KOHLER® engines

SERVICE MANUAL
COMMAND 18, 20, 22, 25 HP
Horizontal Crankshaft

Contents

Section 1
Safety and General Information

Safety Information

For Your Safety!

These precautions should be followed at all times. Failure to follow these precautions could result in injury to yourself and others.

⚠ WARNING

Explosive Fuel can cause fires and severe burns.

Stop engine before filling fuel tank.

⚠ WARNING

Rotating Parts can cause severe injury.

Stay away while engine is in operation.

⚠ WARNING

Hot Parts can cause severe burns.

Do not touch engine while operating or just after stopping.

Explosive Fuel!

Gasoline is extremely flammable and its vapors can explode if ignited. Store gasoline only in approved containers, in well ventilated, unoccupied buildings, away from sparks or flames. Do not fill the fuel tank while the engine is hot or running, since spilled fuel could ignite if it comes in contact with hot parts or sparks from ignition. Do not start the engine near spilled fuel. Never use gasoline as a cleaning agent.

Rotating Parts!

Keep hands, feet, hair, and clothing away from all moving parts to prevent injury. Never operate the engine with covers, shrouds, or guards removed.

Hot Parts!

Engine components can get extremely hot from operation. To prevent severe burns, do not touch these areas while the engine is running—or immediately after it is turned off. Never operate the engine with heat shields or guards removed.

Section 1
Safety and General Information

⚠ WARNING

Accidental Starts can cause severe injury or death.

Disconnect and ground spark plug lead before servicing.

Accidental Starts!
Before servicing the engine or equipment, always disconnect the spark plug leads to prevent the engine from starting accidentally. Ground the leads to prevent sparks that could cause fires. Make sure the equipment is in neutral.

⚠ WARNING

Carbon Monoxide can cause severe nausea, fainting or death.

Do not operate engine in closed or confined area.

Lethal Exhaust Gases!
Engine exhaust gases contain poisonous carbon monoxide. Carbon monoxide is odorless, colorless, and can cause death if inhaled. Avoid inhaling exhaust fumes, and never run the engine in a closed building or confined area.

⚠ WARNING

Explosive Gas can cause fires and severe acid burns.

Charge battery only in a well ventilated area. Keep sources of ignition away.

Explosive Gas!
Batteries produce explosive hydrogen gas while being charged. To prevent a fire or explosion, charge batteries only in well ventilated areas. Keep sparks, open flames, and other sources of ignition away from the battery at all times. Keep batteries out of the reach of children. Remove all jewelry when servicing batteries.

Before disconnecting the negative (-) ground cable, make sure all switches are OFF. If ON, a spark will occur at the ground cable terminal which could cause an explosion if hydrogen gas or gasoline vapors are present.

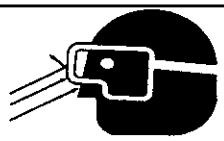
⚠ WARNING

Cleaning Solvents can cause severe injury or death.

Use only in well ventilated areas away from ignition sources.

Flammable Solvents!
Carburetor cleaners and solvents are extremely flammable. Keep sparks, flames, and other sources of ignition away from the area. Follow the cleaner manufacturer's warnings and instructions on its proper and safe use. Never use gasoline as a cleaning agent.

⚠ WARNING



Uncoiling Spring can cause severe injury.

Wear safety goggles or face protection when servicing retractable starter.

Spring Under Tension!
Retractable starters contain a powerful, recoil spring that is under tension. Always wear safety goggles when servicing retractable starters and carefully follow instructions in the "Retractable Starter" Section 7 for relieving spring tension.

⚠ CAUTION

Electrical Shock can cause injury.

Do not touch wires while engine is running.

Electrical Shock!
Never touch electrical wires or components while the engine is running. They can be sources of electrical shock.

Engine Identification Numbers

When ordering parts, or in any communication involving an engine, always give the **Model, Specification and Serial Numbers,** including letter suffixes if there are any.

The engine identification numbers appear on a decal, or decals, affixed to the engine shrouding. See Figure 1-1. An explanation of these numbers is shown in Figure 1-2.

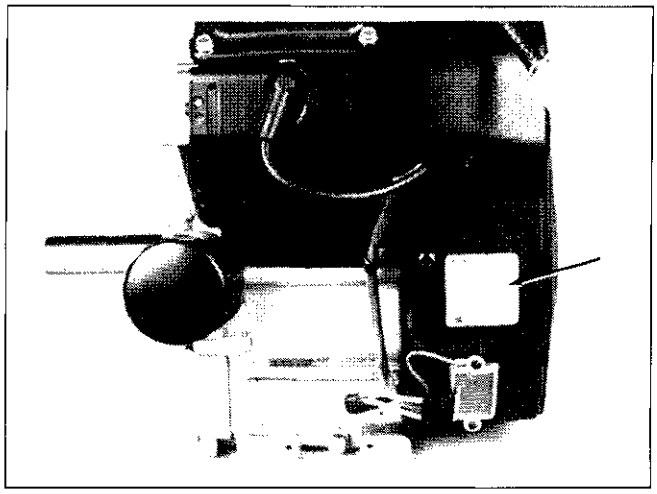


Figure 1-1. Engine Identification Plate Location.

A. Model No. — **C H 18 S**

- **C** — **Command Engine**
- **H** — **Horizontal Crankshaft**
- **18** — **Horsepower**
  - 18 = 18 HP
  - 20 = 20 HP
  - 22 = 22 HP
  - 25 = 25 HP
- **S** — **Version Code**
  - S = Electric Start

B. Spec. No. — **62500**

- **625** — **Engine Model Code**

Code	Model
62	CH18
64	CH20
66	CH22
68	CH25

- **00** — **Variation of Basic Engine**

C. Serial No. — **2105810334**

- **21** — **Year Manufactured**

Year	Manufactured
21	1991
22	1992
23	1993
24	1994
25	1995
26	1996
27	1997

- **05810334** — **Factory Code**

Figure 1-2. Explanation of Engine Identification Numbers.

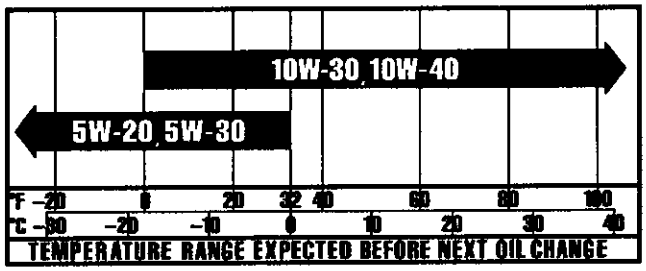
Oil Recommendations

Using the proper type and weight of oil in the crankcase is extremely important. So is checking oil daily and changing oil regularly. Failure to use the correct oil, or using dirty oil, causes premature engine wear and failure.

Oil Type

Use high-quality detergent oil of **API (American Petroleum Institute) Service Class SF, SG or SH**. Select the viscosity based on the air temperature at the time of operation as shown in the following table.

Recommended SAE Viscosity Grades



NOTE: Using other than service class SF, SG or SH oil or extending oil change intervals longer than recommended can cause engine damage.

A logo or symbol on oil containers identifies the API service class and SAE viscosity grade. See Figure 1-3.

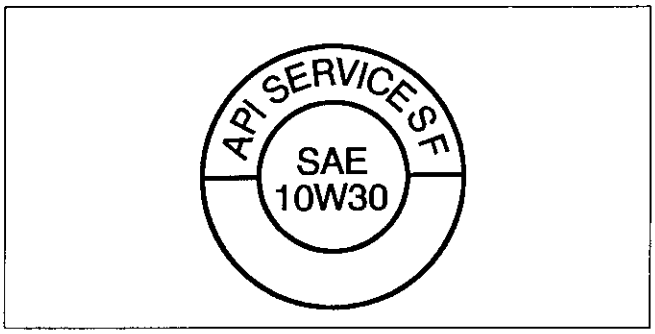


Figure 1-3. Oil Container Logo.

Refer to Section 6 — "Lubrication System" for detailed procedures on checking the oil, changing the oil and changing the oil filter.

Fuel Recommendations

⚠ WARNING: Explosive Fuel!

Gasoline is extremely flammable and its vapors can explode if ignited. Store gasoline only in approved containers, in well ventilated, unoccupied buildings, away from sparks or flames. Do not fill the fuel tank while the engine is hot or running, since spilled fuel could ignite if it comes in contact with hot parts or sparks from ignition. Do not start the engine near spilled fuel. Never use gasoline as a cleaning agent.

General Recommendations

Purchase gasoline in small quantities and store in clean, approved containers. A container with a capacity of 2 gallons or less with a pouring spout is recommended. Such a container is easier to handle and helps eliminate spillage during refueling.

Do not use gasoline left over from the previous season, to minimize gum deposits in your fuel system and to ensure easy starting.

Do not add oil to the gasoline.

Do not overfill the fuel tank. Leave room for the fuel to expand.

Fuel Type

For best results, use only clean, fresh, unleaded gasoline with a pump sticker octane rating of 87 or higher. In countries using the Research method, it should be 90 octane minimum.

Unleaded gasoline is recommended, as it leaves fewer combustion chamber deposits. Leaded gasoline may be used in areas where unleaded is not available and exhaust emissions are not regulated. Be aware, however, that the cylinder head will require more frequent service.

Gasoline/Alcohol blends

Gasohol (up to 10% ethyl alcohol, 90% unleaded gasoline by volume) is approved as a fuel for Kohler engines. Other gasoline/alcohol blends are not approved.

Gasoline/Ether blends

Methyl Tertiary Butyl Ether (MTBE) and unleaded gasoline blends (up to a maximum of 15% MTBE by volume) are approved as a fuel for Kohler engines. Other gasoline/ether blends are not approved.

Periodic Maintenance

WARNING: Accidental Starts!

Before servicing the engine or equipment, always disconnect the spark plug leads to prevent the engine from starting accidentally. Ground the leads to prevent sparks that could cause fires. Make sure the equipment is in neutral.

Maintenance Schedule

These required maintenance procedures should be performed at the frequency stated in the table. They should also be included as part of any seasonal tune-up.

Frequency	Maintenance Required	Refer to:
Daily or Before Starting Engine	Fill fuel tank. Check oil level. Check air cleaner for dirty[1], loose, or damaged parts. Check air intake and cooling areas, clean as necessary[1].	Section 5 Section 6 Section 4 Section 4
Every 25 Hours	Service precleaner element[1].	Section 4
Every 100 Hours	Service air cleaner element[1]. Change oil. Remove cooling shrouds and clean cooling areas[1].	Section 4 Section 6 Section 4
Every 200 Hours	Change oil filter. Check spark plug condition and gap.	Section 6 Section 8

[1] *Perform these maintenance procedures more frequently under extremely dusty, dirty conditions.*

Storage

If the engine will be out of service for two months or more, use the following storage procedure:

1. Clean the exterior surfaces of the engine.
2. Change the oil and oil filter while the engine is still warm from operation. See "Change Oil and Oil Filter" in Section 6.
3. The fuel system must be completely emptied, or the gasoline must be treated with a stabilizer to prevent deterioration. If you choose to use a stabilizer, follow the manufacturer's recommendations, and add the correct amount for the capacity of the fuel system. Fill the fuel tank with clean, fresh gasoline. Run the engine for 2 to 3 minutes to get stabilized fuel into the carburetor.

   To empty the system, drain the fuel tank and carburetor, or run the engine until the tank and system are empty.
4. Remove the spark plugs and add one tablespoon of engine oil into each spark plug hole. Install plugs and **ground** spark plug leads–do not connect the leads to the plug. Crank the engine two or three revolutions.
5. Store the engine in a clean, dry place.

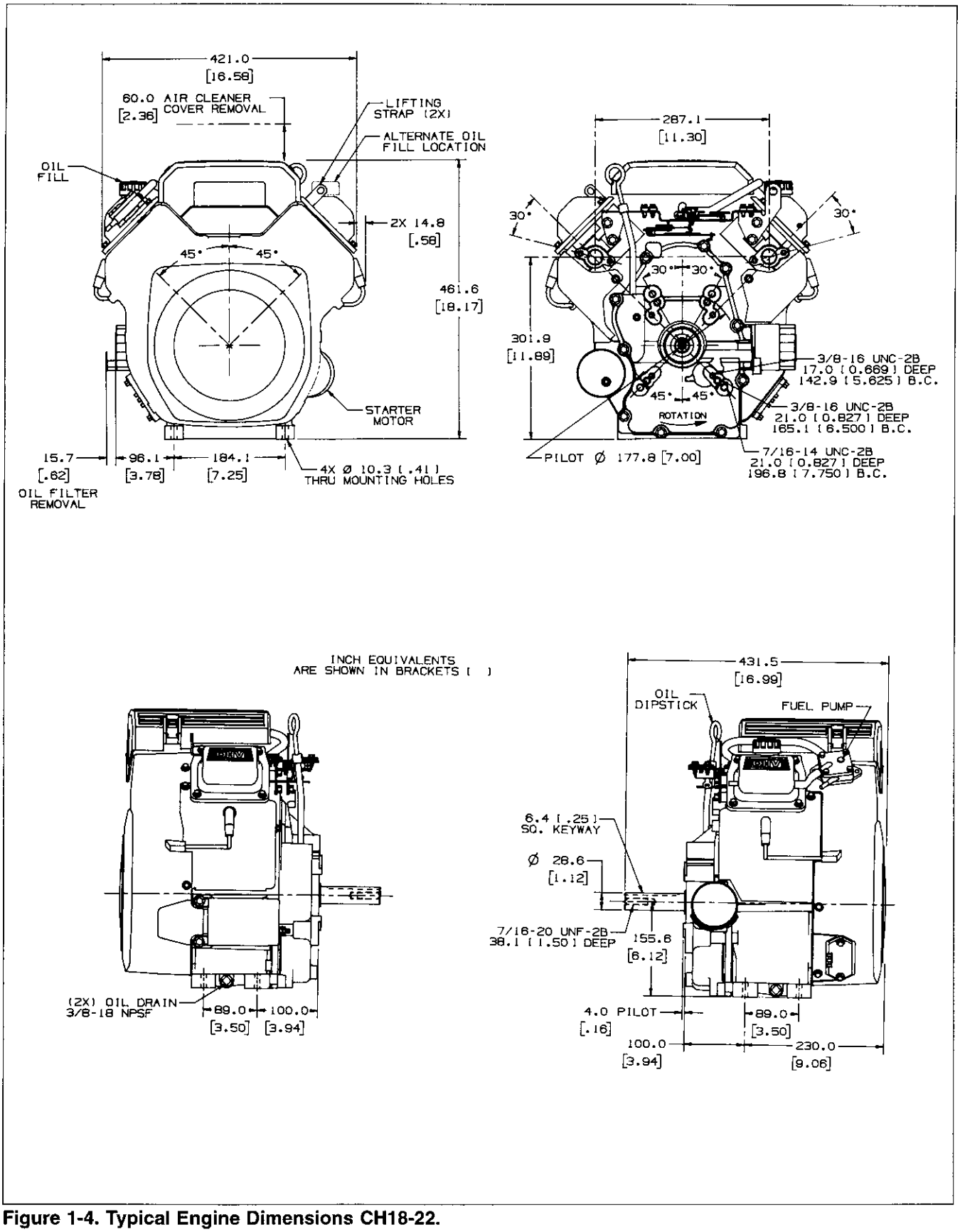


Figure 1-4. Typical Engine Dimensions CH18-22.

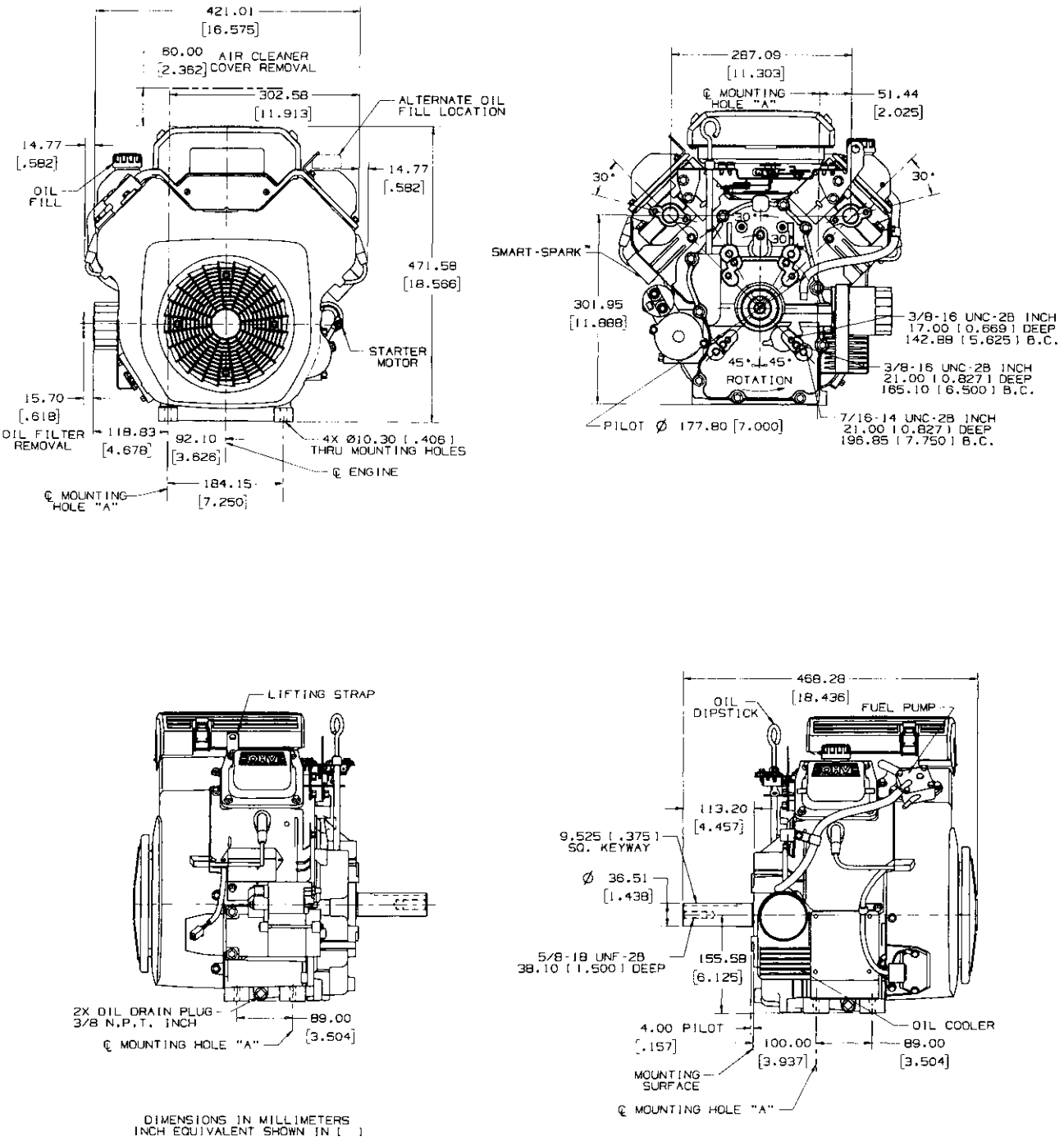


Figure 1-5. Typical Engine Dimensions CH25.

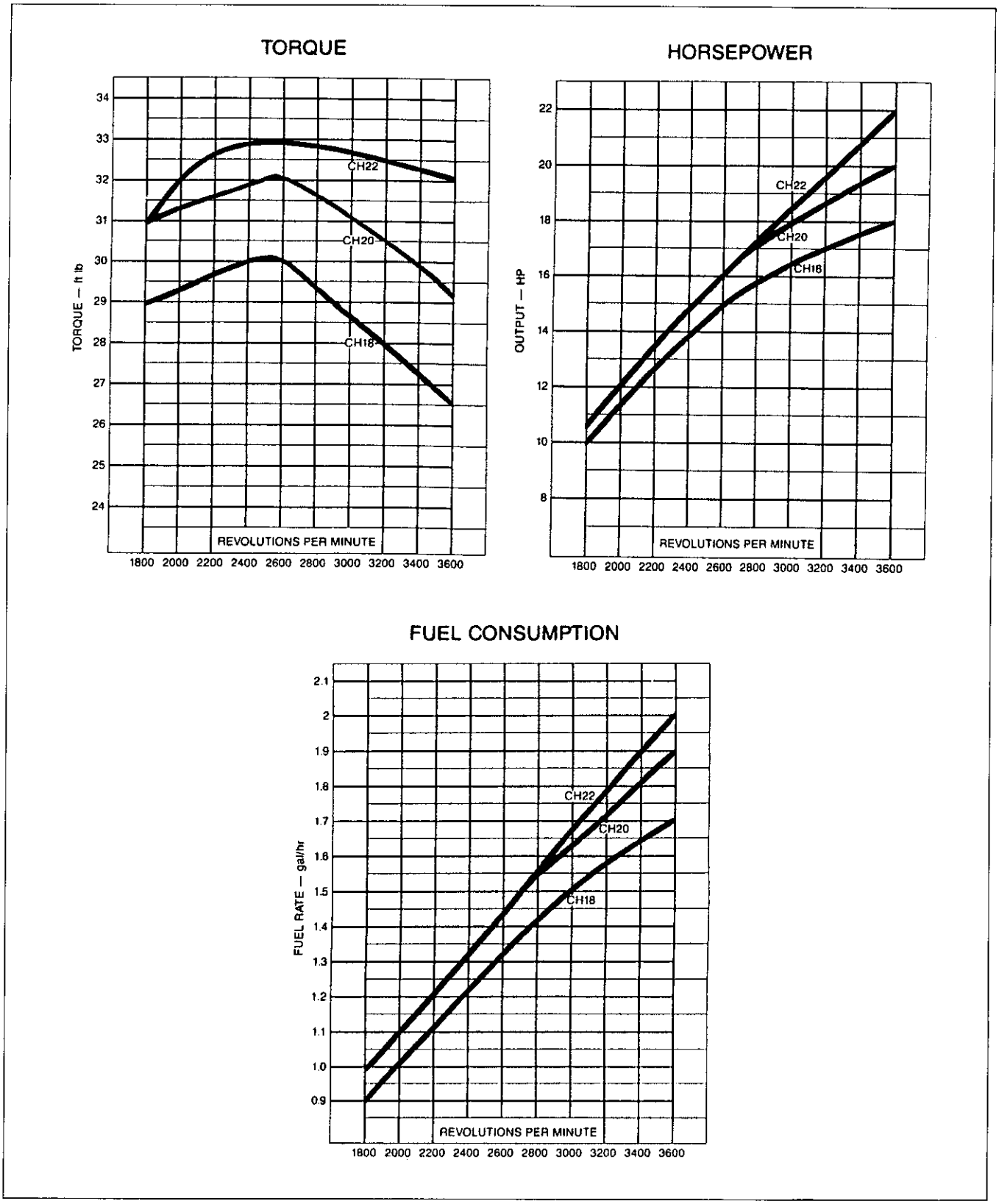
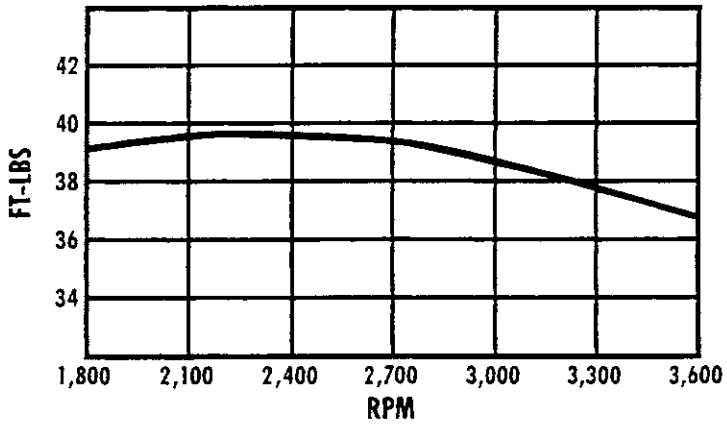
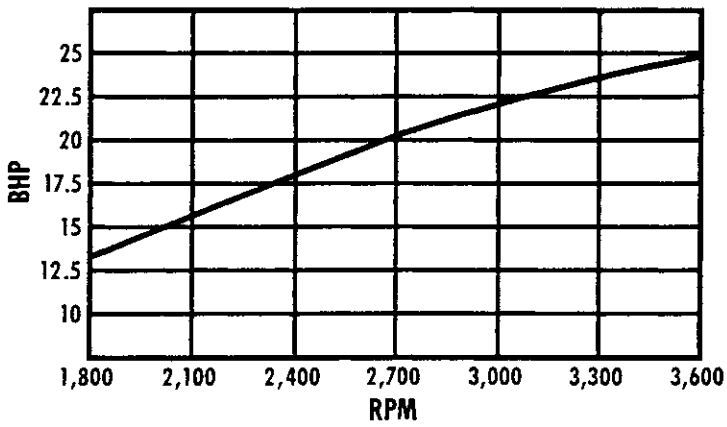


Figure 1-6. Torque, Horsepower and Fuel Curves CH18-22.

CH25 TORQUE CURVE



CH25 POWER CURVE



CH25 FUEL RATE (at WOT)

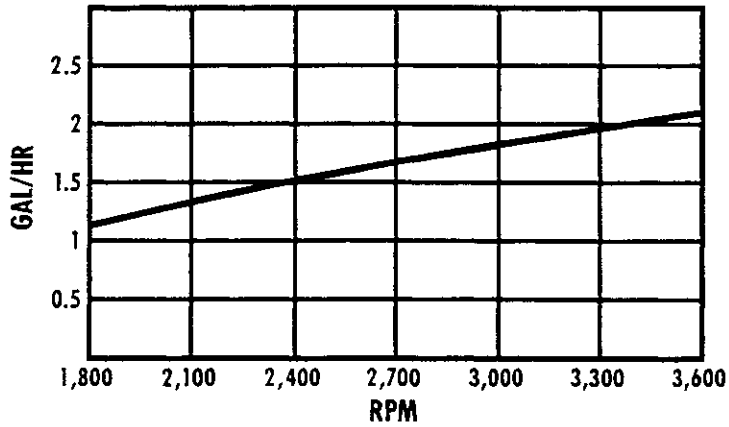


Figure 1-7. Torque, Horsepower and Fuel Curves CH25.

Specifications, Tolerances, and Special Torque Values[1]

Description	CH18-25
General Specifications[1]	
Power (@ 3600 RPM, corrected to SAE J1349)	
CH18	13.4 kW (18 HP)
CH20	14.9 kW (20 HP)
CH22	16.4 kW (22 HP)
CH25	18.6 kW (25 HP)
Peak Torque (See Torque Curves)	
CH18 – @ 2500 RPM	41 N·m (30 ft. lb.)
CH20 – @ 2500 RPM	44 N·m (32 ft. lb.)
CH22 – @ 2500 RPM	45 N·m (33 ft. lb.)
CH25 – @ 2500 RPM	53 N·m (39.5 ft. lb.)
Bore	
CH18, CH20, CH22	77 mm (3.03 in.)
CH25	83 mm (3.27 in.)
Stroke	67 mm (2.64 in.)
Displacement	
CH18, CH20, CH22	624 cc (38 cu. in.)
CH25	725 cc (44 cu. in.)
Compression Ratio	
CH18, CH20, CH22	8.5:1
CH25	9.0:1
Dry Weight	
CH18, CH20, CH22	41 kg (90 lb.)
CH25	43 kg (94 lb.)
Oil Capacity (with filter)	
CH18, CH20, CH22	2.0 U.S. qt. (1.9 L)
CH25	2.1 U.S. qt. (2.0 L)
Angle of Operation - Maximum (At Full Oil Level) All Directions	25°
Blower Housing and Sheet Metal	
M5 Fasteners Torque	4.7 N·m (35 in. lb.)
M6 Fasteners Torque	8.6 N·m (65 in. lb.)
Rectifier Fastener Torque	4.7 N·m (35 in. lb.)

[1] Values are in Metric units. Values in parentheses are English equivalents. Lubricate threads with engine oil prior to assembly.

Camshaft

End Play (With Shim) ..... 0.076/0.127 mm (0.0030/0.0050 in.)

Running Clearance ..... 0.025/0.063 mm (0.0010/0.0025 in.)

Bore I.D.
- New ..... 20.000/20.025 mm (0.7874/0.7884 in.)
- Max. Wear Limit ..... 20.038 mm (0.7889 in.)

Camshaft Bearing Surface O.D.
- New ..... 19.962/19.975 mm (0.7859/0.7864 in.)
- Max. Wear Limit ..... 19.959 mm (0.7858 in.)

Carburetor and Intake Manifold

Intake Manifold Mounting Fasteners Torque ..... 9.9 N·m (88 in. lb.)

Carburetor Mounting Fasteners Torque ..... 9.9 N·m (88 in. lb.)

Connecting Rod

Cap Fastener Torque ..... 17.3 N·m (130 in. lb.)

Connecting Rod-to-Crankpin Running Clearance
- New ..... 0.030/0.055 mm (0.0012/0.0022 in.)
- Max. Wear Limit ..... 0.07 mm (0.0028 in.)

Connecting Rod-to-Crankpin Side Clearance ..... 0.26/0.63 mm (0.0102/0.0248 in.)

Connecting Rod-to-Piston Pin Running Clearance ..... 0.015/0.028 mm (0.0006/0.0011 in.)

Piston Pin End I.D.
- New ..... 17.015/17.023 mm (0.6699/0.6702 in.)
- Max. Wear Limit ..... 17.036 mm (0.6707 in.)

Crankcase

Governor Cross Shaft Bore I.D.
- New ..... 6.025/6.050 mm (0.2372/0.2382 in.)
- Max. Wear Limit ..... 6.063 mm (0.2387 in.)

Breather Cover Mounting Fasteners ..... 8.6 N·m (65 in. lb.)

Oil Drain Plugs ..... 13.6 N·m (10 ft. lb.)

Crankshaft

End Play (Free) ..... 0.070/0.480 mm (0.0028/0.0189 in.)

End Play (With Thrust Bearing Components) ..... 0.050/0.5 mm (0.0020/0.0197 in.)
- Except CH25 Engines Below Serial No. 2403500008 ..... 0.050/0.75 mm (0.0020/0.0295 in.)

Crankshaft Sleeve Bearing I.D. (Crankcase)
- New ..... 40.965/41.003 mm (1.6128/1.6143 in.)
- Max. Wear Limit ..... 41.016 mm (1.6148 in.)

Crankshaft (Cont'd)

Crankshaft to Sleeve Bearing (Crankcase)
- Running Clearance - New ..... 0.03/0.09 mm (0.0012/0.0035 in.)

Crankshaft Bore (In Closure Plate) - New ..... 40.987/40.974 mm (1.6128/1.6143 in.)

Crankshaft Bore (In Closure Plate)-to-Crankshaft
- Running Clearance - New ..... 0.039/0.074 mm (0.0015/0.0029 in.)

Flywheel End Main Bearing Journal
- O.D. - New ..... 40.913/40.935 mm (1.6107/1.6116 in.)
- O.D. - Max. Wear Limit ..... 40.84 mm (1.608 in.)
- Max. Taper ..... 0.022 mm (0.0009 in.)
- Max. Out-of-Round ..... 0.025 mm (0.0010 in.)

Closure Plate End Main Bearing Journal
- O.D. - New ..... 40.913/40.935 mm (1.6107/1.6116 in.)
- O.D. - Max. Wear Limit ..... 40.84 mm (1.608 in.)
- Max. Taper ..... 0.022 mm (0.0009 in.)
- Max. Out-of-Round ..... 0.025 mm (0.0010 in.)

Connecting Rod Journal
- O.D. - New ..... 35.955/35.973 mm (1.4156/1.4163 in.)
- O.D. - Max. Wear Limit ..... 35.94 mm (1.415 in.)
- Max. Taper ..... 0.018 mm (0.0007 in.)
- Max. Out-of-Round ..... 0.025 mm (0.0010 in.)

Crankshaft T.I.R.
- PTO End, Crank in Engine ..... 0.15 mm (0.0059 in.)
- Entire Crank, in V-Blocks ..... 0.10 mm (0.0039 in.)

Cylinder Bore

Cylinder Bore I.D.
- New - CH18, CH20, CH22 ..... 77.000/77.025 mm (3.0315/3.0325 in.)
- New - CH25 ..... 82.988/83.013 mm (3.3195/3.3205 in.)
- Max. Wear Limit - CH18, CH20, CH22 ..... 77.063 mm (3.0340 in.)
- Max. Wear Limit - CH25 ..... 83.051 mm (3.3220 in.)
- Max. Out-of-Round ..... 0.12 mm (0.0047 in.)
- Max. Taper ..... 0.05 mm (0.0020 in.)

Cylinder Head

Cylinder Head Fastener Torque ..... 40.7 N·m (30 ft. lb.)

Max. Out-of-Flatness ..... 0.076 mm (0.003 in.)

Rocker Pivot Fastener Torque ..... 14 N·m (124 in. lb.)

Electric Starter

Starter Mounting Fastener Torque ..... 15.3 N·m (135 in. lb.)

Fan/Flywheel

Fan Fastener Torque ..... 9.9 N·m (88 in. lb.)

Flywheel Retaining Screw Torque ..... 66.4 N·m (49 ft. lb.)

Governor

Governor Cross Shaft to Crankcase
- Running Clearance ..... 0.013/0.075 mm (0.0005/0.0030 in.)

Governor Cross Shaft O.D.
- New ..... 5.975/6.012 mm (0.2352/0.2367 in.)
- Max. Wear Limit ..... 5.962 mm (0.2347 in.)

Governor Gear Shaft-to-Governor
- Gear Running Clearance ..... 0.015/0.140 mm (0.0006/0.0055 in.)

Governor Gear Shaft O.D.
- New ..... 5.990/6.000 mm (0.2358/0.2362 in.)
- Max. Wear Limit ..... 5.977 mm (0.2353 in.)

Ignition

Spark Plug Type (Champion or Equivalent) RC12YC

Spark Plug Gap ..... 1.02 mm (0.040 in.)

Spark Plug Torque ..... 24.4/29.8 N·m (18/22 ft. lb.)

Ignition Module Air Gap ..... 0.2/0.3 mm (0.008/0.012 in.)

Ignition Module Fastener Torque ..... 4.0/6.2 N·m (35/55 in. lb.)

Muffler

Muffler Retaining Nuts Torque ..... 24.4 N·m (216 in. lb.)

Oil Filter/Closure Plate/Oil Cooler

Oil Filter Torque ..... 5.7/9.0 N·m (50/80 in. lb.)

Oil Cooler Torque (Std. CH25 - Option on Others) ..... 40.6 N·m (30 ft. lb.)

Closure Plate Fastener Torque ..... 24.4 N·m (216 in. lb.)

Piston, Piston Rings, and Piston Pin

Piston-to-Piston Pin (Selective Pin) ..... 0.006/0.017 mm (0.0002/0.0007 in.)

Piston Pin Bore I.D.
- New ..... 17.006/17.012 mm (0.6695/0.6698 in.)
- Max. Wear Limit ..... 17.025 mm (0.6703 in.)

Piston Pin O.D.
- New ..... 16.995/17.000 mm (0.6691/0.6693 in.)
- Max. Wear Limit ..... 16.994 mm (0.6691 in.)

Piston, Piston Rings, and Piston Pin (Cont'd)

Top Compression Ring-to-Groove
- Side Clearance - CH18, CH20, CH22 ..... 0.040/0.080 mm (0.0016/0.0031 in.)
- Side Clearance - CH25 ..... 0.025/0.048 mm (0.0010/0.0019 in.)

Middle Compression Ring-to-Groove
- Side Clearance - CH18, CH20, CH22 ..... 0.040/0.072 mm (0.0016/0.0028 in.)
- Side Clearance - CH25 ..... 0.015/0.037 mm (0.0006/0.0015 in.)

Oil Control Ring-to-Groove
- Side Clearance - CH18, CH20, CH22 ..... 0.060/0.202 mm (0.0024/0.0080 in.)
- Side Clearance - CH25 ..... 0.026/0.176 mm (0.0010/0.0070 in.)

Top and Center Compression Ring End Gap
- New Bore - CH18, CH20, CH22 ..... 0.25/0.45 mm (0.0098/0.0177 in.)
- New Bore - CH25 ..... 0.25/0.56 mm (0.0100/0.0224 in.)
- Used Bore (Max.) - CH18, CH20, CH22 ..... 0.77 mm (0.030 in.)
- Used Bore (Max.) - CH25 ..... 0.94 mm (0.037 in.)

Piston Thrust Face O.D.[2]
- New - CH18, CH20, CH22 ..... 76.967/76.985 mm (3.0302/3.0309 in.)
- New - CH25 ..... 82.986 mm (3.3194 in.)
- Max. Wear Limit - CH18, CH20, CH22 ..... 76.840 mm (3.0252 in.)
- Max. Wear Limit - CH25 ..... 82.841 mm (3.3136 in.)

Piston Thrust Face-to-Cylinder Bore[2] Running Clearance
- New - CH18, CH20, CH25 ..... 0.015/0.058 mm (0.0006/0.0023 in.)
- New - CH25 ..... 0.002/0.045 mm (0.001/0.0018 in.)

Speed Control

Speed Control Bracket Assembly
- Fastener Torque ..... 7.3/10.7 N·m (65/95 in. lb.)

Stator

Mounting Screw Torque ..... 4.0 N·m (35 in. lb.)

Throttle/Choke Controls

Governor Control Lever Fastener Torque ..... 9.9 N·m (88 in. lb.)

Valve Cover/Rocker Arms

Valve Cover Fastener Torque ..... 3.4 N·m (30 in. lb.)

Valves and Valve Lifters

Hydraulic Valve Lifter to Crankcase Running Clearance ..... 0.0124/0.0501 mm (0.0005/0.0020 in.)

Intake Valve Stem-to-Valve Guide Running Clearance ..... 0.038/0.076 mm (0.0015/0.0030 in.)

Exhaust Valve Stem-to-Valve Guide Running Clearance ..... 0.050/0.088 mm (0.0020/0.0035 in.)

[2] Measure 6 mm (0.236 in.) above the bottom of the piston skirt at right angles to the piston pin.

Valve and Valve Lifters (Cont'd)

Intake Valve Guide I.D.
- New ..... 7.038/7.058 mm (0.2771/0.2779 in.)
- Max. Wear Limit ..... 7.134 mm (0.2809 in.)

Exhaust Valve Guide I.D.
- New ..... 7.038/7.058 mm (0.2771/0.2779 in.)
- Max. Wear Limit ..... 7.159 mm (0.2819 in.)

Valve Guide Reamer Size
- Standard ..... 7.048 mm (0.2775 in.)
- 0.25 mm O.S. ..... 7.298 mm (0.2873 in.)

Intake Valve Minimum Lift ..... 8.07 mm (0.3177 in.)

Exhaust Valve Minimum Lift ..... 8.07 mm (0.3177 in.)

Nominal Valve Seat Angle ..... 45°

General Torque Values

Metric Fastener Torque Recommendations for Standard Applications

Tightening Torque: N•m (in. lb.) + or - 10%

	Property Class					
	4.8	5.8	8.8	10.9	12.9	Noncritical Fasteners Into Aluminum
Size						
M4	1.2 (11)	1.7 (15)	2.9 (26)	4.1 (36)	5.0 (44)	2.0 (18)
M5	2.5 (22)	3.2 (28)	5.8 (51)	8.1 (72)	9.7 (86)	4.0 (35)
M6	4.3 (38)	5.7 (50)	9.9 (88)	14.0 (124)	16.5 (146)	6.8 (60)
M8	10.5 (93)	13.6 (120)	24.4 (216)	33.9 (300)	40.7 (360)	17.0 (150)

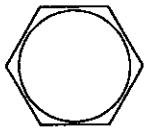
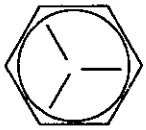
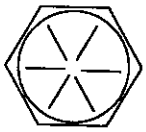
Tightening Torque: N•m (ft. lb.) + or - 10%

	Property Class					
	4.8	5.8	8.8	10.9	12.9	Noncritical Fasteners Into Aluminum
M10	21.7 (16)	27.1 (20)	47.5 (35)	66.4 (49)	81.4 (60)	33.9 (25)
M12	36.6 (27)	47.5 (35)	82.7 (61)	116.6 (86)	139.7 (103)	61.0 (45)
M14	58.3 (43)	76.4 (55)	131.5 (97)	184.4 (136)	219.7 (162)	94.9 (70)

Torque Conversions

N•m = in. lb. x 0.113
N•m = ft. lb. x 1.356
in. lb. = N•m x 8.85
ft. lb. = N•m x 0.737

English Fastener Torque Recommendations for Standard Applications

Tightening Torque: N•m (in. lb.) + or - 20%				
Bolts, Screws, Nuts and Fasteners Assembled Into Cast Iron or Steel				Grade 2 or 5 Fasteners Into Aluminum
	 Grade 2	 Grade 5	 Grade 8	
Size				
8-32	2.3 (20)	2.8 (25)	---------	2.3 (20)
10-24	3.6 (32)	4.5 (40)	---------	3.6 (32)
10-32	3.6 (32)	4.5 (40)	---------	---------
1/4-20	7.9 (70)	13.0 (115)	18.7 (165)	7.9 (70)
1/4-28	9.6 (85)	15.8 (140)	22.6 (200)	---------
5/16-18	17.0 (150)	28.3 (250)	39.6 (350)	17.0 (150)
5/16-24	18.7 (165)	30.5 (270)	---------	---------
3/8-16	29.4 (260)	---------	---------	---------
3/8-24	33.9 (300)	---------	---------	---------
Tightening Torque: N•m (ft. lb.) + or - 20%				
Size				
5/16-24	---------	----------	40.7 (30)	---------
3/8-16	---------	47.5 (35)	67.8 (50)	---------
3/8-24	---------	54.2 (40)	81.4 (60)	---------
7/16-14	47.5 (35)	74.6 (55)	108.5 (80)	---------
7/16-20	61.0 (45)	101.7 (75)	142.4 (105)	---------
1/2-13	67.8 (50)	108.5 (80)	155.9 (115)	---------
1/2-20	94.9 (70)	142.4 (105)	223.7 (165)	---------
9/16-12	101.7 (75)	169.5 (125)	237.3 (175)	---------
9/16-18	135.6 (100)	223.7 (165)	311.9 (230)	---------
5/8-11	149.2 (110)	244.1 (180)	352.6 (260)	---------
5/8-18	189.8 (140)	311.9 (230)	447.5 (330)	---------
3/4-10	199.3 (150)	332.2 (245)	474.6 (350)	---------
3/4-16	271.2 (200)	440.7 (325)	637.3 (470)	---------

Section 2
Special Tools

These quality tools are designed to help you perform specific disassembly, repair, and reassembly procedures. By using tools designed for the job, you can service engines easier, faster, and safer! In addition, you'll increase your service capabilities and customer satisfaction by decreasing engine down time.

Camshaft Endplay Plate	KO-1031
Flywheel Strap Wrench	NU-10357
Flywheel Puller Kit	NU-3226
Rocker Arm Spanner Wrench	(Obtain locally)
Valve Guide Reamer	KO-1026
Water Manometer	25 800 50
Cylinder Leakdown Tester	47 800 02
Ignition System Tester	24 800 01

Contact your Kohler Distributor for price and availability.

Section 2
Special Tools

Engine Analysis Kit No. KO-1000

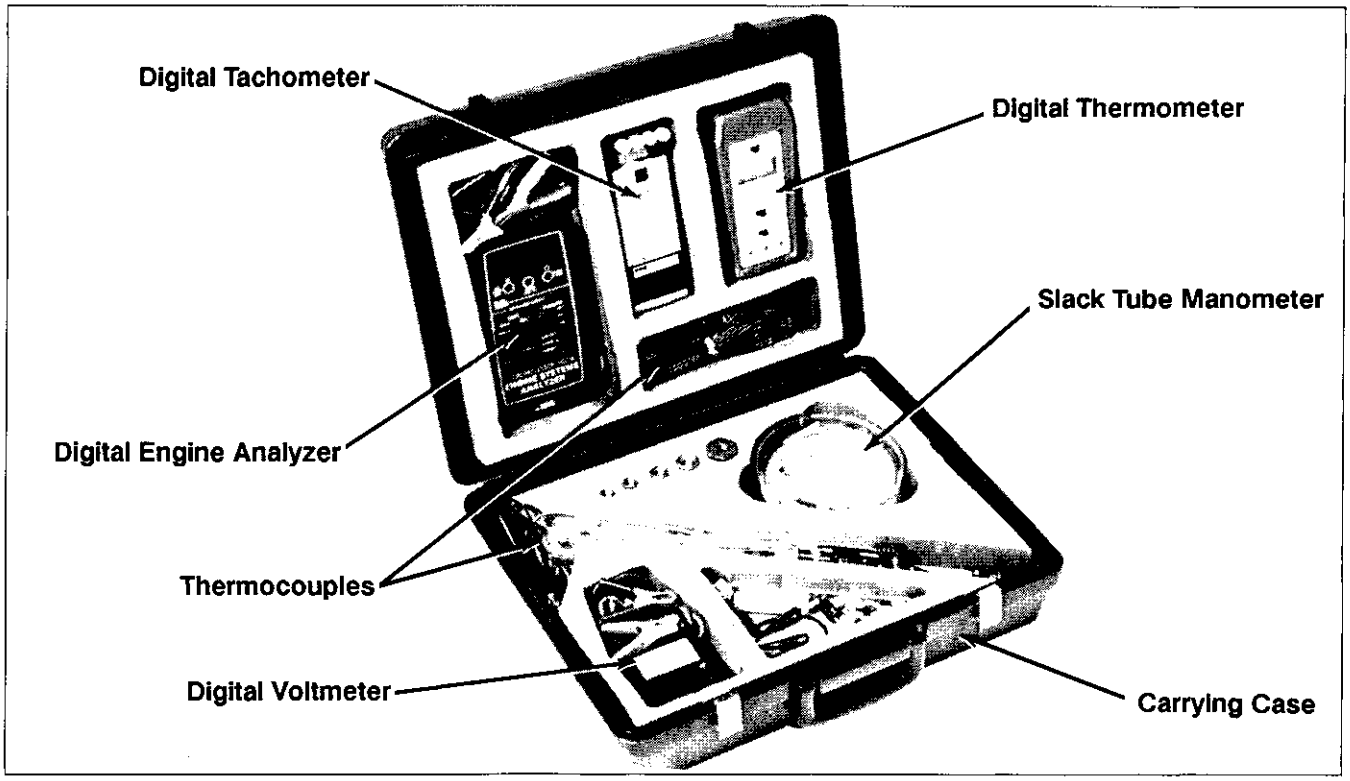


Figure 2-1. Engine Analysis Kit - KO-1000.

The Kohler Engine Analysis Kit contains a selection of instruments that will enable you to measure critical items that relate to engine performance. You will find many uses for these instruments — from basic crankcase vacuum checks to sophisticated application tests.

The Engine Analysis Kit Includes:

Qty.	Description	Part No.
1	Digital Voltmeter	KO-1001
1	Digital Tachometer	KO-1002
1	Digital Thermometer	KO-1004
1	Digital Engine Analyzer	KO-1003
1	Slack Tube Manometer	KO-1005
1	8 ft. Lead with Plug	KO-1006
3	14 mm Spark Plug Thermocouple	KO-1007
2	Head Bolt Thermocouple	KO-1008
1	Oil Sump Thermocouple	KO-1009
1	1/4" x 1/8" Bushing	KO-1010-B
1	3/8" x 1/8" Bushing	KO-1010-A
1	1/2" x 1/8" Bushing	KO-1010-C
1	3/4" x 1/8" Bushing	KO-1010-D
1	Tube with Fittings	KO-1011-B
1	Carrying Case	KO-1013
3	Plain Thermocouple	KO-1015

The voltmeter, tachometer, and engine analyzer feature electronic circuitry and digital readouts. Guidelines for using the instruments and testing are included.

Using the instruments in the Engine Analysis Kit you will be able to:

1. Measure the temperatures of the :
   a. spark plug base gasket/cylinder head bolt,
   b. oil sump, and
   c. air into flywheel and carburetor.
2. Measure engine speed (RPM).
3. Measure crankcase vacuum and exhaust system back pressure.
4. Measure voltage.
5. Measure charging system current.
6. Measure electric starter current (amp) draw.

The Engine Analysis Kit can be ordered complete as shown in Figure 2-1, or the instruments can be ordered individually. Contact your Kohler Distributor for price and availability.

Ignition System Tester

The new Kohler Part No. 24 800 01 can be used to test all ignition systems including the new CD systems.

Special Tools You Can Make

Flywheel Holding Tool

Flywheel removal and reinstallation becomes a "snap" using a handy holding tool you can make out of a piece of an old "junk" flywheel ring gear as shown in Figure 2-2. Using an abrasive cut-off wheel, cut out a six tooth segment of the ring gear as shown. Grind off any burrs or sharp edges. The segment can be used in place of a strap wrench. Invert the segment and place it between the ignition bosses on crankcase so that the tool teeth engage the ring gear teeth on the flywheel. The bosses will "lock" the tool and flywheel in position for loosening, tightening or removing with a puller.

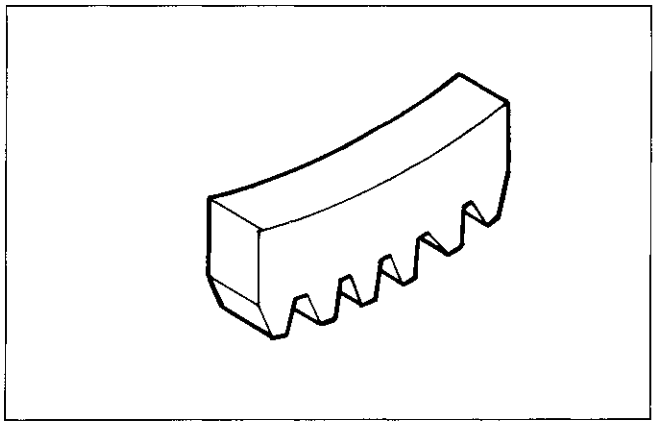


Figure 2-2. Flywheel Holding Tool.

Rocker Arm/Crankshaft Tool

If you don't have a spanner wrench to lift the rocker arms or to turn the crankshaft, you can make a tool for doing this out of an old junk connecting rod.

Find a used connecting rod from a 10 HP or larger engine. Remove and discard the rod cap. If it is a Posi-Lock rod, you will also need to remove the studs. If it is a Command rod, you will need to grind off the aligning steps, so the joint surface is flat. Find a 1" long capscrew with the correct thread size to match the threads in the connecting rod. Obtain a flat washer with the correct I.D. to slip on the capscrew and an O.D. of approximately 1". Kohler Part No. 12 468 05 can be used if you don't have the right size on hand. Assemble the capscrew and washer to the joint surface of the rod, as shown in Figure 2-3.

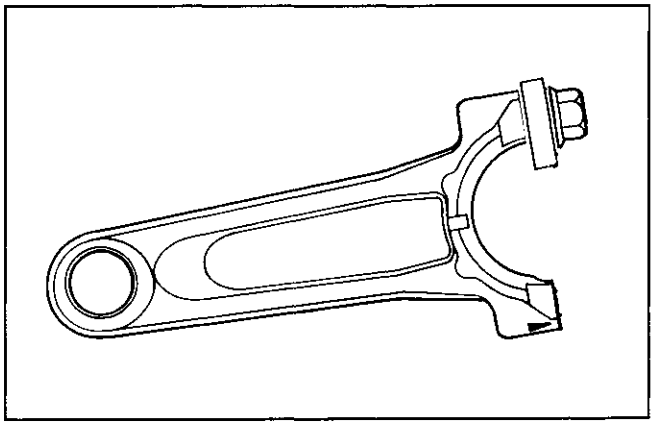


Figure 2-3. Rocker Arm/Crankshaft Tool.

Cylinder Leakdown Tester

Kohler Part No. 47 800 02 Cylinder Leakdown Tester is a valuable alternate to a compression test on these ACR equipped engines. By pressurizing the combustion chamber from an external air source, this tool can determine if valves or rings are leaking. Instructions for using this tester are found on page 3.4 of this manual.

RTV Silicone Sealant

RTV silicone sealant is used as a gasket between the crankcase and closure plate, breather cover and crankcase, and valve cover and heads on some models. The chart below lists some of the approved sealants.

RTV Sealants

Vendor	Vendor No. and Description	
G.E.	RTV-102 White RTV-103 Black RTV-106 Red RTV-108 Clear	RTV-109 Gray RTV-154 Gray RTV-156 Red RTV-1473 Black
Loctite®*	593 Black 594 White 595 Clear	598 Black* 5900 Black
Permatex	6 Blue 6B Blue 6C Blue	6M Blue 66B Clear 66C Clear

*NOTE: Loctite® No. 598 is available in a handy 10 cc size syringe type dispenser (with 2 disposable tips) under Kohler Part No. 25 597 04.

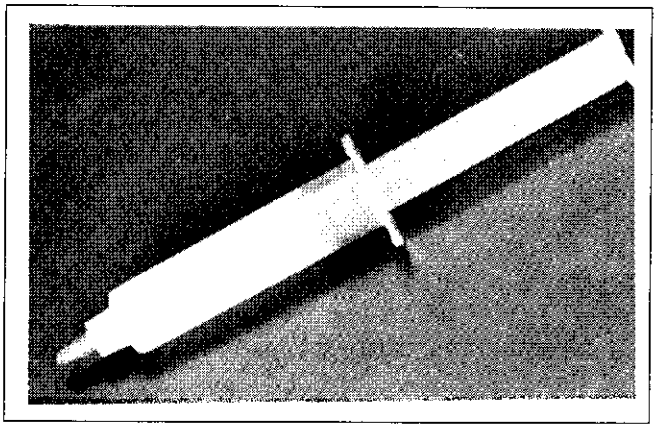


Figure 2-4. Loctite® No. 598 Syringe Dispenser.

NOTE: Always use **Fresh** sealant. Using outdated sealant can result in leakage. Generally, the shelf life of an unopened dispenser is about 1 year while that of a used one is not more than 6 months.

Section 3
Troubleshooting

Troubleshooting Guide

When troubles occur, be sure to check the simple causes which, at first, may seem too obvious to be considered. For example, a starting problem could be caused by an empty fuel tank.

Some common causes of engine troubles are listed below. Use these to locate the causing factors.

Engine Cranks but will not Start

1. Empty fuel tank.
2. Fuel shutoff valve closed.
3. Dirt or water in the fuel system.
4. Clogged fuel line.
5. Spark plug lead disconnected.
6. Key switch or kill switch in "off" position.
7. Faulty spark plugs.
8. Faulty ignition module.
9. Smart Spark™ malfunction (CH22 & CH25).
10. Carburetor solenoid malfunction.

Engine Starts but does not Keep Running

1. Restricted fuel tank cap vent.
2. Dirt or water in the fuel system.
3. Faulty choke or throttle controls.
4. Loose wires or connections that short the kill terminal of ignition module to ground.
5. Faulty cylinder head gasket.
6. Faulty carburetor.

Engines Starts Hard

1. PTO drive is engaged.
2. Dirt or water in the fuel system.
3. Clogged fuel line.
4. Loose or faulty wires or connections.
5. Faulty choke or throttle controls.
6. Faulty spark plugs.
7. Low compression.
8. Weak spark.

Engine will not Crank

1. PTO drive is engaged.
2. Battery is discharged.
3. Safety interlock switch is engaged.
4. Loose or faulty wires or connections.
5. Faulty key switch or ignition switch.
6. Faulty electric starter or solenoid.
7. Seized internal engine components.

Engine Runs but Misses

1. Dirt or water in the fuel system.
2. Spark plug lead disconnected.
3. Loose wires or connections.
4. Engine overheated.
5. Faulty ignition module.
6. Faulty spark plugs.
7. Carburetor adjusted incorrectly.
8. Smart Spark™ malfunction (CH22 & CH25).

Engine will not Idle

1. Restricted fuel tank cap vent.
2. Dirt or water in the fuel system.
3. Faulty spark plugs.
4. Idle fuel adjusting needle improperly set.
5. Idle speed adjusting screw improperly set.
6. Low compression.
7. Stale fuel and/or gum in carburetor.

Engine Overheats

1. Air intake/grass screen, cooling fins, or cooling shrouds clogged.
2. Excessive engine load.
3. Low crankcase oil level.
4. High crankcase oil level.
5. Faulty carburetor.
6. Lean fuel mixture.
7. Smart Spark™ malfunction (CH22 & CH25).

Section 3
Troubleshooting

Engine Knocks

1. Excessive engine load.
2. Low crankcase oil level.
3. Old/improper fuel.
4. Internal wear or damage.
5. Hydraulic lifter malfunction.

Engine Loses Power

1. Low crankcase oil level.
2. High crankcase oil level.
3. Dirty air cleaner element.
4. Dirt or water in the fuel system.
5. Excessive engine load.
6. Engine overheated.
7. Faulty spark plugs.
8. Low compression
9. Exhaust restriction.
10. Smart Spark™ malfunction (CH22 & CH25).
11. Low battery.

Engine Uses Excessive Amount of Oil

1. Incorrect oil viscosity/type.
2. Clogged or improperly-assembled breather.
3. Worn or broken piston rings.
4. Worn cylinder bore.
5. Worn valve stems/valve guides.
6. Crankcase being overfilled.

Oil Leaks from Oil Seals, Gaskets

1. Crankcase breather is clogged or inoperative.
2. Loose or improperly torqued fasteners.
3. Piston blowby or leaky valves.
4. Restricted exhaust.

External Engine Inspection

Before cleaning or disassembling the engine, make a thorough inspection of its external appearance and condition. This inspection can give clues to what might be found inside the engine (and the cause) when it is disassembled.

- Check for buildup of dirt and debris on the crankcase, cooling fins, grass screen and other external surfaces. Dirt or debris on these areas are causes of overheating.

- Check for obvious fuel and oil leaks, and damaged components. Excessive oil leakage can indicate a clogged or improperly-assembled breather, worn or damaged seals and gaskets, or loose or improperly-torqued fasteners.

- Check the air cleaner cover and base for damage or indications of improper fit and seal.

- Check the air cleaner element. Look for holes, tears, cracked or damaged sealing surfaces, or other damage that could allow unfiltered air into the engine. Also note if the element is dirty or clogged. These could indicate that the engine has been underserviced.

- Check the carburetor throat for dirt. Dirt in the throat is further indication that the air cleaner is not functioning properly.

- Check the oil level. Note if the oil level is within the operating range on the dipstick, or if it is low or overfilled.

- Check the condition of the oil. Drain the oil into a container - the oil should flow freely. Check for metal chips and other foreign particles.

  Sludge is a natural by-product of combustion; a small accumulation is normal. Excessive sludge formation could indicate overrich carburetion, weak ignition, overextended oil change interval or wrong weight or type of oil was used, to name a few.

  NOTE: It is good practice to drain oil at a location away from the workbench. Be sure to allow ample time for complete drainage.

Cleaning the Engine

After inspecting the external condition of the engine, clean the engine thoroughly before disassembling it. Also clean individual components as the engine is disassembled. Only clean parts can be accurately inspected and gauged for wear or damage. There are many commercially available cleaners that will quickly remove grease, oil, and grime from engine parts. When such a cleaner is used, *follow the manufacturer's instructions and safety precautions carefully.*

Make sure all traces of the cleaner are removed before the engine is reassembled and placed into operation. Even small amounts of these cleaners can quickly break down the lubricating properties of engine oil.

Basic Engine Tests

Crankcase Vacuum Test

A partial vacuum should be present in the crankcase when the engine is operating at normal temperatures. Pressure in the crankcase (normally caused by a clogged or improperly-assembled breather) can cause oil to be forced out at oil seals, gaskets, or other available spots.

Crankcase vacuum is best measured with a water manometer. Kohler Part No. 25 800 50 is recommended. Complete instructions are provided in kit.

Test the crankcase vacuum with the manometer as follows:

1. Insert the stopper/hose into the oil fill hole. Leave the other tube of manometer open to atmosphere.

   Make sure the shut off clamp is closed.

2. Start the engine and run at no-load high idle speed (3200 to 3750 RPM).

3. Open the clamp and note the water level in the tube.

   The level in the engine side should be a minimum of **10.2 cm (4 in.)** above the level in the open side.

   If the level in the engine side is the same as the open side (no vacuum), or the level in the engine side is lower than the level in the open side (pressure), check for the conditions in the table below.

4. Close the shut off clamp **before** stopping the engine.

Compression Test

Some of these engines are equipped with an automatic compression release (ACR) mechanism. Because of the ACR mechanism, it is difficult to obtain an accurate compression reading. As an alternate, use the leakdown test described in the following:

No Crankcase Vacuum/Pressure in Crankcase

Possible Cause	Solution
1. Crankcase breather clogged or inoperative.	1. Disassemble breather, clean parts thoroughly, reassemble, and recheck pressure.
2. Seals and/or gaskets leaking. Loose or improperly torqued fasteners.	2. Replace all worn or damaged seals and gaskets. Make sure all fasteners are tightened securely. Use appropriate torque values and sequences when necessary.
3. Piston blowby or leaky valves. (Confirm by inspecting components.)	3. Recondition piston, rings, cylinder bore, valves, and valve guides.
4. Restricted exhaust.	4. Repair/replace restricted muffler/exhaust system.

Cylinder Leakdown Test
A cylinder leakdown test can be a valuable alternative to a compression test. By pressurizing the combustion chamber from an external air source you can determine if the valves or rings are leaking, and how badly.

Kohler Part No. 47 800 02 is a relatively simple, inexpensive leakdown tester for small engines. The tester includes a quick disconnect for attaching the adapter hose, and a holding tool.

Leakdown Test Instructions

1. Run engine for 3-5 minutes to warm it up.
2. Remove spark plug(s) and air filter from engine.
3. Rotate crankshaft until piston (of cylinder being tested) is at top dead center of compression stroke. You will need to hold the engine in this position while testing. The holding tool supplied with the tester can be used if the PTO end of the crankshaft is accessible. Slide the holding tool onto the crankshaft and adjust the set screw to fit in the key slot. Install a 3/8" breaker bar into the square hole of the holding tool, so it is perpendicular to both the holding tool and crankshaft PTO. If the flywheel end is more accessible, you can use a breaker bar and socket on the flywheel nut/screw to hold it in position. You may need an assistant to hold the breaker bar during testing. If the engine is mounted in a piece of equipment, you may be able to hold it by clamping or wedging a driven component. Just be certain that the engine cannot rotate off of TDC in either direction.
4. Install the adapter into the spark plug hole, but do not attach it to the tester at this time.
5. Connect an air source of at least 50 psi to the tester.
6. Turn the regulator knob in the increase (clockwise) direction until the gauge needle is in the yellow "set" area at the low end of the scale.
7. Connect tester quick-disconnect to the adapter hose while firmly holding the engine at TDC. Note the gauge reading and listen for escaping air at the carburetor intake, exhaust outlet, and crankcase breather.
8. Check your test results against the table below:

Leakdown Test Results

Air escaping from crankcase breather	Defective rings or worn cylinder walls.
Air escaping from exhaust system	Defective exhaust valve.
Air escaping from carburetor	Defective intake valve.
Gauge reading in "low" (green) zone	Piston rings and cylinder in good condition.
Gauge reading in "moderate" (yellow) zone	Engine is still usable, but there is some wear present. Customer should start planning for overhaul or replacement.
Gauge reading in "high" (red) zone	Rings and/or cylinder have considerable wear. Engine should be reconditioned or replaced.

Section 4
Air Cleaner and Air Intake System

Air Cleaners

General

These engines are equipped with a replaceable, high-density paper air cleaner element. Most are also equipped with an oiled-foam precleaner which surrounds the paper element.

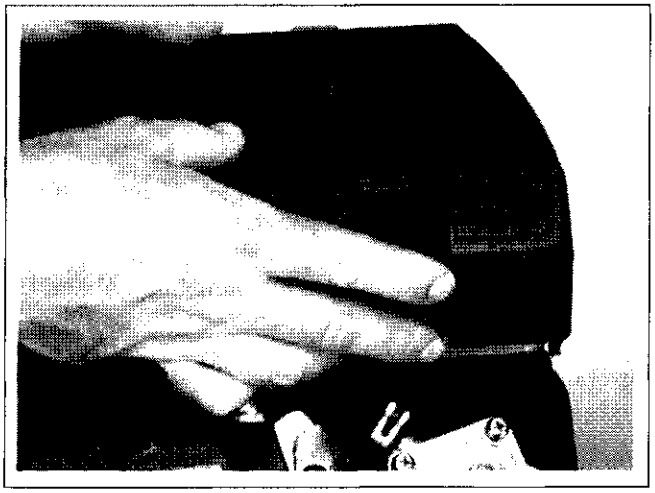


Figure 4-1. Unhooking Latches on Air Cleaner Cover.

Service

Check the air cleaner **daily or before starting the engine**. Check for and correct heavy buildup of dirt and debris along with loose or damaged components.

NOTE: Operating the engine with loose or damaged air cleaner components could allow unfiltered air into the engine causing premature wear and failure.

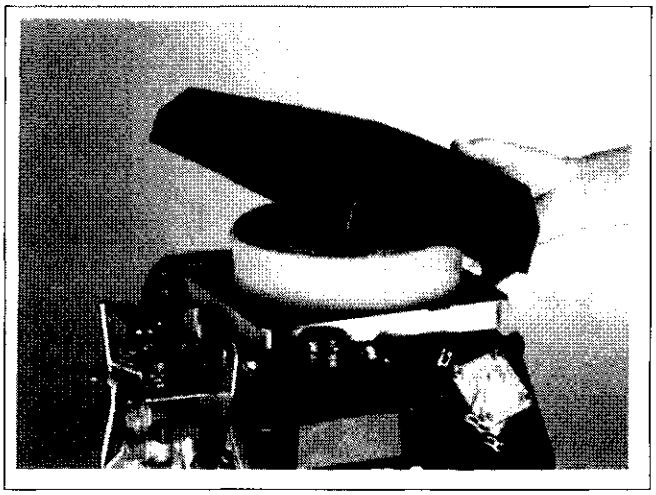


Figure 4-2. Removing Air Cleaner Cover.

Precleaner Service

If so equipped, wash and reoil the precleaner every **25 hours** of operation (more often under extremely dusty or dirty conditions).

To service the precleaner perform the following steps:

1. Unhook the latches located on either side of the air cleaner cover then slide cover upward and lift off.
2. Remove the foam precleaner from the paper air cleaner element.
3. Wash the precleaner in warm water with detergent. Rinse the precleaner thoroughly until all traces of detergent are eliminated. Squeeze out excess water (do not wring). Allow the precleaner to air dry.
4. Saturate the precleaner with new engine oil. Squeeze out all excess oil.
5. Reinstall the precleaner over the paper air cleaner element.

6. Reinstall the air cleaner cover and secure the two latches.

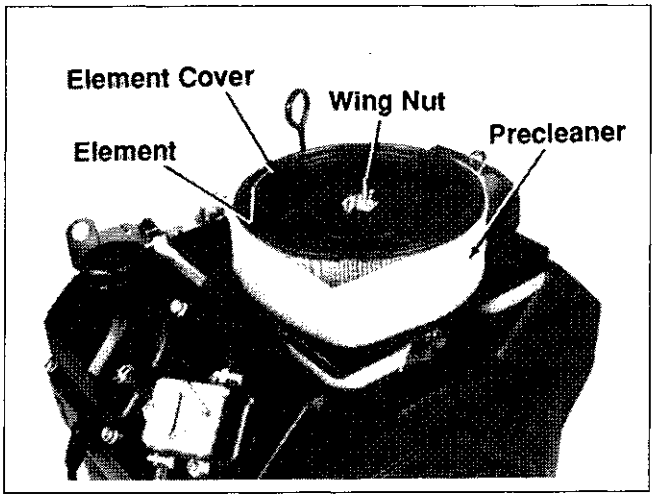


Figure 4-3. Air Cleaner Components.

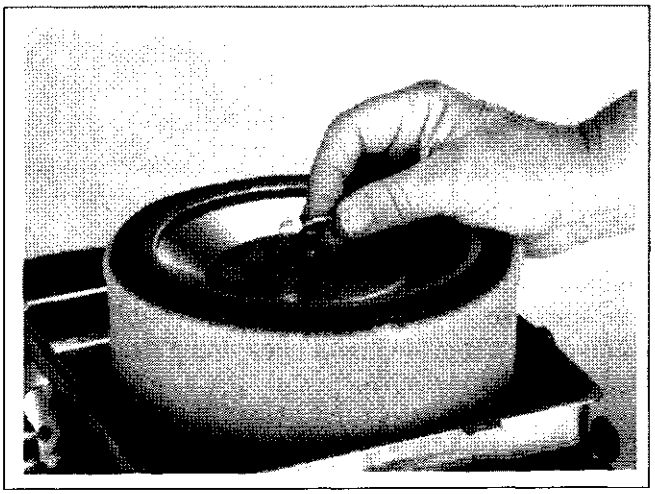


Figure 4-4. Removing Element Cover Wing Nut.

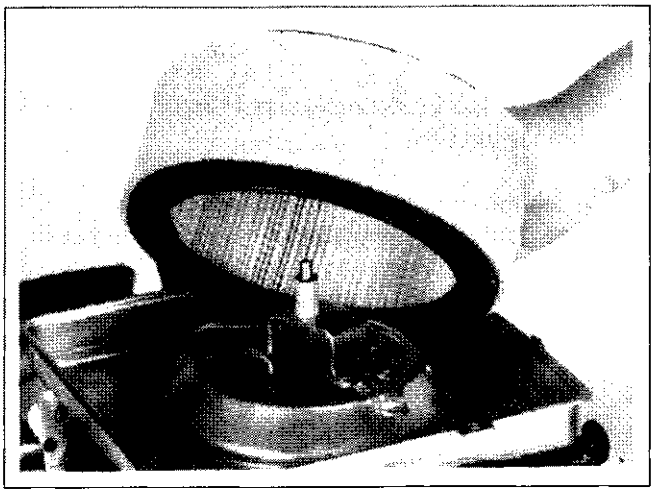


Figure 4-5. Removing Elements.

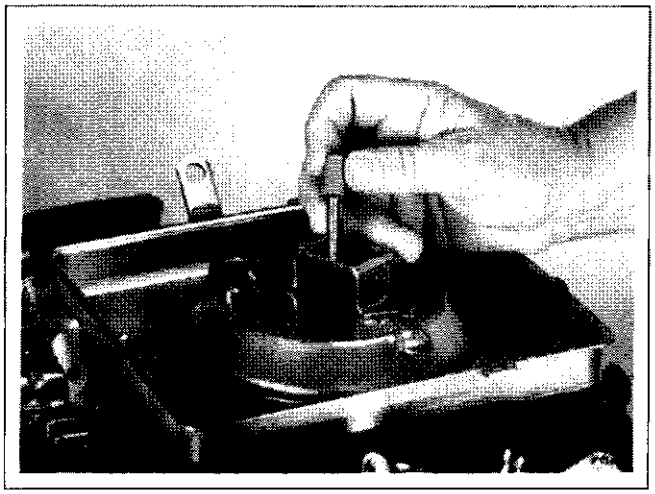


Figure 4-6. Removing Rubber Seal from Bracket.

Paper Element Service (Standard Type)
Every **100 hours** of operation (more often under extremely dusty or dirty conditions), check the paper element. Replace the element as necessary. Follow these steps:

1. Unhook the latches located on either side of the air cleaner cover and remove the cover.

2. Remove the wing nut, element cover, seal and air cleaner element.

3. Remove the precleaner (if so equipped) from the paper element.

4. **Do not wash the paper element or use pressurized air,** as this will damage the element. Replace a dirty, bent, or damaged element with a genuine Kohler element. Handle new elements carefully; do not use if the sealing surfaces are bent or damaged.

5. Reinstall the seal, paper element, precleaner, element cover, flat washer and wing nut.

6. Reinstall the air cleaner cover and secure the two latches.

   NOTE: Make sure the correct depth air cleaner element and rubber seal are used for the engine spec. involved. The CH25 and other specs. use a deeper or extra capacity air cleaner and a longer rubber seal.

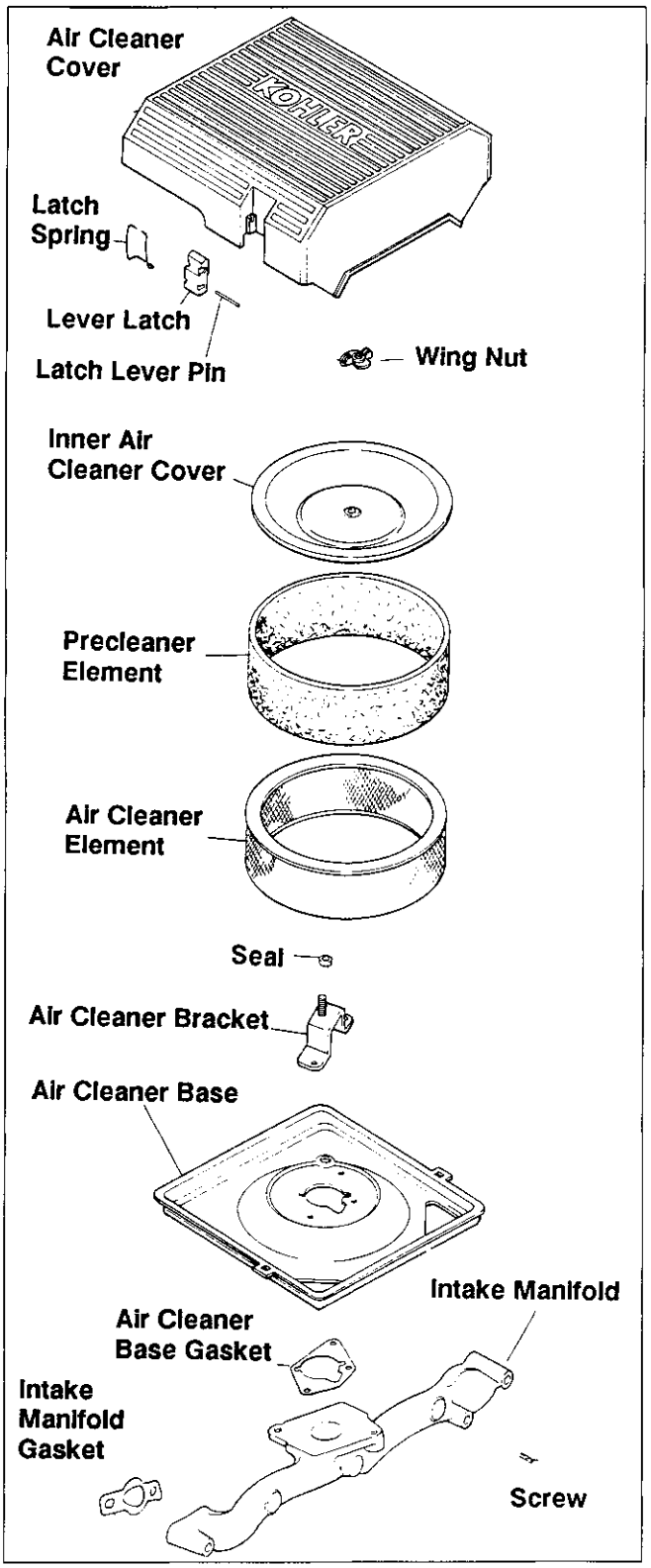


Figure 4-7. Exploded View of Air Intake System Components.

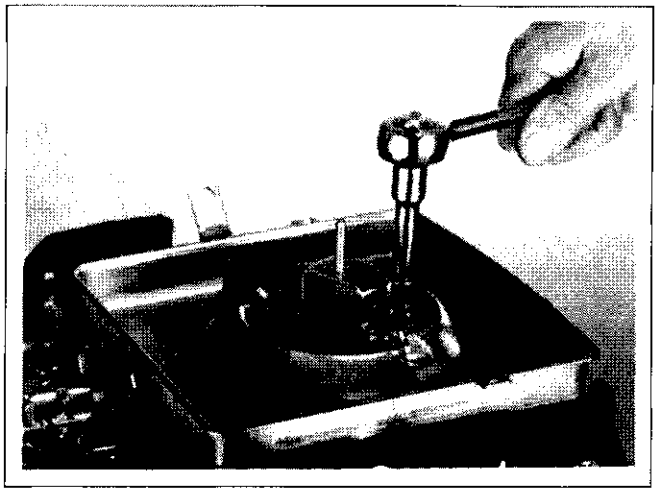


Figure 4-8. Bracket Retaining Screw.

Figure 4-9. Breather Tube.

4

Section 5
Fuel System and Governor

Description

The Command horizontal twins use three different types of fuel systems; gasoline, electronic fuel injection (EFI), or gaseous. Gaseous fuel systems can be either liquefied petroleum gas (LPG or LP) or natural gas (NG). Some dual fuel engines have a combination system, which allows the operator to select either gasoline or LP.

This section covers the standard gasoline fuel systems. The gaseous systems are covered in subsection 5A. The EFI systems are covered in subsection 5B. The governor system, covered at the end of this section, is the same for all fuel systems.

WARNING: Explosive Fuel!

Gasoline is extremely flammable and its vapors can explode if ignited. Store gasoline only in approved containers, in well ventilated, unoccupied buildings, away from sparks or flames. Do not fill the fuel tank while the engine is hot or running, since spilled fuel could ignite if it comes in contact with hot parts or sparks from ignition. Do not start the engine near spilled fuel. Never use gasoline as a cleaning agent.

Fuel System Components

The typical fuel system and related components include the following:

Fuel Tank
In-line Fuel Filter
Fuel Pump
Carburetor
Fuel Lines

Operation

The fuel from the tank is moved through the in-line filter and fuel lines by the fuel pump. On engines not equipped with a fuel pump, the fuel tank outlet is located above the carburetor inlet allowing gravity to feed fuel to the carburetor.

Fuel then enters the carburetor float bowl and is moved into the carburetor body. There, the fuel is mixed with air. This fuel-air mixture is then burned in the engine combustion chamber.

Fuel Recommendations

5

General Recommendations

Purchase gasoline in small quantities and store in clean, approved containers. A container with a capacity of 2 gallons or less with a pouring spout is recommended. Such a container is easier to handle and helps eliminate spillage during refueling.

- Do not use gasoline left over from the previous season, to minimize gum deposits in your fuel system and to ensure easy starting.
- Do not add oil to the gasoline.
- Do not overfill the fuel tank. Leave room for the fuel to expand.

Fuel Type

For best results, use only clean, fresh, unleaded gasoline with a pump sticker octane rating of 87 or higher. In countries using the Research fuel rating method, it should be 90 octane minimum.

Unleaded gasoline is recommended, as it leaves less combustion chamber deposits. Leaded gasoline may be used in areas where unleaded is not available and exhaust emissions are not regulated. Be aware however, that the cylinder head will require more frequent service.

Gasoline/Alcohol blends

Gasohol (up to 10% ethyl alcohol, 90% unleaded gasoline by volume) is approved as a fuel for Kohler engines. Other gasoline/alcohol blends are not approved.

Gasoline/Ether blends
Methyl Tertiary Butyl Ether (MTBE) and unleaded gasoline blends (up to a maximum of 15% MTBE by volume) are approved as a fuel for Kohler engines. Other gasoline/ether blends are not approved.

Fuel Filter
Most engines are equipped with an in-line filter. Visually inspect the filter periodically and replace when dirty with a genuine Kohler filter.

Fuel System Tests
When the engine starts hard, or turns over but will not start, it is possible that the problem is in the fuel system. To find out if the fuel system is causing the problem, perform the following tests.

Troubleshooting – Fuel System Related Causes

Test	Conclusion
1. Check the following: a. Make sure the fuel tank contains clean, fresh, proper fuel. b. Make sure the vent in fuel tank is open. c. Make sure the fuel valve is open.	
2. Check for fuel in the combustion chamber. a. Disconnect and ground spark plug leads. b. Close the choke on the carburetor. c. Crank the engine several times. d. Remove the spark plug and check for fuel at the tip.	2. If there **is** fuel at the tip of the spark plug, fuel is reaching the combustion chamber. If there is **no** fuel at the tip of the spark plug, check for fuel flow from the fuel tank (Test 3).
3. Check for fuel flow from the tank to the fuel pump. a. Remove the fuel line from the inlet fitting of fuel pump. b. Hold the line below the bottom of the tank. Open the shutoff valve (if so equipped) and observe flow.	3. If fuel **does** flow from the line, check for faulty fuel pump (Test 4). If fuel **does not** flow from the line, check for clogged fuel tank vent, fuel pickup screen, in-line filter, shutoff valve, and fuel lines.
4. Check the operation of fuel pump. a. Remove the fuel line from the inlet fitting of carburetor. b. Crank the engine several times and observe flow.	4. If fuel **does** flow from the line, check for faulty carburetor. (Refer to the "Carburetor" portions of this section.) If fuel **does not** flow from the line, check for clogged fuel line. If the fuel line is unobstructed, the fuel pump is faulty and must be replaced.

Section 4
Air Cleaner and Air Intake System

Air Cleaner Components
Whenever the air cleaner cover is removed, or the paper element or precleaner are serviced, check the following:

Air Cleaner Element Cover and Seal - Make sure element cover is not bent or damaged. Make sure the wing nut, washer and seal are in place to ensure the element is sealed against leakage.

Air Cleaner Base - Make sure the base is secured tightly to carburetor and not cracked or damaged.

Breather Tube - Make sure the tube is installed to both the air cleaner base and the breather cover.

NOTE: Damaged, worn or loose air cleaner components can allow unfiltered air into the engine causing premature wear and failure. Tighten or replace all loose or damaged components.

