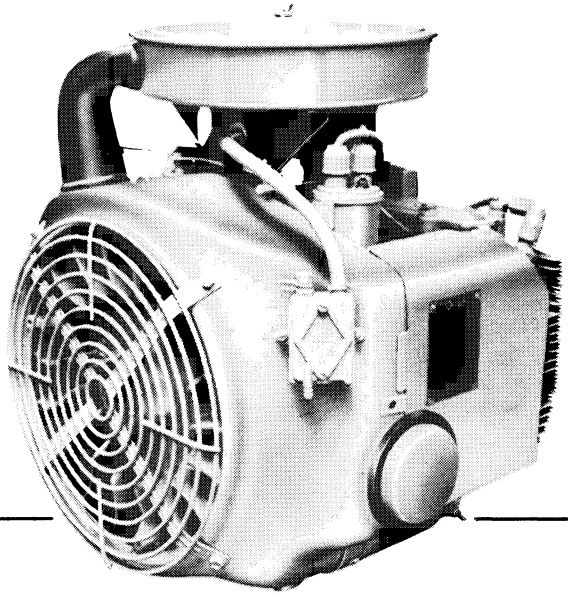
Onan

Operators and Service Manual

B48M Engine



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SPEC A
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MILLER ELECTRIC MFG. CO.

Safety Precautions

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

⚠DANGER ***This symbol if used warns of immediate hazards which will result in severe personal injury or death.***

⚠WARNING ***This symbol refers to a hazard or unsafe practice which can result in severe personal injury or death.***

⚠CAUTION ***This symbol refers to a hazard or unsafe practice which can result in personal injury or product or property damage.***

Fuels, electrical equipment, batteries, exhaust gases and moving parts present potential hazards that can 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 can cause unconsciousness and death. It is an odorless and colorless gas formed during combustion of hydrocarbon fuels. Symptoms of carbon monoxide poisoning are:

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

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

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

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.

Important Safety Precautions

Read and observe these safety precautions when using or working on electric generators, engines and related equipment. Also read and follow the literature provided with the equipment.

Proper operation and maintenance are critical to performance and safety. Electricity, fuel, exhaust, moving parts and batteries present hazards that can cause severe personal injury or death.

FUEL, ENGINE OIL, AND FUMES ARE FLAMMABLE AND TOXIC

Fire, explosion, and personal injury can result from improper practices.

- Used engine oil, and benzene and lead, found in some gasoline, have been identified by government agencies as causing cancer or reproductive toxicity. When checking, draining or adding fuel or oil, do not ingest, breathe the fumes, or contact gasoline or used oil.
- Do not fill tanks with engine running. Do not smoke around the area. Wipe up oil or fuel spills. Do not leave rags in engine compartment or on equipment. Keep this and surrounding area clean.
- Inspect fuel system before each operation and periodically while running.
- Equip fuel supply with a positive fuel shutoff.
- Do not store or transport equipment with fuel in tank.
- Keep an ABC–rated fire extinguisher available near equipment and adjacent areas for use on all types of fires except alcohol.
- Unless provided with equipment or noted otherwise in installation manual, fuel lines must be copper or steel, secured, free of leaks and separated or shielded from electrical wiring.
- Use approved, non-conductive flexible fuel hose for fuel connections. Do not use copper tubing as a flexible connection. It will work–harden and break.

EXHAUST GAS IS DEADLY

- Engine exhaust contains carbon monoxide (CO), an odorless, invisible, poisonous gas. Learn the symptoms of CO poisoning.
- Never sleep in a vessel, vehicle, or room with a genset or engine running unless the area is equipped with an operating CO detector with an audible alarm.
- Each time the engine or genset is started, or at least every day, thoroughly inspect the exhaust system. Shut down the unit and repair leaks immediately.
- Warning: Engine exhaust is known to the State of California to cause cancer, birth defects and other reproductive harm.

Make sure exhaust is properly ventilated.

- Vessel bilge must have an operating power exhaust.
- Vehicle exhaust system must extend beyond vehicle perimeter and not near windows, doors or vents.
- Do not use engine or genset cooling air to heat an area.
- Do not operate engine/genset in enclosed area without ample fresh air ventilation.
- Expel exhaust away from enclosed, sheltered, or occupied areas.
- Make sure exhaust system components are securely fastened and not warped.

MOVING PARTS CAN CAUSE SEVERE PERSONAL INJURY OR DEATH

- Do not remove any guards or covers with the equipment running.
- Keep hands, clothing, hair, and jewelry away from moving parts.
- Before performing any maintenance, disconnect battery (negative [–] cable first) to prevent accidental starting.
- Make sure fasteners and joints are secure. Tighten supports and clamps, keep guards in position over fans, drive belts, etc.
- If adjustments must be made while equipment is running, use extreme caution around hot manifolds and moving parts, etc. Wear safety glasses and protective clothing.

BATTERY GAS IS EXPLOSIVE

- Wear safety glasses and do not smoke while servicing batteries.
- Always disconnect battery negative (–) lead first and reconnect it last. Make sure you connect battery correctly. A direct short across battery terminals can cause an explosion. Do not smoke while servicing batteries. Hydrogen gas given off during charging is explosive.
- Do not disconnect or connect battery cables if fuel vapors are present. Ventilate the area thoroughly.

DO NOT OPERATE IN FLAMMABLE AND EXPLOSIVE ENVIRONMENTS

Flammable vapor can be ignited by equipment operation or cause a diesel engine to overspeed and become difficult to stop, resulting in possible fire, explosion, severe personal injury and death. **Do not operate diesel equipment where a flammable vapor environment can be created by fuel spill, leak, etc., unless equipped with an automatic safety device to block the air intake and stop the engine.**

HOT COOLANT CAN CAUSE SEVERE PERSONAL INJURY

- Hot coolant is under pressure. Do not loosen the coolant pressure cap while the engine is hot. Let the engine cool before opening the pressure cap.

ELECTRICAL SHOCK CAN CAUSE SEVERE PERSONAL INJURY OR DEATH

- Do not service control panel or engine with unit running. High voltages are present. Work that must be done while unit is running should be done only by qualified service personnel.
- Do not connect the generator set to the public utility or to any other electrical power system. Electrocution can occur at a remote site where line or equipment repairs are being made. An approved transfer switch must be used if more than one power source is connected.
- Disconnect starting battery (negative [–] cable first) before removing protective shields or touching electrical equipment. Use insulative mats placed on dry wood platforms. Do not wear jewelry, damp clothing or allow skin surface to be damp when handling electrical equipment.
- Use insulated tools. Do not tamper with interlocks.
- Follow all applicable state and local electrical codes. Have all electrical installations performed by a qualified licensed electrician. Tag open switches to avoid accidental closure.
- With transfer switches, keep cabinet closed and locked. Only authorized personnel should have cabinet or operational keys. Due to serious shock hazard from high voltages within cabinet, all service and adjustments must be performed by an electrician or authorized service representative.

If the cabinet must be opened for any reason:

1. Move genset operation switch or Stop/Auto/Handcrank switch (whichever applies) to Stop.
2. Disconnect genset batteries (negative [–] lead first).
3. Remove AC power to automatic transfer switch. If instructions require otherwise, use extreme caution due to shock hazard.

MEDIUM VOLTAGE GENERATOR SETS (601V TO 15kV)

- Medium voltage acts differently than low voltage. Special equipment and training are required to work on or around medium voltage equipment. Operation and maintenance must be done only by persons trained and qualified to work on such devices. Improper use or procedures will result in severe personal injury or death.
- Do not work on energized equipment. Unauthorized personnel must not be permitted near energized equipment. Induced voltage remains even after equipment is disconnected from the power source. Plan maintenance with authorized personnel so equipment can be de-energized and safely grounded.

GENERAL SAFETY PRECAUTIONS

- Do not work on equipment when mentally or physically fatigued or after consuming alcohol or drugs.
- Carefully follow all applicable local, state and federal codes.
- Never step on equipment (as when entering or leaving the engine compartment). It can stress and break unit components, possibly resulting in dangerous operating conditions from leaking fuel, leaking exhaust fumes, etc.
- Keep equipment and area clean. Oil, grease, dirt, or stowed gear can cause fire or damage equipment by restricting airflow.
- Equipment owners and operators are solely responsible for operating equipment safely. Contact your authorized Onan/Cummins dealer or distributor for more information.

KEEP THIS DOCUMENT NEAR EQUIPMENT FOR EASY REFERENCE.

Table of Contents

General Information

KNOW YOUR ENGINE

Read this manual carefully, observing all *WARNINGS* and *CAUTIONS*. Operating instructions, adjustments and periodic maintenance procedures are given so you . . . the owner, can keep your unit running like new and expect many years of dependable service from it. Remember . . . any machine, regardless of design or type, will perform only in relation to the service it receives. Regularly scheduled maintenance lowers operating costs.

INTRODUCTION

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

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

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

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

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

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

The wiring diagram shows how the engine electrical components are interconnected.

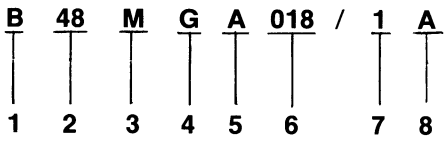
A parts catalog contains detailed exploded views of each assembly and the individual piece part numbers and their proper names for ordering replacement parts.

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

ENGINE MODEL REFERENCE

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

How to interpret MODEL and SPEC NO.



1. Factory code for general identification of basic engine series.
2. Cubic inch displacement.
3. Engine duty cycle.
4. Fuel required (G=gasoline).
5. Cooling system description (A=air-cooling-pressure).
6. BHP rating.
7. Factory code for designated optional equipment, if any.
8. Specification (spec letter) which advances with factory production modifications.

⚠WARNING

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

Specifications

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

SPECIFICATION	UNIT OF MEASURE	SERIES B48M
Number of Cylinders		2
Bore	in (mm)	3.250 (82.55)
Stroke	in (mm)	2.875 (73)
Displacement	cu in (cm^3)	47.7 (782)
Compression Ratio		6.6 to 1
Rated Speed	RPM	3000
Power at Rated Speed	BHP (kW)	16.7 (12.5)
Oil Filter		Full Flow
Oil Capacity Without Filter	Qts (litre)	3.0 (2.84)
Oil Capacity With Filter Change	Qts (litre)	3.25 (3.1)
Crankshaft Rotation (viewed from flywheel)		Clockwise
Governor		Variable Speed Mechanical
Valve Clearance		
Intake	in (mm)	.008 (.20)
Exhaust	in (mm)	.013 (.33)
Spark Plug Gap	in (mm)	.025 (.64)
Breaker Point Gap - Static (Full Separation and Engine Cold)	in (mm)	.021 (.53)
Ignition Timing	BTC	21°

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	3.2490	(82.53)	3.2500	(82.55)
Maximum Allowable				
Taper			0.005	(0.13)
Out-of-Round			0.003	(0.08)
Main Bearing Inside Diameter (Without bearing)	2.187	(55.55)	2.188	(55.58)
Main Bearing Inside Diameter (Installed)	2.0015	(50.84)	2.0040	(50.90)
Camshaft Bearing Bore (Bearing installed)	1.3760	(34.95)	1.3770	(34.98)
CRANKSHAFT				
Main Bearing Journal Diameter	1.9992	(50.78)	2.0000	(50.80)
Main Bearing Clearance	0.0025	(0.064)	0.0038	(0.097)
Connecting Rod Journal Diameter	1.6252	(41.28)	1.6260	(41.30)
Crankshaft End Play	0.006	(0.15)	0.012	(0.30)
CONNECTING ROD				
Large Bore Diameter (Rod bolts properly torqued)	1.6280	(41.35)	1.6285	(41.36)
Connecting Rod Side Clearance	0.0020	(0.051)	0.0160	(0.406)
Piston Pin Bushing Bore (Finished bore)	0.6879	(17.47)	0.6882	(17.48)
Bearing to Crankshaft Clearance				
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)		
Camshaft Lift		0.300	(7.62)	
PISTON				
Clearance in Cylinder				
Measure 90° to pin 1.187 inch below top of piston	0.0033	(0.084)	0.0053	(0.135)
Piston Pin Bore	0.6877	(17.47)	0.6881	(17.48)
Ring Groove Width				
Top 1 Compression Ring	0.080	(2.032)	0.081	(2.057)
No. 2 Compression Ring	0.080	(2.032)	0.081	(2.057)
No. 3 Oil Control Ring	0.188	(4.775)	0.189	(4.801)

DESCRIPTION	MINIMUM		MAXIMUM	
	Inches	(mm)	Inches	(mm)
PISTON PIN				
Clearance in Piston	0.0002	(0.005)	0.0004	(0.010)
Clearance in Connecting Rod				
Aluminum Rod	0.0002	(0.005)	0.0007	(0.018)
Diameter	0.6875	(17.46)	0.6877	(17.47)
PISTON RINGS				
Clearance				
Top Groove	0.003	(0.076)	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	1.4395	(36.56)	1.4405	(36.59)
Seat Outside Diameter	1.470	(37.34)	1.471	(37.36)
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)	0.040	(0.102)
Valve Face Angle		44°		
EXHAUST VALVE SEAT				
Seat Cylinder Head Bore Diameter	1.189	(30.20)	1.190	(30.23)
Seat Outside Diameter	1.192	(30.28)	1.193	(30.30)
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	0.001	(0.025)	0.006	(0.152)
Oil Pump Gear	0.002	(0.051)	0.005	(0.127)

Assembly Torques

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

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

TABLE 1.

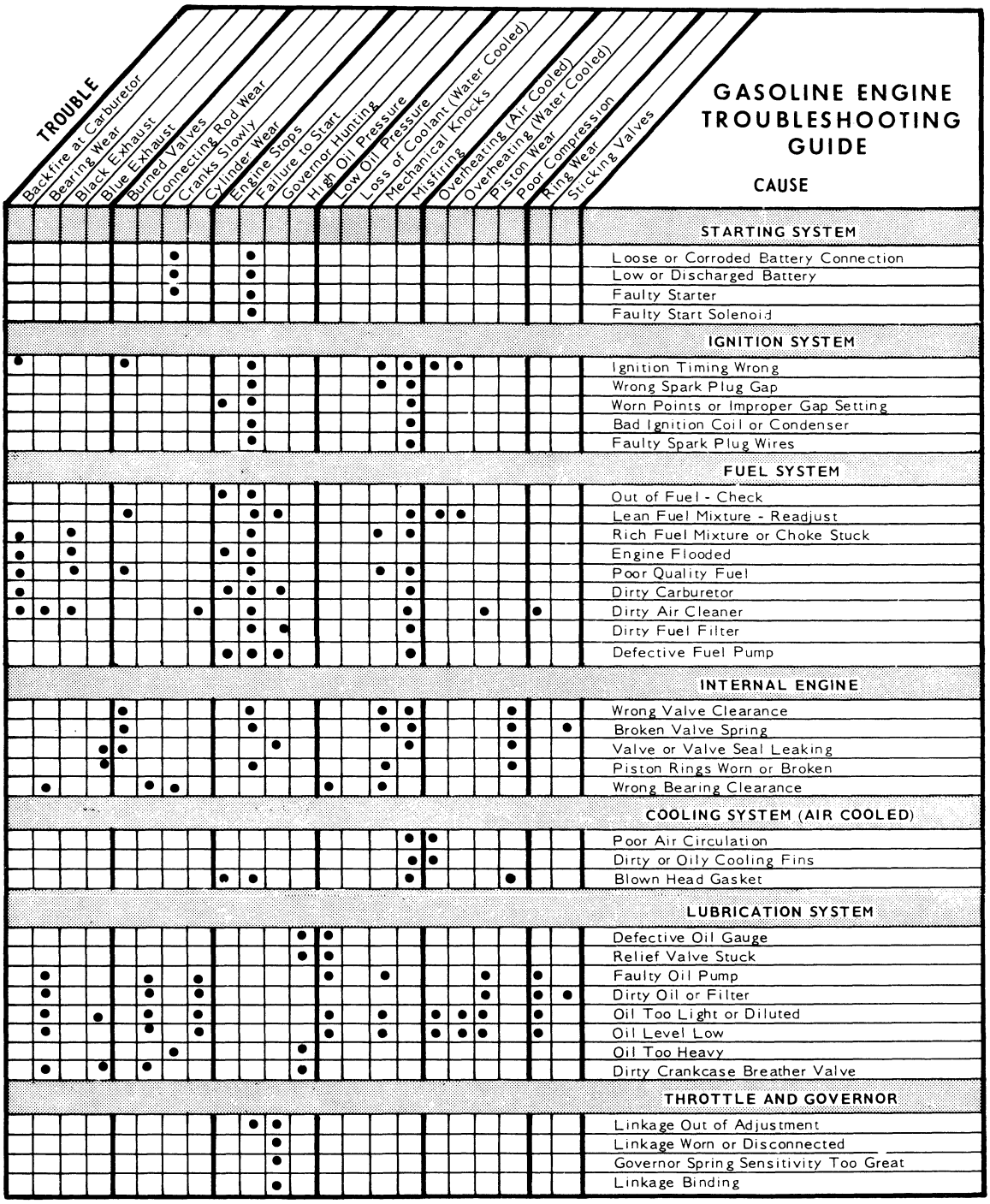
DESCRIPTION	TORQUE SPECIFICATION Ft.-Lb.	Nm	DESCRIPTION	TORQUE SPECIFICATION Ft.-Lb.	Nm
Gearcase Cover	8-10	11-14	Other 5/16" Cylinder Block Stud and Nuts	8-10	11-14
Cylinder Head Bolts (Cold)			Oil Base	18-23	24-31
Asbestos Gasket	16-18	22-24	Intake Manifold Mounting Screws	6-10	8-14
Graphoil Gasket	14-16	19-22	Oil Pump	7-9	10-12
Rear Bearing Plate Screws	25-27	34-37	Valve Cover	1-2	1-3
Starter Mounting Bolts	24-26	33-35	Exhaust Manifold Mounting Screws	6-10	8-14
Connecting Rod Bolt	12-14	16-19			
Flywheel Cap Screw	35-40	48-54			

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 Set-Up

Inspect the engine visually. Check for loose or missing parts and any damage that may have occurred in shipment.

