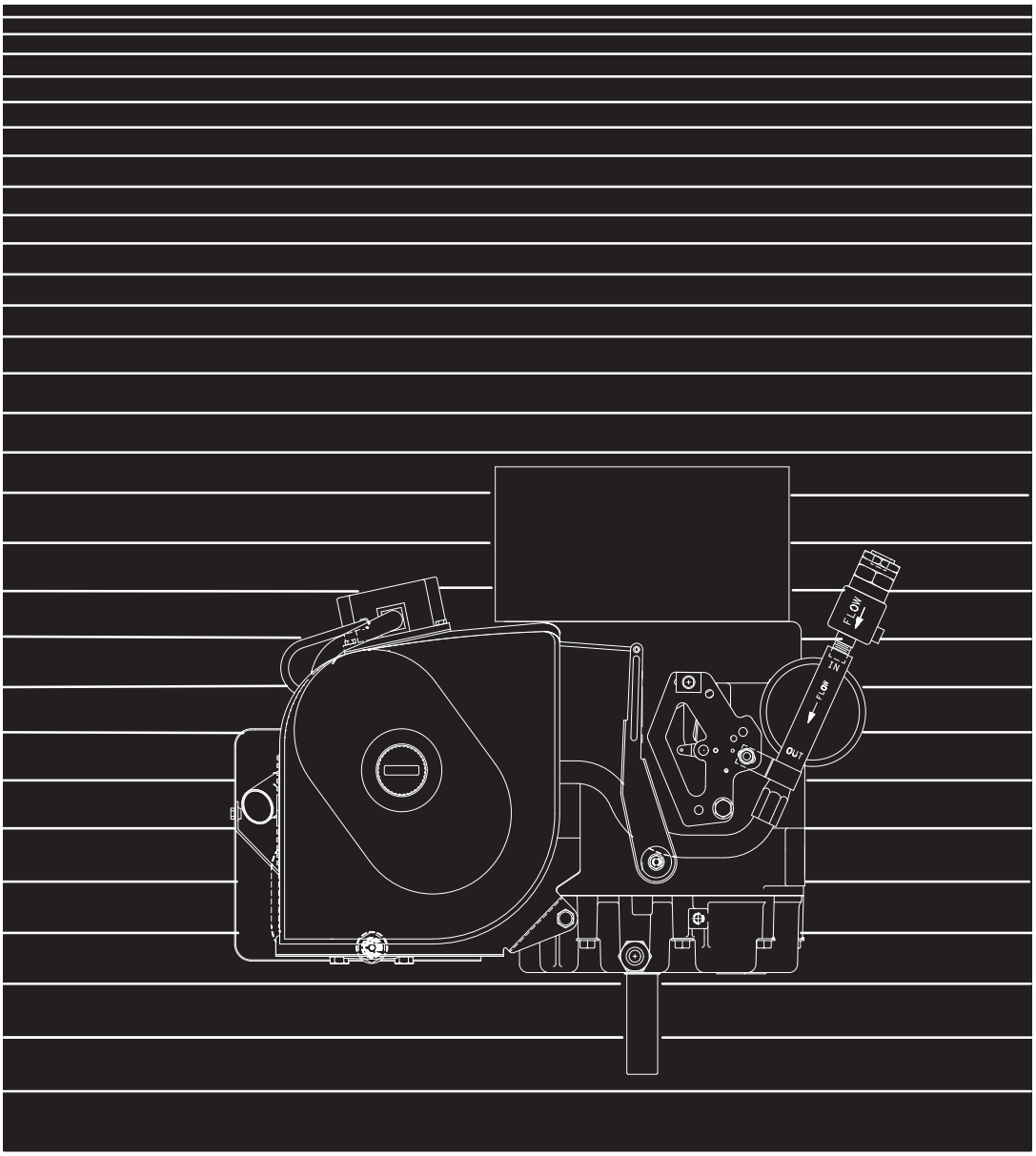
Onan

Engine

Service Manual

E124V, E125V, E140V

Elite Series



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WARNING:

The engine exhaust from this product contains chemicals known to the State of California to cause cancer, birth defects or other reproductive harm.

Table of Contents

Safety Precautions

Thoroughly read the OPERATOR'S MANUAL before operating the engine. Safe operation and top performance can be obtained only with proper operation and maintenance.

The following symbols in this Manual alert you to potential hazards to the operator, service person and equipment.

⚠ DANGER ***alerts you to an immediate hazard which will result in severe personal injury or death.***

⚠WARNING ***alerts you to a hazard or unsafe practice which can result in severe personal injury or death.***

⚠ CAUTION ***alerts you to a hazard or unsafe practice which can result in personal injury or equipment damage.***

Electricity, fuel, exhaust, moving parts and batteries present hazards which can result in severe personal injury or death.

GENERAL PRECAUTIONS

- Keep ABC fire extinguishers handy.
- Make sure all fasteners are secure and torqued properly.
- Keep the engine and its compartment clean. Excess oil and oily rags can catch fire. Dirt and gear stowed in the compartment can restrict cooling air.
- Before working on the engine, disconnect the negative (–) battery cable at the battery to prevent starting.
- Use caution when making adjustments while the engine is running—hot, moving or electrically live parts can cause severe personal injury or death.
- Used engine oil has been identified by some state and federal agencies as causing cancer or reproductive toxicity. Do not ingest, inhale, or contact used oil or its vapors.
- Benzene and lead in some gasolines have been identified by some state and federal agencies as causing cancer or reproductive toxicity. Do not to ingest, inhale or contact gasoline or its vapors.
- Do not work on the engine when mentally or physically fatigued or after consuming alcohol or drugs.
- Carefully follow all applicable local, state and federal codes.

FUEL IS FLAMMABLE AND EXPLOSIVE

- Keep flames, cigarettes, sparks, pilot lights, electrical arc-producing equipment and switches and all other sources of ignition well away from areas where fuel fumes are present and areas sharing ventilation.
- Do not fill the fuel tank while the engine is running.
- Use approved flexible fuel hose for connections at the engine. If there is a possibility that the hose could become a path for battery currents, it must be of the non-conductive type.
- LPG fuel connections must be made only to the *vapor withdrawal* fitting on the LPG container.
- The fuel line must have a manual shutoff valve.
- LPG leaks into an inadequately ventilated space can lead to explosive accumulations of gas. LPG sinks when released into the air and can accumulate inside basements and other below-grade spaces. Precautions must be taken to prevent gas leaks and the accumulation of gaseous fuel in the event of a leak.

ENGINE EXHAUST IS DEADLY!

- Learn the symptoms of carbon monoxide poisoning in this Manual.
- Inspect the exhaust system every time the engine is started and after every eight hours of operation. If exhaust noise changes, shut down the engine immediately and have it inspected.
- The integral exhaust system must not be modified in any way.
- Do not use engine cooling air to heat a room or compartment.
- Make sure there is ample fresh air when operating the engine in a confined area.

BATTERY GAS IS EXPLOSIVE

- Wear safety glasses and do not smoke while servicing batteries.
- When disconnecting or reconnecting battery cables, always disconnect the negative (–) battery cable first and reconnect it last to reduce arcing.

MOVING PARTS CAN CAUSE SEVERE PERSONAL INJURY OR DEATH

- Do not wear loose clothing or jewelry near moving parts such as PTO shafts, fans, belts and pulleys.
- Keep hands away from moving parts.
- Keep guards in place over fans, belts, pulleys, etc.

Section 1. Introduction

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

ABOUT THIS MANUAL

This is the service manual for the Elite series of vertical-shaft engines. They are 1-cylinder, 4-stroke cycle, spark-ignited, overhead-valve (OHV), air-cooled engines. Table 3-1 summarizes other features of these engines.

Sections 2 (*Tolerances and Clearances*) and 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.

Sections 5 through 9 cover service of major subsystems of the engine.

Section 10 (*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.

MODEL NUMBER

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 3-2 for a breakdown of the engine model number.

TABLE 3-1. ENGINE FEATURES

Displacement	390 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)
Oil Capacity (with filter)	1.4 liter (1.5 quart)
Minimum Oil Pressures @ 1500/3300 rpm	New: 80/138 kPa (13/20 psi) Worn: 62/103 kPa (9/15 psi)
Ignition Timing (nonadjustable)	23° BTDC

TABLE 3-2. ENGINE MODEL NUMBER

E	124	V	L	111531	F
|	|	|	|	|	|
1	2	3	4	5	6

1. Model Letter
2. Rated Power or number of cylinders and displacement:
   "140" designates 14.0 bhp (brake horse power)
   "125" designates12.5 bhp
   "124" designates that the engine has "1" cylinder and displacement of "24" cubic inches
3. Shaft Orientation—"V" designates vertical 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.

Section 2. Tolerances and Clearances

All dimensional tolerances and clearances are in millimetres (inches) at 21° C (70° F) unless otherwise indicated.	New or Machined Part Minimum	New or Machined Part Maximum	Part Wear Limit
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—Specs A and B			
Lobe Height, Diameter Over Nose			
E125 Intake	34.31 (1.351)	34.46 (1.357)	33.81 (1.331)
E125 Exhaust	34.62 (1.363)	34.77 (1.369)	34.12 (1.343)
E140 Intake	35.18 (1.385)	35.33 (1.391)	34.68 (1.365)
E140 Exhaust	35.18 (1.385)	35.18 (1.391)	34.68 (1.365)
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)

All dimensional tolerances and clearances are in millimetres (inches) at 21° C (70° F) unless otherwise indicated.	New or Machined Part Minimum	New or Machined Part Maximum	Part Wear Limit
CAMSHAFT—Beginning Spec C			
Lobe Height, Diameter Over Nose			
E124, E125 and E140 Intake	35.09 (1.381)	35.41 (1.394)	34.59 (1.362)
E124, E125 and 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)
CAMSHAFT—Spec E only			
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.	New or Machined Part Minimum	New or Machined Part Maximum	Part Wear 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—Specs A and B			
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.	20.000 (0.7874)	20.010 (0.7878)	20.020 (0.7882)

All dimensional tolerances and clearances are in millimetres (inches) at 21° C (70° F) unless otherwise indicated.	New or Machined Part Minimum	New or Machined Part Maximum	Part Wear Limit
PISTON—Beginning Spec C			
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)
PISTON PIN—Specs A and B			
Piston Pin O.D.	20.000 (0.7874)	20.005 (0.7876)	19.990 (0.7870)
Clearance in Piston Pin Bore	.005 (.0002)	.010 (0.0004)	0.03 (0.0012)
Clearance in Connecting Rod Pin Bore	.010 (0.0004)	.025 (0.0010)	.035 (0.0014)
PISTON PIN—Beginning Spec C			
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)

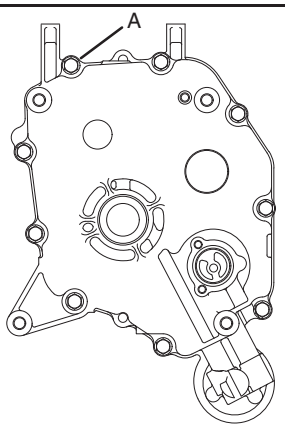
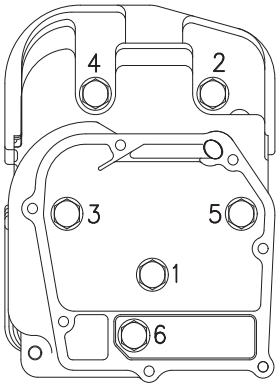
All dimensional tolerances and clearances are in millimetres (inches) at 21° C (70° F) unless otherwise indicated.	New or Machined Part Minimum	New or Machined Part Maximum	Part Wear Limit
INTAKE VALVE			
Valve Stem O.D.	6.960 (0.2740)	6.975 (0.2746)	–
Valve Guide I.D.	7.000 (0.2756)	7.015 (0.2762)	–
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°		–
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 (0.006)		0.25 (0.010)
Face Angle	45°		–
EXHAUST VALVE SEAT			
Seat Width	1.1 (0.043)		1.7 (0.067)
Seat Angle	45°		–

All dimensional tolerances and clearances are in millimetres (inches) at 21° C (70° F) unless otherwise indicated.	New or Machined Part Minimum	New or Machined Part Maximum	Part Wear Limit
VALVE SPRINGS, INTAKE AND EXHAUST—Specs A and B			
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)	5.67 kg (12.5 lb)	6.62 kg (14.6 lb)	–
Spring Load (Valve Open Length)	11.52 kg (25.4 lb)	13.43 kg (29.6 lb)	10.21 kg (22.5 lb)
VALVE SPRINGS, INTAKE AND EXHAUST—Beginning Spec C			
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)
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)

All dimensional tolerances and clearances are in millimetres (inches) at 21° C (70° F) unless otherwise indicated.	**New or Machined Part Minimum**	**New or Machined Part Maximum**	**Part Wear Limit**
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. Bolt Torques

These torque values provide proper tightness without danger of stripping threads. Threads must be clean, rust-free, and lightly oiled, unless otherwise specified. Use pipe thread sealant on all pipe threads. Use thread sealant approved for LPG for all threaded gas fuel fittings.

	DESCRIPTION	BOLT SIZE	METRIC (N-m)	ENGLISH (lb-ft)	INSTRUCTIONS
	Conn Rod Bolts	M8x44	24-27	18-20	
OIL BASE	Oil Base Bolts	M8x50	16-22	12-16	 Torque in clockwise direction starting with bolt “A”. Torque “A” twice
OIL BASE	Oil Pump Cover Screws	M6x14	7-11	5-8	
OIL BASE	Oil Pump Screen Cover Screws	M6x14	7-11	5-8	
OIL BASE	Oil Drain Plugs	3/8 NPT	7-11	5-8	
OIL BASE	Oil Drain Valve	–	16-20	12-15	
OIL BASE	LOPCO	–	9.5-12	7-9	
OIL BASE	Filter Adapter Head	3/4-16	24-30	18-22	
OIL BASE	Oil Filter	–	–	–	< 3/4-1 turn after gasket contacts base
CYLINDER HEAD	Cylinder Head Bolts No. 1-5 No. 6	 M10 M8X50	 42-50 16-22	 31-37 12-16	 Torque in sequence shown. Retorque #2 & #4 (outside valve cover) after others are torqued
CYLINDER HEAD	Valve Lash Adj Nut	M7	7-11	5-8	
CYLINDER HEAD	Valve Cover Bolts	M6X25	7-11	5-8	< Tighten every other bolt until all bolts are tight. Torque first bolt twice.
CYLINDER HEAD	Spark Plug	M14	24-30	18-22	< Do not oil the threads on the spark plug

	DESCRIPTION	BOLT SIZE	METRIC (N-m)	ENGLISH (lb-ft)	INSTRUCTIONS
INTAKE/EXHAUST SYSTEM	Air Deflector Bolts	M8x10 M8x16 M6x10	11-20 7-11	8-15 5-8	
	Pulse Pump to Deflector Nuts	#10	2.3-2.8	(20-25 lb-in)	
	Pulse Pump Spud	1/8NPT	7-11	5-8	
	Int Elbow to Head Bolts	M8x50	11-16	8-12	< Tighten twice (1-2-1)
	Air Cleaner Pan to Air Deflector	1/4x1/2	6.7-8.1	5-6	
	Carb to Int Elbow	M6x85	10-15	7-11	
	Air Cleaner Pan to Air Deflector	1/4x0.5	6.7-8.1	5-6	
	Cyl Air Housing Bolts	M6x10 M8x10	7-11 11-20	5-8 8-15	
	Throttle Stop Screw Bracket	M5x10	2.7-5.4	2-4	
	Exhaust Elbow Bolts	M8x45	11-20	8-15	
	Muffler Bolts	M8x95	16-22	12-16	
ELECTRICAL	Starter Cover Bolts	3/8-16	25-35	18-26	
	Starter Bolts	M8x40	16-22	12-16	
	Alternator Stator Screws	M6x25	10-15	7-11	
	Ignition Coil Bolt	M6x27	10-15	7-11	
	Stator Wire Clamp Screw	M6x14	10-15	7-11	
SHEET METAL	Blower Housing to Manifold Bolt	M6x14	10-15	7-11	
	Blower Housing Bolts	M6x20	7-11	5-8	
	Chaff Screen Bolts	M6x10	7-11	5-8	
	Stationary Guard Bolts	M6x20	1.4-2	(12-18 lb-in)	
	Recoil Starter Cup Screw	M8x16	24-30	18-22	
	Recoil Starter Bolts	M6x12	7-11	5-8	
MISC	Governor Arm Nut	M6	8.1-10.9	6-8	
	Control Plate Stud	M8	11-16	8-12	
	Control Plate Pivot Bolt	M8	11-16	8-12	
	Control Plate Stud Nut	M6	7-11	5-8	
	Throttle Cable Clamp Screw	10-32	1.4-2	(12-18 lb-in)	
	Flywheel Nut	M18	122-138	90-102	
	Oxygen Sensor	M8	60	44	< Apply high temperature anti-seize compound to the threads of the sensor

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

* – See Section 6 for LPG engines equipped with electronic fuel injection.

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
																					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

* – See Section 6 for LPG engines equipped with electronic fuel injection.

Section 5. Carburetor-Type 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.

⚠WARNING ***Benzene and lead in some gasolines have been identified by some state and federal agencies as causing cancer or reproductive toxicity. Do not ingest, inhale or contact gasoline or its vapors.***

GASOLINE CARBURETOR (BEGINNING SPEC E)

Carburetor Replacement

Other than replacing the carburetor main fuel jet (fixed-type) with the optional high-altitude jet (Figure 7-1), fuel mixture adjustments should not be attempted. Nor should the carburetor be overhauled. Instead, a malfunctioning carburetor should be replaced. Before replacing a carburetor, however, make certain 1) that all other necessary engine and generator adjustments and repairs have been performed and 2) that the carburetor is actually malfunctioning (see Section 4).

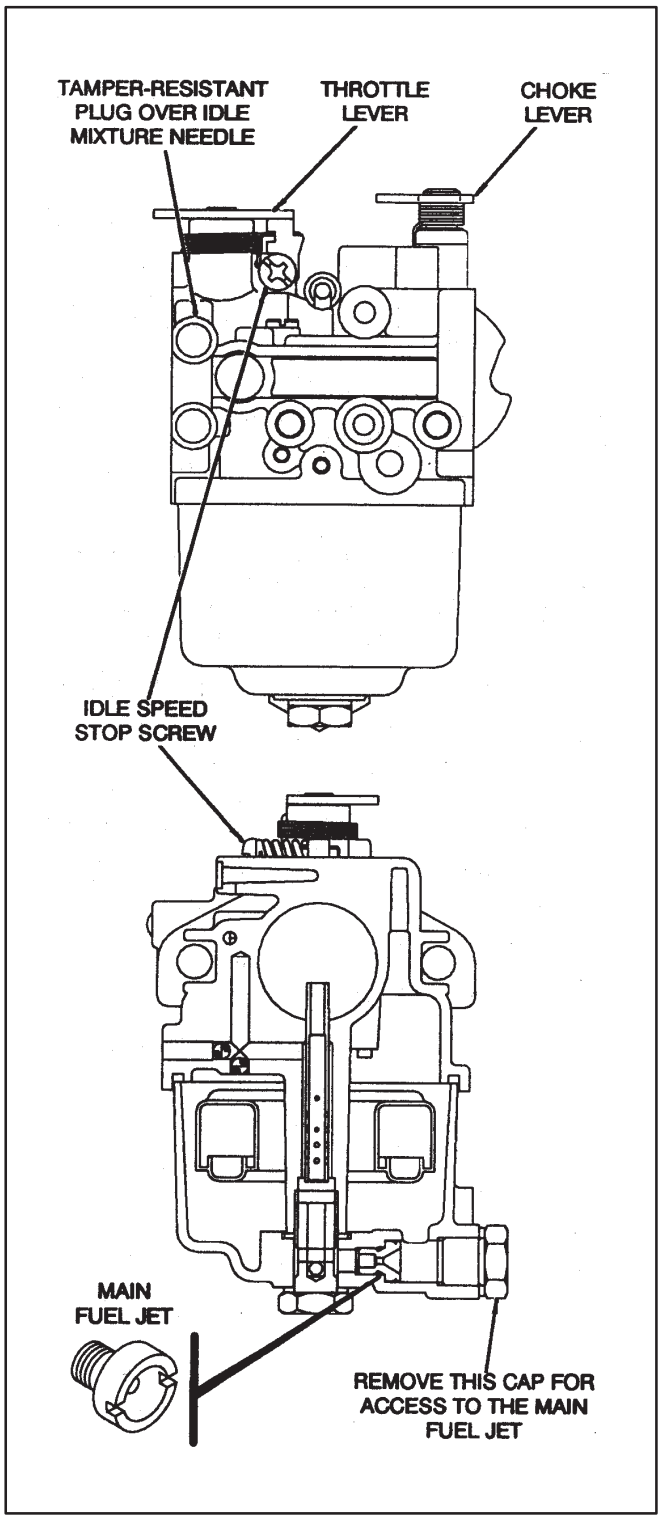


FIGURE 7-1. GASOLINE CARBURETOR (BEGINNING SPEC E)

To remove the carburetor, remove the air cleaner and air cleaner base, disconnect the fuel line and choke and throttle linkages and unbolt the carburetor from the intake manifold. When mounting the carburetor always use new gaskets. Readjust the choke and throttle cables and engine speed as instructed in the engine or equipment Operator's Manual.

Carburetor High-Altitude Jet (Optional)

If the engine is operated at an altitude above 5000 feet (1524 meters), it is recommended that the carburetor main 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.***

GASOLINE CARBURETOR (PRIOR TO SPEC E)

Disassembly

Carburetor parts are delicate and must be handled with care. Never force parts when disassembling or assembling.

Remove the air cleaner assembly and disconnect the fuel line and throttle and choke links. Remove the carburetor assembly from the intake manifold.

Refer to Figure 7-2 for Spec C and to Figure 7-3 for Specs A and B. Remove the float bowl, slide the float pin out and remove the float and float valve. Remove the main jet and idle adjusting screw and spring. For Specs A and B also remove the main nozzle, passage cover and slow jet.

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.***

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

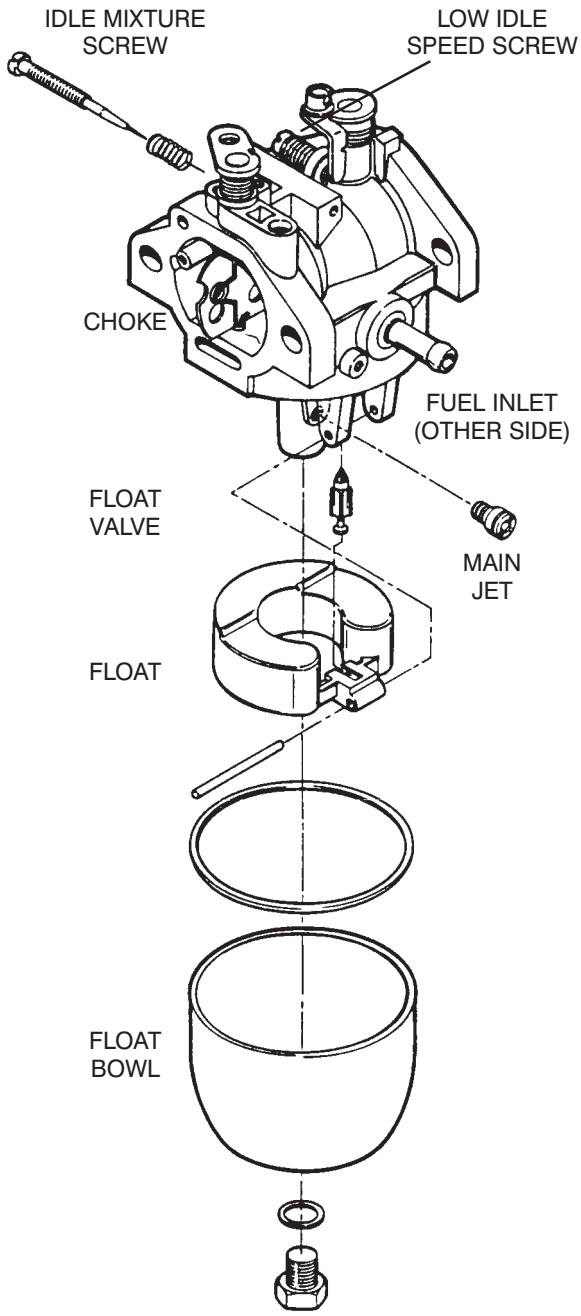


FIGURE 7-2. GASOLINE CARBURETOR (BEGINNING SPEC C)

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

Replace the float if it is cracked, damaged, or loaded with fuel.

