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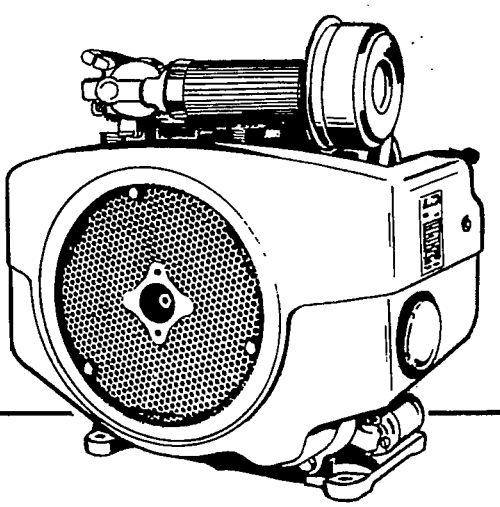
Onan

Service Manual

NHP
NHPV
Engine



940-0750
Spec C
12-87
Printed in U.S.A.

Safety Precautions

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

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

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

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

Safety Codes

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

General

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

Protect Against Moving Parts

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

Batteries

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

Fuel System

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

Exhaust System

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

Exhaust Gas is Deadly!

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

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

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

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

Cooling System

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

Keep the Unit and Surrounding Area Clean

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

TABLE OF CONTENTS

WARNING

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

SPECIFICATIONS

Number of Cylinders	2
Displacement (cubic inch)	60
Cylinder Bore	3-9/16 in. (90.48 mm)
Piston Stroke	3 inch (76 mm)
Horsepower—NHP (Pressure Cooled)	20.0 BHP @ 3600 rpm
Horsepower—NHPV (Vacu-Flo Cooled)	19.5 BHP @ 3600 rpm
Compression Ratio	7.0 to 1
Ventilation Required (cfm @ 3600 rpm) NHP	1080 (30.59 m^3)
(cfm @ 3600 rpm) NHPV	1200 (33.98 m^3)
Oil Capacity	3-1/2 quart (3.3 litre)
Oil Capacity with Filter Change	4 quart (3.8 litre)
Starting	Electric
Ignition	Battery
Combustion Air (cfm @ 3600 rpm)	80 (2.27 m^3)
Fuel	LP Gas
Battery	12 Volt

TUNE-UP SPECIFICATIONS

Cylinder Head Torque	15 lb-ft (20.3 N•m)
Spark Plug Gap	.025-inch (0.64 mm)
Breaker Point Gap	.019-inch (.48 mm)
Ignition Timing (Fixed), Electric Start Units	25° BTC
Tappets (Cold) Intake	.005 inch (0.127 mm)
Exhaust	.013 inch (0.330 mm)

DIMENSIONS AND CLEARANCES

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

DESCRIPTION	MINIMUM		MAXIMUM	
	Inches	(mm)	Inches	(mm)
CYLINDER BLOCK				
Cylinder Bore Honed Diameter	3.5625	(90.49)	3.5635	(90.51)
Maximum Allowable				
Taper			0.003	(0.08)
Out-of-Round			0.003	(0.08)
Main Bearing Inside Diameter (Without bearing)	2.187	(55.55)	2.188	(55.58)
Main Bearing Inside Diameter (Installed)	2.0015	(50.84)	2.0040	(50.90)
Camshaft Bearing Bore (Bearing installed)	1.3760	(34.95)	1.3770	(34.98)
CRANKSHAFT				
Main Bearing Journal Diameter	1.9992	(50.78)	2.0000	(50.80)
Main Bearing Clearance	0.0015	(0.04)	0.0043	(0.11)
Connecting Rod Journal Diameter	1.6252	(41.28)	1.6260	(41.30)
Crankshaft End Play	0.005	(0.13)	0.009	(0.23)
CONNECTING ROD				
Large Bore Diameter (Without bearing installed and rod bolts properly torqued	1.7505	(44.46)	1.7510	(44.48)
Connecting Rod Side Clearance	0.0020	(0.051)	0.0160	(0.406)
Piston Pin Bushing Bore (Without bearing)	0.8115	(20.61)	0.8125	(20.64)
Piston Pin Bushing Bore with Bearing, (Finished bore)	0.7504	(19.06)	0.7508	(19.07)
Bearing to Crankshaft Clearance				
Nodular Iron Rod	0.0005	(0.013)	0.0028	(0.071)
Aluminum Rod	0.0020	(0.051)	0.0033	(0.084)
CAMSHAFT				
Bearing Journal Diameter	1.3740	(34.90)	1.3745	(34.91)
Bearing Clearance	0.0015	(0.038)	0.0030	(0.076)
End Play	0.0030	(0.076)	0.0120	(0.305)
Camshaft Lift		0.300	(7.62)	
PISTON				
Clearance in Cylinder				
Measure 90° to pin 0.10 inch below oil ring				
Strut Type	0.0015	(0.038)	0.0035	(0.089)
Without Strut	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	0.0955	(2.426)	0.0965	(2.451)
No. 2 Compression Ring	0.0955	(2.426)	0.0965	(2.451)
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)	0.3415	(8.674)
Clearance (Stem to Guide)	0.0025	(0.064)	0.064	(0.163)
Valve Face Angle		44°		
EXHAUST VALVE SEAT				
Seat Cylinder Head Bore Diameter	1.2510	(31.78)	1.2520	(31.80)
Seat Outside Diameter	1.2550	(31.88)	1.2560	(31.90)
Valve Seat Width	0.031	(0.787)	0.047	(1.194)
Valve Seat Angle		45°		
VALVE GUIDE				
Inside Diameter	0.344	(8.74)	0.346	(8.79)
TAPPET				
Body Diameter	0.7475	(18.99)	0.7480	(19.00)
Bore Diameter	0.7505	(19.06)	0.7515	(19.09)
Clearance in Bore	0.0015	(0.038)	0.003	(0.076)
VALVE SPRINGS INTAKE AND EXHAUST				
Valve Spring Free Length (Approx.)		1.662	(42.21)	
Valve Spring Length				
Valve Open		1.125	(28.58)	
Valve Closed		1.375	(34.93)	
Spring Load @ 1.375 inch (Valve Closed)	38 lb.	(17 kg)	42 lb.	(19 kg)
Spring Load @ 1.125 inch (Valve Open)	71 lb	(32 kg)	79 lb	(36 kg)
GEAR BACKLASH				
Timing Gear	0.002	(0.051)	0.003	(0.076)
Oil Pump Gear	0.002	(0.051)	0.005	(0.127)

ASSEMBLY TORQUES

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

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

TABLE 1.

DESCRIPTION	TORQUE SPECIFICATION Ft.-Lb.	Nm
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)

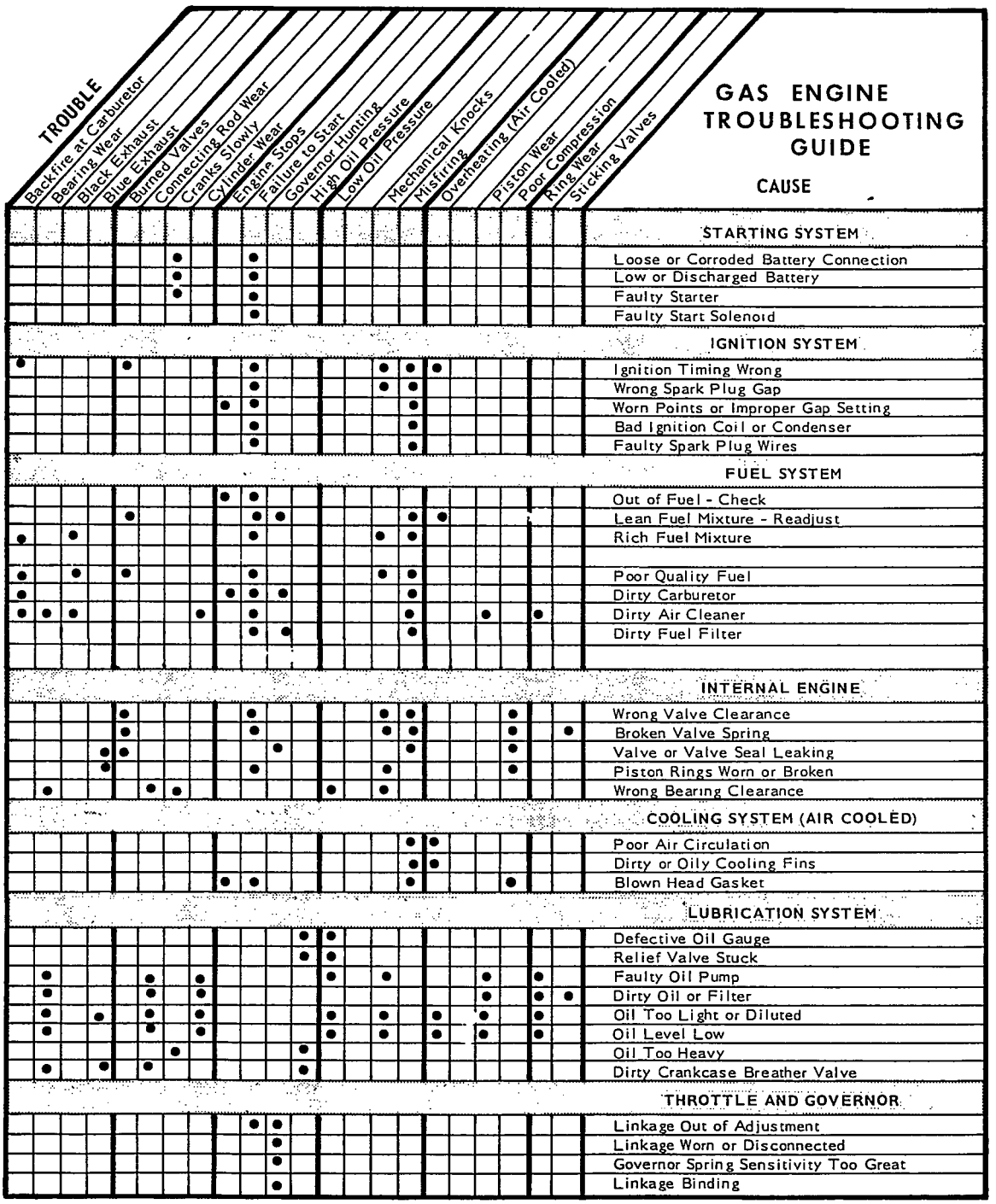
DESCRIPTION	TORQUE SPECIFICATION Ft.-Lb.	Nm
Rear Bearing Plate	25-28	(34-38)
Connecting Rod Bolt		
Iron Rod	27-29	(37-39)
Aluminum Rod	14-16	(19-22)
Flywheel Capscrew	50-55	(67-75)
Starter Mounting Bracket to Oil Base Screws	25-35	(34-47)
Gear Case Cover	8-10	(11-14)
Oil Pump	7-9	(10-12)
Other 3/8 Cylinder 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



ENGINE OIL SOURCE GUIDE

TYPICAL ASHLESS AND LOW ASH GAS ENGINE OILS

CAUTION: *Onan recommends high temperature low ash, gas engine oil designated "SE." The brands listed here and many others are available. Farm co-op stations and diesel-LPG truck stops are possible sources of supply.*

SUPPLIER	BRAND NAME	SULFATED ASH %
International Harvester Co.	IH Low Ash Engine Oil	0.38
American Oil Co.	Amoco LPG Engine Oil	0.40
	Amogas Engine Oil	0.40
	Amogas Ashless Engine Oil	Ashless
Atlantic Richfield Co.	ARCO Fleet	0.40
Boron Oil Co. Div. Std. Oil Co. (Ohio)	Facton AD 69 & 79	0.40
Cato Oil & Grease Co.	Mystik G-240	0.40
	GO 20W-40	0.40
Champlin Petroleum Co.	LPG Motor Oil	0.36
	G.E.O. X-1	0.36
Chevron Oil Co.	Chevron Gas Engine Oil HDAX	Ashless
	Chevron Gas Engine Oil X or 65 X	0.40
Cities Service Oil Co.	Citgo LP-Gas Engine Oil	0.22
D-A Lubricant Co., Inc.	D-A Natural Gas Engine Oil	0.02
Empak Industries, Inc.	Tech-Lube 108	0.27
FS Services, Inc.	FS Low Ash Motor Oil	0.40
Getty Oil Co.	Veedol Adeltide 35	0.40
Imperial Oil Ltd (Canada)	Essolube G	0.40 (Canada only)
Kendall Refining Div (Witco)	Natural Gas-LPG Oil	Ashless
Kerr-McGee Corp.	LPG-NG Ashless Detergent	0.40
Pennzoil	Gas Engine Oil Motor Oil	0.0
Skelly Tagoline	LPG Engine Oil	0.38
Shell Oil Co.	Mysella Oil	Ashless
Sinclair	Osage Super D30	0.08
Standard Oil Co. of California	(See Chevron above)	
Standard Oil Co. of Ohio	(See Boron above)	—
Tennant Co.	#56234	0.8
Texaco	Geotex Hd	0.8
Union Oil Co. of California	Union Gas Engine Oil HD	0.40
Valvoline	AD-1 Gas Engine Oil	—
Farmers Union Central Exchange (Cenex)	HI-TAC	0.3

NOTE: These oils have been represented by the oil suppliers as being formulated with ashless additives or contain dispersants or organometallic oxidation inhibitors. Verification that lubricating oils meet the above requirements is the responsibility of the lubricant supplier.

STARTING

PRE-START INSTRUCTIONS

Inspection: Inspect the engine visually before starting. Check for loose or missing parts and any damage which may have occurred in shipment.

Crankcase Oil: Be sure the crankcase has been filled with high temperature, low ash "SE" oil to the "FULL" mark on the oil level indicator.

The oil capacity is 3-1/2 U.S. quarts (3.3 litre); 4 quarts (3.8 litre) with filter. Fill to the "FULL" mark on the oil level indicator. Engine oil should always be drained when the engine is warm. Remove pipe plug to drain engine oil.

CAUTION **For best results, use high temperature, low ash engine oil specially formulated for gas engine operation. Do not use regular motor oils or excessive carbon will accumulate on the rings and the valves will wear faster requiring more frequent overhauls.**

Farm Co-op Stations and Diesel truck stops are possible sources of supply. The major oil companies also supply ashless oils for LPG gas engines.

CAUTION **Do not overfill crankcase. Do not mix brands nor grades of motor oil.**

Oil consumption may be higher with a multigrade oil than with a single grade oil if both oils have comparable viscosities at 210° F. Therefore, single grade oils are generally more desirable, unless anticipating a wide range of temperatures. Use the proper grade oil for the expected conditions.

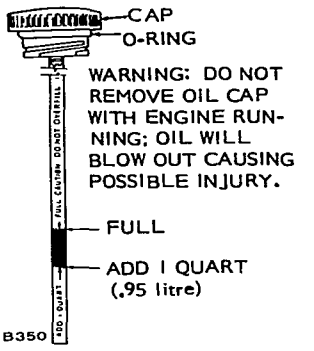


FIGURE 1. OIL LEVEL INDICATOR

TEMPERATURE	GRADE
Below 0°	5W
0° to 32° F (-18° C — 1° C)	10W
32° to 90° F (1° — 32° C)	30
Above 90° F (32° C)	50

Refer to Periodic Service section for recommended oil change intervals.

Fuel: Be sure propane tank has sufficient LP gas for the operating period.

HD-5 propane is recommended for best operating results in Onan LPG engines.

STARTING

The LP Gas engine should start and run in weather as cold as -40° F (-40° C) with lightweight oil in the crankcase. If the carburetor is adjusted and everything else is functioning properly, the engine will start promptly when the START switch and the throttle are closed simultaneously. If the engine does not start within 20 seconds, check the following:

1. Make sure fuel is getting to carburetor.
2. Make sure throttle is closed for maximum engine vacuum at cranking speed.
3. Make sure engine vacuum is sufficient enough to open fuel shutoff devices.
4. Check for low head bolt torques; it should be 15 lb-ft. (20 N.m).
5. Check ignition system and timing (25° BTC).
6. Check oil pressure cutoff switch, if installed.
7. Make sure no propane leaks exist, especially in cold weather.

WARNING **If no leaks are present, external heat can be applied to the vaporizing coil before starting and until exhaust heat is warm enough to vaporize the liquid propane and keep the engine running.**

If engine starts but is low in power:

1. Check for low head bolt torque.
2. Check for proper valve lash (intake—.003 inch [.076 mm]; Exhaust—.014 inch [.356 mm]).

CAUTION **The proper valve adjustment is essential for maintaining low exhaust emissions. Never exceed 200 hours of operation between valve lash adjustments. Never regrind exhaust valves; replace them instead.**

STOPPING THE ENGINE

Disconnect all load before stopping the engine. Engines equipped with battery ignition are stopped by positioning the ignition switch to the OFF position.

INSTALLATION GUIDELINES

VENTILATION

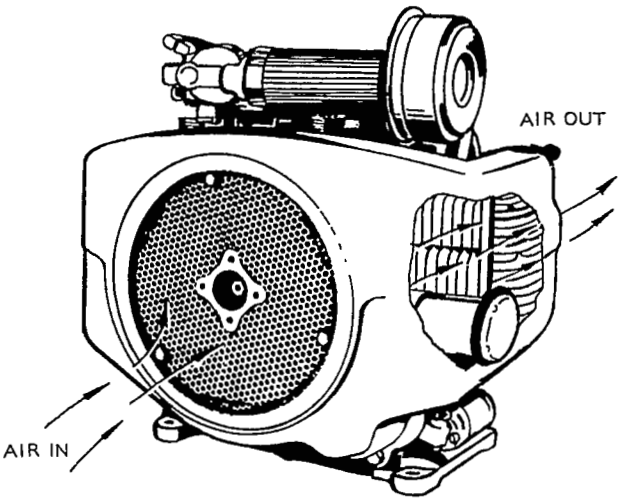
The engine must be provided with a supply of fresh air for cooling and for combustion. Figure 2.

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.

