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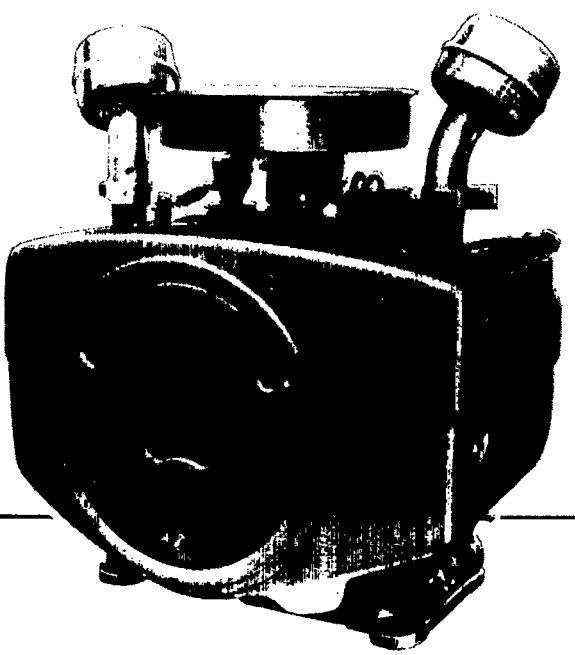
Onan

Service Manual

NHA
NHAV
NHB
NHBV
Engine



940-0753
Spec A-D
7-88
Printed in U.S.A.

Safety Precautions

It is recommended that you read your engine manual and become thoroughly acquainted with your equipment before you start the engine.

WARNING ***This symbol is used throughout this manual to warn of possible serious personal injury.***

CAUTION ***This symbol refers to possible equipment damage.***

Fuels, electrical equipment, batteries, exhaust gases and moving parts present potential hazards that could result in serious, personal injury. Take care in following these recommended procedures.

Safety Codes

- All local, state and federal codes should be consulted and complied with.
- This engine is not designed or intended for use in aircraft. Any such use is at the owner's sole risk.

General

- Provide appropriate fire extinguishers and install them in convenient locations. Use an extinguisher rated ABC by NFPA.
- Make sure that all fasteners on the engine are secure and accurately torqued. Keep guards in position over fans, driving belts, etc.
- If it is necessary to make adjustments while the engine is running, use extreme caution when close to hot exhausts, moving parts, etc.

Protect Against Moving Parts

- Do not wear loose clothing in the vicinity of moving parts, such as PTO shafts, flywheels, blowers, couplings, fans, belts, etc.
- Keep your hands away from moving parts.

Batteries

- Before starting work on the engine, disconnect batteries to prevent inadvertent starting of the engine.
- DO NOT SMOKE while servicing batteries. Lead acid batteries give off a highly explosive hydrogen gas which can be ignited by flame, electrical arcing or by smoking.
- Verify battery polarity before connecting battery cables. Connect negative cable last.

Fuel System

- DO NOT fill fuel tanks while engine is running.
- DO NOT smoke or use an open flame in the vicinity of the engine or fuel tank. Internal combustion engine fuels are highly flammable.
- Fuel lines must be of steel piping, adequately secured, and free from leaks. Piping at the engine should be approved flexible line. Do not use copper piping for flexible lines as copper will work harden and become brittle enough to break.
- Be sure all fuel supplies have a positive shutoff valve.

Exhaust System

- Exhaust products of any internal combustion engine are toxic and can cause injury, or death if inhaled. All engine applications, especially those within a confined area, should be equipped with an exhaust system to discharge gases to the outside atmosphere.
- Do not use exhaust gases to heat a compartment.
- Make sure that your exhaust system is free of leaks. Ensure that exhaust manifolds are secure and are not warped by bolts unevenly torqued.

Exhaust Gas is Deadly!

Exhaust gases contain carbon monoxide, a poisonous gas that might cause unconsciousness and death. It is an odorless and colorless gas formed during combustion of hydrocarbon fuels. Symptoms of carbon monoxide poisoning are:

- Dizziness
- Headache
- Weakness and Sleepiness
- Vomiting
- Muscular Twitching
- Throbbing in Temples

If you experience any of these symptoms, get out into fresh air immediately, shut down the unit and do not use until it has been inspected.

The best protection against carbon monoxide inhalation is proper installation and regular, frequent inspections of the complete exhaust system. If you notice a change in the sound or appearance of exhaust system, shut the unit down immediately and have it inspected and repaired at once by a competent mechanic.

Cooling System

- Coolants under pressure have a higher boiling point than water. DO NOT open a radiator pressure cap when coolant temperature is above 212° F (100° C) or while engine is running.

Keep the Unit and Surrounding Area Clean

- Make sure that oily rags are not left on or near the engine.
- Remove all unnecessary grease and oil from the unit. Accumulated grease and oil can cause overheating and subsequent engine damage and present a potential fire hazard.

TABLE OF CONTENTS

GENERAL INFORMATION

INTRODUCTION

This manual deals with specific mechanical and electrical information needed by engine mechanics for troubleshooting, servicing, repairing, or overhauling the engine.

Use the table of contents for a quick reference to the *separate engine system sections.*

Use the separate Parts Catalogs for parts identification and for establishing their proper location on assemblies.

The troubleshooting guide is provided as a quick reference for locating and correcting engine trouble.

The illustrations and procedures presented in each section apply to the engines listed on the cover. The flywheel-blower end of the engine is the front end so right and left sides are determined by viewing the engine from the front.

The disassembly section contains major overhaul procedures for step by step removal, disassembly, inspection, repair and assembly of the engine components.

If a major repair or an overhaul is necessary, a competent mechanic should either do the job or supervise and check the work of the mechanic assigned to do the job to ensure that all dimensions, clearances and torque values are within the specified tolerances.

The wiring diagram on the last page of the manual shows how the electrical components are interconnected.

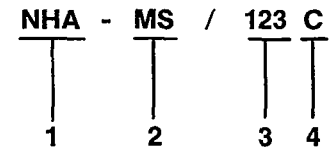
A parts catalog (available at the dealer level) contains detailed exploded views of each assembly and the individual piece part numbers and their proper names for ordering replacement parts.

Use only Genuine Onan replacement parts to ensure quality and the best possible repair and overhaul results. When ordering parts, always use the complete Model and Spec number as well as the Serial number shown on the nameplate.

ENGINE MODEL REFERENCE

Identify your model by referring to the MODEL and SPEC (specification) NO. as shown on the unit nameplate. Always use this number and the engine serial number when making reference to your engine.

How to interpret *MODEL* and *SPEC NO.*



1. Factory code for general identification purposes.
2. Specific Type:
   S—MANUAL starting
   MS—ELECTRIC starting
3. Factory code for designated optional equipment, if any.
4. Specification (spec letter) which advances with factory production modifications.

WARNING

INCORRECT SERVICE OR REPLACMENT OF PARTS MIGHT RESULT IN SEVERE PERSONAL INJURY AND/OR EQUIPMENT DAMAGE. SERVICE PERSONNEL MUST BE QUALIFIED TO PERFORM ELECTRICAL AND/OR MECHANICAL SERVICE.

SPECIFICATIONS

This manual contains S1 metric equivalents that follow immediately in parentheses after the U.S. customary units of measure.

SPECIFICATION	UNIT MEASURE	SERIES NHA	NHAV	NHB	NHBV
Number of Cylinders		2	2	2	2
Bore	in (mm)	3.56 (90.48)	3.56 (90.48)	3.56 (90.48)	3.56 (90.48)
Stroke	in (mm)	3.0 (76)	3.0 (76)	3.0 (76)	3.0 (76)
Displacement	cu in (cm^3)	60 (983)	60 (983)	60 (983)	60 (983)
Compression Ratio		6.5 to 1	6.5 to 1	7.0 to 1	7.0 to 1
Rated Speed (Maximum)	RPM	3000	3000	3300	3200
Power at Rated Speed	BHP (kW)	18 (13.4)	17.5 (13.1)	20 (14.9)	19.5 (14.5)
Oil Filter		Full Flow	Full Flow	Full Flow	Full Flow
Oil Capacity Without Filter	Qt (litre)	3.5 (3.3)	3.5 (3.3)	3.5 (3.3)	3.5 (3.3)
Oil Capacity With Filter Change	Qt (litre)	4.0 (3.8)	4.0 (3.8)	4.0 (3.8)	4.0 (3.8)
Crankshaft Rotation (viewed from flywheel)		Clockwise	Clockwise	Clockwise	Clockwise
Governor		Variable Speed Mechanical		Variable Speed Mechanical	
Valve Clearance (Cold)					
Intake	in (mm)	0.005 (0.127)	0.005 (0.127)	0.005 (0.127)	0.005 (0.127)
Exhaust (Gasoline Fuel)	in (mm)	0.013 (0.330)	0.013 (0.330)	0.013 (0.330)	0.013 (0.330)
Exhaust (Lpg and Natural Gas)	in (mm)	0.013 (0.330)	0.013 (0.330)	0.013 (0.330)	0.013 (0.330)
Spark Plug Gap					
Gasoline Fuel	in (mm)	0.025 (0.64)	0.025 (0.64)	0.025 (0.64)	0.025 (0.64)
Lpg and Natural Gas	in (mm)	0.020 (0.51)	0.020 (0.51)	0.020 (0.51)	0.020 (0.51)
Breaker Point Gap - Static (Full Separation and Engine Cold)	in (mm)	0.016 (0.41)	0.016 (0.41)	0.016 (0.41)	0.016 (0.41)
Ignition Timing	BTC	20°	20°	20°	20°

DIMENSIONS AND CLEARANCES

All clearances given at room temperature of 70° F (21° C). All dimensions in inches (approximate millimetre dimensions in parentheses) unless otherwise specified.

DESCRIPTION	MINIMUM		MAXIMUM	
	Inches	(mm)	Inches	(mm)
CYLINDER BLOCK				
Cylinder Bore Honed Diameter	3.5625	(90.49)	3.5635	(90.51)
Maximum Allowable				
Taper			0.003	(0.08)
Out-of-Round			0.003	(0.08)
Main Bearing Inside Diameter (Without bearing)	2.187	(55.55)	2.188	(55.58)
Main Bearing Inside Diameter (Installed)	2.0015	(50.84)	2.0040	(50.90)
Camshaft Bearing Bore (Bearing installed)	1.3760	(34.95)	1.3770	(34.98)
CRANKSHAFT				
Main Bearing Journal Diameter	1.9992	(50.78)	2.0000	(50.80)
Main Bearing Clearance	0.0015	(0.04)	0.0043	(0.11)
Connecting Rod Journal Diameter	1.6252	(41.28)	1.6260	(41.30)
Crankshaft End Play	0.005	(0.13)	0.009	(0.23)
CONNECTING ROD				
Large Bore Diameter (Without bearing installed and rod bolts properly torqued	1.7505	(44.46)	1.7510	(44.48)
Connecting Rod Side Clearance	0.0020	(0.051)	0.0160	(0.406)
Piston Pin Bushing Bore (Without bearing)	0.8115	(20.61)	0.8125	(20.64)
Piston Pin Bushing Bore with Bearing, (Finished bore)	0.7504	(19.06)	0.7508	(19.07)
Bearing to Crankshaft Clearance				
Nodular Iron Rod	0.0005	(0.013)	0.0028	(0.071)
Aluminum Rod	0.0020	(0.051)	0.0033	(0.084)
CAMSHAFT				
Bearing Journal Diameter	1.3740	(34.90)	1.3745	(34.91)
Bearing Clearance	0.0015	(0.038)	0.0030	(0.076)
End Play	0.0030	(0.076)	0.0120	(0.305)
Camshaft Lift		0.300	(7.62)	
PISTON				
Clearance in Cylinder				
Measure 90° to pin 0.10 inch below oil ring				
Strut Type Spec A-C	0.0015	(0.038)	0.0035	(0.089)
Without Strut Begin Spec D	0.0070	(0.178)	0.0090	(0.229)
Piston Pin Bore	0.7502	(19.055)	0.7506	(19.065)
Ring Groove Width				
Top 1 Compression Ring Spec A-C	0.0955	(2.426)	0.0965	(2.451)
Top 1 Compression Ring Begin Spec D	0.080	(2.032)	0.081	(2.057)
No. 2 Compression Ring Spec A-C	0.0955	(2.426)	0.0965	(2.451)
No. 2 Compression Ring Begin Spec D	0.080	(2.032)	0.081	(2.057)
No. 3 Oil Control Ring	0.188	(4.775)	0.189	(4.801)

DESCRIPTION	MINIMUM Inches	MINIMUM (mm)	MAXIMUM Inches	MAXIMUM (mm)
PISTON PIN				
Clearance in Piston	0.0001	(0.003)	0.0005	(0.013)
Clearance in Connecting Rod				
Nodular Iron Rod	0.00005	(0.001)	0.00055	(0.014)
Aluminum Rod	0.0002	(0.005)	0.0008	(0.020)
Diameter	0.7500	(19.05)	0.7502	(19.06)
PISTON RINGS				
Clearance				
Top Groove	0.002	(0.051)	0.008	(0.203)
Ring End Gap in Cylinder	0.010	(0.254)	0.020	(0.508)
INTAKE VALVE				
Stem Diameter	0.3425	(8.70)	0.3430	(8.71)
Clearance (Stem to Guide)	0.0010	(0.025)	0.0025	(0.064)
Valve Face Angle		44°		
INTAKE VALVE SEAT				
Seat Cylinder Head Bore Diameter	1.5645	(39.74)	1.5655	(39.76)
Seat Outside Diameter	1.5690	(39.85)	1.5700	(39.88)
Valve Seat Width	0.031	(0.787)	0.047	(1.194)
Valve Seat Angle		45°		
EXHAUST VALVE				
Stem Diameter	0.3410	(8.661)	0.3415	(8.674)
Clearance (Stem to Guide)	0.0025	(0.064)	0.064	(0.163)
Valve Face Angle		44°		
EXHAUST VALVE SEAT				
Seat Cylinder Head Bore Diameter	1.2510	(31.78)	1.2520	(31.80)
Seat Outside Diameter	1.2550	(31.88)	1.2560	(31.90)
Valve Seat Width	0.031	(0.787)	0.047	(1.194)
Valve Seat Angle		45°		
VALVE GUIDE				
Inside Diameter	0.344	(8.74)	0.346	(8.79)
TAPPET				
Body Diameter	0.7475	(18.99)	0.7480	(19.00)
Bore Diameter	0.7505	(19.06)	0.7515	(19.09)
Clearance in Bore	0.0015	(0.038)	0.003	(0.076)
VALVE SPRINGS INTAKE AND EXHAUST				
Valve Spring Free Length (Approx.)		1.662 (42.21)		
Valve Spring Length				
Valve Open		1.125 (28.58)		
Valve Closed		1.375 (34.93)		
Spring Load @ 1.375 inch (Valve Closed)	38 lb.	(17 kg)	42 lb.	(19 kg)
Spring Load @ 1.125 inch (Valve Open)	71 lb	(32 kg)	79 lb	(36 kg)
GEAR BACKLASH				
Timing Gear	0.002	(0.051)	0.003	(0.076)
Oil Pump Gear	0.002	(0.051)	0.005	(0.127)

ASSEMBLY TORQUES

The torque values given in Table 1 have been determined for the specific applications. Standard torque values must not be used where those listed in Table 1 apply. The engine assembly torques given here will assure proper tightness without danger of stripping threads. All threads must be clean and lubricated with new engine oil before torquing.

Check all studs, nuts, and capscrews, and tighten as required to keep them from working loose. Refer to the *PARTS MANUAL* for the location of washers and capscrews.

TABLE 1.

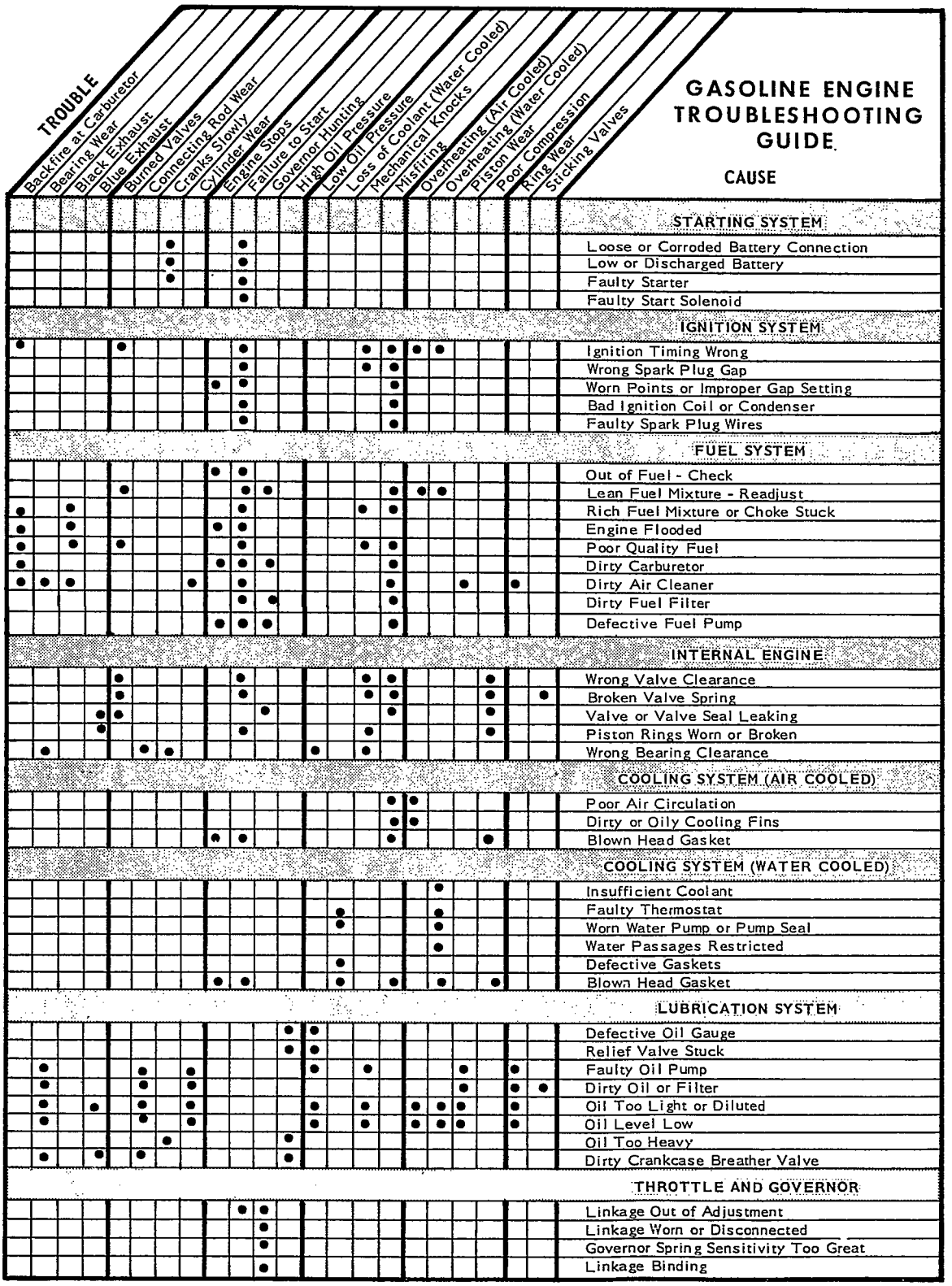
DESCRIPTION	TORQUE SPECIFICATION Ft.-Lb.	Nm	DESCRIPTION	TORQUE SPECIFICATION Ft.-Lb.	Nm
Cylinder Head Nuts (Cold)			Rear Bearing Plate	25-28	(34-38)
Asbestos Gasket without Compression Washers	18-20	(24-27)	Connecting Rod Bolt		
Asbestos Gasket with			Iron Rod	27-29	(37-39)
Compression Washers	13-15	(18-20)	Aluminum Rod	14-16	(19-22)
Graphoil Gasket without			Flywheel Capscrew	50-55	(68-75)
Compression Washers	14-16	(19-22)	Starter Mounting Bracket to		
Graphoil Gasket with			Oil Base Screws	25-35	(34-47)
Compression Washers	11-13	(15-18)	Gear Case Cover	8-10	(11-14)
			Oil Pump	7-9	(10-12)
			Other 3/8 Cylinder Block Nuts	18-23	(24-31)
			Intake Manifold	20-23	(27-31)
			Exhaust Manifold	20-23	(27-31)

SPECIAL TOOLS

The following special tools are available from Onan. For further information see *TOOL CATALOG 900-0019.*

Valve Seat Driver
Valve Guide Driver
Oil Seal Guide and Driver
Combination Bearing Remover (Main and Cam)
Combination Bearing Driver (Main and Cam)
Flywheel Puller

ENGINE TROUBLESHOOTING



FUEL SYSTEM

CARBURETOR

The carburetor has an idle jet and a main jet. The adjustable, idle jet affects engine operation at no-load speed. The main jet adjustment affects operation under load or high speed. Under normal circumstances, factory carburetor adjustments should not be disturbed. If the idle adjustment has been disturbed, turn the main adjustment needle clockwise until it gently seats, then turn it counterclockwise off its seat 1 to 1-1/2 turns to permit starting the engine (Figure 1), then readjust as follows:

CAUTION **Do not force the needle against its seat; doing so will damage it.**

Carburetor Idle Adjustment

1. Allow the engine to run at least 10 minutes to warm up.
2. Move engine speed control to SLOW position. The engine should run at about 1300 rpm.
3. Turn the idle needle out (counterclockwise) until engine begins to slow down or run unevenly. Remember this position; see Figure 1.
4. Turn needle in (clockwise) past the position where the engine runs smoothly until it begins to slow down or run unevenly.
5. Back the needle out to a position approximately halfway between the two positions. This should provide a smooth running idle.

