer for collector ring.
	1297	Stud for holding collector rings.
	1298	Washer for collector-ring stud.
	1299	Insulating bushing for collector rings.
	1300	Insulating washer for collector rings.


27
55
See Fig. 29
17
27
26
97
327
95
90
89
301
152
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104-A2
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101
106
295
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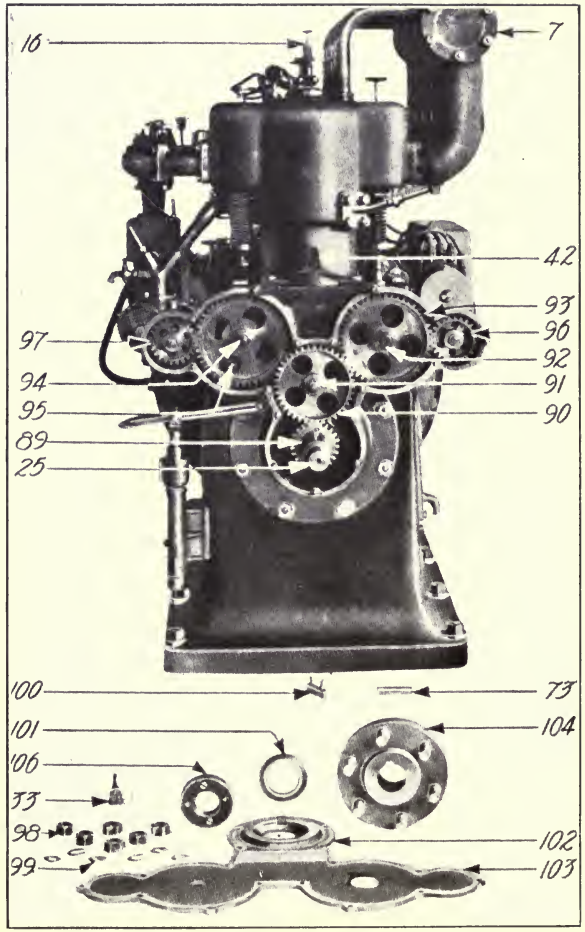
102
100
73
298

Fig. 66.


16
7
42
93
96
92
91
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89
25
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101
106
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98
99
73
104
102
103

Fig. 67.

57a. Miscellaneous parts. Engine viewed from flywheel end (flywheel removed). *(See Figs. 66 and 67.)*

Part No.		Description.
Shown in figure.	Not indicated in figure.	
7	.....	Exhaust header.
	1384	Studs to attach No. 7 to cylinders.
	368	Nuts for No. 1384.
16	.....	See par. 556.
17	.....	See No. 17 et seq., par. 47a.
25	.....	See No. 25 et seq., par. 51.
26	.....	See corresponding number et seq., par. 47a.
27	.....	See corresponding number et seq., par. 47a.
33	.....	See No. 33 et seq., par. 53.
35	.....	See No. 35 et seq., par. 47a.
42	.....	Index.
	395	Upper cover studs on gear case for supporting No. 42.
47	.....	See No. 47 et seq., par. 50.
73	.....	See corresponding number et seq., par. 51.
89	.....	See corresponding number et seq., par. 51.
90–97	.....	See corresponding numbers et seq., par. 53.
98	.....	Nuts for flywheel coupling (Form A engines only).
99	.....	Lock washers for No. 98.
101	.....	See No. 101, par. 51.
102	.....	Lower gear case cover.
103	.....	Upper gear case cover.
104	.....	Flywheel coupling (Form A engines only).
104–A2	.....	See No. 104–A2, par. 50.
106	.....	See No. 106 et seq., par. 51.
152	.....	Drain pipe from exhaust manifold to cylinder jacket.
295	.....	Bolt and nut for Nos. 102 and 103.
298	.....	Nut for Nos. 299 and 395.
299	.....	Short stud to attach Nos. 102 and 103 to gear case.
	395	Upper cover stud on gear case for supporting No. 42.
300	.....	See No. 31 et seq., par. 51.
301	.....	See No. 31 et seq., par. 51.

