

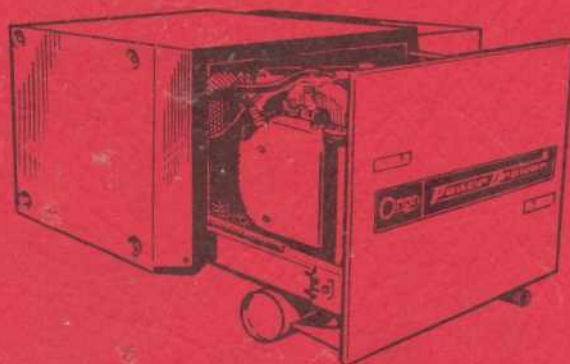
**MAJOR  
SERVICE MANUAL**

FOR

**BF POWER DRAWER**



**4KW ELECTRIC POWER PLANT  
FOR  
RECREATIONAL VEHICLES**



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# GENERAL INFORMATION

## YOUR MANUAL

This manual contains information required for proper maintenance, servicing and overhaul of the 4KW Power Drawer. Study the entire manual to better understand how the plant functions. This will help in maintenance and servicing of the plant, which will result in longer life and more reliable operation.

If possible, use a parts catalog with the service manual. The parts catalog will give a good picture of assembly and disassembly and will help to identify plant components. Since the first and most important part of repair work is correct diagnosis of the trouble, troubleshooting charts are included to help find the fault.

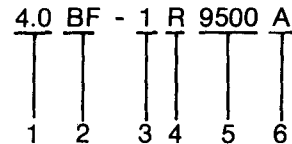
A list of special tools is included in the manual. These are available from Onan, and will make it easier to work on the plant.

When discussing left side and right side in this manual, view the plant from the engine end of the plant, which is designated the front end.

When ordering parts or requesting information always supply the complete MODEL and SPECIFICATION as shown on the Onan nameplate (see "MODEL DESIGNATION" following). This information is necessary to identify your plant among the many models manufactured by Onan.

## MODEL DESIGNATION

The following typical model number is broken down into code segments used by Onan.



1. Indicates kilowatt rating.
2. Series identification.
3. Voltage code of the generator, 1 = 120 volts.
4. Method of starting: R - remote electric starting.
5. Factory code for designating optional equipment, if any.
6. Specification letter which advances when the factory makes production modifications.

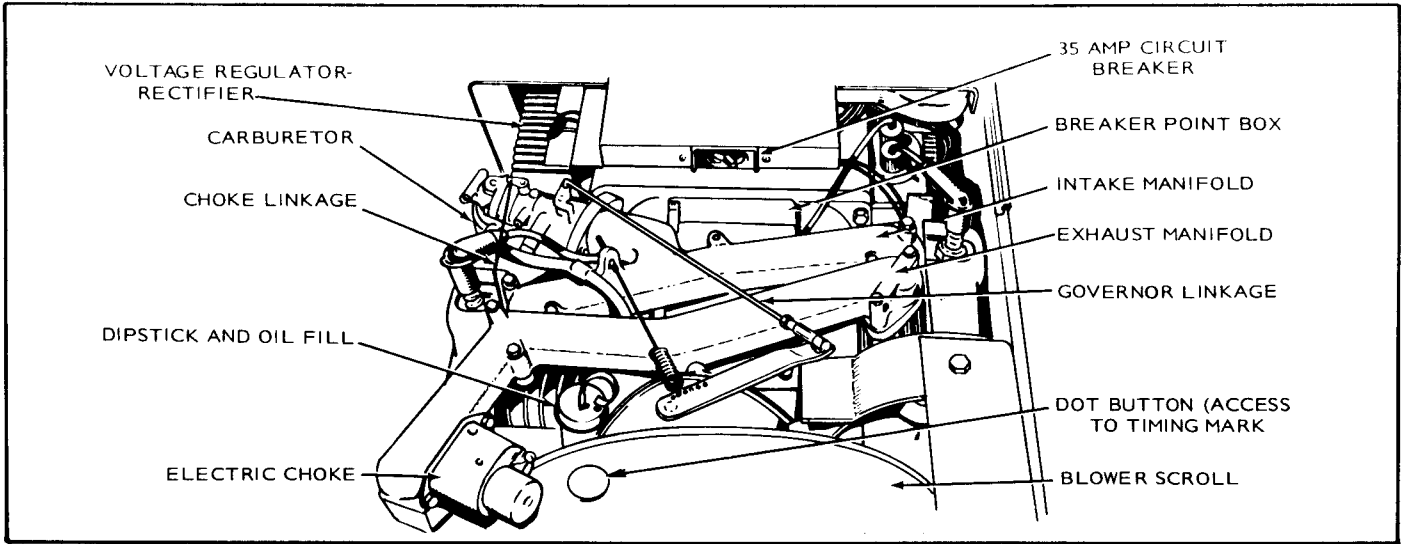


Onan uses this symbol throughout the text to warn of possible equipment damage.

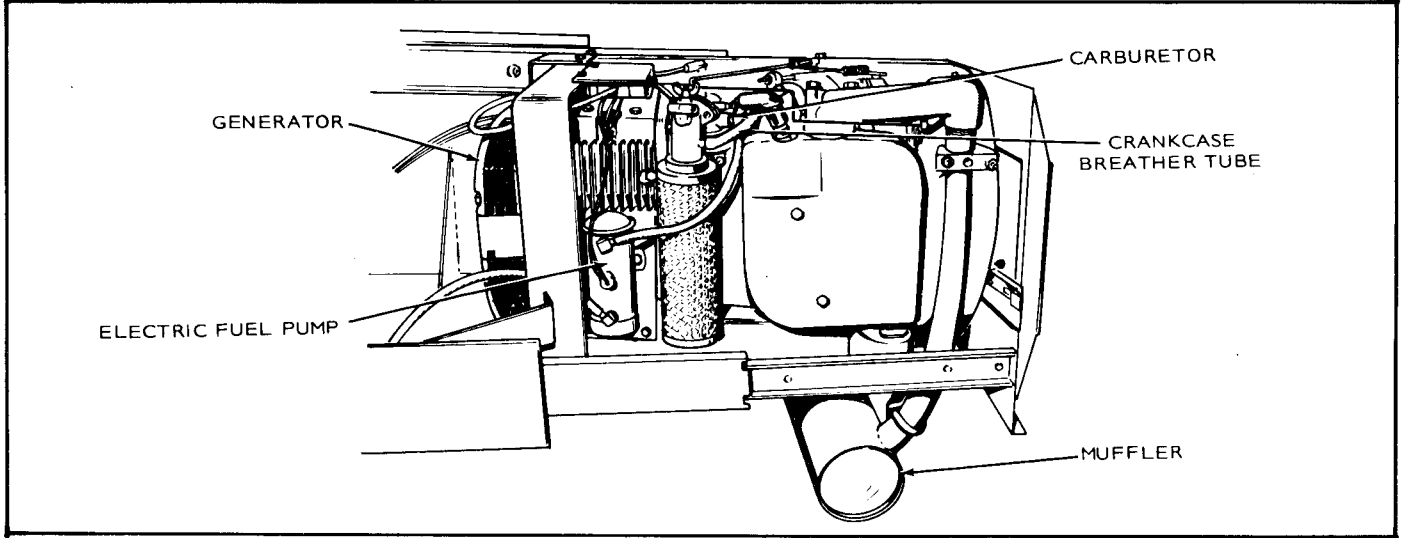


This symbol is used to warn of any possible personal injury.

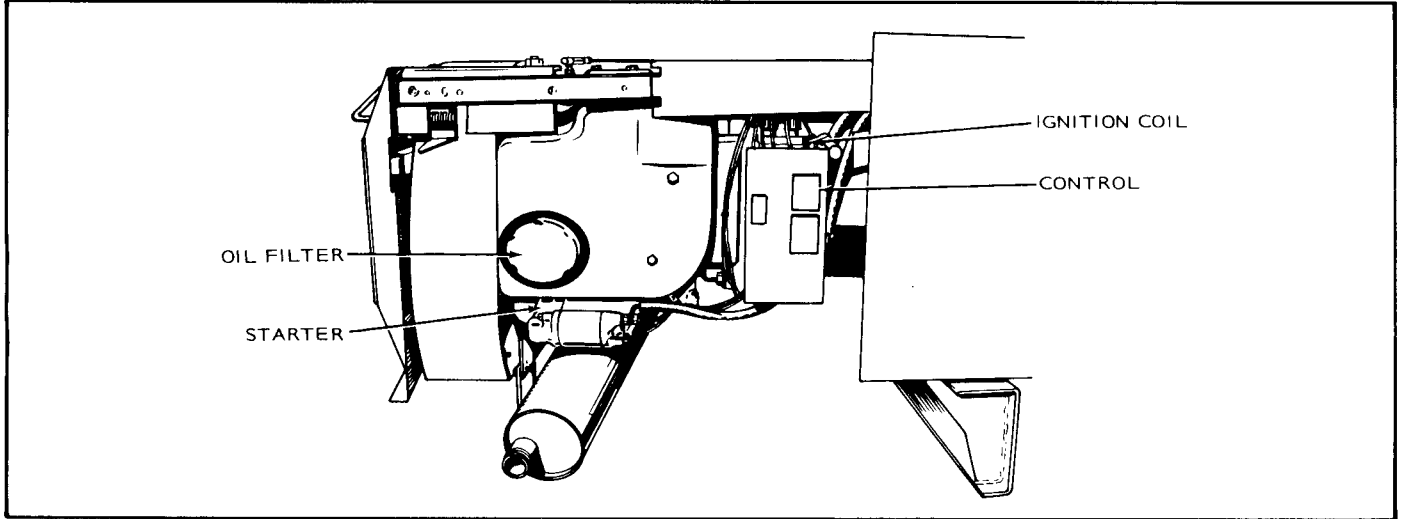
Service information contained herein applies to Model 4.0BF-1R/9500. The basic information can also be used when servicing Model 4.0BF-1R/9000.



**TOP VIEW**



**LEFT SIDE**



**RIGHT SIDE**

# SPECIFICATIONS

## ENGINE

Manufacturer .....	Onan
Design .....	Four Cycle, Air Cooled, L Head
Fuel .....	Gasoline
Fuel Pump .....	12V, Electric
Cylinders .....	Two
Bore .....	3-1/8 Inch
Stroke .....	2-5/8 Inch
Oil Capacity .....	3 Quarts
(With Filter Change) .....	3-1/2 Quarts
Battery Voltage .....	12 Volt Battery Size (Above 0° F Operation) 45 Amp/hr Min.
Battery Charging System .....	9 Ampere, Flywheel Alternator
Starting System .....	Solenoid Shift

## GENERATOR

Manufacturer .....	Onan
Design .....	Revolving Armature, Four Pole, 1800 rpm
60 Hertz Recreational Vehicle Rating .....	4000 Watts (4KW)
Voltage .....	120 Volts
Current Rating .....	33 Amperes
Phase .....	Single
Wire .....	Two

## PROTECTION

Generator .....	35 or 40 Ampere Circuit Breaker
Control (Remote Wiring) .....	5 Ampere Fuse

## TUNE-UP SPECIFICATIONS

Spark Plug Gap .....	.020 Inch
Breaker Point Gap (Cold Setting) .....	.025 Inch
Ignition Timing Reference (Cold, Static) .....	** 26° BTC
Tappet Adjustment (Engine Cold)	
Intake .....	.003 Inch
Exhaust .....	.010 Inch

\*\* Ignition Timing is permanently set at 26° BTC. If breaker points are set properly (.025" Cold), no additional timing is necessary.

# DIMENSIONS AND CLEARANCES

**All dimensions and clearances given in inches unless otherwise specified.  
Readings taken at 70° F.**

	Minimum	Maximum
<b>CYLINDER AND PISTON</b>		
Piston to Pin (70°) .....	.001	.005
Pin to Connecting Rod Clearances .....	.0002	.0007
Piston Ring Gap in Cylinder.....	.010	.020
Piston Clearance in Cylinder, Solid Type - Measured .10 Below Oil Controlling Ring - 90° From Pin .....	.003	.005
Cylinder Bore - Honed Std. ....	3.1265	3.1275
<b>CRANKSHAFT AND CAMSHAFT</b>		
Crankshaft Main Bearing Journal to Bearing Clearance. Steel Backed Aluminum.....	.0025	.0038
Crankshaft End Play .....	.006	.012
Camshaft End Play .....	.003	
Crankshaft Rod Journal to Rod Bearing Clearance. Aluminum Rod .....	.0020	.0033
Connecting Rod End Play.....	.002	.016
Timing Gear Backlash .....	.002	.003
Oil Pump Gear Backlash .....	.002	
<b>TAPPET AND VALVES</b>		
Tappet to Cylinder Block Clearance .....	.0015	.0030
Valve Seat Width .....	1/32	1/8
Valve Stem to Guide - Intake.....	.0010	.0025
Valve Stem to Guide - Exhaust .....	.0025	
Valve Face Angle .....		44°
Valve Seat Angle .....		45°
Valve Tappet Clearance - Intake 70° F.....		.003"
Valve Tappet Clearance - Exhaust 70° F .....		.010"

# ASSEMBLY TORQUES

<b>TORQUE SPECIFICATIONS IN LB. FT.</b>	<b>Minimum</b>	<b>Maximum</b>
Connecting Rod Bolt - Aluminum Rod .....	14	16
Flywheel Mounting Screw .....	35	40
Oil Pump .....	7	9
Gearcase Cover .....	8	10
Rear Bearing Plate .....	25	27
Oil Base Mounting Screws .....	18	23
Cylinder Head Nuts .....	14	16
Manifolds - Intake and Exhaust .....	8	10
Starter Mounting Bolts .....	18	20
Generator Through - Studs .....	15	18
Armature Holddown Nut (12-point) .....	45	50
Spark Plugs .....	15	20

## SPECIAL TOOLS

These special tools are required when overhauling the engine. Other tools are also available from Onan. Order Tool Catalog (900-0019).

VALVE SEAT DRIVER  
VALVE GUIDE DRIVER  
OIL SEAL GUIDE AND DRIVER  
COMBINATION BEARING DRIVER (MAIN & CAM)  
COMBINATION BEARING REMOVER (MAIN & CAM)  
FLYWHEEL PULLER

# ENGINE TROUBLESHOOTING GUIDE

TROUBLE															GASOLINE ENGINE TROUBLESHOOTING GUIDE																		
Backfire at Carburetor	Bearing Wear	Black Exhaust	Blue Exhaust	Burned Valves	Connecting Rod Wear	Crank Slowly	Cylinder Wear	Engine Stops	Governor Hunting	High Oil Pressure	Loss of Coolant (Water Cooled)	Mechanical Knocking	Misfiring	Overheating (Air Cooled)	Piston Wear	Ring Wear	Ring Compression	Sticking Valves	CAUSE														
															<b>STARTING SYSTEM</b>																		
															Loose or Corroded Battery Connection																		
															Low or Discharged Battery																		
															Faulty Starter																		
															Faulty Start Solenoid																		
															<b>IGNITION SYSTEM</b>																		
•			•				•					•	•	•	•				Ignition Timing Wrong														
							•					•	•	•	•				Wrong Spark Plug Gap														
							•					•	•	•	•				Worn Points or Improper Gap Setting														
							•					•	•	•	•				Bad Ignition Coil or Condenser														
							•					•	•	•	•				Faulty Spark Plug Wires														
															<b>FUEL SYSTEM</b>																		
							•	•											Out of Fuel - Check														
							•	•											Lean Fuel Mixture - Readjust														
•	•						•	•											Rich Fuel Mixture or Choke Stuck														
•	•						•	•											Engine Flooded														
•	•						•	•											Poor Quality Fuel														
•	•						•	•											Dirty Carburetor														
•	•						•	•											Dirty Air Cleaner														
•	•						•	•											Dirty Fuel Filter														
•	•						•	•											Defective Fuel Pump														
															<b>INTERNAL ENGINE</b>																		
							•	•											Wrong Valve Clearance														
							•	•											Broken Valve Spring														
							•	•											Valve or Valve Seal Leaking														
							•	•											Piston Rings Worn or Broken														
•							•	•											Wrong Bearing Clearance														
															<b>COOLING SYSTEM (AIR COOLED)</b>																		
																			Poor Air Circulation														
																			Dirty or Oily Cooling Fins														
																			Blown Head Gasket														
															<b>LUBRICATION SYSTEM</b>																		
																			Defective Oil Gauge														
																			Relief Valve Stuck														
																			Faulty Oil Pump														
																			Dirty Oil or Filter														
																			Oil Too Light or Diluted														
																			Oil Level Low														
																			Oil Too Heavy														
																			Dirty Crankcase Breather Valve														
															<b>THROTTLE AND GOVERNOR</b>																		
																			Linkage Out of Adjustment														
																			Linkage Worn or Disconnected														
																			Governor Spring Sensitivity Too Great														
																			Linkage Binding														



# ENGINE DISASSEMBLY

## GENERAL

A 3/8-16 threaded hole in manifold provides space for a lifting eye for removing power plant from vehicle. When complete engine disassembly is necessary, first remove all complete assemblies. Individual assemblies like fuel pump and carburetor can be disassembled and repaired at another time.

## DISASSEMBLY

Common sense dictates the order of disassembly and assembly.

The suggested disassembly procedure is as follows:

1. Drain crankcase oil.
2. Disconnect all exhaust lines, fuel lines and electrical wires (tag all electrical wires).
3. Remove engine from its slide rails and mountings and place on a suitable bench or work stand.
4. Remove all shrouds, mounts, air cleaner, control box, etc.

**When removing generator and control box, tag all wires according to their respective locations.**

5. Remove flywheel, using a puller or pry-bar method.
6. Remove flywheel alternator stator.
7. Remove the gear cover, being careful to protect the oil seal from keyway damage.
8. Remove the crank gear, using a gear puller and ring.
9. Remove fuel pump, oil filter, starter, carburetor, fuel lines, spark plugs, etc.
10. Remove breaker box.
11. Remove oil base, oil pump and cylinder heads.
12. Remove valves, springs, lifters, etc.
13. Remove camshaft and gear assembly.
14. Remove connecting rods, pistons and bearings.
15. Remove rear bearing plate.
16. Remove crankshaft.
17. Remove front main bearing.

Keep all parts in their respective orders. Keep valve assemblies together. Return rod caps to their respective pistons. Analyze the reasons for parts failure. See specific sections of this manual covering dimensions of parts, tolerance and wear limits, etc.

## ASSEMBLY

The engine assembly procedure is normally the reverse of the disassembly procedure, observing proper clearances throughout the engine. Use a torque wrench to assure proper tightness. Coat the internal engine parts with SAE 30 oil as they are assembled. After the internal engine parts are assembled, the engine should turn over by hand freely. Use only genuine Onan parts and Onan special tools when reassembling your engine.

1. Use the proper bearing driver to install front main bearing after coating it with a light film of oil.
2. Insert rear main bearing in rear bearing plate.
3. Install crankshaft and rear bearing plate.
4. Install connecting rods, pistons and bearings.
5. Install camshaft and gear.
6. Install valve assemblies.
7. Install oil pump, oil base and cylinder heads.
8. Install breaker box.
9. Install fuel pump, oil filter, starter, generator, carburetor, fuel lines, spark plugs, etc.
10. Install crank gear, aligning crank gear mark with camshaft.
11. Install gear cover and oil seal.
12. Install flywheel alternator stator.
13. Install flywheel.
14. Install all housings, air cleaner, control box, etc.
15. Reinstall power plant in vehicle, making proper fuel, battery, electrical and exhaust connections. (Refer to wiring diagram when making electrical connections).
16. Fill crankcase with oil.

## OPERATIONAL CHECKOUT

1. Start engine.
2. Check oil pressure.
3. Run engine approximately 15 minutes to bring up to operating temperature.
4. Check for oil leaks, security of electrical connections, fuel lines and exhaust connections.
5. Adjust carburetor and governor linkage.
6. Check output voltage and frequency both at a no-load and full load condition.

## VALVE SYSTEM

Properly seated valves are essential to good engine performance. The aluminum cylinder heads are removable for valve servicing. Do not use a pry to loosen the cylinder head; rap sharply on the edge with a soft faced hammer, taking care not to break any cooling fins. A conventional type valve spring lifter may be used when removing the split type valve spring locks. Clean all carbon deposits from the cylinder heads, piston tops, valves, guides, etc. If a valve face is burned or warped, or the stem worn, install a new valve. Refer to Figure 1.

Valve locks are split, tapered type, the smaller diameter of which must face toward the valve head. Tappets are also replaceable from the valve chamber, after first removing the valve assemblies.

The valve *face* angle is 44 degrees. The valve *seat* angle is 45 degrees. This 1 degree interference angle results in a sharp seating surface between the valve and the top of the valve seat. The interference angle method of grinding valves minimizes face deposits and lengthens valve life.

**CAUTION** The valves should not be hand lapped, because the sharp contact may be destroyed. This is especially important where stellite faced valves and seats are used.

Valve faces should be finished to 44 degrees. Valve seats should be ground with a 45 degree stone and the width of the seat band should be 1/32 inch to 3/64 inch wide. Grind only enough to assure proper seating.

Remove all grinding compound from engine parts and place each valve in its proper location. Make pencil marks at intervals across the valve face and observe if the marks rub off uniformly when the valve is rotated part of a turn against the seat.

**Tappet Adjustment:** The engine is equipped with adjustable valve tappets. The valve tappet clearance should be checked and adjusted when necessary. Adjust the valve clearance only when engine is at ambient temperature. Proceed as follows:

1. Remove all parts necessary to gain access to valve tappets.
2. Remove spark plugs to ease the task of turning the engine over by hand.
3. Use the engine flywheel to turn the engine over slowly by hand until the left hand intake valve opens and closes. Continue turning the flywheel until the TC mark is on the top and lined up with the TC mark on the gear cover. Both valves should be closed. This should place the left hand piston at the top of its compression stroke, the position it must be in to get proper valve adjustment for the left cylinder.
4. For the intake valve, a .003 inch thickness gauge should just pass between valve stem and tappet.
5. For the exhaust valve, a .010 inch thickness gauge should just pass between valve stem and tappet.
6. To correct the valve clearance, use a 7/16 inch open end wrench to turn the adjusting screw to

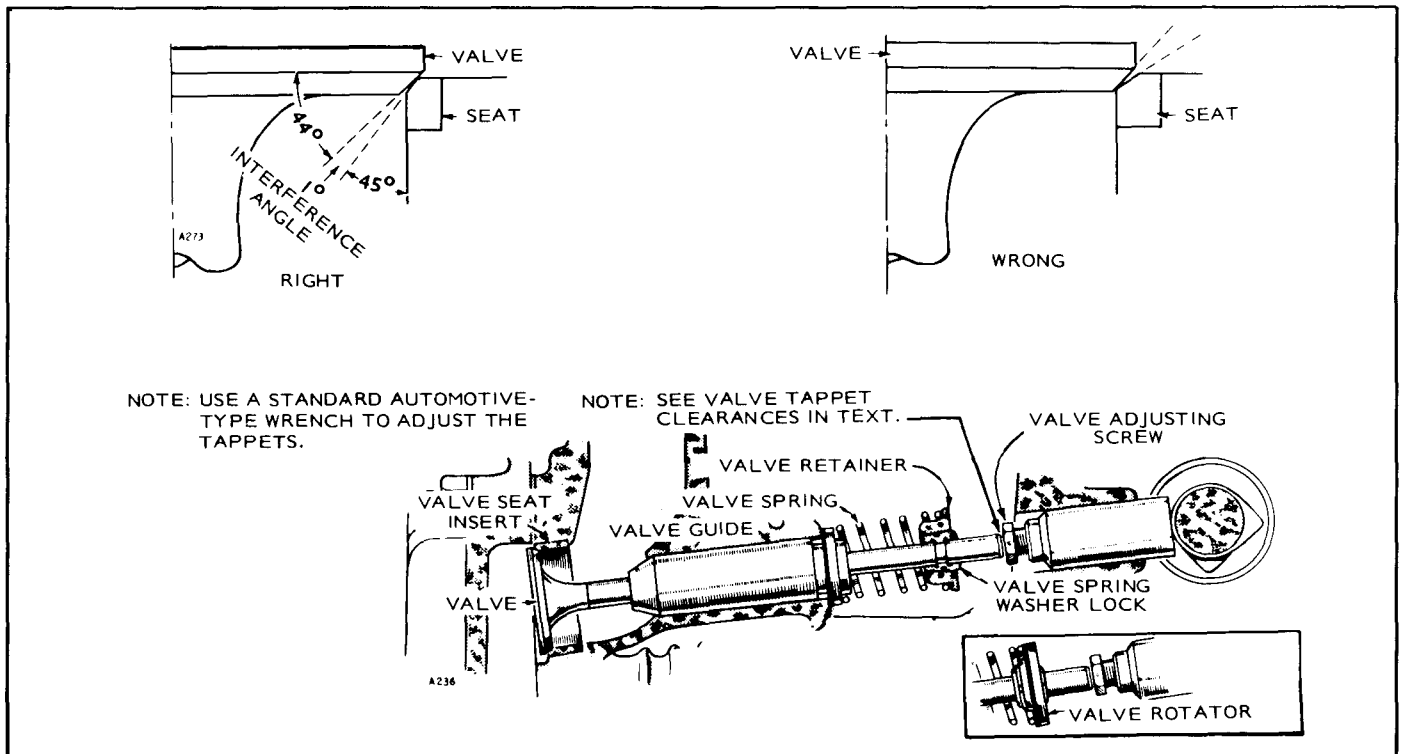


FIGURE 1. VALVE SYSTEM

obtain the correct clearance. The screw is self-locking and will stay where it is set. A 9/16 inch open end wrench is required to hold the tappet while turning the adjusting screw.