Carburetor Main (Load) Adjustment

If engine runs unevenly at half or full load due to faulty carburetion, the main adjusting needle needs readjustment (Figure 1).

1. Start engine and allow it to warm up.
2. Push in on the governor mechanism to slow the unit down to about 400 to 500 rpm.
3. Set idle adjustment so engine runs smoothly.
4. Release governor mechanism to allow engine to accelerate. If engine accelerates evenly and without hesitation, main adjustment is correct. If not, turn needle outward about one half turn and again slow the engine down and release the mechanism. Continue until the engine accelerates evenly and without a hesitation after releasing the governor.
5. If engine tends to hunt (alternate increase and decrease of speed), open the main adjusting needle a little more. Do not open more than one half turn beyond the maximum power point.

Carburetor Float Adjustment

1. Disconnect throttle control, choke cable, and fuel line from carburetor.
2. With a screwdriver, remove the three screws on the top of the carburetor and lift off top.
3. With the carburetor casting inverted and the float resting lightly against the needle and seat, there should be 1/4-inch (6.4-mm) clearance between the bowl cover gasket and the free end of the float (side opposite needle and seat). See Figure 2.
4. If it is necessary to reset the float level, bend the float near the shaft to obtain the correct level.

CAUTION **Loosen packing nut before turning main fuel adjustment and tighten to a snug fit after adjustment has been made. Hold the adjustment while tightening packing nut.**

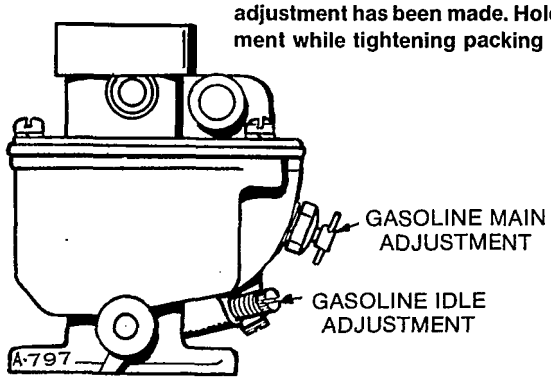


FIGURE 1. GASOLINE IDLE ADJUSTMENT

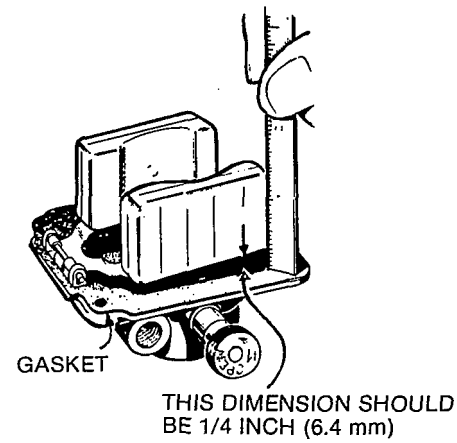


FIGURE 2. FLOAT LEVEL ADJUSTMENT

Carburetor Cleaning

Carburetor maintenance should consist of regular cleaning. Some gasolines have a tendency toward formation of gum deposits inside the carburetor. These deposits can be removed by soaking in a good carburetor cleaning solvent. Use compressed air to clean jets.

Refer to Figure 3 for complete carburetor breakdown.

Complete Replacement

Complete replacement of the carburetor should be performed as follows:

1. Follow the previously given disassembly instructions (under *Carburetor Float Adjustment*) as required for removal of the defective carburetor.
2. Replace the carburetor with a new unit, using attaching parts in good condition and making all the connections previously disengaged.
3. Adjust the needle settings.

DIAPHRAGM-TYPE FUEL PUMP

Figure 4 shows a diaphragm-type fuel pump. If fuel does not reach the carburetor, check the fuel pump before dismantling it.

1. Disconnect the fuel line at the carburetor.
2. Crank the engine and observe if fuel comes from the line at the carburetor.

WARNING **Direct the fuel flow into a container so gasoline does not spill on ignition wires. Use extreme care in this step due to hazard of fire or explosion. Perform in a well-ventilated area to prevent an accumulation of gasoline fumes.**

3. If there is fuel in the tank, and line does not have fuel flowing, the pump needs replacing.

Pump failure is usually caused by a leaking diaphragm, valve or valve gasket, a weak or broken spring, or wear in the drive linkage. Gasoline diluted with oil can also indicate a faulty pump.

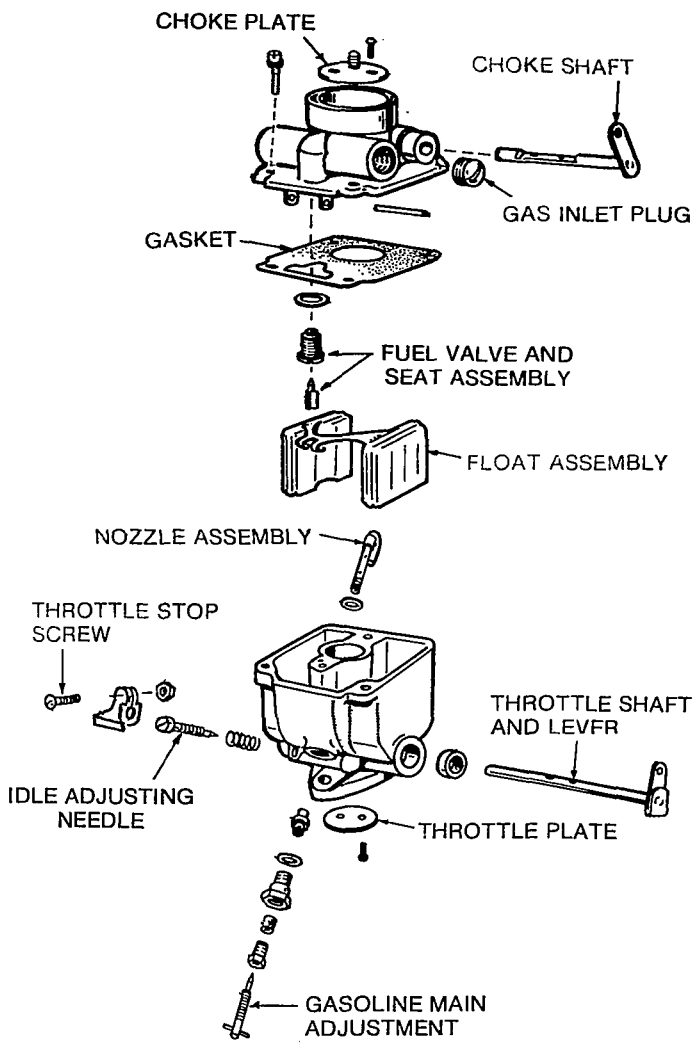
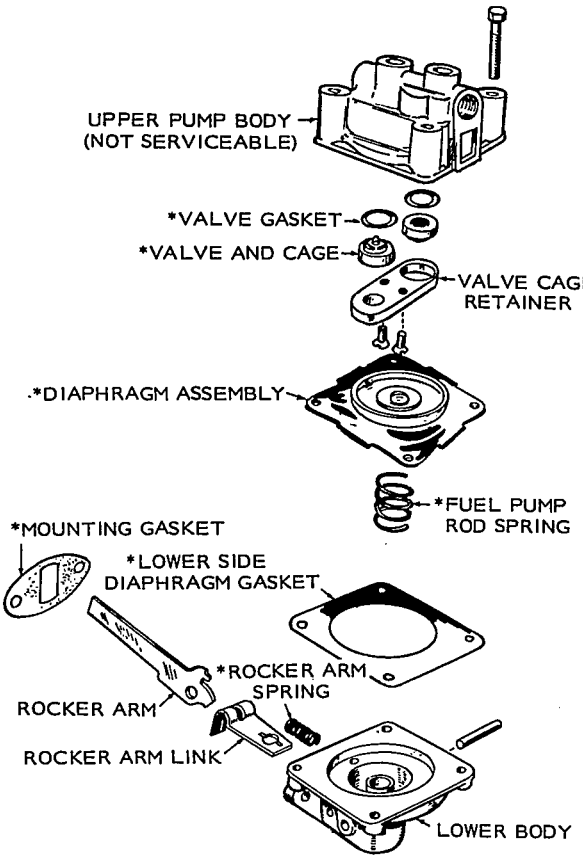


FIGURE 3. CARBURETOR ASSEMBLY



* - PARTS INCLUDED IN REPAIR KIT.

FIGURE 4. DIAPHRAGM-TYPE FUEL PUMP

Fuel Pump Reconditioning

Recondition the fuel pump as follows and refer to Figure 4.

1. Remove the fuel lines and mounting screws holding the pump to the engine.
2. Make an indicating mark with a file across a point at the union of the fuel pump bolt and cover. Remove the assembly screws and the upper pump body.
3. Turn the pump body over and remove the valve plate screw and washer. Remove the valve retainer, valves, valve springs, and valve gasket, noting their position. Discard the valve springs, valves, and valve retainer gasket.
4. Clean the pump body thoroughly with a solvent and a fine wire brush.
5. Holding the pump cover with the diaphragm surface up, place the new valve gasket in the cavity. Assemble the valves in the cavity. Reassemble the valve retainer. Lock in position by inserting and tightening the fuel pump retainer screw.
6. Place the pump body assembly in a clean work area and rebuild the lower diaphragm section.
7. Holding the mounting bracket, press down on the diaphragm to compress the spring under it, then turn the bracket 90 degrees to unhook the diaphragm so it can be removed.
8. Clean the mounting bracket with a solvent and a fine wire brush.
9. Replace the diaphragm operating spring, stand the new spring in the casting, and position the diaphragm. Press down on the diaphragm to compress the spring and turn it 90 degrees. This will reconnect the diaphragm.
10. Hold the bracket, place the pump cover on it (making sure the indicating file marks are in line) and insert the four attaching screws but do not tighten. With the hand on the mounting bracket only, push the pump lever to the limit of its travel and hold in this position while then tightening the four screws. This is important to prevent stretching the diaphragm.
11. Mount the fuel pump on the engine using the new mounting gaskets. Connect the fuel lines.

PULSATING-DIAPHRAGM FUEL PUMP

Pulsating-diaphragm fuel pumps use a combination of crankcase and spring pressure to work a diaphragm and pump the fuel. See Figure 5.

On the downstroke of the engine piston, when crankcase pressure is greatest, the pump diaphragm is forced back against the diaphragm spring compressing it and drawing fuel into the pump intake chamber. The fuel then passes through the intake

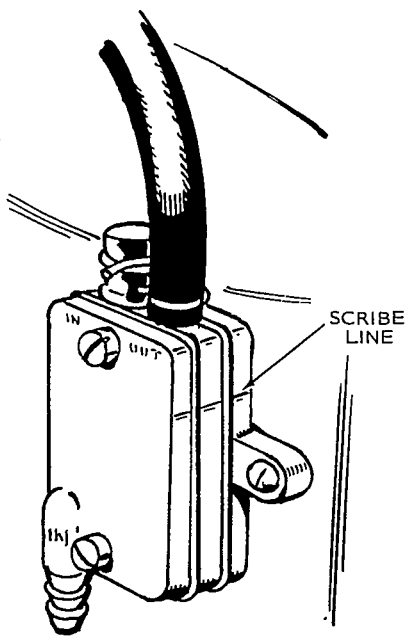


FIGURE 5. PULSATING-DIAPHRAGM FUEL PUMP

reed valve into the output chamber side of the pump. On the compression stroke, when crankcase pressure is the lowest, the diaphragm spring forces the diaphragm out pushing fuel through the pump output reed valve into the output chamber and into the fuel line.

Servicing the Pulsating-Diaphragm Fuel Pump

1. Remove vacuum and fuel lines. Inspect the lines for wear, cracking, etc.
2. Scribe two lines (one each on opposite ends of pump) across pump parts. This will insure correct alignment of pump parts and carburetor when pump is reassembled.
3. Remove fuel pump attaching screws.
4. Holding pump carefully, pull sections of the pump apart. The diaphragm, plunger, return spring and plate, pump body and gaskets will now be loose (Figure 6).
5. Check parts for wear and damage. Replace with new parts where necessary.
6. The pump air bleed hole in pump base must be unclogged to allow unrestricted movement of pump diaphragm.

CAUTION **A clogged diaphragm air bleed hole can cause diaphragm wear and seal damage while inhibiting pump operation.**

7. Replace gaskets and reassemble pump as shown in Figure 6.
8. Install pump and replace lines. Make sure fuel line clamps are replaced on fuel line.

WARNING **Use care when reassembling the pump. All parts must be perfectly aligned or the pump will leak creating a fire hazard.**

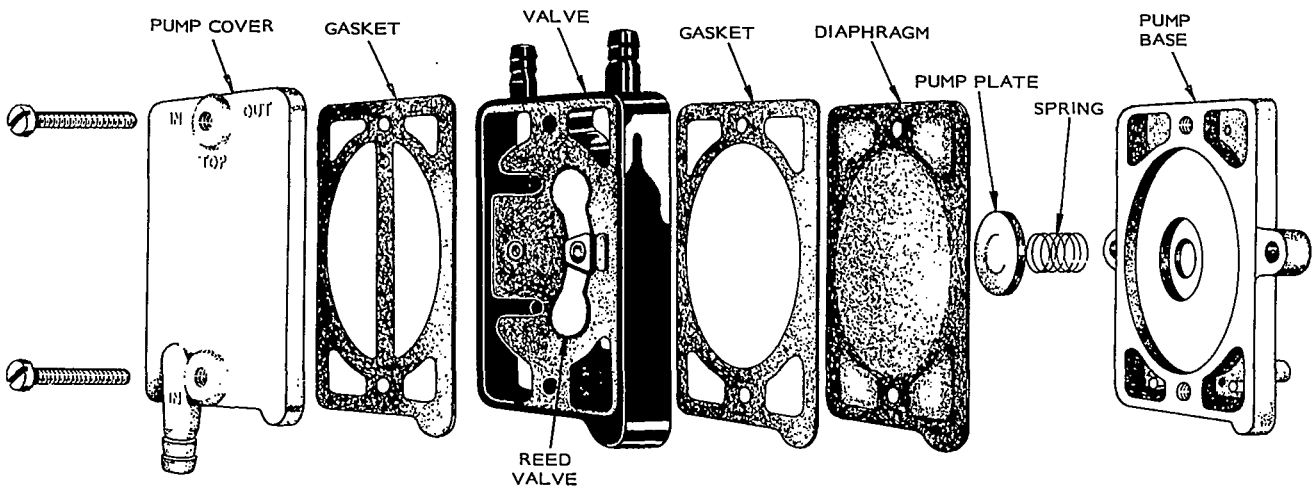


FIGURE 6. PULSATING-DIAPHRAGM FUEL PUMP ASSEMBLY

GOVERNOR SYSTEM

GOVERNOR ADJUSTMENT

Where engine speed is governor controlled, the factory sets the governor for a nominal engine speed of 2400 rpm at no-load operation (unless another speed is specified when the engine is ordered). Proper governor adjustment is one of the most important factors in maintaining the power and speed desired from the engine.

Make sure the carburetor is properly adjusted before checking or changing governor settings.

Before making the governor adjustments, run the engine about 15 minutes to reach normal operating temperature. A tachometer for checking engine speed is required for accurate governor adjustment.

It is difficult to determine if, after long usage, the governor spring has become fatigued. If, after properly making all other adjustments, the regulation is still erratic, install a new spring, Figure 7.

Check the governor arm, linkage, throttle shaft and lever for binding or excessive wear at connecting points. A binding condition at any point will cause the governor to act slowly and regulation will be poor. Excessive looseness will cause a hunting condition and regulation will be erratic. Work the arm back and forth several times by hand while the engine is idling. If either of these conditions exist, determine the cause and adjust or replace parts as needed.

Linkage Adjustment

The engine starts at wide open throttle. You can adjust the length of the linkage connecting the governor arm to the throttle arm by rotating the ball joint housing. Adjust the length so that with the engine stopped and tension on the governor spring, the stop on the carburetor throttle lever is 1/32 inch (0.8 mm) from the carburetor stop boss. This setting allows immediate control by the governor after starting and synchronizes travel of the governor arm and the throttle shaft.

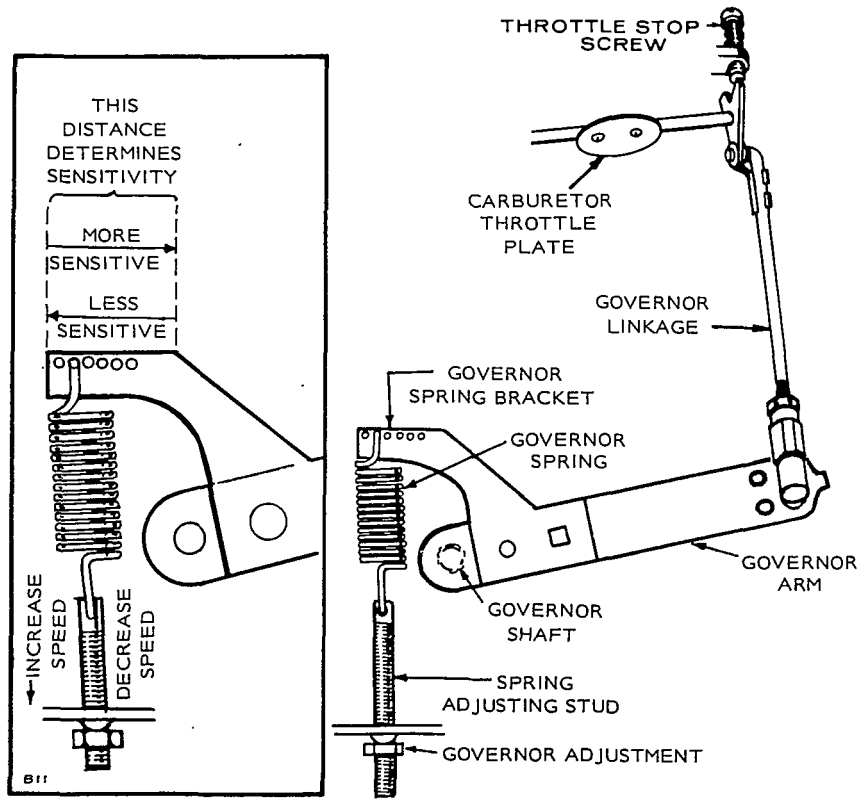


FIGURE 7. STANDARD GOVERNOR ADJUSTMENTS

Speed Adjustment

The speed at which the engine operates is determined by the tension applied to the governor spring. Increasing spring tension increases engine speed, decreasing spring tension decreases engine speed. The no-load speed of the engine should be slightly higher than the requirements of the connected load. For example: If the connected load has to turn at 3510 rpm, set the no-load speed of the engine at about 3600 rpm. Check speed with a tachometer. If a speed adjustment is needed, turn the speed adjusting nut in to increase the speed or out to decrease the speed, Figure 8.

Sensitivity Adjustment

Engine speed from no load to full load should not drop less than 100 rpm. Check the engine speed with no load connected and again after connecting full load. Do not exceed 4000 rpm at no load.

The sensitivity of the governor depends upon the position of the arm end of the governor spring. A series of holes in the governor arm provides for adjustment. To increase sensitivity, move the spring toward the governor shaft. To decrease sensitivity, move the spring toward the linkage end of the governor arm.

If the setting is too sensitive, a hunting condition (alternate increase and decrease in engine speed) will result. If the setting is not sensitive enough, the speed variation between no-load and full-load conditions will be too great. Therefore, the correct sensitivity will result in the most stable speed regulation without causing a surge condition.

Always recheck the speed adjustment after a sensitivity adjustment. Increasing sensitivity will cause a slight decrease in speed and will require a slight increase in the governor spring tension.

Variable Speed Governor Adjustments

These engines are adapted for a wide range of speed settings. The design of the variable speed governors gives an automatic increase in sensitivity when the speed is increased and the result is good stability at all speeds.

To adjust the engine mounted variable speed governor (Figure 8), proceed as follows:

1. Run engine and make necessary carburetor adjustments.
2. Adjust throttle stop screw on carburetor to allow a recommended minimum idling speed of 900 rpm. A lower minimum does not assure smooth operation under load.
3. Adjust governor spring tension for minimum speed of 1500 rpm with no load by positioning control lever.
4. Adjust sensitivity while operating at minimum speed to attain the smoothest no-load to full-load operation as follows:

   To decrease sensitivity, allowing more speed drop from no-load to full-load operation, move the governor spring outward into a different hole in the extension arm (same as sensitivity setting shown in Figure 7).

   To increase sensitivity (closer regulation by the governor which permits less speed drop from no-load to full-load operation), move the governor spring inward into a different hole in the extension arm.
5. Apply a full load and shift variable control to maximum speed. Adjust maximum speed stop screw to stop lever travel in the bracket slot at desired maximum speed position.

