

SERVICE MANUAL

COMMAND CV11-16, CV460-465, CV490-495

VERTICAL CRANKSHAFT



KOHLER
engines

**BORN
TO RUN™**

Contents

Section 1. Safety and General Information

1

Section 2. Special Tools

2

Section 3. Troubleshooting

3

Section 4. Air Cleaner and Air Intake System

4

Section 5. Fuel System and Governor

5

Section 6. Lubrication System

6

Section 7. Retractable Starter

7

Section 8. Electrical System and Components

8

Section 9. Disassembly

9

Section 10. Inspection and Reconditioning

10

Section 11. Reassembly

11

Section 1

Safety and General Information

Safety Precautions

To insure safe operations please read the following statements and understand their meaning. Also refer to your equipment manufacturer's manual for other important safety information. This manual contains safety precautions which are explained below. Please read carefully.



WARNING

Warning is used to indicate the presence of a hazard that *can* cause *severe* personal injury, death, or substantial property damage if the warning is ignored.



CAUTION

Caution is used to indicate the presence of a hazard that *will* or *can* cause *minor* personal injury or property damage if the caution is ignored.

NOTE

Note is used to notify people of installation, operation, or maintenance information that is important but not hazard-related.

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



Accidental Starts can cause severe injury or death.

Disconnect and ground spark plug leads before servicing.



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.

Accidental Starts!

Disabling engine. Accidental starting can cause severe injury or death. Before working on the engine or equipment, disable the engine as follows: 1) Disconnect the spark plug lead(s). 2) Disconnect negative (-) battery cable from battery.

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

Explosive Fuel can cause fires and severe burns.
Stop engine before filling fuel tank.



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.

 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

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

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 "Retractable Starter" Section 7 for relieving spring tension.

 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.

 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.

Section 1

Safety and General Information

1

Engine Identification Numbers

When ordering parts, or in any communication involving an engine, always give the **Model, Specification, and Serial Numbers** of the engine.

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 Decal Location.

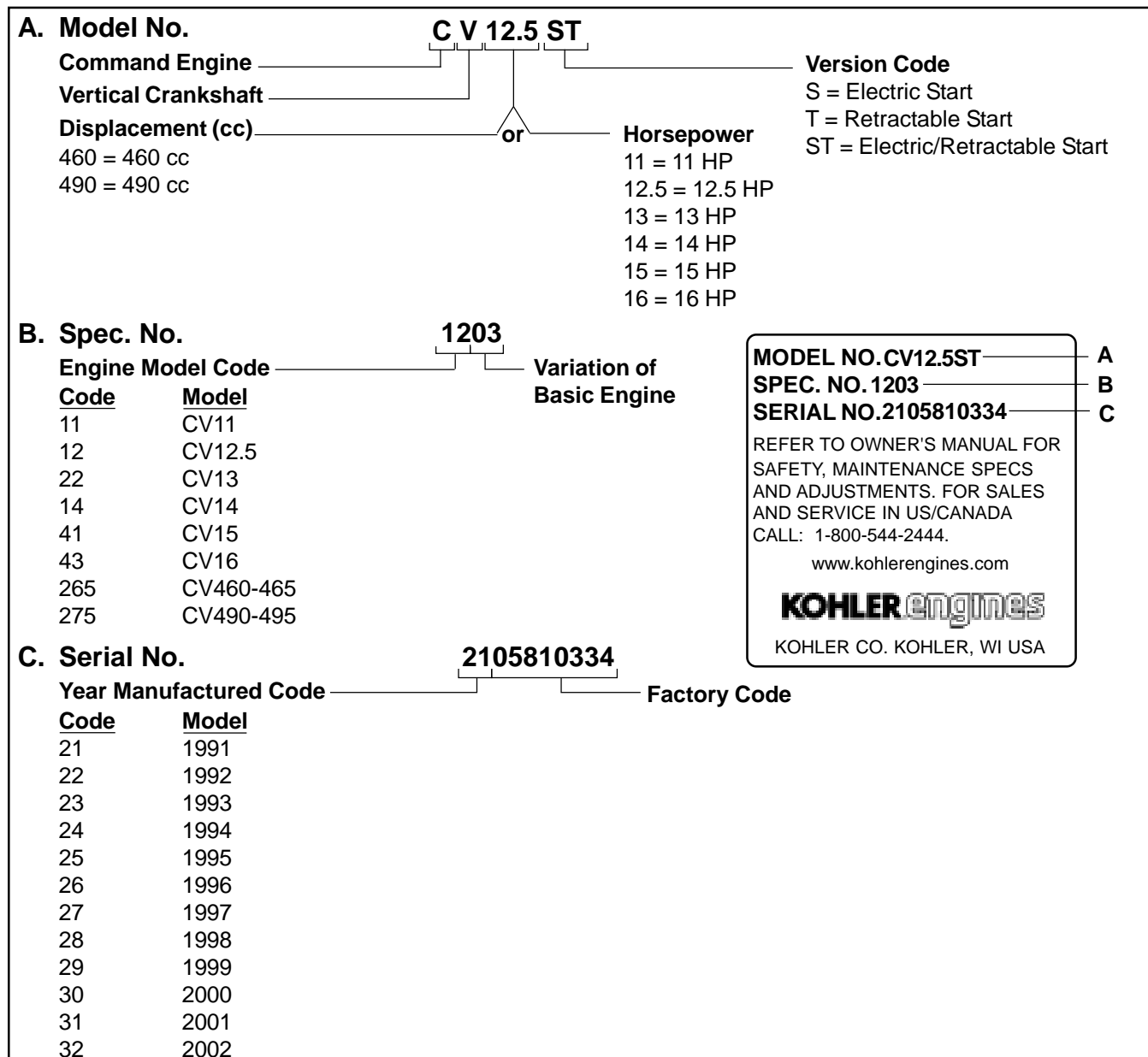


Figure 1-2. Explanation of Engine Identification Numbers.

Section 1

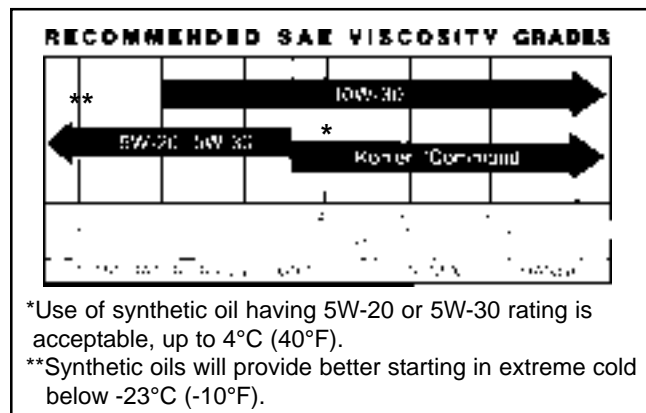
Safety and General Information

Oil Recommendations

Using the proper type and weight of oil in the crankcase is extremely important, as is checking oil daily, and changing oil regularly. Failure to use the correct oil, or using dirty oil, causes premature engine wear and failure. **Synthetic oil** is recommended for use in LPG-fueled engines because there is less oxidation or thickening, and deposit accumulation on intake valves is substantially reduced.

Oil Type

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



NOTE: Using other than service class SG, SH, SJ or higher 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 oil check, oil change, and oil filter change procedures.

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 insure 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 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 maximum of 15% MTBE by volume) are approved as a fuel for Kohler engines. Other gasoline/ether blends are not approved.

Section 1

Safety and General Information

1

Periodic Maintenance



WARNING: Accidental Starts!

Disabling engine. Accidental starting can cause severe injury or death. Before working on the engine or equipment, disable the engine as follows: 1) Disconnect the spark plug lead(s). 2) Disconnect negative (-) battery cable from battery.

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	<ul style="list-style-type: none"> • Fill fuel tank. • Check oil level. • Check air cleaner for dirty¹, loose, or damaged parts. • Check air intake and cooling areas, clean as necessary¹. 	Section 5 Section 6 Section 4 Section 4
Every 25 Hours	<ul style="list-style-type: none"> • Service precleaner element¹. 	Section 4
Every 100 Hours	<ul style="list-style-type: none"> • Replace air cleaner element¹. • Change oil¹. • Remove cooling shrouds and clean cooling areas¹. 	Section 4 Section 6 Section 4
Every 200 Hours	<ul style="list-style-type: none"> • Change oil filter¹. • Check spark plug condition and gap. 	Section 6 Section 8
Annually or Every 500 Hours	<ul style="list-style-type: none"> • Have bendix starter drive serviced². • Have solenoid shift starter disassembled and cleaned². 	Section 8 Section 8

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

²Have a Kohler Engine Service Dealer perform this service. Not necessary on Delco Starters.

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 manufacturers 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 2-3 minutes to get stabilized fuel into the carburetor.

To empty the system, run the engine until the tank and system are empty.

4. Remove the spark plug. Add one tablespoon of engine oil into the spark plug hole. Install the plug, but do not connect the plug lead. Crank the engine two or three revolutions.
5. Remove the spark plug. Cover the spark plug hole with your thumb, and turn the engine over until the piston is at the top of its stroke. (Pressure against thumb is greatest.) Reinstall the plug, but do not connect the plug lead.
6. Store the engine in a clean, dry place.

Section 1

Safety and General Information

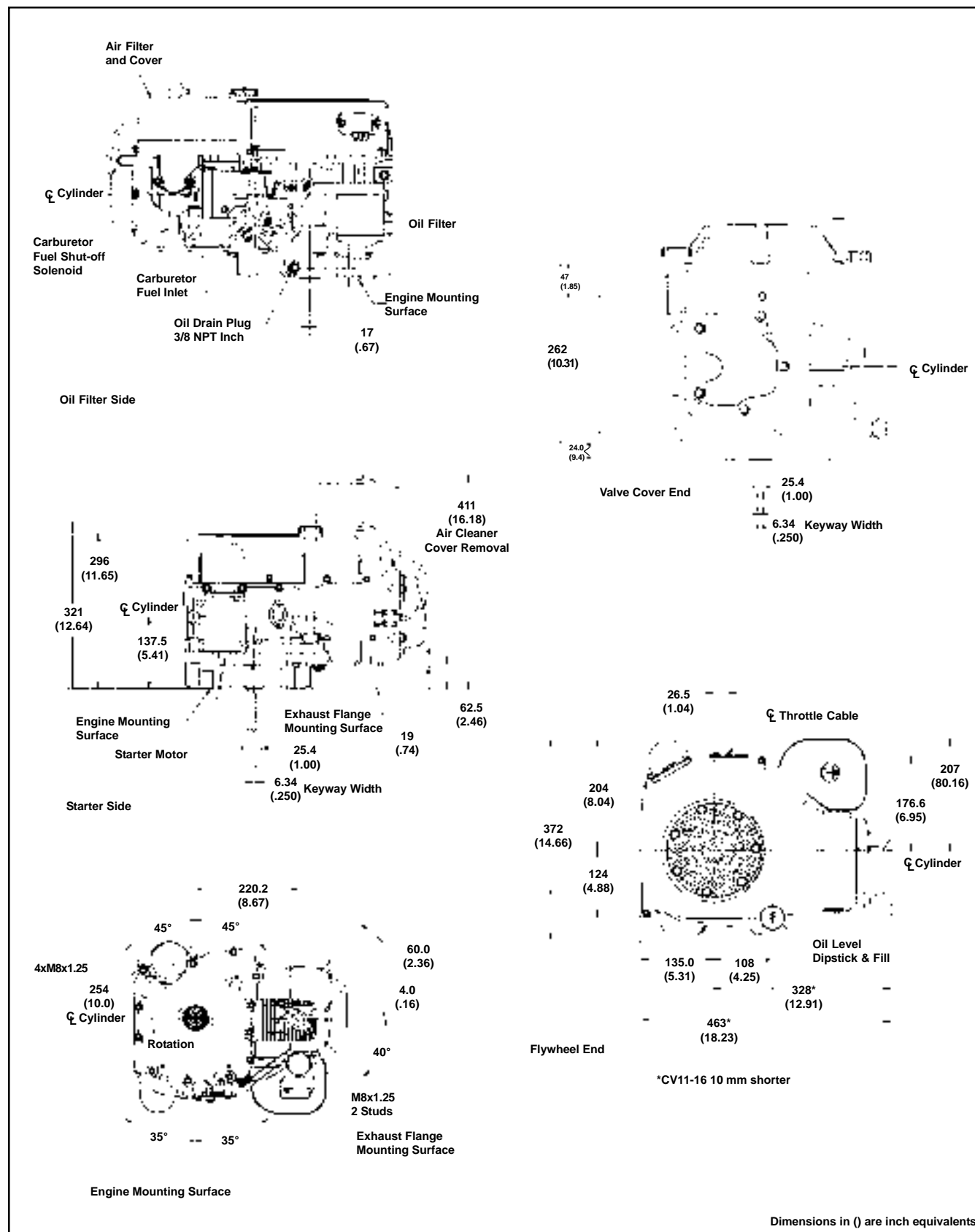


Figure 1-4. Typical Engine Dimensions.

Section 1

Safety and General Information

1

General Specifications¹

Power (@ 3600 RPM, corrected to SAE J1995)

CV11	8.2 kW (11 HP)
CV12.5	9.33 kW (12.5 HP)
CV13	9.75 kW (13 HP)
CV14	10.5 kW (14 HP)
CV15	11.19 kW (15 HP)
CV16	11.9 kW (16 HP)
CV460-465	11.9 kW (16 HP)-13.0 kW (16.5 HP)
CV490-495	12.7 kW (17 HP)-13.4 kW (18 HP)

Max Torque (@ RPM indicated)

CV11	27.4 N·m (20.2 ft. lb.) @ 2000
CV12.5	27.8 N·m (20.5 ft. lb.) @ 2500
CV13	27.8 N·m (20.5 ft. lb.) @ 2500
CV14	28.9 N·m (21.3 ft. lb.) @ 2500
CV15	33.2 N·m (24.5 ft. lb.) @ 2400
CV16	35.3 N·m (26.0 ft. lb.) @ 2400
CV460-465	36.3 N·m (26.8 ft. lb.) @ 2400
CV490-495	37.8 N·m (27.9 ft. lb.)-38.1 N·m (28.1 ft. lb.) @ 2400

Bore

CV11-14, CV460-465	87 mm (3.43 in.)
CV15, CV16, CV490-495	90 mm (3.60 in.)

Stroke

CV11-16	67 mm (2.64 in.)
CV460-465, CV490-495	77 mm (3.03 in.)

Displacement

CV11-14	398 cc (24.3 cu. in. ³)
CV15, CV16	426 cc (26.0 cu. in. ³)
CV460-465	460 cc (27.9 cu. in. ³)
CV490-495	490 cc (29.9 cu. in. ³)

Compression Ratio 8.5:1

Weight (approx.)

CV11-16	39.54 kg (87 lb.)
CV460-465, CV490-495	41.9 kg (90 lb.)

Oil Capacity (approx.) 1.9 L (2.0 U.S. qt.)

Air Cleaner

Base Nut Torque	9.9 N·m (88 in. lb.)
Wing Nut Torque	1.5 N·m (12 in. lb.)

Angle of Operation - Maximum (at full oil level)

Intermittent - All Directions	35°
Continuous - All Directions	20°

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

Section 1

Safety and General Information

Balance Shaft

End Play 0.0575/0.3625 mm (0.0027/0.0137 in.)

Running Clearance 0.0250/0.1520 mm (0.0009/0.0059 in.)

Bore I.D.

New 20.000/20.025 mm (0.7874/0.7884 in.)

Max. Wear Limit 20.038 mm (0.7889 in.)

Balance Shaft Bearing Surface O.D.

New 19.962/19.975 mm (0.7859/0.7864 in.)

Max. Wear Limit 19.959 mm (0.7858 in.)

Camshaft

End Play (free) 0.088/0.393 mm (0.003/0.015 in.)

End Play (with shims) 0.076/0.127 mm (0.003/0.005 in.)

Running Clearance 0.025/0.105 mm (0.0010/0.0041 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

Preliminary Low Idle Fuel Needle Setting 1 Turn

Fuel Bowl Retaining Screw Torque 5.1-6.2 N·m (45-55 in. lb.)

Connecting Rod

Cap Fastener Torque (torque in increments)

6 mm straight shank bolt 11.3 N·m (100 in. lb.)

8 mm step-down bolt 14.7 N·m (130 in. lb.)

8 mm straight shank bolt 22.7 N·m (200 in. lb.)

Connecting Rod-to-Crankpin Running Clearance at 21°C (70°F)

New 0.030/0.055 mm (0.0012/0.0022 in.)

Max. Wear Limit 0.07 mm (0.0025 in.)

Connecting Rod-to-Crankpin Side Clearance 0.18/0.41 mm (0.007/0.016 in.)

Connecting Rod-to-Piston Pin Running Clearance at 21°C (70°F) 0.015/0.028 mm (0.0006/0.0011 in.)

Piston Pin End I.D.

New 19.015/19.023 mm (0.7486/0.7489 in.)

Max. Wear Limit 19.036 mm (0.7495 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.)

Section 1

Safety and General Information

1

Crankshaft

End Play (free)	0.0575/0.4925 mm (0.0022/0.0193 in.)
End Play (thrust bearing with shims)	0.050/0.530 mm (0.0020/0.0209 in.)

Crankshaft Bore in Crankcase I.D.

New	44.965/44.990 mm (1.7702/1.7712 in.)
Max. Wear Limit	44.9758/45.0012 mm (1.7707/1.7717 in.)

Crankshaft Bore in Crankcase Running Clearance

New	0.0300/0.0770 mm (0.0011/0.0030 in.)
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Crankshaft Bore in Oil Pan I.D.

New	41.965/42.003 mm (1.6521/1.6536 in.)
Max. Wear Limit	41.9760/42.0141 mm (1.6526/1.6541 in.)

Crankshaft Bore in Oil Pan Running Clearance

New	0.0300/0.0880 mm (0.0011/0.0034 in.)
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Flywheel End Main Bearing Journal

O.D. - New	44.913/44.935 mm (1.7682/1.7691 in.)
O.D. - Max. Wear Limit	44.84 mm (1.765 in.)
Max. Taper	0.022 mm (0.0009 in.)
Max. Out-of-Round	0.025 mm (0.0010 in.)

Oil Pan End Main Bearing Journal

O.D. - New	41.915/41.935 mm (1.6502/1.6510 in.)
O.D. - Max. Wear Limit	41.86 mm (1.648 in.)
Max. Taper	0.020 mm (0.0008 in.)
Max. Out-of-Round	0.025 mm (0.0010 in.)

Connecting Rod Journal

O.D. - New	38.958/30.970 mm (1.5338/1.5343 in.)
O.D. - Max. Wear Limit	38.94 mm (1.5328 in.)
Max. Taper	0.012 mm (0.0005 in.)
Max. Out-of-Round	0.025 mm (0.0010 in.)

Crankshaft T.I.R.

PTO End, Crank in Engine	0.30 mm (0.012 in.)
Entire Crank, in V-Blocks	0.10 mm (0.0039 in.)

Cylinder Bore

Cylinder Bore I.D.

New	
CV11-14, CV460-465	87.000/87.025 mm (3.4252/3.4262 in.)
CV15, CV16, CV490-495	90.000/90.025 mm (3.5433/3.5443 in.)
Max. Wear Limit	
CV11-14, CV460-465	87.063 mm (3.4277 in.)
CV15, CV16, CV490-495	90.063 mm (3.5458 in.)
Max. Out-of-Round	0.12 mm (0.0047 in.)
Max. Taper	0.05 mm (0.0020 in.)

Section 1

Safety and General Information

Cylinder Head

Cylinder Head Fastener Torque (torque in 2 increments) 20, 40.7 N·m (15, 30 ft. lb.)

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

Rocker Pedestal Fastener Torque 11.3 N·m (100 in. lb.)

Electric Starter

Starter Thru Bolt Torque

UTE/Johnson Electric, Eaton (Inertia Drive) 4.5-5.7 N·m (40-50 in. lb.)

Nippendenso (Solenoid Shift) 4.5-7.5 N·m (40-84 in. lb.)

Delco-Remy (Solenoid Shift) 5.6-9.0 N·m (49-79 in. lb.)

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

Solenoid Mounting Hardware (Nut/Screw) Torque

Nippendenso Starter 6.0-9.0 N·m (53-79 in. lb.)

Delco-Remy Starter 4.0-6.0 N·m (35-53 in. lb.)

Brush Holder Mounting Screw Torque

Delco-Remy Starter 2.5-3.3 N·m (22-29 in. lb.)

Nut, Positive (+) Brush Lead Torque

Nippendenso Starter 8.0-12.0 N·m (71-106 in. lb.)

Delco-Remy Starter 6.0-9.0 N·m (53-79 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.)

Fuel Pump

Fuel Pump Fastener Torque 9.0 N·m (80 in. lb.) Into new as-cast hole
4.2-5.1 N·m (37-45 in. lb.) Into used hole

Fuel Pump Pad Cover Fastener Torque 10.7 N·m (95 in. lb.) Into new as-cast hole
7.3 N·m (65 in. lb.) Into used hole

Governor

Governor Cross Shaft to Crankcase Running Clearance 0.025/0.075 mm (0.0010/0.0030 in.)

Governor Cross Shaft O.D.

New 5.975/6.000 mm (0.2352/0.2362 in.)

Max. Wear Limit 5.962 mm (0.2347 in.)

Governor Gear Shaft-to-Governor Gear Running Clearance ... 0.050/0.160 mm (0.0019/0.0063 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 (Standard) or
Premium Gold 2071 (Pro Series)

Spark Plug Gap

CV11-15, CV460-465, CV490-495 1.02 mm (0.040 in.)

CV11-14 LP, CV16 0.76 mm (0.030 in.)

Section 1

Safety and General Information

1

Ignition (Cont'd)

Spark Plug Torque	24.4-29.8 N·m (18-22 ft. lb.)
Ignition Module Air Gap	0.200/0.300 mm (0.0078/0.0118 in.)
Ignition Module Fastener Torque	6.2 N·m (55 in. lb.) Into new as-cast hole 4.0 N·m (35 in. lb.) Into used hole

Muffler

Muffler Retaining Nuts	24.4 N·m (216 in. lb.)
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Oil Filter/Oil Pan

Oil Filter Torque	10.4-12.7 N·m (90-110 in. lb.)
Oil Filter Drain Plug (1/8" NPT) Torque	7.3-9.0 N·m (65-80 in. lb.)
Oil Pan Fastener Torque	24.4 N·m (216 in. lb.)
Oil Sentry™ Pressure Switch Torque	6.8 N·m (60 in. lb.)
Oil Pump Cover Fastener Torque	6.2 N·m (55 in. lb.) Into new as-cast hole 4.0 N·m (35 in. lb.) Into used hole

Piston, Piston Rings, and Piston Pin

Piston-to-Piston Pin (selective fit)	0.006/0.017 mm (0.0002/0.0007 in.)
Piston Pin Bore I.D.	
New	19.006/19.012 mm (0.7483/0.7485 in.)
Max. Wear Limit	19.025 mm (0.7490 in.)
Piston Pin O.D.	
New	18.995/19.000 mm (0.7478/0.7480 in.)
Max. Wear Limit	18.994 mm (0.74779 in.)
Top Compression Ring-to-Groove Side Clearance	
CV11-14, CV460-465	0.034/0.100 mm (0.0013/0.0039 in.)
CV15, CV16, CV490-495	0.060/0.105 mm (0.0023/0.0041 in.)
Middle Compression Ring-to-Groove Side Clearance	
CV11-14, CV460-465	0.040/0.080 mm (0.0016/0.0032 in.)
CV15, CV16, CV490-495	0.040/0.085 mm (0.0015/0.0033 in.)
Oil Control Ring-to-Groove Side Clearance	
CV11-14, CV460-465	0.036/0.186 mm (0.0014/0.0073 in.)
CV15, CV16, CV490-495	0.036/0.186 mm (0.0014/0.0073 in.)
Top Compression Ring End Gap	
New Bore	
CV11-14, CV460-465	0.250/0.500 mm (0.010/0.020 in.)
CV15, CV16, CV490-495	0.28/0.51 mm (0.011/0.020 in.)
Used Bore (max.)	0.79 mm (0.031 in.)

Section 1

Safety and General Information

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

Center Compression Ring End Gap

New Bore

CV11-14, CV460-465	0.250/0.510 mm (0.0010/0.020 in.)
CV15, CV16, CV490-495	0.22/0.48 mm (0.008/0.018 in.)
Used Bore (max.)	0.76 mm (0.030 in.)

Oil Control Ring End Gap

CV11-14, CV460-465	0.250/1.020 mm (0.010/0.040 in.)
CV15, CV16, CV490-495	0.250/0.760 mm (0.0098/0.0299 in.)

Piston Thrust Face O.D. (See Figure 10-4)

New

CV11-14, CV460-465	86.941/86.959 mm (3.4229/3.4236 in.)
CV15, CV16, CV490-495	89.951/89.969 mm (3.5413/3.5420 in.)

Max. Wear Limit

CV11-14, CV460-465	86.814 mm (3.4179 in.)
CV15, CV16, CV490-495	89.824 mm (3.5363 in.)

Piston Thrust Face (See Figure 10-4)-to-Cylinder Bore Running Clearance - New

CV11-14, CV460-465	0.041/0.044 mm (0.0016/0.0017 in.)
CV15, CV16, CV490-495	0.031/0.043 mm (0.0012/0.0016 in.)

Retractable Starter

Center Screw Torque	7.4-8.5 N·m (65-75 in. lb.)
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Stator

Stator Mounting Screw Torque	6.2 N·m (55 in. lb.)
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Throttle/Choke Controls

Governor Control Lever Fastener Torque	9.9 N·m (88 in. lb.)
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Speed Control Bracket Assembly Fastener Torque	10.7 N·m (95 in. lb.) Into new as-cast hole
	7.3 N·m (65 in. lb.) Into used hole

Valve Cover/Rocker Arms

Valve Cover Fastener Torque	10.7 N·m (95 in. lb.) Into new as-cast hole
	7.3 N·m (65 in. lb.) Into used hole

Rocker Arm I.D.

New	15.837/16.127 mm (0.63/0.64 in.)
Max. Wear Limit	16.13 mm (0.640 in.)

Rocker Shaft O.D.

New	15.90/15.85 mm (0.63 in.)
Max. Wear Limit	15.727 mm (0.619 in.)

Non-Adjustable Valve Lash Configuration

Rocker Arm Screw Torque	11.3 N·m (100 in. lb.)
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Adjustable Valve Lash Configuration

Rocker Arm Pivot Stud Torque	11.3 N·m (100 in. lb.)
Adjustment Set Screw Torque	7.3 N·m (65 in. lb.)

Section 1

Safety and General Information

1

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.)

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

STD 7.048 mm (0.2775 in.)

0.25 mm O.S. 7.298 mm (0.2873 in.)

Intake Valve Minimum Lift 8.96 mm (0.353 in.)

Exhaust Valve Minimum Lift 9.14 mm (0.360 in.)






Nominal Valve Seat Angle 45°






Section 1

Safety and General Information

General Torque Values

Metric Fastener Torque Recommendations for Standard Applications

Tightening Torque: N·m (in. lb.) + or - 10%						
	Property Class					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					Noncritical Fasteners Into Aluminum
Size						
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)

Oil Drain Plugs Tightening Torque: N·m (English Equiv.)

Size	Into Cast Iron	Into Aluminum
1/8" NPT	—	4.5 (40 in. lb.)
1/4"	17.0 (150 in. lb.)	11.3 (100 in. lb.)
3/8"	20.3 (180 in. lb.)	13.6 (120 in. lb.)
1/2"	27.1 (20 ft. lb.)	17.6 (13 ft. lb.)
3/4"	33.9 (25 ft. lb.)	21.7 (16 ft. lb.)
X-708-1	27.1/33.9 (20/25 ft. lb.)	27.1/33.9 (20/25 ft. lb.)

Torque Conversions

$N \cdot m = \text{in. lb.} \times 0.113$
 $N \cdot m = \text{ft. lb.} \times 1.356$
 $\text{in. lb.} = N \cdot m \times 8.85$
 $\text{ft. lb.} = N \cdot m \times 0.737$

Section 2

Special Tools

2

Kohler Special Service Tools

Kohler Co. has made an agreement with the Service Tools Div. of SPX Corp. (a subsidiary of Owatonna Tool Corp.) to handle our special service tools. The intent of this program is to provide you with a single source for all Kohler special tools, and to make it easy and convenient to obtain those tools, at reasonable cost. Tool orders can be placed with SPX by any of three methods. Mail orders should be sent to: OTC/SPX Corp., 655 Eisenhower Dr., Owatonna, MN 55060. You can also fax the order to (800) 578-7375 (USA and Canada) or (507) 455-7063 (International). Finally, you can order by phone at (800) 533-0492 (USA and Canada) or (507) 455-7223 (International).

Repair 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.

Tool Kit No. KO3211A—This basic tool kit includes tools necessary to service Kohler K-Series and Magnum engines.

COMMAND Tool Kit No. KO3213—This kit is designed for the current Kohler Engine Service Dealer already having the KO3211A basic tool kit. This kit includes all additional tools necessary to service current Command series engines.

COMMAND Tool Kit No. KO3214—This kit is for the new Kohler Dealer servicing the Command series engines *only*.

RTV Silicone Sealant

RTV silicone sealant is used as a gasket between the crankcase and closure plate, and between the valve cover and head. The recommended sealant is Loctite® 5900, available under Kohler Part No. 25 597 07-S. Prepare the sealing surfaces of the crankcase and closure plate as directed by the sealant manufacturer or refer to Service Bulletin 252.

Section 2

Special Tools

Diagnostic and Repair Tools

The tools listed in the following table are used for specific diagnosis or repair procedures, as described. Order from SPX Corp.

Description	SPX Part No.
Hydraulic Lifter Tool Designed to remove and install hydraulic lifters	KO1044
Ignition Tester Used for testing output on capacitive discharge (CD) ignition systems	KO1046
Ignition Tester Used for testing output on all other systems, except CD	KO1047
Water Manometer Used for testing crankcase vacuum and exhaust back pressure	KO1048
Inductive Tachometer Used for checking the operating speed (RPM) of an engine	KO3216
Ammeter Set Used for checking current flow in charging and cranking circuits	KO3218
Cylinder Leakdown Tester Used for checking combustion retention and if cylinder, piston, rings, or valves are worn	KO3219
Oil Pressure Test Kit Used to test/verify oil pressure on pressure lubricated engines	KO3220
Electric Starter Service Kit Used to service all electric starters, including solenoid shift	KO3226
Electric Starter Service Kit Used to remove and reinstall drive retainers on most inertia drive starters	KO1049
Rectifier-Regulator Tester Used for testing rectifier-regulators	KO3221
Spark Advance Module Tester Used to test the SAM on engines with Smart Spark	KO3222
Vacuum/Pressure Tester Used like the water manometer but easier to operate, transport, and maintain	KO3223
Spanner Wrench Used for installing push rods or rotating crankshaft	OEM6200
Engine Analysis Kit Used for testing running conditions of Kohler engines in applications	KO1000A

Section 2

Special Tools

2

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 2-1. 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 module bosses on the crankcase, so 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.

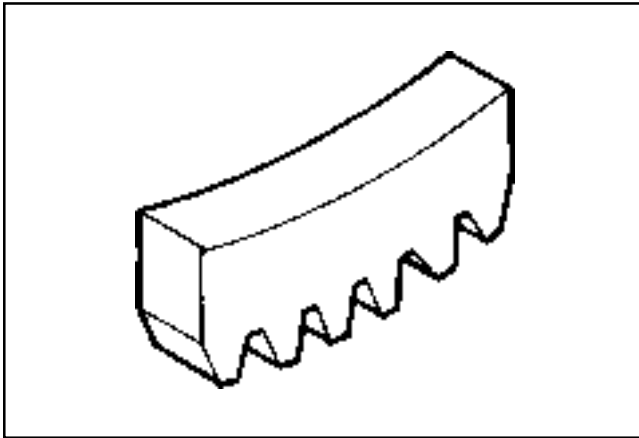


Figure 2-1. Flywheel Holding Tool.

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-S 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 2-2.

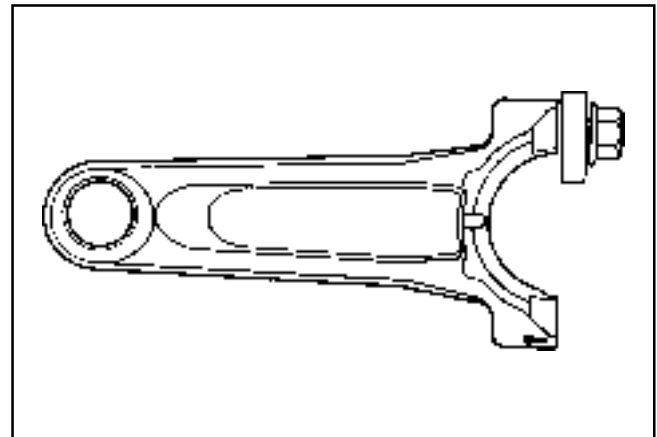


Figure 2-2. Rocker Arm/Crankshaft Tool.

Section 2

Special Tools

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 shut-off 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 plug.
8. Faulty ignition module.

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 carburetor.
6. Faulty cylinder head gasket.

Engine 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 plug.
7. Low compression.
8. Faulty ACR mechanism.

Engine Will Not Crank

1. PTO drive is engaged.
2. Battery (if equipped) 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 (if equipped).
7. Retractable starter not engaging in drive cup.
8. 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 that intermittently short the kill terminal of ignition module to ground.
4. Engine overheated.
5. Faulty ignition module.

Engine Will Not Idle

1. Restricted fuel tank cap vent.
2. Dirt or water in the fuel system.
3. Faulty spark plug.
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.

Engine Knocks

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

Section 3

Troubleshooting

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 plug.
 8. Low compression.
 9. Exhaust restriction.
- 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.

Engine Uses Excessive Amount Of Oil

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

Sludge is a natural by-product of combustion; a small accumulation is normal. Excessive sludge deposits could indicate the oil has not been changed at the recommended intervals, incorrect type or weight of oil was used, overrich carburetion, or weak ignition, to name a few.

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 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.

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.

Section 3

Troubleshooting

3

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 or vacuum/pressure test gauge. See Section 2. Complete instructions are provided with the testers.

Test the crankcase vacuum with the manometer as follows:

1. Insert the rubber stopper into the oil fill hole. Be sure the pinch clamp is installed on the hose and use the tapered adapters to connect the hose between the stopper and one of the manometer tubes. Leave the other tube open to the atmosphere. Check that the water level in the manometer is at the "0" line. Make sure the pinch 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.

To perform the test with the vacuum/pressure gauge, insert the stopper as in step 1. Insert the barbed gauge fitting into the hole in the stopper. Be sure the gauge needle is at "0". Run the engine, as in step 2, and observe the gauge reading. Needle movement to the left of "0" is a vacuum, and movement to the right indicates a pressure.

Incorrect Vacuum 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 with cylinder leakdown test.	3. Recondition piston, rings, cylinder bore, valves, and valve guides.
4. Restricted exhaust.	4. Repair/replace restricted muffler/exhaust system.

Section 3

Troubleshooting

Compression Test

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 below.

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.

The tester listed on page 2.2 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 the engine.
3. Rotate the crankshaft until the piston is at top dead center (TDC) of the 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, align the slot/hole with one of mounting hold on the PTO face, and tighten it onto the crankshaft. Install a 3/8" breaker bar into the slot or square hole of the holding tool, so it is perpendicular to both the holding tool and crankshaft PTO, or insert a shoulder bolt through the slot and thread it into the mounting hole. 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 adequate air source 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. 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.

Go Back

Section 4

Air Cleaner and Air Intake System

4

Air Cleaner

These engines are equipped with a replaceable, high density paper air cleaner element and most also have the optional oiled, foam precleaner which surrounds the paper element.

Two basic types of air cleaners are used. The original configuration is shown in Figure 4-1 and the later configuration in Figure 4-2. On the original style, air is drawn through a duct from the blower housing and from the outside slot. The later type uses a flat base plate with the enclosure provided by the cover.

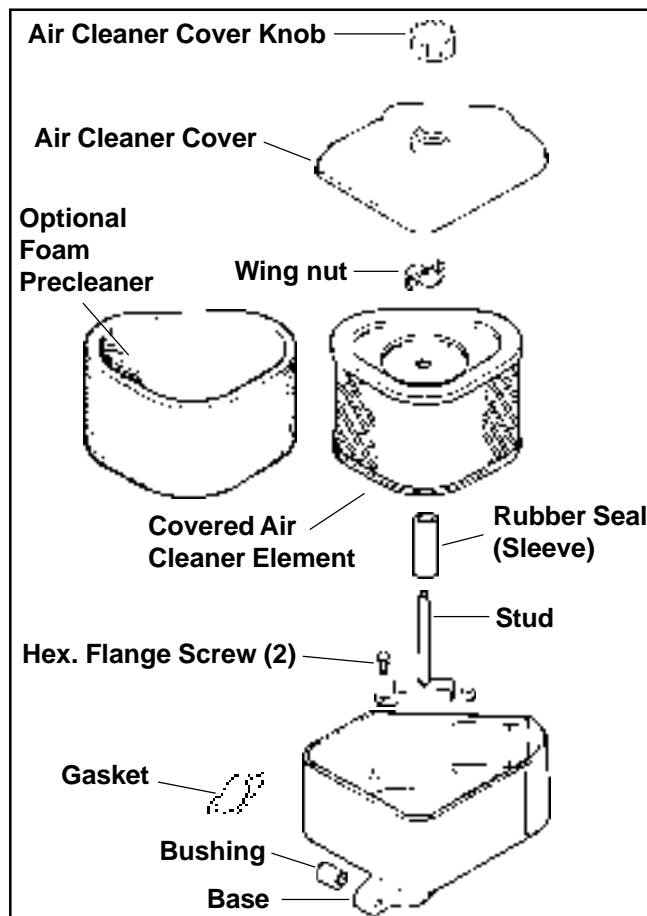


Figure 4-1. Original Air Cleaner Assembly - Exploded View.

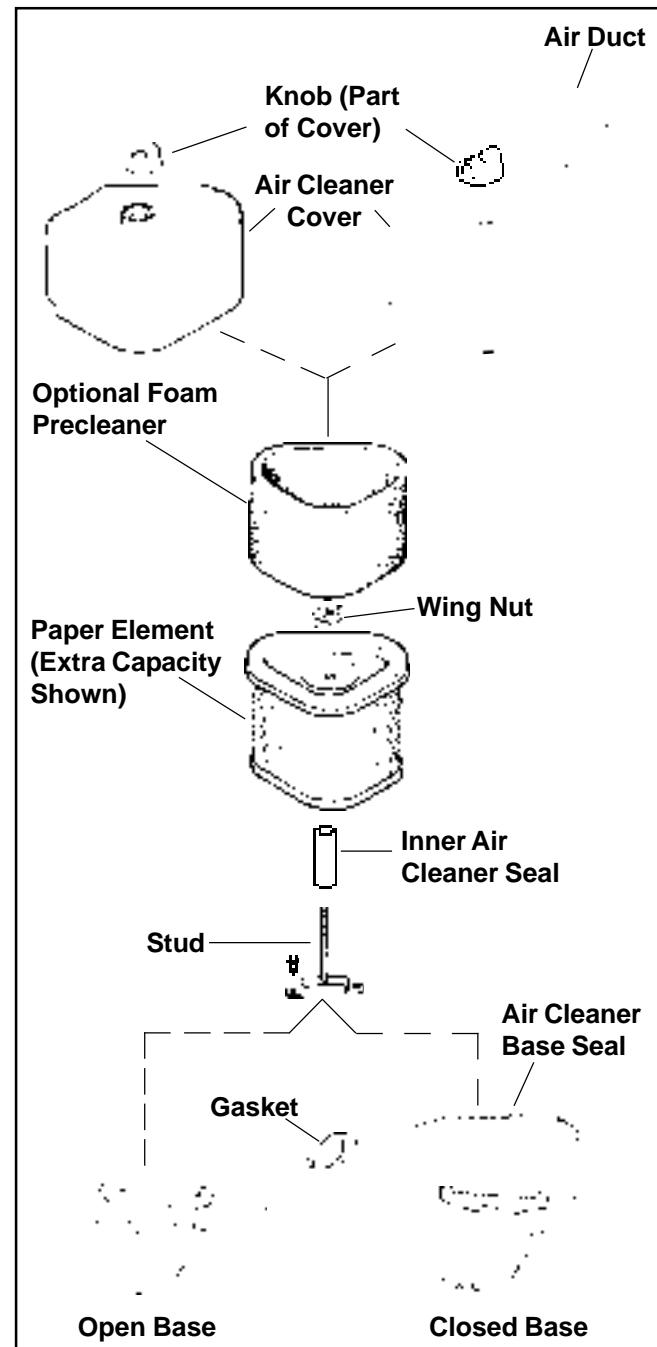


Figure 4-2. Later Style Air Cleaner Assemblies - Exploded View.

Section 4

Air Cleaner and Air Intake System

On these, air is drawn in around the bottom of the cover, or from the blower housing, rather than from slots. The flat base allows debris to be brushed away before the paper element is removed. All types can use either the standard size element or a higher, extra capacity paper element.

The original type uses a separate cover retaining knob which has to be turned completely off to remove the cover. With the later style, the knob snaps into the cover and is turned counterclockwise until it disengages the stud. Other differences are pointed out in the exploded views.

Service

Check the air cleaner **daily or before starting the engine**. Check for and correct any buildup of dirt and debris, and 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.

Precleaner Service

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

1. Remove the precleaner from the paper element.
2. 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.
3. Saturate the precleaner with new engine oil. Squeeze out all excess oil.
4. Reinstall the precleaner over the paper element.
5. Reinstall air cleaner cover and tighten the retaining knob.

Paper Element Service

Every **100 hours** of operation (more often under extremely dusty or dirty conditions), check the paper element. Clean or replace the element as necessary.

1. Remove the wing nut and air cleaner element.
2. Remove the precleaner (if so equipped) from the paper element.

3. Gently tap the flat side of the paper element to dislodge dirt. **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.
4. Inspect the rubber seal (sleeve) on the stud. If it is worn, damaged, or questionable, replace it. A new seal comes packed with each replacement element.
5. Reinstall the precleaner, paper element, wing nut, and air cleaner cover. Make sure the knob is tightened securely.

Inspect Air Cleaner Components

Whenever the air cleaner cover is removed, or the paper element or precleaner are serviced, check the following areas/components:

Air Cleaner Base - Make sure the base is secured and not cracked or damaged. Since the air cleaner base and carburetor are secured to the intake port with common hardware, it is extremely important that the nuts securing these components are tight at all times.

Before reinstalling an air cleaner base that has been removed, make sure the metal bushings in the base mounting holes are present. See Figure 4-3. The bushings prevent damage to the base and maintain the proper mounting torque.

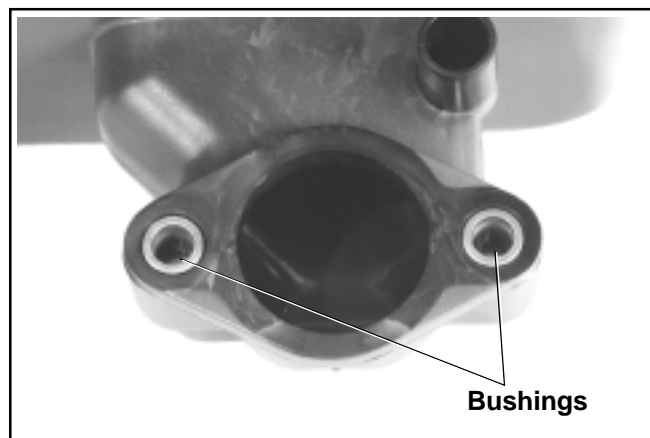


Figure 4-3. Bushings in Air Cleaner Base.

Breather Tube - Make sure the tube is attached to both the air cleaner base and valve 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.

Disassembly

The following procedure is for complete disassembly of all air cleaner components.

1. Loosen the air cleaner cover retaining knob and remove the air cleaner cover.
2. Remove the wing nut and air cleaner element.
3. If so equipped, remove the precleaner from the paper element.
4. Disconnect the breather hose from the air cleaner base.
5. Remove the air cleaner base mounting nuts, air cleaner base, and gasket.
6. If necessary, remove the self-tapping screws and stud from the air cleaner base.

Reassembly

The following procedure is for complete assembly of all air cleaner components.

1. Install the stud and self-tapping screws to the air cleaner base.
2. Install the gasket, air cleaner base, and base mounting nuts. Torque the nuts to **9.9 N·m (88 in. lb.)**.
3. Connect the breather hose to the air cleaner base and valve cover. Secure with hose clamps.
4. If so equipped, install the precleaner (washed and oiled) over the paper element.
5. Install the air cleaner element and wing nut. Thread the wing nut on the stud until it contacts the metal cap on the element, then tighten an additional 1/2-1 turn.
6. Install the air cleaner cover. Tighten the knob securely.

Air Intake/Cooling System

Clean Air Intake/Cooling Areas

To ensure proper cooling, make sure the grass screen, 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, 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.

Air Intake Filter (Optional)

Some engines used under extremely dusty conditions such as floor buffer applications are equipped with a foam air filter which fits over the retractable starter. The filter is held in place by velcro studs affixed to the starter cover. This filter must be checked daily before each start and frequently during operation. It should be serviced whenever wax, dust, or dirt builds up on its surface. If it becomes clogged, the engine can not receive sufficient cooling air and will overheat.

To service, peel the filter loose from the velstuds, lift the filter and carefully work the recoil starter handle through the hole in filter. Clean the filter in soap and warm water, rinse, squeeze out excess water and allow it to air dry. If time will not permit air drying, keep a spare filter on hand (Kohler Part No. 12 050 02-S). When reinstalling, make sure the foam filter seals against the blower housing around its base and is securely attached to the velstuds.

Section 4

Air Cleaner and Air Intake System

Section 5

Fuel System and Governor

5

Gasoline fuel systems are covered in the first part of this section. LPG (liquefied propane gas) systems and the Kohler Emission Sentry™ LPG system are covered starting on page 5.11. The governor systems start on page 5.14.

Fuel Recommendations (Gasoline)



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 (Gasoline)

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 insure easy starting.

Do not add oil to the gasoline.

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

Fuel Type (Gasoline)

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 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 System (Gasoline)

The typical fuel system includes the fuel tank, in-line fuel filter, fuel pump, carburetor, and fuel lines. Some applications use gravity feed without a fuel pump.

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 and gravity moves the fuel.

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.

Troubleshooting

Use the following procedure to check for a suspected fuel delivery problem.

Section 5

Fuel System and Governor

Fuel System Troubleshooting Guide (Gasoline)

Test	Conclusion
1. Check for the following: <ol style="list-style-type: none"> Make sure the fuel tank contains clean, fresh, proper fuel. Make sure the vent in fuel cap is open. Make sure the fuel valve is open. 	
2. Check for fuel in the combustion chamber. <ol style="list-style-type: none"> Disconnect and ground spark plug lead. Close the choke on the carburetor. Crank the engine several times. 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. <ol style="list-style-type: none"> Remove the fuel line from the inlet fitting of the fuel pump. 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, reconnect line and check for faulty fuel pump (Test 4). If fuel does not flow from the line, check for clogged fuel tank vent, fuel pickup screen, shutoff valve, and fuel lines.
4. Check the operation of fuel pump. <ol style="list-style-type: none"> Remove the fuel line from the inlet fitting of the carburetor. 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.

Fuel Filter

Some engines are equipped with an in-line fuel filter. Visually inspect the filter periodically, and replace when dirty with a genuine Kohler filter.

Fuel Pump

Some engines are equipped with an optional mechanical fuel pump.

The fuel pump body is constructed of nylon. The nylon body insulates the fuel from the engine crankcase. This prevents the fuel from vaporizing inside the pump.

Operation

The mechanical pump is operated by a lever which rides on the engine camshaft. The lever transmits a pumping action to the diaphragm inside the pump body. On the downward stroke of the diaphragm, fuel is drawn in through the inlet check valve. On the upward stroke of the diaphragm, fuel is forced out through the outlet check valve. See Figure 5-1.

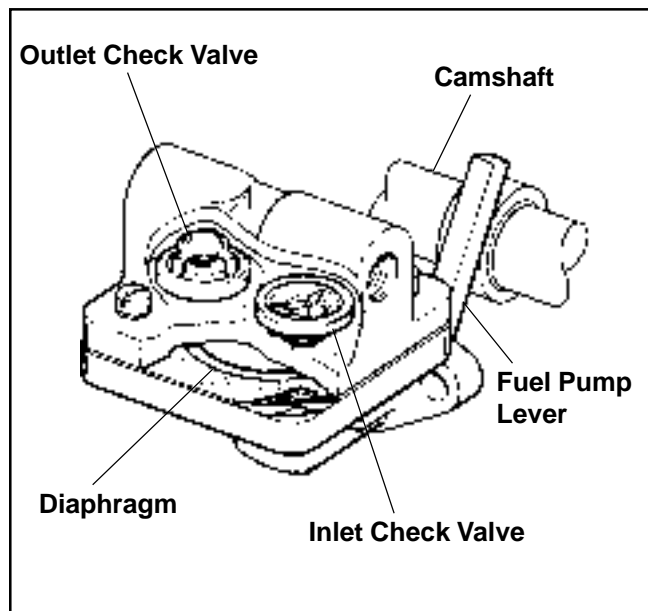


Figure 5-1. Cutaway - Typical Fuel Pump.

Section 5

Fuel System and Governor

5

Repair

Nylon-bodied fuel pumps are not serviceable and must be replaced when faulty. Replacement pumps are available in kits that include the pump and mounting gasket.

Removal

1. Disconnect the fuel lines from the inlet and outlet fittings of the pump.
2. Remove the hex. flange screws, fuel pump, and gasket.
3. If necessary, remove the fittings from the pump body.

Installation

1. **Fittings** - Apply a small amount of Permatex® Aviation Perm-A-Gasket (or equivalent) gasoline resistant thread sealant to the threads of the fittings. Turn the fittings into the pump **5 full turns**; continue turning the fittings in the same direction until the desired position is reached.
2. Install new gasket, fuel pump, and hex. flange screws.

NOTE: Make sure the fuel pump lever is positioned to the **right** of the camshaft (when looking at fuel pump mounting pad). Damage to the fuel pump, and severe engine damage, could result if the lever is positioned to the left of the camshaft.

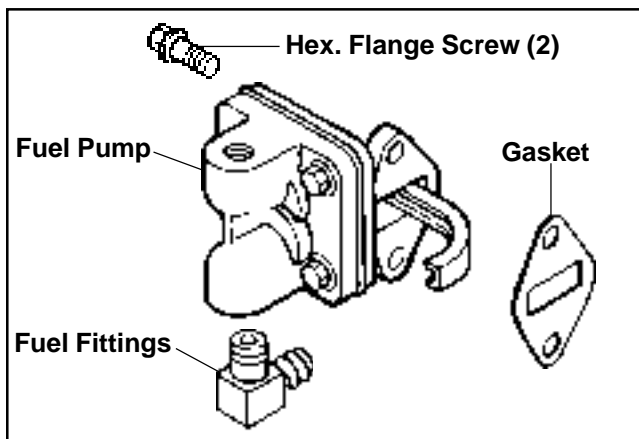


Figure 5-2. Installing Fuel Pump.

3. Torque the hex. flange screws as follows:

Into new as-cast hole—**9.0 N·m (80 in. lb.)**.

Into used hole—**4.2-5.1 N·m (37-45 in. lb.)**.

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

Carburetor (Gasoline)

These engines are equipped with one of two basic types of fixed main jet carburetors—Walbro or Nikki. See Figure 5-3.

Walbro carburetors have a low idle speed screw and a low idle fuel adjusting needle. Nikki carburetors only have a low idle speed screw. Certified carburetors will have fixed idle fuel or a limiter cap on the idle fuel adjusting needle.

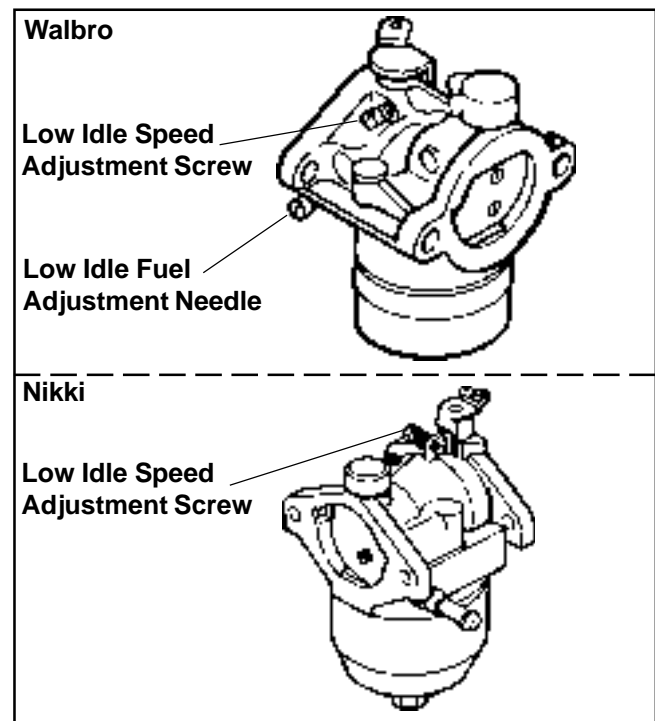


Figure 5-3. Carburetor Adjustment.



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.

Section 5

Fuel System and Governor

Troubleshooting - Gasoline Systems

If engine troubles are experienced that appear to be fuel system related, 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, after checking the items listed above, starting problems or conditions similar to those listed in the following table exist, it may be necessary to adjust or service the carburetor.

Troubleshooting - Gasoline Fuel Systems Carburetor

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 screw, 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. Choke partially closed during operation. Check the choke lever/linkage to ensure choke is operating properly. b. Low idle fuel mixture is improperly adjusted. Adjust low idle fuel needle. c. Float level is set too high. With fuel bowl removed and carburetor inverted, the exposed surface of float must be parallel with the bowl gasket surface of the carburetor body. d. Dirt under fuel inlet needle. Remove needle; clean needle and seat and blow with compressed air. e. Bowl vent or air bleeds plugged. Remove fuel bowl, low idle fuel adjusting needle, and welch plugs. Clean vent, ports, and air bleeds. Blow out all passages with compressed air. f. Fuel bowl gasket leaks. Remove fuel bowl and replace gasket. 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 set too low. With fuel bowl removed and carburetor inverted, the exposed surface of float must be parallel with the bowl gasket surface of the carburetor body. c. Idle holes plugged; dirt in fuel delivery channels. Remove fuel bowl, low idle fuel adjusting needle, and welch plugs. Clean main fuel jet and all passages; blow out with compressed air.
4. Fuel leaks from carburetor.	4a. Float level set too high. See Remedy 2c. b. Dirt under fuel inlet needle. See Remedy 2d. c. Bowl vent plugged. Remove fuel bowl and clean bowl vent. Blow out with compressed air. d. Float is cracked or damaged. Replace float. e. Bowl retaining screw gasket damaged. Replace gasket. f. Bowl retaining screw loose. Torque screw to specifications.