⚠CAUTION ***Oil, fuel, and coolant have been drained from the engine prior to shipping from Onan.***

BATTERIES

The batteries and battery cables used for starting the engine should be of sufficient size to provide prompt starting. Undersized batteries will result in poor starter operation and a very short starter service life.

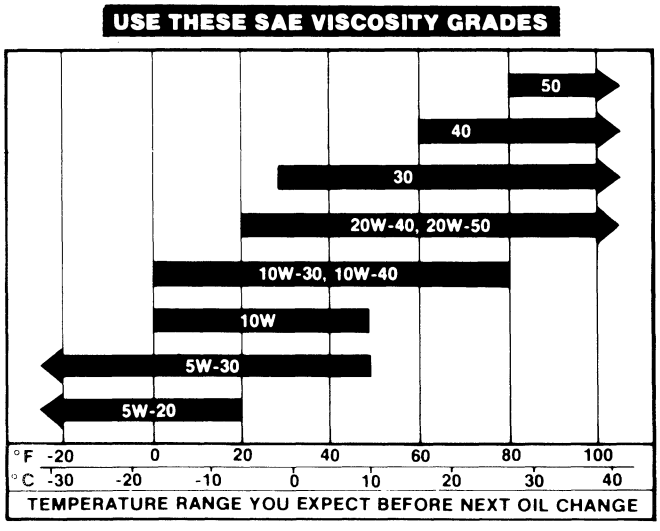
⚠WARNING ***Ignition of explosive battery gases can cause severe personal injury. Do not smoke while servicing batteries.***

CRANKCASE OIL RECOMMENDATIONS

Fill crankcase with correct amount of oil. Refer to *SPECIFICATIONS* for crankcase capacity. Use oils meeting the American Petroleum Institute (API) classification SE or SE/CC.

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

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



Oil Level

Check oil level at least every 8 hours of operation. Check more frequently on a new or reconditioned engine as oil consumption is higher until the piston rings seat properly.

When adding oil between oil changes, it is preferable to use the same brand, as various brands of oil may not be compatible together. Refer to *MAINTENANCE* section for recommended oil change intervals and procedures.

FUEL RECOMMENDATIONS

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

Use clean, fresh, unleaded gasoline. Regular leaded gasoline may also be used but is not a preferred fuel. Do not use highly leaded premium gasoline. Use of unleaded gasoline results in less maintenance.

⚠CAUTION ***Do not use gasoline de-icers. Gasoline de-icers can cause internal damage to carburetor and fuel pump parts. Do not use fuels containing alcohol concentrations greater than ten percent. Fuel containing alcohol may cause poor engine performance and internal engine damage.***

If regular leaded gasoline is used continually, carbon and lead deposits should be removed from the cylinder heads as required because of engine power loss. Unleaded gasoline may be used safely after lead deposits have been removed.

⚠WARNING ***Spilled fuel can ignite and cause serious personal injury or death. Never fill the fuel tank when the engine is running.***

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.

⚠WARNING ***Inhalation of exhaust gases can result in serious personal injury or death. Use extreme care during installation to ensure a tight exhaust system.***

Operation

STARTING

Most engines are equipped with a start-stop switch and cable controlled choke and throttle.

1. Place the throttle control in the *SLOW* position and the choke into the *FULL* choke position.
2. Turn the ignition switch on and engage starter. If engine fails to start after 30 seconds determine the cause. Wait one minute before recranking.

   If the engine fails to start at first attempt, rust inhibitor oil used at the factory may have fouled the plugs. Remove the plugs, clean in a suitable solvent, dry thoroughly and reinstall. Heavy exhaust smoke when the engine is initially started is normal and usually caused by rust inhibitor oil.
3. When the engine starts, gradually push the choke lever in until the engine runs smoothly.
4. Black smoke from the exhaust and a rough running engine usually indicate over-choking.
5. To stop the engine, turn the ignition switch to the *OFF* position.

BREAK-IN PROCEDURE

Controlled break-in is the ideal fitting of all internal moving metal parts. Using the proper oil and applying a conscientious maintenance program during this period helps assure satisfactory service from your Onan engine.

Maintain the proper cooling and lubrication during break-in. Run the engine at half load for the first three hours with intermittent periods of full load to control engine break-in.

⚠CAUTION ***Using the wrong grade and weight of oil and high engine operating temperatures during break-in can cause engine damage.***

Check the oil level at least every five operating hours. Add oil to keep it at the proper level, but never overfill as overfilling may cause the oil to foam and enter the breather system.

HOT WEATHER OPERATION

When operating the engine in temperatures above 100°F (38°C), pay particular attention to the following items to prevent damage:

1. Keep the engine cooling fins clean and free of obstruction.

   ⚠CAUTION ***Plugged or clogged cooling fins can cause overheating and engine damage.***

⚠WARNING ***Contact with rotating machinery can cause serious personal injury or death. Stay clear of rotating components and ensure that protective shields and guards are in place and secured before operating machinery.***

2. See that nothing obstructs air flow to and from the engine.
3. Ensure that you are using the proper grade and weight of oil for ambient temperatures. Check the oil level each time you fill the fuel tank.
4. Check the battery water more frequently than every 50 hours which is recommended under normal conditions. High temperatures cause faster evaporation.
5. Change crankcase oil and filter more frequently than recommended under normal conditions.

COLD WEATHER OPERATION

When the engine is being used in temperatures below 32°F (0°C), check the following items closely:

1. Use the correct grade and weight of oil for the temperature conditions. Change the oil only when the engine is warm. If an unexpected temperature drop occurs when the engine is filled with summer oil, before starting the engine, move it to a warm location until the oil will flow freely.
2. Use fresh fuel. Fill the fuel tank after each day's use to protect against moisture condensation.
3. Keep the battery in a well-charged condition.

DUST AND DIRT

1. Keep unit clean. Keep cooling system clean.
2. Service air cleaner as frequently as required.
3. Change crankcase oil and filter more often than recommended under normal conditions.

OUT-OF-SERVICE PROTECTION

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

1. Run the engine until it reaches normal operating temperature.
2. Turn off the fuel supply and run the engine until it stops.
3. Drain oil from oil base while the engine is still warm. Refill with fresh crankcase oil and attach a tag stating viscosity used.

4. Remove spark plugs. Pour 1 ounce (2 tablespoons or 28 grams) of rust inhibitor or SAE #50 oil into the cylinders. Crank the engine over a few times. Reinstall spark plugs.
5. Service air cleaner as outlined in *MAINTENANCE* section.
6. Clean governor linkage and protect by wrapping with a clean cloth.
7. Plug exhaust outlet to prevent entrance of moisture, dirt, bugs, etc.
8. Wipe entire unit. Coat rustable parts with a light film of grease or oil.
9. Provide a suitable cover for the entire unit.
10. If battery equipped, disconnect and follow standard battery storage procedure.

RETURNING UNIT TO SERVICE

1. Remove cover and all protective wrapping. Remove plug from exhaust outlet.
2. Check tag on oil base and verify that oil viscosity is still correct for existing ambient temperatures.
3. Clean and check battery. Measure specific gravity (1.260 at 77°F [25°C]) and verify level to be at split ring. If specific gravity is low, charge until correct value is obtained. If the level is low, add distilled water and charge until specific gravity is correct. *DO NOT OVERCHARGE.*
4. Check that fuel filter and fuel lines are secure, with no leaks.
5. Check carburetor, adjust if necessary.
6. Connect battery.
7. Start Engine.

After engine has started, excessive blue smoke is exhausted until the rust inhibitor has burned away.

⚠WARNING

EXHAUST GAS IS DEADLY!

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

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

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

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

Maintenance

⚠WARNING ***Accidental starting of the engine can cause severe personal injury or death. Disconnect the battery cable when repairs are made to the engine, controls panel, or associated equipment.***

DAILY CHECKS OR EVERY 8 HOURS

The operator should daily make a complete visual and audible inspection of the engine. Check the following before starting the engine for the first time each day:

1. Check all fuel lines and fittings for possible leakage.
2. Inspect exhaust system for possible leakage and cracks. Locate leaks in muffler and piping while the engine is operating. Repair all leaks immediately after they are detected for personnel safety.
3. Inspect air cleaner system for leaks. Make certain that all clamps and fittings are tight and free of potential leaks.
4. Check crankcase oil level with the engine off. If oil level is at or below "add" mark on dipstick (Figure 1), add sufficient oil of the proper viscosity as specified in the *ENGINE SET-UP* section to bring oil level to the full mark on the dipstick. Do not operate engine with oil level below the "add" mark.

Allow a minimum of 10 minutes for the oil to drain down before checking. The best time to check the oil is after an overnight shut-down period.

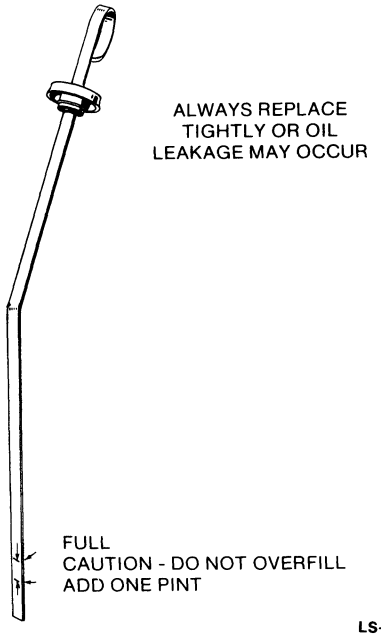


FIGURE 1. CRANKCASE OIL FILL

OIL CHANGE

Change crankcase oil after the first 25 hours of operation and every 100 hours thereafter. If operating in extremely dusty, high ambient, or low ambient conditions change oil more often.

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

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

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

OIL FILTER CHANGE

Replace oil filter (Figure 2) after the first 25 hours of operation, and every 100 hours thereafter. If operating in extremely dusty, high ambient, or low ambient conditions change oil filter more often.

Spin off oil filter element and discard it. Thoroughly clean filter mounting surface and install new element, making sure new gasket is inserted in the element. Apply a thin film of oil to the gasket. Spin element down by hand until gasket just touches mounting pad and then turn down an additional 1/4-1/2 turn. Do not overtighten.

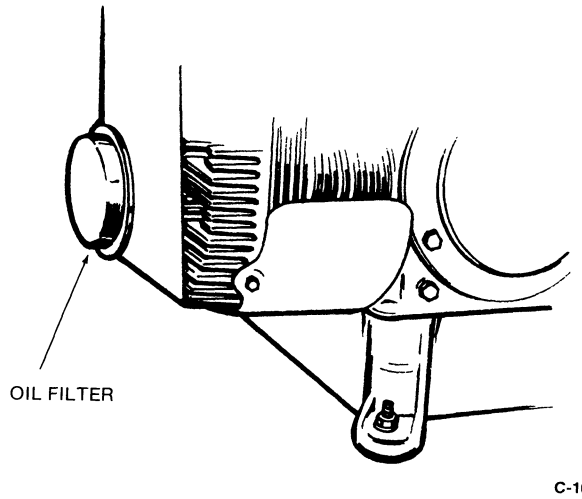


FIGURE 2. OIL FILTER

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

IGNITION

Spark Plugs

Check, and regap spark plugs every 100 hours of operation (Figure 3). Replace spark plugs that show signs of fouling or electrode erosion.

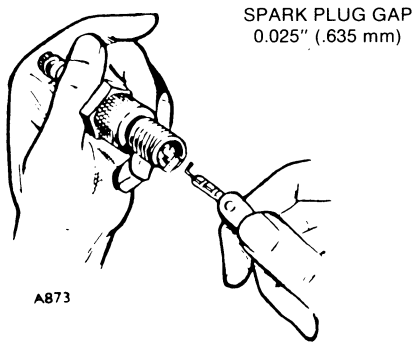


FIGURE 3. SPARK PLUG GAP

Breaker Points

Check breaker points every 100 hours. Replace points and condenser every 200 operating hours. Replace sooner if points are pitted or burned. See *ADJUSTMENTS* section.

COOLING SYSTEM

Check and clean cooling fins and chaff screen at least every 50 hours. Remove any dust, dirt or oil which may have accumulated.

BATTERIES

Disconnect negative ground strap from the battery before working on any part of the electrical system or engine.

Disconnect positive terminals before charging batteries to avoid damaging alternator or regulator.

⚠WARNING ***Ignition of explosive battery gases can cause severe personal injury. Do not smoke while servicing batteries.***

Cleaning Batteries

Keep the batteries clean by wiping them with a damp cloth whenever dirt appears excessive.

If corrosion is present around the terminal connections, remove battery cables and wash the terminals with an ammonia solution or a solution consisting of 1/4 pound of baking soda added to 1 quart of water.

Be sure the vent plugs are tight to prevent cleaning solution from entering the cells.

After cleaning, flush the outside of the battery, the battery compartment, and surrounding areas with clear water.

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

Checking Specific Gravity

Use a battery hydrometer to check the specific gravity of the electrolyte in each battery cell.

Hold the hydrometer vertical and take the reading. Correct the reading by adding four gravity points (0.004) for every five degrees the electrolyte temperature is above 80° F (27°C) or subtracting four gravity points for every five degrees below 80°F (27°C). A fully charged battery will have a corrected specific gravity of 1.260. Charge the battery if the reading is below 1.215.

Checking Electrolyte Level

Check the level of the electrolyte (acid and water solution) in the batteries at least every 50 hours of operation.

Fill the battery cells to the bottom of the filler neck. If cells are low on water, add distilled water and recharge. If one cell is low, check case for leaks. Keep the battery case clean and dry. An accumulation of moisture will lead to a more rapid discharge and battery failure.

⚠CAUTION ***Do not add water in freezing weather unless the engine is to be run long enough (two or three hours) to assure a thorough mixing of water and electrolyte.***

Storing Batteries

If the engine is to be stored for more than 30 days, remove the batteries. With the electrolyte level at the bottom of the split ring, charge the battery before storing it. After every 30 days the battery is in storage, bring it back up to full charge. To reduce self-discharge, store the battery in as cool a place as possible so long as the electrolyte does not freeze.

CRANKCASE BREATHER

If the crankcase becomes pressurized as evidenced by oil leaks at the seals, use the following procedures to service.

Remove the breather tube from the valve cover (see Figure 4). Remove the valve cover, pack, spring, washer, reed valve, and breather baffle. Clean all parts in parts cleaning solvent.