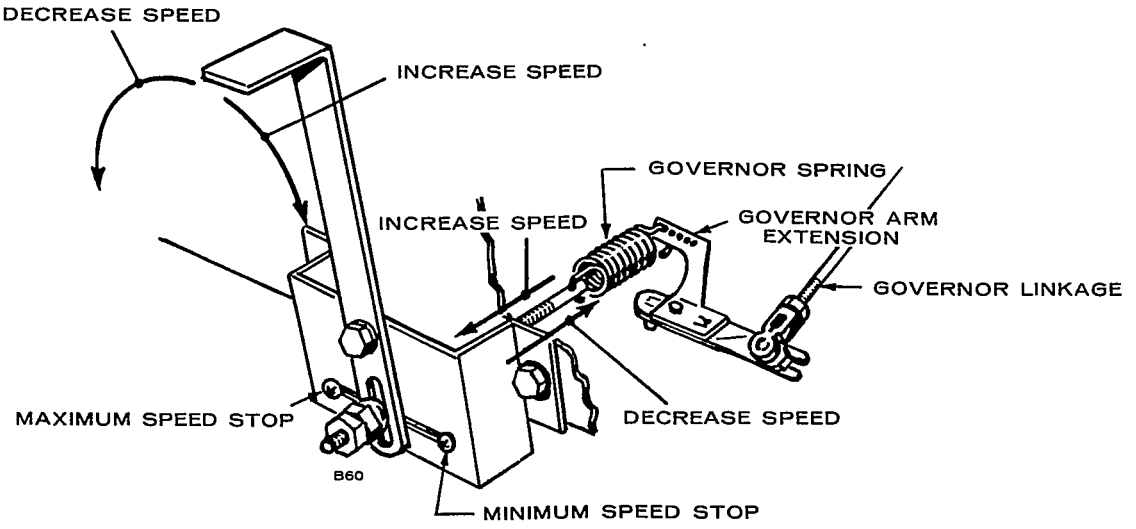


FIGURE 8. VARIABLE SPEED GOVERNOR

Approximately 3000 rpm is the recommended maximum full-load speed for continuous operation. The speed must agree with the load requirements.

To adjust the remote control variable speed governor (Figure 9), proceed as follows:

1. Disconnect linkage (A) at ball joint (C).
2. Push linkage (A) and governor arm (B) as far back (toward carburetor) as they will go.
3. Holding linkage and governor arm toward direction of carburetor, adjust linkage to fit and reconnect ball joint.

   The governor control spring is factory set in the center hole of the governor control shaft bracket. To increase the sensitivity, move the spring loop to the hole nearest the control shaft. To decrease the sensitivity, move the spring outward.
4. After sensitivity has been set, adjust the low speed stop adjustment screw on the control wire bracket.

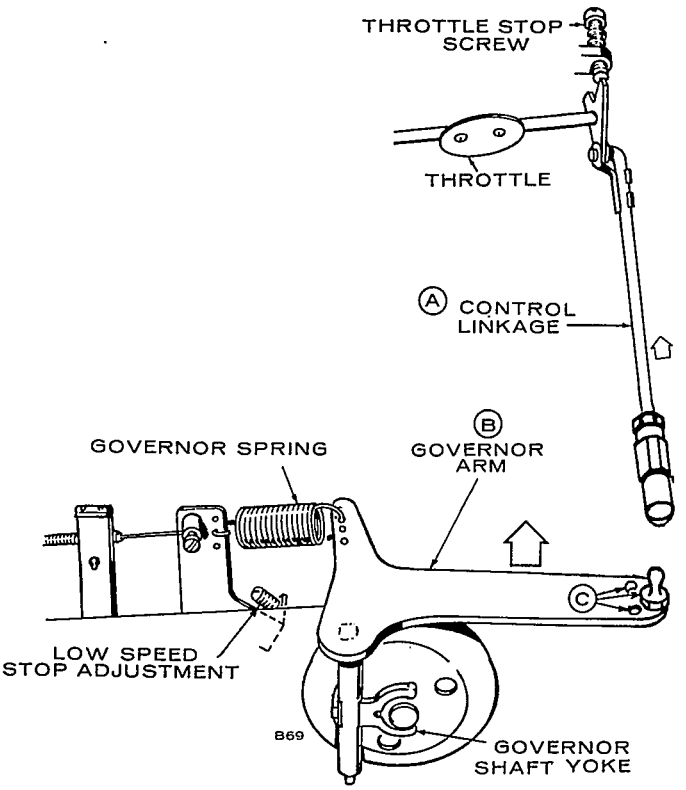


FIGURE 9. VARIABLE SPEED GOVERNOR REMOTE CONTROL

IGNITION SYSTEM

BREAKER POINTS

Begin Spec C Engines

To maintain maximum engine efficiency, check the breaker points every 100 hours of operation and replace if necessary. Proceed as follows:

1. Remove spark plugs and rotate flywheel TC mark to 20° BTC (points open); then rotate it another 90 degrees clockwise to ensure points open fully.
2. Remove breaker box cover and unplug coil wire at coil (+) terminal.
3. Remove condenser (screw A) and detach condenser load and coil lead (screw B), Figure 10.
4. Remove two Allen screws (C) and lift breaker assembly from engine.
5. Replace condenser and point assembly with new parts and reinstall using above procedure in reverse order of removal.
6. Using Allen wrench at screw (D) adjust point gap at 0.016 inch (0.41 mm) using a clean, flat thickness gauge.

   Setting point gap accurately adjusts engine timing.

4. Replace breaker box cover and spark plugs.

If desirable, check ignition timing with a 12-volt test light or continuity tester.

Spec A and B Engines

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

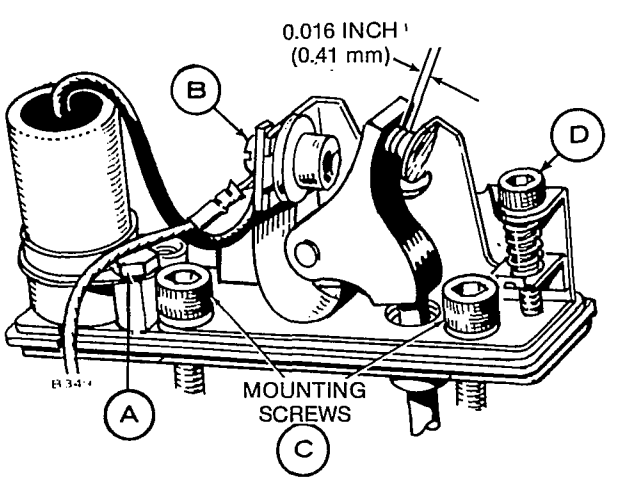


FIGURE 10. BREAKER POINT ADJUSTMENT (BEGIN SPEC C)

1. Remove the two screws and the cover on the breaker box, Figure 11.
2. Remove the two spark plugs so engine can be easily rotated by hand. If plugs have not been changed within the last 100 hours, replace them with new ones after setting the breaker points.
3. Refer to Figure 11. Remove mounting screw (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 screw (A).
6. Rotate the engine by hand until the 20° BTC mark on gear cover aligns with mark on flywheel. Turn another 1/4 turn (90 degrees) to ensure points are fully open.
7. Using a screwdriver inserted in notch (D) on the right side of points, turn points until gap measures 0.016 inch (0.41 mm) with a flat thickness gauge. Tighten mounting screw and recheck gap.

Setting point gap accurately adjusts engine timing. If desirable, check ignition timing with a 12-volt test lighter or continuity tester.

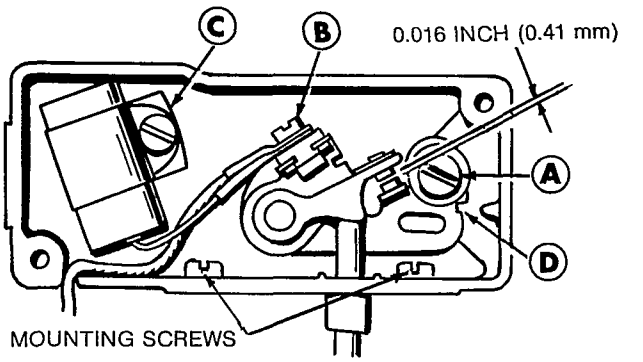


FIGURE 11. BREAKER POINT ADJUSTMENT (SPEC A AND B)

TIMING CHECK—PRESSURE COOLED ENGINE

The timing of 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 20° 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 Check—Engine Running

1. To accurately check the ignition timing, use a timing light with engine running at idle speed. Connect the timing light according to its manufacturer's instructions. You can use either spark plug because they fire simultaneously.
2. Start the engine and check the timing. The pointer on the flywheel should line up with the 20° mark on the cover. The timing hole through the flywheel and the timing marks on the timing gear cover can be seen by looking through the flywheel blower screen. See Figure 12.

If timing marks do not line up, readjust point gap. To advance timing, slightly open gap on breaker points. To retard timing, slightly close gap on breaker points. Recheck timing and breaker point gap after making this adjustment.

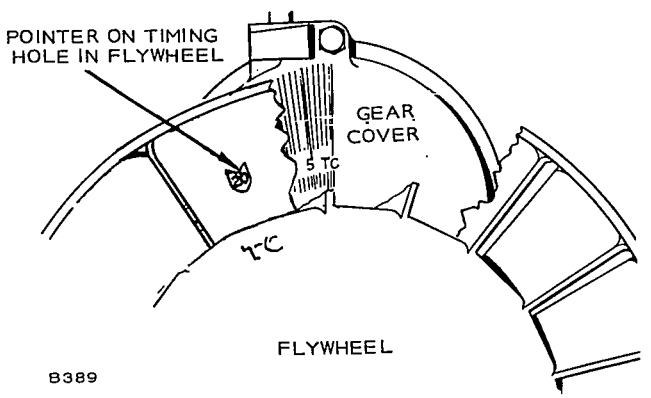


FIGURE 12. FLYWHEEL TIMING HOLE

Timing Check—Engine Not Running

If a timing light is not available, check the timing as follows:

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 (20° BTC).

TIMING CHECK VACU-FLO ENGINE

Engine timing is advanced or retarded by opening or closing the breaker point gap. Setting the point gap at 0.016 inch (0.41 mm) is the most accurate method of timing the engine.

Dynamic timing (engine running) may be less accurate because the sight angle from the viewer to the flywheel scribe mark and timing pointer may vary ± 2° from 20° BTC, Figure 13. The timing pointer is mounted on the cylinder block above the oil filter and accessible by removing the right hand shroud.

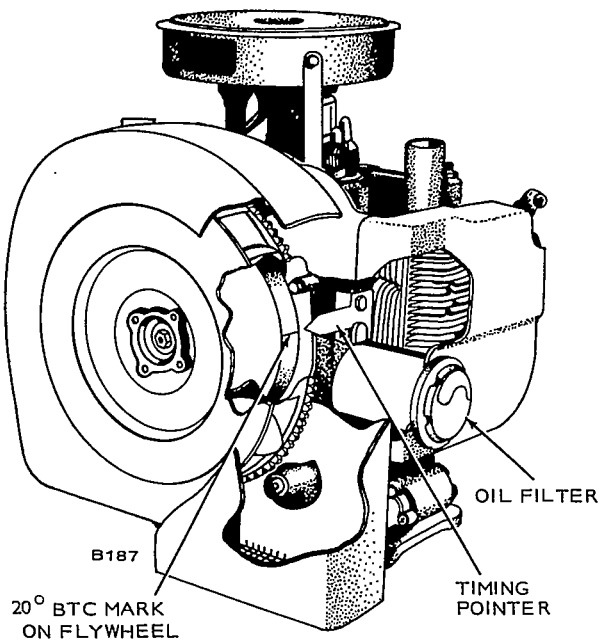


FIGURE 13. VACU-FLO ENGINE—TIMING MARK AND POINTER

SPARK PLUGS

Remove both spark plugs and install new ones every 100 hours. Use Onan spark plugs 167-0240 or equivalent. Check to be sure spark plug gap is set at 0.025 inch (0.64 mm), Figure 14.

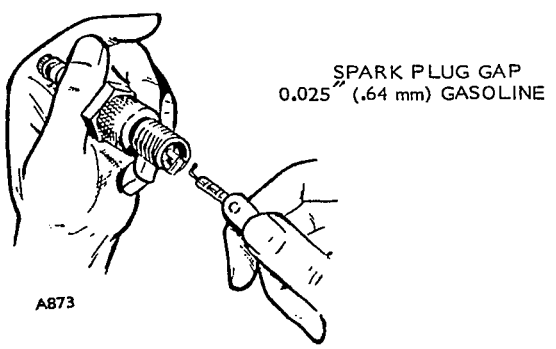


FIGURE 14. SPARK PLUG GAP

IGNITION COIL

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

1. Use a Simpson 270 VOM or equivalent.
2. Place black lead on ground (–) terminal of coil and red lead to positive (+) terminal. Primary resistance should read 4.30 (±10%) ohms @ 70 F (21 C). See Figure 15.
3. Change resistance setting on ohmmeter. Place ohmmeter leads inside of spark plug cable holes. Secondary resistance should read 14,000 (±10%) ohms @ 70 F (21 C).
4. If any of the above conditions are not met, replace coil. Refer to an Onan *PARTS CATALOG* for correct part number.

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.**

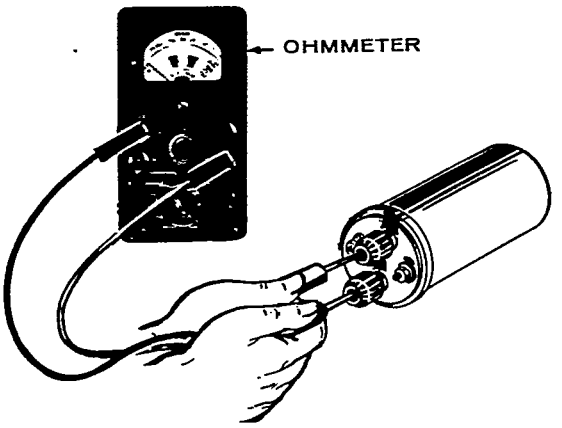


FIGURE 15. COIL TEST

BATTERY CHARGING SYSTEM

BATTERY CHARGING, FLYWHEEL ALTERNATORS

The flywheel alternator is a permanent magnet alternator and uses a solid-state voltage regulator-rectifier for controlling output. Two different alternator systems are used. One is a 20-ampere Synchro system, the other is a 15-ampere Phelon system.

Weak ignition spark or a discharged battery indicate trouble in the charging system. But before testing the engine's charging system, *always check the battery* for serviceability.

Keep these points in mind when testing or servicing the flywheel alternator:

1. Be sure output control plug (connector) is inserted properly. Plug must bottom in receptacle—eliminates any resistance due to a poor connection. Keep clean and tight.
2. Make sure alternator stator leads are not shorted together.
3. Be sure regulator-rectifier output control has a good ground connection. Mating surface for mounting must be clean and fasteners tightened properly.
4. Never reverse the battery leads.

Charging system tests require a full charged battery.

20-AMPERE SYNCHRO SYSTEM

The 20-ampere flywheel alternator systems use a separate regulator and a separate rectifier. See Figure 16. For testing this system, use a voltmeter-ohmmeter such as a Simpson 270 (or equivalent). Various alternator problems with individual test procedures are listed in Table 1.

No Output—Stator Assembly

Examine lead wires for loose or broken connections at the regulator and rectifier. Use the Rx1 scale on the ohmmeter for detecting opens in the stator. Disconnect the three wires that come from alternator stator (two black, one red). Connect ohmmeter test leads to red lead wire and ground to check continuity. The ohmmeter reading should be about 2.0 ohms. See Figure 17 for wiring diagram.

Next, connect meter to black lead wires and ground. Approximately 0.1 ohm should be read from either black lead to ground. If no connection exists between ground and black leads, replace the stator assembly.

Checking Rectifier Assembly

Examine each of the two diodes for breakdown by connecting ohmmeter (Rx1 scale) from one black lead to white lead. Meter should read 10 ohms in proper polarity. A shorted diode would read zero

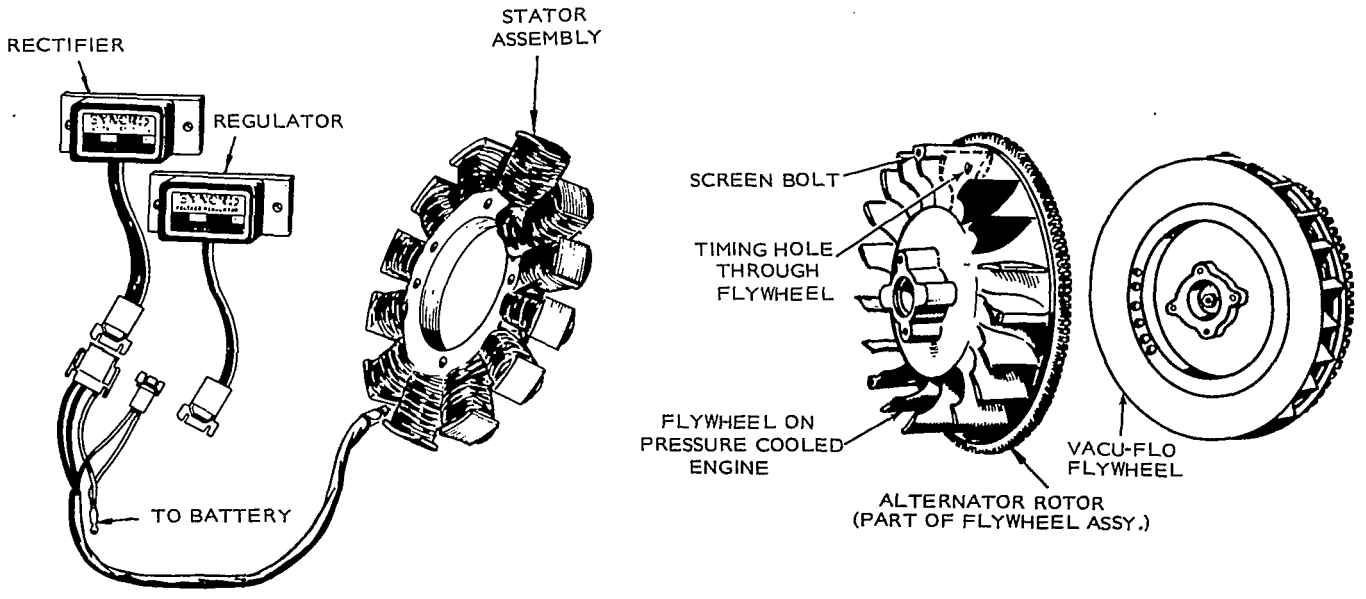
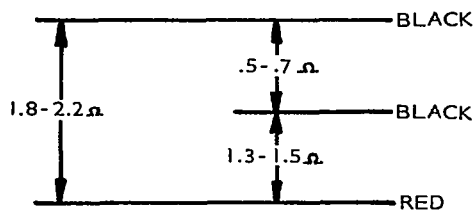


FIGURE 16. 20-AMPERE SYNCHRO SYSTEM

TABLE 1.
TESTING SYNCHRO 20-AMPERE SYSTEM

TEST	VALUE
Battery voltage - unit not running	12 Volts DC
Battery voltage with unit running at 1800 rpm or more	14.2 — 14.8*
AC voltage from stator with plug disconnected and unit running at approximately 1800 rpm	Black to Black
Ohmmeter reading at plug when checking two AC stator leads - unit not running	
Resistance values (Ohms) are as follows between wire pairs. 	

* - 60 Volt minimum at greater than 2000 rpm, Red to Ground.

resistance and would cause a short circuit through the lead winding when in operation. An open diode would read infinity in both directions indicating that replacement is necessary.

Testing Regulator Assembly

To check for proper voltage regulation, attach a DC voltmeter to battery and operate engine at about 1800 rpm. Battery voltage will climb to the preset factory setting (14.2 to 14.8 volts).

Some installations can vary due to voltage drop in the length of ammeter harnesses. Other variations may stem from a loose connector in the harness or loose or corroded battery leads. Low voltage readings at the battery mean poor battery connections.

To test regulator, remove connector. Using the Rx10,000 scale of your ohmmeter, connect one meter lead to red lead wire and other meter lead to regulator base. No deflection should be noted on the ohmmeter in either polarity. Next, connect meter to black lead wire and base of regulator. Meter will deflect fully in one polarity with no deflection in the other.

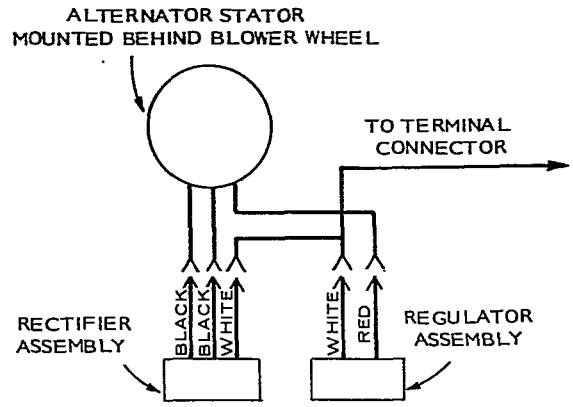


FIGURE 17. 20-AMPERE SYNCHRO SYSTEM DIAGRAM

Full Charge—Will Not Regulate

Check for broken leads at connection to regulator plates. To be sure regulator winding operates properly, connect red lead to ground and start engine. A maximum of 4 amperes should be noted. This would indicate stator winding is satisfactory. If so, replace regulator.

No Charge

If alternator does not charge when load is applied to battery, shut off engine and disconnect one red lead wire from regulator terminal. Be sure lead is taped or isolated from conducting engine parts. Once again, start engine. Alternator should charge to full output. If it does not, replace stator assembly.

15-AMPERE PHELON SYSTEM

The 15-ampere flywheel alternator systems (Figure 18) have a one piece regulator-rectifier assembly. Various alternator problems are listed in Table 2.