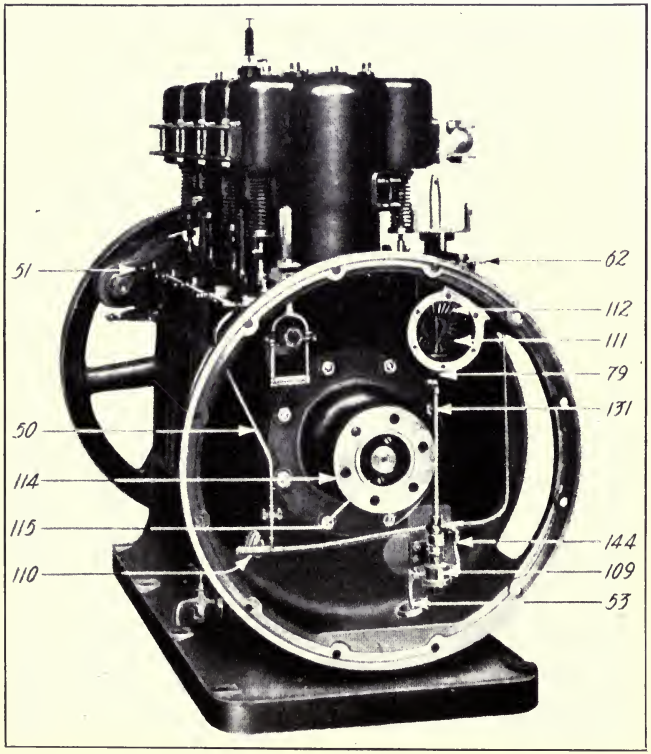
51
62
112
111
79
131
50
114
115
144
110
109
53

Fig. 68.

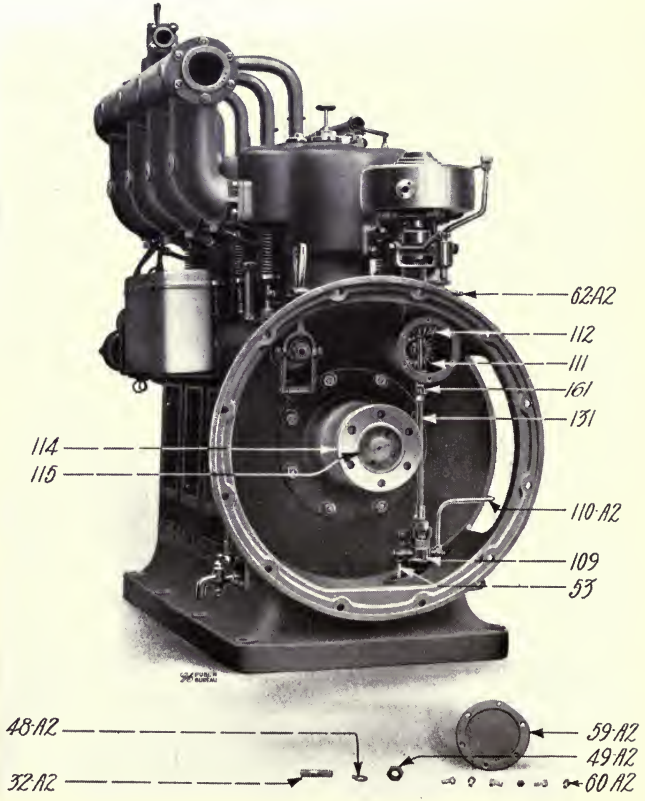
62A2
112
111
161
131
114
115
110A2
109
53
48A2
59A2
49A2
32A2
60A2

Fig. 69.