Section 5

Fuel System and Governor

Adjustment

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

The carburetor is designed to deliver the correct fuel-to-air mixture to the engine under all operating conditions. The main fuel jet is calibrated at the factory and is not adjustable*. The idle fuel adjusting needle is also set at the factory and normally does not need adjustment.

*NOTE: Engines operating at altitudes above approximately 1830 m (6000 ft.) may require a special "high altitude" main jet. Refer to "High Altitude Operation" later in this section.

If, however, the engine is hard-starting or does not operate properly, it may be necessary to adjust or service the carburetor.

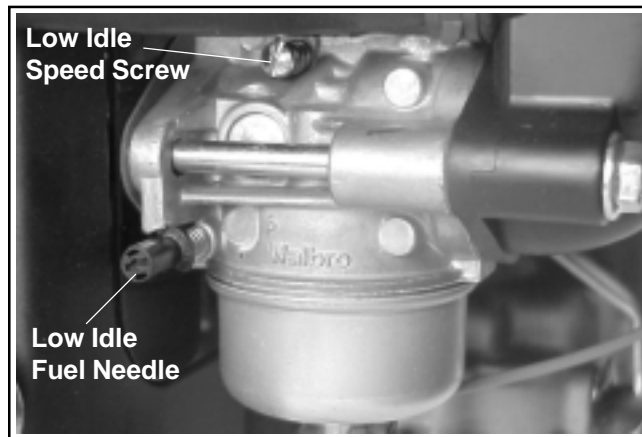


Figure 5-4. Fixed Main Jet Carburetor.

Walbro Carburetor Adjustment

NOTE: Certified engines may have a fixed idle or limiter cap on the idle fuel adjusting needle. Step 2 can only be performed within the limits allowed by the cap.

1. Start the engine and run at half throttle for 5 to 10 minutes to warm up. The engine must be warm before doing step 2.
2. **Low Idle Fuel Needle Setting:** Place the throttle into the "idle" or "slow" position.

Turn the low idle fuel adjusting needle out (counterclockwise) from the preliminary setting until engine speed decreases (rich). Note the position of the needle.

Now turn the adjusting needle in (clockwise). The engine speed may increase, then it will decrease as the needle is turned in (lean). Note the position of the needle.

Set the adjusting needle midway between the rich and lean settings. See Figure 5-5.

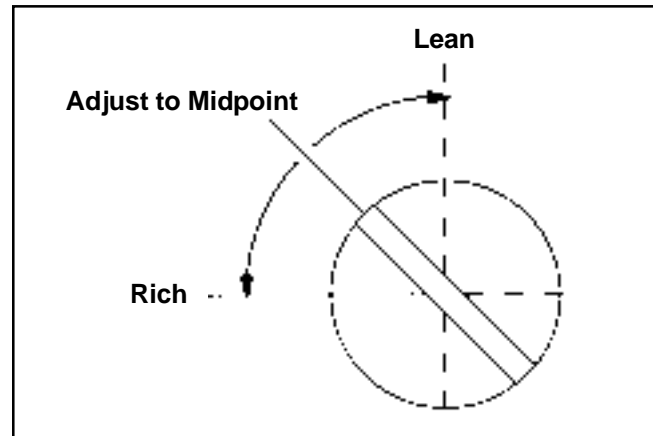


Figure 5-5. Optimum Low Idle Fuel Setting.

Nikki Carburetor Adjustment

NOTE: Certified engines have the idle mixture preset and sealed at the factory. No adjustment is possible.

Low Idle Speed Setting

1. Start the engine and run at half throttle for 5 to 10 minutes to warm up. The engine must be warm before doing step 2.
2. **Low Idle Speed Setting:** Place the throttle control into the "idle" or "slow" position. Set the low idle speed to **1200 RPM*** (± 75 RPM) by turning the low idle speed adjusting screw **in or out**. Check the speed using a tachometer.

*NOTE: The actual low idle speed depends on the application—refer to equipment manufacturer's recommendations. The recommended low idle speed for basic engines is 1200 RPM. To ensure best results when setting the low idle fuel needle, the low idle speed must not exceed 1200 RPM (± 75 RPM).

Section 5

Fuel System and Governor

Disassembly

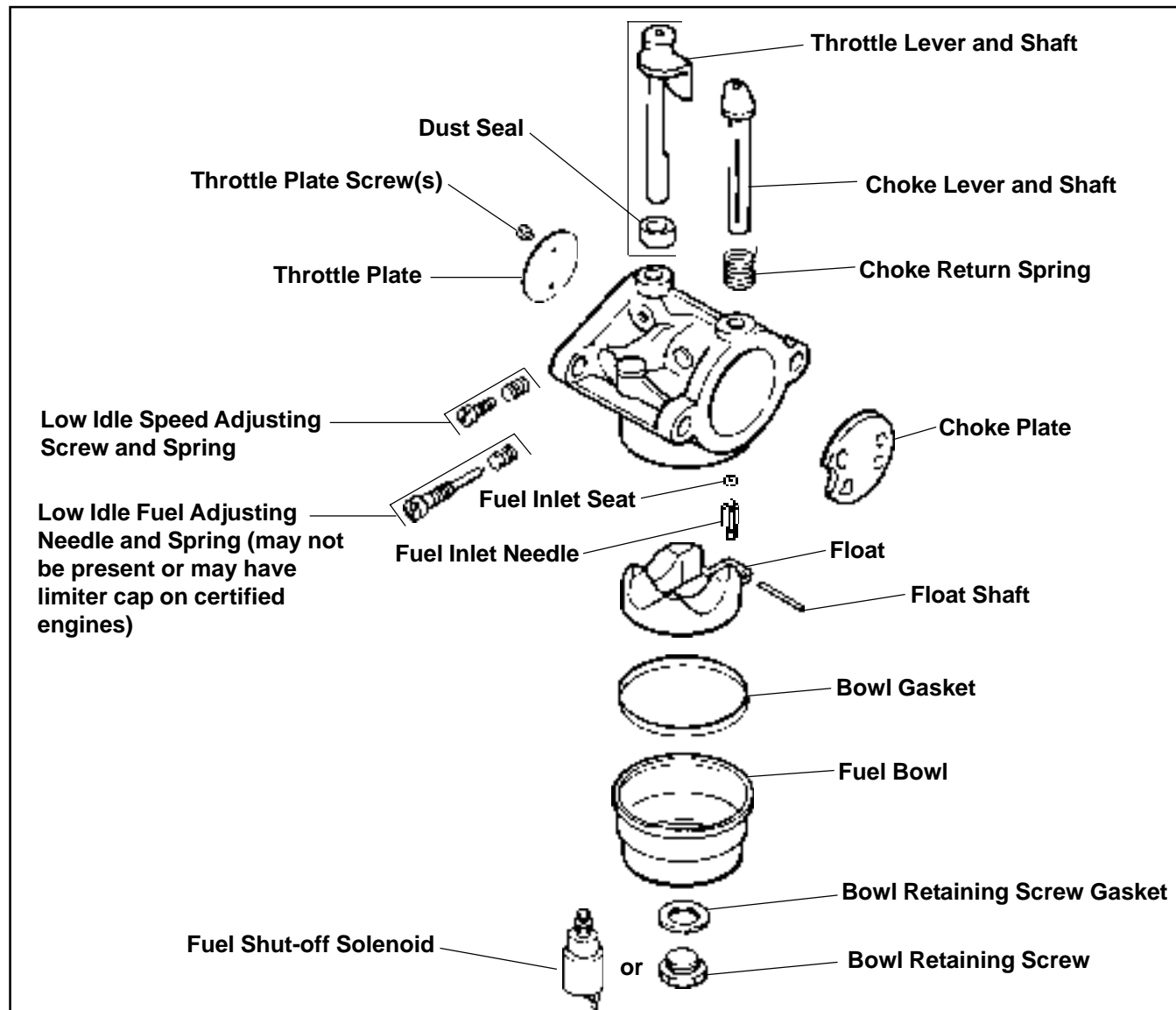


Figure 5-6. Carburetor - Exploded View.

1. Remove the bowl retaining screw, retaining screw gasket, and fuel bowl.
2. Remove the bowl gasket, float shaft, float, and fuel inlet needle.
3. Remove the low idle speed screw and spring. If there is a low fuel adjusting needle without a limiter cap, remove the needle and spring. **Do not** attempt to remove the needle if it has a limiter cap.

Further disassembly to remove the welch plugs, main fuel jet, fuel inlet seat, throttle plate and shaft, and choke plate and shaft is recommended only if these parts are to be cleaned or replaced.

Welch Plug Removal—Walbro Carburetors

In order to clean the idle ports and bowl vent thoroughly, remove the welch plugs covering these areas.

Use Tool No. **KO1018** and the following procedure to remove the welch plugs. See Figure 5-7.

1. Pierce the welch plug with the tip of the tool.

NOTE: To prevent damage to the carburetor, do not allow the tool to strike the carburetor body.

2. Pry out the welch plug with the tip of the tool.

Section 5

Fuel System and Governor

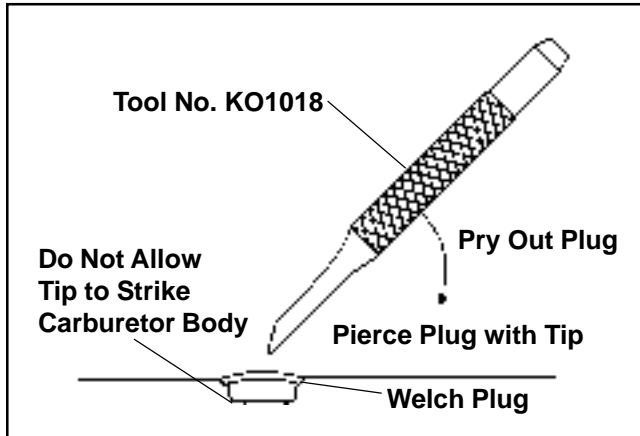


Figure 5-7. Removing Welch Plug.

Main Fuel Jet Removal

The main jet on Walbro carburetors is pressed into the side of the tower portion of the body. Removal is not recommended, unless a high-altitude kit is being installed, in which case the removal instructions will be included in the kit.

The main jet on Nikki carburetors is threaded into the tip of the fuel shut-off solenoid. It can be removed for inspection or cleaning.

Fuel Inlet Seat Removal

The fuel inlet seat is pressed into the carburetor body, **do not** attempt to remove it. If necessary, clean it in place with aerosol carburetor cleaner.

Choke Shaft Removal (Non-Self-Relieving)

1. Because the edges of the choke plate are beveled, mark the choke plate and carburetor body to ensure correct reassembly. See Figure 5-8.

Also take note of the choke plate position in bore, and the position of the choke lever and choke return spring.

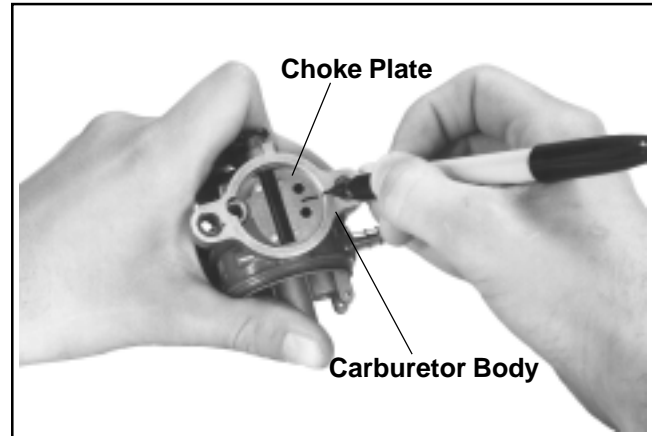


Figure 5-8. Marking Choke Plate and Carburetor Body.

2. Some carburetors have the choke plate inserted into a slot in the choke shaft. Grasp the choke plate with a pliers and pull it out of the slot. See Figure 5-9. Other carburetors will have the choke plate fastened to the shaft with screws. Carefully remove the screws and separate the plate from the shaft. Use a fine-toothed file to remove any burrs from the shaft.

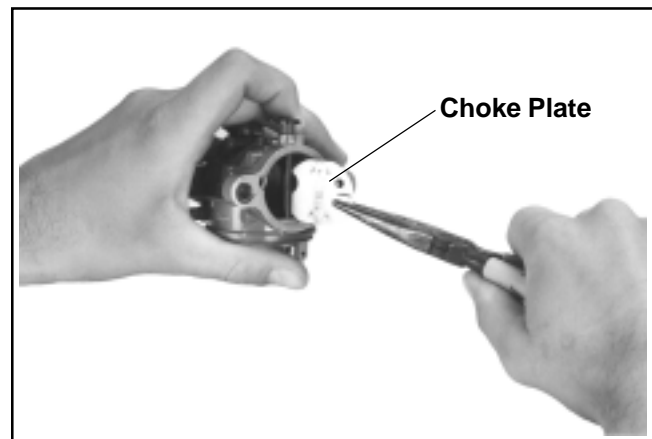


Figure 5-9. Removing Choke Plate.

3. Remove the choke shaft and choke return spring.

Choke Shaft Removal (Self-Relieving)

The self-relieving choke, used on some carburetors is shown in cutaway Figure 5-10. Use the following procedure to replace the self-relieving choke components using Choke Repair Kit No. 12 757 11-S.

Section 5

Fuel System and Governor

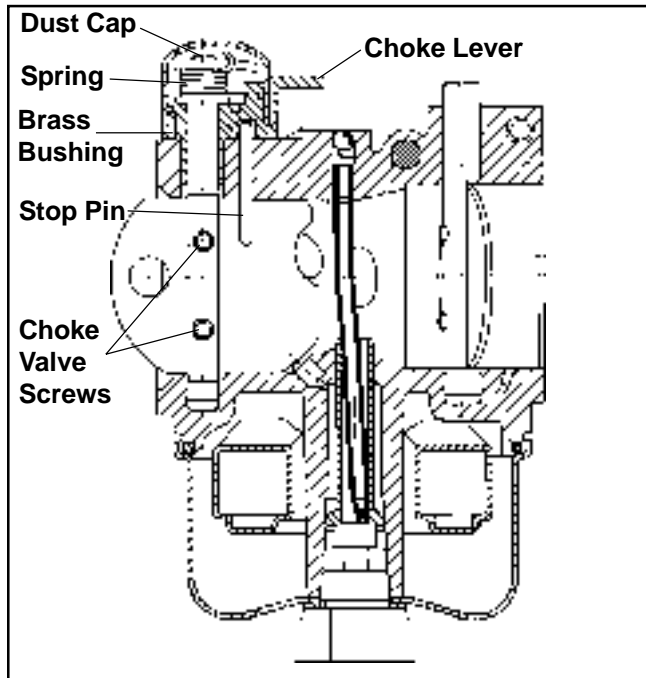


Figure 5-10. Cutaway View Showing Self-Relieving Choke Carburetor.

Removing Old Parts

1. Remove the black dust cover. This cover snaps on and off.
2. Remove and discard the two screws fastening the choke plate to the choke shaft.
3. Remove and discard the choke plate and choke shaft from the carburetor.
4. Remove the upper brass bushing using one of the following procedures:
 - a. Use a slide hammer type bearing puller.
 - b. Use a #3 (for 5/32 dia. hole) screw extractor. Secure extractor in a vise. Turn carburetor on to the extractor. While pulling on the carburetor, lightly tap the carburetor casting with a hammer or use a size 12-28 tap if a #3 screw extractor is not available.

Throttle Shaft Removal

Do not attempt to remove the throttle shaft, as repair kits are not available. Throttle shaft wear is normally accompanied by corresponding wear to the carburetor body, making it impractical to attempt a cost-effective repair. Replace the entire carburetor if the throttle shaft is worn.

Cleaning



WARNING: 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.

All parts should be cleaned thoroughly using a commercial carburetor cleaner. Make sure all gum deposits are removed from the following areas.

- **Carburetor body and bore;** especially the areas where the throttle plate, choke plate and shafts are seated.
- **Idle fuel and idle ports in carburetor bore, main jet, bowl vent, and fuel inlet needle and seat.**
- **Float and float hinge.**
- **Fuel bowl.**
- **Throttle plate, choke plate, throttle shaft, and choke shaft.**

NOTE: Do not submerge the carburetor in cleaner or solvent when fiber, rubber, or foam seals or gaskets are installed. The cleaner may damage these components.

Inspection

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 pin 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.
- Inspect the throttle and choke shaft and plate assemblies for wear or excessive play.

Section 5

Fuel System and Governor

Repair

Always use new gaskets when servicing or reinstalling carburetors. Repair kits are available which include new gaskets and other components. Always refer to the Parts Manual for the engine being serviced to ensure the correct repair kits are ordered.

Reassembly

Choke Shaft Installation (Non-Self-Relieving)

1. Install the choke return spring to the choke shaft.
2. Insert the choke shaft with return spring into the carburetor body.
3. Rotate the choke lever approximately 1/2 turn **counterclockwise**. Make sure the choke return spring hooks on the carburetor body.
4. Position the choke plate as marked during disassembly. Insert the choke plate into the slot in the choke shaft. Make sure the choke shaft is locked between the tabs on the choke plate. If the choke plate was attached with screws, loosely attach the plate to the shaft. Close the choke and center the choke plate in the bore. Tighten, but do not over-tighten the screws. Check that the choke moves freely and that the plate does not bind in the bore.

Choke Shaft Installation (Self-Relieving)



WARNING: Prevent Eye Injury!

Suitable eye protection (safety glasses, goggles, or face shield) should be worn for any procedure involving the use of compressed air, punches, hammers, chisels, drills, or grinding tools.

1. Before installing kit parts, thoroughly clean the carburetor body with compressed air.
2. Install the new bushing through the new lever and align the slot in the bottom of the lever over the lever stop pin. To ensure the proper alignment of the upper bushing and the lower shaft hole use a 3/16 diameter drill blank to align the bushing as it is pressed into the casting.
3. Install choke shaft and spring assembly with the lower spring tang installed in the second notch from the right. See Figure 5-11.

Top View Showing Spring Position



Bottom of Spring in Position 2

Figure 5-11. Choke Lever with Cap Removed.

4. **Loosely** attach the choke plate to the choke shaft using the two screws provided in the choke repair kit. Apply Loctite® No. 609 to the threads of the choke plate retaining screws. Secure these screws **ONLY** after the choke plate is properly aligned in the choke bore. To align choke plate, insert a .010 in. shim between the top right edge of the choke plate and bore. See Figure 5-12. Then while pushing down on the top of the choke shaft, tighten screws securely.

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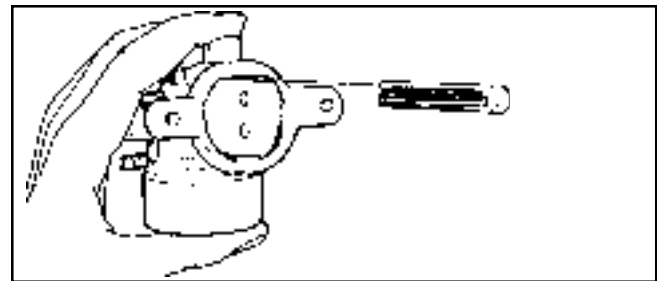


Figure 5-12. Measuring Clearance.

5. Check choke shaft and choke plate for freedom of movement by performing the following:
 - a. Using the choke lever, close the choke plate. The choke lever and choke plate should move in unison.
 - b. While holding the choke lever in the closed position, push on the long side of the choke plate. The choke plate should open and spring closed freely.
 - c. While holding the choke lever in the wide open position, the choke plate should be against the wide open choke plate stop pin.
6. Install new dust cover by pushing it down until it snaps into place.
7. After the carburetor is reinstalled on the engine, recheck choke system for freedom of movement by moving the wire link in the direction to close the choke and releasing it. The link should move freely in both directions.

Section 5

Fuel System and Governor

Welch Plug Installation—Walbro Carburetors

Use Tool No. KO1017 and install new plugs as follows:

1. Position the carburetor body with the welch plug cavities to the top.
2. Place a new welch plug into the cavity with the raised surface **up**.
3. Use the end of the tool that is about the same size as the plug and **flatten** the plug. Do not force the plug below the surface of the cavity. See Figure 5-13.

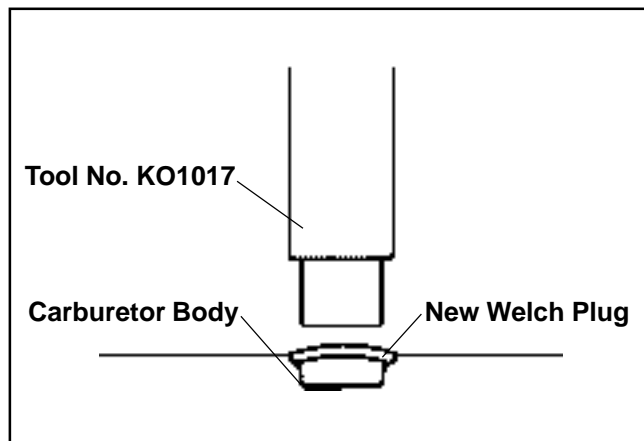


Figure 5-13. Installing Welch Plugs.

4. After the plugs are installed, seal them with Glyptal™ (or an equivalent sealant). Allow the sealant to dry.

NOTE: If a commercial sealant is not available, fingernail polish can be used.

Carburetor Reassembly

1. Install the low idle speed adjusting screw and spring.
2. If removed during disassembly, install the low idle fuel adjusting needle and spring. Turn the 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 will result if the needle is forced.

3. Turn the low idle fuel adjusting needle out (counterclockwise) 1 turn.

4. Insert the fuel inlet needle into the float. Lower the float/needle into the carburetor body. See Figure 5-14.

Install the float shaft.

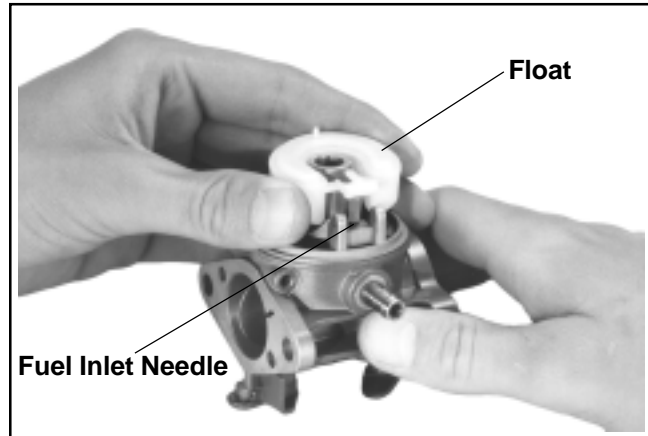


Figure 5-14. Installing Float and Fuel Inlet Needle.

5. Install the bowl gasket, fuel bowl, bowl retaining screw gasket, and bowl retaining screw or fuel solenoid.

Torque the bowl retaining screw to **5.1-6.2 N·m (45-55 in. lb.)**.

High Altitude Operation

When operating the engine at altitudes of 1830 m (6000 ft.) and above, the main fuel mixture tends to get overrich. An overrich mixture 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 engine being serviced for the correct kit number.

Fuel Shut-off Solenoid (Optional)

Some gasoline-fueled engines are equipped with the optional fuel shut-off solenoid, which is installed in place of the bowl retaining screw, to eliminate backfiring when the engine is shut down. If a solenoid-equipped engine will not start, check whether sufficient voltage is reaching the solenoid. A minimum of 7.3 volts DC is required to activate the solenoid. Also check to see that the ground lead from the carburetor body to the air cleaner base mounting stud is properly connected.

Section 5

Fuel System and Governor

5

If these check out, the solenoid should be removed for bench testing. Remember to shut off fuel supply and catch any fuel spilling from the carburetor as the solenoid is removed.

Bench test the solenoid by grounding the solenoid case and applying 12 volt DC to the spade terminal. If the plunger does not retract in this test, the solenoid is faulty and must be replaced. Always use a new fuel bowl gasket whenever the solenoid is installed. Refer to the appropriate wiring diagram in Section 8 for connecting the fuel shut-off solenoid.

LPG Systems

Components of a typical LPG (liquefied propane gas) system are shown in Figure 5-15. This subsection covers standard systems as shown in Figure 5-15 and engines equipped with the Kohler Emission Sentry™ System.



WARNING: Explosive Fuel!

LPG is extremely flammable and 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.

LPG fuel consists primarily of propane, although the fuel supplier may sometimes mix other gases with propane.

Fuel tanks must be filled only by persons qualified in the handling of LPG. Tanks are filled by weight and should not be overfilled (never to more than 80% of total capacity). An air space must be present in the tank to allow fuel to expand.

Tanks must be removed from equipment before filling.

Fuel Recommendations (LPG)



WARNING: Pressurized LPG!

Fuel tanks are filled under pressure and should be handled with care. To prevent tank damage which could endanger the safety of the operator or persons in the area, do not drop or drag tanks on any surface. Use a hand truck when moving, or tilt the tank on its footing in a position slightly off vertical and roll it.

Avoid personal contact with LPG fuel to prevent frostbite. See a physician if frostbite occurs.

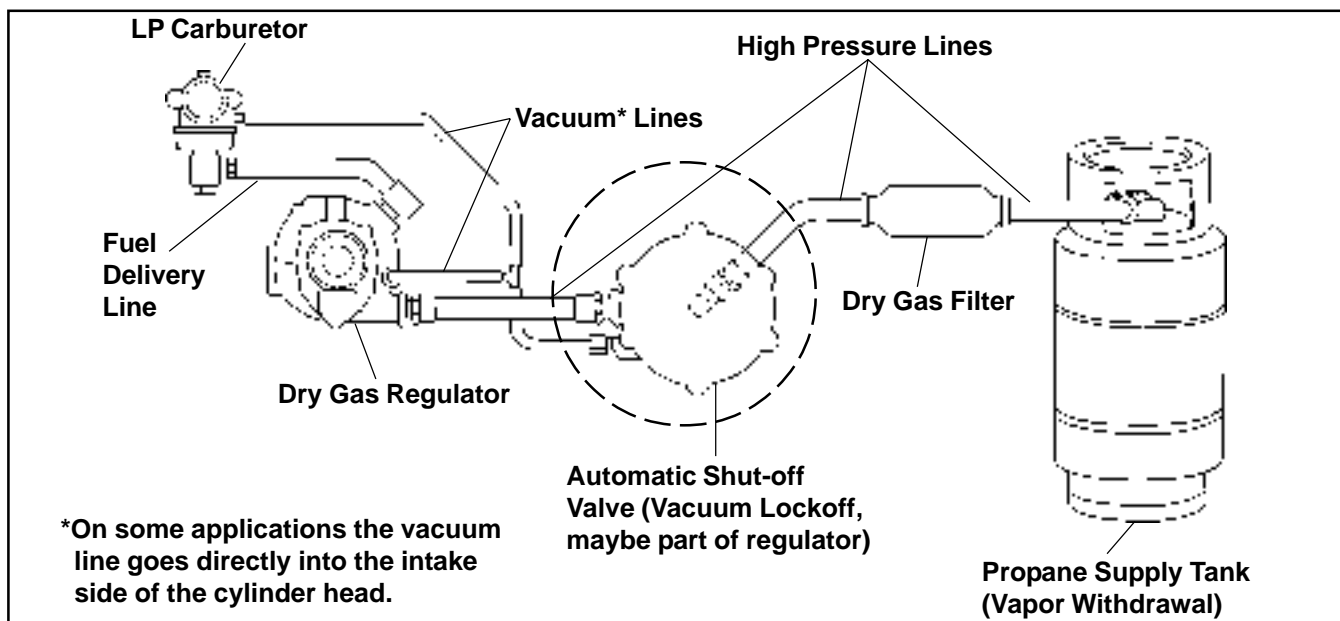


Figure 5-15. Schematic Showing Components of Typical LPG System.

Section 5

Fuel System and Governor

Troubleshooting - LPG Systems

If engine troubles are experienced that appear to be caused by the carburetor, check the following areas before adjusting the carburetor.

- Make sure the air cleaner element is clean and all air cleaner components are fastened securely. This is especially critical on propane-fueled engines.
- Check for a loose or kinked vacuum line, causing regulator not to open.
- Check to make sure the fuel valve on the LPG tank is fully opened.
- Check gauge on LPG tank to make sure there is sufficient fuel present.

If, after checking the items listed above, adjust or service the carburetor as follows.

Adjust Carburetor

1. With the engine stopped, reset the main fuel setting by closing the adjusting screw until it bottoms then turn it 2 1/4 to 2 1/2 turns open (see Figure 5-16).*

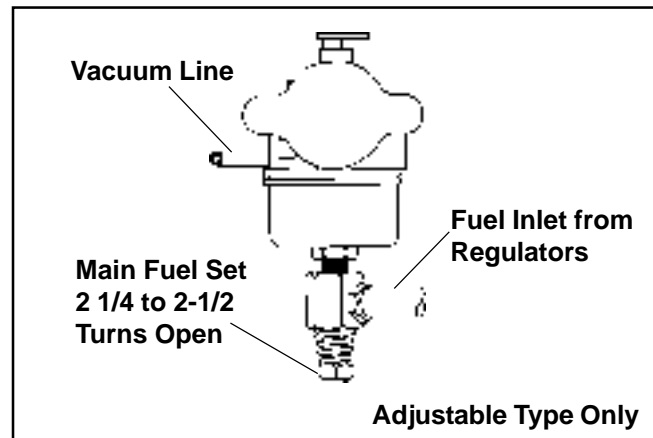


Figure 5-16. LPG Main Fuel Setting.*

*NOTE: Engines equipped with Kohler Emission Sentry™ controls have a fixed main jet carburetor.

3 Way Catalytic Muffler (Not Shown)

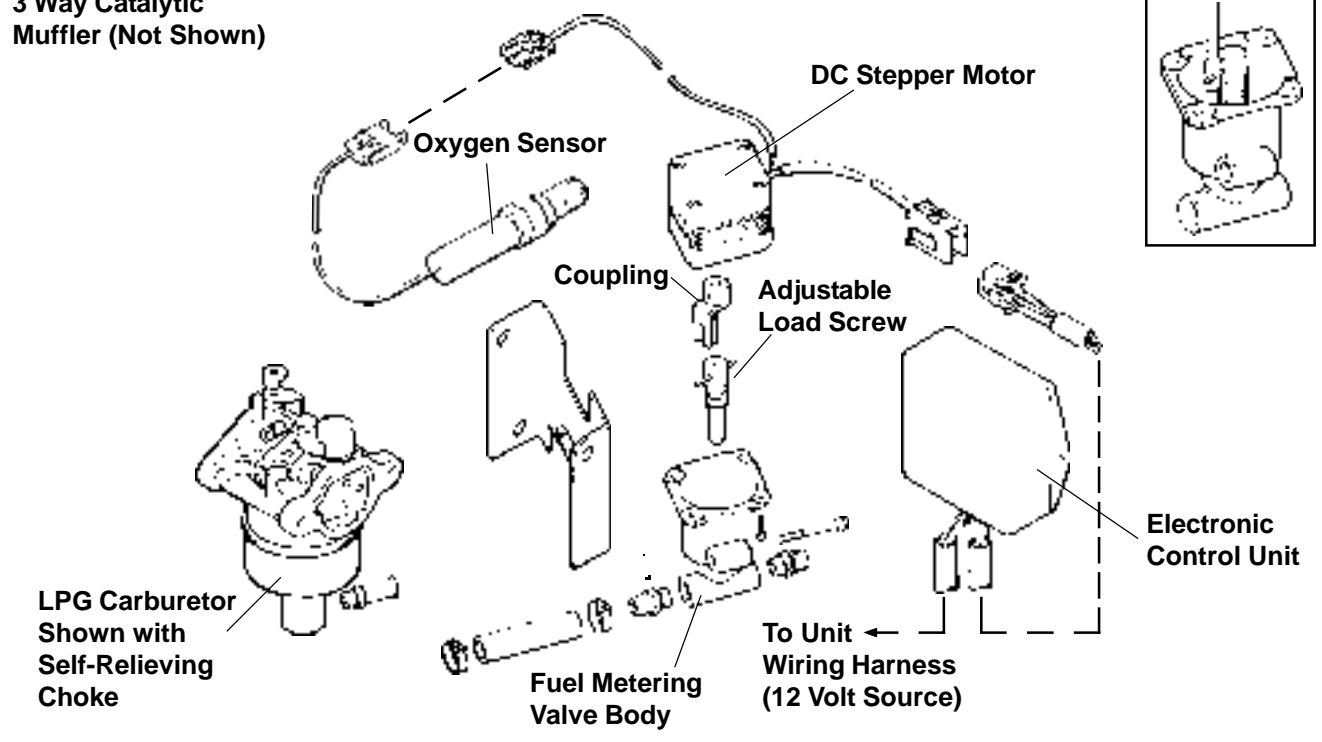


Figure 5-17. Main Components of Kohler Emission Sentry™ System.

Section 5

Fuel System and Governor

5

Kohler Emission Sentry™ System

Some Kohler Command engines are equipped with the Emission Sentry™ System. Emission Sentry™ is a feature which assures the operator that the exhaust emission levels of the engine are well within safe exposure limits. The system does not require any additional daily maintenance beyond the schedule normally specified for Command engines.

Principle of Operation

The Emission Sentry™ System can be broken down into two functions. One function is to control the ratio of air and fuel entering the engine. The second function is treating the exhaust gas, utilizing a 3-way catalytic converter.

The function of air/fuel ratio control is carried out by an oxygen sensor placed in the exhaust stream, an electronic control unit, a stepper motor, and a fuel metering valve. The oxygen sensor indirectly measures the oxygen level in the exhaust stream. An abundance of oxygen indicates a lean condition and a lack of oxygen indicates a rich condition. The sensor sends an electrical signal to the electronic control unit where the signal is analyzed. The electronic control unit then sends a signal to the stepper motor which adjusts the fuel metering valve, thus controlling the amount of fuel entering the engine. The air/fuel ratio is maintained within a set band under all operating conditions. By maintaining the air/fuel ratio at peak performance levels, maximum efficiency is also realized from the 3-way catalytic converter to further reduce emissions.

Operating with Emission Sentry™

The equipment has a 12-volt battery and the engine has an integral electric starter and charging system. Starting is accomplished by simply setting the throttle/choke control and activating the key switch on the dash panel of the unit. When the engine starts, a green, light emitting diode (LED) will illuminate, to indicate that the Emission Sentry™ is on. It will require a warm-up period of about sixty seconds to allow the oxygen sensor to heat up, and the fuel metering valve to stabilize. When first started, the engine will be running rich and may sound rough. As the oxygen sensor heats up and the system stabilizes, however, operation should become progressively smoother. After the system has stabilized (about 1 minute), operation of the equipment can begin.

The oxygen sensor continually monitors the emission levels in the exhaust while the unit is running. If the emission levels exceed a predetermined level, a fault detection circuit will be activated in the electronic control unit. Once activated, the fault detection circuit will continue to monitor the signal from the oxygen sensor for the next 45-60 seconds. If the emission levels remain at an unsafe level, the fault circuit will ground the ignition to kill the engine and illuminate a red LED lamp on the dash panel of the unit. The fault circuit will reset itself automatically in about 2-3 minutes. If the fault circuit is triggered repeatedly, one of the components is malfunctioning or faulty, and the unit should be serviced by an authorized dealer. The fault circuit will not allow the engine to operate more than 45-60 seconds with emissions above the predetermined level.

Troubleshooting the Emission Sentry™ System

If the fault circuit is triggered repeatedly during operation, a fault should be suspected in one of the following areas:

- a. Electrical wires for stepper motor, oxygen sensor, battery cable, or ground cable have been disconnected.
- b. Stepper motor.
- c. Fuel adjusting screw in control valve is binding.
- d. Oxygen sensor.
- e. Electronic control unit.

If the fault circuit is triggered when the engine is idling:

- a. The idle mixture screw on the gas regulator may be improperly adjusted.

To determine where the fault lies, proceed as follows:

1. Check all electrical connections and leads from oxygen sensor, stepper motor, electronic control unit and battery cables. It is best to disconnect wire connectors from oxygen sensor, stepper motor and engine functions and check for corrosion. Reconnect and observe if fault occurs again.

Section 5

Fuel System and Governor

2. The stepper motor, electronic control unit (ECU) and oxygen sensor can all be checked with the Kohler Emission Sentry™ Tester (Kohler Part No. 12 761 07-S).
 - a. Separate the plug connector between the electronic control unit (ECU) and the stepper motor. Plug the separated connectors into the mating connectors on the Emission Sentry™ Tester. Connect the single black lead to battery negative or a good ground on the engine/unit. Turn the key switch on the dash to the “run” position, and push the small toggle switch on the tester to the “open” position. Observe the red LED’s for the ECU and the bicolor LED’s for the stepper motor. The red LED’s should flash in sequence, the bicolor LED’s should alternate colors, and you should hear the stepper motor turning. Now push the toggle switch to the “close” position and repeat your observations. The red LED’s should flash in the reverse sequence, the bicolor LED’s should again alternate, and you should again hear the stepper motor turning. If any or all of the red LED’s are not flashing, the ECU is faulty. If the bicolor LED’s are not alternating and/or the stepper motor is not running, the stepper motor is faulty.
 - b. Allow the toggle switch on the tester to return to the “monitor” position, start the engine, and place the throttle between midrange and fast. Observe the LED’s on the tester. The red and bicolor LED’s should flash as in the previous test. The green LED (oxygen sensor) will be off initially, unless the muffler is still hot from prior running. As the oxygen sensor reaches operating temperature, the green LED should begin to flash on and off. If it stays on or off, or the interval between flashes is more than 25-30 seconds, the oxygen sensor could be faulty or the load adjusting screw in the fuel metering valve may be stuck or binding. Proceed to step 3.
3. Remove the stepper motor/fuel metering valve assembly from the engine. Remove the four small socket head screws and separate the fuel metering valve from the stepper motor. Try to turn the load adjusting screw with the blade of a small screwdriver (see inset in Figure 5-17). If the screw turns freely and easily, the oxygen sensor was faulty (step 2b).

If the screw is stuck or binding, remove it from the valve body, clean the threads with solvent, and reinstall. Check it again for binding. Do not use any type of lubricant on the threads of the load adjusting screw.

NOTE: If the oxygen sensor is removed from the exhaust manifold for any reason, a high temperature anti-seize compound (Loctite® No. 767) should be applied to the threads. A new replacement sensor already has a dry anti-seize compound on the threads; additional compound is not required.

4. If the fault circuit triggers while the engine is idling, but not during normal operation, the idle mixture screw on the regulator is probably out of adjustment. Turn the screw 1/2 turn clockwise, start the engine, and run it at idle for approximately two minutes. If the fault circuit does not trigger, the problem has been corrected. If the fault circuit is triggered and the engine shuts off before two minutes, turn the screw an additional 1/4 turn clockwise and test again for two minutes.

Governor

These engines are equipped with a centrifugal flyweight mechanical governor. It is designed to hold the engine speed nearly constant under changing load conditions. The governor gear/flyweight mechanism is mounted inside the crankcase and is driven off the gear on the balance shaft.

Operation

As the governor gear rotates, centrifugal force causes the flyweights to move outward as speed increases. 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 when the engine speed changes. One end of the cross shaft protrudes through the side of the crankcase. Through external linkage attached to the cross shaft, the rotating action is transmitted to the throttle lever of the carburetor.

Section 5

Fuel System and Governor

5

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 are in “equilibrium” during operation, holding the engine speed nearly constant.

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. This action takes place very rapidly, so a reduction in speed is hardly noticed. As the speed reaches the governed setting, the governor spring tension and the force applied by the regulating pin will again be in equilibrium. This maintains the engine speed at a relatively constant level.

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

Initial Adjustment

Make this initial adjustment whenever the governor arm is loosened or removed from the cross shaft. To ensure proper setting, make sure the throttle linkage is connected to the governor arm and the throttle lever on the carburetor. See Figure 5-18.

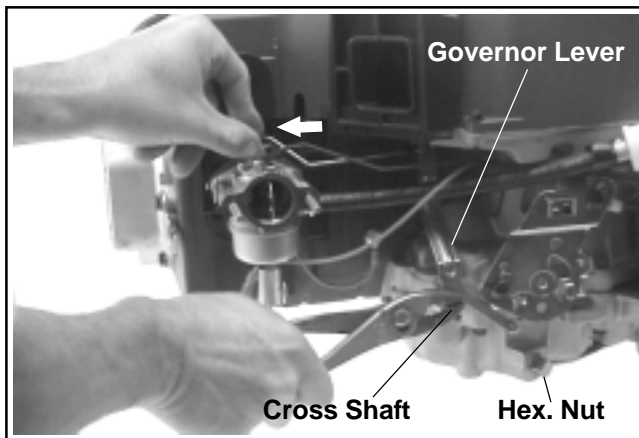


Figure 5-18. Initial Governor Adjustment.

NOTE: Air cleaner removed to show linkage. Adjustment should be made with air cleaner base installed.

1. With the governor lever loose on the cross shaft, pull the lever towards the carburetor (wide open throttle).
2. Grasp the cross shaft with a pliers, or insert a nail into the hole in the end of the cross shaft. Rotate the shaft **counterclockwise** as far as it will turn, then tighten hex. nut securely.
3. Torque the hex. nut to **9.9 N-m (88 in. lb.)**.

Unitized Throttle and Choke Control

Some engines are equipped with a “unitized” throttle and choke control bracket assembly. This assembly controls the choke and engine speed with a single lever.

Throttle Cable Adjustment

1. Loosen the throttle control cable clamp. See Figure 5-19.

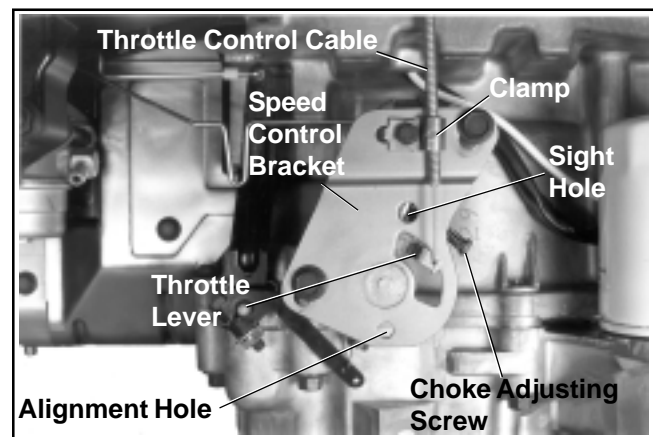


Figure 5-19. Speed Control Bracket Assembly.

2. Place the throttle control lever of the equipment into the “fast” or high idle position.

NOTE: The choke is placed “on” by moving the throttle control slightly past the “fast” position. If the throttle control does not have a designated choke “on” position, be sure to leave sufficient throttle control travel past the “fast” position. This will enable the choke to be placed “on”. See Figure 5-20.

Section 5

Fuel System and Governor

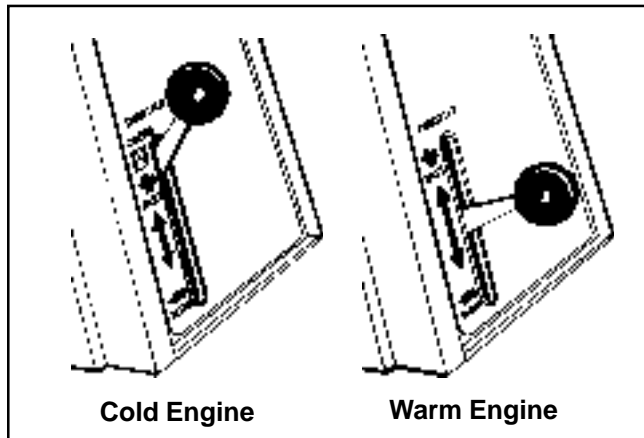


Figure 5-20. Typical Throttle/Choke Controls.

- Align the hole in the throttle lever with the hole in the speed control bracket by inserting a pencil or 6.35 mm (1/4 in.) drill bit. See Figure 5-21.

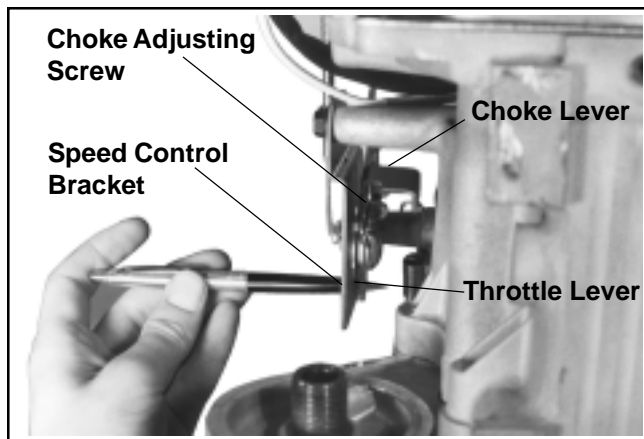


Figure 5-21. Aligning Holes in Speed Control Bracket and Throttle Lever.

- Pull up on the outer shield of the throttle control cable to remove any slack. Tighten the cable clamp securely.

High Idle Speed Adjustment

The recommended maximum no-load high idle speed for most of these engines is **3750 RPM**. The actual high idle speed depends on the application. Refer to the equipment manufacturer's instructions for specific information.



WARNING: Overspeed is Hazardous!

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

- Make sure the throttle cable is adjusted properly (see "Throttle Cable Adjustment").
- Start the engine and allow it to warm up. Place the throttle control lever into the "fast" or high idle position.
- Align the hole in the throttle lever with the hole in the speed control bracket by inserting a pencil or 6.35 mm (1/4 in.) drill bit. See Figure 5-21.
- Loosen the speed control bracket mounting screws. Move the bracket up or down until the desired high idle speed is reached. See Figure 5-22. Check the speed with a tachometer.

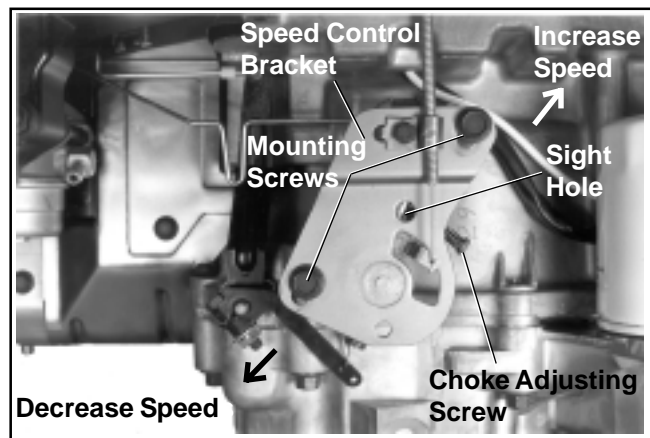


Figure 5-22. Adjusting High Idle Speed.

To increase the high idle speed - move the bracket **up** (towards flywheel).

To decrease the high idle speed - move the bracket **down** (towards PTO).

- Tighten the speed control bracket mounting screws. Recheck the speed with a tachometer and readjust if necessary.

Torque the mounting screws as follows:

Into new as-cast hole—**10.7 N·m (95 in. lb.)**.

Into used hole—**7.3 N·m (65 in. lb.)**.

- Adjust the choke (see "Choke Adjustment" which follows).

Section 5

Fuel System and Governor

Choke Adjustment

This procedure must follow the "High Idle Speed Adjustment" just described. If not already completed, perform that operation first.

1. Turn the choke adjusting screw **out** (counterclockwise), until it no longer contacts the choke lever. Then turn it back **in** (clockwise), until it *just* makes contact.
2. While observing the choke link, move the throttle control lever to the low idle (slow) position, then back to full throttle (fast). The choke link should not move as the throttle moves through the normal range. If it does, back the adjusting screw out until it no longer moves.
3. Move the throttle control lever to the choke position. Check if the choke has fully closed by placing your finger behind (right side) the link loop and applying pressure toward the carburetor. If the controls have been properly set, the link should not move.

Sensitivity Adjustment

Governor sensitivity is adjusted by repositioning the governor spring in the holes in the governor arm. If speed surging occurs with a change in 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.

The position of the governor spring in the governor arm depends on the high idle, no load speed setting (see Figure 5-23):

If the high idle, no load speed is 3600 RPM or less - use the **#2 hole** (count outward from cross shaft).

If the high idle speed is greater than 3600 RPM - use the **#3 hole** (count outward from cross shaft).

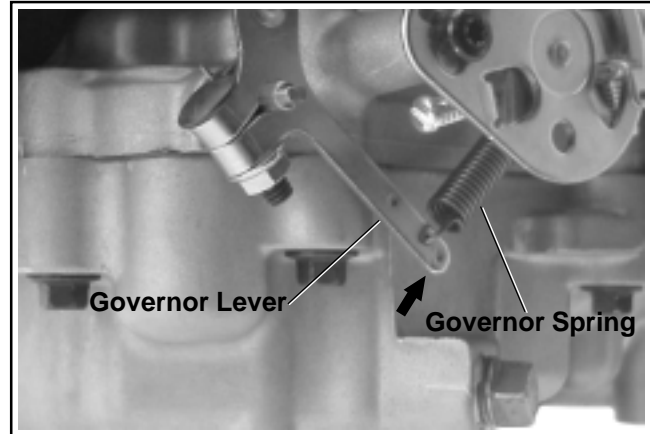


Figure 5-23. Governor Spring Location.

Speed Control Bracket Service

The only serviceable components of the speed control bracket assembly are the choke adjusting screw and spring, choke return spring, and throttle cable clamp and screw. Install the choke return spring as shown. See Figure 5-24.

Replace the assembly if other parts are worn or damaged.

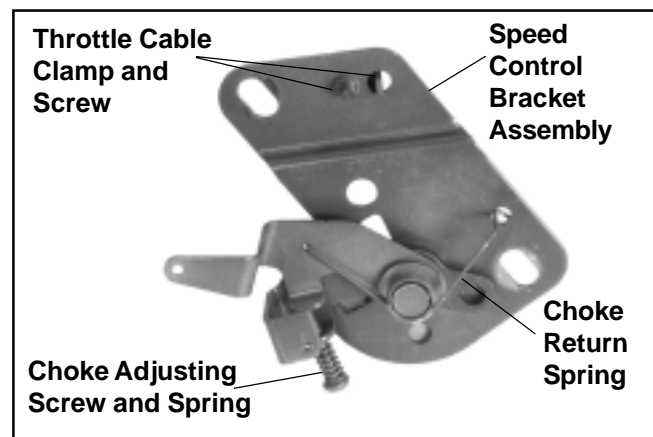


Figure 5-24. Speed Control Bracket Assembly.

Separate Throttle and Choke Control

Some engines are equipped with separate throttle and choke controls. This allows you to adjust the choke and throttle controls individually.

Install Separate Control Cables (See Figure 5-25).

Throttle Control

1. Loosen the 2-cable clamp screws on the engine control plate.

Section 5

Fuel System and Governor

2. Position the application throttle control in the full (fast) throttle position. Then move the throttle lever back 3/16" or 4.75 mm. Insert the cable boden wire into the throttle control lever on the control plate.
3. Position the throttle cable under the cable clamp.
4. Pull on the throttle cable until it stops, hold it, and tighten the cable clamp screw.
5. Move application throttle lever to the slow position then to full throttle. Check the engine control to assure it stops against the stop screw, which means it is properly set.
2. Position the choke cable under the cable clamp.
3. Push the choke (knob/handle) in the application panel until it bottoms, then pull it back approximately 1/16".
4. Push on the choke cable, above the clamp on the engine control plate, until the choke lever stops. Then tighten the cable clamp screw.
5. Pull the choke knob/handle until it stops, check to assure the choke link cannot be moved towards the carburetor by applying finger pressure on the link loop behind the engine control plate. If the choke link moves, adjust by following steps 3 and 4.
6. Push the choke knob/handle in until it bottoms. The choke control link should be free so the engine does not run on partial choke.

Choke Control

1. Insert the choke cable boden wire into the engine choke control lever on the control plate.

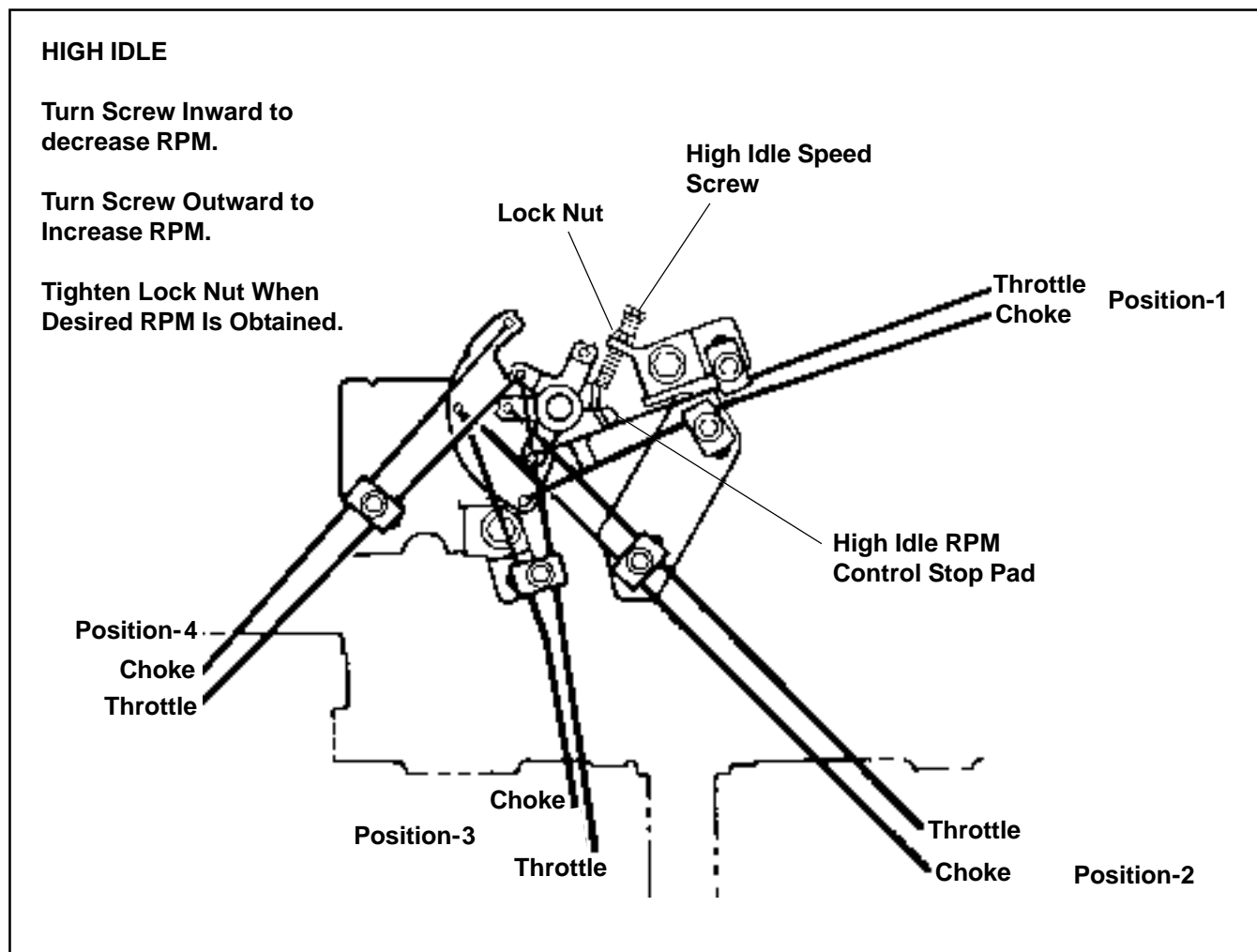


Figure 5-25. Separate Choke and Throttle Cable Control (4 Positions Shown).