Replace the carburetor if there is excessive play in the choke and throttle shafts.

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

Assembly

⚠CAUTION ***The mixture adjustment screw is easily damaged. Turn the mixture adjustment screw in only until light tension can be felt.***

When installing the idle adjusting screw, turn the screw in until LIGHT tension is felt. For Spec C turn the screw out 3-1/8 turns. For Specs A and B turn the screw out 2-1/2 turn.

Turn the carburetor body upside down to assemble the main jet, main nozzle (Specs A and B), float valve, float and float bowl as illustrated in Figure 7-3.

Torque the carburetor mounting bolts to the torque specified in Section 3, reconnect the fuel line and throttle and choke links and secure the air cleaner assembly.

See the instructions that follow in this section for governor, choke and speed adjustments.

CO Adjustment

If a CO (Carbon Monoxide) meter is available, adjust the idle mixture screw to provide 6% to 7% CO at 3300 rpm with no load on the engine. If a meter is not available, set the idle mixture screw at 3-1/8 turns out (Spec C) or 2-1/2 turns out (Specs A and B) as noted above.

⚠WARNING ***Carbon Monoxide is an odorless, invisible, toxic gas that can cause severe personal injury or death. Make sure the exhaust is properly vented to the outside.***

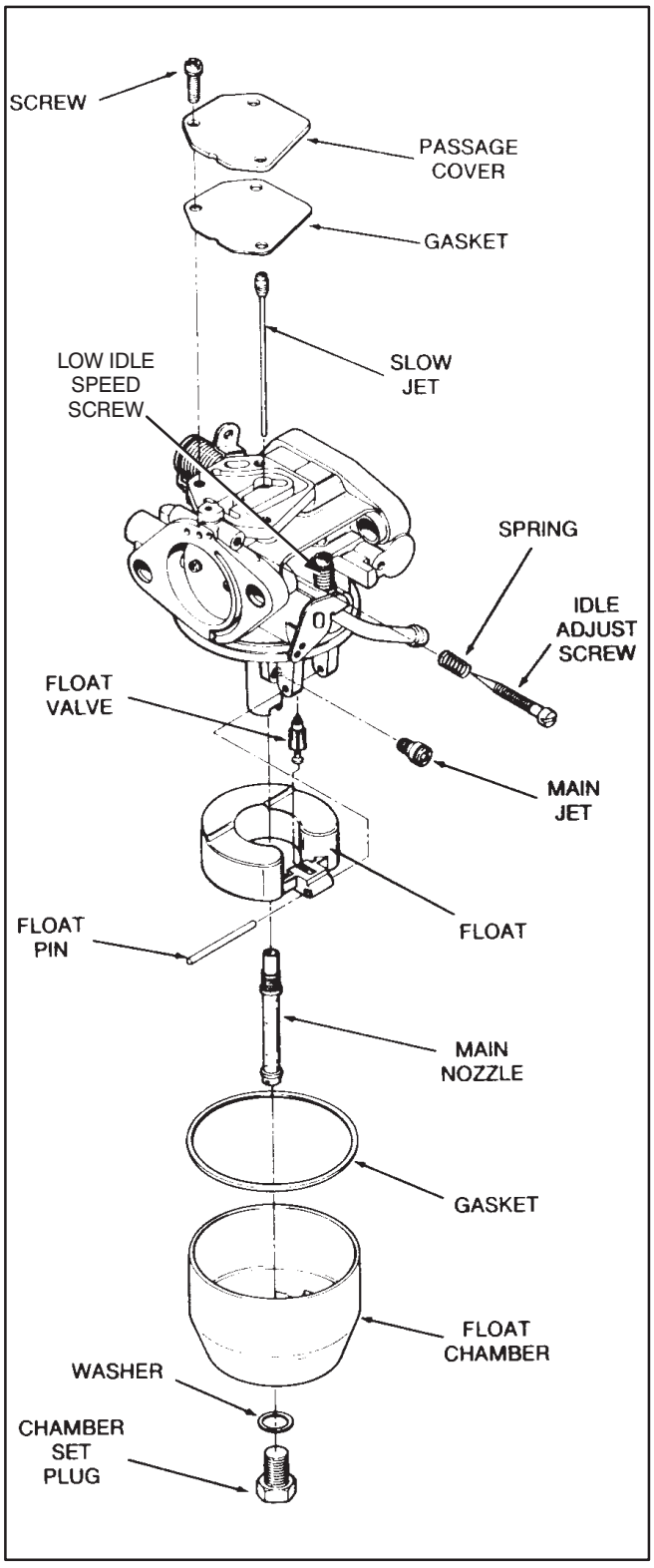


FIGURE 7-3. GASOLINE CARBURETOR (SPECS A AND B)

IMPULSE FUEL PUMP (GASOLINE)

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 7.

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.

⚠WARNING ***Benzene and lead in some gasolines have been identified by some state and federal agencies as causing cancer or reproductive toxicity. Do not ingest, inhale or contact gasoline or its vapors.***

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.

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 ADJUSTMENTS in this section.

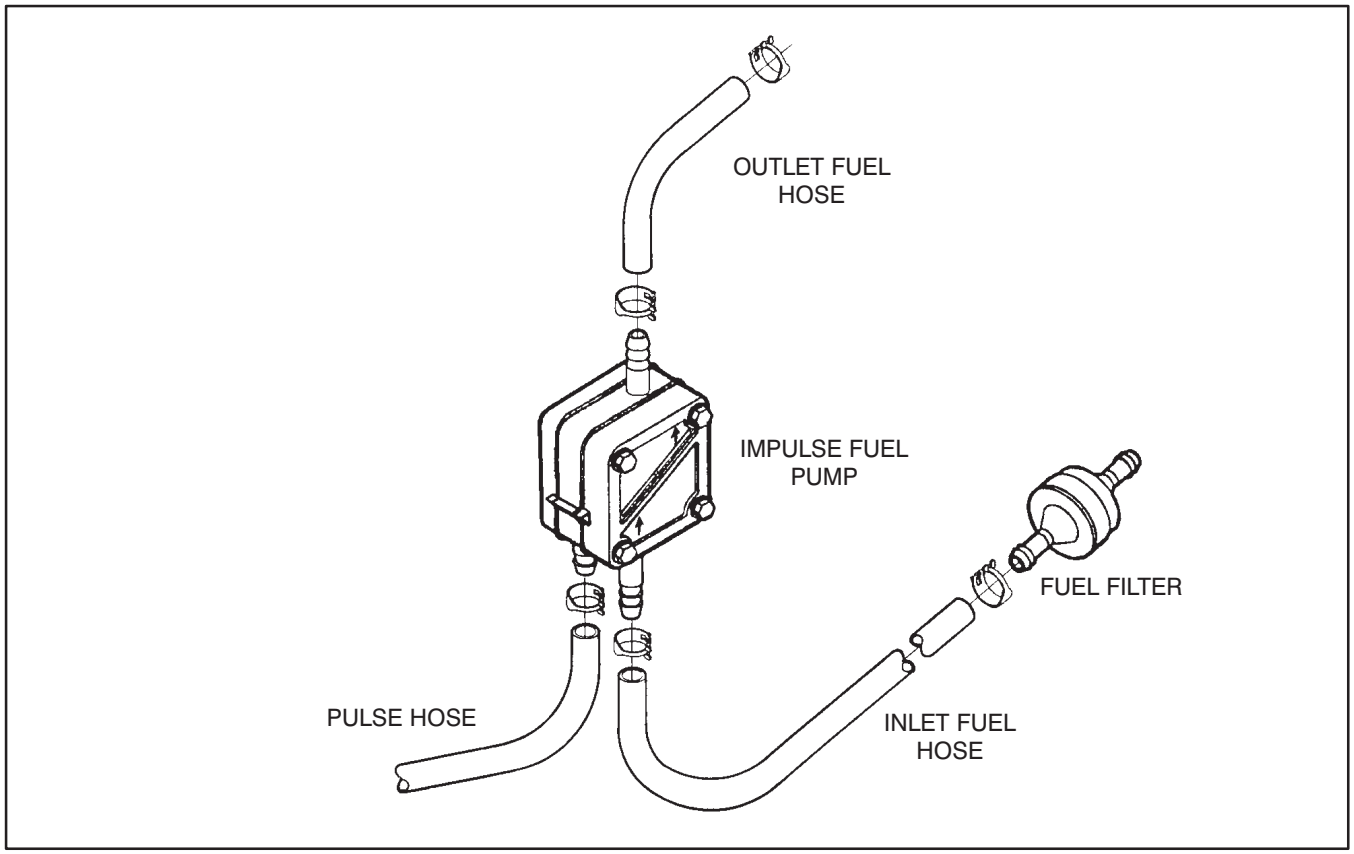


FIGURE 7-4. IMPULSE FUEL PUMP

LPG FUEL SYSTEM

Refer to Figure 7-5. The carburetor, gas pressure regulator, air pump and vacuum sustain valve comprise the LPG fuel system components that are part of the engine assembly. A vacuum cutout device is provided by the equipment manufacturer.

The carburetor should not require service and there are no replaceable parts or adjustments except for the low idle speed screw.

⚠WARNING ***Carbon Monoxide (CO) is deadly! The idle mixture screws on the carburetor and gas pressure regulator are factory set and sealed. DO NOT READJUST.***

Note: It is the responsibility of the user to make certain that indoor carbon dioxide regulations are met.

The air pump is identical to the gasoline fuel pump illustrated in Figure 7-4.

Referring to the block diagram, operation of the LPG fuel system is as follows:

1. Crankcase vacuum pulses cause the air pump to pump clean air from the air cleaner to the vent side of the gas pressure regulator, which has a factory adjusted and sealed bleed valve. This provides for a precisely adjustable flow of gas for proper idle mixture.
2. The vacuum sustain valve consists of a check valve and bleed-off orifice. It bleeds off crankcase vacuum when the engine stops to cause the vacuum lock-out device to shut off the gas supply. The check valve removes the vacuum pulses permitting the lock-out device to open during cranking.

See the instructions that follow in this section for governor, choke and speed adjustments.

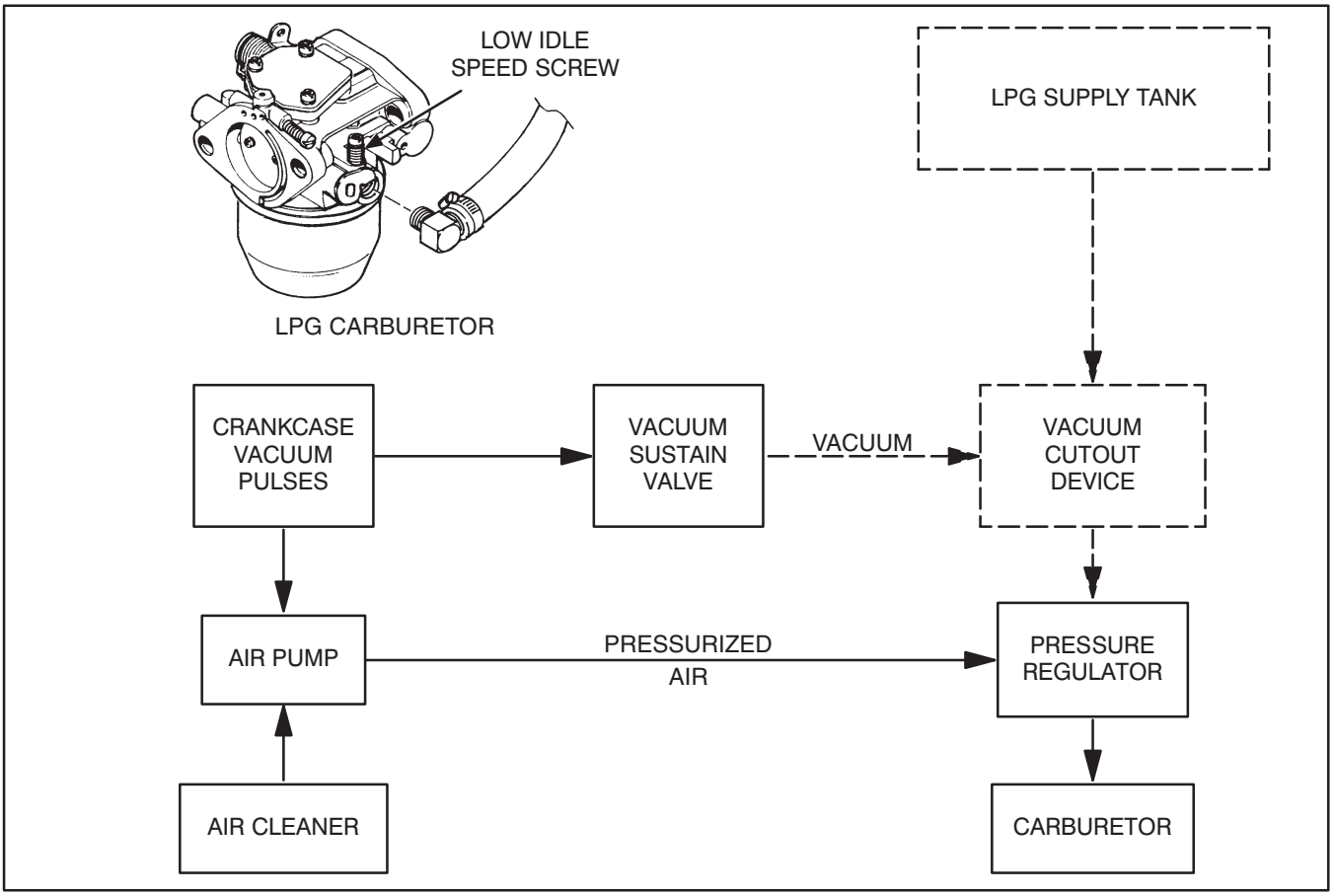


FIGURE 7-5. LPG CARBURETOR AND FUEL SYSTEM BLOCK DIAGRAM

GOVERNOR ADJUSTMENTS

In order to obtain the best performance from the equipment it is essential that the governor lever, low and high idle speeds, choke and speed control cable be adjusted properly.

Symptoms of improper adjustment are: excessive loss of engine speed under load, engine stalling, no-load speed surging, poor starting and spark plug fouling.

The equipment Owner's Manual will specify the low and high idle speed settings for optimum performance. Always set engine speed with an accurate tachometer. Never exceed the high speed setting specified by the equipment manufacturer.

The order of adjustments in this section **MUST** be followed in order to obtain proper adjustments. The order is as follows:

1. Governor Lever Adjustment
2. Idle Speed Adjustments
3. Choke Adjustment
4. Speed Control Cable Adjustment

1. Governor Lever Adjustment

Refer to Figure 7-6. The proper angular relationship between the governor lever and the governor shaft is essential for obtaining the full range of engine speed/load performance. The position of the governor lever should be readjusted whenever the intake manifold is reinstalled after removal for service.

Governor Lever Removal: The governor lever on Spec C gasoline engines is secured to the tapered governor shaft with a nut. On LPG and Spec A and Spec B gasoline engines the lever is clamped around the straight shanked governor shaft with a draw bolt and nut. Before removing the lever, stop the engine and disconnect the throttle link and governor spring. For Spec C gasoline engines use a standard battery cable clamp lifter available at any automotive parts store to break the tapper fit between shaft and lever hub.

Governor Lever Adjustment: The engine must be stopped to assemble and adjust the lever.

1. Loosely assemble the governor lever and shaft so that the lever is free to rotate about the shaft.
2. Attach the throttle link between the governor lever and carburetor. Replace the nylon clips if they are worn or broken.
3. Attach the governor spring, move the throttle control lever to align the lock pin holes in the control plate and throttle control lever and insert a pin to lock the lever in place. See Figure 7-6.
4. Check to see that the governor spring is holding the carburetor throttle plate in the wide open position.
5. For Spec C gasoline engines tighten the lock nut on the end of the governor shaft making sure the governor shaft rotates clockwise against the internal governor parts, and torque to specifications (Section 3). For LPG and Spec A and Spec B gasoline engines use a flat-bladed screwdriver to rotate the governor shaft clockwise against the internal governor parts while tightening the lever draw bolt.
6. Remove the lock pin to release the throttle control lever and proceed to the next adjustment.

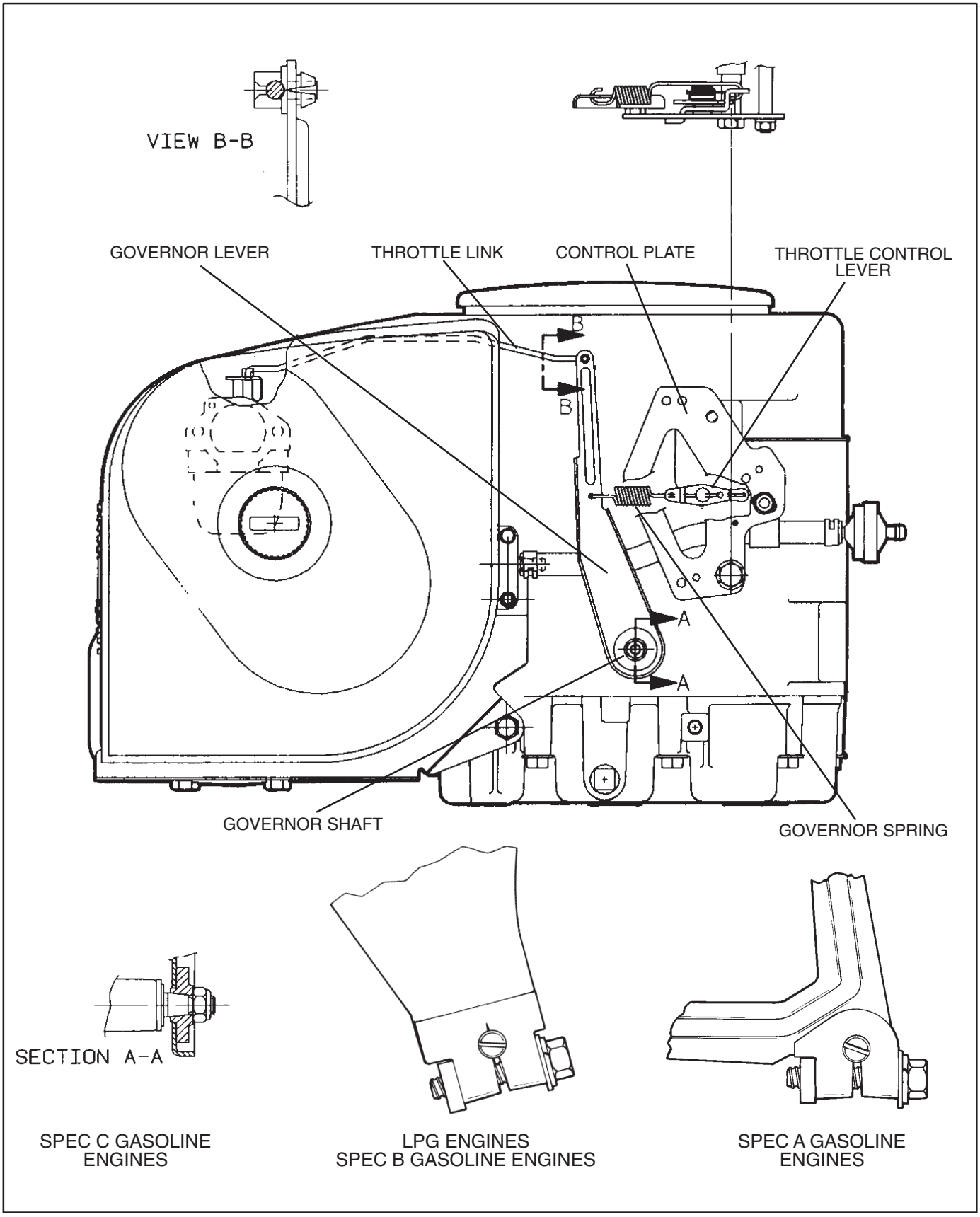


FIGURE 7-6. ENGINE GOVERNOR LEVER

2. Idle Speed Adjustments

⚠WARNING ***Too high a speed setting can cause severe personal injury or death. Follow the manufacturer's specifications for low and high idle speeds as found in the equipment Owner's Manual. Use an accurate tachometer.***

High Idle Speed Adjustment: Refer to Figure 7-7.

1. Set up the tachometer according to the instructions with the tachometer.
2. Start the engine according to the equipment manufacturer's recommendations, observing all safety precautions, and allow the engine to warm up for at least 10 minutes.
3. While the engine is running move the throttle control lever to align the lock pin holes in the control plate and throttle control lever and insert a pin to lock the lever in place. Loosen the speed control cable clamp if necessary.
4. Loosen the choke rod clamp screw and push the choke rod towards the carburetor so that the choke will be fully open.
5. High idle speed is adjusted by rotating the control plate around the pivot bolt—away from the carburetor to increase speed and toward the carburetor to decrease speed. Therefore, loosen the control plate pivot bolt 1/8 turn and the the control plate set bolt 1/4 turn. Adjust high idle speed to that specified by the equipment manufacturer, tighten the control plate bolts, recheck speed and readjust if necessary.
6. Remove the lock pin to release the throttle control lever.

Low Idle Speed Adjustment: Refer to Figure 7-8.

1. Continue running the engine with the tachometer connected and move the throttle control lever to the low idle speed position.
2. Adjust engine speed to the specified low idle speed by turning the low idle speed screw on the carburetor. See Figure 7-1, 7-2 or 7-3, as appropriate. Shut off the engine and proceed to the choke adjustment.

