ONAN E125 V, E140V ENGINE SERVICE MANUAL

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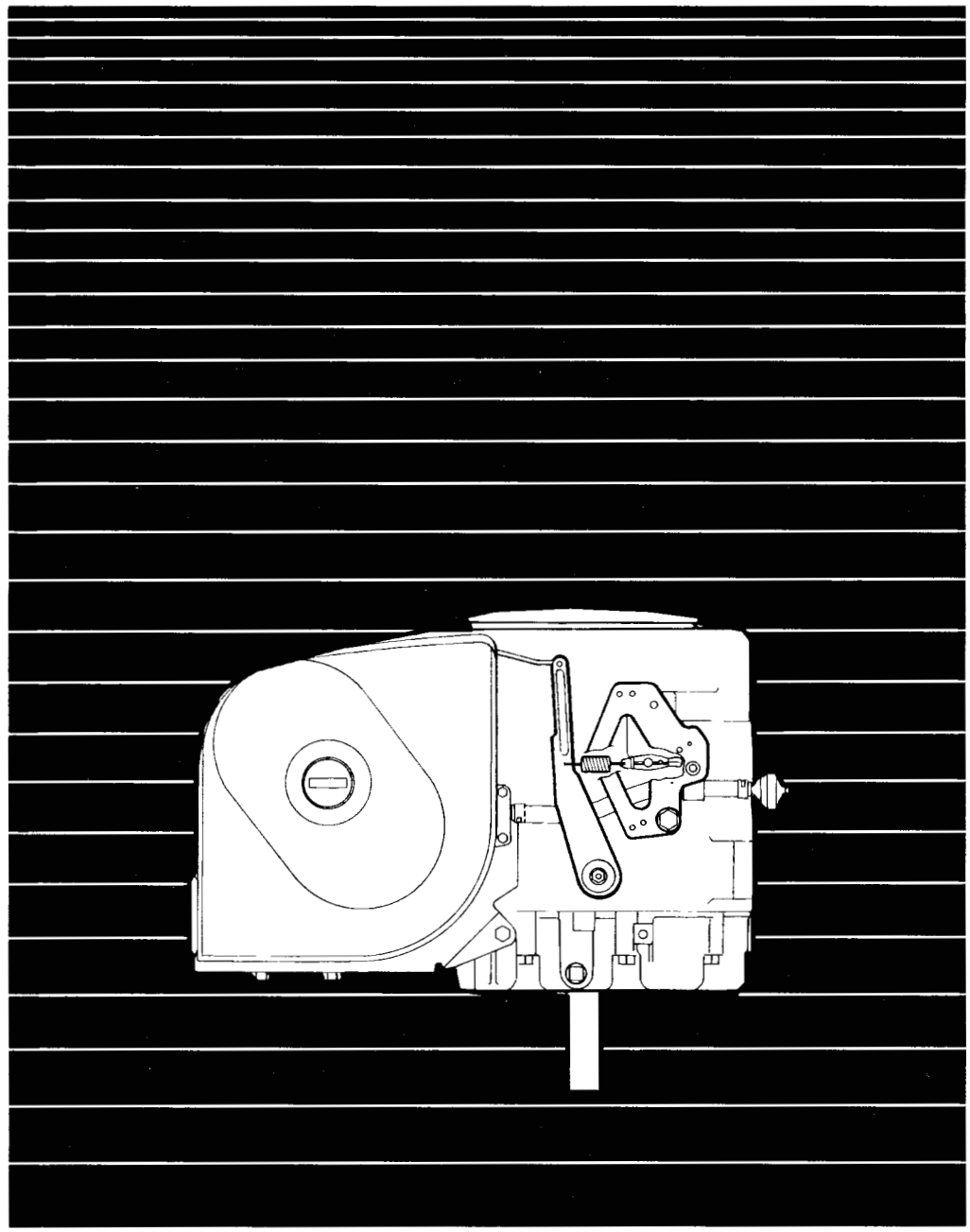
Onan

Engine
Service Manual

E125V, E140V

Elite Series



Printed in U.S.A.

965-0764
Spec A-C
6-94

Safety Precautions

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

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

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

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

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

Fuels, electrical equipment, batteries, exhaust gases and moving parts present potential hazards that can result in severe personal injury. Take care in following these recommended procedures. All local, state and federal codes should be consulted and complied with.

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

GENERAL

- Provide appropriate fire extinguishers and install them in convenient locations. Use an extinguisher rated ABC by NFPA.
- Make sure that all fasteners on the engine are secure and accurately torqued. Keep guards in position over fans, driving belts, etc.
- If it is necessary to make adjustments while the engine is running, use extreme caution when close to hot exhausts, moving parts, etc.
- Used engine oils have been identified by some state and federal agencies as causing cancer or reproductive toxicity. When checking or changing engine oil, take care not to ingest, breathe the fumes, or contact used oil.
- Do not work on this equipment when mentally or physically fatigued, or after consuming any alcohol or drug that makes the operation of equipment unsafe.

BATTERIES

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

PROTECT AGAINST MOVING PARTS

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

FUEL SYSTEM

- DO NOT fill fuel tanks while engine is running.
- DO NOT smoke or use an open flame in the vicinity of the engine or fuel tank. Internal combustion engine fuels are highly flammable.
- Fuel line must be of steel piping, adequately secured, and free from leaks. Piping at the engine should be approved flexible line. Do not use copper piping for flexible lines as copper will work harden and become brittle enough to break.
- Be sure all fuel supplies have a positive shutoff valve.
- Benzene and lead, found in some gasoline, have been identified by some state and federal agencies as causing cancer or reproductive toxicity. When checking, draining or adding gasoline, take care not to ingest, breathe the fumes, or contact gasoline.

EXHAUST SYSTEM

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

EXHAUST GAS IS DEADLY!

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

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

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

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

KEEP THE UNIT AND SURROUNDING AREA CLEAN

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

Supplement 965-1053
Date: 1-95
Insert with-
Title: E125V/E140V Service Manual
Number (Date): 965-0764 (6-94)

PURPOSE

This Supplement transmits the revisions to the Service Manual necessary for covering ***Spec E*** engines. Note that the nameplate on a Spec E engine will have the statement: "This engine meets 1995-1998 California emissions regulations for ULGE engines."

To satisfy California emissions regulations Spec E engines have internal engine modifications and precision-manufactured carburetors with tamper-resistant fuel mixture jets. It should therefore be noted that, other than installing the optional high-altitude jet (Figure 9-3a), fuel mixture adjustments should not be attempted. Nor should the carburetor be overhauled. Instead, a malfunctioning carburetor (see *Engine Troubleshooting*) should be replaced.

California users should note that unauthorized modifications or replacement of fuel, exhaust, air intake, or speed control system components that affect engine emissions are prohibited by California regulations and that the optional high-altitude main jet is not intended for use in California. Modification, removal or replacement of the generator set label is also prohibited.

SERVICE MANUAL 965-0764 REVISIONS

1. Insert this cover sheet behind the front cover of the manual.
2. On **Page 1-1** of the manual add the following note at the bottom of the page: "See the Operator's Manual for fuel and engine oil recommendations and the Periodic Maintenance Schedule."
3. On **Page 9-1** of the manual add "(Does not Apply to Spec E and Later)" to the subheadings "Disassembly" and "Inspection/Service".
4. On **Page 9-2** of the manual add "(Does Not Apply to Spec E and Later)" to the subheading "Assembly" and to the heading "CO Adjustment".
5. Insert the attached page (9-2-1) between **Page 9-2** and **Page 9-3** of the manual.

Attachment: Page 9-2-1.

Table of Contents

⚠WARNING

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

Section 1. General Information

INTRODUCTION

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

Use the separate parts manual for parts identification and for establishing their proper location on assemblies. The parts manual contains detailed exploded views of each assembly and the individual piece part numbers and their proper names for ordering replacement parts.

The illustrations and procedures presented in each section apply to the engines listed on the cover. The air cleaner side of the engine is the front end. Right and left sides are determined by viewing the engine from the front.

If a major repair or an overhaul is necessary, have a trained and experienced mechanic perform the repair and see that all dimensions, clearances and torque values are within the specified tolerances.

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

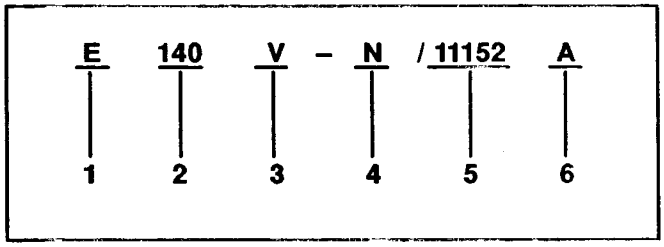
The troubleshooting guide is provided as a quick reference for locating and correcting engine problems.

The wiring diagram shows how the electrical components are interconnected.

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

Use only Genuine Onan replacement parts to provide quality and the best repair and overhaul results. When ordering parts, always use the complete model and spec number as well as the serial number shown on the nameplate.

TABLE 1-1. ENGINE MODEL IDENTIFICATION



1. Model letter designation.
2. BHP rating. Add a decimal one digit in from the right end. (Example 140 = 14.0)
3. Designation (V = vertical shaft, H = horizontal shaft).
4. Engine fuel. (Example N = gasoline, L = LP, D = Dual fuel)
5. Factory code for designated optional equipment, if any.
6. Specification (spec letter) which advances with factory production modifications.

⚠WARNING

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

Section 2. Specifications

These specifications are in customary U.S. units of measure with approximate metric equivalents following in parentheses.

TABLE 2-1. SPECIFICATIONS

SPECIFICATION	UNIT OF MEASURE	SERIES E125V	SERIES E140V
Number of Cylinders		1	1
Bore	mm (in)	84.2 (3.31)	84.2 (3.31)
Stroke	mm (in)	70.0 (2.76)	70.0 (2.76)
Displacement	cm^3 (in^3)	389 (23.7)	389 (23.7)
Compression Ratio		8.5 to 1	8.5 to 1
Power at Rated Speed (3600 rpm)	kW (BHP)	9.3 (12.5)	10.4 (14.0)
Oil Capacity With Filter	Litres (Quarts)	1.7 (1.75)	1.7 (1.75)
Cylinder Compression	kPa (psi)	483 or more (70 or more)	

Section 3. Dimensions and Clearances

All measurements given at room temperature of 70°F (21°C). All measurements are given in millimeters with approximate inch measurements in parentheses. Measurements are for standard size parts. Refer to the headings for notes about which specs are covered, if the spec is not listed the dimensions cover all specs.

TABLE 3-1. DIMENSIONS AND CLEARANCES

DESCRIPTION	FACTORY SPECIFICATION MIN	FACTORY SPECIFICATION MAX	ALLOWABLE LIMIT
CYLINDER BLOCK			
Cylinder Bore I.D.	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)
CRANKSHAFT			
Connecting Rod Journal O.D.	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.	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)

TABLE 3-2. DIMENSIONS AND CLEARANCES

DESCRIPTION	FACTORY SPECIFICATION MIN	FACTORY SPECIFICATION MAX	ALLOWABLE LIMIT
CAMSHAFT – SPEC 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)	35.33 (1.391)	34.68 (1.365)
End Clearance	0.10 (0.004)	0.20 (0.008)	0.25 (0.010)
Oil Base Bearing Clearance	.0.01 (0004)	0.05 (.0020)	0.08 (.0031)
CAMSHAFT – BEGIN SPEC C			
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)
Oil Base Bearing Clearance	0.01 (.0004)	0.05 (.0020)	0.08 (.0031)

TABLE 3-3. DIMENSIONS AND CLEARANCES

DESCRIPTION	FACTORY SPECIFICATION MIN	FACTORY SPECIFICATION MAX	ALLOWABLE LIMIT
PISTON – SPEC A AND B			
Piston Skirt O.D.			
90 deg to Pin, 26.5 from Top of Piston .	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)
PISTON – BEGIN SPEC C			
Piston Skirt O.D.			
90 deg to Pin, 26.5 from Top of Piston .	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 – SPEC A AND B			
Piston Pin O.D.	20.000 (0.7874)	20.005 (0.7876)	19.990 (0.7870)
Clearance in Piston	.005 (.0002)	.010 (0.0004)	0.30 (0.0012)
Clearance in Connecting Rod	.010 (0.0004)	.025 (0.0010)	.035 (0.0014)
PISTON PIN – BEGIN SPEC C			
Piston Pin O.D.	20.000 (0.7874)	20.005 (0.7876)	19.990 (0.7870)
Clearance in Piston	–.001 (.0000)	.012 (0.0005)	0.03 (0.0012)
Clearance in Connecting Rod	.010	.025	.035

TABLE 3-4. DIMENSIONS AND CLEARANCES

DESCRIPTION	FACTORY SPECIFICATION MIN	FACTORY SPECIFICATION MAX	ALLOWABLE LIMIT
PISTON RINGS			
Top Compression Ring Thickness	1.47 (.058)	1.49 (.059)	1.42 (.056)
Second Compression Ring Thickness	1.47 (.058)	1.49 (.059)	1.42 (.056)
Top Compression Ring to Ring Groove Clearance	0.03 (0.001)	0.08 (0.003)	0.13 (0.005)
Second Compression Ring to Ring Groove Clearance	0.03 (0.001)	0.08 (0.003)	0.13 (0.005)
Top Compression Ring End Gap	0.25 (0.010)	0.51 (0.020)	1.00 (0.039)
Second Compression Ring End Gap	0.25 (0.010)	0.51 (0.020)	1.00 (0.039)
Oil Ring Side Rail Gap	0.38 (0.015)	1.40 (0.055)	1.80 (0.071)
INTAKE VALVE			
Valve Stem O.D.	6.960 (0.2740)	6.975 (0.2746)	–
Valve Guide I.D.	7.000 (0.2756)	7.015 (0.2762)	–
Valve Stem to Guide Clearance	0.03 (0.001)	0.06 (0.002)	0.10 (0.004)
E125V Valve Lash	0.075 (.003)		0.25 (0.010)
E140V 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 Guide Clearance	0.04 (.002)	0.08 (.003)	0.10 (.004)

TABLE 3-5. DIMENSIONS AND CLEARANCES

DESCRIPTION	FACTORY SPECIFICATION MIN	FACTORY SPECIFICATION MAX	ALLOWABLE LIMIT
EXHAUST VALVE (cont.)			
E125V Valve Lash	0.075 (.003)		0.25 (0.010)
E140V Valve Lash	0.15 (.006)		0.25 (0.010)
Face Angle	45°		
EXHAUST VALVE SEAT			
Seat Width	1.1 (0.043)		1.7 (0.067)
Seat Angle	45°		
VALVE SPRINGS INTAKE AND EXHAUST – SPEC A AND B			
Valve Spring Free Length (Approx.)	43.5 (1.71)		–
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 – BEGIN SPEC C			
Valve Spring Free Length (Approx.)	43.5 (1.71)		–
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)

TABLE 3-6. DIMENSIONS AND CLEARANCES

DESCRIPTION	FACTORY SPECIFICATION MIN		MAX	ALLOWABLE LIMIT
ROCKER ARM				
Rocker Arm Inside Diameter	12.000 (0.4724)		12.018 (0.4718)	–
Rocker Arm Shaft O.D.	11.973 (0.4714		11.984 (0.4718)	–
Rocker Arm to Shaft Clearance	0.016 (0.0006)		0.045 (0.0018)	0.15 (0.0059)
LUBRICATING SYSTEM				
Engine Oil Pressure				
At Idling	3.0 psi or more			4.0 psi
At 3300 rpm	14.0 psi or more			
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 and Cover Clearance	0.02 (0.001)		0.09 (0.004)	0.25 (0.010)
IGNITION SYSTEM				
Spark Plug Gap	0.89 (0.035)	0.89 (0.035)	1.02 (0.040)	– –
Ignition Timing (BTDC) – Not Adjustable		23°		
Ignition Unit Core to Rotor Magnet Clearance (Air Gap)		0.50 (0.020)		– –
ELECTRICAL SYSTEM				
Commutator O.D.		28.0) (1.102)		27.00 (1.063)
Difference of Commutator O.D.'s	Less than 0.05 (Less than 0.002)			0.016 (0.41)
Armature's 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)
BALANCE SHAFT				
End Clearance (Both Shafts)	0.10 (0.004)		0.20 (0.008)	0.25 (0.010)

Section 4. Assembly Torques

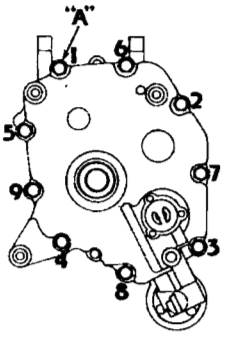
The torque values listed in Table 4-1 have been determined for specific applications. The engine assembly torques given here will provide proper tightness without danger of stripping threads. All threads must be clean, rust free and lightly lubricated.

Tighten all studs, nuts and capscrews as specified to keep them from working loose. Refer to the Parts Manual for the location of washers and capscrews.

TABLE 4-1. ASSEMBLY TORQUES

DESCRIPTION	BOLT SIZE	METRIC (N•m)	ENGLISH (LB•FT)	INSTRUCTIONS
Conn Rod Bolts	M8 x 44	24-27	18-20	
Oil Base Bolts	M8 x 50	16-22	12-16	Torque bolts in closkwise direction starting with "A" Torque "A" twice.
Oil Pump Cover Screws	M6 x 14	7-11	5-8	
Oil Pump Screen Cover	M6 x 14	7-11	5-8	
Oil Drain Plugs	3/8" NPT	7-11	5-8	
Oil Base Pressure Line Plugs	1/4" NPT	7-11	5-8	
LOPCO or Pipe Plug	1/8" NPT	7-11	5-8	
Adapter Filter Head	3/4-16"	24-30	18-22	
Oil Filter	–	–	–	3/4-1 Turn after gskt
Oil Indicator Cap	–	1.5-2	1.1-1.5 (13-18 LB•IN)	contacts base
Cyl Head Bolts				Torque in sequence shown.
No. 1-5 Bolts	M10	42-50	31-37	Two bolts outside valve cover
No. 6 Flange Bolt	M8 x 50	16-22	12-16	(#2 & #4) To be retorqued after others are done.
Valve Lash Adj Nut	M7	7-11	5-8	Tighten every other bolt until
Valve Cover Bolts	M6 x 25	7-11	5-8	all bolts are tightened. Retorque the first bolt twice.
Spark Plug	–	10-24	7-18	
Air Deflector Bolts	M8 x 10			
	M8 x 16	11-20	8-15	
	M6 x 10	7-11	5-8	
Pulse Pump to Deflector Nuts	#10	2.3-2.8	1.7-2.1 (20-25 LB•IN)	
Pulse Pump Spud	1/8" NPT	7-11	5-8	
Int Elbow to Cyl Hd Screws	M8 x 50	11-16	8-12	Tighten twice (1-2-1)
Air Cleaner Pan to Air Deflector	1/4" x .50"	6.7-8.1	5-6 (60-72 LB•IN)	
Carb to Int Elbow	M6 x 85	10-15	7-11	
Knob-Inner Air CLnr	–	–	–	1-1/2-2 turns after cover
Knob-Outer Air Clnr	–	Not Specified	Not Specified	contacts element
Cyl Air Hsg Bolt	M6 x 10	7-11	5-8	
	M8	11-20	8-15	
Exhuast Elbow Bolts	M8 x 45	11-20	8-15	
Muffler Bolts	M8 x 95	16-22	12-16	
Starter Bolts	M8 x 40	16-22	12-16	
Alternator Stator Screws	M6 x 25	10-15	7-11	
Stator Wire Clamp Screw	M6 x 14	10-15	7-11	
Flywheel Nut	M18	122-138	90-102	
Ignition Coil Bolt	M6 x 27	10-15	7-11	
Blower Hsg Bolts	M6 x 20	7-11	5-8	
Voltage Reg Screws	1/4" x .50"	6.7-8.1	5-6 (60-72 LB•IN)	
Chaff Screen Bolt	M6 x 10	7-11	5-8	
Stationary Guard Bolt	M6 x 20	1.4-2	1-1.5 (12-18 LB•IN)	
Recoil Starter Cup Screw	M8 x 16	24-30	18-22	
Recoil Starter Bolts	M6 x 12	7-11	5-8	
Control Plate Stud	M8	11-16	8-12	
Control Plate Pivot Bolt	M8	11-16	8-12	
Nut-Control Plate Stud	M6	7-11	5-8	
Governor Arm Nut	M6	8.1-10.9	6-8	
Throttle Cable Clamp Screw	10-32"	1.4-2	1-1.5 (12-18 LB•IN)	

OIL BASE TORQUE SEQUENCE



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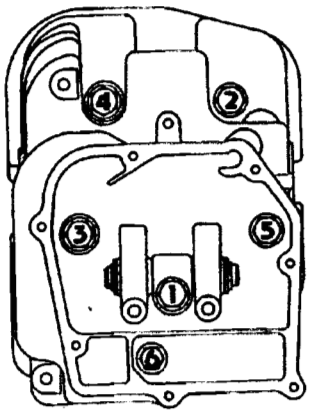
CYLINDER HEAD TORQUE SEQUENCE



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Section 5. Engine Troubleshooting

TROUBLE: Backfiring	Bearing Wear	Black Exhaust	Blue Exhaust	Burned Valves	Con Rod Wear	Cranks Slowly	Cylinder Wear	Engine Stops	Failure to Start	Governor Hunting	High Oil Pressure	Low Oil Pressure	Mechanical Knocks	Misfiring	Overheating	Piston Wear	Poor Compression	Ring Wear	Sticking Valves	CAUSE
																				STARTING SYSTEM
						•			•											Loose or Corroded Battery Connection
						•			•											Low or Discharged Battery
						•			•											Faulty Starter
									•											Faulty Start Solenoid
																				IGNITION SYSTEM
•				•					•				•	•	•					Ignition Timing Wrong
									•				•	•						Wrong Spark Plug Gap
									•					•						Faulty Ignition Coil
									•					•						Faulty Spark Plug Wires
																				FUEL SYSTEM
								•	•					•						Out of Fuel - Check
				•					•	•				•	•					Lean Fuel Mixture
•		•							•				•	•						Rich Fuel Mixture or Choke Stuck
•		•						•	•											Engine Flooded (gasoline)
•		•		•					•				•	•						Poor Quality Fuel (gasoline)
•								•	•	•				•						Dirty Carburetor
•	•	•					•		•					•		•		•		Dirty Air Cleaner
									•	•				•						Dirty Fuel Filter (gasoline)
								•	•	•				•						Faulty Fuel Pump (gasoline)
								•	•											Faulty Vacuum Sustain Valve (LPG)
								•	•											Faulty Vacuum Lock-Out (LPG)
•								•	•					•						Faulty Air Pump (LPG)
•								•	•					•						Faulty Pressure Regulator (LPG)
																				INTERNAL ENGINE
				•					•				•	•			•			Wrong Valve Clearance
				•					•				•	•			•		•	Broken Valve Spring
			•	•						•				•			•			Valve or Valve Seal Leaking
			•						•				•				•			Piston Rings Worn or Broken
	•				•	•						•	•							Wrong Bearing Clearance
																				COOLING SYSTEM
														•	•					Poor Air Circulation
														•	•					Dirty or Oily Cooling Fins
								•	•					•			•			Blown Head Gasket
																				LUBRICATION SYSTEM
											•	•								Faulty Oil Gauge
											•	•								Stuck Relief Valve
	•				•		•	•	•			•	•			•		•		Faulty Oil Pump
								•	•											Faulty Low Oil Pressure Cutout Switch
	•				•		•									•		•	•	Dirty Oil or Filter
	•		•		•		•					•	•		•	•		•		Oil Too Light or Diluted
	•				•		•					•	•		•	•		•		Oil Level Low
						•					•									Oil Too Heavy
																				THROTTLE AND GOVERNOR
									•	•										Linkage Out of Adjustment
										•										Linkage Worn or Disconnected
										•										Governor Spring Sensitivity Too Great
										•										Linkage Binding

Section 6. Maintenance

PERIODIC MAINTENANCE SCHEDULE

Keep an accurate logbook of maintenance, service, and operating time. Follow a regular schedule of inspection and service, based on operating hours.