57b. Miscellaneous parts; engine viewed from generator end (generator removed). *(See Figs. 68 and 69.)*

Part No.		Description.
Shown in figure.	Not indicated in figure.	
32–A2	.....	Coupling stud for armature.
33	.....	See No. 33 et seq., par. 53.
48–A2	.....	Lock washer for No. 32–A2.
49–A2	.....	Nut for No. 32–A2.
51	.....	See par. 50.
53	.....	See par. 50.
59–A2	.....	Governor gear-box cover.
60–A2	.....	Cap screw for No. 59–A2.
62	.....	See par. 50.
62–A2	.....	See par. 50.
79	.....	See No. 9 et seq., par. 48c.
109	.....	See par. 50.
110	.....	See par. 50.
110–A2	.....	See par. 50.
111	.....	See par. 52.
112	.....	See par. 48c.
114	.....	See par. 51.
115	.....	See par. 51.
144	.....	See par. 50.

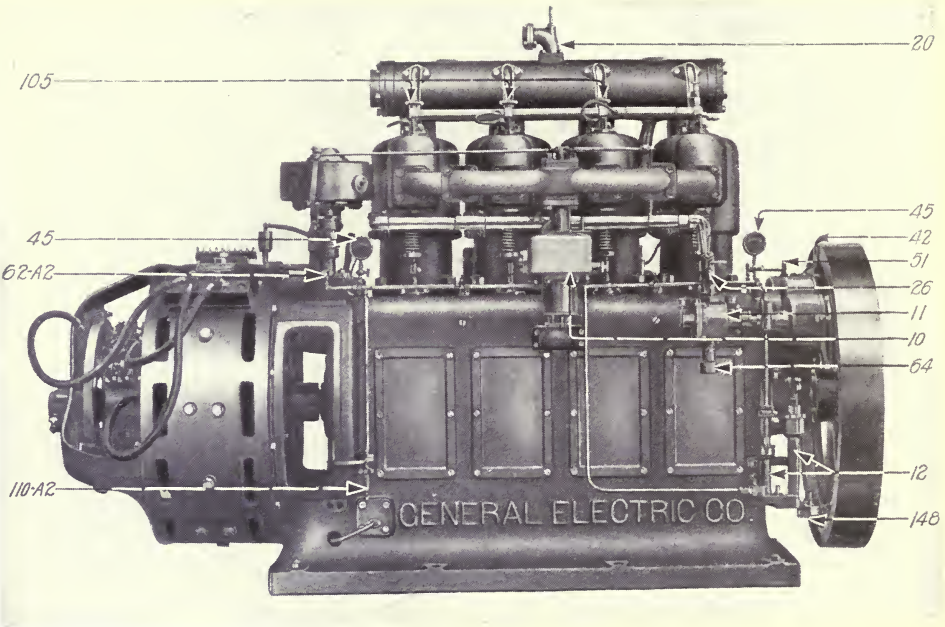
20
105
45
45
42
62-A2
51
26
11
10
64
12
110-A2
148
GENERAL ELECTRIC CO.

Fig. 70.

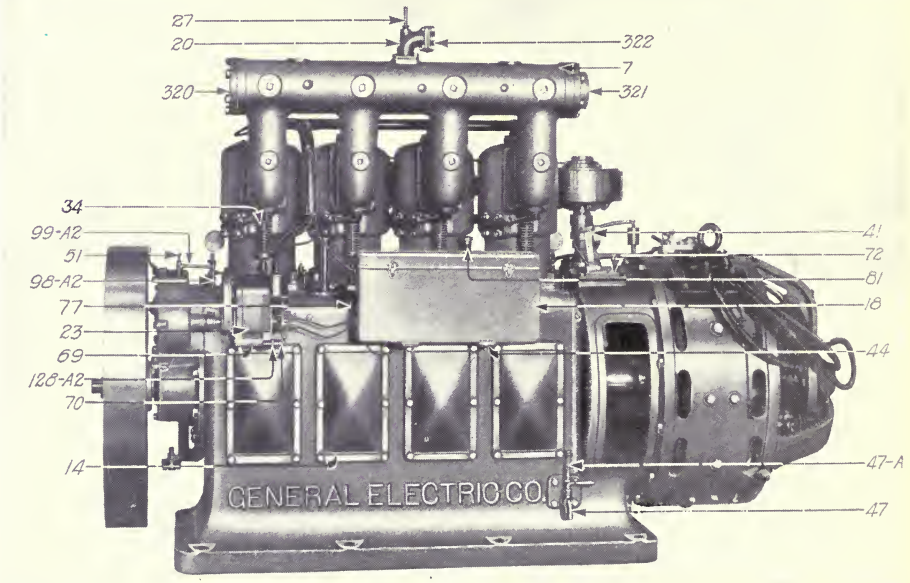
27
20
322
7
320
321
34
99-A2
41
51
72
98-A2
81
77
18
23
44
69
128-A2
70
14
47-A
47
GENERAL ELECTRIC CO.