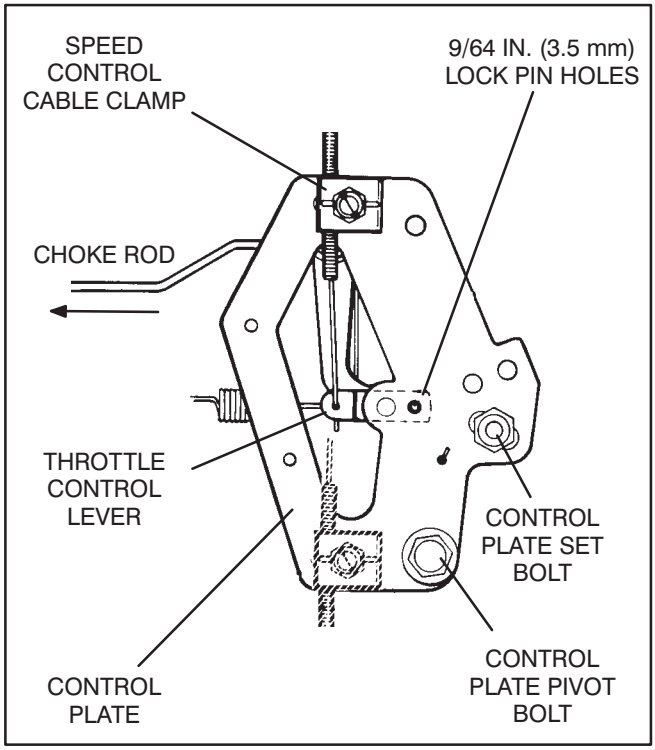


FIGURE 7-7. HIGH IDLE SPEED ADJUSTMENT

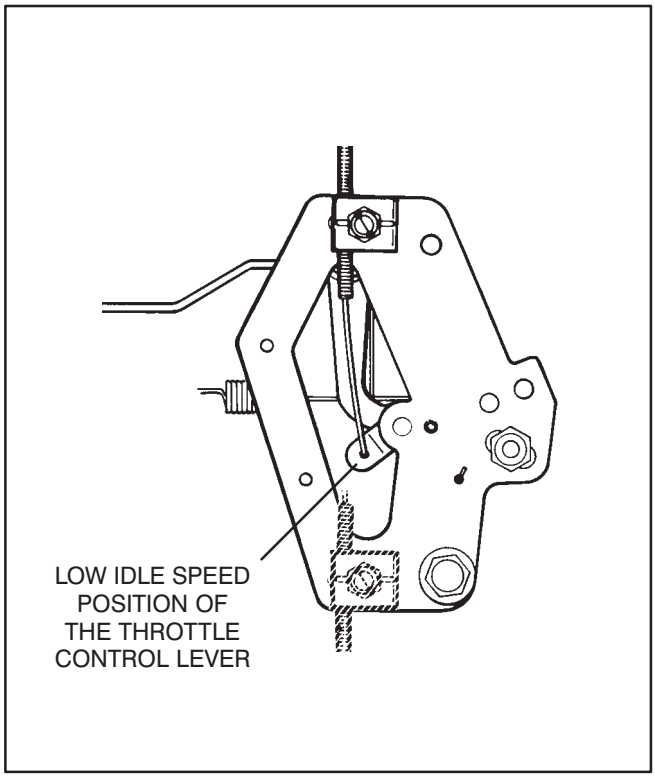


FIGURE 7-8. LOW IDLE SPEED ADJUSTMENT

3. Choke Adjustment

Refer to Figure 7-9. Proper choke adjustment is essential for obtaining consistent starting at low temperatures and wide open operation under normal running conditions.

1. Shut off the engine and loosen the choke rod clamp screw so that the rod is free to move in the choke swivel.
2. Move the throttle control lever to align the lock pin holes in the control plate and throttle control lever and insert a pin, making sure the pin extends past the choke lever to function as a stop for the choke lever.
3. Push the choke rod towards the carburetor to make sure the choke is fully open.
4. Rotate the choke lever towards the carburetor until the lever bears against the pin stop.
5. Tighten the choke rod clamp screw. For Spec A gasoline engines there must be a 0.01 to 0.03 inch (0.25 to 0.76 mm) gap, as shown, between the choke and throttle control levers.
6. Remove the air filter paper element and check that the choke is fully open. Remove the lock pin in the control plate and check operation of the choke linkage. If the linkage binds, replace the components that are damaged.
7. Proceed to the following speed control cable adjustment.

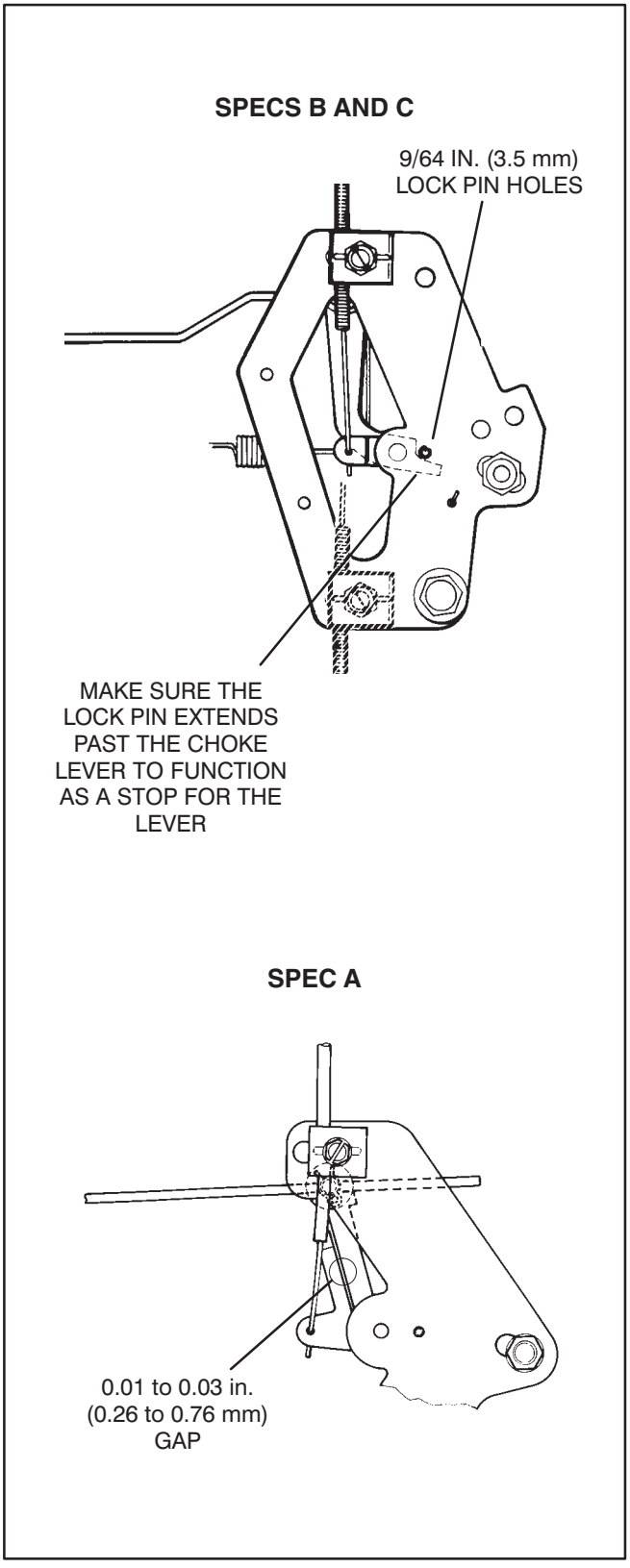


FIGURE 7-9. CHOKE ADJUSTMENT

4. Speed Control Cable Adjustment

Refer to Figure 7-10. The speed control cable must be installed properly to obtain full-load, full-speed operation. Adjust the speed control cable as follows:

1. Stop the engine and loosen the speed control cable clamp located on the engine throttle control plate.
2. Push the speed control lever on the equipment to the high speed position. On equipment without a separate choke control be sure the speed control lever is not in the start or choke position.
3. Move the throttle control lever to align the lock pin holes in the control plate and throttle control lever and insert a pin to lock the lever in place.
4. Remove the slack from the speed control cable and tighten the speed control cable clamp. Remove the lock pin in the control plate.
5. Start the engine according to the equipment manufacturer's recommendations, observing all safety precautions.

AIR CLEANER

See the appropriate Operator's Manual regarding air cleaner maintenance.

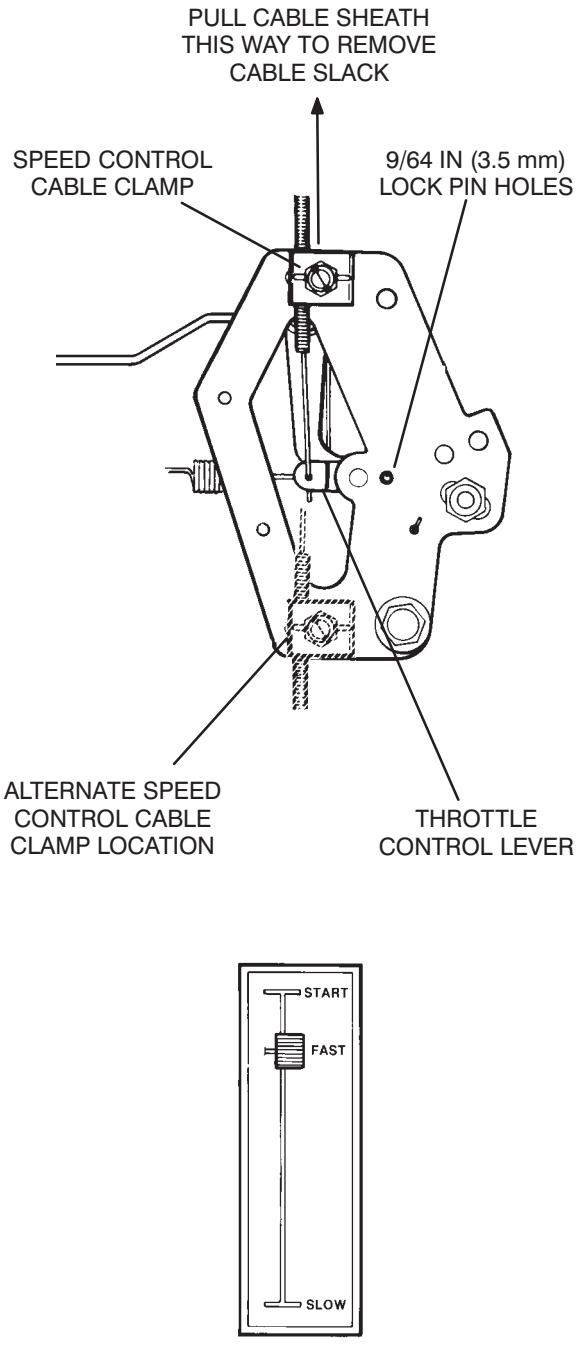


FIGURE 7-10. SPEED CONTROL CABLE ADJUSTMENT

Section 6. Electronic Fuel Injection—LPG

⚠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.

LPG FUEL INJECTION COMPONENTS

Figure 8-1 illustrates the arrangement of the fuel injection components, Figures 8-2 and 8-3 the wiring and Table 8-1 troubleshooting.

Electronic Control unit (ECU)

The ECU is powered by the 12 volt battery and controls all aspects of engine fueling. A well-charged battery is required for operation.

The ECU controls fueling via the fuel shut off solenoid and duty solenoid (injector). It monitors battery voltage, engine speed (magneto pulses), intake manifold absolute pressure (MAP) and exhaust gas excess air (oxygen) and provides two modes of operation: open-loop and closed-loop.

Open-loop Mode: Open-loop operation occurs while the oxygen sensor is warming up (approximately 30 seconds) and during speed and load transitions. MAP sensing is used for load reference and magneto pulses for speed reference. Fueling is controlled via the duty solenoid and is based on comparing the sensed speed-load references with a 36 point fueling matrix consisting of 9 speed and 4 MAP values. The ECU has an adaptive learning feature whereby it updates the fueling matrix.

Closed-loop Mode: Closed-loop operation uses the oxygen sensor in the exhaust manifold as the reference for the correct air-fuel ratio (AFR). The ECU controls fueling via the duty solenoid to maintain an oxygen sensor output of approximately 0.7 volts at all combinations of speed and load within the operating range. AFR is thus maintained within a narrow range near the stoichiometric value for LPG, which is necessary for effective treatment of emissions by the catalytic converter inside the muffler.

Warning Light: The warning light on the ECU comes on at startup and stays on for approximately 30 seconds while the oxygen sensor is warming up (open-loop). During normal operation (closed-loop), the light will blink if AFR dips out of specification, rich or lean. The light will stay on if operation continues rich or lean and the ECU will shut down the engine in a few minutes. (The time is speed dependent: at 3300 rpm, approximately 6 minutes if AFR is lean, 3 minutes if rich.) The engine can be restarted to facilitate troubleshooting and diagnostics, but will go through the same cycle if the condition persists.

MAP Sensor Port: The ECU has a hose fitting for attaching a 0.11 inch ID by 4–1/2 inch long hose to the throttle-body/mixer for sensing intake manifold pressure (vacuum). The ECU will stop the engine if the hose is missing. If the hose is leaking, the warning light on the ECU will blink during warm–up and the engine will stop.

Duty Solenoid (Fuel Injector)

The ECU controls fueling by switching the voltage across the duty solenoid at varying pulse widths (pulse width modulation). The duty solenoid is connected by a pipe fitting to an adaptor on the throttle body. A port in the throttle-body/mixer discharges the gas into the intake air stream. Solenoid coil resistance is 2-4 ohms.

LPG Pressure Regulator

The pressure regulator is intended to be connected to the vapor-withdrawal fitting on an LPG tank. An intermediate pressure regulator should not be used. The regulator maintains 10 psi downstream. It is adjustable after removing the plastic cap.

Fuel Shutoff Solenoid

The opening and closing of the fuel shutoff solenoid is controlled by the ECU. The inlet has a replaceable fuel filter/strainer. Solenoid coil resistance is approximately 10-20 ohms.

Oxygen Sensor

The oxygen sensor is mounted in the exhaust elbow and sends a voltage signal proportional to the differential in oxygen concentration between the exhaust gasses and the atmosphere. After warming up, it sends a signal of 0.7-1.0 VDC when the AFR is rich and 0.0-0.2 VDC when lean. The ECU controls fueling to maintain a signal of approximately 0.7 volts.

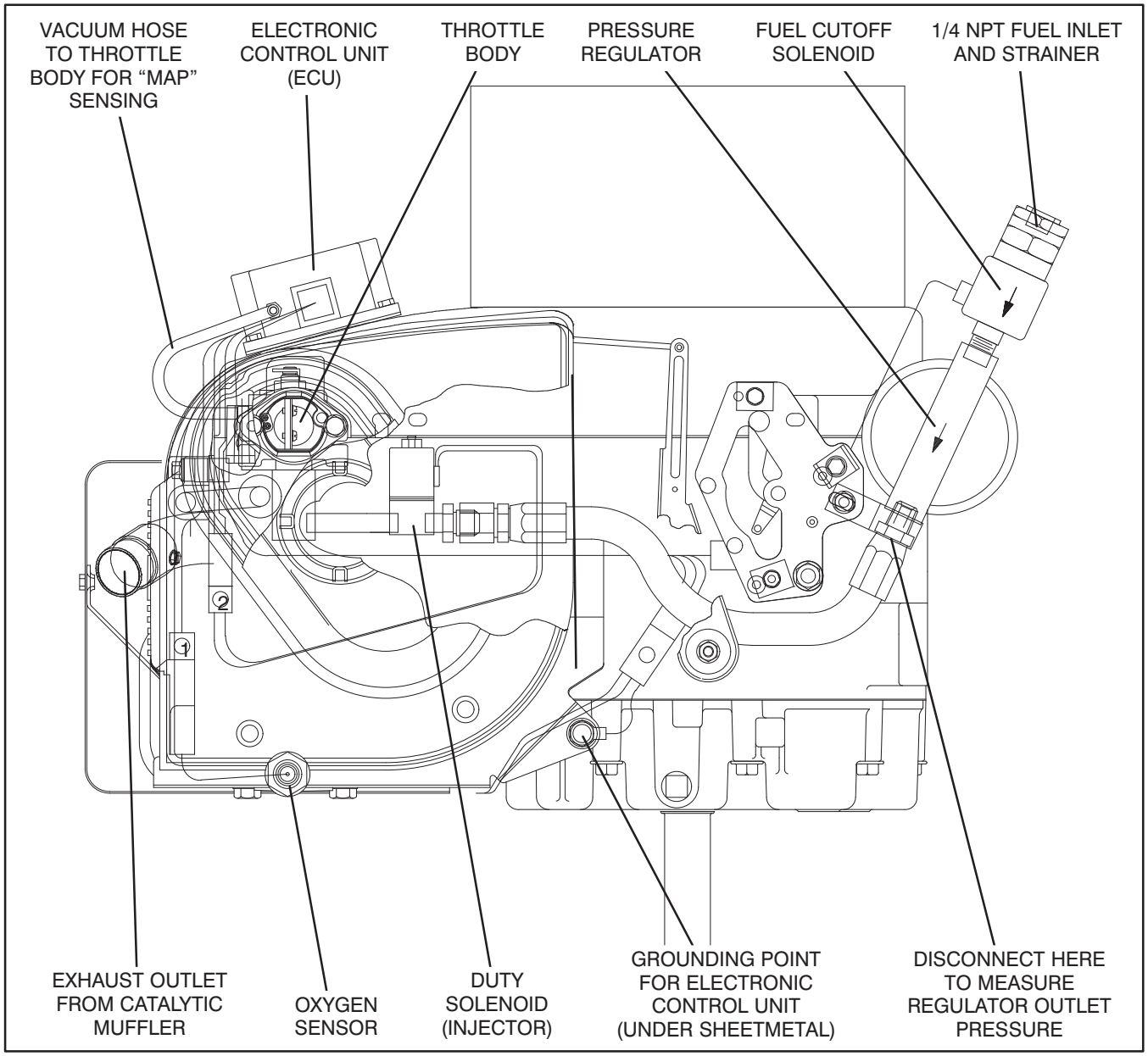


FIGURE 8-1. FUEL INJECTION SYSTEM COMPONENTS

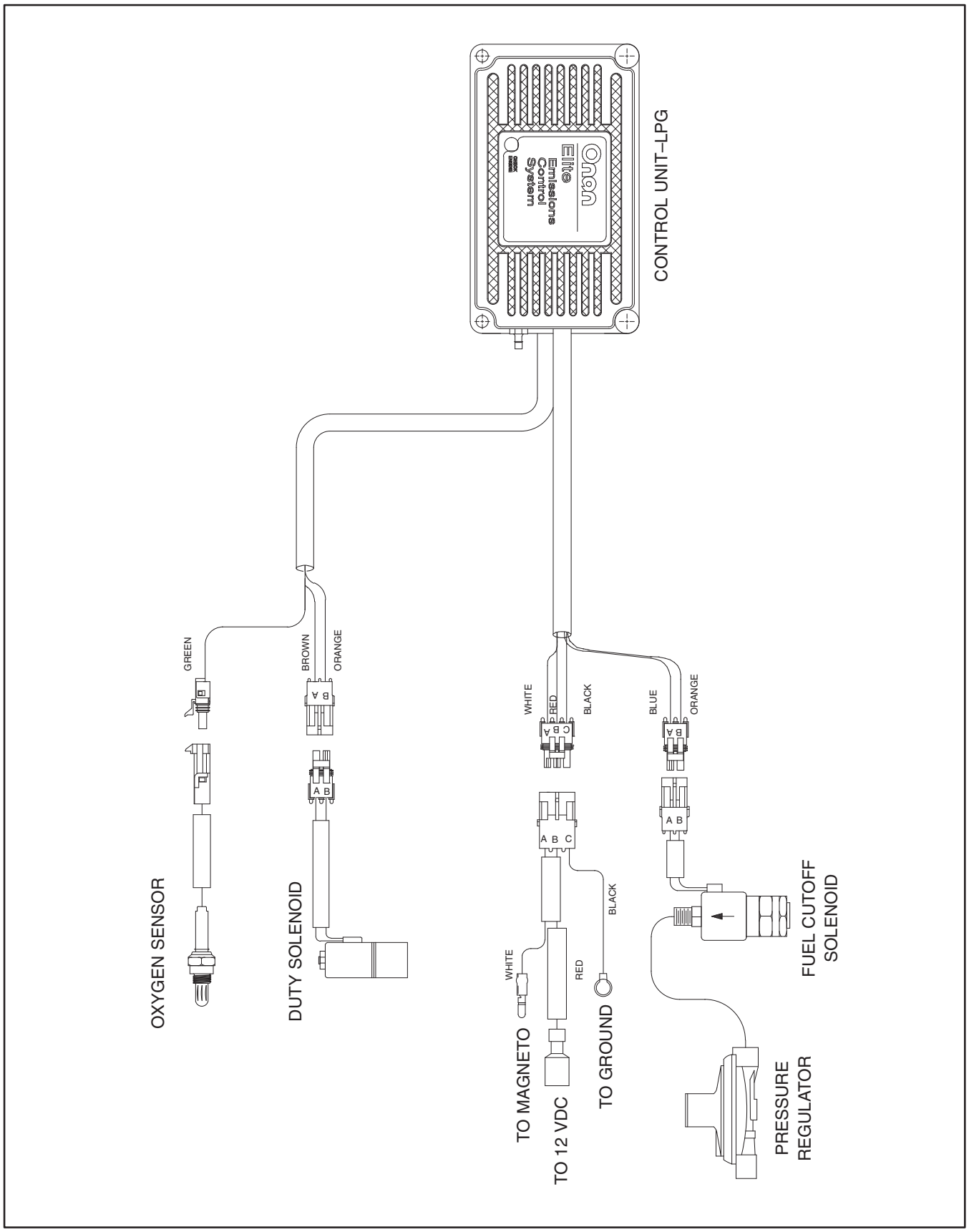


FIGURE 8-2. CONNECTIONS TO THE ELECTRONIC CONTROL UNIT

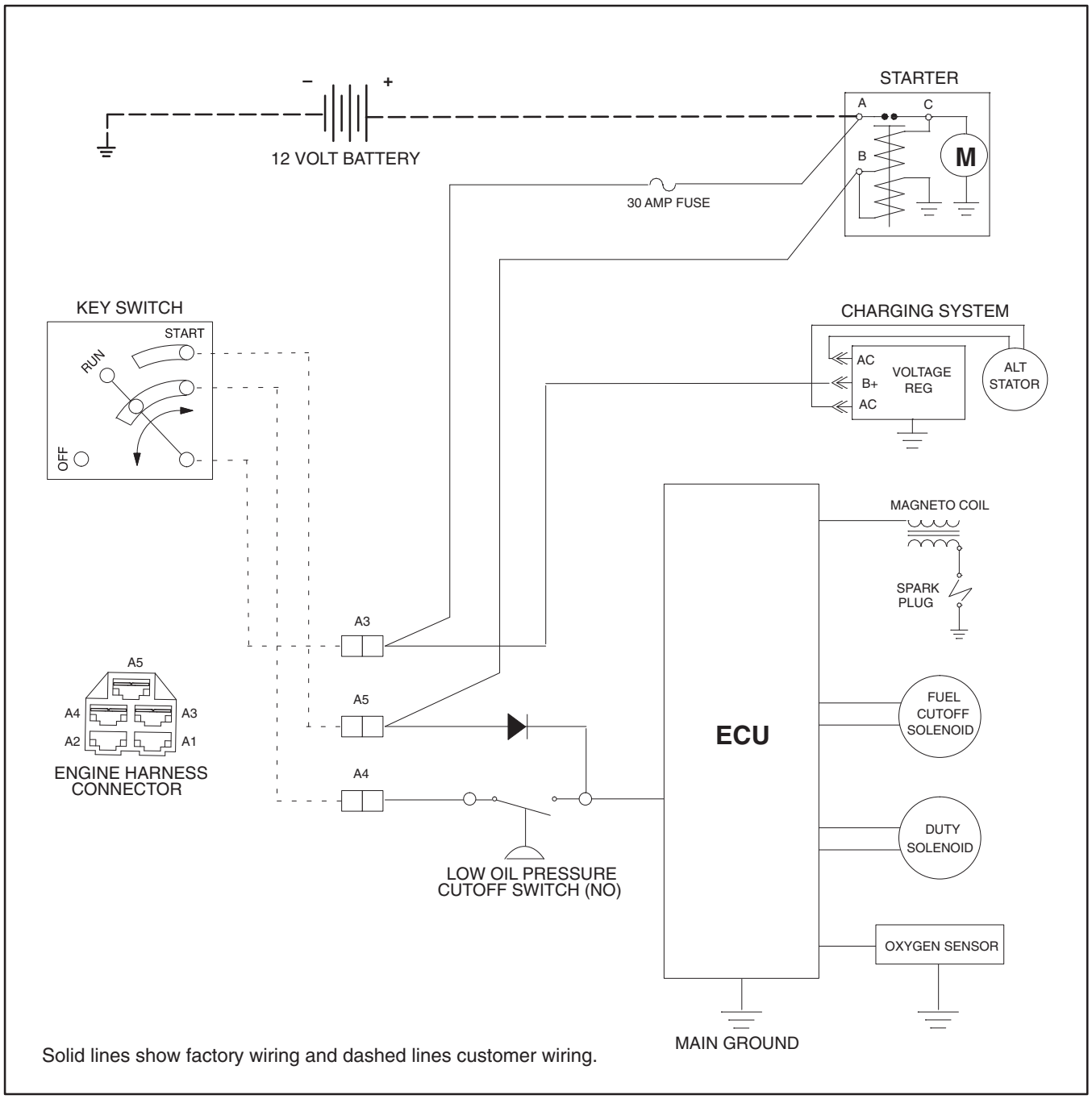


FIGURE 8-3. ENGINE WIRING SCHEMATIC

FUEL SYSTEM TROUBLESHOOTING

Table 8-1 is a guide for troubleshooting to help you quickly diagnose fuel system problems. If the engine fails to start or keeps shutting down, time can be saved by first checking the following:

1. That the manual fuel shutoff valve is open.
2. That the LPG tank is at least half full.
3. That the engine is connected to the vapor-withdrawal fitting on the LPG tank.
4. That the battery cable connections are clean and tight.
5. That the spark plug cable is on the spark plug.
6. That the engine has the proper level of oil.
7. That the ECU (main) grounding screw is tight.
8. That all wiring connectors are secure.
9. That the ECU vacuum hose is connected.
10. Whether maintenance is due—oil change; spark plug, air filter or LPG strainer replacement; spark arrestor cleaning; etc.

