GS-107-AC

INSTRUCTION MANUAL
OPERATION MAINTENANCE OVERHAUL
PARTS LIST

GENERATOR SET

GASOLINE ENGINE DRIVEN, 10KW, 12.5 KVA, 0.8 PF, 60 CYCLES, AIR COOLED, PORTABLE, SELF-CONTAINED SKID & SHIPPING BOX, SHOCK MOUNTED

Spark PLUG - 4 Pc. .025"
Champion H8 .025"
AC C43L .025"
AUTOLITE #226 .025"

ONAN ENG.
mod. JT20-S/967F

(HOL-GAR MODEL GS-107-AC)
(STOCK NO. 6115-000-0006)
SERIAL NOS. 1-1503

Manufactured for

PUBLIC HEALTH SERVICE
Specification PHS-CC-G-202
(27-JULY-1962)

HOL-GAR

MANUFACTURING CORPORATION

Sycamore & Mill Streets
CLIFTON HEIGHTS
Pennsylvania

November 1963

SAFETY NOTICE

Do not attempt to operate or maintain the engine generator set until you have familiarized yourself completely with the equipment by reading the instructions in the manual.

This equipment contains and generates voltages which are dangerous and may be fatal if contacted. Exercise caution and discretion in the operation and maintenance of the equipment. Avoid contacting terminals, binding posts and other exposed connections. Use extra care when control cabinet panel is open.

Stop the engine generator set immediately if there is any doubt in the operating condition and maintenance procedure.

Take no unnecessary chances.

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INTRODUCTION

1. GENERAL

a. This manual contains information for the operation and maintenance of the HOL-GAR Model GS-107-AC, 10 KW, 12.5 KVA, 0.8 PF, Air Cooled, Gasoline Engine Driven, Portable, Self-Contained Skid and Shipping Box, Shock Mounted, Electric Generator Set and a listing of parts.

b. The unit is designed in accordance with Public Health Service Specification PHS-CC-G-202 (27 July 1962).

c. It can provide primary or emergency electric power within its rated capacity (para. 3) for communications, lighting or testing equipment and for other electrically powered equipment.

2. DESCRIPTION

a. Engine Generator Set.

The engine generator set is a self-contained, electric power unit equipped for manual hand crank starting. The unit and its accessoreis are preserved, complete and ready for operation, on the skid-base of the bolted wooden shipping and storage box. Provision for moving and lifting by forklift truck is provided on the skid-base of the shipping and storage box. Access to all components of the generator set is readily made when the outer box is removed. An inspection door in the box provides means of checking condition of preservation of the inter packing barrier and access to one instruction manual.

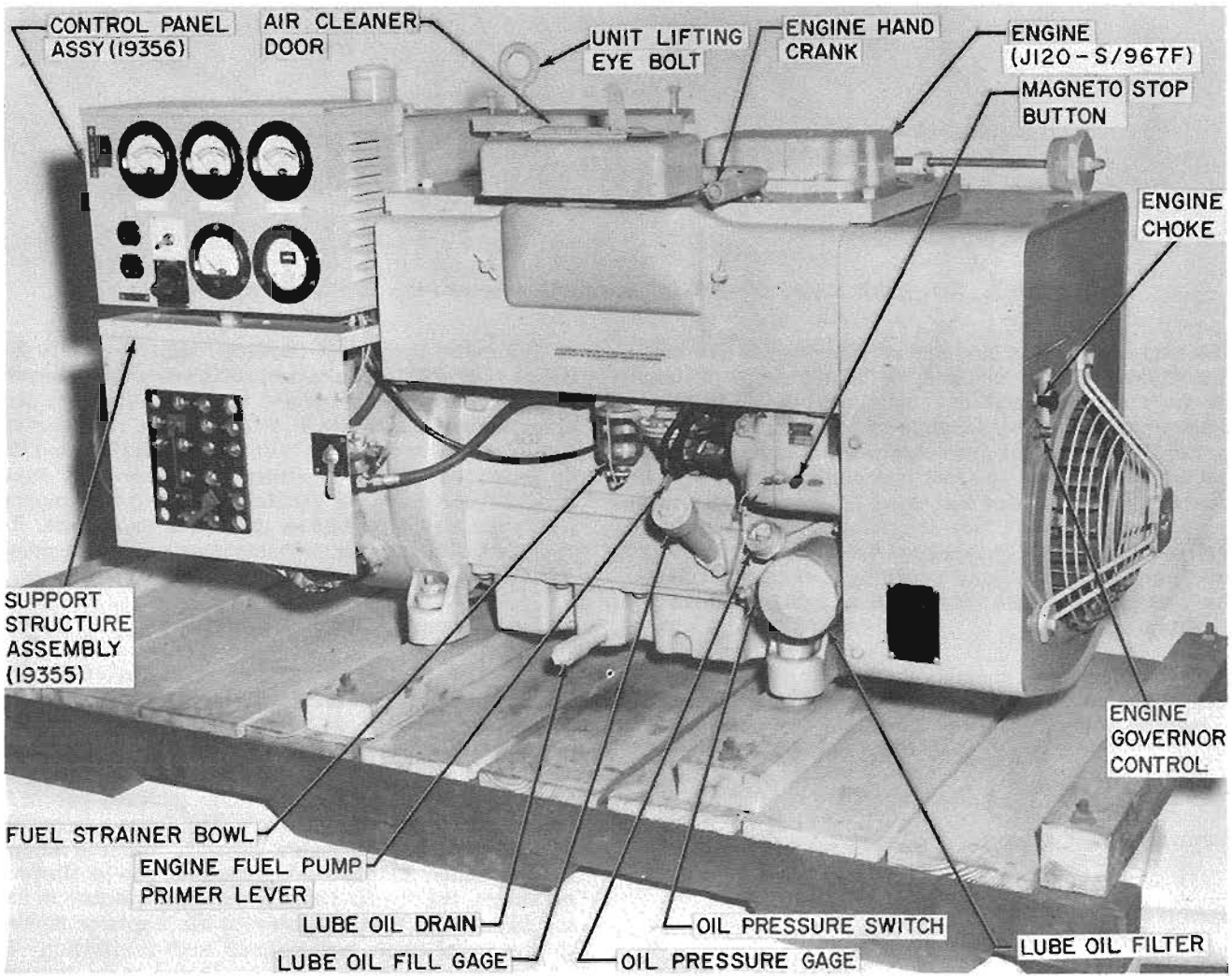


Figure 1. HOL-GAR Model GS-107-AC Engine Generator Set - 3/4 Right Front View

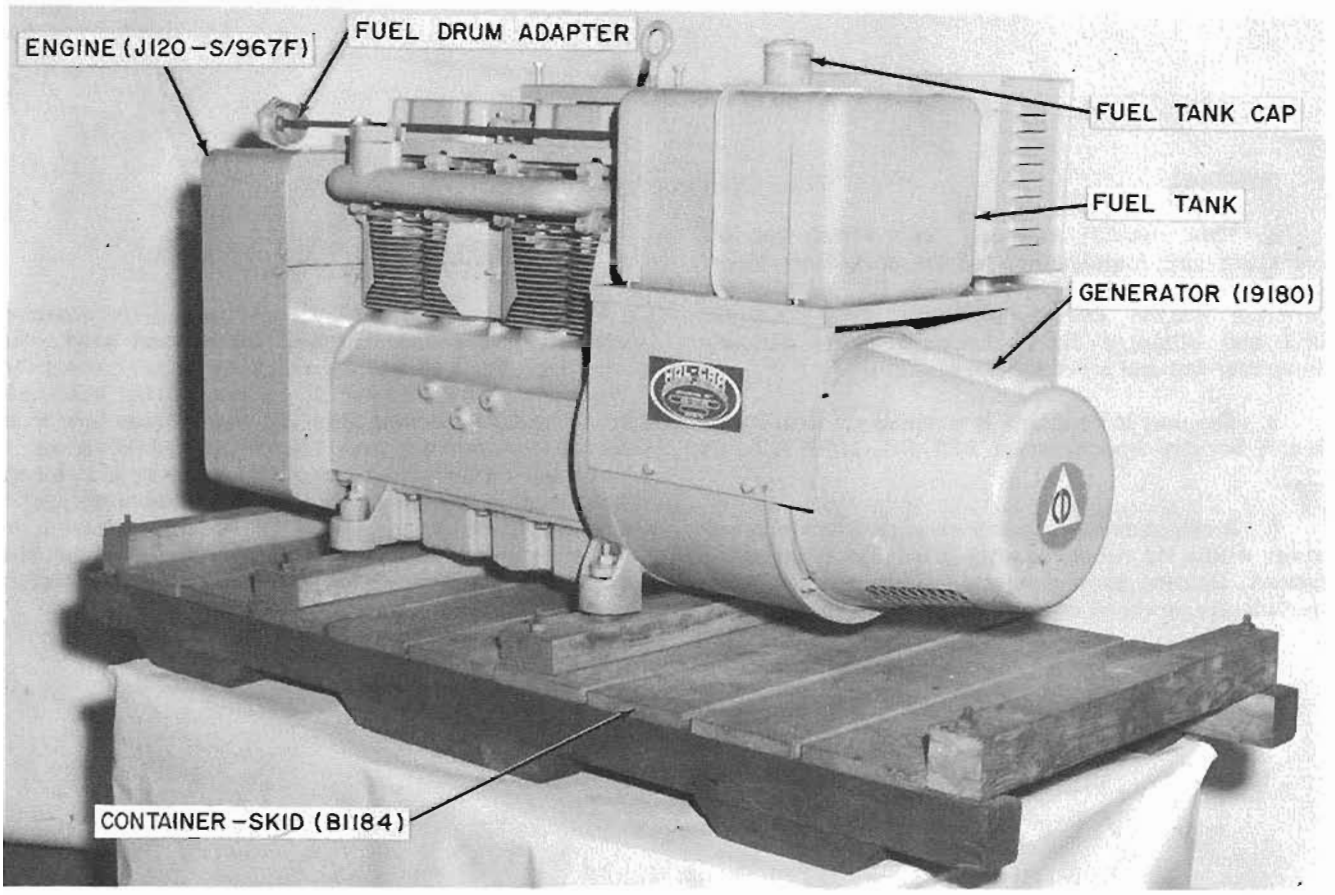


Figure 2. HOL-GAR Model GS-107-AC Engine Generator Set - 3/4 Left Rear View

The engine and generator are rigidly coupled as a unit and suitably shock-mounted on the skid-base portion of the shipping box, for continuous set operation. Operational controls, instruments and external load terminals for the set are contained in the control box and on the engine. The fuel tank inlet is at the top of the tank. An auxiliary fuel valve is provided to allow for a large external fuel supply. A ground terminal for grounding is provided on the unit. The eyebolt assembly on the engine provides means for lifting the unit. Accessories (para. 1. & m.) are provided to facilitate operation.

The complete set consists of the following major component groups which are described in paragraphs b. thru m. below.

Engine	Exhaust	Ignition	Housing
Generator	Cooling	Electrical	Structural
Control	System	System	Accessories
	Fuel System		

b. Engine.

The engine is an ONAN Model J120-S/960F, air-cooled industrial type, which has four cylinders, a 3 - 1/4" bore with a 3 - 5/8 stroke and a displacement of 120 cubic inches. It develops approximately 30.5 HP at 1800 RPM. It is capable of driving the generator to 125 percent of the 3 phase rated output at sea level elevation and 60 degree F. It is of in-line configuration and designed to conform to Specification MIL-E-11275 as amended by the pertinent generator set design specification (para. 3). Military standard high-mortality replacement parts are utilized in the engine. It is equipped with suitable accessories required for proper engine operation and safety. (para 1 & Appendix A).

c. Generator Group.

The HOL-GAR Model 19180 AC Generator is a single bearing, revolving field, 1800 RPM, synchronous type, utilizing a conventional rotating exciter with hermetically sealed, plug-in rheostatic voltage regulator. It has 12 leads reconnectable at the connection board, to provide any of the voltages listed in paragraph 3. The leads are brought out of the frame through a bushing, which is secured to the frame, that has a clamping action to eliminate strain on the leads. Drip proof construction is used throughout the unit. Its integral air impeller secured to the rotor shaft hub insures self-ventilation. The generator rotor is directly connected to the tappered engine crankshaft extension and key fixed in the bore of the rotor shaft. The rotor shaft is hollow to receive

a stud rod which passes through to the engine crankshaft to further secure the rotor to the engine and provide means of securing the exciter armature. The exciter armature fits to the tappered end of the rotor shaft and is secured with a long nut, another long stud which connects to the rotor stud rod and external mounting hardware. The rotor is electrically and mechanically balanced. The brushes, brush rigging, collector ring and commutator are readily accessible by removal of the end cover. The AC generator housing is mounted to the engine block and shockmounted on two feet to the skid-base. Facilities are provided for lifting the complete AC generator.

d. Control Group.

The drip proof control group is mounted at the side of the engine generator set over the generator. This group consists of a control cabinet, engine controls and the connection change board. The control cabinet assembly is shock-mounted to a supporting frame. It contains controls, instruments and components (para. 11) required for the operational inspection, adjustment, safety, regulation and operation of the engine generator set. Power receptacles are also contained on the control panel. The engine controls and instruments required for the operation and operational inspection of the engine are on the engine. The load connection board provides for output change and load connection.

e. Exhaust Group.

The exhaust group components provide muffling and conduction for the engine combustion noises and exhaust gases. It consists of the muffler (part of the engine generator set) and parts integral to the engine (refer Appendix A).

f. Cooling System Group.

This component group is integral to the engine which is equipped with an air impeller and various shrouds that move and direct the flow of air through the engine to maintain it at efficient operating temperatures.

g. Fuel System Group.

This group contains those components that store and deliver fuel to the engine. Fuel may be supplied from the integral fuel tank or from an outside source and either of these two sources may be placed into the fuel system by means of the auxiliary fuel valve. The fuel supply is moved from the sources through the strainer and sediment bowl, by the engine fuel pump, to the carburetor and then to the engine. A primer handle on the engine fuel pump is provided to supply starting fuel to the engine intake manifold.

h. Ignition Group.

This group generates and transmits the ignition spark for firing of the fuel in the engine (refer Appendix A).

i. Electrical System Group.

This component group consists of the wiring, wiring harnesses, cables and other electrical parts such as resistors, capacitors, etc., which are line items of the engine generator set.

j. Housing Group.

This consists of the wood shipping and storage box used to cover and protect the engine generator set. It is bolted to its skid-base.

k. Structural Group.

This group supports and secures the operational components of the generator set. It consists primarily of the skid-base with its support members and hardware.

l. Engine Accessories.

For details of engine accessories refer to Appendix A.

(1) Magneto. The magneto furnishes the electricity to the spark plugs for ignition of the air-fuel mixture in the engine.

(2) Fuel Pump. The fuel pump is attached to the side of the engine. It forces the fuel from the fuel tank through the filter to the carburetor.

(3) Carburetor. The carburetor provides an atomized mixture of fuel and air so that complete burning occurs in the combustion chamber of the engine under various speed and load conditions.

(4) Air Cleaner. One dry foam type cleaner maintains clean air for the carburetor.

(5) Lube Oil Filter. One cartridge type lube oil filter maintains clean lubrication oil.

(6) Fuel Filter. A sediment bowl with screen removes foreign matter from the fuel.

(7) Governor. The governor maintains a constant engine speed as the generator load changes.

(8) Hand Crank. A hand crank for cranking the engine is included with the unit.

(9) Eye Bolt Assembly. Used for lifting unit when installed at rear of engine and for engine when installed at front of engine.

(10) Safety Devices. A low oil pressure switch is provided on the engine to shut it down in the event of low oil pressure.

m. Unit Operational Accessories.

These accessories facilitate operation of the complete unit (para. 3 d & e).

(1) Auxiliary Fuel Hose. This hose is used for connecting an external fuel source to the engine generator set.

(2) Fuel Drum Adapter. This is used to obtain fuel from fuel drums.

(3) Amprobe. This test instrument is a clamp-on type ac volt-ammeter used for checking ac voltage and current.

(4) Line Voltage Indicator. This instrument is used for determining various electrical activity in ac-dc electrical circuits.

(5) Hand Tools. These are provided to aid in maintenance of the unit (para. 3 d).

(6) Ground Rod and Lead. Used to ground unit by driving rod into ground and connecting it to ground terminal with lead.

(7) Fire Extinguisher. This is a 5 lb capacity CO-2 Hand type unit provided with nozzle. It is a government furnished item.

(8) On Equipment Spares. Consist of parts subject to wear. (para. 3 e) and routine maintenance.

3. DATA

a. General.

Manufacturer	HOL-GAR Manufacturing Corporation
Model	GS-107-AC
Stock No.	6115-000-0006
Specification, Design	PHS-CC-G-202 (27 July 62)
Contract	GS-00S-46353
Order	FNW-43774(3)/CD3
Duty	Continuous
Mounting	Shock-Mounted, Wood-Skid Base
Weight (Packed Weight)	1000 lbs.
Length	62 inches
Width	28 inches
Height	37 inches

b. Engine.

Manufacturer	ONAN, Division of Studebaker Corporation
Model	J120-S/967F
Details	Refer Appendix A
Starting	Manual Hand Crank

c. Generator.

Manufacturer	HOL-GAR Manufacturing Corporation
Model	19180
Rated KW, 1 Phase*	10
Rpm	1800
Frequency	60 Cps
Power Factor	0.8
Temperature Rise 2 hrs at 125% load	75°C
Duty	Continuous

Electrical Ratings

Phase	Conn.	Wire	KVA	Volts	Amps	Exc. Volts	Gen. Fd. Current
1	Delta	2	12.5	120	104	34	9.4
1	Delta-Delta	3	12.5	120/240	52	34	9.4
3	WYE	4	18.75	120/208	52	38	10.6
3	WYE	4	18.75	240/416	26	38	10.6
3	Delta	3	18.75	240	45	38	10.6

*Note:- The equivalent 3-phase rated output is 15 KW, 18.75 KVA in a wye or delta connection, only when within the horsepower capability of the engine at low altitudes and moderate temperatures.

d. Unit Operational Accessories (Specify).

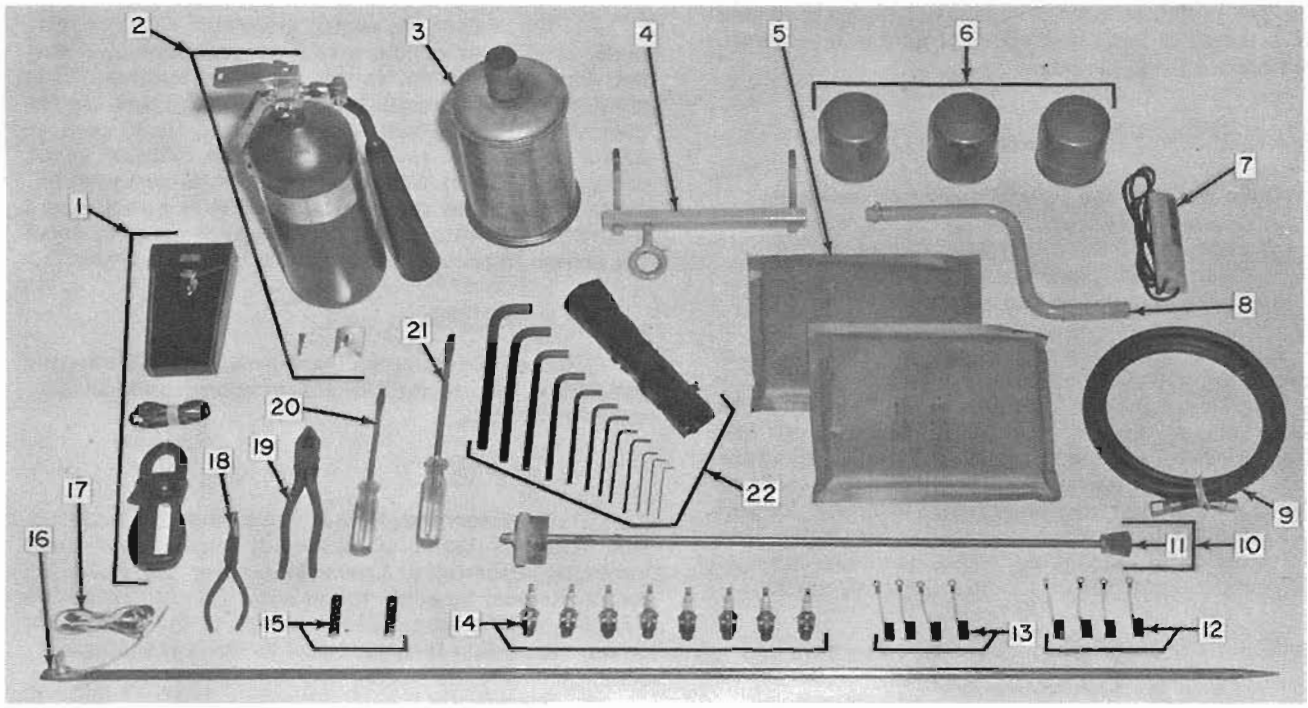
Hose, Auxiliary Fuel (Hol-Gar, 19306)	10 ft.
Adapter (Hol-Gar, 19279)	Fuel Drum
Amprobe (RS-1)	Volt-Ammeter
Indicator, Line Voltage (FSN 6625-284-0264)	AC-DC Voltage & Electrical Activity
Pliers (1 each)	Linemans / Long Nose
Screw drivers (1 each)	6 inch / 8 inch
Wrenches (1 set)	Allen
Rod (Hol-Gar, H-14053-2)	Ground (58"lg)
Lead (Hol-Gar, 19390)	Ground (72"lg)
Fire Extinguisher (G.F.E. 4210-595-1777)	CO-2, 5 lb capacity

e. On Equipment Spares (Specify).

Brush, AC	4
Brush, Exciter	4
Fuse	2
Element, Oil Filter	3
Plugs, Spark	8

f. Operating Supplies.

Fuel Tank Capacity (approx.)	5.3 gals.
Fuel	Regular Gasoline
Fuel Consumption (approx. at full load)	2-1/2 gals./hr. / 20 gals./8 hr. period
Lubrication Oil Capacity	6 qts.
Lubrication Oil Consumption (as req'd)	1 pt. to 1 qt./8 hr. period



1 - Amprobe Volt-Ammeter (1) (Amprobe RS-1)
2 - Fire Extinguisher (1) (G. F. E. 4210-595-1777)
3 - Muffler (1) (#T-8800)
4 - Eye Bolt Assembly
5 - Manuals (2) (GS-107-AC)
6 - Oil Filter Elements (3)
7 - Line Voltage Indicator (1) (FSN 6625-284-0264)
8 - Engine Hand Crank
9 - Auxiliary Fuel Hose (1) (19306)
10 - Fuel Drum Adapter (1) (19279)
11 - Adapter Fuel Strainer (1) (#900)
12 - Brush (4) (18773)
13 - Brush (4) (18383)
14 - Spark Plug (8) (Champion, H-8 or Equal)
15 - Fuse (2)
16 - Ground Rod (1) (H-14053-2)
17 - Ground Rod Lead (1) (19390)
18 - Long Nose Plier
19 - Line Mans Plier
20 - Screwdriver, 6" x 5/16" Tip
21 - Screwdriver, 8" x 3/8" Tip
22 - Wrench Set (Allen), 1/16, 5/64, 3/32, 1/8, 5/32, 3/16, 7/32, 1/4, 5/16, 3/8, 7/16, 1/2.

Figure 3. Unit Operational Accessories And On Equipment Spares

INSTALLATION

4. PACKAGING

a. The unit and accessory parts are preserved and packed within a moisture barrier envelope, and covered with the reuseable wooden shipping and storage box which is secured to the wood skid-base with bolts to allow for frequent removal and installation. The moisture barrier envelope contains desiccant and a humidity indicator which is visible through the inspection door in the box.

Note

Open the interior moisture barrier envelope only when unit is to be used, or when in storage if humidity indicator shows excess moisture, then open for represervation and sealing as condition may warrant.

b. It is advisable to unpack the equipment as close to the installation site as practicable to minimize any possible handling damage. When unpacking the equipment, be sure to remove all securing straps, wires, blocks, padding and protective tape. Be aware of and follow instructions on any special packing or caution notices that may be attached to the set. Inspect the equipment for damage; especially take extra care in inspection if packaging shows shipping damage. Use packing list to check for missing components.

CAUTION

Do not operate controls or attempt to start the engine generator set until you have become familiar with the controls and serviced the set for operation.

5. MOVING

a. It is recommended that a crane or forklift truck capable of supporting the engine generator set be used when lifting or moving the set.

b. When a crane is utilized, use cable or heavy rope slings evenly spaced under the skid-base to balance the weight. Use a spreader to keep slings away from the box or unit. Attach guide ropes to the unit to keep it steady while lifting or moving. If using the eyebolt assembly be sure it is installed at rear of engine.

c. When using a forklift truck, be sure that the lift arms are spaced to support equally the weight of the engine generator set.

6. SITE CONSIDERATIONS

Consider the following when selecting and preparing the installation site for the engine generator set.

a. Proximity of Load.

To reduce transmission line voltage losses place the engine generator set as close as possible to the load.

b. Shelter.

To protect the engine generator set from climatic and local conditions, it is recommended that the unit be placed in an adequate shelter. This shelter must be ventilated to admit sufficient air for engine combustion and to allow heated air to escape. Also, be sure to provide outlets for exhaust gases using pipe, metal tubing or other suitable material. Make the exhaust extensions as short and as straight as practicable allowing it to slope down and away from the engine to prevent accumulation of condensate.

c. Clearances.

Provide working clearances around the engine generator set, to facilitate operational and maintenance activities.

d. Fuel Supply.

To insure an adequate fuel supply, install a fuel tank or tanks of sufficient capacity to meet operating conditions. Consider placing the tanks (55 gallon drums) as close to the engine generator set as practicable. Be sure that the bottom of the tank is not lower than 8 feet from the inlet to the fuel pump.

e. Foundation.

Check firmness of ground to see that it will support the unit. See that ground will have proper drainage to allow area around unit to be as dry as possible. If the engine generator set is installed in an existing shelter, be sure that the bearing surface can support its weight and operational vibrations. If necessary, secure skid to bearing surface.

Note

A typical installation of a generator set is shown in Figure 5. It does not show the GS-107-AC unit which is ready for operation on its integral skid-base.

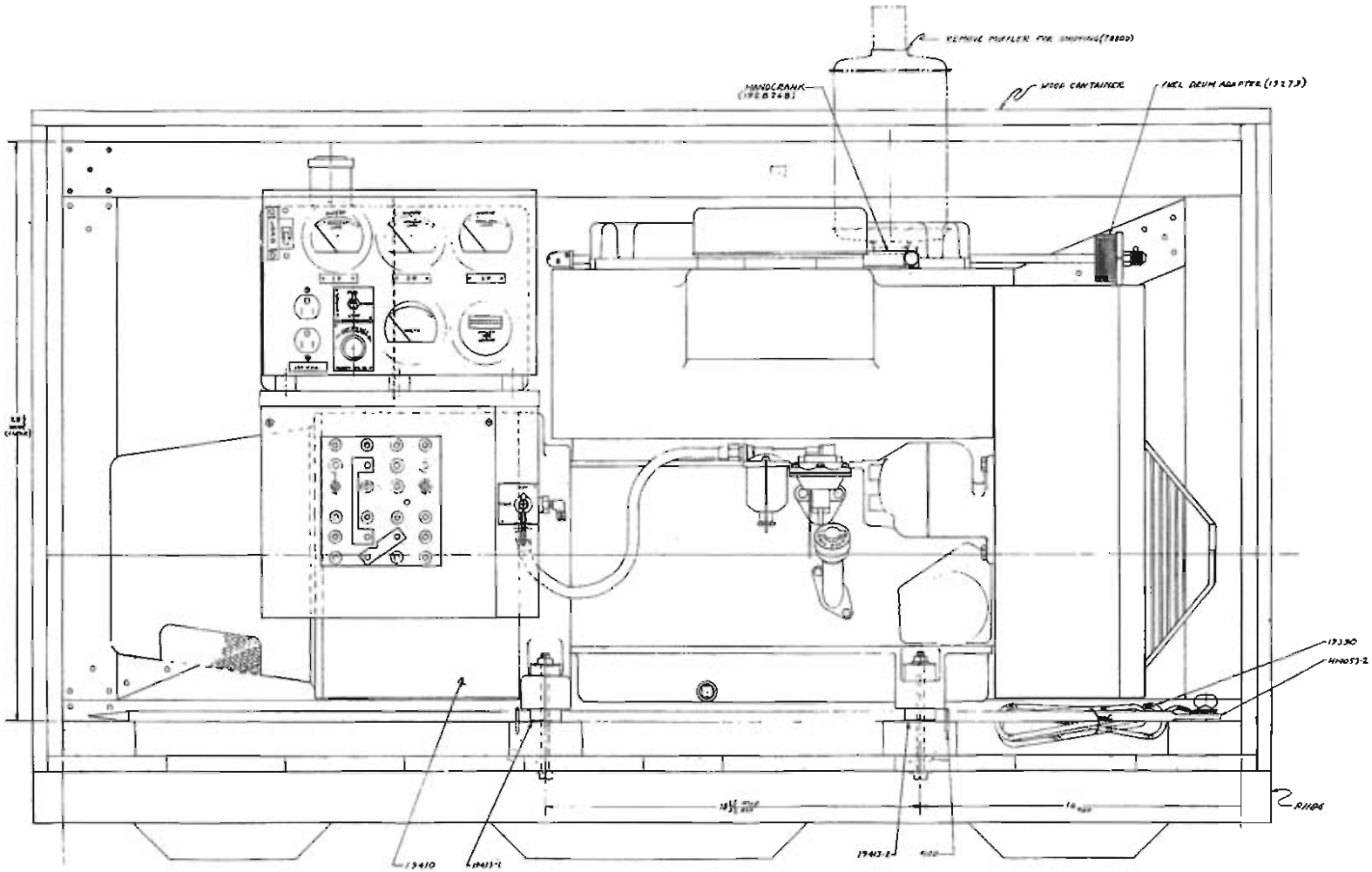
7. MOUNTING

It is recommended that the engine generator set be level in both planes of the skid-base and that the weight of the complete unit be distributed equally on the skid base.

8. ELECTRICAL CONNECTIONS

a. General.

All internal connections, with the output voltage change connection plates connected and the unit



B1184 - Container - Skid Assy (w/mtg hrd)
H14053-2 - Ground Rod
T8800 - Muffler
100 - Staple
192B268 - Hand Crank
OB - Clip, Crane Mtg.
6-32 x 3/8 - Screw, Rd-Hd
6-32 - Nut, Hex, Cap-Ext-Lockwasher

19279 - Fuel Drum Adapter
225S - Clp, Adapter Mtg
6-32 x 3/8 - Screw, Rd - Hd
6-32 - Nut, Cap-Ext-Lockwasher
19390 - Ground Rod Lead
19410 - Engine - Generator Set Sub-Assy
19413 - Shock Mount Kit (1)
19413-1 - Shock Mount Assy, Generator (2)
19413-2 - Shock Mount Assy, Engine (2)

Figure 4. HOL-GAR Model GS-107-AC Engine Generator Set with Container-Right Side

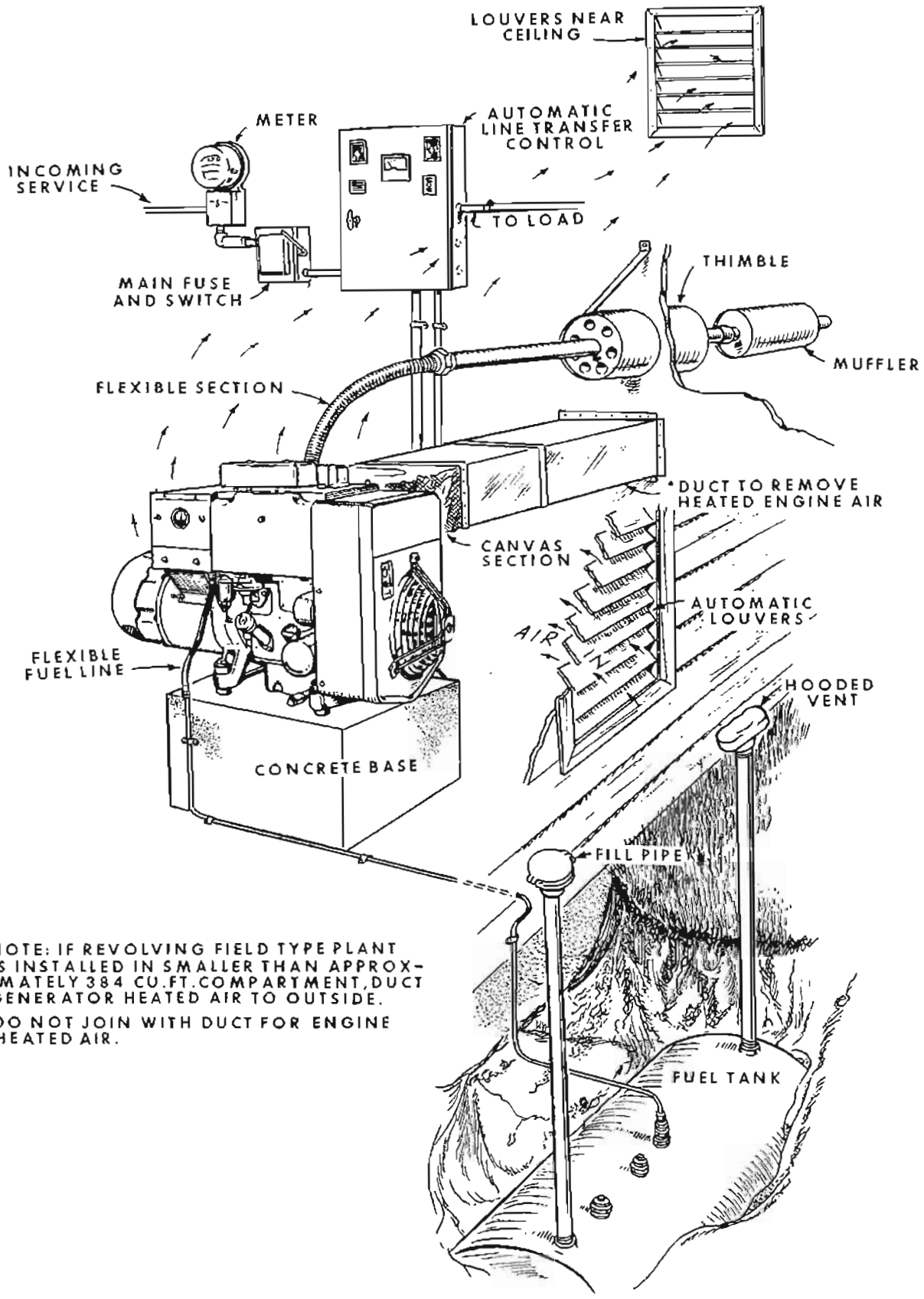


Figure 5. A Typical Installation of a Generator Set

tagged to specified 120/208 3 phase 4 wire operation, are made at the factory. Always check the change plates to see that they are properly connected for intended use and that change plates are secure. Refer to connection diagram when making phase and voltage change.

b. Output Voltage Change Plates.

Output voltage changes of the generator set are made by installing the three connection plates provided with the unit. These are mounted in place on the connection board or stored on the connection board cover. Refer to the connection board diagram and use the following procedure to make change.

(1) Select the plate or plates for the desired output and secure to the connection board as indicated on the diagram.

(2) Make load connections at the load terminals as indicated on the connection diagram.

(3) Store plate or plates not used on the studs of the connection board cover. Replace cover.

c. Power Transmission Cables.

Use the following minimum cable sizes for specified voltage ratings. It is recommended that larger cables or wire sizes be used if load cables are larger than 25 feet.

Voltage	Phase	Wire	Current (amps)	Cable Size (AWG)
120	1	2	104	0
120/240	1	3	52	4
120/208	3	4	52	4
240/416	3	4	26	8
240	3	3	45	4

d. Power Output Connections.

All output power connections are made at the connection change board terminal studs and load terminals (refer to Figure 6). When making connections be sure to check connection board diagram for proper voltage connections. Be sure that the load lines from the engine generator set mate (or phase in) with respective load terminals at the load distribution point. Balance load for generator set as equally as practical between circuits that are being utilized.

e. Ground Connection.

Use ground rod and lead. Install the ground lead (#6AWG bare copper wire) from the ground terminal on the control box support to earth driven ground rod. Do not use fuel lines for grounding purposes.

9. MECHANICAL CONNECTIONS

a. Fuel Line.

The generator set is supplied with one auxiliary fuel hose and fuel drum adapter. The hose is used to connect the engine generator set to an external fuel source when used. The hose is connected at the auxiliary fuel inlet port which has a 1/2 inch SAE 20 flared fitting for the hose connection. The fuel drum adapter is placed in and screwed in the fuel drum opening to make a fuel hose connection point to the external supply.

b. Muffler & Exhaust.

Install muffler on engine at exhaust manifold. If unit is used in a shelter connect a suitable exhaust tube from unit to exterior of the shelter, positioning muffler at any suitable place in the exhaust line preferably outside. (Refer to Figs. 5 and 7)

c. Air Ducts.

If unit is used in a shelter and it is practicable, construct an air duct from the engine to remove the heated engine air from the shelter (refer to Fig. 5).

10. DELIVERY SERVICES

a. General.

The engine generator set equipment is inspected for completeness and adjusted to specific operational requirements prior to shipment. Note that after operational inspection is completed at the factory, the fuel and lubrication oil are drained from the respective systems. Perform the following services and any special services given on attached tags or notices, before placing the engine generator set into operation.

b. Visual.

Check the engine generator set equipment for completeness and damage or loose parts. Correct any deficiencies.

c. Lubrication.

See that the unit is lubricated (refer to Appendix A). Using the engine dipstick, check the level of the lubrication oil. There may be an indication of oil because of drainage from the engine, filters and oil lines. Drain this residual oil and discard it. Fill the crankcase to the full mark on the dipstick. The capacity is 12 pints. Check for and correct any leaks.

d. Fuel.

Fill internal fuel tank with clean gasoline. Be sure that fuel is clean and free of moisture.

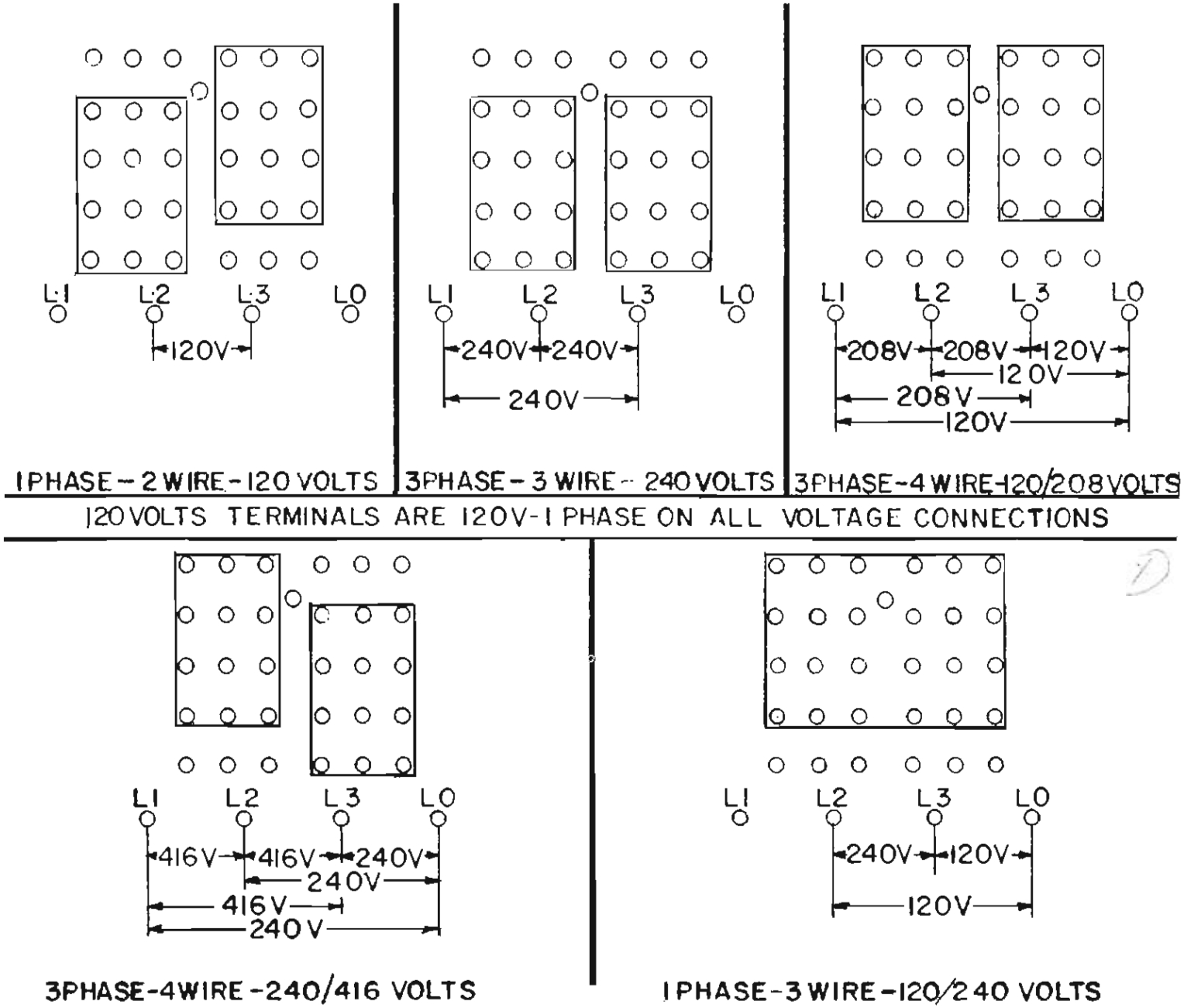


Figure 6. Connection Diagram (19227)

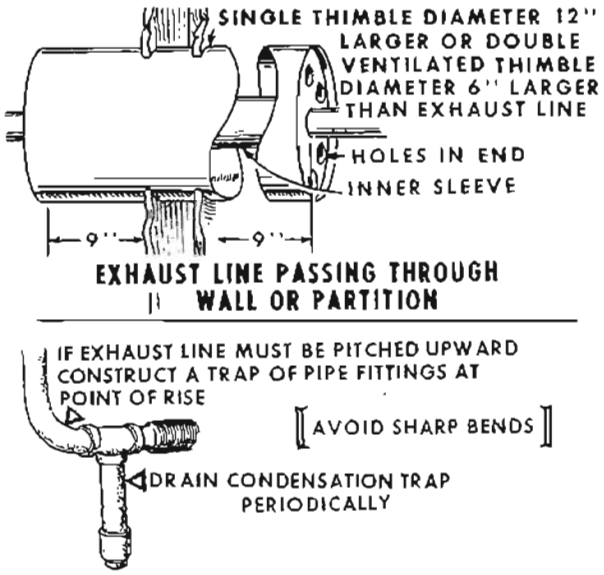


Figure 7. Typical Exhaust Line Connections

e. Air Cleaner.

See that openings are clear. Saturate foam type element with SAE 20W motor oil and squeeze as dry as possible.

f. Controls.

Check all controls and instruments to see that they are present and are in normal off position (para. 11).

g. Electrical Connections.

Check all electrical connections (para. 8).

h. Mechanical Connections.

Check all mechanical connections (para. 9).

i. Operational Check.

Start the engine generator set and ascertain that it is operating properly (paras. 11 to 13).

OPERATION

11. CONTROL COMPONENTS

The controls, instruments and components utilized in the operation, regulation and safety of the engine generator set are listed below with their function (Fig. 8).

Note

Do not operate the controls or start the engine generator set until you have become familiar with the controls and serviced the unit for operation.

ITEM	FUNCTION
A-C Ammeters (3) (Fig. 8)	Indicates per cent rated load and output line current. Meters are indicated as Phase 1, Phase 2 and Phase 3. Meter has 0-50 scale, color coded for single phase and 3 phase. Single phase: green, 0-17.3 (100%); yellow, 17.3-21.6 (125%); red, 21.6-50 (above 125%). Three phase: green, 0-26 (100%); yellow, 26-32.5 (125%); red, 32.5-50 (above 125%). To obtain line current use multiplier in following tabulation.
AC-Voltmeter (Fig. 8)	Indicates output voltage. Has 0-150 scale. To obtain voltage between lines use multiplier in following tabulation.

MULTIPLIERS FOR AMMETERS AND VOLTMETER

CONNECTION	AMMETER MULTIPLIER	VOLTMETER MULTIPLIER
120V-1Ø-2 Wire	*6.00	1.00
120/240 V-1Ø-3 Wire	*3.00	2.00
120/208 V-3Ø-4 Wire Y	2.00	1.73
240/416 V-3Ø-4 Wire Y	1.00	3.47
240 V-3Ø-3 Wire Δ	1.73	2.00

*NOTE:- For these two connections disregard ammeter in Phase 2.

Frequency Meter (Fig. 8)	Indicates frequency of ac output in cps. Normal reading is 60 cycles. Calibrated to read from 58 to 62 cycles.