Use the factory recommended Periodic Maintenance Schedule (based on favorable operating conditions) to serve as a guide to get long and efficient engine life.

Regular service periods are recommended for normal service and operating conditions. If the engine is in an application with extreme temperatures, severe duty cycles, etc., service at more frequent intervals.

Neglecting routine maintenance will result in poor performance and reduced engine life.

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

⚠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.***

TABLE 6-1. PERIODIC MAINTENANCE SCHEDULE

SERVICE THESE ITEMS	AFTER EACH CYCLE OF INDICATED HOURS					
	1	8	25	50	100	200
Clean Flywheel Intake Filter (If Equipped)	X					
Inspect the Engine		X[1]				
Check Oil Level		X				
Service Air Cleaner Element and Element Wrapper			X[2]			
Change Crankcase Oil			X[3]		X[2]	
Replace Oil Filter			X[3]		X[2]	
Clean Cooling Fins				X[2]		
Check Battery Electrolyte Level (If equipped)				X		
Clean Spark Arrester				X		
Check Valve Clearance					X[4]	X
Replace Air Cleaner Element						X[2]
Check or Replace Spark Plug						X

1- Check for fuel leaks. With engine running, visually and audibly check exhaust system for leaks.
2- Perform more often when running under severe operating conditions.
3- Required for initial break-in only.
4- Required for initial 100 hours, 200 hour interval thereafter.

ENGINE INSPECTION

Check the fuel lines and fittings for leaks. Do not the start engine until leaks are repaired.

⚠WARNING ***Breathing exhaust gases can result in severe personal injury or death. Inspect the exhaust system audibly and visually for leaks daily and repair leaks immediately.***

Inspect the exhaust system for cracks and run the engine to check for leaks. Repair problems before allowing the engine to be used.

Examine the air cleaner components for damage, proper fit, etc. Repair or replace components as necessary.

Check the oil level with the engine off and the equipment on a level surface. If the oil level is at or below the full mark on the dipstick, add oil of the proper viscosity (see *Oil Change* section) until the level reaches the full mark. Do not operate the engine with the oil level below the add or above the full mark.

AIR CLEANER AND ELEMENT WRAPPER

Refer to *Air Cleaner,* in section 9, for disassembly, inspection, service and assembly procedures.

OIL CHANGE

Refer to *Oil Change,* in section 7, for inspection and service procedures.

OIL FILTER CHANGE

Refer to *Oil Filter Change,* in 7, for inspection and service procedures.

COOLING

Refer to *Flywheel,* in section 11, for inspection and service procedures.

VALVE CLEARANCE

Refer to *Valve System,* in section 11, for inspection and service procedures.

SPARK PLUG

Refer to *Spark Plug,* in section 8, for inspection and service procedures.

Section 7. Lubrication

A pump driven by one of the balancer shafts provides pressure lubrication of the connecting rod journal through drilled passages in the crankcase and crankshaft. An oil hole in the crank arm provides spray lubrication of the piston, cylinder walls, and other crankcase components. The lubrication system includes an oil pressure relief valve and full-flow oil filter (Specs B and C). The oil pump is accessible by removing a cover in the oil base.

⚠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/or mechanical service.***

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

OIL CHANGE

⚠WARNING ***Crankcase pressure can blow out hot oil, which can cause severe personal injury. Do not check oil while the engine is running.***

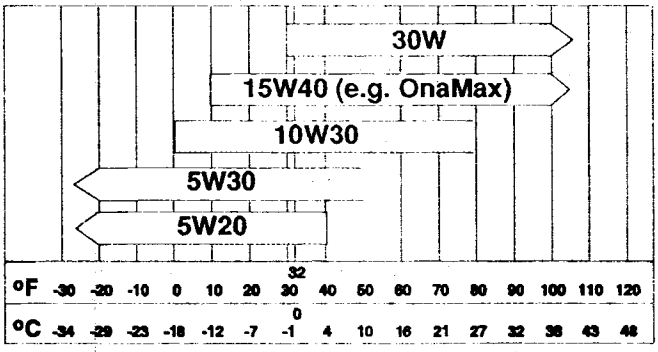
⚠WARNING ***Hot crankcase oil can cause burns if it comes in contact with skin. Wear protective clothing and keep fingers and hands clear when draining oil.***

⚠WARNING ***Some States or federal agencies have determined that used engine oil is carcinogenic and causes reproductive toxicity. Take care not to breathe, ingest or come into contact with used engine oil.***

⚠CAUTION ***Excess oil can cause high oil consumption, high operating temperatures, and oil foaming. Do not overfill crankcase.***

Run the engine until it is thoroughly warm before draining the oil. Stop the engine, place a pan under the drain plug and remove the plug (open the drain cock). Replace the drain plug (close the cock) when the oil has stopped draining. Refill with oil meeting the API classification SG, SG/CD, or SG/CE and having the proper viscosity for the ambient temperature. See Table 7-1. Straight weight oil is recommended for severe duty use and minimum oil consumption at temperatures above 32° F (0° C).

TABLE 7-1. OIL VISCOSITY RECOMMENDATIONS



ANTICIPATED AMBIENT TEMPERATURE

OIL FILTER CHANGE

⚠WARNING ***Hot crankcase oil can cause burns if it comes in contact with skin. Wear protective clothing and keep fingers and hands clear when draining oil.***

⚠CAUTION ***Excess oil can cause high oil consumption, high operating temperatures, and oil foaming. Do not overfill crankcase.***

Spin the oil filter element off and discard it. Clean the filter mounting surface and make sure a gasket is inserted in the new element. Apply a thin film of new oil to the gasket. Spin the element down by hand until the gasket just touches the mounting surface. Then add another 1/2-3/4 turn. Do not overtighten. Fill with oil to the FULL mark and start and run the engine until it is warm. Check for oil leaks. Check oil level.

OIL LEVEL CHECK

⚠WARNING ***Crankcase pressure can blow out hot oil, which can cause severe personal injury. Do not check oil while the engine is running.***

Correct oil level in the crankcase is required to insure proper lubrication and prevent saturating the air cleaner paper element with oil.

Always check the oil with the engine stopped and on a level surface. When checking the oil level, always screw the oil fill cap into the dipstick tube until it lightly seats on the oil fill tube.

The oil fill cap has a rubber seal that seats on the oil fill tube. Inspect this rubber seal and replace if damaged, stretched or missing.

OIL PRESSURE

Refer to Figure 7-1. Install an engine oil pressure tester in the oil base as shown. The engine will have an oil pressure switch or a 1/8" pipe plug in the tapped hole. Start the engine. After warming up, measure the idle and maximum speed oil pressure. If oil pressure is not as specified in Dimensions and Clearances, the following may be the cause:

- engine oil level low
- clogged oil strainer
- defective oil pump
- clogged oil gallery
- excessive clearance between crankshaft journal and connecting rod
- defective relief valve or spring

Determine cause of low oil pressure and correct as necessary.

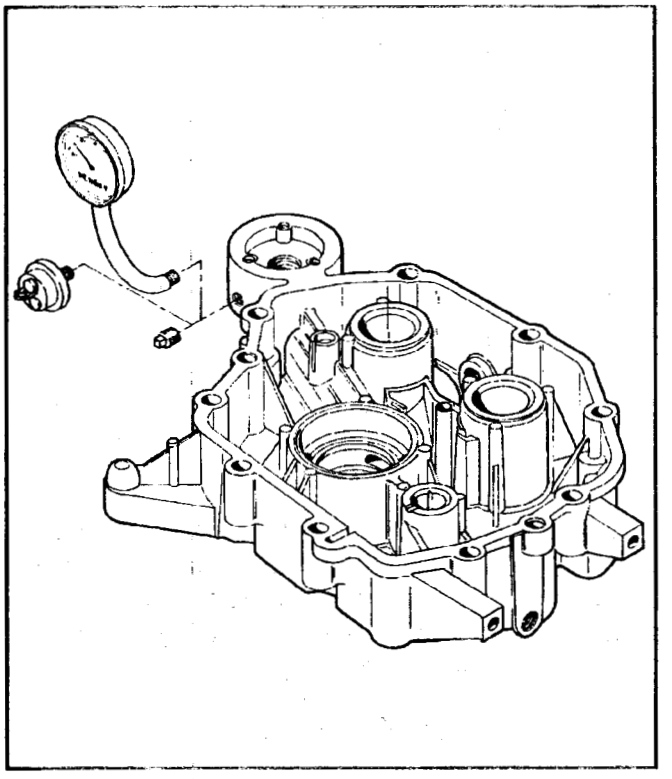


FIGURE 7-1. CHECKING OIL PRESSURE

OIL PRESSURE RELIEF VALVE

Refer to Figure 7-2. On Specs B and C the oil relief valve is accessible only after the oil base has been removed. The check ball and spring are retained by a retainer ring. On Spec A the oil pressure relief valve is removable form the outside by removing the retaining bolt.

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

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

Lubricate the oil relief valve with oil before assembling. On Specs B and C use a new retaining ring and drive it right down to the shoulder of the counter bore.

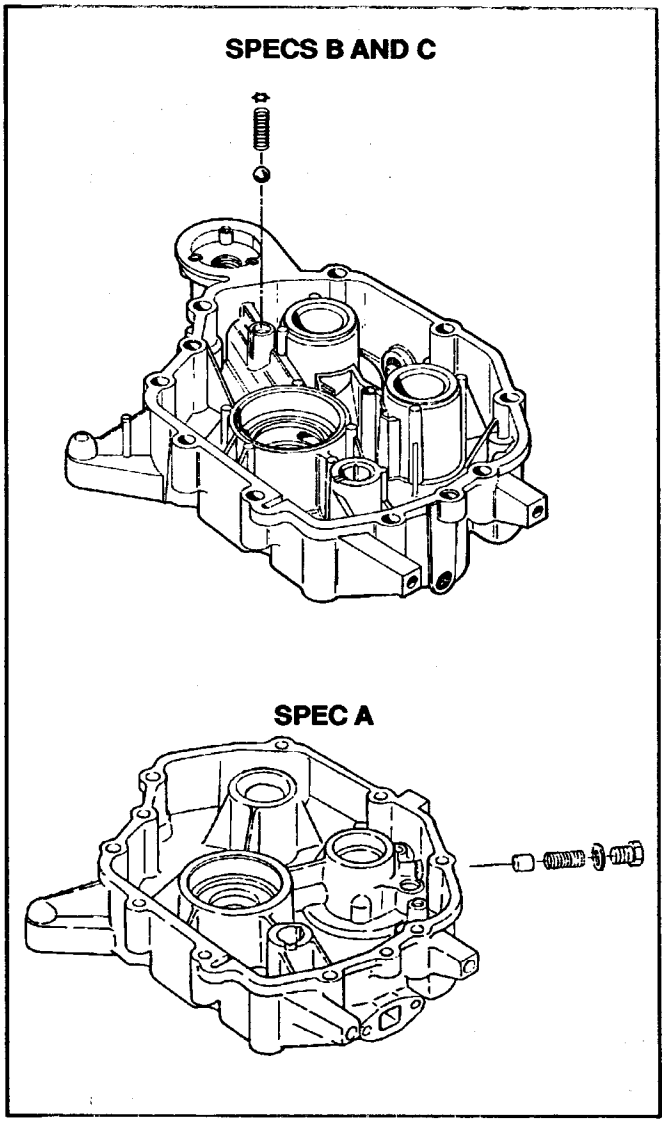


FIGURE 7-2. OIL RELIEF VALVE COMPONENTS

OIL PUMP

Disassembly

Refer to Figure 7-3. Remove the capscrews holding the oil pump cover to the oil base. Separate the inner and outer rotor.

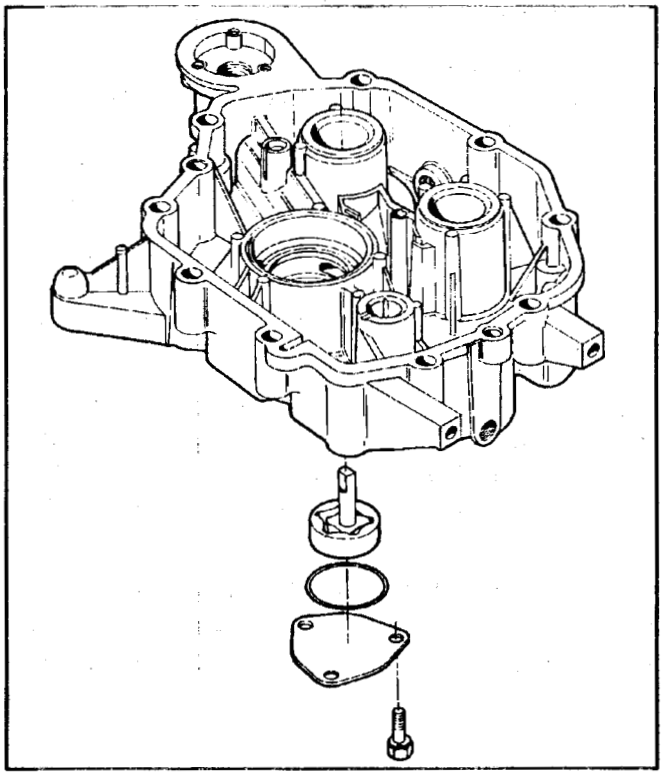


FIGURE 7-3. OIL PUMP DISASSEMBLY

Rotor Lobe Clearance

Refer to Figure 7-4. Measure the clearance between the inner rotor lobes and the outer rotor lobes with a feeler gauge. If clearance is not as specified in *Dimensions and Clearances,* replace oil pump.

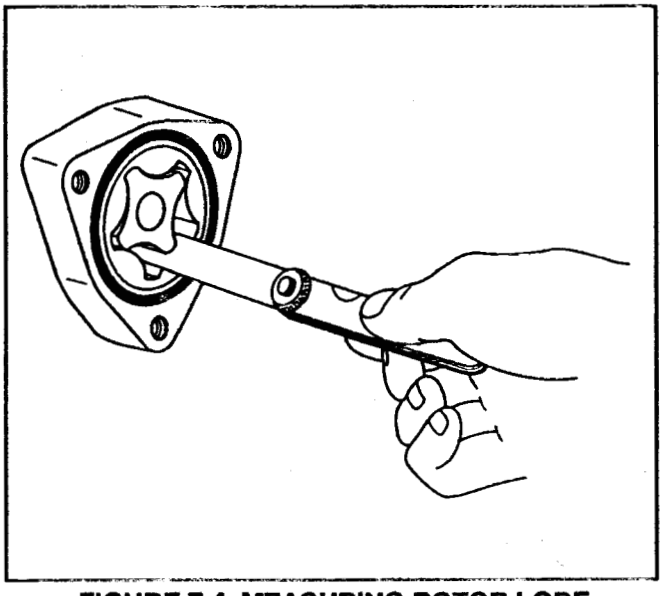


FIGURE 7-4. MEASURING ROTOR LOBE CLEARANCE

Outer Rotor and Pump Body Clearance

Refer to Figure 7-5. Measure the clearance between the outer rotor and the pump body with a feeler gauge. If the clearance is not as specified in *Dimensions and Clearances,* replace the oil pump.

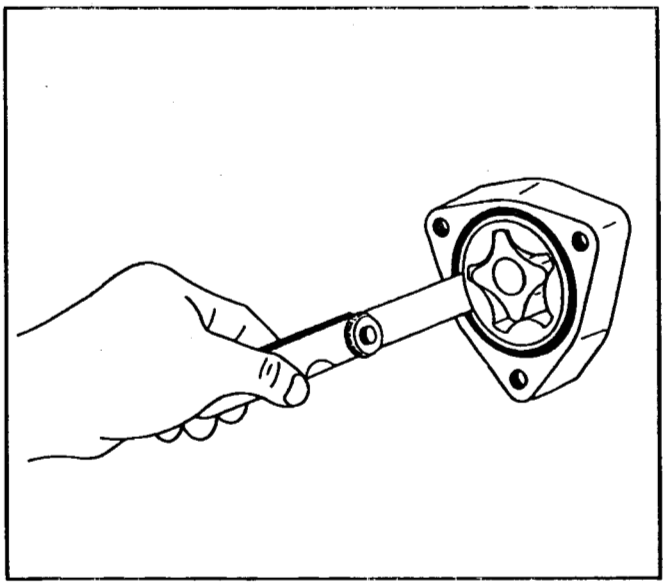


FIGURE 7-5. MEASURING OUTER ROTOR TO PUMP BODY CLEARANCE

Rotor and Cover Clearance

Refer to Figure 7-6. Place a strip of plastigauge on the rotor face. Install the pump cover and tighten the screws to that specified in *ASSEMBLY TORQUES.* Remove the cover carefully and measure the width of the plastigauge with the table provided. If clearance is not as specified in *DIMENSIONS AND CLEARANCE,* replace oil pump.

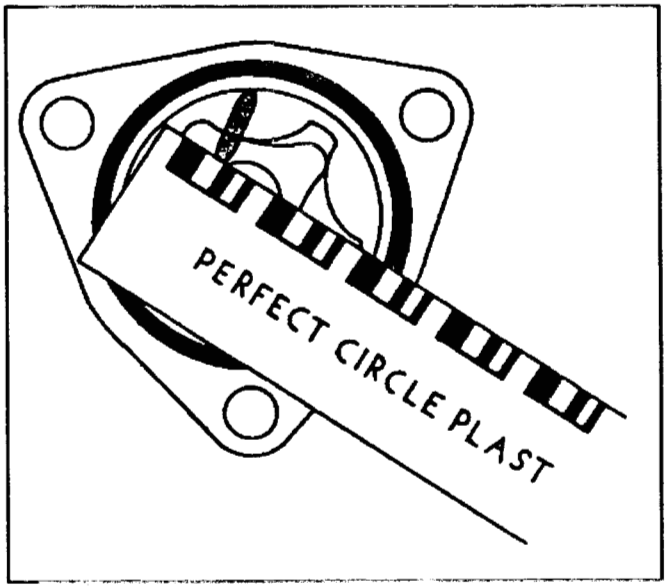


FIGURE 7-6. MEASURING ROTOR TO COVER CLEARANCE

Assembly

Prime each part with oil before reassembling. Follow torques given in *ASSEMBLY TORQUES* when tightening hardware. Check oil pressure after servicing or replacing any lubrication system component.

Section 8. Electrical

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

IGNITION SYSTEM

Refer to Figure 8-1. The ignition coil produces a high voltage pulse that fires the spark plug each revolution of the engine when the magnet in the rim of the flywheel passes across the pole faces of the ignition coil. The ignition circuit may include a throttle plate switch and/or a low oil pressure cutout switch.

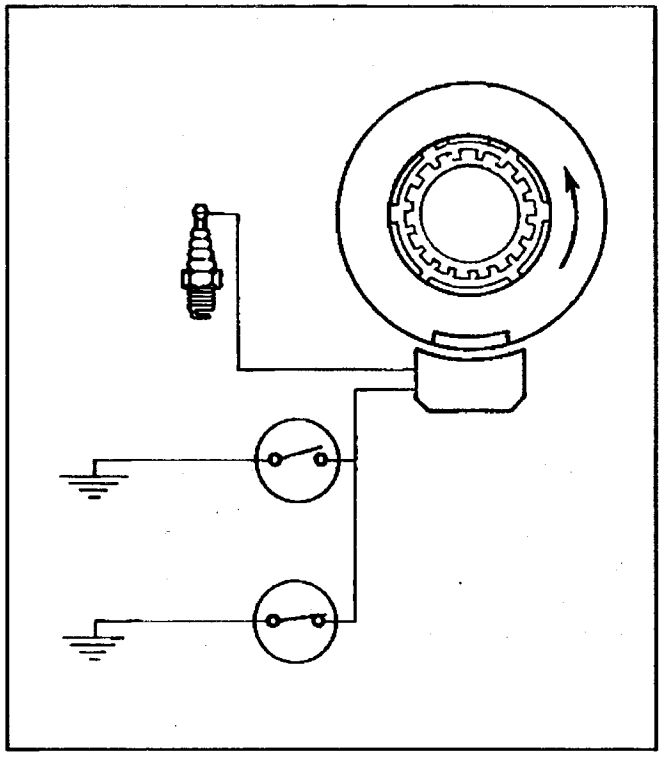


FIGURE 8-1. TYPICAL IGNITION SYSTEM

Spark Plug

Removal: Clean the area around the spark plug before removing it. Remove the spark plug lead from spark plug. Remove the spark plug from the cylinder head.

Inspection/Service: Check or replace spark plugs as recommended in the *Periodic Maintenance Schedule* (located in Operator's Manual). Replace spark plugs that show signs of fouling or electrode erosion.

Installation: Refer to Figure 8-2. Set spark plug gap to that specified in *Dimensions and Clearances.*

Never assemble a cold spark plug into a hot cylinder head.

Tighten spark plug to the torque specified in *ASSEMBLY TORQUES.*

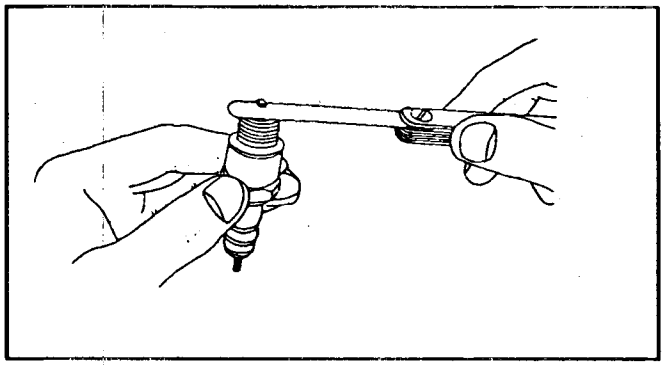


FIGURE 8-1. SPARK PLUG GAP

Ignition Coil

Spark Test: If the engine will not start conduct a spark test as follows:

⚠WARNING ***Gasoline and LPG vapors are extremely flammable and can cause severe injury or death if ignited. Make certain there are no gasoline or LPG fumes present before conducting the spark test.***

⚠WARNING ***Ignition voltage can cause severe personal injury. Do not touch ignition components while conducting the spark test.***

1. Obtain a test plug or new plug of the same type as specified for the engine. Disconnect the spark plug cable from the engine spark plug, connect it to the test plug and ground the side of the test plug to bare metal on the engine block.
2. Crank the engine while looking at the spark plug.

   If the spark is strong, the ignition system is good.

   If the spark is weak, check for and readjust the clearance between the coil and flywheel. Also check the condition of the spark plug cable. If the cable appears damaged, replace the ignition coil.

   If there is no spark, bypass the kill switch (throttle plate switch) and oil pressure switch (if provided) with a jumper to bare metal on the engine block. If there is now spark, replace the faulty switch. If there is no spark, replace the ignition coil.

Measuring Coil/Flywheel Clearance: Refer to Figure 8-2. Measure the clearance between each pole face of the coil and the magnet on the flywheel. If the clearance is not as specified in *Dimensions and Clearances,* loosen the two coil mounting screws and adjust to specifications.

