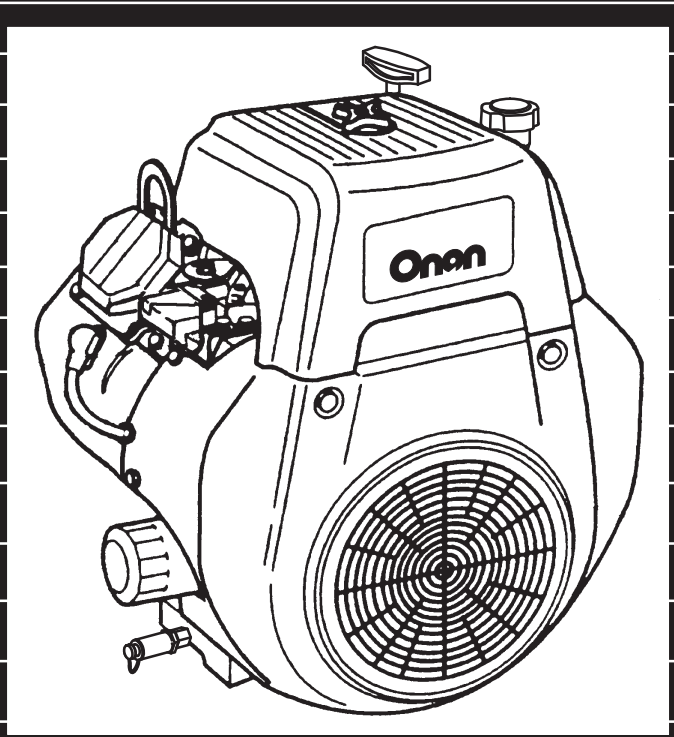
Onan

Engine

Service Manual

Performer Series OHV220



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12–00

⚠ WARNING: ⚠

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

Table of Contents

Safety Precautions

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

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

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

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

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

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

GENERAL PRECAUTIONS

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

⚠WARNING ***This engine is not designed or intended for use in aircraft. Such use can lead to engine failure, severe personal injury or death.***

FUEL IS FLAMMABLE AND EXPLOSIVE

- Keep flames, cigarettes, sparks, pilot lights, electrical arc-producing equipment and switches and all other sources of ignition well away from areas where fuel fumes are present and areas sharing ventilation.
- Do not fill the fuel tank while the engine is running.
- Fuel lines must be copper or steel tubing or piping, adequately secured and free of leaks.
- Use approved flexible fuel hose for connections at the engine. Do not use copper tubing as a flexible connector—vibration will cause it to work-harden and break. Use non-conductive hose if the fuel line could become a path for cranking current.
- LPG leaks into an inadequately ventilated space can lead to explosive accumulations of gas. LPG sinks when released into the air and can accumulate inside basements and other below-grade spaces. Precautions must be taken to prevent gas leaks and the accumulation of gaseous fuel in the event of a leak.
- The fuel line must have a manual shutoff valve unless the highest fuel level in the supply tank is lower than the connection at the engine.

ENGINE EXHAUST IS DEADLY!

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

BATTERY GAS IS EXPLOSIVE

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

MOVING PARTS CAN CAUSE SEVERE PERSONAL INJURY OR DEATH

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

1. General Information

Introduction

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

The Parts Manual contains detailed exploded views of each assembly and their individual piece part numbers and names for ordering replacement parts.

Features of the Performer OHV220 engine are:

- Overhead valve arrangement enables high power and low fuel and oil consumption
- V-twin, four stoke design
- Air-cooled and gasoline fueled
- The light-weight and compact design make it easy to install and utilize for many applications.
- A steel crankshaft and high-load bearing offer durability.
- Pressure lubrication system and large capacity air cleaner enhance reliability of the engine.
- The combustion chamber shape, along with a tuned exhaust valve system, enhances the low exhaust emission and provides high torque at low speed.

A steel crankshaft and high-load bearing offer durability. The pressure lubrication system and large capacity air cleaner enhance reliability of the engine.

The illustrations and procedures presented in each section apply to the Performer OHV220 Engine. The blower housing side of the engine is the front end. Right and left sides are determined by viewing the engine from the front. The No. 1 cylinder is on the right; the No. 2 cylinder is on the left (Figure 1-1).

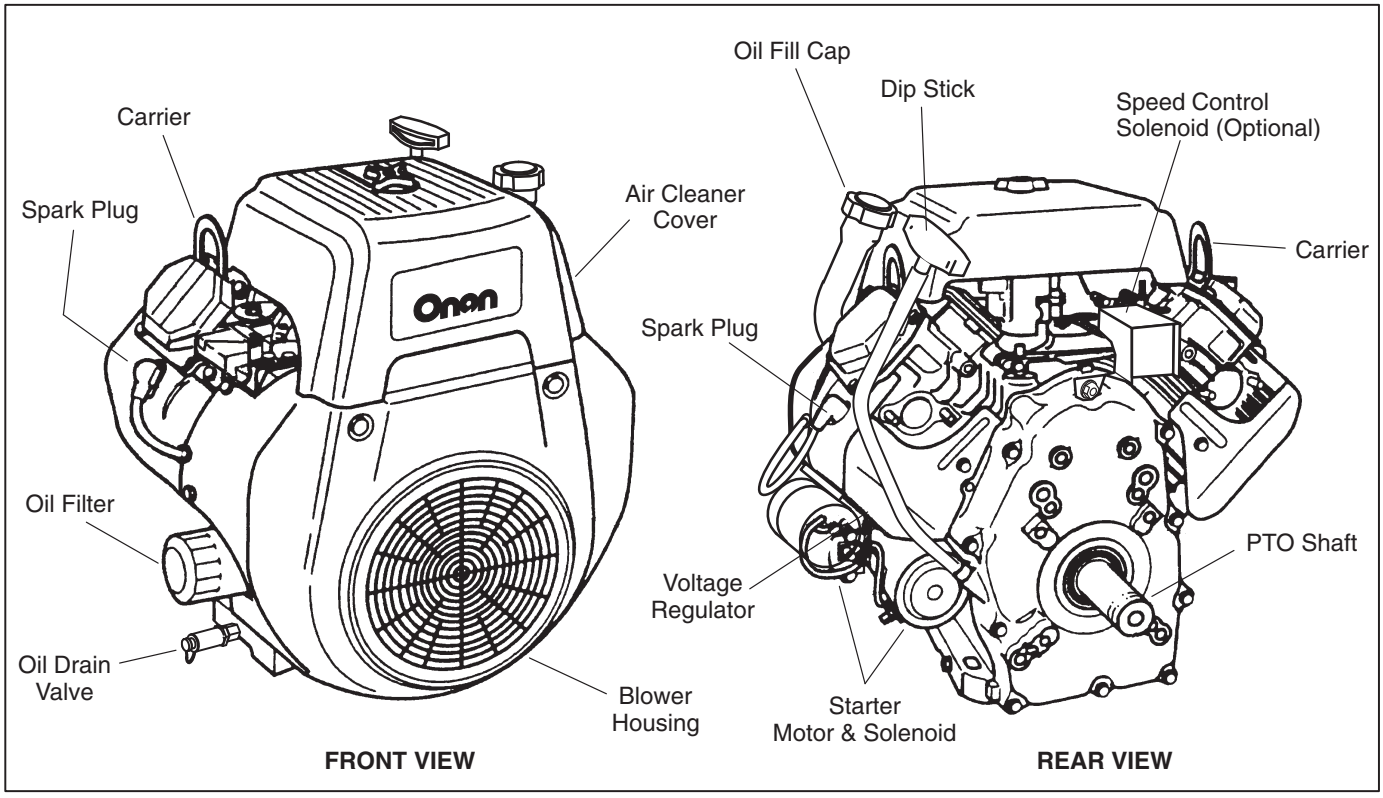


FIGURE 1-1. PERFORMER OHV220 ENGINE

If a major repair or an overhaul is necessary, a trained, experienced mechanic should either do the job or supervise and check the work of the mechanic assigned to the job to ensure that all dimensions, clearances, and torque values are within the specified tolerances.

About this Manual

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

Section 2 contains the specifications for the OHV220 engine for fluids, torques, clearances and tolerances.

The troubleshooting guide in Section 3 provides a quick reference for locating and correcting engine troubles.

Section 4 describes various engine system operations and contains electrical diagrams for the:

- Engine Wiring
- Charging System
- Starter System.

Section 5 describes the engine disassembly procedure when performing a major overhaul. The procedure provides step-by-step instructions for removal and disassembly of engine components.

Section 6 describes inspection and assembly instructions for engine components.

MODEL NUMBER

Use only Genuine Onan® replacement parts to for quality and the best possible repair and overhaul results.

Whenever contacting an dealer or distributor for information, parts or service, always provide the model number and the serial number marked on the nameplate of the engine.

See Table 1-1 for an explaination of the engine model number.

TABLE 1-1. ENGINE MODEL NUMBER

P	220	GI	OHV	XXX	A
|	|	|	|	|	|
1	2	3	4	5	6

1. Model Letter – Performer
2. Number of Cylinders and Rated Horse Power
   A. “220” designates 2 Cylinders at 20 HP
3. Engine Fuel Type and Engine Type – Gas Industrial
4. Engine Type – Overhead Valves
5. Engine Specific Model Number
6. Model Nomenclature Revsion

HOW TO OBTAIN SERVICE

When the Performer 220OHV requires service, contact the nearest dealer or distributor. Factory-trained Parts and Service representatives are ready to handle your service needs.

If you are unable to locate a dealer or distributor, consult the Yellow Pages. Typically, our distributors are listed under:

GENERATORS-ELECTRIC or
ELECTRICAL PRODUCTS

For the name of your local Cummins®/Onan® or Onan-only distributor in the United States or Canada, call 1-800-888-ONAN (this automated service utilizes touch-tone phones only). By entering your area code and the first three digits of your local telephone number, you will receive the name and telephone number of the distributor nearest you.

For outside North America, call Onan Corporation, 1-612-574-5000, 7:30 AM to 4:00 PM, Central Standard Time, Monday through Friday. Or, send a fax to Onan using the fax number 1-612-574-8087.

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

PERFORMANCE CURVE

The power curve shown in Figure 1-2 conforms to SAE internal combustion engine standard test code J1349.

The continuous rated output is the output of an engine at optimum governed speed which is prefera-

ble for engine life and fuel consumption. When the engine is installed, the rated output should be lower than shown.

The maximum torque is the torque rated on the output shaft while the engine is running at maximum output per revolution.

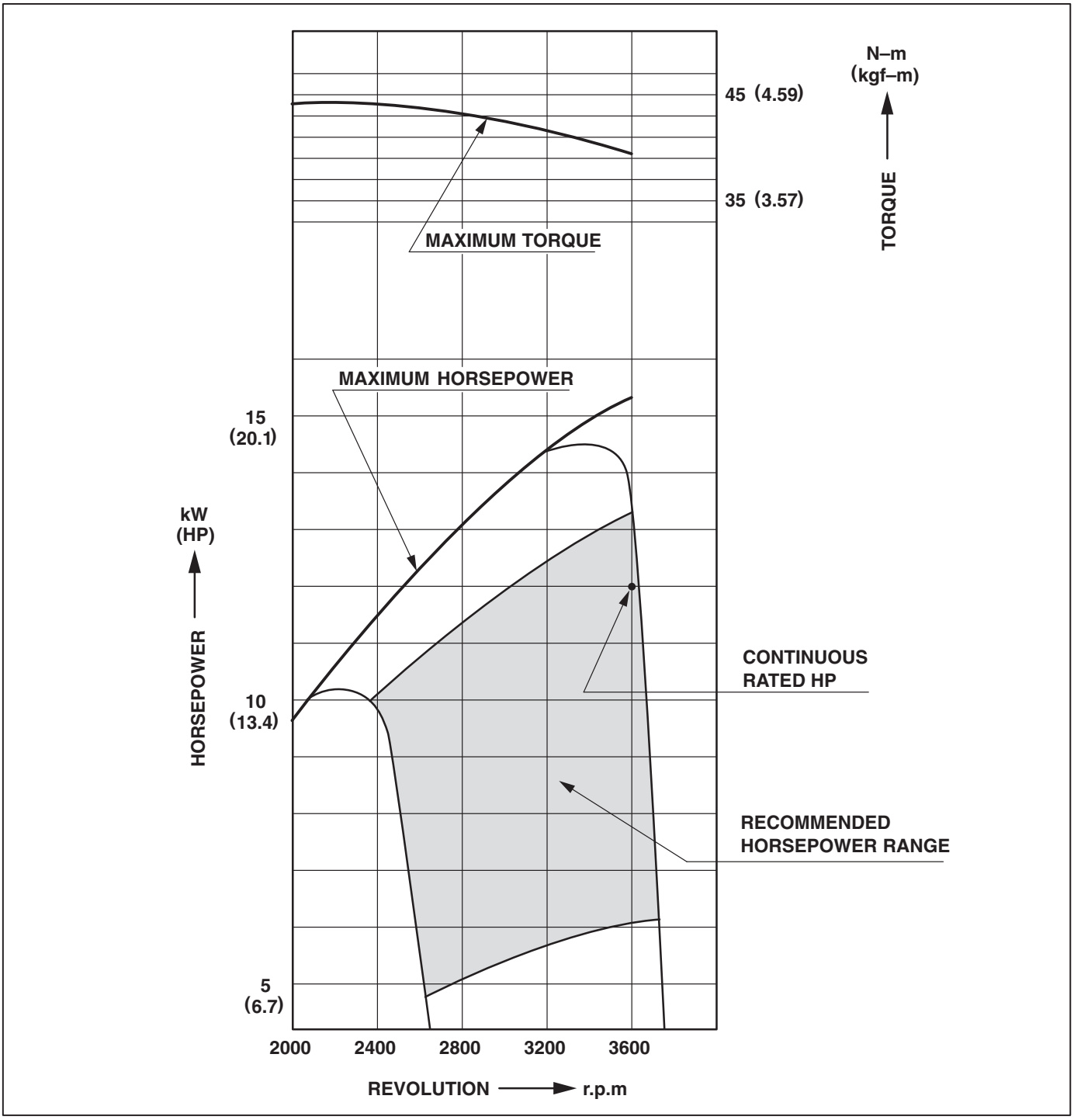


FIGURE 1-2. OHV220 PERFORMANCE CURVE

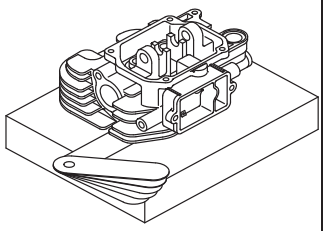
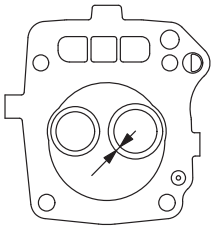
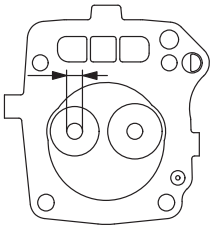
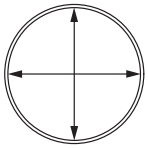
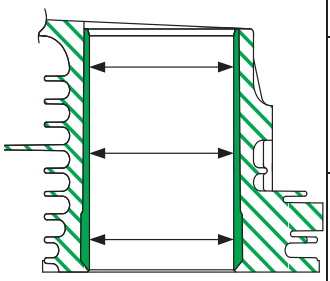
2. Specifications

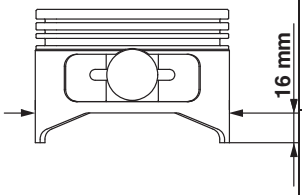
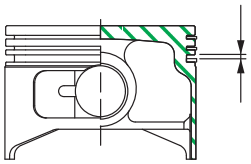
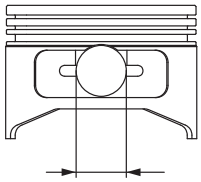
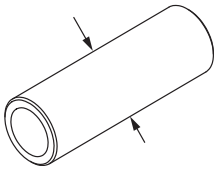
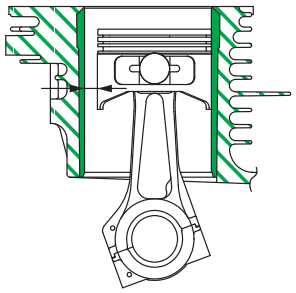
PERFORMER OHV220 ENGINE SPECIFICATIONS

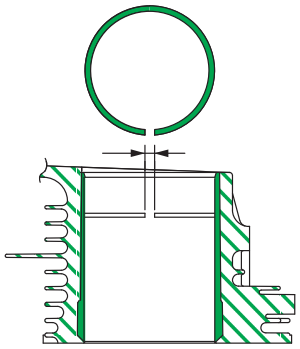
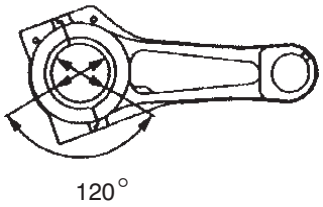
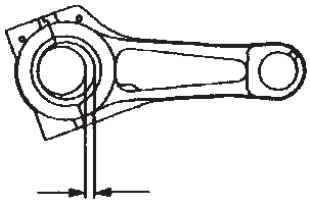
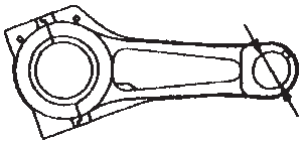
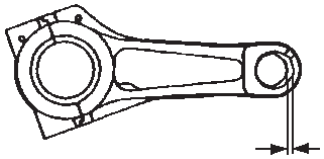
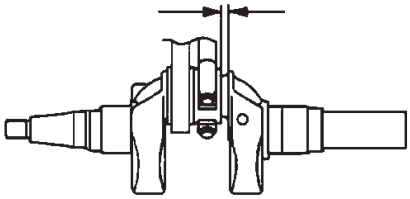
This Manual contains SI metric equivalents that follow immediately in parentheses after the U.S. customary units of measure.