Fig. 71.

57c. Miscellaneous parts; engine viewed from sides. (*See Figs. 70 and 71.*)

Part No.		Description.
Shown in figure.	Not indicated in figure.	
7	.....	See No. 7 et seq., par. 57a.
10	.....	See par. 48b.
11	.....	See par. 47c.
12	.....	See par. 48a.
14	.....	Handhole cover.
	650	Cap bolt for No. 14.
18	.....	See No. 970 et seq., par. 49f.
20	.....	See par. 47a.
23	.....	See par. 49d; see also 527, par. 49c; and 966, par. 49a.
26	.....	See par. 47a.
27	.....	See par. 47a.
41	.....	See par. 53.
42	.....	See No. 42 et seq., par. 57a.
44	.....	See No. 44 et seq., par. 49f.
45	.....	See par. 50.
47	.....	See par. 50.
47–A	.....	See par. 50.
51	.....	See par. 50.
62–A2	.....	See par. 50.
64	.....	See pars. 47b and 47c.
69	.....	See No. 965 et seq., par. 49f.
70	.....	See No. 959 et seq., par. 49f.
72	.....	Locking plate for shifting lever.
	575	Cap screw for No. 72.
77	.....	See No. 965 et seq., par. 49f.
81	.....	Ventilating tube.
	665	Cap screw to attach No. 81 to frame.
98–A2	.....	See par. 50.
99–A2	.....	See par. 50.
105	.....	See par. 52.
110–A2	.....	See par. 50.
128–A2	.....	See No. 961 et seq., par. 49f.
148	.....	See pars. 48a and 48b.
320	.....	Blind flange for exhaust header.
321	.....	Threaded flange for exhaust header.
	607	Stud to attach Nos. 320 and 321 to exhaust header.
	609	Nut for No. 607.

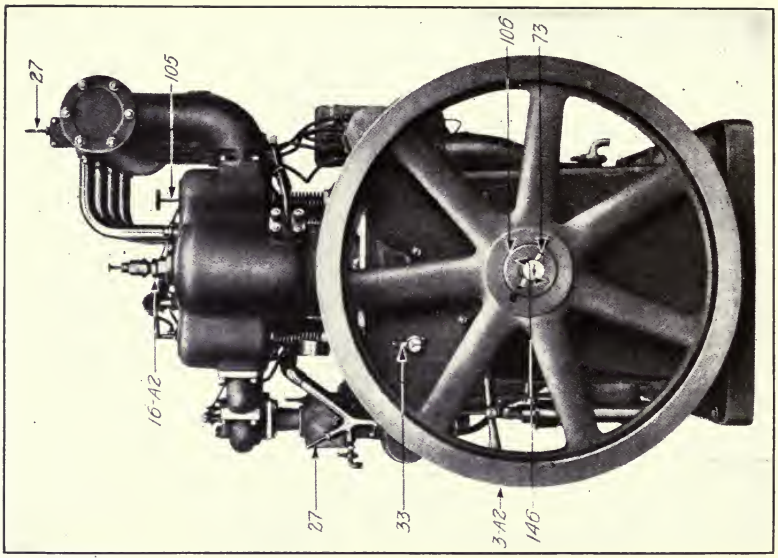
27
105
16·A2
27
33
3·A2
146
106
73

Fig. 72.