Section 5

Fuel System and Governor

5

Starting an Engine Equipped with Separate Control Cables

1. Place the throttle control midway between the "**slow**" and "**fast**" positions. Place the choke control into the "**on**" position.
2. Start the engine.
3. **For a Cold Engine** – Gradually return the choke control to the "off" position after the engine starts and warms up.

The engine/equipment may be operated during the warm up period, but it may be necessary to leave the choke partially on until the engine warms up.

4. **For a Warm Engine** – Return choke to "off" position as soon as engine starts.

Changing the High Idle RPM on Engines with Separate Controls

(Increase or Decrease RPM)

See Figure 5-25 on page 5.18.

1. Loosen the high idle stop screw retaining nut (top side of control plate).
2. Start the engine, move the application throttle lever to full throttle/fast, loosen the throttle cable clamp screw on the engine control plate.
3. **To increase the RPM:** Turn high idle stop screw outward (counterclockwise) and pull on the throttle control cable until the desired RPM is obtained.
4. Tighten the throttle cable clamp screw and the high idle stop screw retaining nut.
5. To assure that the RPM has been obtained, move the throttle lever to low idle/slow then back to full throttle/fast and check the RPM with a tachometer.
6. **To decrease the RPM:** Follow steps 1 and 2. Then push the throttle cable in toward the control bracket assembly to decrease the RPM (check with a tachometer) until the desired RPM is obtained. Tighten the cable clamp screw.

7. Turn the high idle stop screw inward (clockwise) until it stops against the throttle control lever. Then tighten the stop screw retaining nut.
8. Recheck high idle RPM to assure the required RPM has been obtained.

Setting the Low Idle RPM

1. Move the application control to slow position.
2. Using a tachometer, check the RPM. Then, using a screwdriver, turn the low idle stop screw (located at the top of the carburetor) inward (clockwise) to increase the RPM and outward (counterclockwise) to lower the RPM.

Governed Idle Adjustment

A new governed idle control system is now being supplied on some CV Single Cylinder engines. The purpose of the new system is to maintain a desired idle speed regardless of ambient conditions (temperature, parasitic load, etc.) that often change.

The new system requires an additional procedure for setting the idle speed. If speed adjustments are required proceed as follows.

1. Make any necessary speed or control adjustments following the appropriate instructions already covered in this section.
2. Move the throttle control to the idle position. Hold the governor lever away from the carburetor, so the throttle lever is tight against the idle speed adjusting screw. Check the speed with a tachometer and adjust it to 900-1000 RPM. Turn the screw clockwise to increase the speed and counterclockwise to decrease the speed.
3. Release the governor lever and allow the engine to return to the governed idle speed. Check it with a tachometer against the equipment manufacturers recommended idle speed. If adjustment is necessary, use the governed idle adjusting screw on the speed control assembly (see Figure 5-26). Turn the screw clockwise to increase the governed idle speed and counterclockwise to decrease it.

Section 5

Fuel System and Governor

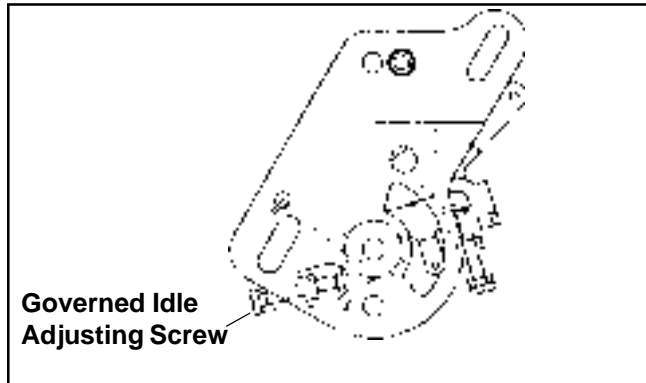


Figure 5-26. Location of Governed Idle Adjusting Screw.

Go Back

Section 6

Lubrication System

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. **Synthetic oil** is recommended for use in LPG-fueled engines because there is less oxidation or thickening, and deposit accumulation on intake valves is substantially reduced.

Oil Type

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

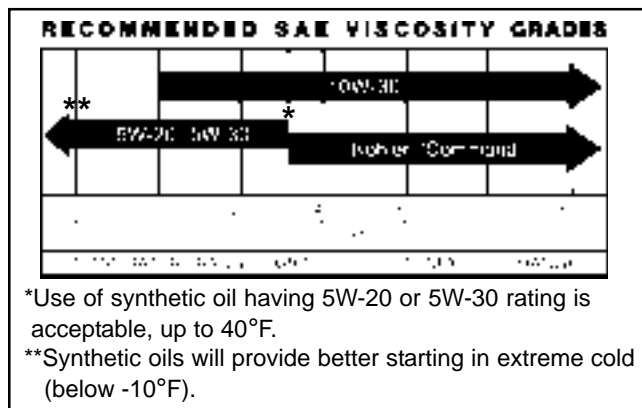


Figure 6-1. Viscosity Grades Table.

NOTE: Using other than service class SG, SH, SJ or higher 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 6-2.



Figure 6-2. Oil Container Logo.

Check 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. To keep dirt, grass clippings, etc., out of the engine, clean the area around the oil fill cap/dipstick before removing it.
3. Unthread and remove the oil fill cap/dipstick; wipe oil off. Reinsert the dipstick into the tube and rest the oil fill cap on the tube. Do not thread the cap onto the tube. See Figure 6-3.

Section 6

Lubrication System

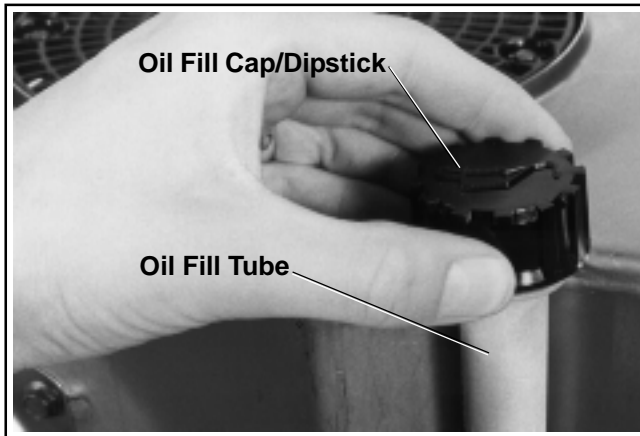


Figure 6-3. Checking Oil Level.

4. Remove the dipstick and check the oil level. The oil level should be up to, but not over the "F" mark on the dipstick. See Figure 6-4.

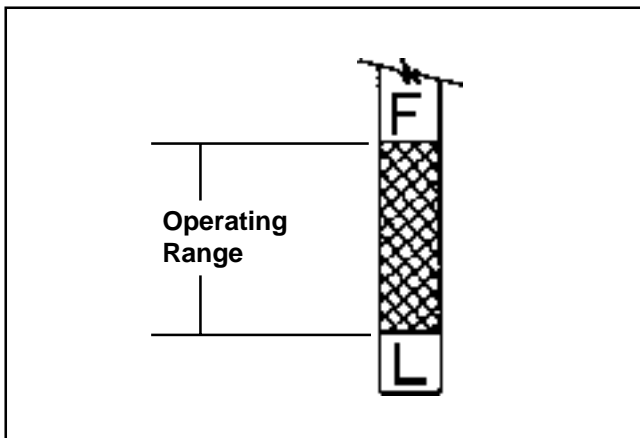


Figure 6-4. Oil Level Dipstick.

5. If the level is low, add oil of the proper type, up to the "F" mark on the dipstick. Always check the level with the dipstick before adding more oil.

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 "L" mark or over the "F" mark on the dipstick.

Change Oil and Oil Filter

Change Oil

Change oil after every **100 hours** of operation. Change the oil while the engine is still warm. The oil will flow more freely and carry away more impurities. Make sure the engine is level when filling or checking oil. Change the oil as follows (see Figure 6-5):

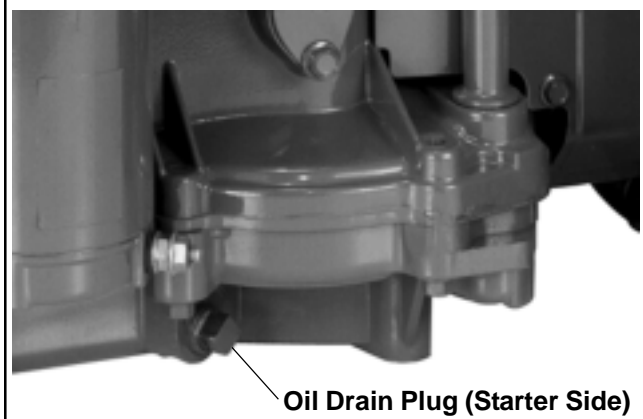
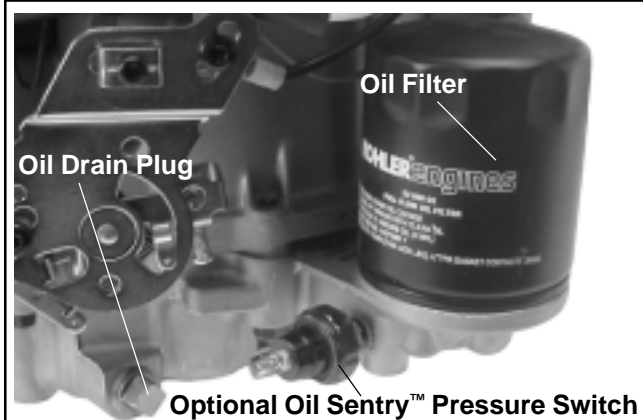
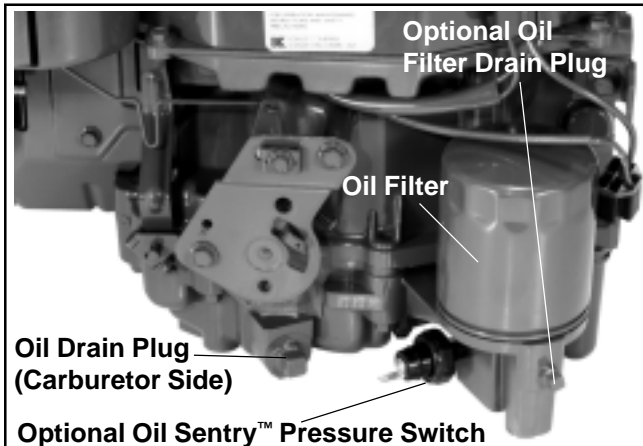


Figure 6-5. Oil Drain Plugs, Oil Filter, Oil Filter Drain Plug, and Optional Oil Sentry™ Switch.

1. Remove the oil drain plug and oil fill cap/dipstick. Be sure to allow ample time for complete drainage.
2. Reinstall the drain plug. Make sure it is tightened to **13.6 N·m (10 ft. lb.)** torque.
3. Fill the crankcase, with new oil of the proper type, to the "F" mark on the dipstick. Always check the level with the dipstick before adding more oil.

Section 6

Lubrication System

- Reinstall the oil fill cap/dipstick and tighten securely.

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 "L" mark or over the "F" mark on the dipstick.

Change Oil Filter

Replace the oil filter **every other oil change (every 200 hours of operation)**. Always use a genuine Kohler oil filter.

Replace the oil filter as follows:

- Drain the oil from the engine crankcase.
- Remove the oil filter drain plug (where applicable) located at the base of the oil filter adapter. Allow the oil filter to drain.
- Remove the old filter and wipe off the filter adapter. Reinstall the oil filter drain plug. Torque the drain plug to **7.3-9.0 N·m (65-80 in. lb.)**.
- Place a new replacement filter in a shallow pan with the open end up. Pour new oil, of the proper type, in through the threaded center hole. Stop pouring when the oil reaches the bottom of the threads. Allow a minute or two for the oil to be absorbed by the filter material.
- Put a drop of oil on your fingertip and wipe it on the rubber gasket.
- Install the replacement oil filter to the filter adapter. Turn the oil filter clockwise until the rubber gasket contacts the filter adapter, then tighten the filter an additional **2/3 to 1 turn**.
- Fill the crankcase with new oil, of the proper type, to the "F" mark on the dipstick.
- Test run the engine to check for leaks. Stop the engine, allow a minute for the oil to drain down, and recheck the level on the dipstick. Add more oil, as necessary, so the oil level is up to but not over the "F" mark on the dipstick.

Full-Pressure Lubrication System

Operation

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

A high efficiency Gerotor™ oil pump is located in the oil pan and is driven by the balance shaft. A pressure relief valve in the oil pan limits the maximum pressure of the system.

Service

The oil pump rotors can be serviced without removing the oil pan. Remove the oil pump cover on the PTO side of oil pan to service the rotors.

The oil pan must be removed to service the oil pickup and oil pressure relief valve.

See Figures 6-6 through 6-8. Also refer to the "Disassembly" and "Reassembly" sections for lubrication system components removal and installation procedures.

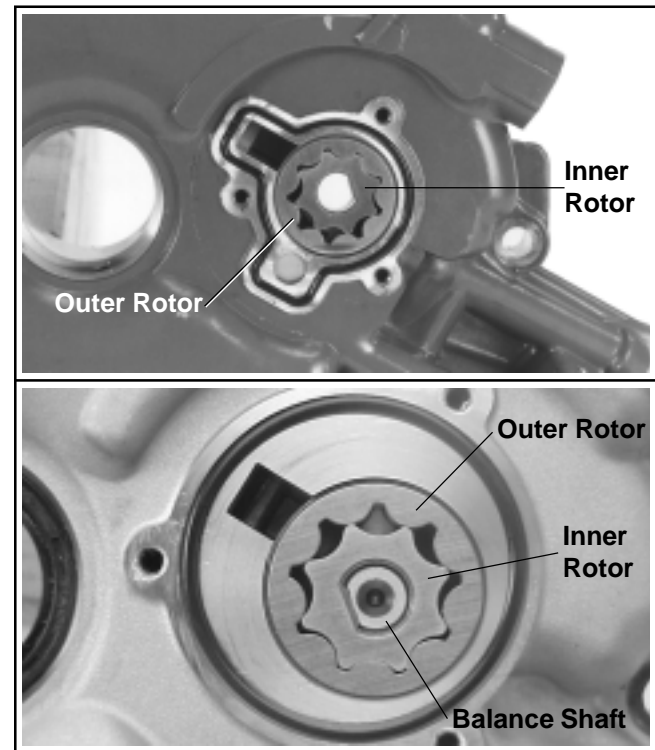


Figure 6-6. Gerotor™ Oil Pump.

Section 6

Lubrication System

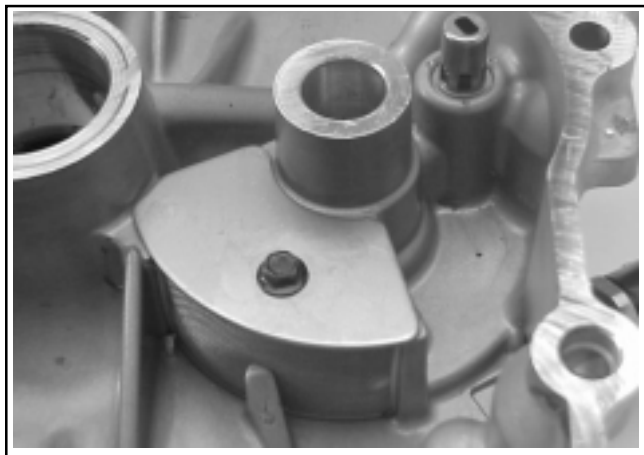


Figure 6-7. Oil Pickup.



Figure 6-9. Engine Mounted Oil Filter.



Figure 6-8. Oil Pressure Relief Valve Styles.

Oil Filter

These engines are equipped with a full-flow oil filter. See Figure 6-9.

The oil filter helps remove sludge and other combustion by-products from the oil. It also extends the oil change interval and cools the oil.

Oil Sentry™

Some engines are equipped with an optional Oil Sentry™ oil pressure monitor. If the oil pressure gets low, Oil Sentry™ will either shut off the engine or activate a warning signal, depending on the application.

Operation

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 2 to 5 psi, the switch contacts open. At oil pressures below approximately 2 to 5 psi, 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™.

Section 6

Lubrication System

Installation

The pressure switch is installed in the oil filter adapter, in one of the main oil galleries of the oil pan. See Figure 6-10. On engines not equipped with Oil Sentry™, the installation hole is sealed with a 1/8-27 N.P.T.F. pipe plug.



Figure 6-10. Oil Sentry™ Pressure Switch.*

*NOTE: Some engines use adapter without oil drain plugs or provision for Oil Sentry™.

To install the Oil Sentry™ switch to the oil filter adapter of oil pan:

1. Apply **Loctite® No. 59241 pipe sealant with Teflon®** (or equivalent) to the threads of the switch.
2. Install the switch into the tapped hole in oil filter adapter.

Torque the switch to **6.8 N·m (60 in. lb.)**.

Testing the Oil Sentry™ Switch

The Oil Sentry™ pressure monitor is a normally-closed switch. It is calibrated to open (break contact) with increasing pressure and close (make contact) with decreasing pressure, within the range of 2.0/5.0 psi.

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 psi** pressure applied to the switch, the tester should indicate **continuity (switch closed)**.
2. Gradually *increase* the pressure to the switch. The tester should indicate a change to **no continuity (switch open)** as the pressure increases through the range of **2.0/5.0 psi**.

The switch should remain open as the pressure is increased to **90 psi maximum**.

3. Gradually *decrease* the pressure to the switch. The tester should indicate a change to **continuity (switch closed)** as the pressure decreases through the range of **2.0/5.0 psi**.

If the switch does not operate as specified, replace the switch.

Testing Oil Pressure

The engine oil pressure can be tested using the oil pressure tester described in Section 2. Follow the instructions included with the tester. The pressure can be tested by removing the oil filter and installing the tester adapter on the filter pad, or by removing the Oil Sentry™ pressure switch (or pipe plug) and threading the tester hose directly into the hole. See Figure 6-10.

Section 6

Lubrication System

Go Back

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.

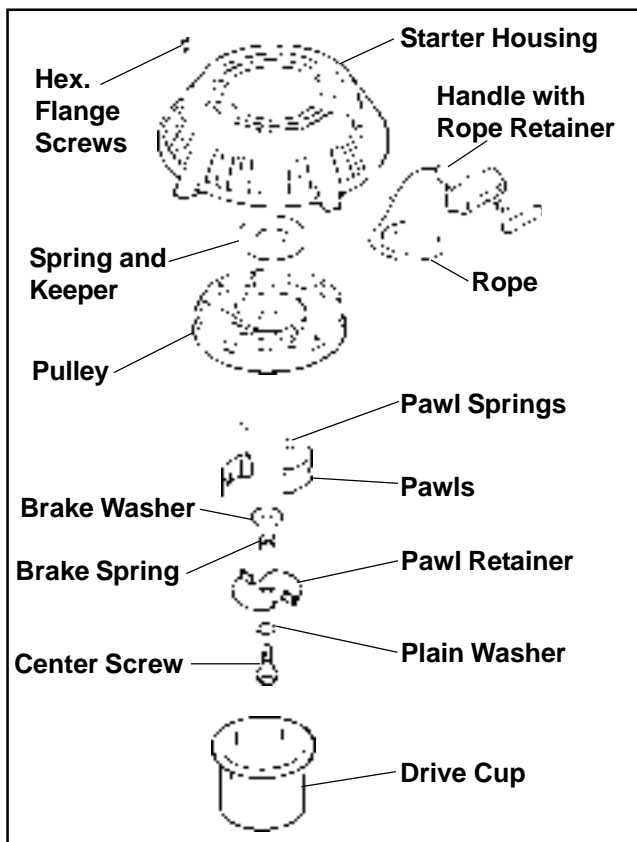


Figure 7-1. Retractable Starter—Exploded View.

To Remove Starter

1. Remove the five hex. flange screws securing the starter to the 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 the drive cup. Hold the handle in this position and tighten the screws securely. See Figure 7-2.

7

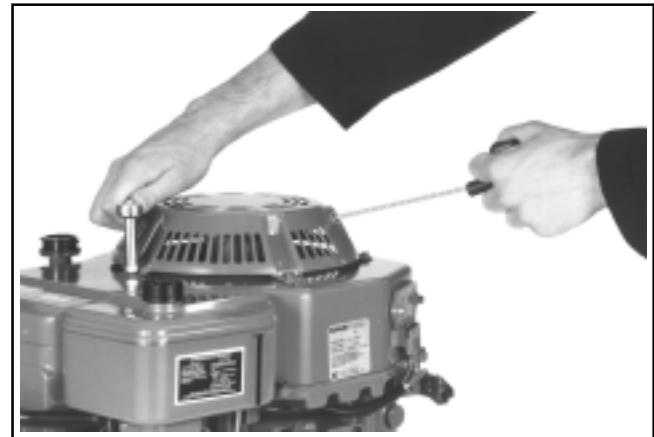


Figure 7-2. Installing Retractable Starter.

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 7-3.

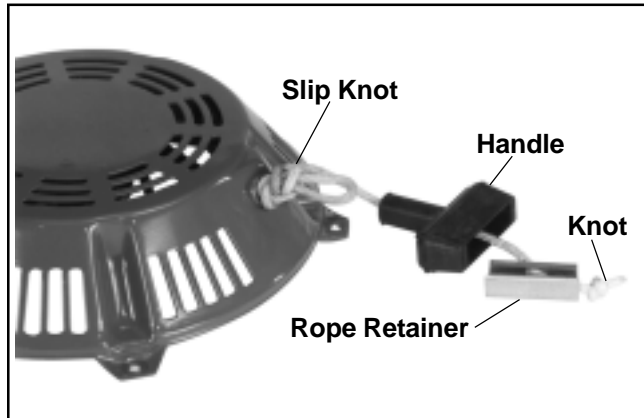


Figure 7-3. Removing Starter Handle.

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 the 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 7-4.

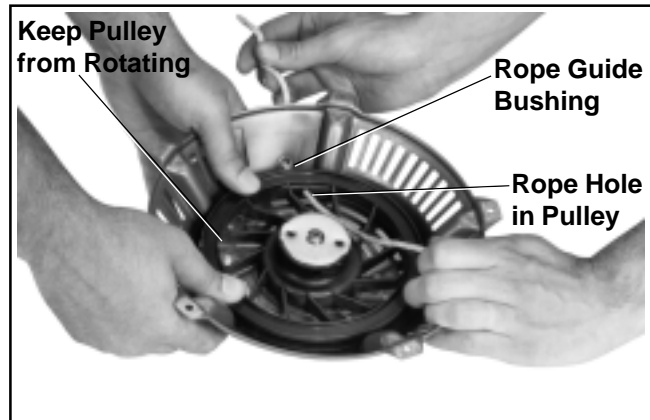


Figure 7-4. Installing Rope.

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

The starter must be disassembled to replace the starter pawls. 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

Section 7

Retractable Starter

Disassembly



CAUTION: Spring Under Tension!

Do not remove the center screw from the 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 eye and 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 page 7.2.)
2. Remove the center screw, washer, and pawl retainer. See Figure 7-5.

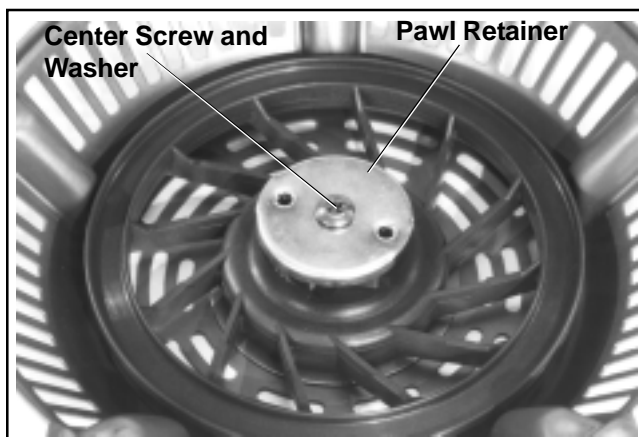


Figure 7-5. Center Screw, Washer and Pawl Retainer.

3. Remove the brake spring and brake washer. See Figure 7-6.

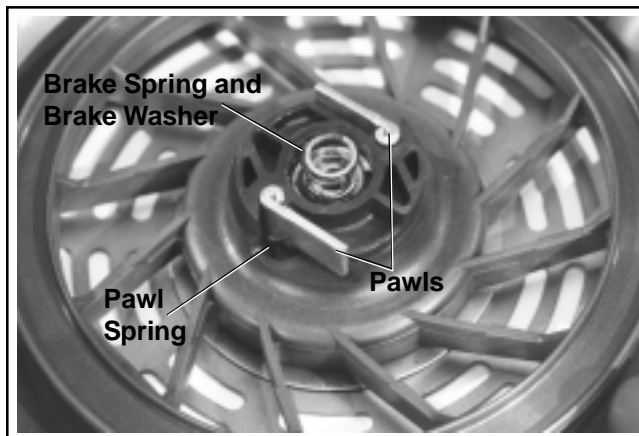


Figure 7-6. Brake Spring and Washer, Pawls, and Pawl Springs.

4. Carefully note the positions of the pawls and pawl springs before removing them.

Remove the pawls and pawl springs from the starter pulley.

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 7-7.

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 7-7. Removing Pulley from Housing.

8. Note the position of the spring and keeper assembly in the pulley. See Figure 7-8.

Remove the spring and keeper assembly from the pulley as a package.



CAUTION: Spring Under Tension!

Do not remove the spring from the keeper. Severe personal injury could result from the sudden uncoiling of the spring.

Section 7

Retractable Starter

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 toward pulley). See Figure 7-8.

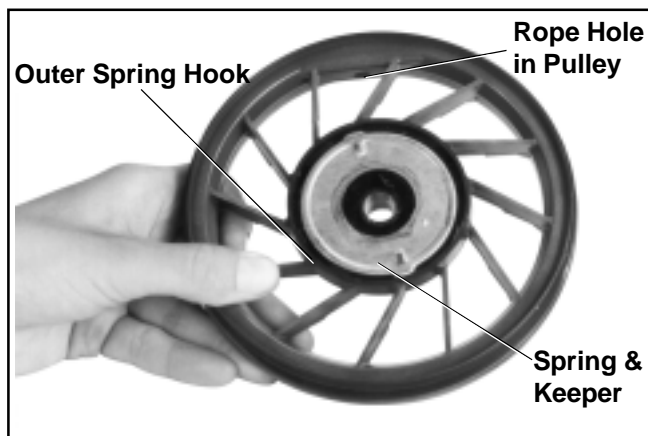


Figure 7-8. Position of Spring and Keeper in Pulley.

2. Install the pulley and spring into the starter housing. See Figure 7-9.

Make sure the pulley is fully seated against the starter housing. Do not wind the pulley and recoil spring at this time.

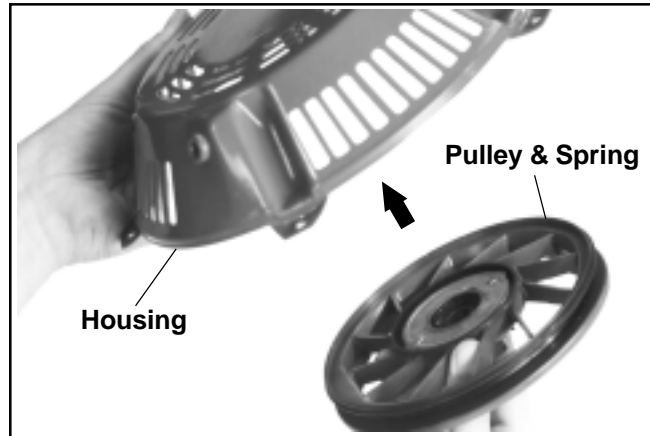


Figure 7-9. Installing Pulley and Spring into Housing.

3. Install the pawl springs and pawls into the starter pulley. See Figure 7-10.

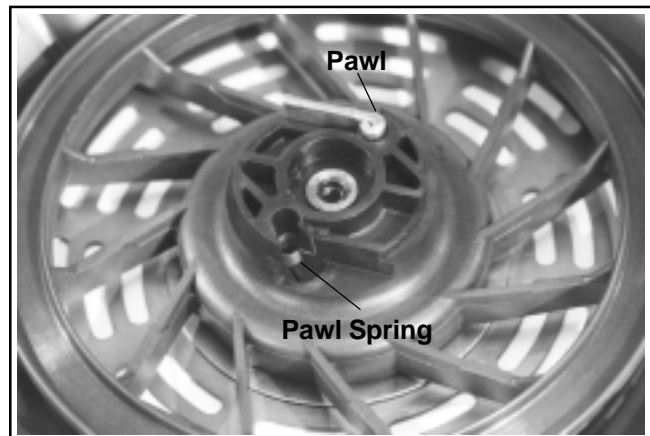


Figure 7-10. Installing Pawls and Pawl Springs.

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.

Go Back

Section 8

Electrical System and Components

This section covers the operation, service, and repair of the electrical system and electrical system components.

Major electrical systems and components covered in this section include the ignition system, battery, battery charging systems, and electric starters.



WARNING: Electrical Shock

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

Spark Plug

Engine misfire or starting problems are often caused by a spark plug that is in poor condition or has an improper gap setting.

These engines are equipped with one of the following spark plugs:

Type: The standard spark plug is a Champion® RC12YC (Kohler Part No. 12 132 02-S). A high-performance spark plug, Champion® Premium Gold 2071 (used on Pro Series engines, Kohler Part No. 12 132 06-S) is also available. Equivalent alternate brand plugs can also be used.

Gap: CV11-15, CV460-465, 490-495 1.02 mm (0.040 in.)
CV11-14 LP, CV16 0.76 mm (0.030 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 the spark plug, check its condition, and reset the gap or replace with a new plug as necessary.

1. Before removing the spark plug, clean the area around the base of the plug to keep dirt and debris out of the engine. Due to the deep recess around the spark plug, blowing out the cavity with compressed air is usually the most effective method for cleaning.

2. Remove the plug and check its condition. Replace the plug if worn or reuse is questionable. (See figures on page 8.2.)

NOTE: Do not clean the 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 by carefully bending the ground electrode. See Figure 8-1.

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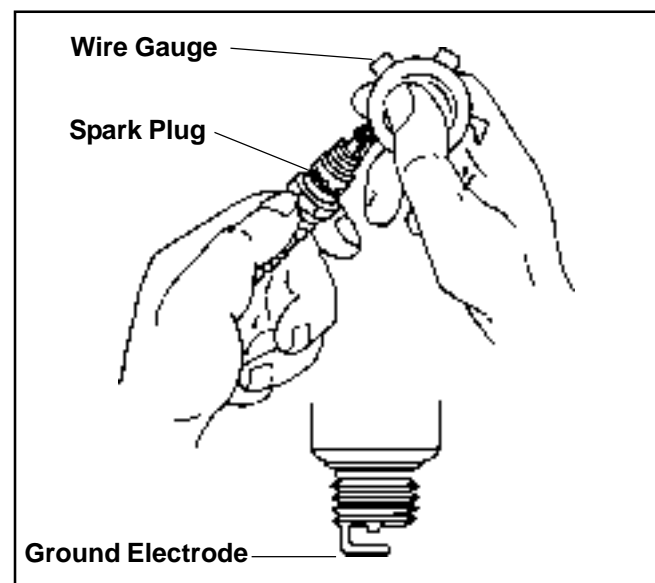


Figure 8-1. Servicing Spark Plug.

Section 8

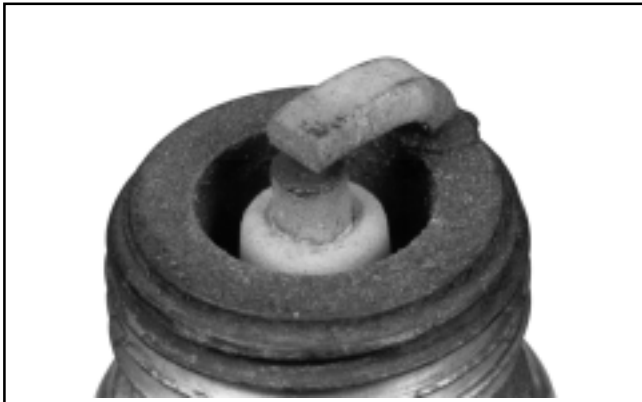
Electrical System and Components

4. Reinstall the spark plug into the cylinder head.
Torque the spark plug to **24.4-29.8 N·m**
(18-22 ft. lb.).

Inspection

Inspect the spark plug as soon 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 regapped and reused.



Worn: On a worn plug, the center electrode will be rounded and the gap will be eroded .010" or more beyond the correct gap. Replace a worn spark plug immediately.



Chalky White Deposits: Chalky white-colored deposits indicate overheating. This condition is usually accompanied by excessive gap erosion. A clogged grass screen, clogged cooling fins, and lean carburetion are some causes of overheating.



Carbon Fouled: Soft, sooty, black deposits indicate incomplete combustion. Incomplete combustion is usually caused by overrich carburetion, weak ignition, or poor compression.



Wet Fouled: A wet plug is caused by excess fuel, or oil in the combustion chamber. Excess fuel could be caused by operating the engine with too much choke or a dirty air filter. Oil in the combustion chamber is usually caused by worn piston rings or valve guides.

Section 8

Electrical System and Components

Electronic Magneto Ignition System, CV11-15, CV460-465, CV490-495 Engines

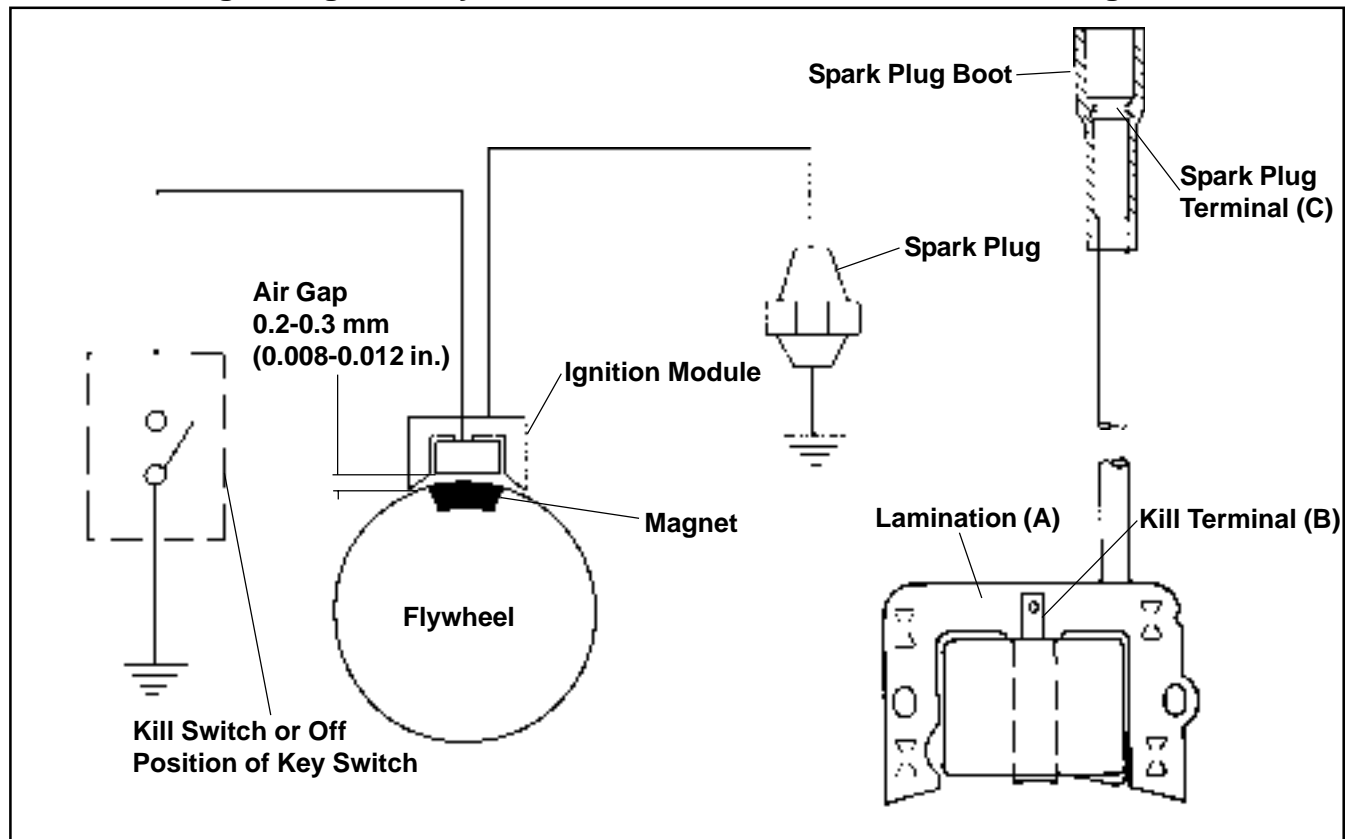


Figure 8-2. Electronic Magneto Ignition System, CV11-15, CV460-465, CV490-495 Engines.

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CV11-15, CV460-465, CV490-495 engines are equipped with a dependable electronic magneto ignition system. The system consists of the following components:

- A magnet assembly which is permanently affixed to the flywheel.
- An electronic magneto ignition module which mounts on the engine crankcase.
- A kill switch (or key switch) which grounds the module to stop the engine.
- A spark plug.

Operation

As the flywheel rotates and the magnet assembly moves past the ignition module, a low voltage is induced in the primary windings of the module. When the primary voltage is precisely at its peak, the primary circuit is interrupted, inducing a high voltage in the secondary windings. This high voltage creates a spark at the tip of the spark plug, which ignites the fuel-air mixture in the combustion chamber.

The timing of the spark is automatically controlled by the module. Therefore, other than periodically checking/replacing the spark plug, no maintenance, timing, or adjustments are necessary or possible with this system.

Section 8

Electrical System and Components

Magneto Ignition System Troubleshooting Guide

The following guide will help locate and correct ignition system problems.

Problem	Test	Conclusion
Engine Will Not Start	1. Make sure the spark plug lead is connected to the spark plug.	
	2. Check the condition of spark plug. Make sure gap is set correctly. See page 8.1.	2. If plug is in good condition, check/adjust gap and reinstall.
	3. a. Test for spark with ignition tester, Part No. KO1047. Disconnect spark plug lead and connect it to the post terminal of the tester. See Figure 8-3. Connect the clip to a good ground, not the spark plug. NOTE: To maintain engine speeds normally obtained during cranking, do not remove the engine spark plug. b. Make sure the engine ignition switch, kill switch, or key switch is in the "run" position. c. Crank the engine and observe the test plug. Visible and audible sparks should be produced.	3. If visible and audible sparks are produced, the ignition module is OK. If visible and audible sparks are not produced: a. Make sure the engine ignition switch, kill switch, or key switch is in the "run" position. b. Check wires and terminals of ignition module and other components for accidental grounding and damaged insulation. c. If wires and terminals are OK, the ignition module is probably faulty and should be replaced. Test module further using an ohmmeter (Test 4).
	4. Measure the resistance of module secondary using an ohmmeter (see Figures 8-2 and 8-4): Zero ohmmeter before testing. Connect one ohmmeter lead to laminations (A). Connect the other lead to the spark plug terminal (C) of high-terminal lead. With the ohmmeter leads connected in this manner, the resistance of secondary should be 7,900 to 18,400 ohms . NOTE: This test cannot be performed unless module has been fired at least once.	4. If the resistance is low or 0 ohms , the module secondary is shorted. Replace the module*. If the resistance is high or infinity ohms , the module secondary is open. Replace the module*. If the resistance is within the specified range, the module secondary is OK. *Refer to the Disassembly and Reassembly Sections for complete ignition module removal and installation procedures.



Figure 8-3. Ignition Tester, Part No. KO1047.



Figure 8-4. Testing Module Secondary.

Section 8

Electrical System and Components

Electronic Ignition System with Spark Advance (Smart Spark™), CV16 Engines

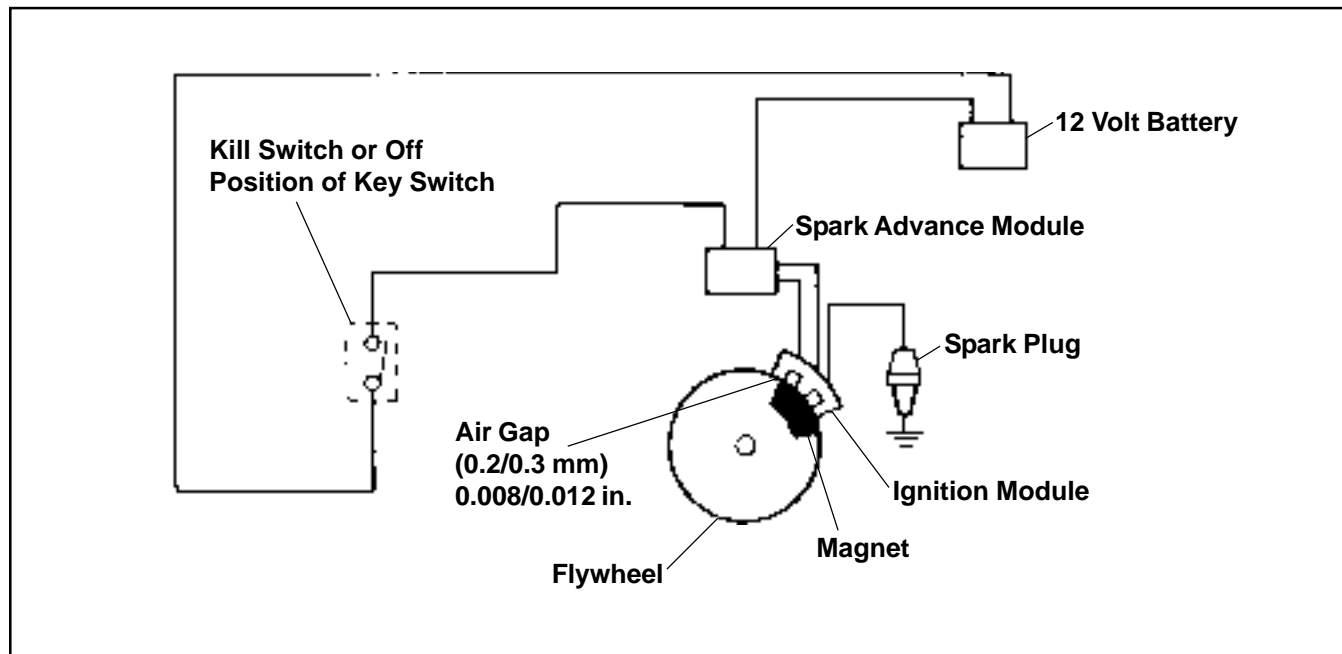


Figure 8-5. Capacitive Discharge Ignition System with Spark Advance.

The CV16 engines are equipped with an electronic capacitive discharge ignition system with electronic spark advance. A typical application (Figures 8-5 and 8-6) consists of the following components.

- A magnet assembly which is permanently affixed to the flywheel.
- An electronic, capacitive discharge ignition module which mounts on the engine crankcase.
- A spark advance module which mounts to the engine shrouding.
- 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.
- A spark plug.

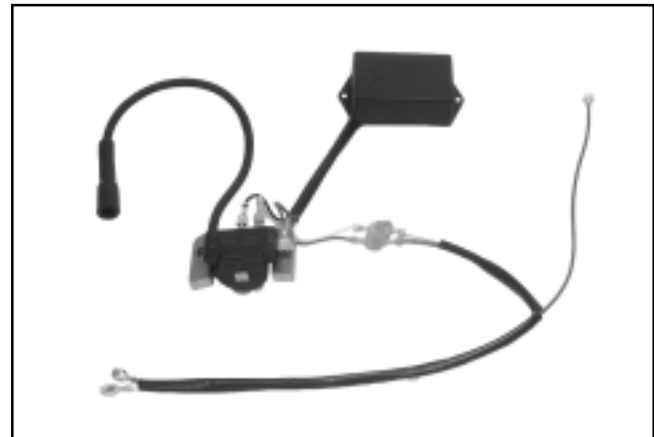


Figure 8-6. Smart Spark™ Components.

Section 8

Electrical System and Components

Operation

As the flywheel rotates, the magnet grouping passes the input coil (L1) of the ignition module, inducing energy in the coil. The resultant pulse is rectified by diode (D1) and charges capacitor (C1). Current from the same pulse also travels through the brown lead to the spark advance module (SAM), and enters the input of the conditioning circuit. The conditioning circuit shapes this pulse, putting it in a useable form for the other circuits. The "conditioned" pulse starts the charge pump, which charges a capacitor in linear fashion, directly related to engine speed. The pulse also resets the delay circuit. The comparator is off during this period.

When the flywheel magnet group has passed the input coil, and the original pulse drops back to zero, the capacitor in the delay circuit begins to charge off of the power source. When the charge on the delay

capacitor exceeds the charge pump capacitor, the comparator changes state and activates the pulse generator. The "generated" pulse returns to the ignition module through the yellow lead and turns "on" the semiconductor switch (SCS), completing the circuits between the charging capacitor (C1) and the transformer (T1). The charging capacitor discharges into the transformer primary (P), inducing a high-voltage pulse in the transformer secondary (S). The high-voltage pulse arcs across the spark plug gap, igniting the fuel-air mixture in the combustion chamber. The longer it takes the delay circuit to surpass the reference voltage in the charge pump capacitor, the later the trigger pulse will occur, retarding the timing accordingly.

The trigger pulse exiting the SAM activates the reset circuit, discharging the capacitor and resetting the circuits for the next cycle.

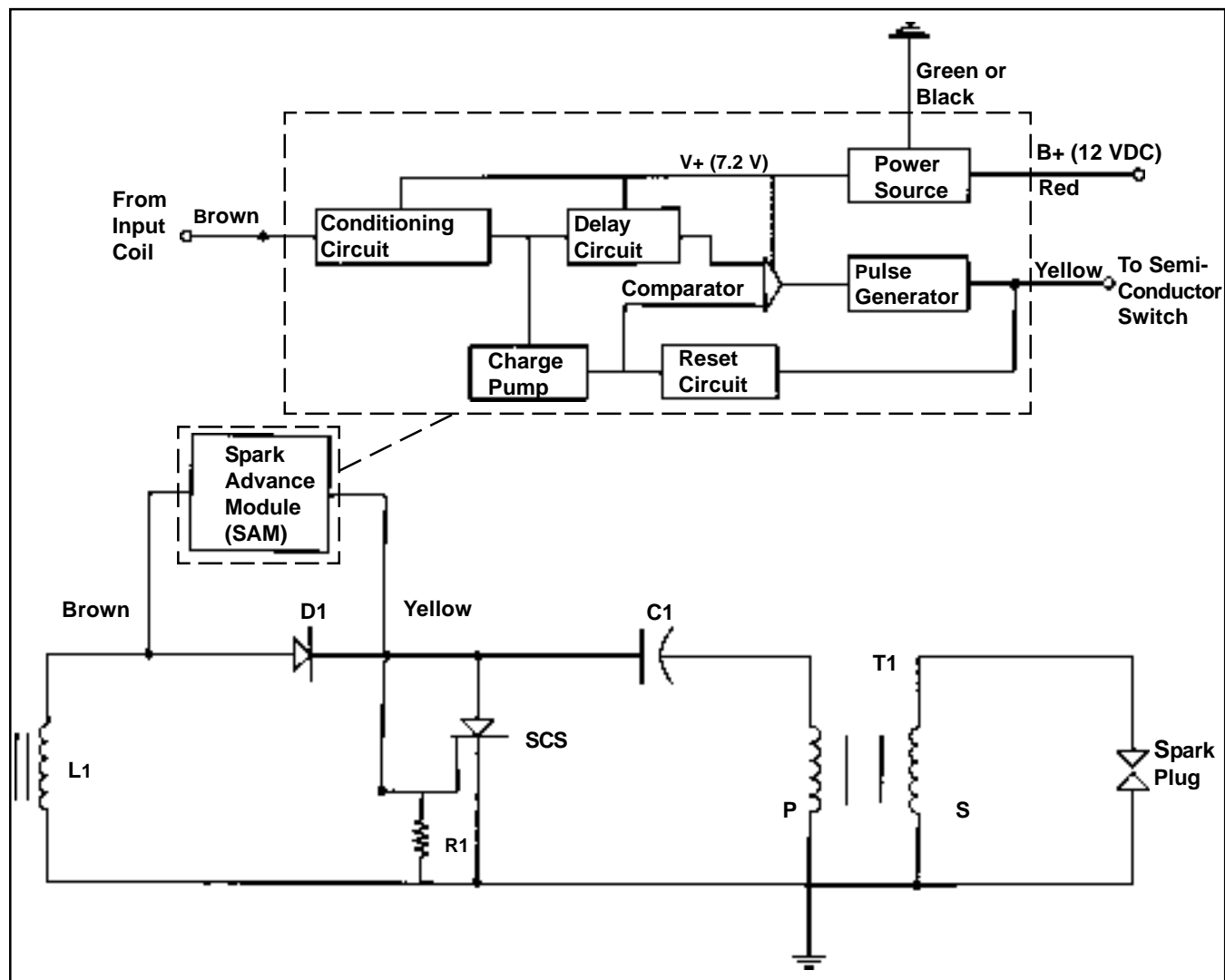


Figure 8-7.

Electrical System and Components

Troubleshooting CD Ignition Systems

The CD ignition system is designed to be trouble-free for the life of the engine. Other than periodically checking/replacing the spark plug, no maintenance or timing adjustment is 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.

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 lead. 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 7.2 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 of Smart Spark™ Ignition Systems on CV16 Engines

The following procedure is provided for troubleshooting ignition problems on CV16 engines. It will allow you to pinpoint the failed components.

Special Tools Required:

- Tester KO1046*
- Multi-meter (digital)

Specifications Required:

- Spark plug gap 0.030"
- Ignition module air gap 0.008-0.012" (0.010")

*NOTE: Ignition tester KO1046 must be used to test Smart Spark™ ignition. Use of any other tester can result in inaccurate findings. Battery on unit must be fully charged and properly connected before making any of these tests. Be sure drive is in neutral and all external loads are disconnected.

Preliminary Test

To be certain the reported problem is in the engine ignition system, it should be isolated from the unit, as follows.

1. Locate the plug connectors where the wiring harnesses from the engine and unit are joined. Separate the connectors and remove the white "kill" lead from the engine connector. Rejoin the connectors, and position or insulate the kill lead terminal so it cannot touch ground. Try to start the engine to verify whether the reported problem is still present.
 - a. If the problem is gone, the electrical system on the unit is suspect. Check the key switch, wires, connections, safety interlocks, etc.
 - b. If the problem persists, continue with the following troubleshooting procedure. Leave the kill lead isolated until all testing is completed.

Troubleshooting Procedure

1. Disconnect spark plug lead and attach it to tester KO1046. Attach tester clip to a good ground, **not** to the spark plug.
2. Crank the engine and observe tester for spark. Do not touch tester while cranking.
3. If no spark is observed, verify that spark advance module (SAM) is getting proper voltage.
 - a. Return to the connector where the engine and unit wiring harnesses are joined and find the double red lead in the back of the engine connector. Using a DC voltmeter with a probe lead, test the voltage at the terminal on the double red lead with the key switch in both the "start" and "run" positions. At least 7.2 volts must be present. If voltage is low, proceed to step 4. If voltage is above 7.2, proceed to step 5.

Section 8

Electrical System and Components

4. Remove the blower housing from the engine.
 - a. Trace the black ground lead from the SAM and check that the ground tab and terminal connections are all tight. Recheck voltage at engine connector. If voltage is still low, check battery, key switch, and wiring on unit.
 - b. When you are certain there is proper voltage at the connector, retest for spark. If there is still no spark, proceed to step 5.
5. If you skipped step 4, remove the blower housing at this time. Check all leads and connections from the SAM to the wiring harness and from the SAM to the ignition module. Pay special attention to the connection in the red lead, as the connectors can be misaligned in a way that the terminals don't make contact. Correct any problems found with the wiring or connections and retest for spark. If no wiring problems were found, or there is still no spark, proceed to step 6.
6. Zero ohmmeter and perform the following resistance checks on the ignition module. Module should be at room temperature (70° F).
 - a. Remove the brown lead and test resistance from the wide tab to the laminations. Resistance should be 145-160 ohms.
 - b. Remove the yellow lead and test resistance from the narrow tab to the laminations. Resistance should be 900-1000 ohms.
 - c. Test resistance from the spark plug lead terminal to the laminations. Resistance should be 3800-4400 ohms.

If any of the resistance readings are outside of the specified ranges, replace the ignition module. If the resistance readings are all good, replace the SAM.

Battery

A 12 volt battery with a minimum current rating of 250 cold cranking amps is recommended. The requirement depends on engine size, applications and starting temperatures. Cranking requirements increase as temperatures decrease and at the same time 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 crank the engine, recharge the battery.

Battery Charging



WARNING: Explosive Gases!

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.

Battery Maintenance

Regular maintenance will ensure the battery will accept and hold a charge.

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 battery clean. A build-up of corrosive acid or grime on the external surfaces can self-discharge the battery. Self-discharging happens rapidly when moisture is present.
3. Wash the cables, terminals, and external surfaces with a 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.

Section 8

Electrical System and Components

Battery Test

Test the battery voltage by connecting DC voltmeter across the battery terminals - crank the engine. If the battery drops below 9 volts while cranking, the battery is discharged or faulty. Refer to Figure 8-8.

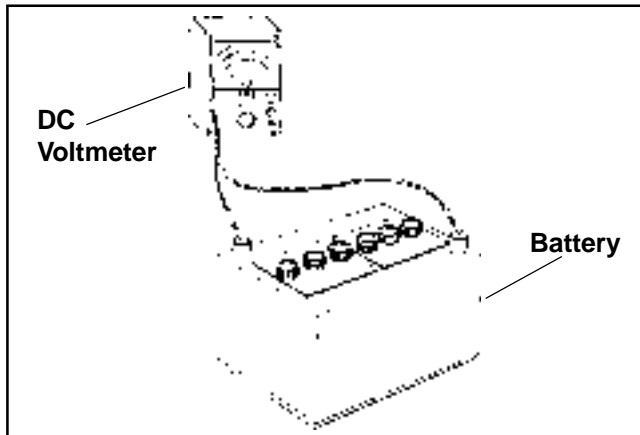


Figure 8-8. Checking Battery Voltage.

Electrical Systems Wiring Diagrams and Battery Charging Systems

Most engines are equipped with 15 amp regulated battery charging systems. Some have 3 amp unregulated systems with optional 70 watt lighting circuit.

Refer to the following wiring diagrams and troubleshooting guides to test and service system.

NOTE: Observe the following guidelines to prevent damage to the electrical system and components.