⚠WARNING ***Most parts cleaning solvents are flammable and could cause serious personal injury if used improperly. Follow the manufacturers recommendations when cleaning parts.***

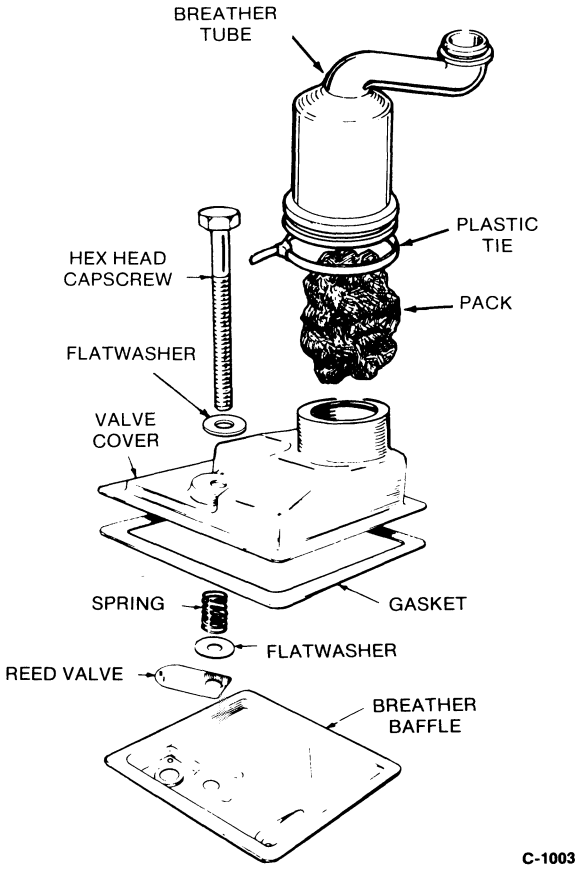


FIGURE 4. CRANKCASE BREATHER

The reed valve must be flat with no sign of a crease. Assemble using a new gasket. Do not overtighten valve cover capscrew.

Reed valve must be assembled as shown with washer on top and breather baffle on the bottom.

⚠CAUTION ***Over tightening the valve cover might cause an air leak and allow dirt to enter the engine. Be careful not to distort the valve cover when tightening.***

AIR CLEANER

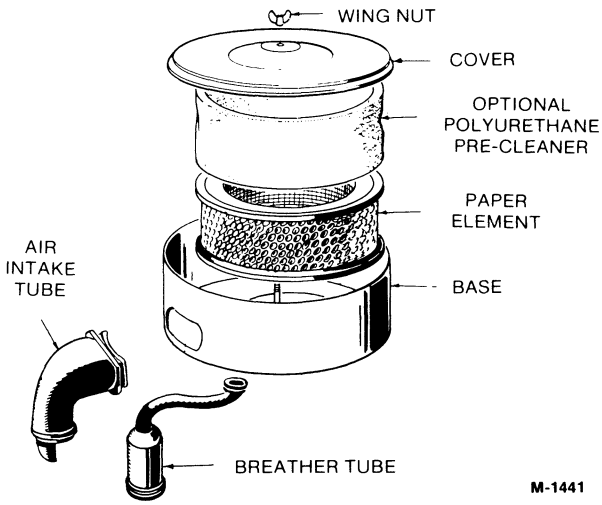
Cartridge Air Cleaner

Check and clean air cleaner element every 25 hours (Figure 5). Clean by gently tapping element on a flat surface. Replace the element every 200 hours. Clean or replace more frequently in dusty operating conditions.

Air Cleaner Wrapper (Pre-Cleaner [if used])

Wash in water and detergent and squeeze dry like a sponge (Figure 5). Allow to dry, then coat evenly with two tablespoons (28 grams) of SAE 30 engine oil. Knead into and wring excess oil from pre-cleaner. Reinstall over cartridge.

Failure to adequately wring out excess oil from the wrapper may cause drop in engine horsepower due to an increased restriction of inlet air.



1. WASH
2. SQUEEZE DRY
3. COAT WITH OIL
4. INSTALL OVER PAPER ELEMENT

FIGURE 5. AIR CLEANER ASSEMBLY

EXHAUST SYSTEM

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

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

PERIODIC MAINTENANCE SCHEDULE

Follow a regular schedule of inspection and servicing, based on operating hours (see *Periodic Maintenance Schedule*). Keep an accurate logbook of maintenance, servicing, and operating time. Use the factory recommended Periodic Maintenance Schedule (based on favorable operating conditions) to serve as a guide to get long and efficient engine life. Regular service periods are recommended for normal service and operating conditions. For continuous duty, extreme temperature, etc., service more frequently. For infrequent use, light duty, etc., service periods can be lengthened accordingly. Neglecting routine maintenance can result in engine failure or permanent damage.

For any abnormalities in operation, unusual noises from the engine or accessories, loss of power, overheating, etc., contact your nearest Onan Service Center.

PERIODIC MAINTENANCE SCHEDULE

SERVICE THESE ITEMS	AFTER EACH CYCLE OF INDICATED HOURS				
	8	25	50	100	200
Inspect Engine Generally	X[1]				
Check Oil Level	X				
Service Air Cleaner		X[2]			
Change Crankcase Oil		X[3]		X[2]	
Check Battery Electrolyte Level			X		
Clean Cooling Fins			X[2]		
Replace Oil Filter		X[3]		X[2]	
Check or Replace Spark Plugs				X	
Check Breaker Points				X	
Replace Points and Condenser					X
Clean Breather Valve					X[2]
Replace Air Cleaner Element					X[2]
Check Valve Clearance			X[3]		X[4]
Compression Check					X[4]
Clean Carbon and Lead Deposits (Cylinder Head)					X[4,5]

X[1] - Check for fuel leaks. With engine running, visually and audibly check exhaust system for leaks.
X[2] - Perform more often when running under severe operating conditions.
X[3] - Initial break-in check only.
X[4] - For detailed maintenance, contact an Onan Service Center or refer to the SERVICE MANUAL.
X[5] - For engines running on unleaded fuel this interval may be extended to 400 hours.

⚠WARNING ***Inhalation of exhaust gases can result in serious personal injury or death. Do NOT use the air cleaner or exhaust elbow as a supporting step. Damage to these and connecting parts can cause an exhaust leak.***

Oil System

PRESSURE LUBRICATION

Pressure lubricated engines use an oil pump to lubricate engine parts. The oil pump takes the oil from the sump and forces it through the filter to the front and rear main bearings and to the front camshaft bearing. The rear camshaft bearing receives its lubrication through vapor. The breaker point plunger cannot be pressure lubricated as oil could be forced up the tube to the breaker points causing engine ignition failure. If oil pressure is low, the pump should be checked.

OIL PUMP

To remove the oil pump, it is necessary to detach the intake cup assembly, as illustrated in Figure 6.

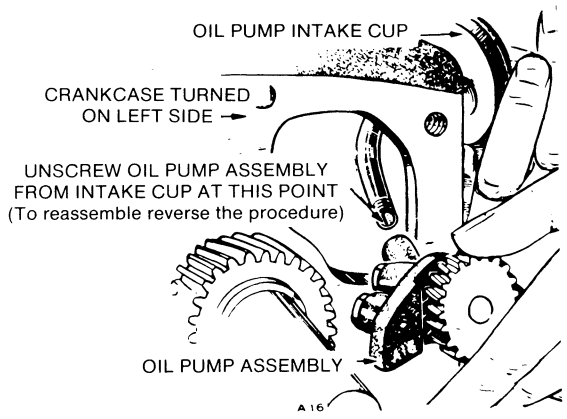


FIGURE 6. OIL PUMP ASSEMBLY

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

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

OIL BY-PASS VALVE

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

The valve is non-adjustable and normally does not need maintenance. To determine if valve is not working correctly (caused by a sticky plunger) inspect as follows:

1. Remove the 3/8-24 x 7/8" capscrew located behind gear cover and under governor arm.
2. Remove spring and plunger with a magnet tool. Clean plunger and spring with a suitable solvent and reinstall.

Fuel System

GOVERNOR OPERATION

The B48M welder engines use a mechanical governor with a two-speed control. The solenoid and its linkage is supplied and installed by Miller Electric.

Low speed is set at 1860 rpm, 60 Hz (1650 rpm, 50 Hz) with no load for generating power (weld solenoid de-energized). High speed is set at 3000 rpm for welding with weld solenoid energized. Refer to Welding Generator Owners Manual for detailed adjustment procedure.

A reliable instrument for checking engine speed is required for accurate governor adjustment. Engine speed can be checked with a tachometer.

Check the governor arm, linkage, throttle shaft, and lever for a binding condition or excessive slack and wear at connecting points. A binding condition at any point will cause the governor to act slowly and regulation will be poor.

The engine starts at wide open throttle. As the engine comes up to speed the governor takes over control to maintain the no load idle speed.

Governor Linkage Adjustments

The tension of the governor spring controls engine speed. The governor spring is factory set in the hole of the governor arm nearest the pivot point or shaft. To decrease sensitivity move spring to hole farthest from pivot.

When an AC power load is applied, the throttle opens proportionally under governor control to provide more engine power.

When the weld (high) speed solenoid is energized for welding, the tension of the spring controls the speed at about 3000 rpm. Sensitivity control is determined by the position of the solenoid spring in the governor arm hole. The throttle opening will vary depending on the load current demands of the welding operation.

The governor linkage rod connects the governor arm (Figure 7) to the throttle shaft lever so they function properly when the engine starts and runs. The linkage rod is adjusted with the engine stopped and the throttle plate at wide open position. The engine will also crank and start in this condition. Adjust the linkage rod as follows:

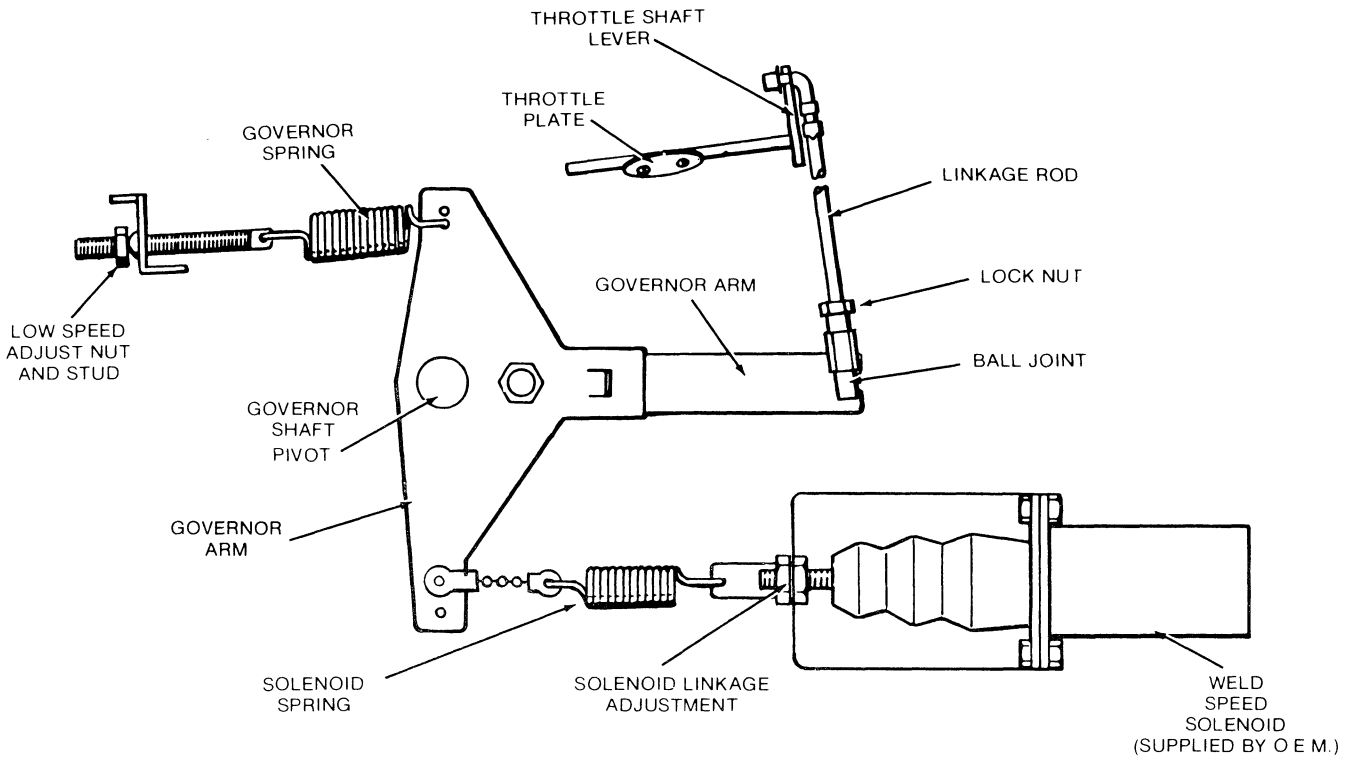


FIGURE 7. TWO SPEED GOVERNOR MECHANISM

1. Loosen lock nut on linkage rod and disconnect linkage at ball joint with engine stopped, Figure 8.
2. Place speed control in the weld position.
3. Move governor arm toward carburetor as far as it will go, then hold it there.
4. Move linkage rod in the same direction as far as it will go and hold it there.
5. With governor arm and linkage rod held in position, rotate ball joint so that socket centerline is one turn short of the ball centerline.
6. Move ball joint over the ball and snap in place.
7. Tighten lock nut against ball joint.
8. The throttle plate should now almost touch the throttle stop.

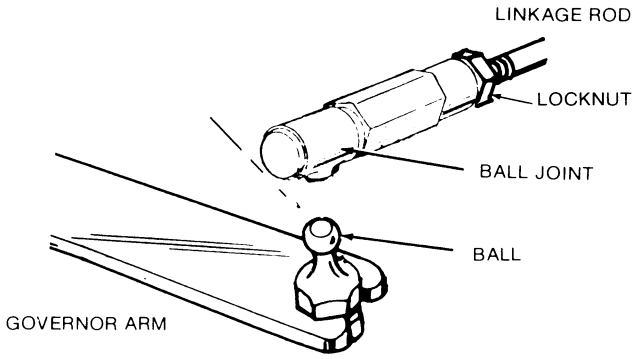


FIGURE 8. BALL JOINT

CARBURETOR ADJUSTMENT

The carburetor adjustments were set for maximum efficiency at the factory and should normally not be disturbed. If adjustments seem necessary, first be sure the ignition system is working properly and is not the source of the problem.

Carburetor Adjustments for AC Power Speed

If adjustment is needed, refer to Figures 7 and 9 and proceed as follows:

1. Turn idle mixture screw in until lightly seated, then back idle mixture screw out 7/8 turn. On engines equipped with optional main fuel adjustment, turn main mixture srew in until lightly seated then back the main mixture screw out 1-1/4 turns to 1-1/2 turns.

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

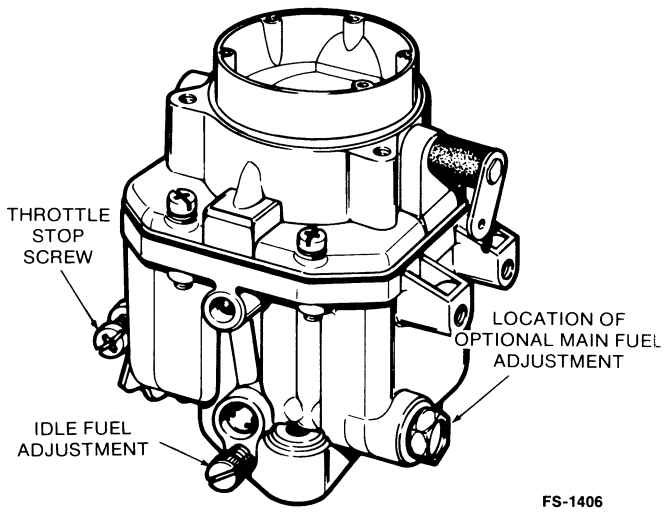


FIGURE 9. CARBURETOR ADJUSTMENTS

2. Position POWER/WELD switch to POWER.
3. Start the engine and allow it to warm up thoroughly (at least 10 minutes).
4. With engine running and no generator load, pull governor arm toward front of engine so the throttle stop screw is against its stop. Continue to hold the governor arm in this position while completing the adjustments described in Steps 5 through 7.
5. Adjust throttle stop screw for about 1800 rpm.
6. Turn the idle adjustment screw in until engine speed drops and then out until engine speed drops again. Over a narrow range between these two settings, engine speed will be at its maximum. Set the idle adjustment screw about 1/8 turn outward from the midpoint of this range (Figure 9).
7. Re-adjust the throttle stop screw to obtain 1700 rpm on 60 Hz models and 1500 rpm on 50 Hz models.
8. Release governor arm.
9. Adjust low speed nut (Figure 7) on governor spring for a stable no load engine speed of 1860 rpm on 60 Hz models and 1650 rpm on 50 Hz models.

   Increasing spring tension increases speed, decreasing spring tension reduces speed.