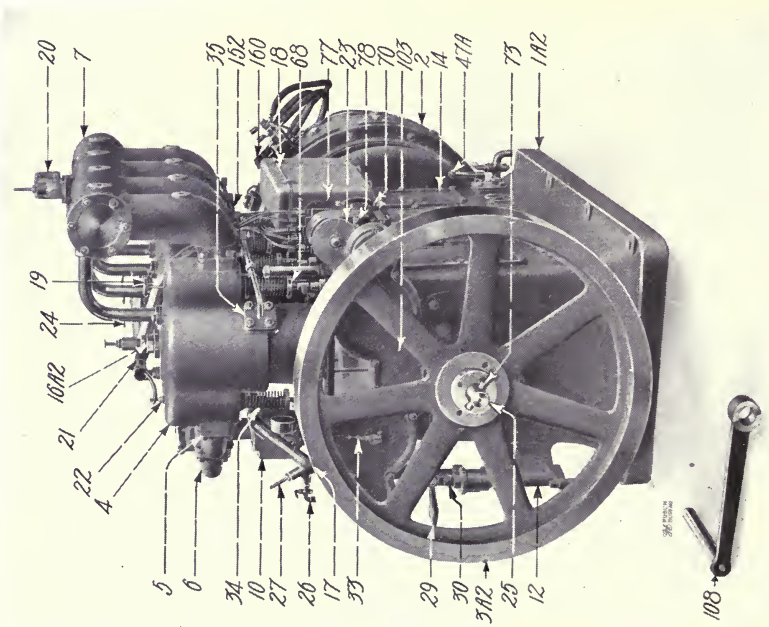
20
7
19
24
10A2
21
22
4
5
6
34
10
27
26
17
33
29
30
3A2
25
12
108
35
152
160
18
68
77
23
78
70
103
2
14
47A
75
1A2

Fig. 73.

57d. Miscellaneous parts; engine viewed from flywheel end (flywheel in place). *(See Figs. 72, 73, and 74.)*

Part No.		Description.
Shown in figure.	Not indicated in figure.	
1–A2	.....	Engine frame.
2	.....	See par. 56a.
3–A2	.....	Flywheel (Form A2 and subsequent engines only).
	3	Flywheel (Form A engines only).
4	.....	See par. 51.
5	.....	See par. 48b.
6	.....	See par. 48b.
7	.....	See par. 57a.
10	.....	See par. 48b.
12	.....	See par. 48a.
14	.....	See par. 57c.
16–A2	.....	See pars. 54a and 54b.
17	.....	See par. 47a.
18	.....	See 970 et seq. par. 49f.
19	.....	See par. 52.
20	.....	See par. 47a.
21	.....	See par. 49f.
22	.....	Spark plug.
23	.....	See par. 49e; also 527, par. 49c, and 966, par. 49a.
24	.....	See par. 52.
25	.....	See par. 51.
26	.....	See par. 47a.
27	.....	See par. 47a.
29	.....	See par. 48a.
30	.....	See par. 48a.
33	.....	See par. 53.
34	.....	See par. 52.
35	.....	See par. 47a.
47–A	.....	See par. 50.
68	.....	See par. 52.
70	.....	See 959, etc., par. 49f.
73	.....	See par. 51.
77	.....	See par. 49c; see also par. 49b.
78	.....	See 1021, par. 49a; 440, par. 49d; 906, par. 49c.

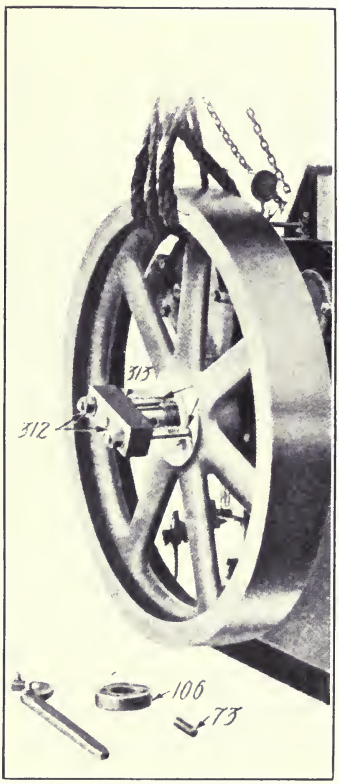

Fig. 74.