Complete Disassembly and Reassembly - Standard Type

If the base plate on the standard type has to be removed, proceed as follows:

1. Remove air cleaner components as described earlier.

2. Remove the hex. flange screws securing the bracket and base (Figure 4-8).

3. Remove the base and gasket--carefully pull the rubber breather tube through the base.

4. Remove tube from under side of base if necessary.

5. Reverse the foregoing steps to reinstall new or serviced components. Tighten screws to **9.9 N·m (88 in. lb.)** torque.

Air Intake/Cooling System

To ensure proper cooling, make sure the grass screen and fan cooling fins and other external surfaces of the engine are kept clean **at all times**.

Every **100 hours** of operation (more often under extremely dusty or dirty conditions), remove the blower housing and other cooling shrouds. Clean the cooling fins and external surfaces as necessary. Make sure the cooling shrouds are reinstalled.

NOTE: Operating the engine with a blocked grass screen, dirty or plugged cooling fins, and/or cooling shrouds removed, will cause engine damage due to overheating.

Fuel Pump

General

These engines are equipped with an external fuel impulse pump. The pumping action is created by the oscillation of positive and negative pressures within the crankcase. This pressure is transmitted to the impulse pump through a rubber hose connected between the pump and the valve cover or crankcase. The pumping action causes the diaphragm on the inside of the pump to pull fuel in on its downward stroke and to push it into the carburetor on its upward stroke. Two check valves prevent fuel from going backward through the pump.

Performance

Minimum fuel delivery rate must be 7.5 L/hr. (2 gal./hr.) with a pressure at .3 psi and a fuel lift of 18" from carburetor inlet. A 1.3 L/hr. (.34 gal./hr.) fuel rate must be maintained at 5 Hz.

Replacing the Fuel Pump

Replacement pumps are available through your source of supply. To replace the impulse pump follow these steps.

1. Disconnect the fuel lines from the inlet and outlet fittings.

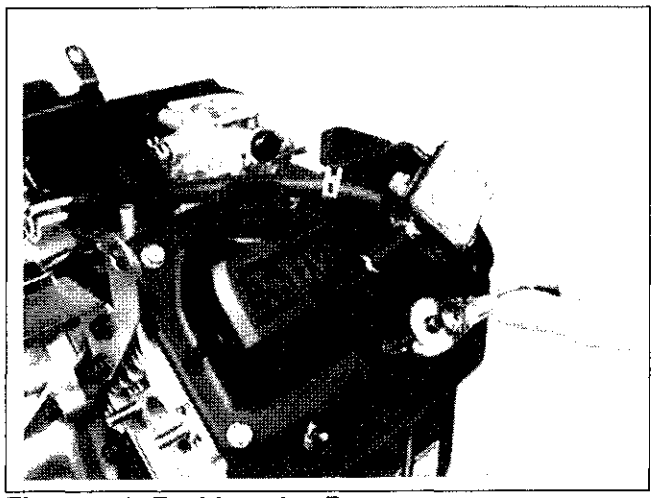


Figure 5-1. Fuel Impulse Pump.

2. Remove the hex. flange screws (securing pump to bracket) and fuel pump.

3. Remove the vacuum line that connects the pump to the crankcase or valve cover*.

4. Install a new pump to pump bracket using the hex. flange screws.

   NOTE: Make sure the orientation of the new pump is consistent with the removed pump. Internal damage may occur if installed incorrectly.

5. Connect vacuum line between impulse pump and crankcase or valve cover*.

   *NOTE: On some models, the pulse line is connected to a vaccum fitting on the crankcase, while on others, it is connected to the valve cover as shown in most illustrations throughout this manual.

6. Tighten the hex. flange screws to **2.3 N·m (20 in. lb.).**

7. Connect the fuel lines to the inlet and outlet fittings.

Carburetor

General

These engines are equipped with fixed main jet carburetors manufactured by Keihin to Kohler specifications. Most have automatic chokes and fuel shut-off solenoids. Keihin carburetors with accelerator pump features are standard on CH22-CH25 models and are furnished as an option on other CH applications where improved performance is required during periods of rapid acceleration. Both types are almost identical except for the accelerator pump parts shown in the inset in Figure 5-5. Most information in the following pertains to both type carburetors–differences are pointed out or shown wherever pertinent.

⚠ WARNING: Explosive Fuel

Gasoline is extremely flammable and its vapors can explode if ignited. Store gasoline only in approved containers, in well ventilated, unoccupied buildings, away from sparks or flames. Do not fill the fuel tank while the engine is hot or running, since spilled fuel could ignite if it comes in contact with hot parts or sparks from ignition. Do not start the engine near spilled fuel. Never use gasoline as a cleaning agent.

Troubleshooting - Carburetor Related Causes

Condition	Possible Cause/Probable Remedy
1. Engine starts hard, runs roughly or stalls at idle speed.	1. Low idle fuel mixture/speed improperly adjusted. Adjust the low idle speed tab, then adjust the low idle fuel needle.
2. Engine runs rich (indicated by black, sooty exhaust smoke, misfiring, loss of speed and power, governor hunting, or excessive throttle opening).	2a. Clogged air cleaner. Clean or replace. b. Choke partially closed during operation. Check the choke lever/ linkage to ensure choke is operating properly. c. Low idle fuel mixture is improperly adjusted. Adjust low idle fuel needle. d. Float level is stuck too high. Separate carburetor air horn from carburetor body, adjust float per steps 4 and 5 on page 5.6. e. Dirt under the fuel inlet needle. Remove needle; clean needle and seat and blow with compressed air. f. Bowl vent or air bleeds plugged. Remove low idle fuel adjusting needle. Clean vent, ports, and air bleeds. Blow out all passages with compressed air. g. Leaky cracked or damaged float. Submerge float to check for leaks.
3. Engine runs lean (indicated by misfiring, loss of speed and power, governor hunting or excessive throttle opening).	3a. Low idle fuel mixture is improperly adjusted. Adjust low idle fuel needle. b. Float level is stuck too low. Separate carburetor air horn from carburetor body, adjust float per steps 4 and 5 on page 5.6. c. Idle holes plugged; dirt in fuel delivery channels. Remove low idle fuel adjusting needle. Clean main fuel jet and all passages; blow out with compressed air.
4. Fuel leaks from carburetor.	4a. Float level stuck too high. See Remedy 2d. b. Dirt under fuel inlet needle. See Remedy 2e. c. Bowl vents plugged. Blow out with compressed air. d. Carburetor bowl gasket leaks. Replace gasket.

Troubleshooting Checklist
When the engine starts hard, runs roughly or stalls at low idle speed, check the following areas before adjusting or disassembling the carburetor.

- Make sure the fuel tank is filled with clean, fresh gasoline.
- Make sure the fuel tank cap vent is not blocked and that it is operating properly.
- Make sure fuel is reaching the carburetor. This includes checking the fuel shut-off valve, fuel tank filter screen, in-line fuel filter, fuel lines and fuel pump for restrictions or faulty components as necessary.
- Make sure the air cleaner base and carburetor are securely fastened to the engine using gaskets in good condition.
- Make sure the air cleaner element is clean and all air cleaner components are fastened securely.
- Make sure the ignition system, governor system, exhaust system, and throttle and choke controls are operating properly.

If the engine is hard-starting or runs roughly or stalls at low idle speed, it may be necessary to adjust or service the carburetor.

High Altitude Operation
When operating the engine at altitudes of 1500 m (5000 ft.) and above, the main fuel mixture tends to get overrich. This can cause conditions such as black, sooty exhaust smoke, misfiring, loss of speed and power, poor fuel economy, and poor or slow governor response.

To compensate for the effects of high altitude, a special high altitude main fuel jet can be installed. High altitude jets are sold in kits which include the jet and necessary gaskets. Refer to the Parts Manual for the correct kit number.

Fuel Shut-off Solenoid

Some carburetors are equipped with an optional fuel shut-off solenoid. The solenoid is attached in place of the fixed main jet screw to the flywheel side of the carburetor. The solenoid has a spring loaded pin that retracts when 12 volt is applied to the lead. The pin blocks the main fuel jet and prevents fuel from entering the carburetor when it is extended.

Below is a simple test made with engine off that can determine if the solenoid is functioning properly:

1. Shut off fuel and remove the solenoid from the carburetor.*
2. Attach a wire between the solenoid bracket and a battery ground with alligator clips.
3. Touch the male terminal of the solenoid lead to the positive post of the battery.
4. If pin retracts, the solenoid is good.

*NOTE: When solenoid is removed, gas will leak out of the carburetor. Shutoff the fuel and use a rag to catch fuel already in the line.

Carburetor Adjustments

General
The fixed main jet carburetor is designed to deliver the correct fuel-to-air mixture to the engine under all operating conditions. The high idle is set at the factory and cannot be adjusted. The low idle fuel adjusting needle is also set at the factory and normally does not need adjustment.

NOTE: Carburetor adjustments should be made only after the engine has warmed up.

Low Idle Fuel Adjusting Needle
To adjust the carburetor idle speed, see Figure 5-2 and follow these steps.

1. With the engine **stopped,** turn the low idle adjusting needle in **(clockwise)** until it bottoms **lightly**.

   NOTE: The tip of the idle fuel adjusting needle is tapered to critical dimensions. Damage to the needle and the seat in the carburetor body will result if the needle is forced.

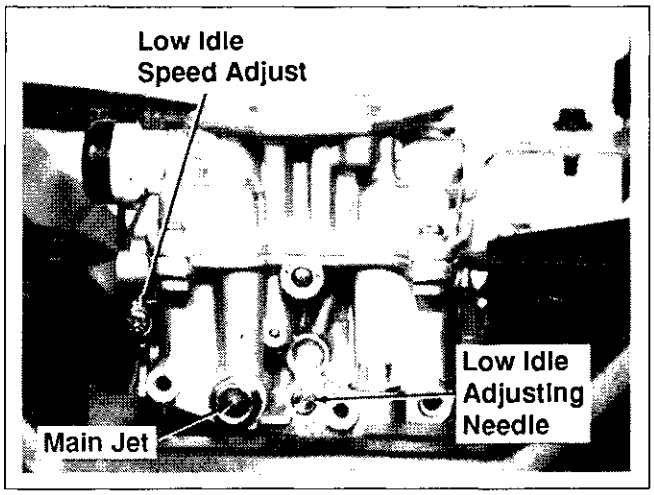


Figure 5-2. Carburetor Low Idle Adjustment.

2. Now turn the adjusting needle out **(counterclockwise)** 1-1/2 turns.
3. Start the engine and run at half-throttle for 5 to 10 minutes to warm up. The engine must be warm before making final settings. Check that the throttle and choke plates can fully open.

   NOTE: The carburetor has a self-relieving choke. Choke plate and shaft assembly is spring loaded. Check to make sure plate moves freely and is not binding and affecting idle fuel delivery.

4. Place the throttle control into the "idle" or "slow" position. Turn the low idle speed adjusting screw in or out to obtain a low idle speed of 1200 RPM (± 75 RPM). Check the speed using a tachometer.

NOTE: The actual low idle speed depends on the application. Refer to the equipment manufacturer's recommendations. The low idle speed for basic engines is 1200 RPM. To ensure best results when setting the low idle fuel needle, the low idle speed should be 1200 RPM (± 75 RPM).

5. Turn the low idle fuel adjusting needle in (slowly) until engine speed decreases and then back out approximately 3/4 turn to obtain the best low speed performance.

6. Recheck the idle speed using a tachometer and readjust the speed as necessary.

Float

It is not necessary to remove the carburetor from the engine to check and adjust the float.

1. Remove the air cleaner and breather hose. Refer to Section 9 - "Disassembly."

2. Disconnect the fuel line from the carburetor. See Figure 5-3.

3. Clean dirt and debris from exterior of carburetor.

4. Remove the four screws holding the two carburetor halves together. Carefully lift the carburetor air horn assembly off the carburetor body and disconnect choke linkage.

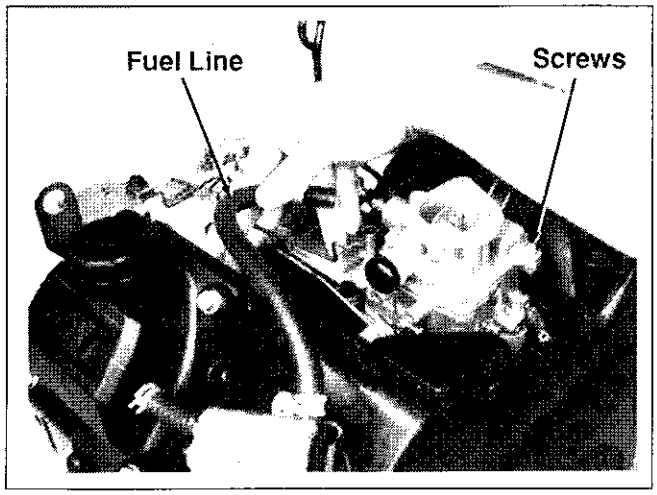


Figure 5-3. Carburetor Mounting Detail.

5. Hold the carburetor air horn so that the float assembly hangs vertically and rests lightly against the fuel inlet needle. The fuel inlet needle should be fully seated but the needle tip should not be depressed. See Figure 5-4.

   NOTE: The fuel inlet needle tip is spring loaded. Make sure float assembly rests against the fuel inlet needle without depressing the tip.

6. The correct float height adjustment is 22 mm (.86 in.) measured from the float bottom to the air horn casting. Adjust the float height by carefully bending the tab.

   NOTE: Be sure to measure from the casting surface, not the rubber gasket surface.

7. If proper float height adjustment cannot be achieved, check to see if the fuel inlet needle is dirty, obstructed or worn. Remove the brass screw and float assembly to remove the fuel inlet needle.

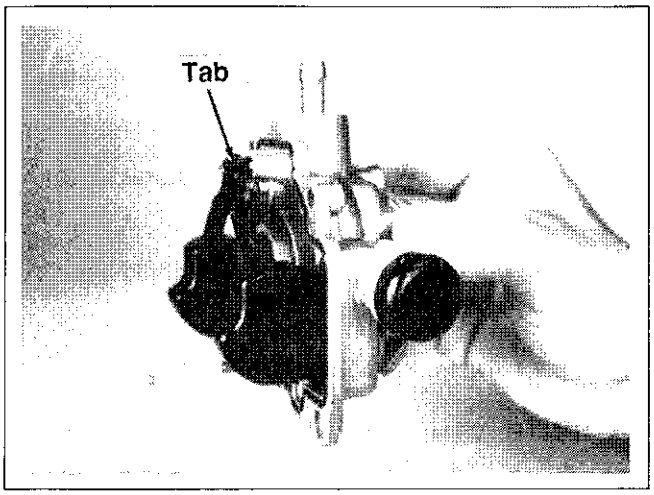


Figure 5-4. Carburetor Float Adjustment.

8. Once proper float height is obtained, carefully lower the carburetor air horn assembly onto the carburetor body connecting choke linkage. Install the four screws. Torque screws to **1.7 N·m (15 in. lb.)**. See Figure 5-3.

9. Connect the fuel line.

10. Install the breather hose and air cleaner assembly following the steps in Section 11 – "Reassembly."

Disassembly
Disassemble the carburetor using the following steps. See Figure 5-5.

1. Remove the air cleaner, breather hose and carburetor. Refer to Section 9 - "Disassembly."

2. Remove the four screws and carefully separate the air horn assembly from the carburetor body.

3. Loosen the screw securing the float assembly to the air horn and remove the float, float shaft and fuel inlet needle.

4. Remove the slow jet from the carburetor body.

   NOTE: The main jet is a fixed jet and can be removed if required. Fixed jets for high altitude are available.

5. Remove the black cap on the end of the choke shaft only if it is necessary to inspect and clean the shaft spring.
6. Remove the low idle speed adjusting screw and spring from the carburetor body.

7. In order to clean the "off-idle" vent ports and bowl vent thoroughly, use a good carburetor solvent (like Gumout™). Blow clean compressed air through idle adjusting needle hole. Be careful to use a suitable shop rag to prevent debris from hitting someone.

8. Remove the performed rubber gasket only if it is to be replaced. If it is removed for any reason, replace it.

Inspection/Repair
Carefully inspect all components and replace those that are worn or damaged.

- Inspect the carburetor body for cracks, holes and other wear or damage.

- Inspect the float for cracks, holes, and missing or damaged float tabs. Check the float hinge and shaft for wear or damage.

- Inspect the fuel inlet needle and seat for wear or damage.

- Inspect the tip of the low idle fuel adjusting needle for wear or grooves.

- The choke plate is spring loaded. Check to make sure it moves freely on the shaft.

  NOTE: The choke and throttle plate assemblies are staked and matched to the shafts at the factory. They are ot serviceable items.

Always use new gaskets when servicing or reinstalling carburetors. Repair kits are available which include new gaskets and other components. These kits are described below.

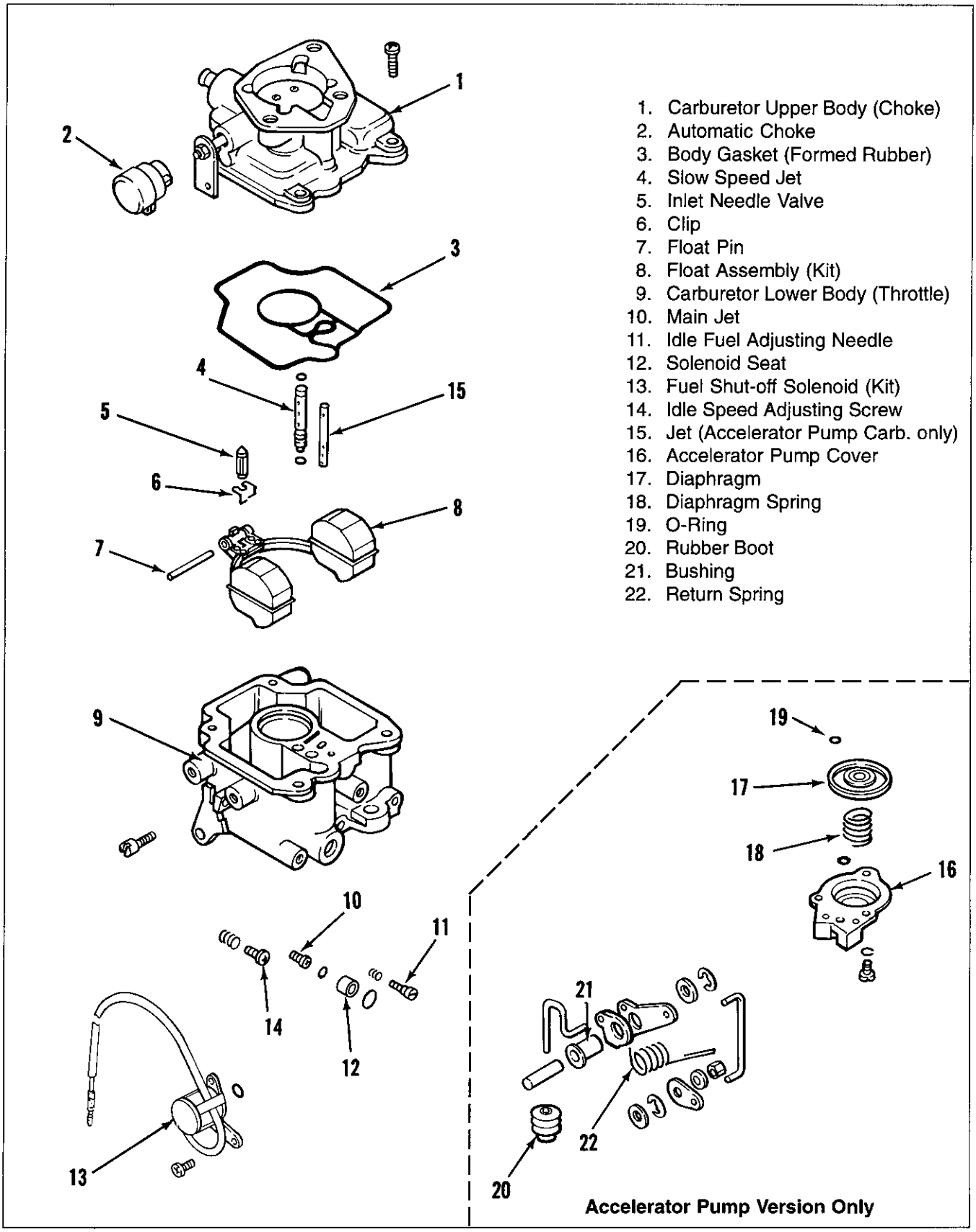


Figure 5-5. Carburetor - Exploded View.

Components such as the throttle and choke shaft assemblies, throttle plate, choke plate, low idle fuel needle, and others, are available separately.

Always refer to the Parts Manual for the engine being serviced to ensure the correct repair kits and replacement parts are ordered.

Carburetor Repair Kit Contains:

Qty.	Description
1	Carburetor Body Gasket
4	Carburetor Body Screw
1	Idle Needle Spring
2	Slow Jet O-Ring
1	Main Jet O-Ring
1	Solenoid O-Ring
1	Solenoid O-Ring
1	Solenoid O-Ring
1	Inlet Needle Clip
1	Inlet Needle
1	Inlet Needle Valve

Float Kit Contains:

Qty.	Description
1	Carburetor Body Gasket
1	Float Screw
1	Float Assembly
1	Float Shaft

High Altitude (1500 Meter) Kit Contains:

Qty.	Description
1	Main Jet Screw O-Ring
1	Main Jet

High Altitude (3000 Meter) Kit Contains:

Qty.	Description
2	Slow Jet O-Ring
1	Main Jet Screw O-Ring
1	Main Jet
1	Slow Jet

Solenoid Assembly Kit Contains:

Qty.	Description
2	Solenoid Screw
1	O-Ring
1	O-Ring
1	O-Ring
1	Solenoid Assembly
1	Solenoid Seat

Accelerator Pump Kit Contains:

Qty.	Description
1	Cover
1	Diaphragm
1	Return Spring
2	O-Rings
1	Boot
1	Bushing (Pad Pump Lever)

Reassembly

Reassemble the carburetor using the following steps. See Figure 5-5.

1. Assemble fuel inlet needle to the float tab. Install the float, float shaft and inlet needle to the air horn. Tighten the screw. Check float height using the procedure found previously in the "Adjustments" subsection.

2. Install the slow jet with the stepped end facing out. Make sure jet is fully seated.

3. Install the low idle adjusting needle and spring.

4. Assemble the air horn and carburetor body using the four screws. Tighten screws to **1.7 N·m (15 in. lb.)**.

5. Install the carburetor on the engine following the procedures in Section 11 - "Reassembly."

Governor

General

The engine is equipped with a centrifugal flyweight mechanical governor. It is designed to hold the engine speed constant under changing load conditions. The governor gear/flyweight mechanism is mounted inside the crankcase and is driven off the gear on the camshaft. The governor works as follows:

- Centrifugal force acting on the rotating governor gear assembly causes the flyweights to move outward as speed increases. Governor spring moves them inward as speed decreases.

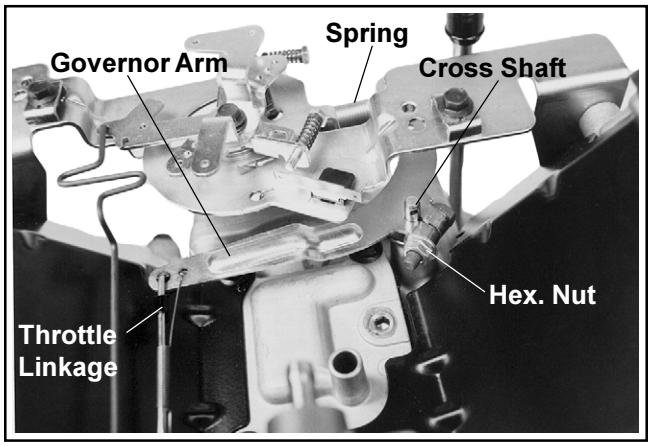


Figure 5-6. Governor Linkage.

- As the flyweights move outward, they cause the regulating pin to move outward.
- The regulating pin contacts the tab on the cross shaft causing the shaft to rotate.
- One end of the cross shaft protrudes through the crankcase. The rotating action of the cross shaft is transmitted to the throttle lever of the carburetor through the external linkage. See Figure 5-6.
- When the engine is at rest, and the throttle is in the “fast” position, the tension of the governor spring holds the throttle plate open. When the engine is operating, the governor gear assembly is rotating. The force applied by the regulating pin against the cross shaft tends to close the throttle plate. The governor spring tension and the force applied by the regulating pin balance each other during operation, to maintain engine speed.
- When load is applied and the engine speed and governor gear speed decreases, the governor spring tension moves the governor arm to open the throttle plate wider. This allows more fuel into the engine, increasing engine speed. As speed reaches the governed setting, the governor spring tension and the force applied by the regulating pin will again offset each other to hold a steady engine speed.

Adjustments

NOTE: Do not tamper with the governor setting. Overspeed is hazardous and could cause personal injury.

General

The governed speed setting is determined by the position of the throttle control. It can be variable or constant, depending on the engine application.

Initial Adjustment

NOTE: The CH26 (EFI) engines require a special initial adjustment procedure, which is covered in subsection 5B. Refer to page 5B.21-5B.23.

Make this adjustment whenever the governor arm is loosened or removed from the cross shaft. See Figure 5-6 and adjust as follows:

1. Make sure the throttle linkage is connected to the governor arm and the throttle lever on the carburetor.
2. Loosen the hex. nut holding the governor lever to the cross shaft.
3. Move the governor lever **towards** the carburetor as far as it will move (wide open throttle) and hold in position.
4. Insert a nail into the hole on the cross shaft and rotate the shaft **counterclockwise** as far as it will turn, then tighten hex. nut securely.

Sensitivity Adjustment
Governor sensitivity is adjusted by repositioning the governor spring in the holes on the governor lever. If speed surging occurs with a change in engine load, the governor is set too sensitive. If a big drop in speed occurs when normal load is applied, the governor should be set for greater sensitivity. See Figure 5-7 and adjust as follows:

1. To increase the sensitivity, move the spring closer to the governor lever pivot point.

2. To decrease the sensitivity, move the spring away from the governor lever pivot point.

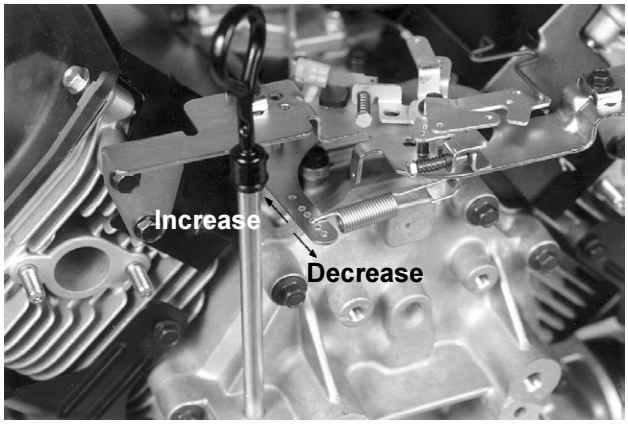


Figure 5-7. Governor Sensitivity Adjustments.

High Idle RPM Speed Adjustment (Refer to Figure 5-8.)

1. With the engine running, move the throttle control to fast. Use a tachometer to check the RPM speed.

2. Loosen the lock nut on high idle adjusting screw. Turn screw outward to decrease, or inward to increase RPM speed. Check RPM with a tachometer.

3. When the desired RPM speed is obtained, retighten the lock nut.

NOTE: Upon establishing the high idle RPM speed, check for a gap between the high idle control and the choke control. The gap may be greater, but no less than .02 in. (.5 mm).

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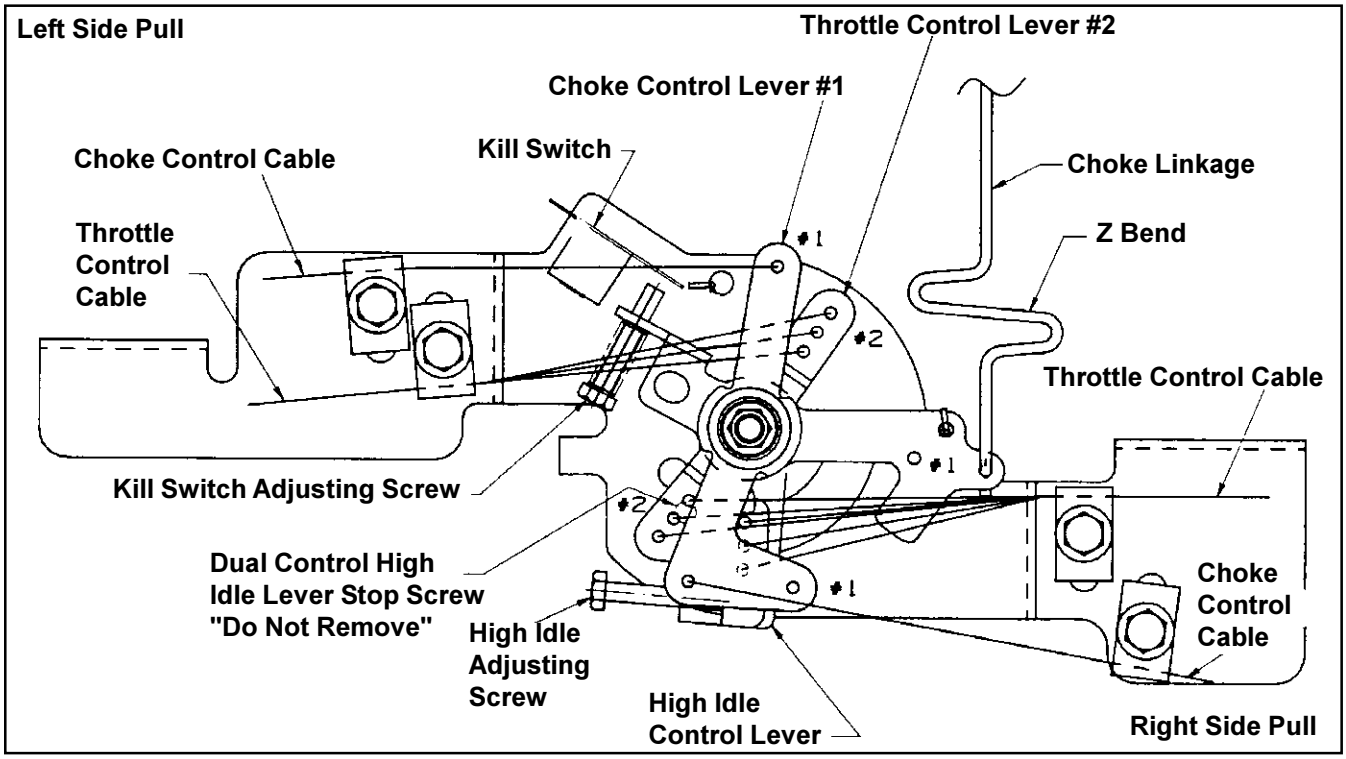


Figure 5-8. Governor Control Connections.

Section 5A
LPG Fuel Systems

WARNING: Explosive Fuel!

LPG is extremely flammable, is heavier than air, and tends to settle in low areas where a spark or flame could ignite the gas. Do not start or operate this engine in a poorly ventilated area where leaking gas could accumulate and endanger the safety of persons in the area.

Proper service and repair of LPG fuel systems requires qualified technicians and special equipment. Many states require special licensing or certification for LPG repair shops and/or technicians. Check state and local regulations before attempting any adjustment, service, or repair of the LPG system or components. Faulty repairs by unqualified or underqualified personnel can have very serious ramifications. The information in this segment is for the exclusive use of qualified LPG service providers.

LPG Fuel System Components

The typical “liquid withdrawal” LPG fuel system consists of the following components:

- LPG Fuel Tank (Liquid Withdrawal)
- Electric Lock-Off/Filter Assembly
- Vaporizer
- LPG Regulator (Combination Primary/Secondary/Vacuum Lock-Off)
- LPG Carburetor
- High Pressure Fuel Line(s)
- Vacuum Line

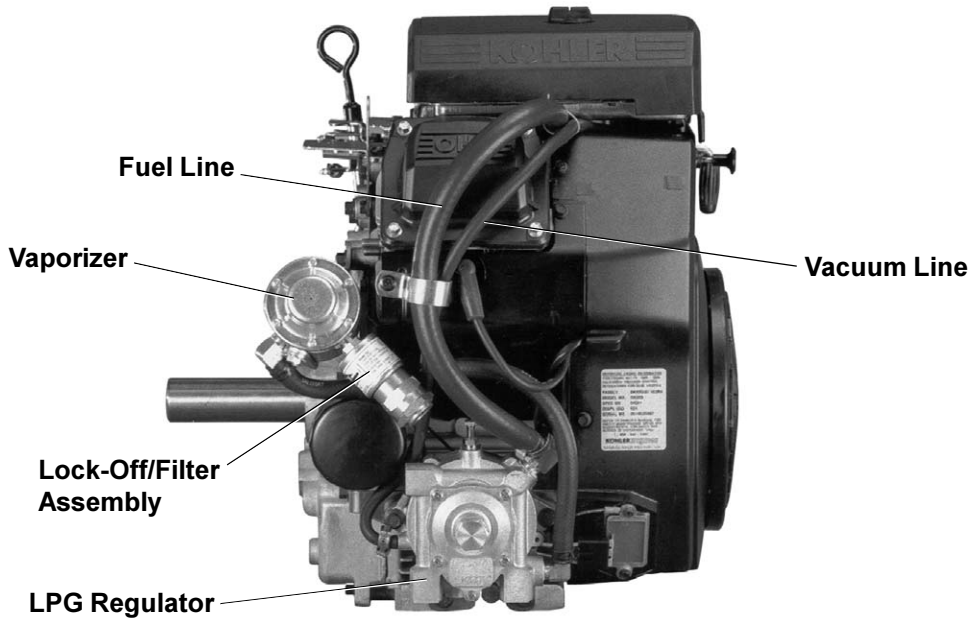


Figure 5A-1.

Operation

In a liquid withdrawal system, the Liquefied Petroleum Gas (LPG) is released from the bottom of the supply tank under high pressure. Upon opening the shut-off valve on the tank, liquid fuel travels out through the high pressure line to the electric lock-off/filter assembly. The lock-off opens internally when the key switch is turned **"on,"** permitting filtered fuel to flow to the vaporizer. The vaporizer is mounted in the flow of the discharged cooling air. It absorbs heat from the cooling air and transfers it to the fuel, changing the liquefied petroleum to a vapor or gaseous state, while partially stepping down the fuel pressure. The gas/vapor flows under this decreased pressure to the regulator where it is further reduced to a usable, regulated pressure. The regulator, activated by intake manifold vacuum, controls fuel flow to the carburetor. In the venturi of the carburetor, the fuel vapor is mixed with incoming air from the air cleaner in the correct ratio for efficient combustion.

Troubleshooting Checklist

If the engine starts hard, runs roughly, or stalls, check the following areas.

- Make sure the LPG fuel tank is filled and shut-off valve is fully opened.
- Make sure fuel is reaching the carburetor.
- Make sure the air cleaner element and precleaner are clean and all components are fastened securely.
- Make sure the ignition, governor, exhaust, throttle, and choke control systems are all operating properly.
- Check compression.

If engine continues to start hard, run roughly, or stall after these checks have been made, use the following troubleshooting guide.

Engine cranks but will not start

1. LPG fuel tank closed, low, or empty.
2. Lock-off not opening electrically, preventing fuel flow to vaporizer.
3. Fuel filter (located inside lock-off) dirty or blocked.
4. Insufficient vacuum signal, regulator not opening.
   a. Vacuum line between carburetor and regulator cracked, leaking, kinked, or pinched.
   b. Carburetor loose.
   c. Intake manifold loose or leaking.
   d. Excessive internal engine wear.
5. Faulty regulator
   a. Primary valve not opening.
   b. Diaphragm spring adjustment incorrect.
   c. Idle adjustment screw incorrectly set.
   d. Vent(s) blocked/restricted.
6. Restricted/blocked fuel line.
7. Blocked carburetor fuel circuit.
8. Loose/leaking fuel enrichment hose (Impco carburetor system).

Hard starting, runs roughly, or stalls at idle speed

1. LPG fuel tank low.
2. Vacuum line between carburetor and regulator pinched, cracked, or leaking.
3. Carburetor idle speed set too low (should be at least 1200 RPM).
4. Carburetor idle circuit restricted.
5. Dirty/restricted air cleaner.
6. Dirty/restricted lock-off filter.
7. Frozen/malfunctioning regulator. Check/adjust primary pressure.
8. Excessive external load on engine.
9. Excessive internal wear.
10. Loose/leaking fuel enrichment hose (Impco carburetor system).

Irregular or inconsistent idle

1. Improper operation/adjustment of regulator, idle adjustment screw, throttle opening, and/or engine governor.
2. Secondary valve in regulator not closing. Readjust idle screw (couterclockwise) so valve can close fully against seat.
3. Loose/leaking vacuum line.
4. Loose carburetor mounting and/or line connections.
5. Damaged diaphragm(s) within regulator.
6. Debris in regulator. Flush debris from drain plug or remove regulator from system, disassemble body and remove debris.
7. Dirt or debris in carburetor. Remove carburetor, disassemble and clean/service as required. If venturi (Impco carburetor) removal is performed, mark its orientation to the carburetor body for proper reinstallation.
8. Loose/leaking fuel enrichment hose (Impco carburetor system).

Engine stalls during operation

1. No fuel.
2. Faulty lock-off or blocked filter.
3. Improper governor setting.
4. Damaged diaphragms within regulator.
5. Vacuum line leaking, loose, or pinched.
6. Restricted fuel line.
7. Loose/leaking fuel enrichment hose (Impco carburetor system).

Low power

1. Air cleaner or exhaust system dirty/restricted.
2. Low fuel.
3. Rich gas condition (flooding) through regulator.
   a. Dirty/restricted valves in regulator.
   b. Damaged primary diaphragm in regulator.
4. No fuel.
   a. Electric lock-off not opening, filter blocked, or restriction within fuel line.
   b. Leaking, loose, or cracked vacuum line from carburetor to regulator.
   c. Leaking, or loose intake system components.
   d. Regulator primary valve not opening.
   e. Secondary, or vacuum lock-off diaphragm within regulator leaking.
   f. Low pressure rubber hose kinked.
   g. Frozen regulator.
5. Improper ignition timing.
6. Loose/incorrect throttle lever/clamp bracket positioning.
7. Loose or incorrectly positioned high speed throttle plate stop.

Engine runs lean

1. Electrical problem causing intermittent lock-off operation, or lock-off is faulty.
2. Filter in lock-off dirty or restricted.
3. Restriction in fuel system.
4. Idle holes plugged; dirt in fuel delivery channels.
5. Carburetor fuel circuit restriction.
6. Loose/leaking fuel enrichment hose (Impco carburetor system).

High fuel consumption

1. Fuel leak. Check lines, connections, and system components for leaks with soapy water. Fix any leaks immediately.
2. Incorrectly set regulator, or leakage from valves in regulator. Readjust, service, or replace regulator as required.
3. Dirty air cleaner or precleaner.
4. Choke plate in carburetor not opening completely.

LPG Carburetor Adjustments

General

The LPG carburetor and regulator are designed to deliver the correct fuel-to-air mixture to the engine under all operating conditions. The high and low idle fuel mixture settings are preset at the factory, and cannot be adjusted. These engines are equipped with an Impco or Nikki carburetor. See Figure 5A-2 and 5A-3. Although both carburetors function similarly, each is unique and should not be interchanged.

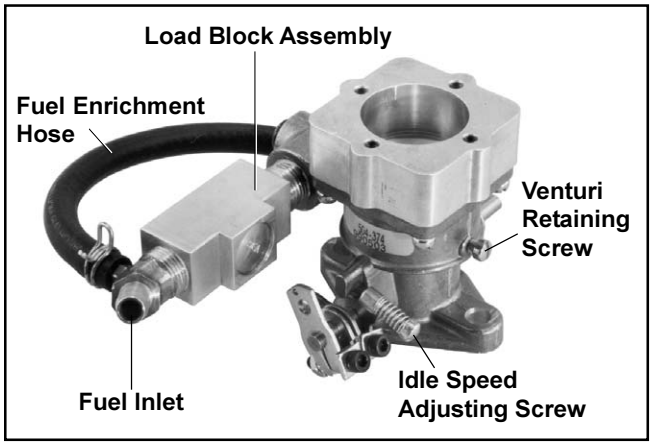


Figure 5A-2. Impco Carburetor.

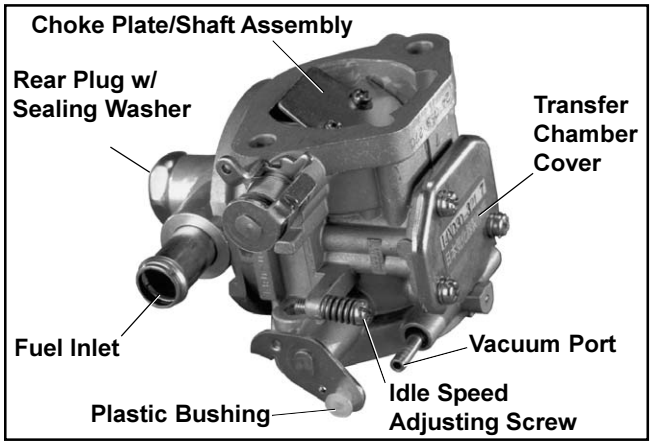


Figure 5A-3. Nikki Carburetor.

Impco carburetors also incorporate the use of an external ‘‘Load Block’’ assembly, which controls the final fuel flow to the carburetor for all throttle positions except idle. See Figure 5A-2. Calibrated and flow-matched to the carburetor, it functions similarly to preset fuel mixture settings in other carburetors. The load block assembly is not available separately, nor is any internal servicing permitted or possible. If a problem is encountered and determined to be caused by the load block, the carburetor should be replaced.

High Altitude Operation
The standard carburetor calibrations will provide proper operation up to altitudes of **1500 m (5000 ft.)**. No internal changes are necessary or available for either carburetor.

NOTE: Carburetor adjustments should be made only after the engine has warmed up.

Idle Speed Adjustment
1. Start the engine and run at half throttle for 5 to 10 minutes. Check that the throttle and choke (Nikki carb) plates can open fully.

2. Place the throttle control into the **"idle"** or **"slow"** position. Turn the low idle speed adjusting screw (See Figure 5A-2 or 5A-3) in or out, to obtain a low idle speed of **1200 RPM (± 75 RPM),** or set to application specifications. Check the speed using a tachometer.

NOTE: The actual low idle speed (RPM) depends on the application. Refer to the equipment manufacturer's recommendations. The low idle speed for basic engines is **1200 RPM**.

LPG Fuel System Component Service

LPG Carburetor - Cleaning
The carburetor may be cleaned if necessary. Removal from the engine and limited disassembly will aid in cleaning.

NOTE: **Impco Carburetor:** Do not loosen or alter the mounted position of the clamping brackets and/or stop collar on the throttle shaft. Each is preset, in correlation to a specific position of the throttle plate (shaft), or acts as a stop. None of these attached components, including the throttle plate or shaft, requires disassembly or removal for any carburetor servicing. All the components on the throttle shaft should be left intact. If the settings of any one of these is inadvertently loosened or altered, each must be checked/reset, or performance and operation will be affected. Refer to the procedure included in the reassembly/installation sequence to check or reset.

Impco Carburetor
1. Turn off fuel supply at tank.

2. Remove the air cleaner, breather hose, fuel line, vacuum hose, choke, and throttle linkages. Remove the mounting hardware, carburetor, and gaskets from the engine. Discard the gaskets.

3. The carburetor venturi may be removed for inspection and appropriate cleaning.

   a. Remove the four screws securing the air cleaner adapter and gasket to the carburetor. See Figure 5A-4.

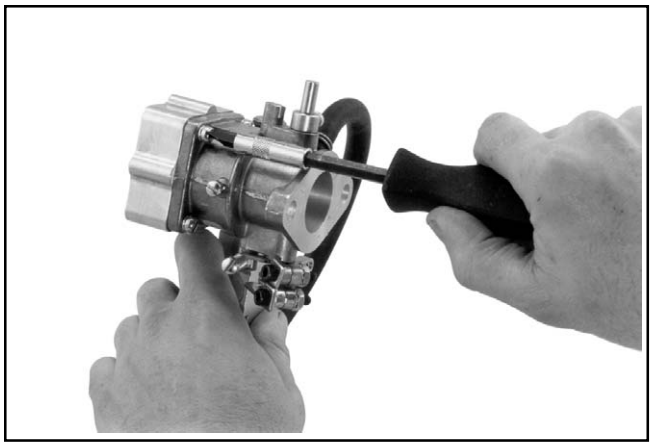


Figure 5A-4.

   b. **Important:** Mark a small line on the outer edge of venturi for proper orientation and reinstallation later.

   c. Loosen the venturi retaining screw on the side of the carburetor body and lift out the venturi. See Figure 5A-5.

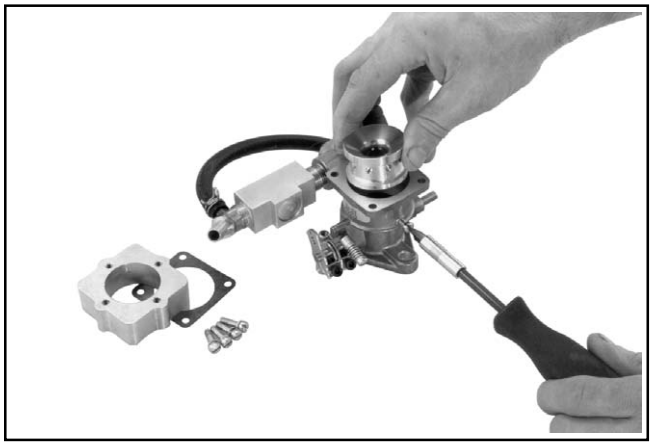


Figure 5A-5.

4. Inspect the overall condition of the fuel enrichment hose attached to the carburetor. It must be free of cracks, deterioration, and damage. Disconnect the fuel enrichment hose from the carburetor fittings to clean or check condition as required. See Figure 5A-6. Replace with a new Kohler high pressure hose (LP rated) if the condition is questionable in any way. Secure new hose using new clamps.

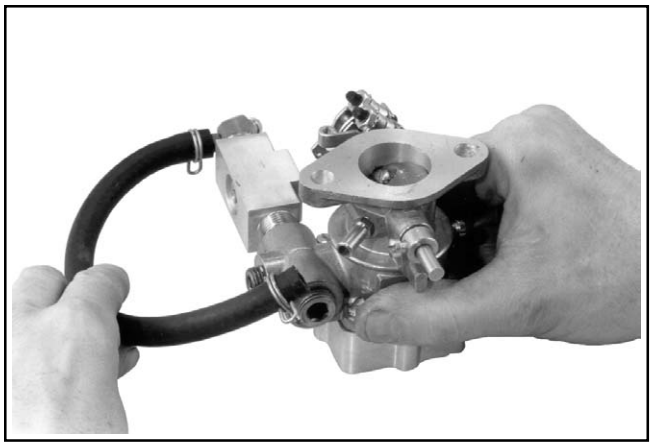


Figure 5A-6.

5. Clean all parts as required, use a good carburetor cleaner, following the manufacturer's instructions. Blow clean, compressed air through all the passages. **Do not** poke or probe into the load block assembly as damage can be done, resulting in serious operational problems. See Figure 5A-7.

Figure 5A-7.

Nikki Carburetor

1. Turn off fuel supply at tank.

2. Remove the air cleaner, breather hose, fuel line, vacuum hose, choke, and throttle linkages. Remove the nuts, carburetor, and gaskets from the engine. Discard the gaskets.

3. Remove the fuel transfer chamber cover by removing the three screws. See Figure 5A-3. Carefully remove the cover and gasket. Discard the gasket.

4. The main jet is fixed and nonadjustable, but may be accessed for cleaning by removing the rear plug and sealing washer. Discard the washer.

5. In order to clean the off-idle transfer passages and carburetor thoroughly, use a good carburetor cleaner and follow the manufacturer's instructions. Blow clean, compressed air through the passages and make sure all are open before reassembling. **Do not** use wire or metal objects to clean passages or carburetor body.

LPG Carburetor - Inspection

1. Inspect the carburetor body and removable venturi (Impco carburetor) for cracks, holes, and other wear or damage.

2. Check the choke shaft (Nikki carburetor only) and the throttle shaft for wear and free movement.

   NOTE: **Do not** attempt to disassemble or remove either shaft from the carburetor body, including the mounted clamp brackets on Impco style carburetors. The screws, attaching the choke and throttle plate to their respective shafts are staked or bonded to prevent loosening. The plate(s) and shaft(s) are not available separately. If detrimental wear or damage is found in any of the parts, the carburetor should be replaced.

LPG Carburetor - Reassembly

Impco Carburetor

1. Slide the venturi into the carburetor body, aligning the position mark made prior to removal. Correctly installed, the discharge holes should not be visible from the top.

2. Secure with the venturi retaining screw. Torque the screw to **4.0 N·m (36 in. lb.)**.

3. Install a new adapter gasket and mount the air cleaner adapter onto the carburetor with the four screws. Torque the screws to **4.0 N·m (36 in. lb.)**.

4. Install a new carburetor gasket onto the intake manifold adapter, followed by the carburetor. Install and finger tighten the mounting fasteners.

5. Connect the ‘‘Z” end of the throttle linkage and the dampening spring to the throttle clamp bracket on the throttle shaft. Attach the opposite end of linkage and spring to the governor lever.

   NOTE: The clamp brackets and stop collar mounted on the throttle shaft should still be in their original positions (See Figure 5A-2), and not require any readjustment/ resetting. Continue with steps 6 and 7. If the mounted position of any one of these was affected or changed, it will be necessary to check and reset the position of each before proceeding. Follow the complete instructions listed after step 7, then continue with steps 6 and 7.

6. Manually move the governor lever toward the carburetor as far as it will go.

7. Check that the throttle plate is now also fully open or reposition the carburetor slightly on the mounting screws so it is fully open. Torque the mounting screws to **9.9 N·m (88 in. lb.)**.

Instructions for Checking/Positioning the Clamp Brackets Mounted on the Throttle Shaft

Use only if the position or mounting of the clamp bracket(s) has been disturbed. Figures show the carburetor removed from the engine for clarity.

Idle Speed Clamp Bracket Position:

1. Counting the number of turns, back the idle speed adjustment screw off (counterclockwise), so only 1 to 1 1/2 of the threads are visible. See Figure 5A-8.

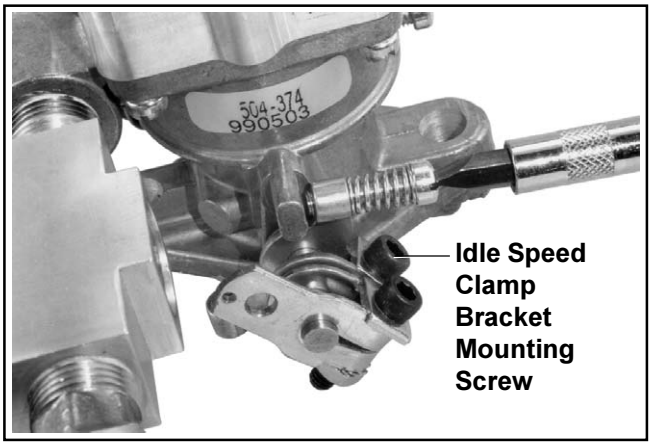


Figure 5A-8. Backing off Idle Speed Screw.

2. Loosen the clamp bracket mounting screw, and pivot the throttle shaft to fully close the throttle plate. See Figure 5A-9.

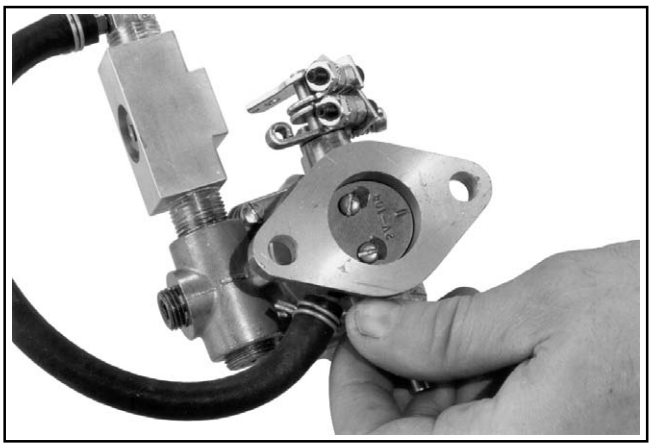


Figure 5A-9. Closing Throttle Plate.

3. Hold the throttle plate closed and rotate the clamp bracket until the end of the screw contacts the stop. Insert a 0.025 mm (0.001 in.) feeler gauge between the carburetor housing and the side of the clamp bracket to set the endplay, then tighten the mounting screw securely. See Figure 5A-10.

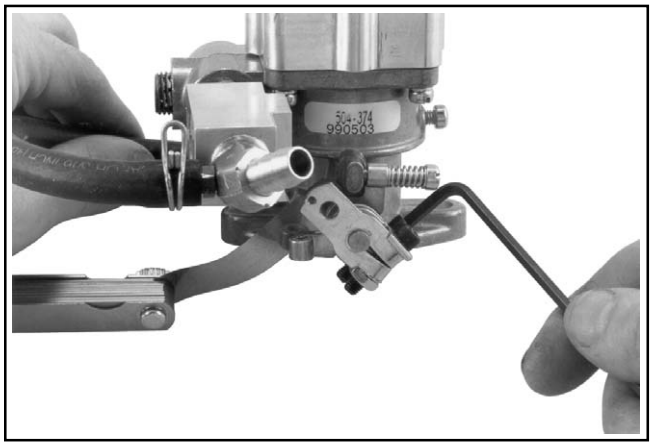


Figure 5A-10. Tightening Idle Speed Clamp Mounting Screw.

4. Reset the idle speed adjustment screw back to the original position.

High Speed/Stop Collar Position:

1. Make sure the idle speed clamp position has already been checked or properly set.

2. Rotate and hold the throttle shaft so the throttle plate is fully open/perfectly vertical. See Figure 5A-11.

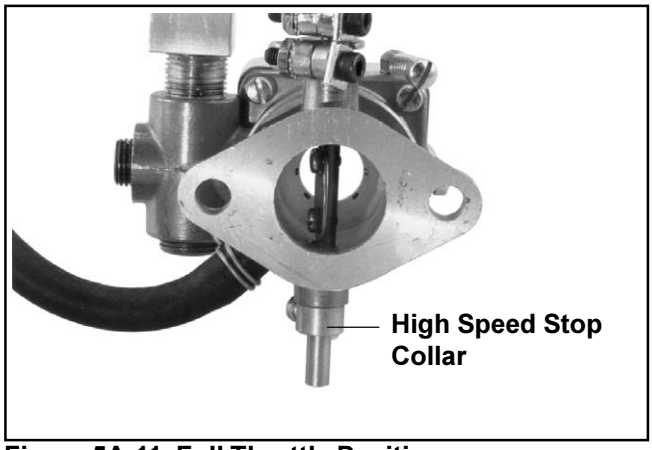


Figure 5A-11. Full Throttle Position.

3. Insert a 0.025 mm (0.001 in.) feeler gauge between the side of the stop collar and the carburetor housing, then check or set the position of the stop collar. The head of the mounting screw **must** be in contact with the carburetor boss from the back (hose/fitting) side, preventing any further rotation over center. Set or adjust the stop collar as required. See Figure 5A-12.

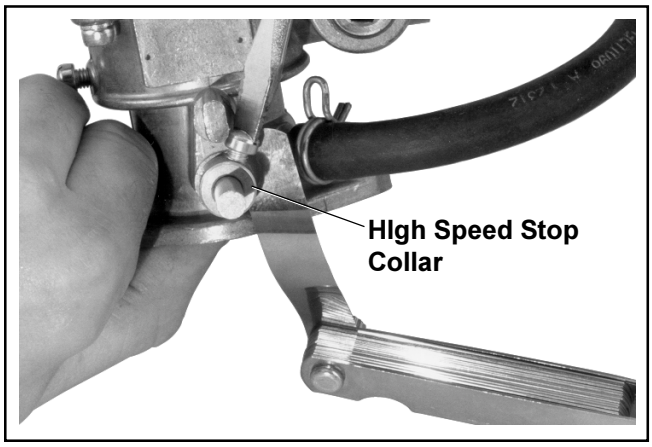


Figure 5A-12. Adjusting/Setting Stop Collar.

4. Tighten the screw securely.

NOTE: After the idle speed clamp bracket and the high speed stop collar positions have been set, check that the throttle shaft pivots freely without binding or restriction.

Throttle Linkage Clamp Bracket Position
Carburetor must be assembled to engine with linkage attached to set this position.

1. The throttle linkage clamp bracket should be positioned as shown in Figure 5A-13 on the idle speed clamp bracket side of the throttle shaft.

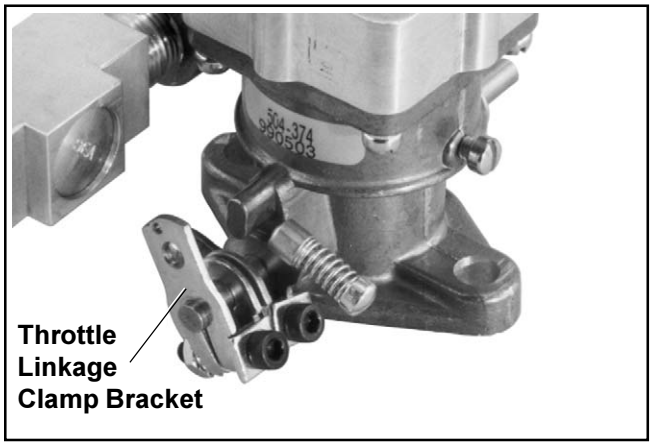


Figure 5A-13. Throttle Linkage Clamp Bracket Position.

5A

2. Manually move the governor lever, with the throttle linkage connected, toward the carburetor as far as it will go. Hold it in this position.

3. Looking down the throat of the carburetor, check that the throttle plate is in the full throttle position and that the head of the high speed collar stop screw is in contact with the carburetor boss. If not, loosen the carburetor mounting screws and reposition the carburetor slightly. Torque the carburetor mounting screws to **9.9 N·m (88 in. lb.)**.

   NOTE: If additional adjustment is required, loosen the throttle linkage clamp bracket mounting screw, set the throttle shaft to the full throttle position against the head of the stop screw, and retighten the clamp mounting screw securely. See Figure 5A-14.

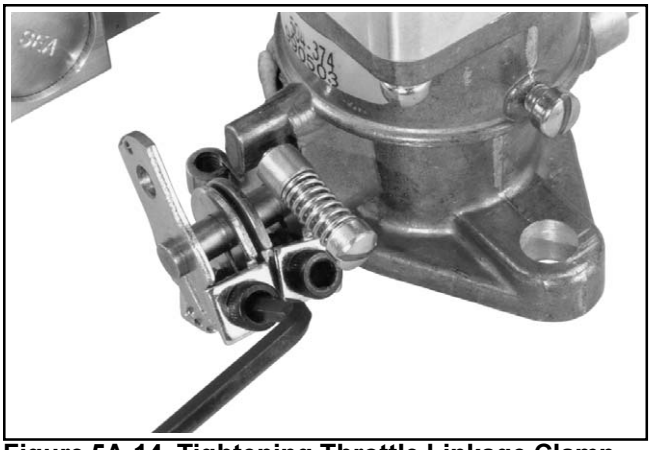


Figure 5A-14. Tightening Throttle Linkage Clamp Bracket.

Nikki Carburetor

1. Reinstall the rear plug with a new sealing washer. Tighten the plug securely.

2. Reinstall fuel transfer chamber cover with a new gasket. Secure with the three screws.

3. Install new carburetor mounting gasket on manifold studs, followed by the carburetor and new air cleaner base gasket.

4. Reconnect the throttle and choke linkages, and the fuel and vacuum lines.

5. Reinstall the air cleaner base and breather tube. Secure base with two mounting nuts. Torque nuts to **9.9 N·m (88 in. lbs.)**. Install the rest of the air cleaner system.

7. Check to be sure all system connections are tight.

8. Reset idle RPM and recheck high idle (governed speed) after starting and allowing sufficient warm-up time.

Electric Lock-Off/Filter Assembly - Functional Test
The electric lock-off can be easily tested to verify that it is functional. Remove it from the system for testing. Using a 12 volt power supply or battery, connect one wire lead to the positive (+) lead of power supply, and touch remaining wire lead to negative (-) lead of power supply. When connection is made, an audible “click” should be heard indicating the opening of the lock-off. While energized, blow compressed air through it to determine if it is blocked or restricted.

Figure 5A-15.

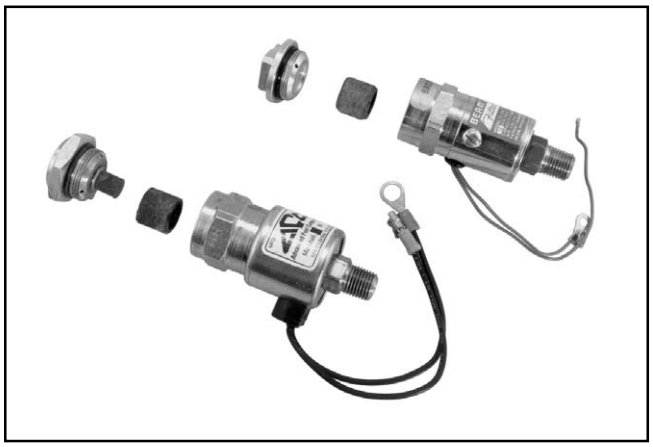


Figure 5A-16.

Electric Lock-Off/Filter Assembly - Filter Service
The filter inside the lock-off assembly should be replaced **every 500 hours** of operation, or if it becomes blocked or restricted. Cleaning of the filter element is not recommended. Order a replacement filter element by the appropriate Kohler part number.

Vaporizer Assembly

The outer surface of the vaporizer should be kept free of dirt and debris accumulation, which will cause a loss of vaporization efficiency. Visual inspection and necessary cleaning should be performed on a regular basis, more frequently under dusty or dirty conditions. The vaporizer should be disassembled, cleaned, and serviced using a rebuild kit **every 1500 hours** or if a problem is encountered.

Figure 5A-17.

LPG Regulator

The regulator controls both the pressure and flow of fuel within the LP system. It is comprised of both a primary and secondary chamber, which are dependent upon one another. Two different styles of regulators are used, based upon the system involved. The Impco (Beam) regulator is shown in Figure 5A-18, and the Nikki regulator is shown in Figure 5A-19. Although the basic design and operating principles are similar, due to system differences the regulators should not be interchanged.

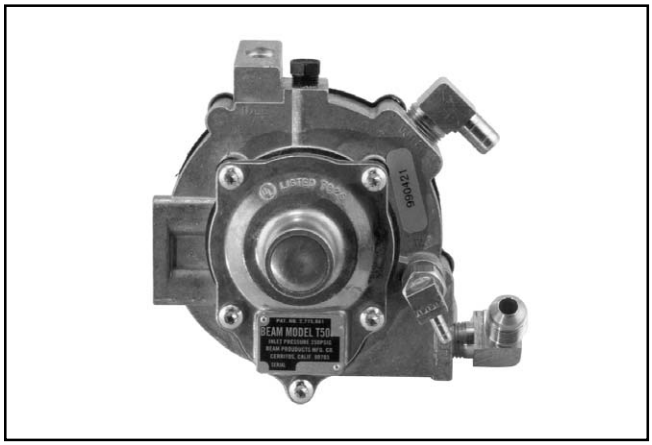


Figure 5A-18. Impco (Beam) Regulator.

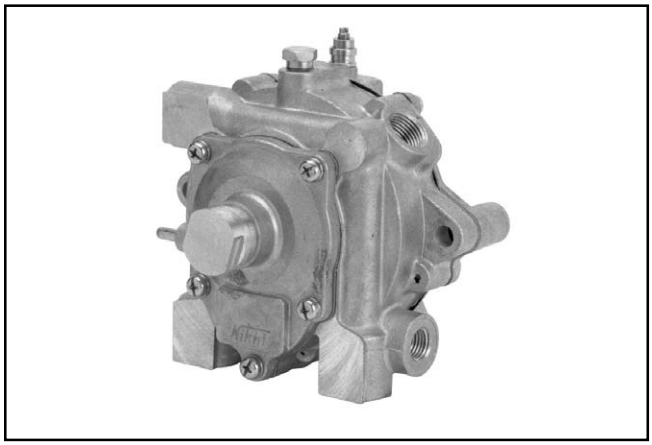


Figure 5A-19. Nikki Regulator.

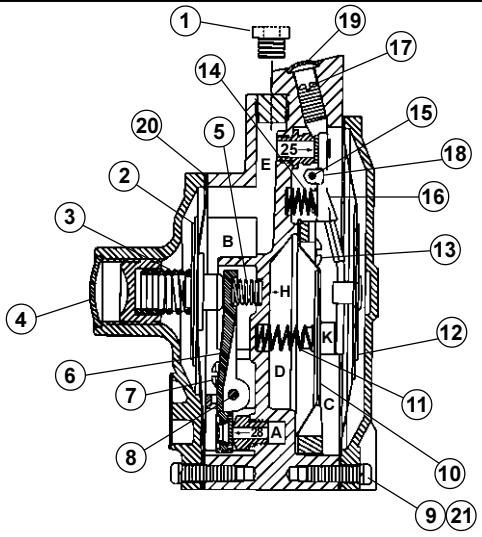
Following are separate sections covering the theory of operation and general service information for each style of regulator. Detailed service/repair instructions are included in the rebuild kit for each regulator.

Impco (Beam) Regulator (See Figure 5A-20)
LPG vapor enters at point **(A)**, then passes into primary area **(B)** at point **(28)**, where pressure is reduced from up to 250 psi at the tank to 4.5 psi in area **(B)**. Fuel pressure against diaphragm **(2)** overcomes spring **(3)** and as movement increases, spring **(5)** will close lever **(6)**. The primary diaphragm breather (not shown in drawing) is vented to secondary chamber so that rupture of this diaphragm would direct fuel into the carburetor.

Fuel now moves through passage **(E)**, past secondary valve **(25)** into secondary area **(C)**. As negative pressure (vacuum) is created at the carburetor venturi and is transmitted through the dry-gas hose to chamber **(C)** secondary diaphragm **(12)** is drawn down and contacts the secondary lever **(16)**. Fuel will flow in proportion to air velocity through carburetor venturi, insuring an ideal mixture at all engine speeds.

Whenever the engine is operating, vacuum diaphragm **(10)** is down against floor **(H)** and spring **(11)** is compressed. The idle and starting adjustment is made with a tamper-resistant screw **(17)** which regulates the whisker wire system (not shown), opening up the secondary orifice slightly (but only when the vacuum diaphragm is drawn down). Very little vacuum is needed to start this vacuum diaphragm travel: 0.2" Mercury to start and 0.5" Mercury for full travel. The instant the engine stops rotating, loss of vacuum in section **(D)** releases diaphragm **(10)** causing bumper **(K)** to push against secondary lever **(16)**, overcoming action of whisker wire and ensuring 100% lock off.

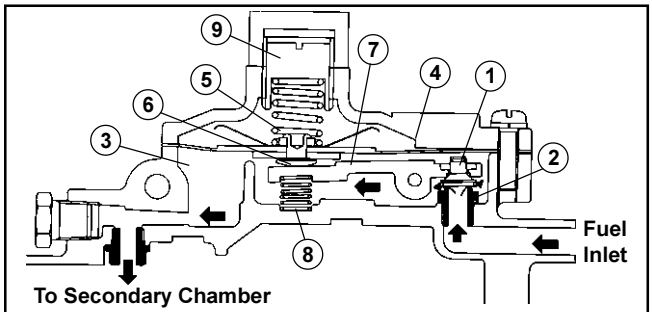
This patented Beam design will lock off primary pressures up to five times in excess of normal and permits starting without priming or choking.



1) 1/8-27 NPT Plug
2) Primary Diaphragm Assembly
3) Primary Spring
4) Expansion Plug
5) Secondary Diaphragm Spring
6) Primary Lever Assembly
7) Fillister Head Screw
8) Primary Pivot Pin
9) Torx Head Screw
10) Vac Lock Diaphragm Assembly
11) Vac Lock Spring
12) Secondary Diaphragm
13) Pan Head Screw
14) Secondary Lever Spring
15) Secondary Pivot Pin
16) Secondary Lever Assembly
17) Adjustment Screw
18) Pan Head Screw
19) Expansion Plug
20) Diaphragm Gasket
21) Split Lock Washer

Figure 5A-20.

Nikki Regulator Primary Chamber
(See Figure 5A-21)
The primary chamber reduces the high pressure fuel flow from the tank and vaporizer down to approximately 4 psi. Fuel flowing from the vaporizer enters the inlet of the regulator under approximately **76 kPa (11 psi)** of pressure. There it is delivered to the primary chamber **(3)** through the clearance between the primary valve **(1)** and valve seat **(2)**. As fuel continues to flow and the primary chamber approaches **29 kPa (4 psi)**, the primary diaphragm **(4)** overcomes the tension of the diaphragm spring **(5)**. As the diaphragm **(4)** and contact button **(6)** move up, the primary lever spring **(8)** pushes the primary lever **(7)** up, in turn closing the primary valve **(1)** and stopping the flow of fuel. As fuel is consumed and the pressure in the primary chamber drops below **29 kPa (4 psi)**, the diaphragm spring **(5)** tension will be greater than the fuel pressure, causing the primary diaphragm **(4)** to be pushed down. This causes the contact button **(6)**, to push the primary lever **(7)** down, in turn opening the primary valve **(1)** and admitting more fuel. In this manner, the pressure within the primary chamber is maintained at a relatively constant **29 kPa (4 psi)**.

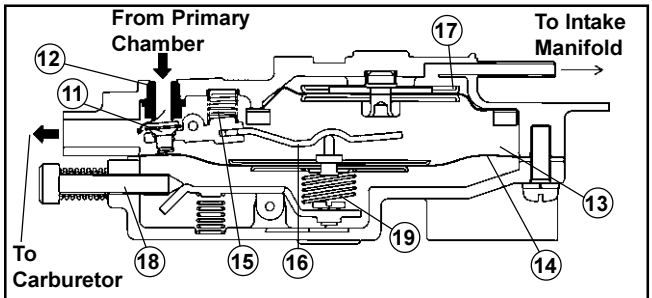


1) Primary Valve
2) Primary Valve Seat
3) Primary Chamber
4) Primary Diaphragm
5) Primary Diaphragm Spring
6) Contact Button
7) Primary Valve Lever
8) Primary Lever Spring
9) Primary Pressure Adjustment

Figure 5A-21. Primary Chamber.

Nikki Regulator Secondary Chamber
(See Figure 5A-22)
The secondary chamber further reduces the fuel pressure from the **29 kPa (4 psi)** of the primary chamber to near **0 kPa (0 psi)** pressure, to prevent excessive fuel flow to the carburetor. Fuel enters the secondary chamber **(13)** through the clearance between the secondary valve **(11)** and the valve seat **(12)**. While the engine is operating, and fuel is being drawn from the secondary chamber, the secondary diaphragm **(14)** is raised by atmospheric pressure, simultaneously lifting the secondary valve lever **(16)**, opening the secondary valve **(11)**, allowing fuel to flow. When the engine is running at idle, there may not be enough vacuum created in the carburetor venturi to overcome the tension of the secondary diaphragm spring **(15)**, and the secondary diaphragm cannot open the valve. Under those conditions, the idle adjusting screw **(18)**, and balance spring **(19)** are used to apply just enough pressure on the diaphragm **(14)** to maintain sufficient fuel flow for idle operation.

The vacuum lock-off mechanism is located in the secondary chamber. When the engine is running, manifold vacuum above the diaphragm **(17)** draws it up, so the secondary valve can function normally. When the engine is stopped, manifold vacuum is terminated, and the diaphragm relaxes and pushes down on the secondary valve lever, preventing any fuel flow or leakage through the regulator.



11) Secondary Valve
12) Secondary Valve Seat
13) Secondary Chamber
14) Secondary Diaphragm
15) Secondary Diaphragm Spring
16) Secondary Valve Lever
17) Vacuum Lock-Off Diaphragm
18) Idle Adjust Screw
19) Balance Spring

Figure 5A-22. Secondary Chamber.

Preventative Maintenance
The regulator is preset at the factory and generally requires no further adjustment. No periodic service is required. Over time, depending on fuel quality, operating environment, and system performance, fuel deposits can accumulate inside the regulator. Those regulators containing a drain plug should be drained every **500 hours** to remove any accumulated deposits. See Figure 5A-23.

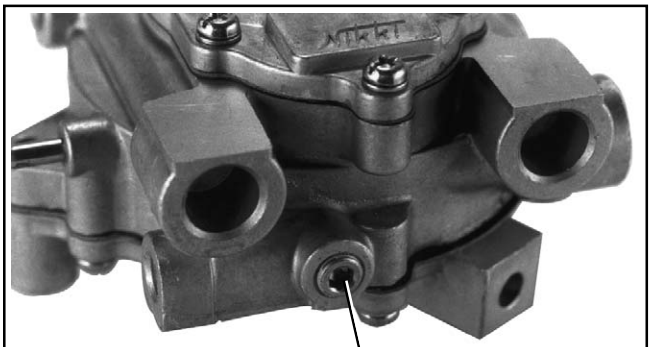


Figure 5A-23. Regulator Drain Plug (some models)

1. Turn supply valve off, run engine out of fuel, and turn off ignition switch.

2. Disconnect and ground the spark plug leads.

3. Remove the 1/8" pipe plug from bottom of regulator and drain any accumulated deposits. See Figure 5A-23.

4. Reinstall plug using pipe sealant with Teflon® (Loctite® 592 or equivalent) on threads and tighten securely. If required, a replacement plug is available as Kohler Part No. X-75-23-S.

Regulator Service
Every 1500 hours it is recommended that disassembly, cleaning, and resetting of the regulator be performed using the regulator rebuilding kit available. Specific instructions are included in the rebuilding kit. Perform the regulator service following the instructions provided. As all adjustments and settings must be reset using specific test equipment, this must be performed by qualified LP personnel only.

Impco (Beam) Regulator Service
Kohler repair kit 24 757 40-S should be used to service the regulator **every 1500 hours,** or whenever cleaning and servicing is required.

Nikki Regulator Service
Kohler repair kit 24 757 39-S should be used **every 1500 hours**.

Section 5B
Electronic Fuel Injection (EFI) Fuel System

Contents

Description

⚠ WARNING

Explosive Fuel can cause fires and severe burns.

Fuel system ALWAYS remains under HIGH PRESSURE.

⚠ WARNING: Explosive Fuel!

Gasoline is extremely flammable and its vapors can explode if ignited. Store gasoline only in approved containers, in well ventilated, unoccupied buildings, away from sparks or flames. Do not fill the fuel tank while the engine is hot or running, since spilled fuel could ignite if it comes in contact with hot parts or sparks from ignition. Do not start the engine near spilled fuel. Never use gasoline as a cleaning agent.

The EFI fuel system remains under high pressure, even when the engine is stopped. Before attempting to service any part of the fuel system, the pressure must be relieved. Pressure tester Kohler Part No. 24 455 04-S has an integral relief valve. Connect the black tester hose to the test valve in the fuel rail. Route the clear hose into a portable gasoline container. Depress the button on the tester relief valve.

Initial Starting/Priming Procedure

Important: The EFI fuel system must be purged of all air prior to the initial start up, and/or any time the system has been disassembled. On most engines, that can be done similar to relieving fuel pressure, as described above.

Test Valve in Fuel Rail:

1. Connect the pressure gauge as described above for relieving fuel pressure. Depress and hold the release button and crank the engine in 10-15 second intervals, allowing a 60 second cool-down period between intervals, until air is purged and fuel is visible in discharge tube.

2. If you do not have the pressure gauge, follow the procedure for engines without a test valve.

NO Test Valve in Fuel Rail:

1. Crank the engine in 10-15 second intervals, allowing a 60 second cool-down period between cranking intervals, until the engine starts.

NOTE: The number of cranking intervals necessary will depend on the individual system design, and/or where the system has been disassembled.

Fuel Recommendations

General Recommendations

Purchase gasoline in small quantities and store in clean, approved containers. An approved container with a capacity of 2 gallons or less with a pouring spout is recommended. Such a container is easier to handle and helps prevent spillage during refueling.

- Do not use gasoline left over from the previous season, to minimize gum deposits in your fuel system, and to ensure easy starting.

- Do not add oil to the gasoline.

- Do not overfill the fuel tank. Leave room for the fuel to expand.

Fuel Type

Do not use leaded gasoline, as component damage will result. Any costs/damages incurred as a result of using leaded fuel will not be warranted. Use only clean, fresh, **unleaded** gasoline with a pump sticker octane rating of 87 or higher. In countries using the Research method, it should be 90 octane minimum.

Gasoline/Alcohol blends

Gasohol (up to 10% ethyl alcohol, 90% unleaded gasoline by volume) is approved as a fuel for Kohler EFI engines. Other gasoline/alcohol blends are not approved.

Gasoline/Ether blends

Methyl Tertiary Butyl Ether (MTBE) and unleaded gasoline blends (up to a maximum of 15% MTBE by volume) are approved as a fuel for Kohler EFI engines. Other gasoline/ether blends are not approved.

EFI Fuel System Components

General
The Electronic Fuel Injection (EFI) system is a complete engine fuel and ignition management design. The system includes the following principal components:

- Fuel Pump
- Fuel Filter
- Fuel Rail
- Fuel Line(s)
- Fuel Pressure Regulator
- Fuel Injectors
- Throttle Body/Intake Manifold
- Engine Control Unit (ECU)
- Ignition Coils
- Oil Temperature Sensor
- Throttle Position Sensor (TPS)
- Speed Sensor
- Oxygen Sensor
- Wire Harness Assembly & Affiliated Wiring,
- Malfunction Indicator Light (MIL)

Operation
The EFI system is designed to provide peak engine performance with optimum fuel efficiency and lowest possible emissions. The ignition and injection functions are electronically controlled, monitored and continually corrected during operation to maintain the theoretical ideal or "stoichiometric" air/fuel ratio of 14.7:1.

The central component of the system is the Motronic™ Engine Control Unit (ECU) which manages system operation, determining the best combination of fuel mixture and ignition timing for the current operating conditions.

An electric fuel pump is used to move fuel from the tank through the fuel line and in-line fuel filter. A fuel pressure regulator maintains a system operating pressure of 39 psi and returns any excess fuel to the tank. At the engine, fuel is fed through the fuel rail and into the injectors, which inject it into the intake ports. The ECU controls the amount of fuel by varying the length of time that the injectors are "on." This can range from 1.5-8.0 milliseconds depending on fuel requirements. The controlled injection of the fuel occurs each crankshaft revolution, or twice for each 4-stroke cycle. One-half the total amount of fuel needed for one firing of a cylinder is injected during each injection. When the intake valve opens, the fuel/air mixture is drawn into the combustion chamber, ignited, and burned.

The ECU controls the amount of fuel injected and the ignition timing by monitoring the primary sensor signals for engine temperature, speed (RPM), and throttle position (load). These primary signals are compared to preprogrammed "maps" in the ECU computer chip, and the ECU adjusts the fuel delivery to match the mapped values. An oxygen sensor provides continual feedback to the ECU based upon the amount of unused oxygen in the exhaust, indicating whether the fuel mixture being delivered is rich or lean. Based upon this feedback, the ECU further adjusts fuel input to re-establish the ideal air/fuel ratio. This operating mode is referred to as "closed loop" operation. The EFI system operates "closed loop" when all three of the following conditions are met:

a. The oil temperature is greater than 35°C (86°F).

b. The oxygen sensor has warmed sufficiently to provide a signal (minimum 375°C, 709°F).

c. Engine operation is at a steady state (not starting, warming up, accelerating, etc.).

During "closed loop" operation the ECU has the ability to readjust temporary and learned adaptive controls, providing compensation for changes in overall engine condition and operating environment, so it will be able to maintain the ideal air/fuel ratio of 14.7:1. The system requires a minimum engine oil temperature greater than 55°C (130°F) to properly adapt. These adaptive values are maintained as long as the ECU is "powered up" by the battery.

During certain operating periods such as cold starts, warm up, acceleration, etc., an air/fuel ratio richer than 14.7:1 is required, and the system operates in an "open loop" mode. In "open loop" operation the monitoring of exhaust gases (output) is not used, and the controlling adjustments are based on the primary sensor signals and programmed maps only. The system operates "open loop" whenever the three conditions for closed loop operation (above) are not being met.

Important Service Notes!

- Cleanliness is essential and must be maintained at all times when servicing or working on the EFI system. Dirt, even in small quantities, can cause significant problems.
- Clean any joint or fitting with parts cleaning solvent before opening to prevent dirt from entering the system.
- Always depressurize the fuel system through the test valve in fuel rail before disconnecting or servicing any fuel system components. See fuel warning on page 5B.2.
- Never attempt to service any fuel system component while engine is running or ignition switch is **"on."**
- Do not use compressed air if the system is open. Cover any parts removed and wrap any open joints with plastic if they will remain open for any length of time. New parts should be removed from their protective packaging just prior to installation.
- Avoid direct water or spray contact with system components.
- Do not disconnect or reconnect the wiring harness connector to the control unit or any individual components with the ignition "on." This can send a damaging voltage spike through the ECU.
- Do not allow the battery cables to touch opposing terminals. When connecting battery cables attach the positive (+) cable to positive (+) battery terminal first, followed by negative (-) cable to negative (-) battery terminal.
- Never start the engine when the cables are loose or poorly connected to the battery terminals.
- Never disconnect battery while engine is running.
- Never use a quick battery charger to start the engine.
- Do not charge battery with key switch "on."
- Always disconnect negative (-) battery cable lead before charging battery, and also unplug harness from ECU before performing any welding on equipment.

