TM 11-973

WAR DEPARTMENT TECHNICAL MANUAL

POWER UNIT PU-53/FRC

WAR DEPARTMENT *JANUARY 1946*

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WASHINGTON 25, D. C., 15 JANUARY 1946

TM 11-973, Power Unit PU-53/FRC, is published for the information and guidance of all concerned.

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BY ORDER OF THE SECRETARY OF WAR:

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Acting The Adjutant General

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QUICK INDEX

WARNING

HIGH VOLTAGE

is used in the operation of
this equipment.

DEATH ON CONTACT

may result if operating personnel
fail to observe safety precautions.

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LIST OF ILLUSTRATIONS

DESTRUCTION NOTICE

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

WHEN — When ordered by your commander.

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

2. Cut — Use axes, handaxes, machetes.

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

4. Explosives — Use firearms, grenades, TNT.

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

USE ANYTHING IMMEDIATELY AVAILABLE FOR DESTRUCTION OF THIS EQUIPMENT.

WHAT — 1. Smash — Cylinder heads, cylinders, crankcase, carburetor, power generator, magneto, all air and fuel filters, pumps, radiator, and control panel.

2. Cut — All electric wiring, cables, hose, and belts.

3. Burn — Fuel, lubricating oil, and technical manuals.

4. Bend — All copper pipes and fuel injection lines.

5. Bury or scatter — All smashed pieces after destroying their usefulness.

DESTROY EVERYTHING

SAFETY NOTICE

This unit generates a high voltage which is dangerous to life. At all times the operator must be careful and observe every safety regulation. Keep clear of all live parts. Never make electrical connection while the unit is in operation. Severe and possibly fatal shocks may be experienced, especially if the power unit is operating on wet or damp ground. Adequate ventilation must be provided, if the power unit is operated in a confined space. Exhaust gases produced are poisonous, and excessive inhalations may result in severe sickness or death.

CAUTION: ALWAYS MAINTAIN THE PROPER OIL LEVELS IN THE CRANKCASE AND IN THE AIR CLEANER OF THE ENGINE, AND LUBRICATE THE ENGINE AT PROPER INTERVALS AS RECOMMENDED IN THE LUBRICATION CHART.

Guards and Shields: Moving or operating parts have been adequately guarded or shielded to provide maximum protection. Do not remove any guards, shields, screens, etc., while the power unit is in operation. To do so removes the safety features provided for your protection.

CAUTION: TOOLS, OILCAN, BOLTS, AND OTHER LOOSE OBJECTS MUST NOT BE PERMITTED TO LIE ON OR NEAR THE GENERATOR SET WHERE THEY MIGHT FALL INTO THE GENERATOR OR BE DRAWN INTO THE ROTATING PARTS BY MAGNETIC ATTRACTION, CAUSING SEVERE DAMAGE TO THE WINDING.

PART ONE

INTRODUCTION

SECTION I. DESCRIPTION OF POWER UNIT PU-53/FRC

1. GENERAL.

a. Power Unit. Power Unit PU-53/FRC is a portable, self-contained power plant consisting of a single-cylinder Diesel engine and an alternating-current (a-c) generator. The generator is driven by dual V-belts and grooved pulleys attached to the flywheel and the alternator rotor shaft. It is designed to supply single-phase alternating current (a-c) for fixed radio installations. The unit is mounted on a skid base of electrically welded heavy structural steel.

b. Engine. The engine is a one-cylinder, four-stroke cycle, valve-in-head, water-cooled, full Diesel, solid injection, horizontal-type machine equipped with a cast iron sub-base, and with a compression release for hand cranking. The cylinder bore is 5 inches and the stroke is 8 inches. It has a piston displacement of 157 cubic inches. The engine develops 12 horsepower at the governed speed of 720 revolutions per minute (rpm).

c. Alternator. The alternator is a four-pole, 60-cycle, single-phase, three-wire generator which produces 110/220 volts at a driven speed for 1,800 revolutions per minute. The current rating is 45.5 amperes at 220 volts or 45.5 amperes from neutral to either outside leg at 110 volts. It is rated at 8 kilowatts (kw), 10 kilovolt-amperes (kva), at 80 percent power factor for continuous duty operation. The frame is dripproof, semi-inclosed, and self-ventilated. The maximum temperature rise is 40° C above ambient temperature.

d. Exciter. The exciter is directly connected to the alternator with the armature mounted on an extension of the main alternator-rotor shaft. It is rated at 0.5 kilowatt, 62.5 volts, 8 amperes. The maximum temperature rise is 40° C above ambient temperature.

e. Drive. The alternating current (a-c) generator is driven by two size C V-belts from a pulley mounted on the engine flywheel. Belt tension is adjustable through a sliding base mounted at rear of engine on the structural steel skid base to which the alternator is bolted.

f. Control Panel (fig. 1). The control panel is inclosed in a steel cabinet designed for wall mounting without brackets, and is radio shield-

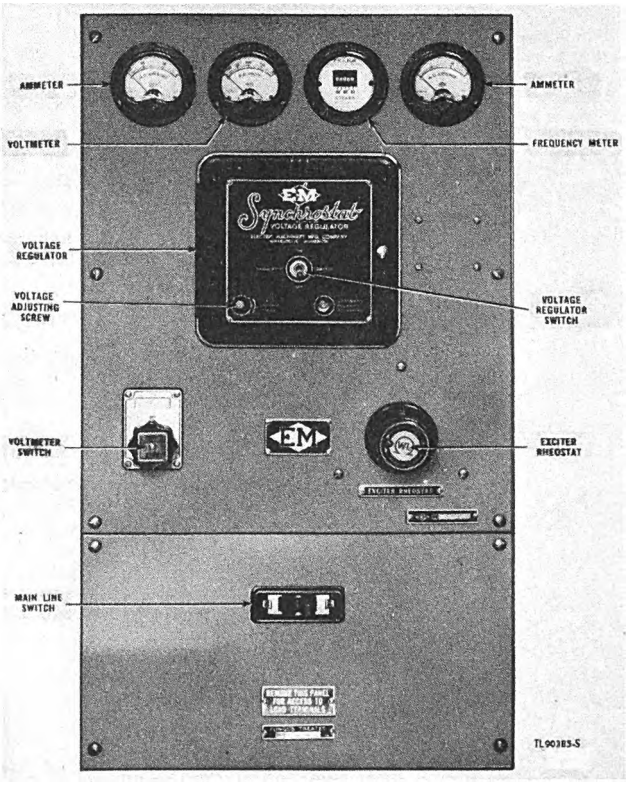


Figure 1. Control panel.

ed. It includes all the necessary meters and instruments for controlling the electrical output of the power unit. It is rated at 8 kw (110/220 volts, single-phase, three-wire, 60 cycles).

g. Miscellaneous Equipment (figs. 2, 3, and 4). In addition to major components, each power unit is equipped with installation materials consisting of an exhaust silencer with piping, copper fuel tubing and fittings, cable and fittings for electrical connections to switchboard, a tool box with mechanic's hand tools, and spare parts as listed in detailed description (par. 5g).

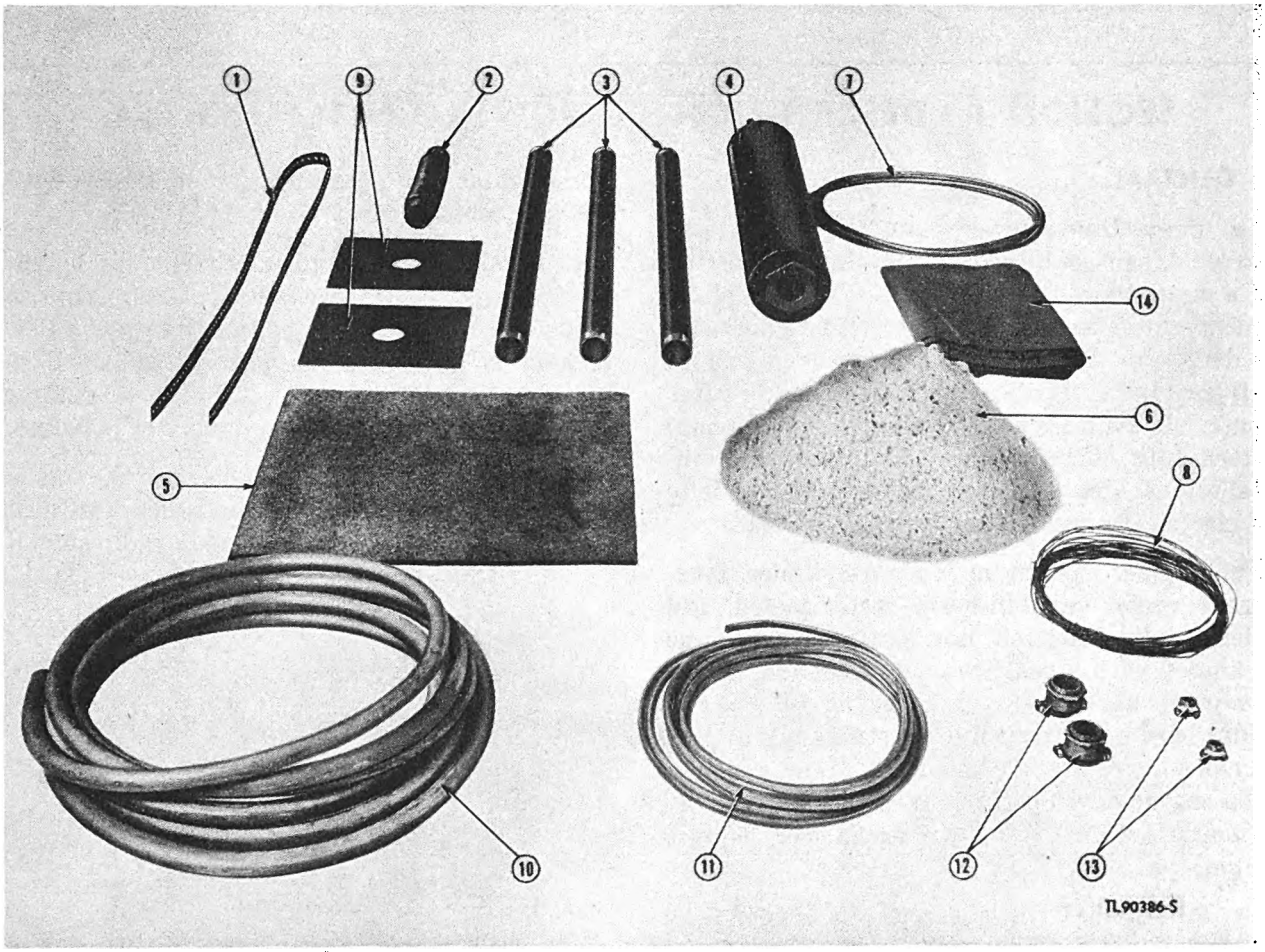


Figure 2. Installation material (large parts).

LEGEND FOR FIGURE 2

1. Perforated hanger iron. 10 ft long, 1⅛ in. x ⅛ in.
2. Flexible exhaust hose, 2 in.
3. Pipe nipple, 4 ft long, 2 in. (3 used).
4. Witte exhaust silencer, 2 in.
5. Three-ply roofing paper, 24 in. x 24 in.
6. Asbestos cement, Eagle Pitcher No. 66 (10 lb).
7. Copper tubing 20 ft long, ⅝ OD, wall thickness, 0.032 in.
8. Black annealed wire, #14 W & M gauge (1 lb).
9. Black sheet steel, #18 USG, 12 in. x 12 in. (2 used).
10. Cable, #4 RL 3-conductor lead sheathed, 33 ft long.
11. Cable, #14 RL 2-conductor lead sheathed, 33 ft long.
12. Straight squeeze connectors 1¼ in. for #4 3-conductor RL cable (2 used).
13. Straight squeeze connectors ½ in. for #14 2-conductor RL cable (2 used).
14. Air duct-canvas.

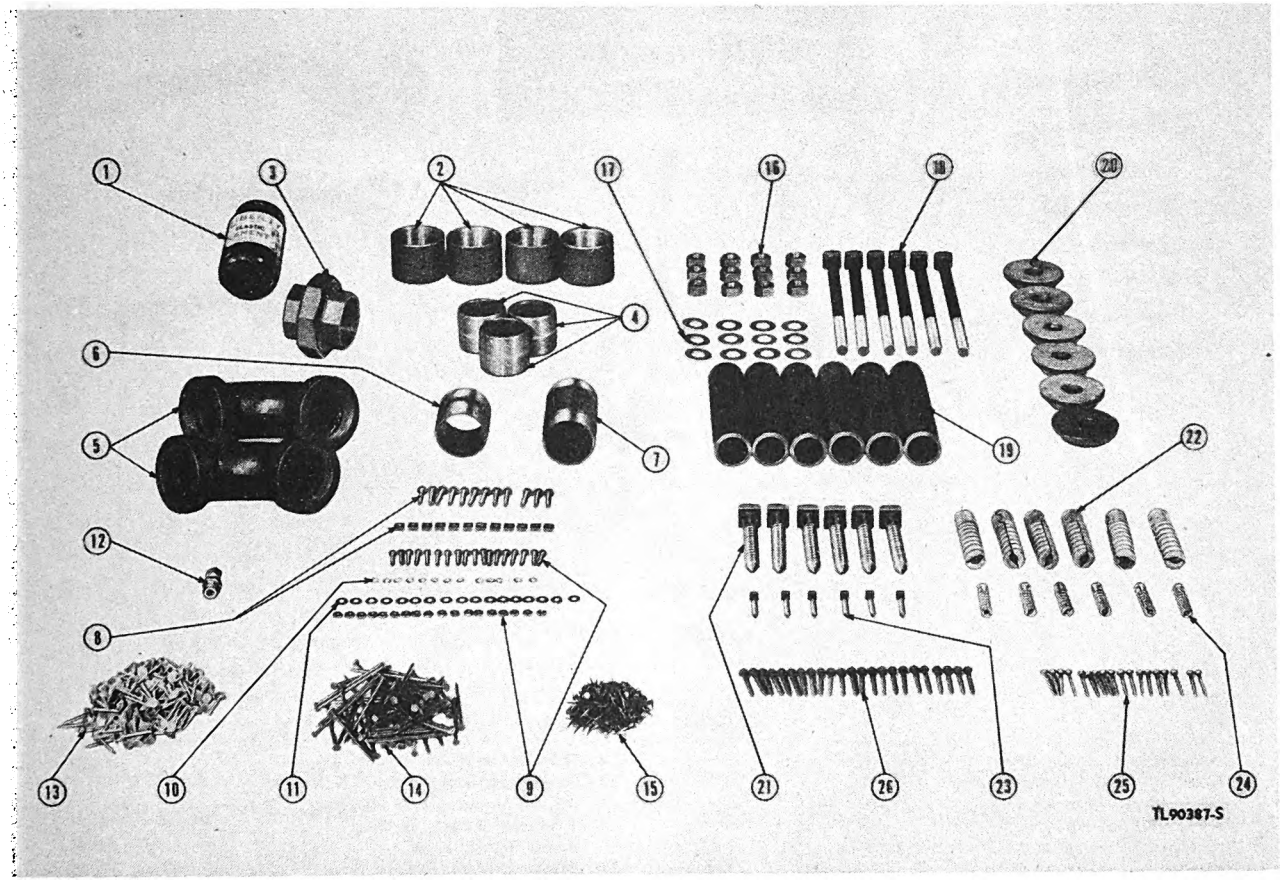


Figure 3. Installation material (small parts).

LEGEND FOR FIGURE 3

1. Roofing cement (1 lb jar).
2. Pipe coupling, 2 in. (4 used).
3. Plain union, 2 in.
4. Close nipple, 2 in. (3 used).
5. Long sweep ell, 2 in. (2 used).
6. Pipe nipple, 2 in. x 2½ in.
7. Pipe nipple, 2 in. x 4 in.
8. Roundhead stove bolts (¼-20 x 1 in.) with square nuts (12 used).
9. Roundhead machine screws (10-24 x ⅞ in.) with hex nuts (18 used).
10. Lockwashers, 3/16 in. (18 used).
11. Plain washers, 3/16 in. S.A.E. (18 used).
12. Compression connector ⅜ in. with ⅜ in. pipe thread.
13. Roofing nails (1 in.), 1 lb.
14. Common nails 10 D (3 in.), 1 lb.
15. Tacks (#8 x 9/16 in.), 1 lb.
16. Rough hexagon nuts ⅝ in.-11 (12 used).
17. Standard punched washers ⅝ in. (12 used).
18. Square head machine bolt (⅝ in.-11 x 10 in.), threaded 3 in. long (6 used).
19. Pipe, 1¼ in. x 7 in. (6 used).
20. Special washers, 3 in. O.D., ⅞ in. I.D., ¾ in. thick (6 used).
21. Lag screws, ⅝ in. x 4 in. (6 used).
22. Expansion shield, ⅝ in. (6 used).
23. Lag screw, ¼ in. x 1½ in. (6 used).
24. Expansion shield, ¼ in. (6 used).
25. Wood screw, flathead (#8 x 1½ in.), (18 used).
26. Wood screw, roundhead (#12 x 1½ in.), (24 used).

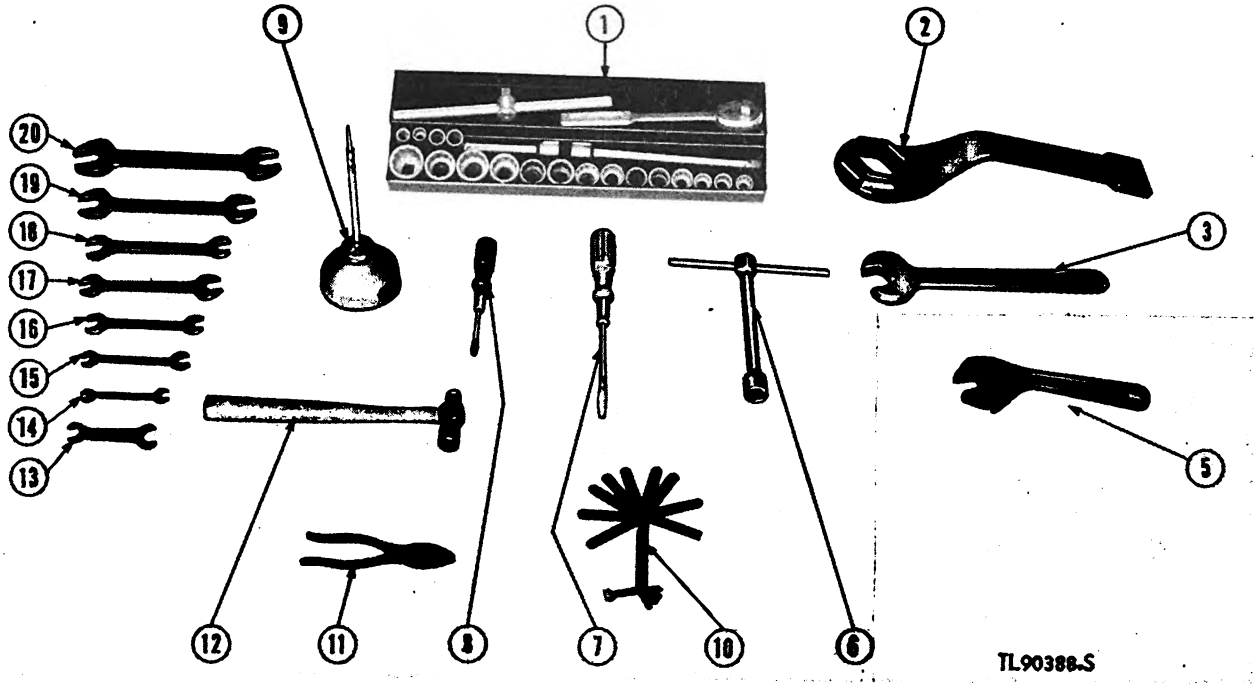


Figure 4. Tools.

LEGEND FOR FIGURE 4

1. Socket wrench set as follows:
   Socket, 7/16 in., ½ in. sq drive.
   Socket, ½ in., ½ in. sq drive.
   Socket, 9/16 in., ½ in. sq drive.
   Socket, 19/32 in., ½ in. sq drive.
   Socket, ⅝ in., ½ in. sq drive.
   Socket, 21/32 in., ½ in. sq drive.
   Socket, 11/16 in., ½ in. sq drive.
   Socket, ¾ in., ½ in. sq drive.
   Socket, 25/32 in., ½ in. sq drive.
   Socket, 13/16 in., ½ in. sq drive.
   Socket, ⅞ in., ½ in. sq drive.
   Socket, 31/32 in., ½ in. sq drive.
   Socket, 15/16 in., ½ in. sq drive.
   Socket, 1 in., ½ in. sq drive.
   Socket, 1-1/16 in., ½ in. sq drive.
   Socket, 1-⅛ in., ½ in. sq drive.
   Socket, 1-3/16 in., ½ in. sq drive.
   Socket, 1-¼ in., ½ in. sq drive.
   Ratchet, reversible.
   Extension, 5 in.
   Extension, 10 in.
   Pin handle with ½ in. adapter.
   Box for above wrenches and attachments.
2. Hexagon flywheel wrench, 2¼ in.
3. Single open-end wrench, 1¼ in.
4. Adjustable wrench, 8 in.
5. T handled socket, ¾ in.
6. Screw driver, 12 in.
7. Screw driver, 6 in.
8. Oilcan with flexible spout, ½ pt.
10. Feeler gauges, 1 set, including 0.002 in., 0.003 in., 0.004 in., 0.006 in., 0.008 in., 0.012 in., 0.013 in., 0.020 in., 0.025 in., 2 in. rule, 6 spark plug gap gauges, and spark plug adjusting tool.
11. Pliers, 6 in.
12. Ball pien hammer, 8 oz.
13. Open end tappet wrench, ½ in. x ⅝ in.
14. Open end wrench, ¼ in. x 5/16 in.
15. Open end wrench, ⅜ in. x 7/16 in.
16. Open end wrench, ½ in. x 9/16 in.
17. Open end wrench, ½ in. x 11/16 in.
18. Open end wrench, ⅝ in. x ¾ in.
19. Open end wrench, ¾ in. x ⅞ in.
20. Open end wrench, 15/16 in. x 1-1/16 in.

2. PERFORMANCE CHARACTERISTICS.

Approximate load	Amperes	Volts	Watts	Cycles	Exciter volts
¼ load	11.0	229	2,020	61.2	30
½ load	22.2	227	4,030	60.8	35
¾ load	33.5	224	6,000	60.3	41
Full load	45.6	220	8,030	59.5	48

3. TABLE OF CONDENSED SPECIFICATIONS.

Engine ---------- Witte Engine Works
Model ---------- MD-282
Cycle ---------- 4
Type of cyl head ---- single-piece, valve-in-head, stud mounted
Number of cylinders ---------- 1
Bore ---------- 5 in.
Stroke ---------- 8 in.
Piston displacement ---------- 157 cu in.
Compression ratio, Diesel cycle ---------- 17 to 1

Engine speed (full-load governed) ____720 rpm
Type of cooling _____water cooled
Horsepower _____12 at 720 rpm
Pistons _____nickel cast-iron
Piston rings ___6 (2 oil control, 4 compression)
Piston pin _____full-floating
Lubrication system _____splash
Air cleaner _____oil-bath type
Oil filter _____metal-disk type
Crankcase oil capacity _____10 quarts
Governor _____Witte, fly ball, variable speed
Main bearings _____Timken tapered roller
Generator _____Electric Machinery Mfg Co., type R-14
Rating _____8 kw (10 kva)
Rating current _____45.5 amperes, at 220 volts
Rating voltage _____110/220 volts
Power factor _____80 percent
Generator speed _____1,800 rpm
Exciter _____Electric Machinery Mfg Co., type 202
Generator brushes ____1-¼ in. x ¼ in. x ⅝ in.; Nat'l. Carbon Co., grade AY
Exciter brushes ____1-1/16 in. x ⅜ in. x ⅜ in.; Nat'l. Carbon Co., grade SA-3590
Generator bearings ____Two single row radial, SKF No. 6308
Drive pulley _____Two C Groove-19.5 in. PD
Drive pulley _____Two C Groove-7.65 in. PD
Drive belts _____Two C-90 V-belts

4. TABLE OF MAJOR COMPONENTS.

Quantity	Name	Dimensions (in.) Width	Length	Height	Weight (lb.)
1	Power Unit PU-53/FRC (crated)	42½	93	55	3150
1	Power Unit PU-53/FRC (uncrated)	34⅜	80	44⅛	2340
1	Engine (uncrated)	30¾	54¼	31⅛	1490
1	Alternator with exciter (uncrated)	23	34	18½	500
1	Control panel (uncrated)	18	12	32	115
1	Base (uncrated)	24	80	8	310
1	Accessories, less exhaust material (uncrated)				40

5. MAJOR COMPONENTS.

Power Unit PU-53/FRC consists of the following major components:

a. Engine. The engine is a one-cylinder, four-stroke cycle, valve-in-head, water-cooled, stationary, horizontal type, equipped with a cast iron sub-base and with a compression release for manual starting. The cylinder bore is 5 inches and the stroke is 8 inches. It has a piston displacement of 157 cubic inches. The engine develops 12 horsepower at the governed speed of 720 rpm. The complete engine is composed of the basic engine with its component parts, and the operating accessories, together with the system assemblies. These are: the compression release and hand crank used only for starting the engine, the cooling system, the lubricating system, the Diesel fuel oil system, the air cleaner, and the exhaust system.

(*1*) *Basic Engine.* The basic engine is of the valve-in-head type, having a single-piece stud-mounted cylinder head, which has cast within it the intake and exhaust passages and the recess into which is fitted the precombustion chamber, all of which are water jacketed. A heavy duty, counter-balanced crankshaft is Timken roller bearing mounted in the crankcase. The main bearings are Timken tapered roller bearings, and the connecting-rod-bearing halves are of the precision, replaceable type, which are grooved to provide distribution of the lubricating oil supplied through a drilled hole and recess in the connecting rod. The piston is equipped with four compression and two oil rings. The camshaft, a one-piece steel forging with three cams (inlet, exhaust and fuel pump cams), is supported at either end in phosphor bronze bushings. The outer end of the camshaft is slotted to provide a drive for the lubricating oil pump. The inner end is machined to receive the cam gear which is driven by the crankshaft pinion. Two flywheels are fitted solidly to the tapered crankshaft (one on each side of the engine).

(*2*) *Cooling System.* The cooling system consists of a flat tube and fin-type radiator, a pusher-type four-blade fan to cool the water in radiator and a water temperature dial gauge. The fan is belt driven from the engine flywheel.

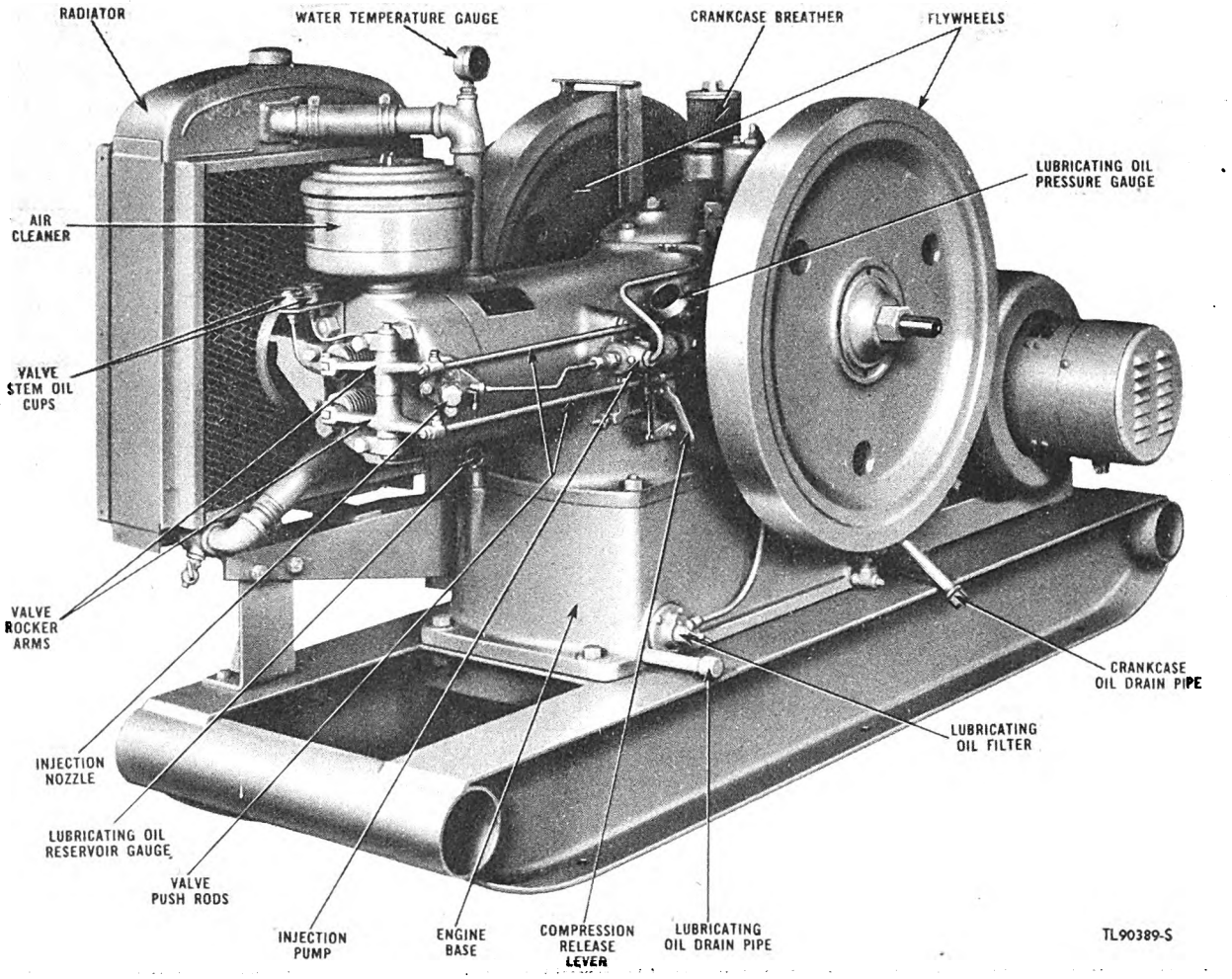


Figure 5. Power Unit PU-53/FRC, quarter view.

The engine is equipped with a thermo-syphon cooling system. When the engine is running, the water in the cylinder jacket becomes heated and rises through a vertical pipe to the top of the radiator, while the cooler water from the radiator flows into the jacket through the lower horizontal pipe. Keep the water in the radiator to full capacity to insure proper circulation.

(*3*) *Lubricating System.* Lubrication is splashed to all working parts of the engine, with the exception of the valve rocker arms, governor bell crank and valve stem guides. The lubrication system consists of an oil reservoir in the cylinder head end of the engine sub-base, a filter located in the side of the reservoir, a small circulating pump of the rotary gear-type to draw the oil from the sub-base through the filter and to deliver it to the engine crankcase from where it overflows, passing back into the reservoir in the sub-base. An oil pressure gauge is provided on the discharge side of the circulating pump to indicate when the pump is working properly. A thermometer is located at the rear of the engine to indicate oil temperature. A bayonet gauge is provided, located in the base under cylinder head for the purpose of determining the amount of lubricating oil in the oil reservoir. The oil level gauge should never show less than three-quarters full at all times.

(*4*) *Diesel Fuel Oil System* (*fig. 36*). The Diesel fuel oil system consists of the following: a fuel transfer pump located on the right hand

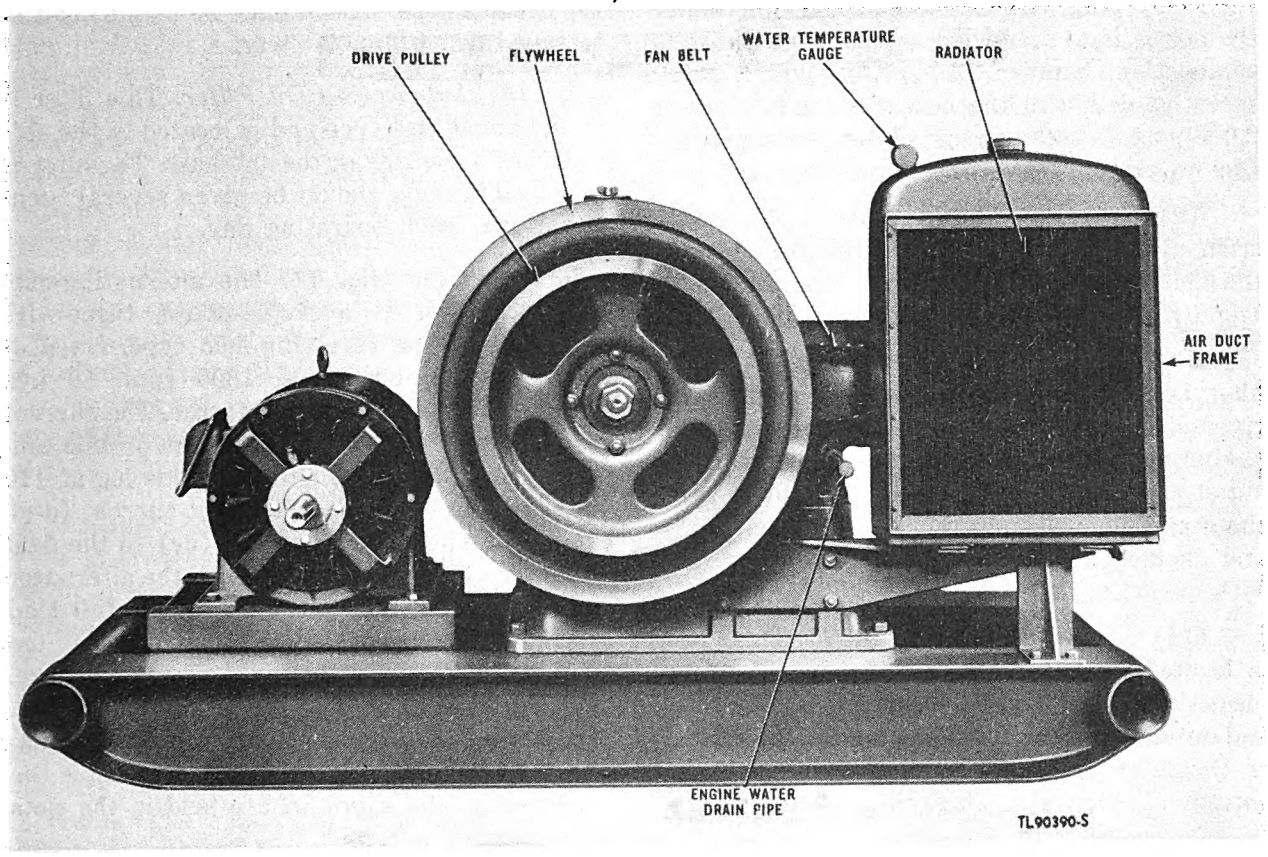


Figure 6. Power Unit PU-53/FRC, radiator side.

side of the engine, an auxiliary fuel filter located below the transfer pump, a final fuel filter located on top of the camcase, a fuel injection pump which is driven from the engine camshaft through the injection pump tappet assembly, a fuel nozzle of the Bosch pintle type which is automatically operated by fuel pressure, a governor of the flyball type which is built into the crankcase and camcase, and a fuel tank in the engine sub-base, a three-way valve for connecting the fuel system to the engine fuel tank or to a storage tank which forms a part of the system but is not supplied as a part of the equipment, and the necessary interconnected piping.

(*5*) *Exhaust System.* The exhaust system includes the following: a flexible hose, an exhaust muffler, and the necessary pipe and fittings. Exhaust gases leave the engine head, pass through the connecting flexible tube, and into the muffler and connecting pipe to the outside atmosphere.

(*6*) *Air Cleaner.* All air entering the engine is drawn through an oil-bath type air cleaner mounted on the air intake of the cylinder head. This unit consists of a cover, the body, and the cleaning element, which is made up of a long strip of finely woven wire screen wound several times upon itself in compact, circular form in the air cleaner body.

(*7*) *Fuel Injection Pump* (*figs. 5 and 28*). The fuel injection pump is a one-cylinder single plunger American Bosch pump, and is flange-mounted to the engine cylinder block on the right side of the engine. The pump plunger is driven from the engine camshaft through the injection pump tappet assembly. The pump plunger is provided with a scroll-shaped bypass which registers with the openings in the plunger barrel. The fuel injection pump control rod and rack are directly connected and operated by the engine governor.

(*8*) *Fuel Injection Nozzle.* The fuel injection nozzle is an American Bosch pintle type, automatically operated by fuel pressure, and is held in place in the cylinder head of the engine by a nozzle holder, which is also used for connecting

the fuel piping with the nozzle. The function of the nozzle is to atomize and spray fuel into the combustion chamber. The spring and adjusting screw assembly in the nozzle is set to open at 2,000 pounds pressure and closes as soon as the fuel oil pressure drops below this figure.

(*9*) *Governor.* The governor is of the centrifugal flyball type. It is an integral part of the control rack and injection pump mechanism (fig. 5).

(*10*) *Auxiliary Fuel Filter* (*fig. 27*). This filter is mounted by a bracket attached to the right side at the rear of the engine above the engine sub-base (fig. 27). It has an inlet and outlet elbow, and a drain plug. This filter is of the replaceable-element type. It is self-cleaning and should be given several turns either way each operating day.

(*11*) *Final Fuel Filter* (*fig. 27*). This filter is located on top of the engine crankcase by means of a clamp type bracket. It has an inlet and outlet elbow, and a filler plug located on top of the filter and a drain plug located on the bottom of the unit. This filter is not of the replaceable type. A complete new unit must be installed when filter is dirty.

(*12*) *Lubricating Oil Filter.* This filter is of the metal disk type and is located in the side of the oil reservoir in the sub-base. The filter is self-cleaning and should be given several turns either way each operating day.

b. Alternator (fig. 7). The alternating-current generator is a single-phase, three-wire generator of the revolving-field type, rated at 110/220 volts, 60 cycles, 1800 rpm, 10 kva (8 kw) at 80 percent power factor. The current rating is 45.5 amperes at 220 volts or 45.5 amperes from neutral to either outside leg at 110 volts. A directly connected, direct-current (d-c) exciter supplies direct current (dc) to the field windings of the alternator. Both the alternator and the exciter will carry the rated full load continuously with a temperature rise not exceeding 40° C above the ambient temperature. The open-type alternator frame is welded steel, and of rigid and rugged construction. The armature is of laminated steel, slotted to receive the stator coils. The windings are held in the slots

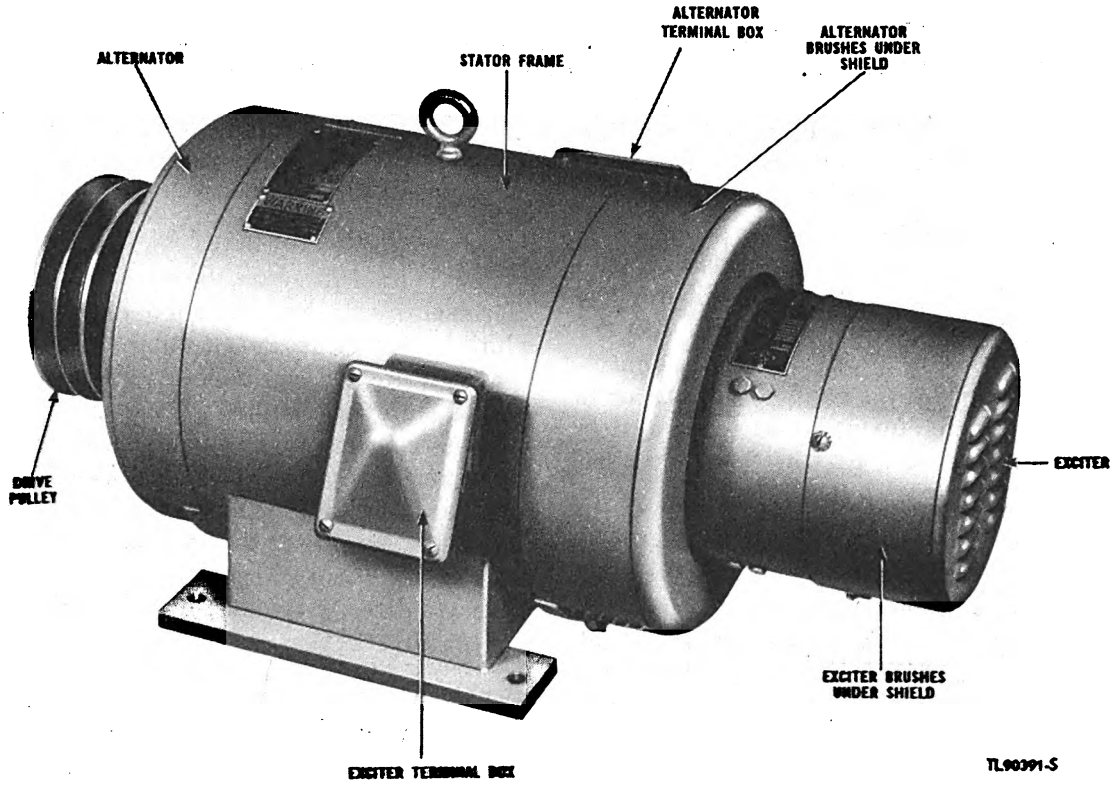


Figure 7. Alternator and exciter.

by moistureproof wedges. The wound stator is impregnated with an acid-, oil-, and moisture-resistant varnish which protects the entire winding from abrasive dust and oil, weak acid, and moisture. The field coils are wound directly on the poles, and are coated with a moisture-resistant varnish. The generator has two ball bearings equipped with grease fittings. The collector-ring brush holders, when assembled at the factory, are mounted so that the lower edge has a clearance of from 1/16 to ⅛ inch from the collector rings. The brush holders are located so that the brushes do not override the edges of the collector rings under normal conditions.

c. Exciter. The d-c exciter is mounted directly on the alternator shaft, and is rotated at 1,800 rpm by means of V-belt drive from the engine flywheel. It consists of a frame (mounted to the alternator frame), two field coils with pole shoes, two interpoles, an armature, two brush holders mounted 180° apart around the commutator, and four carbon brushes. The field poles are bolted into place 180° apart within the frame. The armature, mounted on an extension of the main rotor shaft and secured in place, consists of a quill, a laminated steel stacking, windings impregnated with insulating varnish of high dielectric strength, and a commutator of hard-drawn copper bars insulated with undercut mica, and polished for smooth sparkless operation. A removable metal cover protects the commutator and brush rigging.

d. Base. The base is of the structural-steel-skid type, electrically welded, and is drilled so that it may be bolted to its foundation. It has a pipe at each end to facilitate the lifting of the power unit by means of a sling. The alternator mounting base is attached at the rear of the base behind the engine.

e. Drive. The engine left flywheel is equipped with two belt pulleys, one for driving the cooling system fan, and the other, a double groove pulley for driving the alternator. Belt tension adjustment for the cooling fan is provided by means of a link belt. The alternator V-belts are adjustable by means of a sliding base bolted to the structual steel base at the rear of the engine.

f. Control Panel (fig. 1). The generator control panel contains the connections for the generator, and all the accessory equipment necessary to the performance of the generator. It consists of a steel cabinet with a two section removable front. Mounted on the upper section are the two ammeters, an a-c voltmeter and frequency meter, the voltage regulator, the voltage transfer switch and exciter rheostat. The lower section has an opening through which the main line circuit breaker switch handle protrudes. All other components are mounted on the back of the upper front panel. Connections to the exciter are made at the terminal block mounted below the main line circuit breaker, through knock-out holes in the bottom of the cabinet. Terminals for main line connections are made on the main line circuit breaker through knock-out holes in the bottom of the cabinet.

(*1*) *Control Panel Equipment.* The following pieces of equipment are mounted on the front of the control panel:

(*a*) A-c voltmeter: 0-300 volts scale, indicates the output voltage.

(*b*) Two a-c ammeters: 0-75 amperes scale, indicate the load amperes.

(*c*) Frequency meter: 58-62 cycles scale, indicates the output frequency.

(*d*) Voltage regulator: 230 volt, 50/60 cycle. Regulator automatically controls voltage, regardless of generator load.

(*2*) *Voltage Regulator Interior Components.* Mounted on the rear of the voltage regulator door, and accessible by opening hinged cover, are the following:

a Voltage regulator relay 110 volt a-c coil.

b Shunt field resistor 150 ohms, 75 watts.

c Calibrating resistor 500 ohms, 50 watts.

d Damping transformer.

e Automatic polarity reversal motor, 115 volts, a-c, 60 cycle, single-phase, and switch 250 volts, 3 amperes, 125 volts, 6 amp. a-c or d-c.

f Radio shielding filter.

g On-off switch, 250 volts, 3 amperes.

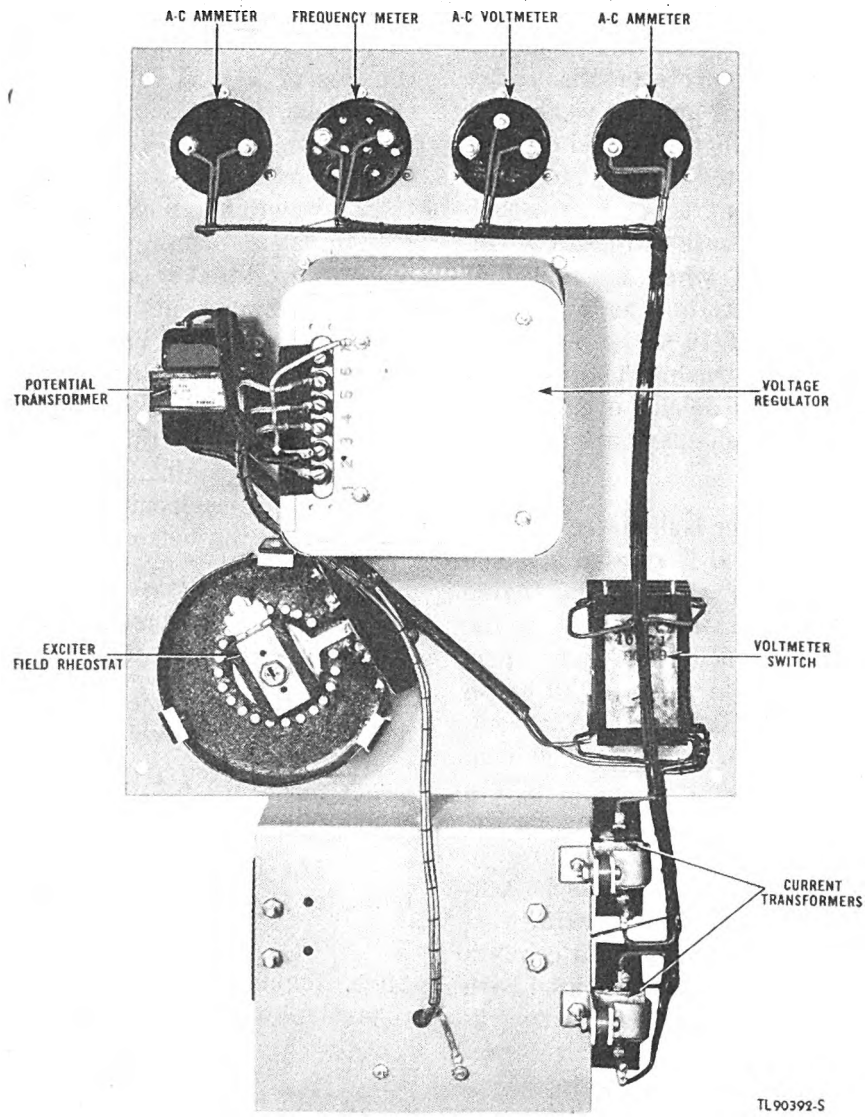


Figure 8. Control panel, rear components.

(*a*) Exciter field rheostat, 160 ohm, 3.2-0.64 amperes; for directly regulating output voltage of main line before throwing in the automatic voltage regulator.

(*b*) Voltmeter switch: Permits reading of voltage between any two lines.

(*c*) Main line air breaker switch (circuit breaker): Serves as the load switch used for applying load to alternator. It trips automatically when the power unit is heavily overloaded.

(*3*) Control Panel Interior Components. Mounted on the reverse side of the control panel front cover, and accessible by removing the two piece front panel, are the following:

(*a*) Two current transformers, primary, 75 amperes, secondary, 5 amperes.

(*b*) Potential transformer, primary 230 volts, secondary 115 volts.

g. Accessories.

(*1*) Spare parts, comprising those essential for the repair and maintenance of the complete unit while in service, are listed as follows:

1 bearing, crank pin, two halves
1 bushing, piston pin
1 set (50) shims, crank pin bearing
4 ring, compression piston
2 ring, oil regulating

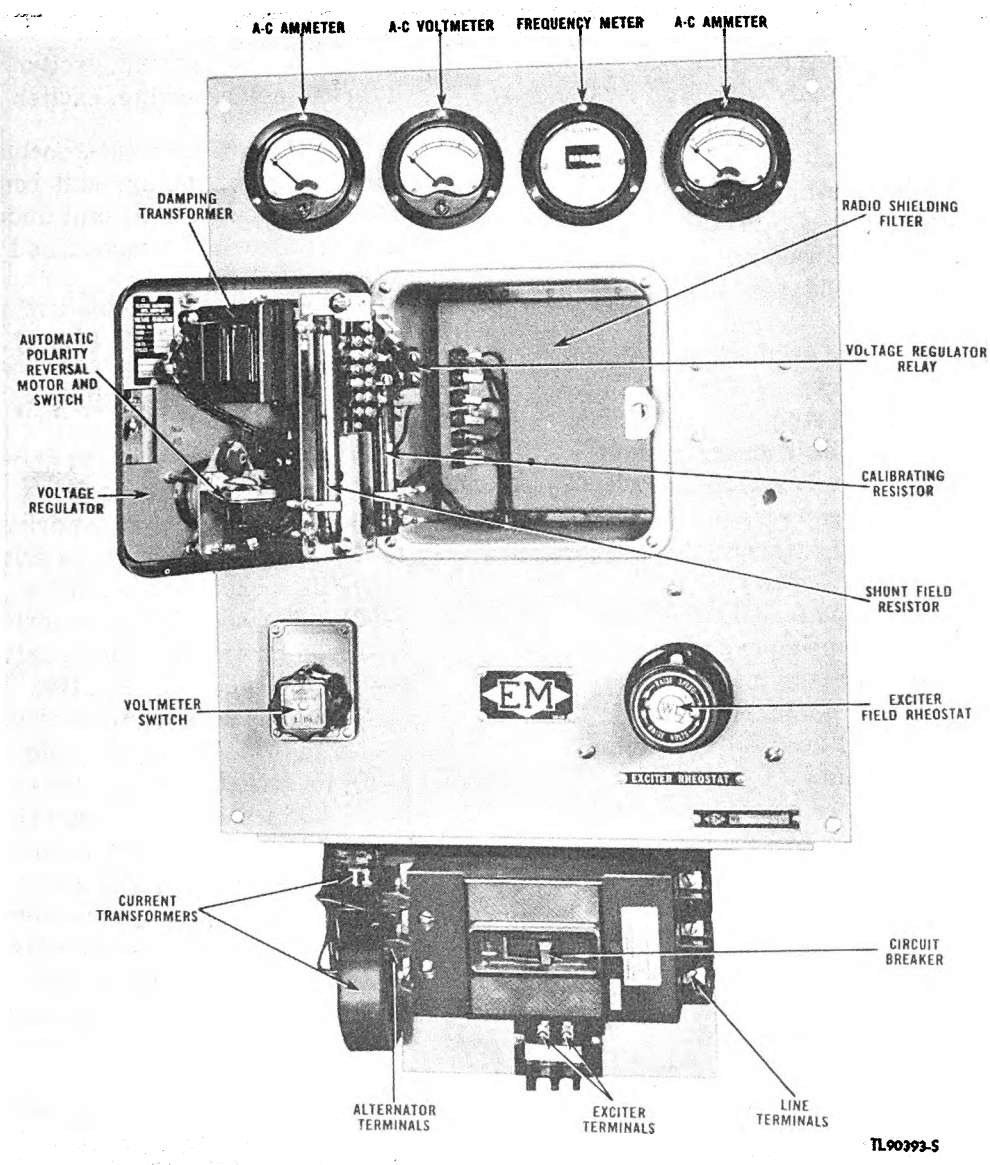


Figure 9. Control panel, front components.

2 ring snap, piston pin
1 cone, roller bearing
1 gasket, camcase cover
1 gasket, crankcase cover
1 gasket, sub-base
1 roller bearing hub assembly includes:
  1 cup, bearing, roller
2 felt, crankshaft
2 gasket, cylinder head
1 Bosch fuel filter assembly
2 bowl, glass, fuel transfer pump
2 gasket, fuel transfer pump
2 seat, cork, glass bowl
1 strainer, fuel
1 center pin assembly
1 spring, governor
1 spring, speeder
1 fuel injection nozzle assembly
1 line, fuel injection
2 washer, nozzle holder
1 injection pump assembly
2 gasket, oil filter flange
1 cartridge, oil filter
1 spring, valve, release
1 gasket, oil pump body
1 spring, pawl, starting crank
1 guide, exhaust, and inlet valve stem
1 insert, valve seat (exhaust)
1 spring, intake or exhaust valve
1 valve exhaust

1 valve, intake
1 lock, valve spring retainer
1 cam roller assembly with pin
1 hardware assembly group consisting of the following:
1 air cleaner cover wingnut
1 camshaft nut
1 camshaft lockwasher
1 connecting rod cap bolt, nut, and cotter
1 counterweight stud and nut
1 crankshaft nut
2 cylinder head stud
2 crankcase to base mounting bolt
2 crankcase cover attaching bolt (½ in. x 1-½ in. cap screw)
2 camcase cover attaching bolt (⅜ in. x 1-½ in. cap screw)
2 side bearing plate attaching bolt
2 oil pump mounting cap screw
1 cylinder head stud nut
1 nozzle holder adapter stud
1 cylinder head stud oil holder nut (¾ in. half nut)
2 fuel filter cover attaching screw #12-24 x ⅝ in. MS Fil H
1 fuel pump bracket mounting screw (5/16 in. x ¾ in. cap screw)
3 fuel pump cover screw #10-32 x ⅝ in. Fil H mach screw
1 governor mounting bolt (⅜ in. x 1-¼ in. cap screw)
1 governor hub nut
1 injection pump mounting stud and nut
1 nozzle holder adapter stud nut
2 oil filter mounting screw #12-24 x ⅝ in. Fil H mach screw
2 oil pump cover plate screw #10-32 x ½ in. Fil H mach screw
1 cam roller rocker arm pin
1 rocker arm shaft nut
2 #90-C "V" belt (matched)
2 generator mounting bolt consisting of:
1-⅝ in.-11 x 1-¾ in. hex head cap screw
1-⅝ in.-11 hex nut
1 bearing, drive end
1 bearing, exciter end
4 exciter brush
4 alternator brush
1 brush-holder assembly, alternator
2 brush-holder assembly, exciter
2 brush-holder spring, alternator
1 brush-holder spring, exciter (LH)
1 brush-holder spring, exciter (RH)

(*2*) Installation materials, including wiring, piping, fittings, tubing, and construction items, necessary to install the unit under normal conditions, are shown in figures 2 and 3.

h. Tools. The following tools are furnished with Power Unit PU-53/FRC (fig. 4).