TABLE 8-1. FUEL SYSTEM TROUBLESHOOTING

⚠ WARNING ***Some engine service procedures present hazards that can result in severe personal injury or death. Only qualified service personnel with knowledge of fuels, electricity, and machinery hazards should perform genset service. See Safety Precautions.***	
PROBLEM	**CORRECTIVE ACTION**
Engine does not crank	1. Check the engine harness fuse (30 amp) and replace it if blown. 2. Check battery voltage while attempting to crank. If less than 6.5 volts, recheck battery connections and check and recharge the battery. 3. Check for proper connections between the key switch and engine harness connector and repair as necessary. 4. Check for B+ at pins A4 (run) and A5 (start) that mate with the engine harness connector. Repair or replace the key switch or wiring if there is no B+ at either pin. 5. Check for B+ at starter solenoid terminal B. Replace the engine harness if there is no B+ at the terminal. Service the starter in accordance with Section 8 if there is B+.
Engine cranks but does not start—LED on	1. Open the manual fuel shutoff valve if closed. 2. Fill the LPG tank if not at least half full. 3. Check battery voltage while cranking. If less than 6.5 volts, recheck battery connections and check and recharge the battery. 4. Check the lead connectors for the duty and fuel shutoff solenoids and reconnect or repair as necessary. 5. Disconnect the duty and fuel shutoff solenoid lead connectors and measure coil resistances. Replace the duty solenoid if coil resistance is not 2-4 ohms. Replace the fuel cutoff solenoid if coil resistance is not 10-20 ohms. 6. While the leads are still disconnected (previous step), bypass the low oil pressure cutoff switch (LOPCO) and turn the key switch on. Check for B+ from the ECU at the orange lead connectors for the duty and fuel solenoids. Replace the ECU if there is no B+ at either connector.

TABLE 8-1. FUEL SYSTEM TROUBLESHOOTING (CONT.)

⚠ WARNING ***Some engine service procedures present hazards that can result in severe personal injury or death. Only qualified service personnel with knowledge of fuels, electricity, and machinery hazards should perform genset service. See Safety Precautions.***	
PROBLEM	**CORRECTIVE ACTION**
Engine cranks but does not start—LED off	1. Tighten the main grounding screw on the block if loose. 2. Disconnect the 3-pin connector (red, black and white) to the ECU. Measure ground continuity through the black lead to the main grounding screw on the block. Replace or repair the wiring harness as necessary if there is no continuity. 3. While the 3-pin connector (red, black and white) is disconnected (previous step), and while holding the key switch at Start, check for B+ at the connector pin for the red lead. A. Replace or repair the wiring harness as necessary if there is no B+. B. Check the mating pin of the red lead to the ECU if there is B+. Reconnect or repair as necessary. If that does not work, replace the ECU.
Engine cranks but does not start—LED blinks	1. Reconnect the MAP (vacuum) hose at both ends. Replace if damaged or leaky.
Lean AFR—LED stays on, shutdown in 6 minutes or more	1. Open the manual fuel shutoff valve fully if partially open. 2. Fill the LPG tank if not at least half full. 3. Check for air leaks in the exhaust elbow and muffler. Repair and replace parts and gaskets as necessary. 4. Check and reconnect or repair the oxygen sensor lead and connector. If that does not work, replace the oxygen sensor. 5. Replace the duty solenoid. 6. Replace the LPG pressure regulator.
Rich AFR—LED stays on, shutdown in less than 6 minutes	1. Reconnect to the engine to the vapor-withdrawal fitting on the LPG tank if connected to the liquid-withdrawal fitting. 2. Replace the air cleaner foam wrapper and paper element if oily. Do not oil the new foam wrapper. 3. Check and reconnect or repair the oxygen sensor lead and connector. If that does not work, replace the oxygen sensor. 4. Replace the duty solenoid. 5. Replace the LPG pressure regulator.
Rich AFR—LED intermittent while engine runs	1. Replace the air cleaner foam wrapper and paper element if oily. Do not oil the new foam wrapper. 2. Check and reconnect or repair the oxygen sensor lead and connector. If that does not work, replace the oxygen sensor. 3. Replace the duty solenoid. 4. Replace the LPG pressure regulator.
Limits of Rich or Lean AFR—LED blinks while engine runs	1. Replace the air cleaner foam wrapper and paper element if oily. Do not oil the new foam wrapper. 2. Check battery voltage while running. If less than 11 volts, recheck battery connections and check and recharge the battery. 3. Check and reconnect or repair the oxygen sensor lead and connector. If that does not work, replace the oxygen sensor. 4. Replace the duty solenoid. 5. Readjust or replace the LPG pressure regulator.

THROTTLE-BODY/MIXER REMOVAL AND INSTALLATION

Throttle-Body/Mixer Removal

Refer to Figure 8-4. Remove the air cleaner assembly. Disconnect the governor linkage and fuel line. Remove the throttle-body/mixer assembly from the intake elbow.

Throttle-Body/Mixer Installation

Install the throttle-body/mixer assembly on the intake elbow. Tighten the through bolts as specified in Section 3. Connect the throttle linkage and fuel line. Make sure the breather tube and rubber seal are installed properly. Always use new gaskets when installing a throttle-body/mixer assembly and note their orientation.

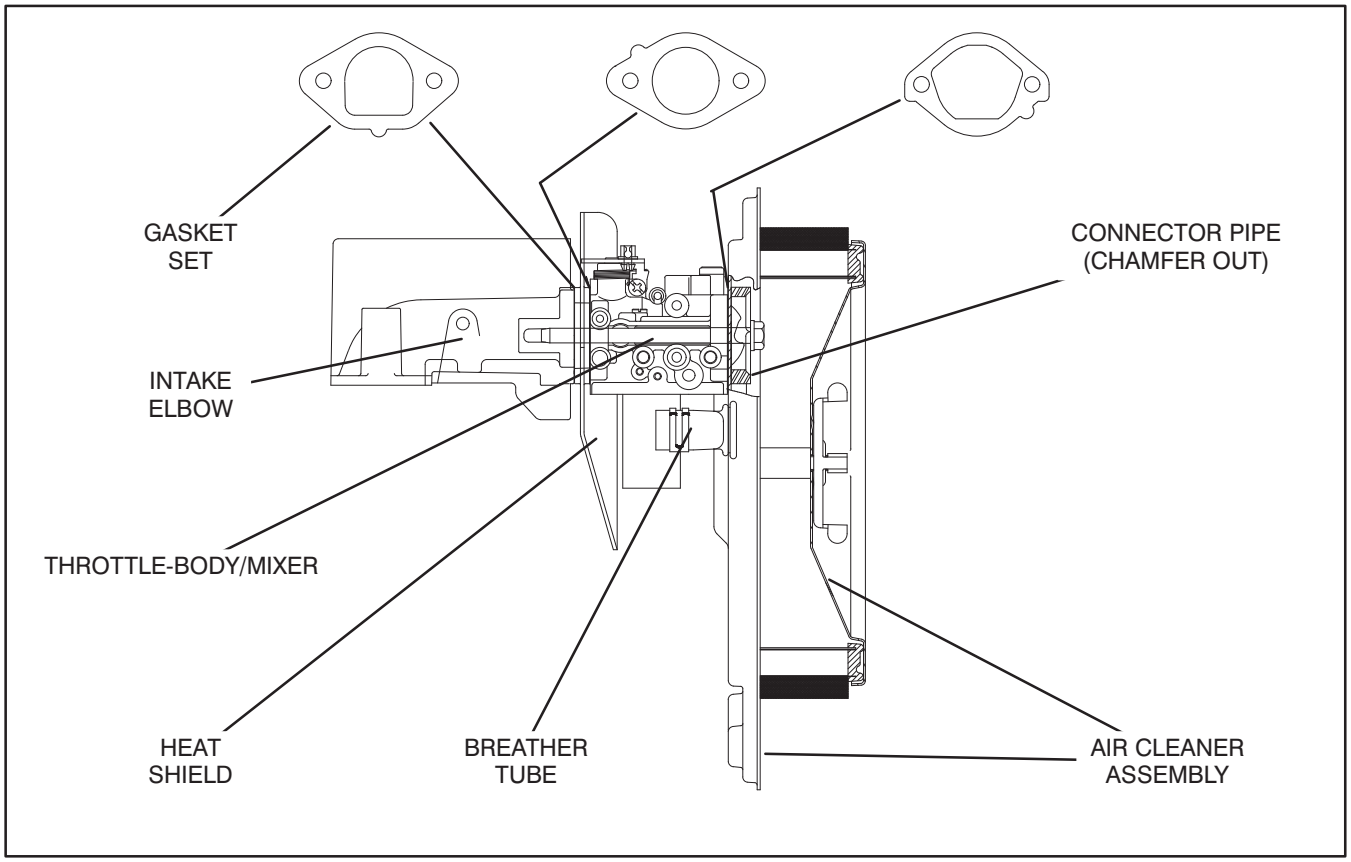


FIGURE 8-4. THROTTLE-BODY/MIXER ASSEMBLY

GOVERNOR LEVER ADJUSTMENT

Refer to Figure 8-5. The proper angular relationship between the governor lever and the governor shaft is essential for obtaining the full range of engine speed/load performance. The position of the governor lever should be readjusted whenever the intake manifold is remounted.

Governor Lever Removal: The governor lever is secured to the tapered governor shaft with a nut. Before removing the lever, stop the engine and disconnect the throttle link and governor spring. Use a standard battery cable clamp lifter available at any automotive parts store to break the tapper fit between shaft and lever hub.

Governor Lever Adjustment: The engine must be stopped to assemble and adjust the lever.

1. Loosely assemble the governor lever and shaft so that the lever is free to rotate about the shaft.
2. Attach the throttle link between the governor lever and throttle-body/mixer. Replace the nylon clips if they are worn or broken.
3. Attach the governor spring, move the throttle control lever to align the lock pin holes in the control plate and throttle control lever and insert a pin to lock the lever in place.
4. Check to see that the governor spring is holding the throttle plate in the wide open position.
5. Tighten the lock nut on the end of the governor shaft making sure the governor shaft rotates clockwise against the internal governor parts, and torque to specifications.
6. Remove the lock pin to release the throttle control lever.

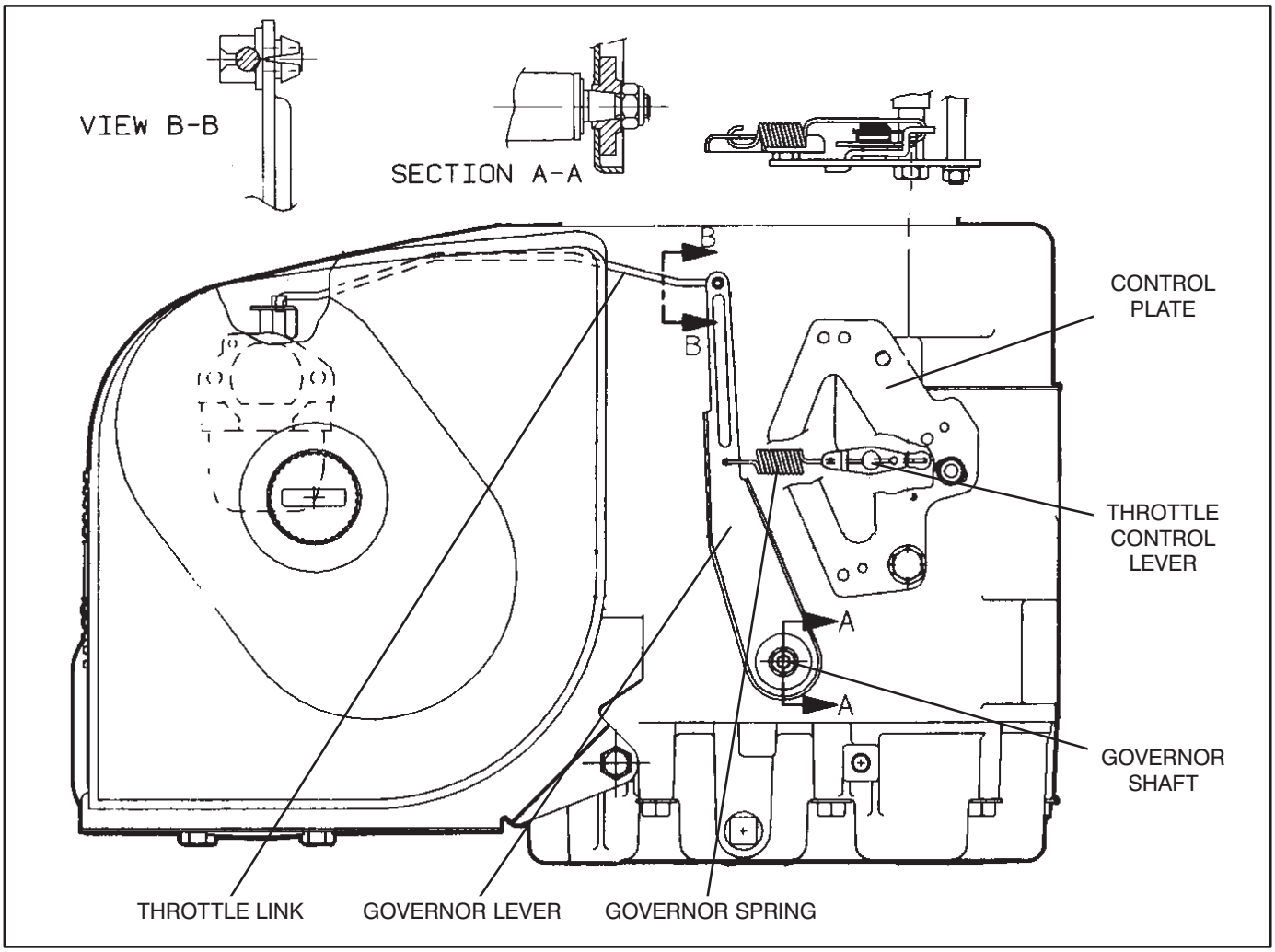


FIGURE 8-5. ENGINE GOVERNOR COMPONENTS

ENGINE SPEED ADJUSTMENTS

These adjustments must be made using an accurate tachometer. Adjust the governor lever (Page 6-8), if necessary, before adjusting engine speed. Set the low-idle and high-idle speeds to the values specified by the equipment manufacture. In the absence of such specifications, it is recommended that low-idle speed be adjusted to 1500 rpm and high-idle speed to 3400 rpm.

⚠WARNING ***Adjusting the engine speed to a value above that specified by the equipment manufacturer 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.***

1.. Remove the outer air cleaner cover for access to the low-idle speed screw (Figure 8-6).

2.. Disconnect all loads and start the engine, observing all of the equipment manufacturer's instructions and precautions.

3.. While holding the throttle lever against the low-idle speed stop screw on the top of the throttle-body/mixer (Figure 8-6), turn the screw to obtain the specified low-idle speed.

4.. Loosen the throttle cable clamp, the speed control plate pivot bolt and the control plate position lock nut.

5.. Lock the throttle control lever in the high-idle position with a 1/8 inch diameter pin (drill bit) inserted as shown.

6.. Pivot the speed control plate clockwise to increase or counterclockwise to decrease engine speed. Tighten the pivot bolt and lock nut when the specified high-idle speed is obtained.

7.. Adjust the throttle cable (Page 6-10).

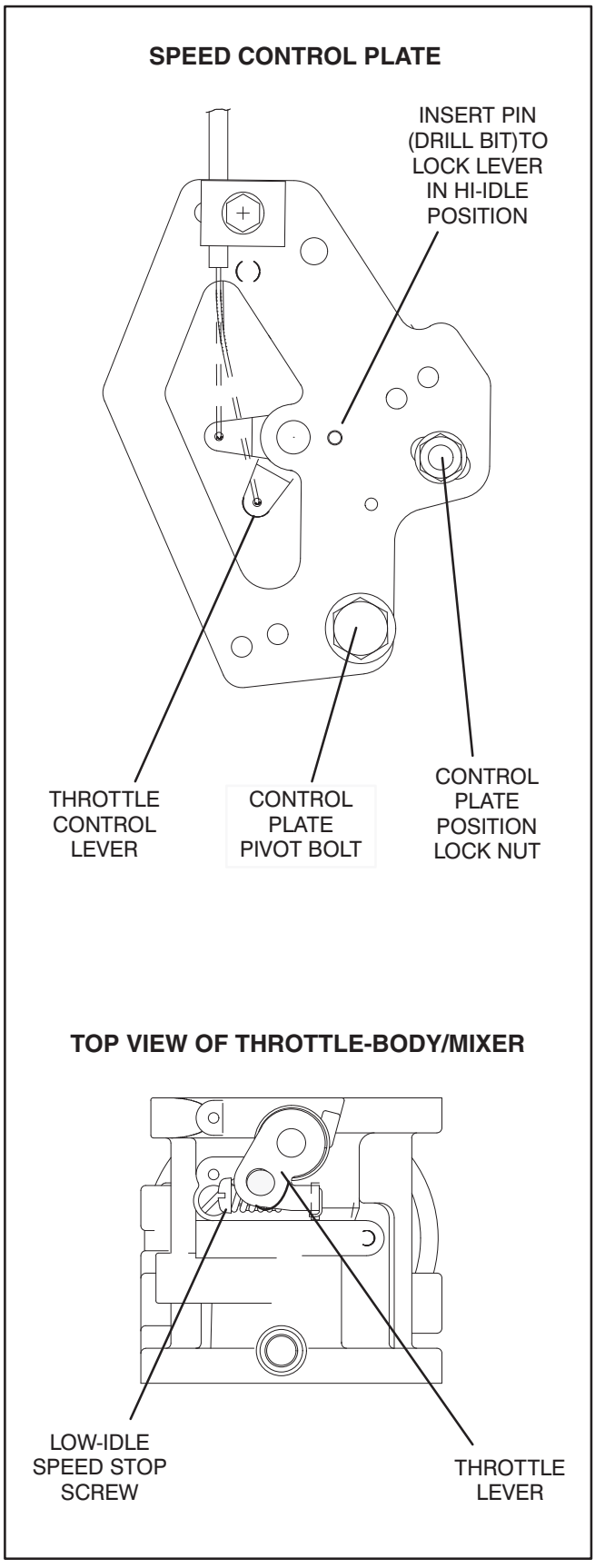


FIGURE 8-6. ENGINE SPEED ADJUSTMENTS

THROTTLE CABLE ADJUSTMENT

1.. Shut off the engine and loosen the throttle cable clamp on the speed control plate (Figure 8-7).

2.. Hook the throttle cable into the throttle control lever.

3.. Lock the throttle control lever in the high-idle position with a 1/8 inch diameter pin (drill bit) inserted as shown.

4.. Push the equipment speed lever to its high position and tighten the throttle cable clamp.

5. Remove the lock pin.

6.. Check for binding. Travel between high-idle and low-idle positions should be approximately 0.72 inch (18 mm).

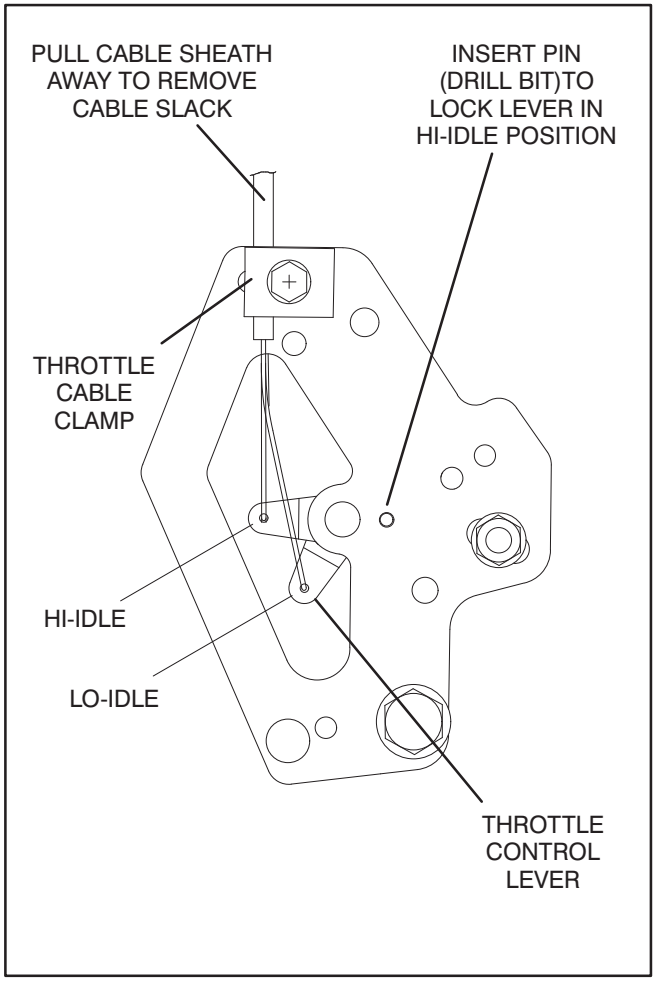


FIGURE 8-7. THROTTLE CABLE ADJUSTMENT AT SPEED CONTROL PLATE

Section 7. Electrical System

IGNITION SYSTEM

Spark Plug

See *Periodic Maintenance* in the Operator's Manual for scheduled spark plug inspection and replacement.

