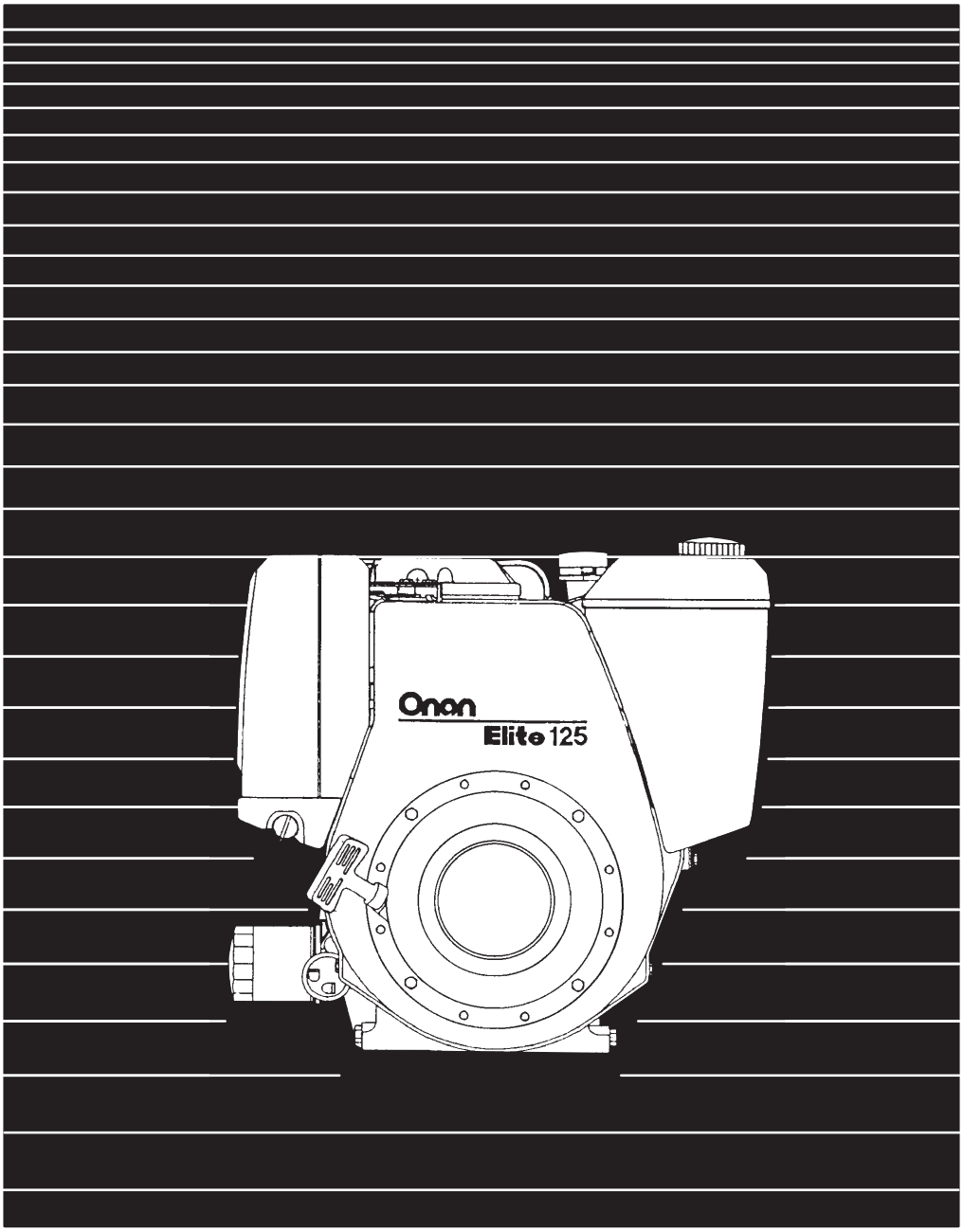
Onan

Engine

Service Manual

E125H, E140H

Elite Series



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Safety Precautions

Before operating the engine, read the Operator's Manual and become familiar with it and the equipment. **Safe and efficient operation can be achieved only if the equipment is properly operated and maintained.**

The following symbols, found throughout this manual, alert you to potentially dangerous conditions to the operator, service personnel, or the equipment.

⚠ DANGER ***This symbol 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 severe personal injury. Take care in following these recommended procedures. All local, state and federal codes should be consulted and complied with.

⚠WARNING ***This engine is not designed or intended for use in any type of aircraft. Use of this engine in aircraft can result in engine failure and cause severe personal injury or death.***

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.
- Used engine oils have been identified by some state and federal agencies as causing cancer or reproductive toxicity. When checking or changing engine oil, take care not to ingest, breathe the fumes, or contact used oil.
- Do not work on this equipment when mentally or physically fatigued, or after consuming any alcohol or drug that makes the operation of equipment unsafe.

BATTERIES

- Before starting work on the engine, disconnect batteries to prevent inadvertent starting of the engine. Disconnect negative (–) cable first.
- 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.

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.

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 line 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.
- Benzene and lead, found in some gasoline, have been identified by some state and federal agencies as causing cancer or reproductive toxicity. When checking, draining or adding gasoline, take care not to ingest, breathe the fumes, or contact gasoline.

EXHAUST SYSTEM

- Exhaust products of any internal combustion engine are toxic and can cause injury, or death if inhaled. When operating the engine in a confined area, make sure the ventilation system is operating properly.
- DO NOT use exhaust gases to heat a compartment.
- Make sure that your exhaust system is free of leaks. Make sure 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 it 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.

KEEP THE UNIT AND SURROUNDING AREA CLEAN

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

Table of Contents

Section 1. Introduction

This is the service manual for the Model E125H and E140H engines. These are 1-cylinder, 4-stroke cycle, spark-ignited, overhead-valve (OHV), air-cooled engines. Table 1-1 summarizes other information about these engines.

TABLE 1-1. USEFUL ENGINE INFORMATION

FEATURE	MODEL E125H	MODEL E140H
Rated Power at 3600 rpm	12.5 bhp	14.0 bhp
Displacement	389 cm^3 (23.7 $inch^3$)	
Bore	84.2 mm (3.31 inch)	
Stroke	70 mm (2.76 inch)	
Compression Ratio	8.5:1	
Minimum Cylinder Compression Test Pressure	483 kPa (70 psi)	
Lubricating Oil Capacity (with filter)	0.95 litre (1 quart)	
Minimum Lubricating Oil Pressures at 1500/3300 rpm (Beginning Spec D)	New: 80/138 kPa (13/20 psi) Worn: 62/103 kPa (9/15 psi)	
Minimum Lubricating Oil Pressures at 1500/3300 rpm (Prior to Spec D)	New: 21/96 kPa (3/14 psi) Worn: –/28 kPa (–/4 psi)	
Ignition Timing (not adjustable)	23° BTDC	

In this manual, the flywheel end is considered the front of the engine. Right and left sides are determined by viewing the engine from the front.

Section 2. Tolerances and Clearances and *Section 3. Assembly Torques* provide information necessary for proper reassembly of the engine. They are referenced throughout the manual.

Section 4. Troubleshooting provides a way to systematically locate engine problems.

Section 5. Fuel System, *Section 6. Electrical System*, *Section 7. Starting System* and *Section 8. Lubrication System* cover service of major subsystems of the engine.

Section 9. Engine Block Assembly covers the complete overhaul of the engine block assembly.

See the separate Operator's Manual for engine operation, maintenance and storage and for fuel and lubricating oil recommendations.

See the separate Parts Manual for part identification numbers and required quantities and for exploded views of the engine subassemblies. Genuine Onan replacement parts are recommended for best results. When ordering parts, always give the complete model and serial numbers appearing on the engine nameplate. See Table 1-2 for a breakdown of the engine model number.

TABLE 1-2. ENGINE MODEL NUMBER

E	140	H	–	N	/11152	A
|	|	|		|	|	|
1	2	3		4	5	6

1. Model Letter
2. Rated Power—"140" designates 14.0 bhp (brake horse power) and "125", 12.5 bhp.
3. Shaft Orientation—"V" designates vertical shaft and "H", horizontal shaft.
4. Engine Fuel—"N" designates gasoline, "L", LPG and "D", dual fuel.
5. Optional Equipment Code—designates muffler, fuel tank, electric starter, etc. or combinations thereof.
6. Spec Letter—designates production modifications.

⚠WARNING

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

Section 2. Tolerances and Clearances

All dimensional tolerances and clearances are in millimetres (inches) at 21° C (70° F) unless otherwise indicated.	FACTORY SPECIFICATION		ALLOWABLE LIMIT
	MINIMUM	MAXIMUM	
CYLINDER BLOCK			
Cylinder Bore I.D.			
Standard	84.200 (3.3150)	84.225 (3.3160)	84.325 (3.3199)
.25 Oversize	84.450 (3.3248)	84.475 (3.3258)	84.575 (3.3297)
.50 Oversize	84.700 (3.3347)	84.725 (3.3356)	84.825 (3.3396)
Cylinder Bore Taper	–	–	0.10 (0.004)
Cylinder Bore Out-of-Round	–	–	0.05 (0.002)
CAMSHAFT			
Lobe Height, Diameter Over Nose			
E125 Intake	34.23 (1.348)	34.55 (1.360)	33.73 (1.328)
E125 Exhaust	34.53 (1.359)	34.85 (1.372)	34.03 (1.340)
E140 Intake	35.09 (1.381)	35.41 (1.394)	34.59 (1.362)
E140 Exhaust	35.09 (1.381)	35.41 (1.394)	34.59 (1.362)
End Clearance	0.10 (0.004)	0.20 (0.008)	0.25 (0.010)
Journal Bearing O.D.	17.975 (.7077)	17.990 (.7083)	17.93 (.7059)
Journal Bearing Clearance (in gearcase)	0.01 (.0004)	0.05 (.0020)	0.08 (.0031)
BALANCER SHAFTS			
End Clearance (Both Shafts)	0.10 (0.004)	0.20 (0.008)	0.25 (0.010)
Journal Bearing O.D.	21.875 (0.8612)	21.890 (0.8618)	21.83 (0.8594)
Journal Bearing Clearance (in gearcase)	0.02 (0.0008)	0.056 (0.0022)	0.08 (0.0031)

All dimensional tolerances and clearances are in millimetres (inches) at 21° C (70° F) unless otherwise indicated.	FACTORY SPECIFICATION		ALLOWABLE LIMIT
CRANKSHAFT			
Stroke	70 (2.76)	70 (2.76)	–
Connecting Rod Journal O.D.			
Standard	33.475 (1.3179)	33.485 (1.3183)	–
.25 Undersize	33.225 (1.3081)	33.235 (1.3085)	–
.50 Undersize	32.975 (1.2982)	32.985 (1.2986)	–
End Clearance	0.10 (.004)	0.20 (.008)	0.25 (0.010)
CONNECTING ROD			
Pin Bore I.D.	20.015 (0.7880)	20.025 (0.7884)	20.071 (0.7902)
Large Bore I.D.			
Standard	33.500 (1.3189)	33.525 (1.3199)	–
.25 Undersize	33.250 (1.3091)	33.275 (1.3100)	–
.50 Undersize	33.000 (1.2992)	33.025 (1.3002)	–
Large Bore Clearance	0.015 (0.0006)	0.050 (0.0020)	0.100 (0.0040)
Side Clearance on Crankshaft	0.40 (0.016)	1.10 (0.043)	1.50 (0.059)
PISTON			
Piston Skirt O.D. 90 Degrees to Pin and 26.5 mm (1.043 inch) from Top of Piston			
Standard	84.09 (3.311)	84.12 (3.312)	–
.25 Oversize	84.34 (3.320)	84.37 (3.322)	–
.50 Oversize	84.59 (3.330)	84.62 (3.331)	–
Pin Bore I.D.	20.004 (0.7876)	20.012 (0.7879)	20.022 (0.7883)

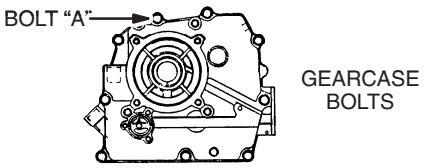
All dimensional tolerances and clearances are in millimetres (inches) at 21° C (70° F) unless otherwise indicated.	FACTORY SPECIFICATION		ALLOWABLE LIMIT
	MINIMUM	MAXIMUM	
PISTON PIN			
Piston Pin O.D.	20.000 (0.7874)	20.005 (0.7876)	19.990 (0.7870)
Clearance in Piston Pin Bore	–.001 (.0000)	.012 (0.0005)	0.03 (0.0012)
Clearance in Connecting Rod Pin Bore	.010 (0.0004)	.025 (0.0010)	.035 (0.0014)
PISTON RINGS			
Top Compression Ring Thickness	1.47 (.058)	1.49 (.059)	1.42 (.056)
Second Compression Ring Thickness	1.47 (.058)	1.49 (.059)	1.42 (.056)
Top Compression Ring to Ring Groove Clearance	0.03 (0.001)	0.08 (0.003)	0.13 (0.005)
Second Compression Ring to Ring Groove Clearance	0.03 (0.001)	0.08 (0.003)	0.13 (0.005)
Top Compression Ring End Gap	0.25 (0.010)	0.51 (0.020)	1.00 (0.039)
Second Compression Ring End Gap	0.25 (0.010)	0.51 (0.020)	1.00 (0.039)
Oil Ring Side Rail Gap	0.38 (0.015)	1.40 (0.055)	1.80 (0.071)
INTAKE VALVE			
Valve Stem O.D.	6.960 (0.2740)	6.975 (0.2746)	–
Valve Guide I.D.	7.000 (0.2756)	7.015 (0.2762)	–
Valve Stem to Valve Guide Clearance	0.03 (0.001)	0.06 (0.002)	0.10 (0.004)
Valve Lash	0.15 (.006)		0.25 (0.010)
Face Angle	45°		–
INTAKE VALVE SEAT			
Seat Width	1.1 (.043)		1.7 (.067)
Seat Angle	45°		–

All dimensional tolerances and clearances are in millimetres (inches) at 21° C (70° F) unless otherwise indicated.	FACTORY SPECIFICATION		ALLOWABLE LIMIT
	MINIMUM	MAXIMUM	
EXHAUST VALVE			
Valve Stem O.D.	7.940 (0.3126)	7.960 (0.3134)	–
Valve Guide I.D.	8.000 (0.3150)	8.015 (0.3156)	–
Valve Stem to Valve Guide Clearance	0.04 (.002)	0.08 (.003)	0.10 (.004)
Valve Lash	0.15 (.006)		0.25 (0.010)
Face Angle	45°		–
EXHAUST VALVE SEAT			
Seat Width	1.1 (0.043)		1.7 (0.067)
Seat Angle	45°		–
VALVE SPRINGS—INTAKE AND EXHAUST			
Valve Spring Free Length (Approx.)	43.5 (1.713)		–
Valve Spring Length			
Valve Closed	32.6 (1.28)		–
Valve Open	23.2 (0.91)		–
Spring Load (Valve Closed Length)	12.6 kg (27.7 lb)	14.6 kg (32.1 lb)	–
Spring Load (Valve Open Length)	26.4 kg (58.2 lb)	28.4 kg (62.7 lb)	24.9 kg (55 lb)
VALVE ROCKER ARM			
Rocker Arm Bore I.D.	12.000 (0.4724)	12.018 (0.4718)	–
Rocker Arm Shaft O.D.	11.973 (0.4714	11.984 (0.4718)	–
Rocker Arm to Rocker Shaft Clearance	0.016 (0.0006)	0.045 (0.0018)	0.15 (0.0059)

All dimensional tolerances and clearances are in millimetres (inches) at 21° C (70° F) unless otherwise indicated.	FACTORY SPECIFICATION		ALLOWABLE LIMIT
	MINIMUM	MAXIMUM	
LUBRICATING SYSTEM			
Rotor Lobe Clearance	0.15 or less (0.006 or less)		0.20 (0.008)
Outer Rotor to Pump Body Clearance	0.12 (0.005)	0.19 (0.007)	0.25 (0.010)
Rotor to Cover Clearance	0.02 (0.001)	0.09 (0.004)	0.25 (0.010)
IGNITION SYSTEM			
Spark Plug Gap	0.89 (0.035)	1.02 (0.040)	–
Magneto Coil to Rotor Magnet Clearance	0.25 (0.010)	0.40 (0.016)	–
STARTER MOTOR			
Commutator O.D.	28.0 (1.102)		27.00 (1.063)
Difference of Commutator O.D.'s	–	0.05 (0.002)	0.016 (0.41)
Armature Shaft to Bushing Clearance	0.02 (0.001)	0.07 (0.003)	0.20 (.008)
Mica Undercut	0.45 (0.018)	0.75 (0.030)	0.20 (0.008)

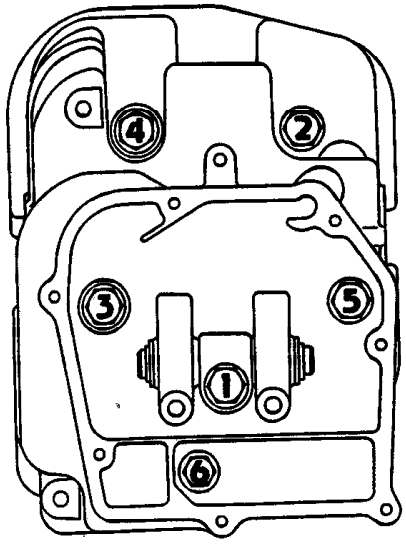
Section 3. Assembly Torques

	DESCRIPTION	BOLT SIZE	METRIC (N-m)	ENGLISH (LB-FT)	INSTRUCTIONS
GEARCASE	Connecting Rod Bolts	M8 x 44	24-27	18-20	
	Gearcase Bolts	M8 x 35, 50, 75	16-22	12-16	< Torque the gearcase bolts in a clockwise direction starting with bolt “A”. Torque bolt “A” twice.
	Oil Pump Cover Screws	M6 x 14	7-11	5-8	
	Oil Pickup Tube	M6 x 14	7-11	5-8	
	Oil Drain Plugs	1/4” NPT	7-11	5-8	
	Fuel Pump Pulse Line Elbow	1/8” NPT	7-9.5	5-7	
	LOPCO or Pipe Plug	1/8” NPT	7-9.5	5-7	
	Adapter Filter Head	3/4”-16	47-54	35-40	
	Oil Filter	–	–	–	< Turn the oil filter 3/4-1 turn after gasket contacts base.
CYLINDER HEAD	Cylinder Head Bolts				
	No. 1-5 Bolts	M10 x 66, 86, 125	42-50	31-37	< Torque the cylinder head bolts in sequence shown. Two bolts outside valve cover (#2 & #4) to be retorqued after others are torqued.
	No. 6 Flange Bolt	M8 x 50	16-22	12-16	
	Valve Lash Adjusting Nut	M7	7-11	5-8	
	Valve Rocker Cover Bolts	M6 x 25	7-11	5-8	< Tighten every other valve rocker cover bolt until all bolts are tightened. Torque the first bolt twice.
	Spark Plug	M14-1.25	24-30	18-22	



	DESCRIPTION	BOLT SIZE	METRIC (N-m)	ENGLISH (LB-FT)	INSTRUCTIONS
INTAKE SYSTEM	Pulse Pump to Air Cleaner Pan	#10	2.3-2.8	1.7-2.1 (20-25 lb-in)	
	Intake Elbow to Cylinder Head	M8 x 50	11-16	8-12	
	Air Cleaner Pan to Cylinder Block	M8 x 16	11-16	8-12	< Tighten twice (1-2-1).
	Carburetor to Intake Elbow	M6 x 85	10-15	7-11	< Tighten twice (1-2-1).
	Air Cleaner Wingnut	1/4”-20	-	-	< Tighten 6 to 8 clicks after seating air cleaner.
	Control Plate Screws	M5 x 16, 30	7-9.5	5-7	
	Throttle Stop Screw Bracket	M5 x 10	2.7-5.4	2-4	
	Fuel Line Hold Down Screw	#10-16	1.4-2	1-1.5 (12-18 lb-in)	
	Throttle Cable Clamp Screw	#10-32	1.4-2	1-1.5 (12-18 lb-in)	
ELECTRICAL	Voltage Regulator Screws	1/4” x 50	6.7-8.1	5-6 (60-72 lb-in)	
	Starter Bolts	M8 x 40	16-22	12-16	
	Alternator Stator Screws	M6 x 25	10-15	7-11	
	Ignition Coil Bolt	M6 x 30	10-15	7-11	
	Connector-Wire Harness to Blower Housing	M4 x 12	1.4-2	1-1.5 (12-18 lb-in)	
SHEET METAL	Blower Housing Bolts	M6 x 20	7-11	5-8	
	Blower Housing to Manifold Bolt	M6 x 14	10-15	7-11	
	Starter Cover Bolts	3/8” x 16	25-35	18-26	
	Chaff Screen Bolts	M6 x 10	7-11	5-8	
	Stationary Guard Bolts	M6 x 20	1-1.2	1-1.5 (12-18 lb-in)	
	Recoil Starter Cup Screw	1/4”-20	7-11	5-8	
	Recoil Starter Bolts	M6 x 12	7-11	5-8	
	Cylinder Air Housing Bolt	M6x10	7-11	5-8	
		M8x16	11-16	8-12	
MISC	Governor Arm Nut	M6	8.1-10.9	6-8	
	Flywheel Nut	M18	122-138	90-102	
	Oil Fill Tube	M8x20	11-16	8-12	

CYLINDER HEAD TORQUE SEQUENCE



NOTE: THESE TORQUE VALUES PROVIDE PROPER TIGHTNESS WITHOUT DANGER OF STRIPPING THREADS. ALL THREADS MUST BE CLEAN AND RUST-FREE. LIGHTLY OIL ALL THREADS EXCEPT ON THE SPARK PLUG.