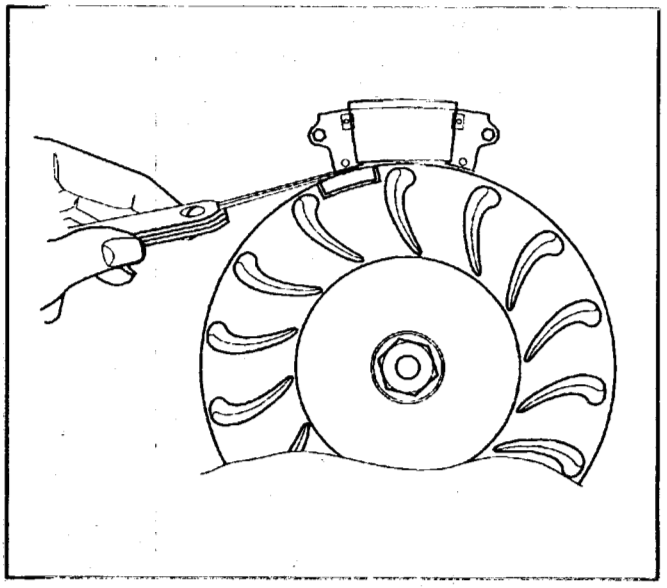


FIGURE 8-2. COIL/FLYWHEEL CLEARANCE

Ignition Timing

Ignition timing is set at the factory and is not adjustable. The solid state ignition components are not adjustable and require no routine maintenance. If the engine's timing is not close to that specified in *Dimensions and Clearances* check the key between the flywheel and crankshaft.

FLYWHEEL ALTERNATORS

When the engine is equipped with a 12 VDC starter motor a permanent magnet flywheel alternator and electronic voltage regulator may be provided for battery charging. Refer to Figure 8-3. The flywheel will have three to six permanent magnets depending on the output capacity.

See *Section 10. Starting* regarding starter motor service.

When the engine is equipped with a 110 VAC starter motor and/or recoil starter a permanent magnet flywheel alternator and full bridge rectifier may be provided for the customer DC interface (clutch, hour meter, etc.). Refer to Figure 8-4. The 110 VAC starter is provided with a power cord connected to a switch / power receptacle block for mounting on the equipment.

See *Section 10. Starting* regarding starter motor service.

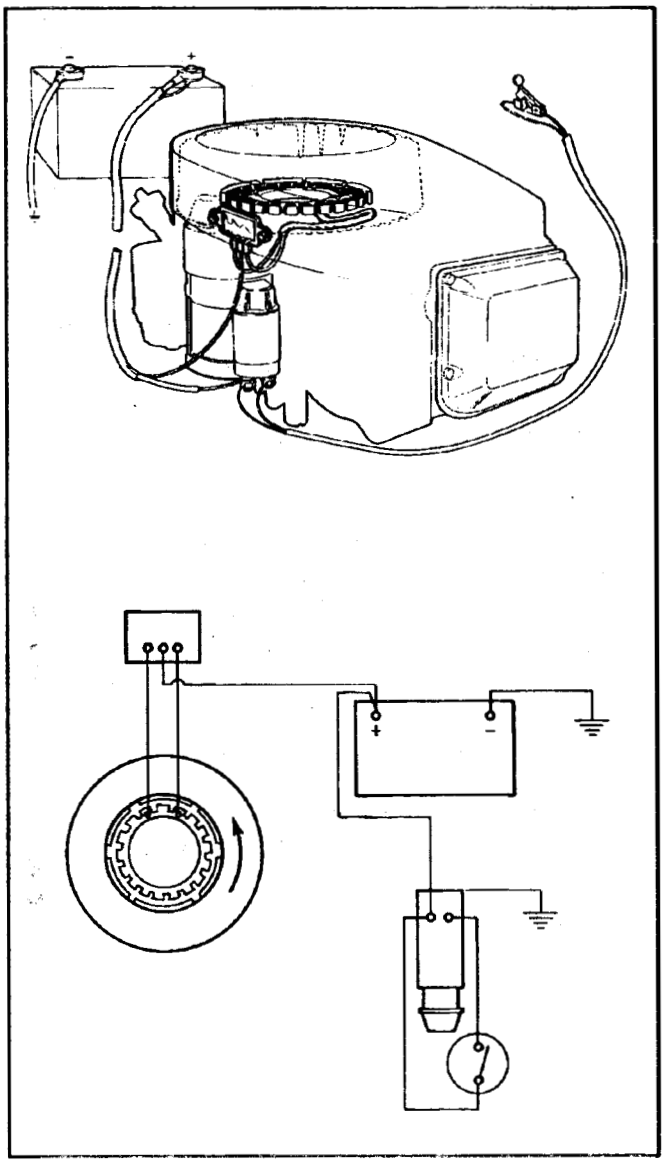


FIGURE 8-3. TYPICAL FLYWHEEL ALTERNATOR SYSTEM FOR BATTERY CHARGING AND 12 VDC STARTER

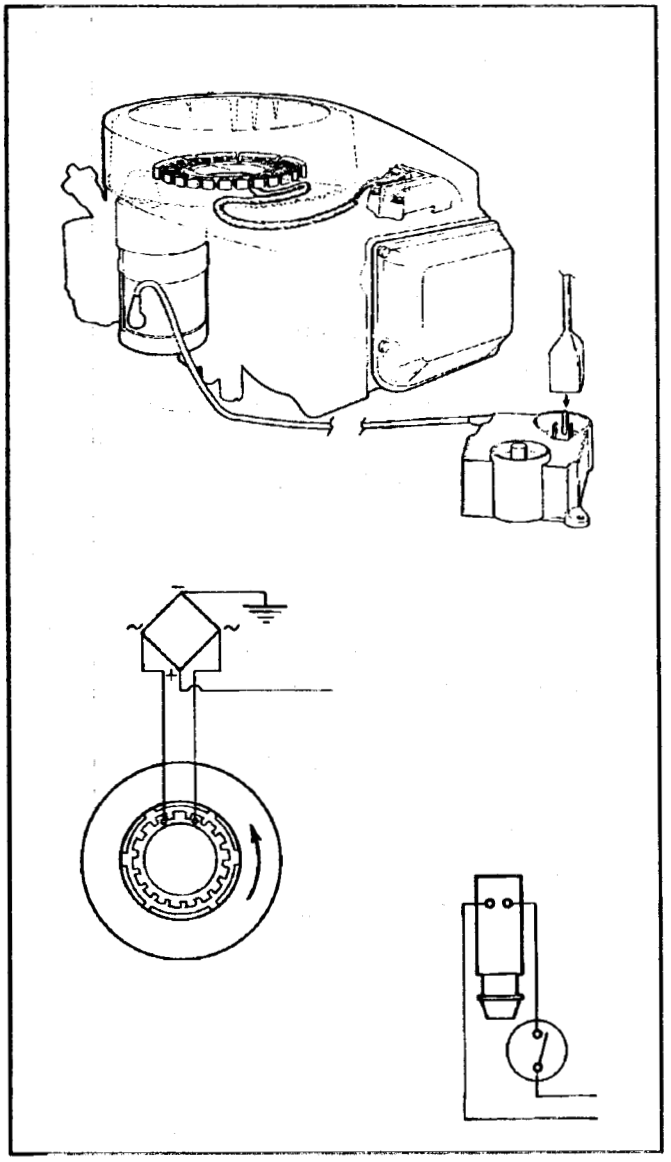


FIGURE 8-4. TYPICAL FLYWHEEL ALTERNATOR SYSTEM FOR CUSTOMER DC INTERFACE AND 110 VAC STARTER

Alternator Output Tests

Keep the following points in mind when testing or servicing the flywheel alternator.

⚠ 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 (engines with 12 VDC starters). 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 of the rectifier bridge (four) are clean and tight.
5. Check to see that the wiring connected to the **B+** terminal (middle) of the voltage regulator or to the + 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.
6. Check to see that the positive and negative battery cables have good connections at the battery and engine and that they are not damaged.

After checking all of the above perform the following tests if there still is no alternator output when the engine is running between 1800 and 3600 RPM. Refer to Table 8-1 for test specifications. Use a multi-meter (Simpson 270) when testing the alternator.

1. Check battery voltage when the engine is not running. (Not applicable on recoil or 110 VAC starter engines.) If not within specifications (Table 8-1), charge the battery before going to Step 2.
2. With the engine running, check voltage regulator output (DC voltage) at the battery terminals or bridge rectifier output (DC voltage), as applicable. Replace the **voltage regulator** if output is greater than specified. If voltage regulator or bridge rectifier output is less than specified, go to Step 3.
3. Disconnect the alternator stator leads from the voltage regulator 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 or bridge rectifier output is low, replace the voltage regulator or bridge rectifier.
4. Shut down the engine and check for electrical resistance between either alternator stator lead and ground (bare engine metal) with an ohmmeter. The meter should indicate infinite resistance on its highest scale. If resistance is high, go to Step 5. If not, replace the stator.
5. Check alternator stator resistance by connecting an ohmmeter across the stator leads. Replace the alternator stator assembly If stator resistance on the lowest scale of the meter is either higher or lower than specified. Replace the flywheel assembly if alternator stator resistance is as specified but alternator stator output is less than specified. The probable cause is loss of magnetism.

TABLE 8-1. ALTERNATOR OUTPUT TEST SPECIFICATIONS

ALTERNATOR	BATTERY VOLTAGE	VOLTAGE REGULATOR OUTPUT	BRIDGE RECTIFIER OUTPUT	ALTERNATOR STATOR OUTPUT	ALTERNATOR STATOR RESISTANCE
Non-Battery Charging Alternator	–	–	Approx. 30 VDC at 1800 RPM Approx. 60 VDC at 3600 RPM	Approx. 29 VAC at 1800 RPM Approx. 57 VAC at 3600 RPM	0.27-0.33 Ohms
5 Amp Battery Charging Alternators	12 to 13 VDC	13.6 to 14.7 VDC at Any Speed in Operating Range	–	Approx. 29 VAC at 1800 RPM Approx. 57 VAC at 3600 RPM	0.27-0.33 Ohms
15 Amp Battery Charging Alternators	12 to 13 VDC	13.6 to 14.7 VDC at Any Speed in Operating Range	–	Approx. 29 VAC at 1800 RPM Approx. 57 VAC at 3600 RPM	0.54-0.66 Ohms
20 Amp Battery Charging Alternators	12 to 13 VDC	13.6 to 14.7 VDC at Any Speed in Operating Range	–	Approx. 29 VAC at 1800 RPM Approx. 57 VAC at 3600 RPM	0.54-0.66 Ohms
Spec A 2.5 Amp Battery Charging Alternator	12 to 13 VDC	–	–	–	0.30-0.36 Ohms

Section 9. Fuel

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

⚠WARNING ***Accidental starting of the engine can result in severe personal injury or death. Disconnect the negative battery cable and spark plug wires while servicing 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.***

GASOLINE CARBURETOR

Disassembly - not applicable, Spec E

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 9-1 for Spec C and to Figure 9-2 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 - not applicable Spec E

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

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.

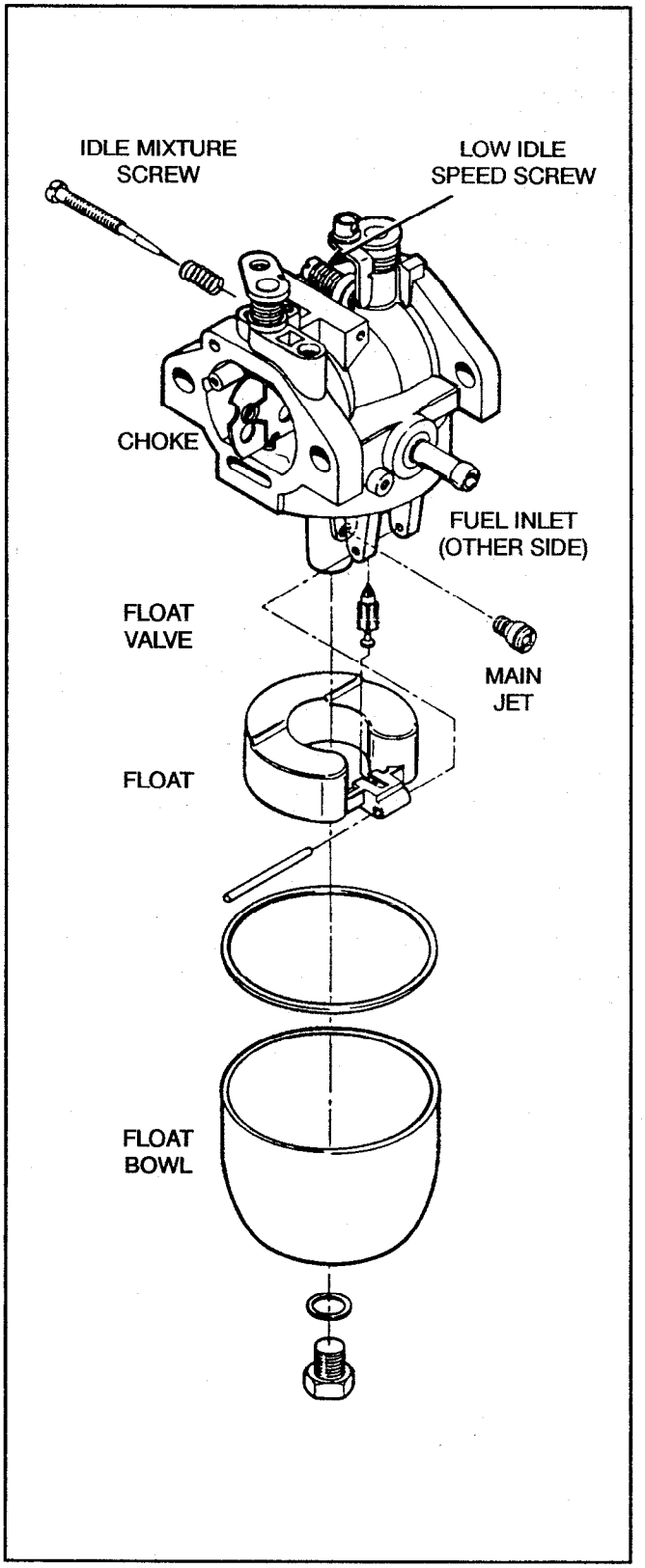


FIGURE 9-1. GASOLINE CARBURETOR (SPEC C)

CARBURETOR (BEGINNING SPEC E)

Carburetor Replacement

Other than replacing the carburetor main fuel jet (fixed-type) with the optional high-altitude jet (Figure 9-3a), 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 *Engine Troubleshooting*).

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 5,000 feet (1,524 metres), it is recommended that the carburetor main fuel jet be replaced with the optional high-altitude jet (which has a slightly smaller orifice).

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

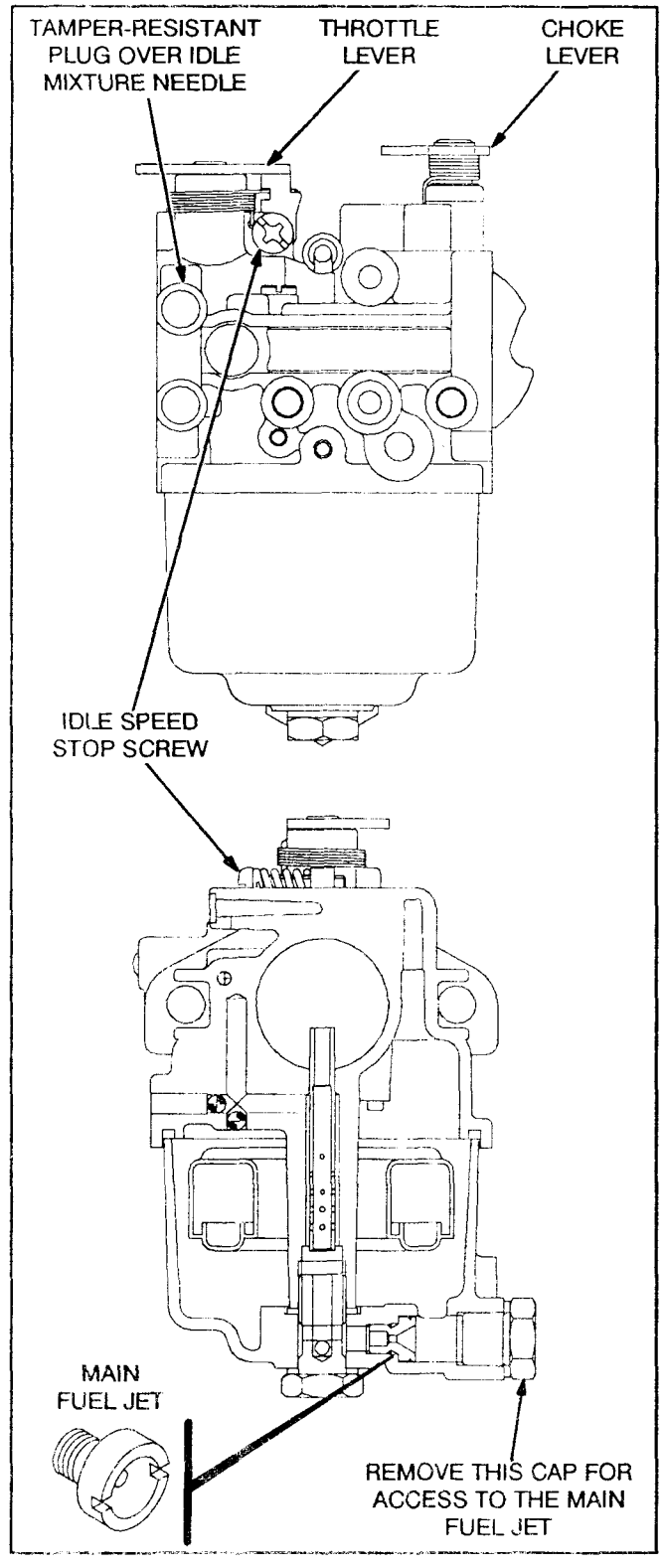


FIGURE 9-3a. CARBURETOR

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 9-1 or 9-2.

Torque the carburetor mounting bolts to the torque specified in *ASSEMBLY TORQUES*, 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.

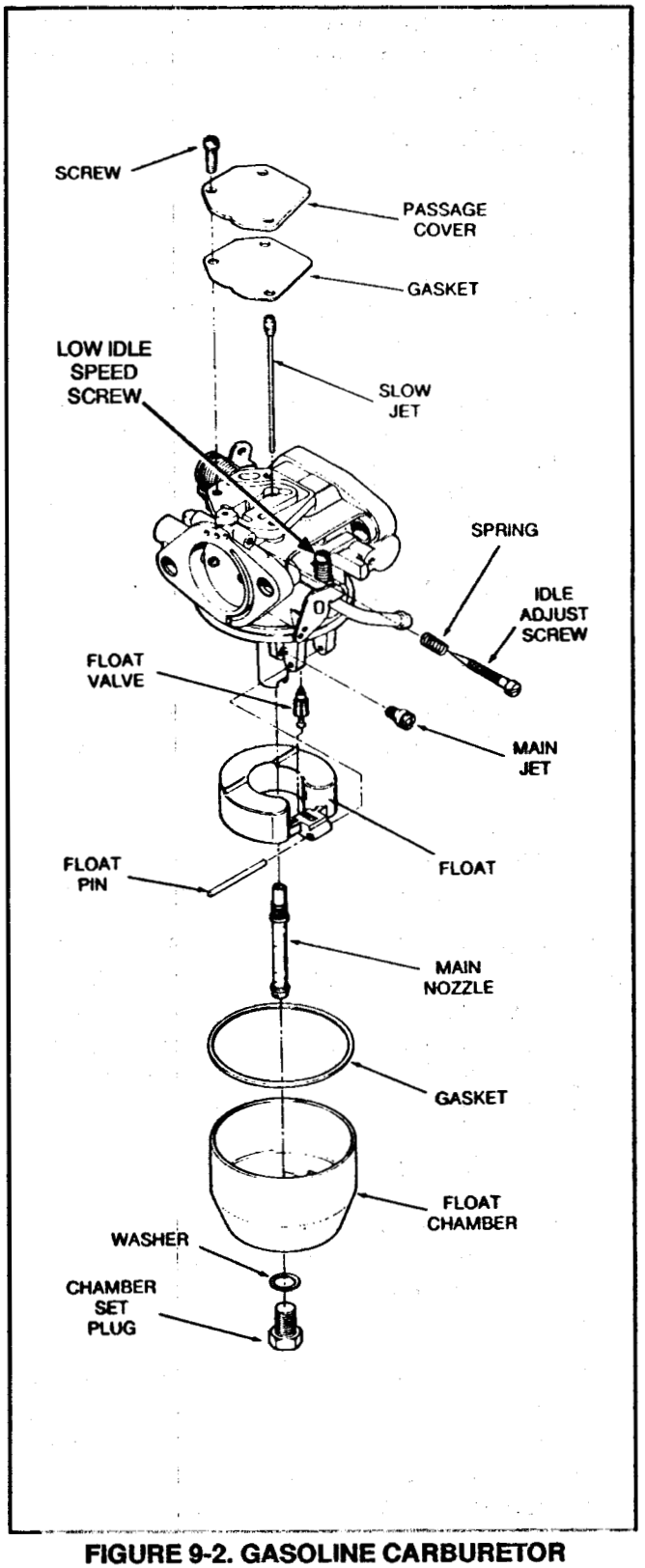


FIGURE 9-2. GASOLINE CARBURETOR (SPECS A AND B)

IMPULSE FUEL PUMP

The engine may be equipped with an impulse type fuel pump that uses crankcase pressure (vacuum) pulses to operate a spring loaded diaphragm inside the pump to pump the fuel through two check valves. Engine crankcase vacuum is connected through a hose to the back of the pump. The fuel flow direction is marked on the cover of the pump.

Use adequate ventilation when working on the fuel system. Prevent ignition sources in the areas sharing ventilation.

If the fuel pump leaks, replace it. This fuel pump is not intended to be rebuilt for a fuel leak problem.

⚠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.***

Inspection/Service

If a problem with fuel delivery to the engine is suspected, check the following items before inspecting the fuel pump.

1. Make sure the fuel shutoff valve is open.
2. Check the fuel filter and replace it if required.
3. Make sure the fuel hoses are not kinked or pinched, causing a fuel restriction. Dips and excessively long runs of fuel line in a hot area can cause vapor locking.
4. Check the fuel tank cap for a restricted vent.
5. Check the oil level to make sure it is at the full mark.
6. Inspect the crankcase, especially at the gaskets, for visible oil leaks, indicating crankcase air leakage that can cause reduced fuel pump performance. Also check the seal on the oil fill tube.
7. If the gasoline has been stored for an extended time, drain and properly dispose of the old gasoline. Refill the fuel tank with fresh unleaded regular gasoline.

If fuel delivery problems still occur, perform the following performance checks based on the symptom.

Engine Will Not Start: Crank the engine, then immediately remove and inspect the spark plug.

If the plug is wet and it has a strong gasoline odor, check for:

- An ungrounded ignition ground wire
- A defective throttle plate or low oil pressure switch or other equipment switch for ignition grounding
- A fouled spark plug
- An improperly adjusted carburetor choke

If the plug is dry, ground the spark plug lead so that ignition sparks can not ignite the gasoline.

Remove the fuel line from the carburetor and splice in a fuel line of approximately eight inches in length. Place the end of the fuel line in a container to collect the gasoline. Crank the engine with the electric starter or the recoil starter for 20 seconds. There should be fuel flow into the container. If there is no fuel flow from the pump, replace the fuel pump as instructed in this section.

Engine Runs But Will Not Operate At High Load: If the engine starves for fuel at high load, connect a gravity feed fuel supply directly to the carburetor. Plug the fuel line from the fuel pump during this test. If the gravity feed fuel supply eliminates fuel starvation, replace the fuel pump as instructed in this section. If the fuel starvation continues, the fuel pump is not the cause.

