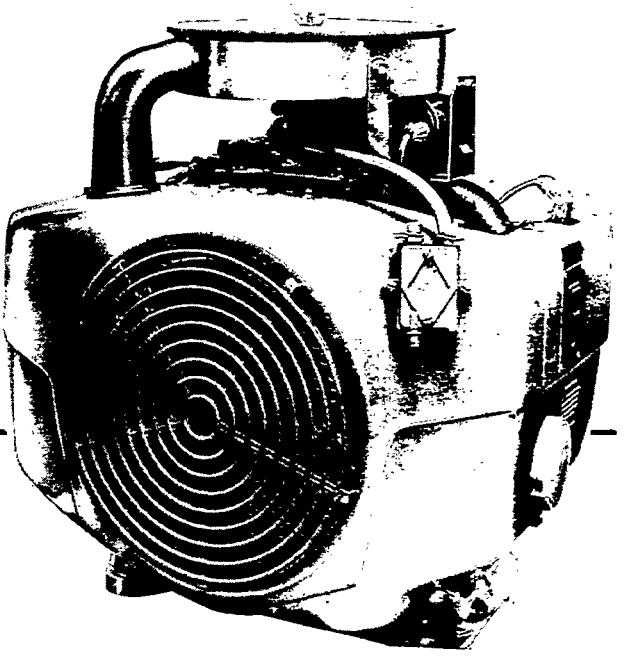
Onan

Service Manual

NH
NHC
NHCV
Engine



940-0751
NHC, NHCV Spec E
NH (RV) Spec J-P
4-87
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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 degrees F (100 degrees 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.

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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.

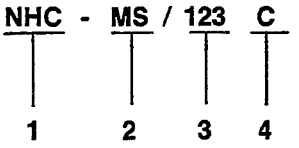
A parts catalog (available at the dealer level) contains detailed exploded views of each assembly and the individual piece part numbers and their proper names for ordering replacement parts.

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 CAN 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 SI metric equivalents that follow immediately in parentheses after the U.S. customary units of measure.

SPECIFICATION	UNIT OF MEASURE	SERIES	
		NHC	NHCV
Number of Cylinders		2	2
Bore	in (mm)	3.56 (90.48)	3.56 (90.48)
Stroke	in (mm)	3.0 (76)	3.0 (76)
Displacement	cu in (cm^3)	60 (983)	60 (983)
Compression Ratio		7.0 to 1	7.0 to 1
Rated Speed (Maximum)	RPM	3600	3600
Power at Rated Speed	BHP (kW)	25 (18.6)	22.5 (16.8)
Oil Filter		Full Flow	Full Flow
Oil Capacity Without Filter	Qt (litre)	3.5 (3.3)	3.5 (3.3)
Oil Capacity With Filter Change	Qt (litre)	4.0 (3.8)	4.0 (3.8)
Crankshaft Rotation (viewed from flywheel)		Clockwise	Clockwise
Governor		Variable Speed Mechanical	
Valve Clearance (Cold)			
Intake	in (mm)	0.005 (0.127)	0.005 (0.127)
Exhaust (Gasoline Fuel)	in (mm)	0.013 (0.330)	0.013 (0.330)
Exhaust (Lpg and Natural Gas)	in (mm)	0.013 (0.330)	0.013 (0.330)
Spark Plug Gap	in (mm)	0.025 (0.64)	0.025 (0.64)
Breaker Point Gap - Static (Full Separation and Engine Cold)	in (mm)	0.016 (0.41)	0.016 (0.41)
Ignition Timing	BTC	20°	20°
Cylinder Compression	psi (kPa)	100 to 120 690 to 827	100 to 120 690 to 827

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	0.0025	(0.064)	0.0038	(0.097)
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	(mm)	MAXIMUM Inches	(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)	0.3420	(8.687)
Clearance (Stem to Guide)	0.0025	(0.064)		
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
Cylinder Head Nuts (Cold)		
Asbestos Gasket without Compression Washers	18-20	(24-27)
Asbestos Gasket with Compression Washers	13-15	(18-20)
Graphoil Gasket without Compression Washers	14-16	(19-22)
Graphoil Gasket with Compression Washers	11-13	(15-18)

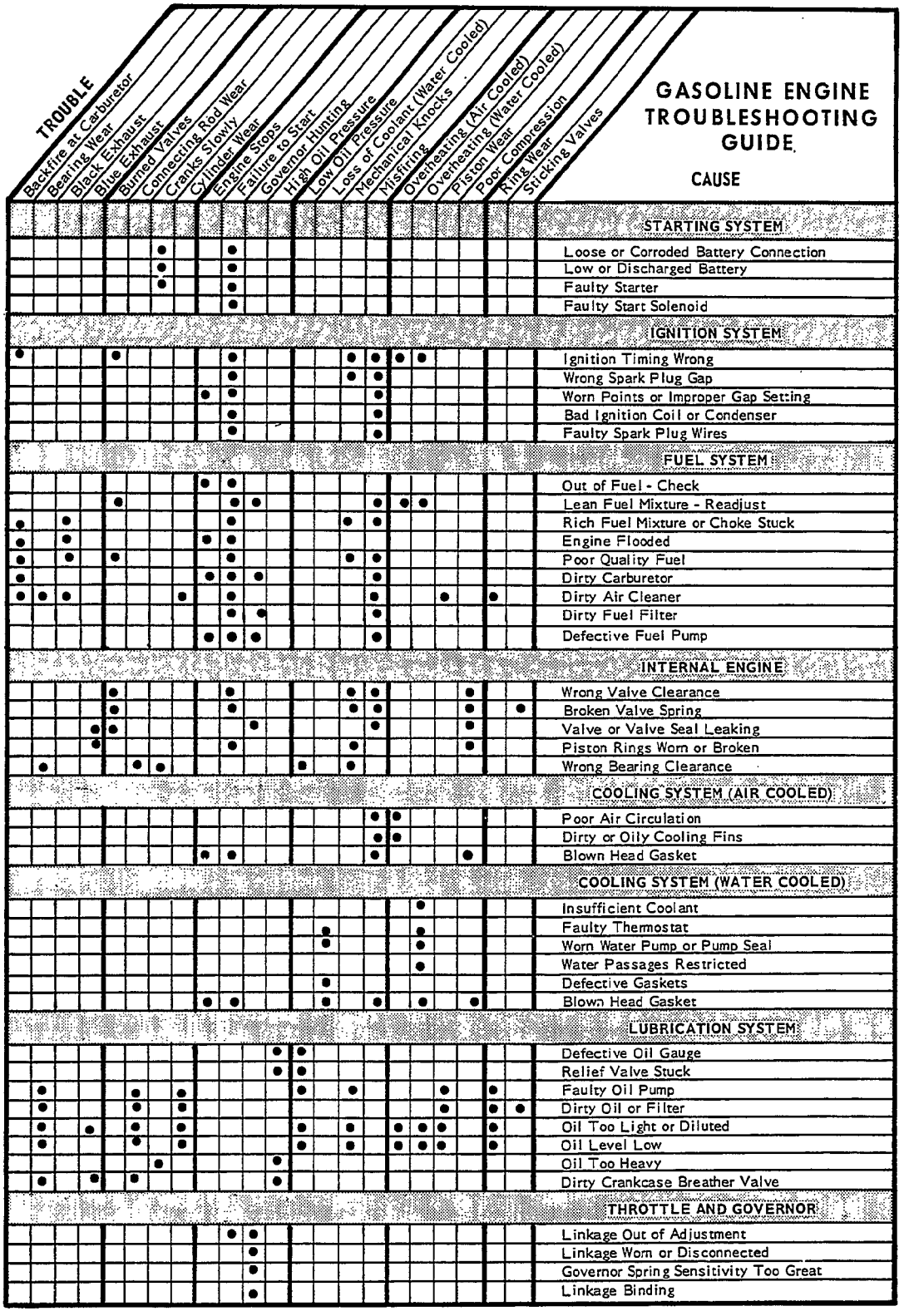
DESCRIPTION	TORQUE SPECIFICATION Ft.-Lb.	Nm
Rear Bearing Plate	25-28	(34-38)
Connecting Rod Bolt		
Iron Rod	27-29	(37-39)
Aluminum Rod	14-16	(19-22)
Flywheel Capscrew	50-55	(68-75)
Starter Mounting Bracket to Oil Base Screws	25-35	(34-47)
Gear Case Cover	8-10	(11-14)
Oil Pump	7-9	(10-12)
Other 3/8 Cylinder 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 Guide and Driver
Combination Bearing Remover (Main and Cam)
Combination Bearing Driver (Main and Cam)
Flywheel Puller

Engine Troubleshooting



NHC, NHCV Installation Guidelines

VENTILATION

The engine must be provided with a supply of fresh air for cooling and for combustion (Figure 1).

Pressure Cooled Engine

Position the air inlet opening directly in front of the engine and as close to the engine blower wheel as possible. The area of the inlet should be not less than 80 square inches (516 cm^2). If louvers or grill work are used, increase the area to compensate for the reduced air flow. Provide extra ventilation if the driven load generates heat during operation.

The heated air outlet must allow the heated air to escape freely and prevent recirculation with the cooling air. A duct between the compartment air inlet and the engine blower housing may be necessary. Locate the air outlet opposite the intake or at least at a 90 degree angle. The area of the outlet should be at least 15 percent larger than that of the inlet. Allow sufficient room on all sides to permit access for servicing.

Open Air Installation

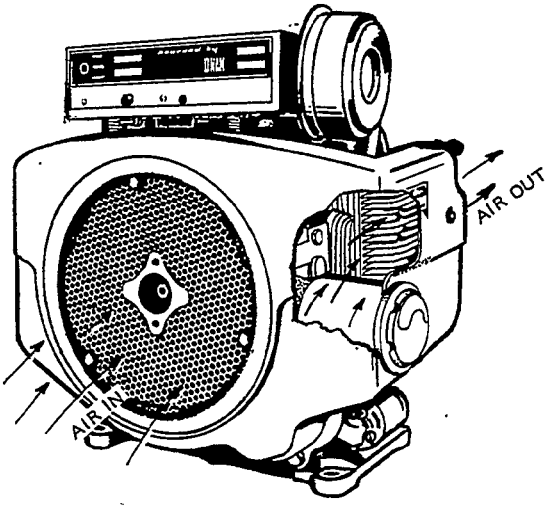
For installations where the engine is operated outside, ventilation will be no problem. However, in protecting the engine from the elements, see that nothing obstructs the flow of air around the engine.

Vacu-Flo Cooled Engine

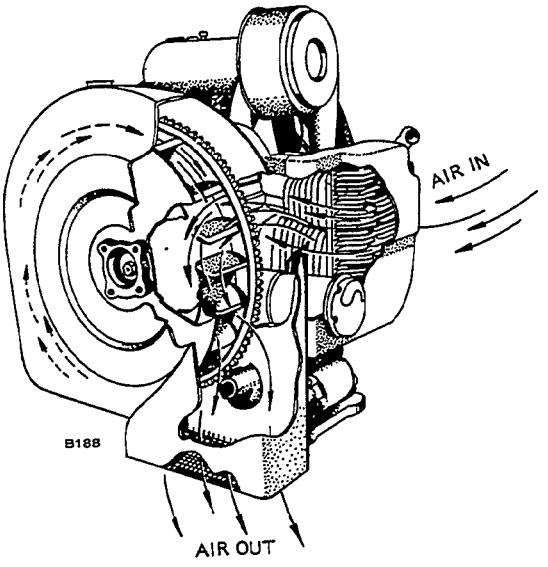
The vacu-flo equipped engine uses an integral flywheel-centrifugal fan to pull cool air into the engine shroud and over the cooling fins and surfaces of the engine (Figure 1). The heated air is directed through an air tight scroll which encases the flywheel fan. The scroll may be positioned to discharge heated air in the downward or the upward left or upward right direction. This is possible because the back section of the scroll (Figure 2) has four identical holes shaped to fit over the end of the starter motor. The scroll outlet has a mesh-type screen for safety.

⚠CAUTION ***The outlet of the vacu-flo scroll must not be restricted or overheating will result. Engine overheating can cause troubles ranging from vapor lock to scored pistons and cylinders.***

The area of the air inlet must be at least 300 square inches (19.35 m^2). If a filter, grille, or louver is used, the inlet opening must be increased accordingly. The air outlet opening should be located as close to the engine as possible.



PRESSURE COOLED



VACU-FLO COOLED

FIGURE 1. AIRFLOW THROUGH ENGINES

If the duct length exceeds 5 feet (1524 mm), increase duct size 30 percent. Use no more than two 90 degree radius-type (not square-type) elbows if it is necessary to change air flow direction. When a duct is used between the scroll discharge and the outlet vent, its unobstructed airflow area must be at least as large as the scroll discharge. The cross-sectional area of the duct must be increased if air flow is restricted by ends, long runs, screens, or the exhaust pipe.

⚠WARNING ***The safety screen used to cover vents must be 1/4-inch (6.35 mm) mesh, or larger, to permit sufficient air flow and must be commensurate with safety standards for hazardous moving parts to avoid personal contact. Provide a short canvas section between the engine air outlet and the external duct or opening to absorb vibration. If operation in cold weather is likely, installing a shutter in the air outlet is advisable. Cold weather can cause overcooling if air flow is not regulated.***

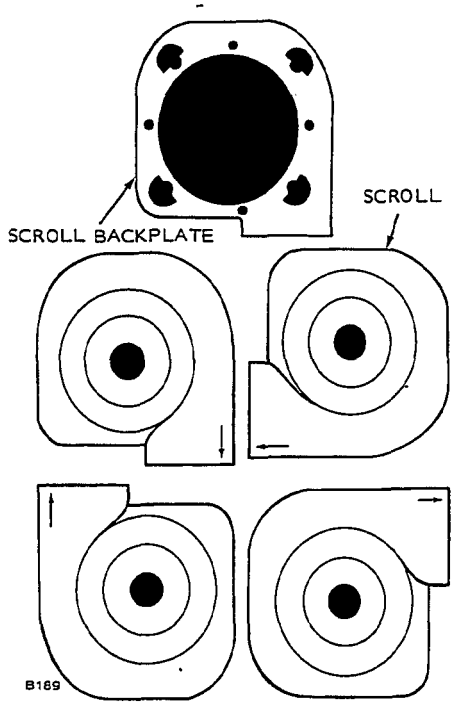


FIGURE 2. VACU-FLO SCROLL POSITIONS

Should a vacu-flo engine chronically overheat, the most likely sources of the problem are:

1. Air inlet is obstructed or too small to allow proper ventilation.
2. Air discharge opening is partially blocked by external ducts or exhaust systems.
3. Recirculation of heated air into fresh air inlet.

EXHAUST

Use a length of flexible stainless steel tubing between the engine exhaust outlet and any rigid piping to absorb engine vibration. Shield the line if it passes through a combustible wall or partition. If turns are necessary, use sweeping type (long radius) elbows. Increase one pipe size (from manifold outlet size) for each additional ten feet in length. Locate the outlet away from the air intake.

CARBURETOR AIR INTAKE

Proper engine efficiency depends upon a supply of fresh air to the carburetor. Under special conditions, it may be necessary to move the air cleaner off the engine, using a longer connection hose as necessary. For extremely dusty or dirty conditions, install a special heavy duty air cleaner.

MOUNTING

There are several acceptable methods of mounting the engine. Among factors to be considered are: location, method of coupling the engine to the load, type of foundation or support, etc. The engine should be mounted on a level surface if possible. Maximum operation angle is 15 degrees sideways, 30 degrees front to rear tilt. If the engine is to operate at an angle, be sure to re-mark the oil level indicator to compensate for the tilt.

The type of installation can affect the life of the engine, the cost of operation, and the frequency of necessary service. Plan the installation carefully to ensure the best performance.

Because of the great variety of uses and the many variations of the engine, these installation instructions are typical or general in nature. Use the installation recommendation given as a general guide.

EXHAUST SYSTEM

Make regular visual and audible inspections of the exhaust system throughout the entire life of the engine. Locate leaks in muffler and piping while the engine is operating. Repair all leaks immediately after they are detected for personnel safety.

⚠WARNING ***Inhalation of exhaust gases can result in serious personal injury or death. Inspect exhaust system audibly and visually for leaks daily. Repair any leaks immediately.***

CONNECTING THE LOAD

The dimensions of various power takeoff shafts are as follows:

SHAFT	DIAMETER	LENGTH	KEY SIZE
STD	1-7/16 (36.51 mm)	3-1/16 (77.78 mm)	3/8 (9.5 mm)
Rockford Clutch	1-7/16 (36.51 mm)	3-1/16 (77.78 mm)	3/8 (9.5 mm)
Gear Reduction	1-1/4 (31.75 mm)	2-3/4 (69.85 mm)	1/4 (6.35 mm)

Belt Drive

V-belts are preferable to flat belts. Consult a reliable belting supplier for recommendations regarding size of pulleys, number of belts, etc. required. A typical belt drive installation is shown in Figure 3.

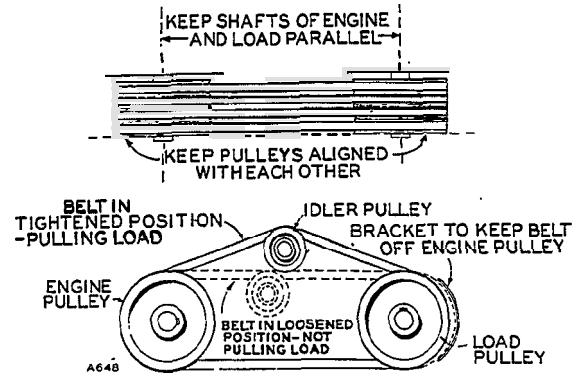


FIGURE 3. DRIVE BELT INSTALLATION

Comply with the following installation requirements:

1. The shafts of the engine and the load must be parallel with each other.
2. The pulleys of the engine and the load must be in alignment.
3. Mount the engine pulleys as close to the engine as possible.
4. If the installation permits, belts should run horizontally.
5. Some method of disconnecting the load for starting is recommended. If a clutch is not used, a belt-tightener idler arrangment can be used.

Flexible Coupling

If a flexible coupling engine-to-load drive is used, the load shaft must be in line and centered with the engine shaft (Figure 4).

Reduction Gear Drive

Reduction gear drives are mounted at the factory (when ordered). The method of connecting the load is the same as when connecting directly to the engine shaft.

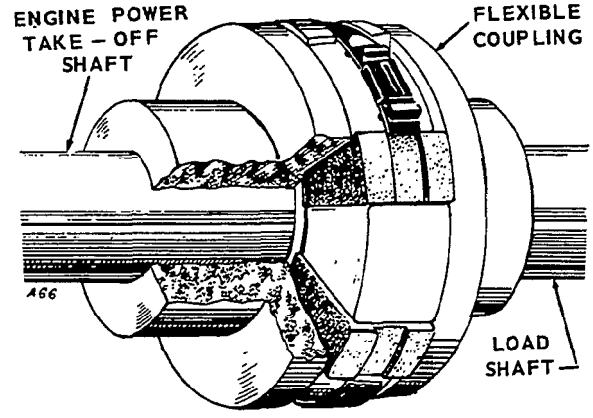


FIGURE 4. FLEXIBLE COUPLING

Drain the gear box after the first 100 hours of operation and refill with fresh lubricant of the recommended grade. Repeat this procedure every six months thereafter, or every 100 hours.

Use only SAE 50 motor oil or SAE 90 mineral gear oil. Do not use lubricants commonly known as extreme pressure lubricants, hypoid lubricants, etc.

Maintain the proper oil level between changes. Overfilling will cause foaming, which can lead to an oil leak due to overheating. Remove the filler plug on top of the case and the oil level plug from the face of the gear case. Fill the case until the oil just begins to flow from the oil level plug hole. Gear box holds 1/2 pint U.S. measure (.24 litre). Reinstall both plugs.

Clutch Installation

A Rockford Clutch can be installed at the factory or in the field, installation procedures are provided with the clutch.

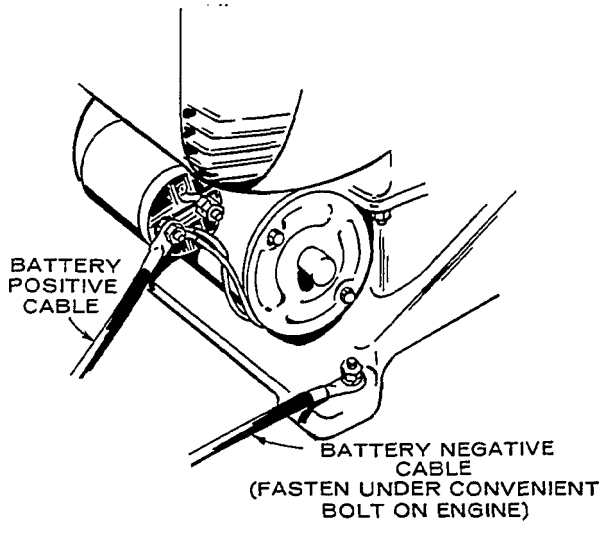


FIGURE 5. BATTERY CONNECTIONS

BATTERY CONNECTIONS (Engines with Automotive Type Separate Starter)

Verify battery polarity before connecting battery cables. Connect negative cable last.

Connect the 12 volt battery positive cable to the engine start switch terminal. Connect the battery negative cable to the ground point on the engine oil base (Figure 5).

OUT-OF-SERVICE PROTECTION

Protect an engine that will be out-of-service for more than 30 days as follows:

1. Run the engine until it reaches normal operating temperature.
2. Turn off the fuel supply and run the engine until it stops.
3. Drain oil from oil base while the engine is still warm. Refill with fresh crankcase oil and attach a tag stating viscosity used.
4. Remove spark plugs. Pour 1 ounce (2 tablespoons or 28 grams) of rust inhibitor or SAE #50 oil into the cylinders. Crank the engine over a few times. Reinstall spark plugs.
5. Service air cleaner as outlined in *MAINTENANCE* section.
6. Clean governor linkage and protect by wrapping with a clean cloth.
7. Plug exhaust outlet to prevent entrance of moisture, dirt, bugs, etc.
8. Wipe entire unit. Coat rustable parts with a light film of grease or oil.
9. Provide a suitable cover for the entire unit.
10. If battery equipped, disconnect and follow standard battery storage procedure.

RETURNING UNIT TO SERVICE

1. Remove cover and all protective wrapping. Remove plug from exhaust outlet.
2. Check tag on oil base and verify that oil viscosity is still correct for existing ambient temperatures.
3. Clean and check battery. Measure specific gravity (1.260 at 77°F [25°C]) and verify level to be at split ring. If specific gravity is low, charge until correct value is obtained. If the level is low, add distilled water and charge until specific gravity is correct.
4. Check that fuel filter and fuel lines are secure, with no leaks.
5. Check carburetor; adjust if necessary.
6. Connect battery.
7. Start engine in a well ventilated area. Exhaust smoke when engine is started is normal and is usually caused by the rust inhibitor oil.

⚠WARNING

EXHAUST GAS IS DEADLY!

Exhaust gases contain carbon monoxide, a poisonous gas that can 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.

Oil System

CRANKCASE OIL

Refer to engine nameplate or *Periodic Maintenance Schedule,* located in the Operator's Manual, for oil change interval. If operating in extremely dusty, high ambient, or low ambient conditions change oil more often.

Run engine until thoroughly warm before draining oil. Stop the engine, place a pan under the drain outlet and remove the oil drain plug or open the drain valve. After the oil is completely drained, replace the drain plug or close the drain valve. Refill with oil of the correct API classification and appropriate SAE viscosity grade for the temperature conditions.

Oil must meet or exceed the API designation SF or SF/CC. Refer to the chart for correct oil viscosity grade.