Section 4. Troubleshooting

PROBLEM	Engine Does Not Start	Engine Cranks Slowly	Engine Stops	Engine Misfires	Engine Backfires	Engine Overheats	Governor Hunts	Black Exhaust	Blue Exhaust	Burned Valves	Connecting Rod Wear	Cylinder Wear	High Oil Pressure	Low Oil Pressure	Mechanical Noise	Piston Wear	Bearing Wear	Low Compression	Ring Wear	Sticking Valves	PROBABLE CAUSE
																					STARTING SYSTEM
	•	•																			Battery Connections Poor
	•	•																			Battery Low or Discharged
	•	•																			Starter Faulty
	•																				Starter Solenoid Faulty
																					IGNITION SYSTEM
	•			•																	Spark Plug Gap Wrong
	•			•																	Magneto Coil Faulty
	•			•																	Spark Plug Wires Faulty
	•			•	•	•				•					•						Magneto Gap Wrong
																					FUEL SYSTEM
	•		•																		Fuel Tank Empty
	•			•		•	•			•											Fuel Mixture Too Lean
	•			•	•			•							•						Fuel Mixture Too Rich
	•		•		•			•													Engine Flooded
	•			•	•			•		•					•						Fuel Quality Poor
	•		•	•	•		•														Carburetor Dirty
	•			•	•			•				•				•	•		•		Air Cleaner Dirty
	•			•			•														Fuel Filter Dirty
	•		•	•			•														Fuel Pump Defective
																					INTERNAL ENGINE
	•			•						•					•			•			Valve Clearance Wrong
	•			•						•					•			•		•	Valve Spring Broken
				•			•		•	•								•			Valve or Valve Seal Leaking
	•								•						•			•			Piston Rings Worn or Broken
		•									•			•	•		•				Bearing Clearance Wrong
																					COOLING SYSTEM
				•		•															Air Circulation Poor
				•		•															Cylinder Cooling Fins Dirty
	•		•	•														•			Head Gasket Blown
																					LUBRICATING SYSTEM
	•		•			•					•	•		•	•	•	•		•		Oil Level Too Low
											•	•				•	•		•	•	Oil or Oil Filter Dirty
	•		•			•			•		•	•		•	•	•	•		•		Oil Viscosity Too Low or Diluted
		•											•								Oil Viscosity Too High
													•	•							Oil Gauge Faulty
													•	•							Relief Valve Stuck
											•	•		•	•	•	•		•		Oil Pump Faulty
																					THROTTLE/GOVERNOR
	•						•														Linkage Out of Adjustment
	•						•														Linkage Worn or Disconnected
	•						•														Linkage Binding
	•						•														Governor Assembled Wrong

Section 5. Fuel System

⚠WARNING ***Improper service or replacement of parts can result in severe personal injury and equipment damage. Service personnel must be qualified to perform electrical and mechanical service.***

⚠WARNING ***Accidental starting of the engine can result in severe personal injury or death. Disconnect the negative (–) battery cable and spark plug wire before servicing the engine, controls, or associated equipment.***

⚠WARNING ***Ignition of fuel can result in severe personal injury or death. Do not smoke or allow any spark, pilot light, or arcing switch or equipment near the fuel system or in areas with shared ventilation.***

Provide adequate ventilation when working on the fuel system.

CARBURETOR REMOVAL/INSTALLATION

Before replacing or overhauling a carburetor, make certain 1) that all other necessary engine and generator adjustments and repairs have been performed and 2) that the carburetor is actually malfunctioning.

Carburetor Removal

Refer to Figure 5-1. Remove the air cleaner assembly. Disconnect the governor linkage, fuel line, throttle linkage, and choke control linkage. Remove the carburetor assembly from the intake elbow.

Carburetor Installation

Install the carburetor assembly on the intake elbow. Tighten the through bolts as specified in *Section 3. Assembly Torques.* Connect choke control linkage, throttle linkage, fuel line, and governor linkage. Make sure the breather tube and rubber seal are installed properly. Install the air cleaner assembly as instructed in this section. Always use new gaskets when installing a carburetor.

Instructions for control cable and speed adjustments follow in this section.

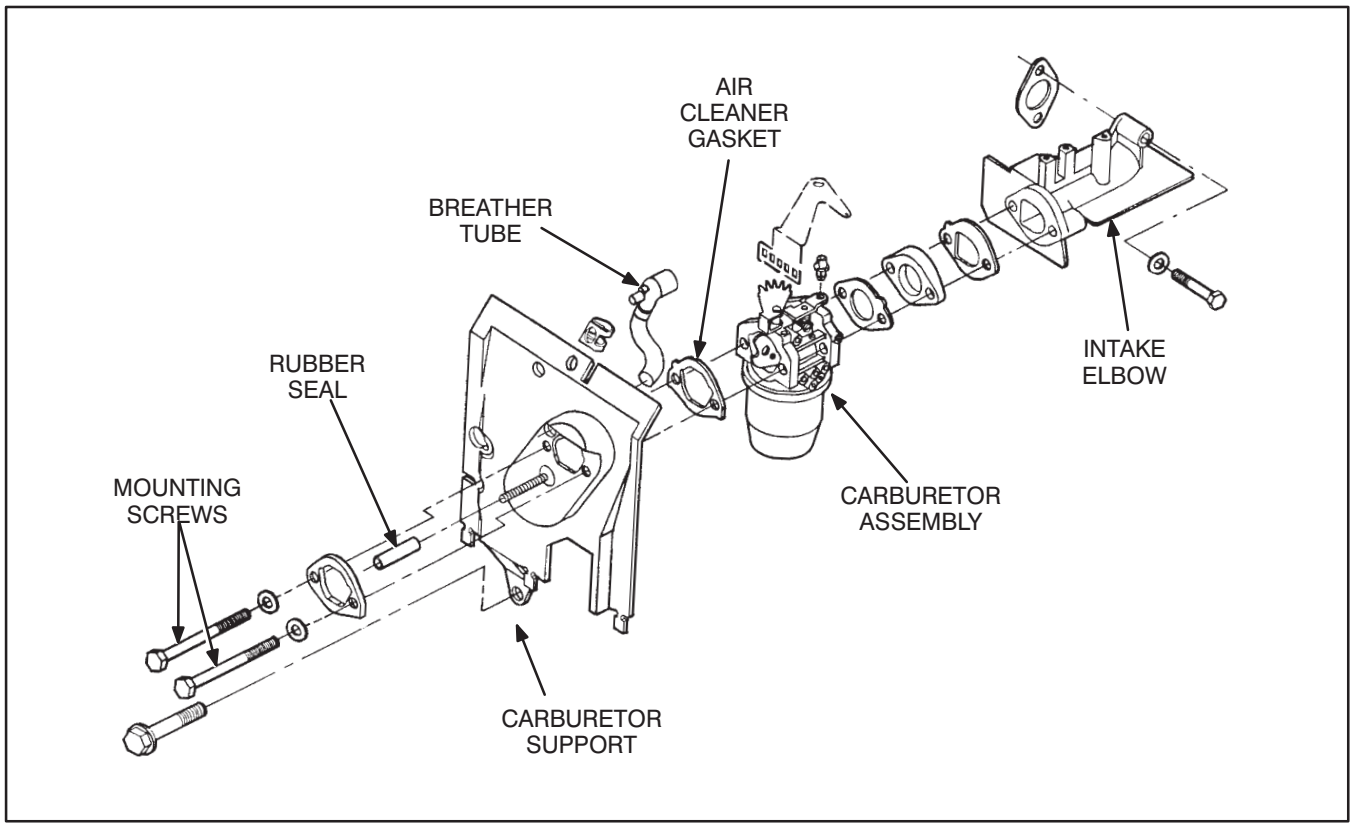


FIGURE 5-1. CARBURETOR ASSEMBLY

CARBURETOR (BEGINNING SPEC C)

Carburetor Replacement

Other than replacing the carburetor main fuel jet (fixed-type) with the optional high-altitude jet (Figure 5-2), fuel mixture adjustments should not be attempted. Nor should the carburetor be overhauled. Instead, a malfunctioning carburetor should be replaced. See CARBURETOR REMOVAL / INSTALLATION in this section.

Carburetor High-Altitude Jet (Optional)

If the engine is operated at an altitude above 5000 feet (1524 metres), it is recommended that the carburetor main fuel jet be replaced with the optional high-altitude jet (which has a slightly smaller orifice).

⚠ CAUTION ***To avoid slipping and gouging the main fuel jet, use a screwdriver with a 5/16 inch (8 mm) wide blade.***

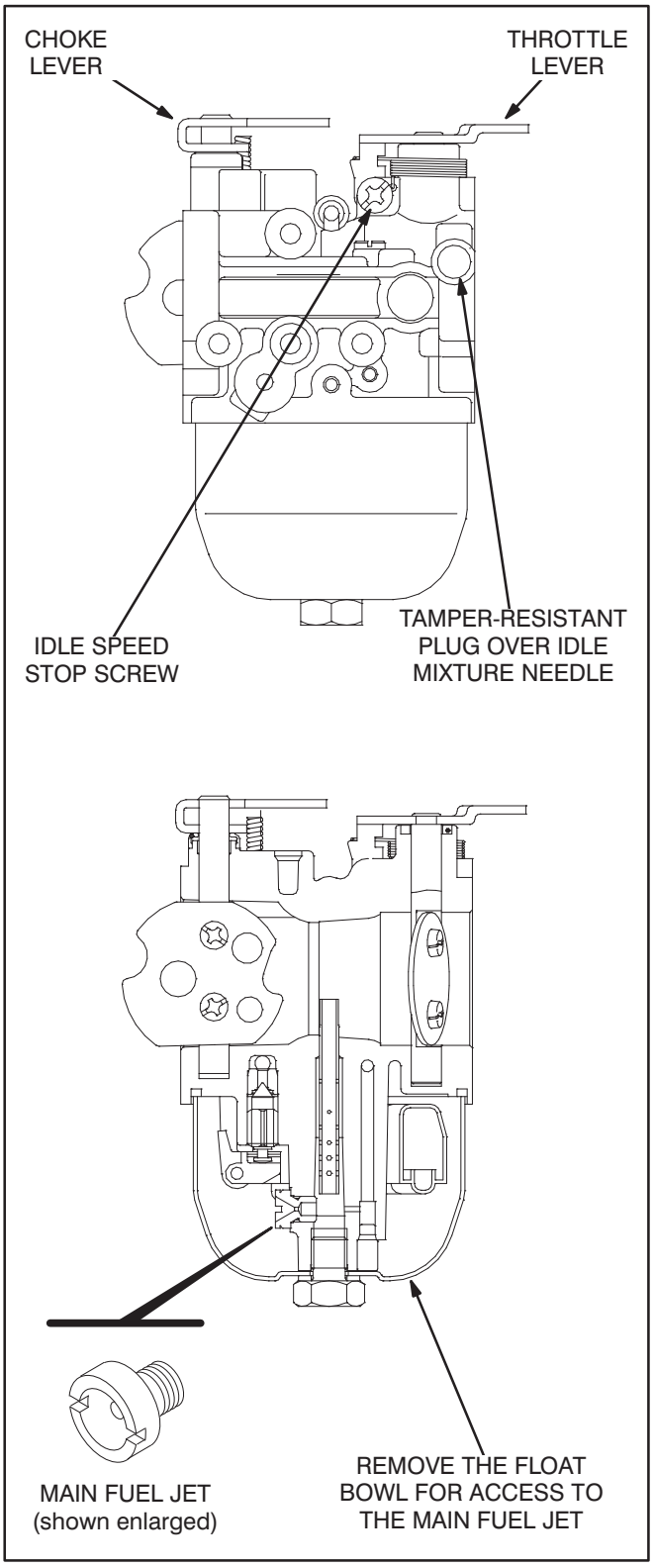


FIGURE 5-2. CARBURETOR

CARBURETOR (PRIOR TO SPEC C)

Carburetor parts are fragile and must be handled with care. Never force a part when disassembling or assembling the carburetor.

Carburetor Disassembly

Remove the chamber set plug and washer from the float chamber (Figure 5-3). Remove the float chamber and gasket. Slide the float pin out from the passage in the carburetor. Remove the float and float valve from the carburetor. Remove the main jet. Remove the idle adjust screw.

Carburetor Inspection/Service

Soak metal components in a carburetor cleaner. Do not soak non-metal parts and gaskets in carburetor cleaner. Follow the cleaner manufacturer's recommendations.

Clean carbon from the carburetor bore, especially around the throttle and choke plates. Dry out all air passages with low air pressure (35 psi). Do not use wire or other objects for cleaning passages; this may damage critical passages.

Replace the float if cracked, damaged, or if it contains fuel.

Inspect the idle adjustment needle. Replace if it's bent, worn, or damaged in any way.

Check the choke and throttle shafts for excessive play in the bore. This condition may necessitate replacement of the carburetor.

Assembly

⚠ CAUTION ***Overtightening the mixture adjustment screw will cause carburetor damage. Turn mixture adjustment screw in only until light tension can be felt.***

Install idle adjust screw. Turn screw in until a LIGHT tension is felt. Turn the screw out 2 turns.

Install the main jet. Install the float valve in the float. Turn the carburetor upside down and install the float valve in the carburetor. Slide float pin into passage in carburetor and float. Install float chamber and gasket on carburetor by screwing in chamber set plug and gasket into carburetor.

CO Adjustment

If a CO (Carbon Monoxide) meter is available, adjust the idle mixture screw to provide 5% to 6% CO at 3300 rpm with no load on the engine. If a meter is not available, set the idle mixture screw at 2 turns out.

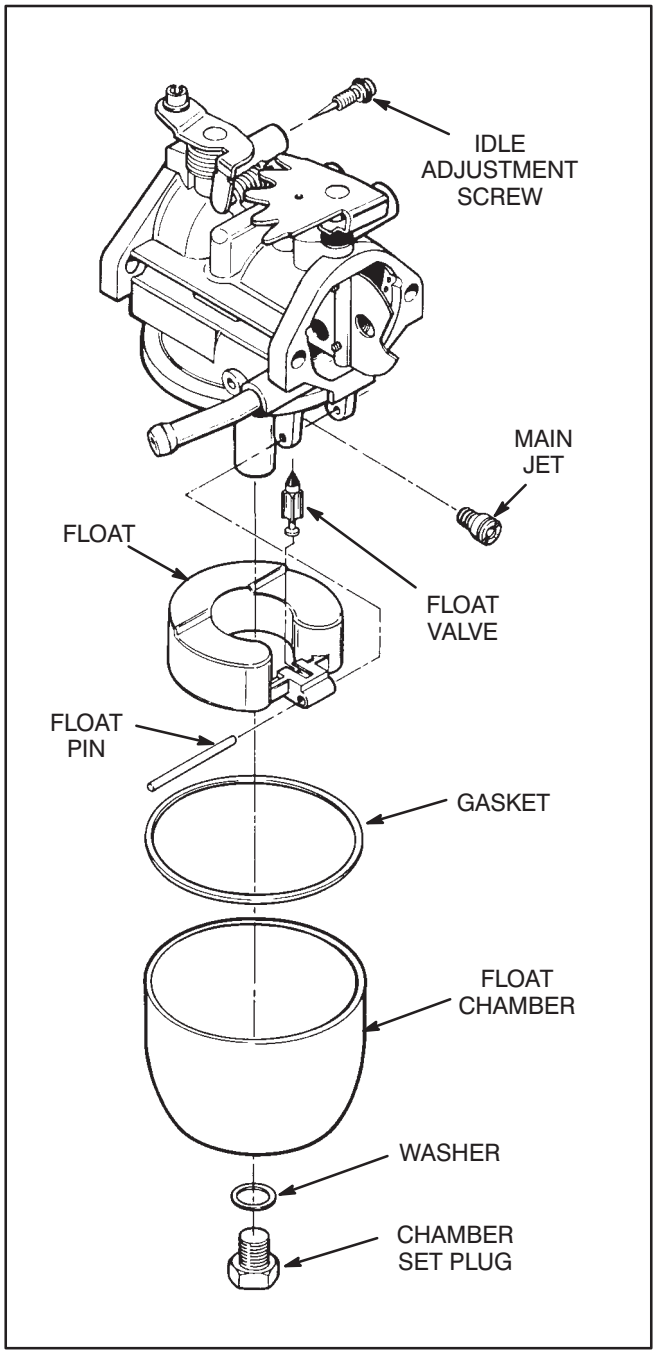


FIGURE 5-3. CARBURETOR COMPONENTS (PRIOR TO SPEC C)

IMPULSE FUEL PUMP

The engine may be equipped with an impulse-type fuel pump which has a spring-loaded diaphragm operated by crankcase pressure pulses. The fuel flow direction is marked on the cover of the pump. Replace the pump if it leaks or fails to pump.

⚠WARNING ***Ignition of fuel can result in severe personal injury or death. Do not smoke or allow any spark, pilot light, or arcing switch or equipment near the fuel system or in areas with shared ventilation.***

Provide adequate ventilation when working on the fuel system.

Inspection/Service

Preliminary Checks and Service: Perform the following checks and service before inspecting the fuel pump if it is suspected that fuel delivery is the problem causing the engine not to start or to starve for fuel under load.

1. Check the fuel tank and refill it as necessary. Replace the fill cap if the vent is plugged.

2. Open all fuel shutoff valves (if any) in the fuel supply line.

3. Check the engine oil level and refill as necessary.

4. Check the fuel hose for kinks, pinches and leaks and service as necessary. Note that dips and long runs of fuel line can lead to vapor lock in hot weather.

5. Replace the fuel filter if necessary.

6. Inspect the crankcase for visible oil leaks, especially around the seal on the oil fill tube, and service as necessary. If the crankcase is not properly sealed the pressure pulses may be too weak to operate the fuel pump as required.

7. If the gasoline in the supply tank is more than six months old, dispose of it properly and refill the tank with fresh fuel. See the Operator's Manual for fuel recommendations.

The Engine Will Not Start: If the engine still will not start after performing any necessary preliminary service, crank the engine and then remove and inspect the spark plug.

If the spark plug is wet and has a strong gasoline smell, the fuel pump is probably okay. Check for:

- A fouled spark plug. Clean and regap or replace a fouled spark plug. Note that a fouled spark plug may indicate the need for engine service.

- An improperly adjusted carburetor choke. See RECONNECTING AND RECLAMPING THE CHOKE AND THROTTLE CABLES in this section.

- A defective or improperly connected "Off" or "Kill" switch. See *Section 6. Electrical System.*

If the spark plug is dry, check fuel pump operation as follows:

- Ground the spark plug lead so that ignition sparks can not ignite the gasoline.

- Disconnect the fuel outlet hose (to the carburetor), connect a hose at least 200 mm (8 inches) long and direct the end of the hose into a container to collect the gasoline.

- Crank the engine with the electric starter or the recoil starter for 20 seconds.

Replace the fuel pump as instructed in this section if there is no fuel flow from the pump. If there is fuel flow, service the carburetor as instructed in this section.

The Engine Runs But Starves For Fuel Under Load: If the engine appears to starve for fuel under load, disconnect the regular fuel supply to the engine, or close the fuel shutoff valve, and connect a gravity supply fuel system directly to the carburetor. Replace the fuel pump as instructed in this section if the problem is eliminated by direct gravity feed. If not, service the carburetor as instructed in this section.

Fuel Pump Removal

Replace a defective fuel pump assembly as follows:

1. Close the fuel shutoff valve.
2. Place a drip pan under the fuel pump and carburetor to collect fuel.
3. Disconnect the starting battery (if equipped). Disconnect the negative (–) cable first to reduce the risk of arcing.
4. Remove the air cleaner cover and air filter assembly.
5. Loosen the screws that secure the fuel pump to the air cleaner pan assembly. (It may be necessary to loosen the air cleaner pan mounting screws to gain access to the fuel pump.)
6. Disconnect the hoses and remove the pump.

Fuel Pump Installation

Installation is the reverse of removal. Replace any damaged or deteriorated fuel lines. Tighten all mounting hardware to that specified in *Section 3. Assembly Torques*.

If it was necessary to loosen the air cleaner pan mounting screws to remove the pump (Step 5), it will be necessary to reposition the governor arm on its shaft and to readjust the engine idle speeds. See GOVERNOR ARM and ENGINE SPEED ADJUSTMENTS in this section.

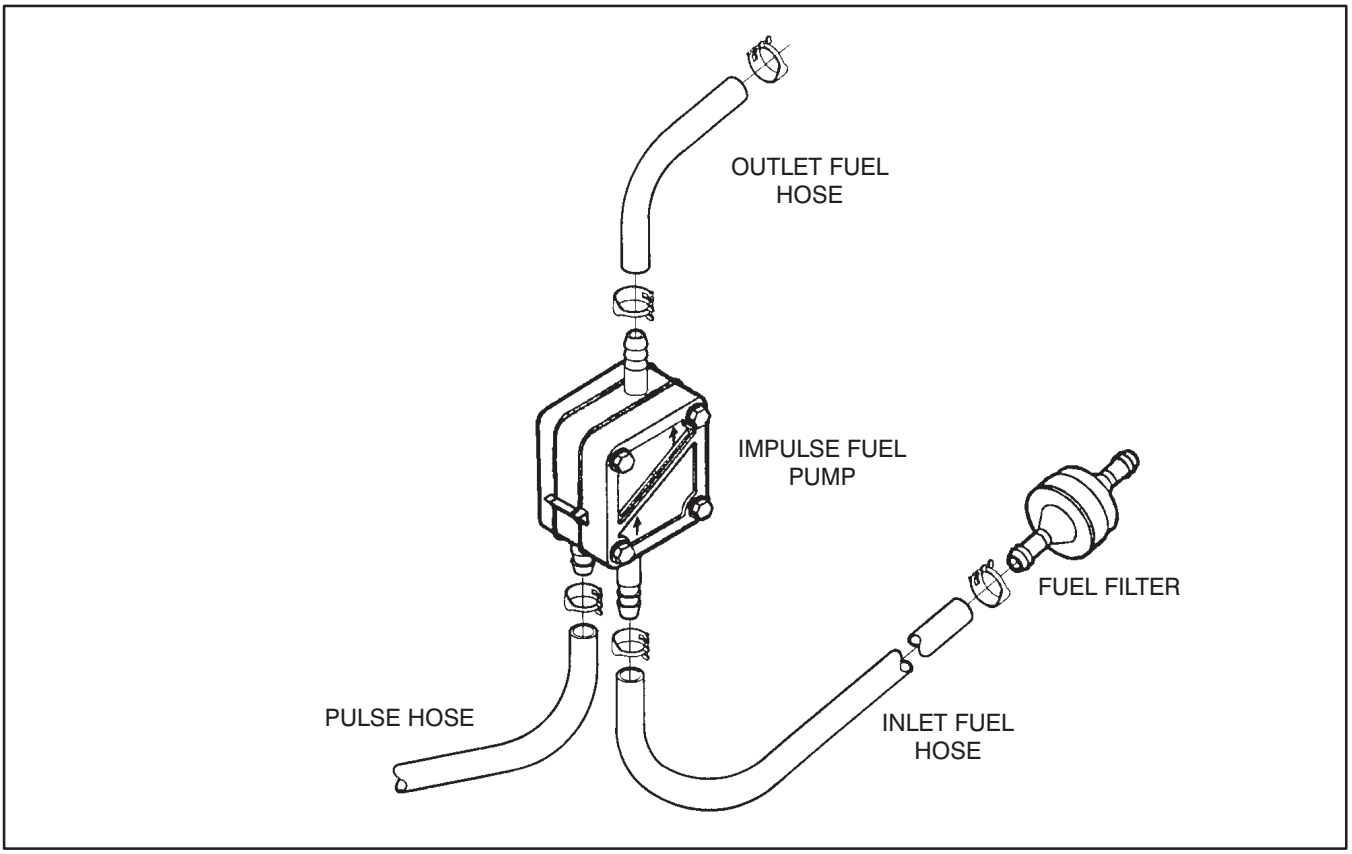


FIGURE 5-4. IMPULSE FUEL PUMP

GOVERNOR ARM

For top performance it is essential that the governor arm, control cables and idle speeds be adjusted properly. The governor arm (Figure 5-5) must be repositioned on its shaft whenever the intake manifold or carburetor is replaced or reinstalled. This must be done BEFORE making speed adjustments so as to compensate for the slightly different alignment of parts after reassembling the carburetor or intake manifold to the engine. See *Section 9. Engine Block Assembly* regarding the internal governor parts.