Electrical Components

Electronic Control Unit (ECU)

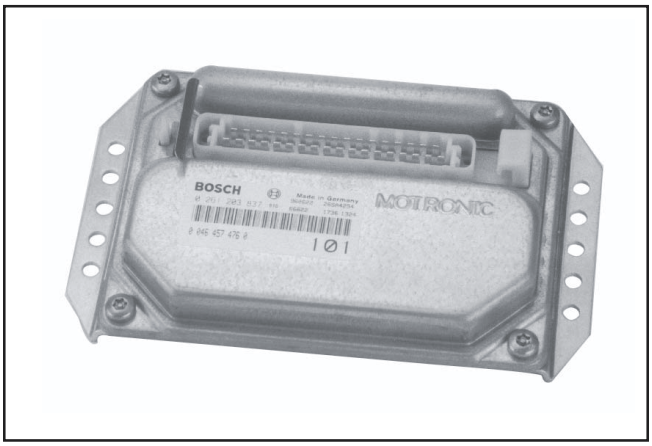


Figure 5B-1. Metal-Cased ECU.

Figure 5B-2. Plastic-Cased ECU.

Two different ECU's have been used in EFI production. The first style has a metal case with a larger connector block. See Figure 5B-1. The second style has a plastic casing and smaller connector block. See Figure 5B-2. Basic function and operating control remains the same between the two, however, due to differences in the internal circuitry as well as the wiring harness, the two ECU's are not interchangeable and have certain individual service/troubleshooting procedures. Where applicable, they are covered individually as "Metal-Cased ECU Systems" or "Plastic-Cased ECU Systems".

General
The ECU is the brain or central processing computer of the entire EFI fuel/ignition management system. During operation, sensors continuously gather data which is relayed through the wiring harness to input circuits within the ECU. Signals to the ECU include: ignition (on/off), crankshaft position and speed (RPM), throttle position, oil temperature, exhaust oxygen levels, and battery voltage. The ECU compares the input signals to the programmed maps in its memory to determine the appropriate fuel and spark requirements for the immediate operating conditions. The ECU then sends output signals to set the injector duration and ignition timing.

The ECU continually performs a diagnostic check of itself, each of the sensors, and the system performance. If a fault is detected, the ECU turns on the Malfunction Indicator Light (MIL) on the equipment control panel, stores the fault code in its fault memory, and goes into a default operating mode. Depending on the significance or severity of the fault, normal operation may continue, or "limp home" operation (slowed speed, richer running) may be initiated. A technician can access the stored fault code using a "blink code" diagnosis flashed out through the MIL. An optional computer software diagnostic program is also available.

The ECU requires a minimum of 7.0 volts to operate. The adaptive memory in the ECU is operational the moment the battery cables are connected, however the adapted values are lost if the battery becomes disconnected for any reason. The ECU will "relearn" the adapted values if the engine is operated for 10-15 minutes at varying speeds and loads after the oil temperature exceeds 55°C (130°F).

To prevent engine over-speed and possible failure, a "rev-limiting" feature is programmed into the ECU. If the maximum RPM limit (4125) is exceeded, the ECU suppresses the injection signals, cutting off the fuel flow. This process repeats itself in rapid succession, limiting operation to the preset maximum.

Service
Never attempt to disassemble the ECU. It is sealed to prevent damage to internal components. Warranty is void if the case is opened or tampered with in any way.

All operating and control functions within the ECU are preset. No internal servicing or readjustment may be performed. If a problem is encountered, and you determine the ECU to be faulty, contact Kohler Co. Engine Service at 1-920-457-4441 for specific handling instructions. Do not replace the ECU without factory authorization.

The relationship between the ECU and the throttle position sensor (TPS) is very critical to proper system operation. If the TPS or ECU is changed, or the mounting position of the TPS is altered, the "TPS Initialization Procedure" (see page 5B.8) must be performed to restore the synchronization.

Engine Speed Sensor

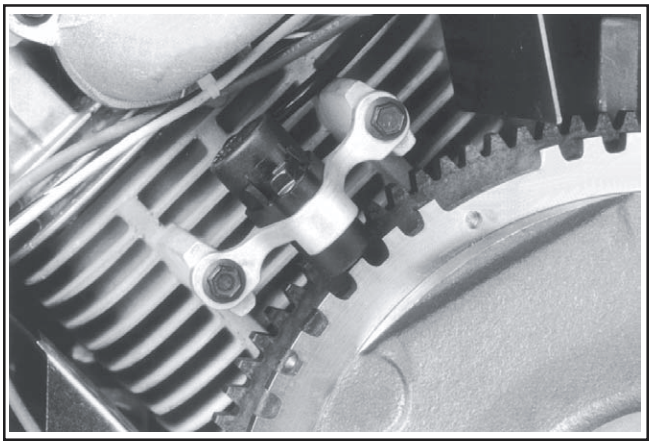


Figure 5B-3. Engine Speed Sensor.

General
The engine speed sensor is essential to engine operation; constantly monitoring the rotational speed (RPM) of the crankshaft. A ferromagnetic 60-tooth ring gear with two consecutive teeth missing is mounted on the flywheel. The inductive speed sensor is mounted **1.5 ± 0.25 mm (0.059 ± 0.010 in.)** away from the ring gear. During rotation, an AC voltage pulse is created within the sensor for each passing tooth. The ECU calculates engine speed from the time interval between the consecutive pulses. The two-tooth gap creates an interrupted input signal, corresponding to specific crankshaft position (84° BTDC) for cylinder #1. This signal serves as a reference for the control of ignition timing by the ECU. Synchronization of the inductive speed pickup and crankshaft position takes place during the first two revolutions each time the engine is started. The sensor must be properly connected at all times. If the sensor becomes disconnected for any reason, the engine will quit running.

Service
The engine speed sensor is a sealed, non-serviceable assembly. If "Fault Code" diagnosis indicates a problem within this area, test and correct as follows.

1. Disconnect main harness connector from ECU.

2. Connect an ohmmeter between the designated pin terminals in the plug:

   Metal-Cased ECU: #3 and #21 pin terminals.

   Plastic-Cased ECU: #9 and #10 pin terminals.

   See chart on page 5B.26 or 5B.29, according to ECU style. A resistance value of **750-1000 Ω** at room temperature (20° C, 68° F) should be obtained. If resistance is correct, check the mounting, air gap, toothed ring gear (damage, runout, etc.), and flywheel key.

3. Disconnect speed sensor connector from wiring harness. It is the connector with one heavy black lead (see Figure 5B-4). Viewing the connector as shown (dual aligning rails on top), test resistance between the terminals indicated. A reading of **750-1000 Ω** should again be obtained.

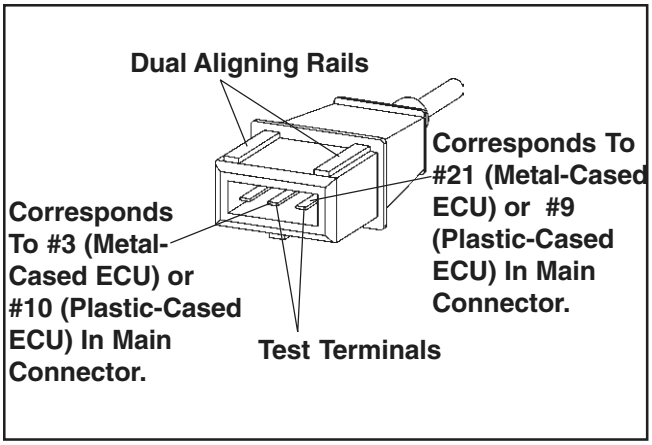


Figure 5B-4. Throttle Position Sensor Connector.

   a. If the resistance is incorrect, remove the screw securing the sensor to the mounting bracket and replace the sensor.

   b. If the resistance in step 2 was incorrect, but the resistance of the sensor alone was correct, test the main harness circuits between the sensor connector terminals and the corresponding pin terminals in the main connector. Correct any observed problem, reconnector the sensor, and perform step 2 again.

Throttle Position Sensor (TPS)

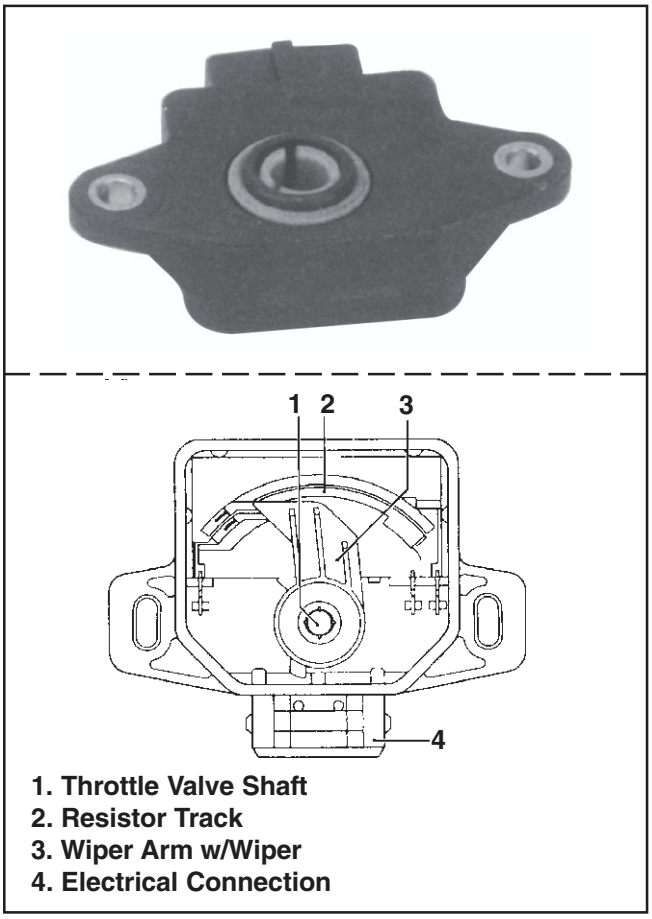


Figure 5B-5. Throttle Position Sensor Details.

General
The throttle position sensor (TPS) is used to indicate throttle plate angle to the ECU. Since the throttle (by way of the governor) reacts to engine load, the angle of the throttle plate is directly proportional to the load on the engine.

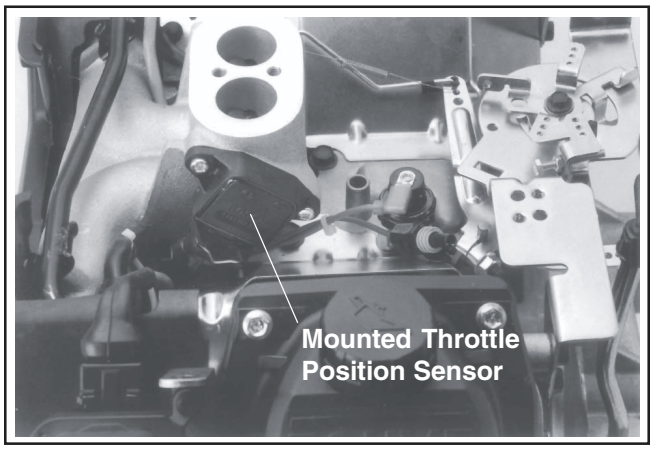


Figure 5B-6. TPS Location.

Mounted on the throttle body/intake manifold and operated directly off the end of the throttle shaft, the TPS works like a rheostat, varying the voltage signal to the ECU in direct correlation to the angle of the throttle plate. This signal, along with the other sensor signals, is processed by the ECU and compared to the internal pre-programmed maps to determine the required fuel and ignition settings for the amount of load.

The correct position of the TPS is established and set at the factory. Do not loosen the TPS or alter the mounting position unless absolutely required by fault code diagnosis or throttle shaft service. If the TPS is loosened or repositioned the "TPS Initialization Procedure" (pages 5B.8-5B.9) **must** be performed to re-establish the baseline relationship between the ECU and the TPS.

Service
The TPS is a sealed, non-serviceable assembly. If diagnosis indicates a bad sensor, complete replacement is necessary. If a blink code indicates a problem with the TPS, it can be tested as follows.

1. Counting the number of turns, back out the idle speed adjusting screw (counterclockwise) until the throttle plates can be closed completely.

2. Disconnect the main harness connector from the ECU, but leave the TPS mounted to the throttle body/manifold.

3. Connect the ohmmeter leads as follows: (See chart on page 5B.26 or 5B.29.)

   Metal-Cased ECU: Red (positive) ohmmeter lead to #12 pin terminal, and Black (negative) ohmmeter lead to #27 pin terminal.

   Plastic-Cased ECU: Red (positive) ohmmeter lead to #8 pin terminal, and Black (negative) ohmmeter lead to #4 pin terminal.

   Hold the throttle closed and check the resistance. It should be **800-1200 Ω.**

4. Leave the leads connected to the pin terminals as described in step 3. Rotate the throttle shaft slowly counterclockwise to the full throttle position. Monitor the dial during rotation for indication of any momentary short or open circuits. Note the resistance at the full throttle position. It should be **1800-3000 Ω.**

5. Disconnect the main wiring harness connector from the TPS, leaving the TPS assembled to the manifold. Refer to the chart below and perform the resistance checks indicated between the terminals in the TPS socket, with the throttle in the positions specified.

Throttle Position	Between Terminals	Resistance Value (Ω)	Continuity
Closed	2 & 3	800-1200	Yes
Closed	1 & 3	1800-3000	Yes
Full	2 & 3	1800-3000	Yes
Full	1 & 3	800-1200	Yes
Any	1 & 2	1600-2500	Yes

   If the resistance values in steps 3, 4, and 5 are within specifications, go to step 6.

   If the resistance values are not within specifications, or a momentary short or open circuit was detected during rotation (step 4), the TPS needs to be replaced, go to step 7.

6. Check the TPS circuits (input, ground) between the TPS plug and the main harness connector for continuity, damage, etc. See chart on page 5B.26 or 5B.29.

   Metal-Cased ECU: Pin Circuits #12 and #27.

   Plastic-Cased ECU: Pin Circuits #8 and #4.

   a. Repair or replace as required.

   b. Turn the idle speed screw back in to its original setting.

   c. Reconnect connector plugs, start engine and retest system operation.

7. Remove the two mounting screws from the TPS. Save the screws for reuse. Remove and discard the faulty TPS. Install the replacement TPS and secure with the original mounting screws.

   a. Reconnect both connector plugs.

   b. Perform the "TPS Initialization Procedure" integrating the new sensor to the ECU.

TPS Initialization Procedure

1. Check that the basic engine, all sensors, fuel, fuel pressure, and battery are good and functionally within specifications.

   Important!

2. **Remove/disconnect ALL external loads from engine** (belts, pumps, electric PTO clutch, alternator, rectifier-regulator, etc.).

3. Start the engine and allow it to warm up for 5-10 minutes, so oil temperature is above 55°C (130°F).

4. Move the throttle control to the idle position and allow engine to stabilize for a minimum of one minute.

5. Install a heavy rubber band around the throttle lever and the manifold boss. On some EFI engines there is a dampening spring on the end of the idle speed screw. The dampening spring (if used) should be fully compressed and the tab on the throttle lever in direct contact with the speed screw. Adjust the idle speed to **1500 RPM**, using a tachometer.

6. Shut off engine.

7. Locate the service connector plug in the wiring harness.

   Metal-Cased ECU: Connect a jumper wire from the TPS initialization pin #8 (gray wire) to the ground pin (black wire), or use jumper connector plug (SPX Part No. KO3217-7, with red jumper wire). See Figure 5B-7.

   Plastic-Cased ECU: Connect a jumper wire from the TPS intialization pin #24 (violet wire) to the battery voltage pin (red wire), or use jumper connector plug (SPX Part No. KO3217-9, with blue jumper wire). See Figure 5B-8.

Figure 5B-7. Service Connector Plug, Metal-Cased ECU Harness.

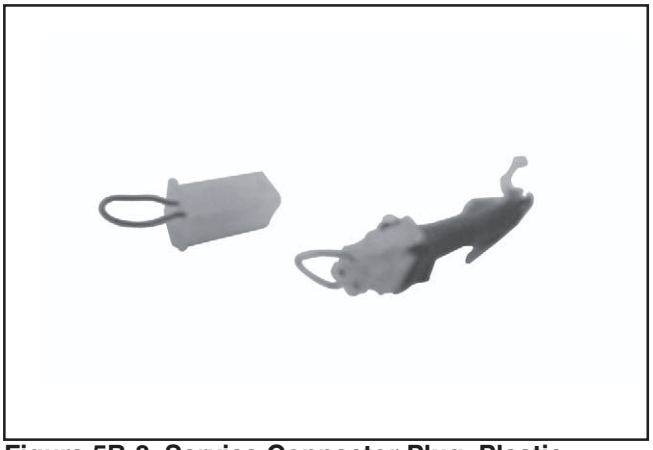


Figure 5B-8. Service Connector Plug, Plastic-Cased ECU Harness.

8. Hold throttle against idle speed stop screw, turn the ignition switch to **"on"** position (do not start engine), and observe the Malfunction Indicator Light (MIL).

   a. The light should blink on/off quickly for approximately 3 seconds and then go off and stay off, indicating the initialization procedure has been successful.

   b. If light stays on or blinking ceases prematurely, the procedure was unsuccessful and must be repeated. Possible causes for unsuccessful learning may be: 1) Movement occurred in either the TPS or throttle shaft during procedure, 2) Crankshaft movement/ rotation was detected by the speed sensor during procedure, 3) Throttle plate position was out of learnable range (recheck the 1500 RPM idle speed adjustment), or 4) Problem with ECU or TPS.

9. When the initialization procedure has been successfully completed, turn off the key switch, remove the jumper wire or connector, and remove the rubber band from the throttle lever.

10. Disconnect negative (-) battery cable temporarily to clear all learned adjustments.

11. Reconnect the battery cable and all external loads. Readjust the idle speed to the equipment manufacturer's specified setting and recheck the high-speed, no-load RPM setting. Observe the overall performance.

Oil Temperature Sensor

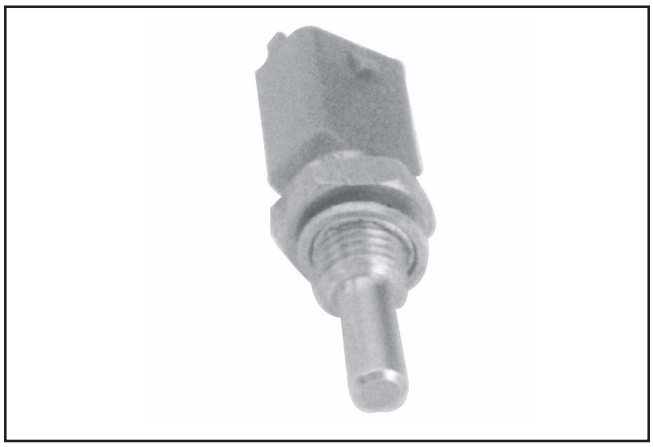


Figure 5B-9. Oil Temperature Sensor.

General
The oil temperature sensor is used by the system to help determine fuel requirements for starting (a cold engine needs more fuel than one at or near operating temperature). Mounted in the oil filter adapter housing, it has a temperature-sensitive resistor that extends into the oil flow. The resistance changes with oil temperature, altering the voltage sent to the ECU. Using a table stored in its memory, the ECU correlates the voltage drop to a specific temperature. Using the fuel delivery "maps", the ECU then knows how much fuel is required for starting at that temperature.

Service
The temperature sensor is a sealed, non-serviceable assembly. A faulty sensor must be replaced. If a blink code indicates a problem with the temperature sensor, it can be tested as follows.

1. Remove the temperature sensor from the adapter housing and cap or block the adapter hole.

2. Wipe sensor clean and allow it to reach room temperature (20°C, 68°F).

3. Unplug the main harness connector from the ECU.

4. With the sensor connected, check the temperature sensor circuit resistance. The value should be **2375-2625 Ω**. See chart on page 5B.26 or 5B.29.

   Metal-Cased ECU: Check between the #14 and #27 pin terminals.

   Plastic-Cased ECU: Check between the #6 and #4 pin terminals.

5. Unplug the sensor connector and check sensor resistance separately. Resistance value should again be **2375-2625 Ω**.

   a. If the resistance is out of specifications, replace the temperature sensor.

   b. If it is within specifications, proceed to Step 6.

6. Check the temperature sensor circuits (input, ground) from the main harness connector to the corresponding terminal in the sensor plug for continuity, damage, etc.

   Metal-Cased ECU: Pin circuits #14 and #27.

   Plastic-Cased ECU: Pin circuits #6 and #4.

Oxygen Sensor

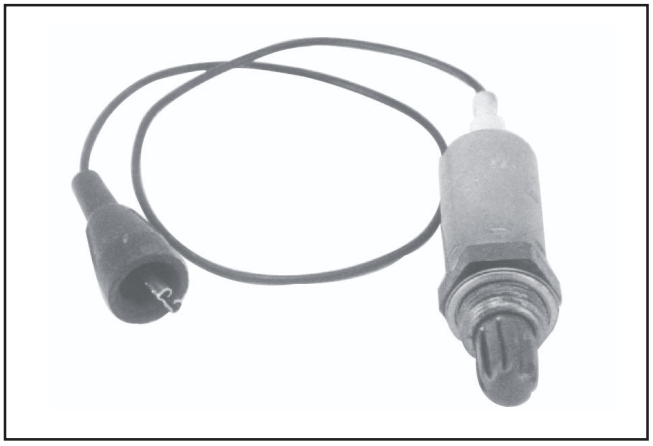
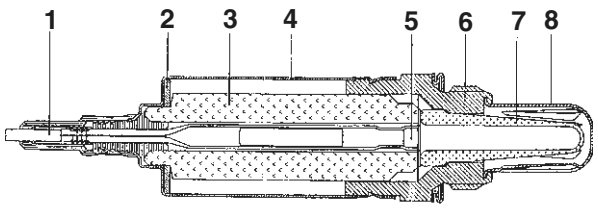


Figure 5B-10. Oxygen Sensor.

General

The oxygen sensor functions like a small battery, generating a voltage signal to the ECU, based upon the difference in oxygen content between the exhaust gas and the ambient air.

The tip of the sensor, protruding into the exhaust gas, is hollow (see cutaway Figure 5B-11). The outer portion of the tip is surrounded by the exhaust gas, with the inner portion exposed to the ambient air. When the oxygen concentration on one side of the tip is different than that of the other side, a voltage signal between 0.2 and 1.0 volts is generated between the electrodes and sent to the ECU. The voltage signal tells the ECU if the engine is straying from the ideal 14.7:1 fuel mixture, and the ECU then adjusts the injector pulse accordingly.



1. Connection Cable
2. Disc Spring
3. Ceramic Support Tube
4. Protective Sleeve
5. Contact Element
6. Sensor Housing
7. Active Ceramic Sensor
8. Protective Tube

Figure 5B-11. Cutaway of Oxygen Sensor.

The oxygen sensor can function only after being heated by exhaust temperatures to a minimum of 375°C (709°F). A cold oxygen sensor will require approximately 1-2 minutes at moderate engine load to warm sufficiently to generate a voltage signal. Proper grounding is also critical. The oxygen sensor grounds through the metal shell, so a good, solid, unbroken ground path back through the exhaust system components, engine, and wiring harness is required. Any disruption or break in the ground circuit can affect the output signal and trigger misleading fault codes. Keep that in mind when doing any troubleshooting associated with the oxygen sensor. The oxygen sensor can also be contaminated by leaded fuel, certain RTV and/or other silicone compounds, carburetor cleaners, etc. Use only those products indicated as "O_2 Sensor Safe."

Service

Like the other sensors already discussed, the oxygen sensor is a non-serviceable component. Complete replacement is required if it is faulty. The sensor and wiring harness can be checked as follows.

NOTE: All tests should be conducted with a good quality, high-impedance, digital VOA meter for accurate results.

1. Oxygen sensor must be hot (minimum of 400°C, 725°F). Run engine for about 5 minutes. With the engine running, disconnect the oxygen sensor lead from the wiring harness. Set VOA meter for DC volts and connect the **red** lead to the disconnected sensor lead, and the **black** lead to the sensor shell. Look for fluctuating voltage from **0.1 v-1.0 v.**

   a. If voltage is in the specified range, go to Step 2.

b. If the voltage is not in the specified range, reconnect the oxygen sensor lead. With the lead connected, probe or connect the sensor connection with the red VOA meter lead. Attach the black VOA meter lead to a known good ground location. Start and run the engine at 3/4 throttle and note the voltage output.

The reading should fluctuate between 0.1 v and 1.0 v which indicates the oxygen sensor is functioning normally and also the fuel delivery controlled by the ECU is within prescribed parameters. If the voltage readings show a steady decline, bump the governor lever to make the engine accelerate very quickly and check the reading again. If voltage momentarily increases and then again declines, without cycling, engine may be running lean due to incorrect TPS initialization. Shut off the engine, perform TPS initialization, and then repeat the test. If TPS initialization cannot be achieved, perform step c.

c. Replace the oxygen sensor (see next page). Run the engine long enough to bring the new sensor up to temperature and repeat the output test from step 1. The fluctuating voltage (0.1 v-1.0 v) should be indicated.

2. Move the **black** voltmeter lead to the engine ground location and repeat the output test. The same voltage (0.1 v-1.0 v) should be indicated.

a. If the same voltage reading exists, go on to Step 3.

b. If the voltage output is no longer correct, a bad ground path exists between the sensor and the engine ground. Touch the black lead at various points, backtracking from the engine ground back toward the sensor, watching for a voltage change at each location. If the correct voltage reading reappears at some point, check for a problem (rust, corrosion, loose joint or connection) between that point and the previous checkpoint. For example, if the reading is too low at points on the crankcase, but correct voltage is indicated when the black lead is touched to the skin of the muffler, the flange joints at the exhaust ports become suspect.

3. With sensor still **hot** (minimum of 400°C, 752°F), switch meter to the Rx1K or Rx2K scale and check the resistance between the sensor lead and sensor case. It should be less than **2.0 KΩ.**

a. If the resistance is less than **2.0 KΩ,** go to Step 4.

b. If the resistance is greater than **2.0 KΩ,** the oxygen sensor is bad, replace it.

4. Allow the sensor to cool (less than 60°C, 140°F) and retest the resistance with the meter set on the Rx1M scale. With sensor cool, the resistance should be greater than **1.0 MΩ.**

a. If the resistance is greater than **1.0 MΩ,** go to Step 5.

b. If the resistance is less than **1.0 MΩ,** the sensor is bad, replace it.

5. With the oxygen sensor disconnected and engine not running, disconnect the main harness connector from the ECU and set the meter to the Rx1 scale. Check the circuit continuity as follows:

Metal-Cased ECU: Check for continuity from pin #9 of the ECU connector (see page 5B.26) to the shell of the oxygen sensor, and from pin #10 to the sensor connector terminal of the main harness. Both tests should indicate continuity.

Plastic-Cased ECU: Check for continuity from pin #15 of the ECU connector (see page 5B.29) to the shell of the oxygen sensor, and from pin #11 to the sensor connector terminal of the main harness. Both tests should indicate continuity.

a. If there is no continuity displayed in either of the tests, check the harness circuit for breaks or damage, and the connections for poor contact, moisture, or corrosion. If no continuity was found in the first test, also check for a poor/broken ground path back through the exhaust system, engine, and mounting (sensor is grounded through its shell).

b. If continuity is indicated, go to step 6.

6. With the key switch in the ‘‘on/run’’ position, using a high impedance voltmeter, check the voltage from the wiring harness oxygen sensor connector to the engine ground location. Look for a steady voltage from **350-550 mv (0.35 - 0.55 v).**

   a. If voltage reading is not as specified, move the black voltmeter lead to the negative post of the battery, to be certain of a good ground. If the voltage is still not correct, the ECU is probably bad.

   b. If voltage readings are correct, clear the fault codes and run the engine to check if any fault codes reappear.

To Replace Oxygen Sensor:

1. Disconnect the oxygen sensor connector from wiring harness.

2. Loosen and remove the oxygen sensor from the exhaust manifold/muffler assembly.

3. Apply anti-seize compound sparingly to threads of new oxygen sensor, if none already exists. **DO NOT** get any on the tip as it will contaminate the sensor. Install sensor and torque to **50/60 N·m (37/44 ft. lb.)**.

4. Reconnect the lead to wiring harness connector. Make sure it can not contact hot surfaces, moving parts, etc.

5. Test run the engine.

Electrical Relay

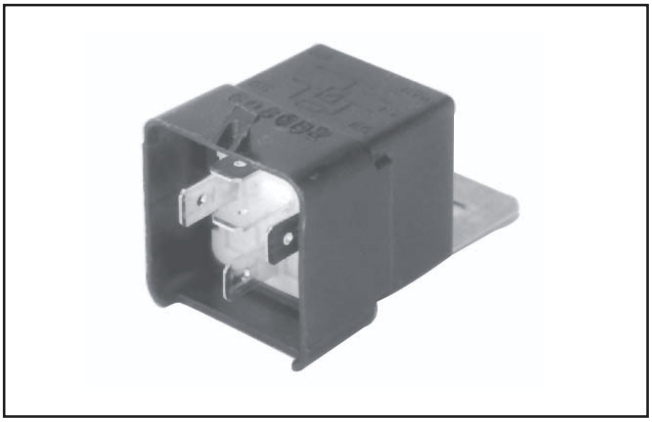


Figure 5B-12. Electrical Relay.

General

The electrical relay is used to supply power to the injectors, coils, and fuel pump. When the key switch is turned “on” and all safety switch requirements met, the relay provides 12 volts to the fuel pump circuit, injectors, and ignition coils. The fuel pump circuit is continuously grounded, so the pump is immediately activated and pressurizes the system. Activation of the ignition coils and injectors is controlled by the ECU, which grounds their respective circuits at the proper times.

Service

A malfunctioning relay can result in starting or operating difficulties. The relay and related wiring can be tested as follows.

1. Disconnect the relay connector plug from the relay.

2. Connect black lead of VOA meter to a chassis ground location. Connect red lead to the #86 terminal in relay connector (see Figure 5B-13). Set meter to test resistance (Rx1). Turn ignition switch from **“off”** to **“on.”** Meter should indicate continuity (ground circuit is completed) for 1 to 3 seconds. Turn key switch back off.

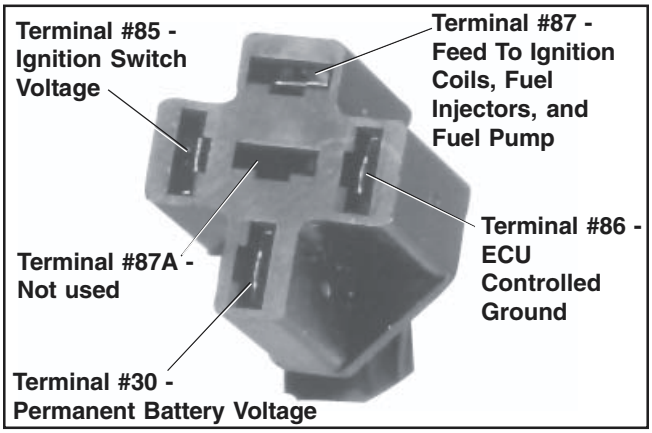


Figure 5B-13. Relay Connector.

   a. Clean the connection and check wiring if circuit was not completed.

3. Set meter for DC voltage. Touch red tester lead to the #30 terminal in relay connector. A reading of **12 volts** should be indicated at all times.

4. Connect red lead of meter to the #85 terminal in relay connector. Turn key switch to the **"on"** position. Battery voltage should be present.

   a. No voltage present indicates a problem in the wiring or at the connector.

   b. If voltage is present, the wiring to the connector is good. Turn ignition switch **"off"** and proceed to test 5 to test the relay.

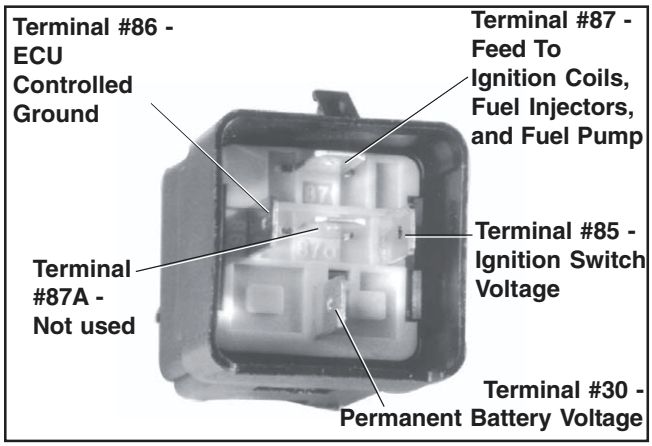


Figure 5B-14. Relay Terminal Details.

5. Connect an ohmmeter (Rx1 scale) between the #85 and #86 terminals in the relay. There should be continuity.

6. Attach ohmmeter leads to the #30 and #87 terminals in relay. Initially, there should be no continuity. Using a 12 volt power supply, connect the positive (+) lead to the #85 terminal and touch the negative (-) lead to the #86 terminal. When 12 volts is applied, the relay should activate and continuity should exist (circuit made) between the #30 and #87 terminals. Repeat the test several times. If, at any time the relay fails to activate the circuit, replace the relay.

Fuel Injectors

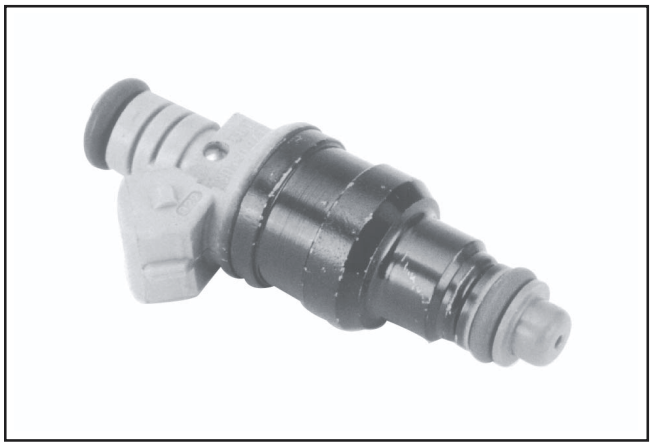


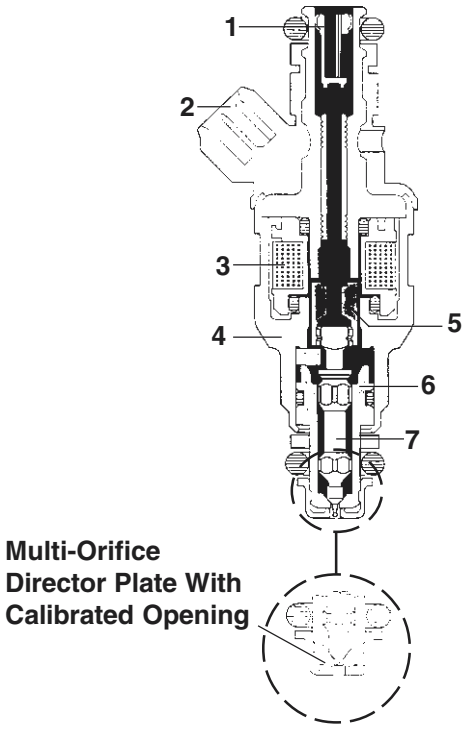
Figure 5B-15. Style 1 Fuel Injector.

Figure 5B-16. Style 2 Fuel Injector.

General

The fuel injectors mount into the intake manifold, and the fuel rail attaches to them at the top end. Replaceable O-Rings on both ends of the injector prevent external fuel leakage and also insulate it from heat and vibration. A special clip connects each injector to the fuel rail, retaining it in place.

When the key switch is on and the relay is closed, the fuel rail is pressurized, and voltage is present at the injector. At the proper instant, the ECU completes the ground circuit, energizing the injector. The valve needle in the injector is opened electromagnetically, and the pressure in the fuel rail forces fuel down through the inside. The “director plate” at the tip of the injector (see inset) contains a series of calibrated openings which directs the fuel into the manifold in a cone-shaped spray pattern.



1. Filter strainer in fuel supply
2. Electrical connection
3. Solenoid winding
4. Valve housing
5. Armature
6. Valve body
7. Valve needle

Figure 5B-17. Fuel Injector Details.

The injector is opened and closed once for each crankshaft revolution, however only one-half the total amount of fuel needed for one firing is injected during each opening. The amount of fuel injected is controlled by the ECU and determined by the length of time the valve needle is held open, also referred to as the “injection duration” or “pulse width”. It may vary in length from 1.5-8 milliseconds depending on the speed and load requirements of the engine.

Service
Injector problems typically fall into three general categories: electrical, dirty/clogged, or leakage. An electrical problem usually causes one or both of the injectors to stop functioning. Several methods may be used to check if the injectors are operating.

1. With the engine running at idle, feel for operational vibration, indicating that they are opening and closing.

2. When temperatures prohibit touching, listen for a buzzing or clicking sound with a screwdriver or mechanic’s stethoscope (see Figure 5B-18).

Figure 5B-18. Checking Injectors.

3. Disconnect the electrical connector from an injector and listen for a change in idle performance (only running on one cylinder) or a change in injector noise or vibration.

If an injector is not operating, it can indicate either a bad injector, or a wiring/electrical connection problem. Check as follows:

NOTE: **Do not** apply voltage to the fuel injector(s). Excessive voltage will burn out the injector(s). **Do not** ground the injector(s) with the ignition **“on.”** Injector(s) will open/turn on if relay is energized.

1. Disconnect the electrical connector from both injectors. Plug a 12 volt test light (SPX Part No. KO3217-6) in one connector.

Figure 5B-19. Volt Test Light.

2. Make sure all safety switch requirements are met. Crank the engine and check for flashing of test light. Repeat test at other connector.

   a. If flashing occurs, use an ohmmeter (Rx1 scale) and check the resistance of each injector across the two terminals. Proper resistance is **12-20 Ω.** If injector resistance is correct, check whether the connector and injector terminals are making a good connection. If the resistance is not correct, replace the injector following steps 1-8 and 13-16 below.

   b. If no flashing occurs, reattach connectors to both injectors. Disconnect the main harness connector from the ECU and the connector from the relay. Set the ohmmeter to the Rx1 scale and check the injector circuit resistance as follows:

      Metal-Cased ECU: Check the resistance between the relay terminal #87 and pin #35 in main connector. Resistance should be **4-15 Ω.**

      Plastic-Cased ECU: Check the resistance between relay terminal #87 and pin #16 in main connector. Then check resistance between relay terminal #87 and pin #17. Resistance should be **4-15 Ω** for each circuit.

      Check all electrical connections, connectors, and wiring harness leads if resistance is incorrect.

Injector leakage is very unlikely, but in those rare instances it can be internal (past the tip of the valve needle), or external (weeping around the injector body). See Figure 5B-20. The loss of system pressure from the leakage can cause hot restart problems and longer cranking times. To check for leakage it will be necessary to remove the blower housing, which may involve removing the engine from the unit.

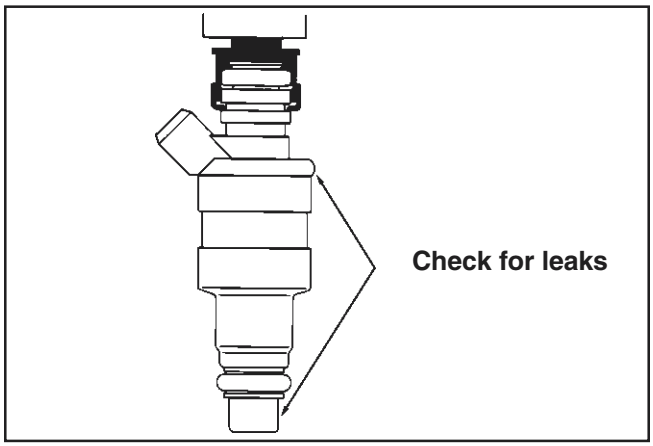


Figure 5B-20. Injector Inspection Points.

1. Engine must be cool. Depressurize fuel system through test valve in fuel rail.

2. Disconnect spark plug leads from spark plugs.

3. Remove the air cleaner outer cover, inner wing nut, element cover and air cleaner element/ precleaner. Service air cleaner components as required.

4. Remove the two screws securing the air cleaner base to throttle body manifold. Remove the air cleaner base to permit access to the injectors. Check condition of air cleaner base gasket, replace if necessary.

5. Remove the flywheel screen if it overlaps the blower housing.

6. If the engine has a radiator-type oil cooler mounted to the blower housing, remove the two oil cooler mounting screws.

7. Remove the blower housing mounting screws. Note the location of the plated (silver) screw attaching the rectifier/regulator ground lead. Remove the blower housing.

8. Thoroughly clean the area around and including the throttle body/manifold and the injectors.

9. Disconnect the throttle linkage and damper spring from the throttle lever. Disconnect the TPS lead from the harness.

10. Remove the manifold mounting bolts and separate the throttle body/manifold from the engine leaving the TPS, fuel rail, air baffle, injectors and line connections intact. Discard the old gaskets.

11. Position the manifold assembly over an appropriate container and turn the key switch **"on"** to activate the fuel pump and pressurize the system. **Do not** turn switch to **"start"** position.

12. If either injector exhibits leakage of more than two to four drops per minute from the tip, or shows any sign of leakage around the outer shell, turn the ignition switch off and replace injector as follows.

13. Depressurize the fuel system following the procedure in the fuel warning on page 5B.2. Remove the two fuel rail mounting screws.

14. Clean any dirt accumulation from the sealing/ mounting area of the faulty injector(s) and disconnect the electrical connector(s).

15. Pull the retaining clip off the top of the injector(s) and remove from manifold.

16. Reverse the appropriate procedures to install the new injector(s) and reassemble the engine. Use new O-Rings any time an injector is removed (new replacement injectors include new O-Rings). Lubricate O-Rings lightly with oil. Torque fuel rail and blower housing mounting screws to **3.9 N·m (35 in. lb.)**, and the intake manifold and air cleaner mounting screws to **9.9 N·m (88 in. lb.)**.

Injector problems due to dirt or clogging are unlikely due to the design of the injectors, the high fuel pressure, and the detergent additives in the gasoline. Symptoms that could be caused by dirty/clogged injectors include rough idle, hesitation/stumble during acceleration, or triggering of fault codes related to fuel delivery. Injector clogging is usually caused by a buildup of deposits on the director plate, restricting the flow of fuel, resulting in a poor spray pattern. Some contributing factors to injector clogging include higher than normal operating temperatures, short operating intervals, and dirty, incorrect, or poor quality fuel. Cleaning of clogged injectors is not recommended; they should be replaced. Additives and higher grades of fuel can be used as a preventative measure if clogging has been a problem.

Ignition System

General

A high voltage, solid state, battery ignition system is used with the EFI system. The ECU controls the ignition output and timing through transistorized control of the primary current delivered to the coils. Based on input from the speed sensor, the ECU determines the correct firing point for the speed at which the engine is running. At the proper instant, it releases the flow of primary current to the coil. The primary current induces high voltage in the coil secondary, which is then delivered to the spark plug. Each coil fires every revolution, but every other spark is "wasted."

Service

Except for removing the spark plug lead by unscrewing it from the secondary tower (see Figure 5B-21), no coil servicing is possible. If a coil is determined to be faulty, replacement is necessary. An ohmmeter may be used to test the wiring and coil windings.

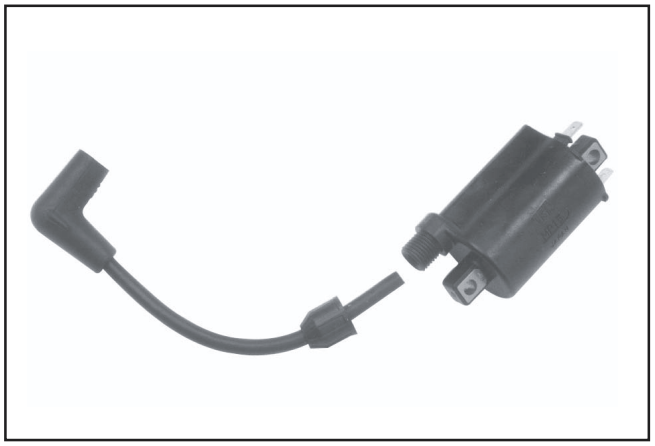


Figure 5B-21. Ignition Coil.

NOTE: **Do not** ground the coils with the ignition **"on,"** as they may overheat or spark.

1. Disconnect the main harness connector from ECU.

   Metal-Cased ECU: Locate pins #1 and #19 in the 35 pin connector. See page 5B.26.

   Plastic-Cased ECU: Locate pins #22 and #23 in the 24 pin connector. See page 5B.29.

2. Disconnect connector from relay and locate terminal #87 in connector.

3. Using an ohmmeter set on the Rx1 scale, check the resistance in circuits as follows:

   Metal-Cased ECU: Check between terminal #87 and pin #1 for coil #1. Repeat the test between terminal #87 and pin #19 for coil #2.

   Plastic-Cased ECU: Check between terminal #87 and pin #22 for coil #1. Repeat the test between terminal #87 and pin #23 for coil #2.

   A reading of **1.8-4.0 Ω** in each test indicates that the wiring and coil primary circuits are OK.

   a. If reading(s) are not within specified range, check and clean connections and retest.

   b. If reading(s) are still not within the specified range, test the coils separately from main harness as follows:

      (1) Disconnect the red and black primary leads from the coil terminals.

      (2) Connect an ohmmeter set on the Rx1 scale to the primary terminals. Primary resistance should be **1.8-2.5 Ω.**

      (3) Disconnect the secondary lead from the spark plug. Connect an ohmmeter set on the Rx10K scale between the spark plug boot terminal and the red primary terminal. Secondary resistance should be **13,000-17,500 Ω.**

      (4) If the secondary resistance is not within the specified range, unscrew the spark plug lead nut from the coil secondary tower and remove the plug lead. Repeat step 6, testing from the secondary tower terminal to the red primary terminal. If resistance is now correct, the coil is good, but the spark plug lead is faulty, replace the lead. If step 5 resistance was incorrect and/or the secondary resistance is still incorrect, the coil is faulty and needs to be replaced.

Wiring Harness

The wiring harness used in the EFI system connects the electrical components, providing current and ground paths for the system to operate. All input and output signaling occurs through a special all weather connector that attaches and locks to the ECU (see Figures 5B-22 and 5B-23).

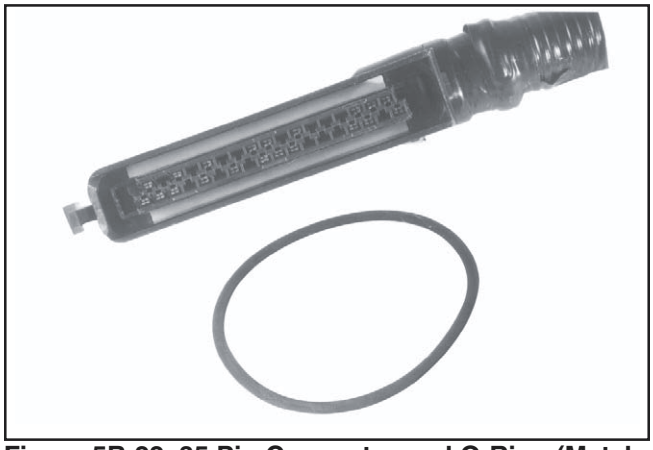


Figure 5B-22. 35 Pin Connector and O-Ring (Metal-Cased ECU).

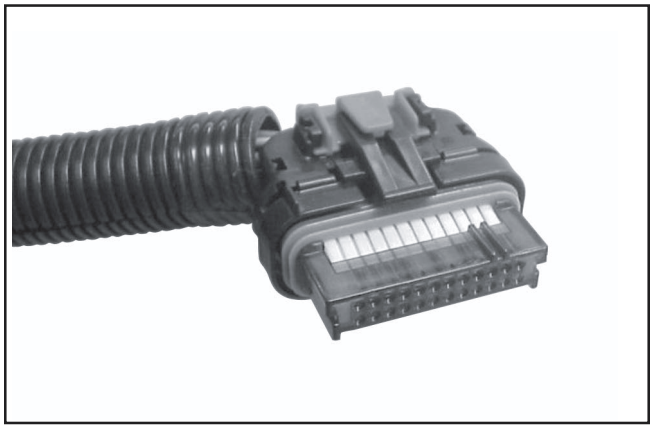


Figure 5B-23. 24 Pin Connector (Plastic-Cased ECU).

The condition of the wiring, connectors, and terminal connections is essential to system function and performance. Corrosion, moisture, and poor connections are more likely the cause of operating problems and system errors than an actual component. Refer to the “Troubleshooting – Electrical’’ section for additional information.

Battery Charging System

EFI engines are equipped with either a 15 or 25 amp charging system to accommodate the combined electrical demands of the ignition system and the specific application. Charging system troubleshooting information is provided in Section 8.

Fuel Components

Fuel Pump

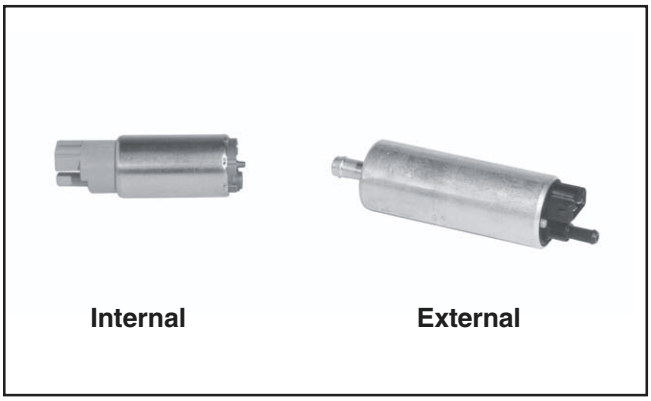


Figure 5B-24. Fuel Pump Styles.

General
An electric fuel pump is used to transfer fuel in the EFI system. Depending on the application, the pump may be inside the fuel tank, or in the fuel line near the tank. The pumps are rated for a minimum output of 25 liters per hour at 39 psi. The pumps have an internal 60-micron filter. In addition, the in-tank style pumps will have a pre-filter attached to the inlet. In-line pump systems may also have a filter ahead of the pump on the pick-up/low pressure side.The final filter is covered separately on page 5B.20.

When the key switch is turned **"on"** and all safety switch requirements are met, the ECU, through the relay, activates the fuel pump, which pressurizes the system for start-up. If the key switch is not promptly turned to the "start" position, the engine fails to start, or the engine is stopped with the key switch "on" (as in the case of an accident), the ECU switches off the pump preventing the continued delivery of fuel. In this situation, the MIL will go on, but it will go back off after 4 cranking revolutions if system function is OK. Once the engine is running, the fuel pump remains on.

Service
The fuel pumps are non-serviceable and must be replaced if determined to be faulty. If a fuel delivery problem is suspected, make certain the pump is being activated through the relay, all electrical connections are properly secured, the fuses are good, and a minimum of 7.0 volts is being supplied. If during cranking, voltage drops below 7.0 volts, a reduction of fuel pressure may occur resulting in a lean starting condition. If required, testing of the fuel pump and relay may be conducted.

1. Connect the black hose of Kohler pressure tester (SPX Part No. KO3217-4) to the test valve in the fuel rail. Route the clear hose into a portable gasoline container or the equipment fuel tank.

2. Turn on the key switch to activate the pump and check the system pressure on the gauge. If system pressure of **39 psi ±3** is observed, the relay, fuel pump, and regulator are working properly. Turn key switch off and depress the valve button on the tester to relieve the system pressure.

   a. If the pressure is too high, and the regulator is outside the tank (just down line from the pump), check that the return line from the regulator to the tank is not kinked or blocked. If the return line is good, replace the regulator (see "Regulator Service" on page 5B.19).

   b. If the pressure is too low, install in-line "T" (SPX Part No. KO3217-8) between the pump and regulator and retest the pressure at that point. If it is too low there also, replace the fuel pump.

3. If the pump did not activate (step 2), disconnect the plug from the fuel pump. Connect a DC voltmeter across the terminals in the plug, turn on the key switch and observe if a minimum of 7 volts is present. If voltage is between 7 and 14, turn key switch off and connect an ohmmeter between the terminals on the pump to check for continuity.

   a. If there was no continuity between the pump terminals, replace the fuel pump.

   b. If the voltage was below 7, test the wiring harness and relay as covered in the "Electrical Relay" section.

4. If voltage at the plug was good, and there was continuity across the pump terminals, reconnect the plug to the pump, making sure you have a good connection. Turn on the key switch and listen for the pump to activate.

   a. If the pump starts, repeat steps 1 and 2 to verify correct pressure.

   b. If the pump still does not operate, replace it.

Fuel Pressure Regulator

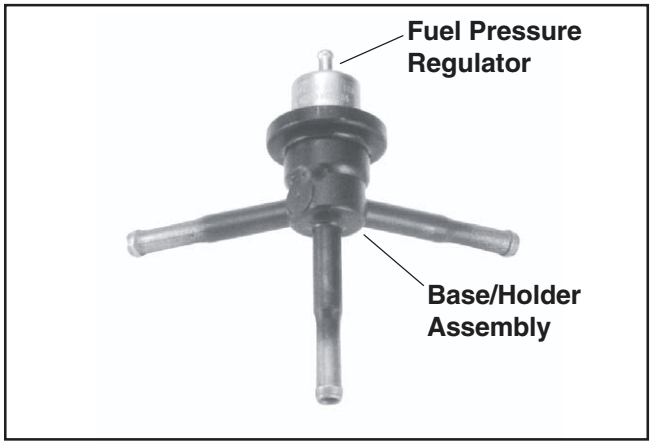


Figure 5B-25. Fuel Pressure Regulator with Base.

General

The fuel pressure regulator assembly maintains the required operating system pressure of 39 psi ± 3. A rubber-fiber diaphragm (see Figure 5B-26) divides the regulator into two separate sections; the fuel chamber and the pressure regulating chamber. The pressure regulating spring presses against the valve holder (part of the diaphragm), pressing the valve against the valve seat. The combination of atmospheric pressure and regulating spring tension equals the desired operating pressure. Any time the fuel pressure against the bottom of the diaphragm exceeds the desired (top) pressure, the valve opens, relieving the excess pressure, returning the excess fuel back to the tank.

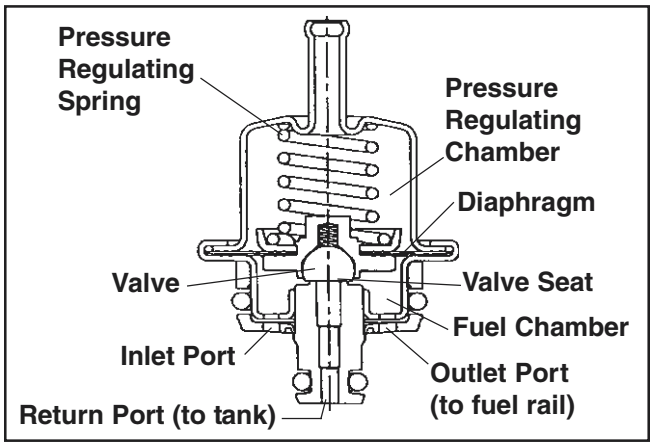


Figure 5B-26. Fuel Pressure Regulator Details.

Service

Depending on the application, the regulator may be located in the fuel tank along with the fuel pump, or outside the tank just down line from the pump. The regulator is a sealed, non-serviceable assembly. If it is faulty, it must be separated from the base/holder assembly and replaced as follows.

1. Shut engine off, make sure engine is cool, and disconnect the negative (-) battery cable.

2. Depressurize fuel system through test valve in fuel rail (see fuel warning on page 5B.2).

3. Access the regulator assembly as required and clean any dirt or foreign material away from the area.

4. Remove the snap ring retaining the pressure regulator in the base/holder assembly. Grasp and pull the old regulator out of the base (see Figure 5B-27).

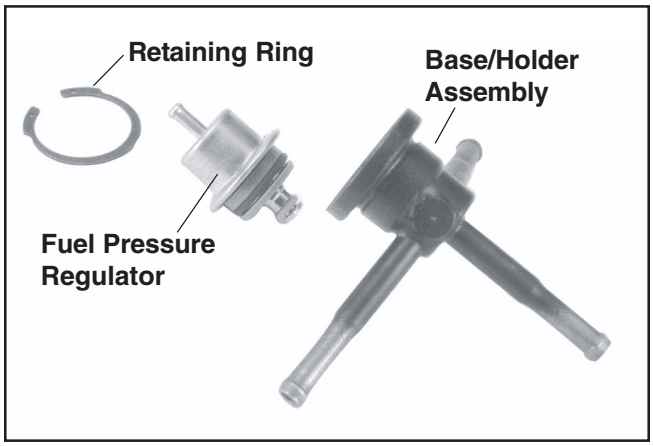


Figure 5B-27. Regulator and Holder Assembly.

5. Always use new O-Rings when reinstalling a regulator. A new replacement regulator will have them already installed. Lightly lubricate the O-Rings with light grease or oil.

6. Install the new regulator by carefully pushing and rotating it into base. Secure with the original snap ring. Be careful not to dent or damage the body of the regulator, as operating performance can be affected.

7. Reassemble any parts removed in step 3.

8. Reconnect the negative (-) battery cable.

9. Recheck regulated system pressure at fuel rail test valve.

Fuel Filter

EFI engines use a high-volume, high-pressure, 10-15 micron, in-line fuel filter.

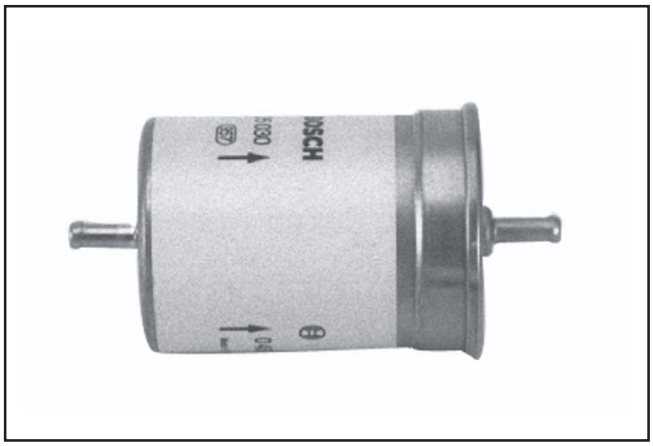


Figure 5B-28. In-Line Fuel Filter.

Service

Filter replacement is recommended **every 1500 hours** of operation or more frequently under extremely dusty or dirty conditions. Use only the specified filter, and install it according to the directional arrows. **DO NOT** use a substitute filter as operating performance and safety can be affected. Relieve system pressure through the safety valve in the fuel rail before servicing.

NOTE: When replacing the fuel filter, wet the interior of the new filter with gasoline before installation, so the high pump pressure doesn't tear the filtering material.

Fuel Rail

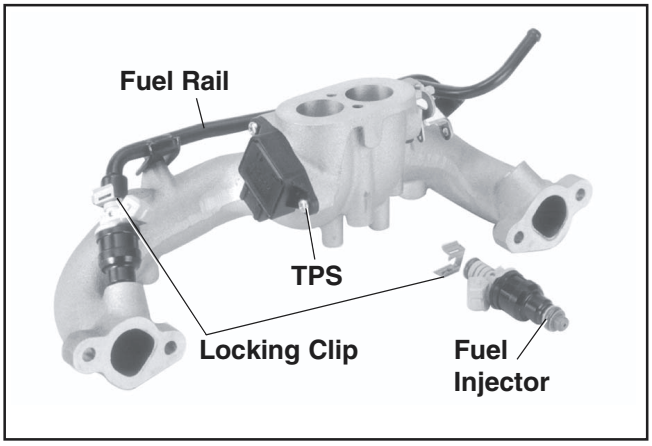


Figure 5B-29. Manifold Assembly.

General

The fuel rail is a formed tube assembly that feeds fuel to the top of the injectors. The tops of the injectors fit into formed cups in the fuel rail. When the rail is fastened to the manifold, the injectors are locked into place. A small retaining clip provides a secondary lock. Incorporated into the fuel rail is a pressure relief/test valve for testing operating pressure or relieving fuel system pressure for servicing. The fuel supply line is attached to the barbed end of the fuel rail with an Oetiker hose clamp.

Service

The fuel rail is mounted to the throttle body/intake manifold. It can be detached by removing the two mounting screws and the injector retaining clips. Thoroughly clean the area around all joints prior to any disassembly. No specific servicing is required unless operating conditions indicate that it needs internal cleaning or replacement.

Fuel Line

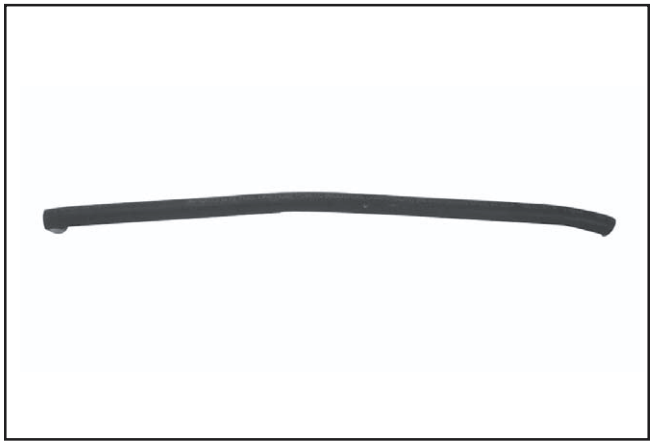


Figure 5B-30. High Pressure Fuel Line.

General
High-pressure fuel line with an SAE R9 rating is required for safe and reliable operation, due to the higher operating pressure of the EFI system. If hose replacement is necessary, order by part number or use only the type specified. Special Oetiker clamps (Kohler Part No. 24 237 05-S) are used on all fuel line connections to prevent tampering and safety hazards with the high fuel pressure. The old clamp must be cut to open a connection, so replacement is necessary each time. Pliers (SPX Part No. KO3217-5) is used to crimp the replacement clamps.

⚠ ***CAUTION:*** *Standard fuel line is not compatible and* ***must not*** *be used! Use* ***only*** *Oetiker clamps (Kohler part no. 24 237 05-S) on fuel line connections.*

Throttle Body/Intake Manifold Assembly

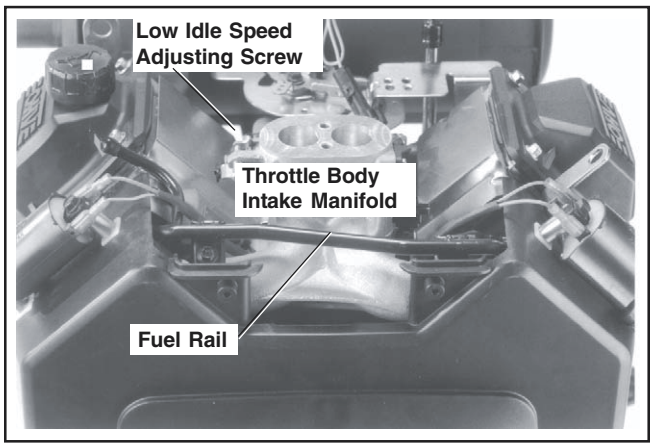


Figure 5B-31. Upper Intake Manifold.

General
The EFI engines have no carburetor, so the throttle function (regulate incoming combustion airflow) is incorporated in the intake manifold assembly. The manifold consists of a one-piece aluminum casting which also provides mounting for the fuel injectors, throttle position sensor, fuel rail, air baffle, idle speed screw, and air cleaner assembly.

Service
The throttle body/intake manifold is serviced as an assembly, with the throttle shaft, throttle plates, and idle speed adjusting screw installed. The throttle shaft rotates on needle bearings (non-serviceable), capped with rubber seals to prevent air leaks.

Idle Speed Adjustment (RPM)

5B

General
The idle speed is the only adjustment that may be performed on the EFI system. The standard idle speed setting for EFI engines is **1500 RPM**, but certain applications might require a different setting. Check the equipment manufacturer's recommendation.

For starting and warm up, the ECU will adjust the fuel and ignition timing, based upon ambient temperature, engine temperature, and loads present. In cold conditions, the idle speed will probably be higher than normal for a few moments. Under other conditions, the idle speed may actually start lower than normal, but gradually increase to the established setting as operation continues. **Do not** attempt to circumvent this warm up period, or readjust the idle speed during this time. The engine must be completely warmed up for accurate idle adjustment.

Adjustment Procedure

1. Make sure there are no fault codes present in the ECU memory.

2. Start the engine and allow it to **fully warm up** and establish closed looped operation (approximately 5-10 min.).

3. Place the throttle control in the "idle/slow" position and check the idle speed with a tachometer. Turn the idle speed screw in or out as required to obtain **1500 RPM**, or the idle speed specified by the equipment manufacturer.

4. The low idle speed adjustment can affect the high idle speed setting. Move the throttle control to the full throttle position and check the high idle speed. Adjust as necessary to **3750 RPM** (no load), or the speed specified by the equipment manufacturer. **Do not exceed 3750 RPM.**

Idle Speed Screw Dampening Spring

A small dampening spring (Kohler Part No. 24 089 42-S) is being used on the end of the idle speed screw of some EFI engines to help stabilize no load operating speeds. See Figure 5B-32.

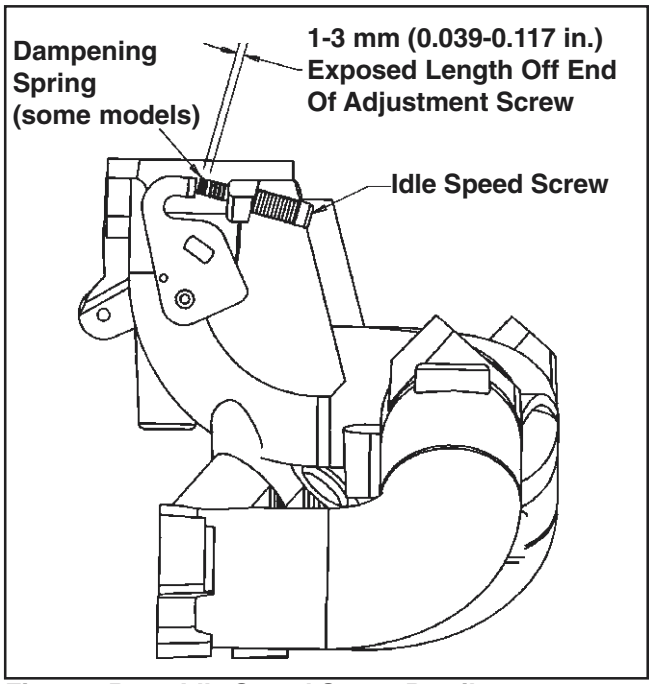


Figure 5B-32. Idle Speed Screw Details.

The idle speed adjustment procedure remains the same for engines with or without a dampening spring. Typically, no periodic servicing is necessary in this area. If however, removal/replacement of the dampening spring is required, reinstall it as follows:

1. Thread the spring onto the end of idle screw leaving **1-3 mm (0.039-0.117 in.)** of the spring extending beyond the end of the idle speed screw.

2. Secure spring onto the screw with a small amount of Permabond™ LM-737 or equivalent Loctite® adhesive. Do not get any adhesive on free coils of spring.

3. Start the engine and recheck the idle speed settings, after sufficient warm up. Readjust as required.

Initial Governor Adjustment

The initial governor adjustment is especially critical on CH26 (EFI) engines because of the accuracy and sensitivity of the electronic control system. Incorrect adjustment can result in overspeed, loss of power, lack of response, or inadequate load compensation. If you encounter any of these symptoms and suspect them to be related to the governor setting, the following should be used to check and/or adjust the governor and throttle linkage.

If the governor/throttle components are all intact, but you think there may be a problem with the adjustment, follow Procedure A to check the setting. If the governor lever was loosened or removed, go immediately to Procedure B to perform the initial adjustment.

A. Checking the Initial Adjustment

1. Unsnap the plastic linkage bushing attaching the throttle linkage to the governor lever. See Figure 5B-33 Unhook the damper spring from the lever, separate the linkage from the bushing, and remove the bushing from the lever. Mark the hole position and unhook the governor spring from the governor lever.

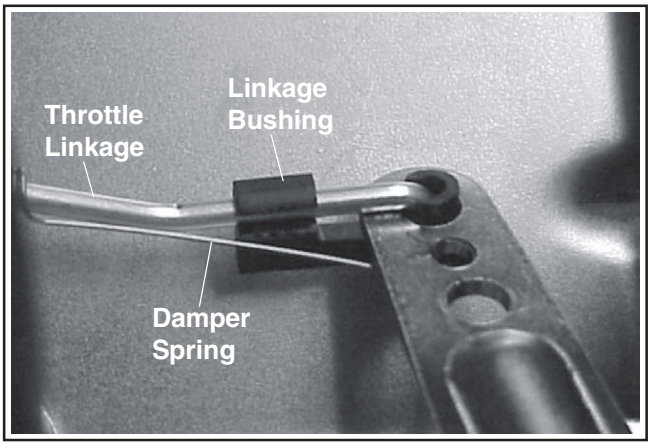


Figure 5B-33. Throttle Linkage/Governor Lever Connection.

2. Check if the engine has a high-speed throttle stop screw installed in the manifold casting boss. See Figure 5B-34.

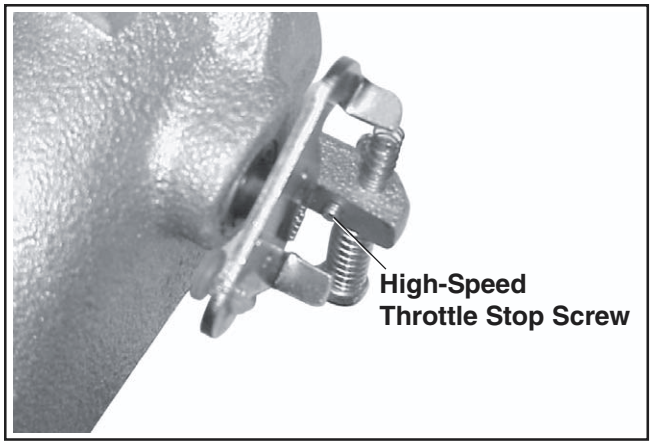


Figure 5B-34. Throttle Details.

a. On engines without a stop screw, pivot the throttle shaft and plate assembly into the "Full Throttle" position. Insert a **1.52 mm (0.060 in.)** feeler gauge between the rear tang of the throttle shaft plate and the underside of the manifold boss. Use a locking pliers (needle nose works best) to temporarily clamp the parts in this position. See Figure 5B-35.

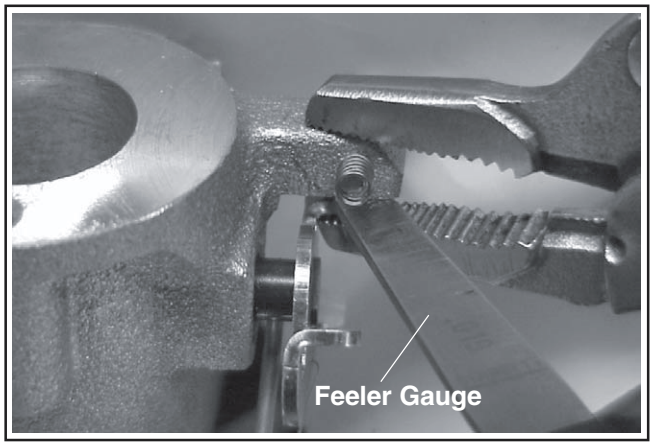


Figure 5B-35. Inserting Feeler Gauge (Engines Without Stop Screw).

b. On engines with a stop screw, pivot the throttle shaft and plate into the "Full Throttle" position, so the tang of the throttle shaft plate is against the end of the high-speed stop screw. See Figure 5B-34. Temporarily clamp in this position.

3. Rotate the governor lever and shaft counterclockwise until it stops. Use only enough pressure to hold it in that position.

4. Check how the end of the throttle linkage aligns with the bushing hole in the governor lever. See Figure 5B-36. It should fall in the center of the hole. If it doesn't, perform the adjustment procedure as follows.

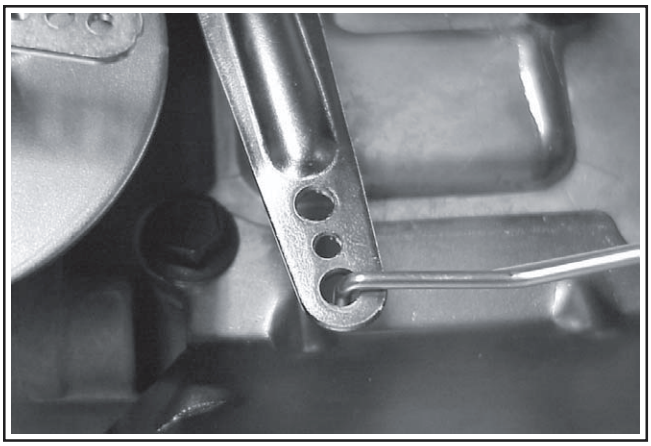


Figure 5B-36. Throttle Link in Center of Hole.

B. Setting the Initial Adjustment

1. Check the split where the clamping screw goes through the governor lever. See Figure 5B-37. There should be a gap of at least 1/32". If the tips are touching and there is no gap present, the lever should be replaced. If not already installed, position the governor lever on the cross shaft, but leave the clamping screw loose.

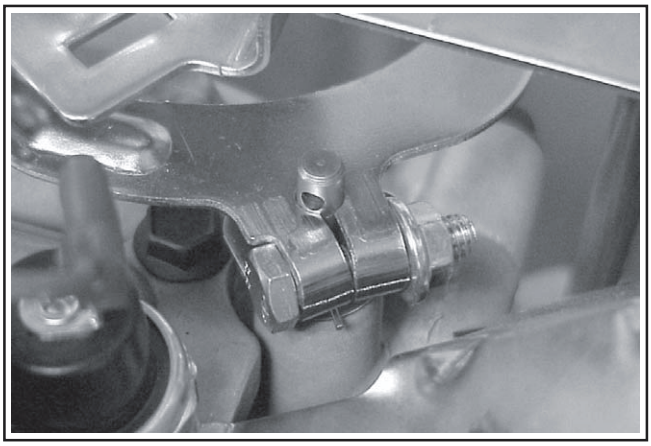


Figure 5B-37. Checking "Split" of Clamp.

2. Follow the instructions in Step 2 of "Checking the Initial Adjustment," then reattach the throttle linkage to the governor lever with the bushing clip. It is not necessary to reattach the damper or governor springs at this time.

3. Insert a nail into the hole in the top of the cross shaft. Using light pressure, rotate the governor shaft **counterclockwise** as far as it will turn, then torque the hex. nut on the clamping screw to **9.9 N·m (88 in. lb.)**. See Figure 5B-38. Make sure that the governor arm has not twisted up or down after the nut has been tightened.

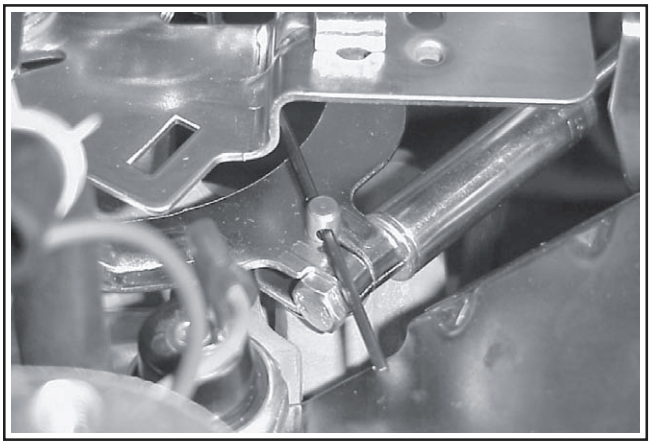


Figure 5B-38. Adjusting Governor Shaft.

4. Verify that the governor has been set correctly. With the linkage still retained in the "Full Throttle" position (Step 2), unsnap the bushing clip, separate the linkage from the bushing, and remove the bushing from the lever. Follow Steps 3 and 4 in "Checking the Initial Adjustment".

5. Reconnect the dampening spring into its governor lever hole from the bottom. Reinstall the bushing and reattach the throttle linkage. See Figure 5B-33. Reattach the governor spring in the marked hole.

6. Start the engine and allow it to fully warm up and establish closed loop operation (approximately 5-10 min.). Check the speed settings and adjust as necessary, first the low idle speed, and then the high speed setting.

Troubleshooting

General
When troubleshooting a problem on an engine with EFI, basic engine operating problems must be eliminated first before faulting the EFI system components. What appears to be an EFI problem could be something as simple as a fuel tank with debris in the bottom or a plugged vent. Be sure the engine is in good mechanical operating condition and all other systems are functional before attempting to troubleshoot the EFI system.

Troubleshooting Guide

Engine starts hard or fails to start when cold
1. Fuel pump not running
2. Engine temp sensor faulty
3. Incorrect fuel pressure
4. TPS faulty
5. TPS offset incorrect
6. Stale fuel
7. Low system voltage
8. Speed sensor loose or faulty
9. Faulty injectors
10. Faulty coils

Engine starts hard or fails to start when hot
1. Fuel pressure low
2. Fuel pump not running
3. Engine temp sensor faulty
4. Insufficient fuel delivery
5. TPS faulty
6. TPS offset incorrect
7. Speed sensor loose or faulty
8. Faulty injectors

Engine stalls or idles roughly (cold or warm)
1. Insufficient fuel delivery
2. TPS faulty
3. TPS offset incorrect
4. Faulty engine temperature sensor
5. Faulty injectors

Engine misses, hesitates, or stalls under load
1. Insufficient fuel delivery
2. TPS faulty
3. Faulty coils
4. Faulty injectors

Electrical System

The EFI system is a 12 VDC negative ground system, designed to operate down to a minimum of 7.0 volts. If system voltage drops below this level, the operation of voltage sensitive components such as the ECU, fuel pump, and injectors will be intermittent or disrupted, causing erratic operation or hard starting. A fully charged, 12 volt battery with a minimum of 250 cold cranking amps is important in maintaining steady and reliable system operation. Battery condition and state of charge should always be checked first when troubleshooting an operational problem.

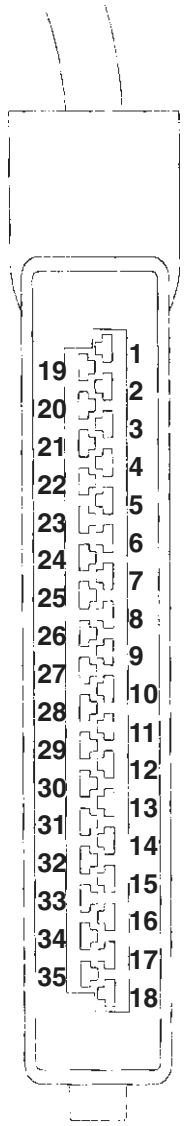
Keep in mind that EFI-related problems are more often caused by the wiring harness or connections than by the EFI components. Even small amounts of corrosion or oxidation on the terminals can interfere with the milliamp currents used in system operation. Cleaning the connectors and grounds will solve problems in many cases. In an emergency situation, simply disconnecting and reconnecting the connectors may clean up the contacts enough to restore operation, at least temporarily.

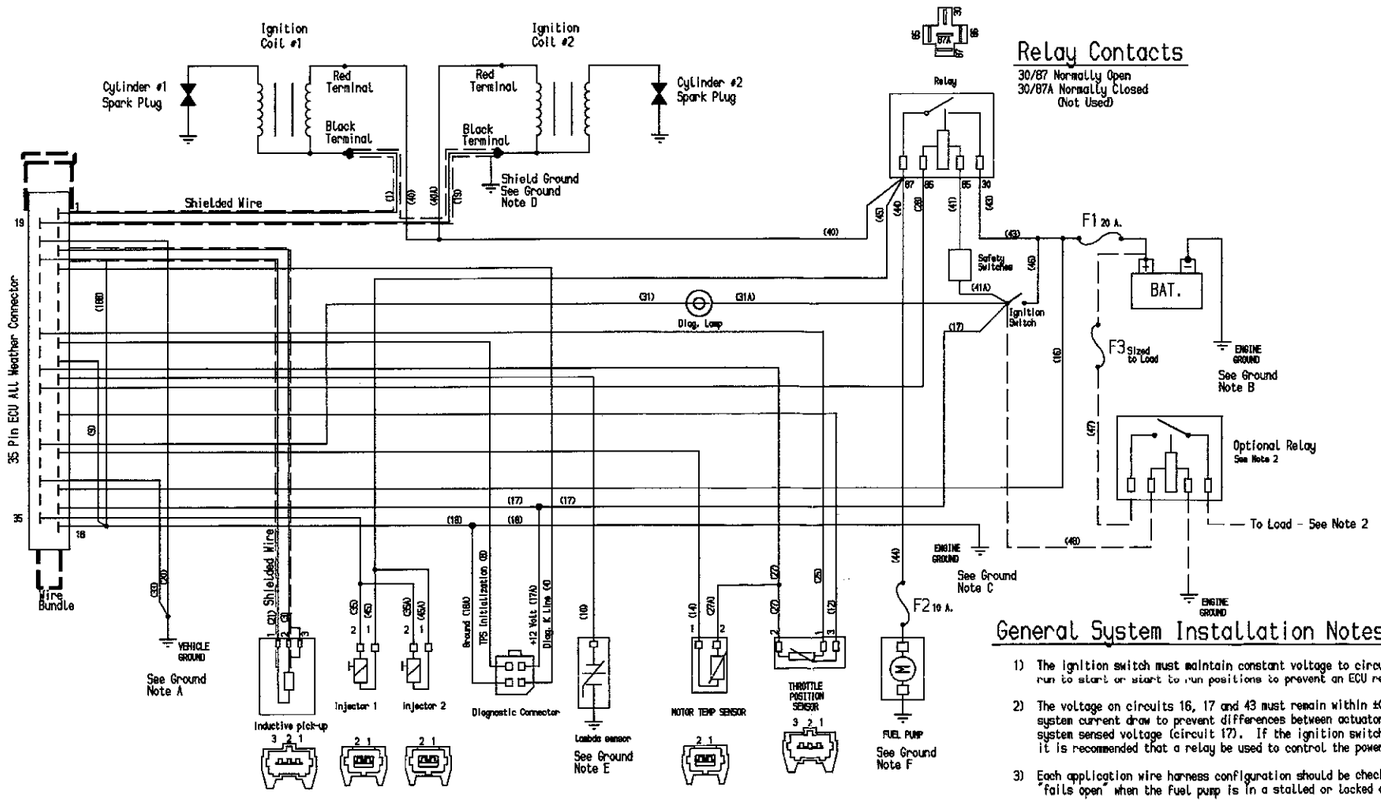
If a fault code indicates a problem with an electrical component, disconnect the ECU connector and test for continuity between the component connector terminals and the corresponding terminals in the ECU connector using an ohmmeter. Little or no resistance should be measured, indicating that the wiring of that particular circuit is OK. An illustrated listing of numerical terminal locations, for each style of ECU connector is provided on page 5B.26 for the metal-cased ECU, and page 5B.29 for the plastic-cased ECU.