ITEM	FUNCTION
Load Switch & Circuit Breaker (Fig. 8) (ON-LOAD-OFF)	Used to apply or remove load. In the event of overload above 125% of rated load or short circuit, the circuit breaker trips and stops ac generator from producing power. It must be reset manually; however reset only after load is checked and adjusted or condition corrected to prevent tripping.
Adjust Volts Knob (Fig. 8)	To adjust voltage output of engine generator set. It controls the voltage regulator by varying the resistance of the rheostat.
Receptacles - 120V A.C. (Duplex) (Fig. 8)	To accommodate external plug-in type utility lines. Two grounding type (3-pole).
Fuse (Fig. 8)	To protect 120V A.C. receptacle circuit. Located on connection board.
Voltage Change Plates (3) (Fig. 8)	For changing unit over to one of the rated voltages, phase and current operations.
Engine-Run-Start-Stop-Switch (Fig. 8)	To open and close magneto circuit for run-start-stop of unit. Start is center position; run-up; stop-down.
Fuel Valve Off-Tank-Aux (Fig. 8)	Used to connect the external or internal fuel supply to the engine and to shut fuel supply completely.
Ground Terminal Stud (Fig. 8)	On control panel support to ground complete unit to rod with lead.
Voltage Regulator (Fig. 14 & 15)	Controls electrical output of main generator so that load variations caused by load changes are stabilized.
Engine Hand Crank (Fig. 1)	Used to manually start engine.
Hand Primer (Fig. 1)	At engine fuel pump. Used to pump fuel into engine for initial starting.
Choke (Fig. 1)	Used to reduce amount of air entering carburetor. Pulling choke out reduces air in fuel-air mixture. Pushing in provides a balanced fuel-air mixture for normal operation. Adjust as may be required by operating conditions.
Engine Governor Control (Fig. 1)	Controls engine speed. See engine operator's manual for details.
Lube Oil Pressure Gauge (Fig. 1)	Indicate lube oil pressure 0-15-30-45-60 scale. Oil pressure should be at least 20 psi, and average 30-35 psi after stabilization of engine heat and load. Pressure may be higher at initial starting and warming.
Low Oil Pressure Switch (Fig. 1)	To ground the magneto and stop engine if lubricating oil drops too low indicating lube system trouble.
Lube Oil Dip Gauge (Fig. 1)	Indicates level of lube oil in crankcase. Has full and low marks.
Magneto Stop Button (Fig. 1)	Use to ground magneto and stop engine.
Air Cleaner Door (Fig. 1)	Open in extreme hot weather, when starting engine.

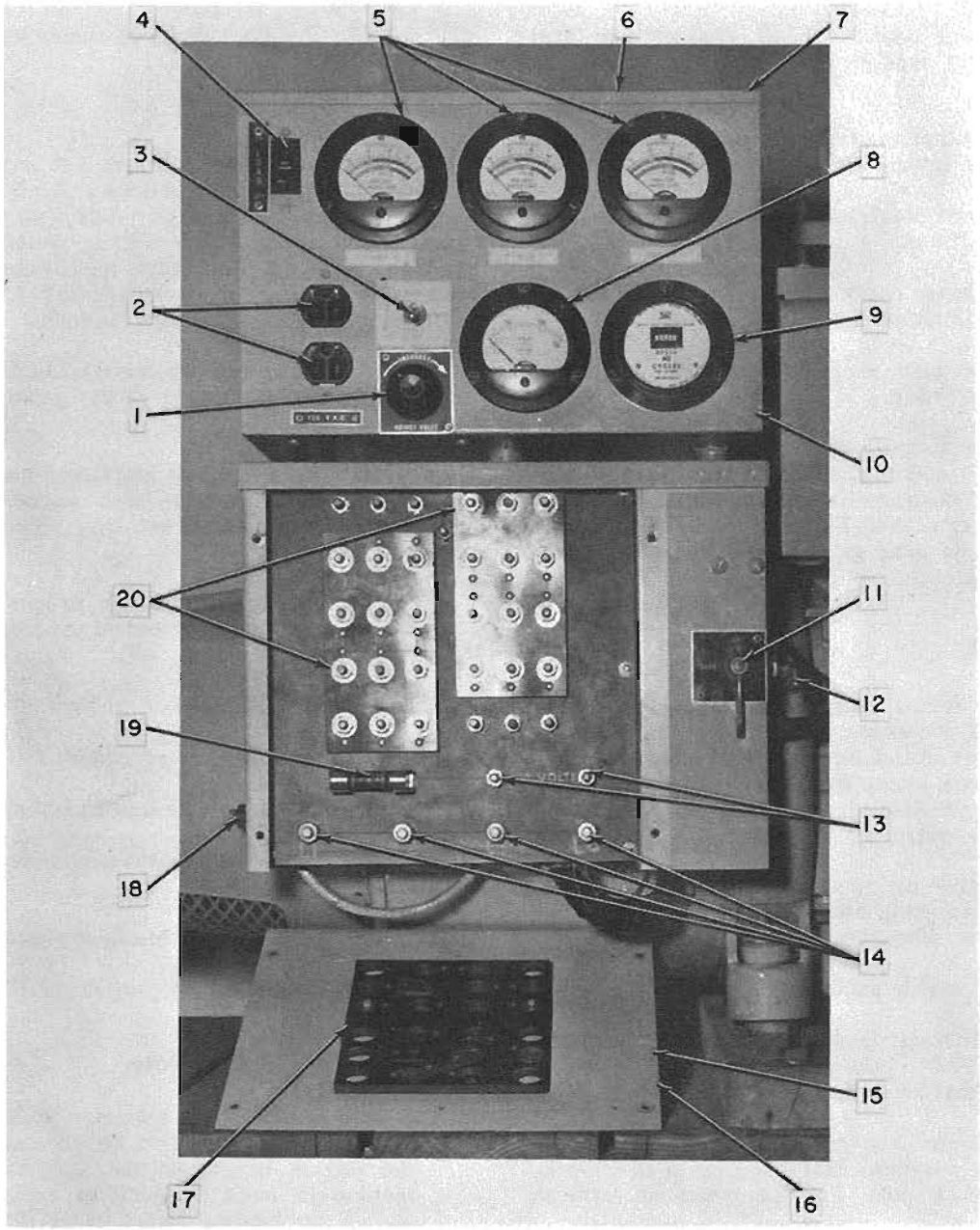
12. OPERATION

The engine generator set normally operates automatically in that the engine speed is governed and controlled to compensate and correct for frequency and load variations caused by load changes.

13. STARTING-STOPPING

a. Preliminary Action.

Perform the following checks and adjustments to make sure that the engine generator set is ready for use.



1 - Adjust Volts Knob
2 - Duplex Receptacle (120v)
3 - Engine Run-Start-Stop Switch
4 - Load Switch - Circuit Breaker
5 - AC-Ammeters (Phase 1 - 2 - 3)
6 - Multiplier Plate (Top) (19230)
7 - Wiring - Schematic Diagram Plate (Inside Top) (19235)
8 - AC - Voltmeter
9 - Frequency Meter
10 - Control Panel Assy (19356)
11 - Fuel Valve Off-Tank-Aux
12 - Auxiliary Fuel Port
13 - 120-Volt Terminals
14 - Load Terminals (L1, L2, L3, L0)
15 - Change Board Diagram Plate (Behind Cover)
16 - Change Board Cover (19226)
10-32 x 3/8-Screw, RD-HD, Cap-Ext-Lock-washer
17 - Patch Panel (1Ø - 3 wire - 120/240 v only) (19358)
1/4 - 20 - Nut, Hex, Brass
1/4 - Int - Lockwasher, Phos - Brz.
18 - Ground Stud
19 - Fuse (15 amp)
20 - Patch Panels (2) (19348)

Figure 8. HOL-GAR Model GS-107-AC Generator Set Controls & Instruments

(1) Ascertain that the unit is serviced for operation (para. 10).

(2) Check lubrication oil level and fuel level in internal fuel tank or external supply. Fill as required.

(3) See that auxiliary fuel valve is in position, as required, for internal or auxiliary fuel supply.

(4) Check electrical (para. 8) and mechanical (para. 9) connections.

(5) Always check change board for proper connections of intended use.

(6) See that shelter (if used) ventilation facilities are in order.

(7) Check outgoing load cables and external load circuits to make sure that no short circuit possibility exists. Be sure load is not connected before starting generator set. External main load switch should be off. Be sure generator set load switch is in OFF position.

b. Starting.

During initial start heavy exhaust smoking from burnout of preservative oils is normal. If engine fails to start at initial start preservative oils may have fouled spark plugs. If this occurs remove spark plugs, clean in gasoline, dry and replace. Use following procedure to start.

(1) Prime carburetor by working fuel pump priming lever at pump about 15 strokes and return inward (down and disengaged).

(2) Set engine switch in START position.

(3) Set hand choke as required by local temperature. Pull choke out for richer mixture, push in for normal mixture.

(4) Engage hand crank to engine with handle at 7:00 o'clock position. Pull crank up to 12 o'clock, with sharp steady pull. Remove crank as soon as engine starts.

(5) Place engine switch in RUN position.

(6) Check oil pressure, it should be at least 20 psi. If pressure doesn't build up, remedy cause.

(7) Readjust choke as engine warms.

c. Load Application.

If practicable, allow unit to warm thoroughly before connecting electrical load. Apply load in steps, when practical, instead of a full load at once. Most installations use a line switch, which is closed to connect the load. For initial operation of a new unit, try to apply quarter loads (1/4-1/2-3/4-Full) at 30 minute intervals to stabilize the unit.

(1) Place load switch (circuit breaker) in ON position to provide power at the generator set load terminals.

(2) After unit is stabilized and load is ascertained, check voltage and adjust with voltage adjustment knob. Once set this should require infrequent attention.

(3) Check meters for proper readings. If overload exists, stop unit and adjust load.

d. Stopping.

Use the following procedure.

(1) Disconnect as much load as possible.

(2) Place load switch (circuit breaker) in OFF position.

(3) Allow engine to idle a short time.

(4) Place engine switch in STOP position.

Note

A stop button is also located at the engine magneto. This can also be pressed against the engine to ground the magneto. If this method is used be sure to return engine switch on control panel to STOP position.

(5) Place fuel valve in OFF position.

MAINTENANCE

14. GENERAL MAINTENANCE

a. Procedure.

Set up a maintenance procedure for the engine generator set based on the type of operation (i.e. continuous, standby or intermittent). The main items to remember are cleanness, lubrication, proper adjustments, leaks, loose parts and improper operation indicated by observation of instruments and control response. If inspections reveal erratic operation that may increase and cause complete failure of the unit, check, order and replace indicated faulty parts before actual breakdown occurs. Use the following minimum servicing and adjustment tabulation as a guide to establish a maintenance procedure. Refer also the engine section (Appendix A) for detail schedules for the engine.

INTERVAL (Hrs)	SERVICE
Daily	Before Operation:- Visually inspect to see that controls and instruments are in order and that there are no loose connections. Check fuel lines for secure fits. See that there are no leaks. Check fuel supply and replenish as required. Inspect for secure engine and generator mountings. See that engine exhaust and ventilation openings are in order. See that openings in ac generator cover are free to allow flow of air. Check engine lube oil, add oil as required (refer Appendix A). During Operation:- See that instruments are functioning properly with normal readings. Check fuel line joints for leaks, correct any. Be alert to unusual noises from the engine, and from the generator that may indicate rubbing or excessive brush sparking. After Operation:- Check for loose parts and secure. Check fuel lines and supply for proper stowage. See that fuel valve is off.
8	Check lubricating oil allowing short interval to drain from filter and lines. Add oil as required. Checking oil before and after operation provides a basis for determining rate of oil consumption and possible trouble in engine operation.
50	Tighten head bolts and adjust valve clearance on a new or overhauled engine. (refer Appendix A).
100	Clean air filter. Clean and set spark plug gap. Change lubricating oil. Clean crankcase breather.
250	Check valve tappet clearance and reset as necessary. Clean and adjust carburetor. Adjust and dress breaker points. Adjust timing. Remove end cover of generator to check condition of brushes, slip rings and commutator. Remove excessive dust and dirt. Be careful not to disturb brush settings if they appear in good shape. See that mounting hardware is secure.
500	Replace spark plugs. Clean combustion chamber and manifold. Adjust governor and throttle linkage. Change lubricating oil filter.
750	Clean slip rings and commutator with a lint free dry cloth. Use a fine sandpaper (#00) to smooth or clean heavily coated rings or commutator; do not use emery or conductive abrasive cloth. Check and replace brushes, if required. See that mounting hardware is secure.
1500	Check magneto. Replace breaker points and condenser. Replace magneto if worn beyond economical repair.
As Required	Clean fuel system. Include draining and flushing tank, sediment bowl, fuel lines and fuel pump. Operating conditions and condition of fuel may increase or decrease this interval. Inspection of sediment bowl provides an indication of fuel condition.

b. Tools.

Only standard mechanics and electricians tools are required for the maintenance of the engine generator set.

(1) Operator's. Refer to paragraph 3 d. for tools provided with unit.

(2) Instruments. Refer to paragraph 3 d., 11 and Appendix B for instruments utilized in the operation and maintenance of the unit.

(3) Engine Maintenance Tools. Refer to engine section, Appendix A.

c. Painting.

For appearance and protection, clean and retouch scratched or work painted surfaces.

d. Removal Procedures.

No special techniques are required for the removal of components of the engine generator set. However, special notice for parts requiring peculiar procedures are contained within the particular component group. When removing a component, take into consideration the position of the component, its size for any required blocking, electrical connections and mechanical connections. Do not use undue force in freeing any component.

15. LUBRICATION

a. Engine.

The engine lubrication system has a capacity of 6 quarts. Change crankcase oil every 100 hours with oil at operating temperature to allow for complete drainage. Change lubricating oil filter every 500 hours. For complete details refer to engine section (Appendix A).

b. Generator Group.

No lubrication is required as a sealed lubricated bearing is used. During inspection of generator, examine area around bearing for possible lubricate seepage that may indicate a broken bearing seal and foretell a possible breakdown of the bearing. If this occurs, replace bearing.

c. Linkage Friction Points.

Check all moving linkage friction points and control cables for free movement. Lubricate as may be required with powdered graphite or light machine or engine oil.

d. Housing & Structural Group.

Place light film of oil or light grease on shipping box mounting bolts and shock mount securing bolts to prevent rust and corrosion.

16. ENGINE GROUP

a. This engine is designed to accommodate military standard interchangeable high mortality service parts. Replacements for these parts should conform to applicable military standards. When working on the engine, use standard automotive repair procedures and practices. For lifting engine alone place eyebolt assembly at front of engine.

b. Refer to engine section for service and maintenance information (Appendix A).

17. GENERATOR GROUP

a. Mounting.

Check mounting of generator periodically to see that it is secure.

Note

Perform the following inspection and maintenance (Pars. b. thru e.) every 250 hours of operation and as indicated. If unit has been performing properly, limit service to careful cleaning by blowing out loose dirt and particles, so that brush rigging and brushes are not disturbed.

b. Output Current and Voltage.

Check the output current and voltage with external meters. If current or voltage is not proper, inspect brushes for signs of wear, proper spring pressure and freedom of action in holder. Examine brush holders and see if they are clean.

c. Slip Rings (=) & Commutator (///).

Surface condition of rings and commutator should appear smooth and clean. Scored, rough or blackened surfaces may be caused by grit or abrasive in brushes, accumulations of dirt around unit and presence of oil or grease. Use a dry lint free textured cloth to remove grease scum accumulations. Moderately rough or scored surfaces can be smoothed by using a fine sandpaper (#00). (Do not use conductive abrasives.) Blow out dirt and grit with clean compressed air.

d. Brush Springs.

A negator type spring is used, which has a rated pressure of approximately 5-6 lbs/sq. inch. The spring pressure should present no problem. Check spring for even set against brush and fit in slot. See that rivet securing spring to its bracket is secure.

e. Brushes.

Check brushes for cracks, chips and uneven wear. At 750 hours, check length of brushes. The collector ring brush has: a total effective length of 3/4 inch from lower edge of brush level at lead end to center of arc; a minimum limit of 3/8 inch from lower edge of brush bevel at lead end to center of arc. The commutator brush has: a total effective length of 11/16 inch from lower edge of brush bevel at lead end to top of bevel at face; a minimum limit of 3/8 inch from lower edge of brush bevel at lead end to top bevel at face. Replace brushes that are worn to the minimum limits or to a point where the lead is exposed on the brush face.

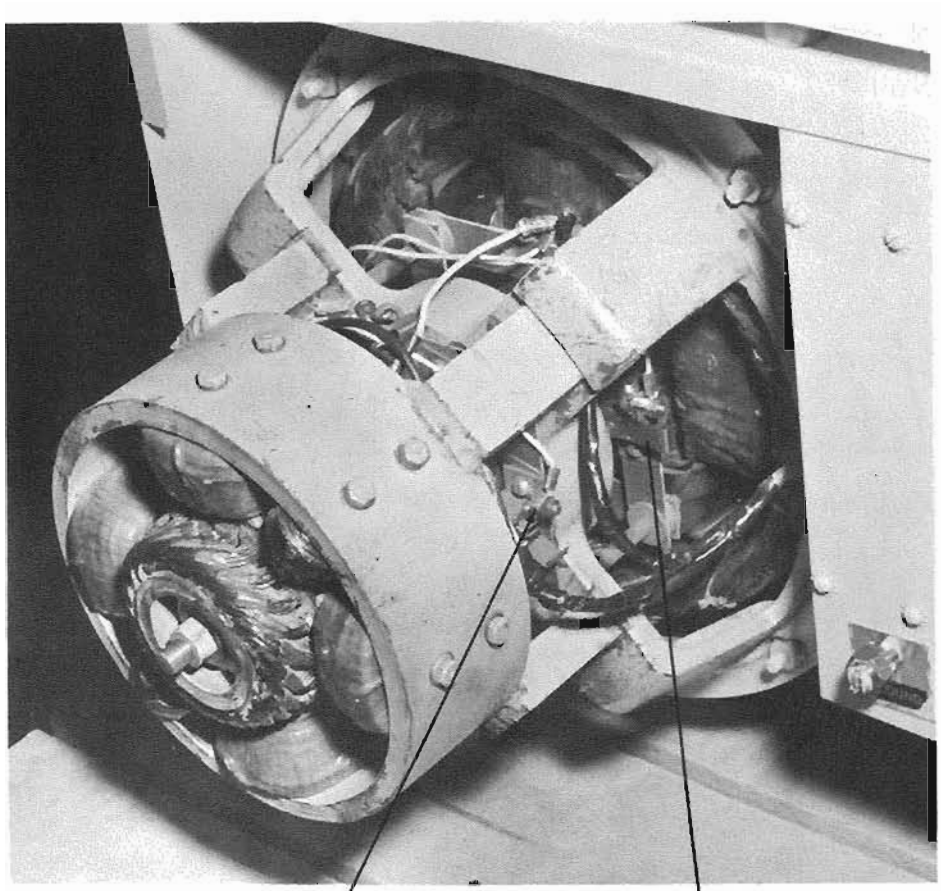
When replacing brushes, it is important that they are carefully fitted to the contact surface. To fit brushes, slip a piece of grade 00 flint paper between contact surface with flint surface facing the brush, being sure that the paper is the same width as the contact surface. Move the paper in one direction only, lift and return until the proper brush surface is obtained. Repeat process until all brushes have been seated. New brushes that have not been seated may spark. If sparking occurs, operate the generator set at a light load to wear brushes. Sparking should diminish as brush acquires full surface contact.

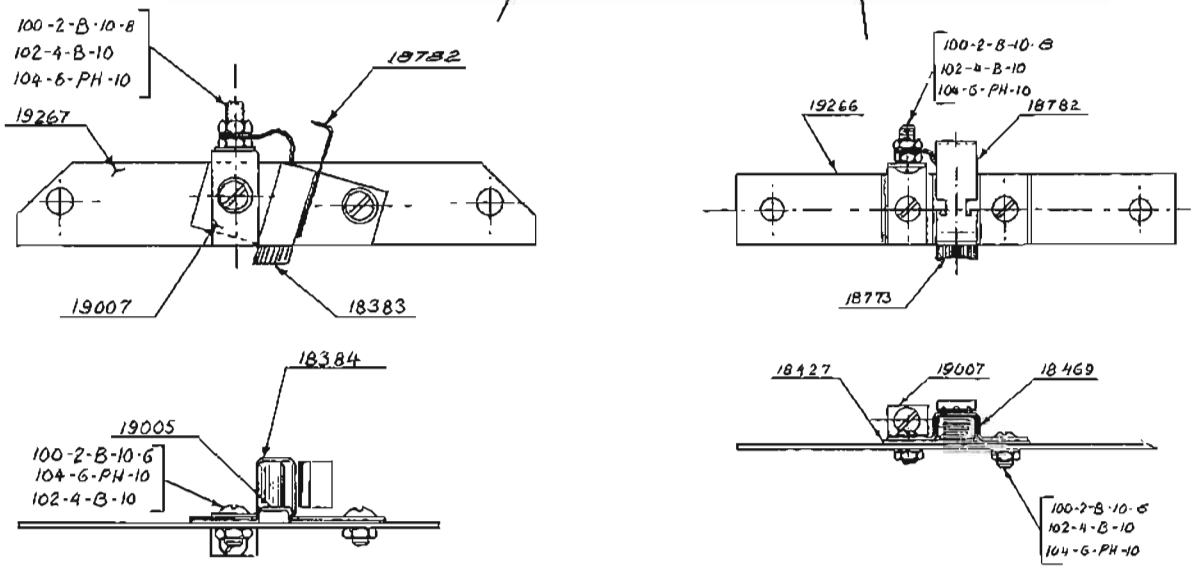
f. Removal.

The ac generator is disassembled into its parts and subassemblies as it is removed from the unit.

(1) Release the end cover by removing the securing hardware. This exposes the bearing bracket assembly.

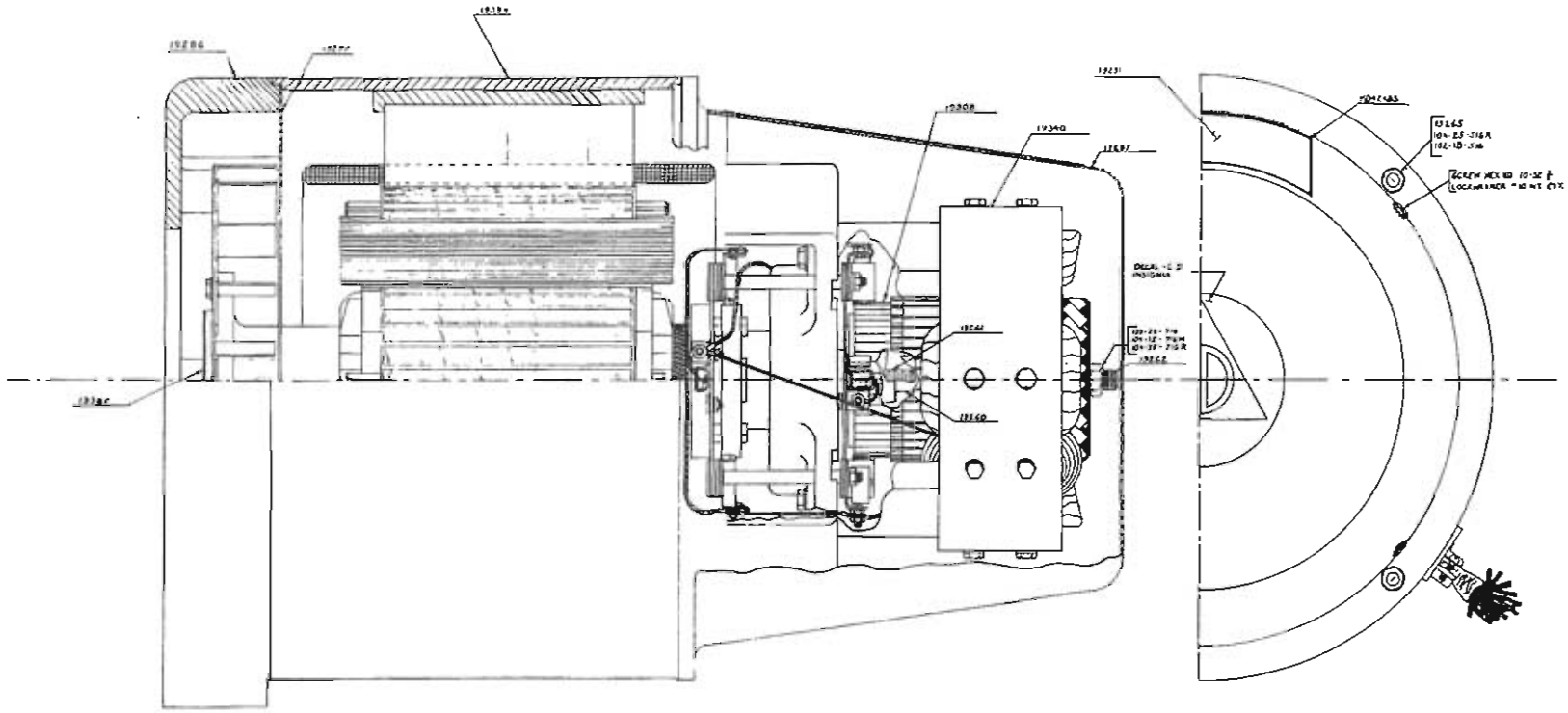
(2) The exciter field frame may then be released from the bearing bracket assembly or the complete bearing bracket assembly may be removed and





100-2-B-10-6 - Screw, RD-HD, Br, 10-32 x 3/8
100-2-B-10-8 - Screw, RD-HD, Br, 10-32 x 1/2
100-2-B-10-10 - Screw, RD-HD, Br, 10-32 x 5/8
102-4-B-10 - Nut, Hex, Br, #10-32
104-6-PH-10 - Washer, Lock, Phos-Brz, #10
18383 - Brush
18384 - Brush Holder
18427 - Brush Holder Plate
18469 - Brush Holder Box
18773 - Brush
18782 - Spring
19005 - Back Plate
19007 - Tab
19266 - Insulator
19267 - Insulator

Figure 9. Commutator (19334) and Collector (19335) Brush Holder Assemblies



CD - Insignia Decal
MD424BS - Rivet
10 - Lockwasher, Int-Ext
10-32 x 3/8 - Screw, Hex-HD, SLTD, S
102-1B-516 - Nut, Hex, S, 5/16-18
102-25-716 - Nut, Hex, S, 7/16-20
104-15-716M - Washer, Flat, 7/16
104-25-516R - Lockwasher, Split, 5/16
104-25-716R - Lockwasher, Split, 7/16
19260 - Stud Nut
19261 - Stud, S, 7/16 x 17 x 17/-17/32
19262 - Stud, S, 7/16 x 4-3/8
19265 - Stud
19277 - Baffle
19286 - Adapter
3/8 - 16 x 1-1/4 - Bolt, Hex-HD, S (MTG to ENG)
3/8 - Lockwasher, Split (MTG to ENG)
19287 - Cover
19291 - Plate, Ident
19308 - Exciter Armature
19340 - Bearing Bracket Assy
19384 - Stator Housing Assy
19385 - Rotor Fan & Bearing Assy

Figure 10. HOL-GAR Model 19180 AC Generator (GS-107-AC)

disassembled at a more convenient working area. Be sure to locate and identify inter-connecting wires before disconnecting. Before releasing the bearing bracket assembly it is best to place blocking under the stator housing and to remove the brushes so that they may not be damaged when the assembly is drawn off the rotating parts. Release the bearing bracket assembly by removing the nuts and washers securing it to the stator housing at the long studs that pass through the housing to the adapter frame. Note that this also releases the stator housing which rests on the long studs and blocking.

(3) The exciter armature is now exposed and can be released by removing the nut and washer securing it to the stud-shaft extension.

(4) At this point if further disassembly is required, it is necessary to release the generator leads at the connection board, the fuel line and electrical connections to the engine and the support structure for the control box and fuel tank from the generator housing. The support structure can then be removed as a complete assembly to expose the remaining parts of the generator.

(5) Disengage the stator housing from the adapter frame, keeping it from dropping and to maintain alignment to the rotor and thru-studs, by placing blocking under it as it is moved from the frame. Remove the stator studs from the adapter frame.

(6) Place blocking under the rotor assembly. Release the rotor by removing the long nut and washer securing it to the stud-shaft extension which passes through the hollow shaft to the engine crankshaft extension. Disengage the rotor from the crankshaft extension and remove. See that key is fixed. The long stud can now be removed from the crankshaft.

(7) Release the adapter frame from the engine by removing the securing screws and lockwashers attaching it to the engine and to the shock mounts.

g. AC Generator Subassemblies.

(1) The bearing bracket assembly requires no special procedure for disassembly. However, note how brush rigging is arranged so that assembly may be facilitated.

(2) The bearing, fan and key may be readily removed from the rotor assembly for replacement. The bearing may be removed with a bearing puller and a new one installed by careful tapping at inner race with soft metal pipe with rod or pressing. Dress slip rings carefully by machine turning or by hand as conditions warrant. If major repair has occurred to disturb balance, check balance and correct.

(3) The stator winding may be separated from the housing by pressing (normal) or hammering out using wood block at outside metal edge. Be sure wiring is released from clamp.

18. CONTROL GROUP

a. General.

Keep the control cabinet assembly free of dust, dirt and other foreign matter that may cause electrical malfunctions. See that control knobs are secure and that switches have proper action. Be sure voltage change plates are clean and in good condition.

b. Current Transformer.

Used in conjunction with the ammeters. Each opening has one turn of lead wire. Check mounting.

c. Meters.

Keep meters clean and observe for proper action and function. Check readings periodically with external meters.

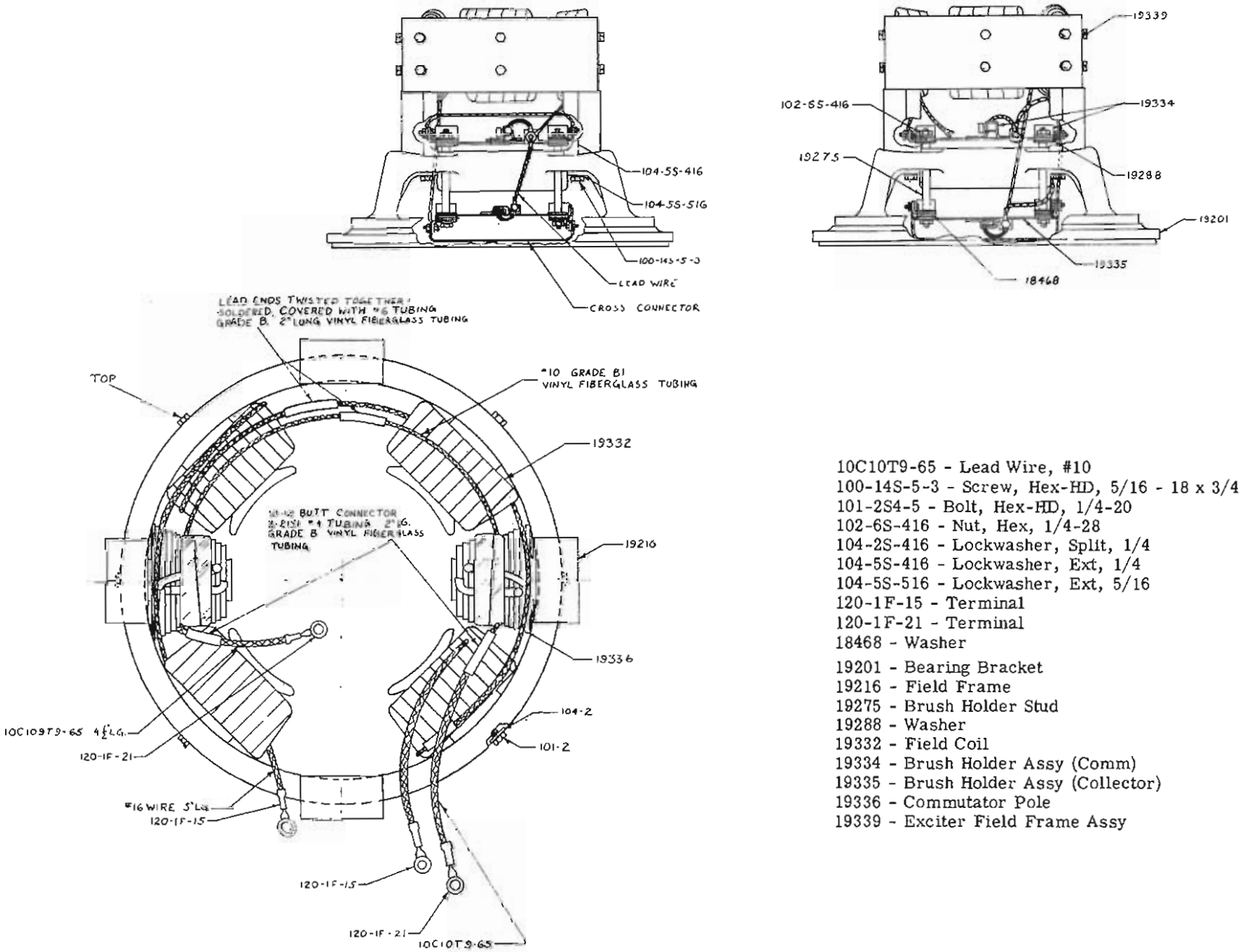
d. Repair, Removal, Installation.

Limit repair to cleaning and replacement of parts. The voltage regulator is the only part that is serviceable (Para. e. below). Depending upon the amount of repair that may be required, consider removing the complete control box from the unit for work at a more convenient location. No special techniques are required as all components are secured with standard hardware. However, observe how parts are installed before removal. When installing parts be sure that the wiring connections are correct; check against wiring diagram (Fig. 17).

e. Voltage Regulator.

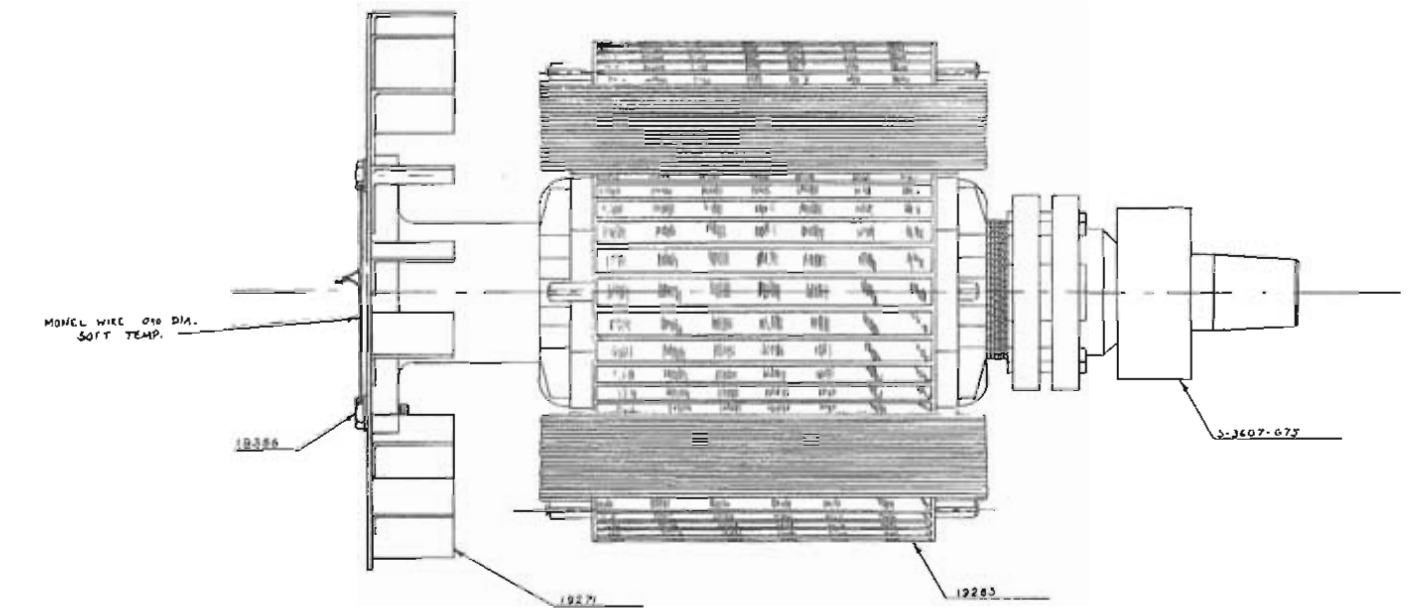
The regohm voltage regulator is used to maintain constant output voltage. It functions as an automatic rehostat. The regulating equipment consists of the controlling element, the regohm, in a separate housing which plugs into a chassis on which are mounted a set of control resistors. In addition, an external voltage adjusting rheostat is supplied. The control resistors are designed to meet the requirements of this generator set. In general, the resistance taper used for one application may not be used for others unless the characteristics are similar. The regohm voltage regulator consists of three elements; a voltage sensitive solenoid, a contact finger assembly and a set of control resistors. The voltage sensitive solenoid consists of a magnetic coil and a magnet circuit closed through a moving armature, which is connected to a push bar. The lower edge of the push bar is biased so that the fingers, which are set approximately parallel to the base, are pushed off their contacts one at a time in sequence. These fingers, in turn, are connected to pins which plug into corresponding socket terminals on the chassis assembly.

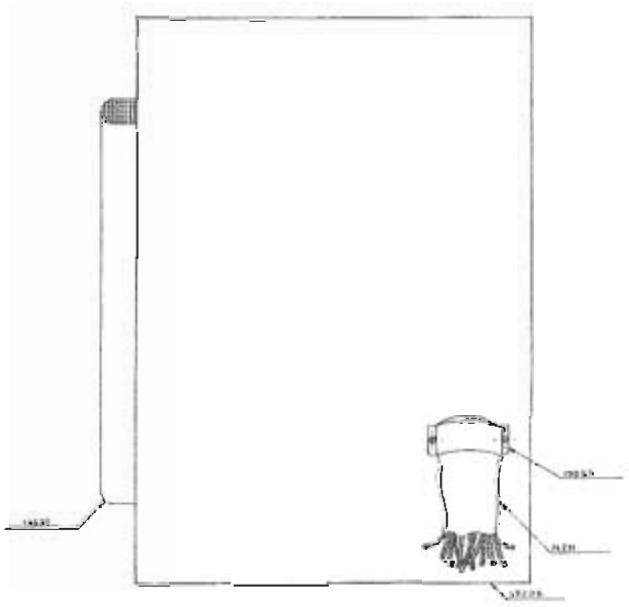
(1) Principles of Operation. As generally used, the regulator acts as an automatic field rheostat which adjusts field current in order to maintain constant output voltage of the generator. In this type of application the contact fingers of the plug-in unit (Regohm) rest on the shorting contact bar when the coil is not energized, reducing the resistance in the field circuit to a minimum.



10C10T9-65 - Lead Wire, #10
100-14S-5-3 - Screw, Hex-HD, 5/16 - 18 x 3/4
101-2S4-5 - Bolt, Hex-HD, 1/4-20
102-6S-416 - Nut, Hex, 1/4-28
104-2S-416 - Lockwasher, Split, 1/4
104-5S-416 - Lockwasher, Ext, 1/4
104-5S-516 - Lockwasher, Ext, 5/16
120-1F-15 - Terminal
120-1F-21 - Terminal
18468 - Washer
19201 - Bearing Bracket
19216 - Field Frame
19275 - Brush Holder Stud
19288 - Washer
19332 - Field Coil
19334 - Brush Holder Assy (Comm)
19335 - Brush Holder Assy (Collector)
19336 - Commutator Pole
19339 - Exciter Field Frame Assy

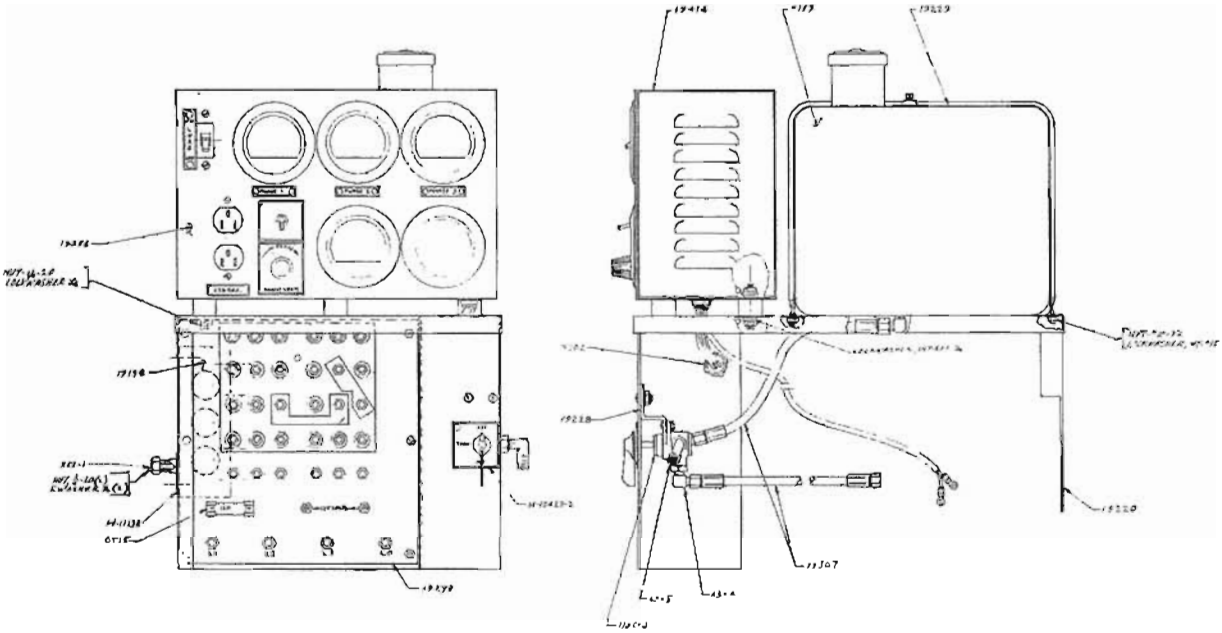
Figure 11. Bearing Bracket (19340) and Exciter Field Frame (19339) Assemblies

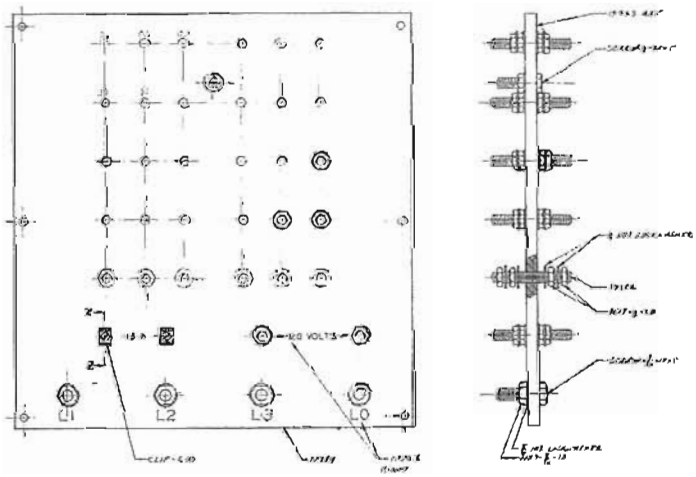




S-3607 - G75 - Bearing, Ball
16211 - Sleeving, Insulating
19087 - Connector, Oval Cable
19208 - Stator Housing
19239 - Stator Winding Assy
19271 - Fan
19283 - Rotor Assy
19386 - Screw, Cap (Mod)

Figure 12. Rotor Fan and Bearing (19385) and Stator Assemblies (19384)

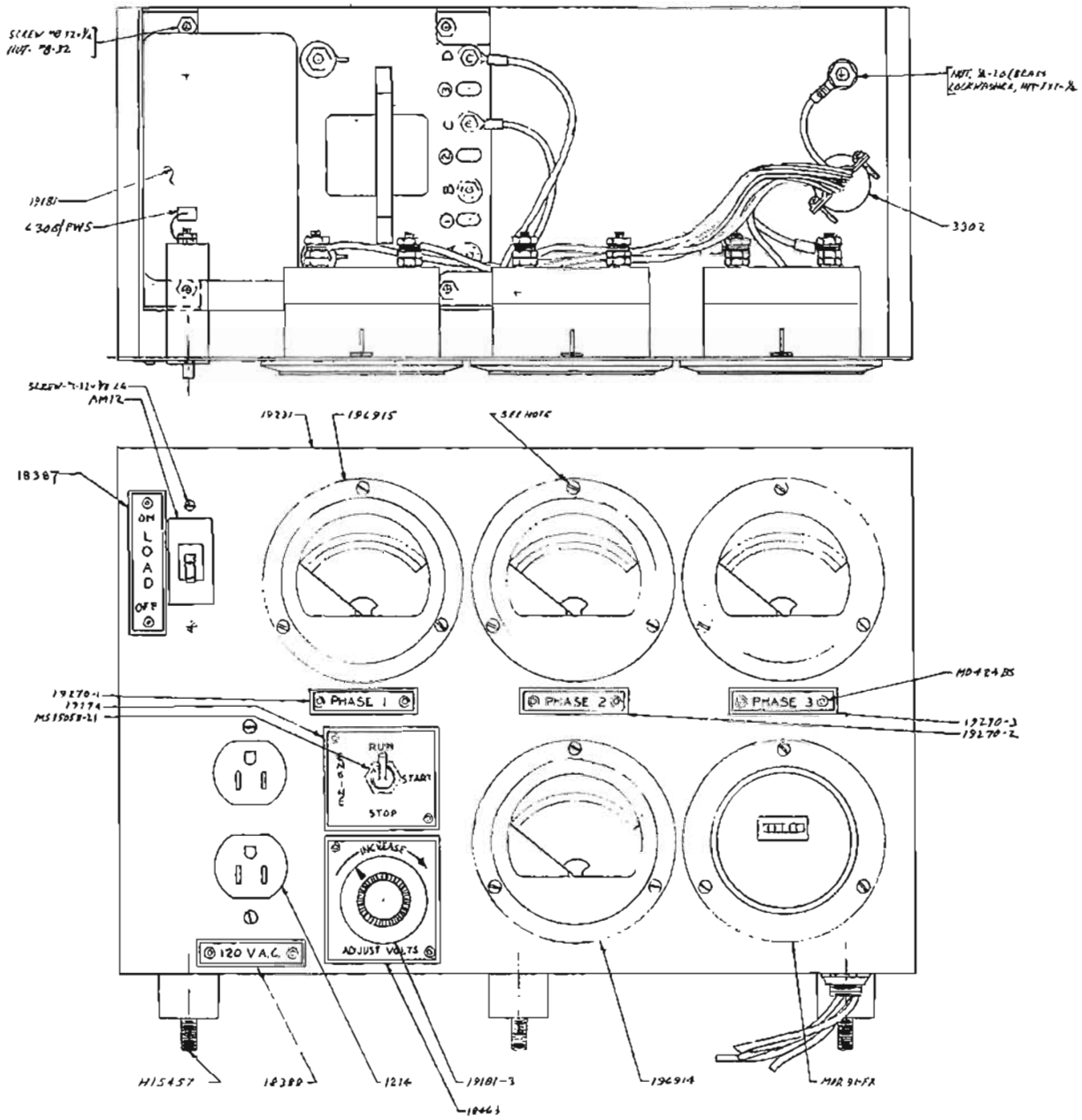




C10 - Fuse Clip
  6-32 x 3/4 - Screw, RD-HD, BR
  6-32 - Nut, Hex, BR
  #6 - Lockwasher, INT, Phos-BR
SSS-1 - Ground Stud
H 11138 - Plate, Indent (GRD)
H 15423-2 - Plate, Ident (3-Way Valve)