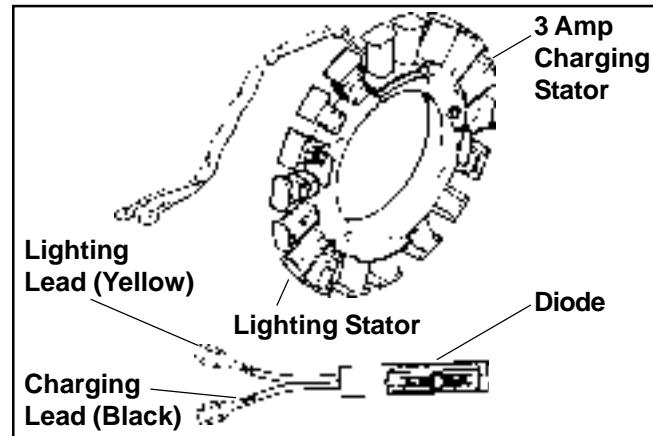


Figure 8-9. 3 amp/70 Watt Stator.

1. Make sure the battery polarity is correct. A negative (-) ground system is used.
2. Disconnect the battery cables (negative (-) cable first), before doing electric welding on the equipment powered by the engine.
3. Prevent the stator (AC) leads from touching or shorting while the engine is running. This could damage the stator.

Section 8

Electrical System and Components

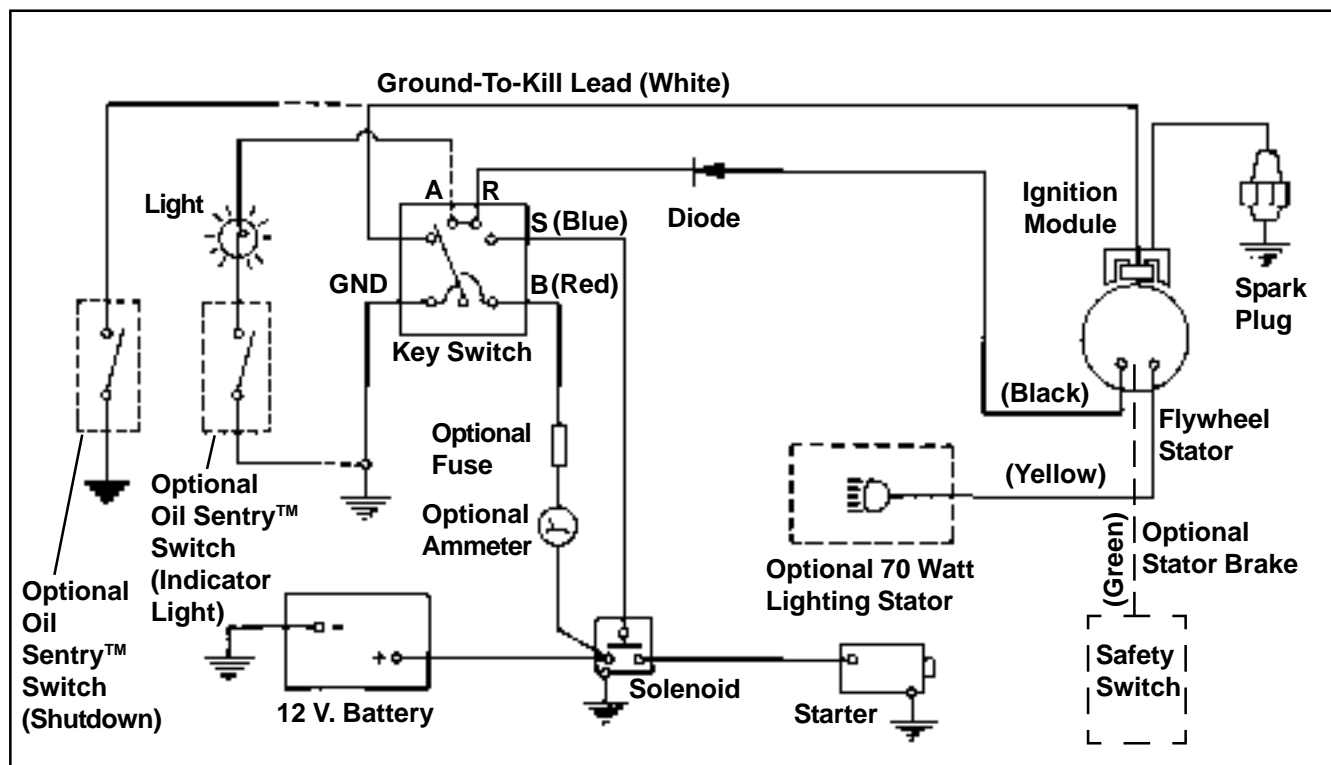


Figure 8-10. CV11-15, CV460-465, CV490-495 3 amp Unregulated Battery Charging System.

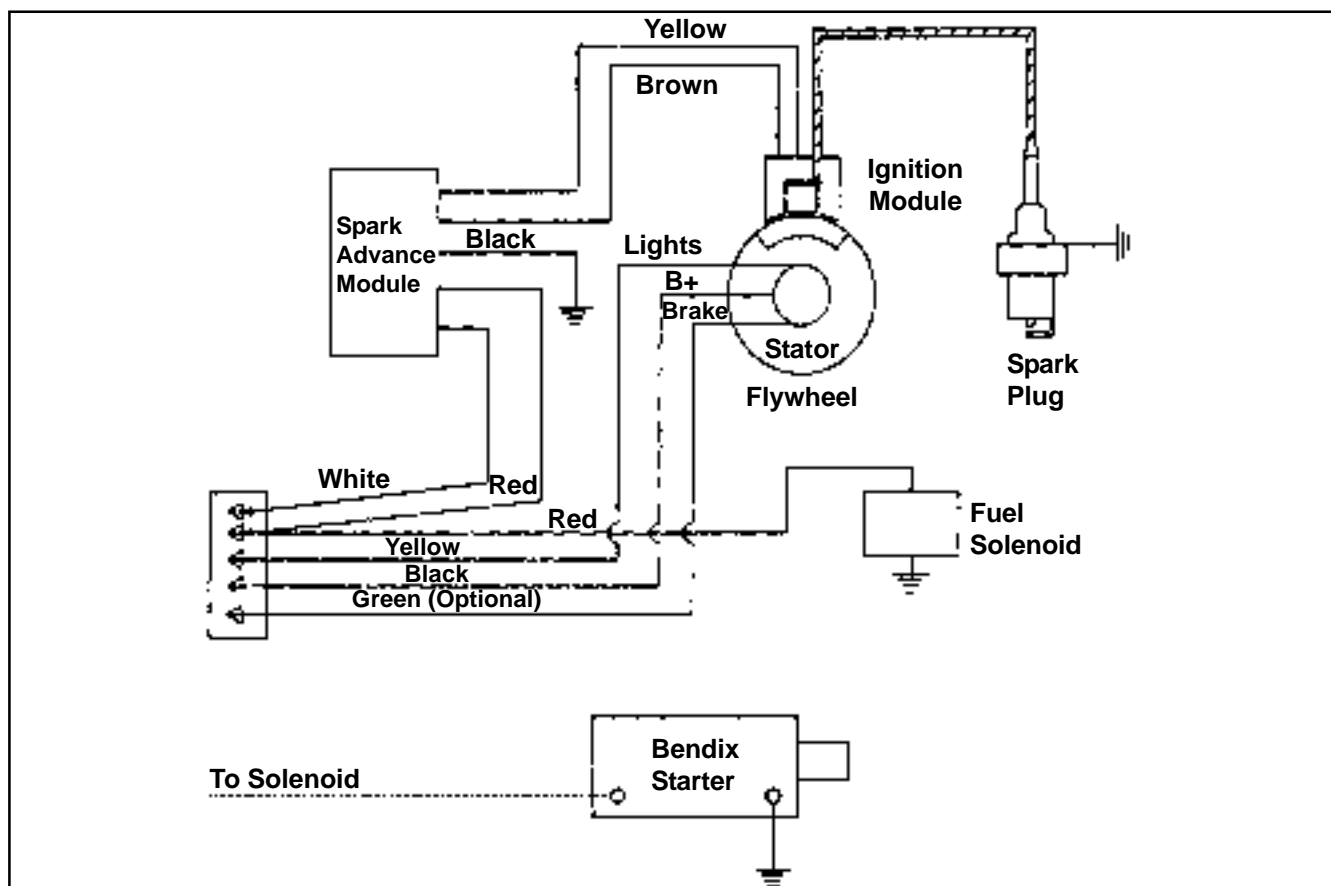


Figure 8-11. CV16 3 amp Unregulated Battery Charging System.

Troubleshooting Guide 3 amp Battery Charging System with 70 Watt Lighting Stator

NOTE: Zero ohmmeters on each scale to ensure accurate readings. Voltage tests should be made with engine running at 3000 RPM - no load. Battery must be fully charged.

Problem	Test	Conclusion
No Charge To Battery	1. With engine running at 3000 RPM, measure voltage across battery terminals using a DC voltmeter.	1. If voltage is more than 12.5 volts , charging system is OK. If voltage is 12.5 volts or less , the stator or diode are probably faulty. Test the stator and diode (Test 2, 3 and 4).
	2. Disconnect the charging lead from battery. With engine running at 3000 RPM, measure voltage from charging lead to ground using a DC voltmeter.	2. If voltage is 20 volts or more , stator winding is OK. If voltage is less than 20 volts , test stator using an ohmmeter (Tests 3 and 4).
	3. With charging lead disconnected from battery and engine stopped, measure resistance from charging lead to ground using an ohmmeter. Note reading. Reverse the leads and measure resistance again. In one direction, the resistance should be infinity ohms (open circuit). With the leads reversed, some resistance should be measured (about midscale on Rx1 range).	3. If resistance is low in both directions, the diode is shorted. Replace the diode. If resistance is high in both directions, the diode or stator winding is open. (Use Test 4).
	4. Cut the sleeving on the charging lead to expose the diode connections. Measure the resistance from the stator side of diode to ground using an ohmmeter.	4. If resistance is approximately 0.5 ohms , stator winding is OK. If resistance is 0 ohms , stator winding is shorted. Replace stator. If resistance is infinity ohms , stator winding or lead is open. Replace stator.
No Lights	1. Make sure lights are not burned out.	1. Replace burned out lights.
	2. Disconnect the lighting lead from the wiring harness. With engine running at 3000 RPM, measure voltage from lighting lead to ground using an AC voltmeter.	2. If voltage is 13 volts or more , stator is OK. Check for loose connections or shorts in wiring harness. If voltage is less than 13 volts , test stator using an ohmmeter (Test 3).
	3. With engine stopped, measure the resistance of stator from lighting lead to ground using an ohmmeter.	3. If resistance is approximately 0.2 ohms , stator is OK. If resistance is 0 ohms , stator is shorted. Replace stator. If resistance is infinity ohms , stator or lighting lead is open. Replace stator.

Section 8

Electrical System and Components

Troubleshooting Guide 3 amp/70 Watt Braking Stator

NOTE: Zero ohmmeteres on each scale to ensure accurate readings. Voltage tests should be made with engine running at 3400 RPM - no load. Battery must be fully charged.

Problem	Test	Conclusion
No Charge To Battery	1. With engine running at 3400 RPM, measure voltage across battery terminals using a DC voltmeter.	1. If voltage is more than 12.5 volts , charging system is OK. If voltage is 12.5 volts or less , the stator or diode are probably faulty. Test the stator and diode (Test 2,3, and 4).
	2. Disconnect the charging lead (black) from the wiring harness. With engine running at 3400 RPM, measure voltage from charging lead to ground using a DC voltmeter.	2. If voltage is 5 volts or more , stator winding is OK. If voltage is less than 5 volts , test stator using an ohmmeter (Tests 3 and 4).
	3. With charging lead disconnected from battery and engine stopped, measure resistance from charging lead to ground using an ohmmeter. Note reading. Reverse the leads and measure resistance again. In one direction, the resistance should be infinity ohms (open circuit). With the leads reversed, some resistance should be measured (about midscale on Rx1 range).	3. If resistance is low in both directions, the diode is shorted. Replace the diode. If resistance is high in both directions, the diode or stator winding is open. (Use Test 4.)
	4. Disconnect the lighting lead (yellow) from the wiring harness. Measure the resistance from the lighting lead to ground using an ohmmeter.	4. If resistance is approximately 0.15 ohms , stator winding is OK. If resistance is 0 ohms , stator winding is shorted. Replace stator. If resistance is infinity ohms , stator winding or lead is open. Replace stator.
No Lights	1. Make sure lights are not burned out.	1. Replace burned out lights.
	2. Disconnect the lighting lead (yellow) from the wiring harness. With engine running at 3400 RPM, measure voltage from lighting lead to ground using an AC voltmeter.	2. If voltage is 13 volts or more , stator is OK. Check for loose connections or shorts in wiring harness. If voltage is less than 13 volts , test stator using an ohmmeter (Test 3).
	3. With engine stopped, measure the resistance of stator from lighting lead to ground using an ohmmeter.	3. If resistance is approximately 0.15 ohms , stator is OK. If resistance is 0 ohms , stator is shorted. Replace stator. If resistance is infinity ohms , stator or lighting lead is open. Replace stator.

Section 8

Electrical System and Components

Problem	Test	Conclusion
No Lights Or Battery Charging (Braking System Test)	1. Make sure lights are not burned out.	1. Replace burned out lights.
	2. Disconnect the braking lead (green) from the wiring harness. With engine running at 3400 RPM, measure voltage from braking lead to ground using an AC voltmeter.	2. If voltage is 35 volts or more , stator is OK. Circuitry on unit that grounds braking lead is shorted. If voltage is less than 35 volts , test stator using an ohmmeter (Test 3).
	3. With the engine stopped, measure the resistance from braking lead to ground using an ohmmeter.	3. If resistance is approximately 0.2-0.4 ohms , stator is OK. If resistance is 0 ohms , stator is shorted. Replace stator. If resistance is infinity ohms , stator or lighting lead is open. Replace stator.

Section 8

Electrical System and Components

CV11-15, CV460-465, CV490-495 Electric Start Engines 15 amp Battery Charging System

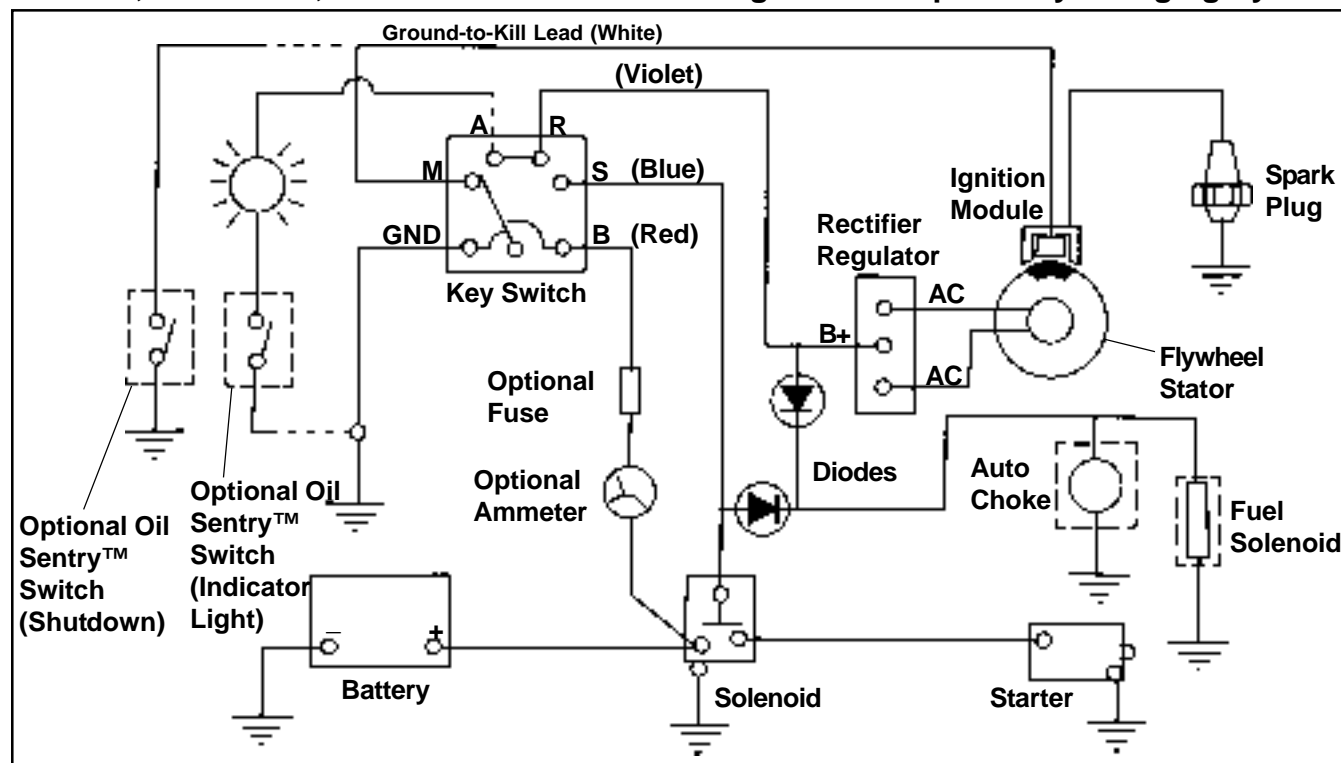


Figure 8-12. CV11-15, CV460-465, CV490-495 Electric Start Engines/15 amp Regulated Battery Charging System.

CV16 Electric Start Engines 15 amp Battery Charging System

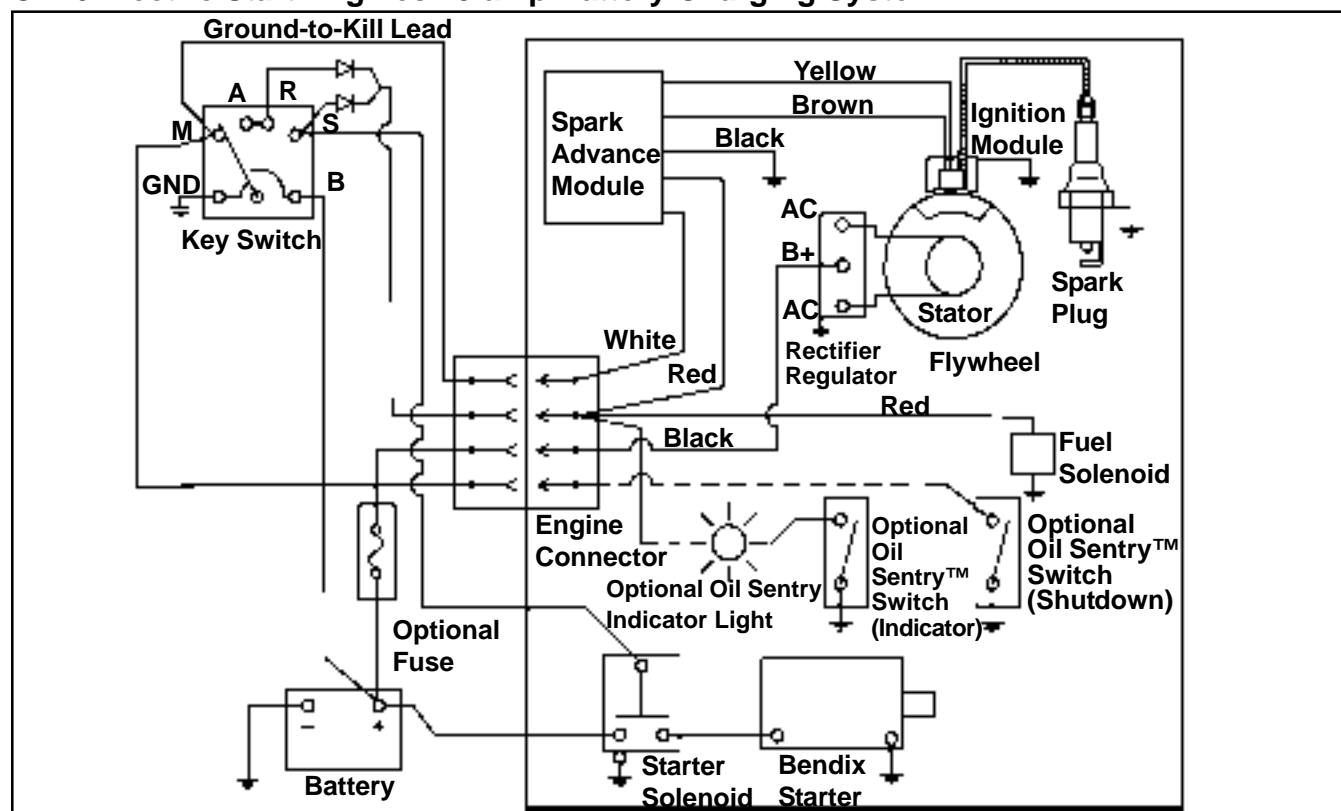


Figure 8-13. CV16 Electric Start Engines/15 amp Regulated Battery Charging System.

Section 8 Electrical System and Components

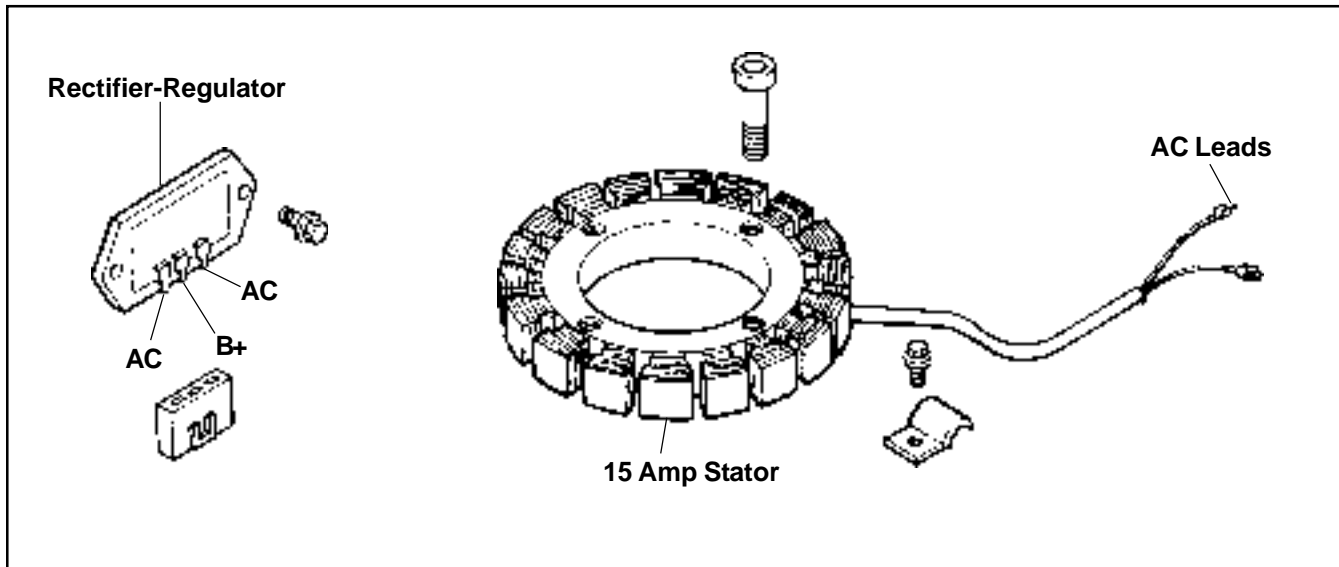


Figure 8-14. 15 amp Stator and Rectifier-Regulator.

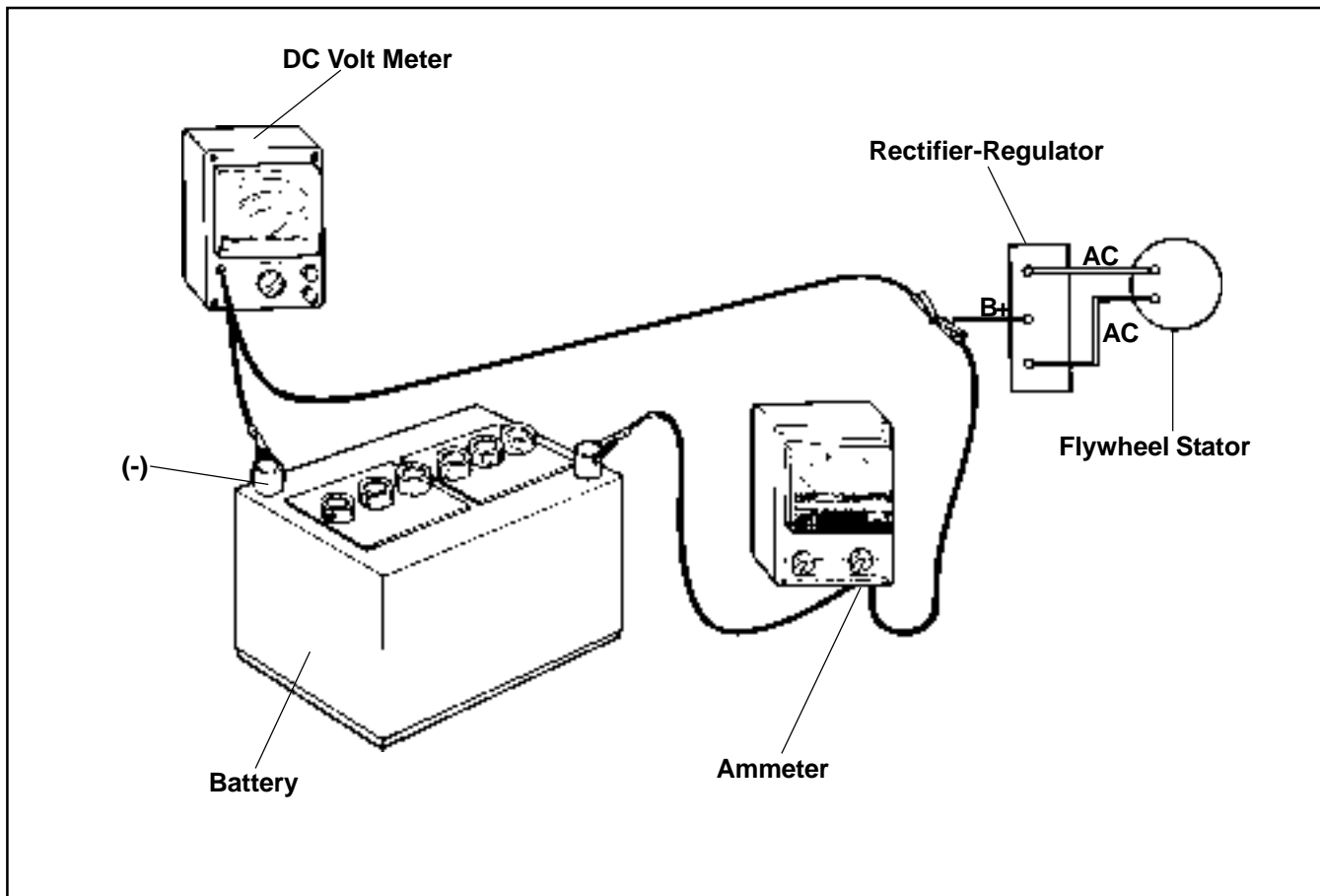


Figure 8-15. Proper Connection to Test 15 amp Charging System.

Section 8

Electrical System and Components

Troubleshooting Guide 15 amp Regulated Battery Charging System.

NOTE: Zero ohmmeters on each scale to ensure accurate readings. Voltage tests should be made with engine running at 3600 RPM - no load. The battery must be fully charged.

Problem	Test	Conclusion
No Charge to Battery	<p>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. See Figure 8-9. With engine running at 3600 RPM, read voltage on voltmeter.</p> <p>If voltage is 13.8 volts or more, place a minimum load of 5 amps* on battery to reduce voltage. Observe ammeter.</p> <p>*NOTE: Turn on lights, if 60 watts or more. Or place a 2.5 ohm, 100 watt resistor across battery terminals.</p>	<p>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.</p> <p>If voltage is less than 13.8 or charge rate does not increase when load is applied, test stator (Tests 2 and 3).</p>
	<p>2. Remove connector from rectifier-regulator. With engine running at 3600 RPM, measure AC voltage across stator leads using an AC voltmeter.</p>	<p>2. If voltage is 28 volts or more, stator is OK. Rectifier-regulator is faulty. Replace the rectifier-regulator.</p> <p>If voltage is less than 28 volts, stator is probably faulty and should be replaced. Test stator further using an ohmmeter (Test 3).</p>
	<p>3a. With engine stopped, measure the resistance across stator leads using an ohmmeter.</p>	<p>3a. If resistance is 0.1/0.2 ohms, the stator is OK.</p> <p>If the resistance is infinity ohms, stator is open. Replace stator.</p>
	<p>3b. With the engine stopped, measure the resistance from each stator lead to ground using an ohmmeter.</p>	<p>3b. If the resistance is infinity ohms (no continuity), the stator is OK (not shorted to ground).</p> <p>If resistance (or continuity) is measured, the stator leads are shorted to ground. Replace stator.</p>
Battery Continuously Charges at High Rate	<p>1. Perform same test as step 1 above.</p>	<p>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.</p> <p>If voltage is more than 14.7 volts, the rectifier-regulator is faulty. Replace rectifier-regulator.</p>

Electrical System and Components

Electric Starters

Some engines in this series use inertia drive 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 8.23.

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 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.

Troubleshooting Guide - Starting Difficulties

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. 2. Battery too small, must be at least 250 cold-cranking amps.
	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.

Section 8

Electrical System and Components

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.

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. See Figure 8-16.

It is not necessary to completely disassemble the starter to service the drive components.

Style "A" Drive Service

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 and 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 spacers, 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-S, 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 (150-170 in. lb.)**. Reinstall the dust cover.

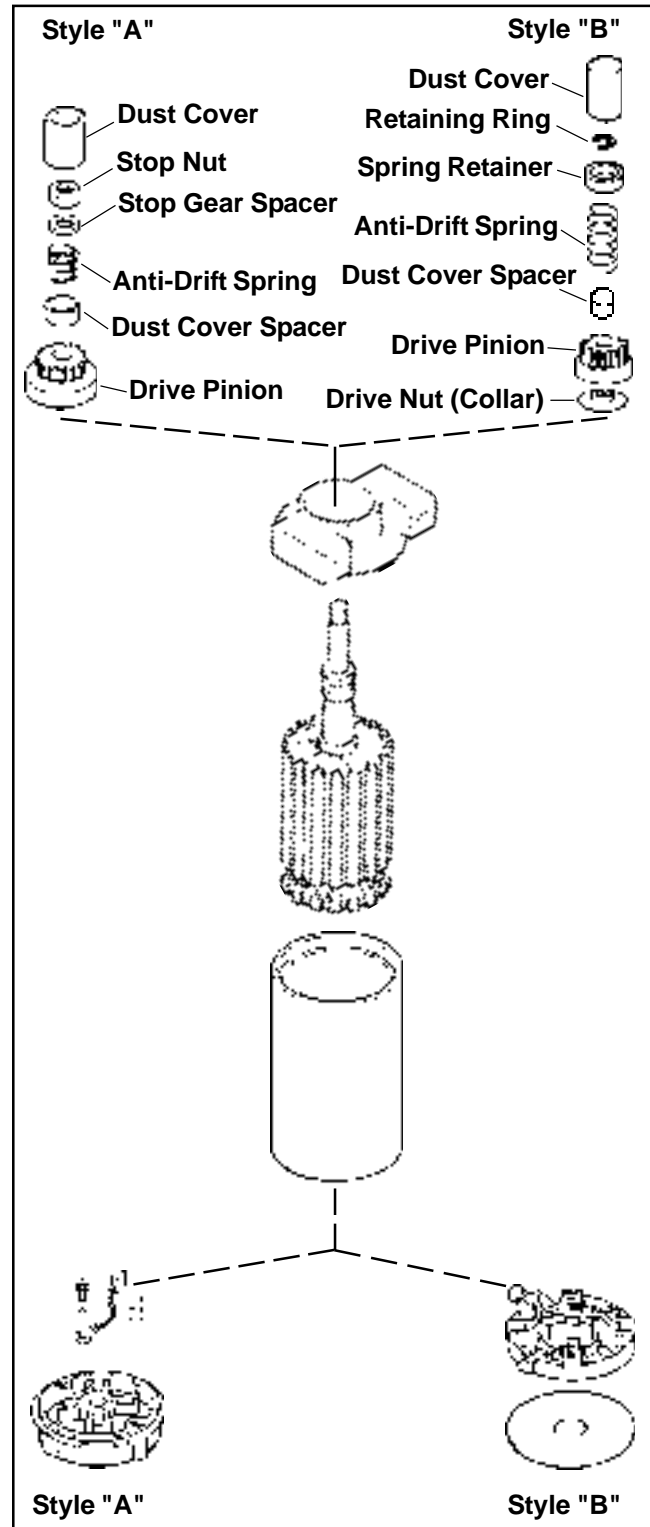


Figure 8-16. Inertia Drive Electric Starter.

Section 8

Electrical System and Components

Style "B" Drive Service

1. The rubber dust cover has a molded lip on the inside that snaps into a groove in the dust cover spacer (see Figure 8-17). Turn the drive pinion clockwise until it reaches the fully extended position. While holding it in the extended position, grasp the tip of the dust cover with a pliers or vise grip and pull it free from the spacer.

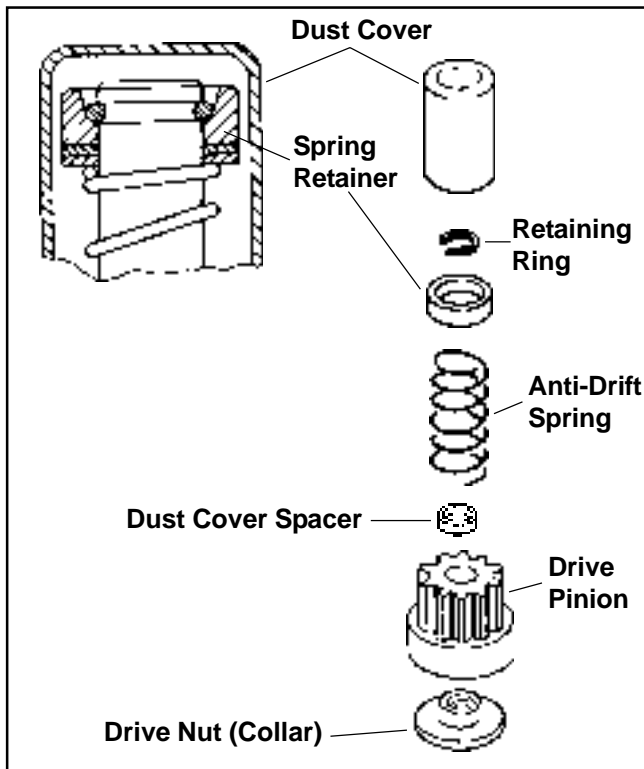


Figure 8-17. Drive Components, "Bonded" Inertia Drive Starter.

2. Disassemble removal tool 25 761 18-S.
3. Again referring to Figure 8-17, grasp the spring retainer and push it toward the starter, compressing the anti-drift spring and exposing the retaining ring.
4. Holding the spring retainer in the retracted position, assemble the inner halves of the removal tool around the armature shaft with the retaining ring in the inner groove (see Figure 8-18). Slide the collar over the inner halves to hold them in position.

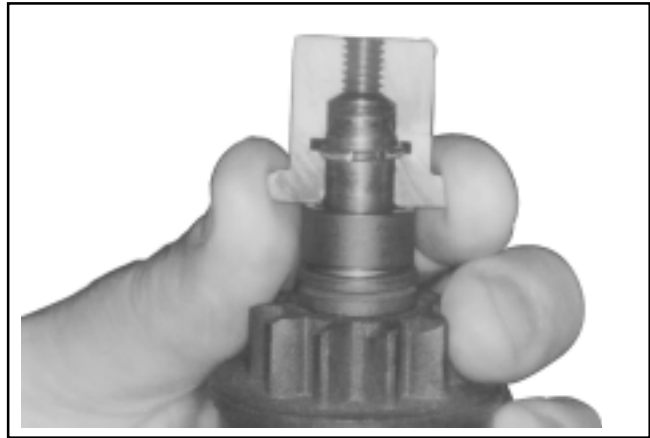


Figure 8-18. Assembling Inner Half of Tool Around Armature Shaft and Retaining Ring.

5. Thread the center screw into the removal tool until you feel resistance. Use a wrench (1 1/8" or adjustable) to hold the base of the removal tool. Use another wrench or socket (1/2" or 13 mm) to turn the center screw clockwise (see Figure 8-19). The resistance against the center screw will tell you when the retaining ring has popped out of the groove in the armature shaft.

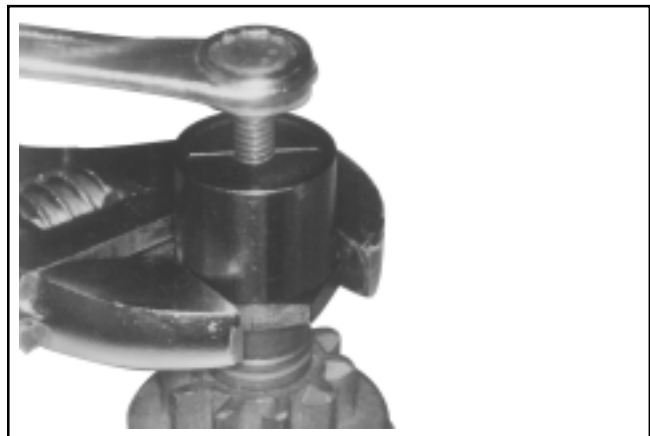


Figure 8-19. Holding Tool and Turning Center Screw (Clockwise) to Remove Retaining Ring.

6. Remove the drive components from the armature shaft, paying attention to the sequence. If the splines are dirty, clean them with solvent.
7. The splines should have a light film of lubricant. Relubricate as necessary with Kohler bendix starter lubricant (Part No. 52 357 01-S). Reinstall or replace the drive components, assembling them in the same sequence as they were removed.

Section 8

Electrical System and Components

Retaining Ring Installation

1. Position the retaining ring in the groove in one of the inner halves. Assemble the other half over the top and slide on the outer collar.
2. Be certain the drive components are installed in correct sequence onto the armature shaft.
3. Slip the tool over the end of the armature shaft, so the retaining ring inside is resting on the end of the shaft. Hold the tool with one hand, exerting slight pressure toward the starter. Tap the top of the tool with a hammer until you feel the retaining ring snap into the groove. Disassemble and remove the tool.
4. Squeeze the retaining ring with a pliers to compress it into the groove.
5. Assemble the inner halves, with the larger cavity, around the spring retainer (see Figure 8-20). Slide the collar over them and thread the center screw in until resistance is felt.
2. Locate the small raised line on the edge of the drive end cap. On starters with Style "A" commutator end caps, it will be aligned with a premarked line on the starter frame. The frame is not premarked on starters with Style "B" end caps. Place a piece of masking tape on the frame and mark a line on the tape in line with the raised line on the end cap. See Figure 8-23.
3. Remove the thru bolts.
4. Remove the commutator end cap with brushes and brush springs (Style "A"). Style "B" end caps remove as a separate piece with the brushes and carrier remaining in the frame.
5. Remove the drive end cap.
6. Remove the armature and thrust washer (if so equipped) from inside the starter frame.
7. Remove the brush/carrier assembly from the frame (Style "B" end cap starters).

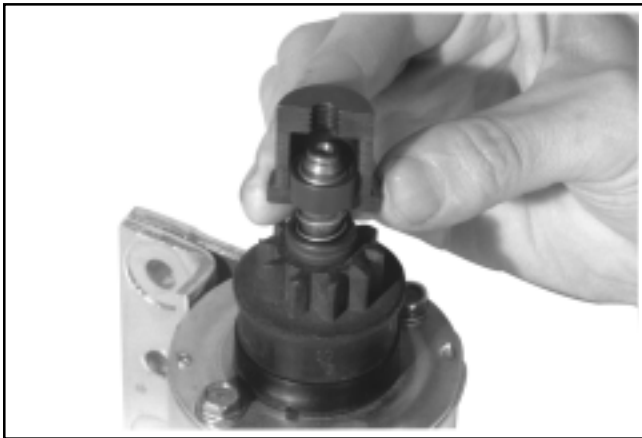


Figure 8-20. Assembling Larger Inner Half Around Spring Retainer.

6. Hold the base of the tool with a 1 1/8" wrench and turn the center screw clockwise with a 1/2" or 13 mm wrench to draw the spring retainer up around the retaining ring. Stop turning when resistance increases. Disassemble and remove the tool.
7. Reinstall the dust cover.

Starter Disassembly

1. Remove the drive components following the instructions for servicing the drive.

Style "A" End Cap Brush Replacement

1. Remove the brush springs from the pockets in brush holder. See Figure 8-21.
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 the 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 holder. Make sure the chamfered sides of brushes are away from the brush springs.

Section 8

Electrical System and Components

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 8-22.

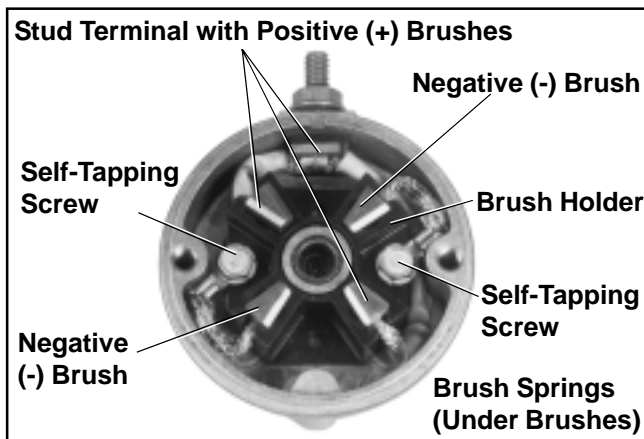


Figure 8-21. Style "A" Commutator End Cap with Brushes.

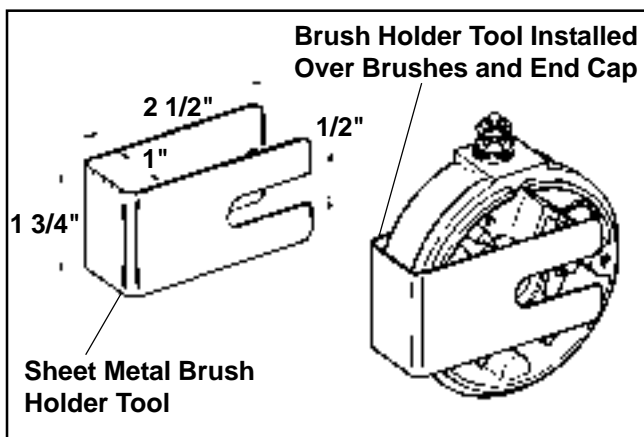


Figure 8-22. Brush Holder Tool (Style "A" End Cap).

Style "B" End Cap Brush Replacement

Starters with Style "B" end caps have the brushes in a plastic carrier housing, separate from the end cap. Replacement brushes come preassembled in the carrier housing, retained with two carton staples.

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.

Starter Reassembly

1. Place the thrust washer (if so equipped) 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 8-23.

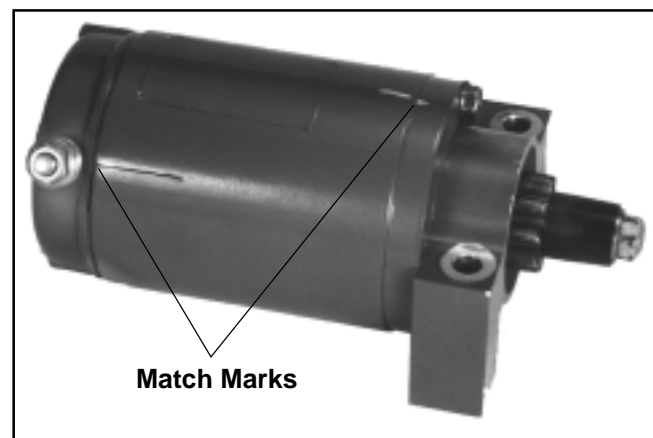


Figure 8-23. Starter Assembly Match Marks.

For Style "A" Commutator End Caps:

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.

For Style "B" Commutator End Caps:

- 4a. If the brush assembly is not being replaced, position the brushes in their pockets in the carrier, move them to the retracted position, and install carton staples to retain them. See Figure 8-24.
- 5a. Align the terminal stud block with the notch in the starter frame and slide the brush/carrier assembly into the frame. The commutator will push the carton staples out as the brush assembly is inserted. Position the end cap over the brush assembly, so the holes for the thru bolts are aligned with those in the brush carrier.

Section 8

Electrical System and Components

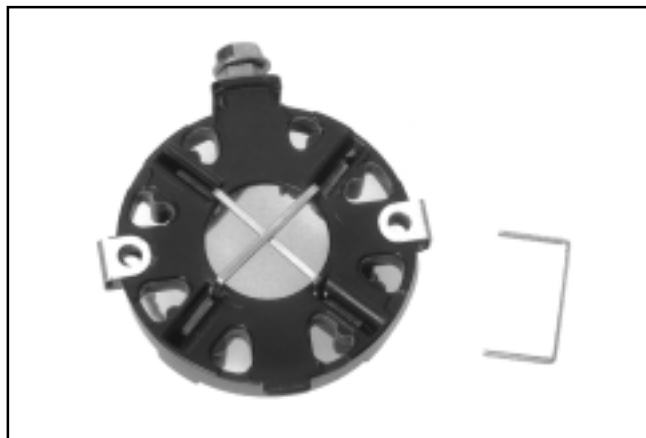


Figure 8-24. Style "B" Commutator End Cap with Brushes.

6. Install the thru bolts and tighten securely.
7. Lubricate the drive shaft with Kohler bendix starter drive lubricant (Part No. 52 357 01-S). Install the drive components following the instructions for servicing the drive.

110 Volt AC Starter

Some engines, on floor care equipment, are equipped with 110 volt, UL approved starters. See Figure 8-25. These starters have no serviceable components. If the starter is damaged, worn, or faulty, the entire starter motor must be replaced.

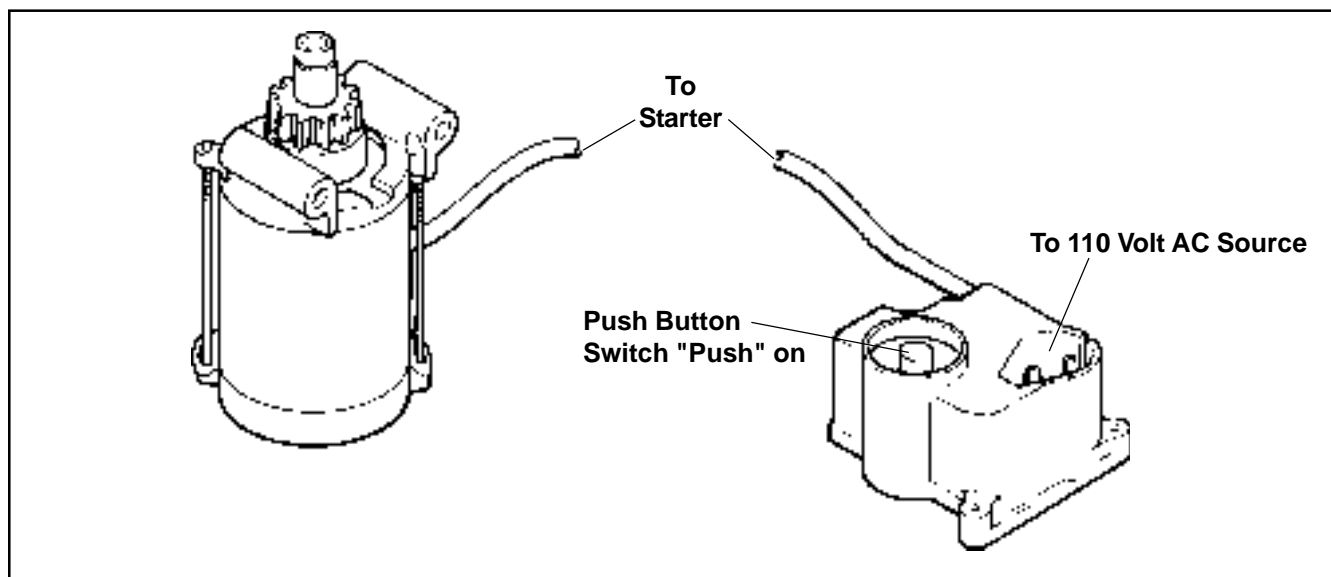


Figure 8-25. 110 Volt UL Approved Electric Starter.

Section 8

Electrical System and Components

Solenoid Shift Electric Starters

The following subsection covers the solenoid shift electric starters. Much of the information in the preceding subsection relates to these starters, therefore it is not repeated here. Refer to Figure 8-26 for disassembly and assembly procedure of the UTE solenoid shift starter. The Nippondenso solenoid shift starter is covered starting on page 8.24. The Delco solenoid shift starter starts on page 8.28.

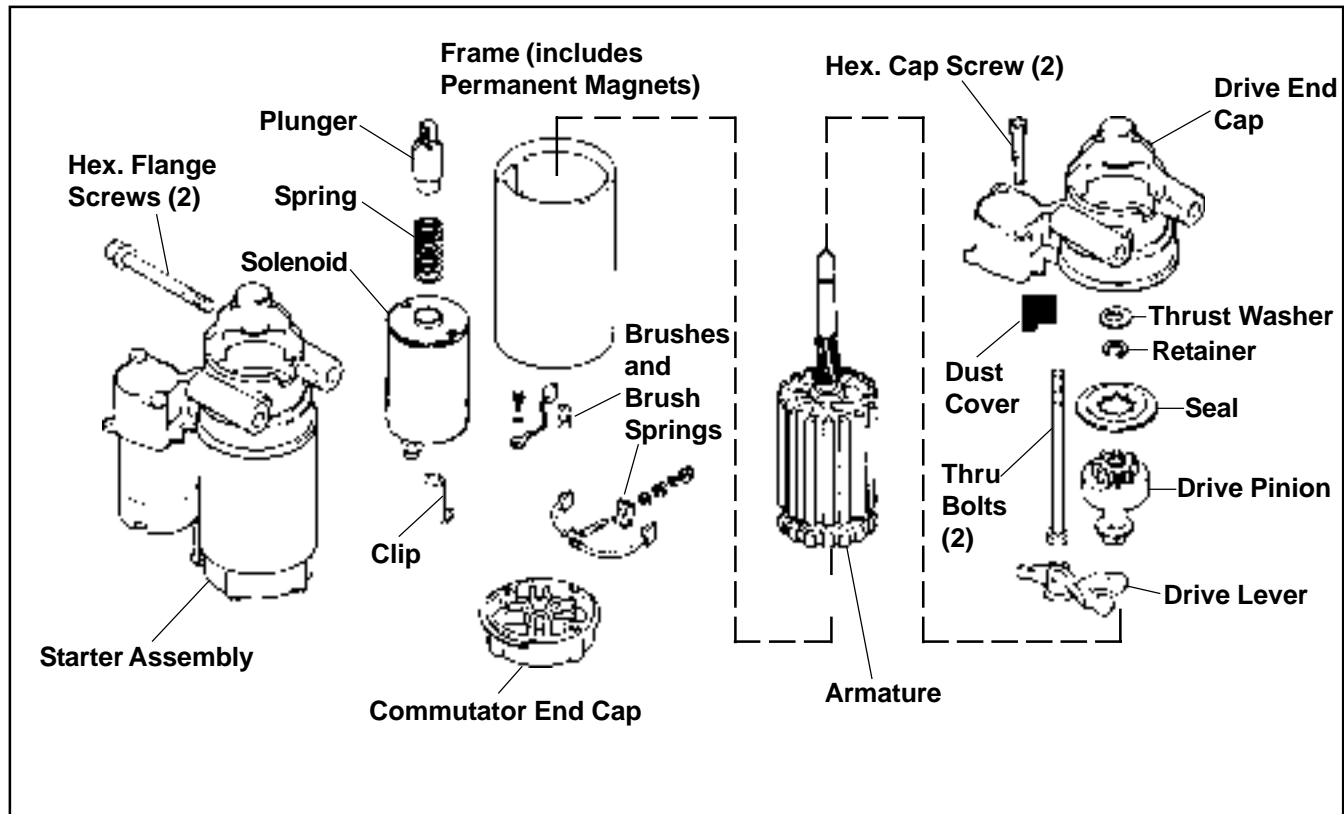


Figure 8-26. UTE Solenoid Shift Electric Starter.

Section 8

Electrical System and Components

Operation (Solenoid Shift Starters)

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.

Starter Removal and Installation

Refer to the "Disassembly" and "Reassembly" sections for starter removal and installation procedures.

UTE Starter Disassembly

1. Remove clip.
2. Remove cap screws and solenoid. Scribe alignment marks on caps and frame to aid assembly.
3. Remove the thru bolts, drive end cap, commutator end cap, and frame.
4. Remove drive lever.
5. Remove thrust washer and retainer to remove drive pinion from shaft.

UTE Brush Replacement

Replacing brushes in the solenoid shift starters is exactly the same procedure as explained for the UTE starter in the previous subsection.

UTE Starter Service

Clean drive lever and armature shaft. Apply Kohler electric starter drive lubricant (52 357 02-S) to lever and shaft.

UTE Starter Reassembly

1. Slide frame over armature and place commutator end cap in position. Hold in position temporarily with tape.

NOTE: Be sure alignment marks on caps and frame are in proper position.

2. Place drive pinion (with seal), thrust washer and retainer on drive shaft.

3. Place lever in position on drive shaft.
4. Place solenoid plunger on drive lever and position drive end cap over drive shaft (be sure the rubber dust cover is in place at the drive lever).
5. Fasten the end caps with the thru bolts.
6. Place the spring in the solenoid and fasten solenoid to drive end cap using hex. cap screws.
7. Replace the clip.

Nippendenso Solenoid Shift Starter

Some specifications call for the Nippendenso solenoid shift starter. Operation of this starter is identical to that previously discussed. There are, however, some differences in servicing the unit. Refer to Figure 8-27 for exploded view of the starter.