1 socket wrench set complete with the following:
1—7/16 in. socket ½ in. sq drive
1—½ in. socket ½ in. sq drive
1—9/16 in. socket ½ in. sq drive
1—19/32 in. socket ½ in. sq drive
1—⅝ in. socket ½ in. sq drive
1—21/32 in. socket ½ in. sq drive
1—11/16 in. socket ½ in. sq drive
1—¾ in. socket ½ in. sq drive
1—25/32 in. socket ½ in. sq drive
1—13/16 in. socket ½ in. sq drive
1—⅞ in. socket ½ in. sq drive
1—31/32 in. socket ½ in. sq drive
1—15/16 in. socket ½ in. sq drive
1—1 in. socket ½ in. sq drive
1—1-1/16 in. socket ½ in. sq drive
1—1-⅛ in. socket ½ in. sq drive
1—1-3/16 in. socket ½ in. sq drive
1—1-¼ in. socket ½ in. sq drive
1—reversible ratchet
1—5 in. extension
1—10 in. extension
1—pin handle with ½ in. adapter
1—box for above wrenches and attachments
1—8 in. adjustable wrench
1—8 oz ball pien hammer
1—12 in. screwdriver
1 set feeler gauges in holder and including the following: 0.002 in., 0.003 in., 0.004 in., 0.006 in., 0.008 in., 0.012 in., 0.013 in., 0.020 in., 0.025 in., 2 in. rule, 6 spark plug gap gauges, and spark plug adjusting tool.
1—½ pt oilcan with flexible spout
1—¼ in. x 5/16 in. open-end wrench
1—⅜ in. x 7/16 in. open-end wrench
1—½ in. x 9/16 in. open-end wrench
1—⅝ in. x ¾ in. open-end wrench
1—½ in. x 11/16 in. open-end wrench
1—½ in. x ⅝ in. open-end wrench (tappet)

1—¾ in. x ⅞ in. open-end wrench
1—15/16 in. x 1-1/16 in. open-end wrench
1—1-¼ in. single open-end wrench
1—2-¼ in. hex flywheel wrench
1—6 in. screwdriver
1—6 in. pliers
1—¾ in. T handled socket
1—starting crank

SECTION II. APPLICATION OF POWER UNIT PU-53/FRC

6. USE WITH OTHER EQUIPMENT.

Power Unit PU-53/FRC is a portable self-contained power plant used to supply single-phase alternating current for fixed radio installations.

SECTION III. INSTALLATION AND ASSEMBLY OF POWER UNIT PU-53/FRC

7. UNCRATING AND UNPACKING.

a. General. Power Unit PU-53/FRC, with the control panel, spare parts, tools, and installation materials, are packed within a crate, 42-½ inches wide, 55 inches high, and 93 inches long. The control cabinet is bolted to a special bracket attached to the top of the skid base. Located at one end of this crate is the exhaust silencer, and the 33 feet of three conductor No. 4 lead sheathed RL cable. Strapped to the floor of the box are the three 4-foot lengths of 2-inch exhaust pipe. A spare parts box, which includes installation materials and the tool box are fastened to the other end of the crate.

b. Uncrating. Exercise care in uncrating to prevent damage to parts and delicate instruments. Because of the construction and weatherproof sealing of this crate, the following procedure is recommended in uncrating. Remove the ¾-inch steel straps running horizontally around upper and lower sides of the crate, and also the reinforcing corner straps. Cut off the waterproof paper covering the roof. Starting at one end of the top, pry up the dressed and matched roof which has been cemented with a roof coat sealer. Starting from the top edge, remove each end panel of the crate (as a unit) by prying it away from the sides of the sealed contact. Remove the spare parts box. The inside bracing may be pried away from each side by springing the side panels outwardly. When the last brace is removed, draw the crate side panels out and down from the top edge, and pry loose from the heavy skid base. The metallic vapor-proof barrier completely inclosing the power unit should then be cut off as near to the sealed edges as possible, and as it extends underneath the complete unit it must be cut around the base. The generating unit may now be slid on rollers to its approximate installation location, while on the wooden skid base, or it may be removed from the crate base prior to rolling, by removing the skid-base mounting bolts. Throughout the uncrating procedure, refer to the packing list included with unit and check against it.

> **NOTE:** Spare parts shipped with this unit have been carefully processed and wrapped to protect them against corrosion and mechanical damage. Each package is clearly labeled and should not be opened until the parts are to be used.

c. Preliminary Care. Remove the corrugated paper covering the complete unit. Remove the covering on the engine-exhaust vent and air-cleaner. Remove the covering over the radiator. Remove the cellulose wadding which protects the vapor-proof barrier from all the sharp corners of the engine. Extreme care should be taken in transporting and handling the power unit. The windings of the alternator are easily damaged. A blow on any part of the windings may be sufficient to injure the insulation and cause a coil to burn out during operation. When the unit is unpacked, or whenever it arrives at a new site, it should be given careful visual inspection for possible damage in transit and shipping. The alternator must be protected against moisture

LEGEND FOR FIGURE 10

1. Engine.
2. Alternator and exciter.
3. Drive belts, alternator and exciter.
4. Skid base.
5. Exhaust muffler and accessories.
6. Fuel supply line.
7. Radiator duct frame.
8. Fan guard.
9. Wiring material.
10. Foundation bolt.
11. Guard V-belt drive.
12. Drive belt fan.
13. Sliding base, alternator and exciter.

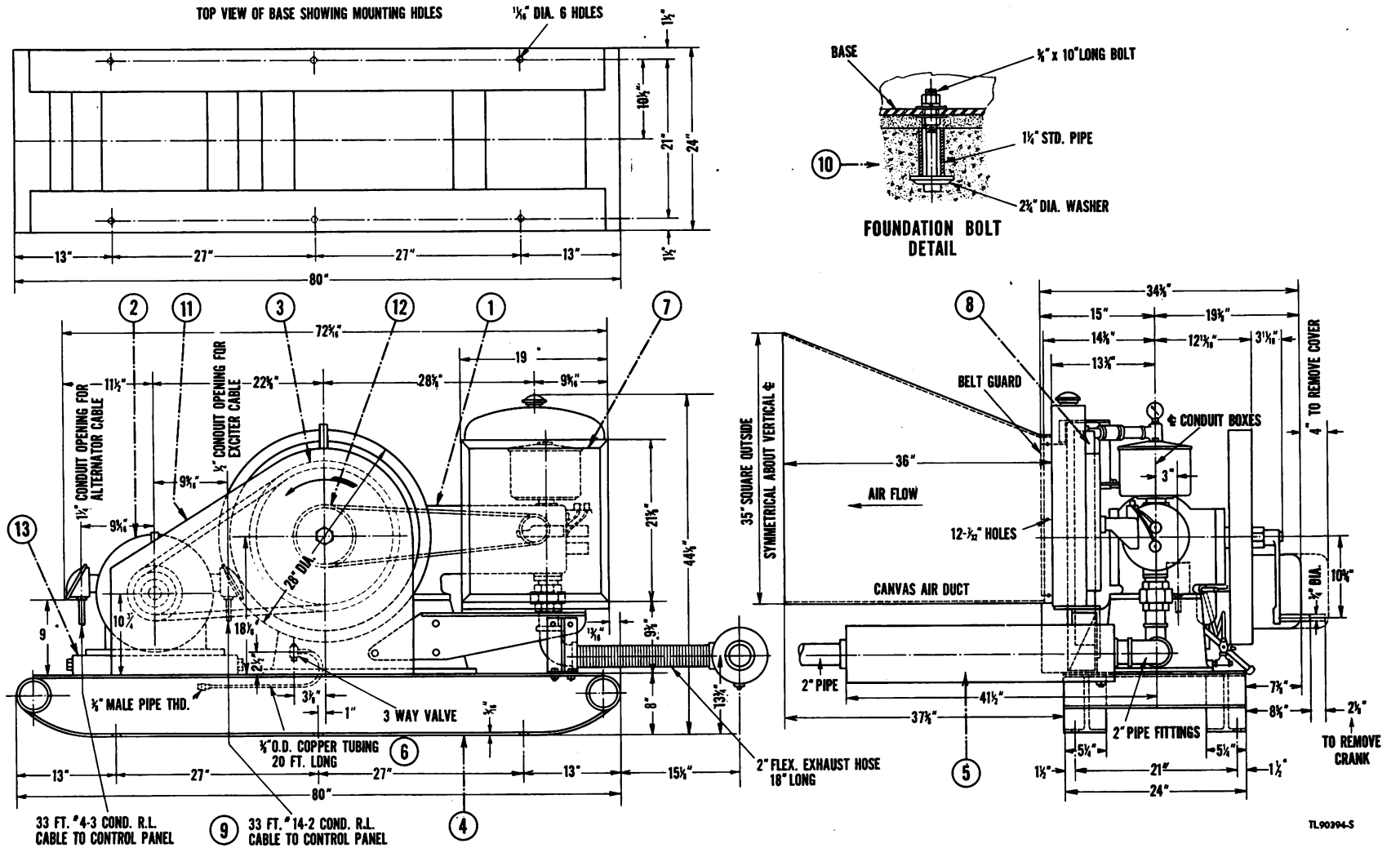


Figure 10. Power Unit PU-53/FRC, dimensions.

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

8. EQUIPMENT CHECKS.

To determine if the unit is delivered complete, check all equipment against the list of major components (par. 5), and against the list of tools given in paragraph 5i.

9. INSTALLATION.

a. General. The information outlined in the following subparagraphs is of a general rather than specific nature since the details of power unit installations generally vary with each installation.

b. Location. When possible, install the power unit together with the control panel within a permanent building or under the best shelter conditions to minimize the effects of weather on service operations. This also lessens the difficulties of protecting fuel, oil, and water additions during inclement weather and most important, the complete unit can be kept cleaner, facilitating operation and adjustments when necessary. When locating the power unit, it is especially important to provide sufficient space to permit easy access to the controls and service points of the engine, as well as proper ventilation and heat disposal. Locate the plant as near to the center of the load as practicable. This assures lower line loss with a given size of wire and improves the control of voltage at the remote end of the lines. The size of the line wires required depends largely upon the distance from the power unit to the load, the amount and kind of load, and the permissible voltage drop between power unit and load. Be sure to use wire that is large enough for the purpose.

(*1*) *Underground Fuel Tank Installation.* In installing the unit, refer to PEA equipment list No. 119R.

(*2*) *Gravity Feed Fuel Tank Installation.* If the supply tank is located so as to provide gravity feed, the supply pipe must enter the tank from the bottom and project 3 inches into the tank, and should be equipped with a shut-off valve near the tank. Do not use check valve. The maximum height from the crankshaft of the engine to the top of the supply tank for this type of installation is 20 feet. If a day tank is used, close all vents.

c. Placing Power Unit on Foundation. This power unit is supplied with a heavy skid-type base. No special foundation is necessary for the installation of this power unit. Any floor of heavy planking or slab concrete capable of supporting the unit weight, without excessive vibration, is satisfactory. Cushion mounts are desirable where noise and vibration must be further dampened. Take care to level the base on the foundation. If it is necessary to bolt or clamp the base to the foundation, care must be exercised so as not to warp the base and cause misalignment of the engine and generator shafts.

d. Control Panel. After locating power unit, attach the control panel to the wall in a convenient location (fig. 11). See PEA Equipment List No. 119R.

10. CONNECTIONS AND INTERCONNECTIONS.

a. General. After the unit has been located in position or secured to its foundation, install the fuel line, the exhaust system, and the radiator duct. Make connections between the generator and the control panel in accordance with the wiring diagram (figs. 11 and 40). Be sure that all electric wires entering the room and within the room are properly supported and insulated. Connect the load wires to the a-c OUTPUT terminals, L1, L0, L2 in control panel bringing the leads in through the bottom of the control panel. The size of insulated shielded cable to use within the room for distributing the load from the main output cables depends on the load amperes and the type of insulation of the cable. For connections between the alternator and control panel, and for power take-off from the control panel, use the lead-sheathed 3-conductor cable furnished with power unit; for exciter connection from exciter to control panel use the lead-sheathed 2-conductor cable furnished. Make sure that all connections are mechanically and electrically secure and that all protective covers have been replaced and are securely fastened. Cables shall be protected from mechanical injury by any available means.

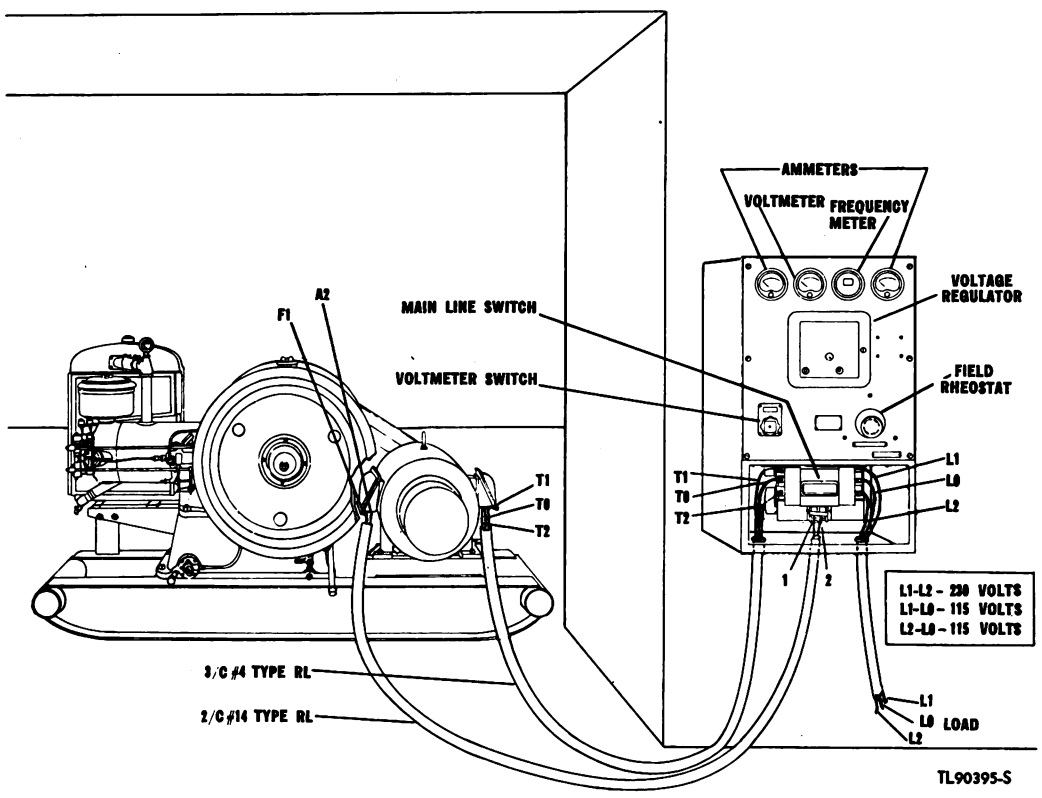


Figure 11. Electrical connections.

b. Fuel Connections. The accessory equipment furnished with each unit includes 20 feet of ⅜-inch OD copper tubing with suitable male fitting for connection to ⅜-inch pipe (fig. 2). Connect the fuel system as illustrated in figure 12. Before the connections to the supply pump are made, fill the suction line with fuel oil. This can be done by pouring fuel oil into the line until it is completely filled.

c. Exhaust Connections. The exhaust assembly accessories furnished with each unit are shown in figure 2. Use this material and connect a union in the exhaust line, close to the engine head, in order that the cylinder head may be removed without tearing down the exhaust line. Install a long sweep ell and connect the flexible hose. Install the muffler as close to the flexible hose as practicable (fig. 8). From the outlet end of the muffler, run the 2-inch pipe to the atmosphere. This pipe is part of the equipment and is furnished in 4-foot lengths.

d. Canvas Air Duct. The radiator is provided with a metal frame to which a canvas duct can be attached to direct the hot air from the pusher fan out of the building and into the atmosphere. If a metal duct is used, install a short section of flexible material, such as canvas, between the frame on the radiator and the duct. Vibration of the engine, while in operation, does not permit installing metal directly onto the metal frame around the radiator. A canvas air duct is supplied (fig. 2).

e. Electrical Connections. Check all electrical connections and wiring to see that they are tight and have been made properly. Also, check all bolts and nuts on the exhaust system and the power unit to see that all piping is properly connected and is tight. See that the load switch on the switchboard is in the OFF position.

11. RADIATOR COOLING.

Power Unit PU-53/FRC is equipped with a thermo-syphon radiator-cooling system. For successful operation an adequate supply of fresh air is essential. Waste heat from a power unit comes from the exhaust pipe, radiator, and engine structure. To prevent the engine room from becoming excessively hot in summer, this waste

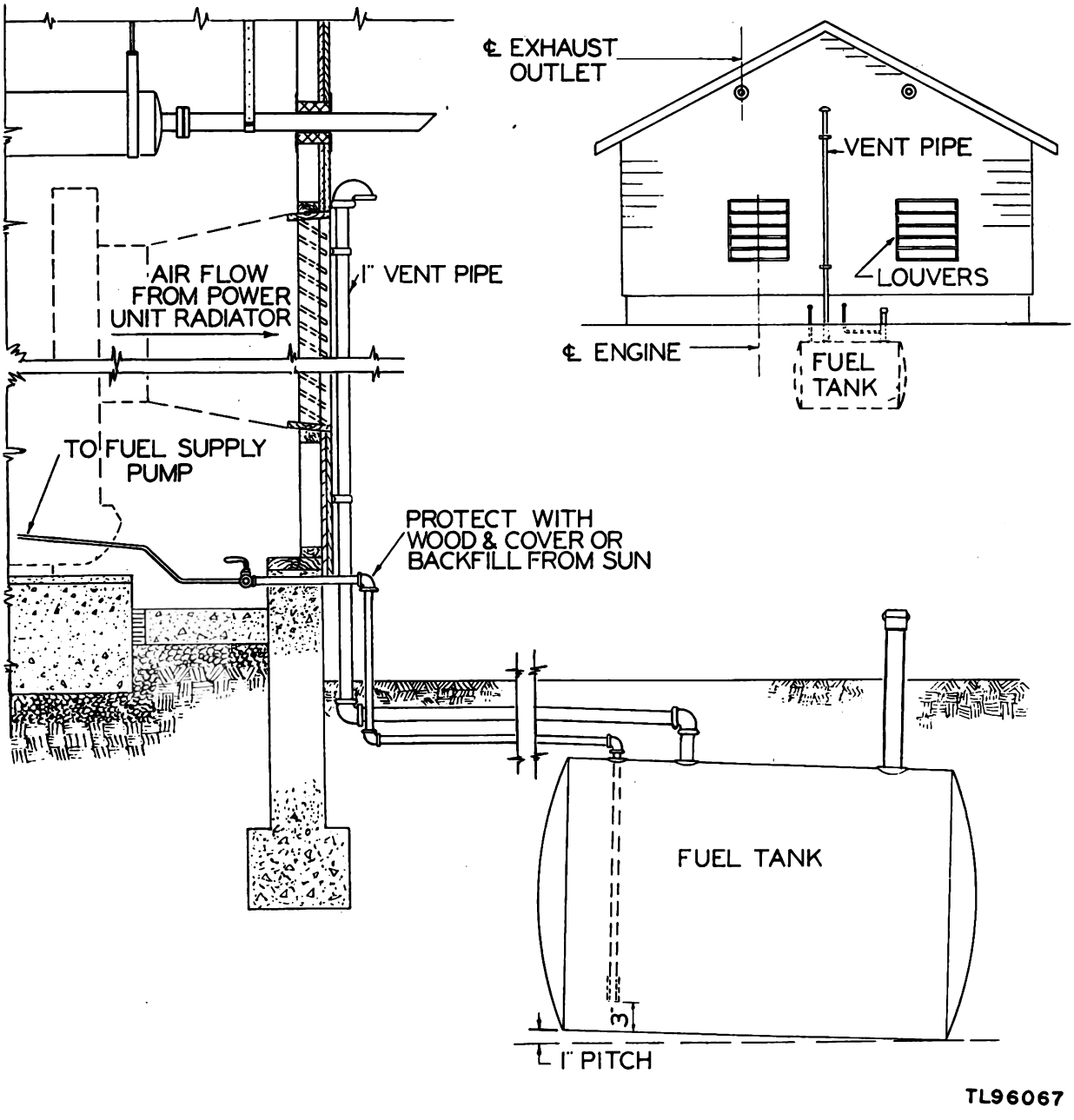


Figure 12. Power Unit PU-53/FRC, fuel tank installation.

heat must be carried outside before being released, and the air in the room must be continually and rapidly changed. Following are suggestions for eliminating excessive engine room temperatures:

a. Exhaust Pipe Layout. Arrange the exhaust pipe layout so as to have the shortest possible length in the engine room. Cover the exhaust pipe completely, where it passes through a wooden wall, with at least 2 inches of asbestos insulation.

b. Ventilation. Thoroughly ventilate the engine room and install the power unit so that air can flow freely through the radiator and out through the canvas air duct. Where door or window area is in any way restricted, galvanized steel ducts, extending from the ceiling above the engine to the top of the building, are recommended to carry off the hot air. Not less than two ducts, 24 by 24 inches in cross-section, should be installed. At the same time provide as many openings in the sides of the engine room

as possible to let in the relatively cool air and facilitate natural circulation. Openings to a shaded side of the building are to be preferred.

NOTE: When any inflammable material is located near the power unit or around the area near the exhaust piping, take every precaution to prevent fire. Check the fuel system from the main fuel tank to the engine before, during, and after operation, for leaks. Any fuel leak is a potential fire hazard. Correct it immediately. Encase any electrical connections to or from the operating units in conduit if not of the inclosed BX cable type.

12. REPACKING INSTRUCTIONS.

If the power unit is not to be used for 30 days or more, or is to be transported to a remote point, prepare the unit as follows: Repeat lubrication precautions every 6 months thereafter. See lubrication chart (fig. 19).

a. Wash, clean, and completely lubricate the engine.

b. Disconnect the fuel oil supply line at the supply pump strainer which is mounted on the right side of the engine, behind the engine flywheel. Remove the vent plug on the injection pump. Remove the filler plug from top of fuel filter which will allow the fuel oil in the filter and fuel line, to drain out. Fill the system through hole in top of fuel filter, with Oil, Engine, Preservative, PE-10 (0°F to —10°F) or PE-30 (above 0°F), replacing the vent plug at the injection pump as soon as the oil appears, then continue to fill the fuel filter. Start engine, let it run at moderate speed for 10 minutes. This will insure the fuel oil preservative reaching the fuel injection nozzle and will thoroughly distribute the oil preservative through the lubricating system. After stopping the engine, drain the excess flushing oil from the injection pump and fuel filter. Replace the vent plug in the injection pump and filler plug on top of fuel filter, and reconnect the fuel oil supply line at fuel supply pump strainer.

c. Drain water from the cooling system. If necessary to drain the lubricating system prior to shipment, attach a red tag to the oil filler plug which reads:

**CAUTION: THIS ENGINE HAS BEEN RUSTPROOFED. DATE:.....
USE ENGINE OIL CONFORMING TO U. S. ARMY SPECIFICATION 2-104, SEASONAL GRADE, WHEN PLACING ENGINE IN SERVICE.**

d. Spray preservative oil (PE) over inlet and exhaust valve rocker arm assembly.

e. If the exhaust system has been dismantled, cover the exhaust opening carefully with tape to prevent moisture from entering the cylinder head. Cover other engine openings similarly.

f. Remove the oil filter element. If any evidence of rust or sludge is found, clean thoroughly. Replace filter element.

CAUTION: The engine must not be run after the flushing operation.

g. Apply a complete but thin coating of light rust-preventive compound to all exposed unpainted parts such as threads and nuts, silencer and exhaust piping. Use a brush to apply the compound, and take care not to wet any rubber parts.

h. Cover alternator and exciter with tarpaulin or other material which will keep out dust and grit and as much moisture as possible. Cover control panel with tarpaulin or other dustproof material.

i. Restore unit to service as follows:

(*1*) Put the compression release lever in priming position, and remove the oil pressure gauge, and pour a mixture of one-half Fuel, Oil, Diesel and one-half Oil, Engine, OE-SAE-10 to fill the opening.

(*2*) Flush the valve and the valve-operating mechanism with same mixture.

(*3*) Remove coverings from the alternator, exciter, and control panel and remove seals from all sealed openings.

(*4*) Crank the engine rapidly until the excess oil has been blown out of the exhaust opening. This operation will loosen any tight piston rings and wash the old gummy oil from the piston.

(*5*) Flush out the crankcase and fill it with the specified grade of lubricating oil (fig. 19).

(*6*) Check all wiring circuits for correct, tight connections.

(*7*) Dry out alternator and exciter.

(*8*) Follow starting procedure as outlined in paragraph 17.

SECTION IV. PREOPERATION PROCEDURES

13. PREPARATION FOR USE.

To prepare the unit for service, proceed as follows:

a. General. When the unit is shipped from the factory, the oil is drained from the engine crankcase, air cleaner, and the fuel injection system. The water is drained from the cooling system. Before starting to operate the unit, check all engine mounting bolts for tightness. Examine the entire engine and check for any cap screws or nuts that may be loose, noting all parts for possible damage or defects which might have occurred while unit was in shipment or since it was last started.

b. Servicing the Unit.

(*1*) *Lubrication.* Lubricate the entire power unit using the lubrication chart (fig. 19) as a guide. Next, move the compression release lever to priming position. Remove the filler plug from top of fuel filter, and the vent plug at the injection pump and fill the system with lubricating oil until the lubricating oil appears at the injection pump vent hole, replace vent plug, then continue to fill the system. Hand-crank the engine so as to distribute the oil over the cylinder wall. While cranking the engine, test for freedom of moving parts. Make sure that the fan clears the radiator and guard, and that all rotating parts are free to rotate without interference. Putting oil in the fuel oil system of a new engine before starting assures positive lubrication of the cylinder and piston immediately after starting, and also eliminates the possibility of scoring. It is only necessary to do this to new engines or to engines that have been idle for a long period of time. Fill the crankcase with lubricating oil (OE), selecting the seasonal grade from the lubrication chart (fig. 19). Put the oil into the crankcase through the plug opening located on top of the engine crankcase cover (fig. 5). The quantity required is 10 quarts. After filling the crankcase, check the oil level with bayonet oil gauge. To do this, remove the gauge from the engine and wipe it clean. Reinsert the gauge full way, remove the gauge and observe the oil level.

CAUTION: Keep the supply of lubricating oil absolutely clean and free from dust, etc. Always use clean containers and wipe filling hole clean before pouring oil into crankcase.

(*2*) *Cooling System.* Alcohol is not recommended as an antifreeze solution since it will boil away at average operating temperatures, and should only be used in event that an approved antifreeze is not available. Recommended antifreeze solutions are shown in the table following:

ANTIFREEZE SOLUTION

Type of antifreeze			Antifreeze to add at temperatures shown (qt)
Ethylene glycol	Alcohol	Glycerine	
	27°F	29°F	1.6
16°F	19°F	21°F	3.2
3°F	10°F	12°F	4.8
—11°F	—2°F	0°F	6.4
—31°F	—18°F	—15°F	8.0

Before filling the cooling system, check to see if the drain cock located on the bottom return water flow pipe is closed, and that all hose connections are tight. Do not use a solution of household salt or any alkali solution, as these are injurious to metal parts.

NOTE: Do not use any of the following in water as an antifreeze: honey, kerosene, fuel oil, glucose, sugar, or calcium chloride. Do not mix different types of antifreeze.

(*3*) *Fuel Oil System.* Fill the main fuel tank with clean Diesel fuel oil (DA). For temperatures below 0°F, use grade X (arctic). Do not use a grade of fuel oil other than specified above. The importance of using clean fuel oil cannot be overemphasized. Dirty fuel will cause rapid wear and clogging of fuel system, resulting in costly shut-downs. After the tank has been filled, remove the filler plug from top of filter and fill completely with clean fuel oil. DO NOT REPLACE THIS PLUG AT THIS TIME. Loosen vent plug on injection pump, close as soon as fuel appears. Disconnect both ends of the fuel line, then loosen delivery valve holder. Raise the governor bell crank as far as it will go. Place the compression lever in STOP position. If delivery valve holder has been loosened sufficiently, fuel oil will run out at this point. When fuel oil flows in a solid stream, free from air bubbles, tighten up the delivery valve holder.

Reconnect the fuel line at injection pump end, leaving it loose at the nozzle holder end. Crank engine either direction until exhaust valve is open. Raise compression release lever sufficiently to let the governor bell crank fall to low position. With the release lever in this position, crank the engine until solid fuel, free from air bubbles, appears at nozzle end of fuel line. Reconnect fuel line to the nozzle holder. Refill the fuel filter to replace fuel used in priming. Replace the plug in top filter.

NOTE: If at any time engine stops because of running out of fuel, the above procedure is necessary to prime the fuel system before the engine can again be started.

(*4*) *Air Intake.* Remove the oil cup from the air cleaner and fill it with lubricating oil (OE) to the oil level mark. Use the same grade of oil as is used in the crankcase. For cold weather operation, see figure 19. Use care in reassembling the oil cup to see that joints and connections are tight so as to prevent the entrance of dirt particles.

14. VISUAL INSPECTIONS.

a. Check the unit for general cleanliness, and remove waste material. Make sure that air passages are not obstructed.

b. Check the foundation of the unit. Make sure that the base of the unit rests solidly on the ground or floor at all points.

c. Inspect the shelter and the area immediately around the unit, make sure that it is clean, and that proper ventilation has been provided.

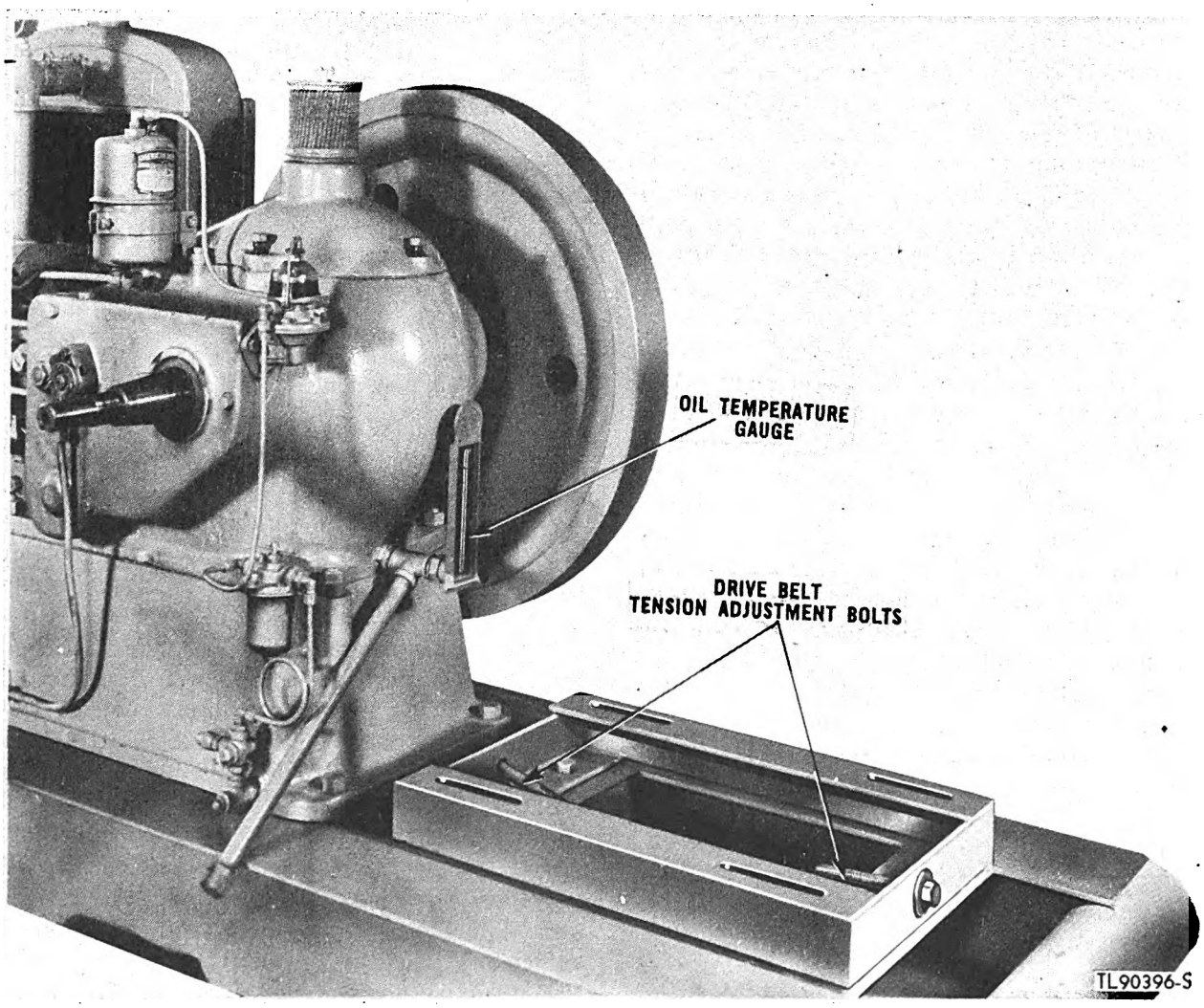


Figure 13. Oil temperature gauge and generator mounting.

PART TWO

OPERATING INSTRUCTIONS

NOTE: For information on destroying the equipment to prevent enemy use, refer to the destruction notice at the front of this manual.

SECTION V. OPERATION

15. STARTING CONTROLS AND INSTRUMENTS.

a. General. This paragraph contains the location, description, use, and purpose of the starting controls and instruments used to start Power Unit PU-53/FRC. Read carefully before attempting to start engine.

b. Engine Controls (fig. 14). The compression release lever is located on the right side of the engine, to the center, and below the injection pump. This lever has four positions: priming, starting, stopping, running. A complete explanation of the mechanical action which takes place when this lever is moved is given in paragraph 16.

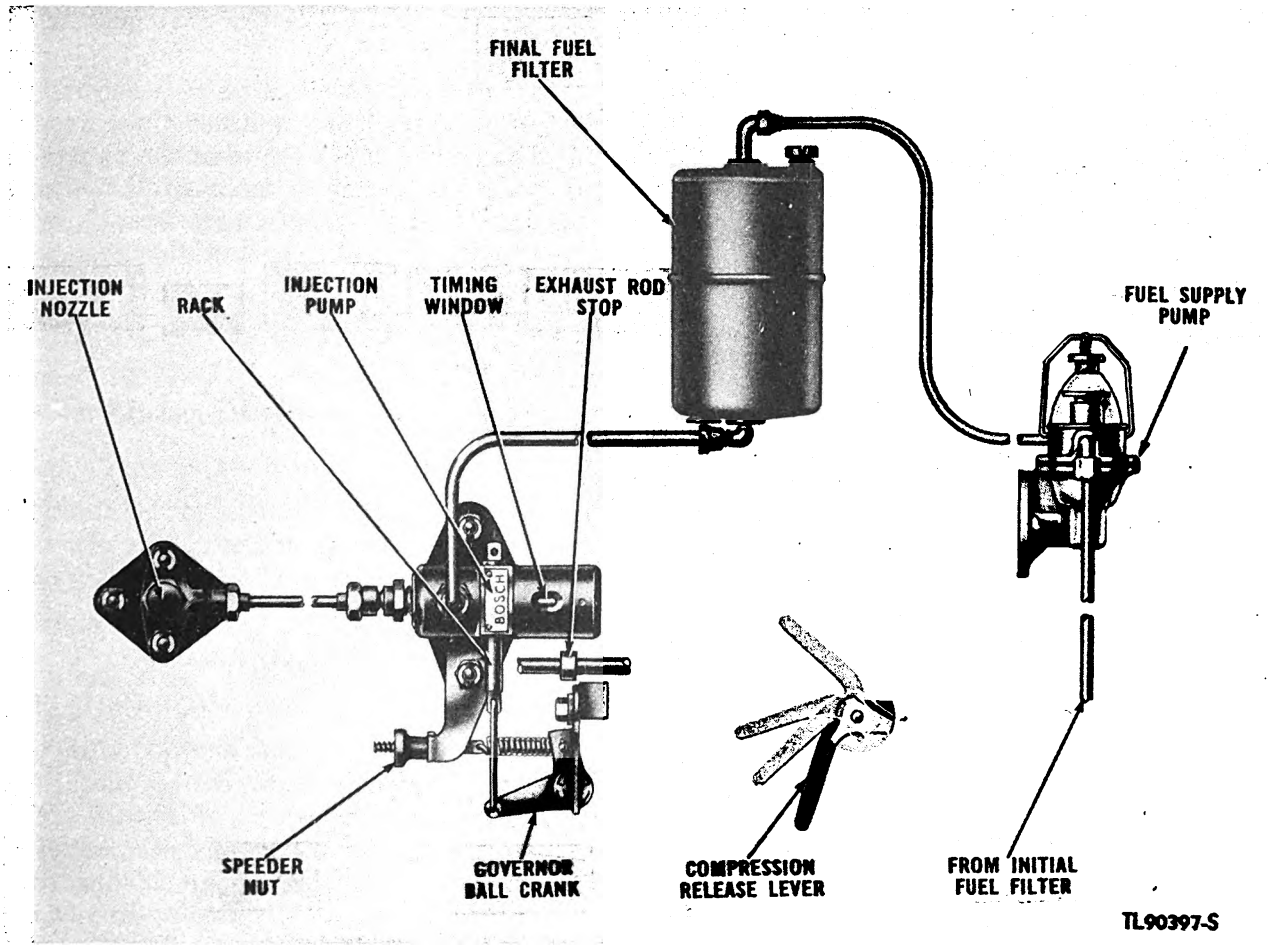


Figure 14. Engine controls.

c. Engine Instruments (fig. 5).

(*1*) *Oil Pressure.* The oil pressure gauge is located on the right side of the engine, above the injection pump. Under all operating conditions, the oil pressure of the engine should hold the indicator needle above 5 pounds pressure.

(*2*) *Water Temperature Gauge.* The water temperature gauge is located on the return water flow pipe to the radiator. When the water has reached operating temperature, the gauge indicator needle should point to the high side of the RUN range. With the engine warmed up and operating, the indicator needle should always be in the RUN position.

(*3*) *Oil Temperature Gauge.* The oil temperature gauge is located on the crankcase at the rear of the engine. When the oil in the crankcase reaches operating temperature, the gauge should read approximately 125°F. With the engine warmed up and operating, thermometer reading should not exceed 180°F.

d. Switchboard Controls (fig. 1).

(*1*) *Main Line Switch.* The main line switch (fig. 1) is an instantaneous, manual reset, surface mounted circuit breaker type OFF-ON switch located in the lower center of the switchboard. Its purpose is to connect the main line load to the generator, and to act as a circuit breaker in case of overload. It is operated by horizontal movement of toggle lever to position marked ON to apply the load, and movement to position marked OFF to disconnect the load.

(*2*) *Voltmeter Transfer Switch.* The voltmeter transfer (fig. 1) switch is a four-position, two section switch located at the extreme left of the panel under the voltage regulator. It is used to switch the voltmeter from one pair of lines to another so as to read the voltage between any pair of lines. Operate by turning to each position and watching voltmeter.

(*3*) *Exciter Field Rheostat.* The exciter field rheostat (fig. 1) is located at the extreme right of the panel under the voltage regulator. It is used to regulate the alternator output voltage by regulating the field resistance of the exciter. It is used before the automatic voltage regulator is switched into the circuit. Operate it by rotating the knob to the left to increase voltage; to the right, to decrease voltage.

(*4*) *Voltage Regulator.* The voltage regulator (fig. 1) is located in the center of the panel under the voltmeter and frequency meter. It is used to control the voltage and maintain it constant regardless of the load when the switch is in the ON position.

e. Switchboard Instruments (fig. 1).

(*1*) *Ammeters.* The ammeters (fig. 1) are of the panel-mount type, 0-75 ampere scale, located at the extreme upper right and left of the panel. They indicate the line load in a-c amperes in each outside line (L1-L2). (Full load rating is 45.5 amperes at 220 volts.)

(*2*) *Voltmeter.* The voltmeter (fig. 1) is of the panel-mount type, 0-300 volt scale, and is located at the top left center of the panel. Nominal full load rating should be 115 or 230 volts maximum. Get the preliminary reading by adjusting the exciter-field rheostat, then switch in the voltage regulator, and adjust the final reading with the a-c voltage adjusting screw located in the lower left side of the voltage regulator door.

(*3*) *Frequency Meter.* The frequency meter (fig. 1) is of the vibrating-reed type, and is located in the top right center of the panel. It indicates deviations from the nominal 60-cycle rating of the generator. No more than ½ cycle deviation from 60 at constant load is permissible.

16. STARTING POWER UNIT PU-53/FRC (fig. 15)

a. Operating Engine under Normal Conditions.

(*1*) *Before Starting Engine.*

(*a*) In case of doubt as to the identity, function, and operation of any of the controls or instruments, review the previous paragraph.

(*b*) Open the valve or valves, if any, in the main Diesel fuel supply lines.

(*2*) *Starting Engine.*

(*a*) Hand-crank the engine until the exhaust valve is open. Raise the governor bell crank to its highest position. Place the compression release lever in priming position (fig. 15). Compression release lever in this position will allow the governor bell crank to drop to its low position. This will permit fuel to pass through injection pump when engine is cranked,

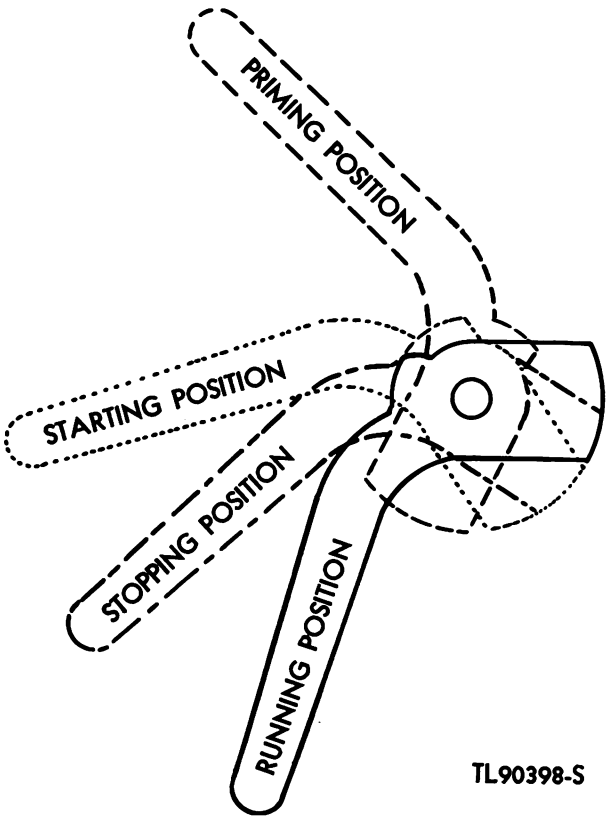


Figure 15. Compression release lever positions.

compression being released through exhaust valve which is held open by a collar on the push rod.

(*b*) Continue to crank the engine several revolutions to expel all air from the fuel lines and fuel nozzle. Make sure that a solid column of fuel is reaching the nozzle. This is easily determined, for as soon as this occurs, a definite creak is heard at the nozzle holder.

(*c*) Lift the governor bell crank (fig. 14) as high as it will go so that the compression release lever can be moved downward to starting position. In this position, compression is still released, but no fuel can enter combustion chamber. Hand-crank the engine and after gaining speed, drop the compression release lever downward to RUN position (fig. 15). Continue to crank engine, and if it is properly primed, engine will start immediately.

NOTE: If engine fails to start, it may be because of air in the injection system. Bleed the air in accordance with instruction in paragraph 13 b (3).

With the compression release lever in the RUN position the action of the governor at the injection pump will maintain the engine adjusted speed (within reasonably constant limits, under variable load conditions) by proportioning fuel to the load.

17. ADJUSTMENTS AND CHECKS AFTER STARTING.

a. Oil Pressure. As soon as the engine starts, check the oil pressure. The indicator needle of the oil pressure gauge (fig. 14) should move from zero to 5 pounds pressure as soon as the engine starts. If the oil is cold, the pressure may be a little slow in coming up. If little or no oil pressure registers at the gauge, immediately stop the engine and inspect the lubricating oil system for the cause of the trouble.

b. Oil Temperature Gauge. As the engine warms up, the oil temperature gauge should increase in degrees Fahrenheit. Should a rapid rise be indicated, immediately stop the engine and inspect the lubricating oil system for the cause of the trouble.

c. Unusual Sounds. Listen for any unusual sounds in the engine that may be a sign of trouble, such as rattles, knocks, squeaks, hums, etc.

d. During Operation Service. During the operation of the engine, the operator should note indicating gauges, etc., as prescribed in subparagraphs a and b above.

18. LOADING THE ALTERNATOR.

a. Preparations Before Loading. Before starting the generating unit for the first time, or after a prolonged period of idleness, make sure that the windings have not been penetrated by moisture, either by accident or because of sweating. If they have, disconnect the exciter-shunt field leads (F1, A2) from the switchboard terminals (1, 2) and operate the set without load for a period of from 1 to 4 hours. This will permit the ventilating fan to dry out the surface moisture. If possible, circulate warm air through the generator to hasten drying.

b. Loading. After being assured that the insulation is satisfactory, operate the generator set for a short time without load. Load the alternator gradually over a period of from 2 to 4 hours. The heat generated by the windings

will slowly evaporate any remaining moisture. The generator should be operated within plus or minus 5 percent of the rated voltage, (110 volts from neutral to either outside leg).

c. Heating. When the generator or exciter feels hot, check the actual temperature with a thermometer. Do not depend on the touch of the hand. The maximum permissible temperature rise above the surrounding air is 40°C (72°F) which, for example, when added to an air temperature of 90°F, results in a total operating temperature of 162°F. This temperature, although within the safe temperature limit, is too high to permit safely holding the hand on the machine.

19. OPERATION OF POWER UNIT PU-53/FRC.

a. Check all wiring and connections between control panel, generator, exciter, and load, with the wiring diagram (fig. 11). See that main line switch is in OFF position, and that the voltage regulator control switch is in OFF position.

b. Start the power unit and bring the generator speed up to approximately 1,800 rpm. Adjust the exciter rheostat (fig. 1) until the desired operating voltage is obtained as indicated by the voltmeter.

c. Move the control switch handle (on door of panel marked REGULATOR SWITCH) to the ON position. Readjust the voltage by turning the a-c voltage adjusting screw.

d. Connect the alternator with the load by closing the circuit breaker (moving handle to ON position). The voltage then should be readjusted to suit load conditions. Should the circuit breaker trip because of overload on the alternator, or because of line trouble, move the handle to the extreme OFF position to reset the breaker. To reapply the load, move the handle to the ON position. However, do not close the circuit breaker until the fault or condition that caused it to trip has been corrected.

20. OPERATION OF VOLTAGE REGULATOR AND METERS.

a. Voltage Regulator. To cut the voltage regulator out of service when the generator is in operation, move the voltage regulator switch to the OFF position, and adjust the generator voltage manually, if necessary, by the exciter field rheostat. When the generator is in operation and the voltage regulator switch is in the ON position, a slight adjustment of approximately 10 volts, plus or minus, to the generator voltage may be obtained by adjusting the slotted adjusting screw in the lower left-hand corner of the regulator door.

b. Ammeter. To read the current in each outside line, read each ammeter. The generator should not be made to deliver more than the rated current of 45.5 amperes in either line, even though the other line is not fully loaded.

c. Frequency Meter. Check frequency meter to determine if the output is 60 cycles. If necessary to bring frequency to 60 cycles, adjust engine speed (par. 18d).

d. Voltmeter. Voltage has already been adjusted before applying load. Variation between no-load and full-load voltage (with voltage regulator in circuit) should not be more than 5 percent. Read the voltmeter occasionally for determination of correct voltage.

21. DESERT OPERATION.

a. Shelter. If this power unit is to be operated in the desert, it is preferable from a maintenance standpoint to inclose it in a shelter. If the equipment is not protected from sand and dust, a break-down may result due to seepage of abrasive sand and dust into the air cleaner. From there, it may enter directly into the cylinder where grinding is very damaging. However, when attempting to shelter the unit, take care not to cut down necessary air circulation about the engine.

b. Precautions.

(*1*) Inspect and clean oil filter, air cleaner, and fuel filters.

(*2*) Inspect and clean the crankcase breather.

(*3*) Clean the cooling system thoroughly.

(*4*) Watch the water and oil temperature gauges closely.

(*5*) Under extremely high temperatures, valve failures may be more frequent. Check the valve clearances and grind the valves if necessary.

22. OPERATION IN ARCTIC CLIMATES.

a. Shelter. If the power unit is to be operated

in below-freezing weather, it is preferable from both a maintenance as well as an operation standpoint, to inclose it within a shelter. During shut-down periods where power unit is located either in an unheated shelter or actually out in the open, cover the entire unit with a tarpaulin to retain as much engine heat as possible.

b. Cooling System. When there is a possibility of the temperature being 32°F or lower, there is danger of water freezing in the cooling system. To overcome this, either drain the cooling system at the end of each run, or fill the system with an antifreeze solution. Refer to paragraph 14b(2) for antifreeze solution table. Keep close check of the entire cooling system for leaks, hose deterioration, etc. Refer to paragraph 54 (item 25) for instructions as to proper methods of filling, draining, and cleaning the cooling system.

c. Fuel System.

(*1*) Use only grade X (arctic) winter-grade fuel oil.

(*2*) Fill the Diesel fuel tank at the end of each day's operation to prevent condensation of moisture in the tank. This is very important, since at low temperatures this water will form ice crystals that will clog fuel lines, filters, jets, etc. If water is known to be in the fuel, strain the fuel through a chamois skin, 200-mesh wire screen, or similar type of strainer that will prevent the passage of water.

d. Lubrication. Lubricate the entire power unit with the approved winter grade lubricants (fig. 19). Selection of the crankcase lubricating oil should be based on the lowest anticipated temperature for the day.

23. OPERATION IN HOT WEATHER.

a. Cooling System. Overheating and loss of cooling water is a general condition in hot weather. To minimize the effects of hot weather:

(*1*) Check the water level in radiator at frequent intervals and see that the radiator filler cap is on tight.

(*2*) Check fan belt for condition and tension (par. 54 (item 29)).

(*3*) Keep radiator core clean and free of foreign material that will affect circulation of air through radiator.

(*4*) Keep cooling system clean by frequent cleaning and flushing if necessary.

b. Lubrication. Lubricate the engine with the correct grades of lubricants for the prevailing temperatures completely. See War Department Lubrication Order (WDLO) (fig. 19).

c. Fuel System. Keep fuel tanks filled to prevent condensation during cool evenings. Be sure that vent in fuel tank filler plug is open.

24. STOPPING THE POWER UNIT.

a. Move the main line circuit breaker switch handle on front of control panel to OFF position.

b. Raise the governor bell crank as high as it will go and place compression release lever in STOP position.

> **CAUTION: In stopping the engine, do not raise the compression release lever higher than explained above, otherwise exhaust valves will be held open. The engine should not stand idle with either valve open.**

c. Perform the maintenance procedures outlined in paragraph 54 depending on the interval of shut-down.

SECTION VI. EQUIPMENT OPERATION CHECK SHEET

25. PURPOSE AND USE OF EQUIPMENT OPERATION CHECK SHEET.

The equipment operation check sheet for Power Unit PU-53/FRC is shown in paragraph 26. Refer to this chart when preparing the unit for operation, when starting it, and when stopping it. Items listed in the column marked *item* are those points on the unit to be checked during each of these steps. Normal indications given in the check sheet are those conditions which must exist if the unit is to perform properly. For example, the fuel tank should be full before the unit is started; the frequency meter should register 60 cycles when the unit is operating under load. A corrective action to be applied to each item to obtain the normal indication required, thereby insuring proper operation, is given in the column headed *corrective measures.*

26. EQUIPMENT OPERATION CHECK SHEET FOR POWER UNIT PU-53/FRC.

	Item No.	Item	Action or condition	Normal indication	Corrective measures
PREPARATORY	1	Crankcase.	Check oil level.	¾ full.	Add oil.
	2	Radiator.	Check coolant level.	2 in. below top of filler.	Add coolant.
	3	Fuel tank.	Check fuel oil level.	Full.	Add fuel.
	4	Air intake.	Check oil level.	Oil level at bead.	Add oil.
	5	Rotating parts.	Hand-crank engine.	Rotate freely.	Clear obstruction.
STARTING	6	Main line switch.	Check position.	OFF.	Move to OFF position.
	7	Governor bell crank.	Raise upward.	At highest upward position.	Raise to highest upward position.
	8	Compression release lever.	Move to priming position.	Lever at approximately 45° above horizontal.	Raise to farthest upward position.
	9	Crank.	Rotate clockwise.	Creaking sound in nozzle holder.	Check fuel lines and connections for leakage of fuel.
	10	Compression release lever.	Raise governor bell crank to highest upward position.	Lever at approximately 30° below horizontal.	Move to starting position.
	11	Crank.	Rotate clockwise.	Increase rotating speed.	No remedy.
	12	Compression release lever.	Move to lowest downward position.	Lever at extreme low position. Definite feel of compression on crank. Engine starts.	Move to running position.
PERFORMANCE	13	Oil pressure gauge.	Check gauge.	Pointer indicating above 5 lbs pressure.	If no indications after 30 seconds of running, stop engine. Check oil supply. Remove gauge and examine screw at bottom of gauge. If loose, tighten. Check for proper seating of oil pump relief valve. Tap upper edge of camcase cover above oil pump or on hexagon nut over oil relief valve.
	14	Exciter rheostat.	Turn counterclockwise.	Voltage rises on voltmeter scale.	Check control panel instruments and parts.
	15	Voltage regulator switch.	Move to ON position.	Voltage regulator in circuit.	Check voltage regulator.

26. EQUIPMENT OPERATION CHECK SHEET FOR POWER UNIT PU-53/FRC (contd).

	Item No.	Item	Action or condition	Normal indication	Corrective measures
PERFORMANCE	16	Voltmeter.	Should register required voltage.	Reading should be within 2½ percent of required voltage.	Adjust voltage regulator adjusting screw. Insert screwdriver in slot of voltage adjusting screw located in lower left-hand corner of voltage regulator. Turn screw either clockwise or counterclockwise to correct reading in accordance with voltage in circuit.
	17	Automatic polarity reversing switch.	Periodically reverses polarity on voltage regulator relay contacts.	Geared indicator rotates counterclockwise as visible through inspection window in lower right-hand corner of voltage regulator cover.	Check connections to synchronous motor and check action of trigger switch.
	18	A-c voltmeter transfer switch.	Check voltages between all lines. Readings should be taken on voltmeter between L1 and L2, between L1 and L0, between L2 and L0.	OFF. Position 1—115V L1 to L0. Position 2—230V L1 to L2. Position 3—115V L2 to L0.	Check connections to switch.
	19	Frequency meter.	Check engine speed.	Meter should read 60 cycles.	Adjust engine speed to 720 rpm.
	20	Circuit breaker (main line switch).	Move to ON position.	Load connected to alternator, engine speed drops, frequency drops, and voltage drops slightly.	If circuit breaker trips, check the line for short circuit. Reset circuit breaker by moving handle to reset position (extreme off).
	21	Ammeters.	Upon application of load, needles move to indicate amount of load in amperes.	Needle reading between 0 and 50 dependent upon amount of load applied.	If ammeter reading is above 50 on both meters, reduce load to bring readings to 50. If load as registered on meters is unequal, balance line by shifting load.
	22	Water temperature gauge.	Check position of gauge needle.	Gauge needles rest at COLD. Needle gradually moves to RUN position during engine warm-up period and remains at this reading during normal operation. Needle moves to HOT position on gauge when coolant in engine exceeds a normal operating temperature of 180°F.	Check gauge for broken parts. Remove possible obstruction in gauge fitting. Check amount of coolant in cooling system. Add coolant if necessary.

26. EQUIPMENT OPERATION CHECK SHEET FOR POWER UNIT PU-53/FRC (contd).

	Item No.	Item	Action or condition	Normal indication	Corrective measures
PERFORMANCE	23	Oil temperature gauge.	Fluid level in glass tube rises or drops depending upon temperature of oil in crankcase.	Temperature reading between 125° and 180°F.	If temperature exceeds 180°, check supply of oil in reservoir in engine sub-base. If dip stick reading shows less than ¾ full, add oil.
STOPPING	24	Circuit breaker (main line switch).	Move to OFF position.	Load disconnected, voltage rises, ammeter reading falls to zero.	If load not removed, check action of circuit breaker.
	25	Compression release lever.	Raise governor bell crank as high as it will go and move compression release lever to stopping position.	Lever at approximately 45° below horizontal (fig. 15).	Move to stopping position.