7. To adjust valves on the right hand cylinder - turn engine one complete revolution and again line up mark on the flywheel and the TC mark on the gear cover. Then follow adjustment procedure given for left hand cylinder.
8. Replace all parts removed in Step 1. Tighten all screws securely. Torque manifold bolts to specified torque.

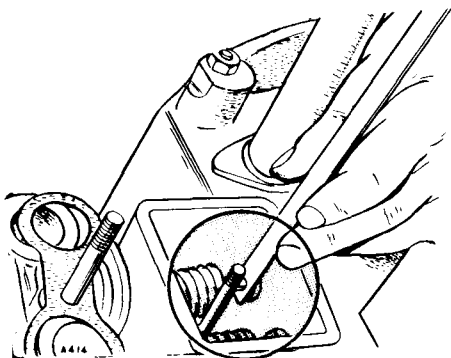


FIGURE 2. ADJUSTING VALVES

## FLYWHEEL

Removing the flywheel is a relatively simple process, but the following procedure must be followed to avoid damage to the gear case and possible injury to the operator.

1. Turn the flywheel mounting screw outward about two turns.

**WARNING** Do not remove the screw completely since it acts as a restrainer when the flywheel snaps loose. If the flywheel is not held by the screw, the spring action in the wheel will cause it to fly off with great force which can cause injury to the operator.

2. Install a puller bar on the flywheel as shown in Figure 3.
3. Turn the puller bar bolts in, alternately, until the wheel snaps loose on the shaft.

**CAUTION** Do not use a screwdriver or similar tool or pry behind the flywheel against the gear case. The gear case cover is die-cast material and will break if undue pressure is applied in this manner.

4. Unscrew the puller from the flywheel, remove the flywheel mounting screw and washer and pull the flywheel off the shaft. Take care not to drop the wheel. A bent or broken fin will destroy the balance. Always use a steel key for mounting the flywheel.

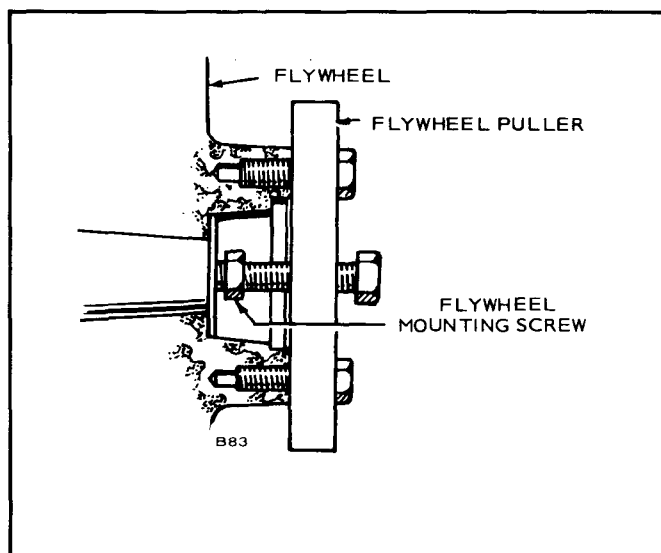


FIGURE 3. FLYWHEEL PULLER

## FLYWHEEL ALTERNATOR STATOR

After disconnecting stator terminal wires, remove the three screws securing stator to gear cover and pull off.

## GEAR COVER

After removing the mounting screws, tap the gear cover gently with a soft faced hammer to loosen it.

When installing the gear cover, make sure that the pin in the gear cover engages the metal lined (smooth) hole in the governor cup. Turn the governor cup so that the metal lined hole is at the three o'clock position. The smooth side of the governor yoke must ride against the governor cup. Turn the governor arm and shaft clockwise as far as possible and hold in this position until the gear cover is installed flush against the crankcase. Be careful not to damage the gear cover oil seal. Adjust the roll (stop) pin to protrude to a point 3/4 inch from the cover's mounting surface.

## GOVERNOR CUP

With the gear cover removed, the governor cup can be taken off after removing the snap ring from the camshaft center pin. Catch the flyballs while sliding the cup off.

Replace with a new part, any flyball which is grooved or has a flat spot; the ball spacer if its arms are worn or otherwise damaged; and the governor cup if the race surface is grooved or rough. The governor cup must be a free spinning fit on the camshaft center pin, but without any excessive play.

When installing the governor cup, tilt the engine so the gear is up, then put the flyballs in place. Install the cup and snap ring on the center pin.

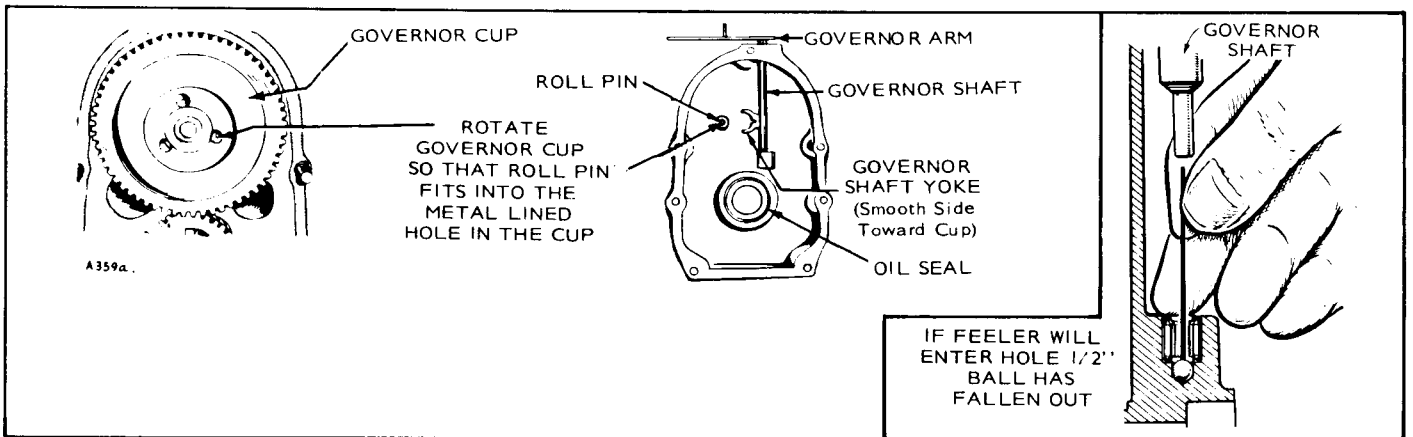


FIGURE 4. GEAR COVER ASSEMBLY

The camshaft center pin extends out 3/4 inch from the end of the camshaft. This distance provides an in and out travel distance of 7/32 inch for the governor cup, as illustrated. Hold the cup against the flyballs when measuring. If the distance is less (the engine will race, especially at no load), replace camshaft. The camshaft center pin cannot be pulled outward or removed without damage. If the center pin extends out too far, the cup will not hold the flyballs properly.

The camshaft and gear must be replaced as an assembly. Before removing the camshaft and gear assembly, remove the cylinder head and valve assemblies. Then remove the operating plunger for the breaker points and tappets.

Each timing gear is stamped with "O" near the edge. The gear teeth must mesh so that these marks exactly coincide when the gears are installed in the engine. When installing the camshaft gear and shaft assembly, be sure that the thrust washer is properly in place behind the camshaft gear. Then install the crankshaft retaining washer and lock ring.

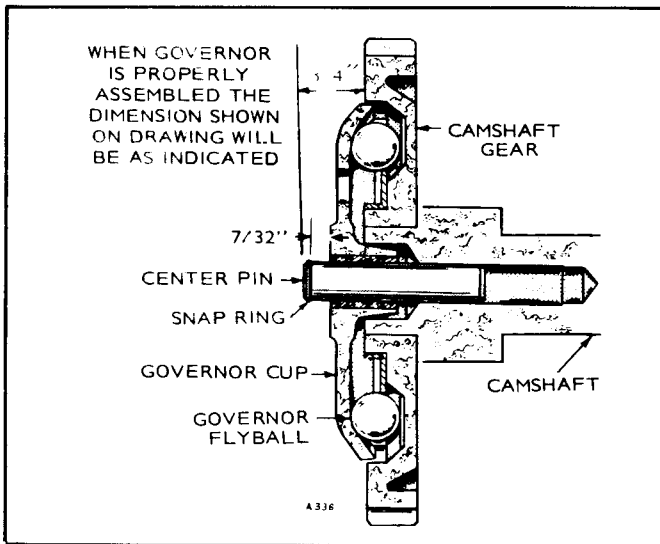


FIGURE 5. GOVERNOR CUP CROSS-SECTION

### TIMING GEARS

If replacement of either the crankshaft gear or the camshaft gear becomes necessary, always install both gears new.

To remove the crankshaft gear, first remove the snap ring and retainer washer, then attach gear pulling ring using two No. 10-32 screws (Figure 6). Tighten the screws alternately until both are tight. Attach a gear puller to the puller ring and proceed to remove the gear.

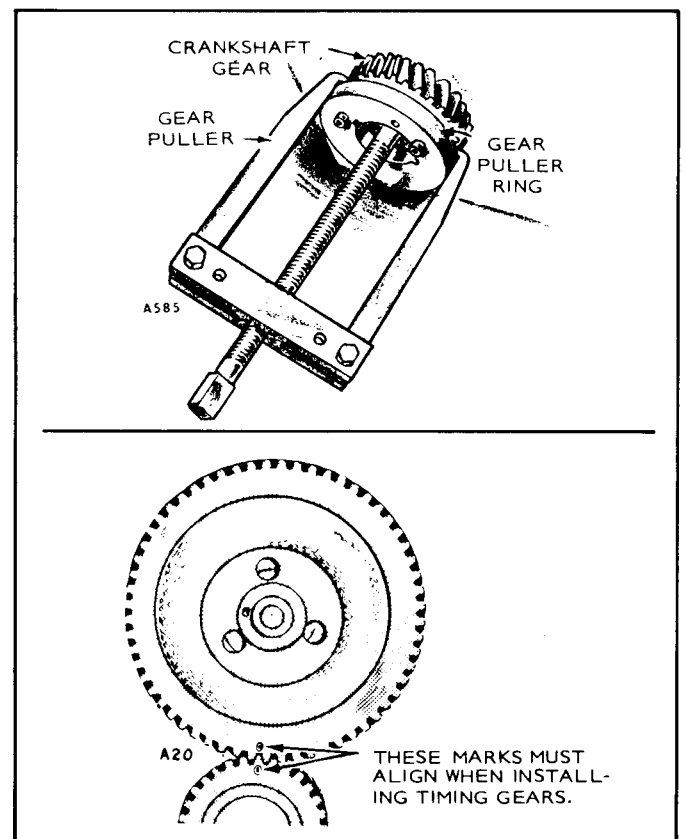


FIGURE 6. TIMING GEAR REMOVAL AND INSTALLATION

## PISTONS AND CONNECTING RODS

**Removal:** Observe the following procedure when removing pistons and connecting rods from the engine.

1. Drain oil.
2. Remove the cylinder heads and oil base pan from the engine.
3. Remove the ridge from the top of each cylinder with a ridge reamer before attempting piston removal (Figure 7). Forcing the piston from the cylinder before reaming may cause damage to the piston lands.
4. Turn the crankshaft until the piston is at the bottom of its stroke and remove the connecting rod bolts. Lift the rod bearing cap from the rod and push the rod and piston assembly out through the top of the cylinder using a hammer handle. Avoid scratching the crankpin and cylinder wall when removing the piston and rod.

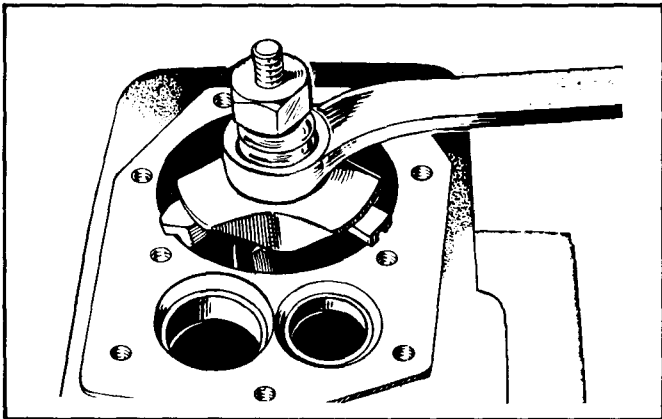


FIGURE 7. REMOVING RIDGE FROM CYLINDER

Mark each piston and rod assembly so they can be returned to their respective cylinders after overhaul. Keep connecting rod bearing caps with their respective rods.

5. Remove the piston rings from the piston with a piston ring spreader as shown in Figure 8. Remove the piston retainer and push the piston pin out.

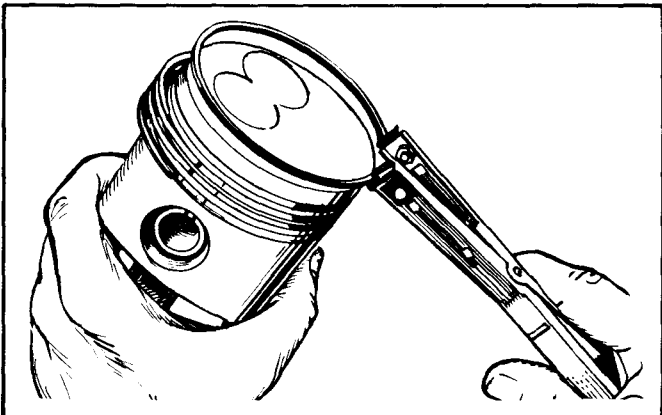


FIGURE 8. REMOVING PISTON RINGS

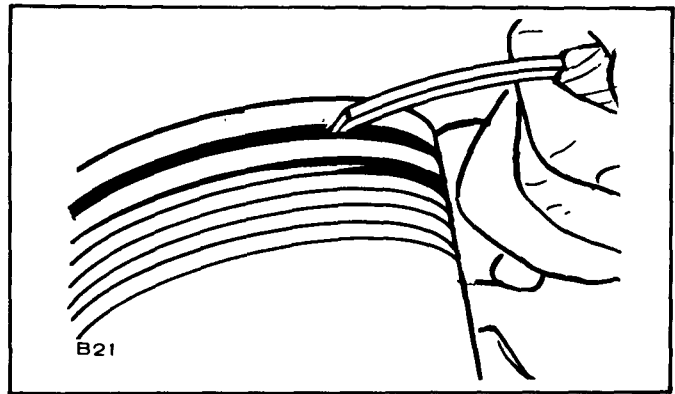


FIGURE 9. PISTON RING GROOVE CLEANING

**Cleaning:** Remove dirt and deposits from the piston surfaces with an approved cleaning solvent. Clean the piston ring grooves with a groove cleaner or the end of a piston ring filed to a sharp point (Figure 9). Care must be taken not to remove metal from the groove sides.

**Do not use a caustic cleaning solvent or wire brush for cleaning pistons.**

When cleaning the connecting rods in solvent, include the rod bore. Blow out all passages with compressed air.

**Inspection:** The following text contains inspection procedures concerning pistons and connecting rods.

### 1. Piston Inspection:

- a. Inspect the pistons for fractures at the ring lands, skirts and pin bosses. Check for wear at the ring lands using a new ring and feeler gauge as shown in Figure 10. Replace the piston when the side clearance of the top compression ring reaches 0.008 inch.
- b. Replace pistons showing signs of scuffing, scoring, worn ring lands, fractures or damage from preignition. Excessive piston wear near the edge of the top ring land indicates preignition.

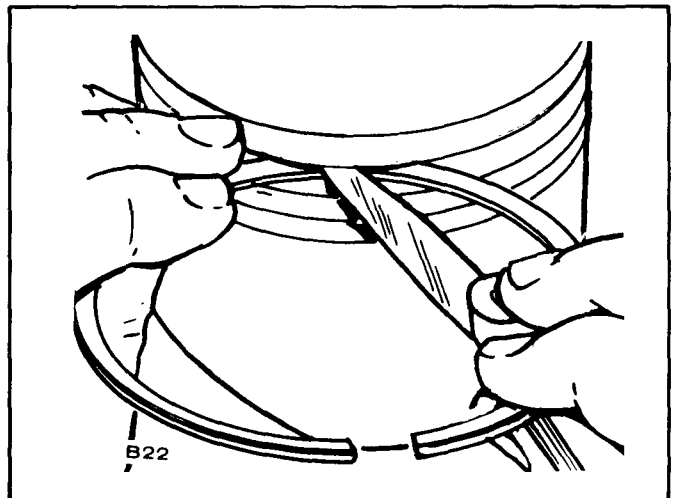


FIGURE 10. CHECKING RING SIDE CLEARANCE

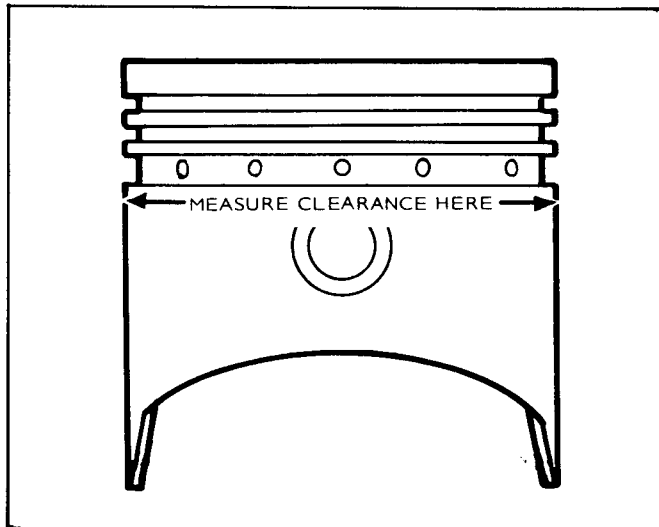


FIGURE 11. MEASURING PISTON CLEARANCE

## 2. Connecting Rod Inspection:

- a. Replace connecting rod bolts or nuts with damaged threads. Replace connecting rods with deep nicks, signs of fractures, scored bores or bores out of round more than 0.002 inch.
- b. Use a new piston pin to check connecting rod for wear. A push fit clearance is required and varies from engine to engine. If a new piston pin falls through a dry rod pin bore as a result of its own weight, replace the rod.

## REPAIR

### 1. Fitting Pistons:

- a. Proper piston tolerances must be maintained for satisfactory operation.
- b. Measure the piston as shown in Figure 11 to be sure the total piston-to-cylinder clearance follows specifications.

### 2. Fitting Piston Rings:

- a. Install the piston ring in the cylinder bore. Invert the piston and push the ring to the end of ring travel, about halfway into the bore, which trues the ring end gap. Check the gap with a feeler gauge as shown in Figure 12.
- b. The practice of filing ring ends to increase the end gap is not recommended. If the ring end gap does not meet specifications, check for the correct set of rings and correct bore size. A cylinder bore that is 0.001 inch under size will reduce the end gap 0.003 inch.

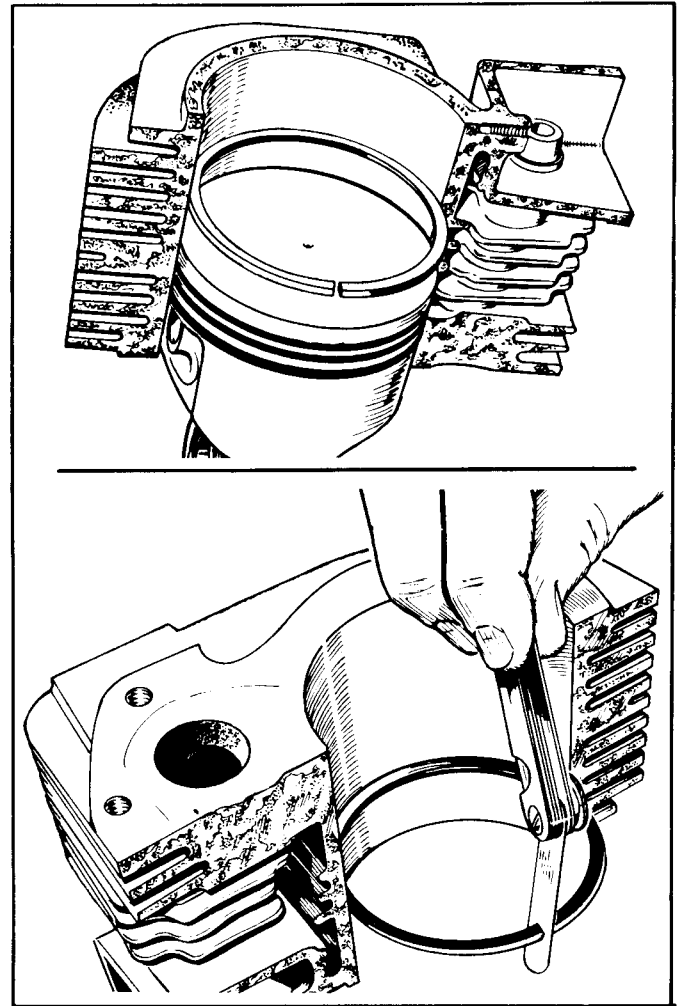


FIGURE 12. CHECKING PISTON RING END GAP

## CYLINDER BLOCK

### Inspection:

1. Make a thorough check for cracks. Small cracks may be detected by coating the suspected area with a mixture of 25 percent kerosene and 75 percent light motor oil. Wipe the part dry and immediately apply a coating of zinc oxide (white lead) dissolved in wood alcohol. If cracks are present, the white coating will become discolored at the defective area.
2. Inspect the cylinder bore for scoring and cooling fins for breakage.
3. Check the cylinder bore for taper, out of round and wear, with a cylinder bore gauge, telescope gauge or inside micrometer (Figure 13). These measurements should be taken at four places - the top and bottom of piston ring travel.
4. Record measurements taken lengthwise at the top and bottom of the piston travel as follows:
  - a. Lengthwise of the block, measure and record as "A" the diameter of the cylinder at the top of the cylinder where greatest ring wear occurs.

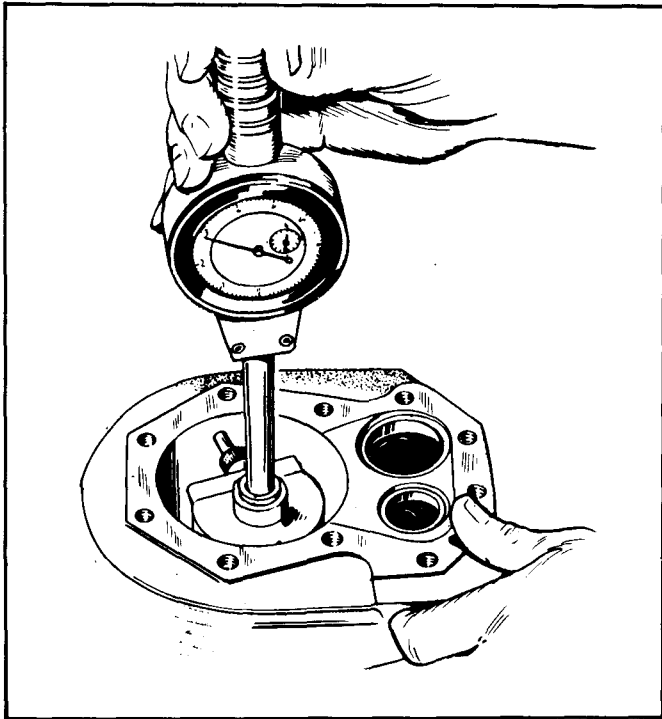


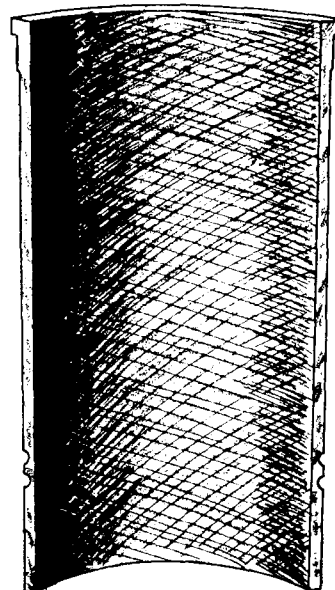
FIGURE 13. MEASURING CYLINDER BORE

- b. Also, lengthwise of the block, measure and record as "B" the cylinder diameter at the piston skirt travel.
- c. Crosswise of the block, measure and record as "C" the diameter of the top of the cylinder at the greatest point of wear.
- d. Measure and record as "D" the diameter at the bottom of the cylinder bore and crosswise of the block.
- e. Reading "A" compared to reading "B" and reading "C" compared to reading "D" indicates cylinder taper.
- f. If cylinder taper exceeds 0.005 inch, rebore and hone to accommodate the next oversize piston. Reading "A" compared to reading "C" and reading "B" compared to reading "D" indicates whether or not the cylinder is out of round. If the out of round exceeds 0.002 inch, the cylinders must be rebored and honed for the next oversize piston. A reboring machine is used when going to oversize pistons. The following repair data covers honing to oversize by use of a hone.

**Repair:**

1. A hone can be used to refinish a cylinder.
2. Anchor the block solidly for either vertical or horizontal honing. Use either a drill press or heavy-duty drill which operates at approximately 250 to 450 rpm.