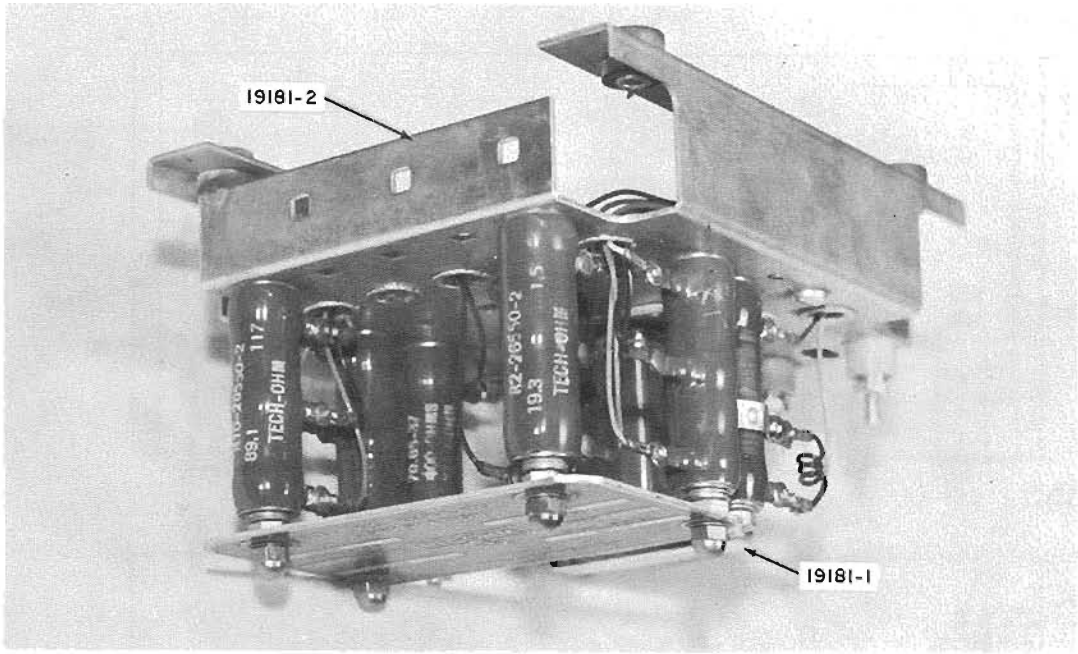
OT15 - Fuse, 15 AMP
#10 - Lockwasher, INT, S
10-32 - Nut, Hex, 5
10-32 x 1/2 - Screw, RD-HD, S
110C-5 - 3-Way Valve
#1/4 - Lockwasher, INT, Phos-BRZ
#1/4 - Lockwasher, INT, S
#1/4 - Lockwasher, INT-EXT, S
1/4-20 - Nut, Hex, BR
1/4-20 - Nut, Hex, S
1/4-20 x 1/2 - Screw, RD-HD, S
1/4-20 x 1 - Screw, RD-HD, BR
153 - Fuel Tank
19154 - Stud
19198 - Current Transformer
19220 - Support Structure
  5/16 - 18 x 3/4 - Bolt, Hex-HD, S
  5/16 - Lockwasher, Split
19229 - Strap, Fuel Tank
19228 - Bracket, 3-Way Valve
19263 - Board
19278 - Connection Board Assy
19307 - Fuel, Hose
  48 x 4 - Connector (1) (Hose To Strainer)
19356 - Control Panel Assy
19368 - Silk Screen (Front)
19369 - Silk Screen (Rear)
19414 - Cover Assy, Control Panel
3302 - Connector, Cable
49 x 4 - Elbow, 90°
49 x 5 - Elbow, 90°
#5/16 - Lockwasher, INT, Phos-BRZ
5/16 - 18 - Nut, Hex, BR
5/16 - 18 x 1 - Screw, Hex-HD, BR

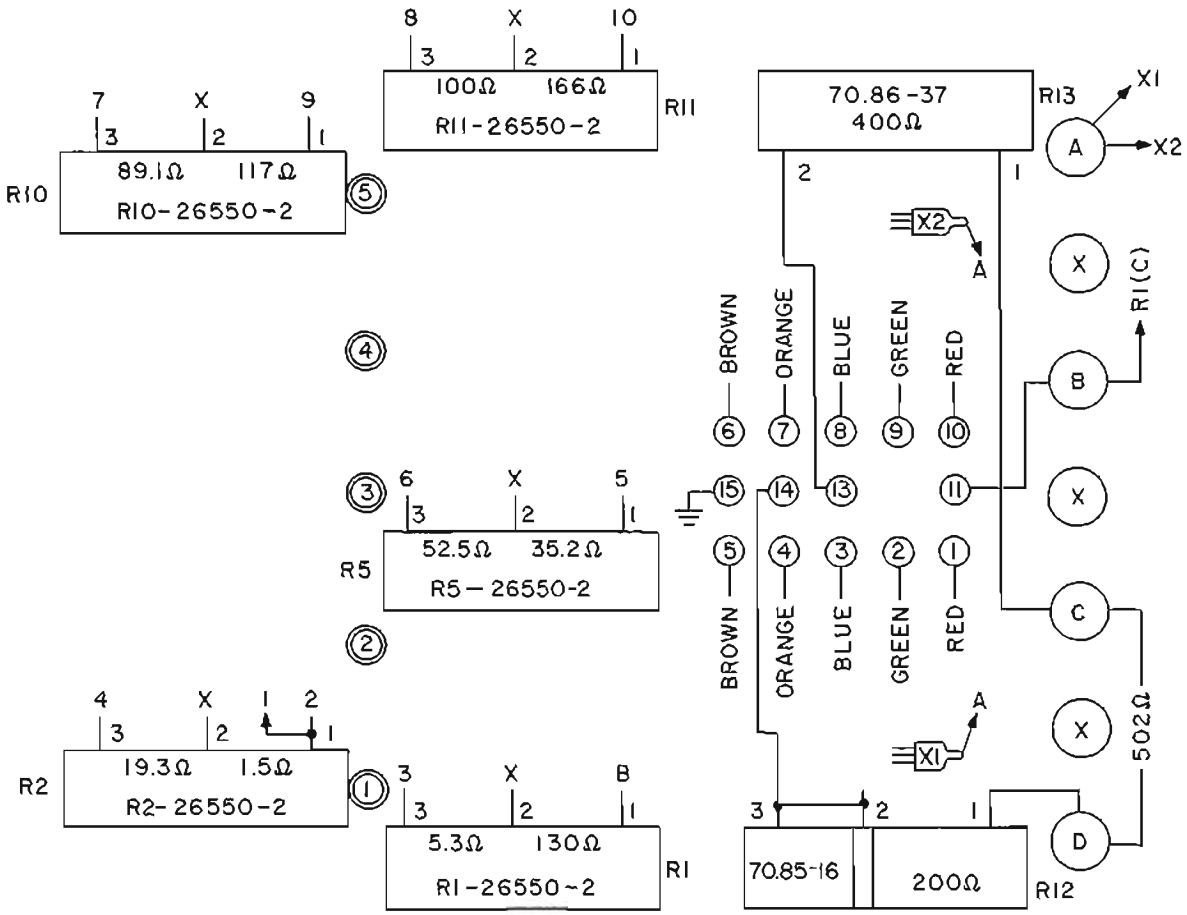
Figure 13. Support Structure Assembly (19355)



AM12 - Circuit Breaker - Load Switch
H15457 - Shock Mounts
MD428BS - Rivet
MS35058-21 - Switch, Engine
1214 - Receptacle, Duplex
#1/4 - Washer, Lock, INT-EXT
1/4-20 - Nut, Hex, S
18387 - Plate, Ident, Load-Switch
18388 - Plate, Ident, 120 VAC
18463 - Plate, Ident, Volts Adjust
19181 - Voltage Regulator Complete W/Rheostat and Knob
19181-3 - Rheostat & Knob
19231 - Body, Control Panel
19270-1 - Plate, Ident, Phase 1
19270-2 - Plate, Ident, Phase 2
19270-3 - Plate, Ident, Phase 3
19274 - Plate, Ident, Engine Switch
196914 - Voltmeter, AC
196915 - Ammeter (% Rated Load)
31-FX - Frequency Meter
3302 - Connector
6-32 - Nut, Hex, Cap-Ext Lockwasher
6-32 x 3/8 - Screw, RD-HD, S
6308/PW5 - Resistor, SW, 1K, WW, 10%
8-32 - Nut, Cap-Ext, Lockwasher
8-32 x 3/4 - Screw, RD-HD, S
NOTE: Mounting Hardware Furnished W/Meters

Figure 14. Control Panel Assembly (19356)





19181 - P/N Includes Complete Voltage Regulator W/Volts Adjust Rheostat & Knob
19181-1 - Element, Regulator Plug-In
19181-2 - Chassis, Regulator (All Resistors Less Element).
Resistors - Part Numbers and Value as indicated above.

Figure 15. Voltage Regulator (19181)

When the magnet coil is energized, the moving armature is attracted to it. This movement is opposed by the reference springs and the armature moves only when the magnetic pull and the pull of the springs are not equal. As the armature moves, it opens or closes fingers, depending upon the direction of motion, increasing or reducing the amount of resistance in the field circuit and thus maintaining a constant output voltage. An example of the operation of the regulator is as follows: If the generator is operating at rated voltage with full load, the regulator is in equilibrium with a certain amount of resistance in the field circuit. Should the load suddenly be removed, the output voltage would tend to rise, increasing the coil voltage and moving rhe armature towards the core. This action would open more fingers and insert more resistance in the field circuit, reducing field current and restoring output voltage to its original value.

(2) Maintenance. Keep the regulator free of dust, dirt, grease and moisture. Do not disturb setting of the adjustable resistor on the chassis.

(3) Replacement of Parts. Limit replacement of parts in the regulator to the plug-in unit, the regulator chassis and to the voltage adjusting rheostat. Resistance of chassis resistors are given as reference only, in the event conditions warrant substitute replacements; otherwise, if resistors burn out, the chassis should be replaced as a unit.

(4) Adjustments. The complete regulator is designed and specifically set and adjusted to operate to the characteristics of the generator set. The range of the voltage adjusting rheostat is the only adjustment that may be required during its operational life. This range can be adjusted by moving the center tap slide of the adjustable resistor on the regulator chassis. The voltage operating range is adjustable to ±5% of rated voltage at full load by means of the adjusting rheostat. The range should be adjustable through the following values on a 120 volt base.

No load	121-133 volts ±1%
Full load	114-126 volts ±1%
125% load	112-124 volts ±1%

(5) Removal-Installation. No special procedures are required to remove or install the voltage regulator or its parts. When removing or installing the plug-in unit use care so that pins are not damaged and that they are alined. A pin is either added or deleted to provide necessary keying. Carefully press unit into socket by hand. Be sure to replace the securing clamp.

19. EXHAUST GROUP

a. General.

Since exhaust fumes are dangerous, make a thorough check of the exhaust tubes and muffler to see that there are no leaks and that fumes are being conducted away from inhabited areas.

b. Muffler.

See that the muffler is mounted securely. Check for corrosion in exhaust tubes and muffler. Replace any corroded parts showing breakage.

20. COOLING SYSTEM GROUP

a. Engine.

See that engine shrouds are secure in place and that engine cooling air flow occurs.

b. AC Generator.

Check openings in generator end cover and under stator housing for air flow.

21. FUEL SYSTEM GROUP

a. Fuel Tank.

Be sure that fuel tank is kept full. Depending on local conditions (extreme cold, high humidity) drain tank enough to remove condensed moisture from bottom of tank.

b. Fuel Lines.

Check fuel lines for secure fit and tight connections. See that the lines are not damaged.

c. Auxiliary Fuel Valve.

Check this valve for proper action.

d. Engine.

For maintenance of fuel system of engine, refer to Appendix A.

22. IGNITION GROUP

a. Unit.

Check wiring (refer Fig. 17) between control panel and engine for secure fit. See that it is not deteriorated. Replace badly frayed wire.

b. Engine.

Check engine ignition wiring (Fig. 16) for secure fit. See that it is clean and not frayed or deteriorated. Replace deteriorated wires (refer to Appendix A).

23. ELECTRICAL SYSTEM GROUP

a. General.

Keep electrical parts clean. Remove loose dust and dirt. Remove scum accumulations with suitable solvent.

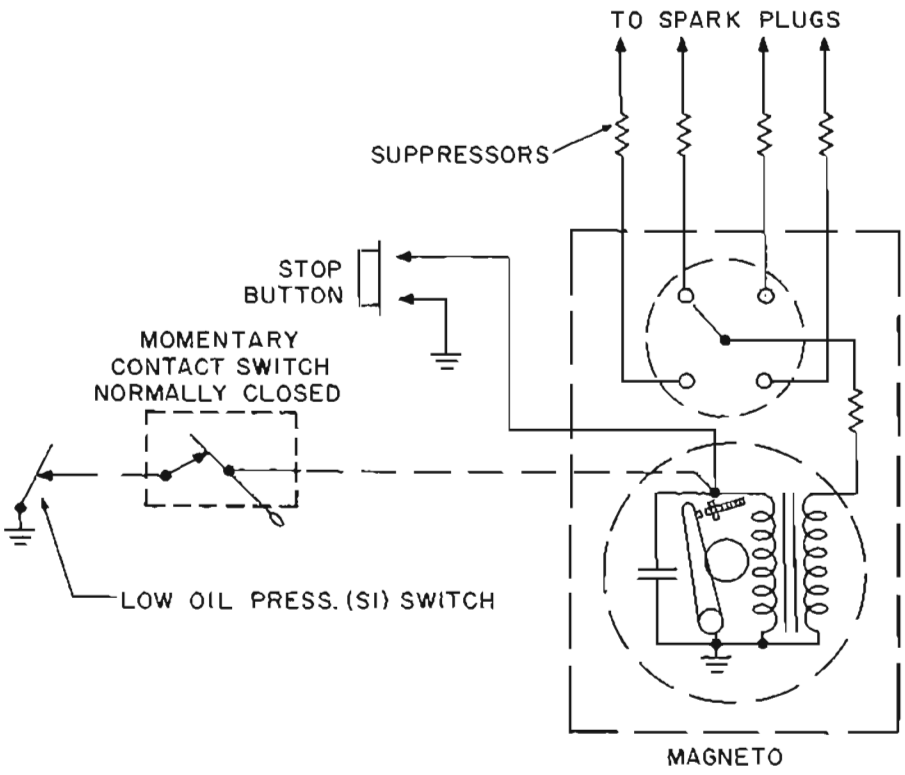


Figure 16. Schematic of Engine Ignition System

b. Wiring.

Check wiring for secure connections. Keep terminals clean and free of corrosion. See that insulation is not frayed, broken or deteriorated. Replace damaged wires and wires having damaged insulation.

c. Switches.

Check switches for proper action.

d. AC Generator.

See that generator load leads are secure and in good condition.

24. HOUSING GROUP

a. Check the shipping box for good condition. Retouch or repaint to original finish. Replace obscured identification markings.

b. Check box lining paper. Replace if torn or damaged.

c. See that inspection door is secure.

d. Account for mounting bolts. Keep in good condition.

e. Replace wood panels or sections of the box if badly damaged or deteriorated. Treat new wood with pentachlorophenol wood preservative. Treat surfaces thoroughly before and after fabrication.

25. STRUCTURAL GROUP

a. Check mounting hardware on skid for secure fit. See that wood panels are secure and not damaged. Check shock mount mounting areas for deterioration. Paint exposed metal hardware surfaces, or apply light film of diesel or engine oil to prevent rust. Keep clean and free of moisture.

b. Replace rotted or damaged wood panels. Original skids were pressure creosoted to 8 lb/cu. ft. retention. Treat new panels as indicated or with a suitable available preservative.

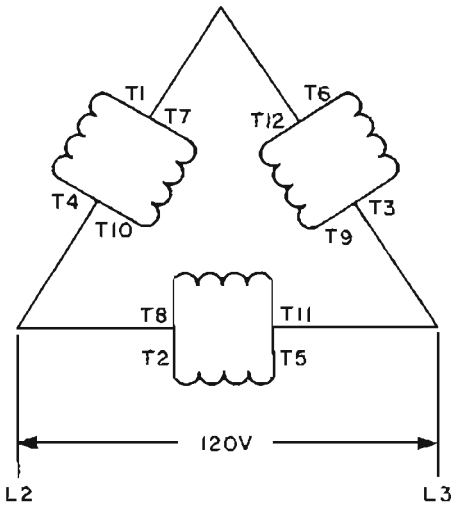
26. ACCESSORIES

a. Engine.

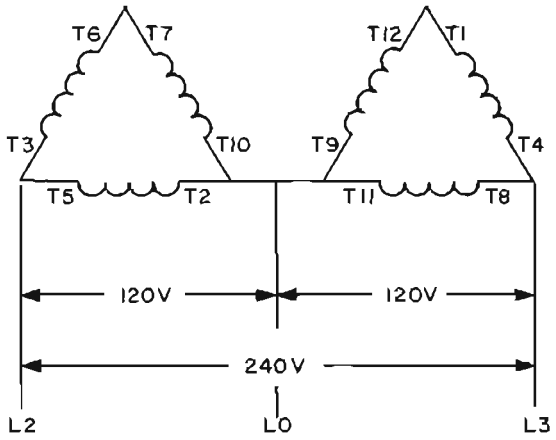
For accessories integral to the engine refer to Appendix A. See that engine lifting eye bolt assembly and handcrank are kept in good condition and properly stowed.

b. Unit Operational.

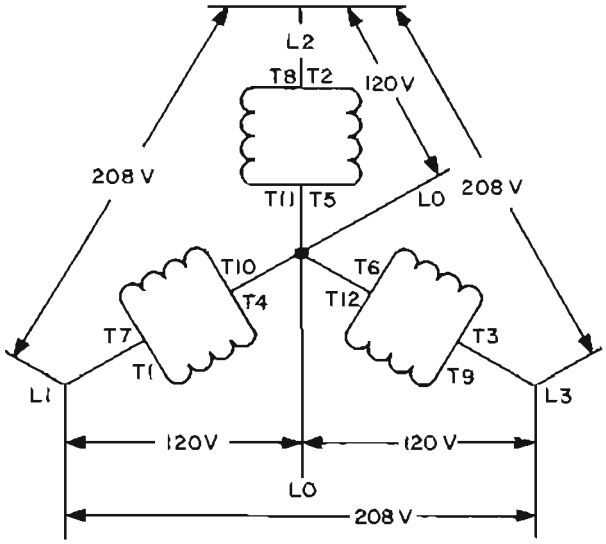
Keep fuel drum adapter and its strainer screen clean; replace damaged screen. Replace worn fuel hose. Keep hand tools in good condition and stow properly. Maintain line voltage indicator and amprobe volt-ammeter in clean condition. Be sure ground rod is properly installed and in good condition.



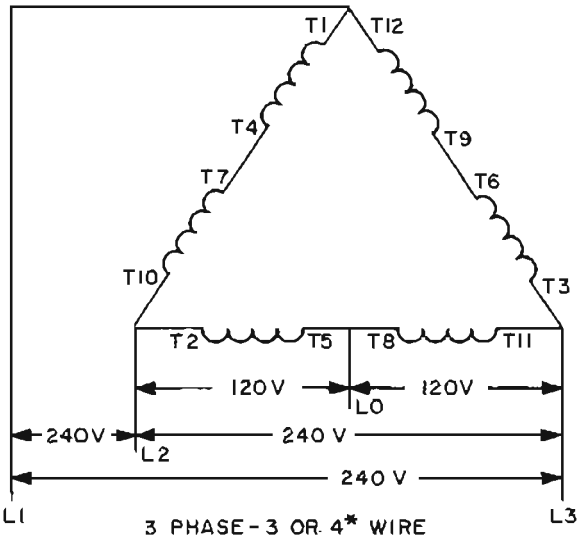
1 PHASE - 2 WIRE - 120 VOLTS



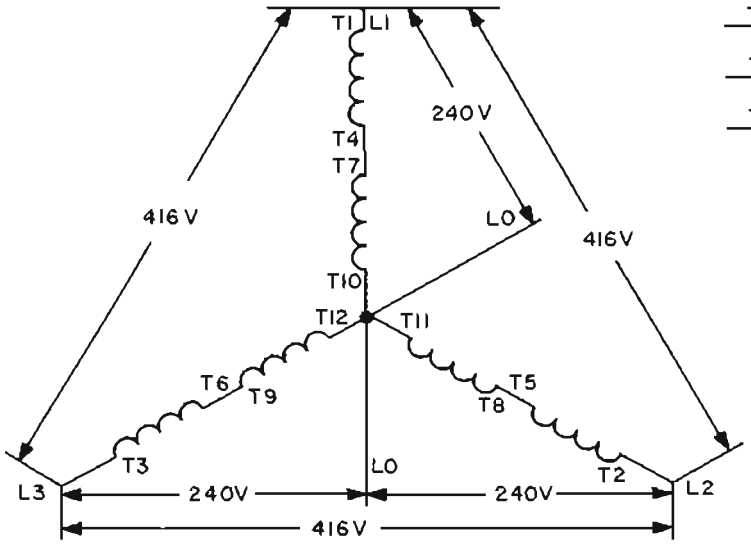
1 PHASE - 3 WIRE - 120/240 VOLTS



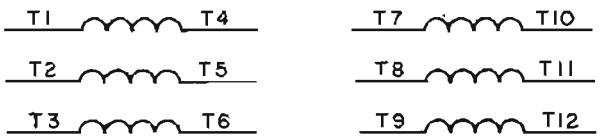
3 PHASE - 4 WIRE - 120/208 VOLTS



3 PHASE - 3 OR 4* WIRE
240/(120)* VOLTS



3 PHASE - 4 WIRE - 240/416 VOLTS



GENERATOR WINDINGS

*NOTE: Although delta is commonly used in the standard three (3) wire configuration, there are locations where the occasion arises to tap, at the mid-point, one (1) phase of a three (3) wire delta circuit, while using the standard three phase leads for a normal three phase load. The center-tapped delta winding is called upon, in addition to its function with the other two phases, to carry a minimal 120 volt lighting load. This circuit is designed to satisfy certain minimal (3 ph-1 ph) characteristics found in some older structures.

Figure 17. AC Generator Schematic Diagrams

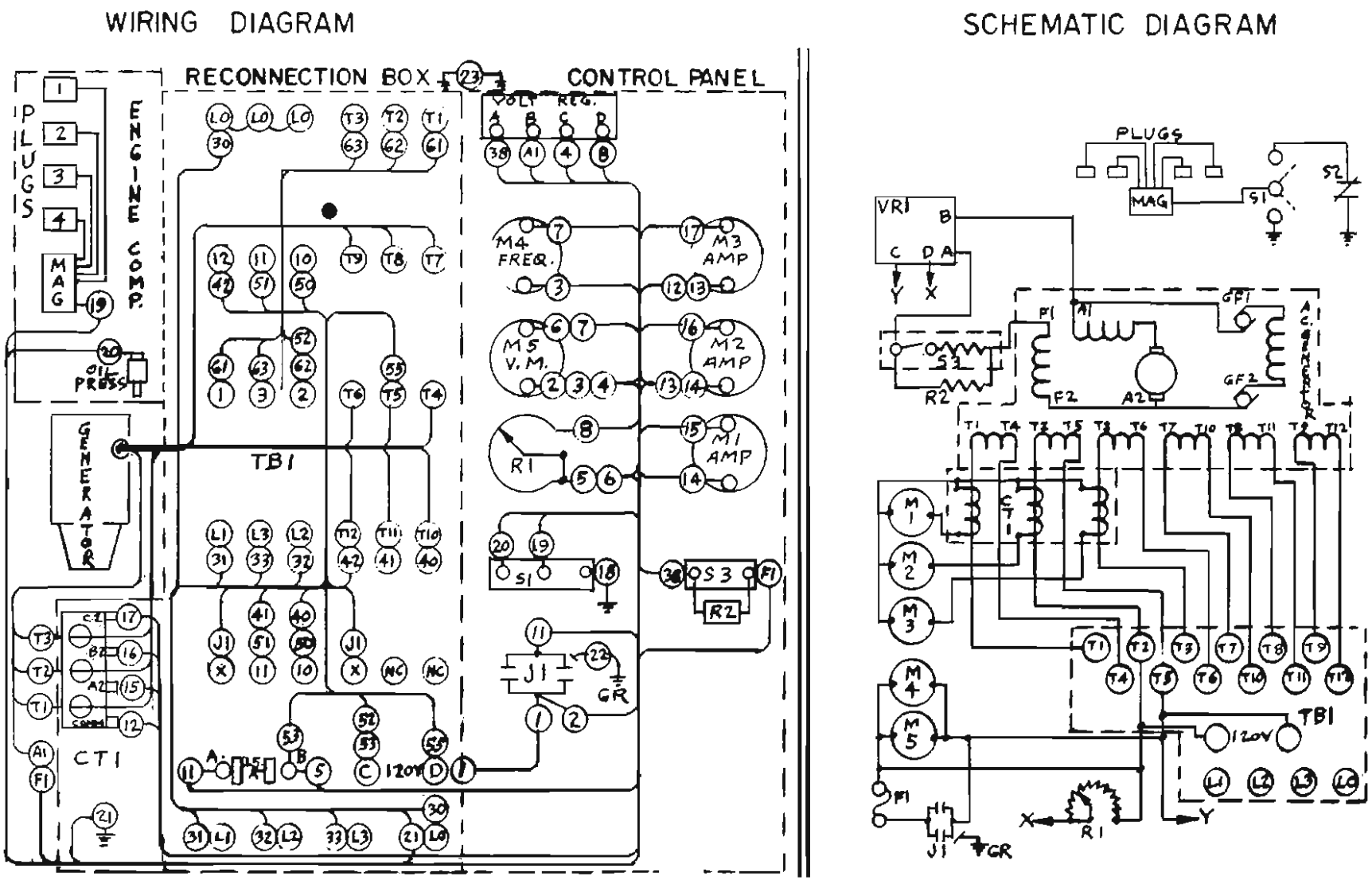


Figure 18. HOL-GAR Model GS-107-AC Wiring & Schematic Diagram (Plate 19235)

Note

Account for and maintain operational accessories as functional parts of the unit.

27. TROUBLE SHOOTING

a. General.

When trouble shooting the engine generator set follow a logical systematic method, utilizing your primary trouble shooting tools, the wiring diagram (see Fig. 18) and the functional information given for the various components (para. 11). Remember the basic function of the engine generator set is to produce power within its rated capacity (para. 3). To accomplish this liquid energy, the fuel is converted to mechanical energy (in the engine) which provides the drive power for the ac generator that produces the electrical power. To aid in the final overall performance of the unit, operational, regulation, and safety components and systems are added. With this in mind, functional disturbances can be categorized into operational, safety, regulation, mechanical drive power, and electric power groups. The trouble shooting tabulation (para. c.) is divided into the groups given and present typical troubles with probable cause and remedy.

b. Electrical Failure.

If generator set fails to produce electric power, the cause may be inside or outside the unit. To ascertain where the fault lies, turn off the generator main switch, disconnect external lines, use tester furnished or test light, across the output terminals, then switch on the main switch. If test light lights or voltage readings are correct, the fault is in the external lines, which should then be corrected. However, if test light does not light, then the fault is within the unit. Proceed to check load connection board, control panel and instrument wiring and internal lines to generator. Remember, one disconnected or improperly connected wire is sufficient to cause lack of power. If wiring between instruments, control panel and generator is correct, then the fault is in the generator itself. First, check the brushes, see that they are properly seated and connections are secure. Examine slip ring and commutator to be sure that they are clean and free from pits and mica ridges; these faults may also cause decreased output and efficiency of the unit before a total breakdown occurs.

c. Trouble Tabulation.

This tabulation is divided into trouble, possible cause and remedy and categoried into operational, safety, regulation, mechanical power and electric power trouble groups.

(1) Operational.

Trouble	Possible Cause	Remedy
Fuel delivery to engine stops or is erratic.	Fuel tank empty. Dirty fuel. Lines dirty, cracked or loose. Defective fuel pump.	Maintain equipment services. Replace fuel. Check lines and connections; replace or tighten. Clean or replace fuel pump (Appendix A).
No response to control switches or knobs.	Loose wires or connections. No actuating voltages. Defective circuit or circuit part.	Locate actuated part in circuit diagram (see fig. 18). Trace wiring, check connections; correct loose connections; replace indicated faulty part. Check actuating voltage peculiar to that circuit.
Improper meter reading or indication.	Component of circuit meter is monitoring, is defective or not functioning properly. Loose connections.	Locate meter in circuit diagram Trace wiring, check connections; replace or splice broken wires, replace indicated faulty part. Check actuating voltage or condition for the meter. If circuitry is correct or condition (temperature, oil pressure or current is satisfactory) check circuit with external meter to see if meter is defective. Replace defective meter.
Improper generator set output.	Load connections not correct. Faulty load. Generator set components malfunctioning.	Shut down unit immediately. Check and correct load connections. Determine if load or generator set is at fault. (Par. b. above).

(1) Operational (Contd)

Trouble	Possible Cause	Remedy
Load Switch-circuit breaker trips.	Unit operating at overload.	Check and adjust load. Reset load switch. If condition continues shut down unit and check external and internal circuits.

(2) Safety.

Trouble	Possible Cause	Remedy
Engine does not start or starts and after operation shuts down for no apparent cause.	Engine pressure safety switch activated or shorted out.	Locate safety switch in wiring diagram (figs. 16 & 18). Check circuit for continuity or grounds. See that conditions for which safety switch was installed doesn't exist. Replace safety switch if defective.
Unit utility fuse burns out.	Utility line to generator receptacle overloaded.	Adjust load, replace defective fuse.
External safety devices keep activating (fuses burn out, circuit breakers dump load).	Excessive load. Defective safety device.	Shut down unit. Check load and adjust. Reset or replace safety device. If condition continues, check and replace defective safety device.

(3) Regulation.

Trouble	Possible Cause	Remedy
Frequency cannot be maintained or engine keeps racing and/or slowing down. Frequency does not stabilize.	Excessive changing load. Governor cannot control engine speed; out of adjustment or defective.	Check load and adjust as required. Adjust engine governor. Replace governor if adjustment cannot be made.
A-c output voltage changing cannot be maintained. Voltage doesn't stabilize.	Excessively changing load. Voltage regulator cannot maintain voltage.	Check load and adjust as required. If load is not at fault check voltage regulator. Replace plug in unit with known good one. See if resistors in regulator are good. Check a-c generator brushes and rigging. Replace if faulty.

(4) Mechanical Power. In addition to the trouble shooting items listed below, refer to the engine section (Appendix A).

Trouble	Possible Cause	Remedy
Engine will not turn over and fire.	Loose or defective wiring.	Tighten all loose connections or replace.
Engine turns but will not start.	Engine flooded.	Push choke control all the way in and turn engine over. If carburetor continues to flood, repair it.
	Carburetor passages restricted by water, ice or corrosion.	Clean fuel system. Replace or repair carburetor.
	Fuel pump defective.	Replace fuel pump.
	Restricted air cleaner.	Remove air cleaner and clean filter.

(4) Mechanical Power. In addition to the trouble shooting items below, refer to the engine section (Appendix A). (Contd)

Trouble	Possible Cause	Remedy
Engine turns but will not start (Contd).	Air leaks around intake manifold.	Replace manifold gaskets.
	Spark plugs damaged, dirty or wet; gap improperly spaced.	Clean, adjust and test spark plugs. Replace any defective plugs.
	Magneto brush worn or damaged.	Replace magneto brush.
	Magneto coil defective.	Replace magneto coil.
	Magneto condenser defective.	Replace magneto condenser.
	Magneto improperly timed to engine.	Time magneto to engine.
	Breaker points improperly spaced, burnt or wet.	Clean and adjust, or replace breaker point.
Engine lacks power.	Low or poor compression.	Overhaul engine - grind valves and replace.
	Defective ignition system.	Check ignition wiring, spark plugs and magneto.
	Carburetor not operating properly.	Check the operation of the carburetor. A lean fuel mixture will cause burned valves and excessive engine temperatures.
	Restricted muffler.	Inspect muffler. Replace if defective.

(5) Electric Power.

Trouble	Possible Cause	Remedy
Complete electric failure. Load switch - circuit breaker trips.	Improper load. Generator set not operating properly.	Shut down unit. Determine if power failure is caused from an external or internal source. (Par. b. above)
Generator does not build up and produce voltage.	Generator exciter open or shorted.	Check continuity of exciter. Check brushes. Replace defective part.
	Loose leads.	Check and tighten terminals.
	Main generator field shorted, open or grounded.	Replace main fields. If grounded due to moisture, clean by spraying with suitable solvent and bake.
	Voltage regulator not functioning.	Replace plug in unit. Check all terminal connections.
Blackened collector rings.	Excessive sparking or flashing at brushes.	Sand or turn down collector rings.
		Replace short brushes.
		Adjust springs - replace weak brush springs.
Intermittent sparking at brushes.	Check for open armature winding.	Locate and repair bad coil or repair defective joint.

(5) Electric Power. (Contd)

Trouble	Possible Cause	Remedy
Excessive hum.	Uneven air gap.	Measure with feeler gauge. Check rotor for balance. Check bearing.
Regular clicking.	Foreign matter in air gap.	Remove rotor and clean.
Brush chatter.	Extreme vibration.	Check brushes and spring set.
Vibration.	Alignment of unit.	Tighten mounting bolts to base and engine.
Overheating (check with thermometer; don't depend on the hand).	Dirt or alignment.	Blow out all dirt in unit, use solvent on wound sections to remove sticky dirt. Check flow of ventilating air. Check for grounds.
Collector ring hot.	Check brushes.	Excessive brush pressure.

PARTS LIST

28. PART ORDERS

a. The parts list is contained within the legend of the illustration.

b. To order parts give the Engine Generator Set Model Number, the part number and the nomenclature shown in the illustration. The wiring diagram (Fig. 18) shows the relative position and gives the reference symbol (ie: TB1, CT-1 etc.) of the electrical component in the generator set. When ordering these parts give the model number of the engine generator set, part number and the wiring diagram reference symbol with nomenclature.

c. Refer to the engine and test equipment sections respectively for parts peculiar to these components and their accessories. It is recommended that these parts be ordered through the HOL-GAR parts supply system.

APPENDIX A

ENGINE SECTION

FOR

ONAN AIR-COOLED GASOLINE ENGINE

MODEL

J120-S/967F

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SECTION I

INTRODUCTION

1. GENERAL

a. This appendix A contains information for the operation and maintenance of the ONAN four-cycle, four cylinder, air-cooled, gasoline engine Model J120-S/967F. and a parts list. Included are complete procedures and data for major repair. It describes preventive maintenance and periodic service to keep the engine in top operating condition. A schedule is presented to encourage the operator to perform the service as suggested and then to adjust the schedule to make it valid for the conditions under which the equipment is being operated. Trouble-shooting charts throughout the manual help locate and diagnose troubles. A major chart provides direction to solutions to probable causes. Then specific charts that offer remedies are provided for the various systems, parts, and components of the engine.

Dimensions, clearances, and test specifications are tabulated. Many illustrations have been included to support the written test, but use the parts section for exploded drawings of related components.

b. By using paragraph references, repetition has been kept to a minimum. Each component or system is covered independently and then tied together with related procedures using the paragraph references.

2. DESCRIPTION

The J120-S/967F engine has a vertical inline block, overhead valves and utilizes spark ignition by magneto for firing. Connecting rod bearings and main bearings are military standard types. Normal engine speed is up to 2700 rpm. A constant speed, flyball type mechanical governor is standard for this engine. The engine uses low octane (regular) gasoline and is manual start.

3. DATA

Manufacturer	ONAN, Division of Studebaker Corp.
Model	J120-S/967F
Specification	Mil-E-11275, Mil-E-11278 per PHS-CC-G-202(27-July-1962)
Cylinder	4
Cylinder Firing Order	1-2-4-3
Displacement	120 cubic ins.
Bore	3-1/4
Stroke	3-5/8
H.P. at 1800 rpm (nominal)	30.5
Compression Ratio	6.5:1
Connecting Rod Bearings	Military Standard
Main Bearings, Precision Type	Military Standard
Magneto, Integral (gear driven)	Standard
Starting	Manual (hand crank)
Governor Regulation (nominal)	5%
Choke	Manual
Total Air Requirement (1800 rpm)	925 cfm
Cooling Air	890 cfm
Combustion Air	35 cfm
Inlet Vent	24 sq. ft.
Outlet Vent (area when duct is used*; w/o duct, make vent as large as possible)	160 sq. ft.*
Air Cleaner	Dry Type
Fuel Pump Lift	8 ft.
Oil Filter (Full Flow)	Std.
Oil Capacity	6 qts (U.S.)
Exhaust Connection Size (Pipe Tapped)	1-1/2
Height	25 ins.
Width	20 ins.
Length	37 ins.
Weight	375 lbs.
Torque & Clearance Data	See pars. 19 & 21

SECTION II

OPERATIONAL INFORMATION

4. PREPARATION OF ENGINE

a. Installation

(1) Location. Provide adequate access for service and repair. Protect the engine from adverse weather. Consider location of related systems, such as fuel, exhaust and ventilation.

(2) Mounting. Be sure the engine is level and securely mounted. Maximum tilt: for front or rear lift is 30°; left lift (carburetor side) is 40°; and right lift is 45°. Compensate for any tilt when checking crankcase oil.

(3) Ventilation. Good ventilation is needed to cool the engine and to support combustion. Avoid recirculation of ventilating air. Locate vents so the flow

of air from the inlet to the outlet will pass over the engine. The outlet should be slightly higher than the inlet. Allow for heat produced by complementary equipment.

(4) Exhaust. Exhaust is poisonous. Pipe exhaust gases outside. Exhaust pipes must not terminate near inlet vents. Avoid sharp bends. Use sweeping, long radius elbows. Use a section of seamless, flexible tubing between the engine and any rigid piping to restrict vibration. Increase pipes 1 size for each additional 10 foot span. Protect walls and partitions through which exhaust pipes pass with a metal shield. Install a suitable muffler preferably as close to the engine as practicable. Pitch exhaust pipes downward or provide a condensate trap at the point where a rise in the exhaust system begins.

(5) Oil Drain Extension. For service convenience, install an oil drain extension made from standard pipe and fittings in the 1/2 inch tapped oil drain port in the oil base. Consider installing a suitable valve.

(6) Fuel Supply. Locate separate fuel tanks no lower than 8 feet below the engine fuel pump. Use auxiliary fuel pump to provide additional lift. Avoid gravity feed of fuel to the engine from tanks not mounted at engine. When sharing a fuel tank, do not connect to an existing line at a point above the fuel supply level. The fuel supply line must be air tight. Install a shut-off valve at the fuel tank for service convenience. Run a vent to the outside of a compartment within which a fuel tank is installed. Use a clean fresh "regular" grade of gasoline. Do not use highly leaded "premium" grades. Never fill the tank while the engine is running. Leave room for expansion when filling the tank. OBSERVE SAFETY PRECAUTIONS WHEN HANDLING GASOLINE.

b. Lubrication

(1) Crankcase Oil. The capacity is 6 quarts. Be sure that engine is level when filling for the first time. Fill to the full mark (F) on the indicator (fig. A-1) with proper grade of engine oil (para. 14). Do not mix brands or grades. Always install dipstick indicator air tight.

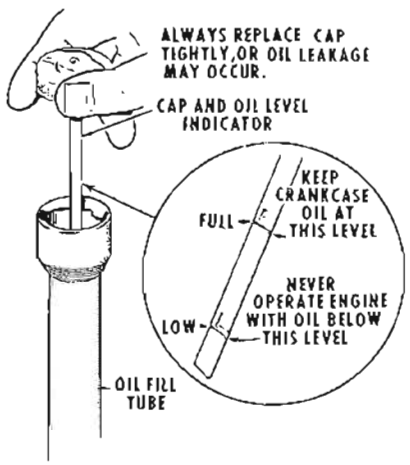


Figure A-1. Engine Lubricating Oil Level

(2) Governor Linkage. Lubricate the linkage at the carburetor and ball joint ends with powdered graphite (preferably) or a light sewing machine oil (fig. A-2).

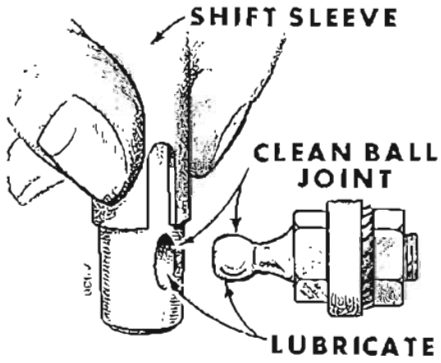


Figure A-2. Lubrication Of Governor Linkage

5. STARTING-STOPPING

a. General.

The following instructions pertain to engine starting only. Refer to equipment instructions of which engine is a component, for complete starting procedure.

b. Preliminary.

Be sure the installation is complete and the engine is serviced with lubricating oil and fuel. Heavy exhaust smoking from burn-out of rust inhibitor oil is normal during the first few minutes of the initial run. If the engine fails to start at the first attempt, remove the spark plug(s), clean in gasoline, dry, and reinstall.

c. Manual Crank Starting.

(1) Prime carburetor; make certain priming lever is down when finished.

(2) Set the hand choke as required by temperature.

(3) Engage the crank with the crank dog.

(4) Position crank handle at 7 o'clock.

(5) Pull crank with hard, steady pull to 12 o'clock.

(6) See that oil pressure is at least 20 psi.

(7) Readjust choke as engine warms up.

d. Load Application.

Apply the load for new and reconditioned engines in 4 steps. Wait 30 minutes between each step. Maximum and thrust on the main bearings should not exceed 1000 pounds.

e. Stopping.

Disconnect as much load as practical from the engine before shut-down. Stop engine having momentary contact stop switch by holding switch to stop position until engine stops completely. Releasing switch before engine is fully stopped will allow engine to continue to run.

f. Inspection.

Make a visual inspection of engine. Check for oil and fuel leaks. Check for excessive vibrations. Be aware of unusual noises.

6. UNUSAL OPERATING CONDITIONS

a. High Temperatures.

(1) See that nothing obstructs air flow to and from the engine.

(2) Keep the cooling fins clean. See that air housings are properly installed and undamaged.

(3) Keep the ignition timing properly adjusted.

(4) Be sure fuel-air mixture gives best operation.

b. Low Temperatures.

(1) Use the proper SAE No. oil for the temperature conditions. Change oil only when warm from running. If an unexpected temperature drop occurs, move the engine to a warm location, or apply heat directly to the crankcase until the oil flows freely.

(2) Use fresh, winter grade (not "premium" type) gasoline. Protect against moisture condensation. Below 0°F, open the carburetor main jet 1 additional turn.

(3) Keep the breaker points and the spark plugs clean and properly adjusted.

(4) Partially restrict the flow of cooling air; however, use care to avoid over-heating.

c. Extreme Dust and Dirt.

(1) Keep the engine clean. Do not allow cooling fins to become coated or obstructed with debris.

(2) Service the air cleaner as frequently as necessary.

(3) Change crankcase oil every 100 operating hours.

(4) Keep oil and gasoline supplies in dust-tight containers.

(5) Keep the governor linkage connections clean.

d. High Altitude.

For operation at altitudes of 2500 feet or more, close the carburetor main jet adjustment slightly to maintain proper air-to-fuel ratio. Refer to paragraph 11 e. Maximum power will be reduced approximately 4 per cent for each 1000 foot increase to altitude.

7. PROTECTION OF ENGINE FOR EXTENDED PERIODS

a. General.

Unless otherwise directed by pertinent governing specifications, use the following procedure to protect an engine (only) that is to be out of service for more than 30 days.

b. Protection Procedure.

(1) Run the engine until thoroughly warmed up.

(2) Turn off the fuel supply and run until the engine stops from lack of fuel.

(3) Drain the oil from the oil base while still warm. Attach a warning to refill before operation.

(4) Remove each spark plug. Pour 1 oz. (two tablespoons) of rust inhibitor (or SAE #50) oil into the cylinder. Crank the engine over a few times. Leave at top center position. Reinstall each spark plug.

(5) Service the air cleaner.

(6) Lubricate the governor linkage. Protect against dust etc. by wrapping with a clean cloth.

(7) Plug the exhaust outlet to prevent entrance of moisture or dirt.

(8) Wipe the entire unit clean. Coat parts likely to rust with a light film of grease or oil.

(9) Provide a suitable cover for the entire unit.

SECTION III

GENERAL MAINTENANCE, REPAIR AND REBUILD

8. PREVENTIVE MAINTENANCE

a. General.

Routine periodic service is important. The following tabulated maintenance is recommended to keep the engine in good operating condition and is based on units operating under favorable conditions. Use the tabulation as a guide, and revise it so the schedule of service periods become valid for the engine under prevailing operating conditions.

SERVICE ITEMS	INTERVAL (HOURS) 8	100	200	500	1000	5000	SERVICES NOTES b. below/PARS
Inspect Engine Generally	x						(1)
Check Fuel Supply	x						(2)
Check Oil Level	x						(3)
Lubricate Governor Linkage		xa					(4)/par. 13
Service Air Cleaner Foam type			xa				(5)/par. 11i.
Change Crankcase Oil		b	x				(6)/par. 14
Crankcase Breather			x				14g
Clean and Adjust Spark Plugs			x				(7)/12f.
Check Breaker Points			x				(8)/12e.
Empty Fuel Sediment Bowl			x				(9)/(11)
Check Valve Clearance	d			x			(11)/(16)
Replace Oil Filter			c	x			(10)/ 14
Clean Carburetor				x			(11)/ 11
Clean Engine					x		10a.
Clean Rocket Box Oil Line Holes					x		(11)/ 14d.
Clean Combustion Chamber					x		(11)/ 11a. 16a.
Grind Valves					x		(11)/ 16
Complete Reconditioning						x	(11)

a. . . .Service more often under extreme dust conditions.
b. . . .See service note para.b(6)
c. . . .See service note para.b(10)
d. . . .Tighten head bolts and adjust valve clearance after first 50 hours on a new or overhauled engine.

b. Service Notes.