PART THREE

MAINTENANCE INSTRUCTIONS

SECTION VII. OPERATOR'S PREVENTIVE MAINTENANCE

NOTE: Gasoline will not be used as a cleaning fluid for any purpose. Solvent, Dry Cleaning, is available as a cleaning fluid through established supply channels. Oil, Fuel, Diesel, may be used for cleaning purposes when dry-cleaning solvent (SD) is not on hand. Carbon tetrachloride will be used as a cleaning fluid only in the following cases: where inflammable solvents cannot be used because of the fire hazard, and for cleaning electrical contacts including relay contacts, plugs, commutators, etc.

27. MEANING OF PREVENTIVE MAINTENANCE.

To understand *preventive maintenance,* it is necessary to distinguish it from trouble shooting and repair. The primary function of preventive maintenance is to prevent major breakdowns and the consequent necessity of repair. The primary function of trouble shooting and repair is to locate and correct existing defects. The importance of preventive maintenance cannot be overemphasized. For basic procedures refer to TM 37-250, Basic Maintenance Manual, and TM 37-2810, Motor Vehicle Inspections and Preventive Maintenance Services.

28. PURPOSE OF OPERATOR'S MAINTENANCE

a. To insure mechanical efficiency, it is necessary to inspect the equipment systematically before operation, while at halt (during stand-by periods), and after operation. The operator must be constantly on the alert for any indications of faulty operation, so that defects may be detected and corrected before they result in serious damage or failure. Certain scheduled maintenance services will be performed each day before operating the unit, during at-halt or stand-by periods, and at the end of each day's run, immediately after stopping the unit.

b. Every operator will see that W.D. Form 48 is with the unit and properly filled out. Every organization will thoroughly school each operator in performing the maintenance operations listed on this form and explained in this manual.

c. The items listed on W.D. Form 48 are expanded in this manual to provide specific procedures for the accomplishment of the inspections and services. These services are arranged to facilitate inspection and insure that the unit will receive a thorough check.

29. PREVENTIVE MAINTENANCE SERVICES.

a. General. These services are the responsibility of the commanders of operating organizations. They comprise the scheduled maintenance services performed by power unit operators (first echelon) and unit mechanics (second echelon) respectively.

b. First Echelon. Ordinarily, the power unit operator (first echelon) will replenish fuel, oil, grease, and coolant. He will perform necessary

cleaning operations; tighten loose nuts, bolts, screws, and other fastenings; care for tools and accessories; and make such emergency repairs as are within the scope of his ability, tool equipment, and parts available. He will see that all lubrication operations scheduled for daily lubrication on the lubrication chart are properly and regularly performed. These operations are performed by the operator daily, before operation, at-halt (during shut-down periods), and after operation. He will assist the unit mechanic (second echelon) in performing the weekly maintenance on the unit.

c. Second Echelon. The unit mechanic (second echelon) will perform the weekly and monthly maintenance operations with the assistance of the unit operator (first echelon) and all service operations within the scope of his ability, tool, and spare part equipment available. He will also perform all lubrication operations scheduled for weekly lubrication on lubrication chart and will check to see that daily lubrication operations have been properly performed by the unit operator. The unit mechanic will report any maintenance or repair operations beyond the scope of the second echelon to the officer in charge.

d. Driver's Trip Ticket and P.M. Service Record (W.D. Form 48). Every operator of an individual power unit or power unit installation will provide himself with W.D. Form 48, Driver's Trip Ticket and P.M. Service Record. To adapt this form to power unit operation, the following interpretation of various headings on that form will be necessary. *Time Out* will be interpreted as the start of a period of power unit operation. *Time In* will be understood as the end of that operating period. *Kind of Work* will be interpreted as the equipment for which the power unit was used as a source of power. The *Speedometer* heading will be ignored and the reading of the *Hour Meter* will be entered under that heading at the beginning and end of the operating period, if such a meter is provided on the unit. If no such meter is provided, only the total number of hours operated during the operating period will be recorded. No entry will be required under the heading *Trip or Load Record.* Under the heading *Passengers or Weight,* enter the load in amperes during the operating period and under the heading *Speedometer or Hour Meter,* enter the total number of hours for which the load entered was carried by the unit. The *Dispatcher's Signature* will be that of the officer charged with the equipment. All other entries on the front of the form are self-explanatory. On the reverse side of W.D. Form 48 are listed the before-operation, during-operation, at-halt, and after-operation services. The power unit operator will line out all operations listed which do not apply to power units and will perform all remaining operations. Upon the completion of each group of service operations, the unit operator will place his initials in the space provided. The balance of the back of the form is self-explanatory.

30. BEFORE-OPERATION SERVICE.

a. Purpose. This inspection schedule is designed primarily as a check to see that the power unit has not been damaged, tampered with, or sabotaged, since the last after-operation service was performed. Combat conditions may have rendered the power unit unsafe for operation, and it is the duty of the operator to determine if the power unit is in condition to operate normally. This operation must be performed even under extreme tactical situations.

b. Procedures. Before-operation service consists of following the instructions contained in the items listed below (W.D., A.G.O. Form 48, back), and correcting or reporting abnormal conditions. Upon completion of the before-operation service, results should be reported promptly to the officer in charge.

31. BEFORE-OPERATION SERVICE ITEMS.

a. Item 1, Tampering and Damage. Check for injury to the power unit that may have resulted from falling debris, shell fire, sabotage, collision, and booby traps. Look for signs of tampering and sabotage, such as loosened or damaged accessories or drive belts.

b. Item 3, Fuel, Oil, and Water. Check the amount of fuel in the tanks, noting any indications of leaks or tampering. Add fuel if necessary and check spare fuel cans. Check oil level. Add oil if necessary. Check level and condition of coolant (water or antifreeze solution). Add antifreeze if required.

> **NOTE:** Any appreciable change in levels since the last after-operation service should be investigated and reported to the officer in charge.

DRIVER'S TRIP TICKET AND P. M. SERVICE RECORD						U.S.A. NUMBER
DRIVER'S NAME: J.C. Watkins, PFC						DATE: 18 Oct 1945
REPORT TO: Sgt. R.E. Wood						TIME OUT: 0900
ORGANIZATION: 342 Sig. Service Co.						TIME IN: 1700
DEPARTMENT OR ADDRESS						
KIND OF WORK (or route): Power Supply for AN/FRC-1						
REQUESTED BY (Organization or individual)			DISPATCHER'S SIGNATURE: F.M. Wilson, Capt. Sig. C.			
SPEEDOMETER			HOUR METER			
IN: X	OUT: X	TOTAL MILES: X	IN: 1462	OUT: 1470	TOTAL HOURS: 8	
FUEL ADDED: 8 GALS.	I HAVE PERFORMED THE "PREVENTIVE MAINTENANCE SERVICES" OF THIS FORM AND RECORDED ALL DEFICIENCIES AND ANY ACCIDENT					
OIL ADDED: 3 QTS.	J.C. Watkins — DRIVER'S SIGNATURE					
I HAVE NOTED ALL ENTRIES ON THIS FORM AND TAKEN THE NECESSARY ACTION: F.M. Wilson, Capt. Sig. C. — DISPATCHER'S, ETC., SIGNATURE						

TRIP OR LOAD RECORD	PASSENGERS OR WEIGHT	SPEEDOMETER OR HOUR METER
FROM	Average	1462
TO	33 amps	1470
TO		
TO		
TO		
TO		
TO		
TO		
TO		

VEHICLE RELEASED AT (Speedometer Hour Meter, date, hour): 1012 hours 1 Oct 1945 0900

OFFICIAL USER (Signature and Grade): J.C. Watkins

WAR DEPARTMENT FORM 48
APPROVED 15 DECEMBER 1944

TL90399S

Figure 16. W.D., A.G.O. Form 48, front, adapted for use with Power Unit PU-53/FRC.

DRIVER'S DAILY PREVENTIVE MAINTENANCE SERVICES

PERFORM THESE SERVICES ACCORDING TO THE INSTRUCTION IN TM 37-2810, OR VEHICLE OPERATOR'S MANUAL.

BEFORE OPERATION SERVICE

1. TAMPERING AND DAMAGE
2. FIRE EXTINGUISHERS
3. FUEL, OIL AND WATER
4. ACCESSORIES AND DRIVES
5. AIR BRAKE TANKS
6. LEAKS - GENERAL
7. ENGINE WARM-UP
8. CHOKE OR PRIMER
9. INSTRUMENTS
10. HORN AND W/S WIPERS
11. GLASS AND R/V MIRRORS
12. LAMPS AND REFLECTORS
13. WHEEL AND FLANGE NUTS
14. TIRES AND/OR TRACKS
15. SPRINGS AND SUSPENSIONS
16. STEERING LINKAGE
17. FENDERS AND BUMPERS
18. * TOWING CONNECTIONS
19. BODY, LOAD AND TARPS
20. DECONTAMINATOR
21. TOOLS AND EQUIPMENT
22. ENGINE OPERATION
23. OPERATOR'S PUBLICATIONS
24. AMPHIBIAN ITEMS
24.1. MAT'L'S HANDLING EQUIP ITEMS
24.2. SPECIAL ENGINEER ITEMS
25. DURING OPERATION CHECK
Electrical controls

OPERATOR'S INITIALS _____

DURING OPERATION SERVICE

26. STEERING BRAKES
27. FOOT AND HAND BRAKES
28. CLUTCH
29. TRANSMISSION
30. TRANSFER
31. ENGINE AND CONTROLS
32. INSTRUMENTS
33. STEERING GEAR
34. RUNNING GEAR
35. BODY AND TRAILER
36. GUNS MOUNTINGS AND ELEVATING, TRAVERSING, GYRO, AND FIRING CONTROLS
37. AMPHIBIAN ITEMS
37.1. MAT'L'S HANDLING EQUIP ITEMS
37.2. SPECIAL ENGINEER ITEMS

OPERATOR'S INITIALS _____

AT HALT SERVICE

38. FUEL, OIL AND WATER
39. TEMPERATURES - HUBS, BRAKE DRUMS
40. AXLE AND TRANSFER VENTS
41. PROPELLER SHAFTS
42. SPRINGS AND SUSPENSIONS
43. STEERING LINKAGE
44. WHEEL AND FLANGE NUTS
45. TIRES AND/OR TRACKS
46. LEAKS - GENERAL
47. ACCESSORIES AND BELTS
48. AIR CLEANERS
49. FENDERS AND BUMPERS
50. TOWING CONNECTIONS
51. BODY, LOAD AND TARPS
52. APPEARANCE AND GLASS
53. AMPHIBIAN ITEMS
53.1. MAT'L'S HANDLING EQUIP ITEMS
53.2. SPECIAL ENGINEER ITEMS

OPERATOR'S INITIALS _____

AFTER OPERATION SERVICE

54. FUEL, OIL AND WATER
55. ENGINE OPERATION
56. INSTRUMENTS
57. HORN AND W/S WIPERS
58. GLASS AND R/V MIRRORS
59. LAMPS AND REFLECTORS
60. FIRE EXTINGUISHERS
61. DECONTAMINATOR
62. * BATTERY AND VOLTMETER
63. * ACCESSORIES AND BELTS
64. * ELECTRICAL WIRING
65. AIR CLEANERS AND BREATHER CAPS
66. * FUEL FILTERS
67. ENGINE CONTROLS
68. * TIRES AND/OR TRACKS
69. * SPRINGS AND SUSPENSIONS
70. STEERING LINKAGE
71. PROPELLER SHAFT, CENTER BEARING AND VENT
72. AXLE AND TRANSFER VENTS
73. LEAKS - GENERAL
74. GEAR CASES
75. * AIR BRAKE TANKS
76. FENDERS AND BUMPERS
77. * TOWING CONNECTIONS
78. BODY, LOAD AND TARPS
79. ARMOR AND FRONT ROLLER
80. VISION DEVICES
81. TURRET AND GUN MOUNTINGS AND ELEVATING, GYRO, TRAVERSING, AND FIRING CONTROLS
82. * TIGHTEN - WHEEL, RIM, AXLE DRIVE FLANGE, AND SPRING U-BOLT NUTS
83. * LUBRICATE AS NEEDED
WDLO NO. _____
DATE _____
84. * CLEAN ENGINE AND VEHICLE
85. * TOOLS AND EQUIPMENT
86. * AMPHIBIAN ITEMS
87. * MAT'L'S HANDLING EQUIP ITEMS
88. * SPECIAL ENGINEER ITEMS

OPERATOR'S INITIALS _____

*THOSE ITEMS MARKED BY AN ASTERISK (*) REQUIRE ADDITIONAL WEEKLY SERVICES AND IT IS MANDATORY THAT THEY BE PERFORMED AS PRESCRIBED.

RECORD ANY ACCIDENT AND ALL DEFICIENCIES, INDICATING IF CORRECTED:

TL90400S

Figure 17. W.D., A.G.O. Form 48, back, adapted for use with Power Unit PU-53/FRC.

c. Item 4, Accessories and Drives. Check all accessories, including air cleaner, oil filter, fuel filters, fuel pump, radiator, fan and shroud for loose connections and mountings. Check pulleys and belts for looseness and wear.

d. Item 6, Leaks, General. Check under the power unit for fuel, oil and water leaks. Check the cooling system for leaks, paying particular attention to the radiator core and connecting hose. Check the engine crankcase, oil filters, oil tanks, and lines for leaks. Check the fuel system for leaks. Trace all leaks to their source and correct or report them to the officer in charge.

e. Item 9, Instruments.

(*1*) *Oil Pressure Gauge.* As soon as the engine starts, check the lubricating oil pressure. Upon starting, the indicating needle on the oil pressure gauge (fig. 15) will read rather high, but as the engine warms up, the reading will drop. The gauge should always register above 5 pounds pressure. If the oil is cold the indicating needle may be slow in registering the pressure. In the event that the oil pressure gauge does not register within 30 seconds after starting, stop the engine immediately. Investigate the cause of failure, and report it to the officer in charge.

(*2*) *Frequency Meter.* Observe whether the frequency meter is operating properly. It should indicate approximately 60 cycles. Deviation should be no more than ½ cycle from 60 cycles when load is applied.

(*3*) *Voltmeter.* The no-load reading should be about 115/230 volts.

(*4*) *Temperature Gauges.* Engine temperature should increase gradually during warm-up period. Extremely low temperature after warm-up period of reasonable length may indicate existing troubles. Investigate and correct them. When the water has reached operating temperature, the indicator on the water temperature gauge (fig. 5) should point to the high side of the RUN range. With the engine warmed up and operating, the indicator needle should always be in the RUN position. Do not permit the engine to run for any extended length of time if the needle stays in either the COLD or HOT positions. The oil temperature gauge is located on the crankcase at the rear of the engine. When the oil in the crankcase reaches operating temperature, the gauge should read approximately 125°F. With the engine warmed up and operating, the thermometer reading should not exceed 180°F.

f. Item 21, Tools and Equipment. See that tools and equipment belonging to the power unit are present, serviceable, and properly mounted or stowed away.

g. Item 22, Engine Operation. Upon starting it is characteristic for a Diesel engine to be a bit noisy. However, such noise will be eliminated as the engine warms up. After engine has reached normal operating temperature, check any unusual noises or abnormal operating conditions which would cause trouble later.

h. Electrical Controls. Add this item to Form 48 (fig. 17). Note if electrical controls operate smoothly, and whether their operation is followed by the proper instrument indications. Notify the officer in charge of faulty operation. Keep the control panel dry and clean. Tighten all connections. See that they have proper clearances and insulation. Check instruments before each period of operation for broken glasses, bent needles, and cracks or breaks in bakelite parts. Blow out all dirt and dust from the control panel with compressed air. Wipe out any accumulated grease or moisture.

i. Item 25, During-operation Check. Start the during-operation services as soon as the load is placed on the generator.

32. DURING-OPERATION SERVICE.

a. General. While the power unit is in operation under its normal load, listen for rattles, knocks, squeaks, or hums that may be an indication of trouble. Look for trouble in the cooling system. Watch for smoke from any part of the power unit. Be alert to detect the odor of overheated components such as the generator or the rheostat. Check for fuel vapor from leaks in the fuel system, exhaust gas, or other abnormal odors. Watch the instruments on the control panels frequently, and note unusual instrument indications that may signify trouble in the system or circuit in which that instrument is used.

b. Procedures. During-operation service consists of following the instructions contained in the items listed below. Make a record of minor defects to be corrected (that cannot be cor-

rected during operation) during the next stop period.

33. DURING-OPERATION SERVICE ITEMS.

a. Item 31, Engine and Controls. Be on the alert for deficiencies in engine performance such as lack of usual power, misfiring, unusual noise or stalling, indications of engine overheating, or unusual exhaust smoke. Notice whether the engine responds to the controls satisfactorily, and see that the controls are in proper adjustment.

b. Item 32, Instruments. Observe the readings of all instruments frequently during operation to see if they are indicating properly.

(*1*) *Water Temperature Gauge.* See that the gauge indicating pointer is in the normal sector on scale (except when operating under unusual conditions). Excessive engine heat usually indicates trouble and should be investigated immediately.

(*2*) *Oil Temperature Gauge.* The oil temperature gauge is located on the crankcase at the rear of the engine. When the oil in the crankcase reaches operating temperature, the gauge should read approximately 125°F. With the engine warmed up and operating, the thermometer reading should not exceed 180°F.

(*3*) *Oil Pressure Gauge.* In case of an unusual drop, or no oil pressure, stop the engine immediately. Report trouble to the officer in charge for correction. Lack of oil pressure may indicate insufficient oil, leaks, or a defective oil pump. Neglect to correct the cause will result in premature wear and damage to the engine.

(*4*) *Frequency Meter.* Check the frequency meter for more than ½ cycle deviation from 60 cycles with a constant load on generator.

34. AT-HALT OR STOP SERVICE.

a. General. The at-halt service should be regarded as minimum battle maintenance. Perform it under all tactical conditions even though the more extensive maintenance services may be slighted or omitted.

b. Procedures. The at-halt service consists of investigating and correcting any abnormal conditions noted during operation. Follow instructions contained in the following items. At the end of the stop period, report immediately any uncorrected conditions to the officer in charge.

35. AT-HALT OR STOP SERVICE ITEMS.

a. Item 38, Fuel, Oil, and Water. Check the Diesel fuel supply to see that it is adequate to operate the unit until the next refueling time. Fill tank if necessary. Make sure the fuel is clean and is of good quality. It is recommended that the fuel tank be filled at the end of the day's run if prevailing temperature is below freezing. This practice eliminates the possibility of condensation forming inside the tank. Replace fuel tank filler cap and see that vent hole therein is open at all times to assure a proper flow of fuel. Check oil level dip stick for oil level within reservoir (fig. 5). Add crankcase oil if necessary to bring oil level to FULL. Check coolant to see that it is at proper level; add coolant if necessary. Do not fill the radiator to overflowing; leave sufficient space (2 inches) for expansion. Never pour cold water into an empty system, if engine is hot, as it may cause cylinder or cylinder head to crack. Always pour water slowly to avoid sudden temperature changes within cooling system.

b. Item 39, Temperature. The generator bearing housings and the generator frame may get too hot to touch under normal operating conditions. Be alert for the odor of burning rubber insulation and insulation varnish. Report such odors to the officer in charge.

c. Item 46, Leaks, General. Check beneath the unit for indications of leaks. Check to see whether oil is leaking from the crankcase, oil tanks, oil filter, or lines. Check the cooling system for leaks, paying particular attention to the radiator core and connecting hose.

d. Item 47, Accessories and Belts. Check to see that all accessories, fan, air cleaner, fuel pump, fuel oil filters, etc. are secure and that fan and drive belts are in correct adjustment and are not frayed. Adjust the belts (par. 54 (item 29)) only in emergencies. Ordinarily, the operator should report them for handling by the unit mechanic.

e. Item 48, Air Cleaner. If operating under extremely dusty or sandy conditions, inspect the air cleaner (fig. 5) and breather cap (fig. 5) to see that they are in condition to filter the air properly. Service if necessary (par. 37).

f. Item 51, Body and Tarpaulin. Inspect the entire power unit chassis and skid base. Check

the tarpaulins (if used) to see that they are not damaged, and are properly secured if in place over the unit, or folded if not in use.

36. AFTER-OPERATION AND WEEKLY SERVICE.

a. General. When performing the after-operation service, remember any irregularities noticed during the operation of the unit, in the before-operation, during-operation, and at-halt services. Lubricate the equipment as soon as the unit is stopped so that, if draining of the crankcase is necessary, the oil will not have settled and will be in a free flowing condition. Perform the after-operation service in such a manner as to reduce the before-operation service to an absolute minimum. The after-operation service will be performed by the unit operator preceding any weekly service which will be performed by the unit mechanic. The operator will assist the unit mechanic in the performance of all scheduled weekly preventive maintenance service. The weekly preventive maintenance service will consist of appropriate items listed on W.D., A.G.O. Form No. 461.

b. Procedures. The after-operation service consists of following the instructions contained in items given below. Certain items of the after-operation service that are marked on W.D. Form 48 by an asterisk require additional weekly service. The procedures for the additional weekly service are indicated in subparagraph (2) of each applicable item that follows.

37. AFTER-OPERATION AND WEEKLY SERVICE ITEMS.

a. Item 54, Fuel, Oil, and Water.

(*1*) Check coolant level and replenish if necessary, taking care to leave sufficient space for expansion. If an appreciable amount of coolant is required, especially in freezing temperature, check the value of the antifreeze. Fill fuel tank. Bring engine crankcase oil to proper level. Refill spare fuel, oil, and water cans. If an unusual amount of oil or coolant is required for the engine, check for leaks and report the condition.

(*2*) During the period when antifreeze is in use, have hydrometer test made of coolant weekly.

b. Item 55, Engine Operation. Check to see that the engine functions satisfactorily. Note any tendency of engine to miss or backfire, or any unusual engine noise or vibration that might indicate worn parts, loose mountings, or incorrect fuel mixture. Correct or report any unsatisfactory engine operating characteristics noted during operation.

c. Item 56, Instruments. Check all instruments to see that they are securely mounted, properly connected, and undamaged.

d. Item 63, *Accessories and Belts.

(*1*) Check all accessories, generator, exciter, regulators, and fan for loose connections in couplings or mountings. Check the adjustment of the fan and drive belts. Belts should deflect ¾ to 1 inch. Report loose or unserviceable belts to the officer in charge.

(*2*) Tighten or adjust any loose connections, linkage, or mountings on accessories. Examine all belts for fraying, wear, cracking, or presence of oil. Check all belts halfway between their respective pulleys to determine whether the belts are properly adjusted. Loose belts may cause improper operation and the unit may become damaged. Tight adjustment, on the other hand, will cause abnormal wear and stretch to belts, and places undue strain on both engine and generator bearings. Ordinarily, the operator should not adjust the belts except in an emergency. Report improper adjustment or unserviceable belts to the officer in charge.

e. Item 64, *Electrical Wiring.

(*1*) Check all control circuit wiring to see that it is securely connected, clean, and undamaged.

(*2*) Check all easily accessible wiring to see that it is securely connected and supported, that the insulation is not cracked or chafed, and that its conduits and shielding are in good condition and secure.

f. Item 65, *Air Cleaners and Breathers.

(*1*) Check to see that oil in the air cleaner is at the correct level and not excessively dirty. Excessive dirt in the oil may be felt with the fingers. If the oil in the cleaner is excessively dirty, clean and refill the cleaner bowl with fresh oil. If operating in sandy or dusty territory, remove the air cleaner and breather more often. In order to keep abrasive dirt out of the engine, the air cleaner and breather must be

kept clean and properly serviced at all times.

(*2*) Remove and disassemble the air cleaner (par. 54 (item 34)). Clean the bodies and elements in dry-cleaning solvent (SD). Fill the reservoirs to the correct level with clean engine oil. Apply engine oil to the element and allow excess to drain. When reassembling the cleaner, make sure the gasket is in good condition and in place. Reinstall the air cleaner, giving special attention to mountings to see that the cleaner is pressed firmly in place against the air horn seals, correctly aligned, and secure. Also check to see that all ducts connecting the air cleaner to the engine are secure and not damaged.

g. Item 66, *Fuel Filters.

(*1*) Examine fuel filters for leakage, damage, and loose mounting.

(*2*) Remove drain plug to allow water and sediment to drain out of the filter bowl. Replace the drain plug, tighten it securely, and note whether fuel is leaking from the drain plug.

h. Item 67, Engine Controls. Check for possible wear or damage to compression release lever (fig. 14). Check for worn or disconnected linkage between governor and fuel injection control rod.

i. Item 73, Leaks, General. Check beneath the unit for fuel, oil, or water leaks. Trace all leaks to their source and correct or report them.

j. Item 78, Body and Tarpaulin. Inspect the power unit carefully for damage or loose parts. Lash all ropes securely, if used. Check tarpaulin, if used, for rips or holes.

k. Item 83, *Lubricate as Needed.

(*1*) Items that are normally lubricated by the operator should be lubricated if inspection indicates the necessity. See lubrication chart (fig. 19).

(*2*) Lubricate in accordance with the lubrication order. Lubricate all points shown on the lubrication chart requiring weekly lubrication. The need for more frequent lubrication than is provided by regular lubrication schedule is usually due to abnormally hot, wet, or dusty operating conditions (par. 48).

l. Item 84, *Clean Engine.

(*1*) Remove dirt, grease, and excess oil from the exterior of the engine.

(*2*) Wipe greasy surfaces of unit thoroughly with dry-cleaning solvent (SD). Do not rub lusterless paint enough to create a shine that might cause reflection. If unit is cleaned, take care to see that the solvent or dirt does not get into the bearings, fuel tank, or crankcase.

m. Item 85, *Tools and Equipment.

(*1*) Check unit packing lists to see that all tools and equipment assigned to the unit are present and properly stowed or mounted.

(*2*) Clean all tools and equipment of rust, mud, or dirt, and see that they are in good condition. Report missing or unserviceable tools to the officer in charge.

n. Electrical Controls (W.D. Form 48 (fig. 17)).

(*1*) Check mechanical operation of all switches, circuit breaker, rheostat, relay, voltage regulator, and other electrical controls.

(*2*) Inspect controls for tightness of mounting, condition of wiring, and cleanliness. Tighten loose mounting screws or bolts and terminal connections. Remove any accumulation of dust, dirt, grease, or other foreign matter from control mechanisms and from the control boxes.

o. Power Connections.

(*1*) Inspect all leads for secure connections and condition. Check all terminals and lugs for corrosion, loose connections, and fungi.

(*2*) Tighten all loose connections or mountings. Clean terminal surfaces if they are corroded or dirty. Notify the officer in charge if leads or cables are broken or insulation is frayed, cracked, or stripped from the conductors.

SECTION VIII. LUBRICATION

38. LUBRICATION INSTRUCTIONS.

a. Lubrication is an essential part of preventive maintenance, determining to a great degree the serviceability of parts and assemblies.

b. It is extremely important that the lubricants and lubricant containers be kept clean and free from foreign matter, and that each lubricating point be well cleaned before lubricant is applied.

c. In the field it may not always be possible to supply the complete assortment of lubricants called for in the lubrication chart. In such cases, it will be necessary to make the best use of those that are available, subject to inspection by the officer concerned, and in consultation with all responsible personnel.

39. DAILY.

After the power unit has been operating for 1 day, proceed as follows:

a. Crankcase Oil Level. Check oil level with crankcase gauge and add sufficient new oil to bring level up to FULL mark on gauge. To check oil level, remove the gauge, wipe the gauge clean and insert it into place until felt washer under ring handle of gauge rests firmly against the casting. Remove the gauge again and read oil level. Marks on the gauge clearly indicate LOW and FULL levels. For cold weather lubrication, see cold weather note on the lubrication chart (fig. 19).

b. Air Cleaner. Check to see that the oil in reservoir is up to indicated level (fig. 18). If necessary, add engine oil (OE) as specified on the lubrication chart.

c. Valve Stem Oiler Assembly. Be sure that wicks in valve stem oiler assembly (fig. 19) are saturated with fuel oil to assure proper lubrication to valve stem guides to prevent valves sticking. Fill cups with fuel oil. Do not use lubricating oil in these valve stem oilers as it will have a tendency to gum up the guides.

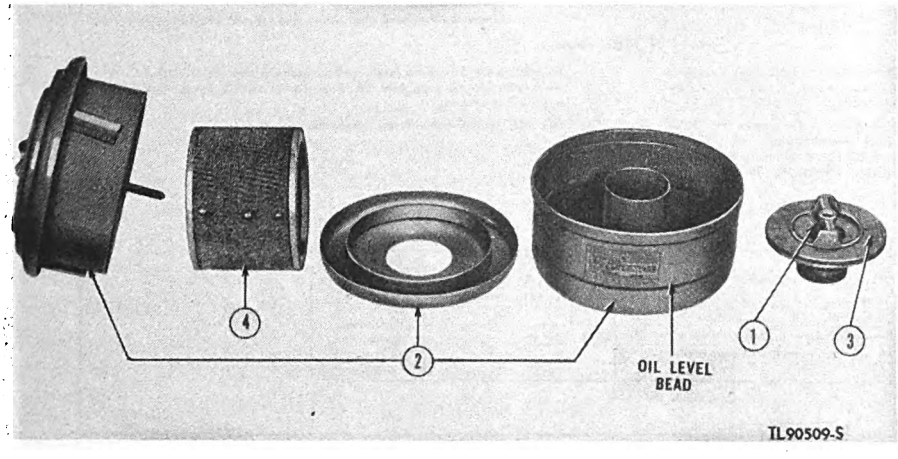
d. Rocker Arm Assembly. Wipe off oil cups. Raise lids and check to see that cup body contains an ample quantity of lubricating oil (OE) to lubricate the rocker arms, the rocker arm rollers, and push rod sockets. Lubrication of these should be oiled with a hand oiler in accordance with the lubrication chart.

40. WEEKLY.

a. Routine. Check all points covered under the daily check (par. 39).

b. Fuel Oil Sediment Bowl. Loosen thumbnut at top of bowl, swing bail aside and remove bowl, gasket, and strainer. Clean strainer and inside of bowl, replace bowl, swing bail in position and tighten thumbnut. In cleaning, handle the small screen with care; any damage to the screen will permit water and dirt to pass through the screen.

c. Primary Fuel Filter. Disconnect the fuel lines connected to the primary fuel filter (fig.



LEGEND FOR FIGURE 18

1. Base, filter.
2. Bowl, air cleaner.
3. Gasket, cork.
4. Filter element, air.

Figure 18. Air cleaner, disassembled.

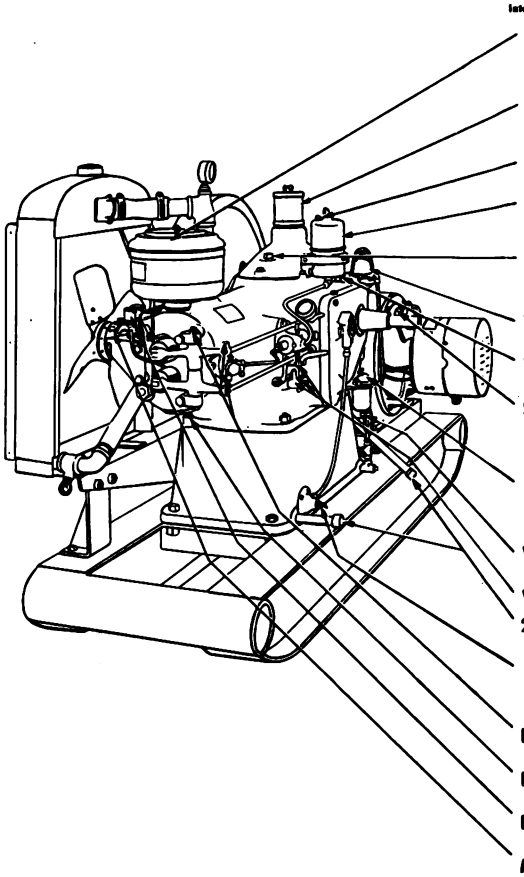
LUBRICATION CHART

POWER UNIT PU-53/FRC

(Witte Engine Model MD-282)

Clean parts with SOLVENT, dry cleaning, or with OIL, Fuel, Diesel. Dry before lubricating.

Intervals given are maximums for normal 8-hour day operation. For abnormal conditions of activities, intervals should be shortened to compensate.



Interval - Lubricant

D	OE	**Air Cleaner** Check level and refill to level mark Every W, remove, drain, clean and refill Every M, remove and wash all parts
W	OE	**Crankcase Breather** Remove, wash, dry thoroughly and saturate element with OE. Permit excess OE to drain, then replace
W		**Fuel Filter Bleeder Plug** Remove screw plug to release any accumulated air, replace plug
3M		**Fuel Filter** One time use only, remove when clogged and replace with new filter
2W		**Crankcase Fill** Between crankcase drain intervals if necessary to add oil, remove breather and lift crimped washer from seat inside cover. After draining, remove crankcase cover to refill crankcase
W		**Fuel Strainer** Remove and clean sediment bowl and screen
W		**Fuel Filter Drain Plug** Remove drain plug and drain water and sediment, replace plug
S	WB	**Power Generator Bearing (Both Ends)** Remove generator end bells and grease fill and drain plugs, insert grease fitting and lubricate sparingly with WB grease. Run power generator until operating temperature is reached to expell excess lubricant, then replace fill and drain plugs
½D		**Fuel Filter** Turn handle 1 full turn. Every M, remove metal filter cartridge, clean discs and blades. Refill with clean oil, fuel, Diesel. Caution: Do not take discs and blades apart when cleaning.
W		**Fuel Filter Drain Plug** Remove drain plug and drain water and sediment, replace plug
W	OE	**Governor Ball Crank and Linkage**
2W	OE	**Crankcase Drains** Drain and refill. Cap. Approx. 8 QTS.
½D		**Oil Filter** Turn handle 1 full turn. Every M, remove metal filter cartridge, clean filter discs and blades. Caution: Do not take discs and blades apart when cleaning
D	OE	**Rocker Shaft Bracket and Valve Rocker Arms** Fill oil cups
D		**Crankcase Level Gage** Check level
D		**Valve Stems** Saturate wicks in oilers with OIL, Fuel, Diesel
M	OE	**Fan Bearing** Remove Guard to reach plug. Remove plug and refill with OE

NOTES

1. CRANKCASE—Drain only when hot. Refill to FULL mark on gage. Run engine a few minutes and recheck oil level. Caution: Be sure pressure gage indicates oil is circulating.
2. COLD WEATHER NOTE—Below 0°F, drain crankcase. Refill crankcase with 6 qts. OE 10, check level and mark this level "X" on the gage. Add 2 qts. OIL, Fuel, Diesel to bring level from "X" to FULL mark. During operation maintain at "X" level mark by adding OE 10. Immediately before shutdown fill to "X" level mark with OE 10, then add OIL, Fuel, Diesel to FULL mark. Run engine five minutes.
3. DO NOT LUBRICATE—Power generator exciter.

KEY

LUBRICANTS	EXPECTED TEMPERATURE			INTERVALS
OE-Oil, engine	Above 32°F	32°F to 0°F	Below 0°F	½D–4 Hrs.
Crankcase	OE 30	OE 10	See cold weather note	D–Daily
Except crankcase	OE 30	OE 10	PS	W–Weekly
WB-Grease, general purpose, No. 2 all temperatures.				2W–2 Weeks
PS-Oil, lubricating, preservative, special.				M–Monthly
				3M–3 Months
				S–6 Months

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Figure 19. Lubrication chart, Power Unit PU-53/FRC.

19). Remove the six screws holding the filter unit to the filter housing. Clean the filter thoroughly in dry-cleaning solvent (SD), and clean the inside of the filter housing with a lint-free rag. Replace the filter in the housing, secure the six screws and lockwashers, and reconnect the fuel lines to the filter.

d. Final Fuel Oil Filter Drain. Remove the drain plug (fig. 27) in the bottom of the final fuel filter for 5 to 10 seconds while the engine is running. Flush the filter of water or sediment, then close the drain plug.

e. Air Cleaner. Thoroughly clean the outside of the air cleaner, especially at connection to air cleaner body. Unscrew wingnut and remove assembly. Empty out old oil, clean and refill oil cup to oil level bead. Use engine oil (OE) as specified in the lubrication chart.

f. Fan Bearing. Remove guard to reach plug. Wipe away all dirt from fan hub. Remove screw in fan bearing housing and refill with engine oil (OE) using hand oiler (fig. 19).

g. Oilcan Points. Lubricate the governor-to-injection pump linkage and the compression release lever bearing with a few drops of lubricating oil (OE). Lubricate the pawl and handle bearing on the engine starting crank. Fill the three oil cups on the valve rocker arms (not the oil cups on the cylinder head) with lubricating oil (OE). Be sure to wipe off dust and dirt from parts before lubricating them, and wipe off excess oil from around the parts after lubrication.

41. SEMIMONTHLY.

a. Routine. Check all points covered under the weekly check (par. 40).

b. Crankcase Drain.

(*1*) *At Temperatures Above 0°F.* With the engine hot, remove the oil reservoir drain pipe cap from the base of the engine (fig. 19), and the crankcase drain pipe cap, and allow the oil to drain into a pan or other suitable receptacle. DO NOT USE ANY FLUSHING AGENT. Replace the drain pipe caps and refill the reservoir with clean engine oil (OE) according to temperature conditions above 0°F, as shown on the lubrication chart, to FULL mark on the gauge. The capacity of the lubricating oil reservoir is 10 quarts. Run the engine a few minutes and recheck oil level. Add oil if necessary. Check oil pressure gauge. Make sure the gauge indicates that the oil is circulating.

(*2*) *At Temperatures Below 0°F.* With the engine hot, remove the drain pipe caps from the base of the engine and the crankcase and allow the lubricating oil to drain into a suitable receptacle. Refill the reservoir with 8 quarts of engine oil (OE) SAE 10. Check the oil level and mark with an X on the bayonet gauge. Add 2 quarts Diesel fuel oil to bring the level mark from X to FULL. During operation keep the oil level in the crankcase at the X mark by adding engine oil (OE) SAE 10. Immediately before shut-down, fill to X mark with engine oil (OE) SAE 10 and then add Diesel fuel oil to the FULL mark. Start the engine and run it for 5 minutes to circulate the fuel oil mixture.

c. Oil Filter. After each draining of lubricating oil from the crankcase preparatory to refilling, the handle on the oil filter unit should be turned by hand several times each way. This expells all grit, dirt or other foreign matter from the cleaning element of the filter unit, permitting free flow of clean oil into lubricating oil lines. In case the cleaners should be stuck tight so that the handle cannot be turned by hand, the oil filter should be removed and thoroughly cleaned. NEVER USE A WRENCH OR OTHER TOOL IN ENDEAVORING TO TURN HANDLE OF FILTER WHICH HAS BECOME CLOGGED. As a precautionary measure, the filter should be removed about every 4 months and rinsed in dry-cleaning solvent (SD) to remove all dirt or gum. After cleaning, turn filter handle several times to check for free movement of laminated cleaning disks, then replace filter unit with sub-base and turn down holding screws tightly.

e. Crankcase Breather (fig. 19). Remove and disassemble the crankcase breather assembly by removing the thumbscrew on top of the breather. Clean wire mesh element thoroughly by washing it with dry-cleaning solvent (SD). Saturate it with engine oil (OE), clean the exterior of the breather, reassemble, and install.

42. MONTHLY.

a. Routine. Check all points covered under the weekly check (par. 40).

b. Air Cleaner. Remove entire air cleaner unit from the engine. This is done by unscrew-

ing the wingnut hold-down bolt, removing cover and lifting the assembly out of the body. Then remove the body by giving it a slight upward jolt on its under side. Drain oil from bowl. Wash the bowl, filter assembly, and all other parts with Diesel fuel oil or dry-cleaning solvent (SD), removing all dirt and sediment. Allow all parts to dry thoroughly. Refill the bowl with clean engine oil (OE) to level of the bead located about 1½ inches above bottom of outer bowl. Reassemble the air cleaner and replace it on the engine making sure all connections are tight.

43. AFTER EVERY THREE MONTHS OF OPERATION.

a. Routine. Check all points covered under the weekly check (par. 40).

b. Power Generator Bearing (Both Ends). Remove generator end bells and grease, fill and drain plugs (fig. 20). Insert grease fitting and lubricate sparingly with WB grease. Run power generator until operating temperature is reached to expell excess lubricant, then replace fill and drain plugs. Avoid overlubrication.

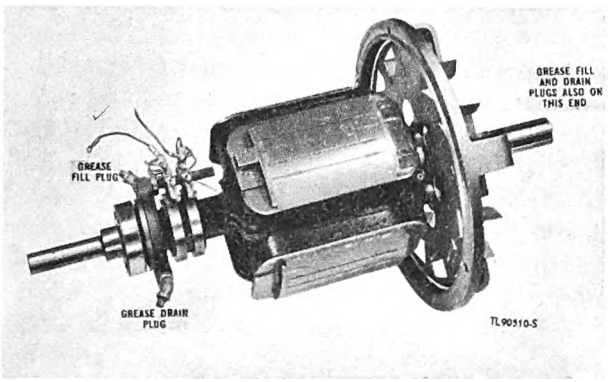

Figure 20. Power generator grease fill and drain plugs.

c. Fuel Oil Filter (fig. 19). Loosen hexagon head cap screw at top of unit to release air trapped within the filter. Remove plug located at bottom of filter and allow unit to drain off any water which may have collected therein. Tighten down air vent nut and replace drain plug.

44. AFTER EVERY SIX MONTHS OF OPERATION.

a. Routine. Check all points under the 3-month check (par. 43).

b. Fuel and Oil Lines. Disconnect and remove all fuel and lubricating oil lines. Clean them thoroughly, inside and out, removing all grit, dirt, or other foreign matter. Flush lines with Diesel fuel oil or dry-cleaning solvent (SD) and allow to dry before reconnecting lines into place.

c. Fuel Oil Filter (fig. 19). Disconnect fuel lines to fuel oil filter unit. Loosen cap screw and nut on encircling clamp and remove oil filter unit and discard. Replace with new filter unit. Position new filter into place and tighten cap screw and nut on clamp. Reconnect fuel lines and tighten connections.

NOTE: Under normal operating conditions and after 2,000 or 3,000 hours of engine operation (its life depending on the quality and freedom from dirt of the fuel used), the filter will have become loaded with foreign material. The filter unit cannot be disassembled and cleaned; but should, upon becoming clogged, be discarded and replaced with a new filter.

45. LUBRICATION UNDER SPECIAL CLIMATIC CONDITIONS.

a. Extreme Humidity. In a climate of high humidity as in the tropics, metal parts corrode and rust more rapidly than in dry climates. Light application of preservative oil (PE) on nuts, bolts and infrequently used adjustment parts will prevent them from corroding and aid in disassembling the equipment when necessary.

b. Extreme Heat, Sand and Dust.

(*1*) *General.* Take all possible care to keep dust, dirt and sand from getting on lubricated parts. Instead of adding new lubricant at regular intervals, clean the parts whenever practicable, and relubricate them. Inspect and clean the equipment daily. Inspect the air cleaner and oil filter daily for accumulation of sand and dust and clean them whenever necessary. Lubrication must be performed frequently, and smaller amounts of lubricant used to avoid excessive leakage around seals. If excessive leakage develops, inspect the seals and if worn, replace them.

(*2*) *Crankcase Oil.* The crankcase drain interval should be reduced from semimonthly depending on the condition of the oil. Check the oil level daily, and bring up to the level mark if necessary, by adding clean lubricating oil.

(*3*) *Air Cleaner.* Rub the finger along the bottom of the inside of the oil cup, and if any

amount of sand or grit has accumulated, drain the bowl, clean it, and refill with clean oil. Keep crankcase breather clean at all times.

(*4*) Supplies. Prevent sand and dirt from getting into supplies of fuels, oil, or grease when in storage and when being transferred to equipment.

c. Cold Weather Operation. When operating in extremely cold temperatures, drain the engine crankcase when the unit is to remain shut down for a period of several hours. Drained lubricating oil should then be stored in a warm place for future use. Attach a tag to the unit, as a warning to others, that the crankcase must be filled before operating the unit. See the lubrication order attached to the unit for the correct lubricants to use under various temperature conditions. For additional information on cold weather lubrication, see cold weather note on the War Department Lubrication Order.

46. RECORDS AND REPORTS.

a. Records. A complete record of lubrication must be kept for each power unit.

b. Reports. If lubrication instructions are followed and proper lubricants used, and satisfactory results are not obtained, make a report to the officer in charge.

SECTION IX. UNIT MECHANICS' PREVENTIVE MAINTENANCE TECHNIQUES

47. SCOPE.

a. Preventive Maintenance Services. Regular scheduled maintenance inspections and services are a preventive maintenance function of the using arms, and are the responsibilities of commanders of operating organizations. An efficient control system is an essential aid in determining when power units are due for periodic maintenance services, either because of time elapsed or hours operated.

b. Frequency. The frequency of the preventive maintenance services performed by unit mechanics (or other designated maintenance personnel) outlined in this section is considered a minimum requirement for normal operation of Power Unit PU-53/FRC. Under unusual operating conditions, such as extreme temperatures or dusty or sandy terrain, it may be necessary to perform certain maintenance services more frequently.

c. First Echelon Participation. The operators should be present and should assist mechanics while periodic second echelon preventive maintenance services are performed. Ordinarily the operator should present the power unit for a scheduled preventive maintenance service in a reasonably clean condition; that is, it should be dry and not be caked with mud or grease to such an extent that inspection and servicing will be seriously hampered. However, the power unit should not be washed or wiped thoroughly clean, since certain types of defects, such as cracks, leaks, and loose or shifted parts or assemblies, are more evident if the surfaces are slightly soiled or dusty.

d. Technical Inspections.

(*1*) These inspections are performed by technically qualified personnel (usually third echelon or higher), directly supervised by technically qualified officers. Technical inspections are made for the following purposes:

(*a*) To determine whether the power supply should be continued in service or withdrawn for overhaul or reclamation of component parts.

(*b*) To determine the extent of damage and estimate the cost of repair in report of survey and other similar proceedings.

(*c*) To investigate causes of difficulties encountered by combat troops with the power unit so that efficiency may be improved.

(*2*) Whenever the power unit is repaired by a third or higher echelon maintenance shop it will receive a technical inspection to make sure all defects have been corrected before it is returned to the using organization.

(*3*) Except in a theater of operations, technical inspections will be made whenever power unit accountability is transferred to determine power unit conditions.

48. RECORDS AND REPORTS.

a. Unit Mechanics' Maintenance and Technical Inspection. The following War Department forms for use as work sheets, referred to in TM 37-2810 and here modified to Signal Corps requirements for use with power units, are provided to serve as reminders and records of the unit mechanics' preventive maintenance services and technical inspections:

(*1*) W.D., A.G.O. Form 461 (Preventive Maintenance Service and Technical Inspection Work Sheet for Wheeled and Half-Track Vehicles), adapted (by elimination of solely vehicular items) to power units above 2.5 kilowatts which are used by the Signal Corps (fig. 22).

(*2*) The columns headed *6000 Mile* and *1000 Mile* on W.D., A.G.O. Form 461 are comparable to the semiannual and monthly maintenance of power units used by the Signal Corps. Make notations to that effect on this form. The column headed Tech Insp applies without modification to power units.

(*3*) The general procedures listed in paragraph 54 are to be applied in conducting the maintenance services and technical inspection. The manner in which each item listed on the form is to be inspected and serviced is explained in detail in paragraph 51.

(*4*) Technical inspections are usually performed by third echelon. The maintenance services are performed by unit mechanics (second echelon).

(*5*) If instructions other than those contained in either the general or the specific procedures are required for the correct performance of preventive maintenance service or for the correction of a deficiency, consult the signal officer in charge.

b. Use of W.D., A.G.O. Form No. 460 (fig. 21). Preventive maintenance services will be scheduled over a 31 day period. The inside right-hand page of Form No. 460 contains 31 columns for the 31 days of a month. The adjacent columns on the left-hand page will be used to list the rank and name of operator, equipment nomenclature, remarks, unit serial number (this will be the number assigned the unit by the using organization and not that of the piece of equipment). Only one line for each power unit will be used to record the periodic maintenance services performed during the month.

c. Recording Services. Services will be recorded on the corresponding line with the nomenclature of each power unit.

d. Legend. In the column representing the appropriate date, the symbol legend for weekly W, monthly M, semiannually S, will be entered. The letter symbol P will be used to indicate equipment deadlined for lack of parts. The letter symbol A will be used to indicate equipment deadlined because of accident. The letter symbol O will indicate equipment forwarded to higher echelons for repair.

e. Interpretation of Symbols. For purposes of power unit maintenance, any period of 8 operating hours or any number of periods of operation totaling 8 hours will be considered as 1 day; a total of 64 operating hours will be considered as 1 week; a total of 256 operating hours will be considered as 1 month; and a total of 1,024 operating hours will be considered as ½ year.

f. Entries. The officer in charge will plot W.D., A.G.O. Form No. 460 in advance of each monthly period making his entries in pencil. These penciled entries will be traced in with ink when the service is performed. These services will be entered in the appropriate spaces as W_1 indicating the first weekly service, W_2 indicating the second weekly service, and W_3 indicating the third weekly service. These weekly services will be figured from the last preceding monthly service. The monthly services will be figured from the last preceding monthly service. The monthly services will be similarly entered with M_1, M_2, M_3, M_4, and M_5, and will be figured from the last preceding semiannual service of the unit. The letter symbol S will be used to indicate the semiannual service. If the unit is deadlined for lack of parts, accident, or higher echelon repairs, the appropriate symbol will be entered in the proper space for each day that the unit is out of service. When the unit is returned to service, the previously plotted services will be carried out the same as if there had been no interruption of service. In the event that combat conditions make it impractical to perform the scheduled service on the scheduled date, the service will be performed at the earliest opportunity and the regularly scheduled date

NO.	RANK AND NAME	EQUIPMENT NOMENCLATURE	REMARKS	UNIT SERIAL NO.	ACCESSORY	EQUIPMENT REG. NO.
1	P. J. KELLEY T/4	PE-197	FULL SERVICE	12		6542 X
2	T/4 MONROE A.L	PE-95-G	FULL SERVICE	13		45216
3	PFC. MURRY J.C.	PE-75-W	STAND BY	21		15543
4						
5						
6						
7						
8						
9						
10						
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25						
26						
27						

PREVENTIVE MAINTENANCE ROSTER — MONTH — YEAR

NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	NO.
1	W1							W2						W3				P	P			M1							W1		O	1
2				M3							W1	P	P	P				W2			O	O	O	O	W3							2
3		W3							S							W1							W2							W3		3
4																																4
5																																5
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PREVENTIVE MAINTENANCE ROSTER

PLAN YOUR MAINTENANCE IN ADVANCE

WORK YOUR PLAN

ORGANIZATION: 701st Sig. Bn.

MONTH: June 1945

16—43691-1

TL902038

Figure 21. W.D., A.G.O. Form No. 460, adapted for use with Power Units.

circled to indicate that the service was performed. A sample of W.D., A.G.O. Form No. 460, properly filled out is shown as figure 21.

49. PREVENTIVE MAINTENANCE WORK SHEET.

a. General Description of Work Sheet.

(*1*) W.D., A.G.O. Form No. 461 (Preventive Maintenance Service and Technical Inspection Work Sheet for Wheeled and Half-Track Vehicles), adapted for use with Power Unit PU-53/FRC is provided to serve as a reminder and record of the unit mechanics' preventive maintenance services and technical inspections (figs. 22 and 23).

(*2*) The column titles *6000 Mile* and *1000 Mile* on W.D., A.G.O. Form No. 461 are comparable to the semiannual and monthly periods of maintenance of this power unit. Notations to that effect shall be made on this form. The column headed Tech Insp applies without modification to this power unit.

b. Usage of Work Sheet.

(*1*) The general procedures listed in this paragraph are to be applied in performing the maintenance services and technical inspection. The manner in which each item listed on the

PREVENTIVE MAINTENANCE SERVICE AND TECHNICAL INSPECTION

WD No. _____

WORK SHEET

FOR

WHEELED AND HALF-TRACK VEHICLES

(See AR 850-15)

Mileage _____ Date 16 Oct 1945

Organization 342 Sig. Service Co.

Vehicle nomenclature Power Unit (Make) PU-53/FRC (Model) 8 KW (Size) (Drive) (Body Type)

Special instructions: See TM 9-2810 for detailed instructions and procedures. See vehicle maintenance manual for technical information.

Legend for marking: √—Satisfactory X—Adjustment required XX—Repair or replacement required O—Defect corrected

SYMBOLS: □ —INSPECT AND CORRECT C—CLEAN T—TIGHTEN A—ADJUST L—SPECIAL LUBRICATION S—SERVE

~~1000-MILE MAINTENANCE~~ OR TECHNICAL INSPECTION Monthly ~~1000-MILE~~ MAINTENANCE

Line out words and column that do not apply.