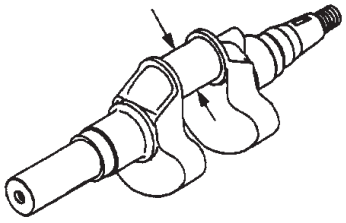
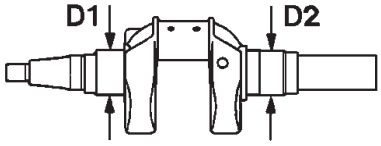
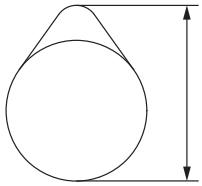
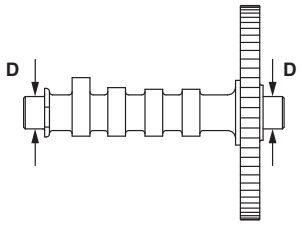
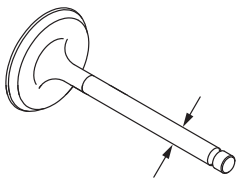
Engine Type	4-Cycle, V-Twin Cylinder, Horizontal Shaft, Overhead Valve,
Rated Output	20.5 HP/3600 rpm (15.3 kW/3600)
Continuous Output	16.0 HP/3600 rpm (11.9kW/3600)
Bore x Stroke	3.15” x 2.56” (80 mm x 65 mm)
Displacement	39.90 cu in (653 cc)
Compression Ratio	8.3:1
Maximum Output	15.3 kW / 20.5 HP / 3,600 rpm
Maximum Torque	32.7 ft/lbs @ 2,200 rpm
Starting System	Electric Start
Carburetor	Horizontal Shaft, Float Type
Fuel	Unleaded Gasoline using a Diaphragm Pulse Pump
Lubrication	Full Pressure with Full Flow Spin-On Filter
Oil Type	Automobile Engine Oil SAE Class SE or Higher (See Engine Oil Recommendation)
Oil Capacity	1.64 qt (1550 cc)
Charging System	12 volt 15 amp
Dry Weight	96.9 lbs (44 kg)
Dimensions (LxWxHx)	12.5” x 19.0” x 19.0” (317 mm x 477 mm 475 mm)
Direction of Rotation	CCW as Viewed from the PT shaft side
Cooling System	Forced Air Cooling
Ignition System	Flywheel Magneto (Solid State)
Spark Plug Type	NGK–BP6ES or BRP6ES (Champion – N9YC or RN9YC) Gap: 0.023–0.027 in (.0.6–0.7 mm)
Governor System	Centrifugal Fly Weight
Air Cleaner	Double Element Assembly

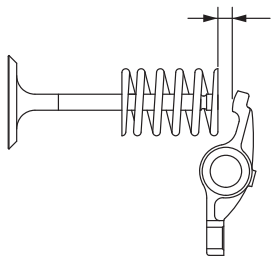
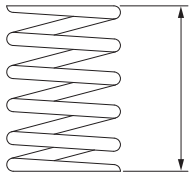
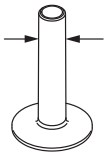
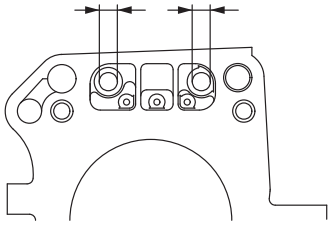
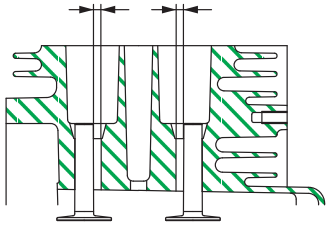
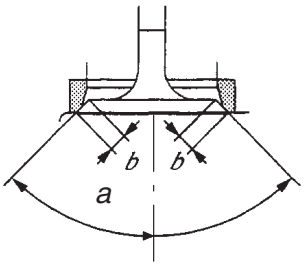
DIMENSIONS AND CLEARANCES

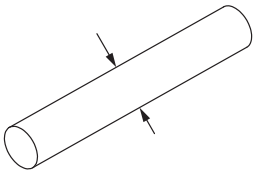
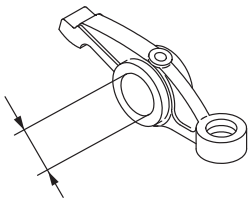
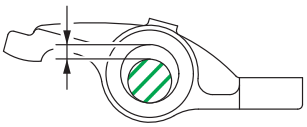
ITEM		STANDARD inches (mm)	MAXIMUM inches (mm)
Cylinder Head			
Flatness 		0.002 or less (0.05 or less)	0.004 (0.1)
Valve seat contact width 	Intake/ Exhaust	0.028 – 0.039 (0.7 – 1.0)	0.079 (2.0)
Valve guide inside diameter 		0.2376 – 0.2383 (6.035 – 6.053)	0.242 (6.15)
Cylinder			
Inside diameter  	STD	3.1496 – 3.1504 (80.000 – 80.019	Rebore when the difference between the max. and min. of diameter reaches 0.004 (0.1)
	1st Reboring	3.159 – 3.160 (80.250 – 80.269)	3.159 – 3.160 (80.250 – 80.269)
	2nd Reboring	3.169 – 3.170 (80.500 – 80.519)	————
Roundness after reboring		0.004 (0.01)	————
Cylindricity after reboring		0.0006 (0.015)	————

ITEM		STANDARD inches (mm)	MAXIMUM inches (mm)
Piston			
Piston size (at skirt in thrust direction) 	STD	3.148 – 3.149 (79.968 – 79.988)	3.145 (79.878)
	1st outer diameter	3.158 – 3.159 (80.218 – 80.238)	3.155 (80.128)
	2nd outer diameter	3.168 – 3.169 (80.468 – 80.488)	3.164 (80.378)
Ring groove side clearance 	Top	0.0002 – 0.0035 (0.05 – 0.09)	0.006 (0.15)
	2nd	0.0012 – 0.0028 (0.03 – 0.07)	0.006 (0.15)
	Oil Ring	0.0022 – 0.0069 (0.057 – 0.175)	0.006 (0.15)
Piston pin hole 		0.8262 – 0.8269 (20.989 – 21.002)	0.8281 (21.035)
Piston pin outer diameter 		0.8264 – 0.8268 (20.991 – 21.000)	0.8251 (20.960)
Clearance between piston and cylinder at skirt area 		0.0005 – 0.0020 (0.012 – 0.051)	0.0098 (0.25)

ITEM		STANDARD inches (mm)	MAXIMUM inches (mm)
Piston *(continued)* Piston ring end gap 	Top 2nd	0.0079 – 0.0157 (0.2 – 0.4)	0.0591 (1.5)
	Oil Ring	0.0079 – 0.0276 (0.2 – 0.7)	0.0591 (1.5)
Connecting Rod Large end inner diameter 		1.5354 – 1.5361 (39.000 – 39.016)	1.5394 (39.100)
Clearance between crankpin and inner diameter 		0.0012 – 0.0024 (0.030 – 0.060)	0.0079 (0.2)
Small end inner diameter 		0.8272 – 0.8277 (21.010 – 21.023)	0.8299 (21.080)
Clearance between piston pin and inner diameter 		0.0004 – 0.0013 (0.010 – 0.032)	0.0047 (0.12)
Large end side clearance 		0.0039 – 0.0157 (0.1 – 0.4)	0.0394 (1.0)

ITEM			STANDARD inches (mm)	MAXIMUM inches (mm)
Crankshaft				
Crankpin outer diameter			1.5337 – 1.5343 (38.956 – 38.970)	1.5315 (38.90)
Journal diameter			D1: 1.77102 – 1.77165 (44.984 – 45.000) D2: 1.77110 – 1.77154 (44.986 – 44.997)	———
Camshaft				
Cam height (internal and external)			1.4213 – 1.4291 (36.1 – 36.3)	1.4154 (35.95)
Journal outer diameter "D"			0.7861 – 0.7866 (19.967 – 19.980)	0.7854 (19.950)
Valve				
Valve stem outer diameter		Intake	0.2350 – 0.2356 (5.970 – 5.985)	0.2303 (5.85)
		Exhaust	0.2346 – 0.2352 (5.960 – 5.975)	0.2303 (5.85)
Clearance between valve stem and valve stem guide		Intake	0.0022 – 0.0033 (0.050 – 0.083)	0.0118 (0.30)
		Exhaust	0.0024 – 0.0037 (0.060 – 0.093)	0.0118 (0.30)

ITEM		STANDARD inches (mm)	MAXIMUM inches (mm)
Valve *(continued)* Valve clearance 	Intake/ Exhaust Measured Cold	0.0034 – 0.0045 (0.085 – 0.115)	
Valve spring Free length 		1.5551 (39.5)	———
Tappet Outer stem diameter 		0.03528 – 0.3533 (8.960 – 8.975)	0.3516 (8.93)
Inner guide diameter 		0.3543 – 0.3549 (9.00 – 9.015)	0.3575 (9.08)
Tappet guide clearance 		0.0010 – 0.0022 0.025 – 0.055)	0.0059 (0.15)
Valve seat angle Cut angle (a) Contact width (b) 		a: 45° b: 0.028 – 0.039 (0.7 – 1.0)	0.079 (2.0)

ITEM	STANDARD inches (mm)	MAXIMUM inches (mm)
Rocker Arm Shaft diameter 	0.4719 – 0.4722 (11.986 – 11.994)	0.4693 (11.92)
Rocker arm hole diameter 	0.4727 – 0.4734 (12.006 – 12.024)	0.4752 (12.07)
Arm shaft clearance 	0.0005 – 0.0015 (0.012 – 0.038)	0.0059 (0.15)

ELECTRICAL SPECIFICATIONS

COMPONENT	RATING
Voltage Regulator Output	12V 15 Amp
Ignition Coil Resistance Primary Secondary	 7.8 Ohms 7.8 Ohms
Charge Coil Nominal Output Resistance	 12V 15 Amp 9 ohms
Ignition coil air gap	0.012 – 0.020” (0.3 – 0.5 mm)
Fuel Pump At low idle At high idle (minimum measurements)	Inlet vacuum 2.6” of mercury Outlet pressure 1.7 psi Inlet vacuum 2.6” of mercury Outlet pressure 1.7 psi

ASSEMBLY SPECIFICATIONS

COMPONENT	CLEARANCE
End play between crankshaft and camshaft	0.006 – 0.013” (0.152 – 0.330mm)
Clearance between crankcase and bearing cover	0.014” (0.36mm)
Clearance between rocker arm and valve stem end	0.003 – 0.004” (0.085 – 0.115mm)
Clearance between ignition coils and flywheel	0.012 – 0.020” (0.3 – 0.5mm)

ENGINE OIL RECOMMENDATION

EXPECTED AMBIENT TEMPERATURES	SAE VISCOSITY GRADE
32° F (0° C) and higher	30
10° F to 100° F (–12° C to 38° C)	15W-40 (OnaMax)
0° F to 80° F (–18° C to 27° C)	10W-30 10W-40
–20° F to 50° F (–28° C to 10° C)	5W-30

After the first 20 hours of operation the initial oil and oil filter should be replaced.

⚠ CAUTION ***Used engine oil has been identified by some state and federal agencies as causing cancer or reproductive toxicity. Do not ingest, inhale, or contact used oil or its vapors.***

Thereafter, change the oil every 100 hours of operation and change the oil filter every 200 hours.

TORQUE SPECIFICATIONS

ITEM	TORQUE
Breather cover	26.4 – 43.2 in/lb (2.9 – 4.9 N·m)
Carburetor bolts	12.3 – 13.7 ft/lbs (16.7 – 18.6 N·m)
Charge coil	13.2 – 30 in/lbs (1.5 – 3.4 N·m)
Connecting rod bolts	16.3 – 19.9 ft/lbs (22.1 – 27.0 N·m)
Cylinder head bolts	24.6 – 30.4 ft/lbs (33.3 – 41.2 N·m)
Flywheel nut	61.5 – 68.7 ft/lbs (83.3 – 93.1 N·m)
Ignition coil	5.1 – 6.6 ft/lbs (6.9 – 8.8 N·m)
Intake manifold nuts & Main bearing cover bolts	12.3 – 13.7 ft/lbs (16.7 – 18.6 N·m)
Oil filter	9 ft/lbs (12.3 N·m)
Oil pressure switch	4.3 – 7.2 ft/lbs (5.9 – 9.8 N·m)
Oil relief plug	10.9 – 18.1 ft/lbs (11.8 – 14.7 N·m)
Rocker arm nut	7.2 – 10.1 ft/lbs (9.8 – 13.7 N·m)
Rocker arm cover	26.4 – 43.2 in/lbs (2.9 – 4.9 N·m)
Spark plug: new Used	8.7 – 10.9 ft/lbs 11.8 – 14.7 N·m) 16.6 – 19.5 ft/lbs (22.5 – 26.5 N·m)
Starter motor bolts	12.3 – 13.7 ft/lbs (16.7 – 18.6 N·m)

3. Engine Troubleshooting

⚠WARNING ***Many troubleshooting procedures present hazards that can result in severe personal injury or death. Only qualified service personnel with knowledge of fuels, electricity, and machinery hazards should perform service procedures. Review the safety precautions on the inside cover page.***

⚠WARNING ***Hot engine parts can cause severe burns. Always allow the engine time to cool before performing any maintenance or service.***

Refer to other sections within this manual or the Operators Manual for procedures to test, adjust, repair or replace engine components.

Problem	Possible Cause	Remedy
Starter does not operate	Poor connection of key or starter switch wiring	Check, repair or replace
	Discontinuity between key switch or start switch and starter motor	Replace wiring
	Discontinuity between battery and starter motor	Replace battery cables
	Weak or low charged battery	Charge or replace battery
	Poor battery terminal connections	Check and clean terminals, replace if damaged
	Faulty solenoid switch	Check, repair or replace
	Faulty starter motor	Repair or replace starter
	Crankshaft has seized	Check crankshaft bearings and crankshaft bearing surface
	A piston and cylinder have seized	Check pistons and cylinder bores
Starter operates but engine does not start	No fuel in system	Refill
	Poor connection or discontinuity of ignition system wires	Check wire connections and ignition coils for shorts
	Faulty starter motor	Slow cranking RPM caused by a faulty starter motor or low battery voltage at starter
Low engine speed while cranking	Low battery	Charge battery
	Bad connection between battery and starter motor	Clean or repair
	Bad connection between battery and ground	Clean or repair
	Starter motor has worn brushes or bearing	Repair or replace starter motor
	Improper engine oil	Replace with recommended engine oil

Problem	Possible Cause	Remedy
Ignition system malfunctions	Spark plug: Improper gap No insulator Carbon deposits	 Adjust Replace Clean
	Ignition coil No insulation or discontinuity Bad connection or discontinuity of ignition coil	 Check for grounded wire and replace Replace coil(s)
	Improper air gap between ignition coil and flywheel	Check and adjust
Fuel system malfunctions	Fuel tank is empty	Refill tank
	Fuel pump is plugged up	Disassemble and clean
	Fuel hose is plugged or pinched	Check lines, replace if necessary
	Air is mixing into fuel lines	Check and tighten connections
	Plugged fuel filter or air infiltration	Clean or replace fuel filter
	Carburetor Flooding Clogged or damaged Throttle valve not functioning Low fuel flow to carburetor	 The floats are sticking Disassemble and clean Check throttle shaft and linkage, adjust governor lever Faulty fuel cut-off valve or wiring
	Engine idles too high	Adjust or replace control solenoid
	Idle unstable	Check govenor linkage and springs
Low compression/ Insufficient output	Loose spark plug(s)	Retighten or replace plug wire
	Head gaskets are leaking	Retighten or replace gasket
	Worn piston ring(s) or seizure	Replace ring(s)
	Incorrect valve and seat contact	Adjust or replace
	Valve stem seizure	Repair or replace
	Incorrect valve clearance	Check and adjust
	Ignition coil(s) faulty	Check and replace
	Improper gap between coil and flywheel	Check and adjust
	Charge coil is demagnetized	Replace charge coil
	Fuel system problems	Check system
	Low air intake	Clean air cleaner elements Check throttle valve for full opening

Problem	Possible Cause	Remedy
Overheating	Cooling air flow obstructed	Check air inlet and cylinder baffle and clean out
	Improper engine oil	Replace
	Lean air/fuel mixture	Check for plugged passages in carburetor
	Excessive back pressure of exhaust system	Check, clean or replace muffler and spark arrestor (if equipped)
	Engine is overloaded	Change to rated load
High oil consumption	Oil is leaking	
	Loose drain valve or gasket	Check and replace gaskets if necessary
	Filter not properly installed	
	Bearing cover bolts are loose	
	Bearing cover gasket is worn or damaged	
	Oil is diluted	
	Piston oil rings are faulty	Replace piston rings
	Piston rings worn, siezed or making poor contact	Hone cylinders and install oversize piston rings
	Piston and cylinder are worn	
	Valve stem is worn	Replace valve guides
	Oil level is too high	Adjust oil level
	Cylinder breather is faulty	Replace breather cover assembly
Pre-Ignition	Ignition sytem faulty	
	Ignition system wiring is poor	Check wiring and connections
	Improper or damaged spark plug(s)	Clean or replace
	Fuel system malfunction	
	Lean air/fuel mixture	Check for plugged carburetor
	Carburetor damaged	Disassemble and clean
	Fuel lines clogged or damaged	Clean or replace
	Vacuum leak	Replace gaskets
	Cylinder head	
	Carbon deposit in combustion chamber	Remove and clean out carbon
	Cylinder head gasket leaking	Replace gasket
	Valve system	
	Improper valve clearance	Adjust valve lash
	Valve heat deterioration	Replace or regrind
	Valve spring deterioration	Replace springs

Problem	Possible Cause	Remedy
Engine misfire	Ignition system	
	Improper spark plug gap or damaged plug	Clean, adjust or replace
	Faulty ignition coil	Replace coil(s)
	Damaged or poor connection of ignition wires	Check connections or replace wires
	Fuel system	
	Lean air/fuel mixture due to clogged carburetor	Disassemble and clean carburetor
	Improper gasoline or water infiltration	Replace gasoline and filter
	Engine valves	
	Valves are deteriorated or out of adjustment	Adjust or replace valves
	Valve spring is faulty	Replace springs

4. Engine Systems

INTRODUCTION

This section presents an overview of the following OHV220 engine systems.

- Lubrication System
- Fuel System
- Electrical System
- Starting System

LUBRICATION SYSTEM

Oil and Filter Change

Refer to *Periodic Maintenance* in the Operator's Manual for oil and filter change intervals and procedures.

Pressure Lubrication

All engines use an oil pump to provide a constant flow of oil to the engine parts. The oil supply collects in the bottom of the crankcase. A relief valve is used to control oil pressure.

Oil Pump Operation

A large trochoid type oil pump is driven directly by the crankshaft, delivering pressurized oil to the journal and pin portions of crankshaft, camshaft etc.

A cartridge type oil filter is located in the bottom of the crankcase. Through this cartridge oil filter, oil is forced onto rotating parts such as journal and pins of the crankshaft and camshaft.

Oil is fed through the oil pump filter into the oil pump. The oil pressure is adjusted by the relief valve after discharging from oil pump. Oil is then splashed onto the cylinder, piston, and the cylinder head valve system. See Figure 4-1.

A by-pass valve is incorporated into the cartridge type oil filter. In the event the oil filter element becomes clogged, the engine oil is fed through the by-pass valve into the crankcase oil passage.

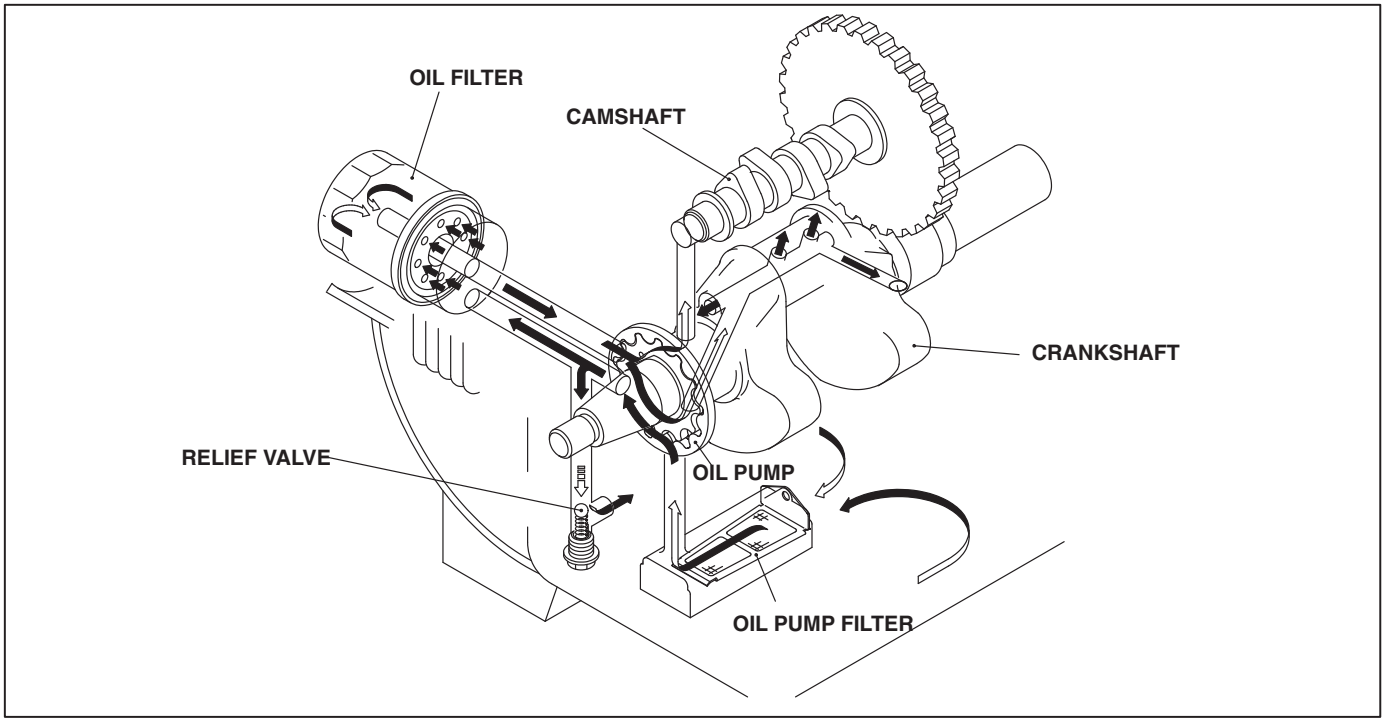


FIGURE 4-1. LUBRICATION SYSTEM

Relief Valve

The relief valve is located on the bottom of the crankcase. It is non-adjustable and normally does not require maintenance. However, each part of the relief valve is replaceable.