Clean the area around the plug before removing it. 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).

Magneto

These engines use a magneto consisting of a stationary coil and flywheel magnet to fire the spark plug (Figures 9-2 and 9-3). The primary winding of the coil has a grounding terminal for connecting a shutoff switch. Ignition timing is determined by the angular relationship of the flywheel magnet to the shaft keyway and is not adjustable (Table 3-1).

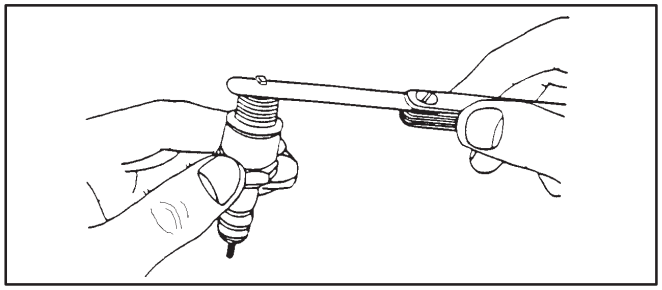


FIGURE 9-1. SPARK PLUG GAP

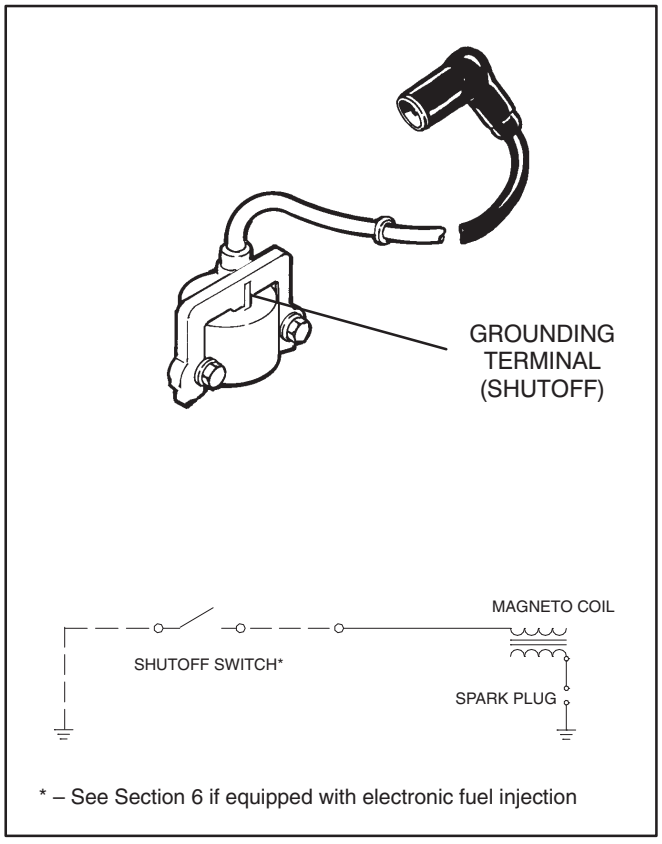


FIGURE 9-2. MAGNETO COIL ASSEMBLY

⚠WARNING ***Gasoline and 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 (Section 4), 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
  - The stop 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.

Magneto Air Gap: Measure the air gap between the core of the magneto coil and flywheel magnet (Figure 9-3). If necessary, loosen the magneto coil mounting screws and readjust the gap as specified (Section 2).

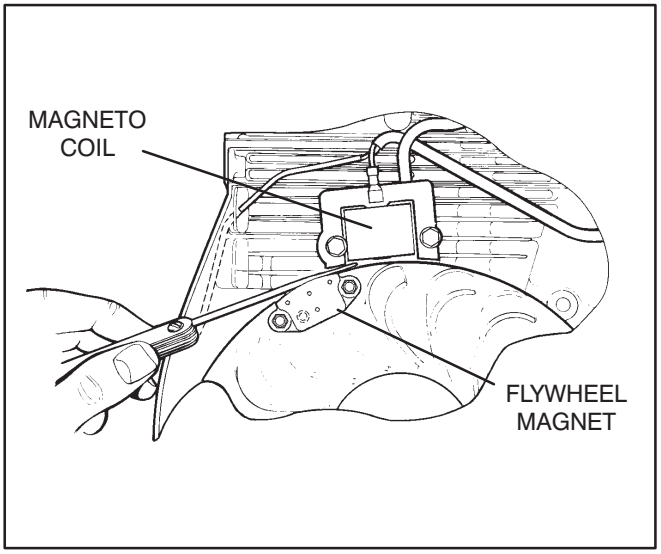


FIGURE 9-3. MEASURING MAGNETO AIR GAP

DC 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 9-4). The system consists of a permanent magnet flywheel alternator and a solid state rectifier or voltage regulator.

The flywheel must be removed for access to the alternator stator. See Section 10.

Checking DC System Connections

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) or bridge rectifier (four) are clean and tight.

5. Check to see that the wiring connected to the **B+** terminal (middle) of the voltage regulator or **+** and **–** terminals of the bridge rectifier are 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.

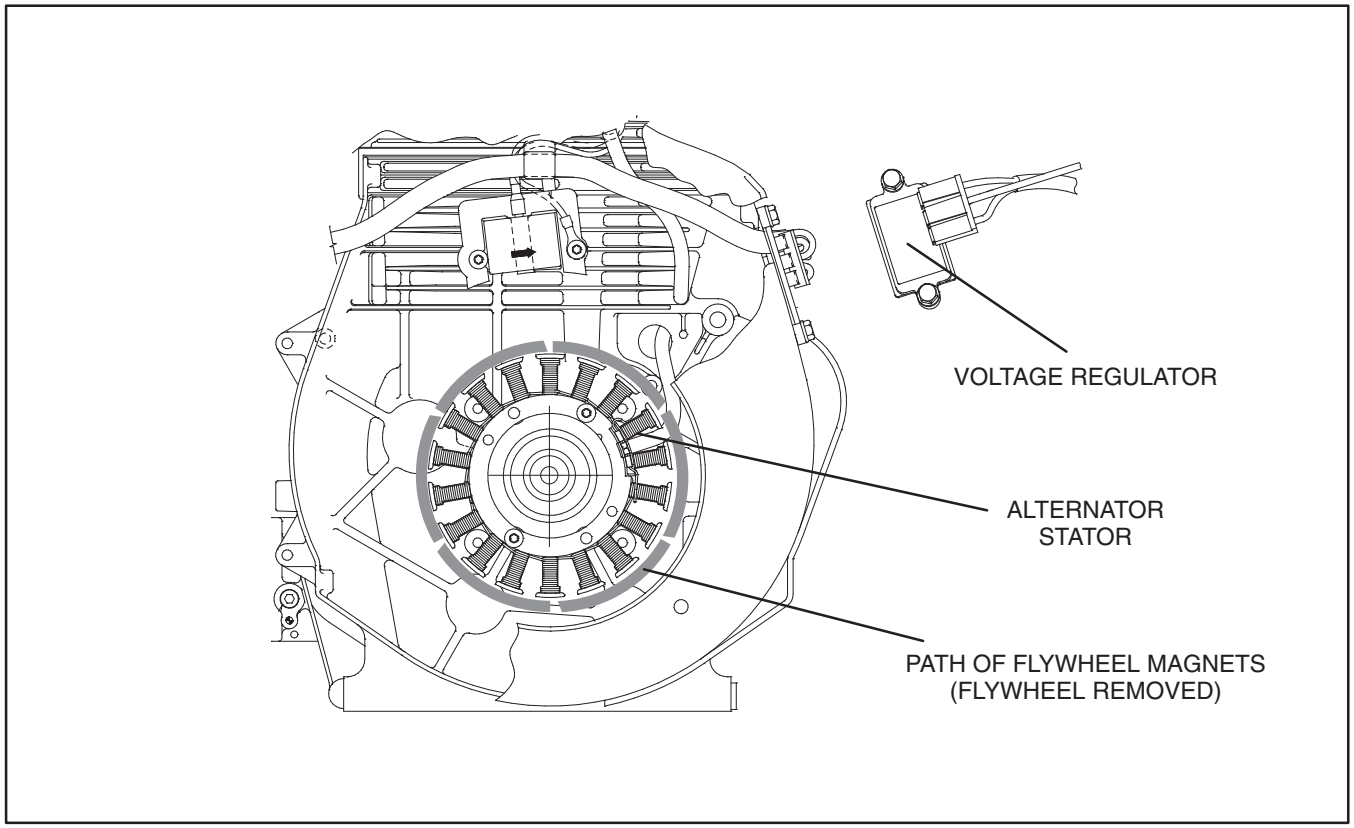


FIGURE 9-4. FLYWHEEL ALTERNATOR AND VOLTAGE REGULATOR

Alternator Output Tests

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 9-1 for test specifications. Use a multi-meter (Simpson 270) when testing the alternator.

1. Check battery voltage, if applicable, when the engine is not running. If not within specifications (Table 9-1), 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 9-4) or bridge rectifier 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. Replace the stator if it is shorted to ground (low resistance). If it is shorted, go to Step 5.

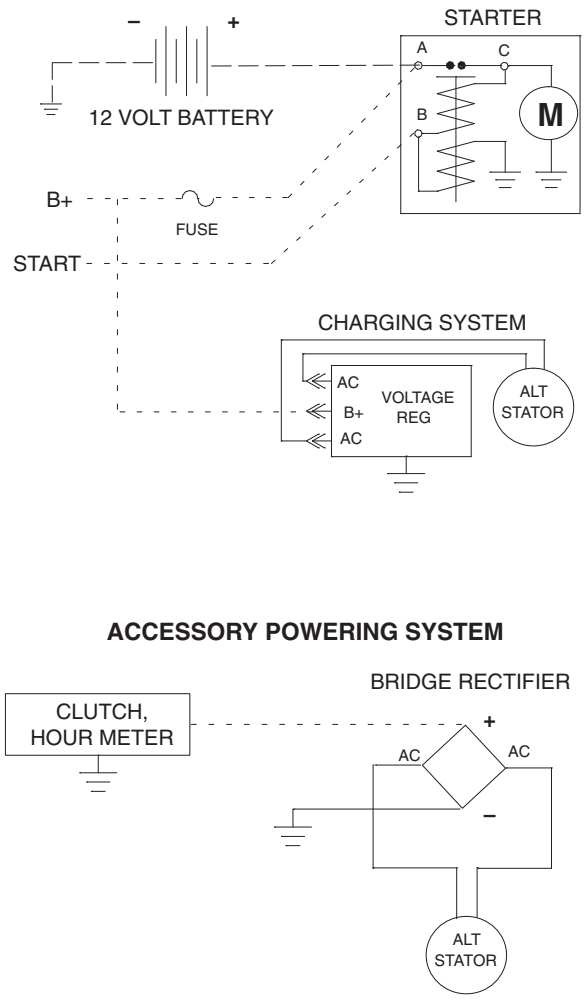
5. Check alternator stator resistance by connecting an ohmmeter across the stator leads. Replace the alternator stator assembly if stator resistance on the lowest scale of the meter is either higher or lower than specified. Replace the flywheel assembly if alternator stator resistance is as specified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

WIRING CONNECTIONS

Figure 9-5 shows typical custormer connections. See Section 6 for connections on engines equipped for electronic fuel injection of LPG.

TABLE 9-1. 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



Solid lines show factory wiring and dashed lines customer wiring.

FIGURE 9-5. TYPICAL WIRING CONNECTIONS—CARBURETED ENGINES ONLY

Section 8. 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 10-1. 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.

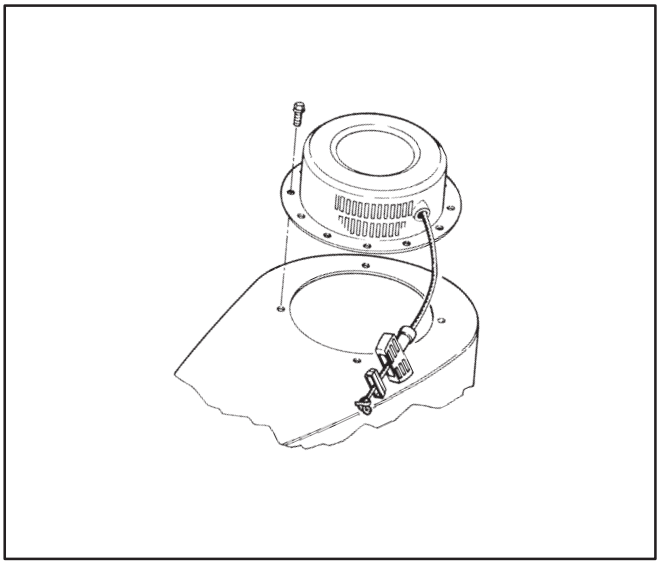


FIGURE 10-1. RECOIL STARTER

110 VAC STARTER

Disassembly: Refer to Figure 10-2. Remove the two drive cap mounting screws and remove the assembly from the engine.

Inspection/Service: Replace the entire plug/switch/motor assembly if the motor does not operate or is not strong enough to turn the engine. Replace the pinion gear and associated parts if the pinion is worn and/or binds on the shaft. The parts are available in kit form. Follow the kit instructions. If the drive cap bearing appears worn, replace the drive cap.

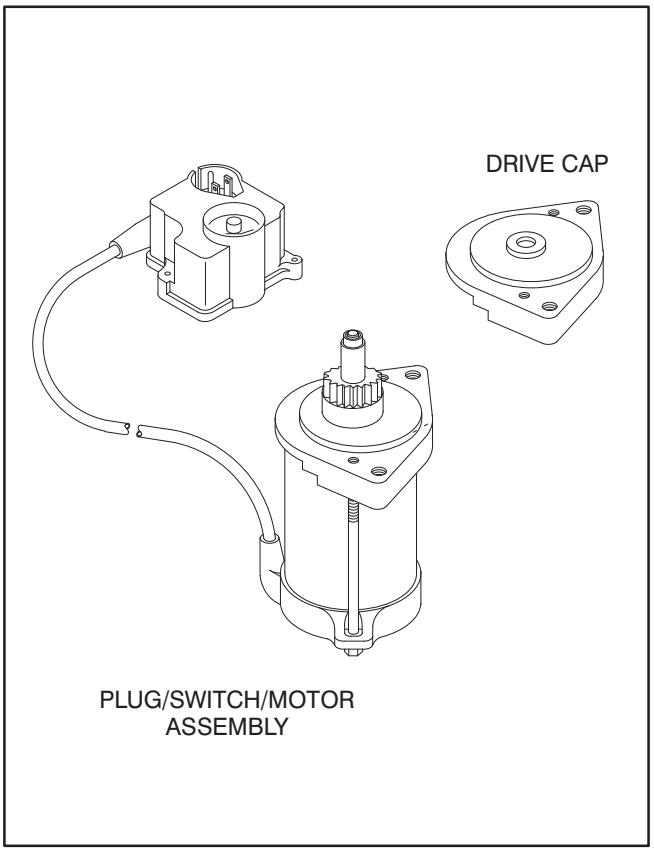


FIGURE 10-2. 110 VAC STARTER

SOLENOID SHIFT STARTER

See Section 7 for typical wiring connections at the starter solenoid.

Inspection: Refer to Figure 10-3. 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 10-3). 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 10-3). If the motor responds, it is probably okay and it may only be necessary to replace the solenoid.

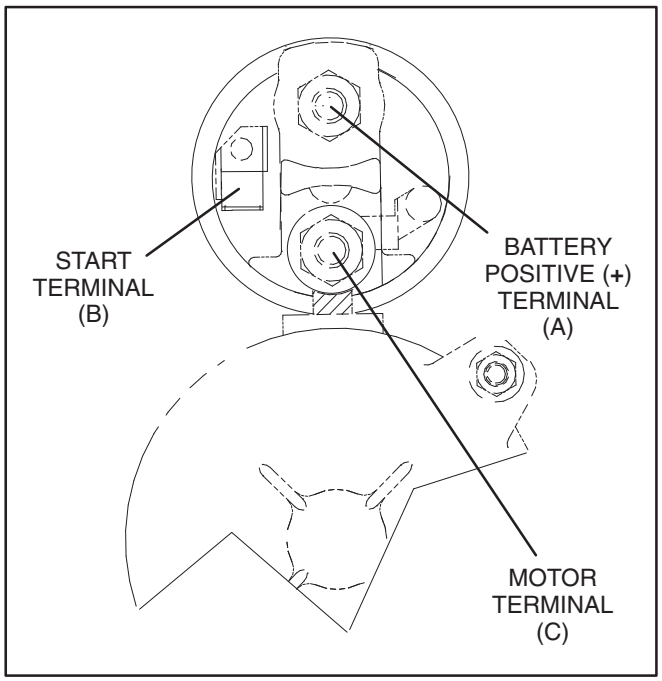


FIGURE 10-3. STARTER SOLENOID TERMINALS

⚠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 10-4. 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.

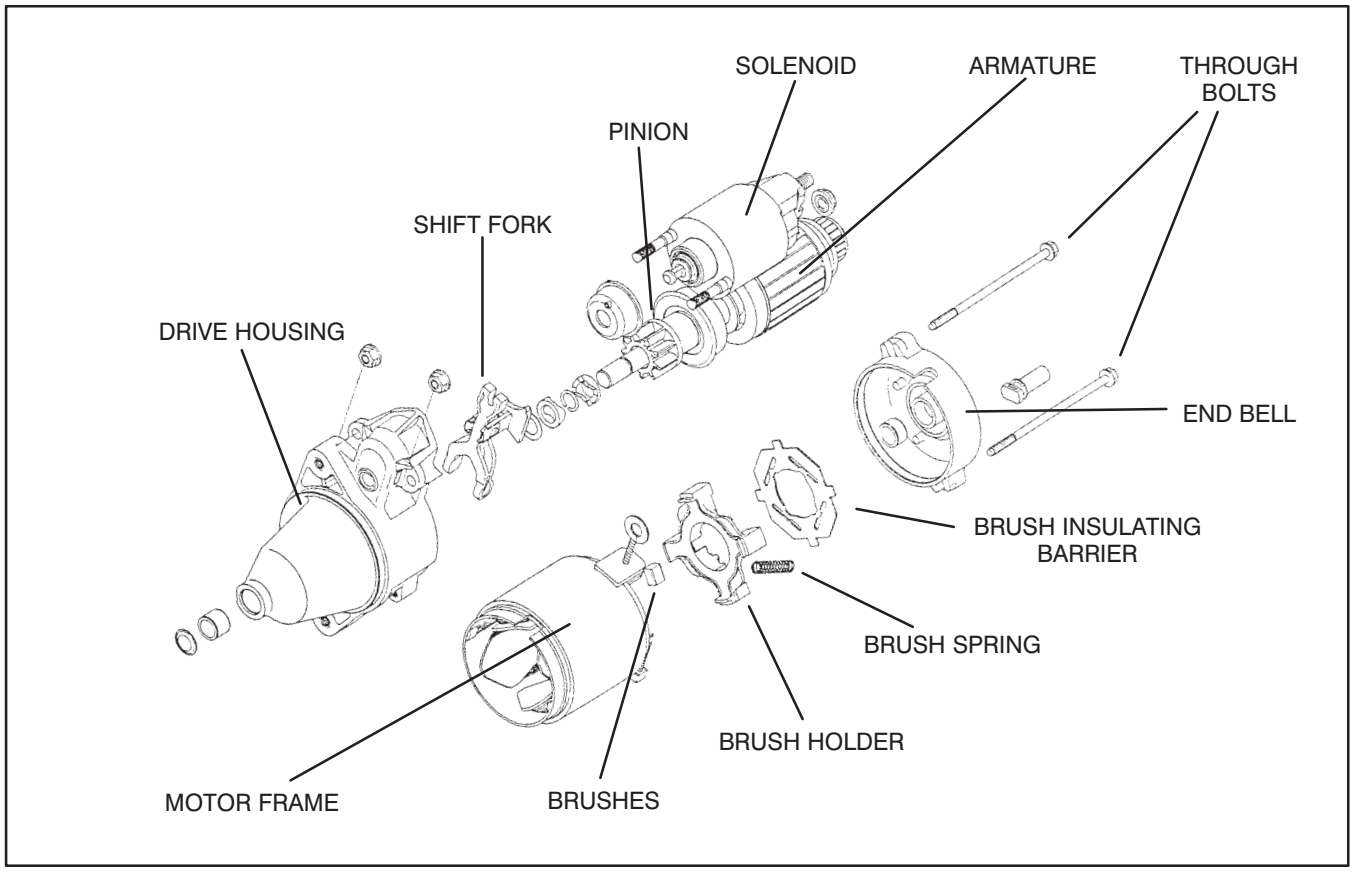


FIGURE 10-4. SOLENOID SHIFT STARTER

Armature

Checking Integrity of Winding Insulation: Refer to Figure 10-5. 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.

Checking Integrity of Windings: Refer to Figure 10-6. 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.

Motor Frame

Checking Integrity of Windings: Refer to Figure 10-7. 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.)

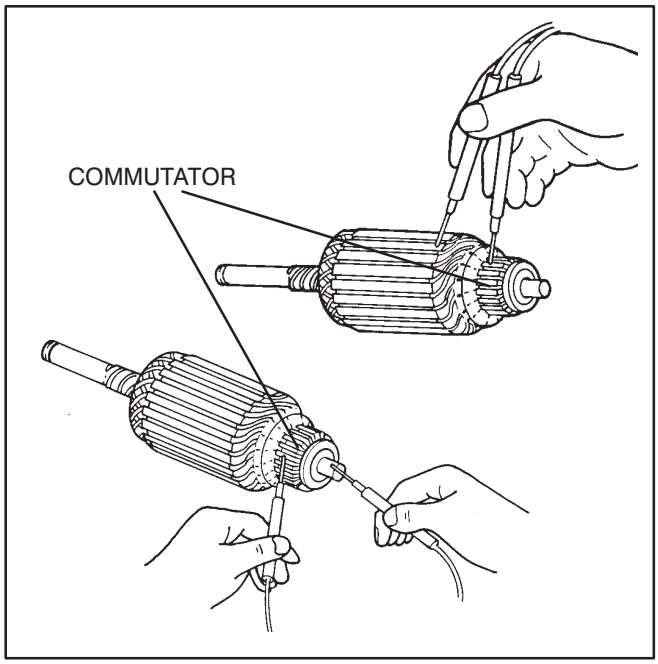


FIGURE 10-5. CHECKING ARMATURE WINDING INSULATION

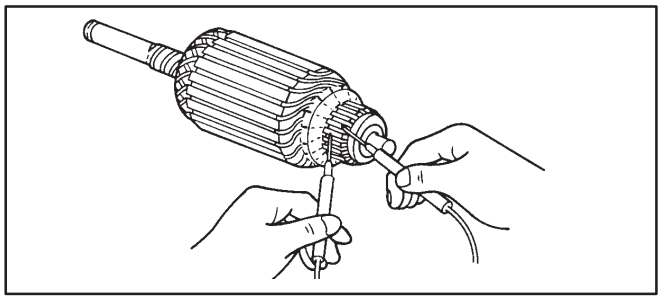


FIGURE 10-6. CHECKING ARMATURE WINDINGS

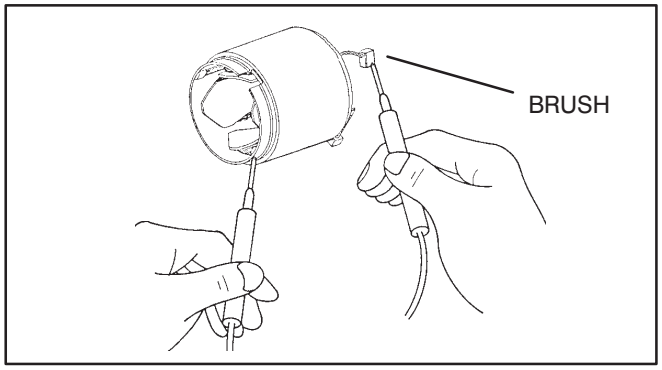


FIGURE 10-7. MOTOR FRAME WINDINGS

Brushes

Refer to Figure 10-8. 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).