NOTE: When performing voltage or continuity tests, avoid putting excessive pressure on or against the connector pins. Flat pin probes are recommended for testing to avoid spreading or bending the terminals.

Metal-Cased ECU Systems

Pin #	Component
1	Ignition Coil #1
2	Not used
3	Engine Speed Sensor
4	ECU Production Test Terminal
5	Not Used
6	Not Used
7	Not Used
8	TPS Initialization Terminal
9	Engine Ground
10	0_2 Sensor
11	Not Used
12	Throttle Position Sensor
13	Not Used
14	Oil Temperature Sensor
15	Not Used
16	ECU Permanent Battery Voltage
17	ECU Switched Battery Voltage
18	Engine Ground
19	Ignition Coil #2
20	Vehicle Ground
21	Engine Speed Sensor
22	Not Used
23	Not Used
24	Not Used
25	Throttle Position Sensor
26	Not Used
27	Throttle Position Sensor/Oil Temperature Sensor
28	Power Relay
29	Not Used
30	Not Used
31	Malfunction Indicator Light
32	Not Used
33	Vehicle Ground
34	Not Used
35	Fuel Injectors





General System Installation Notes:

1) The ignition switch must maintain constant voltage to circuits 17, 31A, and 41A as the key is swept from run to start or start to run positions to prevent an ECU reset during starting.

2) The voltage on circuits 16, 17 and 43 must remain within ±0.2 volts of each other regardless of system current draw to prevent differences between actuator voltage (circuits 40, 44 and 45) and system sensed voltage (circuit 17). If the ignition switch controls a powered circuit (ie lights, horn), it is recommended that a relay be used to control the powered circuit as shown.

3) Each application wire harness configuration should be checked that the fuel pump fuse (F2) "fails open" when the fuel pump is in a stalled or locked condition.

4) A resistive spark plug with either a resistive spark plug wire or resistive spark plug boot must be used to prevent electrical system noise.

5) The safety switches are to be wired in series with the power relay.

6) It is recommended that the ECU be mounted vertically with the wire bundle down or horizontally with the All Weather connector down.

7) It is recommended that the ECU housing be grounded to the chassis. The ECU should not be mounted to the engine nor should it be powerwashed.

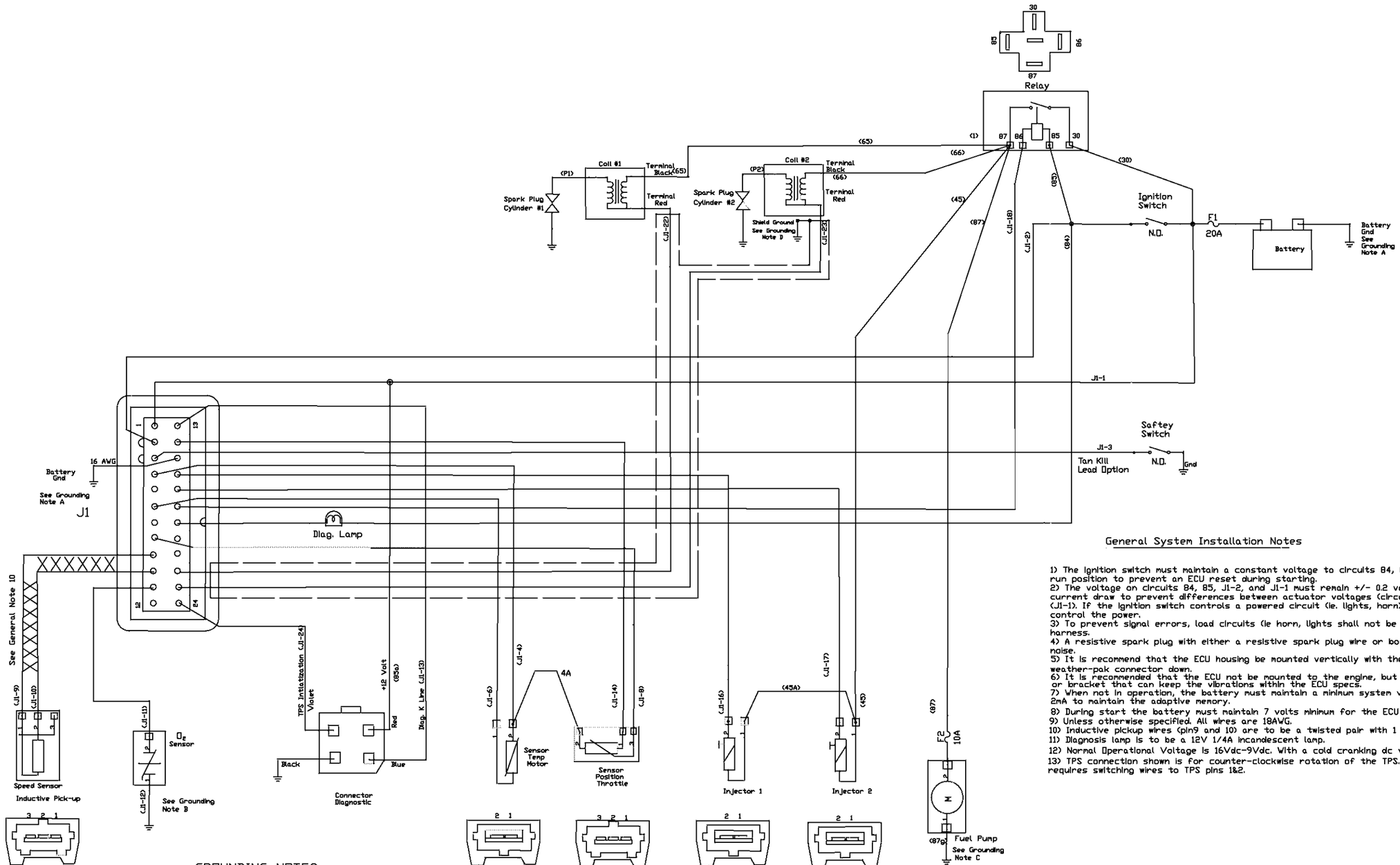
8) When not in operation, the battery must maintain a minimum system voltage of 7 volts with a current draw of 20mA to maintain adaptive memory.

9) During a start, the battery must maintain 7 volts minimum system voltage for ECU operation during crank.

9) Unless otherwise specified: All wires are 18 AWG.

Grounding Notes

Note	Item	Instruction
A	Injector/Ignition Output Driver	Attach to chassis as close to ECU as possible
B	Battery	Attach to engine block near starter
C	ECU	Attach to engine block near blower housing
D	Shield	Attach to engine block near Coil #2. Wire from shield to ground Location to be as short as possible.
E	Lambda Sensor	The lambda grounds to the engine via the exhaust system. If a slip joint exhaust system is used, a grounding strap from the engine to the muffler near the lambda sensor is required.
F	Fuel Pump	Attach to chassis
.	.	



GROUNDING NOTES

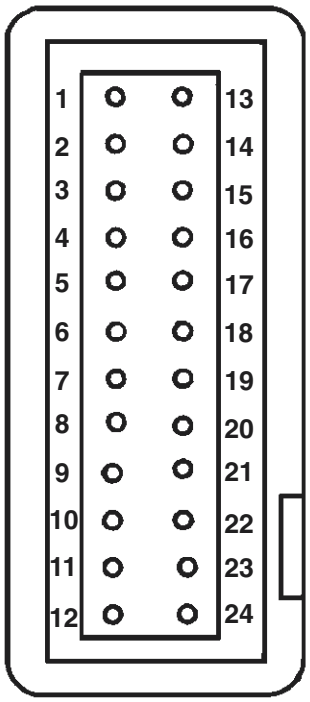
Note	Item	Instruction
A	Battery	Attached to engine block near starter
B	Lambda Sensor	The sensor grounds to the engine via the muffler. If two leaded sensor is used pin 12 is lambda ground. If aslip joint is used, a grounding strap is required.
C	Fuel Pump	Attached to chassis.
D	Shield	Attached to engine block close to the coil.

General System Installation Notes

1) The ignition switch must maintain a constant voltage to circuits 84, 85, and J1-2 as the key is swept from run position to prevent an ECU reset during starting.
2) The voltage on circuits 84, 85, J1-2, and J1-1 must remain +/- 0.2 volts of each other regardless of system current draw to prevent differences between actuator voltages (circuits 65, 66, 45, and 87) and system voltage (J1-1). If the ignition switch controls a powered circuit (ie. lights, horn) it is recommended that a relay be used to control the power.
3) To prevent signal errors, load circuits (ie horn, lights shall not be powered from the EFI engine or wire chassis harness.
4) A resistive spark plug with either a resistive spark plug wire or boot must be used to prevent electrical system noise.
5) It is recommend that the ECU housing be mounted vertically with the wire bundle down or horizontally with the weather-pak connector down.
6) It is recommended that the ECU not be mounted to the engine, but be attached it an isolator plate or or bracket that can keep the vibrations within the ECU specs.
7) When not in operation, the battery must maintain a minimum system voltage of 7 volts with a current draw of 2mA to maintain the adaptive memory.
8) During start the battery must maintain 7 volts minimum for the ECU operations during crank.
9) Unless otherwise specified. All wires are 18AWG.
10) Inductive pickup wires (pin9 and 10) are to be a twisted pair with 1 twist per inch.
11) Diagnosis lamp is to be a 12V 1/4A incandescent lamp.
12) Normal Operational Voltage is 16Vdc-9Vdc. With a cold cranking dc voltage of 7Volts.
13) TPS connection shown is for counter-clockwise rotation of the TPS. Clockwise rotaion requires switching wires to TPS pins 1&2.

Plastic-Cased ECU Systems

Pin #	Function
1	Permanent Battery Voltage
2	Switched Ignition Voltage
3	Safety Switch
4	Throttle Position Sensor (TPS) and Temperature Sensor
5	Not Used (Ground)
6	Oil Temperature Sensor Input
7	Not Used
8	Throttle Position Sensor (TPS) Input
9	Speed Sensor Input
10	Speed Sensor Ground
11	Oxygen Sensor Input
12	Not Used (Oxygen Sensor Ground if needed)
13	Diagnostic Line
14	Throttle Position Supply Voltage
15	Battery Ground
16	Injector 1 Output
17	Injector 2 Output
18	Fuel Pump Relay Output
19	Malfunction Indicator Light (MIL)
20	Not Used (Tach Output if needed)
21	Not Used
22	Ignition Coil #1 Output
23	Ignition Coil #2 Output
24	TPS Initialization Terminal



Fuel System

WARNING: Fuel System Under Pressure!
The fuel system operates under high pressure. System pressure must be relieved through the test valve in the fuel rail prior to servicing or removing any fuel system components. Do not smoke or work near heaters or other fire hazards. Have a fire extinguisher handy and work only in a well-ventilated area.

The function of the fuel system is to provide sufficient delivery of fuel at the system operating pressure of 39 psi ± 3. If an engine starts hard, or turns over but will not start, it may indicate a problem with the EFI fuel system. A quick test will verify if the system is operating.

1. Disconnect and ground the spark plug leads.

2. Complete all safety interlock requirements and crank the engine for approximately 3 seconds.

3. Remove the spark plugs and check for fuel at the tips.

    a. If there is fuel at the tips of the spark plugs, the fuel pump and injectors are operating.

    b. If there is no fuel at the tips of the spark plugs, check the following:

        (1) Make sure the fuel tank contains clean, fresh, proper fuel.

        (2) Make sure that vent in fuel tank is open.

        (3) Make sure fuel tank valve (if so equipped) is fully opened.

        (4) Make sure battery is supplying proper voltage.

        (5) Check that the fuses are good, and that all electrical and fuel line connections are good.

        (6) Test fuel pump and relay operation as described earlier under “Fuel Pump – Service.”

Fault Codes

The ECU continuously monitors engine operation against preset performance limits. If the operation is outside the limits, the ECU activates the MIL and stores a diagnostic code in its fault memory. If the component or system returns to proper function, the ECU will eventually self-clear the fault code and turn off the MIL. If the MIL stays illuminated, it warns the customer that dealer service is required. Upon receipt, the dealer technician can access the fault code(s) to help determine what portion of the system is malfunctioning. Eleven 2-digit blink codes are available.

The codes are accessed through the key switch and displayed as blinks or flashes of the MIL. Access the codes as follows.

1. Start with the key switch off.

2. Turn the key switch on-off-on-off-on, leaving it on in the third sequence. The time between sequences must be less than 2.5 seconds.

3. Any stored fault codes will then be displayed as a series of MIL blinks (from 2 to 6) representing the first digit, followed by a pause, and another series of blinks (from 1 to 4) for the second digit (see Figure 5B-39).

    a. It’s a good idea to write down the codes as they appear, as they may not be in numerical sequence.

    b. Code 61 will always be the last code displayed, indicating the end of code transmission. If code 61 appears immediately, no other fault codes are present.

Example of Diagnostic Display

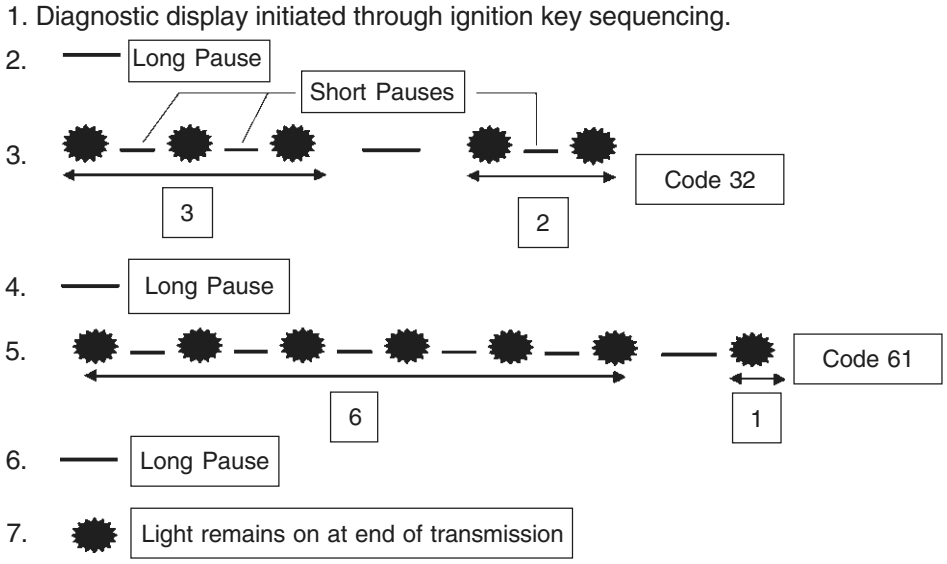


Figure 5B-39.

After the problem has been corrected, the fault codes may be cleared as follows.

1. Disconnect the negative (-) battery cable from battery terminal for 1 minute, or disconnect the main harness connector from the ECU for one minute.

2. Reconnect the cable and tighten securely. Start the engine and allow it to run for several minutes. The MIL should remain off if the problem was corrected, and the fault codes should not reappear (codes 31, 32, 33, and 34 may require 10 -15 minutes of running to reappear).

The following chart lists the fault codes, what they correspond to, and what the visual indications will be. Following the chart is a list of the individual codes with an explanation of what triggers them, what symptoms might be expected, and the probable causes.

Diagnostic Code Summary

CODE	COMPONENT/SENSOR	BLINK DIAGNOSTIC	MIL ILLUMINATED
21	Engine Speed Synchronization	Yes	Yes
22	Throttle Position Sensor (TPS)	Yes	Yes
23	Engine Control Unit (ECU)	Yes	Yes
24	Engine Speed Sensor	No	Yes
31	Oxygen Sensor (short hi/low)	Yes	Yes
32	Oxygen Sensor (no change)	Yes	No
33	Fuel System/Oxygen Sensor (temporary adaption at limit)	Yes	No
34	Fuel System/Oxygen Sensor (learned adaption at limit)	Yes	Yes
42	Oil Temperature Sensor	Yes	Yes
61	End of Code Transmission	Yes	N/A

Code: 21
Source: Engine Speed Sensor
Explanation: ECU receiving inconsistent tooth count signals from speed sensor.
Expected Engine Response: Possible misfire as ECU attempts to resynchronize, during which time fuel and spark calculations are not made.

Possible Causes:

1. Engine Speed Sensor Related
   a. Sensor connector or wiring.
   b. Sensor loose or incorrect air gap.
   c. Flywheel key sheared.

2. Speed Sensor Ring Gear Related
   a. Damaged teeth.
   b. Varying gap (gear loose/out of alignment).

3. Engine Wire Harness Related **Metal-Cased ECU**
   a. Pin circuits 3 and/or 21 wiring or connectors.
   b. Shielding for pin circuits 3 and/or 21 damaged or not properly grounded.
   c. Poor grounds in system (battery, ECU, oxygen sensor, shielding, fuel pump, ignition output).
   d. Pin circuits 3 and/or 21 routed near noisy electrical signals (coils, spark plug lead, plug connector).

3. Engine Wire Harness Related **Plastic-Cased ECU**
   a. Pin circuits 9 and/or 10 wiring or connectors.
   b. Shielding for pin circuits 9 and/or 10 damaged or not properly grounded.
   c. Poor or improper grounds in system (battery, ECU oxygen sensor, shielding, fuel pump, ignition output).
   d. Pin circuits 9 and/or 10 routed near noisy electrical signals (coils, spark plug lead, plug connector).

4. ECU/Harness Related
   a. ECU-to-harness connection problem.

Code: 22
Source: Throttle Position Sensor (TPS)
Explanation: Unrecognizable signal is being sent from sensor (too high, too low, inconsistent).
Expected Engine Response: A “limp-home” operating mode occurs, with an overall decrease in operating performance and efficiency. Fuel delivery is based upon the oxygen sensor and five mapped values only. Rich running (black smoke) will occur until “closed loop” operation is initiated. A stumble or misfire on hard acceleration and/or erratic operation may be exhibited.

Possible Causes:

1. TPS Sensor Related
   a. Sensor connector or wiring.
   b. Sensor output affected or disrupted by dirt, grease, oil, wear, or breather tube position (must be to side opposite the TPS).
   c. Sensor loose on throttle body manifold.

2. Throttle Body Related
   a. Throttle shaft or bearings worn/damaged.

3. Engine Wire Harness Related **Metal-Cased ECU**
   a. Pin circuits 12, 25 and/or 27 damaged (wiring or connectors).
   b. Pin circuits 12, 25 and/or 27 routed near noisy electrical signal (coils, alternator).
   c. Intermittent 5 volt source from ECU (pin circuit 25).

3. Engine Wire Harness Related **Plastic-Cased ECU**
   a. Pin circuits 4, 8, and/or 14 damaged (wiring, connectors).
   b. Pin circuits 4, 8, and/or 14 routed near noisy electrical signal (coils, alternator).
   c. Intermittent 5 volt source from ECU (pin circuit 14).

4. ECU/Harness Related
   a. ECU-to-harness connection problem.

Code: **23**
Source: ECU
Explanation: ECU is unable to recognize or process signals from its memory.
Expected Engine Response: Engine will not run.

Possible Causes:
1. ECU (internal memory problem).
   a. Diagnosable only through the elimination of all other system/component faults.

Code: **24** (Will not blink out)
Source: Engine Speed Sensor
Explanation: No tooth signal from speed sensor. MIL light will not go out when cranking.
Expected Engine Response: None-engine will not start or run as ECU is unable to estimate speed.

Possible Causes:
1. Engine Speed Sensor Related
   a. Sensor connector or wiring.
   b. Sensor loose or air gap incorrect.

2. Speed Sensor Wheel Related
   a. Damaged teeth.
   b. Gap section not registering.

3. Engine Wire Harness Related
   a. Pin circuit wiring or connectors.
   Pin(s) 3 and/or 21 for **metal-cased ECU.**
   Pin(s) 9 and/or 10 **plastic-cased ECU.**

4. ECU/Harness Related
   a. ECU-to-harness connection problem.

Code: **31**
Source: Fuel Mixture or Oxygen Sensor
Explanation: Oxygen sensor not sending proper voltage signal to ECU.
Expected Engine Response: System operates under “open loop” control only. Until fault is detected and registered by ECU, engine will run rich if oxygen sensor is shorted to ground or lean if it is shorted to battery voltage. After fault is detected, performance can vary, depending on cause. If performance is pretty good, the problem is probably with the oxygen sensor, wiring, or connectors. If the engine is still running rich (laboring, short on power) or lean (popping or misfiring), the fuel mixture is suspect, probably incorrect TPS initialization.

Possible Causes:
1. TPS Initialization Incorrect
   a. Lean condition (check oxygen sensor signal with VOA and see Oxygen Sensor section).

2. Engine Wire Harness Related
   a. Pin circuit wiring or connectors.
   Pin 10 for **metal-cased ECU.**
   Pin 11 for **plastic-cased ECU.**

3. Oxygen Sensor Related
   a. Sensor connector or wiring problem.
   b. Exhaust leak.
   c. Poor ground path to engine (sensor is case grounded).

Code: **32**
Source: Oxygen Sensor
Explanation: No change in the sensor output signal.
Expected Engine Response: "Open loop" operation only, may cause a drop in system performance and fuel efficiency.

Possible Causes:

1. Engine Wiring Harness Related
   a. Pin circuit wiring or connectors.
      Pin 10 for **metal-cased ECU.**
      Pin 11 for **plastic-cased ECU.**

2. Oxygen Sensor Related
   a. Sensor connector or wiring problem.
   b. Sensor contaminated or damaged.
   c. Sensor below the minimum operating temperature (375° C, 709° F).
   d. Poor ground path to engine (sensor grounds through shell, see Oxyen Sensor section).

Code: **33**
Source: Oxygen Sensor/Fuel System
Explanation: Temporary fuel adaptation control is at the upper or lower limit.
Expected Engine Response: Erratic performance. Will run rich (smoke) if on the lower limit or lean (misfire) if on the upper limit.

Possible Causes:

1. Fuel Supply Related
   a. Ran out of gas.
   b. Fuel inlet screen plugged (in-tank fuel pump only).
   c. Incorrect fuel pressure at fuel rail.

2. Oxygen Sensor Related
   a. Sensor connector or wiring problem.
   b. Sensor contaminated or damaged.
   c. Exhaust leak.
   d. Poor ground path.
   e. Pin circuit wiring or connectors.
      Pin 10 for **metal-cased ECU.**
      Pin 11 for **plastic-cased ECU.**

3. TPS Sensor Related
   a. Throttle plate position incorrectly set or registered during "Initialization."
   b. TPS problem or malfunction.

4. Engine Wiring Harness Related
   a. Difference in voltage between sensed voltage (pin circuit 17 for **metal-cased ECU,** pin circuit 2 for **plastic-cased ECU**) and actual injector voltage (circuit 45/45A).

5. Systems Related
   a. Ignition (spark plug, plug wire, ignition coil.
   b. Fuel (fuel type/quality, injector, fuel pump, fuel pressure.
   c. Combustion air (air cleaner dirty/restricted, intake leak, throttle bores).
   d. Base engine problem (rings, valves).
   e. Exhaust system leak.
   f. Fuel in the crankcase oil.
   g. Blocked or restricted fuel return circuit to tank.

6. ECU Related
   a. ECU-to-harness connection problem.

Code: **34**
Source: Oxygen Sensor/Fuel System Components
Explanation: Long term fuel adaptation control is at the upper or lower limit.
Expected Engine Response: System operates "closed loop." No appreciable performance loss as long as the temporary adaptation can provide sufficient compensation.

Possible Causes:

1. Oxygen Sensor Related
   a. Sensor connector or wiring.
   b. Sensor contaminated or damaged.
   c. Exhaust leak.
   d. Poor ground path.
   e. Pin circuit wiring or connectors.
      Pin 10 for **metal-cased ECU.**
      Pin 11 for **plastic-cased ECU.**

2. TPS Sensor Related
   a. Throttle plate position incorrect during "Initialization" procedure.
   b. TPS problem or malfunction.

3. Engine Wiring Harness Related
   a. Difference in voltage between sensed voltage (pin circuit 17 for **metal-cased ECU,** pin circuit 2 for **plastic-cased ECU**) and actual injector voltage (circuit 45/45A).
   b. Problem in wiring harness.
   c. ECU-to-harness connection problem.

4. Systems Related
   a. Ignition (spark plug, plug wire, ignition coil.
   b. Fuel (fuel type/quality, injector, fuel pressure, fuel pump).
   c. Combustion air (air cleaner dirty/restricted, intake leak, throttle bores).
   d. Base engine problem (rings, valves).
   e. Exhaust system leak (muffler, flange, oxygen sensor mounting boss, etc.).
   f. Fuel in the crankcase oil.
   g. Altitude.
   h. Blocked or restricted fuel return circuit to tank.

Code: **42**
Source: Oil Temperature Sensor
Explanation: Not sending proper signal to ECU.
Expected Engine Response: Engine may be hard to start because ECU can't determine correct fuel mixture.

Possible Causes:
1. Temperature Sensor Related
   a. Sensor wiring or connection.

2. Engine Wiring Harness Related **Metal-Cased ECU**
   a. Pin circuits 14 and/or 27A damaged (wires, connectors) or routed near noisy signal (coils, alternator, etc.).
   b. ECU-to-harness connection problem.

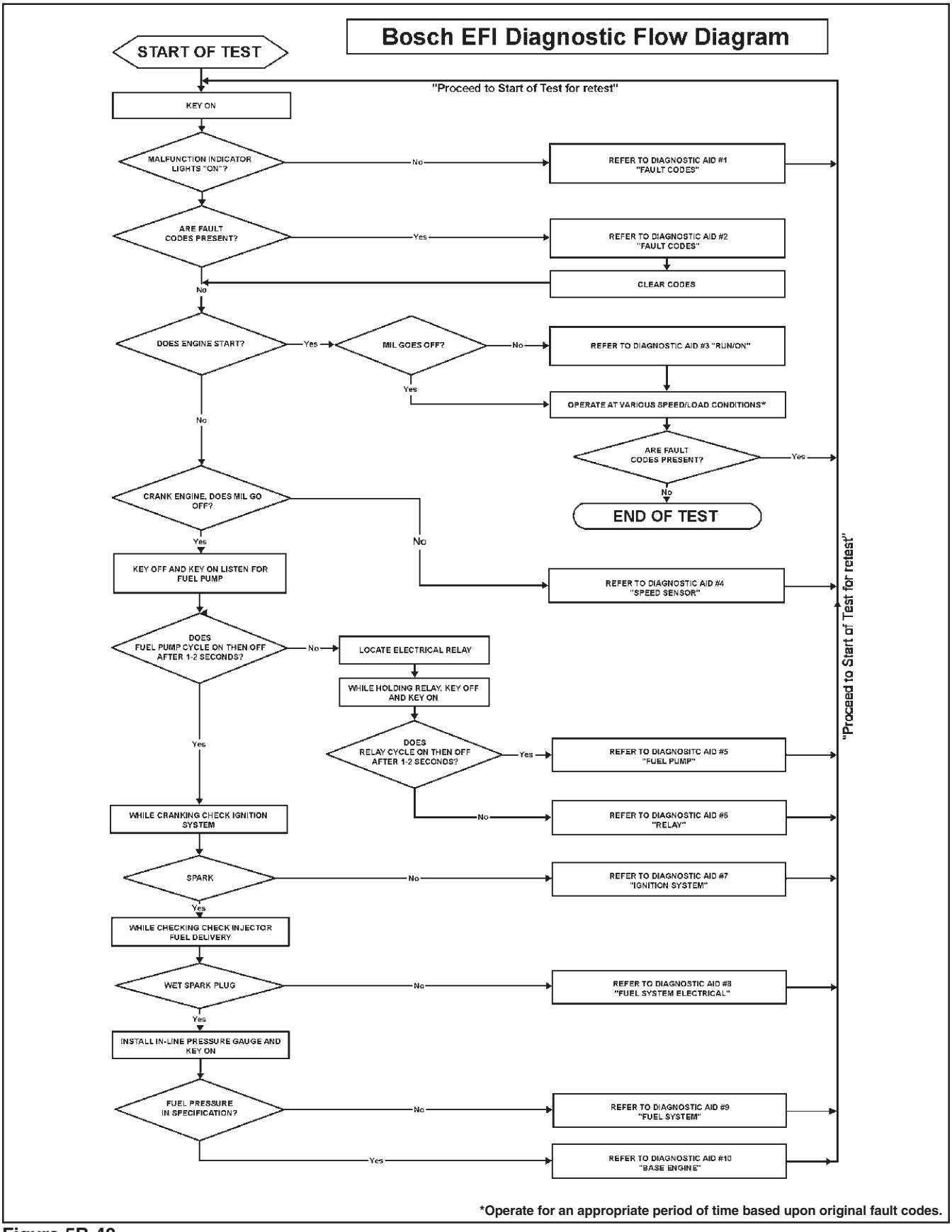
2. Engine Wiring Harness Related **Plastic-Cased ECU**
   a. Pin circuits 6 and/or 4A damaged (wires, connectors) or routed near noisy signal (coils, alternator, etc.).
   b. ECU-to-harness connection problem.

3. System Related
   a. Engine is operating above the 176°C (350°F) temperature sensor limit.

Code: **61**
Source: _____
Explanation: Denotes the end of fault codes. If signaled first, no other fault codes are present.

Troubleshooting Flow Chart

The following flow chart (on page 5B.36) provides an alternative method of troubleshooting the EFI system. The chart will enable you to review the entire system in about 10-15 minutes. Using the chart, the accompanying diagnostic aids (listed after the chart), and any signaled fault codes, you should be able to quickly locate any problems within the system.



*Operate for an appropriate period of time based upon original fault codes.

Figure 5B-40.

Flow Chart Diagnostic Aids

Diagnostic Aid #1 "SYSTEM POWER" (MIL does not illuminate when key is turned **"on"**)

Possible causes:

1. Battery
2. Main system fuse
3. MIL light bulb burned out
4. MIL electrical circuit problem
   Metal-Cased ECU: Pin circuits 31 and 31A.
   Plastic-Cased ECU: Pin circuits 19 and 84
5. Ignition switch
6. Permanent ECU power circuit problem
   Metal-Cased ECU: Pin circuit 16
   Plastic-Cased ECU: Pin circuit 1
7. Switched ECU power circuit problem
   Metal-Cased ECU: Pin circuit 17
   Plastic-Cased ECU: Pin circuit 2.
8 ECU grounds
9. ECU

Diagnostic Aid #2 "FAULT CODES" (Refer to detailed fault code listing before flow chart and "servicing" information for the respective components)

1. Code 21 - Engine Speed Synchronization
2. Code 22 - Throttle Position Sensor (TPS)
3. Code 23 - Engine Control Unit (ECU)
4. Code 31 - Oxygen Sensor
5. Code 32 - Oxygen Sensor
6. Code 33 - Fuel System (temporary adaptation factor)
7. Code 34 - Fuel System (permanent adaptation factor)
8. Code 42 - Oil Temperature Sensor
9. Code 61 - End of Fault/Blink Code Transmission.

Diagnostic Aid #3 "RUN/ON" (MIL remains **"on"** while engine is running)*

Possible causes:

1. Fault codes which turn on MIL when engine is running.
   a. Code 21 - Engine Speed Synchronization
   b. Code 22 - Throttle Position Sensor (TPS)
   c. Code 23 - Engine Control Unit (ECU)
   d. Code 31 - Oxygen Sensor (shorted)
   e. Code 34 - Fuel System (permanent adaptation at limit)
   f. Code 42 - Oil Temperature Sensor
2. MIL circuit grounded between light and ECU.
   Metal-Cased ECU: Pin circuit 31.
   Plastic-Cased ECU: Pin circuit 19.
3. ECU

*NOTE: MIL in **Metal-Cased ECU** systems is an LED. The MIL in **Plastic-Cased ECU** systems must be a 1/4 watt incandescent lamp.

Diagnostic Aid #4 "SPEED SENSOR" (MIL does not turn off during cranking)

Possible causes:

1. Speed sensor
2. Speed sensor circuit problem
   Metal-Cased ECU: Pin circuits 3 and 21
   Plastic-Cased ECU: Pin circuits 10 and 9.
3. Speed sensor/toothed wheel air gap
4. Toothed wheel
5. Flywheel key sheared
6. ECU

Diagnostic Aid #5 "FUEL PUMP" (fuel pump not turning on)

Possible causes:

1. Fuel pump fuse
2. Fuel pump circuit problem
   Metal-Cased ECU: Circuits 43, 44, and relay
   Plastic-Cased ECU: Circuits 30, 87, and relay
3. Fuel pump

Diagnostic Aid #6 "RELAY" (relay not operating)

Possible causes:
1. Safety switches/circuit(s) problem
   Metal-Cased ECU: Circuits 41 and 41A
   Plastic-Cased ECU: Circuit 3
2. Relay circuit(s) problem
   Metal-Cased ECU: Circuits 28, 41, and 41A
   Plastic-Cased ECU: Circuits 18, 85, 30, and 87
3. Relay
4. ECU grounds
5. ECU

Diagnostic Aid #7 "IGNITION SYSTEM" (no spark)

Possible causes:
1. Spark plug
2. Plug wire
3. Coil
4. Coil circuit(s)
   Metal-Cased ECU: Circuits 1, 19, 40, 40A, 43, and relay
   Plastic-Cased ECU: Circuits 22, 23, 65, 66, 30, and relay
5. ECU grounds
6. ECU

Diagnostic Aid #8 "FUEL SYSTEM-ELECTRICAL" (no fuel delivery)

Possible causes:
1. No fuel
2. Air in fuel rail
3. Fuel valve shut off
4. Fuel filter/line plugged
5. Injector circuit(s)
   Metal-Cased ECU: Circuits 35, 35A, 45, and 45A
   Plastic-Cased ECU: Circuits 16, 17, 45, and 45A
6. Injector
7. ECU grounds
8. ECU

Diagnostic Aid #9 "FUEL SYSTEM" (fuel pressure)

Possible causes for low fuel system pressure:
1. Low fuel
2. Fuel filter plugged
3. Fuel supply line plugged
4. Pressure regulator
5. Fuel pump

Possible causes for high fuel system pressure:
1. Pressure regulator
2. Fuel return line plugged or restricted.

Diagnostic Aid #10 "BASIC ENGINE" (cranks but will not run)

Possible causes:
1. Refer to basic engine troubleshooting charts within service manual sections 3, 5, and 8.

Common Complaints/Problems

Following are some of the most common complaints or problems reported by customers. For each problem, you will find a list of the most likely causes or areas to be investigated. Always start by checking if there are any stored fault codes to steer you in the right direction.

Engine starts hard or fails to start when cold. (Code 42)
1. Fuel pump not activating/operational.
2. Temperature sensor faulty.
3. Fuel pressure insufficient/incorrect.
4. Fuel injector(s) leaking.
5. Fuel injector(s), fuel filter, fuel line, or fuel pick-up dirty, clogged, or restricted.
6. Speed sensor malfunction.
7. Stale fuel.
8. Low system voltage.
9. Bad spark plug(s) or coil(s).
10. Base ignition timing incorrect.

Engine starts hard or fails to start when warm. (Code 42)
1. Insufficient fuel system pressure.
2. Temperature sensor faulty.
3. Fuel injector(s) leaking.
4. Fuel injector(s), fuel filter, fuel line, or fuel pick-up dirty/restricted.
5. Low fuel pressure.
6. Wrong grade of fuel.
7. Bad spark plug(s) or coil(s).
8. Low system voltage.
9. Speed sensor problem.
10. Base ignition timing problem.

Engine stalls or idles roughly. (Code 22, 34, 42)
1. Vacuum (intake air) leak.
2. Fuel injector(s), fuel filter, fuel line, or fuel pick-up dirty/clogged/restricted.
3. Insufficient fuel pressure/delivery.
4. Temperature sensor faulty.
5. TPS faulty or "TPS Initialization Procedure" incorrect.
6. Leaking fuel injector O-Rings.
7. Bad spark plug(s) or coil(s).

Engine idles too fast (after full warm-up).

1. Throttle linkage binding or not returning to idle position.
2. Idle speed adjustment incorrect.
3. Vacuum (intake air) leak.
4. Leaking fuel injector O-Rings (injector to manifold).
5. Temperature sensor faulty.
6. TPS faulty or “TPS Initialization Procedure.” incorrect.
7. Base ignition timing incorrect.

Engine misses, hesitates, or stalls under load.
(Code 22, 34)

1. Fuel injector(s), fuel filter, fuel line, or fuel pick-up dirty/restricted.
2. Dirty air cleaner.
3. Insufficient fuel pressure or fuel delivery.
4. Vacuum (intake air) leak.
5. Improper governor setting, adjustment or operation.
6. Speed sensor malfunction.
7. TPS faulty, mounting problem or “TPS Initialization Procedure” incorrect.
8. Bad coil(s), spark plug(s), or wires.
9. Base ignition timing incorrect.

Low Power

1. Throttle plates in throttle body/intake manifold not fully opening to WOT stop (if so equipped).
2. Insufficient fuel delivery.
3. Dirty air filter.
4. Faulty/malfunctioning ignition system.
5. TPS faulty or mounting problem.
6. Basic engine problem exists.
7. Improper governor adjustment.
8. Plugged/restricted exhaust.
9. One injector not working.
10. One spark plug, coil, or wire not working.

Section 6
Lubrication System

General

This engine uses a full pressure lubrication system. This system delivers oil under pressure to the crankshaft, camshaft and connecting rod bearing surfaces. In addition to lubricating the bearing surfaces, the lubrication system supplies oil to the hydraulic valve lifters.

A high-efficiency gerotor pump is located in the closure plate. The oil pump maintains high oil flow and oil pressure, even at low speeds and high operating temperatures. A pressure relief valve in the closure plate limits the maximum pressure of the system.

Service

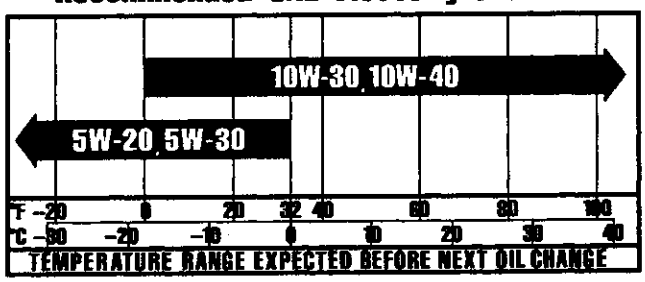
The closure plate must be removed to service the oil pickup, the pressure relief valve and the oil pump. Refer to the appropriate procedures in Section 11.

Oil Recommendations

Using the proper type and weight of oil in the crankcase is extremely important; so is checking oil daily and changing the oil and filter regularly.

Use high-quality detergent oil of **API (American Petroleum Institute) service class SF, SG or SH.** Select the viscosity based on the air temperature at the time of operation as shown in the following table.

Recommended SAE Viscosity Grades



NOTE: Using other than service class SF, SG or SH oil or extending oil change intervals longer than recommended can cause engine damage.

A logo or symbol on oil containers identifies the API service class and SAE viscosity grade. See Figure 6-1.

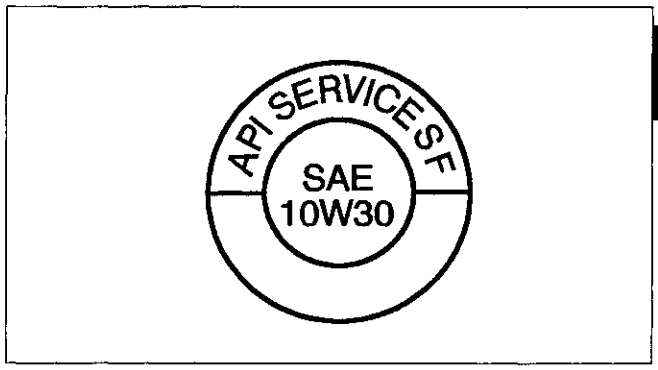


Figure 6-1. Oil Container Logo.

The top position of the symbol shows service class such as **API SERVICE CLASS SF.** The symbol may show additional categories such as **SH, SG/CC, or CD.** The center portion shows the viscosity grade such as SAE 10W-30. If the bottom portion shows "Energy Conserving," it means that oil is intended to improve fuel economy in passenger car engines.

Checking Oil Level

The importance of checking and maintaining the proper oil level in the crankcase cannot be overemphasized. Check oil **BEFORE EACH USE** as follows:

1. Make sure the engine is stopped, level and is cool so the oil has had time to drain into the sump.

2. Clean the area around the dipstick before removing it. This will help to keep dirt, grass clippings, etc., out of the engine.

3. Remove the dipstick; wipe oil off. Reinsert the dipstick into the tube until fully seated. See Figure 6-2.

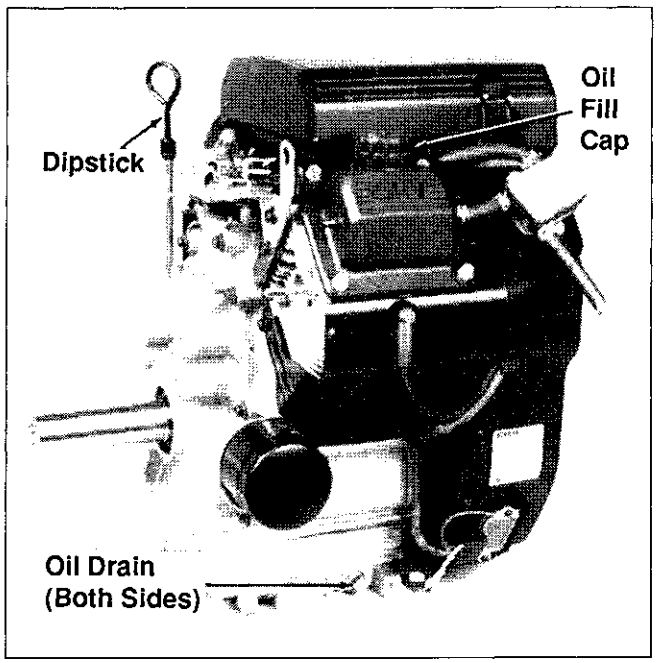


Figure 6-2. Location of Oil Fill Cap/Dipstick.

4. Remove dipstick and check oil level. The level should be between the "F" and "L" marks. If low, add oil of proper type up to the full mark. Reinstall oil fill cap and dipstick.

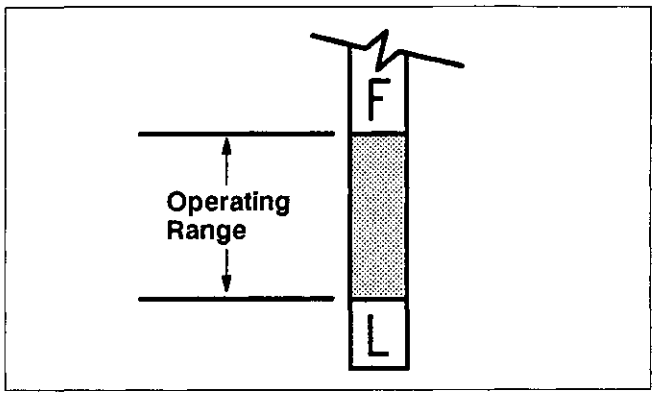


Figure 6-3. Oil Level Marks on Dipstick.

NOTE: To prevent extensive engine wear or damage, always maintain the proper oil level in the crankcase. Never operate the engine with the oil level below the low mark or above the full mark on the dipstick.

Changing Oil and Oil Filter

Changing Oil

For a new engine, change oil after the first 5 hours of operation. Thereafter, change oil after every **100 hours** of operation. See the "Viscosity Grades" table for recommended oil.

For an overhauled engine or an engine rebuilt with a new short block, use 10W-30 — weight service class SF, SG or SH oil for the first **5 hours** of operation. Change the oil after this initial run-in period. Refill with service class SF, SG or SH oil as specified in the "Viscosity Grades" table on page 6.1.

Change the oil while the engine is still warm. The oil will flow freely and carry away more impurities. Make sure the engine is level when filling or checking oil.

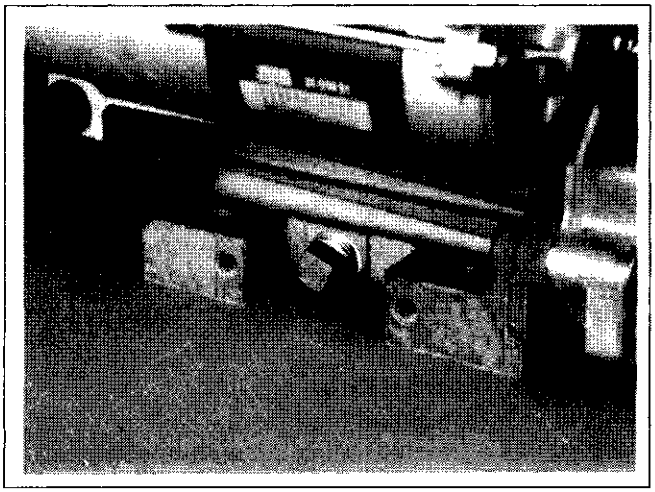


Figure 6-4. Location of Oil Drain on Starter Side.

Change the oil as follows:

1. Remove one of the oil drain plugs. A drain plug is located on either side of the crankcase; one is adjacent to and below the oil filter, the other is below the starter. (See Figure 6-4.)

2. Allow all oil to drain and then reinstall the drain plug. Tighten to **13.6 N·m (10 ft. lb.)** torque.

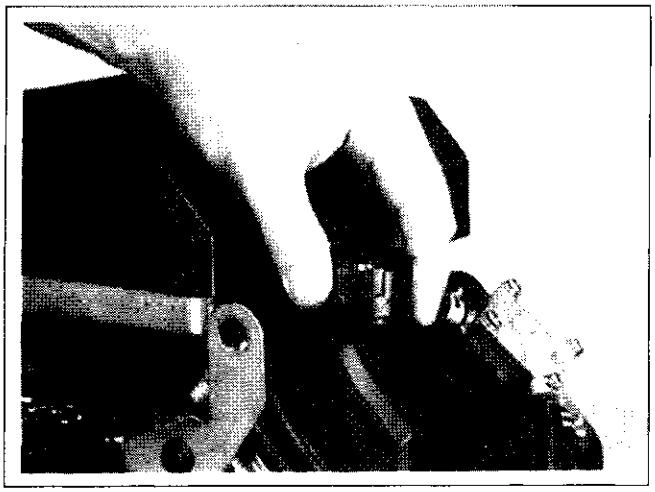


Figure 6-5. Removing Oil Fill Cap.

3. Remove the oil fill cap and fill the engine with the proper oil to the "F" mark on the dipstick. Always check the oil level with the dipstick before adding more oil.

4. Reinstall the oil fill cap.

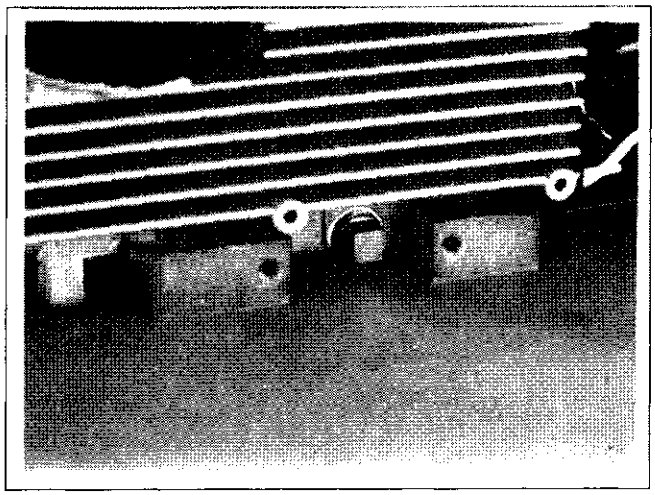


Figure 6-6. Oil Drain Plug and Oil Filter.

Changing Oil Filter
Replace the oil filter **at least every other oil change (every 200 hours of operation)**. Always use a *genuine Kohler oil filter*. Change the filter as follows (see Figure 6-6):

1. Remove one of the oil drain plugs. A drain plug is located on either side of the crankcase; one is adjacent to and below the oil filter, the other is below the starter.

2. Allow all oil to drain and then reinstall the drain plug. Tighten **13.6 N·m (10 ft. lb.)**.

3. Remove the old filter and wipe off the filter adapter with a clean cloth.

4. Apply a thin coating of oil to the rubber gasket on the new oil filter.

5. Install the new oil filter to the filter adapter. Hand tighten the filter clockwise until the rubber gasket contacts the adapter, then tighten the filter an additional **1/2 turn**.

6. Remove the oil fill cap and fill the engine with the proper oil to the "F" mark on the dipstick. Always check the oil level with the dipstick before adding more oil.

7. Reinstall the oil fill cap/dipstick.

8. Start the engine and check for oil leaks. Correct any leaks and recheck oil level before placing the engine into service.

Oil Sentry™

General
Some engines are equipped with an optional Oil Sentry™ oil pressure monitor. If the pressure gets low, Oil Sentry™ will either shut off the engine or activate a warning signal depending on the application.

The pressure switch is designed to break contact as the oil pressure increases, and make contact as the oil pressure decreases. At oil pressure above approximately 3.0/5.0 psig, the switch contacts open. Below this pressure, the switch contacts close.

On stationary or unattended applications (pumps, generators, etc.), the pressure switch can be used to ground the ignition module to stop the engine.
On vehicular applications (lawn tractors, mowers, etc.) the pressure switch can be used to activate a "low oil" warning light.

NOTE: Make sure the oil level is checked BEFORE EACH USE and is maintained up to the "F" mark on the dipstick. This includes engines equipped with Oil Sentry™.

Installation
The Oil Sentry™ pressure switch is installed on the breather cover next to the breather tube. See Figure 6-7.

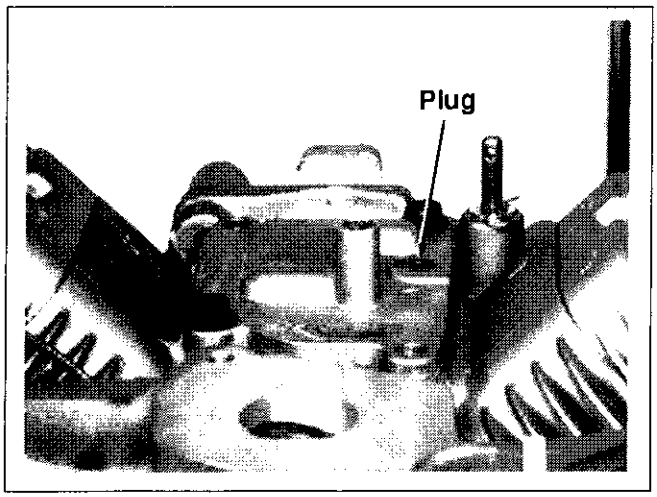


Figure 6-7. Location of Oil Sentry™ Switch (or plug).

On engines not equipped with Oil Sentry™ the installation hole is sealed with a 1/8-27 N.P.T.F. pipe plug.

To install the switch, follow these steps:

1. Apply **Loctite® No. 592 Pipe Sealant with Teflon** (or equivalent) to the threads of the switch.

2. Install the switch into the tapped hole in the breather cover. See Figure 6-7.

3. Tighten the switch to **4.5 N·m (40 in. lb.)**.

Testing
Compressed air, a pressure regulator, pressure gauge and a continuity tester are required to test the switch.

1. Connect the continuity tester across the blade terminal and the metal case of the switch. With **0 psig** pressure applied to the switch, the tester should indicate **continuity (switch closed)**.

2. Gradually increase the pressure to the switch. As pressure increases through the range of **3.0/5.0 psig,** the tester should indicate a change to **no continuity (switch open)**. The switch should remain open as the pressure is increased to **90 psig maximum**.

3. Gradually decrease the pressure through the range of **3.0/5.0 psig**. The tester should indicate a change to **continuity (switch closed) down to 0 psig**.

4. Replace the switch if it does not operate as specified.

Section 7
Retractable Starter

WARNING: Spring Under Tension!

Retractable starters contain a powerful, recoil spring that is under tension. Always wear safety goggles when servicing retractable starters and carefully follow instructions in this section for relieving spring tension.

To Remove Starter

1. Remove the five hex. flange screws securing the starter to blower housing.
2. Remove the starter.

To Install Starter

1. Install the retractable starter and five hex. flange screws to blower housing. Leave the screws slightly loose.
2. Pull the starter handle out until the pawls engage in the drive cup. Hold the handle in this position and tighten the screws securely.

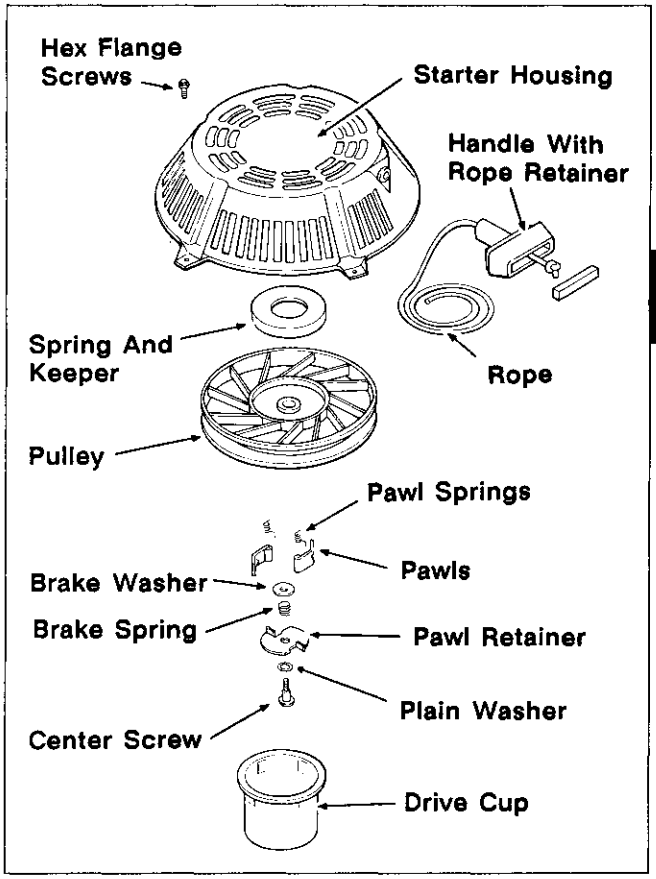


Figure 7-1. Retractable Starter - Exploded View.

7

Section 7
Retractable Starter

Rope Replacement

The rope can be replaced *without* complete starter disassembly.

1. Remove the starter from the engine blower housing.

2. Pull the rope out approximately 12" and tie a temporary (slip) knot in it to keep it from retracting into the starter. See Figure 7-2.

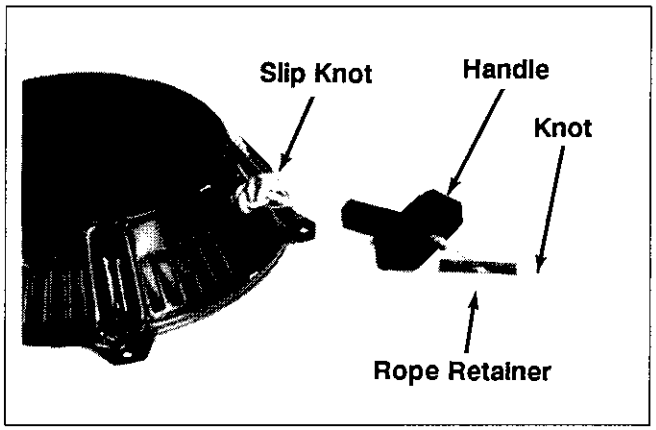


Figure 7-2. Removing Starter Handle.

3. Remove the rope retainer from inside the starter handle. Untie the single knot and remove the rope retainer and handle.

4. Hold the pulley firmly and untie the slip knot. Allow the pulley to rotate slowly as the spring tension is released.

5. When all spring tension on the starter pulley is released, remove the rope from pulley.

6. Tie a single knot in one end of the new rope.

7. Rotate the pulley counterclockwise (when viewed from pawl side of pulley) until the spring is tight. (Approximately 6 full turns of pulley.)

8. Rotate the pulley clockwise until the rope hole in pulley is aligned with rope guide bushing of starter housing.

   NOTE: Do not allow the pulley/spring to unwind. Enlist the aid of a helper if necessary, or use a C-clamp to hold the pulley in position.

9. Insert the new rope through the rope hole in starter pulley and rope guide bushing of housing. See Figure 7-3.

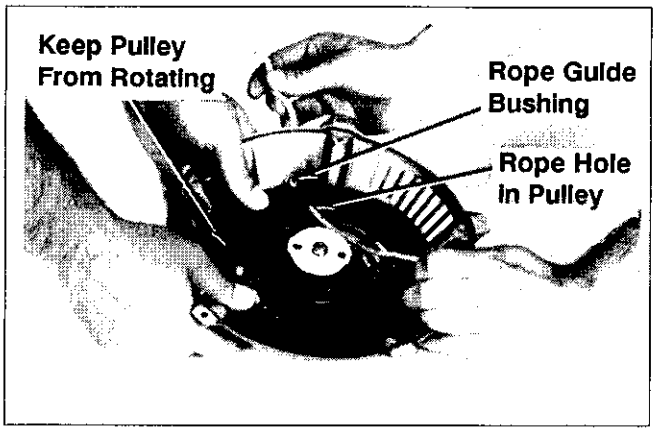


Figure 7-3. Installing Rope.

10. Tie a slip knot approximately 12" from the free end of rope. Hold the pulley firmly and allow it to rotate slowly until the slip knot reaches the guide bushing of housing.

11. Slip the handle and rope retainer onto the rope. Tie a single knot at the end of the rope. Install the rope retainer into the starter handle.

12. Untie the slip knot and pull on the handle until the rope is fully extended. Slowly retract the rope into the starter.

    When the spring is properly tensioned, the rope will retract fully and the handle will stop against the starter housing.

Pawls (Dogs) Replacement

To replace the pawls, follow disassembly steps 1-4 and reassembly steps 3-8 on the following pages. A pawl repair kit is available which includes the following components:

Pawl Repair Kit

Qty.	Description
1	Pawl Retainer
1	Center Screw
2	Pawl (Dog) Spring
1	Brake Spring
2	Starter Pawl (Dog)
1	Brake Washer
1	Washer

Disassembly

⚠ WARNING: Spring Under Tension!
Do not remove the center screw from starter until the spring tension is released. Removing the center screw before releasing spring tension, or improper starter disassembly, can cause the sudden and potentially dangerous release of the spring. Follow these instructions carefully to ensure personal safety and proper starter disassembly. Make sure adequate face protection is worn by all persons in the area.

1. Release spring tension and remove the handle and starter rope. (Refer to "Rope Replacement," steps 2 through 5 on previous page.)

2. Remove the center screw, washer, and pawl retainer. See Figure 7-4.

3. Remove the brake spring and brake washer. See Figure 7-5.

4. Carefully note the positions of the pawls and pawl springs before removing them.

   Remove the pawls and pawl springs from the starter pulley.

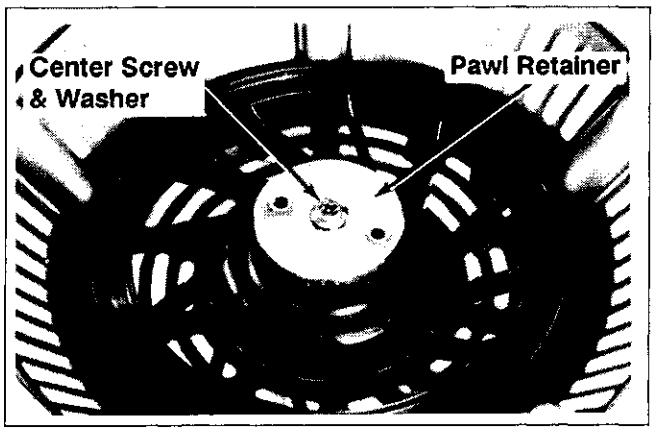


Figure 7-4. Center Screw, Washer and Pawl Retainer.

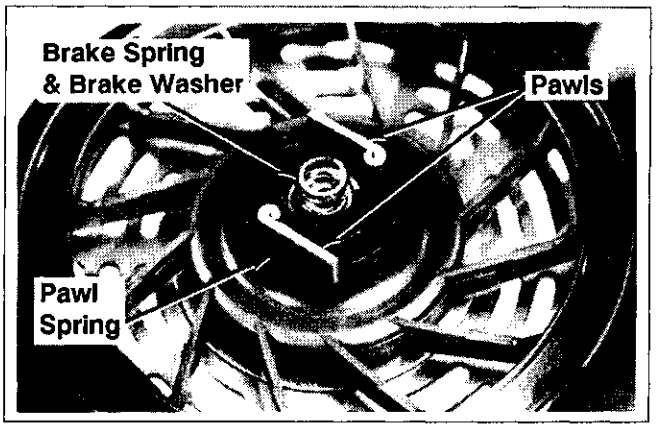


Figure 7-5. Brake Spring and Washer, Pawls, and Pawl Springs.

5. Rotate the pulley **clockwise 2 full turns**. This will ensure the spring is disengaged from the starter housing.

6. Hold the pulley into the starter housing. Invert the pulley/housing so the pulley is away from your face, and away from others in the area.

7. Rotate the pulley slightly from side to side and carefully separate the pulley from the housing. See Figure 7-6.

   If the pulley and the housing do not separate easily, the spring could be engaged in the starter housing, or there is still tension on the spring. Return the pulley to the housing and repeat step 5 before separating the pulley and housing.

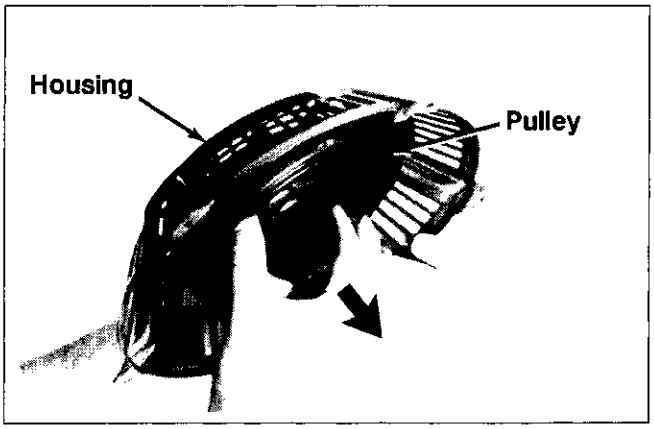


Figure 7-6. Removing Pulley from Housing.

8. Note the position of the spring and keeper assembly in the pulley. See Figure 7-7.

   Remove the spring and keeper assembly from the pulley as a package.

⚠ WARNING: Spring Under Tension!
Do not remove the spring from the keeper. Severe personal injury could result from the sudden uncoiling of the spring.

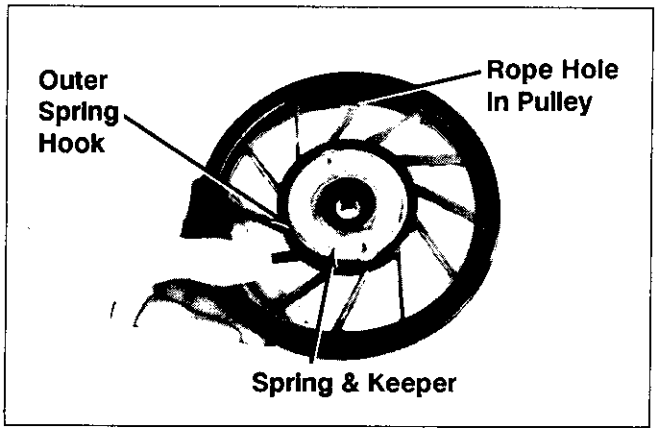


Figure 7-7. Position of Spring and Keeper in Pulley.

Inspection and Service

1. Carefully inspect the rope, pawls, housing, center screw, and other components for wear or damage.

2. Replace all worn or damaged components. Use only genuine Kohler replacement parts as specified in the Parts Manual. All components shown in Figure 7-1 are available as service parts. Do not use nonstandard parts.

3. Do not attempt to rewind a spring that has come out of the keeper. Order and install a new spring and keeper assembly.

4. Clean all old grease and dirt from the starter components. Generously lubricate the spring and center shaft with any commercially available bearing grease.

Reassembly

1. Make sure the spring is well lubricated with grease. Place the spring and keeper assembly inside the pulley (with spring towards pulley). See Figure 7-7.

2. Install the pulley with spring and keeper assembly into the starter housing. See Figure 7-8.

   Make sure the pulley is fully seated against the starter housing. Do not wind the pulley and recoil spring at this time.

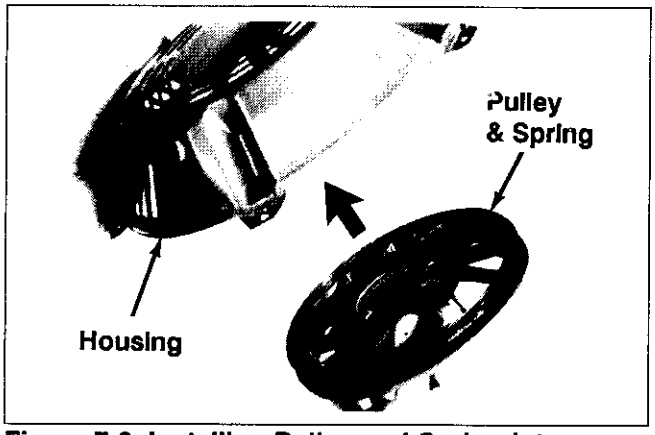


Figure 7-8. Installing Pulley and Spring into Housing.

3. Install the pawl springs and pawls into the starter pulley. See Figure 7-9.

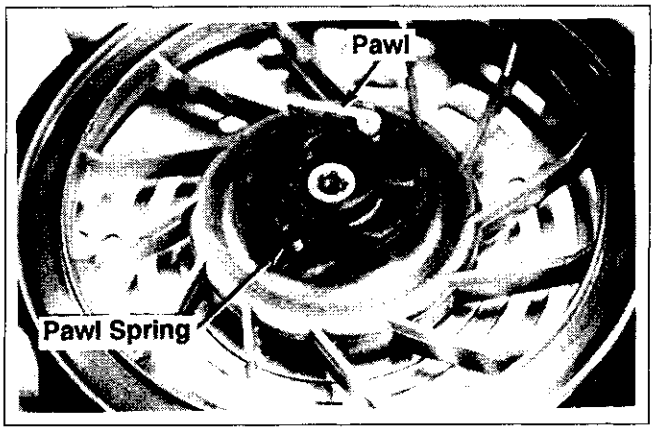


Figure 7-9. Installing Pawls and Pawl Springs.

4. Place the brake washer in the recess in starter pulley; over the center shaft.
5. Lubricate the brake spring sparingly with grease. Place the spring on the plain washer. (Make sure the threads in center shaft remain clean, dry, and free of grease and oil.)
6. Apply a small amount of **Loctite® No. 271** to the threads of the center screw. Install the center screw, with washer and retainer, to the center shaft. Torque the screw to **7.4/8.5 N·m (65/75 in. lb.)**.
7. Tension the spring and install the rope and handle as instructed in steps 6 through 12 under "Rope Replacement" on page 7.2.
8. Install the starter to the engine blower housing as instructed in "To Install Starter" on page 7.1.

Section 8
Electrical System and Components

This section covers the operation, service and repair of the electrical system and electrical system components. Systems and components covered in this section are:

- Spark Plugs
- Battery and Charging System
- Electronic CD Ignition System
- Electric Starter
- Smart Spark™ (CH22, CH25)

Spark Plugs

Engine misfire or starting problems are often caused by a spark plug that has improper gap setting or is in poor condition.

The engine is equipped with the following spark plugs:

Type:	Champion® RC12YC (or equivalent)
Gap:	1.02 mm (0.040 in.)
Thread Size:	14 mm
Reach:	19.1 mm (3/4 in.)
Hex. Size:	15.9 mm (5/8 in.)

Spark Plug Service

Every **200 hours** of operation, remove each spark plug. Check its condition and either reset the gap or replace with a new plug as necessary. To service the plugs, perform the following steps:

1. Before removing each spark plug, clean the area around the base of the plug to keep dirt and debris out of the engine.
2. Remove the plug and check its condition. See "Inspection" following this procedure. Replace the plug if necessary.

   NOTE: Do not clean spark plug in a machine using abrasive grit. Some grit could remain in the spark plug and enter the engine causing extensive wear and damage.

3. Check the gap using a wire feeler gauge. Adjust the gap to **1.02 mm (0.040 in.)** by carefully bending the ground electrode. See Figure 8-1.

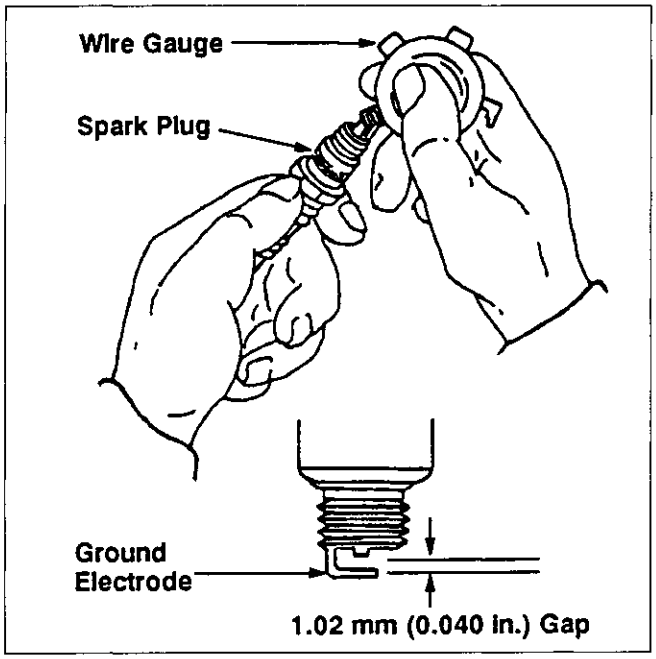


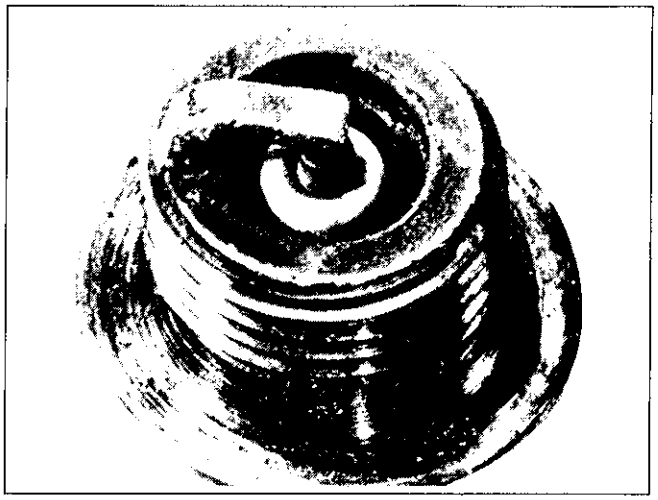
Figure 8-1. Servicing Spark Plug.

4. Reinstall the spark plug into the cylinder head and tighten to **24.4/29.8 N·m (18/22 ft. lb.)**.

8

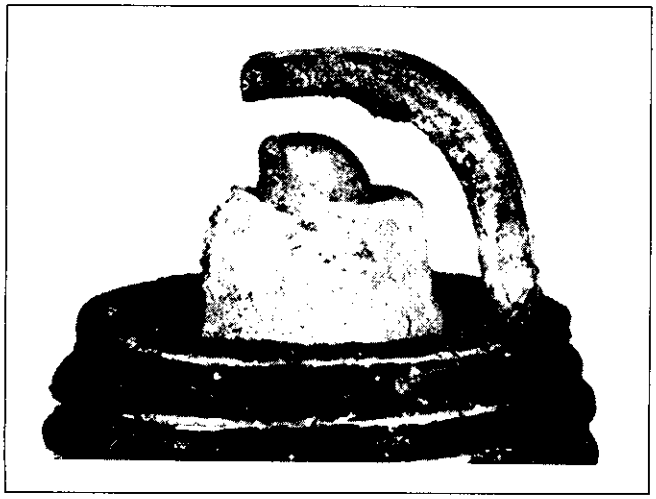
Inspection
Inspect each spark plug as it is removed from the cylinder head. The deposits on the tip are an indication of the general condition of the piston rings, valves, and carburetor.

Normal and fouled plugs are shown in the following photos:

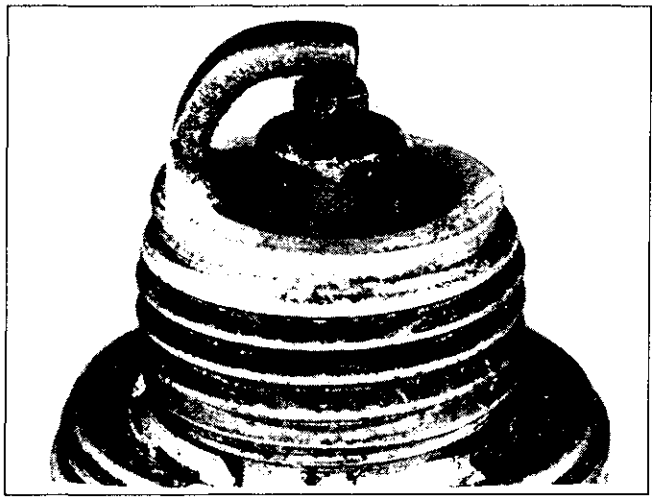


Normal: A plug taken from an engine operating under normal conditions will have light tan or gray colored deposits. If the center electrode is not worn, a plug in this condition could be set to the proper gap and reused.

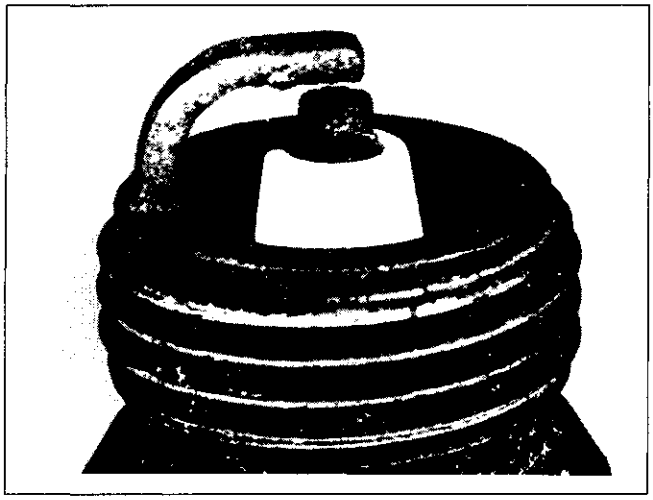
Carbon Fouled: Soft, sooty, black deposits indicate incomplete combustion caused by overrich carburetion, weak ignition, or poor compression.



Worn: On a worn plug, the center electrode will be rounded and the gap will be greater than the specified gap. Replace a worn spark plug immediately.



Wet Fouled: A wet plug is caused by excess fuel or oil in the combustion chamber. Excess fuel could be caused by a carburetor problem, or operating the engine with too much choke. Oil in the combustion chamber is usually caused by a breather problem, worn piston rings or valve guides.



Overheated: Chalky, white deposits indicate very high combustion temperatures. This condition is usually accompanied by excessive gap erosion. Lean carburetor settings, an intake air leak, or incorrect spark timing are normal causes for high combustion temperatures.

Battery

General

A 12 volt battery with a minimum current rating of 250 cold cranking amps should be sufficient for cranking most engine models. The actual cold cranking requirement depends on engine size, application and starting temperatures. Cranking requirements increase as temperatures decrease and battery capacity shrinks. Refer to the operating instructions of the equipment this engine powers for specific battery requirements.

If the battery charge is not sufficient to turn over the engine, recharge the battery.

Battery Maintenance

Regular maintenance is necessary to prolong battery life.

WARNING: Explosive Gas!

Batteries produce explosive hydrogen gas while being charged. To prevent a fire or explosion, charge batteries only in well ventilated areas. Keep sparks, open flames, and other sources of ignition away from the battery at all times. Keep batteries out of the reach of children. Remove all jewelry when servicing batteries.

Before disconnecting the negative (-) ground cable, make sure all switches are OFF. If ON, a spark will occur at the ground cable terminal which could cause an explosion if hydrogen gas or gasoline vapors are present.

1. Regularly check the level of electrolyte. Add distilled water as necessary to maintain the recommended level.

   NOTE: Do not overfill the battery. Poor performance or early failure due to loss of electrolyte will result.

2. Keep the cables, terminals, and external surfaces of the battery clean. A build-up of corrosive acid or grime on the external surfaces can cause the battery to self-discharge. Self-discharge occurs rapidly when moisture is present.

3. Wash the cables, terminals, and external surfaces with a mild baking soda and water solution. Rinse thoroughly with clear water.

   NOTE: Do not allow the baking soda solution to enter the cells as this will destroy the electrolyte.

Battery Test
To test the battery, you will need a DC voltmeter. Perform the following steps (see Figure 8-2):

1. Connect the voltmeter across the battery terminals.

2. Crank the engine. If the battery drops below 9 volts while cranking, the battery is discharged or faulty.

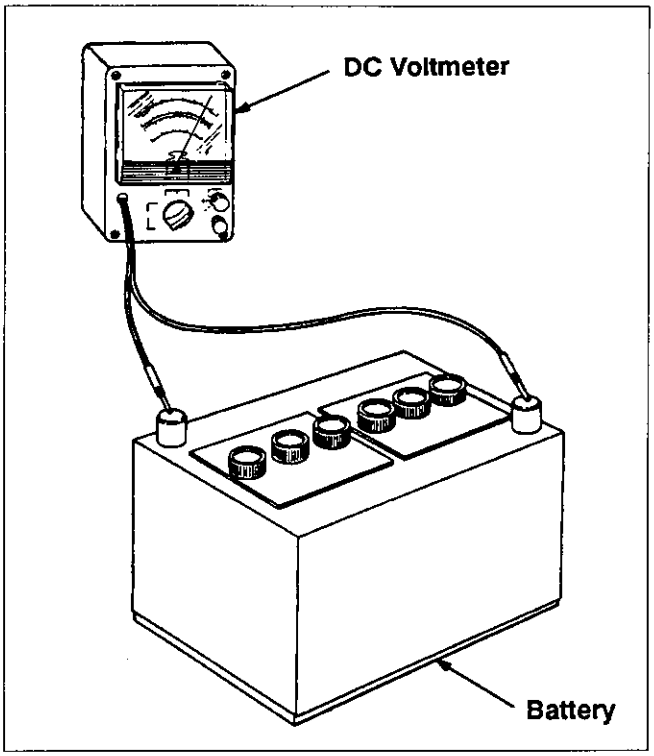


Figure 8-2. Battery Voltage Test.

Electronic CD Ignition Systems

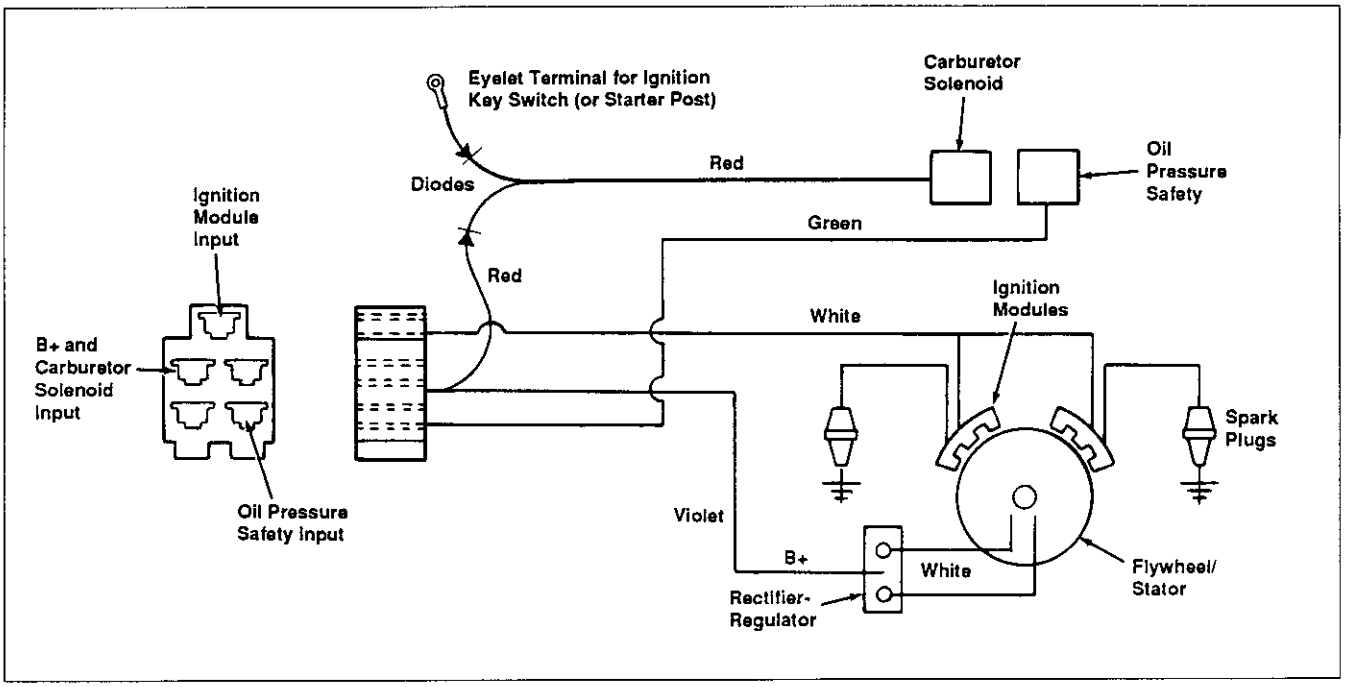


Figure 8-3. Electronic CD Ignition System.