These supplement the service tabulation (para. a. above).

(1) Inspection. Check for leaks, loose connections, etc. Keep engine clean.

(2) Fuel Supply. Check supply to avoid running out of fuel. Never fill tank while engine is running. Use clean, fresh "regular" grade gasoline. Never fill completely; allow some space for expansion.

(3) Oil Level. Keep level to the F (fill) mark on the indicator, when adding, use the same brand as in crankcase.

(4) Governor Linkage. Use lubricating graphite on the ball joint, and link-to-throttle. If graphite is not available, use a light sewing machine type oil.

(5) Air Cleaner. (refer para 11f.). Foam type - Wash element in gasoline or diesel fuel every 200 hours. Saturate with SAE 20W motor oil, and squeeze as dry as possible.

(6) Crankcase Oil. Change oil only when warm after operating. If oil is too cold to flow, do not start engine. Move to a warm location or apply heat externally until oil flows freely. The oil filter is a full-flow type. Change the oil every 100 operating hours under the following conditions: extremely low temperatures, short periods of operation, when using highly leaded gasoline, extremes of dust and dirt.

(7) Spark Plug. Remove spark plugs. Clean and adjust electrode gap. If engine runs rough or if plug fails to pass a standard test, install new spark plugs.

(8) Breaker Points. Refer to paragraph 12 for correct gap distances. Replace burned or faulty points. If only slightly burned, dress smooth with file or fine stone. Measure gap with thickness gauge. Ignition breaker points must be correctly gapped. Crank engine to fully open breaker points. Loosen and move stationary contact to correct the gap. Retighten and recheck gap. Ignition points should break contact just when timing mark aligns for degree of spark advance specified in clearances. Replace condenser if spark is weak or if points burn readily.

(9) Fuel Sediment. Empty carburetor and fuel filter (strainer) bowls of any accumulated sediment. Clean filter screen thoroughly. Reassemble and check for leaks.

(10) Oil Filter. The oil filter is a full-flow type (all oil is filtered enroute to bearings). A by-pass permits unfiltered oil to reach bearings if filter

becomes clogged. Place a drip pan below filter. Unscrew oil filter counter-clockwise using both hands or a filter wrench (box or strap type). Clean filter mounting area. Turn new filter on hand tight, then a 1/4 turn further using a filter wrench. Change the oil filter more often if, because of freezing temperatures or extreme dust conditions, the oil becomes so black and dirty the markings on the level indicator can't be seen through the oil.

(11) Major Engine Service. Remove carbon and lead deposits from combustion chamber, valves, etc. as often as experience dictates, depending on operating conditions. Adjust valve clearances when cold. Flush rocker box cover oil line in fuel, and clean small holes using fine wire (do not enlarge holes). Clean entire engine to insure efficient cooling and operation. Perform other services as inspection or operation shows necessary.

9. TROUBLE SHOOTING

a. A good rule to follow in locating engine trouble is to never make more than one adjustment at a time. Stop and think how the engine operates, and figure out the probable cause of any irregular operation. Then locate the trouble by a process of elimination. In many instances, a symptom indicating trouble in one unit may be caused by improper function of a closely related unit or system. Remember that the cause is usually a simple one, rather than a mysterious and complicated one.

b. If a general tune-up is found necessary, perform necessary operations in this sequence: Spark Plugs, Ignition Cables, Ignition Points. Ignition Timing, Valve Clearance, and Carburetor.

Chart 1. ENGINE TROUBLE SHOOTING

TROUBLE	POSSIBLE CAUSE	REMEDY
Engine cranks too slowly	Oil in crankcase too heavy for low temperature	See para. 14 a. for oil recommendations
Engine cranks but won't start	Fuel system faulty	Refill tank
	Gasoline fuel	
	No fuel in tank	Refill tank
	Filter screen clogged	Clean filter (para. 11)
	Water in fuel	Replace fuel
	No gasoline at carburetor	See Trouble-Shooting Chart 2
	Defective fuel pump	
	Carburetor choked too much	Check choke adjustment (para. 11d.)
	Engine flooded	Correct operating procedures or adjust choke
	General	
	Ignition system faulty	See Trouble-Shooting Chart 3
	Poor Compression	See Trouble-Shooting Chart 6 and par 16 g.
	Poor Fuel	Change fuel
	Wrong timing	Retime
	Air intake restricted	Clean air cleaner. (para 11h.)
Engine hard to start	Restricted air intake	Clean air cleaner (para 11h.)
	Poor fuel	Change fuel
	Defective ignition system	See Trouble-Shooting Chart 3

Chart 1. ENGINE TROUBLE SHOOTING (cont)

TROUBLE	POSSIBLE CAUSE	REMEDY
Engine hard to start (cont)	Incorrect timing	
	Defective fuel pump	Repair or replace fuel pump - For tests see para.11c.
	Poor compression	See Trouble-Shooting Chart 6 and para 16b.
Engine misses and backfires but fails to start	Water in gasoline	Change fuel
	Air leaks around intake manifold	Inspect all gaskets on manifold
	Improper firing order	Inspect ignition distributor system
	Ignition timing incorrect	Retime ignition
	Moisture on breaker points	Clean points
Engine races (stop engine immediately by closing throttle)	Too much fuel caused by:	
	Disconnected governor mechanism	See para. 13 & Trouble-Shooting Chart 4
	Defective governor	
	Incorrect governor adjustment	See para 13 & Trouble-Shooting Chart 4
Engine stops unexpectedly	Vapor lock in fuel line, fuel pump or carburetor	Allow engine to cool; check for possible over-heating, (para. 10b).
	Defective ignition	See Trouble-Shooting Chart 3
	Lack of fuel	Refill tank
	Internal seizure	To test, crank by hand. Disassemble and repair
	Excessive crankcase pressure, caused by clogged breather	Remove and clean breather
Low engine power	Restricted air intake	Clean air cleaner
	Poor fuel	Change fuel (para. 11a).
	Poor compression	Check compression, para 16b. and Trouble-Shooting Chart 6
	Defective ignition (engine not firing on all cylinders)	See Trouble-Shooting Chart 3

Chart 1. ENGINE TROUBLE SHOOTING (cont)

TROUBLE	POSSIBLE CAUSE	REMEDY
Low engine power (cont)	Incorrect ignition timing	See Trouble-Shooting Chart 3
	Improper choke operation	See para 11d.
	Heavy carbon deposits in cylinders	Clean cylinders, See para 11a.
	Faulty carburetion	See Trouble-Shooting Chart 2
Engine misses at light load	Spark plug gaps too narrow	Set at .025''
	Intake air leak	Inspect intake manifold and carburetor
	Faulty ignition system	See Trouble-Shooting Chart 3
	Uneven compression	See para 16b.
	Spark plugs defective	See para 12f.
	Clogged carburetor idle jet	Clean carburetor
	Defective high tension cables	Inspect and replace if necessary
Engine misfires at heavy load	Spark plug gap too wide	Adjust to .025
	Clogged carburetor	Clean carburetor (para 11e).
	Clogged fuel screen	Clean (para. 11b).
	Valve lash too tight	Adjust lash (para 17a).
	Defective ignition system	See Trouble-Shooting Chart 3
Engine backfires	Poor fuel	Change fuel
	Clogged fuel screen	Clean (para. 11g).
	Spark too late	Time ignition
	Leaking intake valve	Check compression
	Improper firing order	Inspect ignition distributor system (correct order 1-2-4-3)
	Lean Fuel Mixture	Adjust carburetor (para 11e).
Excess oil consumption, light blue smoky exhaust	Poor compression	See Trouble-Shooting Chart 6 and para 16b.
	Crankcase oil too light or diluted	Change to correct oil, para 14a. If diluted see Trouble-Shooting Chart 5.

Chart 1. ENGINE TROUBLE SHOOTING (cont)

TROUBLE	POSSIBLE CAUSE	REMEDY
Excess oil consumption, light blue smoky exhaust (cont)	Engine misfiring	See Engine Misfiring this chart
	Excess oil in crankcase	Drain to full level
	Engine overheating	See para. 10b.
	Defective intake valve stem oil seal	Replace (para. 16)
	Worn intake valve, guide or valve stem	Replace (para. 16)
	Faulty ignition	See Trouble-Shooting Chart 3
Excess oil consumption, no increase in smoke	Oil leak from oil base or connections	Inspect engine; check for clogged crankcase breather
	Leaky crankshaft oil seals	Inspect oil seals, para 18b. (2) and 18e. (5). Check for clogged crankcase breather
Black, smoky exhaust, excessive fuel consumption fouling of spark plugs with black soot, possible lack of power under load.	Fuel mixture too rich	Adjust carburetor, para 11e.
	Choke not open	See para 11d.
	Clogged air intake	Clean air cleaner, para 11 i.
Dull, metallic thud; if not bad may disappear after few minutes of operation	Worn crankshaft bearing	Replace bearing
Sharp, metallic thud, especially when cold engine first started	Low oil supply	Add oil
	Oil badly diluted	Replace oil
Tapping sound, clacking, light clicking	Valve clearance too great	Check valve clearance para 16a.
	Broken valve spring	Replace valve spring
Metallic knock under no load conditions and when stopping	Worn connecting rod bearings	Replace bearings
Hollow clicking sound with engine cool and under load	Loose piston	Check piston clearance
Light pounding knock	Loose connecting rod bearing	Replace bearings
	Low oil supply	Add oil, check for cause of low oil
	Oil badly diluted	Replace oil
Pinging sound when engine is suddenly or heavily loaded	Carbon in cylinder	Remove carbon
	Spark too early	Adjust breaker points. Retime spark if necessary

Chart 1. ENGINE TROUBLE SHOOTING (cont)

TROUBLE	POSSIBLE CAUSE	REMEDY
Pinging sound when engine is suddenly or heavily loaded (cont)	Wrong spark plug	Install correct spark plug
	Valve hot	Adjust valve clearance
	Fuel stale or low octane	Use good, fresh fuel
	Lean fuel mixture	Clean and adjust carburetor
	Engine hot	Check air circulation
Engine overheats (see para 10b.)	Defective ventilating system	Check engine and ducts
	Defective installation	Inspect complete installation including ducts etc.
	Improper lubrication	Check oil system
	Late ignition timing	Retime ignition
	Fuel mixture too lean	Adjust carburetor (para 11e).
Low or high oil pressure	See Trouble-Shooting Chart 5	
Spark plug fouled in short periods of time on gasoline operation	Wrong spark plug gap.	Clean spark plugs and set at 0.025"
Speed fluctuations or incorrect speed	See Trouble-Shooting Chart 4 & para 13.	

10. VENTILATION SYSTEM

a. Maintenance.

A pressure type of air cooling system is used to remove heat produced during normal operation. Air is drawn into the blower housing at the front of the engine and forced by blades on the flywheel past the cylinders to a discharge on the right side of the engine. All components in the ventilation system are essential for adequate cooling of the engine. (fig. A-3)

Check all parts for proper installation. Clean the engine cooling fins as required by operating conditions to maintain efficient heat transfer to the circulating air. Check for broken flywheel blades and cylinder fins. Refer to paragraph b. for indicators of overheating. Make this maintenance a part of your regular periodic inspection and repair program.

b. Overheating.

Sometimes difficult to detect, overheating of air-cooled engines is usually indicated first by recurrent vapor locks and later by piston scoring. The 3 most probable causes of overheating are: (1) dirty cooling surfaces, (2) operating without the engine air housing, and (3) insufficient air flow resulting from incorrect location or size of vents.

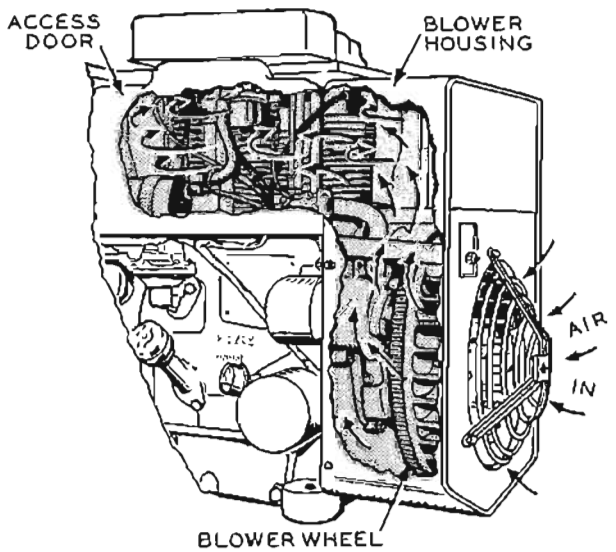


Figure A-3. Typical Engine Cooling Air Flow

CAUTION

The air housing, including the access door, must be properly installed when the engine is running. Major damage could occur within only a few minutes of operating without it.

11. FUEL SYSTEM

a. Description and Fuel.

This engine has a conventional gasoline fuel system (fig. A-4). A fuel pump and carburetor are used to supply a metered fuel-air mixture to the combustion chamber. A manual choke is used instead of an electric type. Regular grade gasoline should be used in these engines; they don't need premium gasolines. One of the most important things to consider is the content of Tetra Ethyl Lead in the fuel. Premium fuels contain more lead than regular, but the lead quantity also varies among the many brands of fuel. Especially in constant speed operation, the build up of deposits in the combustion chambers is proportional to the amount of lead in the gasoline. So more lead means more deposits and more frequent head removal for cleaning. On engines that require frequent combustion chamber cleaning, the period between cleaning can often be extended by changing fuel.

If fuel is stored for any great length of time, it can oxidize and form gums - the fuel becomes stale. ONAN recommends changing stored fuel as often as every season to insure fresh fuel, especially where there is a great change in weather between seasons.

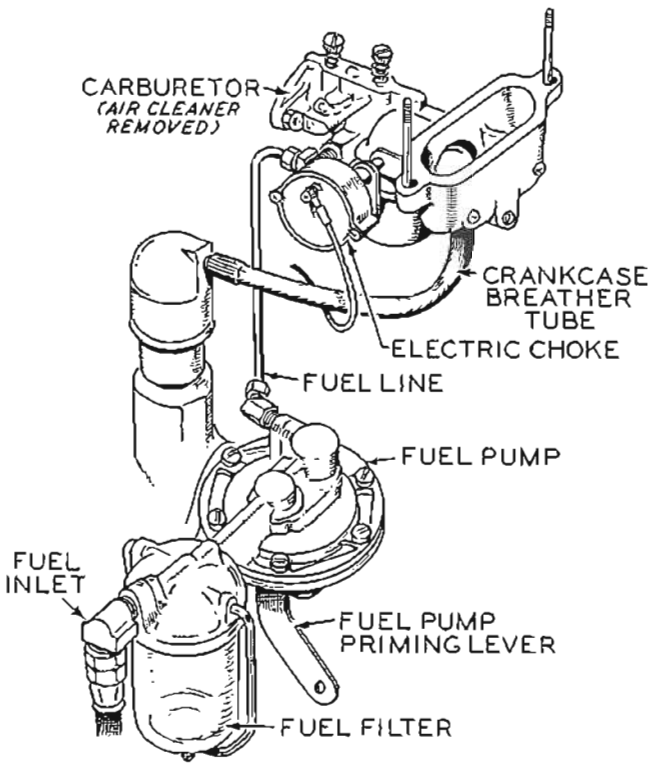


Figure A-4. Engine Gasoline Fuel System (Electric Choke Shown Not Used, Refer To Figure A-8 For Manual Choke)

b. Maintenance.

For gasoline fuel systems, periodic maintenance should consist of cleaning the fuel strainer, cleaning or replacing the air cleaner (para. i. below) and cleaning and adjusting the carburetor. For service periods, see paragraph 8.

To clean the fuel strainer, remove the fuel sediment bowl and the screen (fig. A-5) and thoroughly wash the screen. At the same time, remove the carburetor float bowl and clean it. Reassemble and check for leaks.

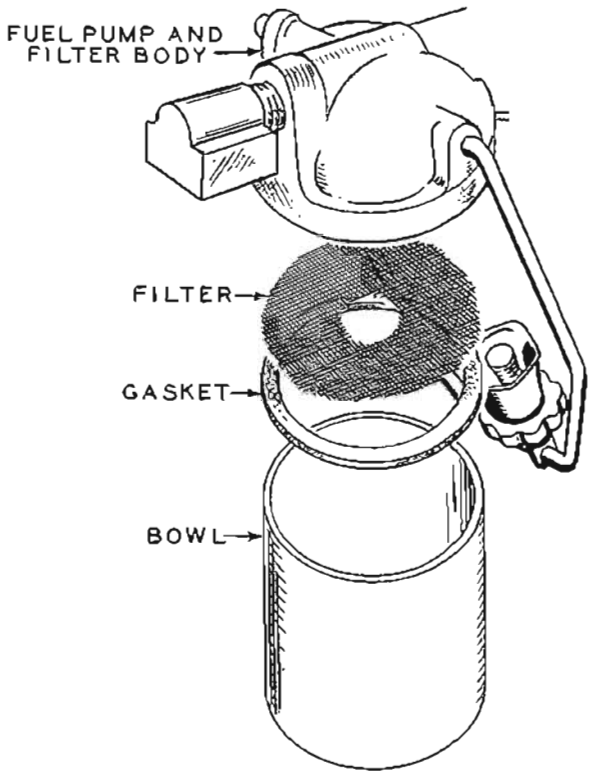


Figure A-5. Primary Filter

c. Gasoline Fuel Pump.

The fuel pump is on the accessory side of the engine. If fuel doesn't reach the carburetor: check the fuel tank and see that fuel valve is open; remove the line from the pump outlet and work the priming lever on the pump (if no primer, crank engine). Fuel should spurt from the pump; but if not, remove the pump for repair or replacement.

(1) Testing. If the fuel pump delivers fuel, test it with a pressure gauge or manometer. Perform these tests before removing the pump from the engine. Disconnect the pump outlet line and install a pressure gauge (fig. A-6).

Test the valves and diaphragm by operating the priming lever a few times and watching the pressure. It shouldn't drop off rapidly after priming has stopped.

Next run the engine at governed speed of 1/2 throttle on the fuel remaining in the carburetor, and measure the fuel pump pressure developed. Pressure should be between 2 and 3 psi with the gauge about 16" above the fuel pump.

A low pressure reading indicates extreme wear in one part or some wear in all parts, and the pump should be overhauled or replaced. If the reading is above maximum, the diaphragm is probably too tight or the diaphragm spring too strong. This can also be caused by fuel seeping under the diaphragm retainer nut and between the diaphragm layers, causing a bulge in the diaphragm. Overhaul the pump and replace the defective parts.

Low pressure with little or no pressure leak after pumping stops indicates a weak or broken spring or worn linkage, and in most cases the pump should be replaced.

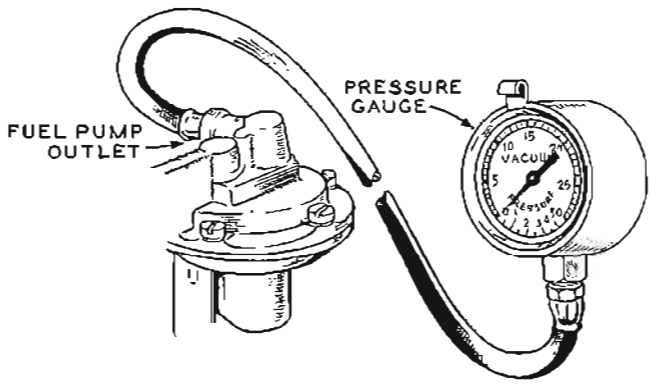


Figure A-6. Measuring Fuel Pump Pressure.

(2) Removal & Disassembly (fig. A-7).

(a) Remove the pump inlet and outlet. Remove the 2 capscrews holding the pump to the engine and lift it off.

(b) Notch the pump cover and body with a file so they can be assembled in the same relative position, and remove the 6 screws holding them together.

(c) Tap the body with a screwdriver to separate the 2 parts. Don't pry them apart - this would damage the diaphragm.

(d) Remove the screws holding the valve plate to the cover and lift out the valve and cage assemblies.

(e) Drive out the rocker arm hinge pin.

(f) Remove the rocker arm, spring and link.

(g) Lift out the diaphragm assembly and diaphragm spring.

(3) Repair. Fuel pump failure is usually due to a leaking diaphragm, valve or valve gasket. A kit is available for replacement of these parts. Because the extent of wear cannot be detected by the eye, replace all parts in the kit. If the diaphragm is broken or leaks, check for diluted crankcase oil. Occasionally, failure is due to a broken or weak spring or wear in the linkage. In those cases, install a new pump.

(4) Assembly.

(a) When installing a new diaphragm, soak it in fuel before assembling. Insert the diaphragm spring and soaked diaphragm into the pump body.

(b) Insert the link and rocker arm into the body; hook it over the diaphragm pull rod. Align the rocker arm with the rocker arm pin hole and drive in the pin. The priming lever must be in the position shown in figure A-7 when installing the rocker arm.

(c) Compress the rocker spring and install between the body and rocker arm.

(d) Insert the valve cages, gaskets, and valve cover plate. Position the inlet valve with spring showing and the outlet valve with spring in the cover recess.

(e) Assemble the cover to the body with notch marks lined up. Install the screws but don't tighten.

(f) Push the rocker arm in full stroke and hold it in this position to flex the diaphragm. NOTE: The diaphragm must be flexed or it will deliver too much fuel pressure.

(g) Tighten the cover screws alternately and securely, then release the rocker arm.

(h) Install the pump on the engine; be careful to get pump arm over cam on camshaft. Repeat the pressure test, paragraph c. (1) above.

d. Manual Choke (fig. A-8).

A manual choke is provided at the front of the engine. It is used to reduce the amount of air entering the carburetor. Pulling choke out reduces air in fuel-air mixture. Pushing in provides a balanced fuel-air mixture. It is adjusted as may be required by operating conditions.

e. Carburetor.

The gasoline carburetor is a horizontal draft type, with an upturned intake horn (air cleaner adapter). The carburetor consists of 3 major sections - the bowl and float, the idle circuit, and the load circuit.

Fuel enters the carburetor through the inlet valve (fig. A-9) and passes into the float chamber. To control the fuel level in the bowl, the float closes the inlet valve when fuel reaches a certain height, and opens it when the fuel lever drops.

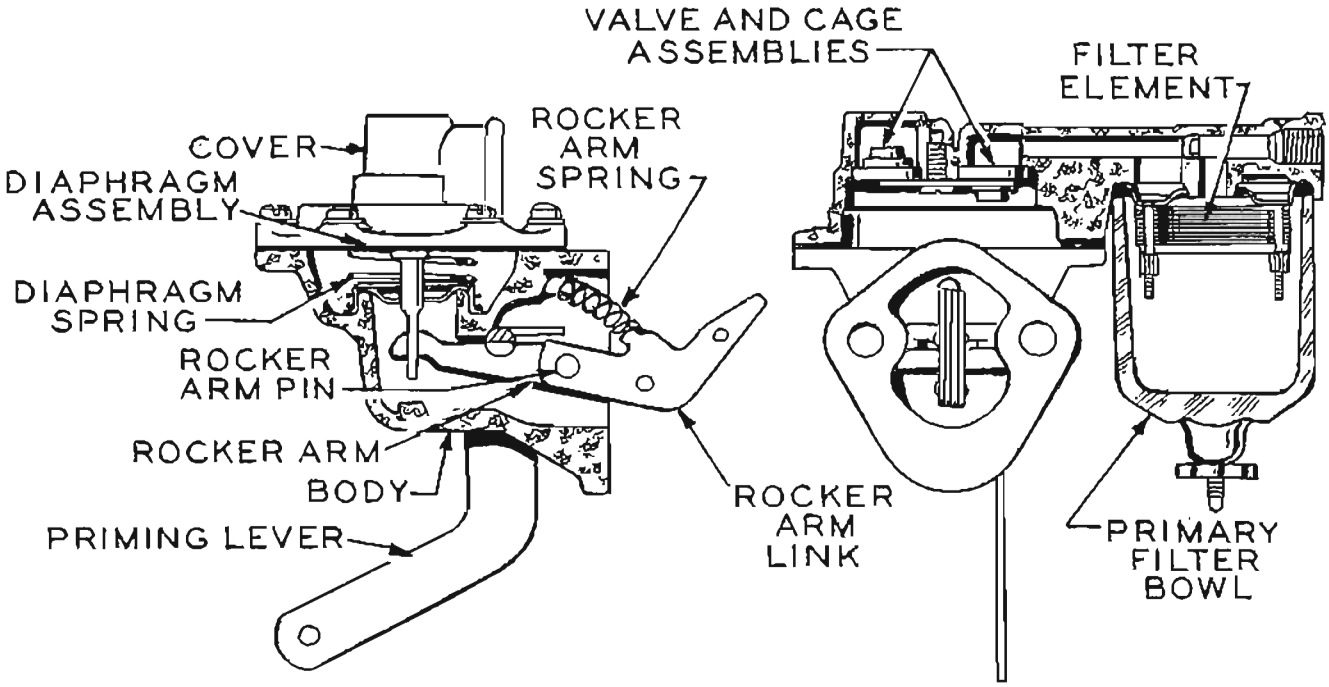


Figure A-7. Cross Section Of Fuel Pump.

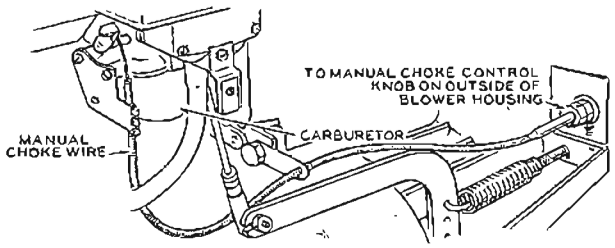


Figure A-8. Manual Choke.

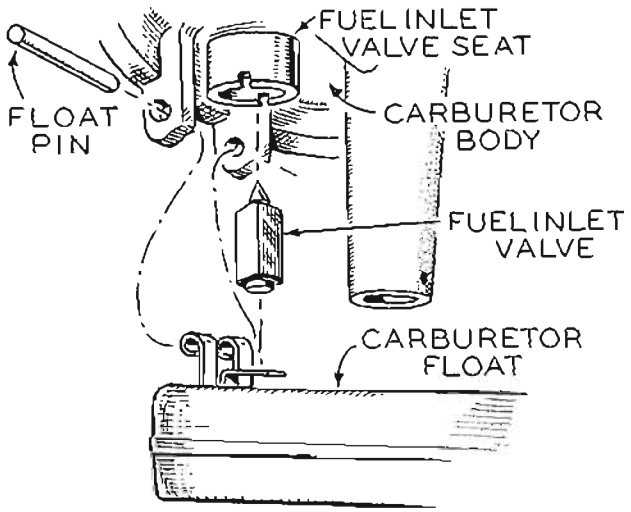


Figure A-9. Carburetor Inlet Valve.

The idle circuit (fig. A-10) supplies fuel at idling speed. Since the throttle plate is nearly closed at idle, the intake manifold vacuum is high. The pressure difference between the manifold and float chamber causes fuel to flow through the idle circuit. The pressure difference draws fuel up through the hollow center of the main adjusting needle, through passages in the carburetor body to the idle ports. Bleed holes in the main adjusting needle allow air to bleed in and mix with the fuel. When the throttle is almost completely closed, the fuel passes out through the idle port which is controlled by the idle adjusting needle. As the throttle is opened to increase power, it gradually exposes the idle transfer port through which fuel is also drawn.

As the engine governor opens the throttle further under increased load, the increased air flow through the carburetor produces a low pressure at the venturi (narrow section of the carburetor throat). This pressure drop draws fuel up the main nozzle to be mixed with air at the nozzle opening. This is the load circuit (fig. A-10); the main adjusting needle controls its fuel delivery.

At the same time, because the throttle is open, the manifold vacuum decreases so the idle circuit becomes less effective. In a certain range, the two circuits blend, both delivering fuel, but as load is increased, the load circuit takes over.

Whenever load is increased, with the load circuit in operation, the governor opens the throttle to deliver more fuel. The main nozzle won't immediately deliver this increased fuel because of the jet controlled by the adjusting needle. To prevent a power lag when load is increased, a metering wall around the outside

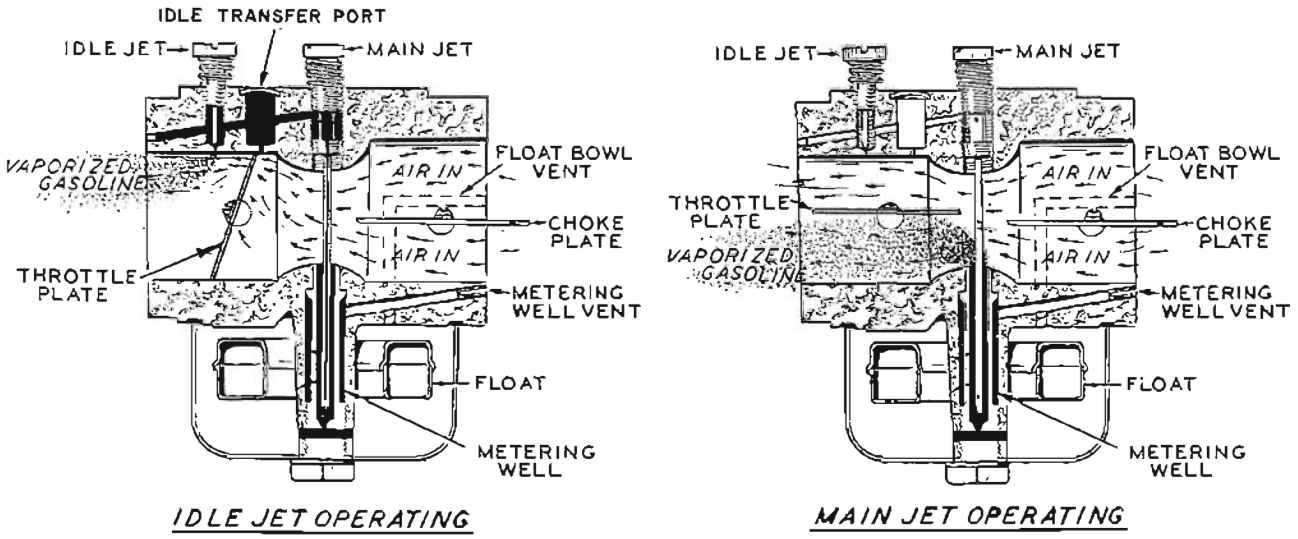


Figure A-10. Carburetor Idle Circuit (Left) And Main Load Circuit (Right).

of the nozzle delivers fuel until the main jet can catch up with the increased demand.

(1) Adjustment. Adjusting the carburetor means obtaining the correct fuel-to-air mixture for smooth, efficient operation. The carburetor should be adjusted in 2 steps - first the idle adjustment, and then the load adjustment. NOTE: If the carburetor is completely out of adjustment so the engine won't run, open both needle valves 1 to 1-1/2 turns off their seats to permit starting. Don't force the needle valves against their seats. This will bend the needle.

Before adjusting the carburetor, be sure the ignition system is working properly and the governor is adjusted. Then allow the engine to warm up.

(a) With the engine idling, turn the idle adjustment out until the engine speed drops slightly below normal. Then turn the needle in until speed returns to normal.

(b) Apply a full load to the engine.

(c) Over-ride the governor and check acceleration. If the engine accelerates evenly without a lag, the main adjustment is correct. If not, adjust the needle outward about 1/2 turn and again check acceleration. Continue until the engine accelerates evenly without a time lag.

Finally, set the throttle stop screw (fig. A-11) to allow 1/32" clearnace to the stop pin with the engine running at no load. This prevents excessive hunting when a large load is suddenly removed.

(2) Removal and Disassembly.

(a) Remove the air housing door and top panel.

(b) Remove the fuel line, governor linkage and choke cable.

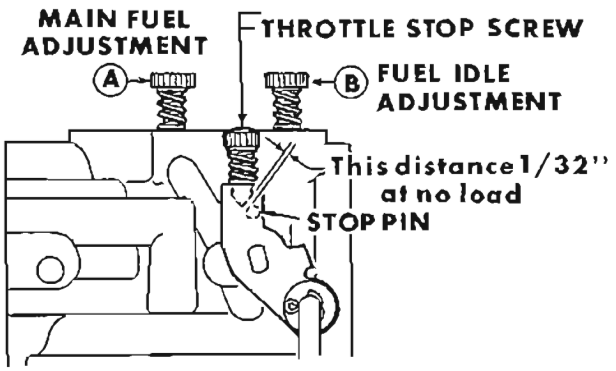


Figure A-11. Carburetor Adjustments.

(c) Remove the 2 carburetor mounting nuts and pull off the carburetor.

(d) Remove the air cleaner adapter from the carburetor.

(e) Remove the float bowl nut and pull off the bowl.

(f) Remove the float pin and float.

(g) Lift out the float valve and unscrew its seat.

(h) Remove the no load adjusting needle.

(i) Remove the load adjusting needle and spring.

(j) Remove the throttle plate screws and the plate, and pull out the throttle shaft.

(k) Remove the choke plate screws and plate, and pull out the choke shaft.

(3) Cleaning and Repair. To clean the carburetor, soak all components thoroughly in a good carburetor cleaner, following the cleaner manufacturer's instructions. Be sure all carbon is cleaned from the carburetor bore, especially in the area of the throttle valve. Blow out the passages with compressed air. If possible, avoid using wire to clean out the passages.

Check the adjusting needles and nozzle for damage. If the float is loaded with fuel or damaged, replace it. The float should fit freely on its pin without binding. Invert the carburetor body and measure the float level (fig. A-12).

If necessary, bend the small lip that the intake needle rides on to adjust float level.

Check the choke and throttle shafts for excessive side play, and replace if necessary. Don't remove the coating (olive drab color) on the throttle shaft. This is Teflon, used to reduce wear and friction between the shaft and carburetor body.

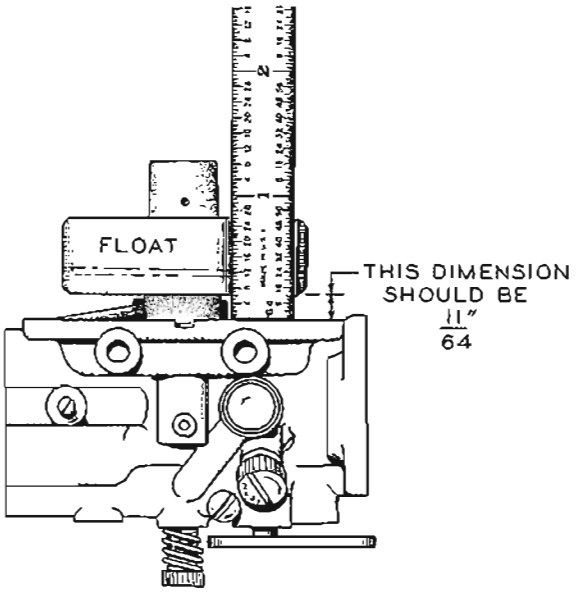


Figure A-12. Measurement Of Carburetor Float Level.

(4) Assembly and Installation.

(a) Install the throttle shaft and valve, using new screws, (as shown in fig. A-10, left) with bevel mated to the carburetor body. On valve plate marked with the letter "C", install them with the mark toward the idle port when viewed from the flange end of the carburetor. To center the valve, back off the stop screw, close the throttle lever, and seat the valve by tapping it with a small screw driver; then tighten the 2 screws.

(b) Install choke shaft and valve. Center the valve in the same manner as the throttle valve (Step (1)). Always use new screws.

(c) Install the main nozzle, making sure it seats in the body casting.

(d) Install the intake valve seat and valve.

(e) Install the float and float pin. Center the pin so the float bowl doesn't ride against it.

(f) Check the float level with the carburetor casting inverted (fig. A-12 & par (3) above).

(g) Install the bowl gasket, bowl and bowl nut. To ensure satisfactory fuel delivery, be sure gasket is in place; tighten the nut.

(h) Install the load adjusting needle with its spring. Turn in until it seats and back out 1 to 1-1/2 turns.

(i) Install the idle adjusting screw finger tight. Then back out 1 to 1-1/2 turns.

(j) Install the air horn assembly and gasket.

(k) Install the carburetor on the engine and connect the gasoline inlet, governor mechanism, breather hose, and choke.

(l) Install the air cleaner and the air housing.

f. Air Cleaner (fig. A-13).

This consists of a foam element over a metal retainer. About every 200 hours, remove the foam element and wash it thoroughly in gasoline. Then dip it in crankcase oil and squeeze as dry as possible. Replace element only if damaged.

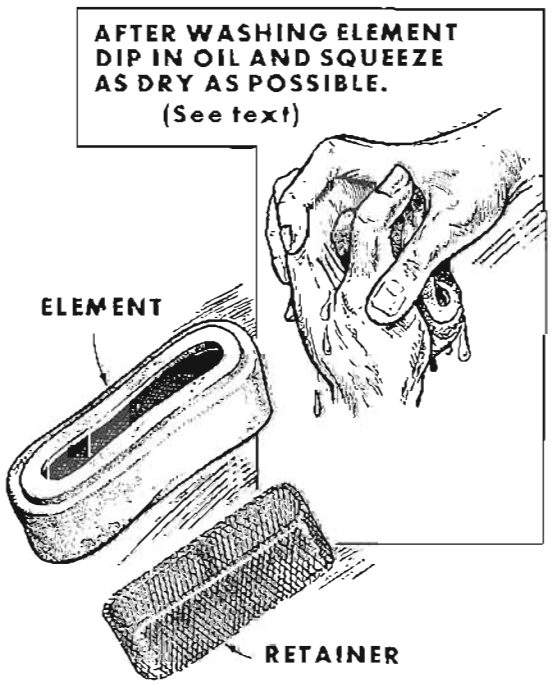


Figure A-13. Foam Element Type Air Cleaner.

Chart 2. FUEL SYSTEM TROUBLE SHOOTING

TROUBLE	POSSIBLE CAUSE	REMEDY
No fuel to carburetor	Vapor lock in fuel line or pump	Allow engine to cool; para. 10b.
	Defective fuel pump	See para 11c. (1)
	Restricted fuel line	Clean or replace
	Clogged fuel strainer	Clean, (para 11b.) adjust service periods and check source of contamination
Flooding	Overchoking	Adjust or repair choke
	Incorrect adjustment of carburetor float level	See para. 11e. (3)
Excessive fuel consumption	Engine overloaded	Reduce load
	Poor compression	See para 16b.
	Carburetor out of adjustment	Adjust carburetor

12. IGNITION SYSTEM

a. Testing.

The purpose of the ignition system is to produce a spark in each cylinder at the correct time to ignite the fuel-air mixture. The most complete test for an ignition system is to check the final result, spark on the spark plugs. Remove each plug in turn, reinstall the ignition wire to that plug and hold the plug base against a good ground on the engine. Then crank the engine and watch the spark. A good blue spark indicates a healthy ignition system, a weak or yellow spark or no spark, a poor ignition system. The defect can be caused by defective breaker points, coil condenser, or wiring. A good spark on all but 1 cylinder indicates a defective spark plug or defective high tension wire.

b. Gear Driven Magneto (Fig A-14).

This magneto has an impulse coupling which serves as a spark retard device, in addition to providing a hot spark at manual cranking speeds. It is a self contained unit in which a voltage is produced in the primary windings of a coil multiplied in the secondary winding of the same coil and distributed to the spark plugs. It serves the same purpose as the battery, coil, and distributor in a battery ignition system.

The rotating member of the magneto comprises the impulse mechanism, a permanent magnet, a breaker cam, and a pinion gear. Other parts include a laminated core, coil, condenser, breaker points, distributor arm gear, distributor cap, and a stop lever. All these components, except the laminated core, can be removed when necessary for service and repair. In operation, the laminated core is magnetized by the revolving magnet to produce a voltage in the primary windings.

When the breaker points open to interrupt current flow in the primary, a voltage is induced in the secondary. The high voltage produced in the secondary flows to the distributor arm gear, which in turn distributes high voltage at the proper time to the spark plugs, where it jumps the gap to ignite the fuel.

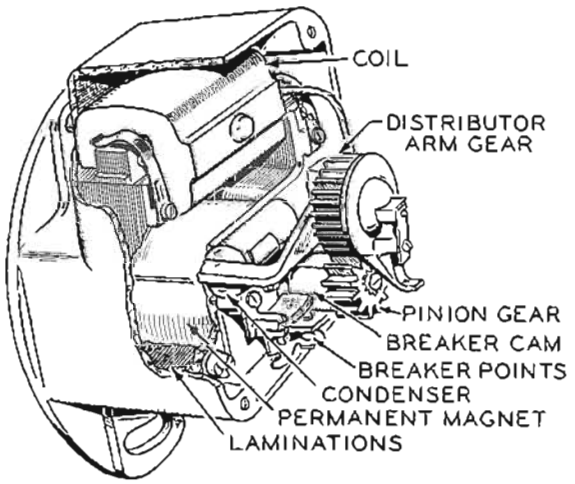


Figure A-14. Cutaway View Of Impulse Magneto

(1) Maintenance. - Check the breaker points periodically for pitting and for the proper clearance of .015". If the contacts are dirty, clean them with lacquer thinner or any other suitable solvent. If the contacts are badly pitted, replace both the movable and stationary parts.

(2) Testing. A simple test to determine magneto performance is to hold one of the spark plug leads about 1/4" from a good groun while cranking the engine. If no spark occurs between the lead and ground, test the coil, rotor, points, and condenser. Make sure the stop button is not grounded.

(a) Coil (fig. A-15). This procedure is for the Eiseman coil tester. Remove the coil from the magneto; leave the laminated core in place in the coil. Connect the ground lead of the tester to the bare ground wire of the coil and connect the breaker lead of the tester to the insulated primary wire of the coil. Finally, connect the spark lead of the tester to the high tension terminal on the coil. If the coil requires more than 1.5 amperes on the core, replace it.

For the spark output test, set the spark gap at 5 mm. Marginal leak tests should be made with the secondary terminal disconnected from the test lead.

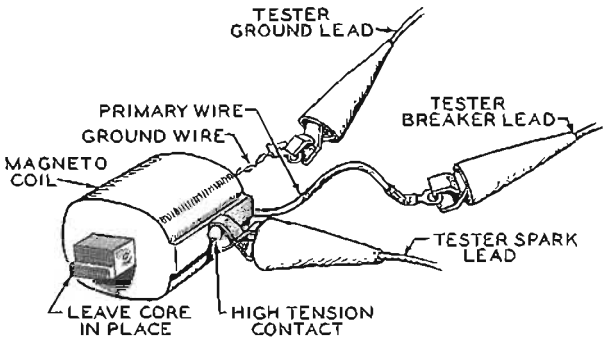


Figure A-15. Connections For Testing The Magneto Coil

(b) Magnetic Rotor. There's no easy way to test the strength of the magnetic field produced by the magnets on the rotor, but chances are if a screwdriver is strongly attracted, the magnetism is satisfactory. Unless the results of the coil test indicate there might be low voltage at the core, look for some other cause of abnormal performance.

(c) Breaker Points. It may be desirable to measure spring tension on the movable contact. Get specification from a Wico representative. Check contact alignment.

(d) Condenser. If a standard condenser tester is available, test the condenser for capacity, breakdown, and low insulation resistance. Otherwise, replace the condenser the same time as badly pitted breaker points.

(3) Disassembly, Repair and Reassembly. A complete breakdown of the impulse magneto in the parts catalog shows component relationships. Use that breakdown to help with the disassembly, repair, and reassembly of this magneto. Only the assemblies which may pose problems are covered here in this manual. Obtain wear specifications from a Wico representative.

CAUTION

Under no circumstances should the screws holding the laminated coil, the distributor arm bridge, and the distributor arm contact bar be removed. These parts demand precise installation by factory trained personnel.

(a) Distributor Arm and Pinion Gear (fig. A-16). Lift the geared distributor arm from its pivot. Remove the screw holding the pinion gear, and lift off the pinion gear. Check these parts for excessive wear. When installing these parts, make sure their timing marks are aligned.

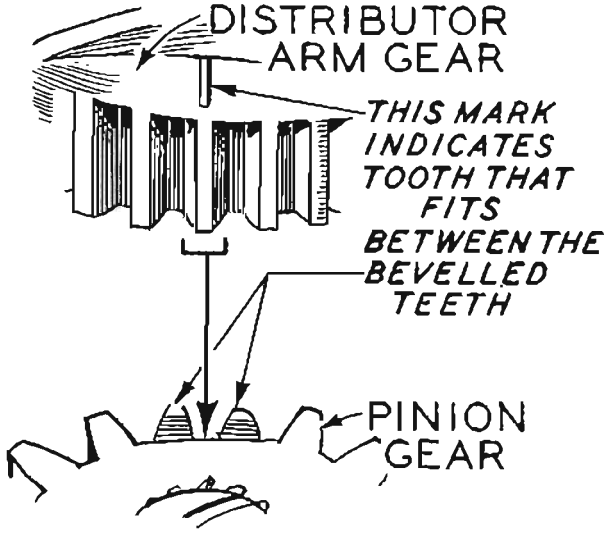


Figure A-16. Timing Distributor Gear.

(b) Rotor. With the pinion gear off, the rotor can be taken out after removing the 4 screws holding the impulse stop. Then grab the drive cup and pull the complete coupling and rotor assembly out of the magneto.

It is practically impossible for the rotor to lose its magnetism. A screwdriver strongly attracted to the rotor is indication of a serviceable rotor.

When re-installing the rotor, make sure the rotor and the inside of the housing are free from dirt and chips. Have the impulse stop on the correct side and the lag angle (Para. (4) (b) below) before tightening the 4 screws.