The governor arm and shaft have been designed so that a standard battery cable clamp lifter available at any automotive parts store can be used to pull the arm from the shaft taper.

⚠WARNING ***Accidental starting of the engine can result in severe personal injury or death. Always disconnect the spark plug and battery (negative [–] cable) before adjusting the governor.***

Governor Arm Removal

1. Remove throttle link 4 from governor arm 6 to prevent damage to the link and carburetor.
2. Loosen lock nut 3 until it extends slightly beyond the end of the shaft.
3. Place the puller arms around the hub of the governor arm, center the puller screw so that it bears on the lock nut and then turn the screw until the governor arm breaks loose.

Governor Arm Adjustment

1. Loosely assemble the governor arm to the governor shaft and start the lock nut.
2. Re-attach link 4 to the governor arm and carburetor. Replace clips 5 if they are worn or broken.
3. Push the top of the governor arm toward the carburetor until it stops and hold it there while performing the next steps.
4. Check to see that the governor spring is pulling the carburetor throttle to the wide open position.
5. Tighten the lock nut, making sure the governor shaft rotates clockwise against the internal governor parts and tighten as specified in *Section 3. Assembly Torques*.

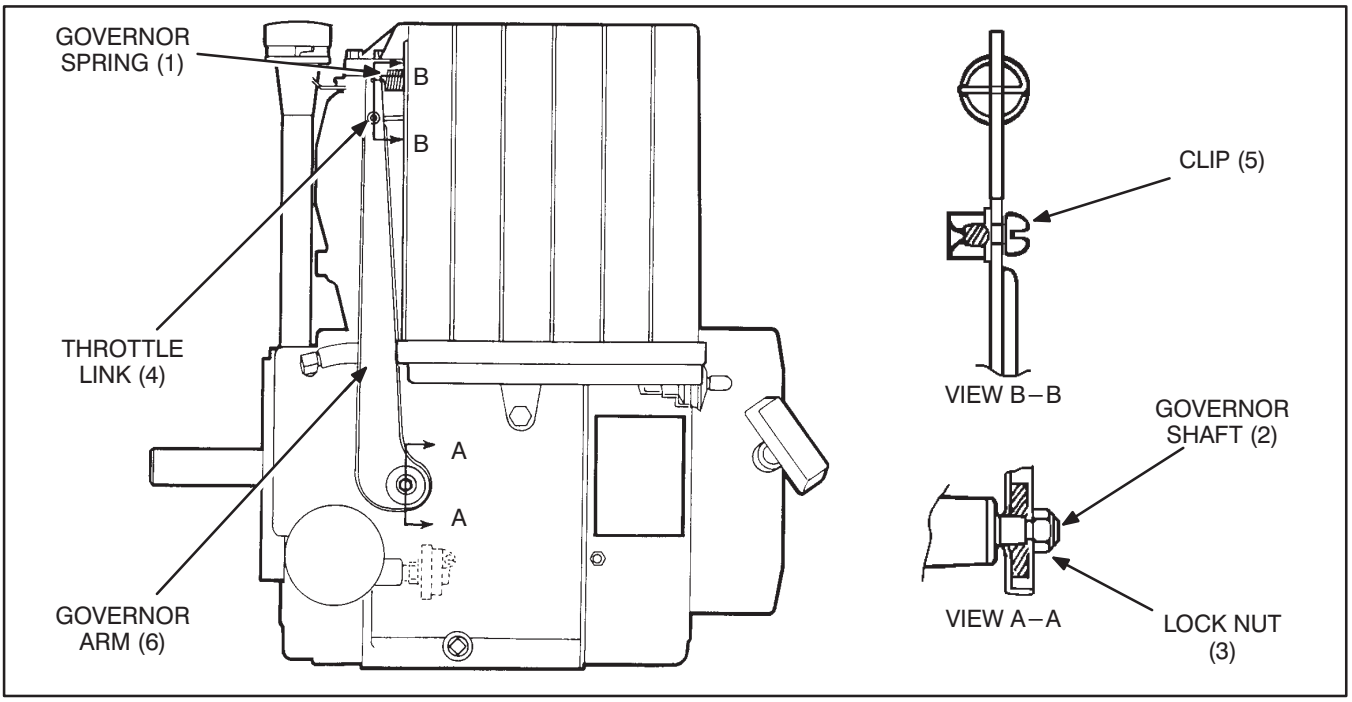


FIGURE 5-5. ENGINE GOVERNOR ADJUSTMENTS

RECONNECTING AND RECLAMPING THE CHOKE AND THROTTLE CABLES

If the engine is so equipped, the choke and throttle cables are secured by a single clamp (choke cable above throttle cable) to a bracket at the top of the engine (Figure 5-6). If necessary, reconnect and reclamp the cables as follows:

1. Stop the engine and disconnect the spark plug and, if so equipped, the battery (negative [–] cable).

   ⚠WARNING ***Accidental starting of the engine can result in severe personal injury or death. Always disconnect the spark plug and battery (negative [–] cable) before resetting the engine control cables.***

2. Push the choke knob in to the full open-choke position and the equipment throttle lever to its lowest speed position.
3. Loosen the cable clamp at the engine bracket if necessary and hook the cable wires into the hook holes in the choke and throttle control arms, if not already hooked. Note that there are two hook holes in each control arm. Make sure the wires are hooked appropriately, as shown, for the cable clamp location being used. Otherwise, the cable will bind, preventing full movement.
4. Rotate the choke and throttle control arms clockwise, and while holding them against their stops, pull the slack out of the cables and tighten the cable clamp.
5. Check for smooth movement and full travel of the equipment choke knob and throttle lever. Remove the air cleaner element as instructed in this section to see that the choke plate opens and closes fully. Move the equipment throttle lever to see that the throttle control arm touches the stop plate and that the throttle shaft arm touches the stop screw.
6. Reassemble the air cleaner and reconnect the spark plug and battery.

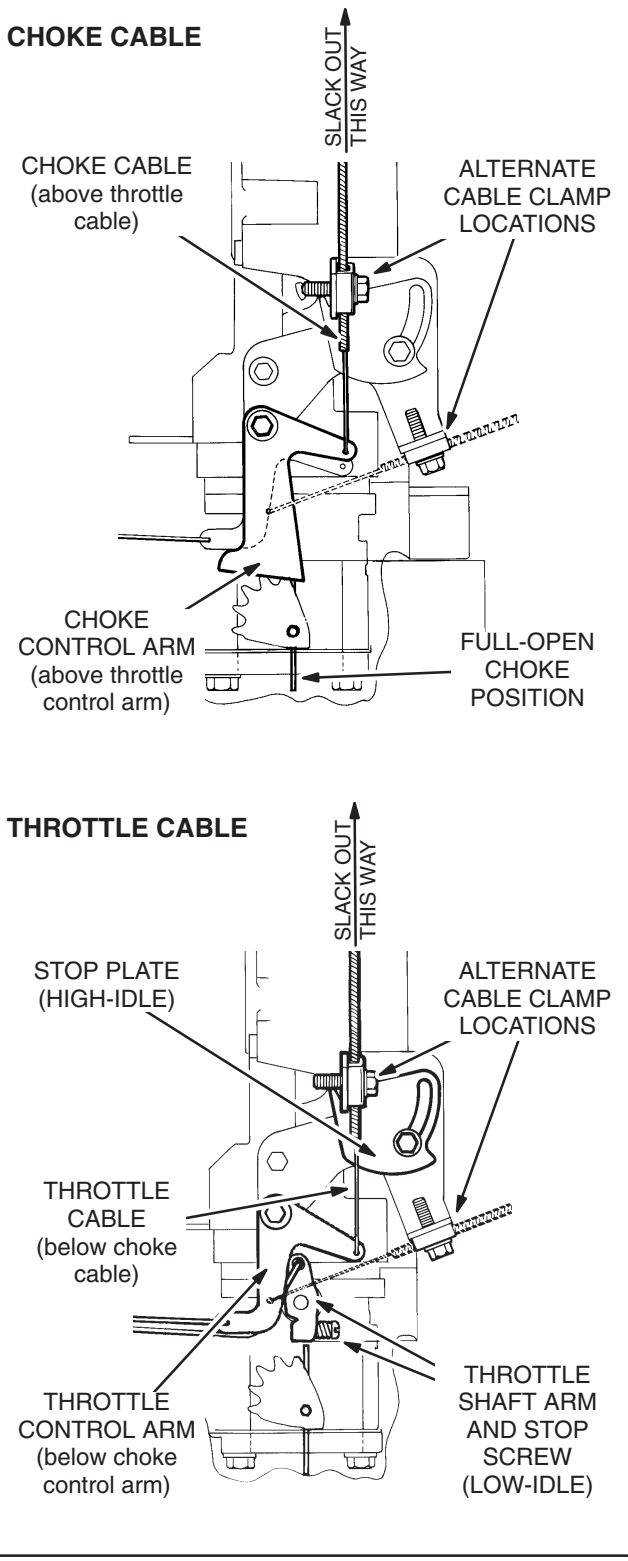


FIGURE 5-6. CHOKE AND THROTTLE CABLES

ENGINE SPEED ADJUSTMENTS

Engine speed adjustment must be attempted only by a qualified mechanic and the adjustments must be made using an accurate tachometer. Set the low-idle and high-idle speeds to the values specified in the equipment Operator's Manual. In the absence of such specifications it is recommended that low-idle speed be adjusted to 1400 RPM and high-idle speed to 3400 RPM.

⚠WARNING ***Adjusting the engine speed to a value above that specified by the equipment manufacture could cause the equipment to operate at speeds in violation of Federal and State Standards for Safety for the equipment.***

⚠WARNING ***Moving parts can cause severe personal injury or death. Take care when measuring engine speed with a tachometer and follow the meter instructions. You must be a qualified mechanic.***

Refer to Figure 5-7. If necessary, first adjust the governor arm and reconnect and adjust the choke and throttle control cables as instructed in this section.

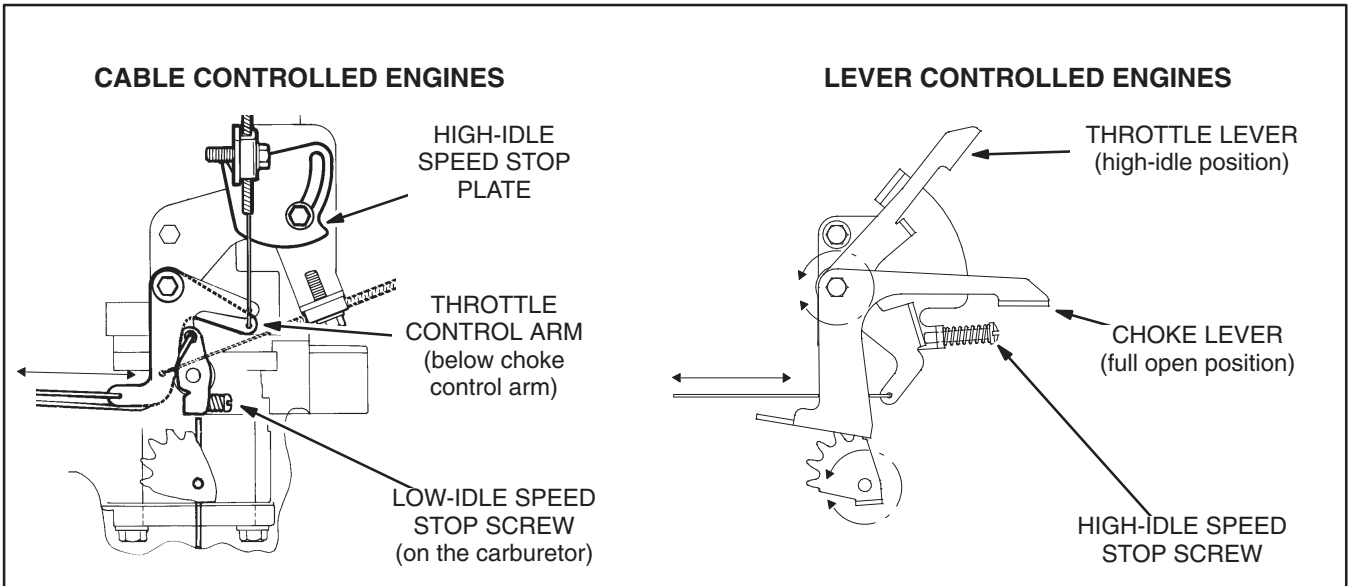
Then adjust the low-idle and high-idle engine speeds as follows:

1. Start the engine, observing all of the equipment manufacturer's instructions and precautions, and move the equipment (engine) throttle lever to its lowest speed position.

2. Adjust the low-idle speed stop screw (on the carburetor) to obtain the specified low-idle speed.

3. On cable controlled engines move the equipment throttle lever to its highest speed position. Loosen the high-idle speed stop plate clamping screw and rotate the stop plate while holding the throttle control arm against it until the specified high-idle speed is obtained and then retighten the clamping screw. On lever controlled engines adjust the lever stop screw while holding the throttle lever up against it until the specified high-idle speed is obtained.

4. Check for full, smooth movement of the throttle control arm (lever) between its two stop positions.



Note: Do not loosen the high-idle speed stop plate (stop screw) unless you are a qualified mechanic and have an accurate tachometer to set the high-idle speed in accordance with the equipment manufacturer's specifications.

FIGURE 5-7. SPEED ADJUSTMENTS

AIR CLEANER MAINTENANCE

Refer to *Periodic Maintenance* in the Operator's Manual for scheduled foam wrapper maintenance and air cleaner element replacement. Refer to Figure 5-8.

Outer Cover

To remove the outer cover, rotate the quarter-turn fastener counterclockwise to its vertical position. Then lift the cover and remove it. To reinstall the outer cover, place the cover over the base, push the quarter-turn fastener in and then rotate it clockwise to its horizontal position.

Foam Wrapper Maintenance

When performing maintenance on the foam wrapper only, do not remove the inner air cleaner cover. Remove and wash the foam wrapper in water and detergent. Squeeze the foam wrapper dry like a sponge. Rinse with clean water and allow it to dry. Coat the wrapper evenly with one tablespoon (14 grams) of SAE 30 engine oil. Knead the oil into the wrapper and wring out the excess oil.

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

Install the foam wrapper over the paper air cleaner element by stretching it over the inner cover. Completely cover all exposed paper pleats. Replace the foam wrapper when it becomes torn or stretched.

Air Cleaner Element Replacement

To keep anything from entering the carburetor and engine while the air cleaner element is off, pull the choke knob to the full-choke position to close the choke plate in the carburetor. Remove the outer cover and wipe away loose dust and debris from the air cleaner assembly. Remove the mounting nut, inner cover and air cleaner element. Wipe off dust and debris from the air cleaner base.

Install the new paper element and secure it with the inner cover and mounting nut. Tighten the nut 1-1/2 turns after seating it on the cover. Reinstall the foam wrapper and outer cover.

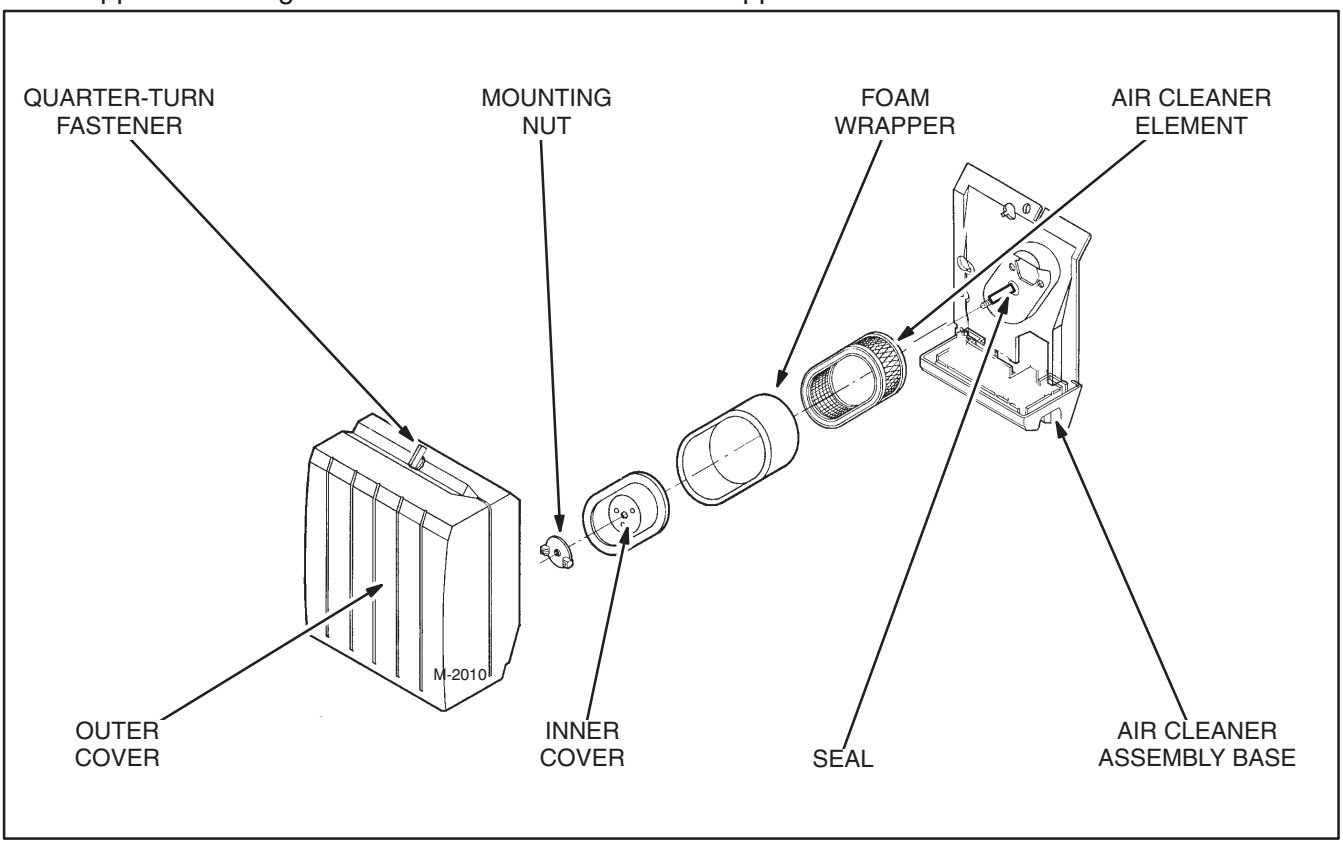


FIGURE 5-8. AIR CLEANER ASSEMBLY

Section 6. Electrical System

IGNITION SYSTEM

Spark Plug

See *Periodic Maintenance* in the Operator's Manual for scheduled spark plug inspection and replacement. See *Section 2. Tolerances and Clearances* for spark plug gap (Figure 6-1).

Clean the area around the plug before removing it. Never assemble a cold spark plug into a hot cylinder head because the plug will get too tight when the engine cools down. To prevent crossthreading the spark plug, always thread it in by hand until it seats. If the spark plug is being reused, tighten it with a wrench an additional 1/4 turn. If the spark plug is new, tighten it an additional 3/8 to 1/2 turn. If you have a torque wrench, tighten it to 20 lbs-ft (26 N-m).

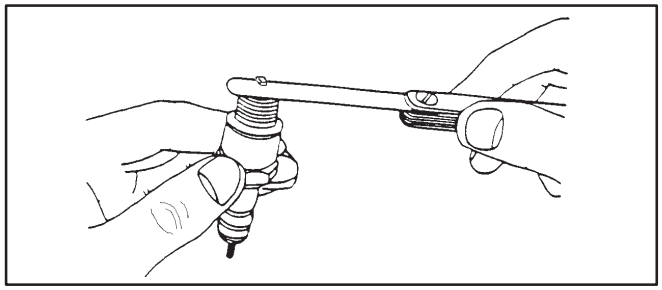


FIGURE 6-1. SPARK PLUG GAP

Magneto

These engines use a magneto consisting of a stationary coil and flywheel magnet to fire the spark plug (Figures 6-2 and 6-3). The primary winding of the coil has a grounding terminal for connecting a shutoff (kill) switch (Figure 6-5). Ignition timing is determined by the angular relationship of the flywheel magnet to the shaft keyway and is not adjustable (Table 1-1, *Section 1. Introduction*).

⚠WARNING ***Gasoline is highly flammable and can cause severe personal injury or death. Make certain that no gasoline or other flammable fumes are present during ignition testing***

⚠WARNING ***Electrical shock can cause severe personal injury or death. Do not touch the ignition components during testing.***

Ignition Spark Check: If the spark plug has been serviced or replaced but the ignition system still appears to be the cause of the problem (see *Section 4. Troubleshooting*), perform an ignition spark check by disconnecting the spark plug cable from the spark plug (do not remove the plug) and connecting it to a test plug. (If you do not have a test plug, use a new plug of the same type.) Ground the side electrode of the test plug to the engine block, crank the engine and observe the test plug. **Do not touch the plug or plug wire during testing**.

- **Good Spark –** The ignition system is not the problem.
- **Weak Spark –** Check and readjust the magneto air gap as instructed in this section. Replace the magneto coil assembly if the spark plug cable and connector are not in good condition.
- **No Spark –** First check to see that:
  - The grounding lead is not damaged or being pinched (see Figure 6-5)
  - The stop (kill) switch is connected properly
  - The low oil pressure cutoff switch is functioning properly.

  Then, if there is still no spark, and the grounding terminal is not being grounded, replace the magneto coil assembly.

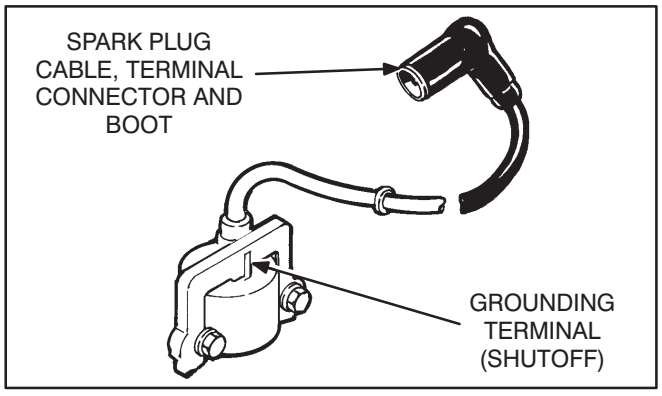


FIGURE 6-2. MAGNETO COIL ASSEMBLY

Magneto Air Gap: Measure the air gap between the core of the magneto coil and flywheel magnet (Figure 6-3). If necessary, loosen the magneto coil mounting screws and readjust the gap as specified (*Section 2. Tolerances and Clearances*).