⚠WARNING ***Crankcase pressure can blow out hot oil and cause serious burns. Do NOT check oil while the engine is operating.***

⚠WARNING ***Hot crankcase oil can cause burns if it is spilled or splashed on skin. Keep fingers and hands clear when removing the oil drain plug and wear protective clothing.***

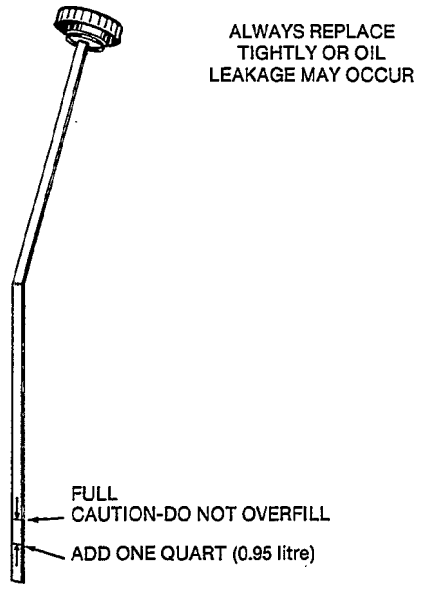
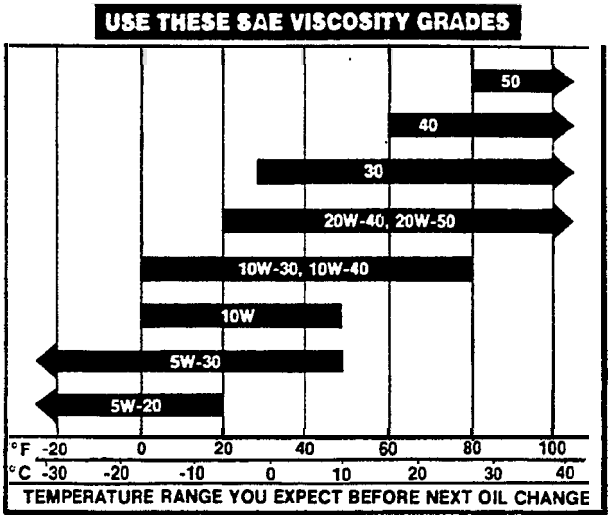
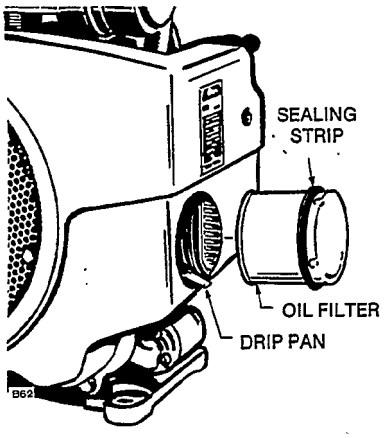


FIGURE 6. CRANKCASE OIL FILL

⚠CAUTION ***Do not overfill crankcase. Excess oil causes higher operating temperatures and may cause foaming.***

Oil level should be to the FULL mark of the dipstick. Start engine and run for a short time to check for oil leaks around the drain plug.





FILTER 7. OIL FILTER

OIL FILTER CHANGE

Refer to engine nameplate or *Periodic Maintenance Schedule,* located in the Operator's Manual, for oil filter change interval. If operating in extremely dusty, high ambient, or low ambient conditions change oil more often.

Spin off oil filter element and discard it. Thoroughly clean filter mounting surface and install new element, making sure new gasket is inserted in the element.

Apply a thin film of oil to the gasket. Spin element down by hand until gasket just touches mounting pad and then turn down an additonal 1/4-1/2 turn. Do not overtighten.

With oil in crankcase, start engine and check for leaks around filter element. Retighten only as much as necessary to eliminate leaks; do not overtighten.

CRANKCASE BREATHER

The crankcase breather prevents pressure from building up in the crankcase. It also prevents oil contamination by removing moisture or gasoline vapors and other harmful blow-by materials from the crankcase. These vapors are routed to the carburetor where they are mixed with incoming air and burned in the combustion chamber. A sticky breather valve can cause leaks, high oil consumption, rough idle, reduced engine power and a rapid formation of sludge and varnish within the engine.

Crankcase Breather Service

This engine uses a crankcase breather valve for maintaining crankcase vacuum. If the crankcase becomes pressurized as evidenced by oil leaks at the seals, clean baffle and valve in a suitable solvent.

Clean or replace crankcase breather baffle periodically. Be sure baffle material doesn't come apart and work into the manifold.

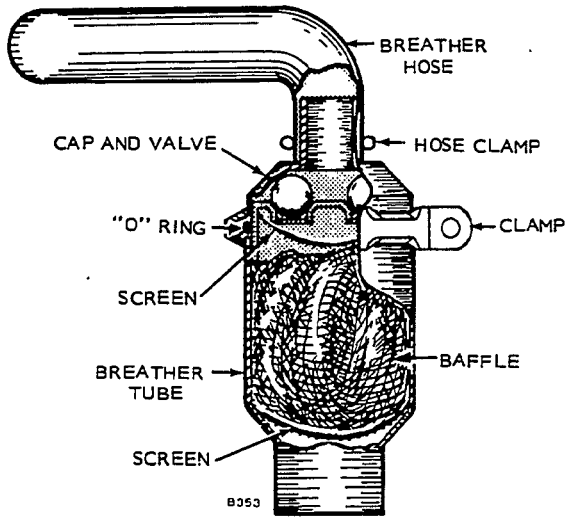


FIGURE 8. CRANKCASE BREATHER

To disassemble, remove breather hose from cap and valve assembly. Remove cap and valve assembly and wash in a suitable solvent. Replace cap and valve if balls do not move freely. Pull baffle out and wash in solvent. To allow free operation of the valve, screens must be positioned as shown in Figure 8.

PRESSURE LUBRICATION

All engines use an oil pump to provide a constant flow of oil to the engine parts. The oil supply collects in the oil base where it is picked up by the oil pump pick-up cup. A by-pass valve is used to control oil pressure. Drain oil before removing oil base and always use a new gasket when replacing the oil base.

Oil Pump

The oil pump (Figure 9) is mounted behind the gear cover and is driven by the crankshaft gear. Inlet pipe and screen assembly are attached directly to the pump body. A discharge passage in pump cover 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.

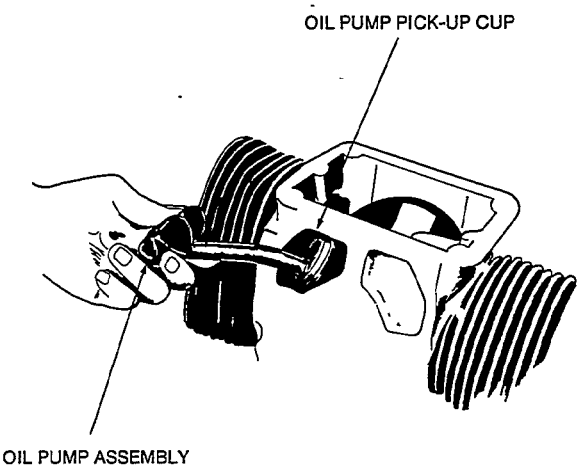


FIGURE 9. OIL PUMP ASSEMBLY

Circumferential grooves in the main bearings supply oil to 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; rear cam bearing is splash lubricated. Oil overflow from the bypass valve provides lubrication to the camshaft drive gears.

Normal oil pressure should be 30 psi (207 kPa) or higher when the engine is at normal operating temperature. If pressure drops below this value at governed speed, inspect oil system for faulty components.

Check oil pump thoroughly for worn parts. Prime the oil pump with lube oil before reinstalling. Except for gaskets and pick-up cup, component parts of the pump are not available individually. Install a new pump assembly if any parts are worn.

Oil By-Pass Valve

The by-pass valve (located to the right and behind gear cover, Figure 10) controls oil pressure by allowing excess oil to flow directly back to the crankcase. Normally the valve begins to open about 20 psi (138 kPa).

The valve is non-adjustable and normally does not need maintenance. Determine if valve is operating normally by inspecting plunger action as follows:

1. Remove the 3/8 x 24 x 7/8 cap screw located behind gear cover and under governor arm.

2. Remove spring and plunger with a magnet tool.

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

   Plunger Diameter..... 0.3105 to 0.3125 in. (7.89 to 7.94 mm)

   Spring
   Free Length..... 1.00 inch (25.4 mm)
   Load ..... 2.6±0.2 lbs. (11.6±0.9 N) when compressed to 0.5 inch (12.7 mm)

4. Check the valve seat and clean away any accumulation of metal particles which could cause erratic valve action. Verify that the valve seat is not damaged.

5. Clean plunger and spring in parts cleaning solvent and install.

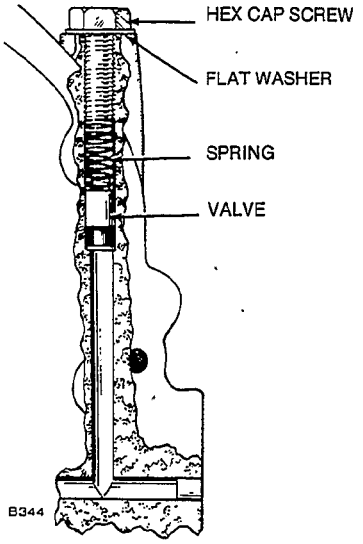


FIGURE 10. BY-PASS VALVE

Fuel System

CARBURETOR ADJUSTMENTS

The carburetor mixture screws and the float level were set for maximum efficiency at the factory and will seldom require readjustment. If adjustment seems necessary, first be sure the ignition system is working properly and is not the source of the problem.

If adjustment is needed, refer to Figures 11 and 12 and Table 1 and proceed as follows:

TABLE 1. CARBURETOR ADJUSTMENTS

Carburetor	Idle Mixture	Main Mixture
Sidedraft	1 to 1-1/2	1 to 1-1/2
LUA	1-3/8 to 1-5/8	1-1/4 to 1-1/2
Nikki	1-1/2	N.A.

1. Turn mixture screw(s) in until lightly seated, then back them out the number of turns specified in Table 1.

⚠WARNING ***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. Failure to tighten the packing nut can result in leaking fuel, creating a serious fire hazard.***

⚠CAUTION ***Forcing the mixture adjustment screws tight will damage the needle and seat. Turn in only until light tension can be felt.***

2. Start the engine and allow it to warm up thoroughly (at least 10 minutes).

3. Move the engine speed control to the slow position.

4. Determine if the engine has a governor low speed adjustment screw (Figure 12).

5. Pull the governor back (Figure 12) so the throttle stop screw is against its stop. Continue to hold the governor arm in this position while completing the adjustments described in steps 6 through 8.

6. If the governor does not have a low speed adjustment screw, adjust the throttle stop screw to obtain 1200 rpm. If the governor does have a low speed adjustment screw, adjust the throttle stop screw to obtain 1100 rpm.

7A. **Sidedraft and LUA carburetors:** Turn the idle adjustment screw in until engine speed drops and then out until engine speed drops again. Over a narrow range between these two settings, engine speed will be at its maximum. Set the idle adjustment screw about 1/8 turn outward from the midpoint of this range.

B. **Nikki carburetor:** This carburetor has a limited adjustment range between the stops of ± 1/8 turn. Adjust carburetor for highest rpm within this range.

8. Re-adjust the throttle stop screw to obtain the rpm specified in step 6 and release the governor arm.

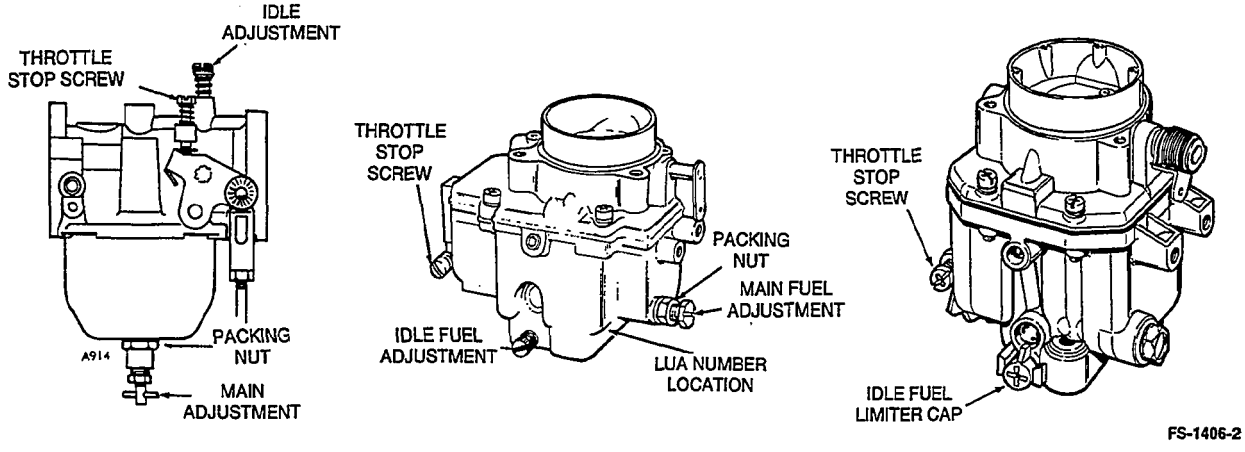


FIGURE 11. MIXTURE ADJUSTMENTS

9. Engines without a governor low speed adjustment screw require no further low speed adjustments. Engines with a governor low speed adjustment screw require the following low speed adjustment:
   A. Check to see that the governor linkage moves freely and is not binding.
   B. Adjust the governor low speed adjustment screw to obtain 1200 rpm.
10. Check the main mixture adjustment (sidedraft and LUA carburetors only) by rapidly accelerating the engine from idle to full speed. The engine should accelerate evenly and without hesitation. If it does not, turn the main adjustment screw out in 1/8 turn increments until the engine accelerates smoothly, but do not turn it out more than 1/2 turn beyond the original setting.

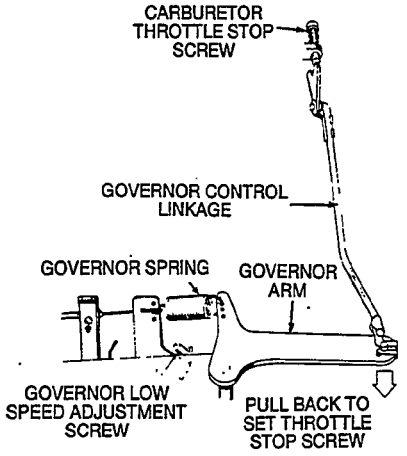


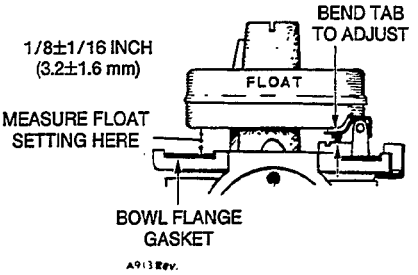
FIGURE 12. IDLE SPEED ADJUSTMENT

Float Adjustment

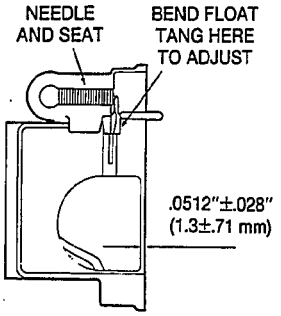
An exceedingly high float setting will usually result in an engine that is hard to start when warm. If the setting is too low, the engine may not receive enough fuel under sudden acceleration or load change. Adjust setting as follows:

1. Disconnect throttle control, choke leads, breather hose, air cleaner inlet hose, and fuel line from carburetor.
2. Remove the four bolts that hold the intake manifold assembly in place and remove the complete carburetor and intake manifold assembly as one unit. Then remove carburetor from intake manifold for easier handling when checking float level.
3. Separate the upper body of the carburetor from the fuel bowl section.
4. Measure float level (Figure 13).
5. If the setting is incorrect, remove the float assembly to adjust. Bend the assembly slightly at the location specified in Figure 13.

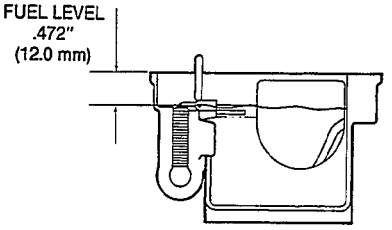
⚠CAUTION ***Attempting adjustments with the float assembly installed may result in deformation of the inlet needle and seat.***



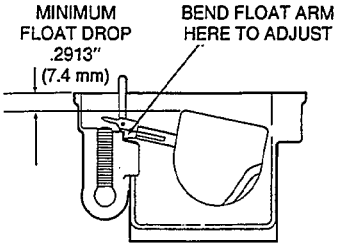
SIDE DRAFT CARBURETORS



FLOAT LEVEL ADJUSTMENT



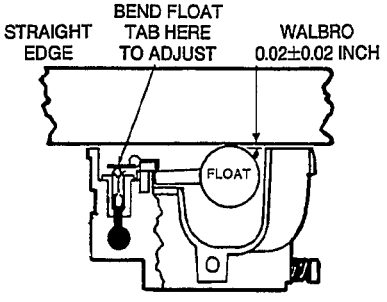
WITH FUEL



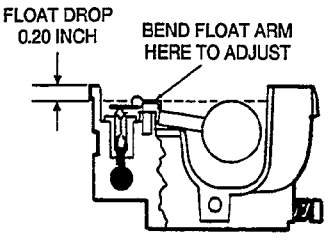
NO FUEL

FS-1683

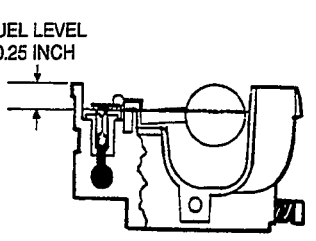
NIKKI carburetor with limited idle mixture adjustment.



FLOAT LEVEL ADJUSTMENT



NO FUEL



FLOAT DROP ADJUSTMENTS

LUA CARBURETORS

FIGURE 13. FLOAT LEVEL ADJUSTMENT

FS-1524

CARBURETOR OVERHAUL

Carburetion problems that are not corrected by mixture or float adjustments are usually a result of gummed-up fuel passages or worn internal parts. The most effective solution is a carburetor overhaul.

In general, overhauling a carburetor consists of disassembly, a thorough cleaning, and replacement of worn parts. Carburetor repair kits are available that supply new gaskets and replacements for those parts most subject to wear.

General instructions for overhauling a carburetor are given below. Carefully note the position of all parts while removing to assure correct placement when reassembling. Read through all the instructions before beginning for a better understanding of the procedures involved. Carburetor components are shown in Figures 14, 15 and 16.

⚠WARNING ***Ignition of fuel can cause serious personal injury or death by fire or explosion. Do not permit any flame, cigarette, or other igniter near the fuel system.***

Removal and Disassembly (Except Nikki)

1. Disconnect all lines, linkages, wires, and attaching nuts or bolts; then remove the carburetor from the engine. (Downdraft carburetors may require removal of the intake manifold to disconnect.)
2. Remove air cleaner adapter, if so equipped, and automatic choking assembly.
3. Remove throttle and choke plate retaining screws, then plates. Pull out throttle and choke shafts, being careful not to damage the teflon coating applied to some throttle shafts.
4. Remove main and idle mixture screw assemblies.
5. On downdraft carburetors, remove attaching screws and separate upper and lower carburetor sections. On sidedraft models, unscrew the retaining screw and remove fuel bowl from the upper carburetor body.
6. Carefully note position of float assembly parts then slide out retaining pin and remove the float assembly, any springs or clips, and the needle valve.
7. Unscrew and remove needle valve seat.

Removal and Disassembly (Nikki)

1. Remove air cleaner and hose.
2. Disconnect governor and throttle linkage, choke control and fuel line from carburetor.
3. Remove the four intake manifold cap screws and lift complete manifold assembly from engine. Remove carburetor from intake manifold.
4. Remove main jet and idle adjustment needle.
5. Remove attaching screws and separate upper and lower carburetor sections.
6. Carefully note position of float assembly parts, then pull out retaining pin and float assembly.
7. Remove needle valve.

Cleaning and Repair

1. Soak all metal components not replaced in carburetor cleaner. Do not soak non-metal floats or other non-metal parts. Follow the cleaning manufacturer's recommendations.
2. Clean all carbon from the carburetor bore, especially where the throttle and choke plates seat. Be careful not to plug the idle or main fuel ports.
3. Dry out all passages with low pressure air (35 PSI). Avoid using wire or other objects for cleaning which may increase the size of critical passages.
4. Check the condition of the adjustment needle; replace if damaged. Replace float if loaded with fuel or damaged.
5. Check the choke and throttle shafts for excessive play in their bore. This condition may necessitate replacement of the carburetor.
6. Replace old components with new parts.

Reassembly and Installation (Except Nikki)

1. Install needle valve and seat, fuel bowl gasket, and float assembly. Make sure that all clips and springs are properly placed and that the float moves freely without binding. Check float level and adjust as necessary.
2. Rejoin upper and lower carburetor sections on downdraft carburetors — fuel bowl and upper carburetor body on sidedraft models.

   The float spring on Zenith sidedraft carburetors rides on the inner face of the fuel bowl. Be sure to catch the end of the spring when reinstalling the bowl (Figure 15).
3. Slide in throttle shaft and install throttle plate, using new screws if furnished in repair kit. Before tightening the screws, the plate must be centered in the bore. To do so, back off the throttle stop screw as necessary and completely close the throttle lever. Seat the plate by tapping with small screwdriver, then tighten screws. Install the choke shaft and plate in the same manner.
4. Install main and idle mixture screw assemblies. Turn in screws until lightly seated and then out the number of turns specified in Table 1.

   ⚠CAUTION ***Forcing the mixture adjustment screws tight will damage the needle and seat. Turn in only until light tension can be felt.***
5. Reinstall carburetor on engine and connect fuel lines, linkages, and wires.
6. Reset mixture screws according to directions given earlier in this section. Install air cleaner adapter, where used, and air cleaner.

Reassembly and Installation (Nikki)

1. Install needle valve, main jet, and float assembly. Make sure float pivot pin is properly placed and float moves freely without binding.

2. Turn carburetor on its side and measure float level (Figure 13). Adjust float level only if necessary. Measure float drop (the distance from the top of carburetor body to top of float). Adjust only if necessary.

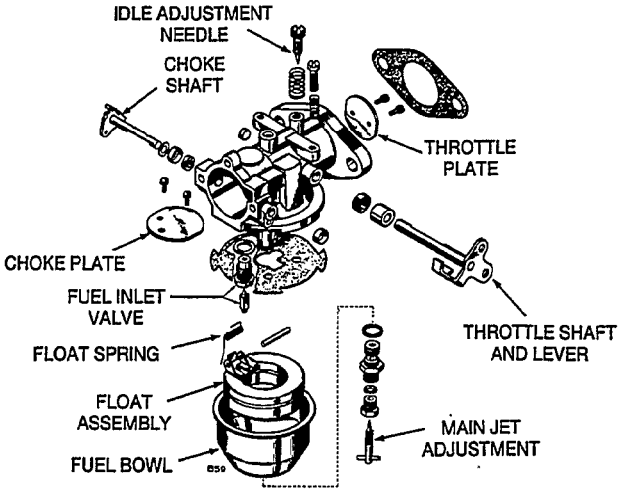
3. Position gasket on lower carburetor section and install upper carburetor section.