Weld (High) Speed Adjustment (Optional)

Lower atmospheric pressures (thinner air) at higher altitudes (about 5000 feet) demand leaner fuel-air mixtures for best performance. Adjustment is accomplished by replacing the screw plug and fixed main jet with a Variable Speed Jet Kit. After installing the Variable Speed Jet Kit adjust the main fuel adjustment as follows:

1. Allow engine to run at least 10 minutes to warm up.
2. Set weld current for maximum output.
3. Position POWER/WELD switch to WELD.
4. Position AUTOMATIC IDLE switch to OFF.
5. Adjust main fuel adjustment needle for best weld current output with welder operating at continuous load.
6. Adjust governor-solenoid linkage to make a full stroke with engine running at 3000 rpm.

Re-adjustment may be necessary to improve performance each time the welder is moved to a different altitude. If the welder is moved to an altitude below 5000 feet, replace the altitude compensation needle with the original screw plug for best performance. Readjust idle needle too.

⚠CAUTION ***Consult Miller Electric Mfg. Company Service Department for approved methods of loading welder.***

GOVERNOR SENSITIVITY ADJUSTMENT

To set governor sensitivity for the best speed drop between no load and full load, proceed as follows:

1. Make sure governor linkage and speed adjustments are correct and governor spring is in hole nearest to governor shaft pivot. See Figure 7.
2. Check engine speed with no load.
3. Check engine speed with full load.
4. Position governor spring in hole in governor arm that provides the least speed and voltage drop between no load and full power load operation and gives the best no load stability.
5. Re-check speed adjustment after sensitivity adjustment is made because an increase in sensitivity may cause a slight increase in speed.

Weld Solenoid Linkage Adjustment

To adjust the solenoid for a stable 3000 rpm weld speed, proceed as follows:

1. Make sure governor linkage, sensitivity and speed are correctly set and engine is warmed up. Place solenoid spring in hole nearest governor shaft pivot.
2. Set welder for maximum output.
3. Position POWER/WELD switch to WELD.
4. Position AUTOMATIC IDLE switch to OFF.
5. Adjust solenoid linkage (Figure 7) so that a full stroke of the energized solenoid operates the engine at 3000 rpm.
6. Connect solenoid spring in hole in governor arm that provides the least speed drop between no load and full weld load operation and best stability.

⚠CAUTION ***If the high speed solenoid is not properly adjusted, it is possible to burn out the solenoid.***

CARBURETOR OVERHAUL

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

In general, overhauling a carburetor consists of complete disassembly, a thorough cleaning, and replacement of worn parts. Carburetor repair parts are available.

General instructions for overhauling a carburetor are given below. Carefully note the position of all parts while removing to assure correct placement when reassembling. Read through all the instructions before beginning for a better understanding of the procedures involved. Carburetor components are shown in Figure 10.

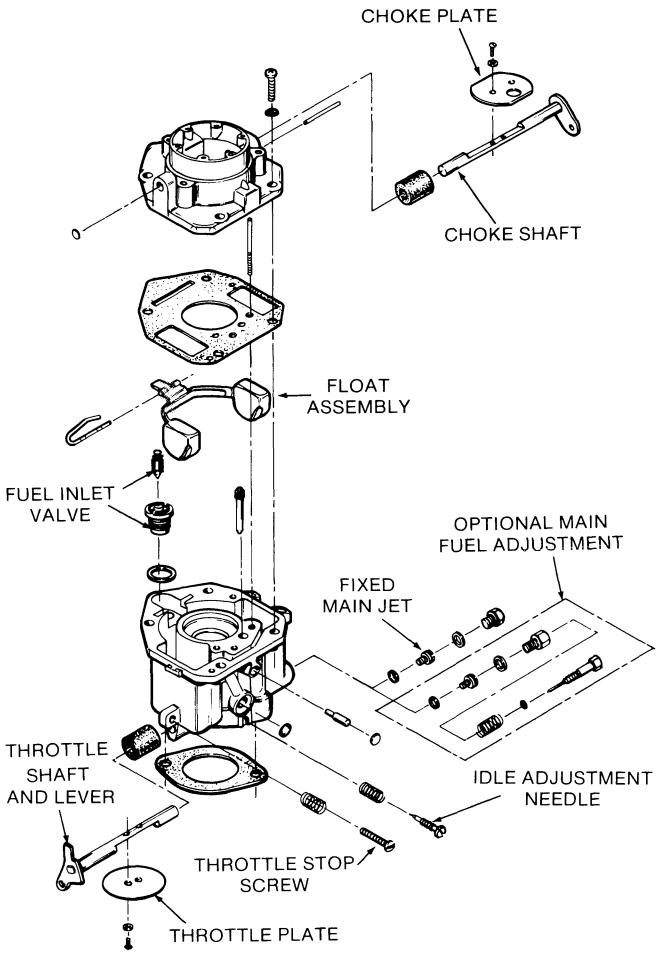


FIGURE 10. CARBURETOR ASSEMBLY

Removal and Disassembly

1. Disconnect all lines, linkages, wires and attaching nuts and bolts, then remove the carburetor and intake manifold from the engine.
2. Remove throttle and choke plate retaining screws, then plates. Pull out throttle and choke shafts.
3. Remove main jet and idle adjustment needle.

4. Remove attaching screws and separate upper and lower carburetor sections.
5. Carefully note position of float assembly parts, then pull out retaining pin and float assembly.
6. Remove needle and unscrew needle valve seat.

Cleaning and Repair

1. Soak all metal components not replaced in carburetor cleaner. Do not soak non-metal floats or other non-metal parts. Follow the cleaning manufacturer's recommendations.
2. Clean all carbon from the carburetor bore, especially where the throttle and choke plates seat. Be careful not to plug the idle or main fuel ports.
3. Dry out all passages with low pressure air (35 PSI). Avoid using wire or other objects for cleaning that may increase the size of critical passages.
4. Check the condition of adjustment needle replace if damaged (Figure 11). Replace float if loaded with fuel or damaged.
5. Check the choke and throttle shafts for excessive play in their bore and replace if necessary.
6. Replace old components with new parts.

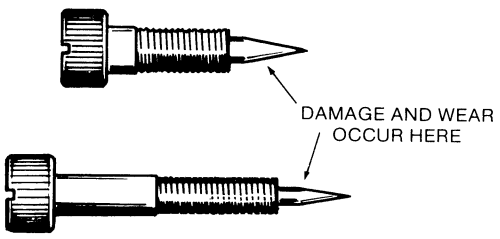


FIGURE 11. MIXTURE NEEDLE INSPECTION

Reassembly and Installation

1. Install needle valve and seat, main jet and float assembly. Make sure that float pivot pin is properly placed and that the float moves freely without binding.
2. Turn the carburetor and check the float setting (see Figure 12). The float should have a specific clearance from the machined mating surface (without gasket). Bend the float tab as required.
3. Position gasket on lower carburetor section and install upper carburetor section.
4. Slide in throttle shaft and install plate using new screws. Before tightening the screws, the plate must be centered in the bore. To do so, back off the throttle stop screw as necessary and completely close the throttle lever. Seat the plate by tapping with a small screwdriver, then tighten screws. Install the choke shaft and plate in the same manner.

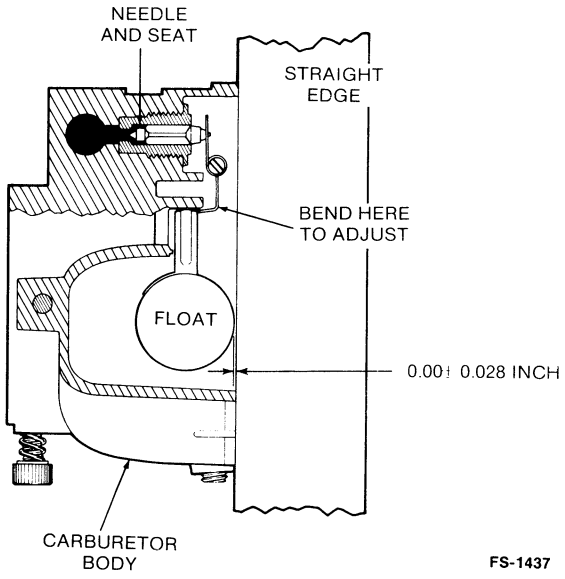


FIGURE 12. FLOAT LEVEL ADJUSTMENT

5. Install idle adjustment screw, throttle stop screw, and fixed main jet plug or optional main fuel adjustment needle.
6. Mount carburetor on intake manifold and install assembly on engine.
7. Mount air cleaner assembly. Connect air intake hose, breather hose, fuel line, vacuum line, and throttle linkage.
8. Adjust carburetor and governor according to directions given earlier in this section.

PULSATING-DIAPHRAGM FUEL PUMP

Pulsating diaphragm fuel pumps, or pulse pumps, rely on changes in crankcase vacuum to create a pulsating movement of the pump diaphragm. As the engine's pistons move outward, a vacuum is created. This vacuum is transmitted to the pump diaphragm, causing it to pull back and suck fuel into the pump. As the engine's pistons move inward, crankcase vacuum is reduced and the diaphragm return spring pushes the pump diaphragm forward, forcing fuel through the pump outlet.

Fuel Pump Repair

1. Remove the vacuum and fuel lines. Inspect the lines for wear, cracking or brittleness. Replace as necessary.
2. To insure correct alignment when reassembling, scribe a line across the outer pump parts on each end of the pump.

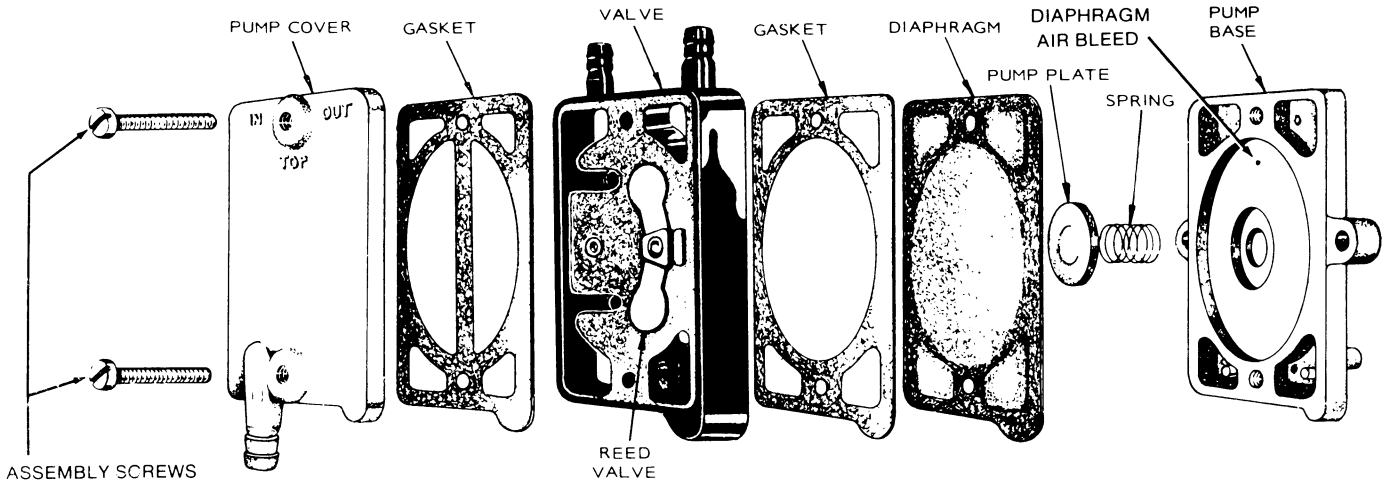


FIGURE 13. EXPLODED VIEW OF FUEL PUMP

3. Holding the pump carefully, remove the assembly screws (Figure 13).
4. Carefully pull apart the pump sections and check for worn or damaged parts. Replace with new parts where necessary or install pump repair kit.
5. Check and unclog if necessary the small diaphragm air bleed hole located behind the pump diaphragm in the pump base.

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

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

⚠WARNING ***Fuel leakage is a fire and explosion hazard that can cause severe personal injury or death. Use care when reassembling fuel pump. All parts must align perfectly or pump will leak fuel.***

Ignition and Battery Charging

IGNITION TIMING

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

BREAKER POINTS

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

Replacement and Adjustment

1. Remove spark plugs.
2. Remove breaker box cover. Rotate crankshaft clockwise (facing flywheel) until points are fully open.
3. Remove condenser (screw A) and detach condenser lead and coil lead screw (screw B). See Figure 14.
4. Remove two Allen screws (C) and lift breaker assembly from engine.
5. Replace condenser and point assembly with new parts and reinstall using above procedure in reverse order of removal.
6. Adjust point gap by rotating crankshaft clockwise (facing flywheel) by hand until the points are fully open. Set the point gap (using flat feeler gauge) by adjusting the Allen screw (D) inward or outward (Figure 11). A .021 point gap is equivalent to 21° BTC.

   Make sure feeler gauge is clean and free of any grease, oil or dirt.
7. Replace breaker box cover, coil wire, spark plugs, and spark plug cables.

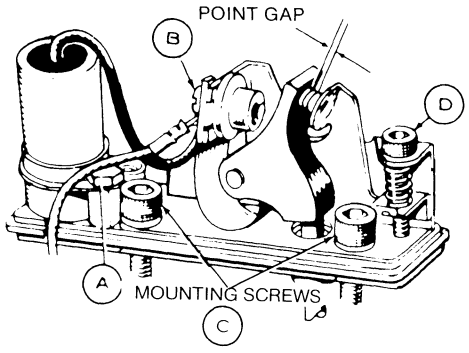


FIGURE 14. SETTING POINT GAP

Continuity Test

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

1. Adjust breaker points.
2. Remove blower housing to expose timing marks on top of gearcase cover and flywheel (Figure 15).

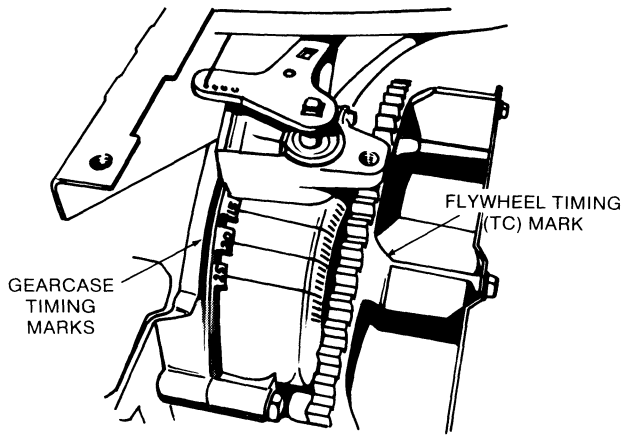


FIGURE 15. TIMING MARKS

3. Rotate flywheel clockwise until timing mark is aligned with the proper number of timing degrees (Figure 15) stamped on the top of gearcase cover. Refer to *SPECIFICATIONS* for proper number of timing degrees.
4. Connect an ohmmeter or a continuity test lamp set across the ignition breaker points. Touch one test prod to the coil lead terminal (screw B Figure 14).
5. Touch the other test prod to a good ground on the engine.
6. Turn crankshaft against rotation (counterclockwise) until the points close. Then slowly turn the crankshaft with rotation (clockwise).
7. The lamp should go out or continuity lost just as the points break which is where ignition occurs. If timing is early (advanced) the point gap is too large. If timing is late (retarded) the point gap is too small. Adjust point gap accordingly.

IGNITION COIL

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

1. Use a Simpson 260 VOM or equivalent.
2. Place black lead on ground (-) terminal of coil and red lead to positive (+) terminal. Primary resistance should read 3.87 - 4.73 ohms.
3. Change resistance setting on ohmmeter. Place ohmmeter leads inside of spark plug cable holes (Figure 16). Secondary resistance should read 12,600 - 15,400 ohms.
4. If any of the above conditions are not met, replace coil. Refer to *PARTS CATALOG* for correct part number.

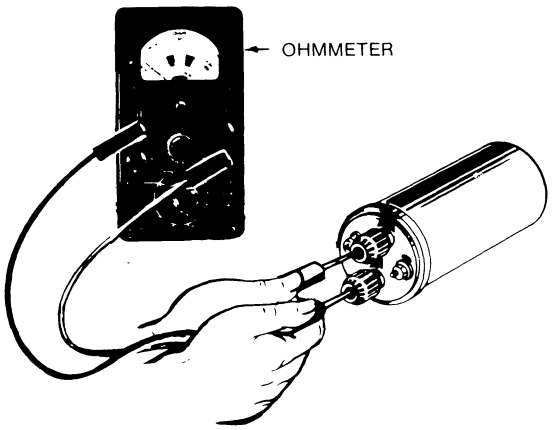


FIGURE 16. COIL TEST

BATTERY JUMP STARTING

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

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

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

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

⚠WARNING ***Never jump start a frozen battery. To do so can cause the battery to explode. Never expose the battery to an open flame or an electrical spark because a battery creates highly explosive hydrogen gas.***

5. Jump starting in any other manner may result in damage to the battery or the electrical system.
6. Start engine. Refer to *OPERATION* for starting procedure.