12 VDC OUTPUT SYSTEM

The engine may be equipped to provide a 12 volt DC (Direct Current) output for powering equipment accessories and/or recharging the cranking battery (Figure 6-4). The system consists of a permanent magnet flywheel alternator and a solid state rectifier/voltage regulator. There are two output ratings available: 5 amp and 20 amp. The 5 amp system has 3 magnets in the flywheel and the 20 amp system 6.

The flywheel must be removed for access to the alternator stator. See *Section 9. Engine Block Assembly.*

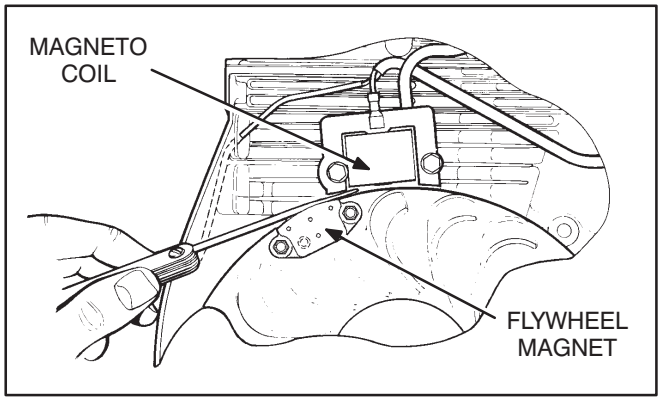


FIGURE 6-3. MEASURING MAGNETO AIR GAP

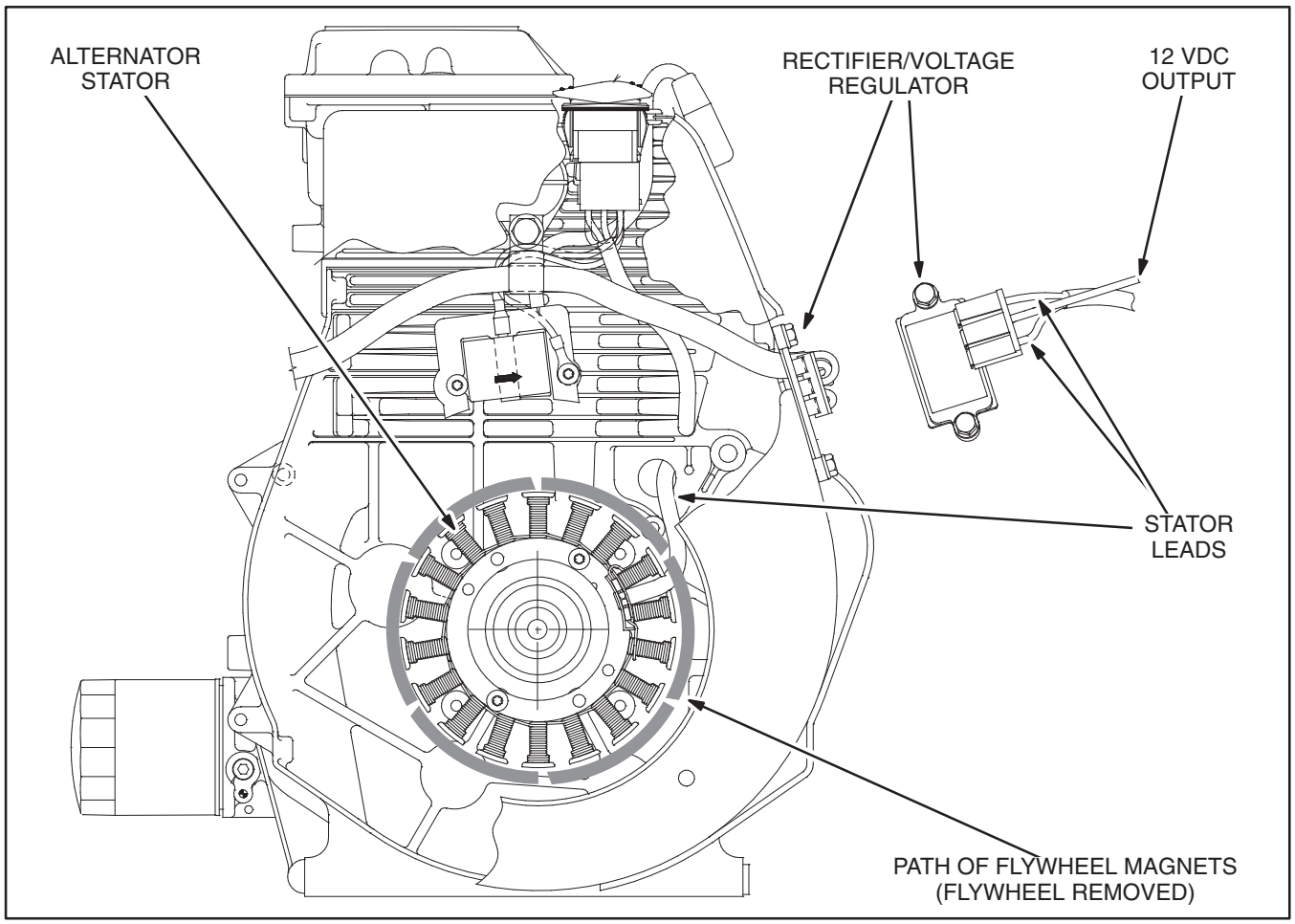


FIGURE 6-4. FLYWHEEL ALTERNATOR AND VOLTAGE REGULATOR

12 VDC System Tests

Keep the following points in mind when testing or servicing the 12 VDC output system.

⚠ CAUTION ***Operation with reversed positive (+) and negative (–) battery connections or without connection to a battery will damage the voltage regulator and/or the alternator stator.***

1. Never reverse the battery leads.

2. Charging system tests require a fully charged battery in good condition. Make sure the engine is being run long enough and fast enough in service to recharge the battery after each start. Alternator output is proportional to engine speed and accessories consume power otherwise available for battery recharging.

3. The voltage regulator has built in protection against open circuit and short circuit faults (B+ terminal). It will not "turn on" under either condition or when battery discharge is extreme.

4. Check to see that the connections at the terminals of the voltage regulator (three) are clean and tight.

5. Check to see that the wiring connected to the **B+** terminal (middle) of the voltage regulator is not damaged, shorted or grounded.

6. To ensure a good ground path to battery negative (–), check to see that the voltage regulator mounting surface is clean and that the screws are tight.

7. Check to see that the positive and negative battery cables have good connections at the battery and engine and that they are not damaged.

After checking all of the above perform the following tests if there still is no alternator output when the engine is running between 1800 and 3600 RPM. Refer to Table 6-1 for test specifications. Use a multi-meter (Simpson 270) when testing the alternator.

TABLE 6-1. 12 VDC OUTPUT SYSTEM TEST SPECIFICATIONS

BATTERY VOLTAGE	VOLTAGE REGULATOR OUTPUT	STATOR OUTPUT	STATOR RESISTANCE
12 to 13 VDC	13.6 to 14.7 VDC @ Any Speed Within Operating Range	Approx. 29 VAC @ 1800 RPM & 57 VAC @ 3600 RPM	5 amp system: 0.54 to 0.66 Ohms 20 amp system: 0.27 to 0.33 Ohms

1. Check battery voltage when the engine is not running. If not within specifications (Table 6-1), charge the battery before going to Step 2.

2. With the engine running, check voltage regulator output (DC voltage) at the battery terminals. Replace the voltage regulator if output is greater than specified. If voltage regulator output is less than specified, go to Step 3.

3. Disconnect the alternator stator leads from the voltage regulator (see Figure 6-4) and test for alternator stator output (AC voltage) with the engine running. If stator output is less than specified, go to Step 4. If stator output is as specified but voltage regulator output is low, replace the voltage regulator.

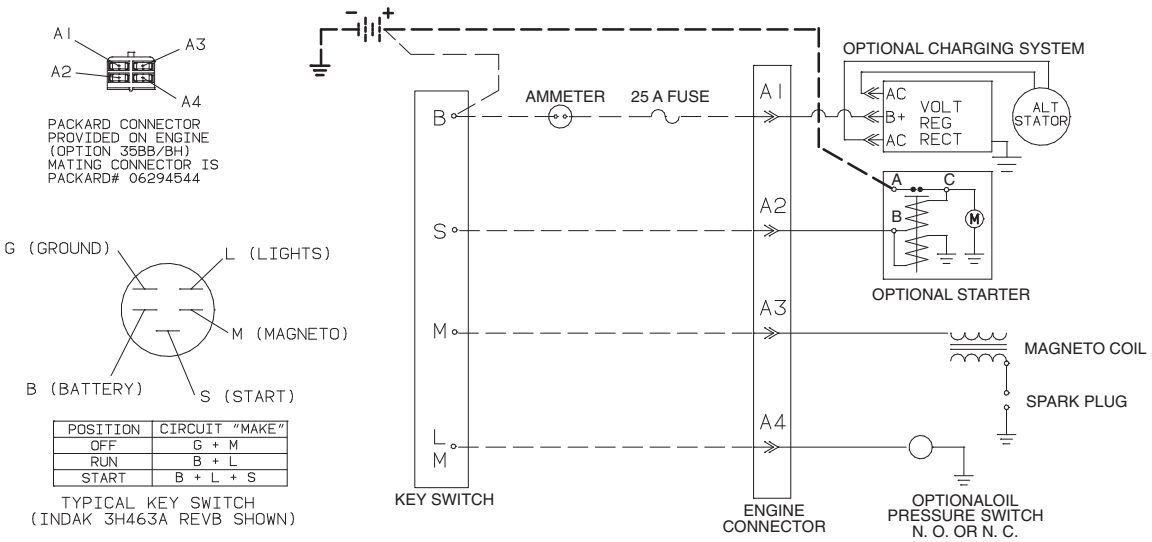
4. Shut down the engine and check for electrical resistance between either alternator stator lead and ground (bare engine metal) using an ohmmeter. The meter should indicate infinite resistance on its highest scale. If resistance is high, go to Step 5. If not, replace the stator.

5. Check alternator stator resistance by connecting an ohmmeter across the stator leads. Replace the alternator stator assembly if stator resistance on the lowest scale of the meter is either higher or lower than specified. Replace the flywheel assembly if alternator stator resistance is as specified but alternator stator output is less than specified. The probable cause is loss of magnetism.

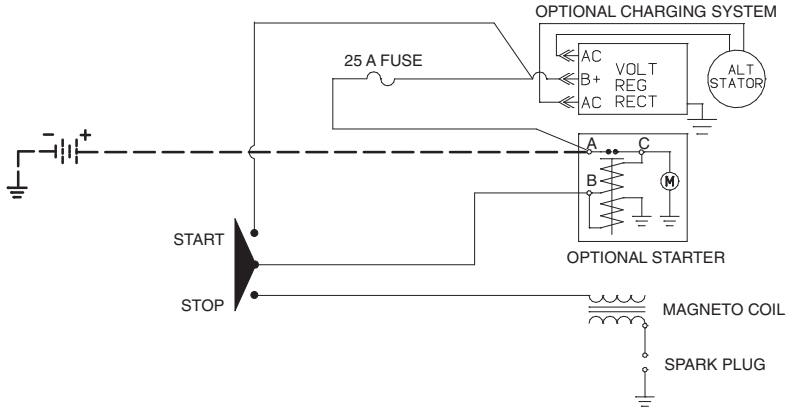
WIRING CONNECTIONS

Figure 6-5 includes schematics of typical engine wiring connections.

WIRING HARNESS WITH 4-PIN CONNECTOR FOR CUSTOMER CONNECTIONS



ENGINE WITH OPTIONAL START/STOP SWITCH



BASIC ENGINE WITH OPTIONAL KILL SWITCH

BASIC ENGINE WITH LEAD FOR KILL SWITCH

NOTE:
ENGINE WIRING SHOWN BY SOLID LINES
AND CUSTOMER SUPPLIED WIRING BY DASHED LINES

FIGURE 6-5. SCHEMATICS OF TYPICAL ENGINE WIRING CONNECTIONS

Section 7. Starting System

⚠WARNING ***Accidental starting of the engine can result in severe personal injury or death. Disconnect the negative (–) battery cable and spark plug wire before servicing the engine, controls, or associated equipment.***

RECOIL STARTER

Disassembly: Refer to Figure 7-1. Remove the four capscrews holding the recoil assembly on the engine. Remove the recoil assembly from the blower housing.

Inspection/Service: Inspect the assembly as a unit. The rope should pull out freely with spring tension, pulling the rope back in without binding or slack. When pulling the rope out, the dog ears should come out of their cup and they should not be bent, broken, or missing.

Assembly: Place the recoil assembly on the blower housing and rotate it so that the cord pull handle is conveniently located for starting the engine. Install and tighten the four capscrews to the torque specified in *Section 3. Assembly Torques.*

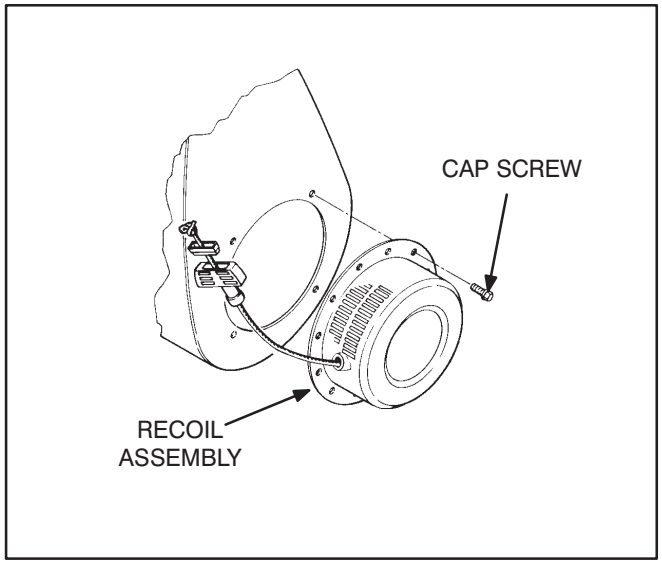


FIGURE 7-1. RECOIL STARTER REMOVAL

SOLENOID SHIFT STARTER

See *Section 6. Electrical* for typical wiring connections at the starter solenoid.

Inspection: Refer to Figure 7-2. Before removing a starter because the engine does not crank:

1. Make sure that the battery is fully charged and that the connections are clean and tight and that the battery cables are in good condition. If it is necessary to reconnect the battery, connect the positive (**+**) battery cable first.

2. Disconnect the spark plug cable so that the engine will not start. Then bypass the start circuit with a jumper between the Start and the Battery Positive (**+**) terminals on the solenoid (Figure 7-2). If the engine cranks, the solenoid and starter are probably okay. If the engine does not crank, go to Step 3.

3. Bypass the starter solenoid with a jumper between the Motor and the Battery Positive (**+**) terminals on the solenoid (Figure 7-2). If the motor responds, it is probably okay and it may only be necessary to replace the solenoid.

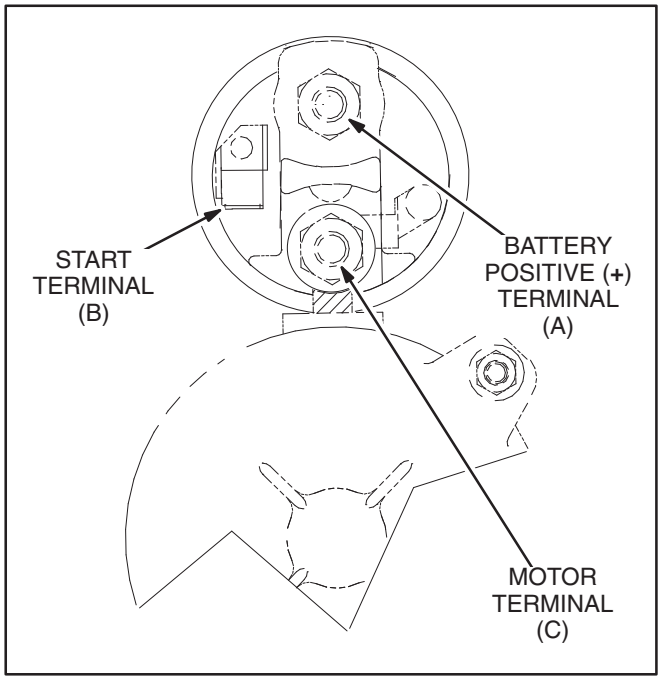


FIGURE 7-2. STARTER SOLENOID TERMINALS

⚠WARNING ***Accidental starting of the engine can result in severe personal injury or death. Disconnect the negative (–) battery cable and spark plug wire before servicing the engine, controls, or associated equipment.***

Disassembly: Refer to Figure 7-3. Remove the starter assembly from the engine if either the solenoid or motor appears to be the part that is malfunctioning. Remove the solenoid mounting nuts and disconnect the connecting lead to the motor. Remove the solenoid by sliding it up to disconnect the shift fork. If the motor is the part that is malfunctioning, continue by removing the two motor through bolts. Before loosening the through bolts, however, scratch register lines on the drive housing, motor frame and end bell so that these parts can be easily reassembled the same way relative to each other. While removing the motor end bell be prepared to catch the brush springs, which tend to spring loose. Remove the brush insulating barrier, brush springs and brush holder. Separate the motor frame from the drive housing and then withdraw the shift fork and armature.

Assembly: Assembly is the reverse of disassembly. Apply grease to the shift fork hinge and prongs and the splines on the armature shaft.

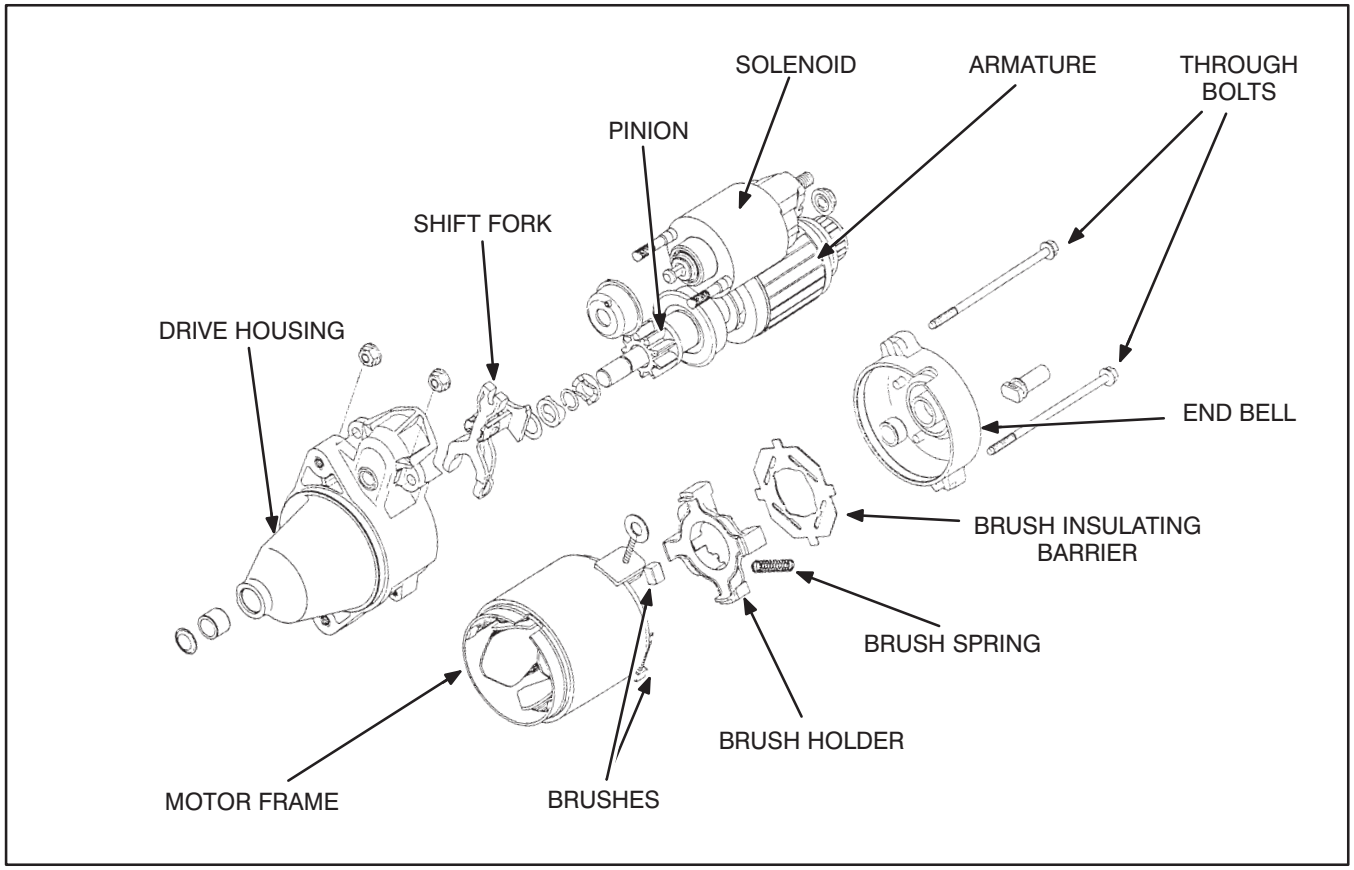


FIGURE 7-3. SOLENOID SHIFT STARTER

Armature

Checking Integrity of Winding Insulation: Refer to Figure 7-4. To check winding insulation integrity, check electrical resistance (use an ohmmeter) between any commutator segment and the armature core and again between the segment and the armature shaft. Replace the armature if the meter does not indicate high (infinite) resistance.