The new Smart Spark™ ignition system used on the CH22 & CH25 is an advanced version of the CD ignition system used on CH18 & CH20 engines. It's operation can be best understood by first understanding the standard system and how it works. Since both systems will continue in use, it is advantageous to understand them both. The operation of the standard system is explained first then expanded to cover Smart Spark™.

Operation of CD Ignition Systems

A. Capacitive Discharge with Fixed Timing

This system (Figure 8-3) consists of the following components.

- A magnet assembly which is permanently affixed to the flywheel.
- Two electronic capacitive discharge ignition modules which mount on the engine crankcase (Figure 8-4).
- A kill switch (or key switch) which grounds the modules to stop the engine.
- Two spark plugs.

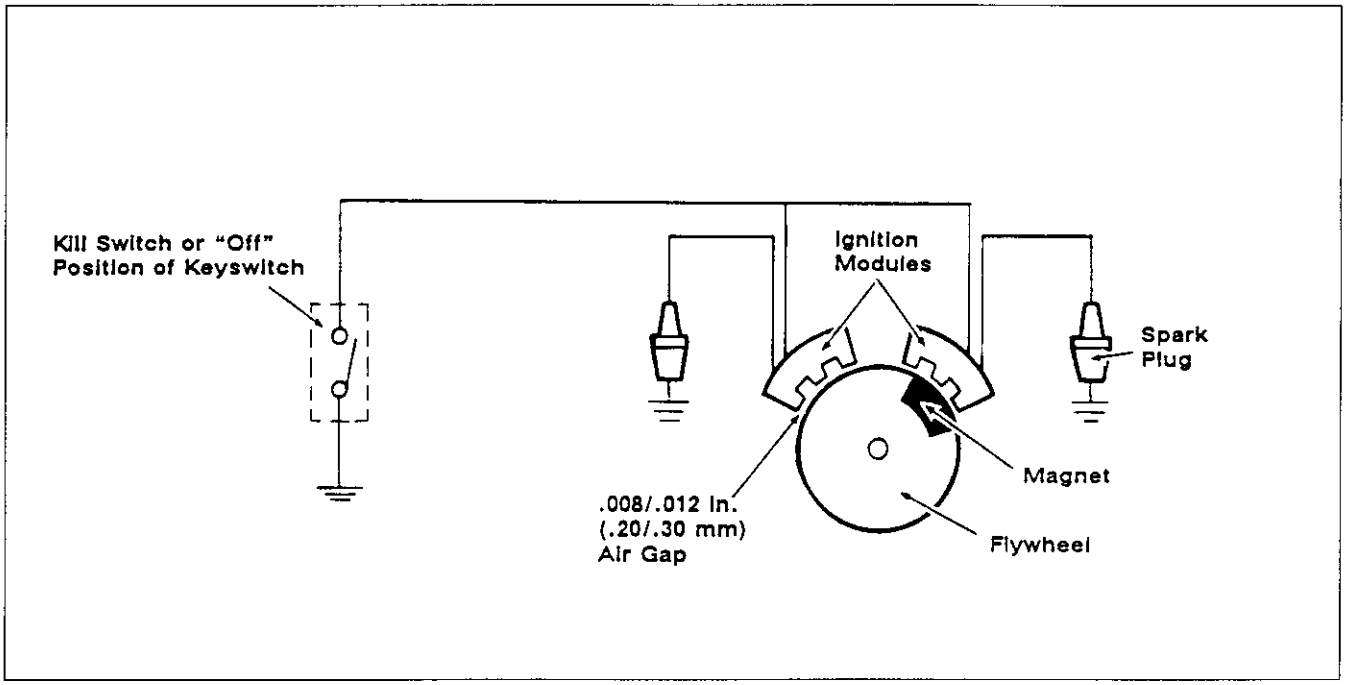


Figure 8-4. Capacitive Discharge Ignition System.

The timing of the spark is controlled directly by the location of the flywheel magnet group as referenced to engine top dead center.

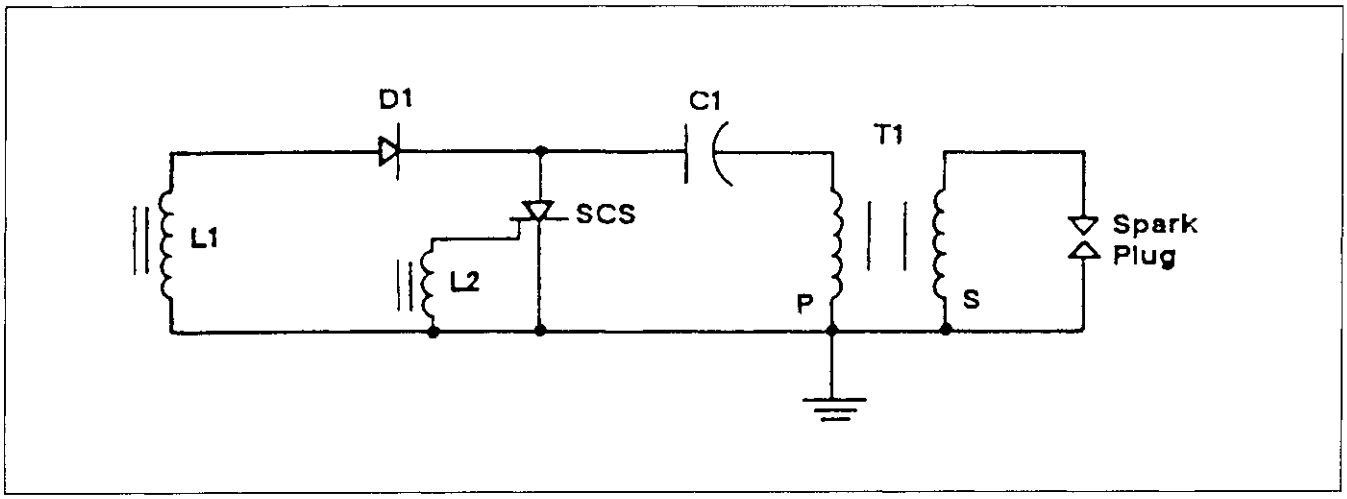


Figure 8-5. Capacitive Discharge Ignition Module.

Operation: As the flywheel rotates, the magnet grouping passes the input coil (L1). The corresponding magnetic field induces energy into the input coil (L1). The resultant pulse is rectified by D1 and charges capacitor C1. As the magnet assembly completes its pass, it activates the triggering device (L2), which causes the semiconductor switch (SCS) to turn on. With the device switch "ON," the charging capacitor (C1) is directly connected across the primary (P) of the output transformer (T1). As the capacitor discharges, the current initiates a fast rising flux field in the transformer core. A high voltage pulse is generated from this action into the secondary winding of the transformer. This pulse is delivered to the spark plug gap. Ionization of the gap occurs, resulting in an arc at the plug electrodes. This spark ignites the fuel-air mixture in the combustion chamber.

B. Capacitive Discharge with Electronic Spark Advance **(Smart Spark™)**.

The CH22 and CH25 engines are equipped with an electronic capacitive discharge ignition system with electronic spark advance. A typical application (Figure 8-6) consists of the following components.

- A magnet assembly which is permanently affixed to the flywheel.
- Two electronic capacitive discharge ignition modules which mount on the engine crankcase (Figure 8-5).
- A spark advance module which mounts to the engine shrouding (Figure 8-7).
- A 12 volt battery which supplies current to the spark advance module.
- A kill switch (or key switch) which grounds the spark advance module to stop the engine.
- Two spark plugs.

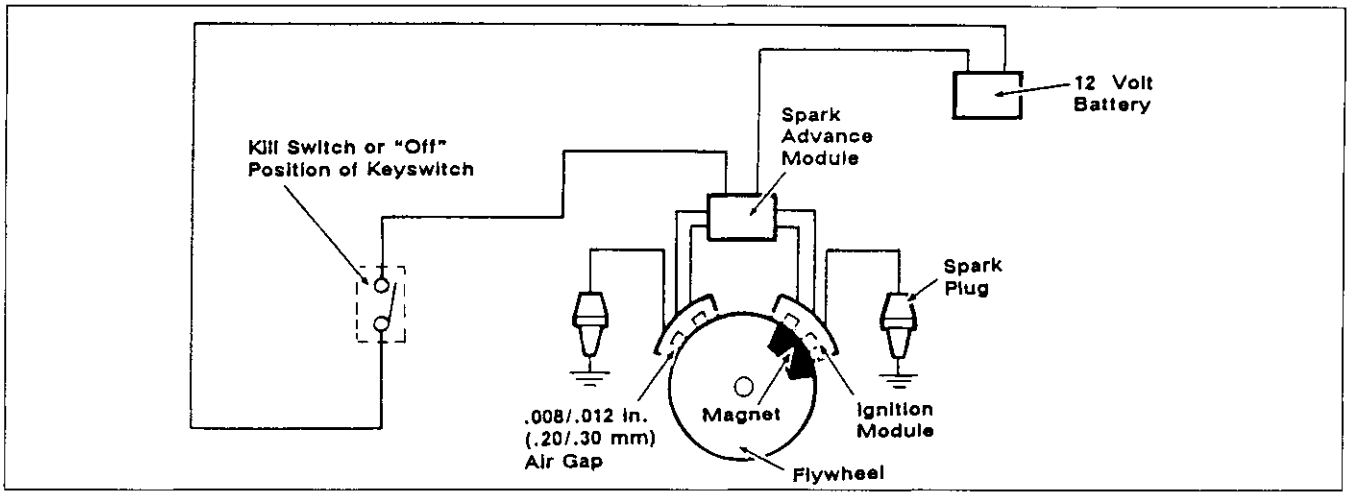


Figure 8-6. Capacitive Discharge Ignition System with Spark Advance.

The timing of the spark is controlled by the location of the flywheel magnet group as referenced to the engine top dead center and the delay created by the spark advance module.

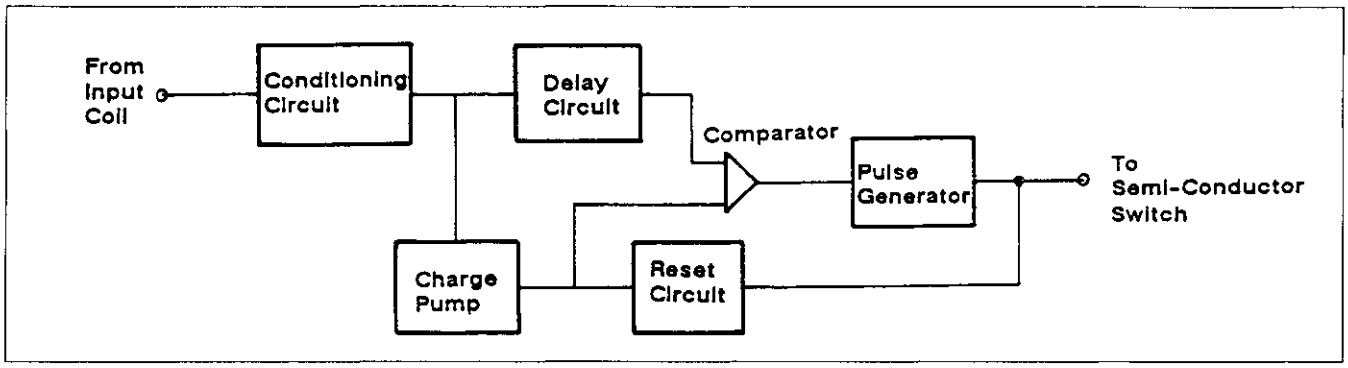


Figure 8-7. Block Diagram - Spark Advance Module.

Operation: The ignition module for this system operates in the same fashion as the fixed timing module, except the trigger circuit for the semiconductor (L2, Figure 8-5) is replaced by the spark advance module (Figure 8-7).

The pulse generated by the input coil of the ignition module (L1, Figure 8-5) is fed to the input of the conditioning circuit. The conditioning circuit shapes this pulse, putting it in a useable form for the additional circuits. This pulse starts the charge pump, which charges a capacitor in a linear fashion that can be directly related to the engine speed. At the same time the pulse resets the delay circuit for length of the pulse width. The comparator is off during this period and no output is generated. As soon as the original pulse drops back to zero, the capacitor in the delay circuit begins to charge.

When the charge on the delay capacitor exceeds the charge on the charge pump capacitor the comparator changes state, activating the pulse generator. This pulse turns "ON" the CD ignition module semiconductor. Energy is then transferred to the secondary of the output transformer (T1, Figure 8-5). The high voltage pulse generated here is delivered to the spark plug, causing arcing of the spark gap and igniting the fuel-air mixture in the combustion chamber. As the trigger pulse is generated, all associated circuits are reset, their capacitors discharged. The longer it takes the delay circuit to surpass the charge pump capacitor voltage, the later the trigger pulse will occur, retarding the timing accordingly.

Troubleshooting CD Ignition Systems

The CD ignition systems are designed to be trouble free for the life of the engine. Other than periodically checking/replacing the spark plugs, no maintenance or timing adjustments are necessary or possible. Mechanical systems do occasionally fail or break down, however, so the following troubleshooting information is provided to help you get to the root of a reported problem.

⚠ WARNING: Electrical Shock!

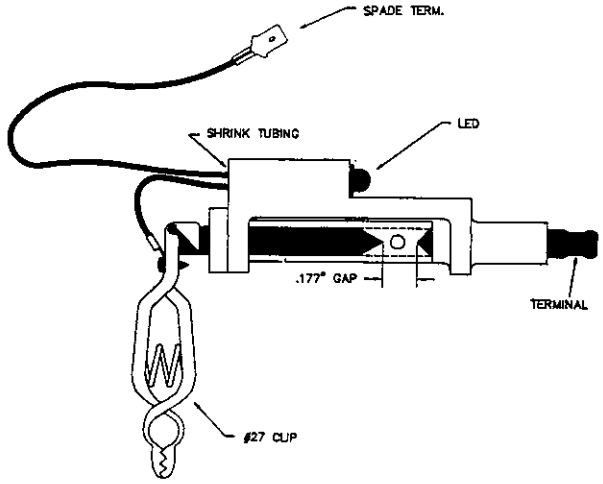
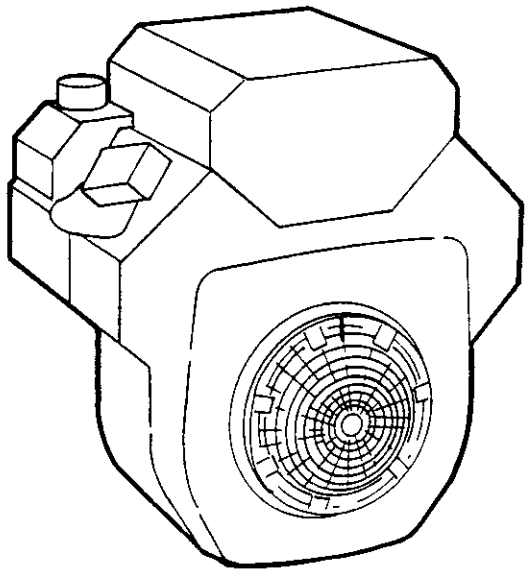
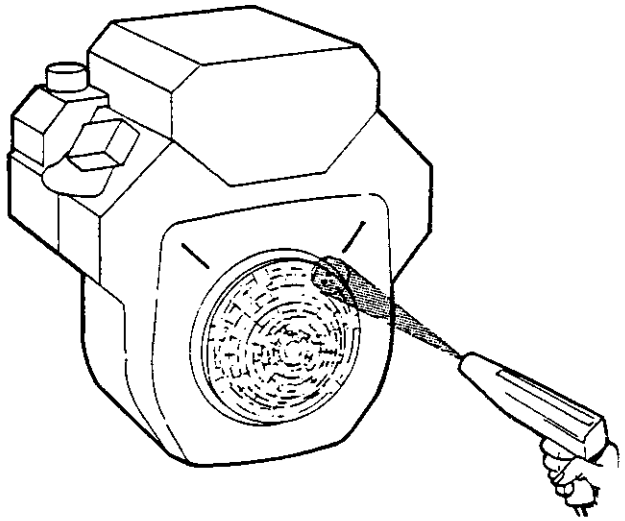
Never touch electrical wires or components while the engine is running. They can be sources of electrical shock.

Reported ignition problems are most often due to poor connections. Before beginning the test procedure, check all external wiring. Be certain all ignition-related wires are connected, including the spark plug leads. Be certain all terminal connections fit snugly. Make sure the ignition switch is in the run position.

NOTE: The CD ignition systems are sensitive to excessive load on the kill lead. If a customer complains of hard starting, low power, or misfire under load, it may be due to excessive draw on the kill circuit. Disconnect any auxiliary kill wires or safety switches connected to the kill circuit and operate the engine to determine if the reported problem is gone.

NOTE: The spark advance module (SAM), used with Smart Spark™, requires an external power source of at least 7 volts DC. If you are installing a replacement battery on a unit that has an engine with Smart Spark™, be certain the battery is fully charged prior to installation.

Testing Procedure

Test	Conclusion
1. Test for spark on both cylinders with Kohler ignition tester, Part No. 24 800 01. 	1. If one side is not firing, check all wiring, connections, and terminations on that side. If wiring is okay, replace ignition module and retest for spark. If neither side is firing, recheck position of ignition switch and check for shorted kill lead. Proceed further only if the engine has Smart Spark™. If the engine still has no fire on either side, the spark advance module (SAM) could be at fault, proceed to step 3. If both spark plugs are firing, but the engine seems short on power or acts like it's only running on one cylinder, one module may be firing out of time, go to step 2. If both plugs are firing, but the engine will not start, go to step 3.
2. Use a marking pen or a piece of narrow tape to make a line near the edge of the flywheel screen.  Connect an automotive timing light to monitor spark on the #1 cylinder. Run the engine at idle and use the timing light beam to locate the timing line you drew on the screen. Draw a mark on the blower housing in line with the timing line on the screen. Accelerate to full throttle and watch the movement of the timing line. Stop the engine, move the timing light to the #2 side and repeat the procedure. Then stop the engine.	2. The marks you made on the blower housing, corresponding to the firing points of the respective cylinders, should be 90° apart. As you accelerated to full throttle the timing line should have advanced 5° to 15° (moved counterclockwise 1/2-3/4" or 13-19 mm) from its position at idle.  If the marks on the blower housing are at the same position, one of the ignition modules is firing out of time, usually indicating a wiring problem between the SAM and the ignition module. You will need to check the wiring from the SAM to the ignition modules. If the wiring and connections are good, replace the SAM.

8

Testing Procedure (Cont'd)

Test	Conclusion
3a. Check the power source lead (red), the ground lead (green), and the kill lead (white) from the SAM. Be certain they are in good condition and properly connected. Be certain the kill lead is not shorted to ground. b. Trace the power source lead (red) to the starter solenoid. Connect a DC voltmeter from the same solenoid terminal to ground. Locate the external kill lead (white) wire that comes out of the shrouding just above the starter. Use a jumper wire to connect the kill lead to ground to prevent the engine from starting. Crank the engine with the starter motor and read DC voltage at the solenoid terminal. Remember to disconnect the kill lead and jumper following test. c. Disconnect the yellow lead at one of the ignition modules. Connect the lead wire from Kohler Ignition Tester, Part No. 24 800 01, to the yellow lead. Attach the tester clip to ground. Crank the engine and observe the tester LED. Move the tester to the other ignition module and repeat the procedure. Remember to reconnect the yellow lead to the first module before testing the second.	3a. Correct any problem found. b. The SAM requires 7 volts DC to function. If voltage at solenoid terminal dropped below 7 during cranking, replace battery on unit, or temporarily hook up known good battery to test if ignition system becomes functional. Retest voltage with replacement battery installed. If voltage at solenoid stayed above 7, proceed to 3c. c. The tester LED should flash during cranking, indicating that the SAM is working and sending firing pulses to the ignition module. If it does not flash, replace the SAM and retest.

Battery Charging Systems

General

These engines are equipped with either a 15 amp or 25 amp regulated battery charging system. See Figure 8-8 for the 15 amp system diagram and Figure 8-10 for the 25 amp system diagram.

NOTE: Observe the following guidelines to avoid damage to the electrical system and components:

- Make sure the battery polarity is correct. A negative (-) ground system is used.
- Disconnect the rectifier-regulator leads and/or wiring harness plug before doing electric welding on the equipment powered by the engine. Also, disconnect other electrical accessories in common ground with the engine.
- Prevent the stator (AC) leads from touching or shorting while the engine is running. This could damage the stator.

15 amp Regulated Charging System

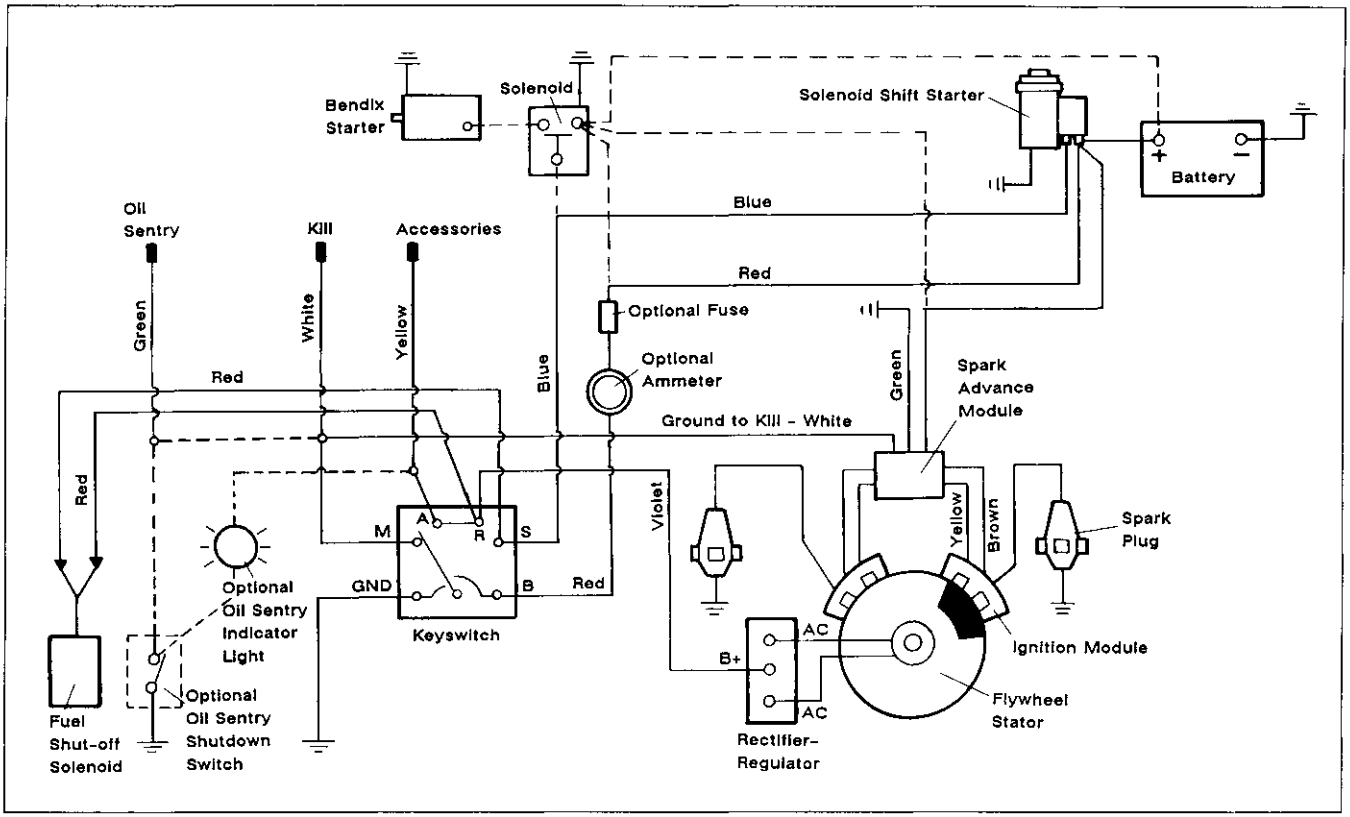


Figure 8-8. Wiring Diagram - 15 amp Regulated Battery Charging System.

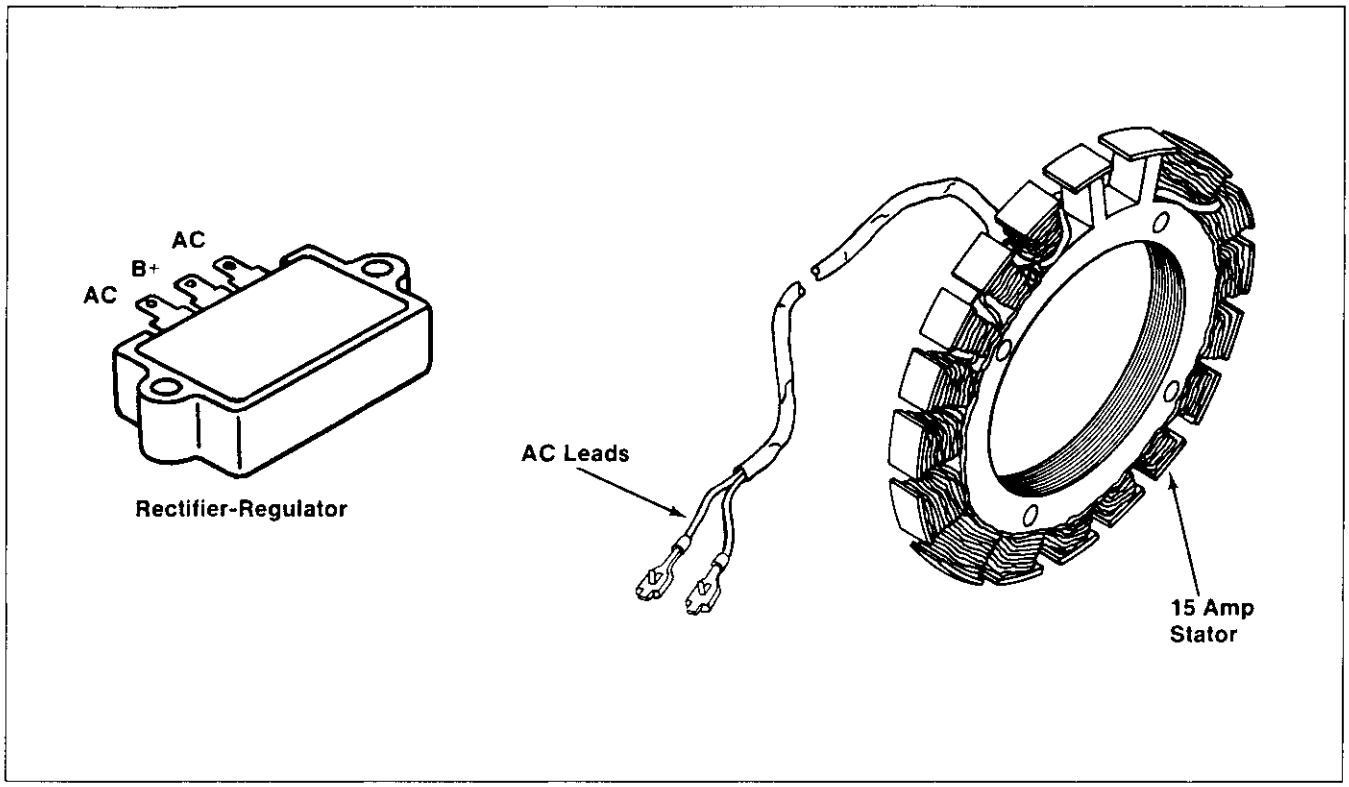


Figure 8-9. 15 amp Stator and Rectifier-Regulator.

25 amp Regulated Charging System

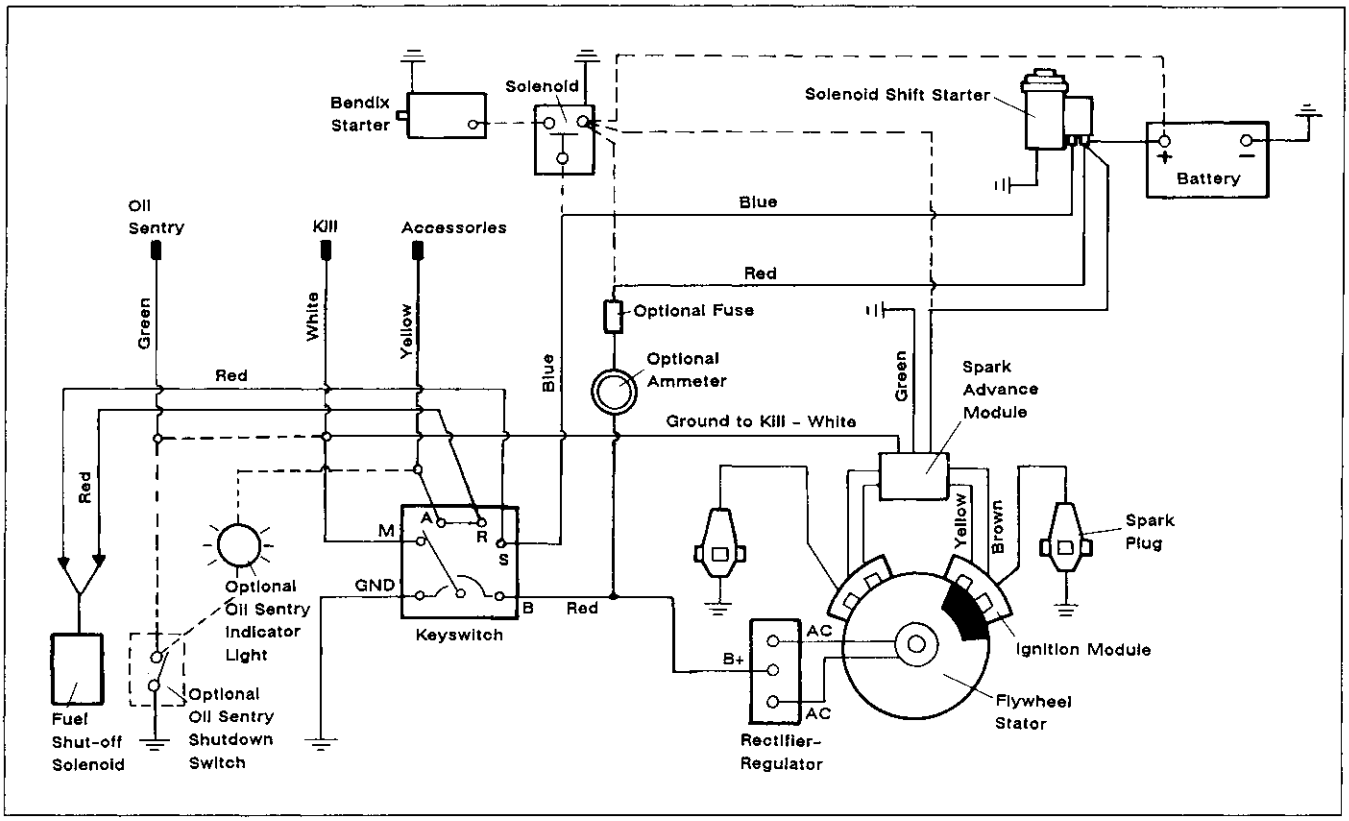


Figure 8-10. Wiring Diagram - 25 amp Regulated Battery Charging System.

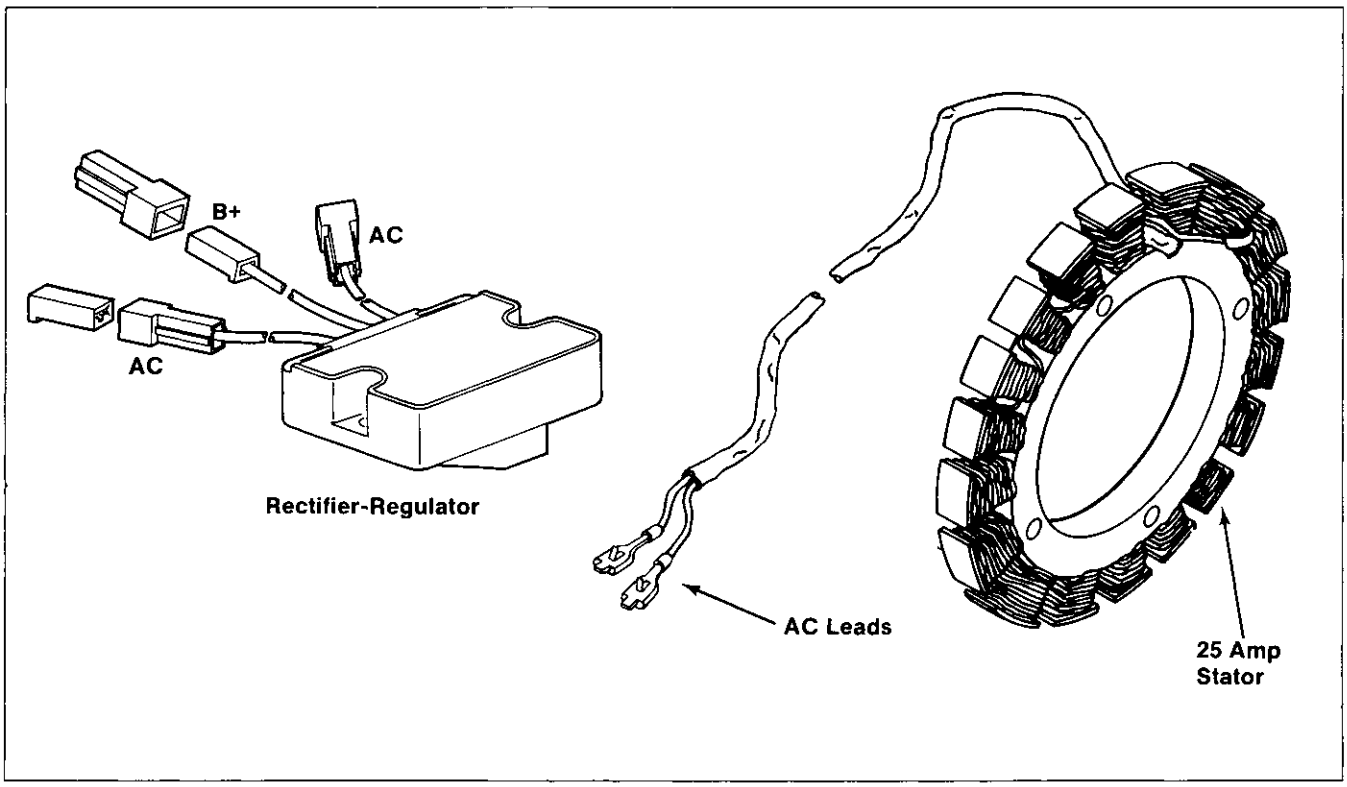


Figure 8-11. 25 amp Stator and Rectifier-Regulator.

Stator
The stator is mounted on the crankcase behind the flywheel. Should the stator have to be replaced, follow the procedures in Section 9 - "Disassembly." See Figure 8-9 for 15 amp stator or Figure 8-11 for 25 amp stator.

Rectifier-Regulator
The rectifier-regulator is mounted on the blower housing. To replace it, disconnect the plug, remove the two mounting bolts and ground strap.

NOTE: When installing the rectifier-regulator, take note of the terminal markings and install the plug accordingly.

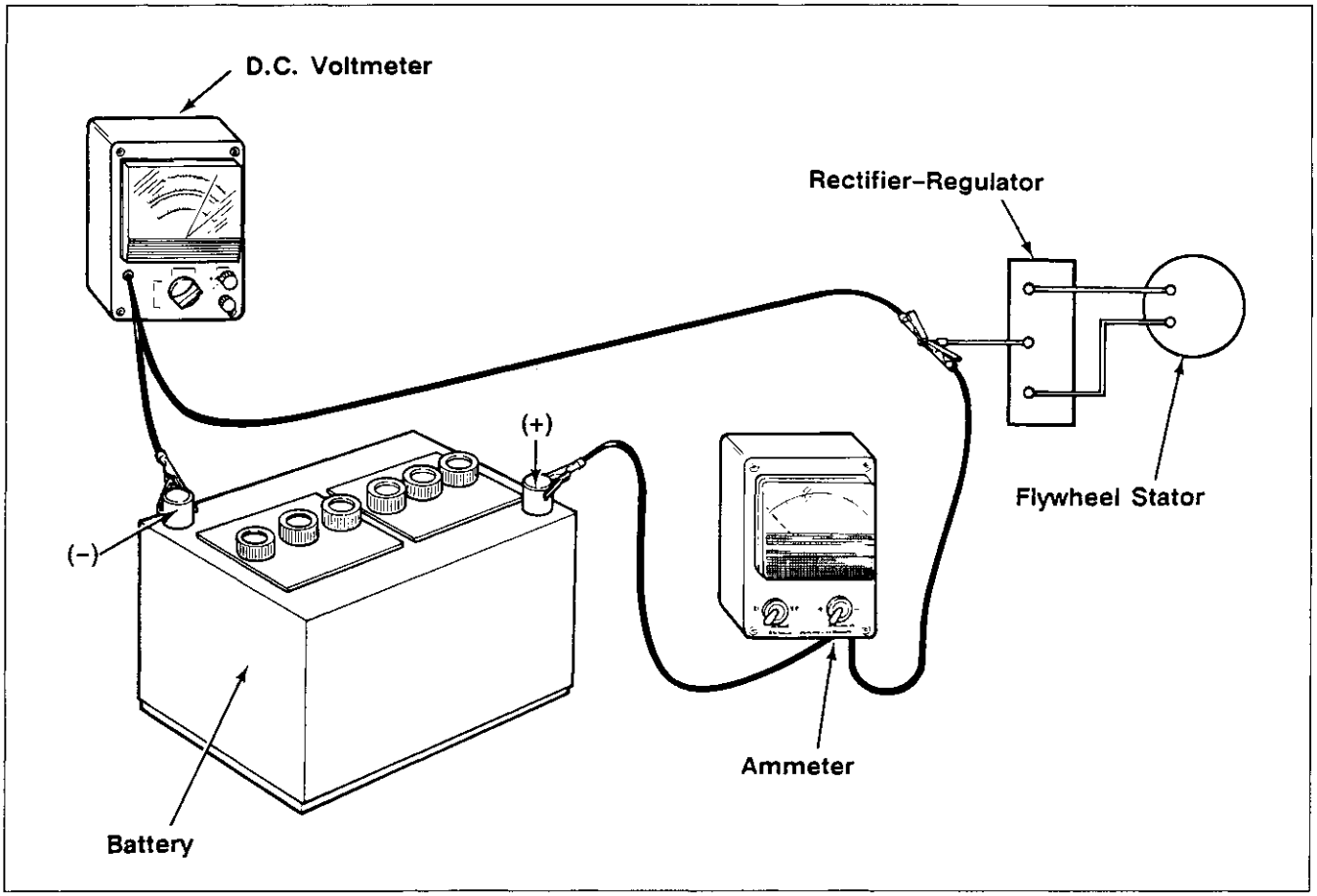


Figure 8-12. Connections for Testing Charging System.

Troubleshooting Guide

15/25 amp Battery Charging System

When problems occur in keeping the battery charged or the battery charges at too high a rate, the problem can usually be found somewhere in the charging system or with the battery.

NOTE: **Always zero ohmmeter on each scale before testing** to ensure accurate readings. Voltage tests should be made with the engine running at 3600 RPM - no load. The battery must be fully charged.

Problem	Test	Conclusion
No Charge to Battery	1. Trace B+ lead from rectifier-regulator to key switch, or other accessible connection. Disconnect it from switch or connection. Connect an ammeter from loose end of B+ lead to positive terminal of battery. Connect DC voltmeter from loose end of B+ lead to negative terminal of battery. With engine running at 3600 RPM, read voltage on voltmeter. If voltage is 13.8 volts or more, place a minimum load of 5 amps* on battery to reduce voltage. Observe ammeter. *NOTE: Turn on lights, if 60 watts or more. Or place a 2.5 ohm, 100 watt resistor across battery terminals.	1. If voltage is 13.8-14.7 and charge rate increases when load is applied, the charging system is OK and battery was fully charged. If voltage is less than 13.8 or charge rate does not increase when load is applied, test stator (Tests 2 and 3).
	2. Remove connector from rectifier-regulator. With engine running at 3600 RPM, measure AC voltage across stator leads using an AC voltmeter.	2. If voltage is **28 volts or more,** stator is OK. Rectifier-regulator is faulty. Replace the rectifier-regulator. If voltage is **less than 28 volts,** stator is probably faulty and should be replaced. Test stator further using an ohmmeter (Test 3).
	3a. With engine stopped, measure the resistance across stator leads using an ohmmeter.	3a. If resistance is **0.064/0.2 ohms,** the stator is OK. If the resistance is **infinity ohms,** stator is open. Replace stator.
	3b. With the engine stopped, measure the resistance from each stator lead to ground using an ohmmeter.	3b. If the resistance is **infinity ohms** (no continuity), the stator is OK (not shorted to ground). If resistance (or continuity) **is measured,** the stator leads are shorted to ground. Replace stator.
Battery Continuously Charges at High Rate	1. Perform same test as step 1 above.	1. If the voltage is **14.7 volts or less** the charging system is OK. The battery is unable to hold a charge. Service battery or replace as necessary. If voltage is **more than 14.7 volts,** the rectifier-regulator is faulty. Replace rectifier-regulator.

Electric Starting Motors

Some engines in this series use inertia drive type starting motors while others use solenoid shift type. The inertia drive types are covered first and the solenoid shift type is covered starting on page 8.20.

Starting Motor Precautions

NOTE: Do not crank the engine continuously for more than 10 seconds at a time. If the engine does not start, allow a 60 second cool-down period between starting attempts. Failure to follow these guidelines can burn out the starter motor.

NOTE: If the engine develops sufficient speed to disengage the inertia drive type starter but does not keep running (a false start), the engine rotation must be allowed to come to a complete stop before attempting to restart the engine. If the starter is engaged while the flywheel is rotating, the starter pinion and flywheel ring gear may clash, resulting in damage to the starter.

NOTE: If the starter does not crank the engine, shut off the starter immediately. Do not make further attempts to start the engine until the condition is corrected.

NOTE: Do not drop the starter or strike the starter frame. Doing so can damage the starter.

Starter Removal and Installation

Refer to the "Disassembly" and "Reassembly" Sections for starter removal and installation procedures.

Inertia Drive Electric Starters

This subsection covers the operation, troubleshooting, and repair of the inertia drive permanent magnet electric starters. Two different types of inertia drive starters are used. One is from United Technologies Enterprises (UTE) and the other from Eaton. Differences are pointed out wherever pertinent.

Troubleshooting Guide - Starting Motor Related

Problem	Possible Fault	Correction
Starter Does Not Energize	Battery	1. Check the specific gravity of battery. If low, recharge or replace battery as necessary.
	Wiring	1. Clean corroded connections and tighten loose connections. 2. Replace wires in poor condition and with frayed or broken insulation.
	Starter Switch or Solenoid	1. Bypass the switch or solenoid with a jumper wire. If starter cranks normally, replace the faulty components.
Starter Energizes But Turns Slowly	Battery	1. Check the specific gravity of battery. If low, recharge or replace battery as necessary.
	Brushes	1. Check for excessively dirty or worn brushes and commutator. Clean using a coarse cloth (not emery cloth). 2. Replace brushes if excessively or unevenly worn.
	Transmission or Engine	1. Make sure the clutch or transmission is disengaged or placed in neutral. This is especially important on equipment with hydrostatic drive. The transmission must be exactly in neutral to prevent resistance which could keep the engine from starting. 2. Check for seized engine components such as the bearings, connecting rod, and piston.

Operation - Inertia Drive Starters
When power is applied to the starter, the armature rotates. As the armature rotates, the drive pinion moves out on the splined drive shaft and into mesh with the flywheel ring gear. When the pinion reaches the end of the drive shaft, it rotates the flywheel and "cranks" the engine.

When the engine starts, the flywheel rotates faster than the starter armature and drive pinion. This moves the drive pinion out of mesh with the ring gear and into the retracted position. When power is removed from the starter, the armature stops rotating and the drive pinion is held in the retracted position by the anti-drift spring.

UTE Starter Drive Service
Every **500 hours** of operation (or annually, whichever occurs first), clean and lubricate the splines on the starter drive shaft. If the drive pinion is worn, or has chipped or broken teeth, it must be replaced.

It is not necessary to completely disassemble the starter to service the drive components. Service the drive as follows:

1. Remove the starter from the engine and remove the dust cover.
2. Hold the drive pinion in a vice with soft jaws when removing or installing the stop nut. The armature will rotate with the nut until the drive pinion stops against internal spacers.

   NOTE: Do not overtighten the vise as this can distort the drive pinion.

3. Remove the stop nut, stop gear spacer, anti-drift spring, dust cover spacer, and drive pinion.
4. Clean the splines on drive shaft thoroughly with solvent. Dry the splines thoroughly.
5. Apply a small amount of Kohler electric starter drive lubricant, Part No. 52 357 01, to the splines. The use of other lubricants may cause the drive pinion to stick or bend.
6. Apply a small amount of Loctite® No. 271 to the stop nut threads.
7. Install the drive pinion, dust cover spacer, anti-drift spring, stop gear spacer, and stop nut. Torque the stop nut to **17.0/19.2 N·m (135 in. lb.)**. Reinstall the dust cover.

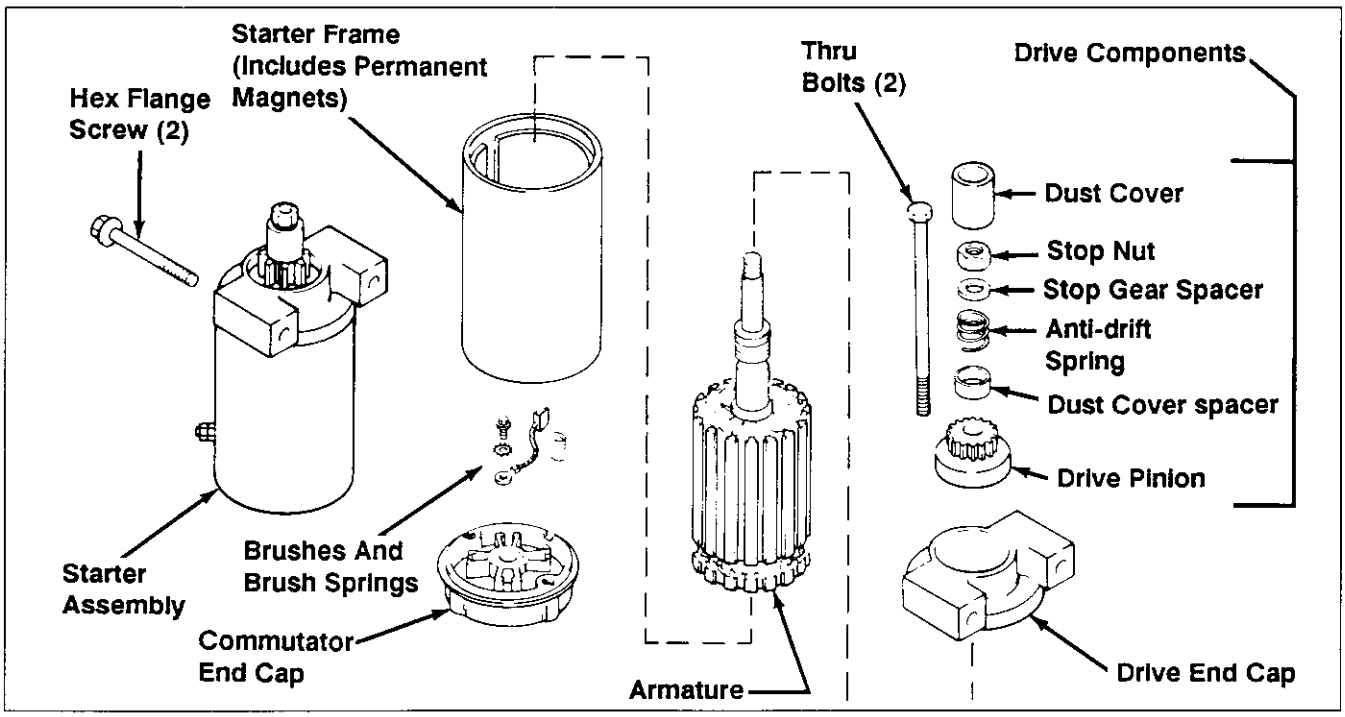


Figure 8-13. UTE Inertia Drive Electric Starter.

UTE Starter Disassembly

1. Remove the dust cover, stop nut, stop gear spacer, anti-drift spring, dust cover spacer, and drive pinion. Refer to "UTE Starter Drive Service" starting on page 8.16.

2. Scribe a small line on the drive end cap, opposite the line on the starter frame. These lines will serve as match marks when reassembling the starter. See Figure 8-16 on page 8.18.

3. Remove the thru bolts.

4. Remove the commutator end cap with brushes and brush springs.

5. Remove the drive end cap.

6. Remove the armature and thrust washer from inside the starter frame.

UTE Brush Replacement

1. Remove the brush springs from the pockets in brush holder. See Figure 8-14.

2. Remove the self-tapping screws, negative (-) brushes, and plastic brush holder.

3. Remove the hex. flange nut and fiber washer from the stud terminal.

   Remove the stud terminal with positive (+) brushes and plastic insulating bushing from the end cap.

4. Reinstall the insulating bushing to the new stud terminal with positive (+) brushes. Install the stud terminal with bushing into the commutator end cap. Secure the stud with the fiber washer and hex. flange screw.

5. Install the brush holder, new negative (-) brushes, and self-tapping screws.

6. Install the brush springs and brushes into the pockets in brush holer. Make sure the chamfered sides of brushes are away from the brush springs.

   NOTE: Use a brush holder tool to keep the brushes in the pockets. A brush holder tool can easily be made from thin sheet metal. See Figure 8-15.

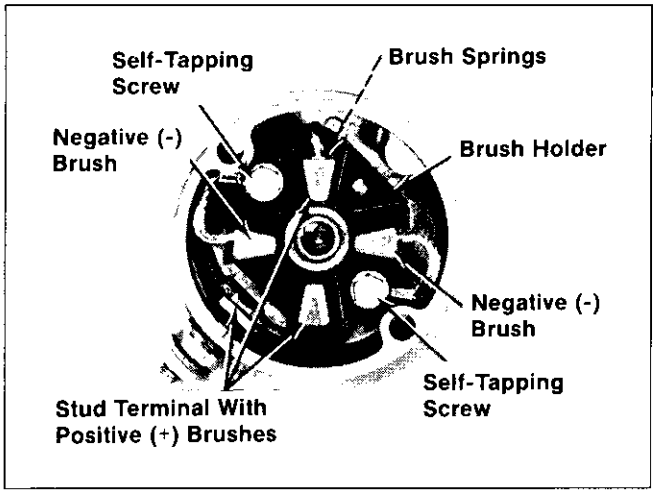


Figure 8-14. Commutator End Cap with Brushes (UTE Starter Shown).

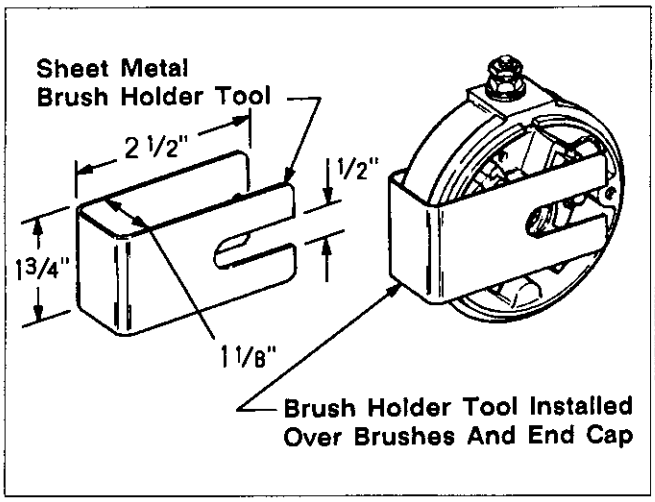


Figure 8-15. Brush Holder Tool (For UTE Starters - Not Eaton or Nippendenso).

UTE Commutator Service

Clean the commutator with a coarse, lint free cloth. Do not use emery cloth.

If the commutator is badly worn or grooved, turn it down on a lathe or replace the armature.

UTE Starter Reassembly

1. Place the thrust washer over the drive shaft of armature.

2. Insert the armature into the starter frame. Make sure the magnets are closer to the drive shaft end of armature. The magnets will hold the armature inside the frame.

3. Install the drive end cap over the drive shaft. Make sure the match marks on the end cap and starter frame are aligned. See Figure 8-16.

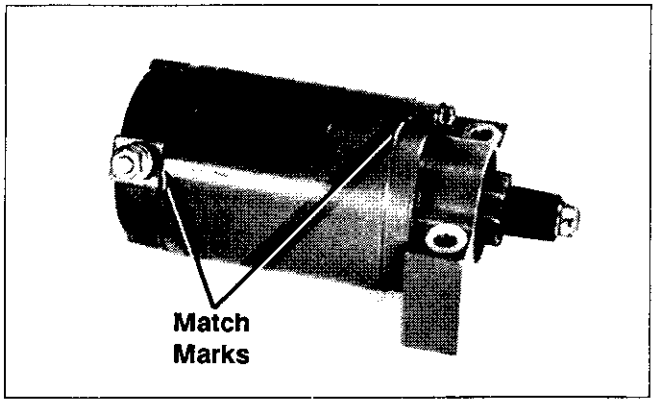


Figure 8-16. UTE Starter Assembly Match Marks.

4. Install the brush holder tool to keep the brushes in the pockets of the commutator end cap.

5. Align the match marks on the commutator end cap and starter frame. Hold the drive end and commutator end caps firmly to the starter frame. Remove the brush holder tool.

6. Install the thru bolts and tighten securely.

7. Lubricate the drive shaft with Kohler electric starter drive lubricant. Install the drive pinion, dust cover spacer, anti-drift spring, stop gear spacer, stop nut, and dust cover. Refer to "UTE Starter Drive Service" on page 8.16.

Eaton Inertia Drive Starters

Some specifications call for the Eaton inertia drive starters. The operational explanation and starting motor troubleshooting guide found earlier in this section for the UTE inertia drive starter also pertains to the Eaton. The Eaton starter does not require spline lubrication service at any regular interval as specified for the UTE. Another difference is that the commutator brushes cannot be serviced individually on the Eaton as they are riveted to the commutator end cap. The following service kits and parts are available for the Eaton.

Drive Parts Kit (Includes the following items):

Qty.	Description
1	Cover, dust
1	Ring, C-clip (retaining)
1	Retainer, spring
1	Spring, anti-drift
1	Collar (drive nut)

Drive Kit (Includes the following items):

Qty.	Description
1	Kit, drive (Includes Drive Parts Kit)
1	Pinion, drive

Servicing Eaton Starter

If the commutator surface is worn or damaged, replace the armature. Order a new commutator end cap assembly if brushes need replacing. Use the appropriate drive kit as listed earlier if drive kit components need to be replaced. After thoroughly cleaning the splines of armature shaft with solvent, apply a small amount of Kohler electric starter drive lubricant (Part No. 52 357 01) to spline to prevent sticking and binding.

Eaton Starter Disassembly

1. To remove the dust cover, extend the pinion all the way out, grasp the end of the end cap with pliers and work it back and forth until it snaps free.

2. Remove the retaining ring from groove in the armature by capturing the ring at the open end and twisting it upward until free of groove.

3. Remove the spring retainer, nylon washer, flat washer, anti-drift spring and drive pinion.

4. Turn the drive nut or collar until it clears the spiral of the armature shaft then remove.

5. Remove the two thru bolts. Note: The threaded ends are scotch coated and may be difficult to break loose.

6. Separate the drive end cap, pull the starter frame from around the armature.

7. Separate the commutator end cap assembly from the commutator end of the armature.

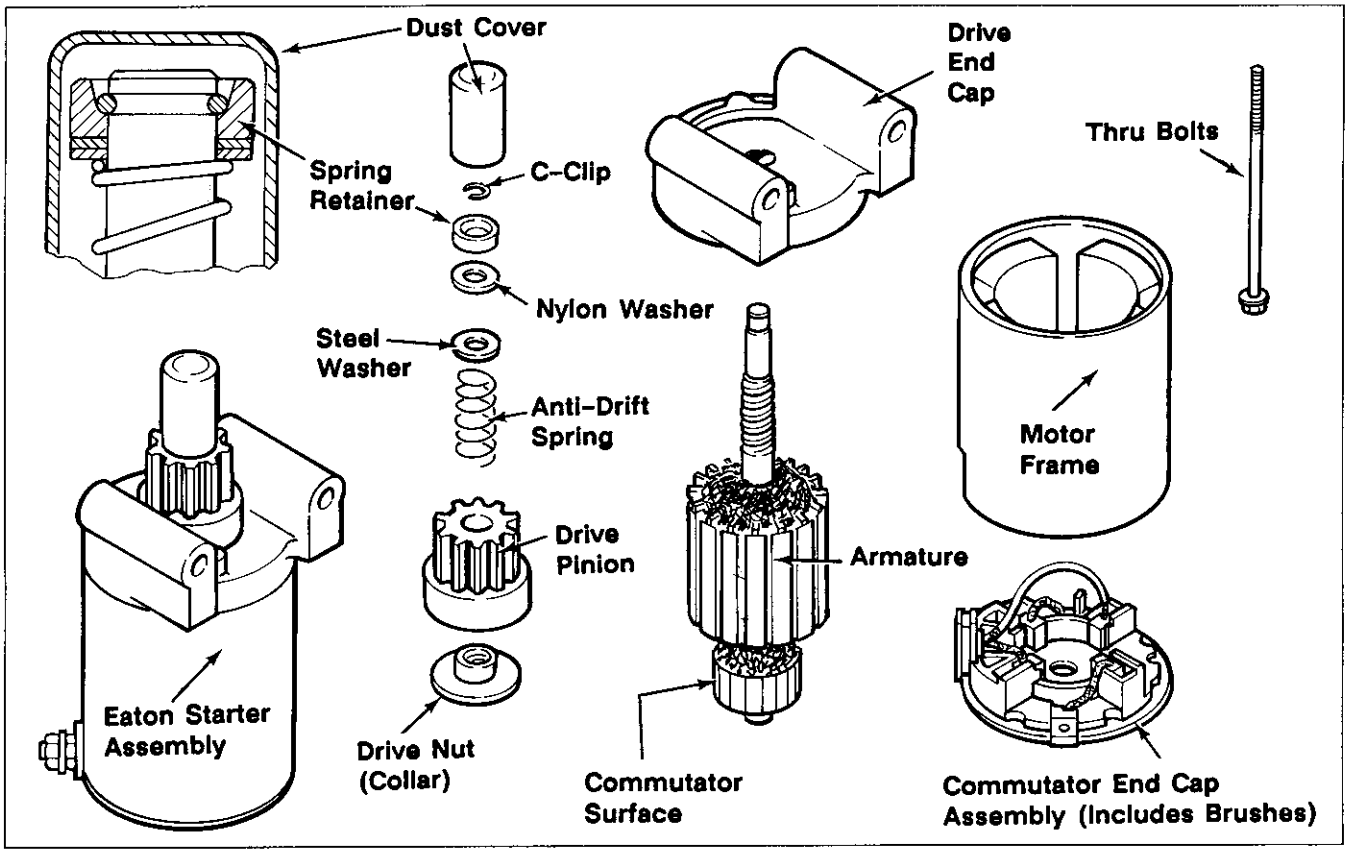


Figure 8-17. Exploded View of Eaton Inertia Drive Starter.

8

Reassembly of Eaton Starter

1. Insert armature shaft thru the drive end cap and install the starter frame over the armature. Align locating tabs in appropriate slots.

2. NOTE: A cup washer should be holding the brushes in place in the commutator end cap. If this has slipped down into the recess in end cap to release the brushes, fashion a tool out of a larger paper clip to hold the brushes in place while reinstalling the cup washer. Straighten out the clip then put a 1/2 square corner bend in it about 2" down from one end. Keep this tool in place while starting the brushes onto the commutator of the armature then pull it out. Make sure key in end cap and notch in frame are properly aligned then push end cap into place.

3. Apply small amount of Loctite® No. 271 to threads of thru bolts then turn these into drive end cap. Tighten to **4.5/5.7 N·m (40/50 in. lb.)**.

4. Using new parts from appropriate kit or reinstalling existing drive components, assemble in sequence shown in Figure 8-16. Make sure spline has been cleaned and lubricated as described in Eaton starter service instructions.

5. Install and connect starter to engine. Refer to Section 11.

Solenoid Shift Electric Starter

The following subsection covers the solenoid shift electric starter. Much of the information in the proceeding subsection relates to this type starter also, so it is not repeated here. A Nippendenso solenoid shift starter is used.

Operation (Solenoid Shift Starter)

When power is applied to the starter the electric solenoid moves the drive pinion out onto the drive shaft and into mesh with the flywheel ring gear. When the pinion reaches the end of the drive shaft it rotates the flywheel and cranks the engine.

When the engine starts and the start switch is released the starter solenoid is deactivated, the drive lever moves back, and the drive pinion moves out of mesh with the ring gear into the retracted position.

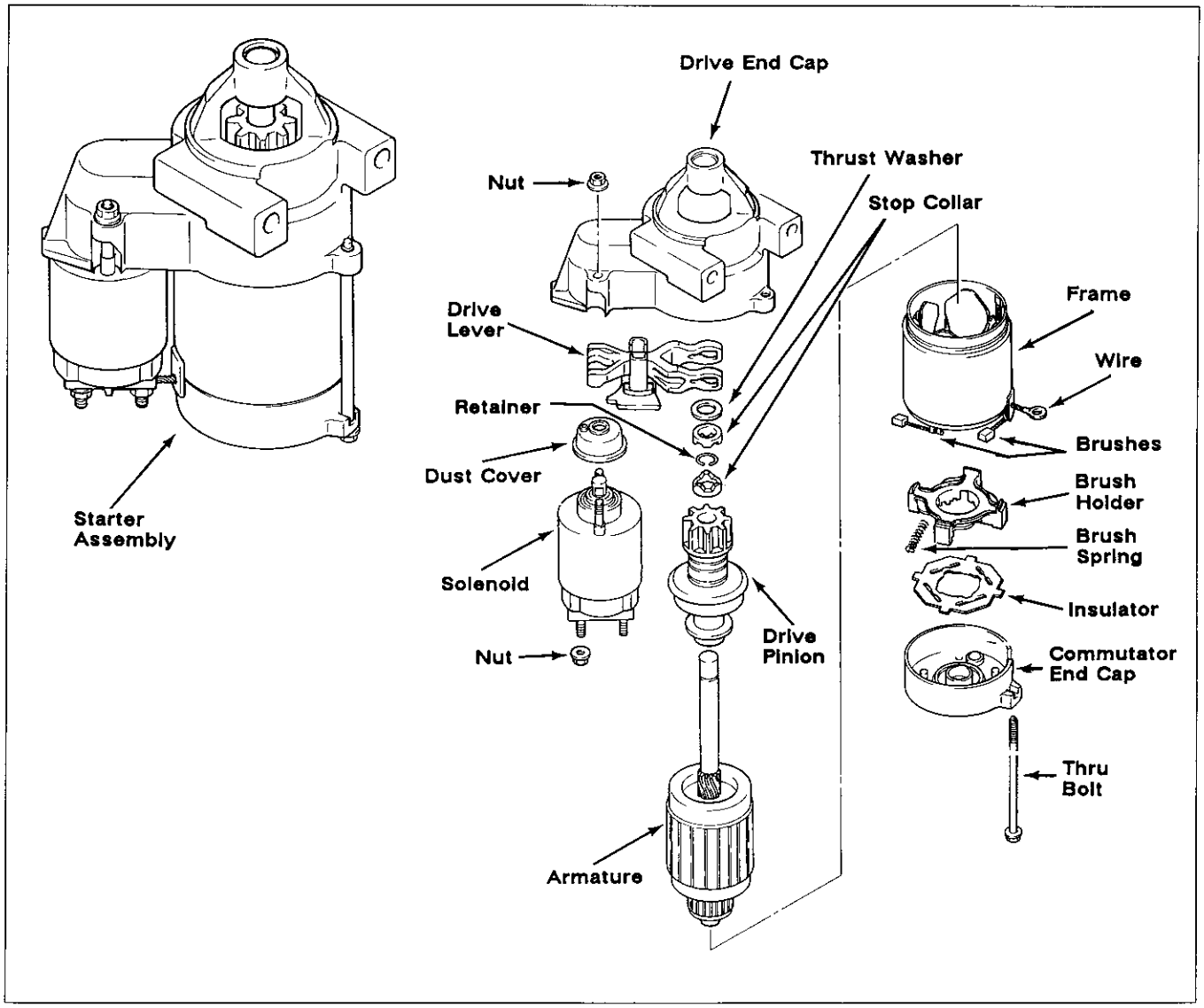


Figure 8-18. Nippendenso Solenoid Shift Starter.

Starter Disassembly

1. Disconnect the wire from the solenoid.
2. Remove the hex. nuts securing the solenoid, and remove the solenoid from the starter assembly.
3. Remove the two thru bolts.
4. Remove the commutator end cap.
5. Remove the insulator and brush springs from the brush spring holder.
6. Remove the armature from the frame.
7. Remove the drive lever and armature from the drive end cap.

   NOTE: When removing the lever and armature be careful not to lose the thrust washer.

8. The stop collar consists of two similar pieces held in place by being snapped over a retainer. The retainer is held in place by a groove in the armature shaft. To remove the stop collar the two pieces must be pried off the retainer.
9. When the stop collars are removed the retainer can be removed from the armature shaft. Do not reuse the retainer.

Brush Replacement

The brushes in the starter are part of the starter frame, brush kit Part No. 52 221 01 contains four replacement brushes and springs. If replacement is necessary, all four brushes should be replaced.

1. Remove brushes from brush holder, and remove brush holder from frame.
2. Cut the brush lead wire at the edge of the post with a pair of nippers.
3. File off burrs on the post.
4. The replacement brushes have a solid portion on them which should be crimped on the post.
5. Solder the crimped portion to the post.
6. Replace the brush holder in the frame and place the brushes in the brush holder. Reinstall the springs.

Starter Service

Clean drive lever and armature shaft. Apply Kohler electric starter drive lubricant (Part No. 52 357 01) to lever and shaft.

Starter Reassembly

1. Insert the rear stop collar on the armature shaft.
2. Place the retainer in the groove on the armature shaft.

   NOTE: Always use a new retainer. Tighten the retainer in the groove to secure.

3. Fit the front stop collar over the shaft and bring the front and the rear stop collars together over the retainer. Using two pairs of pliers apply even force to the two collars until they snap over the retainer and nest into one another.
4. Reassemble the remaining components of the starter in reverse order from disassembly.

Section 9
Disassembly

⚠ WARNING: Accidental Starts!

Before servicing the engine or equipment, always disconnect the spark plug leads to prevent the engine from starting accidentally. Ground the leads to prevent sparks that could cause fires. Make sure the equipment is in neutral.

General

Clean all parts thoroughly as the engine is disassembled. Only clean parts can be accurately inspected and gauged for wear or damage. There are many commercially available cleaners that will quickly remove grease, oil and grime from engine parts. When such a cleaner is used, follow the manufacturer's instructions and safety precautions carefully.

Make sure all traces of the cleaner are removed before the engine is reassembled and placed into operation. Even small amounts of these cleaners can quickly break down the lubricating properties of engine oil.

Typical Disassembly Sequence

The following sequence is suggested for complete engine disassembly. The sequence can be varied to accommodate options or special equipment.

1. Disconnect spark plug leads.
2. Shut off and/or drain all fuel from the tank.
3. Drain oil from crankcase and remove oil filter.
4. Remove muffler.
5. Remove air cleaner assembly.
6. Remove control panel (if so equipped).
7. Remove fuel pump.
8. Remove throttle controls.
9. Remove external governor controls.
10. Remove carburetor.
11. Remove electric starter motor.
12. Remove outer baffles and blower housing.
13. Remove Oil Sentry™ (if so equipped).
14. Remove inner baffles and breather cover.
15. Remove valve covers.
16. Remove ignition modules.
17. Remove intake manifold.
18. Remove spark plugs.
19. Remove cylinder heads and hydraulic lifters.
20. Remove grass screen and fan.
21. Remove flywheel.
22. Remove stator and backing plates.
23. Remove closure plate assembly.
24. Remove camshaft.
25. Remove connecting rods with pistons and rings.
26. Remove crankshaft.
27. Remove governor cross shaft.

Disconnect Spark Plug Leads

1. Disconnect the leads from the spark plugs. See Figure 9-1.

   NOTE: Pull on boot only, to prevent damage to spark plug lead.

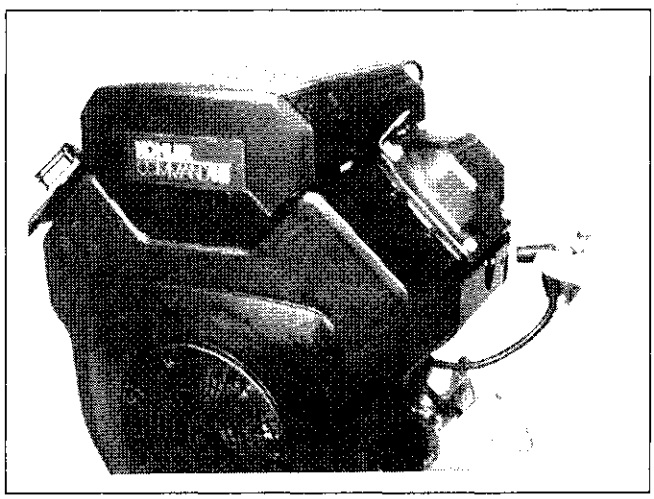


Figure 9-1. Disconnect Both Spark Plug Leads.

9

Drain Oil From Crankcase and Remove Oil Filter

1. Remove oil fill cap and dipstick and one or both of the oil drain plugs.

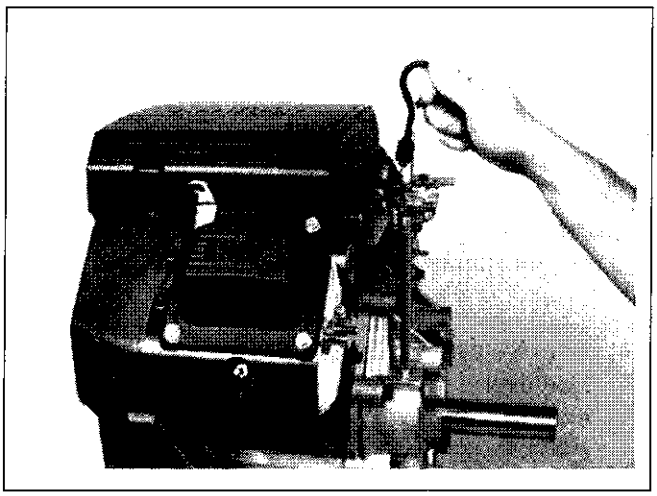


Figure 9-2. Removing Dipstick from Tube.

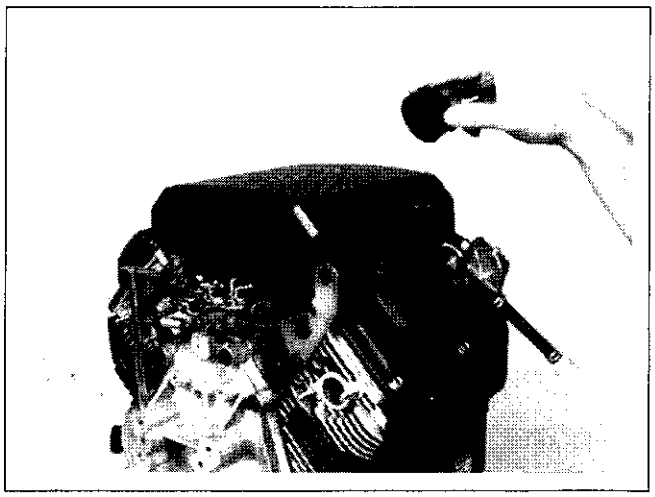


Figure 9-3. Removing Oil Fill Cap from Cover.

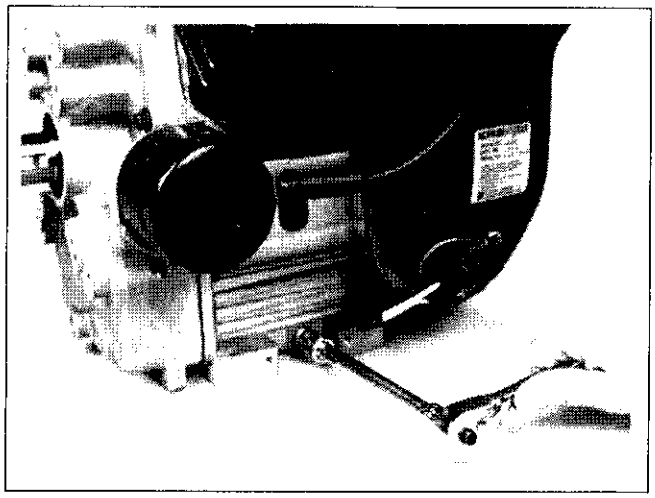


Figure 9-4. Removing Oil Drain Plug.

2. Allow ample time for the oil to drain from the crankcase and oil filter.

3. Remove and discard the oil filter. See Figure 9-5.

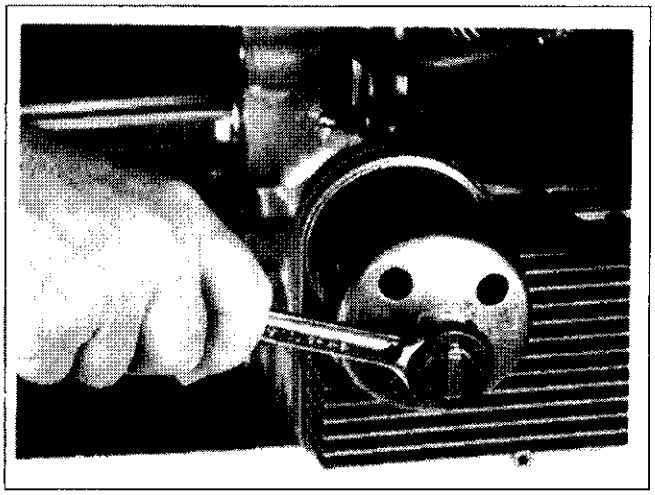


Figure 9-5. Removing Oil Filter.

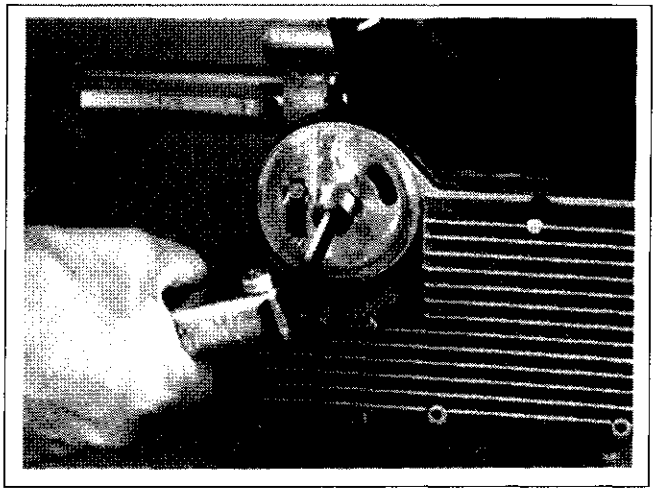


Figure 9-6. Removing Oil Filter Adapter.

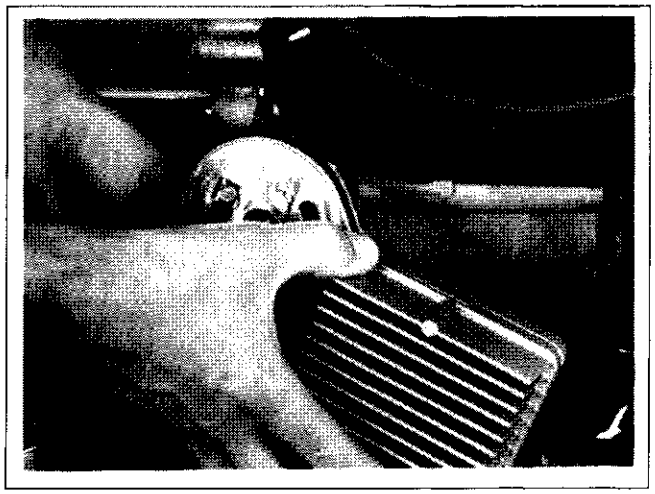


Figure 9-7. Removing Oil Cooler.

4. The oil cooler shown in Figures 9-5 through 9-7 is standard equipment on the CH25 and may be an option on other models. If so equipped, remove the adapter (see Figures 9-6 and 9-7) and the cooler.

Remove Muffler

1. Remove the exhaust system and attaching hardware from the engine.

Remove Air Cleaner Assembly

1. Disengage the latches located on either side of the standard air cleaner cover and remove the cover. Refer to Section 4.

2. Remove the wing nut, washer and seal from the element cover.

3. Remove the element cover, element and precleaner and the stud seal.

4. Remove the hex. flange screws securing the bracket and base. See Figure 9-8.

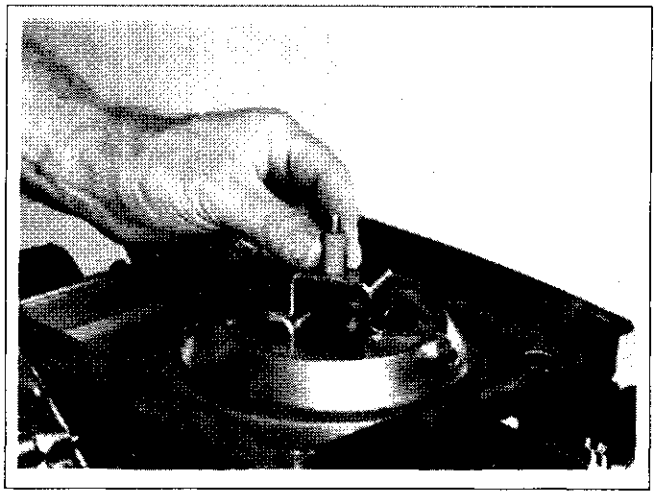


Figure 9-8. Removing Air Cleaner Base Retainer.

5. Remove the bracket then remove the base and gasket while carefully pulling the rubber breather tube through the base. See Figure 9-9.

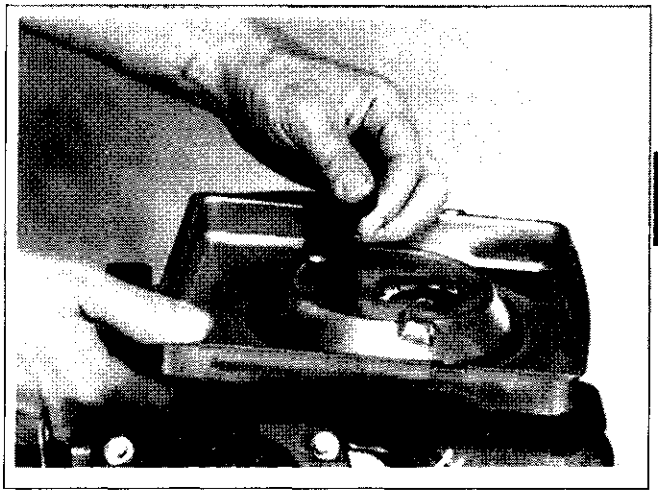


Figure 9-9. Removing Breather Tube from Base.

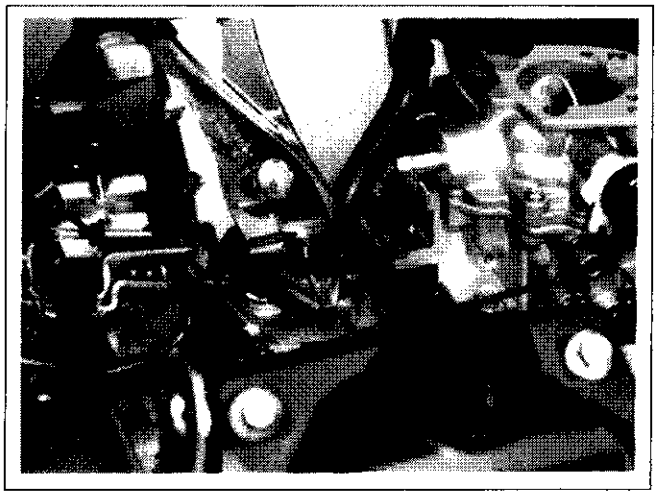


Figure 9-10. Removing Tube from Breather Cover.