With the engine running between 1800 to 2600 rpm, observe the panel ammeter (if not already equipped, connect a test ammeter). If no charging is evident, proceed with the *No Charge Test.* If ammeter shows a constant higher charge rate, follow the *High Charge Rate Test* procedure.

No Charge Test

1. Check the B+ to ground voltage using a DC voltmeter. See Figure 19 for wiring diagram.
2. If voltmeter reads 13.8 volts or higher, add a load to system (e.g. headlights) to reduce battery voltage to below 13.6 volts.
3. Observe ammeter. If charge rate increases, consider the system as satisfactory. If charge rate does not increase, proceed with testing.
4. Disconnect plug from regulator-rectifier and test the AC voltage at the plug with engine running near 3600 rpm. If AC voltage reads less than 28 volts with 15 ampere system or 41 volts with 20 ampere system, replace the stator.

TABLE 2. TESTING PHELON SYSTEMS

BASIC TEST	PROCEDURE	TEST VALUES	
		15A. SYSTEM	20A. SYSTEM
1. Battery	Battery Voltate — unit not running.	12 VDC	12 VDC
2. Regulator	Battery Voltage after unit is running 3 to 5 minutes.	13.6 to 14.7 VDC	13.6 to 14.7 VDC
3. Alternator Stator and Wiring	Ohmmeter reading from stator output — unit not running. Check at plug.	0.1 to 0.2 Ohms	0.3 to 0.5 Ohms
4. Alternator and Wiring	Measure AC open circuit stator voltage with unit running. Measure between two stator leads with plug disconnected and unit running at approximately 3600 rpm.	28 VAC minimum 65 VAC maximum	41 VAC

High Charging Rate Test

Perform this test as follows:

1. Check B+ to ground voltage with a DC voltmeter.
2. If voltmeter reads over 14.7 volts, replace regulator-rectifier assembly.
3. If reading is under 14.7 volts, the system is probably okay. Recheck the battery and connections. If the battery does have a low charge, but accepts recharging, system is okay.

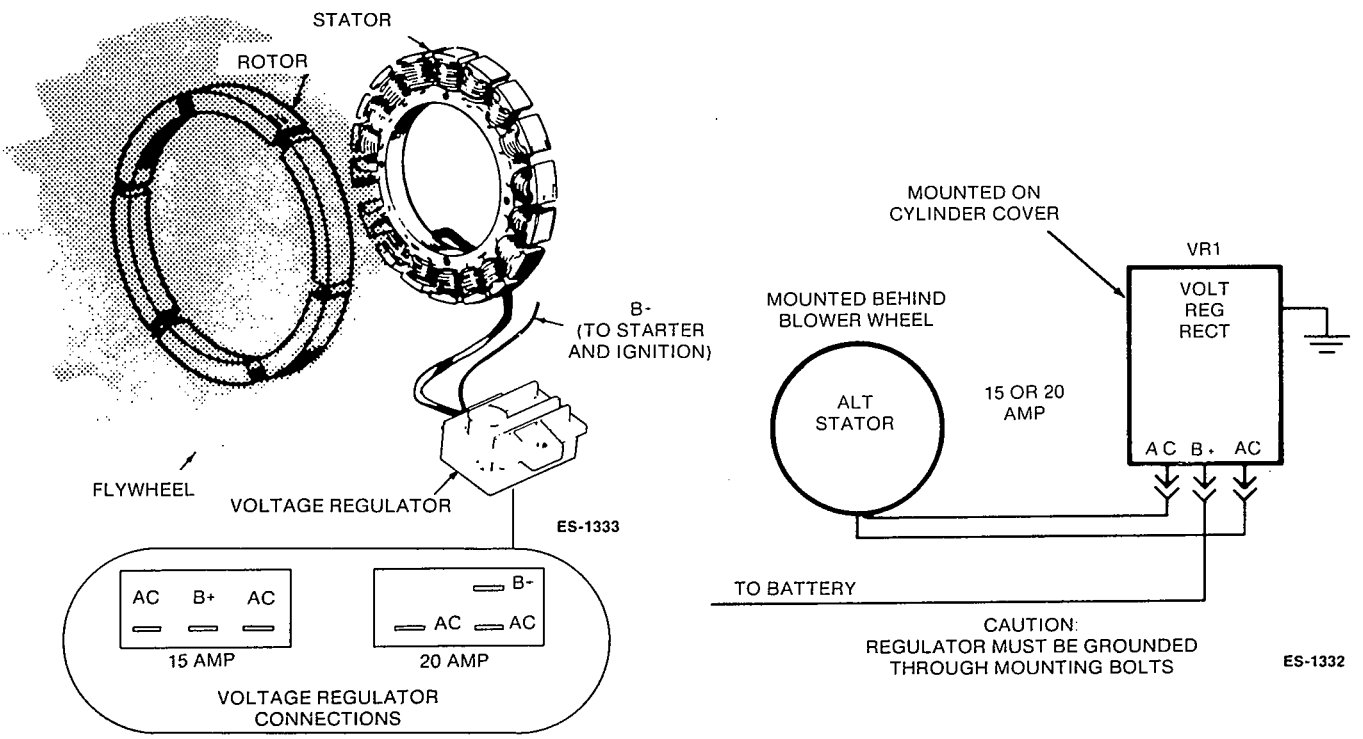


FIGURE 19. PHELON SYSTEM

BATTERY INSPECTION

Check battery cells with a hydrometer. The specific gravity reading should be approximately 1.260 at 77 F (25 C), Figure 20.

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.

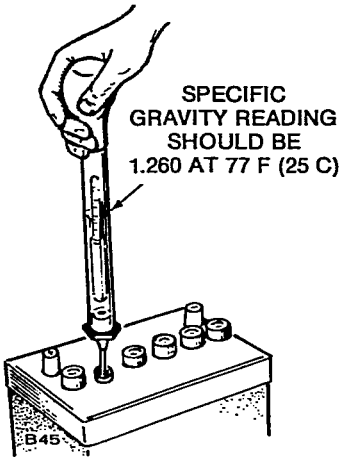


FIGURE 20. SPECIFIC GRAVITY TEST

Keep the battery terminals clean and tight. Push the cable terminal down flush with or slightly below the top of the battery post (Figure 21). After making connections, coat the terminals with a light application of petroleum jelly or grease to retard corrosion.

Poor contact at the battery cable connections is often a source of trouble. Make sure battery cables are in good condition and that contacting surfaces are clean and tightly connected. Do not reverse battery leads. Use recommended battery tools when disconnecting leads to avoid mechanical battery damage.

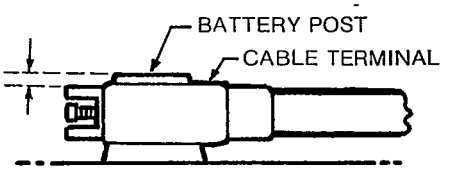


FIGURE 21. BATTERY CABLE CONNECTION

STARTING SYSTEM

ELECTRIC STARTER

Normally the starter will require little or no service other than possible brush replacement. See Figure . However, if through accident or misuse, the starter requires service or overhaul, the following procedures will provide the information necessary to perform this service.

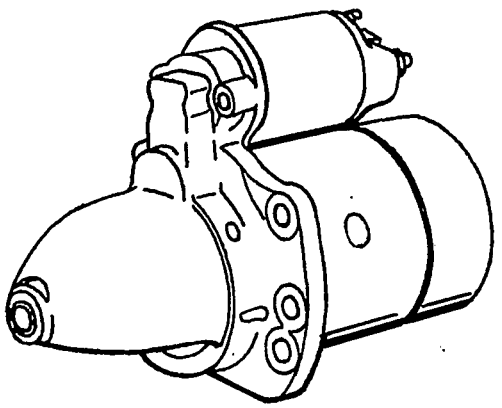


FIGURE 22. STARTER ASSEMBLY

STARTER DISASSEMBLY

1. Loosen the M terminal nut on the solenoid switch (which attaches solenoid motor terminal to field coil connector) and remove the connector to the starter assembly. Then unscrew attaching screws and remove the solenoid switch

The packings for the solenoid switch are mounted so that the steel packing is located in the front bracket side.

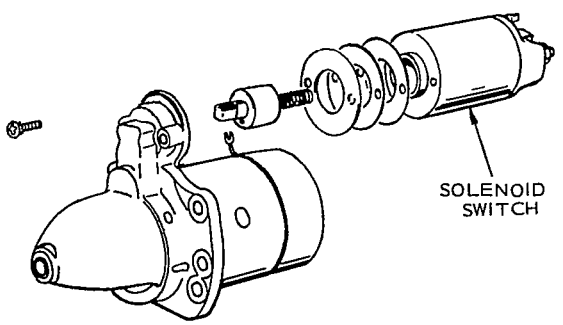


FIGURE 23. SOLENOID SWITCH REMOVAL

2. After removing the through bolts, the starting motor can be divided into three parts—the front bracket, housing and rear bracket. The spacing washers shown in Figure 4 are used for adjustment of the thrust gap of the armature shaft and are placed between the rear bracket and the commutator.

These washers are inserted so the steel washer is located in the commutator side.

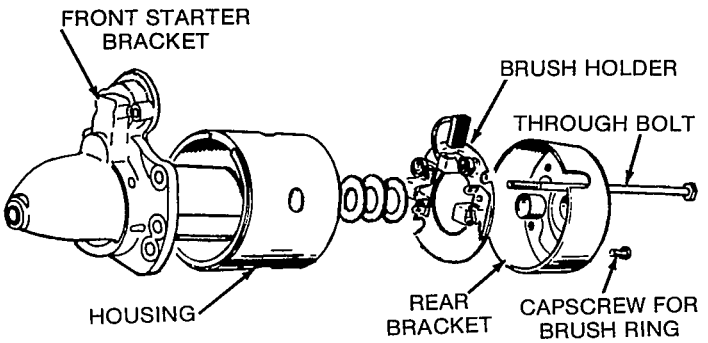


FIGURE 24. REMOVING THROUGH BOLTS

3. The armature can easily be removed from the front bracket. Be careful not to miss a small steel washer used in the end of the armature shaft. The shift lever can be removed along with the armature when it is removed. In this case, the spring holder, lever springs and retainer can be taken out before the lever. e Figure
4. Remove the ring after driving the pinion stopper toward the pinion gear using a cylindrical tool as

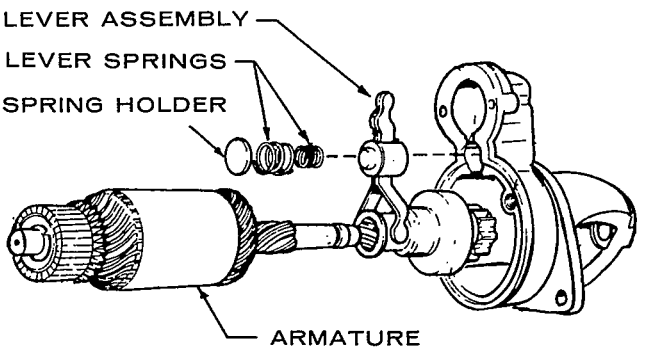


FIGURE 25. ARMATURE REMOVAL

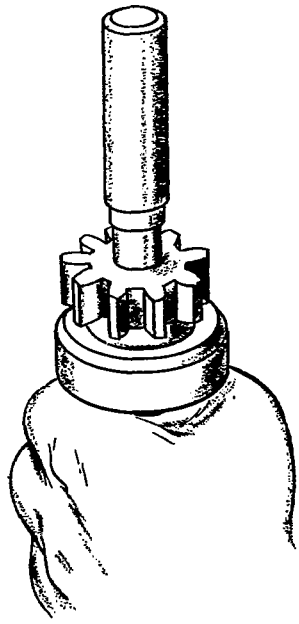


FIGURE 26. RING REMOVAL

shown in Figure 26. Remove the overrunning clutch and the pinion stopper simultaneously.

5. One of the brushes has been soldered to the brushholder (Figure 27). The brush springs can be removed from the brushholder.

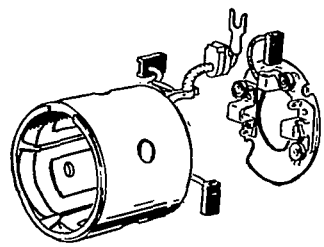


FIGURE 27. STARTER BRUSHES

STARTER REASSEMBLY

Inspect the parts carefully in accordance with the procedure described in *Inspection of Parts*. Make any repair necessary. Reassembly is the reverse of disassembly. Take the following precautions.

1. Clean all of the parts carefully with a dry cloth and compressed air if it is available.

CAUTION **Do not use steam or high pressure water to clean the starter. Otherwise, water particles are entrapped in the starter after reassembly.**

Clean bearing-equipped parts with a brush dipped in "Varsol" or other comparible mineral spirits. Do not immerse the field coil assembly, yoke assembly, armature, solenoid, or brushes in cleaning solvent. It will damage the insulation. Do not immerse the overrunning clutch in cleaning solvent because the solvent will wash the lubricant from the clutch.

2. Apply SAE 20 oil to the armature shaft and splines. Apply grease (Shell Albania No. 2 or equivalent) sparingly on the shift lever pin, the joint of the shift lever and plunger, the plunger and spacing washers at the end of the shaft.
3. To mount the overrunning clutch; first insert the pinion stopper into the armature shaft, then apply the ring to the groove of the shaft rigidly. For the insertion of the ring, use a tool as shown in Figure 28 and pull the pinion stopper up.

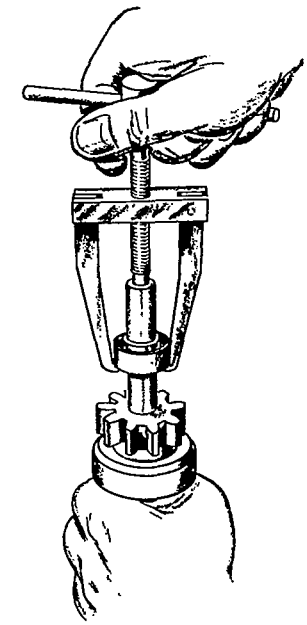


FIGURE 28. MOUNTING OVERRUNNING CLUTCH

4. Use spacing washers to adjust the armature to give end play of 0.004 to 0.020 inch (0.10 to 0.51 mm).
5. Tighten the through bolts to a torque of 35 to 44 in.-lb (4.0 to 5.0 N•m).
6. Insert the shift lever as shown in Figure 29 into the front bracket.

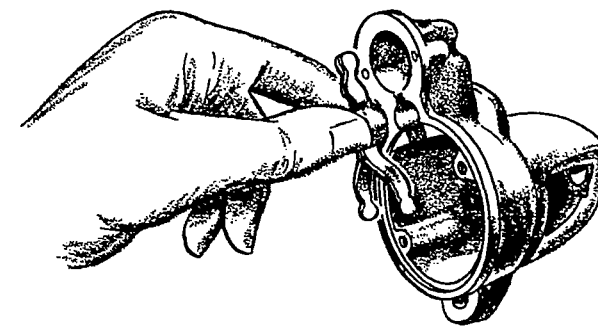


FIGURE 29. INSTALLING SHIFT LEVER

INSPECTION OF PARTS

Testing Armature for Short Circuits

Place the armature in a growler and hold a thin steel blade parallel to the core and just above it while slowly rotating the armature in the growler (Figure 30). A shorted armature will cause the blade to vibrate and be attracted to the core. Replace shorted armature.

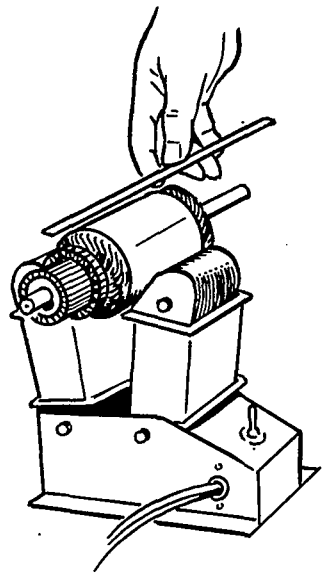


FIGURE 30. ARMATURE SHORT CIRCUIT TEST

Testing Armature for Grounds

Touch armature shaft or core and the end of each commutator bar with a pair of ohmmeter leads (Figure 31). A low ohmmeter reading indicates a grounded armature. Replace a grounded armature.

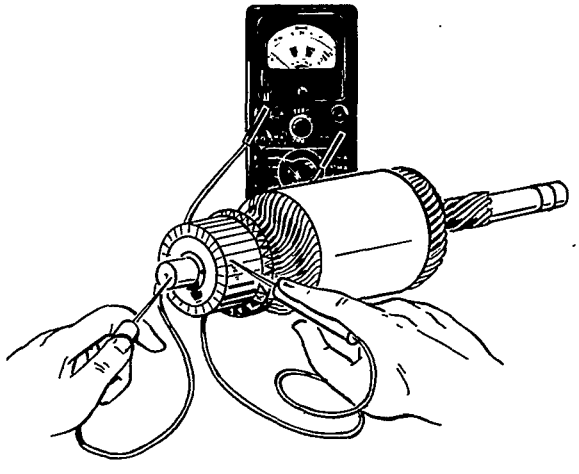


FIGURE 31. ARMATURE GROUND TEST

Testing Armature for Open Circuit

The most likely place for an open to occur is at the commutator riser bars. Inspect the points where the conductors are joined to the commutator bars for loose connections.

Testing Commutator Runout

Place armature in a test bench and check runout with a dial indicator (Figure 32). When commutator runout exceeds 0.004 inch (0.102 mm), reface the commutator.

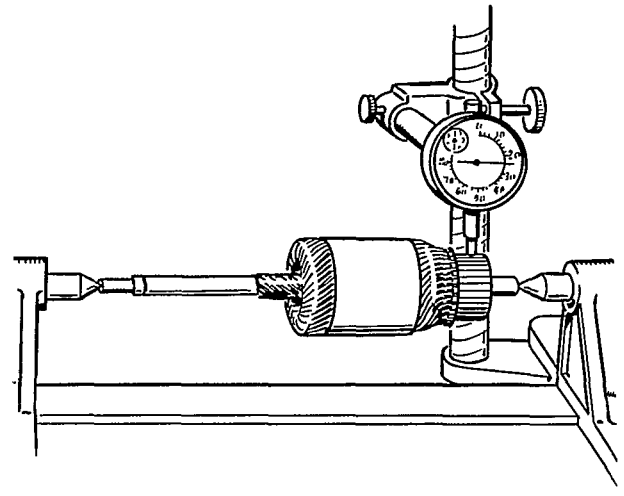


FIGURE 32. CHECKING COMMUTATOR RUNOUT

Testing Armature Shaft Runout

You can check the armature shaft for runout as shown in Figure 33. A bent armature can often be straightened, but a new armature is required if the shaft is worn.

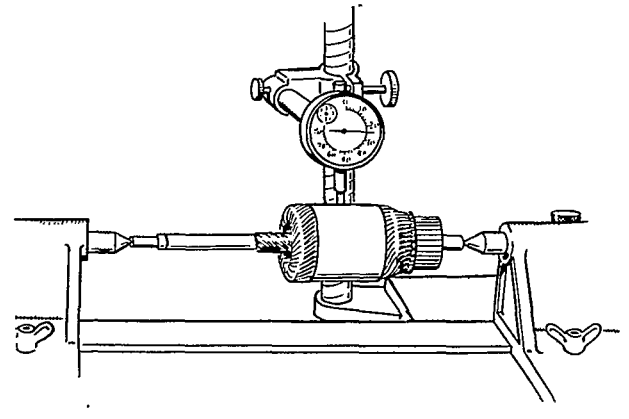


FIGURE 33. CHECKING ARMATURE SHAFT RUNOUT

Testing Field Coils for Grounds

Place one lead on the connector and the other on a clean spot on the frame after unsoldering the shunt field coil wire (Figure 34). A low ohmmeter reading indicates a grounded field either at the connector or in the windings.

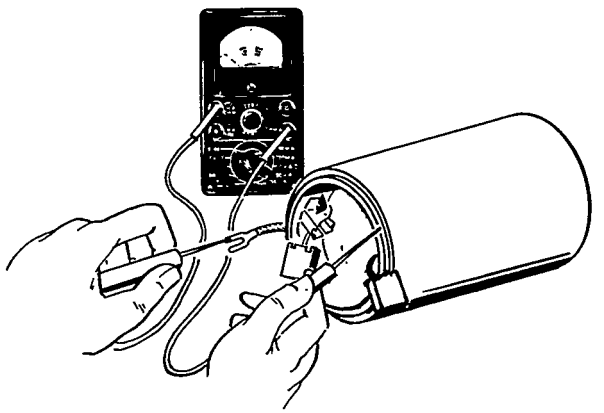


FIGURE 34. FIELD COIL GROUND TEST

Testing Field Coils for Open Circuits

Place one lead on the connector and the other on a clean spot on the brushholder (Figure 35). A high ohmmeter indicates the field coil is open. Check the other three brushholders in the same manner.

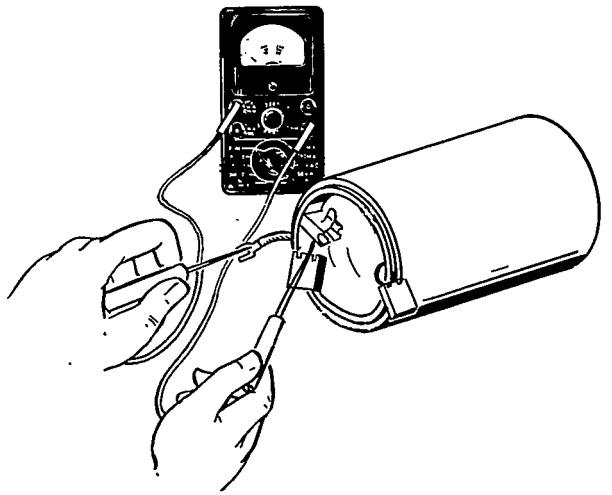


FIGURE 35. FIELD COIL OPEN CIRCUIT TEST

Inspection of Brushes

When brushes are worn to the wear limits as shown in Figure 36, replace them. See that the brushes move smoothly in the brushholders.