4. Install idle adjustment screw, throttle stop screw, and fixed main jet plug.

5. Mount carburetor on intake manifold and install assembly on engine.

6. Mount air cleaner assembly. Connect air intake hose, breather hose, fuel line, vacuum line, and throttle linkage.

7. Adjust carburetor and governor according to directions given in this section.



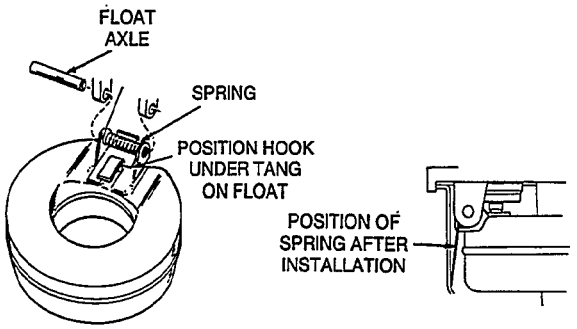


FIGURE 15. SIDEDRAFT CARBURETOR ASSEMBLY

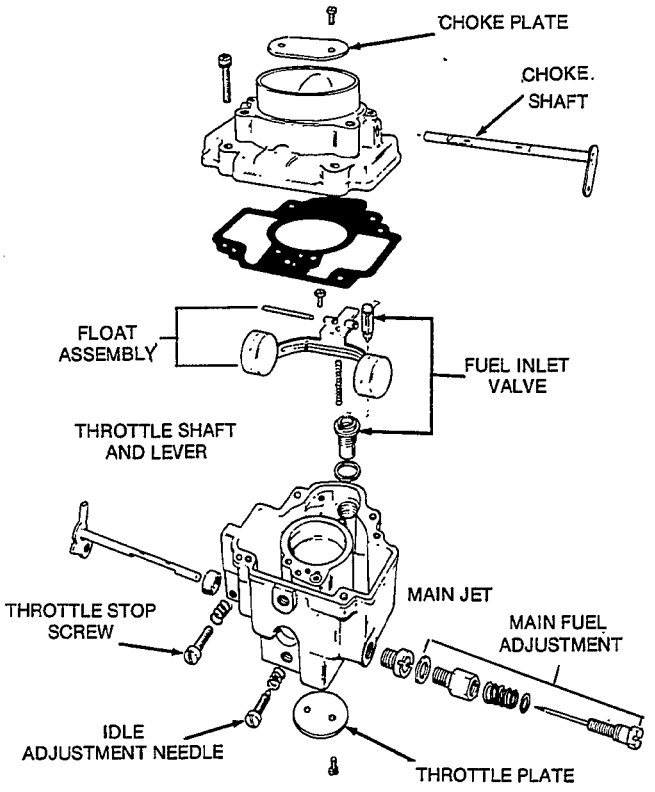


FIGURE 14. DOWNDRAFT LUA CARBURETOR ASSEMBLY

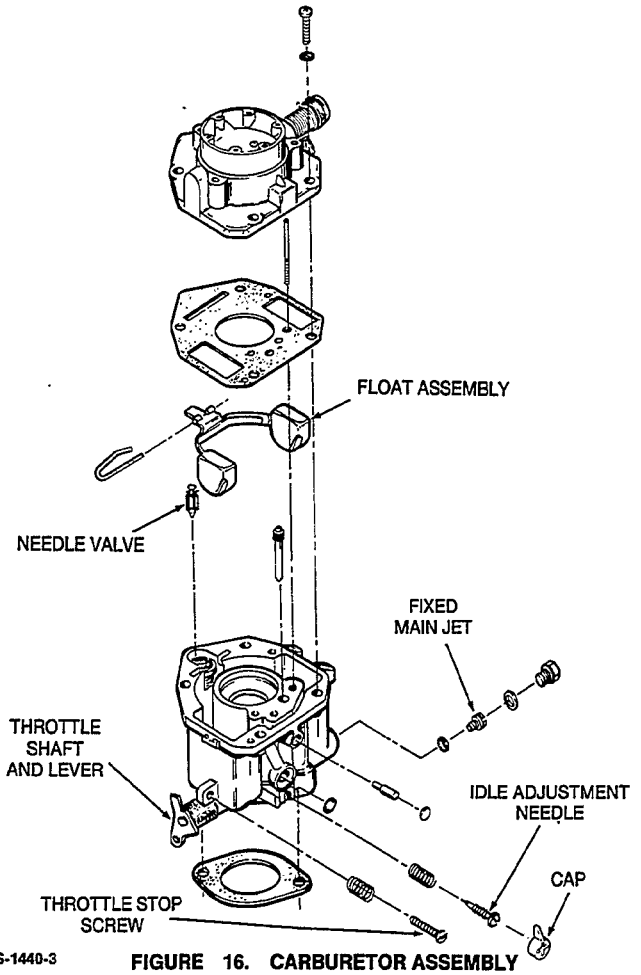


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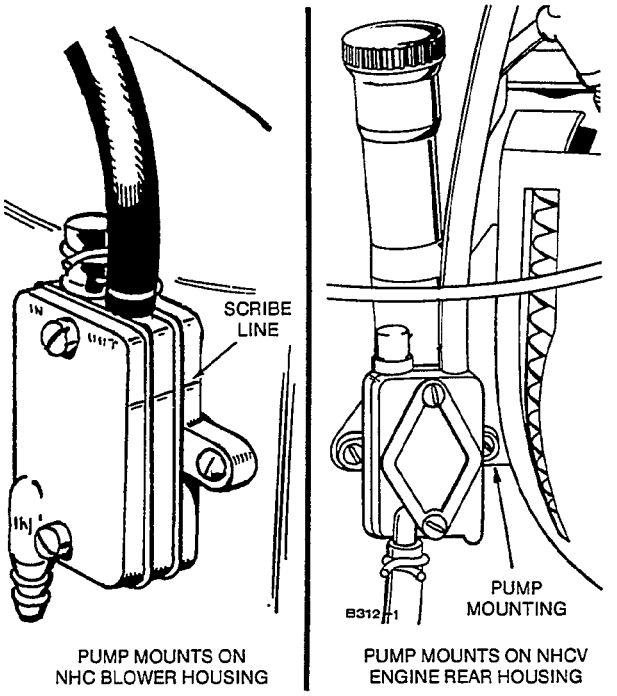
FIGURE 16. CARBURETOR ASSEMBLY

FUEL PUMPS

These engines are equipped with either a mechanical fuel pump, pulsating diaphragm fuel pump (pulse pump), or a remote electric fuel pump. Mechanical pumps are mounted on top of the engine crankcase, in front of the carburetor. Pulse pumps are mounted on the upper right corner of the engine blower housing on NHC engines and on the engine rear housing on NHCV engines (Figure 17).



PUMP MOUNTS ON NHC BLOWER HOUSING

PUMP MOUNTS ON NHCV ENGINE REAR HOUSING

FIGURE 17. PULSE PUMP LOCATIONS

Mechanical Fuel Pump Test

This type of pump can be tested for proper operation by checking for fuel flow to the carburetor. Proceed as follows:

⚠WARNING ***Gasoline is highly flammable and potentially explosive! Use extreme care when performing this test. Direct fuel flow into a suitable container and make sure area is well ventilated to prevent accumulation of gasoline fumes.***

1. Remove the fuel line from the pump outlet or at the carburetor inlet.
2. Using some type of container to catch the fuel, crank the engine over several times. If the engine is a manual start, operate the pump priming lever instead. If the pump is electric, simply turn the ignition switch on to activate the pump.
3. Fuel should spurt out. If it does not, be sure the problem is not an empty or shutoff fuel tank; then, remove the pump for repair or replacement.

Pulse Pump Test Procedure

Before testing make certain that fuel pump vacuum line connections are tight and free of leaks.

1. Operate engine at an idle for five minutes to ensure that carburetor is full of fuel.
2. Shut engine off and remove fuel inlet line from fuel pump.

⚠WARNING ***Spilled fuel can ignite and cause serious personal injury or death. Thoroughly clean-up any spilled fuel.***

3. Connect a vacuum gauge to fuel pump inlet using a piece of fuel hose with clamps.
4. Start engine and allow to idle for five seconds. Record vacuum gauge reading.
5. Move throttle control to high idle position. Wait five seconds and record vacuum gauge reading.
6. Shut engine off and remove vacuum gauge hose from fuel pump inlet. Connect fuel inlet line to fuel pump.
7. Remove fuel outlet line from fuel pump.

⚠WARNING ***Spilled fuel can ignite and cause serious personal injury or death. Thoroughly clean-up any spilled fuel.***

8. Connect a pressure gauge to fuel pump outlet using a piece of fuel hose with clamps.
9. Start engine and allow to idle for five seconds. While holding pressure gauge level with pump outlet record pressure gauge reading.
10. Move throttle control to high idle position and allow engine to run for five seconds. While holding pressure gauge level with pump outlet, record pressure gauge reading.
11. Shut engine off and remove pressure gauge hose from fuel pump outlet. Connect fuel outlet line to fuel pump.

Repair or replace the fuel pump if test readings are not within the values specified in TABLE 1.

TABLE 1
PULSE PUMP TEST SPECIFICATIONS

Engine Speed	Pump Inlet Vacuum (Minimum)	Pump Outlet Pressure (Minimum)
Low Idle	2.6 inches of mercury	1.7 psi
High Idle	2.6 inches of mercury	1.7 psi

Pulse Pump Repair

This section applies only to Facet fuel pump. The Nikki fuel pump is not repairable; replace unit if test readings are not within the values specified in Table 1.

1. Remove the vacuum and fuel lines. Inspect the lines for wear, cracking, and brittleness. Replace as necessary.
2. To insure correct alignment when reassembling, scribe a line across the outer pump parts on each end of the pump (Figure 17).
3. Holding the pump carefully, remove the assembly screws.
4. Carefully pull apart the pump sections and check for worn or damaged parts. Replace with new parts where necessary or install pump repair kit (Figure 18).
5. Check and unclog (if necessary) the small diaphragm air bleed hole located behind the pump diaphragm in the pump base (Figure 18).

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

6. Replace gaskets and reassemble pump. Reinstall assembly screws, checking the scribe marks for proper alignment. Reinstall fuel and vacuum lines and clamps.

⚠WARNING ***Use care when reassembling and reinstalling the pump. Improper parts alignment or misconnected fuel lines can result in leaking fuel, creating a serious fire hazard.***

Mechanical Pump Removal and Repair

Removal:

1. Remove the fuel inlet and outlet lines from the pump.
2. Remove the two capscrews holding the pump to the engine.
3. Remove the pump, spacer (if used) and gasket from the engine and discard the gasket.

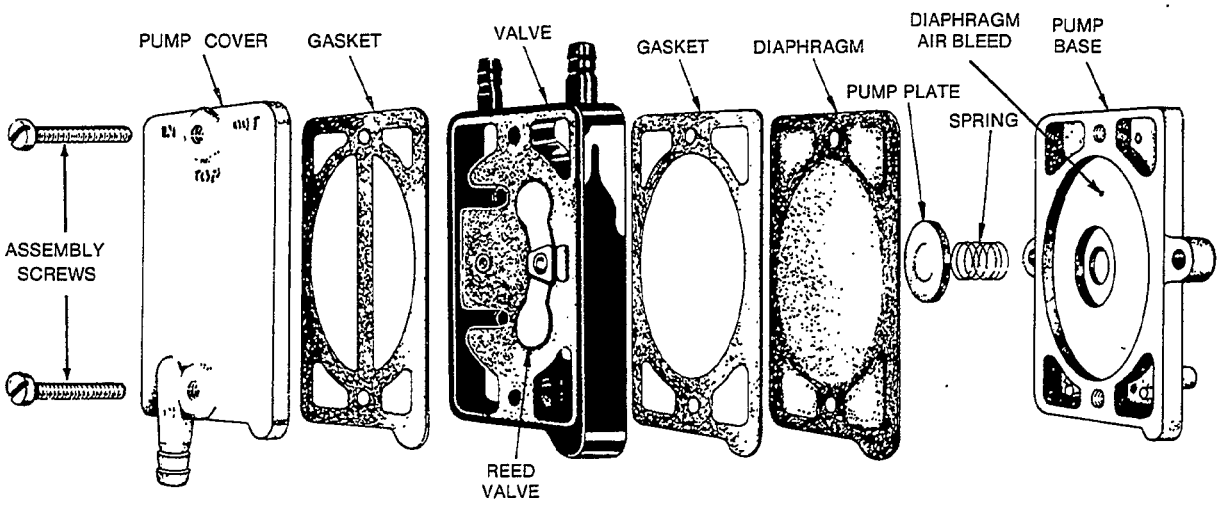


FIGURE 18. EXPLODED VIEW OF FACET PULSE PUMP

Repair:
Repair kits are available that provide replacements for those parts of the pump most subject to wear. If the operator chooses to repair the pump rather than install a new one, the use of all parts included in the repair kit is recommended. Proceed as follows:

1. After the pump is removed from the engine, scribe a line on the flanges of the upper and lower pump bodies to assure correct positioning when reassembling.

2. Remove the securing screws and separate the upper and lower pump bodies.

3. Detach the valve cage retainer from the pump upper body. Noting their position, remove the valve and cage assemblies and their gaskets from the retainer (Figure 19).

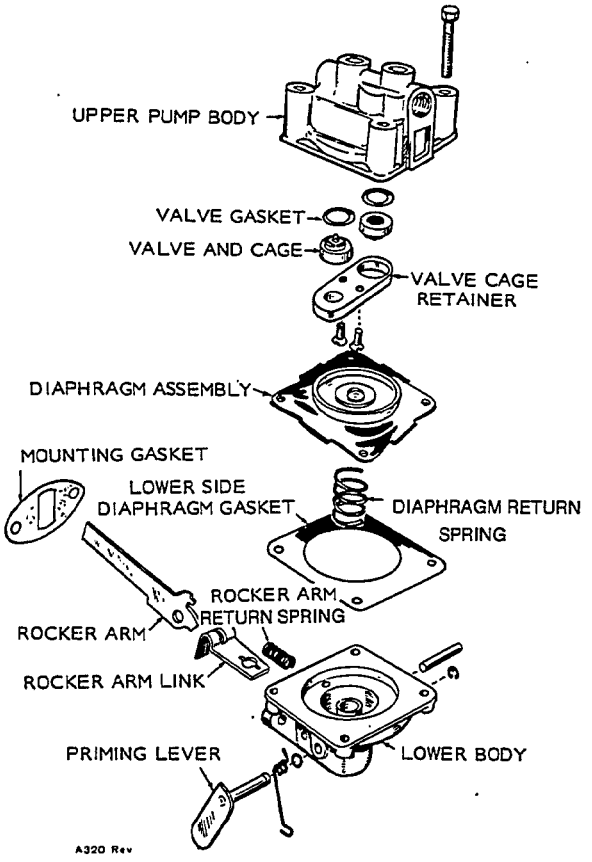


FIGURE 19. MECHANICAL FUEL PUMP - EXPLODED VIEW

4. Detach the pump diaphragm by pressing its metal base into the pump body and turning it 1/4 turn.

5. The rocker arm return spring can normally be removed without removal of the rocker arm from the pump body. Use a small screwdriver or tweezers to compress the spring and tip it off the rocker arm catch. When installing the new spring, make sure it is properly placed before remounting the pump.

6. Clean in solvent all pump parts that will not be replaced and allow to dry.

7. Install the new valve and cage assemblies and their gaskets in the retainer. Be sure the assemblies are in proper position and fully seated. Reinstall the retainer and assemblies in the pump upper body.

8. To install the new pump diaphragm, turn the pump lower body upside-down and place the diaphragm and spring in the body. Press the base of the diaphragm up into the body of the pump and turn 1/4 turn.

9. Install new rocker arm return spring. Check for proper spring placement.

10. Place the upper and lower bodies of the pump together with the scribe marks aligned. Start the four securing screws, making sure they do not chew into the diaphragm fabric. Leave the screws 2 or 3 turns loose.

11. Operate the rocker arm several times to flex the new diaphragm fully. While holding the rocker arm fully flexed, tighten the body screws.

⚠CAUTION ***Failure to flex the rocker arm fully while tightening the pump bodies together will result in excessive pump pressure and possible engine flooding or pump diaphragm failure.***

Installation:
1. Remove all gasket material from mounting faces and spacer (if used). Apply oil-resistant sealer to both sides of the gasket(s) and to the threads of the attaching capscrews.

2. Place the gasket (and spacer if used) on the mounting face of the pump. Slide the mounting capscrews through the pump and gasket (and spacer) to prevent the gasket from slipping out of place.

3. Lightly place the pump in position on the engine, making sure the rocker arm is riding on the camshaft lobe. Start both capscrews and check for proper gasket placement.

4. Connect the fuel inlet and outlet lines.

5. Operate the engine and check for leaks.

Electric Fuel Pump

All engines used on Onan N series generator sets are equipped with an electric fuel pump. The pump is manufactured by Facet (a division of Bendix Corporation) and carries a Facet nameplate. An internal fuel shutoff valve is a standard feature on this pump. Older versions of this pump carry the Bendix nameplate and do not have an internal fuel shutoff valve. Service procedures for the Facet or Bendix pump are the same.

⚠WARNING ***Do not substitute automotive type electric fuel pumps for standard Onan supplied electric pumps. The output pressure is much higher and can cause carburetor flooding or fuel leakage, creating a fire hazard.***

Pump Test: Test the fuel pump by checking the pump outlet pressure. Use the following procedure.

1. Remove the fuel line from the pump outlet and install a pressure gauge.
2. Press the START switch and hold it for several seconds until pressure reading is constant.
3. Pressure reading should be 2-1/2 to 3-1/4 psi (17.2 to 22.4 kPa). If the retension is good, the pressure should stay constant or drop off very slowly.

A low pressure reading with little or no pressure drop indicates a weak or broken diaphragm or diaphragm spring, worn linkage, or leaky check valves. If pressure is above maximum, the pump diaphragm is too tight or the diaphragm (or plunger) return spring is too strong. Any of the above conditions are cause for repair or replacement of the pump.

Fuel Pump Repair: Service of the Facet pump is limited to the bottom cover, filter, plunger tube, and plunger assembly. All parts of the electric system are hermetically sealed in a gas atmosphere and are not serviceable. If electrical failure occurs, replace the pump.

⚠CAUTION ***Do not tamper with the seal at the center of the mounting bracket on the side of the pump as it retains the dry gas which surrounds the electrical system. Electrical system components are not serviceable.***

Use the following procedure for servicing the pump:

1. Using a 5/8-inch wrench, loosen, the pump cover, then remove by hand.
2. Remove the filter, magnet and cover gasket (Figure 20).

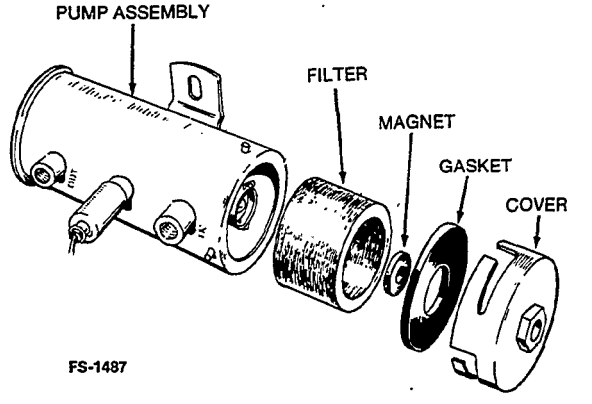


FIGURE 20. REMOVAL OF MAGNET AND FILTER

3. Using a thin nose pliers, remove the retainer spring from the plunger tube. Remove the washer, "O" ring seal, cup valve, plunger spring and plunger from tube (Figure 21).

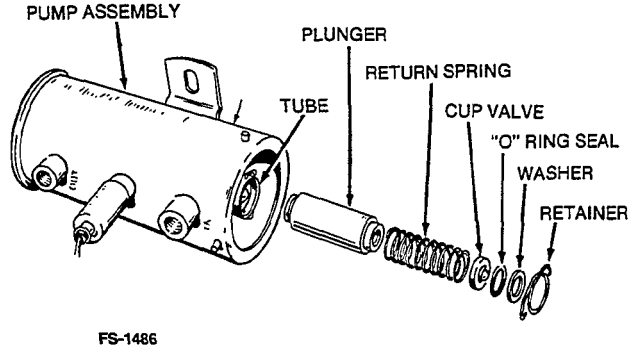


FIGURE 21. REMOVAL OF PLUNGER ASSEMBLY

4. Wash all parts (except gasket and seal) in parts cleaning solvent. Blow out solvent and dirt with low pressure compressed air. Slosh the pump assembly in cleaning solvent, blow dry and swab the inside of the plunger tube with a cloth wrapped around a stick. If the plunger does not wash clean or has rough spots, gently clean the surface with crocus cloth.

⚠WARNING ***Most parts cleaning solvents are flammable and can cause serious personnel injury if used improperly. Follow the manufacturer's recommendations when cleaning parts.***

5. Insert plunger in tube, buffer spring end first. Check fit by slowly sliding the plunger back and forth in the tube. It should move fully without any tendency to stick. If a click cannot be heard as the plunger is slid from one end to the other, the internal pump assembly is not functioning properly and the pump should be replaced.
6. Install plunger spring, cup valve, "O" ring seal and washer. Compress the spring and install the retainer with ends in the side holes of the tube.
7. Check cover gasket and replace if deteriorated. Place cover gasket and magnet in the bottom cover and install filter and cover assembly on pump. Twist cover on by hand and tighten securely with a 5/8-inch wrench.

Fuel Shutoff Valve (When Used)

The external fuel shutoff prevents fuel flow into the carburetor after engine shutdown. It connects electrically to the ignition power terminal and energizes during engine cranking and running to allow fuel flow. The device fastens directly to the fuel pump inlet (Figure 22).

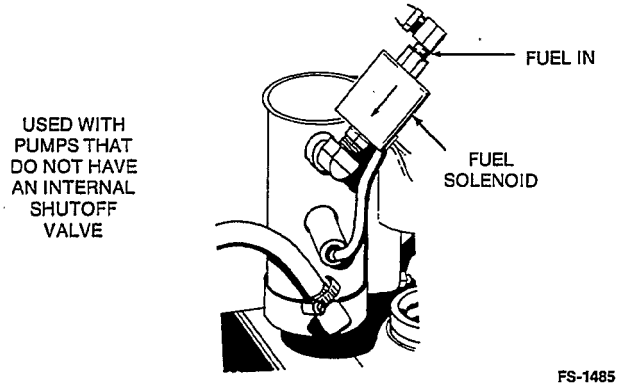


FIGURE 22. FUEL SOLENOID

To test the solenoid, connect a jumper wire from the B+ terminal on the control box to the plus (+) side of the ignition coil. If the solenoid is good, a click should be heard when the wire makes contact.

⚠CAUTION ***Twisting the body of the solenoid will cause internal damage. Apply twisting force with a wrench only at the hex nut located near the fuel inlet.***

Fuel Filters

Facet/Bendix Fuel pumps incorporate a filter within the casing of the pump (Figure 23). Use a 5/8 inch wrench to twist off the bottom of the pump and remove the filter element. If the filter is dirty, replace it along with the cover gasket.

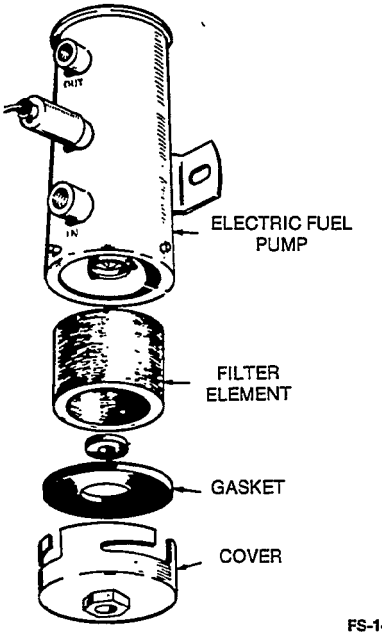


FIGURE 23. BENDIX AND FACET ELECTRIC PUMP FILTER

ELECTRIC CHOKE

The choke consists of a bi-metal coil and an electric heating element. The bi-metal coil connects to the choke shaft and holds the choke plate nearly closed when the engine is cold.

As the engine starts, current is supplied to the electric heating element in the choke cover. Heat from the element causes the bi-metal coil to twist. The twisting action of the coil turns the choke valve shaft and gradually opens the valve. Heat from the element keeps the choke open while the engine is running.

⚠WARNING ***The choke cover gets very hot during normal operation and can cause serious burns if touched. Do not touch the choke cover while the set is operating.***

If the engine starts but runs roughly and blows out black smoke after a minute or two of operation, the choke is set too rich. If the engine starts but sputters or stops before it warms up, the choke is set too lean.

Adjustment

Table 2 lists average choke settings. Loosen the two mounting screws and rotate the choke cover until the correct setting is attained. Check the setting by starting the engine and observing its operation. Be sure to retighten the mounting screws after adjustment (Figure 24).