Commutator

Commutator: Refer to Figure 10-9. 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). Replace the armature assembly if the commutator cannot be cleaned up and still meet the specified diameter.

Commutator Mica: Refer to Figure 10-10. Use a saw blade to undercut the commutator mica if the undercut is less than specified (Section 2) and chamfer the segment edges.

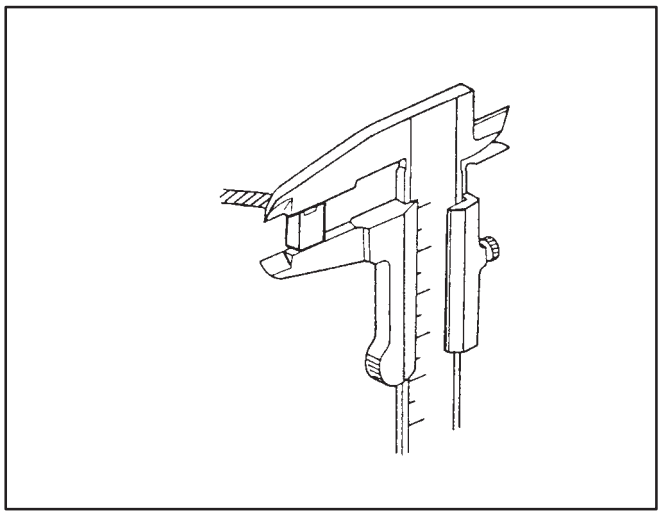


FIGURE 10-8. MEASURING BRUSH LENGTH

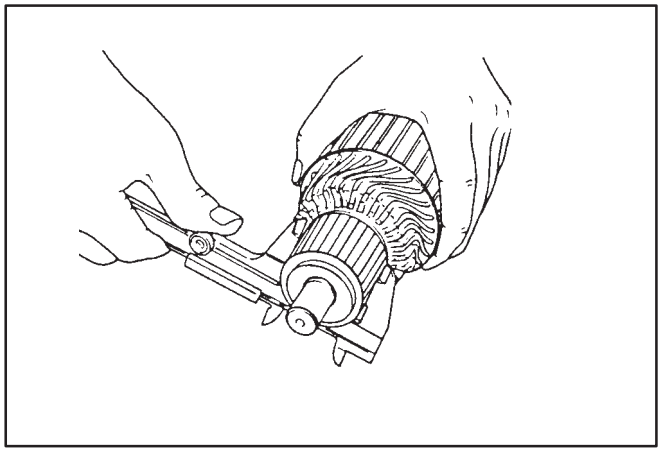


FIGURE 10-9. MEASURING COMMUTATOR O. D.

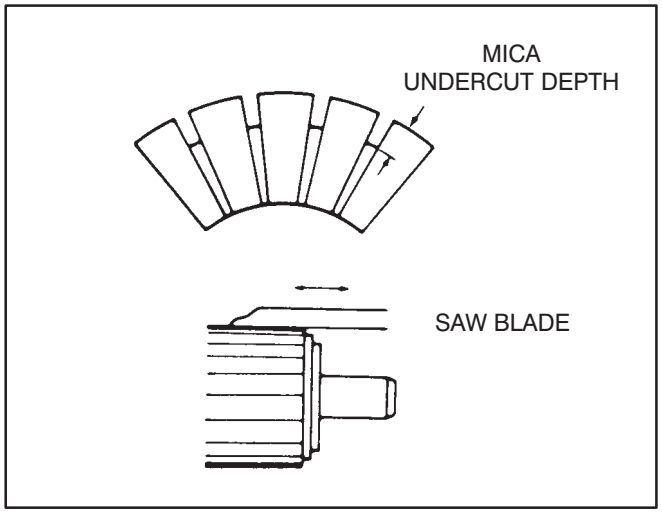


FIGURE 10-10. MICA UNDERCUT DEPTH

Pinion

Inspection/Service: Refer to Figure 10-11. 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.***

Armature Shaft Bushings

Refer to Figure 10-12. 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).

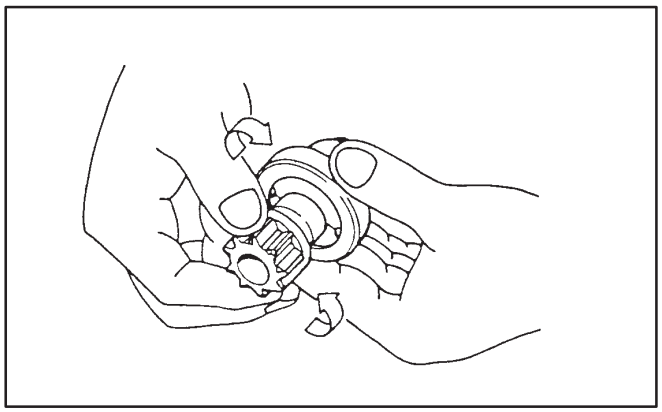


FIGURE 10-11. CHECKING OPERATION OF PINION OVER-RUNNING CLUTCH

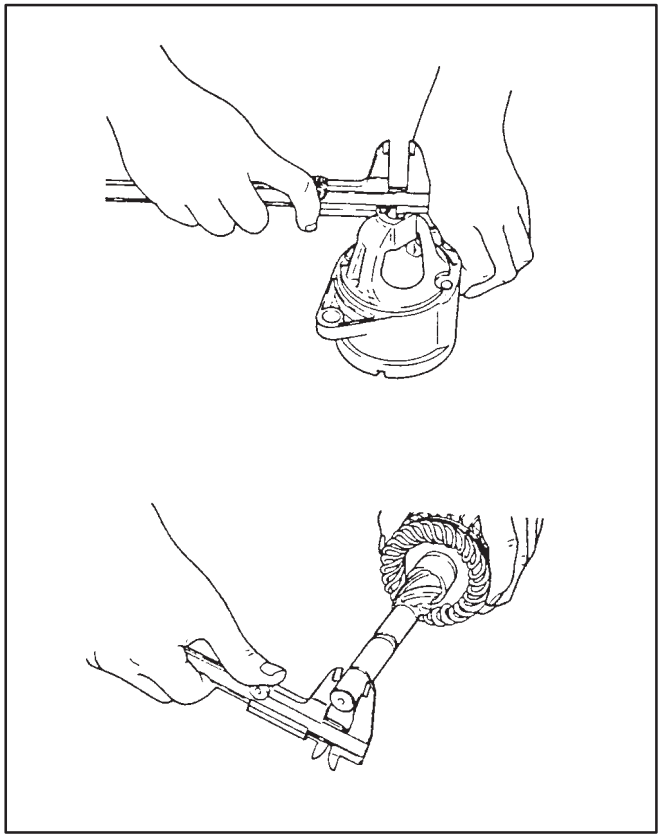


FIGURE 10-12. MEASURING BUSHING I. D. AND ARMATURE SHAFT O. D.

Section 9. 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 oil base and to the crankshaft connecting rod journal (Figure 11-1). The oil pump is located in the oil base and is driven by a balancer shaft. It is accessible by removing the oil pump cover on the oil base (Figure 11-3). Oil pressure is controlled by an oil relief valve (Figure 11-7).

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.

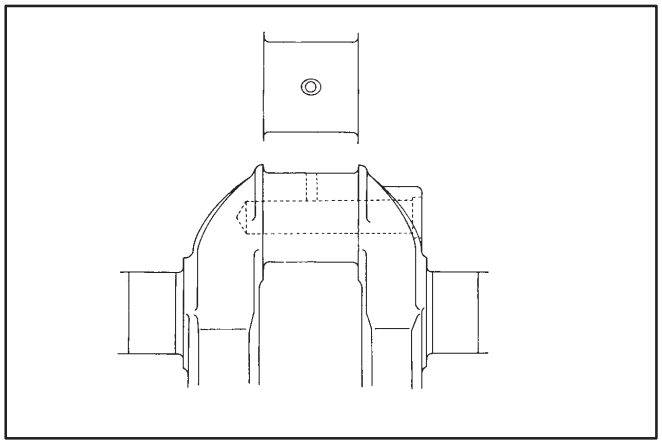


FIGURE 11-1. OIL HOLE IN THE CRANKSHAFT CONNECTING ROD JOURNAL

CHECKING OIL PRESSURE

Refer to Figure 11-2. Install an engine oil pressure gauge in the oil base 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 3-1, Section 1. 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.

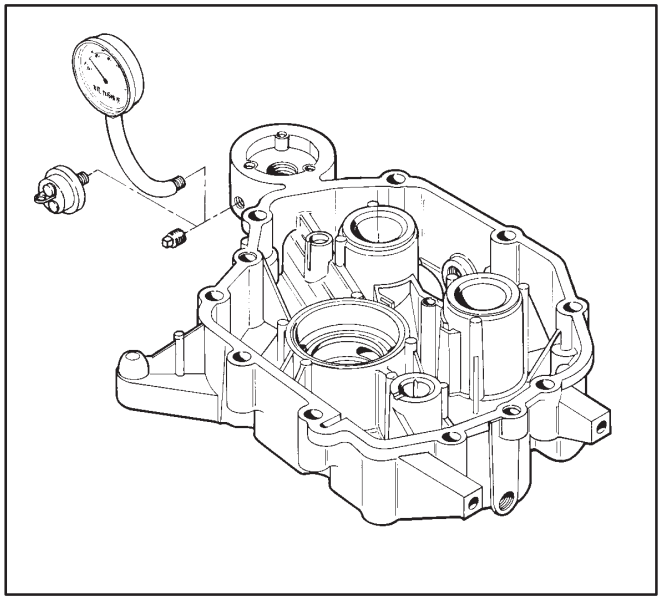


FIGURE 11-2. OIL PRESSURE CHECK

OIL PUMP

Disassembly

Refer to Figure 11-3. Remove the capscrews holding the oil pump cover to the oil base. Separate the inner and outer rotor.

Inspection/Service

Rotor Lobe Clearance: Refer to Figure 11-4. 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, replace the oil pump.

Outer Rotor and Pump Body Clearance: Refer to Figure 11-5. 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, replace the oil pump.

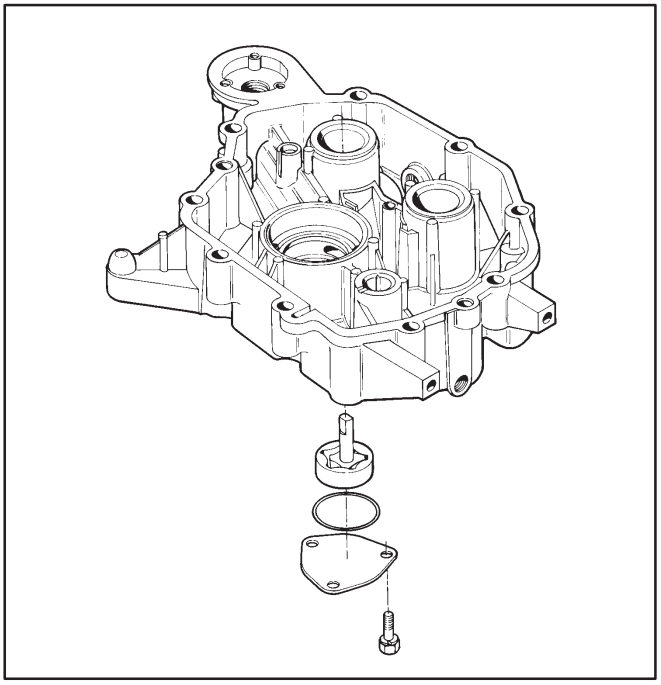


FIGURE 11-3. OIL PUMP DISASSEMBLY

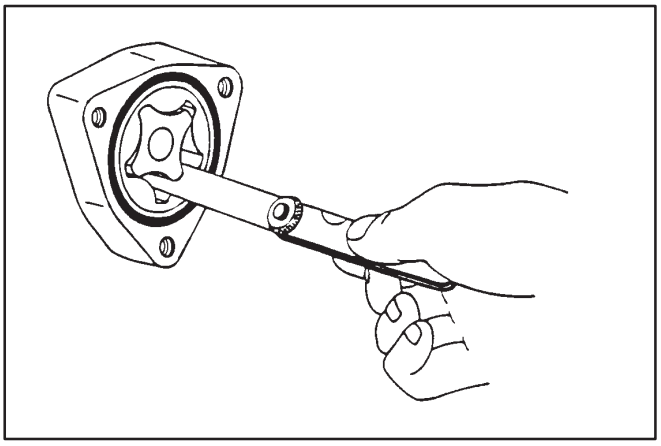


FIGURE 11-4. MEASURING PUMP ROTOR LOBE CLEARANCE

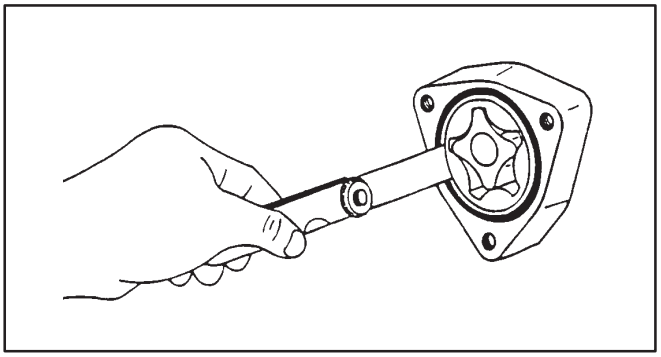


FIGURE 11-5. MEASURING PUMP OUTER ROTOR TO BODY CLEARANCE

Rotor and Cover Clearance: Refer to Figure 11-6. Put a strip of plastigauge on the rotor face. Install the pump cover and tighten the screws to that specified in Section 3. Remove the cover carefully and measure the width of the plastigauge with the table provided. If clearance is not as specified in Section 2, replace the oil pump.

Assembly

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

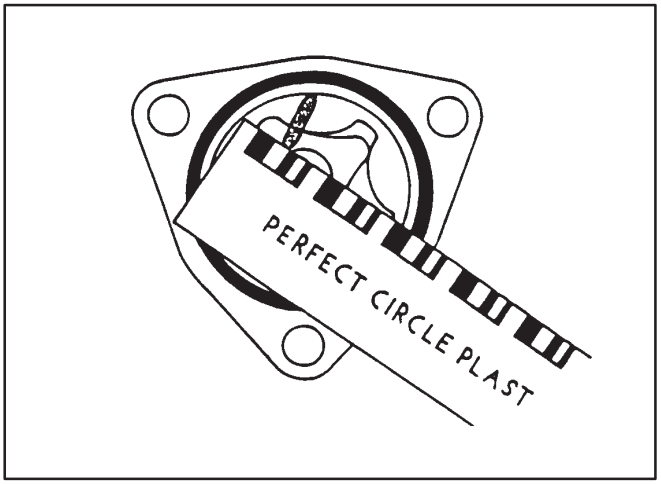


FIGURE 11-6. MEASURING PUMP ROTOR TO COVER CLEARANCE

OIL PRESSURE RELIEF VALVE

Disassembly

Refer to Figure 11-7. The oil pressure relief valve is assembled in the oil base and is accessible only after the oil base has been removed from the engine block (Section 10). Remove the retaining ring, relief valve spring, and check ball.

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.

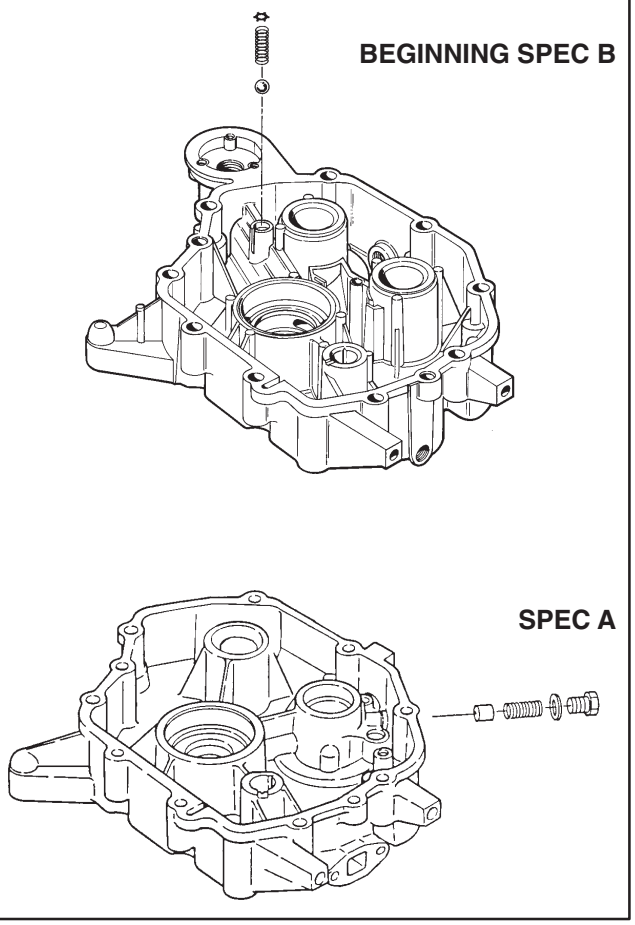


FIGURE 11-7. OIL RELIEF VALVE

Section 10. Engine Block Assembly

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 ***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.***

It is necessary to remove the flywheel when rebuilding the engine block assembly or gaining access to the battery charging alternator stator (Section 7). 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.

⚠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.***

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).

VALVE COVER

Remove the valve 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).

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 (Section 2), loosen the locknut and turn the lash adjusting screw until the specified lash is obtained. Tighten the locknut and recheck lash.

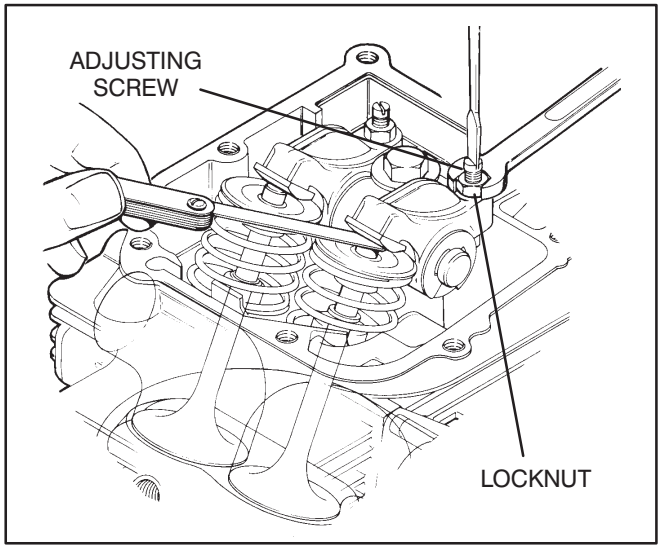


FIGURE 12-1. ADJUSTING VALVE LASH

VALVE ROCKER ARMS

Refer to Figure 12-2. 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 (Section 2), 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.

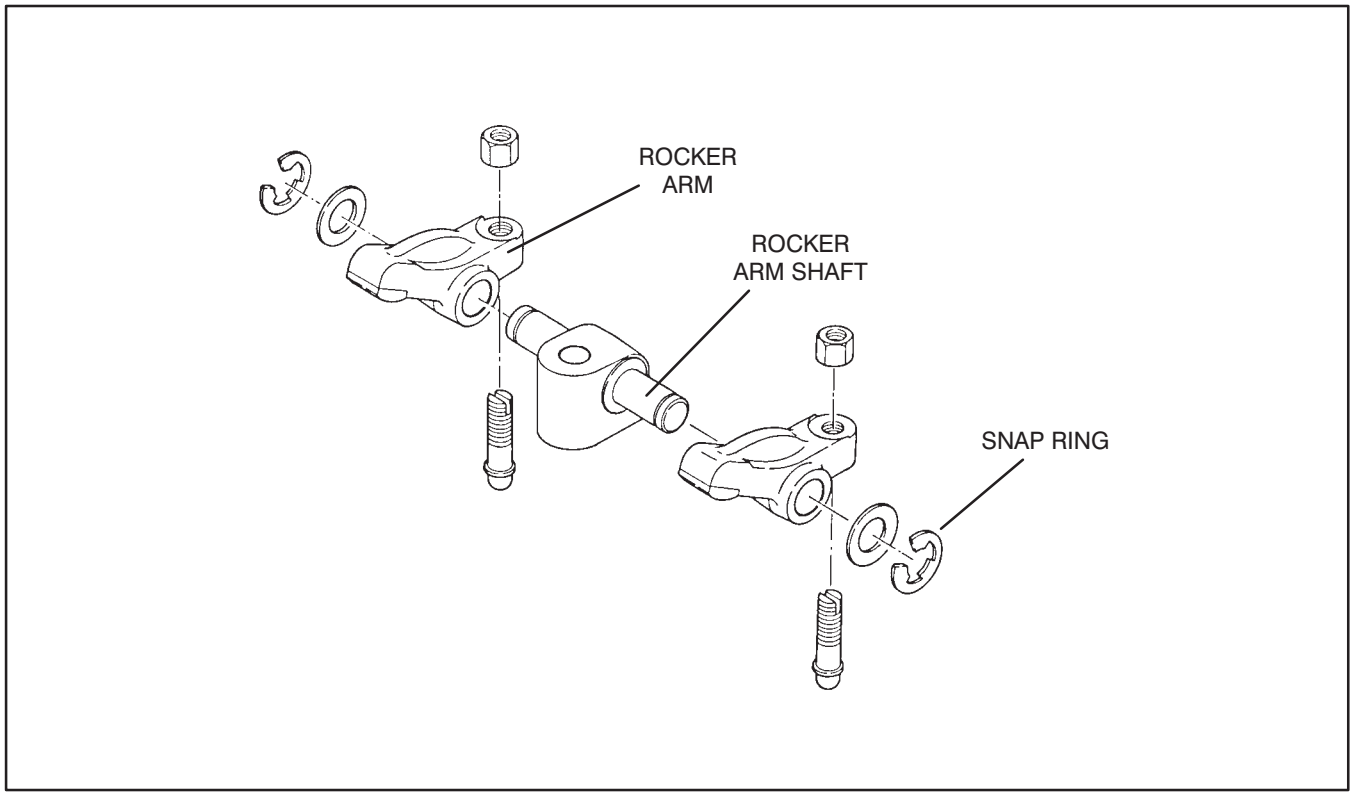


FIGURE 12-2. VALVE ROCKER ARM ASSEMBLY

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 12-3. 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 (Section 3). 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.

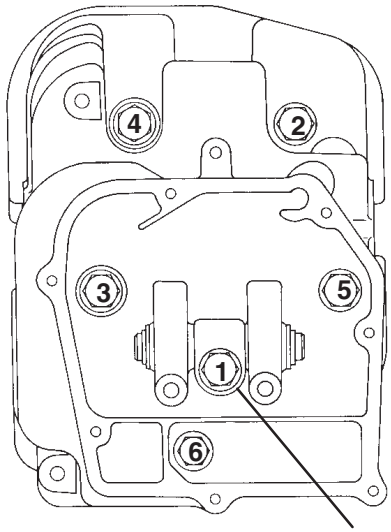


FIGURE 12-3. CYLINDER HEAD BOLTS

VALVES

The engine is of the overhead valve design (Figure 12-4). 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.