3. Connect drill to hone and start drill. Move the hone up and down in the cylinder approximately 40 cycles per minute. Usually the bottom of the cylinder must be worked out first because it is smaller. Then when the cylinder takes a uniform diameter, move the hone up and down all the way through the bore. Follow the hone manufacturer's recommendations for wet or dry honing and oiling the hone.
4. Check the diameter of the cylinder regularly during honing. A dial bore gauge is the easiest method but a telescoping gauge can be used. Check the size at six places in the bore: measure twice at the top, middle and bottom at 90 degree angles.
5. The crosshatch formed by the scratching of the stones should form an angle of 23 degrees. This can be achieved by moving the hone up and down in the cylinder about 40 cycles per minute.
6. Clean the cylinder block thoroughly with soap, water and clean rags. A clean white rag should not be soiled on the cylinder wall after cleaning is complete. Do not use a solvent or gasoline since they wash the oil from the walls but leave the metal particles.
7. Dry the crankcase and coat it with oil.



PRODUCE CROSS HATCH SCRATCHES FOR FAST RING SEATING

FIGURE 14. CROSSHATCH PATTERN

## CRANKSHAFT

Inspect the bearing journals. If they are scored and cannot be smoothed out by dressing down, replace the crankshaft.

Whenever making major repairs on the engine, always inspect the drilled passages of the crankshaft. Clean them to remove any foreign material and to assure proper lubrication of the connecting rods.

## BEARINGS (Figures 15-18)

**Removal:** Removing camshaft or crankshaft bearings requires complete disassembly of the engine. Use a press or a suitable drive plug to remove the bearings. Support the casting to avoid distortion and avoid damaging the bearing bore during removal and installation. Use oil on the bearings to reduce friction when installing and again lubricate with oil after installing.

**Replacement:** Crankshaft main bearings are precision type which do not require line reaming or line boring after installation. They are available in standard size and .002 inch undersize. Expand the bearing bore by placing the casting in hot water or in an oven heated to 200 degrees F.

### CAUTION

If a torch is used, apply only a little heat.

To ease assembly, cool the precision bearing to shrink it. Align the oil hole(s) in the bearing with the oil hole(s) in the bearing bore. The oil passage must be at least 1/2 open. Lubricate bearings with SAE20 oil before installing. The cold oiled precision bearing should require only light taps to position it with a driving tool. If head of lock pin is damaged, use side cutters or Easy Out tool to remove and install new pin. Apply oil to thrust washer (one used with each bearing) to hold it in place while installing the crankshaft. Oil grooves in thrust washers must face the crankshaft and washers must be flat (not bent). The two notches on each washer must fit over the two lock pins to prevent riding on the crankshaft.

Original front bearing uses a separate thrust washer. Replacement front bearing is a one piece assembly with thrust washer part of the bearing. Do not use a separate thrust washer when installing this replacement part. See Figures 16 and 17.

New camshaft bearings are precision type which *do not* require line reaming or line boring after installation. Coat the bearing with SAE20 to reduce friction. Place the bearing on the crankcase over the bearing bore with the elongated hole in proper position and narrow section facing out (except bores without oil holes install with bearing groove at the top). Be sure to start the bearing straight. Press the front bearing in flush with the outside end of the bearing bore. Press the rear bearing in flush with the bottom of counterbore which received the expansion plug (see Figure 15).

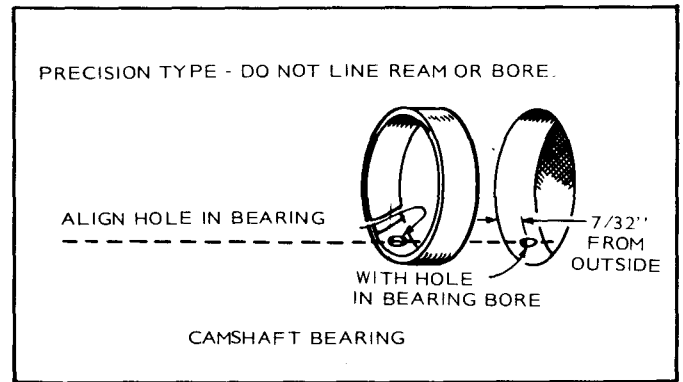


FIGURE 15. CAMSHAFT BEARINGS

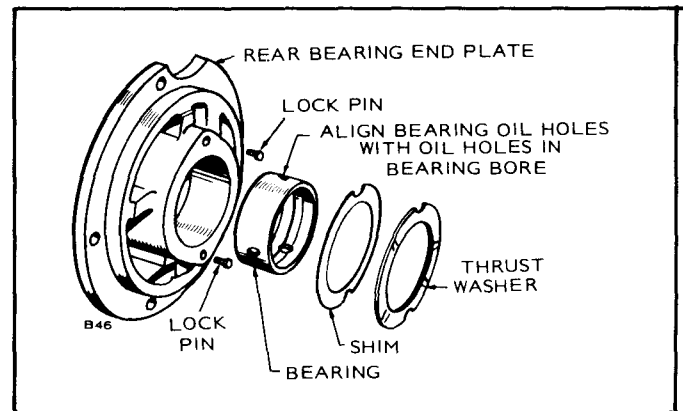


FIGURE 16. REAR MAIN BEARING

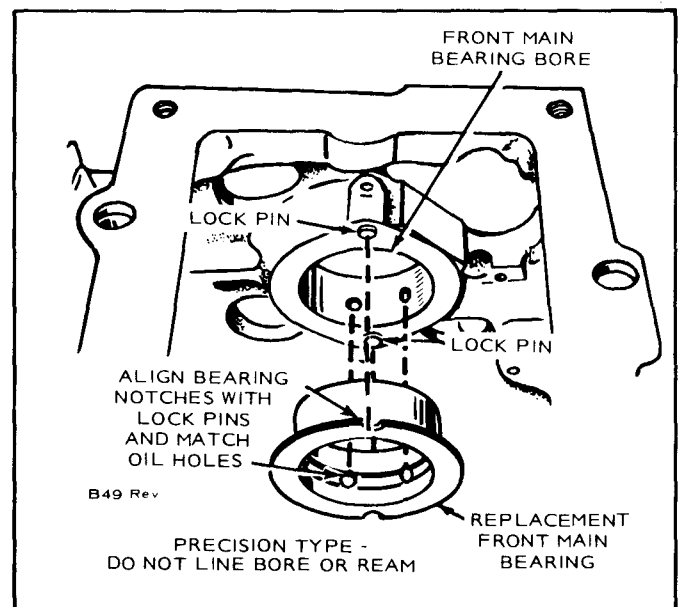


FIGURE 17. FRONT MAIN BEARING



## CRANKSHAFT ENDPLAY

After the rear bearing end plate has been tightened using the torque recommended in *ASSEMBLY TORQUES* check the crankshaft endplay as shown in Figure 18. If there is too much endplay (see *DIMENSIONS AND CLEARANCES* for minimum and maximum endplay), remove the rear bearing end plate and add a shim between the thrust washer and plate. Reinstall the end plate making sure the thrust washer and shim notches line up with the lock pins. Torque and recheck endplay of the crankshaft.

### Checking Bearing Clearance with Plastigage:

1. Make certain that all parts are marked or identified so that they are installed in their original positions.
2. Place a piece of correct size Plastigage in the bearing cap the full width of the crankshaft rod surface about 1/4 inch off center (Figure 19).
3. Rotate the crank about 30 degrees from bottom dead center and reinstall the bearing cap; tighten the bolts to the torque specified in the *TABLE OF TORQUES AND CLEARANCES*. Do not turn the crankshaft.
4. Remove the bearing cap. Leave the flattened Plastigage on the part to which it has adhered and compare the widest point with the graduations on the Plastigage envelope to determine bearing clearance.

## OIL SEALS (Figure 20)

The bearing plate must be removed to replace the oil seal. Drive the oil seal out from the inside.

Before installing the seals, fill the space between lips with a multi-purpose grease. This will improve sealing.

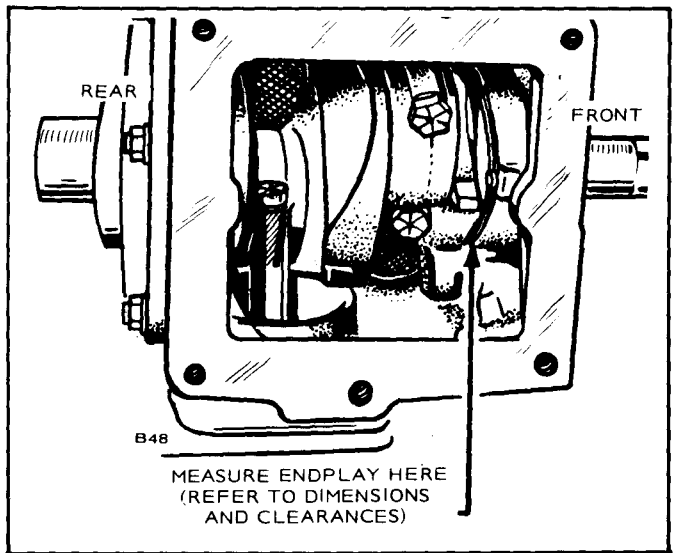


FIGURE 18. CRANKSHAFT ENDPLAY

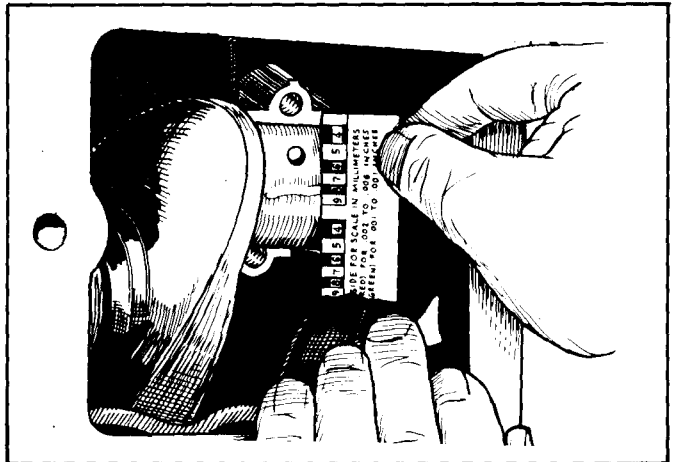


FIGURE 19. MEASURING BEARING CLEARANCE

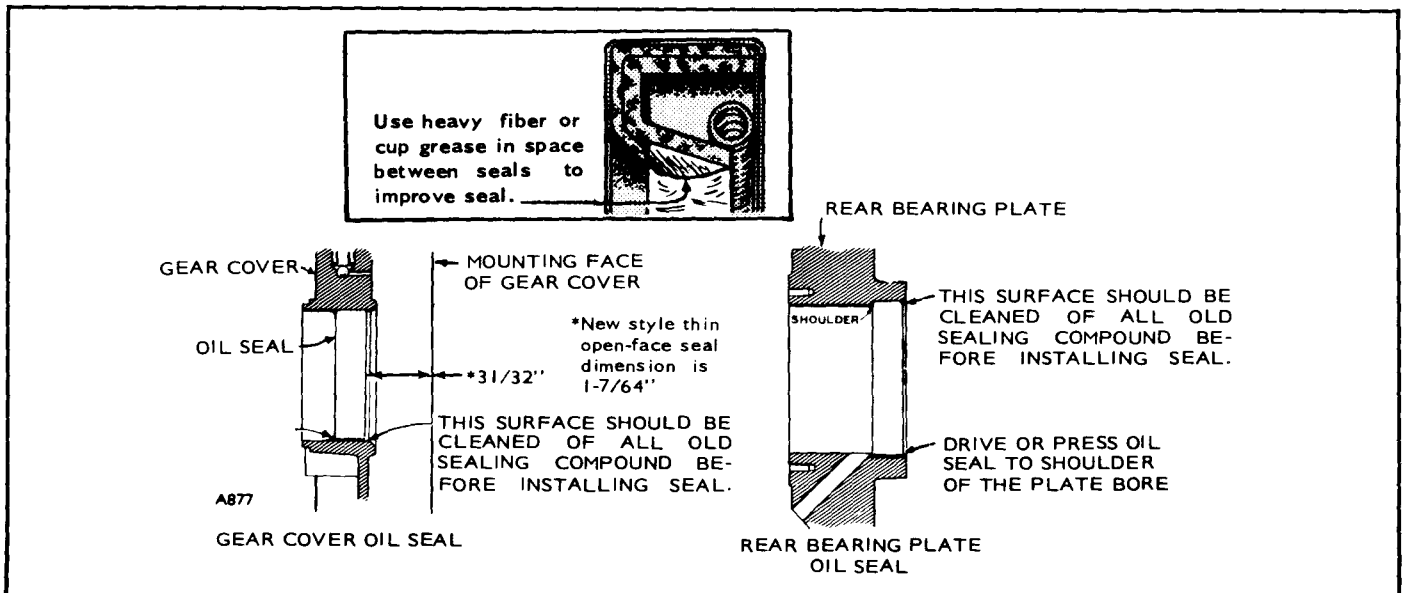


FIGURE 20. OIL SEALS

When installing the gear cover oil seal, tap the seal inward until it is 31/32 inch from the mounting face of the cover.

When installing the bearing plate oil seal, tap the seal into the bearing plate bore to bottom against the shoulder in the plate bore. Use a seal expander or place a piece of shim stock around the end of the crankshaft when replacing the bearing plate to avoid damaging the seal. Remove the shim stock as soon as the plate is in place.

## ASSEMBLY

1. Lubricate all parts with engine oil.
2. Position piston on its respective rod and install the pin.
3. Install the rings on the pistons starting with the oil control ring (Figure 21). Use a piston ring spreader to prevent twisting or excessive expansion of the ring. Some oil control rings and all compression rings have a dot or the word "top" on one side of the ring to indicate which side faces the top of the piston. Unmarked piston rings can be installed either way. If the oil control ring has a coil expander, install the expander first and then close until the coil ends butt. The joint should be 180 degrees from the gap of that ring.

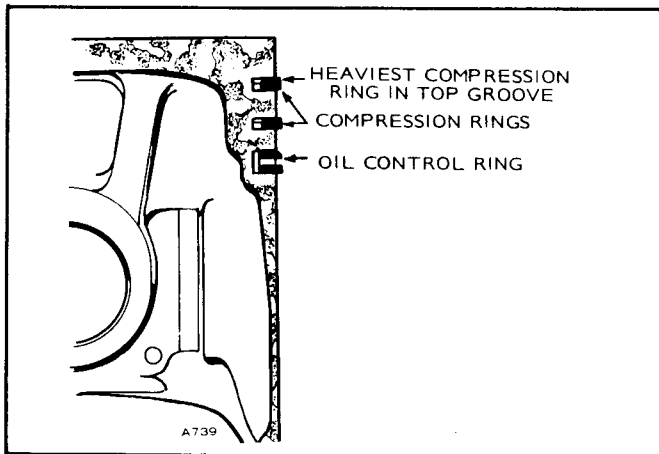


FIGURE 21. PISTON RINGS

## INSTALLATION OF PISTON IN CYLINDER

### Installation of Piston in Cylinder:

1. Turn the crankshaft to position the number one rod bearing journal at the bottom of its stroke.
2. Lubricate the number one piston assembly and inside of the cylinder. Compress the rings with a ring compressor as shown in Figure 22.
3. Position the piston and rod assembly in the cylinder block.

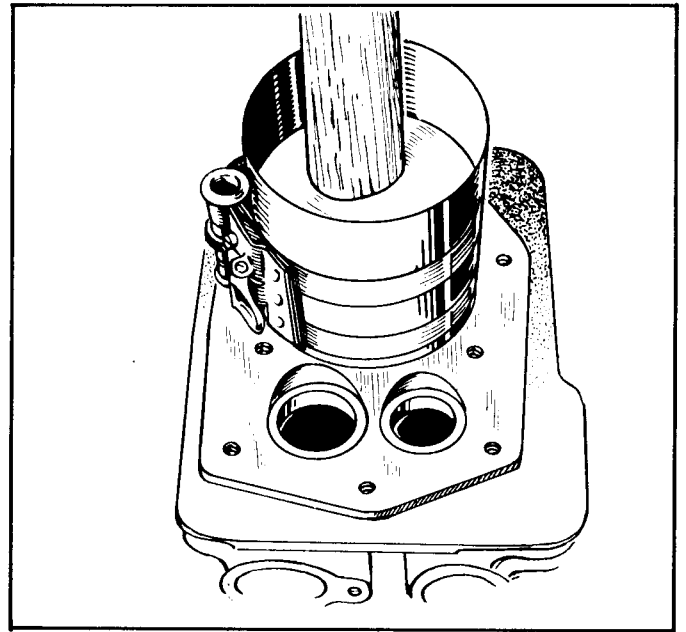


FIGURE 22. INSTALLING PISTON

The connecting rod numbers should always face away from the camshaft or bottom side of engine. See Figure 23.

4. Tap the piston down into the bore with the handle end of a hammer until the connecting rod is seated on the journal (Figure 22). Install the bearing cap on the rod with the witness marks and stamped reference numbers matching the marks on the rod. Install and tighten the bolts to the specified torques.

The bearing cap must be tapped several times to properly align it with the rest of the connecting rod. Clearance varies on the journal if this is not done.

Install the remaining pistons and rods in the same manner. Crank the engine over by hand to see that all bearings are free.

5. Install the oil base with a new gasket.
6. Install the cylinder heads and torque 14-16 ft. lb.
7. Replace oil and break-in engine.

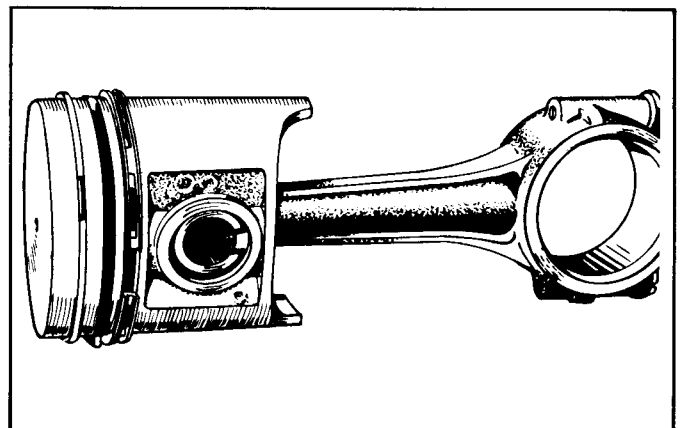


FIGURE 23. PISTON ASSEMBLY

## CYLINDER HEADS

Remove the cylinder heads for cleaning when poor engine performance is noticed.

1. Use a 1/2 inch socket wrench to remove cylinder head nuts. Lift heads off.

**CAUTION** Do not remove heads when they are hot. Warpage may occur.

2. After removing heads, clean out all carbon deposits. Be careful not to damage the outer sealing edges where gaskets fit. The heads are made of aluminum and can be damaged by careless handling.
3. Use new head gaskets and clean both the heads and the cylinder block thoroughly where the head gaskets rest.
4. Place heads in position and follow head torque tightening sequence shown in Figure 24. Start out tightening all nuts to 5 ft-lb, then 10 ft-lb, etc., until all nuts are torqued 14-16 ft-lb.
5. Recheck torque before engine has run a total of 50 hours.

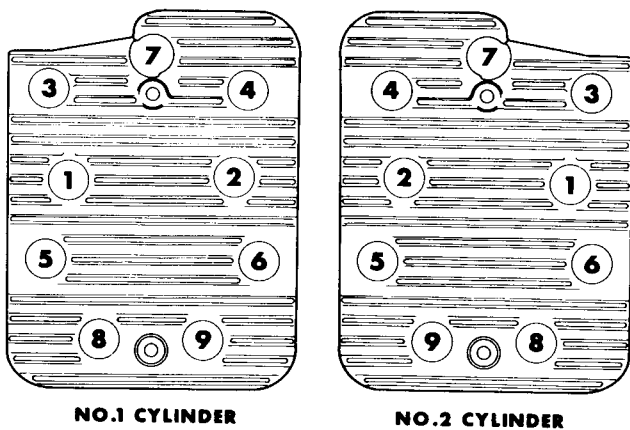


FIGURE 24. CYLINDER HEAD TORQUE SEQUENCE

# OIL SYSTEM

## CRANKCASE OIL

Change crankcase oil every 100 operating hours and only when engine is warm. (*EXCEPTION:* Drain initial oil fill at 25 operating hours.)

To drain, remove the 1/2 inch cap screw (requiring 3/4 inch socket) on oil pan. After oil drains, replace the cap screw and refill crankcase with 3 quarts (3½ with filter change) of a good quality detergent oil. Oil must meet or exceed the API (American Petroleum Institute) designation SE or SE/CC; this oil was formerly designated as MS, MS/DG or MS/DM.

For temperatures above 30 degrees F use SAE30 oil; for temperatures below 30 degrees F, use 10W or 5W30.

In extremely dusty conditions or in very cold weather, change oil at least every 50 hours of operation.

### CAUTION

Do not overfill crankcase. Do not use service DS oil. Do not mix brands nor grades of motor oil.

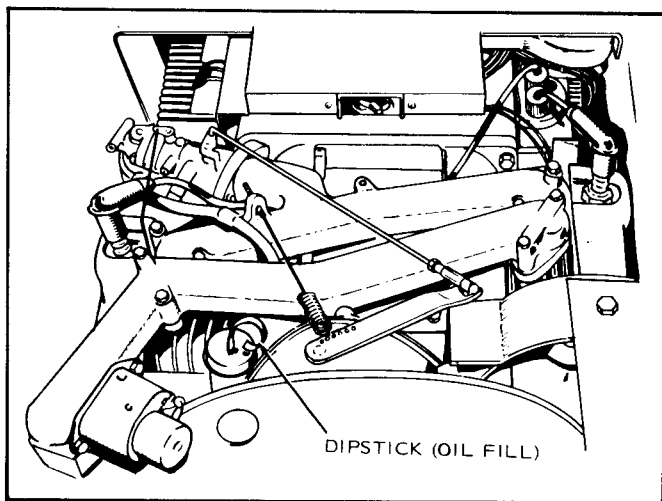


FIGURE 25. DIPSTICK LOCATION

## OIL FILTER

Change the crankcase oil filter every 200 hours. Filter is located above starter on right side of engine. Remove by turning filter counterclockwise with a filter wrench. Before installing new filter, coat gasket on base of filter with a light film of oil. Install by turning clockwise until friction is noted, then turn an additional 1/4 to 1/2 turn. See Figure 26.

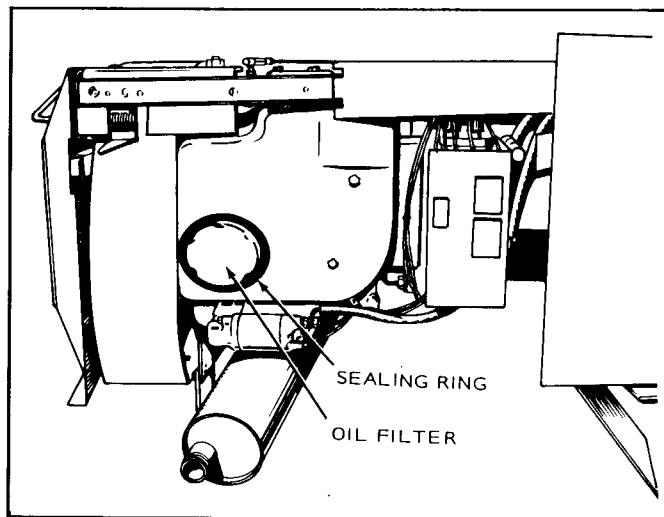


FIGURE 26. OIL FILTER LOCATION

### CAUTION

Do not over-torque oil filter. Be sure ring is installed around oil filter. This ring acts as an air seal and prevents loss of cooling air.

## CRANKCASE BREATHER

This engine uses a crankcase breather valve for maintaining crankcase vacuum. No maintenance is generally required. If the crankcase becomes pressurized as evidenced by oil leaks at the seals, clean baffle and valve in a suitable solvent. Crankcase breather disassembly requires removal of exhaust manifold. See Figure 27.

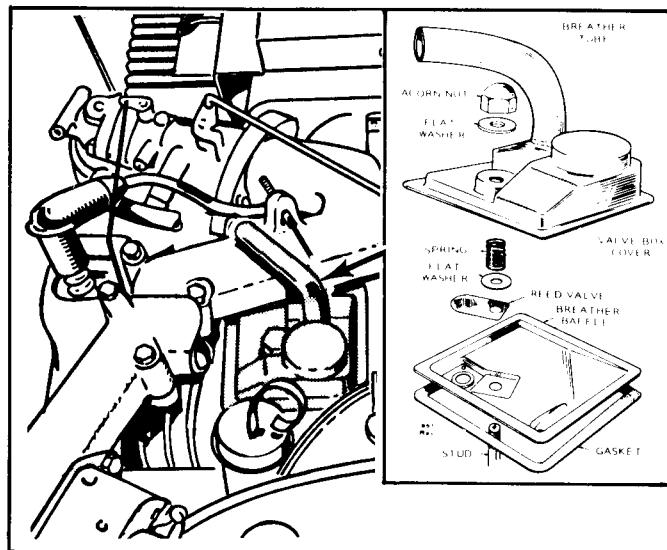


FIGURE 27. CRANKCASE BREATHER ASSEMBLY

# FUEL SYSTEM

## CARBURETOR DISASSEMBLY AND REPAIR

### Removal:

1. Disconnect fuel inlet hose and crankcase breather hose.
2. Remove air cleaner assembly.
3. Disconnect governor, throttle linkage, and choke control.
4. Remove two hold-down screws and lift carburetor from intake manifold.