FLYWHEEL ALTERNATOR

This unit is equipped with a permanent magnet flywheel alternator and solid-state voltage regulator-rectifier (output control). See Figure 17. As with all solid-state electrical units, precautions are necessary when servicing. Observe the following:

⚠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.***

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

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

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

Charging system tests require a full charged battery.

With the engine running observe the battery charge condition. If no charging is evident, proceed with the *No Charge Test*. If ammeter shows a constant higher charge rate, follow the *HIGH CHARGE RATE TEST* procedure.

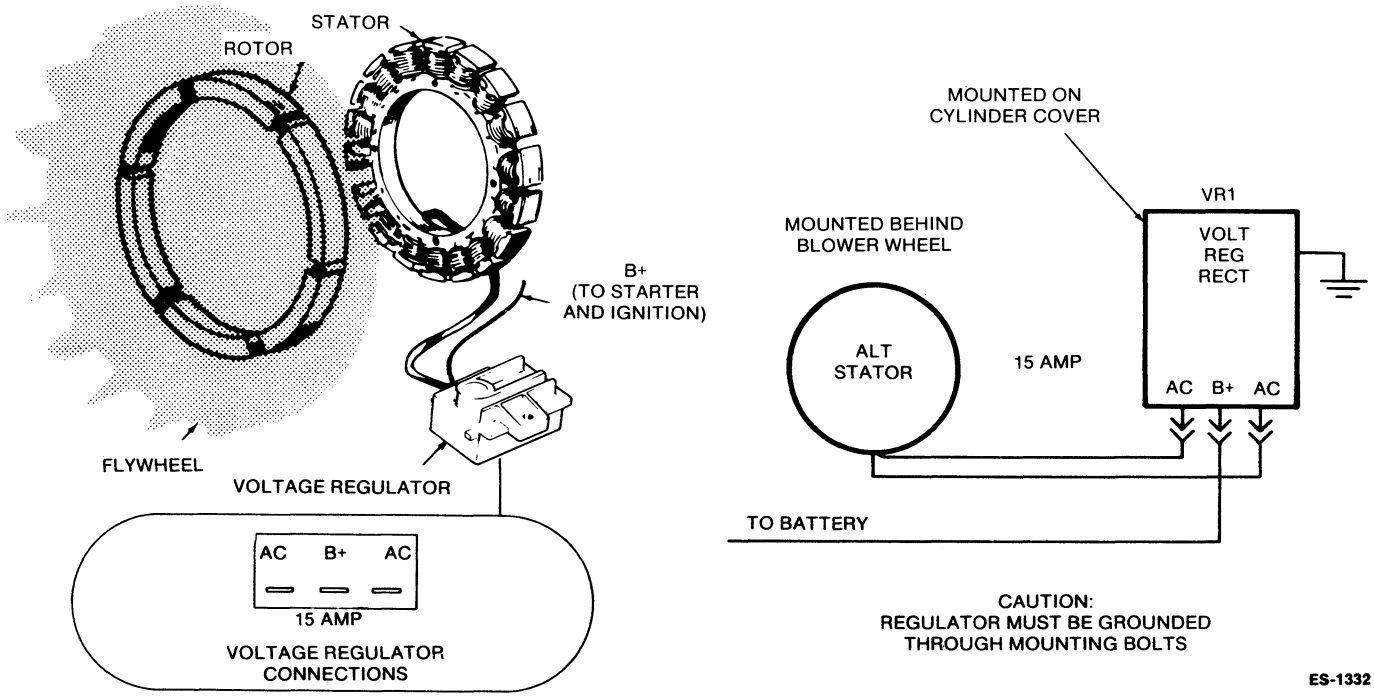


FIGURE 17. FLYWHEEL ALTERNATOR SYSTEM

No Charge Test

1. Check the B+ to ground voltage using a DC voltmeter.
2. If voltmeter reads 13.8 volts or higher, add a load to system (e.g. headlights) to reduce battery voltage to below 13.6 volts.
3. Observe ammeter. If charge rate increases, consider the system as satisfactory. If charge rate does not increase, proceed with testing.
4. Disconnect plug from regulator-rectifier and test the AC voltage at the plug with engine running near 1800 rpm. If AC voltage reads less than 20 volts, replace the stator. If AC voltage is greater than these values, replace the regulator-rectifier assembly.

High Charging Rate Test

Perform this test as follows:

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

Various alternator problems are listed in Table 1.

TABLE 1. TESTING 15-AMPERE SYSTEM

BASIC TEST	PROCEDURE	TEST VALUES 15A. SYSTEM
1. Battery	Battery Voltage—unit not running.	12 VDC
2. Regulator	Battery Voltage after unit is running 3 to 5 minutes.	13.6 to 14.7 VDC
3. Alternator Stator and Wiring	Ohmmeter reading from stator output—unit not running. Check at plug.	0.1 to 0.2 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 1800 rpm.	20 VAC minimum 65 VAC maximum

Starting System

ELECTRIC STARTER

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

Starter Disassembly

1. Remove stop nut and pinion gear.
2. Remove the through-bolts and separate the end cap, the housing and the armature (see Figure 18).
3. Disassemble the drive assembly and the drive end cap by loosening the self-locking nut.

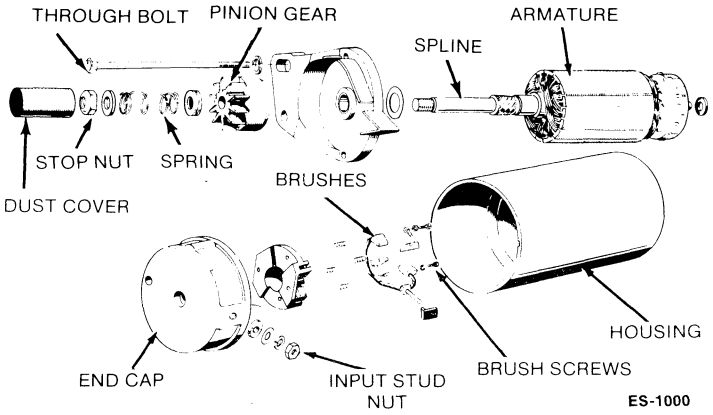


FIGURE 18. STARTER DISASSEMBLY

Inspection of Parts

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 19.

Testing Armature for a Short Circuit: Use a growler for locating shorts in the armature. Place armature in growler and hold a thin steel blade (e.g. hacksaw blade) parallel to the core and just above it while slowly rotating armature in growler. A shorted armature will cause the blade to vibrate and be attracted to the core. If armature is shorted, replace with a new one (Figure 20).

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

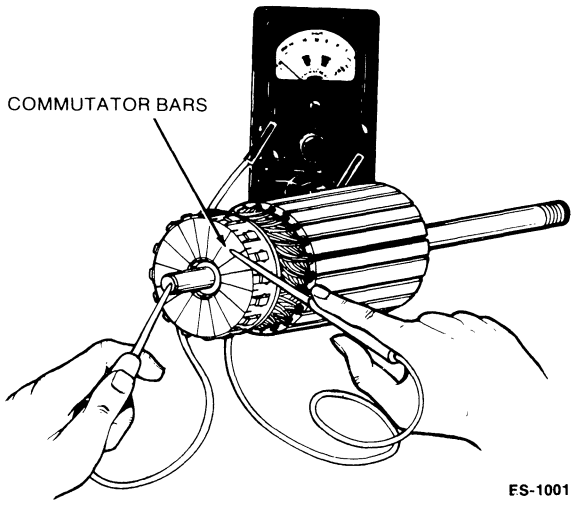


FIGURE 19. TESTING ARMATURE FOR GROUNDS

Brush Inspection: If brushes are worn shorter than 1/4 inch (6.35 mm), replace them. Check to see that brushes move smoothly in the brush holders. See Figure 21.

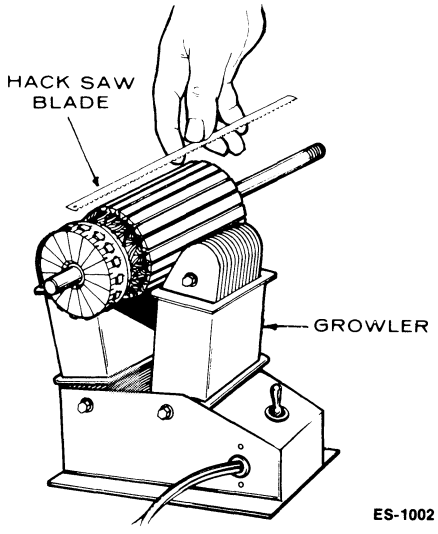


FIGURE 20. TESTING ARMATURE FOR SHORT CIRCUITS

Housing Inspection: Magnets are glued to inside of housing. Magnets must be secure and free of cracks.

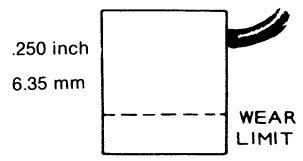


FIGURE 21. BRUSH WEAR LIMIT

Pinion Gear: If pinion gear is badly worn, has broken teeth, or pinion splined sleeve is damaged replace pinion gear and dust cover assembly. If pinion gear is in good condition wipe armature shaft spline and pinion clean.

Starter Assembly

1. Before reassembling the starter, wipe off any dirt from parts with a clean cloth or blow off with filtered, compressed air.

   ⚠CAUTION ***Do not immerse bearings in cleaning fluid. Use a brush dipped in clean engine oil for dirt removal.***

2. Assemble brushes so that the chamfered side is away from the brush springs. Make sure brush wires do not rub against the commutator or end cap.

3. Torque brush screws to a value of 3 to 3-1/2 ft-lbs (4 to 5 N•m).

4. Torque input stud nut to a value of 4 to 5 ft-lbs (5 to 7 N•m).

5. Apply a thin film of grease to the commutator end of the armature shaft and to the portion of the shaft that contacts the bearings. Apply a generous film of silicone base grease (GE Versilube 322-L) to the shaft threads.

6. Torque stop nut to a value of 20 to 25 ft-lbs (27 to 34 N•m).

7. Torque thru-bolts to a value of 4.5 to 6 ft-lbs (6 to 8 N•m).

8. Apply a small amount of a silicone based grease (GE Versilube 322-L) to armature shaft spline.

9. Install dust cap, pinion gear, dust cover spacer, anti-drift spring, stop nut washer, and stop nut.

10. Push dust cover on until it snaps into position.

Checking Gear Lash

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

1. Before installing the starter, make sure the starter mounting surfaces on the engine base are free of dirt and oil to assure good electrical contact.

2. Install the starter motor and tighten the mounting bolts just enough to hold the starter in place.

3. Remove the spark plugs from the engine to allow free movement of the flywheel.

4. Manually pull the starter pinion gear outward on its shaft so that its teeth mesh fully with those on the flywheel.

5. Measure the amount of free travel (lash) between the pinion gear teeth and the ring gear teeth, as shown in Figure 22. Proper lash is 0.020 ± 0.010 in. (0.51 ± 0.25 mm). Loosen and adjust the starter motor, as necessary, to obtain the correct setting.

6. Remove flywheel and torque starter mounting capscrews to 24 to 26 ft-lbs (33 to 35 N•m).

   ⚠CAUTION ***Failure to torque starter bolts properly may cause starter failure and ring gear damage.***

7. Install flywheel spark plugs, blower housing, and cylinder air housings.

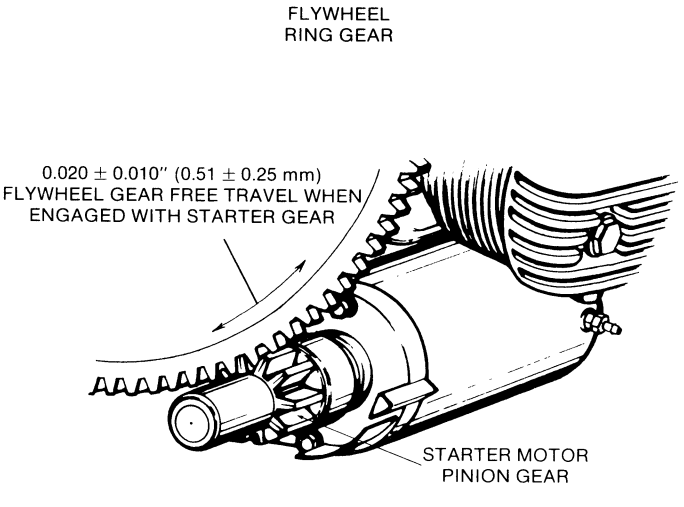


FIGURE 22. CHECKING STARTER GEAR LASH

Engine Disassembly

DISASSEMBLY/ASSEMBLY

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

Suggested Disassembly Order

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

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

Suggested Assembly Procedure

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

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

Operation

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

Tappet Adjustment

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

1. Remove ignition key to prevent accidental starting.
2. Remove all parts necessary to gain access to valve tappets.
3. Remove spark plugs to ease the task of turning the engine over by hand.
4. Use the engine flywheel to turn the engine over slowly by hand until the left hand intake valve opens and closes. Continue turning the flywheel until the TC mark is on the top and lined up with the TC mark on the gear cover. Both valves should be closed. This should place the left hand piston at the top of its compression stroke, the position it must be in to get proper valve adjustment for the left cylinder.

5. The correct feeler gauge for the valve adjustment (see *SPECIFICATIONS*) should pass freely between valve stem and tappet; a .002 inch (0.05 mm) thicker gauge should not (Figure 24).

6. To correct the valve clearance, use a 7/16-inch open end wrench to turn the adjusting screw to obtain the correct clearance. The screw is self-locking and will stay where it is set. A 9/16-inch (14 mm) open end wrench is required to hold the tappet while turning the adjusting screw.

7. To adjust valves on the right hand cylinder, turn engine one complete revolution and again line up mark on the flywheel and the TC mark on the gear cover. Then follow adjustment procedure given for left hand cylinder.

8. Replace all parts removed in Step 2. Tighten all screws securely. Torque manifold bolts to specified torque.

VALVE SYSTEM

Properly seated valves are essential to good engine performance. The aluminum cylinder heads are removable for valve servicing. Do not use a pry to loosen the cylinder head; rap sharply on the edge with a soft faced hammer, taking care not to break any cooling fins. A conventional type valve spring compressor may be used when removing the valve spring locks, which are of the split type. Clean all carbon deposits from the cylnder heads, piston tops, valves, guides, etc. If a valve face is burned or warped, or the stem worn, install a new one. Refer to Figure 23.

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

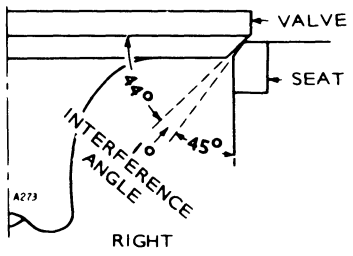
Worn valve stem guides may be replaced from inside the valve chamber. Valve locks are split, tapered type, of which the smaller diameter must face toward the valve head. Tappets are also replaceable from the valve chamber, after first removing the valve asssemblies.

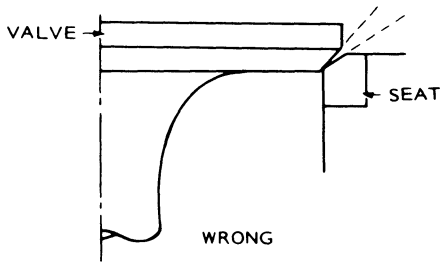
The valve *face* angle is 44 degrees. The valve *seat* angle is 45 degrees. This 1-degree interference angle results in a sharp seating surface between the valve and the top of the valve seat. The interference angle method of grind valves minimizes face deposits and lengthens valve life.

The valves should not be hand lapped, if at all avoidable, because the sharp contact may be destroyed. This is especially important where chrome cobalt faced valves and seats are used. Valve faces should be finished in a machine to 44 degrees. Valve seats should be ground with a 45-degree stone and the width of the seat band should be 1/32-inch to 3/64-inch (0.79 to 1.2 mm) wide. Grind only enough to assure proper seating.