Oil Pressure Switch

The oil pressure switch is mounted on the same housing as the oil filter. If oil pressure becomes low while flowing to the oil pump, the switch will trigger a shutdown condition.

Crankcase Breather

The crankcase breather prevents pressure from building up in the crankcase. It also prevents oil contamination by removing moisture or gasoline vapors and other harmful blow-by materials from the crankcase. These vapors are routed to the carburetor where they are mixed with incoming air and burned in the combustion chamber.

A sticky breather valve can cause oil leaks, high oil consumption, rough idle, reduced engine power, and a rapid formation of sludge and varnish within the engine.

Replace the breather if it's broken or cracked, or if the crankcase becomes pressurized indicated by oil leaks at the seals or excessive oil in the air cleaner housing.

FUEL SYSTEM

The fuel system consists of a fuel pump, carburetor, fuel filter, shut-off valve and control linkage.

Fuel Pump

A diaphragm type fuel pump is mounted on the front of the engine. The pump is operated by vacuum pressure inside the crankcase.

The fuel pump is not serviceable and should be replaced if faulty.

Fuel Pump Test Procedure

Before testing, make certain the fuel pump vacuum and fuel line connections are tight and free of leaks.

⚠WARNING ***Ignition of fuel can result in severe personal injury or death. Thoroughly clean up any spilled fuel. Do not smoke or allow any flame, spark, pilot light, or arcing switch or equipment, or other source of ignition near the work area or areas sharing ventilation.***

1. Operate the engine at an idle for five minutes until the carburetor is full of fuel.
2. Shut the engine off and remove the fuel supply-line from the fuel pump.
3. Connect a vacuum gauge to the fuel pump inlet using a piece of fuel hose with clamps.
4. Start the engine and allow to idle for at least five seconds. Record the vacuum gauge reading.
5. Move the throttle control to the high idle position. Wait at least five seconds and record the vacuum gauge reading.
6. Shut the engine off and remove the vacuum gauge hose from the fuel pump inlet. Connect the fuel inlet line to the fuel pump.
7. Shut the engine off and remove the pressure gauge hose from the fuel pump outlet. Connect the fuel outlet line to the fuel pump.

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

8. Remove the fuel outlet line from the fuel pump.
9. Connect a pressure gauge to the fuel pump outlet using a piece of fuel hose with clamps.
10. Start the engine and allow to idle for at least five seconds. While holding the pressure gauge level with the pump outlet, record pressure gauge reading.
11. Move the throttle control to the high idle position and allow the engine to run for at least five seconds. While holding the pressure gauge level with the pump outlet, record pressure gauge reading.
12. Shut the engine off and remove the pressure gauge hose from the fuel pump outlet. Connect the fuel outlet line to the fuel pump.

Replace the fuel pump if test readings are not within values specified in Table 4-1.

TABLE 4-1. PULSE PUMP TEST SPECIFICATIONS

ENGINE SPEED	PUMP INLET VACUUM (Minimum)	PUMP OUTLET PRESSURE (Minimum)
Low Idle	2.6 inches of mercury	1.7 psi
High Idle	2.6 inches of mercury	1.7 psi

CARBURETOR

The engine is equipped with a down draft carburetor with a float-controlled fuel system and fixed main jet.

Carburetors are calibrated carefully for sure starts, good acceleration, low fuel consumption and sufficient output.

FLOAT SYSTEM Fuel flows from the fuel tank into the float chamber through a needle valve. When the fuel rises to a specific level, the float rises. When its buoyancy and fuel pressure are balanced, the needle valve closes to shut off the fuel, thereby keeping the fuel at a predetermined level. Fuel vapors are sucked into the combustion chamber through air vents in the carburetor body. See Figure 4-2.

PILOT SYSTEM The pilot system feeds the fuel to the engine during idle and low-speed operation. Fuel is fed through the main jet to the pilot jet, where it is metered and mixed with the air from the pilot air jet. The fuel/air mixture is fed to the engine through the pilot outlet and the by-pass. When idling, the fuel is fed mainly from the pilot outlet.

MAIN SYSTEM The main system feeds the fuel to the engine during medium- and high-speed operation. Fuel is metered by the main jet and fed to the main nozzle. Air metered by the main air jet is mixed with the fuel through the emulsion tube, and the mixture is atomized out of the main bore. Then it's mixed again with the air taken through the air cleaner into an optimum fuel-air mixture, which is supplied to the engine.

CHOKE The choke is used for easy start-up when the engine is cold. When the starter is operated with a choke valve fully closed, the negative pressure applied to the main nozzle increases and draws more fuel; thus easily starting the engine.

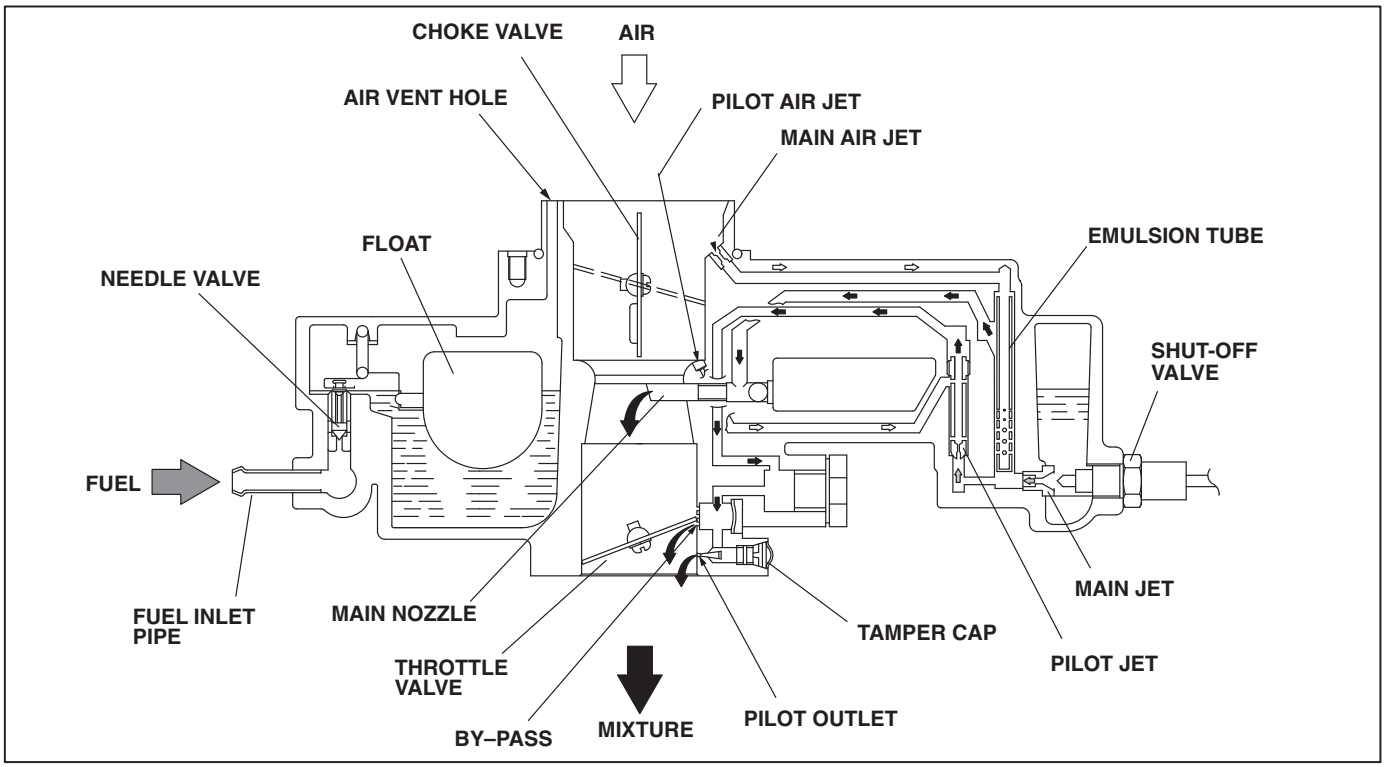


FIGURE 4-2. CARBURETOR SYSTEM

SHUT-OFF VALVE A fuel shut-off valve prevents engine run-on when the engine is turned off. When the engine is on, the valve is activated and the plunger is pulled in to open the main jet. When the engine is off, the power source to the valve is off. The plunger is pushed out by the return spring and stops the fuel flow to the main jet.

Carburetor Replacement

Do not adjust the fuel mixture, rebuild or overhaul the carburetor. A malfunctioning carburetor should be replaced. Before replacing a carburetor, however, make certain that:

- All other necessary engine and generator adjustments and repairs have been performed
- The carburetor is actually malfunctioning (see *Section 3: Engine Troubleshooting*).

⚠ CAUTION ***Unauthorized modifications or replacement of fuel, exhaust, air intake, or speed control system components that affect emission on California certified engines are prohibited by law in the State of California.***

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

Speed Control Solenoid (Optional)

The *speed control solenoid* monitors the rate of the load and automatically adjusts the engine to the appropriate idle speed.

The solenoid is faulty if the idle does not pull to low. Replace the solenoid.

CHARGING SYSTEM

Magneto

The ignition system contains a flywheel magneto with automatic advancing characteristics. This system is free from start-up failure due to dirty, burnt or a corroded point surfaces because there are no points.

The electronic automatic advancing provides easy starts and stable high performance at operating speed by advancing the ignition timing to the most suitable point.

THEORY: Refer to Figure 4-3. Revolution of the flywheel generates electricity on the primary side of the ignition coil, and the base current $I1$ to the power transistor. Current $I1$ turns the power transistor "on" and the electric current $I2$ flows.

During low idle, after the flywheel reaches the ignition point, the low speed ignition timing control circuit runs the base current $I3$ turning the signal transistor A "on". This allows the current $I1$ to bypass as current $I4$. The power transistor turns "off" and the current $I2$ is abruptly shut, resulting in high voltage generated in the secondary coil producing sparks at the spark plugs.

During high speed operation, the advancing control circuit operates the ignition timing to run base current $I5$ turning the signal transistor B "on". This allows current $I1$ to bypass as current $I6$. The power transistor turns "off" and the current $I2$ is abruptly closed, resulting in high voltage generated in the secondary coil producing sparks at the spark plugs.

The engine timing advances relative to the engine speed controlled by this circuit. This timing advance system is contained within the magneto coils and is not serviceable nor can the individual electronic components be replaced.

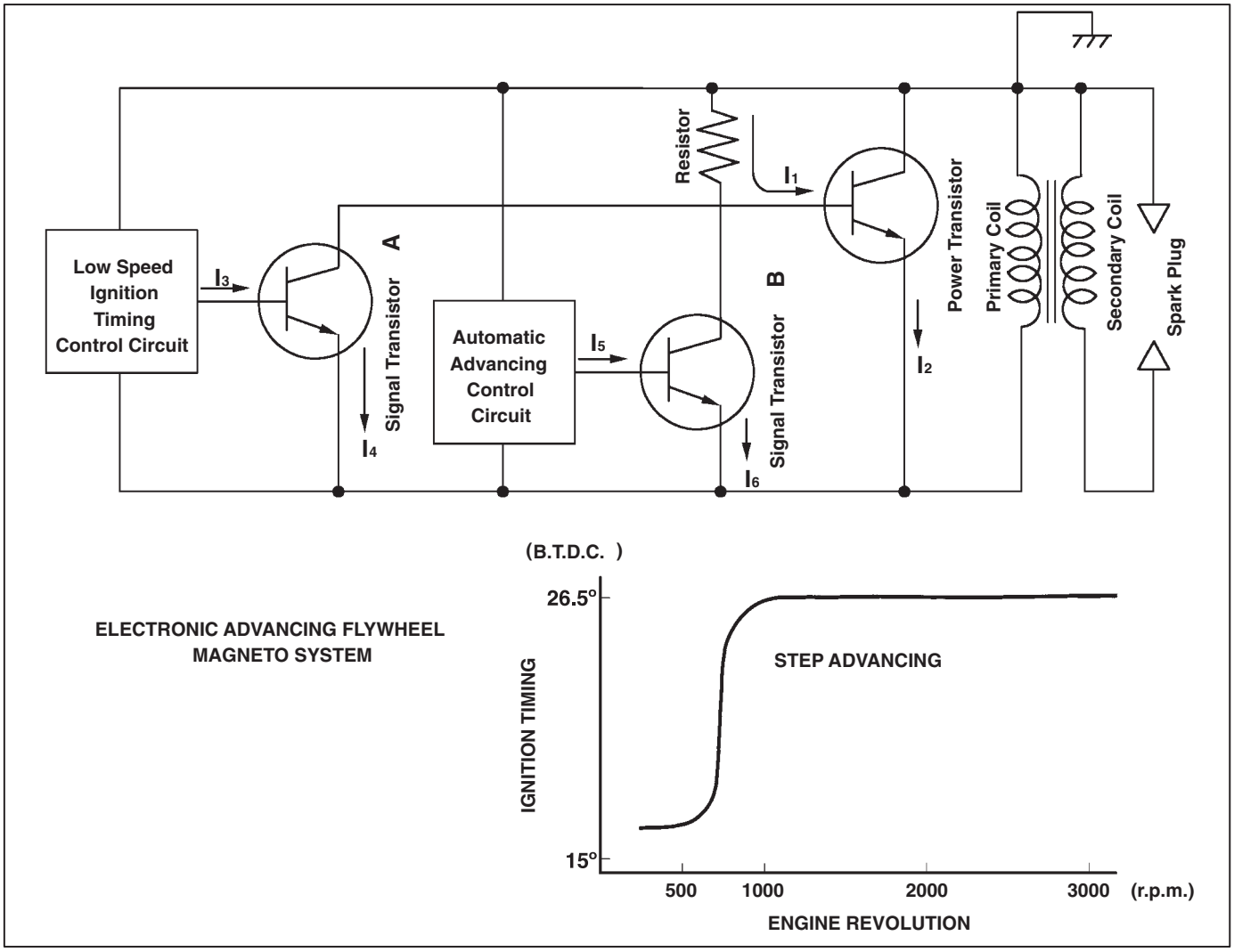


FIGURE 4-3. MAGNETO SYSTEM

Ignition TIming

The ignition timing is preset at the factory and is not adjustable.

Spark Plugs

Check or replace spark plugs as recommended in the *Periodic Maintenance Schedule* in the Operator's Manual. Replace spark plugs that show signs of fouling or electrode erosion.

Battery Inspection

⚠WARNING ***Battery gas is explosive. Wear safety glasses and do not smoke while servicing batteries. Lead acid batteries give off a highly explosive hydrogen gas which can be ignited by flame, electrical arcing or smoking.***

Check battery cells with a hydrometer. The specific gravity reading should be between 1.260 and 1.290 at 77°F (25°C).

If one or more cells are low on water, add distilled water and recharge. Keep the battery case clean and dry. An accumulation of moisture or dirt will accelerate discharge and battery failure.

Keep the battery terminals clean and tight. Push the cable terminal down flush with or slightly below the top of the battery post. After making connections, coat the terminals with a light application of petroleum jelly or grease to retard corrosion.

⚠WARNING ***Always disconnect the negative cable first, and reconnect it last to reduce the risk of arcing and explosion.***

Jump Starting

Occasionally, it may be necessary to jump start (charge) a weak battery using a charged booster battery. If jump starting is necessary, the following procedure is recommended to help prevent starter damage, battery damage, and personal injuries.

1. Disconnect engine load.

2. Use a battery of the same voltage (12V) as is used with your engine.

3. Attach one end of the positive booster cable (red) to the positive (+) terminal of the booster battery. Attach the other end on the positive cable to the positive (+) terminal of your engine battery.

   ⚠WARNING ***Electrical arcing can cause severe personal injury. Do not allow positive and negative cable ends to touch.***

4. Attach one end of the negative booster cable (black) to the negative (–) terminal of the booster battery. Attach the other end of the negative cable to a solid chassis ground on your engine.

5. Jump starting in any other manner may result in damage to the battery or the electrical system.

   ⚠WARNING ***Jump starting a battery incorrectly can cause either battery to explode, resulting in severe personal injury or death. Do not allow any spark, flame, pilot light, lit cigarette, or other ignition sources near the battery. Do not jump start a frozen battery.***

6. Turn ignition switch to start engine.

   ⚠CAUTION ***Overcranking the engine can cause starter damage. Do not engage starter for longer than 30 seconds. If engine does not start, allow 5 minutes for starter to cool between cranking intervals.***

STARTING SYSTEM

Starter

Normally, the starter requires little or no service other than possible brush replacement. However, if through accident or misuse, the starter requires service or overhaul, the following provides the information necessary to perform this service.

Functional Operation

When the engine is turned ON, low electric current (M →) flows through the coil of the solenoid and the coil is excited. The plunger is pulled and higher current (S →) flows through the starter. See Fig 4-4

Starter Service

When starting the engine, note the starter motor action. The pinion gear should mesh quickly with the flywheel ring gear and spin the engine. Once the engine starts and the solenoid opens, the starter should disengage and stop. If the starter cranks the engine slowly, or not at all, check the start circuit components. Failure to crank is usually caused by a low battery charge, defective battery cables, corroded or poor connections, or low temperatures. After checking these variables and the starter continues to crank slowly, remove and repair the starter.

Assembly: Assembly is the reverse of disassembly. Apply grease to the shift fork hinge and prongs and the splines on the armature shaft. Torque mounting bolts as specified in Section 2, page 2-8.