Always work on carburetor in clean conditions.

### Replacing Needle and Valve Seat:

1. Remove 7/16 inch hex at base of fuel bowl and lift bowl from carburetor.
2. Push out pin that holds float to carburetor body. Disconnect spring holding needle to float.
3. Remove float and set aside in a clean place. Pull out needle and using a large screwdriver remove needle valve seat.
4. Install new valve seat and needle and replace float.
5. Adjust float.

## CARBURETOR FLOAT ADJUSTMENT

1. Invert float and casting.
2. With the float resting lightly against the needle and seat, there should be .07 to .11 inch clearance between base of float and carburetor casting.

A drill bit can be used for this measurement as shown in Figure 29. Use a 3/32 inch drill bit or any bit between .07 inch (No. 50) and .11 inch (No. 35).

3. If it is necessary to reset float level, remove the float from carburetor and bend the float tang, near the pin, to obtain correct float level.

### CAUTION

Do not bend the float when installed; doing so may cause deformation of needle or seat.

4. Check the float closely for signs of leakage. Repair or replace float if damaged or filled with gasoline.
5. Before assembling carburetor, remove filter screen from float bowl and clean both screen and base of float bowl.
6. Install new gaskets when reassembling.

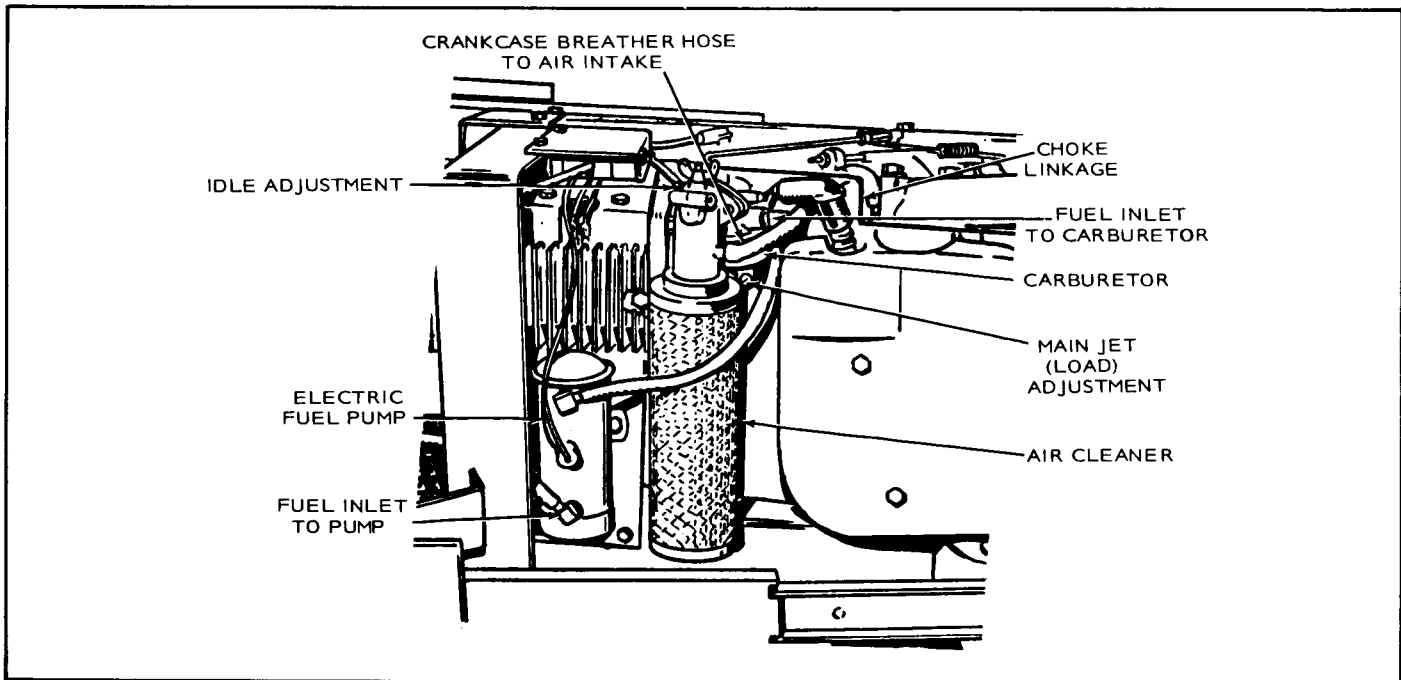


FIGURE 28. FUEL SYSTEM

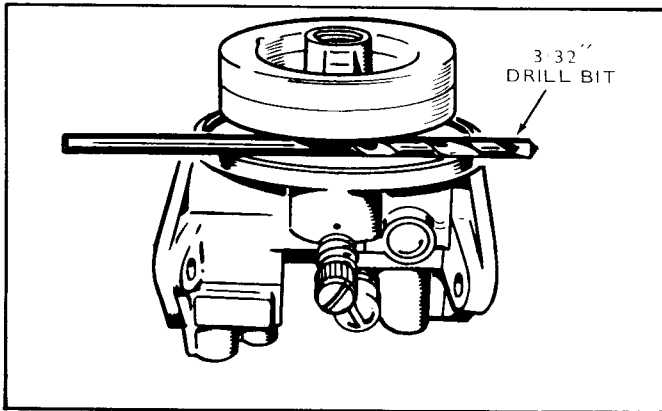


FIGURE 29. CARBURETOR FLOAT ADJUSTMENT

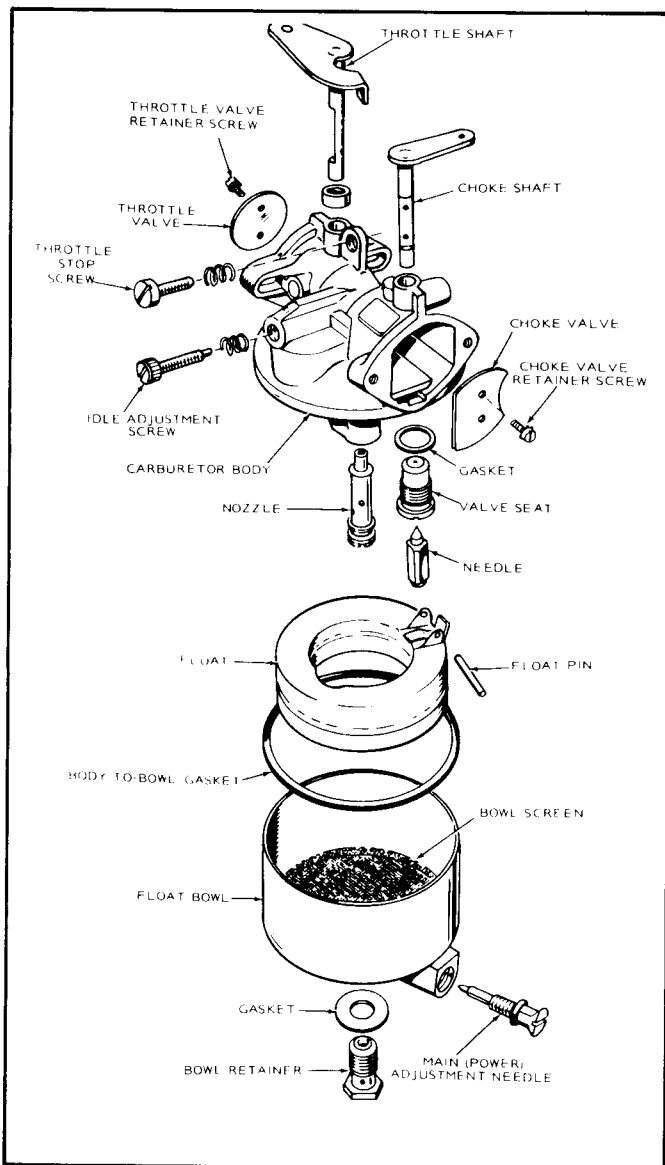


FIGURE 30. EXPLODED VIEW OF CARBURETOR

## CARBURETOR CLEANING AND INSPECTION

To clean the carburetor, soak all components thoroughly in a good carburetor cleaner, following the manufacturer's instructions. Be sure to remove all carbon from carburetor bore, especially in the area of the throttle valve. After soaking, clean out all passages with filtered, compressed air.

Check the adjusting needles and nozzle for damage. If float is loaded with fuel or damaged, replace it. The float should fit freely on its pin without binding.

Check the choke and throttle shafts for excessive side play and replace if necessary.

## FUEL PUMP

Every 400 hours or sooner, drain fuel pump and check filter element. Remove fuel pump mounting screws and turn off hex nut on base of pump. If element appears dirty, replace with a new one. Be sure to replace gaskets when reassembling. Static fuel pump pressure should be 2½ to 3¼ psi.

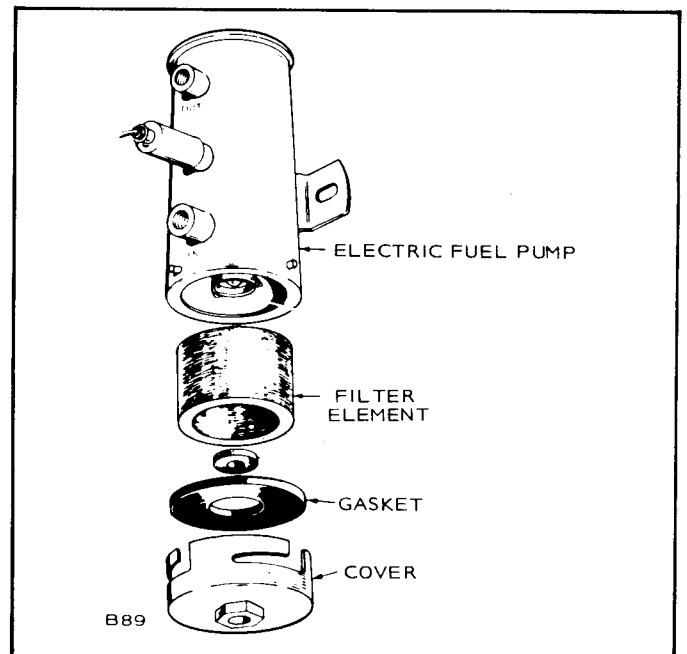


FIGURE 31. FUEL PUMP FILTER ELEMENT

## FUEL SOLENOID

An electric fuel solenoid mounts between fuel pump outlet and carburetor inlet. The solenoid opens during cranking and running. A defective solenoid will not allow plant to start. (Refer to Fuel System and Control System Troubleshooting Guides.)

## AIR CLEANER ELEMENT

Check and clean element at least every 100 hours. Loosen wing nut to remove. Clean by tapping base lightly on a flat surface. Replace element at least every 200 operating hours; clean or replace more often in dusty conditions.

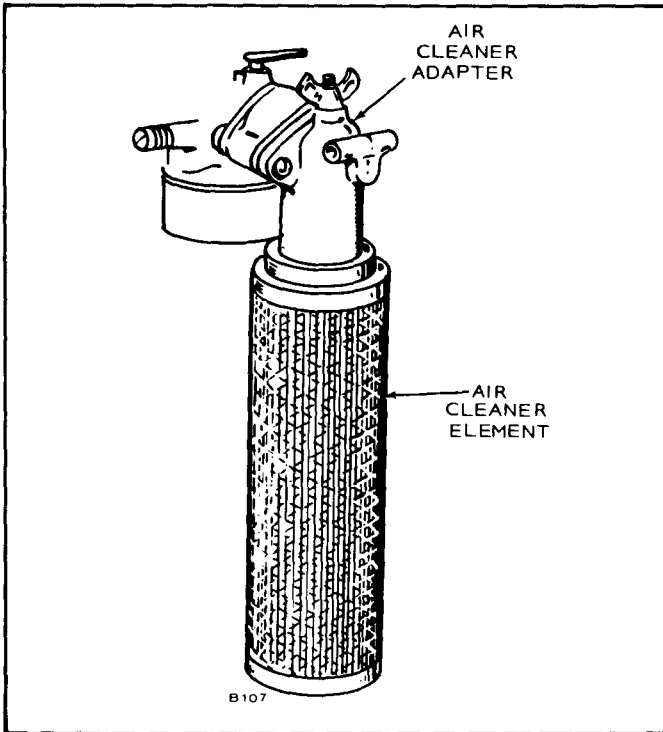


FIGURE 32. AIR CLEANER ELEMENT

## ELECTRIC CHOKE

Manually check movement of choke travel to be sure it is not stuck open or closed. Voltage at choke should be 12 volts during start and drop to zero during run. If choke does not move at room temperature with 12 volts applied, replace it.

This choke should not require any seasonal readjustment. If adjustment becomes necessary proceed as follows:

1. Loosen choke lever clamp screw.
2. With lever fully forward (away from carburetor), adjust so choke valve is completely closed or not more than 1/4 inch open.
3. Tighten clamp screw.

## CARBURETOR ADJUSTMENTS

The carburetor has a main fuel (power) adjustment and an idle fuel adjustment. The main adjustment affects operation under heavy load conditions. The idle adjustment affects operation under light or no-load conditions. Under normal circumstances, adjustments should not be disturbed. If adjustments

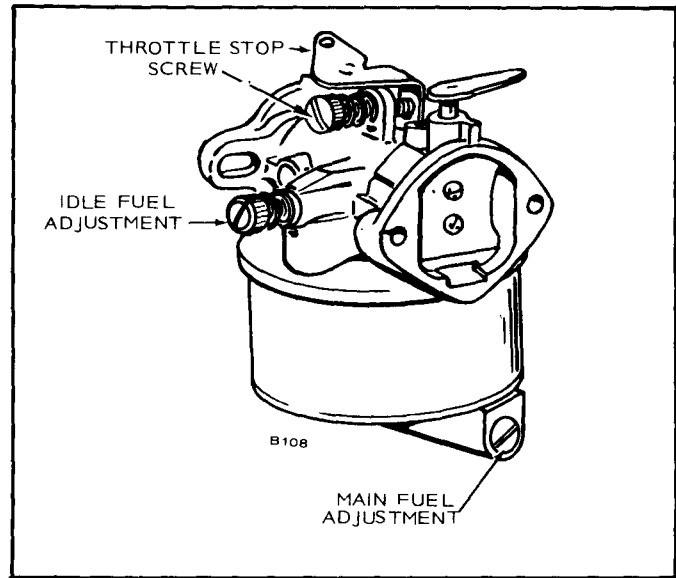


FIGURE 33. CARBURETOR ADJUSTMENTS

have been disturbed turn main fuel jet 1-1/4 turn off its seat and idle fuel jet one turn off its seat to permit starting. Then readjust them for smooth operation.

**CAUTION** Forcing the needle against its seat will damage it. The needle does not completely shut off fuel when turned fully in.

Set the throttle stop screw (located on the carburetor throttle lever), with no load connected to the plant. Turn stop so it just touches adjustment screw; then turn adjustment screw (with stop still touching it) until unit is running at 1500 rpm. When stop is released, governor will then control no-load speed at 1850 to 1890 rpm.

Before final adjustment, allow the engine to warm up. Adjust the idle fuel jet with no load connected. Open the main jet until the engine runs smooth under acceleration with no load. Slightly more fuel may be needed (open about 1/4 turn further) when sudden load is applied or if operating in extremely cold weather.

If the engine develops a "hunting" condition (alternate increase and decrease of engine speed), try correcting by opening the main adjusting needle a little more.

**CAUTION** Do not open main fuel jet more than 1/2 turn beyond the maximum power point.

## GOVERNOR

Before making governor adjustments, run the unit about 15 minutes under light load to reach normal operating temperature. (If governor is completely out of adjustment, make a preliminary adjustment at no load to first attain a safe voltage operating range).

Engine speed determines the output voltage and current frequency of the generator. By increasing the engine speed, generator voltage and frequency are increased, and by decreasing the engine speed, generator voltage and frequency are decreased. An accurate voltmeter or frequency meter (preferably both) should be connected to the generator output in order to correctly adjust the governor. A small speed drop not noticeable without instruments will result in an objectionable voltage drop. The engine speed can be checked with a tachometer.

A binding in the bearings of the governor shaft, in the ball joint, or in the carburetor throttle assembly will cause erratic governor action or alternate increase and decrease in speed (hunting). A lean carburetor adjustment may also cause hunting. Springs of all kinds have a tendency to lose their calibrated tension through fatigue after long usage. If all governor and carburetor adjustments are properly made, and the governor action is still erratic, replacing the spring with a new one and resetting the adjustments will usually correct the trouble.

1. Adjust the carburetor idle needle with no load connected.
2. Adjust the carburetor main jet for the best fuel mixture while operating the set with a full rated load connected.
3. Adjust the length of the governor linkage and check linkage and throttle shaft for binding or excessive looseness.
4. Adjust the governor spring tension for rated speed at no load operation.
5. Adjust the governor sensitivity.
6. Recheck the speed adjustment.
7. Set the carburetor throttle stop screw.

**Linkage:** The engine starts at wide open throttle. The length of the linkage connecting the governor arm to the throttle shaft and lever is adjusted by rotating the ball joint. Adjust this length so that with the engine stopped and tension on the governor spring, the stop on the carburetor throttle lever just contacts the stop. This setting allows immediate control by the governor after starting. It also synchronizes travel of the governor arm and the throttle shaft.

**Speed Adjustment:** With the warmed-up unit operating at no load, adjust the tension of the governor spring. Refer to *VOLTAGE CHART* and *SPEED CHART* (Figure 34). Turn the speed adjusting nut to obtain a voltage and speed reading within the limits shown.

**Sensitivity Adjustment:** Refer to Figure 34. Check the voltage and speed, first with no load connected and again with a full load. Adjust the sensitivity to give the closest regulation (least speed and voltage difference between no load and full load) without causing a hunting condition.

To increase sensitivity (closer regulation), shift the spring toward the governor shaft.

An adjustment for too much sensitivity will cause alternate increase and decrease of engine speed (hunting).

To decrease sensitivity, shift the spring toward the outer end of the governor arm. Too little sensitivity will result in too much difference in speed between no load and full load conditions.

Any change in the sensitivity adjustment usually requires a compensating speed (linkage) adjustment.

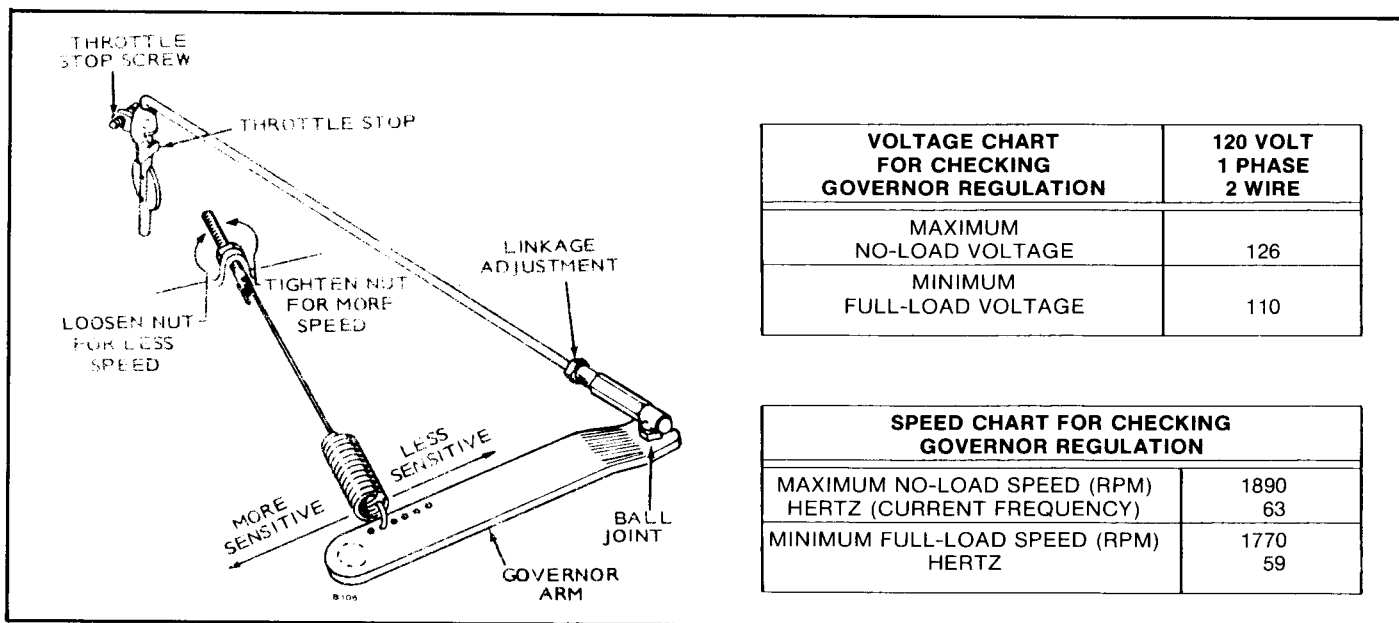


FIGURE 34. GOVERNOR ADJUSTMENTS



## FUEL SYSTEM TROUBLESHOOTING GUIDE

TROUBLE	CAUSE	REMEDY
FUEL LEAKS FROM CARBURETOR	1. Float level set too high	1. With fuel bowl removed and carburetor inverted, set float parallel to bowl flange (3/32" clearance)
	2. Dirt under inlet valve	2. Remove inlet valve, clean seat by rinsing in clean fuel and blow off with compressed air
	3. Bowl vent plugged	3. Remove bowl and blow clean with compressed air
	4. Collapsed float caused by blowing assembled carburetor with compressed air	4. Replace float
	5. Carburetor gummed from storage. Float stuck to screen	5. Remove fuel bowl and clean with suitable solvent.
ENGINE SMOKES AND RUNS RICH	1. Dirty air filter	1. Clean or replace
	2. Improper adjustment	2. Set idle and power needles at one turn open. After engine starts and runs, set for optimum performance
	3. Nozzle boss gasket leaks. Engine runs with power needle seated	3. Remove fuel bowl and replace gasket. Tighten bowl retainer securely.
	4. Air bleeds in carburetor plugged	4. Remove fuel bowl, idle and power needles. Clean thoroughly with compressed air.

**FUEL SYSTEM TROUBLESHOOTING GUIDE**  
(Continued)

TROUBLE	CAUSE	REMEDY
ENGINE RUNS LEAN	1. Improper adjustment	1. Set idle and power needles at one turn open. After engine starts and runs, set for optimum performance.
	2. Idle holes plugged. Dirt in fuel delivery channels	2. Remove fuel bowl, idle and power needles. Clean thoroughly with compressed air
	3. Float level set too low. Low level in fuel bowl	3. With fuel bowl removed and carburetor inverted, set float parallel to bowl flange (3/32" clearance)
	4. Fuel filter in electric fuel pump dirty	4. Remove filter and replace
	5. Fuel filter (screen) in bowl plugged	5. Remove fuel bowl. Clean thoroughly and replace
ENGINE STARTS HARD	1. Improper adjustment	1. Set idle and power needles at one turn open. After engine starts and runs, set for optimum performance
	2. No fuel in carburetor	2. Check carburetor drain valve. If no fuel in bowl, clean tank filter and carburetor. Check electric fuel pump operation. Check electric solenoid valve.
	3. Choke valve not closing	3. Check controls for proper travel
GOVERNOR SURGE	Throttle shaft and valve binding	Remove and replace shaft if worn. Clean carburetor body. Reassemble throttle shaft assembly into carburetor body as far as possible. Hold firmly in place in this position while assembling throttle valve. Make certain valve does not bind in throttle bore when opening and closing throttle.

# IGNITION AND BATTERY CHARGING

## BREAKER POINTS (Cold Setting)

To maintain maximum efficiency from the engine, change the breaker points every 200 hours of operation. Proceed as follows:

1. Remove the two screws and the cover on the breaker box.
2. Remove the two spark plugs so engine can be easily rotated by hand. Check condition of spark plugs at this time.
3. Refer to Figure 35. Remove mounting nut (A) and pull the points out of the box just far enough so screw (B) can be removed and leads disconnected.
4. Remove screw (C) and replace condenser with a new one.
5. Replace points with a new set but do not completely tighten mounting nut (A).
6. Remove the dot button on blower housing. This provides an access to view timing mark.
7. Rotate the engine clockwise (facing flywheel) by hand until the 26 degree BTC mark on gear cover aligns with mark on flywheel. Turn another 1/4 turn (90 degrees) to ensure points are fully open.
8. Using a screwdriver inserted in notch (D) on the right side of points, turn points until gap measures .025 inch with a flat thickness gauge. (Be sure feeler is clean.) Tighten mounting screw and recheck gap.
9. Check ignition timing.

## IGNITION TIMING

The timing on the engine is preset at the factory. A non-movable breaker point box is used, however a slight timing change could be made by adjusting points.

The engine is equipped with an automotive type battery ignition system. Both spark plugs fire simultaneously, thus the need for a distributor is eliminated. Spark advance is set at 26 degrees BTC (before top center) and should be maintained for best engine performance. Always check timing after replacing ignition points or if noticing poor engine performance. Proceed as follows:

### Timing Procedure - Engine Not Running - Cold Setting

1. Connect a continuity test lamp set across the ignition breaker points. Touch one test prod to the breaker box terminal to which the coil lead is connected and touch the other test prod to a good ground on the engine.
2. Turn crankshaft against rotation (counterclockwise) until the points close. Then slowly turn the crankshaft with rotation (clockwise).
3. The lamp should go out just as the points break which is the time at which ignition occurs (26 degrees BTC).