TABLE 2. CHOKE SPECIFICATIONS

AVERAGE CHOKE SETTING	
Ambient Temp	**Choke Opening**
58° (14°C)	closed
66° (19°C)	1/4 open
72° (22°C)	1/2 open
76° (24°C)	3/4 open
82° (28°C)	open

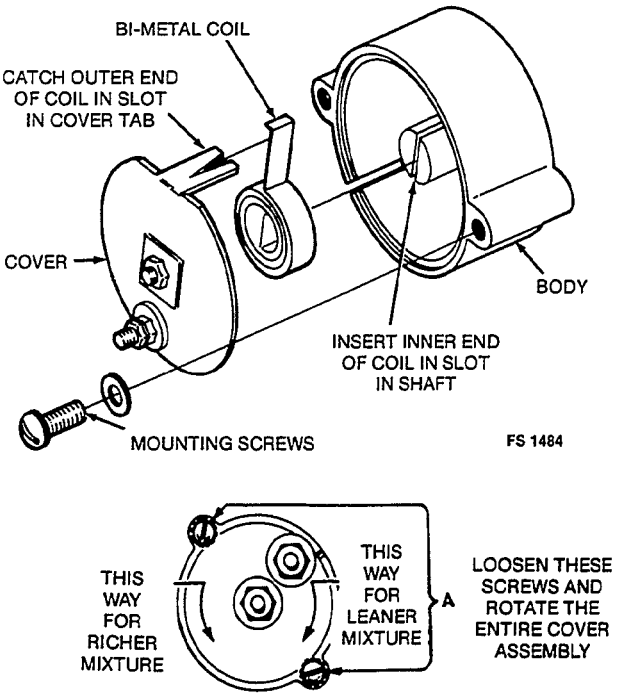


FIGURE 24. ELECTRIC CHOKE ADJUSTMENT

Repair

If the choke fails to operate, check to see if the heating element is working. If it is, the choke cover should become hot after a few minutes of engine operation. If the cover does not get hot, check for current at the cover terminal. The engine must be running. Trace down any opens or shorts.

Remove the choke cover to inspect the heating element and coil. See that the element is not burned out or broken. The bi-metal coil must not be damaged, dragging in the housing, or have an improperly directed spiral.

When installing a new coil, maintain the original direction of spiral inward from the fastening screw. Be sure the coil sets squarely in the housing so it will not bind. Coil should not touch inside of choke body.

AIR CLEANER

⚠CAUTION ***If air cleaner becomes too dirty, engine will not receive sufficient air to run properly. Symptoms: Loss of power, flooding, hard starting, and overheating.***

Engine is equipped with a paper element. If the engine is equipped with polyurethane precleaner it must be removed, cleaned, and oiled every 25 hours of operation, or more often under extremely dusty conditions.

1. To clean precleaner wash in water and detergent (Figure 25). Remove excess water by squeezing like a sponge and allow to dry thoroughly.
2. Distribute two tablespoons of SAE 30 engine oil evenly around the precleaner. Knead into precleaner and wring out excess oil.
3. Depending on conditions in which the engine is operating, the inner paper element should be replaced whenever it becomes excessively dirty or oily.

⚠CAUTION ***Never run engine with air cleaner removed. Dirt will enter engine and wear out rings causing excessive blow-by.***

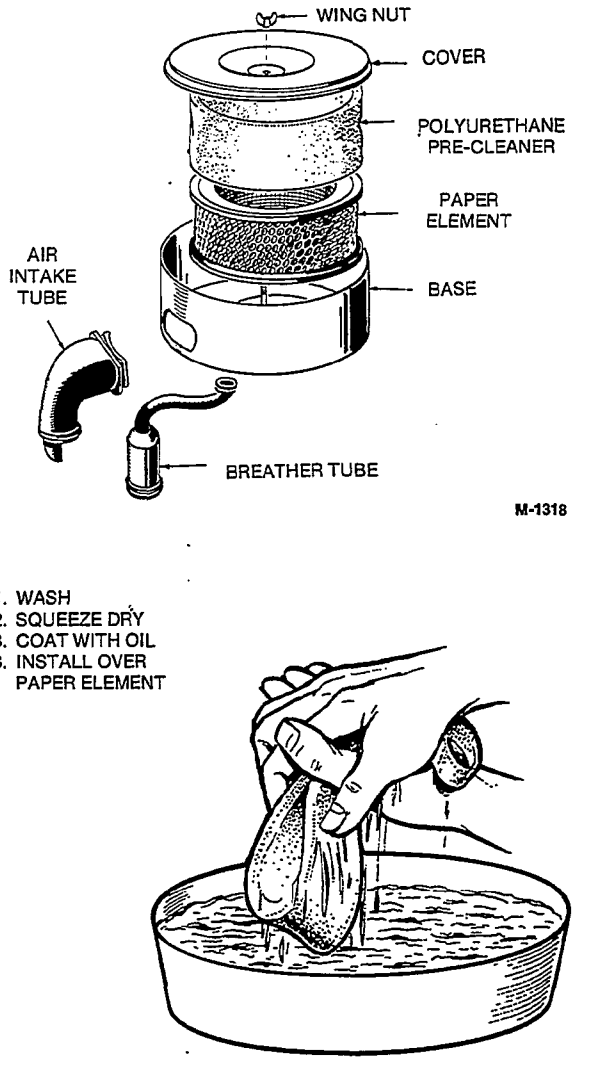


FIGURE 25. AIR CLEANER ASSEMBLY

GOVERNOR ADJUSTMENT

Where engine speed is governor controlled, the governor is set at the factory to allow 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.

Before making governor adjustment, run the engine in a well ventilated area for about 15 minutes to reach normal operating temperature.

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 (Figures 26 and 27).

A tachometer for checking engine speed is required for accurate governor adjustment.

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 idles. If either of these conditions exist, determine the cause and adjust or replace parts as needed.

Procedure

1. Adjust the carburetor main jet for the best fuel mixture at full load operation.
2. Adjust the carburetor idle needle with no load connected.
3. Adjust the length of the governor linkage.
4. Check the governor linkage and throttle shaft for binding or excessive looseness.
5. Adjust the governor spring tension for nominal engine speed at no load operation.
6. Check the rpm drop between no load and full load operation, and adjust the governor sensitivity as needed (should be about 8%).
7. Recheck the speed adjustment.
8. Set the carburetor throttle stop screw.

Linkage

The engine starts at wide open throttle. The length of the linkage connecting the governor arm to the throttle arm is adjusted 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 (0.794 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.

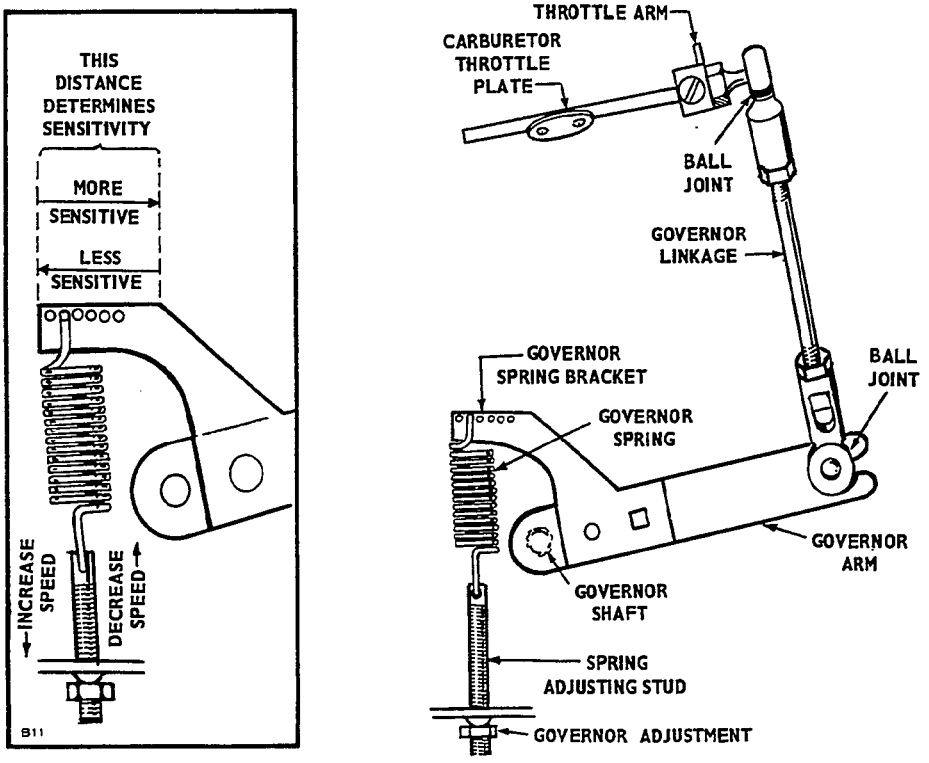


FIGURE 26. GOVERNOR ADJUSTMENTS

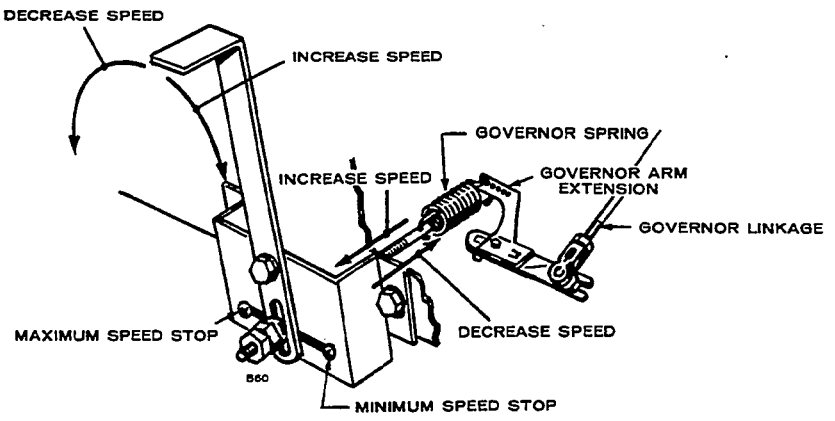


FIGURE 27. VARIABLE SPEED GOVERNORS

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 speed requirements of the connected load. For example, if the connected load is 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 26).

Sensitivity Adjustment

The engine speed drop from no-load to full-load should not be more than 400 rpm. Check the engine speed with no load connected and again after connecting full load. Do not exceed rated 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 Adjustment

These engines are adapted for use where a wide range of speed settings is desired. 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 variable speed governors, refer to Figure 27 and the following:

1. Run the engine and make necessary carburetor adjustments.
2. Adjust the throttle stop screw on the carburetor to allow a recommended minimum idling speed of 1100 rpm. A lower minimum does not assure smooth operation under load.
3. Adjust the tension of the governor spring for minimum speed.

   For governors having a manual control arm, set lever to minimum speed with no load and adjust the spring tension for about 1500 rpm.

   For governors having a Bowdin wire remote control knob (NHC engines with mounted engine controls), pull back the knob and slide to the first notch (low speed). Adjust speed to about 1500 rpm (or the desired low speed) at no load by turning the knob as required.
4. Adjust the sensitivity while operating at minimum speed to attain the smoothest no load to full load operation as follows:

   To decrease sensitivity (allow more speed drop from no-load to full-load operation), move the governor spring outward into a different groove or hole in the extension arm.

   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 groove or hole in the extension arm.
5. Apply a full load and shift the variable control to maximum speed—moving the control arm to the right or shifting the control knob and slide to the second notch. For the governor control with the control arm, set the screw in the bracket slot to stop lever travel at the desired maximum full-load speed position. For the control with the control know and slide, increase or decrease speed by turning the knob as required.

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

Ignition and Battery Charging

IGNITION TIMING

Timing is preset at the factory. Slight timing changes can be made by adjusting the points.

The engine is equipped with an automatic type battery ignition system. Both spark plugs fire simultaneously, thus the need for a distributor is eliminated.

BREAKER POINTS

The timing is adjusted during initial engine assembly and is fixed by the point gap adjustment. To maintain maximum engine efficiency, change the breaker points every 200 hours of operation.

Replacement and Adjustment

1. Remove spark plugs.
2. Remove breaker box cover. Rotate crankshaft clockwise (facing flywheel) until points are fully open.
3. Remove condenser (screw A) and detach condenser lead and coil lead screw (screw B). See Figure 28.
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. Adjust point gap by rotating crankshaft clockwise (facing flywheel) by hand until the points are fully open. Set the point gap (using flat feeler gauge) at .016 inch (0.41 mm) by adjusting the socket head screw (D) inward or outward (Figure 28). Make sure feeler gauge is clean and free of any grease, oil, or dirt. A .016 inch point gap is equivalent to 20° BTC.
7. Replace breaker box cover, coil wire, spark plugs, and spark plug cables.

Continuity Test

As a check for proper ignition timing a continuity test may be performed:

1. Adjust breaker points.
2. Remove air intake hose or cylinder shroud to expose timing marks (Figure 29).
3. Rotate flywheel clockwise until timing mark is aligned with the mark corresponding to 20° BTC on top of gearcase cover.
4. Connect an ohmmeter or a continuity test lamp set across the ignition breaker points. Touch one test prod to the coil lead terminal (screw B Figure 28).
5. Touch the other test prod to a good ground on the engine.
6. Turn crankshaft against rotation (counterclockwise) until the points close. Then slowly turn the crankshaft with rotation (clockwise).
7. The lamp should go out (continuity lost) just as the points break, which is where ignition occurs. If timing is early (advanced), the point gap is too large. If timing is late (retarded), the point gap is too small. Adjust point gap accordingly.

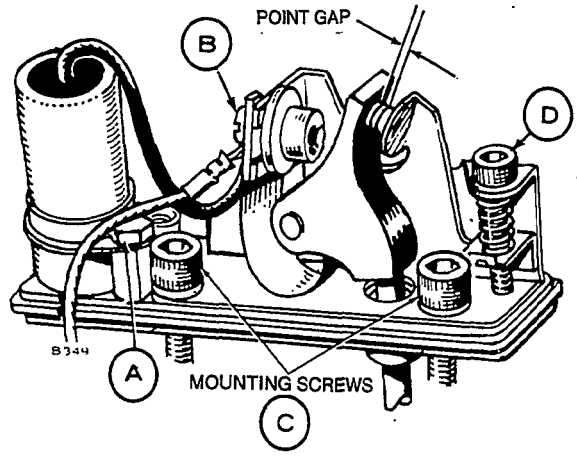
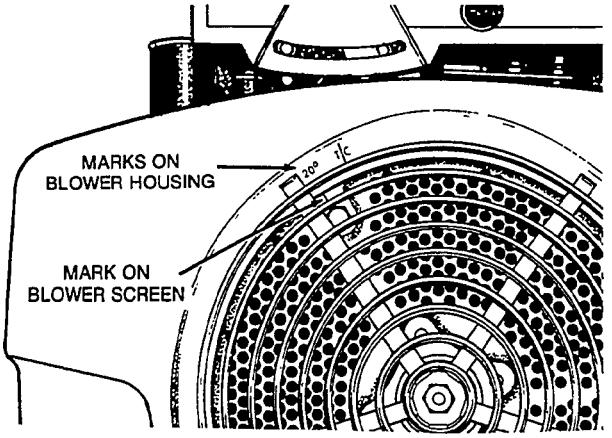
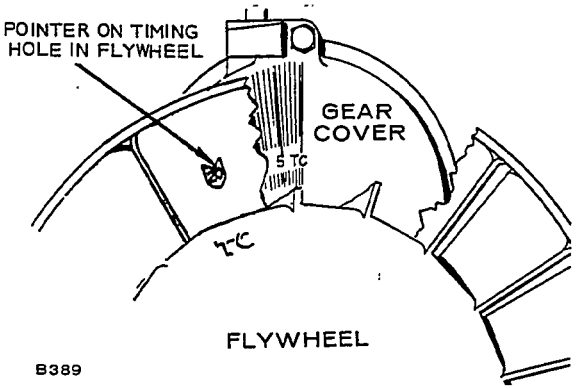


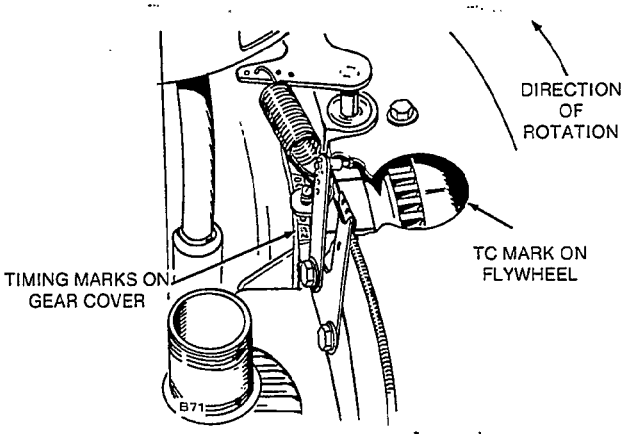
FIGURE 28. SETTING POINT GAP



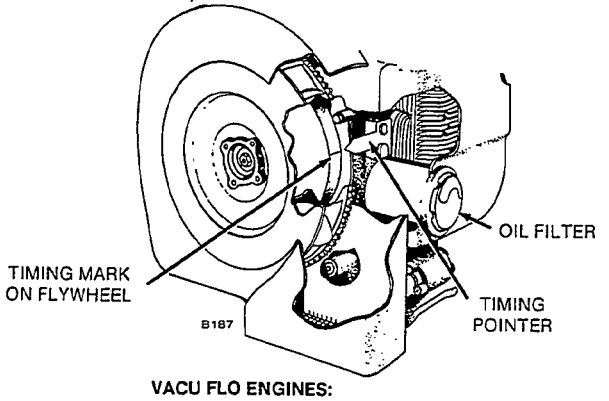
TIMING MARKS ON BLOWER HOUSING



TIMING MARKS ON GEAR COVER - VIEW THRU BLOWER WHEEL



PRESSURE COOLED: REMOVE AIR INTAKE HOSE TO VIEW TIMING MARKS



VACU FLO ENGINES:
REMOVE AIR SHROUD FROM RIGHT CYLINDER TO VIEW TIMING MARKS

FIGURE 29. TIMING MARK LOCATIONS

IGNITION COIL

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

1. Use a Simpson 260 VOM or equivalent.
2. Place black lead on ground (-) terminal of coil and red lead to positive (+) terminal. Primary resistance should read 3.87-4.73 ohms.
3. Change resistance setting on ohmmeter. Place ohmmeter leads inside of spark plug cable holes (Figure 30). Secondary resistance should read 12,600-15,400 ohms.
4. If any of the above conditions are not met, replace coil. Refer to *PARTS CATALOG* for correct part number.

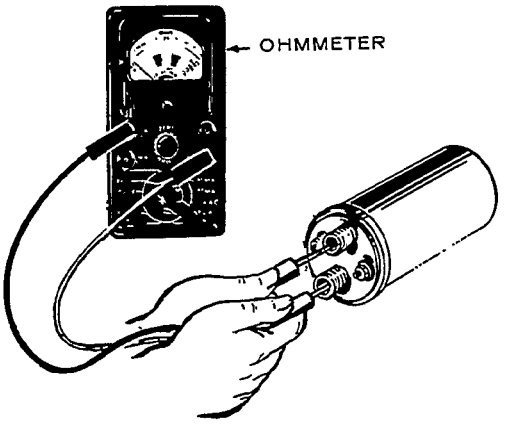


FIGURE 30. COIL TEST

SPARK PLUGS

Check, and regap spark plugs every 100 hours of operation (Figure 31). Replace spark plugs that show signs of fouling or electrode erosion.

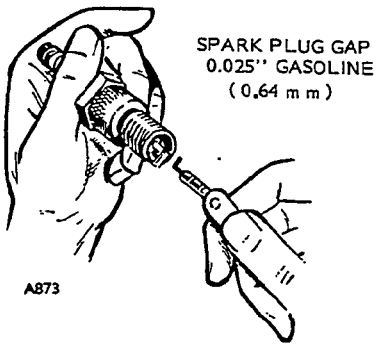


FIGURE 31. SPARK PLUG GAP

BATTERY INSPECTION

Check battery cells with a hydrometer. The specific gravity reading should be approximately 1.260 at 77° F (25° C), Figure 32.

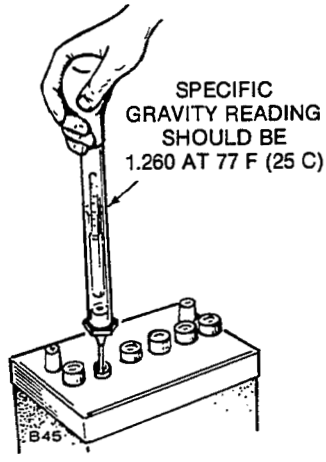


FIGURE 32. SPECIFIC GRAVITY TEST

If one or more cells are low on water, add distilled water and recharge. Keep the battery case clean and dry. An accumulation of moisture will lead to a more rapid discharge and battery failure.

Keep the battery terminals clean and tight. Push the cable terminal down flush with or slightly below the top of the battery post (Figure 33). After making connections, coat the terminals with a light application of petroleum jelly or grease to retard corrosion.

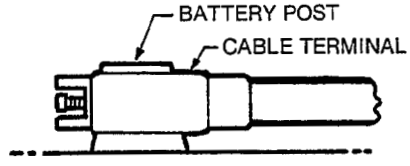


FIGURE 33. BATTERY CABLE CONNECTION

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 physical damage to battery.

⚠WARNING ***Do not smoke while servicing batteries. Explosive gases are emitted from batteries while charging. Ignition of these gases can cause severe personal injury.***

BATTERY JUMP STARTING

Occasionally, it may be necessary to jump start a weak battery using a charged booster battery to start your engine. If jump starting is necessary, the following procedure is recommended in order to prevent starter damage, battery damage and personal injuries.

⚠CAUTION ***Do not engage starter for periods longer than 30 seconds without allowing 5 minutes for starter to cool. Starter failure may result if these guidelines are not followed.***

1. Disconnect engine load.
2. Use only a battery of the same voltage (12V) as is used with your engine.
3. Attach one end of the positive booster cable (red) to the positive (+) terminal of the booster battery. Attach the other end of the positive cable to the positive (+) terminal of your engine battery.
4. Attach one end of the negative (-) booster cable (black) to negative (-) terminal of booster battery. Attach other end of negative cable to a solid chassis ground on your engine.

⚠WARNING ***Arcing may cause severe personal injury. Do not allow the positive and negative cable ends to touch each other because it will short the battery causing arcing.***

5. Jump starting in any other manner may result in damage to the battery or the electrical system.
6. Turn ignition switch to ON to start engine.

⚠WARNING ***Jump starting a frozen battery can explode and can cause severe personal injury. Never jump start a frozen battery. To do so may cause the battery to explode. Never expose the battery to an open flame or an electrical spark because a battery discharges highly explosive hydrogen gas.***

FLYWHEEL ALTERNATOR

The flywheel alternator is a permanent magnet alternator and uses a solid-state voltage regulator-rectifier for controlling output.

Three different alternator systems are used with NHC and NHCV engines; 20 amp Synchro system, 15 amp Phelon system, 20 amp Phelon system.