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

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





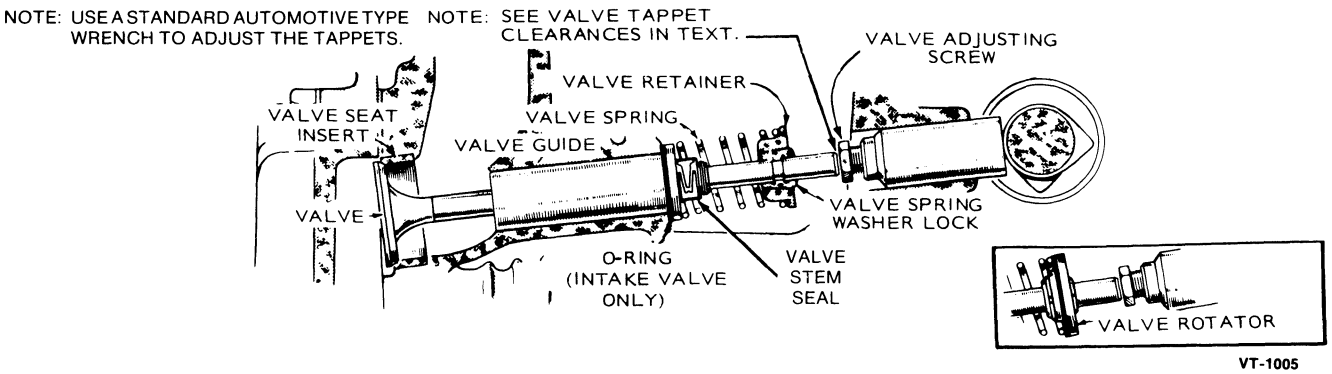


FIGURE 23. VALVE ASSEMBLY

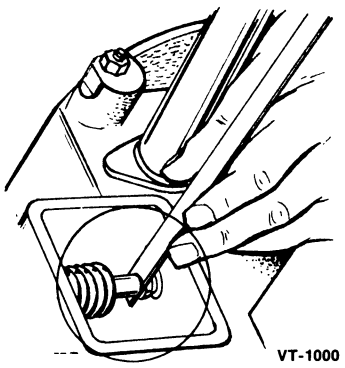


FIGURE 24. VALVE CLEARANCE

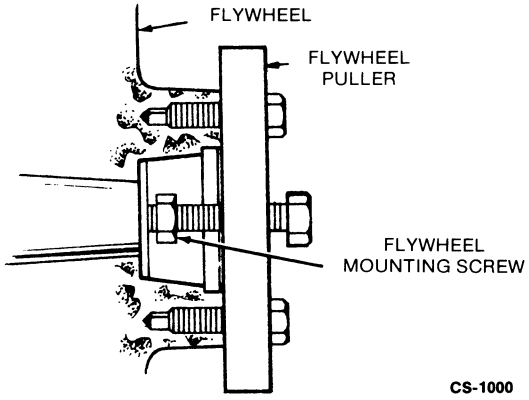


FIGURE 25. BLOWER WHEEL PULLEY

FLYWHEEL

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

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

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

2. Install a puller bar on the flywheel as shown in Figure 25.
3. Turn the puller bar bolts in, alternately, until the wheel snaps loose on the shaft.

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

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

GEAR COVER

After removing the mounting screws, tap the gear cover gently with a soft faced hammer to loosen it (see Figure 26).

When installing the gear cover, make sure that the pin in the gear cover engages the nylon lined (smooth) hole in the governor cup. Turn the governor cup so that the nylon lined hole is at the three o'clock position. Use a small amount of grease to assist in holding governor cup in position. The smooth side of the governor yoke must ride against the governor cup. Turn the governor arm and shaft clockwise as far as possible and hold in this position until the gear cover is installed flush against the crankcase. Be careful not to damage the gear cover oil seal.

GOVERNOR CUP

With the gear cover removed, the governor cup can be taken off after removing the snap ring from the camshaft center pin. Catch the flyballs while sliding the cup off (Figure 27).

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

When installing the governor cup, tilt the engine so the gear is up, put the flyballs in place (equally spaced) and install the cup and snap ring on the center pin.

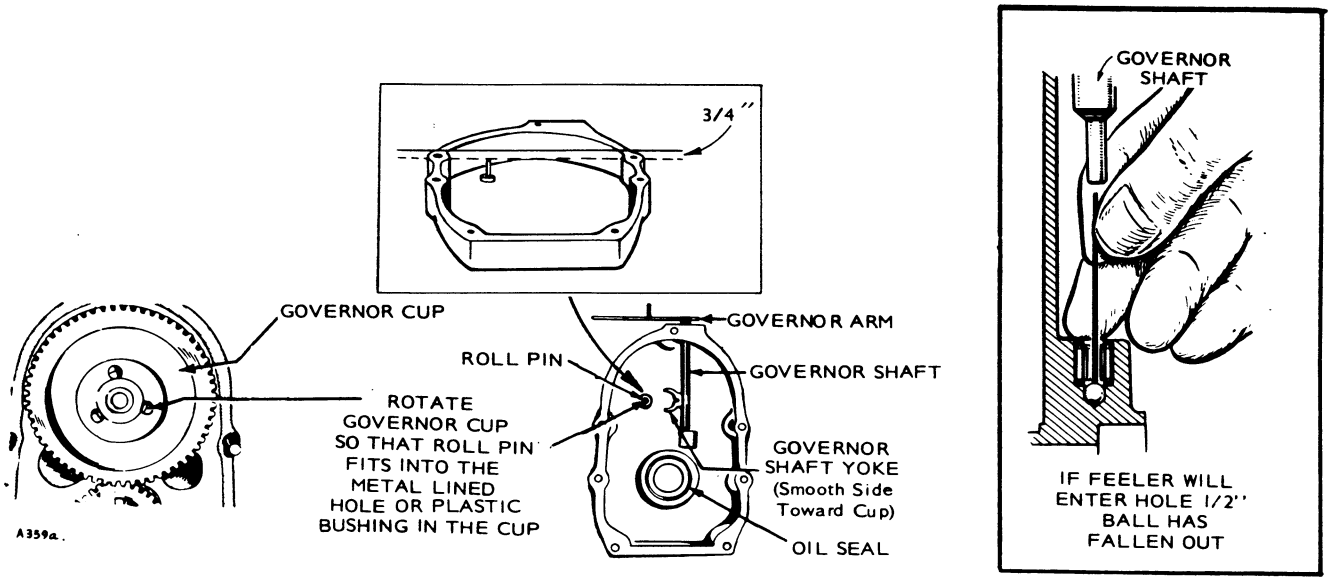


FIGURE 26. GEAR COVER ASSEMBLY

The camshaft center pin extends out 3/4 inch (19 mm) from the end of the camshaft. This distance provides an in-and-out travel distance of 7/32 inch (5.6 mm) for the governor cup, as illustrated. Hold the cup against the flyballs when measuring. The camshaft center pin cannot be pulled outward or removed without damage. If the center pin extends out too far, the cup will not hold the flyballs properly. If the distance is less than 7/32" (5.6 mm), (the engine will race, especially at no load) remove the center pin and press in a new pin.

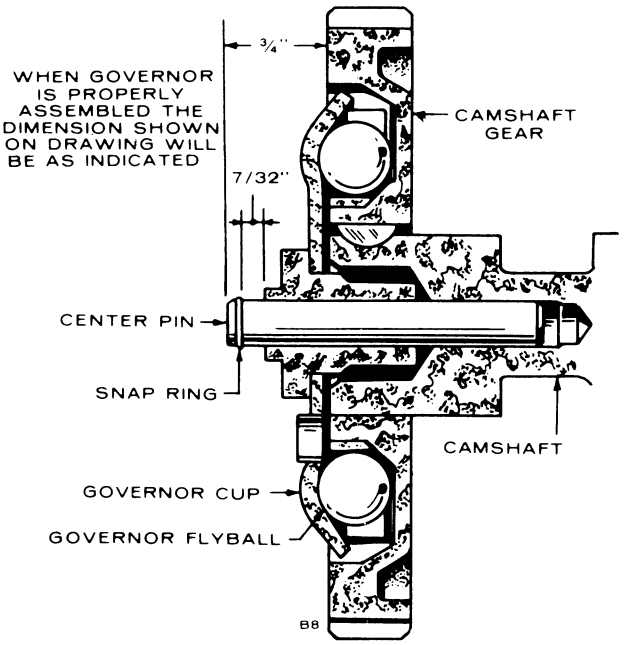


FIGURE 27. GOVERNOR CUP DETAILS

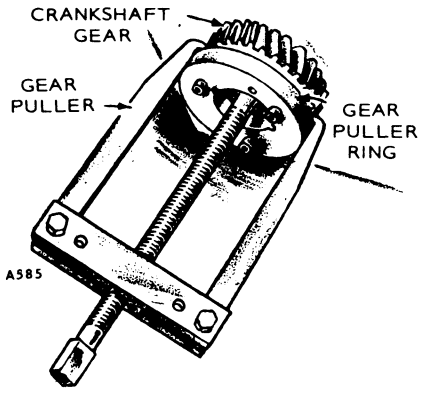
TIMING GEARS

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

To remove the crankshaft gear, first remove the snap ring and retainer washer, then attach the gear pulling ring using two No. 10-32 screws (Figure 28). Tighten the screws alternately until both are tight. Attach a gear puller to the puller ring and proceed to remove the gear.

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

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



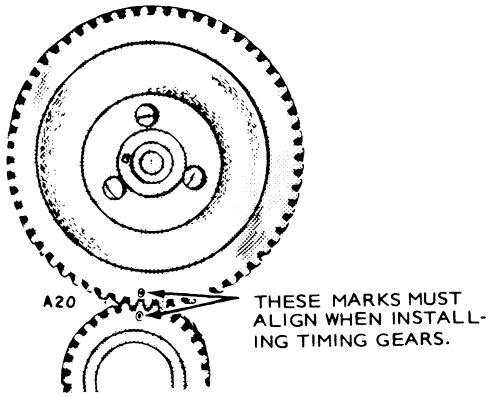


FIGURE 28. TIMING GEAR REMOVAL AND INSTALLATION

PISTONS AND CONNECTING RODS

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

1. Drain oil.
2. Remove the cylinder head and oil base pan from the engine.
3. Remove the ridge from the top of each cylinder with a ridge reamer before attempting piston removal (Figure 29).

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

4. Turn the crankshaft until the piston is at the bottom of its stroke and remove the connecting rod nuts. Lift the rod bearing cap from the rod and push the rod and piston assembly out through the top of the cylinder using a hammer handle. Avoid scratching the crankpin and cylinder wall when removing the piston and rod.

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

5. Remove the piston rings from the piston with a piston ring spreader as shown in Figure 30. Remove the piston pin retainer and push the piston pin out.

Remove dirt and deposits from the piston surfaces with an approved cleaning solvent. Clean the piston ring grooves with a groove cleaner or the end of a piston ring filed to a sharp point (Figure 31). Care must be taken not to remove metal from the groove sides.

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

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

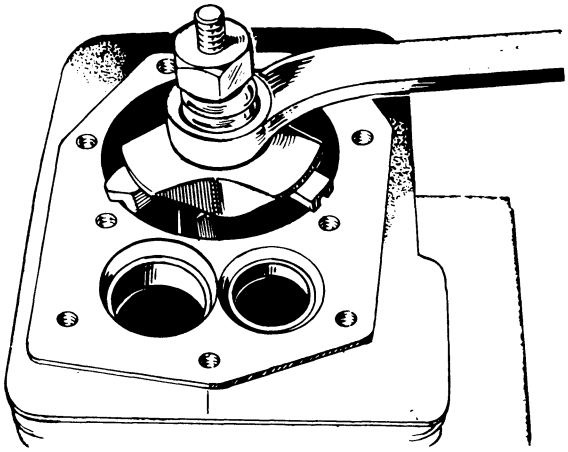


FIGURE 29. REMOVING RIDGE FROM CYLINDER

Inspection

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

Piston Inspection:

1. Inspect the pistons for fractures at the ring lands, skirts and pin bosses. Check for wear at the ring lands using a new ring and feeler gauge as shown in Figure 32. Replace the piston when the side clearance of the top compression ring reaches 0.004 inch.

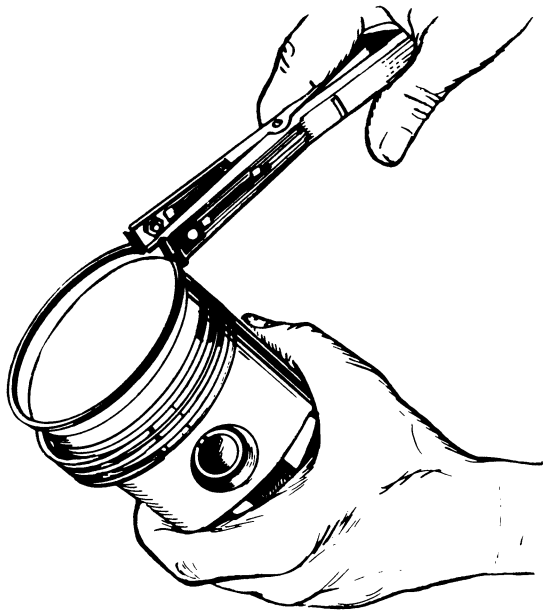


FIGURE 30. REMOVING PISTON RINGS

2. Replace pistons showing signs of scuffing, scoring, worn ring lands, fractures or damage from preignition. Excessive piston wear near the edge of the top ring land indicates preignition.

Connecting Rod Inspection:

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

Fitting Pistons:

1. Proper piston tolerances must be maintained for satisfactory operation.
2. Measure the piston to cylinder clearance as shown in Figure 33 to be sure the total clearance follows specifications.

Fitting Piston Rings:

1. Install the piston ring in the cylinder bore. Invert the piston and push the ring to the end of ring travel, about halfway into the bore, which trues the ring end gap. Check the gap with a feeler gauge as shown in Figure 34.
2. The practice of filing ring ends to increase the end gap is not recommended. If the ring end gap does not meet specifications, check for the correct set of rings and the correct bore size A cylinder bore that is 0.001 inch (0.03 mm) under size will reduce the end gap 0.003 inch (0.08 mm).