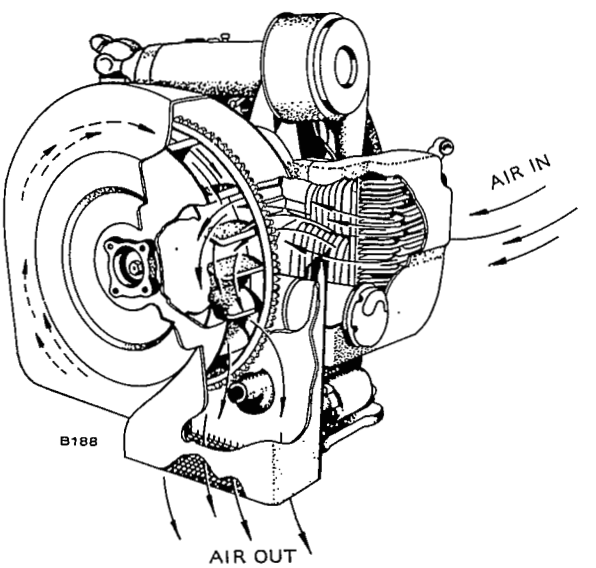
The heated air outlet must allow the heated air to escape freely and prevent recirculation with the cooling air. A duct between the compartment air inlet and the engine blower housing may be necessary. Locate the air outlet opposite the intake or at least at a 90 degree angle. The area of the outlet 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, upward, left or right direction. This is possible because the back section of the scroll (Figure 3) has four identical holes shaped to fit over the end of the starter motor. The scroll outlet has a mesh-type screen for safety.



PRESSURE COOLED



VACU-FLO COOLED

FIGURE 2. AIRFLOW THROUGH ENGINES

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 louvers are used, the inlet opening must be increased accordingly. The air outlet opening should be located as close to the engine as possible.

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 bends, long runs, screens or the exhaust pipe. Exhaust pipes running inside Vacu-Flo ducts should be covered with asbestos tape.

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.**

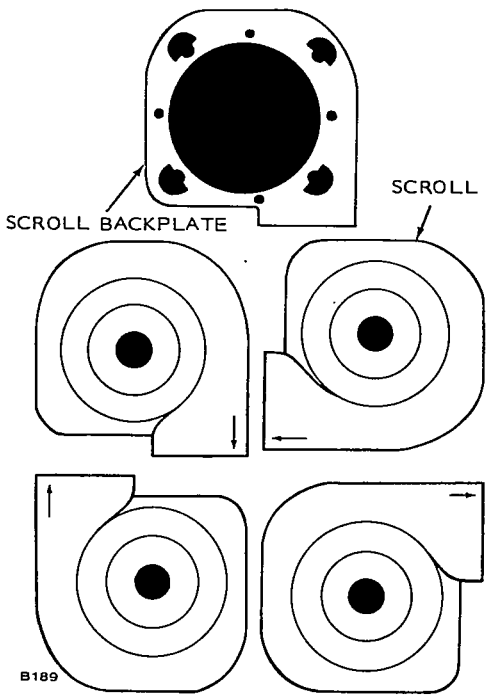


FIGURE 3. VACU-FLO SCROLL POSITIONS

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

WARNING **Exhaust gases are toxic. Provide an adequate exhaust system to properly expel exhaust gases. Check exhaust system regularly for leaks. Ensure that exhaust manifolds are secure and not warped. Be sure the unit is well ventilated.**

Use a length of flexible 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 recommendations given as a general guide.

CHECKING FOR FUEL AT CARBURETOR

WARNING **Do not permit any flame, cigarette, or other igniter near the fuel system. Propane gas is highly flammable and potentially explosive in confined spaces. Use your sense of smell to detect leaks.**

1. Disconnect fuel line at carburetor.
2. Momentarily, press primer button; you should smell gas at end of fuel line. If not, check fuel lines back to supply tank.

With experience, you should be able to feel gas pressure on the regulator diaphragm when you press the primer button.

3. Look for one or more shutoff devices.
4. On vacuum operated shutoff valve systems, close throttle (fully) to aid engine starting with better vacuum.
5. If fuel is present at carburetor, check ignition system or other engine malfunctions.

CONNECTING TO 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 4.

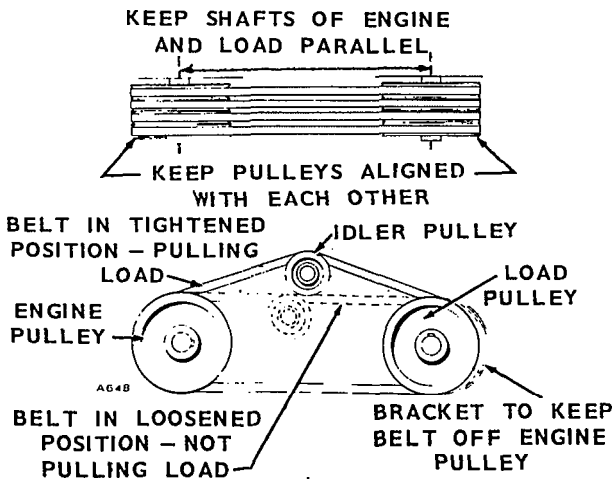


FIGURE 4. DRIVE BELT INSTALLATION

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 arrangement 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 5).

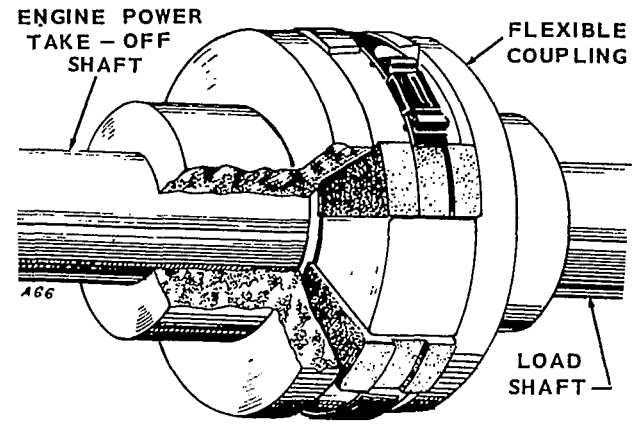


FIGURE 5. FLEXIBLE COUPLING

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.

Clutch Installation: A Rockford Clutch can be installed at the factory or in the field. Install the clutch according to the following instructions and Figure 6.

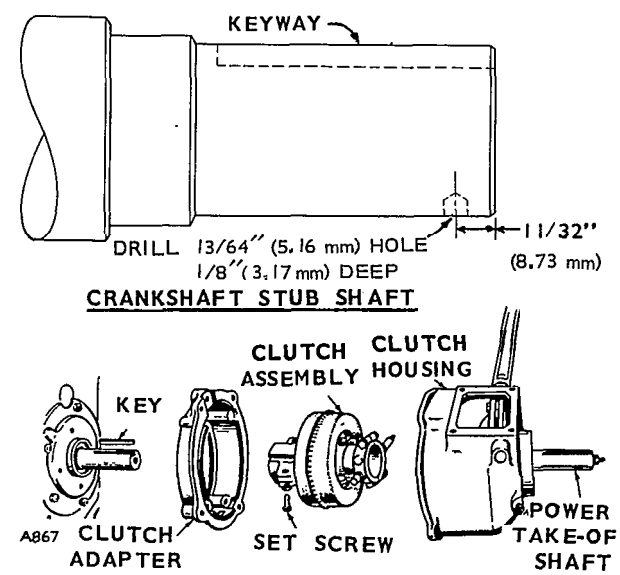


FIGURE 6. CLUTCH INSTALLATION

Provide room for the clutch adapter casting by plugging the wet holes with a 3/8-16 x 1/2-inch slotted headless set screw. Apply sealing compound to the threads and install screw flush with the cylinder block.

Drill a 13/64-inch (5.16 mm) hole (or filed slot) in the crankshaft for the clutch set screw. Locate center of hole 11/32-inch (8.73 mm) from the end and directly opposite the keyway in the crankshaft.

Install the clutch adapter, with drain slot downward, using two cap screws 3/8-16 x 2-inches on the lower and one cap screw 3/8-16 x 1-3/4-inch on the upper #2 cylinder side (cylinder nearer clutch). Install the 3/8 x 3-7/8-inch stud through the adapter into the engine block upper remaining hole. Use a lock washer on each assembly screw. Use a flat washer and a lock washer under the stud nut.

Install the crankshaft key. Remove the clutch set screw. Install the clutch assembly (less housing) to the crankshaft, driving it on carefully with a soft-faced hammer until set screw hole is aligned. Install set screw to bottom in crankshaft hole, then back it out one full turn. Tighten clutch retaining screws until clutch is clamped securely to crankshaft. Lock the screws and tighten the set screw.

Apply grease to splined power takeoff shaft. Position the clutch throw-out to align the grease fitting with the hole in the housing (#1 cylinder side, horizontal). Pull the throw-out collar outward to remove tension.

Install the clutch housing so that the clutch throw-out fork engages the throw-out collar. Be sure the serrated shaft is properly meshed with the clutch plate. Use two cap screws 7/16-14 x 2-inches on the lower and one cap screw 7/16-14 x 1-3/3-inch on the upper #2 cylinder side. Install the stud washer and nut. Lubricate the two grease fittings just until grease appears.

BATTERY CONNECTIONS (Engines with Automotive Type Separate Starter)

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 7).

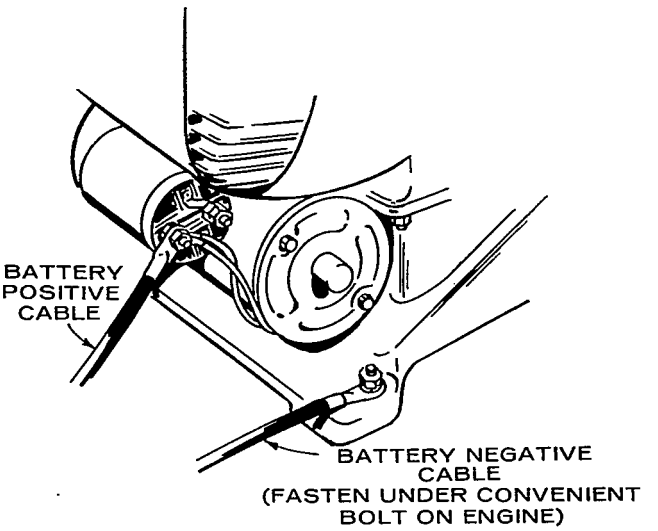


FIGURE 7. BATTERY CONNECTIONS

PROTECTION FOR EXTENDED OUT-OF-SERVICE PERIOD

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

1. Run engine until thoroughly warmed up.
2. Turn off fuel supply and run until engine stops from lack of fuel.
3. Drain oil from oil base while still warm. Attach a warning tag to refill before operation.
4. Remove each spark plug. Pour one ounce (two tablespoons) of rust inhibitor (or SAE #50) oil into cylinder. Crank engine over a few times to distribute oil film on cylinder walls and rings. Reinstall each spark plug.
5. Service air cleaner per maintenance schedule.
6. Lubricate governor linkage. Protect against dust, etc. by wrapping with a clean cloth.
7. Plug exhaust outlet to prevent entrance of bugs, moisture, or dirt.
8. Wipe entire unit clean. Coat parts likely to rust with a light film of grease or oil.
9. Provide a suitable cover for entire unit.

   Disconnect battery and follow standard battery storage procedure.

CAUTION **Discharged batteries are subject to severe damage if exposed to freezing temperatures. Store all batteries in a fully charged condition and maintain charge during storage.**

RETURNING THE SET TO OPERATION

1. CHECK SERVICE IDENTIFICATION TAGS to properly service the engine.
2. Uncover and remove all storage seals from engine. Remove any dust, dirt, or foreign matter.
3. CHECK fuel supply tanks. CHECK lubricating oil for moisture or contamination (drain if necessary). CHECK fuel line connections, all wiring connections, and exhaust line connections.
4. Service air cleaner per maintenance schedule.
5. Check tag on oil base and verify that oil viscosity is still correct for existing ambient temperature.
6. Clean and check battery. Measure specific gravity (1.260 at 25° C [77° F]) and verify level to be at split ring. If specific gravity is low, charge until correct value is obtained. If level is low, add distilled water and charge until specific gravity is correct.DO NOT OVERCHARGE.

   WARNING **Do not smoke while servicing batteries. Explosive gases are emitted from batteries in operation. Ignition of these gases can cause severe personal injury.**
7. Check engine for fuel or oil leaks. Correct leakage as required.
8. Install fully charged batteries.
9. Start engine and check while running for leaks, correct voltage output, and proper cooling.

After engine has started, excessive blue smoke will be exhausted and the engine will run rough until the rust inhibitor or oil has burned away.

OIL SYSTEM

PRESSURE LUBRICATION

The NHP-NHPV engines use an oil pump to lubricate engine parts (Figure 8). If oil pressure is low, the pump should be checked.

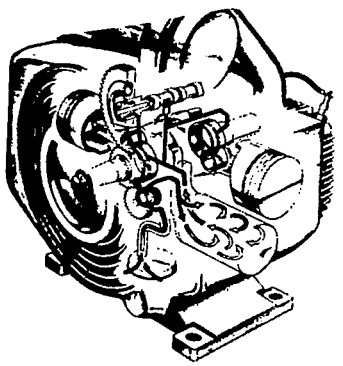


FIGURE 8. OIL SYSTEM

OIL PUMP

The oil pump (Figure 9) is mounted on the front of the crankcase behind the gear cover and is driven by the crankshaft gear.

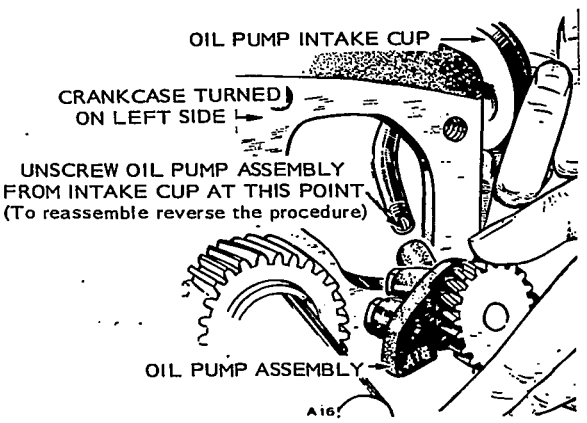


FIGURE 9. OIL PUMP ASSEMBLY

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

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

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

The oil overflow from the bypass valve furnishes lubrication to the camshaft drive gears.

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

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

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

OIL 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 30 psi.

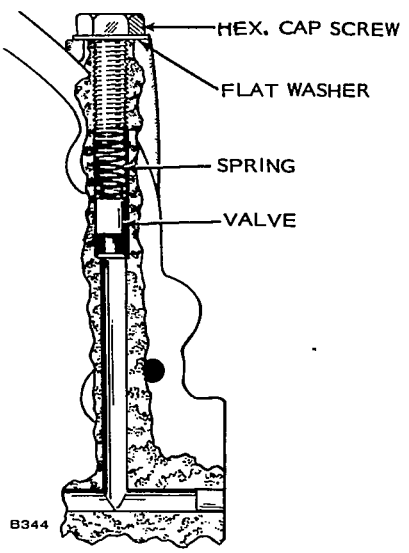


FIGURE 10. BY-PASS VALVE

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

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

To remove the valve, unscrew the recessed plug in the rear bearing plate and lift out the spring and plunger assembly. Determine proper valve operation by checking the spring and plunger according to the following measurements.

Plunger Diameter ..... .3105" to .3125"
Spring
Free Length ..... 2-5/16"
2.225 lb. .11 lb. at 1-3/16"

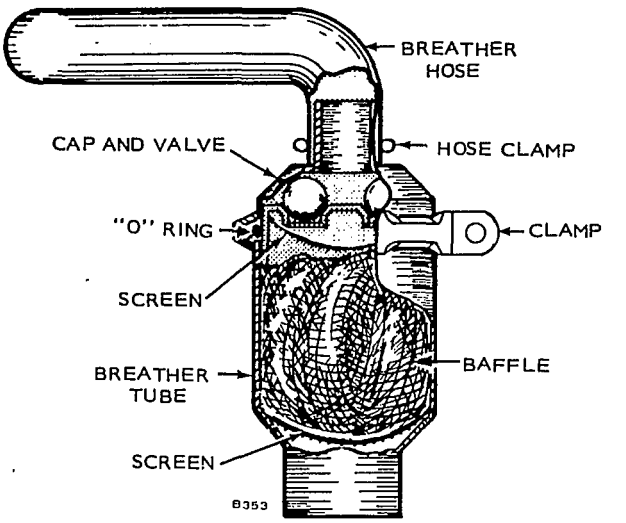
CRANKCASE BREATHER

The crankcase breather maintains a partial vacuum in the crankcase during operation to control oil loss and ventilate the crankcase, Figure 11.

To disassemble, remove the rubber cap from the crankcase tube and pry the valve out of the cap. Wash the valve in fuel at regular intervals and, if defective, replace it. Also, pull the baffle out of the breather tube and clean it. Install the valve with the perforated disk toward the engine.

OIL FILTER

The full-flow filter (Figure 12) is mounted on the filter plate at the left front corner of the crankcase. Replace normally after every 200 hours of operation. Remove the filter by turning counterclockwise. Lubricate the gasket on the new filter with engine oil. Install the filter until the gasket touches the base and tighten 1/2 turn; do not overtighten.