(c) Drive Cup and Spring. Place the flat sides of the rotor in a brass-jawed vise. Remove the snap ring, thrust washer, and drive gear. Next, turn the drive cup clockwise until the projections on the drive cup clear the projections on the driven flange. Then pull the drive cup outward far enough for the spring to unwind.

CAUTION

There is a pre-load of 1 complete turn on the impulse spring, so be careful when releasing the drive cup. When the spring has unwound, pull the cup, with spring inside, off the shaft.

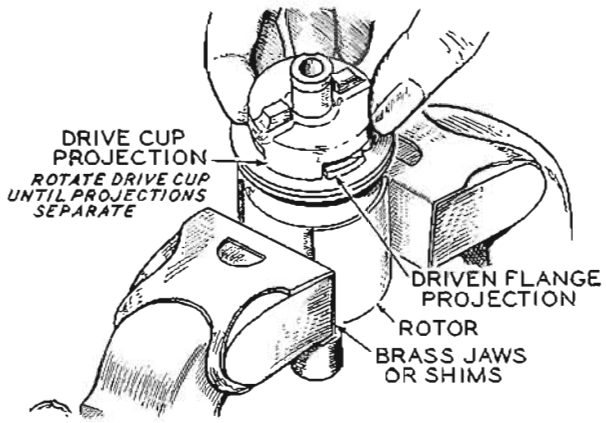


Figure A-17. Removing Dry Cup And Spring.

To get the spring out of the drive cup, use a screwdriver as a pry and work the spring out.

To replace the spring, locate the spring over the cup so the inner eye of the spring is over the slot on the inside wall of the cup. Install the spring so there is a clockwise spiral toward the inner eye. Insert the outer eye as far as possible into the proper slot. Insert the inner eye of the spring in the drive cup spacer slot. With a screwdriver, large enough to bind in the center hole of the spacer, wind the spring around the spacer until the spring slides into the drive cup. (This method of winding the spring eliminates any possiblity of distorting or scratching the spring surface.) The spring may be more easily inserted if the lugs of the drive cup are securely held in a vise.

To re-install the drive cup and spring on the magneto, first make sure all parts are clean. Pack grease between the turns of the spring. Pull the inner eye outward until 1 turn of of the spring stays out of the cup (fig. A-18).

Then place the drive cup on the shaft and engage the inner eye with the notch in the drive cup spacer washer. Push the drive cup in; but keep it out far enough so the projections on the drive cup clear the flange. Set the spring pre-load as follows: make a half turn and allow the cup projections to lock against the driven flange; then with a fresh hold on the drive cup, make the final half turn to give a 1 turn pre-load. Push the drive cup firmly into place. Install the drive gear and snap ring.

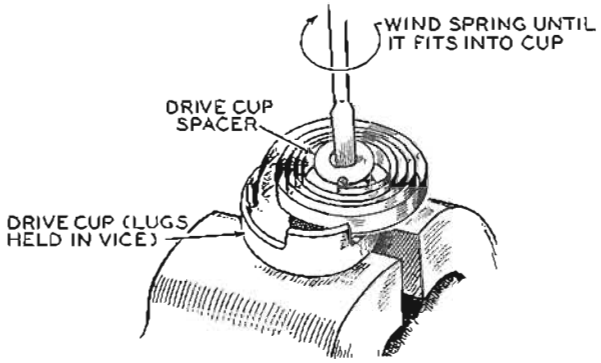


Figure A-18. Installing Drive Spring In Cup.

(d) Driven Flange and Trip Arms. (fig. A-19). The driven flange assembly should pull off easily, but if not, use an arbor press; support the flange with a steel ring under the impulse stop assembly. If the flange has to be pressed off, it will be necessary to install a new oil slinger. To remove the trip arms, push the point of a knife between the trip arm pivot and snap ring, near the opening of the snap ring. With the ring sprung out slightly; the knife can be inserted between the pivot and snap ring, directly opposite from the opening. Use new snap rings to secure the trip arms.

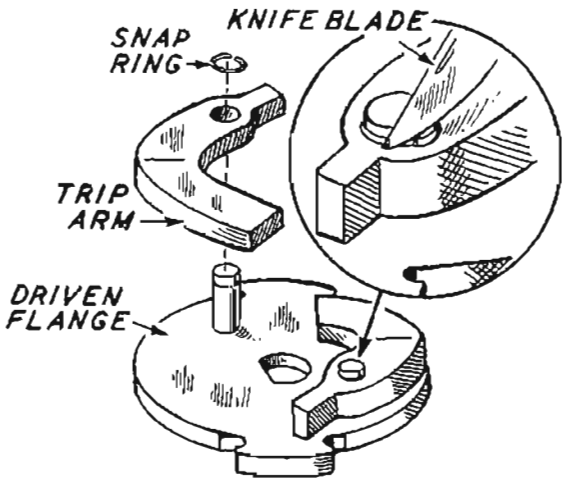


Figure A-19. Driven Fan And Trip Arms.

When re-installing the trip arm snap ring, use a socket, or tubular stock, of a size slightly larger than the pivot, to force the snap ring over the trip arm pivot.

(e) Impulse Stop. See para. (4) (b) below.

(f) Core and Coil. The assembly is held in place by a clamp at each end. To remove the assembly from the magneto, disconnect the primary wire at the breaker points and then remove both clamps. Pull on the coil hard enough to offset the magnetic forces that tend to hold the core to the laminations. If the core must be removed from the

coil, be sure to provide support so the primary will not separate from the secondary when the necessary force is applied to the core. The core is held in by a spring wedge.

(4) Adjustments. There are only 2 adjustments to be concerned with in respect to the magneto as a unit - (1) the breaker point gap and (2) the lag angle.

(a) Breaker Points. Adjust the points for a fully opened clearance of 0.15". Double check the adjustment. Check point timing as explained in paragraph (5) below.

(b) Lag Angle. Lag angle is the rotary distance the point of ignition is retarded during starting. Or it's simply the difference in degrees between ignition at starting (static) and at running. The engines covered by this manual operate with an ignition point of 25°BTC at speeds up to 2700 rpm. Ignition at starting occurs near TDC. It follows that the desired lag angle is 25°C.

Maintain the lag angle adjustment made at the factory. Magnetos on units shipped after 12/1/62 had 2 punch marks (fig. A-20) to indicate the proper relationship between the impulse stop and housing. NOTE - if there are no punch marks on your magneto do not disassemble the magneto until some kind of witness marks are made to ensure correct reassembly.

(5) Timing. Ignition for operation up to 1800 rpm occurs at 25°BTC. During cranking when the impulse coupling is in operation, the ignition point is retarded about 25°. When the engine starts, centrifugal force causes the impulse coupling to be disengaged, resulting in an automatic spark advance to 25°BTC.

Begin by removing the spark plug from No. 1 cylinder and turning the flywheel in the direction of normal rotation until pressure builds up in the cylinder. Then with No. 1 on the compression stroke, continue turning until the 25° mark is aligned with the timing pointer.

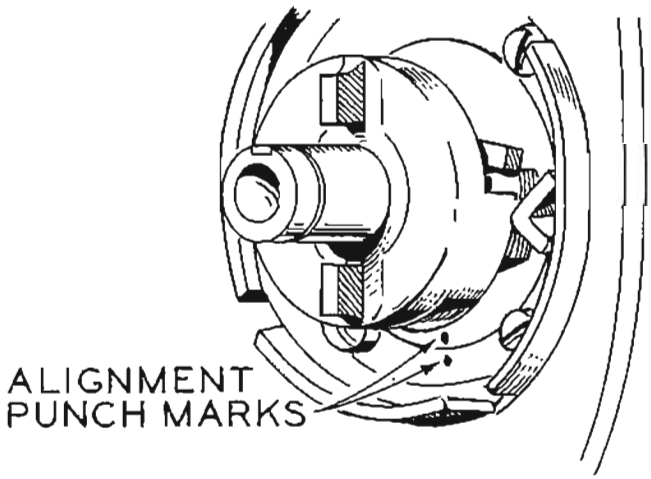


Figure A-20. Lag Angle Punch Marks.

Turn the magneto until the white mark on the rotor is visible in the window of the magneto. The white mark is for positioning the magneto at No. 1 cylinder. With the mounting gasket in place mount the magneto on the studs. Push the magneto in so the gears mesh, it may be necessary to rotate the magneto within the elongated slots before the helical gear engages the cam gear. Tighten the magneto to its mounting for positive movement. Install the spark plug leads. Run the engine and use a timing light to get exact timing. Correct timing is 25°BTC and the white mark on the magneto rotor should also be visible in the window at this position. Move the magneto in the elongated slots for precise location. Tighten the magneto to its mount securely.

c. Spark Plugs.

This engine uses standard automotive spark plugs. Champion H-8 or equivalent. The plugs should be removed at regular intervals for cleaning and inspection. If the plugs are in good condition; they can be cleaned on a commercial plug cleaner and re-gapped. For gasoline operation, the spark plug gap should be set at .025". But when spark plug electrodes become excessively worn or if the plugs are damaged, replace them. When re-installing spark plugs or installing new plugs, always install new gaskets.

Chart 3. IGNITION SYSTEM TROUBLE SHOOTING

TROUBLE	POSSIBLE CAUSE	REMEDY
No spark	Defective breaker points	Inspect points for dirt, burning, pitting. Check clearance
	Defective high tension leads	Replace
	Defective spark plugs	Replace
	Defective magneto coil	Replace

Chart 3. IGNITION SYSTEM TROUBLE SHOOTING (Cont'd)

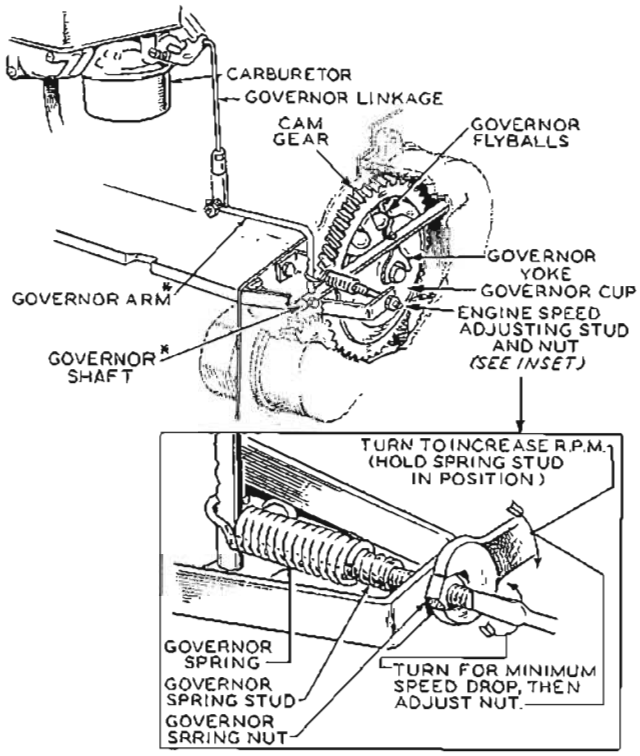
TROUBLE	POSSIBLE CAUSE	REMEDY
Weak, yellow spark - usually causing hard starting	Dirty, burned or pitted breaker points	Clean or replace the points
	Defective ignition condenser	Test and replace if defective
	Defective spark plugs	Replace
	Weak magneto coil	Replace
Excessively burned or pitted ignition points	Dirty points	Keep points clean at all times
	Breaker gap too small	Adjust
	Defective ignition condenser	Check the condenser on a commercial tester
	Using the wrong ignition condenser	Use only the condenser specified
Weak or no spark on some cylinders - usually indicated by engine missing	Defective hi-tension leads	Replace
	Defective spark plug	Clean or replace
Oil fouled spark plugs	Worn rings or pistons	Check compression, (para 16b.)
	Worn valve stems or guides	Check clearance (para 16d.)
	Faulty ignition wires	Replace
	Weak magneto coil	Test and replace if necessary
	Too cold a plug	Replace with hotter plugs
Gas fouled plugs (dry black fluffy deposit)	Excessive choking	Check choke operation
	Too rich a fuel mixture	Adjust carburetor
	Too cold a spark plug	Change to hotter plugs
Burned spark plugs (dry, shiny, glossy deposits on insulator or possibly cracked insulator)	Too lean a fuel mixture	Adjust carburetor
	Poor engine cooling	Check ventilation system, (para 10).
	Poorly seated valves	Check compression (para 16).
	Improper timing	Retime the ignition
	Too hot a spark plug	Change to colder plugs
	Improper plug installation	Be sure seals and threads are clean and gaskets good; use only recommended torque
	Compression leakage through the spark plug	Be sure seats and gaskets are in good condition

13. GOVERNOR SYSTEM

a. Description.

The purpose of an engine governor is to maintain a constant engine speed during changes in power demands. A governor responds to changes in power demands by varying the throttle position.

The governor maintains engine speed at about 1800 rpm. The speed sensing device is a ball and cup mechanism on the camshaft gear. A yoke, resting on the cup, is connected to the governor arm, which in turn is connected to the throttle lever. Any change in engine speed is transmitted from the cup to the yoke, and onto the throttle. Tension on the governor spring determines the speed at which the engine is governed. A stud screwed into the spring is used to vary the number of effective coils for getting the desired sensitivity; the speed drop from no load to full load, (fig. A-21).



*NOTE: GOVERNOR ARM SHOULD BE FLUSH WITH BOTTOM OF HOLE IN GOVERNOR SHAFT

Figure A-21. Constant Speed (1 Spring) Governor

b. Maintenance.

The linkage must be able to move freely through its entire level. Periodically lubricate the ball joints with graphite or light non-gumming oil. Also inspect the linkage for binding, excessive slack, and wear.

(1) Testing and Repair. Removing the gear cover for access to the governor cup and other internal governor parts is covered in paragraph 18. External service and repair is limited to testing spring tension and checking ball joints.

(2) Adjustments. Speed and sensitivity adjustments of the governor are made at the same place in the same way. Refer to the illustrations and the appropriate procedures.

(a) Speed. Change the spring tension with the speed adjusting nut while holding the sensitivity stud in place with a screwdriver. More tension gives more speed (fig. A-22). Turn the nut clockwise for more tension and speed. Turn the nut counterclockwise to reduce governed speed. Use a tachometer to indicate engine speed.

(b) Sensitivity. There are coarse and fine adjustments for sensitivity. The coarse adjustment is made by relocating the spring in the notches in the governor arm. Moving the spring up on the governor arm will decrease sensitivity. The fine adjustment is made by changing the number of effective coils in the governor spring by turning the sensitivity stud farther in or out. Turn the stud counterclockwise to increase sensitivity. Adjust for maximum sensitivity without a hunting condition (fig. A-22). If the speed drops too much when full load is applied, unscrew the governor adjusting stud to use more coils of the spring. Hold the stud and turn the speed nut slightly for more spring tension to compensate for reduced rpm caused by making more coils operative. A too close sensitivity adjustment, approaching no speed drop when load is applied, will result in a hunting condition (alternate increase and decrease in speed).

(c) Throttle Stop Screw. Set the throttle stop screw, located on the throttle lever; with no load connected and while running at rated speed. Turn the screw to give 1/32" clearance between the screw and pin. This prevents starving when load is removed.

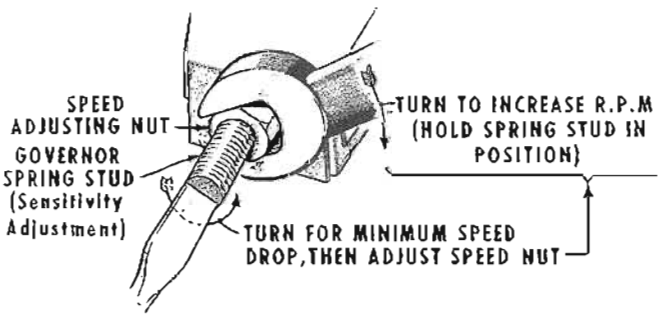


Figure A-22. Governor Adjustment

Chart 4. GOVERNOR TROUBLE SHOOTING

TROUBLE	POSSIBLE CAUSE	REMEDY
Speed too high (engine races)	Governor incorrectly adjusted.	Adjust for proper speed.
	Governor yoke installed backwards	Turn so machine side of yoke touches governor cup
	Governor cup improperly installed	Paragraph 18
	Linkage binding	Clean or replace linkage
Speed too low	Governor incorrectly adjusted	Adjust for proper speed
	Low engine power (won't reach governed speed)	See Trouble-Shooting Chart 1
Hunting condition	Governor spring tension too great	Adjust sensitivity
Poor sensitivity	Excessive wear in linkage	Replace governor linkage
Governor acts slowly	Binding in linkage	Clean and lubricate linkage

14. OIL SYSTEM

a. Description.

All working parts of the engine are pressure lubricated. The oil system includes an oil intake cup, gear type oil pump, by-pass valve, oil pressure gauge, full-flow oil filter, and crankcase passages and drillings. Oil is held in the oil base, drawn by the pump, and delivered through the oil filter. Lines to the rocker housing, drillings in the crankcase to crankshaft and camshaft bearings, crankshaft passages to connecting rod bearings and connecting rod spray holes complete the oil system plumbing.

Because it helps to control oil consumption, the crankcase breather is included in this system.

Normal oil pressure should be 25 psi or higher when the engine is at operating temperature. If pressure drops below 20 psi at half throttle or governed speed, inspect the oil system for faulty components.

b. Maintenance.

Periodic oil system maintenance should include changing crankcase oil, cleaning the crankcase breather (para h.), cleaning rocker box oil lines (para e.) and replacing the oil filter (para. g.). Maintain service periods (para. 8).

Always use a good quality detergent oil classified for service "DG" or "MS/DG". Service "DS" oil is satisfactory but costs more. Use a single viscosity oil, multi-viscosity oils increase oil consumption. Use the proper SAE number for the expected ambient temperatures.

Temperatures	Commercial	Military
Above 90° F	SAE 50	OE50, Spec MIL-L-2104
30° to 90° F	SAE 30	OE30, Spec MIL-L-2104
0° to 30° F	SAE 10W	OE10, Spec MIL-L-2104
Below 0° F	SAE 5W	OE-S, Spec MIL-L-10295

c. Oil Pump.

The oil pump is mounted on the crankcase behind the gear cover and is driven by the crankshaft gear.

(1) Removal.

(a) Remove the gear cover (para. 18c.) and oil base.

(b) Unscrew the intake cup from the pump.

(c) Remove the crankshaft lock ring and gear retaining washer.

(d) Loosen the two capscrews holding the pump and remove the pump.

(2) Repair. Except for the gaskets, component parts of the pump are not individually available. If the pump is defective or excessively worn, replace it. Disassemble the pump by removing the two capscrews holding the pump cover to the body. Inspect for excessive wear in gears and shafts. To improve pump performance, adjust the gear end clearance by changing the gasket thickness between the pump body and cover. Use the thinnest gasket that permits free movement of the pump shaft. Oil all parts when reassembling the pump.

(3) Installation. Before installing, fill the pump intake and outlet with oil for priming. Mount the pump on the engine, and adjust for .005" lash between the pump gear and crankshaft gear. Mount the intake cup on the pump so it is parallel to the bottom of the crankcase.

d. By-Pass Valve (fig. A-23).

Located on the outside of the rear bearing plate, the by-pass valve controls oil pressure by allowing excess oil to flow directly back to the oil pan. Normally, the valve begins to open about 25 psi. It is non-adjustable and normally needs no maintenance.

To determine if high oil pressure is caused by the plunger sticking closed or low oil pressure by the plunger sticking open, clean and inspect the valve.

To remove the valve, unscrew the recessed plug in the rear bearing plate, and lift out the spring and plunger assembly. Determine proper valve operation by checking the spring and plunger against the values given below:

Plunger Diameter	.3365" to .3380"
Spring	
Free Length	2-5/16 ± 1/16"
Force at 1-3/16"	2.225 ± .11 lbs.

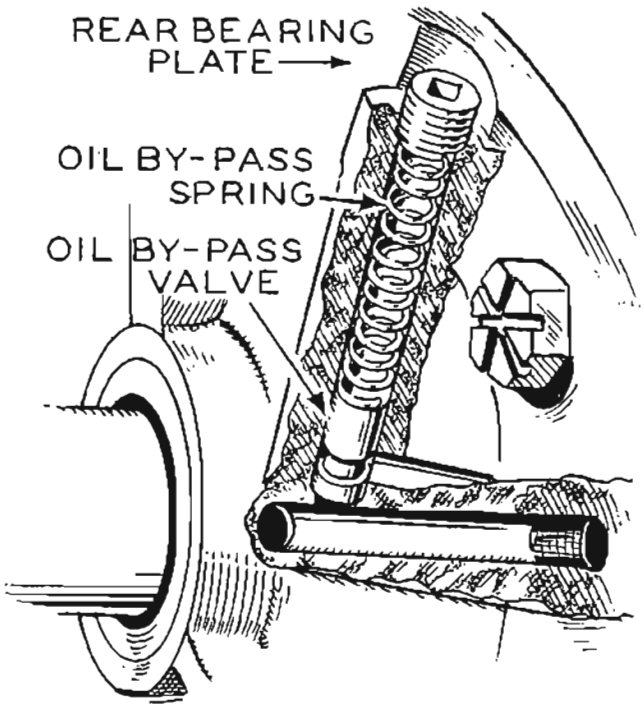
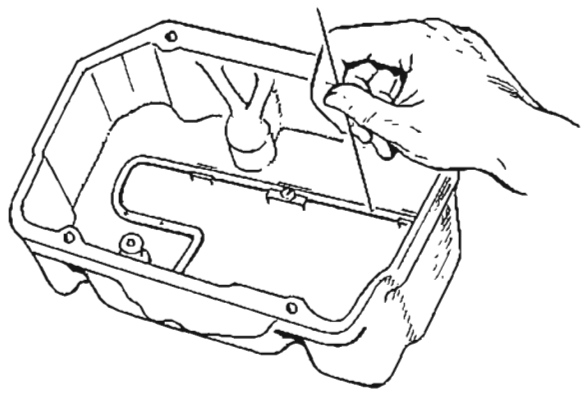


Figure A-23. Oil By-Pass Valve

e. Oil Lines (fig. A-24).

The rocker box oil line should be flushed with fuel and the small holes cleaned with fine wire at regular intervals. Clean out all other oil lines and drillings with compressed air whenever the engine is disassembled or overhauled. Reach the oil gauge passage by removing the oil filter mounting plate. All external oil lines, the rocker box oil line and the internal oil line to the rear bearing are replaceable, if damaged.



FLUSH ROCKER BOX OIL LINE WITH FUEL AND CLEAN HOLES WITH FINE WIRE.

Figure A-24. Rocker Box Oil Line.

f. Oil Pressure Gauge.

The oil pressure gauge is located on the lower front corner of the cylinder block. If it is faulty, replace it. Remove it with a wrench, and screw in a new gauge. Before replacing, check for a clogged oil passage behind the gauge.

g. Oil Filter.

The full-flow filter is mounted on the filter plate at the left front corner of the crankcase. It requires periodic replacement normally every 500 hours of operation. Remove the filter by turning counterclockwise with both hands or a filter wrench. Oil the new gasket and then install a new filter; turn it hand tight plus 1/4 to 1/2 turn. If at any time the oil becomes so dirty that markings on the dip stick can't be seen, change the oil filter and adjust the filter service period accordingly.

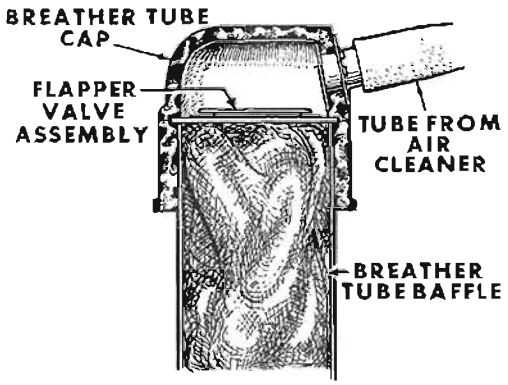
h. Crankcase Filter (fig. A-25).

The crankcase breather, located in the rear left corner of the crankcase maintains a partial vacuum in the crankcase during operation to control oil loss and ventilate the crankcase. It includes a metal filter packed into the tube on the crankcase, a rubber cap and hose connecting it to the engine air horn.

To disassemble, remove the rubber cap from the crankcase tube. Check the baffle in the breather tube, clean or replace if clogged.

Chart 5. OIL SYSTEM TROUBLE SHOOTING

TROUBLE	POSSIBLE CAUSE	REMEDY
Diluted oil	Leaky fuel pump diaphragm	Rebuild pump
	Worn compression rings or scored cylinders	Inspect rings and cylinder walls
Sludge in crankcase	Dirty oil filter	Replace oil filter; adjust oil filter service periods
	Run for long periods at idle	Review operating procedures
Excess oil consumption, light blue smoky exhaust	Worn or sticking piston rings	Check compression. Clean or replace rings
	Dirty breather system	Clean (para 14h.)
	Oil too light or diluted	Replace with proper grade of oil - If diluted check for cause
	Engine over-heating	See para. 10.
Excess oil consumption; no change in exhaust	Leaking oil seals	Inspect crankshaft front and rear oil seals
	Leaky oil base gasket	Check for leaks around gasket. Replace if necessary
	Dirty breather system	Clean (para 14h.)
Low oil pressure	Worn bearings	Rebuild engine
	Oil by-pass stuck open	Clean by-pass valve
	Oil supply low	Add oil. Check cause of oil consumption
	Worn oil pump	Install new pump
	Defective oil gauge	Replace gauge
High oil pressure	Oil by-pass stuck closed	Clean
	Oil too heavy	Replace with lighter oil
	Clogged oil passages	Clean all lines and oil passages



NOTE: FLAPPER VALVE ASSEMBLY NOT USED WITH THIS ENGINE

Figure A-25. Crankcase Breather.

15. STARTING SYSTEM

This engine uses a manual starting system. It is engaged and activated by use of the hand-crank at the front of the engine. Gearing within the flywheel and on the crankshaft facilitate cranking. Refer to parts list for parts in the system.

16. CYLINDER HEADS AND VALVES

a. Maintenance.

Each aluminum cylinder head assembly contains valves, valve seat inserts and guides, rocker arms and spark plugs. The valve assemblies are operated by pushrods running through the cylinder head and push rod shields to the camshaft.

Check the valve clearances at regular intervals (para 8). In addition, scrape the combustion chambers clean

and inspect the valves and valve seats at regular periods. If the combustion chambers show excessive carbon build up, clean them more often.

Always check the valve clearance while the engine is at room temperature (approximately 70°F). Turn the flywheel so the cylinder for the valve to be checked is 10° past the TDC position of the compression stroke. Adjust the clearance with the self locking nut (fig. A-26 & A-27). The valve clearances are for intake 0.012 and for exhaust 0.015.

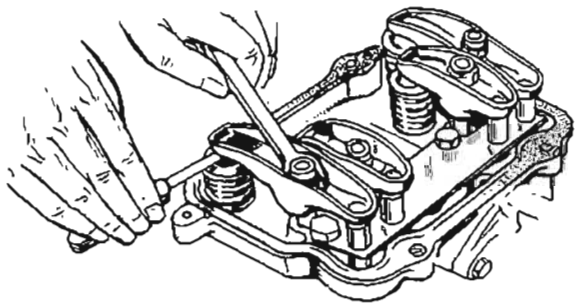


Figure A-26. Adjusting Valve Clearance.

b. Testing.

The cylinder compression test can be used to determine the condition of valves, pistons, piston rings and cylinders.

To check compression, run the engine until thoroughly warm. Stop it and remove all spark plugs. Insert the compression gauge in a spark plug hole, crank the engine, and note the reading. To check for piston blow-by, squirt a small amount of SAE 50 oil into the cylinder and repeat the check. An increase in compression with oil in the cylinder indicates piston blow-by.

Compression of a standard new engine cranking at about 300 rpm is about 110 psi. Compression should be fairly uniform, normally with less than 10 psi difference between the highest and lowest cylinder, taken at the same cranking rpm. Excessively high readings indicate carboned combustion chambers.

Compression readings will deviate considerably from the above readings because of differences in cranking speed, altitude and ambient temperature conditions. Therefore the specification is given only as a guide. The best indication of leakage is the pressure difference between cylinders or a compression increase when oil is added to the cylinder.

Another check of valve condition is to listen at the intake manifold (air cleaner removed) and the exhaust outlet while the engine is turned over by hand. A hissing sound indicates a leaking valve. Be careful when using this test because there will always be a slight hissing during the start of each compression stroke as the intake valve finishes closing. To detect piston ring blow-by, listen at the oil fill opening. However, if the valves are leaking badly, piston ring leakage may not be noticeable.

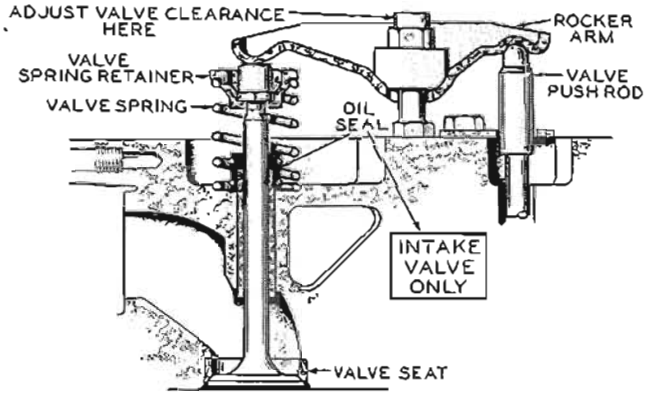


Figure A-27. Cross Section Of Valve Assembly.

c. Disassembly (refer fig. A-27).

Valves, tappets, rocker arms and pushrods should be kept in order and returned in order at assembly.

(1) Remove the air housing access door and air housing top.

(2) Remove the rocker box covers, spark plugs, and connecting oil lines to the cylinder heads.

(3) Remove the intake and exhaust manifold.

(4) Remove the rocker arms and push rods.

(5) Remove the capscrews holding each cylinder head to the cylinder block.

(6) Remove each head. If it sticks, rap it sharply with a soft hammer. Don't use a pry.

(7) Using a valve spring compressor, disassemble the valve assemblies.

d. Repair.

Thoroughly clean all components of the cylinder head assemblies. Remove all the carbon deposits from the combustion chambers and clean all gasket surfaces.

(1) Valves. Remove all carbon and check each valve for burning and pitting and each stem for warping. Valves that are slightly pitted or burned, refinish on an accurate valve grinder to a 45° angle. But if they are badly pitted, or will have a thin edge when refaced replace them.

Check refinished valves for a tight seat to the valve seat with an air pressure type testing tool or by applying Prussian blue or pencil marks on the valve face and rotating it against the seat. If the valve seats tightly, the Prussian blue or pencil marks will rub off evenly all the way around the valve face.

(2) Valve Guides. Check valve-guide-to-valve clearance, (para 17). If the proper clearances can't be obtained by replacing the valves, replace the guides. Drive the old guides into the valve chambers. Drive new guides in until they protrude 11/32" from the rocker box side of the head. Ream the new guides to the proper diameter (para 17).

(3) Valve Seats. If the valve seats are pitted, refinish them. Using conventional seat grinding equipment, reface each seat to a 45° angle and a seat width of 3/64 to 1/16". You should be able to reface each seat several times before it becomes necessary to replace it. If, however, the valve seats are loose or cannot be refaced, replace them. Use ONAN tool #420B272 in a drill press (fig. A-28) to remove each valve seat. Adjust the tool to cut 1/64" from the edge of the seat. Oil the pilot to keep it from seizing in the valve guide. Cut each seat down to a narrow rind on edges and bottom and break it out with a sharp tool. Be careful not to cut into the counterbore bottom.

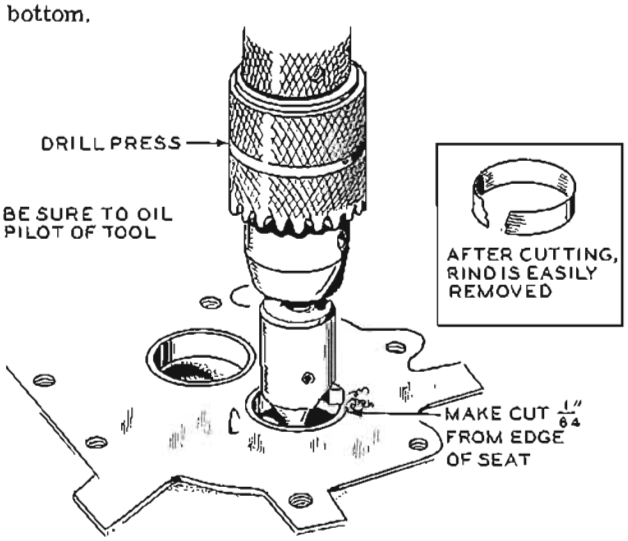


Figure A-28. Cutting Out Valve Seat with Onan Tool (420B272)

Thoroughly clean the valve seat counterbore and remove any burrs from the edges. If the counterbore is damaged, it will have to be remachined for an oversize seat. Oversize seats are available in .002, .005, .010, and .025". Otherwise, install new standard size seat inserts.

Drive the new valve seat inserts in place. Be certain that each seat rests solidly on the bottom of the counterbore at all points. To make installation easier, heat the cylinder head in an oven at 325° for about 1/2 hour and cool the valve seats in dry ice.

After installation and before facing the new seats, peen the head material against the valve seat in the 3 areas between the machine roll marks (fig. A-29).

Face each new seat to a 45° angle and width of approximately 3/64". The finished seat face should contact the approximate center of the valve face. Check the contact point with either Prussian blue or pencil marks on the valve face. Make any corrections on the seat, not the valve face.

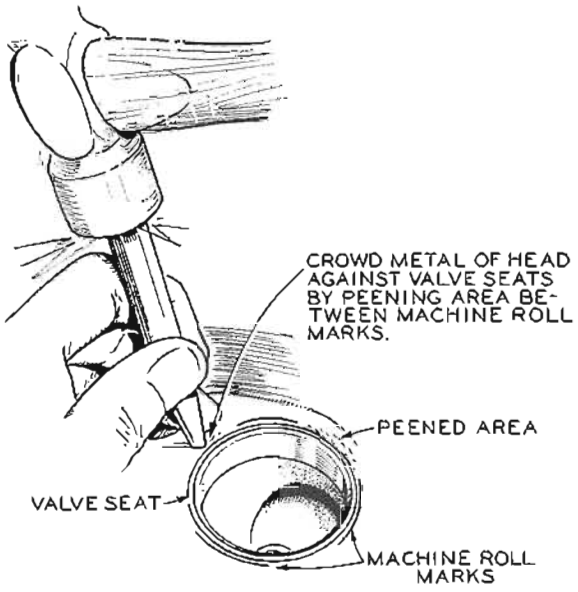


Figure A-29. Peening Valve Seat

(4) Valve Springs. Check the valve springs on an accurate compression scale. Valve spring data is given in paragraph 17. Replace any spring that is weak, cracked or pitted or has ends out of square.

e. Assembly.

(1) Push a valve stem oil seal onto each intake valve guide and clamp in place. Then oil the inside surface of each seal.

(2) Oil the stem of each valve lightly and insert each in its own guide.

(3) Using a valve spring compressor, compress each valve spring with its spring retainer in place, and insert the retainer locks.

(4) Install each head assembly and gasket on the cylinder block and install the capscrews 1 or 2 turns.

(5) Make up push rod shield assemblies by installing an "O" ring on one end of the rod and a spring, washer, and "O" ring on the opposite end, (fig. A-30).

(6) Lift the cylinder heads and install the pushrod shield assemblies (fig. A-30).

(7) Install the intake manifold to the heads and tighten the nuts to 13 to 15 lb-ft. Tighten the cylinder head capscrews to 28 to 30 lb-ft following the sequence in figure A-31.

(8) Install the exhaust manifold, oil lines, spark plugs and carburetor.

(9) Install the valve stem caps.

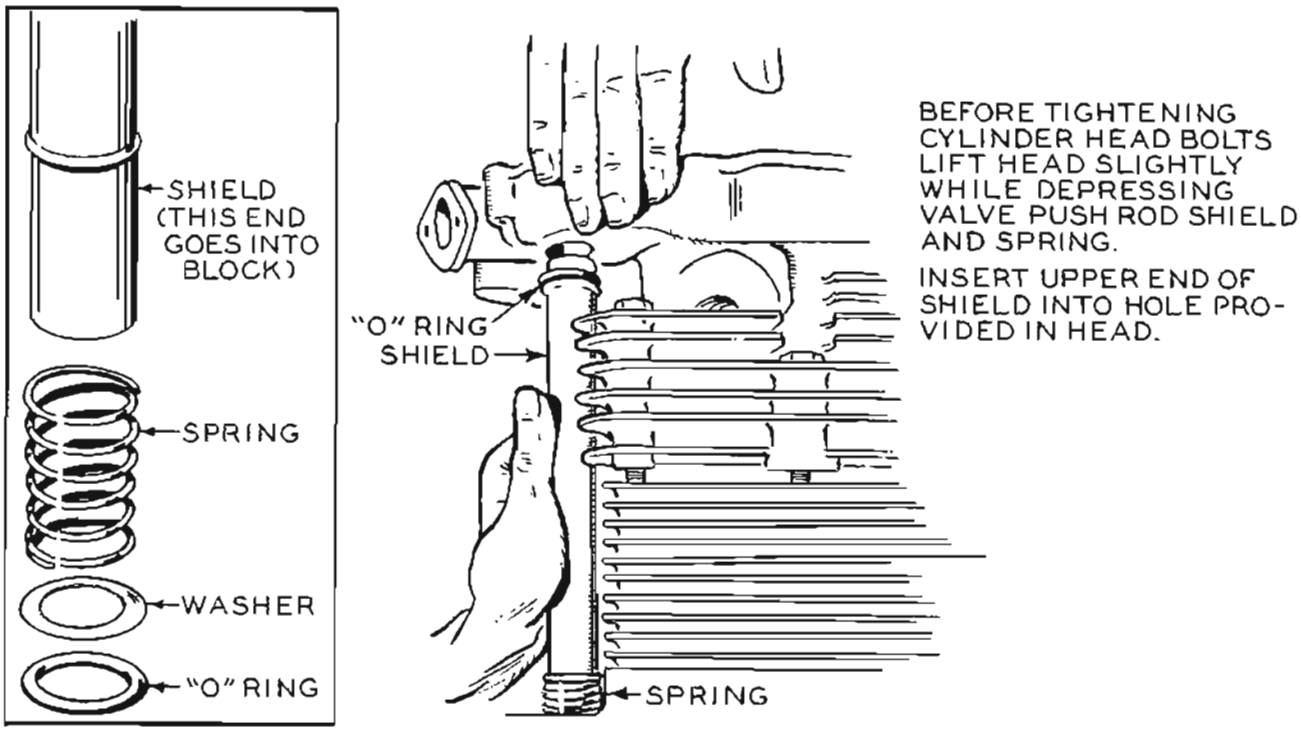


Figure A-30. Installing Pushrod Shields

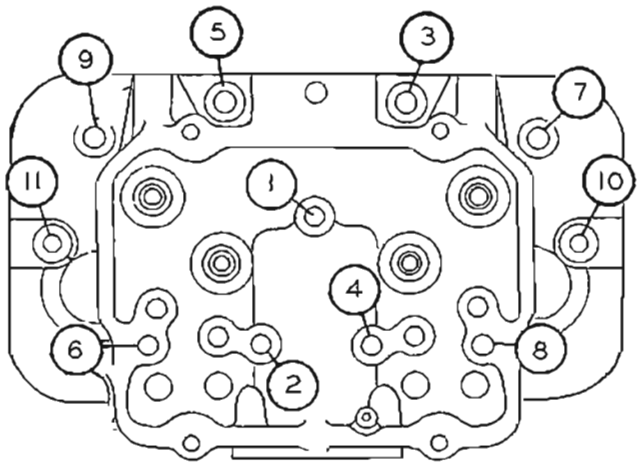


Figure A-31. Sequence For Tightening Head Bolts

(10) Install the pushrods, rocker arms, and rocker arm nuts.

(11) Set the valve clearance.

Note

After the first 50 hours of operation, retighten the cylinder head bolts and check valve clearance.

(12) Reinstall the rocker box cover.

(13) Reinstall the air housing and access door.

17. PISTONS, CONNECTING RODS AND CYLINDERS

a. Removal and Disassembly.

The engine has aluminum pistons; each piston is tapered and fitted with 2 compression rings, expander and an oil control ring (fig. A-32). Full floating piston (wrist) pins are held in place with a snap ring at each end. The lower end of each connecting rod contains half shell, precision bearings and the upper end, semi-finished bushings.

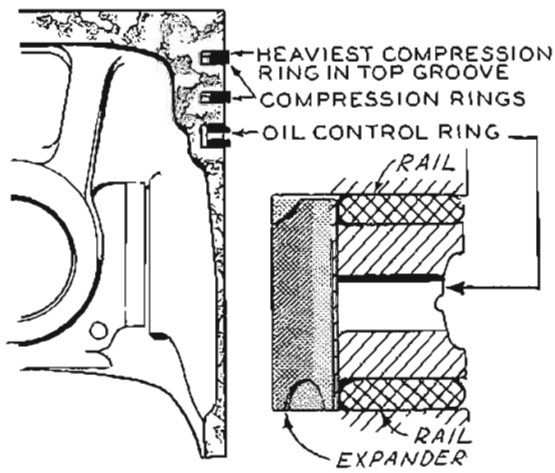


Figure A-32. Piston Rings

Chart 6. CYLINDER HEADS AND VALVES TROUBLE SHOOTING

TROUBLE	POSSIBLE CAUSE	REMEDY
Poor compression	Leaky head gasket.	Replace head gasket.
	Valves sticking.	See Sticking Valves, this chart.
	Broken valve spring.	Replace spring, check valve condition.
	Leaky valves.	Regrind valves.
	Burned valves and seats.	Regrind valves and seats.
	Insufficient valve clearance.	Adjust clearance.
Valve breakage.	Weak valve springs.	Replace weak springs.
	Excessively strong valve springs.	Replace springs.
	Worn guides which set up thrust action.	Replace guides.
	Excessive valve clearance	Adjust valve clearance.
Valve burning	Close valve clearance.	Re-adjust valve clearance.
	Weak springs.	Replace springs.
	High temperatures, causing valve stretch.	Check for engine over heating.
	Valve seat or face off center.	Regrind seat, replace valve.
	Loose valve seat inserts.	Replace seats. Rebore and use oversize if necessary.
	Improper cooling of valve seats or guides due to clogged cooling system.	Refer to paragraph 10. Overheating
Sticking valves	Coked or gummed oil on stem.	Clean or replace valve.
	Incorrect valve clearance.	Adjust valve clearance.
	Weak or broken springs.	Replace springs.
	Dirty, scored or gummy guides.	Clean or replace valves and guides.
	Incorrect clearance between valve and guide.	Correct clearance.

The connecting rods and caps are stamped with numbers for installation in the proper cylinder. When removing piston assemblies, check the marking so each can be reinstalled in the proper cylinder, and keep all components of each piston assembly together.

(1) Drain the crankcase oil and remove the oil base.

(2) Remove the air housing and cylinder heads.

(3) Scrape off the carbon ring at the top of each cylinder to prevent damaging rings or pistons.

(4) Remove the connecting rod cap from each connecting rod and push the assembly through the top of the cylinder bore. If the ridge at the top of the cylinder interferes with piston removal, cut it down with a ridge cutter before taking the piston assembly out.

(5) Using a ring expander, remove the rings from each piston.

(6) Remove the 2 retaining rings and push the piston pin from each piston.

b. Cylinders.

The cylinder walls should be free of scratches and pitting. Check each with an inside reading micrometer for excessive out-of-round or taper. The original dimensions were 3.2495 to 3.2505". If necessary, rebore the cylinder to fit the next oversize piston. Pistons and rings are available in .020, and .040" oversize. If the cylinders don't need refinishing, remove any existing ridges from the top of the wall with a ridge cutter or, if the ridge is small, a deglazing stone.

c. Pistons.

Thoroughly clean and inspect each piston. Clean the carbon from the ring grooves and be sure all oil holes are open. If any piston is badly scored or burred, loose in the cylinder, has badly worn ring grooves or otherwise isn't in good condition, replace it. Check clearance to the cylinder by inserting each piston in its cylinder. Check the clearance 90° from the axis of the piston pin below the oil ring at top of skirt. Pistons are selective fit, clearance should be .002 to .004 inch. If it isn't within limit, replace the piston and check the cylinder for possible reconditioning.

d. Piston Pins.

Each piston pin should be a thumb push fit into its piston at room temperature. If the pin is excessively loose, install a new one. If still too loose, install the next oversize pin. If the piston is worn enough that the oversize pin won't fit, replace the piston.

e. Rings (fig. A-33).

Inspect each ring carefully for fit in the piston grooves and seating on the cylinder wall. Fit each ring to the cylinder wall at the bottom of its travel, using a piston to square the ring in the bore. Check the end gap with a feeler gauge. It should be .010 to .020". If the gap is too small, file the butt ends of the rings. Don't use rings that need a lot of filing; they won't seat right on the cylinder walls. If oversize pistons are used, use the correct oversize rings.

When replacing piston rings, always de-glaze the cylinder walls. Use either a de-glazing hone or emery paper to break the cylinder glaze without changing the diameter of the cylinder bore. Work the hone or paper so you end up with a cross hatched pattern. After de-glazing, be sure to remove all residue from the cylinder walls and the rest of the engine.

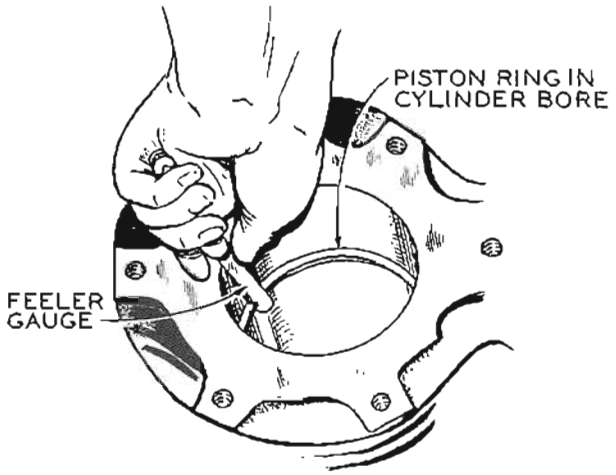


Figure A-33. Measuring Piston Ring End Gap

f. Connecting Rods.