Starter Disassembly

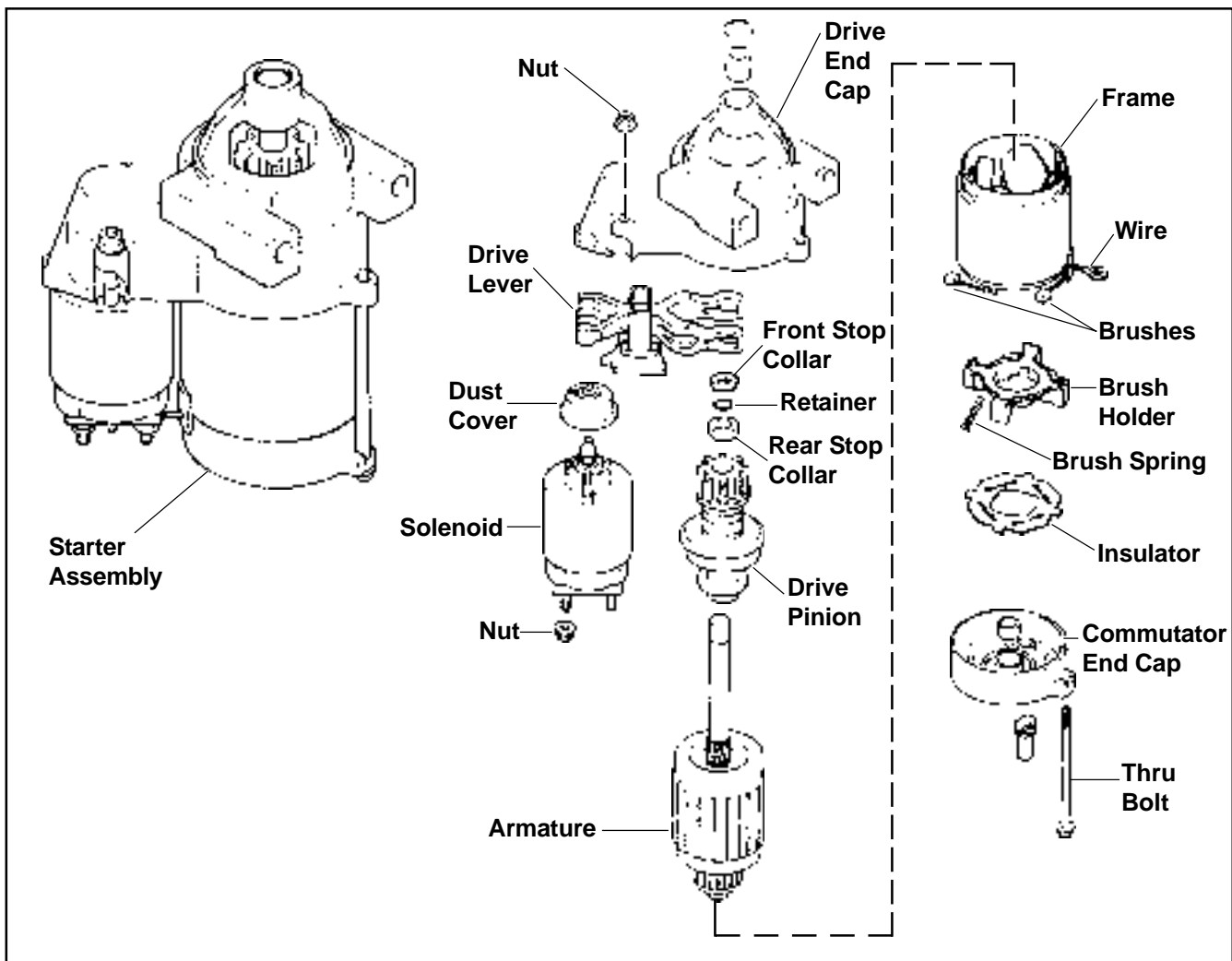
1. Disconnect the wire from the solenoid.
2. Remove the hex. nuts securing the solenoid, and remove the solenoid from the starter assembly.
3. Remove the two thru bolts.
4. Remove the commutator end cap.
5. Remove the insulator and brush springs from the brush spring holder.
6. Remove the armature from 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.

Section 8

Electrical System and Components



8

Figure 8-27. Nippendenso Solenoid Shift Starter.

9. When the stop collars are removed, the retainer can be removed from the armature shaft. Electric starter service kit KO3226 (see Section 2) includes a special pliers for removing the retainer. Do not reuse the retainer.
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. Snap the insulator into the brush holder to keep the springs from popping out.

Brush Replacement

The brushes in the starter are part of the starter frame. Brush kit Part No. 52 221 01-S 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.

Starter Service

Clean drive lever and armature shaft. Apply Kohler electric starter drive lubricant (52 357 02-S) to lever and shaft.

Section 8

Electrical System and Components

Starter Reassembly

1. Install the drive pinion onto the armature shaft.
2. Slide the stop collar onto the armature shaft below the retaining ring groove. Make sure the recessed side of the stop collar is “up”.
3. Position a new retainer in the groove of the armature shaft, and carefully tighten with a pliers to secure.

NOTE: Always use a new retainer. Do not nick or damage armature shaft.

4. Use an open end wrench and slide the stop collar up, until the recessed section encases the retaining ring and locks the collar into position. See Figure 8-28.



Figure 8-28. Lock Collar around Retaining Ring.

5. Install the thrust washer onto the armature shaft and lightly lubricate the end of the shaft with drive lubricant.
6. Position the lubricated drive lever around the drive pinion assembly and insert the assembly into the drive end cap. Seat the “pivot” section of drive lever into the corresponding section within the housing. See Figure 8-29.



Figure 8-29. Installing Armature.

7. Mount the brush holder to rear of starter frame. Install the four brushes into the corresponding slots. Then carefully work (set) each of the four brush springs into position behind the brushes. Slide the rubber insulating grommet onto the small corresponding plastic tab on frame. See Figure 8-30.



Figure 8-30. Mounting Brush Holder to Frame.

Section 8

Electrical System and Components

8. Position the insulator over the brushes and springs. Hold it firmly in place so the springs do not come out. See Figure 8-31.



Figure 8-31. Holding Insulator in Place.

9. Stand the armature/drive end cap assembly on end so the commutator end is "up". Place brush/armature installation tool over the end of the armature shaft until it rests against the commutator. See Figure 8-32.



Figure 8-32. Tool on end of Armature.

10. Carefully slide the frame, with the brush plate assembly, down over the tool and onto armature and drive end cap, aligning the cutout with lever section (on top). The rubber insulating grommet should also be "up". See Figure 8-33.

NOTE: Maintain pressure on the insulator while installing so the springs do not come out.



Figure 8-33. Installing Frame with Brush Plate Assembly.

11. Remove the tool and install the commutator end cap, aligning the cutout with the insulating grommet. See Figure 8-34.



Figure 8-34. Installing End Cap.

12. Install and tighten the two thru bolts.
13. Make sure the dust cover is in place on the solenoid. Install solenoid, engaging the plunger end with the yoke of the drive lever. Check by pulling solenoid towards the rear. Mount the solenoid to the starter using the two hex. flange nuts. Tighten securely. See Figure 8-35.

Section 8

Electrical System and Components



Figure 8-35. Installing Thru Bolts.

14. Connect the braided (brush) lead to lower main solenoid terminal and secure with the hex. flange nut. See Figure 8-36.

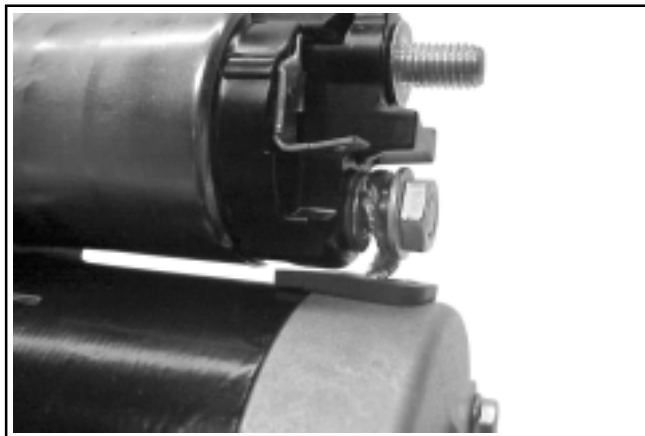


Figure 8-36. Connecting Brush Lead.

Delco-Remy Starters

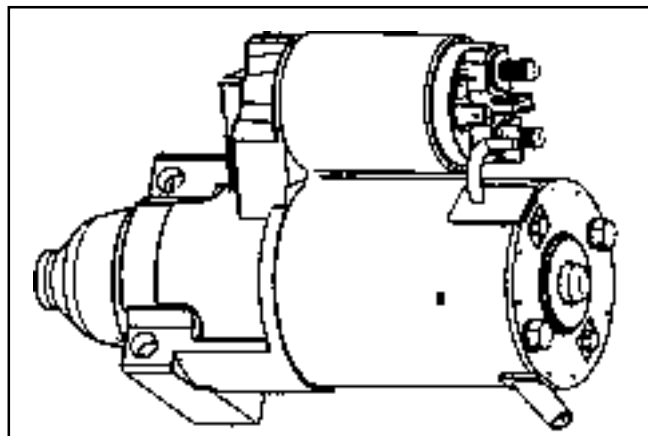


Figure 8-37.

Starter Disassembly

1. Remove the hex. nut and disconnect the positive brush lead/bracket from the solenoid terminal.
2. Remove the three screws securing the solenoid to the starter. Remove the solenoid and plunger spring from the drive end cap. See Figures 8-38 and 8-39.

Some solenoids are fastened with external Torx head screws.



Figure 8-38. Removing Solenoid Screws.

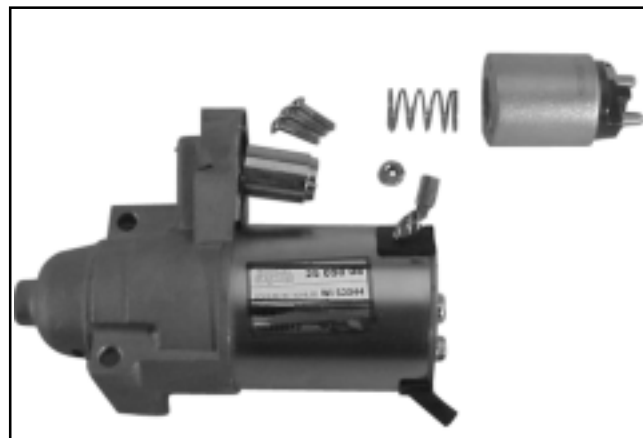


Figure 8-39. Solenoid Removed From Starter.

Section 8

Electrical System and Components

3. Lift and unhook the plunger assembly from the drive lever. Remove the gasket from the recess in the housing. See Figure 8-40.

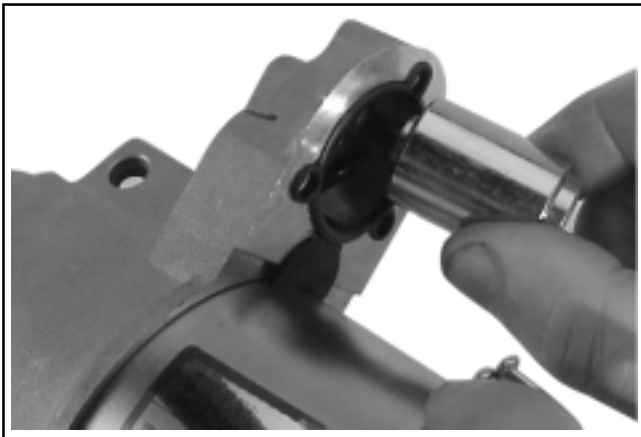


Figure 8-40. Removing Plunger.

4. Remove the two thru (larger) bolts. See Figure 8-41.



Figure 8-41. Removing Thru Bolts.

5. Remove the commutator end plate assembly, containing the brush holder, brushes, springs, and locking caps. Remove the thrust washer from inside the commutator end. See Figure 8-42.

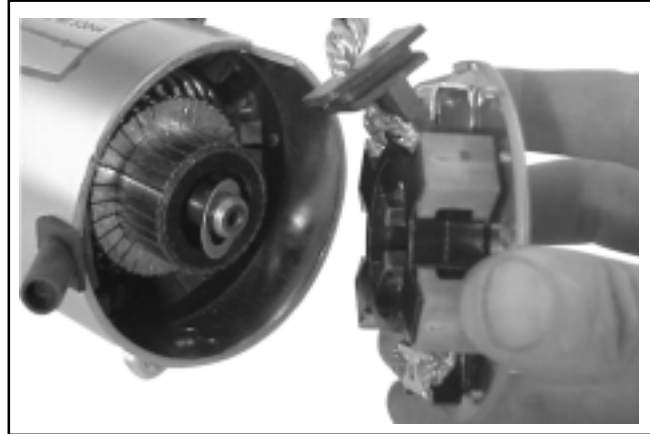


Figure 8-42. Removing Commutator End Plate Assembly.

6. Remove the frame from the armature and drive end cap. See Figure 8-43.



Figure 8-43. Starter Frame Removed.

7. Remove the drive lever pivot bushing and backing plate from the end cap. See Figure 8-44.

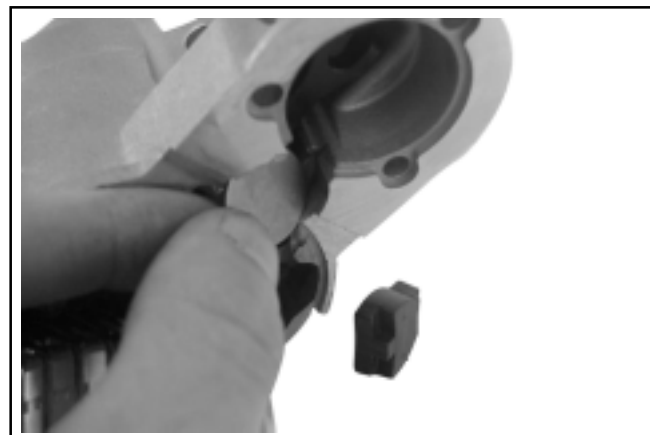


Figure 8-44.

Section 8

Electrical System and Components

8. Take out the drive lever and pull the armature out from the drive end cap. See Figure 8-45.
9. Remove the thrust washer from the armature shaft. See Figure 8-45.

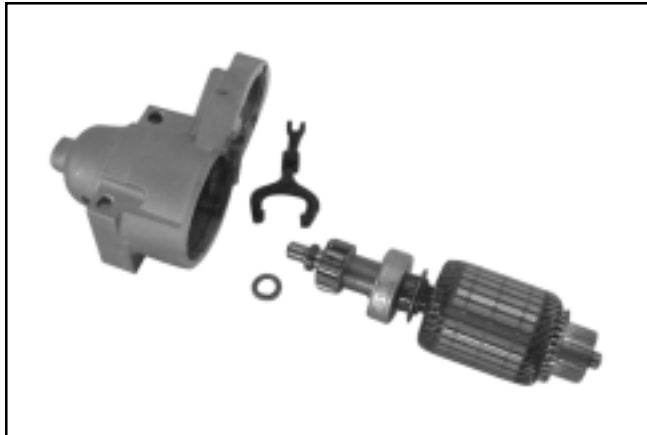


Figure 8-45. Armature and Lever Removed.

10. Push the stop collar down to expose the retaining ring. See Figure 8-46.



Figure 8-46. Retaining Ring Detail.

11. Remove the retainer from the armature shaft. Save the stop collar.

NOTE: Do not reuse the old retainer.



Figure 8-47. Removing Retaining Ring.

12. Remove the drive pinion assembly from the armature.
13. Clean the parts as required.

NOTE: **Do not** soak the armature or use solvent when cleaning. Wash and dry/clean using a soft cloth, or compressed air.

Section 8

Electrical System and Components

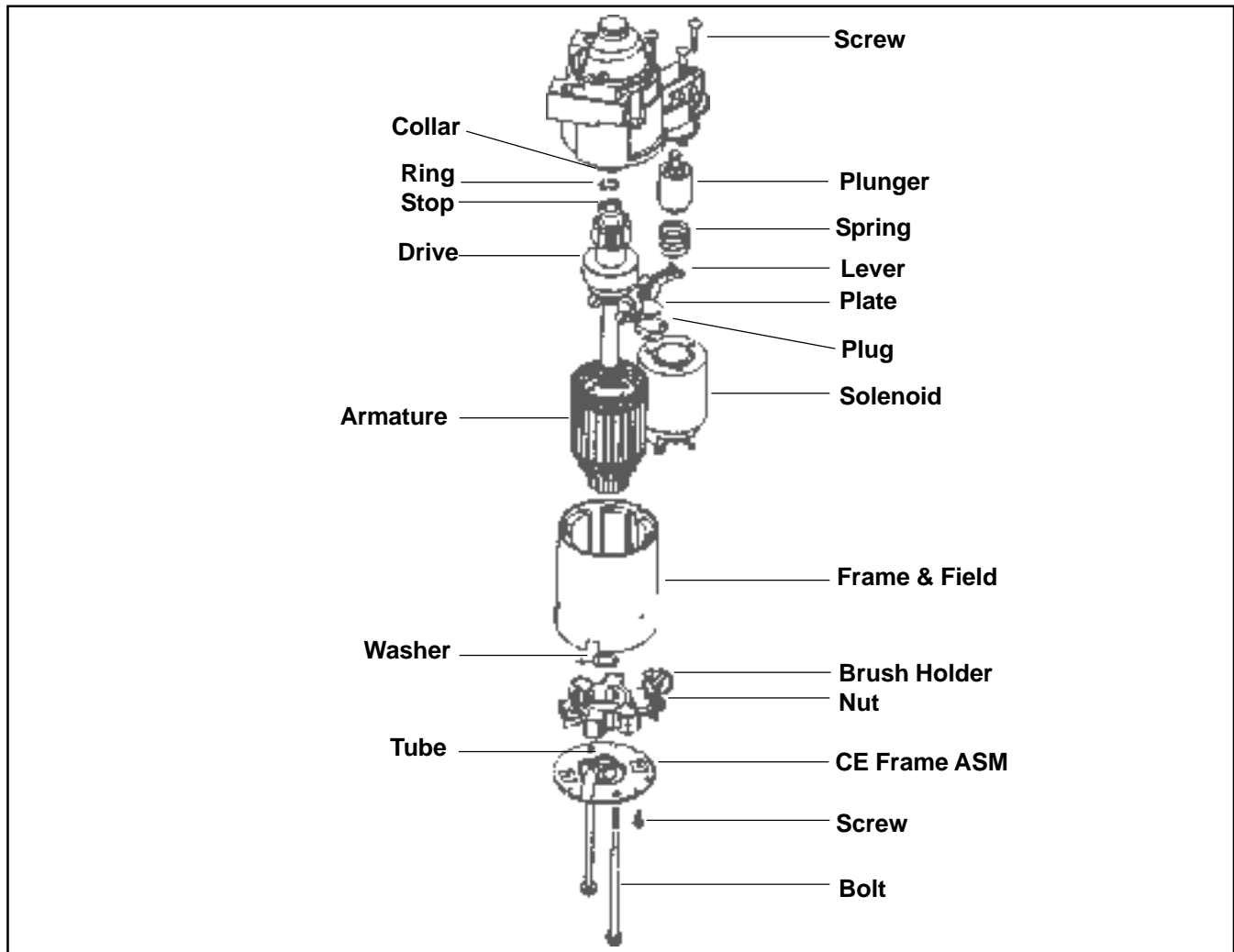


Figure 8-48. Delco-Remy Solenoid Shift Starter.

Inspection

Drive Pinion

Check and inspect the following areas:

- The pinion teeth for abnormal wear or damage.
- The O.D. surface between the pinion and the clutch mechanism for nicks or burrs which could cause seal damage.
- Check the drive clutch by holding the clutch housing and rotating the pinion. Pinion should rotate in one direction only.

Brushes and Springs

Inspect both the springs and brushes for wear, fatigue, or damage. Measure the length of each brush. The minimum length for each brush is **7.6 mm (.300 in.)**. See Figure 8-49. **Replace the brushes if they are worn undersize, or their condition is questionable.**

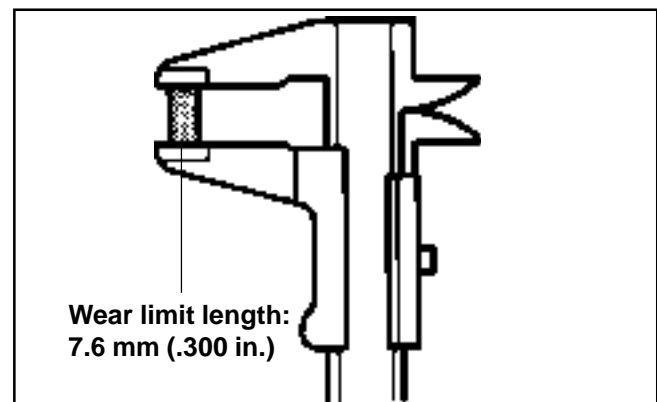


Figure 8-49. Checking Brushes.

Section 8

Electrical System and Components

Armature

1. Clean and inspect the commutator (outer surface). The mica insulation of the commutator must be lower than the O.D surface (undercut) to ensure proper operation of the commutator. See Figure 8-50.

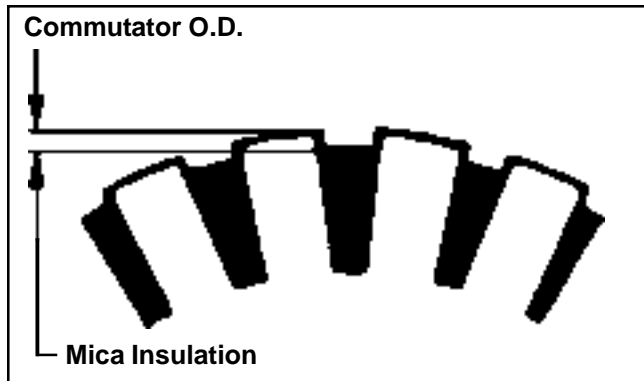


Figure 8-50. Commutator Mica Inspection.

2. Use an ohmmeter set to the Rx1 scale. Touch the probes between two different segments of the commutator, and check for continuity. See Figure 8-51. Test all the segments. Continuity **must** exist between all or the armature is bad.

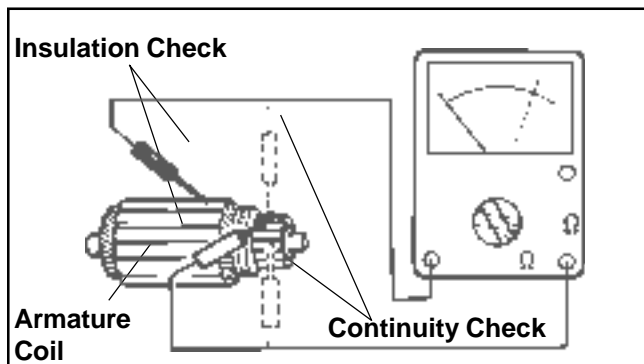


Figure 8-51. Checking Armature.

3. Check for continuity between the armature coil segments and the commutator segments. See Figure 8-51. There should be no continuity. If continuity exists between any two, the armature is bad.
4. Check the armature windings/insulation for shorting.

Shift Fork

Check that the shift fork is complete, and the pivot and contact areas are not excessively worn, cracked or broken.

Brush Replacement

The brushes and springs are serviced as a set (4). Use Brush and Spring Kit, Kohler Part No. **25 221 01-S**, if replacement is necessary.

1. Perform steps 1-5 in "Starter Disassembly."
2. Remove the two screws securing the brush holder assembly to the end cap (plate). Note the orientation for reassembly later. See Figure 8-52. Discard the old brush holder assembly.



Figure 8-52. Removing Brush Holder.

3. Clean the component parts as required.
4. The new brushes and springs come preassembled in a brush holder with a protective sleeve that will also serve as an installation tool. See Figure 8-53.



Figure 8-53. Service Brush Kit.

5. Perform Steps 10-13 in the "Starter Reassembly" sequence. (Installation must be done after the armature, drive lever and frame are installed, if the starter has been disassembled.)

Section 8

Electrical System and Components

Starter Service

Clean the drive lever and armature shaft. Apply Kohler electric starter drive lubricant, Part No. **52 357 02-S** (Versilube G322L or Mobil Temp SHC 32), to the lever and shaft. Clean and check the other starter parts for wear or damage as required.

Starter Reassembly

1. Apply new drive lubricant (Kohler Part No. **52 357 02-S**) to the armature shaft splines. Install the drive pinion onto the armature shaft.
2. Install and assemble the stop collar/retainer assembly.
 - a. Install the stop collar down onto the armature shaft with the counter bore (recess) up.
 - b. Install a new retainer in the larger (rear) groove of the armature shaft. Squeeze with a pliers to compress it in the groove.
 - c. Slide the stop collar up and lock it into place, so the recess surrounds the retainer in the groove. If necessary, rotate the pinion outward on the armature splines, against the retainer, to help seat the collar around the retainer.

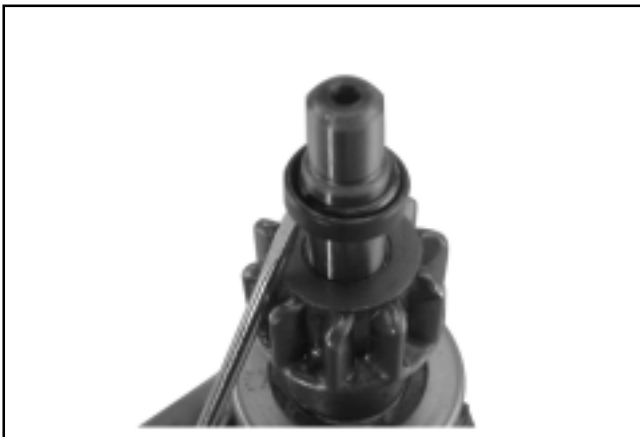


Figure 8-54. Installing Stop Collar and Retainer.

NOTE: Always use a new retainer. Do not reuse old retainers.

3. Install the offset thrust (stop) washer so the smaller "offset" of washer faces the retainer/collar. See Figure 8-55.

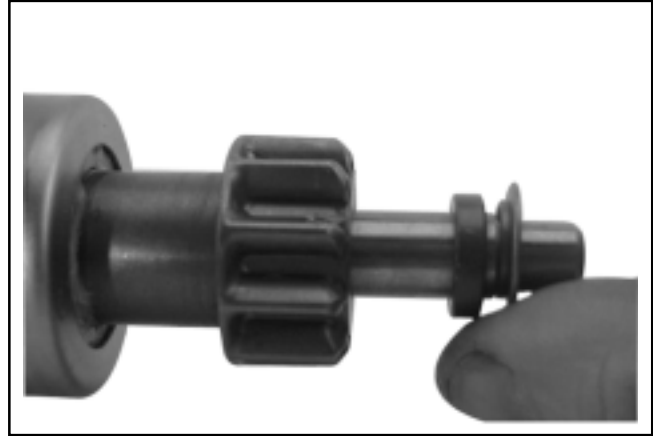


Figure 8-55. Installing Thrust Washer.

4. Apply a small amount of oil to the bearing in the drive end cap, and install the armature with the drive pinion.
5. Lubricate the fork end and center pivot of the drive lever with drive lubricant (Kohler Part No. **52 357 02-S**). Position the fork end into the space between the captured washer and the rear of the pinion.
6. Slide the armature into the drive end cap, and at the same time seat the drive lever into the housing.

NOTE: Correctly installed, the center pivot section of the drive lever will be flush or below the machined surface of the housing which receives the backup washer. See Figure 8-56.

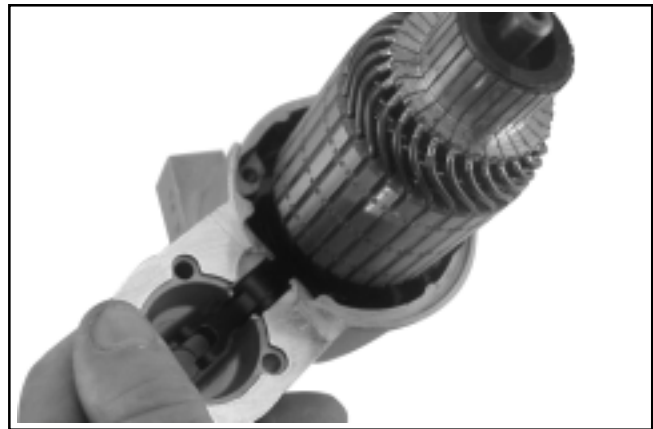


Figure 8-56. Installing Armature and Pivot Lever.

Section 8

Electrical System and Components

7. Install the backup washer, followed by the rubber grommet, into the matching recess of the drive end cap. The molded recesses in the grommet should be "out", matching and aligned with those in the end cap. See Figure 8-57.

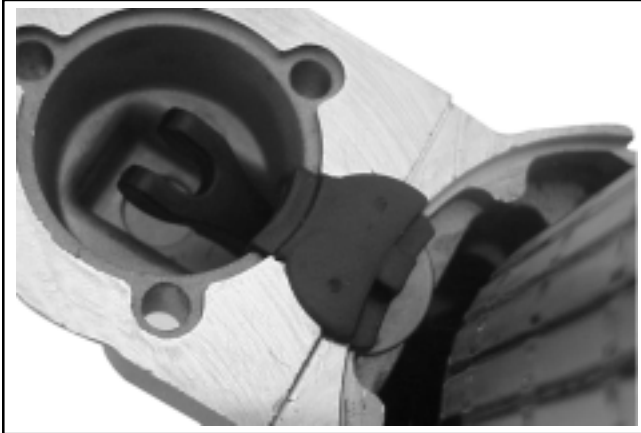


Figure 8-57. Installing Backup Washer and Grommet.

8. Install the frame, with the small notch forward, onto the armature and drive end cap. Align the notch with the corresponding section in the rubber grommet. Install the drain tube in rear cutout, if it was removed previously. See Figure 8-58.



Figure 8-58. Installing Frame and Drain Tube.

9. Install the flat thrust washer onto the commutator end of the armature shaft. See Figure 8-59.

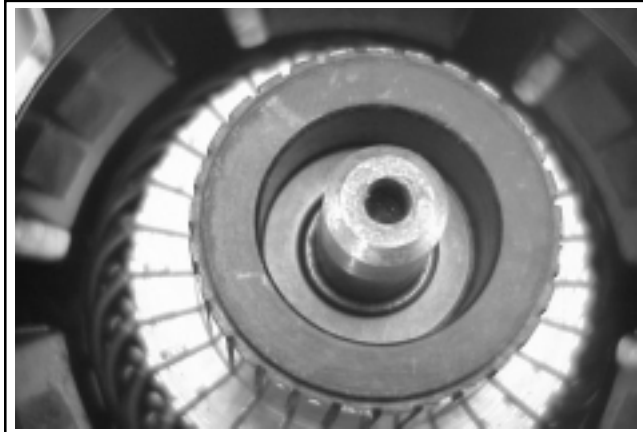


Figure 8-59. Installing Thrust Washer.

10. Starter reassembly when **replacing** the Brushes/ Brush Holder Assembly:
 - a. Hold the starter assembly vertically on the end housing, and carefully position the assembled brush holder assembly, with the supplied protective tube, against the end of the commutator/ armature. The mounting screw holes in the metal clips must be "up/out." Slide the brush holder assembly down into place around the commutator, and install the positive brush lead grommet in the cutout of the frame. See Figure 8-60. Save the protective tube, it may be used for future servicing.



Figure 8-60. Installing Brush Holder Assembly With Supplied Tube.

Starter reassembly when **not replacing** the Brushes/ Brush Holder Assembly:

- a. Carefully unhook the retaining caps from over each of the brush assemblies. Do not lose the springs.

Section 8

Electrical System and Components

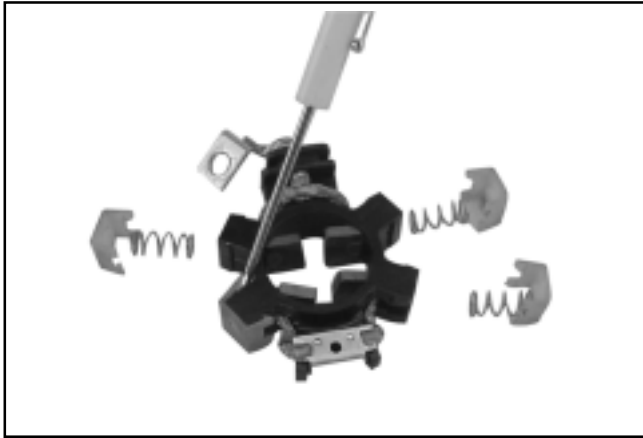


Figure 8-61. Removing Retaining Caps.

- b. Position each of the brushes back in their slots so they are flush with the I.D. of the brush holder assembly. Insert Brush Installation Tool No. KO3226-1 (w/extension), or use the tube described above from a prior brush installation, through the brush holder assembly, so the holes in the metal mounting clips are "up/out."
- c. Install the brush springs and snap on the four retainer caps. See Figure 8-62.



Figure 8-62. Brush Installation Tool with Extension.

- d. Hold the starter assembly vertically on the end housing, and carefully place the tool (w/extension) and assembled original brush holder assembly onto the end of the armature shaft. Slide the brush holder assembly down into place around the commutator, install the positive brush lead grommet in the cutout of the frame. See Figure 8-63.

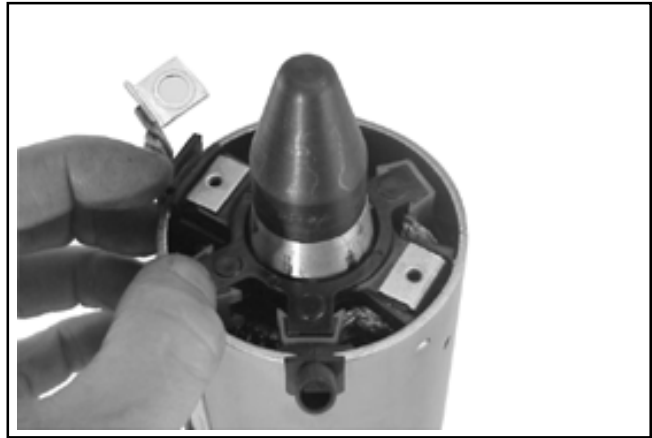


Figure 8-63. Installing Brush Holder Assembly Using Tool with Extension.

11. Install the end cap onto armature and frame, aligning the thin raised rib in the end cap with the corresponding slot in the grommet of the positive brush lead.
12. Install the two thru bolts, and the two brush holder mounting screws. Torque the thru bolts to **5.6-9.0 N·m (49-79 in. lb.)**. Torque the brush holder mounting screws to **2.5-3.3 N·m (22-29 in. lb.)**. See Figures 8-64 and 8-65.



Figure 8-64. Torquing Thru Bolts.

Section 8

Electrical System and Components



Figure 8-65. Torquing Brush Holder Screws.

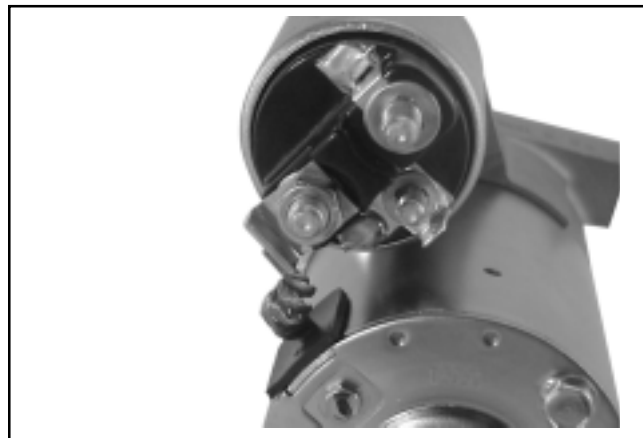


Figure 8-67. Positive Brush Lead Connection.

13. Hook the plunger behind the upper end of the drive lever, and install the spring into the solenoid. Insert the three mounting screws through the holes in the drive end cap. Use these to hold the solenoid gasket in position, then mount the solenoid. Torque the screws to **4.0-6.0 N·m (35-53 in. lb.)**. See Figure 8-66.

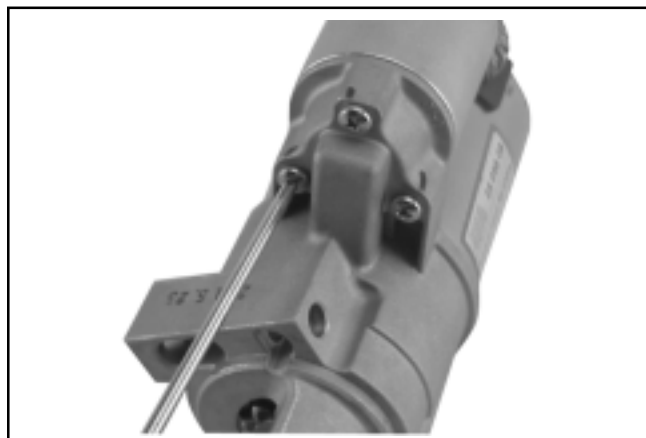


Figure 8-66. Installing Solenoid Screws.

14. Connect the positive brush lead/bracket to the solenoid and secure with the hex. nut. Torque the nut to **6-9 N·m (53-79 in. lb.)**, do not overtighten. See Figure 8-67.

Completed Starter Photo

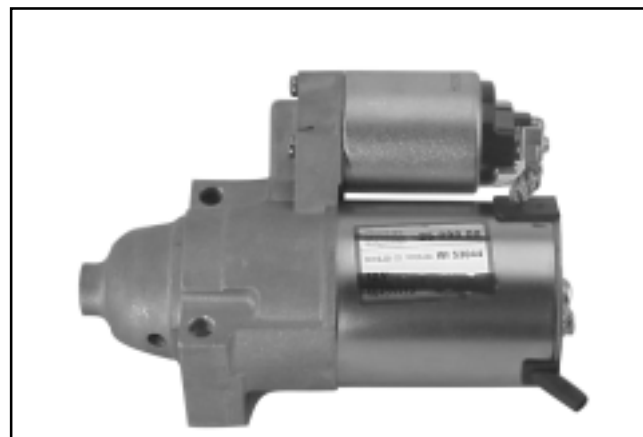


Figure 8-68. Delco-Remy Solenoid Shift Starter.

Go Back

Section 9

Disassembly



WARNING: Accidental Starts!

Disabling engine. Accidental starting can cause severe injury or death. Before working on the engine or equipment, disable the engine as follows: 1) Disconnect the spark plug lead(s). 2) Disconnect negative (-) battery cable from battery.

The following sequence is suggested for complete engine disassembly. This procedure can be varied to accommodate options or special equipment.

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

1. Disconnect spark plug lead.
2. Drain oil from crankcase and remove oil filter.
3. Remove Oil Sentry™ pressure switch.*
4. Remove muffler.
5. Remove retractable starter.
6. Remove electric starter.
7. Remove air cleaner.
8. Remove external governor components and carburetor.
9. Remove fuel pump.*
10. Remove rectifier-regulator.*
11. Remove extended oil fill tube.
12. Remove blower housing and baffles.
13. Remove ignition module.
14. Remove fuel line.
15. Remove valve cover and cylinder head.

*If so equipped.

16. Remove drive cup, grass screen, flywheel, and fan.
17. Remove stator and wiring harness.
18. Remove oil pan.
19. Remove oil pickup, oil pressure relief valve, and oil pump.
20. Remove camshaft and hydraulic lifters.
21. Remove balance shaft.
22. Remove connecting rod and piston.
23. Remove piston from connecting rod.
24. Remove piston rings.
25. Remove crankshaft.
26. Remove flywheel end oil seal and bearing.
27. Remove governor cross shaft and governor gear.

Disconnect Spark Plug Lead

Drain Oil from Crankcase and Remove Oil Filter

1. Remove the oil drain plug and oil fill cap/dipstick. See Figure 9-1.
2. Remove the oil filter drain plug located at the base of the oil filter adapter on some models.
3. Allow ample time for the oil to drain from the crankcase and oil filter.
4. Remove and discard the oil filter.

Remove Oil Sentry™ Pressure Switch (on models so equipped)

1. Disconnect the leads from the pressure switch.
2. Unthread and remove the pressure switch from the oil filter adapter. See Figure 9-1.

Section 9

Disassembly

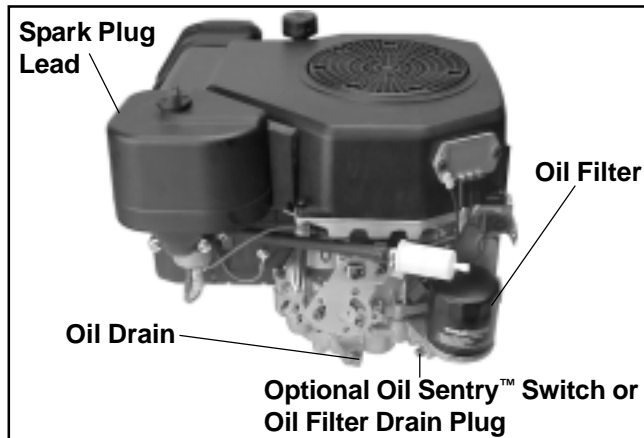


Figure 9-1. Removing Spark Plug Lead, Oil Drains, Oil Filter, and Oil Sentry™ Switch (oil filter drain plug not on all models).

Remove Muffler

1. Remove the hex. flange nuts from exhaust studs and hex. flange screws from muffler bracket. See Figures 9-2 and 9-3.
2. Remove the muffler and gasket from exhaust outlet flange. Some engines may have an additional heat deflector insert tube in the exhaust port, behind the muffler flange. If present, remove it also.

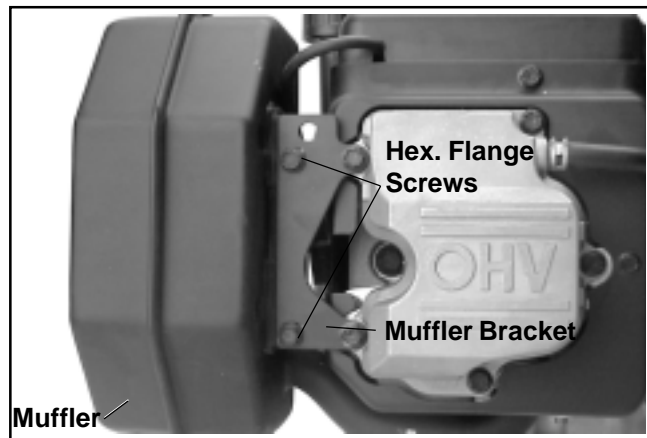


Figure 9-2. Removing Muffler.

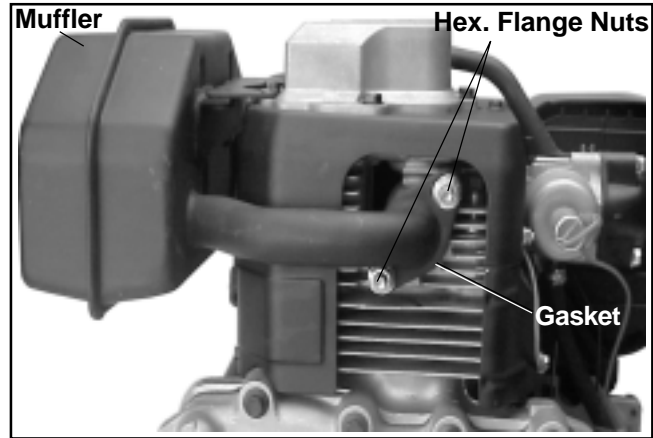


Figure 9-3. Removing Muffler.

Remove Retractable Starter

1. Remove the five hex. flange screws and retractable starter. See Figure 9-4.

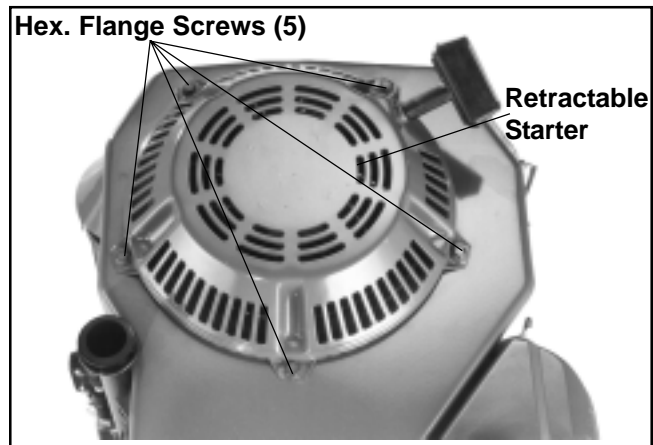


Figure 9-4. Removing Retractable Starter.

Remove Electric Starter

Electric Starter (Bendix Drive or Solenoid Shift)

1. Disconnect the lead from the stud terminal on the electric starter. See Figure 9-5. Disconnect both leads on Solenoid Shift Starter.
2. Remove the two hex. flange screws and starter assembly. Some bendix drive starters have additional spacers between the mounting flange and crankcase or under the head of the mounting bolt. After noting their placement, remove and retain the spacers.

Section 9

Disassembly

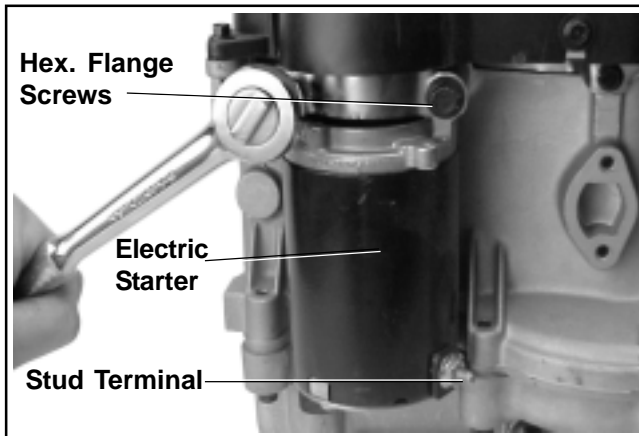


Figure 9-5. Removing Bendix Drive Starter.

Remove Air Cleaner

1. Loosen the knob and remove the air cleaner cover. See Figure 9-6.
2. Remove the wing nut, air cleaner element, and precleaner (if so equipped).
3. Loosen the hose clamps and disconnect the breather hose from the air cleaner base and valve cover. See Figure 9-7.
4. Remove the hex. flange nuts from the intake studs. Remove air cleaner base and gasket from studs.



Figure 9-6. Removing Air Cleaner Cover.

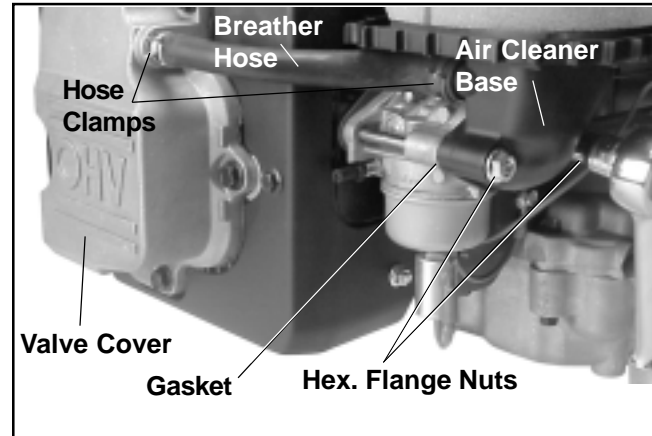


Figure 9-7. Removing Air Cleaner Base.

Remove External Governor Components and 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. Remove the throttle linkage from the bushing in the governor lever. See Figure 9-8. Reattach bushing to throttle linkage.

Remove the other end of the throttle linkage from the bushing in the carburetor throttle lever.

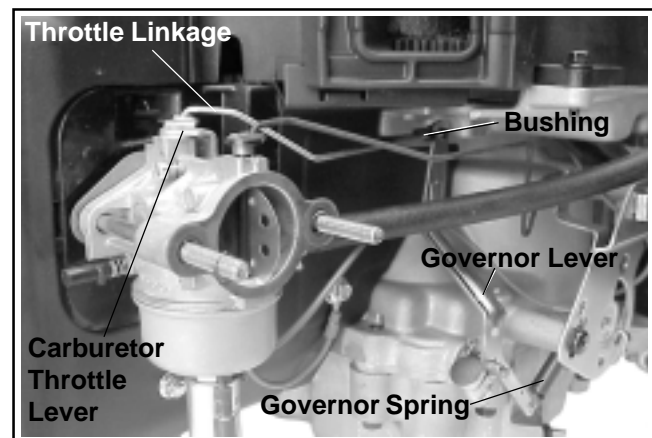


Figure 9-8. Removing Throttle Linkage.

2. Disconnect the governor spring from the governor lever and from the throttle control lever of the speed control bracket.

Section 9

Disassembly

3. Remove the two hex. flange screws and speed control bracket. See Figure 9-9.

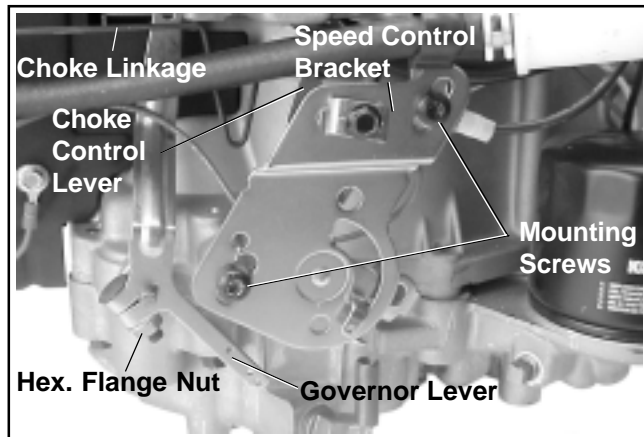


Figure 9-9. Removing Speed Control Bracket.

4. Disconnect the choke linkage from the choke control lever of speed control bracket.
5. Loosen the hex. flange nut and remove the governor arm from the cross shaft.
6. Disconnect the fuel line from the inlet fitting of the carburetor. See Figure 9-10.

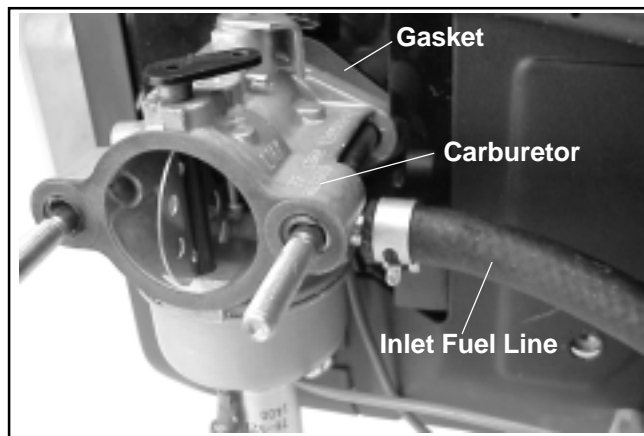


Figure 9-10. Removing Fuel Line and Carburetor.

7. Remove the baffle screw and internal tooth washer securing the ground lead for the fuel solenoid, if so equipped. See Figure 9-11.

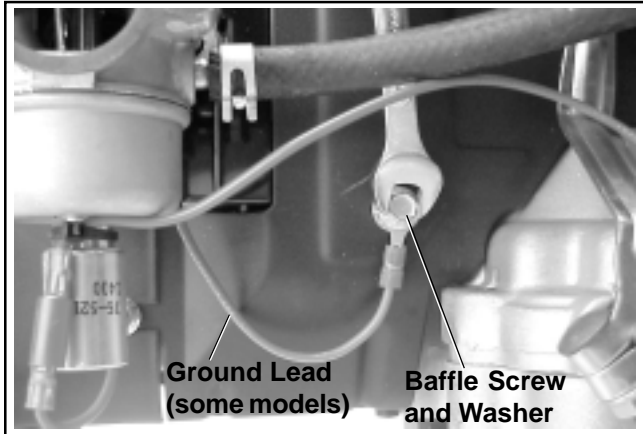


Figure 9-11. Removing Baffle Screw and Washer.

8. Remove the carburetor and gasket from the intake studs.

Remove Fuel Pump (If So Equipped)



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 from the outlet and inlet fittings of the fuel pump. See Figure 9-12.
2. Remove the two hex. flange screws, fuel pump, and gasket.

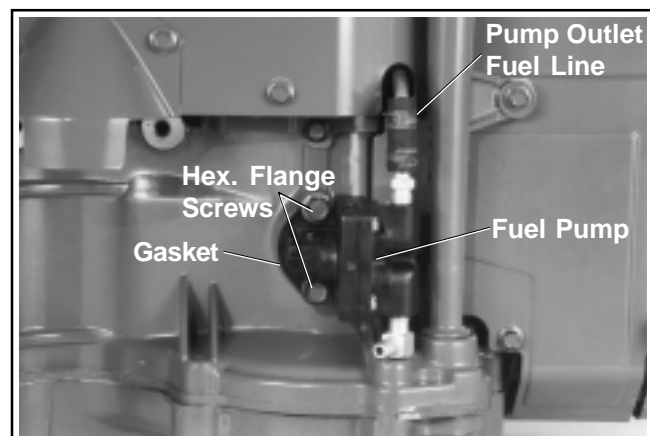


Figure 9-12. Removing Fuel Pump.

Section 9 Disassembly

Remove Rectifier-Regulator (If Required)

1. Remove the connector from the rectifier-regulator. See Figure 9-13.
2. Remove the two screws securing the rectifier-regulator and individual ground lead (if used).

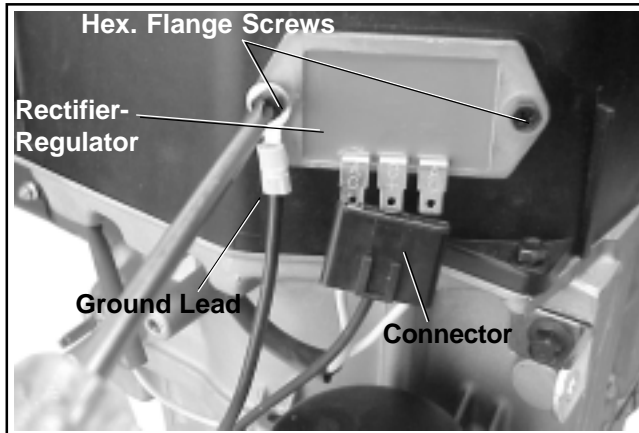


Figure 9-13. Removing Rectifier-Regulator (not on all models).

Remove Extended Oil Fill Tube

1. Remove the hex. flange screw securing the oil fill tube to the blower housing/crankcase. See Figure 9-14.
2. Pull the oil fill tube out of the crankcase flange.

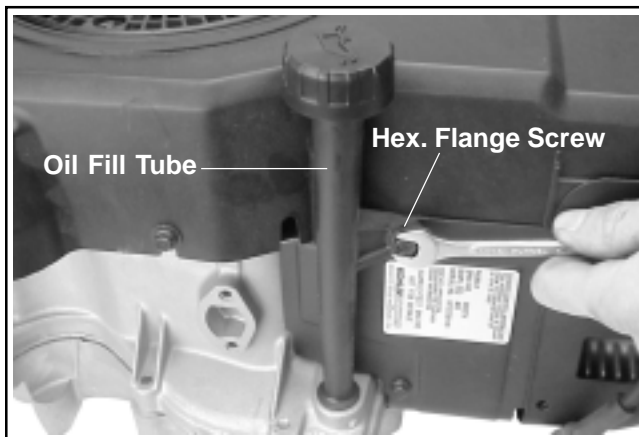


Figure 9-14. Removing Oil Fill Tube.

Remove Blower Housing and Baffles

1. See Figure 9-15, 9-16, and 9-17. Remove the six screws securing the blower housing and any commonly mounted clamps/brackets. Remove the blower housing.

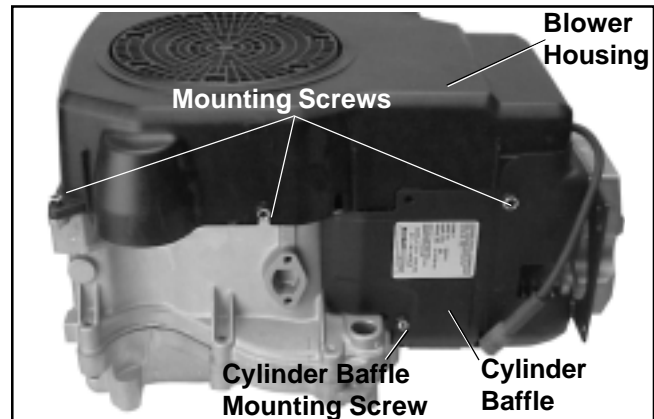


Figure 9-15. Removing Blower Housing and Baffles.