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

FIGURE 11. CRANKCASE BREATHER

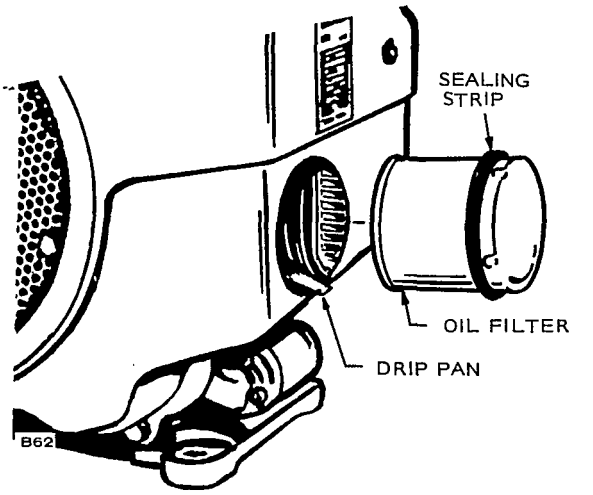


FIGURE 12. OIL FILTER

FUEL SYSTEM

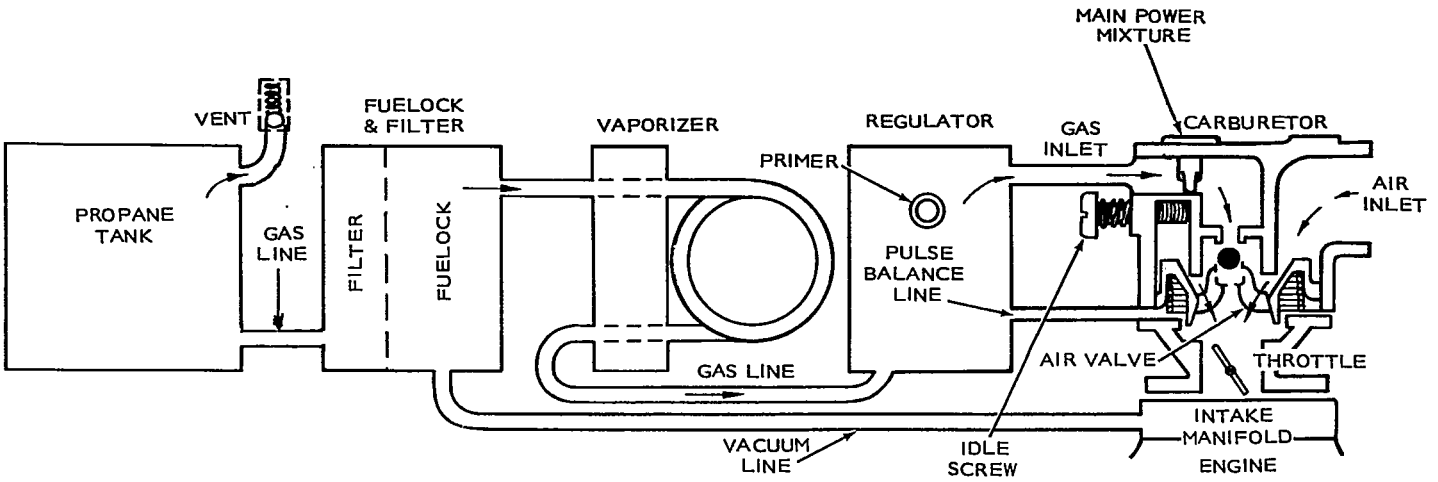


FIGURE 13. LIQUID WITHDRAWAL FUEL SYSTEM, BLOCK DIAGRAM

GENERAL

A typical liquid withdrawal LP gas fuel system consists of a vacuum fuel lock and filter, a vaporizer, a fuel regulator, and a gas carburetor connected by flexible hoses, Figure 13. A pulse balance line is needed for one and two cylinder engines between the carburetor and regulator. A vacuum line is needed between the intake manifold and the fuelock and filter. Some systems have a vacuum or solenoid operated fuel cutoff valve or both; the solenoid operated valve may be tied in with the ignition system.

The engine and carburetor operate on propane (Liquefied Petroleum Gas-LPG). Onan recommends HD-5 propane (95% propane minimum) for best operating results. This discussion covers only systems and components used with propane liquid withdrawal applications.

FUELOCK AND FILTER

The IMPCO vacuum operated fuelock and filter is combined in one unit, Figure 14. It should be trouble-free and maintenance-free for extended periods. Normally, no adjustments or filter replacements are needed on a periodic basis, but repair kits and replacement filters are available for complete overhaul if a malfunction occurs. Each kit includes detailed and illustrated installation procedures and new replacement parts.

The fuel inlet and outlet take 1/4-inch NPT fittings. The vacuum connection takes a 1/8-inch NPT fitting for a 1/4-inch I.D. hose. The fuelock opens with 2 inches water column at normal tank pressure.

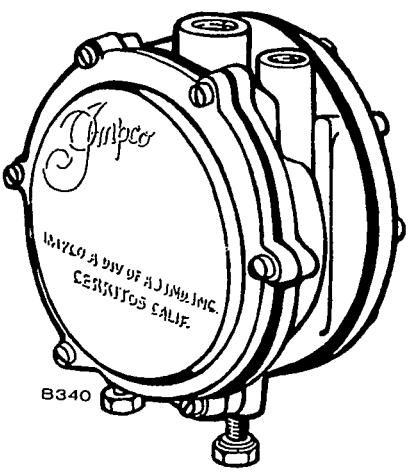


FIGURE 14. FUELOCK AND FILTER

The fuelock and filter unit replaces a separate line filter, an electric solenoid lockoff valve and a vacuum controlled switch required on earlier gas engine applications.

VAPORIZER COIL

The liquid propane vaporizer coil utilizes exhaust heat in its close wrap around either exhaust pipe. The vaporizer consists of a steel mounting bar and 4-1/2 coils of stainless steel tubing, Figure 15.

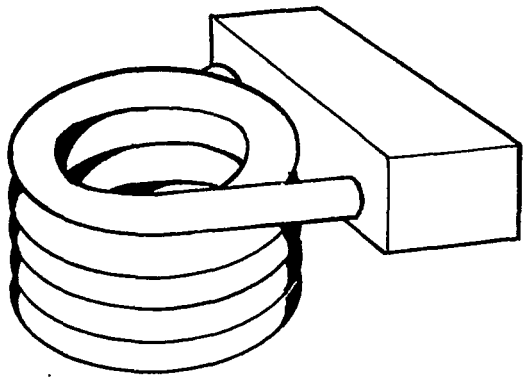


FIGURE 15. VAPORIZER COIL

REGULATOR

The IMPCO regulator is a two-stage regulator (LP Gas Converter) with a hand primer, Figure 16. It should be trouble and maintenance free for extended periods of operation. Repair kits are available for a complete overhaul if a malfunction occurs. The kit includes detailed and illustrated installation instructions. The secondary regulator lever assembly is subject to wear under heavy duty operation and may require replacement during an overhaul. The low pressure spring (blue) for vacuum control gives a negative 1-1/2-inch water column measurement on a manometer. The two vapor outlet ports and the LPG inlet have 1/2-inch pipe thread. The balance line connection is 1/8-inch pipe thread.

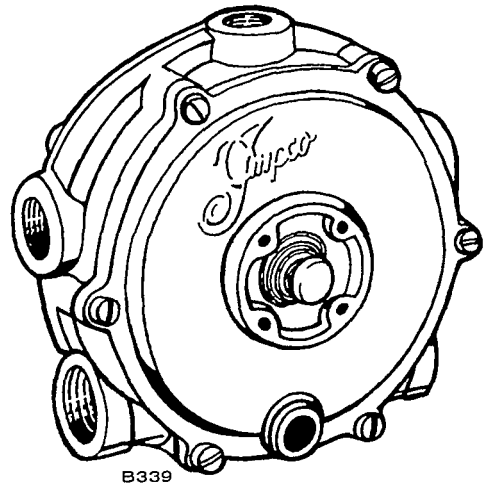


FIGURE 16. GAS REGULATOR

GAS CARBURETOR

The carburetor or mixer employs a unique, moving venturi (air valve, metering valve and venturi combined) to measure airflow, to meter gas flow, and to mix the intake air and gas, Figure 17. The throttle controls engine speed and power in the same way as the carburetors on other gas or gasoline engines. An idle jet, a main jet (power mixture adjustment) and a throttle stop screw provide carburetor adjustments for maximum engine power and efficiency with low exhaust emissions.

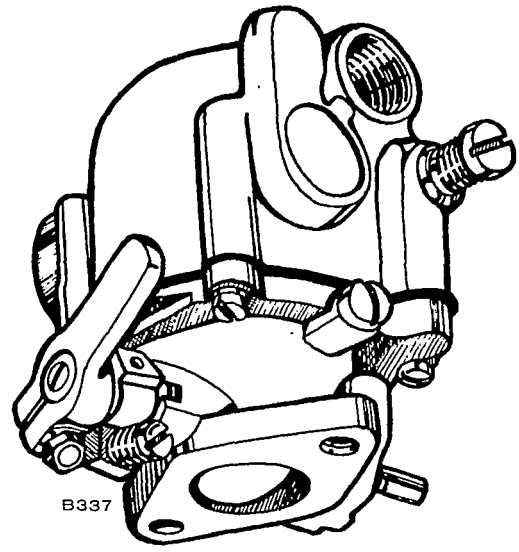


FIGURE 17. GAS CARBURETOR

CARBURETOR OPERATION

In operation, the moving venturi/air valve or air valve assembly opens in direct proportion to the breathing requirements of the engine to give optimum mixtures and good air/fuel distribution, Figure 18.

The air valve assembly operates in an up-and-down, piston-like motion inside the cylindrical cavity of the throttle body assembly. When the engine is stopped, the air valve assembly is held in a closed position by a metering spring, Figure 18A. The gas passage in the throttle body is completely closed off by means of a synthetic rubber seat on the metering valve. When the engine is started, the air valve assembly moves downward off the gas passage inlet, allowing entry of gas into the venturi throat where it mixes with high-velocity intake air, Figure 18B. The higher the load demand, the greater the air and gas opening up to maximum throttle.

Carburetor vacuum provides a sufficiently strong metering signal (or metering force) to the fuel regulator. The better the signal, the less important precise pressure regulation of the fuel becomes.

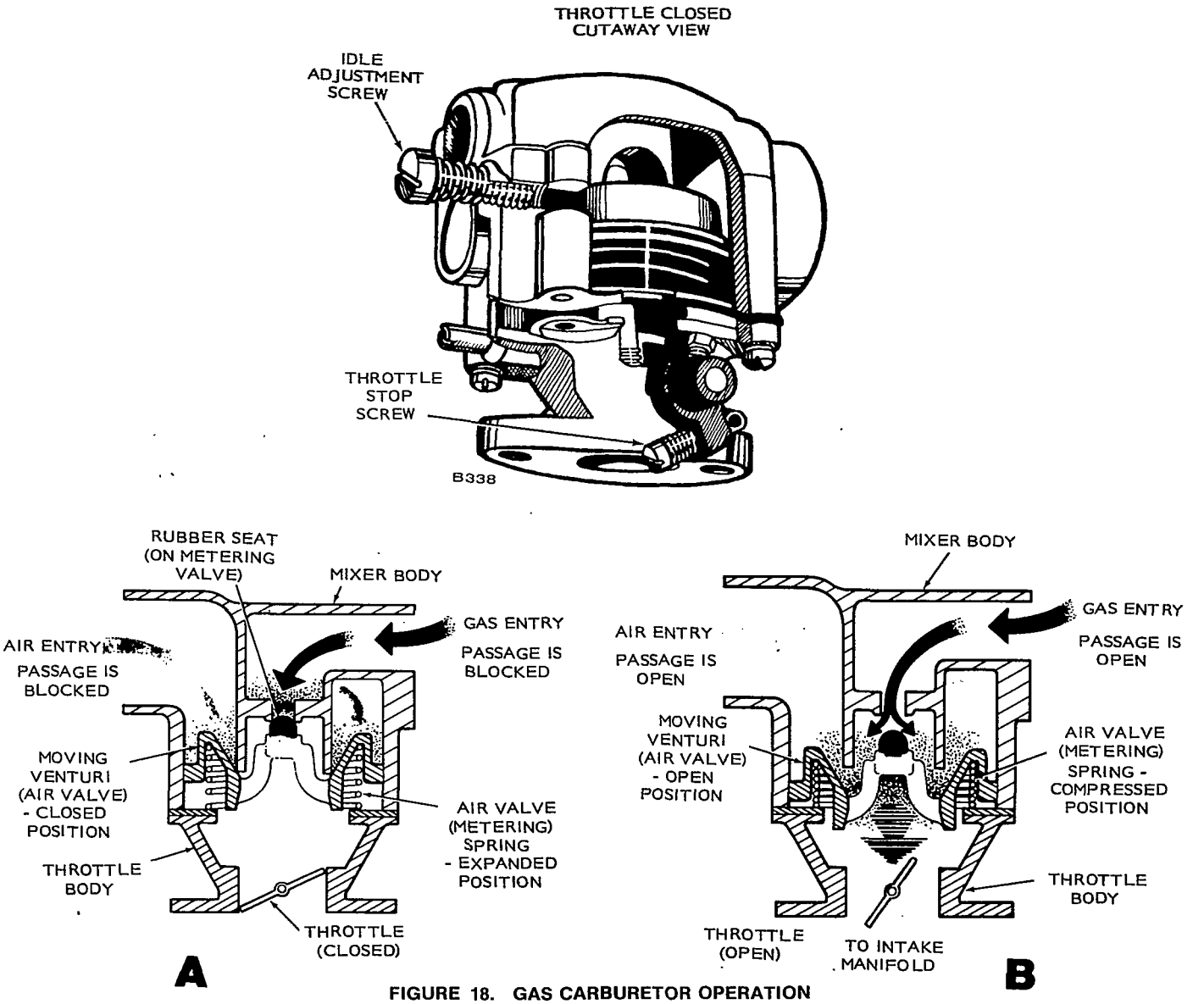


FIGURE 18. GAS CARBURETOR OPERATION

Under heavy pulsing conditions with two-cylinder engines, oscillations of the air valve are reduced by a breather hole with a check valve in the plate that supports the air valve and spring. The check valve vents air allowing the air valve movement and relieves any pressure surges caused by backfire, without closing the air valve.

A constant depression spring positioned between the check valve and the air valve assembly provides constant tension against the air valve to keep the vacuum curve flat. This spring limits the vacuum signal transmitted from the intake manifold, holding it between 0.5- and 1.5-inches of mercury. The constant tension on the air valve assembly amplifies the signal at idle and limits it at full throttle. The air valve provides good breathing at top speed, eliminates flat spots at low speeds, and prevents lag in the pulse signal to the regulator. Therefore, throttle response is good with fast acceleration.

The idle adjustment/bypass system consists of an adjustable port for air through the air/fuel passage wall which bypasses the venturi to the throttle. At idle, the flow of air is past the idle adjustment screw into a port in the mixer body, past an idle cutoff piston in the throttle body where it enters the air/fuel passage. The idle cutoff piston is normally held in a closed position by a spring effectively blocking the passage of air through the idle port at less than 5 inches of vacuum. At idle, the piston is retracted allowing air to be metered by the idle adjustment screw. But during cranking and under heavy loads, the piston blocks the idle port enriching the fuel/air mixture for quick starts and acceleration. The idle mixture adjustment screw is tapped into the air bypass port in the throttle body. Turning the screw in or out meters the amount of air entering the port accordingly. Normally, only a very small opening past the screw is needed.

CARBURETOR ADJUSTMENTS

Gas engines with LPG carburetors maintain low exhaust emissions (Carbon Monoxide CO, Hydro Carbons HC, and oxides of Nitrogen Nox) as long as: the carburetor is adjusted properly, the engine remains in good service condition, and high temperature, low ash crankcase oil is used.

INITIAL START ADJUSTMENTS (At factory or after service or maladjustment)

1. Set main power mixture to position shown in Figure 19.
2. Turn idle screw in fully clockwise.
3. Turn idle screw out 2-1/2 turns counterclockwise.
4. Connect or turn on fuel supply to regulator.
5. Check (smell) for propane leaks.
6. Start engine—it should start within 20 seconds if fuel is available to carburetor.

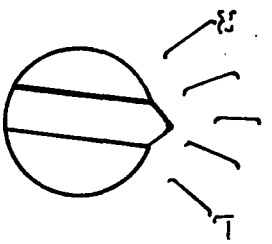


FIGURE 19. INITIAL START ADJUSTMENT

CHECKING FOR FUEL AT CARBURETOR

WARNING **Do not permit any flame, cigarette, or other igniter near the fuel system. Propane gas is highly flammable and potentially explosive in confined spaces. Use your sense of smell to detect leaks.**

1. Disconnect fuel line at carburetor.
2. Momentarily, press primer button; you should smell gas at end of fuel line. If not, check fuel lines back to supply tank.

With experience, you should be able to feel gas pressure on the regulator diaphragm when you press the primer button.

3. Look for one or more shutoff devices.
4. On vacuum operated shutoff valve systems, close throttle (fully) to aid engine starting with better vacuum.
5 If fuel is present at carburetor, check ignition system or other engine malfunctions.

CARBURETOR ADJUSTMENTS WITHOUT EXHAUST ANALYZER

1. Run new engine at least ten hours at normal service load. Avoid high loads before proper adjustments are made.
2. Run engine at maximum throttle at normal rpm for ten minutes, or set main power mixture near mark between L and R as shown in Figure 19.
3. Set main power mixture as lean as possible without noticeable loss in power output. If frost develops and remains on regulator for more than five minutes, check for propane leaks and ensure that vaporizer coil wraps tightly around exhaust pipe.
4. If engine functions properly but frost remains on regulator, the carburetor power mixture is too rich. Adjust for maximum efficiency.
5. Recheck head bolt torque and valve lash after carburetor is adjusted.

IDLE SCREW AND IDLE STOP ADJUSTMENT

1. Run engine at idle speed (1200 rpm) for ten minutes.
2. Adjust idle screw for maximum speed; maximum speed should be attained when idle screw is turned fully clockwise into carburetor.
3. Set idle stop screw speed at 1350 rpm.
4. Turn idle screw out until engine speed slows to 1200 rpm.

CARBURETOR ADJUSTMENTS WITH EXHAUST ANALYZER

Exhaust analyzers (with at least ±3 percent accuracy) should be infra-red equipment, but flame ionization can be used for measuring hydrocarbon emissions in parts per million (n-hexane). All data is based on dry measurements which are obtained after removing all water vapor from the exhaust samples. A heat measurement will be about 15 percent less than a dry measurement, if none of the water vapor is removed from the samples.

Main Power Adjustment:

1. Run engine at open throttle for normal maximum rpm for ten minutes or set main power mixture at mark between L and R as shown in Figure 19 .
2. Adjust main jet for 1.0-plus 0.5-percent CO emission.
3. If frost develops and remains on regulator for more than five minutes, check for leaks and be sure vaporization coil wraps tightly around exhaust pipe.