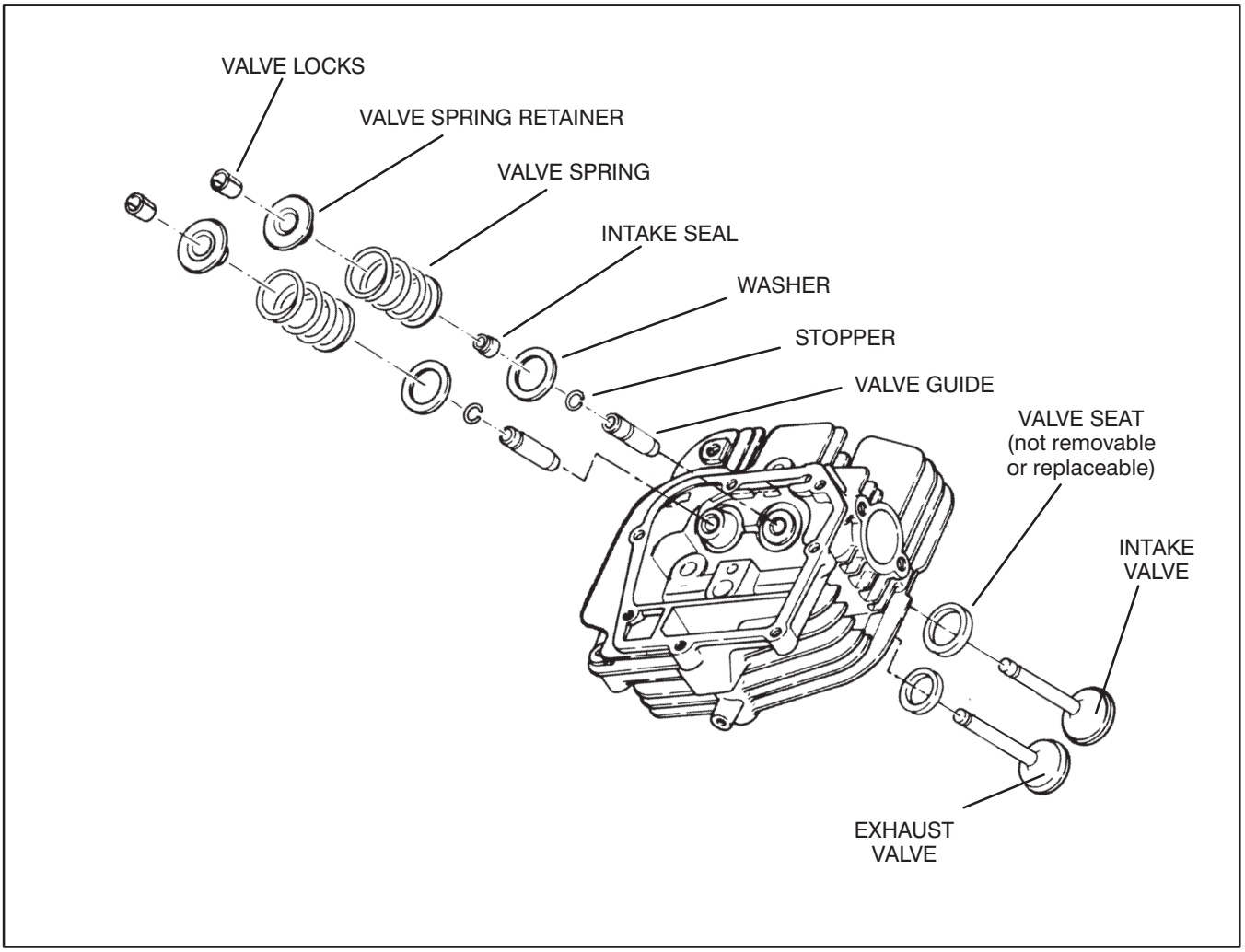


FIGURE 12-4. VALVE ASSEMBLY

Inspection and Service

Valve Stem and Valve Guide Clearance: Refer to Figures 12-5 and 12-6. 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 (Section 2), replace the guide or guide and valve.

Valve Guide Replacement: Refer to Figure 12-7. 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.***

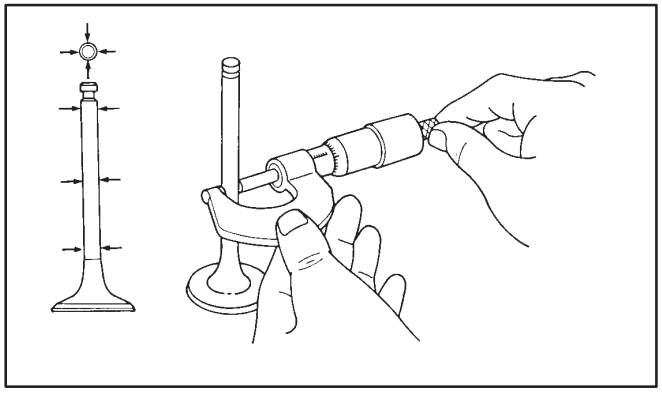


FIGURE 12-5. MEASURING VALVE STEM DIAMETER

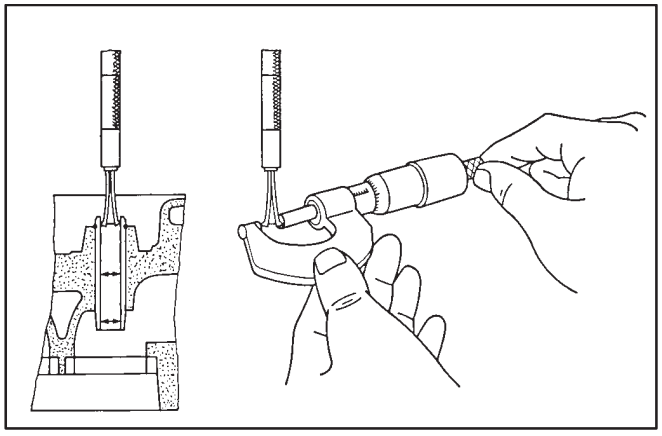


FIGURE 12-6. MEASURING VALVE GUIDE BORE

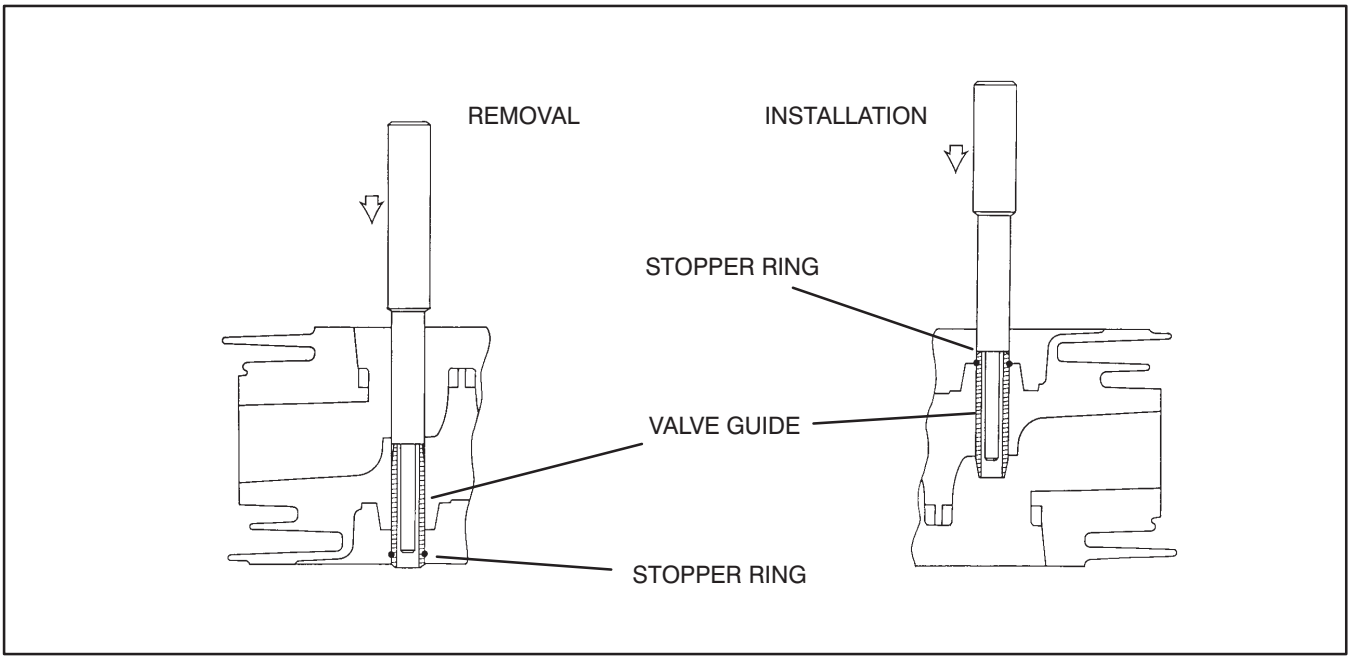


FIGURE 12-7. REPLACING VALVE GUIDE

Valve Face: Refer to Figure 12-8. 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.

Valve Seat: Refer to Figures 12-9 and 12-10. 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.

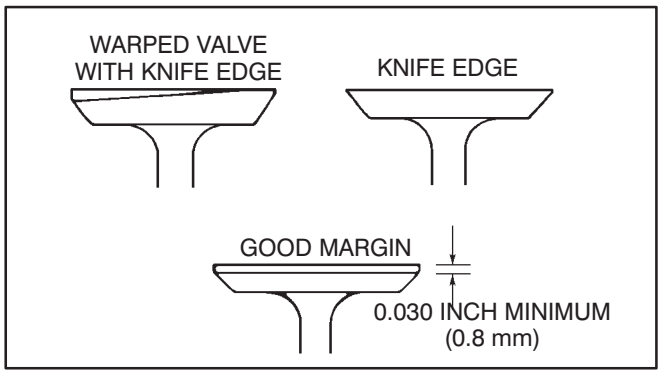


FIGURE 12-8. VALVE HEAD MARGIN

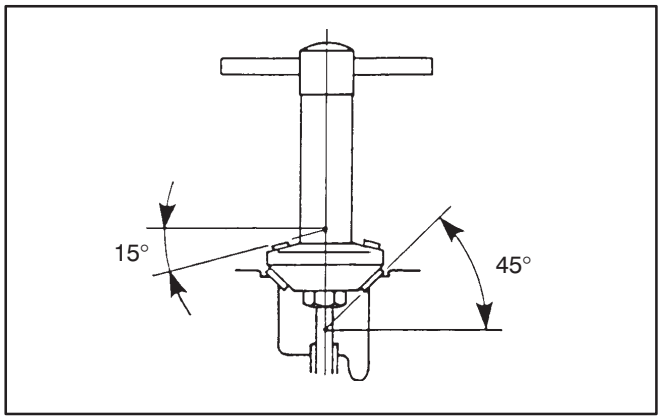


FIGURE 12-9. VALVE SEAT CUTTER

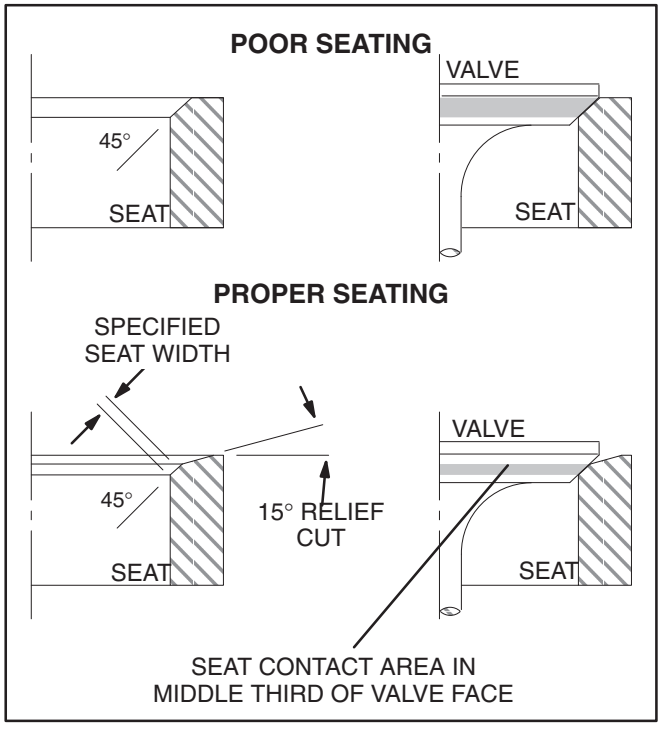


FIGURE 12-10. VALVE SEATING

Valve Springs: See Figure 12-11. 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.

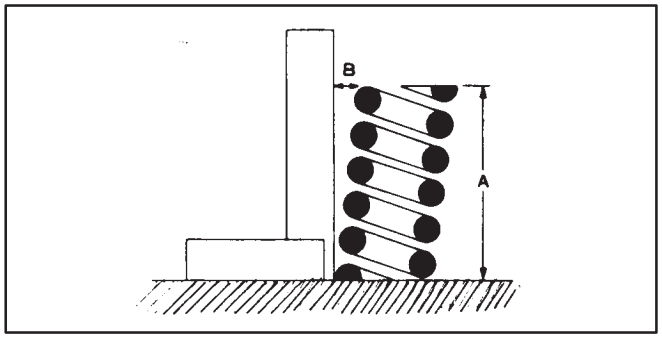


FIGURE 12-11. MEASURING VALVE SPRING HEIGHT AND SQUARENESS

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 the fuel line, exhaust pipe, battery cables (Negative [–] first), throttle cable, etc.
3. Remove the engine from the equipment.
4. Remove the air cleaner assembly, carburetor, and air deflector.
5. Remove the muffler, fuel tank, chaff screen, blower housing, cylinder shroud, etc.
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 oil base. *Note that the four shafts supported inside the oil base have end play shims which may stay on their shafts or come off with the oil base. 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. Use a torque wrench (Section 3). Coat the internal engine parts with oil as they are assembled. After the internal engine parts are assembled, the engine should turn over freely by hand. 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 oil base.
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 the equipment.
13. Reconnect fuel, exhaust, battery (Negative [–] cable last), throttle control, etc.
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 Section 5 or Section 6.

OIL BASE

Disassembly

Remove the oil pressure switch (if provided) located next to the oil filter. Unscrew the oil base mounting screws. Tap the oil base with a plastic hammer to remove it. Do not pry it off with a screwdriver, chisel, etc.

Note the shaft end-clearance shims (Figure 12-12). They may come off with the shaft or remain in the bore in the oil base. Tag each shim so that it can be replaced on its shaft during reassembly.

Reassembly

Always use new crankshaft oil seals. 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 each shaft end-clearance shim on its shaft. Use Plasti-gage to check shaft end clearance whenever an oil base, crankshaft, camshaft or a balancer shaft is replaced and obtain the shims necessary to meet the end clearance specified (Section 2).

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 oil base mounting bolts in a clockwise pattern to the torque specified (Section 3). Torque the bolt first torqued once more.

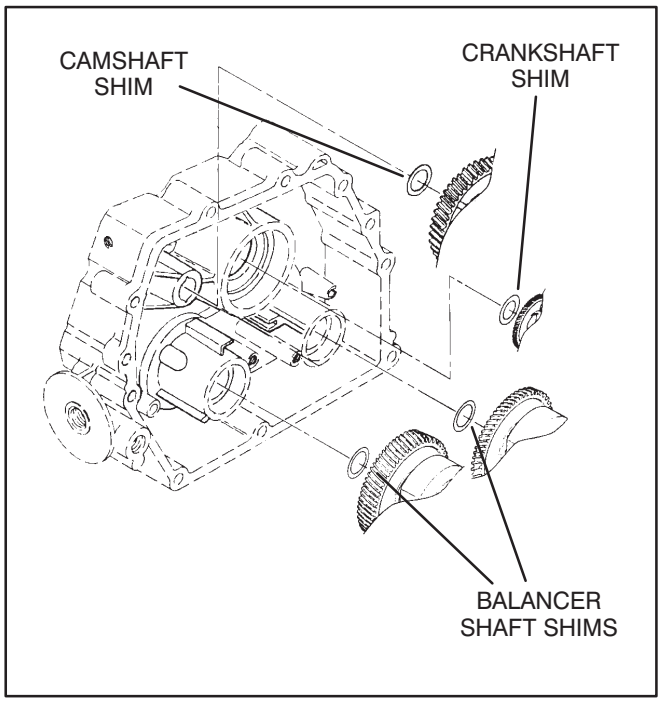


FIGURE 12-12. SHAFT END-CLEARANCE SHIM LOCATIONS

GOVERNOR

With the oil base 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 12-13). 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 12-13) for position of flyweight and sleeve.

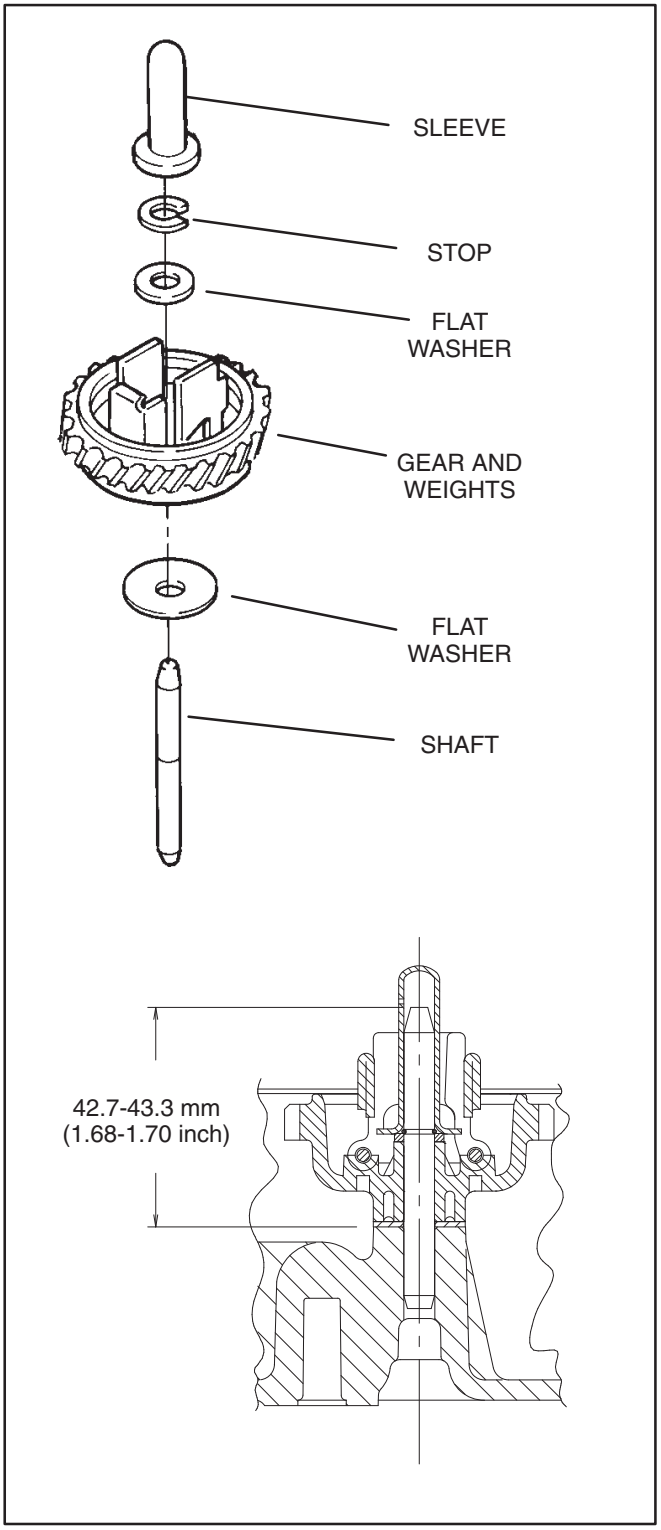


FIGURE 12-13. GOVERNOR

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 (Section 2).

Assembly

Refer to Figure 12-14. 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.

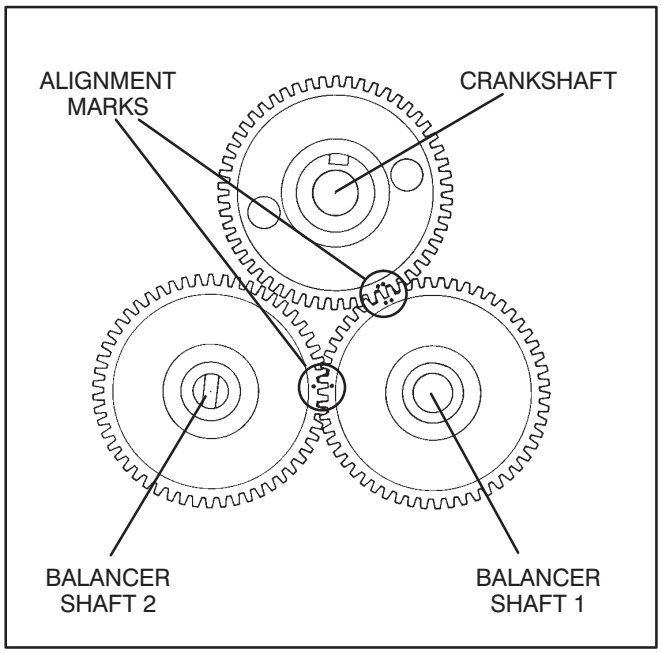


FIGURE 12-14. BALANCER SHAFT ALIGNMENT

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 12-15. Measure the crankshaft journal diameter. If the diameter is not as specified (Section 2), 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).

Camshaft Lobe Height: Refer to Figure 12-16. Measure the height of each cam at its highest point. If measurements are not as specified (Section 2), replace the camshaft.

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 (Section 2).

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 12-17.