Fuel Pump Removal

Refer to Figure 9-3. The pump is not intended to be rebuilt and should be replaced as a complete assembly.

1. Turn off the fuel shutoff valve at the tank.
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.
6. Disconnect the pulse hose from the fuel pump.
7. Disconnect the inlet fuel hose from the fuel pump.
8. Disconnect the outlet fuel hose from the fuel pump (it may be necessary to loosen the air cleaner pan mounting screws to gain access to the fuel pump).
9. Remove the fuel pump.

Fuel Pump Installation

Install the new fuel pump in reverse order of removal. Replace any damaged or deteriorated fuel lines. After installation, check governor and engine speed adjustments for proper engine response.

Tighten all mounting hardware to that specified in *Assembly Torques*.

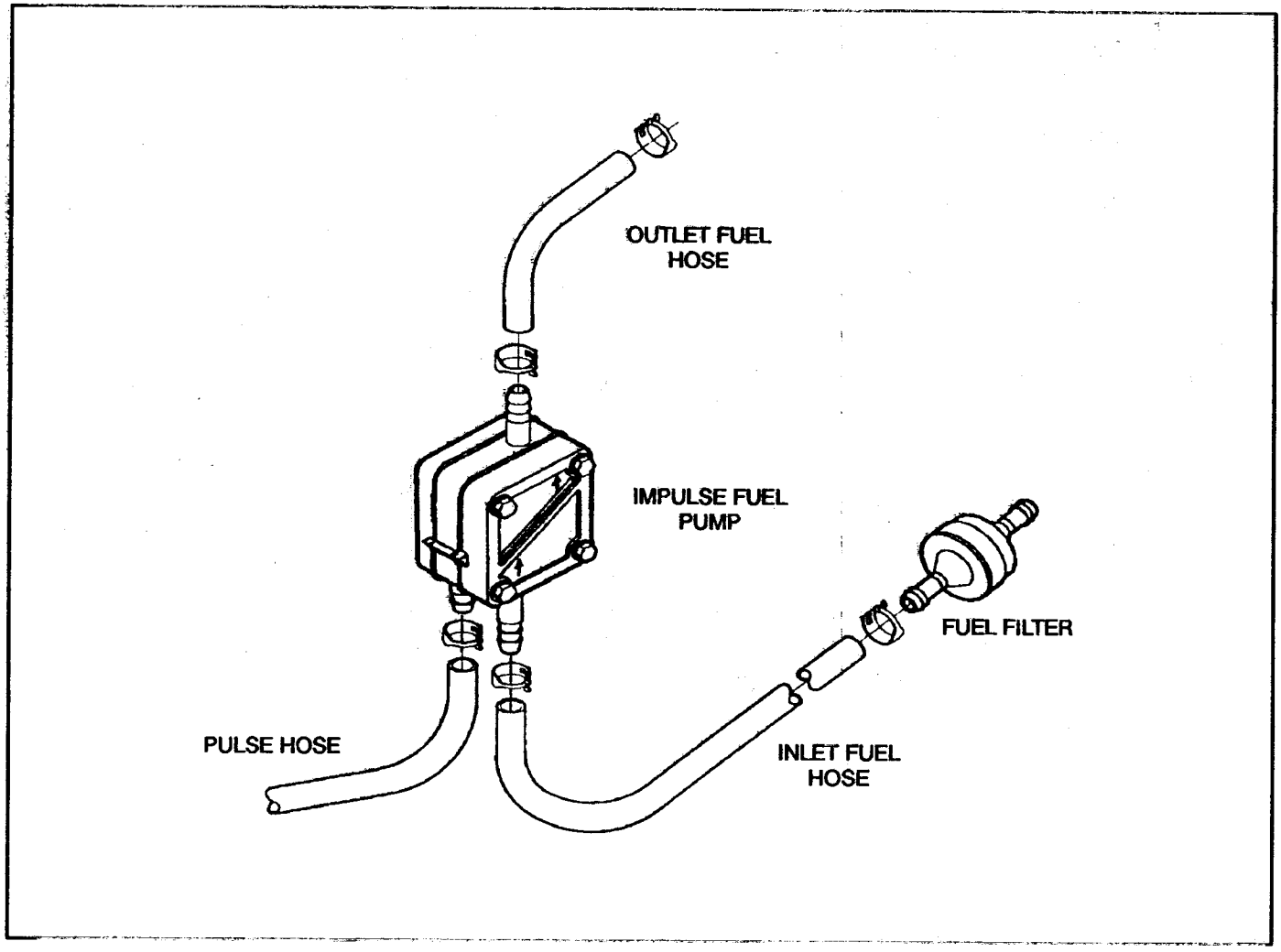


FIGURE 9-3. IMPULSE FUEL PUMP

LPG FUEL SYSTEM

Refer to Figure 9-4. 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 9-3.

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.

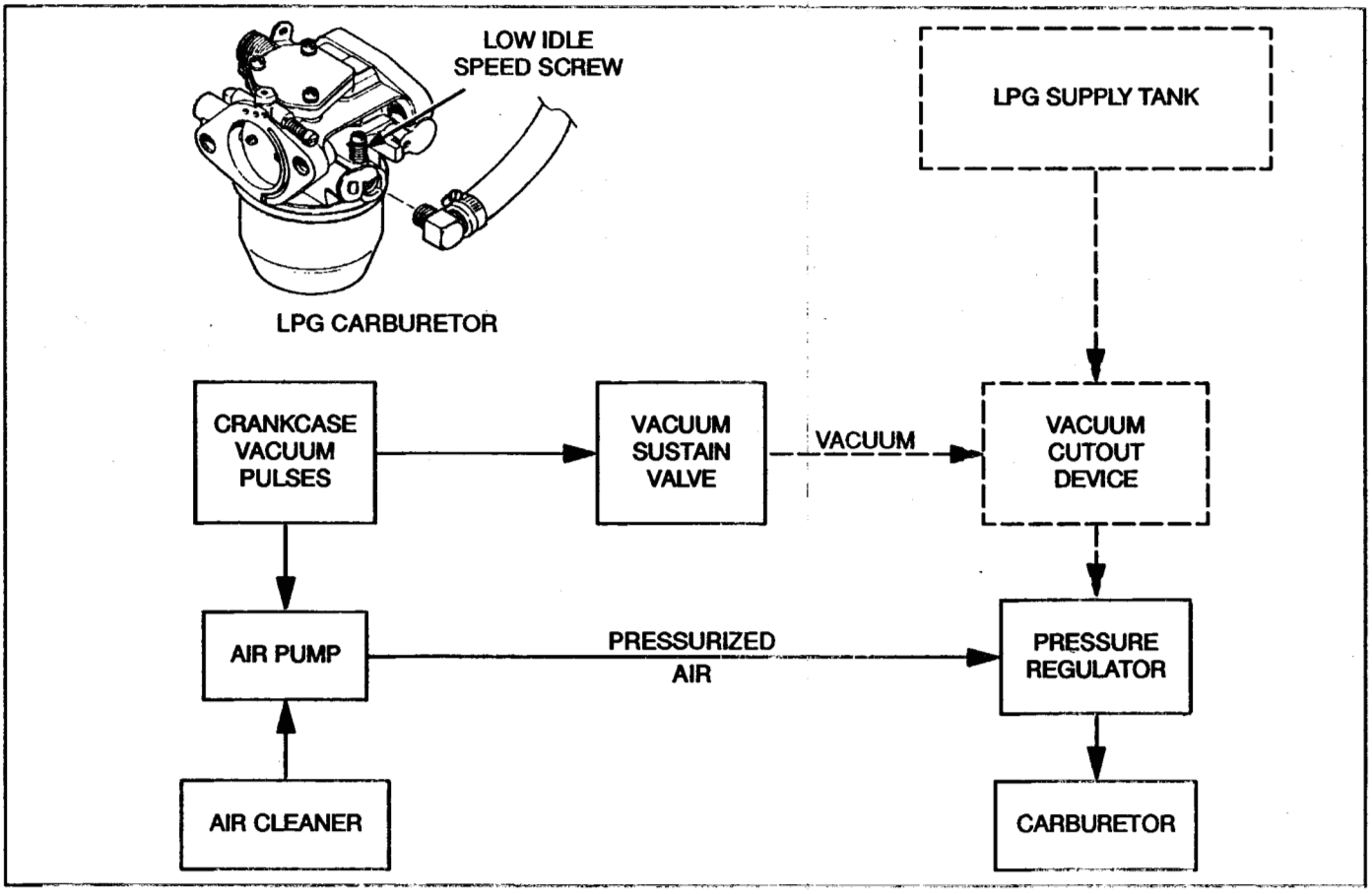


FIGURE 9-4. LPG CARBURETOR AND FUEL SYSTEM BLOCK DIAGRAM

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 9-5. 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 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 9-6.
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. 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.

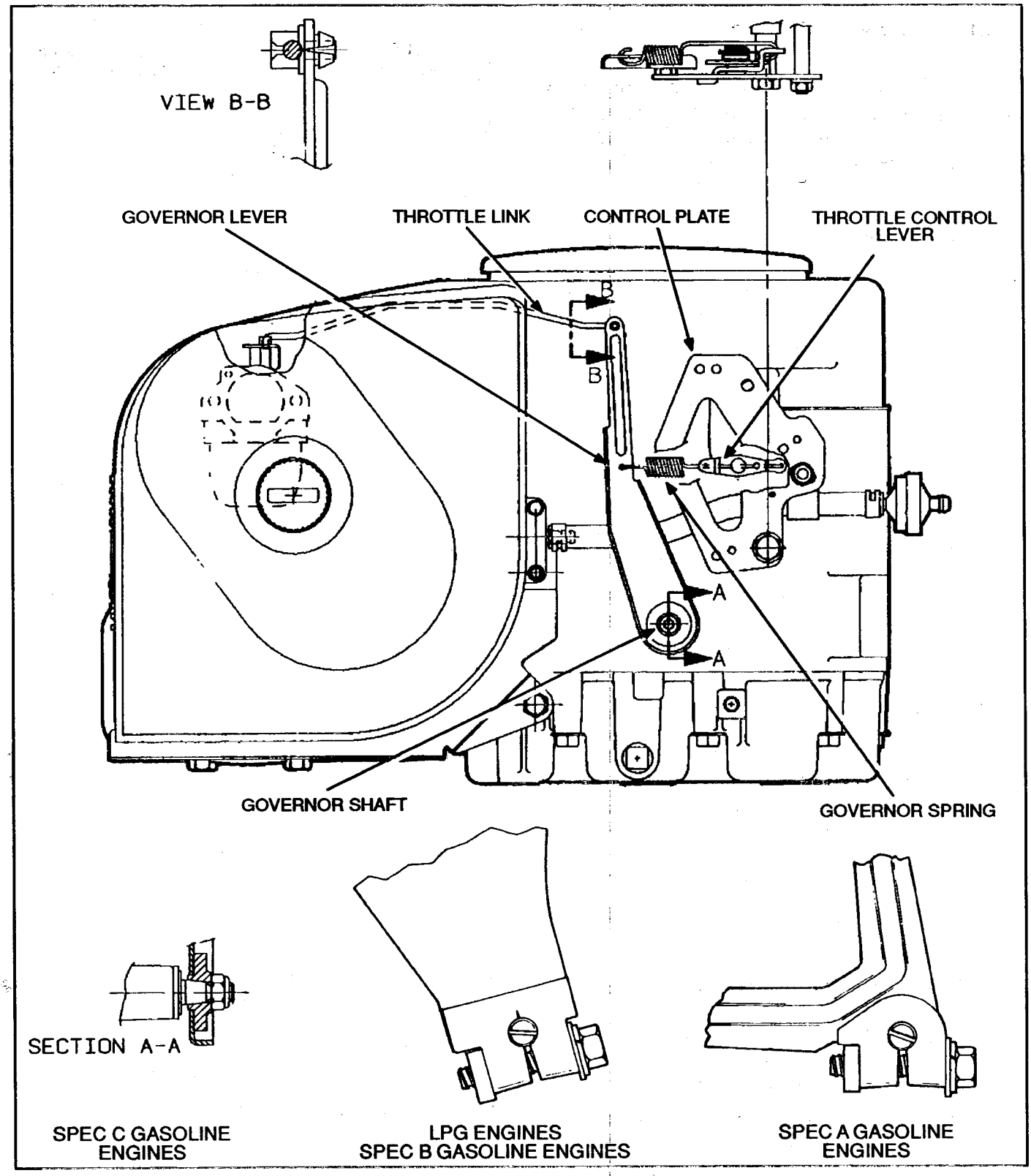


FIGURE 9-5. ENGINE GOVERNOR LEVER

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 9-6.

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 9-7.

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 9-1, 9-2 or 9-4, as appropriate. Shut off the engine and proceed to the choke adjustment.

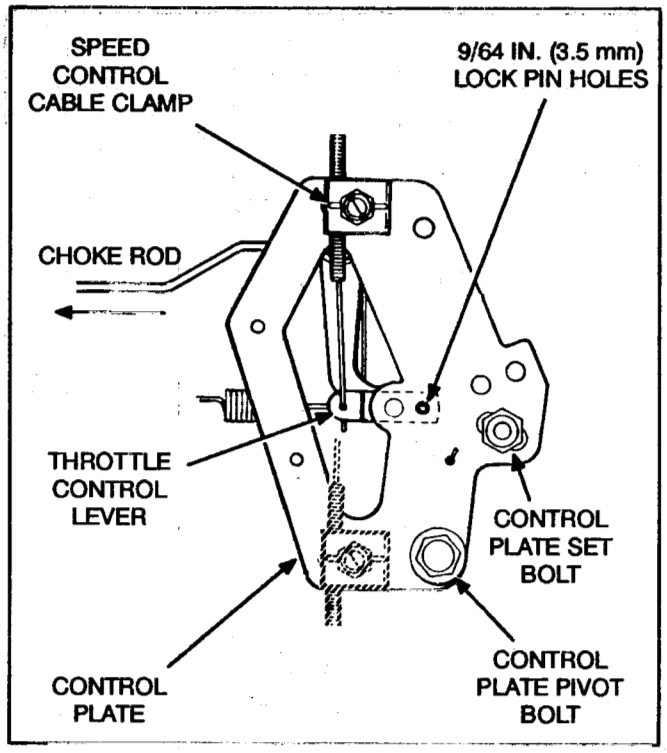


FIGURE 9-6. HIGH IDLE SPEED ADJUSTMENT

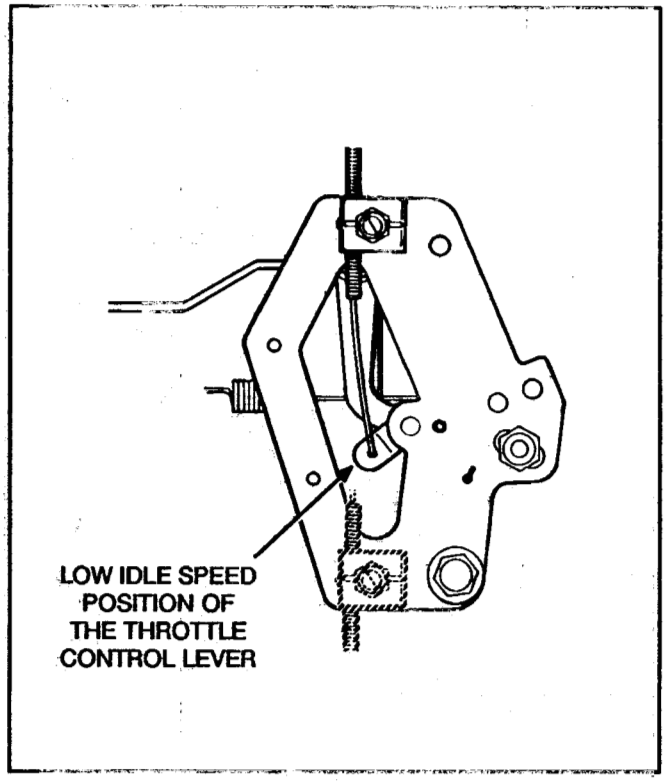


FIGURE 9-7. LOW IDLE SPEED ADJUSTMENT

3. Choke Adjustment

Refer to Figure 9-8. 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.

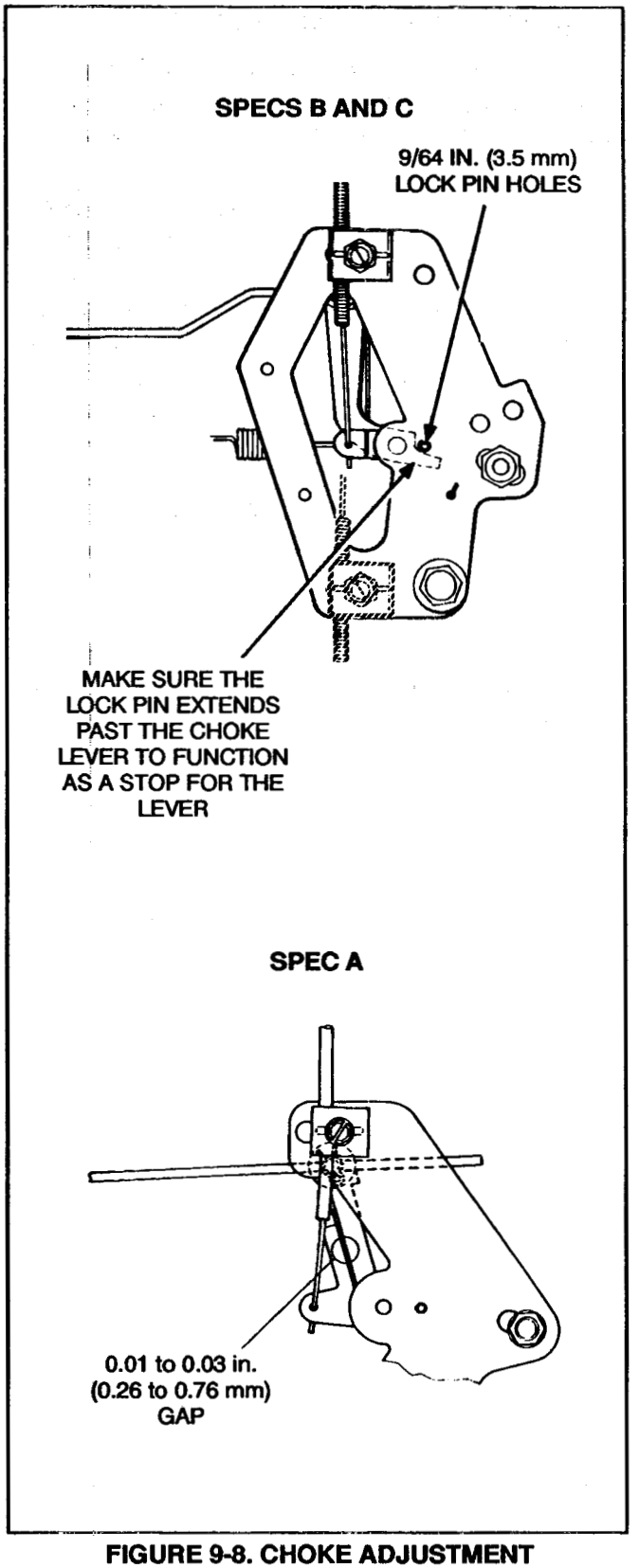


FIGURE 9-8. CHOKE ADJUSTMENT

4. Speed Control Cable Adjustment

Refer to Figure 9-9. 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.

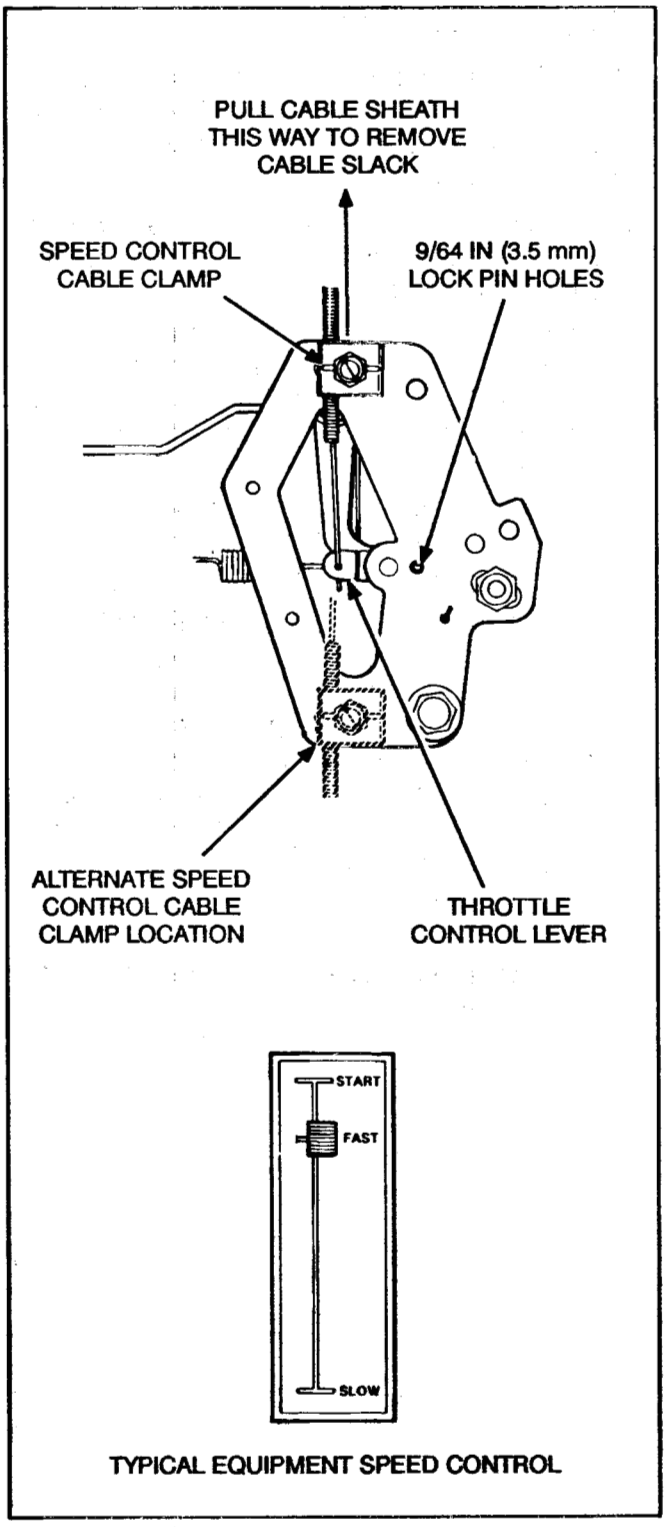


FIGURE 9-9. SPEED CONTROL CABLE ADJUSTMENT

AIR CLEANER

Foam Wrapper Element

Refer to Figure 9-9. See Periodic Service Schedule for foam wrapper service interval. Remove the outer air cleaner nut and plastic outer cover. When servicing the foam wrapper only **DO NOT** remove the inner air cleaner nut and inner cover.