When the fuel system functions properly, the regulator should be frost free after about five minutes running time.

Idle Screw Adjustment:

1. Run engine at 1200 rpm for ten minutes.

2. Using idle stop screw and idle mixture screw, set engine exhaust emissions for .2 ± .1 percent CO at 1200 rpm on richest mixture possible.

If this condition is met, the CO emission will exceed .5 percent when idle screw is turned one half turn counterclockwise from setting attained in step 2.

3. Return to 0.2 ± 0.1 percent CO idle screw setting.

At proper idle adjustment, the HC emission should be under 1000 ppm and CO_2 emission will be 8 to 10 percent.

THROTTLE STOP ADJUSTMENT

1. Adjust throttle stop clamp for maximum service load; throttle should be 20 degrees from vertical position at wide open throttle. Throttle travel from open to closed position should be 50 degrees.

CAUTION **Do not change the throttle stop to increase the throttle opening. Increasing the throttle opening beyond this point does not increase the power output of the engine because the carburetor is designed for even larger engines. It may, however, adversely affect governor operation.**

2. Check throttle linkage for freedom of movement.

GOVERNOR SYSTEM

GOVERNOR ADJUSTMENT

The governor is set at the factory to allow a nominal engine idle speed of 1200 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 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 20 and 21).

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.
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 (0.79 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.

Speed Adjustment: The speed at which the engine operates is determined by the tension applied to the governor spring. Increasing spring tension increases

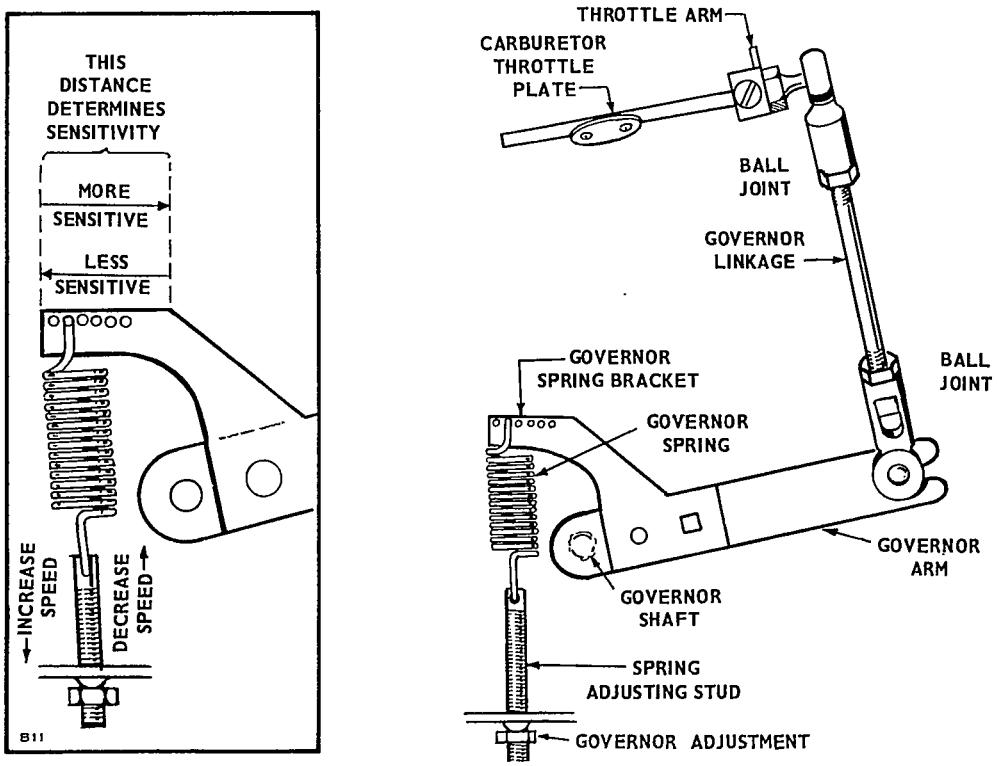


FIGURE 20. GOVERNOR ADJUSTMENTS

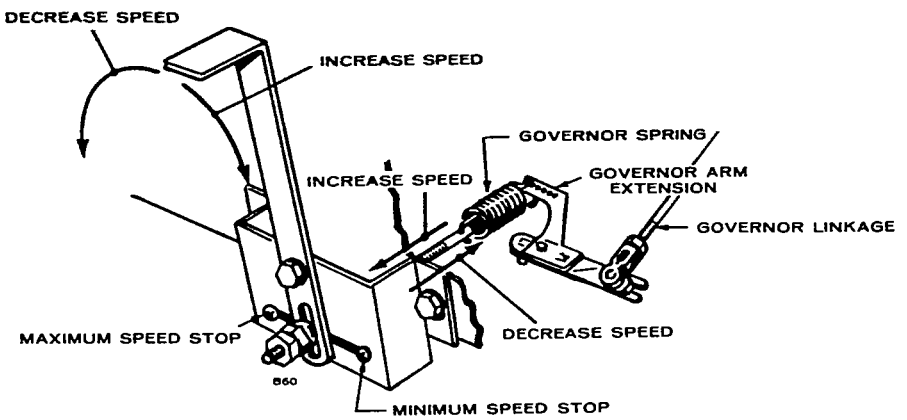


FIGURE 21. VARIABLE SPEED GOVERNORS

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 requires 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 20).

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

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

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

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

VARIABLE SPEED GOVERNOR ADJUSTMENTS

These engines are adapted for 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 21 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 900 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 (on 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 knob 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 SYSTEM

BREAKER POINTS—TIMING

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

1. Remove spark plugs and rotate flywheel TC mark to 25° BTC (points open); then rotate it another 90 degrees clockwise to ensure points open fully.
2. Remove breaker box cover and unplug coil wire at coil (+) terminal.
3. Remove condenser (screw A) and detach condenser lead and coil lead (screw B).
4. Remove two Allen screws (C) and lift breaker assembly from engine.
5. Replace condenser and point assembly with new parts and reinstall using above procedure in reverse order of removal.
6. Using Allen wrench at screw (D) adjust point gap at .019 inch (0.48 mm) using a clean, flat thickness gauge.

Setting point gap accurately adjusts engine timing.

7. Replace breaker box cover and spark plugs.

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

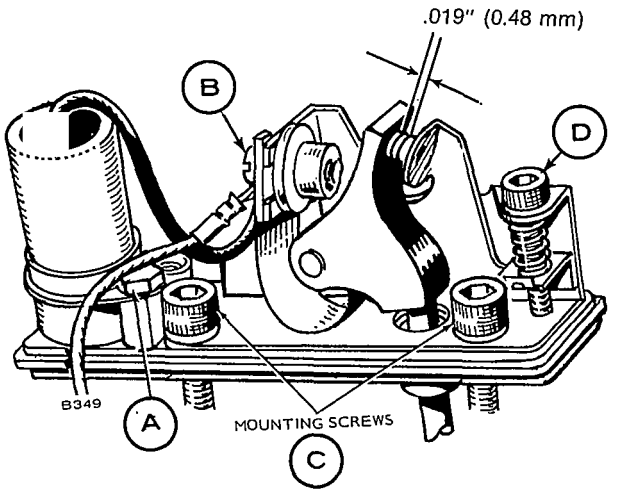


FIGURE 22. BREAKER POINT ADJUSTMENT

TIMING CHECK—PRESSURE COOLED ENGINE

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

The engine is equipped with an automotive type battery ignition system. Both spark plugs fire simultaneously, thus the need for a distributor is eliminated. Spark advance is set at 25° BTC (before top center), and should be maintained for best engine performance. Always check timing after replacing ignition points or if noticing poor engine performance. Proceed as follows:

Timing Check—Engine Running:

1. To accurately check the ignition timing, use a timing light with engine running at idle speed. Connect the timing light according to its manufacturer's instructions. Either spark plug can be used as they fire simultaneously.
2. Start the engine and check the timing. The pointer on the flywheel should line up with the 25° mark on the cover. The timing hole through the flywheel and the timing marks on the timing gear cover can be seen by looking through the flywheel blower screen. See Figure 23.

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

Timing Check—Engine Not Running: If a timing light is not available, check the timing as follows:

1. Connect a continuity test lamp set across the ignition breaker points. Touch one test prod to the breaker box terminal to which the coil lead is connected and touch the other test prod to a good ground on the engine.
2. Turn crankshaft against rotation (counterclockwise) until the points close. Then slowly turn the crankshaft with rotation (clockwise).
3. The lamp should go out just as the points break which is the time at which ignition occurs (25° BTC).

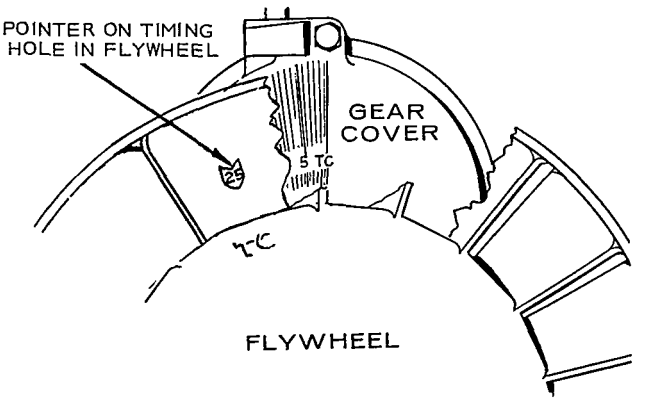


FIGURE 23. FLYWHEEL TIMING HOLE

TIMING CHECK—VACU-FLO ENGINE

Engine timing is advanced or retarded by opening or closing the breaker point gap. Setting the point gap at 0.019 inch (0.48 mm) is the most accurate method of timing the engine.

Dynamic timing (engine running) may be less accurate because the sight angle from the viewer to the flywheel scribe mark and timing pointer may vary ± 2° from 25° BTC, Figure 24.

The timing pointer is mounted on the cylinder block above the oil filter; it is made accessible by removing the right hand shroud.

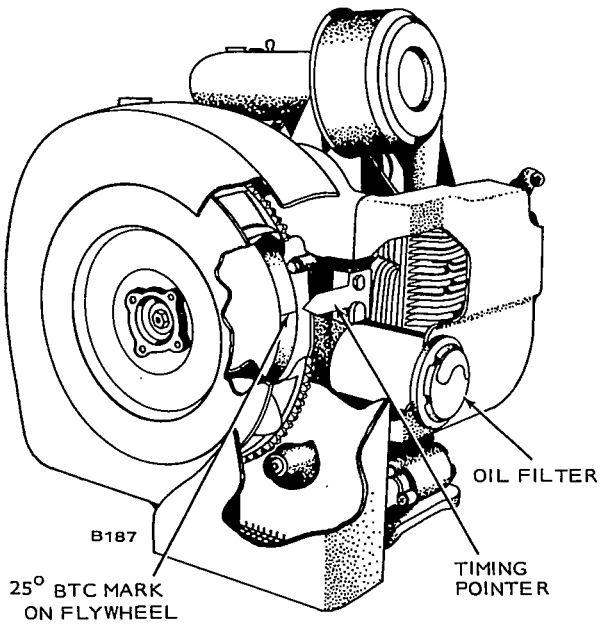


FIGURE 24. VACU-FLO ENGINE—TIMING MARK AND POINTER

SPARK PLUGS

Remove both spark plugs and install new ones every 100 hours. Use Onan spark plugs 167-0240 or equivalent. Check to be sure spark plug gap is set at .025 inch (0.64 mm), Figure 25.

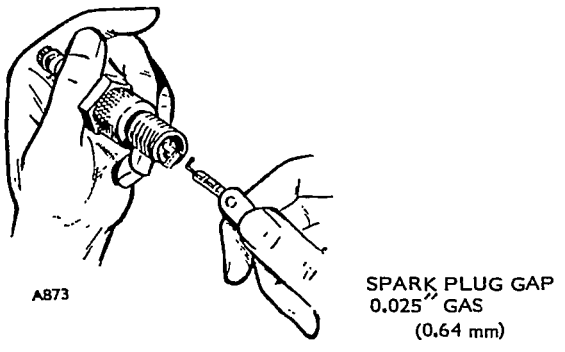


FIGURE 25. SPARK PLUG GAP

IGNITION COIL

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

1. Use Simpson 260 VOM or equivalent.
2. Place black lead on ground (-) terminal of coil and red lead to positive (+) terminal. Primary resistance should read 4.30 (± 10%) ohms @ 70° F.
3. Change resistance setting on ohmmeter. Place ohmmeter leads inside of spark plug cable holes (Figure 26). Secondary resistance should read 14,000 (±10%) ohms @ 70° F.
4. If any of the above conditions are not met, replace coil. Refer to *Parts Catalog* for correct part number.

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

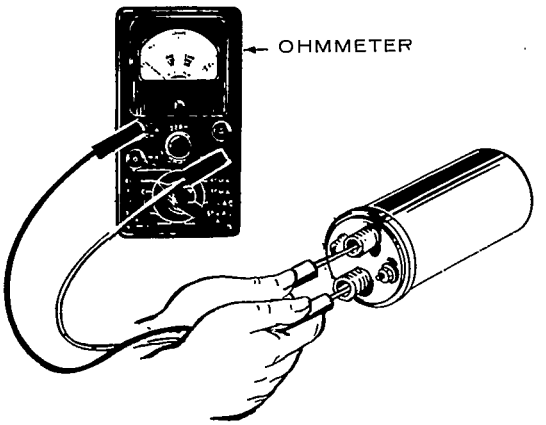


FIGURE 26. COIL TEST

BATTERY INSPECTION

Check battery cells with a hydrometer. The specific gravity reading should be approximately 1.280 at 80° F, Figure 27.

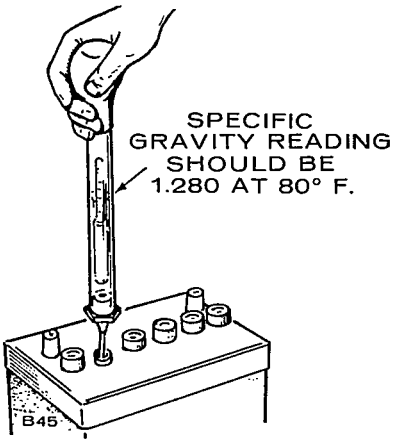


FIGURE 27. SPECIFIC GRAVITY TEST

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

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

BATTERY CHARGING SYSTEM

BATTERY CHARGING, FLYWHEEL ALTERNATORS

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

Two different alternator systems are used with NHP and NHPV engines. One is a 20 amp Synchro system; the other is a 15 amp Phelon system.

A 30-ampere fuse is included in the battery charging system to protect the alternator in case the battery cables are accidently reversed. Replace the fuse with Onan Fuse 321-0162, Buss AGC30 or equivalent.

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

TESTING OR SERVICING

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

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

Charging system tests require a fully charged battery.

20 AMP SYNCHRO SYSTEM

The 20 amp flywheel alternator systems use a separate regulator and a separate rectifier, Figure 28.

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 3.

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 29 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 connection exists between ground and black leads, stator assembly should be replaced.

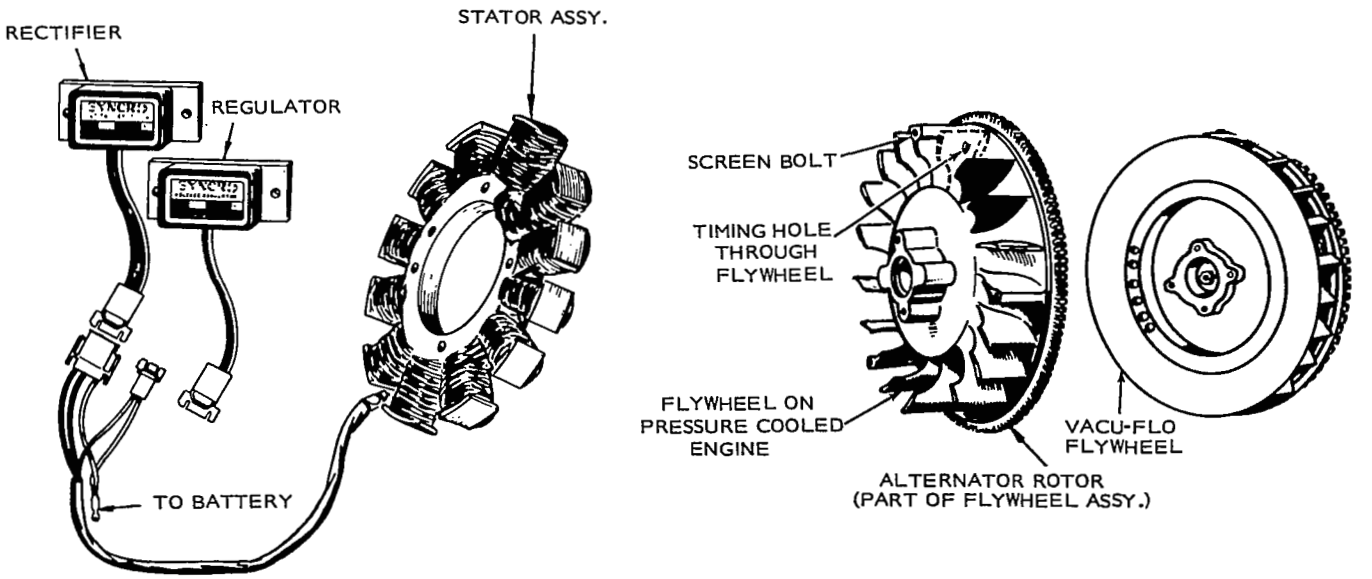
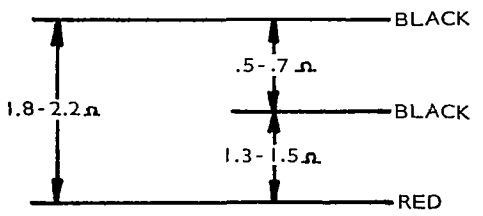


FIGURE 28. 20 AMP SYSTEM

TABLE 3. 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* Volt DC
AC voltage from stator with plug disconnected and unit running at approximately 1800 rpm	17 volts AC Black to Black
Ohmmeter reading at plug when checking two AC stator leads - unit not running	
Resistance values (Ohms) are as follows between wire pairs. 	