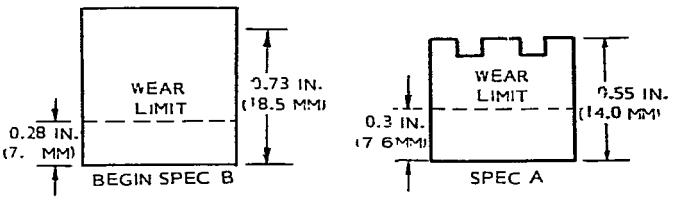


FIGURE 36. BRUSH WEAR LIMITS

Inspection for Brush Spring Tension

Measure brush spring tension with a tension meter as shown in Figure 37. Push the brush and take a reading just as the brush projects a little from the brushholder. On a new brush, the spring tension should be 49 to 59 ounces (1390 to 1670 grams) for begin Spec B engines; 29 to 38 ounces (820 to 1075 grams) for Spec A engines.

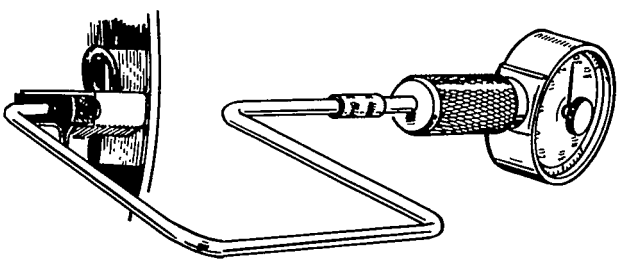


FIGURE 37. MEASURING BRUSH SPRING TENSION

INSPECTION AFTER OVERHAUL

1. For no load test, the starting motor is wired as shown in Figure 38 and run. The value of the meter reading at this condition should be as follows:

	Begin Spec B	Spec A Only
Voltage	10.5	11.5
RPM	5000	3700
Max. Current Draw (Amp)	53	60

The conductor for this test should be large enough and as short as possible. If anything is wrong in the above test, inspect the following items:

Annealed brush springs
Improperly seated brushes
Insufficient armature endplay
Shorted, open or grounded armature
Grounded or open field coil
Poor electrical connection
Dirty commutator

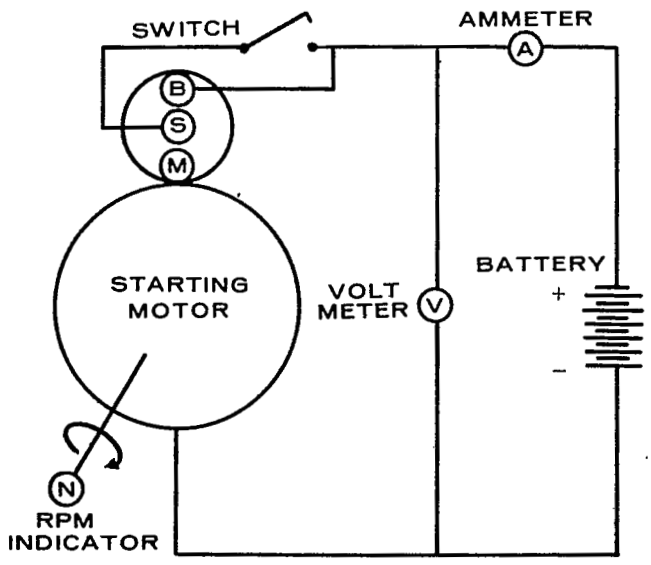


FIGURE 38. WIRING STARTER FOR NO LOAD TESTS

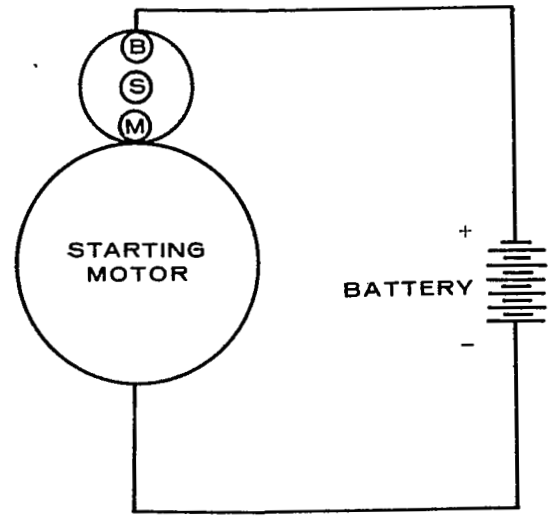


FIGURE 39. BATTERY CONNECTIONS

2. To adjust pinion clearance, connect the battery to the starting motor as shown in Figure 39. This will allow the pinion of the starting motor to slide and stop. In this state, measure the clearance between the end of the pinion and pinion stop when the pinion is pushed lightly toward the commutator end. Clearance should be 0.02 to 0.06 inch (0.51 to 1.52 mm). Adjust for proper clearance by removing the solenoid switch attaching screws and select the proper thickness of the fiber packings shown in Figure 40.

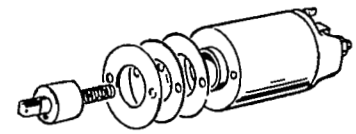


FIGURE 40. ADJUSTING PINION CLEARANCE

OIL SYSTEM

PRESSURE LUBRICATION

The NHA and NHB engines use an oil pump to lubricate engine parts (Figure 41). If oil pressure is low, the pump should be checked.

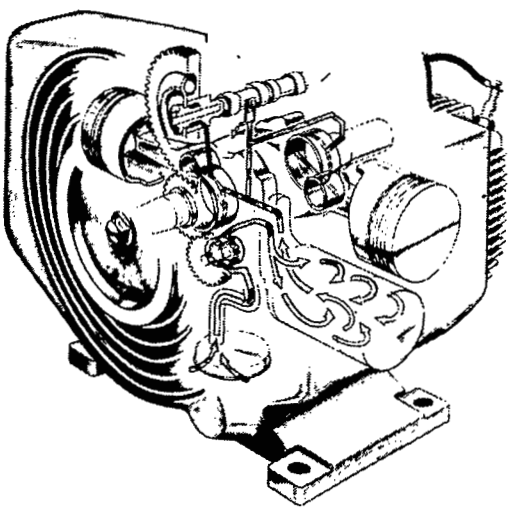


FIGURE 41. OIL SYSTEM

OIL PUMP

The oil pump (Figure 42) is mounted on the front of the crankcase behind the gear cover and is driven by the crankshaft gear.

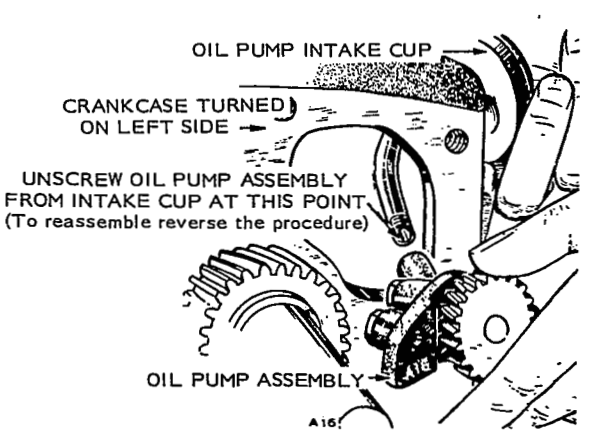


FIGURE 42. OIL PUMP ASSEMBLY

The inlet pipe and screen assembly is attached directly to the pump body. A discharge passage in the cover of the pump registers with a drilled passage in the crankcase. Parallel passages distribute oil to the front main bearing, rear main bearing and pressure control bypass valve. The oil overflow from the bypass valve furnishes lubrication to the camshaft drive gears.

Circumferential grooves in the main bearings supply oil to the connecting rod bearings through drilled passages from each main journal.

A drilled passage connects the front main bearing oil supply to the front camshaft bearing. The flyball governor is lubricated by a drilled passage in the front camshaft journal.

Normal oil pressure should be 30 psi (200 kPa) or higher when the engine is at operating normal temperature. If pressure drops below 30 psi (200 kPa) at governed speed, inspect the oil system for faulty components.

Check the oil pump thoroughly for worn parts. Oil the pump to prime it before reinstalling. Except for gaskets and suction cup, the component parts of the pump are not available individually. Install a new pump assembly if required.

If new oil pump gaskets are installed, they should be the same thickness as those removed. A gasket kit with various thickness gaskets is available.

OIL BYPASS VALVE

The bypass valve (located to the right and behind gear cover, Figure 43), controls oil pressure by allowing excess oil to flow directly back to the crankcase. Normally the valve begins to open about 30 psi (200 kPa).

The valve is nonadjustable and normally needs no maintenance. To determine if abnormal (high or low) oil pressure is caused by a sticky plunger, inspect as follows:

1. Remove 3/8" - 24 x 1 inch capscrew located behind gear cover and under governor arm.
2. Remove spring and plunger with a magnet tool. Clean plunger and spring with a suitable solvent and reinstall.

To remove the valve, unscrew the recessed plug in the rear bearing plate and lift out the spring and plunger.

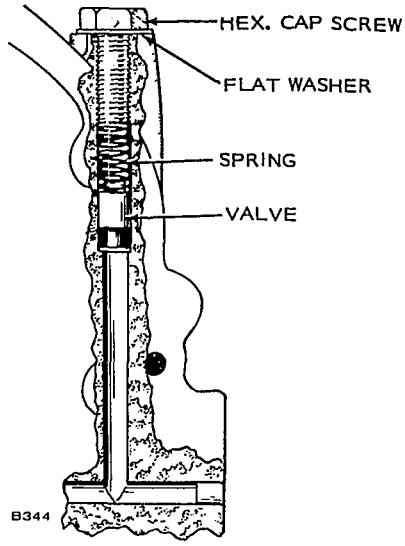


FIGURE 43. BYPASS VALVE

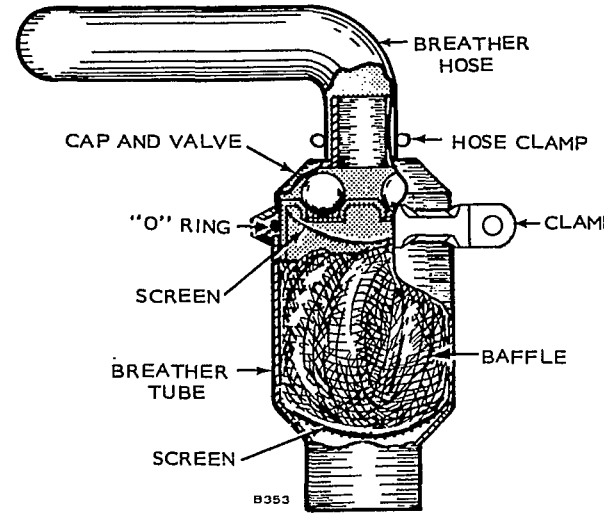


FIGURE 44. CRANKCASE BREATHER

assembly. Determine proper valve operation by checking the spring and plunger according to the following measurements.

Plunger Diameter ..... .3105 to .3125 (7.89 to 7.94)

Spring
Free Length ..... 1 in. (25.4 mm)
Load (compressed to .5 in.) ..... 2.6 ± .2 lbs.

CRANKCASE BREATHER

The crankcase breather maintains a partial vacuum in the crankcase during operation to control oil loss and ventilate the crankcase, Figure 44. To disassemble, remove the rubber cap fromthe crankcase tube and pry the valve out of the cap. Wash the valve in a petroleum-base solvent at regular intervals and, if defective, replace it. Also, pull the baffle out of the breather tube and clean it. Install the valve with the perforated disk toward the engine.

WARNING **Use extreme care when cleaning with a petroleum-base cleaner due to fire hazard.**

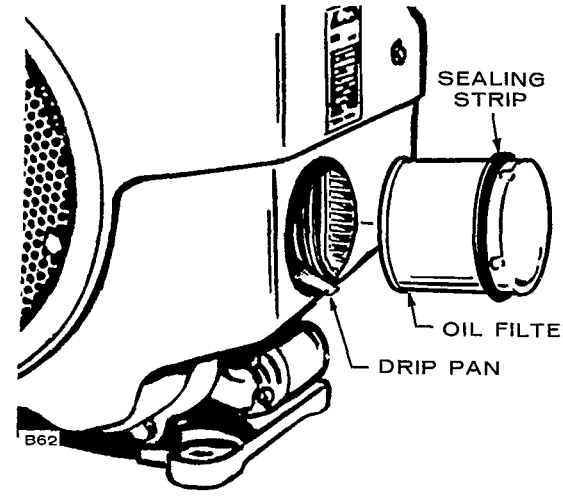


FIGURE 45. OIL FILTER

OIL FILTER

The full-flow filter (Figure 45) is mounted on the filter plate at the left front corner of the crankcase. Replace normally after every 200 hours of operation. Remove the filter by turning counterclockwise. Lubricate the gasket on the new filter with engine oil. Install the filter until the gasket touches the base and tighten a half turn. Do not overtighten.

Engine Disassembly

DISASSEMBLY/ASSEMBLY

When complete engine disassembly is necessary, first remove all complete assemblies. Individual assemblies such as fuel pump and carburetor can be disassembled and repaired at another time.

Suggested Disassembly Order

1. Drain crankcase.
2. Disconnect all exhaust lines and electrical lines.
3. Remove engine from its mountings and place on a suitable bench or work stand.
4. Remove all housings, shrouds, blower housings, etc.
5. Remove flywheel, using a puller. Remove flywheel key.
6. Remove the gear cover, being careful to protect the oil seal from keyway damage.
7. Remove the crank gear, Using a gear puller and ring.
8. Remove all accessories such as oil filter, starter, intake manifold, fuel lines, spark plugs, etc.
9. Remove breaker point box.
10. Remove oil base, oil pump, and cylinder heads.
11. Remove valves, springs, lifters, etc.
12. Remove camshaft and gear assembly.
13. Remove connecting rods and pistons.
14. Remove rear bearing plate.
15. Remove crankshaft.
16. Remove front bearing.

Keep all parts in their respective orders. Keep tappet and valve assemblies together. Return rod caps to their respective pistons. Analyze the reasons for parts failure.

Suggested Assembly Procedure

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

1. Install front main bearing in cylinder block.
2. Insert rear main bearing in rear bearing plate.
3. Insert crankshaft and rear bearing plate.
4. Install crank gear.
5. Install piston and connecting rods.
6. Install camshaft and gear assembly; align crank gear mark with cam gear mark.
7. Install valve assemblies.
8. Install oil pump, oil base, and cylinder heads.
9. Install breaker point box.
10. Install all accessories, such as oil filter, starter, fuel lines, and spark plugs.
11. Install gear cover and oil seal.
12. Install flywheel.
13. Set breaker points to obtain proper timing.
14. Check valve clearance.
15. Install all housings and air cleaner.
16. Fill crankcase with oil.

Operation

Start engine and check oil pressure. Run for approximately 15 minutes to bring engine to operating temperature. Check for oil leaks, fuel leaks, and exhaust leaks. Adjust carburetor and governor for speed and sensitivity.

Tappet Adjustment

The engine is equipped with adjustable valve tappets. The valve tappet clearance should be checked and adjusted, if necessary, at least every 200 operating hours or when poor engine performance is noticed. Adjust the valve clearance only when engine is at ambient temperature. Proceed as follows:

1. Remove ignition key to prevent accidental starting.
2. Remove all parts necessary to gain access to valve tappets.
3. Remove spark plugs to ease the task of turning the engine over by hand.
4. 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.

5. Clearances are given in *Specifications Section.* For each valve, the gauge should just pass between the valve stem and valve tappet (Figure 51).
6. To correct the valve clearance, turn the adjusting screw as needed to obtain the right clearance. The screw is self locking.
7. To adjust valves on the right hand cylinder, turn engine one complete revolution. Then line up mark on the flywheel and the TC mark on the gear cover. Follow adjustment procedure given for left hand cylinder.
8. Replace all parts removed. Tighten all screws securely. Torque manifold bolts.

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 bar 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 valve spring locks, which are of the split type. 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 one. Refer to Figure 53.

An optional valve stem seal is used on the intake valve guides of some engines. This seal must be replaced each time the valve is removed.

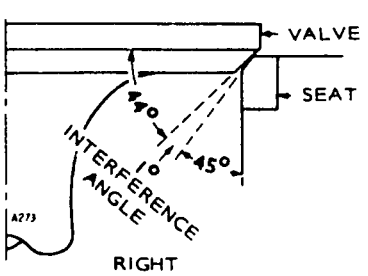
Worn valve stem guides may be replaced from inside the valve chamber. Valve locks are split, tapered type, of which the smaller diameter must face toward the valve head. Tappets are also replaceable from the valve chamber, after first removing the valve assemblies.

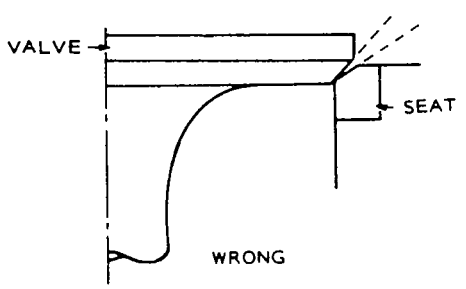
The valve *face* angle is 44 degrees. The valve *seat* angle is 45 degrees. This 1-degree interference angle results in a sharp seating surface between the valve and the top of the valve seat. The interference angle method of grinding valves minimizes face deposits and lengthens valve life.

The valves should not be hand lapped, if at all avoidable, because the sharp contact may be destroyed. This is especially important where chrome-cobalt faced valves and seats are used. Valve faces should be finished in a machine 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 (0.79 to 1.2 mm) wide. Grind only enough to assure proper seating.

Remove all grinding compound from engine parts and place each valve in its proper location. Check each valve for a tight seat, using an air pressure testing tool. If such a tool is not available, use machinist blueing or a felt tip pen to mark the valve face and observe if the marks rub off uniformly when the valve is rotated part of a turn against the seat. Lightly oil the valve stems and assemble all parts removed.

The positive type valve rotators prolong valve life and decrease valve repairs. When functioning properly, the valve is rotated a fraction of a turn each time it opens. While at open position, the valve must rotate freely. If rotators are faulty, install new rotators.





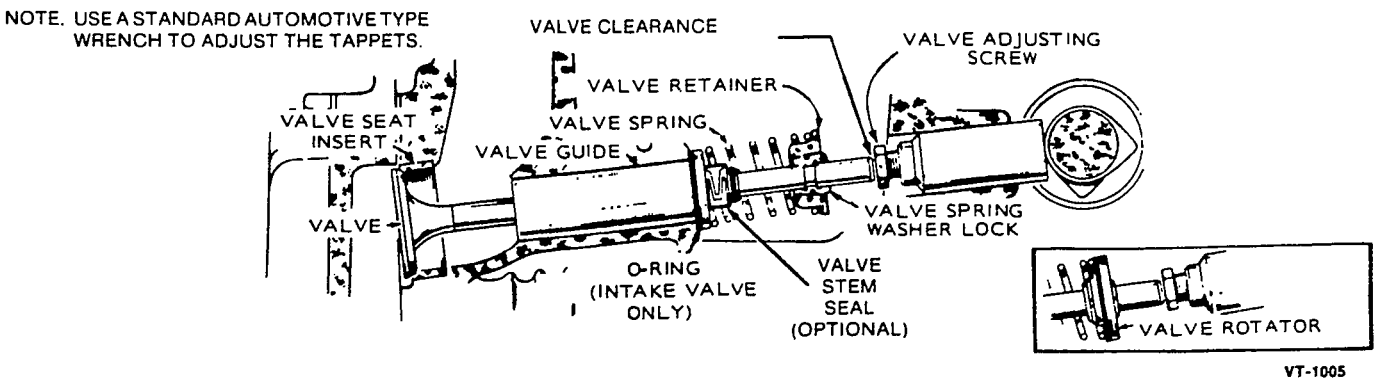


FIGURE 53. VALVE ASSEMBLY

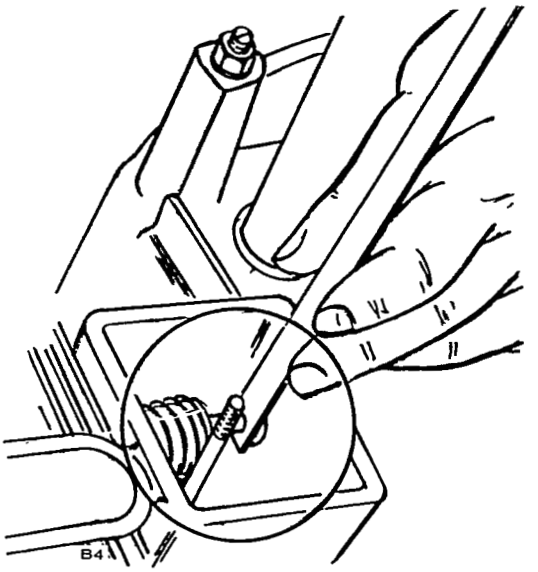


FIGURE 54. VALVE ADJUSTMENT

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.