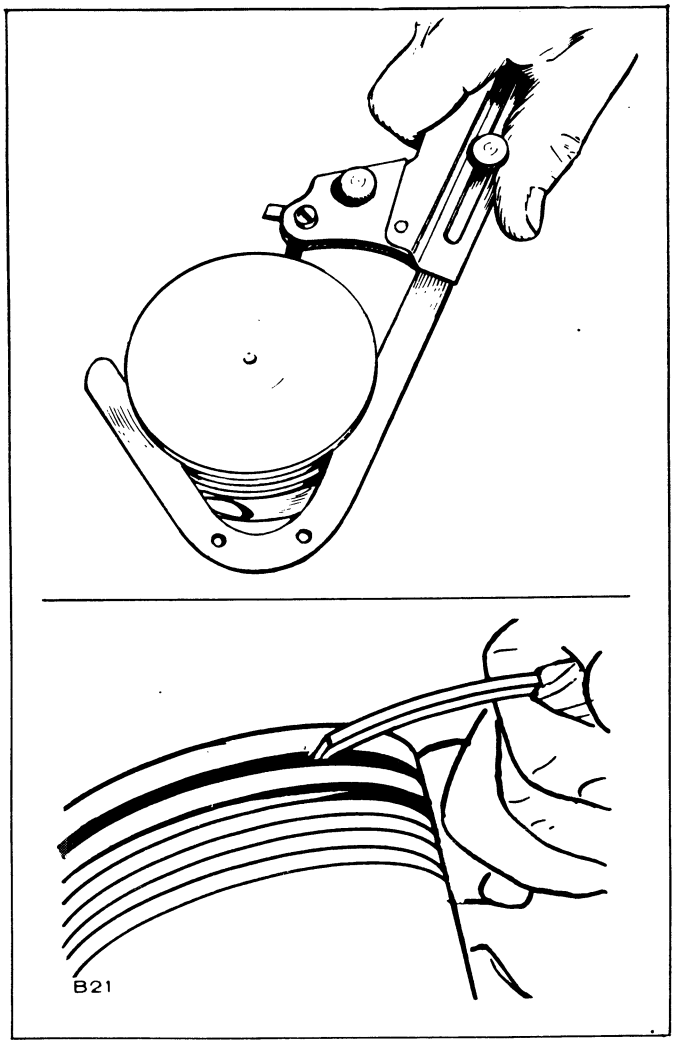


FIGURE 31. PISTON GROOVE CLEANING

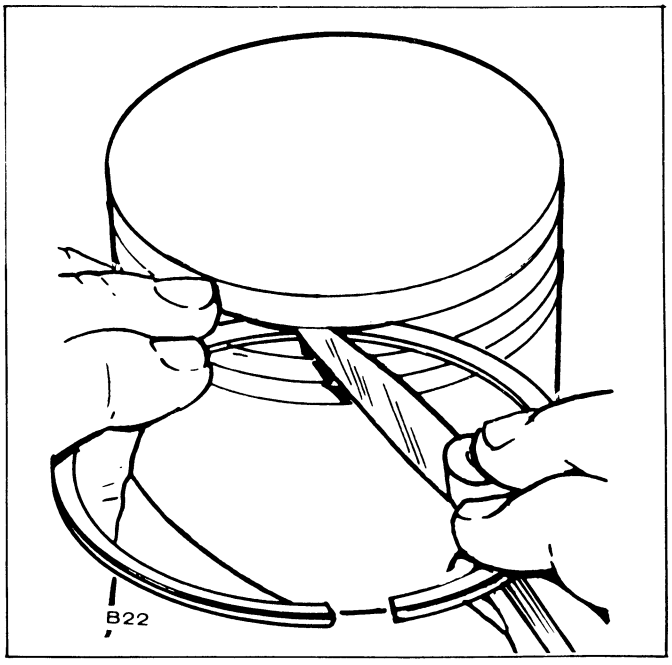


FIGURE 32. CHECKING RING SIDE CLEARANCE

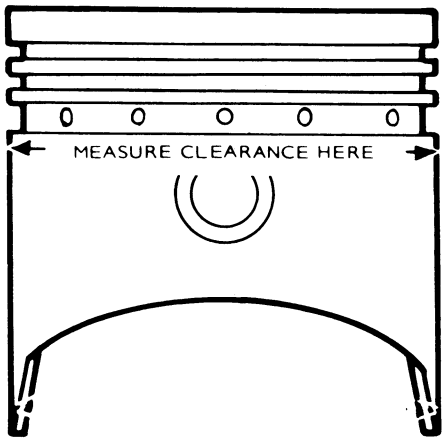


FIGURE 33. MEASURING PISTON CLEARANCE

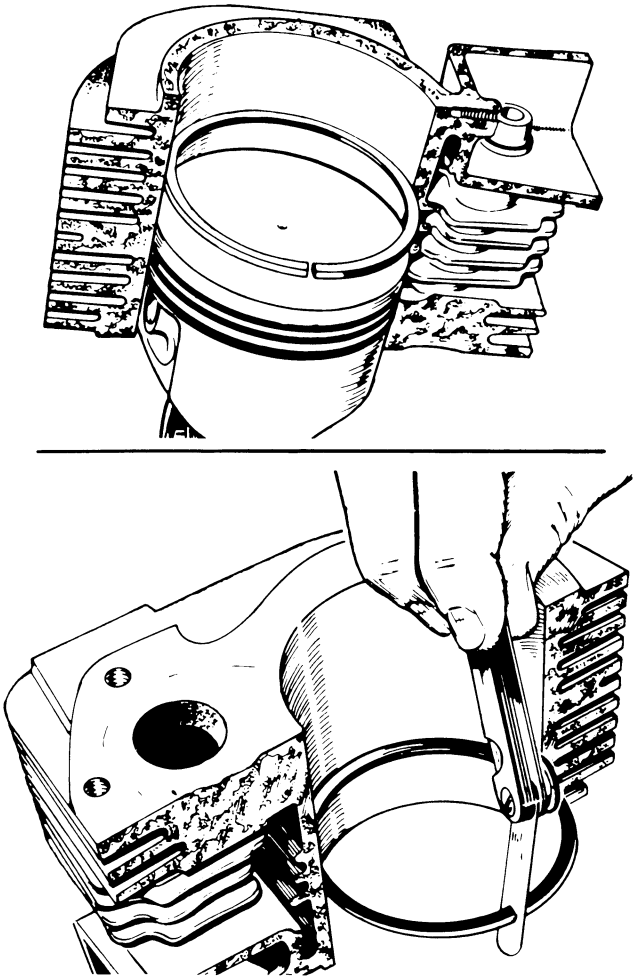


FIGURE 34. POSITIONING OF PISTON RING AND MEASURING OF END GAP

CYLINDER BLOCK

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

Cleaning

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

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

Inspection

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

1. Make a thorough check for cracks. Minute cracks may be detected by coating the suspected area with a mixture of 25 percent kerosene and 75 percent light motor oil. Wipe the part dry and immediately apply a coating of zinc oxide (white lead) dissolved in wood alcohol. If cracks are present, the white coating will become discolored at the defective area. Always replace a cracked cylinder block.
2. Inspect all machined surfaces and threaded holes. Carefully remove any nicks or burrs from machined surfaces. Clean out tapped holes and clean up any damaged threads.
3. Check top of block for flatness with a straight edge and a feeler gauge.

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

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

1. Check cylinder bore for taper, out of round and wear with a cylinder bore gauge, telescope gauge or inside micrometer. These measurements should be taken at four places, top and bottom of piston ring travel, parallel and perpendicular to axis of crankshaft.
2. Record measurements taken at top and bottom of piston travel as follows (see Figure 35):

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

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

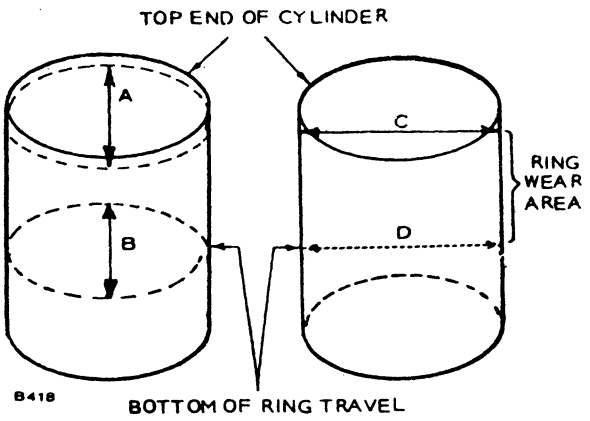
C. Measure and record as "C" cylinder bore diameter (perpendicular to crankshaft) near the top of cylinder bore where greatest amount of wear occurs.

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

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

If cylinder taper exceeds 0.005 inch (0.13 mm), rebore and hone cylinder to the next oversize.

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



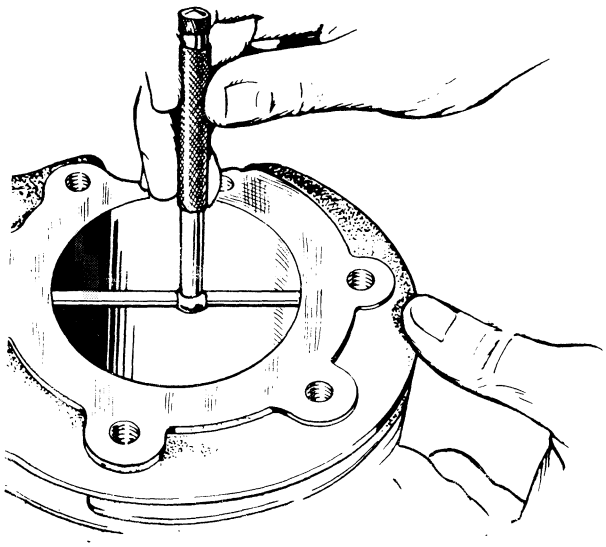


FIGURE 35. METHODS OF MEASURING THE DIAMETER OF A CYLINDER BORE

Reboring the Cylinder

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

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

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

When reboring cylinders, take the following precautions:

1. Make sure cutting tool is properly ground before using it.

2. Be sure top of engine block is smooth and deposit free.

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

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

Honing Cylinders (Using Precision Hones)

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

1. Position block solidly for either vertical or horizontal honing. Use either a drill press or heavy-duty drill which operates at approximately 250 to 450 rpm.

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

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

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

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

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

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

8. Dry crankcase and coat it with oil.

Deglazing Cylinder Bores

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

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

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

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

3. The deglazing tool should be driven by a slow speed drill. Move deglazing tool up and down in cylinder (10 to 12 complete strokes) rapidly enough to obtain a crosshatch pattern as shown in Figure 36.

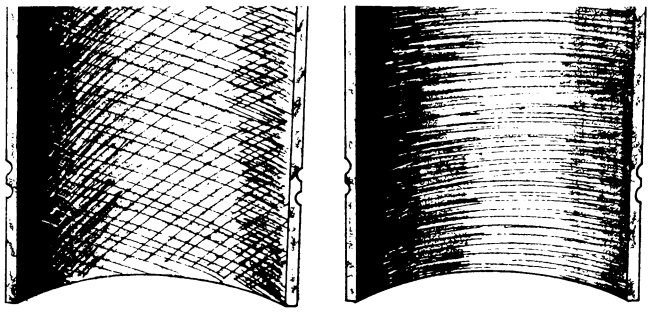


FIGURE 36. CROSS HATCHING

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

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

Valve Seats

Inspect valve seat inserts. If seats are loose, cracked or severely pitted, new ones must be installed. Remove valve seat inserts using a valve seat removal tool.

Removal: Remove carbon and combustion deposits from valve seat. Select proper puller size determined by inside diameter of valve seat. On some pullers use a new seat as a guide to adjust puller depth (Figure 37). Puller jaws must expand into cylinder block at the point where bottom of valve seat insert rests on cylinder block (Figure 37). Position puller on valve seat and tighten hex nut. Clamp cylinder block to a solid bench. Attach slide hammer to puller. Between blows with the slide hammer tighten hex nut.

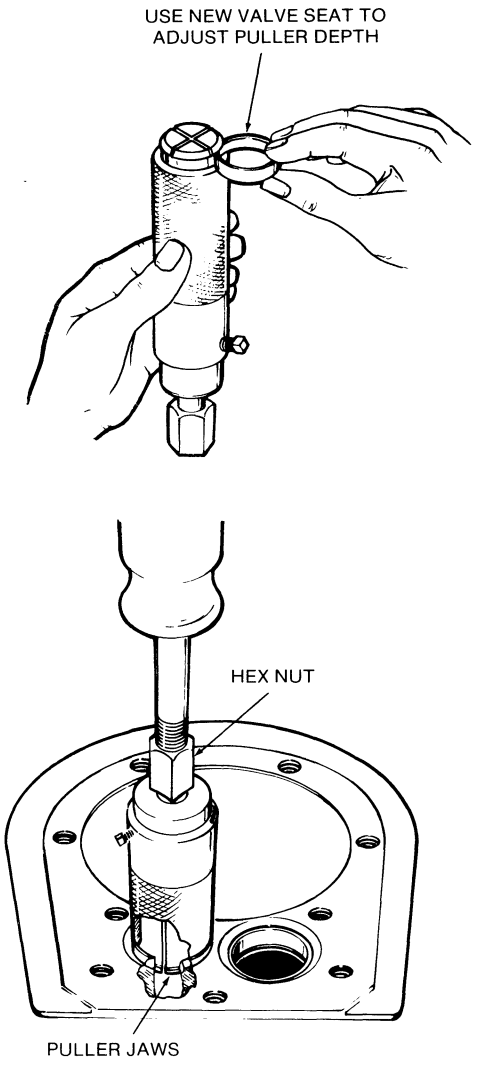


FIGURE 37. VALVE SEAT REMOVAL

Installation: After the old seat has been removed, clean out any carbon or metal burrs from the seat insert recess. Use a valve seat insert driver and hammer to install the insert (Figure 38). Quickly drive valve seat insert in so that the insert goes in evenly to the bottom of recess in the cylinder block. Make certain that the valve seat insert rests solidly on the bottom of the recess all the way around its circumference (Figure 38).

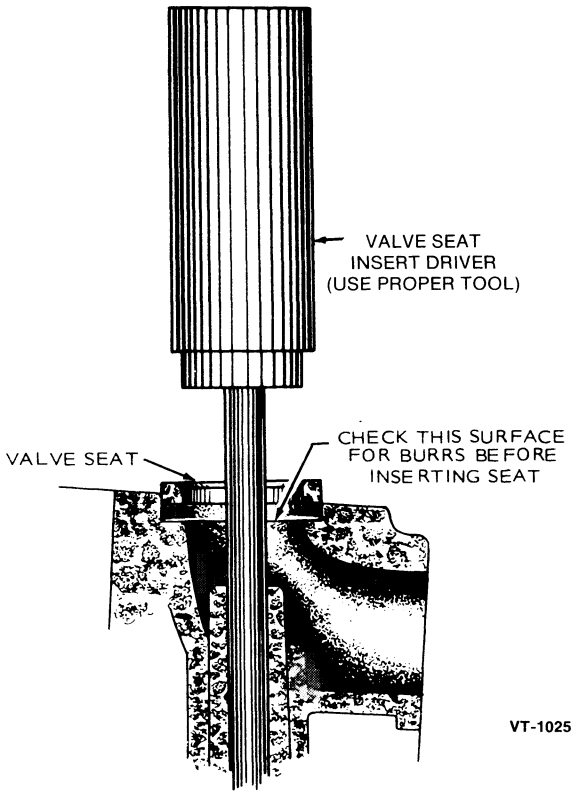


FIGURE 38. INSERTING NEW VALVE SEAT

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

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

CRANKSHAFT

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

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

BEARINGS

Removing camshaft or crankshaft bearings (Figures 39-41) 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.

New camshaft bearings are precision type which *do not* require line reaming or line boring after installation. Coat the bearing with SAE 20 oil to reduce friction. Place the bearing on the crankcase over the bearing bore with the elongated hole in proper position and narrow section facing out (except bores without oil holes install with bearing groove at the top). Be sure to start the bearing straight. Press the front bearing in flush with the bottom of counterbore which received the expansion plug (see Figure 39).

Crankshaft main bearings are precision type which do not require line reaming or line boring after installation. They are available in standard size and .002 inch (0.05 mm) undersize. Expand the bearing bore by placing the casting in hot water or in an oven heated to 200° F (93° C).

⚠CAUTION ***If a torch is used, apply only a little heat. Distortion will result from too much local heat.***

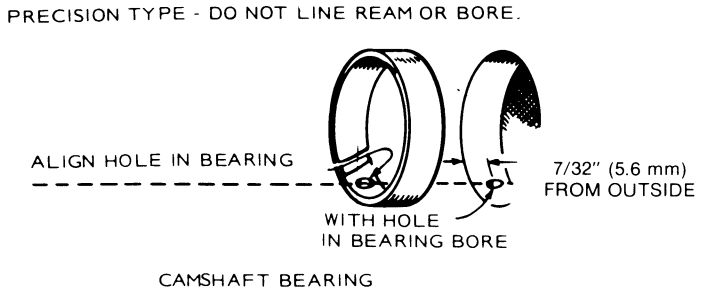


FIGURE 39. CAMSHAFT BEARING

To ease assembly, cool the precision bearing to shrink it. Align the oil hole(s) in the bearing with the oil hole(s) in the bearing bore. The oil passage must be at least 1/2 open. Lubricate bearings with SAE 20 oil before installing. The cold oiled precision bearing should require only light taps to position it with a driving tool. If head of lock pin is damaged, use side cutters or Easy Out tool to remove and install new pin. Apply oil to thrust washer (one used with each bearing) to hold it in place while installing the crankshaft. Oil grooves in thrust washers must face the crankshaft and washers must be flat (not bent). The two notches on each washer must fit over the two lock pins to prevent riding on the crankshaft.

Original front bearing uses a separate thrust washer. Replacement front bearing is a one piece assembly with thrust washer part of the bearing. Do not use a separate thrust washer when installing this replacement part. See Figures 40 and 41.