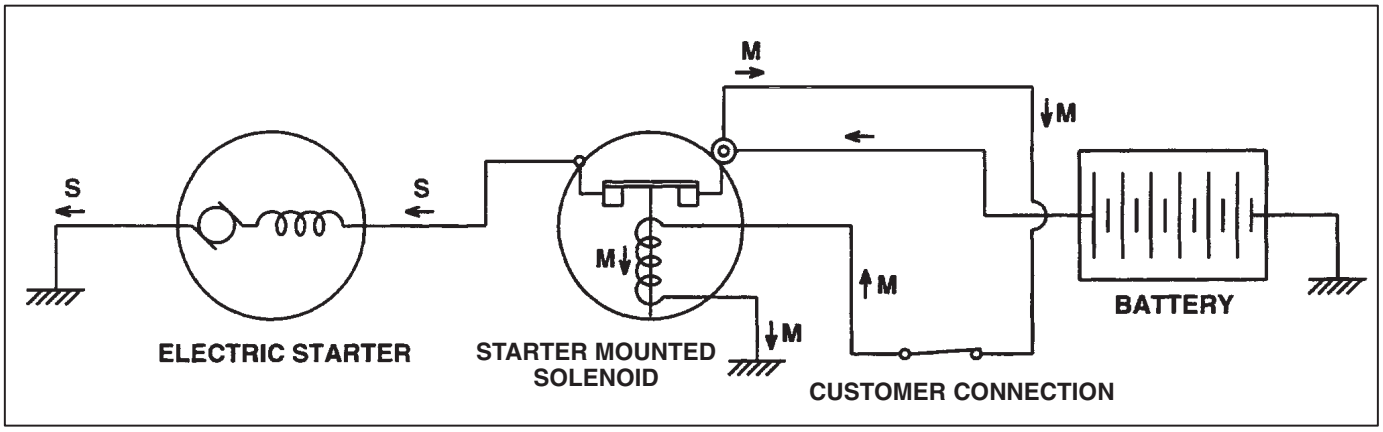


FIGURE 4-4. STARTING SYSTEM DIAGRAM

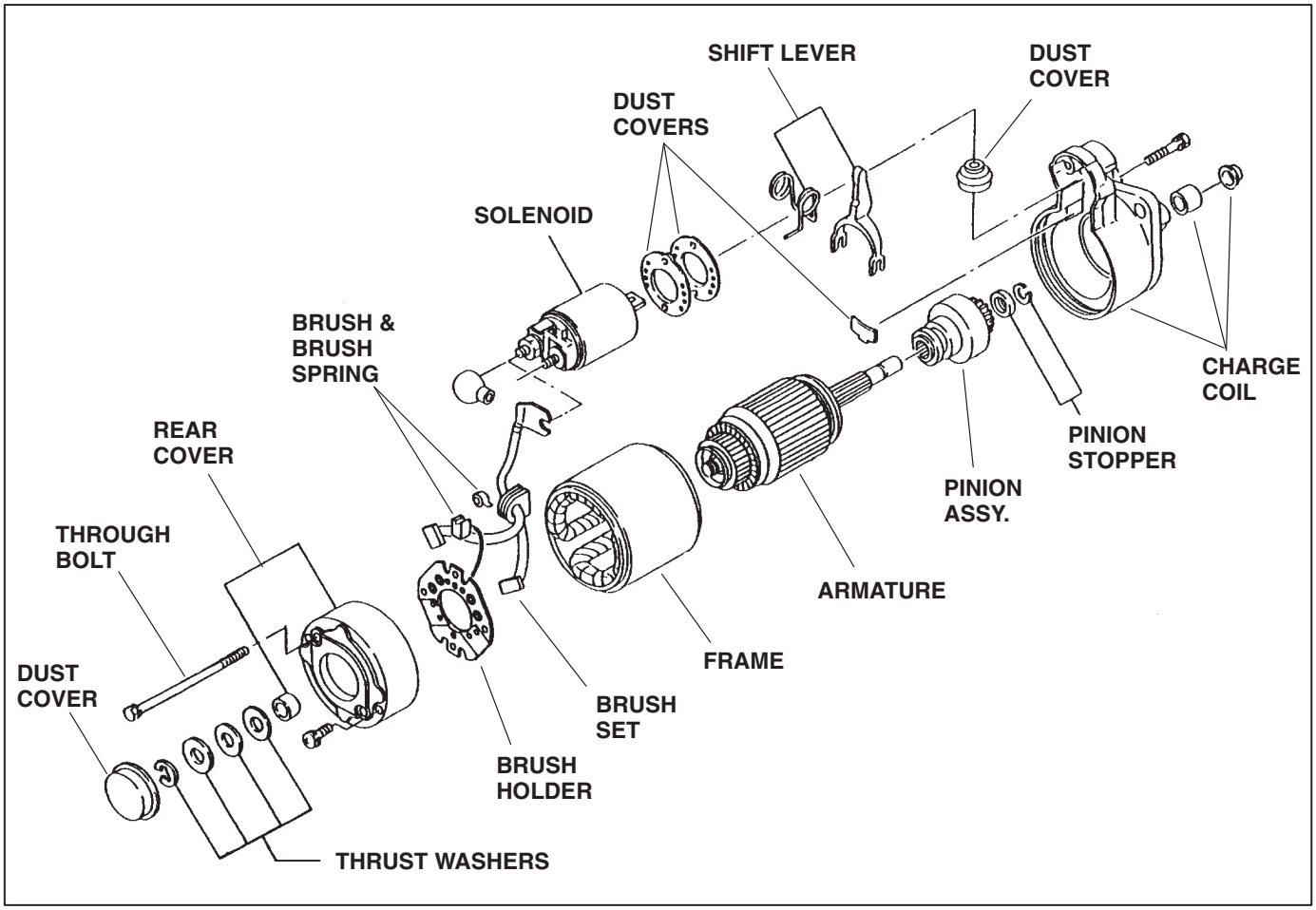


FIGURE 4-5. STARTER ASSEMBLY

Solenoid Inspection

For typical wiring connections at the starter solenoid, refer to Figure 4-6.

Before removing a starter because the engine does not crank:

1. Make sure the battery is fully charged, the connections are clean and tight and the battery cables are in good condition. If it is necessary to reconnect the battery, connect the positive (+) battery cable first.
2. Disconnect the spark plug cable so that the engine will not start. Bypass the start circuit with a jumper between the start and the positive battery (+) terminal on the solenoid (Figure 4-6). If the engine cranks, the solenoid and starter are probably okay. If the engine does not crank, go to Step 3.
3. Bypass the starter solenoid with a jumper between the motor and the positive battery (+) terminal on the solenoid (Figure 4-6). If the motor responds, it is probably okay and it may only be necessary to replace the solenoid.

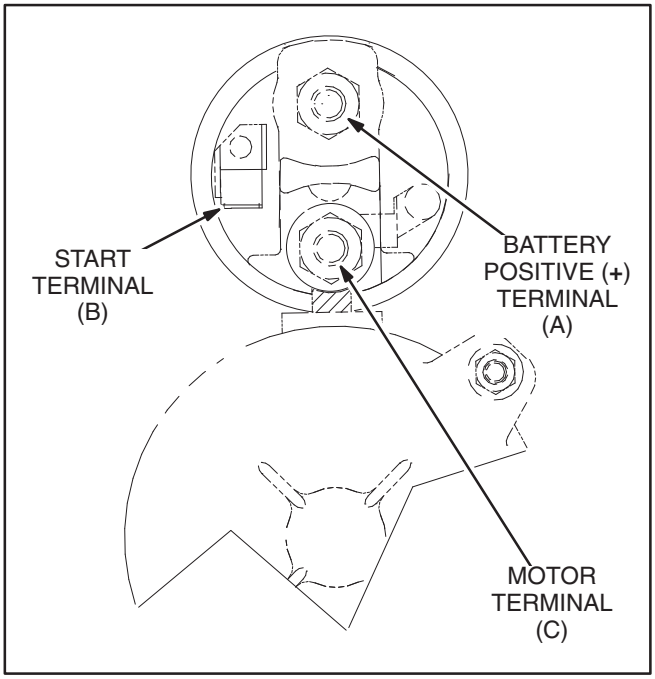


FIGURE 4-6. STARTER SOLENOID TERMINALS

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

Pinion

Inspection/Service: Refer to Figure 4-7. Replace the pinion assembly if the pinion teeth and armature shaft splines are worn or damaged. Check the over-running clutch by rotating the pinion clockwise and counterclockwise. Replace the pinion assembly if it does not turn smoothly counterclockwise or lock clockwise.

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

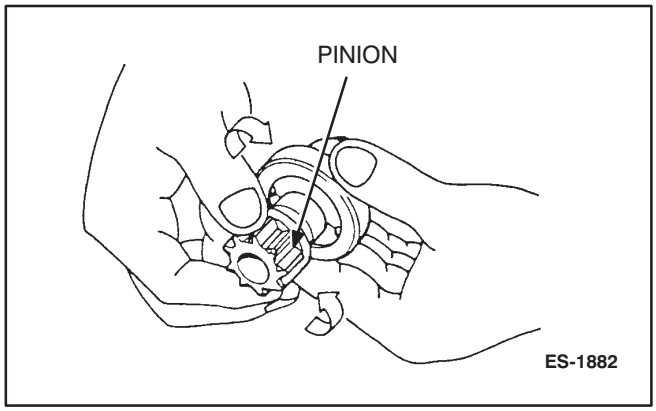


FIGURE 4-7. CHECKING OPERATION OF THE PINION OVER-RUNNING CLUTCH

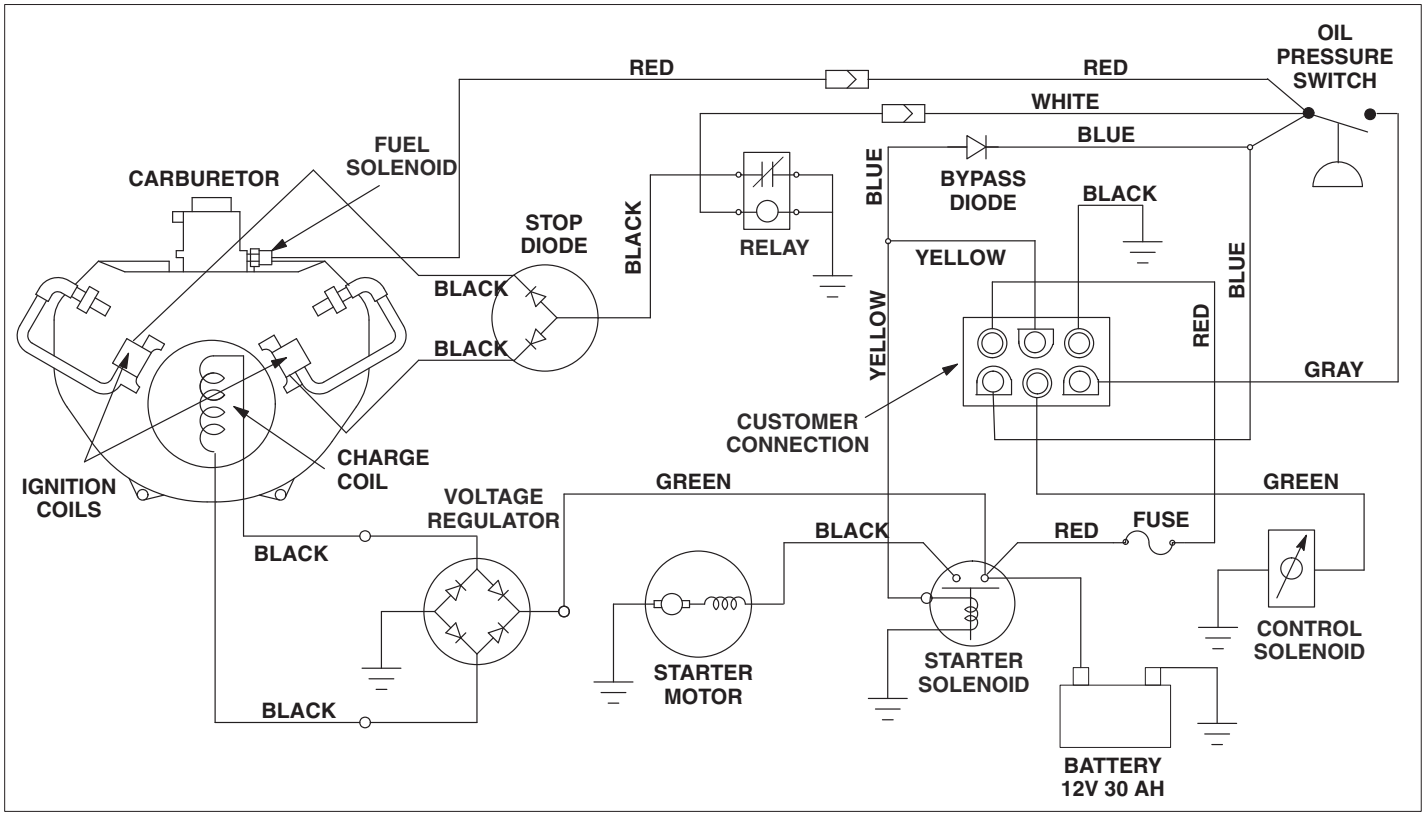


FIGURE 4-8 ENGINE WIRING DIAGRAM (6 PIN)

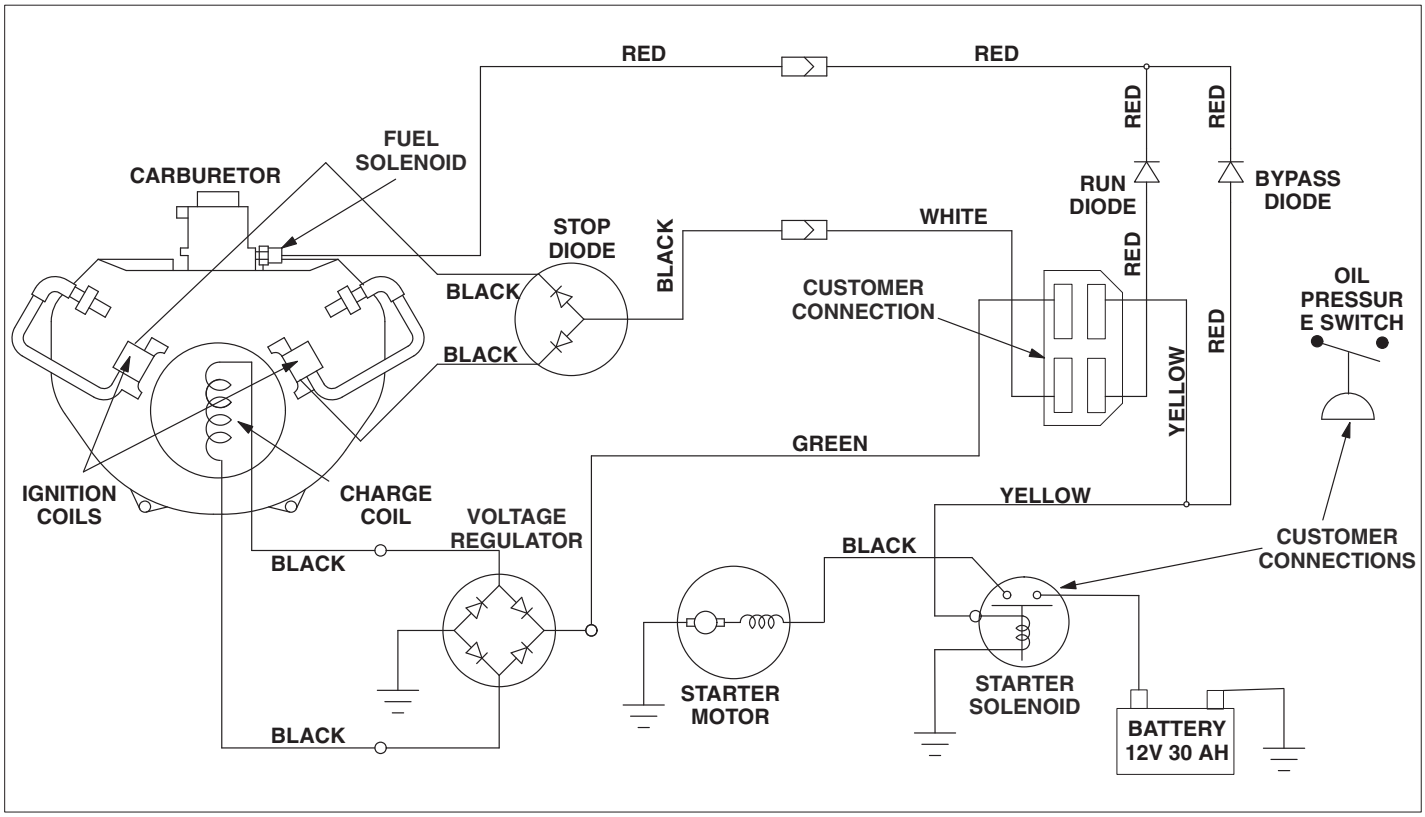


FIGURE 4-9 ENGINE WIRING DIAGRAM (4 PIN)

5. Disassembly

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

Suggestions

- If you are uncertain about linkages, wiring or hose connections, label or tag items before removing them.
- Have small boxes on hand to hold disassembled parts by group.
- Prevent loosing and misplacing parts by temporarily assembling each group of disassembled parts.
- Clean parts in washing fluid if necessary.

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

Special Tools

Both American- and metric-size sockets and wrenches will be needed. A ring spreader will be needed to remove and install pistion rings. For pulling the flywheel, a universal-type puller can be used as shown below.

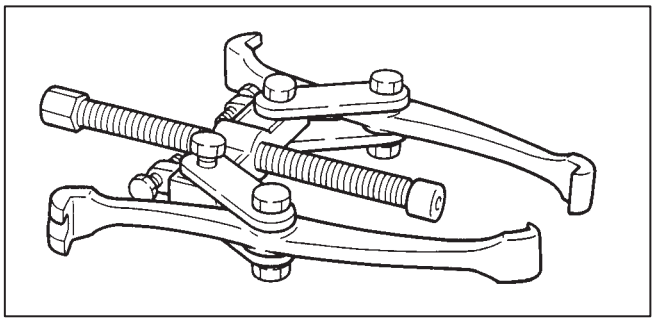


FIGURE 5-1. FLYWHEEL PULLER

Preparation

1. Remove the fuel supply line.

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

2. Disconnect exhaust and battery cables, negative (–) cable first.

   ⚠WARNING ***Arcing can ignite explosive hydrogen gas given off by batteries, causing severe personal injury. Arcing can occur if the negative (–) battery cable is connected and a tool being used to connect or disconnect the positive (+) battery cable accidentally touches the frame or other grounded metal part of the set. To prevent arcing, always remove the negative (–) cable first, and reconnect it last.***

3. Disconnect the electrical connector between the engine and accessory.
4. Remove the engine from its mountings and place upright in a well lit and ventilated work area.
5. Drain the engine oil.

   ⚠CAUTION ***Used engine oil has been identified by some state and federal agencies as causing cancer or reproductive toxicity. Do not ingest, inhale, or contact used oil or its vapors.***

Disassembly Procedures

The following pages describe and illustrate engine disassembly.