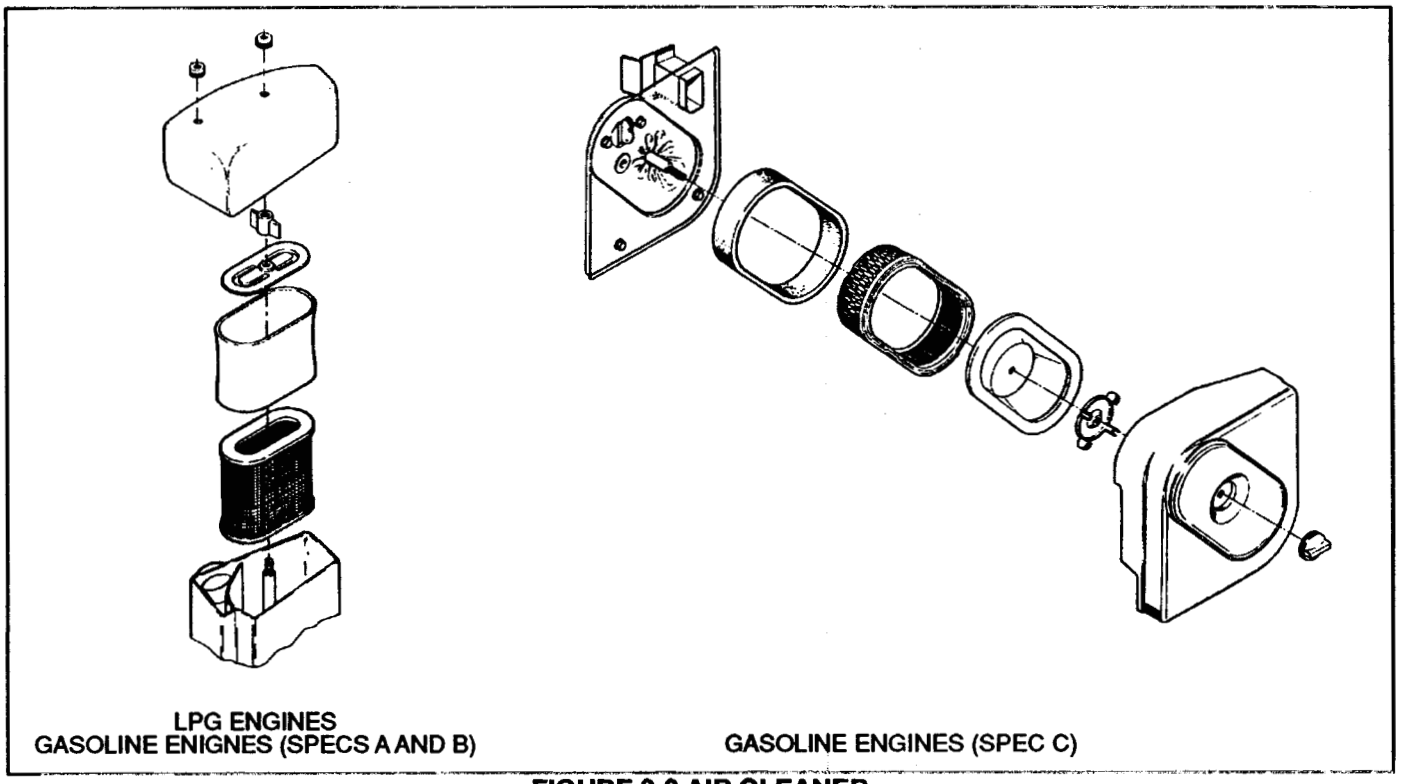
Wipe away loose dirt and chaff from the air cleaner assembly and then remove the foam wrapper by pulling the foam wrapper over the inner cover. Wash the foam wrapper in water and detergent and squeeze dry like a sponge. Rinse with water. Dry the foam wrapper by compressing between several sheets of paper toweling. Apply 2 tablespoons of new engine oil and knead into the foam wrapper until it is evenly distributed. Remove excess oil by compressing the foam between several sheets of paper toweling. Failure to remove excess oil will cause the paper air cleaner to become oil soaked. This will cause a loss in engine performance and a shortened paper air cleaner element life.

Install the foam wrapper over the paper air cleaner element by stretching over the inner cover. Completely cover all exposed paper pleats on the air cleaner paper element. If the foam wrapper has stretched or become torn, replace the foam wrapper. Assemble the outer air cleaner cover and nut.

Paper Element

Refer to Periodic Maintenance Schedule for air cleaner service and replacement interval. Service or replace more often when operating under severe operating conditions.

Remove the outer air cleaner nut and plastic outer cover. Wipe away loose dirt and chaff from the air cleaner assembly and then remove the inner air cleaner nut and inner air cleaner cover. Remove the air filter paper element and foam wrapper from the engine. Wipe off excess dirt from air cleaner base and install the new paper element, inner cover and inner nut. Tighten the inner nut one and a half turns after seating on the inner cover. Service the foam wrapper per the instructions given above. Assemble the outer air cleaner cover and nut.



LPG ENGINES
GASOLINE ENIGNES (SPECS A AND B)

GASOLINE ENGINES (SPEC C)

FIGURE 9-9 AIR CLEANER

Section 10. Starting

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

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. Install and torque the four capscrews to the torque specified in *Assembly Torques.*

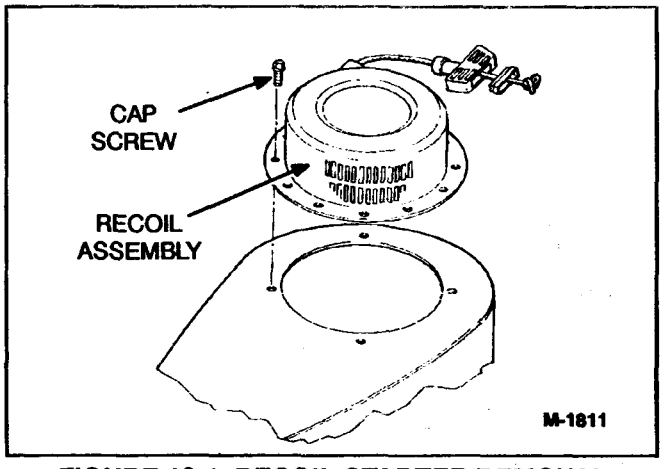


FIGURE 10-1. RECOIL STARTER REMOVAL

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.

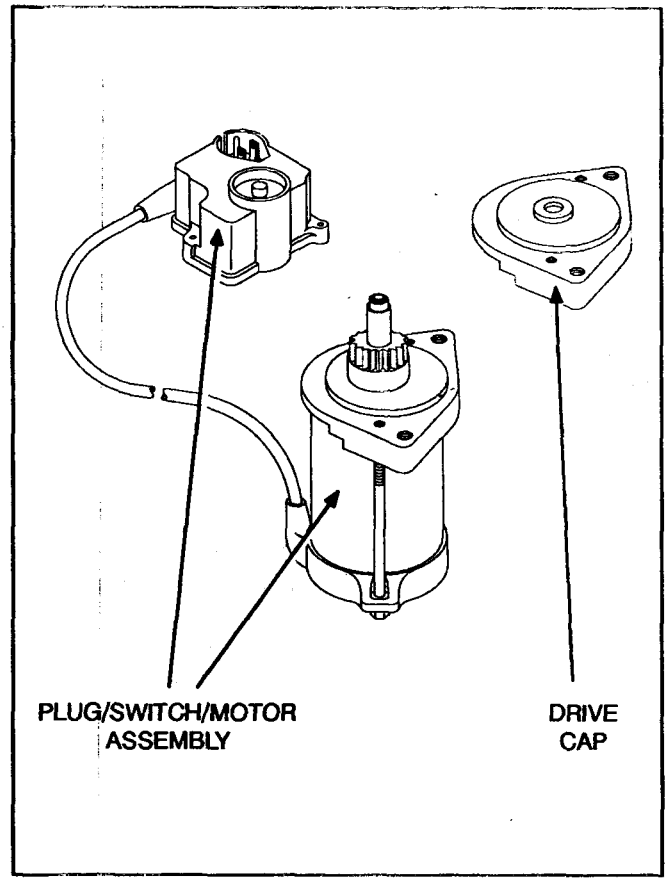


FIGURE 10-2. 110 VAC STARTER

SOLENOID SHIFT STARTER

⚠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.***

Inspection/Service: With the starter assembled, disconnect the connecting lead from the starter solenoid C terminal. Connect a jumper lead from the connecting lead to the battery positive terminal. Connect a jumper lead momentarily between the starter motor housing and the battery negative terminal. If the motor doesn't run, check the motor for problems.

Disassembly: Refer to Figure 10-3. Remove the starter from the engine. Unscrew the solenoid mounting nuts and disconnect the connecting lead. Remove the solenoid by sliding it up to disconnect the shift fork. Unscrew the two motor through bolts and remove the motor end bell. Carefully remove the brush insulator, brushes (four), brush springs and brush holder. Separate the motor frame from the drive housing and then draw the armature out with the shift fork.

Assembly: Refer to Figure 10-3. Assembly is the reverse of disassembly. Apply grease to the shift fork hinge and prongs and the splines on the armature shaft.

Solenoid

Attraction Text: Connect a jumper lead from the ST terminal to the positive terminal of a 6 volt battery. Connect a jumper lead between the C terminal and negative terminal of a 6 volt battery. If the plunger pulls in and holds strongly, the solenoid is good; if it doesn't, replace solenoid.

Retention Test: Connect a jumper lead from the ST terminal to the positive terminal of a 6 volt battery. Connect a jumper lead between the solenoid body and negative terminal of a 6 volt battery. Push the plunger in and release it. If the plunger stays in, the solenoid is good; if it doesn't, replace solenoid.

Plunger Return Stroke: Apply 12 volts between terminal C and the solenoid body. Push the plunger in and then release it. If the plunger returns immediately, the solenoid is good; if it doesn't, replace solenoid.

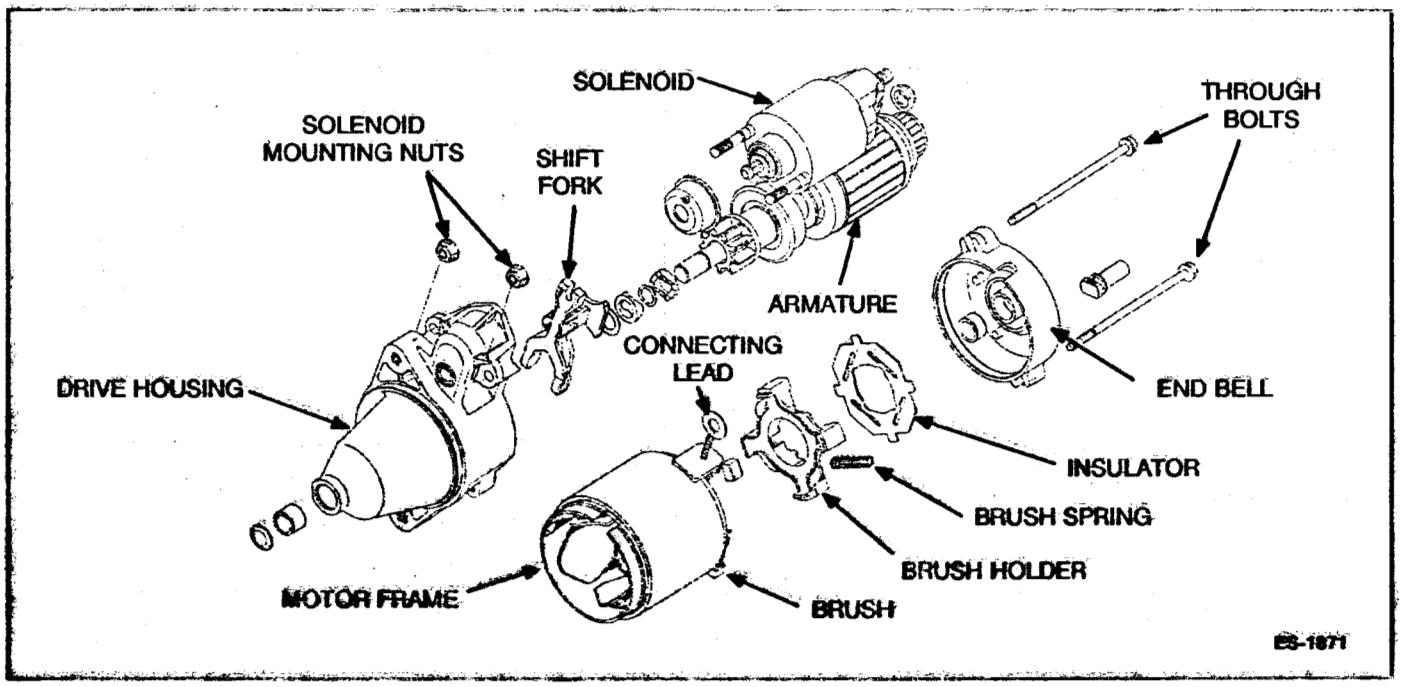


FIGURE 10-3. SOLENOID SHIFT STARTER

Armature

Continuity Between Segments: Refer to Figure 10-4. Check for continuity between the segments of the commutator. If there is no continuity, replace the armature.

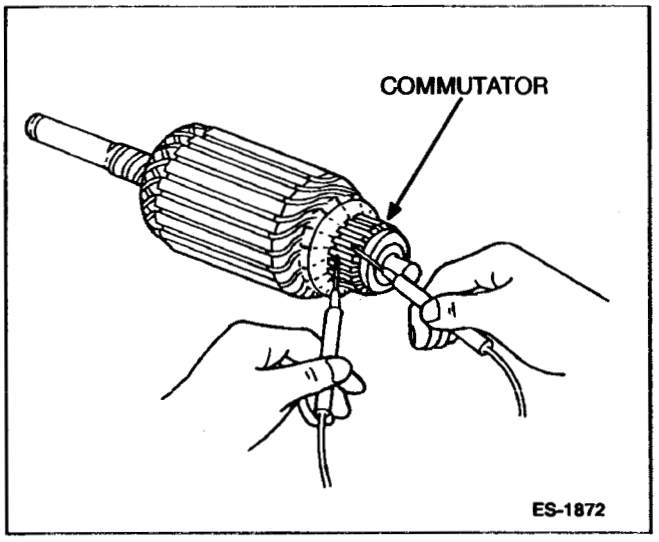


FIGURE 10-4. MEASURING SEGMENT CONTINUITY

Armature Coil Core and Commutator Continuity: Refer to Figure 10-5. Check for no continuity between the commutator and the armature coil core. If continuity exists, replace the armature.

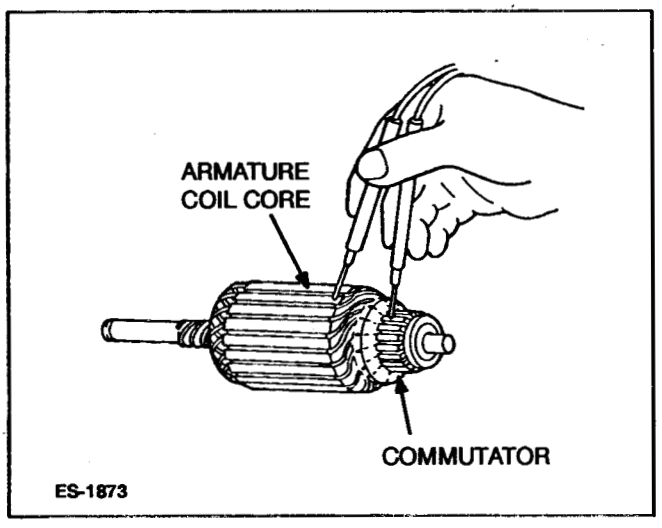


FIGURE 10-5. MEASURING ARMATURE COIL CORE AND COMMUTATOR CONTINUITY

Armature Coil Core and Commutator Continuity: Refer to Figure 10-6. Check for no continuity between the commutator and armature's shaft. If continuity exists, replace the armature.

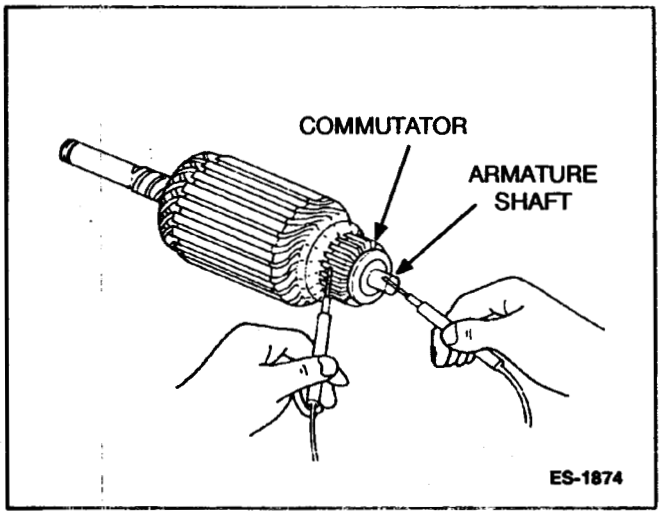


FIGURE 10-6. MEASURING ARMATURE SHAFT AND COMMUTATOR CONTINUITY

Armature Shaft and Bushing Clearance: Refer to Figure 10-3, 10-7, and 10-8. Measure the bushing inside diameter in the starter drive housing and end frame. Measure the armature shaft outside diameter on the pinion side and commutator side. If the clearance is not as specified in *Dimensions and Clearances,* replace the bushing.

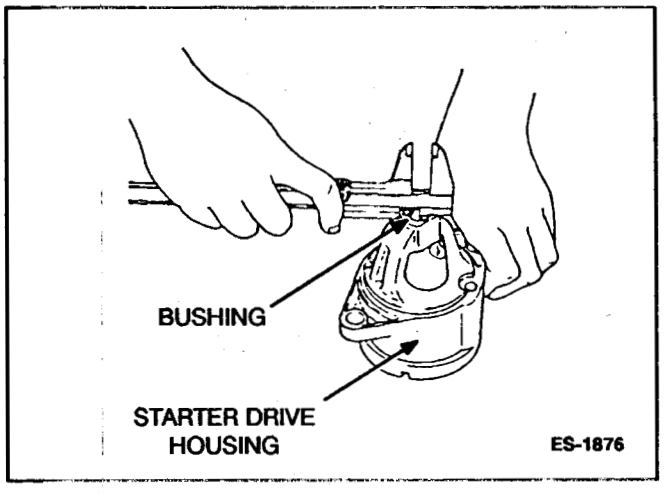


FIGURE 10-7. MEASURING STARTER DRIVE HOUSING INSIDE DIAMETER

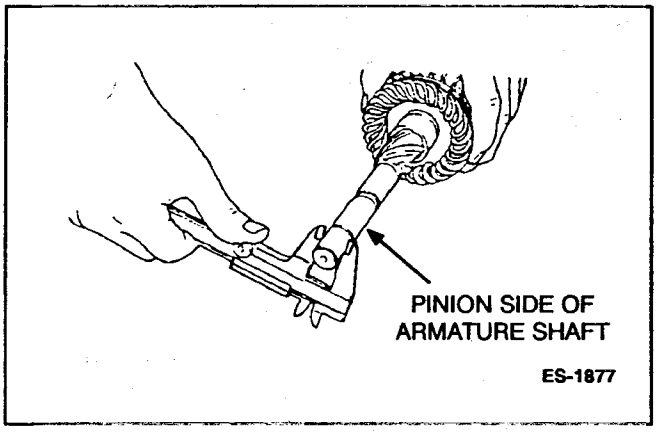


FIGURE 10-8. MEASURING ARMATURE SHAFT OUTSIDE DIAMETER

Commutator And Mica

Commutator: Refer to Figure 10-9. Clean commutator surface with sandpaper. Measure the commutator outside diameter at several points. If the difference of the outside diameter is not as specified in *Dimensions and Clearances,* correct the commutator on a lathe to factory specifications. If the minimum outside diameter is less than the allowable limit, replace the armature.

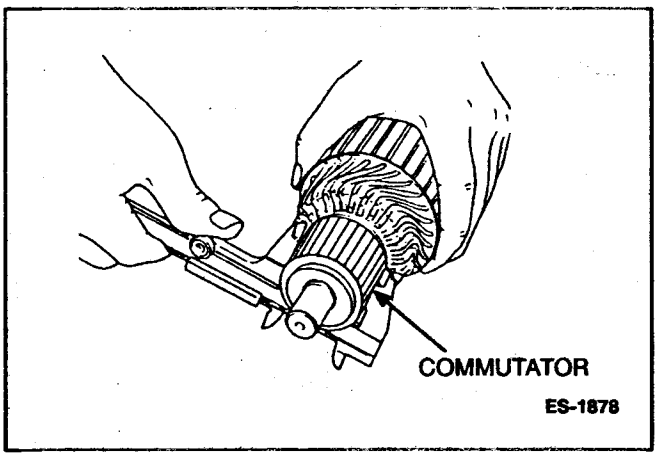


FIGURE 10-9. MEASURING COMMUTATOR OUTSIDE DIAMETER

Mica: Refer to Figure 10-10. Measure the mica undercut depth. If the undercut is less than that specified in *Dimensions and Clearances,* use a saw blade to increase the depth and then chamfer the segment edges.

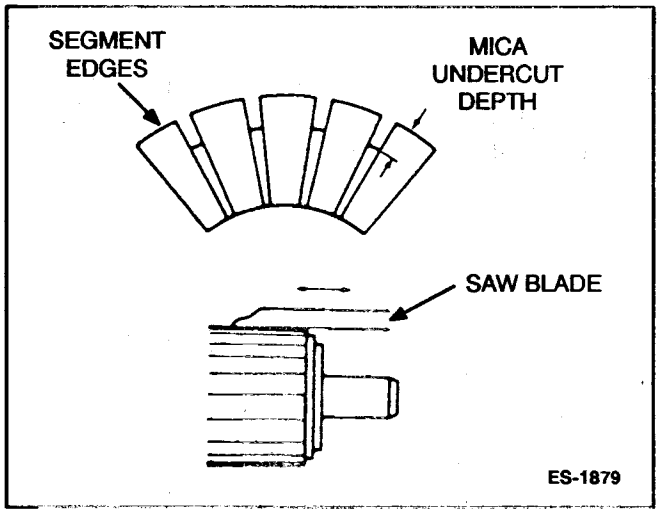


FIGURE 10-10. MICA UNDERCUT DEPTH

Starter Body

Inspection: Refer to Figure 10-11. Check for continuity across the starter body and brushes. There are four brushes in the starter body. The two that are not grounded are 180° apart starting at the terminal which connects to the solenoid. The two that are grounded are located 90° from the non-grounded terminals. If continuity exists at the non-grounded terminals, replace the starter body. If continuity does not exist at the grounded terminals, replace the starter body.

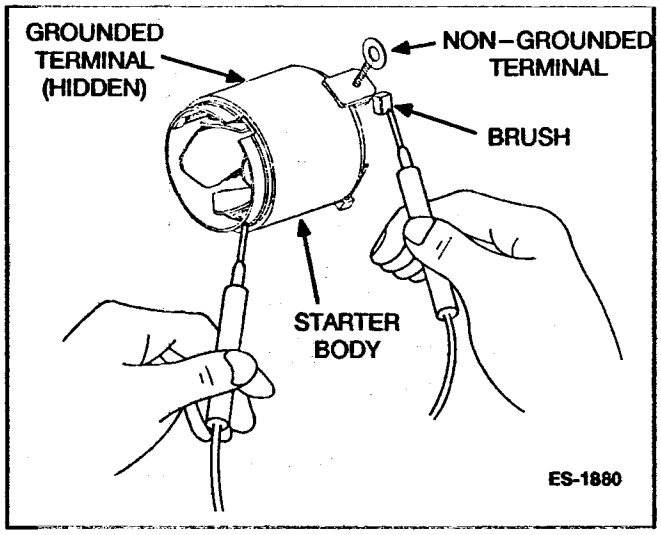


FIGURE 10-11.CHECKING FOR STARTER BODY CONTINUITY

Brushes

Inspection/Service: Refer to Figure 10-12. Clean the brush base with sandpaper. Measure the brush length. If the length is not as specified in *Dimensions and Clearances,* replace the starter body and brush holder.