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

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.

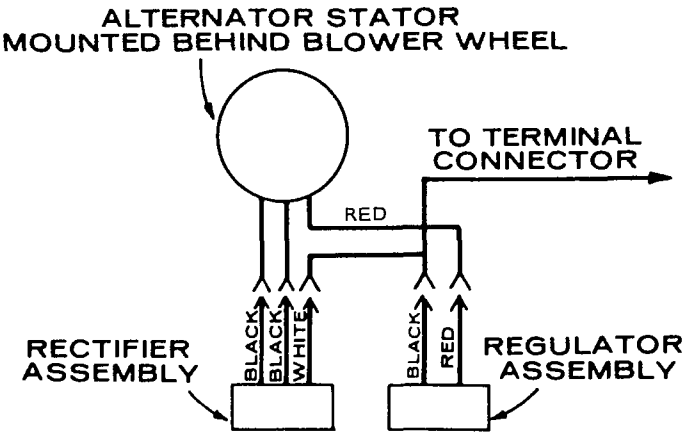


FIGURE 29. 20 AMP SYNCHRO SYSTEM

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 doesn't, replace stator assembly.

15 AMP PHELON SYSTEM

The Phelon flywheel alternator systems (Figure 30) have a one piece regulator-rectifier assembly. Various alternator tests are listed in Table 4.

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

Use a volt-ohmmeter such as the Simpson 270, when testing the charging system.

1. Examine lead wires for loose or broken connections.

2. 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 4 for resistance specifications.

TABLE 4. 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 nut 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

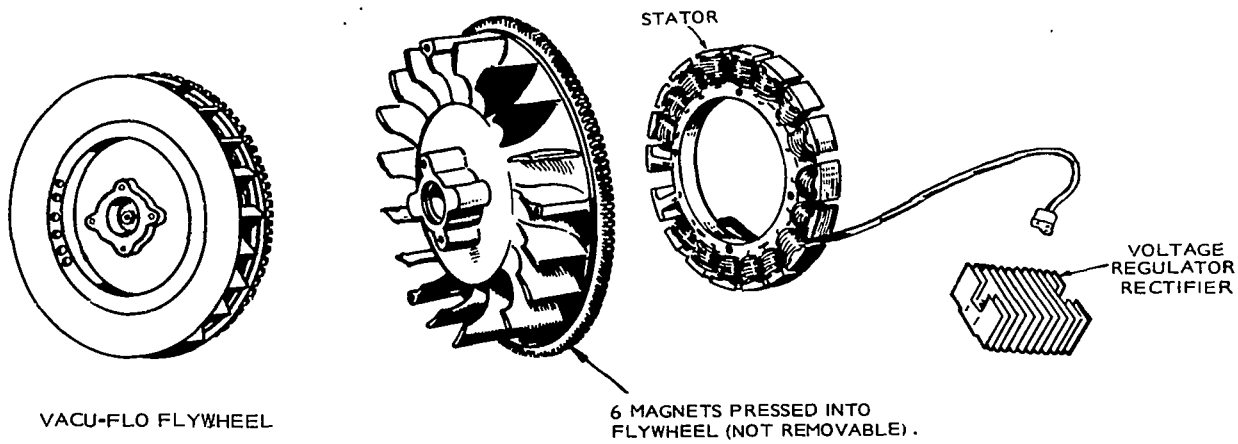


FIGURE 30. 15 AMP SYSTEM (PHELON)

Next connect one ohmmeter test lead to stator wire, connect the other test lead to ground. If the ohmmeter reading is low the stator is grounded and must be replaced.

3, Disconnect plug from regulator-rectifier and test the AC voltage at the plug with engine running near 3600 rpm. If AC voltage reads less than specified in Table 4 replace stator assembly.

4. With engine running check the B+ to ground voltage (regulator output) using a DC voltmeter. Voltage output should be within the values specified in Table 4. If voltage is greater than specified replace regulator-rectifier assembly.

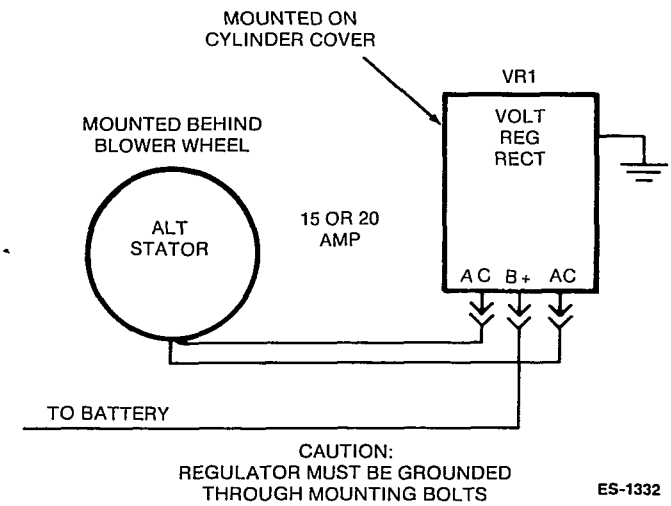


FIGURE 31. 15 AMP PHELON SYSTEM

STARTING SYSTEM

ELECTRIC STARTER REPAIR

CAUTION **To prevent insulation damage, do not use steam or high pressure water to clean the starter assembly (Figure 32).**

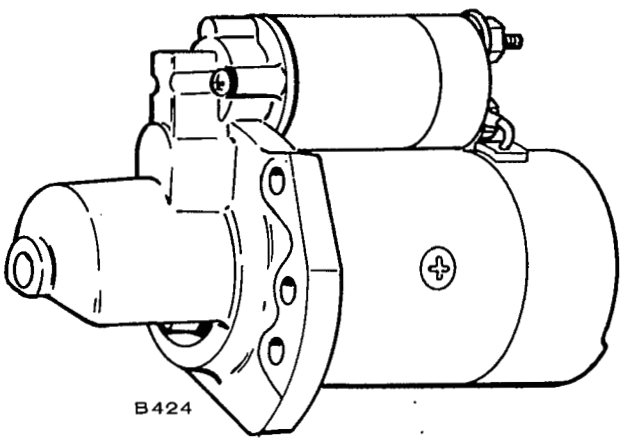


FIGURE 32. STARTER ASSEMBLY

DISASSEMBLY

1. Loosen the M terminal nut on the magnetic switch and remove the connector. Then unscrew attaching screws and remove the magnetic switch, Figure 33.

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

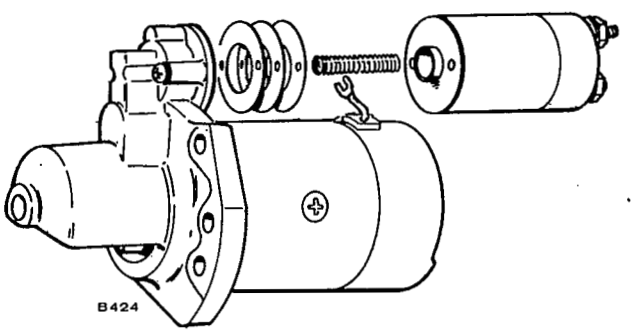


FIGURE 33. MAGNETIC SWITCH REMOVAL

2. After removing the thru bolts, the starting motor can be divided into three parts—the front bracket, housing and rear bracket. The spacers shown in Figure 34 are used for adjustment of the thrust gap of the armature shaft and are placed between the rear bracket and the commutator.

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

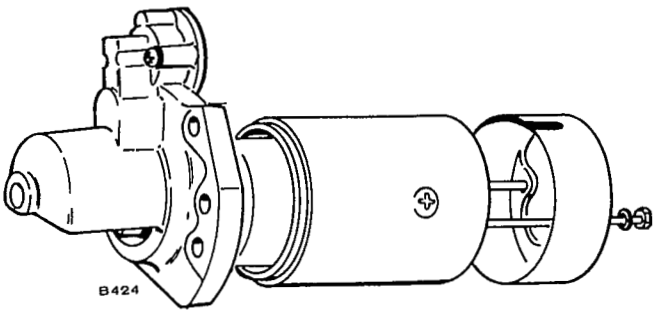


FIGURE 34. REMOVING THROUGH BOLTS

3. The armature can easily be removed from the front bracket. Be careful not to miss a small steel washer used in the end of the armature shaft. The shift lever can be removed along with the armature when it is removed. In this case, the spring holder, lever springs and retainer can be taken out before the lever. See Figure 35.

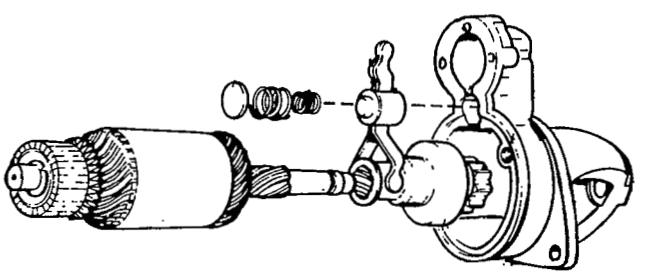


FIGURE 35. REMOVING ARMATURE

4. Remove the ring after driving the pinion stopper toward the pinion gear using a cylindrical tool as shown in Figure 36. The overrunning clutch and the pinion stopper should be removed simultaneously.
5. All four brushes have been soldered to the brushholder in the same way. The brush springs can be removed from the brushholder.
6. The pole shoes may be removed if necessary, by removing the flat head machine screws from the frame.

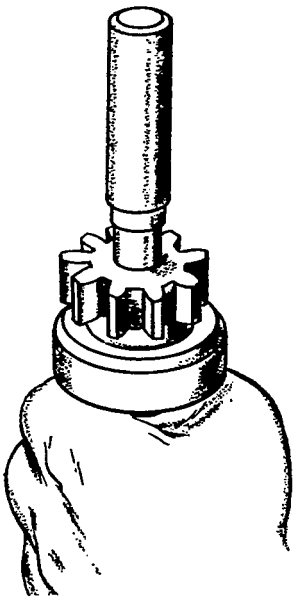


FIGURE 36. REMOVING RING

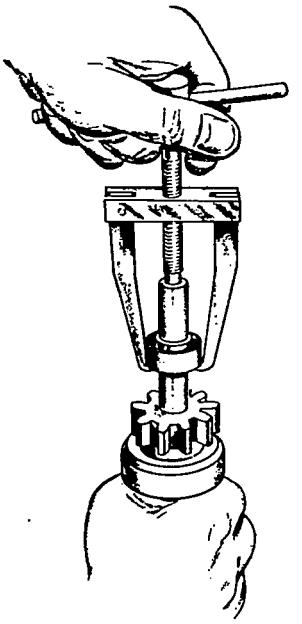


FIGURE 38. MOUNTING OVERRUNNING CLUTCH

REASSEMBLY

Inspect the parts carefully in accordance with the procedure described in *Inspection of Parts*. Make any repairs necessary. Reassembly is the reverse of disassembly. The following precautions should be taken:

CAUTION **Parts containing lubricated bearings must not be immersed in cleaning fluid to prevent breakdown of lubricant. These parts should be cleaned with a brush dipped in "Varsol" or any other comparable mineral spirits. Do not immerse overrunning clutch in cleaning solvent. Thoroughly dry any parts that have come into contact with the cleaning fluid.**

1. Inspect brushes (Figure 37) and clean all parts carefully with a dry cloth and compressed air if it is available.
2. Apply 20 weight non-detergent oil to the armature shaft and splines. Apply grease (Shell Albania No. 2 or equivalent) sparingly on the shift lever pin, the joint of the shift lever and plunger, the plunger and spacing washers at the end of the shaft.
4. Use spacing washers to adjust the armature to give end play of .004" to .020" (0.10 to 0.51
5. Tighten the thru bolts to a torque of 3 to 4 (4.0 to 4.5 N.m).
6. Insert the shift lever as shown in Figure 39 into the front bracket.

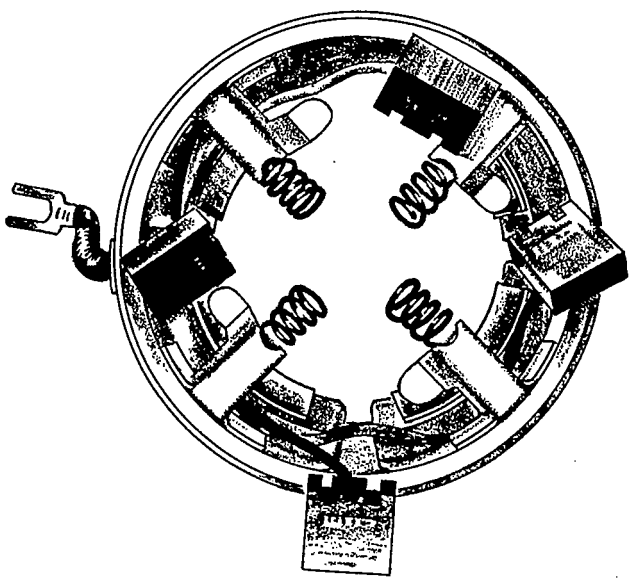


FIGURE 37. BRUSHES

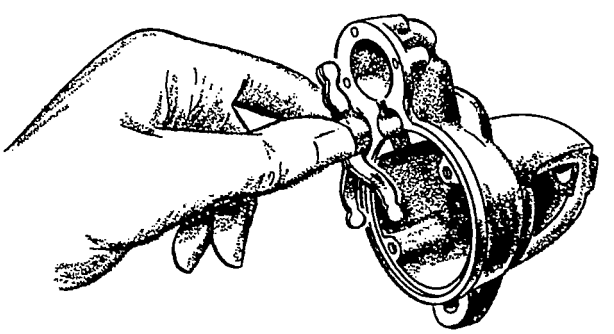


FIGURE 39. INSTALLING SHIFT LEVER

INSPECTION OF PARTS

1. **Testing Armature for Short Circuits.** Place the armature in a growler and hold a thin steel blade parallel to the core and just above it while slowly rotating the armature in the growler. A shorted armature will cause the blade to vibrate and be attracted to the core. Replace shorted armature. See Figure 40.

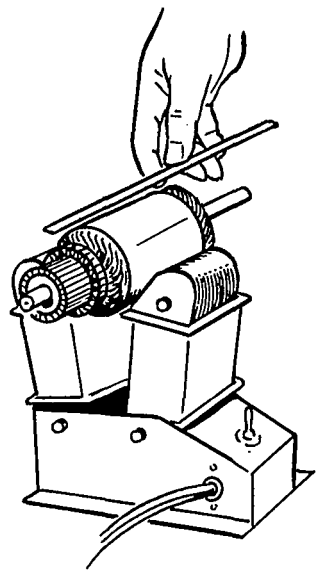


FIGURE 40. ARMATURE SHORT CIRCUIT TEST

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

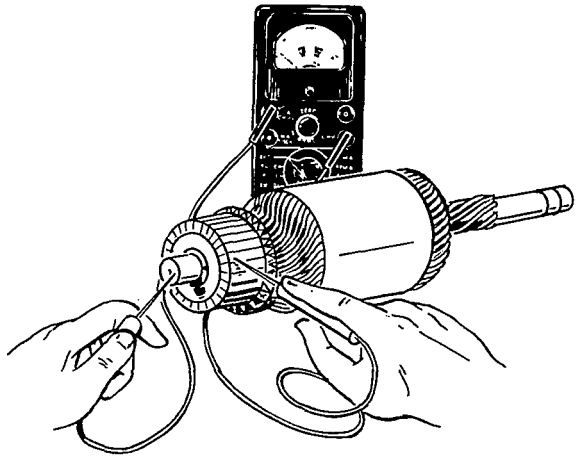


FIGURE 41. ARMATURE GROUND TEST

3. **Testing Armature for Open Circuit.** The most likely place for an open circuit to occur is at the commutator riser bars. Inspect the points where the conductors are joined to the commutator bars for loose connections.

4. **Testing Commutator Runout.** Place armature in a test bench and check runout with a dial indicator. When commutator runout exceeds .004-inch (0.10 mm), commutator should be refaced (Figure 42).

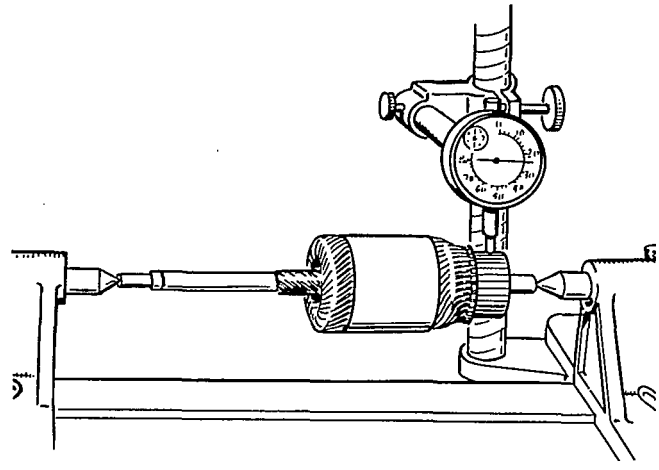


FIGURE 42. CHECKING COMMUTATOR RUNOUT

5. **Testing Armature Shaft Runout.** The armature shaft as well as the commutator may be checked. A bent armature often may be straightened, but if the shaft is worn, a new armature is required (Figure 43).

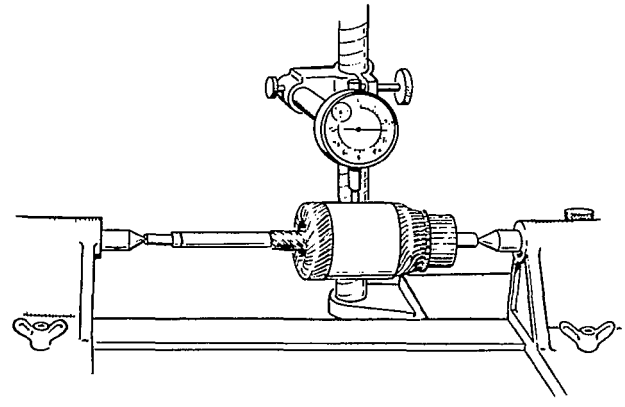


FIGURE 43. CHECKING ARMATURE SHAFT RUNOUT

6. **Testing Field Coils for Grounds.** Place one lead on the connector and the other on a clean spot on the frame after unsoldering shunt field coil wire. If the ohmmeter reading is low, the fields are grounded, either at the connector or in the windings (Figure 44).