Clean the connecting rods and check each for defects. Check the upper connecting rod bushings for proper clearance with the piston pin. Clearance should be .0002 to .0007". If the bushings are excessively worn, press them out and install new ones, pressing the new bushings in until they are centered in the connecting rod (fig. A-34). After installation, drill the bushings with a 3/16" drill through the counterbored hole in the connecting rod top. Finally, ream the bushings to the proper size. Be sure the connecting rod oil spray hole is open.

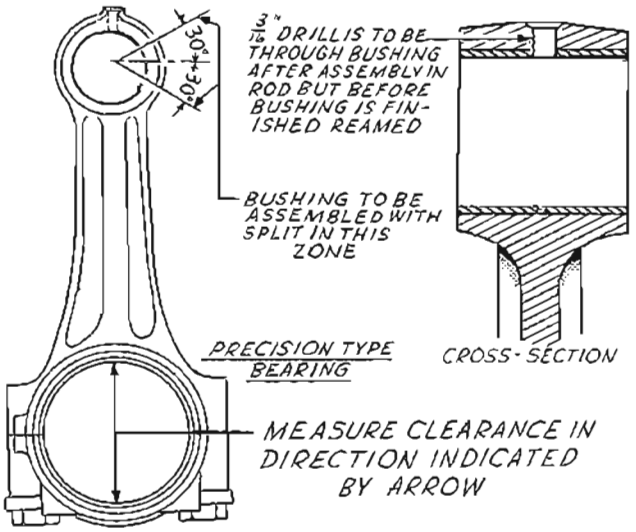


Figure A-34. Connecting Rod

g. Connecting Rod Bearings.

Inspect the connecting rod bearings for burrs, breaks, pits and wear. Measure the clearance between bearings and the crankshaft journal. The clearance should be .001 to .003 inch. If necessary, replace

with new precison bearings. For information about the crankshaft connecting rod journals, see paragraph 18 f. .

h. Assembly and Installation.

(1) Assemble the connecting rods and pistons with pins and retaining rings. Facing the side of connecting rod with oil spray hole, install piston with arrow pointed to the right (fig. A-34 & A-35).

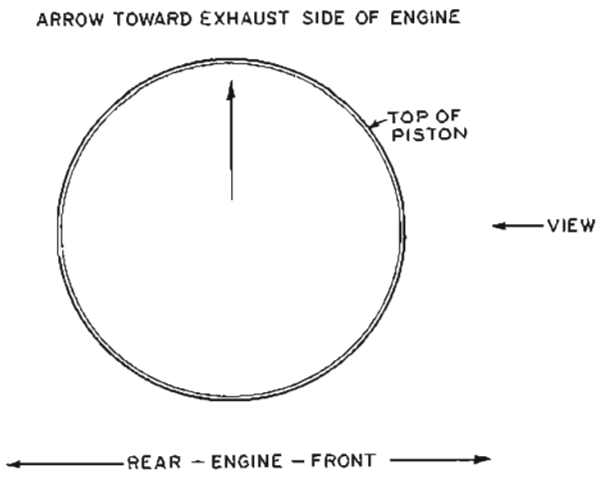


Figure A-35. Top of Piston

(2) Install all rings on each piston. Tapered type rings will be marked "TOP" or identified in some other manner. Place this mark toward the closed end of the piston. Space the ring gaps 1/3 of the way around the piston from one another. No gap should be in line with the piston pin. Oil the rings and pistons.

(3) Position a bearing half in each connecting rod. Be sure there is no dirt under the bearing. This could cause high spots and early bearing failure.

(4) Oil the cylinder walls and pistons. Install each piston in the proper cylinder using a suitable installer. Each assembly should be installed with the arrow mark on the piston toward the right when facing front (flywheel end) of engine (fig. A-35).

(5) Position each connecting rod on the crankshaft, oil the journal, and install its rod cap with bearing half. When installing the rod cap, position so the raised witness mark on the forging matches the mark on the connecting rod (fig. A-36).

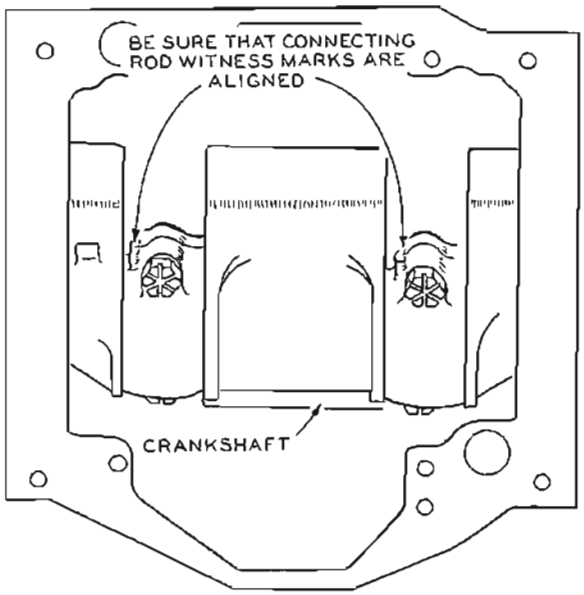


Figure A-36. Connecting Rod Witness Mark

(6) Tighten the connecting rod capscrews to the specified torque.

(7) Crank the engine over by hand to see that all bearings are free.

(8) Reinstall the oil base with a new gasket.

(9) Reinstall the cylinder heads, (para 16 e.).

i. Break-In Period.

Whenever new rings or pistons are installed or a cylinder refinished, the engine must be run-in before regular operation can be resumed. Run the engine for 15 to 20 minutes at no load, about 1/2 hour at 1/3 load and 2 to 3 hours at 2/3 load. Then regular operation can be resumed.

Chart 7. PISTONS, CONNECTING RODS AND CYLINDERS TROUBLE SHOOTING

TROUBLE	POSSIBLE CAUSE	REMEDY
Poor compression	Loose cylinder heads.	Tighten.
	Sticking rings.	
	Worn rings.	Replace rings, check cylinder condition.
	Worn cylinder walls and pistons.	Refinish cylinders, replace pistons.
	Leaky head gasket.	Replace head gasket.

Chart 7. PISTONS, CONNECTING RODS AND CYLINDERS TROUBLE SHOOTING (cont)

TROUBLE	POSSIBLE CAUSE	REMEDY
Piston and cylinder and ring wear	Operated with dirty air cleaner.	Change air cleaner service periods.
	Air leak between air cleaner and engine.	Repair leaks.
	Faulty cylinder oil control.	Check rings.
	Engine run on low or dirty oil.	Add or replace oil. Check cause of loss. If dirty, adjust service periods.
	Overheating.	See Trouble-Shooting Chart 2.
Worn connecting rod, bushings and bearings	Engine run with low oil.	Add oil, check cause of oil loss.
	Badly diluted, dirty or wrong grade of oil.	Change oil. Check cause of dilution. If dirty, check service periods.
	Clogged oil passages.	Clean oil passages and drillings.

18. ENGINE DISASSEMBLY

a. General.

If engine disassembly is necessary, observe the order presented below. As disassembly progresses, the order may be changed somewhat as will be self-evident. The engine assembly procedure is the reverse of disassembly. Any special assembly instructions for a particular component are included in the applicable paragraph. When reassembling check each paragraph for these special assembly instructions or procedures.

b. Flywheel (fig. A-37).

The flywheel is at the front end of the engine and is tapered fit on the crankshaft. To remove it, first remove the blower housing. The flywheel can then be removed by using the crank dog as a puller. To do this, first remove the crank dog and flywheel mounting capscrew. Then remove the large washer from the flywheel mounting capscrew and re-install the screw part way. Install the washer into the crank dog and re-install the crank dog so the washer bears against the end of the flywheel mounting screw. Tighten the 2 crank dog capscrews alternately until the flywheel comes loose.

c. Gear Cover.

Detach the upper governor ball joint and remove magneto. Remove screws holding the gear cover, tap it with a soft hammer.

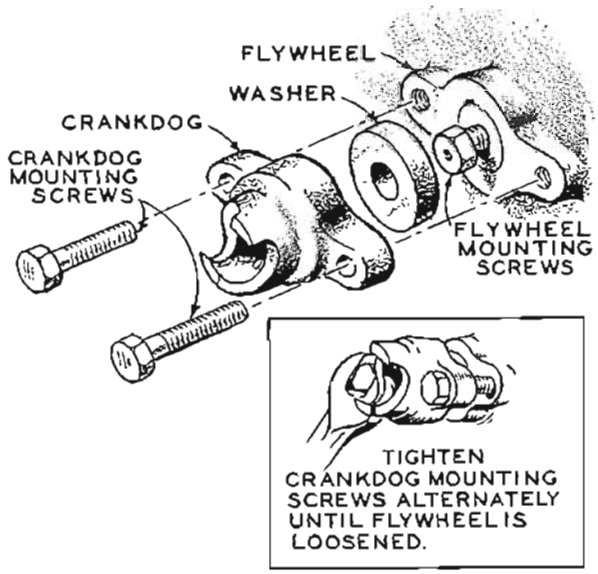


Figure A-37. Pulling Flywheel

(1) Governor Shaft. The governor shaft is supported by 2 sets of needle bearings. To remove the shaft from the gear cover, remove the governor yoke and pull the shaft from the gear cover. If the shaft binds during operation, clean the bearings; if the shaft is loose, replace the bearings. To remove the larger bearing, drive both bearing and oil seal out from the outside of the gear cover. Remove the smaller bearing with an easy-out or similar tool. Press new bearings and an oil seal into place.

(2) Gear Cover Oil Seal (fig. A-38). Replace the oil seal if damaged or worn. Drive the old seal out from inside the gear cover. Lay the cover on a board so the seal boss is supported. Using an oil seal driver, insert the new seal from the inside with the rubber lip toward the outside of the gear cover (open side of seal inward) and drive it flush with the outside surface. During gear cover installation, reverse the driver to protect the oil seal.

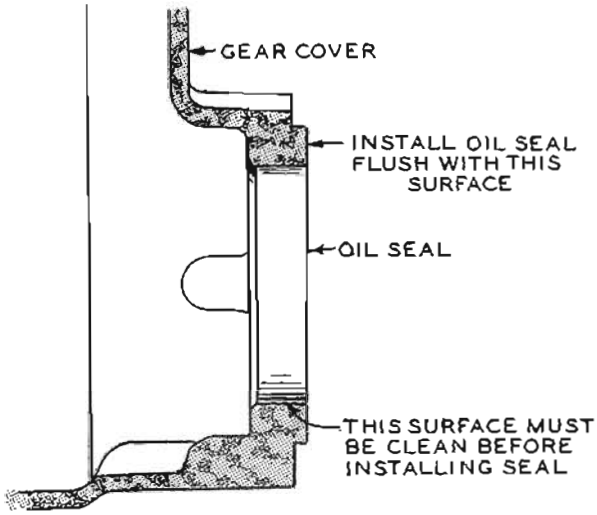


Figure A-38. Gear Cover Oil Seal

(3) Gear Cover Assembly (fig. A-39).

(a) Work the governor shaft to check for binding and see that the governor-shaft-end-thrust ball is in place.

(b) Turn governor yoke so the smooth side is toward governor cup.

(c) Turn the governor cup so the stop pin in the gear cover will fit into one of the holes in the cup surface (fig. A-39). Measure the distance from the end of the stop pin to the mounting face of the cover. It should be 25/32". If it isn't, replace the pin.

(d) Using the oil seal driver or a piece of shim stock over the crankshaft keyway to protect the oil seal, install the gear cover. Tighten the mounting screws to the specified torque. Before tightening the screws, be sure the stop pin is in the governor cup hole (fig. A-39).

(e) Install and retime the magneto (para 12 e.).

d. Governor Cup (fig. A-40).

To remove the governor cup, remove the snap ring from the camshaft center pin and slide the cup off. Be sure to catch the 1a flyballs that will fall out when the cup is removed.

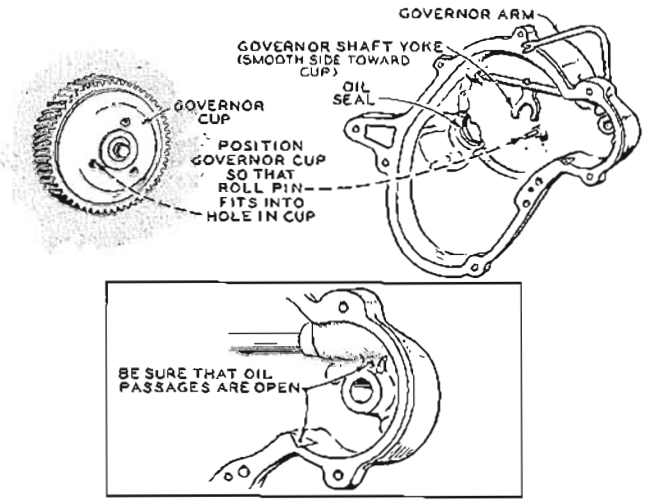


Figure A-39. Gear Cover Installation

(1) Repair. Replace any flyballs that have flat spots or grooves. Replace the cup if the race surface is grooved or rough. The governor cup must be a free spinning fit on the camshaft center pin, but should be replaced if excessively loose or wobbly.

Check the distance the center pin extends from the camshaft gear. This distance must be 25/32" to give the proper travel distance for the cup. If it is less, the engine may race, if more, the cup won't hold the balls properly. If the distance is too great, drive or press the center pin in. If it is too small, replace the pin; it can't be removed without damaging the surface. In some cases, if the distance is too small, the head of the governor cup can be ground to give the necessary 7/32" travel distance.

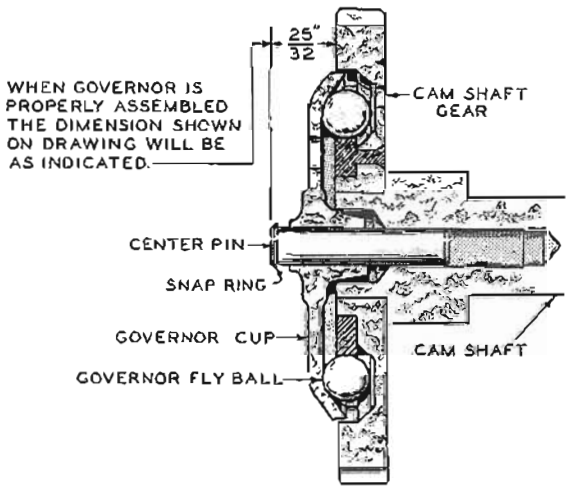


Figure A-40. Cross Section of Governor Cup

(2) Installation. To install the governor assembly, tip the front of the engine upward. Set the flyballs in their recesses and position the governor cup on its shaft. Finally, install the snap ring on the center pin.

e. Camshaft.

The camshaft is a 1-piece machined casting driven by the crankshaft. It rides on sleeve bearings pressed into the crankcase. In addition to opening and closing the valves, the camshaft operates the fuel pump.

(1) Removal. Note that rocker arms, pushrods and tappets, should be kept in order and returned in same order at assembly.

(a) Remove the rocker arms and pushrods from the valve chambers.

(b) Remove the fuel pump from the engine.

(c) Remove the magneto (para 12).

(d) Remove the crankshaft gear retaining washer by removing the lock ring on the crankshaft.

(e) Lay the engine on its side to avoid dropping tappets, and remove the camshaft assembly as a group. If necessary, pry it out with a screwdriver between the camshaft gear and crankcase.

CAUTION

Be sure the camshaft lobes don't catch on any pushrod tappets as the assembly is being removed.

(f) Remove the pushrod tappets. These can be removed only from the camshaft end of the pushrod holes.

(2) Repair. If a lobe has become slightly scored, dress it smooth with a fine stone. If the camshaft is badly worn or scored, replace it. For information about the center pin, paragraph d. above.

(3) Camshaft Gear. This gear, a pressed fit on the camshaft, is driven at 1/2 crankshaft speed. The camshaft gear drives the magneto. To remove the gear, use a hollow tool or pipe that will fit inside the gear bore and over the center pin. Press the camshaft out of the gear bore. Be careful not to damage the center pin.

(4) Camshaft Bearings. The camshaft bearings should be replaced if the clearance to the camshaft is greater than specified or if the bearings show cracks, breaks, burrs, excessive wear, or other defects (fig. 41).

The camshaft-to-bearing clearance should be .0012" to .0037". To check the rear bearing, remove the expansion plug at the rear of the crankcase.

Press new bearings into place (fig. A-42) using a bearing driving tool. Press the rear bearing flush with the bottom of the expansion plug recess. Press the front bearing in flush with the crankcase front surface so the crankcase and bearing oil passages align. Don't attempt to ream the bearings; they are

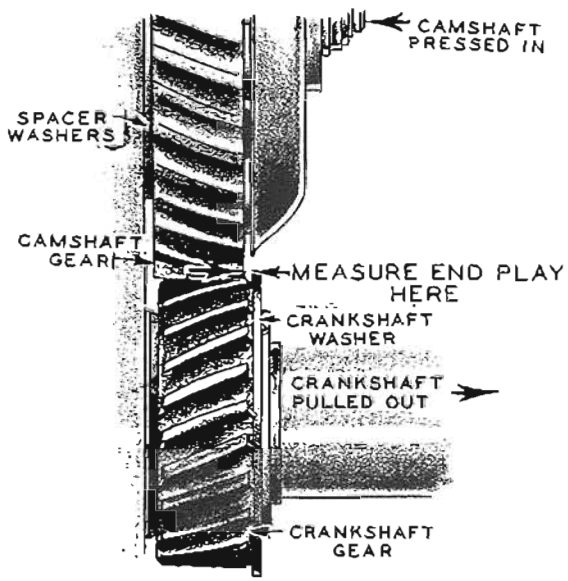


Figure A-41. Measuring Camshaft End Play

a precision type. After the rear bearing is installed, insert a new expansion plug in the recess, using sealing compound, and expand it into place with sharp blows at its center.

(5) Camshaft Installation.

(a) Install the key and press the camshaft gear on to its shaft.

(b) Install the governor components (para. 10) on the camshaft.

(c) Slide the thrust washer onto the shaft.

(d) Lay the engine on its side or end and insert the pushrod tappets.

(e) Install the camshaft assembly in the engine. Align the timing marks on the camshaft and crankshaft gears (fig. A-43).

(f) Replace the pushrods and fuel pump.

(g) Install and retime the magneto (para. 12).

f. Crankshaft.

The crankshaft is a counterbalanced type made of ductile iron. The crankshaft rides on 3 bearings, the front one housed in the crankcase and the rear one in the bearing plate. A split bearing provides support at the center of the crankshaft.

(1) Removal.

(a) Remove the lock ring and retaining washer in front of the crankshaft gear.

(b) Pull off the crankshaft gear. It has two 1/4-20" UNC tapped holes for attaching a gear pulling ring (ONAN tool 420A248). Use care not to damage teeth if the gear is to be re-used (fig. A-44).

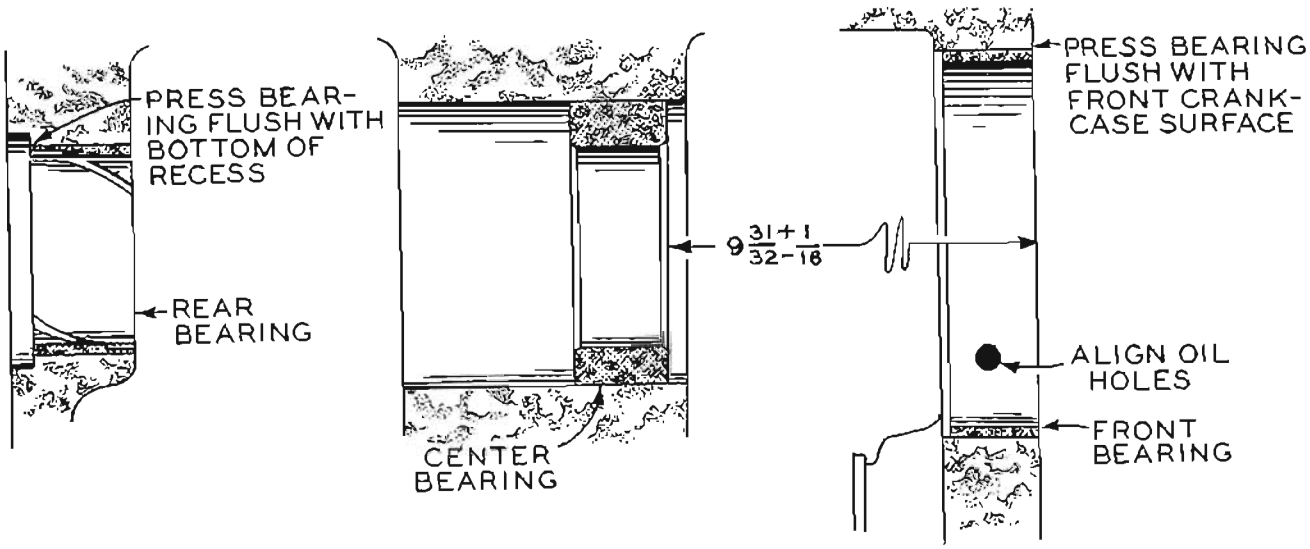


Figure A-42. Camshaft Bearing Installation

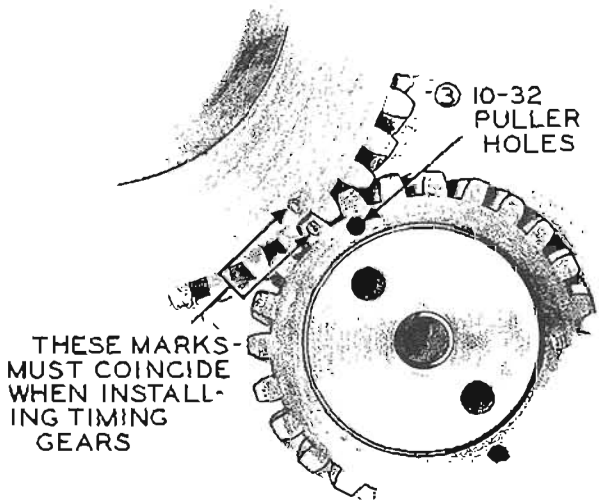


Figure A-43. Aligning Timing Gears

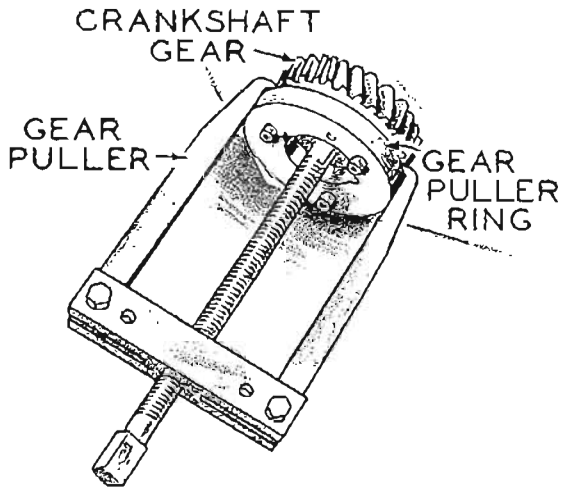


Figure A-44. Removing Crankshaft Gear

(c) Remove the oil pan and the piston-and-connecting rod assemblies.

(d) Remove the bearing cap from the center main bearing.

(e) Remove the rear bearing plate from the crankcase. For proper crankshaft end play, either re-use the original rear bearing plate gaskets or measure their thickness and order new ones.

(f) Remove the crankshaft through the rear opening in the crankcase. (Catch the upper half of the main bearing support as it slides off its mounting surface).

(2) Inspection. Thoroughly clean the crankshaft and blow out all oil passages with compressed air. Check all journals for out-of-round, taper, grooves, or ridges. Pay particular attention to ridges or grooves on either side of the oil hole areas. Unusual conditions here often point to previous neglect of oil cleanliness precautions. If the journal dimensions are not within the limits or the journals are scored, replace the crankshaft.

(3) Main Bearing. If the main bearing clearances (para. 17 g.) are greater than the limits or the bearings are worn, grooved or broken, replace them. Precision replacement bearing inserts and thrust washers are available for all main bearings. Don't attempt to ream the bearings. Align and press the new bearings halves into the front and rear housings, insert the center bearing when the crankshaft is reinstalled. (fig. A-45)

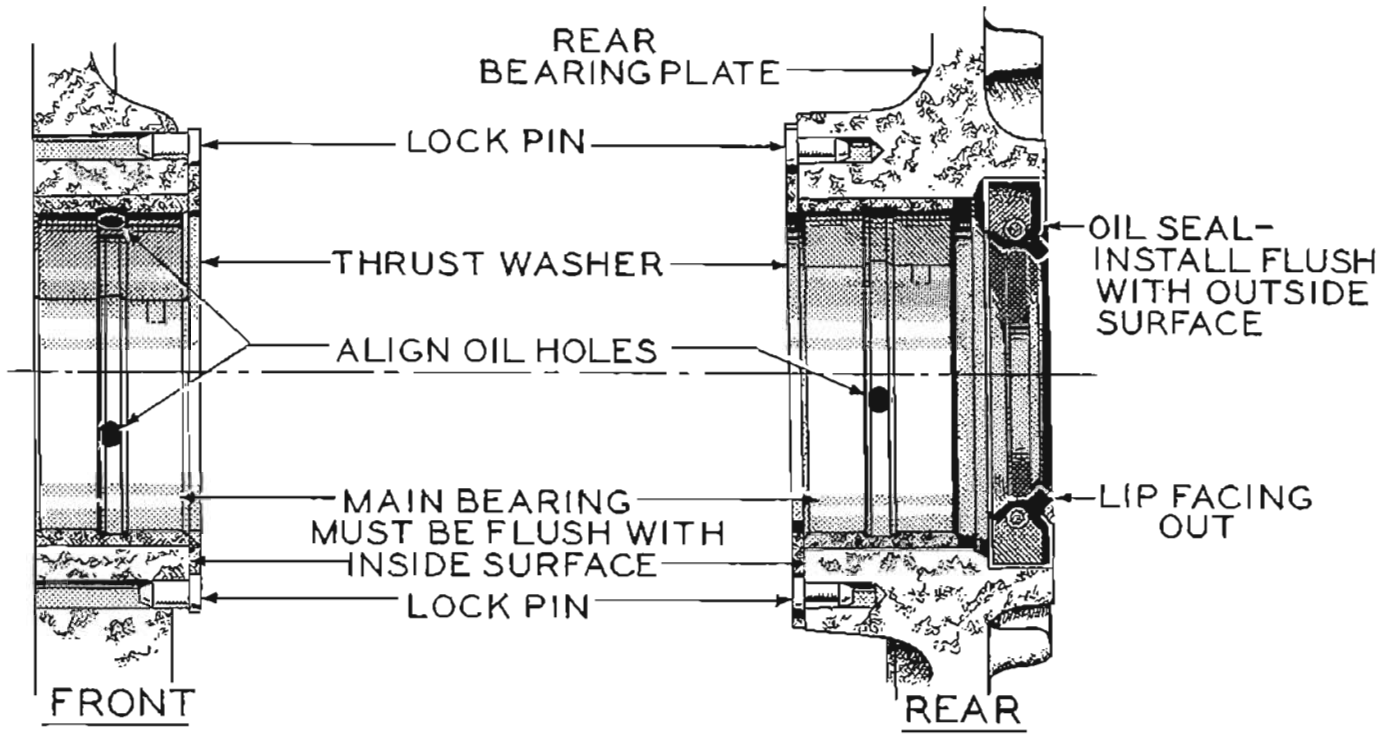


Figure A-45. Main Bearing Installation

(4) Rear Oil Seal (fig. A-45). The crankshaft rear oil seal is in the rear bearing plate. If damaged, drive it out from the inside of the plate. Using the oil seal installing tool, install a new seal with the open side facing inward. Drive the new seal flush with the rear surface of the bearing plate. Leave the seal installer on during bearing plate installation for protection.

(5) Installation. After crankshaft is installed be sure it is not frozen in place.

(a) Press the main bearings into place using a arbor press if available, if not available make two plates as shown in figure A-46. Plates should be 1/8" or more thick, other parts consist of 3/8" diameter (or larger) x 3" bolt, 2 washers and a nut.

1. Wire bearings together firmly making sure bearing tabs are the same side opposite each other.

2. Position front main bearing with tabs next to block and lined up with keyways. Position the rear main bearing on the lock pin side with tabs next to the bearing plate. Place bearings on a very slight angle in gearing bore.

3. Position press plates, the plate with 3 holes in the inside of block or on lock pin side of bearing plate making sure to align holes with thrust washer lock pins. Install bolt, washers and nut until finger tight.

4. Use a light hammer and tap high side until bearing is evenly in place (measure with scale). Do not force too hard or damage may result.

5. After bearings are started evenly tighten nut. Remove wire after bearings are well started.

6. Tighten until top plate contacts block or bearing plate. NOTE: Be sure holes in plate align with lock pins before pressing the bearing all the way in bearing plate.

(b) Install the thrust washers and locking pins.

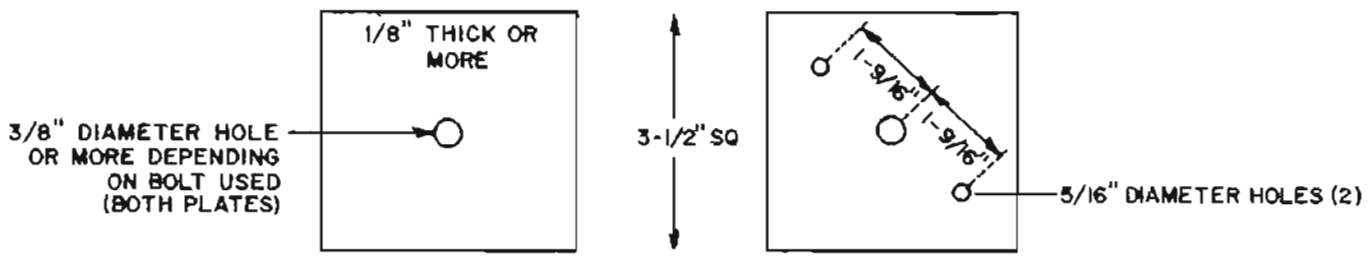


Figure A-46. Main Bearing Pressing Plates

(c) Oil the bearing surfaces and install the crankshaft from the rear of the crankcase, through the rear bearing plate hole.

(d) Mount and secure the rear bearing plate with the same thickness of new gaskets as removed.

(e) Heat the crank gear to about 350°F. Install the key on the crankshaft, then drive the gear into place. Install the retaining washer and lock ring.

(f) Set the upper half of the center main bearing housing on the crankshaft and rotate it into place. Be sure it is installed with the side marked FRONT toward the crankshaft gear. Set the 2 positioning dowels on the upper bearing mount. Install the center main bearing cap, and torque the bolts to 97 - 102 lb ft. (fig. A-47).

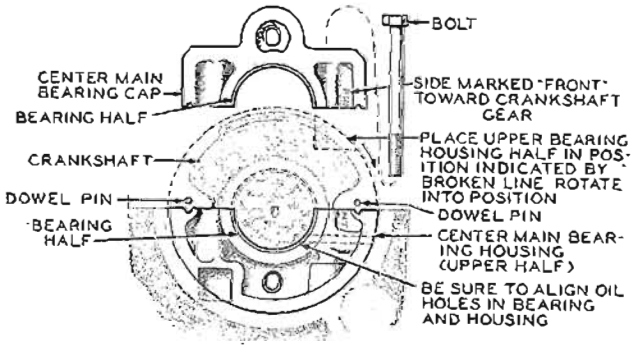


Figure A-47. Center Main Bearing Installation

(g) Check the crankshaft end play (fig. A-48). Use enough rear bearing plate gaskets to provide .010 to .015 inch end play.

(h) Install piston assemblies (para. 17h.)

g. Crankcase.

If the center main bearing support requires replacement, the whole crankcase must be replaced or returned to the factory to have a new housing fitted.

19. ASSEMBLY TORQUES

a. Description.

The assembly torques given here will assure proper tightness without danger of stripping threads. If a torque wrench isn't available, estimate the degree of tightness necessary for the stud, nut, or screw. Be careful not to strip threads. Use reasonable force only and a wrench of normal length.

Specially designed place bolts (fig. A-49) don't require a lock-washer or gasket. Don't attempt to use a lockwasher with these bolts; it will defeat their purpose. Check all studs, nuts and screws often and tighten as needed to keep them from working loose.

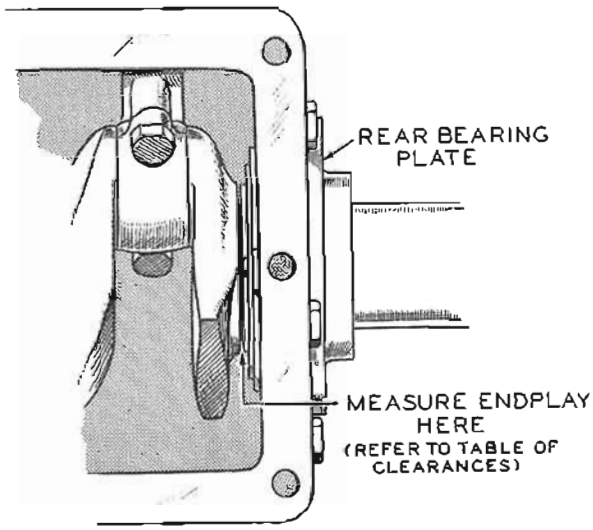


Figure A-48. Crankshaft End Play

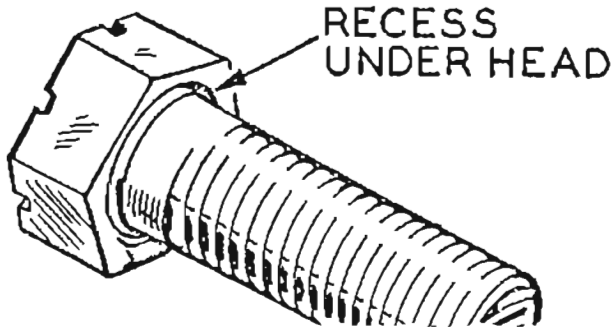


Figure A-49. Place Bolt Identification

b. Torque Specifications.

Torques listed are in lb-ft.

Center Main Bolt	97-102
Connecting Rod Bolt	27-29
Cover-Rocker Box	8-10
Cylinder Head Bolt	28-30
Exhaust Manifold Nuts	13-15
Flywheel Mounting Screw	65-70
Fuel Pump Mounting Screws	15-20
Gear Cover	15-20
Intake Manifold	13-15
Oil Base Mounting Screws	45-50
Oil Filter	Hand Tight + 1/4-1/2 Turn
Oil Pump Mounting Screws	15-20
Rear Bearing Plate	40-45
Rocker Arm Nut	4-10*
Rocker Arm Stud	18-20
Spark Plug	25-30

*This torque is due to friction between the threads only and locks the nuts in place. The rocker arm nuts adjust valve lash.

20. SPECIAL TOOLS

a. General.

The listed special tools are available from ONAN to aid service and repair work on the engine. These are not supplied with the unit.

b. Tools.

Crankshaft Gear Pulling Ring	420A248
Driver, Front Camshaft Bearing	420A252
Driver, Rear Camshaft Bearing	420B250
Driver, Center Camshaft Bearing	420B254
Driver, Valve Seat	420B270
Oil Seal Guide and Driver	420B250
Valve Seat Remover	420B272
Replacement Bits for 420B272	420B274
Wrench, Oil Filter - Box Type (For Purolator full flow filter)	420P268

21. CLEARANCE DATA

All values are inches unless specified (minimum/maximum).

Magneto Breaker Point Gap (WICO)	.015
Spark Plug Gap	.025
Ignition Timing Spark Advance	25°BTC
Firing Order	1-2-4-3
Camshaft	
Bearing Journal Diameter, Front	2.2500/2.2505
Bearing Journal Diameter, Rear	1.1875/1.1880
Bearing Journal Diameter, Center	1.2580/1.2582
Bearing Clearance Limit	.0012/.0037
End Play, Camshaft	.007/.039
Cam Tappet Diameter	.7475/.7480
Cam Tappet Hole Diameter	.7505/.7515
Connecting Rods	
Large Bearing Bore Diameter	2.1871/2.1876
Small Bushing Bore Diameter (without bushing)	1.004/1.045
Piston Pin Bushing Inside Diameter (bushing reamed)	.9903/.9906
Distance Center Large Bearing Bore to Small Bushing Bore	5.998/6.002
Clearance, Large Bearing to Crankshaft	.001/.003
Cylinder	
Cylinder Bore	3-1/4
Cylinder Diameter Limits (honed)	3.2495/3.2505
Crankshaft	
Main Bearing Journal Diameter (STD)	2.2430/2.2435
Crankshaft Main Bearing Clearance	.0024/.0049
Connecting Rod Journal Diameter	2.0600/2.0605
Connecting Rod Bearing Clearance	.001/.003
End Play, Crankshaft	.010/.015
Piston	
Piston Clearance to Cylinder Wall (Selective fit 1/4 inch below oil ring at top of skirt)	.002/.004
Piston to Cylinder (1-1/4 inch from bottom of skirt)	.008/.0028
Ring Groove Width Top	.096/.097
Ring Groove Width, 2nd	.0955/.0965
Ring Groove Width, 3rd	.1880/.1895
Piston Pin	
Length	2.738/2.753
Diameter	.9899/.9901
Piston Clearance	Thumb Push Fit
Connecting Rod Bushing Clearance (Pin in Rod)	.0002/.0007
Piston Rings	
Ring Type	
Top	Compression
2nd	Compression
3rd	Oil Control
Ring Width	
Top	.0925/.0935
2nd	.0930/.0935
3rd	.1860/.1865
Piston Ring end gap	.010/.020
Valve, Intake	
Stem Diameter	.3405/.0415
Clearance in Guide	.0005/.0025
Seat Angle	45°
Valve Clearance	.012
Valve, Exhaust	
Stem Diameter	.3405/.3415
Clearance in Guide	.0025/.0045
Seat Angle	45°
Valve Clearance	.015
Valve Guide	
Length	1-25/32
Outside Diameter	.4690/.4695
Cylinder Block Bore Diameter	.467/.468
Inside Diameter (after reaming)	
Exhaust	.344/.345
Intake	.342/.343
Valve Seats	
Valve Seat Bore Diameter (standard)	
Intake	1.547/1.548
Exhaust	1.361/1.362
Seat Outside Diameter	
Intake	1.550/1.551
Exhaust	1.364/1.365
Seat Width	3/64/1/16
Seat Angle	45°
Available Oversizes	.002/.005 .010 .025
Valve Springs	
Free Length	1-7/8
Length, Valve Closed	1.528
Load, Valve Closed	45 - 49 lbs
Length, Valve Open	1.214
Load, Valve Open	83 - 93 lbs

22. ENGINE PARTS

a. General.

(1) The parts are illustrated in groups of related items, with the items listed within the legend

of the illustration (figs. 50 thru 63). Illustrations represent typical items and not necessarily a particular part number. Part numbers shown are for the actual manufacturer of the engine, ONAN, unless otherwise indicated. For some parts several numbers are given with the pertinent manufacturer. Military standard (MS) equivalent part numbers are also listed when applicable. The legends contain the following information for each part: Figure Index No. - Description - (Quantity Used) - (ONAN Part No. Listed First) - (Other Part No.) ec*

*Note: ec indicates emergency common, refer para.d. below.

(2) Use part number and description to assure proper identification. When ordering parts, it is advisable to list the engine model number J120-S/967F and serial number. Be sure to state quantity required, method of shipment and correct destination.

(3) Order engine parts from ONAN or their local authorized parts and service station, or from the pertinent manufacturer. Parts may also be ordered through the Hol-Gar Manufacturing Corporation's parts supply system.

b. Engine Orientation.

Right and left sides are determined when facing the blower or cranking (FRONT) end of the engine. This applies to engine only.

c. Service Kits.

The following kits are peculiar to the complete engine. For other kits refer to particular group of related parts.

Engine	168K84
Engine Overhaul Kit	522K196

d. Emergency Replacement Parts.

This engine is of the ONAN standard J series. Many parts are interchangeable in the J30; J60 and J120 engines. In emergencies when parts supply sources may become limited, parts may be canabilized from other J series engines. Common parts are indicated by ec (emergency common) in the legend listing.

e. Authorized Parts and Service Centers.

These are listed below by state. Those identified with a star have servicemen that have been trained at ONAN Factory Service School.

AUTHORIZED PARTS AND SERVICE CENTERS

ALABAMA

Armstrong Equipment Company
*4601 1st Avenue No. - P.O. Box 2837
Birmingham 6

Kennedy Engine Company
261 South Water Street
Mobile

Armstrong Equipment Company
31 Highway North, P.O. Box 888
Montgomery 2

ALASKA

Airport Machinery Company, Inc.
P. O. Box 539
Anchorage

The Carrington Company
112 North Turner
Fairbanks, Alaska

K-P-R Incorporated
Box 2436
Juneau

Alvine's Marine Repair
Box 984
Kodiak

The White Diesel Eng.
Div. of the White Motor Company
900 Water Street
Ketchikan

Wrangell Machine Works
Wrangell

ARIZONA

Commercial Distributors
Corner Arroyo & Elm Streets
Nogales

Equipment Sales Company
720 South 19th Avenue
Phoenix

Wilco, Inc.
3042 North Stone
Tucson

ARKANSAS

Magneto Service & Supply Company
618 N. West Avenue
Eldorado

Capital Cycle and Equipment Co.
*1007 Center Street
Little Rock

CALIFORNIA

Valley Magneto Service
1019 N. Chester
Bakersfield

Johnson Brothers, Inc.
*16 Yosemite Avenue
Fresno 21

Equipment Service, Inc.
*1855 Cota Avenue
Long Beach

Sweinhart Electric Company
*2900 East Olympic Boulevard
Los Angeles

California Electric Works
424 - 8th Avenue
San Diego 1

Cal-West Electric, Inc
*461 South Van Ness Avenue
San Francisco

Townsends Auto Electric Company
205 Van Ness Avenue
Watsonville

COLORADO

BKS Industrial
Division of B. K. Sweeney Co.
*1501 23rd Street
Denver 17

CONNECTICUT

Onan Eastern Corporation
*21-34 Broadway
Long Island City 6, New York

Geils and Foerst Marine Electric Co
Incorporated (Marine Only)
197 City Island Avenue
New York

DELAWARE

Curtis Engine and Equipment Co.
*2200 Sherwood Avenue
Baltimore 18, Maryland

DISTRICT OF COLUMBIA

Southern Oxygen Company
P. O. Box 5087
*Washington 19
2900 52nd Avenue
Bladensburg, Md.)