### Timing Procedure - Engine Running - Hot Setting

1. To check the ignition timing with unit running use a timing light. Connect the timing light according to its manufacturer's instructions. Either spark plug can be used as they fire simultaneously.
2. Remove the dot button on blower housing to provide an access to view timing marks.
3. Start the engine and check the timing. The mark on the flywheel should line up with the 21 degree mark on the cover when engine is warmed up.
4. Replace dot button, breaker box cover and any other hardware removed from engine.

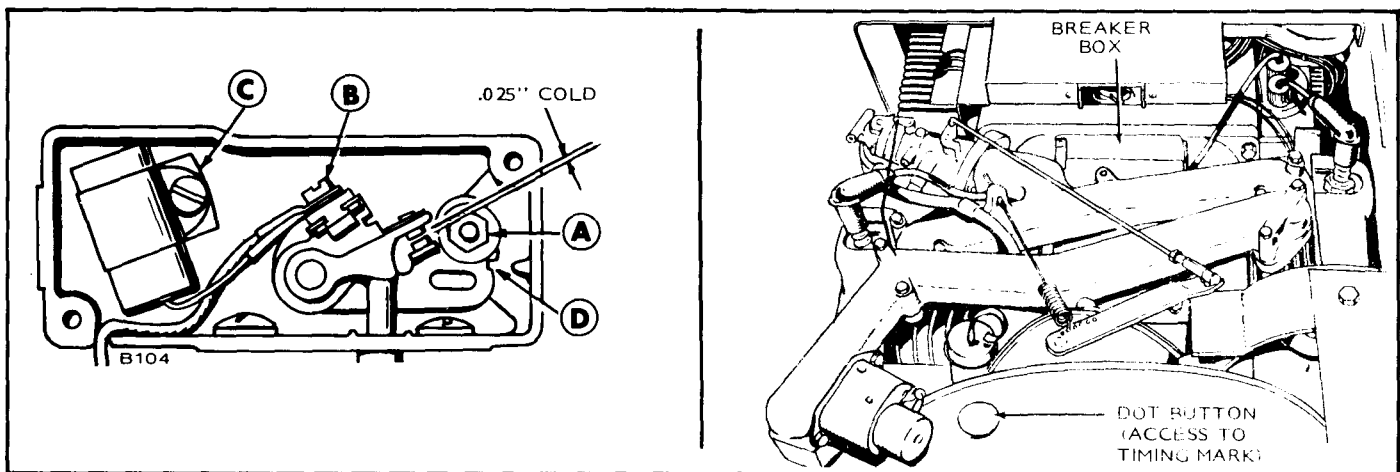


FIGURE 35. BREAKER BOX AND TIMING ACCESS HOLE

## SPARK PLUGS

Remove both spark plugs and install new ones every 250 hours. Use Onan No. 167-0245 or equivalent. Check to be sure spark plug gap is set at .020 inch.

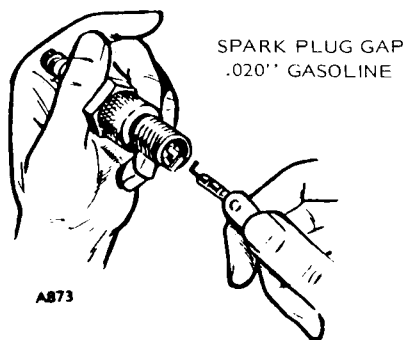


FIGURE 36. SPARK PLUG GAP

## IGNITION COIL

To test primary and secondary windings within the ignition coil proceed as follows:

1. Use a Simpson 260 VOM or equivalent.
2. Place black lead on ground (-) terminal of coil and red lead to positive (+) terminal. Primary resistance should read 4.30 ( $\pm 10\%$ ) ohms.
3. Change resistance setting on ohmmeter. Place ohmmeter leads inside spark plug cable holes (Figure 37). Secondary resistance should read 14,000 ( $\pm 10\%$ ) ohms.
4. If any of the above conditions are not met, replace coil.

**CAUTION** This engine uses a 12 volt, negative ground system. Alternator must be connected to battery at all times when engine is running. Do not reverse battery cables.

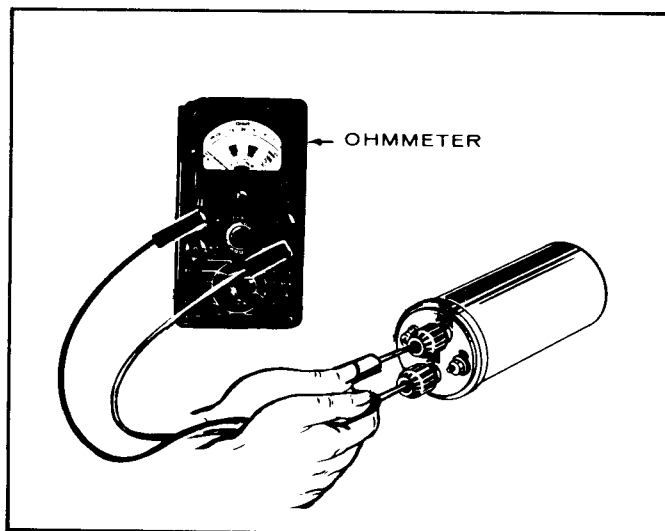


FIGURE 37. TESTING COIL

**Battery Inspection:** Check battery cells with a hydrometer. The specific gravity reading should be approximately 1.280 at 80 degrees F.

If one or more cells are low on water, add distilled water and recharge.

Keep the battery case clean and dry. An accumulation of moisture will lead to a more rapid discharge and battery failure.

Keep the battery terminals clean and tight. After making connections, coat the terminals with a light application of petroleum jelly or grease to retard corrosion.

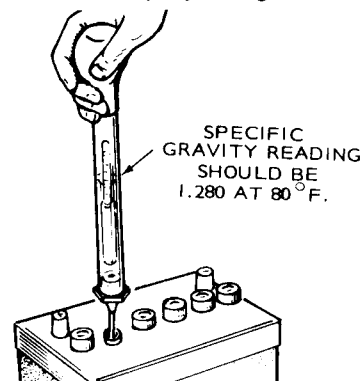


FIGURE 38. SPECIFIC GRAVITY TEST

## FLYWHEEL ALTERNATOR

This unit is equipped with a permanent magnet flywheel alternator and solid-state voltage regulator-rectifier (output control). As with all solid-state electrical units, precautions are necessary when servicing. Observe the following.

### Precautions:

1. Do not connect battery cables in the wrong polarity.
2. Do not short together alternator stator leads.
3. Do not run without a battery. Damage will occur to regulator and battery ignition coil.

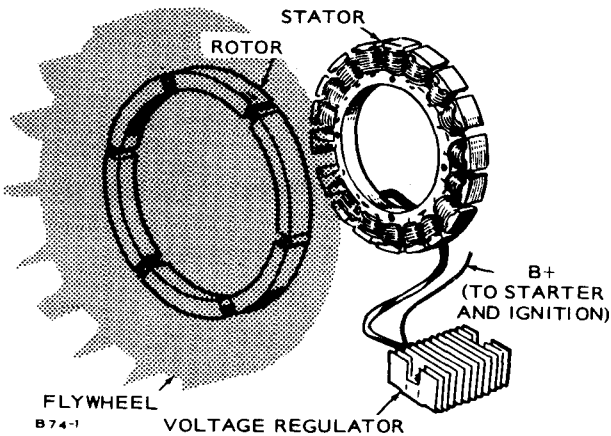
### Preservice Checks:

1. Check for a good ground between equipment and regulator-rectifier case.
2. Be sure output control plug (connector) is properly inserted into stator receptacle to eliminate any resistance due to a poor connection. Keep it clean and tight.
3. Check battery and its connection to be sure it is serviceable.

**CAUTION** Charging system tests require a fully charged battery.

## TESTING BATTERY CHARGING SYSTEM

BASIC TEST	PROCEDURE	TEST VALUES
1. Battery	Battery Voltage - unit not running	12 VDC
2. Regulator	Battery Voltage after unit is running 3 to 5 minutes.	13.6 to 14.7 VDC
3. Alternator Stator and Wiring with Fully Charged battery.	Ohmmeter reading from stator output - unit not running. Disconnect wire terminating at AC terminal of voltage regulator and wire terminating at BAT terminal of start solenoid. Insert ohmmeter between these wires.	.2 to .6 Ohms
4. Alternator Stator and Wiring	Measure AC stator output voltage with unit running. Disconnect wire terminating at AC terminal of voltage regulator. Measure AC voltage (unit running) between this wire and BAT terminal of start solenoid.	28 VAC



**FIGURE 39. FLYWHEEL ALTERNATOR**

# STARTING SYSTEM

## SPECIFICATIONS

Engaging System .....	Solenoid-operated Overrunning Clutch
Nominal Output .....	0.68 Hp
Rated Voltage .....	D.C. 12 V.
Field Connection .....	Compound
Direction of Rotation .....	Counterclockwise (Viewing from pinion end)
Weight .....	6.76 lbs.

## DESIGN

The starter consists of two parts: a low voltage compound DC motor and a means of transmitting motor power to the flywheel ring gear. The constructional difference between this type of starter and others is that the lever spring is located in the central portion of the front bracket. The shift lever, which is operated by solenoid, causes the overrunning clutch

assembly to move along the armature shaft toward the flywheel. As the pinion and flywheel teeth make contact, the shift lever continues to move and make electrical contact to spin the armature. The lever spring compresses, holding the pinion gear against the flywheel gear. As soon as the armature rotates and the gear teeth line up, the gears will mesh.

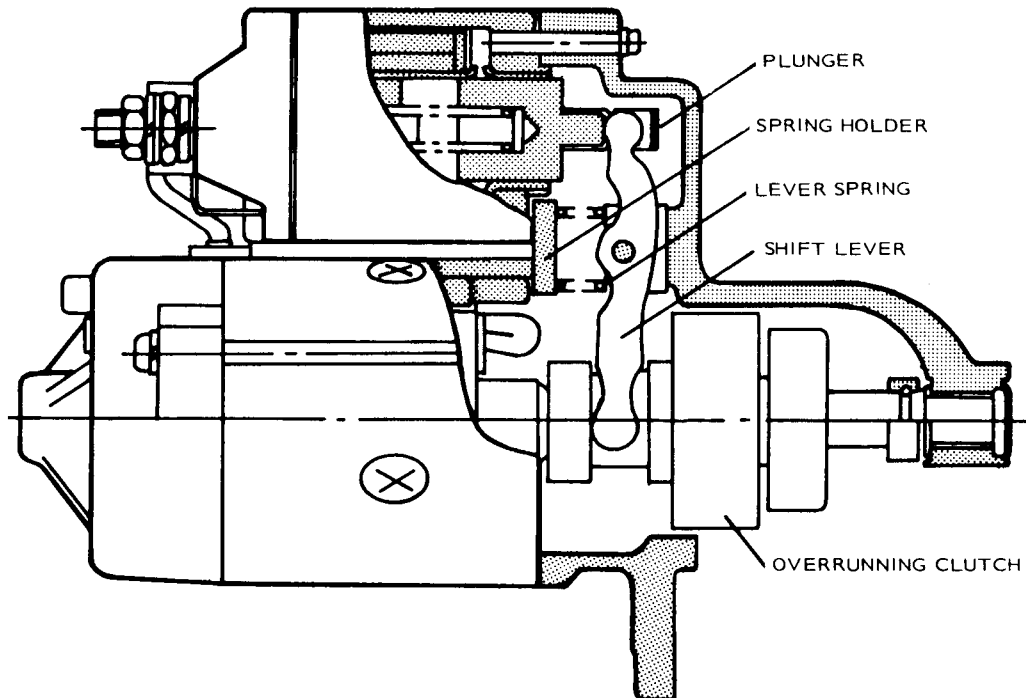


FIGURE 40. STARTER

## STARTER REMOVAL

Starter removal requires removal of the generating set from its slide rails and mounts.

1. Remove blower scroll from front of engine (four screws).

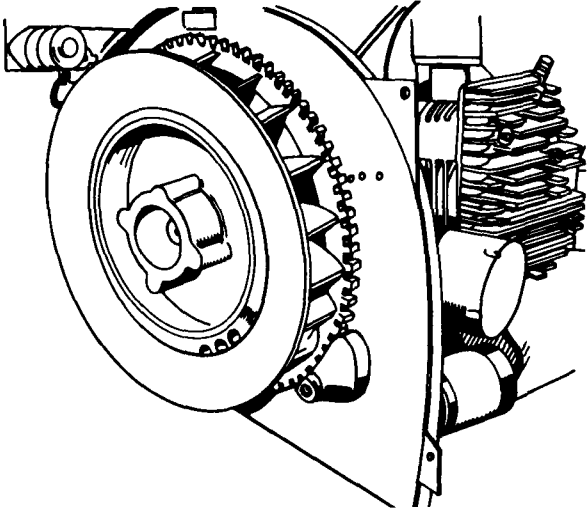


FIGURE 41. BLOWER SCROLL REMOVED

2. Remove flywheel with a flywheel puller or loosen center cap screw and direct a sharp blow to loosen. It helps to pull forward on one side of flywheel when striking with a hammer. If using this procedure be sure to leave center cap screw loosely in place or blower wheel will fall on floor.
3. Remove left and right hand air shrouds that cover cylinder heads.
4. Remove exhaust manifold.
5. Remove blower scroll backing plate (two screws on bottom - two on gear cover).

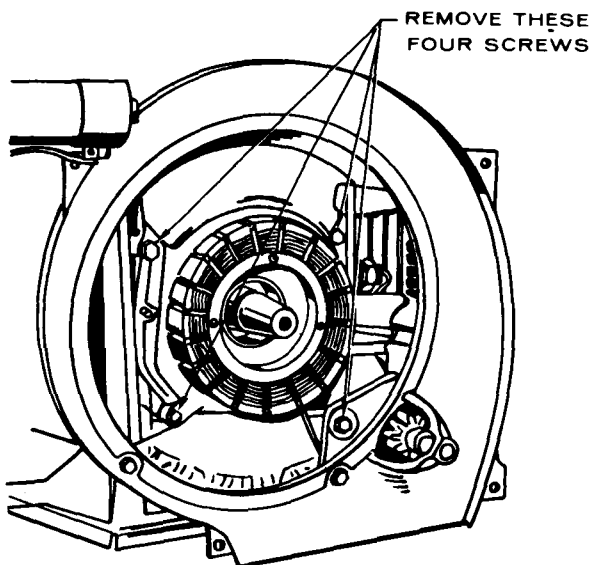


FIGURE 42. REMOVING BACKING PLATE

6. Disconnect heavy wire that connects to starter.
7. Remove two starter hold-down studs and lift out starter.

## STARTER DISASSEMBLY

Disassemble the starter as follows:

1. Loosen the nut that attaches the solenoid motor terminal to the field coil connector lead and take off the connector lead.

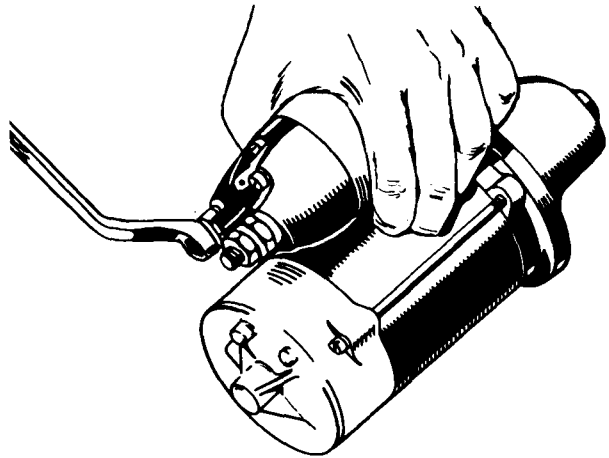


FIGURE 43.

2. Loosen the retaining screws and remove the solenoid from the front bracket. Simultaneously, the fiber washers, the return spring and the solenoid plunger will be removed.

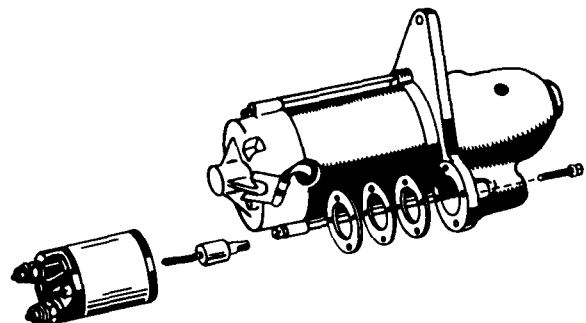


FIGURE 44

- Unscrew the through bolts and separate the yoke with the rear bracket from the front bracket.

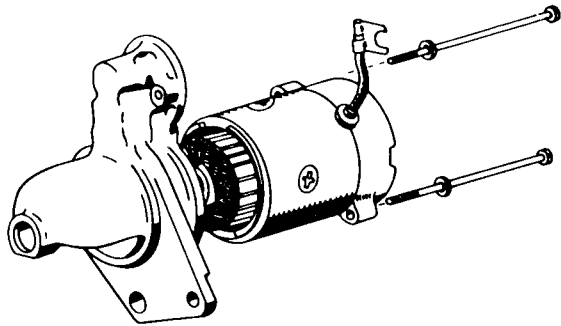


FIGURE 45

- Removing the insulated brush from the brush holder permits separation of the rear bracket from the yoke.

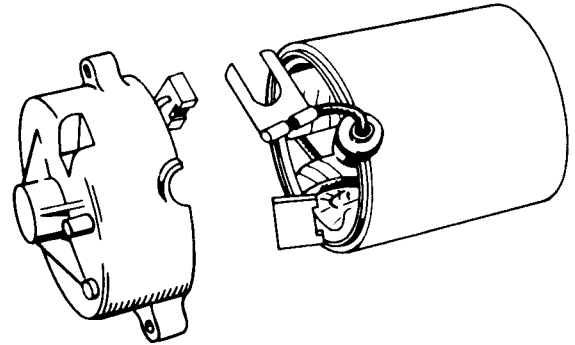


FIGURE 47

- Remove the armature from the front bracket. Simultaneously, the shift lever, the lever spring and the spring holder will be removed.

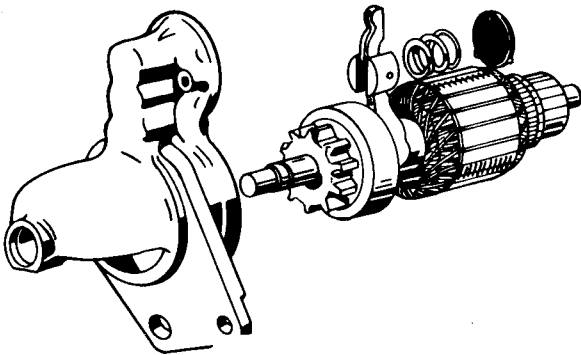


FIGURE 46

- If it is necessary to remove overrunning clutch, first, put a metal cylinder of suitable size over the end of armature shaft so it rests on the stop ring. Then tap the cylinder lightly with a hammer, the stop ring towards armature and lock ring. Remove ring from groove in shaft so the overrunning clutch and the stop ring will be removed from the armature shaft.

## CLEANING PARTS

**CAUTION** 1. Do not immerse parts in cleaning solvent. Immersing the field coil, yoke assembly, armature and solenoid will damage the insulation. Wipe these parts with a cloth only.

2. Do not immerse the overrunning clutch in cleaning solvent. The clutch is prelubricated at the factory, and solvent will wash lube from clutch.

3. Wash all other parts in solvent and dry the parts.

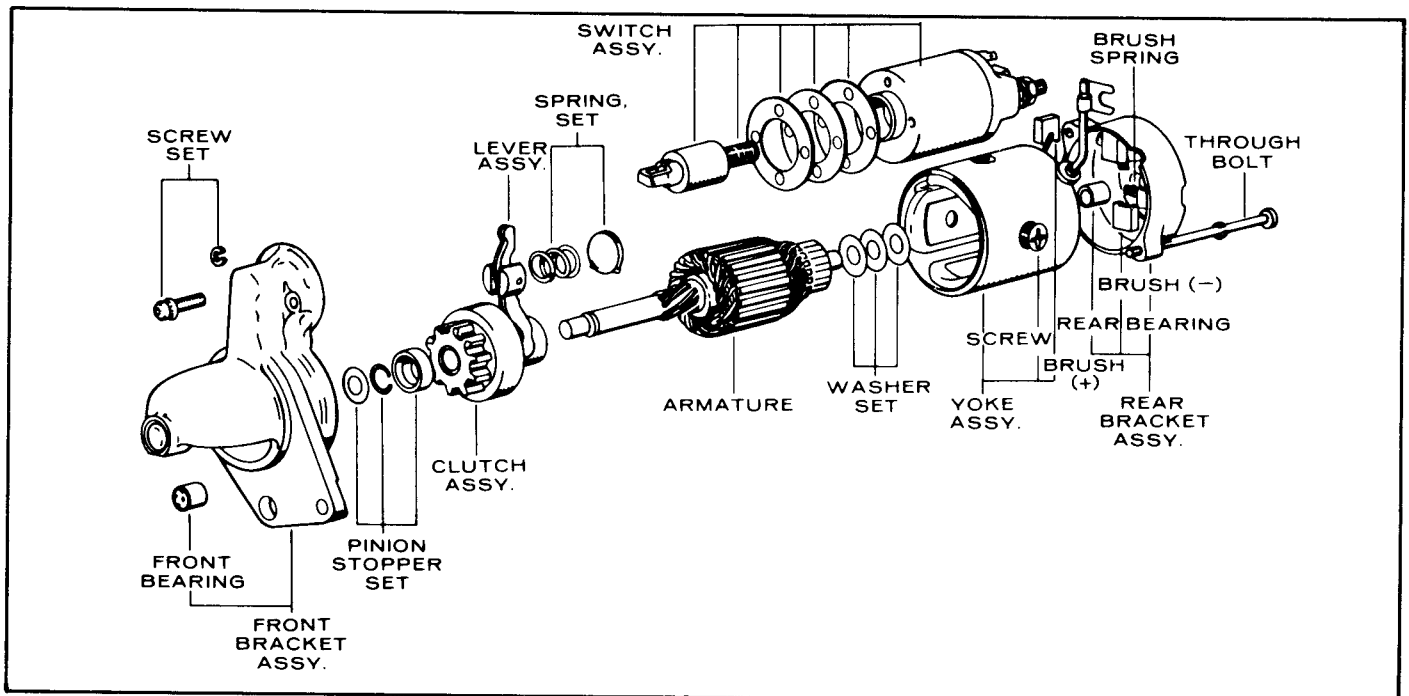


FIGURE 48. EXPLODED VIEW OF STARTER



## INSPECTION OF PARTS

**Grounded Armature:** Use a 120 volt test lamp set for testing armature for grounds. If lamp lights when one probe of test lamp is touched to commutator with other probe to the core, the armature is grounded and must be replaced.

IF ARMATURE IS GOOD  
LAMP SHOULD NOT LIGHT

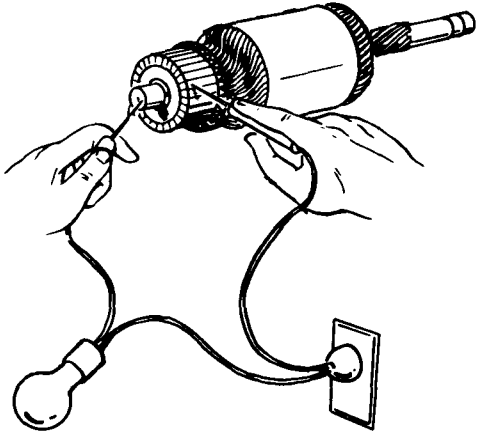


FIGURE 49. TESTING FOR GROUNDED ARMATURE

**Shorted Armature:** Use a growler tester for testing armature for a short circuit. Place armature in growler and hold a thin, steel blade (hacksaw blade) parallel to the core and just above it while slowly rotating armature in growler. A shorted armature will cause blade to vibrate and be attracted to the core.

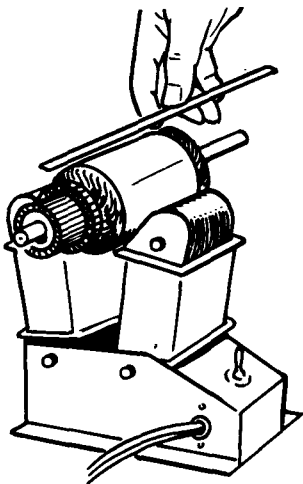


FIGURE 50. TESTING FOR A SHORT CIRCUIT

**Open Armature:** The most likely place to check for an open circuit is at the commutator riser bars. Inspect for loose connections on points where the conductors are joined to the commutator bars.

**Commutator Runout:** Place armature in a pair of v-blocks and measure runout with a dial indicator. Measure both shaft and commutator. A bent shaft requires replacement of armature. When runout exceeds .004 inch, commutator should be refaced. Remove only enough metal to provide a smooth, even surface.