57d. Miscellaneous parts; engine viewed from flywheel end (flywheel in place)—Continued.

Part No.		Description.
Shown in figure.	Not indicated in figure.	
103	.....	See par. 57a.
105	.....	See par. 52.
106	.....	See par. 51.
146	.....	See par. 51.
152	.....	See par. 47a.
160	.....	See par. 56i.
311	.....	Studs for flywheel puller.
312	.....	Nuts for 311.
313	.....	Crossbar for flywheel puller.

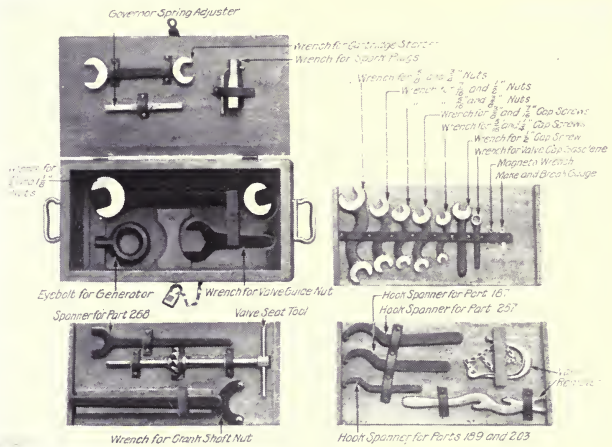

Fig. 75.

58. Tool box. (*See Fig. 75.*)

Part No.		Description.
Shown in figure.	Not indicated in figure.	
157	.....	Eye bolt for generator.
252–A2	.....	Wrench for cartridge starter.
329	.....	Gap gauge (make and break gauge in fig. —) for G. E. magneto.

58. Tool box—Continued.

Part No.		Description.
Shown in figure.	Not indicated in figure.	
330	.....	Wrench for G. E. magneto *or*—
	896	Contact adjusting plug for Eisemann magneto.
	897	Socket wrench, elbow, Eisemann magneto.
	898	Combination wrench and spark gap adjuster. Eiseman magneto, *or*—
	978	Combination wrench and gap gauge for Splitdorf magneto.
331	.....	Wrench for valve cap of gasoline pump.
332	.....	Wrench, $\frac{1}{2}$-inch cap screws.
333	.....	Wrench, $\frac{5}{16}$ and $\frac{1}{4}$ inch cap screws.
334	.....	Wrench, $\frac{3}{8}$ and $\frac{7}{16}$ inch cap screws.
335	.....	Wrench, $\frac{5}{16}$ and $\frac{3}{8}$ inch nuts.
336	.....	Wrench, $\frac{7}{16}$ and $\frac{1}{2}$ inch nuts.
337	.....	Wrench, $\frac{5}{8}$ and $\frac{3}{4}$ inch nuts.
379	.....	Wrench, governor spring adjuster.
381	.....	Wrench for valve guide nuts.
382	.....	Wrench, $\frac{7}{8}$ and $1\frac{1}{8}$ inch nuts.
383	.....	Hook spanner for parts Nos. 189 and 203.
384	.....	Hook spanner for part No. 187.
385	.....	Hook spanner for part No. 257.
386	.....	Valve remover.
387	.....	Spanner for No. 268.
388	.....	Wrench for crank-shaft nut.
390	.....	Wrench for 1-inch hexagonal spark plugs.
391	.....	Valve-seat tool.
507	.....	Tool box complete with tools (*see No. 647*).
509	.....	Padlock, with key and chain.
647	.....	Tool box without tools and padlock (*see No. 507*).