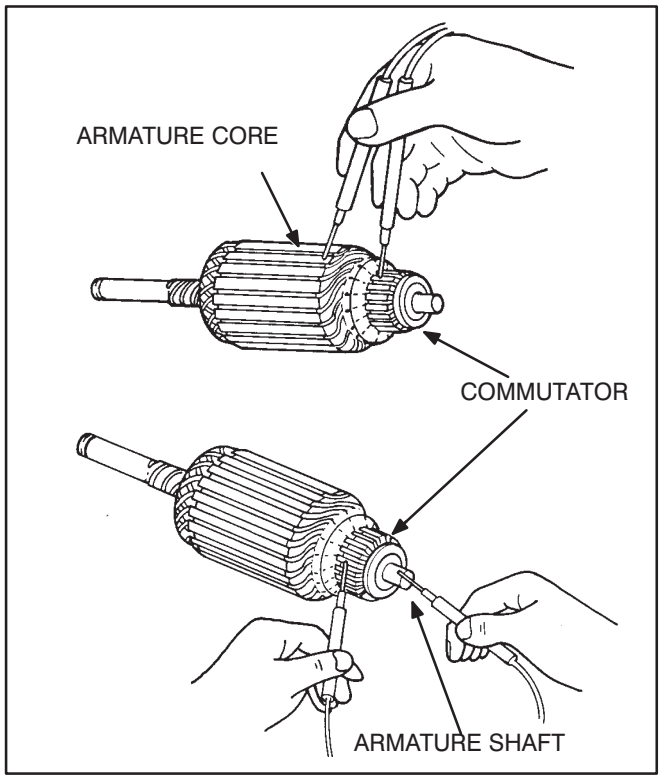


FIGURE 7-4. CHECKING INTEGRITY OF ARMATURE WINDING INSULATION

Checking Integrity of Windings: Refer to Figure 7-5. To check winding integrity, check electrical continuity (use an ohmmeter) between pairs of commutator segments all the way around the commutator. Make sure every segment is checked. Replace the armature if a winding is open (high resistance) at any segment.

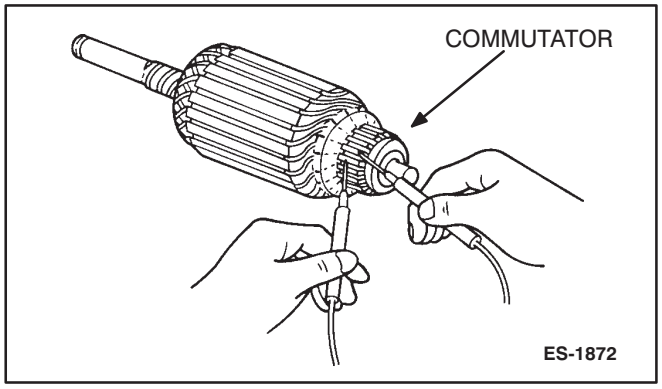


FIGURE 7-5. CHECKING INTEGRITY OF ARMATURE WINDINGS

Motor Frame

Checking Integrity of Windings: Refer to Figure 7-6. Two of the four brushes are connected directly to the motor frame windings, one to each pair of windings. The other ends of the two pairs of windings are crimped directly to the motor frame (grounded). To check the integrity of each winding pair, check continuity (use an ohmmeter) between its brush and the crimp on the motor frame. Replace the motor frame if either winding pair is open (high resistance). (This test will not detect if a single winding of a pair is open. If the windings look burnt or smell bad, it is recommended that the motor frame be replaced.)

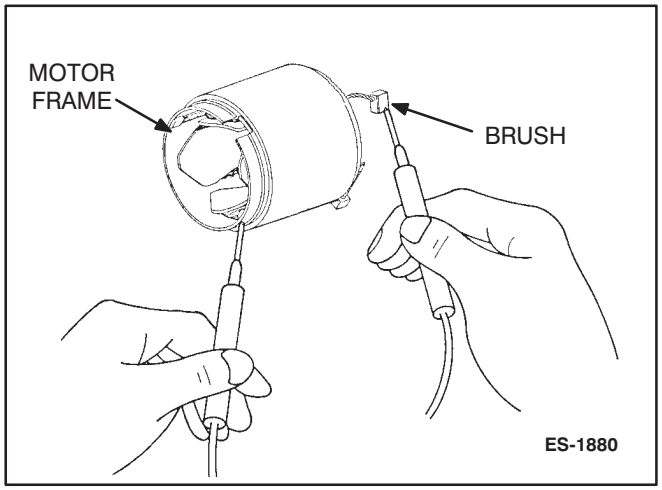


FIGURE 7-6. CHECKING INTEGRITY OF MOTOR FRAME WINDINGS

Brushes

Refer to Figure 7-7. Clean up the brushes with sandpaper and measure their lengths. Replace the motor frame, brush holder and brush springs if any brush is shorter than specified (*Section 2. Tolerances and Clearances*).

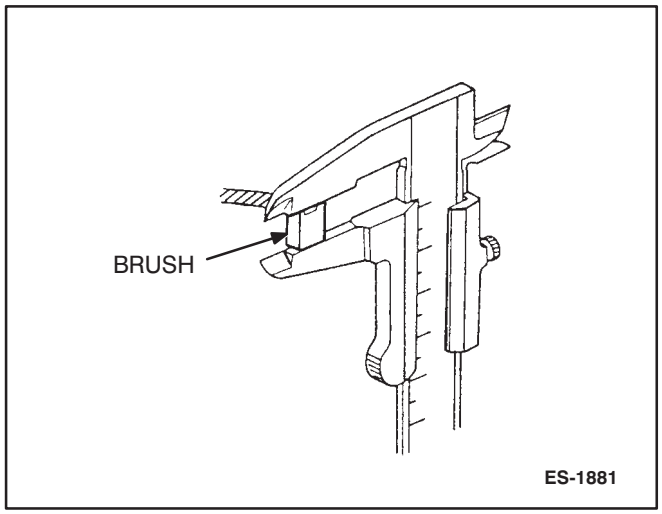


FIGURE 7-7. MEASURING BRUSH LENGTH

Commutator

Commutator: Refer to Figure 7-8. Clean the commutator surface with sandpaper and measure the outside diameter at several locations around the commutator. Turn the commutator in a lathe if the differences in measurements are greater than specified (*Section 2. Tolerances and Clearances*). Replace the armature assembly if the commutator cannot be cleaned up and still meet the specified diameter.

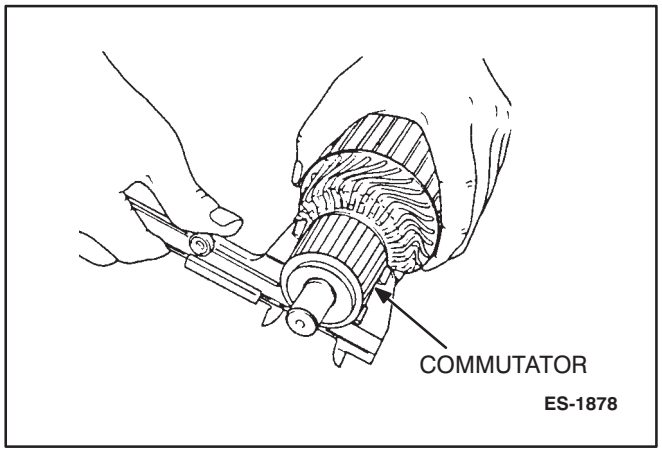


FIGURE 7-8. MEASURING COMMUTATOR O. D.

Commutator Mica: Refer to Figure 7-9. Use a saw blade to undercut the commutator mica if the undercut is less than specified (*Section 2. Tolerances and Clearances*) and chamfer the segment edges.

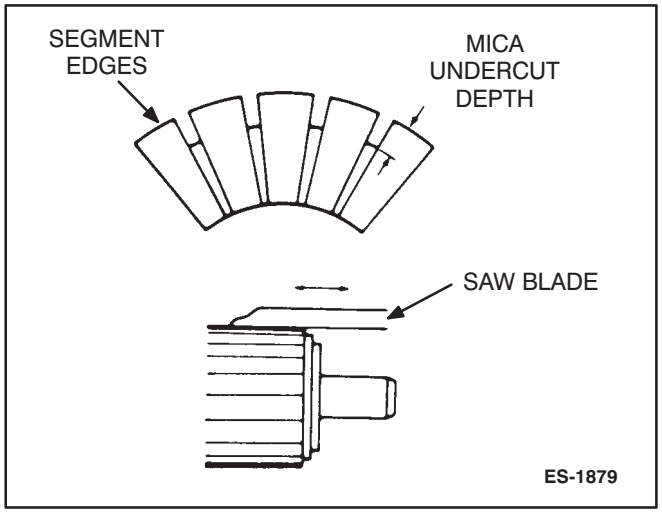


FIGURE 7-9. MICA UNDERCUT DEPTH

Pinion

Inspection/Service: Refer to Figure 7-10. Replace the pinion assembly if the pinion teeth and armature shaft splines are worn or damaged. Check the over-running clutch by rotating the pinion clockwise and counterclockwise. Replace the pinion assembly if it does not turn smoothly counterclockwise or lock clockwise.

⚠ CAUTION ***Cleaning the pinion over-running clutch in liquid cleaning solution will result in starter damage.***

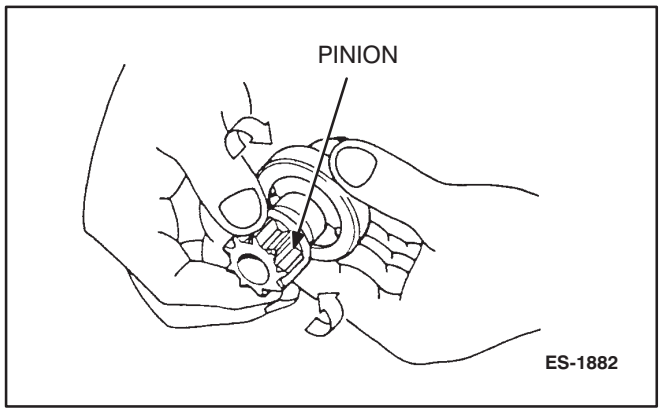


FIGURE 7-10. CHECKING OPERATION OF THE PINION OVER-RUNNING CLUTCH

Armature Shaft Bushings

Refer to Figure 7-11. Measure the inside diameters of the bushings in the starter drive housing and end bell and the corresponding shaft diameters. Replace the bushings if the clearances are greater than specified (*Section 2. Tolerances and Clearances*).

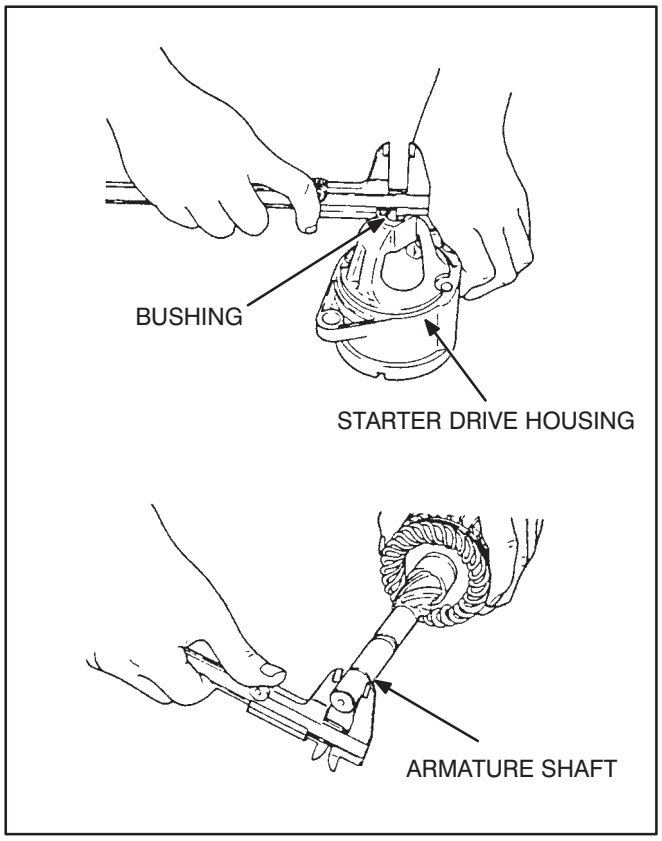


FIGURE 7-11. MEASURING BUSHING I. D. AND ARMATURE SHAFT O. D.

Section 8. Lubrication System

⚠WARNING ***Improper service or replacement of parts can result in severe personal injury and/or equipment damage. Service personnel must be qualified to perform electrical and mechanical service.***

An oil pump is used to provide pressure lubrication, via the oil filter, to the journal bearings in the gearcase and to the crankshaft connecting rod journal (Figure 8-1). The oil pump is located in the gearcase and is driven by a balancer shaft. It is accessible by removing the oil pump cover on the gearcase (Figure 8-3). Oil pressure is controlled by an oil relief valve (Figure 8-7).

Refer to the Operator's Manual for lubricating oil specifications and instructions on how to check the oil level and change the oil and oil filter. The crankcase and oil filter hold 0.95 litre (1 quart) of oil.

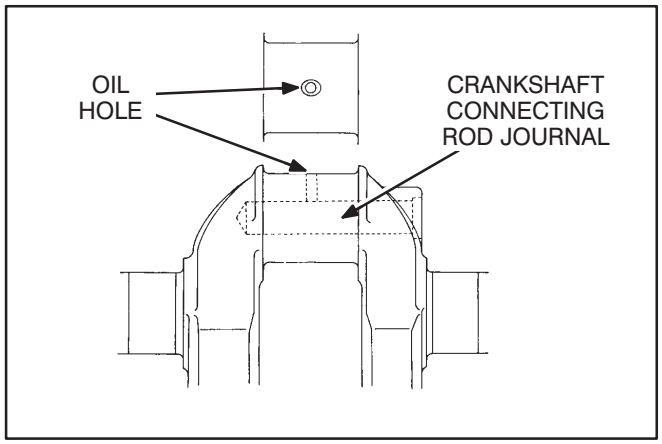


FIGURE 8-1. OIL HOLE IN THE CRANKSHAFT CONNECTING ROD JOURNAL

CHECKING OIL PRESSURE

Refer to Figure 8-2. Install an engine oil pressure gauge in the gearcase as shown. The engine will have an oil pressure switch or a 1/8 inch pipe plug in the tapped hole. Start the engine and observe the oil pressure as the engine warms up. The oil pressure should not be less than that specified in Table 1-1, *Section 1. Introduction*. Low oil pressure may indicate:

- low oil level
- oil of the wrong viscosity
- oil diluted by fuel
- clogged oil filter
- defective oil pump
- clogged oil gallery
- worn crank journal / connecting rod
- defective relief valve or spring

Determine the cause of the low oil pressure and perform the necessary service.

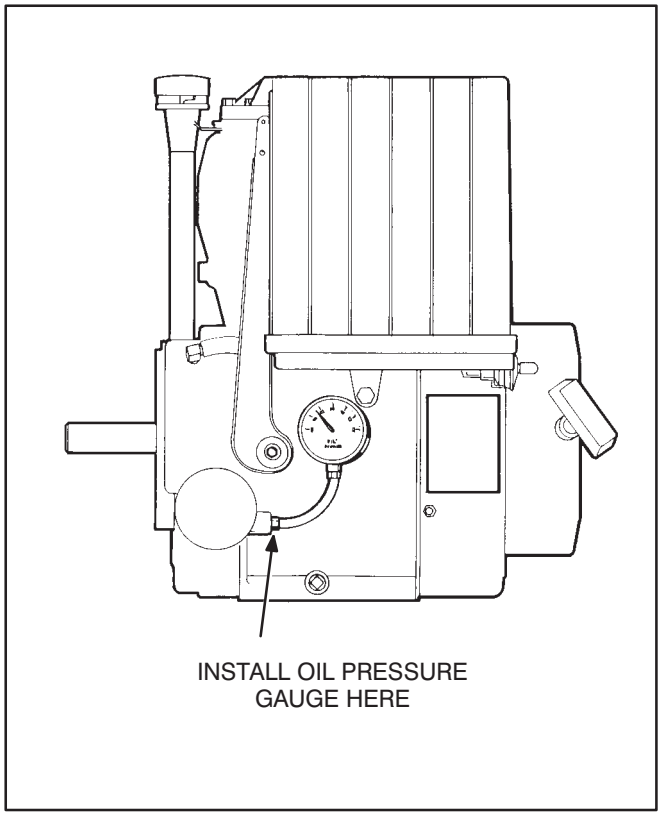


FIGURE 8-2. OIL PRESSURE CHECK

OIL PUMP

Disassembly

Refer to Figure 8-3. Remove the capscrews holding the oil pump cover to the gearcase. Separate the inner and outer rotor.

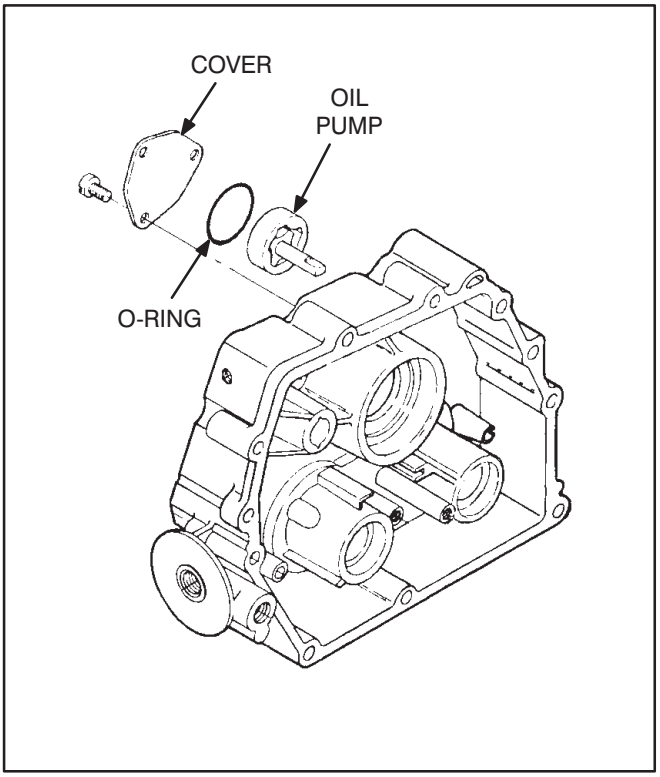


FIGURE 8-3. OIL PUMP DISASSEMBLY

Inspection/Service

Rotor Lobe Clearance: Refer to Figure 8-4. Measure the clearance between the inner rotor lobes and the outer rotor lobes with a feeler gauge. If the clearance is not as specified in *Section 2. Tolerances and Clearances,* replace the oil pump.

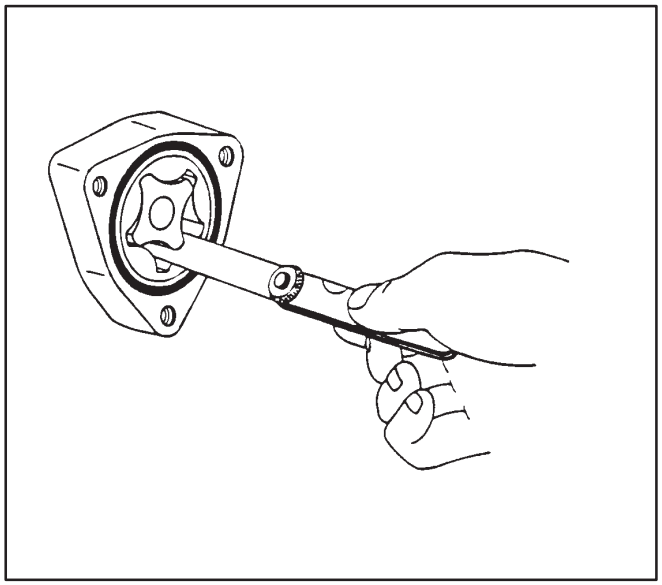


FIGURE 8-4. MEASURING ROTOR LOBE COMPONENTS

Outer Rotor and Pump Body Clearance: Refer to Figure 8-5. Measure the clearance between the outer rotor and the pump body with a feeler gauge. If the clearance is not as specified in *Section 2. Tolerances and Clearances,* replace the oil pump.

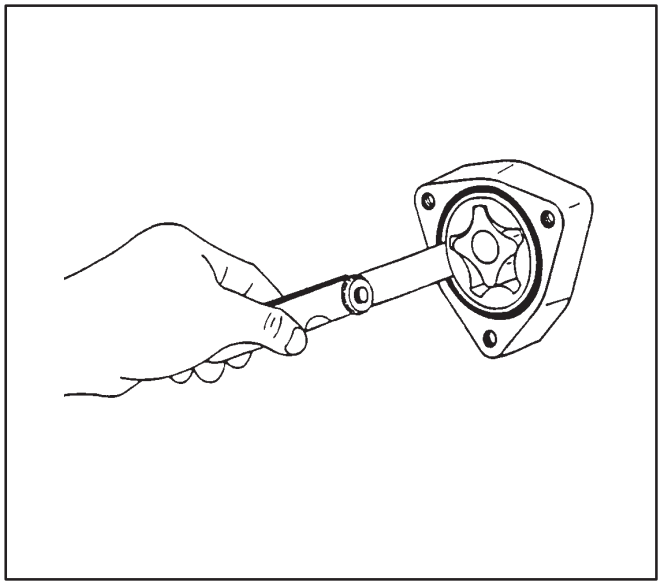


FIGURE 8-5. MEASURING OUTER ROTOR TO PUMP BODY CLEARANCE

Rotor and Cover Clearance: Refer to Figure 8-6. Put a strip of plastigauge on the rotor face. Install the pump cover and tighten the screws to that specified in *Section 3. Assembly Torques.* Remove the cover carefully and measure the width of the plastigauge with the table provided. If clearance is not as specified in *Section 2. Tolerances and Clearances,* replace the oil pump.

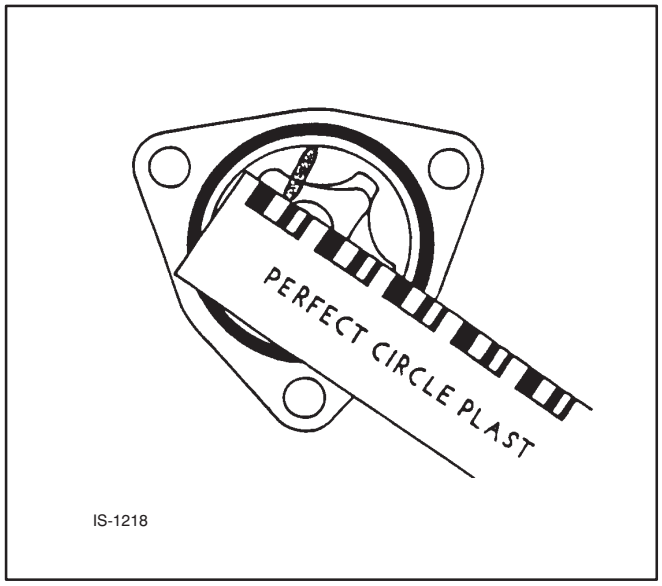


FIGURE 8-6. MEASURING ROTOR TO COVER CLEARANCE

Assembly

Lubricate each part with oil before reassembling. Follow torques given in *Section 3. Assembly Torques* when tightening hardware. Check the oil pressure after servicing or replacing any lubrication system component.