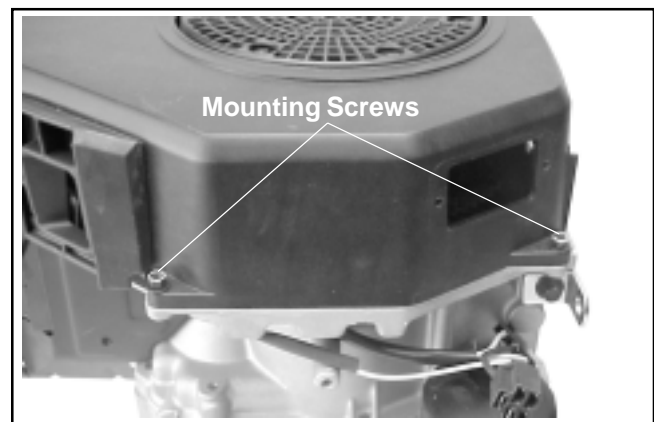


Figure 9-16. Removing Blower Housing and Baffles.

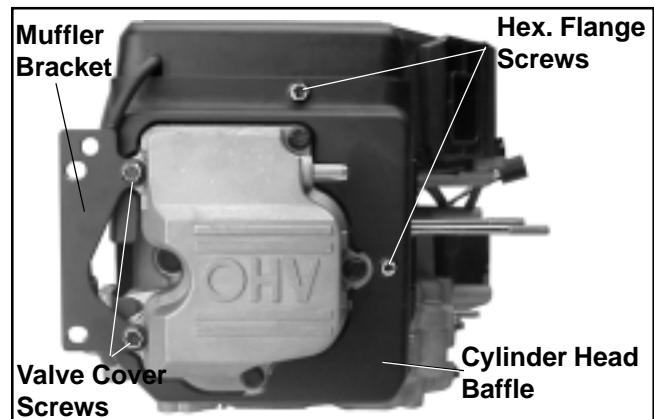


Figure 9-17. Removing Blower Housing and Baffles.

2. Remove the hex. flange valve cover screws and any loose spacers (stamped steel valve covers) which also attach the muffler and/or lift bracket. Note the assembly orientation for proper reassembly later.

Section 9

Disassembly

3. Remove the hex. flange nut on stud securing the carburetor side baffle,* if not removed previously during carburetor removal. Remove the screws attaching the cylinder head baffle. See Figure 9-18.

* If so equipped.

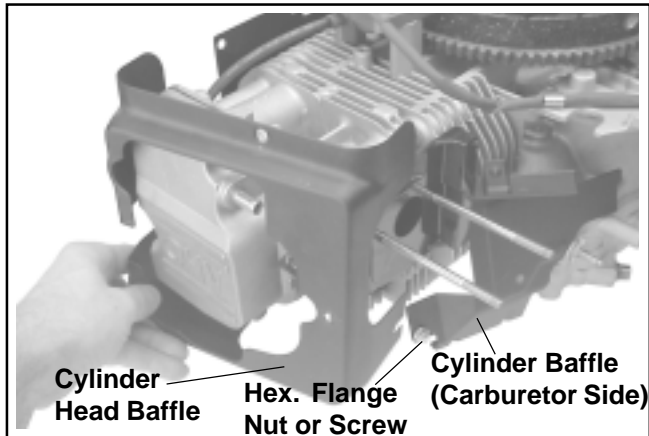


Figure 9-18. Removing Blower Housing and Baffles.

4. Carefully loosen and remove the heat deflector and gasket from intake studs. The heat deflector is made from a plastic that is quite brittle. Do not pry on the corners, or you risk cracking/breaking the deflector. If prying is necessary to loosen the deflector, pry near the intake studs. See Figure 9-19.

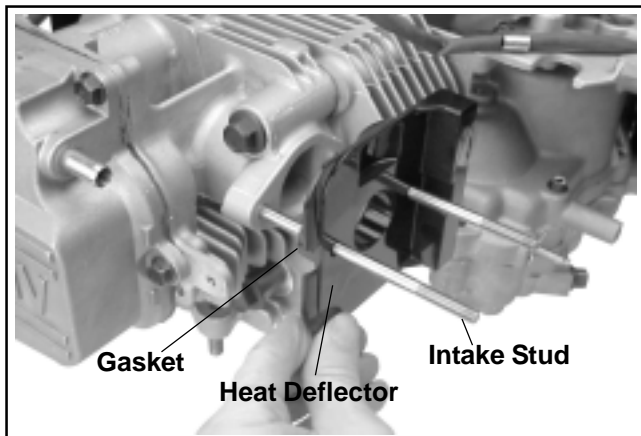


Figure 9-19. Removing Heat Deflector.

5. Remove the two hex. flange screws and starter side cylinder barrel baffle.
6. Remove the two hex. flange screws and blower housing back plate. See Figure 9-20.

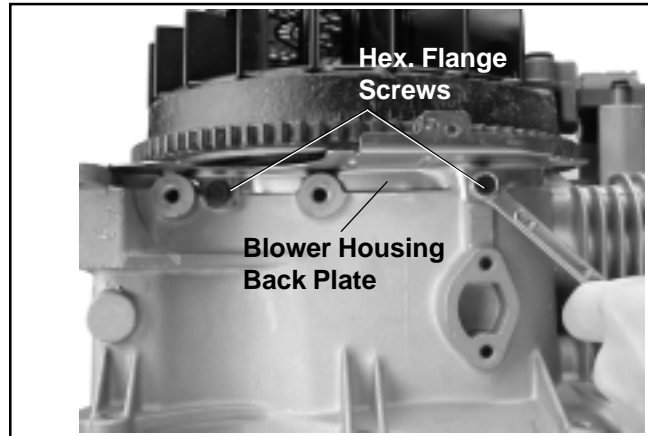


Figure 9-20. Removing Back Plate.

Remove Ignition Module

1. Disconnect the kill lead from the ignition module. See Figure 9-21.

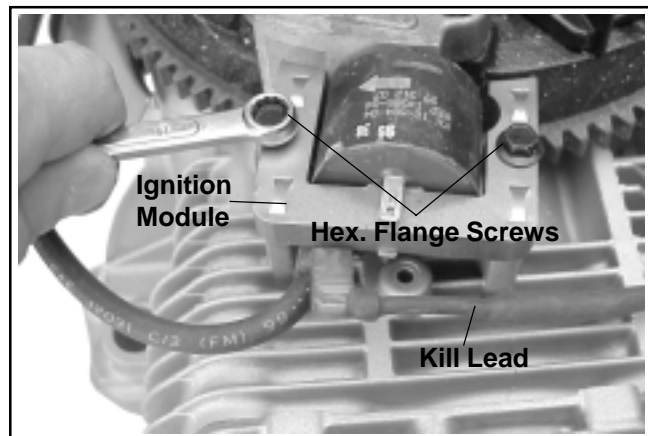


Figure 9-21. Removing Ignition Module.

2. Rotate flywheel magnet away from ignition module.
3. Remove the two hex. flange screws and ignition module.

Remove Fuel Line

1. Remove the hex. flange screw, clip, fuel line and rubber grommet. See Figure 9-22.

Section 9

Disassembly

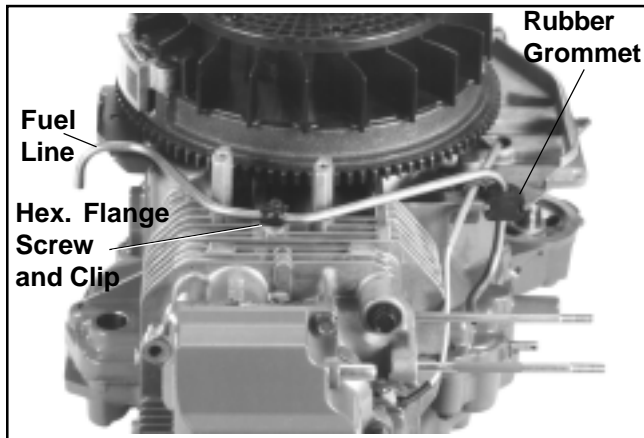


Figure 9-22. Removing Fuel Line (not on all models).

Remove Valve Cover and Cylinder Head

1. Remove the remaining hex. flange mounting screws and any loose spacers (stamped steel covers) from the valve cover. Note their placement/orientation. Remove the valve cover from the cylinder head assembly. See Figure 9-23 and 9-24.

NOTE: The valve cover is sealed to the cylinder head using RTV silicone sealant. When removing valve cover, use care not to damage the gasket surfaces of cover and cylinder head. To break the RTV seal, hold a block of wood against one of the flat faces of the valve cover. Strike the wood firmly with a mallet. If the seal doesn't break loose after 1 or 2 attempts, repeat procedure on other side.

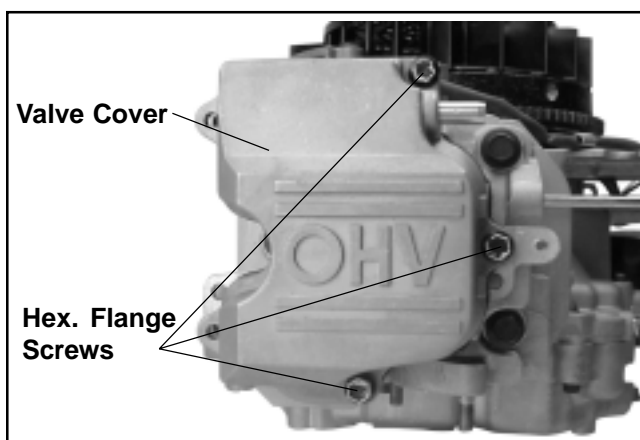


Figure 9-23. Removing Valve Cover.

2. Remove the hex. flange screws, spacer (from the screw between the intake and exhaust ports), cylinder head, push rods, and cylinder head gasket.

If the push rods will be reused, they should be marked with a piece of tape ("I" or "E" at the time of removal, so they are reinstalled in the same location. See Figures 9-24 and 9-25.

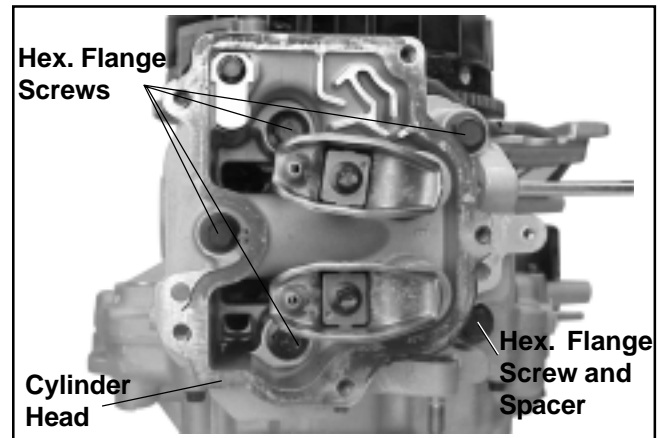


Figure 9-24. Removing Cylinder Head.

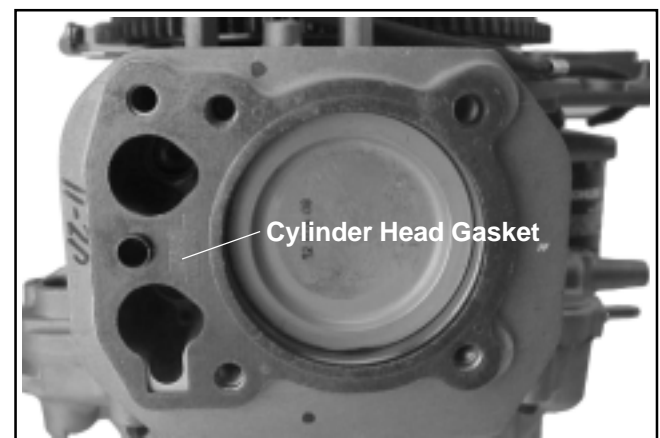


Figure 9-25. Removing Cylinder Head Gasket.

Disassemble Cylinder Head

Two basic styles of heads are used. The first style utilizes a rocker bridge configuration as shown in Figure 9-26. The second style contains separate rocker arm assemblies (with or without a guide plate), and either a non-adjustable or adjustable valve lash configuration. Variations of this style are shown in Figure 9-27. Components are unique to each head configuration. Follow the appropriate procedure based upon the configuration involved.

NOTE: Before disassembly, determine the specific head configuration involved, and mark all valve train components to assure they are reassembled on same side.

1. Remove the spark plug. See Figure 9-26.

Section 9

Disassembly

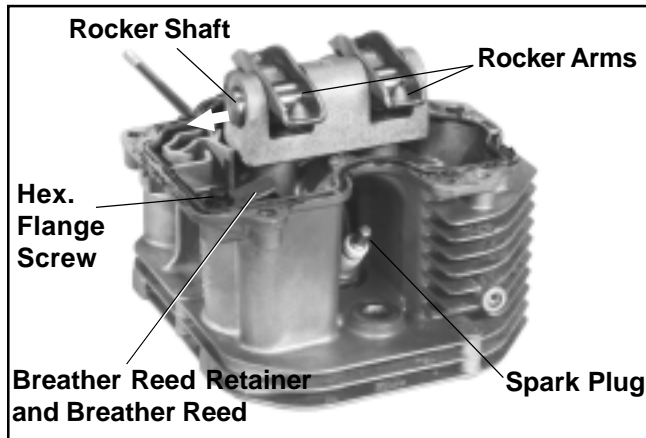


Figure 9-26. Removing Spark Plug, Breather, and Rocker Arms (Rocker Bridge Head).

2. Remove the hex. flange screw, breather reed retainer, and breather reed.
3. **Rocker Bridge Heads** - Figure 9-26
 - a. Remove the rocker shaft (from the breather side of head), and the rocker arms.
 - b. Remove the two hex. cap screws and the rocker bridge.

Heads with Separate Pivots/Rocker Arms - Figure 9-27

• Non-Adjustable Valve Lash Configurations -

- a. Remove the hex. flange screws securing the rocker arm/pivot assemblies and guide plate (if so equipped) to the head.

• Adjustable Valve Lash Configuration -

- a. Loosen the set screws and remove the adjustment nuts on the rocker arm pivot studs.
- b. Remove the rocker arm/pivot assemblies.

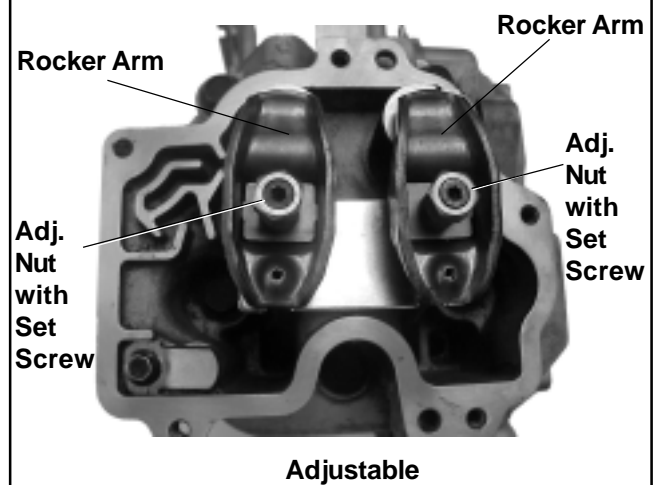
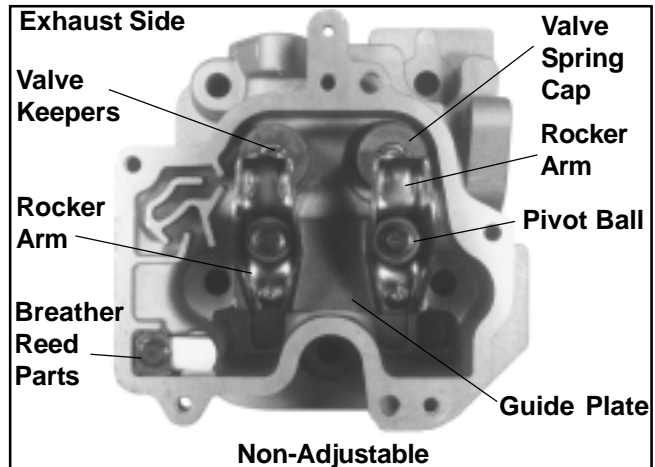


Figure 9-27. Separate Rocker Arm/ Pivot Assembly Style Head.

4. Remove the valves.
 - a. Compress the valve springs using a valve spring compressor. See Figure 9-28.
 - b. Remove the keepers, valve spring caps, valve springs, the retainers* or exhaust valve rotator (early models only) and the intake valve stem seal. Some engines also have a stem seal on the exhaust valve. Remove it also when present.

*Not used on some models.

NOTE: Note the order of all parts removed. Reassemble in the same order, unless the head is being replaced, and the instructions in the head kit specify otherwise.

Section 9 Disassembly

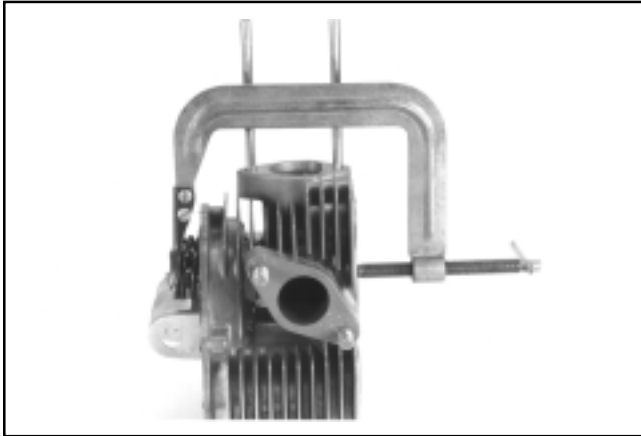


Figure 9-28. Removing Valves with Valve Spring Compressor.

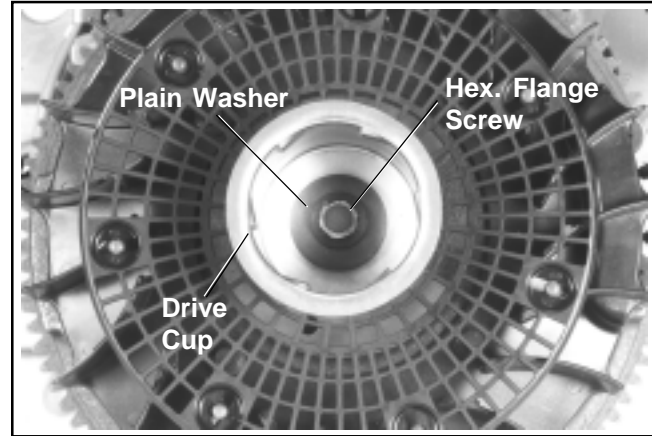


Figure 9-30. Removing Flywheel Retaining Screw and Drive Cup. (Recoil Start Models.)

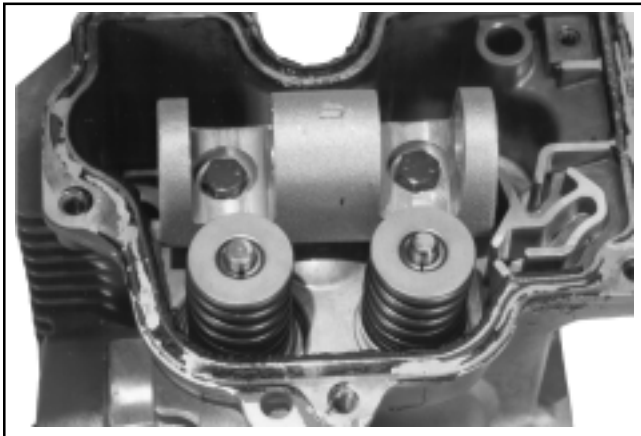


Figure 9-29. Removing Valves. (Bridge Type Head.)

Remove Drive Cup, Grass Screen, Flywheel and Fan

NOTE: Always use a flywheel strap wrench or flywheel holding tool (see Section 2) to hold the flywheel when loosening or tightening the flywheel retaining screw. Do not use any type of bar or wedge between the fins of the cooling fan, as the fins could become cracked or damaged.

Recoil Start Models

1. Remove the hex. flange screw, plain washer, and drive cup. See Figures 9-30 and 9-31.

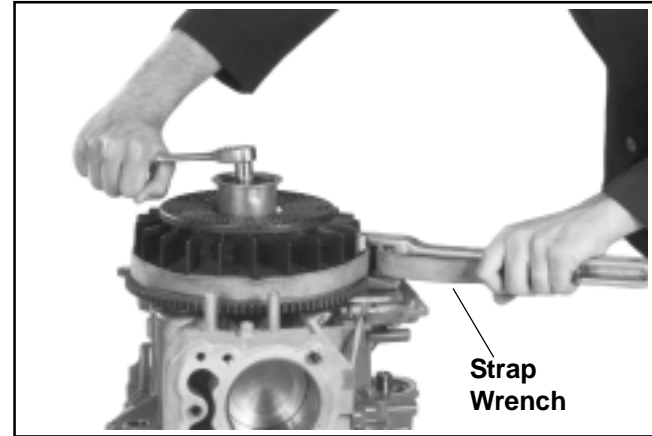


Figure 9-31. Loosening Flywheel Fastener.

2. Remove the grass screen from fan. See Figure 9-32.

Electric Start Models

1. Engines without a retractable starter will not have a drive cup. Remove the hex. flange screw and washer.

NOTE: Some engines have a domed cooling fan, with a solid center hub covering the flywheel screw. On those engines, it will be necessary to remove the screen and fan first, to access the screw and washer.

All Models

The grass screen snaps onto six small knobs on the cooling fan. Some engines have additional push-on retaining clips on three of the knobs to prevent the screen from working loose.

Section 9

Disassembly

1. Check if the extra retaining clips are present. If so, cut the clips, so they can be removed and discard. Mark the tops of the knobs where they were located. Order 3 new clips, Part No. 24 018 03-S, for installation during reassembly.
2. Remove the screen by unsnapping it from the fan. See Figure 9-32.

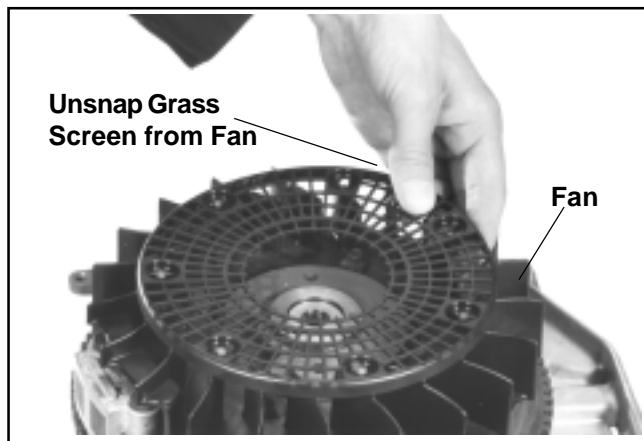


Figure 9-32. Removing Plastic Grass Screen.

3. Remove the flywheel from the crankshaft using a puller. See Figure 9-33.

NOTE: Always use a puller to remove the flywheel from the crankshaft. Do not strike the crankshaft or flywheel, as these parts could become cracked or damaged.

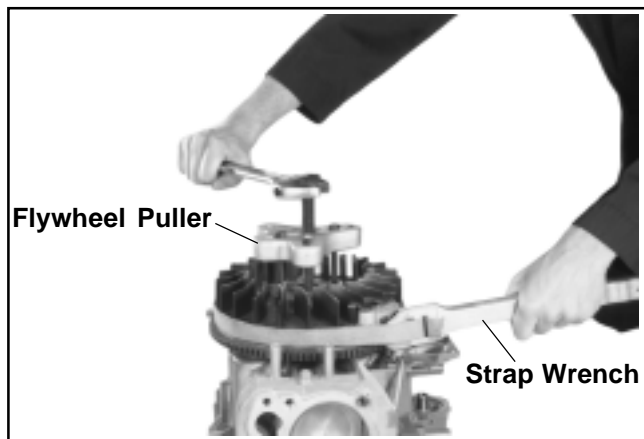


Figure 9-33. Removing Flywheel with a Puller.

4. Remove the four hex. flange screws, spacers, and fan from flywheel. See Figure 9-34. Later engines will have shoulder screws and no spacers.

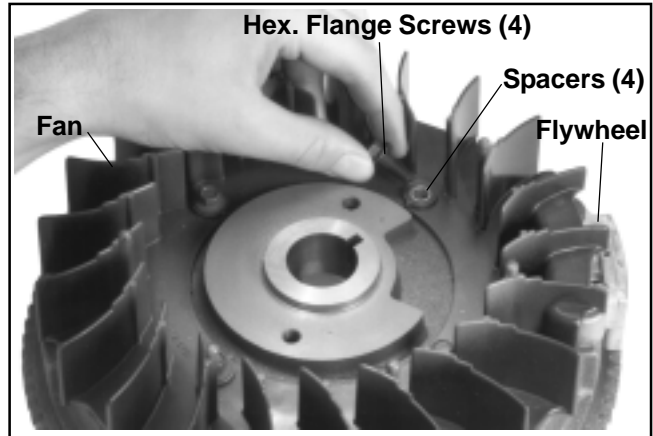


Figure 9-34. Removing Fan from Flywheel.

Remove the Stator and Wiring Harness

1. Remove the stator leads from connector body.
2. Remove the hex. flange screw and clip securing the stator leads to the crankcase. See Figure 9-35.
3. Remove the hex. flange screw and clip securing the kill lead to the crankcase. Remove the four hex. socket head screws and stator.

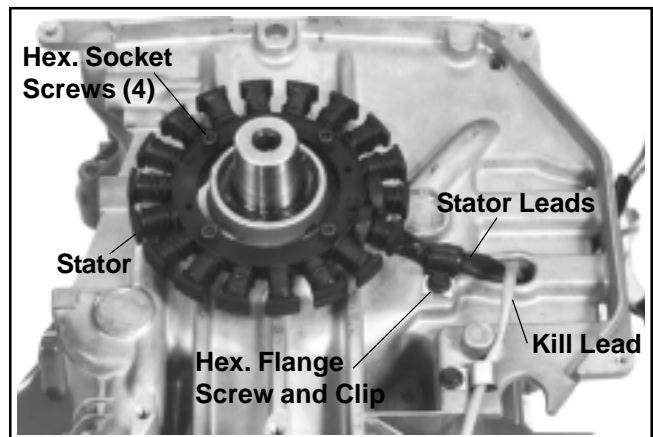


Figure 9-35. Removing Stator.

Remove Oil Pan

1. Invert the engine, so the PTO end of crankshaft is up.
2. Remove the twelve hex. flange screws securing the oil pan to the crankcase. See Figure 9-36.

Section 9 Disassembly

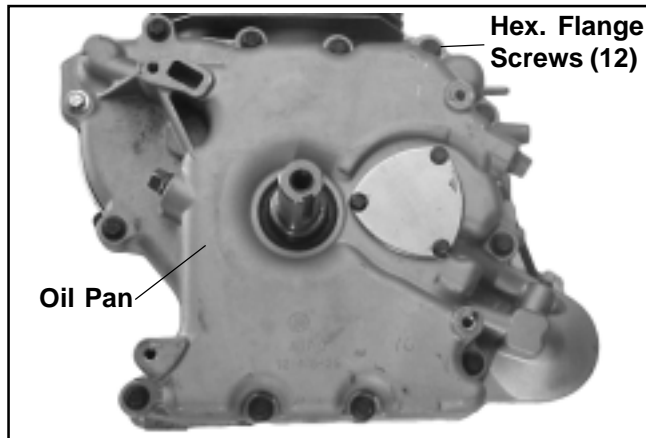


Figure 9-36. Removing Oil Pan.

3. Locate the splitting tabs on the oil pan and crankcase. Insert the drive end of a 3/8" breaker bar between the splitting tabs and rotate the handle to break the RTV seal between the crankcases and oil pan. See Figure 9-37.

NOTE: Pry only in the splitting tabs. Do not pry on the gasket surfaces of the crankcase or oil pan as this can cause leaks.

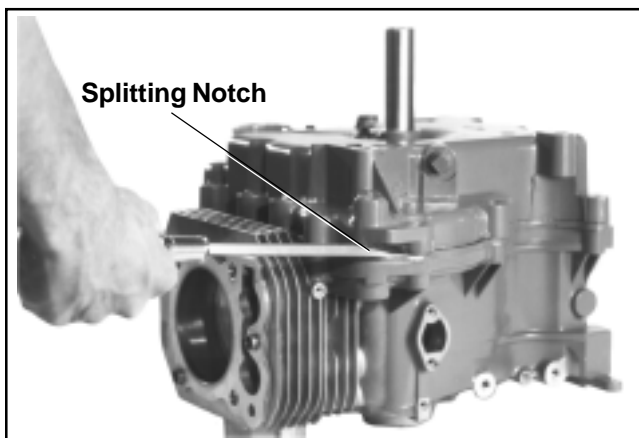


Figure 9-37. Splitting the Oil Pan Crankcase.

Remove Oil Pickup, Oil Pressure Relief Valve, and Oil Pump

1. Remove the oil seal from the oil pan.
2. Remove the hex. flange screw, oil pickup cover and oil pickup screen. See Figure 9-38.

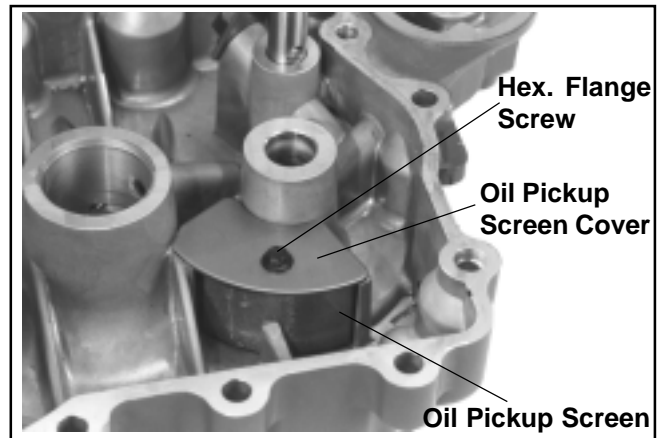


Figure 9-38. Removing Oil Pickup.

3. Identify the type of oil pressure relief valve used. If the relief valve assembly is like that shown in Figures 9-39 and 9-40, remove the hex. flange screw, retaining bracket, relief valve body, piston, and spring. If the relief valve is like that shown in Figure 9-41 removal is not necessary.

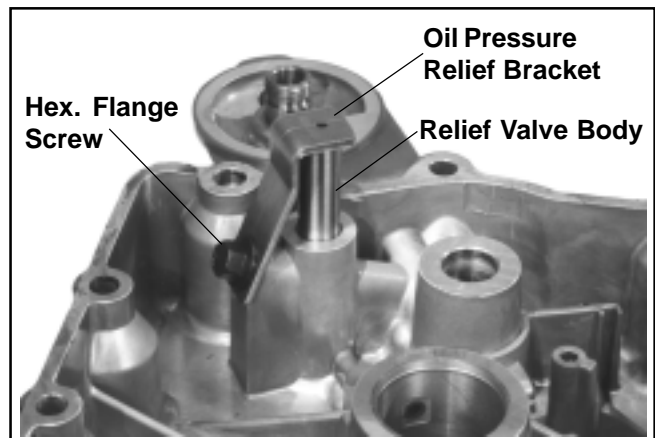


Figure 9-39. Removing Oil Pressure Relief Valve Bracket (Early Style).

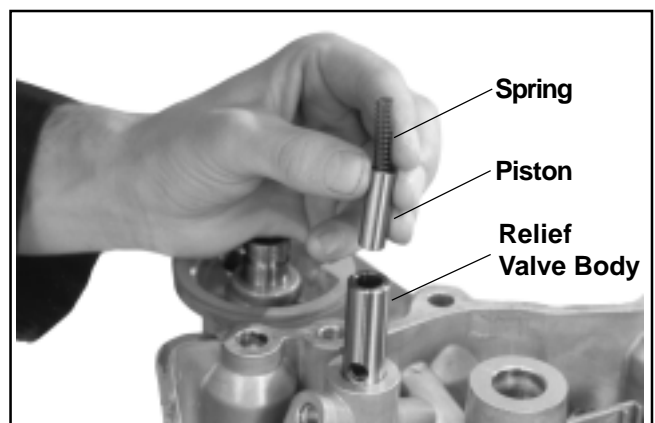


Figure 9-40. Removing Oil Pressure Relief Valve Body, Piston, and Spring (Early Style).

Section 9

Disassembly



Figure 9-41. Later Style - Oil Pressure Relief Valve.

NOTE: Later one-piece relief valves (Figure 9-41) are staked in place and do not require removal, unless replacement is necessary.

4. Remove the three hex. flange screws, oil pump cover, O-Ring, and oil pump rotors. See Figures 9-42 and 9-43.

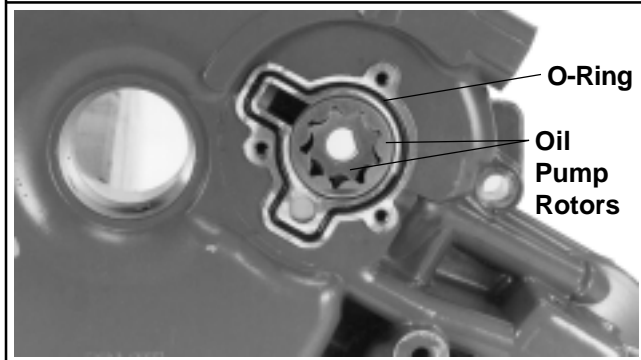
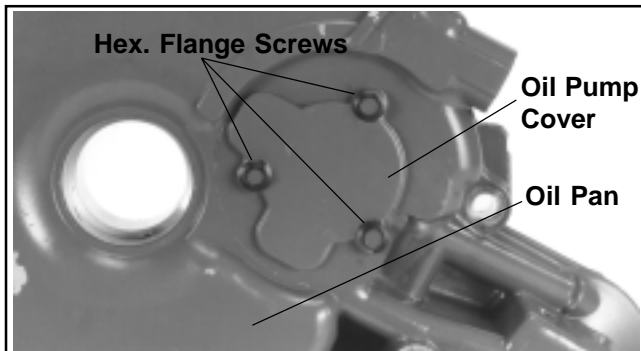


Figure 9-42. Original Style - Removing Oil Pump Covers and Rotors.

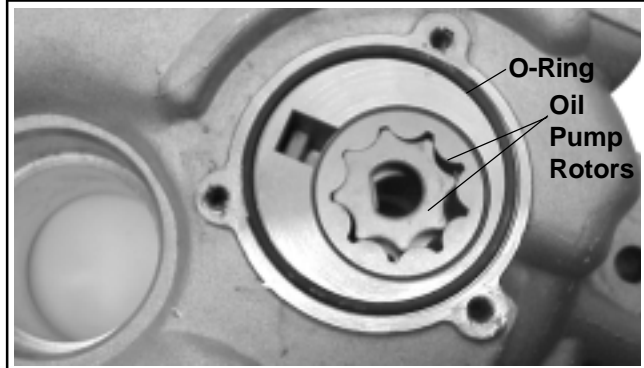
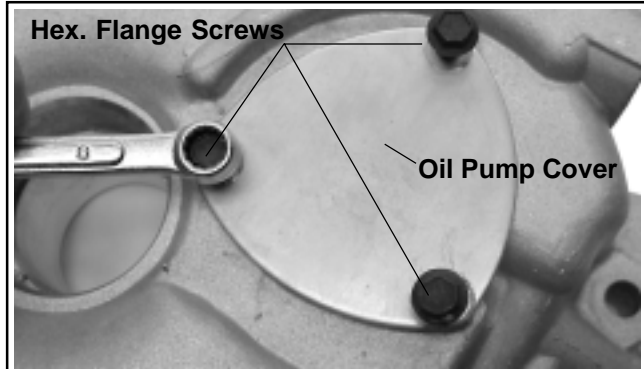


Figure 9-43. New Style - Removing Oil Pump Covers and Rotors.

Remove Hydraulic Lifters and Camshaft

1. From the cylinder head side, pull lifters out of their bores with the lifters tool (see Section 2).
2. Mark or identify the hydraulic lifters as either intake or exhaust. The exhaust lifter is nearest to the PTO side of the crankcase.
3. Remove the camshaft and shim (not on all models). See Figure 9-44.

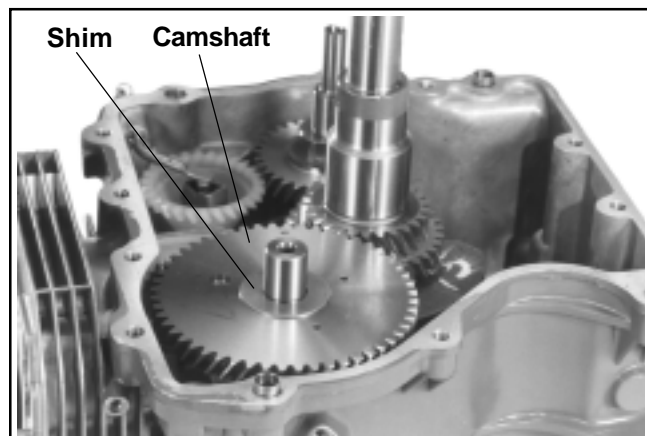


Figure 9-44. Removing Camshaft.

Section 9

Disassembly

Remove Balance Shaft

1. Remove the balance shaft from the crankcase. See Figure 9-45. On CV460-495 engines rotate the crankshaft clockwise so the timing marks are one to two teeth past being aligned. See Figure 9-46. This will permit the counterweights of the two shafts to clear.

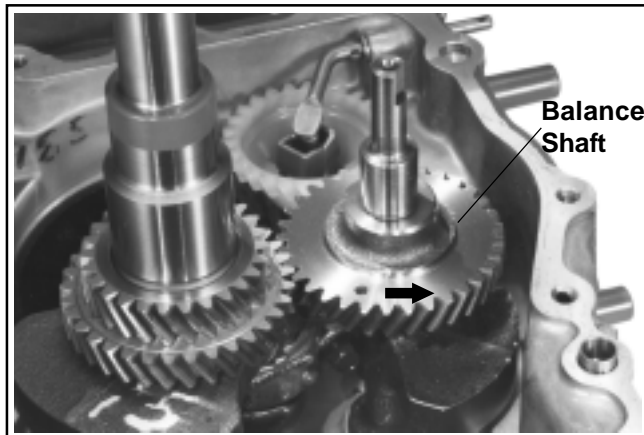


Figure 9-45. Removing Balance Shaft.



Figure 9-46.

Remove Connecting Rod and Piston

1. Remove the two hex. flange screws and connecting rod cap. See Figure 9-47.

NOTE: If a carbon ridge is present at the top of the bore, use a ridge reamer tool to remove it before attempting to remove the piston.

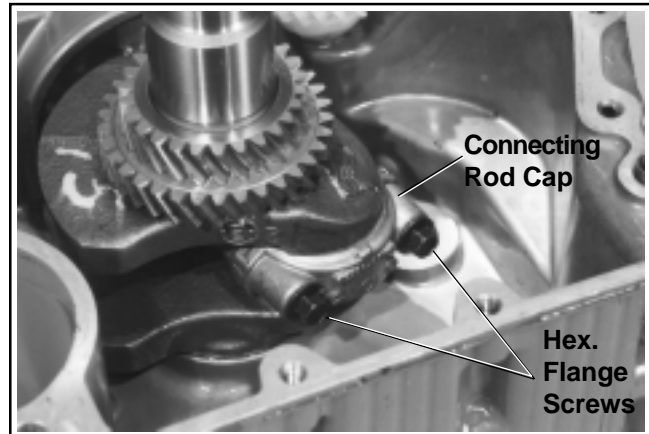


Figure 9-47.

2. Carefully push the connecting rod and the piston away from the crankshaft and out of the cylinder bore.

Remove Piston from Connecting Rod

1. Remove the wrist pin retainer and wrist pin. Separate the piston from the connecting rod. See Figure 9-48.

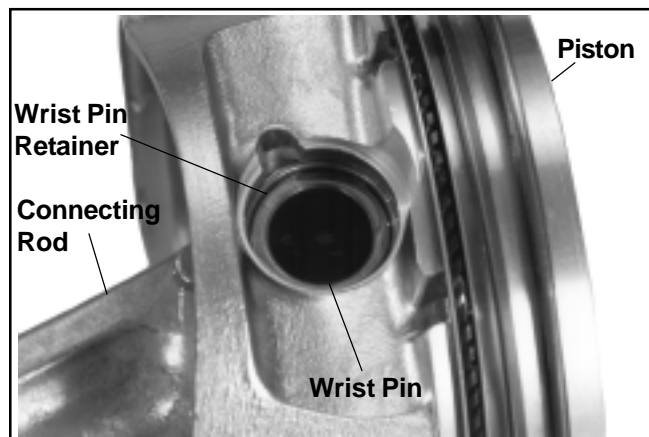


Figure 9-48. Separating Piston from Connecting Rod.

Section 9

Disassembly

Remove Piston Rings

1. Remove the top and center compression rings using a ring expander tool. See Figure 9-49.

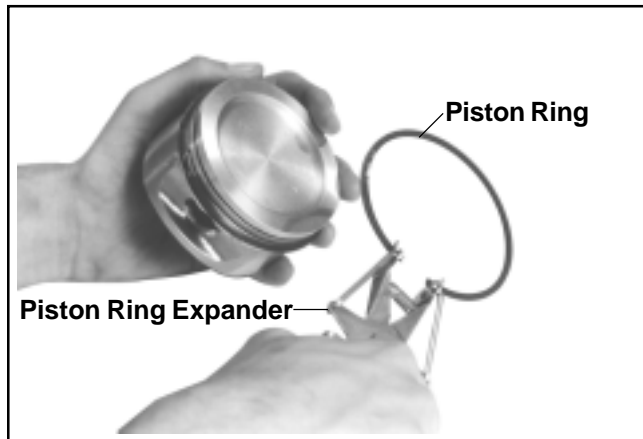


Figure 9-49. Removing Piston Rings.

2. Remove the oil control ring rails, then remove the spacer.

Remove Crankshaft

1. Remove the woodruff key from the flywheel taper end of crankshaft.
2. Remove the crankshaft from the crankcase. See Figure 9-50.

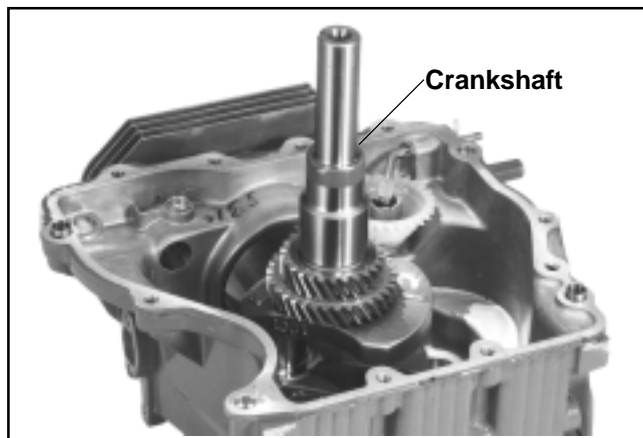


Figure 9-50. Removing Crankshaft.

Remove Flywheel End Oil Seal

1. Remove the oil seal from the crankcase.

Remove Governor Cross Shaft and Governor Gear

1. Remove the hitch pin and plain washer from the governor cross shaft. See Figure 9-51.

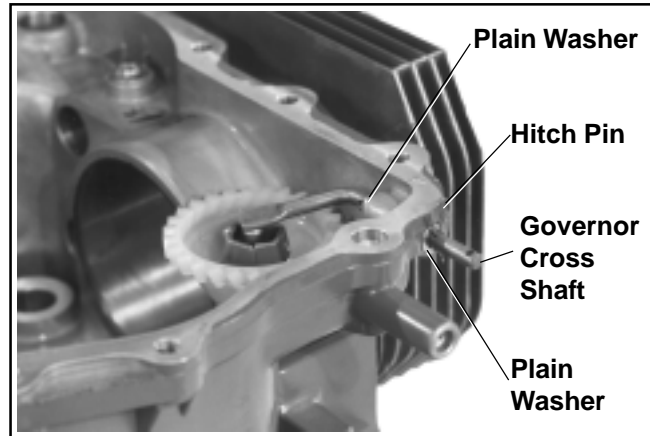


Figure 9-51. Removing Governor Cross Shaft.

2. Remove the cross shaft and plain washer from the crankcase.
3. Remove the governor shaft oil seal from the crankcase. See Figure 9-52.

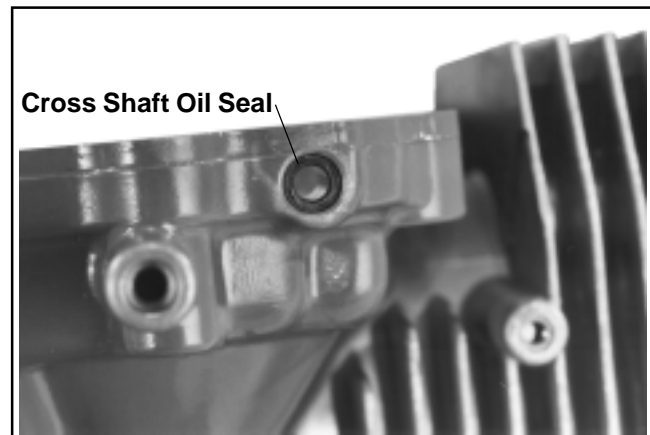


Figure 9-52. Removing Cross Shaft Oil Seal.

4. If necessary, remove the governor gear and regulating pin. See Figure 9-53.

NOTE: The governor gear is held onto the governor gear 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 (such as when reboring, doing major engine rebuilding, etc.).

Section 9
Disassembly

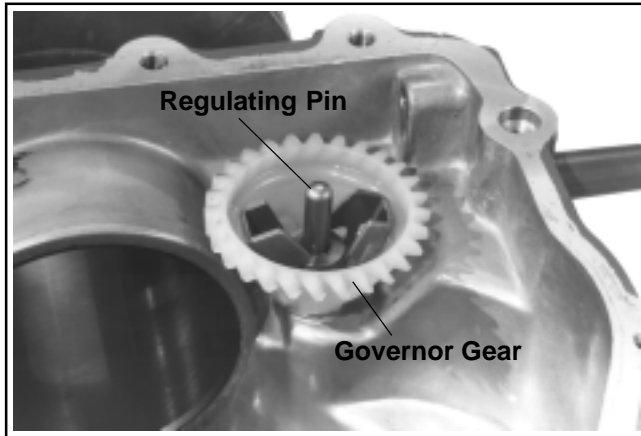


Figure 9-53. Removing Governor Gear.

Section 9

Disassembly

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

Retractable Starter, Section 7

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 scrape 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)

This engine is equipped with an **Automatic Compression Release (ACR)** mechanism. The 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.

Benefits

Because of the reduced compression at cranking speeds, several important benefits are obtained:

1. Manual (retractable) starting is much easier. Without ACR, manual starting would be virtually impossible.
2. Electric start models can use a starter and battery size that are practical for the applications in which these engines are used.
3. ACR eliminates the need for a spark retard/advance mechanism. A spark retard/advance mechanism would be required on engines without ACR to prevent the "kickback" that would occur during starting. ACR eliminates this "kickback" making manual starting safer.

Section 10

Inspection and Reconditioning

4. The choke control setting is less critical with ACR. In the event of flooding, excess fuel is blown out the opened exhaust valve and does not hamper starting.
5. Engines with ACR start much faster in cold weather than engines without ACR.
6. Engines with ACR can be started with spark plugs that are worn or fouled. Engines without ACR probably could not be started with those same spark plugs.

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.

Some engines have replaceable crankshaft bearings, most do not. Inspect the crankshaft bearing and/or journal surface 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.

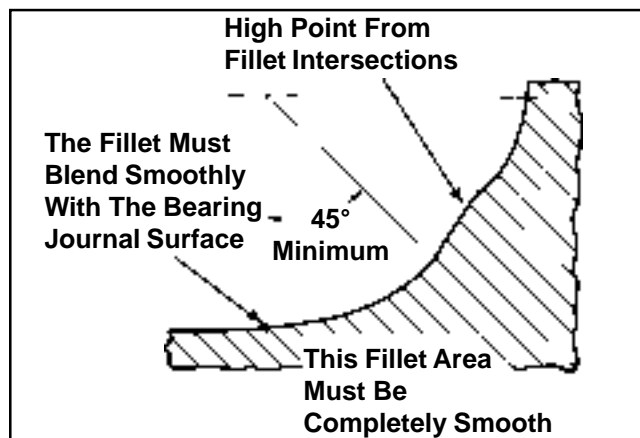


Figure 10-1. Crankpin Fillets.

On engines with a replaceable bearing insert on the flywheel end, 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 CV11-16, CV460-465, CV490-495 engine, grinding stone deposits can get caught in the 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.

Procedures to Remove 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-S 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.

Section 10

Inspection and Reconditioning

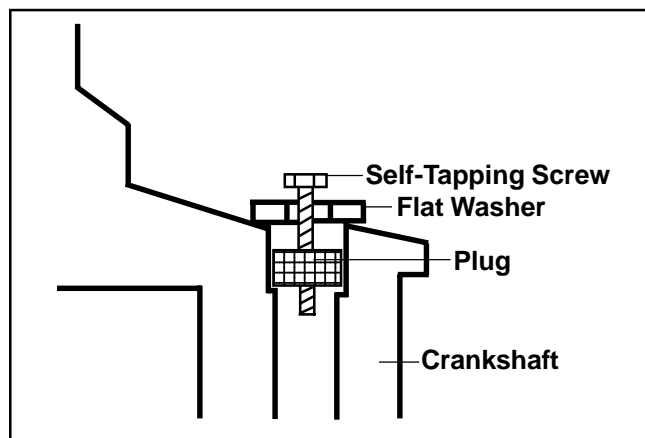


Figure 10-2. Removing Plug.

Crankcase

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 scored, 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 **0.08 mm (0.003 in.)**, **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. Replacement pistons are manufactured to precise tolerances. It is not necessary to "fit" the piston to the cylinder. Start with the new cylinder bore diameter (from Section 1), add the desired oversize dimension, and machine the cylinder to that exact size. The corresponding oversize piston will then fit the cylinder with the correct running clearance.

Boring

When over-sizing to 0.25 mm (0.010 in.) or 0.50 mm (0.020 in.), the initial resizing should be done with a boring bar, until the cylinder is within 0.08-0.12 mm (0.003-0.005 in.) of the desired size. Then use the following procedures for honing to the final dimension. For 0.08 mm (0.003 in.) oversize, skip the boring bar and go right to honing.

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. 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).

Section 10

Inspection and Reconditioning

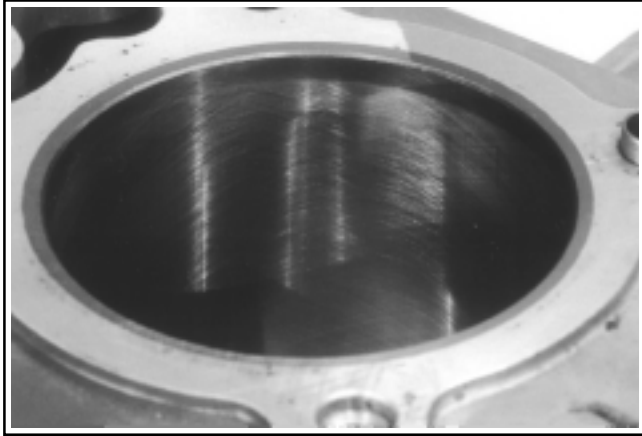


Figure 10-3. Cylinder Bore Crosshatch after Honing.

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 perpendicular to the piston pin, and up from the bottom of the piston skirt as indicated in Figure 10-4, based on the model involved.

Measure 6 mm (0.24 in.) on CV11-14, CV460-465 Engines, 8.5 mm (0.33 in.) on CV15,16, CV490-495 Engines, Above the Bottom of Piston Skirt at Right Angles to Piston Pin.

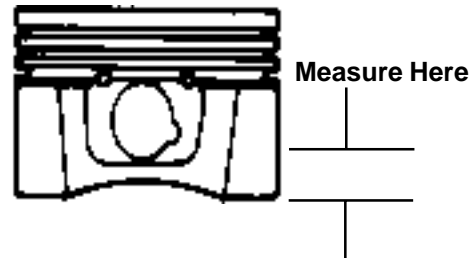


Figure 10-4. Measuring Piston Diameter.

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 offer replacement ring gears. Replace the flywheel if the ring gear is damaged.

Section 10

Inspection and Reconditioning

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.

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, burned face, 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.

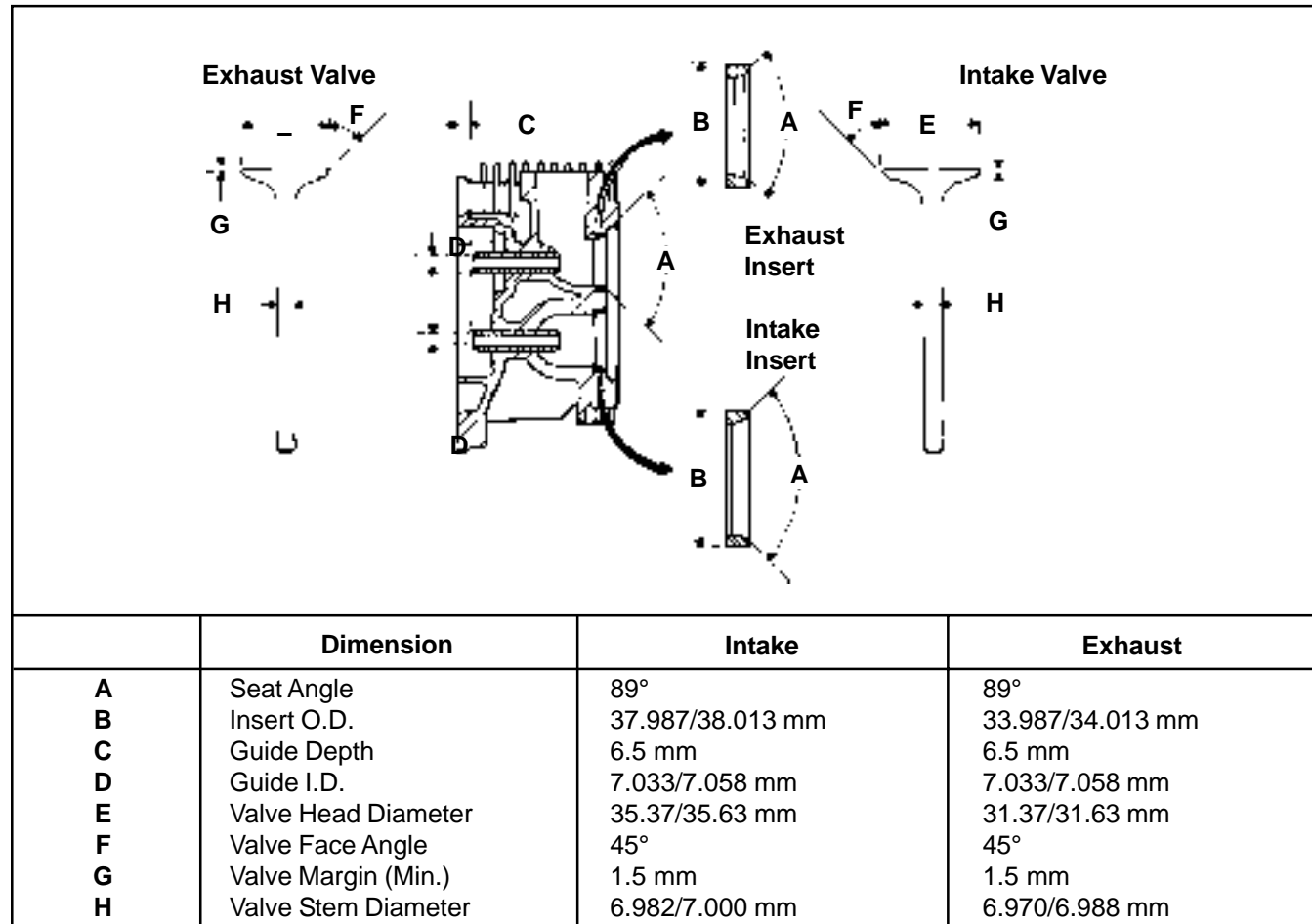


Figure 10-5. Valve Details.