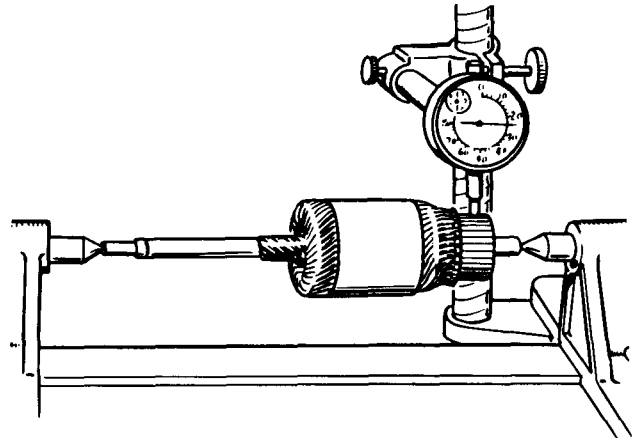


FIGURE 51. CHECKING COMMUTATOR RUNOUT

**Open Field Coil:** Use a 120 volt test lamp set for this test. Connect one probe of test lamp to the yoke and the other probe to insulated brush. If lamp does not light, the field coil is open.

This starter is compound wound, having a series coil and a shunt coil. The grounded end of the shunt coil is soldered inside of the yoke.

**Grounded Field Coil:** Use a 120 volt test lamp set for testing for a grounded field coil. First disconnect the grounded end of shunt coil as shown in Figure 52. Then connect one probe of test lamp to yoke and the other probe to field coil connector lead. If lamp lights, field coil is grounded.

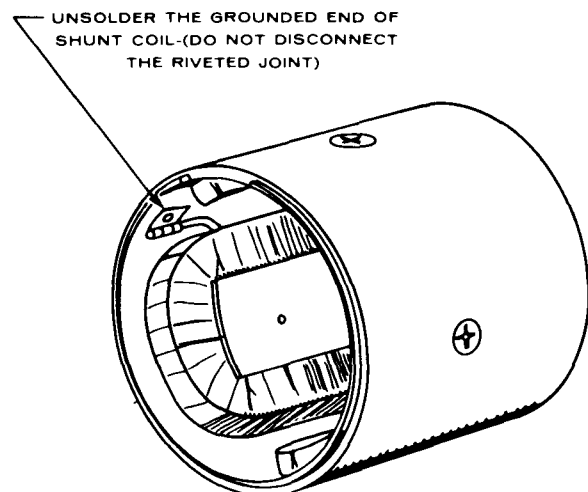


FIGURE 52

## BRUSH REPLACEMENT

Brushes that are worn out to the wear limit line should be replaced. Brushes can be replaced after removing the rear bracket.

When resoldering the brushes, make a low resistance connection, using a high temperature solder and resin flux.

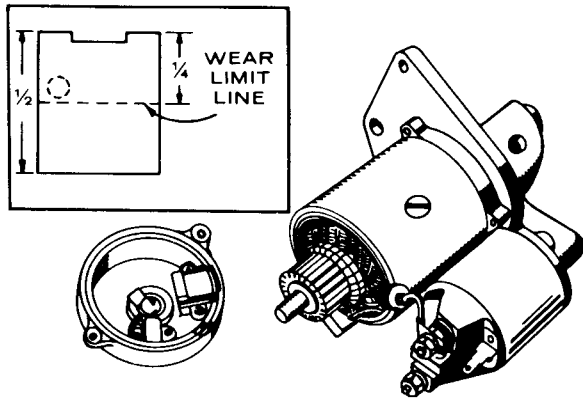


FIGURE 53. BRUSH WEAR LIMIT

**Brush Springs:** The spring tension should be taken using a push-type spring scale until the top of a new brush protrudes 1/16 inch from the brush holder. Spring tension should be 36 to 48 ounces. See Figure 54.

**Overrunning Clutch:** The pinion gear should rotate smoothly in one direction (not necessarily easily), but should not rotate in opposite direction. If pinion gear does not function properly, or if pinion gear is worn or burred, replace the overrunning clutch.

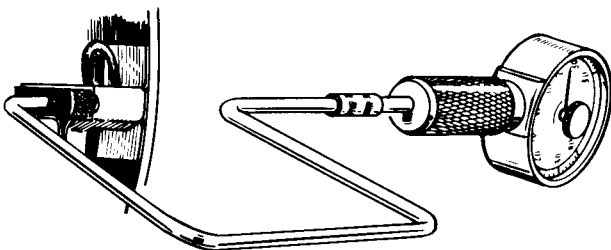


FIGURE 54. CHECKING BRUSH SPRING TENSION

## REASSEMBLY

Reassembly is the reverse of disassembly. Note the following:

1. Lubricate armature shaft and splines with a very light grade oil. A medium or heavy oil and grease may cause faulty operation in cold weather.
2. Install the overrunning clutch assembly, the ring and the stop ring on the armature shaft. Drive pinion stopper far enough on shaft to install stop ring. Then using a puller (Figure 55) pull stopper against ring.

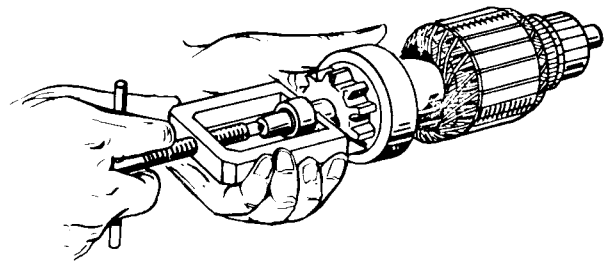


FIGURE 55

3. Apply a small amount of lubriplate on the shift lever pivot pin and lever holders.

Install the shift lever over the clutch assembly with position indicated in Figure 56. This is important, if the shift lever is not properly positioned the pinion gear travel will be restricted causing a locking in the clutch mechanism.

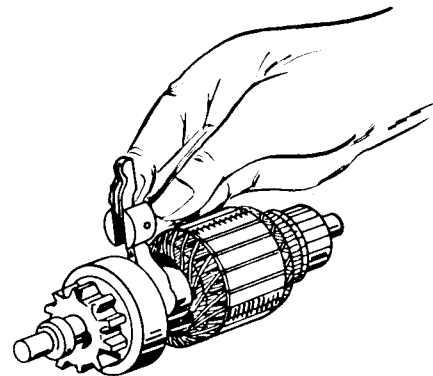


FIGURE 56

- Place the thrust washer on the drive end of the shaft. Slide the armature with the lever into the front bracket.

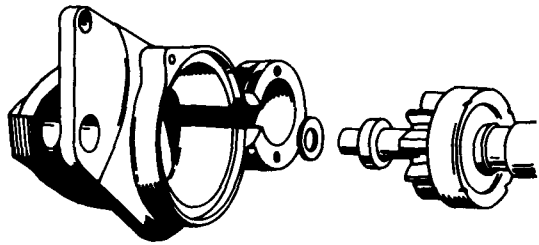


FIGURE 57

- Place the lever spring and the spring holder into the front bracket with the direction shown in Figure 58.

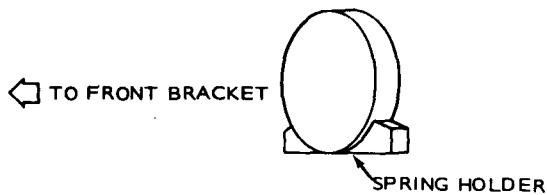


FIGURE 58

- Position the Yoke to the front bracket. Be sure that the yoke is properly indexed to the front bracket.

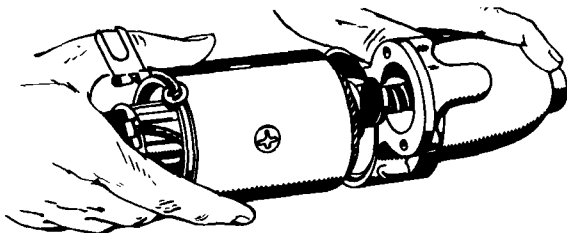


FIGURE 59

- Place the thrust washer (steel) and washer (fiber) on the commutator end of shaft, and apply a small amount of lubriplate on the shaft.

In case three washers are used, the fiber washer is placed between the steel washers.

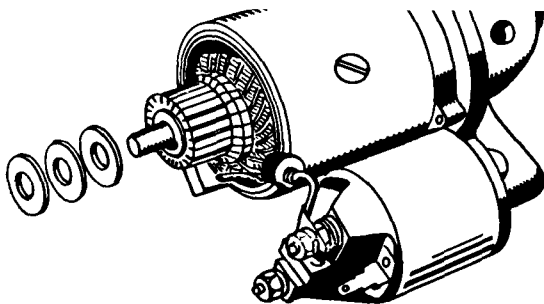


FIGURE 60

- Insert two brushes and springs in their brush holders and push them against spring tension. Secure the brushes by iron wires as shown in Figure 61.

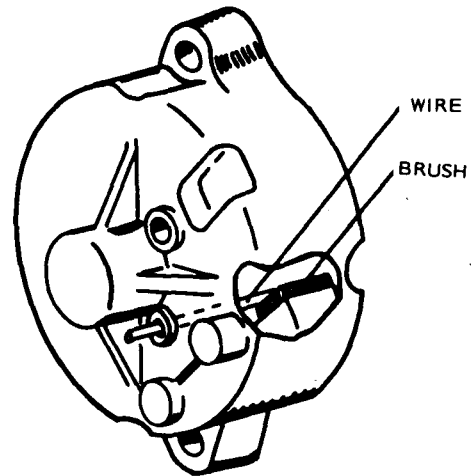


FIGURE 61

- When securing the brushes, position the rear bracket to the yoke, inserting the rubber gasket to the slot of the rear bracket. After the rear bracket is installed to the yoke, withdraw iron wires so the brushes and the commutator come in contact. Then, insert the bushings into the holes to keep out dirt.
- Fasten through bolts securely.
- Install the solenoid plunger over the top of the shift lever in the front bracket. Be sure that the pinion gear is moved when the plunger is pulled manually.

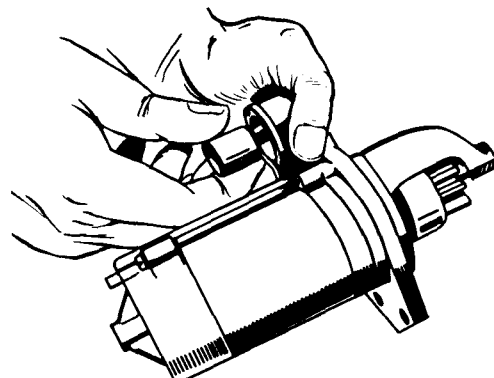


FIGURE 62

- Install the solenoid.

**CAUTION** The return spring, in this case, should be straight in the proper position between the bore of the solenoid and the bore of the plunger.

## TESTING AND ADJUSTING

**Adjusting Pinion Clearance:** After the starter is reassembled the pinion clearance must be adjusted to give sufficient clearance between the end of the pinion and the stop ring when the pinion is in mesh with the ring gear of the engine.

1. Connect a battery of the proper voltage between the "Switch" terminal of the solenoid and the bracket of the starter (ground), so the pinion will travel.
2. Then, push the pinion back until play is taken out of the lever and the clutch mechanism.
3. Measure the pinion clearance.
4. The clearance should be 0.002 to 0.008 inch. Adjust by removing the solenoid and increasing or decreasing the number of the fiber washers.

Increasing the number of the washers decreases clearance, and decreasing the number of the washers increases clearance.

**No Load Test:** For this test connect starter as shown in Figure 63. The values of this test should be as follows:

Battery Voltage . . . . . 11.5 Volts  
Minimum RPM . . . . . 6000 RPM  
Maximum Current Draw . . . 55 Amps

**CAUTION** 1. Before installing the starter, be sure starter and engine mounting surfaces are free of dirt and oil. These surfaces must be clean to make a good electrical contact.

2. Don't operate the starter more than 30 seconds, or serious damage may result. Starters are not designed for continuous operation.

3. When the engine does not rotate, don't hold the starter in a stall condition more than 10 seconds.

4. The wires between the battery and the starter should be of sufficient size to carry the electric load without excessive voltage drop.

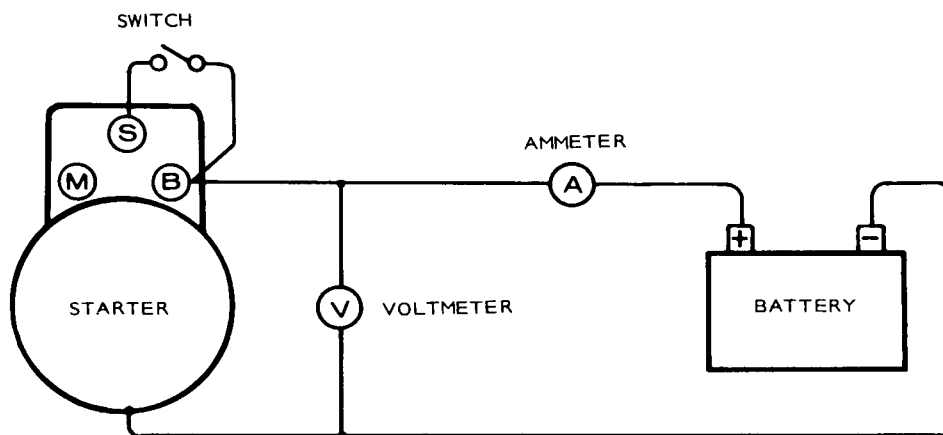


FIGURE 63. NO LOAD TEST

# AC GENERATOR MAINTENANCE

## GENERAL

The generator uses a revolving armature and normally needs little care other than a periodic check of the brushes and collector rings. If a major generator repair becomes necessary, have the equipment checked and tested by a qualified electrician who is thoroughly familiar with the operation of electric generating equipment.

All accessories must be taken off and power plant must be removed from its slide rails for disassembly and repair of the generator.

## BRUSH REMOVAL AND REPLACEMENT

To gain access to brushes, remove plastic end bell screens. Measure brush wear as shown in Figure 64, using a small, narrow scale inserted into top of brush block. If brushes need replacing remove and tag wires connecting to brush blocks. Then remove brush blocks and lift out of end bell. Pull out the brushes and springs from bottom of brush block. Clean out any dirt or oil from brush block at this time.

New brushes are shaped to fit and seldom need sanding to seat properly. Always replace brushes as a set and use only the correct brushes as listed in the *PARTS CATALOG*. Never use a substitute brush which may appear to be the same but may have entirely different electrical characteristics.

Note that brush blocks are stamped "BRG END" on one side. Be sure this stamped side faces bearing end of generator for correct brush alignment. Tighten the brush block screws to 40-70 in-lb. (4-6 ft-lb.). If some sparking occurs after replacing brushes, run the plant with a light load until brushes seat properly. Check brush springs for freedom of movement.

## GENERATOR DISASSEMBLY

1. Remove power plant from its slide rails.
2. Remove all accessories attached to the generator.
3. Tag and remove all leads.
4. Loosen and lift out both brush rigs.
5. Remove four generator through-stud nuts.
6. Lift or pull end bell from frame assembly. Do not pry loose with a screwdriver, use a plastic hammer and tap around edges of end bell to loosen.
7. Remove frame (field) assembly, being careful not to let it rest or drag on the armature.

**CAUTION** Four seals are used between frame (field) assembly and engine-to-generator adapter. These seals must be used when reassembling generator or the generator will overheat.

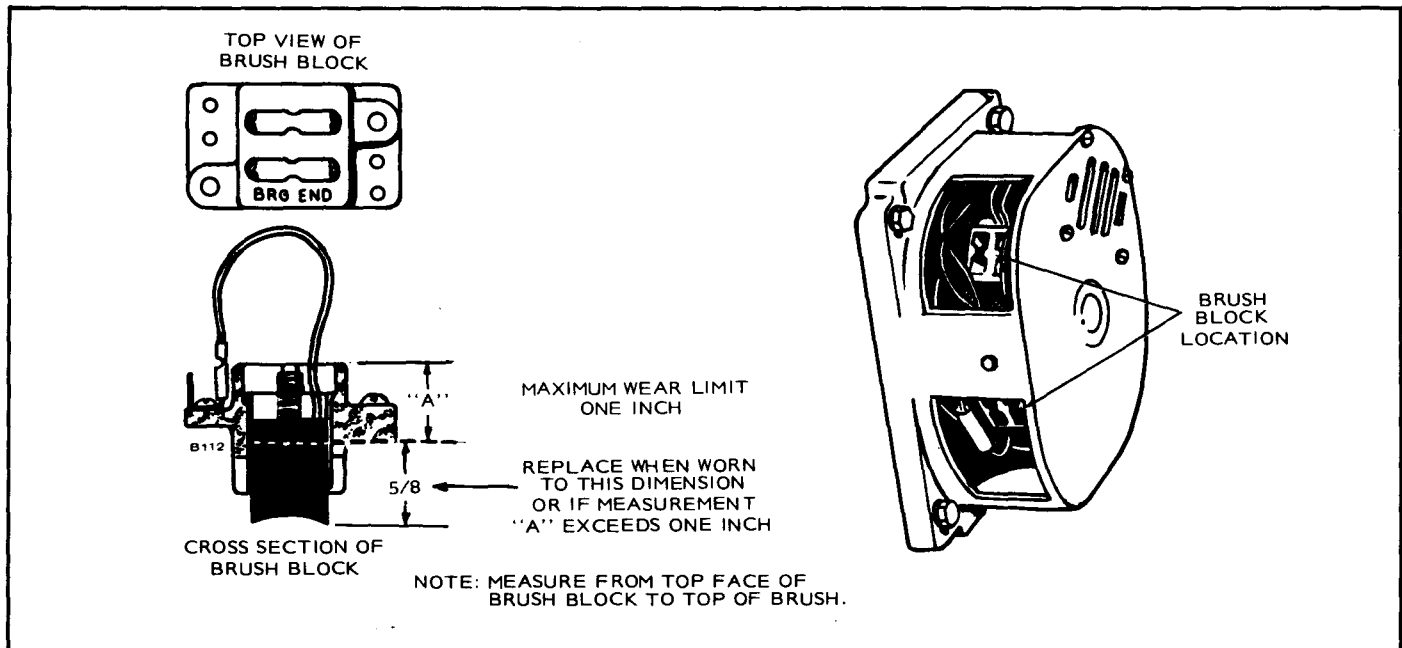


FIGURE 64. BRUSH WEAR LIMITS

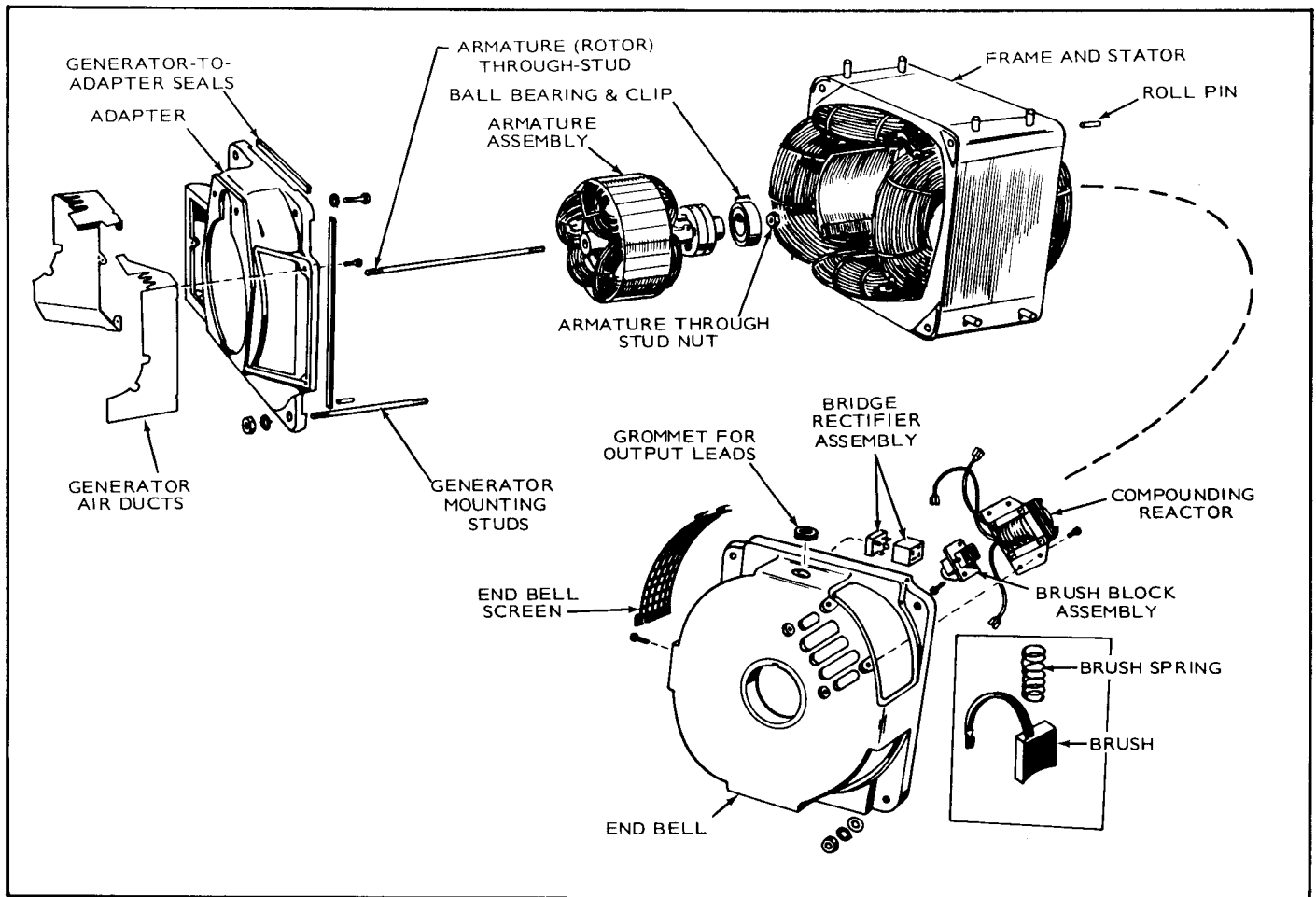


FIGURE 65. EXPLODED VIEW OF AC GENERATOR

8. Using a square 3/8 inch drive, insert into 12-point (internal wrenching) armature hold-down nut and remove.
9. While pulling outward with one hand under the armature, strike a sharp end-wise blow on armature shaft to loosen armature. The armature has an internal taper which fits onto the external taper of engine adapter. If the armature does not come loose, place a heavy brass rod on the armature shaft near the ball bearing and strike a sharp downward blow on the rod with a hammer. Rotate the armature 1/2 turn before repeating.

**CAUTION** Do not strike the collector rings or bearing.

### ARMATURE GROUND TEST

Use a 120 volt series test lamp set for this test. Armature must be removed from generator for this test.

Place one test prod on one of the collector rings and the other test prod on the armature shaft. Test lamp should not light. If the test lamp lights, the AC winding or a collector ring is grounded to the shaft. Test both collector rings in this manner.

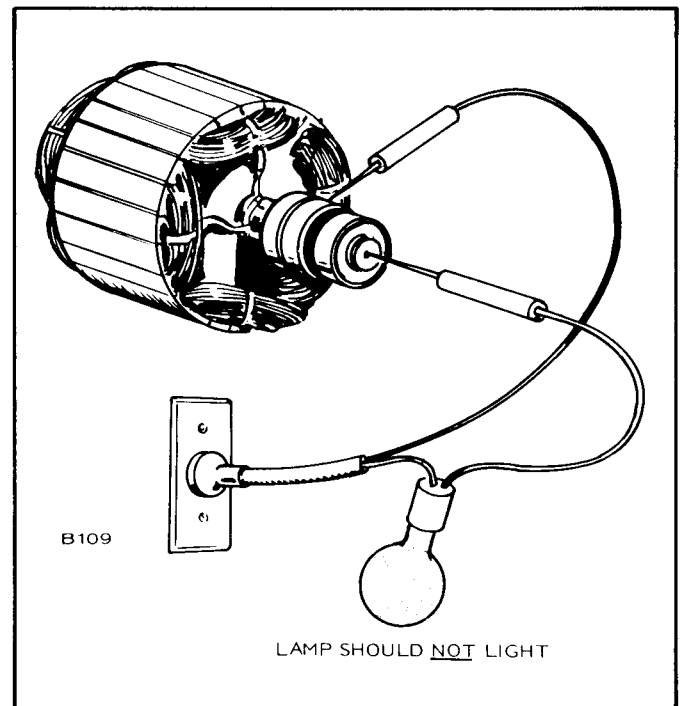


FIGURE 66. ARMATURE GROUND TEST

## ARMATURE OPEN TEST

Use a 120 volt series test lamp set for this test. Place one prod on each collector ring. The test lamp should light. If lamp does not light, armature is open and must be replaced.

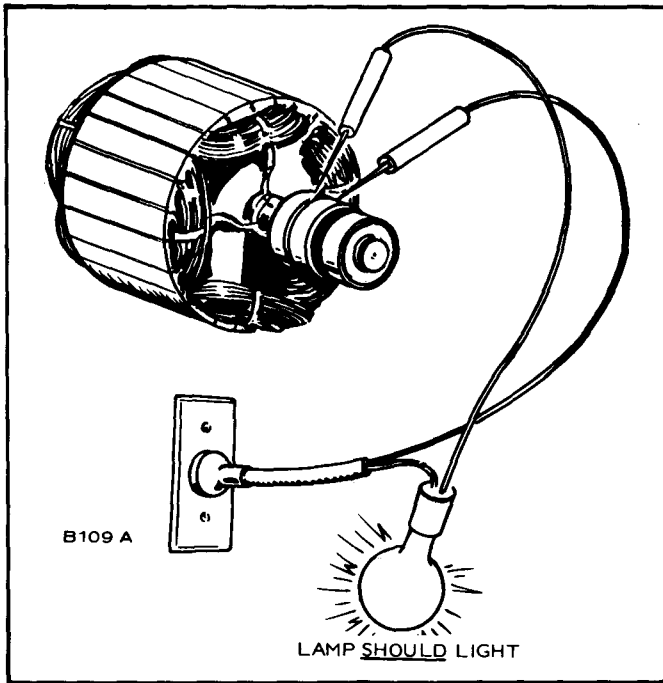


FIGURE 67. ARMATURE OPEN TEST

## TESTING FIELD WINDINGS FOR GROUNDS

To test the field assembly for grounds, disconnect all field leads and use a 120 volt series test lamp set. Touch one prod to F1 (+) and the other prod to the frame. Lamp should not light. If lamp lights, field is grounded and must be replaced. (Test F2 lead in the same manner.)