OIL PRESSURE RELIEF VALVE

Disassembly

Refer to Figure 8-7. The oil pressure relief valve is assembled in the gearcase and is accessible only after the gearcase has been removed from the engine block. See *Section 9. Engine Block Assembly.* Remove the retaining ring, relief valve spring, and check ball.

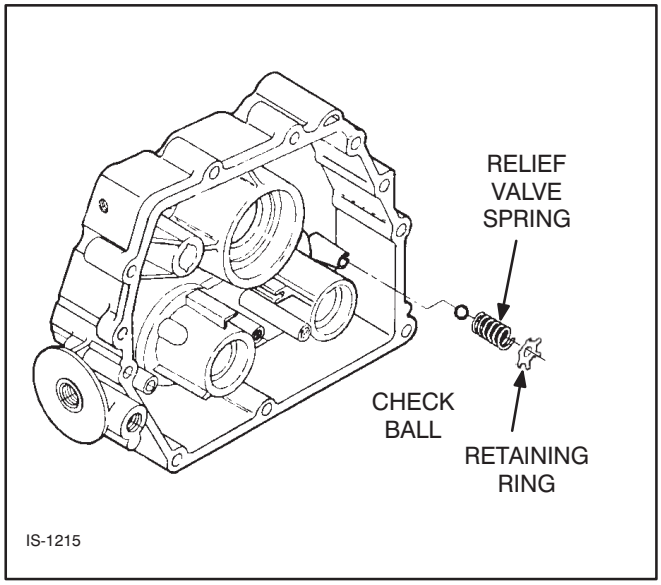


FIGURE 8-7. OIL RELIEF VALVE COMPONENTS

Inspection/Service

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

Wash the components in solvent and allow to dry. Inspect components for damage, wear, etc. Replace parts as necessary.

Assembly

Oil the check ball and oil passage in the gearcase before assembling. Use a new retaining ring and drive it in down to the bottom of the passage counterbore.

Section 9. Engine Block Assembly

⚠WARNING ***Accidental starting of the engine can result in severe personal injury or death. Disconnect the negative (–) battery cable and spark plug wire before servicing the engine, controls, or associated equipment.***

CYLINDER COMPRESSION TEST

It is recommended that a cylinder compression test be performed to determine the condition of valves, piston, piston rings and cylinder. To check cylinder compression pressure:

1. Run the engine until it is thoroughly warm, stop it and remove the spark plug.

2. Remove the air cleaner and place the throttle and the choke in their wide open positions.

3. Insert the compression gauge in the spark plug hole, crank the engine and read the pressure.

The compression gauge should indicate at least 483 kPa (70 psi). There may be variations due to equipment, temperature, atmospheric conditions and altitude. This value is for a warm engine at cranking speed (about 300 rpm).

FLYWHEEL REMOVAL

⚠WARNING ***Improper flywheel removal can result in severe personal injury. Loosen the flywheel nut only a couple of turns before using a flywheel puller so that the nut will restrain the flywheel when it breaks loose from the shaft taper.***

It is necessary to remove the flywheel when rebuilding the engine block assembly or gaining access to the battery charging alternator stator (see *Section 6. Electrical System*). To remove the flywheel, remove the recoil starter assembly if so equipped (including the cup on the flywheel) or the inlet screen, and the surrounding sheet metal. Then loosen the flywheel mounting nut a couple of turns and use a flywheel puller to break the flywheel free of the shaft taper. Remove the woodruff key in the crankshaft.

Replace the flywheel assembly if the ring gear is worn, gear teeth or fan blades are missing or the alternator magnets are weak. Clean up all parts making sure the shaft taper and flywheel bore are clean and free of oil. *Reinstall the key in the shaft* and tighten the flywheel nut to the specified torque (*Section 3. Assembly Torques*).

VALVE ROCKER COVER

Remove the valve rocker cover to gain access to the cylinder head bolts, breather assembly, valve rocker arms, push rods and valves. Always use a new gasket when reinstalling the cover and make sure the mating surfaces are clean and undamaged. Tighten the cover bolts in a two-step, crisscross patten to the specified torque (*Section 3. Assembly Torques*).

ADJUSTING VALVE LASH

See *Periodic Maintenance* in the Operator's Manual for scheduled valve lash adjustments.

The engine must be at room temperature when adjusting valve lash. Remove the valve rocker cover and spark plug. Turn the engine over until the piston is at COMPRESSION TOP DEAD CENTER. Check intake and exhaust valve lash (clearance) with a feeler gauge. If the clearance is not as specified in *Section 2. Tolerances and Clearances*, loosen the locknut and turn the lash adjusting screw until the specified lash is obtained. Tighten the locknut and recheck lash.

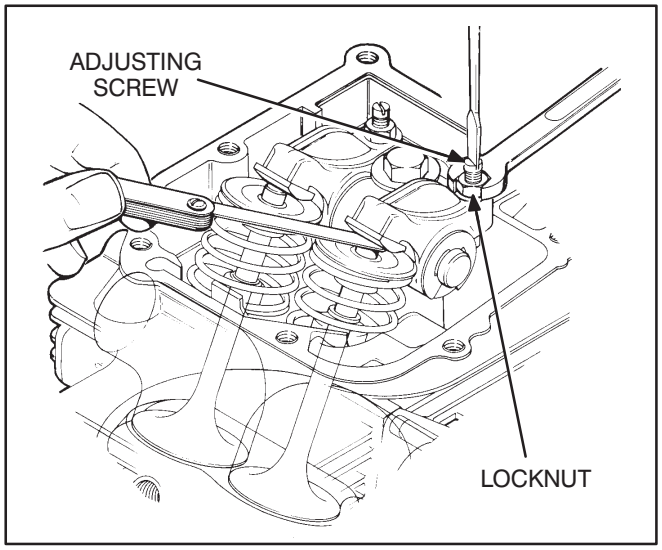


FIGURE 9-1. ADJUSTING VALVE LASH

VALVE ROCKER ARMS

Refer to Figure 9-2. Remove the snap rings and washers on the ends of the rocker arm shaft and pull off the rocker arms. Determine the clearance between rocker arm bore and shaft by measuring the shaft diameter and the rocker arm bore. If the clearances are not as specified in *Section 2. Tolerances and Clearances*, replace the rocker arms and/or shaft.

Apply engine oil to the rocker arm shaft when reassembling the rocker arms.

VALVE PUSHRODS AND TAPPETS

Replace pushrods that are bent or that have worn ends. The pushrods can be removed once the valve rocker arms have been removed.

Replace tappets that have rough, scuffed or worn faces. The tappets can be removed from inside the crankcase once the camshaft has been removed. Also check the cam lobes for scuffing and height if the tappets are worn. Very little wear normally takes place between tappets and the tappet bores in the block. If the tappets feel loose in their bores, it may be necessary to replace the block.

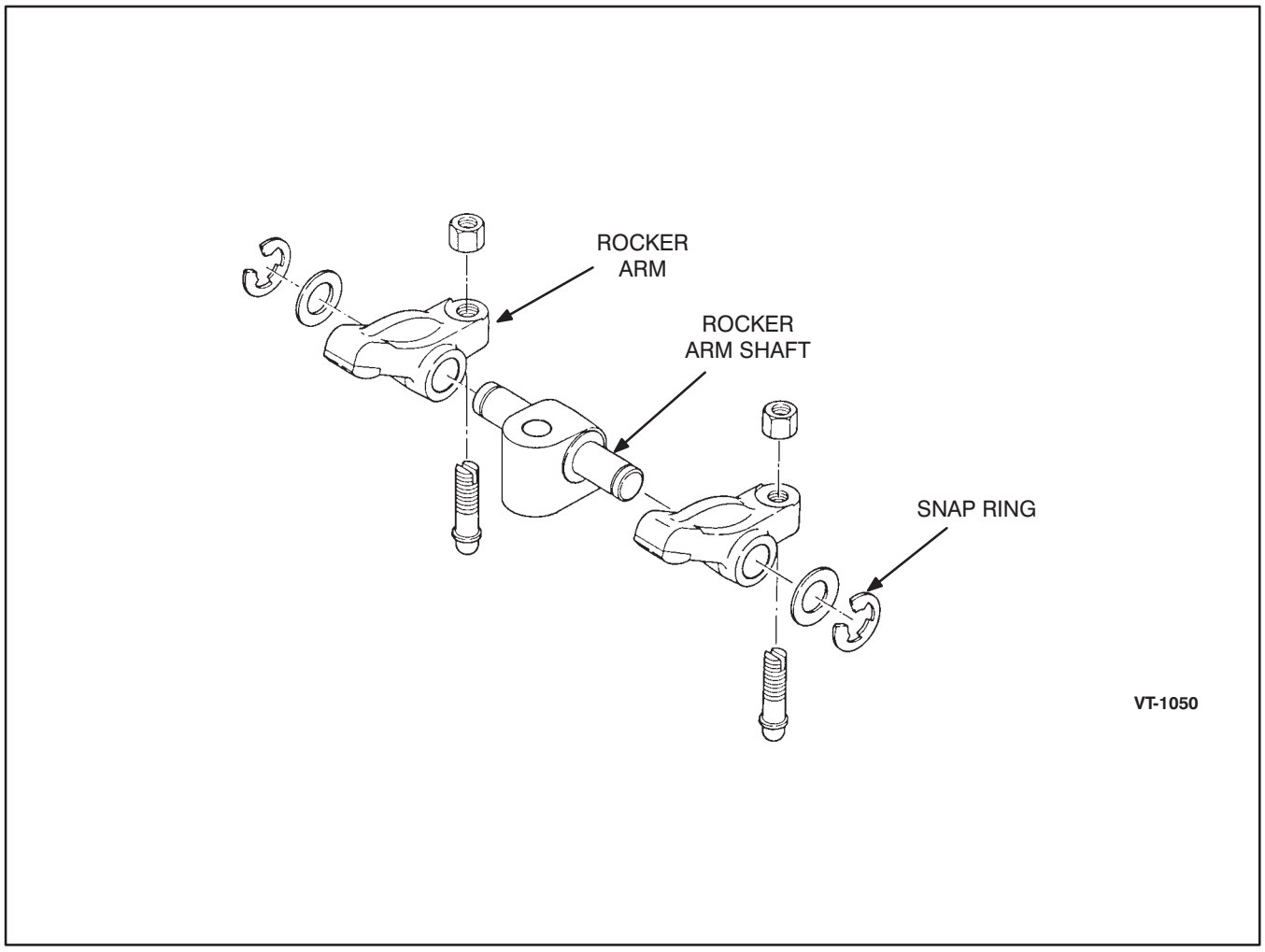


FIGURE 9-2. VALVE ROCKER ARM ASSEMBLY

CYLINDER HEAD

Disassembly

⚠ CAUTION ***The cylinder head can be damaged by removing it when the engine is hot (above 100° F [37° C]). Let the engine cool down before removing the cylinder head.***

Refer to Figure 9-3. Remove the valve rocker cover, rocker arm assembly and spark plug. Pull out the push rods. Remove the remaining cylinder head bolts and remove the cylinder head and head gasket.

Assembly

⚠ CAUTION ***The cylinder head can be damaged by over-tightening the head bolts. Use a torque wrench.***

Install a new cylinder head gasket. Position the cylinder head on the engine and position the rocker arms, bolts, and washers as shown. Make sure the pushrods are properly installed in their tappets and rocker arms. Tighten the cylinder head bolts in the numbered sequence as specified in *Section 3. Assembly Torques*. Retorque bolts 2 and 4 after all bolts have been torqued. Adjust valve lash and replace the valve rocker cover as instructed in this section.

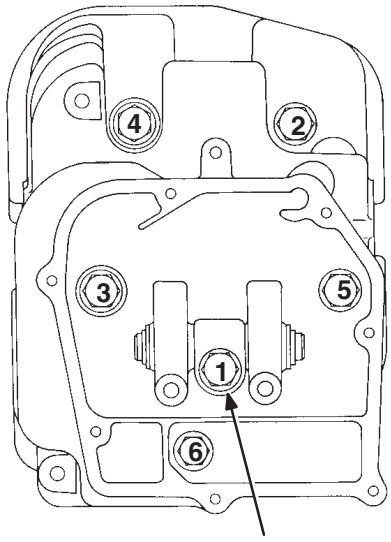


FIGURE 9-3. CYLINDER HEAD BOLTS

VALVES

The engine is of the overhead valve design (Figure 9-4). A properly functioning valve system is essential for top engine performance.

Disassembly

Remove the rocker arm assembly and the cylinder head from the engine as instructed in this section. Compress the valve springs and pull out the valve locks. Remove the valve spring retainers, valve springs, washer (shield on exhaust valve only), and valves.

Reassembly

After cleaning, inspection and service, apply engine oil to the valves and valve guides and reassemble the valves in the reverse order in which they were disassembled.

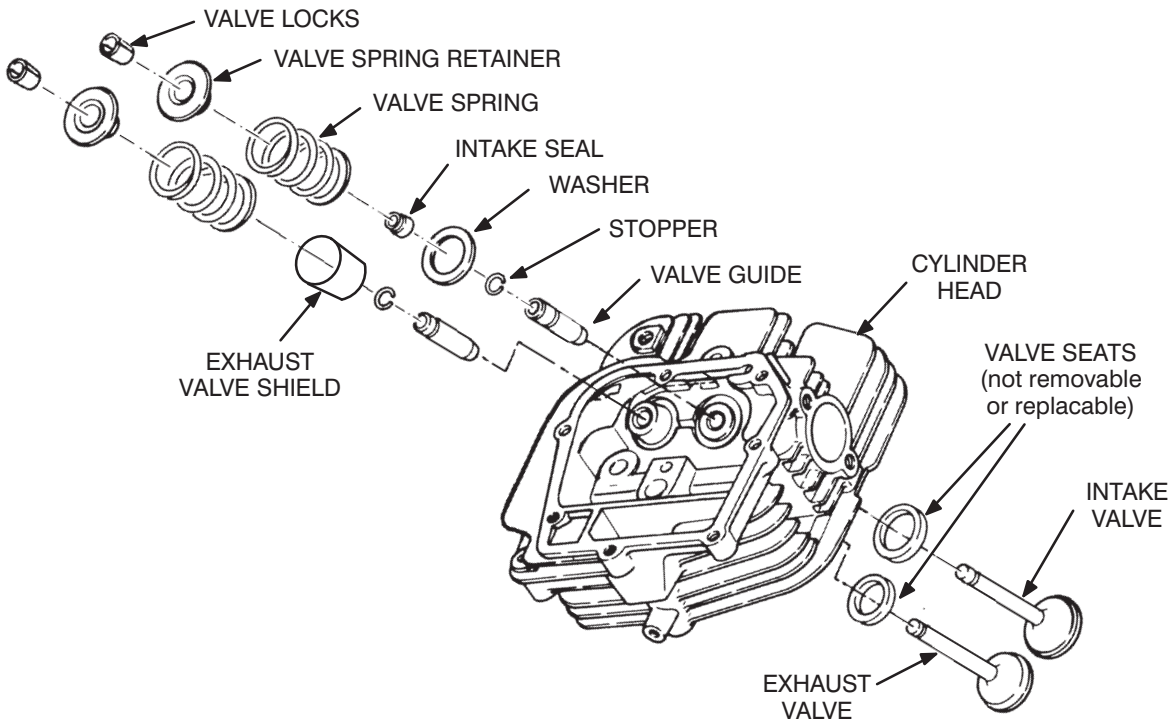


FIGURE 9-4. VALVE ASSEMBLY

Inspection and Service

Valve Stem and Valve Guide Clearance: Refer to Figures 9-5 and 9-6. Remove carbon from the valve stems and guides. Measure the valve stem outside diameter at six locations. Measure the valve guide bore at three locations. Calculate the clearance. If the clearance is not as specified in *Section 2. Tolerances and Clearances*, replace the guide or guide and valve.

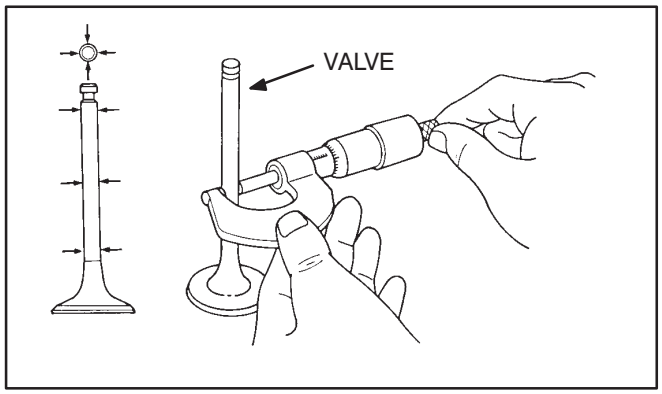


FIGURE 9-5. MEASURING VALVE STEM DIAMETER

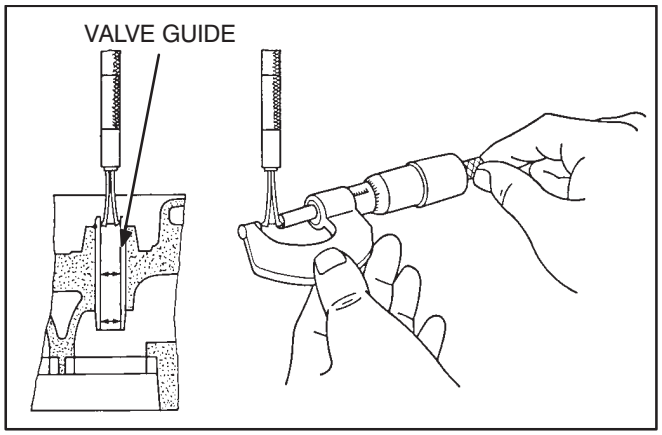


FIGURE 9-6. MEASURING VALVE GUIDE BORE

Valve Guide Replacement: Refer to Figure 9-7. Press out the valve guide using a special valve guide replacing tool. Apply engine oil to the new valve guide, install the stopper ring on the guide and press the guide in until the stopper ring contacts the cylinder head.

⚠ CAUTION ***Driving out old valve guides can cause guide and guide bore damage. Do not strike guide or guide bores with driver during removal.***

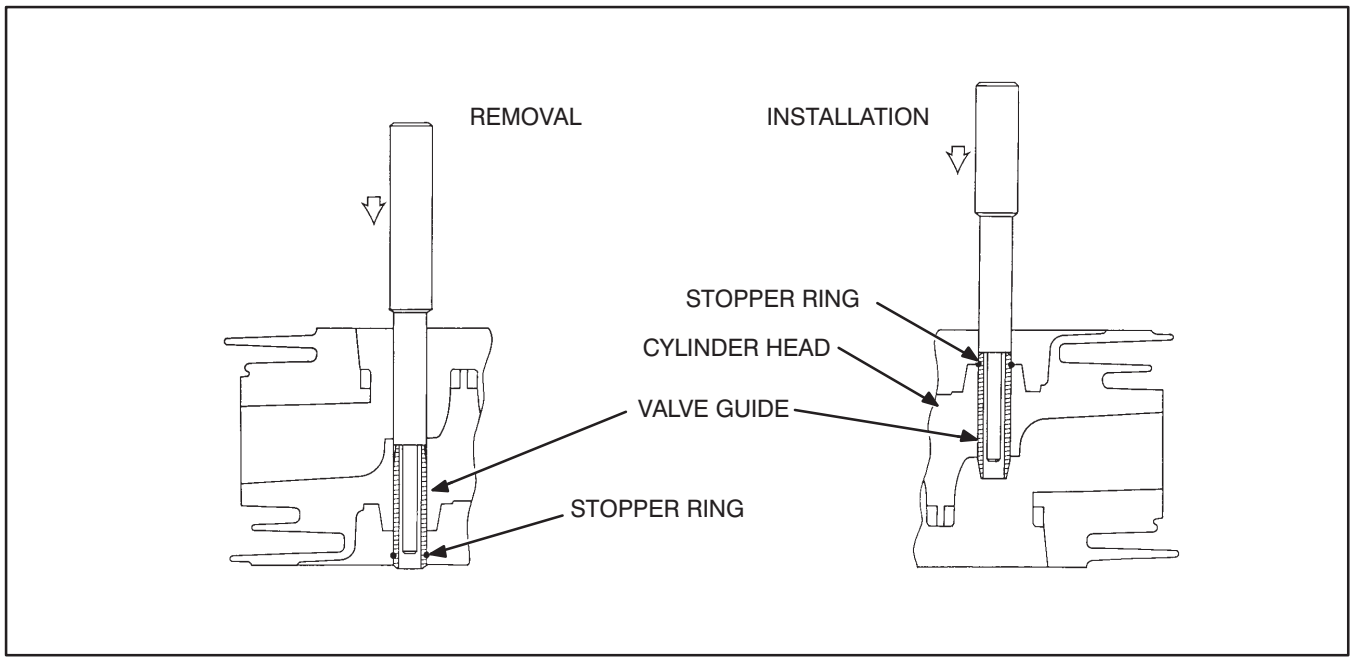


FIGURE 9-7. REPLACING VALVE GUIDE

Valve Face: Refer to Figure 9-8. Refinish used valves with a valve grinding machine. The specified face angle is 45°. Remove all pits and groves on the valve face, removing as little material as possible. A margin of at least 0.030 inch (0.8 mm) is required for strength and good heat dissipation. If the end of the valve stem is worn, true it up square with the stem using the refacer wheel of the valve grinding machine. If the valve is warped, a knife edge will form. (Make sure the valve is being held properly in the grinder chuck.) Replace a valve that cannot be refinished properly.

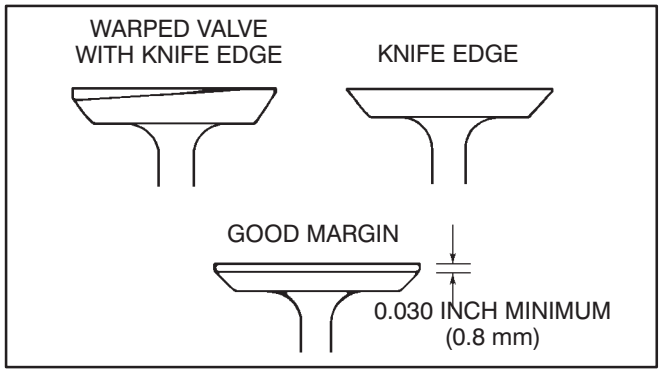


FIGURE 9-8. VALVE HEAD MARGIN

Valve Seat: Refer to Figures 9-9 and 9-10. Clean the valve seat and measure the seat width. Apply red lead to the new or refinished valve face and rotate it against the valve seat to check for pits and groves in the seat and for proper valve seating. Use a 45° valve seat cutter to remove all pits and groves in the seat, and if the valve guide was replaced, to make the valve guide bore and valve seat concentric. Relieve the face of the seat with a 15° valve seat cutter, if necessary, to obtain the specified seat width and to seat the contact area in the middle third of the valve face. It may be necessary to alternate cuts between the 45° and 15° cutters to seat the valve properly. Replace the cylinder head if there is insufficient valve seat material left to clean it up and properly seat the valve.