Section 10

Inspection and Reconditioning



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.

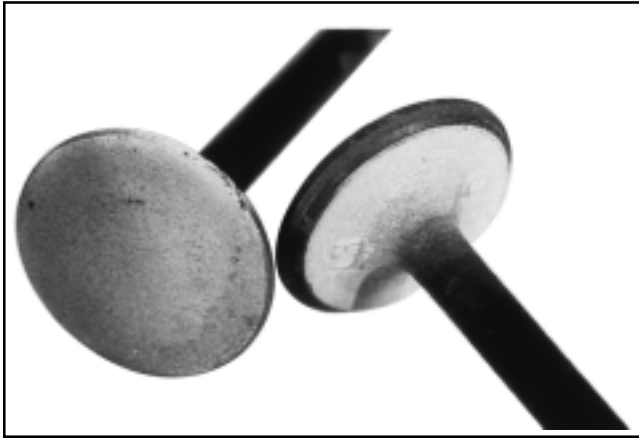


Bad Condition: The valve depicted here should be replaced. Note the warped head; margin damaged and too narrow. These conditions could be attributed to excessive hours or a combination of poor operating conditions.



Coking: Coking is normal on intake valves and is not harmful. If the seat is good, the valve could be reused after cleaning.

Section 10 Inspection and Reconditioning



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 treated with stabilizer or 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.

Section 10

Inspection and Reconditioning

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. **KO1026**. 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 10-4 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.

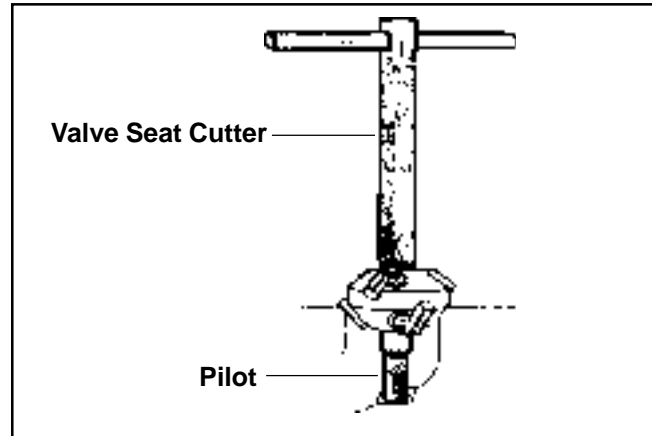


Figure 10-6. Typical Valve Seat Cutter.

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.

Valve Stem Seals

These engines use valve stem seals on the intake valves and sometimes on the exhaust. 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 part of the piston assembly; if the pin boss or the pin are worn or damaged, a new piston assembly is required.

Section 10

Inspection and Reconditioning

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. 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. A worn ring usually takes on a shiny or bright appearance.

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.

Replacement pistons are available in STD bore size, and in **0.08 mm (0.003 in.)**, **0.25 mm (0.010 in.)**, and **0.50 mm (0.020 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. The **0.08 mm (0.003 in.)** oversize piston uses a STD ring set. Always use new piston rings when installing pistons. **Never reuse old rings.**

The cylinder bore must be deglazed before service ring sets are used.


10

Figure 10-7. Common Types of Piston and Ring Damage.

Section 10

Inspection and Reconditioning

Some important points to remember when servicing piston rings:

1. 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.
2. Remove old rings and clean up grooves. **Never reuse old rings.**
3. Before installing the rings on the piston, place each of the top two rings in its running area in the cylinder bore and check the end gap (see Figure 10-8). This gap should be **0.77 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.

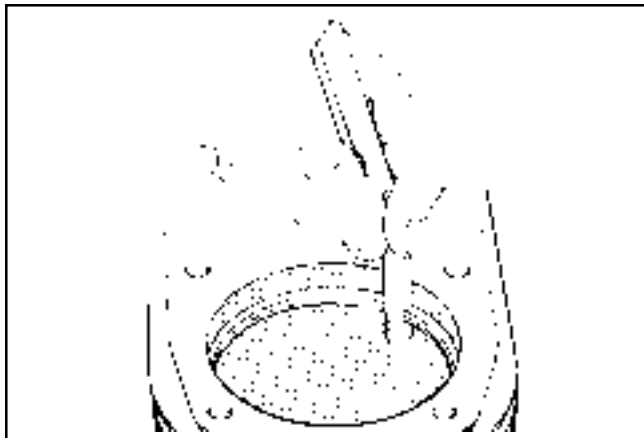


Figure 10-8. Measuring Piston Ring End Gap.

4. After installing the new compression (top and middle) rings on the piston, check piston-to-ring side clearance using a feeler gauge. Compare readings against the indicated specifications. If the side clearance is greater than the maximum specified, a new piston **must** be used. Refer to Figure 10-9.

Top Compression Ring-to-Groove Side Clearance

CV11-14, CV460-465 0.034/0.100 mm (0.0013/0.0039 in.)

CV15,16, CV490-495 0.060/0.105 mm (0.0024/0.0041 in.)

Middle Compression Ring-to-Groove Side Clearance

CV11-14, CV460-465 0.040/0.080 mm (0.0016/0.0031 in.)

CV15,16, CV490-495 0.040/0.085 mm (0.0016/0.0033 in.)



Figure 10-9. Measuring Piston Ring Side Clearance.

Install 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. Install the bottom (oil control) ring first and the top compression ring last. Refer to Figure 10-10.

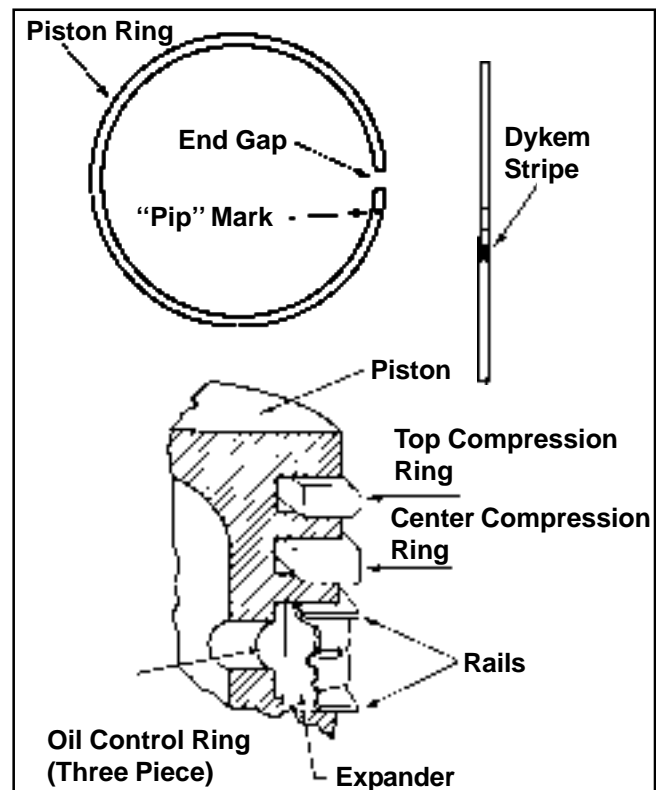


Figure 10-10. Piston Ring Installation.

Section 10

Inspection and Reconditioning

1. Oil Control Ring (Bottom Groove): Install the expander and then the rails. Make sure the ends of the 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 (if present) is to the left of the 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 (if present) is to the left of the 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 if scored or excessively worn.

Service replacement connecting rods are available in STD crankpin size and **0.25 mm (0.010 in.)** undersize. Always refer to the appropriate parts information to ensure that correct replacements are used.

Oil Pump

Inspection and Service

Pump can be checked/replaced without removing oil pan.

Oil Pressure Relief Valve

If an early style (five-piece) oil pressure relief valve body, piston, and spring is used (see Figure 10-11). Check that piston and body are free of nicks or burrs. Check the spring for any wear or distortion. The free length of the spring should be approximately **0.992 in.** Replace the spring if worn, out of specification, or damaged/distorted.

If the later style (one-piece) oil pressure relief valve (see Figure 10-12) is used (staked to the closure plate), it should only be removed if it is going to be replaced. Check to see that internal spring-loaded piston is free.

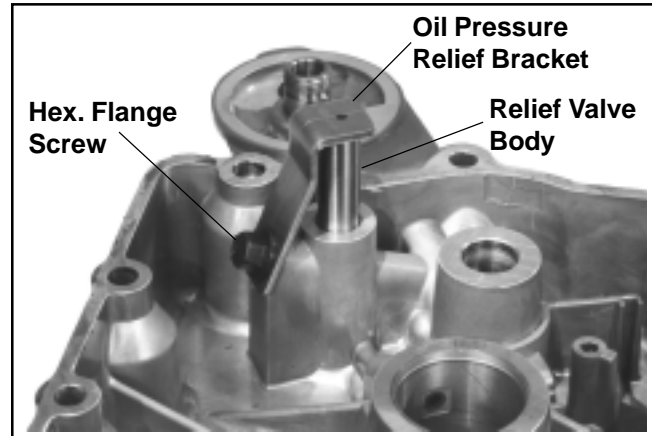


Figure 10-11. Five-Piece Oil Pressure Relief Valve.



Figure 10-12. One-Piece Oil Pressure Relief Valve.

Governor Gear and Shaft

Inspection

Inspect the governor gear teeth. Look for any evidence of worn, chipped, or cracked teeth. If one or more of these problems is noted, replace the governor gear.

The gear is held on the governor shaft by molded tabs which are damaged when the gear is removed. Never reuse the gear once it has been pulled from the shaft. Replace the governor shaft only if it is damaged or worn.

Procedure to Remove Governor Shaft:

1. Remove governor gear assembly and regulating pin.
2. Locate governor pin from flywheel side of crankcase. With a small punch, drive the pin toward the inside of the crankcase. This could also be done with a press. DO NOT remove the governor pin with a vise grip or pliers, you may damage the crankcase.

Section 10

Inspection and Reconditioning

Procedure to Install Governor Shaft:

1. Install new pin by pressing or lightly tapping into crankcase. It must be installed so that it protrudes 1.289 plus or minus .004 in. above the crankcase boss. See Figure 10-13.

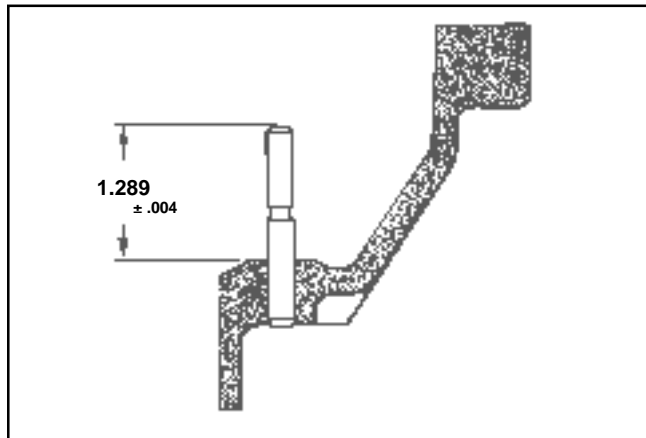


Figure 10-13. Governor Shaft.

2. Install new governor regulating pin, Part No. 12 380 01-S, and governor gear assembly Part No. 12 043 05-S.
3. Make sure governor gear assembly rotates freely.

Stamped Steel Valve Cover

If the engine has stamped steel valve cover, the sealing surface must be checked for flatness prior to reinstallation. Hold the valve cover down firmly against a flat, level surface or piece of glass, and check around the entire perimeter that a .012 in. (.30 mm) feeler gauge cannot be inserted anywhere. See Figures 10-14. If the gauge goes in anywhere, the cover needs to be replaced.



Figure 10-14. Checking with Feeler Gauge.

Go Back

Section 11

Reassembly

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. This procedure may be varied to accommodate options or special equipment.

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, damage, or failure.

NOTE: Always use new gaskets.

NOTE: Make sure all components have been cleaned **BEFORE** reassembly.

Typical Reassembly Sequence

1. Install governor gear and cross shaft.
2. Install crankshaft.
3. Install piston rings.
4. Install piston to connecting rod.
5. Install piston and connecting rod.
6. Install balance shaft.
7. Install hydraulic lifters and camshaft.
8. Install oil pressure relief valve and oil pickup.
9. Install oil pan to crankcase.
10. Install oil pump.
11. Install oil seals.
12. Install stator and wiring harness.
13. Install fuel line.
14. Install fan, flywheel, grass screen, and drive cup*.
15. Reassemble cylinder head components.
16. Install cylinder head.
17. Install ignition module.
18. Install baffles and blower housing.
19. Install valve cover and muffler bracket*.
20. Install extended oil fill tube.
21. Install rectifier-regulator.*
22. Install fuel pump.*

*If so equipped.

23. Install carburetor and external governor components.
24. Install air cleaner and adjust governor.
25. Install electric starter.
26. Install retractable starter.
27. Install muffler.
28. Install oil filter and oil drain plugs.
29. Prepare the engine for operation.

Install Governor Gear and Cross Shaft

NOTE: Do not reuse an old (removed) governor gear.

1. Install the thrust washer to governor gear shaft.
2. Position the regulating pin to governor gear/flyweights as shown in Figure 11-1. Slide the governor gear/regulating pin over the governor gear shaft.

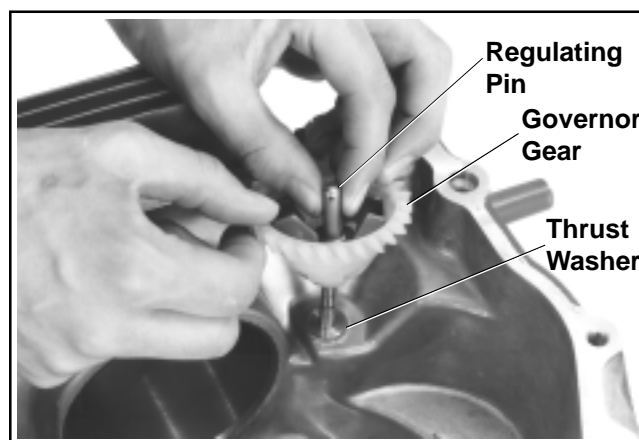


Figure 11-1. Installing Governor Gear.

Section 11

Reassembly

3. Using the KO1030 oil seal installer, install a new governor cross shaft oil seal into the crankcase. See Figure 11-2.

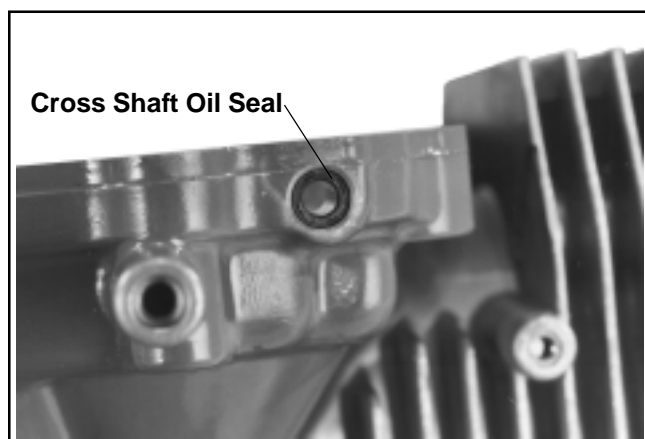


Figure 11-2. Cross Shaft Oil Seal.

4. Install smaller plain washer to the cross shaft and insert the cross shaft (from inside) through the crankcase and oil seal. See Figure 11-3.
5. Install larger plain washer and hitch pin.

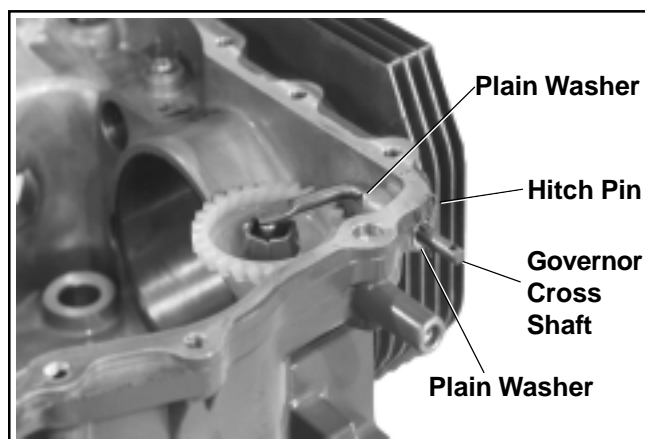


Figure 11-3. Installing Cross Shaft.

Install Crankshaft

1. Lubricate the flywheel end bearing surfaces of the crankshaft and crankcase with engine oil.
2. Insert the crankshaft through the flywheel end bearing. See Figure 11-4.

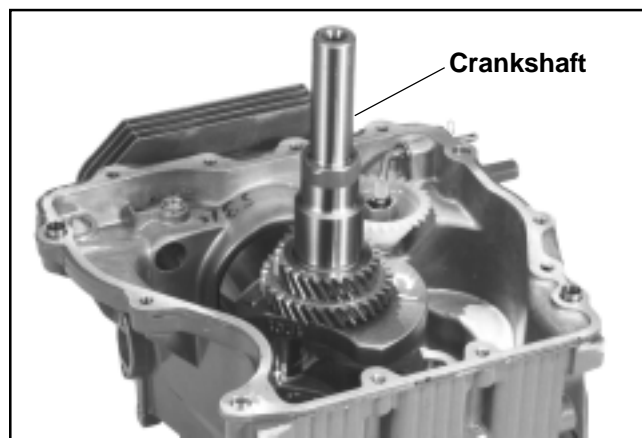


Figure 11-4. Installing Crankshaft.

Install Piston Rings

NOTE: For detailed piston inspection procedures and piston ring installation procedure refer to Section 10 – “Internal Components.”

Install Piston to Connecting Rod

1. Assemble the piston to the connecting rod. See Figure 11-5.

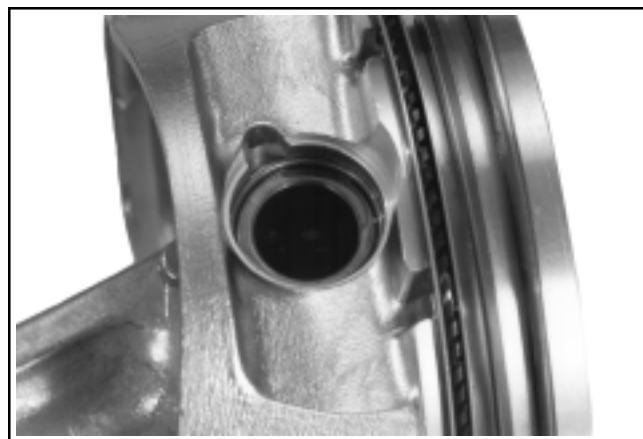


Figure 11-5. Installing Piston to Connecting Rod.

Section 11

Reassembly

On CV460-495 models the offset of the connecting rod and cap must be oriented to the left, with the part number up. The arrow on the piston must point away from the part number. See Figure 11-6 and 11-7.



Figure 11-6. Connecting Rod Configuration to Piston with the Part Number "up".



Figure 11-7. Arrow on Piston.

Install Piston and Connecting Rod

NOTE: Proper orientation of the piston/connecting rod 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.
2. Lubricate the cylinder bore, piston, and rings with engine oil. Compress the piston rings using a piston ring compressor. See Figure 11-8. Push the piston through the compressor so the oil control (bottom) ring is just above the lower edge of the compressor.

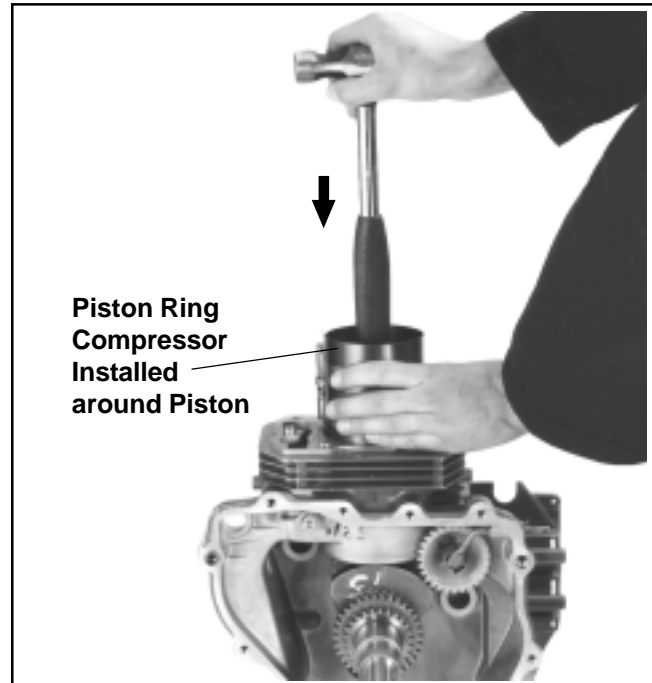


Figure 11-8. Installing Piston and Connecting Rod.

3. Place the ring compressor on the top surface of the crankcase and make certain it is seated down around the entire circumference. The "FLY" arrow on the piston should point toward the flywheel side of the crankcase. See Figure 11-9. Use a soft, rubber grip hammer handle and tap the piston/connecting rod into the bore. The first tap should be rather firm, so the oil ring moves from the compressor into the bore in one smooth, quick motion. Otherwise the oil ring rails may spring out and jam between the ring compressor and the top of the bore.

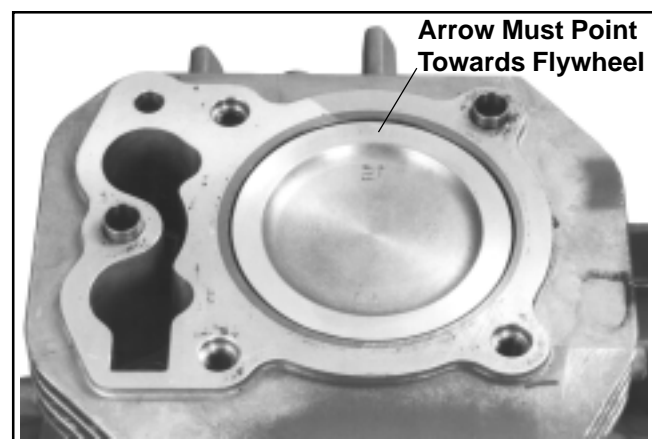


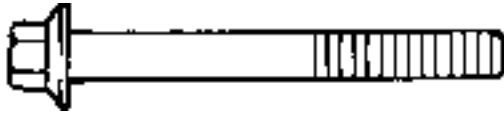
Figure 11-9. Piston Installation Identifier.

Section 11

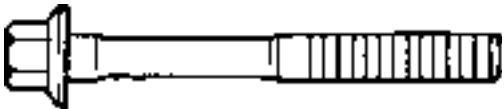
Reassembly

4. Lubricate the crankshaft journal and connecting rod bearing surfaces with engine oil. Install the rod cap to connecting rod.
5. Three different types of connecting rod bolts have been used in production and each has a different torque value. See Figures 11-10 and 11-11.
The 8 mm straight shank style rod bolts must be torqued in increments to **22.7 N·m (200 in. lb.)**.
The 8 mm step-down shank style rod bolts must be torqued in increments to **14.7 N·m (130 in. lb.)**.
The 6 mm straight shank style rod bolts must be torqued in increments to **11.3 N·m (100 in. lb.)**.
Illustrated instructions are also provided in the service rod package.

Torque these to 22.7 N·m (200 in. lb.)
8 mm Straight Shank



Torque these to 14.7 N·m (130 in. lb.)
8 mm Step-Down



Torque these to 11.3 N·m (100 in. lb.)
6 mm Straight Shank

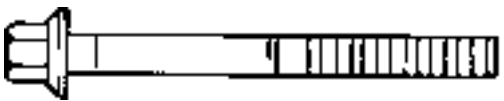


Figure 11-10. Connecting Rod Bolts.

6. Rotate the crankshaft until the piston is at top dead center in the cylinder bore.

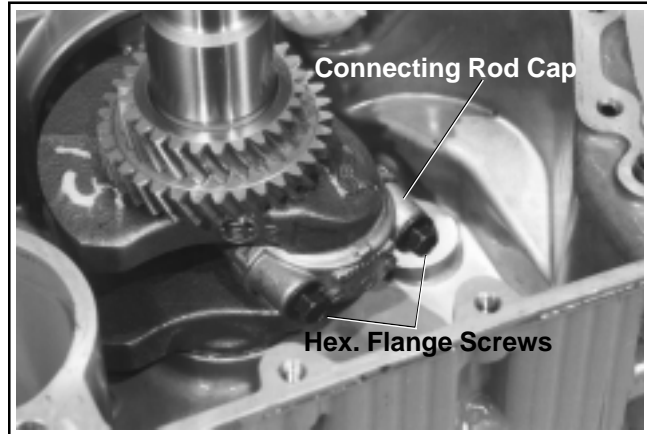


Figure 11-11. Installing Connecting Rod Fasteners.

Install Balance Shaft

1. Lubricate the balance shaft bearing surfaces of crankcase and balance shaft with engine oil.
2. Align the timing marks on the balance shaft gear and the larger gear on the crankshaft. Lower the balance shaft into the bearing surface in the crankcase.

On CV460-495 models, the crankshaft and the balance shaft must be rotated down three teeth past the timing marks for the counterweights of both shafts to clear when installing. After sliding the balance shaft into place rotate the shaft upward and check to make sure the two timing marks are aligned. See Figure 11-12.

On all other models, make sure the balance shaft gear, large crankshaft gear and the governor gear teeth mesh and the timing marks are aligned. See Figure 11-12.



Figure 11-12. Aligning to Check Installed Position.

Section 11

Reassembly

Installing Camshaft

1. Lubricate the camshaft lobes and bearing surfaces with engine oil.
2. Align the timing marks on the camshaft gear and the smaller crankshaft gear. Lower the camshaft into the bearing surface in crankcase. Make sure the camshaft gear and smaller gear on crankshaft mesh and the timing marks are aligned. See Figure 11-13.



Figure 11-13. Aligning Timing Marks on Crank Gear and Cam Gear.

Determine Camshaft End Play

1. Install the shim* spacer, removed during disassembly, to the camshaft.
2. Install the camshaft end play checking Tool No. KO1031 to the crankcase and camshaft. Secure the tool to the crankcase with the hex. flange screws provided. See Figure 11-14.

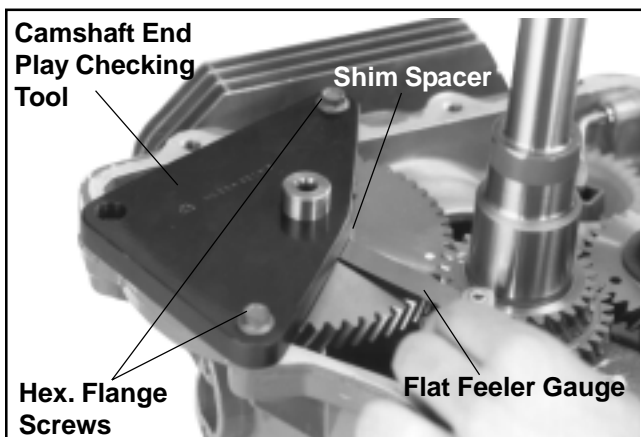


Figure 11-14. Checking Camshaft End Play.

3. Using a flat feeler gauge, 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.)**.

*Not on all models.

4. If the camshaft end play is not within the specified range, remove the end play checking tool and add, remove, or replace shims as necessary.

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:	0.89535/0.93345 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 end play checking tool and recheck end play.
6. Repeat steps 4 and 5 until the end play is within the specified range.

Install Oil Pressure Relief Valve

Early (Five-Piece) Style Oil Pressure Relief Valve

1. Place the relief valve body in the cavity of the oil pan, so the relief hole is just above the boss.
2. Insert the piston and spring into the body. See Figure 11-15.

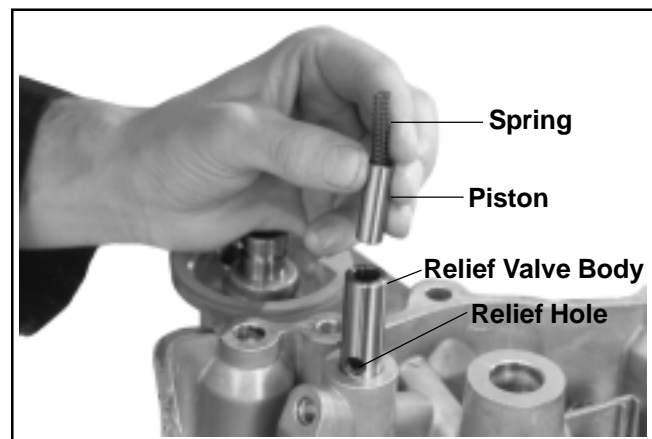


Figure 11-15. Installing Oil Pressure Relief Valve Body, Plunger, and Spring.

Section 11

Reassembly

3. Push bracket down until it seats against top of relief valve body. Secure with hex. flange screw. See Figure 11-16.

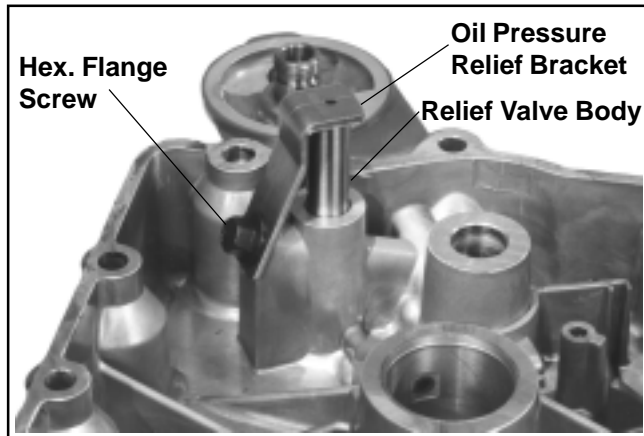


Figure 11-16. Installing Oil Pressure Relief Valve Bracket.

Later (One-Piece) Style Oil Pressure Relief Valve

1. If this style relief valve is replacing an early five-piece relief valve, reinstall the original retaining screw to block the hole. Tighten securely.



Figure 11-17. Later Style Oil Pressure Relief Valve.

2. Use a piece of thin wall metal tubing or deep socket with a slightly smaller O.D. than base. Press or tap new relief valve into the bore of the closure plate until it bottoms. See Figure 11-18.

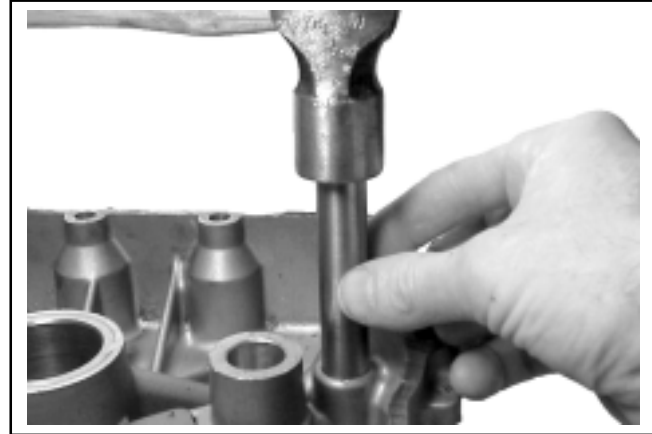


Figure 11-18. Inserting New Relief Valve into Bore of Closure Plate.

3. Stake the casting boss with a center punch in 3 or 4 locations near the inner edge to lock the relief valve into place. See Figure 11-19. Do not use Loctite®.

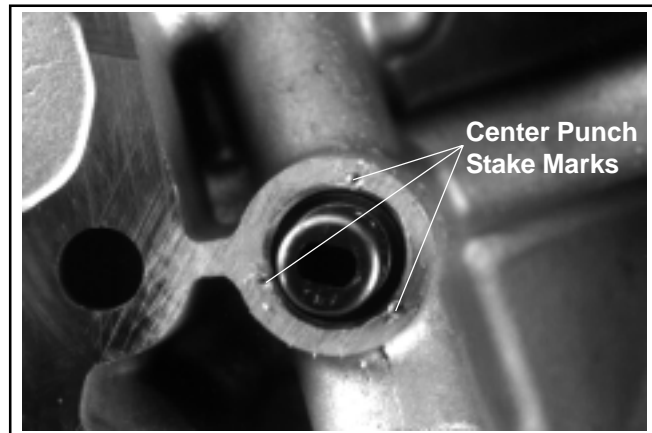


Figure 11-19. Center Punch Stake Marks.

Install Oil Pickup

1. Install the oil pickup screen, screen cover and hex. flange screw. See Figure 11-20.

Section 11

Reassembly

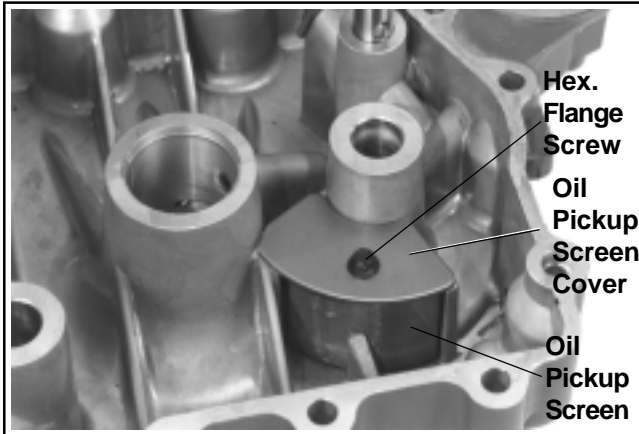


Figure 11-20. Installing Oil Pickup Components.

Install Oil Pan to Crankcase

RTV silicone sealant is used as a gasket between the oil pan and crankcase. Refer to page 2.1 for the approved sealant.

NOTE: Always use fresh sealant. Using outdated sealant can result in leakage.

1. Prepare the sealing surfaces of the crankcase and oil pan as directed in Service Bulletin 252.

NOTE: Do not scrape the surfaces when cleaning as this will damage the surfaces. This could result in leaks. The use of a gasket removing solvent is recommended.

2. Apply a 1/16" bead of sealant to the *oil pan* as shown in Figure 11-21. Apply a second bead to the section between point "A" and point "B".

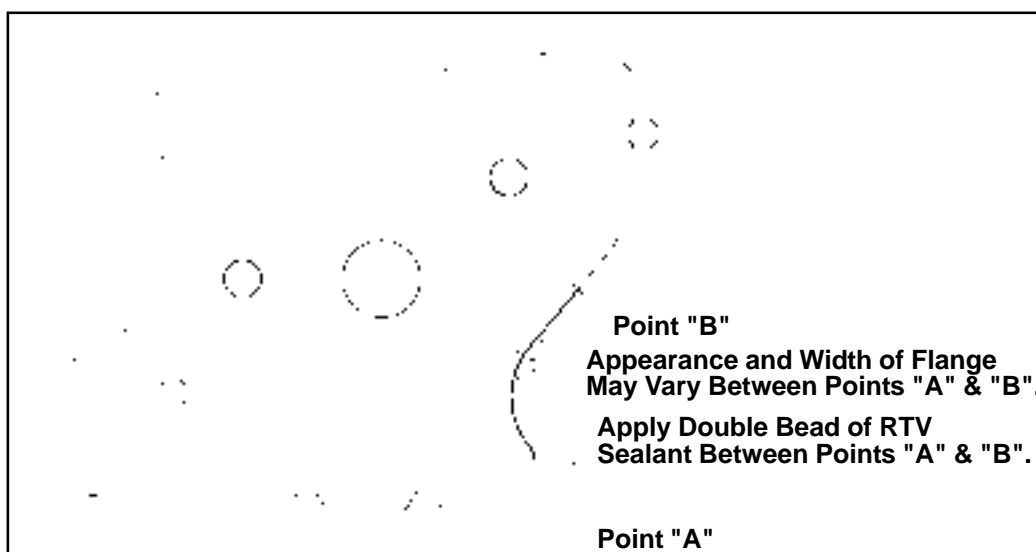


Figure 11-21. Oil Pan Sealant Pattern.

3. Install the oil pan to the crankcase and install the twelve hex. flange screws. Tighten the screws hand tight.
4. Torque the fasteners, in the sequence shown in Figure 11-22 to **24.4 N-m (216 in. lb.)**.

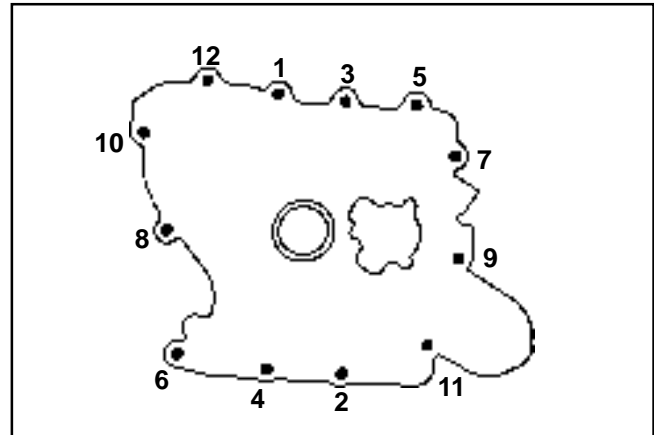


Figure 11-22. Oil Pan Fastener Torque Sequence.

Section 11

Reassembly

Install Oil Pump

1. Lubricate the oil pump cavity and oil pump rotors with engine oil. Install the outer and inner oil pump rotors. See Figure 11-23.

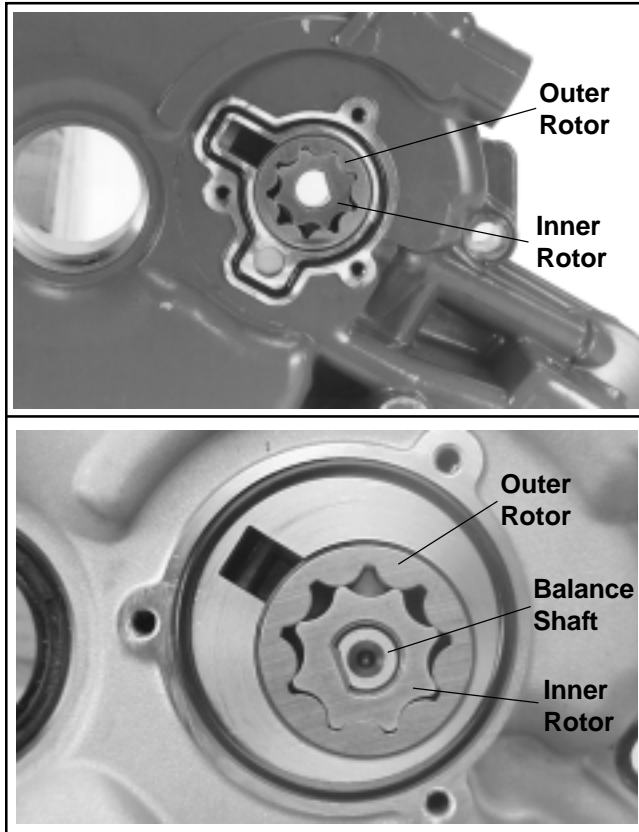


Figure 11-23. Installing Oil Pump Gears and O-Ring.

2. Install the O-Ring in the groove in the oil pan.
3. Install the oil pump cover (machined side towards O-Ring). Secure with three hex. flange screws. See Figure 11-24.

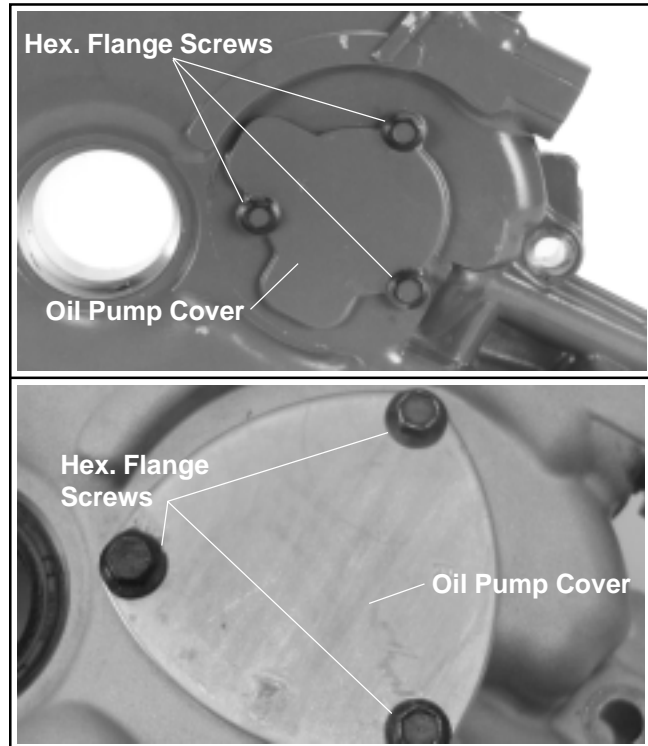


Figure 11-24. Installing Oil Pump Cover.

Torque the screws as follows:

Into new as-cast hole—**6.2 N·m (55 in. lb.)**.

Into used hole—**4.0 N·m (35 in. lb.)**.

Install Oil Seals

1. Slide the seal protector sleeve, Kit No. KO1037, over the crankshaft. Generously lubricate the lips of oil seal with light grease. Slide the oil seal over the sleeve.
2. Use handle Kit No. KO1036 and seal driver Kit No. KO1027. Install the seals until the driver bottoms against the crankcase or oil pan. See Figure 11-25.

Section 11

Reassembly

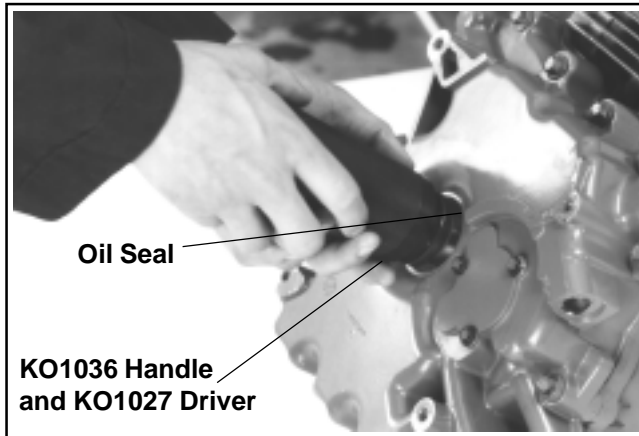


Figure 11-25. Installing Oil Seals.

Install Stator and Wiring Harness

1. Push the stator leads through the hole to the outside of the crankcase. See Figure 11-26.

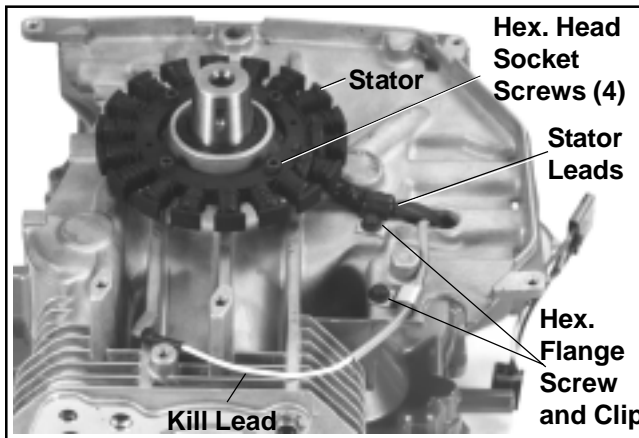


Figure 11-26. Installing Stator.

2. Install the stator using four hex. socket head screws.

Torque the screws to **6.2 N-m (55 in. lb.)**.

3. Secure the stator leads to the crankcase with the clip and hex. flange screw.
4. Be sure the locking tangs on the stator lead terminals are bent/angled upward. Insert and lock the terminals into the outer positions of the connector body.
5. Install the kill lead through the same hole as the stator lead, from the outside of the crankcase. Secure the kill lead to the crankcase with the clip and hex. flange screw. See Figure 11-26.

Install Fuel Line

1. Install the grommet to the carburetor side of fuel line.
2. Install the fuel line, clamp and hex. flange screw. Make sure the grommet is inserted in the notch in the crankcase. See Figure 11-27.*

*Not on all models.

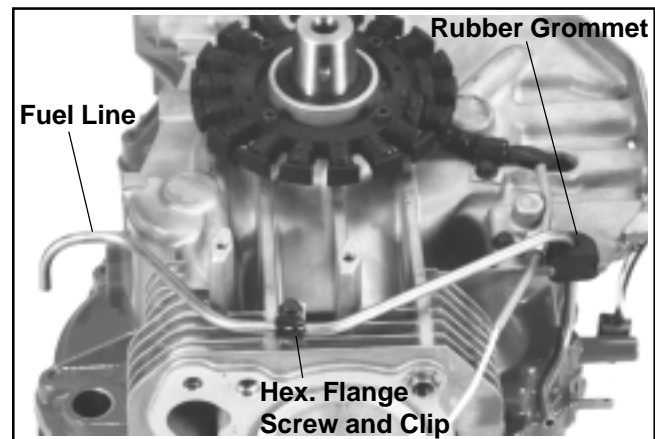


Figure 11-27. Installing Fuel Line.

Install Fan and 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.

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 specification.

1. Install the woodruff key into the keyway in the crankshaft. Lubricate threads of flywheel retaining screw.

NOTE: Make sure the 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.

Section 11

Reassembly

- Reattach the fan to the flywheel, using the spacers and hex. flange screws, or shoulder screws. See Figure 11-28. Torque the hex. flange screws to **9.9 N·m (88 in. lb.)**. On electric start models, with the domed fan, proceed through step 4 before reattaching the fan.

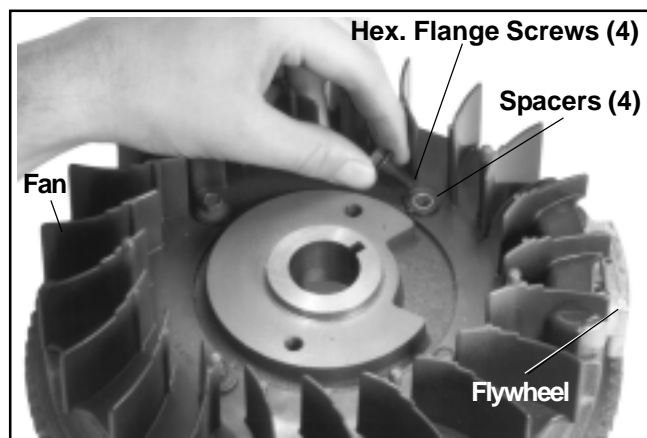


Figure 11-28. Installing Fan to Flywheel.

- Place the flywheel over the keyway/crankshaft.
Retractable Starter Models: Install grass screen, drive cup, plain washer (flat side towards the drive cup), and the hex. flange screw. See Figure 11-29.

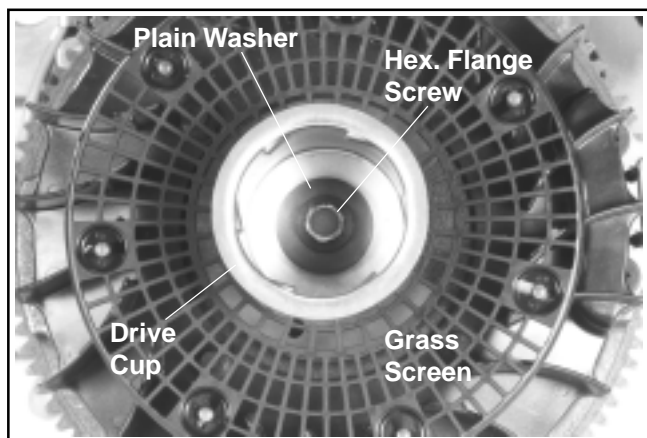


Figure 11-29. Installing Flywheel (Retractable Starter Models).

Electric Start Models: Install the plain washer and the hex. flange screw. See Figure 11-30.

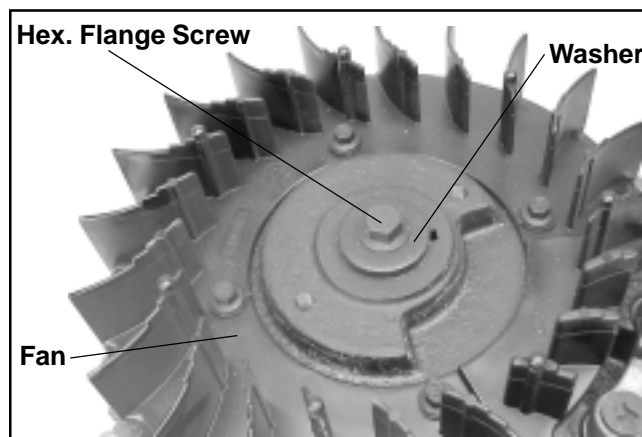


Figure 11-30. Installing Flywheel Retaining Screw and Washer (Electric Start Models).

- Hold the flywheel with a strap wrench or holding tool (see Section 2) and torque the hex. flange screw to **66.4 N·m (49 ft. lb.)**. See Figures 11-31 and 11-32.

NOTE: Always use a flywheel strap wrench or flywheel holding tool to hold the flywheel when tightening the flywheel fastener. Do not use any type of bar or wedge between the cooling fins or flywheel ring gear, as these parts could become cracked or damaged.

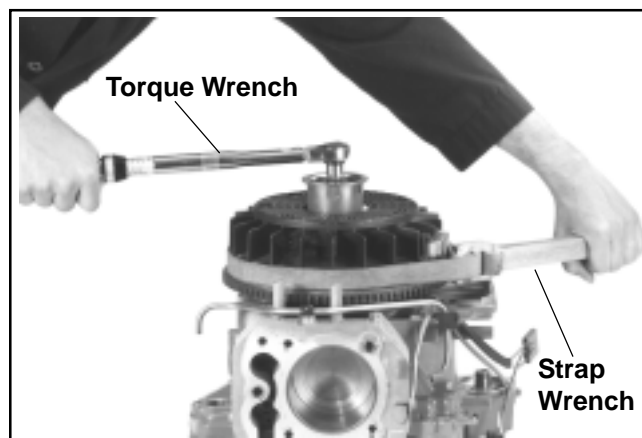


Figure 11-31. Torquing Flywheel Fastener (Retractable Starter Models).

Section 11

Reassembly

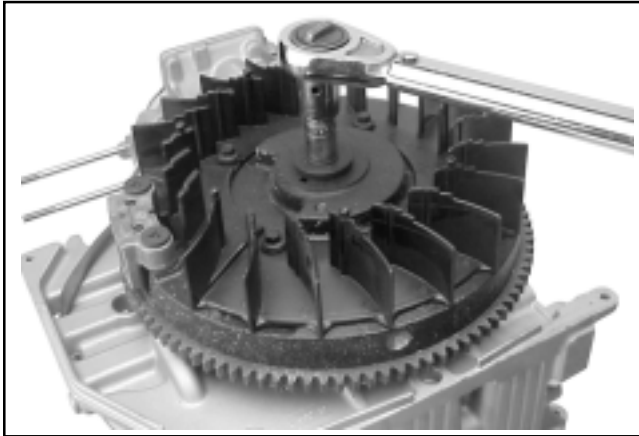


Figure 11-32. Torquing Flywheel Fastener (Electric Start Models).

5. Install the grass screen onto the fan assembly (electric start models). See Figure 11-33. If the engine originally had extra retainers on three of the snap knobs, you were instructed to mark those knobs during the disassembly procedure. Install new retainers (Part No. 24 018 03-S) on the opposite three knobs from where the original retainers were located.

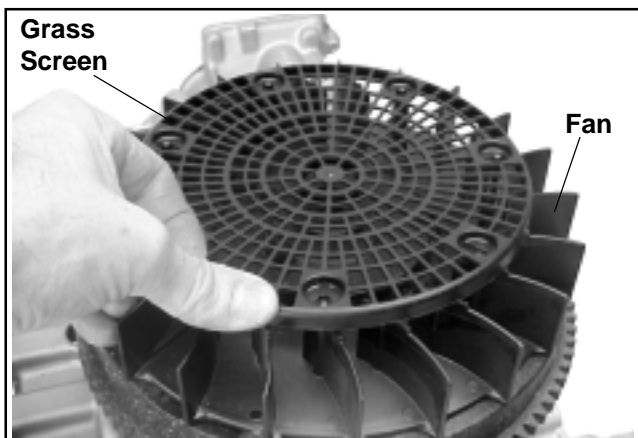


Figure 11-33. Installing Grass Screen (Electric Start Models).

Install Hydraulic Lifters

Adjustable Valve Lash Configuration Only

1. Bleed the hydraulic lifters of internal oil so the plunger in the lifter can be depressed by hand. Use an old cutoff push rod mounted in a drill press, arbor press, or vice, and slowly apply pressure **two or three times** to bleed the lifters. See Figure 11-34. If a vice is used in bleeding the lifters, be sure to install protective coverings over the jaws to avoid damage to the base of the lifter(s).



Figure 11-34. Push Rod Tool.

NOTE: Another tool for bleeding may be made from an old tappet and ball bearing welded together. See Figure 11-35.

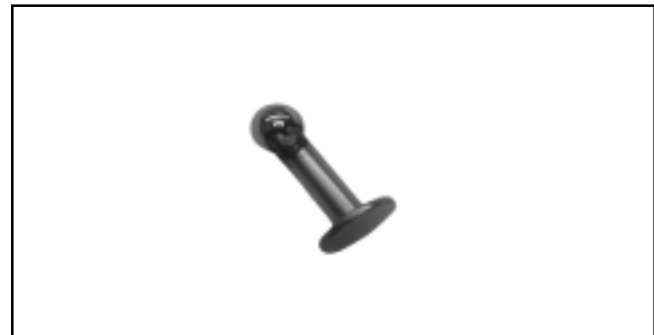


Figure 11-35. Tappet and Ball Bearing Welded Together.