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

⚠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.***

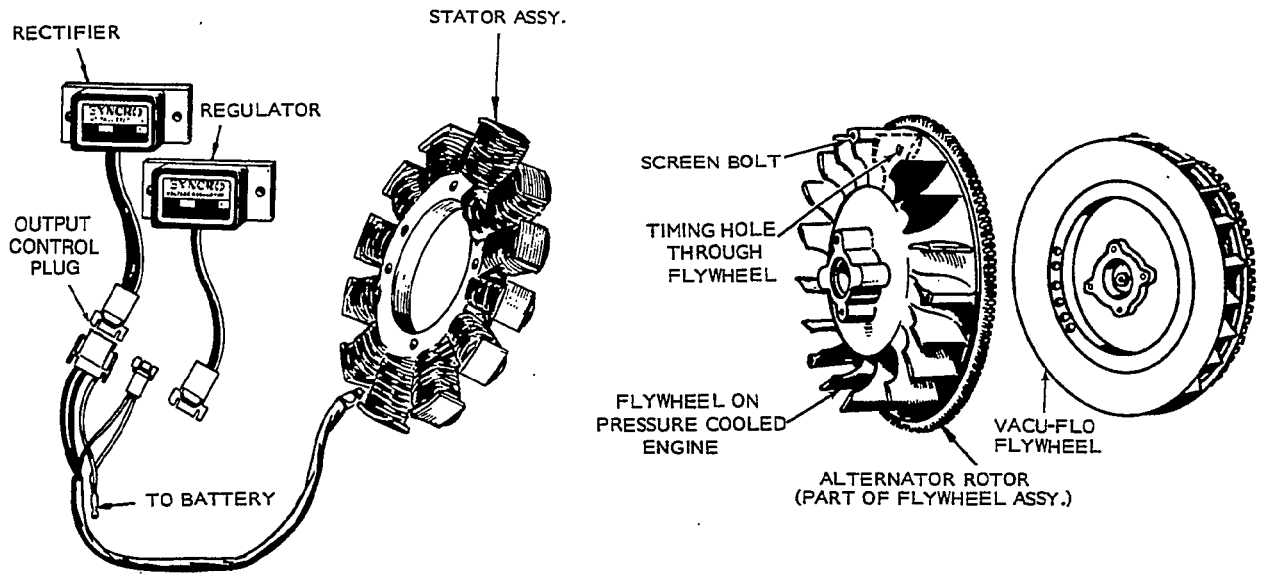


FIGURE 34. 20 AMP SYSTEM

TESTING OR SERVICING

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

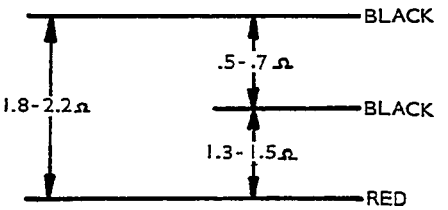
1. Be sure engine is being run long enough and fast enough to recharge battery after each start. Alternator output is reduced in direct proportion to engine rpm. Also, power required for accessories reduces power available to recharge battery.
2. Be sure output control plug (connector) is inserted properly. Plug must bottom in receptacle—eliminates any resistance due to a poor connection. Keep clean and tight.
3. Make sure alternator stator leads are not shorted together.
4. Be sure regulator-rectifier output control has a good ground connection. Mating surface for mounting must be clean and fasteners tightened properly.
5. Never reverse the battery leads.
6. Charging system tests require a fully charged battery.

20 Amp Synchro System

The 20 amp flywheel alternator systems use a separate regulator and a separate rectifier, Figure 34.

Testing: For testing this system, use a voltmeter-ohmmeter such as a Simpson 270. Various alternator problems with individual test procedures are listed in Table 2.

TABLE 2. TESTING SYNCHRO 20 AMP 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 VDC depending on charge condition of battery
AC voltage from stator with plug disconnected and unit running at approximately 1800 rpm	23 VAC minimum* 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 	

* - 48 VAC maximum at 3600 rpm.

No Output—Stator Assembly: Examine leadwires 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 leadwire and ground to check continuity. The ohmmeter reading should be about 2.0 ohms. See Figure 34a for wiring diagram.

Next, connect meter to black leadwires and ground. Approximately 0.1 ohm should be read from either black lead to ground. If no continuity exists between ground and black leads, stator assembly should be replaced.

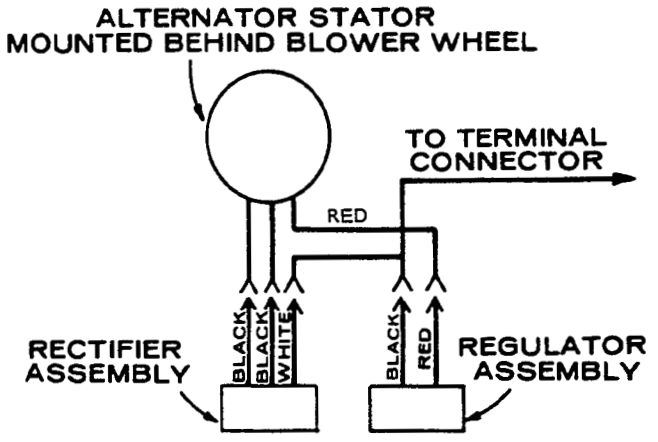


FIGURE 34a. 20 AMP SYNCHRO SYSTEM

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 resistance and would cause a short circuit through the lead winding when in operation. An open diode would read infinite 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 may 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 leadwire and other meter lead to regulator base. No deflection should be noted on the ohmmeter in either polarity. Next, connect meter to black leadwire and base of regulator. Meter will deflect fully in one polarity, with no deflection in the other.

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 leadwire 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 Amp Phelon System

The Phelon flywheel alternator systems (Figure 35) have as one piece regulator-rectifier assembly. Various alternator tests are listed in Table 3.

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 *Alternator Output Test.*

Alternator Output Test

1. With the engine running, check the battery terminal voltage (regulator output) using a DC voltmeter. Voltage output should be within the values specified in Table 3. If voltage is greater than specified replace regulator-rectifier assembly. If voltage is less than specified, proceed to step 2.

2. Examine all wires for loose, corroded, broken connections, short circuits, etc. Check fuses. Repair as needed to assure complete circuits from regulator-rectifier B+ terminal to battery positive (+) terminal and from battery negative (-) terminal to regulator-rectifier case. If battery voltage remains low with engine running, proceed to step 3.

3. Disconnect plug from regulator-rectifier and test the AC voltage at the plug with engine running near 3600 rpm. If AC voltage reads more or less than specified in Table 3, proceed to step 4. If AC voltage is as specified but DC voltage is low, replace regulator-rectifier.

4. Use the Rx1 scale on the ohmmeter for detecting opens in the stator (unit not running). Disconnect plug from regulator-rectifier. Connect ohmmeter test leads to wires coming from stator. Refer to Table 3 for resistance specifications. If resistance is not as specified, replace stator. If stator resistance readings are as specified and windings are not shorted to ground, low AC voltage may be due to loss of magnetism. If so, blower wheel assembly must be replaced. Check for magnetism with steel tool blade. Next, connect one ohmmeter test lead to stator wire, connect the other test lead to gorund. If the ohmmeter reading is low the stator is grounded and must be replaced.

TABLE 3. TESTING PHELON SYSTEMS

BASIC TEST	PROCEDURE	TEST VALUES	
		15A. SYSTEM	20A. SYSTEM
1. Battery	Battery Voltage — 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	23 VAC minimum 48 VAC maximum

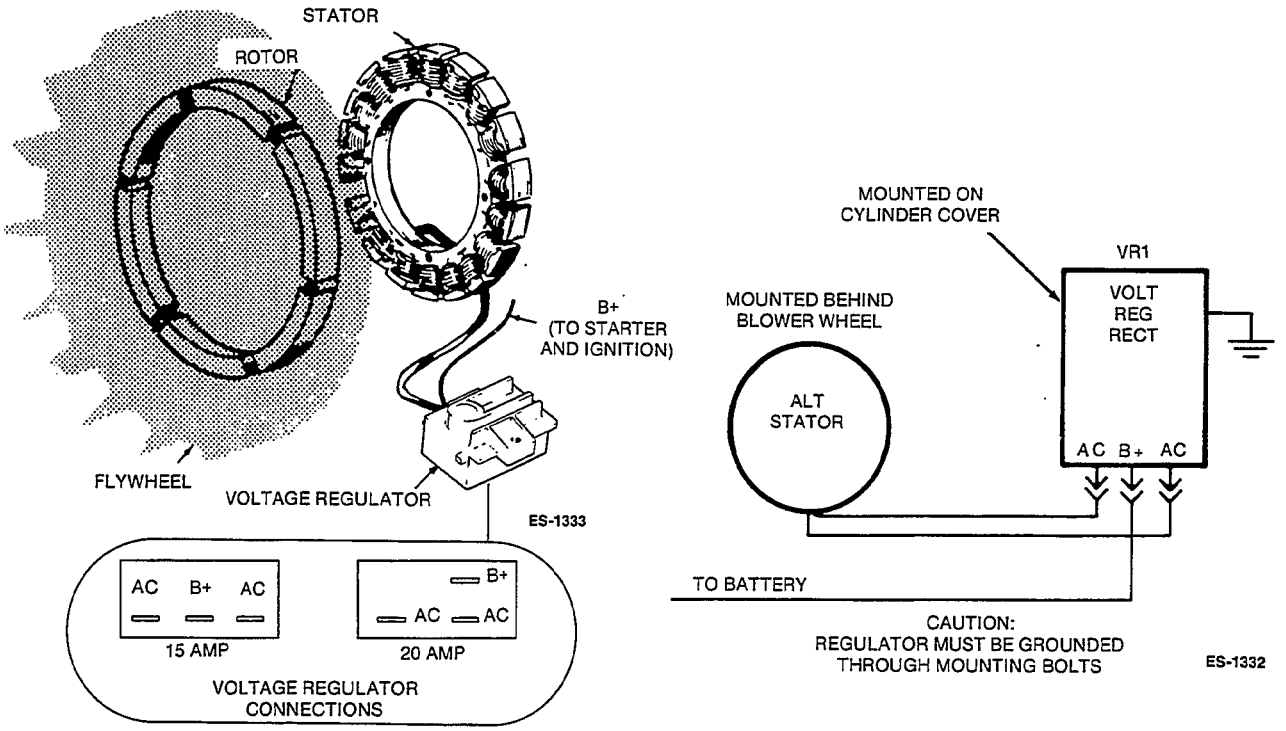


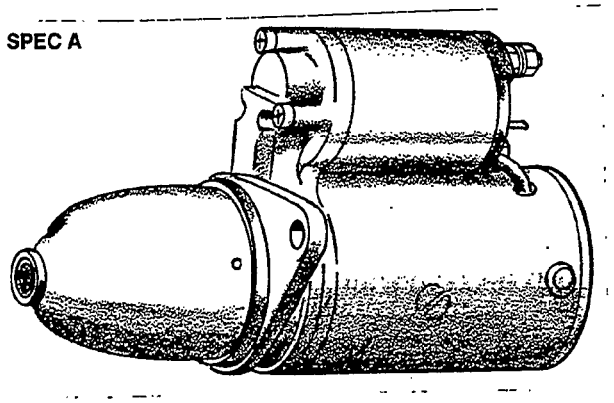
FIGURE 35. PHELON SYSTEM

Starting System

ELECTRIC STARTER

The electric starter contains three main assemblies: an electric starting motor; a pinion gear and clutch which engages with the ring gear on the engine flywheel during starting; and a solenoid-switch assembly which shifts the pinion gear into the engine ring gear and activates the starting motor.

The starter will seldom require service other than possible brush replacement. Before attempting starter repair, make sure the electrical system leading to the start solenoid is not the source of the problem. If the starter binds or slips during cranking, or is excessively noisy, the gear lash between the starter and the flywheel ring gear may be incorrect. Information on setting the gear lash is provided at the end of this section.



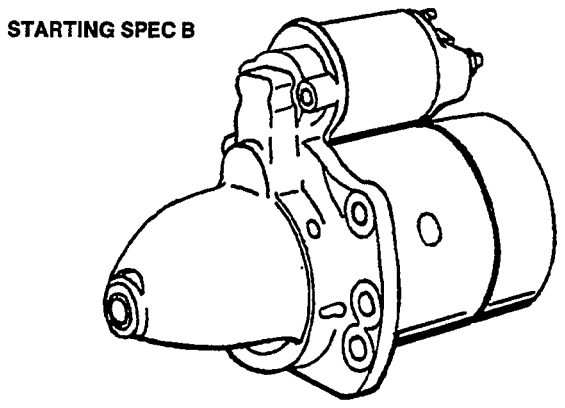


FIGURE 36. STARTER ASSEMBLIES

STARTER DISASSEMBLY AND REPAIR

Starter disassembly and inspection procedures are provided below. Common sources of starter malfunction include worn commutator brushes, worn armature bearings, a stripped pinion gear, or a faulty solenoid-switch.

Removal

1. Disconnect the positive battery cable from the starter solenoid-switch.
2. Remove the blower housing from the front of the engine.
3. Holding the starter in place, remove the starter mounting bolts, then remove the starter.

Disassembly

Some differences in configuration exist between the starter used during Spec A and the starter that has been used from Spec B to the present (Figure 36). However, disassembly procedures for either are basically the same. Using Figure 37 as a guide, proceed as follows:

1. Remove the field coil strap where it connects to the solenoid-switch.
2. Detach the mounting screws, and remove the solenoid-switch from the starter motor.
3. Remove the starter thru-bolts. Separate the front bracket from the starter housing. The solenoid shift lever and spring components will come loose as the front bracket is removed. The armature may also be removed from the starter housing at this time.
4. Remove the brush holder retaining screws from the back of the rear bracket. Separate the rear bracket from the starter housing and the brush holder.
5. To remove the pinion gear and clutch from the armature shaft, drive the pinion stopper away from the retaining ring it holds in place (Figure 38). Remove the retaining ring and slide the pinion stopper, pinion gear and clutch off of the armature shaft.

Inspection of Parts

Pinion Gear and Clutch: The pinion gear should rotate smoothly (not necessarily easily) in one direction and not at all in the opposite direction. If the gear is worn or burred, or does not rotate properly, replace the gear and clutch assembly. Also check the teeth on the flywheel ring gear for signs of excessive wear and replace if necessary.

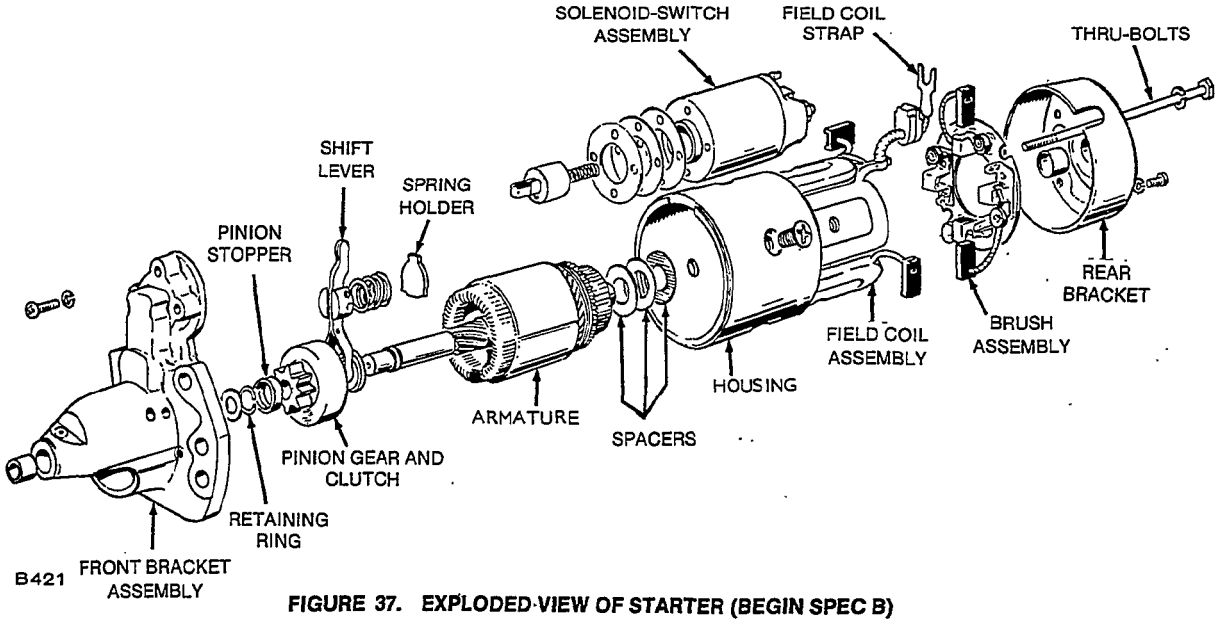


FIGURE 37. EXPLODED VIEW OF STARTER (BEGIN SPEC B)

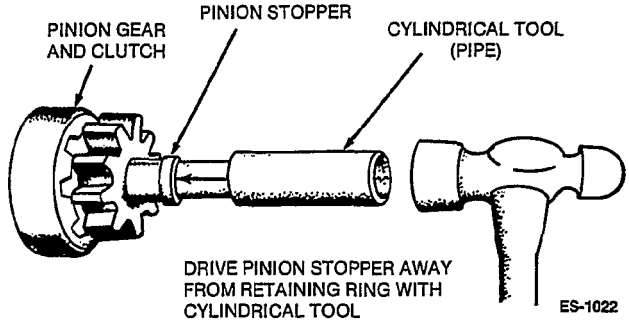


FIGURE 38. PINION GEAR AND CLUTCH REMOVAL

Brush Inspection: When brushes are worn to the wear limits (Figure 39), replace them. See that the brushes move smoothly in the brushholders.

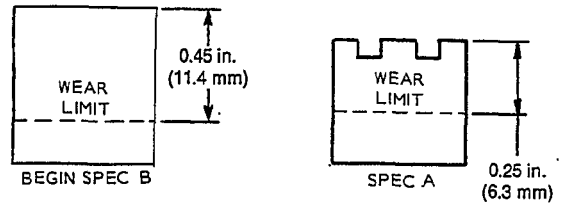


FIGURE 39. BRUSH WEAR LIMITS

Measure the brush spring tension by placing the brush holder assembly in place over the commutator end of the armature. Hook a spring scale over the spring near the brush and take a reading as the spring just leaves the brush. On a new brush, the tension should be 49 to 59 ounces (1390 to 1670 grams). For the Spec A starter, the tension shoud be 29 to 38 ounces (820 to 1075 grams).

Testing Armature for a Short Circuit: Use a growler for locating shorts in the armature. Place armature in growler and hold a thin steel blade (e.g. hacksaw blade) parallel to the core and just above it while slowly rotating armature in growler. A shorted armature will cause the blade to vibrate and be attracted to the core. If armature is shorted, replace with a new one (Figure 40).

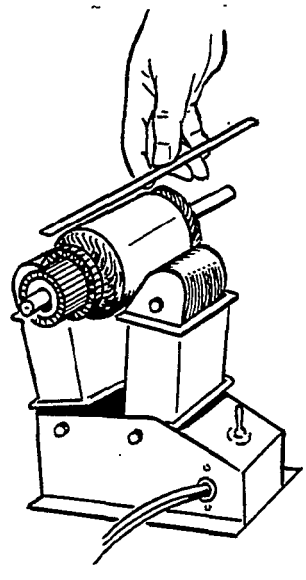


FIGURE 40. ARMATURE SHORT CIRCUIT TEST

Testing Armature for Grounds: Touch armature shaft or core and the end of each commutator bar with a pair of ohmmeter leads (Figure 41). If the ohmmeter reading is low, it indicates a grounded armature. Replace a grounded armature.

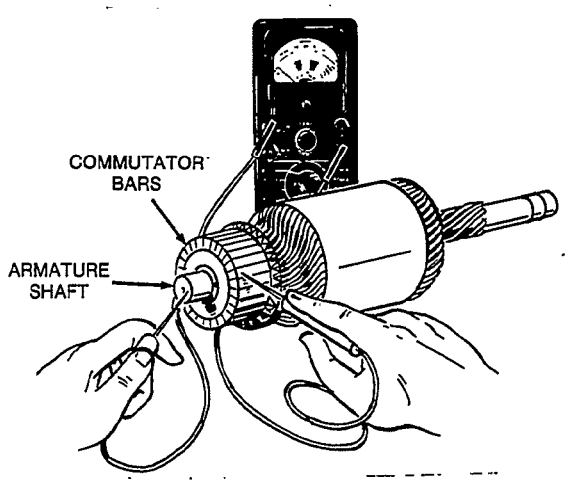


FIGURE 41. ARMATURE GROUND TEST

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

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 42). A low ohmmeter reading indicates a grounded field either at the connector or in the windings.

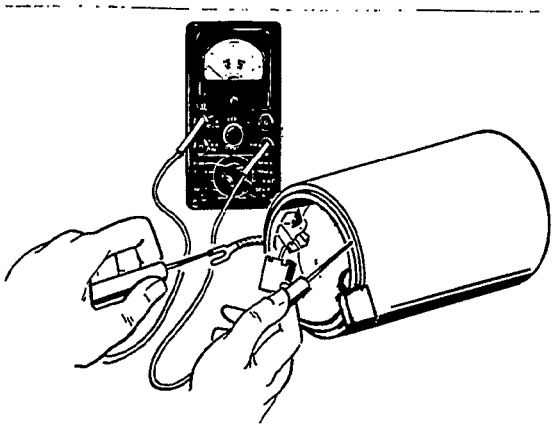


FIGURE 42. FIELD COIL GROUND TEST

Testing Field Coils for Open Circuits: Place one lead on the connector and the other on a clean spot on the brushholder (Figure 43). A high ohmmeter reading indicates the field coil is open. Check the other three brushholders in the same manner.

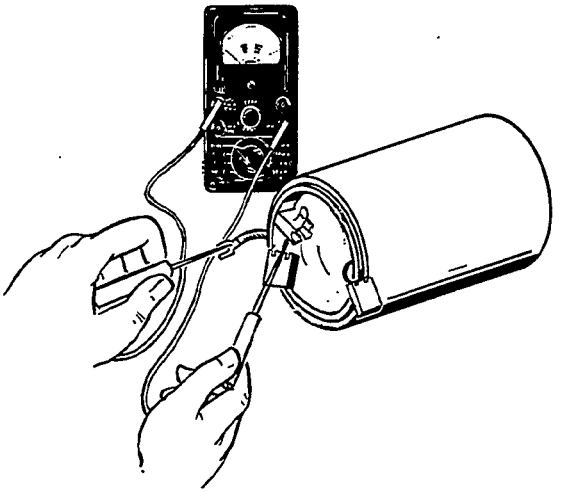


FIGURE 43. FIELD COIL OPEN CIRCUIT TEST

Testing Commutator Runout: Place armature in a test bench and check runout with a dial indicator (Figure 44). When commutator runout exceeds 0.004 inch (0.102 mm), reface the commutator.

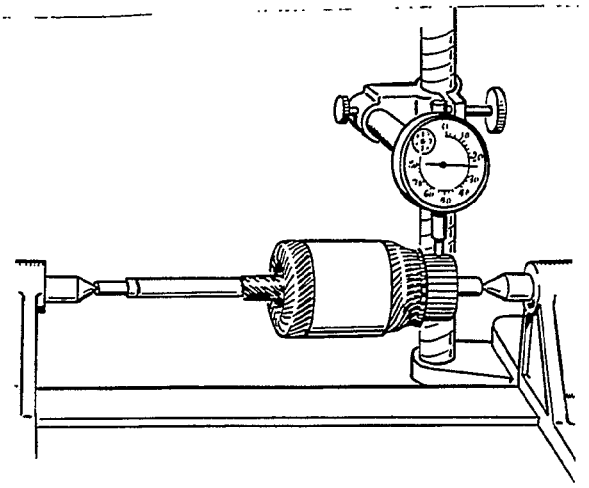


FIGURE 44. CHECKING COMMUTTOR RUNOUT

Testing Armature Shaft Runout: You can check the armature shaft for runout as shown in Figure 45. A bent armature can often be straightened, but a new armature is required if the shaft is worn.

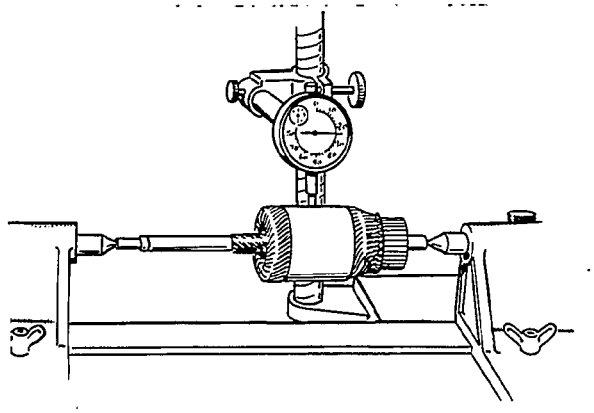


FIGURE 45. CHECKING ARMATURE SHAFT RUNOUT

CLEANING PARTS

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

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

3. Wash all other parts in solvent and dry.

STARTER ASSEMBLY

1. Lubricate armature shaft with a very light grade oil. A medium or heavy oil or grease may cause faulty operation in cold weather.
2. Slide the pinion gear and clutch assembly and the pinion stopper onto the armature shaft. Position the retaining ring in its groove on the armature shaft, and secure the pinion stopper over it using a puller such as that shown in Figure 46.