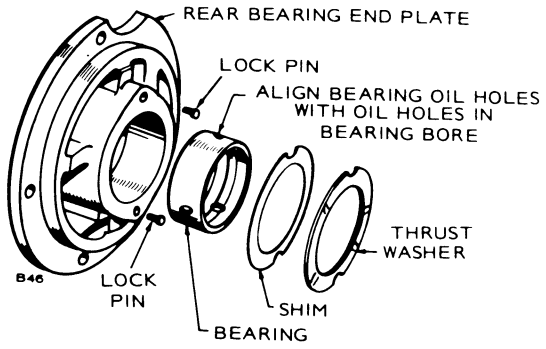


FIGURE 40. BEARINGS FOR REAR BEARING PLATE

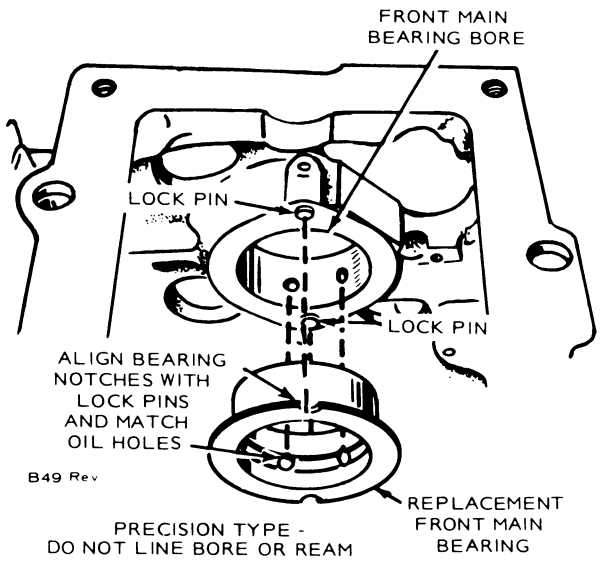


FIGURE 41. FRONT MAIN BEARING INSTALLATION

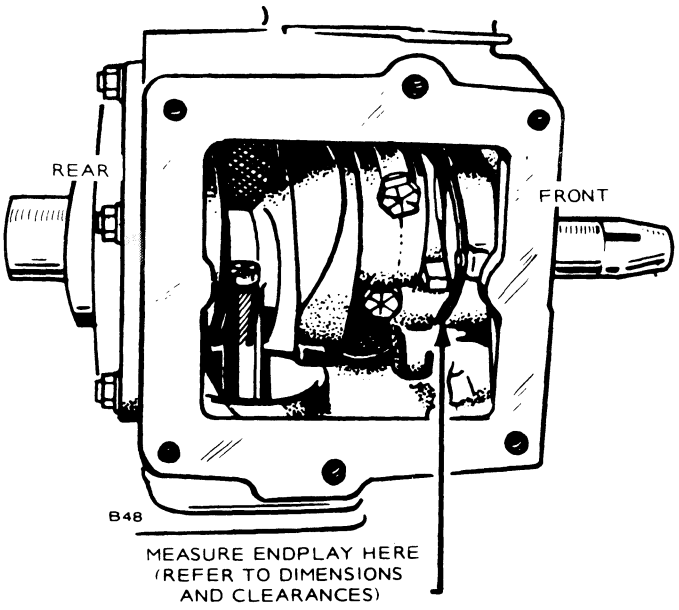


FIGURE 42. CRANKSHAFT ENDPLAY

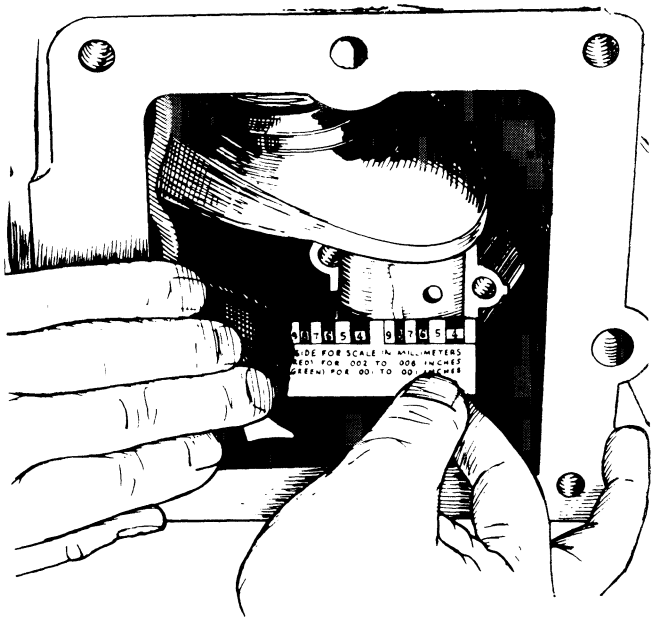


FIGURE 43. MEASURING BEARING CLEARANCE

CRANKSHAFT ENDPLAY

After the rear bearing end plate has been tightened using the torque recommended in *ASSEMBLY TORQUES*, check the crankshaft endplay as shown in Figure 42. If there is too much endplay (see *DIMENSIONS AND CLEARANCES* for minimum and maximum endplay), remove the rear bearing end plate and add a shim between the thrust washer and plate. Reinstall the end plate making sure the thrust washer and shim notches line up with the lock pins. Torque and recheck endplay of the crankshaft.

Checking Bearing Clearance with Plastigauge

1. Make certain that all parts are marked or identified so that they are reinstalled in their original positions.
2. Place a piece of correct size Plastigauge in the bearing cap the full width of the crankshaft rod surface about 1/4 inch (6.35 mm) off center (Figure 43).
3. Rotate the crank about 30 degrees from bottom dead center and reinstall the bearing cap; tighten the bolts to the torque specified in *ASSEMBLY TORQUES AND SPECIAL TOOLS*. Do not turn the crankshaft.
4. Remove the bearing cap. Leave the flattened Plastigauge on the part to which it has adhered and compare the widest point with the graduations of the Plastigauge envelope to determine bearing clearance.

OIL SEALS

The bearing plate must be removed to replace the oil seal (see Figure 44). Drive the oil seal out from the inside.

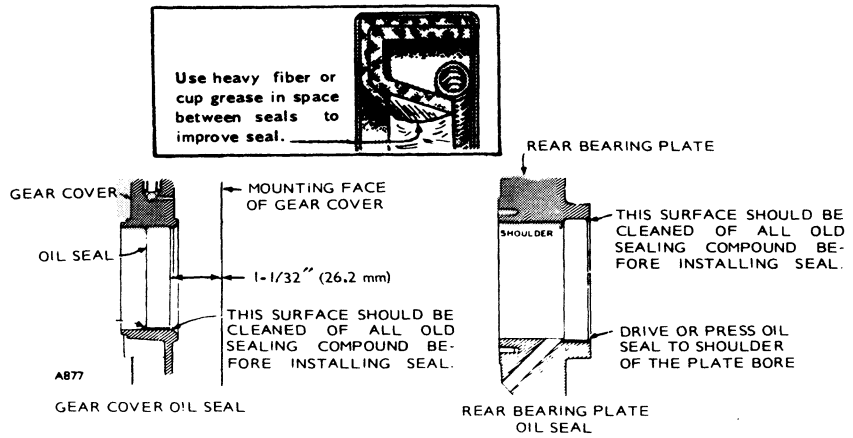


FIGURE 44. GEAR COVER AND REAR BEARING PLATE OIL SEALS

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

When installing the gear cover oil seal, tap the seal inward until it is 1-1/32 inch (26 mm) from the mounting face of the cover.

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

PISTON ASSEMBLY

1. Lubricate all parts with engine oil.
2. Position piston on its respective rod and install the pin.
3. Install the rings on the pistons starting with the oil control ring (Figure 45). Use a piston ring spreader to prevent twisting or excessive expansion of the ring. Compression rings have a dot or the word "top" on one side of the ring to indicate which side faces the top of the piston. Unmarked piston rings can be installed either way. The oil control ring has an expander; install the expander first and then close until the expander ends butt. The joint should be 180 degrees from the gap of that ring.

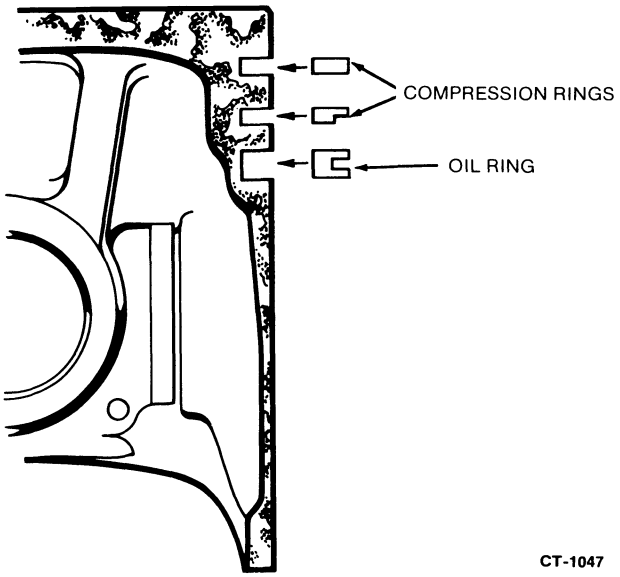
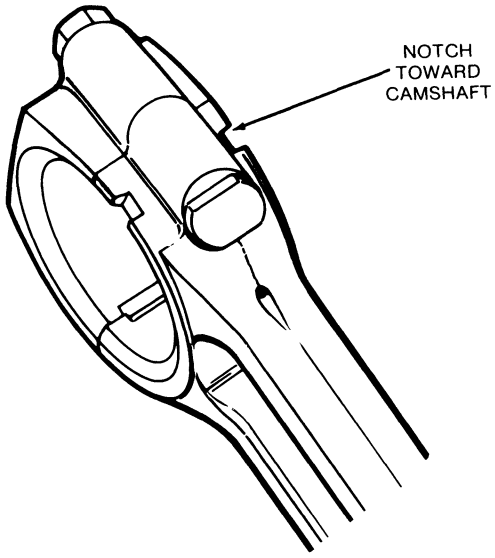


FIGURE 45. PISTON RINGS

INSTALLATION OF PISTON IN CYLINDER

1. Turn the crankshaft to position the number one rod bearing journal at the bottom of its stroke.
2. Lubricate the number one piston assembly and inside of the cylinder. Compress the rings with a ring compressor as shown in Figure 46.
3. Position the piston and rod assembly in the cylinder block. Notched side of connecting rod must face camshaft.

Rod bolts are off-set toward outside of block.



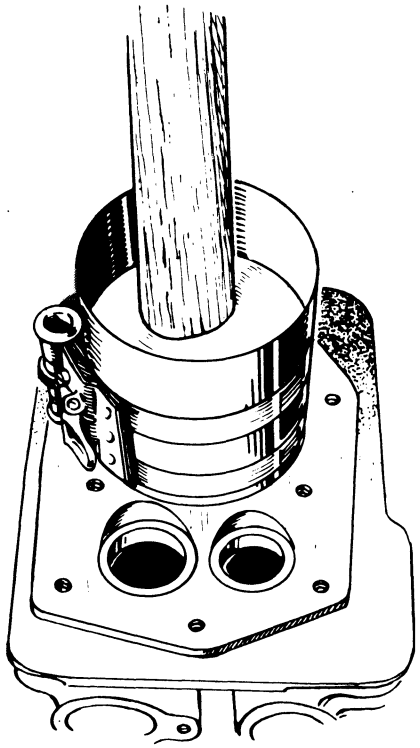


FIGURE 46. INSTALLING PISTON AND CONNECTING ROD

4. Tap the piston down into the bore with the handle end of a hammer until the connecting rod is seated on the journal (Figure 46). Install the bearing cap on the rod. Install and tighten the nuts evenly in steps to the specified torques.

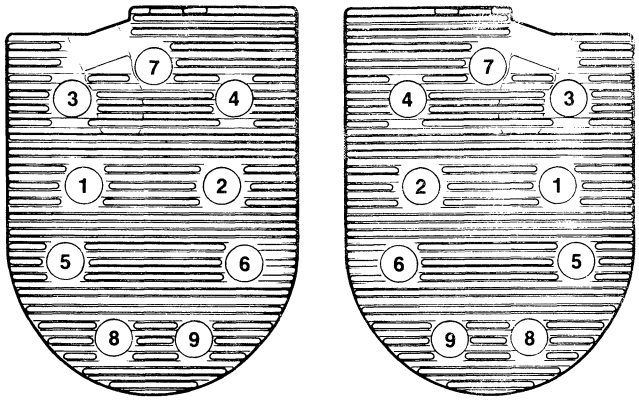
   The bearing cap must be tapped to properly align it with the rest of the connecting rod. Clearance varies on the journal if this is not done.

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

5. Install the oil base with a new gasket.

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

7. Replace oil and break in engine.



NO. 1 CYLINDER NO. 2 CYLINDER

C-1093

FIGURE 47. CYLINDER HEAD TORQUE SEQUENCE

CYLINDER HEADS

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 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.***

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.

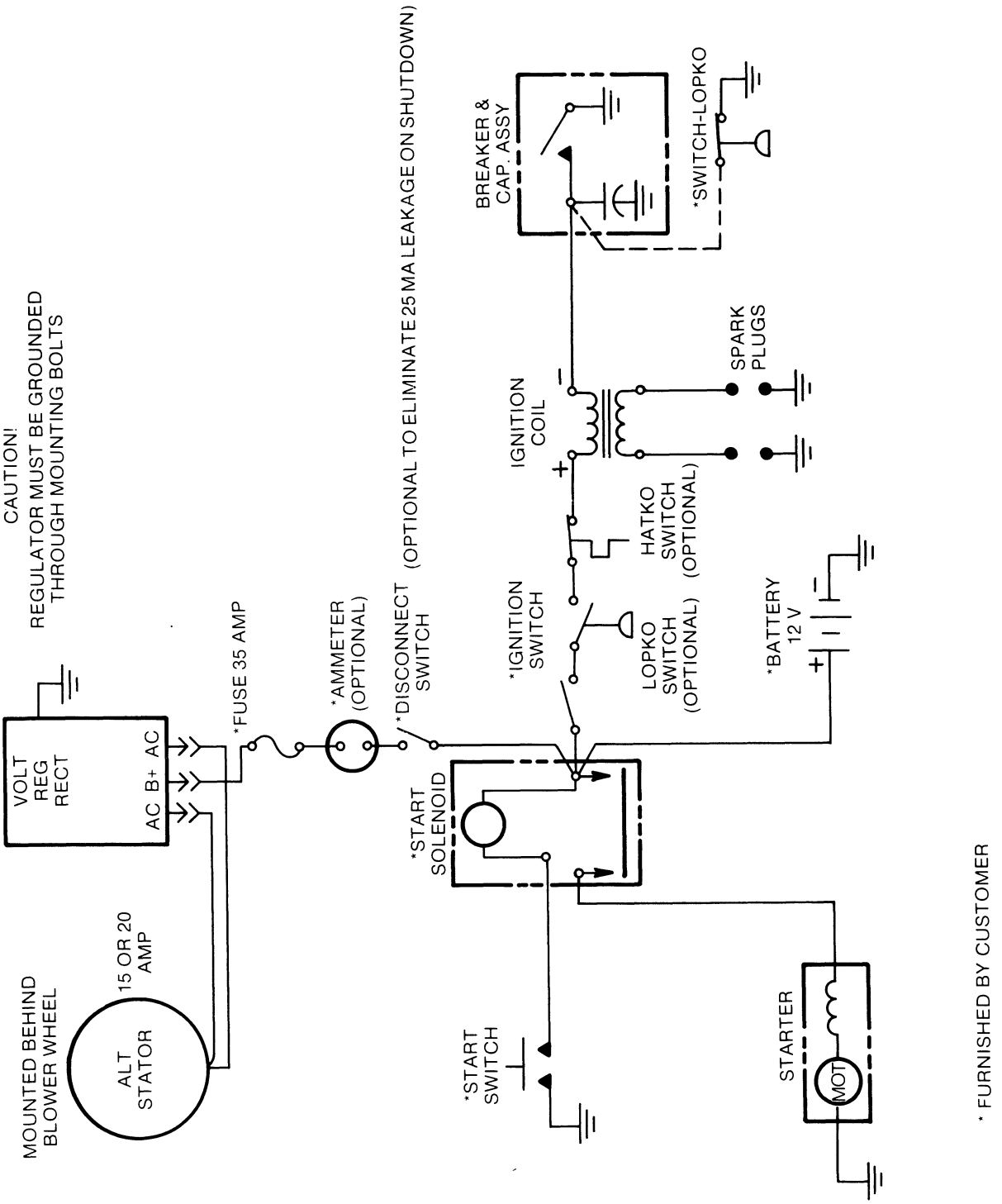
3. Use new head gaskets and clean both the heads and the cylinder block thoroughly where the head gaskets rest.

4. Place a head gasket on the cylinder block and align the stud holes in the gasket with the stud holes in the cylinder block. While holding the gasket against hte cylinder block, carefully install the cylinder head on the engine. Do not attempt to slide the head bolts through the gasket without the cylinder block behind it or the gasket may tear.

5. Follow the head torque sequence shown in Figure 47.

   Tighten all bolts to 5 ft lbs. (7 N•m), then 10 ft. lbs. (14 N•m), etc., until all bolts are torqued to 16 to 18 ft. lb. (22-24 N•m). Recheck all head bolts for correct torque.

Engine Wiring Diagram



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