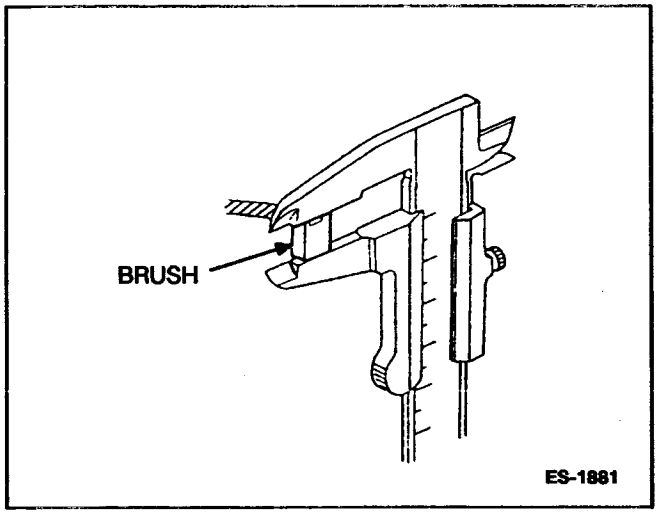


FIGURE 10-12. MEASURING BRUSH LENGTH

Overrunning Clutch

⚠WARNING ***Cleaning overrunning clutch in liquid cleaning solution will result in starter damage. Do not clean overrunning clutch in liquid cleaning solutions.***

Inspection/Service: Refer to Figure 10-13. Inspect the pinion and spline teeth for wear and damage. If wear or damage exists, replace pinion. Rotate the pinion clockwise and see if it turns freely. Replace the pinion if it doesn't. Rotate the pinion clockwise to see if it locks. Replace the pinion if it doesn't.

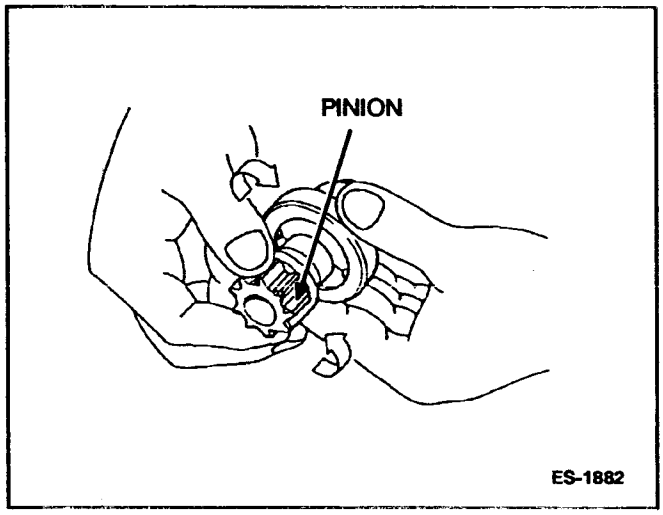


FIGURE 10-13. CHECKING PINION FOR PROPER OPERATION

Section 11. Engine Block Assembly

INTRODUCTION

This section covers service procedures for the engine block assembly. A compression test can be performed to determine the condition of the engine.

⚠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.***

ENGINE DISASSEMBLY/ASSEMBLY

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

Suggested Disassembly Order

1. Drain crankcase oil.
2. Disconnect all fuel, exhaust and electric lines.
3. Remove the engine from its mountings and place it on a suitable bench or work stand.
4. Remove the muffler, chaff screen, blower housing, cylinder air housing, etc.
5. Remove the air cleaner assembly, carburetor, and air deflector.
6. Remove the ignition module.
7. Remove the flywheel using a puller.
8. Remove all accessories such as oil filter, starter, intake manifold, exhaust manifold, spark plug, etc.
9. Remove the valve cover and cylinder head assembly.
10. Remove the oil base carefully, keeping all end play shims on their respective shafts.
11. Remove the balance shaft assemblies.
12. Remove the connecting rod and piston.
13. Remove crankshaft and camshaft assemblies.

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

1. Install tappets, crankshaft and camshaft assemblies.
2. Install the connecting rod and piston.
3. Install the balance shaft assemblies.
4. Install the oil base, reuse the original end play shims on their respective shafts.
5. Install the cylinder head assembly and lash valves.
6. Install the accessories such as valve cover, oil filter, starter, intake manifold, exhaust manifold, spark plug, etc.
7. Install the flywheel and ignition module.
8. Install the air deflector, carburetor, and cleaner assembly.
9. Install the cylinder air housing, muffler, blower housing, chaff screen, etc.
10. Install the engine on its mounting.
11. Connect all fuel, exhaust and electric lines.
12. Fill 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 leaks, fuel leaks, and exhaust leaks. Adjust carburetor and governor for speed and sensitivity.

Compression Test

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

To check compression:

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

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

FLYWHEEL

Disassembly

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

⚠WARNING ***Incorrect flywheel removal can result in severe personal injury. Do not remove the flywheel nut completely when using the flywheel puller.***

Remove screen or recoil starter assembly and flywheel cup if equipped with recoil starter. Remove sheet metal surrounding flywheel. Loosen the flywheel mounting nut. Use a flywheel puller to remove flywheel. Remove the woodruff key on the crankshaft.

Service/Inspection

Remove dirt, chaff, or other contaminants from screen and flywheel. Inspect screen and flywheel for damage. Replace screen if damaged in any way. Replace flywheel if ring gear or flywheel is damaged in any way.

Assembly

Clean tapered section of the flywheel so no oil or dirt are present. Install woodruff key on the crankshaft. Install flywheel on crankshaft and tighten to torque specified in *Assembly Torques.* Install sheet metal. Tighten bolts to torque specified in *Assembly Torques.*

VALVE COVER

Remove the valve cover to gain access to the cylinder head, breather assembly and valve system.

1. Remove the valve cover mounting bolts and pull off the valve cover.
2. Clean the valve cover. Be careful not to damage the surface of the cover where the gasket mounts.
3. Clean the cylinder head and cover thoroughly in the cover gasket mating area. Make sure the breather assembly is correctly seated in the cylinder head cavity.
4. Install a new valve cover gasket.
5. Place the valve cover in position and install the mounting bolts. Torque all of the bolts in a star pattern until they are tightened to the specified torque.

ROCKER ARM

Disassembly

Refer to Figure 11-1. Remove snap ring and pull out rocker arm.

Inspection/Service

Rocker Arm and Rocker Arm Shaft Clearance:

Measure the rocker arm shaft outside diameter. Measure the rocker arm inside diameter and calculate the clearance. If clearance is not as specified in *Dimensions and Clearances*, replace the rocker arms. If clearance still exceeds that specified in *Dimensions and Clearances*, replace rocker arm shaft assembly.

Assembly

Apply engine oil to the rocker arm shaft. Assemble components on rocker arm shaft.

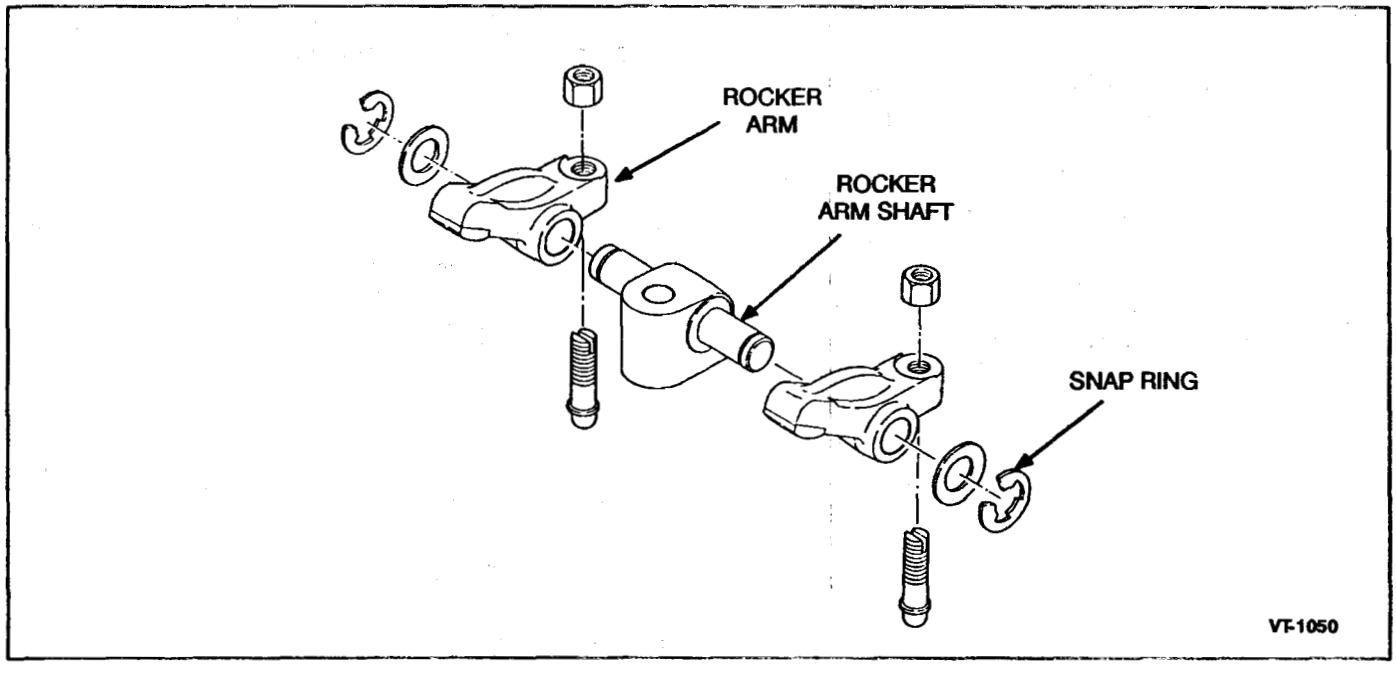


FIGURE 11-1. ROCKER ARM ASSEMBLY

CYLINDER HEAD

Disassembly

⚠WARNING ***Torquing or removing the cylinder head when hot (above 100°F [37°C]) will result in head damage. Allow the head to cool to below 100°F (37°C) before torquing or removing.***

Refer to Figure 11-2. The engine must be at room temperature before starting this procedure. Remove the valve cover capscrews and valve cover. Remove the spark plug. Remove the rocker arm assembly by unscrewing bolt holding the assembly on. Pull out the push rods. Remove the remaining cylinder head screws and remove the cylinder head. Remove the cylinder head gasket.

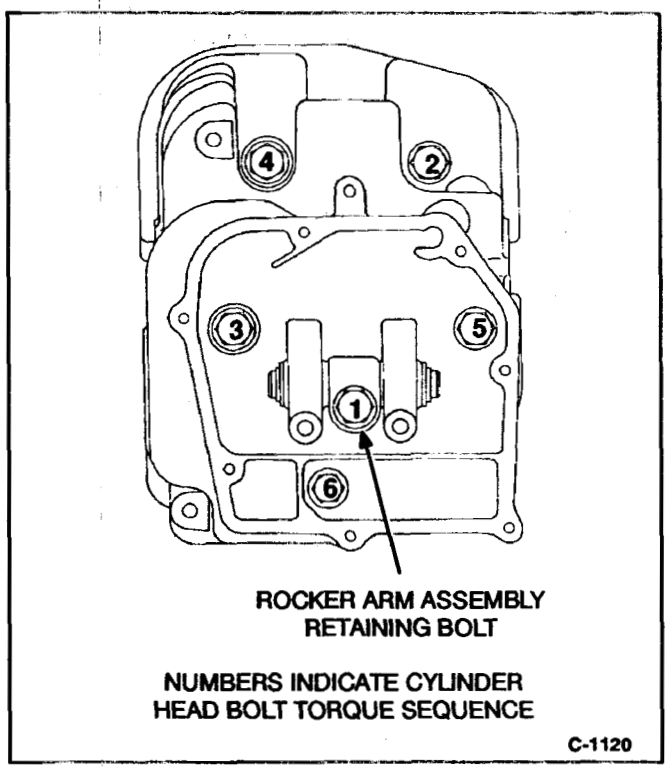


FIGURE 11-2. CYLINDER HEAD BOLTS

Assembly

⚠ CAUTION ***Over torquing bolts can cause engine damage. Do not over torque nuts.***

Refer to Figure 11-2. Install a new cylinder head gasket. Position cylinder head on engine and position rocker arm, bolts, and washers in positions shown. Make sure push rods are properly installed in tappets and rocker arm. tighten cylinder head bolts to the torque specified in *Assembly Torques* in the order: bolt 1, bolt 2, bolt 3, bolt 4, bolt 5, bolt 6. Bolts 2 and 4 must be retorqued after all bolts are torqued. Adjust valve clearance. Remove the gasket from valve cover. Install the breather in the cylinder head. Install a new valve cover gasket and tighten valve cover capscrews in a two-step cross pattern to the torque specified in *Assembly Torques.*

VALVE SYSTEM

This engine uses an overhead valve design, shown in figure 11-3. A properly functioning valve system is essential for good engine performance. Use the following procedures to inspect and service the valve system.

Tappets

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

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

Valves, Springs, Guides

Disassembly

Refer to Figure 11-3. Compress valve springs and pull out the valve locks. Remove the valve spring retainer, valve spring, washer and valve.

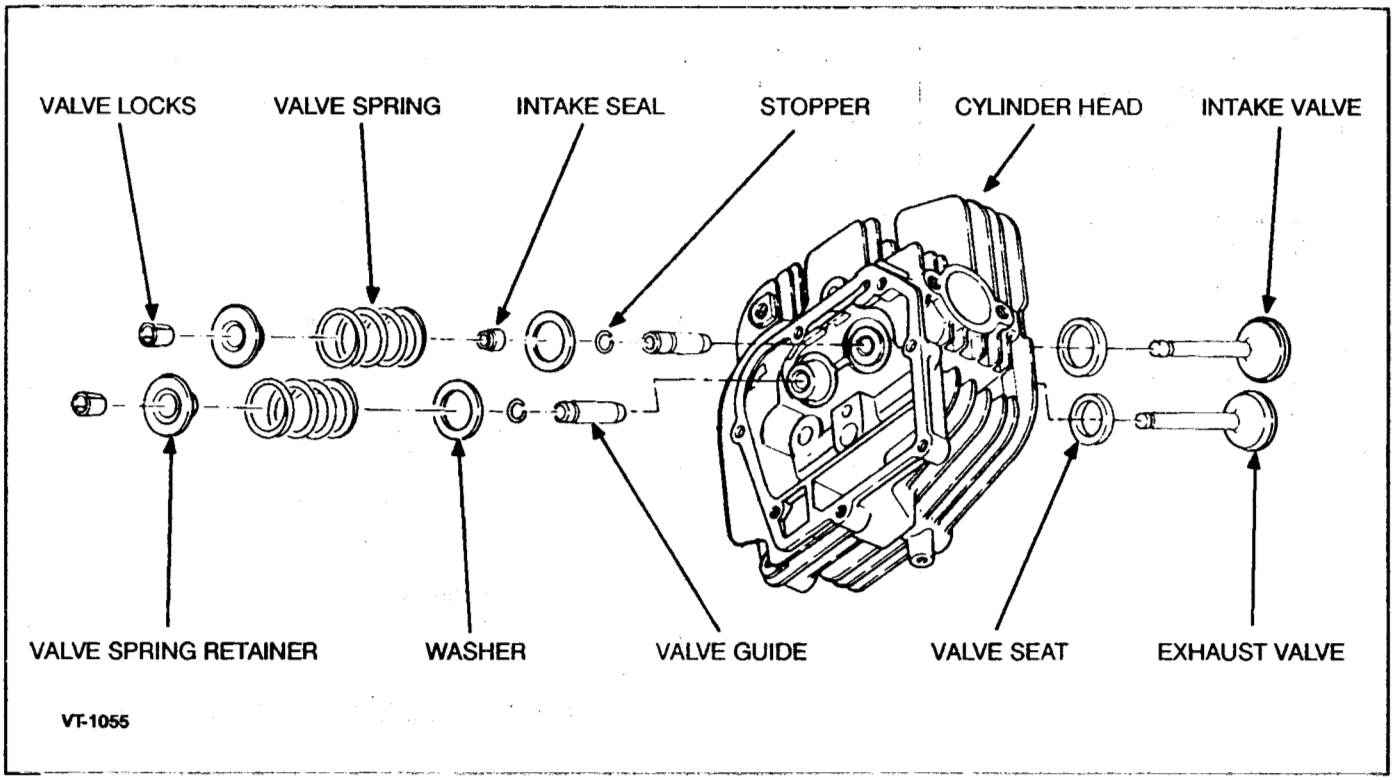


FIGURE 11-3. VALVE ASSEMBLY

Inspection/Service

Valve Stem and Valve Guide Clearance:

Refer to Figures 11-4 and 11-5. Remove carbon from valve guide and valve stem. Measure the valve stem outside diameter at six positions. Measure the valve guide inside diameter at three positions. Calculate the clearance. If the clearance is not as specified in *Dimensions and Clearances*, replace the valve. If clearance still exceeds the allowable limit, replace the valve guide.

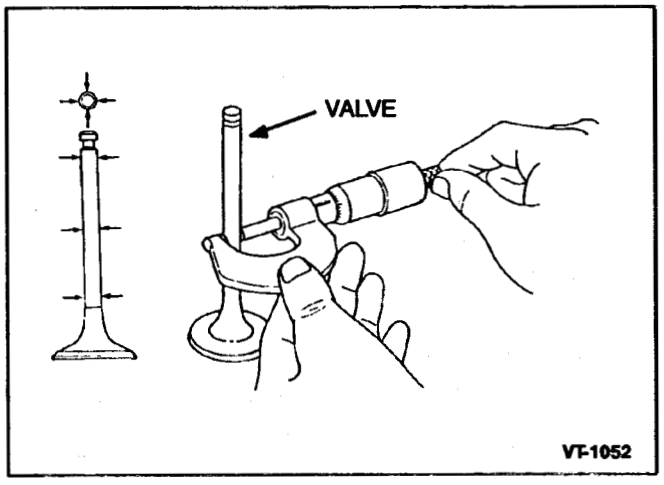


FIGURE 11-4. MEASURING VALVE STEM

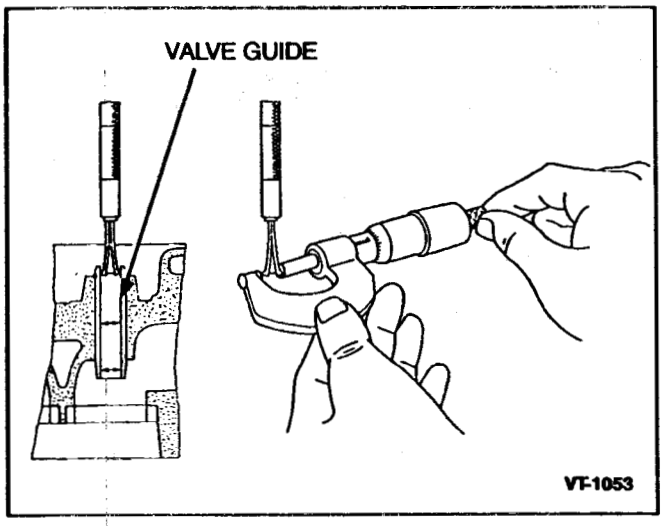


FIGURE 11-5. MEASURING VALVE GUIDE

Valve Guide Replacement:

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

Refer to Figure 11-6. Press out the used valve guide using a special valve guide replacing tool. Apply engine oil to a new valve guide. Install a stopper ring to the valve guide. Press the new valve guide in until the stopper ring contacts the cylinder head. Ream the new guide to achieve the specified stem to guide clearance.

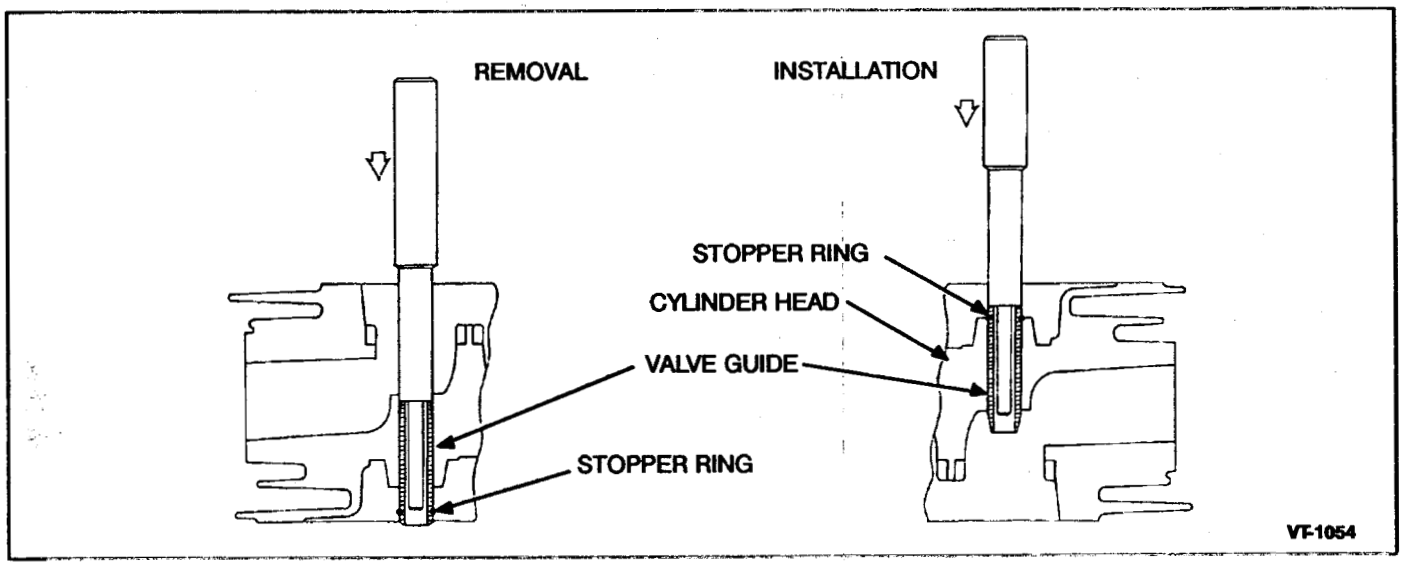


FIGURE 11-6. REPLACING VALVE GUIDE

Assembly

Clean off any carbon on the valve stem and valve guide hole. Apply engine oil to the valve and valve guide. Assemble in reverse of disassembly procedures.

Valve Spring:

Check valve springs for cracks, worn ends, distortion, and tension. If spring ends are worn, check valve spring retainer for wear. Check for spring distortion by placing the spring on a flat surface next to a square. Measure height of spring (A) and rotate it against square edge to measure distortion (B), see Figure 11-7. If distortion exceeds 0.06 inch (1.5 mm) replace the spring. Check spring tension at the valve open position using an accurate valve spring tester. Replace any valve spring that is weak, cracked, worn, or distorted.

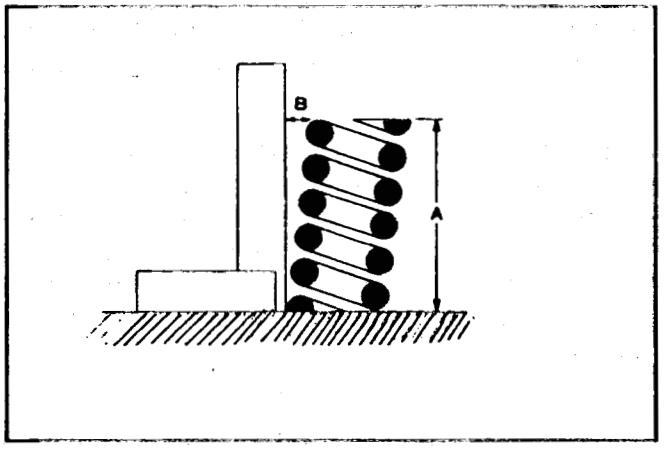


FIGURE 11-7. MEASURING VALVE SPRING

Valve Face and Seat Grinding

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

Refinish valve faces to a 45° angle on a valve refacing machine. The first cut from valve face must be a light grinding. Check if there is an unevenness of metal being removed. If only part of valve's face has been touched, check to see if the valve is properly seated in the machine or if the valve is warped, worn, or distorted. When cut is even around the whole valve face, keep grinding until the complete face is ground clean. Be sure the correct valve face angle is maintained. When the valve head is warped, a knife edge will be ground (Figure 11-8) on part or all of the head due to the large amount of metal that must be removed to completely reface the valve. Heavy valve heads are required for strength and good heat dissipation. Knife edges lead to breakage, burning, and pre-ignition due to heat localizing on the edge.