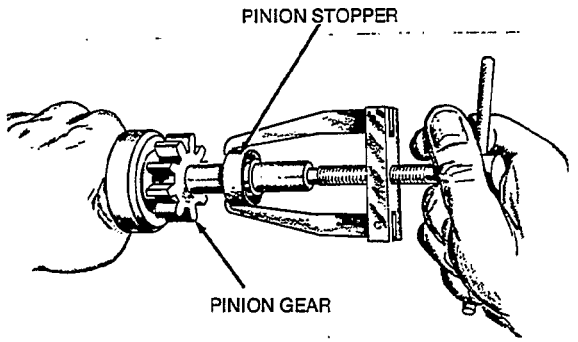


FIGURE 46. INSTALLING PINION GEAR AND CLUTCH

3. Apply a small amount of Lubriplate on the shift lever pivot pin and lever holders (unless the holders are made of nylon, in which case no lubricant is needed).

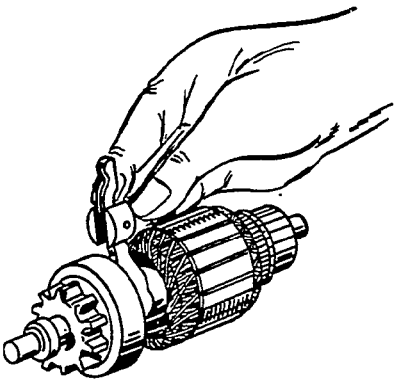


FIGURE 47. SHIFT LEVER INSTALLATION

4. Place the shift lever assembly in position on the armature as shown in Figure 47. Slide the thrust washer onto the end of the armature shaft, and install the armature and shift lever assembly in the front bracket (Figure 48).

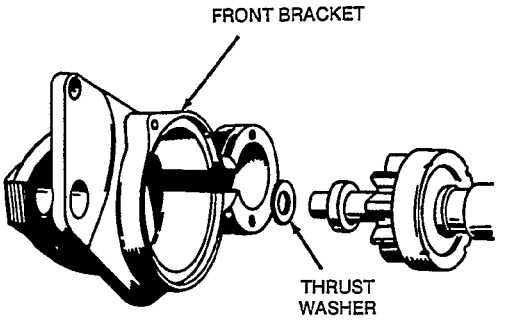


FIGURE 48. ARMATURE INSTALLATION

5. Place the shift lever spring and spring holder in the front bracket. Slide the starter housing over the armature and align with the front bracket.
6. Position the brush holder and brushes in place on the commutator end of the armature, pulling the brushes back against spring tension to allow the holder to slide in place.
7. Install the rear bracket making sure the thru-bolt and brush holder screw holes are properly positioned. Slide thru-bolts into position and screw in place. Install the brush holder attaching screws.
8. Install the solenoid-switch, catching the solenoid plunger on the solenoid shift lever.

INSPECTION AFTER OVERHAUL

1. For no-load test, the starting motor is wired as shown in Figure 49 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

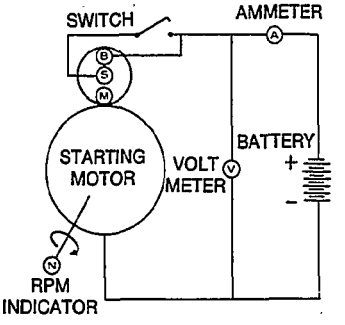


FIGURE 49. WIRING STARTER FOR NO-LOAD TESTS

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

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

2. To adjust pinion clearance, connect the battery to the starting motor as shown in Figure 50. 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 51.

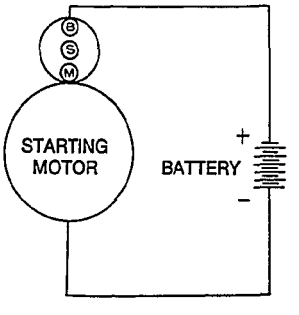


FIGURE 50. BATTERY CONNECTIONS

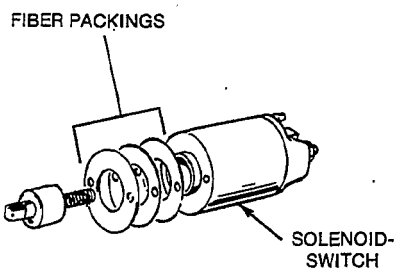


FIGURE 51. ADJUSTING PINION CLEARANCE

CHECKING GEAR LASH

Always check starter-to-flywheel gear lash when reinstalling the starter on the engine. Lash should also be checked if the starter binds or slips during cranking or is excessively noisy. Proceed as follows:

1. Before installing the starter, make sure the starter mounting surfaces on the engine base are free of dirt and oil to assure good electrical contact.
2. Install the starter motor and tighten the mounting bolts just enough to hold the starter in place.
3. Remove the spark plugs from the engine to allow free movement of the flywheel.
4. Manually pull the starter pinion gear outward on its shaft so that its teeth mesh fully with those on the flywheel.
5. Measure the amount of free travel (lash) between the pinion gear teeth and the ring gear teeth, as shown in Figure 52. Proper lash is 0.020±0.010 in. (0.51±0.25 mm). Loosen and adjust the starter motor as necessary to obtain the correct setting.
6. Torque down the starter mounting bolts and reinstall the engine spark plugs.

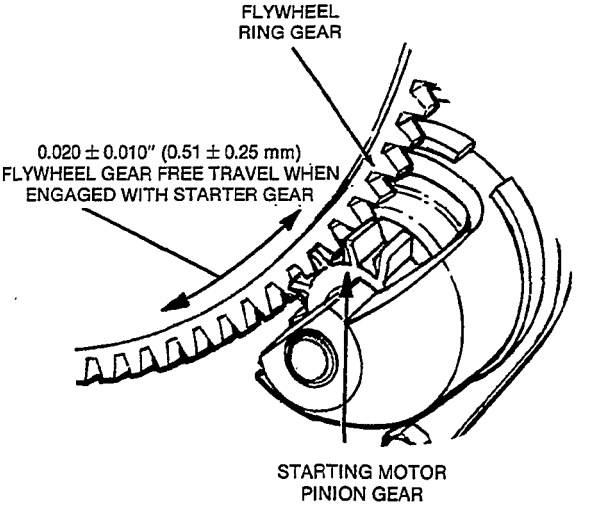


FIGURE 52. CHECKING STARTER GEAR LASH

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.
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, crankshaft, and front bearing.

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

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 the internal engine parts with oil as they are assembled. After the internal engine parts are assembled, the engine should turn over by hand freely. Use only genuine Onan parts and special tools when reassembling your engine.

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

Testing Compression

The compression tester is used to determine the condition of valves, pistons, piston rings and cylinders.

To check compression:

1. Run the engine until thoroughly warm.
2. Stop engine and remove spark plugs.
3. Remove air cleaner and place throttle and choke in the wide open position.
4. Insert the compression gauge in one spark plug hole.

Refer to *SPECIFICATIONS SECTION* for compression pressures. There may be variations due to temperature, atmospheric conditions and altitude. These pressures are for a warm engine at cranking speed (about 300 rpm).

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. Place a socket wrench on the flywheel capscrew and rotate the crankshaft in a clockwise direction until the left intake valve (viewed from flywheel end) opens and closes. Continue turning the crankshaft until the TC mark on the flywheel is lined up with the TC mark on the gear cover. This should place the left piston (#1) at the top of its compression stroke. Verify that the left intake and exhaust valves are closed and there is no pressure on the valve lifters.
5. The correct feeler gauge for the valve adjustment *(SPECIFICATIONS)* should pass freely between valve stem and tappet; a 0.002 inch (0.05 mm) thicker gauge should not (Figure 53).
6. To correct the valve clearance, use a 7/16-inch open end wrench to turn the adjusting screw to obtain the correct clearance. The screw is self-locking and will stay where it is set. A 9/16-inch (14 mm) open end wrench is required to hold the tappet while turning the adjusting screw.
7. To adjust valves on the right hand cylinder, turn engine one complete revolution and again line up mark on the flywheel and the TC mark on the gear cover. Then follow adjustment procedure given for left hand cylinder.
8. Replace all parts removed in Step 2. Tighten all screws securely. Torque manifold bolts to specified torque.

VALVE SYSTEM

A properly functioning valve system is essential for good engine performance. All engines utilize an L-head type valve design as shown in Figure 53. Access to the valve system can be obtained by removing the cylinder heads and the valve covers on top of the engine. A valve spring compressor must be used to remove valves from the cylinder block.

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

Place valves, springs, retainers, and tappets in a rack as they are removed from cylinder block so they can be identified and reinstalled in their original locations. Discard old valve stem seals and replace with new ones during assembly.

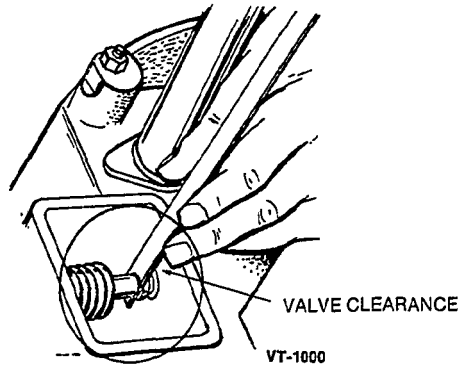
Use the following procedures to inspect and service the valve system.

Inspection

Clean carbon from the valves, valve seats, valve guides, and cylinder block.

Valves: Check the valve face for evidence of burning, warpage, out-of-round, and carbon deposits.

Burning and pitting are caused by the valve failing to seat tightly. This condition is often caused by hard carbon particles on the seat. It may also be due to weak valve springs, insufficient tappet clearance, warpage, and misalignment.



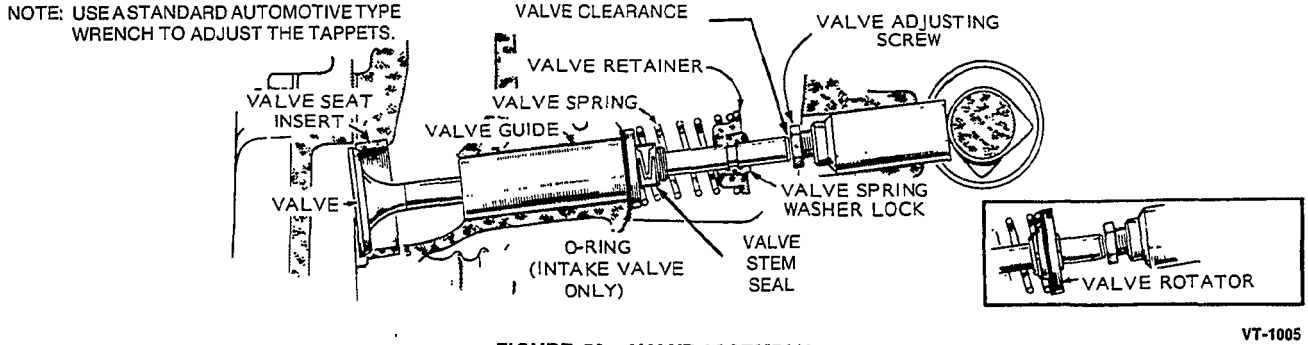


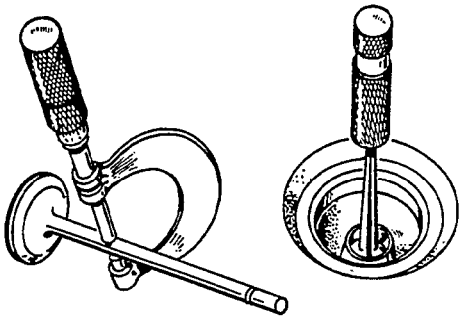
FIGURE 53. VALVE ASSEMBLY

Warpage occurs chiefly in the upper stem due to its exposure to intense heat. Out-of-round wear follows when the seat is pounded by a valve whose head is not in line with the stem and guide. If a valve face is burned or warped, or if the stem is worn, install a new valve.

Too much clearance in the intake guide admits air and oil into the combustion chamber, upsetting carburetion, increasing oil consumption, and making heavy carbon deposits. Carbon reduces heat dissipation. Clean metal is a good heat conductor but carbon insulates and retains heat. This increases combustion chamber temperatures which causes warping and burning.

Unburned carbon residue gums valve stems and causes them to stick in the guide. Deposits of hard carbon with sharp points projecting become white hot and cause pre-ignition and pinging.

Refinish valves that are slightly pitted or burned on an accurate valve grinder. If valves are badly pitted or have a thin margin when refacing, replace them.



VT-1020

FIGURE 54. VALVE STEM AND VALVE GUIDE INSPECTION

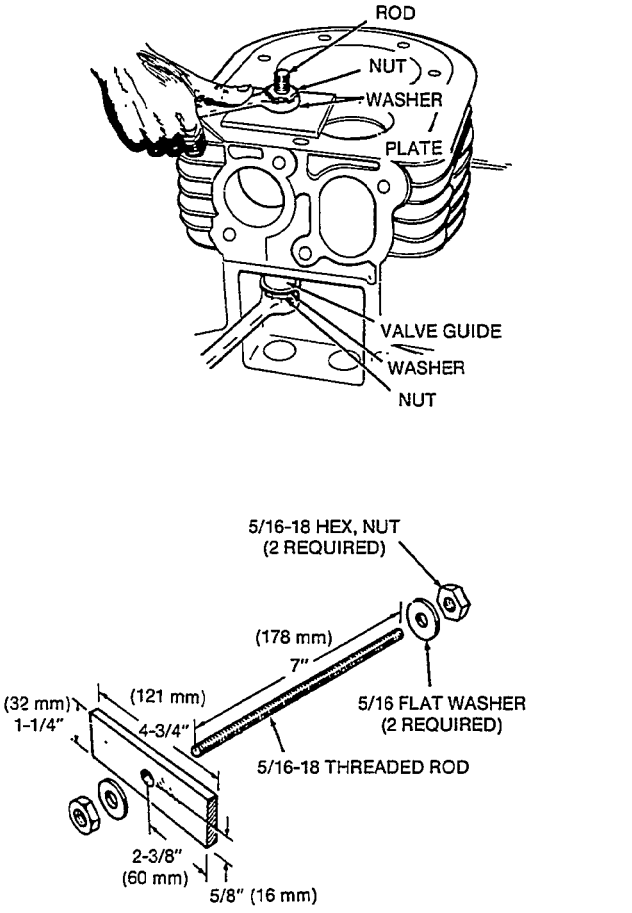
Stems And Guides: Always check valve stems and guides for wear (Figure 54). Use a hole gauge to measure the valve guide. When clearance with stem exceeds that specified in *DIMENSIONS AND CLEARANCES*, replace either valve or guide or both, as may be necessary. Always regrind seat to make concentric with the newly installed guide.

Worn valve stem guides can be replaced from inside the valve chamber (a seal is provided behind the intake valve guides only). The smaller diameter of the tapered valve guides must face toward the valve head. Tappets are also replaceable from the valve chamber after first removing the valve assemblies.

Valve Guide Removal: Before removing valve guides, use an electric drill with a wire brush to remove carbon and other foreign material from top surface of guides. Failure to perform this operation may result in damage to the guide bores. Drive the guides out with a hammer and valve guide driver.

⚠CAUTION ***Driving out old guides can damage the tappet bores. Be careful not to strike bores with driver.***

Valve Guide Installation: Run a small polishing rod covered with crocus cloth through valve guide holes to clean out carbon and other foreign materials. Place a new gasket on the intake valve guide, and coat the outer edge of each new guide with oil. Place guide, notch-up, in cylinder block and press in until guide stops or protrudes 11/32 inch (8.7 mm) from rocker box side of block. A suggested method of installation is shown in Figure 55.



VT-1023

FIGURE 55. VALVE GUIDE INSTALLATION

Valve Stem Seals: Do not reuse valve stem seals. Each time the valves are removed from cylinder block, a new seal must be used when valve is reinstalled.

⚠CAUTION ***Do not remove valve after seal is installed. Valve can be withdrawn only as far as the groove in valve stem. Do not allow valve stem seal to come in contact with groove or seal damage will result.***

Valve Spring: Check valve springs for cracks, worn ends, distortion, and tension. If spring ends are worn, check valve spring retainer for wear. Check for spring distortion by placing spring on a flat surface next to a square. Measure height of spring and rotate it against square edge to measure distortion. If distortion exceeds 0.06 inch (1.5 mm) replace spring. Check spring tension at the installed height for both the valve open and closed position using an accurate valve spring tester. Replace any valve spring that is weak, cracked, worn, or distorted.

Valve Rotators: 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. There is no easy way to determine if a valve rotator is good or bad. Onan recommends that valve rotators be replaced at each major overhaul or if a build-up of carbon is noted on valve face and valve seat.

Valve Seats: Inspect valve seat inserts. If seats are loose, cracked or severely pitted, new ones must be installed. Remove valve seat inserts using a valve seat removal tool. If valve seat insert bores in cylinder block are damaged or worn so that a press fit cannot be obtained when installing new standard size valve seat inserts, the bores must be machined for an oversize seat.

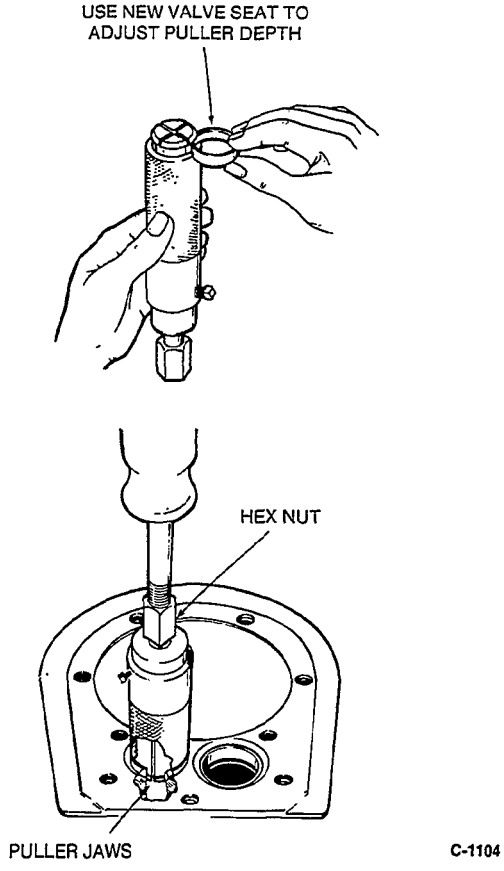


FIGURE 56. VALVE SEAT REMOVAL

Valve Seat Removal: Remove carbon and combustion deposits from valve seat. Select proper puller size determined by inside diameter of valve seat. On some pullers use a new seat as a guide to adjust puller depth (Figure 56). Puller jaws must expand into cylinder block at the point where bottom of valve seat insert rests on cylinder block (Figure 56). Position puller on valve seat and tighten hex nut. Clamp cylinder block to a solid bench. Attach slide hammer to puller. Tighten hex nut between each blow with the slide hammer.

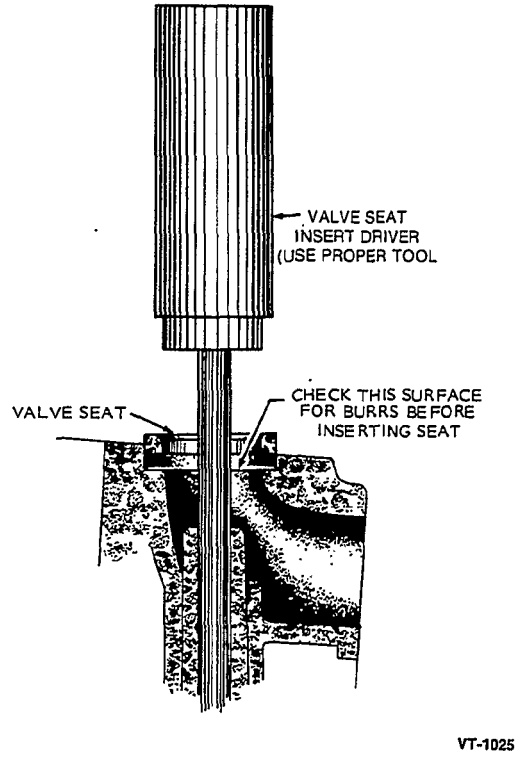


FIGURE 57. INSERTING NEW VALVE SEAT

Valve Seat Installation: After the old seat has been removed, clean out any carbon or metal burrs from the seat insert recess. Use a valve seat insert driver and hammer to install the insert (Figure 57). Drive the valve seat insert in so that insert enters the recess evenly. Make certain that the valve seat insert rests solidly on the bottom of the recess all the way around its circumference (Figure 57).

To assure a tight valve seat fit and eliminate the danger of seat loosening in the bore, valve seat must be staked.

Insert valve seat staker into valve seat or guide in cylinder block. Using a lead hammer, strike the staking tool a sharp blow to wedge new valve securely in place. It will be necessary to refinish valve seat inserts before installing valves.

TAPPETS

Very little wear takes place on tappet diameters or in tappet bores. If the clearance between tappet and bore in cylinder block exceeds specifications, replace the tappet.

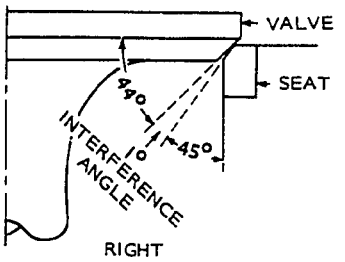
Inspect the tappet faces which contact camshaft lobes for roughness, scuffing, or concave wear. Replace any worn tappets. If tappets are worn, inspect camshaft for wear.

VALVE FACE AND SEAT GRINDING

Some engines are equipped with a premium valve package (aluminized intake valves). If the aluminized valve face does not clean-up using a wire brush, the valve face may be refinished. This removes the aluminized coating from the valve face. An aluminized valve that has been refinished will normally have a life expectancy equal to a standard valve. If longer valve life is required, worn or damaged valves should be replaced with new premium valves.

Before installing new valves or previously used valves, inspect valve seats for proper valve seating. If used valves are reinstalled, the valve stems should be cleaned and valve faces ground to their specified angles of 44°. Refinish valve seats to a 45° angle. When refacing valves and seats, remove all evidence of pitting and grooving. If end of valve stem is pitted or worn, true it and clean it up on the refacer wheel. A very light grind is usually enough to square stem and remove any pits or burrs. The valve guide should be thoroughly cleaned. If valve guide is worn, or valve is warped, the necessary parts must be replaced.

By grinding the valve face and seat at slightly different angles, a fine line of contact on face and seat is obtained, eliminating the need to lap the seating surfaces. The one degree difference in angles is defined as the interference angle (Figure 58). The seat angle is greater than that of the valve face. This assures contact at the maximum diameter on valve seat seating surface.

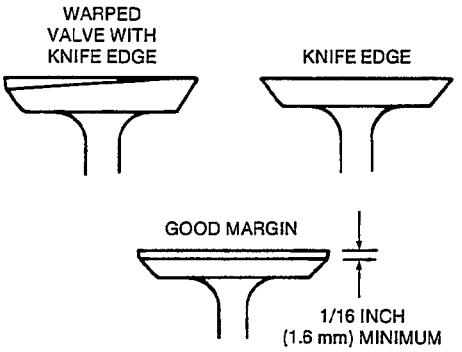


VT-1021

FIGURE 58. VALVE INTERFERENCE ANGLE

Refinish valve faces to a 44° angle on a valve refacing machine. The first cut from valve face must be a light grinding. Check if there is an unevenness of metal being removed. If only a part of the valve face has been touched, check to see if valve is properly seated in machine or if valve is warped, worn, or distorted. When cut is even around the whole valve face, keep grinding until complete face is ground clean. Be sure the correct valve face angle is maintained. When valve head is warped, a knife edge will be ground (Figure 59) on part or all of the head due to the large amount of metal that must be completely removed to reface valve. Heavy valve heads are required for strength and good heat dissipation. Knife edges lead to breakage, burning, and pre-ignition due to heat localizing on the edge.