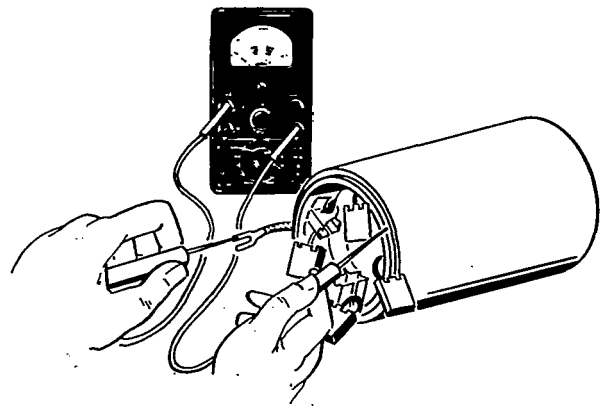


FIGURE 44. FIELD COIL GROUND TEST

7. **Testing Field Coils for Open Circuit.** Place one lead on the connector and the other on a clean spot on the brushholder. If the ohmmeter reading is high, the field coil is open. Check the other three brushholders in the same manner (Figure 45).

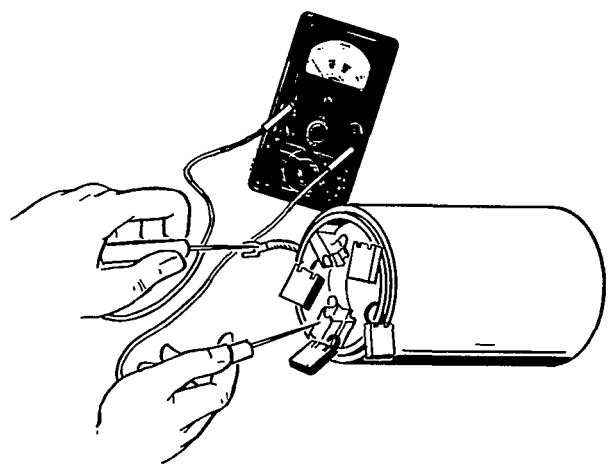


FIGURE 45. FIELD COIL OPEN CIRCUIT TEST

8. **Inspection of Brushes.** Replace brushes when they are worn less than .3-inch (7.62 mm) as shown in Figure 46. See that all brushes move freely in their holders.

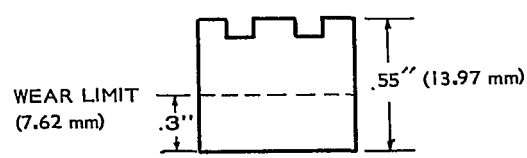


FIGURE 46. BRUSH WEAR LIMIT

9. **Inspection for Brush Spring Tension.** Measure brush spring tension with a tension meter as shown in Figure 47. Push the brush and take a reading just as the brush projects a little from the brushholder. On a new brush the spring tension should be 29 ounces (822 g; 0.81 kg) to 38 ounces (1077 g; 1.06 kg).

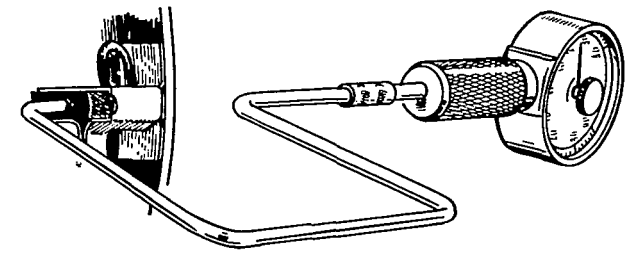


FIGURE 47. BRUSH SPRING TENSION TEST

INSPECTION AFTER OVERHAUL

1. For no load test, the starting motor is wired as shown in Figure 48 and revolved. The meter readings for this test should be:

Voltage	11.5 volt
Speed	3700 rpm minimum
Current Draw	60 amp maximum

The conductor for this test should be large enough to carry 60 amps and as short as possible. If anything is wrong in the above test, inspect the following items:

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

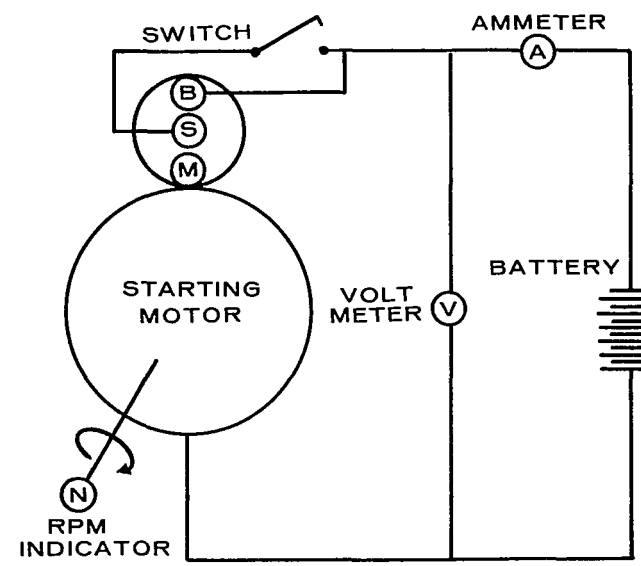


FIGURE 48. STARTING MOTOR WIRING

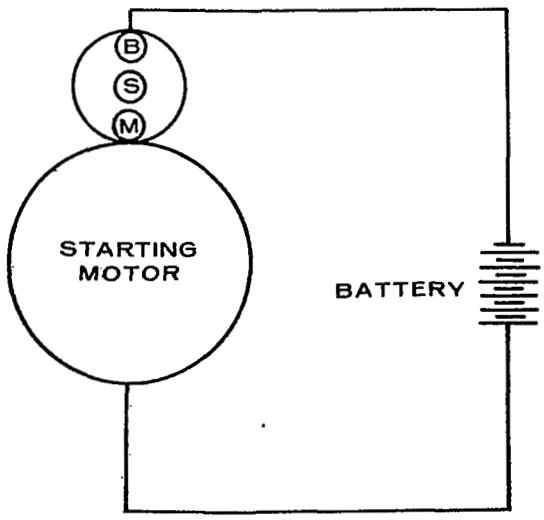


FIGURE 49. BATTERY CONNECTIONS

2. **Adjusting Pinion Clearance.** Connect the battery to the starting motor as shown in Figure 49. 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 stopper when the pinion is pushed lightly toward the commutator end. Clearance should be .02-inch (0.51 mm) to .06-inch (1.52 mm). Adjust for proper clearance by removing the magnetic switch attaching screws and select proper thickness of the fiber packings shown in Figure 50.

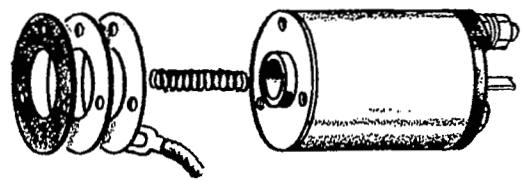


FIGURE 50. ADJUSTING PINION CLEARANCE

ENGINE DISASSEMBLY

VALVES

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

Worn valve stem guides may 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.

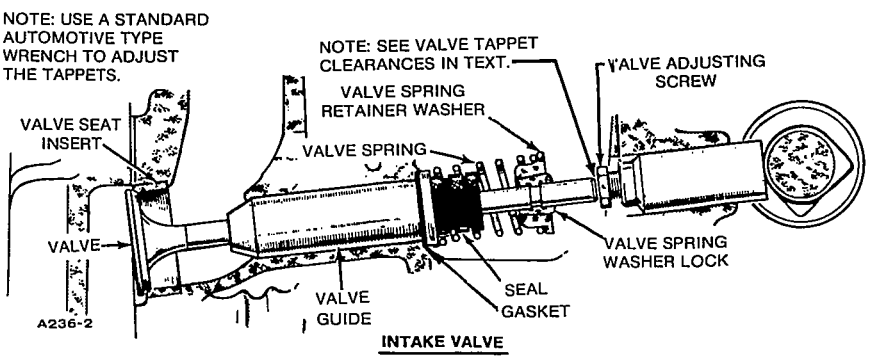
The valve *face* angle is 44 degrees. The valve *seat* angle is 45 degrees. This 1-degree interference angle results in a sharp seating surface between the valve and the top of the valve seat. The interference angle method of grinding valves minimizes face deposits and lengthens valve life (Figure 51).

CAUTION **Grinding intake valves is not recommended because it removes the aluminized coating, thereby greatly reducing the life of the valve.**

The exhaust valves can be reground as long as the proper dimensions are maintained. This is especially important where stellite faced valves and seats are used. Valve faces should be finished in a machine to 44 degrees. Valve seats should be ground with a 45-degree stone and the width of the seat band should be 1/32-inch (0.79 mm) to 3/64-inch (1.19 mm) wide. Grind only enough to assure proper seating.

Remove all grinding compound from engine parts and place each valve in its proper location. Check each valve for a tight seat, using an air pressure type testing tool. If such a tool is not available, make pencil marks at intervals across the valve face and observe if the marks rub off uniformly when the valve is rotated part of a turn against the seat.

Lightly oil the valve stems and reassemble all parts removed. Adjust the valve clearance.



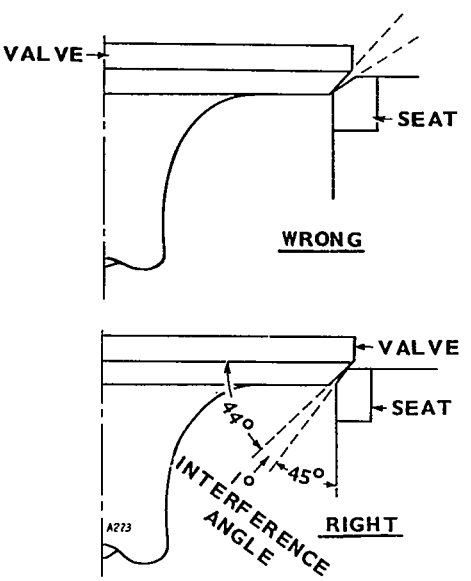


FIGURE 51. VALVE SYSTEM

Tappet Adjustment: The engine is equipped with adjustable valve tappets. The valve tappet clearance should be checked and adjusted, if necessary, at least every 400 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 all parts necessary to gain access to valve tappets.
2. Remove spark plugs to make turning the engine easier.
3. Use the engine flywheel to turn the engine over slowly by hand until the left hand intake valve opens and closes. Continue turning the flywheel until the TC mark is on the top and lined up with the TC mark on the gear cover. Both valves should be closed. This should place the left hand piston at the top of its compression stroke, the position it must be in to get proper valve adjustment for the left cylinder.
4. Clearances are shown in Figure 52 and *Tune-up Specifications.* For each valve, the gauge should just pass between the valve stem and valve tappet.
5. To correct the valve clearance, turn the adjusting screw as needed to obtain the right clearance. The screw is self locking.
6. 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.
7. Replace all parts removed. Tighten all screws securely. Torque manifold bolts.

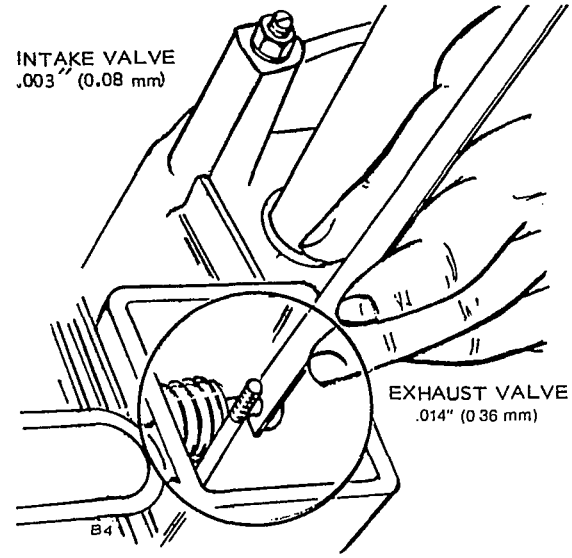


FIGURE 52. VALVE ADJUSTMENT

FLYWHEEL

Use a suitable puller (with claws or with bolts to agree with flywheel) to pull the flywheel.

CAUTION **Do not drop the flywheel. A broken fin will destroy the balance. Always use a steel key for mounting the flywheel.**

If a puller is not available turn the flywheel mounting screw outward about two turns. Use a screwdriver behind the flywheel to take up the crankshaft end play. Then strike a sharp endwise blow on the head of the cap screw with a heavy soft-faced hammer to loosen.

GEAR COVER

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

CAUTION **When installing the gear cover, make sure that the roll pin in the gear cover engages the metal lined (smooth) hole or plastic bushing in the governor cup, Figure 53.**

The roll pin protrudes upward from the cover and its outer end is 3/4 inch from a straight edge placed across the cover mounting surface.

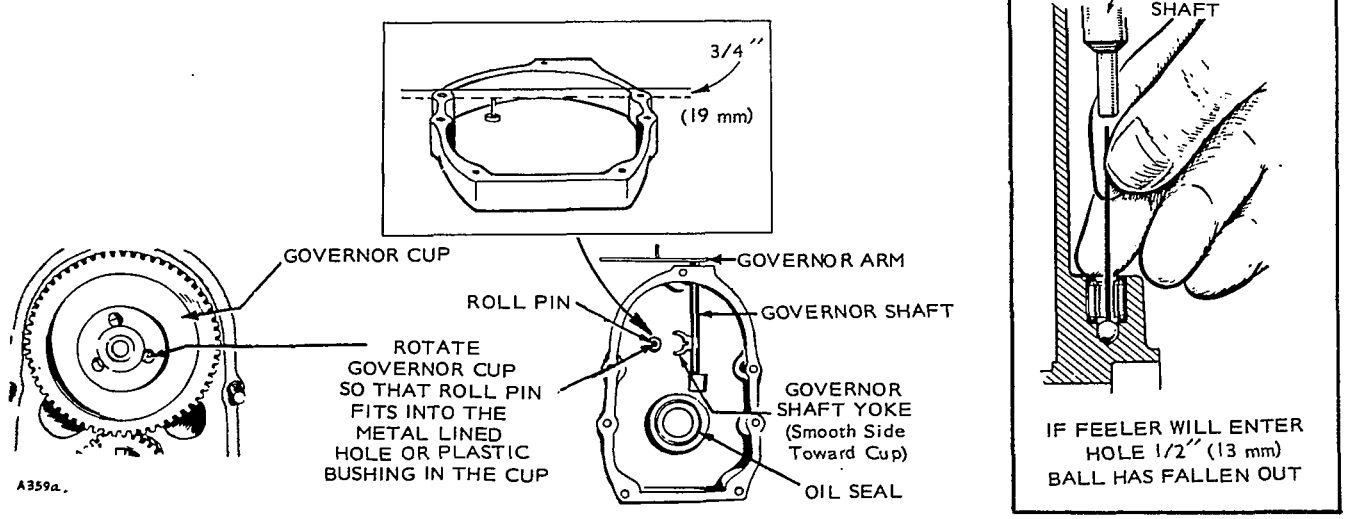


FIGURE 53. GEAR COVER ASSEMBLY

Turn the governor cup so that the metal lined hole is at the three o'clock position. The smooth side of the governor yoke must ride against the governor cup. Turn the governor arm and shaft clockwise as far as possible and hold in this position until the gear cover is installed flush against the crankcase. Be careful not to damage the gear cover oil seal.

GOVERNOR CUP

With the gear cover removed, the governor cup can be taken off after removing the snap ring from the camshaft center pin, Figure 54. Catch the flyballs while sliding the cup off.

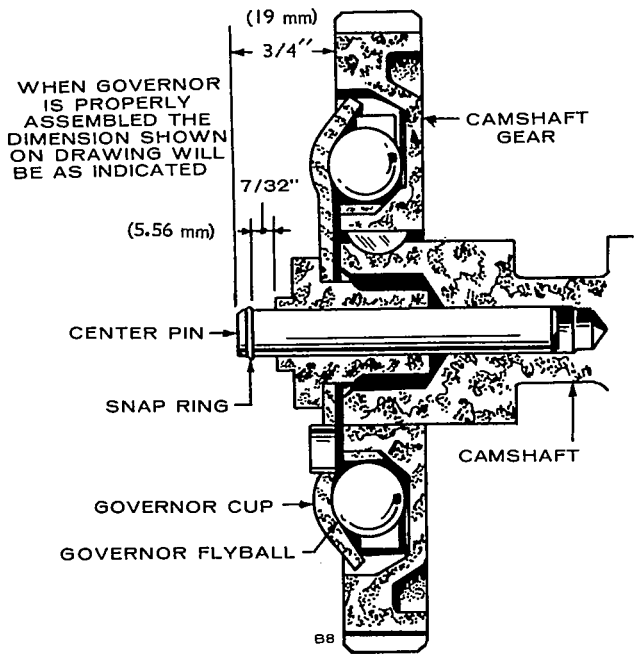


FIGURE 54. GOVERNOR CUP DETAILS

Replace any flyball that is grooved or has a flat spot. If the arms of the ball spacer are worn or otherwise damaged, remove the spacer by splitting with a chisel. Replace the spacer with a new one. The governor cup must spin freely on the camshaft center pin without excessive looseness or wobble. If the race surface of the cup is grooved or rough, replace it with a new one.

When installing the governor cup, tilt the engine so the gear is up, put the flyballs in place 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 (5.56 mm) for the governor cup, as illustrated. Hold the cup against the flyballs when measuring. If the distance is less (the engine may race, especially at no load), remove the center pin and press a new pin in only the required amount. Otherwise, grind off the hub of the cup as required. The camshaft center pin cannot be pulled outward nor removed without damage. If the center pin extends out too far, the cup will not hold the flyballs properly.