ROAD TEST

1 Before Operation Inspection

~~2 Air Pressure (build-up) (governor cut-off) (low-pressure indicator)~~

3 Dash Instruments and Gages: (oil pressure) ~~(tachometer)~~ (ammeter) (voltmeter) ~~(speedometer and odometer) (tachometer)~~ (temperature) (fuel) ~~(air pressure)~~

~~4 Horns, Mirrors, and Windshield Wipers~~

~~5 Brakes: foot, hand and trailer (braking effect) (feel) (side pull) (noise) (chatter) (pedal travel) (hand control air or electric)~~

~~6 Clutch (free travel) (drag) (noise) (chatter) (grab) (slip)~~

~~7 Transmission and Transfer (lever action) (declutching) (vibration)~~ (noise)

~~8 Steering (free play) (bind) (reaction) (shimmy) (side pull) (column and wheel)~~

~~9 Engine (idle) (acceleration) (power) (noise) (governed speed)~~

10 Unusual Noises (attachments) ~~(cab) (body) (wheels or tracks)~~

~~11 Brake Booster Operation~~

~~12 Air Brake System Leaks~~

13 Temperatures (brake drums) (hubs) (axles) (transmission) (transfer)

14 Leaks (engine oil) (water) (fuel)

~~15 Track Tension (final road test)~~

~~16 Gear Oil Level and Leaks (axles) (transmission) (transfer)~~

~~Power Vacuum Brake Survey~~

~~17 Unusual Noises (engine) (belts) (accessories) (transmission) (transfer) (shafts and joints) (axles) (wheel bearings)~~

ENGINE AND ACCESSORIES

18 Cylinder Head and Gasket

19 Valve Mechanism (clearances) (lubrication) (cover gaskets)

~~20 Spark Plugs (gaps) (deposits)~~

21 Compression Test (record)

~~22 Battery (cables) (hold-downs) (cables) (record gravity and voltage)~~

23 Crankcase (leaks) (oil level)

24 Oil Filters, Coolers, and Lines

25 Radiator (core) (shell) (shutters) (mountings) (hose) (cap and gasket) (antifreeze, record) (overflow tank) (steam relief tube and valve)

26 Water Pump, Fan, and Shroud

27 Generator, Starter, and Switch

~~28 Air Compressor (unloader valve) (governor) (lines)~~

29 Drive Belts and Pulleys

~~30 Tachometer Drive and Adapter~~

~~31 Distributor (cap) (rotor) (points) (shaft) (advance units)~~

~~32 Coil and Wiring (high and low voltage) (supports)~~

~~1000-MILE MAINTENANCE~~ OR TECHNICAL INSPECTION Monthly ~~1000-MILE~~ MAINTENANCE

~~33 Manifolds and Heat Control (gaskets) (seasonal setting)~~

34 Air Cleaners (carburetor) (Diesel) ~~(air compressor)~~

~~35 Breather Caps and Ventilators~~

36 Carburetor (choke) (throttle) (linkage) (governor)

37 Fuel Filters, Screen, and Lines

38 Fuel Pump (vacuum and pressure)

~~39 Starter (action) (noise) (speed)~~

40 Leaks (engine oil) (fuel) (water)

~~41 Ignition Timing (advance)~~

~~42 Engine Idle and Vacuum Test~~

~~43 Regulator Unit (connections) (voltage) (current) (cut-out)~~

~~44 Power Tire Pump (drive) (lines)~~

45 Diesel Fuel Injector Pump

46 Diesel Fuel Nozzles and Lines

~~CHASSIS, BODY, & ATTACHMENTS~~

47 *Tires and Rims (valve stems and caps) (condition) (direction) (matching) (spare carriers)

ON HALF-TRACKS DO 106 TO 115 NOW

48 *Rear Brakes (drums) (supports) (cylinders) (cams and shafts) (magnets and armatures)

49 *Rear Brake Shoes (linings) (links) (guides) (anchors)

50 *Torque Rods (bushings) (brackets)

51 *Rear Spring Seats and Bearings

52 *Rear Wheels (bearings) (seals) (drive flanges) (nuts)

53 *Front Brakes (drums) (supports) (cylinders) (cams and shafts) (hose) (air chambers) (push rods and seals) (adjusters)

54 *Front Brake Shoes (linings) (links) (guides) (anchors)

55 *Steering Knuckles (joints) (bearings) (seals) (boots)

56 *Front Springs (clips) (leaves) (U-bolts) (hangers) (shackles)

57 Steering (arms) (tie rods) (drag link) (seals and boots) (Pitman arm) (gear) (column) (wheel)

58 Front Shock Absorbers and Links

59 Knee Action Suspension

60 *Front Wheels (bearings) (seals) (flange) (axle end play) (nuts)

61 Front Axle (pinion end play) (seal) (vent) (alinement)

62 Front Propeller Shaft (joints and alinement) (seals) (flanges)

63 Engine (mountings and braces) (ground strap) (side pans)

~~64 Hand Brake (ratchet and pawl) (linkage) (drum or disk) (lining)~~

~~65 Clutch Pedal (free travel) (linkage) (return spring)~~

~~66 Brake Pedal (free travel) (linkage) (return spring)~~

~~67 Brake Master Cylinder (vent) (fluid level) (leaks) (switch)~~

~~68 Brake Vacuum Booster (linkage) (air cleaner and hose) (cylinder)~~

~~1000-MILE MAINTENANCE~~ OR TECHNICAL INSPECTION Monthly ~~1000-MILE~~ MAINTENANCE

~~69 Air Brake Application Valve~~

70 *Air-Brake Reservoirs

71 Transmission (mountings) (seals) (power take-off) (linkage)

72 Transfer (mountings) (linkage) (seals) (vent) (power take-off)

73 Rear Propeller Shafts (see 62)

74 Center Bearing (seals) (vent) (oil level) (mountings)

75 Rear Axles (pinion end play) (seals) (vents) (alinement)

76 *Rear Air Brake (chambers) (rods and seals) (slack adjusters)

77 *Rear Springs (clips) (leaves) (U-bolts) (hangers) (shackles)

78 Rear Shock Absorbers and Links

~~79 *Cab and Body Mountings~~

80 *Frame (rails and cross members)

81 *Wiring, Conduits, and Grommets

82 Fuel Tanks, Fittings, and Lines

~~83 *Brake Lines (fittings) (hose)~~

84 Exhaust Pipes and Muffler

85 *Vehicle Lubrication

~~LOWER VEHICLE TO GROUND~~

86 Toe-In and Turning Stops

87 Winch (clutch) (brake) (drive) (shear pin) (cable) (guides)

88 Fifth Wheel (bed plate and bolts)

89 Tractor-to-Trailer Brake Hose, Wiring and Connections

90 Hoist (mounting) (drive) (controls) (pump) (lines) (cylinder)

91 *Lamps (head, tail, body, running, directional, stop, and blackout)

92 *Safety Reflectors

93 Front (bumpers) (roller) (tow hooks) (brush guards) (grills)

94 Hood (hinges) (fasteners)

95 Front Fenders and Running Boards

96 Cab or Pass. Body (doors) (hardware) (glass) (top and frame) (curtains and fasteners) (seats) (upholstery and trim) (safety straps and grab rails) (floor boards and mats) (ventilators) (map compartment and tables)

~~97 Heater, Fan, and Defroster~~

98 Circuit Breaker and Fuse Block

~~99 *Rear Fenders and Splash Guards~~

100 *Body (panels) (rear doors) (tailgate and chains) (floor) (skid-strips) (stakes) (sockets) (bows) (tops) (tarpaulins) (end curtains) (troop seats) (stowage compartments)

101 *Rear Bumper and Pintle Hook (latch and lock pin) (draw-bar)

102 Armor Plate (body) (cowl) (doors) (windshield) (port covers)

103 *Paint and markings

104 Radio Bonding (suppressors) (filters) (condensers) (shielding)

~~105 Armament (guns) (mounts) (rails) (spare parts) (covers)~~

*TRAILER ITEMS ALSO COMMON TO OTHER WHEELED VEHICLES

FOLD TO ◀— VEHICLE NOMENCLATURE LINE —▶ AND FILE

TL90511S

W. D., A.G.O. Form No. 461 April 15, 1943

Figure 22. W. D., A.G.O. Form No. 461, front, adapted for use with Power Unit PU-53/FRC.

RECORD: Compression pressure: Cylinder No. 1 ____ 2 ____ 3 ____ 4 ____ 5 ____ 6 ____ 7 ____ 8 ____ 9 ____ 10 ____ 11 ____ 12 ____

BATTERY: SPECIFIC GRAVITY—Cell No. 1 ____ 2 ____ 3 ____ 4 ____ 5 ____ 6 ____ Antifreeze protection to ____ °F

VOLTAGE— Cell No. 1 ____ 2 ____ 3 ____ 4 ____ 5 ____ 6 ____

Man hours required for this 1,000 mile maintenance ____ 6,000 mile maintenance ____ or tech. inspection ____

Driver ____ (Grade or title) Mechanic or inspector ____ (Grade or title)

Repairs by higher echelon entered on Job Order Request No. ____ Supervising officer ____ (Grade or title)

Repairs requested ____ (Date) (Initials) Vehicle forwarded ____ (Date) (Initials) Vehicle returned ____ (Date) (Initials)

Disposition of work sheets: 1000 Mile—May be retained until completion of next 6000 mile, then destroy
6000 Mile—May be retained until completion of next 6000 mile, then destroy
Technical inspection—May be retained until completion of next 6000 mile, then destroy
} EARLIER DESTRUCTION MAY BE ORDERED BY LOCAL COMMAND

REMARKS OR RECOMMENDATIONS: ____

6000-MILE MAINTENANCE
OR TECHNICAL INSPECTION
1000-MILE MAINTENANCE

ITEMS SPECIAL TO HALF-TRACKS

T — 106 Tracks (guides) (tread wear)
CLAT — 107 Sprockets (flanges) (bearings) (seals)
CT — 108 Brake (drums) (supports) (cylinders)
CA A — 109 Brakes Shoes (linings) (links) (guides) (anchors)
CLAT — 110 Idlers (flanges) (bearings)
111 Idler (posts) (shackles) (shafts) (adjusting rods) (brackets)
T — 112 Frame Brackets and Cross Tube
113 Bogie (crab assemblies) (springs and blocks) (guides and slides) (arms and bolts)
CL — 114 Bogie Rollers: Upper and Lower (tires) (bearings) (seals) (bolts)
A A — 115 Track Tension (on ground)

ITEMS SPECIAL TO AMPHIBIANS

NOTE: The following items 116 to 123 are the required minimum maintenance for amphibian vehicles in land operations. For maintenance requirements for water operations, consult the vehicle maintenance manual.

6000-MILE MAINTENANCE
OR TECHNICAL INSPECTION
1000-MILE MAINTENANCE

T T — 116 Rudder and Shearpins, Propeller Strut and Bearing
117 Propeller Shaft Housings (seals) (boots) (plugs)
118 Hull (plugs) (rub strakes) (decks) (hatches) (ventilators) (compartments) (bulkheads) (plates) (frame)
TA TA — 119 Bilge Pumps (drives) (valves) (controls) (lines) (strainers)
T T — 120 Water Propeller (shafts) (joints) (bearings) (stuffing box)
121 Hand Crank Ratchet and Cover
T — 122 Rudder (shafts) (arms) (cables) (rod) (brackets) (stuffing-box)
123 Anchor, Hand Bilge Pump and Boat Hook

ITEMS SPECIAL TO TRAILERS

T — 124 Tow Hitch (king pin) (fifth wheel plates) (lunette) (tongue)
125 Air and Electric Connections
126 Safety Devices (chains) (switch and battery)

~~6000-MILE MAINTENANCE~~
OR TECHNICAL INSPECTION
~~1000-MILE~~ monthly MAINTENANCE

127 ~~Landing gear (shafts) (wheels)~~ (supports) (lock pin) (gears) (crank)
128 Front and Rear Axles
129 Electric Brake (application controller) (load control) (resistor)
130 ~~Parking Brakes (ratchet) (pawl)~~

TOOLS AND EQUIPMENT

131 Tools (vehicle) (pioneer)
132 ~~Fire Extinguishers~~
133 ~~Decontaminator~~
134 First-Aid Kit (if specified)
135 Publications and Form No. 26
136 ~~Traction Devices (chains) (plates and connectors) (grousers)~~
137 ~~Tow (chain) (cable) (rope) (block)~~
138 ~~Spare (shearpins) (fuses) (bulbs)~~
139 Fuel and Water Cans and Bracket
140 Fuel Can Nozzle and Bucket
141 Modifications (FSMWO's completed)
142 Final Road Test (repeat items 2 to 16)

NOTE: Correct or report all deficiencies found during final road test.

U. S. GOVERNMENT PRINTING OFFICE: 1943 O - 522386
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Figure 23. W.D., A.G.O. Form No. 461, back, adapted for use with Power Unit PU-53/FRC.

form is to be inspected and serviced is explained in detail in paragraph 53.

(2) If instructions other than those combined in either the general or the specific procedures are required for the correct performance of a preventive maintenance service or for the correction of a deficiency, consult the signal officer in charge.

NOTE: Second echelon personnel must be so thoroughly trained in these procedures that they will apply them automatically.

c. Adapting Work Sheet for Use with Power Unit PU-53/FRC.

(1) Enter all of the required identification data for the power unit in the space provided at the top of each form. The unit nomenclature should be complete; the serial number, operating organizations, data, and hours of operation should also be recorded.

(2) In order to indicate on the work sheet whether one of the periodic preventive maintenance services or the technical inspection is being performed, line out all words in the headings that do not apply to the service or inspection to be performed.

d. Explanation of Work Sheet. Opposite each item on these work sheets, a rectangle or box is placed, either under the periodic maintenance service heading, under the technical inspection heading, or under both. These boxes indicate which of the maintenance services or inspection is to be performed for each item. Each box indicates that the item is to be inspected and corrected when necessary. Special service symbols like C, T, A, L, or S appear in some of the boxes. These symbols indicate that certain additional mandatory services are to be performed, and are explained in detail in subparagraph f below.

NOTE: If possible, all defects should be corrected upon discovery, or reported or delivered to a higher echelon for correction.

e. General Explanation of Procedures.

(1) The general inspection of each item also applies to any supporting member or connection, and usually includes a check to see whether the item is in good condition, correctly assembled, secure, or excessively worn. The mechanics must thoroughly understand the following explanations:

(2) The inspection for *good condition* is usually an external visual inspection to determine whether the unit is damaged beyond safe or satisfactory limits or whether it is in such a condition that damage will result during operation. The term *good condition* is explained further by such terms as the following: not bent or twisted, not chafed or burned, not broken or cracked, not bare or frayed, not dented or collapsed, not torn or cut, not deteriorated, and adequately lubricated.

(3) The inspection of a component to see that it is *correctly assembled* is usually an external visual inspection to determine whether it is in its normal assembled position in the unit.

(4) The check of a component to determine whether it is *secure* is usually an external visual inspection or a hand-feel, a pry-bar, or a wrench check for looseness in the unit. Such an inspection will always include any brackets, and all lockwashers, locknuts, locking wires, or cotter pins, used to secure the tightening.

(5) The frequently used term *excessively worn*, will be understood to mean worn close to or beyond serviceable limits, and likely to result in failure if not replaced before the next scheduled inspection.

f. Explanation of Service Symbols. Special service symbols, as applied to the items of the periodic preventive maintenance services, indicate that the part is to receive certain mandatory services. For example: a T in an inspection box indicates that the part must not only be secure, but that the mounting bolts must be tightened properly with a wrench. These symbols are:

(1) *A, Adjust.* Make all necessary adjustments in accordance with the technical manual, special bulletins, or other current directives.

(2) *C, Clean.*

(a) Clean components of the power unit to remove lubricant or dirt, using specified dry-cleaning solvent (SD). After the parts are cleaned, rinse them in clean fluid and dry them well. Take care to keep the parts clean until reassembled. Keep cleaning fluid away from rubber or other material which it will damage.

(b) Clean the protective grease coating from new parts. This material is usually not a

good lubricant.

(*3*) *L, Special Lubrication.* Special lubrication (L) applies either to lubrication operations that do not appear on the lubrication order, or to items that do appear on the order but should be performed in connection with the maintenance operations if parts have to be disassembled for inspection.

(*4*) *S, Serve.* Compliance with the symbol S usually consists of performing special operations, such as replenishing battery water; draining and refilling units with oil; and changing or cleaning the fuel or oil-filter cartridge.

(*5*) *T, Tighten.* All tightening operations should be performed with sufficient wrench torque (force on the wrench handle) to tighten the unit according to good mechanical practice, using the proper tool without an extension handle. Use a torque-indicating wrench where specified. Do not overtighten, as this may strip threads. Tightening will always be understood to include the correct installation of lockwashers, locknuts, and cotter pins or locking wires provided to secure the tightening.

g. Recording of Markings on Work Sheet. The equipment condition and the correction of defects should be indicated by the following markings:

(*1*) Mark the box with a ✓ if found satisfactory.

(*2*) Mark the box X if adjustment is required.

(*3*) Mark the box XX if repair or replacement is required.

(*4*) When a defect is found and not corrected immediately, or if correction is to be made by higher echelon, explain under REMARKS, using the item number for identification. When such a defect is corrected, either by organization mechanics or by higher echelon mechanics, encircle the X or XX; for example: (X) or (XX).

h. Determining Higher Echelon Participation. The following considerations will determine whether a maintenance operation should be referred to a higher echelon, or performed by the operating organization. Repair to this power unit will be performed in the lowest echelon of maintenance consistent with:

(*1*) Availability of suitable tools.

(*2*) Availability of necessary parts.

(*3*) Capabilities of mechanics.

(*4*) Time available.

(*5*) Tactical situation.

i. Special Conditions.

(*1*) When conditions make it difficult to perform the complete preventive maintenance service at one time, it can sometimes be handled in sections, planning to complete all operations within the week, if possible. All available time at rest periods and in bivouac areas must be utilized if necessary. When limited by the tactical situation, items marked with special service symbols in the boxes should be given first consideration.

(*2*) If a job order (W.D., A.G.O. Form No. 9-76) is used when a power unit is sent to a higher echelon for the correction of any defect beyond the scope of organization maintenance, the job order number will be inserted in the space provided on the reverse side of the form.

j. Handling of Work Sheet.

(*1*) The forms may be reduced to convenient size for filing by folding up the line marked *Vehicle Nomenclature.* They are to be filed only after all items marked X or XX have been corrected.

(*2*) Hold all monthly maintenance work sheets in the organization file until the next semiannual maintenance work sheet is filed, and then destroy them. The semiannual maintenance work sheet, or technical inspection reports, may be held until the next semiannual maintenance form is filed, and then destroyed.

50. PERFORMING ITEMS ON WORK SHEET.

a. Use of W.D., A.G.O. Form No. 461.

(*1*) Perform the items on this form in the numerical sequence in which they are listed wherever possible, since they have been arranged in this sequence for maximum efficiency and economy of motion. The general order of the listed items is:

(*a*) A running test, and closely related items.

(*b*) Maintenance operations, consisting

of operations on the engine and engine accessories.

(*c*) Tools and equipment.

(*d*) Final running test.

(*2*) Line out all items on the form which do not apply to maintenance procedures for Power Unit PU-53/FRC. Figures 22 and 23 show W.D., A.G.O. Form No. 461 with nonapplicable maintenance items deleted.

b. Performing Items on Work Sheet.

(*1*) Specific procedures for performing each item in the monthly and semiannual services and in the technical inspection are described on the following pages. Each of these pages of specific procedures has three columns at its left edge, corresponding to the monthly maintenance, the semiannual maintenance, and the technical inspection of W.D., A.G.O. Form No. 461, respectively. While the semiannual maintenance and technical inspection are both indicated in the same column on the work sheet, separate columns are provided in the procedure pages for clarification. The detailed procedures for each maintenance service and technical inspection will be found in the procedure columns opposite the item numbers.

(*2*) Very often a particular item does not apply to either the monthly maintenance, the semiannual maintenance, or the technical inspection. To determine which items to perform, follow the item numbers down the appropriate column opposite the procedures.

(*3*) Whenever it is necessary to disassemble a part or assembly during the technical inspection, perform the special services indicated for that item as they appear in the boxes opposite the semiannual maintenance item on the work sheet.

c. Sample. Examination of the sample procedure on the Diesel fuel nozzle and lines (shown below) will show the number 46 (item number) appearing in three columns. The first place the number appears is in the monthly column, opposite to that part of the Diesel fuel nozzle and lines procedures dealing with the examination of the parts without removing them from the engine. The position of item number 46 in this column opposite this particular portion of the procedure means: Once monthly, the parts are to be examined as described in that portion of the Diesel fuel nozzle and lines test. Similarly, the appearance of item number 46 in the technical inspection and semiannual columns opposite the part of the procedures dealing with the removal of the parts from the engine for examination means: Every 6 months, and also when a technical inspection is being performed, the parts are to be removed from the engine and examined as described in that part of the complete Diesel fuel nozzle and lines procedure. Item number 46 also appears opposite the SERVE and BLEEDING procedures, meaning that every 6 months the Diesel fuel nozzle and lines are to be examined and replaced as indicated as outlined in the text below. To summarize: The Diesel fuel nozzle and lines are to be examined, without removal from the engine, every month; removed for technical inspection and replacement every 6 months. Examination of Form No. 461 (fig. 22) shows the letter S appearing in the semiannual box opposite item 46. Upon examination of the Work Sheet (Form No. 461) the unit mechanic will be directed to replace the Diesel fuel nozzle as outlined in item 46 procedures below.

SAMPLE

Tech Insp	Semi-annual	Monthly		
		46	**Diesel Fuel Nozzle and Lines.** See that these items are in good condition, secure, and do not leak.	Applies to monthly maintenance only.
46	46		Remove the nozzle, turn the flywheel, and observe the spray pattern. Watch for after-dribble. **CAUTION: Take every precaution to keep spray away from personnel.**	Applies to technical inspection and semiannual maintenance.
	46		**Serve.** Exchange the nozzle for a new or reconditioned and tested nozzle. Replace and tighten all line connections.	Applies to semiannual maintenance only.

Tech Insp	Semi-annual	Monthly
	46	

Bleeding Air and Checking Fuel Flow. If engine fails to run, it may be due to the presence of air in the fuel system. Bleed the system by venting the fuel filters, injection pump, and nozzle.

51. MAINTENANCE ITEMS.

Tech Insp	Semi-annual	Monthly
1	1	1
3	3	3

OPERATION TEST

The operator of a power unit is often unaware of defects in the equipment which have developed gradually, and to which he has become accustomed. The fact that many operators lack the ability to detect the developing causes of failures makes it desirable for the unit mechanic to test the operation of the unit as part of the periodic preventive maintenance procedures. During and before this test, any repairs and adjustments necessary to insure safe operation should be made. The appropriate paragraph in the following maintenance procedures should be consulted. If a defect is found during the test which does not require immediate correction, note it on the work sheet (Form No. 461) and make provisions for securing necessary replacement parts. The defect can be corrected later.

NOTE: If the tactical situation does not permit a complete test, perform items 3, 9, 10, and 14.

Before-operation Service. Perform the before-operation service as a check to determine whether the power unit is in a satisfactory condition to make the running test safely, and that it is adequately supplied with fuel, engine oil, and coolant (water or antifreeze).

Dash Instruments and Gauges (fig. 5). During the warm-up period, operate the engine at governed speed and note the following:

Lubricating Oil Pressure Gauge. The dial of the gauge is marked from 0 to 30. Immediately after starting, the gauge may register a high oil pressure, but this drops as the engine warms up. The pressure at all times should be greater than 5 pounds. If the pressure falls below this point, stop the engine immediately. Check the lubricating oil level and see that the lubricating oil filter is clean. Check to see that the relief valve is seating. Often tapping the camcase will be sufficient to make the relief valve seat itself. Remove the gauge and make sure that the screw at the bottom of the gauge is tight.

Oil Temperature Gauge. This gauge is of the thermometer type, and is located at the crankshaft end of the engine. During normal operation, it should indicate a crankcase temperature of approximately 125°F. If the temperature rises above 180°F, check to be sure that the lubricating oil reservoir is ¾ full and that there is sufficient oil pressure. An abnormally high crankcase temperature may be an indication of the burning of a crankshaft or connecting rod bearing.

Water Temperature Gauge. The gauge dial is divided into three sections, COLD, RUN, and HOT. During normal operation, the gauge indicating needle should be pointing to the high side of the green RUN section. If the gauge should remain in the red HOT position, stop the engine and determine the cause of trouble (par. 65). If the indicating needle should remain in the white COLD range, it may be necessary to restrict the flow of air through the radiator by means of tarpaulins until the engine reaches

Tech Insp	Semi-annual	Monthly	
			proper operating temperature, since a cold engine will not perform satisfactorily.
10	10	10	**Unusual Noises.** Listen for knocks and rattles while the engine is under both light and heavy loads. Be on the alert continually for unusual noises that would indicate looseness of parts or damage of malfunctioning components.
13	13	13	**Temperatures.** After completing the run, note as follows: *Generator Housing.* Feel the generator housing cautiously for abnormal temperatures. If the housing feels too hot, check the temperature with a thermometer, since the housing is normally too hot to keep a hand on it. Permissible temperature rise is 40°C or 72°F above air temperature. *Generator Bearings.* Feel the bearing housing for evidence of overheating. If any bearing is overheated, lack of lubrication or excessive wear of the bearing is indicated. Report worn bearings promptly to the officer in charge.
14	14	14	**Leaks.** Look underneath the unit for engine oil, fuel oil, or water leaks, and determine their source if leaks are found.
18	18	18	**Cylinder Head and Gasket.** Look for cracks or indications of oil, water, or compression leaks around studs, cap screws, and gasket. **CAUTION: Cylinder heads should not ordinarily be tightened unless there is a definite indication of looseness or leaks. If tightening is necessary, proceed as described in paragraph 102. When a new gasket is installed, tighten three times as follows: First, upon installation; second, after engine is warmed up; third, after completing final test.**
19	19	19	*Valve Mechanism.* Examine valve tappet clearances while hot. Valve tappets, rocker arms, shafts, and springs should be in good condition, correctly assembled, and secure. Oil cups should be filled, the two cups feeding the valves with fuel oil, and the three cups on the rocker arms with lubricating oil. *Valve Clearance.* Correct valve clearance is necessary to insure even and efficient engine operation. Too much clearance causes excessive wear on the valve lever mechanism and also tends to retard valve opening and advance valve closing. Too little clearance causes a loss of compression, missing, and eventual burning of the valves and valve seats. This clearance must be between 0.010 inch and 0.012 inch when the engine is hot and the valves in the closed (out) position. Clearance is measured between the rocker arm rollers and the ends of the valve stems.
	19		*Adjust.* Stop the engine, after running it long enough to bring it up to operating temperature. Set the compression release lever in the starting position. Turn the flywheel to make sure that the intake (upper) valve is closed. Move the compression release lever to the stop position. The exhaust (lower) valve should be closed. If not, turn the flywheel until both valves are closed.

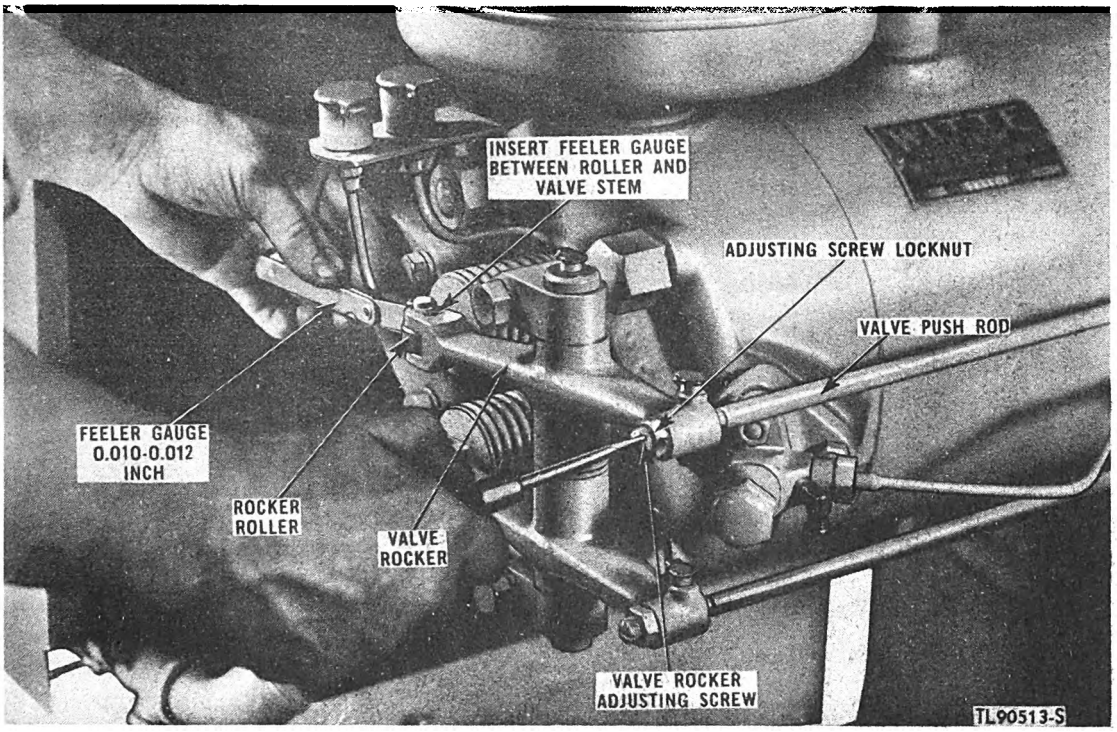

Figure 24. Valve clearance adjustment.

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21	21	

Loosen the adjusting screw locknuts on both valve levers (fig. 24). Insert an 0.010 to 0.012 feeler gauge in turn between the intake and exhaust valve stems and their rocker arm rollers. Turn the adjusting screws (fig. 24) in or out as necessary to snugly hold the feeler gauge in position. After the correct clearance is secured, hold the adjusting screw in place with a screwdriver and at the same time tighten the locknut. Check the clearance after the locknut has been tightened.

Compression Test. Start the engine and let it run until normal engine operating temperatures are established. Stop the engine.

Remove the nozzle and nozzle holder by disconnecting the fuel injector line from the nozzle holder and removing the nuts from the nozzle holder studs. Handle the nozzle with care and keep it clean while it is removed from the engine.

Attach a suitable compression gauge to the nozzle port. With the compression lever in the starting position, spin the flywheel as when starting the engine.

When sufficient speed has been reached, put the lever in the running position and note the compression reading as the engine goes through a compression cycle. Repeat this several times, and note the average reading on Form No. 461.

Compression pressure depends on cranking speeds, engine temperature, and compression ratio. A new engine has compression pressures of approximately 525 pounds per square inch (psi) at hand cranking speed. If the reading indicated by the compression gauge is reasonably high (400 psi at

Tech Insp	Semi-annual	Monthly

cranking speed), compression pressure may be considered normal. If pressure is weak, inject a few ounces of oil in the nozzle port while the piston is farthest toward the crankshaft. Turn the flywheel several times to distribute the oil in the piston rings. Repeat the compression test. The oil seals the rings so that a low reading on the first test that remains low on the second test indicates leaky valves. A low reading on the first test, that becomes high on the second test, indicates leaky rings. An extremely low reading may indicate a leaking cylinder head gasket.

23	23	23

Crankcase. With the unit operating without load, examine the crankcase and timing gear cover for oil leaks. Stop the engine and after the oil has drained into the crankcase, check to see whether the oil is up to proper level.

NOTE: If an oil change is due, drain the crankcase and refill to proper level with oil as specified on the lubrication chart.

	24	24

Oil Filters, Coolers, and Lines. Inspect the oil filters and all external oil lines to see whether they are in good condition, secure, and do not leak. Remove the cartridge from the lubricating oil filter and wash the element thoroughly in Diesel oil or dry-cleaning solvent. Make sure that no foreign matter remains between the disks and blades of the element.

CAUTION: Do not disassemble the disks or blades of the element.

25	25	25

Radiator. Inspect cooling system parts to see that they are in good condition, correctly assembled, securely mounted, connected, and do not leak. Note whether the core air passages are obstructed with dirt, insects, or trash, and whether the core fins are badly bent. Also examine the coolant for rust, oil, or other foreign matter.

	25	25

Clean. Clean dirt, insects, and trash from the exterior of the core by blowing out with compressed air or by using a stream of water, carefully applied, from the rear side of the core. (Do not use steam.)

CAUTION: Use only a suitably shaped piece of wood or blunt instrument in straightening fins; otherwise tubes may be punctured.

	25	

Tighten. Tighten all loose radiator mountings and hose clamps.

	25	

Draining Cooling System. Drain the cooling system by opening the drain cock at the bottom of the radiator and the drain pipe on the radiator side of the engine. Remove the radiator filler cap to prevent a vacuum being formed in the upper radiator and slowing down the drain flow.

Cleaning Cooling System. Efficiency of the cooling system is seriously impaired by dirt or sludge. To clean the cooling system, drain the coolant, and close the drains when the system is empty. Fill the system with a solution of cleaner and neutralizer (stock No. 51-C-1568-500) and water. Run the engine from 6 to 8 hours, then drain and refill with clean water.

Filling Cooling System. The cooling system should be filled to capacity during operation. The water must be clean and free of alkaline substances (use soft or rain water if possible). Do not pour cold water into an empty system if engine is hot as it may cause the cylinder head to crack. To fill

Tech Insp	Semi-annual	Monthly	
			the system, close the drains at the bottom of the radiator and at the radiator side of the engine. Remove the radiator filler cap and pour water into the upper radiator until the level is just below the top of the filler neck. Replace the radiator filler cap.
26	26	26	**Water Pump, Fan, and Shroud.** Inspect the fan blades to see whether they are in good condition, properly secured to the hub, and whether the fan guard is in good condition and secure to the radiator.
	26	26	Tighten the cap screws holding the fan blades to the fan hub. Tighten the nut holding the fan shaft in the fan bracket, and tighten and align the fan bracket. Replace and secure the fan guard to the radiator.
27	27	27	**Power Generator and Exciter.** Remove the covers from the exciter and generator and check all nuts, cap screws, bolts (internal and external) for presence and tightness. Check the grease fittings to see that the bearings are adequately greased. Check wiring for broken insulation and for tight, properly insulated connections. Check brushes for presence, cracking, or breakage.
			During Operation. If alternator is heating excessively, there will be a distinct odor of burning insulation and usually smoke. If this occurs, stop the engine at once. Perform tests in paragraph 62 to determine the trouble.
			Check excessive sparking at the brushes. There should be a slight blue spark at the point of contact between brushes and commutator slip rings. This spark should not follow the commutator or slip rings in the direction of rotation. Should this condition, known as ring fire, occur, stop the engine at once and service the commutator as outlined in paragraph 107.
			Check the brushes to see that they slide freely in the holders and that they are making full contact with the commutator and slip rings. Sand the brushes if they are making insufficient contact as explained in paragraph 107. Maintain brush pressure at 4 to 6 ounces for the slip-ring brushes, 7 to 10 ounces for exciter brushes by adjustment of brush-holder springs. Check the neutral position of the exciter brushes.
29	29	29	**Drive Belts and Pulley.** Observe all drive belts for evidence of fraying condition, excessive wear, and deterioration. See that all drive pulleys and hubs are in good condition and securely mounted.
	29	29	*Adjust.* Adjust the belts as follows:
			Fan Belt. Check the fan belt frequently to assure maintenance of the correct tension. Correct tension may be determined by depressing the belt midway between the two pulleys by thumb pressure. Slack should be 1 to 1½ inches (fig. 25); if more or less, adjust by loosening the nut holding the fan pulley and moving the pulley enough to give proper tension to the belt. The belt should never contact the bottom of the pulley or be set tighter than the tension specified, or rapid wear of the belt will result. If the belt becomes frayed or grease-soaked, it will slip on the pulley and should be replaced. After a new belt has been run approximately 50 hours, check the tension and adjust if necessary. A link may readily be removed by sliding it off the rivet holding it, and rejoining the belt by sliding the previous link over the next rivet.

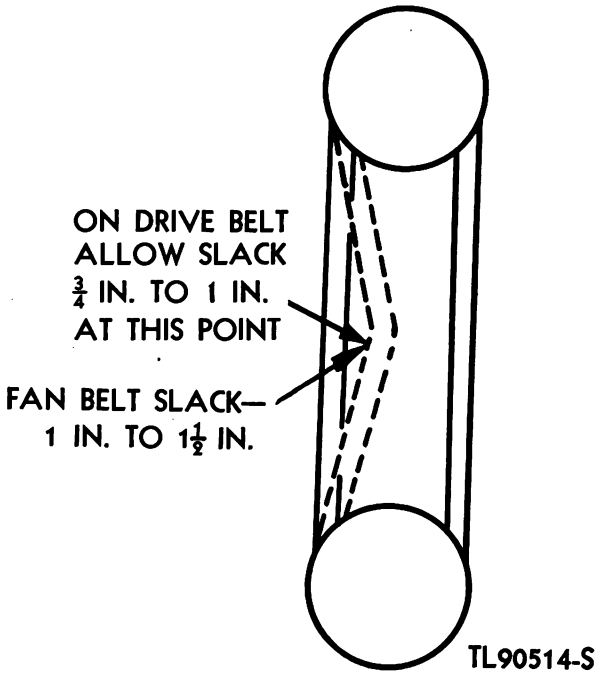

Figure 25. Correct belt adjustment.

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34	34	34

Generator Drive Belts. The drive belts must be checked frequently, since the maintenance of the proper tension and the condition of the belt are of great importance to the operation of the generator. Correct tension can be determined by depressing the belt with the hands midway between the two pulleys. Slack should be between ¾ and 1 inch (fig. 25); if it is less, tighten the belts as follows: Loosen the four bolts holding the generator to the mounting base; turn out the bolt on the side of the generator base toward the engine until the head of the bolt is out about ½ inch from the base; turn the bolt on the opposite side of the base clockwise, thus sliding the generator on its base away from the engine to tighten the belt (fig. 13); turn this bolt until the belt has the necessary tension, then tighten the bolt on the opposite side of the generator base. Tighten the generator mounting bolts. The belts should never be tighter than the tension specified, as rapid wear will result, and greater tension will decrease, if anything, the efficiency of the drive. If the belts have become frayed or grease-soaked, they will slip on the pulleys, and should be replaced. After the new belts have been run approximately 50 hours, check the tension and adjust if necessary. Never replace one belt of a pair, always replace both belts with new belts.

Air Cleaners. Remove the air cleaner element and observe its condition. Note the oil in the reservoir, paying particular attention to the quantity of dirt present. Also see that the oil level is satisfactory. Wash the element in Diesel oil or dry-cleaning solvent (SD) and allow it to dry. Dip the element in engine oil (OE) and allow the excess oil to drain from the element. Fill the reservoir with clean oil and reassemble the unit. Make certain that all gaskets, clamps, hose, etc., are present, in good condition, and properly installed.

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36	36	36
	36	
	36	

Carburetor (Choke, Throttle, Linkage, Governor). See that the governor and the linkage to the injection pump are in good condition, secure, and correctly assembled. See that the governor and linkage are not excessively worn.

Operational Check. Operating the compression release lever to start the engine will show whether this part of the mechanism is functioning properly. Check to see that the lever performs properly in the priming, starting, running, and stopping positions. Make sure that contact of the lever with the stop on the exhaust valve rod is firm and that play in the lever is not enough to allow the exhaust rod stop to slip past the compression release lever. Check to see that valve rod stop is not worn so as to permit it to slip past the end of the compression release lever.

Governor Check. The operation of the governor is indicated by the frequency output of the generator. Ordinarily, the adjustment of the knurled nut to increase or decrease the tension on the speed changer spring (fig. 14) is sufficient to control the operation of the governor. Operate the engine under varying loads, watching the frequency as indicated by the meter on the control panel. The frequency should not change more than 5 percent from full to no load, and if there is a considerable change in output frequency, check the governor to see that it is working properly. If the knurled nut on the speed changer spring cannot be adjusted sufficiently for the proper speed of operation, set the knurled nut midway in its range of adjustment, and adjust the governor as follows: Remove the camcase cover; adjust the governor regulating screw (fig. 26) until the output frequency of the generator is 60 cycles exactly; change the load on the generator and note whether the adjustment is correct. Replace the camcase cover. If the governor does not seem to control the engine properly, examine it carefully to see that it is in proper operating condition. If the governor is operating satisfactorily, the trouble very likely lies in the fuel injection pump. Replace the pump with a new or reconditioned and tested one if this is the case.

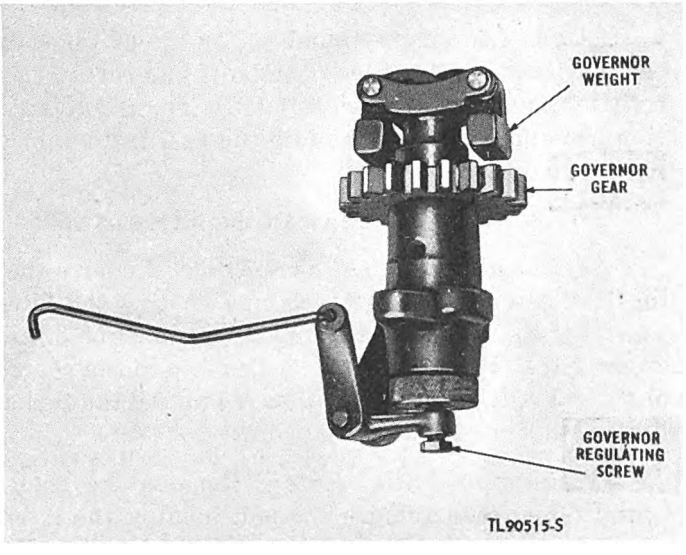


Figure 26. Governor, removed from engine.

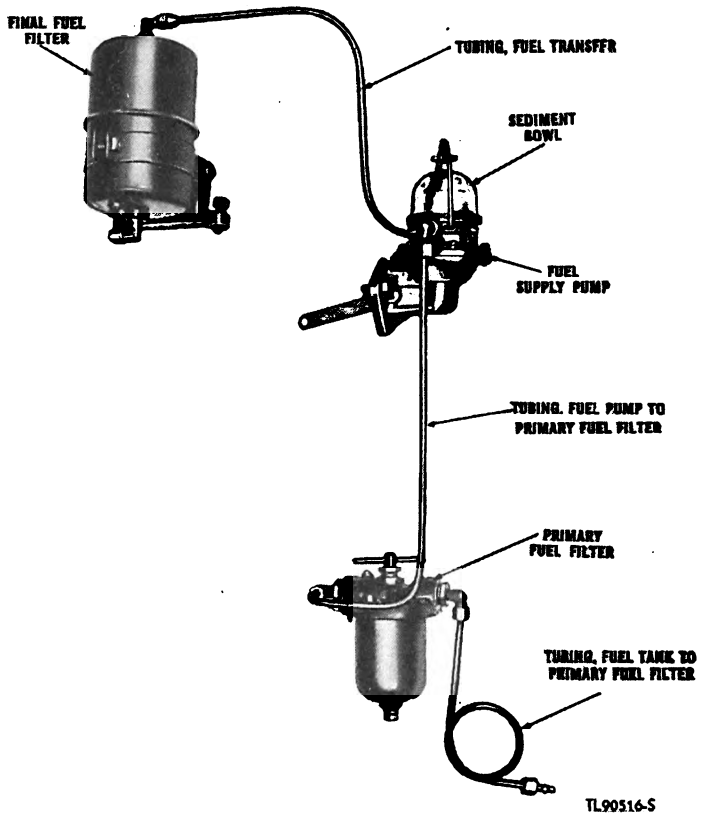


Figure 27. Fuel supply pump and filters.

Tech Insp	Semi-annual	Monthly
37	37	37
	37	37
	37	
	37	

Fuel Filters, Screen and Lines. The fuel supply system involves the fuel supply and injection pumps, two filters, and a sediment bowl (fig. 27). See that the connections and joints in the fuel supply lines are secure and do not leak. Turn the handle on the filter nearest the base of the engine to see that it turns easily, indicating freedom from grit between the plates of the filter. Inspect the sediment bowl for evidence of dirt and water.

Clean. Loosen the thumbnut on top of the sediment bowl and remove the bowl and screen. Clean the bowl and screen thoroughly and very carefully with dry-cleaning solvent (SD) or carbon tetrachloride. If this operation has allowed air to get into the fuel system, bleed the system in accord with item 46 below.

Service. Service and clean the filters as follows:

Replacement of Final Fuel Filter. Remove the fuel supply lines from the final filter. Loosen the clamps holding the filter and remove the unit. The filter cannot be disassembled, but must be discarded and replaced with a new filter. Put the new filter in place in the reverse order of the removal of the old unit. Since air will have entered the fuel supply system, bleed the lines as indicated in item 46 below.

Cleaning of Initial Filter. Remove the fuel supply lines from the initial filter, then remove the bolt holding the filter bracket to the engine base. Remove the filter. The unit can now be disassembled readily and cleaned in dry-cleaning solvent (SD). Reassemble and replace the filter

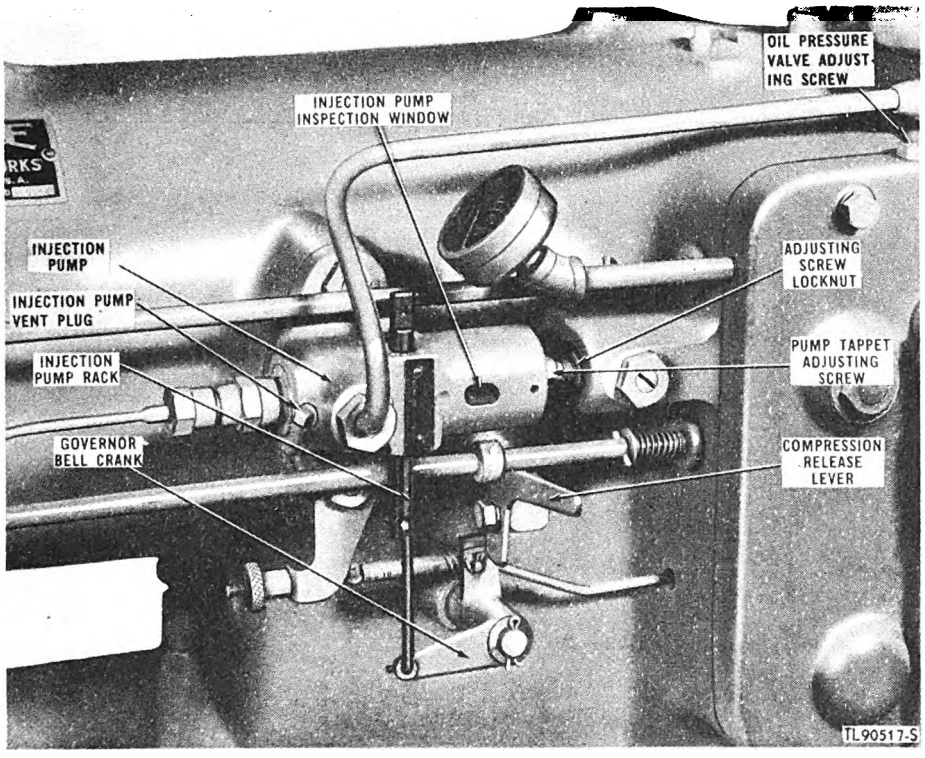


Figure 28. Injection pump timing adjustment.

Tech Insp	Semi-annual	Monthly	
			carefully, making sure that all screws and nuts are secured.
38	38	38	**Fuel Pump.** See that the fuel supply pump and lines (fig. 27) are in good condition, secure, and not leaking. Replace any pump that does not produce proper pressure, and check the new pump to see that it is satisfactory.
40	40	40	**Leaks.** Look under the engine for engine oil, fuel oil, and water leaks. Trace all leaks to their source, and report or correct them.
45	45	45	**Diesel Fuel Injection Pump.** The American Bosch plunger-type injection pump is flange-mounted to the side of the engine cylinder jacket. The plunger operates at a constant stroke and is driven from the engine camshaft through the injection pump tappet assembly (fig. 28). The pump plunger is provided with a scroll-shaped bypass, which in turn registers with openings in the plunger barrel. Revolving the plunger by means of the control rod and rack changes the relative position of the scroll bypass with the openings in the plunger barrel, thus accurately metering the amount of fuel delivered to the engine as demanded by varying loads on the generator. The fuel pump control rod and rack are directly connected to and operated by the engine governor.
	45	45	*Tighten.* Inspect and tighten the fuel line connections to the injection pump and to all other components of the fuel supply system. All connections must be fuel-tight to prevent fuel leakage and airtight to prevent air and dirt from entering the system. If a loose connection is discovered, especially between the final fuel filter and the injection pump, notify higher

Tech Insp	Semi-annual	Monthly	
			echelon so that a detailed inspection of the pump may be made before any further operation. Bleed air from system if loose components have been noted, or if any unit in the fuel supply system has been removed for inspection or replacement.
	45	45	*Adjust.* Check and adjust the fuel injection pump timing. The timing can be adjusted by means of a tappet adjusting screw (fig. 28). Turn the engine until the injection mark on the rim of the flywheel is in line with the center of the small window in the injection pump housing, being sure that when setting the wheel in position, the piston is on the compression and not on the exhaust stroke. This can be checked by noting the position of the exhaust valve. The valve will be open and near the point of closing if the piston is on the exhaust stroke. With the flywheel in the correct position, the mark on the injection pump plunger guide, viewed through the inspection window, should coincide with the mark on the side of the window. If it is found that the marks do not coincide, loosen the locknut on the tappet adjusting screw (fig. 28) and turn the screw in the proper direction to bring the marks into line. Tighten the adjusting-screw locknut and check the adjustment. To do this, back up the flywheel and then turn it forward again. Turn the flywheel until the injection mark on the flywheel is at a point opposite the inspection window and the marks on the inspection window are in line.
			CAUTION: When checking the timing, turn the flywheel slowly and be sure that the mark on the injection pump plunger is visible in the inspection window at all times.
46	46	46	**Diesel Fuel Nozzles and Lines.** See that these items are in good condition, secure, and do not leak. Examine the fuel nozzles for correct delivery and fuel leakage as follows: Remove the nozzle, turn the flywheel, and observe the pattern and condition of the fuel spray.
			CAUTION: Take every precaution to keep the spray away from personnel. Stop the engine and observe whether there is any after-dribble from the spray nozzle. If the spray pattern is not normal or a dribble occurs, replace the nozzle with a new or reconditioned and inspected nozzle.
	46	46	*Serve.* Exchange the spray nozzle for a new or reconditioned and tested nozzle. Take care to tighten the fuel nozzle holder mounting nuts and the fuel line connection securely.
	46		*Bleeding Air and Checking Fuel Flow in Fuel System.* If the engine fails to start or run, the trouble may be due to the presence of air in the fuel system. Bleed the fuel system as follows: Remove the filler plug from the top of the final filter (fig. 27) and fill the filter completely with clean fuel oil. Do not replace the plug at this time. Loosen the vent plug on the injection pump (fig. 28). Close the vent as soon as fuel appears. Disconnect both ends of the injection fuel line, then loosen the delivery valve holder. Place the compression release lever in the stop position with the governor bell crank raised as far as it will go. If the delivery valve holder has been loosened sufficiently, fuel oil will run out at the holder. As soon as fuel runs out in a solid stream, free from bubbles, tighten up the delivery valve holder. Reconnect the injection fuel line at the injection pump, leaving the

Tech Insp	Semi-annual	Monthly	
			nozzle end free. Turn the engine flywheel in either direction until the exhaust valve is open. Raise the compression release lever to the priming position and turn the flywheel until a solid stream of fuel, free from air bubbles, appears at the nozzle end of the fuel line. Reconnect the line to the nozzle holder. Refill the final fuel filter with clean fuel oil to replace the fuel lost in bleeding. Replace the filler plug in the top of the oil filter. The air will now have been bled out of the fuel supply system.
63	63	63	**Engine Mountings.** These items should be in good condition. If the mounting bolts are loose, tighten them.
80	80	80	**Frame (Side and Cross Members).** Inspect frame (brackets, skid base, and cross members) to see that they are in good condition, secure, and correctly aligned. If the frame appears to be out of line, report the condition to the officer in charge.
81	81	81	**Wiring and Cables.** Observe these items to see that they are in good condition, properly supported, connected, and secure.
82	82	82	**Fuel Tanks, Fittings, and Lines.** Inspect fuel tanks to see that they are in good condition and securely mounted. Examine plug for plugged vent (fig. 29).
			Main Fuel Tank Inspection. Check the filler opening and vent for a clogged condition. Remove screen (when used) and clean with dry-cleaning solvent (SD). If a drain plug is provided, remove it and allow all water and sediment to drain from the bottom of the tank. Replace plug and tighten securely. Take every precaution to keep the fuel free from dirt and moisture content. Where the main fuel supply is subject to atmospheric or artificial heat during operating periods, fill tank before temperature decreases (night time or after engine operation) to prevent condensation of moisture in the tank. If possible, the fuel entering and leaving the main fuel supply tank should be filtered by easily removed and serviceable filters of an approved type. The importance of using clean fuel oil cannot be overemphasized. Dirty fuel will cause rapid wear and clogging of fuel system, resulting in costly shut-downs.

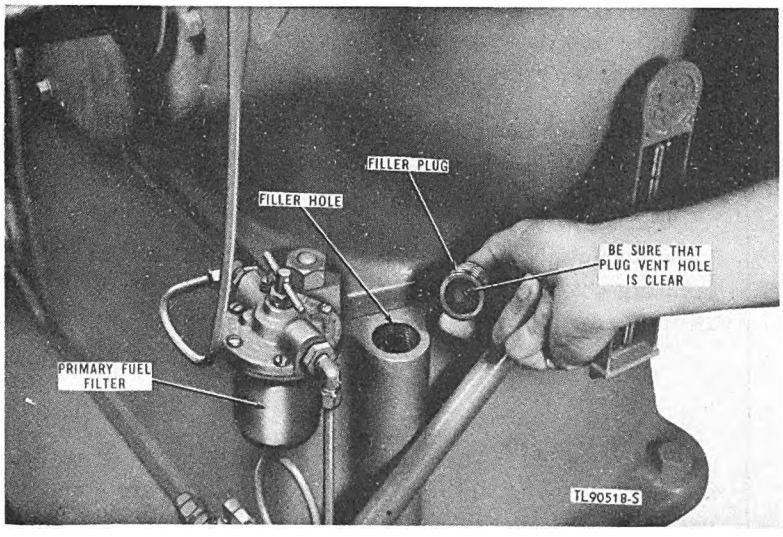


Figure 29. Air vent in fuel filler cap.

Tech Insp	Semi-annual	Monthly	
84	84	84	**Exhaust Pipes and Muffler.** Examine the exhaust pipe to see that it is securely attached to the engine, and that the other end is securely clamped to the muffler. Inspect the muffler to see that it is in good condition and securely mounted. Check the outside pipe to see that it is securely attached to the muffler, properly supported, and unobstructed at its outer end. See that the drain in the muffler is at the lowest point and not clogged.
85	85	85	**Lubrication.** Check with the operator to determine whether lubrication is needed. If the operator cannot supply the information, consult the duty roster or other lubrication records for dates on which lubrication was last performed. Check these dates against the lubrication chart (fig. 19) and apply lubricants wherever necessary. Make a record of all completed jobs to avoid the possibility of overlubrication by uninformed maintenance personnel and plant operators. Check all lubrication fittings for clogged condition and if found missing or damaged, replace them. Clean the hole in which the new fitting is to be installed.
	85		*Pressure Regulating Valve.* A pressure regulating valve composed of a plunger, spring, gasket, and nut is located in the camcase cover (fig. 28). The spring tension is set for a minimum of 5 pounds of oil pressure. After prolonged use, the valve should be checked for tension. It should not be necessary to screw the valve seat so that the slotted head is inset from the camcase wall. With the slotted head flush with the inner camcase wall, proper tension should be provided by the valve spring. If it should be necessary to screw the seat in farther than this point, replace the spring. Be sure, however, that the pump is operating properly and providing sufficient pressure, since the valve will not make up entirely for a worn pump.
98	98	98	**Circuit Breaker.** Check the connections at the rear of the circuit breaker for corrosion, looseness, and poorly soldered joints. With the power unit inoperative, check the circuit breaker handle for snappy action. **NOTE:** Check the circuit breaker during operation by applying the load and observing the ammeter and voltmeter for erratic readings while pushing and twisting the circuit breaker handle.
103	103	103	**Paint and Markings.** Examine the paint on the entire unit for flaky condition. Note scratches and rust spots. Check for bright spots that might cause glare or reflection. Inspect markings and identification for legibility.
104	104	104	**Radio Bonding (Suppressors, Filters, Capacitors, and Shielding).** See that bonding connections are in good condition, clean, and secure. Note whether all items are securely mounted. **NOTE:** Report any irregularities, except cleaning and tightening, to the officer in charge.
131	131	131	**Tools (fig. 4).** Check all tools against the packing list to see that they are all present. Inspect to see that tools are in good condition, clean, and properly stowed or securely mounted. Examine tools with cutting edges to see that they are sharp.

Tech Insp	Semi-annual	Monthly	
134	134	134	**First-aid Kit.** See that the kit is in good condition, and that all of its items are present and properly packed. Report any deficiencies immediately.
135	135	135	**Publications and Forms.** See that the following are present and in a legible condition: Technical manual; TM 11-973 W.D., A.G.O. Form 48 (Trip Ticket) W.D., A.G.O. Form No. 468 (Unsatisfactory Equipment Report).
139	139	139	**Fuel and Water Cans, and Brackets.** Observe whether they are in good condition, and secure; that the caps fit tightly and are secured to the cans with chains. Note whether the cans are leaking.
140	140	140	**Fuel Can Nozzle and Bucket.** This equipment should be present, in good condition, clean, and properly stowed.
141	141	141	**Modifications (MWO's).** Inspect the equipment to determine whether all modification work orders have been completed.
142	142	142	**Final Test.** Make final test, rechecking items 3, 9, 10, 13, and 14. Confine this test to the minimum time necessary for satisfactory observation.

NOTE: Correct or report all deficiencies found during final test.

SECTION X. MOISTUREPROOFING AND FUNGIPROOFING

52. MOISTUREPROOFING AND FUNGIPROOFING.

a. General. When operated in tropical areas where temperature and relative humidity are extremely high, Signal Corps equipment requires special attention. These are some of the problems met:

(*1*) Resistors, capacitors, coils, chokes, transformer windings, etc., fail because of the effects of fungus growth and excessive moisture.

(*2*) Electrolytic action, often visible in the form of corrosion, takes place in resistors, coils, chokes, transformer windings, etc., causing eventual break-down.

(*3*) Hook-up wire insulation and cable insulation break down. Fungus growth accelerates deterioration.