Disassembly Procedures

1. After the oil has been drained, remove the dip stick, and dip stick tube.

2. Remove the air cleaner cover, elements and base secured with (3) 10–32mm cap screws.

3. Remove the breather tube from the #1 cylinder head secured with a hose clamp.

4. Remove the fuel pump with mount. Disconnect the fuel hose to carburetor and pulse hose.

5. Remove the blower housing secured with (8) M6 flange bolts.

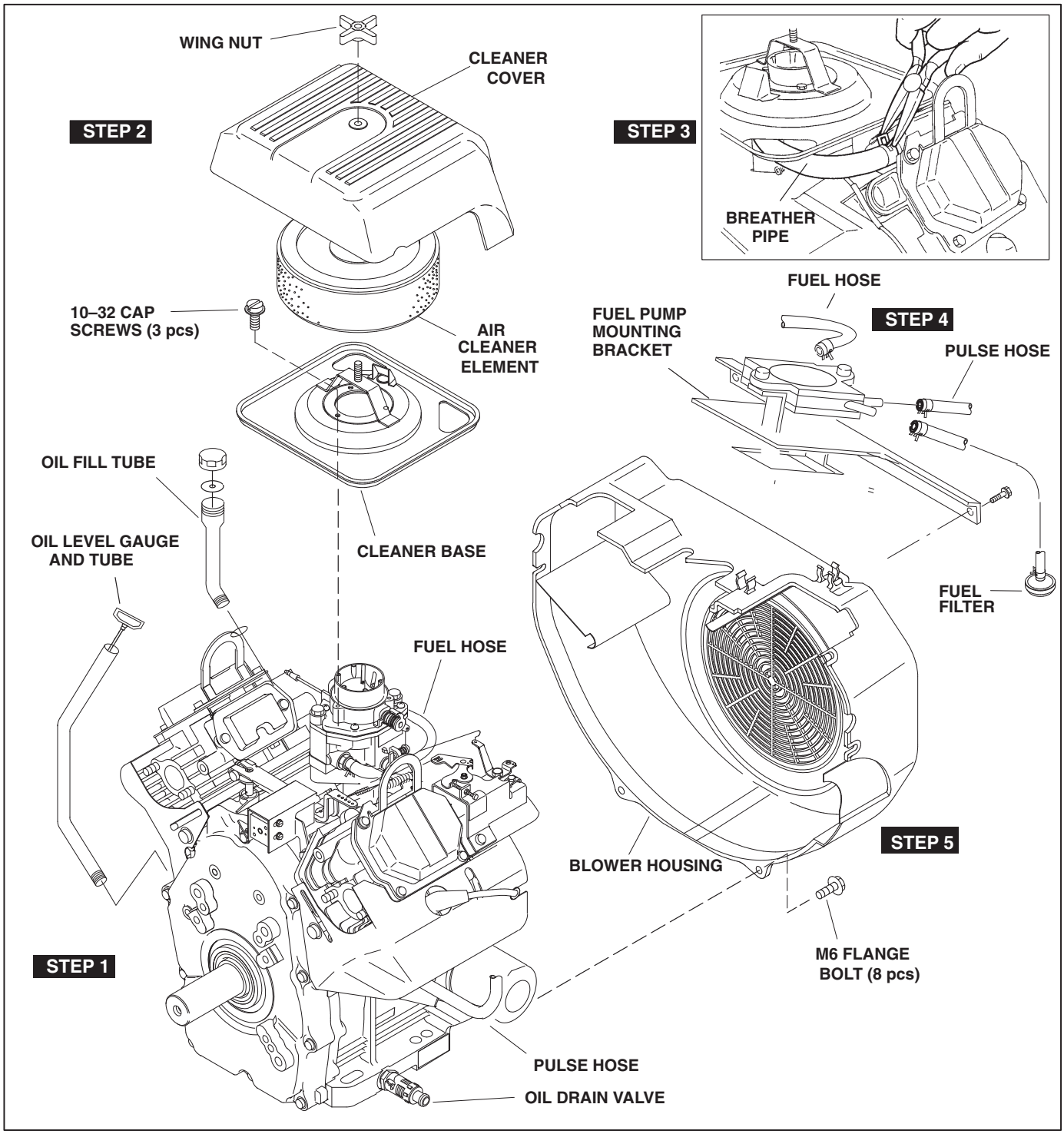


FIGURE 5-2.

6. Remove the speed and choke control linkage and mounting bracket.

7. Disconnect the wiring harness under the speed control solenoid. Remove the speed control solenoid and the governor lever, if required.

8. Remove the carburetor secured by (2) M8 bolts.

NOTE: For reassembly purposes, torque the carburetor bolts between 12.3 and 13.7 ft/lbs (16.7 – 18.6 N·m).

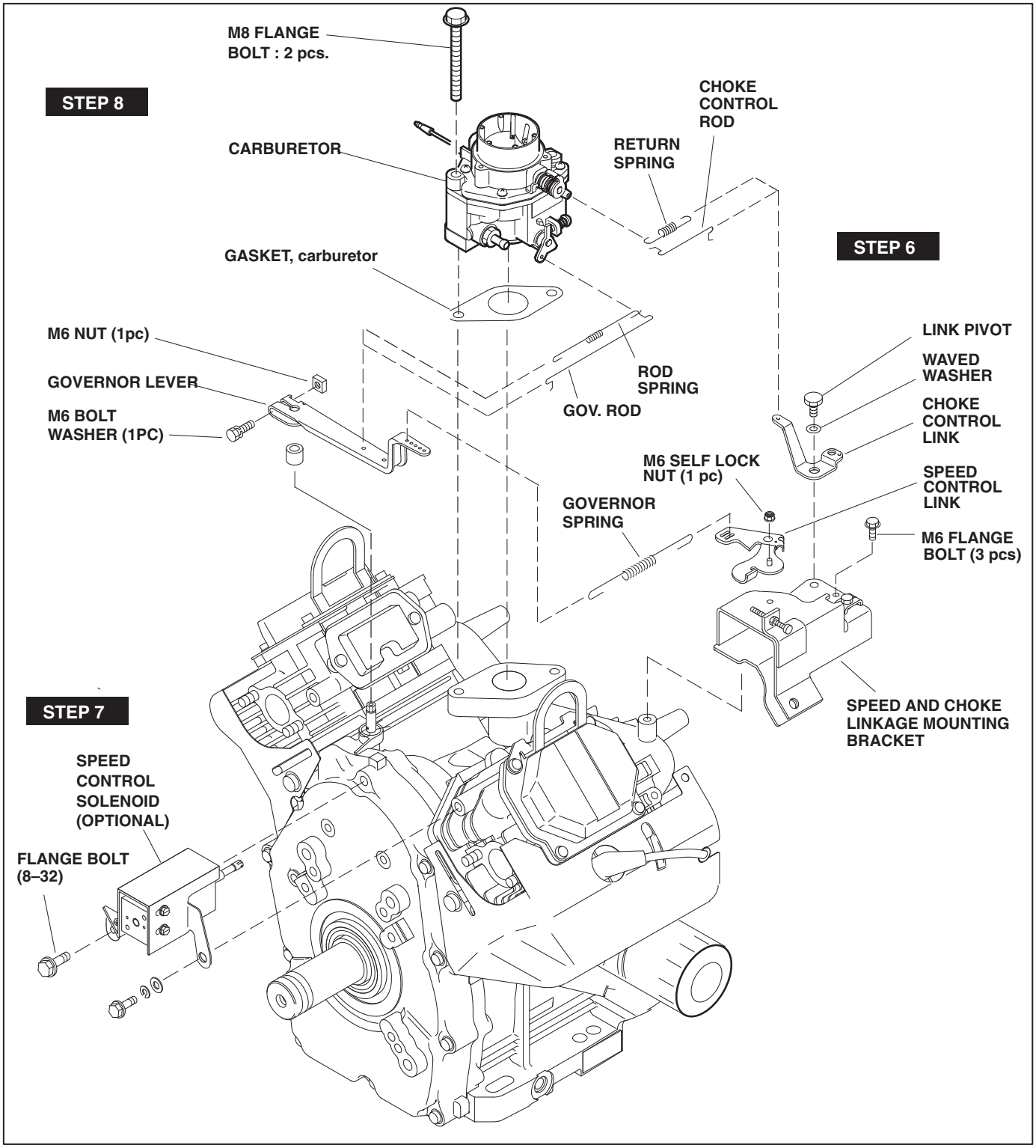


FIGURE 5-3.

9. Disconnect the spark plug wires and the wiring to each ignition coil. Cut the cable ties securing wires to the manifold. Remove the coils secured with (2) M6 bolts.

10. Pull out the connector under the relay attached to the cylinder baffle.

11. Remove the relay, the wire holder, and the two ground wires secured with flanged bolts.

12. Remove the red/white/blue wire terminal from the oil pressure switch. Remove the oil pressure switch if necessary. Disconnect the yellow wire at the starter.

NOTE: For re-assembly purposes, torque the M6 coil bolts between 5.1 and 6.5 ft/lb (6.9 – 8.8N·m).

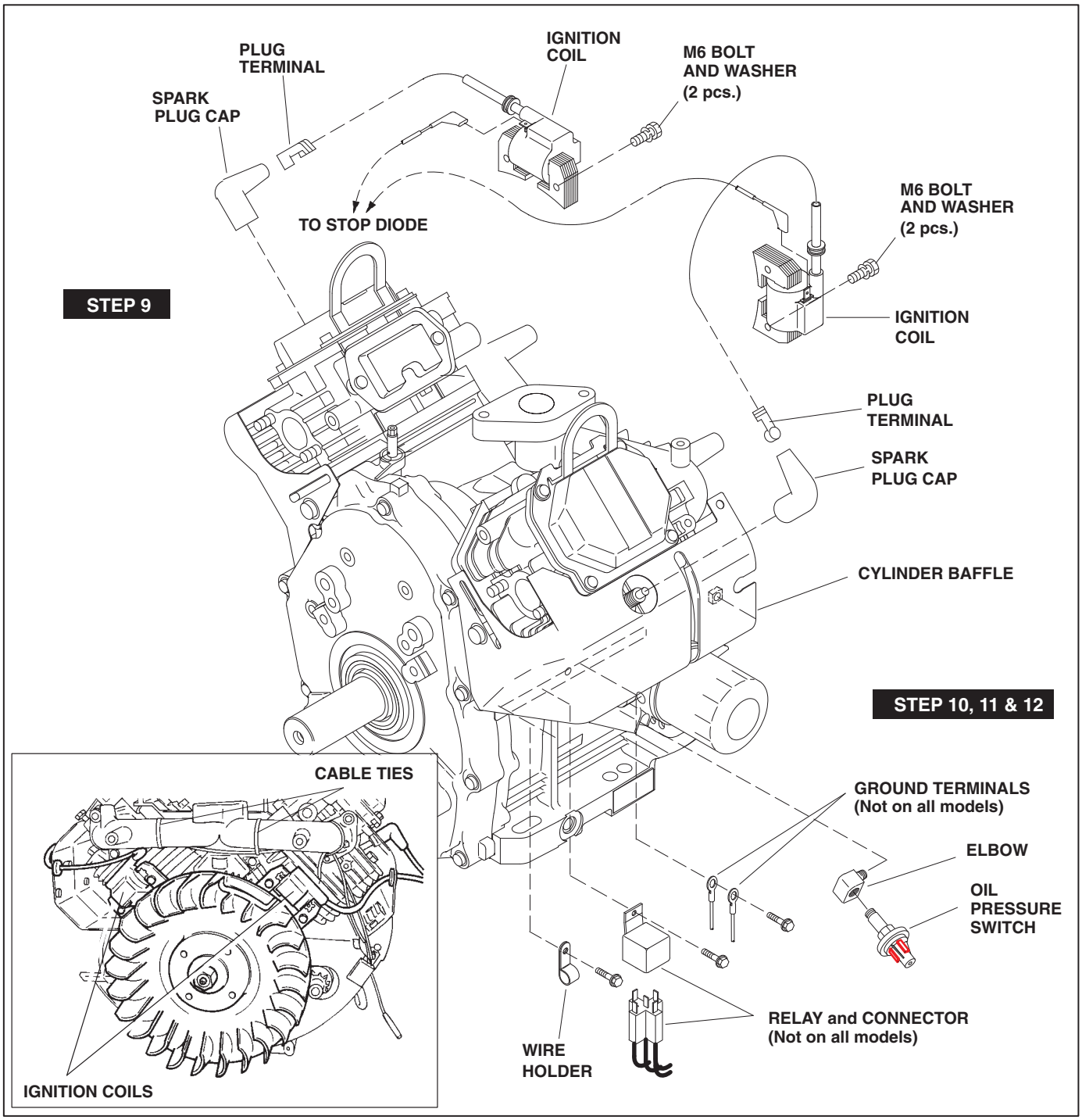


FIGURE 5-4.

13. Remove all four cylinder baffles secured by M6 bolts.
14. Remove the spark plugs, if necessary.
15. Remove the intake manifold secured by (4) M8 flange nuts.

NOTE: For re-assembly purposes, torque the M8 manifold nuts between 12.3 to 13.7 ft/lbs (16.7 – 18.6 N·m).

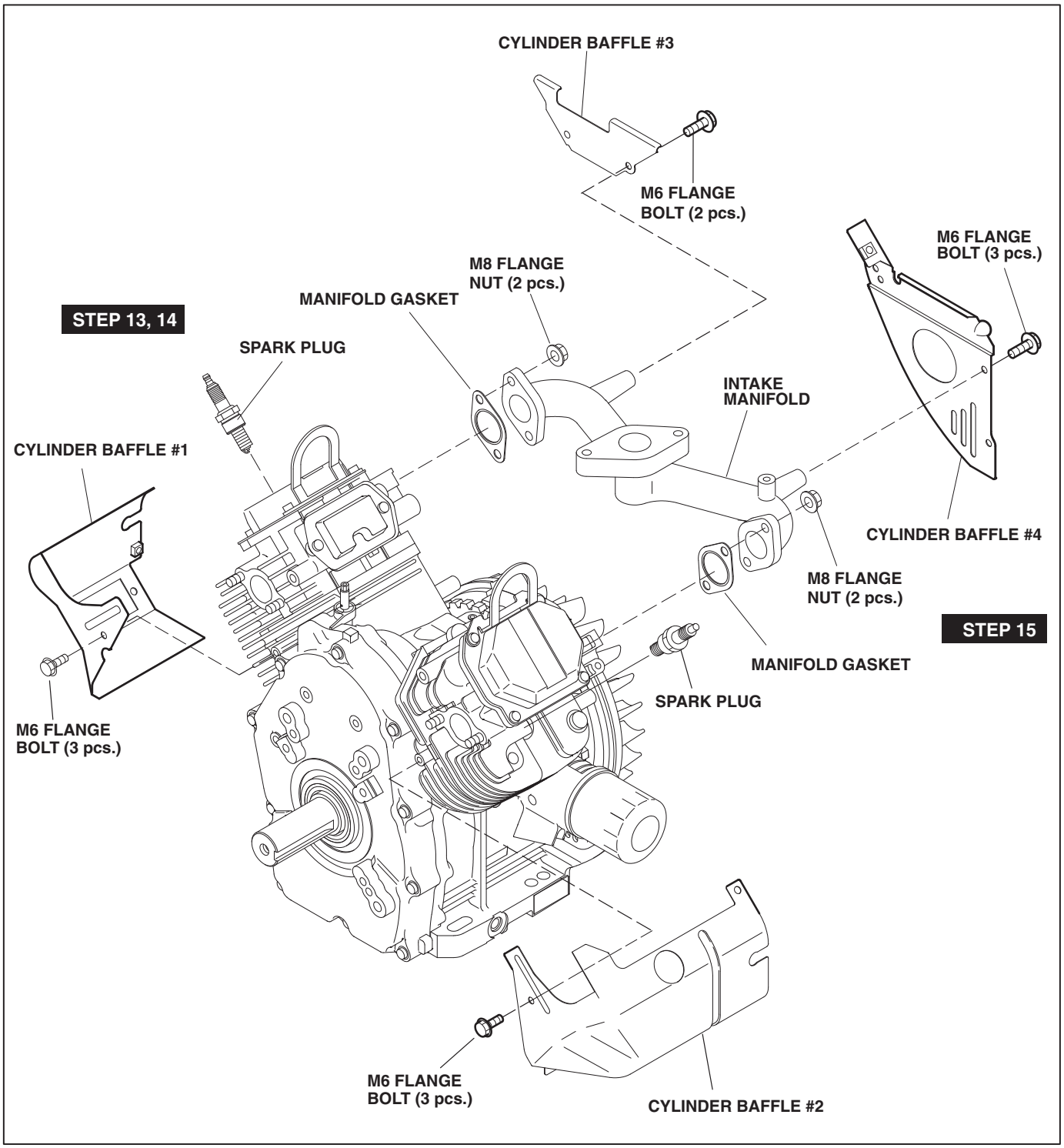


FIGURE 5-5.

16. Remove the rocker arm covers secured with (4) M6 bolts each.

17. Before removing the rocker arms and shafts, turn the flywheel to “dead center” (TDC) with the mark “T” adjusted to number 1 or 2 inscribed on the cylinder head (Figure 6-11). Use a permanent marker to mark the *original* position of each push rod, rocker arm and valve for reassembly.

18. Remove the cylinder head from the engine body secured with (4) M10 flange bolts each.

NOTE: For reassembly purposes, torque the cylinder head flange bolts between 24.6 and 30.4 ft/lb (33.3 – 41.2 N·m).

Torque the rocker arm nuts between 7.2 and 10.1 ft/lbs (9.8 – 13.7 N·m).

Torque the rocker arm cover bolts between 26.4 and 43.3 in/lbs (2.9 – 4.9 N·m).

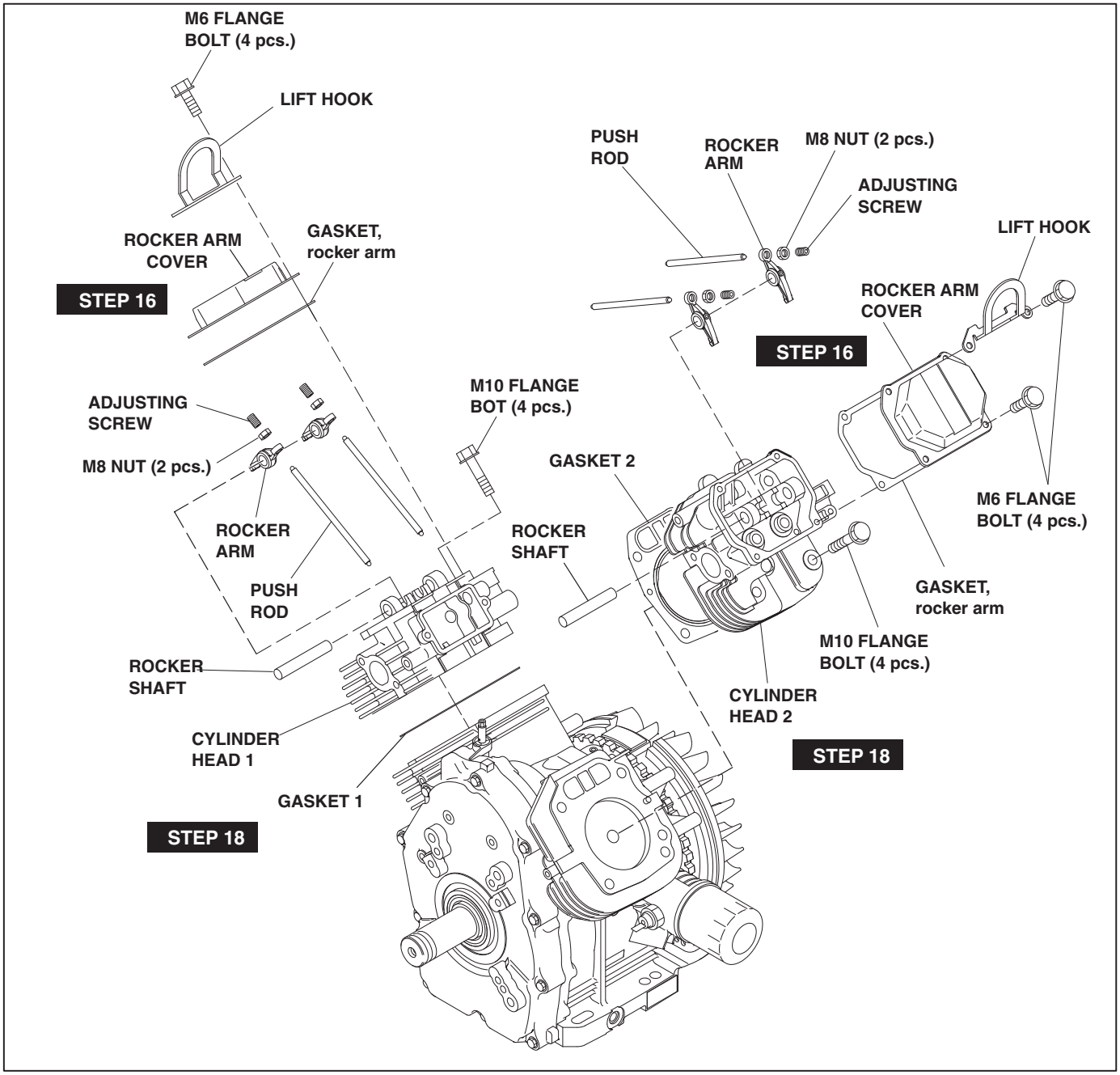


FIGURE 5-6.