6. Remove the rubber breather tube from the breather cover. See Figure 9-10.

Remove Fuel Pump

⚠ WARNING: Explosive Fuel!
Gasoline is extremely flammable and its vapors can explode if ignited. Store gasoline only in approved containers, in well ventilated, unoccupied buildings, away from sparks or flames. Do not fill the fuel tank while the engine is hot or running, since spilled fuel could ignite if it comes in contact with hot parts or sparks from ignition. Do not start the engine near spilled fuel. Never use gasoline as a cleaning agent.

1. Disconnect the fuel lines at the carburetor and at the in-line fuel filter. See Figure 9-11.

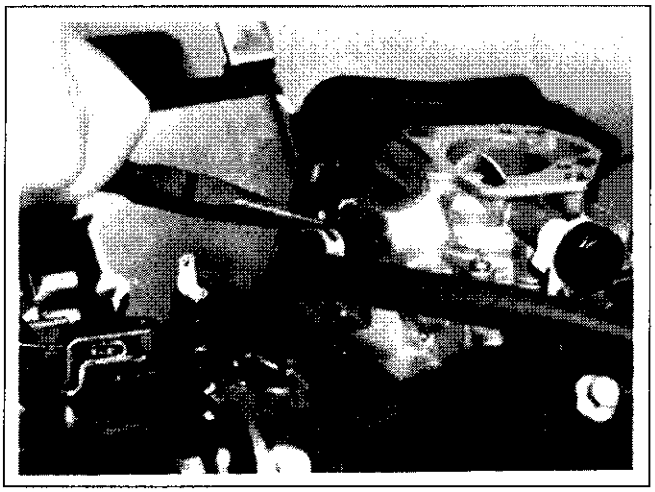


Figure 9-11. Disconnecting Fuel Inlet Line at Carburetor.

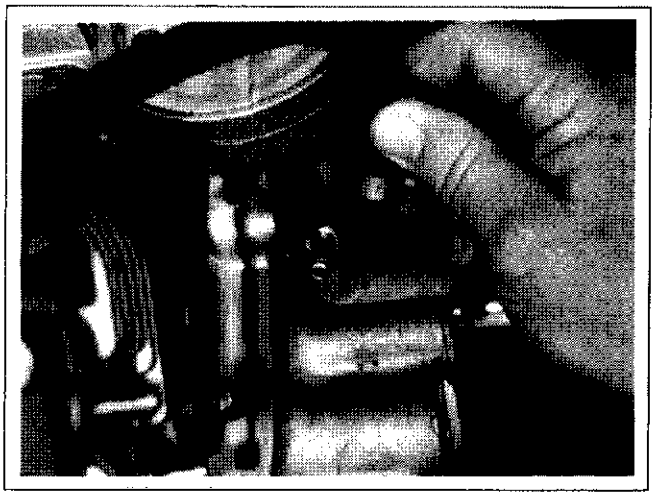


Figure 9-12. Disconnecting Pulse Line from Crankcase (Latest Model).

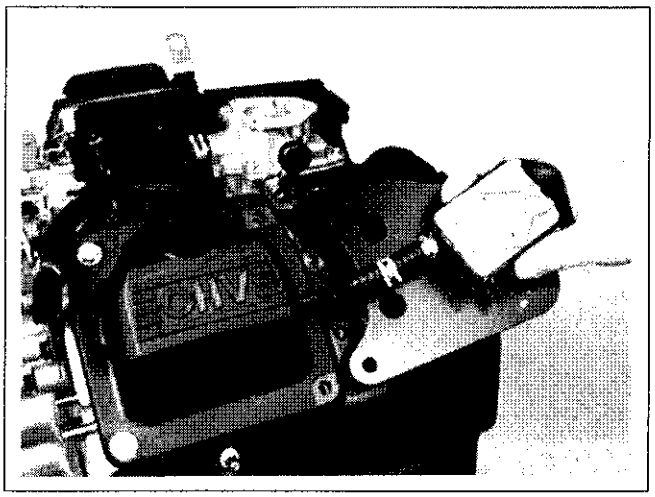


Figure 9-13. Disconnecting Pulse Line from Valve Cover (Earlier Models).

2. Disconnect the pulse (vacuum) line from the crankcase or from the valve cover on earlier models. See Figures 9-12 and 9-13.

3. Remove the two hex. flange screws securing the fuel pump to the bracket on earlier models or to the blower housing on latest design models. See Figure 9-14.

Figure 9-14. Removing Screws Holding Fuel Pump.

4. Note or mark orientation of fuel pump then remove the fuel pump with lines attached as shown in Figure 9-15.

Figure 9-15. Remove Fuel Pump and Lines as an Assembly.

Remove Control Panel (If so equipped)

1. Disconnect low oil light wires.
2. Disconnect choke control cable from throttle control bracket.
3. Disconnect throttle control shaft from throttle control bracket.
4. Remove panel from housing.

Remove Throttle & Choke Controls

1. Remove the four hex. flange screws securing the control bracket to the cylinder heads. See Figure 9-16.

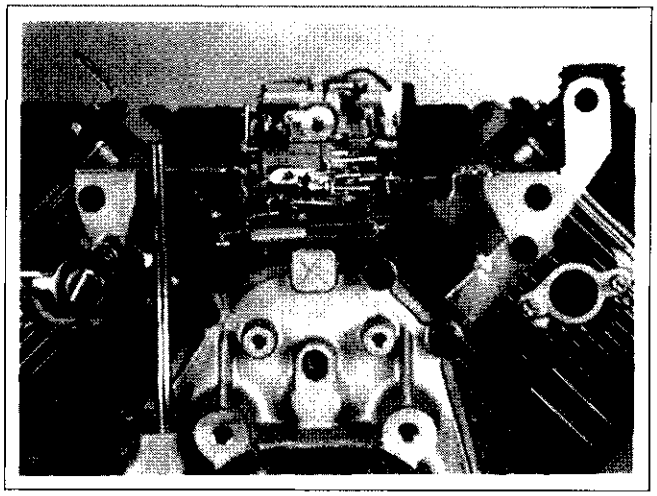


Figure 9-16. Removing Control Bracket.

2. Mark spring hole locations and disconnect the spring from the governor lever. See Figure 9-17.

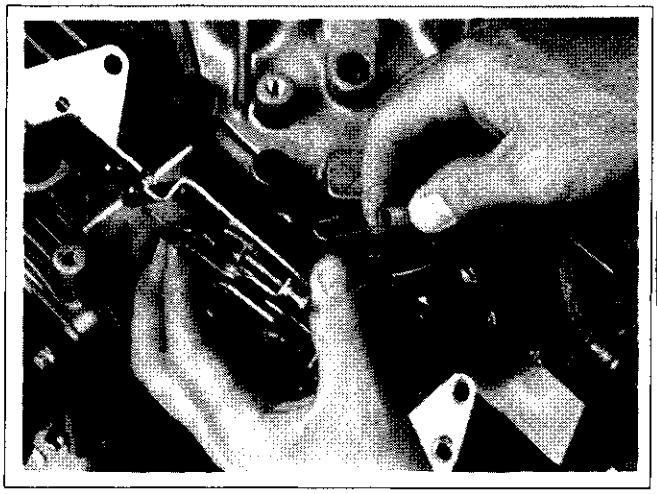


Figure 9-17. Disconnecting Spring from Bracket.

3. Remove the choke linkage from the choke actuator lever and carburetor. See Figure 9-18.

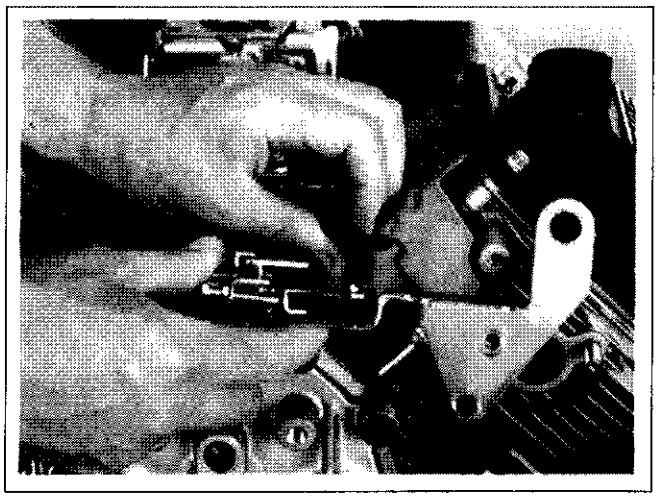


Figure 9-18. Disconnecting Choke Linkage from Actuator Lever.

Remove External Governor Controls

1. Loosen the hex. flange nut and remove governor lever from the cross shaft. See Figure 9-19. Leave lever attached to the throttle linkage and lay it on the top of the crankcase.

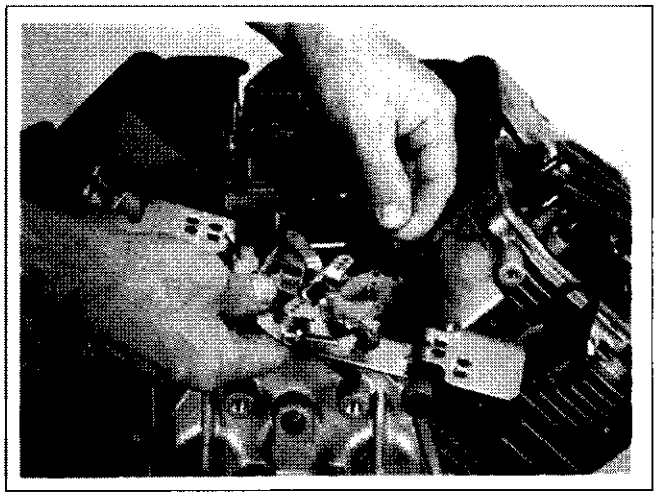


Figure 9-19. Removing Governor Lever from Cross Shaft.

Remove Carburetor

⚠ WARNING: Explosive Fuel!
Gasoline is extremely flammable and its vapors can explode if ignited. Store gasoline only in approved containers, in well ventilated, unoccupied buildings, away from sparks or flames. Do not fill the fuel tank while the engine is hot or running, since spilled fuel could ignite if it comes in contact with hot parts or sparks from ignition. Do not start the engine near spilled fuel. Never use gasoline as a cleaning agent.

1. Disconnect lead to fuel shutoff solenoid (if so equipped).

2. Remove the two carburetor mounting screws. See Figure 9-20.

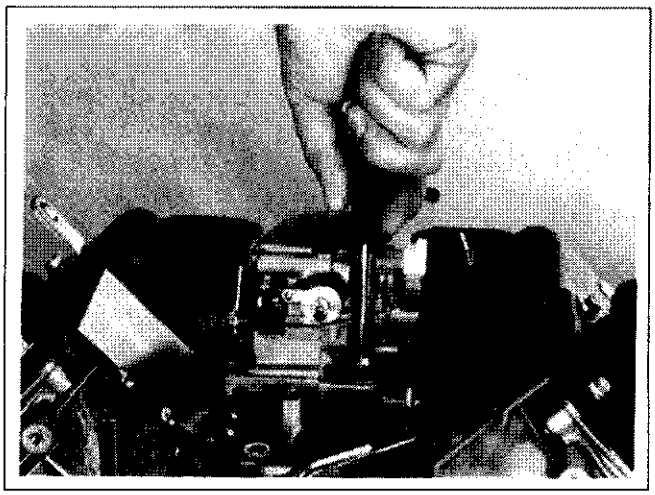


Figure 9-20. Removing Carburetor Retaining Screws.

3. Remove the carburetor, throttle linkage and governor lever as an assembly. See Figure 9-21.

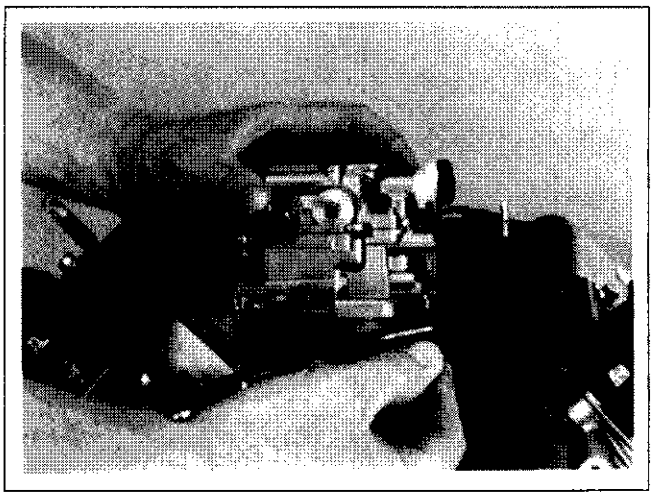


Figure 9-21. Removing Carburetor Assembly.

4. Remove the carburetor gasket.

5. If necessary, the carburetor, throttle linkage and governor lever can be separated. Reattach the bushings to the linkage following separation to avoid losing them.

Remove Oil Sentry™ (If so equipped)

1. Disconnect the wire lead from the Oil Sentry™ Switch.

2. Remove the Oil Sentry™ Switch from the breather cover Figure 9-22.

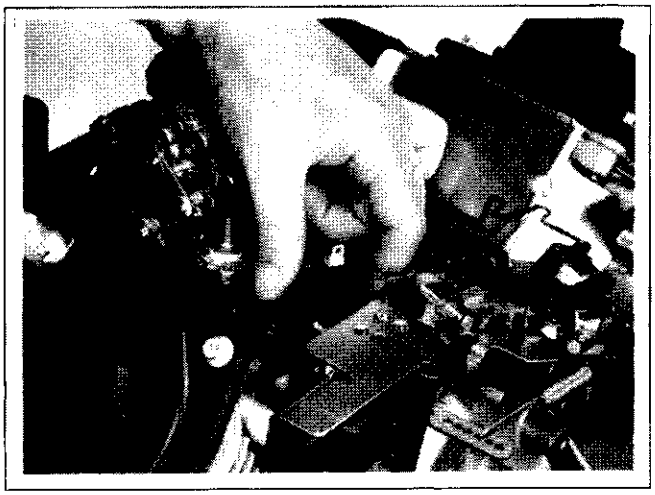


Figure 9-22. Removing Oil Sentry™ Switch from Breather Cover.

Remove Electric Starter Motor

1. Disconnect leads from solenoid on starter.

2. Remove the two hex. flange screws. See Figure 9-23.

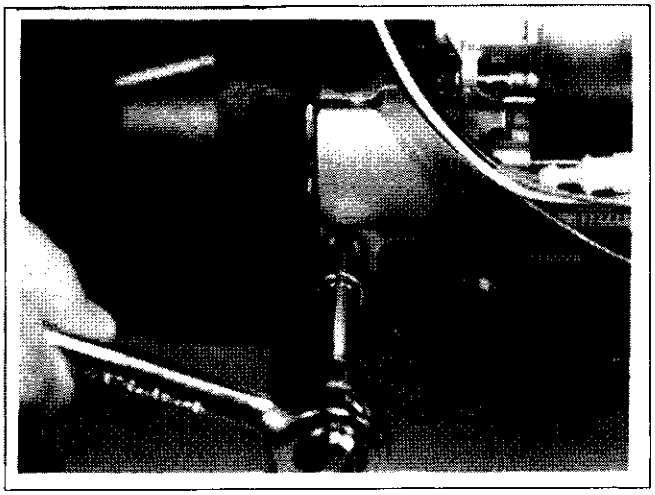


Figure 9-23. Removing Electric Starter Motor.

3. Remove the starter assembly and spacers (if any used).

Remove Outer Baffles and Blower Housing

1. Disconnect the plug from the rectifier-regulator on blower housing. See Figure 9-24.

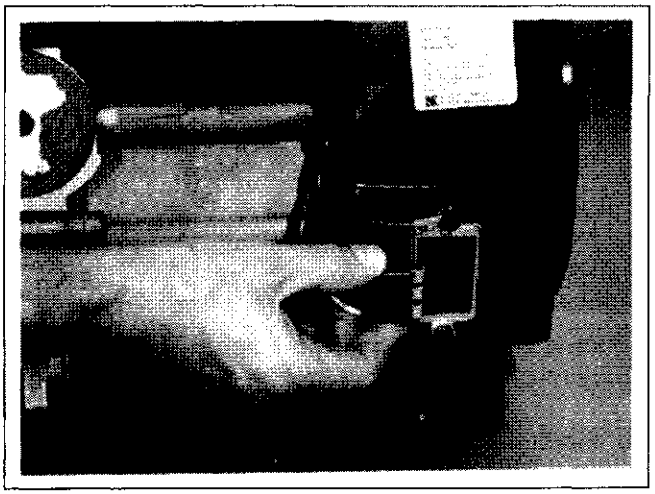


Figure 9-24. Disconnecting Plug from Rectifier-Regulator.

2. Use tip of dipstick to bend locking tang then remove B+ (center lead) from terminal plug as shown in Figure 9-25. This will allow the blower housing to be removed without disturbing the wiring harness.

Figure 9-25. Remove B+ Lead from Terminal Plug.

3. The rectifier-regulator does not have to be detached from the blower housing, however, if the engine is a CH22 or CH25 the Smart Spark™ module should be removed from the housing. See Figure 9-26.

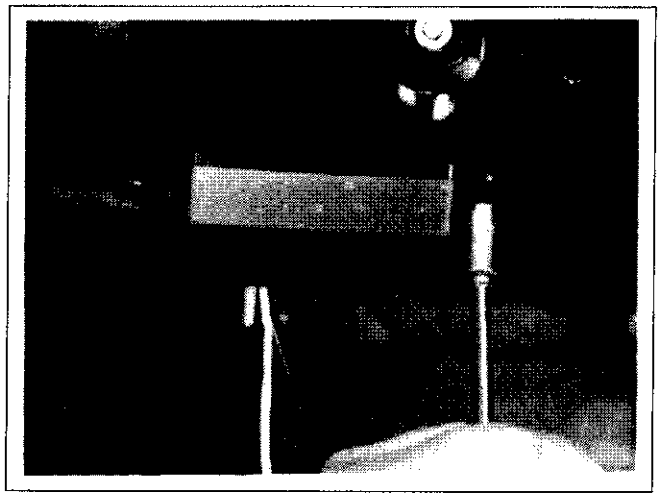


Figure 9-26. Detach the Smart Spark™ Module (CH22 and CH25 Only).

4. Remove the three (each side) hex. flange screws from both outer baffles. Note the position of the two short screws (on bottom) for replacement. See Figure 9-27.

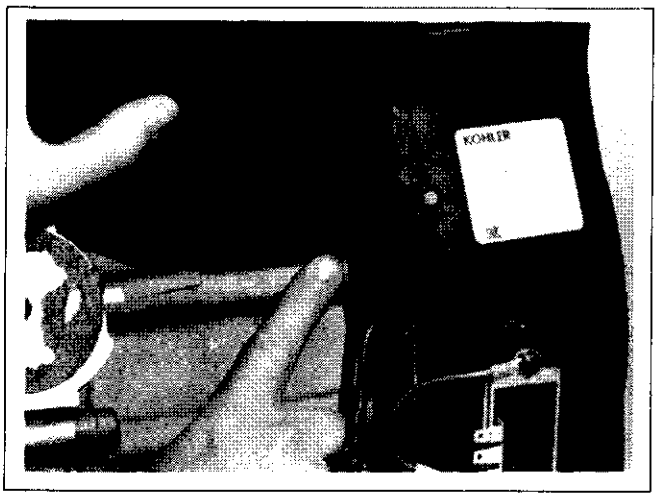


Figure 9-27. Note Location of Two Short Screws.

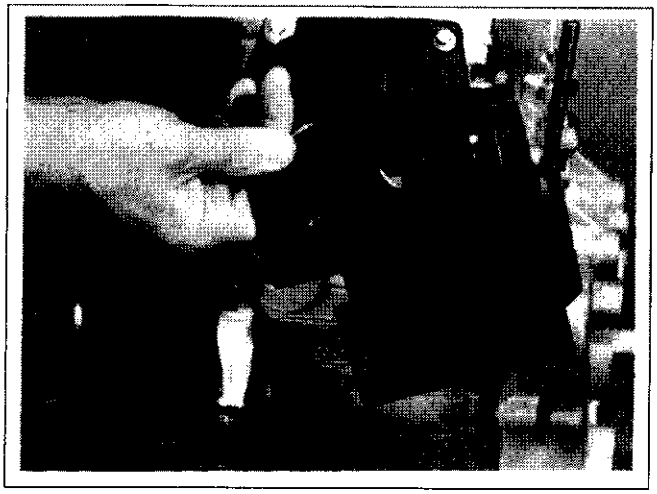


Figure 9-28. Removing Outer Baffles.

5. Remove the outer baffles on both sides. See Figure 9-28.

6. On engines having the metal grass screen, remove the screen before removing the blower housing. (The plastic grass screen can be removed later.) See Figure 9-29.

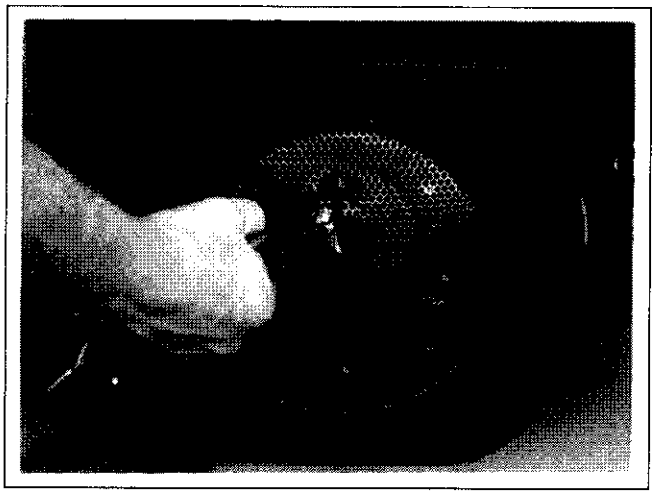


Figure 9-29. Removing Metal Grass Screen.

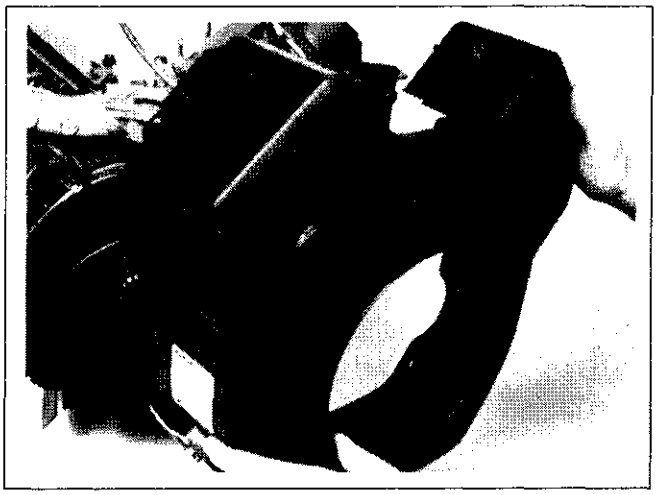


Figure 9-30. Removing Blower Housing.

7. Remove the remaining hex. flange screws and detach the blower housing. See Figure 9-30.

8. Disconnect plug from keyswitch in blower housing if engine is so equipped.

Remove Inner Baffles and Breather Cover

The inner (or valley) baffles are attached at one corner using the same fasteners as the breather cover. See Figure 9-31.

1. Remove the two hex. flange screws securing the inner baffles.

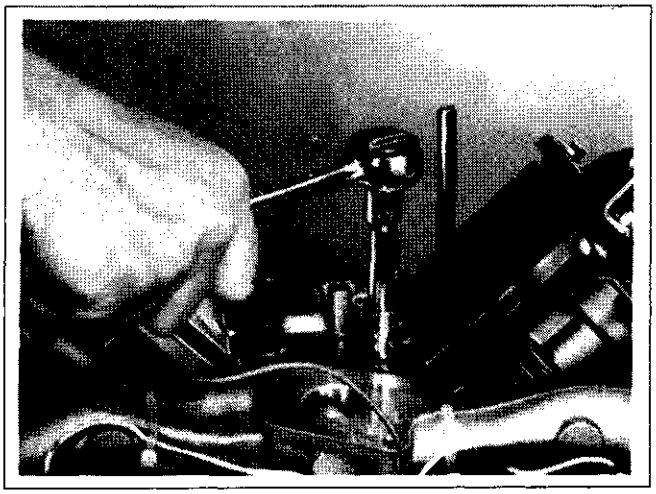


Figure 9-31. Removing Fasteners Holding Baffle and Breather Cover.

2. Remove both inner baffles. See Figure 9-32.

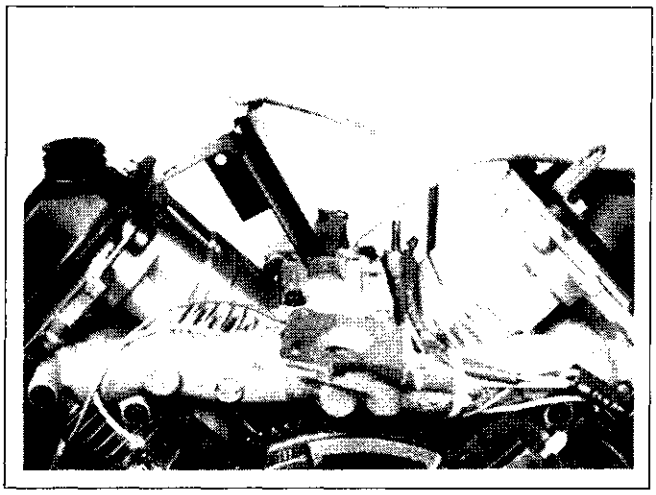


Figure 9-32. Removing Inner Baffles.

3. Remove the two remaining screws holding the breather cover to the crankcase. See Figure 9-32.

4. Pry under the protruding edge of the breather cover with a screwdriver to break the RTV seal (see Figure 9-33). Do not pry on the sealing surfaces as it could cause damage resulting in leaks. Latest engines use a formed gasket rather than RTV sealant.

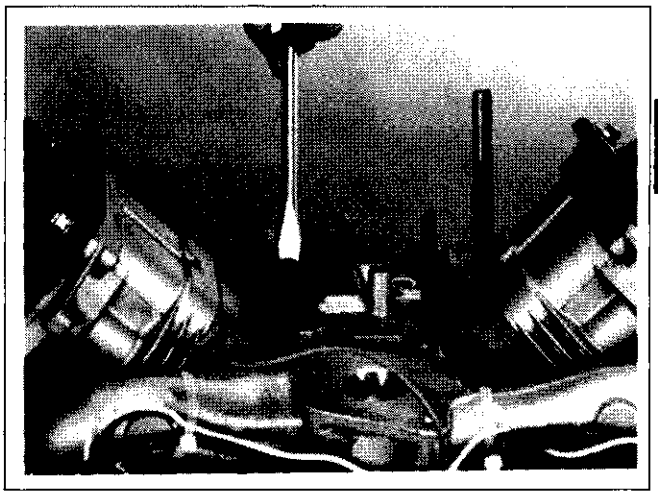


Figure 9-33. Breaking Breather Cover Seal.

5. Remove the breather cover. See Figure 9-34.

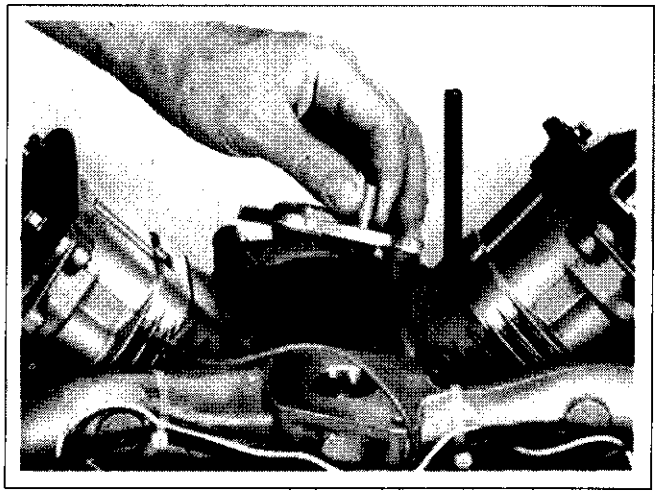


Figure 9-34. Removing Breather Cover.

6. Remove the breather filter from housing. See Figure 9-35.

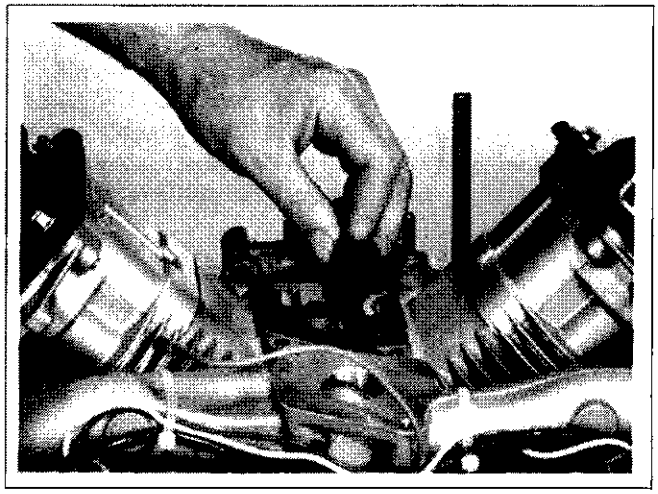


Figure 9-35. Removing Breather Filter.

7. Remove the hex. flange screw, breather reed retainer and breather reed from housing. See Figure 9-36.

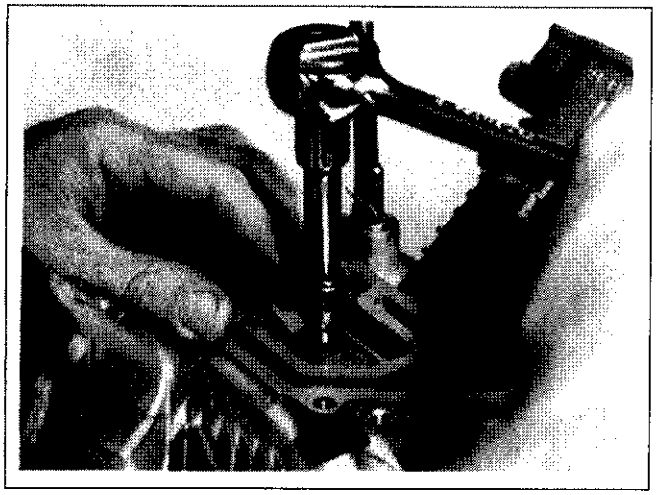


Figure 9-36. Removing Breather Reed.

Remove Valve Covers

1. Remove the four hex. flange screws securing each valve cover. Note position of lifting strap.

2. Remove the valve covers, valve cover gaskets or O-Ring (if used) and lifting strap. Note which side of the engine has the oil fill valve cover. See Figure 9-37.

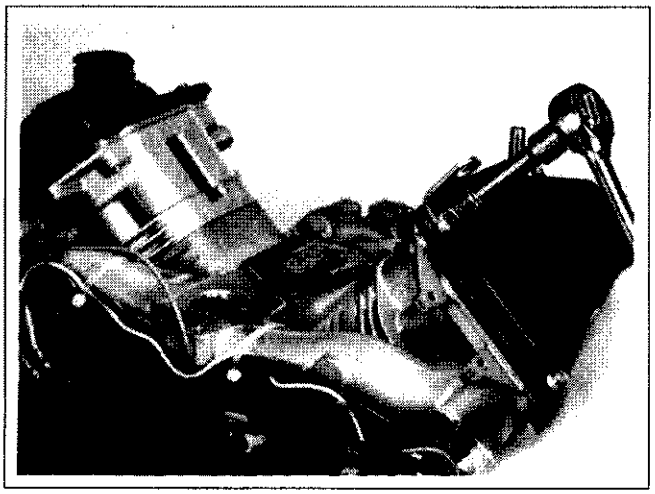


Figure 9-37. Removing Valve Covers.

Remove Ignition Modules

1. Disconnect the leads from each ignition module. See Figure 9-38.

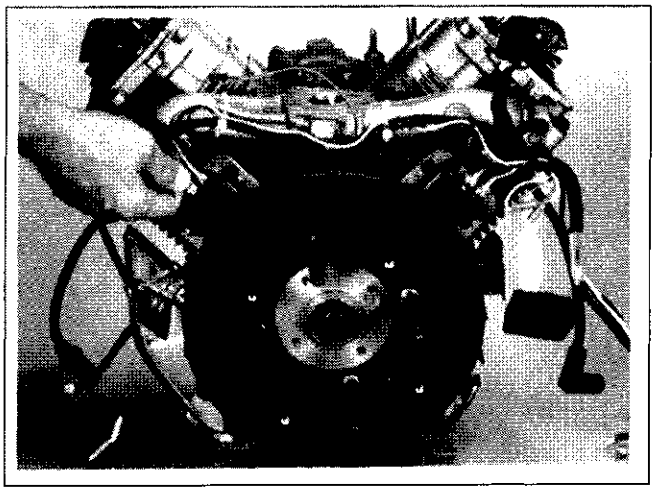


Figure 9-38. Disconnecting Leads from Ignition Modules.

2. Rotate flywheel to position magnet away from modules.

3. Remove the mounting screws and ignition modules. Note the position of ignition modules.

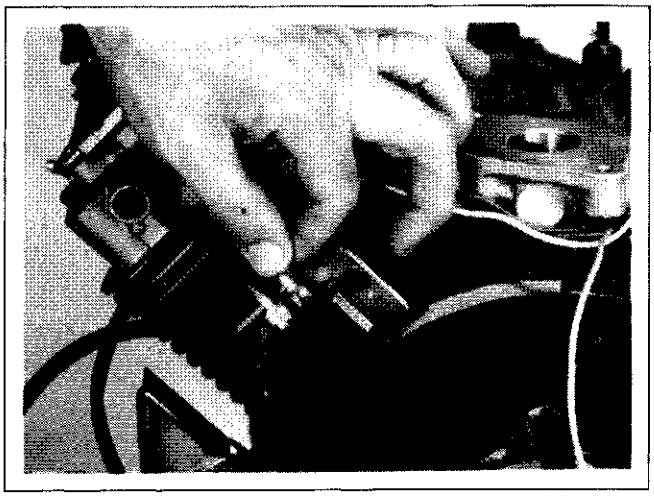


Figure 9-39. Position of Smart Spark™ Ignition Module (CH22 and CH25).

Remove Intake Manifold

1. Remove the four hex. flange screws securing the intake manifold to the cylinder heads. Note which screws hold the wiring clamps.

2. Remove the intake manifold and intake manifold gaskets. See Figure 9-40.

3. Leave the wiring harness attached to the manifold.

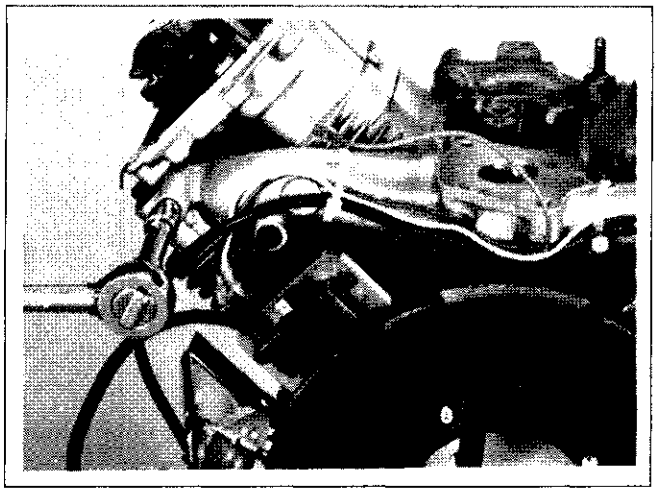


Figure 9-40. Removing Intake Manifold.

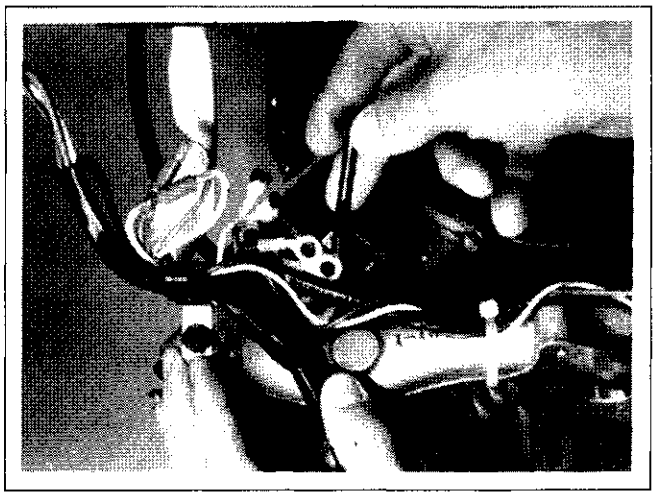


Figure 9-41. Bolt Wiring Harness Detail.

Remove Spark Plugs

1. Remove the spark plug from each cylinder head.

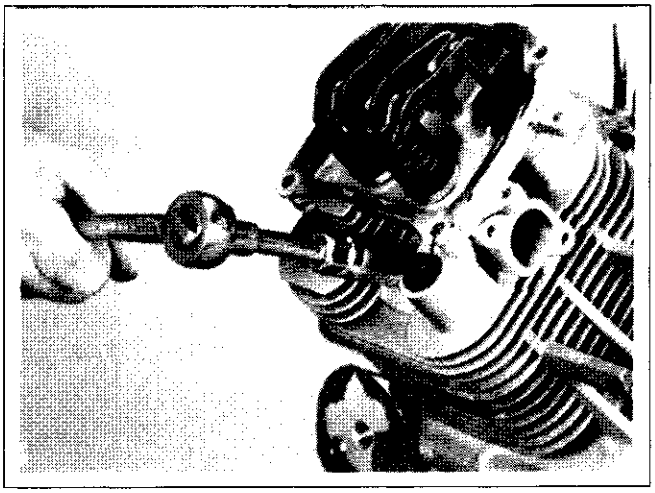


Figure 9-42. Remove Both Spark Plugs.

Remove Cylinder Heads and Hydraulic Lifters

1. Remove the four hex. flange screws securing each cylinder head. See Figure 9-43.

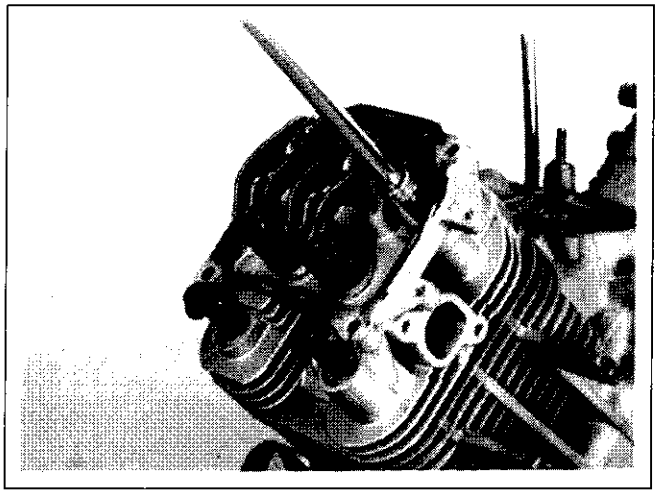


Figure 9-43. Removing Cylinder Head Fasteners.

2. Mark the position of the push rods.

3. Carefully remove the push rods, cylinder heads and head gaskets. See Figure 9-44.

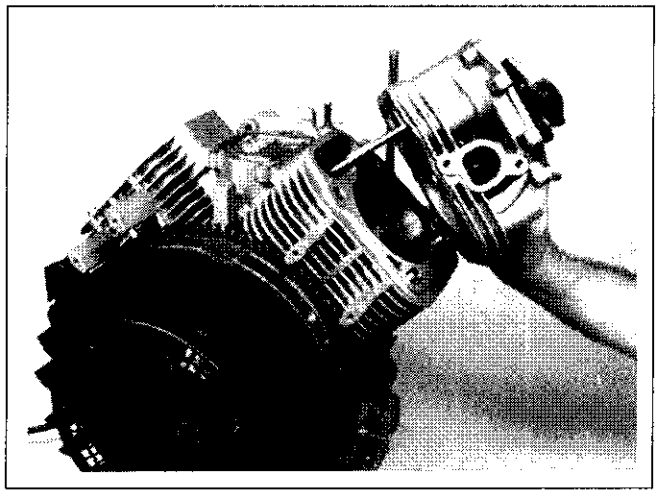


Figure 9-44. Removing Cylinder Head Assembly.

4. Remove the lifters. Mark to identify the hydraulic lifters as either **intake** or **exhaust** and **cylinder 1** or **cylinder 2**. Hydraulic lifters should always be reinstalled in the same position. See Figures 9-45 and 9-46.

NOTE: The exhaust lifters are located on the output shaft side of the engine while the intake lifters are located on the fan side of the engine. **The cylinder head number is bossed on the outside of each cylinder head.**

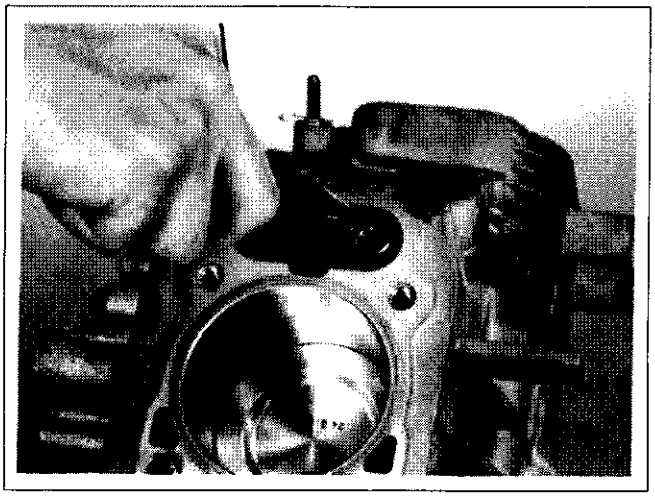


Figure 9-45. Removing Hydraulic Lifter.

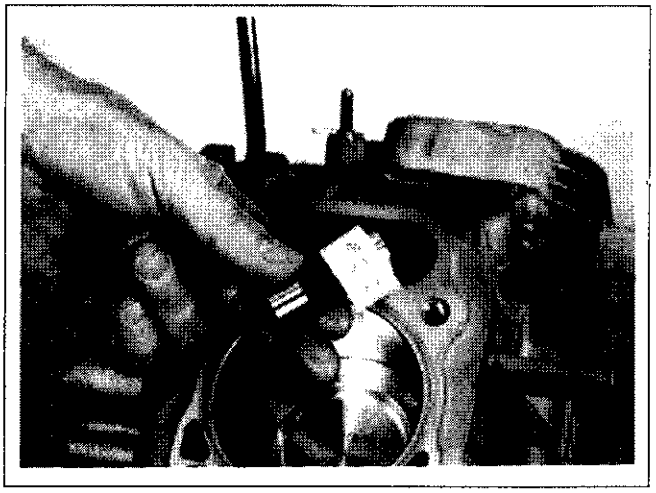


Figure 9-46. Mark Position of Hydraulic Lifters.

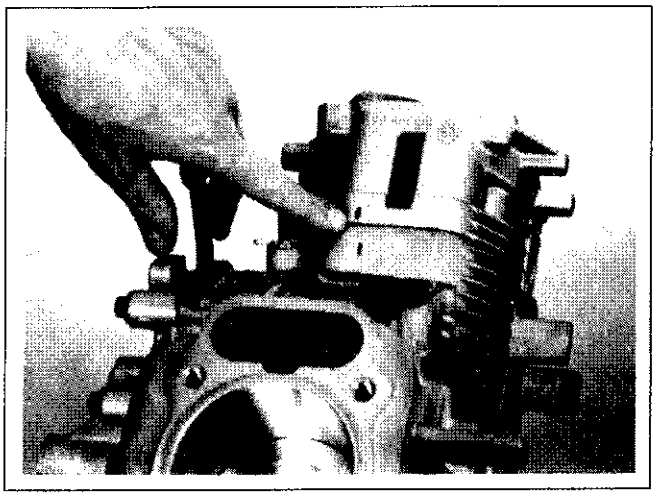


Figure 9-47. Match Marks on Cylinder Barrel and Heads.

Disassemble Cylinder Heads

1. Remove the two hex. flange screws, rocker arm pivots and rocker arms from cylinder head. See Figure 9-48.

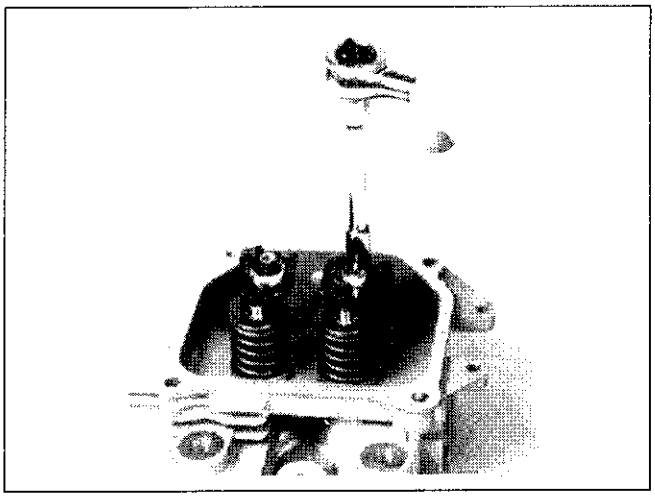


Figure 9-48. Removing Rocker Arms.

2. Compress the valve springs using a valve spring compressor. See Figure 9-49.

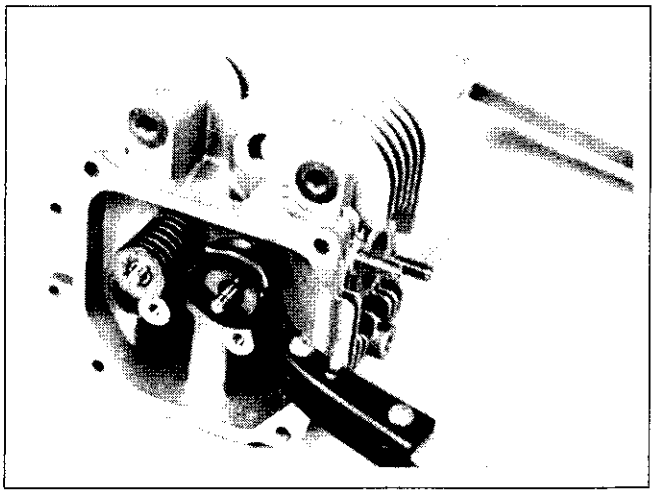


Figure 9-49. Removing Valves with Valve Spring Compressor.

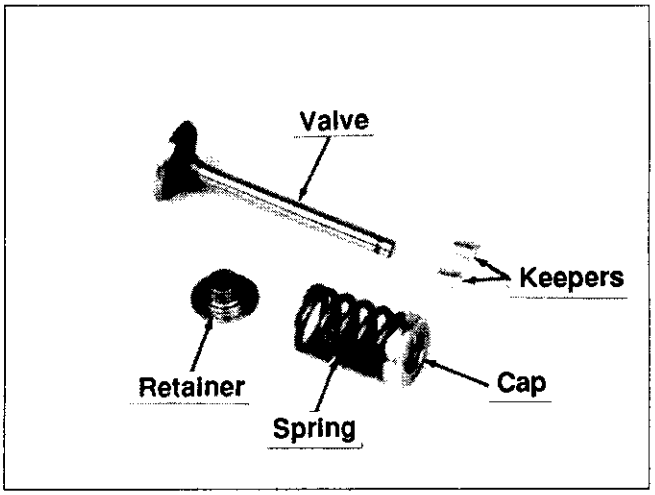


Figure 9-50. Valve Train Components.

3. Once valve spring is compressed, remove the following items (see Figures 9-50 and 9-51):

   - valve spring keepers
   - valve spring retainers
   - valve springs
   - valve spring caps
   - intake and exhaust valves (Mark position!)
   - valve stem seals (intake valve only)

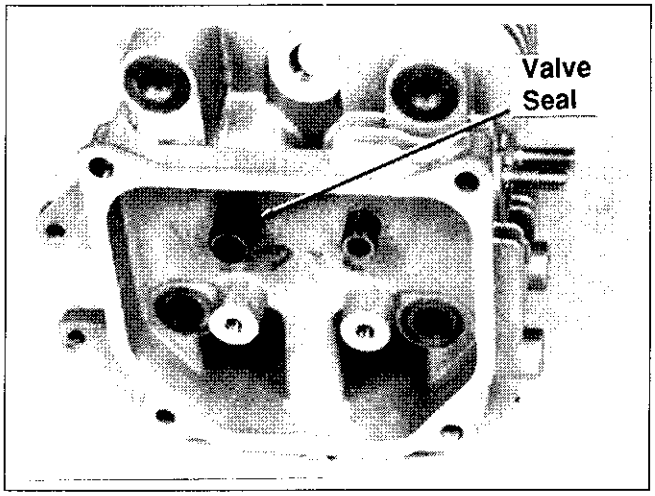


Figure 9-51. Intake Valve Seal Location.

NOTE: These engines use valve stem seals on the intake valves. Always use a new seal when valves are removed from the cylinder head. Also, replace the seals if they are deteriorated or damaged in any way. Never reuse an old seal.

4. Repeat the foregoing procedure for the other cylinder head. Do not interchange parts from one cylinder head to the other.

Remove Grass Screen and Fan

1. Remove the plastic type grass screen by carefully unsnapping it from the retaining knobs on the flywheel fan. See Figure 9-52.

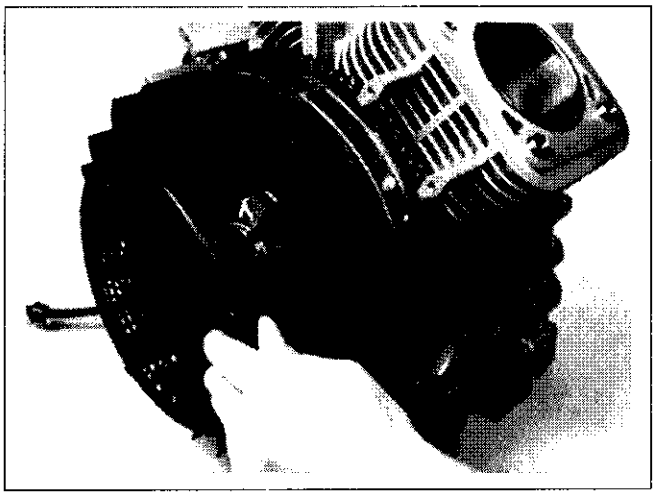


Figure 9-52. Removing Plastic Type Grass Screen.

2. Remove the four hex. flange screws and fan. See Figure 9-53.

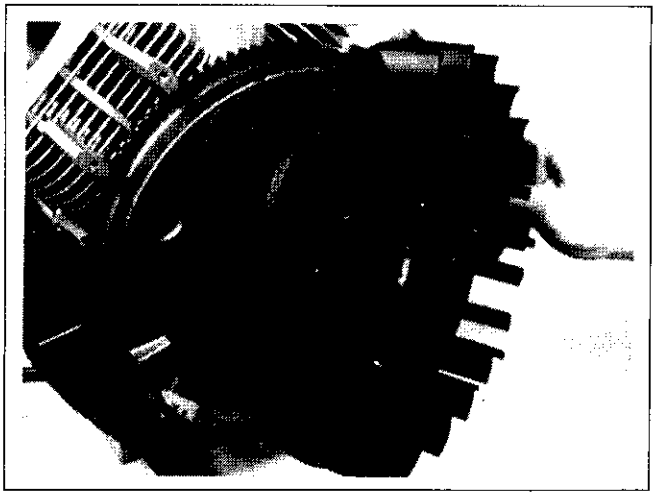


Figure 9-53. Removing Fan.

Remove Flywheel

1. Use a flywheel strap wrench or holding tool (see Section 2) to hold the flywheel and loosen the hex. flange screw securing the flywheel to the crankshaft. See Figure 9-54.

NOTE: Always use a flywheel strap wrench or holding tool to hold the flywheel when loosening or tightening the flywheel screw. Do not use any type of bar or wedge to hold the flywheel. Use of such tools could cause the flywheel to become cracked or damaged.

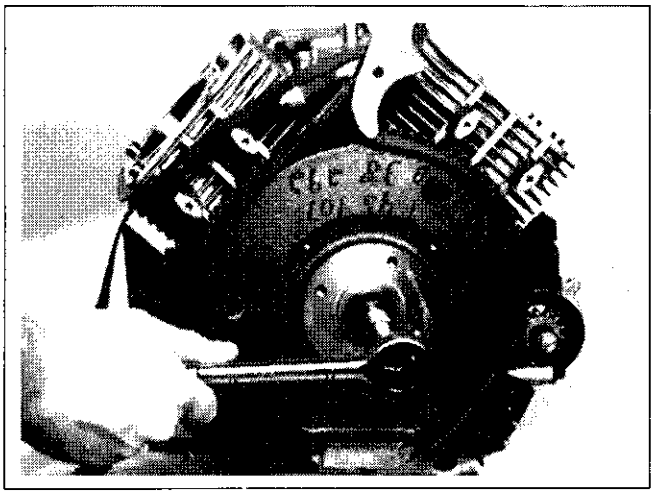


Figure 9-54. Removing Flywheel Fastener Using Strap Wrench.

2. Remove the hex. flange screw and washer.

3. Use a puller to remove the flywheel from the crankshaft. See Figure 9-55.

NOTE: Always use a flywheel puller to remove the flywheel from the crankshaft. Do not strike the crankshaft or flywheel, as these parts could become cracked or damaged. Striking the puller or crankshaft can cause the crank gear to move, affecting crankshaft end play.

4. Remove the woodruff key.

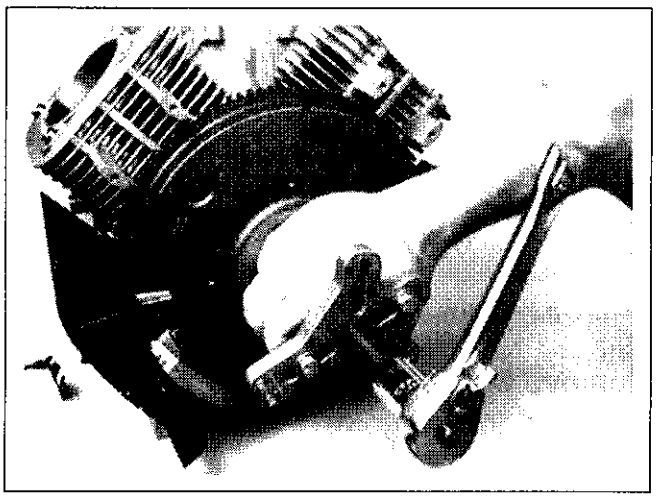


Figure 9-55. Removing Flywheel with a Puller.

Remove Stator and Backing Plates

1. Remove the four flange screws securing the backing plates. See Figure 9-56. Remove backing plates.

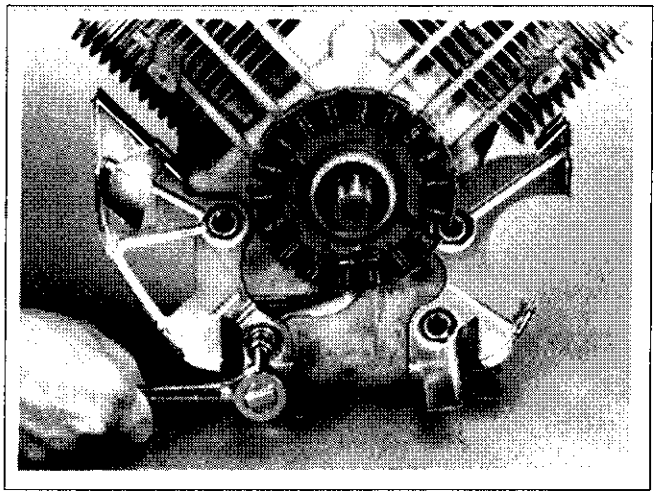


Figure 9-56. Removing Backing Plates.

2. Remove the two hex. screws and stator. See Figure 9-57. Note position of stator lead.

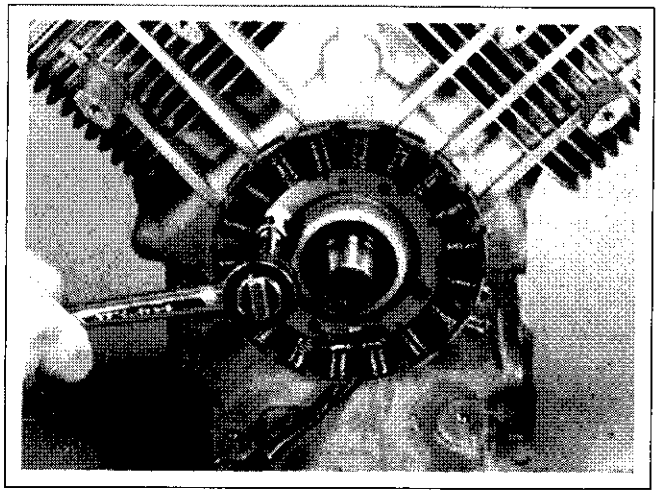


Figure 9-57. Removing Alternator Stator.

Remove Closure Plate Assembly

1. Remove the ten hex. flange screws securing the closure plate to the crankcase. See Figure 9-58.

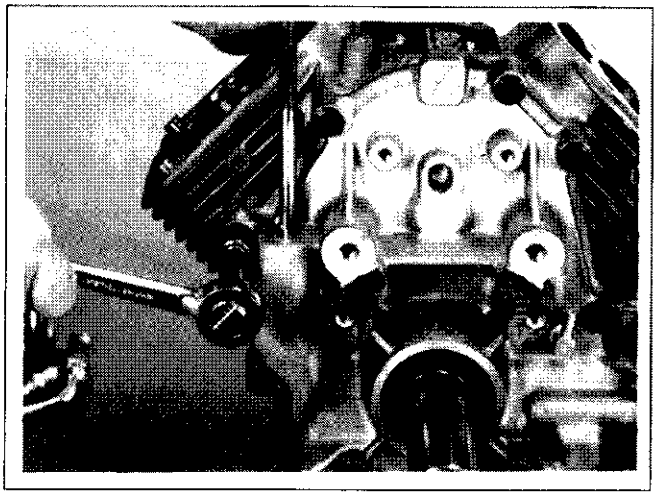


Figure 9-58. Removing the Ten Closure Plate Fasteners.

2. Locate the three splitting tabs that are cast into the perimeter of the closure plate. Insert the drive end of a 1/2" breaker bar between the top splitting tab and the crankcase. Hold the handle horizontal and pull it toward you to break the RTV seal. If necessary, pry at the bottom tabs also. See Figure 9-59. Do not pry on the sealing surfaces as this could cause leaks. Carefully pull closure plate from crankcase.

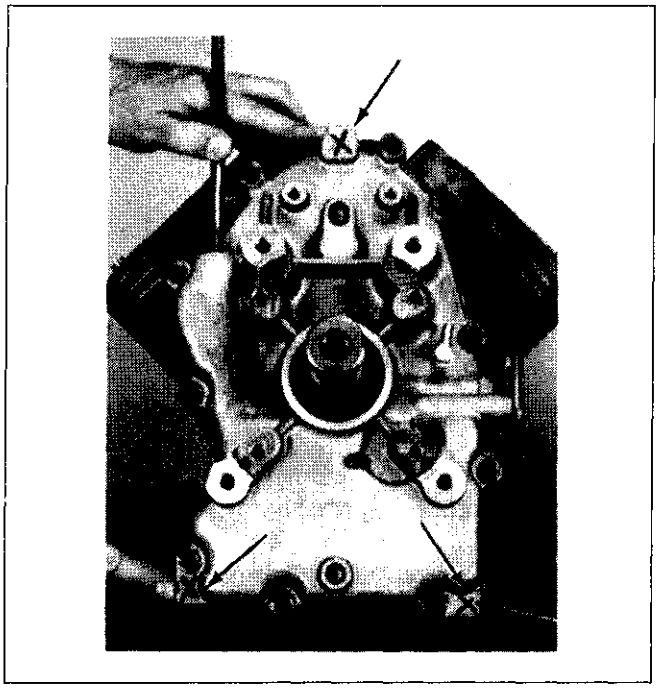


Figure 9-59. Location of Three Splitting Tabs.

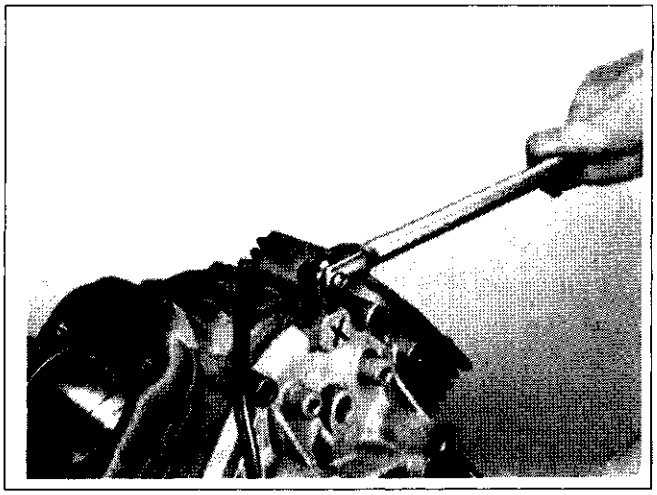


Figure 9-60. Breaking Seal on Top Splitting Tab.

Governor Assembly

The governor assembly is located inside the closure plate. If service is required, refer to the service procedures under "Governor Assembly" in Section 10.

Oil Pump Assembly

The oil pump is mounted to the inside of the closure plate. If service is required, refer to the service procedures under "Oil Pump Assembly" in Section 10.

Remove Camshaft

1. Remove the camshaft and shims. See Figure 9-61.

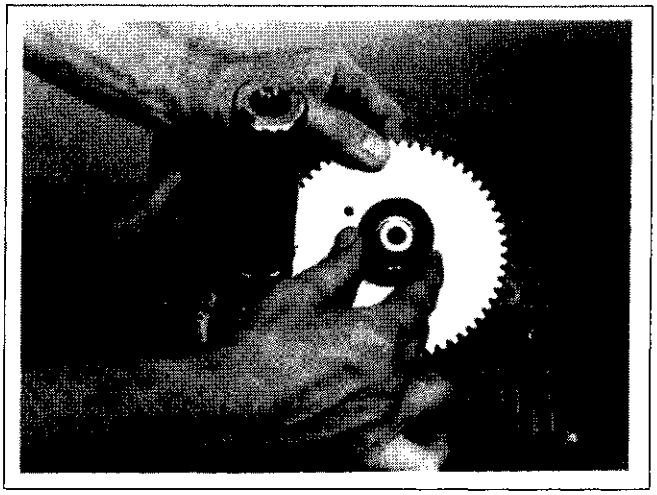


Figure 9-61. Removing Camshafts (Note Shims).

Remove Connecting Rods with Pistons and Rings

1. Remove the two hex. flange screws securing the closest connecting rod end cap. Remove the end cap. See Figure 9-62.

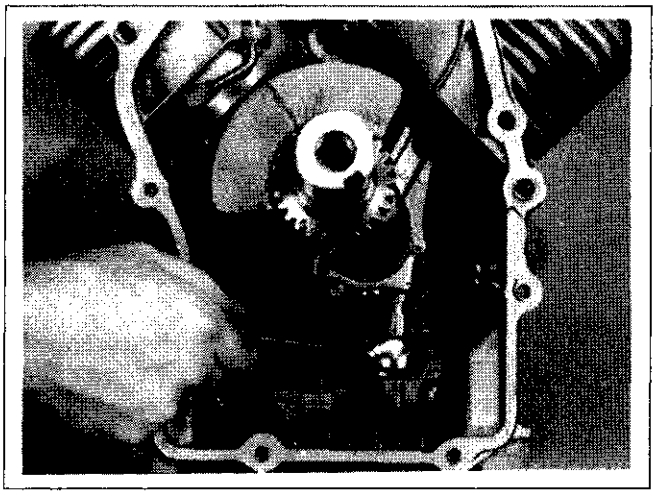


Figure 9-62. Removing Connecting Rod Bolts.

NOTE: If a carbon ridge is present at the top of either cylinder bore, use a ridge reamer tool to remove it before attempting to remove the piston.

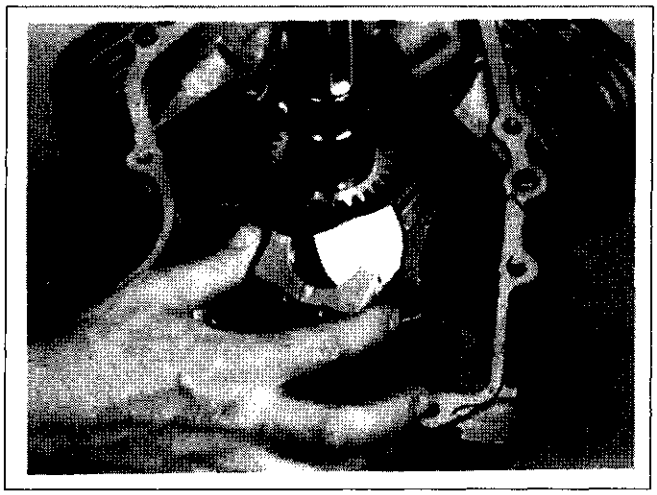


Figure 9-63. Mark End Cap with Cylinder Number Before Removal.

NOTE: The cylinders are numbered on the crankcase. Use the numbers to mark each end cap, connecting rod and piston for reassembly. **Do not** mix end caps and connecting rods.

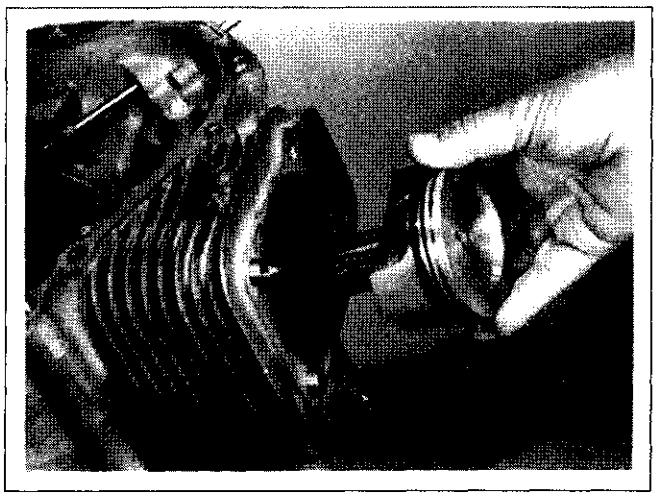


Figure 9-64. Removing Piston/Connecting Rod Assemblies.

2. Carefully remove the connecting rod and piston assembly from the cylinder bore. See Figure 9-64.

3. Repeat the above procedures for the other connecting rod and piston assembly.

Remove Crankshaft

1. Carefully pull the crankshaft from the crankcase. See Figure 9-65. Note thrust ring washers and shims if used.

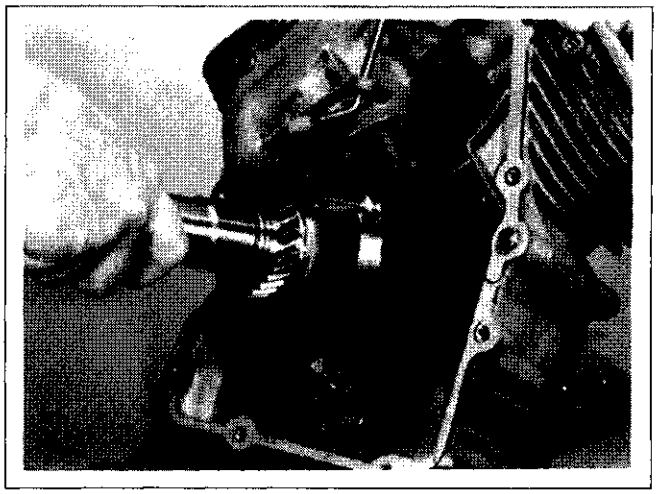


Figure 9-65. Removing Crankshaft.

Remove Governor Cross Shaft

1. Remove the hitch pin and plain washer from the governor cross shaft. See Figure 9-66.

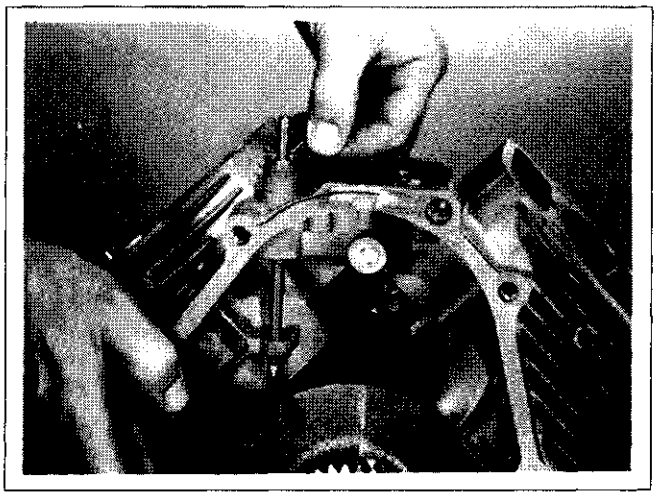


Figure 9-66. Removing Governor Cross Shaft Hitch Pin.

2. Remove the cross shaft through the inside of the crankcase. See Figure 9-67.

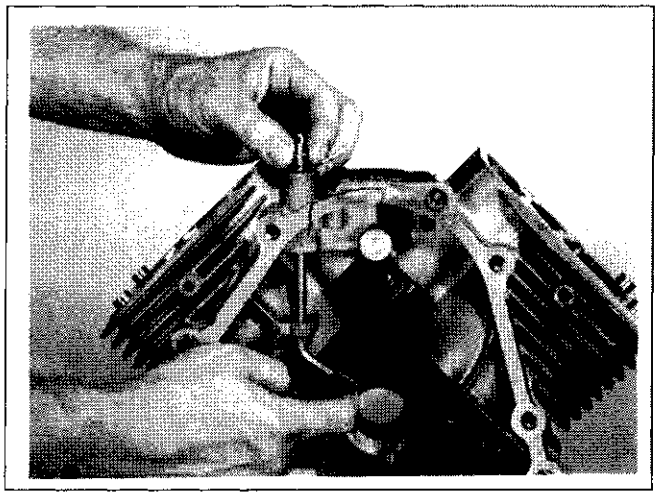


Figure 9-67. Pulling Governor Cross Shaft.

Remove Flywheel End Main Bearing and Oil Seal

1. Remove oil seal from crankcase. See Figure 9-68.

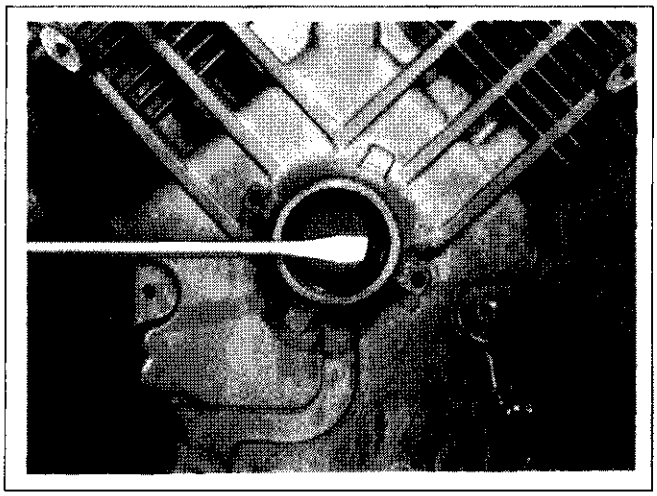


Figure 9-68. Removing Oil Seal.

2. Remove main bearing (if so equipped) from crankcase using a hammer and bearing remover. See Figure 9-69.

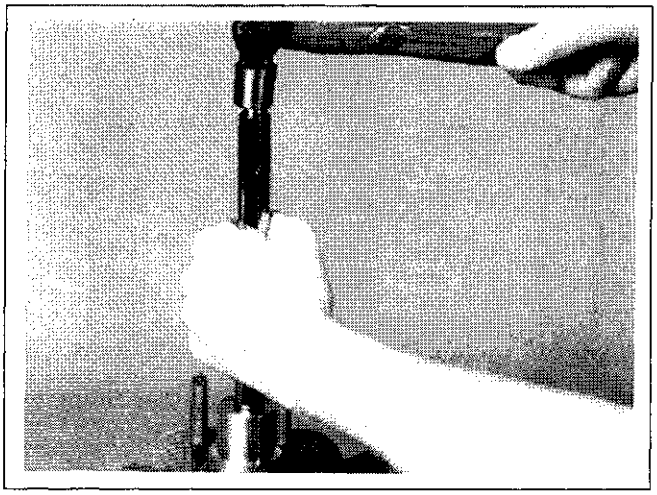


Figure 9-69. Removing Main Bearing.

Section 10
Inspection and Reconditioning

This section covers the operation, inspection, and repair/reconditioning of major internal engine components. The following components are not covered in this section. They are covered in sections of their own:

Air Cleaner, Section 4
Carburetor & External Governor, Section 5
Ignition, Charging & Electric Starter, Section 8

Clean all parts thoroughly. Only clean parts can be accurately inspected and gauged for wear or damage. There are many commercially available cleaners that will quickly remove grease, oil, and grime from engine parts. When such a cleaner is used, follow the manufacturer's instructions and safety precautions carefully. Use gasket remover or paint remover to remove the old RTV from valve cover, cylinder head, crankcase, and oil pan. Do not scrap the surfaces when cleaning as this will damage the surfaces. This could result in leaks.

Make sure all traces of the cleaner are removed before the engine is reassembled and placed into operation. Even small amounts of these cleaners can quickly break down the lubricating properties of engine oil.

Refer to A Guide to Engine Rebuilding (TP-2150) for additional information. Measurement Guide (TP-2159-A) and Engine Inspection Data Record (TP-2435) are also available; use these to record inspection results.

Automatic Compression Release (ACR)

Some engines are equipped with the optional **Automatic Compression Release** (ACR) mechanism. ACR lowers compression at cranking speeds to make starting easier.

Operation

The ACR mechanism consist of a flyweight, spring and pivoting control pin assembly attached to the gear on the camshaft. At cranking speeds (700 RPM or lower), the control pin protrudes above the exhaust cam lobe. This pushes the exhaust valve off its seat during the first part of the compression stroke. The reduced compression results in an effective compression ratio of about 2:1 during cranking.

After starting, engine speed increases to over 700 RPM, and centrifugal force overcomes the force of the flyweight spring. The flyweight moves outward, pulling the arm of the control pin, so it pivots into the "run" position. The control pin no longer has any effect on the exhaust valve and the engine operates at full power.

When the engine is stopped, the spring returns the flyweight lever and control pin assembly to the compression release position ready for the next start.

Camshaft

Inspection and Service

Inspect the gear teeth of the camshaft. If the teeth are badly worn, chipped, or some are missing, replacement of the camshaft will be necessary.

Crankshaft

Inspection and Service

Inspect the gear teeth of the crankshaft. If the teeth are badly worn, chipped, or some are missing, replacement of the crankshaft will be necessary.

Inspect the crankshaft bearing surfaces for scoring, grooving, etc. Do not replace bearings unless they show signs of damage or are out of running clearance specifications. If the crankshaft turns easily and noiselessly, and there is no evidence of scoring, grooving, etc., on the races or bearing surfaces, the bearings can be reused.

Inspect the crankshaft keyways. If worn or chipped, replacement of the crankshaft will be necessary.

Inspect the crankpin for score marks or metallic pickup. Slight score marks can be cleaned with crocus cloth soaked in oil. If wear limits, as stated in "Specifications and Tolerances" are exceeded, it will be necessary to either replace the crankshaft or regrind the crankpin to **0.25 mm (0.010 in.)** undersize. If reground, a **0.25 mm (0.010 in.)** undersize connecting rod (big end) must then be used to achieve proper running clearance. Measure the crankpin for size, taper, and out-of-round.

NOTE: If the crankpin is reground, visually check to insure that the fillet blends smoothly with the crankpin surface. See Figure 10-1.

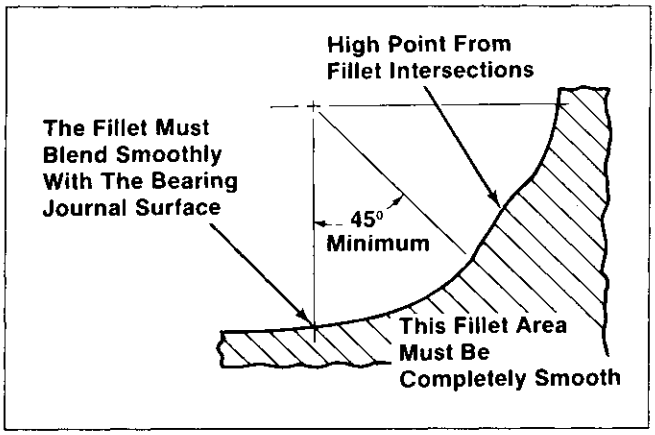


Figure 10-1. Crankpin Fillets.

The crankshaft flywheel end main bearing journal can be ground two sizes under. The connecting rod journal can be ground one size under.

When grinding a crankshaft on a CH18-25 engine, grinding stone deposits can get caught in oil passages which could cause severe engine damage. Removing the plug each time the crankshaft is ground provides easy access for cleaning any grinding deposits that may collect in the oil passages.

Use the following procedure to remove and replace the plug.

Procedure to Remove Crankshaft Plug:

1. Drill a 3/16" hole through the plug in the crankshaft.

2. Thread a 3/4" or 1" long self-tapping screw with a flat washer into the drilled hole. The flat washer must be large enough to seat against the shoulder of the plug bore. See Figure 10-2.

3. Tighten the self-tapping screw until it draws the plug out of the crankshaft.

Procedure to Install New Plug:

1. Use a single cylinder camshaft pin Part No. 47 380 09 as a driver and tap the plug into the plug bore until it seats at the bottom of the bore. Make sure the plug is tapped in evenly to prevent leakage.

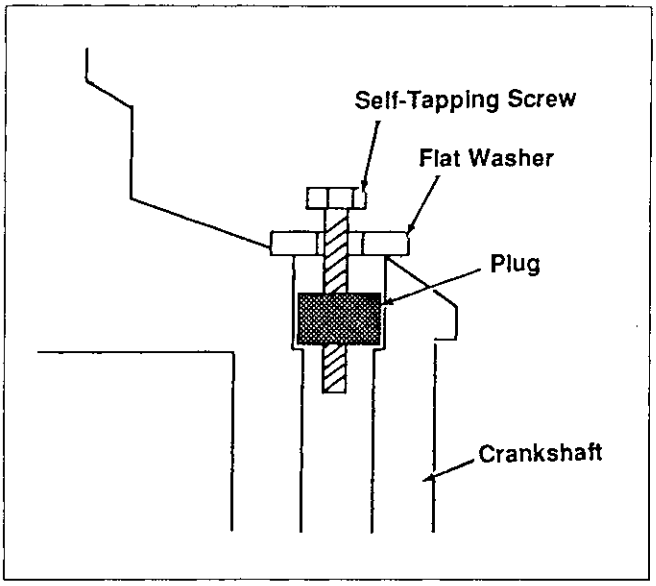


Figure 10-2. Removing Crankpin Plug.

Crankcase

NOTE: CH25 engines feature POWER-BORE™ cylinders. These are plated with nickel-silicone in a special patented process for increased power, superior oil control, reduced exhaust emission and virtually permanent cylinder life. If the cylinder bore is damaged on a CH25, it cannot be resized or honed as described in the following which applies to CH18 through CH22 models. Use a new miniblock or short block for the CH25 models.

Inspection and Service

Check all gasket surfaces to make sure they are free of gasket fragments. Gasket surfaces must also be free of deep scratches or nicks.

Check the cylinder bore wall for scoring. In severe cases, unburned fuel can cause scuffing and scoring of the cylinder wall. It washes the necessary lubricating oils off the piston and cylinder wall. As raw fuel seeps down the cylinder wall, the piston rings make metal to metal contact with the wall. Scoring of the cylinder wall can also be caused by localized hot spots resulting from blocked cooling fins or from inadequate or contaminated lubrication.

If the cylinder bore is badly scored, excessively worn, tapered, or out-of-round, resizing is necessary. Use an inside micrometer to determine amount of wear (refer to the "Specifications, Tolerances, and Special Torque Values", in Section 1), then select the nearest suitable oversize of either **0.25 mm (0.010 in.)** or **0.50 mm (0.020 in.)**. Resizing to one of these oversizes will allow usage of the available oversize piston and ring assemblies. Initially, resize using a boring bar, then use the following procedures for honing the cylinder. NOTE: Oversizing does not apply to CH25 models.

Honing

While most commercially available cylinder hones can be used with either portable drills or drill presses, the use of a low speed drill press is preferred as it facilitates more accurate alignment of the bore in relation to the crankshaft crossbore. Honing is best accomplished at a drill speed of about **250 RPM** and **60 strokes** per minute. After installing coarse stones in hone, proceed as follows:

1. Lower hone into bore and after centering, adjust so that the stones are in contact with the cylinder wall. Use of a commercial cutting-cooling agent is recommended.

2. With the lower edge of each stone positioned even with the lowest edge of the bore, start drill and honing process. Move the hone up and down while resizing to prevent the formation of cutting ridges. Check the size frequently.

   NOTE: Measure the piston diameter and resize the bore to the piston to obtain the specified running clearances. Keep in mind the temperatures caused by honing may cause inaccurate measurements. Make sure the bore is cool when measuring.