## TESTING FIELD WINDINGS FOR AN OPEN CIRCUIT

For this test use either an ohmmeter or a 120 volt series test lamp set.

**Using an Ohmmeter:** Disconnect external leads and connect ohmmeter leads to F1 (+) and F2 (-). Resistance in the windings should read 28.8 ohms ( $\pm 3\%$ ) at 70 F.

**Using a Test Lamp Set:** Disconnect external leads and touch test prods to F1 and F2. The lamp should light. If not, field winding is open and must be replaced.

Check terminal ends closely for loose connections. These can be fixed easily without replacing the whole assembly.

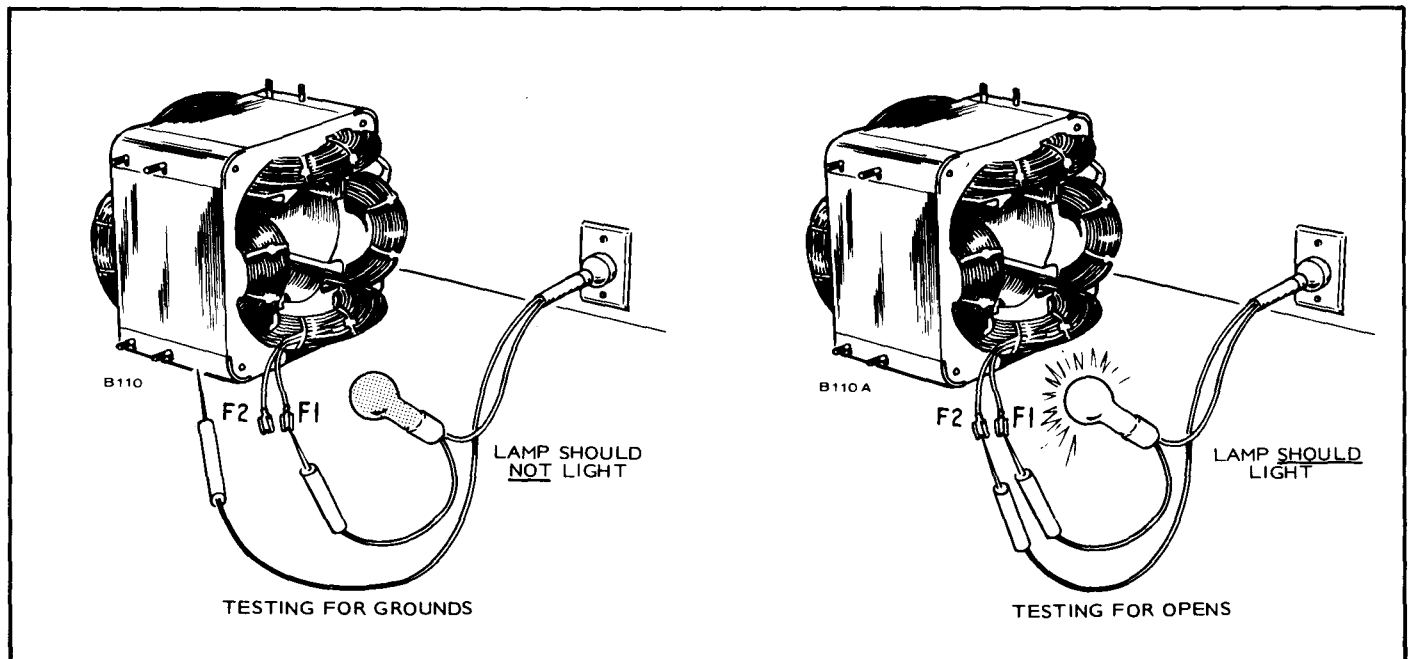


FIGURE 68. TESTING FIELD WINDINGS

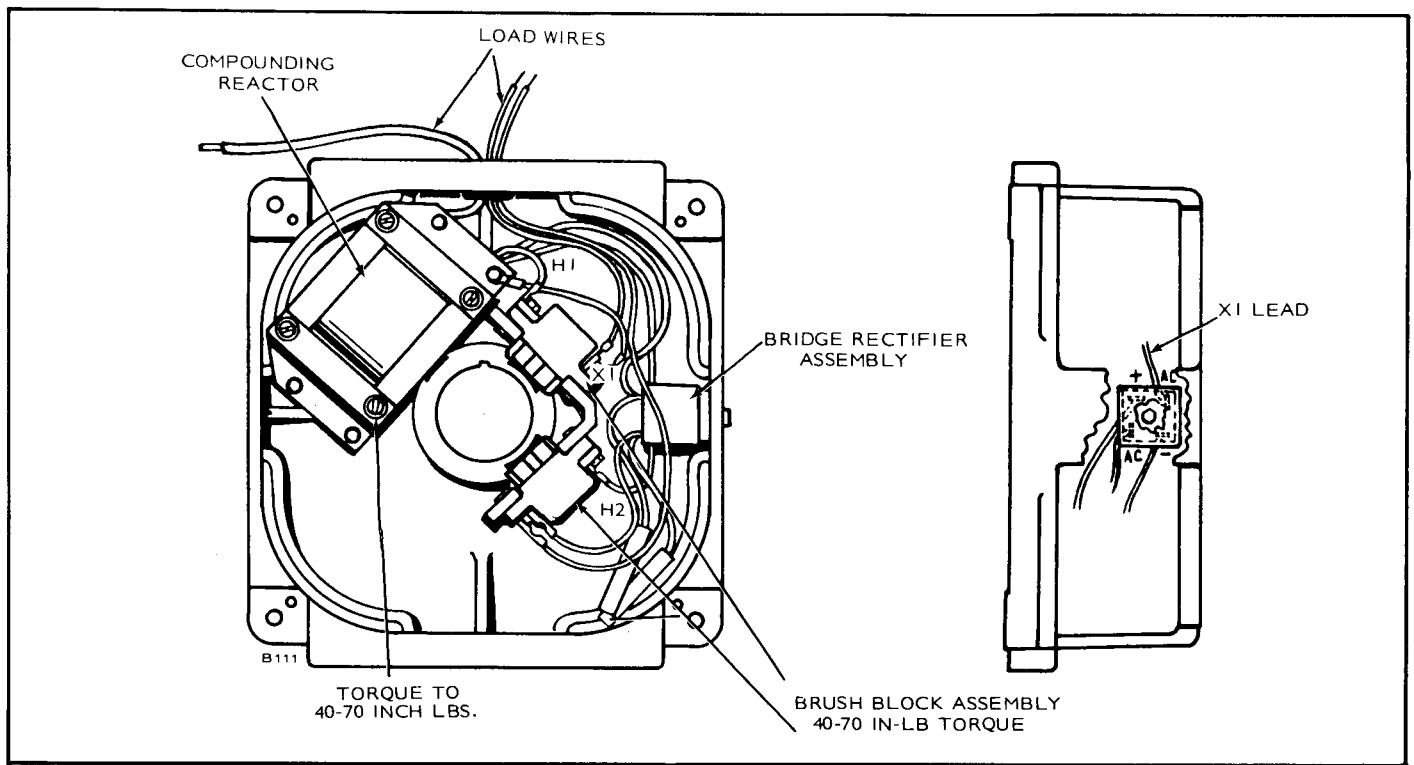


FIGURE 69. END BELL ASSEMBLY

### TESTING BRIDGE RECTIFIER

To accurately test bridge rectifier proceed as follows:

1. Loosen No. 8-32 screw to remove bridge rectifier assembly (see Figure 69 for location).
2. Disconnect the nylon connector from bridge rectifier assembly, noting the polarity marking of bridge rectifier assembly and connector.
3. Pull out from end bell and remove bridge rectifier from its case.

**CAUTION** Note that connector can only be mounted in the end bell one direction, but the bridge rectifier can be mounted in (4) four directions of which only one will work.

4. Use an ohmmeter to test bridge rectifier. Set the ohmmeter dial to R x 1 scale.
5. Now place meter leads on points shown in Figure 70 and note readings from Table below.

OHMMETER BLACK LEAD *	OHMMETER RED LEAD *	RESISTANCE
A	B	* 8 ohms
A	D	* 8 ohms
B	C	* 8 ohms
D	C	* 8 ohms
B	A	Infinity
D	A	Infinity
C	B	Infinity
C	D	Infinity

\* -  $\pm 10\%$  - Readings taken at 70 F.

6. If any tests do not agree with the above readings, install a new bridge rectifier.

**CAUTION** All terminals are marked on both bridge rectifier and nylon case. Observe proper polarity when reinstalling. If installed wrong, generator voltage will not build up.

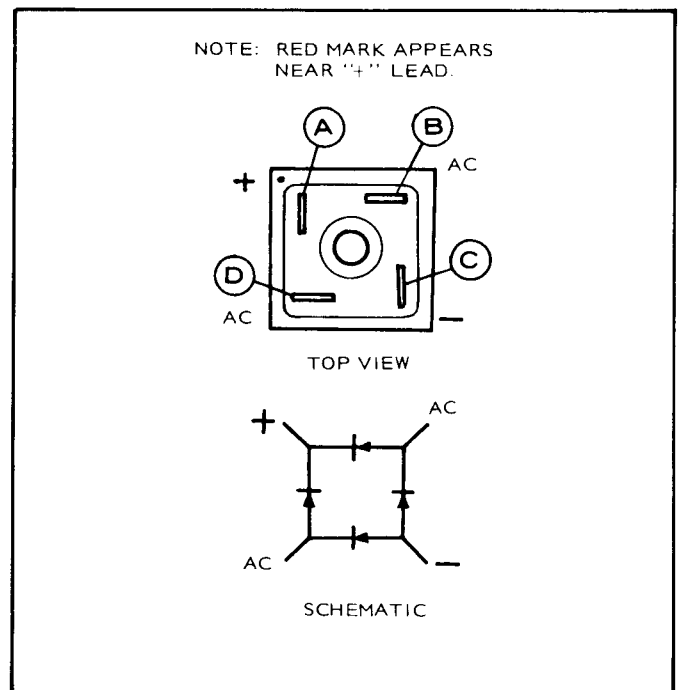


FIGURE 70. TESTING BRIDGE RECTIFIER



## COLLECTOR RINGS

Collector rings acquire a glossy brown finish in normal operation. Do not attempt to maintain a bright, newly machined appearing surface. Ordinary cleaning with a dry, lint-free cloth is usually sufficient. Very fine sandpaper (#240 or finer) may be used to remove slight roughness. Use only light pressure on the sandpaper, while the plant is running. Do not use emery or carborundum paper or cloth. Clean out all carbon dust from the generator.

## GENERATOR BEARING

The generator is prelubricated and double-sealed. Replace bearing approximately every 5 years or at each engine overhaul.

## COMPOUNDING REACTOR

If output voltage is high with no electrical load connected to the generator, with generator running at 1800 rpm, then the compounding reactor is probably defective. Test as shown in Figure 71, using a variac.

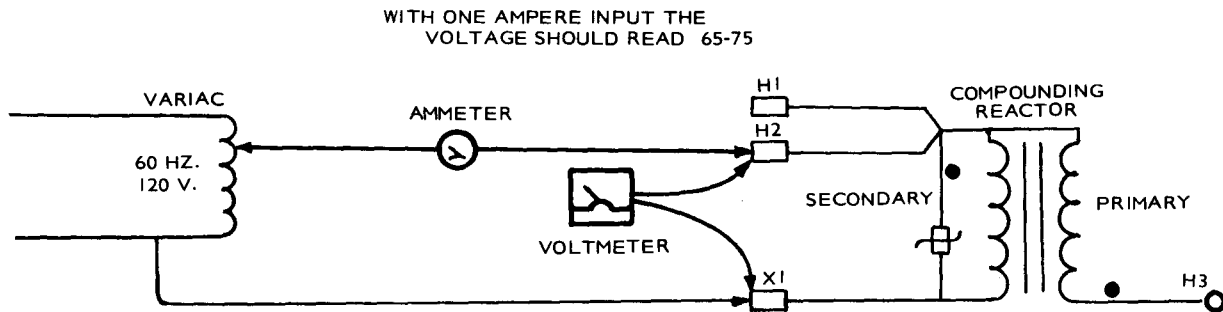


FIGURE 71. TESTING COMPOUNDING REACTOR

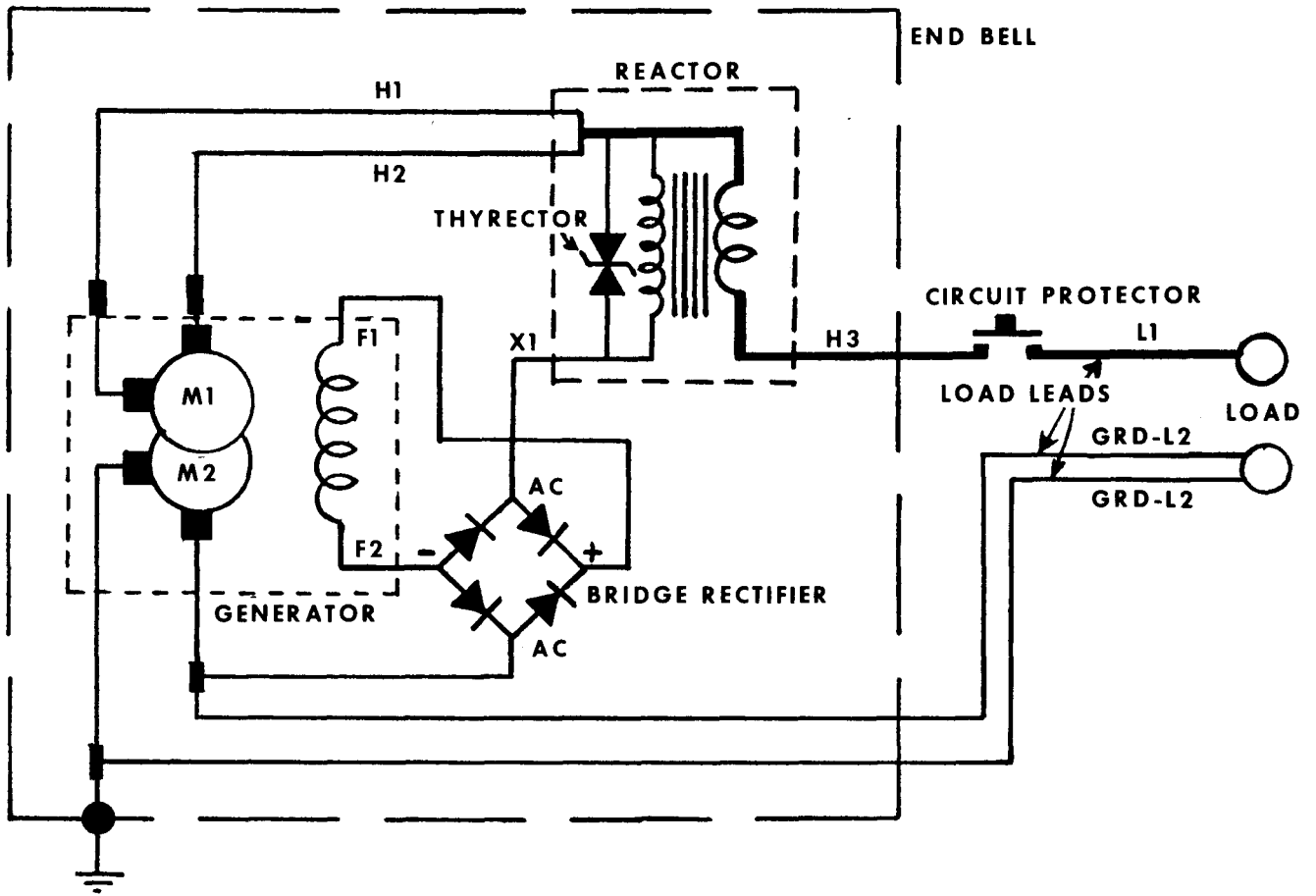


FIGURE 72. AC GENERATOR SCHEMATIC

### GENERATOR VALUES FOR 4KW

MODEL	TYPICAL N.L. VOLTS	TYPICAL F.L. VOLTS	N.L. VOLTS X1 to H1	N.L. VOLTS F1 to F2	RESISTANCE F1 to F2	RESISTANCE H1 to X1	CURRENT FULL LOAD
4KW	125	112	100 VAC	40V DC	28 Ohms	0.83 Ohms	33 Amps

\* N.L. - No Load  
F.L. - Full Load

### GENERATOR TORQUE VALUES

DESCRIPTION	TORQUE VALUE
Generator Through Studs (4)	15-18 Ft.-Lb.
Armature Holddown Nut - 12 Point	45-50 Ft.-Lb.
Compounding Reactor Studs	4- 6 Ft.-Lb.
Brush Block Assembly Studs	4- 6 Ft.-Lb.

## GENERATOR TROUBLESHOOTING GUIDE

TROUBLE	POSSIBLE CAUSE	CORRECTIVE ACTION
NO AC OUTPUT VOLTAGE	1. Blown fuse or circuit breaker.	1. Replace fuse or reset breaker and look for cause.
	2. Disconnected wire or lead on brushes, bridge rectifier or reactor assembly.	2. Reconnect wire or wires.
	3. Brushes not making contact with collector rings.	3. Check brush springs for free movement or brushes which may be excessively worn.
	4. Open, grounded or short circuit in field or armature winding.	4. Test with series test lamp and repair or replace as necessary.
	5. Defective bridge rectifier assembly.	5. Test with ohmmeter and replace if defective.
	6. Bridge rectifier assembly installed wrong in its case.	6. Reinstall making sure marks on case and rectifier match.
LIGHTS FLICKER INTERMITTENTLY	1. Loose or broken lead/ leads in generator.	1. Repair broken lead or reconnect loose lead.
	2. Brushes stuck in holder.	2. Loosen brush and clean or turn rings in lathe.
LOW AC OUTPUT VOLTAGE	1. External short circuit on line.	1. Locate and eliminate short circuit problem.
	2. Generator overloaded.	2. Remove part of load.
	3. Shorted or grounded circuit in field or armature winding.	3. Test with series test lamp or ohmmeter and replace if defective.
	4. Engine not running properly causing generator to slow down.	4. Refer to Engine Troubleshooting guide.

**GENERATOR TROUBLESHOOTING GUIDE**  
(Continued)

TROUBLE	POSSIBLE CAUSE	CORRECTIVE ACTION
NOISY GENERATOR	1. Defective bearing in end ball.	1. Replace bearing.
GENERATOR OVERHEATS	1. Generator overloaded.	1. Remove part of load.
	2. Windings and parts covered with oil or dirt.	2. Clean generator.
	3. Air intake restricted or incoming air too hot.	3. Take necessary steps to allow for proper cooling.
	4. Shorted or grounded circuit in armature or field windings.	4. Test with ohmmeter or series test lamp and replace if defective.
	5. Air seals are damaged or missing.	5. Replace air seals or tape over the air leak.
AC OUTPUT VOLTAGE HIGH WITH NO LOAD CONNECTED AND GENERATOR RUNNING AT 1800 RPM	1. Compounding reactor defective.	1. Remove, test and replace.

# CONTROLS

## THEORY OF OPERATION

### Starting

To start, push start switch S3. Battery current flows through K1 solenoid, K2 contacts and start switch S3 to battery negative (GND). K1 solenoid closes contacts, feeding current to starter motor and to choke E1 plus K3 relay. K3 relay contacts close the circuit to the ignition coil T1 and fuel pump E2 plus fuel solenoid K4. The engine cranks and the fuel pump, fuel solenoid and ignition operate to start the engine.

### Engine Starts

When the engine starts and rpm increases, the flywheel alternator develops a voltage which is rectified and energizes relay K2. Relay K2 contacts close to hold relay K3 energized, and K2 normally closed contacts open to drop K1 start solenoid. K3 contacts maintain current to ignition coil, fuel pump and fuel solenoid. The engine runs and K2 remains energized.

### Stop Engine

Relay K3, energized by K2, maintains ignition. To stop engine, push the stop switch which shorts out K3. Relay K3 drops out to remove power from the fuel pump, fuel solenoid and ignition coil. Resistor R2 absorbs the power that was supplied to K3 during the period the stop switch is held closed as the engine slows to a stop.

### Low Oil Pressure Shutdown

The control has a time delay of 2 to 4 seconds for a low oil pressure shutdown. If a low oil pressure condition occurs, the low oil pressure switch S2 closes to charge capacitor C3 through resistor R3. When the voltage on capacitor C3 matches the voltage of the divider R5-R6, the programmable unijunction transistor Q1 "fires" to trigger CR8. CR8 turns on to de-energize K3 relay. K2 contacts open as the engine stops and CR8 turns off.

## EMERGENCY START-STOP OPERATION

In an emergency, the control board can be bypassed to start or stop the unit. Connect a jumper between terminals 9 and 11 to energize the ignition, fuel solenoid and fuel pump. Then temporarily jumper terminals 1 and 7 to energize starter. Remove this jumper as soon as the engine starts and runs. DO NOT jumper while engine is running. To stop, remove the jumper from terminals 9 and 11.

**CAUTION** This emergency operation DOES NOT provide fuse protection, start disconnect or low oil pressure shutdown and should not be used without monitoring the electric power plant.

## FUSE PROTECTION

A 5 amp fuse, installed on control board, protects the board from shorts in the remote wiring. If fuse is blown it can be replaced (after correcting trouble) by removing cover on control and replacing with an identical 5 ampere fuse.

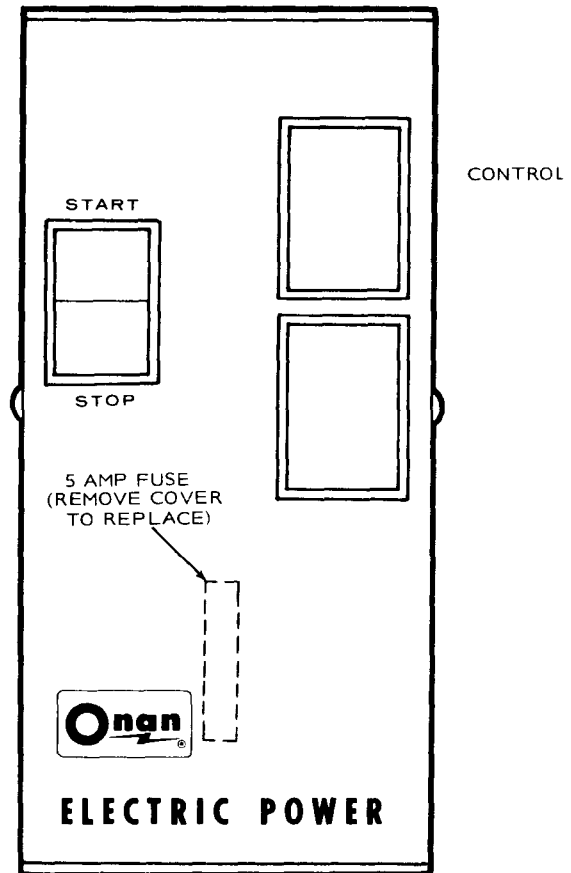
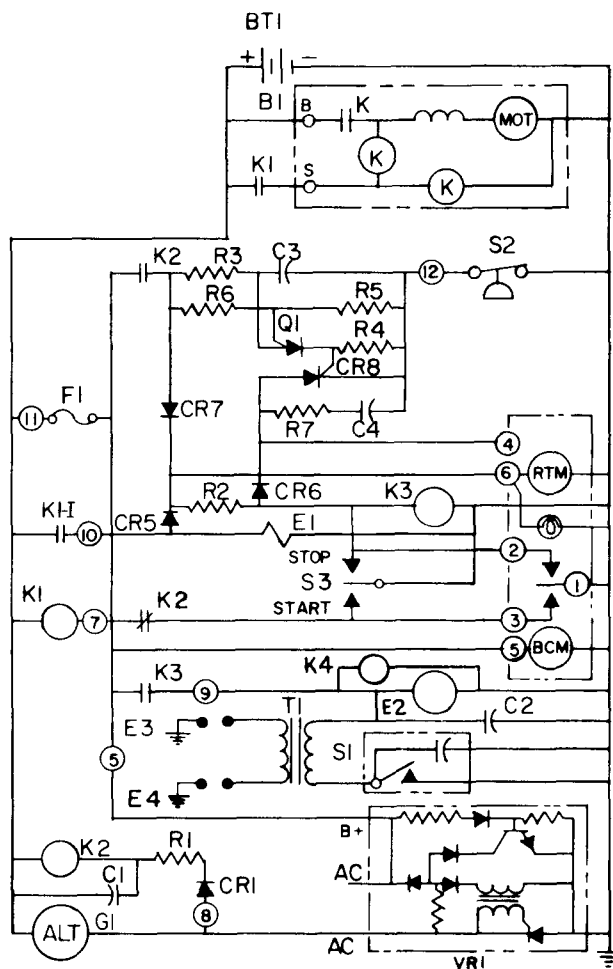


FIGURE 73. FUSE LOCATION

## SCHEMATIC



- |              |                             |           |                                |
|--------------|-----------------------------|-----------|--------------------------------|
| BT1 .....    | Battery                     | S1 .....  | Breaker Box                    |
| B1 .....     | Starter                     | S2 .....  | Low Oil Pressure Switch        |
| E1 .....     | Electric Choke              | S3 .....  | Start-Stop Switch              |
| E2 .....     | Fuel Pump                   | T1 .....  | Ignition Coil                  |
| E3, E4 ..... | Spark Plugs                 | VR1 ..... | Voltage Regulator              |
| F1 .....     | 5 amp. Fuse                 | RTM ..... | Running Time Meter (Opt.)      |
| G1 .....     | Battery Charging Alternator | BCM ..... | Battery Condition Meter (Opt.) |
| K1 .....     | Start Solenoid              | K4 .....  | Fuel Solenoid                  |

FIGURE 74. CONTROL SYSTEM SCHEMATIC

# CONTROL SYSTEM TROUBLESHOOTING GUIDE

This troubleshooting section is divided into four parts, A, B, C and D as follows:

- A. Engine does not crank.
- B. Engine cranks but does not start.
- C. Engine runs for 3 or 4 seconds, then stops.
- D. Low battery - low charge rate.