CAUTION ***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 on the flywheel.
3. Turn the puller capscrews 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.

GEAR COVER

After removing the mounting screws, tap the gear cover gently with a soft faced hammer to loosen it (see Figure 55). Make certain flywheel key is removed from crankshaft before removing gear cover.

When installing the gear cover, make sure that the pin in the gear cover engages the nylon lined (smooth) hole in the governor cup. Turn the governor cup so that the nylon lined hole is at the three o'clock position. Use a small amount of grease to assist in holding governor cup in 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.

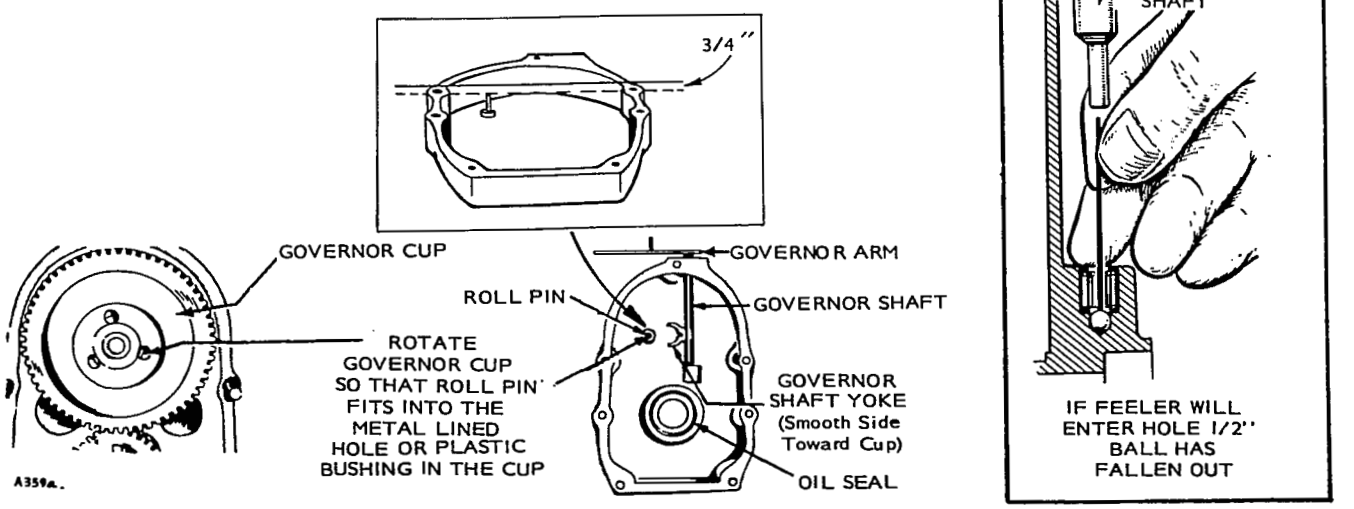
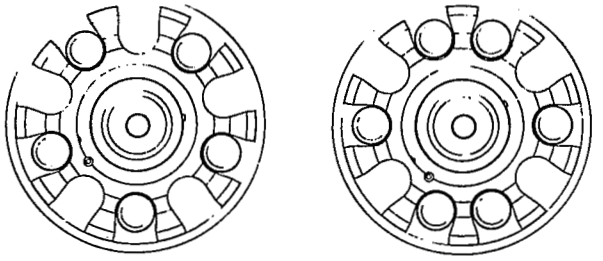
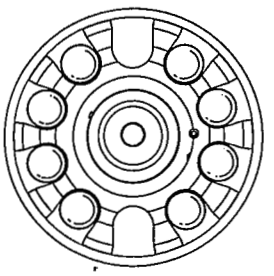


FIGURE 55. GEAR COVER ASSEMBLY



5 BALL GOVERNOR

6 BALL GOVERNOR



8 BALL GOVERNOR

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FLYBALL LOCATIONS

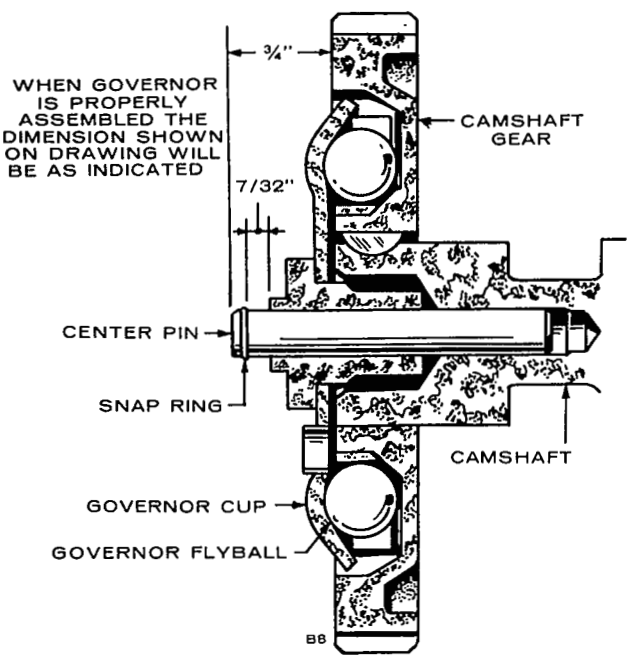


FIGURE 56. GOVERNOR CUP DETAILS

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 (Figure 56).

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. Put the flyballs in place (equally spaced), and install the cup and snap ring on the center pin.

The camshaft center pin extends out 3/4 inch (19 mm) from the end of the camshaft. This distance provides an in-and-out travel distance of 7/32 inch (5.6 mm) for the governor cup, as illustrated. Hold the cup against the flyballs when measuring. 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. If the distance is less than 7/32 inch (5.6 mm), the engine will race, especially at no-load. Remove the center pin and press in a new pin.

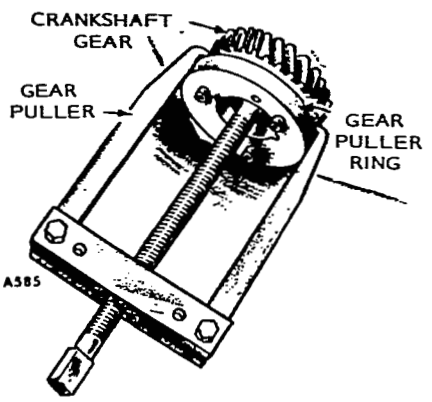
TIMING GEARS

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

The camshaft and gear must be removed 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.

To remove the crankshaft gear, first remove the snap ring and retainer washer. Then attach the gear pulling ring, using two No. 10-32 screws (Figure 57). Tighten the screws alternately until both are tight. Attach a gear puller to the puller ring and proceed to remove the gear.

Each timing gear (crankshaft and cam) 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.



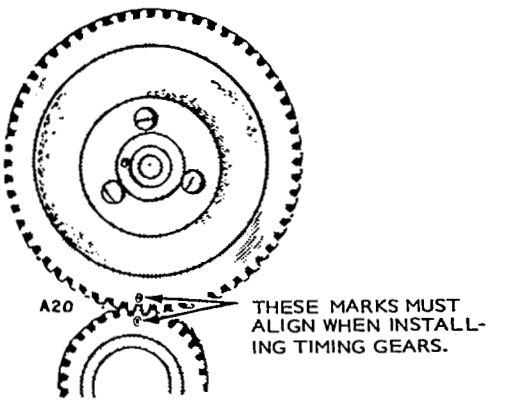


FIGURE 57. TIMING GEAR REMOVAL AND INSTALLATION

PISTONS AND CONNECTING RODS

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

1. Drain oil.
2. Remove the cylinder head and oil base pan from the engine.
3. Remove carbon from top of cylinder bore and check for a ridge. Remove ridge (Figure 58) with a ridge reamer before attempting piston removal.

CAUTION ***Using a ridge reamer to remove carbon can cause damage to cylinder bore.***

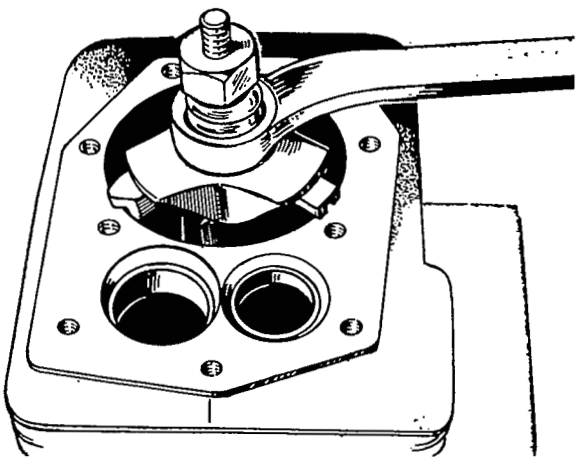


FIGURE 58. REMOVING RIDGE FROM CYLINDER

CAUTION ***Forcing the piston from the cylinder before reaming may cause damage to the piston lands and break rings.***

4. Turn the crankshaft until the piston is at the bottom of its stroke, and remove the connecting rod nuts. 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.

Mark each piston and rod assembly so they can be returned to their respective cylinders after overhual. 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 59. Remove the piston pin retainer and push the piston pin out.

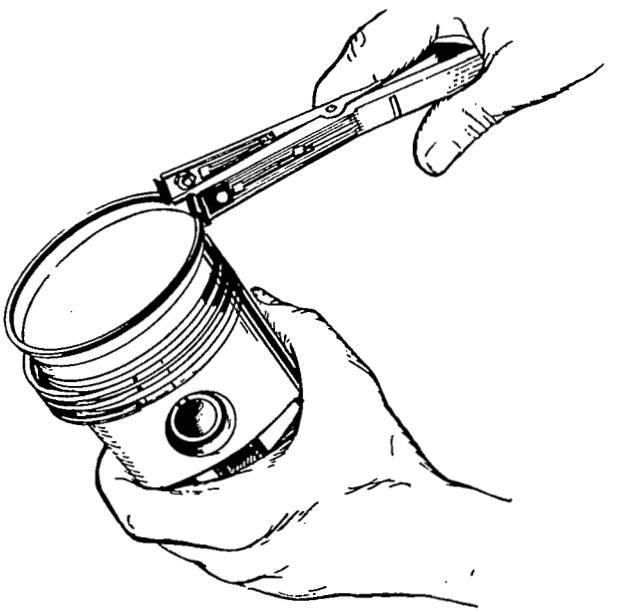


FIGURE 59. REMOVING PISTON RINGS

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 60). Care must be taken not to remove metal from the groove sides or bottom.

CAUTION ***Do not use a caustic cleaning solvent or wire brush for cleaning pistons. These materials will cause piston damage.***

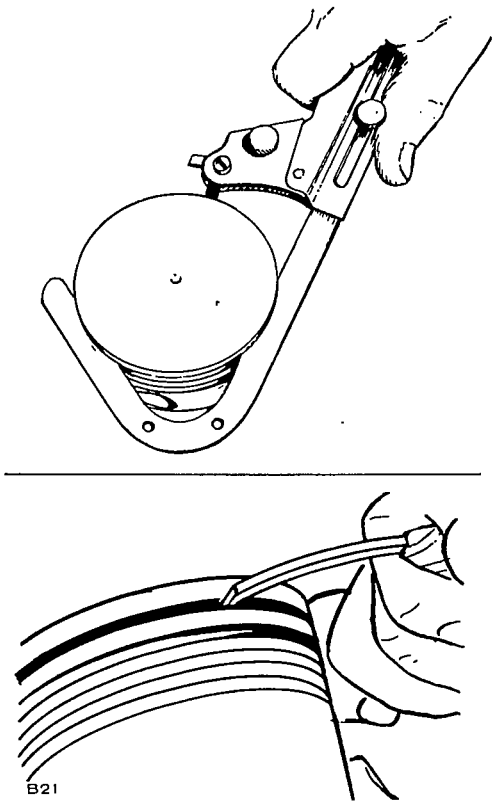


FIGURE 60. PISTON GROOVE CLEANING

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

Engines that have been fitted with 0.005 inch (0.13 mm) oversize pistons at the factory are identified by the letter E after the serial number. Number is stamped on the cylinder block and on the unit nameplate.

Inspection

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

Piston Inspection:

1. 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 61. Replace the piston when the side clearance of the top compression ring reaches 0.006 inch.

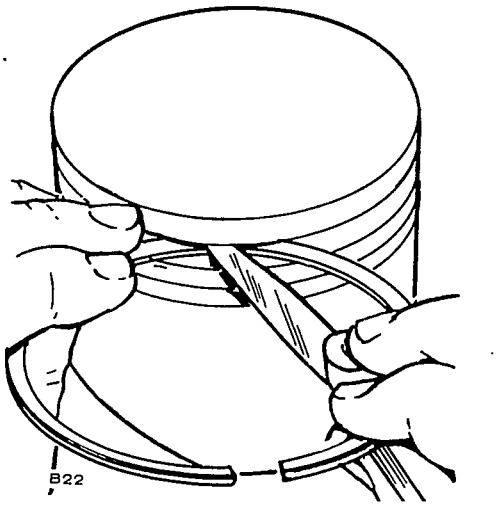


FIGURE 61. CHECKING RING SIDE CLEARANCE

2. Replace pistons showing signs of scuffing, scoring, worn ring lands, fractures, or damage from pre-ignition. Excessive piston wear near the edge of the top ring land indicates pre-ignitiion.
3. Proper piston tolerances must be maintained for satisfactory operation.
4. Measure the piston to cylinder clearance, as shown in Figure 62, to be sure the total clearance follows specifications.

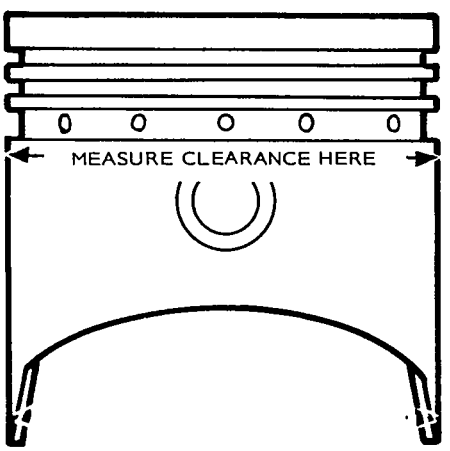


FIGURE 62. MEASURING PISTON CLEARANCE

Connecting Rod Inspection:

1. Replace connecting rod bolts and 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.
2. 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.

Piston Rings:

1. 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. This trues the ring end gap. Check the gap with a feeler gauge as shown in Figure 63.
2. 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 correctness of ring and bore sizes. A cylinder bore that is 0.001 inch (0.03 mm) under size will reduce the end gap 0.003 inch (0.08 mm).

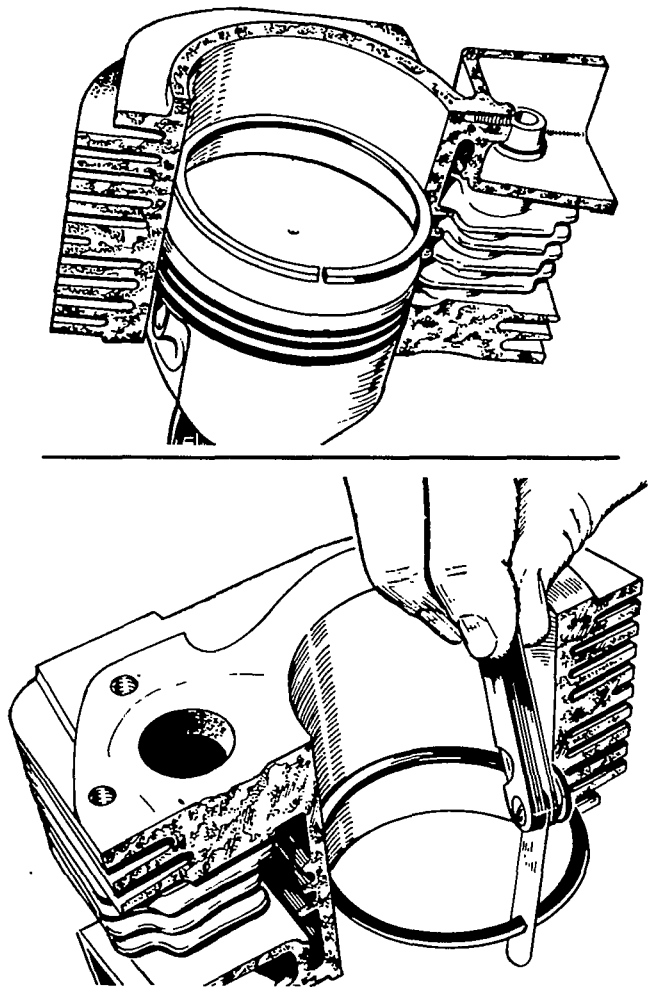


FIGURE 63. POSITIONING OF PISTON RING AND MEASURING OF END GAP

CYLINDER BLOCK

The cylinder block is the main support for all other basic engine parts. Crankshaft and camshaft are supported by the block, assuring alignment of the crankshaft and cylinder bores.

Cleaning

After removing pistons, crankshaft, cylinder heads, etc., inspect block for cracks and extreme wear. If block is still serviceable, prepare it for cleaning as follows:

1. Scrape all old gasket material from block. Remove oil by-pass to allow cleaning solution to contact inside of oil passages.
2. Remove grease and scale from cylinder block by agitating in a bath of commercial cleaning solution or hot soapy washing solution.
3. Rinse block in clean hot water to remove cleaning solution.

Inspection

When rebuilding the engine, thoroughly inspect block for any condition that would make it unfit for further use. This inspection must be made after all parts have been removed and block has been thoroughly cleaned and dried.

1. Make a thorough check for cracks. Minute 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. Always replace a cracked cylinder block.
2. Inspect all machined surfaces and threaded holes. Carefully remove any nicks or burrs from machined surfaces. Clean out tapped holes and clean up any damaged threads.
3. Check top of block for flatness with a straight edge and a feeler gauge.

Cylinder Bore Inspection: Inspect cylinder bores for scuffing, scratches, wear, and scoring. If cylinder bores are scuffed, scratched, scored, or worn, they must be rebored and honed for the next oversize piston.

When the appearance of cylinder bores is good and there are no scuff marks, check cylinder bore for wear or out of roundess as follows:

1. Check cylinder bore for taper, out of round, and wear with a cylinder bore gauge, telescope gauge or inside micrometer. These measuremets should be taken at four places, top and bottom of piston ring travel, parallel and perpendicular to axis of crankshaft.
2. Record measurements taken at top and bottom of piston travel as follows (see Figure 64):

A. Measure and record as "A" the cylinder bore diameter (parallel to crankshaft) near the top of cylinder bore where greatest amount of wear occurs.

B. Also measure and record as "B" cylinder bore diameter (parallel to crankshaft) at the bottom of piston travel.

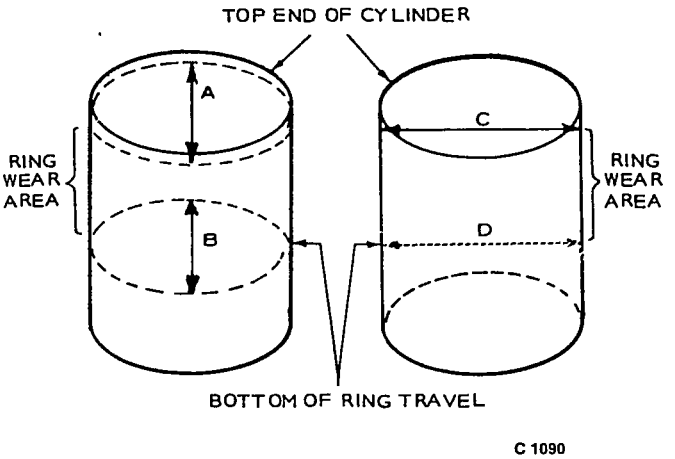
C. Measure and record as "C" cylinder bore diameter (perpendicular to crankshaft) near the top of cylinder bore where greatest amount of wear occurs.

D. Also measure and record as "D" cylinder bore diameter (perpendicular to crankshaft) at the bottom of piston travel.

E. Reading "A' subtracted from reading "B" and reading "C" subtracted from reading "D" indicates cylinder taper.

   If cylinder taper exceeds 0.003 inch (0.08 mm), rebore and hone cylinder to the next oversize.

F. Reading "A" compared to reading "C" and reading "B" compared to reading "D" indicate whether or not cylinder is out of round. If out of round exceeds .003 inch (0.08 mm), the cylinders must be rebored and honed to the next oversize. A reboring machine is used when going to oversize pistons. The following repair data covers honing to oversize by use of a hone.



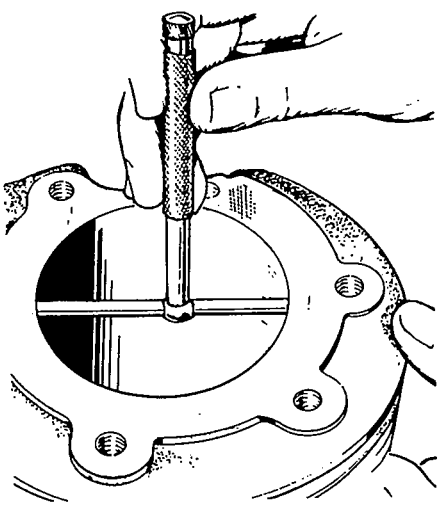


FIGURE 64. METHODS OF MEASURING THE DIAMETER OF A CYLINDER BORE

Reboring the Cylinder

Rebore and hone engine whenever cylinder bore is worn, damaged, out of round, or if cylinder taper exceeds specifications. A worn cylinder bore should be resized to the smallest standard oversize diameter at which it will clean up. The final finish and bore diameters should then be obtained by honing.