(*4*) Moisture forms electrical leakage paths on terminal boards and insulating strips, causing flash-overs.

b. Reducing Failures. A moistureproofing and fungiproofing treatment has been devised which, if properly applied, provides a reasonable degree of protection against fungus growth, insects, corrosion, salt spray, and moisture. The treatment involves the use of a moisture- and fungi-resistant varnish applied with a spray gun or brush. Refer to TB SIG 13, Moistureproofing and Fungiproofing Signal Corps Equipment, for a detailed description of the varnish-spray method of moistureproofing and fungiproofing and the supplies and equipment required in this treatment.

> **CAUTION: Varnish spray may have poisonous effects if inhaled. To avoid inhaling spray, use respirator if available; otherwise, fasten cheesecloth or other cloth material over nose and mouth. Never spray varnish or lacquer near an open flame. Do not smoke in a room where varnish or lacquer is being sprayed. The spray may be highly explosive.**

c. Power Unit PU-53/FRC. Make all repairs and adjustments necessary for proper operation of the control panel.

(*1*) *Disassembly.*

(*a*) Remove the four bolts holding the main line air breaker switch terminal cover. Remove cover.

(*b*) Remove the six bolts holding front panel instrument cover. Remove panel assembly.

(*c*) Disconnect the input and load leads to the main line air breaker switch (figs. 9 and 11).

(*d*) Disconnect the two exciter leads from the exciter terminal strip (fig. 9).

> **NOTE:** All screws and bolts that are removed in disassembly should be immediately replaced in their original positions and left there during treatment. This will keep their threads in good condition and prevent the screws and bolts from getting lost. Also tighten all screws on the terminals from which leads were not disconnected. This will insure good contact between conducting surfaces.

(*2*) *Cleaning.* Clean all dirt, dust, rust, and fungus from the control panel. Clean all oil and grease from the surfaces to be varnished.

(*3*) *Masking.*

(*a*) Mask all soldering lugs on the ends of wires that have been disconnected.

(*b*) Mask the glass on the four meters (fig. 30).

(*c*) Mask the adjusting screws of the voltmeter and ammeter (fig. 30).

(*d*) Mask the joint between the meter and the meter case.

(*e*) Mask the sliding brush of the exciter rheostat as shown in figure 31.

(*f*) Mask the synchrostat voltage regulator relay contacts (fig. 30).

(*g*) Mask the synchrostat voltage regulator shunt field resistor (fig. 30).

(*h*) Mask the synchrostat voltage regulator calibrating resistor (fig. 30).

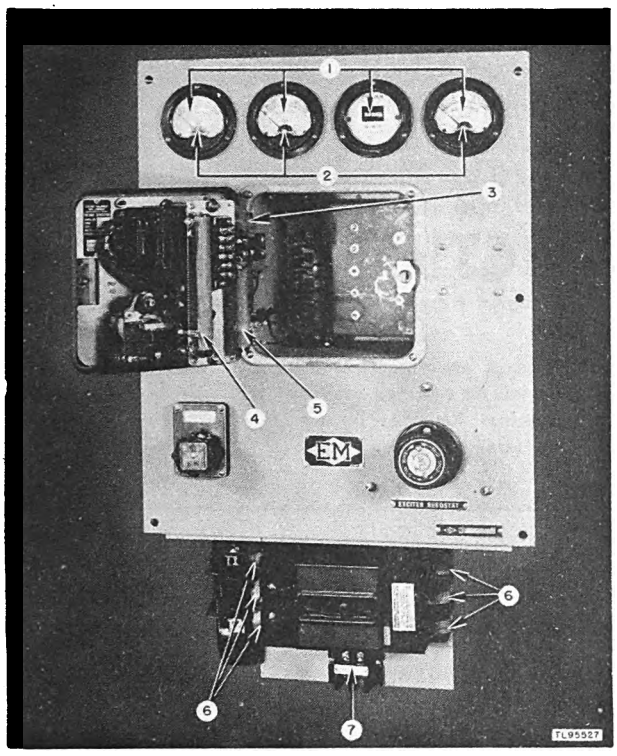


Figure 30. Front of control panel, showing masking.

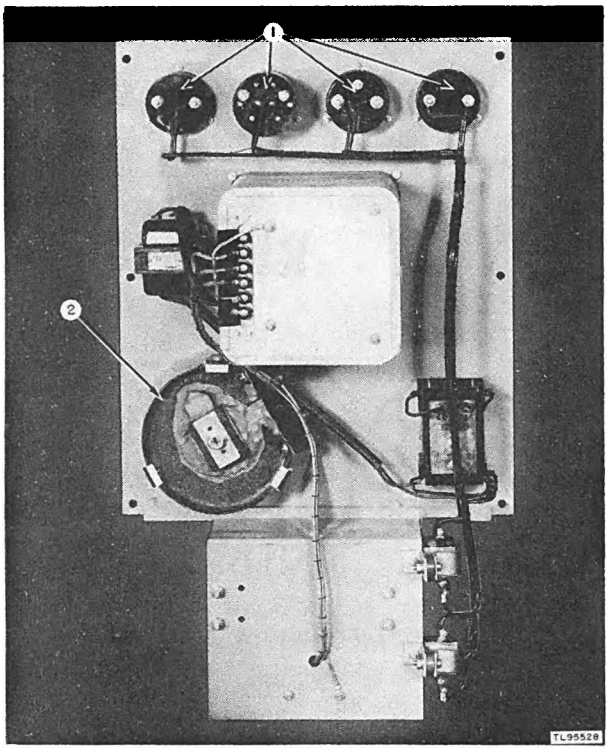


Figure 31. Rear of control panel, showing masking.

(*i*) Mask the main line air breaker switch input and load terminal lugs (fig. 30).

(*j*) Mask the exciter terminal strip (fig. 30).

(*4*) D*rying*. Place the control panel in a baking oven and bake from 4 to 6 hours at 140°F.

CAUTION: If the impregnating compound in any part should begin to melt, decrease the temperature and increase the drying time approximately 1 hour for each 10°F decrease in temperature.

(*5*) *Varnishing.*

(*a*) Apply three coats of moistureproofing and fungiproofing varnish (Lacquer, Fungus-resistant, spec No. 71-2202 (stock No. 6G1005.3), or equal). Allow each coat to air-dry for 15 or 20 minutes before applying the next coat.

(*b*) Apply varnish immediately after the equipment is dried. If varnish is not applied immediately, moisture condenses on the equipment. Varnish applied over the moisture peels off readily after the varnish has dried.

(*6*) *Reassembly.*

(*a*) Remove all masking tape, being careful not to peel varnish from near-by areas.

(*b*) Reassemble all disassembled parts of the control panel and check the operation.

(*7*) *Marking.* Mark MFP and the date of treatment near the nameplate.

EXAMPLE: MFP—8 Jan 46.

d. Treating Equipment After Repairs. If during repair, the coating of protective varnish has been punctured or broken, and if complete treatment is not needed to reseal the equipment apply a brush-coat to the affected part. Be sure the break is completely sealed.

PART FIVE

REPAIR INSTRUCTIONS

NOTE: Failure or unsatisfactory performance of equipment used by Army Ground Forces and Army Service Forces will be reported on W.D., A.G.O. Form No. 468 (Unsatisfactory Equipment Report); by Army Air Forces, on Army Air Forces Form No. 54 (Unsatisfactory Report).

SECTION XI. THEORY OF EQUIPMENT

53. ENGINE COMPONENTS AND SYSTEMS.

a. General. The function of the complete Diesel engine in Power Unit PU-53/FRC is to supply mechanical power to drive the alternator by means of a double-grooved pulley bolted to the flywheel and connected to a similar but much smaller double-grooved pulley on the generator rotor shaft by two V-belts. The compression release lever and governor linkage which control engine operation are mounted directly on the engine, while the switches and instruments which control the alternator output are all mounted on and operated from a separate control panel. Subparagraphs b through g below explain the functional operation of the individual systems which make up the complete engine.

b. Principle of Operation. The principle of operation of the Diesel engine is based on the physical law of gases governing the relation of volume, pressure and temperature. For example, a decrease in volume causes an increase in pressure and a corresponding increase in temperature. All fuel oil, regardless of gravity, has what is known as a firing point. That is, when the fuel is raised to a certain temperature, it will ignite and burn, and in the process of burning, energy is liberated. The Diesel engine is of the four-stroke cycle, full Diesel, solid injection type. The four-stroke cycle principle covers four strokes of the piston or two complete revolutions of the crankshaft for each cycle as follows:

(*1*) *First or Suction Stroke.* The piston moves away from the cylinder head, drawing fresh, clean air only (not a mixture of fuel and air) into the cylinder through the open inlet valve.

(*2*) *Second or Compression Stroke.* The piston moves towards the cylinder head, both valves being closed, compressing the charge of air to approximately 530 pounds of pressure, resulting in a temperature of this highly compressed air of approximately 1,000°F. (Fuel injection begins near the end of this stroke.)

(*3*) *Third or Firing Stroke.* The fuel that is being injected into the hot combustion chamber under 2,000 pounds pressure and in a finely divided form, has started to burn, causing a rapid rise in pressure, driving the piston away from the head, the expanding gases being converted mechanically by the connecting rod and crankshaft into power. (The exhaust valve opens near the end of this stroke.)

(*4*) *Fourth or Exhaust Stroke.* The piston again moves towards the cylinder head, expelling the burned gases, thus completing the cycle.

c. Combustion Principle. In the combustion system, the volume above the piston consists of two chambers:

(*1*) The main chamber, being the space between the top of the piston and the cylinder head proper.

(*2*) The precombustion chamber, between the main combustion chamber and the fuel injector (fig. 48). During the compression stroke, compressed air is forced into the precombustion chamber at high pressure and temperature. Near the end of this stroke, fuel injection begins. The fuel enters the precombustion chamber, immediately ignites and causes a very rapid rise in the temperature and pressure inside this chamber. This rapid rise in pressure results in a very high velocity discharge of the partially burning gases and remaining unburned fuel through the venturi-shaped opening into the main combustion chamber. This discharge strikes the top of the piston near one side and at an angle of 30° from the horizontal, and spreads out in a fan-shape over the entire main combustion chamber. The result is a very thorough mixing of the remaining unburned fuel with the hot compressed air in the main combustion chamber, producing smooth, clean combustion and maximum power with a minimum of detonation.

d. Starting System (fig. 14).

(*1*) The Diesel engine is started by means of a hand crank. By placing the hand crank in position on the crankshaft end and turning it clockwise, piston movement begins and other component operating units also begin to function. However, before the engine begins to operate, the compression release lever (fig. 15) must be manipulated prior to and during the cranking of the engine. This lever controls the flow of fuel entering the injection nozzle in the cylinder head, in proper amounts for priming, starting, running, or stopping, dependent upon the position at which the lever is set. For example: When the compression release lever is set at its priming position, the exhaust valve in the cylinder head is held open. This prevents setting up compression within the cylinder, allowing the free turning of the crank, while at the same time permitting the fuel injection pump to function and inject fuel into the injection nozzle line. Turning the engine through several revolutions while the compression release lever is in the priming position will not only set up a solid column of fuel within the injection nozzle line but will also expell all air which may be trapped within the fuel line or nozzle.

(*2*) To move the lever to its starting position after priming, it is necessary to raise the governor bell crank (fig. 12) as far as it will go. This permits the free movement of the lever for setting it in any of the four positions mentioned above. When the lever is set in the starting position, the exhaust valve still remains open, releasing compression within the cylinder. In this position the flow of fuel from the pump to the injection nozzle is cut off, while continuing to allow free turning of the hand crank.

(*3*) Before attempting to move the lever from starting to running position, it is necessary to accelerate the cranking speed to build up sufficient momentum within the engine to carry over the compression stroke of the piston. After gaining the required cranking speed, move the lever to its running position with the left hand while continuing to crank the engine with the right. If the engine has been properly primed it will start immediately. When the compression release lever is lowered to the running position, the governor bell crank drops, opening ports in the fuel injection pump, and permitting fuel to enter the injection nozzle line under pressure from the fuel injection pump. The compression release lever in running position also allows the exhaust valve to close so as to set up compression within the cylinder.

(*4*) Stopping the engine is accomplished by raising the governor bell crank sufficiently to allow moving the compression release lever to its stopping position (fig. 15). When the governor bell crank is raised, the ports within the fuel injection pump which permit fuel to flow into the injection nozzle line close and shut off the fuel supply to the injection nozzle, thus causing the engine to stop. The compression release lever in the stopping position holds the governor bell crank in the raised or cut-off position.

e. Lubricating System.

(*1*) The lubricating system on the engine is a combination system of pressure and splash. It consists of an oil reservoir in the cylinder head end of the engine base, an oil filter, and a small circulating oil pump located on the camcase cover. The oil filter is of the laminated metal disk type and is located in the side of the engine base with its element extending well into the oil reservoir (fig. 5). The purpose of this filter is to clean the oil drawn from the reservoir

of any grit or impurities, thus preventing the clogging of the pump suction line, oil pump, and oil pump relief valve. When the filter element handle is turned in either direction, the laminated fluted disks, stacked on the handle, rotate between a similar set of stationary disks fastened to a rigid supporting bar. By this action and because the rotating and stationary disks are alternately stacked one next to the other, all dirt or grit is wiped off the filter element and drops into the bottom of the engine sub-base.

(*2*) The lubricating oil circulating pump is of rotary gear type, located on the camcase cover and directly driven from the end of the camshaft. A driven and a free gear are mounted on different centers in the pump, so that at the point where the gears mesh a pressure is created, and a suction is present where the gears unmesh. The suction draws oil from the reservoir, and the pressure forces oil into the engine. The oil is discharged into the crankcase through a spring-loaded oil relief valve. An oil pressure gauge (fig. 5) indicates pressure in the line ahead of the relief valve. This valve permits the oil pressure in the line between the pump and valve to increase to a minimum of 5 pounds per square inch (psi) which is indicated by the gauge. When the oil pressure exceeds the back pressure exerted by the valve spring, the valve opens and permits the oil to flow into the oil pan. This pan is cast integrally with the lower half of the engine crankcase, and holds approximately 10 quarts of oil. The oil within this pan serves as the supply for the splash system of lubrication within the crankcase. All oil pumped through the lubricating system flows into this pan, and when it becomes filled to capacity, excess oil overflows back into the oil reservoir in the engine sub-base. The splash system lubricates all working parts within the engine crankcase. This is accomplished by the rotating motion of the crankshaft which picks up oil within the pan and distributes it to all wearing surfaces. A dip wire held in place by the lower connecting rod bolt accentuates the splash action and also serves as a means for more directional distribution of the lubricating oil. The piston, piston pin, pin bushing, and cylinder wall are constantly lubricated by an oil mist within the crankcase set up by the pressure and splash system of lubrication. The fuel transfer pump eccentric in the camcase serves as an oil slinger to oil entering the camcase, throwing the lubricating oil that follows the crankshaft out from the main bearing, to lubricate the parts in the camcase. A return drain hole near the bottom and in the inner wall of the camcase prevents filling of the camcase and permits oil in the camcase to flow back into the oil reservoir in the engine base.

(*3*) Because the valve rocker arms, the governor bell crank, and the valve stem guides are not fully inclosed within the unit, they are not lubricated by the system described above. These parts, therefore, must be lubricated by manual means, using a hand oilcan and applying lubricating oil in accordance with the lubrication chart.

f. Cooling System (fig. 32). The engine is equipped with a thermo-syphon system of cooling utilizing a radiator and a fan. The thermo-syphon principle as applied in circulating the coolant within the engine and the radiator is quite simple. When the engine is running, the coolant within the cylinder jacket becomes heated and rises through a vertical pipe to the upper part of the radiator because this heated liquid has expanded and thus is lighter per unit of volume than the cool liquid. When the liquid reaches the radiator, it becomes cooled and, thus heavier, flows down through the radiator

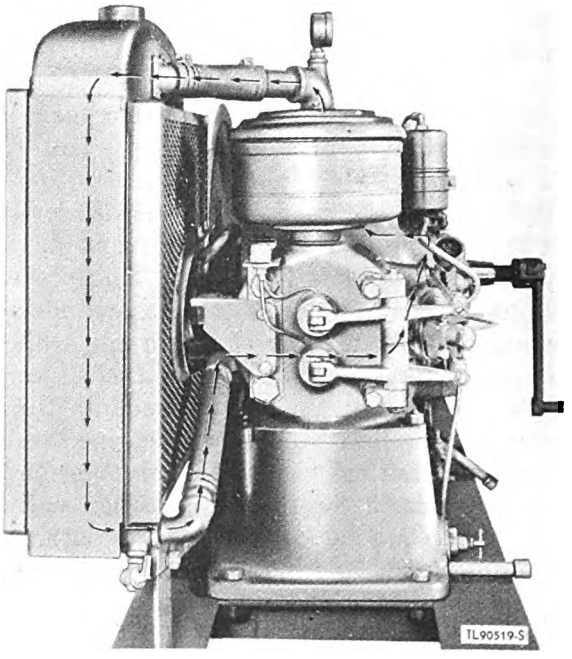


Figure 32. Coolant flow diagram.

and into the jacket through a lower pipe and hose connection. This establishes a circulatory system which constantly draws away hot coolant from the engine unit into the radiator where it is cooled by air streams drawn in by a blower type radiator fan (fig. 32). Because the Diesel engine is by principle a *heat* engine it performs at maximum efficiency when operating at engine temperatures between 160° to 180°F. When filled with fresh, clean, soft water, the capacity and design of the system (2.3 gallons in radiator and 1.7 gallons in cylinder jacket) permit continuous operation at the above mentioned temperature. A thermometer (heat indicator) is installed in the vertical outlet pipe as shown in figure 5.

g. Air Cleaner. Clean air is assured in the engine by an oil-bath air cleaner. The air, after entering the intake, passes to the oil bowl where it goes through a bath of oil. As the air rises to the cleaner outlet, it passes through a series of oil-bathed screens where fine dust is removed (fig. 18). As the oil from the screen works back down to the bowl, it carries with it the dirt removed from the air. The air cleaner can work efficiently only as long as the bowl is free from accumulated dust. When this dust accumulates in the bowl, the bowl must be removed, cleaned, and refilled with new clean oil of the recommended viscosity (fig. 33).

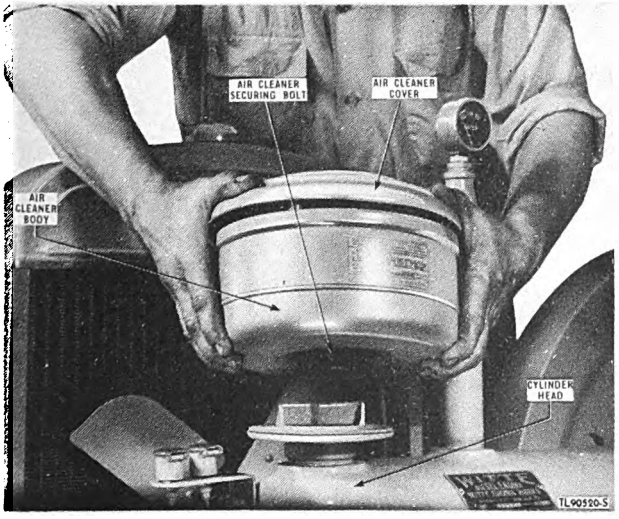


Figure 33. Air cleaner removal.

h. Diesel Fuel System.

(*1*) *Description.* The fuel system is composed of the following: A fuel oil supply tank; a fuel supply pump; a fuel strainer; two fuel oil filters; a governor; a fuel oil injection pump; and a fuel injection nozzle. The injection pump (fig. 35) is the most important part of the system. Its purpose is to deliver accurately metered fuel, under high pressure, in amounts required by the engine load and at a precise moment, to the injector spray nozzle. Changes in load affect the governor which controls the action of the injection pump as described in paragraph 54. All parts of this system are individually mounted to the engine for easy accessibility, removal, and replacement.

(*2*) *Operation.* The fuel is drawn from the fuel supply tank through the primary fuel filter by means of suction created by the fuel transfer pump (fig. 34). The fuel passes through a series of metal disk cleaning elements in the

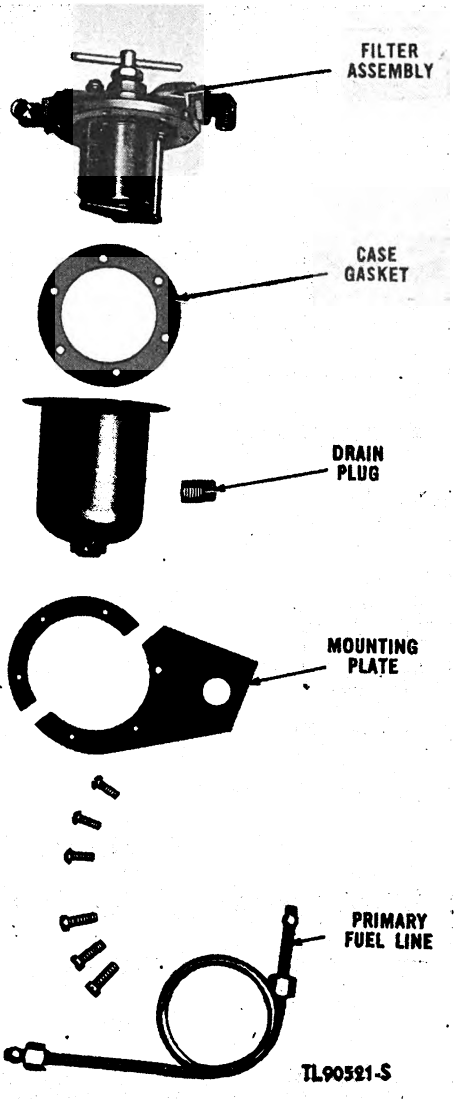


Figure 34. Primary fuel filter, disassembled.

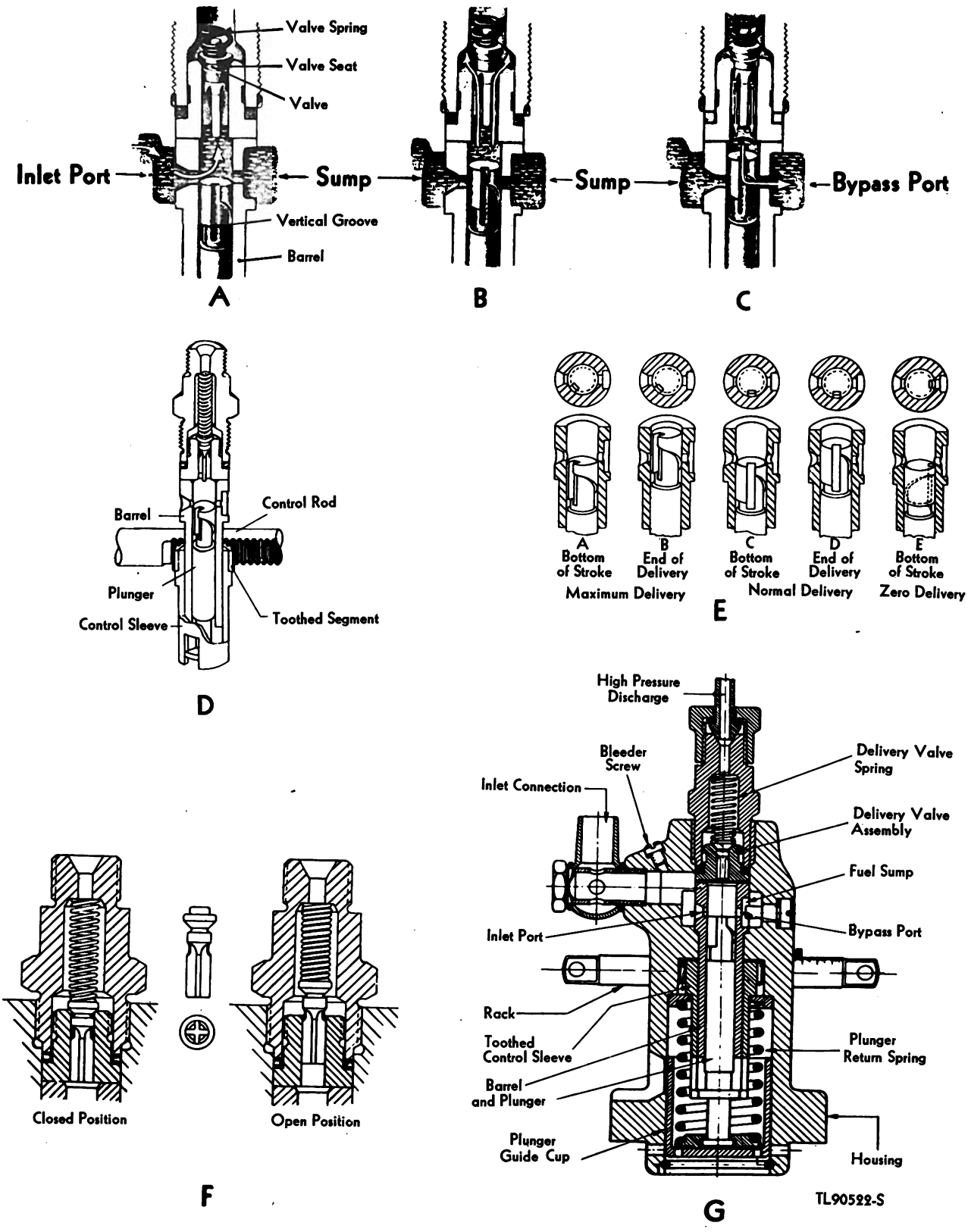


Figure 35, cross-section, typical injection pump.

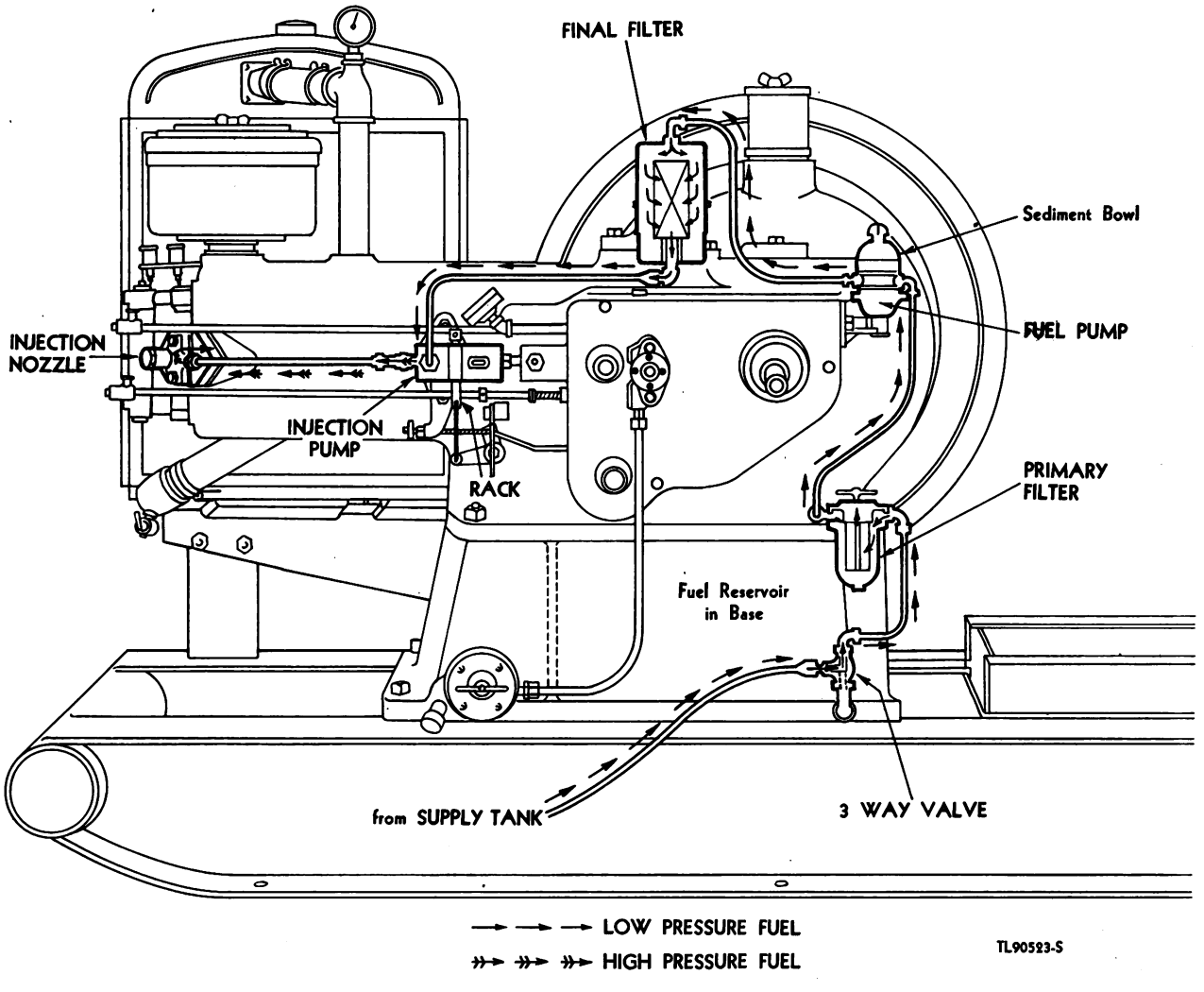


Figure 36. Fuel flow diagram.

filter and enters the fuel pump (fig. 27) from which it is forced under pressure of 3 to 5 pounds per square inch through a secondary filter. A sediment bowl and a screen attached to the fuel transfer pump act to separate dirt and water from the fuel. The final fuel filter is located on top of the crankcase and is of the sealed cartridge type. Its function is to further remove, from the fuel, any abrasive material which may have passed through the primary filter and sediment bowl, as well as to separate and remove any water which may have entered into the fuel supply. by possible condensation in tank or lines. From the final filter, the fuel under uniform pressure from the fuel pump, goes to the plunger in the injection pump. Here, the fuel trapped within the pump body is subjected to extreme pressure created by the forward movement of the plunger within the pump. The plunger is driven by an eccentric from the camshaft. When this pressure reaches 2,000 pounds per square inch, the fuel nozzle valve (fig. 46) opens, injecting fuel in a fine spray into the combustion head of the cylinder where it is ignited by the heat of compression within the cylinder. An overflow connection is provided on the nozzle assembly from which a very small amount of fuel oil may drop occasionally. This leakage through the injection nozzle valve is purposely allowed to provide lubrication for the valve.

(*3*) *Schematic Diagram of Fuel System* (*fig. 36*). The injection pump and various important parts of the Diesel fuel system as a whole are portrayed in detail in the schematic

diagram (fig. 36). This schematic diagram shows the course of fuel from the time it leaves the supply tank (not shown) until it enters the engine.

i. Exhaust System. The purpose of the exhaust system is to carry the exhaust gases to the outside atmosphere and to silence the exhaust noises. This system incorporates a steel cylinder type silencer connected to the engine (fig. 2) by means of fittings, flexible tubing, and the necessary pipe and couplings to extend it away from the engine into the outside atmosphere.

54. FUEL DELIVERY AND ENGINE SPEED CONTROL BY GOVERNOR AND BELL CRANK ACTION.

a. The power output of the engine is controlled by the variation in the amount of fuel injected into the combustion chamber. This variation of the amount of fuel delivered by the injection pump to the nozzle is regulated by the action of the plunger helix.

b. By referring to figure 35 (G), it will be seen that the fuel injection pump consists chiefly of a housing with an integral mounting flange, a plunger guide cup, a pump element assembly comprising plunger and barrel, a toothed control sleeve, a plunger return spring, spring seats, and a control rod. The housing also contains the fuel sump, the delivery valve assembly with gasket, the delivery valve spring, the delivery valve holder and the nipple nut for connection of the high-pressure discharge tubing.

(*1*) Through the inlet connection (fig. 35 (G)), the fuel enters the sump in the upper part of the housing. As soon as the upper edge of the plunger, during its downward stroke, opens the two radial, opposite ports in the barrel, known as inlet and bypass ports, the fuel rushes into the barrel while the plunger is at the bottom of its stroke (fig. 35 (A)). During the first part of the upward stroke of the plunger, some of the fuel in the barrel is displaced back into the sump through the inlet and bypass ports, until these two ports are completely closed. Shortly afterwards, the fuel is placed under pressure, the spring-load delivery valve is lifted off its seat, and the fuel is delivered through the discharge tubing into the spray nozzle, whence it is discharged into the combustion chamber of the engine (fig. 35 (B)).

(*2*) Delivery of fuel ceases as soon as the helix on the plunger passes the bypass port in the barrel, for at this instant the pressure chamber communicates with the sump by way of the vertical groove and helix on the plunger, allowing the fuel not yet delivered in the discharge tubing to bypass back into the sump (fig. 35 (C)).

(*3*) The termination of the fuel delivery, which also controls the quantity of fuel delivered per stroke, is varied by turning the plunger in its barrel, i.e., by bringing the helix into various positions with relation to the bypass port. To accomplish this, a control sleeve (fig. 35 (D)) is slipped over the barrel, the sleeve being provided with a toothed segment at its upper end and with two longitudinal, opposite slots at its lower end in which the cross flange of the plunger is guided. The teeth of the toothed segment engage corresponding teeth on the control rod and, by shifting the latter, either manually or automatically by means of the governor, the plunger is rotated in its barrel in either direction.

(*4*) The less the control rod is moved away from its *stop* position and the less the plunger is thereby turned in its barrel, the sooner the helix opens the bypass port and the smaller the fuel delivery per stroke will be (fig. 35 (E)). The farther the control rod is moved away from its *stop* position and the farther the plunger is turned in its barrel, the later the helix opens the bypass port and the larger the fuel delivery per stroke will be.

(*5*) For maximum fuel delivery, the plunger, by moving the control rod farthest away from its *stop* position, is turned farthest in its barrel, resulting in very late opening of the bypass port by the helix, i.e., in the maximum effective plunger lift. For zero delivery, with the control rod in the *stop* position, the plunger is turned in its barrel until its vertical groove registers with the bypass port. In this position, the pressure chamber in the barrel is in constant communication with the sump during the entire mechanical stroke of the plunger; therefore, no fuel is delivered by the latter.

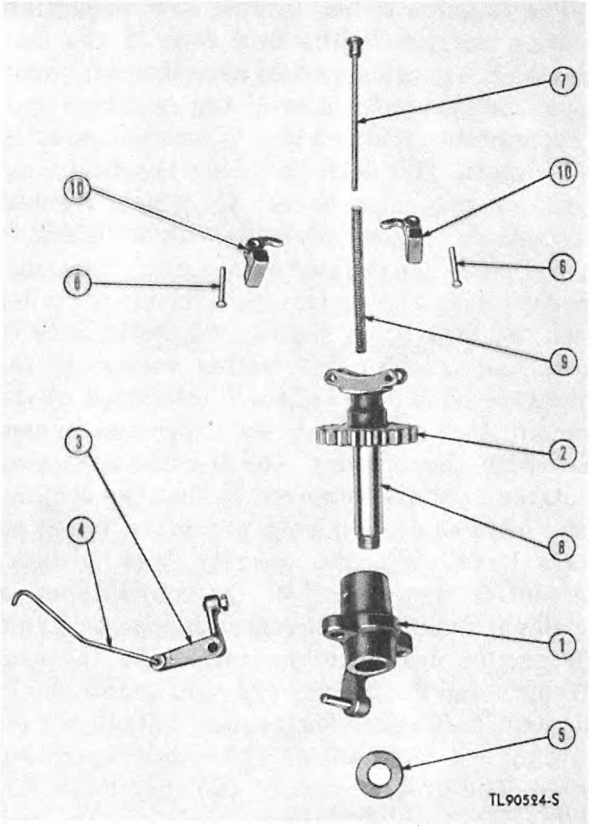
(*6*) When the helix of the plunger uncovers the bypass port in the barrel during the latter part of the upward stroke, the pressure in the barrel is immediately released and the delivery

valve is quickly returned to its seat by the combined action of its spring and the great difference in pressure which then exists between the barrel and the discharge tubing. This closes off communication between the pressure chamber in the barrel and the nozzle until the next delivery stroke takes place. In returning to its seat, the delivery valve performs a double function: first, it prevents excessive draining of fuel from the discharge tubing during bypassing, as well as during the suction stroke of the plunger; second, it relieves the pressure in the discharge tubing. This pressure relief is accomplished by means of the accurately lapped relief or displacement piston provided on the delivery valve proper below its conical seat and above its flutes (fig. 35 (F)).

(7) Before the delivery valve actually reseats, after the helix of the plunger has uncovered the bypass port in the barrel, it reduces the pressure in the discharge tubing by increasing the volume therein by a quantity equal to the volume of the relief piston, for the latter slides down into the delivery valve seat with a plunger-like action. As a result of this rapid reduction in pressure, the nozzle valve at the other end of the discharge tubing *snaps* to its seat, thus instantaneously terminating the fuel injection from the spray nozzle and thereby eliminating *dripping*.

c. The external control of the fuel delivery per stroke is accomplished by means of the control rod, one end of which is connected to the governor of the engine. There is a certain amount of dead movement of the control rod in its *stop* position, i.e., the rod must be moved by about 3/16 inch from its full *stop* position before delivery of fuel commences. From that point on, however, the quantity of fuel delivered is directly proportional to the movement of the control rod.

d. The governor has a preset speed adjustment setting of 720 rpm, and is accordingly factory-adjusted to maintain this speed within close limits during engine operation. The action of the governor (fig. 37), upon any change of engine load condition will increase or decrease the amount of fuel injected into the cylinder combustion chamber, to maintain the preset governed speed of 720 rpm. In operation, when the load increases, engine speed tends to drop very slightly; as a consequence the centrifugal force on the governor flyballs (10) decreases, thus allowing the flyballs to come together slightly. This causes the governor center pin (7) to move inward, thus reducing the compression load on the governor spring (9). With compression on the governor spring reduced, the tension of the speed changer spring will cause the governor lever (3) to drop slightly, with the linkage rod (4) serving to pull the governor bell crank and control rack downward. This action rotates the helix on the injection pump plunger as described above and increases its power output. Conversely, if the load on the engine is decreased, the engine speed tends to rise very slightly and the governor flyballs move apart slightly because of the increased centrifu-



LEGEND FOR FIGURE 37

1. Bearing, governor.
2. Gear, spur.
3. Lever, governor.
4. Link, injection pump.
5. Nut, knurled.
6. Pin, weight.
7. Pin assembly, governor center.
8. Spindle, governor.
9. Spring, compression.
10. Weight, governor.

Figure 37. Governor, disassembled.

gal force, creating a compression load on the governor spring and forcing the governor center pin outwards. This causes the governor lever (3), as well as the governor bell crank and the control rack, to move upward, rotating the plunger in the opposite direction and reducing the power output.

e. Under a constant load, the governor tends to seek an equilibrium position. This position is obtained when the force produced by the rotation of the flyballs balances the forces exerted by the governor springs. While seeking this position, the injection pump rack oscillates. Excessive oscillation is known as *hunting* or *surging*.

55. EXCITER (fig. 56).

The function of the exciter is to supply excitation current to the field coils of the generator. It consists of a field assembly with main poles and interpoles, a revolving armature with a commutator, and two sets of brushes mounted 180° apart. The field, including the field ring, forms a magnetic circuit in which residual magnetism remains when the exciter is not in operation. When the engine is started, the armature revolves and carries its conductors (coils) past the field poles, cutting magnetic lines of force and inducing alternating voltage in the armature coils. The coils are connected to the commutator, which revolves under and in contact with the brushes. The brushes and commutator bars are arranged so that the commutator bars in contact with any given brush always have the same polarity, and a direct current is thus taken off the commutator. A small portion of this current is carried back into the exciter field winding, increasing the field strength and building up the voltage induced in the armature coils. The exciter voltage is thus built up to a maximum of 62.5 volts at operating speed. The greater part of the current at this voltage is carried through leads to the commutator brushes and the slip-ring brushes, for excitation of the alternator revolving field.

56. GENERATOR (fig. 70).

The function of the generator is to convert the mechanical energy of the engine to alternating-electric current at the voltage and frequency indicated on the nameplate fastened to alternator housing. Its major component parts consist of a revolving field with carbon brushes riding against slip rings, and a wound stator. Direct current at approximately 62.5 volts is carried into the revolving field through the brushes and slip rings. The four poles of the revolving field produce magnetic lines of force which, when revolving past the coils of the stator, set up alternating currents in the stator windings. Three leads from these windings are brought out to a junction box, and are provided with terminals to facilitate connection to the control panel.

57. CONTROL PANEL (fig. 9).

a. General. The function of the control panel is to control the alternator output through the action of the various components and to distribute it to the load.

b. Voltage Regulation Components. Voltage regulation is provided for in two ways; by a manually controlled variable resistor (exciter field rheostat) and by an automatic type voltage regulator.

(*1*) Manual Controlled Variable Resistor (*fig. 9*). The manually controlled variable resistor is connected directly into the exciter field circuit, and its primary purpose is to adjust the output voltage of the alternator to the condition of the load, by varying the exciter voltage. Any variation in load will cause a variation of voltage in the circuit which can be corrected by manipulation of the knob of the exciter rheostat. When the output voltage, as indicated on the voltmeter, has been set at the desired value, with the generator running, the manually controlled variable resistor can then be cut out of the circuit by flipping the toggle switch located at the center of the voltage regulator case over to the ON position. By this action the automatic regulator begins to function, and maintenance of the desired voltage then becomes dependent upon the automatic voltage regulator.

(*2*) *Automatic Voltage Regulator.* The function of the automatic voltage regulator is to automatically maintain at a constant value, the desired preset voltage across the lines while the unit is in operation. If, when the automatic voltage regulator is switched into the circuit, the voltmeter does not indicate the correct value, adjustment of the automatic regulator should be promptly made while it is in operation. This is readily done by turning the voltage-adjusting

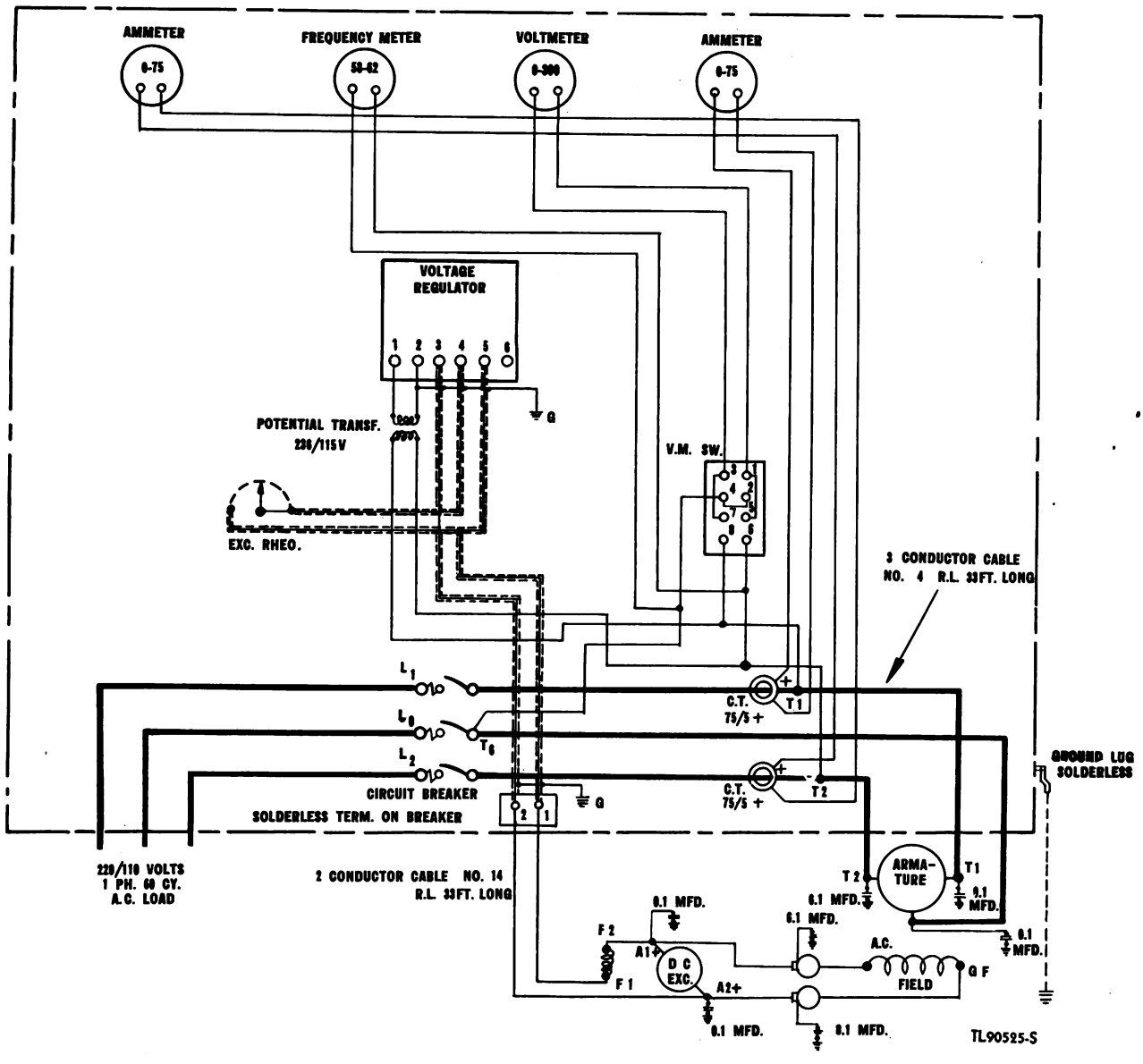


Figure 38. Power Unit PU-53/FRC, wiring diagram.

slotted screw (marked A-C Voltage) which is on the front of the regulator case. The voltage regulator has a laminated core, A, with voltage coil C, and a spring steel vibrator, V. Vibrator V is held under tension by voltage adjusting screw B, so that when the voltage coil is not energized, vibrating contact V, and stationary contact S, are pressed together to short-circuit the shunt field resistor. Voltage coil C is connected to the generator, hence is energized by the alternating current of the generator. The alternating current in the relay coil causes a pulsating magnetic flux in relay core A which rises to a maximum every 1/120th of a second, with each alternation of the generator voltage. Under the pulsating magnetic force of the relay core, the vibrator is attracted so that it pulsates 120 times per second. The regulator contacts open slightly each time the voltage wave reaches a positive or negative maximum and close each time the voltage wave goes through zero. The length of time the contacts are open during each pulsation of the vibrator depends on the load condition of the generator. When the load is removed from the generator, so that the generator voltage tends to rise, the duration of the

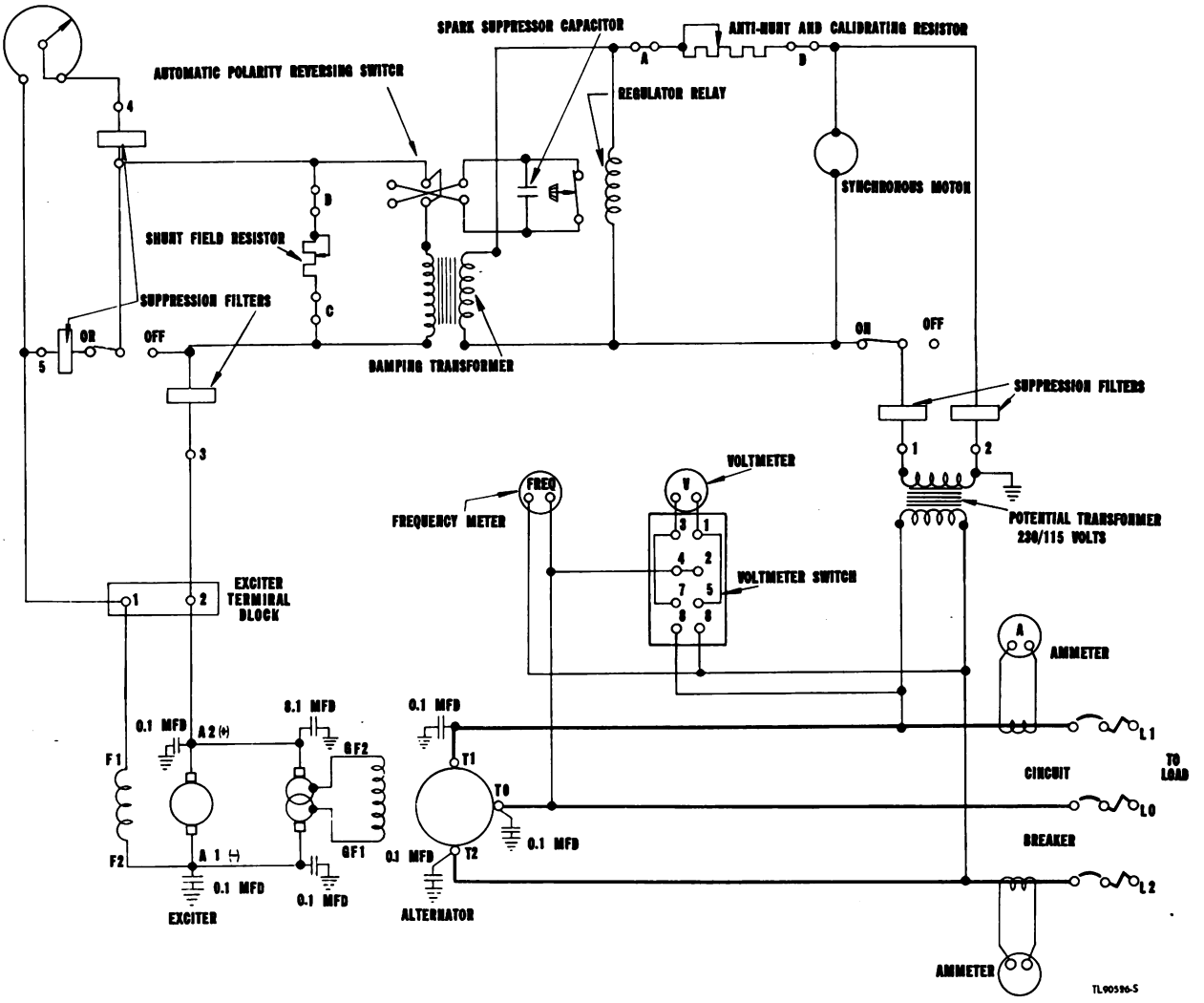


Figure 39. Power Unit PU-53/FRC, schematic diagram.

opening of regulator contacts will be longer, inserting the exciter shunt-field resistor for a longer period during each pulsation of the vibrator, thus lowering the generator excitation and causing the voltage to return to normal. When the load is added to the generator so that the generator voltage tends to drop, the duration of the opening of the regulator contacts will be shorter, or the contacts will not open at all, thus raising the generator voltage to normal. The positive, rapid action and low inertia of the vibrator of the regulator and its operation twice every cycle of the alternating current, makes it responsive within ½ cycle to minimize voltage fluctuations, and very sensitive to maintain accurate average voltage.

NOTE: It is not necessary to take the regulator out of service in order to shut down the generator. Without touching the regulator, the generator may be shut down and later restarted as often as desired. The regulator automatically starts and stops with the generator.

(*3*) *Damping Transformer.* To stabilize the regulated voltage and prevent excessive swinging under various conditions of excitation change, a damping effect is introduced into the regulator coil circuit by means of a damping transformer. The use of this device eliminates the need for dashpots or similar mechanical antihunting devices which require adjustment and maintenance. The damping transformer is of a special type having a small air gap in the laminated iron magnetic circuit. One winding is connected in series with the exciter field of the generator whose voltage is being regulated. The other winding is connected in series with the regulator coil. When there is a change in

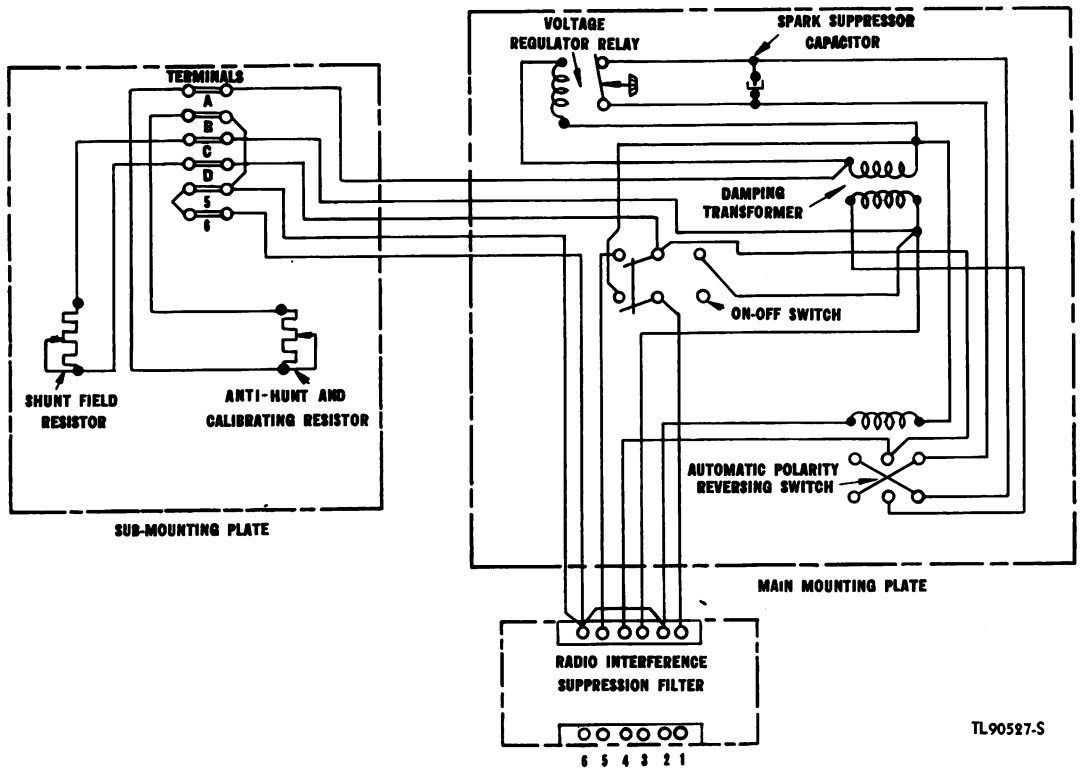


Figure 40. Voltage regulator, wiring diagram.

excitation voltage as a result of the regulating action of the regulator, there is an induced transfer of energy from one winding to the other of the damping transformer. The energy thus introduced into the circuit of the regulator coil acts by reason of its direction, magnitude, and time to electrically damp excessive action of the relay, thus preventing the relay from carrying the change in regulating resistance and consequent change in excitation too far. Since the damping transformer operates only when the excitation of the generator is changing, it being remembered that the excitation circuit is direct current, the damping transformer has no effect when the regulated voltage is steady and the regulator is in a balanced condition.

c. Function of Other Components. The MAIN LINE AIR CIRCUIT BREAKER acts as a loading switch, and also as a protective device in case of overload or short circuit in the main line. The A-C AMMETERS show the load on each line. The A-C VOLTMETER, used in conjunction with the VOLTMETER SWITCH indicates the voltage produced by the generator. The FREQUENCY METER indicates the frequency of the generated voltage which should be approximately 60 cycles at full load (fig. 40).

SECTION XII. TEST EQUIPMENT USED IN TROUBLE SHOOTING

58. STANDARD TEST EQUIPMENT.

When testing the generator windings, have the following equipment at hand:

a. Pair of test leads with prods.

b. Test lamp, 115-volt, and socket.

c. D-c voltmeter.

d. An armature growler will be found very helpful.