19. Remove the intake and exhaust valves.

20. Disassemble the breather assembly secured to the #1 cylinder head with (2) M6 flange bolts.

NOTE: For reassembly purposes, torque the breather cover flange bolts between 26.4 and 43.2 in/lb (2.9 – 4.9 N·m).

Do not reuse the intake valve stem oil seal. Each time the valves are removed from the cylinder block, a new seal must be used when the valve is reinstalled.

⚠ CAUTION ***Removing a valve after installing a valve stem seal can cause seal damage. Do not allow valve stem groove to come in contact with the valve stem seal after installation.***

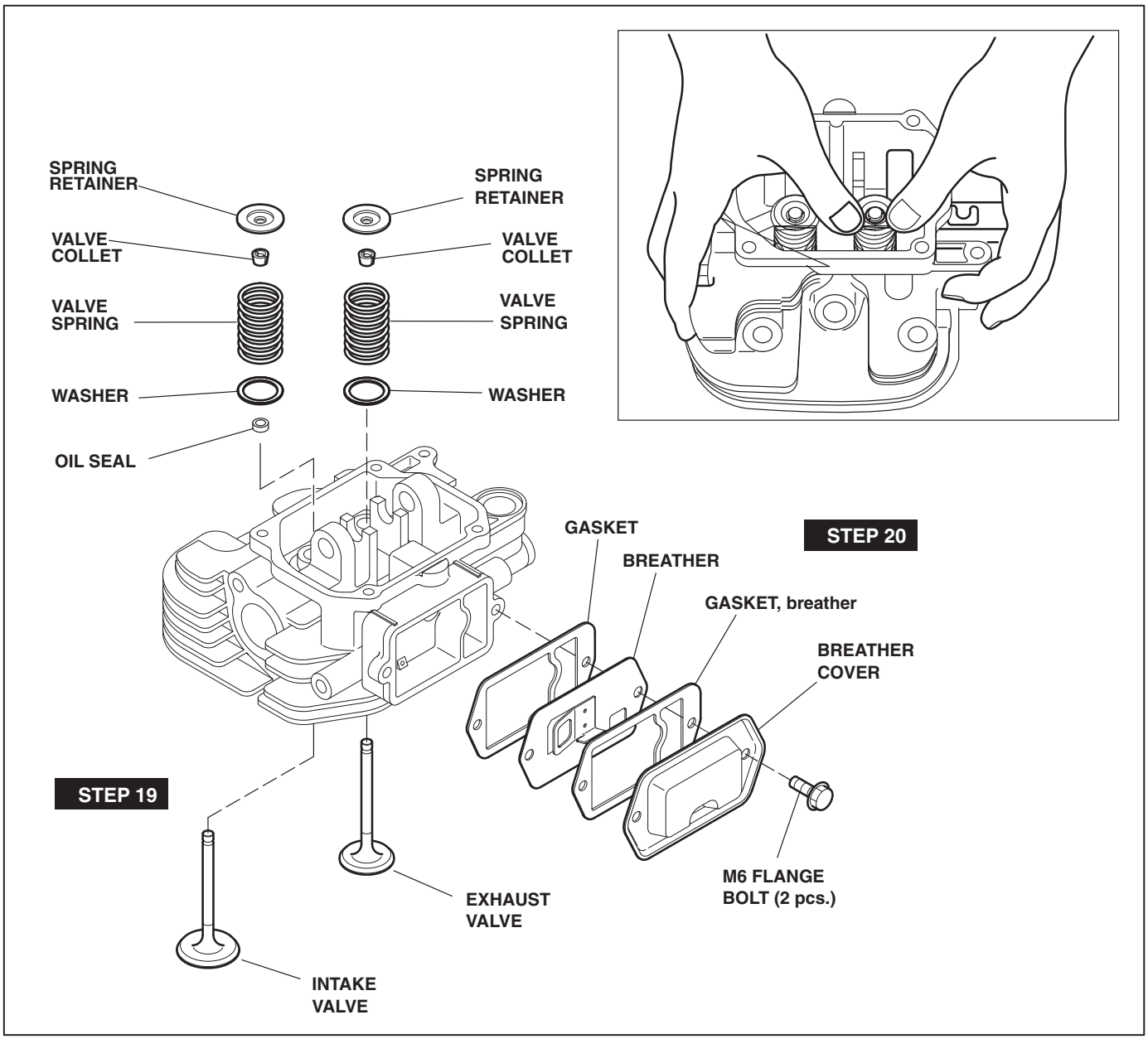
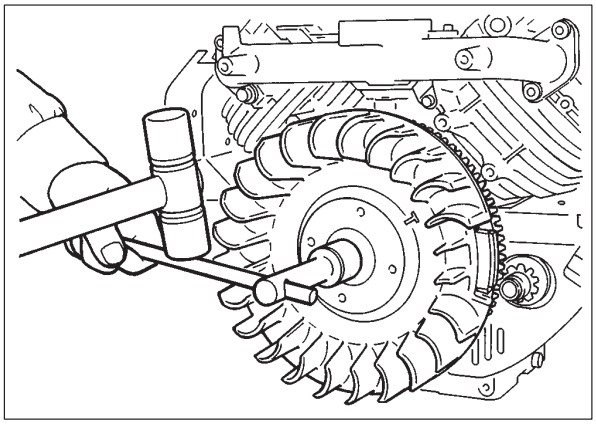
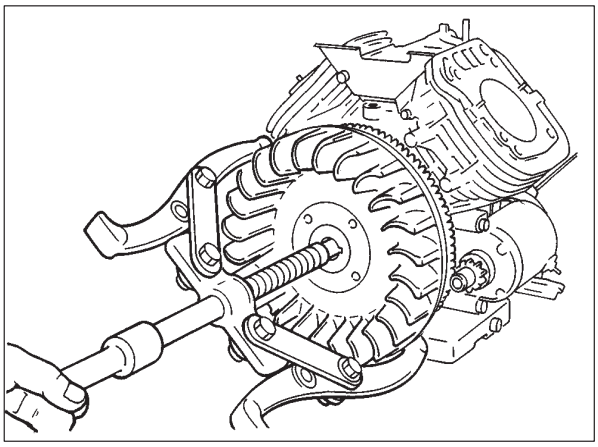


FIGURE 5-7.





STEP 21

FIGURE 5-8.

⚠ CAUTION ***Improper flywheel removal can cause gear case damage. Do not use any tools to pry against the gear cover when removing the flywheel.***

21. Remove the flywheel with the blower unit attached by:

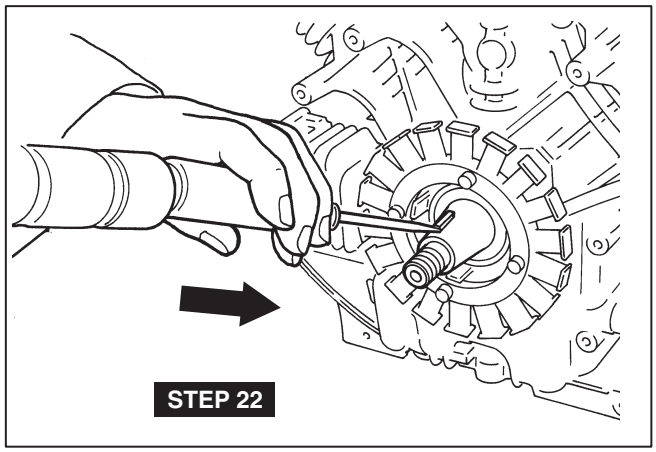
    A. Remove the M18 nut, lock washer and plain washer from the crankshaft.

    B. Using a universal flywheel puller, pull the flywheel away from the gear ring.

    C. Replace the crankshaft washers and nut.

22. Pound out the woodruff key on the crankshaft.

NOTE: For reassembly purposes, torque the crankshaft nut between 61.5 and 68.7 ft/lbs (83.3 – 93.1 N·m).



STEP 22

FIGURE 5-9.

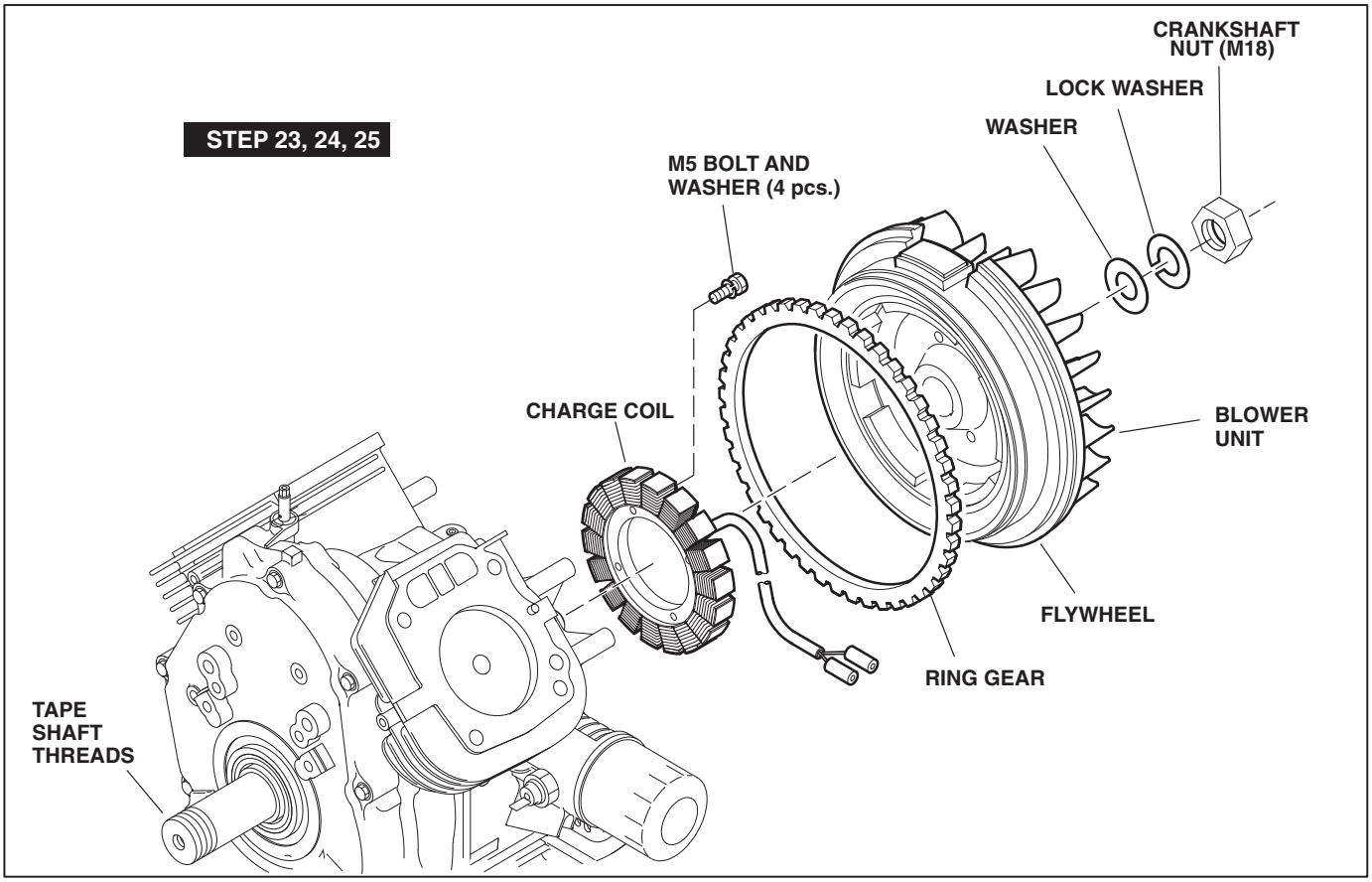


FIGURE 5-10.

23. Remove the gear ring.

24. Remove the charge coil secured by (4) M6 bolts and washers.

    NOTE: For reassembly purposes, torque the charge coil bolts between 13.2 and 30 in/lb (1.5 – 3.4 N·m).

25. To avoid damage to the oil seal, wrap the threaded portion of the crankshaft with electrical tape.

26. Remove the (10) M8 bolts securing the gear case cover to the engine body. Tap the cover gently with a soft-faced hammer to loosen it. Be careful not to damage the gear cover oil seal.

27. With the gear cover removed, the governor gear can be removed.

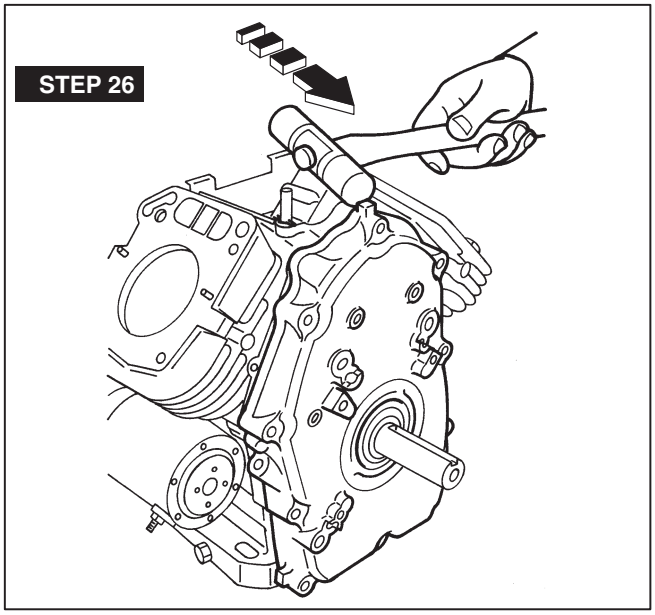


FIGURE 5-11.

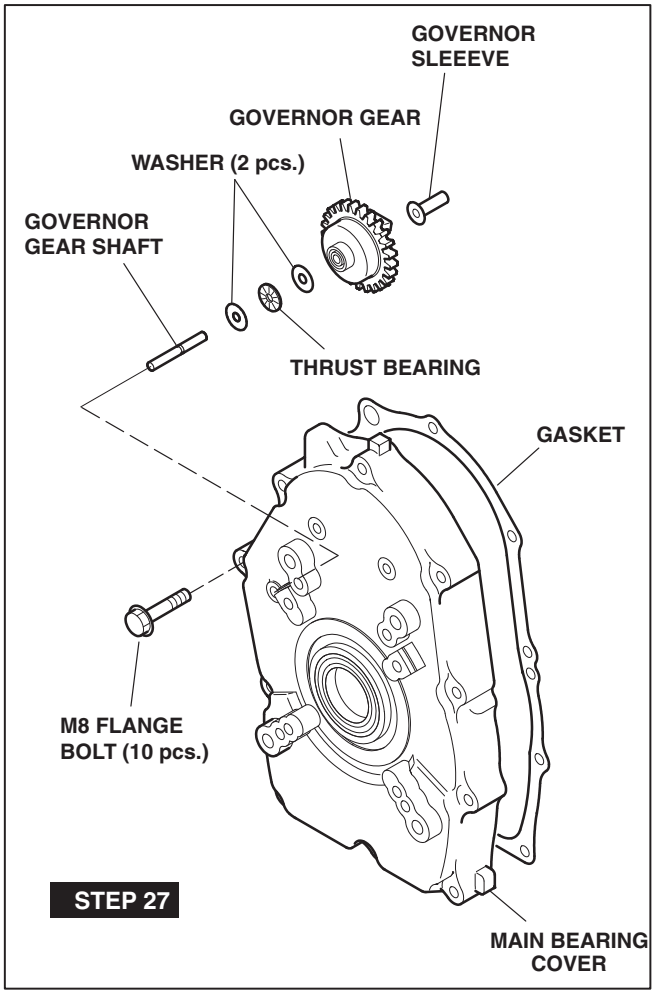


FIGURE 5-12.

28. Line up the timing marks of the camshaft gear and the crankshaft gear, then pull out the camshaft.

29. Using a marker, identify the position and location of each tappet before removing.

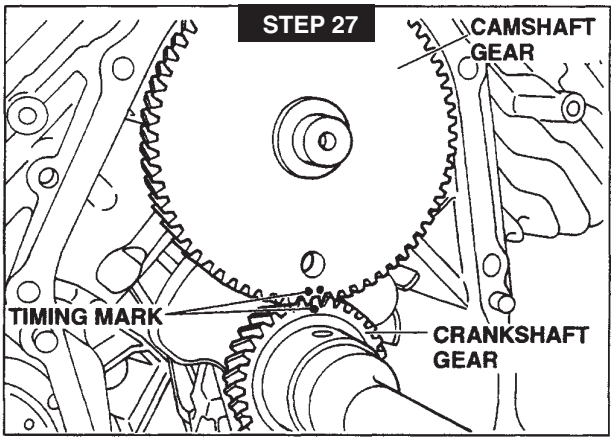


FIGURE 5-13. STEP 28

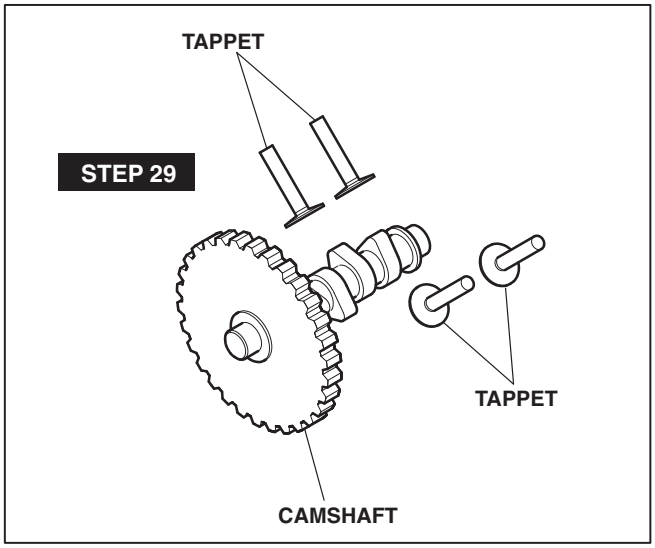


FIGURE 5-14.

30. Remove the ridge from the top of each cylinder with a ridge reamer before removing the piston.

    Remove the piston and connecting rod by:

    A. removing the (2) M8 connecting rod bolts,

    B. take off the connecting rod cap,

    C. push the connecting rod upwards and remove with piston.

31. After removal, mark the location of each piston and rod assembly so they can be returned to their respective cylinders.

    NOTE: For purposes of reassembly, torque the connecting rod bolts between 16.3 and 19.9 ft/lb (22.1 – 27.0 N·m).