FLORIDA

George's Electric Repair
617 S. Andrews Avenue
Ft. Lauderdale

Davies Cycle Center
1407 Citrus Street
Fort Myers

Ft. Myers Armature Works, Inc
2333 2nd Street
Ft. Myers

Diesel Power, Inc.
511 S. 3rd Street
Fort Pierce

Collins Manufacturing Company
130 Washington Avenue
Homestead

Marine-Industrial Equipment Corp.
*710 Haines Street
Jacksonville 6

Key West Electrical Repair
611 Front Street
Key West

United Parts, Inc
320 South Dixie Highway
Melbourne

Motor Services, Inc
3026 North Miami Avenue
Box 217, B.V. Station
Miami 37

Peninsular Armature Works, Inc
3525 N. W. 51st Street
Miami 42

R. B. Grove, Inc.
*261 S.W. 6th Street
Miami 36

Marine Electrical Service Inc.
*1480 N. W. 22nd Court
Miami 35

Highway Equipment Company
*1016 West Church Street
Orlando

Kennedy Florida Engine Co.
P.O. Box 1387, Municipal Pier
Panama City

Green Machine Works
9 West Cedar, P. O. Box 429
Pensacola

Tampa Armature Works, Inc.
*401 South Morgan Street
Tampa 1

Marine Engine & Equipment Co.
1713 North Dixie Highway
West Palm Beach

GEORGIA

Blalock Machinery & Equipment Co
920 West Broad Avenue
Albany

Blalock Machinery & Equipment Co
*225 Forsyth Street S.W.
Atlanta 2

Bowers Auto Electric
565 Broadstreet
Augusta

Mowers & Motors, L'td
1115 13th Street
Columbus

Carburetor & Electric Service
704 Third Street
Macon

Jones Equipment Company
61 Main Street, Garden City
Savannah

HAWAII

Hilo Iron Works Co
P.O. Box 987
1266 Kam Avenue
Hilo

Honolulu Iron Works Co.
P.O. Box 3140
570 Auahi Street
Honolulu

Honolulu Iron Works Company
726 Main Street
Kahului, Maui

Honolulu Iron Works Company
Kauai Branch
Nawiliwili, Kauai

IDAHO

Oakley-Moody Service, Inc.
813 Grove Street, Box 2699
Boise

Intermountain Equipment Company
*Broadway at Myrtle Street
Boise

ILLINOIS

Industrial Engine & Parts Division
*H. R. R. Zimmerman Company
2345 South Pulaski Road
Chicago 23

Ther Electric & Machine Works
(Welder Only)
17 South Jefferson Street
Chicago 6

National Industrial Supply Co.
*Division of National Auto Supply Co.
1100 Illinois Avenue
East St. Louis

Automotive Ignition Company
418 N. Franklin
Peoria

Lohse Lawn & Garden Center
*Div. of Lohse Automotive Service
500 16th Street
Rock Island

INDIANA

Evansville Auto Parts, Inc.
201-207 N.W. Riverside Drive
Evansville

Stockberger Machinery, Inc.
*630 High Street
Fort Wayne

Demco, Inc.
610 West Main Street, Box 241
Greenwood

IOWA

Electrical Engineering & Equip Co
*1201 Walnut Street
Des Moines

B and G Automotive Supply
1084 Iowa Street
Dubuque

KANSAS

Southwest Equipment Company
114 East Poplar
Dodge City

Kemper Auto Electric
Garden City

Bell Engine Service
3810 West Tenth
Great Bend

The Carlson Company, Inc.
*6045 North Broadway, P O Box 822
Wichita 1

KENTUCKY

Virgil Heck Equipment Company
*620 West Kentucky Street (Box 713)
Louisville 1

Fall City Boat Works, Inc.
(Marine Only)
132 N. Fourth Street
Louisville 2

Marine Sales & Service Inc
(Marine Only)
1330 River Road
Louisville 6

LOUISIANA

Teche Tractor Company
P. O. Box 236
Baldwin

*Brady Engine Company of Berwick, Inc
Berwick

Brady Engine Company of Galliano, Inc.
Galliano

Harvey Diesel, Inc.
*2300 Destrehan Avenue
Harvey

Brady Engine Co of Houma Inc.
*1707 East Main Street
Houma

Iberia Onan Service
908 West St. Peter
New Iberia

Menge Pump and Machinery Co., Inc.
*226 North Market Street
Shreveport

MAINE

Leen's Electric Motor Service
*54 Wilson Street
Brewer

Stanley J Leen Co., Inc.
*35 Union Street
Portland

Manset Marine Supply Co
Southwest Harbor
(Marine Only)

MARYLAND

Curtis Engine & Equipment Co.
*2200 Sherwood Avenue
Baltimore 18

MASSACHUSETTS

J. H. Westerbeke Corp.
*35 Temean St.
Dorchester 22

Superior Electric Company, Inc
*501 St. James Avenue
Springfield

MICHIGAN

A. P. Hopkins Corporation
*13931 Oakland Avenue
Detroit (Highland Park) 3

Marquette Public Service Garage
*246 W. Washington St.
Marquette

Electric Equipment & Sepply Co.
*2701 Mellwraith Street
Muskegon Heights

AUTHORIZED PARTS AND SERVICE CENTERS (Cont)

MINNESOTA

Minnesota-Onan Corporation
*2525 East Franklin Avenue
Minneapolis 6

Horvick Electric Motor Co
*305 Main Avenue
Moorhead

MISSISSIPPI

Kennedy Marine Engine Co.
P. O. Box 167
*(Reynoir & Jackson Sts.)
Biloxi

Kennedy Marine Engine Co. of Pascagoula
137 Delmas Avenue
Pascagoula

Taylor Machinery Corporation
*U. S. Highway 80 at South Gallatin
Jackson

MISSOURI

National Industrial Supply Co
*Division of National Auto Supply Co.
1100 Illinois Avenue
East St. Louis

Oxygen Service Company
(Welder Only)
539 Southwest Blvd.
Kansas City

Welding Equipment Supply Co., Inc.
*1900 Truman Road
Kansas City

Venetian Boat Harbor (Marine Only)
*Portage des Sioux

MONTANA

Great Northern Tool and Supply Co
*2224 Minnesota Avenue
Billings

Great Northern Tool and Supply Co
301 Second Street South
Great Falls

NEBRASKA

Anderson Equipment Company, Inc
*5532 Center Street
Omaha 6

NEVADA

Clark County Wholesale Mercantile Company
512 South Main
Las Vegas

Air Service Company
241 South Virginia Street
Reno

NEW HAMPSHIRE

Wright Electric Motors
*D. W. Highway North
Manchester

NEW JERSEY

Onan Eastern Corporation
*21-34 Broadway
(Long Island City 6, N. Y.)

Geits & Foerst Marine Electric Co., Inc. (Marine Only)
197 City Island Avenue
(New York, N. Y.)

Rhoads Equipment Company
*4652 N. 15th Street
(Philadelphia 41, Pennsylvania)

NEW MEXICO

Car Parts Depot, Inc
212 11th Street
Alamogordo

Desert Industrial, Inc.
*531 Haines Street
Albuquerque

Air Equipment & Supply
822 S. Canal Street
Carlsbad, New Mexico

El Paso Welding Supply
228 E. Bowman Street
Las Cruces

Savage Brothers Electric
426 East 2nd Street
Roswell

NEW YORK

Fox Equipment Company
*2018 Seneca Street
Buffalo 10

Onan Eastern Corporation
*21-34 Broadway
Long Island City 6

Geits & Foerst Marine Electric Co., Inc. (Marine Only)
197 City Island Avenue
New York

R. B. Wing and Son Corporation
*83 Second Avenue
Rensselaer

Berger Brothers Electric Motors, Inc
*395 State Street, Cor. Brown
Rochester 8

Power Plant Engineering Co.
*928 South Salina Street
Syracuse 4

NORTH CAROLINA

H. B. Owsley & Son, Inc.
*Pineville Road
Charlotte

H. B. Owsley & Son, Inc.
Box 8627
Greensboro

H. B. Owsley & Son, Inc.
1212 North William
Goldsboro

NORTH DAKOTA

Horvick Electric Motor Co
*305 Main Avenue
Fargo-Moorhead

Paris Hardware
208 West Main Street
Mandan

Electric & Magneto Service Co.
101 Main Street
Williston

OHIO

Air Cooled Engines, Inc.
*Division of Hopkins & Kipp, Inc.
357 West Bowery Street
Akron 7

The Cincinnati Electric Equip. Co.
*16 East 72nd Street
Cincinnati

Northmont Welding and Repair
R.R. Route No. 1, Box 75
Clayton

Industrial Engine Parts Co.
1431 East 32nd Street
Cleveland 14

Parts, Incorporated
2401 Carnegie Avenue
Cleveland 15

The Day and Maddock Co.
6201 Almira Avenue S.W.
Cleveland 2

Tullor Corporation
*947 W. Goodale Blvd.
Columbus 12

Efaw Electric & Radiator Co., Inc
303 South Market Street
St. Clairsville

Howard T. Moriarty Co.
143 Broadway Avenue
Toledo

Allied Supply
235-237 Corry Street
Yellow Springs

Goss Supply Company
620 Marrella Street
Zanesville

OKLAHOMA

Mechanical & Electrical Equip. Co.
*712-714 South Wheeling
Tulsa

OREGON

Electrical Construction Company
*2121-2147 N.W. Thurman Street
Portland 10

PENNSYLVANIA

Force Electric Inc.
1814-26 Union Avenue
Altoona

J. C. Schultz
*2123 Parade Street
Erie

C. Edgar Thoman Auto Electric, Inc.
277 Valley Street
Lewistown

Oil City Electric & Magneto
1 Central Avenue
Oil City

Rhoads Equipment Company
*4652 N. 15th Street
Philadelphia 40

Drave-Doyle Company
2001 Preble Avenue, N.S.
Pittsburgh 33

A. F. Shane & Company
*440 South Evaline Street
Pittsburgh 24

Fowler Engineering Company
*34 Main Street
Watsontown

RHODE ISLAND

Schmidt Electric Company
*137 Chestnut Street
Providence

SOUTH CAROLINA

State Machinery & Supply Co.
*1005 Meeting Street
West Columbia

SOUTH DAKOTA

Shakstad Electric and Machine Works
*1400 "I" Avenue
Sioux Falls

TENNESSEE

Osborne Equipment Company
1501 East 39th Street
Chattanooga

Osborne Equipment Company
*Market at Front Street
Knoxville

Maritime and Industrial Inc.
*80 South Front Street, Box 53
Memphis 1

Stephens Distributing Company
*1201 North 1st Street
Nashville 7

TEXAS

Oilfield Motor Service
Alice

Service and Supply
*P. O. Box 191
1301 West 6th Avenue
Amarillo

Sea Garden Sales Co., Inc.
(Marine Only)
P. O. Box 320
Brownsville

Lightbourn Equipment Company
*3235 Halifax
Dallas 7

El Paso Welding Supply
P. O. Box 42, 1535 Bassett Ave
El Paso

Applied Power Equipment & Mfg. Co.
2333 Gulf Terminal Drive
Houston

Harrison Equipment Co.
*1113 Bell Avenue, Box 1505
Houston 1

Gordin Machinery Company
Box 8
Lubbock

McEntyre Bros.
*2705 Kermit Highway
Odessa

*Sabine Propeller & Marine Service Co
West Lakeshore Drive
Port Arthur

Port Arthur Electric Service
2619 Seventh Street
Port Arthur

Gillespie Engine Service and Supply Co
Sabine Pass

Lightbourn Equipment Company
*8339 San Pedro Avenue, P. O. Box 13070
San Antonio 13

UTAH

Motor Mercantile Co.
54 West 7th South
Salt Lake City

VERMONT

T and L Electric Co.
*White River Junction

VIRGINIA

Paxton Company
*1019 Main Street
Norfolk 10

J. P. Long Company
*1811 Rosemath Road, Scotts Addition
Richmond 30

WASHINGTON

Fremont Electric Company
806 Main Street
Bremerton

Fremont Electric Company
*744 N. 34th Street
Seattle

K and N Electric Motors, Inc
1311 North Washington Street
Spokane

Rowand Machinery Co.
808 Division Street
Spokane

Western Wright Marine
1525 Commerce Street
Tacoma

WEST VIRGINIA

West Virginia Tractor & Equipment Co.
*1701 Fifth Avenue
Charleston 22,

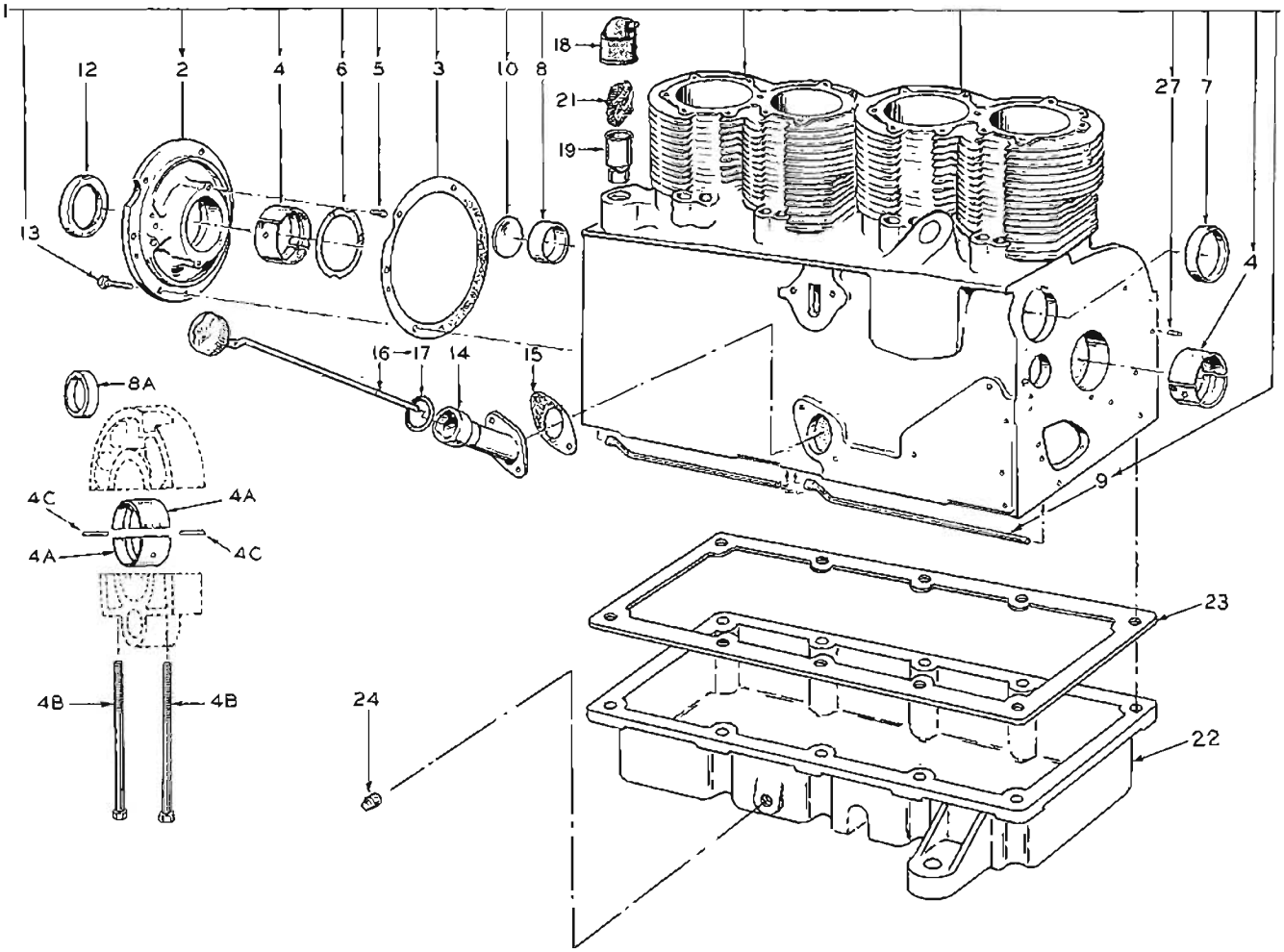
West Virginia Tractor & Equipment Co.
P.O. Box 587, Milford Street Ext
Clarksburg

WISCONSIN

Clymar Engineering & Sales, Inc.
*416 West Walnut Street
Milwaukee 12

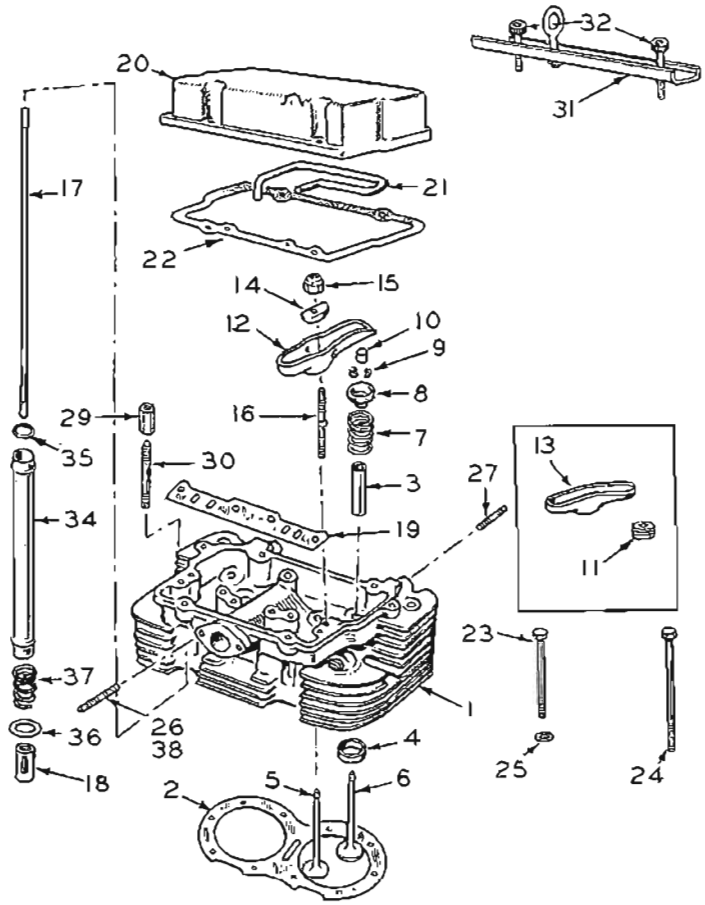
WYOMING

Power Service Company
*P O. Box 1150 (355 South Ash St.)
Casper



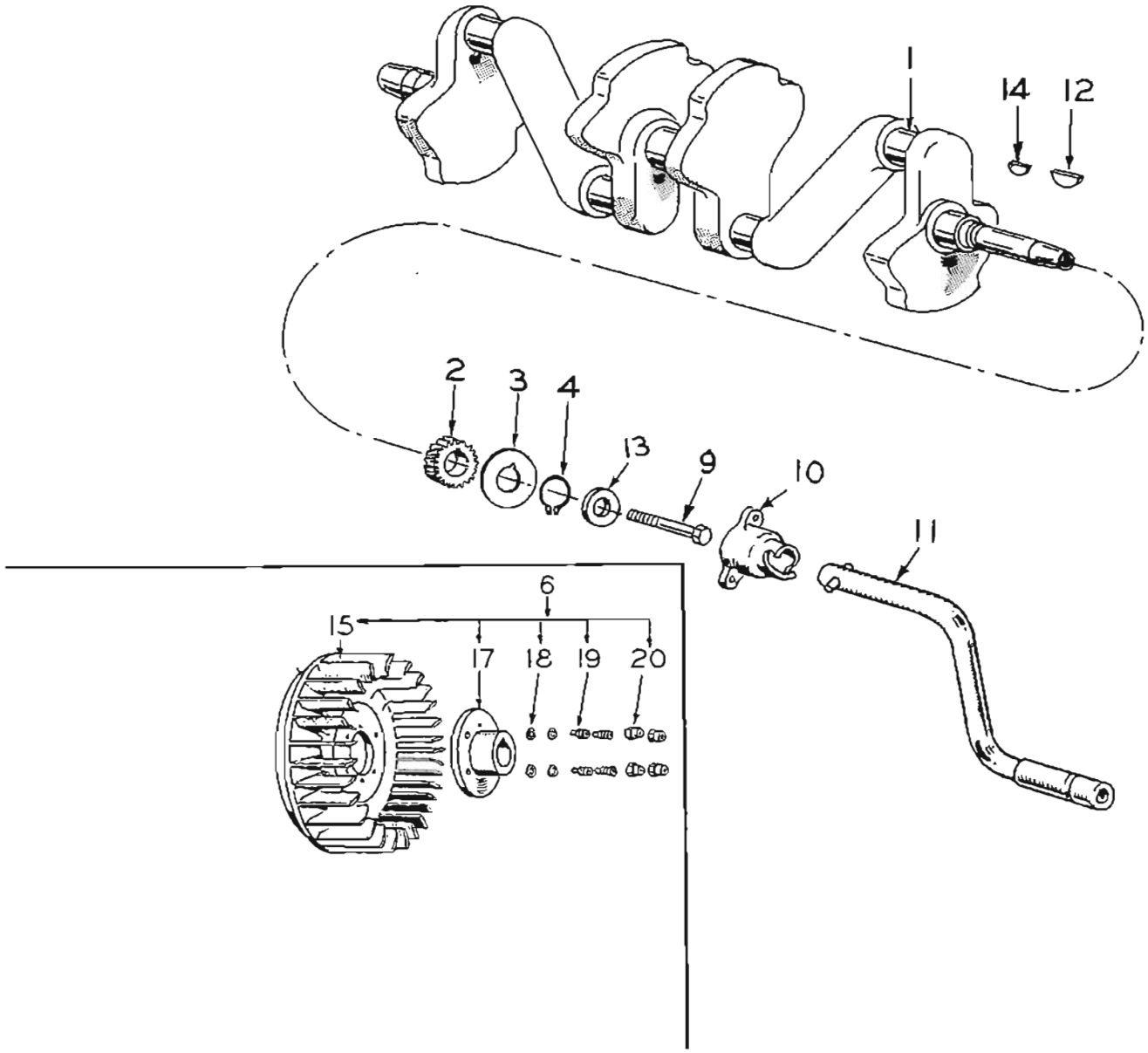
1 Cylinder Block Assy, Includes Brgs - (1) - (110A1436)
2 Plate, Rear Brg, Less Bearing & Pin - (1) - (101B376)
3 Gasket Kit, Rear Brg Plate - (1) - (101K358) ec
4 Bearing Half, Precision, Main-Front or Rear - (4) - (101-375) - (MS 13989-1)
4A Bearing Half, Precision, Main-Center - (2) - (101B361) - (MS 13987-1)
4B Bolt, Center Main Brg Hsg - (2) - (101A342)
4C Pin, Dowel, Center Main Brg Hog-(2)-(516 A149)
5 Pin, Lock, Crankshaft Thrust Washer - (4) - (516A72) ec
6 Washer, Crankshaft Thrust - (2) - (104A420) ec
7 Bearing, Precision Camshaft, Front, Std only - (1) - (101B363) ec
8 Bearing, Precision Camshaft, Rear, Std only - (1) - (101B365) ec
8A Bearing, Precision Camshaft, Center, Std only - (1) - (101B364)
9 Tube, Crankcase Oil { Front - (1) - (120B586) / Rear - (1) - (120B585)
10 Plug, Expansion, Rear Camshaft Opening - (1) - (517-53) ec
12 Seal, Oil, Crankshaft Rear - (1) - (509-86) ec
13 Bolt, Place, Rear Brg Plate, 3/8-16x1-1/4" - (6) - (805-19) ec
14 Tube, Oil Fill - (1) - (123A649) ec
15 Gasket, Oil Fill Tube Mtg - (1) - (123A667) ec
16 Cap & Indicator, Oil Fill - (1) - (123A698)
17 Gasket, Oil Fill Cap - (1) - (123A191) ec
18 Cap, Breather Tube - (1) - (123A787) ec
19 Tube, Breather - (1) - (123A645)
20 Not Used
21 Baffle, Breather Tube - (1) - (123-452) ec
22 Base, Oil - (1) - (102E476)
23 Gasket, Oil Base - (1) - (102B475)
24 Plug, Pipe, 1/2", Oil Drain - (1) - (505-56) ec
25 Not Used
26 Not Used
27 Pin, Dowel, Gear Cover Locating - (2) - (516-141)

Figure A-50. Crankcase and Oil Base Group



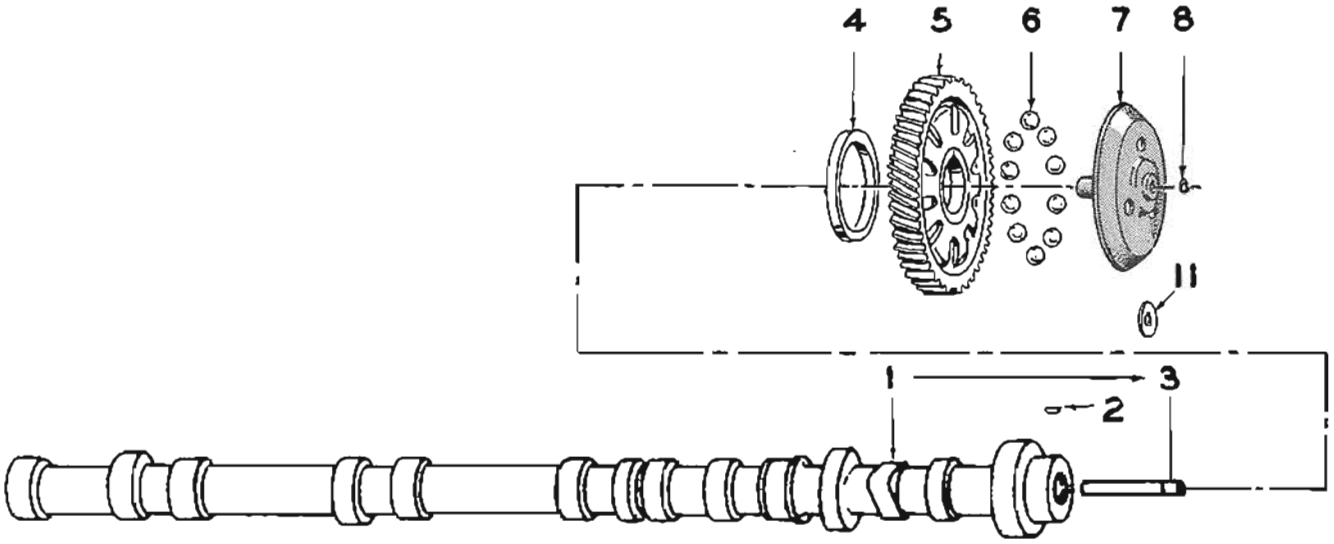
1 Head Cylinder - (2) - (110B1212) ec J60 only
2 Gasket, Cylinder Head - (2) - (110B1223) ec J60 only
3 Guide, Valve - (8) - (110B1216) ec
4 Insert, Intake Valve Seat, Specify: Std, .002, .005, .010, or .025 Oversize - (4) - (110A1214) ec
4 Insert, Exhaust Valve Seat, Stellite, Specify: Std, .002, .005, .010 or .025 Oversize - (4) - (110A1215) ec
5 Valve, Intake - (4) - (110B1413) - (MS 13999-6)
6 Valve, Exhaust, Stellite - (4) - (110A860) - (MS 13999-1)
7 Spring, Valve - (8) - (110A1221) ec
8 Retainer, Valve Spring - (8) - (110B1220) ec
9 Lock, Valve Spring Retainer - (16) - (110A858) - (MS 13997-1) ec
10 Cap, Valve Stem - (8) - (110A859) - (MS 13998-1) ec
11 Seal, Oil, Intake Valves, Includes Retainer Rings - (4) - (509A90) ec
12 Arm, Rocker, Exhaust - (4) - (115B128) ec
13 Arm, Rocker, Intake - (4) - (115B129) ec
14 Ball, Rocker Arm - (8) - (115B127) ec
15 Locknut, Hex, Rocker Arm - (8) - (115B150) ec
16 Stud, Rocker Arm - (8) - (115A131) ec
17 Rod, Push, Valve - (8) - (115A145) ec
18 Tappet, Valve - (8) - (115A132) ec
19 Guide, Push Rod - (2) - (115B142) ec J60 only
20 Cover, Rocker - (2) - (115D164) ec J60 only
21 Line, Oil, Rocker Cover - (2) - (120B561) ec J60 only
22 Gasket, Rocker Cover - (2) - (115B130) ec J60 only
23 Screw, Hex-Cap, Cylinder HD Mtg, 3/8-16x2" - (6) - (110A815) ec
24 Screw, Hex-Cap, Cylinder HD Mtg, 3/8-16x4-3/4" - (10) - (110A1225) ec
24 Screw, Hex-Cap, Cylinder HD Mtg, 3/8-16x4" - (4) - (110A1282) ec J60 only
25 Washer, Cylinder HD screw - (14) - (526-174) ec
26 Stud, Carburetor Mtg - (2) - (520A526) ec
27 Stud, Exhaust Manifold Mtg - (8) - (520A608) ec
28 Not Used
29 Nut, Extension, Lifting Bar - (2) - (403A620)
30 Stud, Cylinder HD Mtg - (2) - (520A626)
31 Bar & Eye Assy, Lifting - (1) - (403A628)
32 Screw, Hex-Cap, Lifting Bar, 3/8-16x5-1/2" - (800-67)
34 Shield, Pushrod - (8) - (115A137) ec
35 O-Ring, Push Rod Shield - (16) - (509-84) ec
36 Washer, Flat, Push Rod Shield - (8) - (115A155) ec
37 Spring, Retaining, Push Rod Shield - (8) - (115A146) ec
38 Stud, Intake Manifold - (4) - (520A338)

Figure A-51. Cylinder Head, Valve and Rocker Box Group



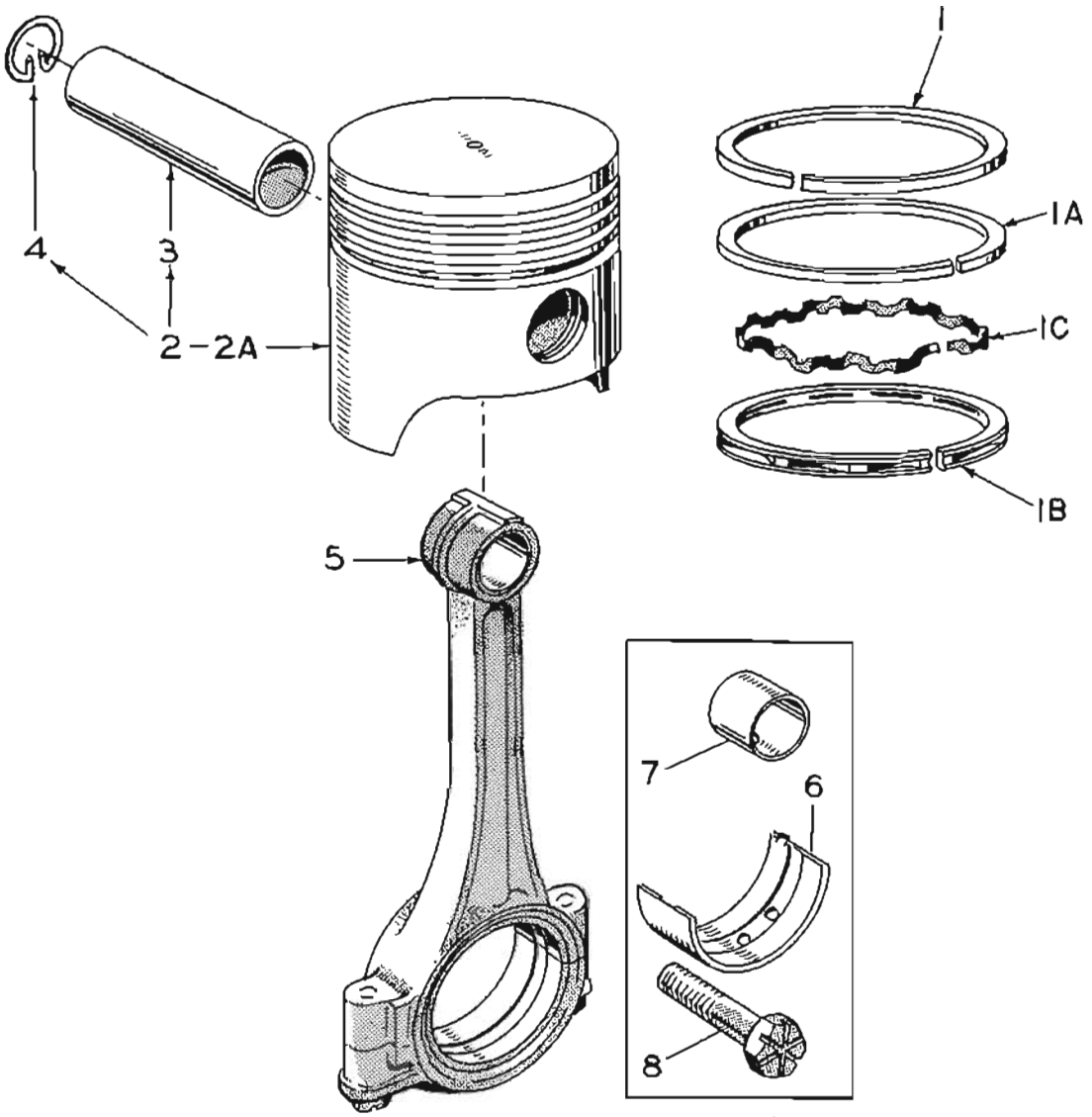
1 Crankshaft - (1) - (104E460) Not as shown
2 Gear, Crankshaft - (1) - (104B418) ec
3 Washer, Crankshaft Gear Retainer - (1) - (104A416) ec
4 Ring, Lock, Crankshaft Gear Washer - (1) - (518-188) ec
5 Not Used
6 Flywheel Assy, Includes Hub, Complete - (1) - (134C1446)
7 Not Used
9 Screw, Hex, Flywheel, 7/16-14x5-1/2" - (1) - (800-500) ec
10 Crankdog - (1) - (104B429) ec
11 Crank, Hand - (1) - (192B268)
12 Key, Woodruff, Flywheel - (1) - (515-153) ec
13 Washer, Flywheel Mtg Screw - (1) - (526A185) ec
14 Key, Woodruff, Crankshaft Gear - (1) - (515-1) ec
15 Flywheel Only - (1) - (134D1400)
17 Hub, Flywheel - (1) - (134B1401)
18 Washer, Flat, Special, Hub to Flywheel - (4) - (526A187)
19 Spacer & Washer Assy, Hub to Flywheel - (4) - (104A543)
20 Nut, Stover, 3/8-24, Hub to Flywheel - (4) - (115B150)

Figure A-52. Crankshaft and Flywheel Group



1 Camshaft, Includes Center Pin - (1) - (105A230)
2 Key, Camshaft Gear - (1) - (515-1) ec
3 Pin, Camshaft Center - (1) - (150A75) ec
4 Washer, Camshaft Thrust - (1) - (105A205) ec
5 Gear, Camshaft, Includes Flyball Spacer & Plate - (1) - (105B223)
6 Flyball, Governor - (12) - (510-46) ec
7 Cup, Governor - (1) - (150A962)
8 Ring, Snap, Center Pin - (1) - (150A78)
9 Not Used
10 Not Used
11 Washer, Thrust, Governor Yoke - (1) - (150A859)

Figure A-53. Camshaft Group



1 Ring, Piston, Top Compression
- STD - (4) - (113A80) - (MS 13933-4)
- .020" Oversize - (4) - (113A80H) - (MS 13933-5)
- .040" Oversize - (4) - (113A80L) - (MS 13933-6)

1A Ring, Piston, Intermediate Compression
- STD - (4) - (113A79) - (MS 13932-4)
- .020" Oversize - (113A79H) - (MS 13932-5)
- .040" Oversize - (113A79L) - (MS 13932-6)

1B Ring, Piston, Oil Control
- STD - (4) - (113A78) - (MS 13931-4)
- .020" Oversize - (4) - (113A78H) - (MS 13931-5)
- .040" Oversize - (4) - (113A78L) - (MS 13931-6)

1C Ring, Expander - (4) - (113A77) - (MS 13930-2)

2 Piston & Pin, Includes Retaining Rings, Specify: STD, .020" or .040" Oversize - (4) - (112A104)

2A Piston, w/o Piston Pin
- STD - (4) - (112C66) - (MS 13959-1)
- .020" Oversize - (4) - (MS 13959-2)
- .040" Oversize - (4) - (MS 13959-3)

3 Pin, Piston - (4) - (112A67) - (MS 13996-2)

4 Ring, RTNG, Piston Pin - (8) - (112A68) - (MS 13962-1)

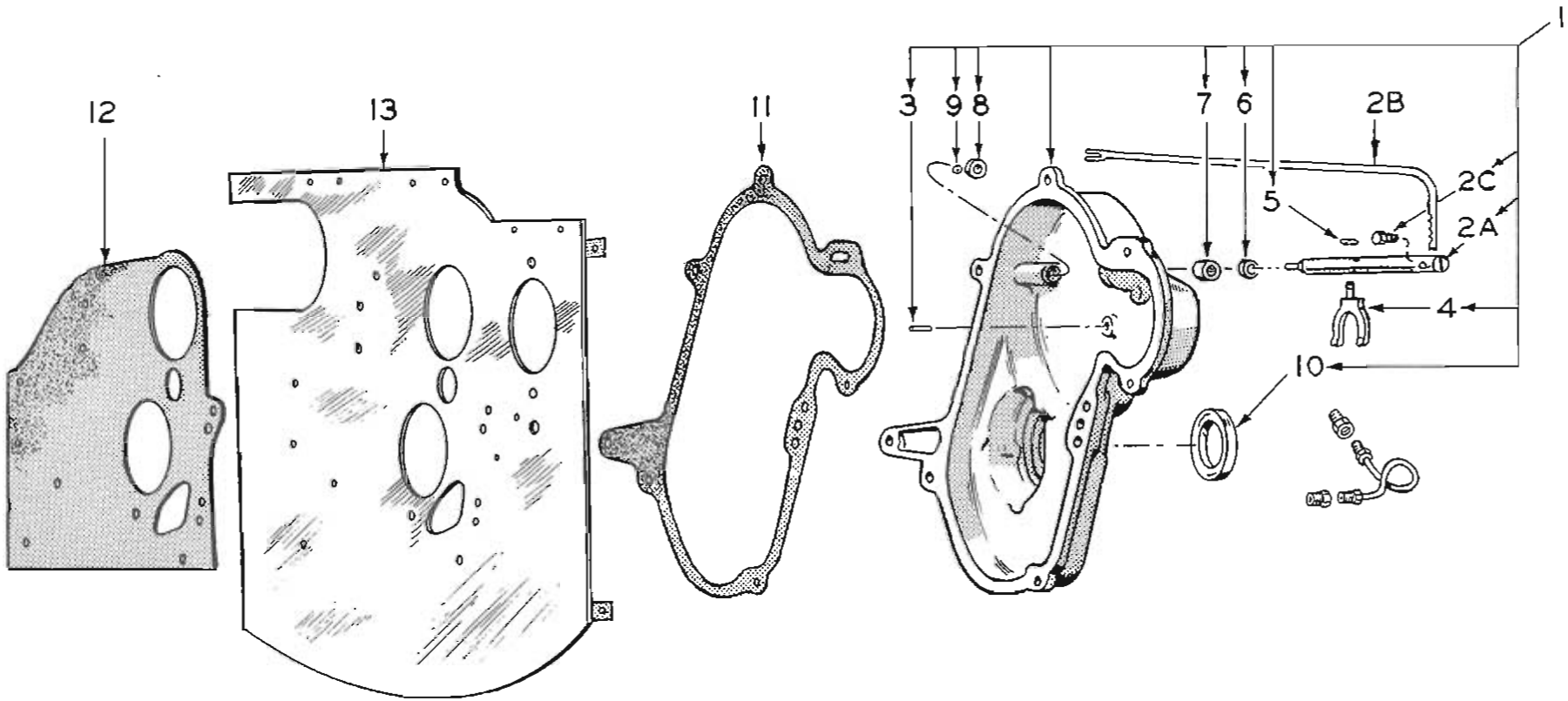
5 Rod Assy, Connecting, w/brgs, Pin Bushing, Bolts - (4) - (114A184)

6 Bearing, Connecting Rod, Upper or Lower Half - (8) - (114-181) - (MS 13994-1)

7 Bushing, Pin - (4) - (114B91)- (MS 13963-1)

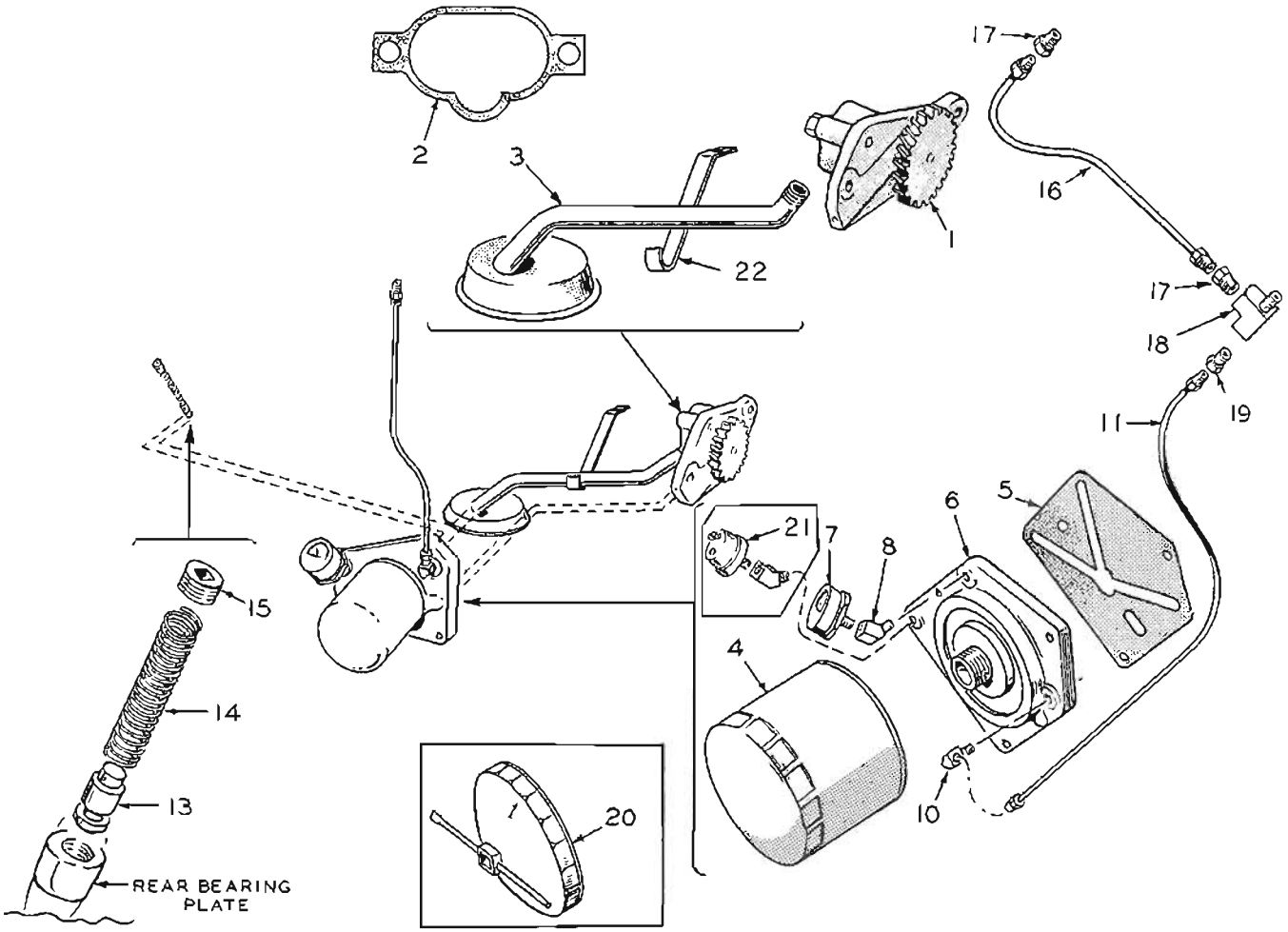
8 Bolt, Place, Connecting Rod, 5/16-24x1-13/16" - (8) - (805-12).