Replace any valve that cannot be entirely refaced while keeping a good valve margin (Figure 11-8) or is warped, worn, or damaged in any way. The amount of grinding necessary to true a valve indicates whether the valve head is worn or warped.

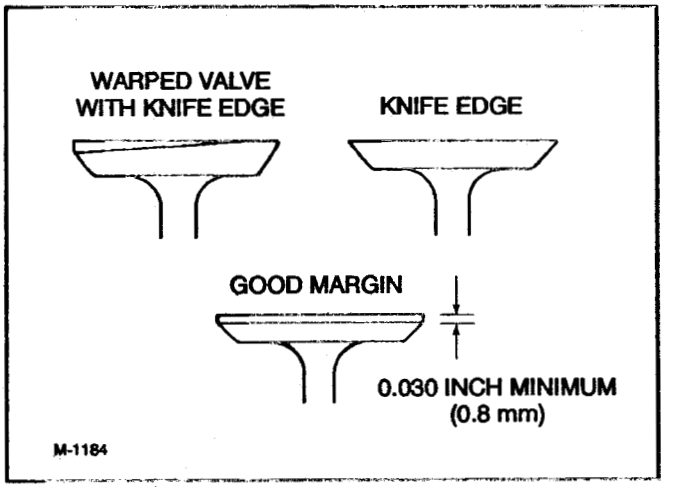


FIGURE 11-8. VALVE HEAD MARGIN

Inspection/Service

Valve Seat Width:

Clean the valve seat surface. Measure the valve seat width. Apply red lead to the valve surface to check for scratches and unevenness. If the measurement is within that specified in *Dimensions and Clearances*, check the seating ratio. If the ratio is less than 70%, refit it. If the measurement is not as specified in *Dimensions and Clearances*, replace the cylinder head and valve and refit the valve seat.

Valve Seat Cutting:

Refer to Figures 11-9 and 11-10. Clean the valve seat up by using a 45° valve seat cutter. Replace the valve and visually check the contact position between the valve face and seat with red lead. Cut the upper surface of the valve seat with a 15° valve seat cutter until the valve seat touches to the center of the valve face (A should equal B as shown in Figure 11-10). Cut the valve seat again with the 45° valve seat cutter and recheck the contact between the valve and seat. Repeat the last two steps until the correct contact is achieved. Lap valve until the seated rate becomes more than 70% of the total contact area.

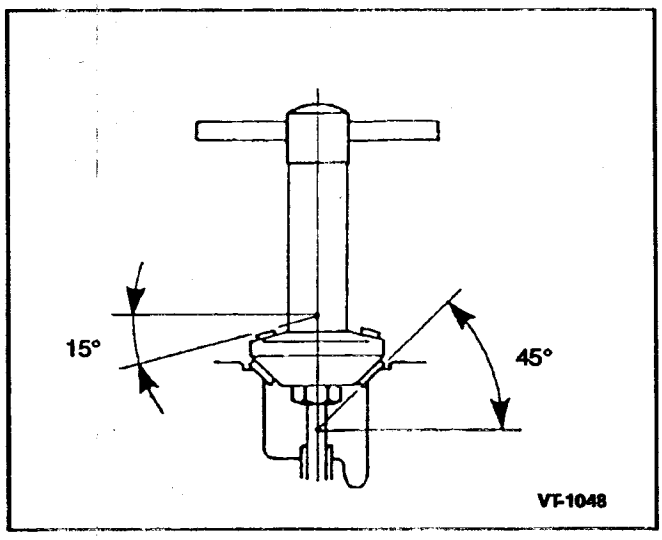


FIGURE 11-9. VALVE SEAT CUTTER

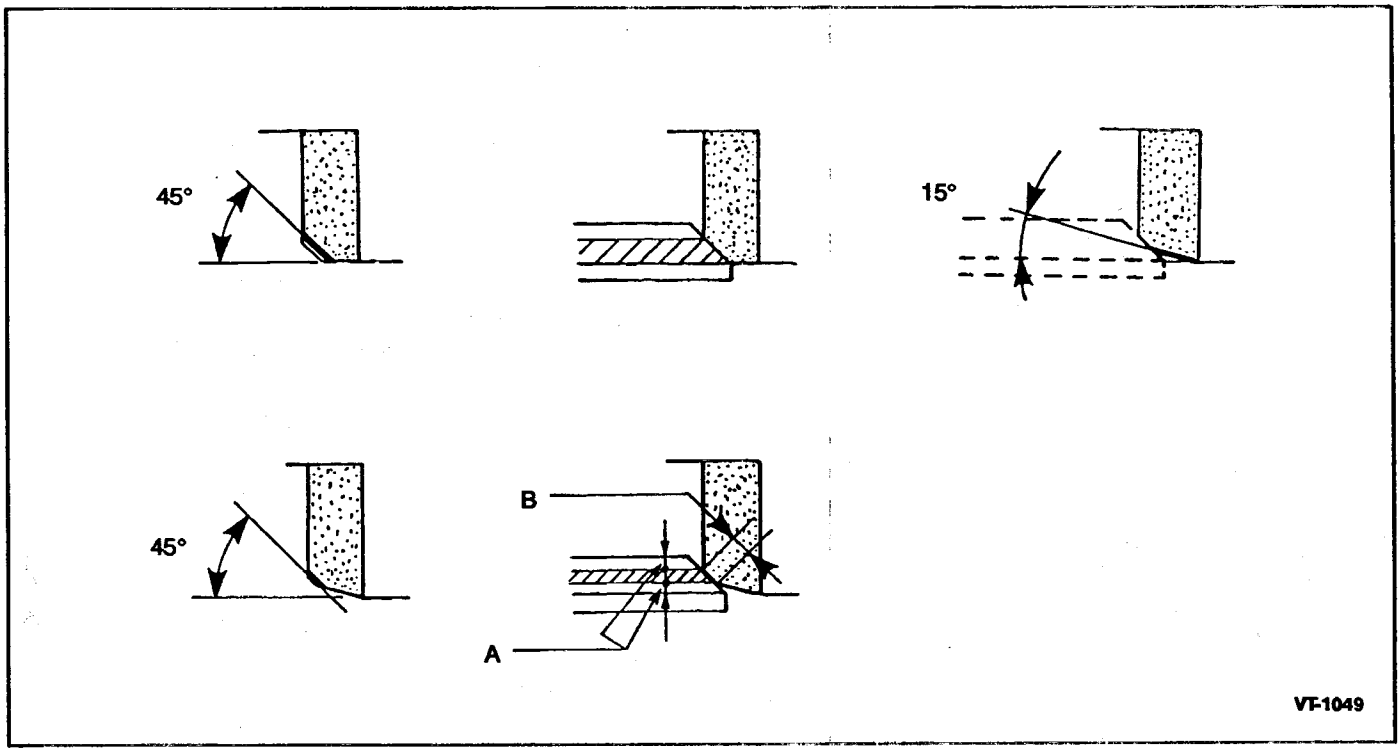


FIGURE 11-10. VALVE SEAT CONTACT

Valve Clearance:

The engine must be at room temperature when performing this test. Remove the valve cover. Remove the spark plug. Turn the engine over until the piston is at COMPRESSION TOP DEAD CENTER. Check the intake and exhaust valve clearance with a feeler gauge. If the clearance is not as specified in *Dimensions and Clearances*, loosen the lash adjusting nut and turn the lash adjusting screw until the correct dimension is obtained. Tighten lash adjusting nut and recheck clearance measurement.

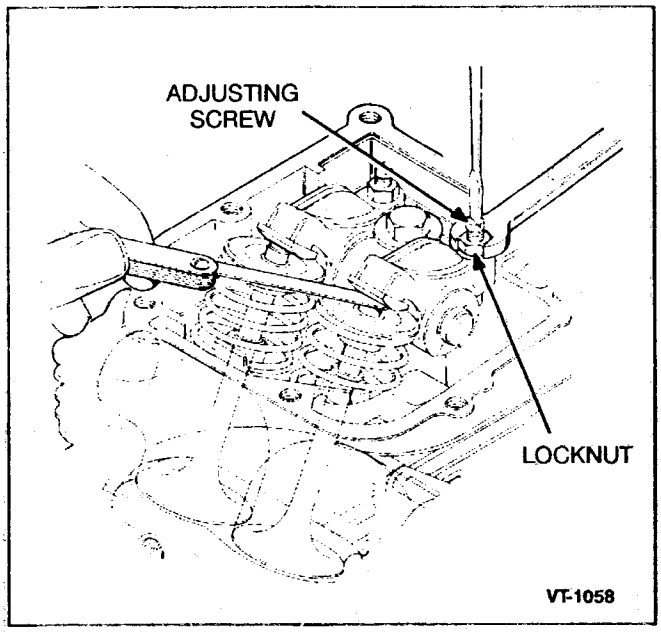


FIGURE 11-11. MEASURING VALVE LASH

OIL BASE

Disassembly

Remove the oil pressure switch located next to the oil filter. Unscrew the oil base mounting screws. Tap the oil base with a plastic hammer. Remove oil base. Do not pry cover off with a screwdriver, chisel, etc. Note where all shims come off from.

Assembly

Install a new oil base gasket. Install shims in their original locations (Figure 11-12). If the crankshaft, camshaft or balancer shafts have been replaced, use Plasti-gage to check their end clearances. Shim as necessary to obtain the clearances specified in *Dimensions and Clearances*.

Apply grease to the oil seal lip and make sure it's not damaged when installing the oil base. 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 in *Assembly Torques*. Torque the bolt first torqued once more.

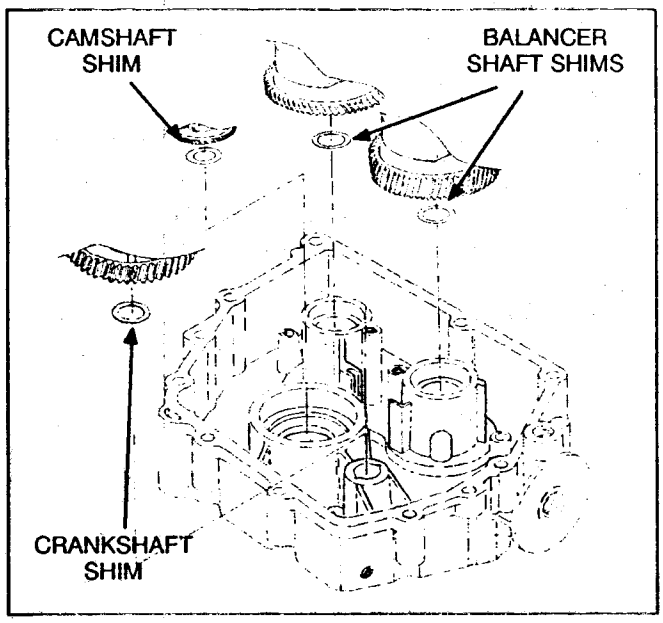


FIGURE 11-12. SHIM LOCATIONS

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 11-13). 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 11-13) for position of flyweight and sleeve.

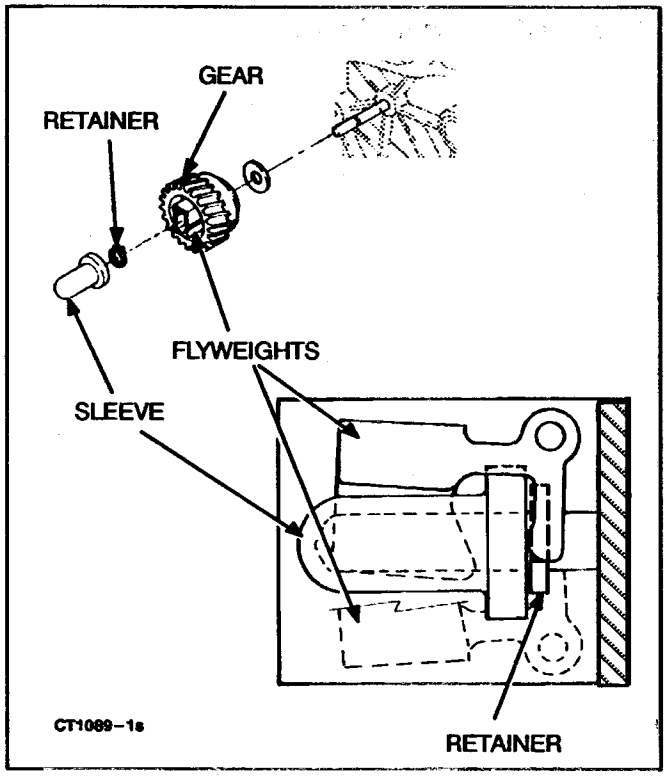


FIGURE 11-13. GOVERNOR

BALANCING SHAFTS

Disassembly

Carefully pull each shaft out, one at a time.

Oil Base Bearing to Shaft Clearance:

Measure the balancer journal bearing O.D. on both balancer shafts. Measure the corresponding oil base bearing I.D.'s. If the measurements are not as specified in *Dimensions and Clearances*, replace the defective parts.

Assembly

Refer to Figure 11-14. 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.

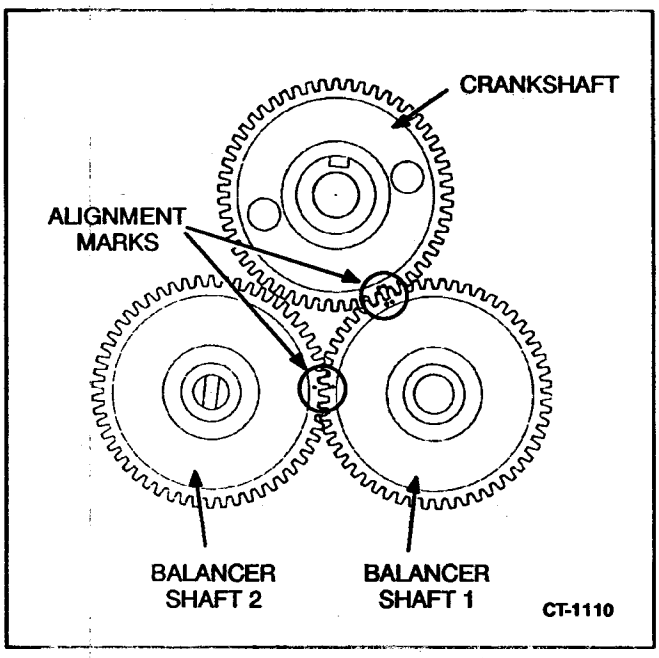


FIGURE 11-14. BALANCING SHAFT ALIGNMENT

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 11-15. Measure the crankshaft journal. If the crankshaft journal is not as specified in *Dimensions and Clearances*, use an undersize connecting rod and correct the crankshaft journal. Precisely grind the corner radius of the journal to a 0.07 to 0.09 inch radius (1.8 to 2.2 mm). Chamfer the oil hole circumference with an oil stone to a 0.04 to 0.06 inch (1.0 to 1.5 mm) radius. The journal surface must be fine finished to higher than 6 µin (0.4 µm Ra).

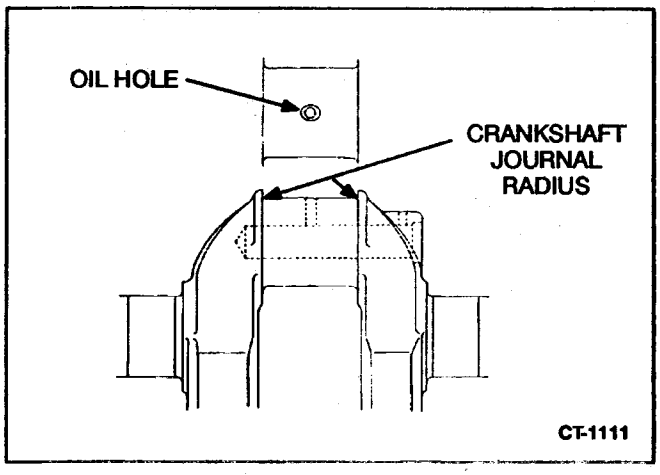


FIGURE 11-15. CRANKSHAFT JOURNAL

Camshaft Lobe Height:

Refer to Figure 11-16. Measure the height of each cam at its highest point. If measurements are not as specified in *Dimensions and Clearances*, replace the camshaft.

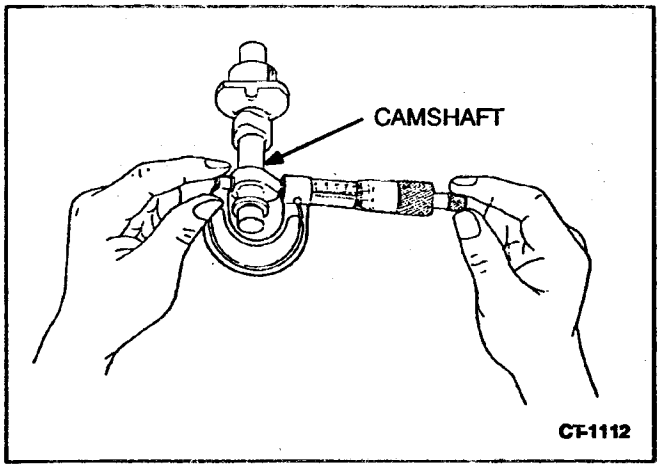


FIGURE 11-16. MEASURING CAMSHAFT LOBE HEIGHT

Oil Base Bearing to Camshaft Clearance:

Measure the camshaft journal bearing O.D. Measure the corresponding oil base bearing I.D. If the measurements are not as specified in *Dimensions and Clearances*, replace the defective parts.

Assembly

Install tappets into the block. Refer to Figure 11-17. 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 the crankshaft and camshaft timing marks up and insert both into the block at the same time.

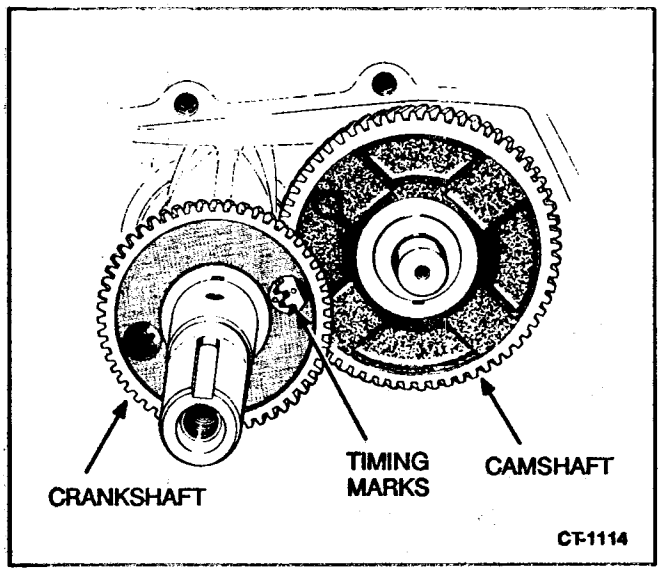


FIGURE 11-17. CRANKSHAFT AND CAMSHAFT TIMING MARKS

COMPRESSION RELEASE SYSTEM

This engine has a compression release system that decreases the amount of effort required to start the engine and reduces engine run-on when stopping (Figure 11-18).

The system works as follows:

1. As the engine is started, a spring holds in the flyweight, which in turn pushes a decompression pin upward.
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.

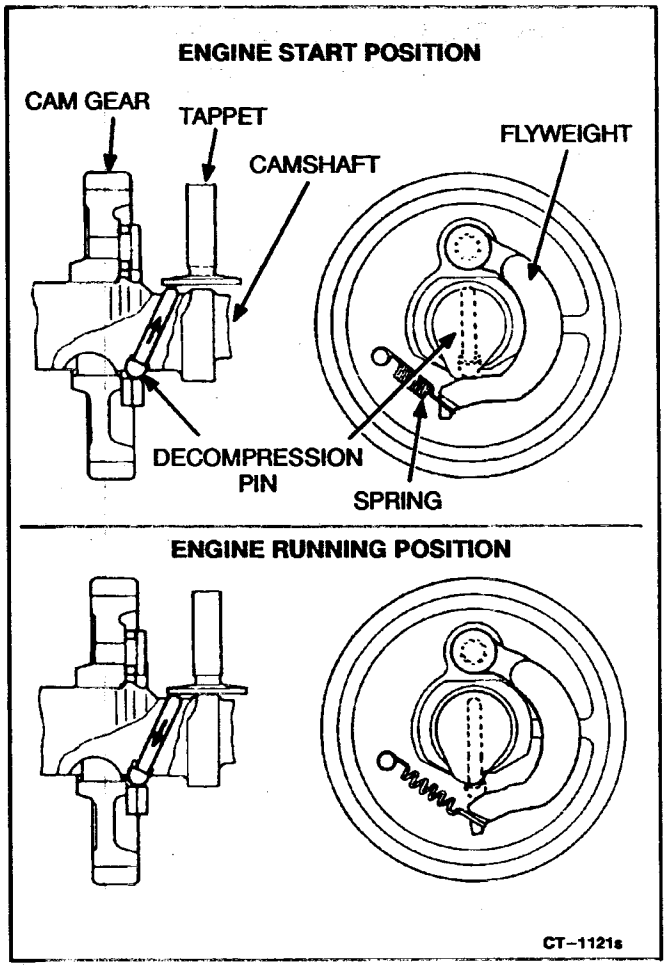


FIGURE 11-18. COMPRESSION RELEASE SYSTEM

PISTON, PISTON PIN, RINGS, CONNECTING ROD

Disassembly

⚠ CAUTION ***Improper piston removal can cause piston damage. Use a ridge reamer to remove cylinder ridge before removing piston.***

Refer to Figure 11-19. Unscrew the connecting rod screws and remove the connecting rod cap. Turn the crankshaft so the piston is at top dead center. Pull the piston and connecting rod out of the cylinder liner. Make a mark on the piston on the same side as the machined surface on the connecting rod.

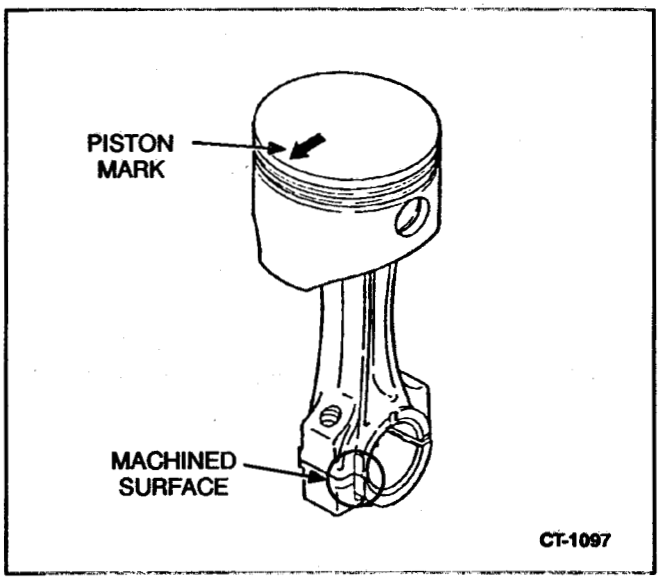


FIGURE 11-19. PISTON MARKING

Refer to Figure 11-20. Remove rings from piston by using a ring tool. Remove the piston pin snap ring and push out the piston pin.