All Head Configurations

1. Lightly lubricate the bottoms of the lifters with oil and install into their respective bores. See Figure 11-36. **Do not prime the lifters.**

NOTE: Hydraulic lifters should always be installed in the same position as before disassembly.

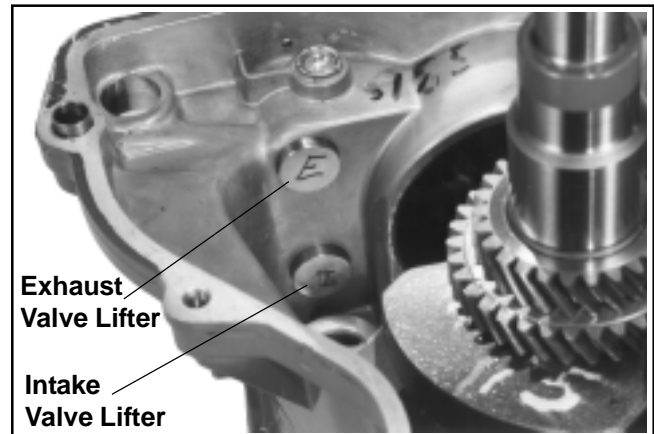


Figure 11-36. Installing Hydraulic Lifters (Camshaft Removed to Show Lifter Positions).

Section 11

Reassembly

Reassemble Cylinder Head

Refer to Figure 11-37 for cylinder head differences. Assemble the components accordingly, based on head configuration involved.

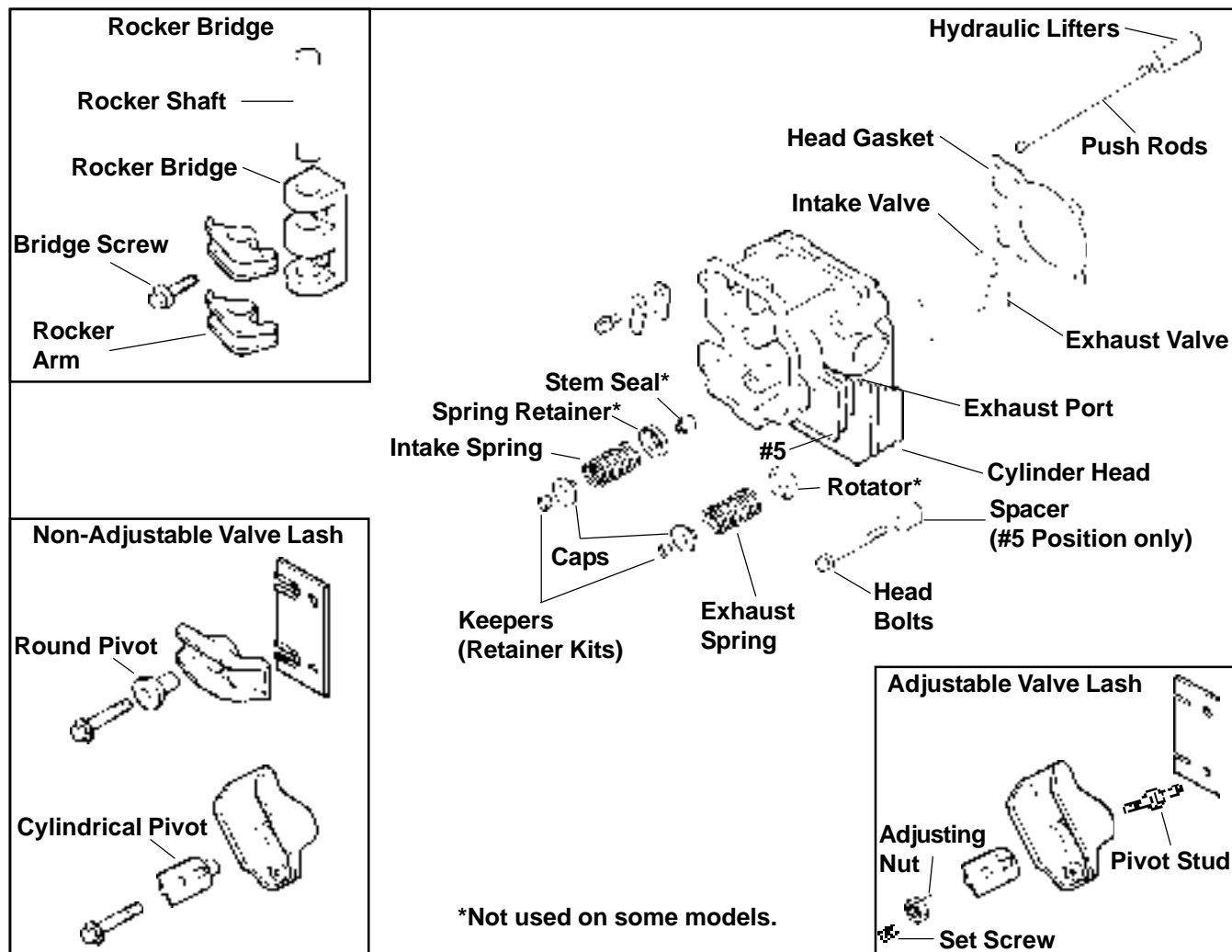


Figure 11-37. Cylinder Head Valve Train Differences.

1. **Rocker Bridge Heads Only**—Install the rocker bridge to the cylinder head. See Figure 11-38. Make sure the small (counterbored) hole is towards the exhaust port side of the cylinder head. Secure the rocker bridge with the two M6 hex. cap screws. Torque screws to **11.3 N·m (100 in. lb.)**.
2. Install the intake valve stem seal*, intake valve, spring retainer*, intake valve spring, and valve spring cap. Compress the valve spring using a valve spring compressor and install the keepers. See Figure 11-39.
3. Install the exhaust valve stem seal (if used), exhaust valve, spring retainer*, exhaust valve spring, and valve spring cap. Compress the valve spring using a valve spring compressor and install the keepers. See following NOTE regarding exhaust valve rotator use.

NOTE: Exhaust valve rotators are no longer used. **Do not** attempt to install rotators if a new head is being installed, or head did not use one originally.

*Not used on some models.

Section 11

Reassembly

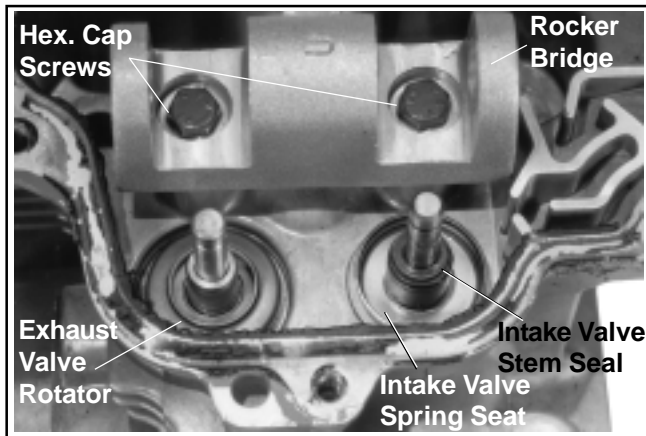


Figure 11-38. Installing Rocker Bridge and Valves.

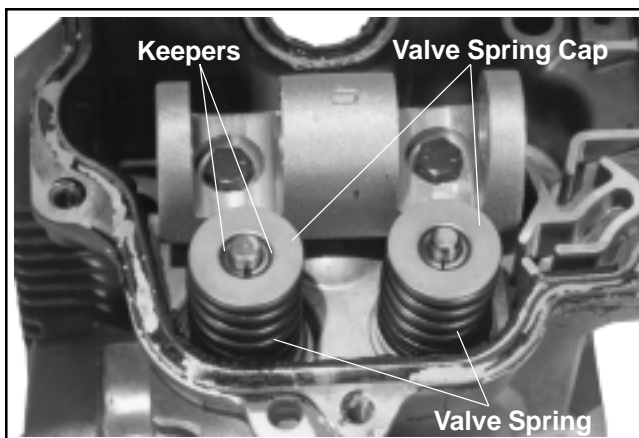


Figure 11-39. Installing Valve Keepers.

4. Rocker Bridge Heads—Figure 11-40

- a. Position the rocker arms over the valve stems and rocker arm bridge. Insert the pin through the rocker bridge and rocker arms, from the breather reed side.

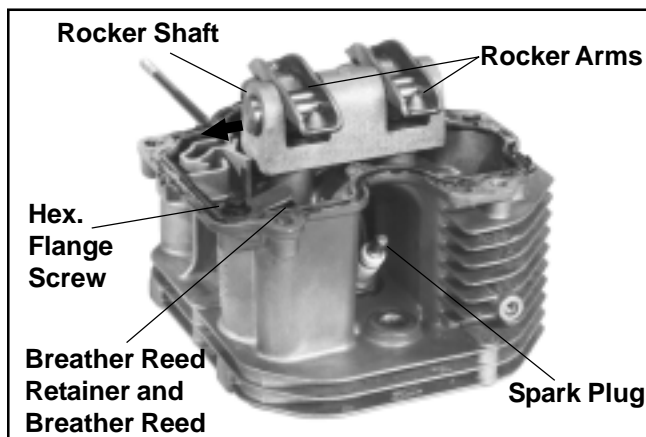


Figure 11-40. Installing Rocker Arms (Rocker Bridge Type).

Heads with Separate Pivots/Rocker Arms—Figure 11-37

• Non-Adjustable Valve Lash Configuration

- a. Position the pivots in the sockets of the rocker arms. Insert the screws through the pivots, rocker arms, and guide plate (some models). Start the screws into the cylinder head and **finger tighten only at this time.**

• Adjustable Valve Lash Configuration

- a. Position the guide plate on the head, with the formed lips "down," and install the two pivot studs. Torque the pivot studs to **11.3 N·m (100 in. lb.)**. Lubricate the bottoms of the rocker arm pivots with oil and position within rocker arms. Install the rocker arm/pivot assemblies on the studs.

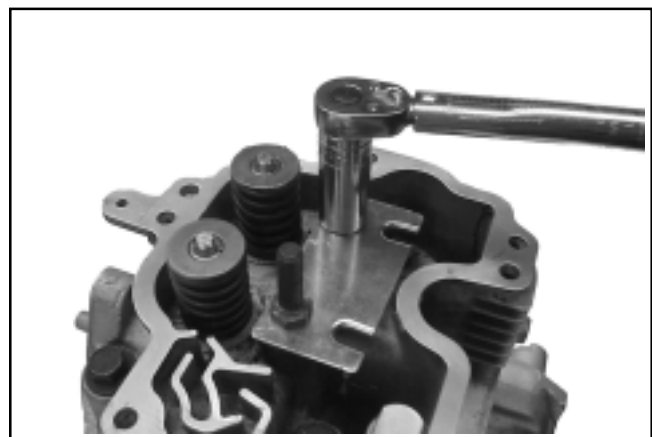


Figure 11-41. Torquing Pivot Studs (Adjustable Valve Lash).

Section 11

Reassembly

- b. Start the set screw into the nut, but only a few turns or it may hamper lash adjustment. Start the adjustment nut with the set screw on the end of each stud.

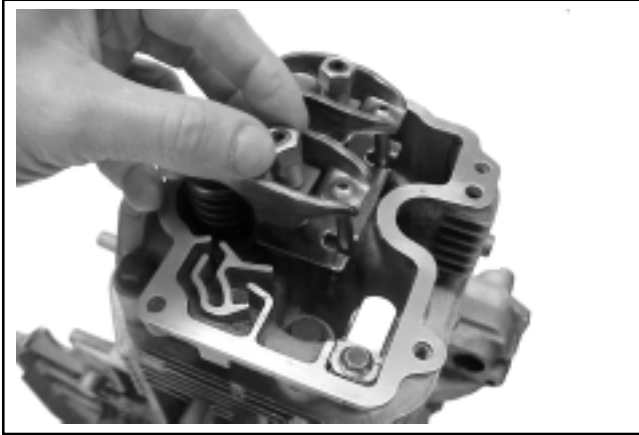


Figure 11-42. Installing Adjustment Nut.

5. Install breather reed and reed retainer, secure with the M5 hex. flange screw. Torque the screw to **6.2 N·m (55 in. lb.)** in a new hole, or **3.9 N·m (35 in. lb.)** in a used hole.
6. Install the exhaust studs (if removed previously, or a new head is being installed). The threaded end with the oval point or identification symbol must be out.

Install Cylinder Head

1. Rotate the crankshaft to TDC of the compression stroke and make sure the lifters are installed in the lifter bores with the socket end up.
2. a. Install a new cylinder head gasket and the cylinder head assembly on the crankcase.

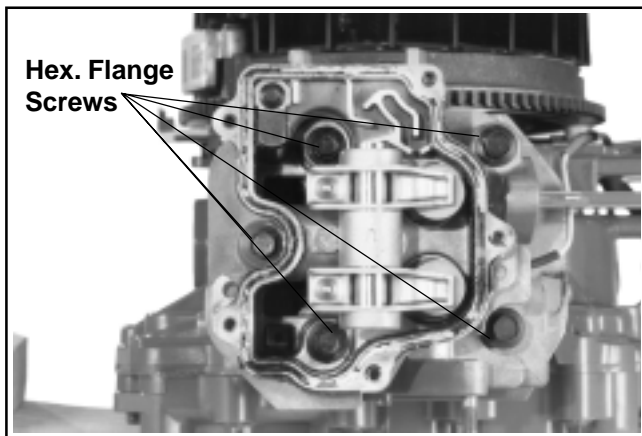


Figure 11-43. Installing Cylinder Head (Rocker Bridge Type Shown).

- b. Apply Loctite® No. 59241 thread sealant to the threads of two of the shorter (81 mm/3.1 in.) head bolts, and install them into location 3 and 4. See Figure 11-44.
- c. If the engine has a high temperature cutout switch, insert a long (90 mm/3.5 in.) head bolt through the special washer (flat on one edge), and the cutout switch. Install it in position 1.
- d. Determine the correct length head bolt for position 5, based upon the length of spacer used. If the spacer used is **27 mm (1.062 in.)** long, use a long (90 mm/3.5 in.) head bolt. If the spacer used is **17 mm (.669 in.)** long, use a shorter (81 mm/3.1 in.) head bolt. Insert the appropriate head bolt through the spacer and washer, and install it in position 5. See Figure 11-44.
- e. Install head bolts in the remaining positions.
- f. Following the sequence in Figure 11-44, torque the bolts to **20 N·m (15 ft. lb.)**. Then repeat the sequence to a final torque of **40.7 N·m (30 ft. lb.)**.

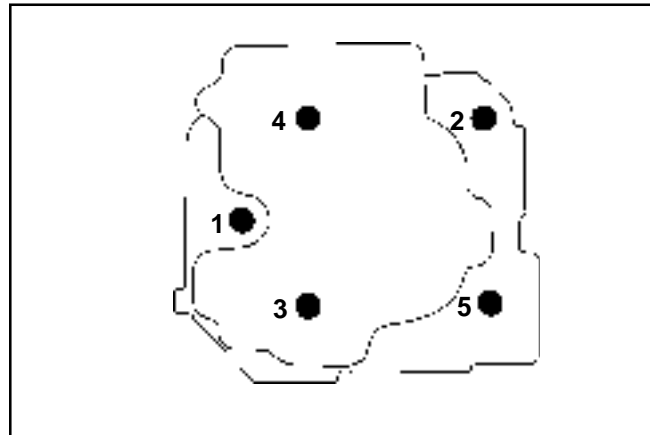


Figure 11-44. Cylinder Head Fastener Torque Sequence.

3. Install the push rods in their original position.
4. **Rocker Bridge Heads—Figure 11-37**
 - a. Compress the valve spring and seat the push rods into the sockets under the end of the rocker arms.

Section 11

Reassembly

Heads with Separate Pivots/Rocker Arms– Figure 11-37

- Non-Adjustable Valve Lash Configuration
 - a. Seat the push rods into sockets under the end of the rocker arm and align the rocker arms over the valve stems. Hold the rocker arm in the position and torque the screws to **11.3 N·m (100 in. lb.)**. See Figure 11-45.

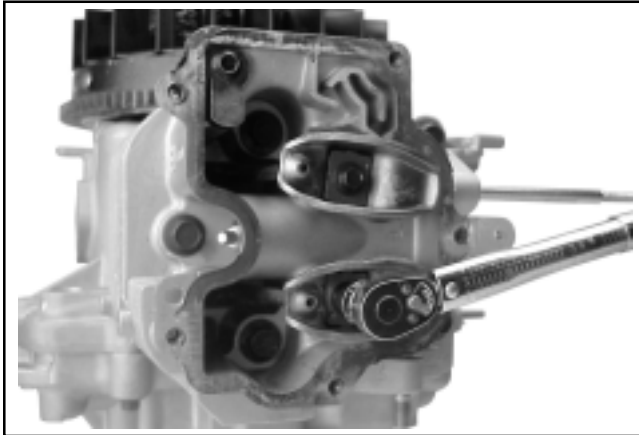


Figure 11-45. Torquing Rocker Arm Mounting Screws.

- Adjustable Valve Lash Configuration
 - a. Position the push rods within slots in guide plate and seat the push rods into sockets under the end of the rocker arms. Align the rocker arms over the valve stems.
 - b. Apply downward pressure to the push rod side of rocker arm, to compress the lifter and "bottom" the plunger in the lifter bore. **Hold in this position** for Steps "c".

NOTE: It takes two hands to make the lash adjustment. You will probably need a clamping device or an assistant to hold the lifter compressed while you make the adjustment.

- c. Insert a .07/.12 mm (.003/.005 in.) feeler gauge between the rocker arm and end of valve, and turn the adjustment nut "clockwise" (down) until a slight drag is felt on the feeler gauge. See Figure 11-46.

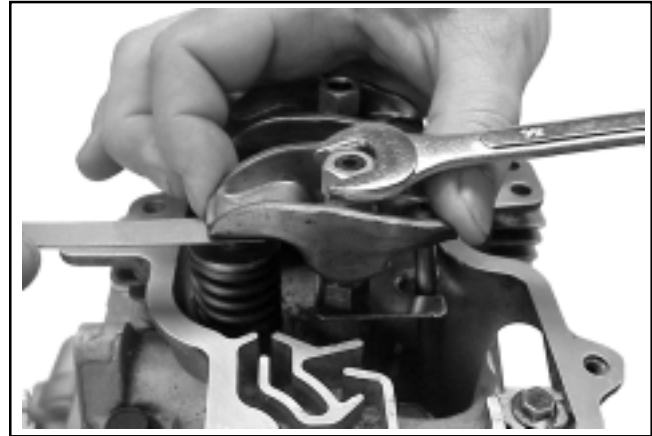


Figure 11-46. Adjusting Valve Lash.

- d. Hold the adjustment nut from turning and tighten the set screw to lock it in position. Torque the set screw to **7.3 N·m (65 in. lb.)**. See Figure 11-47. After tightening, verify lash is .07/.12 mm (.003/.005 in.); readjust if necessary.



Figure 11-47. Torquing Set Screw (Adjusting Valve Lash).

- e. Repeat steps "b", "c", and "d" on the other rocker arm.
5. If the head has a threaded hole in the intake port, install the pipe plug or vacuum line. The pipe plug should be installed for all applications which do not have a metal vacuum line at this location. Use pipe sealant with Teflon® on the threads.
6. Install the spark plug into the cylinder head. Torque the spark plug to **24.4-29.8 N·m (18-22 ft. lb.)**.

Section 11

Reassembly

Install Ignition Module

1. Rotate the flywheel so the magnet is away from the ignition module bosses. Install the ignition module to the bosses on crankcase, using the hex. flange screws. The directional arrow (on some modules) denoting proper flywheel rotation must be up. Move the module as far from the flywheel/magnet as possible. Tighten the hex. flange screws slightly.
2. Insert a **0.25 mm (0.010 in.)** flat feeler gauge or shim stock between the magnet and ignition module. See Figure 11-48. Loosen the screws so the magnet pulls the module against the feeler gauge.

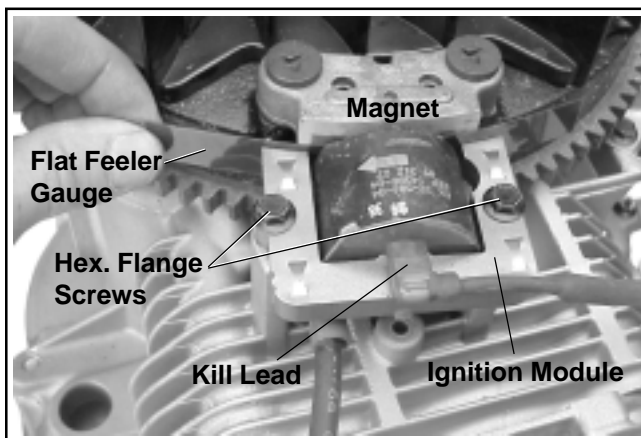


Figure 11-48. Installing Ignition Module.

3. Tighten the hex. flange screws as follows:
 Into new as-cast hole—**6.2 N·m (55 in. lb.)**.
 Into used hole—**4.0 N·m (35 in. lb.)**.
4. Rotate the flywheel back and forth; check to make sure the magnet does not strike the module. Check the gap with feeler gauge and readjust if necessary.
 Final Air Gap: **0.203/0.305 mm (0.008/0.012 in.)**.
5. Connect the kill lead to the tab terminal on the ignition module.

Install Baffles and Blower Housing

NOTE: Leave all hardware slightly loose until all sheet metal pieces are in position.

1. Install the blower housing back plate and two hex. flange screws. See Figure 11-49.

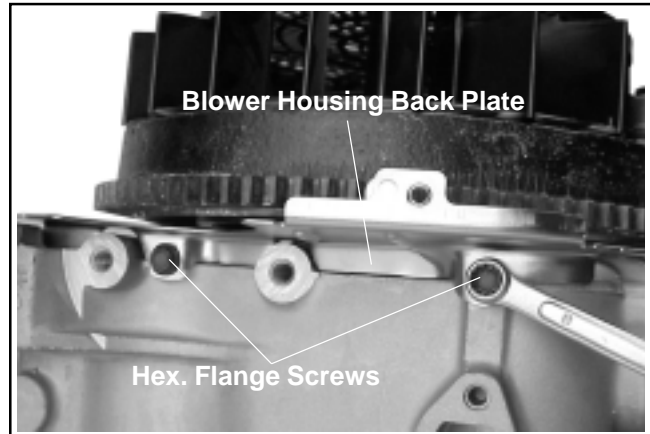


Figure 11-49. Installing Blower Housing Back Plate.

2. Install the starter side cylinder barrel baffle and one hex. flange screw. See Figure 11-50.

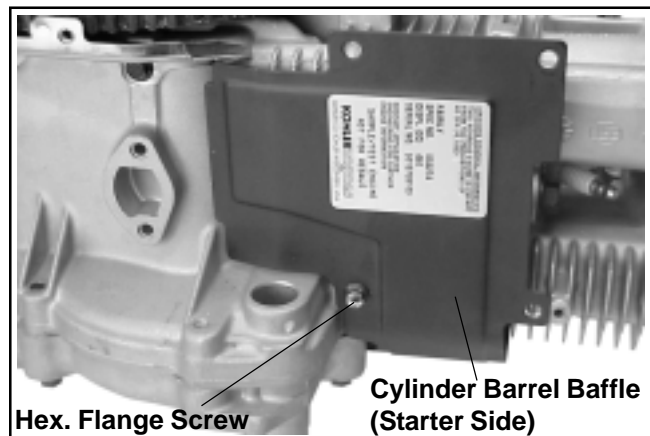


Figure 11-50. Installing Starter Side Cylinder Baffle (not on all models).

3. Install gasket and heat deflector to the intake studs. Place the carburetor side cylinder baffle in position and attach with the one hex. flange screw. Temporarily install the silver screw if the screw also attaches the fuel solenoid ground lead. See Figure 11-51.

Section 11 Reassembly

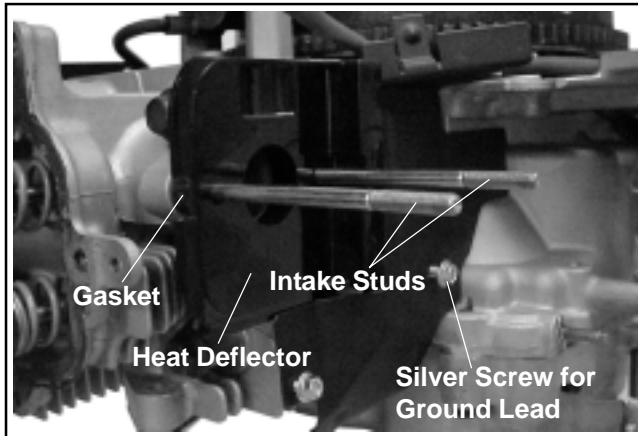


Figure 11-51. Installing Heat Deflector and Carburetor Side Baffle (not on all models).

4. Install the cylinder head baffle and secure with the two hex. flange screws. Later production models use one screw and one hex. flange nut. See Figure 11-52.

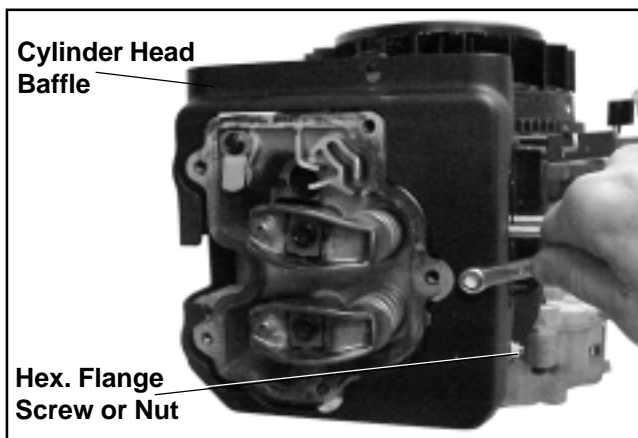


Figure 11-52. Installing Cylinder Head Baffle.

5. Install the grommet around the high tension lead (metal blower housings only). Insert the grommet into the slot in the end of the blower housing. Plastic blower housings have a formed slot to contain the lead. Install the blower housing and secure with the mounting screws. See Figures 11-53 and 11-54.

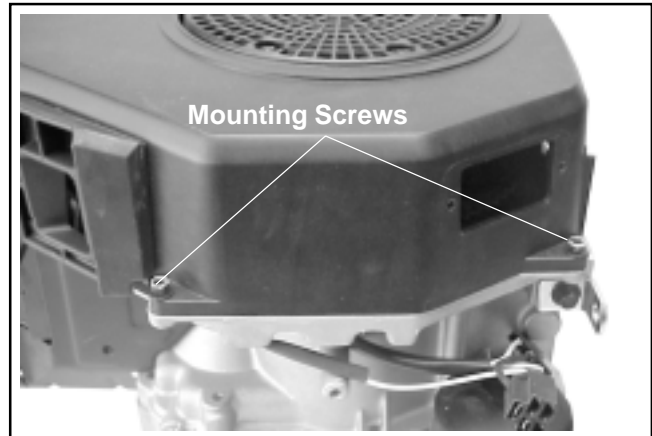


Figure 11-53. Installing Blower Housing.

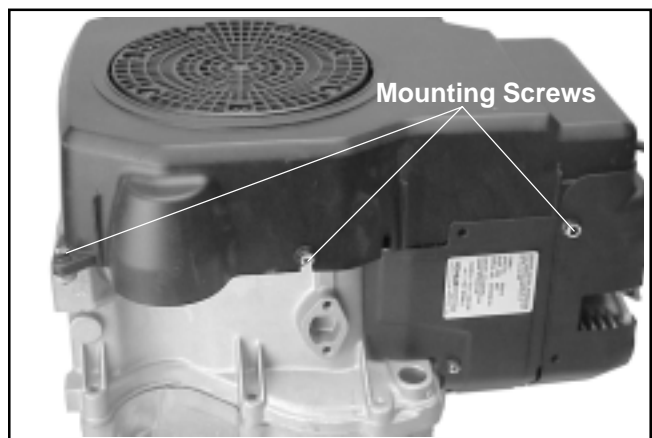


Figure 11-54. Installing Blower Housing.

6. Tighten all hardware securely when all sheet metal pieces are in position.

Install Valve Cover and Muffler Bracket

RTV silicone sealant is used between the valve cover and crankcase. Refer to page 2.1 for the approved sealant.

NOTE: Always use fresh sealant. Using outdated sealant can result in leakage.

1. Prepare the sealing surfaces of the cylinder head and valve cover following Service Bulletin 252. If it is a stamped steel valve cover, the flatness of the sealing surface must be checked prior to reinstallation. See Section 10.

Section 11

Reassembly

2. Apply a 1/16" bead of RTV sealant to the cylinder head as shown in Figure 11-55.

NOTE: To ensure proper adhesion of the sealant to both sealing surfaces, perform Step 3 immediately (5 minutes maximum) after application of RTV sealant.

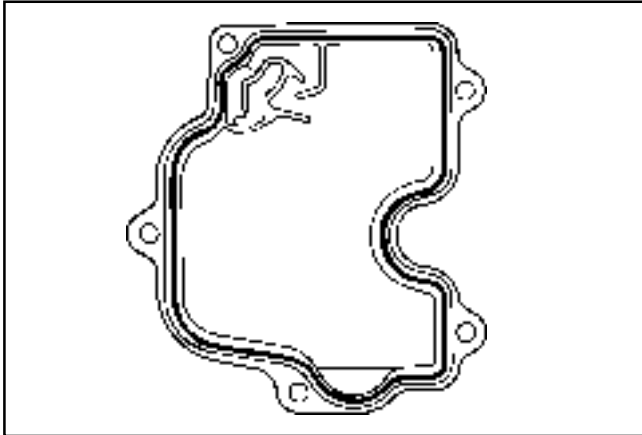


Figure 11-55. Valve Cover Sealant Pattern.

3. Install the valve cover, any attached mounting brackets (muffler, fuel tank, lifting) along with any spacers (stamped steel cover) originally used. Secure with the five hex. flange screws.

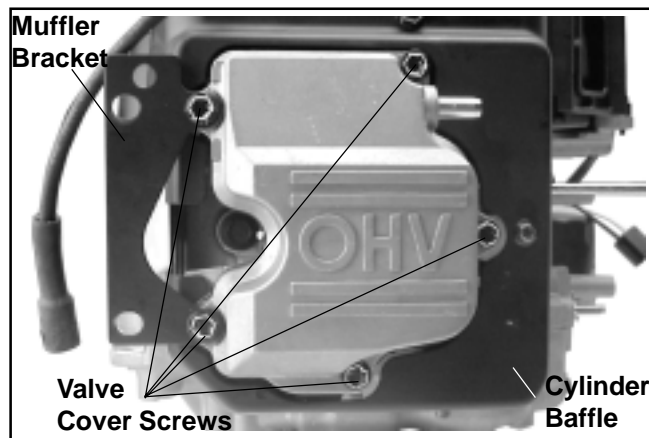


Figure 11-56. Installing Valve Cover (Cast Aluminum Cover Shown).

4. Torque the screws in the sequence shown in Figure 11-57, as follows:

Into new as-cast hole—**10.7 N·m (95 in. lb.)**.

Into used hole—**7.3 N·m (65 in. lb.)**.

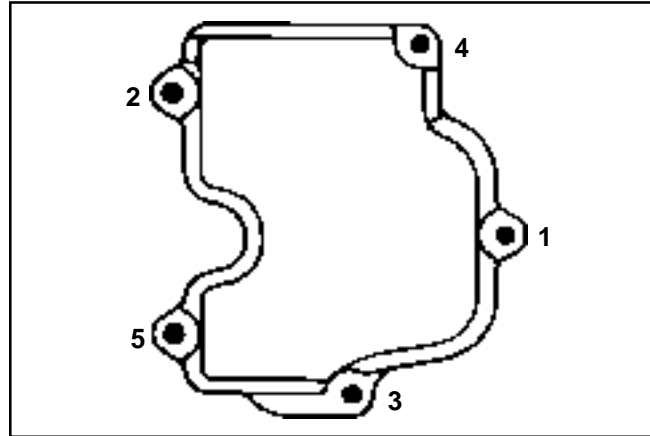


Figure 11-57. Valve Cover Torque Sequence.

Install Extended Oil Fill Tube

1. Make sure the two O-Rings on the oil fill tube and the O-Ring in the oil fill cap are in place.
2. Install the oil fill tube into the hole in the crankcase. See Figure 11-58.

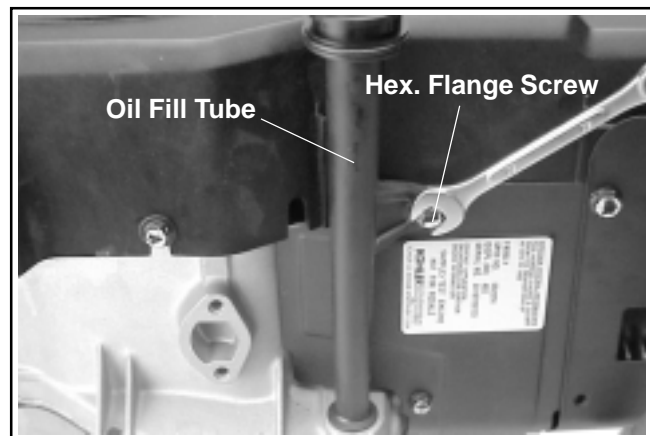


Figure 11-58. Installing Oil Fill Tube.

3. Secure the oil fill tube to the crankcase with the hex. flange screw.

Install Rectifier-Regulator (If So Equipped)

1. Install the rectifier-regulator including the ground lead (if used), and secure it with the two mounting screws. See Figure 11-59.
2. Be sure the B+ (red) lead is installed in the connector, and plug the connector into the rectifier-regulator.

Section 11 Reassembly

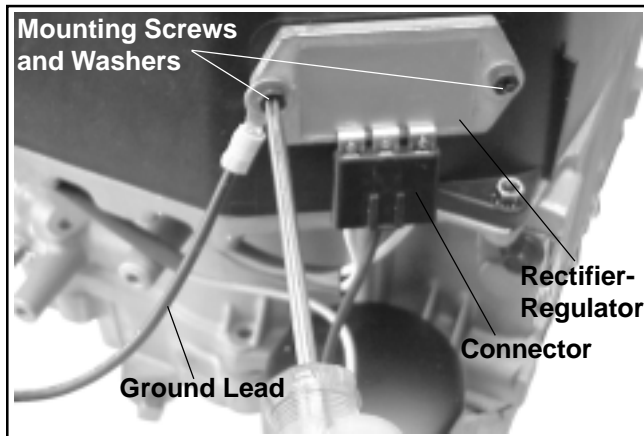


Figure 11-59. Installing Rectifier-Regulator (not on all models).

Install Fuel Pump (If So Equipped)

1. Install the rubber line and two hose clamps to the fuel pump end of the metal fuel line. Secure the rubber fuel line to the steel fuel line with one of the clamps. See Figure 11-60.

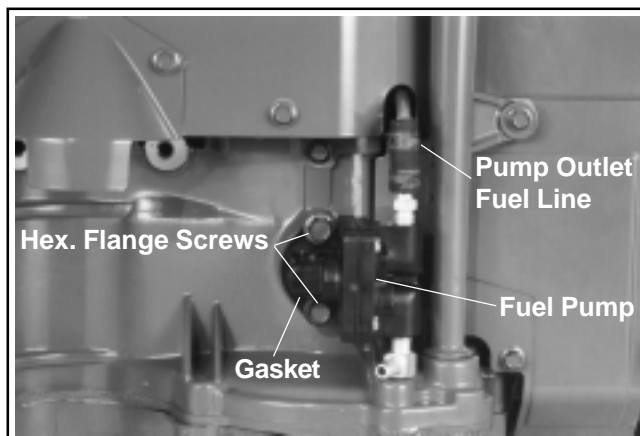


Figure 11-60. Installing Fuel Pump.

2. Install the gasket, fuel pump, and two hex. flange screws. Torque the screws as follows:

Into new as-cast hole—**9.0 N·m (80 in. lb.)**.

Into used hole—**4.2-5.1 N·m (37-45 in. lb.)**.
3. Install the opposite end of the rubber line to the outlet fitting of the fuel pump. Secure the fuel line to the outlet fitting with the other hose clamp.

Install Carburetor and External Governor Components

1. Install the rubber fuel line and secure the rubber fuel line to the metal fuel line with a hose clamp.
2. Install the bushing and attach the throttle linkage to the carburetor throttle lever. See Figure 11-61.

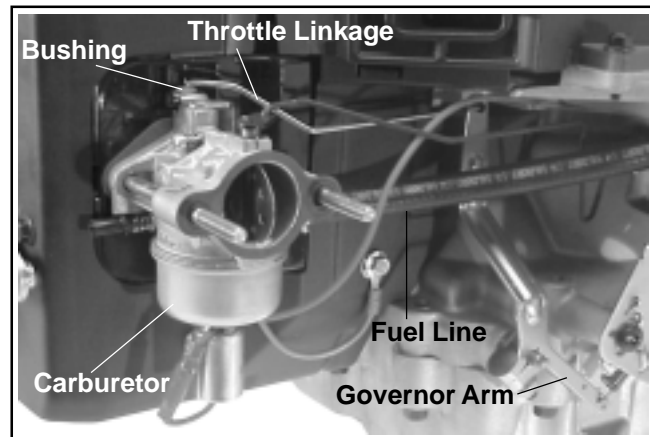


Figure 11-61. Installing Carburetor and External Governor Components.

3. Install the gasket and carburetor onto the intake studs. Install the free end of the rubber fuel line to the carburetor inlet fitting. Secure the fuel line with the other hose clamp. See Figure 11-62.

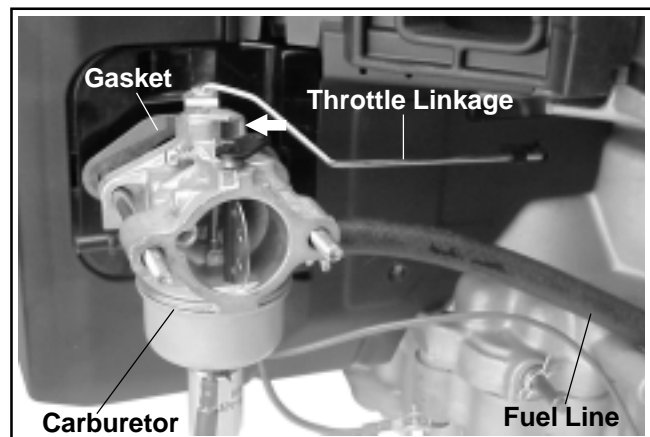


Figure 11-62. Installing Gasket, Carburetor and Fuel Line.

Section 11

Reassembly

4. Attach the ground lead from carburetor fuel solenoid (if applicable) to the silver screw and lock washer on the cylinder baffle. See Figure 11-63.

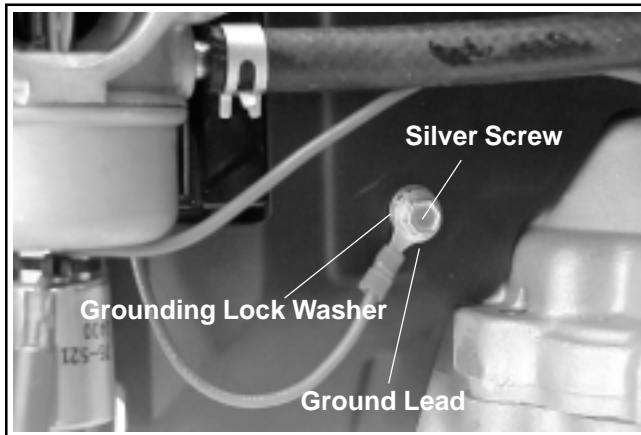


Figure 11-63. Attaching the Ground Lead.

5. Install the governor lever onto the cross shaft, but **DO NOT** tighten at this time. Adjustment and setting of the governor lever is performed after the air cleaner base is installed.
6. Install the throttle linkage and bushing to the governor lever.
7. Connect the long end of the choke linkage to the carburetor choke lever. See Figure 11-64.
8. Connect the other end of the choke linkage to the choke lever on speed control bracket.
9. Attach the speed control bracket assembly with the two mounting screws. On some models, the upper screw also secures a ground lead (rectifier-regulator) and an attaching clip (fuel line).
10. Install the governor spring in the appropriate hole in the governor arm, and through the hole/slot in the throttle lever on the governor bracket assembly. See Figure 11-64. Refer to Section 5 for correct hole use/spring installation.

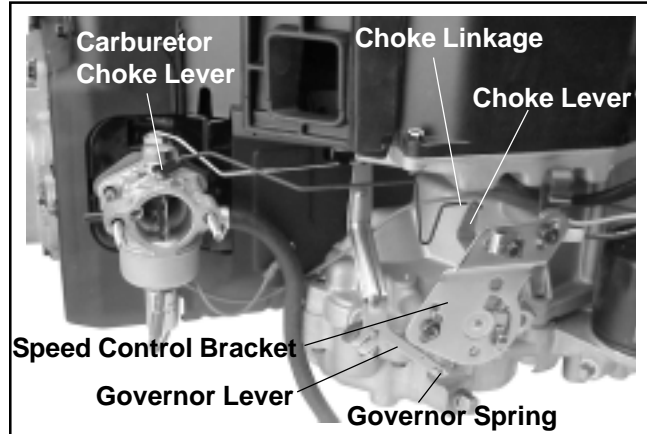


Figure 11-64. Installing Choke Linkage and Speed Control Bracket.

Install Air Cleaner and Make Initial Governor Adjustment

1. Make sure the metal bushings in the air cleaner base mounting flange are in place and in good condition.
2. Install the gasket, air cleaner base, and hex. flange nuts. Torque the nuts to **9.9 N·m (88 in. lb.)**. See Figure 11-65.

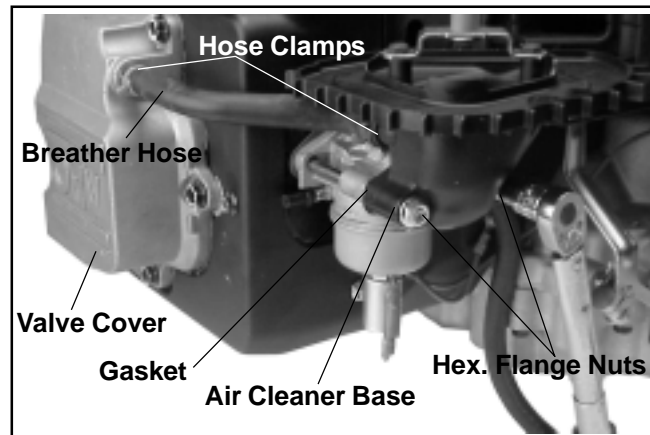


Figure 11-65. Installing Air Cleaner Base.

3. Make sure that the hose clamps are installed on the breather hose, at least 1" in from the ends. Attach the end with the larger I.D. to the air cleaner base, and the other end to the valve cover nipple. Secure with the hose clamps.
4. Make the initial governor adjustment.
 - a. Push the governor lever and throttle linkage **towards the carburetor** (wide open throttle) and hold.

Section 11

Reassembly

- b. Grasp the cross shaft with a pliers and turn the shaft **couterclockwise** as far as it will go, then tighten the hex. nut securely. See Figure 11-66.

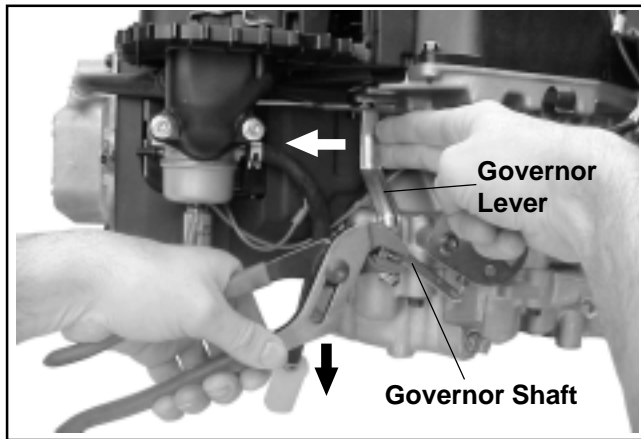
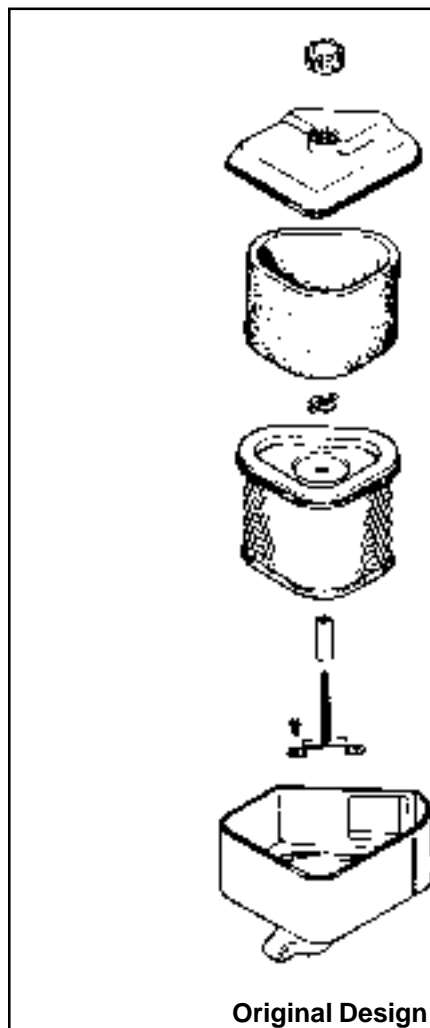
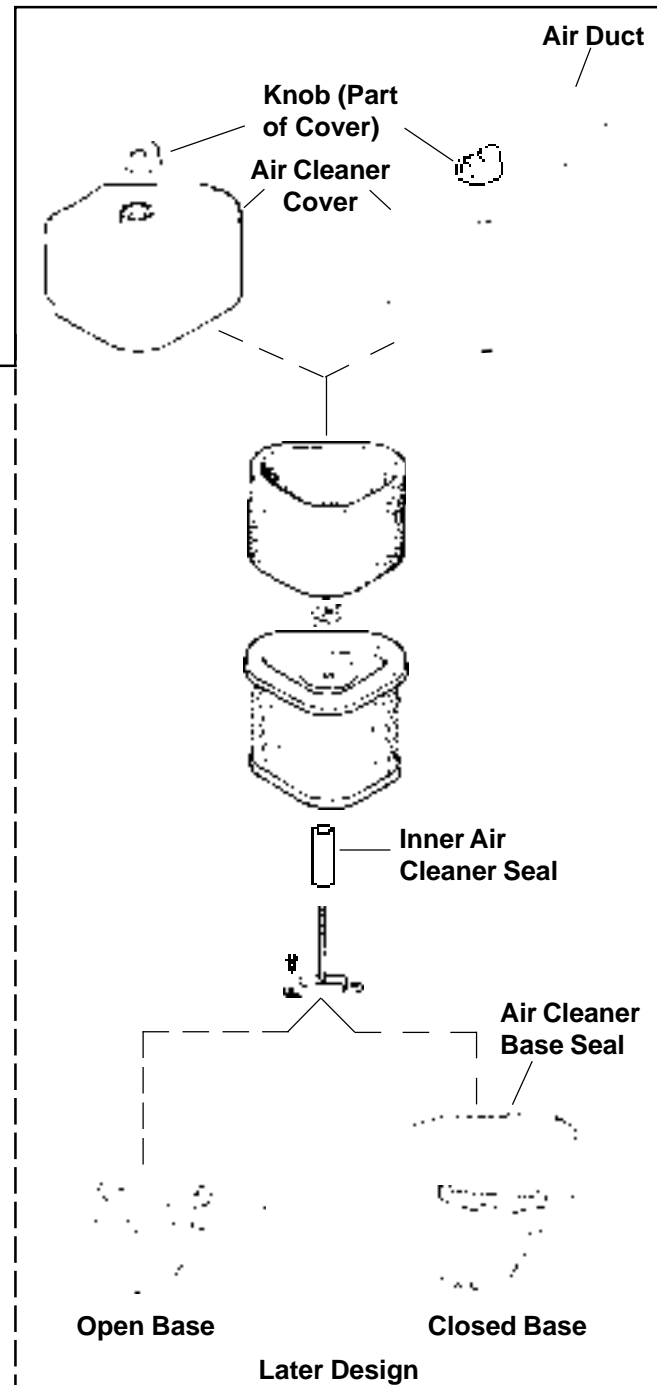


Figure 11-66. Adjusting the Governor.

5. Be sure the rubber sleeve seal is installed on the air cleaner base stud. Install the air cleaner element and precleaner. Secure the element with the wing nut. See Figure 11-67.



Original Design



Open Base

Closed Base

Later Design

Figure 11-67. Air Cleaner Details.

Section 11

Reassembly

6. Install the air cleaner cover and tighten the knob securely. See Figure 11-68.

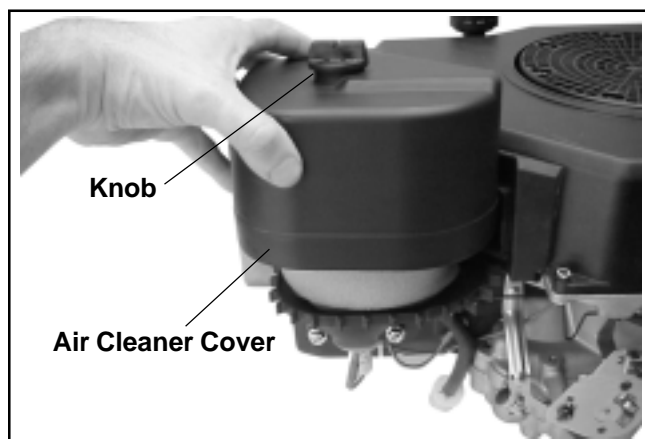


Figure 11-68. Installing Air Cleaner Cover.

Install Electric Starter

Electric Starter (Bendix Drive or Solenoid Shift)

1. Install the starter and secure with the two hex. flange screws. If there were spacers on the mounting screws, be sure they are reinstalled. Torque the screws to **15.3 N·m (135 in. lb.)**. See Figure 11-69.

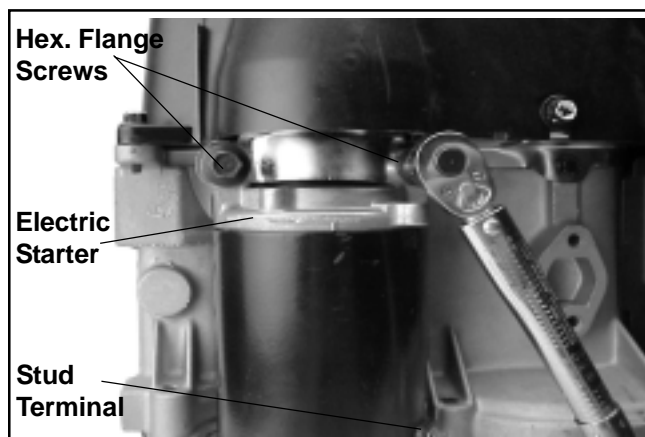


Figure 11-69. Installing Bendix Drive Starter.

2. Connect the starter leads to the terminals on the electric starter and/or solenoid.

Install Retractable 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. See Figure 11-70.

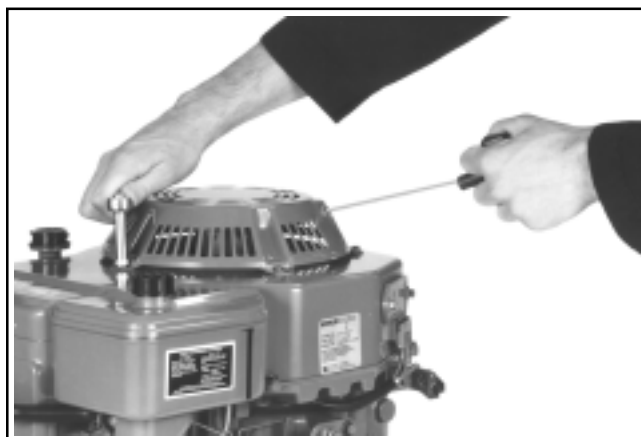


Figure 11-70. Installing Retractable Starter.

Install Muffler

1. Install the gasket, muffler, and hex. flange nuts to the exhaust port studs. Leave the nuts slightly loose. See Figure 11-71. Start the two hex. flange screws that fasten the muffler to the bracket. See Figure 11-72.

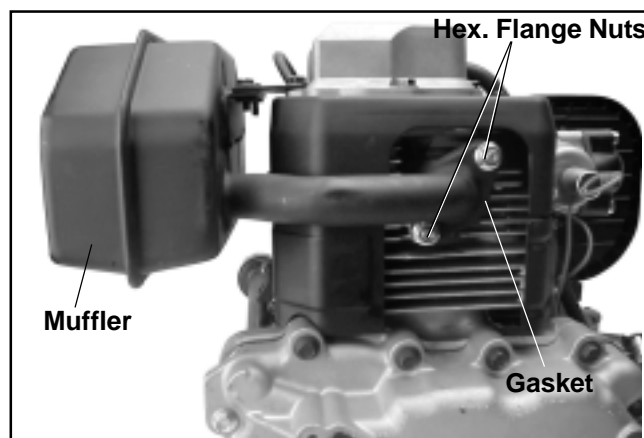


Figure 11-71. Install Muffler.

2. Torque the hex. flange nuts to **24.4 N·m (216 in. lb.)**. Tighten the hex. flange screws securely.

Section 11

Reassembly

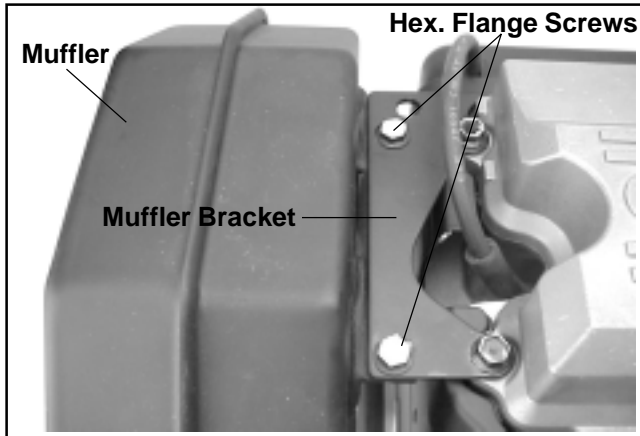


Figure 11-72. Installing Muffler.

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 (if so equipped), 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.
5. Before starting the engine, turn the engine over slowly by hand. If it can be turned over completely and compression is noted, the engine can be test run. If, however, it cannot be turned over completely (locks up at some point), return the piston to TDC between the intake and exhaust strokes and wait ten minutes to allow the lifters time to bleed down, then check for compression again. If still improper, repeat the hydraulic valve lifter and rocker arm/pivot assembly installation, for the head configuration used.

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. Refer to "Lubrication System" section, Figure 6-9. Start the engine and allow it to idle for 90 seconds. Check to be certain that oil pressure (40 psi or more) is present. Run the engine for 5-10 minutes between idle and mid-range. Adjust the carburetor settings as necessary.
2. Make sure the maximum engine speed does not exceed 3750 RPM. 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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