**Always stop the power plant and disconnect the battery leads before removing the cover or printed circuit board. After removing control cover, use a long nose pliers to remove flag connectors from terminals on board. Pull flag connectors straight out to avoid breaking control board terminals. Although dust covers on two relays (K2 and K3) are removable, DO NOT attempt to adjust the contacts on these relays; they are precision set at the factory. The only maintenance required on these relays is blowing out sand and dirt with a low pressure, compressed air source.**

To correct a problem, answer the question of the step either YES or NO. Then refer to the number in whichever column question was answered, and proceed to that step next.

A.	ENGINE DOES NOT CRANK	YES	NO
1A.	Check battery. Are battery terminals clean and are cables tight?	2A	---
2A.	Check battery cables for correct polarity. Is 12 volts present across battery terminals with engine stopped and is 8 volts or higher present with engine cranking?	3A	10A
3A.	Remove cover on printed circuit board. Jumper terminal 7 to 3. Press start switch. Does engine crank?	4A	5A
4A.	K2 contact is defective. Replace printed circuit board.	---	---
5A.	Jumper terminal 7 to 1. Does engine crank?	6A	7A
6A.	Start switch S3 is defective. Replace printed circuit board.	---	---
7A.	Jumper from S terminal of B1 starter motor to positive (+). Does engine crank?	8A	9A
8A.	Replace K1 start solenoid.	---	---
9A.	Starter is defective. Remove and perform tests listed in STARTING SYSTEM section and/or replace starter.	---	---
10A.	Replace battery.	---	---

B.	ENGINE CRANKS BUT DOES NOT START	YES	NO
1B.	Is F1 fuse on control board OK?	3B	2B
2B.	Replace with an identical 5 amp fuse. Correct problem which caused fuse to burn.	---	---
3B.	While engine cranks, check K1-I start solenoid voltage. Is 12 volts present between terminals 10 and 1?	5B	4B
4B.	Replace K1 start solenoid.	---	---
5B.	Jumper terminals 9 to 11. Does engine start when start switch is pushed?	6B	7B
6B.	K2 contacts are defective. Replace printed circuit board.	---	---
7B.	Fuel solenoid K4 must be open during starting and running. Remove fuel line from carburetor. Does fuel pulsate from line when start switch is pushed?  <b>WARNING:</b> Use extreme care for tests 7B and 8B. Direct the fuel flow into a suitable container and make sure area is well ventilated to prevent accumulation of gasoline fumes.	11B	8B
8B.	Disconnect fuel solenoid from line and check fuel pump E2. Pump will click when operating properly. Does fuel pulsate from pump (solenoid disconnected) when start switch is pushed?	10B	9B
9B.	Fuel pump (or wiring) is defective and must be replaced.	---	---
10B.	Fuel solenoid is defective and must be replaced.	---	---
11B.	Is electric choke closed when engine is cranking?	13B	12B
12B.	Voltage at choke terminal when engine is cranking should be 12 volts. If choke does not move (at room temperature) with 12 volts applied, replace it. Also check wire from choke to control for shorts to ground.	---	---
13B.	The fault is in the ignition system. Check points, plugs, wires and coil. Refer to IGNITION section.	---	---



<b>C.</b>	<b>ENGINE RUNS 3 OR 4 SECONDS - THEN STOPS</b>	<b>YES</b>	<b>NO</b>
1C.	Check oil level. Refill to FULL mark on dipstick. Does engine now continue to run?	---	2C
2C.	Check voltage from terminal 11 to 12. Is it 12 volts with engine stopped and does voltage drop to zero when engine runs?	---	3C
3C.	Check oil pressure sensor wire for shorts to ground by visually tracing wire from S2 low oil pressure switch to control. Is wire grounded?	4C	5C
4C.	Replace or repair wire making sure it isn't rubbing against anything that may again cause a grounding problem.	---	---
5C.	Replace low oil pressure switch S2.	---	---
<b>D.</b>	<b>LOW BATTERY - LOW CHARGE RATE</b>	<b>YES</b>	<b>NO</b>
1D.	With engine cranking, measure voltage at terminal 8 to BAT terminal of K1 start solenoid. Is 6 volts present?	2D	3D
2D.	Check battery connections. They must be clean and tight.	---	---
3D.	Check flywheel alternator G1 output. Disconnect AC lead that connects to voltage regulator VR1 and connect voltmeter to this lead and BAT terminal of K1 start solenoid. This checks AC open circuit voltage. Start engine. Is AC output voltage approximately 28 volts with unit running at 1800 rpm?	5D	4D
4D.	Replace alternator stator G1.	---	---
5D.	Connect a voltmeter across battery terminals. Start engine. Does DC voltage increase to 13 to 14-1/2 volts after engine is running for a few minutes?	---	6D
6D.	Remove and replace voltage regulator VR1.	---	---

# REMOTE ACCESSORIES

## ONAN REMOTE SWITCH (300-0985)

This switch provides a remote start-stop option in addition to the plant mounted start-stop switch. A small amber lamp, located on center of switch, glows when the electric power plant is running. To install, proceed as follows:

1. Determine location of remote control and cut a hole in motor home panel to accommodate switch (Figure 75).
2. Wires provided for remote connections terminate within plant junction box. Connect four lengths of #18 multistrand wire to wires in junction box labeled 1, 2, 3 and 6. Connect to corresponding terminals on remote switch.

Use an approved connection method within junction box (e.g. wire nuts or connector block).

3. Route remote wires through a separate knockout plug on plant junction box.

Do not route these remote wires through the same conduit as AC load wires. Use a separate conduit (greenfield) for these wires.

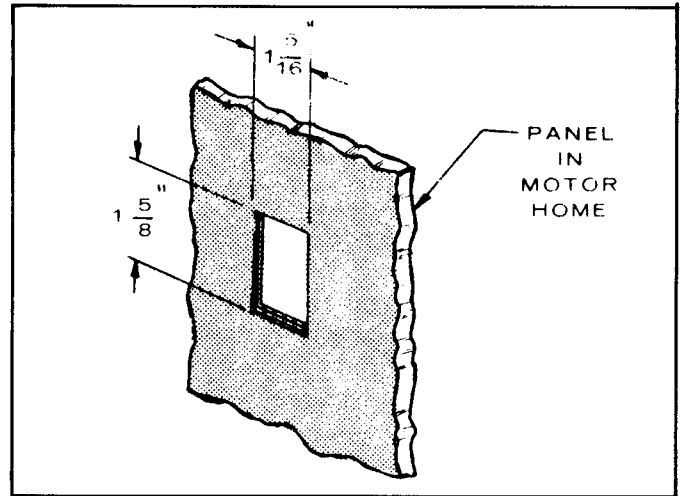


FIGURE 75. PANEL CUTOUT (300-0985)

4. Make connections to remote switch (Figure 76), then secure remote switch to motor home panel with #5 wood screws.

**WARNING** Seal opening made between plant compartment and motor home interior to prevent deadly exhaust gases from entering motor home.

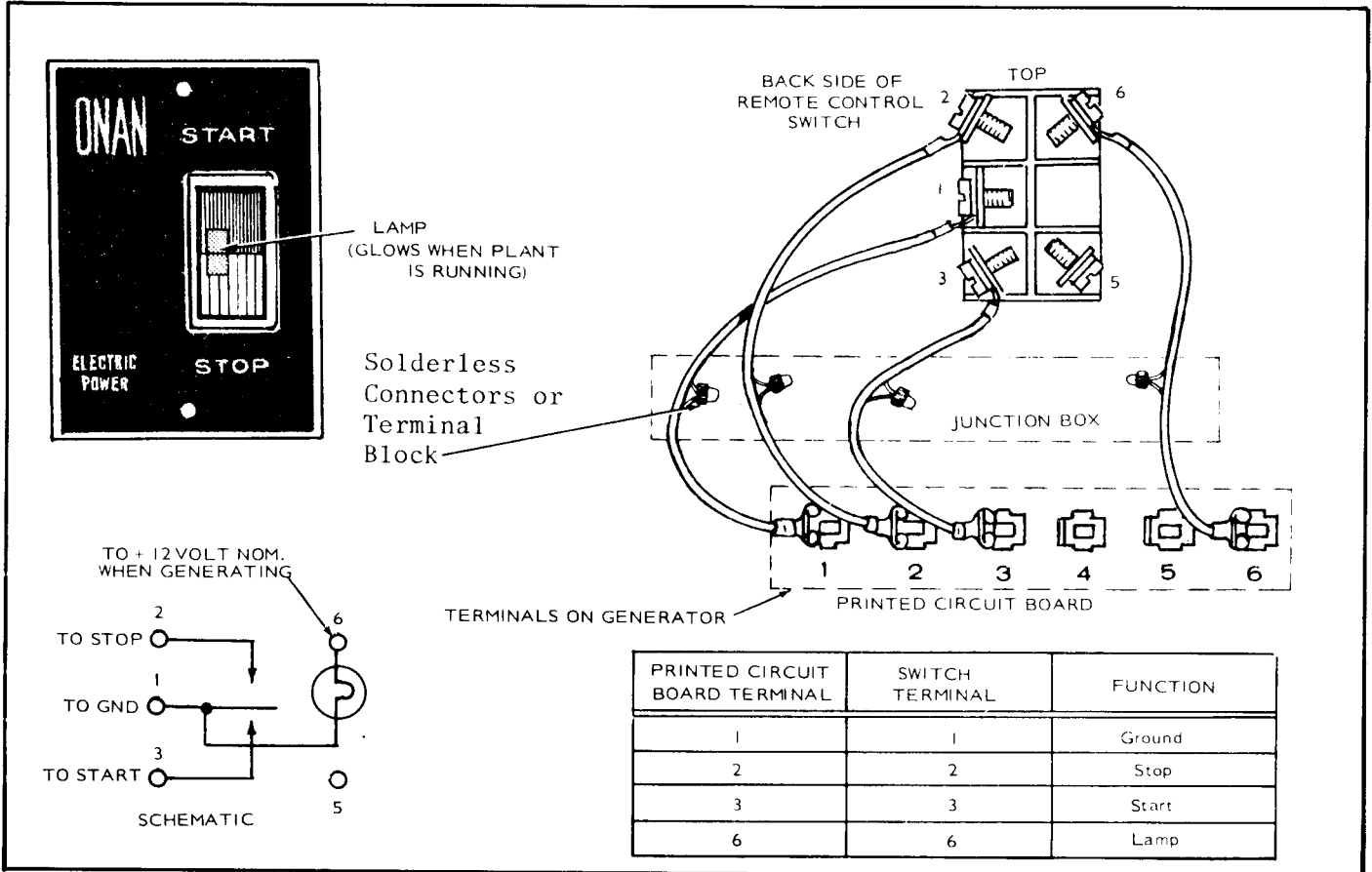


FIGURE 76. REMOTE CONTROL SWITCH (300-0985)

# ONAN DELUXE REMOTE CONTROL (300-0986)

This switch provides a remote start-stop option in addition to the plant mounted start-stop switch. A small amber lamp, located on center of switch, glows when the electric power plant is running. A running time meter (time totalizer) shows the total number of plant operating hours. It is useful for performing accurate maintenance procedures on the plant. A battery condition meter monitors battery charge condition. Connection for control is as follows:

1. Determine location of remote control and cut a hole in motor home panel to accommodate control (Figure 77).
2. Wires provided for remote connections terminate within plant junction box. Connect five lengths of No. 18 wire to wires in junction box. These wires are labeled 1, 2, 3, 5 and 6; they must connect to corresponding terminals on remote control panel.
3. Route remote wires through a separate knockout plug on junction box.

Use an approved connection method (e.g. wire nuts or connector block).

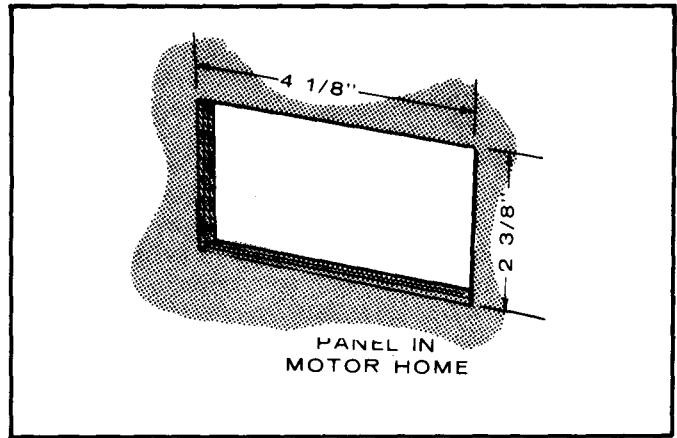


FIGURE 77. PANEL CUTOUT (300-0986)

Do not route these remote wires through the same conduit as the AC load wires. Use a separate conduit (greenfield) for these wires.

4. Make connections to remote control panel (Figure 78), then secure remote control panel with #5 wood screws.

**WARNING** Seal any opening made between plant compartment and motor home interior to prevent deadly exhaust gases from entering the motor home.

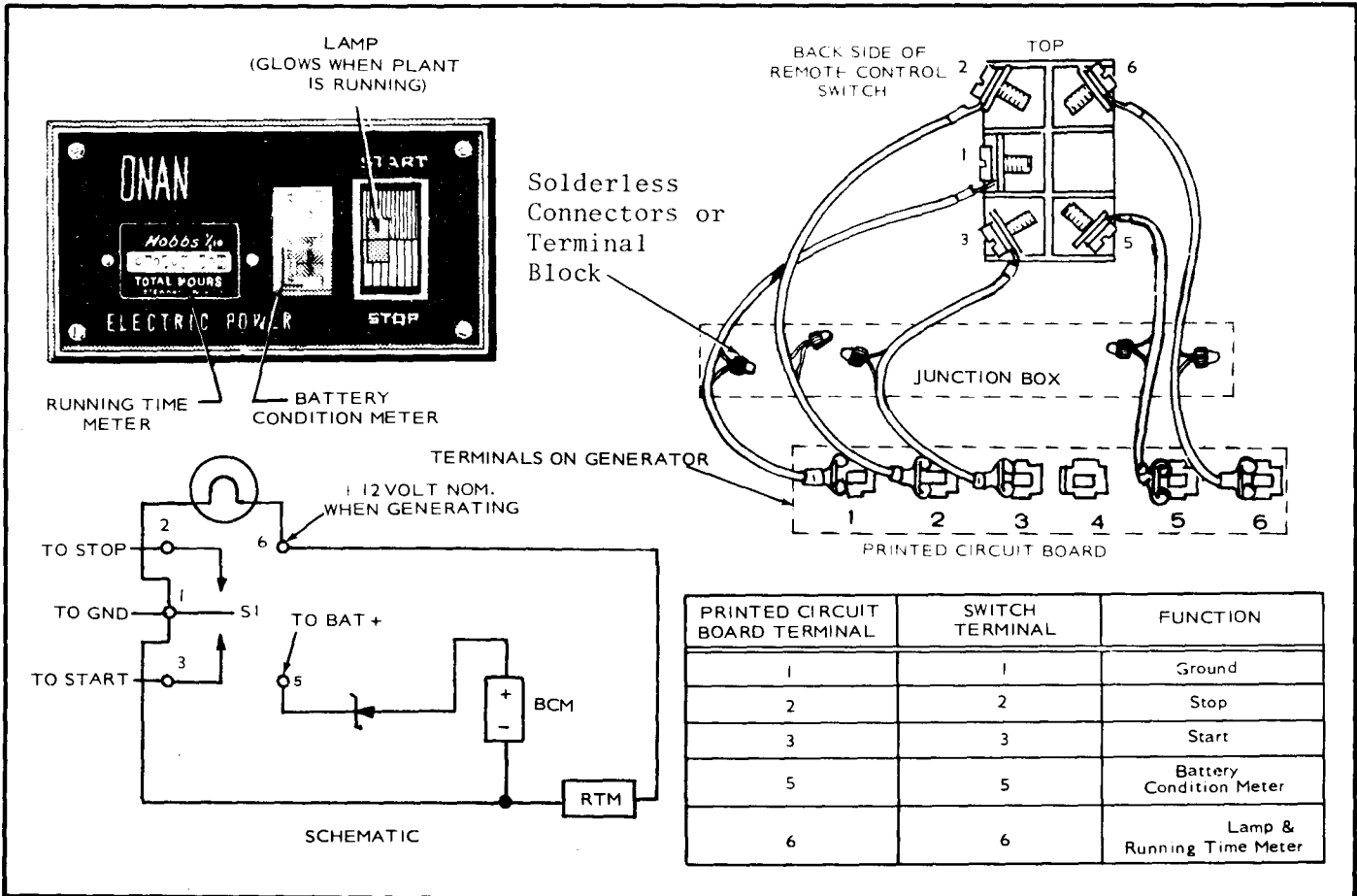


FIGURE 78. DELUXE REMOTE CONTROL (300-0986)

## INSTRUMENT CONNECTIONS

The following instructions will help when installing individual switches and indicators.

**Remote Start-Stop Switch:** A remote start-stop switch can connect to terminals 1 and 3 for start and terminals 1 and 2 for stop. Use a single throw, double throw switch (momentary) rated at 5 amperes, such as Onan switch 308-0341. This switch can be remotely connected with up to 100 feet of number 18 wire.

**Remote Voltmeter:** A 0-15 volt DC voltmeter can connect to terminals 1 (-) and 5 (+) to measure battery voltage.

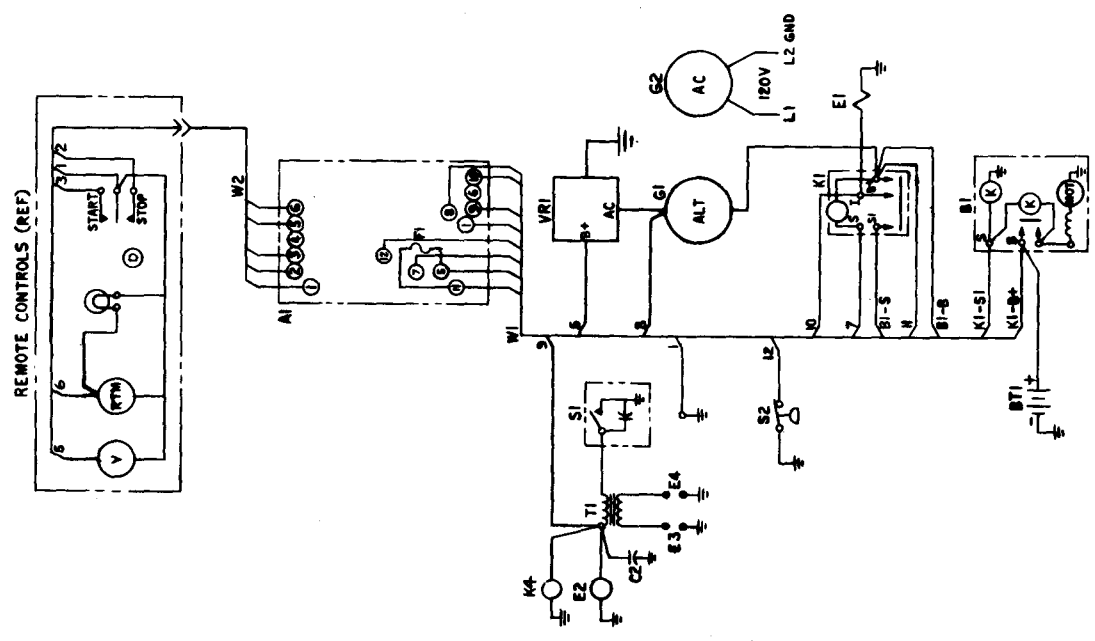
**Running Time Meter:** A running time meter, such as Onan 302-0885, can connect to terminals 1 (-) and 6 (+) to indicate the total running time of the electric power plant. These terminals are rated at 12 volts and a maximum load of 1 ampere.

**Charge Ammeter:** A DC ammeter (0-15 amperes) can connect to unit to read battery charging current. Disconnect alternator lead from K1 start solenoid and connect to positive side of ammeter. Connect negative lead to K1 start solenoid (battery terminal).

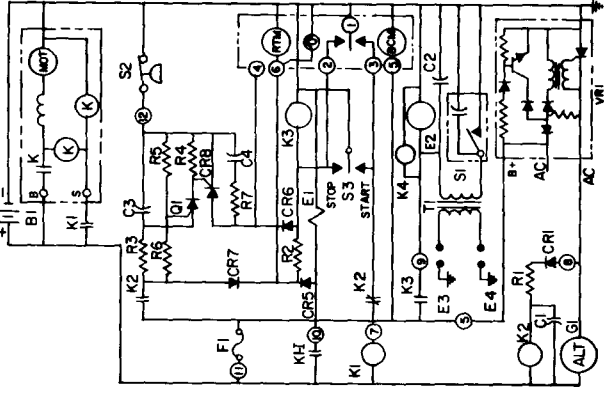
The charge current should be 9 amperes maximum at 1800 rpm (room temperature). The charge current tapers to less than 2 amperes as battery voltage increases to 14-15 volts.

611C1094

WIRING DIAGRAM



SCHEMATIC



NOTE: 1. MIN START DISCONNECTS 675 RPM.

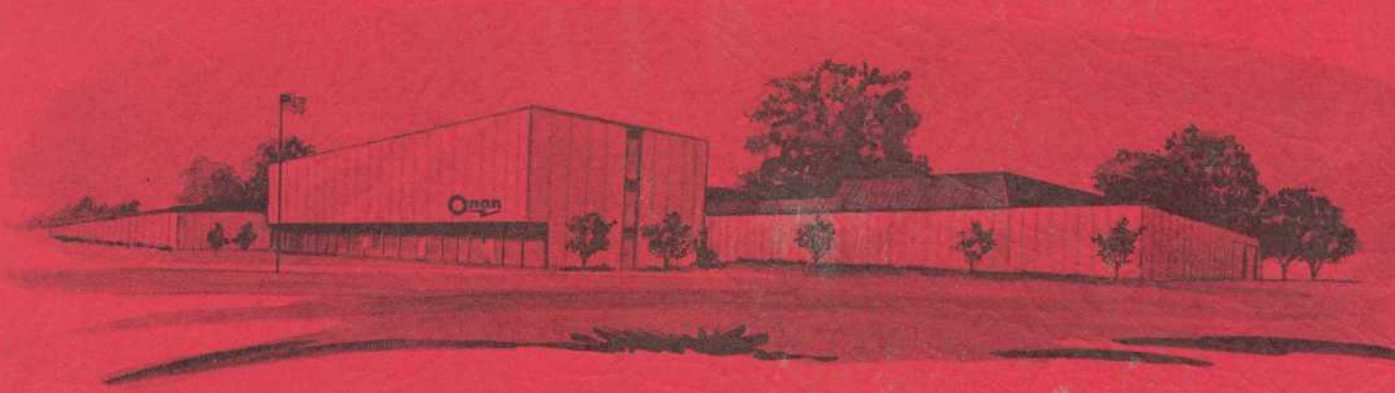
REF. DES.	PART NO.	QTY.	DESCRIPTION
A1	3000MS	1	CONTROL ASSE-GEN SET
B1		1	CONTROL-HOT HOME
BT1		1	STARTER-SOLENOID SHIFT
C2		1	BATTERY-12 VOLT CAPACITOR
E1		1	CHOKE
E2		1	FUEL PUMP
E3,4		2	SPARK PLUG
G1		1	ALTERNATOR
G2		1	GENERATOR
K1		1	SOLENOID-START
K2		1	BREAKER & CAP ASSEY
K3		1	SWITCH-LOW OIL PRESS
K4		1	SOLENOID - FUEL
T1		1	COIL-IGNITION
VR1		1	VOLTAGE REGULATOR
W1		1	WIRING HARNESS-GEN SET
W2		1	WIRING HARNESS-REMOTE

REV.	DATE	BY	CHKD.	DESCRIPTION
1	7-7-72	CDR		CONTROL - GEN SET (WIRING DIAGRAM)
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611C1094

4-0BF-IR/500R  
-01  
120 V, 1 PM, 3 W, 60 Hz

PLANT WIRING DIAGRAM



**ONAN** 1400 73RD AVENUE N.E. • MINNEAPOLIS, MINNESOTA 55432  
A DIVISION OF ONAN CORPORATION