PISTON AND RINGS

Whenever there is a noticeable wear ridge at the top of each cylinder, remove the ridge before removing the pistons. If not, the rings can catch the ridge when pushing out the pistons and cause a ring land fracture. See Figure 55.

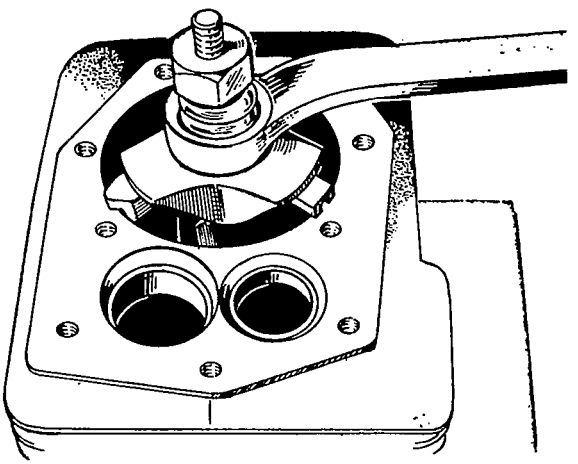


FIGURE 55. REMOVING WEAR RIDGE

To remove the piston and connecting rod assemblies, turn the crankshaft until a piston is at the bottom of the stroke. Remove the nuts from the connecting rod bolts. Lift the rod bearing cap from the rod and push the rod and piston assembly out the top of the cylinder with the handle end of a hammer. Be careful not to scratch the crankpin or the cylinder wall when removing these parts.

Keep the connecting rod bearing caps and bearings with their respective rods.

The pistons are fitted with two compression rings and one oil control ring with an expander. Remove these rings from the piston using a piston ring spreader.

Clean the piston ring grooves with a groove cleaner or the end of a broken ring filed to a sharp point. All passages should be cleaned with a non-caustic solvent. Clean the rod bore and the back of the connecting rod bearings thoroughly.

Mark each piston to make sure the rod will be assembled on the piston from which it was removed. Remove the piston pin retainer from each side and push the pin out.

Inspect the pistons for fractures at the ring lands, skirts and pin bosses. Check for wear at the ring land

using new rings and a feeler gauge as shown in Figure 56. See *Dimensions and Clearances* for proper side clearance measurement and ring groove widths.

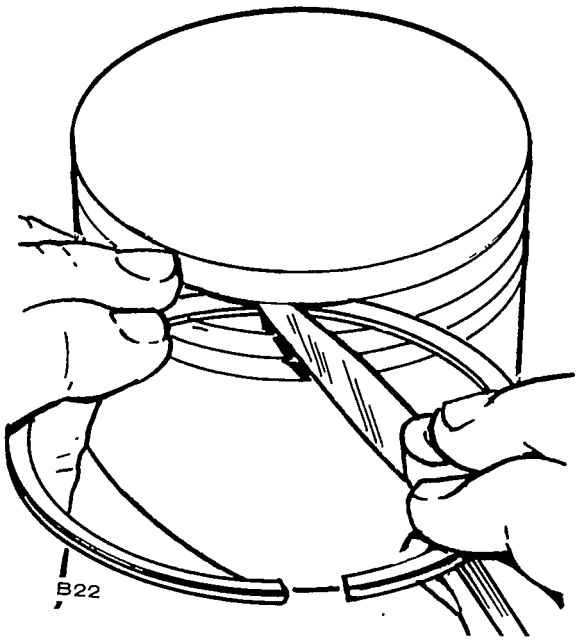


FIGURE 56. RING LAND INSPECTION

Improper width rings or excessive ring side clearance can result in ring breakage. New rings in worn ring grooves don't have good cylinder wall contact (Figure 57).

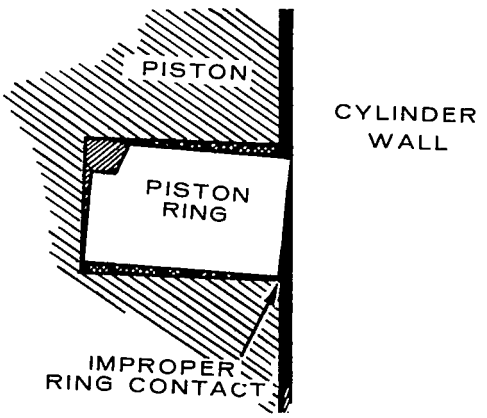


FIGURE 57. NEW RING IN WORN RING GROOVE

Replace pistons showing signs of bad scoring or burring, excessive skirt clearance, wavy or worn ring lands, fractures or damage from detonation. Replace piston pins showing fractures, scored bores or bores out of round more than 0.002-inch (0.05 mm).

Use a new piston pin to check the pin bushing in the connecting rod for wear. The clearance should be as shown in *Dimensions and Clearances.*

Before installing new rings on the piston, check the ring gap by placing each ring squarely in its cylinder, at a position corresponding to the bottom of its travel (Figure 58). The gap between the ends of the ring is given in *Dimensions and Clearances.* Rings which are slightly oversize may be filed as necessary to obtain the correct gap, but do not use rings which require too much filing. Standard size rings may be used on .005" oversize pistons. Rings that are .010", .020", .030" and .040" oversize are to be used on corresponding oversize pistons. Rings of the tapered type are usually marked *top* on one side, or identified in some other manner and the ring must be installed with this mark toward the closed end of the piston.

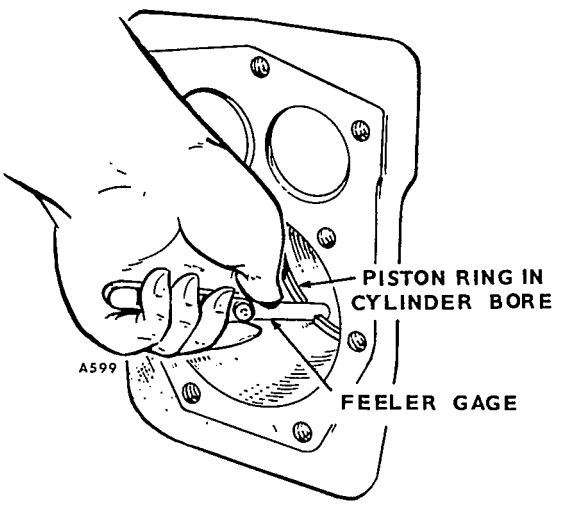


FIGURE 58. FITTING PISTON RINGS TO THE CYLINDER

Engines that have been fitted with .005" oversize pistons at the factory are identified by the letter E after the serial number which is stamped on the cylinder block and on the unit nameplate.

The standard cylinder bore size appears in *Dimensions and Clearances.*

Space each ring gap one third of the way around the piston from the preceding one, with no gap directly in line with the piston pin. The bottom piston ring groove should be fitted with an expander and an oil control ring and the two upper grooves fitted with compression rings. If a chrome faced ring is used, it will be in the top groove. The oil control ring is selected for best performance in regard to the correct unit pressure characteristics.

The piston is fitted with a full-floating type piston pin. The pin is kept in place by two lock rings in the piston, one at each side. Be sure these lock rings are properly in place before installing the piston and connecting rod in the engine. Refer to *Dimensions and Clearances* for the correct piston-to-cylinder clearance.

CONNECTING RODS

Connecting rods should be serviced at the same time as the pistons and rings. Replaceable bushings and bearings are used. Bearings are available in standard or .002", .010", .020" or .030" undersize.

Proper clearance is obtained by replacing the pin bushing and the bearings. The rod bearings are precision size and require no reaming.

Install the connecting rods and caps with raised lines (witness marks) aligned and with the caps facing toward the oil base. The rod and cap numbered 2 fits on the crankshaft journal nearest the bearing plate. Coat the crankshaft journal bearing surfaces with oil before installing the rods. Crank the engine by hand to see that the rods are free. If necessary, rap the connecting rod cap screws sharply with a soft-faced hammer to set the rod square on the journal.

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 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.

Crankshaft Regrinding: Crankshaft grinding requires a trained, experienced operator, with precision equipment. Onan emphasizes that if facilities or trained personnel are not available, the crankshaft may be sent to the factory.

Special procedures must be observed when reworking crankshafts. In addition to machining, the crankshaft must be super finished.

BEARINGS

Removal of the camshaft or crankshaft bearings requires complete disassembly of the engine. Use a press or a suitable drive plug to remove the bearings. Support the casting to avoid distortion and avoid damaging the bearing bore during removal and installation. Use oil on the bearings to reduce friction when installing and again lubricate with oil after installing, Figure 59. Use combination bearing driver 420-0324 to install the camshaft bearings.

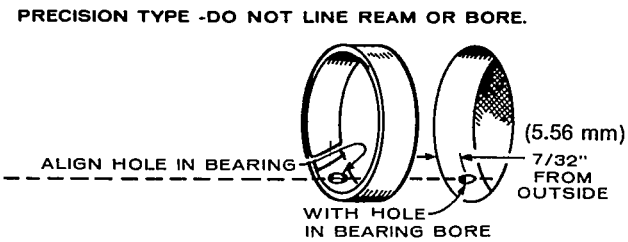


FIGURE 59. CAMSHAFT BEARING

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

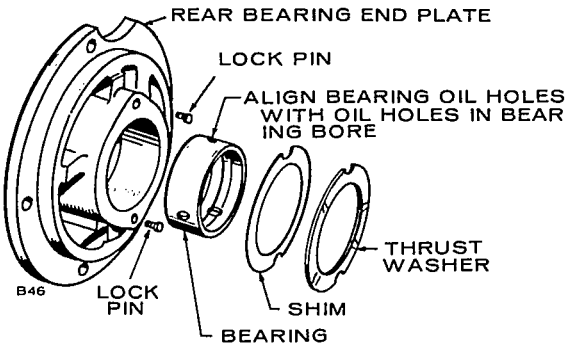
New crankshaft main bearings are precision type which *do not* require line reaming or line boring after installation. They are available in standard size, .002", .010", .020" or .030" undersize.

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

For putting in either the front or rear main bearing, using instructions following, always align the oil hole(s) in the bearing with the oil hole(s) in the bearing bore. The oil passage must be at least 1/2 open.

The cold oiled precision bearing should require only light taps to position it. In the rear bearing plate, install the bearing flush to 1/64-inch (0.40 mm) below the end of the bore using combination driver (same one used for camshaft bearing). See Figure 60.

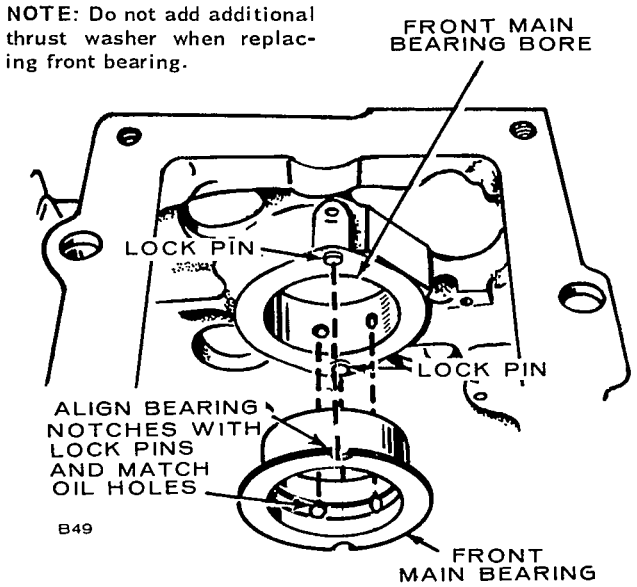
If the special combination tool isn't available, it's necessary to remove the lock pins with side cutters or Easy Out tool. After the new bearings are installed, insert new lock pins.



PRECISION TYPE- DO NOT LINE REAM OR BORE

FIGURE 60. 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 61. Do not add an additional thrust washer to this front bearing.



PRECISION TYPE-
DO NOT LINE BORE OR REAM OR BORE

FIGURE 61. FRONT BEARING INSTALLATION

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

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

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

Lubricate the front main bearing lightly with oil and insert the crankshaft. With the rear bearing plate gasket in place and the rear plate bearing lubricated, slide the thrust washer (grooves toward crankshaft) and plate over the end of the crankshaft. Line up the notches of the thrust washer with the lock pins before tightening the end plate or the 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 62. 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 60) 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.

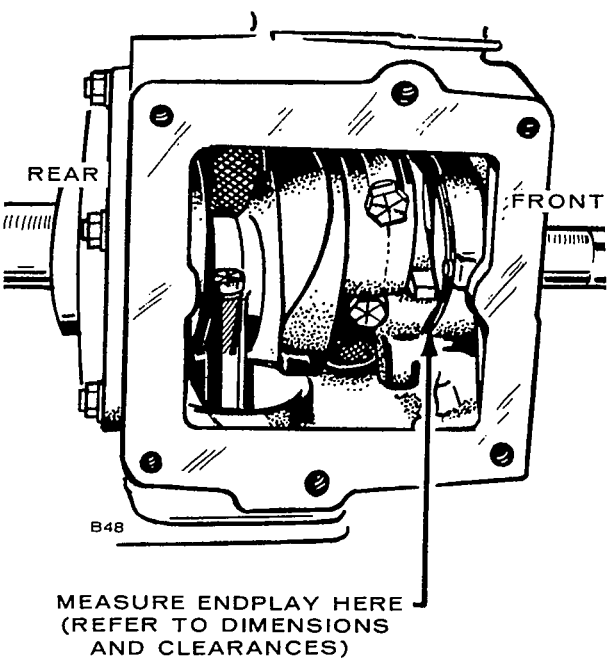


FIGURE 62. CRANKSHAFT ENDPLAY

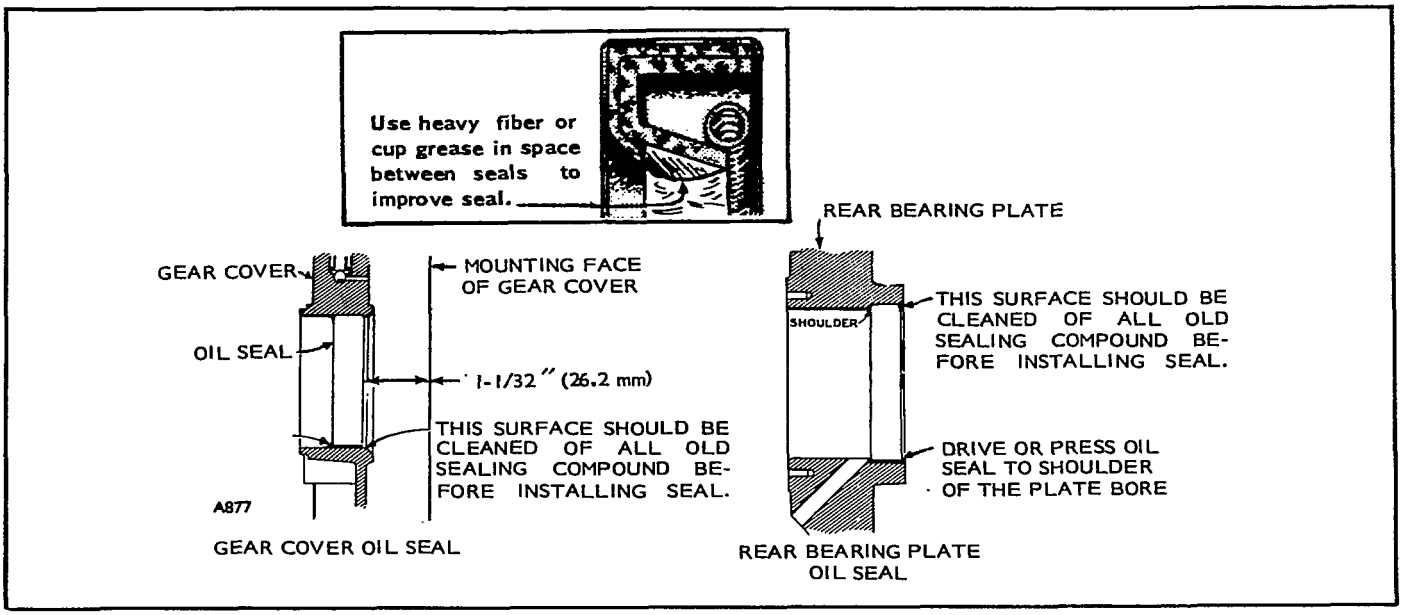


FIGURE 63. GEAR COVER AND REAR BEARING PLATE OIL SEALS

OIL SEALS

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

Before installing the seals, fill the space between seals with a fibrous grease or stiff cup grease. This will improve sealing. See Figure 63.

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

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

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.

CYLINDER

The cylinder wears very little in normal service. If, through improper lubrication or accident, the cylinder wall should become scored or worn badly, the cylinder may be rebored and honed to accommodate a new piston and ring set of the available oversizes. Pistons are available in .005", .010", .020", .030" and .040" oversize. Piston rings are available in .010", .020", .030" and .040" oversize. Use standard size rings on a .005-inch oversize piston. Remove any ridge which may have become formed at the top of piston ring travel in the cylinder bore. Engine might be fitted at the factory with a .005-inch oversize piston and are so indicated by a letter E following the engine serial number stamped on the cylinder block and on the unit nameplate.

The standard cylinder bore size appears in *Dimensions and Clearances.*

OIL PUMP

To remove the oil pump, it is necessary to detach the intake cup assembly as shown in Figure 64.

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

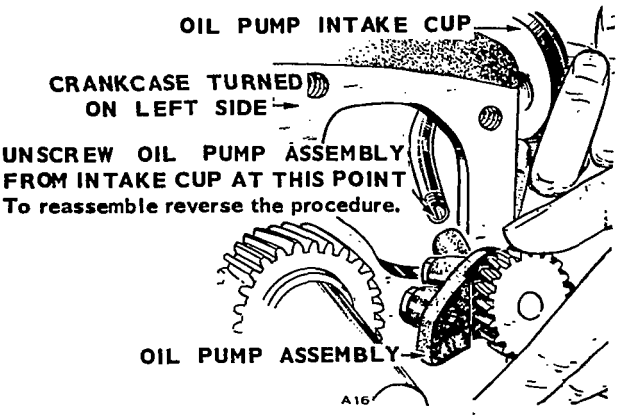


FIGURE 64. OIL PUMP ASSEMBLY

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 65. 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 66.