Lapping compound is not recommended for seating valves. If it is used, thoroughly flush the cylinder head with soap and water to remove every trace of the abrasive material so that it will not enter the engine and cause wear.

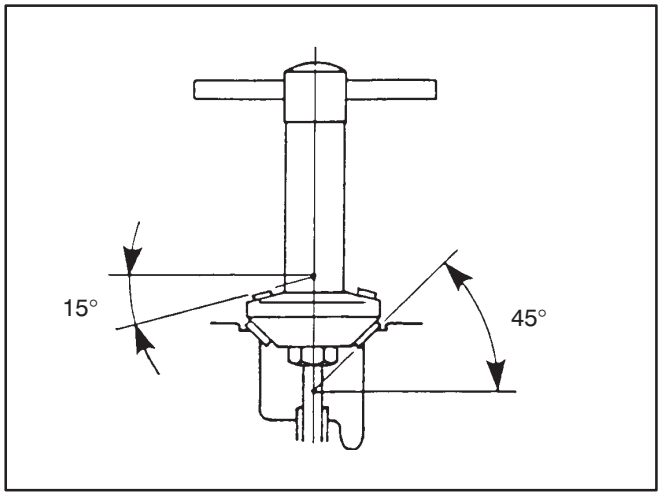


FIGURE 9-9. VALVE SEAT CUTTER

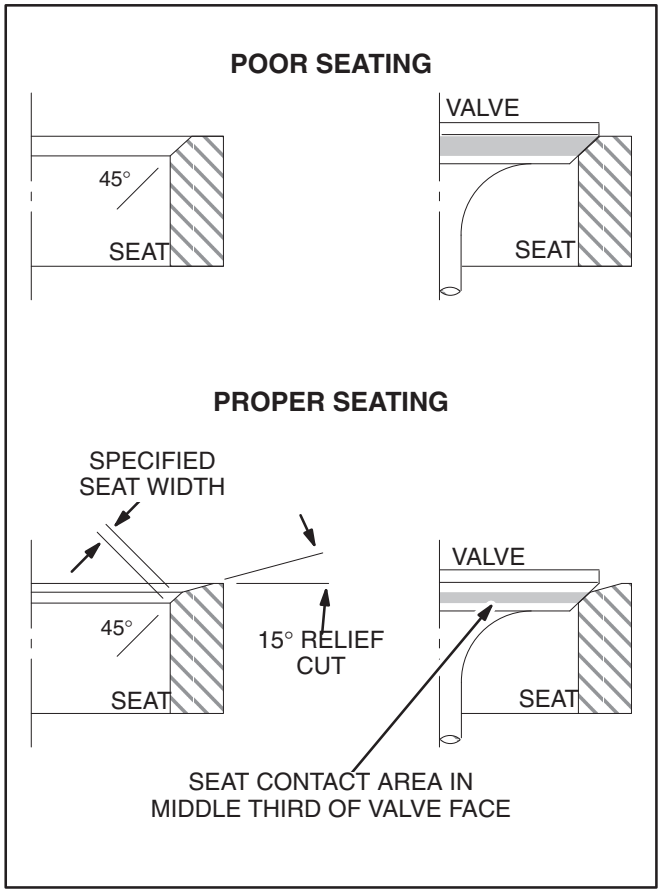


FIGURE 9-10. VALVE SEATING

Valve Springs: See Figure 9-11. Check spring free-height, squareness, end wear and open-valve spring tension. Check the valve spring retainers for wear also if the spring ends are worn. Check spring height (A) by placing the spring on a flat surface next to a square. Check squareness by rotating the spring against the square. The spring is not considered square if (B) exceeds 1.5 mm (0.06 inch). Check open-valve spring tension using an accurate valve spring tester. Replace a valve spring that is weak, broken, worn or not square.

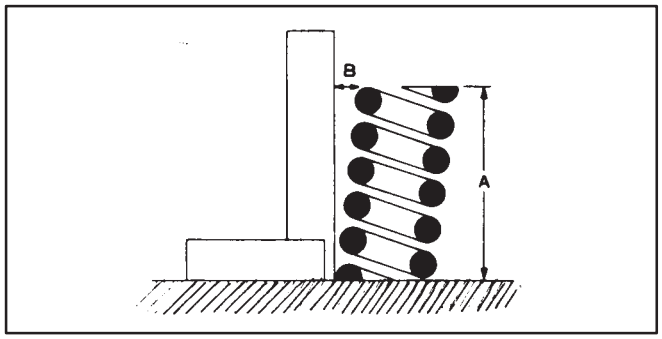


FIGURE 9-11. MEASURING VALVE SPRING HEIGHT AND SQUARENESS

ENGINE DISASSEMBLY/ASSEMBLY

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

Suggested Disassembly Order

1. Drain crankcase oil.
2. Disconnect all fuel, exhaust and electric lines.
3. Remove the engine from its mountings and place it on a suitable bench or work stand.
4. Remove the muffler, fuel tank, chaff screen, blower housing, cylinder shroud, etc.
5. Remove the air cleaner assembly, carburetor, and air deflector.
6. Remove the magneto coil.
7. Remove the flywheel (use a puller) and the alternator stator.
8. Remove all accessories such as oil filter, starter, intake manifold, exhaust manifold, etc.
9. Remove the cylinder head assembly.
10. Remove the gearcase. *Note that the four shafts supported inside the gearcase have end play shims which may stay on their shafts or come off with the gearcase. Locate each shim right away and identify it or wire it to its shaft so that it can be reinstalled on its shaft.*
11. Remove the balancer shaft assemblies.
12. Remove the connecting rod/piston assembly.
13. Remove the crankshaft and camshaft.
14. Remove the valve tappets.
15. Remove the governor assembly.

Keep all parts in their respective orders. Keep valve assemblies together. Analyze the reasons for parts failure.

Suggested Assembly Procedure

Engine assembly is normally the reverse of disassembly. See *Section 2. Tolerances and Clearances*. Use a torque wrench. 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 the engine.

1. Install the valve tappets, crankshaft and camshaft.
2. Install the connecting rod/piston assembly.
3. Install the balancer shafts.
4. Install the governor assembly.
5. Install the gearcase.
6. Install the cylinder head assembly and adjust valve lash.
7. Install the accessories such as the oil filter, starter, intake manifold, exhaust manifold, etc.
8. Install the alternator stator and flywheel.

9. Install and gap the magneto coil.

10. Install the air deflector, carburetor, and cleaner assembly.

11. Install the cylinder shroud, muffler, fuel tank, blower housing, chaff screen, etc.

12. Install the engine on its mounting.

13. Connect all fuel, exhaust and electric lines.

14. Fill the crankcase with oil.

Operation

Start the engine and check oil pressure. Run for approximately 15 minutes to bring engine to operating temperatures. Check for oil, fuel, and exhaust leaks. Adjust low- and high-idle speeds. See *Fuel System*.

GEARCASE

Disassembly

Remove the oil pressure switch (if provided) located next to the oil filter. Unscrew the gearcase mounting screws. Tap the gearcase with a plastic hammer to remove it. Do not pry it off with a screwdriver, chisel, etc. Note where all shims come off from. (They may come off with the shaft or remain in the bore in the gearcase.)

Assembly

Always use a new gearcase gasket and crankshaft oil seal. See BALL BEARINGS and CRANKSHAFT OIL SEALS at the end of this section for instructions on how to replace ball bearings and oil seals. Install the shaft end clearance shims on their original shafts (Figure 9-12). Use Plasti-gage to check shaft end clearnce whenever a gearcase, crankshaft, camshaft or a balancer shaft is replaced and obtain the shims necessary to meet the end clearance specified in *Section 2. Tolerances and Clearances.*

Apply grease to the lip of the crankshaft oil seal and make sure it is not damaged when installing the gearcase. Be sure the oil pump shaft lines up with the slot on the balancer shaft. Tighten the gearcase mounting bolts in a clockwise pattern to the torque specified in *Section 3. Assembly Torques*. Torque the bolt first torqued once more.

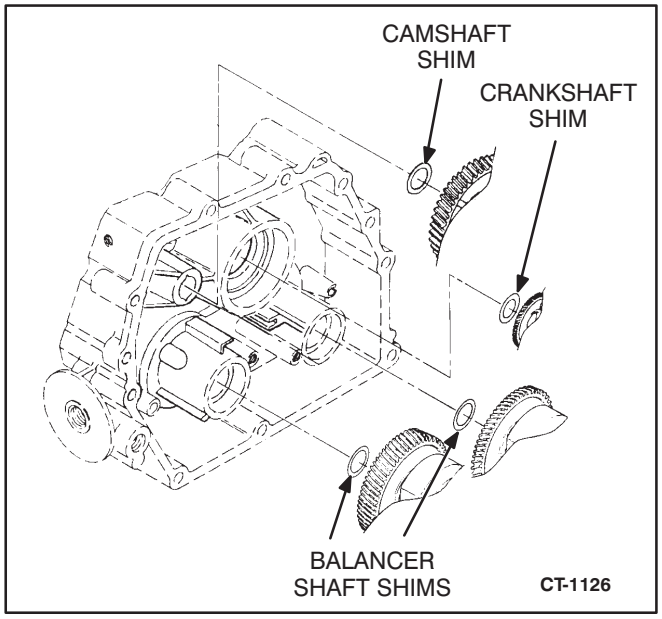


FIGURE 9-12. SHAFT END CLEARANCE SHIM LOCATIONS

GOVERNOR

With the gearcase removed, the governor can be inspected or disassembled for service. The governor assembly must spin freely on the center pin without excessive looseness or wobble. Sleeve tip wear is the most common cause of governor failure. Check for flat spots on the sleeve tip. If the governor sleeve, gear, or flyweights are worn or damaged, replace them.

To disassemble, pull the governor gear assembly off the mounting shaft (Figure 9-13). To assemble, install the washer, gear assembly, and retainer onto the shaft. Thread the sleeve between the flyweights and push the assembly onto the shaft. See inset drawing (Figure 9-13) for position of flyweight and sleeve.

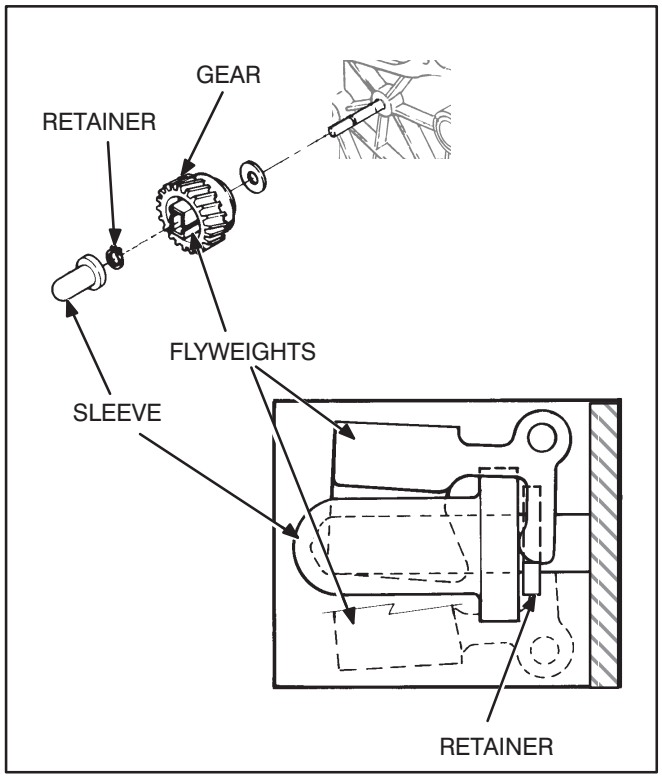


FIGURE 9-13. GOVERNOR

BALANCER SHAFTS

Disassembly

Carefully pull each shaft out, one at a time.

Journal Bearing Clearance: Measure the journal O. D. of each balancer shaft and the corresponding bearing I. D. in the gearcase. Replace the gearcase and/or balancer shaft(s) if the clearance is not as specified in *Section 2. Tolerances and Clearances*.

Assembly

Refer to Figure 9-14. Align the alignment marks on the gears. The crankshaft has two alignment marks which must line up with balancer shaft 1. Balancer shaft 1 has one alignment mark which must line up with the one alignment mark on balancer shaft 2. Install each shaft one at a time.

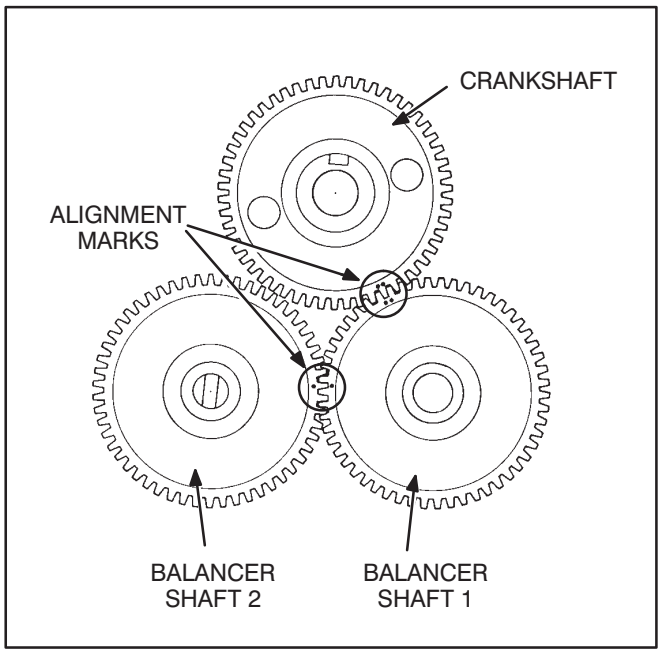


FIGURE 9-14. BALANCER SHAFT ALIGNMENT

CRANKSHAFT AND CAMSHAFT

Disassembly

Set the engine block on the flywheel side. Pull the crankshaft out with the camshaft. Remove the tappets.

Inspection/Service

Crankshaft Journal: Refer to Figure 9-15. Measure the crankshaft journal diameter. If the diameter is not as specified in *Section 2. Tolerances and Clearances,* or is scored, grind it to the next undersize for which an undersize connecting rod is available. The corner radii of the journal must be ground to 0.07 to 0.09 inch (1.8 to 2.2 mm). Chamfer the oil hole circumference with an oil stone to a 0.04 to 0.06 inch (1.0 to 1.5 mm) radius. The journal surface must be fine finished to higher than 6 µin (0.4 µm Ra).

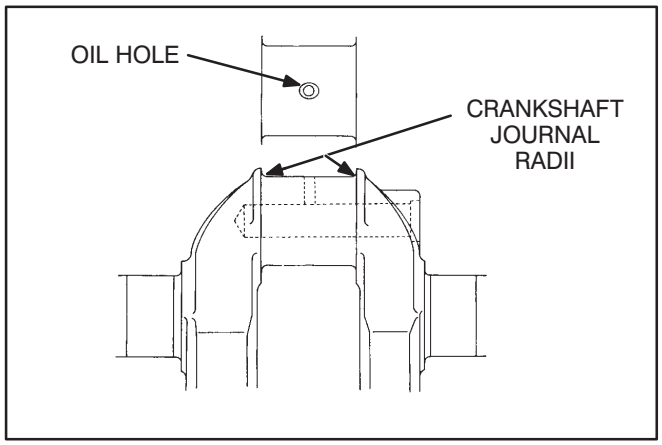


FIGURE 9-15. CRANKSHAFT JOURNAL

Camshaft Lobe Height: Refer to Figure 9-16. Measure the height of each cam at its highest point. If measurements are not as specified in *Section 2. Tolerances and Clearances,* replace the camshaft.

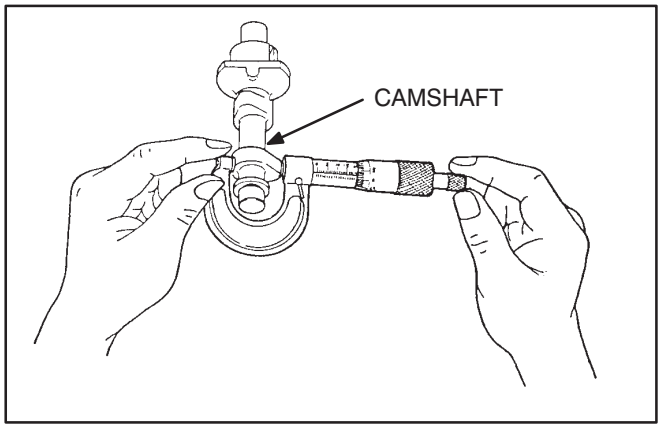


FIGURE 9-16. MEASURING CAMSHAFT LOBE HEIGHT

Camshaft Journal Bearing Clearance: Measure the camshaft journal bearing O. D. and the corresponding bearing I. D. in the gearcase. Replace the gearcase and/or the camshaft if the clearance is not as specified in *Section 2. Tolerances and Clearances*.

Assembly

Install the tappets in the block. Apply engine oil to the governor lever shaft. Apply grease to the oil seal lip and be careful not to roll the seal when inserting the crankshaft. Line up the crankshaft and camshaft timing marks and insert both into the block at the same time. Refer to Figure 9-17.

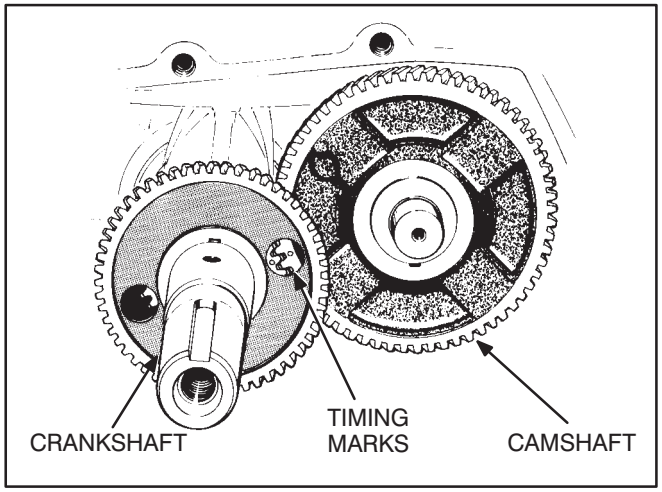


FIGURE 9-17. CRANKSHAFT AND CAMSHAFT TIMING MARKS

COMPRESSION RELEASE SYSTEM

This engine has a compression release system that decreases the amount of effort required to start the engine and reduces engine run-on when stopping (Figure 9-18).

The system works as follows:

1. As the engine is started, a spring holds in the flyweight, which in turn pushes a decompression pin upwards.
2. The decompression pin pushes up on the exhaust tappet and opens the exhaust valve momentarily to release compression and make starting easier.
3. As the engine speeds up, the flyweight is forced outward by centrifugal force and the decompression pin moves down so that it no longer opens the exhaust valve.
4. When the engine is stopped, engine speed drops and the flyweight pulls in and the decompression pin moves up. The pin opens the exhaust valve again releasing compression.

The most common problem with this system is a faulty spring. The spring may be too long or it may not be connected. A spring that is too long will reduce the decompression cutoff speed. Make sure the spring is properly attached, if a problem with the cutoff speed is suspected, replace the spring.

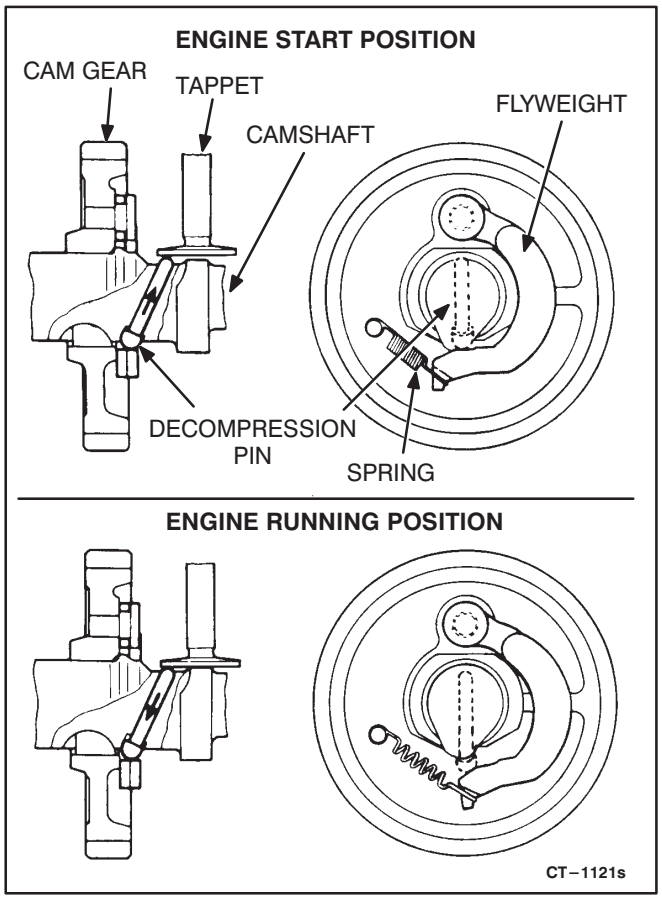


FIGURE 9-18. COMPRESSION RELEASE SYSTEM

PISTON / CONNECTING ROD

Disassembly and Inspection

⚠CAUTION ***Use a ridge reamer to remove the ridge at the top of the cylinder so as not to damage the piston when withdrawing it.***

Removing Piston and Connecting Rod: Refer to Figure 9-19. Remove the connecting rod cap, turn the crankshaft so the piston is at top dead center and pull the piston and connecting rod out the top of the cylinder. Make a mark on the piston on the same side as the machined surface on the connecting rod.

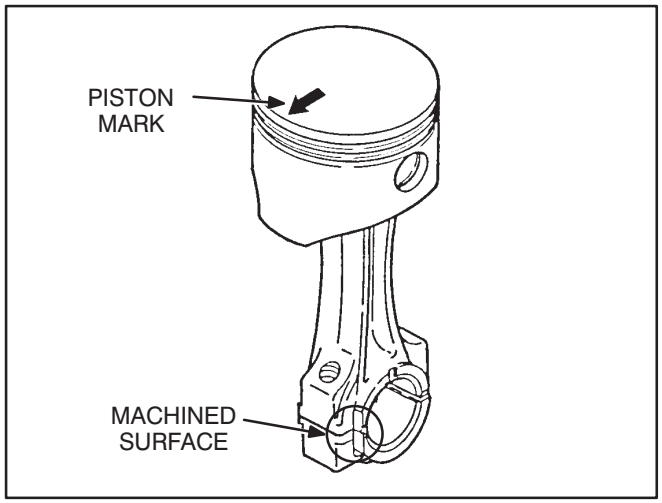


FIGURE 9-19. PISTON MARKING

Inspecting Piston For Wear and Fractures: Refer to Figure 9-20. Remove the rings from the piston by using a ring tool. Remove the piston pin snap rings and push out the piston pin. Look for fractures at the piston ring lands, skirts and pin bosses and for scuffing, scoring and wear. Excessive piston wear near the edge of the top ring land indicates preignition. Replace a piston that is worn or has fractures.