Figure A-54. Piston and Connecting Rod Group



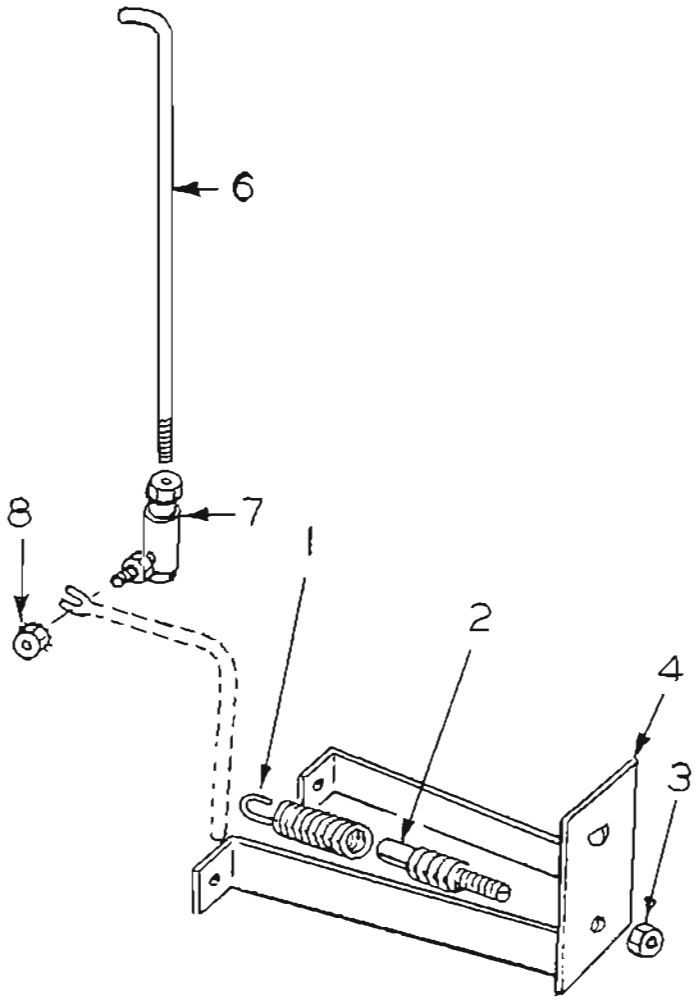
1 Cover Assy, Gear, Complete, Includes Parts Marked* - (1) - (103C262)
2A Shaft, Governor - (1) - (150B838)* ec J30 only
2B Arm, Governor - (1) - (150B836)
2C Screw, Hex-Mach, 8-32x1/2" - (1) - (815-176)* ec J30 only
3 Pin, Roll, Governor Cup Stop - (1) - (516-117)* ec
4 Yoke, Governor - (1) - (150A777)*ec
5 Ring, Yoke Rtng, E-Shape - (1) - (518-129)* ec
6 Seal, Oil, Governor Shaft - (1) - (509P88)* ec
7 Bearing, Needle, Governor Shaft, for 1/2" Shaft - (1) - (510P48)* ec
8 Bearing, Needle, Governor Shaft, for 1/4" Shaft - (1) - (510P49)* ec
9 Bearing, Ball, Governor Shaft Thrust, 5/16 - (1) - (510-43)* ec J60 only
10 Seal, Oil, Gear Cover - (1) - (509-87)* ec
11 Gasket, Gear Cover - (1) - (103C251) ec J60 only
12 Gasket, Gear Cover - (1) - (103C218) ec
13 Backplate, Gear Cover - (1) - (103D226) ec

Figure A-55. Gear Cover Group



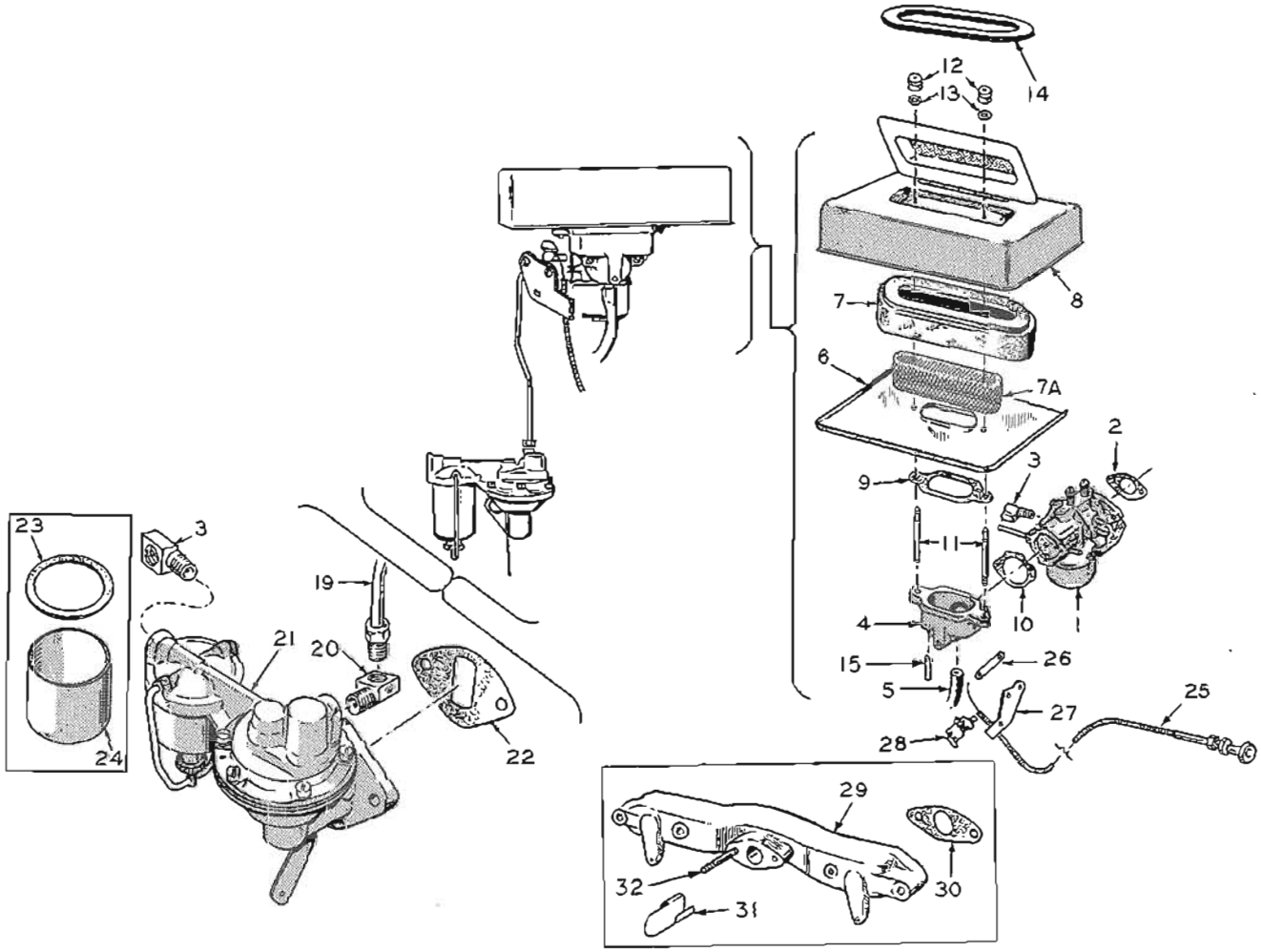
1 Pump Assy, Oil - (1) - (120B547) ec
2 Gasket Kit, Oil Pump - (1) - (120K580) ec
3 Cup Assy, Oil Pump Intake - (1) - (120B601) not as shown
4 Filter, Oil, 3-1/2" lg - (1) - (122A185) ec
5 Gasket, Oil Filter Adapter - (1) - (122A188) ec
6 Adapter Assy, Oil Filter - (1) - (122C182)
7 Gauge, Oil Pressure - (1) - (193P122) ec
8 Elbow, Street 45°, (1) For Oil Gauge, (1) For Low Oil Pressure Cut-off Switch - (502A53) ec
9 Not Used
10 Elbow, Inverted Male, Oil Line To Filter Adapter - (1) - (502-19) ec
11 Line, Oil, Adapter Plate To Cylinder Head - (1) - (120A562) ec
12 Not Used
13 Valve, Oil By-pass - (1) - (120A539) ec
14 Spring, Oil By-pass - (1) - (120A555) ec
15 Plug, Pipe, 1/8", Counter Sunk, Oil By-pass - (1) - (505-274) ec
16 Line, Oil, Cylinder-HD No. 1 To Cylinder-HD NO. 2 - (1) - (120B575)
17 Connector, Inverted Male, Upper, Oil Line - (2) - (502-97)
18 Tee, Restricted, Upper, Oil Line - (1) - (502A242)
19 Connector, Inverted Male, Lower, Oil Line - (1) - (502-30)
20 Wrench, Oil Filter - (Accessory, Not Furnished w/this Unit) - (420P268) ec
21 Switch, Low Oil Pressure Cut-off - (1) - (309A169)
22 Bracket, Oil Intake Cup - (1) - (120A602)

Figure A-56. Oil System Group



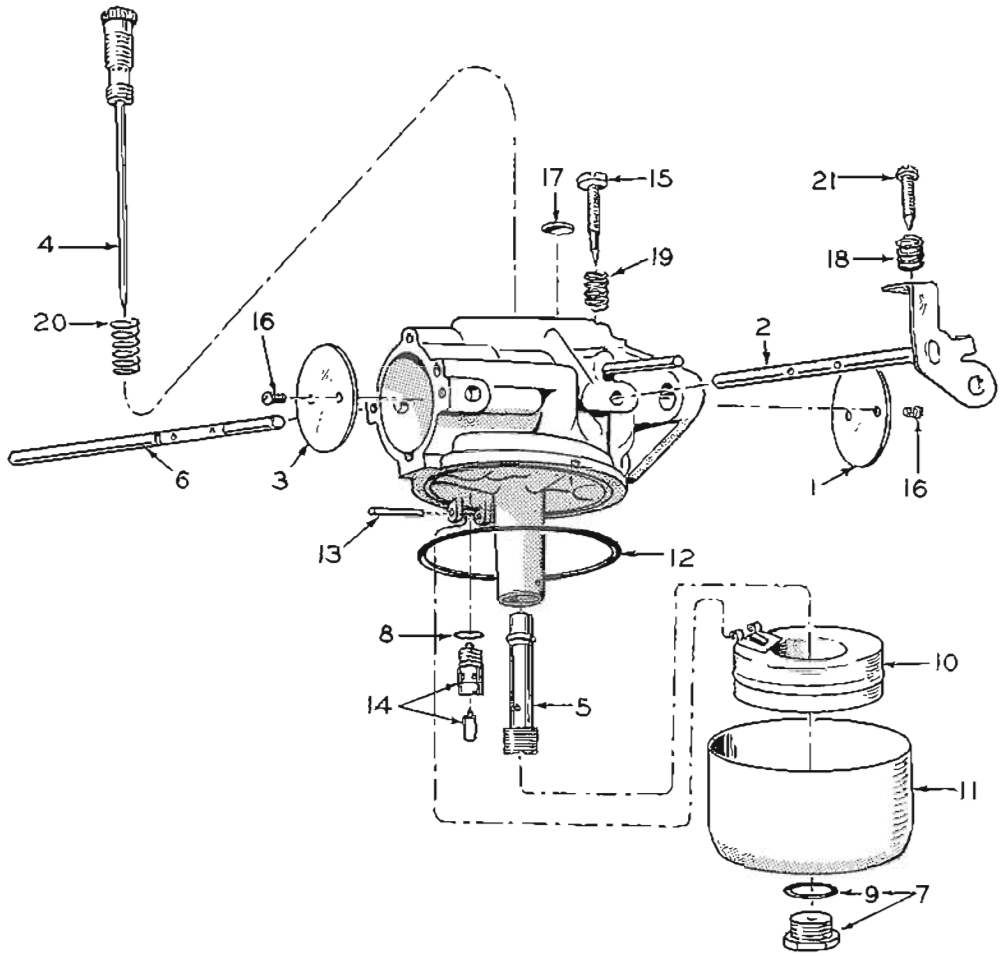
1 Spring, Governor - (1) - (150A861)
2 Stud, Governor - Adjusting - (1) - (150A863)
3 Nut, Governor Adj Stud - (1) - (104A91) ec
4 Bracket Assy, Governor - (1) - (150A815)
6 Link, Governor - (1) - (150A841)
7 Joint, Ball - (1) - (150A639) ec
8 Nut, Keps, Ball Joint To Governor Arm - (1) - (870-131) ec
9 Not Used

Figure A-57. Governor Control Group



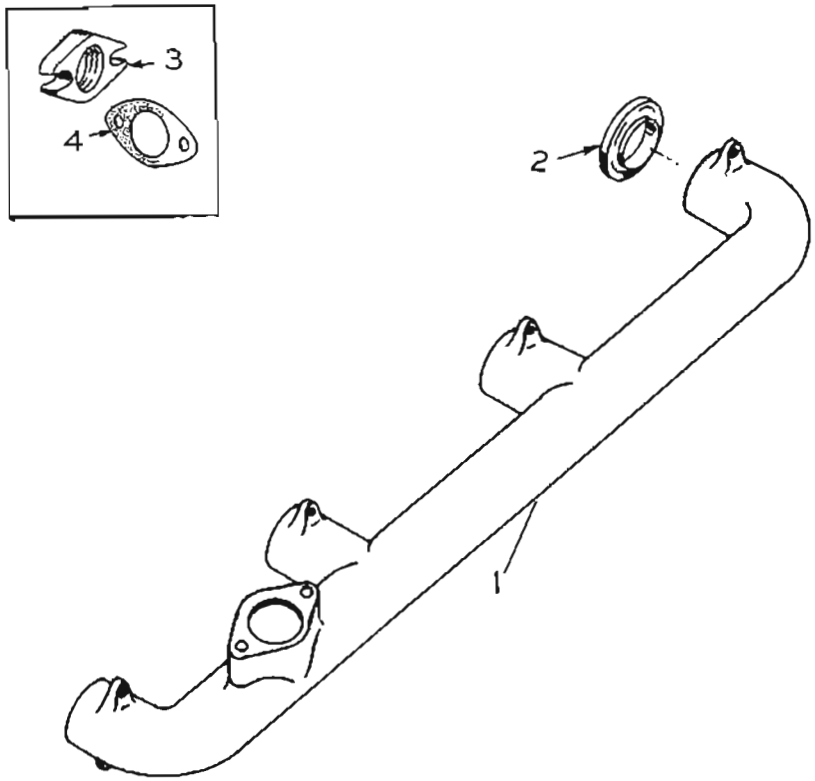
1 Carburetor, Manual Choke - (1) - (143C289)
2 Gasket, Carburetor Flange - (1) - (141A281) ec
3 Elbow, Inverted, Carb Inlet And Fuel Pump Inlet - (2) - (502-2) ec
4 Adapter, Air Cleaner, Includes Plastic Breather Tube - (1) - (140A647)
5 Hose, Breather Cap To Air Cleaner Adapter - (1) - (503A416)
6 Pan, Air Cleaner - (1) - (140C595) ec
7 Element, Air Cleaner - (1) - (140B640) ec
7A Retainer, Air Cleaner Element - (1) - (140B641) ec
8 Cover Assy, Air Cleaner - (1) - (140C744)
9 Gasket, Air Cleaner - (1) - (140C584) ec
10 Gasket, Air Cleaner Adapter To Carb - (1) - (140A585) ec
11 Stud, Air Cleaner - (2) - (520A621) ec
12 Nut, Knurled, Brass - Air Cleaner - (2) - (871-70) ec
13 Washer, Rubber, Air Cleaner - (2) - (140A602) ec
14 Gasket, Air Cleaner Cover Door - (1) - (140A725)
15 Tube, Air Cleaner Adapter Breather, Plastic - (1) - (123A732)
16, 17, 18 Not Used
19 Line, Fuel Pump To Carb - (1) - (159B744)
20 Elbow, Inverted Male, Fuel Pump Outlet - (1) - (502-2) ec J60 only
21 Pump, Fuel - (1) - (149A805) ec J60 only
22 Gasket, Fuel Pump Mtg - (1) - (149A792) ec
23 Gasket, Fuel Pump Bowl - (1) - (149P517) ec
24 Bowl, Fuel Pump - (1) - (149-116) ec J60 only
25 Choke, Cable Assy, Manual - (1) - (153B332)
26 Arm, Manual Choke - (1) - (153A326) ec
27 Bracket, Manual Choke - (1) - (153A327) ec
28 Clip, Manual Choke Arm - (1) - (518P176)
29 Manifold, Intake - (1) - (154D749)
30 Gasket, Intake Manifold - (2) - (154A733)
31 Baffle, Distributor, Cylinder HD - (2) - (110A1312)
32 Stud, Carb Mtg - (2) - (520A526)
— Repair Kit, Fuel Pump, Includes Diaphragm Assy, Valves & Gaskets - (149K875)

Figure A-58. Fuel System Group



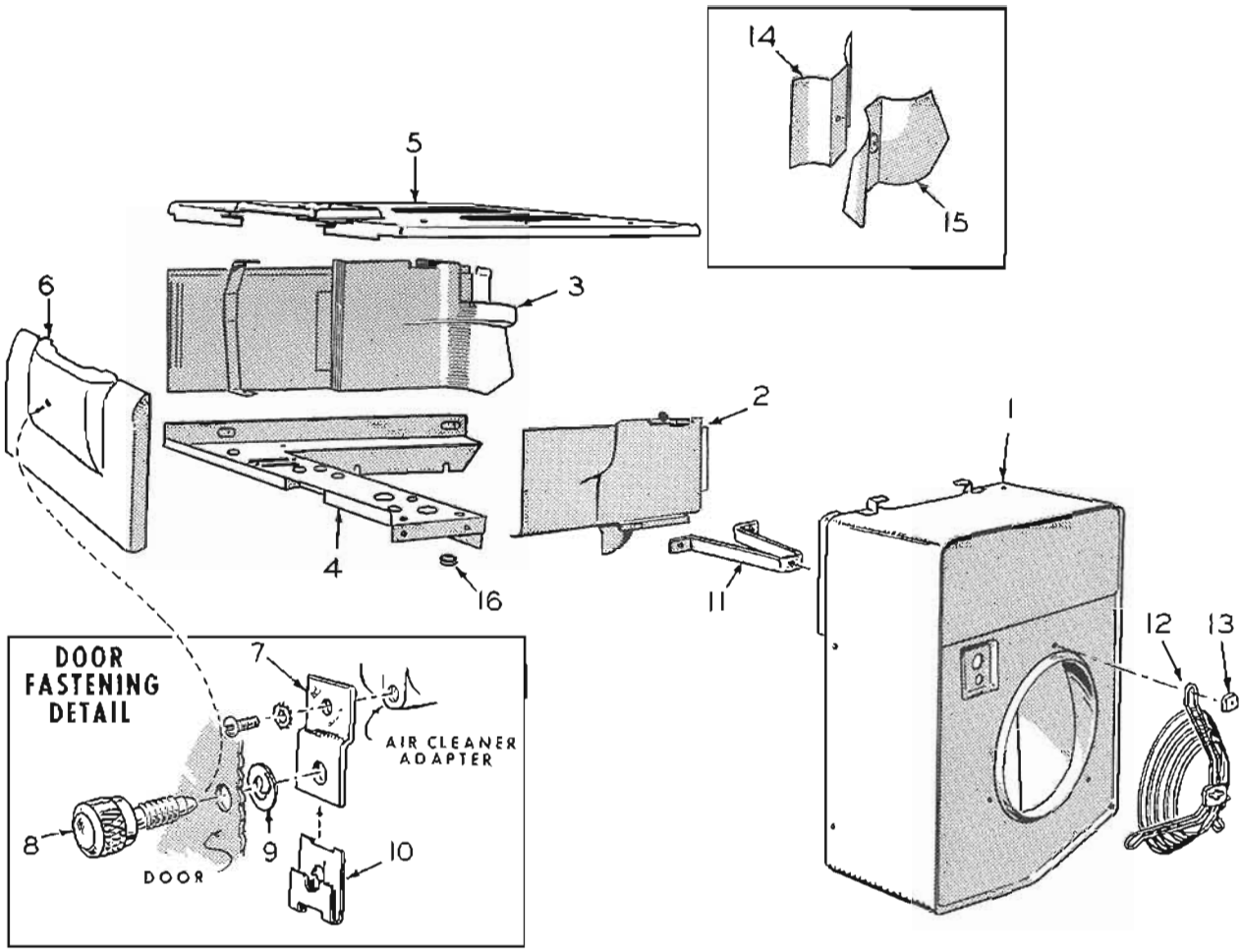
— Repair Kit, Carb, Includes Parts Marked** - (143K241)
— Gasket Kit, Carb, Includes Parts Marked* - (143K201) ec
— Gasket, Carb Mtg, Shown In Fig. A-58 - (141A281)* ec
1 Valve, Throttle - (1) - (143-202) ec
2 Shaft & Lever, Throttle - (1) - (143-234)
3 Choke, Valve - (1) - (143-220) ec
4 Needle, Idle Jet & High Speed Adj - (1) - (143-235)**
5 Nozzle - (1) - (143-237)**
6 Shaft & Lever, Choke, Manual - (1) - (143-221) ec
7 Screw & Gasket, Bowl - (1) - (143-208) ec
8 Gasket, Fuel Inlet Valve - (1) - (143A15)* ec
9 Gasket, Bowl Screw - (1) - (143-209)* ec
10 Float & Lever - (1) - (143-105) ec
11 Bowl - (1) - (143-210) ec
12 Gasket, Bowl Ring - (1) - (143-77)* ec
13 Pin, Float Lever - (1) - (143-212)** ec
14 Valve, Fuel Inlet - (1) - (143-39)** ec
15 Screw, Idle Adj - (1) - (143-213) ec
16 Screw, RD-HD, #3-48x3/16, Choke & Throttle Valve Attaching - (4) - (812-14)** ec
17 Plug, Welsh - (1) - (143-110) ec
18 Spring, Throttle Lever Adj Screw - (1) - (143-214) ec
19 Spring, Idle Adj Screw - (1) - (143-112) ec
20 Spring, High Speed Adj Needle - (1) - (143-114)
21 Screw, Throttle Lever Adj - (1) - (143-215)
22 Spring, Choke Shaft - (1) - (143-113)
23 Ball, Choke Shaft - (1) - (143-117)

Figure A-59. Carburetor Parts Group



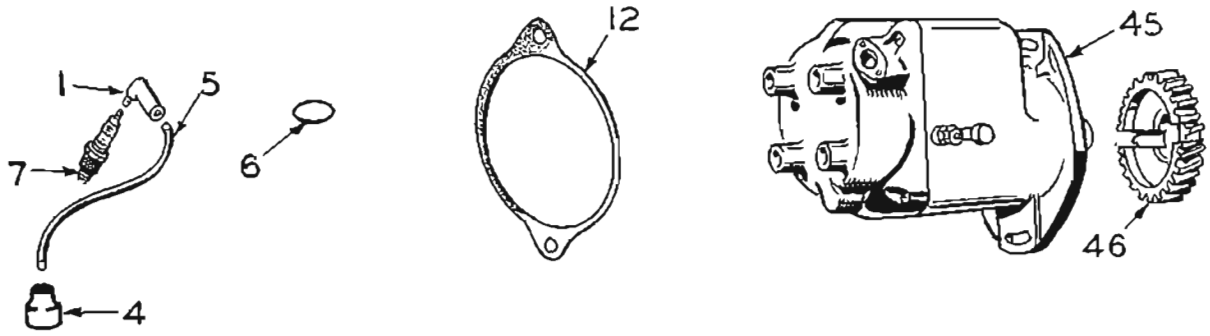
1 Manifold, Exhaust - (1) - (154D714) Not as shown
2 Gasket, Exhaust Manifold to Head - (4) - (154A463) ec
3 Flange, Exhaust Manifold Outlet - (1) - (155A782) ec
4 Gasket, Exhaust Outlet - (1) - (154A738)

Figure A-60. Manifold Group



1 Housing, Blower - (1) - (134D1087)
2 Housing, Cyl Air, Front - (1) - (134D1048) ec
3 Housing, Cyl Air, Rear - (1) - (134C1051)
4 Pan, Cyl Air Hsg, Bottom - (1) - (134D1418)
5 Cover, Cyl Air Hsg - (1) - (134D1201)
6 Panel, Air Hsg Door - (1) - (134D1202)
7 Bracket, Air Hsg Door - (2) - (134A1089)
8 Screw, Fastener, Air Hsg Door & Cover - (6) - (134A1373)
9 Washer, Fastener, Screw RTNR, Air Hsg Door & Cover - (12) - (134A1180) ec
10 Clip, Fastener Screw, Air Hsg Door & Cover - (6) - (870-178) ec
11 Support, Blower Hsg & Grille - (1) - (134B1088)
12 Grille & Crank Support - (1) - (134D1091) ec
13 Retainer, Grille - (1) - (134A1092) ec
14 Baffle, Center, Carb Side - (1) - (134B1097)
15 Baffle, Center, Opposite Carb Side - (1) - (134B1098)
16 Grommet, Ignition Cables, Bottom Cyl Hsg - (2) - (508A5) ec J60 only

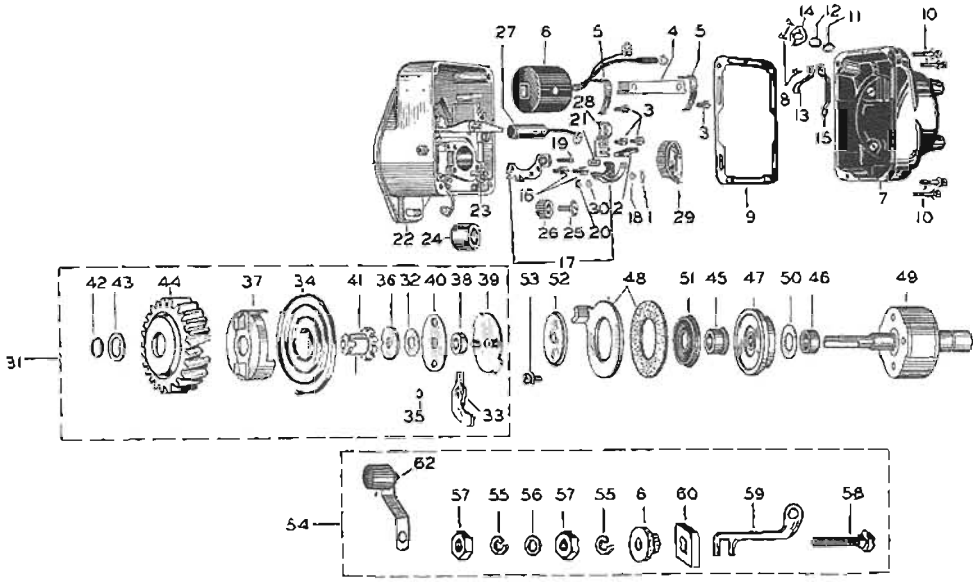
Figure A-61. Air Housing Group



1 Suppressor, Spark Plug - (4) - (314P32)
4 Nipple, Rubber, Spark Plug Cable - (4) - (160A558) ec
5 Cable, Spark Plug, W/Items 1 & 4 { 22-1/2" LG - (2) - (167A1410); 17" LG - (1) - (167A1427); 28-1/2" LG - (1) - (167A1429)
6 O-Ring, Spark Plug Cables - (4) - (509P18)
7 Plug, Spark - (4) - (167-4) - (Champion, H-8 or Equal) ec
12 Gasket, Breaker, Plate Mtg - (1) - (160A721) ec
45 Magneto Assy, Includes Drive Gear - (1) - (162A242) - (WICO, XH-2686)*
46 Gear, Magneto Drive - (1) - (160B674)

NOTE: For breakdown see Figure A-63. Order magneto parts from nearest WICO dealer or WICO Electric Company, West Springfield, Mass.

Figure A-62. Ignition Group



— Magneto Assy, Includes Drive Gear - (1) - (162C242) - (WICO, XH-2686)*
1 Lock, Breaker Arm - (1) - (WICO, 4210)
2 Wiper, Cam, Felt - (1) - (WICO, 5077)
3 Screw, (2) Condenser Clamp, (2) Coil Core Clamp - (4) - (WICO, 5411)
4 Core, Coil - (1) - (162-244) - (WICO, X5524)
5 Clamp, Coil Core - (2) - (WICO, 5633)
6 Coil - (1) - (162-246) - (WICO, X5700B)
7 Cap Assy, Distributor - (1) - (162-248) - (WICO, X5777)
8 Screw, (1) Coil Contact, (2) Window Clamp Plate - (3) - (WICO, 5536)
9 Gasket, Distributor Cap - (1) - (WICO, 5618)
10 Screw & Lock Washer, Distributor Cap Mtg - (4) - (WICO, 5622)
11 Gasket, Window Seal - (1) - (WICO, 5719)
12 Window - (1) - (WICO, 5753)
13 Spring, Coil Contact - (1) - (WICO, 5773)
14 Plate, Window Clamp - (1) - (WICO, 5895)
15 Interlead, Secondary - (1) - (WICO, X6001)
16 Screw, Fixed Contact Clamp - (2) - (WICO, 5900)
17 Point Set, Breaker - (1) - (162-204) - (WICO, 5996)
18 Washer, Breaker Point Aligning - (1) - (WICO, 3219)
19 Screw, Breaker, Spring Clamp - (1) - (WICO, 5431)
20 Washer, Breaker Point Aligning - (1) - (WICO, 5717)
21 Felt, Breaker Arm - (1) - (WICO, 7644)
22 Housing Assy - (1) - (WICO, X6196)
23 Pivot, Breaker Arm - (1) - (WICO, 5603)
24 Bushing, Breaker Plate - (1) - (WICO, 5610)
25 Screw & Washer, Distributor Gear - (1) - (WICO, 6466)
26 Gear, Distributor - (1) - (162-250) - (WICO, 6865)
27 Condenser - (1) - (162-227) - (WICO, X6916)
28 Clamp, Condenser - (1) - (WICO, 6924)
29 Rotor Distributing - (1) - (162-251) - WICO, X9564)
30 Washer - (1) - (WICO, 10407)
31 Coupling Assy, Impulse - (1) - (162-249) - (WICO, X6516) Item 44 not part of this assy.
32 Washer, Flange Spacing - (1) - (WICO, M-42XA)
33 Arm, Trip, - (2) - (WICO, A-179X)
34 Spring, Drive - (1) - (WICO, 15-186)
35 Ring, Snap - (2) - (WICO, A-243X)
36 Washer, Drive Cup Spacing - (1) - (WICO, IVA-583)
37 Cup, Drive - (1) - (WICO, 2061A)
38 Spacer, Driven Flange - (1) - (WICO, 2122)
39 Flange, Driven - (1) - (WICO, X2286)
40 Retainer, Drive Spring - (1) - (WICO, 2288)
41 Nut, Lock, Impulse - (1) - (WICO, 6412)
42 Ring, Lock Impulse - (1) - (WICO, 6424)
43 Washer, Thrust - (1) - (WICO, 6425)
44 Gear, Drive - (1) - (160B674) Not Part of Item 31, Refer Fig. A-62
45 Spacer, Impulse - (1) - (WICO, 5518)
46 Spacer, Bearing Cage - (1) - (WICO, 5520)
47 Bearing & Cage Assy - (1) - (162-243) - (WICO, X5521) consists of:
Ring, Rtng, Rotor Brg - (1) - (WICO, 5516)
Bearing, Rotor - (1) - (WICO, 5517)
Cage Rotor Brg - (1) - (WICO, 5567)
48 Plate & Gasket, Impulse Stop - (1) - (162-245) - (WICO, X5549)
49 Rotor - (1) - (162-247) - (WICO, Y5710)
50 Shield, Ball Brg - (1) - (WICO, 5926)
51 Seal, Oil - (1) - (WICO, 6199)
52 Slinger, Oil - (1) - (WICO, 6204)
53 Screw & Lockwasher, Impulse Stop Clamp - (4) - (WICO, 6465)
54 Connection Assy, Grd - (1) - (WICO, X5654)
55 Washer, Lock, Grd Stud - (2) - (WICO, M-55XA)
56 Washer, Grd, Stud - (1) - (WICO, IXA-256)
57 Nut, Grd Stud - (2) - (WICO, 3230)
58 Stud, Grd - (1) - (WICO, 3945)
59 Connector, Grd - (1) - (WICO, 5635)
60 Lock, Insulating, Grd Stud - (1) - (WICO, 9820)
61 Insulator, Grd Stud - (1) - (WICO, 11874)
62 Button, Stop - (1) - (WICO, X5632)

*NOTE: Order magneto parts from nearest WICO dealer or WICO Electric Company West Springfield, Mass. Give part number and description.

Figure A-63. Magneto Parts Group

APPENDIX B
TEST EQUIPMENT SECTION

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B-3 Eight Ways To Use Ideal Line Indicator 61-005		B-5
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1. VOLT-AMMETER

a. Description.

This is an Amprobe model RS-1 rotary scale snap around instrument used to obtain voltage and current values in a-c electrical circuits. It is supplied with voltage test leads and case.

b. Data (Fig. B-1).

Manufacturer	Amprobe Instrument Corporation 630 Merrick Road Lynbrook, N.Y.
Model	Amprobe RS-1
Scale Range, Current	0-5/0-15/0-40/0-100 amperes a.c.
Voltage	0-150/0-600 volts a.c.
Frequency	60 cycles
Accuracy (volts & amps)	Within 3% of full scale
Voltage Breakdown Test	3000 volts a.c.
Patent Numbers (U.S. Pat. Office)	2,633,845 and D160,179 Others Pending

c. Control Components.

The following controls are used to operate the volt-ammeter.

Pointer Lock Button	Locks (to right) or releases (to left) meter indicator pointer.
Transformer Jaws	Encircles one conductor of electric circuit to obtain electrical current activity to operate meter.
Jaw Trigger	Pressed to open one transformer jaw.
Rotary Scale Selector	Rotate to select proper meter scale.
Zero Adjust Screw	Rotate to set indicator pointer at zero.
Scale	Indicates extent of electrical activity in volts or amperes.
Test Leads	Use to conduct electrical activity to meter for voltage readings.
Test Lead Receptacles	On meter to insert bayonet pins of test leads.

d. Reading of Scale (Fig. B-2).

(1) When taking either voltage or current readings always start with the highest range scale and then select lower scale ranges to obtain more accurate lower readings.

(2) If reading is below half scale on the lowest range of the meter, and greater accuracy is desired, loop the conductor (if practical) two or more times around the transformer jaws and divide the reading by the number of turns.

e. Current Readings (Printed Black).

(1) Release pointer by moving lock button to left.

(2) Turn rotary scale selector to obtain highest current meter scale (100-Amps).

(3) Press jaw trigger to open jaws.

(4) Encircle one conductor with the transformer jaws. Release finger pressure from trigger to allow jaws to close around the conductor before reading meter.

(5) Obtain reading from scale. If required, proceed to lower range scales (par. d. above).

f. Voltage Readings (Printed Red).

(1) Insert bayonet type pins of voltage test leads into voltage receptacles at bottom of voltammeter. Push in against the receptacle spring and twist to lock in place.

(2) Turn rotary scale selector to obtain highest voltage meter scale (600 volts).

(3) Release pointer by moving lock button to left.

(4) Connect one test lead to one side of line. Then with meter in one hand (or resting in suitable position) touch the other side of the line with the other test lead. If voltage does not exceed 600 volts, attach second lead and read voltage on 600 volt red scale. If voltage is below 150, rotate scale to the lower range scale (150 volts) and read voltage.

g. Maintenance.

(1) Storage. Keep meter clean. When not in use, keep pointer locked. Store meter and leads in its case.

(2) Zero Adjustment. For accuracy, set pointer exactly on zero line by rotating the zero adjust screw. If, while adjusting the pointer swings away from the zero line and does not come to rest directly over it, it is possible that the scale window is statically charged. To neutralize, fog the window, just as in cleaning eye-glasses.

(3) Repairs. Refer to manufacturer paragraph b. above.

2. LINE VOLTAGE INDICATOR

a. Description.

This is an Ideal model 61-005 line voltage indicator used to obtain nominal voltage values and current indications in electrical circuits. It is supplied with voltage test leads.

b. Data.

Manufacturer	Ideal Industries, Inc., Sycamore, Illinois
Model	61-005
Federal Stock Number	6625-284-0264
Scale Range, D-C Voltage	115/230/600
A-C Voltage	115/220/440/550
Current	Indicator Light.
Patent Numbers	2,791,748

c. Control Components.

The following controls are used to operate the line voltage indicator.

Test Leads	Use to conduct electrical activity to instrument for voltage readings, current indications, frequency, or circuit continuity tests.
Indicator Lights	Coded Blk-Red. Negative side glows when current is DC. Both glow when current is AC.
Voltage Scale	DC: 115/230 color coded green; 600 red. AC: 115/220 color coded green; 440/550 red. Indicator moves down scale.

d. Operation.

Various methods of using the line voltage indicator are shown and explained in figure B-3. NOTE: This instrument is intended for intermittent service only; continuous operation, especially on high voltages, will burn out the coil. To prevent damage to test leads, hold leads by plastic prod handles only. All indications are relative for determining nominal line voltage only. Try the instrument first on a known voltage to become familiar with the indicators.

e. Maintenance.

(1) Storage. Keep instrument clean. Store in secure place free from dust, dirt and excessive vibrations.

(2) Repairs. Limit repairs to the replacement of parts shown in figure B-4. Contact the manufacturer paragraph b. above for parts and repairs which are beyond capabilities in the field. Always include complete description, part number and nameplate data for parts.

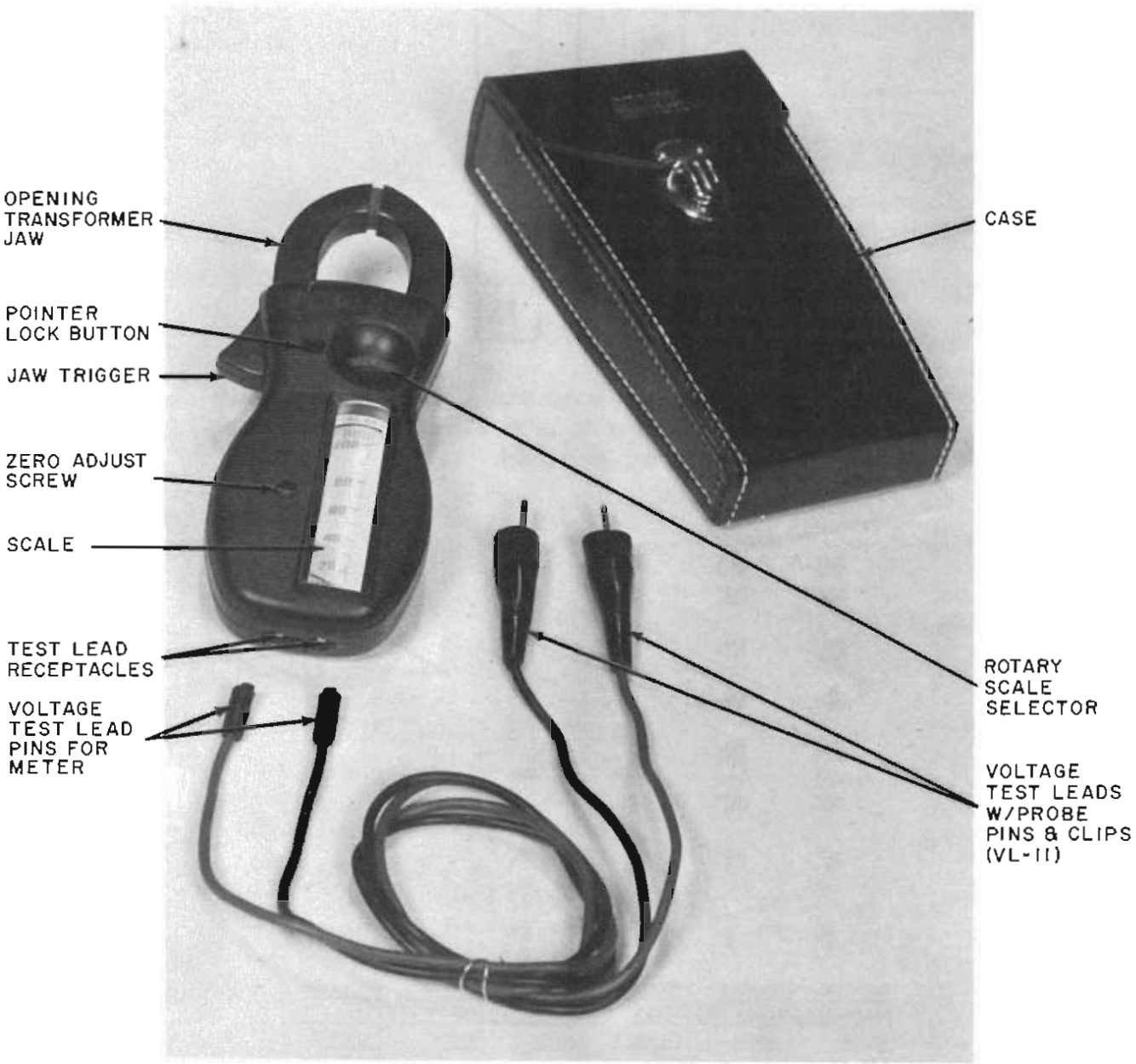
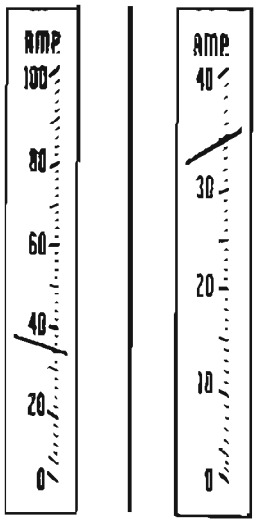
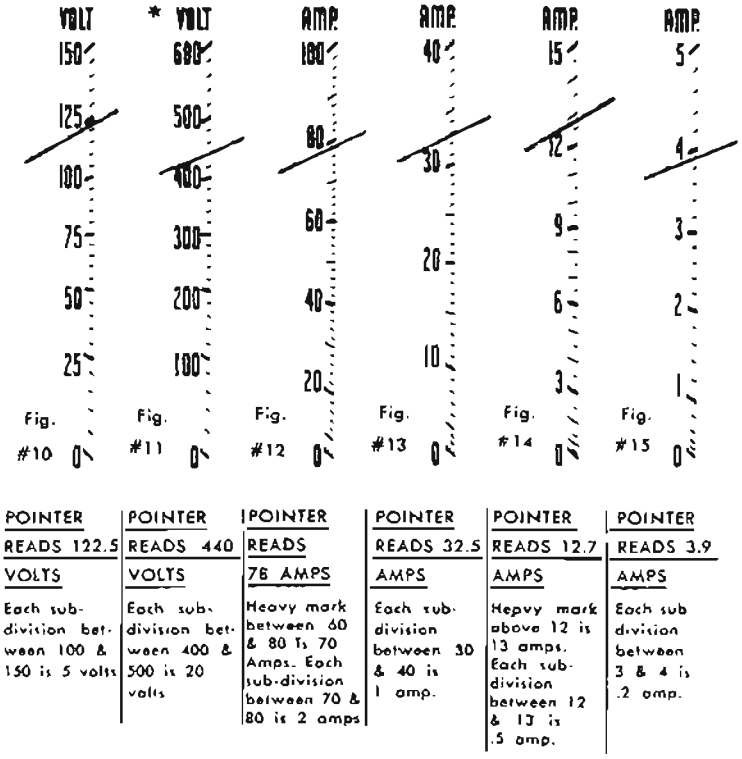


Figure B-1. Amprobe RS-1 Volt-Ammeter



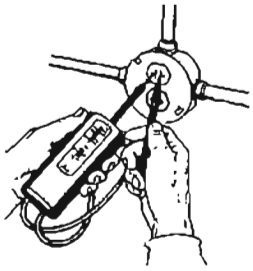
If pointer indicates below 40 amps on 100-amp scale set rotary scale selector to next lower current range (40) and take reading as 35 amps.



Sample meter readings for voltage and current readings on various scales.

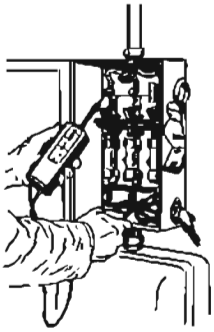
Figure B-2. Amprobe RS-1 Volt-Ammeter Scale Readings

1. TESTING FOR AC OR DC VOLTAGE AND VALUE



Place one test prod on one terminal of the line, or pierce insulation with prod. Then place other prod on terminal, or pierce insulation of other side of line. DC or AC voltage will be indicated by the scale and also by the neon lamp. If current is DC, only negative side of lamp will glow; both sides glow if current is AC.

2. LOCATING BLOWN FUSES

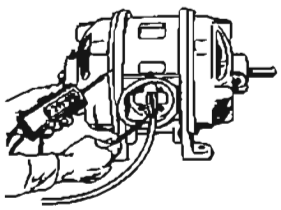


Hold one test prod on the source side of one fuse and the other test prod on the load side of the other fuse. If there is no voltage indicated, the fuse next to the test prod on the load side is blown. If voltage is indicated, the fuse next to the test prod on the load side is O. K. The same test should then be made with the prod on the opposite sides of the same two fuses, to check the other fuse. On a three phase circuit, lower than normal line voltage or no voltage with this test indicates a blown fuse.

3. FINDING GROUNDED SIDE OF LINE

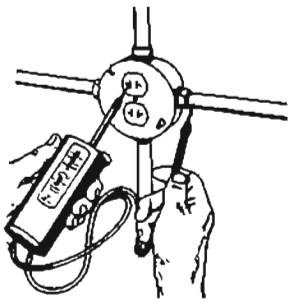
Touch one test prod to normal ground such as conduit, etc. Touch the other test prod to each of the line terminals until one is found that does not give a voltage indication. That one is the grounded circuit.

4. TESTING FOR "GROUNDED" SIDE OF MOTOR OR APPLIANCE



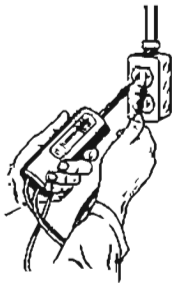
Turn appliance or motor "on". Touch one test prod to the frame and the other prod to each of the terminal connections. No glow or scale indication shows grounded side.

5. LOCATING EXCESSIVE LEAKAGE TO GROUND



Hold one test prod on normal ground such as conduit, etc. Touch other test prod to terminal of one side of line or unit being tested. If result is normal voltage reading and bright lamp glow, test other side of line, or unit. A LOW resistance ground is indicated by no scale reading. A HIGH resistance ground leakage is shown by a dull lamp glow, and a sub-normal reading.

6. TESTING FOR 25 OR 60 CYCLE FREQUENCY



Hold one test prod to each side of AC line. A low frequency hum and slow vibrations indicate 25 cycle current. 60 cycle current is indicated by a higher frequency hum and more rapid vibrations.

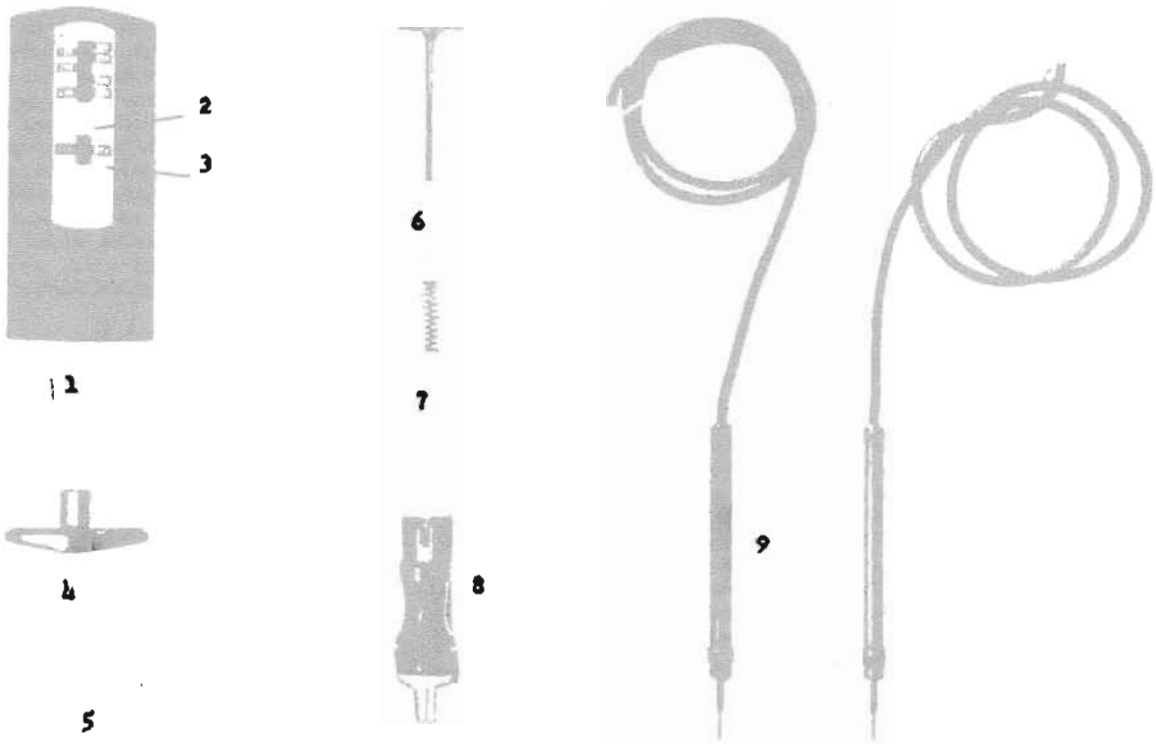
7. DETERMINING POLARITY OF DC CURRENT

Touch one test prod to each side of the line. Only one side of the neon lamp will glow, and the line corresponding to that side is negative. Test prods are color-coded to correspond to name plate.

8. CONTINUITY TESTS OF CORDS, MOTORS, APPLIANCES, ETC.

Plug cord into outlet and touch prods to each cord terminal. Lamp glow and scale reading indicates cord is good. Connect one side of unit or appliance cord to one side of line. Touch other terminal or unit with one test prod and touch other prod to other side of line. A broken circuit is indicated by no lamp glow or scale reading. A poor contact is indicated by a dull glow and a partial scale reading.

Figure B-3. Eight Ways to Use the Ideal Voltage Tester



1 Case (H-427)
2 Nameplate (K-2045)
3 Adhesive Blank (L-4741)
4 End Cap (K-2043)
5 Screw (503.31)
6 Indicator (L-4731)
7 Indicator Spring (L-4736)
8 Coil Assembly (K-2046)
9 Test Prod Assembly (1 Blank, 1 Red) (61-021)
- Carrying Case (Vinyl) (Optional) (61-009)
- Carrying Case (Leather) (Optional) (61-010)

Figure B-4. Ideal Line Voltage Tester 61-005 (FSN-6625-284-0264)