Replace any valve that cannot be entirely refaced while keeping a good valve margin (Figure 59) or that is warped, worn, or damaged in any way. The amount of grinding necessary to true a valve indicates whether valve head is worn or warped.



M-1184

FIGURE 59. VALVE HEAD MARGIN

When new valve seats are installed, or previously used seats reground, refinishing must be done with a valve seat grinder used according to the manufacturer's directions.

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.

Place each valve in its proper location. Check each valve for a tight seat. Make several marks at regular intervals across the valve face using machinist's bluing. Observe if the marks rub off uniformly when the valve is rotated part of a turn against the seat. The valve seat should contact the valve face evenly at all points. The line of contact should be at the center of the valve face.

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 (Figure 60). 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.

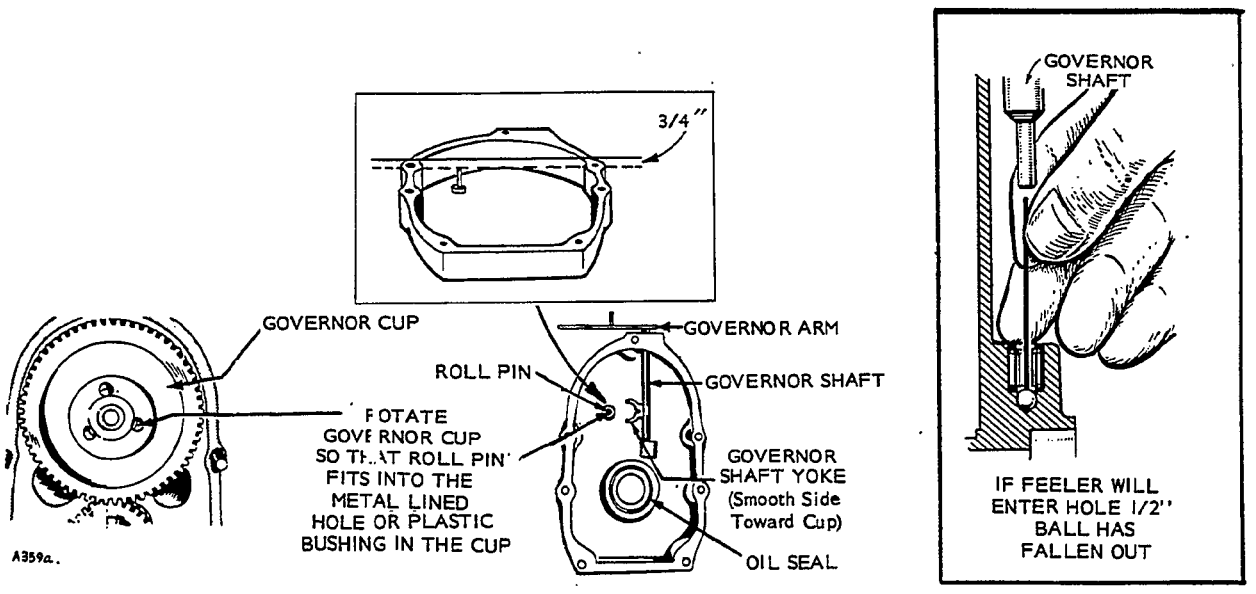


FIGURE 60. GEAR COVER ASSEMBLY

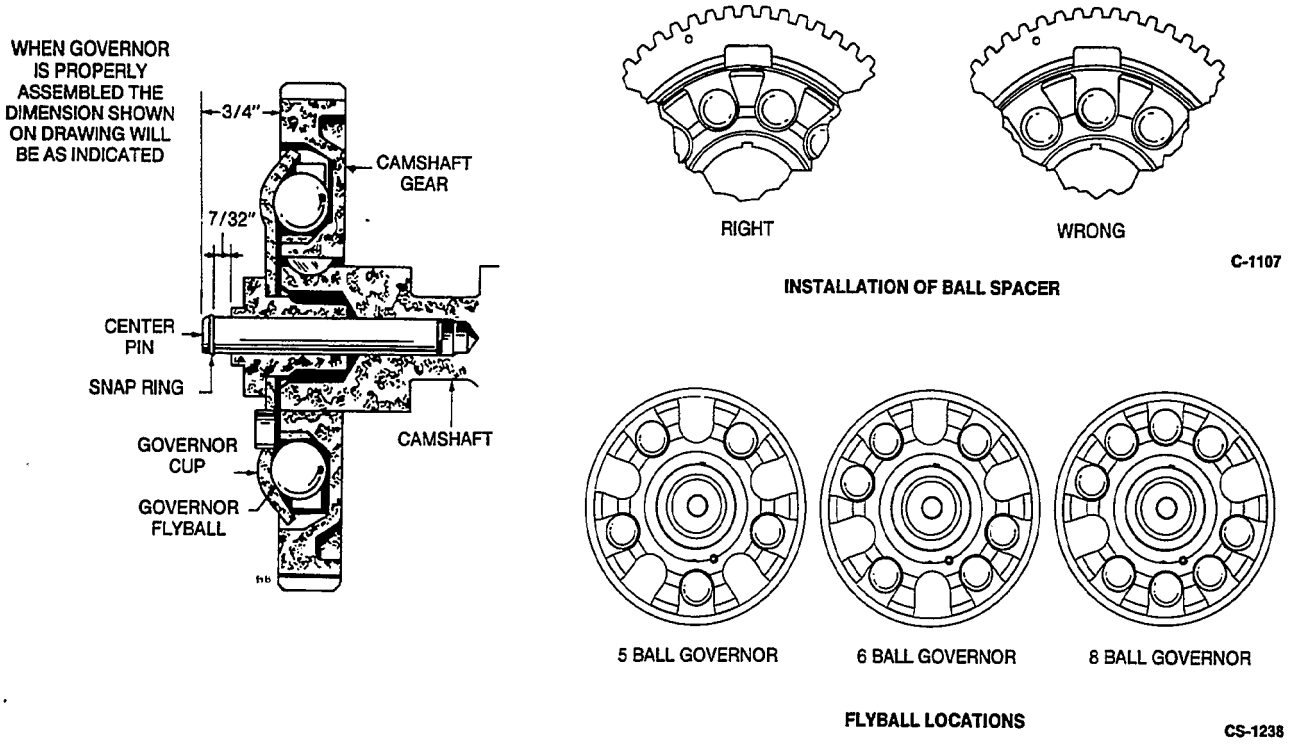


FIGURE 61. GOVERNOR CUP DETAILS

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 61).

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; the gear/spacer assembly if loose on gear hub, 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.

If replacing the ball spacer, be sure to position it so an arm is lined up with the space on the camshaft gear (if your camshaft gear does not have a space in it, disregard this paragraph). If the ball spacer arm is not lined up with the space in the camshaft gear, a flyball can slip into the space and cause engine racing and governing problems (Figure 61).

When installing the governor cup, tilt the engine so the gear is up, put the flyballs in place (Figure 61), 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" (5.6 mm), (the engine will race, especially at no load) remove the center pin and press in a new pin.

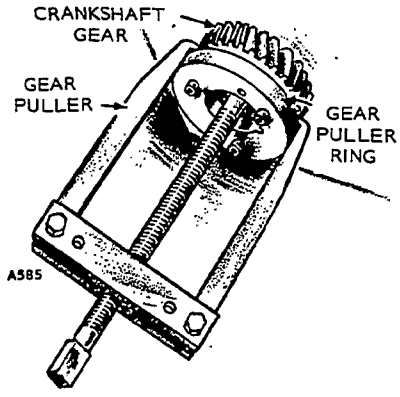
TIMING GEARS

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

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

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 62). 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 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.



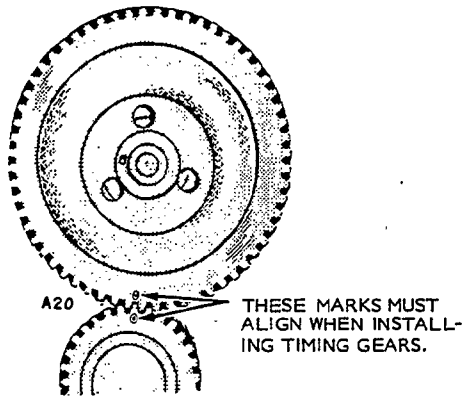


FIGURE 62. TIMING GEAR REMOVAL AND INSTALLATION

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 63) with a ridge reamer before attempting piston removal.

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

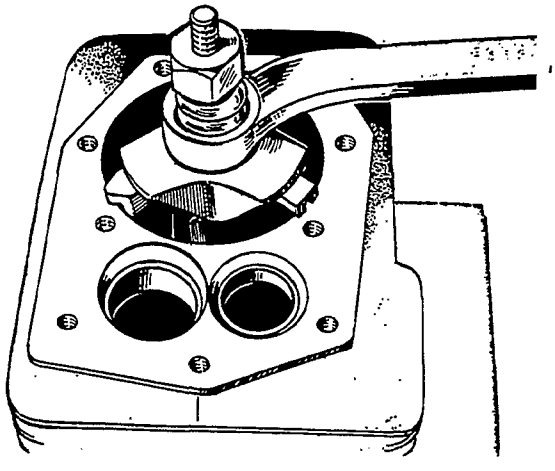


FIGURE 63. REMOVING RIDGE FROM CYLINDER

⚠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 overhaul. Keep connecting rod beairng caps with their respective rods.

5. Remove the piston rings from the piston with a piston ring spreader as shown in Figure 64. Remove the piston pin retainer and push the piston pin out.

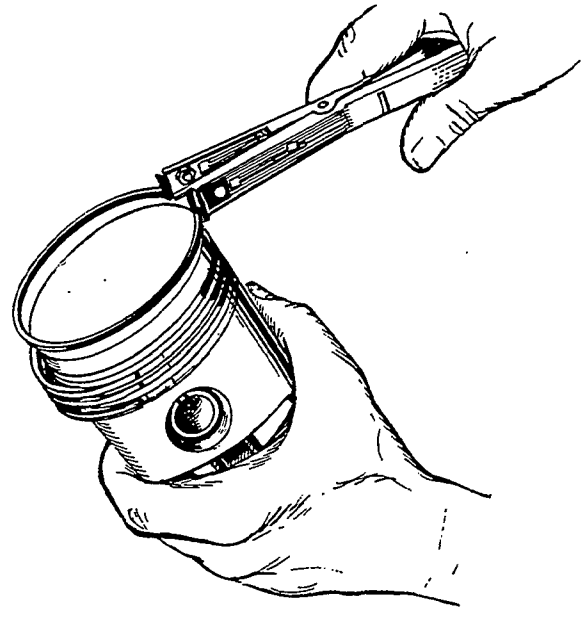


FIGURE 64. REMOVING PISTON RINGS

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 65). 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.***

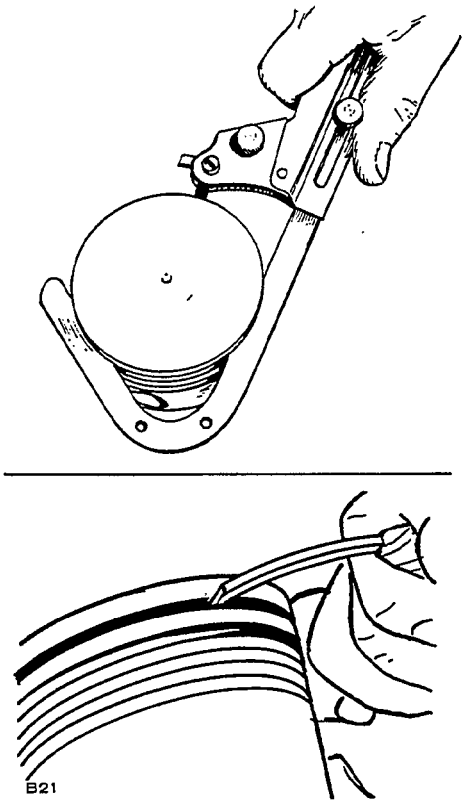


FIGURE 65. PISTON GROOVE CLEANING

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 66. Replace the piston when the side clearance of the top compression ring reaches 0.008 inch (0.20 mm).

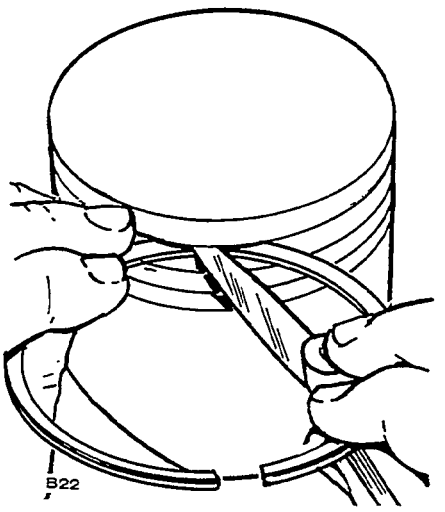


FIGURE 66. CHECKING RING SIDE CLEARANCE

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-ignition.
3. Proper piston tolerances must be maintained for satisfactory operation.
4. Refer to *DIMENSIONS AND CLEARANCES* to determine where to measure piston to be sure the total clearance follows specifications.

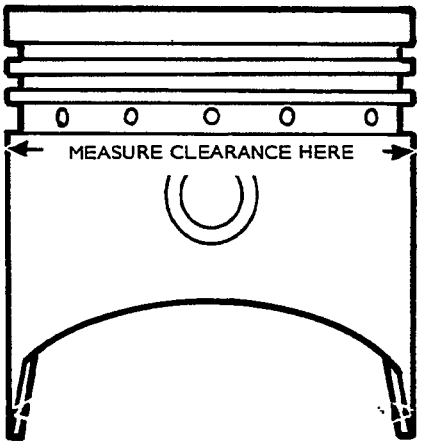


FIGURE 67. MEASURING PISTON CLEARANCE

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 (Figure 68).

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).

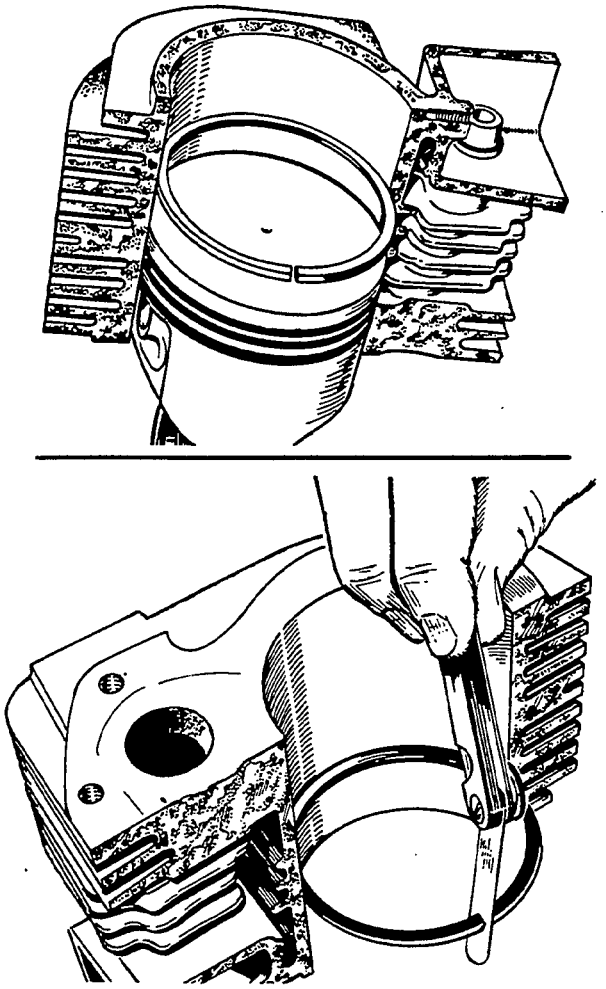


FIGURE 68. POSITIONING OF PISTON RING AND MEASURING OF END GAP

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 (Figure 69):

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.

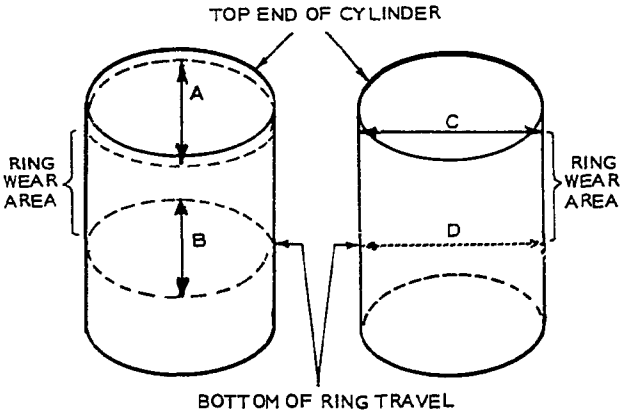
C. Measure and record as "C" cylinder bore diameter (perpendicular to crankshaft) near the top of cylinder bore where greatest amount of wear occurs.

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 that specified in *DIMENSIONS AND CLEARANCES,* 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 that specified in *DIMENSIONS AND CLEARANCES,* the cylinders must be rebored and honed to the next oversize. A reboring machine is used when going to oversize pistons.



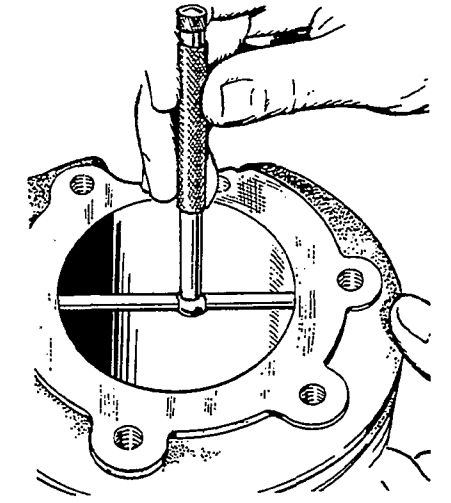


FIGURE 69. METHODS OF MEASURING THE DIAMETER OF A CYLINDER BORE

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 70.

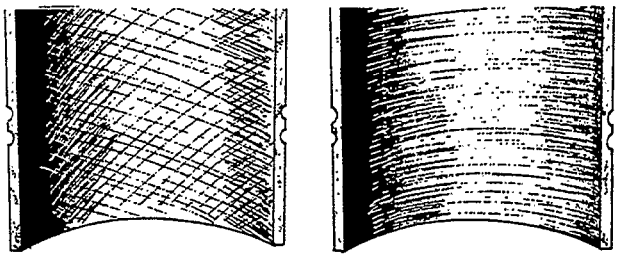


FIGURE 70. CROSS HATCHING

⚠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

With camshaft and crankshaft removed, use a micrometer to measure diameter of bearing journals. Use a dial bore gauge or a telescopic gauge and micrometer to measure inside diameter of bearings. Refer to *Dimension and Clearance Section* to determine if clearances are within specifications.

Any bearing that is scored, chipped, pitted or worn beyond the specified limits must be replaced.

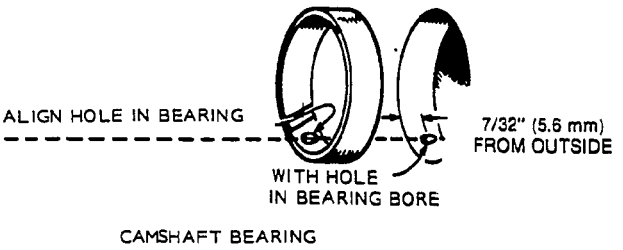


FIGURE 71. FRONT CAMSHAFT BEARING

Removal of the camshaft bearings requires complete disassembly of the engine. Use a press or a suitable driver to remove bearings. Support casting to avoid distortion and to avoid damaging the bearing bore during removal and installation.

Replacement camshaft bearings are precision type which do not require line reaming or line boring after installation. Clean outside of the bearing and bearing bore in the block. Before installing cam bearings use Locktite Bearing Mount on outside diameter of bearing. Use a combination bearing driver to install bearings. Place the bearing on the crankcase over the bearing bore with the lubricating hole (front only) in the 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 cyliner block (Figure 71). Press in the rear camshaft bearing until past the ignition plunger hole. Lubricate bearing surfaces with oil after installing.

New crankshaft main bearings are precision type which *do not* require line reaming or line boring after installation. Use a press or a suitable driver to remove bearings. Support casting to avoid distortion and to avoid damaging the bearing bore during removal and installation.

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

Before installing the front main bearing, use the towelette included with the bearing kit to clean the outside of the bearing and 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 from the small tube to the mating surfaces of the bearing and the bearing bore. Align the oil holes in the bearing with the oil holes in the bearing bore (Figure 73). The oil passage should be at least half open. Install the bearing flush with the block, using the combination driver. Wipe off any exesss Locktite around the bearing. Allow at least one hour for hardening at room temperature.

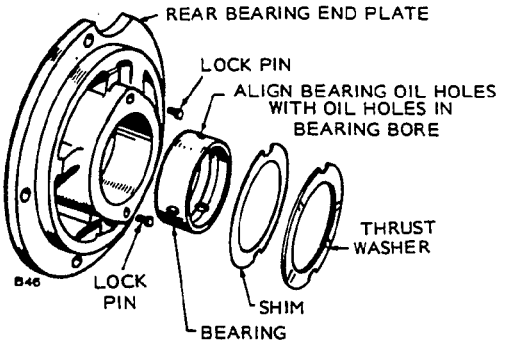


FIGURE 72. BEARINGS FOR REAR BEARING PLATE

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 73. Do not add an additional thrust washer to this front bearing.

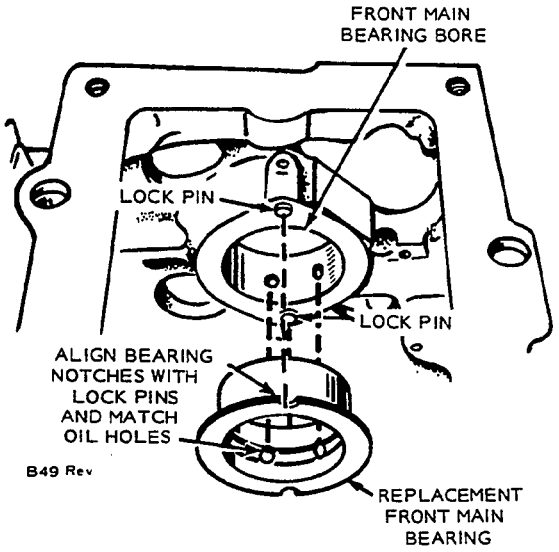


FIGURE 73. FRONT BEARING INSTALLATION

In the rear bearing plate, install the bearing flush to 1/64 inch (0.40 mm) below the end of the bore. Be sure to align the oil holes in the bearing with the oil holes in the bearing bore (Figure 72). The oil passage must be at least half open. Lubricate bearing after installation.

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 cranksahft, 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 (Figure 72).

Lubricate the front main bearing lightly with oil and insert the crankshaft. With the raar 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 74. 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 72) 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.