   A. Asbestos head gasket torque procedure:

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

WARNING ***Asbestos gaskets contain fibers that when airborne 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), etc., until the correct torque is reached. The top six nuts should be tightened to 12 ft-lb (16 Nm) and the bottom four nuts should be tightened to 15 ft-lb (20 Nm).

   After the head nuts have been tightened once, it will be necessary to tighten each head nut to the specified torque a second time. Follow the same sequence shown in Figure 66. Failure to re-torque could result in a blown head gasket.

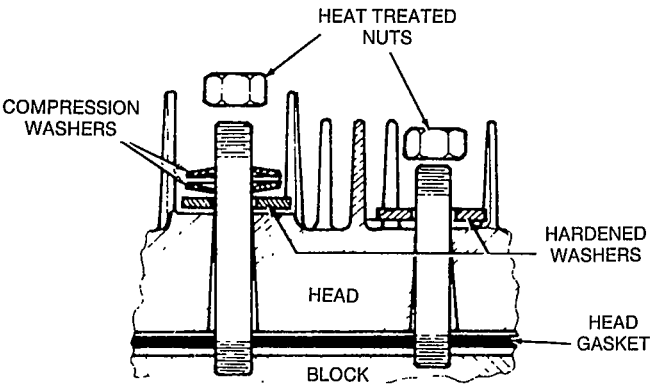


FIGURE 65. CYLINDER HEAD WITH COMPRESSION WASHERS

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.

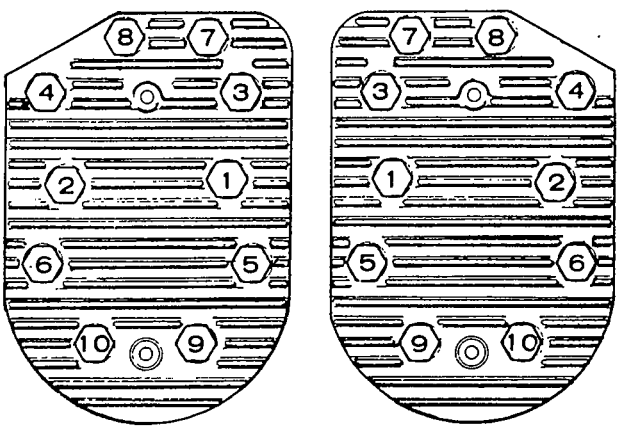


FIGURE 66. HEAD BOLT TIGHTENING SEQUENCE

CYLINDER HEAD STUD TEST AND REPLACEMENT PROCEDURE

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

Parts Required

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

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

2. Remove the nuts and compression washers (do not remove the flatwashers) from the top six studs on each cylinder head (see Figure 67). Each stud will have two compression washers and one flatwasher arranged in the sequence shown in Figure 68.

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

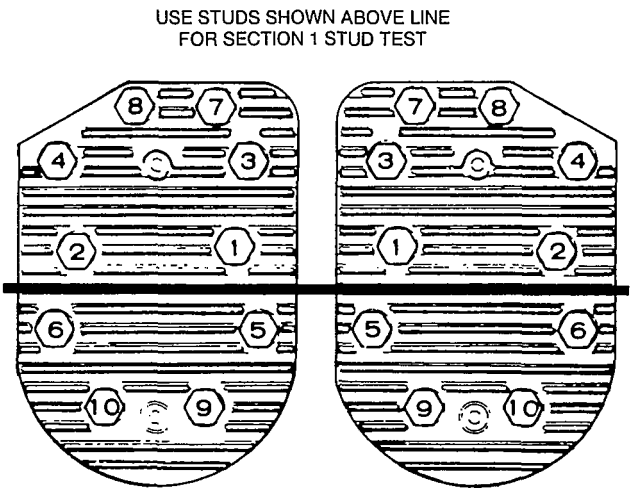
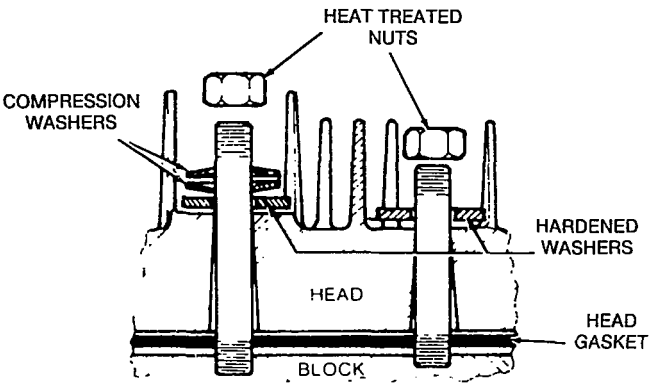


FIGURE 67. CYLINDER HEADS



6 LONG STUDS (TOP) — TORQUE TOP SIX NUTS TO 12 LB-FT. (COLD)

4 SHORT STUDS (BOTTOM) — TORQUE BOTTOM FOUR NUTS TO 15 LB-FT.

FIGURE 68. 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 69 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 70). 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 70).

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.

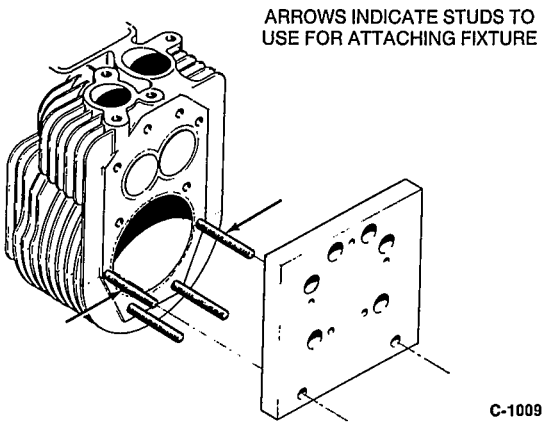


FIGURE 69. REPAIR FIXTURE

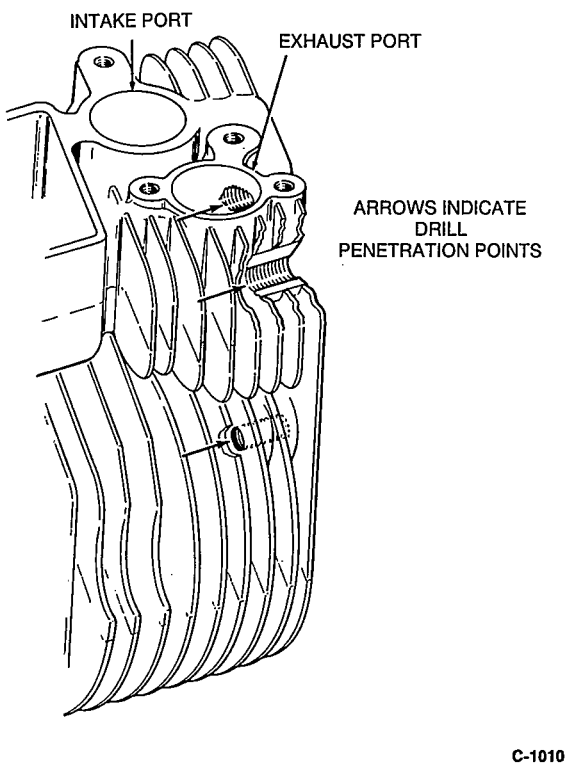


FIGURE 70. DRILLING PROCEDURE

INTAKE MANIFOLD GASKET REPLACEMENT

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 manifolds 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.

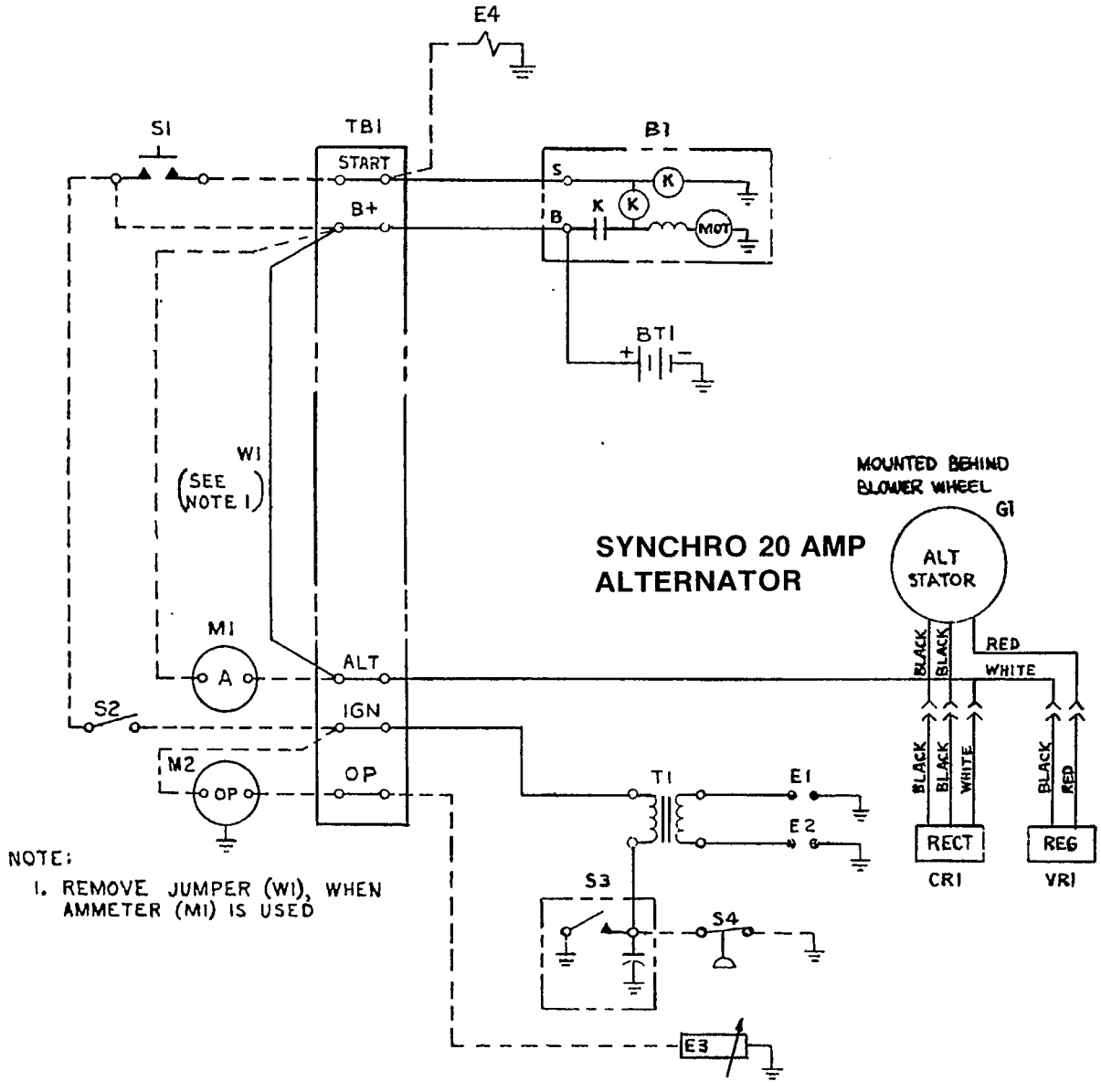
5. Reinstall the intake manifold tightening the four hold down bolts to 20 to 23 ft-lb (27-31 Nm) of torque.

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 NHP and NHPV 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:

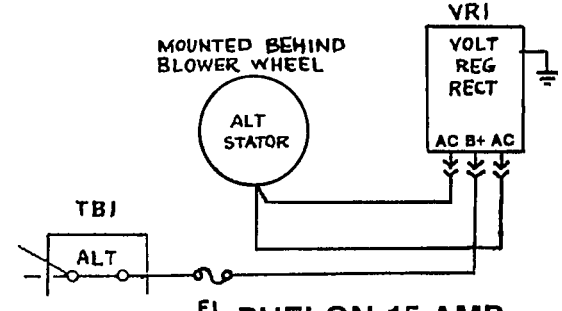


SYNCHRO 20 AMP ALTERNATOR

	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)

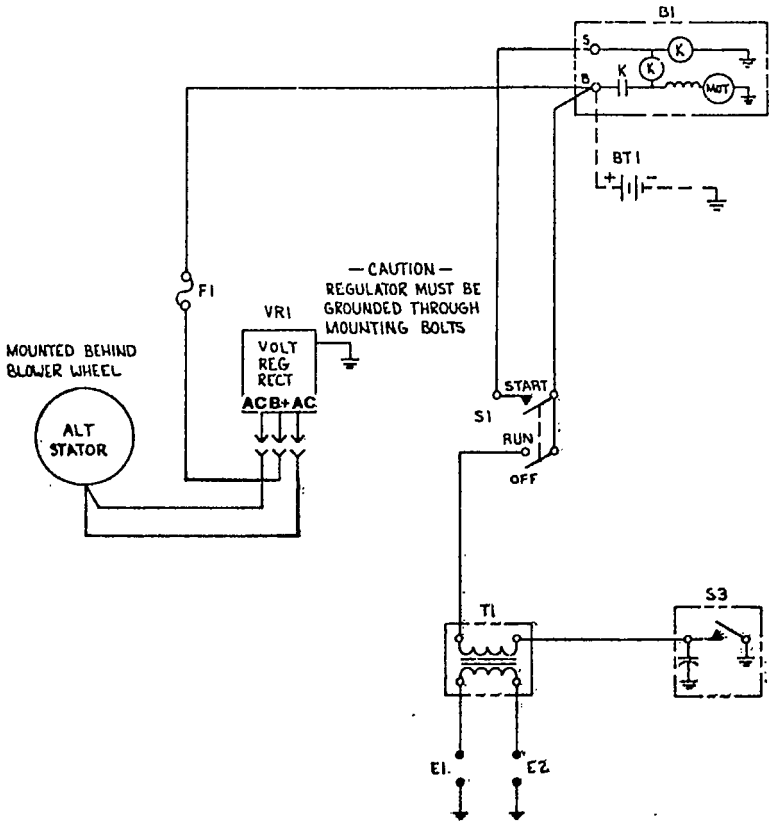
* WHEN USED

CAUTION!
REGULATOR MUST BE GROUNDED THROUGH MOUNTING BOLTS



PHELON 15 AMP ALTERNATOR

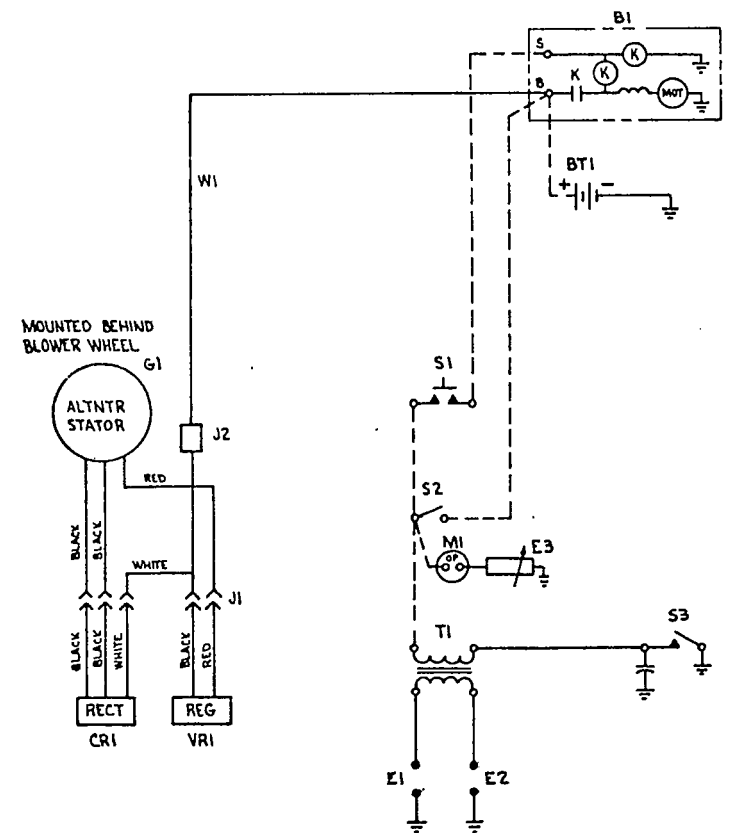
ENGINE CONTROL WIRING DIAGRAM WITH OPTIONS



WIRING DIAGRAM FOR FLYWHEEL ALTERNATOR (PHELON 15 AMP)

(622-0386)

REF DES	PART NO.	QTY	DESCRIPTION
B1		1	STARTER & SOLENOID-ENGINE
BT1		1	BATTERY, 12 V
E1 & 2		2	SPARK PLUG
F1		1	FUSE, 35 AMP
		1	HOLDER-FUSE
G1		1	ALTERNATOR-FLYWHEEL 15 AMP
J1		1	CONNECTOR
S1		1	SWITCH-START, RUN, OFF
S2		1	BREAKER & CAP ASSEMBLY
T1		1	IGNITION COIL-(ONAN)
VR1		1	REGULATOR-RECTIFIER-VOLTAGE



WIRING DIAGRAM FOR FLYWHEEL ALTERNATOR (SYNCRO 20 AMP)

(622-0382)

REF DES	PART NO	DWG SIZE	QTY	DESCRIPTION
B1			1	STARTER & SOLENOID-ENG
BT1			1	BATTERY, 12V
CR1			1	RECTIFIER ASSY
E1, E2			2	SPARK PLUG
E3	193-0108	A	1	SENDER-OIL PRESSURE
J1			1	CONNECTOR
J2			1	CONNECTOR-FASTON
M1	193-0107	B	1	METER-OIL PRESSURE
S1			1	SWITCH-START
S2			1	SWITCH-IGN
S3			1	BREAKER & CAP ASSY
T1			1	IGNITION COIL
VR1			1	REGULATOR-VOLTAGE
W1	336-1590	A	1	LEAD ASSY
G1			1	ALTERNATOR-FLYWHEEL 20 AMP

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