3. When the bore is within **0.064 mm (0.0025 in.)** of desired size, remove the coarse stones and replace with burnishing stones. Continue with the burnishing stones until within **0.013 mm (0.0005 in.)** of desired size and then use finish stones (220-280 grit) and polish to final size. A crosshatch should be observed if honing is done correctly. The crosshatch should intersect at approximately 23-33° off the horizontal. Too flat an angle could cause the rings to skip and wear excessively, too steep an angle will result in high oil consumption (refer to Figure 10-3).

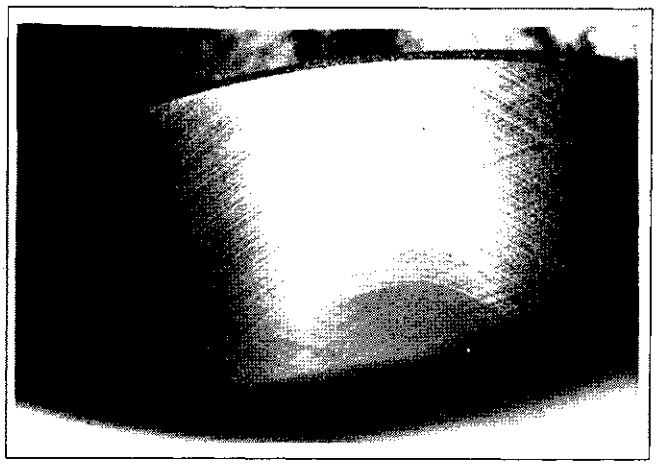


Figure 10-3. Cylinder Bore Crosshatch after Honing.

4. After resizing, check the bore for roundness, taper, and size. Use an inside micrometer, telescoping gauge, or bore gauge to take measurements. The measurements should be taken at three locations in the cylinder – at the top, middle, and bottom. Two measurements should be taken (perpendicular to each other) at each of the three locations.

Clean Cylinder Bore After Honing

Proper cleaning of the cylinder walls following boring and/or honing is very critical to a successful overhaul. Machining grit left in the cylinder bore can destroy an engine in less than one hour of operation after a rebuild.

The final cleaning operation should always be a thorough scrubbing with a brush and hot, soapy water. Use a strong detergent that is capable of breaking down the machining oil while maintaining a good level of suds. If the suds break down during cleaning, discard the dirty water and start again with more hot water and detergent. Following the scrubbing, rinse the cylinder with very hot, clear water, dry it completely, and apply a light coating of engine oil to prevent rusting.

Measuring Piston-to-Bore Clearance
Before installing the piston into the cylinder bore, it is necessary that the clearance be accurately checked. This step is often overlooked, and if the clearances are not within specifications, engine failure will usually result.

NOTE: Do not use a feeler gauge to measure piston-to-bore clearance – it will yield inaccurate measurements. Always use a micrometer.

Use the following procedure to accurately measure the piston-to-bore clearance:

1. Use a micrometer and measure the diameter of the piston **6 mm (0.24 in.)** above the bottom of the piston skirt and perpendicular to the piston pin (see Figure 10-4).

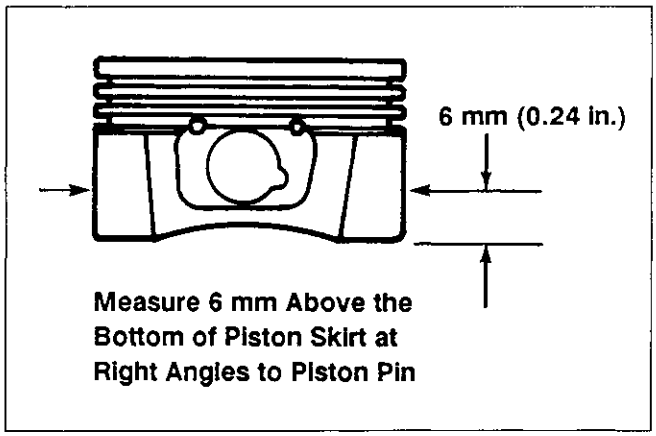


Figure 10-4. Measuring Piston Diameter.

2. Use an inside micrometer, telescoping gauge, or bore gauge and measure the cylinder bore. Take the measurement approximately **63.5 mm (2.5 in.)** below the top of the bore and perpendicular to the piston pin.

3. Piston-to-bore clearance is the difference between the bore diameter and the piston diameter (step 2 minus step 1).

Flywheel

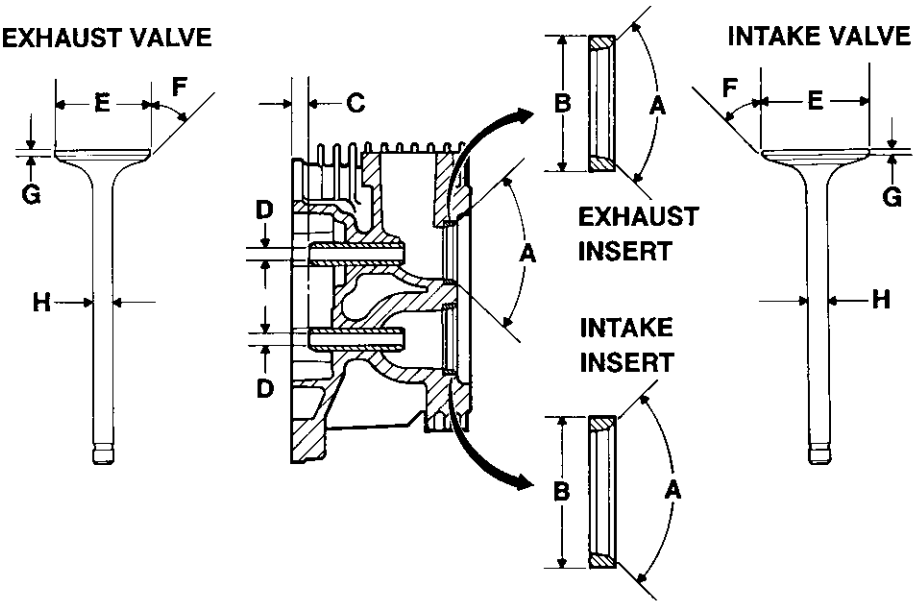
Inspection
Inspect the flywheel for cracks, and the flywheel keyway for damage. Replace flywheel if cracked. Replace the flywheel, the crankshaft, and the key if flywheel key is sheared or the keyway is damaged.

Inspect the ring gear for cracks or damage. Kohler does not provide ring gears as a serviceable part. Replace the flywheel if the ring gear is damaged.

Cylinder Head and Valves

Inspection and Service

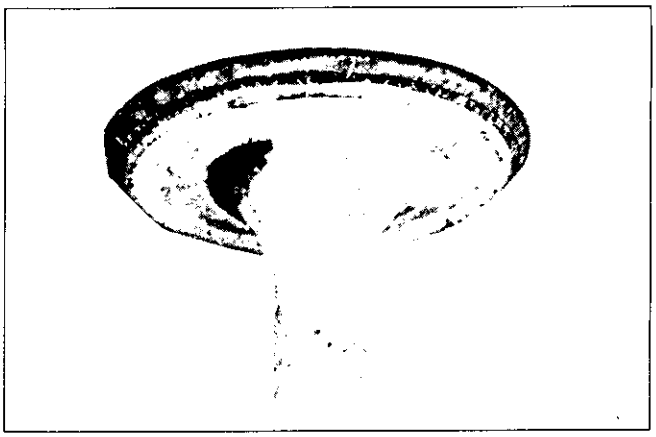
Carefully inspect the valve mechanism parts. Inspect the valve springs and related hardware for excessive wear or distortion. Check the valves and valve seat area or inserts for evidence of deep pitting, cracks, or distortion. Check clearance of the valve stems in guides. See Figure 10-5 for valve details and specifications.



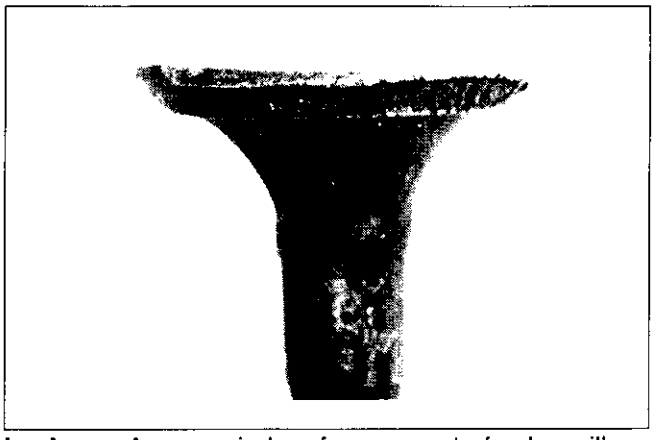
	Dimension	Intake	Exhaust
A	Seat Angle	89°	89°
B	Insert O.D.	36.863/36.887 mm	32.863/32.887 mm
C	Guide Depth	6 mm	4 mm
D	Guide I.D.	7.038/7.058 mm	7.038/7.058 mm
E	Valve Head Diameter	33.37/33.63 mm	29.37/29.63 mm
F	Valve Face Angle	45°	45°
G	Valve Margin (Min.)	1.5 mm	1.5 mm
H	Valve Stem Diameter	5.72/5.92 mm	5.72/5.92 mm

Figure 10-5. Valve Details.

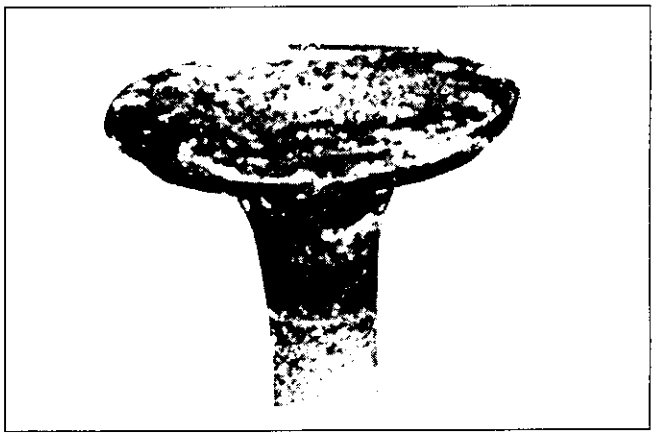
Hard starting, or loss of power accompanied by high fuel consumption may be symptoms of faulty valves. Although these symptoms could also be attributed to worn rings, remove and check the valves first. After removal, clean the valve heads, faces, and stems with a power wire brush. Then, carefully inspect each valve for defects such as warped head, excessive corrosion, or worn stem end. Replace valves found to be in bad condition. A normal valve and valves in bad condition are shown in the accompanying illustrations.



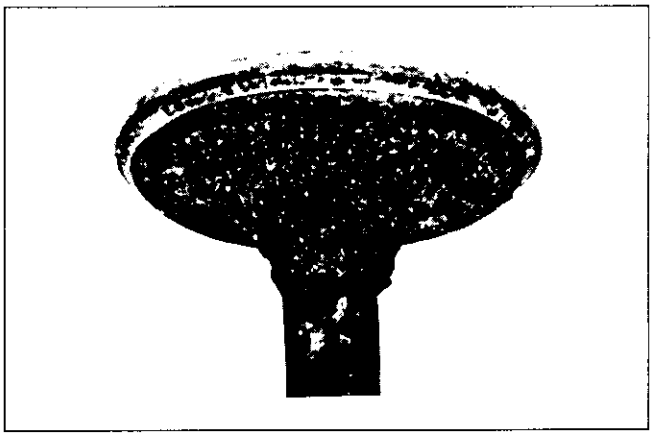
Normal: Even after long hours of operation a valve can be reconditioned and reused if the face and margin are in good shape. If a valve is worn to where the margin is less than 1/32" do not reuse it. The valve shown was in operation for almost 1000 hours under controlled test conditions.



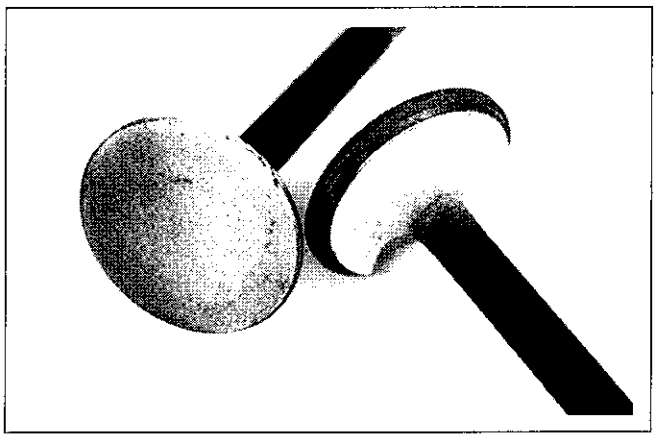
Leakage: A poor grind on face or seat of valve will allow leakage resulting in a burned valve on one side only.



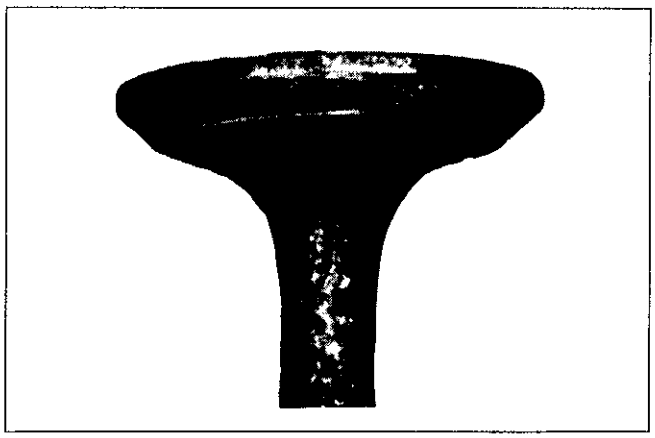
Bad Condition: The valve depicted here should be replaced. Note the warped head; margin damaged and too narrow. These conditions could be attributed to excessive hours or a combination of poor operating conditions.



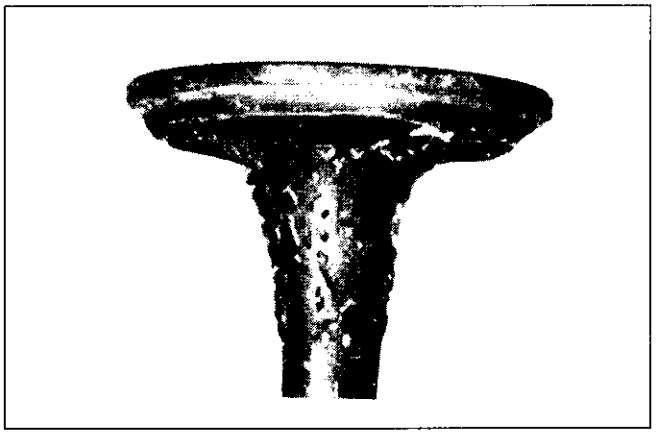
Coking: Coking is normal on intake valves and is not harmful. If the seat is good, the valve could be reused after cleaning.



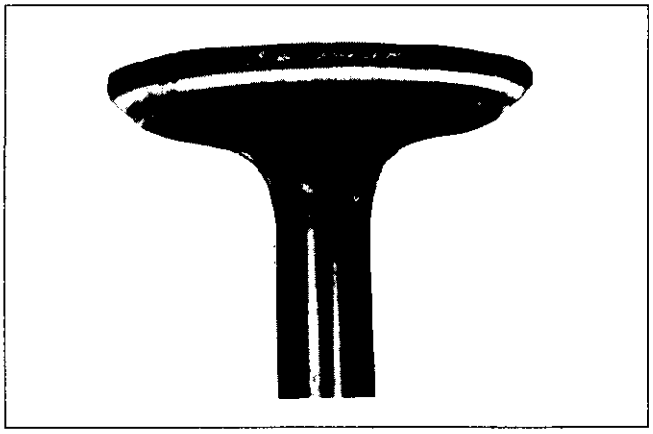
Excessive Combustion Temperatures: The white deposits seen here indicate very high combustion temperatures, usually due to a lean fuel mixture.



Stem Corrosion: Moisture in fuel or from condensation are the most common causes of valve stem corrosion. Condensation occurs from improper preservation during storage and when engine is repeatedly stopped before it has a chance to reach normal operating temperatures. Replace corroded valves.



Gum: Gum deposits usually result from using stale gasoline. This condition is often noted in applications where fuel is not drained out of tank during the off season. Gum is a prevalent cause of valve sticking. The cure is to ream the valve guides and clean or replace the valves, depending on their condition.



Overheating: An exhaust valve subject to overheating will have a dark discoloration in the area above the valve guide. Worn guides and faulty valve springs may cause this condition. Also check for clogged air intake, and blocked fins when this condition is noted.

Valve Guides
If a valve guide is worn beyond specifications, it will not guide the valve in a straight line. This may result in burnt valve faces or seats, loss of compression, and excessive oil consumption.

To check valve guide-to-valve stem clearance, thoroughly clean the valve guide and, using a split-ball gauge, measure the inside diameter. Then, using an outside micrometer, measure the diameter of the valve stem at several points on the stem where it moves in the valve guide. Use the largest stem diameter to calculate the clearance. If the **intake** clearance exceeds **0.038/0.076 mm (0.0015/ 0.003 in.)** or the **exhaust** clearance exceeds **0.050/ 0.088 mm (0.0020/0.0035 in.)**, determine whether the valve stem or guide is responsible for the excessive clearance.

Maximum (I.D.) wear on the **intake** valve guide is **7.134 mm (0.2809 in.)** while **7.159 mm (0.2819 in.)** is the maximum allowed on the exhaust guide. The guides are not removable but can be reamed **0.25 mm (0.010 in.)** oversize with Tool No. **KO-1026**. Valves with **0.25 mm** oversize stems must then be used.

If the guides are within limits but the valve stems are worn beyond limits, replace with new valves.

Valve Seat Inserts
Hardened steel alloy intake and exhaust valve seat inserts are press fitted into the cylinder head. The inserts are not replaceable on the engines but can be reconditioned if not too badly pitted or distorted. If cracked or badly warped, the cylinder head should be replaced.

Recondition the valve seat inserts following the instructions provided with the valve seat cutter being used. A typical cutter is shown in Figure 10-6. The final cut should be made with an 89° cutter as specified for the valve seat angle in Figure 10-5. With the proper 45° valve face angle as specified in Figure 10-5 and the valve seat cut properly (44.5° as measured from centerline when cut 89°) this would result in the desired 0.5° (1.0° full cut) interference angle where the maximum pressure occurs on the outside diameters of valve face and seat.

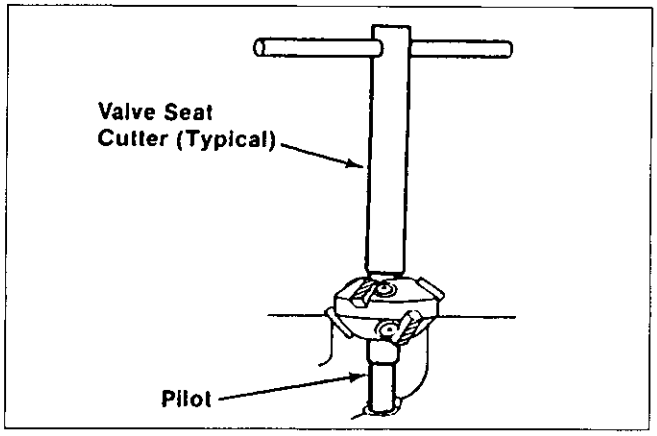


Figure 10-6. Typical Valve Seat Cutter.

Lapping Valves
Reground or new valves must be lapped in, to provide fit. Use a hand valve grinder with suction cup for final lapping. Lightly coat valve face with "fine" grade of grinding compound, then rotate valve on seat with grinder. Continue grinding until smooth surface is obtained on seat and on valve face. Thoroughly clean cylinder head in soap and hot water to remove all traces of grinding compound. After drying cylinder head, apply a light coating of **SAE 10** oil to prevent rusting.

Intake Valve Stem Seal
These engines use valve stem seals on the intake valves. Always use a new seal when valves are removed from cylinder head. The seals should also be replaced if deteriorated or damaged in any way. **Never reuse an old seal.**

Pistons and Rings

Inspection

Scuffing and scoring of pistons and cylinder walls occurs when internal temperatures approach the welding point of the piston. Temperatures high enough to do this are created by friction, which is usually attributed to improper lubrication, and/or overheating of the engine.

Normally, very little wear takes place in the piston boss-piston pin area. If the original piston and connecting rod can be reused after new rings are installed, the original pin can also be reused but new piston pin retainers are required. The piston pin is included as part of the piston assembly – if the pin boss in piston or the pin, are worn or damaged, a new piston assembly is required.

Ring failure is usually indicated by excessive oil consumption and blue exhaust smoke. When rings fail, oil is allowed to enter the combustion chamber where it is burned along with the fuel. High oil consumption can also occur when the piston ring end gap is incorrect because the ring cannot properly conform to the cylinder wall under this condition. Oil control is also lost when ring gaps are not staggered during installation.

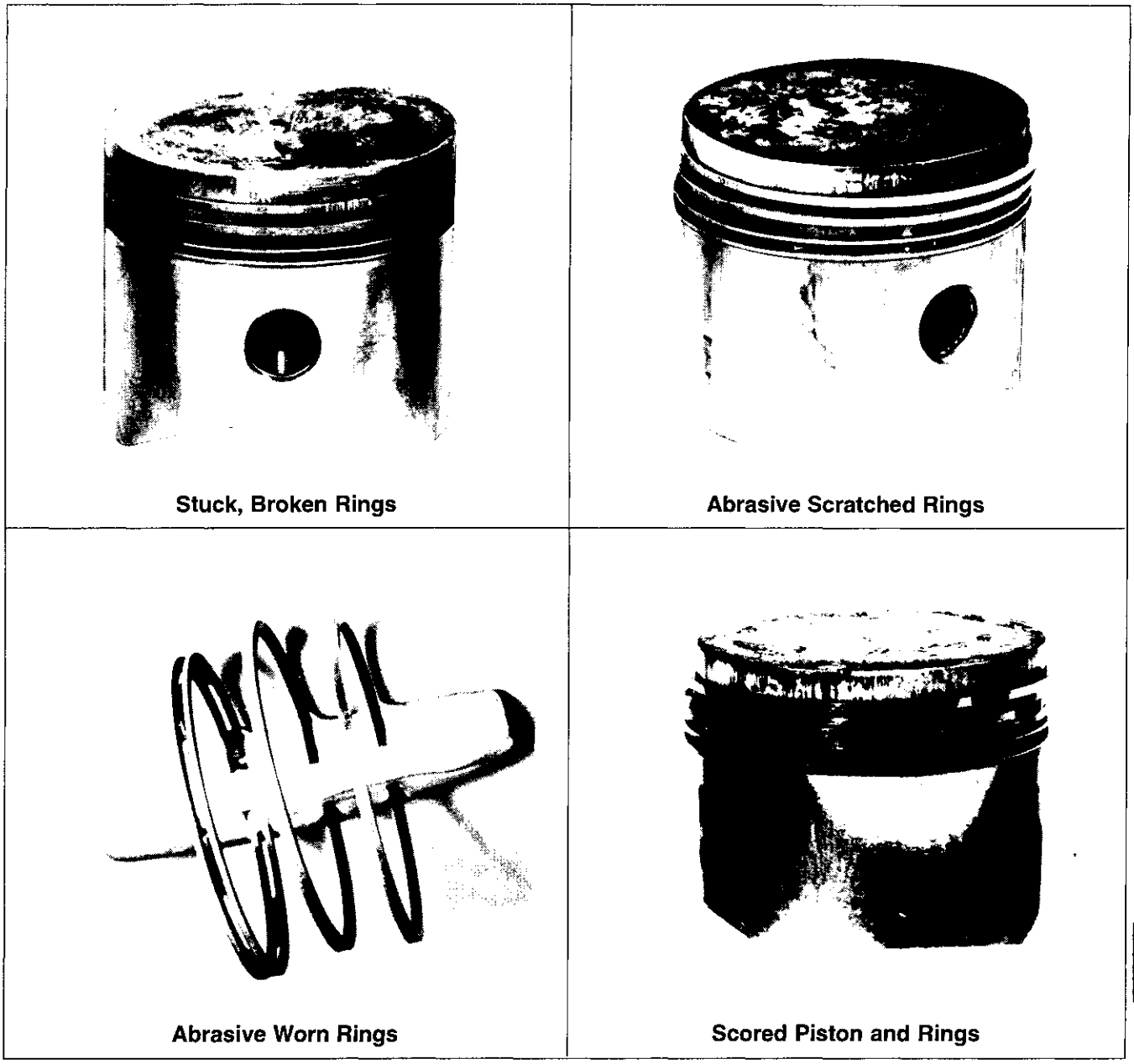
When cylinder temperatures get too high, lacquer and varnish collect on pistons causing rings to stick which results in rapid wear.

Scratches on rings and pistons are caused by abrasive material such as carbon, dirt, or pieces of hard metal.

Detonation damage occurs when a portion of the fuel charge ignites spontaneously from heat and pressure shortly after ignition. This creates two flame fronts which meet and explode to create extreme hammering pressures on a specific area of the piston. Detonation generally occurs from using low octane fuels.

Preignition or ignition of the fuel charge before the timed spark can cause damage similar to detonation. Preignition damage is often more severe than detonation damage. Preignition is caused by a hot spot in the combustion chamber from sources such as: glowing carbon deposits, blocked fins, improperly seated valve, or wrong spark plug.

See Figure 10-7 for some common types of piston and ring damage.



Stuck, Broken Rings

Abrasive Scratched Rings

Abrasive Worn Rings

Scored Piston and Rings

Figure 10-7. Common Types of Piston and Ring Damage.

Replacement pistons are available in STD bore size, and in **0.25 mm (0.010 in.)**, and **0.50 mm (0.20 in.)** oversizes. Replacement pistons include new piston ring sets and new piston pins.

Service replacement piston ring sets are also available separately for STD, **0.25 mm (0.010 in.)**, and **0.50 mm (0.020 in.)** oversized pistons. Always use new piston rings when installing pistons. **Never reuse old rings.**

Some important points to remember when servicing piston rings:

1. The cylinder bore must be deglazed before service ring sets are used.

2. If the cylinder bore does not need reboring and if the old piston is within wear limits and free of score or scuff marks, the old piston may be reused.

3. Remove old rings and clean up grooves. **Never reuse old rings.**

4. Before installing the rings on piston, place the top two rings, each in turn, in its running area in cylinder bore and check end gap (see Figure 10-8). This gap should be **0.75 mm (0.030 in.) max.** in a used cylinder bore and **0.3/0.5 mm (0.012/0.020 in.)** in a new cylinder bore.

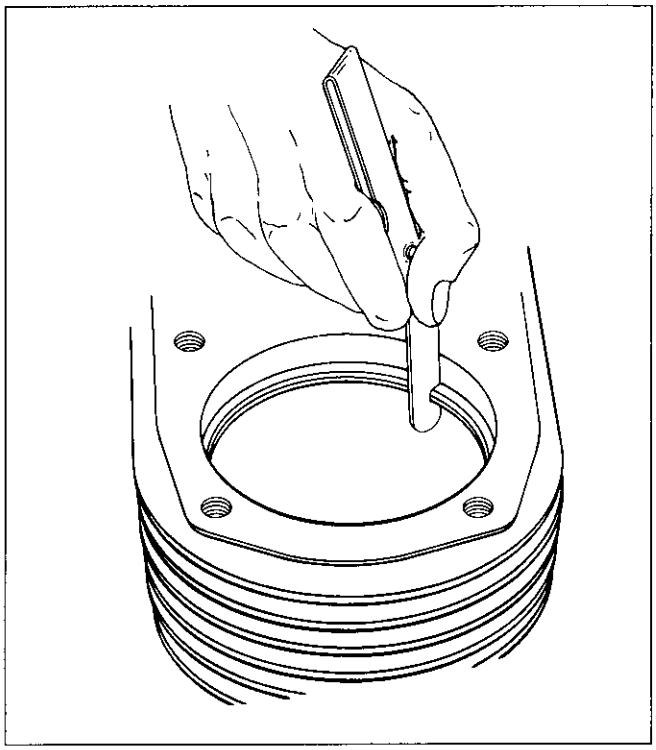


Figure 10-8. Measuring Piston Ring End Gap.

5. After installing the new compression (top and middle) rings on piston, check piston-to-ring side clearance. Maximum recommended side clearance is **0.040/0.105 mm (0.0016/ 0.0041 in.)**. If side clearance is greater than specified, a new piston **must** be used. Refer to Figure 10-9.

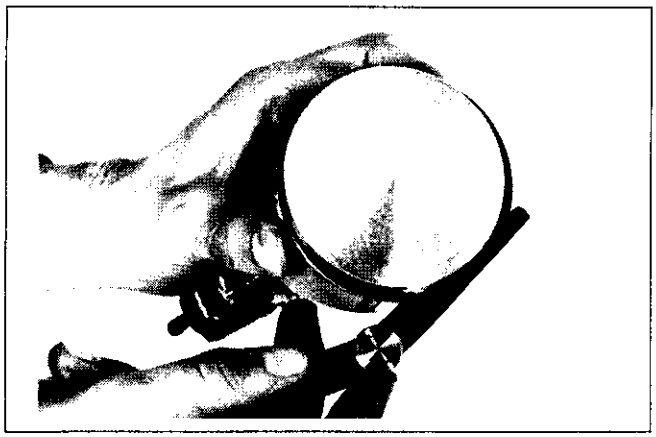


Figure 10-9. Measuring Piston Ring Side Clearance.

Install New Piston Rings

To install piston rings, proceed as follows:

NOTE: Rings must be installed correctly. Ring installation instructions are usually included with new ring sets. Follow instructions carefully. Use a piston ring expander to install rings (see Figure 10-10). Install the bottom (oil control) ring first and the top compression ring last. Refer to Figure 10-11.

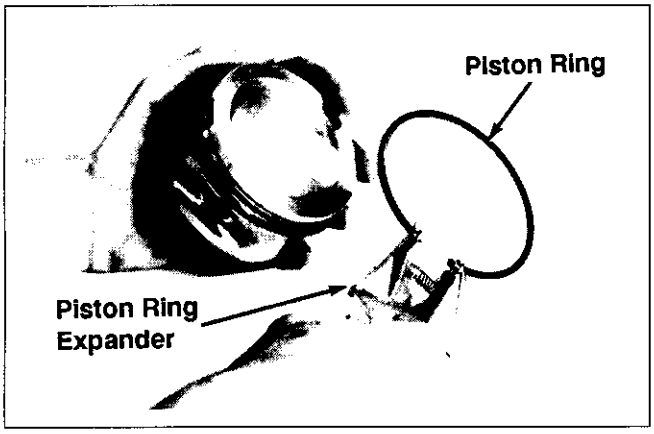


Figure 10-10. Installing Piston Rings.

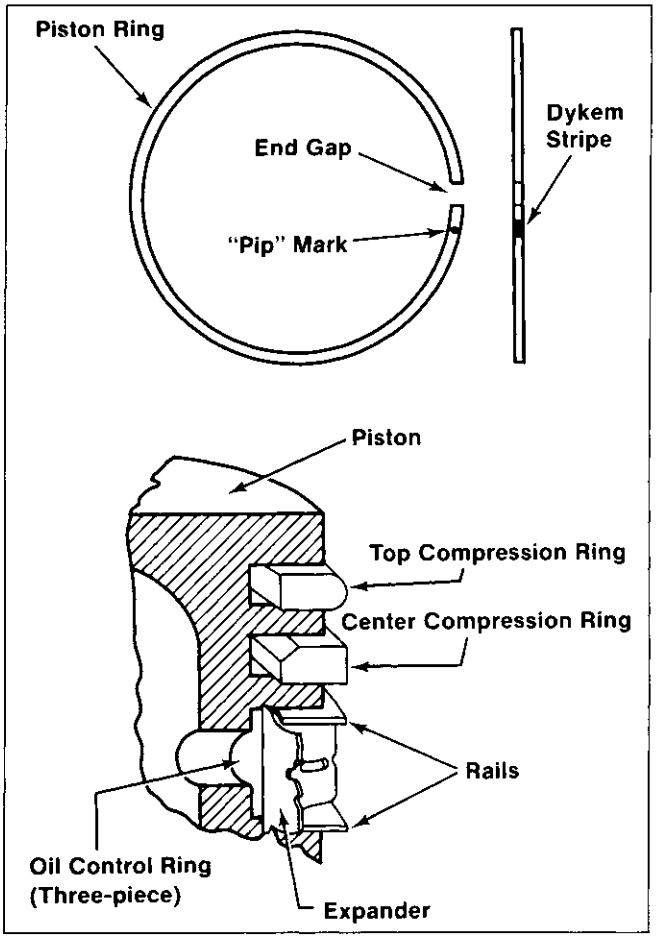


Figure 10-11. Piston Ring Installation.

1. Oil Control Ring (Bottom Groove): Install the expander and then the rails. Make sure the ends of expander are not overlapped.

2. Compression Ring (Center Groove): Install the center ring using a piston ring installation tool. Make sure the "pip" mark is up and the PINK dykem stripe is to the left of end gap.

3. Compression Ring (Top Groove): Install the top ring using a piston ring installation tool. Make sure the "pip" mark is up and the BLUE dykem stripe is to the left of end gap.

Connecting Rods

Offset Stepped-Cap Connecting Rods are used in all these engines.

Inspection and Service

Check bearing area (big end) for excessive wear, score marks, running and side clearances (refer to Section 1, "Specifications, Tolerances, and Special Torque Values"). Replace rod and cap if scored or excessively worn.

Service replacement connecting rods are available in STD crankpin size and **0.25 mm (0.010 in.)** undersize. The **0.25 mm (0.010 in.)** undersized rod can be identified by the drilled hole located in the lower end of the rod shank. Always refer to the appropriate parts information to ensure that correct replacements are used.

Servicing Hydraulic Lifters

Whenever an engine has been disassembled, before reassembly of the engine, the hydraulic lifters should be primed. Use the following procedure.

1. Place hydraulic lifter in a vertical position on a clean, flat surface.

2. Use a lever-operated oil can filled with SAE 5W-30 oil, and insert nozzle into oil feed hole of the lifter body (see Figure 10-12).

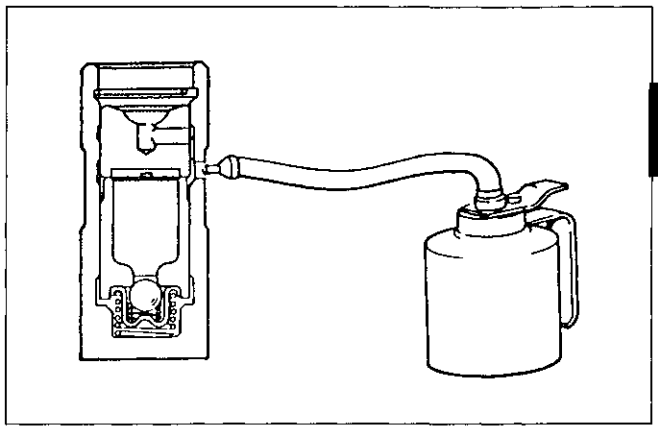


Figure 10-12. Priming Lifters.

3. Pump oil into lifter body until oil level fills body and seeps out socket. Oil is to be level with the top of lifter body.

4. Place push rod on top of lifter socket. Push down, lifter should feel solid. If socket can be pushed down into lifter body, repeat step 3, and retest as above.

Closure Plate Assembly

Inspection

- Inspect the oil seal in the closure plate and remove it if it is worn or damaged. The new oil seal is installed after crankcase is reassembled. Refer to "Install Closure Plate Oil Seal" on page 11.6.

Governor Assembly

Inspection

Inspect the governor gear teeth. Replace the gear if it is worn, chipped, or if any teeth are missing.

Inspect the governor weights. They should move freely in the governor gear.

Disassembly

The governor gear **must** be replaced once it is removed from the oil pan.

NOTE: The governor gear is held onto the shaft by small molded tabs in the gear. When the gear is removed from the shaft, these tabs are destroyed and the gear must be replaced. Therefore, remove the gear **only if** absolutely necessary.

1. Remove the regulating pin and governor gear assembly. See Figure 10-13.

2. Remove the thrust washer located under the governor assembly.

3. Carefully inspect the governor gear shaft and replace it only if it is damaged. After pulling damaged shaft, press or lightly tap replacement shaft into closure plate to depth shown in Figure 10-14.

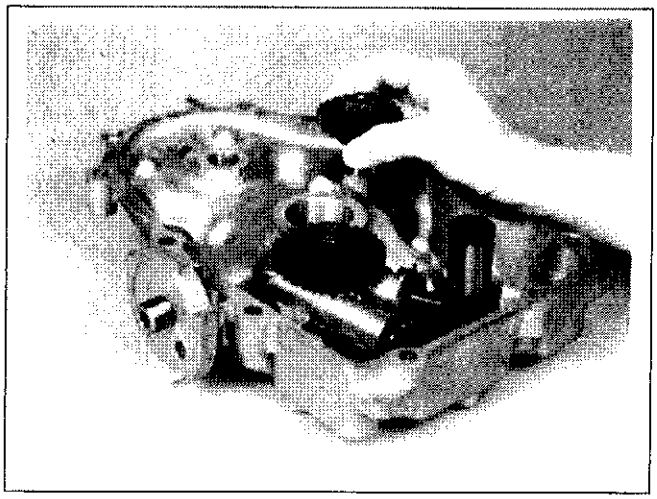


Figure 10-13. Governor Assembly.

Reassembly

1. Install the thrust washer on the governor gear shaft.

2. Position the regulating pin to the governor gear/ flyweights assembly and slide both onto governor shaft.

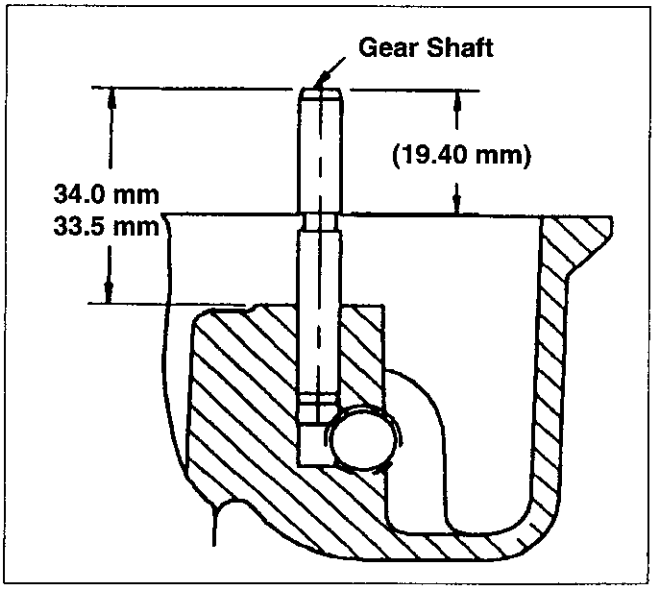


Figure 10-14. Governor Shaft Press Depth.

Oil Pump Assembly

Disassembly

1. Remove the two hex. flange screws.
2. Remove the oil pump assembly from the closure plate.
3. Remove the oil pump cover and oil pump rotors.
4. Remove the oil pickup by pulling it free from the oil pump body.
5. Remove the oil pressure relief valve piston and spring. See Figure 10-15.

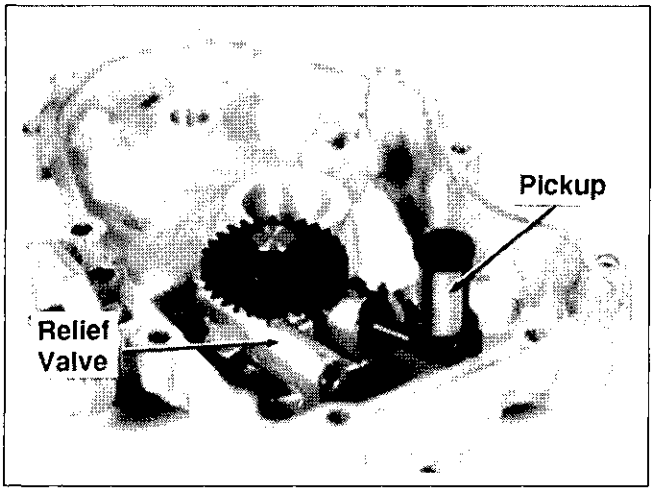


Figure 10-15. Oil Pump, Oil Pickup and Relief Valve.

Inspection

Inspect the oil pressure relief valve piston. It should be free of nicks or burrs.

Check spring for wear or distortion. Spring free length should be approximately **47.4 mm (1.8 in.)**. Replace the spring if it is distorted or worn. See Figure 10-16.

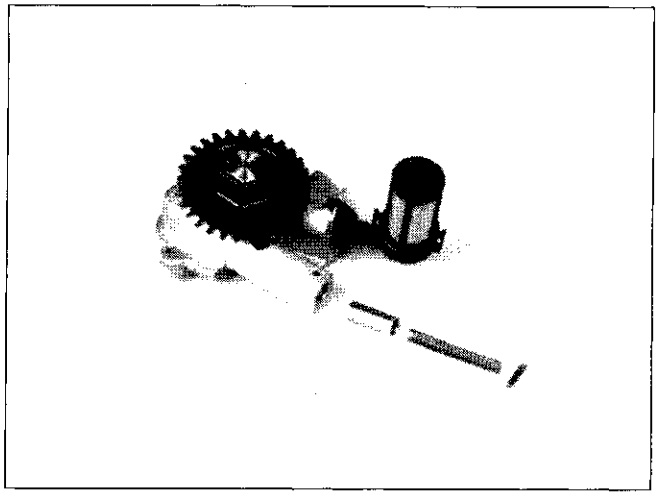


Figure 10-16. Oil Pressure Relief Valve Piston and Spring.

Reassembly

1. Install the pressure relief valve piston and spring.
2. Install the oil pickup to the oil pump body.
3. Install the oil rotors.
4. Install the oil pump body to the closure plate and secure with two hex. flange screws. Torque the hex. flange screws as follows:

First Time Installation:	**10.7 N·m (95 in. lb.)**
All Reinstallations:	**6.7 N·m (60 in. lb.)**

5. After torquing, rotate gear for freedom of movement. Make sure there is no binding of pump. If binding occurs, loosen screws, reposition pump, retorque and recheck movement.

Governor Cross Shaft Oil Seal

If the governor cross shaft seal is damaged and/or leaks, replace it using the following procedure.

Remove the oil seal from the crankcase and replace it with a new one. Install the new seal using oil seal installer. See Figure 10-17.

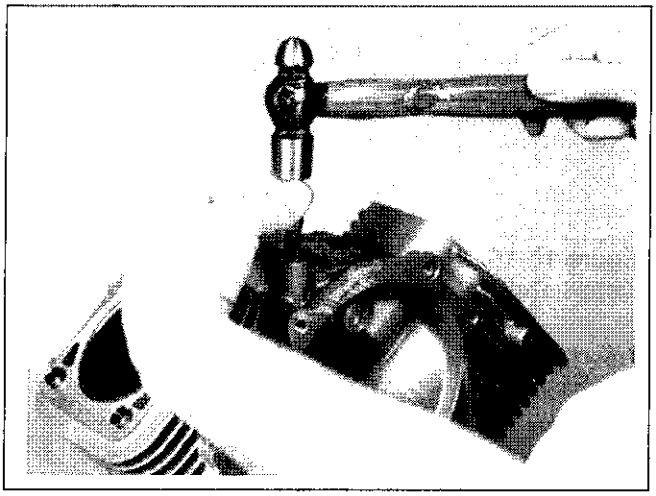


Figure 10-17. Installing Cross Shaft Oil Seal.

Section 11
Reassembly

General

NOTE: Make sure the engine is assembled using all specified torque values, tightening sequences and clearances. Failure to observe specifications could cause severe engine wear or damage. Always use new gaskets.

Make sure all traces of any cleaner are removed before the engine is assembled and placed into operation. Even small amounts of these cleaners can quickly break down the lubricating properties of engine oil.

Typical Reassembly Sequence

The following sequence is suggested for complete engine reassembly. This procedure assumes that all components are new or have been reconditioned, and all component subassembly work has been completed. The sequence may vary to accommodate options or special equipment. Detailed procedures can be found in subsequent subsections.

1. Install flywheel end main bearing.*
2. Install governor cross shaft.
3. Install crankshaft.
4. Install connecting rods with pistons and rings.
5. Install camshaft.
6. Install closure plate assembly.
7. Install stator and backing plates.
8. Install flywheel.
9. Install fan and grass screen.
10. Install hydraulic lifters.
11. Install cylinder heads.
12. Install intake manifold.
13. Install ignition modules.
14. Install breather cover and inner baffles.
15. Install blower housing and outer baffles.
16. Install carburetor.
17. Install external governor controls.
18. Install throttle controls.
19. Install valve covers.

*Not used on CH25.

20. Install electric starter motor.
21. Install fuel pump.
22. Install Oil Sentry™.
23. Install control panel (if so equipped).
24. Install air cleaner assembly (see Section 4).
25. Install muffler.
26. Install oil filter and add oil to crankcase.
27. Connect spark plug leads.

Install Flywheel End Main Bearing and Oil Seal (On models so equipped)

1. Check to make sure that there are no nicks or burrs in the crankshaft bore of the crankcase.

2. Mark the position of one of the oil galleries on the crankcase. See Figure 11-1.

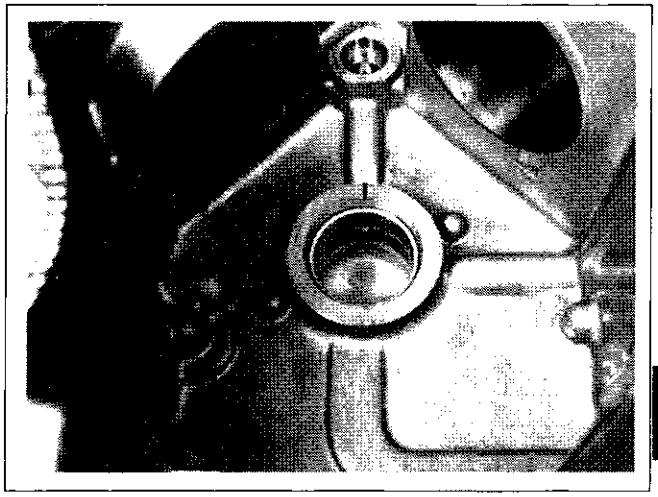


Figure 11-1. Marking Position of Oil Gallery.

3. Assemble the bearing installer and handle. Place the sleeve bearing on the bearing installer. Apply a light coat of engine oil to the bearing and crankcase bore.

4. Align oil hole of bearing with the alignment notch on the bearing installer. Position the bearing installer so that the alignment notch lines up with the mark on the crankcase.

5. Drive the bearing into the crankcase. Make sure the bearing is installed straight and true in bore and that the tool bottoms against the crankcase.

   NOTE: Make sure the hole in the sleeve bearing is aligned with the oil gallery in the crankcase. Improper positioning can cause engine failure due to lack of lubrication.

6. Apply a light coat of engine oil to the outside diameter of the oil seal.

7. Drive the oil seal into the crankcase using a seal driver. Make sure the oil seal is installed straight and true in bore and that the tool bottoms against the crankcase. See Figure 11-2.

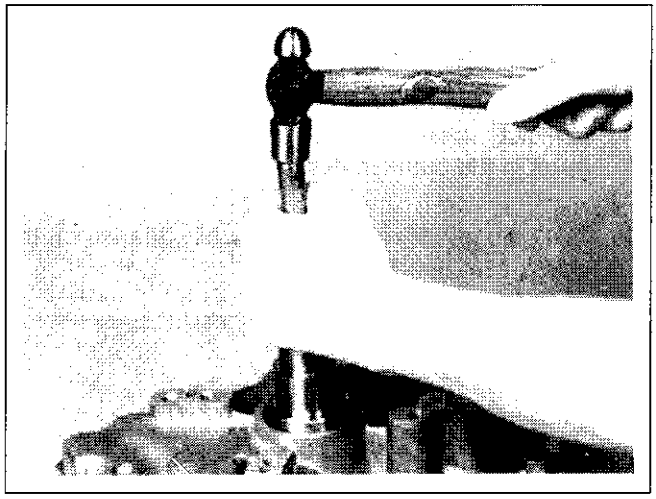


Figure 11-2. Install Oil Seal.

Install Governor Cross Shaft

1. Install the cross shaft through the inside of the crankcase. See Figure 11-3.

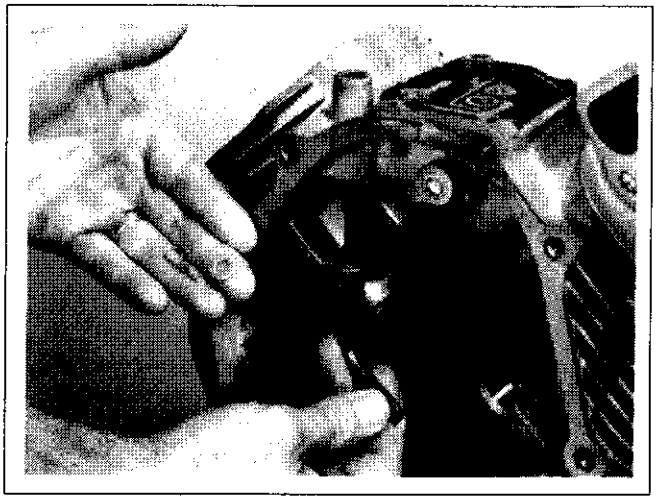


Figure 11-3. Installing Governor Cross Shaft.

2. Install the plain washer and hitch pin onto the governor cross shaft. Make sure that hitch pin is inserted into the smaller, lower hole of cross shaft. See Figure 11-4.

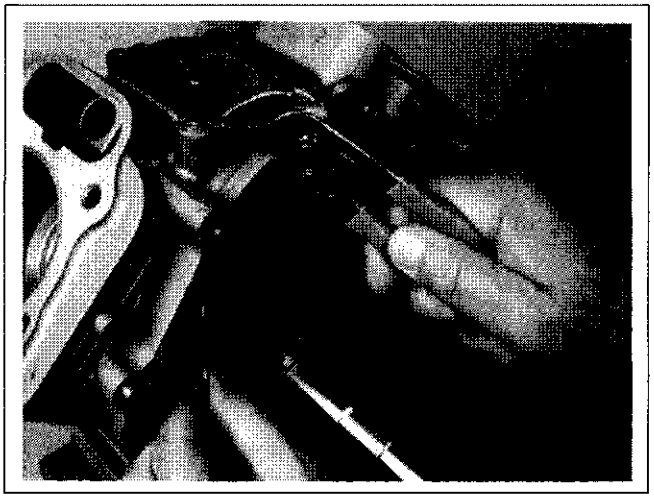


Figure 11-4. Installing Governor Cross Shaft Hitch Pin.

Install Crankshaft

1. Carefully slide flywheel end of crankshaft through main bearing in crankcase. See Figure 11-5.

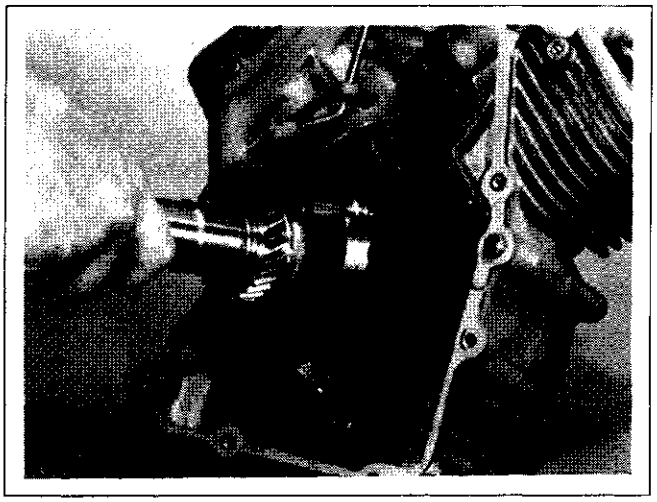


Figure 11-5. Installing Crankshaft.

Install Connecting Rods with Pistons and Rings

NOTE: The cylinders are numbered on the crankcase. Make sure to install piston, connecting rod and end cap into its appropriate cylinder bore as previously marked at disassembly. Do not mix end caps and connecting rods.

NOTE: Proper orientation of the piston/connecting rod assemblies inside the engine is extremely important. Improper orientation can cause extensive wear or damage.

1. Stagger the piston rings in the grooves until the end gaps are 120° apart. The oil ring rails should also be staggered.

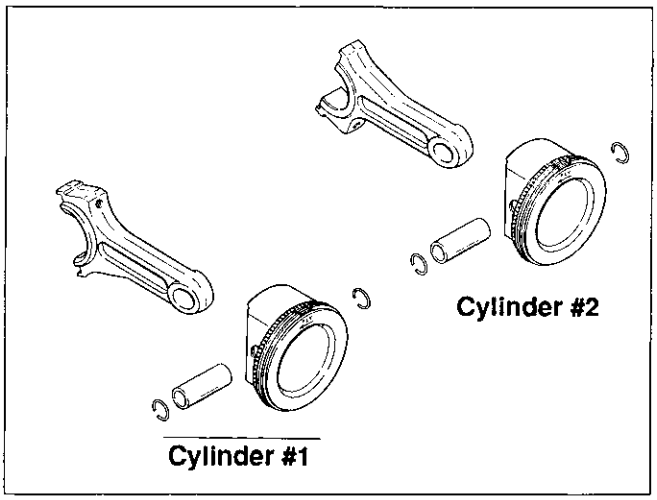


Figure 11-6. Piston, Connecting Rod and End Cap Detail.

2. Lubricate cylinder bore, piston and piston rings with engine oil. Compress the rings of the #1 piston using a piston ring compressor.

3. Lubricate the crankshaft journals and connecting rod bearing surfaces with engine oil.

4. Make sure "Fly" stamping on piston is facing towards the flywheel side of the engine. Use a hammer with rubber grip and gently tap the piston into the cylinder as shown in Figure 11-7. Be careful that the oil ring rails do not spring free between the bottom of ring compressor and top of the cylinder

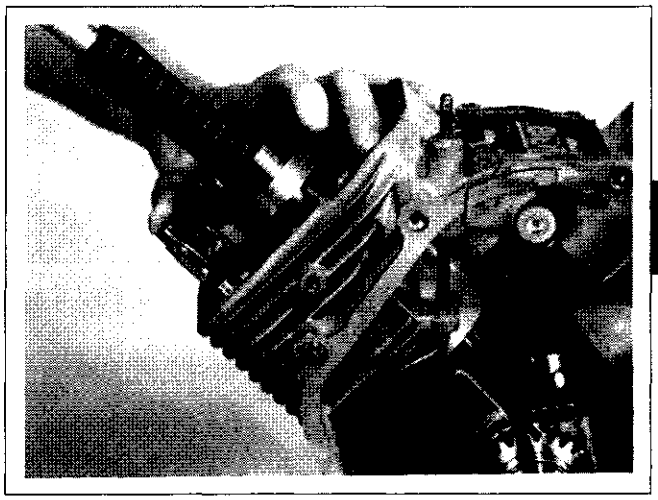


Figure 11-7. Installing Piston Assembly Using Ring Compressor Tool.

5. Install the inner rod cap to the connecting rod using the two hex. flange screws and torque in increments to **17.3 N·m (130 in. lb.)**. See Figures 11-8 and 11-9.

   NOTE: Make sure to align the chamfer of the connecting rod with the chamfer of its mating end cap. When installed, the flat faces of the connecting rods should face each other. The faces with the raised rib should be toward the outside.

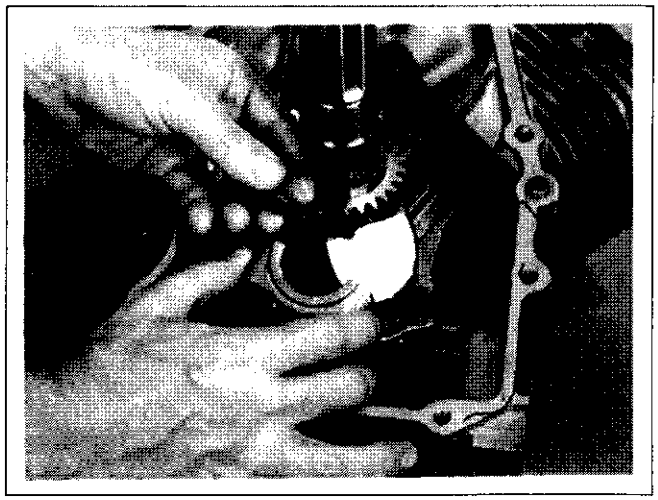


Figure 11-8. End Cap and Rod Bolt Detail.

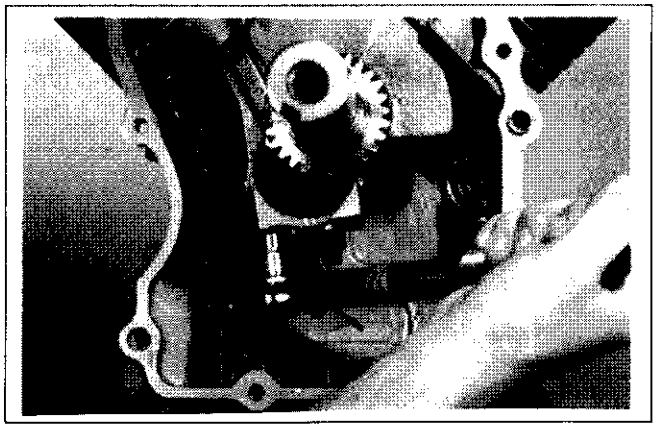


Figure 11-9. Tightening Connecting Rod End Cap.

6. Repeat the above procedure for the other connecting rod and piston assembly.

Install Camshaft

1. Lubricate the camshaft bearing surfaces of crankcase and camshaft with engine oil.

2. Position timing mark of crankshaft gear at the 12 o'clock position.

3. Turn governor cross shaft clockwise until lower end of shaft contacts crankcase. Make sure cross shaft remains in this position while installing the camshaft.

4. Slide the camshaft into the bearing surface of the crankcase, positioning the timing mark of camshaft gear at the 6 o'clock position. Make sure that camshaft gear and crankshaft gear mesh with both timing marks aligned. See Figure 11-10.

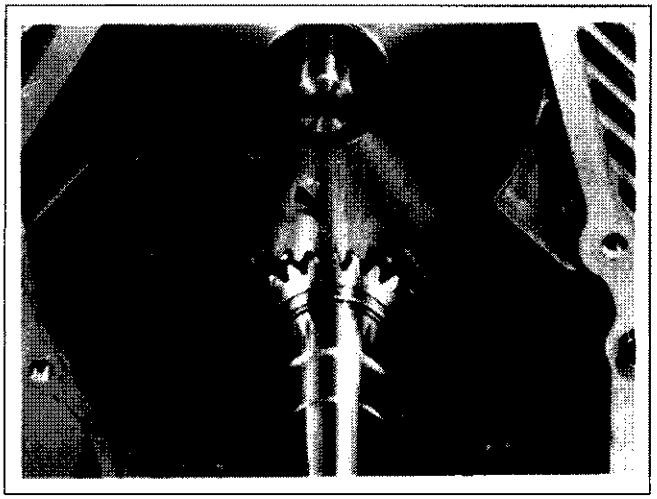


Figure 11-10. Aligning Crankshaft and Camshaft Timing Marks.

Determining Camshaft End Play

1. Install the shim removed during disassembly onto the camshaft.

2. Position the camshaft end play checking tool on the camshaft. See Figure 11-11.

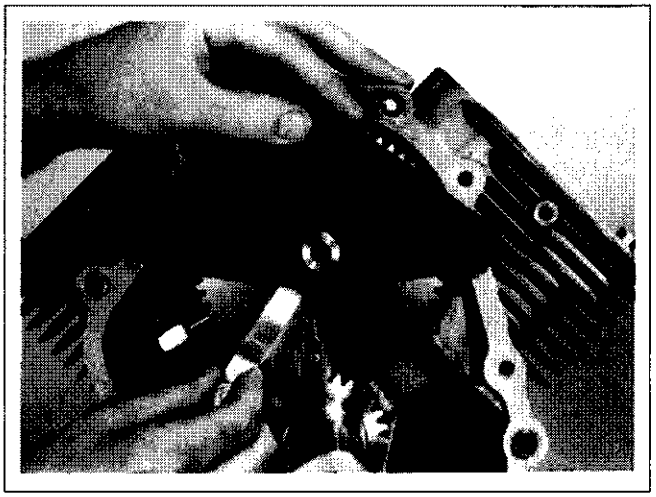


Figure 11-11. Checking Camshaft End Play.

3. Apply pressure on the camshaft end play checking tool (pushing camshaft toward crankshaft). Use a feeler gauge to measure the camshaft end play between the shim spacer and the end play checking tool. Camshaft end play should be **0.076/0.127 mm (0.003/0.005 in.)**.

4. If the camshaft end play is not snug within the specified range, remove the end play checking tool and add, remove or replace shims as necessary. See Figure 11-12.

   Camshaft Shims
   Several color coded shims are available:

White:	0.69215/0.73025 mm (0.02725/0.02875 in.)
Blue:	0.74295/0.78105 mm (0.02925/0.03075 in.)
Red:	0.79375/0.83185 mm (0.03125/0.03275 in.)
Yellow:	0.84455/0.88265 mm (0.03325/0.03475 in.)
Green:	0.89535/0.99345 mm (0.03525/0.03675 in.)
Gray:	0.94615/0.98425 mm (0.03725/0.03875 in.)
Black:	0.99695/1.03505 mm (0.03925/0.04075 in.)

5. Reinstall the camshaft end play checking tool and check end play. Repeat step 4 until end play is within specifications.

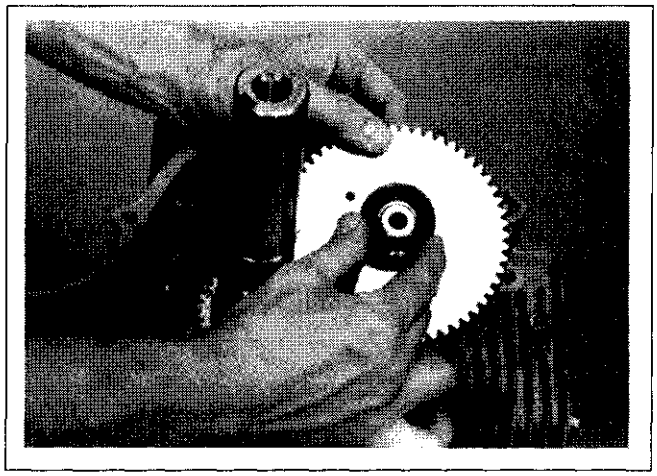


Figure 11-12. Remove or Add Shims as Needed to Obtain Correct End Play.

Oil Pump Assembly

The oil pump is mounted to the inside of the closure plate. If service was required, and the oil pump was removed, refer to the assembly procedures under "Oil Pump Assembly" in Section 10.

Governor Assembly

The governor assembly is located inside the closure plate. If service was required, and the governor was removed, refer to the assembly procedures under "Governor Assembly" in Section 10.

Thrust Bearing, Washer and Shim

Some specifications use a needle type thrust bearing, thrust washer and shim spacer to control end play of the crankshaft. See Figure 11-13. If these items are noted during disassembly, make sure they are reinstalled in the sequence shown in Figure 11-14. A different procedure will have to be followed to check and adjust crankshaft end play on these models.

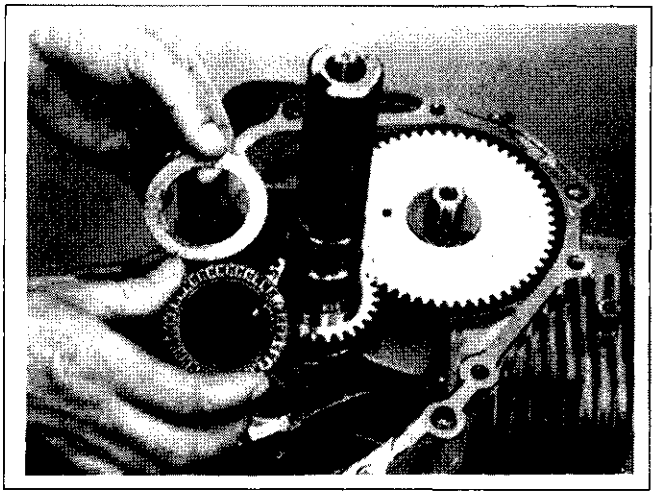


Figure 11-13. Thrust Bearing, Washer and Shim Used on Some Models.

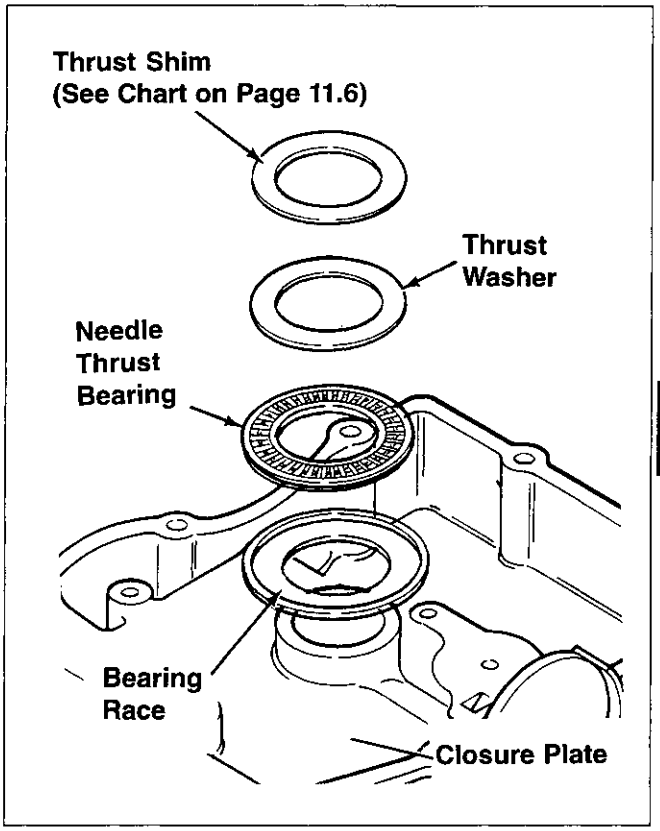


Figure 11-14. Correct Sequence of Thrust Bearing, Washer and Shim in Closure Plate.

The race for the thrust bearing presses loosely into the closure plate. If it is not already installed, push it into the crankshaft bore inside the closure plate. Pack the thrust bearing with heavy grease and stick the bearing into the race. Wipe some grease on the face of the thrust washer and stick it onto the thrust bearing. Wipe some grease on the face of the original shim spacer and stick it onto the thrust washer.

Install the closure plate onto the crankcase WITHOUT applying RTV sealant and secure it with only two or three of the fasteners at this time. Use a dial indicator to check the crankshaft end play. End play should be 0.05/0.50 mm (0.0020/0.0197 in.), except for CH25 engines below Serial No. 2403500008 end play should be 0.050/0.75 mm (0.0020/0.0295 in.). Shim spacers are available in the three color coded thicknesses listed below if adjustment is needed.

Crankshaft End Play Shims

GREEN	0.8366-0.9127 mm (0.8750 mm Nominal)
YELLOW	1.0652-1.1414 mm (1.1033 mm Nominal)
RED	1.2938-1.3700 mm (1.3319 mm Nominal)

Remove the closure plate. If end play requires adjustment, remove the original spacer and install the appropriate size shim spacer in it's place. Then follow the procedure under "Install Closure Plate Assembly."

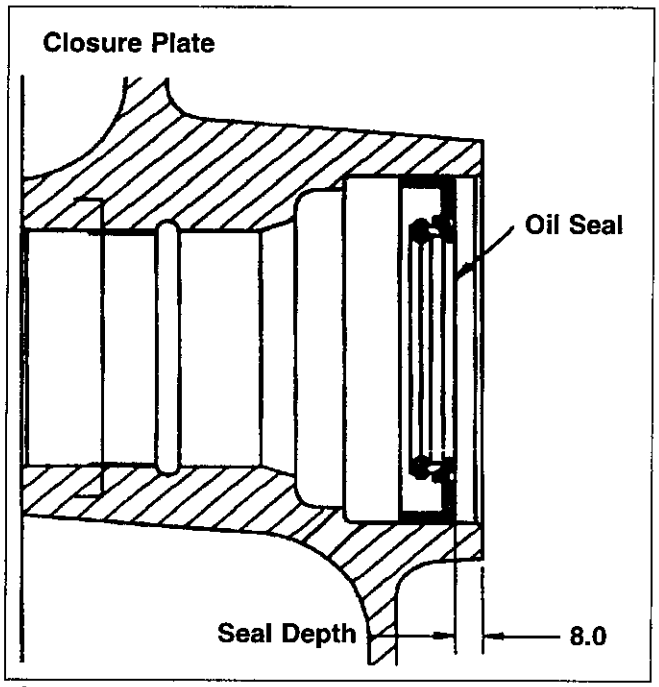


Figure 11-15. Oil Seal Depth in Closure Plate.

Install Closure Plate Oil Seal

1. Check to make sure that there are no nicks or burrs in the crankshaft bore of the closure plate.

2. Apply a light coat of engine oil to the outside diameter of the oil seal.

3. Drive the oil seal into the closure plate using a seal driver. Make sure the oil seal is installed straight and true in bore to depth shown in Figure 11-15.

Install Closure Plate Assembly

RTV silicone sealant is used as a gasket between the closure plate and the crankcase. Refer to the chart on page 2.4 of the "Special Tools" Section 2 of this manual for a listing of approved sealants. Always use fresh sealant. Using outdated sealant can result in leakage.

1. Prepare the sealing surfaces of the crankcase and closure plate as directed by the sealant manufacturer.

2. Check to make sure that there are no nicks or burrs on the sealing surfaces of the closure plate or crankcase.

3. Apply a 1/16" bead of sealant to the sealing surface of the closure plate. See Figure 11-16 for sealant pattern.

4. Make sure end of governor cross shaft is lying against the bottom of cylinder 2 inside of crankcase.

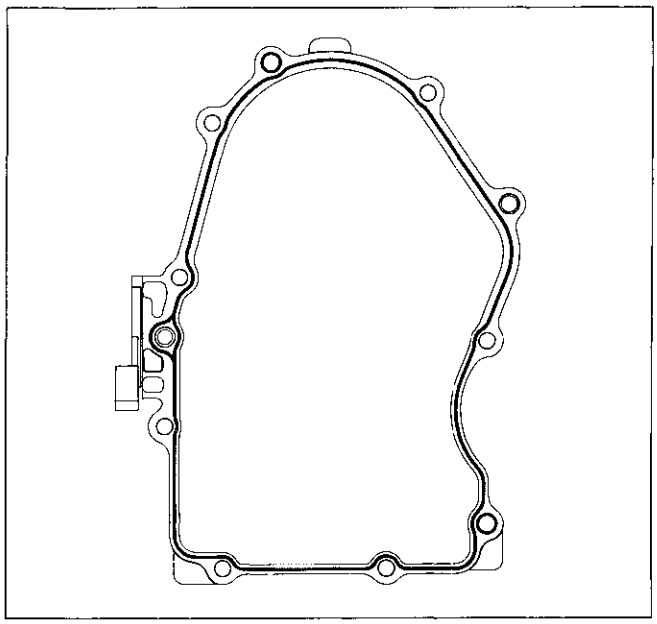


Figure 11-16. Closure Plate Sealant Pattern.

5. Install closure plate to crankcase. Carefully seat the camshaft with shim and crankshaft into their mating bearings. Rotate crankshaft to help engage oil pump and governor gear meshes. See Figure 11-17.

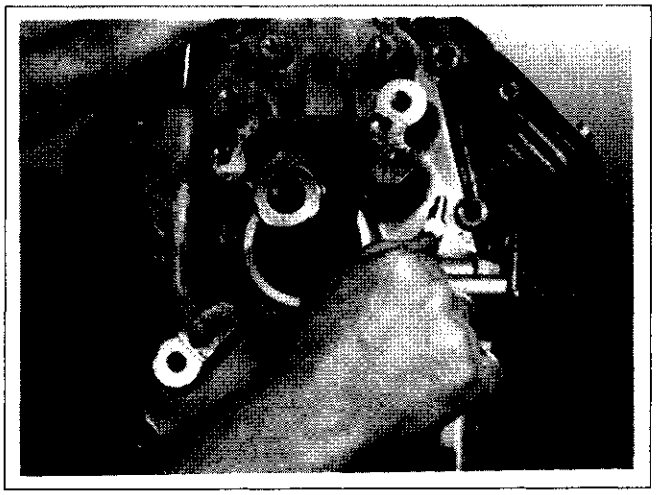


Figure 11-17. Using Spanner Wrench to Turn Crankshaft.

6. Install the ten hex. flange screws securing the closure plate to the crankcase. Torque fasteners in the proper sequence to **24.4 N·m (216 in. lb.)**. See Figure 11-18 for the proper torque sequence.

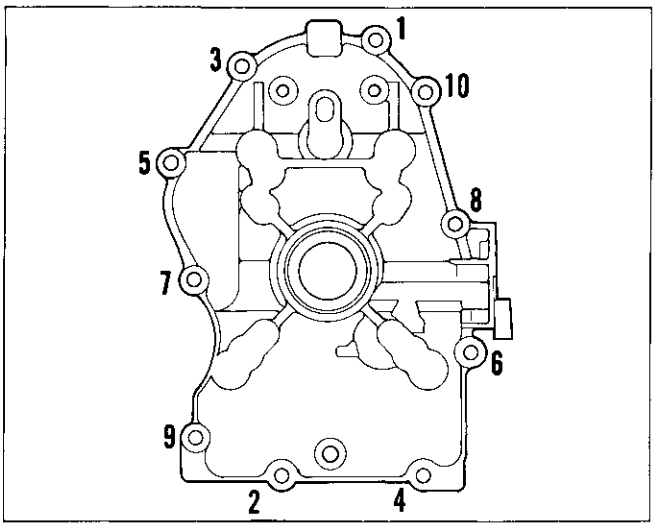


Figure 11-18. Fastener Torque Sequence.

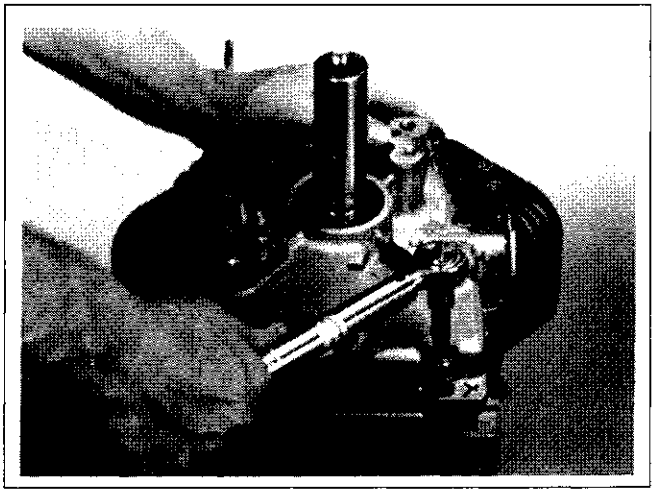


Figure 11-19. Tighten Closure Plate Fasteners to Specified Torque.

Install Stator and Backing Plates

1. Position the stator so that the leads are at the bottom and facing the crankcase.

2. Install stator using the two hex. flange screws and torque to **4 N·m (35 in. lb.)**. See Figure 11-20.

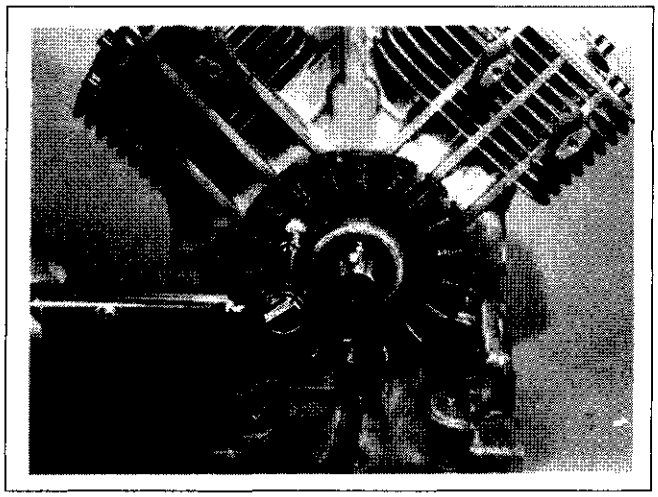


Figure 11-20. Tighten Stator Screws to Torque Specified.

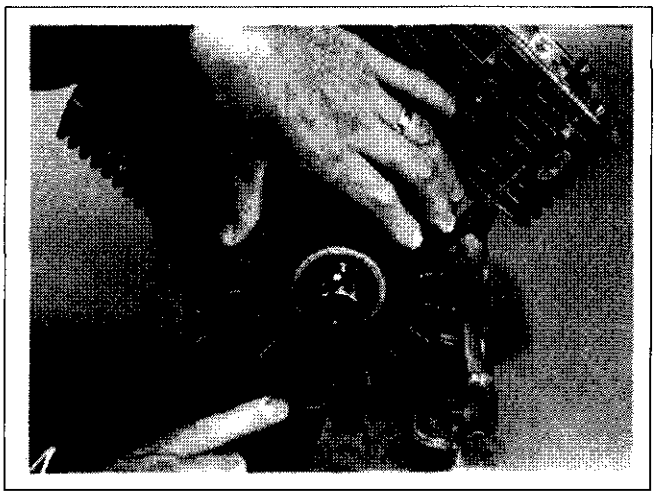


Figure 11-21. Route Stator Leads in Groove.

3. Make sure the wiring harness is routed properly in the crankcase channel behind backing plate.

4. Install the backing plates and secure with four hex. flange screws.

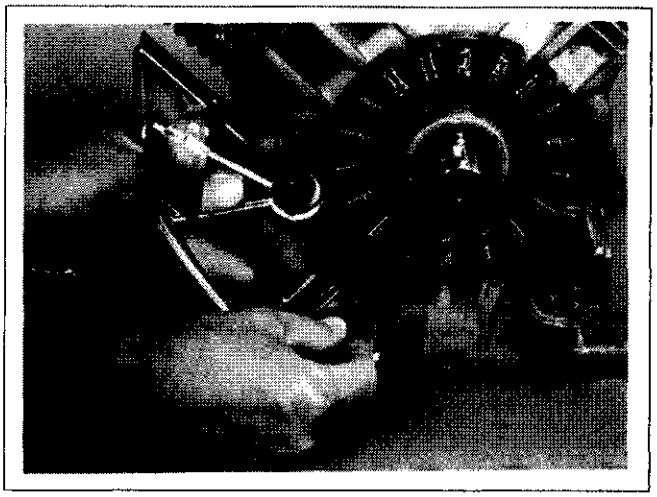


Figure 11-22. Installing Backing Plates.

Install Flywheel

⚠ WARNING: Damaging Crankshaft and Flywheel Can Cause Personal Injury!
Using improper procedures to install the flywheel can crack or damage the crankshaft and/or flywheel. This not only causes extensive engine damage, but can also cause personal injury, since broken fragments could be thrown from the engine. Always observe and use the following precautions and procedures when installing the flywheel.

Figure 11-23. Clean and Dry Taper of Crankshaft.

NOTE: Before installing the flywheel make sure the crankshaft taper and flywheel hub are clean, dry and completely free of lubricants. The presence of lubricants can cause the flywheel to be over-stressed and damaged when the flange screw is torqued to specifications.

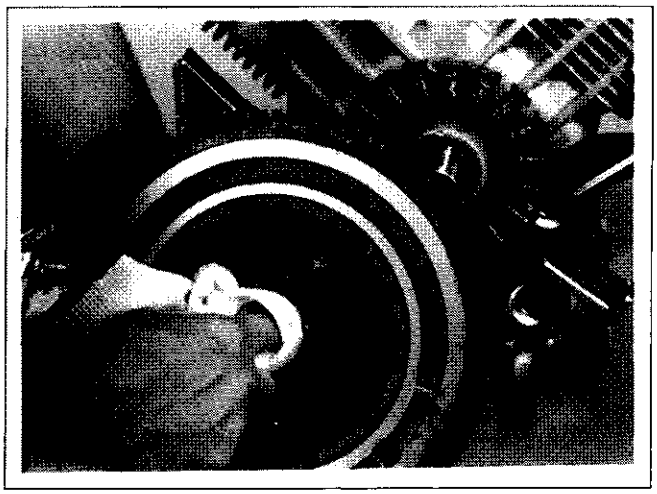


Figure 11-24. Clean and Dry Flywheel Hub.

Figure 11-25. Carefully Align Keyway to Key.

NOTE: Make sure flywheel key is installed properly in the keyway. The flywheel can become cracked or damaged if the key is not installed properly in the keyway.

1. Install the woodruff key into the keyway of the crankshaft. Make sure that key is properly seated and parallel with shaft.

2. Install flywheel onto crankshaft being careful not to shift woodruff key.

3. Install the hex. flange screw and washer.

4. Use a flywheel strap wrench or holding tool to hold the flywheel and torque the hex. flange screw securing the flywheel to the crankshaft to **66.4 N·m (49 ft. lb.)**. See Figure 11-26.

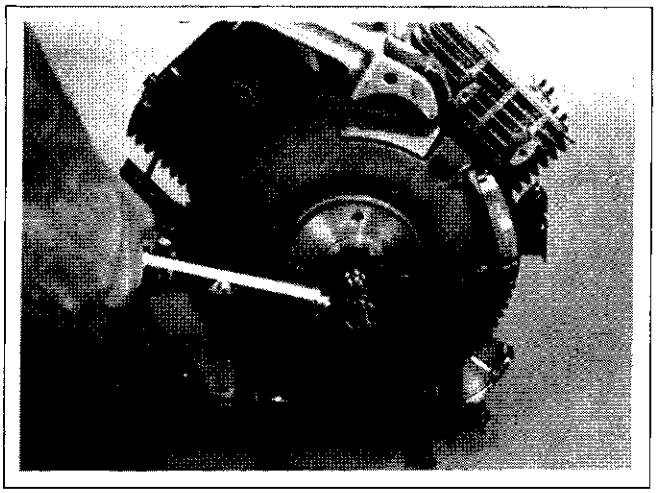


Figure 11-26. Hold Flywheel with a Strap Wrench While Torquing Fastener.