59. IMPROVED TEST EQUIPMENT USED IN TESTING THE POWER GENERATOR.

a. General Test. Many of the following testing instructions may be used without disassembling the exciter or alternator. In each instance

where an exciter armature winding or an alternator field winding tests open-circuited, short-circuited, or grounded, the practical repair is to install a new rotor assembly. If a stator winding tests open-circuited, short-circuited, or grounded, the practical repair is to install a new stator winding assembly unless the trouble is in the leads outside the winding proper. The rotor windings and the stator windings can be successfully repaired only at a competent rewinding shop. The tests require the use of a 115-volt lamp and socket, two test prods, and the necessary connecting wire. Certain tests require a d-c voltmeter. Before starting the tests, remove the band cover from the exciter, lift all brushes high in their holders and set the ends of the springs against them to hold them high. Disconnect the three stator winding cables from the terminals on the circuit breaker on the control panel, and the exciter cables from the d-c terminal block below the circuit breaker on the control panel. Refer to the wiring diagram as shown in figure 38. In using the test prods, make sure that good electrical connection is made at points of contact. Connect the test prods with leads to a source of 115 volts ac or dc. Connect the 115-volt lamp socket in series with one of these leads. In this way, when the prods contact a complete circuit, the lamp will light.

b. Testing Stator Windings for Grounds. Touch one test prod to the stator frame. Touch the other prod in succession to cable terminal T1, T0, or T2 (fig. 38). If the lamp lights, the stator winding is grounded. Inspect the cables throughout their lengths, since it is possible that the ground may be in the cable instead of in the winding. If so, tape the defective section of the cable with several layers of rubber tape, half-lapped, then with two layers of friction tape. If the ground is in the winding proper, replace the winding assembly.

c. Testing Stator Windings for Open Circuits. Touch one test prod to cable terminal T0 and the other test prod to cable terminals T1 and T2 in succession. If the lamp does not light, the winding is open-circuited. Repeat the test, sticking the prods through the cable insulation and into the copper in the cable near the two terminals instead of touching the terminals. If the circuit does not test open on this test, but tests open when contact is made at the terminals, it indicates that a terminal is loose on its cable. Sweat it securely on with solder.

d. Testing Stator Windings for Short Circuit.

(*1*) A preliminary and inconclusive indication of a short circuit in the alternator stator winding is a magnetic humming noise in the winding. This is similar to the humming noise made by a transformer. It is only an indication, not a conclusive test.

(*2*) A shorted winding in the stator is frequently indicated by a burned spot in the winding.

(*3*) An inside growler will positively indicate a short circuit in the stator windings.

(*4*) Connect the d-c source of power across terminals T1 and T2. Connect a voltmeter in the test leads and take readings across terminals T1 and T0 and across terminals T0 and T2. Both of these readings should be the same, each one being one-half the voltage of the source of power. If one voltage is lower than the other, then that winding showing the low voltage is shorted.

e. Testing Alternator Field Winding for Open Circuit. Raise slip-ring brushes in holders. Touch one test prod to each collector ring. If the lamp does not light, the field winding is open-circuited.

f. Testing Alternator Field Winding for Short Circuit. If a considerable number of turns in one coil is short-circuited, that coil will run hotter than other coils which are in good condition. Grounds at two points in the winding would short-circuit the intervening portion and the winding will test grounded. (For this test, the unit should be dismantled.)

g. Testing Rotor Windings for Grounds. Touch one test prod to the rotor shaft and the other to a collector ring. If the lamp lights, the alternator field winding is grounded. Touch one test prod to the exciter armature quill and the other to the exciter commutator. If the lamp lights, the exciter armature winding or the commutator is grounded.

h. Testing the Exciter Armature for Open or Short Circuit. This test requires the use of an armature growler after first removing the exciter frame. However, if there is a short circuit

or an open circuit in either the winding or the commutator, it will show up in either a burned commutator bar or a burned armature winding, and there will be a very bad sparking on open circuit.

i. Testing Exciter Field Windings for Grounds. Disconnect the exciter field leads from the exciter brushes and from the generator. Touch one test prod to the exciter frame. Touch the other test prod to any of the field leads. If the lamp lights, the winding is grounded. Inspect the leads. If the ground is in a lead, tape the defective section with several layers of friction tape. If the ground is in the winding proper, remove the exciter field. Remove the two hexagonal-head bolts holding the pole body to the frame. Push the pole body and coil away from the frame slightly and test again for ground. The ground is at the coil last loosened before the test indicates that the ground has been removed. Remove the pole body from that coil and locate the grounded spot on the coil by visual inspection. Install a new winding. When a new winding is not available, if possible, repair the coil by taping the defective area with several layers of friction tape carefully half-lapped, and shellac the area. Replace the coil after the shellac has dried.

j. Testing Exciter Field Windings for Open or Short Circuit. The exciter field coils are connected in series. Use the test prods to test for open circuit. Test for short circuit by connecting the series of shunt coils across a 115-volt d-c source and taking a voltage reading across each of the coils. If the voltage is lower across one coil than across the other, that coil has some turns short-circuited. To test for open circuit in the field winding, touch one test prod to each of the two ends of each of the coils. If the lamp does not light, there is an open circuit. Unless the trouble is located at connections between coils or in leads and is easily repaired, install new coils.

k. Other Tests. The same test set may be used for many tests for grounds, open circuits, or short circuits elsewhere on the power unit and the control panel. When the lamp lights, the circuit between prods is complete, and vice versa.

SECTION XIII. TROUBLE-SHOOTING PROCEDURES

60. GENERAL TROUBLE-SHOOTING INFORMATION.

No matter how well equipment is designed and manufactured, faults occur in service. When such faults occur, the repairman must locate and correct them as rapidly as possible. Take advantage of the material supplied in this manual to help in the rapid location of faults. Consult the following trouble-shooting data when necessary:

a. Engine and generator trouble charts (pars. 65 and 66).

b. Control panel wiring diagram (fig. 38).

c. Illustrations of components, front, top, and bottom views aid in locating and identifying parts.

61. SEQUENCE OF TROUBLE-SHOOTING PROCEDURE.

The trouble chart which follows indicates various symptoms of trouble which are readily detected. When the nature of the trouble has been determined, check the various points under the heading Cause in the sequence given. Follow the sequence given since seemingly major troubles may be reduced to minor troubles by checking the items in the prescribed order. All referenced items are contained in paragraph 51.

62. ENGINE TROUBLE CHART.

Trouble	Cause	Check	Remedy
Engine fails to start.	Fuel supply shut off.	Check for restriction in fuel line.	Open bottom plug in final filter to see if fuel is present there. Proceed in direction indicated toward injection pump, or toward fuel tank.
	Controls incorrectly positioned.	See instructions (par. 51, item 36).	Position properly.
	Controls out of adjustment or not functioning.	Check position and condition.	Clean and adjust (par. 51, item 36).
	Fuel system air-bound.	Check for loose line joints and leakage past gaskets.	Bleed the fuel system (par. 51, item 46) after correcting any leaks found.
	Fuel pump strainer dirty or clogged.	Check condition of strainer.	Clean (par. 51, item 37) or replace.
	Fuel filters clogged.	Inspect elements.	Clean or replace elements (par. 51, item 37). Empty and clean sediment bowl.
	No fuel being delivered.	Check for presence of fuel at nozzle, at injection pump.	Remove nozzle and crank engine. Note whether spray is present and correct. If nozzle is clogged, clean or replace. If no fuel at nozzle, check fuel to and through pump. Clean fuel line. Be sure that pump is delivering oil at sufficient pressure.
	Air intake restricted.	Check air cleaner.	Service air cleaner.
Missing and uneven operation.	Poor fuel or water in fuel.	Check fuel and drain system.	Replace with good fuel. Service sediment bowl (par. 51, item 82).
	Controls out of adjustment.	Check control positions.	Adjust controls (par. 51, item 19).
	Air intake restricted.	Check air cleaner.	Service air cleaner.
	Exhaust restricted.	Check exhaust system throughout.	Remove any restriction. Note whether sharp bends in exhaust pipe are restricting exhaust.
	Faulty timing of injection pump to engine.	Check timing.	Adjust timing (par. 51, item 45).
	Intermittent fuel delivery.	Check for any restriction in complete fuel system. Inspect injection pump (par. 51, item 45).	Clear any restriction. Service the injection pump (par. 80).
	Injection nozzles dirty or leaking.	Check condition and connections.	Clean and repair (par. 51, item 46).
	Faulty engine.	Check for leaking valves. Make compression test (par. 51, item 21).	Adjust valves (par. 51, item 19).

62. ENGINE TROUBLE CHART (contd).

Trouble	Cause	Check	Remedy
Engine smokes.	Engine overloaded.	Check load specifications.	Reduce load.
	Poor fuel.	Check condition and grade.	Drain and change to correct grade. Service sediment bowl (par. 51, item 82).
	Improper lubricant.	Check grade in use.	Change to proper grade (fig. 19).
	Improper governor adjustment.	Check adjustment. Check condition of governor adjusting screw, and center rod.	Adjust governor. Replace adjusting screw and center rod if necessary.
	Engine worn.	Check compression (par. 51, item 21) and condition of wear.	Disassemble and repair if indicated. Examine valves and valve seats, rings. Regrind valves, replace rings if needed. Watch for scored cylinder wall.
Engine knocks.	Engine is cold.	Check water and oil temperature.	Allow engine to reach running temperature. If air temperature is cold, cover radiator with tarpaulin.
	Poor fuel or water in fuel.	Check condition and grade of fuel.	Drain system, replace fuel with correct grade. Clean sediment bowl (par. 51, item 82).
	Injection nozzle leaking.	Check fuel line connections, and check nozzle.	Repair or replace the nozzle. Do not attempt to adjust the nozzle.
	Faulty timing of injection pump.	Check timing (par. 51, item 45).	Adjust timing (par. 51, item 45).
	Excessive carbon in engine.	Inspect head and valves for carbon.	Remove head and clean. Clean precombustion chamber if necessary.
	Broken or loose parts in engine.	Disassemble engine and check for loose parts.	Tighten loose parts or replace if indicated.
Lack of power.	Engine misses.	Check for poor fuel, leaking injection nozzle, faulty timing of injection pump, excessive carbon or broken or loose parts.	Repair any leaks, correct timing, clean out carbon, replace any broken parts.
	Engine overheats.	Check for sufficient coolant, restriction in radiator core fan belt tension. Check timing.	Flush cooling system and add coolant, clear any restriction in core, adjust or replace fan belt. Correct timing.
Low oil pressure.	Insufficient lubricant.	Check and correct any leaks.	Add lubricant.
	Leaking oil line to pressure gauge.	Check fitting for leaks. Check gauge for operation.	Tighten fittings. Replace gauge.
	Relief valve not properly seated.	Check seating of valve.	Tap top of camcase. Remove camcase cover and correct trouble.

63. GENERATOR TROUBLE CHART.

Trouble	Cause	Check	Remedy
Sparking at the brushes.	Too much load.	Check voltmeter and ammeter readings to make sure that they indicate no higher voltage or current than indicated on the nameplate.	Reduce the load.
	Brushes not seated properly.	Remove brushes and check for uneven wear or dirt on brushes or commutator.	Seat brushes using fine sandpaper (par. 104).
	Brushes sticking in the holders.	Check to see that all brushes move freely in their holders.	Readjust brushes or replace with new ones of the correct sizes. Check springs for proper tension.
	Rough, dirty, or eccentric commutator.	Check for uneven wear on commutator and brushes.	Clean out dirt. If only slightly rough, use coarse cloth or very fine sandpaper; if rough, send the unit to a depot for repair.
	Open armature.	Check to see if a coil lead is disconnected or open.	Solder the coil lead back on, or return the unit to a depot.
	Grounded or open or shorted field winding.	Check for breaks or shorts in the field.	Replace open or shorted fields. A grounded field may be repaired by insulating at the point where ground occurs. Return to depot for repairs.
Voltage too low.	Engine speed low.	Check speed with tachometer.	Increase speed of engine by adjusting the knurled tension spring nut.
	Brushes do not seat properly.	Remove brushes and check for uneven wear.	Adjust brushes with fine sandpaper (par. 104).
	Voltage regulator not functioning properly, too much load.	Check this table below. Check meter.	See below in this table. Reduce load.
A-c voltage drops badly when generator is loaded.	Exciter field rheostat turned too far toward *lower*.	Check position of rheostat.	Turn to correct position. Voltage regulator will maintain correct voltage.
	Voltage regulator not functioning properly, too much load.	Check this table below. Check meter.	Reduce load.
Voltage too high.	Speed of engine too high.	Check engine speed with tachometer.	Adjust governor by means of knurled tension spring nut.
	Automatic voltage regulator not functioning.	Check control panel trouble chart.	See control panel trouble chart.
Armature too hot.	Armature overloaded.	Check voltmeter and ammeter readings to make sure that load noted on nameplate is not being exceeded.	Reduce the load.
	Armature coil short-circuited.	Check for breaks in insulation.	Replace the armature. This should be done at Signal Corps repair depot.

63. GENERATOR TROUBLE CHART (contd).

Trouble	Cause	Check	Remedy
Armature too hot.	Armature striking on pole pieces.	Check the generator bearings to be sure that they are not excessively worn. Check the line-up of the drive pulleys. Check for loose pole pieces.	Replace bearings if necessary. Align engine and generator. Return the unit to a Signal Corps repair depot.
	Poor ventilation.	Check air space around the generator.	Make sure there is at least a 2-foot clearance on all sides of the generator.
Field coils too hot.	Short circuit in field coils.	Check for breaks in the field.	Replace open or shorted fields. A grounded field may be repaired by insulating at the point where the ground occurs.
	Poor ventilation.	Check air space around the generator.	Make sure that there is at least a 2-foot clearance around all sides of the generator.
Generator is noisy.	Armature striking a pole. Drive pulley loose.	Check for loose wires. Check fit.	Replace armature if necessary. Return the unit to a depot. Tighten setscrews.
No output from generator.	Short circuit in the exciter leads.	Check for short circuit.	Pass current from a battery through the alternator field coils. If trouble is then corrected, check exciter leads for shorts. Repair the exciter.
	Brushes not making contact.	Check to see if brushes are stuck.	Make sure that brushes move freely in their holders. Replace with new brushes if necessary.
	Capacitor short-circuited.	Disconnect the capacitor and see if current flows in the line.	Replace the capacitor.
	Short-circuited exciter armature.	Check for breaks in the armature or dirt on the commutator bars (par. 59).	Remove dirt and grease. Replace the armature. If necessary, return it to the depot.
	Short-circuited or open-circuited field coils.	Check for short circuits and open circuits (par. 59).	Replace open or shorted fields. A grounded field may be repaired by insulating at the point where the ground occurs. Return the unit to the depot.
	Field coils reversed.	Pass current through the field coil and check to see that the coils alternate north and south.	Change the position of the coils. Return the unit to the depot if necessary.
Commutator too hot.	Sparking at brushes.	See checks previously outlined.	See remedies previously outlined.
	Too much pressure on brushes.	Pressure should be approximately 2½ to 3½ pounds per square inch of brush surface.	Adjust spring tension.

63. GENERATOR TROUBLE CHART (contd).

Trouble	Cause	Check	Remedy
Commutator too hot.	Too much load.	Check voltmeter and ammeter readings to be sure that generator is not being overloaded.	Reduce the load.
	Poor ventilation.	Check air space around the generator.	Make sure that there is at least a 2-foot clearance on all sides of the generator.

64. CONTROL PANEL TROUBLE CHART.

Trouble	Cause	Check	Remedy
Voltmeter fails to register.	Loose or broken leads.	Check complete circuit (fig. 38).	Tighten or replace leads.
	Alternator not functioning.	Check generator trouble chart.	See generator trouble chart (par. 63).
	Voltmeter broken.	If alternator functions and wiring is perfect, trouble is in voltmeter.	Replace the voltmeter.
Ammeters fail to register.	Loose or broken leads.	Check the complete circuit wiring diagram (fig. 38)).	Tighten or replace the leads.
	Alternator not functioning.	Check generator trouble chart.	See generator trouble chart (par. 63).
	Current transformer defective.	Check transformer for open circuit or short circuit.	Replace transformer.
	Ammeters broken.	If trouble is not located after above checks, ammeters are broken.	Replace the ammeters.
Frequency meter fails to register.	Loose or broken leads.	Check the circuit (wiring diagram (fig. 38)).	Tighten or replace the leads.
	Drive belts slipping.	Check belt tension.	Adjust belt tension.
	Engine speed less than 696 rpm, or greater than 744 rpm.	Check engine speed.	Adjust speed.
	Defective meter.	If the circuit check does not reveal the trouble, the meter is defective.	Replace the meter.
Voltmeter fluctuates excessively.	Engine not running properly.	Check engine trouble chart (par. 62).	See engine trouble chart (par. 62).
	Voltage regulator not functioning properly.	Check voltage regulator controls.	File, clean, and adjust contacts.
	Incorrect wiring.	Check all wiring (wiring diagram (fig. 38)).	Correct the wiring.
Main line circuit breaker trips to OFF position.	Generator overloaded.	Check ammeter readings.	Reduce the load.
	Short circuit in the line.	Check the line completely for breaks or crossed wires.	Repair the broken or shorted circuit.

64. CONTROL PANEL TROUBLE CHART (contd).

Trouble	Cause	Check	Remedy
Automatic voltage regulator fails to function.	ON-OFF switch is in OFF position.	Check voltage regulator switch.	Move switch to ON.
	Short or open circuits.	Check regulator resistors, relay coil, and wiring for short or open circuits.	Replace parts or leads broken. Tighten connections.
	Voltage regulator contacts bent or stuck.	Check the voltage regulator contacts.	Adjust contacts if necessary. File contacts flat.
	Voltage regulator adjusting screw in wrong position.	Check to see that the regulating screw is not turned too far in the *increase voltage* direction.	Set the *increase voltage* screw properly.
A-c voltage is erratic.	Voltage regulator not adjusted properly.	Check the setting of regulator shunt-field resistance.	Resistor should be set for minimum *hunting* of the regulator, but not at less than 50 percent of its resistance. Set this resistance just below the point that produces *hunting*.
	Voltage regulator connections loose.	Check all connections.	Tighten connections.
	Voltage regulator contacts rough or out of adjustment.	Check contacts to see that they are not pitted or humped. Check to see that the air gap between regulator contacts is 1/32 inch.	File the contacts flat. Adjust the air gap between the contacts to 1/32 inch. In some cases, a closer setting is necessary to eliminate *hunting*.
Voltage sensitivity is poor.	Loose connections in the voltage regulator.	Check electrical and mechanical parts and connections in regulator for looseness.	Tighten all parts and connections.
	Voltage regulator contacts rough or out of adjustment.	Check regulator contacts for roughness. Check air gap to see if it is 1/32 inch.	File regulator contacts flat. Adjust air gap between the points to 1/32 inch.
	Shunt-field resistor in regulator improperly set.	Check this table above.	See notation above.
Voltage droops excessively under load, and generator is operating properly.	Regulator ON-OFF switch is at OFF.	Check switch position.	Throw switch ON.
	Regulator shunt-field resistor not properly set.	Check setting of the resistor.	Adjust the setting of the shunt-field resistor to decrease voltage droop.
Voltage regulator contacts spark too much.	Regulator capacitor open or shorted.	Check the capacitor by replacement.	Replace the capacitor.
	Broken or loose leads in the regulator.	Check the wiring of the regulator.	Replace broken leads and tighten connections.

SECTION XIV. SPECIAL TOOLS

65. TOOL FOR UNDERCUTTING MICA.

To improvise a tool for undercutting the mica between the segments of the exciter commutator, proceed as follows: Grind a piece of broken hacksaw blade to the exact width of the mica. Grind one end of the blade to enable the fitting of a wooden handle, and fit the handle to the blade.

66. TOOL FOR REMOVING CRANKSHAFT AND GENERATOR BEARINGS.

A tool for the removal of the ball bearings on the generator and the tapered roller bearings on the engine crankshaft can be improvised as follows: The tool consists of three steel bars, four long bolts, and nuts for the bolts. Two of the bars should be of a size and length and drilled so that they can be placed parallel to each other behind the bearing to be pulled. The third bar is placed over the end of the shaft, thus it should be of a width and drilled so that bolts through the two bars behind the bearing will pass through this plate when it is in place over the end of the shaft. The bolts should be long enough to allow for removal of any of the four bearings. To use the tool, place the two bars behind the bearing with the four bolts extending through them. Place the third bar over the end of the shaft, insert the bolts through this bar, and put nuts on the bolts. To remove the bearing, screw the four nuts down evenly, taking one turn on each nut and then going to an opposite nut, so that the bearing will be pulled straight off of the shaft.

SECTION XV. DISASSEMBLY AND REPAIR

67. ENGINE DISASSEMBLY AND REPAIR.

A separate paragraph is devoted to each system, accessory, or major unit, and contains detailed instructions for the disassmbly, inspection, and repair of the item. A complete description, together with operation, removal, adjustment, or test and installation is included on such items or assemblies that have not previously been covered elsewhere in this manual.

68. LUBRICATING OIL PRESSURE GAUGE (fig. 5).

a. General. Refer to paragraph 51 (item 3) for description and operation.

b. Removal. Simply unscrew the gauge from the elbow on the oil pressure line.

c. Repair. Other than tightening the screw at the bottom of the gauge if it should become loose, no repairs on the gauge should be attempted. Replace the gauge if it is inoperative.

69. LUBRICATING OIL FILTER.

a. General. Refer to paragraph 51 (item 85) for description and maintenance of the lubricating oil filter. An internal view of filter is shown in figure 41.

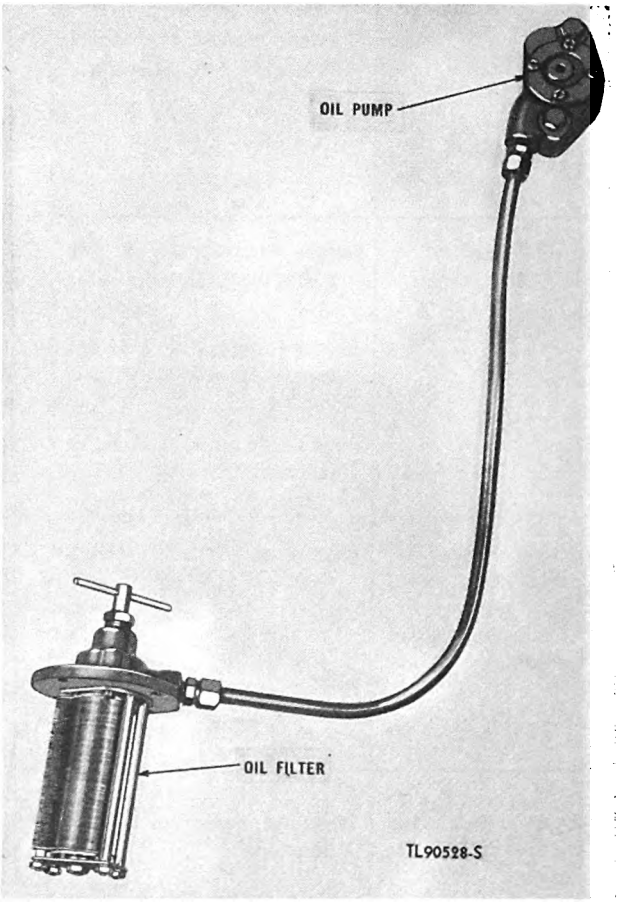


Figure 41. Lubricating oil filter and pump.

b. Removal. Disconnect the oil line from the filter. Both ends of the line need not be disconnected. Remove the four roundhead screws holding the filter to the engine base. Pull out the filter.

c. Inspection and Repair. The only operation ordinarily necessary on the oil filter is an occasional cleaning of the filter. Wash the unit thoroughly in Diesel fuel oil or with dry-cleaning solvent (SD).

d. Installation. Make sure that the filter gasket is intact before replacing the filter. If not, insert a new gasket. Replace the filter in the engine base. Secure it with the four roundhead screws and lockwashers. Connect the oil line.

70. PRESSURE REGULATING VALVE.

a. General. See paragraph 51 (item 85) for description and maintenance of the pressure regulating valve.

b. Removal.

(*1*) Remove the flywheel from the camcase side of the engine. To accomplish this, loosen the hexagonal nut on the flywheel shaft, but do not remove the nut. Hold a bar against the hub on the engine side of the flywheel, and strike it firmly with a timber or a heavy hammer. The flywheel will loosen, but will be prevented from falling off by the hexagonal nut. Remove the nut and remove the flywheel.

(*2*) To remove the camcase cover, disconnect the lubricating oil line from the oil pump on the side of the cover. Remove the two hexagonal-head bolts holding the fuel sediment bowl filter. This filter can be left in place. Remove the three small hexagonal-head bolts around the edge of the camcase cover. Lift off the cover, using care to avoid damaging the cover gasket.

(*3*) To remove the valve, unscrew the valve seat (fig. 28), then remove the valve and the valve spring.

c. Inspection and Repair. The valve, valve seat, and spring should be thoroughly washed in Diesel fuel oil or with dry-cleaning solvent (SD). If the spring is found to be so weak that the valve seat must be tightened to a point where the slotted head is inset from the camcase wall, replace the spring. No other repairs are ordinarily necessary to the valve, though any of its parts may be replaced readily.

d. Installation.

(*1*) Replace the valve in the reverse order of its removal.

(*2*) Apply a coat of high-grade sealer to the camcase cover gasket, and replace the gasket and cover, using care to avoid damaging the gasket. If the gasket is damaged in any way, replace it. Replace and secure the three hexagonal-head bolts and lockwashers around the edge of the camcase cover. Replace the two hexagonal-head bolts and lockwashers holding the fuel sediment bowl filter. Replace the lubricating oil line on the lubricating oil pump.

(*3*) Replace the flywheel, making sure that the shaft key is in place.

71. LUBRICATING OIL PUMP.

a. Description. The lubricating oil pump (fig. 41) is of the single-stage rotary gear type, is located on the outside of the camcase, and driven off the end of the camshaft. The pump draws lubricating oil from the oil reservoir through

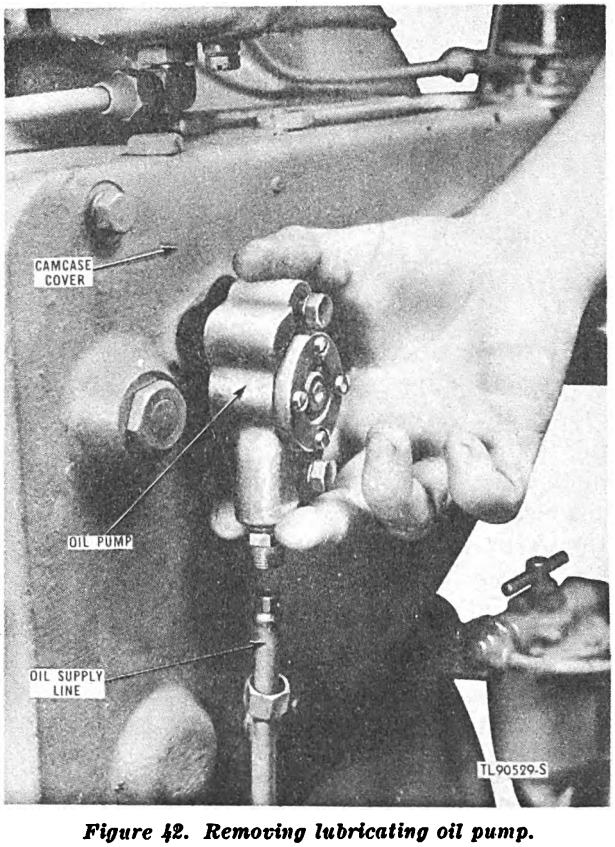


Figure 42. Removing lubricating oil pump.

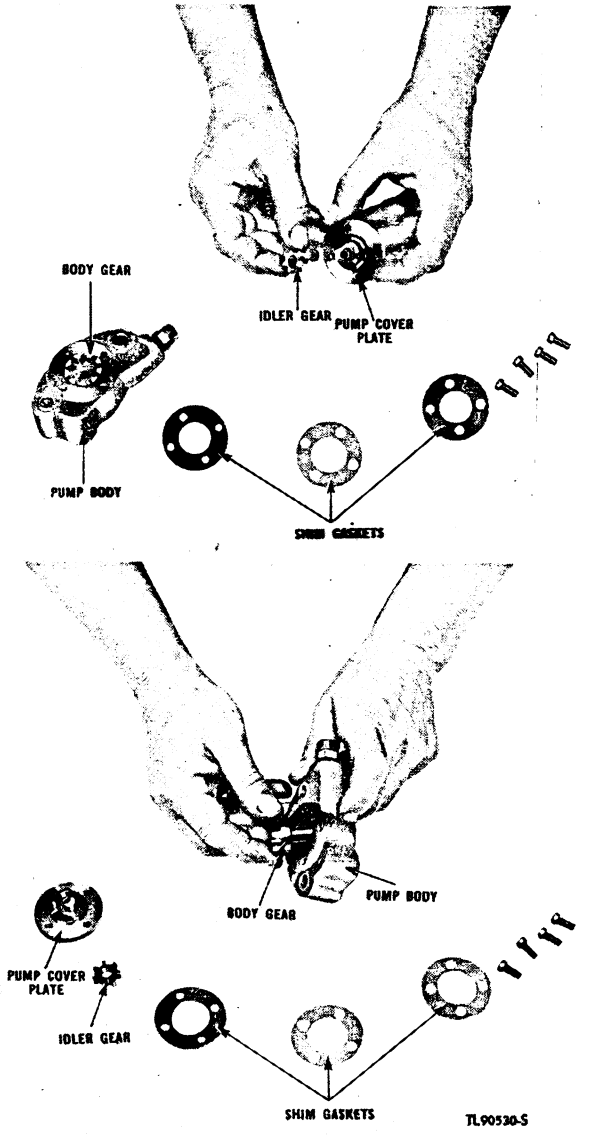


Figure 43. Lubricating oil pump, disassembly.

the oil filter and forces it against the pressure regulating valve into the crankcase. The lubricating oil overflows into the crankcase, returning to the reservoir. Splashers in the crankcase distribute the oil, and oil is also forced along the crankshaft to the camcase, where it bathes the parts in the camcase and returns through a drain hole into the crankcase.

b. Removal. Disconnect the line leading to the lubricating oil filter. Remove the two hexagonal-head bolts holding the pumps to the camcase. Remove the pump (fig. 42).

c. Disassembly and Repair. To disassemble the pump, remove the four roundhead screws from the cover on the side of the pump. This operation can be performed without removing the pump from the camcase cover. Wear on the pump will ultimately result in some end play on the pump shaft. This can be corrected by the removal of one or more of the thin shims on the end of the shaft. Removal of the shims will result in higher oil pressure, necessitating the adjustment of the oil pressure regulating valve. Shims should not be removed to the extent that the pump shaft does not turn freely when rotated by hand.

d. Installation. Reassemble the parts of the pump in the reverse order of their removal. Replace the pump on the camcase, securing the two hexagonal-head bolts and lockwashers. Reconnect the oil line to the pump.

72. FAN.

a. Description. A four-blade fan, 16 inches in diameter, is mounted to and driven from the fan-drive pulley. The fan-drive pulley is driven by a V-belt from a pulley on the engine crankshaft.

b. Removal (fig. 44). Remove the six screws holding the wire fan guard and remove the guard. Remove the fan bracket by turning down the bolt bracing the bracket against the cylinder shell and removing the two hexagonal head bolts holding the bracket to the cylinder head. Remove the fan belt by the following method: Hold the belt with the left hand, insert a screwdriver under a top link as far as the slot in the link; work the top of the screwdriver through the slot so that the tip of the blade rests on the head of the rivet; lift the handle of the screwdriver so that the link slides on the screwdriver blade over the head of the rivet; repeat the process on the succeeding rivets until the belt is uncoupled. Lift out the fan and its bracket. The fan and pulley can be removed from the bracket by removing the hexagonal-nut on the fan shaft.

c. Repair. Straighten any fan blade that has become bent out of line. Check the rivets holding the fan blades to be sure that they are tight.

d. Installation. Holding the bracket in place, replace the two hexagonal-head bolts that hold the bracket to the cylinder head. Do not tighten the bolts entirely until the bolt bracing the bracket against the cylinder shell has been adjusted to hold the bracket parallel to the cyl-

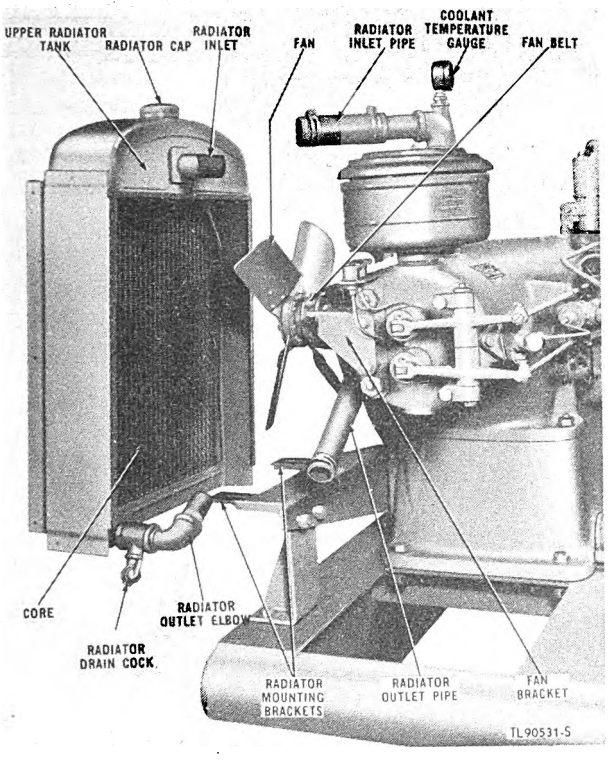


Figure 44. Radiator removal.

inder shell. When the bracket is secure, replace the fan guard.

73. FAN BELT.

a. Description. The fan belt is composed of multiple flexible impregnated canvas links, riveted together.

b. Removal. Remove the belt by the method explained in paragraph 72b above.

c. Repair. It is possible to replace worn links in the belt by uncoupling the belt as explained above, and putting new links in place on the rivets. It is recommended, however, that a new belt be installed if wear is evident. The belt can readily be shortened by uncoupling it and removing one or more links.

d. Installation. When replacing the belt, bolt the fan shaft to the bracket as far from the cylinder head as possible. This will allow maximum take-up without removing links. If the belt is too long, remove links to correct the length. Couple the belt by slipping the links over the rivets in the reverse procedure of their removal. When the belt is in place, adjust it as explained in paragraph 51 (item 29).

74. RADIATOR (fig. 44).

a. Description. The radiator is composed of a flat-tube and fin type core permanently mounted between upper and lower water tanks. It is securely mounted to the power unit frame on brackets attached to the lower water tank by two studs. The fan guard is fastened to the rear of the radiator, and a canvas air duct can be fastened to a frame on the front of the radiator. A drain cock is provided in the lower water return reducing tee. The radiator is provided as a complete assembly that cannot be disassembled.

b. Removal. Remove the wire fan guard at the rear of the radiator. Loosen the clamps and disconnect the top and bottom hose connections. Remove the two hexagonal nuts in the brackets at the bottom of the radiator. Lift the radiator off.

c. Repair. Straighten any bent fins. Perform this operation very carefully to prevent injury to the tubes or to the bond between the tubes and fins. Use a fin straightening tool or a shaped piece of wood. Examine the upper and lower water tanks for cracks. Examine the inlet and outlet hoses for deterioration, and install new hoses if necessary. Flush out the radiator thoroughly, and flush the fins, with water under pressure, from front and rear to remove all dirt. Do not use steam to clean the radiator. If the tanks or tubes are damaged, replace the radiator. Temporary repairs can be made on damaged tubes if only relatively few tubes are leaking by pinching these tubes with long-nose pliers above and below the breaks and bending the tubes so that they do not leak.

d. Installation. Replace the radiator in the reverse order of its removal. Be sure that the hose clamps are tight to prevent leakage around the hoses.

75. WATER TEMPERATURE GAUGE.

a. Description. The water temperature gauge is mounted in the engine coolant outlet pipe, at the top of the engine (fig. 44). The dial is divided into three sections, identified as COLD, RUN, and HOT. During normal operation the gauge indicating needle should point to the high side of the green RUN range. If the indicating needle remains in the red HOT range, stop the engine and determine the cause of overheating.

If the indicating needle should remain in the white COLD range, it may be necessary to restrict the flow of air through the radiator by covering the radiator with a tarpaulin or by partly closing the air outlet.

b. Removal. Drain the coolant to a level below the temperature gauge. Unscrew the gauge from the inlet pipe. Use an open-end wrench of correct size on the hexagonal nut, reducing fitting for the purpose.

c. Repair. Do not attempt any repairs on the temperature gauge. Replace the gauge if it is inoperative.

d. Installation. Replace the gauge in the inlet pipe. Replace the coolant that was drained out.

76. INITIAL FUEL FILTER.

a. General. Refer to paragraph 51 (item 37) for description and maintenance of the initial fuel filter.

b. Removal. It is not necessary to remove the entire filter assembly for repair, since the filter unit is separately removable. To remove the entire filter assembly, disconnect the fuel lines and remove the large hexagonal nut holding the filter bracket to the engine base. To remove the filter unit only, disconnect the fuel lines and remove the six oval-head screws around the top of the filter.

c. Repair. Clean the filter unit thoroughly in dry-cleaning solvent (SD) or Diesel fuel oil. Clean out the filter housing and remove and clean the drain plug in the bottom of the housing.

d. Assembly. Assemble the filter and replace it in the reverse order of its removal. If the gasket between the filter and the filter housing is not entirely intact, replace it.

77. FUEL SUPPLY PUMP (fig. 45).

a. General. The fuel supply pump is of the diaphragm type. It is driven by the fuel pump eccentric, on the camshaft in the camcase. The pump is conveniently mounted outside the camcase. The sediment bowl is housed together with the pump. Fuel, in entering the pump, fills the glass bowl on top of the pump and passes through a fine wire screen. The bowl and screen act to trap any dirt or water that may be present in the fuel.

b. Removal. Disconnect the fuel lines going into and out of the pump. Remove the two hexagonal-head bolts holding the pump to the camcase. Remove the pump and the rocker arm.

c. Repair. It is possible to replace the glass bowl and the filter screen quite readily, but it is not advisable to attempt repairs on the pump itself. It is quite likely that the removal and replacement of the pump will have allowed air to get into the fuel system. Bleed the system as outlined in paragraph 51 (item 46).

78. FINAL FUEL FILTER (fig. 27).

a. General. Refer to paragraph 51 (item 37) for description and maintenance of the final fuel filter.

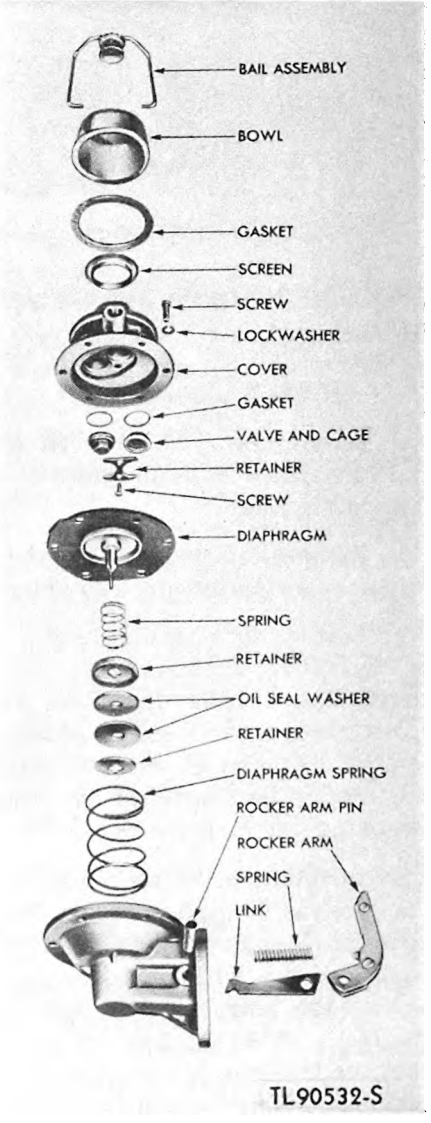


Figure 45. Fuel supply pump, disassembled.

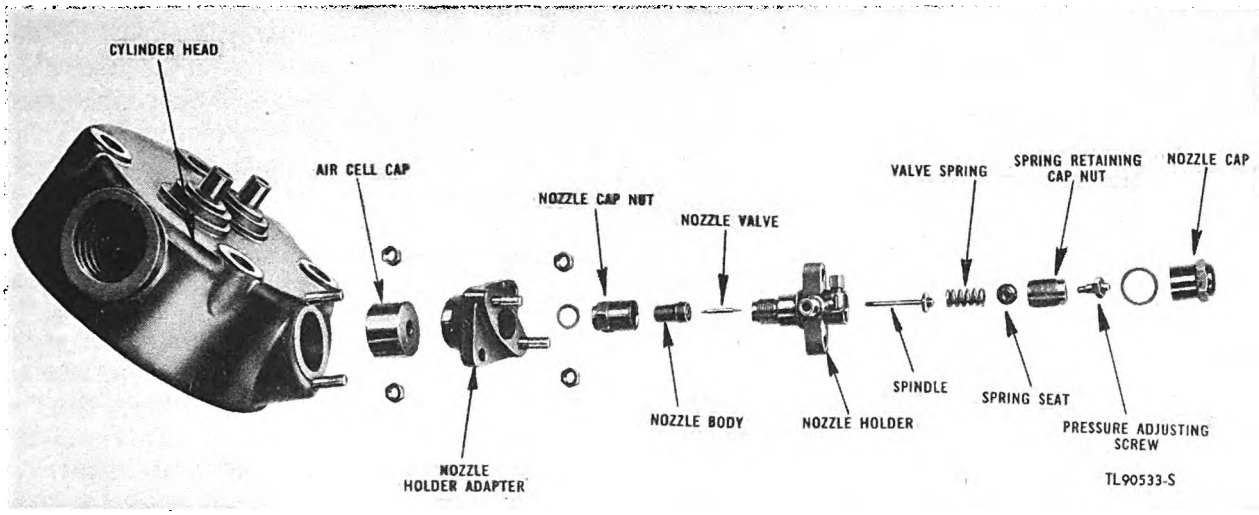


Figure 46. Injection nozzle, disassembled.

b. Removal. To remove the filter, disconnect the fuel lines entering and leaving the filter. Loosen the bolt holding the filter clamp and remove the filter. No repairs can be made to the filter. Replace filters as described in paragraph 51 (item 37).

c. Installation. Install new filters in the reverse order of filter removal. It is necessary to bleed the fuel system when the filter has been replaced (par. 51 (item 46)).

79. FUEL INJECTION NOZZLE.

a. Description. The nozzle is of the pintle type, automatically operated by fuel pressure. The function of the nozzle is to atomize and spray fuel into the engine precombustion chamber. It incorporates a valve and spring arrangement (fig. 46) that keep the nozzle closed until sufficient pressure is attained. The nozzle is designed to prevent after-dribble, which causes damage to the nozzle, piston, and valves.

b. Removal. Disconnect the fuel line from the nozzle. Remove the two hexagon nuts holding the nozzle holder to the studs on the cylinder head. Remove the nozzle and nozzle holder. Unscrew the nozzle cap nut and remove the nozzle from its holder.

c. Repair. Do not attempt to adjust or repair the nozzle, but replace it if trouble is suspected. Inspect the nozzle for excessive carbon, and inspect the holder and nozzle for possible cracks or damage. If the nozzle is dirty, the interior of the nozzle body can be cleaned (after soaking in dry-cleaning solvent (SD)), with a small strip of clean wood dipped in the solvent. The nozzle valve (fig. 46) should be rubbed with a solvent-soaked, clean, soft, lint-free cloth. Hard or sharp tools, emery paper, or power should never be used on the nozzle. Before being reassembled, the nozzle valve and nozzle body should be washed in clean fuel oil, and then, on being brought together, examined carefully to see that the valve revolves and moves in and out easily. If a Diesel engine fuel injection nozzle tester is available, adjust the nozzle opening pressure at 2,000 pounds per square inch.

> **CAUTION: The injection nozzle and valve are matched to each other to very fine tolerances. Do not interchange parts, and do not replace just one of the parts. Always replace with a new matched nozzle and valve.**

d. Installation. Reassemble the nozzle and nozzle holder in the reverse order of their disassembly. Replace the nozzle holder and the fuel line. It may be necessary to bleed the fuel system according to the procedure given in paragraph 51 (item 46).

80. FUEL INJECTION PUMP.

a. General. Refer to paragraph 51 (item 45) for description, operation, and maintenance of the fuel injection pump.

b. Removal.

(*1*) *Preparations for Removal.* First thor-

oughly clean the entire exterior of the pump, especially the fuel line connections to the pump. Take every care to prevent the entry of dirt into the pump mechanism.

(*2*) *Draining Fuel.* Open the bottom plug in the final filter and drain the fuel from the filter, since it would run out of the fuel line at the pump when that line is disconnected. Open the plug in the side of the injection pump (fig. 28) and allow the fuel in the pump to drain. Replace the plug before proceeding.

(*3*) *Disconnecting Fuel Lines.* Disconnect both fuel lines from the pump, putting threaded caps on the openings in the pump. If caps are not available, close up the holes with clean corks, clean cloths, cellophane, or masking tape so that dirt cannot get into the pump.

(*4*) *Disconnecting Governor Bell Crank.* Remove the cotter pin at the junction of the governor bell crank (fig. 47) and the injection pump rack. Separate the two parts.

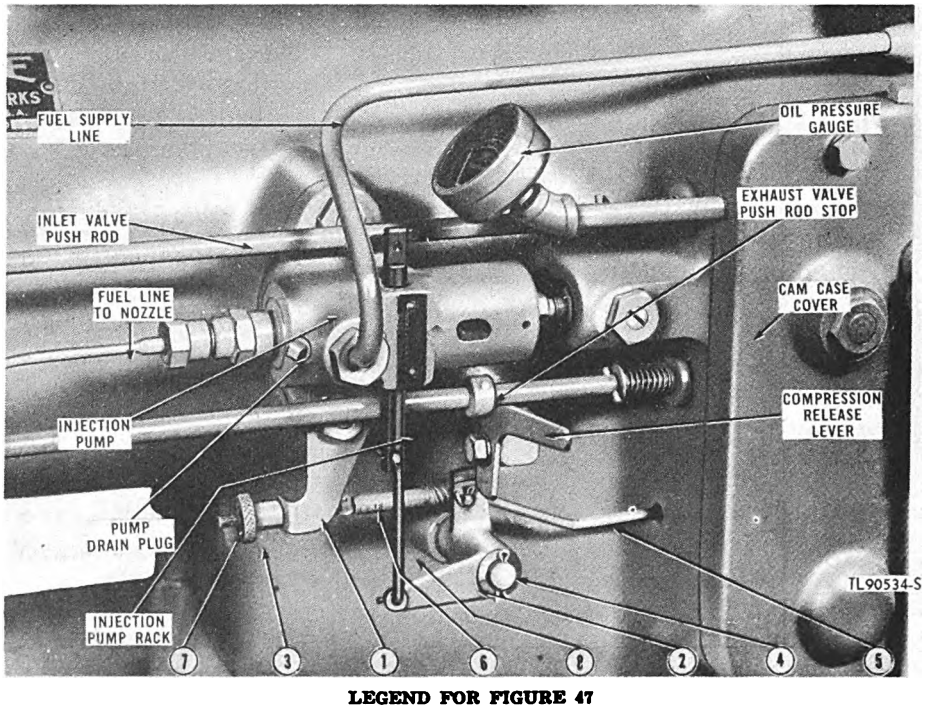
(*5*) *Removing the Injection Pump.* Turn the engine flywheel so that the pump plunger is all of the way out. Loosen the hexagon nut on the plunger shaft nearer the pump and turn the nut back on the shaft away from the pump. Remove the two hexagon nuts on the studs holding the pump on the engine. Remove the pump, being careful not to let dirt touch any part of it. Wrap the projecting parts of the pump rack to keep it clean.

c. Repair. No repair should be attempted. Replace the injection pump if it is inoperative.

d. Installation. Replace the injection pump in the reverse order of its removal. After installation it will be necessary to bleed the fuel system according to paragraph 51 (item 46) and to time the injection pump (item 45).

81. STARTING MECHANISM AND CONTROLS.

a. Description. The starting mechanism consists of the compression release lever and the linkage that controls the operation of the injection pump for priming, starting, running, and stopping. The assembly is mounted on the engine between the injection pump and the camcase (fig. 47). For a complete description and operation, refer to paragraph 51 (item 36).



LEGEND FOR FIGURE 47

1. Bracket, speeder.
2. Crank, bell.
3. Nut, knurled.
4. Pin, bell crank fulcrum.
5. Rod, connecting.
6. Spring, extension.
7. Stem, speeder.
8. Link, injection pump.

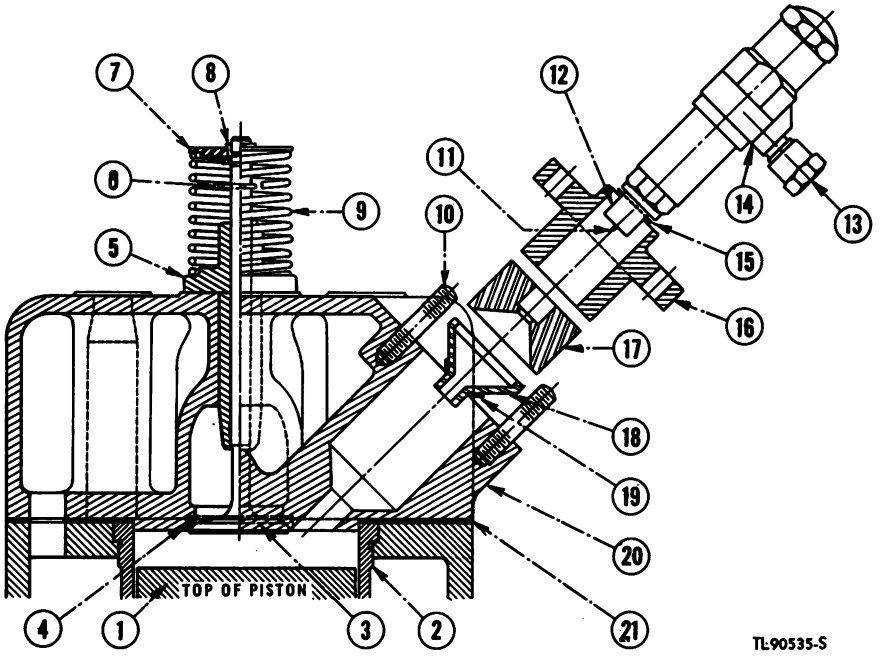
Figure 47. Starting and injection pump control mechanism.

b. Removal. To remove the governor bell crank, remove the cotter pin holding the crank on the shaft, the cotter pin holding the rod that connects the crank to the injection pump rack, and the cotter pin holding the crank and the governor control rod. To remove the compression release lever, remove the hexagon nut holding the lever on the compression release lever bracket.

c. Repair. Clean all parts thoroughly in dry cleaning solvent (SD), and dry them with compressed air. If any of the parts show wear to the extent that the compression release lever does not engage the stop on the exhaust valve push rod, or that the linkage from the governor to the injection pump has excessive play, replace the worn parts. When the parts have been reassembled, insert several drops of lubricating oil in the oil hole on the governor bell crank.

82. CYLINDER HEAD AND INTAKE AND EXHAUST VALVE MECHANISM.

a. Description (fig. 48). The cylinder head has cast within it the intake and exhaust passages and the recess into which is fitted the precombustion chamber. Pressed into the head are removable intake and exhaust valve guides and removable valve seat inserts. Thus either the guides or the seats can be replaced when they show wear. The precombustion chamber, or air cell, is used to increase the efficiency of the engine. During the compression stroke, air is forced into the precombustion chamber at high pressure and temperature. Near the end of this stroke, injection begins, fuel being sprayed into the precombustion chamber. The fuel ignites immediately, causing a very rapid rise in the temperature and pressure in this chamber. This rapid rise in pressure results in a



LEGEND FOR FIGURE 48

1. Piston, engine.
2. Liner, cylinder.
3. Insert, valve seat.
4. Valve, engine inlet.
5. Guide, stem.
6. Pin, cotter.
7. Washer, lock.
8. Retainer, spring.
9. Spring, compression.
10. Stud, adapter.
11. Injection nozzle valve.
12. Injection nozzle body.
13. Fuel line coupling.
14. Holder, nozzle.
15. Washer, flat.
16. Adapter, nozzle holder.
17. Cap, air cell.
18. Liner, air cell.
19. Gasket, copper asbestos.
20. Head, cylinder.
21. Gasket, alupac.

Figure 48. Cylinder head, injection nozzle, and valve assembly.

very high velocity discharge of the partially burning gases and remaining unburned fuel through the venturi-shaped opening into the main combustion chamber. The burning fuel is thus caused to spread out over entire combustion chamber, resulting in the very thorough mixing of the unburned fuel with the hot compressed air in the combustion chamber. This makes for smooth, clean combustion with maximum power and minimum detonation.

b. Tabulated Data.

Valve seat width	1/8 in.
Valve seat angle	45°
Valve seat insert	intake and exhaust
Stem guides (replaceable)	Yes
Stem diameter	0.372 in.-0.371 in.
Stem clearance in guide	0.003 in.
Tappet clearance, hot	0.010 in.-0.012 in.
Valve spring, free length	3.0 in.
Valve spring test	2 1/8 in. - 18 lbs
Intake valve specifications:	
Head diameter	2.375 in.
Port diameter	2 1/8 in.
Lift	13/32 in.
Valve opens	6° before TDC
Valve closes	30° after BDC
Exhaust valve specifications:	
Head diameter	2.125 in.
Port diameter	1 7/8 in.
Lift	13/32 in.
Valve opens	45° before BDC
Valve closes	8° after TDC

c. Maintenance. After removal or replacement of the cylinder head, the only maintenance necessary is the adjustment of the clearance between the rocker arm rollers and the valve stems. Refer to paragraph 51 (item 19) for intake and exhaust valve adjustment for clearance.

d. Removal.

(*1*) *Valve-lever Mechanism.* Remove the two hexagon nuts holding the rocker arms to the valve rods. Remove the two hexagonal-head cap screws holding the rocker arm bracket to the cylinder head. Remove the bracket and the rocker arms. It is not necessary to remove the rocker arms from the rocker arm bracket.

(*2*) *Cylinder Head and Valves.* Remove the valve-lever mechanism as noted above. Remove the fan bracket. Disconnect the fuel line from the nozzle holder. Remove the four hexagon nuts holding the head and slide the head off of the studs.

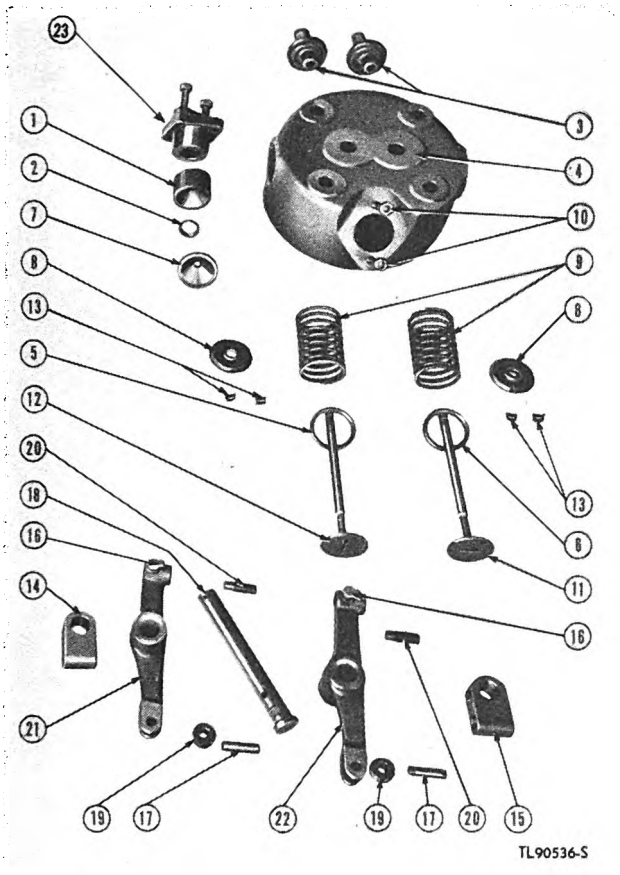
e. Disassembly.