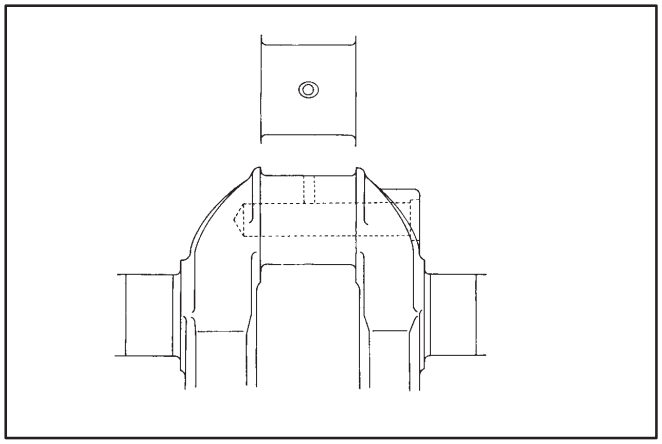


FIGURE 12-15. CRANKSHAFT JOURNAL

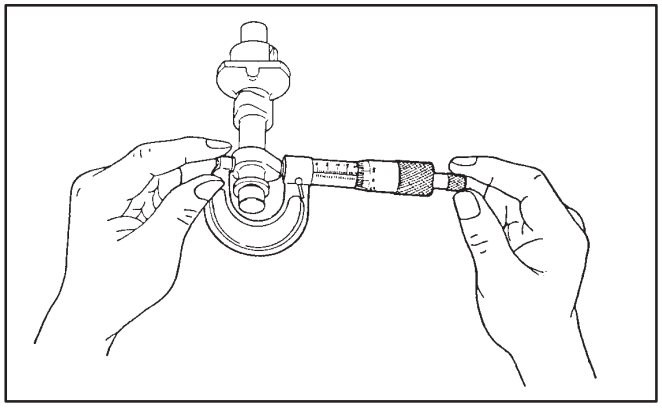


FIGURE 12-16. MEASURING CAMSHAFT LOBE HEIGHT

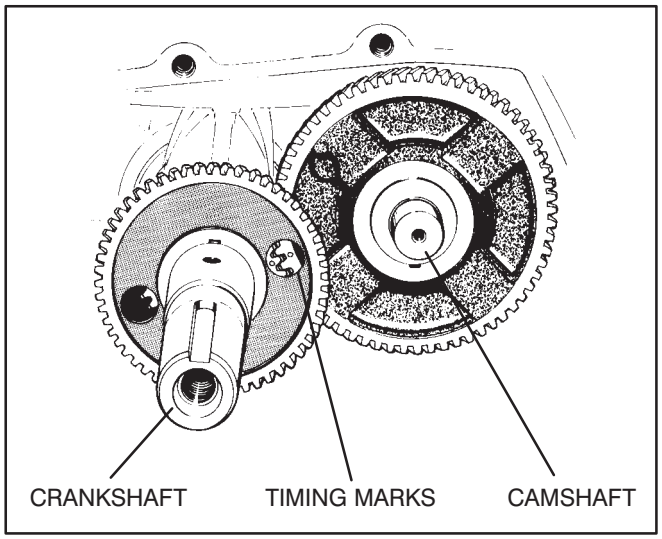


FIGURE 12-17. TIMING MARKS

COMPRESSION RELEASE SYSTEM

The engine may have a compression release system that decreases the amount of effort required to start the engine and reduces engine run-on when stopping (Figure 12-18).

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.

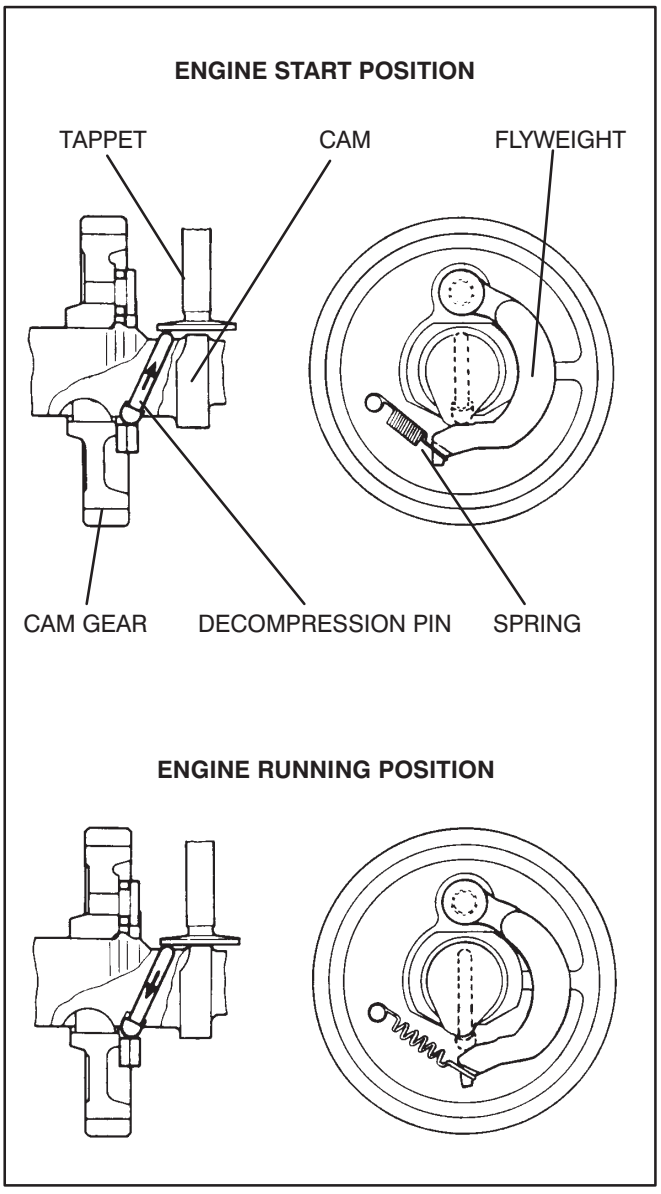


FIGURE 12-18. COMPRESSION RELEASE SYSTEM

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 12-19. 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.

Inspecting Piston For Wear and Fractures: Refer to Figure 12-20. 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.***

Piston Ring Groove Clearance: Refer to Figure 12-21. 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).

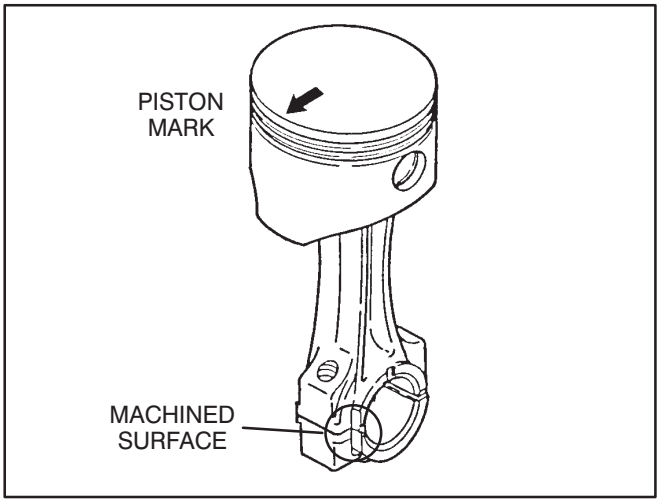


FIGURE 12-19. PISTON MARKING

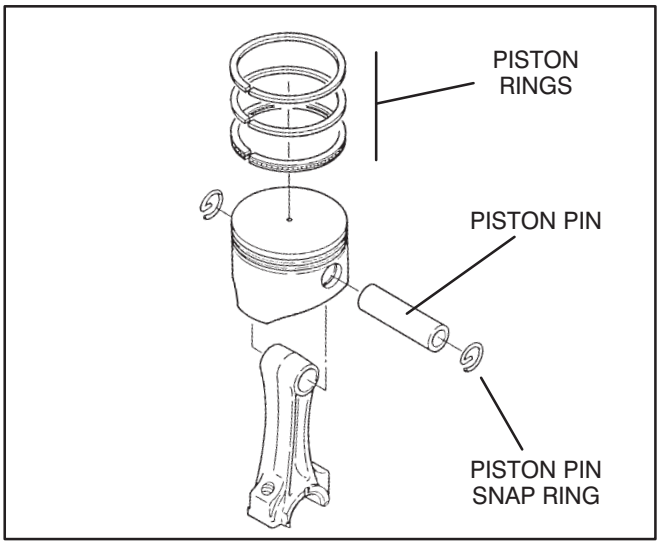


FIGURE 12-20. PISTON ASSEMBLY

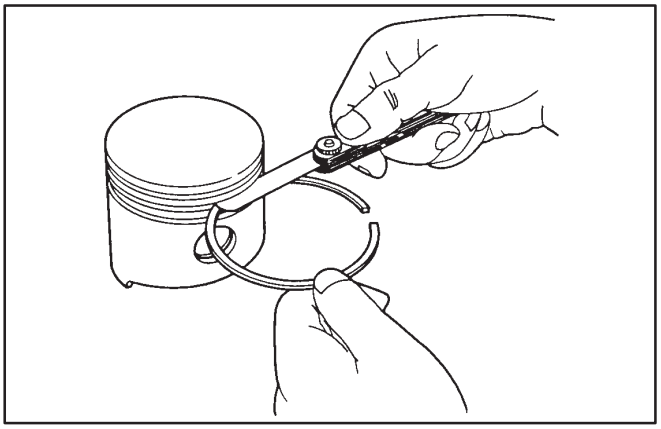


FIGURE 12-21. MEASURING RING GROOVE CLEARANCE

Piston Pin Bore Diameter: Refer to Figure 12-22. Measure the piston pin bore diameter at various places. Replace the piston if the diameter is not as specified (Section 2)

Piston Pin Outside Diameter: Refer to Figure 12-23. Measure the piston pin outside diameter. Replace the piston pin if the diameter is not as specified (Section 2).

Connecting Rod Piston Pin Bore Diameter: Refer to Figure 12-24. 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).

Connecting Rod To Crankshaft Journal Oil Clearance: Refer to Figure 12-25. 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), 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.

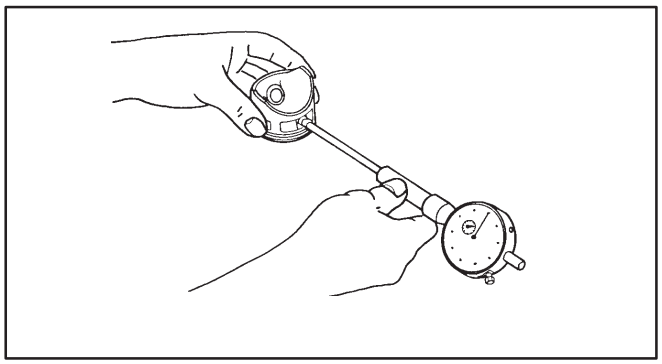


FIGURE 12-22. MEASURING PISTON PIN BORE

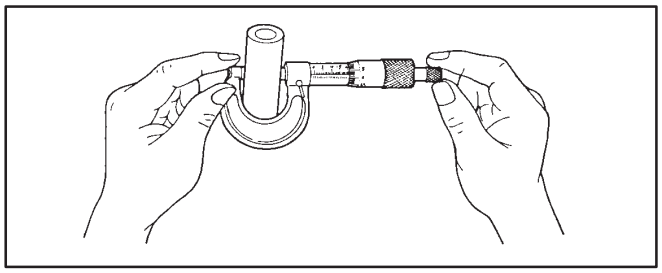


FIGURE 12-23. MEASURING PISTON PIN DIAMETER

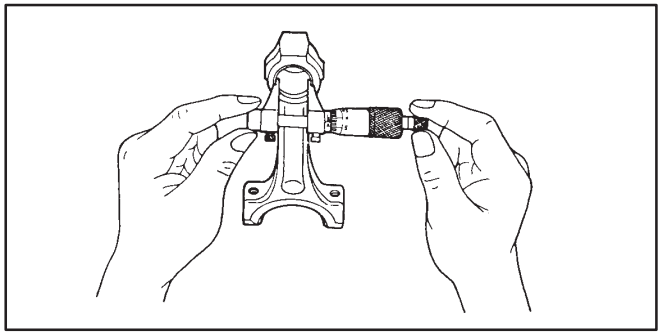


FIGURE 12-24. MEASURING CONNECTING ROD PISTON PIN BORE

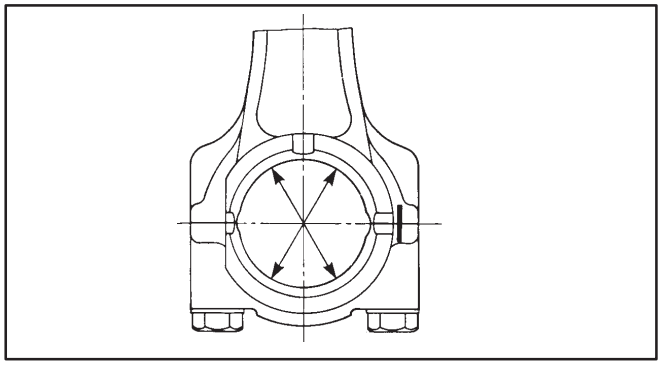


FIGURE 12-25. MEASURING CONNECTING ROD CRANK BORE

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).

Assembly

Refer to Figure 12-26. 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.

Refer to Figure 12-27. 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.

Refer to Figure 12-28. Position rings on piston as shown. Gap on top ring must face opposite of intake and exhaust valves.

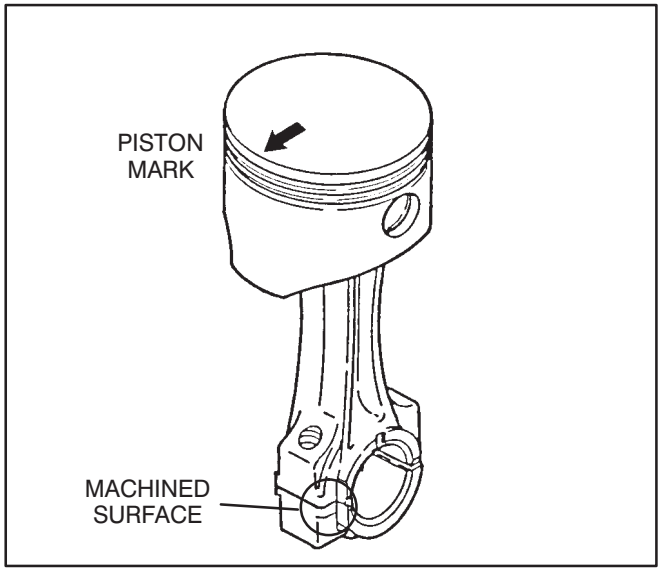


FIGURE 12-26. ASSEMBLING PISTON

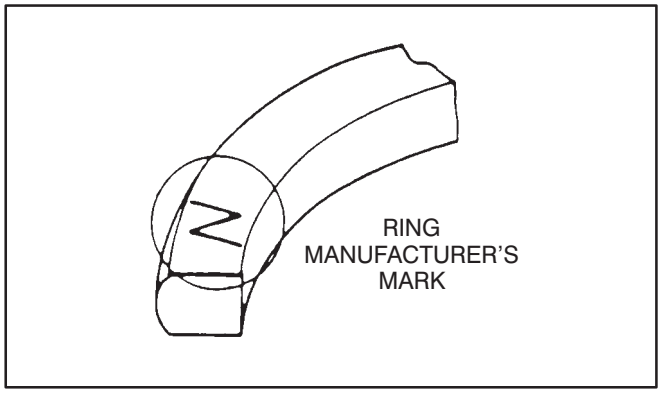


FIGURE 12-27. RING MARK

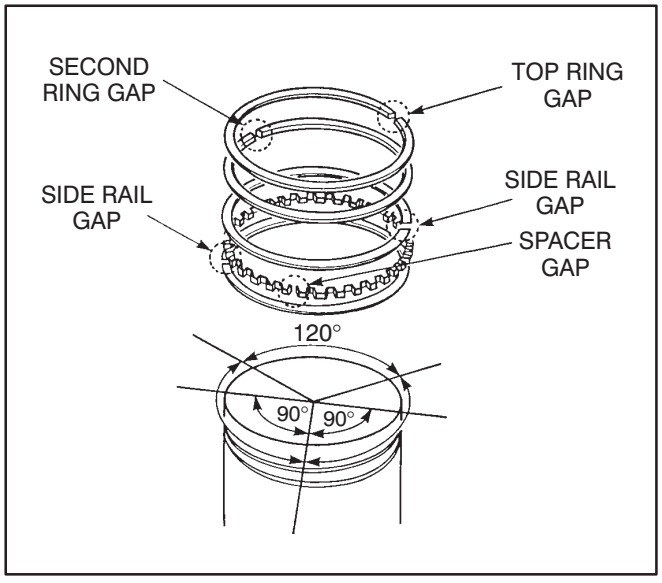


FIGURE 12-28. ASSEMBLING RINGS

Refer to Figure 12-29. 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.

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

Refer to Figure 12-30. 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 (Section 3).

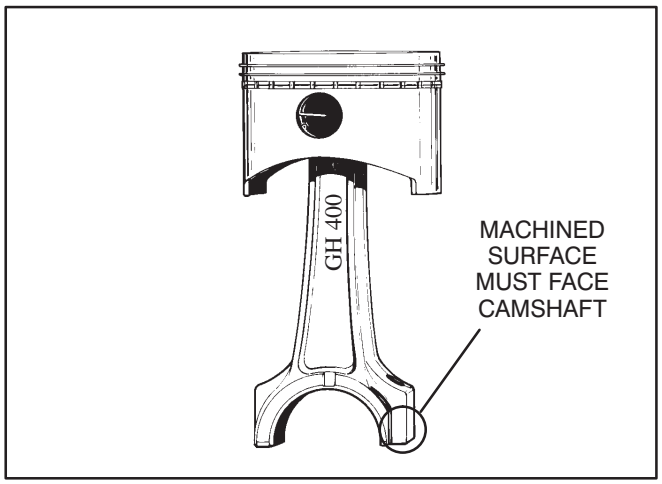


FIGURE 12-29. PISTON ORIENTATION

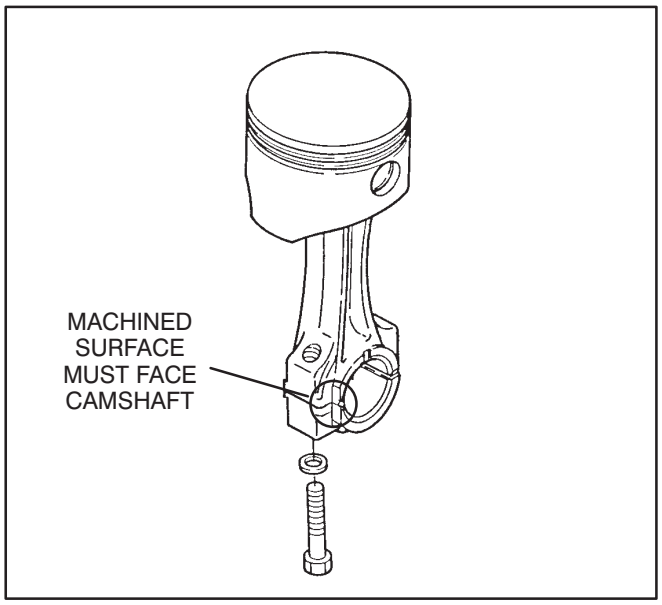


FIGURE 12-30. CONNECTING ROD AND CAP ALIGNMENT

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 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 12-31). 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 (Section 2), 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 (Section 2), 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.

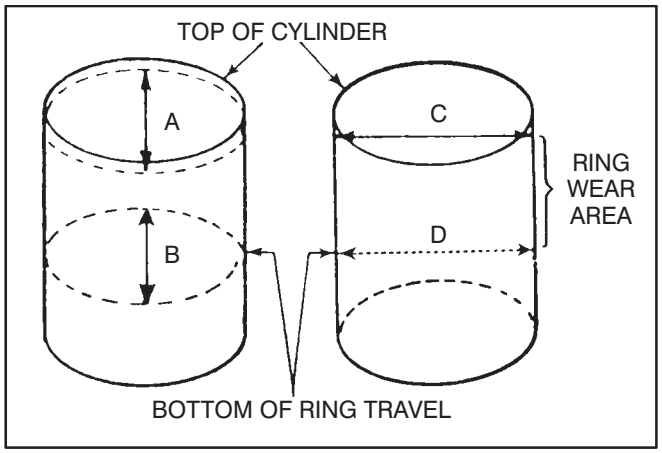


FIGURE 12-31. LOCATIONS FOR MEASURING CYLINDER BORE DIAMETER

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). Honing should produce a 20 to 40 RMS surface finish with a 23 degree crosshatch pattern (Figure 12-32) for rapid piston ring break-in.

⚠ 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.

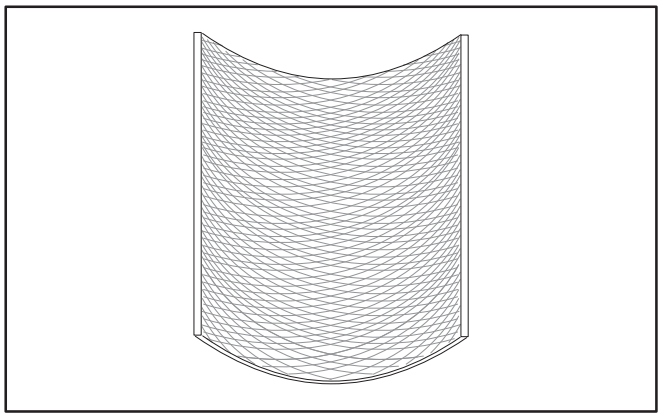


FIGURE 12-32. PROPER HONE CROSSHATCH IN BORE

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 12-32).

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. 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 oil base carries one crankshaft ball bearing assembly and the engine block the other (Figure 12-33). 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 oil base 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 oil base. 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 oil base as shown in Figure 12-33. Apply a light coating of grease to the lips of the oil seals to provide lubrication until engine oil reaches them.

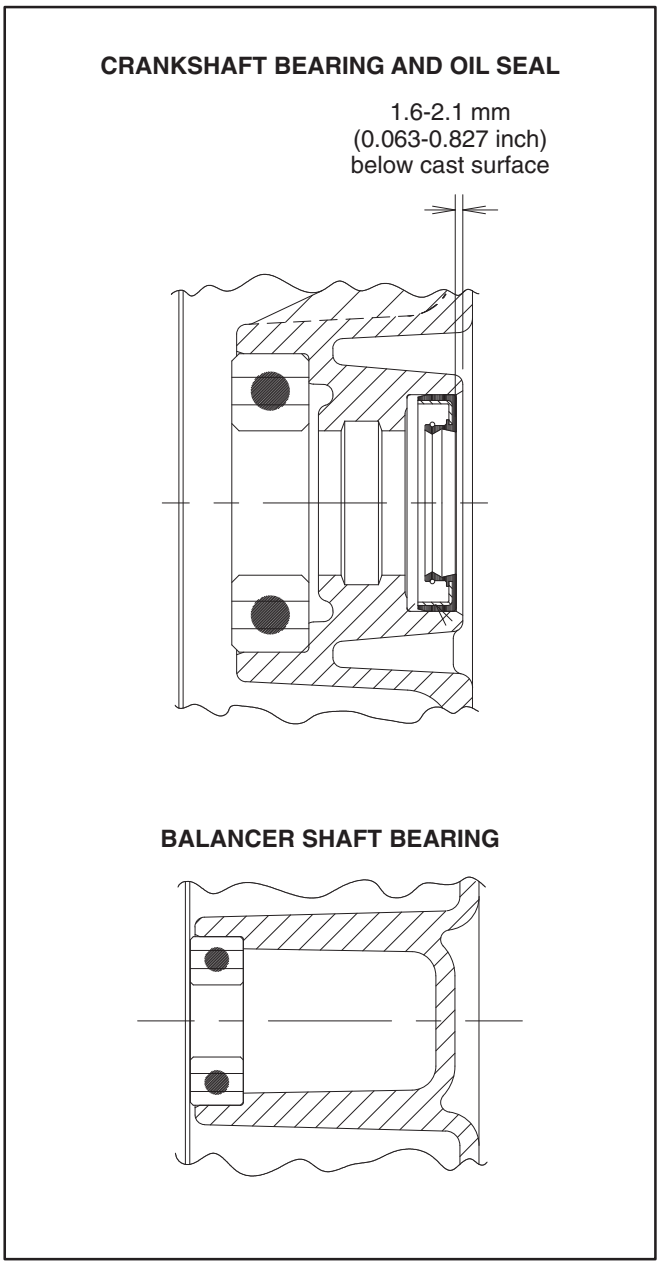


FIGURE 12-33. SHAFT BEARINGS AND OIL SEAL IN OIL BASE

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