Install Flywheel Fan

1. Install fan to flywheel using the four hex. flange screws. **NOTE:** Position ears located at rear perimeter of fan in recesses of flywheel. See Figure 11-27.

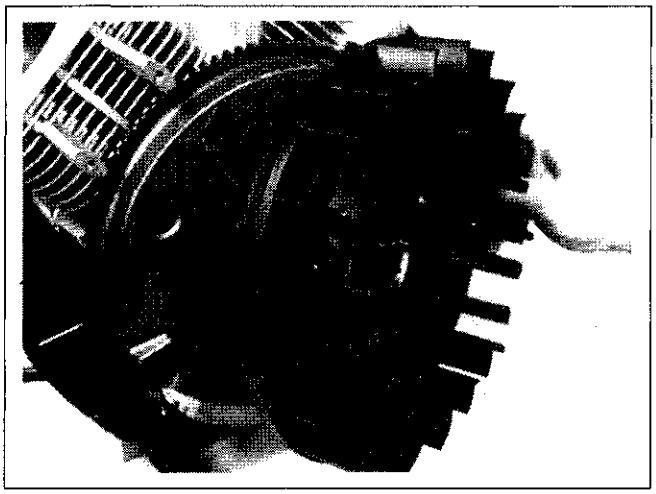


Figure 11-27. Installing Fan on Flywheel.

2. Torque the hex. flange screws to **9.9 N·m (88 in. lb.)**.

Install Grass Screen (Plastic Type)

1. If the engine uses the plastic type grass screen, install retainers then snap screen onto the fan. See Figure 11-28. If equipped with the metal type, the screen is installed later.

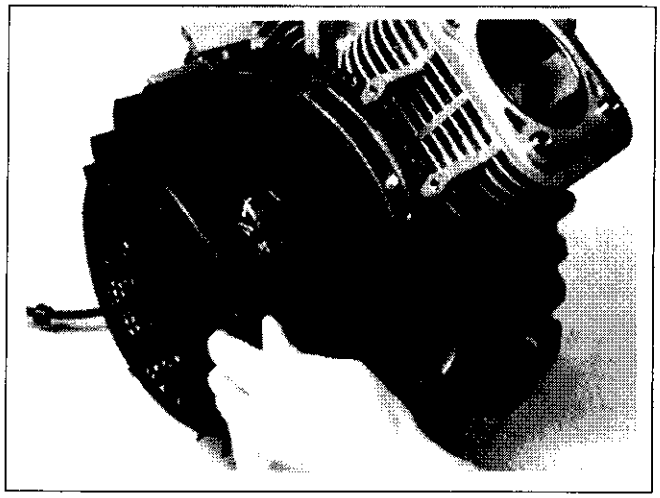


Figure 11-28. Installing Plastic Type Grass Screen.

Install Supports for the Metal Type Grass Screen

1. If the metal type grass screen is used; apply blue Loctite® No. 242 (removable) on threads of supports then position spacer washer and install the four supports as shown in Figure 11-29.

Figure 11-29. Installing Supports for Metal Type Grass Screen.

2. Tighten the supports with a torque wrench to **9.94 N·m (88 in. lb.)** torque. See Figure 11-30. The metal grass screen will be installed to the supports after the blower housing is in place.

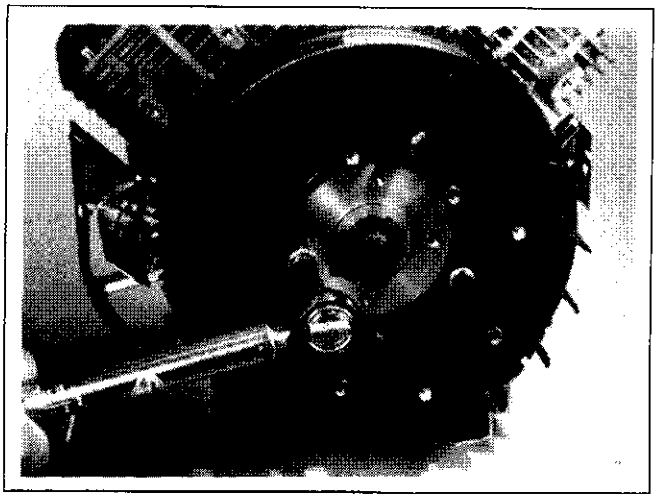


Figure 11-30. Tighten Supports for Metal Screen to Torque Specified.

Install Hydraulic Lifters

1. Lubricate the hydraulic lifters and lifter bores in crankcase with engine oil.

2. See "Hydraulic Lifters" in Section 10 and follow the priming procedures.

   NOTE: Hydraulic lifters should always be installed in the same position as before disassembly.

3. Note the mark or tag identifying the hydraulic lifters as either intake or exhaust and cylinder 1 or cylinder 2. Install the hydraulic lifters into their appropriate location in the crankcase. See Figure 11-31.

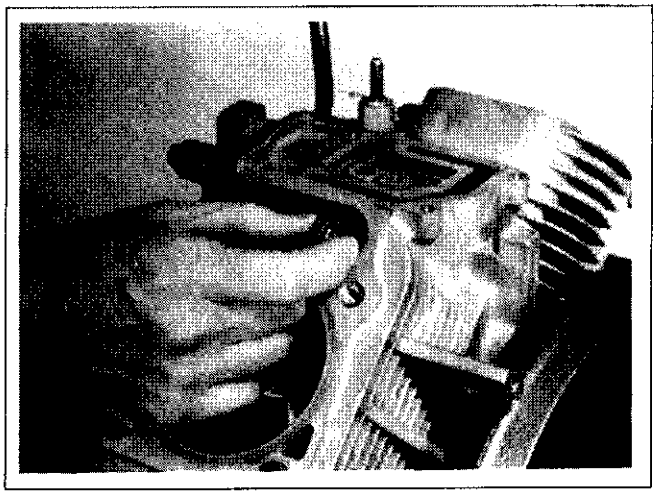


Figure 11-31. Install Primed Lifter in Proper Position.

NOTE: The exhaust lifters are located on the output shaft side of the engine while the intake lifters are located on the fan side of the engine. The cylinder head number is bossed on the outside of each cylinder head.

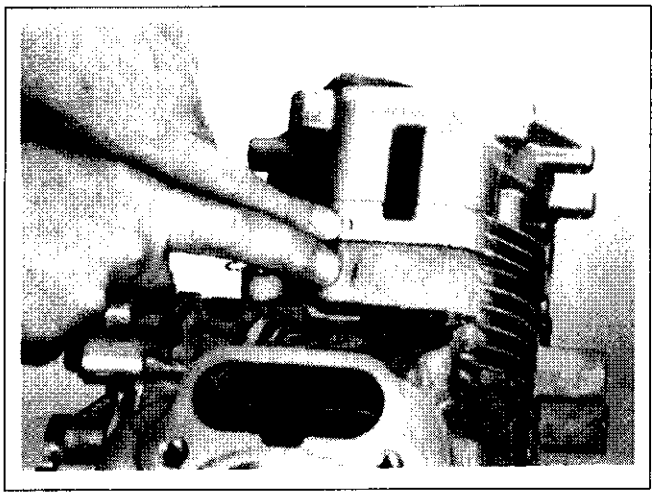


Figure 11-32. Match Marks on Cylinder Barrel and Head.

Assemble Cylinder Heads

Prior to installation, lubricate all components with engine oil paying particular attention to the tip of valve stem seal, valve stems and valve guides. Install the following items in the order listed below using a valve spring compressor. See Figures 11-33 thru 11-35.

- Intake and exhaust valves
- Valve spring caps
- Valve springs
- Valve spring retainers
- Valve spring keepers

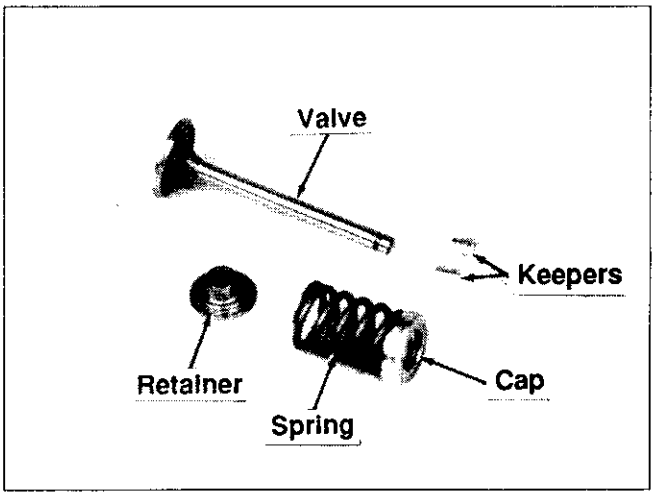


Figure 11-33. Valve Components.

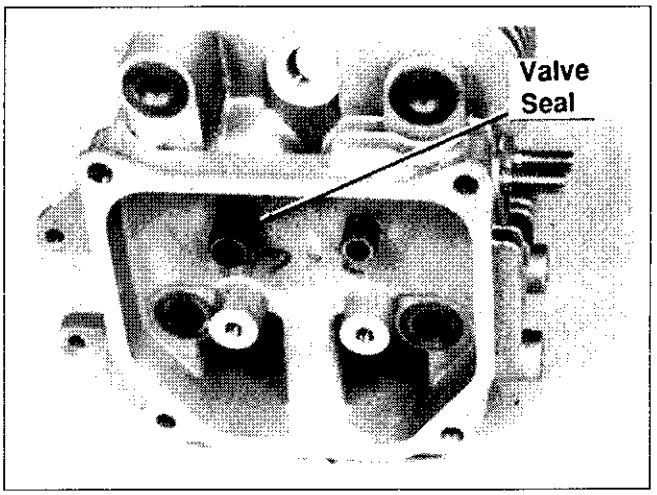


Figure 11-34. Valve Seal Location.

Valve Stem Seals

These engines use valve stem seals on the intake valves and some exhaust valves (if used). Always use a new seal when valves are installed in the cylinder head. Also, replace the seals if they are deteriorated or damaged in any way. Never reuse an old seal.

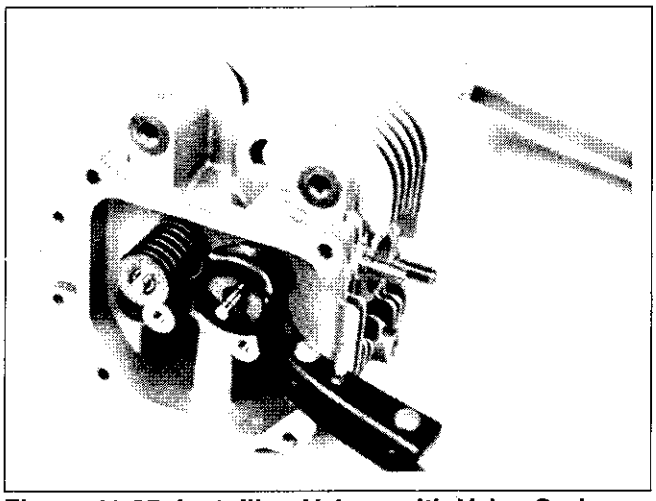


Figure 11-35. Installing Valves with Valve Spring Compressor.

Install Cylinder Heads

1. Check to make sure there are no nicks or burrs on the sealing surfaces of the cylinder head or crankcase.

2. Rotate the crankshaft to position the piston in cylinder 1 to top dead center (TDC) on the compression stroke.

3. Install a new cylinder head gasket.

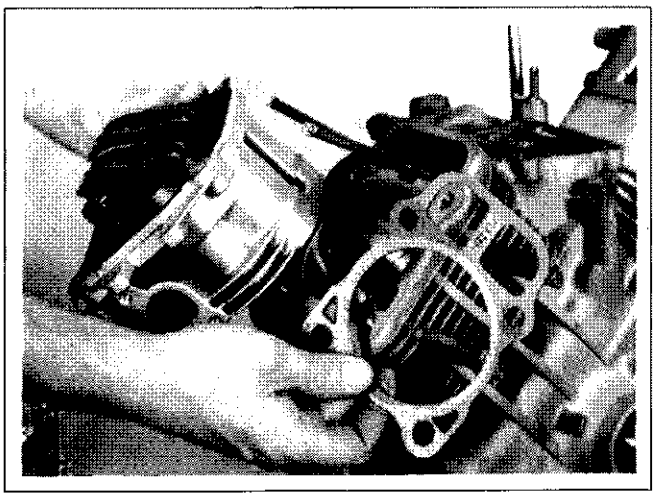


Figure 11-36. Always Use New Head Gaskets.

NOTE: Match numbers embossed on cylinder heads and crankcase (see Figure 11-32).

4. Install the cylinder head and start the four hex. flange screws. See Figure 11-37.

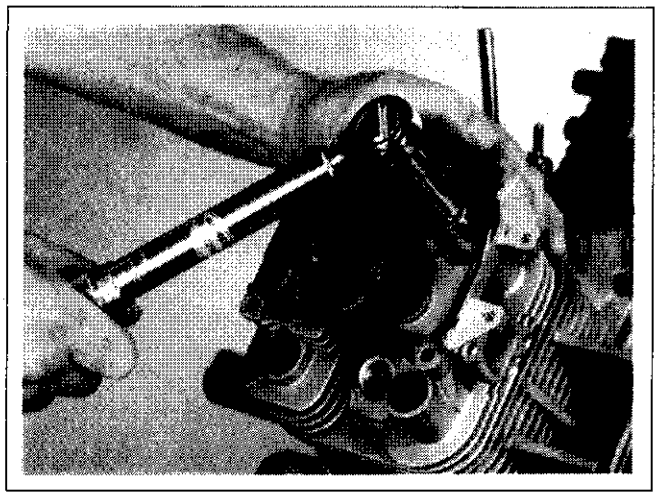


Figure 11-37. Tighten Cylinder Head Fasteners in Sequence and to Torque Specified.

5. Initially torque the four hex. flange fasteners in the proper sequence to **20 N·m (15 ft. lb.)**. See Figure 11-38 for the proper torque sequence. Repeat the procedure, torquing fasteners to a final value of **40.7 N·m (30 ft. lb.)**.

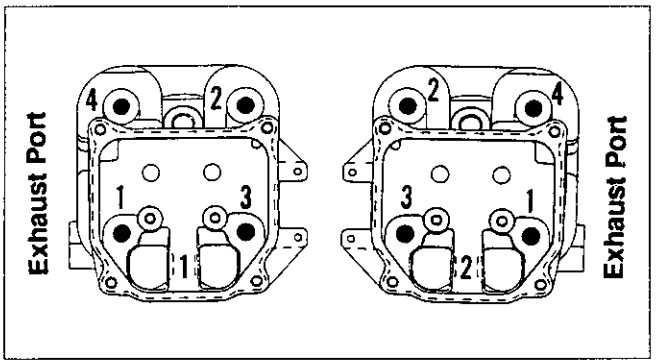


Figure 11-38. Cylinder Head Fastener Torque Sequence.

Install Push Rods and Rocker Arms

Earlier models used hollow push rods which were drilled through. These require special rocker arms. They are not interchangeable with the latest "solid" push rods and associated rocker arms. Do not mix these. A replacement kit is available with "solid" components.

NOTE: Push rods should always be installed in the same position as before disassembly.

1. Note the mark or tag identifying the push rod as either intake or exhaust and cylinder 1 or cylinder 2. Dip ends of push rods in engine oil and install, making sure that each push rod ball seats in its hydraulic lifter socket. See Figure 11-39.

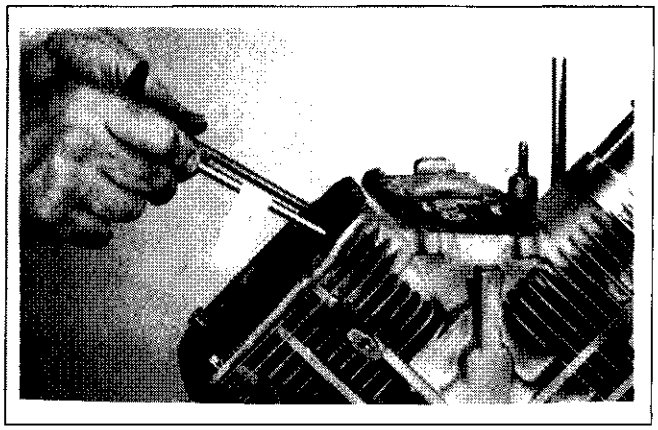


Figure 11-39. Install Push Rods in Same Position as Removed.

2. Apply grease to contacting surfaces of rocker arms and rocker arm pivots. Install rocker arms and rocker arm pivots on cylinder head and start the two hex. flange screws. See Figure 11-40.

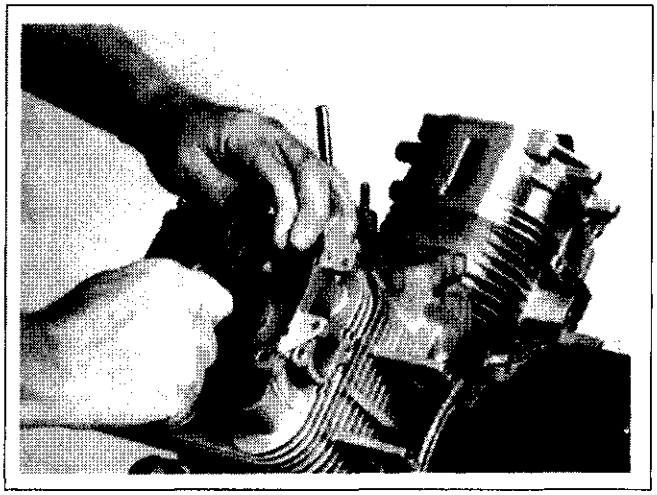


Figure 11-40. Tighten Rocker Arms to Torque Specified.

3. Torque hex. flange screws to **14 N·m (124 in. lb.)**. Repeat for other rocker arm.

4. Use a spanner wrench or rocker arm lifting tool (see Section 2) to lift rocker arms and position push rods underneath.

5. Repeat steps for the remaining cylinder. Do not interchange parts from one cylinder head with parts from the other cylinder head.

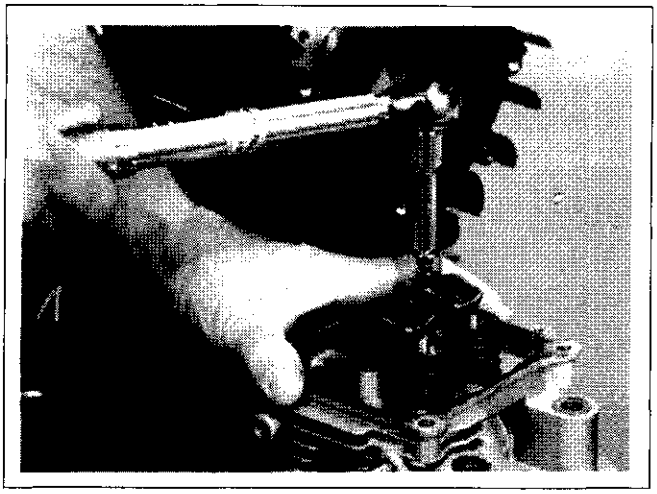


Figure 11-41. Using Spanner Wrench to Lift Rocker Arm Over Push Rod Ball.

6. Rotate engine to check for free operation of the valve train. Check the clearance between valve spring coils at full lift. Minimum allowable clearance is **0.25 mm (0.01 in.)**.

Install New Spark Plugs

1. Use new Champion® RC12YC (or equivalent) spark plugs.

2. Set gap at 1.02 mm (0.040 in.).

3. Install new plugs and tighten to **24.4/29.8 N·m (18/22 ft. lb.)**. See Figure 11-42.

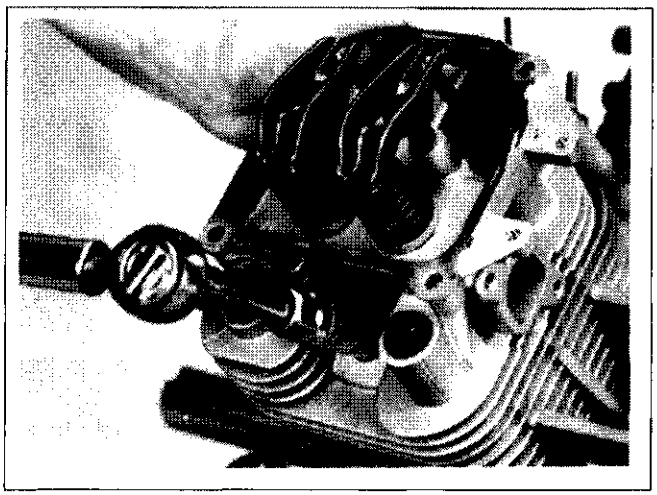


Figure 11-42. Install New Spark Plugs and Tighten to Torque Specified.

Install Ignition Modules

1. Rotate flywheel to position magnet as far away as possible from the location where ignition modules will be installed.

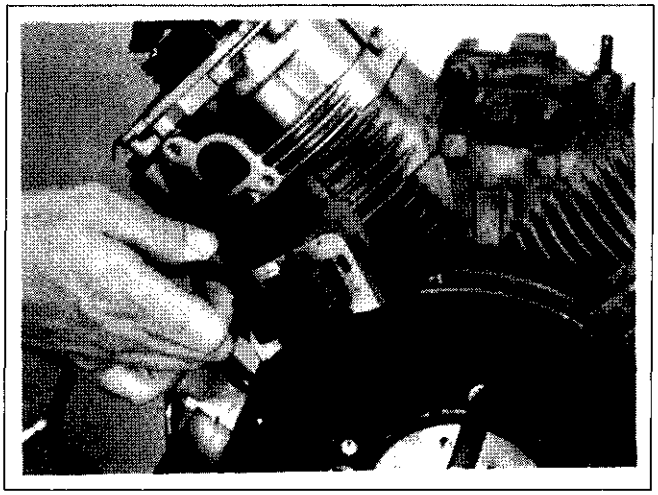


Figure 11-43. Installing Ignition Module.

2. Install each ignition module to crankcase bosses with two allen head (or hex. flange screws on some models). Slide the modules up as far away from the flywheel as possible then tighten the screws.

3. Rotate the flywheel to position the magnet directly under an ignition module.

4. Insert a **0.25 mm (0.010 in.)** flat feeler gauge or shim stock between the magnet and ignition module (see Figure 11-44). Loosen the screws enough to allow the magnet to pull the module down against the feeler gauge.

5. Torque the two hex. flange screws to **4.0 N·m (35 in. lb.)**.

6. Repeat steps 3 through 5 for the other ignition module.

7. Rotate the flywheel back and forth checking for clearance between the magnet and ignition modules. Make sure the magnet does not strike the modules. Check the gap with a feeler gauge and readjust if necessary. Final Air Gap: **0.203/ 0.305 mm (0.008/0.012 in.)**.

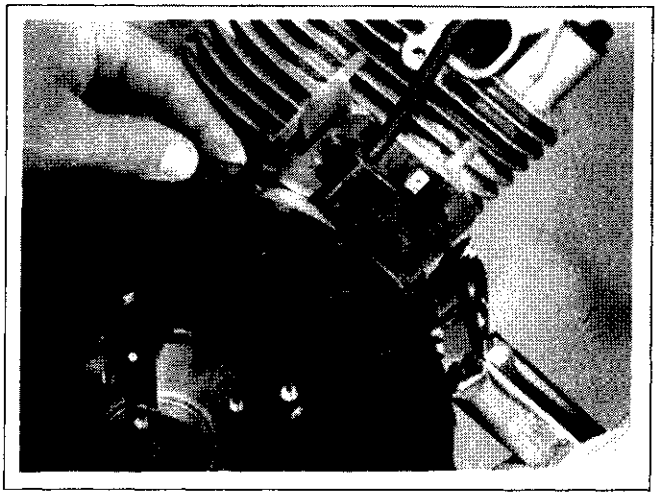


Figure 11-44. Checking Air Gap of Ignition Modules.

Install Intake Manifold

1. Install intake manifold and new intake manifold gaskets to the cylinder heads using four hex. flange screws. Torque hex. flange screws to **9.9 N·m (88 in. lb.)**. See Figure 11-46.

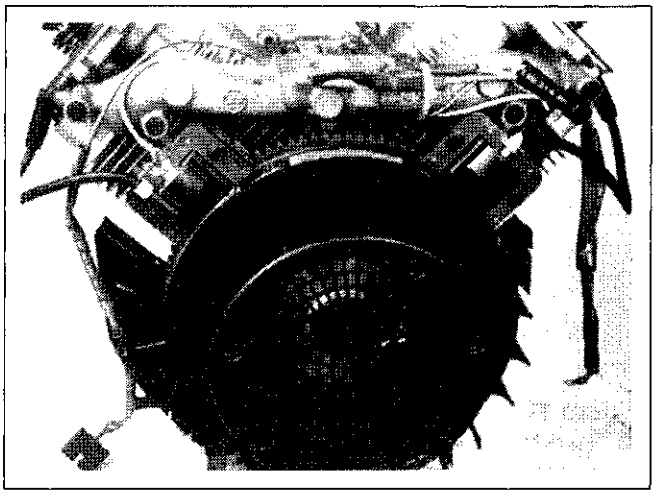


Figure 11-45. Routing of Wiring Harness.

NOTE: If wires are disconnected from ignition module on engines with "Smart Spark™" Grafo grease must be applied to the terminals to prevent corrosion and current jump. Smart Spark™ "hot" lead must be connected into key switch.

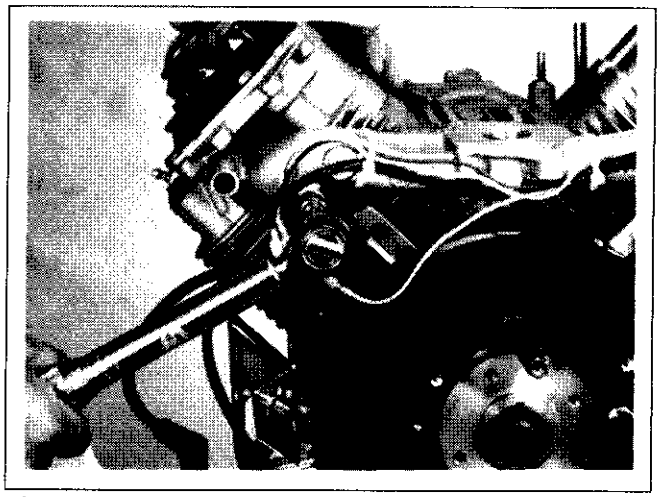


Figure 11-46. Tighten Intake Manifold to Specified Torque.

2. Connect the kill lead to the tab terminal on each standard type ignition module. See Figure 11-47.

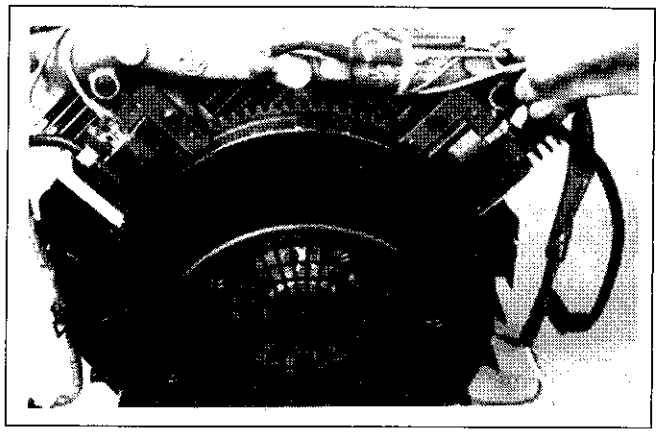


Figure 11-47. Connect Kill Leads on Engines with Standard Ignition Systems (not Smart Spark™).

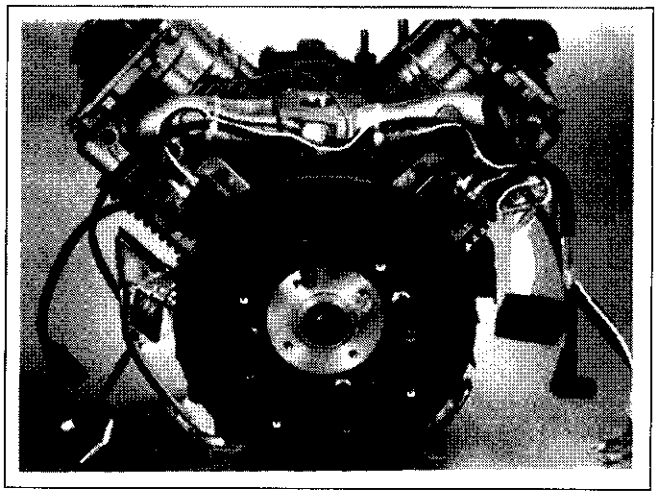


Figure 11-48. Harness Detail on Engines with Smart Spark™.

Install Breather Cover and Inner Baffles

RTV sealant was used between the breather cover and the crankcase however a formed gasket is now used in place of the sealant. The gasket is recommended, however, RTV silicone sealant can still be used. Refer to Section 2, page 2.4 for types of approved sealants if you elect to use RTV. Install as follows:

1. Prepare the sealing surfaces of the crankcase and breather cover by using gasket removing solvent (paint remover). DO NOT scrape surfaces as this could result in leakage.

2. Check to make sure there are no nicks or burrs on sealing surfaces.

3. Install the hex. flange screw, breather reed retainer and breather reed into the crankcase as shown in Figure 11-49.

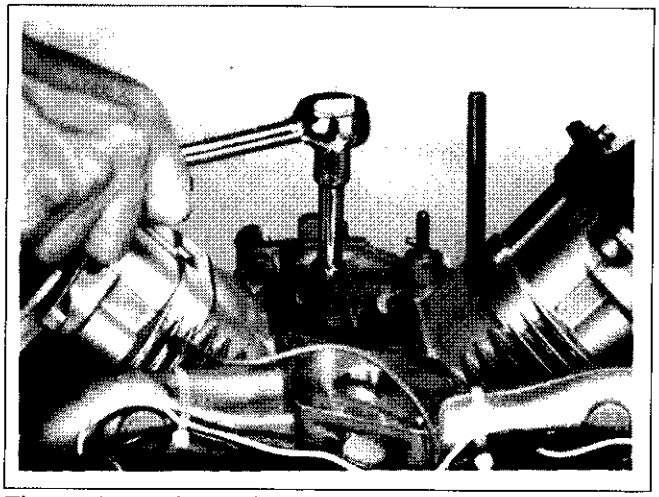


Figure 11-49. Installing Breather Reed Assembly.

4. Insert the air breather filter into crankcase. See Figure 11-50.

5. Apply a 1/16" bead of sealant to sealing surface of the breather cover if using RTV or install the formed gasket instead of sealant.

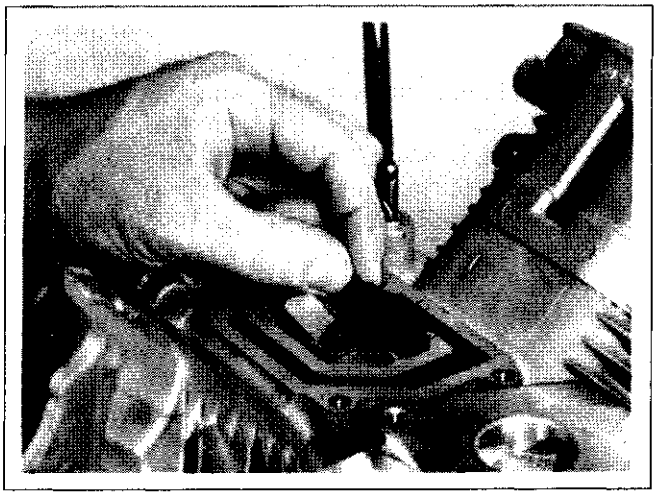


Figure 11-50. Installing New Air Breather Filter.

6. Carefully position breather cover on crankcase. Make sure filter hairs are not in cover seating surface. Check to make sure no sealant (if used) is near Oil Sentry™ switch area. Install first two hex. flange screws at positions shown in Figure 11-51 and **finger** tighten these at this time.

Figure 11-51. Install Two Screws Indicated First.

7. Install the inner baffles using remaining two hex. flange screws (see Figure 11-52) and tighten finger tight. **Do not** tighten the four hex. flange screws at this time. They will be torqued following installation of blower housing and outer baffles. Refer to Figure 11-59 for breather cover tightening sequence and final torque specifications.

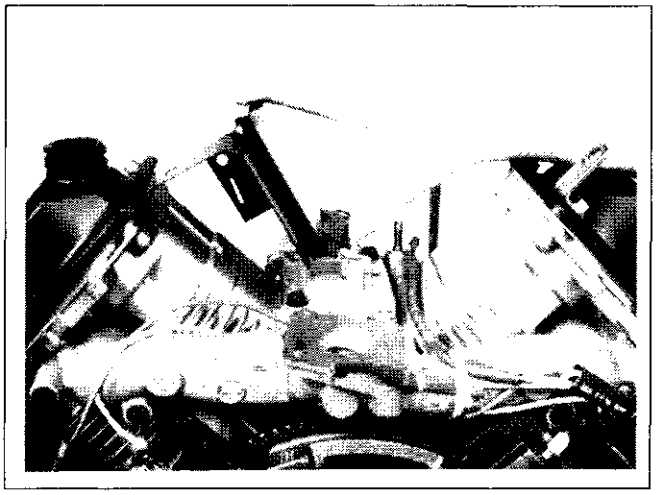


Figure 11-52. Positioning Inner Baffles.

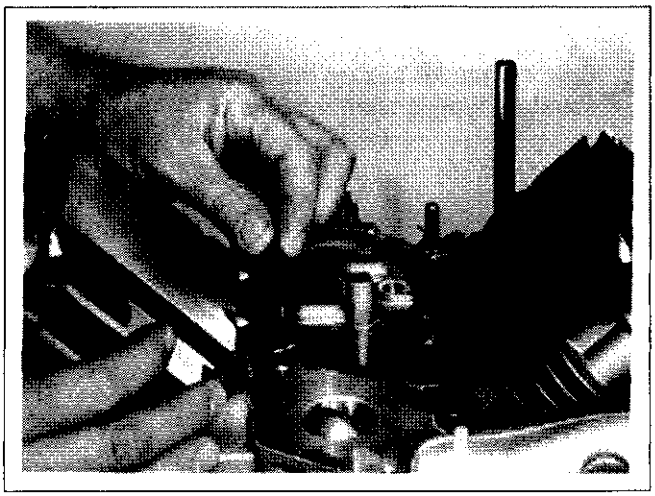


Figure 11-53. Finger Tighten Two Remaining Cover Screws.

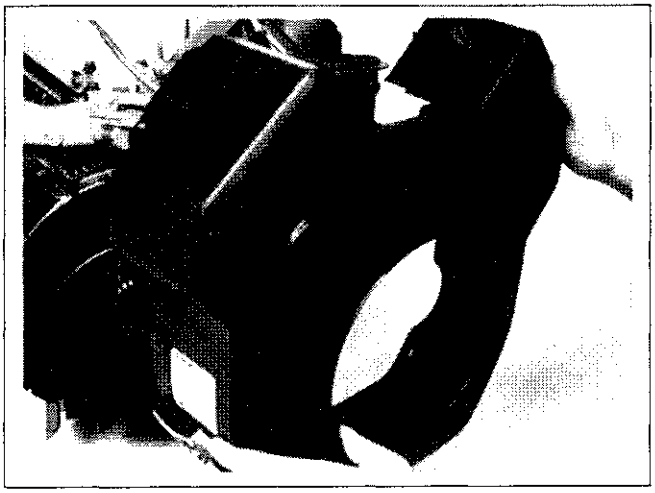


Figure 11-54. Reinstalling Blower Housing.

Install Blower Housing and Outer Baffles

NOTE: Do not completely tighten screws until all items are installed to allow shifting for hole alignment.

1. Connect wires to start switch (if so equipped).

2. Pull wiring harness and leads out on appropriate sides. See Figure 11-55.

3. Slide blower housing into position over front edge of inner baffles. See Figure 11-54.

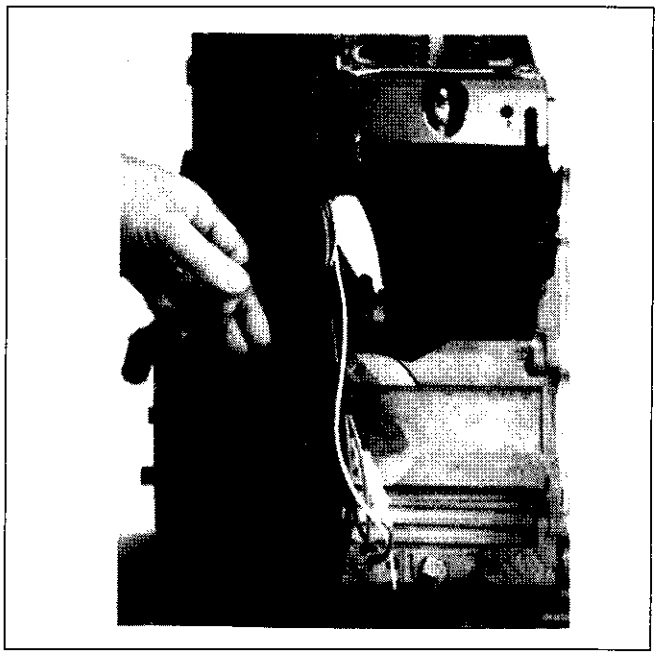


Figure 11-55. Pull Wiring Harness and Leads Out.

4. Install the remaining six blower housing hex. flange screws. Torque all remaining hex. flange screws to **8.6 N·m (65 in. lb.)**. Reattach the ground wire from the rectifier-regulator with the lower hex. flange screw to the blower housing.

5. Install the outer baffles and secure using the four hex. flange screws (two long, two short) in the front mounting holes (when facing fan). Install the two short screws in the lower front mounting holes of the outer baffles. Use the short screw on the left side to mount the wire harness bracket. Torque the short screws to **4.7 N·m (35 in. lb.)**. See Figures 11-56 and 11-57.

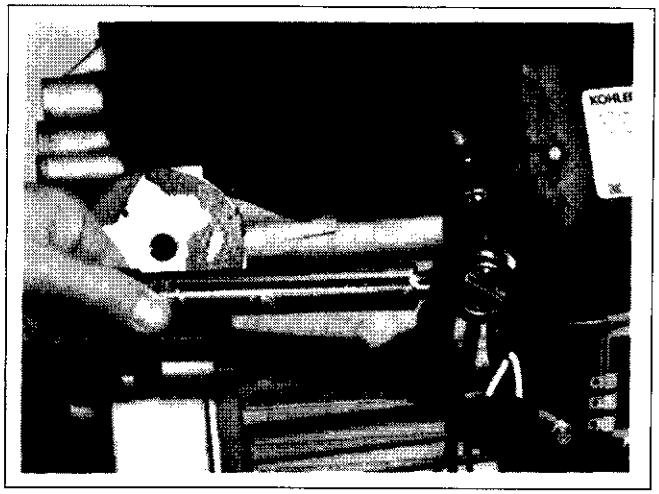


Figure 11-56. Tighten Short Screws to Torque Specified.

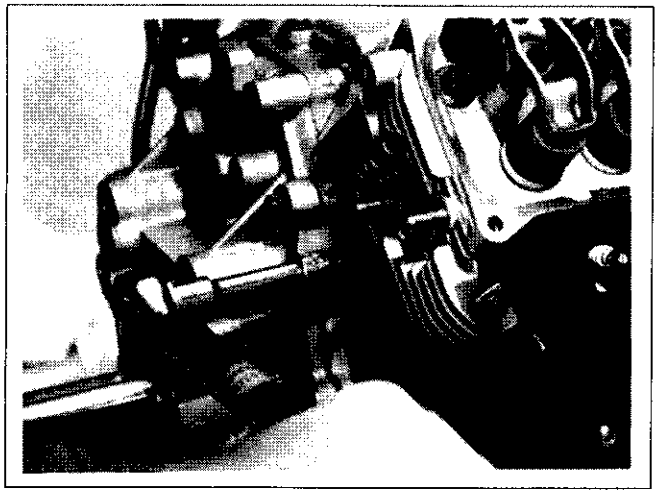


Figure 11-57. Tighten Baffle Mounting Screws.

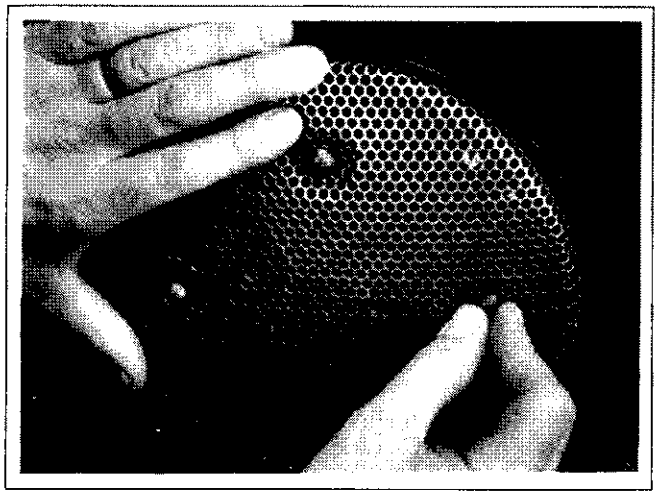


Figure 11-58. Install Metal Type Grass Screen.

6. The metal grass screen can now be attached to the supports.

8. Torque the four breather cover hex. flange screws to **8.6 N·m (65 in. lb.)** in the sequence shown in Figure 11-59. This same torque applies to both RTV sealant and the formed gasket.

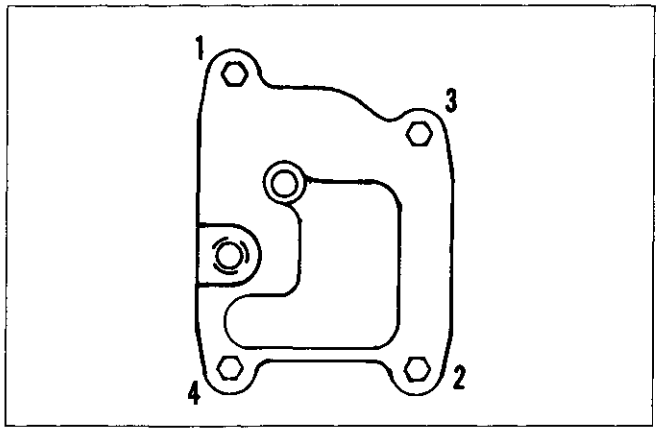


Figure 11-59. Breather Cover Fastener Torque Sequence.

Reconnect Rectifier-Regulator

1. Connect the rectifier-regulator ground lead to the housing with a washer next to the housing and screw through the eyelet as shown in Figure 11-60.

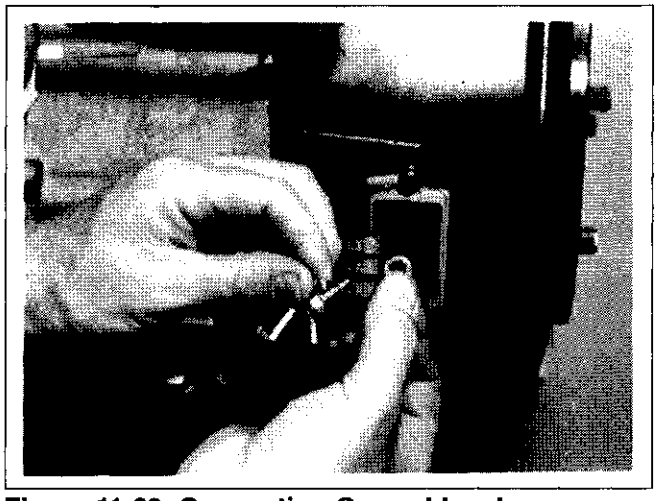


Figure 11-60. Connecting Ground Lead to Housing.

2. Install the B+ terminal/lead into the center position of the rectifier-regulator plug and connect the plug into the rectifier-regulator on the blower housing. See Figure 11-61.

Figure 11-61. Reconnecting B+ Terminal.

Smart Spark™ Module

1. On CH22 and CH25 models reinstall the Smart Spark™ Module to the blower housing. Do not overtighten the retaining screws. See Figure 11-62.

Figure 11-62. Reinstalling Smart Spark™ Module.

Install Electric Starter Motor

1. Install the starter cover, starter motor and spacers using the two hex. flange screws (see Figure 11-46). Make sure that spacers are installed between the starter motor and the crankcase.

2. Torque the two hex. flange screws to **15.3 N·m (135 in. lb.)**.

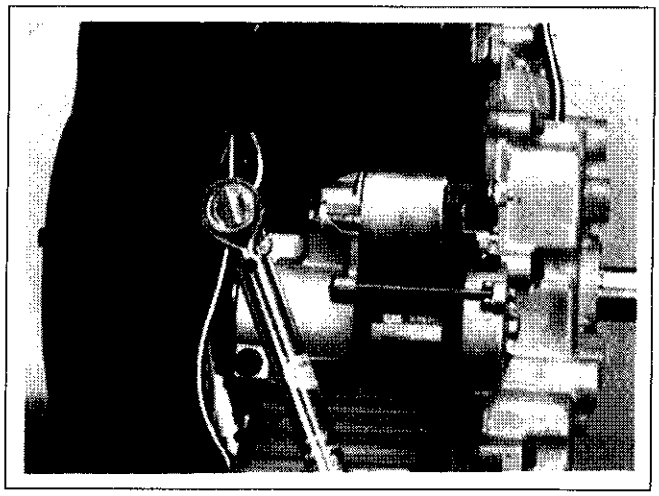


Figure 11-63. Installing Electric Starter Motor.

3. On the solenoid shift starter, connect leads to solenoid. See Figure 11-64.

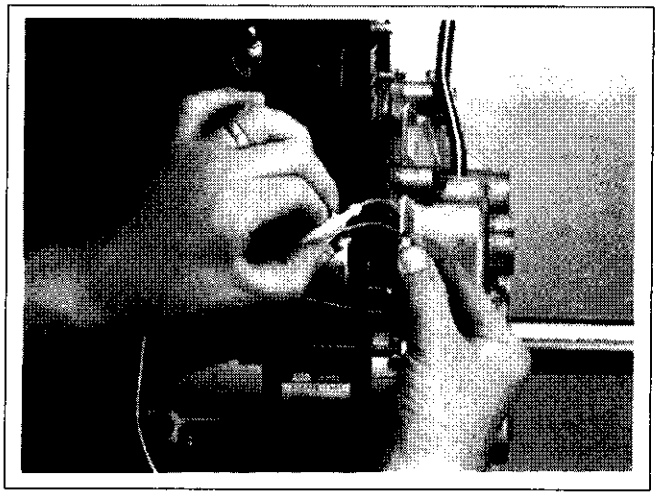


Figure 11-64. Connecting Leads to Starting Motor.

NOTE: If the engine uses a side mount muffler on the starter side, be sure to tie the wires close to the starter to avoid contact with hot exhaust parts.

Install Fuel Pump

⚠ WARNING: Explosive Fuel!
Gasoline may be present in the carburetor and fuel system. Gasoline is extremely flammable and its vapors can explode if ignited. Keep sparks and other sources of ignition away from the engine.

1. Install pump and lines as an assembly. Connect the pulse line to the crankcase vacuum fitting or valve cover, whichever source is used. See Figure 11-65.

NOTE: If a new fuel pump is being installed, make sure the orientation of the new pump is consistent with the removed pump. Internal damage may occur if installed incorrectly.

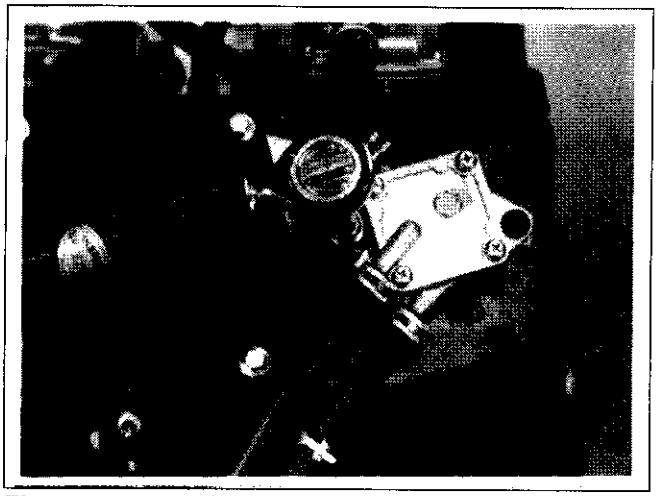


Figure 11-65. Reinstall Fuel Pump.

Install Carburetor

⚠ WARNING: Explosive Fuel!
Gasoline may be present in the carburetor and fuel system. Gasoline is extremely flammable and its vapors can explode if ignited. Keep sparks and other sources of ignition away from the engine.

1. Install the carburetor gasket. Make sure all holes align and are open.

2. Install the carburetor, throttle linkage and governor lever as an assembly. See Figure 11-66.

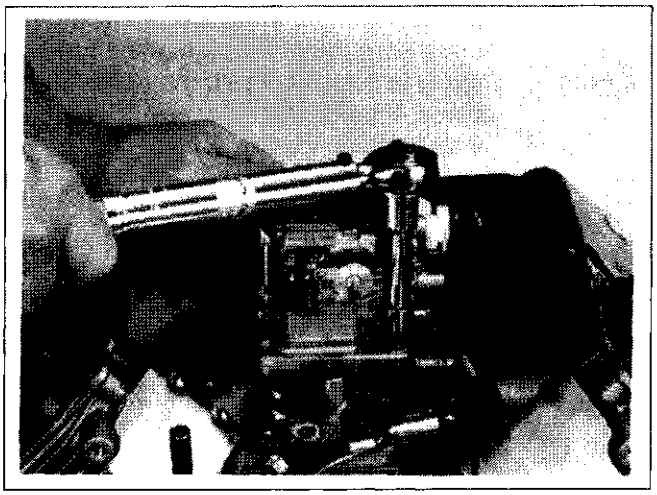


Figure 11-66. Installing Carburetor Assembly.

3. Tighten the two carburetor mounting screws to **9.9 N·m (88 in. lb.)**.

Install External Governor Controls

1. Install the governor lever onto the governor cross shaft. See Figure 11-67.

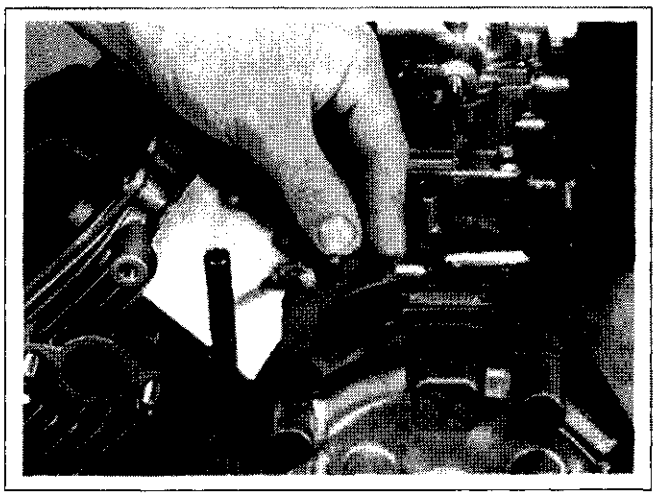


Figure 11-67. Install Governor Arm to Shaft.

2. Make sure the throttle linkage is connected to the governor arm and the throttle lever on the carburetor.

3. Move the governor lever **TOWARDS** the carburetor as far as it will move (wide open throttle) and hold in position.

4. Insert a nail into the hole on the cross shaft and rotate the shaft **COUNTERCLOCKWISE** as far as it will turn, then tighten hex. nut securely. See Figure 11-68.

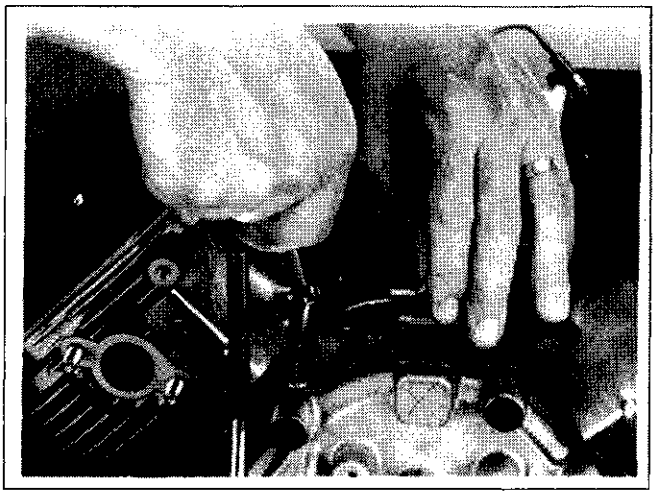


Figure 11-68. Adjusting Governor Arm.

5. Reconnect the lead wire to the fuel shutoff solenoid if so equipped.

Install Throttle & Choke Controls

1. Connect the choke linkage to the carburetor and choke actuator lever. See Figure 11-69.

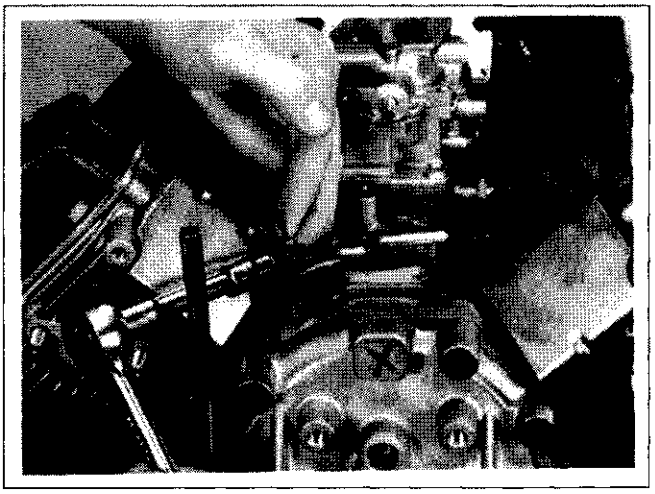


Figure 11-69. Connecting Choke Linkage.

2. Install the throttle control bracket to the cylinder heads using the four hex. flange screws. Torque hex. flange screws to **7.3/10.7 N·m (65/95 in. lb.)**. See Figure 11-70.

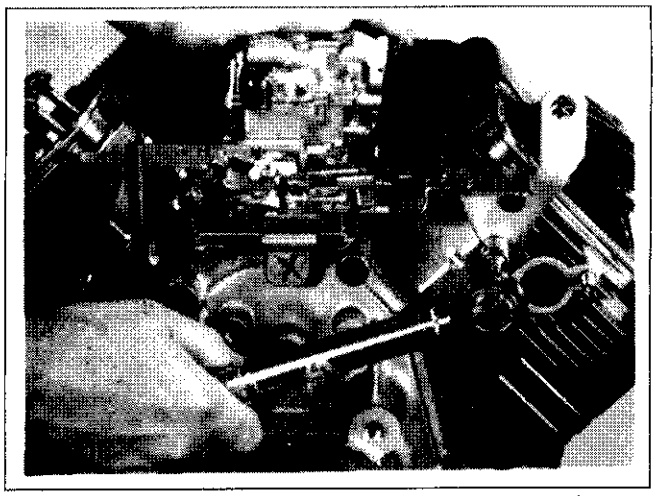


Figure 11-70. Tightening Speed Control Bracket.

3. Connect governor spring from throttle control bracket to the appropriate hole in the governor lever as indicated in the following chart. Note that hole positions are counted from the pivot point of the governor arm and lettered from the pivot point of the actuating lever. See Figures 11-71 and 11-72.

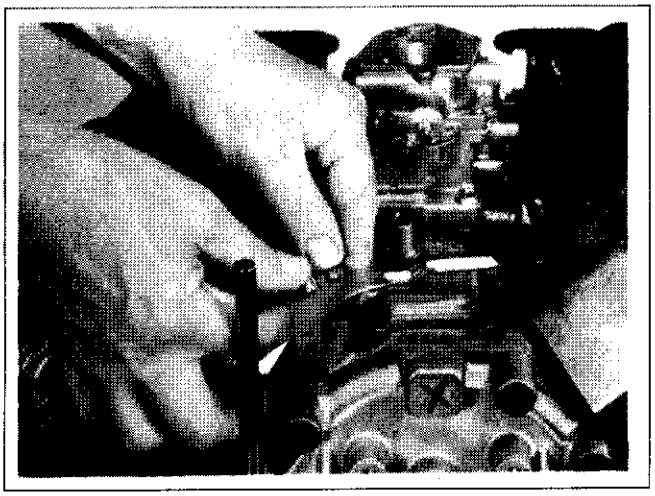
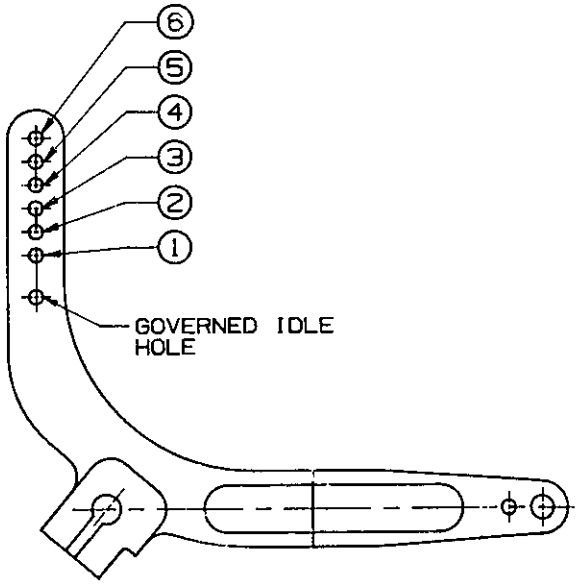


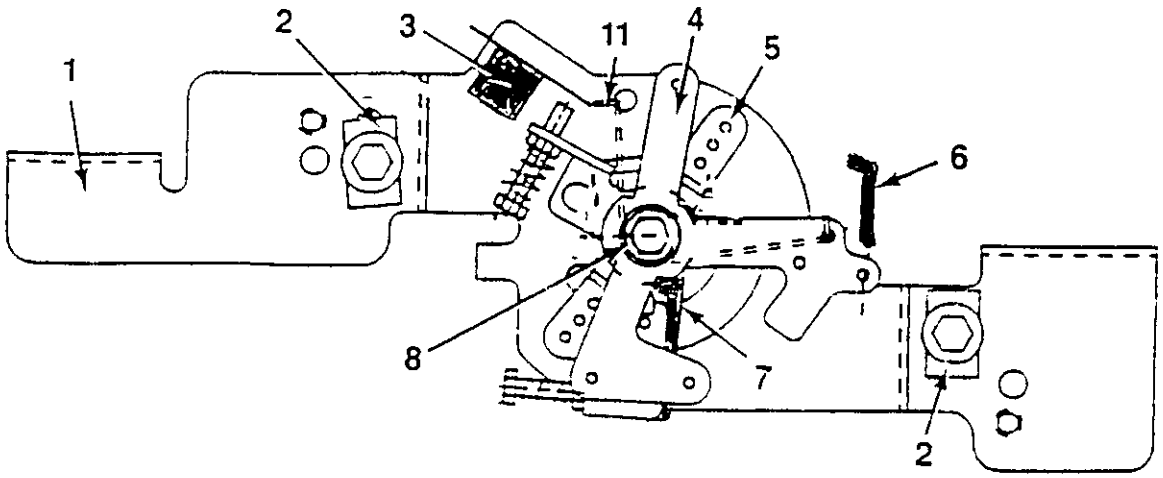
Figure 11-71. Connecting Spring to Governor Arm.



Governor Spring Chart

High Idle RPM	Gov. Lever Hole No.	Governor Spring Color Code
3801-4000	5	Clear
3601-3800	4	Clear
3451-3600	3	Clear
3301-3450	2	Clear
3101-3300	4	Purple
2951-3100	3	Purple
2800-2950	2	Purple
3750*	3	Clear
3150*	3	Purple

*5% Regulation (others 10%)



Item	Description
1	Bracket, speed control
2	Clamp, cable (some applications)
3	Kill Switch (some applications)
4	Lever, choke (top position)
5	Lever, throttle control (middle)
6	Linkage, choke control
7	Lever, throttle actuator (bottom)
8	Screw, M5x0.8x20
9	Washer, wave
10	Washer, flat (3)
11	Spring, choke return
12	Nut, M5x0.8 lock

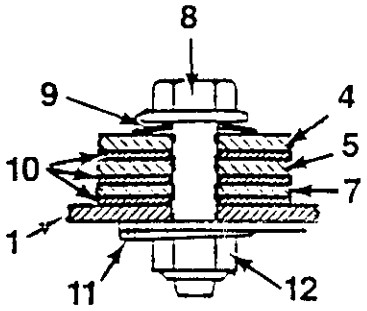


Figure 11-72. Throttle/Choke Control Bracket and Governor Lever Detail.

Install Oil Sentry™ (If so equipped)

1. Apply thread sealant then install the Oil Sentry™ to the breather cover. See Figure 11-73. Tighten to **5.08 N·m (45 in. lb.)**.

2. Connect the wire lead from the warning light on the blower housing or panel to the Oil Sentry™ terminal.

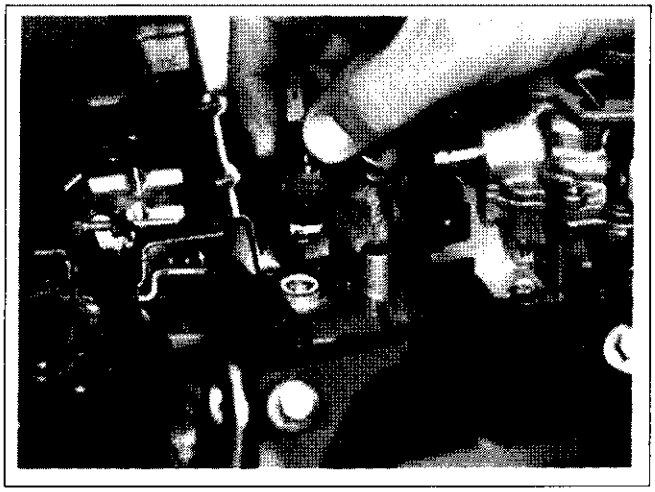


Figure 11-73. Installing Oil Sentry™ Switch.

Install Valve Covers

Three different types of valve covers have been used. One type used a gasket between the cover and cylinder head. Another used RTV sealant. The latest type uses an O-Ring which is installed in a groove in the cover instead of a gasket or RTV sealant. Metal spacers are used around the bolt holes on O-Ring type covers which require the higher torque value noted in step 5. Kits are available for updating to the latest O-Ring design.

1. If using the gasket or RTV sealant type cover, prepare the sealing surfaces of cylinder head and cover as directed by the sealant manufacturer. Refer to Section 2, Page 2.4 for approved sealants. Always use fresh sealant – using outdated sealant could result in leakage. With O-Ring type covers, make sure the sealing surfaces are cleaned.

2. Make sure there are no nicks or burrs on the sealing surfaces.

3. With covers requiring RTV sealant, apply a 1/16" bead of sealing surface of both cylinder heads then install a new cover gasket on each then apply a second bead of sealant on the top surface of the gaskets. If using O-Ring type, install new O-Ring in groove in covers and **do not** use gaskets or RTV sealant.

4. Locate the cover with oil fill neck on same side as removed and install lifting strap in same position. With O-Ring type covers, position cover on cylinder head, insert a spacer in each of the screw holes. On both types, install the eight hex. flange screws (4 each cover) and finger tighten these.

5. With covers using gasket or RTV sealant, torque the cover fasteners to **3.4 N·m (30 in. lb.)**. With O-Ring type covers, torque the fasteners to **7.9 N·m (70 in. lb.)**. Tighten covers in sequence shown in Figure 11-74.

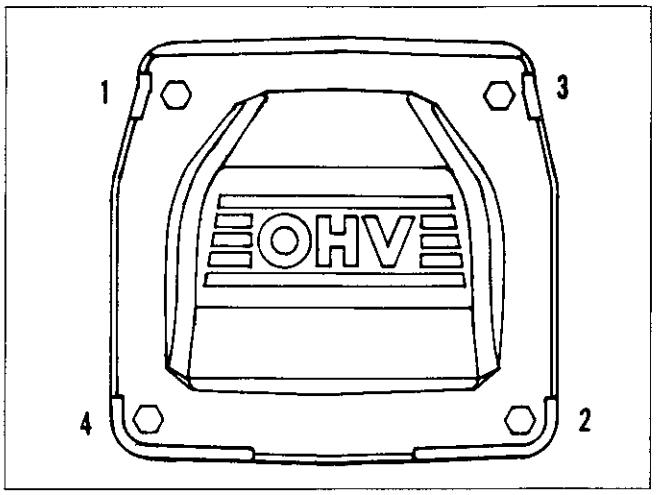


Figure 11-74. Valve Cover Fastener Torque Sequence.

*NOTE: Fastener #2 used to secure fuel pump bracket on earlier models.

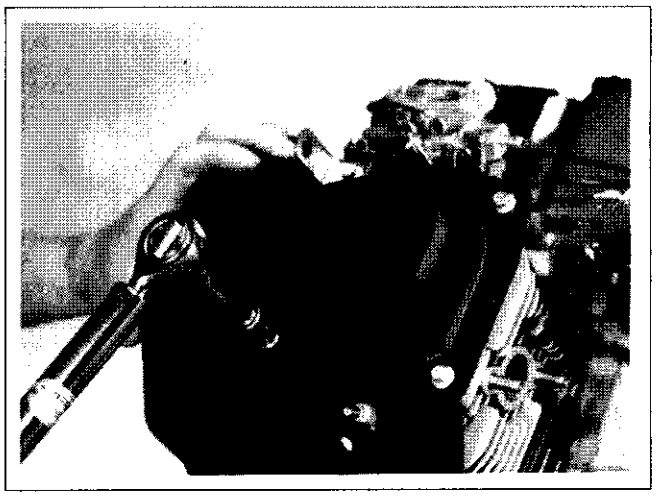


Figure 11-75. Tightening Valve Cover Screws.

Install Air Cleaner Assembly

Refer to Section 4 for air cleaner reassembly procedure.

1. Install the rubber breather tube to the breather cover and connect the fuel inlet line to the carburetor. See Figure 11-76.

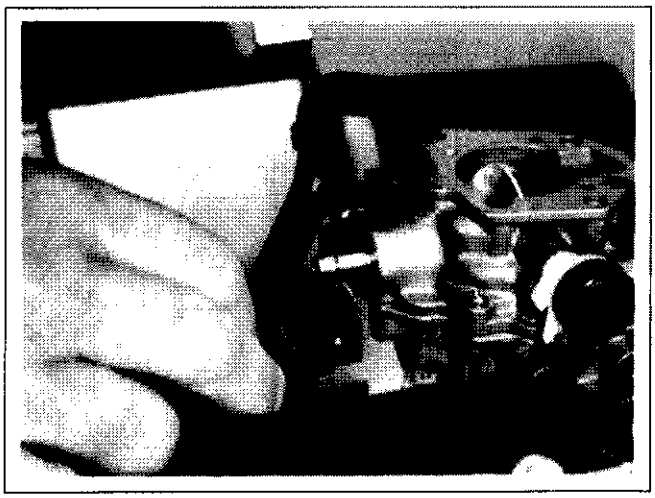


Figure 11-76. Connecting Fuel Inlet Line.

2. Position the gasket and air cleaner base while carefully pulling the loose end of the rubber breather tube through the base. See Figure 11-77.

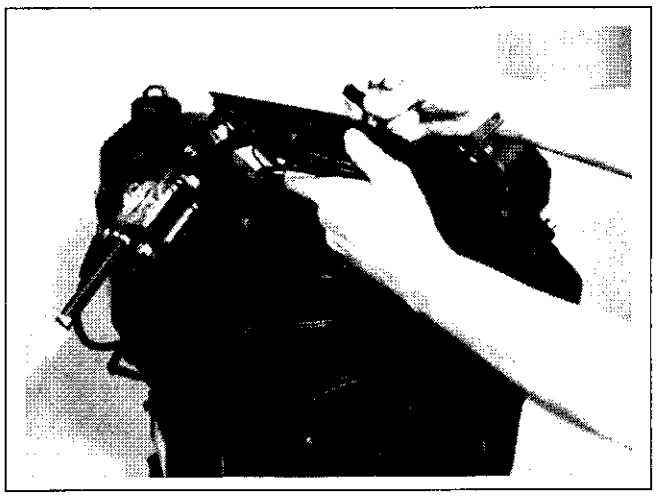


Figure 11-77. Pulling Breather Tube Through Base.

NOTE: Route fuel inlet line as shown in Figure 11-78 to avoid restriction.

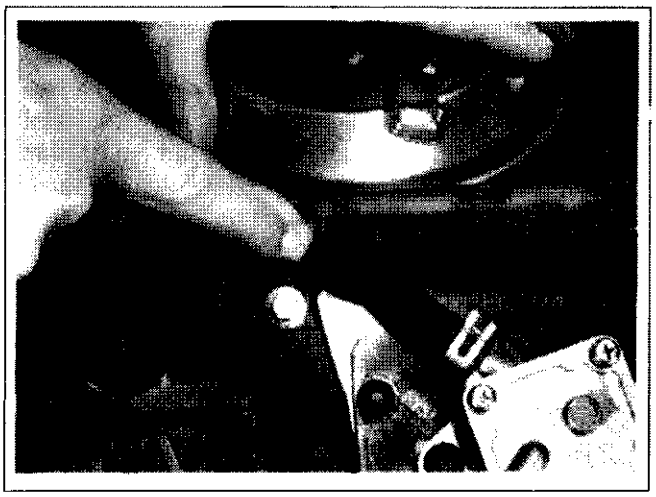


Figure 11-78. Fuel Inlet Line Detail.

3. Secure the air cleaner base and bracket using the hex. flange screws. Position bracket with hole towards breather tube. Be careful not to drop screws into carburetor. Tighten screws to **9.9 N·m (88 in. lb.)**. See Figure 11-79.

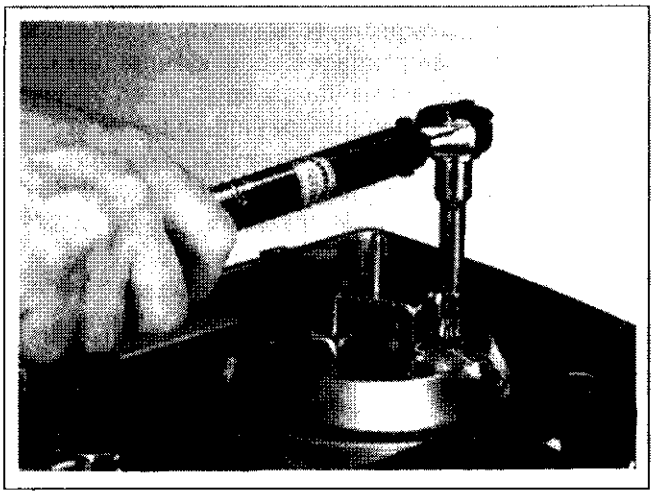


Figure 11-79. Tightening Base Screws.

4. Install breather tube in hole in bracket.

5. Install air cleaner components as described in Section 4.

Install Muffler

1. Install the muffler and attaching hardware to the muffler bracket. Torque screws to **9.9 N·m (88 in. lb.)**.

2. Install the hex. flange nuts to the exhaust studs. Torque hex. flange nuts to **24.4 N·m (216 in. lb.)**.

Reinstall Oil Cooler (CH22 and CH25)

1. Reinstall the oil cooler on CH22 and CH25 models. Install new gasket between cooler and closure plate. Torque nipple adapter to **54.2 N·m (40 ft. lbs.)**. See Figure 11-80.

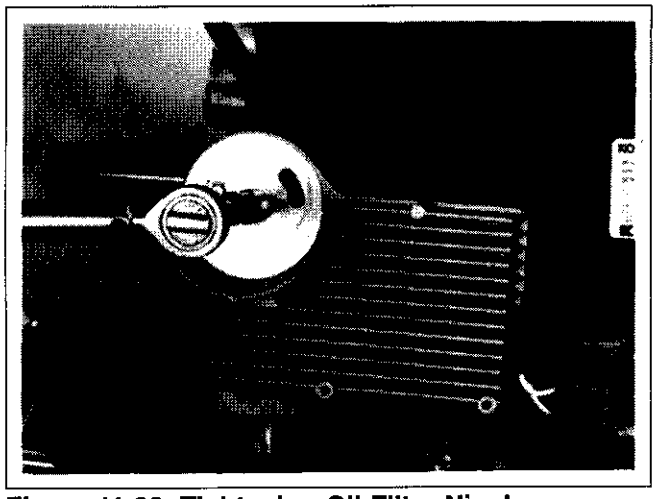


Figure 11-80. Tightening Oil Filter Nipple.

Install Oil Filter and Fill Crankcase with Oil

1. Apply a thin coating of engine oil to the rubber gasket of a new oil filter and thread the filter onto the adapter nipple. See Figure 11-81.

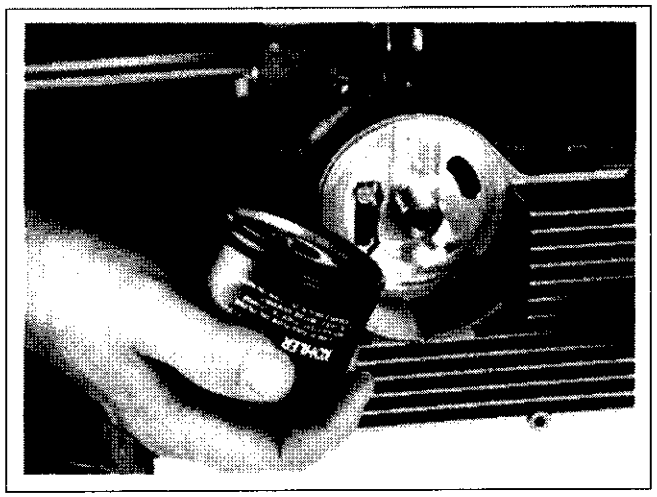


Figure 11-81. Installing New Oil Filter.

2. Hand tighten the filter until the rubber gasket contacts the adapter, then tighten the filter an additional 1/2 turn.

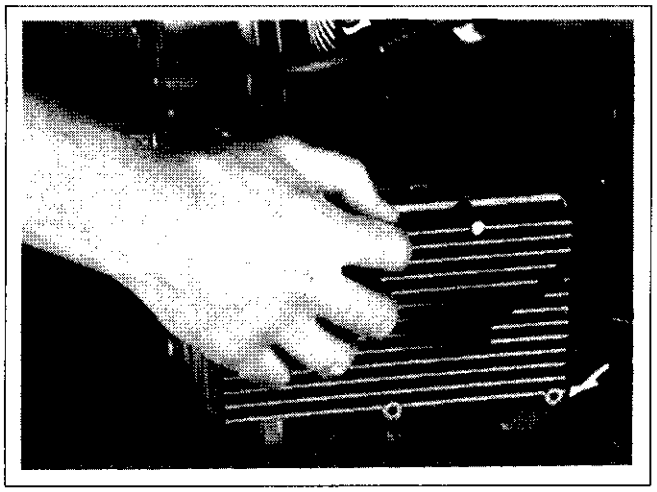


Figure 11-82. Hand Tightening Oil Filter.

3. Install oil drain plug. See Figure 11-83. Torque plug to **13.6 N·m (10 ft. lb.)**.

   NOTE: Make sure that both oil drain plugs are installed and torqued to the above specifications to prevent oil leakage.

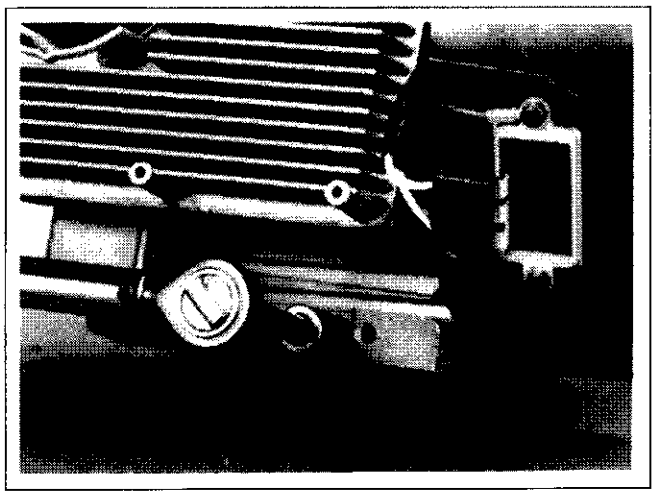


Figure 11-83. Reinstall and Torque Both Oil Drain Plugs.

4. Reinstall the oil level dipstick. See Figure 11-84.

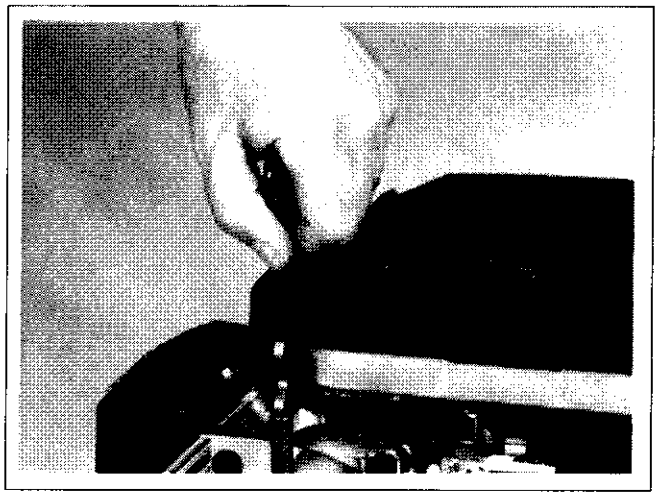


Figure 11-84. Reinstall the Dipstick in Tube.

5. Make sure O-Ring is in place then reinstall the oil fill cap on valve cover. See Figure 11-85.

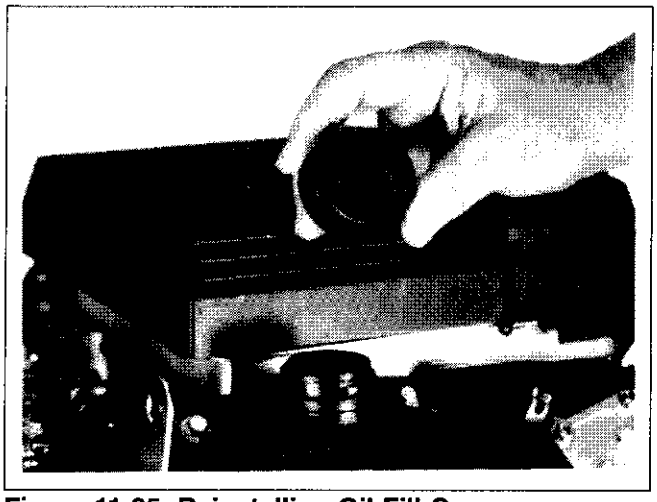


Figure 11-85. Reinstalling Oil Fill Cap.

Connect Spark Plug Leads

1. Connect the leads to the spark plugs. See Figure 11-86.

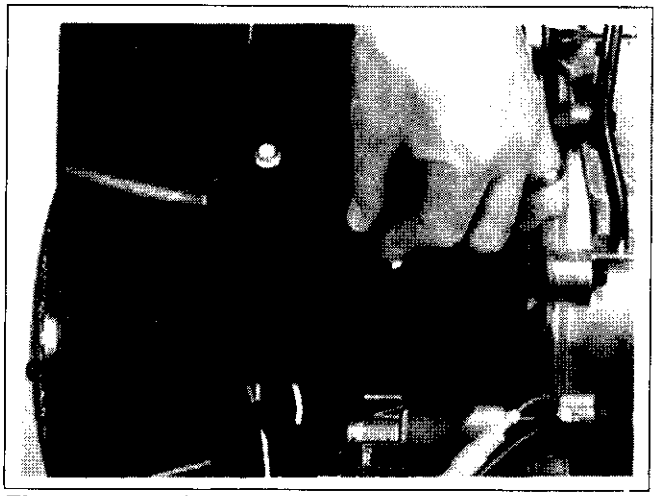


Figure 11-86. Connect Spark Plug Leads.

Prepare the Engine for Operation

The engine is now completely reassembled. Before starting or operating the engine, be sure to do the following.

1. Make sure all hardware is tightened securely.
2. Make sure the oil drain plugs, oil sentry pressure switch, and a new oil filter are installed.
3. Fill the crankcase with the correct amount, weight, and type of oil. Refer to oil recommendations and procedures in the "Safety and General Information" and "Lubrication System" sections.
4. Adjust the carburetor, idle fuel needle, or idle speed adjusting screw as necessary. Refer to the "Fuel System and Governor" section.

Testing the Engine

It is recommended that the engine be operated on a test stand or bench prior to installation in the piece of equipment.

1. Set the engine up on a test stand. Install an oil pressure gauge in the location normally used for Oil Sentry™. Refer to "Lubrication System" section, Figure 6-6. Start the engine and check to be certain that oil pressure (20 psi or more) is present. Run the engine for 5-10 minutes between idle and midrange. Adjust the carburetor mixture settings as necessary.
2. Make sure the maximum engine speed does not exceed 3750 RPM (no load). Adjust the throttle and choke controls and the high speed stop as necessary. Refer to the "Fuel System and Governor" section.

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