(*1*) *Valves.* Using a valve spring compressor, compress each valve and remove the valve-spring keys (fig. 49). Remove the tool and lift off the valve spring-seats and springs. Remove the stem retaining cotter pins, and remove the valves from the inside of the cylinder head.

(*2*) *Precombustion Chamber.* The precombustion chamber (fig. 48) consists of two parts, the air cell and the air cell cap. The nozzle holder and the nozzle are carried in the nozzle holder adapter and can be removed without disturbing the adapter. The adapter holds the air cell and the air cell cap in place. A soft gasket seals the seating of the air cell in the cylinder head, but the mating surfaces of the air cell and the air cell cap are ground for metal-to-metal contact. A gasket is used where the nozzle holder fits into the nozzle holder adapter. In disassembling these parts, use care to keep them clean, and not to scratch the mating surfaces. The nozzle holder and nozzle are removed by removing the two hexagon nuts holding the nozzle holder to the nozzle holder adapter. The adapter is held to the cylinder head by two hexagon nuts on studs in the cylinder head. The nozzle is removed from the nozzle holder by unscrewing the hexagonal head of the nozzle. Use great care to keep the parts of the nozzle clean. When replacing the parts related to the precombustion chamber, use new gaskets, and tighten the nozzle holder adapter and the nozzle holder nuts very carefully and evenly to assure proper seating of the parts. Improper seating will result in distortion of the parts and hot gases leaking by the ground surfaces and damaging them.

f. Inspection and Repair.

(*1*) *Cylinder Head and Valves.* Clean all parts thoroughly. Clean carbon off of the inner face of the head, out of valve ports and valve guide bores, and off valve heads. Use a scraper or carbon-cleaning brush powered by an electric drill. Flush out the water passages in the cylinder head and remove accumulated



LEGEND FOR FIGURE 49

1. Cap, air cell.
2. Gasket, copper asbestos.
3. Guide, valve stem.
4. Head, cylinder.
5. Insert, valve seat.
6. Insert, valve seat.
7. Liner, air cell.
8. Retainer, valve spring.
9. Spring, valve.
10. Stud, adapter.
11. Valve, engine exhaust.
12. Valve, engine inlet.
13. Key, valve spring retainer.
14. Bracket, lower.
15. Bracket, top.
16. Cup, oil.
17. Pin, roller.
18. Pin, valve rocker fulcrum.
19. Roller, rocker arm.
20. Screw, adjusting.
21. Arm, rocker, inlet.
22. Arm, rocker, exhaust.

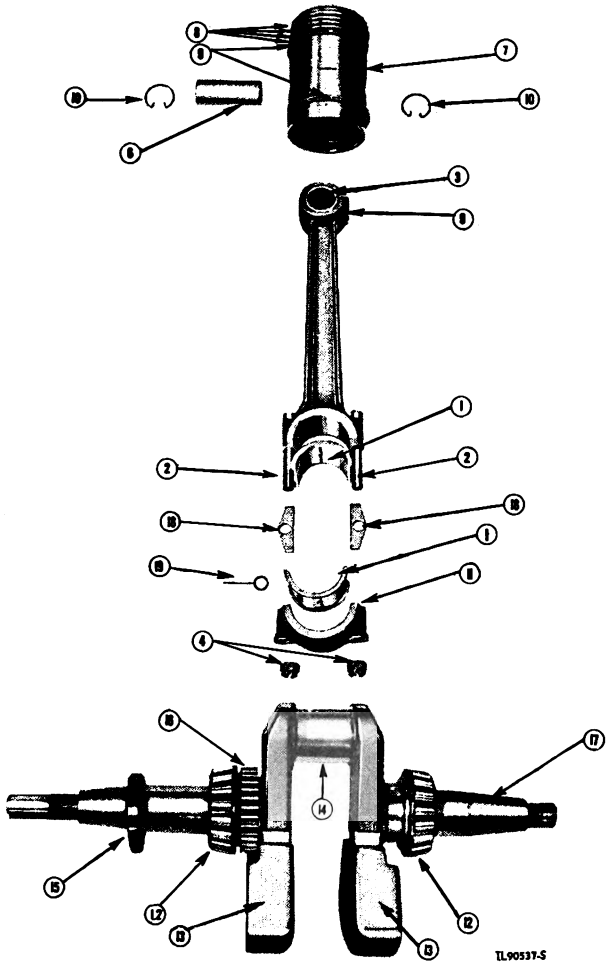
Figure 49. Cylinder head and valve mechanism, disassembled.

scale. Inspect all parts for serviceable condition. Refer to subparagraph b for dimension specifications, and replace any valves worn beyond limit listed. Inspect the valve stems and valve-guide bores for scoring and the valve faces and seats for pitting. The valve springs must test to 18 pounds when compressed to 2½ inches. Replace the springs if they do not meet this test. If the valve-seat inserts are damaged or excessively worn, replace them. To compensate for normal wear, the valve-seat inserts can be ground to their original 45° seat, using a stone-type grinder (material in inserts is too hard for metal cutters). Should the valves or the valve-seat inserts become worn to the extent that the top edges of the valves are below the tops of the valve seats, replace the valve seats and replace or reface the valves. This condition forms a pocket to collect carbon and dirt and results in the quick pitting of the valves and valve seats. Since the valve guides must be used as a pilot when regrinding the valve seats, clean the guides thoroughly before the regrinding operation with a conventional valve-guide cleaner. The bore of the valve-guide should check concentric with the bore of the valve seat within 0.002 inch. When assembled, valve stems should have 0.002- to 0.004-inch clearance in the valve guide. If the clearance is excessive, replace the valve guides. Press the valve guides in place from the outside of the cylinder head. The guides are furnished ground and reamed to size. Check each cylinder head stud for secure mounting and for stripped threads.

83. PISTON, CONNECTING ROD, AND CYLINDER SLEEVE ASSEMBLIES.

a. Description (fig. 50).

(*1*) *Connecting Rod.* The connecting rod assembly carries the piston pin bushing in the small part of the rod, and the crank pin bearing in the large end of the rod. Both halves of the crank pin bearing are identical and may be interchanged when the back half of the bearing shows considerable wear. The top half is doweled in the cap to prevent the bearing from turning. The crank pin bearing is of the removable bronze-back babbit-lined type, the two halves so fitted that when they are drawn up tight, the edges are flush with the milled surface of the rod and cap and securely anchored by the thin metal shims which are gripped between the rod and cap and the two bearing halves. The shims provide a simple, accurate means of bearing adjustment. The bearing halves are grooved to provide for the distribution of lubricating oil supplied through a drilled hole and recess in the connecting rod.



LEGEND FOR FIGURE 50

1. Bearing, sleeve.
2. Bolt, connecting rod.
3. Bushing, piston pin.
4. Nut, castle.
5. Pin, dowel.
6. Pin, wrist.
7. Piston, engine.
8. Ring, piston.
9. Ring, piston.
10. Ring, retainer.
11. Rod, connecting.
12. Cone, bearing.
13. Counterweight, crankshaft.
14. Crankshaft.
15. Eccentric.
16. Gear, spur.
17. Key, Woodruff.
18. Shims, bearing, connecting rod.
19. Thrower, oil.

Figure 50. Piston, connecting rod, and crankshaft group.

(*2*) *Piston and Rings.* The piston is fitted with a full floating type of piston pin, heat-treated, hardened, and ground for a push fit in the piston. Piston pin snap rings (fig. 50), seated in grooves in the piston pin bosses, prevent the pin from traveling endways and coming in contact with the cylinder sleeve wall, yet allows for free floating movement of the pin. This piston has four compression rings and two oil control rings, one oil control ring being located directly above, and the other directly below the piston pin. The oil control ring grooves are provided with oil return holes and the slight undercut immediately ahead of the oil control rings is provided with oil drain holes on the top side only.

(*3*) *Cylinder Sleeve.* The cylinder sleeve is of the wet type, the outer surface being in direct contact with the circulating water. A rubber cylinder sleeve gasket seals against any possible water leaks at the crankcase end of the sleeve, and no gasket is required at the head end of the sleeve, since both the cylinder casting and this end of the sleeve are sealed by the cylinder head gasket.

b. Tabulated Data.

(*1*) *Connecting Rod.*

Length (center to center)	18 in.
Crank pin diameter	2.875 in.
Bearing, length (total)	3 in.
Bearing, running clearance	0.003 in.-0.008 in.
Rod, end clearance	0.005 in.-0.012 in.
Bolts, number per cap	2
Bolts, size	5/8 in.-18 x 4 3/8 in.
Bearing cap, angle of split	90°
Removable from top of block	Yes

(*2*) *Piston Assembly.*

Clearance (at bottom of skirt)	0.0055 in.
GO gauge (½-inch wide ribbon)	0.004 in.
Light pull (½-inch wide ribbon)	0.004 in.
NO GO gauge (½-inch wide ribbon)	0.005 in.
Tight pull (½-inch wide ribbon)	0.0045 in.

(*3*) *Piston Rings.*

Width, compression rings	0.195 in.-0.1865 in.
Width, oil control rings	0.182 in.-2.490 in.
Ring gap	0.010 in.-0.020 in.
Vertical clearance, compression rings	0.020 in.-0.030 in.

Vertical Clearance, oil control rings ----------0.086 in.-0.096 in.

(4) *Piston Pin.*

Length ----------4-7/32 in.
Diameter ----------1.8115 in.
Clearance in rod bushing ------0.002 in.
Clearance in piston bore -------0.000 in.-0.0005 in.

c. Removal.

(1) Remove the valve-lever mechanism and the cylinder head (par. 82). Remove the four hexagonal-head bolts holding the crankcase cover, and remove the cover.

(2) Remove the cotter pins from the connecting rod bolts and remove the nuts which secure the connecting rod cap to the crankshaft. Remove the cap and the lower half of the bearing. The upper half of the bearing can be removed as soon as the connecting rod is pushed free of the crankshaft. Push the piston and connecting rod assembly out of the head end of the cylinder. When the piston and rod have been removed, the piston pin and the rod can be removed readily by squeezing the prongs of the piston-pin retainer rings and pulling them from their grooves.

(3) To remove the sleeve, remove the cylinder head, the crankcase cover, and the piston and connecting rod. With the crank pin up as shown in figure 51, place a stout piece of wood against the sleeve end as shown in the illustration. Then, by turning the flywheel backwards, the sleeve will be pushed back until it is free of the barrel. If the sleeve is a particularly tight fit in the barrel, it may be necessary to *bump* it a few times with the crankshaft to start it, after which it should slide out easily.

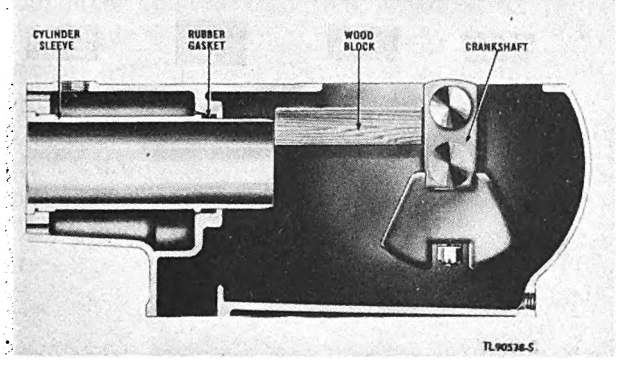


Figure 51. Cylinder sleeve removal.

d. Inspection and Repair.

(1) Check the connecting rod in an alignment gauge for alignment with the piston and crankpin. It must be straight and free from twist.

(2) The running clearance of the piston pin in the connecting rod bushing (fig. 50) should be 0.0003 to 0.0005 inch and pin clearance in the piston bore should be 0.0003 to 0.0005 inch. If the clearance between the piston pin and the connecting rod bushing is excessive, the bushing and piston can be reamed to fit a 0.005-inch oversize piston pin to the clearance specified above. If the connecting rod bushing is damaged or worn beyond the point where a 0.005-inch oversize piston pin can be utilized, service bushings are available, but they must be reamed and burnished after assembly to the running clearances specified above.

(3) The connecting-rod bearings should be inspected closely for evidences of normal or unusual wear or damage. If any unusual wear or damage is noted, replace the bearings. At the same time, make a detailed check of the engine, particularly of the crankshaft, connecting rod, and connecting-rod cap to make sure that replacement bearings will be used with serviceable parts. The bore of the connecting rod and cap as well as the backs of bearings must be absolutely clean and smooth and free from oil. This is extremely important, since bearings will not seat perfectly if there is any dirt or oil between the bearing shells and rod or cap. Wash the rod and the cap in dry-cleaning solvent (SD) and *dry thoroughly*. Always clean out the drilled oil passages in the crankshaft and block before replacing bearings. A rifle-barrel brush or brass rod should be run through oil passages to dislodge any sludge, grit, or bearing material.

(4) The clearance between the connecting-rod bearing and the crankshaft should be such that there is no looseness between them. To check this, rock the flywheel back and forth with a thumb on the connecting rod bearing at the crank cheek. The bearing should be adjusted so that with the nuts down tight on the cap, the shaft is free to turn, yet not loose in the bearing. Should looseness be indicated, remove the cotter keys and the bearing bolt nuts, carefully lift the connecting-rod cap off, and remove a

shim from one side. Replace the cap, and try it again for looseness. If it is still loose, remove the cap and remove a shim from the other side.

CAUTION: When it is necessary to remove more than one shim, always take them from alternate sides. Remove just enough shims so that with the nuts drawn down tight, the bearing is snug on the journal, but not so tight that the shaft does not turn freely.

(*5*) Clean the piston thoroughly, particularly the ring grooves, before new rings are installed. Drill or clean out the oil-return holes in the oil-control ring lands to insure free flow of oil at this point. Check the ring clearance in the groove by rolling the rings around the piston.

(*6*) Fit new rings into the cylinder sleeves before assembling them on the piston. To do this, insert the piston ring in the cylinder sleeve, and use the piston to force the ring down into the lower portion of the sleeve. This squares the piston ring with the cylinder sleeve. Then the piston is removed and the ring gap checked with a feeler gauge. The rings must not have a gap greater than 0.010 to 0.020 inch.

CAUTION: When new piston rings are being installed on a used piston for use in a used sleeve, wear on the sleeve might ordinarily cause noisy performance and possible breakage of the top compression ring or ring lands when the top ring reaches the top of the stroke. If possible, it is better to remove the ridge at the top of the cylinder sleeve with a ridge reamer or equivalent, instead of beveling the top ring.

e. Installation. Particular care should be taken in the installation of the cylinder sleeve. Reassemble all other parts carefully in the reverse order of their removal. Before installing the sleeve, see that all parts are clean and not damaged. Place a new, clean, sleeve gasket on the small end of the sleeve. Apply a liberal mixture of soap and water to the two ends of the sleeve where it contacts the cylinder casting. Do not use lubricating oil on the gasket, as it has a tendency to rot the rubber. Start the sleeve into the cylinder, and if the parts have been thoroughly lubricated with soap and water, it should take but little pressure to slide the sleeve into place.

CAUTION: No great pressure should be required or used in getting the sleeve into position. If the sleeve seems to stick, it is evidence that the gasket has not entered properly. Attempting to force the sleeve into position with the rubber gasket sticking or in the wrong position will result in injury to the gasket, and an improper seal between the cylinder casting and the sleeve, resulting in a bad water leak.

After the sleeve is in position, blocks of wood and a bar across the cylinder head studs, as shown in figure 52, can be used to fit the sleeve securely in the cylinder casting.

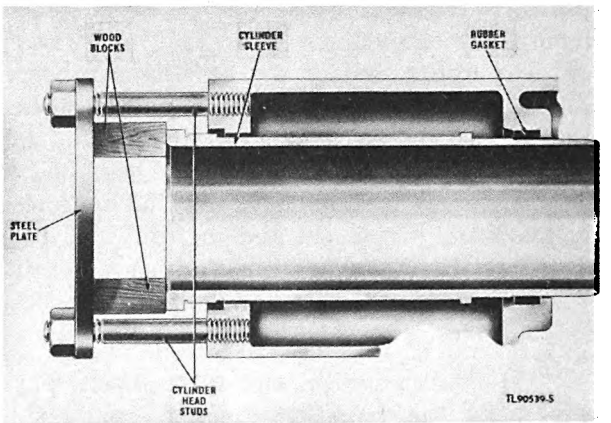


Figure 52. Cylinder sleeve installation.

84. CAMCASE AND TIMING GEAR AND RELATED PARTS.

a. Description. The camcase and camcase cover inclose the camshaft together with roller rockers for the valve rods, the injection pump tappet roller, the fuel supply pump eccentric, drive for the lubricating oil pump, and the governor control mechanism. The camshaft gear in the crankcase is driven by the crankshaft pinion, and the gears are marked for the proper relationship (fig. 53). There are punch marks on two adjacent teeth of the camshaft gear, and a punch mark on one tooth of the crankshaft pinion. For the correct placement of the gears, the marked tooth on the crankshaft pinion should mesh between the adjacent marked teeth on the camshaft gear.

b. Removal.

(*1*) *Camcase Cover.* To remove the cam-

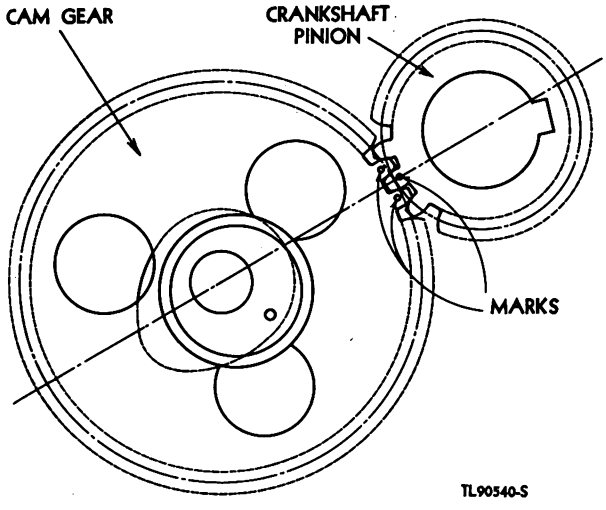


Figure 53. Camshaft and crankshaft gear timing marks.

case cover, remove the flywheel next to the camcase, loosen but do not remove the nut holding the flywheel, and drive the inner hub of the flywheel with a heavy hammer and block of wood until the flywheel is loose. Remove the hexagonal-head nut on the fuel supply pump that goes into the camcase cover. Disconnect the lubricating oil line from the lubricating oil pump. Remove the three hexagonal-head bolts around the edge of the camcase cover. Remove the cover.

(2) *Inlet and Exhaust Roller Rockers.* The inlet and exhaust roller rockers are interchangeable. The roller rocker assembly should be replaced should any part of it become inoperative. To remove the rocker assembly, remove the flywheel and camcase cover as noted immediately above. Remove the four hexagonal-head bolts holding the crankcase cover plate, and remove the plate. Turn the other flywheel so that the piston is on the compression stroke (both valves closed) and the counterweights on the crankshaft are up. Remove the valve push rods (fig. 54) by dropping them from the valve rocker sockets, and pull them out of the camcase. A nut inside the crankcase holds the camshaft gear on the camshaft. Bend up the lockwashers holding the nut and remove the nut and washer. Drive the camshaft out of the camshaft gear by striking the gear end of the shaft with a babbitt or a wood hammer. Use care to prevent the nose of the inlet valve cam from striking against the injection pump tappet roller. Remove the inlet roller rocker by removing the nut from the stud that holds it, and driving out the stud from the crankcase side. Remove the exhaust roller rocker from the cam-

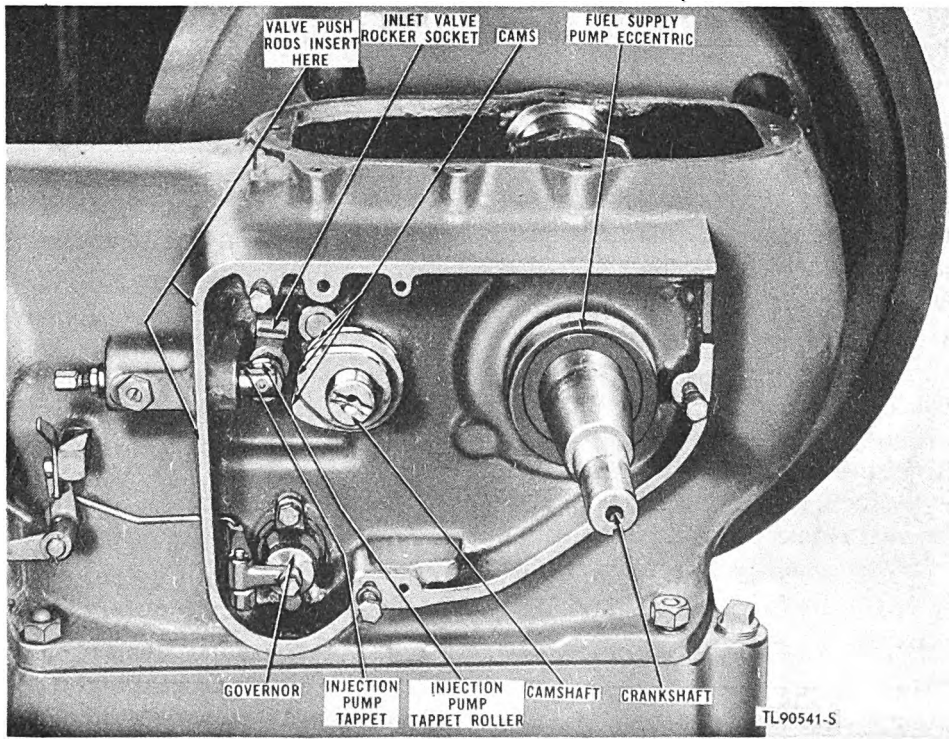


Figure 54. Camcase, cover removed.

case cover in a similar manner.

c. Inspection and Repair.

(*1*) Inspect the camcase cover gasket for wear or damage. Be sure that there are no breaks in the gasket.

(*2*) Examine the condition of the crankshaft pinion and the camshaft gear. Replace them if they show excessive wear or damage. Be sure that the two gears are in proper mesh, as indicated by the punch marks on the gear teeth, as explained above.

(*3*) Examine the inlet and exhaust roller rockers. See that the rollers turn freely and do not have any flat or pitted spots. Inspect the injection pump tappet roller.

85. CAMSHAFT AND CAMSHAFT BEARINGS.

a. Description. The camshaft is a single-piece, steel forging with the three cams ground integral from a master cam, assuring their being in the correct relative positions. The camshaft is supported at either end by renewable phosphor bronze bearings. The camshaft gear, in the crankcase, drives through a Woodruff key, and is secured to the camshaft by a hexagon nut with a flat-locked washer.

b. Tabulated Data.

Camshaft bearings, number	2
Running clearance	0.002 in.
Camshaft end clearance	0.005 in.-0.012 in.
Service bearings	reamed to size
Camshaft drive	spur gear
Number of teeth in gear	60
Lubrication	splash

c. Removal. Remove the camshaft and camshaft gear as outlined in paragraph 84 b (2) above, in the removal of the valve roller rockers.

d. Inspection and Repair. Clean the camshaft thoroughly, inspect the journals and cams, and measure for wear or damage (subpar. b above). The two camshaft bearings are of the replaceable type. Service bearings are reamed to size (Refer to preceding subparagraph b for information. On normal running clearance, camshaft bearing journal diameters, and camshaft bearing size.)

86. CRANKSHAFT, MAIN BEARINGS, AND FLYWHEEL.

a. Description. The crankshaft is a heat-treated, open-hearth steel, drop forging. All fits and bearing surfaces are ground to close limits. The crankshaft is securely supported in the crankcase by two Timken roller bearings (fig. 50).

b. Tabulated Data.

Crankshaft bearings, journal diameter	2½ in.
Main bearings, number	2
Main bearings, type	Timken tapered roller, Nos. 639, 632
Crankshaft end clearance	0.005 in.-0.007 in.

c. Removal.

(*1*) *General.* Drain the oil from the crankcase through the plug on the drain pipe at the oil temperature gauge. Remove the four hexagonal-head nuts holding the crankcase cover plate and remove the plate. Remove the camcase cover and both valve push rods as outlined in paragraph 84 above.

(*2*) *Counter-weight Studs.* Remove the nuts holding the counter-weight studs. Drive the weights off the studs by striking them with a hammer first on one side and then on the opposite side. Remove the counter-weight studs, by means of a stud puller, or by locking two nuts on the studs and removing them with an open-end wrench.

(*3*) *Flywheels.* Remove the flywheel on the camcase side of the engine as explained in paragraph 84. To remove the opposite flywheel, remove the belt guard and remove the generator drive belts, then remove the flywheel in the same manner as before, slipping the fan belt off its pulley after the flywheel has been loosened and before removing it.

(*4*) *Connecting Rod.* Remove the connecting rod bearing cap and its half bearing, disengaging them from the crankshaft, and removing the connecting rod from its engagement with the crank journal. Replace the bearing cap and bearing on the connecting rod, and fit the nuts loosely, to avoid loss or damage to the parts. Then pull the connecting rod and piston forward and up, but do not attempt to remove the rod and piston entirely from the cylinder.

(*5*) *Camshaft.* Remove the camshaft gear as explained in paragraph 84. Use care to avoid damaging the injection pump tappet roller by letting the inlet cam nose strike it when the

camshaft is being driven out of the camshaft gear.

(*6*) *Fuel Supply Pump Eccentric.* Remove the fuel supply pump eccentric from the crankshaft on the camcase side. This can be accomplished by driving the crankshaft out of the eccentric, or by gripping the eccentric with a pipe wrench (using shims to protect the eccentric), turning it, and pulling outward while turning.

(*7*) *Crankshaft.* Remove the four hexagonal-head bolts holding the bearing side cover plate (fig. 5), and remove the plate. Remove the crankshaft through the opening in the side of the crankcase.

d. Inspection and Repair.

(*1*) Inspect the crankshaft main bearings carefully. See that there is no dirt or metal in the roller bearing races. Watch closely for chipped or flatted rollers. See that the bearing turns freely, yet without excessive play. Replace the bearing if there is evidence of excessive wear or damage.

(*2*) Examine the crankshaft pinion gear. It is keyed on to the shaft, and can be replaced by driving it off should there be damage to the teeth of the gear. The gear should fit on the shaft very tightly, with no evidence of play in any direction.

87. CRANKCASE.

The crankcase is an integral part of the engine cylinder casting. Any crack or defect in the crankcase necessitates the complete disassembly of the engine as outlined in the preceding paragraphs. Inspect the crankcase for cracks and damage.

88. ENGINE BASE.

a. Description. The engine base is a one-piece casting. The base itself is divided into two reservoirs, one holding lubricating oil, the other holding fuel oil. All connections between the engine and the engine base are exterior.

b. Removal. To remove the engine base, remove the lubricating oil line from the base. Disconnect the fuel supply line from the base. Disconnect the coolant hoses from the radiator. Remove the wire fan guard from the inside of the radiator. Remove the generator drive belts. Remove the four hexagon nuts from the engine base studs at the four corners of the base. By means of a hoist, lift the engine off of the engine base.

c. Inspection and Repair. Inspect the engine base for cracks or damage, and replace the base if indicated. Clean any rust spots on the inside or outside of the base, and repaint. Clean all dirt from the oil reservoirs.

89. BELT GUARD.

a. Description. The belt guard is formed of heavy sheet steel. Its purpose is to protect personnel from the generator drive belt and pulleys. It is necessary to remove the guard for access to the pulleys or drive belts, and for removal of the generator.

b. Removal. Remove the three bolts and nuts fastening the guard to the power unit base. Remove the two bolts holding the upper guard brackets. Remove the guard.

SECTION XVI. REASSEMBLY AND INSTALLATION OF ENGINE PARTS

90. OIL PUMP ASSEMBLY AND INSTALLATION.

a. Assembly (fig. 43). With the lubricating oil pump housing removed from the camcase cover, insert the impeller gear in the pump from the camcase side of the housing. Insert the impeller so that the dog that engages the end of the camshaft is toward the camcase. The position in rotation of the impeller is not important. From the cover side of the pump housing, insert the idler gear into the pump. Replace the pump cover and shims, and insert and tighten the four screws holding the cover.

b. Installation. Lift the lubricating oil pump assembly into position on the camcase cover. Insert and tighten the two hexagonal-head bolts holding the pump to the camcase cover. With the camcase cover removed from the camcase,

check for end play in the oil pump. If there is noticeable endplay, remove the oil pump cover without removing the pump from the camcase cover, and remove one of the shims from under the oil pump cover. Replace the cover. Check again for end play. The pump impeller should be able to be turned freely in the pump.

91. FAN INSTALLATION (fig. 44).

a. Fan Bracket. The fan and shaft may be secured to the fan bracket before installing the bracket. Slip the fan belt over the fan pulley before securing the bracket. Insert and tighten the two hexagonal-head bolts holding the bracket to the cylinder head. Adjust the bolt that spaces the rear end of the bracket from the cylinder shell casting. Slip the fan belt onto the fan pulley. If necessary, adjust the fan shaft in the fan bracket so that the fan belt has the proper tension (par. 51, (item 29)).

b. Fan and Fan Shaft. If the fan bracket is in place, it is not possible to insert the fan and fan shaft in the bracket. Remove the fan bracket and insert the threaded end of the fan shaft in the slot in the bracket. Turn the hexagon nut on the shaft, but do not tighten it completely. Install the fan belt and the bracket and adjust tension on the fan belt as explained in subparagraph a, immediately above. Install the fan guard on the fan side of the radiator and secure the seven screws holding the guard to the radiator.

92. FAN BELT INSTALLATION.

Slip the fan belt over the driving flywheel. Remove the fan bracket, leaving the fan shaft secured to the bracket. Slip the belt around the bracket, and over the fan pulley. Replace and adjust the bracket and adjust the tension of the fan belt as noted in paragraph 73. Replace the fan guard and the seven screws holding the guard.

93. RADIATOR INSTALLATION (fig. 44).

Lift the radiator into place on the two brackets mounted to the engine base. Place the radiator so that the studs at the bottom of the radiator fit into the holes in the brackets. Be sure that the rubber and canvas pads are in place between the radiator and the brackets. Secure the two nuts on the radiator studs, thus securing the radiator to the brackets. Install the upper and lower hoses. Make sure that the hose clamps are tight, in order to prevent leakage. Install the fan bracket, fan, and fan belt according to instructions in paragraphs 94 and 92.

94. WATER TEMPERATURE GAUGE INSTALLATION.

Insert the water temperature gauge and element in the hole in the circulating pipe elbow above the engine cylinder. Secure the gauge by screwing down the gauge nut. Make sure that the gauge is facing in the most convenient direction.

95. INITIAL FUEL SUPPLY FILTER INSTALLATION.

a. Insert the filter body into the filter housing. Make sure that the cover gasket is in place, and in good shape. Secure the six cap screws holding the filter body and cover in the filter housing.

b. Attach the filter bracket (with filter) to the stud in the engine base, having removed the nut on the stud if necessary. Secure the nut holding the bracket on the stud. Connect the fuel lines to the filter, observing the arrows on top of the filter for direction of fuel flow. The arrows should point in the direction of fuel flow to the fuel supply pump.

96. FUEL SUPPLY PUMP INSTALLATION.

a. Before installation, make sure that the fine wire screen and glass sediment bowl are completely clean. Fit the screen and the glass bowl over the pump, and secure the bowl by means of the clamp provided.

b. Insert the pump eccentric shaft in the opening in the camcase. Insert and secure the two hexagonal-head bolts holding the pump to the camcase and camcase cover. The pump can be installed whether or not the camcase cover is in place, but if the cover is not in place, it will only be possible to secure one bolt until the cover has been replaced.

97. FUEL INJECTION NOZZLE, ASSEMBLY AND INSTALLATION.

a. Assembly. Insert the pintle-type nozzle in the nozzle seat (fig. 46). Place the nozzle and nozzle seat in the nozzle cap, and screw the nozzle cap firmly and carefully onto the nozzle holder. Insert the nozzle plunger, long end first, into the nozzle holder from the top of the nozzle

holder. Place the nozzle spring over the nozzle plunger, and the spring cap over the spring. Turn the threaded sleeve into the nozzle holder as far as it will go, and insert the adjusting screw and nut into the top of the sleeve. Put the top gasket in place around the sleeve and down on the nozzle holder and install and secure the nozzle nut on top of the entire assembly. Note that all of these parts should be thoroughly clean and entirely free of lint before assembly. Do not change the setting of the adjusting screw and nut unless the nozzle has been functioning improperly. If the nozzle is out of adjustment, adjust the screw for a very fine, cone-shaped mist. This adjustment cannot be made until the nozzle has been assembled and connected with the high-pressure fuel supply line on the engine.

b. Installation. If the air cell and air-cell cap are not installed, insert a new gasket in the tapered seat in the cylinder head and put the air cell and air-cell cap (fig. 48) in place. Place the nozzle holder adapter on the studs on the cylinder head over the air-cell cap. Tighten the nuts holding the nozzle holder very carefully and evenly, since the air cell and air-cell cap are a metal-to-metal fit, and any cocking of the parts will result in hot gas leaks with very injurious results. Insert a new gasket in the nozzle holder adapter for the nozzle seat, and place the nozzle and nozzle holder in the adapter. Carefully tighten the bolts securing the nozzle holder to the adapter. Connect the fuel supply line to the nozzle. Bleed the fuel supply system as described in paragraph 51 (item 46).

98. FUEL INJECTION PUMP INSTALLATION.

a. Installation (fig. 47). Place the pump in position on the two studs on the side of the engine cylinder. Place the bracket holding the governor adjustment thumbscrew over the lower stud. Secure the two hexagon nuts holding the pump. Connect the pump plunger to the tappet shaft, without tightening the tappet adjusting screw. Connect the fuel lines from the final filter and to the injection nozzle. Fit the end of the governor-end bell crank into the end of the injection pump control rod, and secure it by means of a cotter key. Connect the governor adjustment thumb nut and spring if they are not already in place.

b. Bleeding Air and Timing Fuel Injection. Remove the filler plug from the top of the final fuel filter and bleed air from the entire fuel system according to the method outlined in paragraph 51 (item 46). Before attempting to start the engine, check the timing according to paragraph 51 (item 45). Be sure that the initial and final fuel filters are clean and operative; that the sediment bowl is clean and free from water; and the pump screen clean. If timing and all of the above service adjustments are normal and in good order and the engine still runs in a rough, erratic manner, too slowly, or too fast, refer to paragraph 62 to determine cause and repair procedure.

99. CYLINDER HEAD AND INTAKE AND EXHAUST VALVE MECHANISM, INSTALLATION.

a. Cylinder Head and Valves (fig. 49).

(*1*) *Assembly.* Making sure that the valve seats and guides are in place in the cylinder head, place the valves in the head. Install the valve springs and the valve spring seats. With a compressor tool, compress the springs until the valve seat keys can be put in place. Insert the retaining cotter keys in the valve stems.

(*2*) *Installation.* Make sure that the cylinder gasket surfaces on the cylinder head and the block are clean and dry. Coat a new gasket thoroughly on both sides with a mixture of graphite and lubricating oil, and put the gasket and the cylinder head in place. Tighten the hexagon nuts on the head stud very carefully, being careful not to tighten one ahead of the others. No particular order is necessary for the tightening of the four nuts. It is well to tighten the nuts again later when the engine has been run briefly.

b. Intake and Exhaust Valve Mechanism. Put the rocker arm assembly in place on the cylinder head, and secure the two hexagonal-head bolts holding the assembly. The rocker arm rollers should be in place at the ends of the valve stems. Insert the valve push rods on the ends of the rocker arms. Loosen the adjusting screw nuts, and adjust the nuts so that the clearance between the rocker arm rollers and the valves, with both valves closed, is between 0.010 and 0.012 inch. This adjustment must be checked when the engine is warm. Tighten the adjusting screw locknuts. Install the fan bracket and fan belt as explained in paragraphs 91 and 92.

Install the nozzle and nozzle holder as outlined in paragraph 97. Fill the cooling system. Operate the engine until it has thoroughly warmed up and inspect for leaks. Check the tightness of the cylinder head studs, and check the valve mechanism adjustment for proper clearance between rocker arm rollers and valves.

100. PISTON, CONNECTING ROD, AND CYLINDER SLEEVE ASSEMBLY AND INSTALLATION (fig. 50).

a. Piston Assembly.

(*1*) Heat the piston in boiling water until it has expanded sufficiently for the piston pin to enter freely into the piston pin hole of the piston without pressing or tapping it. Place the connecting rod in position inside of the piston with its bushing in alignment with the piston pin hole in the piston, then install the piston pin. Thoroughly dry the piston (with compressed air if possible).

(*2*) Square the rings in the cylinder by driving each of the rings to the smallest part of the cylinder with the piston. Check the ring gaps carefully. There must be a gap of between 0.007 and 0.008 inch between the ends of the rings when they are in this position. Avoid rings having a smaller or larger gap.

(*3*) Squeeze the pronged ends of the piston pin retainer rings and install one ring in the groove in the piston at each end of the piston pin, in order to hold the pin in position. Using a piston ring expander, install six piston rings on the piston. One oil control ring should be installed directly below the piston pin, and one oil ring immediately above the piston pin. Be sure to stagger the ring gaps around the piston.

b. Piston Installation. It is not advisable to install a new piston with new rings in an old sleeve. The best policy is to install new piston, rings, and sleeve in a matched set as supplied for the engine.

(*1*) After making sure that the cylinder bore and the outside surface of the sleeve is absolutely clean and smooth, coat the outside of the sleeve and a new rubber gasket thoroughly with a mixture of white lead and linseed oil. Place the rubber gasket over the small end of the sleeve. Insert the sleeve carefully in the block and push it down. Do not force the sleeve into place. If it sticks, it is an indication that the rubber gasket is out of place and is not seating properly. Remove the sleeve and straighten the gasket. If the gasket is not seated properly, water will be able to leak into the crankcase. Drive the sleeve up solid, using a block of wood placed over the top of the sleeve.

(*2*) Immerse the piston and connecting rod assembly in oil, and install the assembly in the cylinder, using a piston-ring compressor.

(*3*) Before replacing the connecting rod bearing cap, coat the halves of the bearing or the journal with lubricating oil. Replace the bearing half and the bearing cap so that the punch marks on the two sides of the bearing line up, thus assuring that the cap is replaced in its original position. Draw the two hexagon nuts up tightly and evenly, and insert new cotter keys and clinch them closely. If there is play in the bearing, remove the cap and remove a shim from one side of the cap, or one shim from each side, if necessary. Handcrank the engine to test for free and smooth rotation of the crankshaft. Install the cylinder head and valve mechanism (par. 99), the fan and fan belt (pars. 91 and 92), and the nozzle and nozzle holder (par. 97).

101. CAMCASE COVER AND CAMSHAFT AND RELATED PARTS, INSTALLATION.

a. Valve Roller Rockers. Insert the inlet roller rocker stud from the crankcase into the camcase. Place the inlet roller rocker on the stud and secure the hexagon nut holding the rocker. Insert the injection pump tappet in the tappet hole from the camcase end (fig. 54). Place the exhaust valve roller rocker on its stud on the camcase cover, and secure the hexagon nut holding the rocker.

b. Camshaft and Camshaft Gear. Install the camshaft in its bearing, from the camcase side. With the crankcase cover plate off, turn the engine until the crankshaft counterweights are up, on the compression stroke. Place the camshaft gear on the keyed camshaft so that the two marked teeth on the gear straddle the single marked tooth on the crankshaft pinion. Secure the hexagon nut and lockwasher on the camshaft. Remember that the hub side of the camshaft gear is placed toward the crankcase wall. Bend the lockwasher over the nut on the camshaft. Insert the valve push rods through the

camcase and into the roller rocker arms. Connect them to the valve rocker sockets (fig. 54).

c. Camcase Cover. See that the gasket surfaces on the camcase and camcase cover are clean. Coat both surfaces with a light coat of lubricating oil. Check to see that the gasket is intact, and if not, obtain a new one. Rotate the keyed oil pump shaft so that it will mesh with the end of the camshaft when the cover is installed. Put the camcase cover in place and secure the three hexagonal-head bolts around the edge of the cover. Connect the oil line to the lubricating oil pump. Install the fuel supply pump if it is not in place, and secure the two hexagonal-head bolts holding it to the camcase and camcase cover. Connect the fuel supply lines to the fuel supply pump, the inlet line being connected to the outer connection on the pump.

d. Flywheel. With the key in place on the crankshaft, put the flywheel on the shaft. Secure the hexagon nut holding the flywheel.

e. Injection Pump Timing, Bleeding, and Valve Clearance Check. Bleed the fuel supply system according to the instructions in paragraph 51 (item 46). Time the injection pump as outlined in paragraph 51 (item 45). Check the clearance between the valves and the valve rocker arm rollers according to paragraph 97.

102. CRANKSHAFT, MAIN BEARINGS, AND FLYWHEEL INSTALLATION.

a. Crankshaft and Bearings. Before installing the crankshaft, make sure that the crankshaft and its journals are clean, dry, and free from lint. Clean out the crankcase thoroughly with a lint-free cloth. Install the crankshaft pinion on the keyed end of the crankshaft, and put the roller bearing cones in place on the shaft. Insert the crankshaft in the engine through the open side of the engine. Put the side bearing cover plate and shims in place on the studs on the side of the engine, and secure the four hexagon nuts holding the bearing plate in place. Check for end play in the crankshaft. If end play is excessive, remove the side bearing plate, remove one of the shims, and replace the plate. Position the camshaft gear with the crankshaft pinion as described in paragraph 101. The crankshaft should turn freely without binding.

b. Connecting Rod. Make sure that the connecting rod bearing halves are clean and free from lint. Put some lubricating oil on the crankshaft journal. Put the connecting rod and its bearing half in place on the journal, and install the other bearing half, shims, and bearing cap so that the punch marks on the rod and cap line up. Secure the two hexagon nuts on the bearing cover. Try the bearing for looseness. If there is play in the bearing, remove the cap and remove a shim from one side of the cap. If it should be necessary to remove several shims, remove them from alternate sides of the bearing cap. When the bearing fits properly, secure the hexagon nuts, and insert and clinch new cotter keys in place.

c. Crankcase Cover Plate and Flywheel. Install the crankcase cover plate and secure the four nuts holding the plate. Lift the flywheel into place and secure the hexagon nut holding the flywheel. Install the fan belt according to paragraph 91. Install the generator drive belts and check them for tension according to paragraph 51 (item 29).

103. DRIVE BELT GUARD INSTALLATION.

Put the drive belt guard in place (fig. 5). Install and secure the three bolts holding the bottom of the guard to the power unit base, and secure the nuts holding the two guard top brackets.

104. ALTERNATOR AND EXCITER REPAIRS.

a. Brushes. Inspect the brushes thoroughly by removing them from their brush holders and checking them for length. Any brush that is less than $\frac{5}{8}$ inch in length should be replaced. Replace all brushes of a set (all exciter brushes, or all slip-ring brushes), so that all brushes in a set will be of uniform length. Do not replace just one brush. Sand in new brushes to a good seating contact. This may be done by drawing a strip of #00 sandpaper around the commutator, sanded side out, while the brush rests on the sanded surface of the paper with normal spring tension. Make sure that the sandpaper contacts a large area of the commutator in both directions from the brush. Draw the sandpaper in the direction of normal armature rotation (fig. 55). Raise the brush for the return stroke. Repeat until a proper seating surface has been obtained. Sand the slip-ring brushes in the same way. After sanding, blow out sand, dirt, and carbon dust with compressed air. Exciter

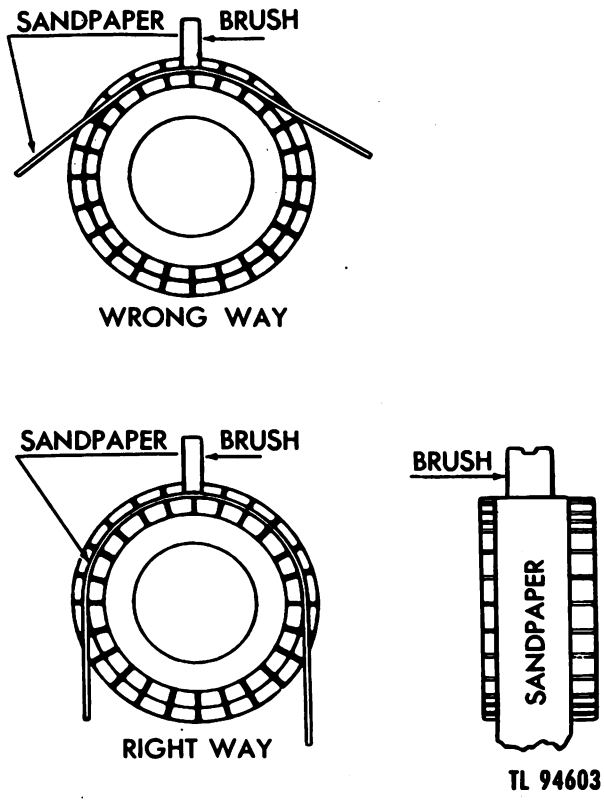


Figure 55. Sanding brushes.

brushes should be inspected periodically for wear, spring pressure, and freedom in holders. If stuck, brushes should be removed and cleaned. Brush shunt connections should be tight. Brush springs are designed to give desired pressure. Adjust brush spring pressure by inserting a piece of paper between each brush and the commutator, and tightening the respective brush springs to hold the paper in place. Loosen each brush spring enough to permit removing the paper easily. When this has been done, the pressure of each brush spring is correct. Brushes supplied are the proper grade for service conditions. In making brush replacements, it is essential that this same grade of brush be used to avoid difficulties with commutation. When replacing brushes it is important that they be carefully fitted to the commutator using #00 sandpaper. Poor performance will result if brushes are poorly fitted. Be sure the rocker arm is returned to its original position when brushes are sanded, otherwise poor commutation will result. The alternator slip-ring brushes should always move freely in the holders. Clean brush holders periodically, as necessary, since dirty holders will cause brushes to stick, resulting in burning of collector rings and excessive brush wear. Collector ring brush holders are of the radial type so that brushes are suitable for operation in either direction of rotation. Pigtail connections must always be tightened securely where fastened to brush holder or terminal fixture. (Brush tension on commutator brushes should be about 7 to 10 ounces; on slip-ring brushes, 4 to 6 ounces.)

b. Commutator. The commutator acquires a mahogany-colored surface after being in service a short time. If smooth, this surface requires no attention. Slight roughness may be improved by holding a piece of #00 sandpaper against the surface while the engine operates slowly. Brushes should be lifted from the holders while this operation is being performed. A badly worn, burned, or pitted commutator will require finishing in a lathe. After refinishing, or when the copper has worn down flush with the mica, undercut the mica 1/32 inch.

c. Slip Rings. The slip rings require the same attention as the commutator except that there is no mica to be undercut.

d. Connections. Check the entire power unit for loose electrical connections, loose bonding-strap connections, loose bolts, nuts, and screws of any kind or in any location. Keep all of these tight at all times. At bonding-strap connections and certain other points, special lockwashers with internal and external teeth are used, not only for locking the screws or bolts securely, but also because the teeth make good electrical contact with adjacent surfaces. Make sure that such washers are used at the proper places.

e. Windings. All of the windings of the alternator and exciter should be given a very thorough inspection at least once a year. Dirt and grease should be thoroughly removed. Extreme care should be used to prevent the grease from the bearing housing from leaking along the shaft and being thrown against the windings. Grease and dirt should be removed with a cloth dampened with dry-cleaning solvent (SD). Do not soak the windings. After the windings have been cleaned, they should be thoroughly dried either by natural ventilation or by means of applied heat. Windings that have been exposed to moisture must be dried out. To do this, disconnect the exciter shunt-field leads and operate the power unit without load for a

period of from 1 to 4 hours. This will permit the ventilation fan to dry out the surface moisture. If possible circulate warm air through the generator to hasten drying. If it is suspected that the insulation might still be faulty, check the resistance with a megger before reconnecting the exciter shunt-field leads. If the above treatment fails to remove sufficient moisture to permit safe operation of the set, the generator should be dismantled and the wet coils dried in an oven. After the windings have been cleaned and dried, treat them with insulating varnish. Brush or spray the varnish on while the windings are warm. Windings that have been dried in an oven should be properly baked after the insulating varnish has dried.

f. Removal. Loosen the generator-belt tension bolts in the generator base (fig. 13) and remove the drive belts from the generator pulleys. Remove the four bolts, lockwashers, and nuts securing the generator to its base. Remove the generator assembly from its base by attaching a hoist hook through the eyebolt in the top of the generator.

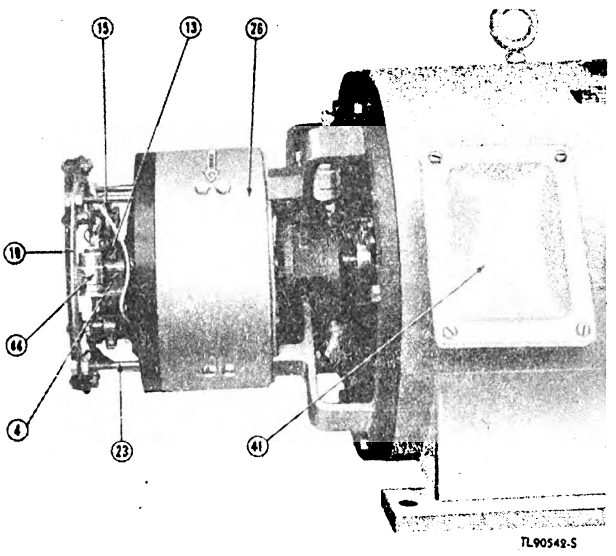
g. Disassembly.

(*1*) *Dismantling the Exciter.* The generator assembly need not be removed from the power unit base for this operation on the exciter.

WARNING: Do not work on the exciter or the alternator while the engine is running.

(*a*) Remove the slip-ring end-bell cover by loosening the bolt holding the clamp at the bottom of the cover.

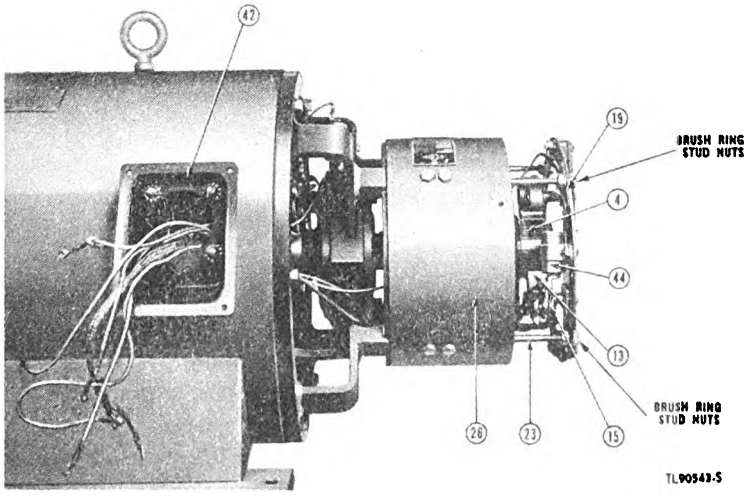
(*b*) Remove the exciter end cover by removing the two cap screws and loosening the bolt holding the clamp at the bottom of the cover.



LEGEND FOR FIGURE 56

4. Commutator.
13. Brush.
15. Holder assembly.
19. Ring assembly, brush holder.
23. Stud.
26. Frame, d-c generator.
41. Junction box and cover (alternator).
44. Capacitor.

Figure 56. Exciter, right side, covers removed.



LEGEND FOR FIGURE 57

4. Commutator.
13. Brush, electrical contact.
15. Holder assembly, contact brush.
19. Ring assembly.
23. Stud.
26. Frame, d-c generator.
42. Junction box, and cover (exciter).
44. Capacitor, fixed.

Figure 57. Exciter, left side, covers removed.

(*c*) Disconnect and remove the exciter brushes (fig. 56). When the brush leads are disconnected, disconnect the other generator lead connections to the brush holders, removing the capacitor leads at the same time. Tag all of the leads for identification in replacing them.

(*d*) Remove the four cap screws holding the exciter field frame to the alternator bearing bracket (fig. 58).

(*e*) Tap on the exciter field frame to loosen it, and pry the frame loose with small prying bars. Remove the frame by hand (fig. 58).

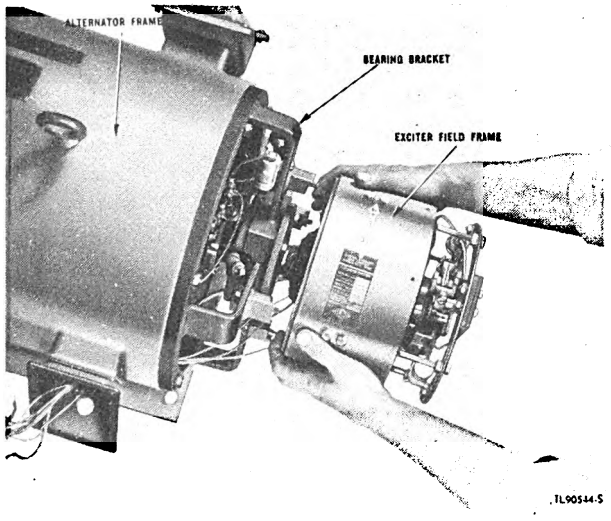


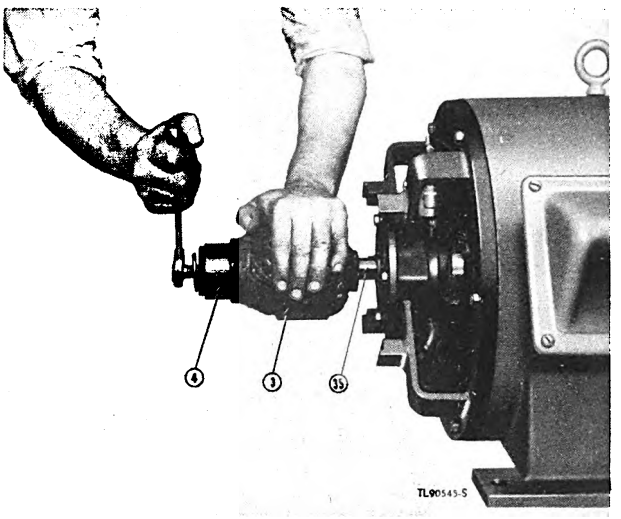
Figure 58. Removing exciter frame.

(*f*) Remove the hexagonal-head bolt from the end of the exciter armature shaft. The armature will now have to be pulled from the shaft. One way to do this is by inserting a 5/8-inch-11 bolt, about 12 inches in length, in the threaded end of the armature shaft. Tightening this bolt will pull the armature off of the shaft (fig. 59).

(*g*) Remove the brush rigging by removing the four hexagon nuts holding the rigging on studs in the exciter field frame.

(*h*) To remove the field coils, remove the eight cap screws from the exterior of the exciter frame (fig. 60).

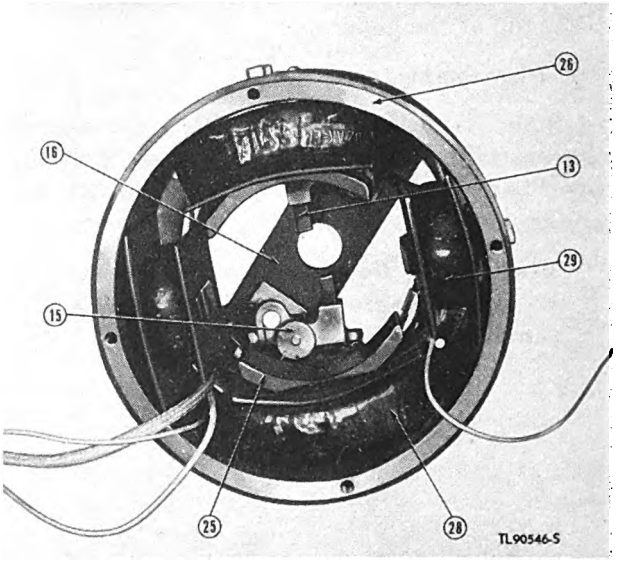
(*2*) *Dismantling the Alternator.* After the exciter has been removed, continue the dismantling as follows:



LEGEND FOR FIGURE 59

3. Armature, generator (exciter).
4. Commutator.
35. Shaft.

Figure 59. Removing exciter armature.