CAUTION ***If boring bar is operated incorrectly, it will produce a rough cylinder surface that may not clean up even when honed. Boring should be done only by qualified service personnel who are careful in their work.***

After boring to the correct oversize cylinder bore dimension piston and ring clearance should be appropriate. There is no need to adjust or "fit" pistons and rings.

When reboring cylinders, take the following precautions:

1. Make sure cutting tool is properly ground before using it.
2. Be sure top of engine block is smooth and deposit free.

3. Clean base of boring bar before bar is set up. Deposits under boring bar will cause it to tilt, and the cylinder will be distorted after boring.

4. Make an initial rough cut, followed by a finish cut. Then hone cylinder bore to the specified oversize.

Honing Cylinders (Using Precision Hones)

Refer to hone manufacturer's recommended grit size to produce specified surface finish of 20 to 40 RMS. Too rough of a finish will wear out the rings and too smooth of a finish can retard piston ring seating.

1. Position 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.

2. Follow hone manufacturer's instructions for the use of oil or lubricant on stones. Do not use lubricants with a dry hone.

3. Insert hone in bore and adjust stones to fit snugly to the narrowest section. When adjusted correctly, the hone should not shake or chatter in cylinder bore, but will drag freely up and down when hone is not running.

4. Connect drill to hone and start drill. Feel out bore for high spots, which cause an increased drag on stones. Move hone up and down in bore with short overlapping strokes about 40 times per minute. Usually bottom of cylinder must be worked out first because it is smaller. As cylinder takes a uniform diameter, move hone up and down all the way through cylinder bore.

5. Check diameter of the cylinder regularly during honing. A dial bore gauge is the easiest method, but a telescoping gauge can be used. Check size at six places in bore; measure twice at top, middle and bottom at 90-degree angles.

6. Crosshatch formed by the stones should form an included angle of 23 degrees. This can be achieved by moving the rotating hone (250 to 450 rpm) up and down in cylinder bore about 40 times per minute.

7. Clean cylinder bores thoroughly with soap, water, and clean rags. A clean white rag should not become soiled on wall after cleaning is complete. Do not use a solvent or gasoline, since they wash oil from the walls but leave metal particles.

8. Dry crankcase and coat it with oil.

Deglazing Cylinder Bores

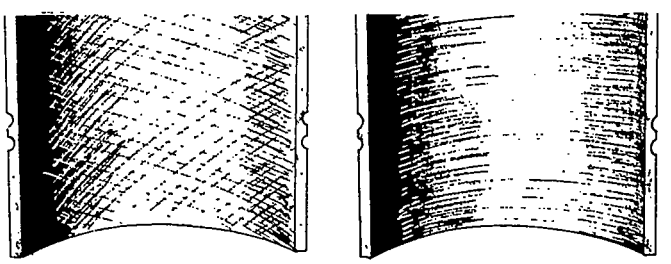
Deglaze the cylinder bores if there are no scuff marks and no wear or out of round beyond specifications before installing new rings. Deglazing gives a fine finish but does not enlarge cylinder diameter, so the original pistons with new rings may still be used.

The reason for deglazing a cylinder is to provide cavities to hold oil during piston ring break-in.

1. Wipe cylinder bores with a clean cloth which has been dipped in clean, light engine oil.

2. Use a brush type deglazing tool with coated bristle tips to produce a crosshatch pattern in the cylinder bore.

3. The deglazing tool should be driven by a slow speed drill. Move deglazing tool up and down in cylinder (10 to 12 complete strokes) rapidly enough to obtain a crosshatch pattern as shown in Figure 65.



PRODUCE CROSS HATCH SCRATCHES FOR FAST RING SEATING

AVOID THIS FINISH

C-1091

FIGURE 65. CROSS HATCHING

CAUTION ***Never use gasoline or commercial cleaners to clean cylinder bores after deglazing or honing. These solvents will not remove abrasives from the walls. Abrasives not removed from engine will rapidly wear rings, cylinder walls, and bearing surfaces of all lubricated parts.***

4. Clean cylinder bore thoroughly with soap, water, and clean rags. Continue cleaning until a clean white rag shows no discoloring when wiped through cylinder bore.

CRANKSHAFT

Inspect the bearing journals. If they are scored and cannot be smoothed out by dressing down, the bearing journals should be refinished to use nearest available undersize bearings or a new crankshaft should be installed. If a worn main bearing journal cannot be fitted with an available precision type undersize bearing, then refinish it to the next undersize. If a worn rod journal cannot be fitted by installing new bearing inserts (forged rod), then refinish it to take the next corresponding undersize bearing insert available.

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.

Shot Peening: On older model engines, shot peening is required to prevent failures. When the shaft is machined, follow the data to shot peen each crankpin fillet.

1. Almen gauge reading: 0.012A
2. Mask off connecting rod bearing areas.
3. Peen with 0.019 inch (0.49 mm) diameter cast steel shot.
4. Peen for 30 seconds on each crankpin fillet.

Undersize bearings and connecting rods are available to rework the shaft to 0.010, 0.020, and 0.030 inch undersize.

BEARINGS

Removal of the 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 to avoid damaging the bearing bore during removal and installation. Use oil on the bearings to reduce friction when installing, and lubricate again with oil after installing (Figure 66). Use combination bearing driver 420-0324 to install the camshaft bearings.

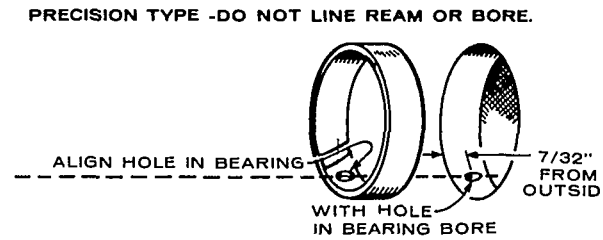


FIGURE 66. CAMSHAFT BEARING

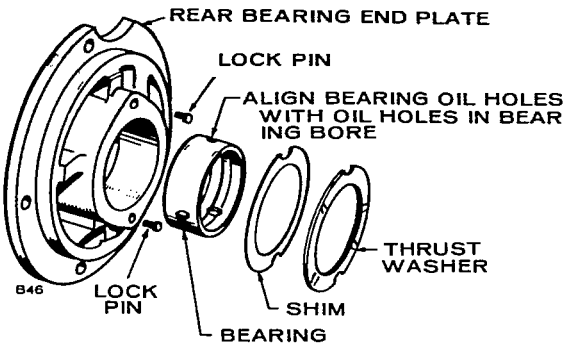
Replacement camshaft bearings are precision type which do not require line reaming or line boring after installation. Coat the bearing with lubricating oil to reduce friction. Place the bearing on the crankcase over the bearing bore with the lubricating hole (front only) in proper position. Be sure to start the bearing straight. Press in the front bearing flush with the outside end of the bearing bore. Front cam bearing oil hole must line up with oiling hole in cylinder block. Press in the rear bearing until past the ignition plunger hole.

New crankshaft main bearings are precision type which *do not* require line reaming or line boring after installation. They are available in standard size, 0.002, 0.010, 0.020, or 0.030 inch undersize.

Before putting in the main bearings, expand the bearing bore by placing the casting in hot water or in an oven heated to 200°F (94°C). If practical, cool the precision bearing to shrink it.

CAUTION ***If a torch is used, apply only a little heat. Distortion will result from too much local 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 (Figures 67 and 68). The oil passage must be at least half open. The cold precision bearing should require only light taps with a driving tool to position it. In the rear bearing plate, install the bearing flush to 1/64 inch (0.40 mm) below the end of the bore. If head of lock pin is damaged, use side cutters or Easy Out tool to remove and install new pin. 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.

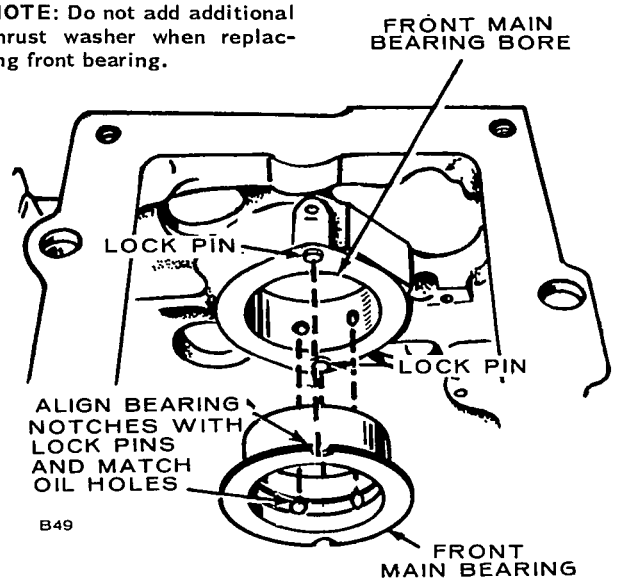


PRECISION TYPE- DO NOT LINE REAM OR BORE

FIGURE 67. BEARINGS FOR REAR BEARING PLATE

Engines shipped from the factory have separate thrust washers and main bearings for both front and rear of engine. Front bearing replacement part is a one piece bearing (with attached thrust washer) as shown in Figure 68. Do not add an additional thrust washer to this front bearing.

NOTE: Do not add additional thrust washer when replacing front bearing.



PRECISION TYPE-
DO NOT LINE BORE OR REAM OR BORE

FIGURE 68. FRONT BEARING INSTALLATION

Before installing the front bearing, use the Locktite Bearing Mount furnished in the bearing kit. Use the towelette in the package to clean the outside of the bearing and the bearing bore in the block.

CAUTION ***Breathing vapor from towelette and prolonged contact with skin can be harmful. Be sure area is well ventilated.***

After allowing three to four minutes for drying, apply the Locktite Bearing Mount from the small tube to the mating surfaces of the bearing and bearing bore. Install the bearing flush with the block, using the combination driver just used for the rear bearing. Wipe off any excess Locktite around the bearing. Allow at least one hour for hardening at room temperature.

Lubricate the front main bearing lightly with oil and insert the crankshaft. With the rear bearing plate gasket in place and the rear plate bearing lubricated, slide the thrust washer (grooves toward crankshaft) and plate over the end of the crankshaft. Line up notches of thrust washer with lock pins before tightening end plate or lock pins will be damaged.

A light film of oil on the thrust washer may hold it in place while installing the crankshaft.

CRANKSHAFT ENDPLAY

After the rear bearing end plate has been tightened, using the torque recommended in *Assembly Torques and Special Tools,* check the crankshaft endplay as shown in Figure 69. 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 (Figure 67) 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.

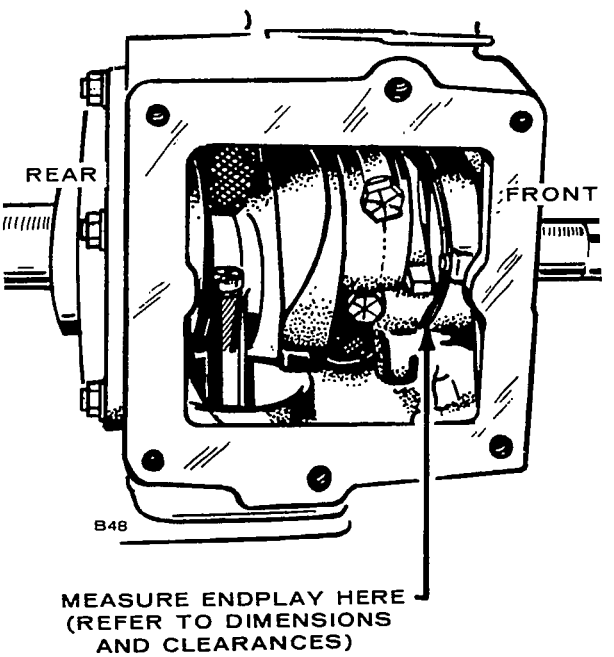


FIGURE 69. CRANKSHAFT ENDPLAY

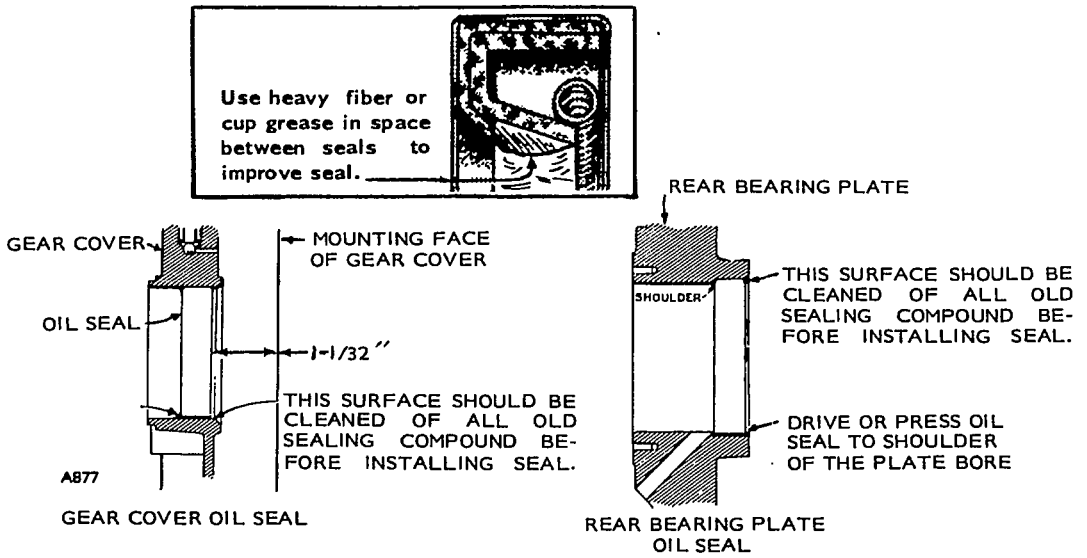


FIGURE 70. GEAR COVER AND REAR BEARING PLATE OIL SEALS

OIL SEALS

The bearing plate must be removed to replace its oil seal. Drive the oil seal out from the inside, using bearing plate driver and gear cover driver.

Before installing the seals, fill the space between seals with a fibrous grease or stiff cup grease. This will improve sealing. See Figure 70.

When installing the gear cover oil seal, press the seal inward until it is 1-1/32 inch (26.2 mm) from the mounting face of the cover. Install new style, thin open face seal, 1-7/64 inches (28.18 mm) from mounting face of cover.

When installing the bearing plate oil seal, press 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.

Engines equipped with some types of reduction gear assemblies do not use the rear oil seal. The reduction gear assembly is oiled directly from the engine crankcase. Refer to the instructions screened on the case of the reduction gear assembly.

OIL PUMP

To remove the oil pump, it is necessary to detach the intake cup asembly as shown in Figure 71.

Check the oil pump thoroughly for worn parts. Oil the pump to prime it before installing. Except for gaskets, the component parts of the pump are not available individually. The suction cup is available separately. Install a new pump assembly, if required.

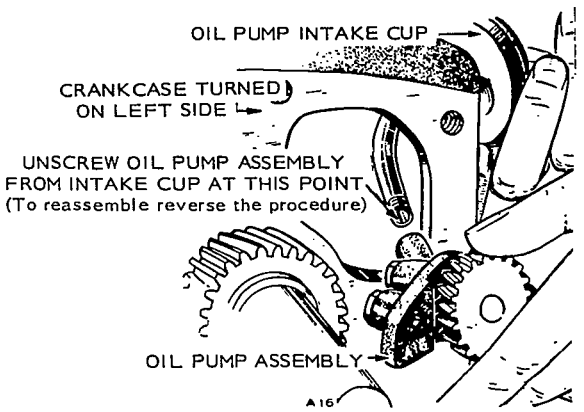


FIGURE 71. OIL PUMP ASSEMBLY

PISTON 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 72). Use a piston ring spreader to prevent twisting or excessive expansion of the ring. 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. The oil control ring has an expander; install the expander first and then close until the expander ends butt. The joint should be 180 degrees from the gap of that ring.

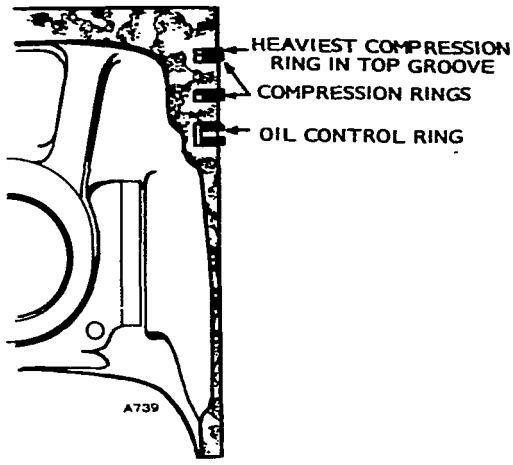


FIGURE 72. PISTON RINGS

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 the inside of the cylinder. Compress the rings with a ring compressor as shown in Figure 73.

3. Position the piston and rod assembly in the cylinder block. Oil hole in connecting rod must face camshaft.

   Rod bolts are off-set toward outside of block.

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 73). Install the bearing cap on the rod. Install and tighten the bolts evenly, in steps, to the specified torques.

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

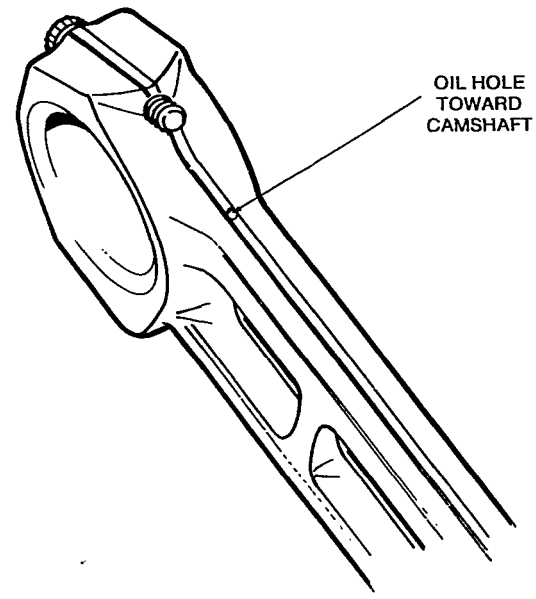
5. Install the remaining piston and rod in the same manner. Crank the engine over by hand to see that all bearings are free.

6. Install oil pump pick up tube and cap.

7. Install the oil base with a new gasket.

8. Install the cylinder heads. See *Cylinder Head* section for torques and torquing procedure.

9. Replace oil and break in engine.



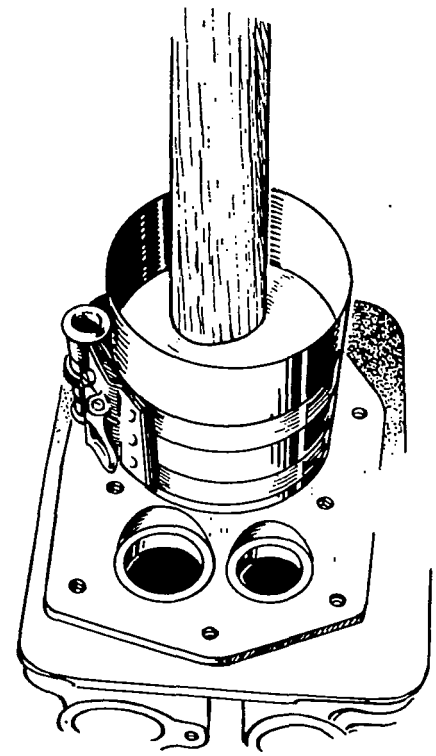


FIGURE 73. INSTALLING PISTON AND CONNECTING ROD

CYLINDER HEAD GASKET REPLACEMENT

Remove the cylinder heads for lead cleaning and gasket change at least every 200 hours, or when poor engine performance is noticed. For engines running on unleaded fuel this interval may be extended to 400 hours.

1. Use a 1/2 inch (13 mm) socket wrench to remove cylinder head bolts. Lift heads off.

   CAUTION ***Do not torque or remove heads when they are hot. Warpage may occur.The gasket surface must be below 100° F before removal. At temperatures above 100° F, the gasket will become gummy and difficult to remove from the surface of the block and cylinder head.***

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 a head gasket on the cylinder head, and align the stud holes in the gasket with the stud holes in the cylinder head. While holding the gasket against the cylinder head, carefully install the cylinder head on the engine. Do not attempt to slide the gasket over the studs without the cylinder head behind it or the gasket may tear.

5. Some engines have two compression washers and one hardened washer on the long cylinder head studs (top 6 studs on each side) as shown in Figure 74. When these washers are used, they must be installed as shown. When properly installed, only the outside edges of the compression washers will be in contact with each other. Install a flat washer and nut on each of the four bottom studs.

6. Follow the head torque sequence shown in Figure 75.

   A. Asbestos head gasket torque procedure:

   Tighten all nuts to 5 ft-lb (7 Nm), then 10 ft-lb (14 Nm), etc. until all nuts are torqued to 18 to 20 ft-lb (24-27 Nm). Recheck all head nuts for correct torque.

   WARNING ***Asbestos gaskets contain fibers that when airborne may be harmful to your health. Use a respirator when handling and installing gaskets.***

   B. *Graphoil head gasket torque procedure:*

   Start out tightening all nuts to 5 ft-lb (7 Nm), then 10 ft-lb (14 Nm), etc., until the correct torque is reached. The top six nuts should be tightened to 12 ft-lb (16 Nm) and the bottom four nuts should be tightened to 15 ft-lb (20 Nm).