⚠CAUTION ***Using caustic cleaning solvents and wire brushes to clean a piston can cause damage to the piston.***

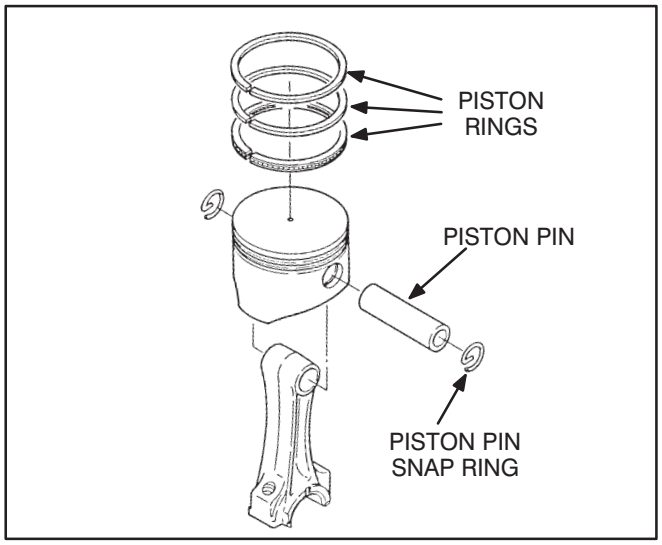


FIGURE 9-20. PISTON ASSEMBLY

Piston Ring Groove Clearance: Refer to Figure 9-21. To check for ring grove wear remove carbon from the ring groves, insert a new piston ring and measure the side clearance at several locations. Replace the piston if the clearance is greater than specified (*Section 2. Tolerances and Clearances*).

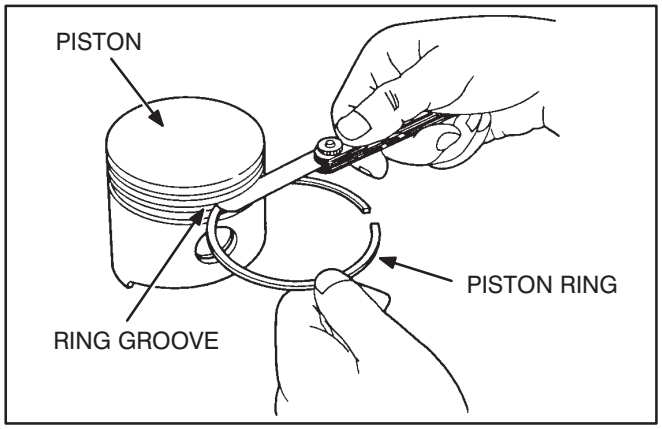


FIGURE 9-21. MEASURING RING GROOVE CLEARANCE

Piston Pin Bore Diameter: Refer to Figure 9-22. Measure the piston pin bore diameter at various places. Replace the piston if the diameter is not as specified (*Section 2. Tolerances and Clearances*).

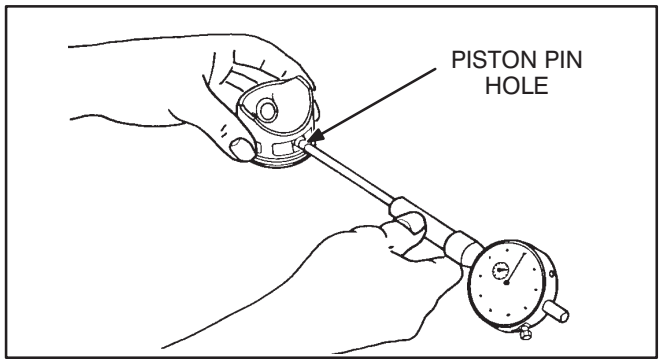


FIGURE 9-22. MEASURING PISTON PIN BORE

Piston Pin Outside Diameter: Refer to Figure 9-23. Measure the piston pin outside diameter. Replace the piston pin if the diameter is not as specified (*Section 2. Tolerances and Clearances*).

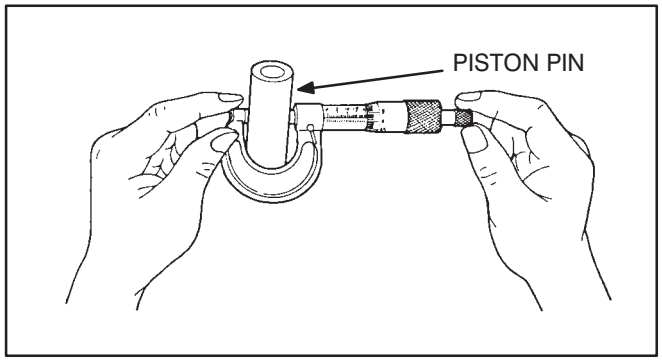


FIGURE 9-23. MEASURING PISTON PIN DIAMETER

Connecting Rod Piston Pin Bore Diameter: Refer to Figure 9-24. Measure the connecting rod piston pin bore diameter with an inside micrometer. Replace the connecting rod if the diameter is not as specified (*Section 2. Tolerances and Clearances*).

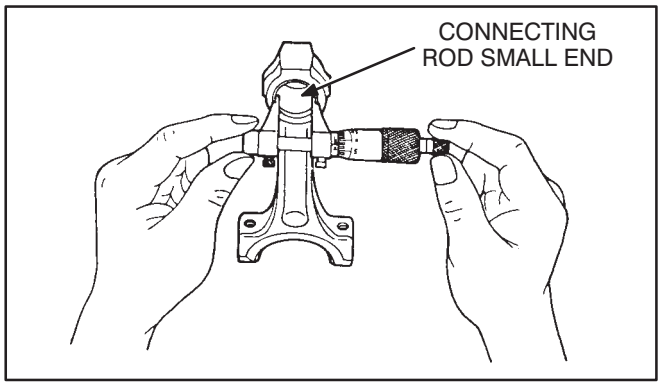


FIGURE 9-24. MEASURING CONNECTING ROD PISTON PIN BORE

Connecting Rod To Crankshaft Journal Oil Clearance: Refer to Figure 9-25. Check oil clearance whether reusing the old connecting rod or a new undersized rod with a reground crank journal. Either use Plasti-gage or measure the connecting rod bore at the locations indicated (the cap bolts must be torqued to specifications) and subtract the crank journal diameter. If the clearance is greater than specified (*Section 2. Tolerances and Clearances*), it will be necessary to grind the journal to the next undersize and obtain a matching undersized connecting rod. If there is not enough clearance, either the crank journal diameter is wrong or the connecting rod is of the wrong undersize.

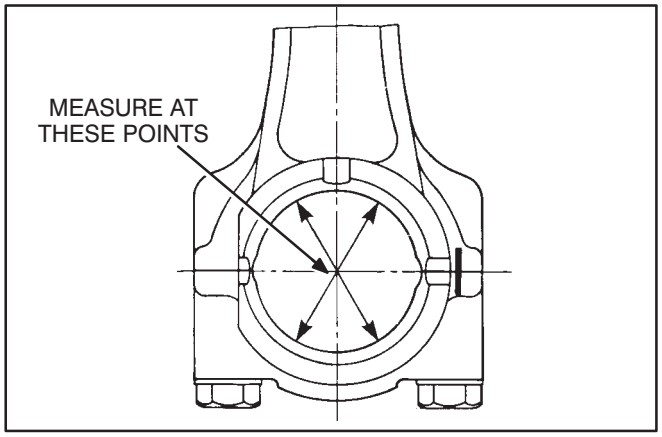


FIGURE 9-25. MEASURING CONNECTING ROD CRANK BORE

Connecting Rod Side Clearance: Assemble the connecting rod to the crankshaft and measure the side-to-side clearance of the connecting rod on the crankshaft. Replace the connecting rod if the clearance is not as specified (*Section 2. Tolerances and Clearances).*

Assembly

Refer to Figure 9-26. Immerse the piston in 212°F oil for 10 to 15 minutes and then insert the piston pin into the piston and connecting rod. Insert piston pin snap rings. Be sure the connecting rod machined surface is on the same side as the piston mark.

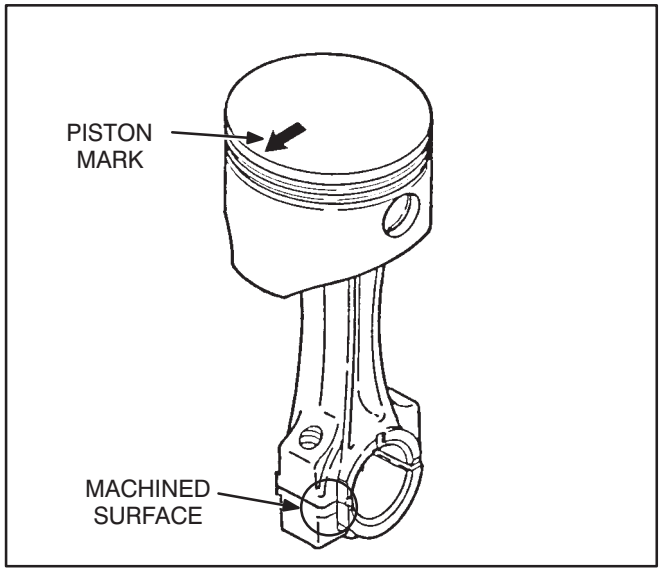


FIGURE 9-26. ASSEMBLING PISTON

Refer to Figure 9-27. Always install new rings when assembling the engine. *Old rings will not reseat properly*. Install the rings with the ring manufacturer's mark facing towards the top of the piston.

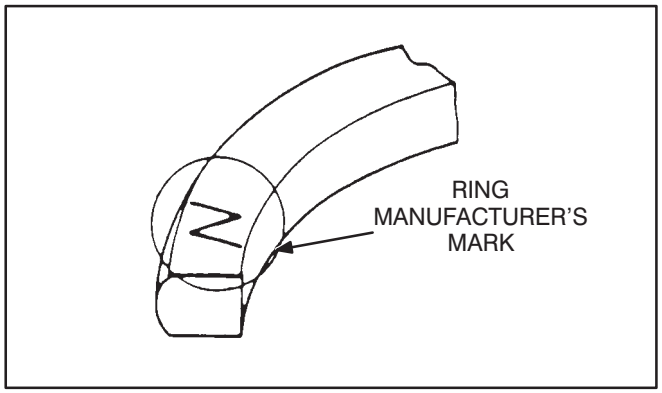


FIGURE 9-27. RING MARK

Refer to Figure 9-28. Position rings on piston as shown. Gap on top ring must face opposite of intake and exhaust valves.

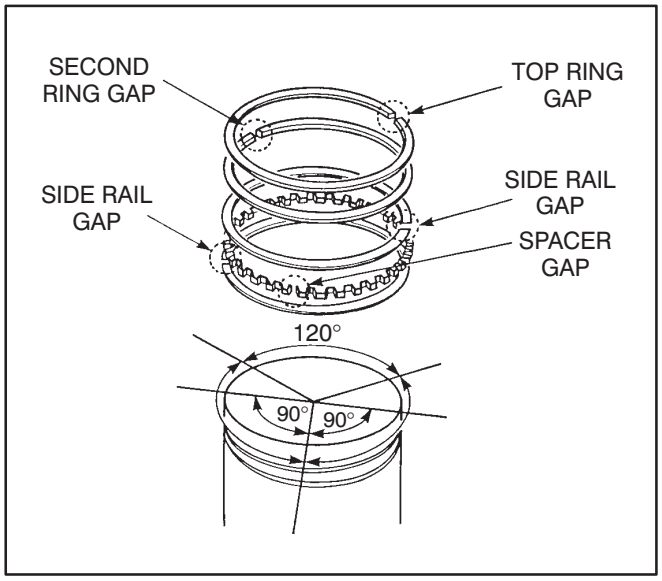


FIGURE 9-28. ASSEMBLING RINGS

Refer to Figure 9-29. Apply engine oil to the cylinder bore. Line up the piston and connecting rod so the machined surface of the connecting rod faces towards the camshaft.

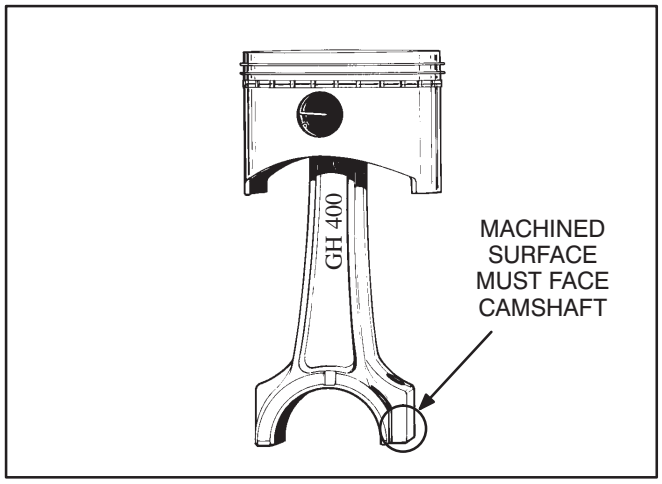


FIGURE 9-29. PISTON ORIENTATION

⚠ CAUTION ***An improperly installed piston will cause engine damage. The machined side of the connecting rod must face the camshaft.***

Refer to Figure 9-30. Use a ring compressor to insert the piston and connecting rod into the cylinder. Apply engine oil to the inside diameter of the connecting rod cap and connecting rod screws. Align the machined surfaces of the connecting rod and connecting rod cap. Apply oil to the connecting rod bolts and tighten them to the torque specified in *Section 3. Assembly Torques*.

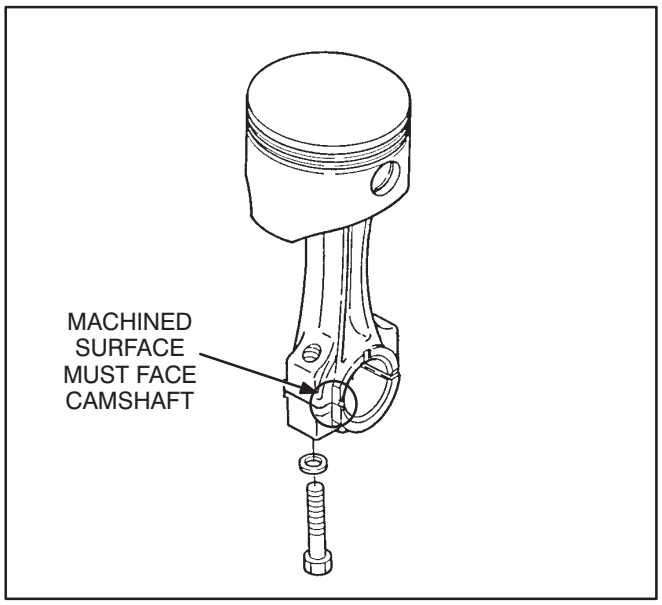


FIGURE 9-30. CONNECTING ROD AND CAP ALIGNMENT

ENGINE BLOCK

The engine block is the main support for all other basic engine parts and subassemblies.

Cleaning

After removing the cylinder head, gearcase, piston, crankshaft, etc., inspect the block for cracks and wear. If block is still serviceable, prepare it for cleaning as follows:

1. Scrape all old gasket material from block. Remove the oil by-pass (*Lubrication*) to allow cleaning solution to enter the oil passages.

2. Remove grease and scale from the engine block by agitating it in a bath of commercial cleaning solution or hot soapy solution.

3. Rinse the block in clean hot water to remove the cleaning solution.

Inspection

General Inspection For Cracks And Damage: Thoroughly inspect the block for any condition that would make it unfit for further use. This inspection must be made after all parts and subassemblies have been removed and the block has been cleaned and dried.

1. Minute cracks can 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 engine 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 the top of the block for flatness with a straight edge and a feeler gauge.

Cylinder Bore Inspection: Inspect the cylinder bore for scuffing, scratches, wear, and scoring. If the cylinder bore is scuffed, scratched, worn, or scored, rebore the cylinder to the next oversize.

If the bore looks good and there are no scuff marks, check the bore for wear or out-of-roundness using a cylinder bore gauge, telescopic gauge or inside micrometer (Figure 9-31). Measure the bore at four locations: top and bottom of piston ring travel, parallel and perpendicular to the axis of the crankshaft. Record and analyze the measurements as follows:

1. Measure and record as “A” the cylinder bore diameter (parallel to crankshaft) near the top of cylinder bore.

2. Measure and record as “B” cylinder bore diameter (parallel to crankshaft) at the bottom of piston travel.

3. Measure and record as “C” cylinder bore diameter (perpendicular to crankshaft) near the top of cylinder bore.

4. Measure and record as “D” cylinder bore diameter (perpendicular to crankshaft) at the bottom of piston travel.

5. The differences between “A” and “B” and between “C” and “D” indicate cylinder taper. If cylinder taper exceeds that specified in *Section 2. Tolerances and Clearances,* rebore the cylinder to the next oversize.

6. The differences between “A” and “C” and between “B” and “D” indicate cylinder out-of-roundness. If cylinder out-of-roundness exceeds that specified in *Section 2. Tolerances and Clearances*, rebore the cylinder to the next oversize.

7. If cylinder taper and out-of-roundness are within specifications, it will only be necessary to deglaze the bore. The old piston can be reused if it is not worn or damaged. New piston rings should always be used.

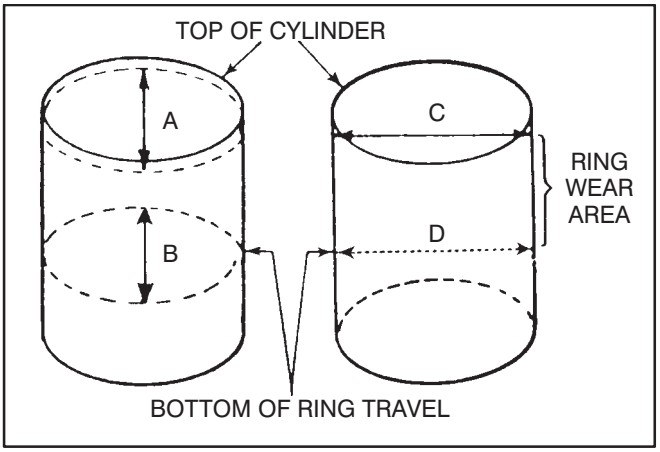


FIGURE 9-31. LOCATIONS FOR MEASURING CYLINDER BORE DIAMETER

Reboring and/or Honing the Cylinder

Rebore and/or hone a scuffed, out-of-round, tapered or otherwise worn cylinder to the next oversize bore (*Section 2. Tolerances and Clearances*). Honing should produce a 20 to 40 RMS surface finish with a 23 degree crosshatch pattern (Figure 9-32) for rapid piston ring break-in.

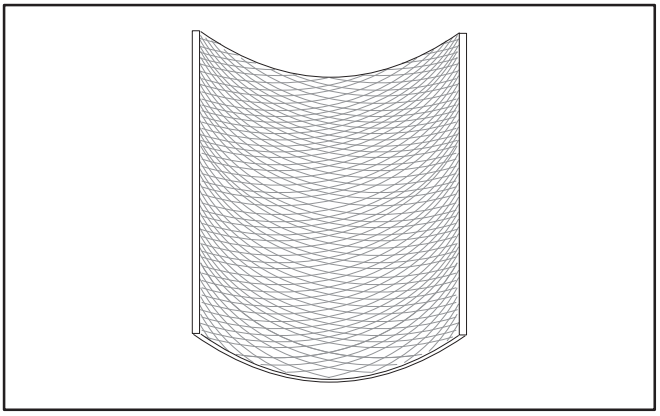


FIGURE 9-32. PROPER HONE CROSSHATCH IN BORE

⚠ CAUTION ***Improper boring/honing can damage the engine block beyond repair. It should be done by a qualified engine shop with proper equipment.***

Boring: When reboring the cylinder make sure that the top of the engine block is smooth and deposit free and that the base of the boring bar is clean. Deposits between the boring bar and block will cause it to tilt and bore at an angle to the true cylinder axis.

Precision Honing: Refer to the hone manufacturer's recommended grit size to produce the specified surface finish of 20 to 40 RMS.

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

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

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

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

6. The 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 the cylinder about 40 times per minute.

7. Thoroughly clean the engine block with soap, water and clean rags. A clean white rag will not become soiled when the cylinder wall is clean. *Solvents and gasoline are not effective in removing the metal and abrasive particles which can cause engine wear.*

8. Dry the block and coat the cylinder bore with oil.

Deglazing the Cylinder Bore

When the cylinder bore is not out-of-round or tapered beyond specifications nor scuffed or otherwise worn, it is necessary only to deglaze the bore so that the new rings will break in rapidly. The old piston can be reused if it is not worn or fractured or otherwise unusable. To deglaze the bore:

1. Wipe the cylinder bore with a clean cloth that has been dipped in clean, light engine oil.

2. Use a brush type deglazing tool with coated bristle tips.

3. Use a slow speed drill to drive the deglazing tool. Move the deglazing tool up and down in the cylinder bore 10 to 12 complete strokes rapidly enough to obtain a crosshatch pattern (Figure 9-32).

4. Thoroughly clean the engine block with soap, water and clean rags. A clean white rag will not become soiled when the cylinder wall is clean. *Solvents and gasoline are not effective in removing the metal and abrasive particles which can cause engine wear.*

5. Dry the block and coat the cylinder bore with oil.

Checking for Correct Piston and Ring Size

To double check that the right piston size has been obtained, measure the diameter as indicated in *Section 2. Tolerances and Clearances*. To double check that the right piston ring size has been obtained, insert one of the rings in the package into the cylinder and square it up with the piston. Then measure the ring gap with a feeler gauge. The gap must be as specified.

BALL BEARINGS

The gearcase carries one crankshaft ball bearing assembly and the engine block the other. The engine block also carries ball bearing assemblies for the camshaft and the two balancer shafts. Use a bearing puller to remove these bearings from the gearcase and block. Clean the bearing mounting surfaces before pressing in new bearing assemblies.

CRANKSHAFT OIL SEALS

Use an oil seal remover to pry the crankshaft oil seals out of the engine block and gearcase. Clean the oil seal seating surfaces and lubricate the surfaces before installing new oil seals. Press the new oil seals into the engine block and gearcase until they are flush in their bores. Apply a light coating of grease to the lips of the oil seals to provide lubrication until engine oil reaches them.

Cummins Power Generation
1400 73rd Avenue N.E.
Minneapolis, MN 55432
763-574-5000
Fax: 763-528–7229