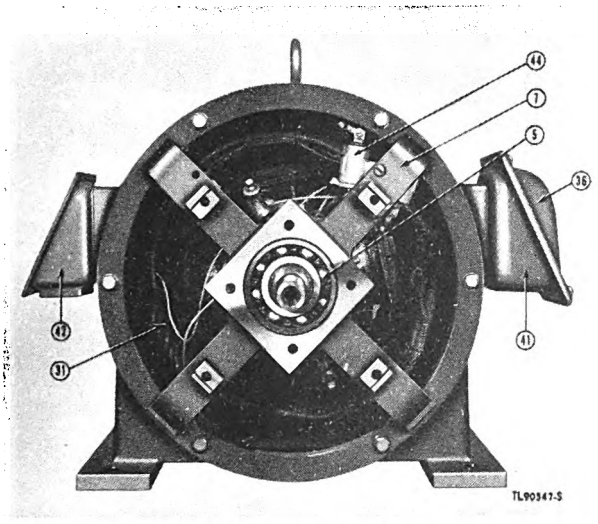


LEGEND FOR FIGURE 60

13. Brush, electrical contact.
15. Holder assembly, contact brush.
16. Insulator, brush-holder stud.
25. Field pole, d-c generator.
26. Frame, d-c generator.
28. Winding, main field.
29. Winding assembly, interpole field.

Figure 60. Interior of exciter.

(*a*) Remove the six cap screws and lockwashers holding the bearing bracket to the alternator frame (fig. 61). Remove the bracket by prying with small bars around its circumference. It is not necessary to support the rotor

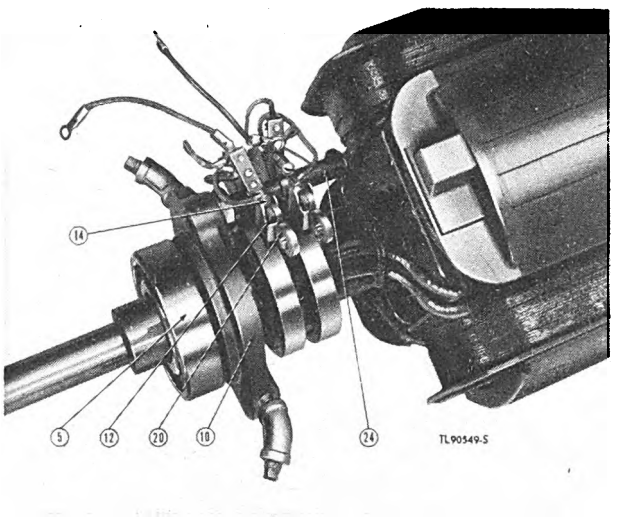


LEGEND FOR FIGURE 61

5. Bearing, ball.
7. End bell, front.
31. Pole and winding assembly.
36. Cover, junction box.
41. Junction box, alternator.
42. Junction box, exciter.
44. Capacitor, fixed.

Figure 61. Bearing bracket and bearing, exciter end of alternator.

at this point because it will be supported by the stator frame. It is advisable to tap the edges of the bearing in removing the bearing bracket, so that the bearing stays on the rotor shaft, rather than coming off with the bracket frame (fig. 62).

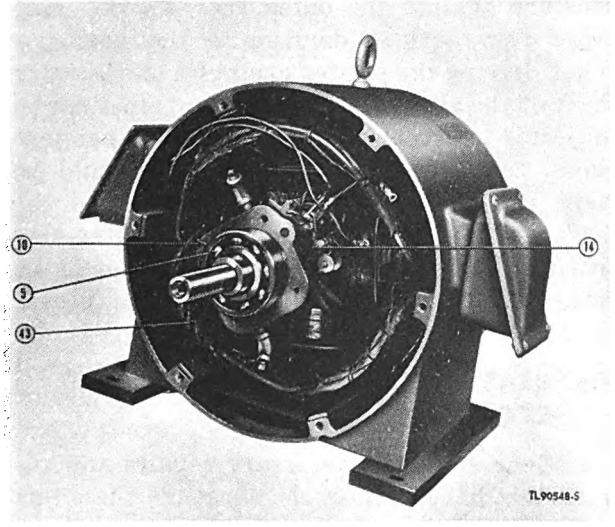


LEGEND FOR FIGURE 63

5. Bearing, ball.
10. Retainer, bearing, front inner.
12. Brush, electrical contact.
14. Holder assembly, contact brush.
20. Spring, alternator brush holder.
24. Stud, alternator brush holder.

Figure 63. Alternator brush-holder assembly and slip rings.

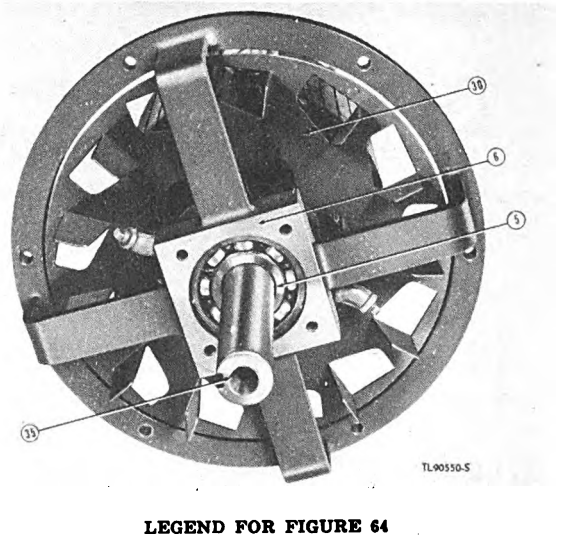
(*b*) Remove the brushes from the brush holders (fig. 63), and disconnect the exciter armature leads, capacitor leads, stator leads, and brush pigtails from the brush holders. Replace the screws in the brush holders, and tag all leads for identification in reassembly. It is



LEGEND FOR FIGURE 62

5. Bearing, ball.
10. Retainer, bearing, rear inner.
14. Holder assembly, contact brush.
43. Stator, a-c generator.

Figure 62. Alternator bearing and brush holders.



LEGEND FOR FIGURE 64

5. Bearing, ball.
6. End bell, rear.
30. Fan.
35. Shaft.

Figure 64. Drive end of alternator rotor, bearing cap removed.

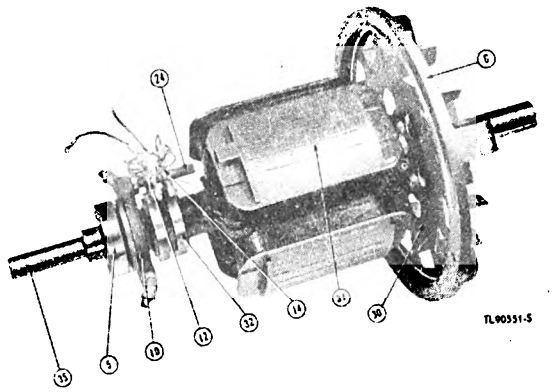
not necessary at this time to remove the brush rigging before the removal of the rotor.

(*c*) Remove the four cap screws holding the bearing cover on the pulley end of the alternator rotor shaft. Remove the six cap screws and lockwashers holding the bearing bracket to the stator frame. Pry the bracket away from the stator frame until sufficient space appears between the bracket and the stator frame to insert a support for the rotor (fig. 64).

(*d*) Place blocks under the rotor or preferably support it with a sling and a hoist. Then swing the whole assembly (rotor and bearing bracket, fig. 65) away from the stator frame assembly. The bearing bracket may be removed from the rotor by the same method that the bearing bracket was removed in subparagraph (2) (a), above.

(*e*) The stator frame will now appear as in figure 66. The only further dismantling that can be done is the removal of the stator coils from the frame. The core assembly is welded into the frame, thus the only disassembly operation possible is to pull the coil windings out from the slots in the laminations.

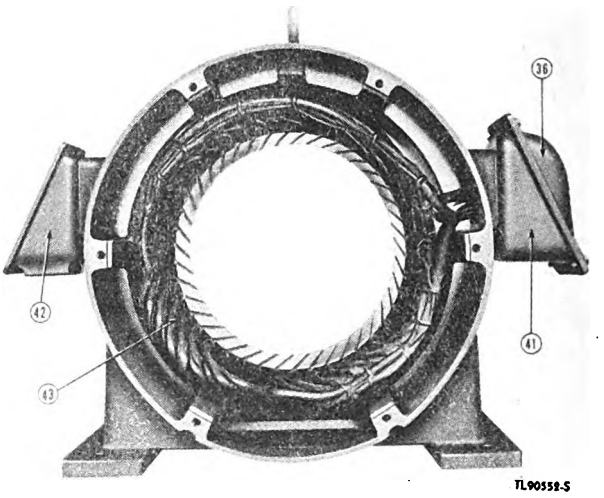
(*f*) Remove the ball bearings from both ends of the rotor shaft with a bearing puller, observing every possible precaution to avoid injury to the bearings. In removing or mounting ball bearings, pressure should be applied only against the inner race. Cover the bearing carefully during this operation to prevent the entrance of foreign matter. Do not attempt to remove or mount a ball bearing by exerting pressure against the outer race, as this may cause very serious damage to the bearings. When driving the exciter armature on the rotor shaft of the alternator, the bearing must not be subjected to actual pressure, especially hammer blows. Any pressure of this kind should be taken up by supporting the outer end of the shaft against a stop of some kind. After new bearings have been installed, they should be packed about one-third full with bearing grease (WB).



LEGEND FOR FIGURE 65

5. Bearing, ball.
6. End bell, rear.
10. Retainer, bearing, front inner.
12. Brush, electrical contact.
14. Holder assembly, contact brush.
24. Stud.
30. Fan.
31. Pole and winding assembly.
32. Ring assembly, collector.
35. Shaft.

Figure 65. Alternator rotor assembly.



LEGEND FOR FIGURE 66

36. Cover, alternator junction box.
41. Junction box, alternator.
42. Junction box, exciter.
43. Stator, a-c generator.

Figure 66. Alternator stator assembly.

105. REASSEMBLY OF ALTERNATOR AND EXCITER.

a. General. After necessary repairs and adjustments have been made, assemble the alternator and exciter, using all possible precautions. Make sure that all contact surfaces between parts are clean before fitting them together. Tighten all nuts, screws, and connections securely. Use lockwashers, preferably new, in all places where they were used originally.

b. Assembly of the Alternator.

(*1*) Press the ball bearings on both ends of the rotor shaft, as indicated in paragraph 104 g (2) (f).

(*2*) Check to see that the coil windings are firmly in place in the slots in the laminations. No winding should project above the lamination surface.

(*3*) Swing the rotor and bracing bracket (fig. 68) into place, using a hoist if available. Attach the bearing bracket to the stator frame using the six cap screws and lockwashers. Tighten the cap screws fingertight, then tighten them alternately with a wrench.

(*4*) Replace the bearing cap on the pulley end of the rotor shaft, and secure it with the four cap screws and lockwashers provided.

(*5*) Replace the brushes in their brush holders (fig. 63) and reconnect the exciter leads, capacitor leads, and brush pigtails at the brush-holder connections, following the identification tags put on the leads during removal. Tighten all screws securely and use lockwashers where provided.

(*6*) Swing the other bearing bracket into place on the exciter end of the alternator, and slide it carefully into place over the ball bearing to prevent injury to the bearing. Note that the correct position of the bearing bracket is indicated by the capacitor, which should be at the top when assembly is complete. Replace the six cap screws and lockwashers which fasten the bearing bracket to the stator frame. Tighten these cap screws fingertight after hammering bearing bracket into position (using a block of wood to protect the casting), then tightening the cap screws alternately with a wrench, a turn at a time until they are secure.

c. Assembly of the Exciter. After the alternator has been assembled, proceed as follows to assemble the exciter:

(*1*) Replace the bearing cap on the rotor shaft, and insert and secure the four cap screws and lockwashers holding the cap in place.

(*2*) Place the exciter armature on the rotor shaft, winding end toward the alternator, and drive it carefully into place, using a block of wood against the end of the armature. When the armature is nearly in place, insert the armature bolt and washer. Tightening the bolt will push the armature up to its proper position.

(*3*) Set the exciter brush ring in place on the four studs in the exciter field frame. The two marks on the ring must straddle the top, right-hand stud exactly. Secure the four hexagon nuts and lockwashers holding the frame.

(*4*) With the field coils fastened in place by means of cap screws in the exciter field frame, replace the frame over the armature and up against the alternator bearing bracket, so that the line on the front edge of the exciter frame is vertical and is at the top of the frame. Tap the exciter field frame into place with a mallet and a wood block, and bolt it to the alternator bearing bracket by means of the four cap screws that enter the bearing bracket from the alternator side of the bracket. Making sure that the lockwashers are in place on the cap screws, tighten the four cap screws securely.

(*5*) Replace the exciter brushes in their brush holders, and reconnect the exciter field leads, alternator leads, capacitor leads, and brush pigtails, following carefully the identification tag placed on the leads in the disassembly of the unit.

(*6*) Replace the exciter end cover and tighten it by means of the two cap screws at the top of the cover and the clamp at the bottom of the cover.

(*7*) Replace the slip-ring end-ball cover between the alternator and the exciter and secure it by tightening the clamp at the bottom of the coupling cover. Attach the alternator pulley and the cap screw holding it.

106. ALTERNATOR AND EXCITER INSTALLATION.

a. Installation. Attach a hoist hook through the eyebolt in the top of the alternator, and position the set on the power unit base, with the pulley end of the alternator shaft on the side with the engine pulley. Attach the alternator to the base with four bolts, lockwashers, and nuts (fig. 13). Do not pull up the nuts tight.

b. Tightening Belt. Install the two drive belts from the alternator pulley to the engine pulley. Now loosen the generator belt adjusting bolt (fig. 13) that is closer to the engine, and tighten

the opposite bolt until the drive belts have the tension indicated in figure 25 (par. 51 (item 29)). By means of a square, ascertain that the generator shaft is parallel with the engine crankshaft, and tighten the four bolts holding the alternator to the engine base. The inner adjusting bolt can be tightened sufficiently to keep it from vibrating.

c. Connections. Connect the wiring from the control panel to the terminal boxes on the alternator, as shown in figure 9. Replace the covers on the terminal boxes on the alternator.

107. INTERFERENCE SUPPRESSION.

a. General. To reduce radio interference, the power unit is equipped with capacitors, suppressors, bonding straps, and internal-external tooth (IET) lockwashers. A complete check-up would include at least a visual inspection of the equipment to make sure that none of it is missing, and that all connections are clean and tight. In case of excessive radio interference, a more thorough check-up must be made. An abnormal condition of the power unit or the load may result in more interference than the suppression equipment can control. Therefore, do not assume that the suppression equipment is at fault until the power unit has been checked thoroughly for such a condition.

b. Capacitors. Make sure that all are in place, and that connections are tight. As in the case of radio capacitors, the suppression capacitors may be removed and tested individually. Replace any capacitor that tests open, shorted, or incorrect capacity.

c. Commutators, Slip Rings, and Brushes. Make sure that there is no abnormal arcing at the exciter brushes. Commutators and slip rings must be smooth and clean. The mica on the commutator of the exciter must be undercut. All brushes must seat properly, with proper spring tensions and proper position.

d. Faulty Contacts. If switch or a-c circuit breaker contacts are suspected of making poor contact, test one at a time by connecting a jumper across its terminal when it is in a normally closed position. If a switch or the a-c circuit breaker should test defective, install a new one. A similar jumper test may be made across the suspected contacts of a relay or the voltage regulator. Study the wiring diagram and make sure that the jumper is used across the correct terminals and only while the contacts being tested are normally closed.

e. Interference from Outside Sources. Defective lamps, transformers, or appliances, or poor connections anywhere on the load circuit may result in radio interference which must be corrected at its source. Any commutator-type motor may cause radio interference by brush-sparking. This condition may be caused by poor condition of the commutator, wrong brush setting, improperly seated brushes, too light spring tension, excessive current caused by overloading the motor, or low-line voltage.

108. CONTROL PANEL, REPAIR AND INSTALLATION.

a. General. All of the components of the control panel are adjusted and the polarity set in fabrication. The main line circuit breaker (a-c circuit breaker) switch is sealed against tampering and should be replaced in the event of failure. The damping transformer and the automatic polarity reversing switch should be replaced if inoperative. The voltage regulator is regulated and adjusted in manufacture and no adjustment (except for voltage setting) should be required. Replace any inoperative ammeter, voltmeter, or frequency meter. Tighten the control knobs of the exciter field rheostat and the rotary voltmeter switch.

b. Removal. Remove the four roundhead screws holding the circuit breaker panel and remove the panel. Disconnect leads 1 and 2 from the terminal block below the circuit breaker. Disconnect leads L1, L2, and L0, and leads T1, T2, and T0 from the terminals on either side of the main circuit breaker. Remove the connectors from the sheathed cable and flexible conduits (fig. 9), and remove the three wiring assemblies. Remove the six roundhead machine screws and lockwashers holding the control panel, and remove the panel from the protecting case.

c. Disassembly, Repair, and Reassembly.

(*1*) Refer to the control panel wiring diagram (fig. 38) for the removal or installation of wires or cables from connection to each component. Remove or connect any wire or cable and any attaching nut, screw, and lock-

washer to remove or install component. In the event of damage to components beyond the scope of repair with maintenance stock materials, replace the damaged part.

(*2*) To keep the voltage regulator in good condition, see that the polarity reversing switch (fig. 67) is in operation, and check on the tungsten contacts of the regulator at frequent intervals. The contacts should be clean, and free from pits or points. They can be dressed down with an ignition contact file, or they can be removed and ground with a fine emery stone or a fine oil stone. Grind them only enough to take off the main projections. When the points become too badly damaged, or worn down to their steel backings, replace them. To do this, unscrew the stationary contact, and replace it with a new one; remove the vibrator and vibrator contact by removing the two bolts and nuts in the vibrator clamp, and replace with a new vibrator and vibrator contact. Check the air gap between the vibrator and the relay magnet core as follows: Loosen the stationary contact adjusting screw clamping bolt, and turn the adjusting screw until the stationary contact is as far back as it will go; start the engine, and with the generator in operation, back off the vibrator contact by means of the voltage adjusting screw (fig. 67) until the voltage reads at the normal value; this will usually be about three turns past the point where the contacts first touch; with this contact pressure, adjust the airgap between the magnet core and the vibrator to 1/32 inch; this adjustment is made by turning the stationary contact adjusting screw; tighten the adjusting-screw clamping bolt.

d. Installation. Install the control panel in the protecting case, and secure the six roundhead machine screws and lockwashers holding the panel. Attach the flexible conduits and sheathed cable through openings in the bottom of the case and secure them with their connectors. Connect leads 1 and 2 to the terminal block under the circuit breaker, and leads L1, L2, and L0, and leads T1, T2, and T0 to their respective terminals at either side of the circuit breaker. Replace the circuit breaker panel, and secure the four roundhead machine screws and lockwashers holding the panel.

109. INSTRUMENTS, REPAIR AND INSTALLATION.

a. General. There are three instruments in separate locations on the engine, the water and oil temperature gauges, and the oil pressure gauge. None of the gauges can be repaired should it become inoperative.

b. Removal and Installation. Remove the water temperature gauge by unscrewing it from the elbow in the coolant pipe on top of the engine. Remove the oil pressure gauge by unscrewing it from the elbow on the pipe leading into the side of the camcase cover. Remove the oil temperature gauge by loosening the setscrew in the securing nut, and unscrewing the nut to remove the gauge from the lug in the bottom of the crankcase on the generator end of the engine. Replace any of the instruments in the reverse order of its removal. In all cases, the gauges should fit tightly in their places so that they do not permit oil or coolant leakage. In replacing any gauge, position it so that it can be seen conveniently by the operator.

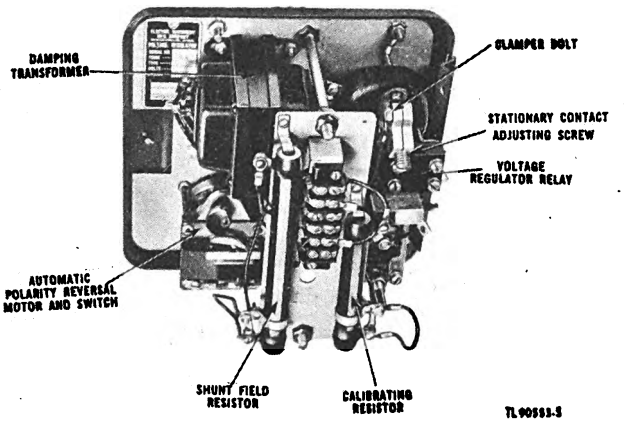


Figure 67. Voltage regulator, rear view.

SECTION XVII. OTHER REPAIR PROCEDURES

110. PAINTING AND REFINISHING.

a. When the painted surface of the power unit is scratched, or the finish has been damaged, rust and corrosion of the unprotected surface may occur. This action may be prevented by thoroughly cleaning and painting the damaged surface. The extent of the treatment required will depend upon various conditions. If only small portions of the unit have been scratched or scraped, proceed as follows:

(*1*) Remove all traces of oil or grease with dry-cleaning solvent (SD) and thoroughly sandpaper the spot or spots to be painted. Apply the paint in light, even coats with a small brush. Two light coats of paint are more effective than one heavy coat.

(*2*) If the painted surface of the unit is blistered from overheating, remove all of the old paint with paint remover, and thoroughly clean the surface to be painted with sandpaper or steel wool. Apply a smooth, even priming coat; sand the priming coat lightly with fine sandpaper; and complete the paint job with two light, even coats of finish paint of the same color.

(*3*) Refinish the entire unit whenever it has received a complete overhaul. If the painted surface is in fair condition, repaint all scrapes and scratches. If the painted surface is in poor condition, badly chipped, scratched, or marked, the entire unit should be repainted as instructed in subparagraph b below.

CAUTION: Avoid getting paint on moving parts. Do not paint electrical contacts.

b. Remove all of the old paint with paint remover, thoroughly clean and sandpaper the unit using either sandpaper or steel wool. Make sure that all grease and oil are removed from the parts to be painted. Apply a priming coat to the surface and then sand the coat down with fine sandpaper. Finish the painting by applying two light finishing coats.

111. EMERGENCY REPAIRS.

a. If a bullet or piece of shrapnel punctures a tube in the radiator core, cut the tube or break it with a pair of pliers, if it is not completely severed. With pliers, strip the fins from the tube above and below the break for approximately ½ inch. Bend the broken ends of the tube so that the bent ends are parallel with the tube. Flatten both the bent ends and the tube to stop the flow of water.

b. If a bullet or a piece of shrapnel hits the control panel, place a jumper wire over the damaged meters or circuits. Consult the wiring diagram (fig. 38) if possible, before doing this, since in some cases this may not be entirely advisable.

112. RUSTPROOFING BEFORE STORAGE OR SHIPMENT.

When repairs and test are complete, while the engine is still warm, and before it is removed from the test stand, process the engine for rustproofing according to instructions in paragraph 12.

SECTION XVIII. REPAIR AND ANALYSIS DATA

113. TABLE OF ENGINE SPECIFICATIONS, TOLERANCES, AND CLEARANCES.

Intake valve seat width ---------- ⅛ in.

Exhaust valve seat width ---------- ⅛ in.

Intake valve guide, side clearance ---- 0.003 in.

Exhaust valve guide, side clearance --- 0.003 in.

Intake valve rocker arm clearance, hot ---------- 0.012 in.

Exhaust valve rocker arm clearance, hot ---------- 0.012 in.

Valve timing, intake opens ---------- 6° before top dead center.

Valve timing, exhaust
opens_____45° before bottom dead center.

Main bearing diameters_____2.500 in.

Main bearing thrust
clearance_____0.005 in. to 0.007 in. cold.

Connecting-rod crank pin
diameter _____2.875 in.

Connecting-rod bearing diameter
clearance_____0.003 in. to 0.008 in.

Connecting-rod bearing end
clearance_____0.005 in. to 0.012 in.

Camshaft bearing diameter_____1.8115 in.

Camshaft bearing clearance_____0.002 in.

Cylinder bore_____5 in.

Piston clearance
(at bottom of skirt)_____0.0055 in.

Number and type of piston
rings_____6 rings (4 compression, 2 oil).

Piston ring vertical clearance
0.020 in. to 0.030 in. compression rings.
0.086 in. to 0.096 in. oil rings.

Piston pin diametral clearance_____0.002 in.

114. TABLE OF CIRCUIT RESISTANCES, VOLTAGES, AND CAPACITANCES.

a. Alternator Voltages and Other Data.

110/220 volts.

60 cycles.

Single phase, 3 wire.

1,800 revolutions per minute.

45.5 amperes at full load at 220 volts.

Capacitors (5 used)—0.1 mf 500vdcw.

b. Exciter Voltages and Other Data.

62.5 volts dc.

0.8 amperes.

1,800 revolutions per minute.

500 watts.

Capacitors (2 used)—0.1 mf 500 vdcw.

c. Control Panel Data (fig. 9).

Exciter field rheostat resistance is 160 ohms (330 watts).

Calibrating resistor resistance is 500 ohms (50 watts).

Shunt-field resistor resistance is 150 ohms (75 watts).

Circuit breaker rated at 70 amperes.

Potential transformer rated at 230/115 volts, 50/133 cycles, 50 volt-amperes.

Current (ammeter) transformers rated at 75/5 amperes ac (2 used).

Noise suppressor capacitor rated at 0.03 mf.

NOTE: Since the d-c resistance of the generator armature windings is too low to be effectively read on an ordinary ohmmeter, tests for continuity, shorts, and grounds in the electrical system, control panel, and generator are made with a 115-volt lamp in series with a 115-volt line as described in paragraph 59.

115. WAR DEPARTMENT UNSATISFACTORY EQUIPMENT REPORT (fig. 68).

a. When trouble in equipment used by the Army Ground Forces or Army Service Forces occurs more often than repair personnel feel is normal, War Department Unsatisfactory Equipment Report, W.D., A.G.O. Form No. 468, should be filled out and forwarded through channels to the Office of the Chief Signal Officer, Washington 25, D. C. Refer to TM 37-250 for complete instructions on the handling of this report.

b. When trouble in equipment used by Army Air Forces occurs more often than repair personnel feel is normal, Army Air Forces Form No. 54 should be filled out and forwarded through channels.

WAR DEPARTMENT

UNSATISFACTORY EQUIPMENT REPORT

FOR	TECHNICAL SERVICE: Signal Corps — MATERIEL		DATE: 21 April 1945
FROM	ORGANIZATION: 579 Signal Repair Co.		STATION: A.P.O. 95, N.Y. N.Y.
TO	NEXT SUPERIOR HEADQUARTERS: Sig O III Army	STATION	TECHNICAL SERVICE

COMPLETE MAJOR ITEM

NOMENCLATURE	TYPE	MODEL
Power Unit PE-000	Diesel Engine driven	U.D.-9

MANUFACTURER	U. S. A. REG. No.	SERIAL No.	DATE RECEIVED
V-G Mfg Co.	000-P-44	21A531	5 Jan 1945

EQUIPMENT WITH WHICH USED (*if applicable*): AN/FRC-1

DEFECTIVE COMPONENT—DESCRIPTION AND CAUSE OF TROUBLE

PART NO.	TYPE	MANUFACTURER	DATE INSTALLED
R-000	Thrust bearing	E-Z Roll Bearing Co	Original

DESCRIPTION OF FAILURE AND PROBABLE CAUSE (*If additional space is required, use back of form*): Bearing badly worn due to inadequate dust protection.

DATE OF INITIAL TROUBLE	TOTAL TIME INSTALLED			TOTAL PERIOD OF OPERATION BEFORE FAILURE					
	YEARS	MONTHS	DAYS	YEARS	MONTHS	DAYS	HOURS	MILES	ROUNDS
14 April 1945					3	4	5		

BRIEF DESCRIPTION OF UNUSUAL SERVICE CONDITIONS AND ANY REMEDIAL ACTION TAKEN: Desert operation. Extreme sand and dust. Improvised felt washer for added protection.

TRAINING OR SKILL OF USING PERSONNEL			RECOMMENDATIONS (*If additional space is required, use back of form*)
POOR	FAIR	GOOD	
	✓		Additional shields should be provided.

ORIGINATING OFFICER

TYPED NAME, GRADE, AND ORGANIZATION	SIGNATURE
JAMES ROE, CAPT. SIG. C.	James Roe

FIRST ENDORSEMENT

TO CHIEF	TECHNICAL SERVICE	OFFICE	
NAME, GRADE, AND STATION		STATION	DATE

Instructions

1. It is imperative that the chief of technical service concerned be advised at the earliest practical moment of any constructional, design, or operational defect in matériel. This form is designed to facilitate such reports and to provide a uniform method of submitting the required data.
2. This form will be used for reporting manufacturing, design, or operational defects in matériel, petroleum fuels, lubricants, and preserving materials with a view to improving and correcting such defects, and for use in recommending modifications of matériel.
3. This form will not be used for reporting failures, isolated material defects or malfunctions of matériel resulting from fair-wear-and-tear or accidental damage nor for the replacement, repair or the issue of parts and equipment. It does not replace currently authorized operational or performance records.
4. Reports of malfunctions and accidents involving ammunition will continue to be submitted as directed in the manner described in AR 750-10 (change No. 3).
5. It will not be practicable or desirable in all cases to fill all blank spaces of the report. However, the report should be as complete as possible in order to expedite necessary corrective action. Additional pertinent information not provided for in the blank spaces should be submitted as inclosures to the form. Photographs, sketches, or other illustrative material are highly desirable.
6. When cases arise where it is necessary to communicate with a chief of service in order to assure safety to personnel, more expeditious means of communication are authorized. This form should be used to confirm reports made by more expeditious means.
7. This form will be made out in triplicate by using or service organization. Two copies will be forwarded direct to the technical service; one copy will be forwarded through command channels.
8. Necessity for using this form will be determined by the using or service troops.

W. D., A. G. O. Form No. 468
30 August 1944

This form supersedes W. D., A. G. O. Form No. 468, 1 December 1943, which may be used until existing stocks are exhausted.

TL96851

U. S. GOVERNMENT PRINTING OFFICE 16—41546-1

Figure 68. W.D., A.G.O. Form No. 468, Unsatisfactory Equipment Report.

APPENDIX

SECTION XIX. REFERENCES

116. PARTS LIST.

SIG 1 Introduction to ASF Signal Supply Catalog.

SIG 2 Complete Index to ASF Signal Supply Catalog.

SIG 3 List of Items for Troop Issue.

SIG 4-1 Allowances for Expendable Supplies.

SIG 5 Stock List of All Items.

SIG 10 Fixed Plant Maintenance List.

117. DECONTAMINATION.

TM 3-220 Decontamination.

118. DEMOLITION.

FM 5-25 Explosives and Demolitions.

119. CAMOUFLAGE.

FM 5-20 Camouflage, Basic Principles.

120. OTHER TECHNICAL PUBLICATIONS.

FM 21-6 List of Publications for Training.

TM 37-2810 Motor Vehicle Inspections and Preventive Maintenance Services.

TM 10-575 Diesel Engines and Fuels.

TB SIG 13 Moistureproofing and Fungiproofing Signal Corps Equipment.

121. FORMS.

Forms mentioned in this manual used by operating or repair personnel for the purpose of making records and reports, are as follows:

Army Air Forces Form No. 54 (Unsatisfactory Report).

W.D., A.G.O. Form No. 468 (Unsatisfactory Equipment Report).

W.D., A.G.O. Form No. 460 (Preventive Maintenance).

W.D., A.G.O. Form No. 461 (Preventive Maintenance Service and Technical Inspection Work Sheet for Wheeled and Half-Track Vehicles).

W.D. Form 48 (Driver's Trip Ticket and Preventive Maintenance Service Record).

SECTION XX. MAINTENANCE PARTS

122. MAINTENANCE PARTS FOR POWER UNIT PU-53/FRC.

The following information was compiled on 20 September 1945. The appropriate pamphlet of the ASF Signal Supply Catalog for Power Unit PU-53/FRC is:

SIG 10-605, Power Unit PU-53/FRC, Fixed Plant Maintenance List (when published).

For an index of available catalog pamphlets, see the latest issue of ASF Signal Supply Catalog SIG 2.

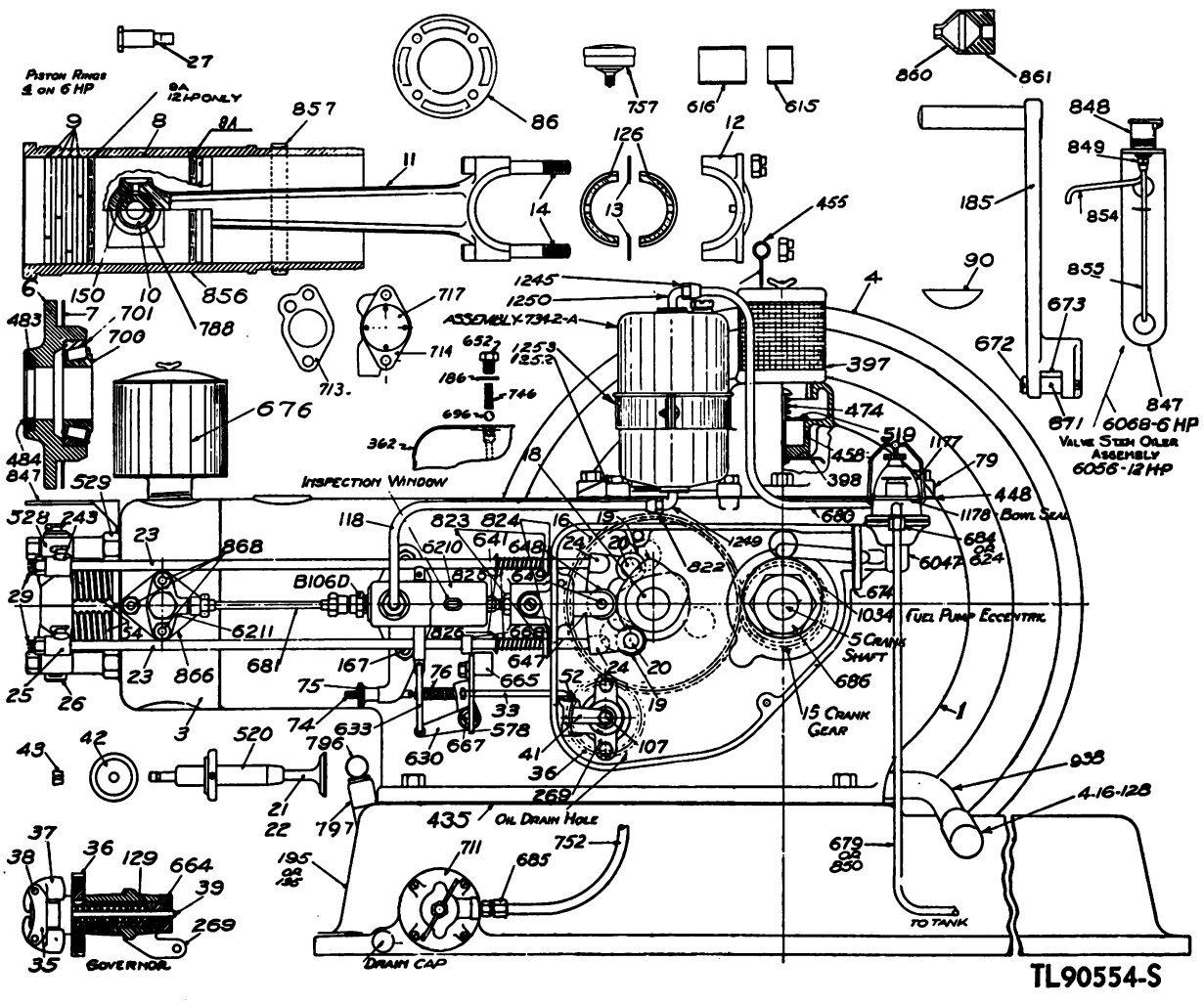


Figure 69. Engine parts diagram.

122. MAINTENANCE PARTS FOR POWER UNIT PU-53/FRC.

Ref symbol	Signal Corps stock No.	Name of part and description	Mfr's part and code No.
		ENGINE PARTS	
		Air Cleaner Group	
Fig. 18	3H955-7	AIR CLEANER ASSEMBLY: Air Maze dwg 37M-OBGL.	6846
Fig. 18	6Z3854-19	ELEMENT: wire mesh.	AP-81
Fig. 18	3H2154.7-6	GASKET: cork, Air Maze #AP-6B.	AP-6B
		Camshaft Group	
Fig. 69 (18)	3H1919/C1	CAMSHAFT.	KD-18-C
Fig. 69 (16)	3H1919/G18	GEAR: camshaft, 60 teeth.	MD-16-A
	6L996-9-1	KEY, shaft: cam gear.	KD-464
		Connecting Rod & Piston Group	
Fig. 50	3H5055A-2	CONNECTING ROD ASSEMBLY.	6216-A
Fig. 50	3H1919/B3	BEARING, sleeve: two halves.	MD-126-D
Fig. 69 (150)	3H1919/B24	BUSHING, piston pin.	MD-150-A

122. MAINTENANCE PARTS FOR POWER UNIT PU-53/FRC (contd).

Ref symbol	Signal Corps stock No.	Name of part and description	Mfr's part and code No.
	6L3944-7A	PIN, dowel: connecting rod bearing.	KD-678
Fig. 50	3H1919/S10	SHIM, bearing.	MD-13
	3H5571	THROWER, oil.	M-455
Fig. 50	3H4190.2	PISTON.	MD-8-2
Fig. 50	3H4200.4-1	PIN, piston.	MD-10-A
Fig. 50	3H1919/R9	RING, piston: compression.	MD-9-1
Fig. 50	3H1919/R8	RING, piston: oil.	MD-9-A
Fig. 50	3H1919/R10	RING, piston pin: retainer.	MD-788
		Crankshaft Group	
Fig. 50	3H1919/C3	CRANKSHAFT ASSEMBLY.	6227-A
Fig. 69 (700)	3H1919/C10	CONE, bearing: Timken #639.	MD-700
Fig. 69 (701)	3H1919/C15	CUP, bearing: Timken #632.	MD-701
Fig. 69 (15)	3H2230.1-12	GEAR, crank: 30 teeth.	MD-15-A
Fig. 69 (686)	6L2522-10-35	NUT, crankshaft.	KD-686
	6L3948-8	PIN, crank gear.	KD-465
Fig. 69 (90)	3H2676-1	KEY, flywheel: Woodruff ½" w x ¾" h x 2¾" diam.	MD-90
		Cylinder Block & Crankcase Group	
	3H372	CYLINDER BLOCK ASSEMBLY.	6223-B
Fig. 69 (616)	3H1919/B1	BUSHING, camshaft.	KD-616
	3H1919/G3	GASKET, paper camcase cover.	MD-449-B
Fig. 52	3H1919/G5	GASKET, neoprene: cylinder liner.	MD-857
Fig. 52	3H2691-2	LINER, cylinder.	MD-856-2
Fig. 69 (615)	3H1919/B2	BUSHING, camshaft: short.	KD-615
Fig. 19	3H438.3	BREATHER, crankcase.	KD-397-A
	3H5225.4-1	FELT: grease retainer, crankshaft.	V-483
	3H1919/G4	GASKET, cork: crankcase cover.	MD-448
	3H1919/G6	GASKET, paper: sub-base.	MD-435
	3H1919/H5	RETAINER ASSEMBLY.	6228
	3H5041.3-8	RING, retainer: crankshaft.	V-484
Fig. 69 (7)	3H5241.2-23	SHIM, roller bearing hub.	MD-7
Fig. 69 (474)	3H5255.16	SPRING, compression: crankcase breather.	KD-474
Fig. 13	3H5567	THERMOMETER, lube oil: Palmer #6074.	PC-6074
		Cylinder Head Group	
Fig. 49	3H2500-4	CYLINDER HEAD ASSEMBLY: includes guides, inserts, valves, springs, studs, pins, retainers and washers.	6226-A
Fig. 46	3H1380.11	COVER, air cell.	MD-861
	3H1919/G2	GASKET, cylinder head.	MD-86-1
Fig. 49	3H2154.14-1	GASKET, copper asbestos: air cell.	KD-390
	3H785	CHAMBER, precombustion air cell.	MD-860
Fig. 69 (529)	6L3512-10-30	NUT, stud.	MD-529
	6L31179	STUD, cylinder head.	MD-100A

122. MAINTENANCE PARTS FOR POWER UNIT PU-53/FRC (contd).

Ref symbol	Signal Corps stock No.	Name of part and description	Mfr's part and code No.
		Engine Control Group	
Fig. 47	3H1919/G13	OIL PRESSURE GAUGE.	KD-757
Fig. 5	3H4512.3-1/J2	THERMOMETER, water temperature: Rochester Mfg Co. Model 2025.	AD-846-A
		Engine Sub-base Group	
	3H640.2-3	BUSHING, oil gauge: lubricating.	AD-797
	3H2154.15-1	GASKET, felt: lube oil gauge.	AD-862
Fig. 5	3H1919/G12	GAUGE, oil: bayonet type.	AD-796
	3H983.1	VALVE, brass: Cranecoy #268.	268
		Fuel Filter Group	
Fig. 27	3H3811/C2	FILTER ASSEMBLY: one time use, final, Amer Bosch FSP-10A3.	7342-A
Fig. 27	3H955.2	FILTER ASSEMBLY: primary, Cuno #DS-10865.	7372
	3H4512.3-1/G2	GASKET, filler plug.	A-186
Fig. 19	3H640.4	PLUG, filler.	KD-652
		Fuel Injection Group	
Fig. 46	3H1919-1/H10	HOLDER, nozzle: pintle type Amer Bosch AKB50S55.	6211-A
Fig. 48	3H1919-1/N1	NOZZLE ASSEMBLY: Amer Bosch ADN-8-S3.	6212
	3H1919/L3	TUBING ASSEMBLY: fuel injector.	6286
	3H4512.3-1/W3	WASHER, copper nozzle holder.	KD-877
		Fuel Injection Pump Group	
Fig. 47	3H1919-1/P6	INJECTION PUMP ASSEMBLY: Amer Bosch #APF1B-8ON-S67.	6210-A
	3H6680-1	DELIVERY VALVE SEAT ASSEMBLY: Amer Bosch #PVE30/1Z.	PVE30/1Z
	3H4423	PLUNGER AND BARREL ASSEMBLY: Amer Bosch #PPK1/2Z.	PPK1/2Z
	6L18605-7.95	SCREW, barrel set w/gasket.	WSR2099/2X
	3H5255.17	SPRING, plunger cup: Amer Bosch #WSF2161A400X.	WSF2161A400X
	3H5255.17-1	SPRING, delivery valve: Amer Bosch #WSF2141A1X.	WSF2141A1X
Fig. 24	3H1919/T1	TAPPET ASSEMBLY.	6231
	6L3940-17	PIN, roller.	KD649
Fig. 24	3H5056	ROLLER, tappet.	KD648
Fig. 24	3H4512.3-1/S4	SCREW, adjusting.	KD-641
Fig. 54	3H5450	TAPPET, fuel injection pump.	MD647
		Fuel Transfer Pump Group	
Fig. 45	3H1919/P6	TRANSFER PUMP ASSEMBLY.	6047
Fig. 45	3H1919/B15	BOWL, fuel filter: glass AC #1523094.	AD-1177
Fig. 45	3H1919-1/S6	GASKET, cork: fuel strainer AC #1523096.	AD-1178
Fig. 45	3H1919-1/S30	STRAINER, wire mesh: AC #1523099.	4-9-9
	3H4512.3-1/G5	GASKET, fuel pump.	AD-674
Fig. 27	3H2694-7	TUBING, copper: Cuno filter to fuel tank, #20B&S.	CM-188
Fig. 27	3H2694-6	TUBING, copper: fuel pump to Cuno filter, #20B&S.	CM-189
Fig. 27	3H6670.2	TUBING ASSEMBLY, copper: fuel transfer.	8217
Fig. 69 (118)	3H2694-11	TUBING ASSEMBLY, copper: fuel filter to injection pump.	6878

122. MAINTENANCE PARTS FOR POWER UNIT PU-53/FRC (contd).

Ref symbol	Signal Corps stock No.	Name of part and description	Mfr's part and code No.
		Governor Group	
Fig. 26	3H2477A-3	GOVERNOR ASSEMBLY.	6219-1
Fig. 37	3H321-64	BEARING, governor.	KD-269
	3H5247-1	COLLAR, governor spring.	MD-206
Fig. 37	3H2230.1-13	GEAR, spur.	KD-36
	6L995-3	KEY, Woodruff: governor gear ⅛" w x 13/64" lg x ½" diam.	AD-213
Fig. 37	3H1919-1/P11	PIN ASSEMBLY, governor center.	6104-A
Fig. 37	3H5251	SPINDLE, governor.	KD-35
Fig. 37	3H1919/S2	SPRING, compression.	KD-129-1
Fig. 37	3H2681.3	LEVER, governor.	A-41-A
Fig. 37	3H2698.2	LINK, injection pump.	KD-633
Fig. 47	6L3948-49	PIN, bell crank fulcrum.	KD-667
	6L3945-27	PIN, lever.	A-52
Fig. 47	3H5055-5	ROD, connecting.	MD-33-A
Fig. 47	3H4512.3-1/S3	SPRING, extension: speed change.	KD-76
Fig. 47	3H4512.3-1/S2	STEM, governor.	A-74-A
		Muffler Group	
Fig. 2	3H2546-2	HOSE, muffler: metallic; flexible.	MD-1264
Fig. 2	3H3981-5	MUFFLER.	6886-1
		Oil Filter Group	
Fig. 41	3H1919-1/F2	FILTER ASSEMBLY, lube oil.	6023-A
Fig. 41	3H1919-2/C10	ELEMENT, filter: brass.	KD-710-1
	3H4512.3-1/G6	GASKET, flange.	KD-712
		Oil Pump Group	
	3H250-3	BALL, relief.	KD-696
	3H1919-1/G14	GASKET, oil pump.	KD-713
Fig. 42	3H1919/P7	OIL PUMP ASSEMBLY.	6021
	3H1919-1/S40	SPRING, compression: oil pump.	AD-746
	3H2694-12	TUBING, copper: oil pump suction	MD-752-1
		Starting Crank Group	
	3H1919/C2	CRANK ASSEMBLY.	6089
	3H5265	PAWL, starting crank.	KD-671
	6L3948-36-1	PIN, pawl.	KD-672
	3H1919/S3	SPRING, compression: starting crank pawl.	KD-673
		Radiator & Fan Group	
Fig. 44	3H340-2	BELT, "V" type: Veelos, link type size B, 21/32" w.	MD-772-1
Fig. 44	3H370.1-5	FAN ASSEMBLY, 4 blades, Schwitzer-Cummins #115589 counterclockwise rotation.	7026
Fig. 44	3H948.10-2	CLAMP, hose.	4-11-8
Fig. 44	3H948.10-1	CLAMP, hose.	4-11-9
Fig. 44	3H983.2	COCK, drain: Interbrass #43-E.	4-16-99
Fig. 44	3H2546-3	HOSE, radiator: 1¼" ID x 8½" long, 3 ply.	4-11-16
Fig. 44	3H2546-4	HOSE, radiator: 1½" ID x 6" long, 3 ply.	4-11-20
	3H3997	PAD, radiator: rubber belting.	AD-631
	3H4600P1-1	PULLEY, grooved: fan drive.	MD-844-1
Fig. 44	3H4610-4	RADIATOR: 2.3 gals, Perfex #R2229B modified.	CM-1161
	6L31154-35	STUD, mtg: fan pulley.	4-3-97

122. MAINTENANCE PARTS FOR POWER UNIT PU-53/FRC (contd).

Ref symbol	Signal Corps stock No.	Name of part and description	Mfr's part and code No.
		Valve Group	
Fig. 49	3H1919-1/G24	GUIDE, stem: valve.	KD-520
Fig. 49	3H2568.1-3	INSERT, intake valve.	MD-691-1
Fig. 49	3H1919/J4	INSERT, exhaust valve.	MD-691
Fig. 49	3H1919-3/R10	RETAINER, spring valve.	KD-42-A
Fig. 49	3H1919/S1	SPRING, inlet and exhaust valve.	KD-54
	3H2694-9	TUBING, copper: exhaust valve stem oiler.	MD-855
	3H2694-10	TUBING, copper: valve stem oiler.	MD-854
Fig. 49	3H1919/V1	VALVE, exhaust.	MD-21-D
Fig. 49	3H1919/V2	VALVE, inlet.	MD-22-1
Fig. 49	3H4512.3-1/W2	WASHER, lock: valve spring.	KD-43
		Valve Rocker Arm Group	
Fig. 49	3H1919/R15	ARM ASSEMBLY, rocker: exhaust valve.	6285-A
Fig. 49	3H1919/R16	ARM ASSEMBLY, rocker: inlet valve.	6284
Fig. 49	6L4727-20S	SCREW, adjusting: valve rocker.	KD-29-A
	3H941.4	COLLAR, exhaust valve rod.	KD-668
	3H2154.15	FELT, oil retainer: valve push rod, Felters Co. Inc. #3310.	KD-824
	3H1919-1/R13	ROCKER ASSEMBLY, roller: inlet and exhaust.	6229-A
Fig. 49	3H5058	ROLLER, rocker arm: valve.	KD-244
	3H1919-1/R18	ROLLER, cam: inlet and exhaust.	KD-19
	6L3952-14-13	PIN, roller cam.	KD-20
	3H1919/R3	ROD, push: valve.	MD-23-A
	6L18605-4.39	SCREW, set.	4-20-125
	6L18604-6.31	SCREW, set.	4-20-121
	3H1919/S4	SPRING, compression: oil retainer.	KD-825
		GENERATOR PARTS	
Fig. 13	3H175	BASE ASSEMBLY, adjustable, Elec Mach #24462.	24462
Fig. 61	3H4540.1/7	BEARING, ball: SKF #6308.	6308
Fig. 63	3H550-24	BRUSH, carbon: 1¼" long x ¼" w x ⅝" thk, National Carbon #AY w/leads.	82240
Fig. 63	3H2507.1-16	BRUSH-HOLDER ASSEMBLY (incl holders and springs): Elec Mach #22260.	22260
Fig. 61	3D481	CAPACITOR: 0.1 mf, 500 v AC/DC Tobe Deutschmann #SVIR7.	Sig Type CA-481
	3H2154.8-9	GASKET, gen junction box.	80203
	3H2154.8-8	GASKET, gen junction box.	80301
Fig. 63	3H5255-13	SPRING, brush: cadmium-plated Elec Mach #67240.	67240
		EXCITER PARTS	
Fig. 60	3H525-195	BRUSH, exciter: carbon ⅜" x ⅜" x 1-1/16" long w/leads National Carbon #SA-3590.	82001
Fig. 60	3H2507.1-17	BRUSH-HOLDER ASSEMBLY (incl RH & LH fingers and springs and holder).	22081
	3H2154.8-10	GASKET, junction box.	80201
	3H5255-15	SPRING, brush: LH, enameled.	67002
	3H5255-14	SPRING, brush: RH, enameled.	67001

122. MAINTENANCE PARTS FOR POWER UNIT PU-53/FRC (contd).

Ref symbol	Signal Corps stock No.	Name of part and description	Mfr's part and code No.
		SWITCHBOARD PARTS	
Fig. 1	3F1075-5	AMMETER, AC: 0-75 amp, Roller Smith #TAS42001.	TAS42001
Fig. 9	3H900-30-11	CIRCUIT BREAKER: 70 amp, thermal, 3 pole, Westinghouse #1222017.	1222017
Fig. 9	3F2746-7	FREQUENCY METER: 58 to 62 cyc, 115 v, Biddle #MF5-4961.	MF5-4961
Fig. 9	3Z1891-49	FILTER, voltage regulator: Elec Mach #2612.	2612
Fig. 9	3Z7160-1	RHEOSTAT: 160-ohm, 330 w, 3.2-6.4 amp, Ward Leonard #66-445.	66-445
Fig. 9	3Z9825-3.4	SWITCH, rotary: voltmeter, 4 pos, 2 sect, Roller Smith #R-2.	40371
Fig. 9	2Z9900.16	TRANSFORMER, current, AC: 75-5 ratio, Elec Mach #2220.	2220
Fig. 9	3H4964.1-12	VOLTAGE REGULATOR: 220 v, 50/60 cyc Elec Mach #SM form G-2.	GR-2
Fig. 9	2Z7587-162	RELAY, armature: voltage reg, SPST, normally closed, Elec Mach #2325.	2325
Fig. 9	3Z6050-192	RESISTOR, adjustable: 500-ohm, 50 w, Milwaukee Res Co MM-500-A.	MM-500-A
Fig. 9	3Z6015-85	RESISTOR, adjustable: 150-ohm, 75 w, Milwaukee Res Co MN-150-A.	MN-150-A
Fig. 1	3Z9858-28.1	SWITCH, voltage regulator: DPDT, toggle, Leviton #704.	704
Fig. 9	3Z9903A-62	SWITCH ASSEMBLY, polarity reversing: includes cam operating motor Hayden #5034B and switch, Elec Mach #2655.	2655
Fig. 9	2Z9614-160	TRANSFORMER, damping: Franklin Mfg Co. #18589A, Elec Mach #M-8880.	18589A
Fig. 9	2Z9637.59	TRANSFORMER, potential: 230/115 v, 50-133 cyc, Westinghouse type MT, frame 410, style 920562.	920562
Fig. 9	3H4580A/23	VOLTMETER, AC: 0-300 v, Roller Smith #TAS-4205.	TAS-4205
	6L80148	GROUP HARDWARE ASSEMBLY: includes screws, nuts, washers, studs, and bolts, used in Power Unit PU-53/FRC as follows: 1 ea MD-1022 Air cleaner cover wingnut. 1 ea KD-659 Camshaft nut. 1 ea KD-690 Camshaft lockwasher. 2 ea MD-14 Connecting rod, cap bolts, nut and cotter pin. 1 ea MD-168A Counterweight stud and nut. 1 ea KD-686 Crankshaft nut 4 ea MD-100A Cylinder head stud. 2 ea 4-20-52 Crankcase cover attaching bolt (½ x 1½ cap screw). 2 ea 4-20-28 Camcase cover attaching bolts ⅜ x 1½ cap screw. 2 ea 4-20-35 Side bearing plate attaching bolts. 2 ea 4-20-8 Oil pump mtg cap screws. 4 ea MD-529 Cylinder head stud nut. 1 ea MD-868 Nozzle holder adapter stud. 1 ea 4-15-12 Cylinder head stud oil holder nut. 2 ea 4-20-75 Fuel filter cover attaching screws 12-24 x ⅝ MS Fil H.	L-7021-38

Ref symbol	Signal Corps stock No.	Name of part and description		Mfr's part and code No.
		1 ea 4-20-3	Fuel pump bracket mtg screw 5/16 x ¾ cap screw.	
		3 ea 4-20-146	Fuel pump cover screw 10-32 x ⅝ Fil H mach screw.	
		1 ea 4-20-25	Governor mtg bolt ⅜ x 1¼ cap screw.	
		1 ea KD-664	Governor hub nut.	
		1 ea AD-764	Injection pump.	
		4-15-37	Mtg stud and nut.	
		1 ea 4-15-8	Nozzle holder adapter stud nut.	
		2 ea 4-20-75	Oil filter mtg screw 12-24 x ⅝ Fil H mach screw.	
		2 ea. 4-20-1	Oil pump cover plate screw 10-32 x ½ Fil H mach screw.	
		1 ea KD27-1	Cam roller rocker arm pin.	
		1 ea KD-820	Rocker arm shaft nut.	
		2 ea MD 651A	Crankcase to base mtg bolts.	

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