NOTE.—In addition to the tools listed above, the following tools will be issued to isolated stations or forts where Ordnance Department tools are not available:

1 washer cutter, $\frac{1}{2}$ inch to 6 inches.
1 duster, Universal, No. 1.
1 file, flat bastard, 12-inch.
1 file, half-round, 12-inch.
1 file, round, 12-inch.
3 files, saw, triangular, 6-inch.
6 file handles.
1 hammer, copper, 2-pound, with handle.
1 hammer, machinist, ball peen, 3-pound, with handle.
1 pair pliers, cutting, 8-inch.
1 screw driver, 6-inch.
1 screw driver, 12-inch.
1 monkey wrench, 6-inch.
1 monkey wrench, 12-inch.
1 monkey wrench, 18-inch.
1 Stillson wrench, 6-inch.
1 Stillson wrench, 14-inch.
1 Stillson wrench, 18-inch.

Requisitions for the additional tools listed above should explain in detail the condition which makes such additional tools necessary.

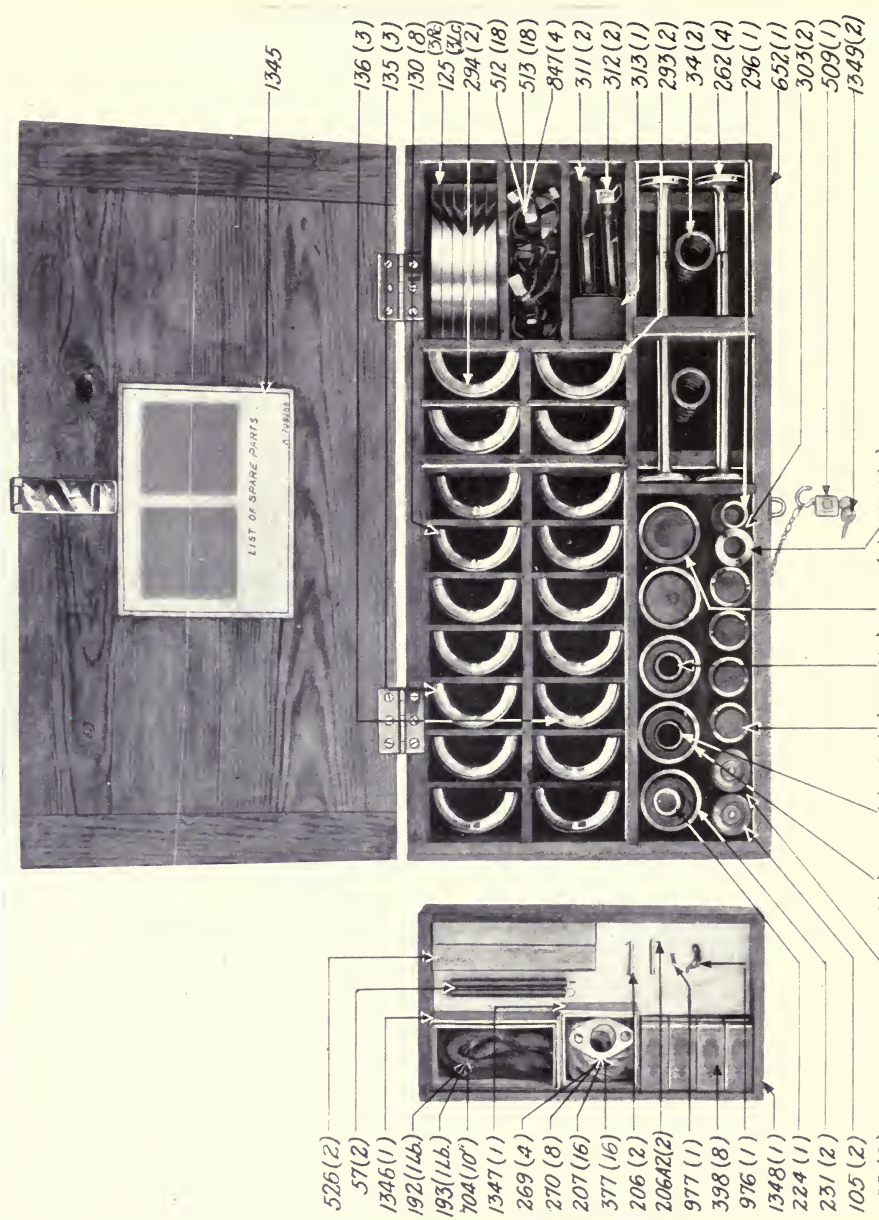

Fig. 76. (*Figures in parentheses indicate authorized allowances of spare parts.*)