32. Use a piston ring spreader to remove the piston rings.

33. Remove the m18 nut and washers securing the crankshaft in position and remove crankshaft.

    A. Retain the spacer on the crankshaft.

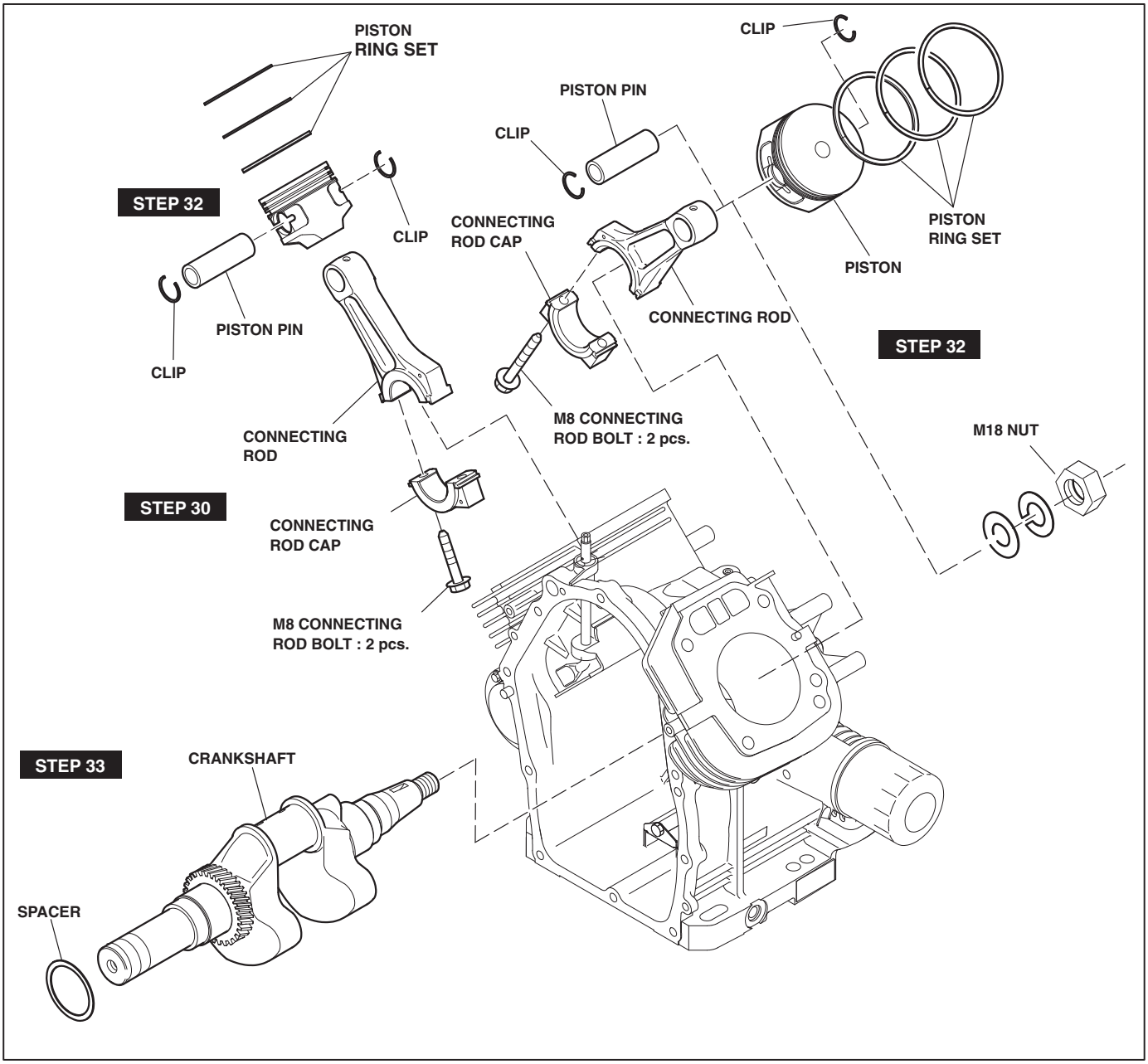


FIGURE 5-15.

34. Remove the remainder of the engine crankcase parts.

A. Remove the starter and solenoid secured by (2) M8 flange bolts.

B. Remove the oil pump assembly secured by (4) M6 flange bolts.

C. Remove the governor lever shaft secured with a snap pin and washer.

D. Remove the inner oil pump filter secured by (1) M10 flange bolt.

E. Twist off the canister oil filter.

NOTE: For reassembly purposes, torque the starter mounting bolts between 12.3 and 13.7 ft/lbs (16.7 – 18.6 N·m).

Torque the oil filter bolt to 9 ft/lbs (12.3 N·m).

Torque the oil relief plug between 10.9 and 18.1 ft/lbs (11.8 – 14.7 N·m).

Refer to the next section *Reassembly Procedures* for specific inspection and reassembly instructions.

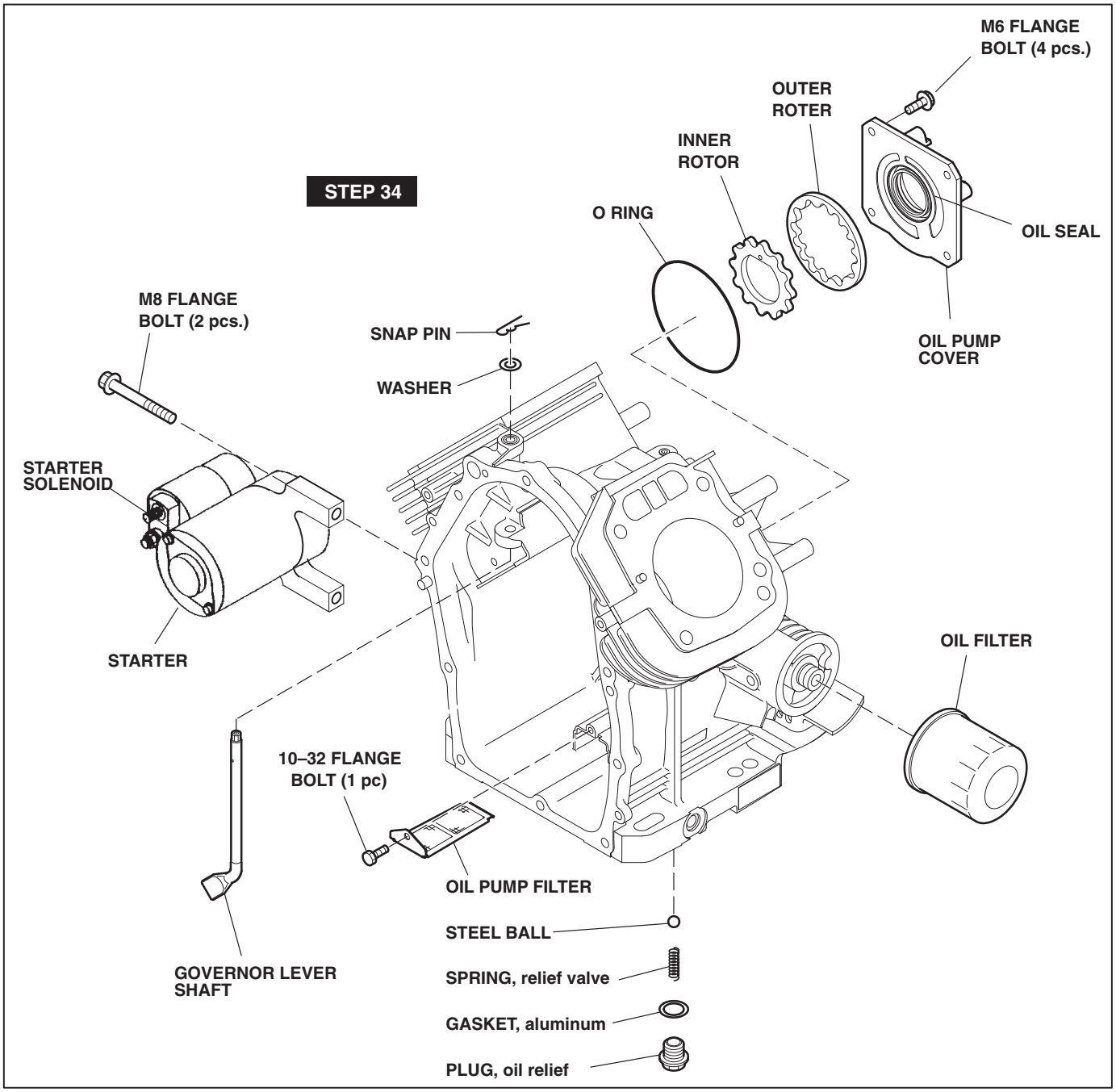


FIGURE 5-16.

6. Engine Reassembly

PRECAUTIONS

1. Clean parts thoroughly before reassembly.
   A. Make sure the piston, cylinder, crankshaft, connecting rod and bearings are particularly clean.
2. Scrape off all carbon deposits from cylinder head, top of piston and piston ring grooves.
3. Check lips of oil seals. Replace any oil seal where the lip is damaged. Apply grease to the lip before reassembly.
4. Replace all gaskets with new ones.
5. If necessary, replace keys, pins, bolts, nuts, etc.
6. Torque bolts and nuts to specification. Refer to the "TORQUE SPECIFICATIONS" Table in Section 2.
7. Apply oil to rotating and meshing parts.
8. Check and adjust clearances and end plays where specified in this section.

SPECIAL TOOLS

No special tools are required for disassembly of the engine. Metric-size sockets and wrenches will be needed. A ring spreader will be needed to install pistion rings, and a ring compressor will be used to install the pistons.

BREAK–IN OPERATION

An engine that has been completely overhauled with new piston, rings, valves and connecting rods should be thoroughly *broken-in* before being placed into service. Good bearing surfaces and running clearances between the various parts can be established only by operating the engine under reduced speed and loads for a period of time.

To break-in the engine:

1. Run the engine at 2500 rpm, without a load, for 10 minutes.
2. Run the engine at 3,000 rpm for 10 minutes.
3. Run the engine at 3,600 rpm for 10 minutes.
4. Run the engine with a load of 8 HP at 3,600 rpm for 30 minutes.
5. Run the engine with a load of 16 HP at 3,600 rpm for 30 minutes.

While the engine is being tested, check for fuel and oil leaks.

Make final carburetor adjustments and regulate the engine operating speed.

After the first 20 hours of normal operation, change the oil and oil filter.

PRE-ASSEMBLY

Inspect and pre-assemble the engine subassemblies prior to replacing in crankcase.

Crankcase

1. Replace oil pump filter in bottom of crankcase (Figure 5-16).
2. Insert ball and relief valve spring into bottom of crankcase. Tighten plug to specified torque.

   Torque the relief valve plug between 10.9 and 18.1 ft/lbs (11.8 – 14.7 N·m).
3. Replace the governor lever shaft and secure with a snap pin and washer.
4. Replace the oil drain valve, if removed, and the oil filter.

Cylinder Heads, Valves and Rocker Arms

- Clean valves and wash cylinder head thoroughly.
- Remove carbon and gum deposits from the valves, seats, ports and guides.
- Inspect valves, valve seats and valve guides.
- Replace valves that are badly burned, pitted or warped.
- Valve guides should be replaced when valve stem clearance exceeds specifications. (Refer to the DIMENSIONS AND CLEARANCES tables in Section 2 for clearance specifications.)
  If clearance has been exceeded, draw valve guides out and press new guides in. After replacing valves and guides, lap valves in place until a uniform ring shows around the face of the valve.

1. Insert an oil seal to the intake valve guide only (Figure 6-1).
2. Apply oil to washer, valve spring and valve stem. Place cylinder head on flat table and install washer, valve spring, valve and spring retainer (Figure 6-1).
3. Install rocker arm and shaft.

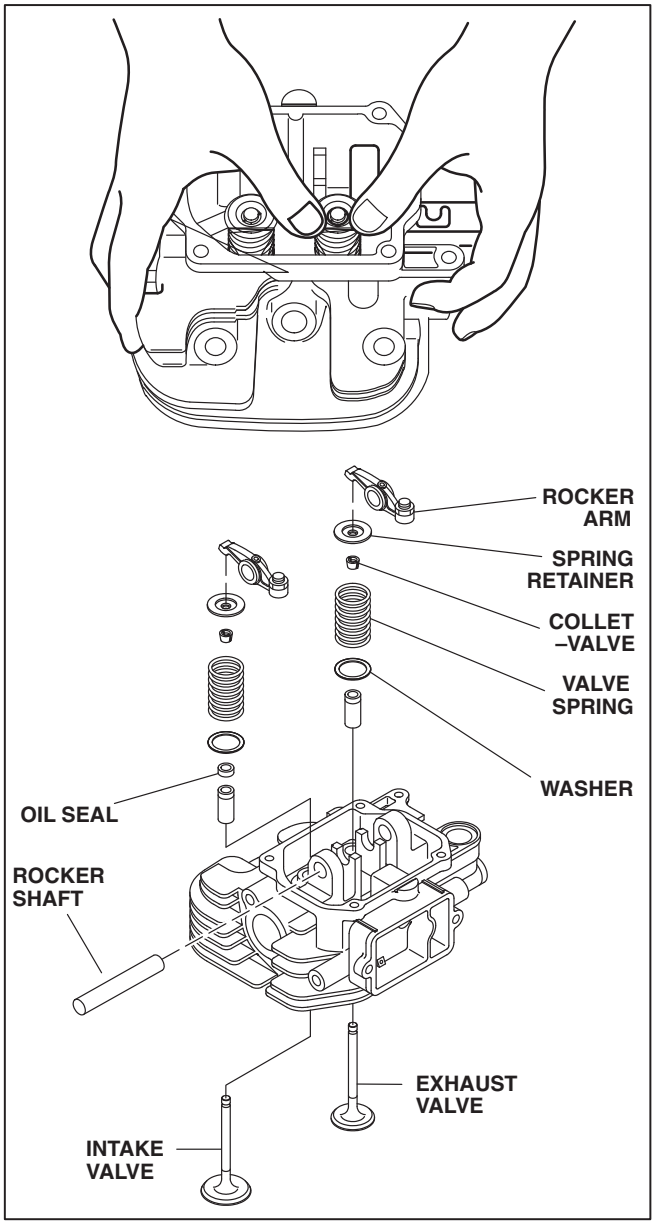


FIGURE 6-1.

Pistons and Connecting Rods

1. Install the oil control ring first, then the second ring and top ring. Using a piston ring spreader expand rings just far enough to slip over piston and into the correct groove. Use care not to distort ring (Figure 6-2).

   A. Install the second ring with punched mark beside the gap on the top side.

   B. Top ring can be placed either way.

   C. As for oil ring, rails should be placed on and below the expander.

   D. Arrange gaps of piston rings as shown in Figure 6-5.

   Compression rings may have a dot or the word “top” on one side of the ring to indicate which side faces the top of the piston. Unmarked piston rings can be installed either way.

2. Apply oil to the small end of connecting rod and piston pin. Position the piston on its respective rod and install the pin.
3. To secure the pin, place retaining rings on each side of the pin.

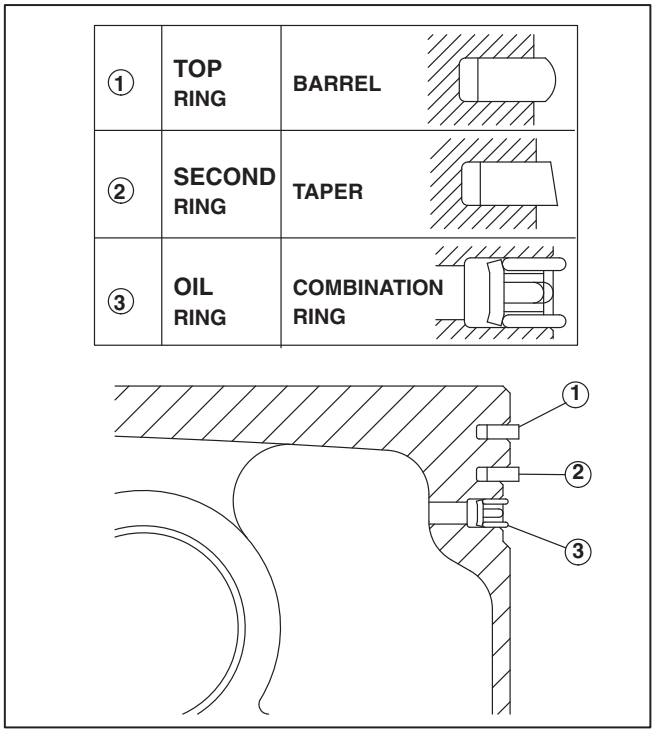


FIGURE 6-2.

Main bearing cover and governor gear

1. Insert washers onto governor gear shaft.

2. Insert governor gear along with sleeve into governor gear shaft (Figure 6-3).

RE-ASSEMBLY PROCEDURES

Crankshaft

1. Install crankshaft into crankcase (Figure 6-4).

   NOTE: Apply adequate oil to bearing portion of crankcase. For easy installation, put crankcase on box or wood blocks.

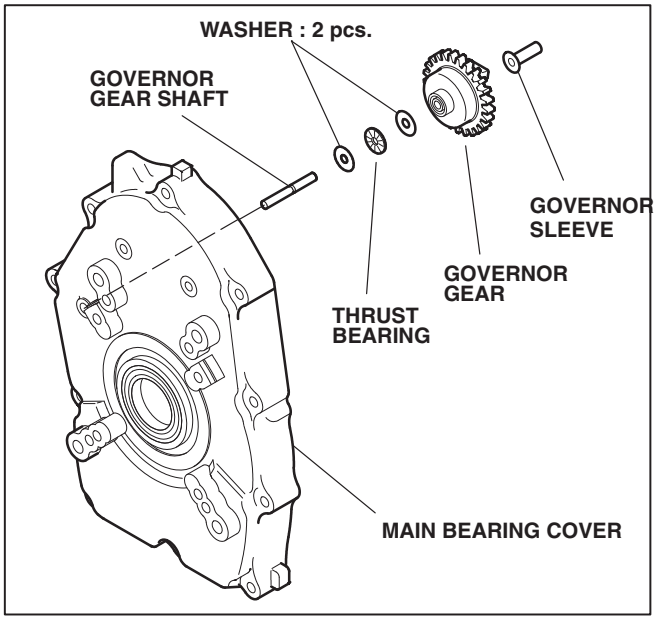


FIGURE 6-3.

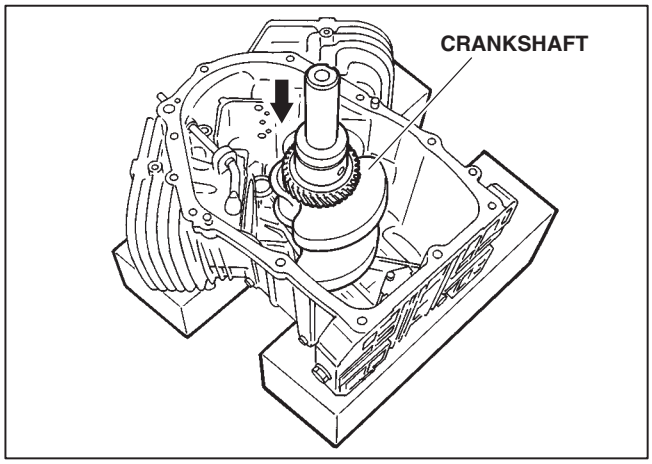


FIGURE 6-4.

Pistons and Connecting Rods

1. Install each piston and connecting rod assembly into cylinder by using a piston ring compressor to hold piston rings.

   A. The “1” mark on the connecting rod for #1 cylinder and “2” mark for #2 cylinder should face towards the flywheel when inserted (Figure 6-5).