   After the head nuts have been tightened once, it will be necessary to tighten each head nut to the specified torque a second time. Follow the same sequence shown in Figure 75. Failure to retorque could result in a blown head gasket.

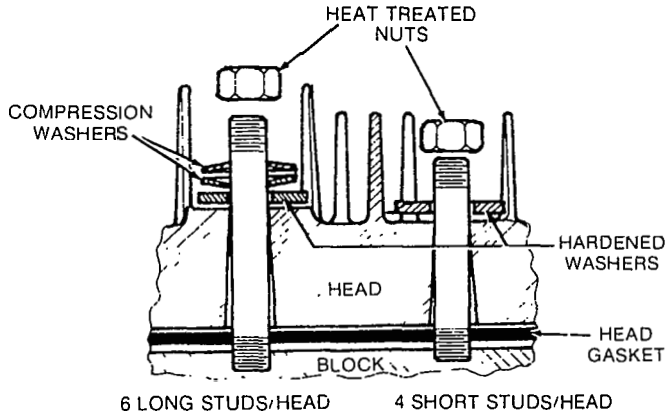


FIGURE 74. CYLINDER HEAD WITH COMPRESSION WASHERS

CAUTION ***Too much torque will flatten the compression washers and could result in engine damage.***

7. Recheck torque before engine has run a total of 50 hours.

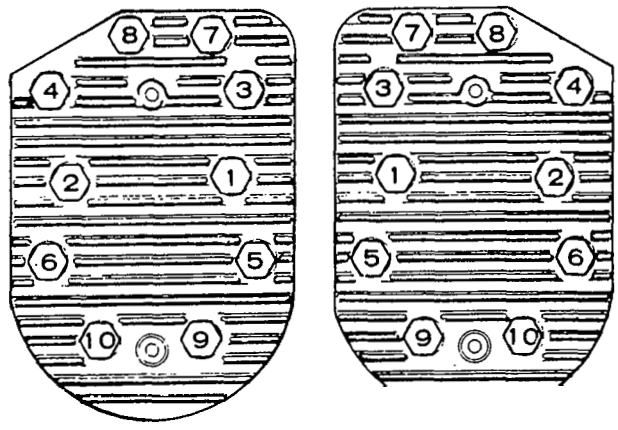


FIGURE 75. HEAD BOLT TIGHTENING SEQUENCE

CYLINDER HEAD STUD TEST AND REPLACEMENT PROCEDURE

This cylinder head stud replacement procedure should be used whenever replacing any of the top six studs on a NHC block. The use of a Helicoil is not a recommended repair procedure. If a Helicoil has been used, the cylinder block must be replaced. Graphoil head and intake manifold gaskets should also be used when replacing cylinder head studs.

Parts Required

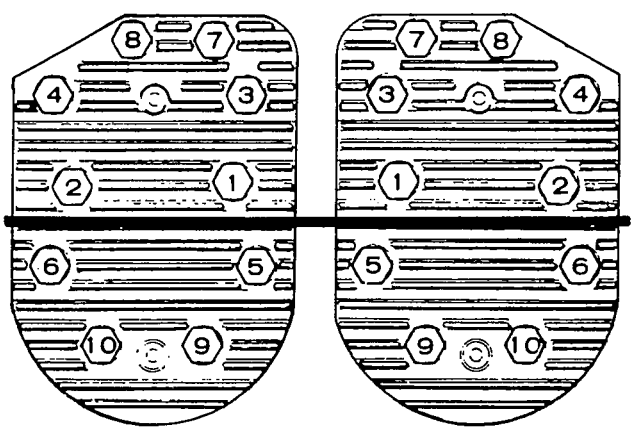
Part No.	Description
520-0912	Step stud
110-2987	Head gasket
154-2219	Intake manifold gasket
420-0398	Drilling fixture (Reusable tool)

1. Disconnect the spark plug wires and remove the spark plugs and cylinder head air shrouds from each cylinder.

2. Remove the nuts and compression washers (do not remove the flatwashers) from the top six studs on each cylinder head (see Figure 76). Each stud will have two compression washers and one flatwasher arranged in the sequence shown in Figure 77.

Do not remove the nuts from the bottom four studs before the test procedure is completed.

USE STUDS SHOWN ABOVE LINE FOR SECTION 1 STUD TEST



LEFT CYLINDER RIGHT CYLINDER

NUMBERS INDICATE CORRECT TIGHTENING SEQUENCE FOR CYLINDER HEAD NUTS

FIGURE 76. CYLINDER HEADS

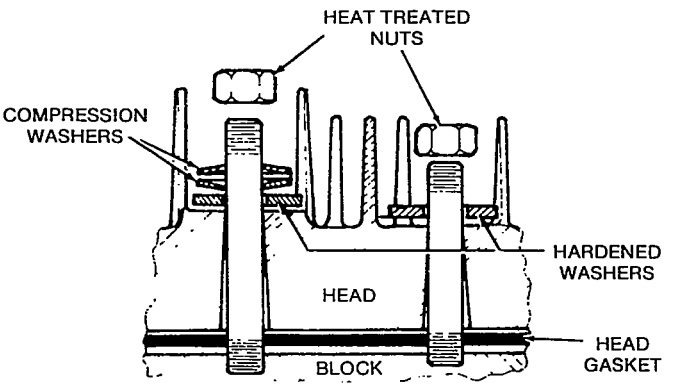


FIGURE 77. CYLINDER HEAD STUDS

3. Replace the nuts and then test the top six cylinder head studs by tightening (use an accurate torque wrench) each nut to 30 ft-lb (40 Nm) of torque. Make a note of any studs that cannot be tightened to 30 ft-lb of torque.

4. Remove the cylinder-head nuts, flatwashers, cylinder head, and head gasket. Discard the head gasket and remove any studs that could not be torqued to 30 ft-lb (40 Nm) without thread pull out.

5. Examine the gasket surfaces of the block and cylinder head for distortion or irregularities that could cause leakage. Check the head and block for warpage by laying a straight edge over the length of the gasket surface. If a 0.005 inch feeler gauge fits between the straight edge and gasket surface, the part must be replaced or milled flat. A maximum of 0.010 inch may be machined from the cylinder block or head.

On some engines, it is possible that a groove from the old head gasket fire ring may be impressed into the head and/or block. If this is the case, it is essential that the part be replaced or milled to remove the imperfection.

If all of the top six studs accepted 30 ft-lb of torque without pulling out, the new head gasket may be put on without replacement of the studs. If this is the case, skip steps 6 through 12.

6. Fit the special repair fixture (Onan Tool #420-0398) to the surface of the block. Use the studs shown in Figure 78 and two cylinder head nuts to secure fixture to head of block.

   Some applications may require that three or four flatwashers be placed over the studs between the block and fixture to space the fixture away from the block. This will be necessary if the fixture does not clear the sheet metal scroll backing plate.

7. Insert the small size bushing into the fixture over the hole(s) with damaged threads and lock it in place. With the bushing as a guide, drill out the damaged threads using a 27/64 size drill bit. If drilling out the holes on the SIDE of the block, drill through to the fourth fin (see Figure 79). If drilling out the holes at the TOP of the block, it will be necessary to remove the corresponding intake or exhaust manifold. The drill bit should penetrate completely into the port but should not contact the opposite wall of the port (see Figure 79).

8. Replace the small bushing with the large bushing and lock into place. Using a 1/2-13 tap, carefully form the threads, making sure there are full threads the entire length of the hole.

9. After all drilling and tapping is completed, remove the special fixture and repeat the same operation on the other cylinder if necessary.

10. Remove the ridge around all new holes using a flat file or a 45° chamfer tool. When using a chamfer tool, the depth of the chamfer should be 1/32 to 1/16 inch deep.

11. Apply screw thread retaining compound (Loctite 242) to the large end of each new step stud. Install the stepped replacement stud, making sure the entire stepped portion is below the gasket surface.

12. When putting a stepped stud into the hole that penetrates into the exhaust port, it will be necessary to cut approximately 3/16 to 1/4 inch (3 threads) off the stepped portion of the stud. No part of this stud may extend into the exhaust port or it will interfere with the exhaust manifold assembly.

13. Turn engine so that both valves are closed. Using a flat scraper and/or wire brush, remove all lead and carbon deposits from the top of the piston, valve area, and cylinder head combustion chamber.

14. Blow out all residual debris and metal chips using low pressure (35 PSI or less) air. If a hole was drilled into either the exhaust or intake port, open the valve on that port and blow it out thoroughly. Replace manifold if removed during the drilling and tapping operations.

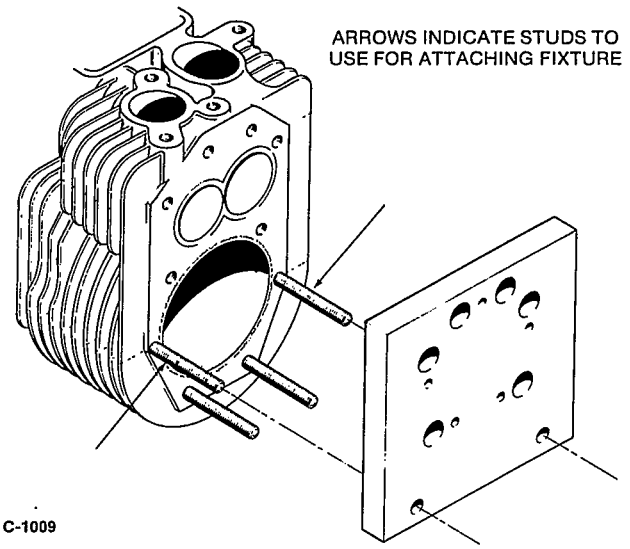


FIGURE 78. REPAIR FIXTURE

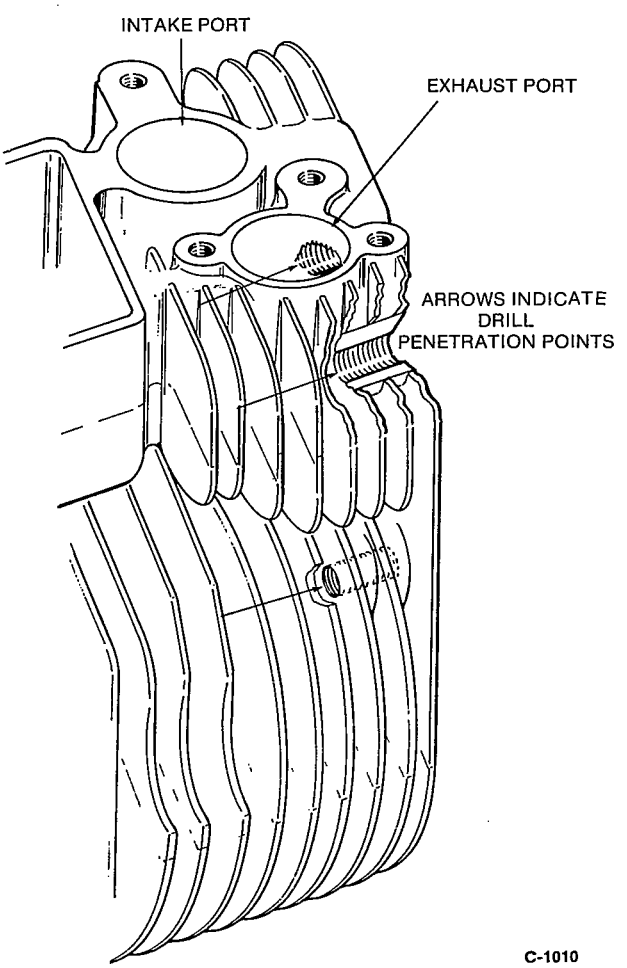


FIGURE 79. DRILLING PROCEDURE

INTAKE MANIFOLD GASKET REPLACMENT

1. Remove the governor control rod from the governor arm and the breather tube from the air cleaner.

2. Remove all dirt from the area around the intake manifold and cylinder head interface. Remove the four bolts holding down the intake manifold assembly, and move the manifold so that it is possible to work on the gasket area.

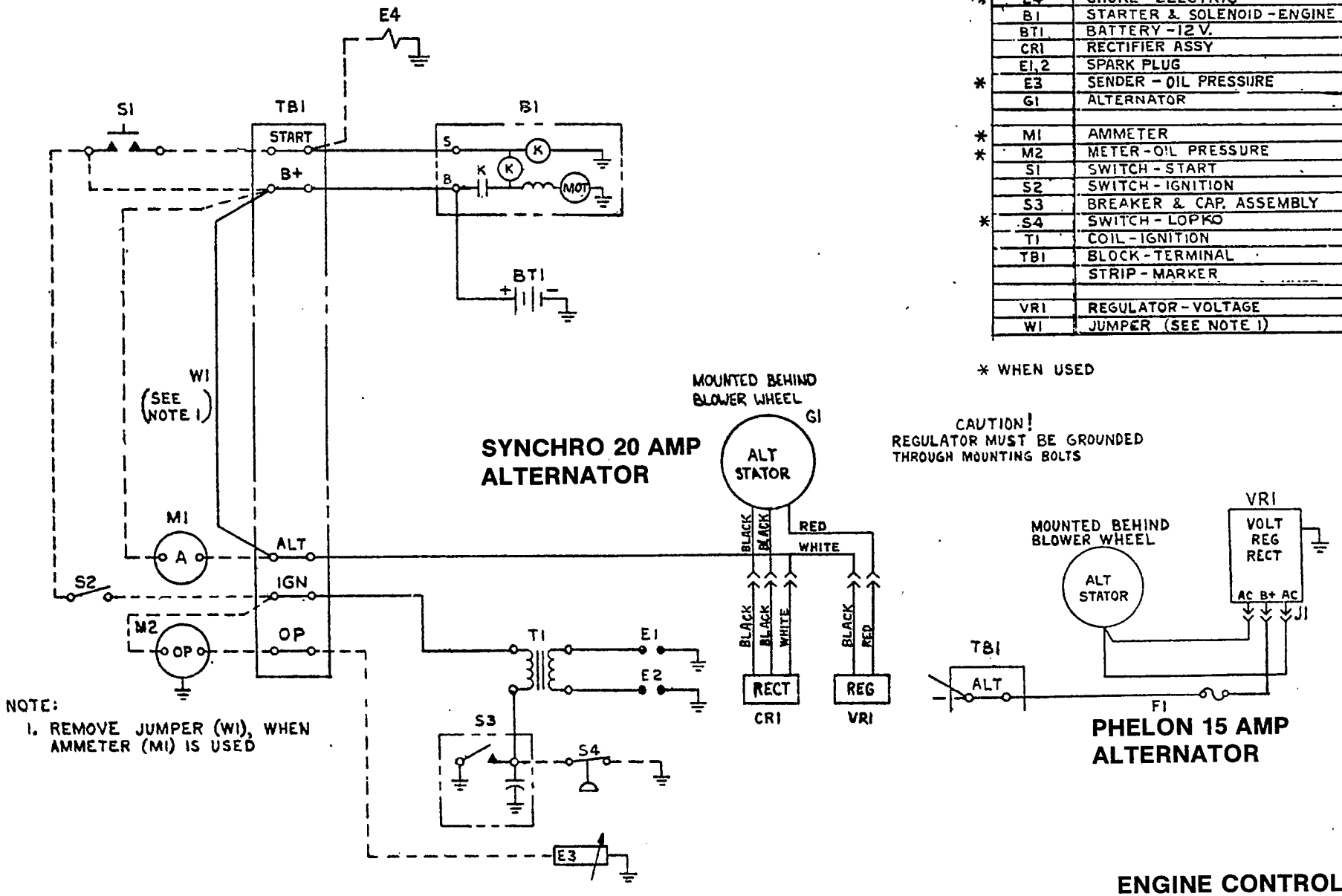
3. Remove the intake manifold gasket. On some models, the intake manifold gasket is tied to the exhaust manifold gasket. In these cases, use a cutting tool (chisel) to separate the intake manifold section of the gasket. Follow the outline of the exhaust manifold as closely as possible when cutting.

4. Install the new intake manifold gasket, making sure it is properly positioned. Make certain the outline of the gasket follows outline of port. Installing the gasket upside down will allow air leakage. This will cause lean operation and allow entry of dirt which will eventually lead to engine destruction.

5. Reinstall the intake manifold tightening the four hold down bolts to 20 to 23 ft-lb (27-31 Nm) of torque.

6. Reattach the governor control rod and air cleaner breather tube.

CAUTION ***Do not reuse any gaskets which have been damaged by tearing, erosion, or galling.***



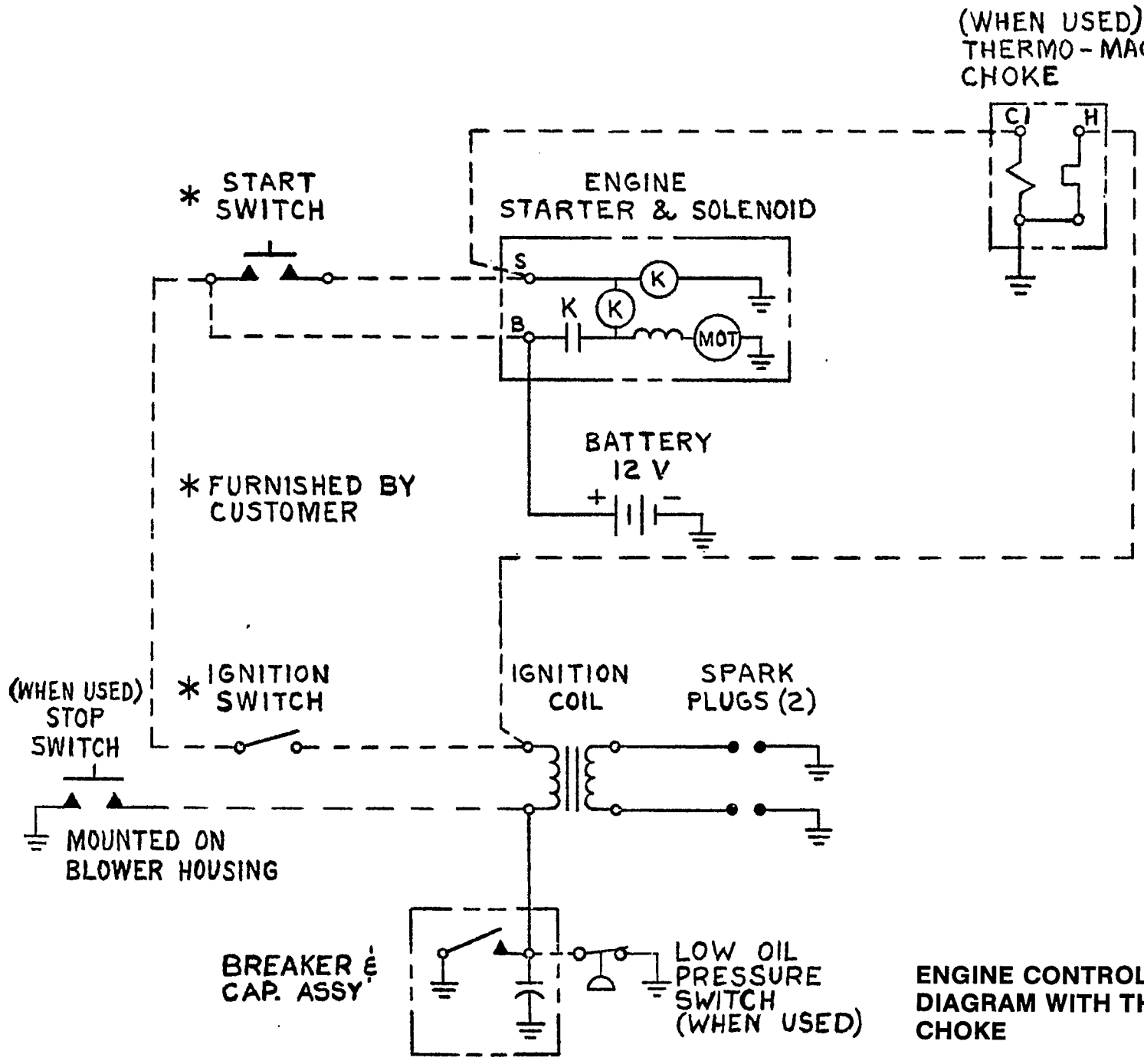
NOTE:

1. REMOVE JUMPER (W1), WHEN AMMETER (M1) IS USED

	REF DES.	DESCRIPTION
		PARTS LIST (REF)
*	E4	CHOKE - ELECTRIC
	B1	STARTER & SOLENOID - ENGINE
	BT1	BATTERY - 12 V.
	CR1	RECTIFIER ASSY
	E1,2	SPARK PLUG
*	E3	SENDER - OIL PRESSURE
	G1	ALTERNATOR
*	M1	AMMETER
*	M2	METER - OIL PRESSURE
	S1	SWITCH - START
	S2	SWITCH - IGNITION
	S3	BREAKER & CAP. ASSEMBLY
*	S4	SWITCH - LOPKO
	T1	COIL - IGNITION
	TB1	BLOCK - TERMINAL
		STRIP - MARKER
	VR1	REGULATOR - VOLTAGE
	W1	JUMPER (SEE NOTE 1)

* WHEN USED

ENGINE CONTROL WIRING DIAGRAM WITH OPTIONS



ENGINE CONTROL WIRING DIAGRAM WITH THERMO-MAGNETIC CHOKE

Onan Corporation
1400 73rd Avenue N.E.
Minneapolis, Minnesota 55432

Telephone: (612) 574-5000
Telex: 275477
Cable ONAN