59. Spare part box. (*See Fig. 76.*)

Authorized allowance.	Part No.	Description.
8	22	Spark plugs (shown as No. 398 in figure).
2	34	Main valve spring.
2	57	Spring for throttle rod ($4\frac{1}{4}$ inches long)
		or
2	*500*	*Spring for throttle rod ($6\frac{1}{4}$ inches long).*
2	105	Relief cock and primer valve.
4	121	Bushing for wrist pin.
2	122	Wrist pin.
6	125	Piston ring (3 right cut; 3 left cut).
8	130	Lining for connecting-rod head.
3	135	Upper lining for inside bearing of crank shaft.
3	136	Lower lining for inside bearing of crank shaft.
1 lb.	192	Metallic packing for mechanically operated gasoline pump.
1 lb.	193	Metallic packing for hand-operated gasoline pump.
1	204	Plastic metallic packing ($\frac{3}{16}$ inch by 10 inches) for water pump (shown as No. 704 in figure).
2	206	Taper pin for No. 205.
2	206A2	Cotter pin for No. 206 and brush-holder bolt.
16	207	Gasket for Nos. 64, 55, 613, 614, and 615.
1	224	Indicator glass for carbureter.
2	231	Bushing for cam shaft (flywheel end).
2	231A2	Bushing for cam shaft (generator end).
6	232	Middle bushing for cam shaft.
4	262	Intake and exhaust valve.
4	269	Copper asbestos gasket for Nos. 16, 16A2, and 24.
8	270	Tauril packing for Nos. 16, 16A2, and 24.
2	293	Lower lining for end bearing of crank shaft.
2	294	Upper lining for end bearing of crank shaft.
1	296	Upper bushing for governor shaft.
1	297	Lower bushing for governor shaft.
2	303	Bushing for No. 43 and No. 80.
1	304	Bushing for idler gear.
2	311	Studs for flywheel puller.
2	312	Nuts for No. 311.
1	313	Crossbar for flywheel puller.
16	377	Gasket for Nos. 35, 17, and 689.
	398	(See No. 22.)
1	509	Yale lock for spare-part box.
100	510	No. 10 gauge blank cartridge.

59. Spare part box—Continued.

Authorized allowance.	Part No.	Description.
18	512	Brush for 115-volt generator
		or
18	*513*	*Brush for 230-volt generator.*
4	520	Brush for 115-volt fan motor (shown as No. 847 in figure)
		or
4	*521*	*Brush for 230-volt fan motor (shown as No. 847 in figure).*
2	526	100° centigrade thermometer, 7 inches long.
1	652	Spare-part box, complete, less padlock.
	704	(See No. 204.)
	847	(See Nos. 520 and 521.)
1	878	Brass substitute for indicator glass of carbureter.
1	976	Breaker bar with platinum for Splitdorf magneto.
1	977	Platinum contact screw with lock nuts for Splitdorf magneto
		or
1	*879*	*Interrupter lever for Eisemann magneto.*
1	*724*	*Interrupter contact screw for Eisemann magneto.*
1	*725*	*Adjustable contact screw for Eisemann magneto*
		or
1	*442*	*Interrupter lever for G. E. magneto.*
1	*443*	*Interrupter contact screw for G. E. magneto.*
1	1345	List of spare parts.
1	1346	Box for spare gaskets.
1	1347	Box for spare packings.
1	1348	Tray for spare-part box.
2	1349	Keys for No. 509.

INDEX OF PARTS.

INDEX OF SUBJECTS.

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