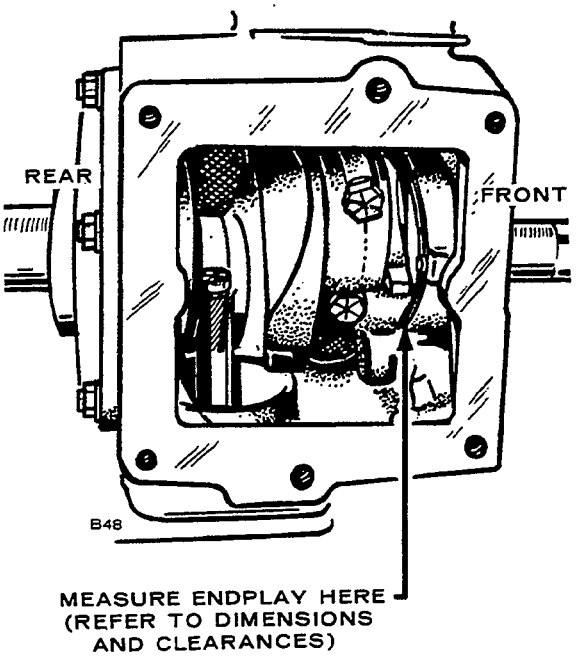


FIGURE 74. CRANKSHAFT ENDPLAY

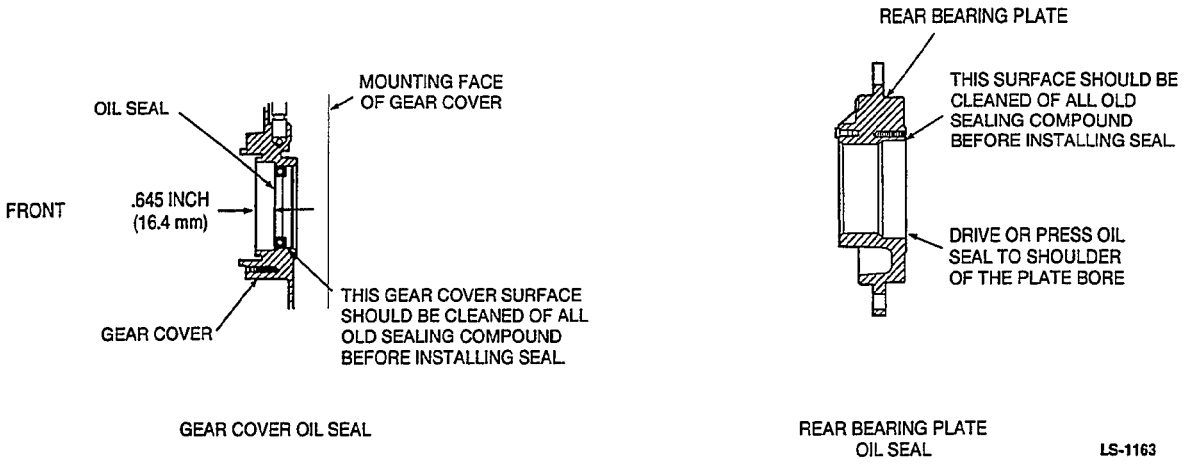


FIGURE 75. GEAR COVER AND REAR BEARING PLATE OIL SEALS

OIL SEALS

The bearing plate must be removed to replace the oil seal (Figure 75). Drive the oil seal out from the inside.

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

When installing the gear cover oil seal, tap the seal inward until it is .645 inch (16.4 mm) from the front of the gear cover.

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

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 76). 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.

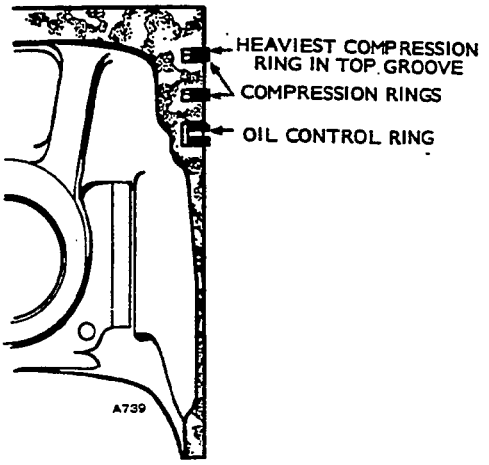


FIGURE 76. PISTON RINGS

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 77.

3. Position the piston and rod assembly in the cylinder block. Oil hole in connecting rod must face camshaft. Rod bolts must be 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 77). 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.

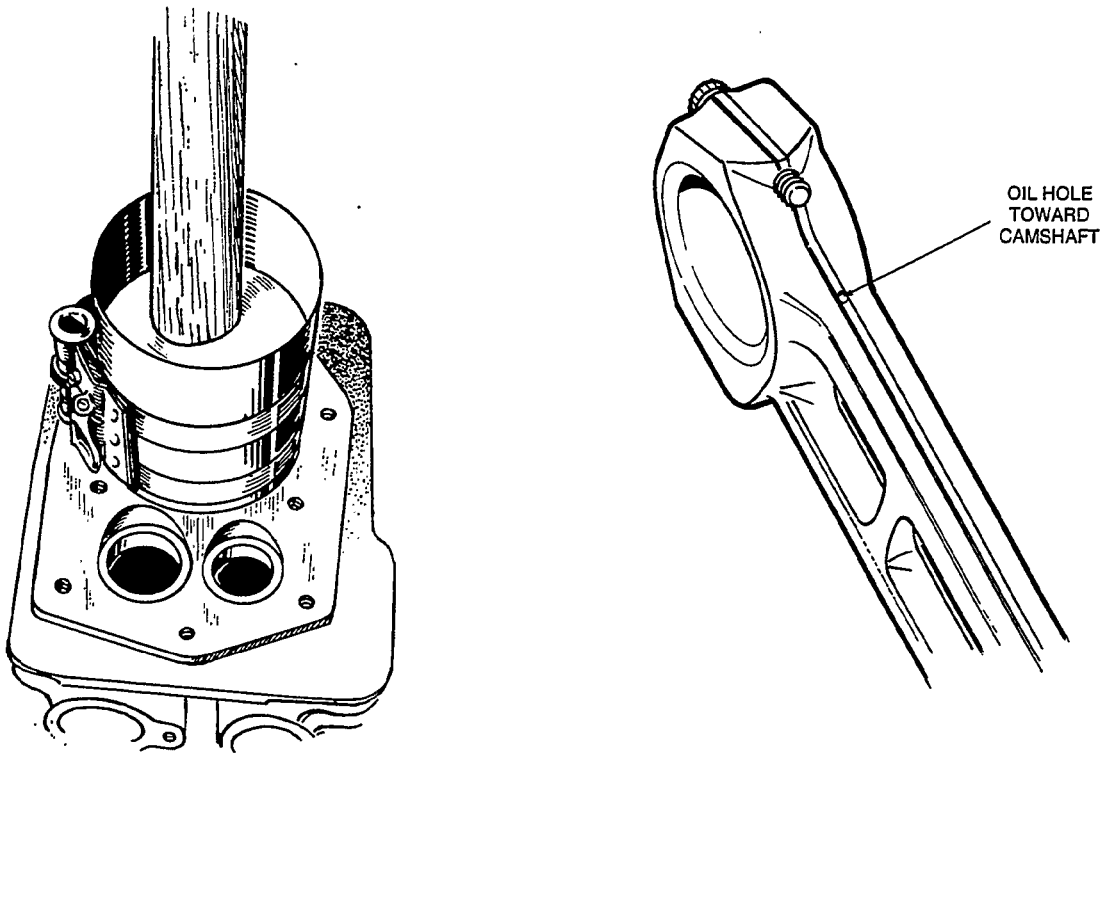


FIGURE 77. INSTALLING PISTON AND CONNECTING ROD

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 78. 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 79.

   A. Asbestos head gasket torque procedure:
   Tighten all nuts to 5 ft-lbs (7 Nm), then 10 ft-lb (14 Nm), then to the torque specified in the *ASSEMBLY TORQUES* section. Recheck all nuts for correct torque.

   ⚠WARNING ***Asbestos gaskets contain fibers that when airborne can 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), then to the torque specified in the *ASEMBLY TORQUES* section. Recheck all nuts for correct torque.

   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 79. Failure to re-torque could result in a blown head gasket.

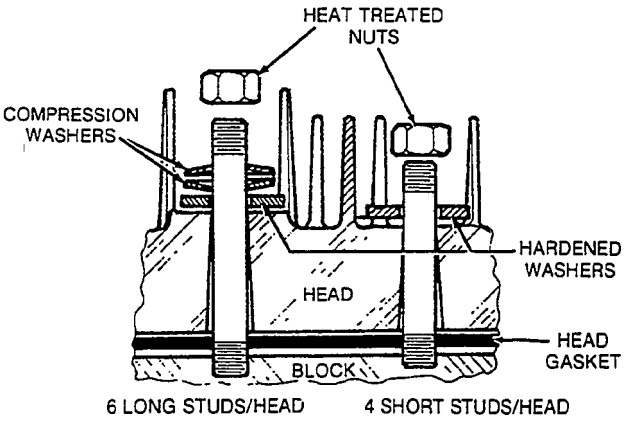


FIGURE 78. CYLINDER HEAD WITH COMPRESSION WASHERS

⚠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.

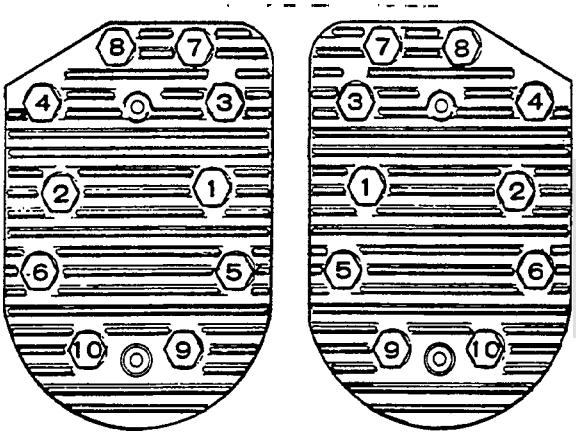


FIGURE 79. HEAD BOLT TIGHTENING SEQUENCE

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 (Figure 80). Each stud will have two compression washers and one flatwasher arranged in the sequence shown in Figure 81.

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

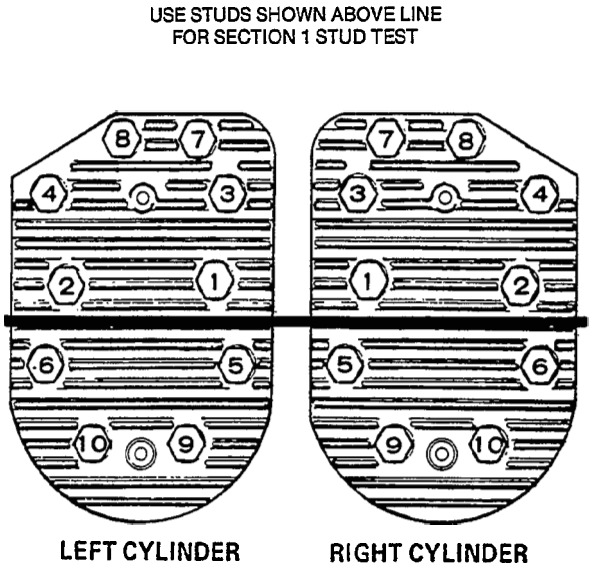


FIGURE 80. CYLINDER HEADS

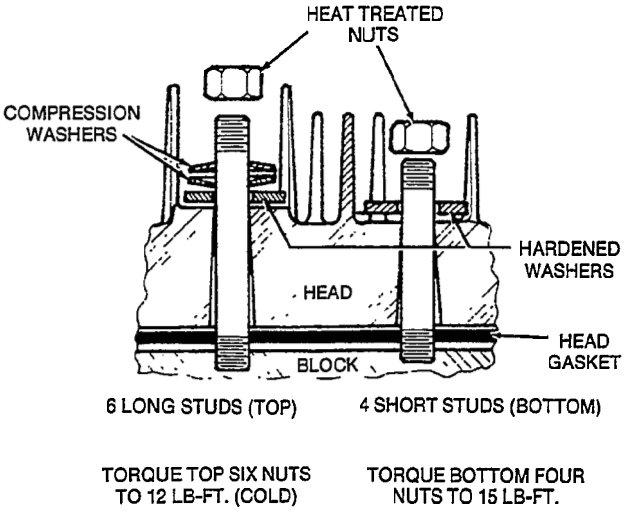


FIGURE 81. CYLINDER HEAD STUDS

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 82 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 brushing 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 83). 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 83).

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.

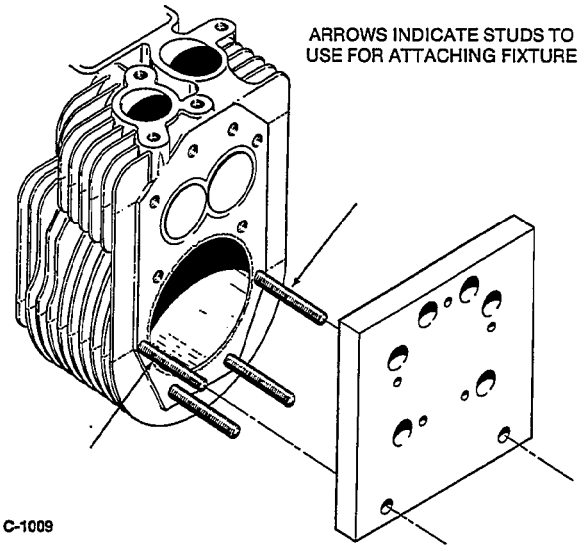


FIGURE 82. REPAIR FIXTURE

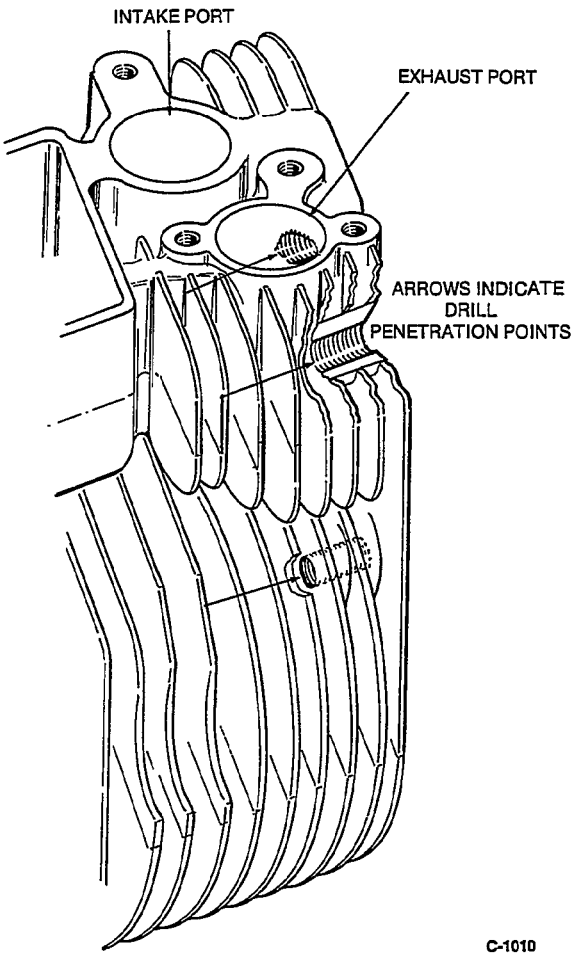


FIGURE 83. DRILLING PROCEDURE

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.

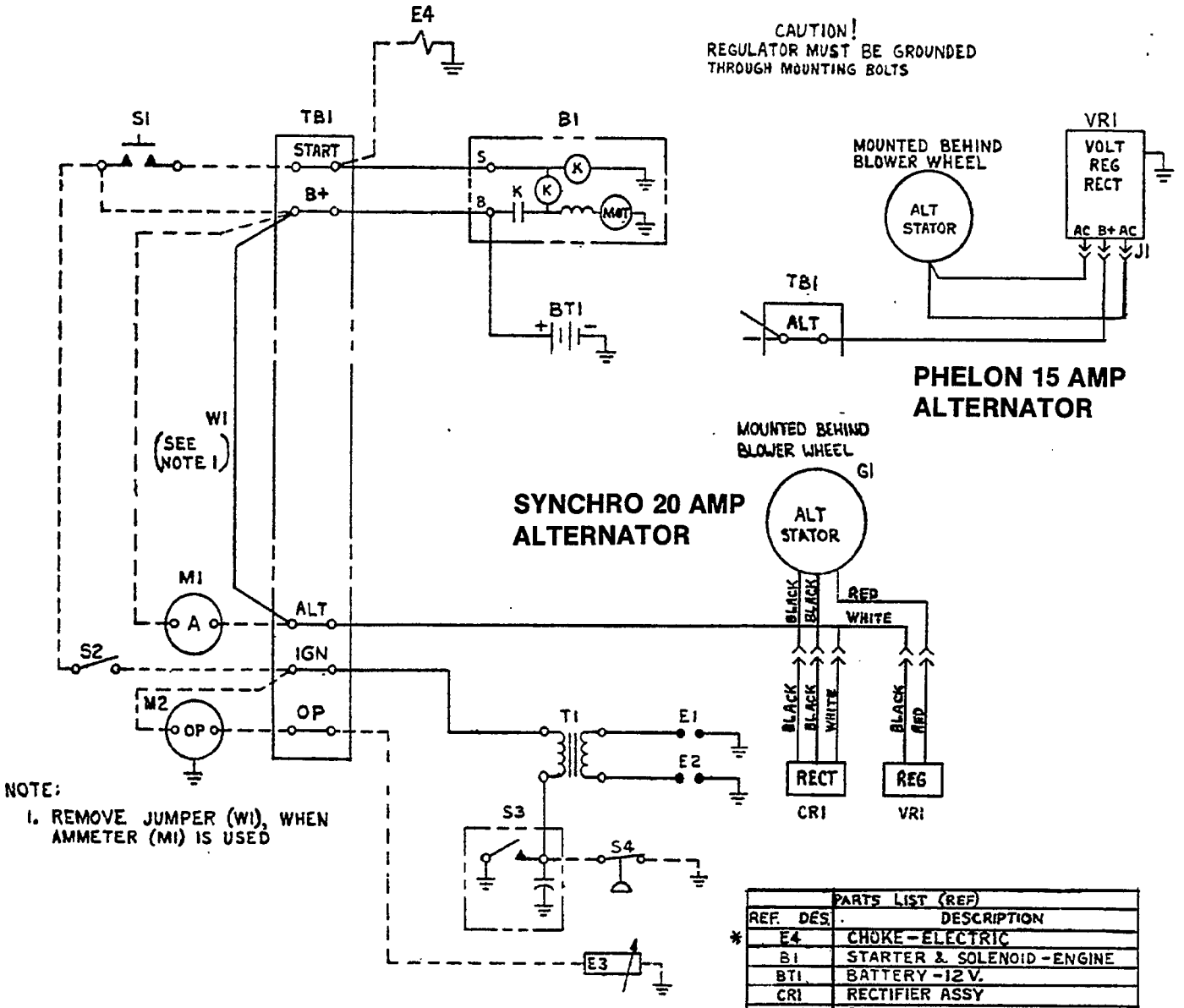
5. Reinstall the intake manifold tightening the four hold down bolts to 20 to 23 ft-lb (27-31 Nm) of torque.

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.***

Wiring Diagrams

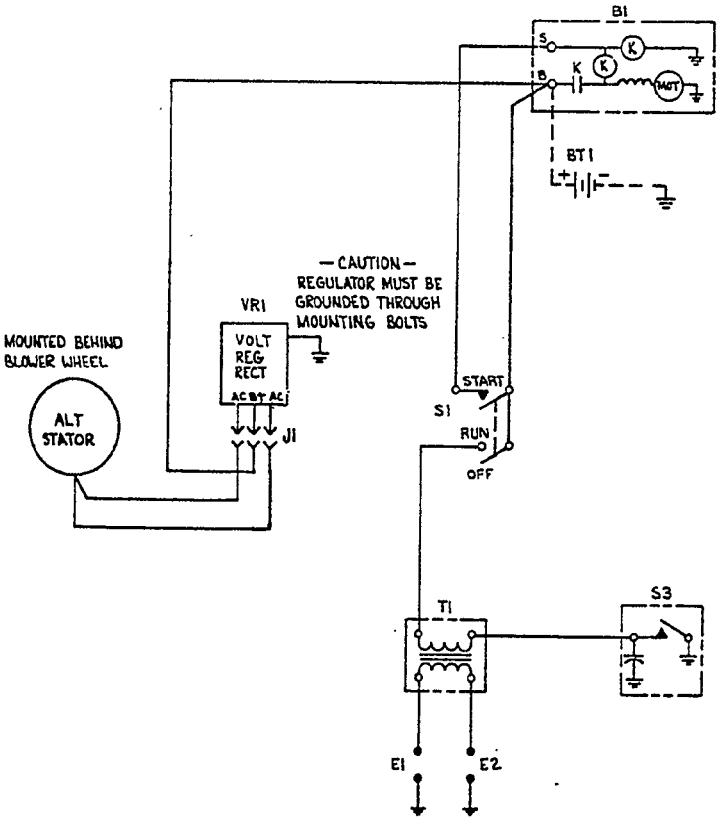
The wiring diagrams in this section are typical for NHC and NHCV engines with 15-or 20-amp flywheel alternators and other options. The separate engine control wiring diagrams shipped with each unit should be used for troubleshooting. The following drawings are included herein:



ENGINE CONTROL WIRING DIAGRAM WITH OPTIONS

	PARTS LIST (REF)	
	REF. DES.	DESCRIPTION
*	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)

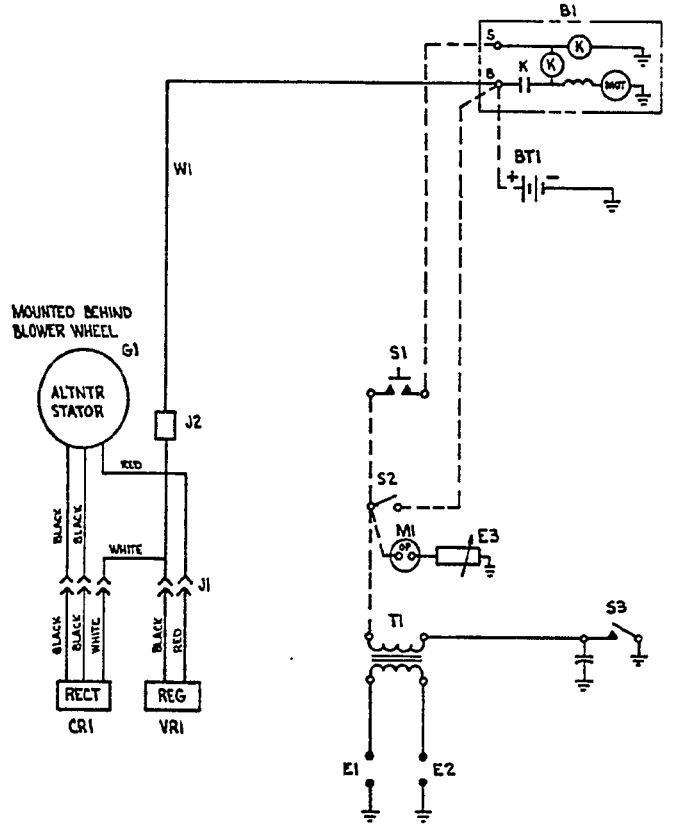
* WHEN USED



WIRING DIAGRAM FOR FLYWHEEL ALTERNATOR (PHELON 15 AMP)

(622-0386)

REF. DES.	DESCRIPTION
B1	Starter & Solenoid-Engine
BT1	Battery, 12 V.
E1 & 2	Spark Plug
G1	Alternator-Flywheel 15 Amp
J1	Connector
S1	Switch-Start, Run Off
S2	Breaker & Cap Assembly
T1	Ignition Coil (Onan)
VR1	Regulator-Rectifier Voltage



WIRING DIAGRAM FOR FLYWHEEL ALTERNATOR (SYNCRO 20 AMP)

(622-0382)

REF. DES.	DESCRIPTION
B1	Starter & Solenoid - Engine
BT1	Battery, 12 V.
CR1	Rectifier Assy.
E1, E2	Spark Plug
E3	Sender, Oil Pressure
J1	Connector
J2	Connector - Faston
M1	Meter - Oil Pressure
S1	Switch - Start
S2	Switch - Ignition
S3	Breaker & Cap Assy.
T1	Ignition Coil
VR1	Regulator - Voltage
W1	Lead Assy.
G1	Alternator - Flywheel 20 Amp.

Onan

Cummins Power Generation
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