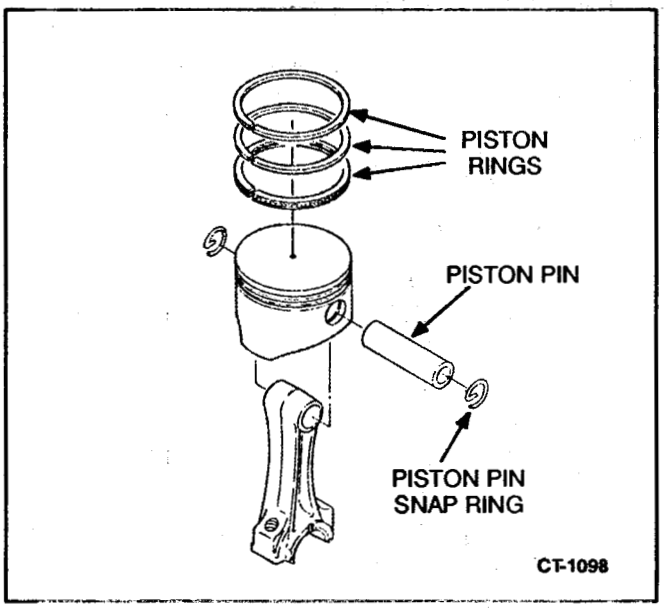


FIGURE 11-20. PISTON ASSEMBLY

Piston Inspection

⚠ CAUTION ***Improper piston cleaning can cause piston damage. Do not use a caustic cleaning solvent or wire brush for cleaning pistons.***

Follow the procedures given below when inspecting pistons and connecting rods.

Piston Inspection:

1. Inspect the piston for fractures at the ring lands, skirts and pin bosses. Check for wear at the ring lands using a new ring and feeler gauge (Figure 11-23). Replace the piston when the side clearance of the top compression ring reaches that specified in *Dimensions and Clearances.*
2. Replace a piston showing signs of scuffing, scoring, worn ring lands, fractures or damage from preignition. Excessive piston wear near the edge of the top ring land indicates preignition.

Piston Pin Hole Inside Diameter:

Refer to Figure 11-21. Measure the piston pin hole inside diameter at various places. If the measurement is not as specified in *Dimensions and Clearances*, replace the piston.

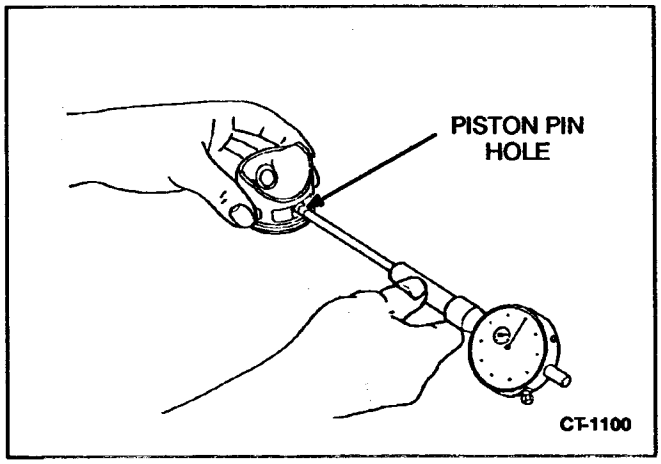


FIGURE 11-21. MEASURING PISTON PIN HOLE

Piston Pin Outside Diameter:

Refer to Figure 11-22. Measure the piston pin outside diameter. If the measurement is not as specified in *Dimensions and Clearances*, replace the piston pin.

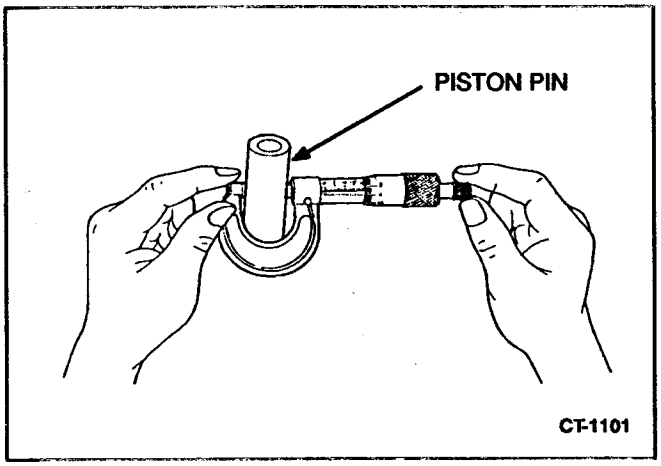


FIGURE 11-22. MEASURING PISTON PIN

Piston Ring and Ring Groove Clearance:

Refer to Figure 11-23. Remove carbon from the ring grooves. Insert a new piston ring into the ring groove and measure the clearance at several points. If the measurements are not as specified in *Dimensions and Clearances*, replace the piston.

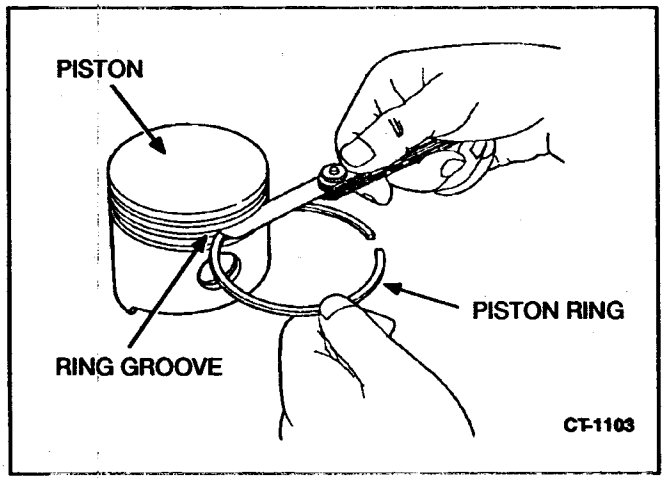


FIGURE 11-23. MEASURING RING GROOVE CLEARANCE

Connecting Rod Small End Inside Diameter:

Refer to Figure 11-24. Measure the connecting rod small end inside diameter with an inside micrometer. If dimension is not as specified in *Dimensions and Clearances*, replace the connecting rod.

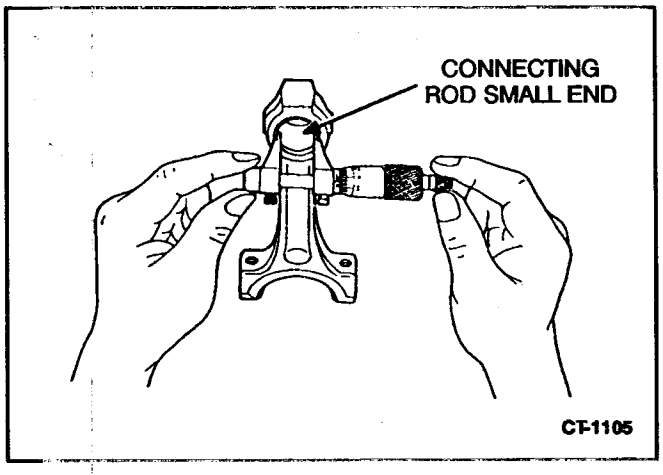


FIGURE 11-24. MEASURING CONNECTING ROD SMALL END

Connecting Rod to Crankshaft Journal Oil Clearance:

Refer to Figure 11-25. Measure the crankshaft journal outside diameter with an outside micrometer. If the dimension is not as specified in *Dimensions and Clearances*, grind the crankshaft journal and replace the connecting rod. Tighten the connecting rod screws to the torque specified in *Assembly Torques*. Measure the connecting rod large end inside diameter at the points shown. If the dimension is not as specified in *Dimensions and Clearances*, replace the connecting rod. Calculate oil clearance. If the oil clearance is not as specified in *Dimensions and Clearances*, grind the crankshaft journal and replace the connecting rod.

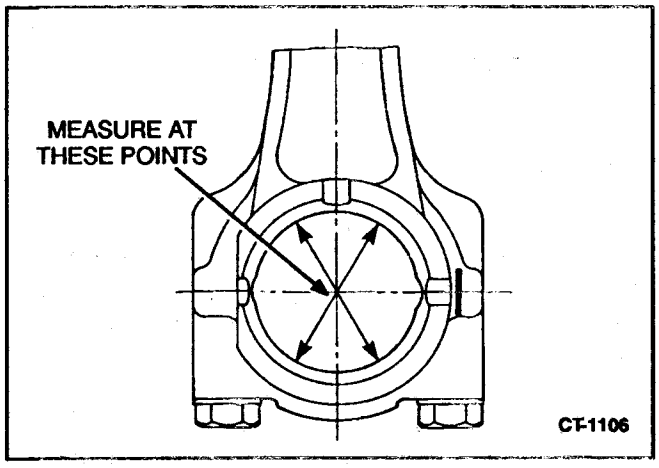


FIGURE 11-25. MEASURING CONNECTING ROD LARGE END

Connecting Rod Side Clearance:

Assemble the connecting rod to the crankshaft. Measure the side clearance of the connecting rod on the crankshaft. If dimension is not as specified in *Dimensions and Clearances*, replace the connecting rod.

Assembly

Refer to Figure 11-26. Immerse the piston in 212°F oil for 10 to 15 minutes and then insert the piston pin into the piston and connecting rod. Be sure the connecting rod machined surface is on the same side as the piston mark.

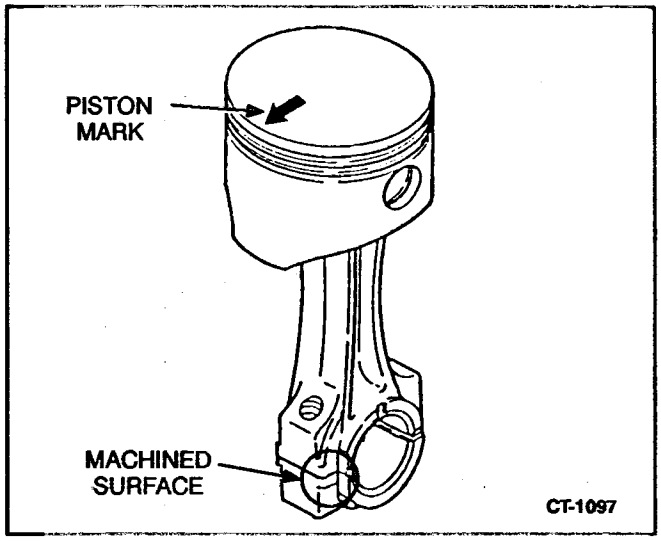


FIGURE 11-26. ASSEMBLING PISTON

Refer to Figure 11-27. Always install new rings when assembling the engine. Existing rings will not seat properly. Install the rings with the ring manufacturer's mark facing toward the top of the piston.

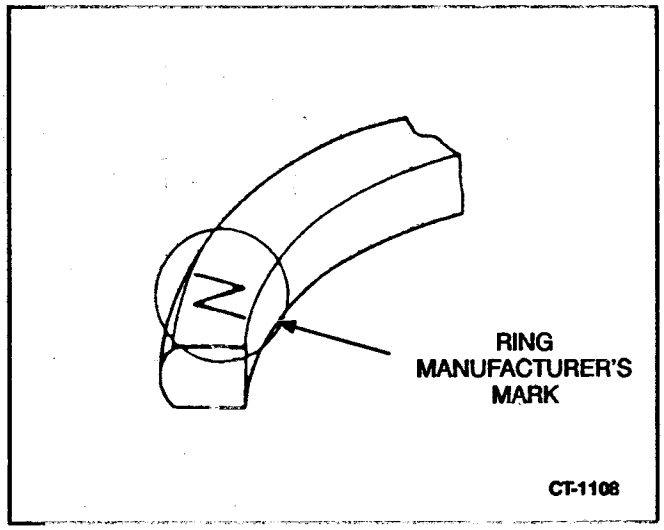


FIGURE 11-27. RING MARK

Refer to Figure 11-28. Insert piston pin snap ring. Position rings on piston as shown. Gap on top ring must face opposite of intake and exhaust valves.

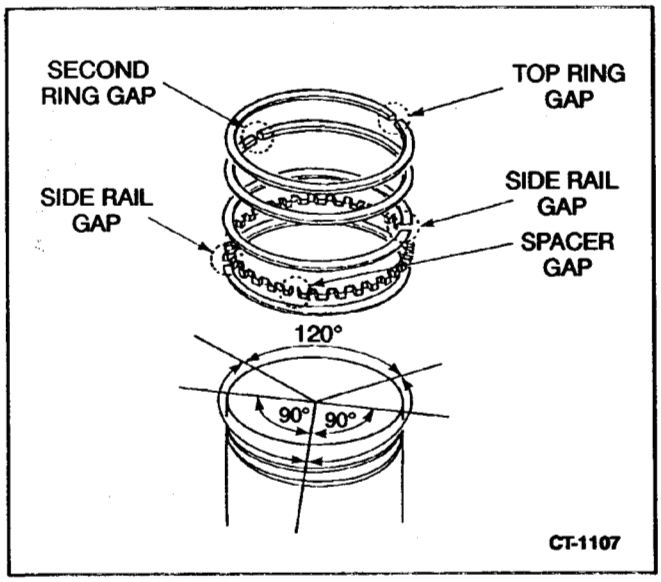


FIGURE 11-28. ASSEMBLING RINGS

Refer to Figure 11-29. Apply engine oil to the cylinder liner. Line up the piston and connecting rod so the machined surface of the connecting rod faces towards the camshaft.

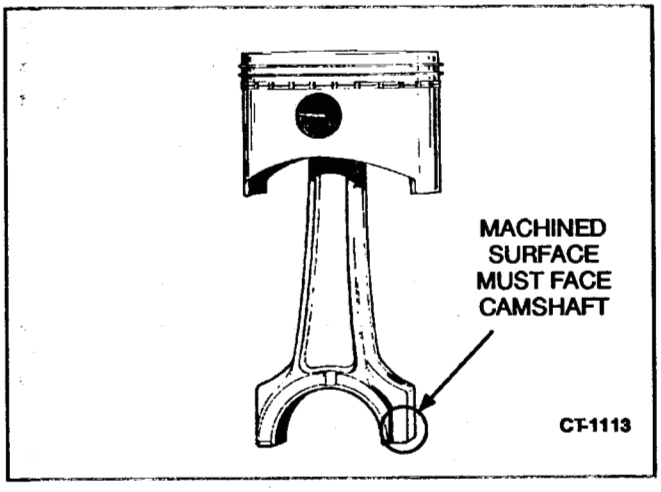


FIGURE 11-29. PISTON ORIENTATION

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

Refer to Figure 11-30. Use a ring compressor to insert the piston and connecting rod in into the cylinder liner. Apply engine oil to the inside diameter of the connecting rod cap and connecting rod screws. Align the machined surfaces of the connecting rod and connecting rod cap. Apply oil to the connecting rod bolts and tighten them to the torque specified in *Assembly Torques*.

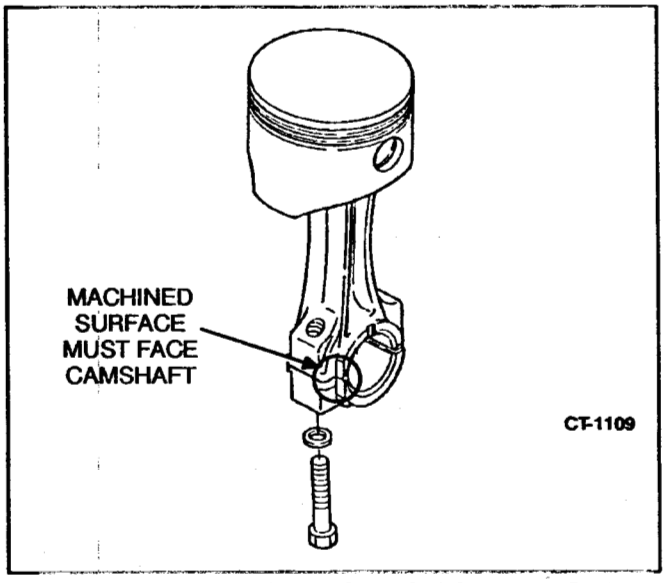


FIGURE 11-30. CONNECTING ROD AND CAP ALIGNMENT

CYLINDER BLOCK

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

Cleaning

After removing pistons, crankshaft, cylinder heads, 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 oil by-pass to allow cleaning solution to contact inside of oil passages.
2. Remove grease and scale from the cylinder block by agitating it in a bath of commercial cleaning solution or hot soapy washing solution.
3. Rinse the block in clean hot water to remove the cleaning solution.

Inspection

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

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

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

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

1. Check cylinder bore for taper, out of round, and wear with a cylinder bore gauge, telescopic gauge, or inside micrometer. These measurements should be taken at four places: top and bottom of piston ring travel, parallel and perpendicular to axis of crankshaft (Figure 11-31).
2. Record measurements taken at top and bottom of piston travel as follows:
   A. Measure and record as "A" the cylinder bore diameter (parallel to crankshaft) near the top of cylinder bore.

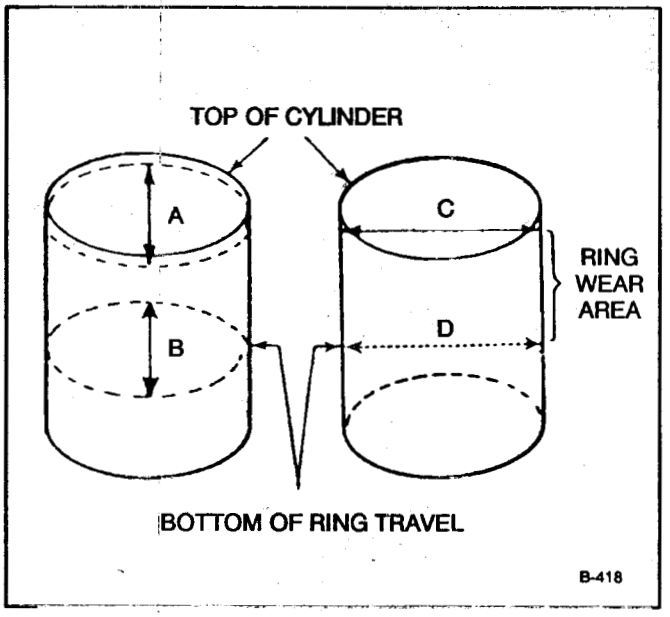


FIGURE 11-31. METHODS OF MEASURING THE DIAMETER OF A CYLINDER BORE

   B. Measure and record as "B" cylinder bore diameter (parallel to crankshaft) at the bottom of piston travel.
   C. Measure and record as "C" cylinder bore diameter (perpendicular to crankshaft) near the top of cylinder bore.
   D. Measure and record as "D" cylinder bore diameter (perpendicular to crankshaft) at the bottom of piston travel.
   E. Reading "A" subtracted from reading "B" and reading "C" subtracted from reading "D" indicates cylinder taper.

      If cylinder taper exceeds that specified in *Dimensions and Clearances* rebore and hone cylinder to the next oversize.
   F. Reading "A" compared to reading "C" and reading "B" compared to reading "D" indicate whether or not cylinder is out of round. If out of round exceeds that specified in *Dimensions and Clearances* the cylinders must be rebored and honed to the next oversize.

Reboring the Cylinder

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

⚠ CAUTION ***Improper boring will result in engine damage. Boring must be done by qualified mechanics.***

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

When reboring cylinder, take the following precautions:

1. Make sure the cutting tool is properly ground before using it.
2. Be sure the top of engine block is smooth and deposit free.
3. Clean the base of the boring bar before bar is set up. Deposits under the boring bar will cause it to tilt and the cylinder will be distorted after boring.
4. Make an initial rough cut, followed by a finish cut. Then hone the cylinder bore to the specified oversize.

Honing Cylinder (Using Precision Hones)

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

1. Position block solidly for either vertical or horizontal honing. Use either a drill press or heavy-duty drill which operates at approximately 250 to 450 rpm.
2. Follow hone manufacturer's instructions for the use of oil or lubricant on stones. Do not use lubricants with a dry hone.
3. Insert hone in bore and adjust stones to fit snugly to the narrowest section. When adjusted correctly, the hone should not shake or chatter in cylinder bore, but will drag freely up and down when hone is not running.
4. Connect the drill to the hone and start drill. Feel out the bore for high spots, which cause an increased drag on stones. Move hone up and down in bore with short overlapping strokes about 40 times per minute. Usually the bottom of cylinder must be worked out first because it is smaller. As the cylinder takes a uniform diameter, move the hone up and down all the way through cylinder bore.
5. Check the diameter of the cylinder regularly during honing. A dial bore gauge is the easiest method but a telescoping gauge can be used. Check size at six places in bore: measure twice at top, middle and bottom at 90-degree angles.
6. Crosshatch formed by the stones should form an included angle of 23 degrees. This can be achieved by moving the rotating hone (250 to 450 rpm) up and down in cylinder bore about 40 times per minute.
7. Clean cylinder bore thoroughly with soap, water and clean rags. A clean white rag should not become soiled on wall after cleaning is complete. Do not use a solvent or gasoline since they wash oil from the walls but leave the metal particles.
8. Dry crankcase and coat it with oil.

Deglazing Cylinder Bore

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

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

1. Wipe cylinder 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 to produce a crosshatch pattern in the cylinder bore.
3. Use a slow speed drill to drive the deglazing tool. Move the deglazing tool up and down in the cylinder (10 to 12 complete strokes) rapidly enough to obtain a crosshatch pattern (Figure 11-32).

   ⚠ CAUTION ***Improper cylinder cleaning will result in engine damage. Do not use gasoline, solvents, or commercial cleaners to clean cylinder bore.***

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

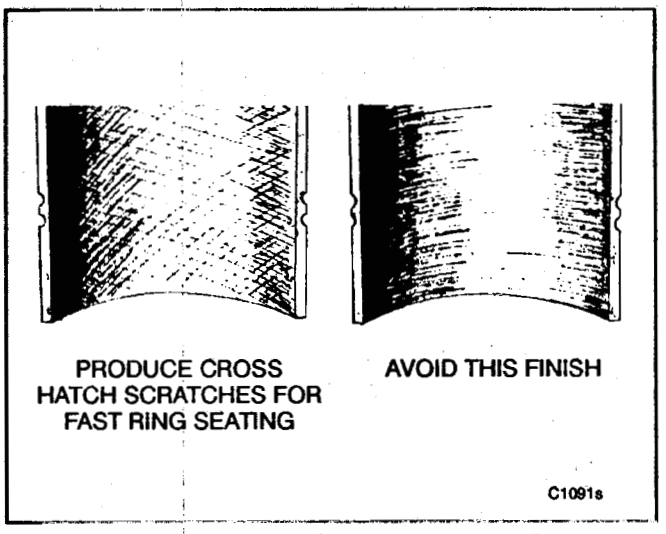


FIGURE 11-32. CROSSHATCHING

BALL BEARINGS

The oil base holds one crankshaft bearing. The engine block contains one camshaft bearing, one crankshaft bearing and two balancer shaft bearings. Use a bearing puller to remove these bearings. Clean the bearing mounting surfaces and press new bearings back in.

OIL SEAL

Use an oil seal remover to pry the oil seal out of the engine block. Clean the oil seal resting surface and lubricate the surface before installing a new oil seal. Press the new oil seal into the engine block until the oil seal is flush with the cylinder block boss. Lubricate the lips of the oil seal with a light coating of grease. This provides initial lubrication until engine oil reaches the seal.