   B. Apply enough oil to piston rings, connecting rod bearings (large end) and cylinder bore before assembly.

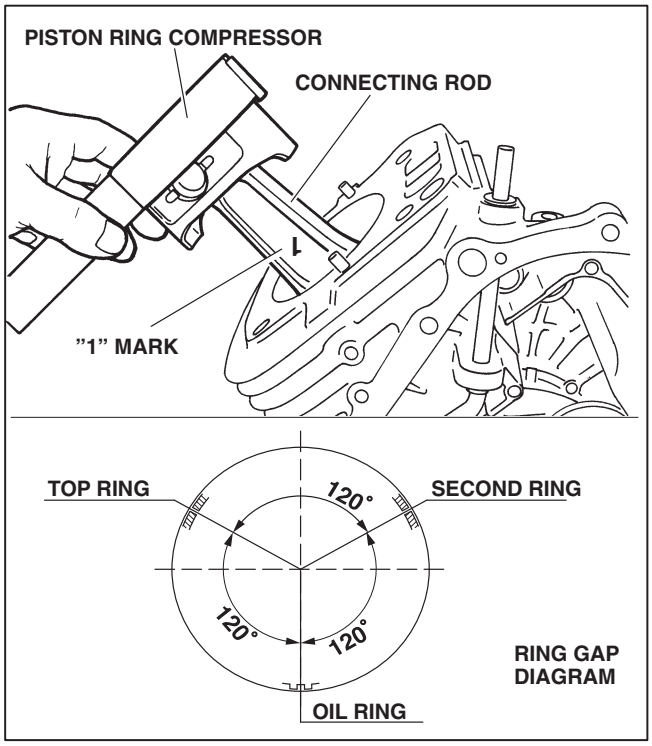


FIGURE 6-5.

2. Temporary install the key and flywheel on the crankshaft, then turn crankshaft to BDC (bottom dead center). Lightly tap the top of the piston until large end of the rod meets the pin on the crankshaft.

3. Match the alignment marks on the connecting rod cap to connecting rod and clinch together. (Figure 6-6). Tighten the connecting rod bolts to the specified torque.

   Torque the (2) M8 bolts between 16.3 and 19.9 ft/lbs (22.1 – 27.0 N·m).

4. Check for free movement of piston and connecting rod by turning crankshaft slowly.

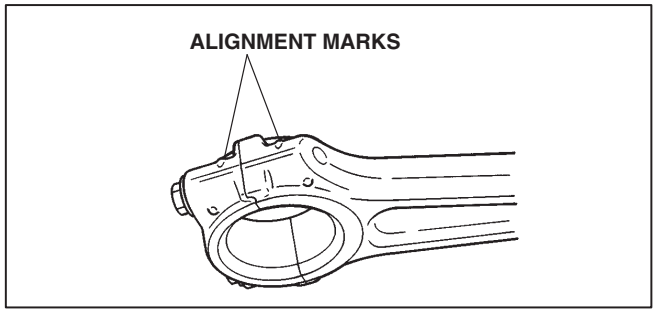


FIGURE 6-6.

Tappets and Camshaft

1. Grease tappets and insert into their original position. Push tappets in all the way to avoid damage to the camshaft.

2. Lubricate bearing surfaces of the camshaft. Install camshaft into the crankcase aligning the timing mark on the camshaft to the timing mark on the crankshaft gear. See Figure 6-7.

   ⚠ CAUTION ***Incorrect alignment will cause engine malfunction.***

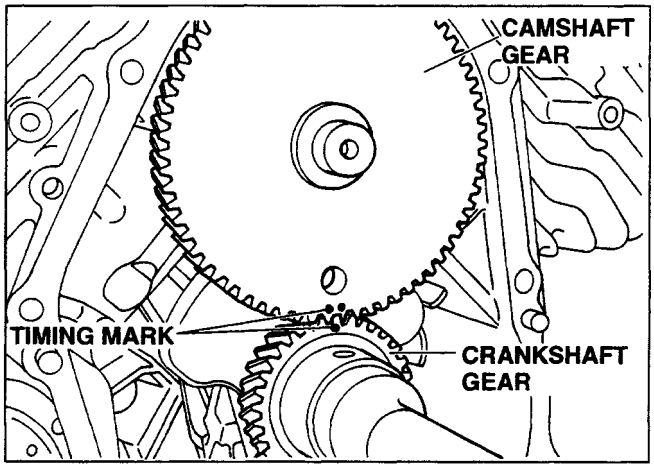


FIGURE 6-7.

3. Adjust the side clearance.

   A. Measure the end play of crankshaft and camshaft. Adjust end play between 0.006″ and 0.013″ (0.152 – 0.330mm) using the proper spacer.

   B. Spacer Calculation: (Refer to FIgure 6-8.)
      "A″ + 0.014″ – "B″ (① – ②)

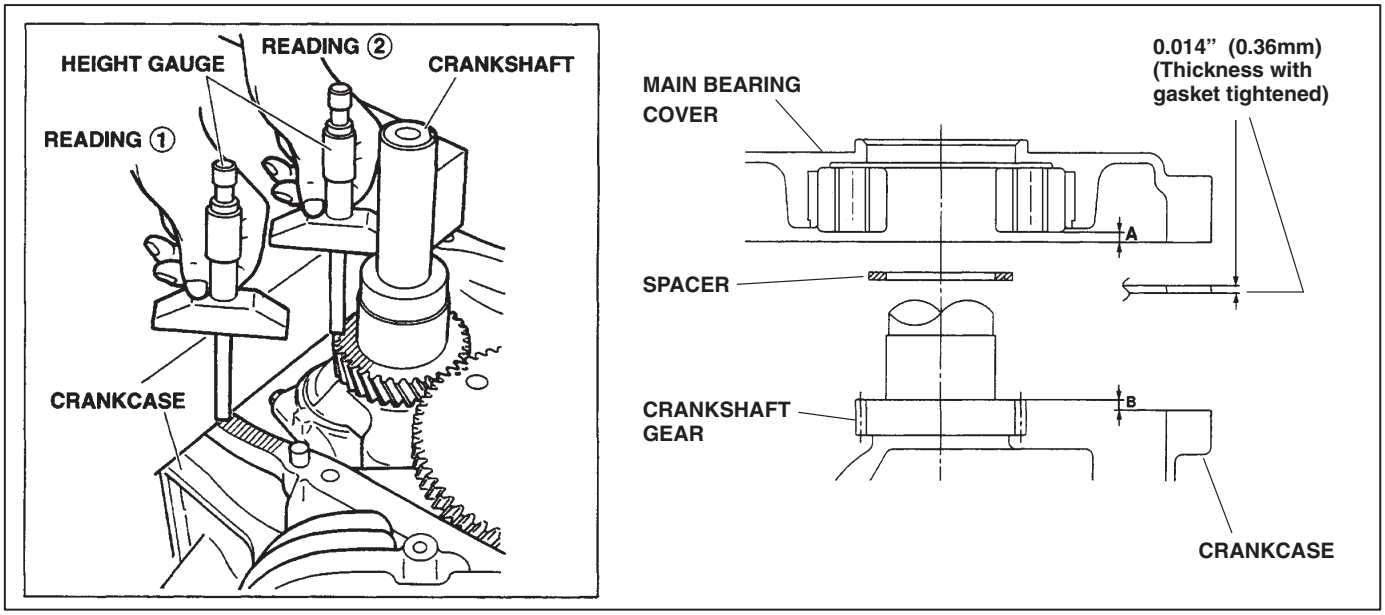


FIGURE 6-8.

Main Bearing Cover

1. Place an oil seal guide onto PTO shaft to avoid damaging the main bearing cover oil seal.

   Make sure the governor lever shaft and the oil pump filter are installed in the crankcase.

2. Place gasket onto the mating surface of crankcase.

3. Using a soft hammer, tap the cover until it touches the crankcase mating surface. Make sure the governor gear and camshaft gear are properly engaged.

4. Lubricate the oil seal lip and bearing surfaces, and install main bearing cover. Tighten bolts gradually in an even pattern to the specified torque.

   Torque the (10) M8 flange bolts between 12.3 and 13.7 ft/lbs (16.7 – 18.6N·m).

5. Rotate crankshaft slowly and check for smooth operation and side clearance.

Oil Pump and Cover

1. Apply oil to inner and outer rotors of oil pump and position them on the crankshaft.

2. Position an o-ring in onto crankcase (Figure 6-9).

3. Grease the oil seal and install on the oil pump cover.

4. Install the oil pump cover with arrow mark pointing upwards.

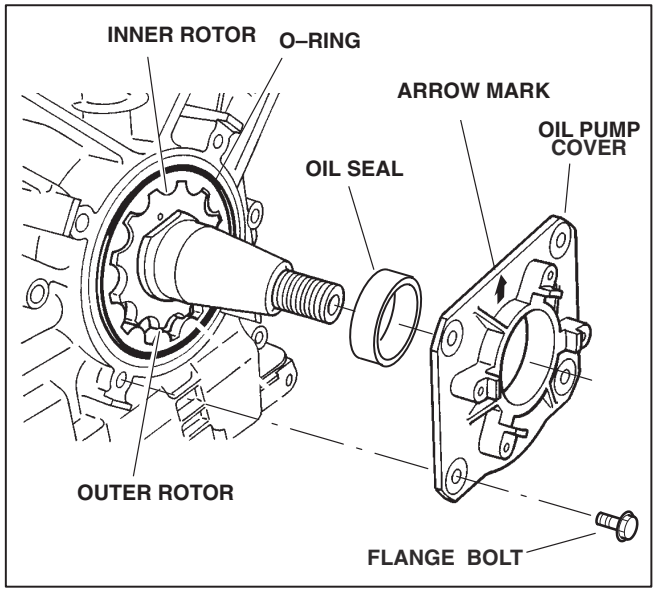


FIGURE 6-9.

Cylinder Heads

NOTE: Inspect the dwell pin and replace if damaged.

1. Place new head gaskets onto crankcase.

2. Install #1 and #2 cylinder heads. Tighten bolts gradually in an even pattern to the specified torque.

   Torque the(4) M10 flange bolts between 24.6 and 30.4 ft/lb (33.3 – 41.2 N·m) on each cylinder head.

Push Rods

1. Rotate the crankshaft until the tappets are at their lowest position.

2. Loosen the rocker arm adjustment setscrews.

3. Insert the push rods into the concave end of the tappet. With the valve spring depressed, Insert the other end of the push rod into the concave part of the rocker arm adjustment screws.

4. Temporally tighten the adjusting screws.

Valve Clearance Adjustment

NOTE: Temporally place the flywheel in position for easier operation.

1. Rotate crankshaft clockwise to the TDC (top dead center) of compression stroke by matching the "T" mark on the flywheel with the "1" mark on #1 cylinder head (Figure 6-11).

2. Loosen locknut on rocker arm and turn adjusting screw to adjust the clearance between rocker arm and valve stem end. (Figure 6-10.)

   Valve Clearance: 0.004" (0.085 – 0.115 mm) Cold condition

3. Tighten locknut to the specified torque.

   Torque the (2) M8 locknuts between 7.2 and 10.1 ft/lb (9.8 – 13.7 N·m) on each rocker arm set.

4. Adjust valve clearance on the #2 cylinder side in the same manner.

5. Rotate crankshaft several times and check the valve clearance again. Make final adjustments to each valve, if necessary.

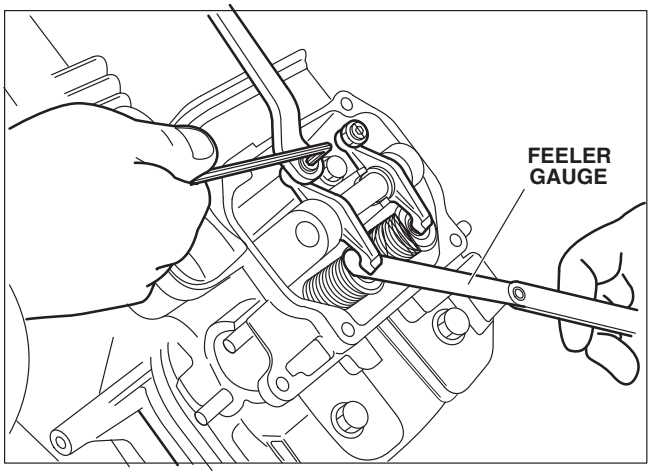


FIGURE 6-10.

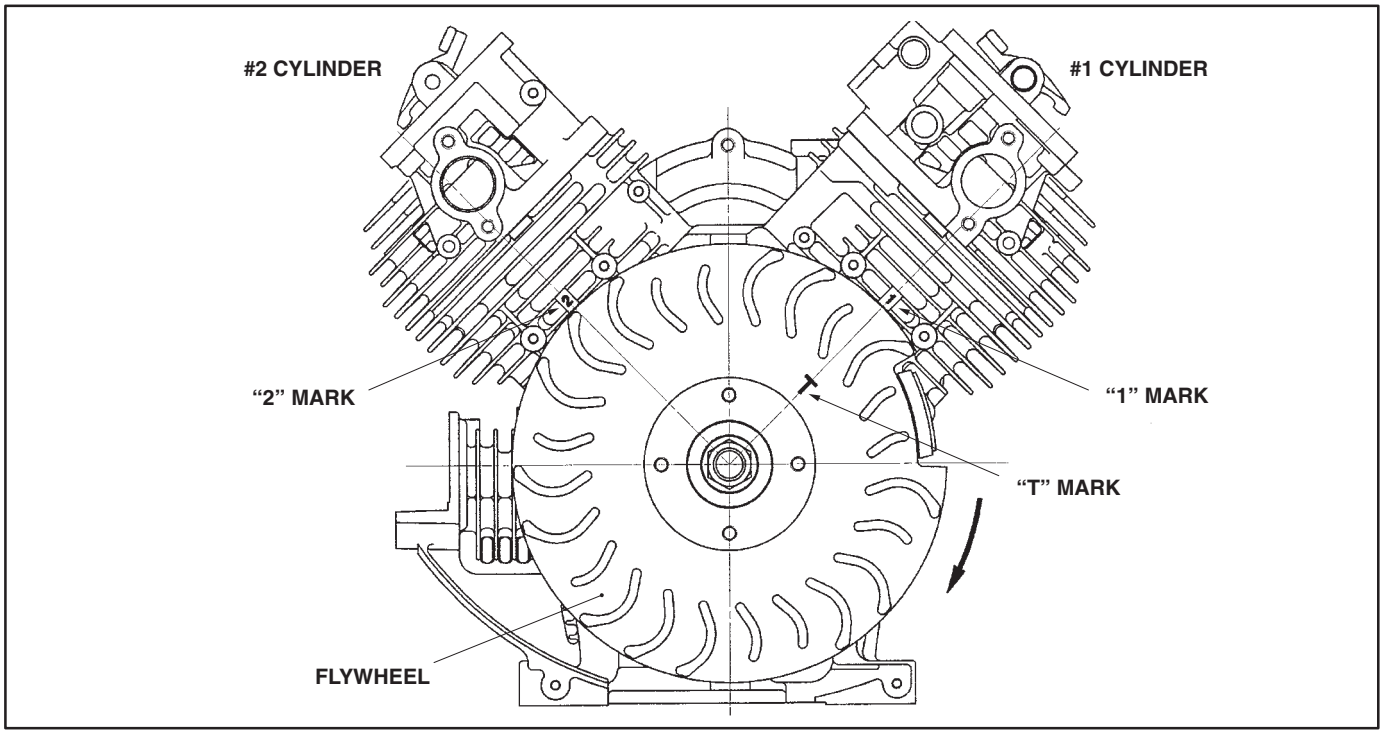


FIGURE 6-11.

Rocker Arm Covers

Install each rocker arm cover using new gaskets.

Attach lift hooks to the upper bolts on each cover. Tighten bolts to the specified torque.

Torque the (4) M6 flange bolts between 24.4 and 43.2 in/lbs (2.9 – 4.9 N·m) on each cover.

Breather Plate and Cover

The crankcase breather prevents pressure from building up in the crankcase. It also prevents oil contamination by removing moisture or gasoline vapors and other harmful blow-by materials from the crankcase. These vapors are routed to the carburetor where they are mixed with incoming air and burned in the combustion chamber. A sticky breather valve can cause oil leaks, high oil consumption, rough idle, reduced engine power, and a rapid formation of sludge and varnish within the engine.

1. Attach breather plate (breather valve) and breather cover to crankcase using the proper gaskets.
2. Position the breather plate so the reed valve is opens away from the cylinder head. (Figure 6-12.)
3. Tighten the breather cover bolts to the specified torque.

   Torque the (2) M6 flange bolts between 24.6 and 43.2 in/lbs (2.9 – 4.9 N·m).

   NOTE: Over-tightening the bolts will result in gasket damage. Replace torn or damaged gaskets if necessary.

Replace the breather if it's broken or cracked, or if the crankcase pressure is indicated by oil leaks at the seals or excessive oil in the air cleaner housing.

Spark Plugs

1. Reinstall the spark plugs to each cylinder.
2. Use type NGK–BP6ES or BRP6ES (CHAMPION – N9YC or RN9YC).
3. Torque spark plugs as specified below.

TORQUE NOTES:

New Plugs: between 8.7 and 10.8 ft/lbs (11.8 – 14.7 N·m).

Used Plugs: between 16.6 and 19.5 ft/lbs (22.5 – 26.5 N·m).

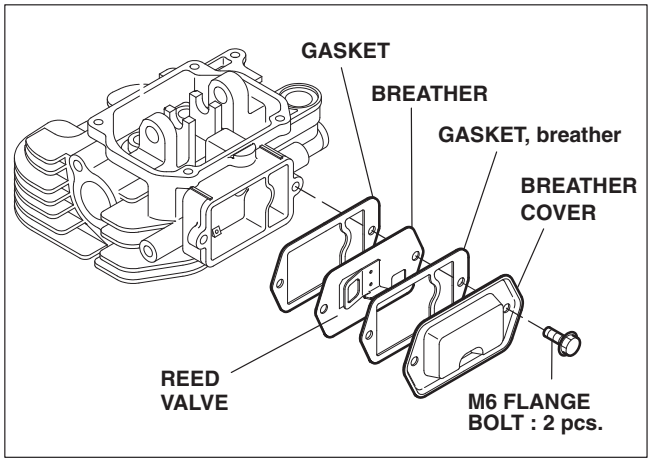


FIGURE 6-12.

Charge Coil

1. Install charge coil with the wires routed at the 2-o'clock position (Figure 6-13).

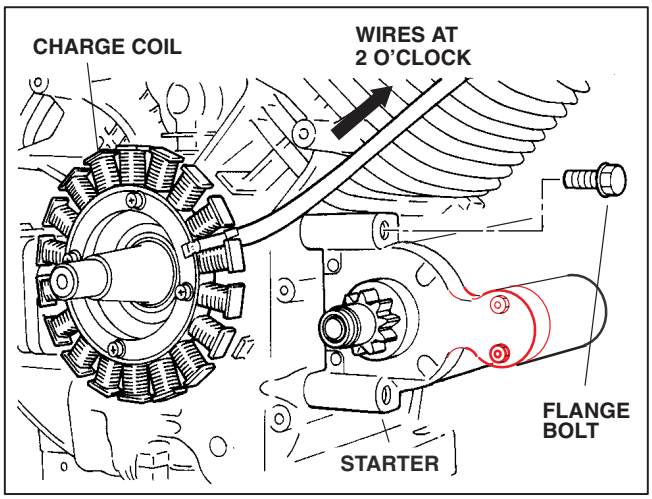


FIGURE 6-13.

2. Tighten the bolts and washers gradually in an even pattern to the specified torque (Figure 6-13).

   Torque the (4) M5 bolts between 13.2 and 30 in/lbs (1.5 – 3.4N·m).

Starter Motor

1. Install starter and solenoid assembly. Tighten the flange bolts to specified torque.

   Torque the (2) M8 bolts between 12.3 and 13.7 ft/lbs (16.7 – 18.6N·m).

Intake Manifold

1. Place a stainless steel gasket onto both #1 and #2 cylinder heads and install intake manifold onto engine studs. Secure with flange nuts to the specified torque.

   Torque the (2) M8 flange nuts between 12.3 and 13.7 ft/lbs (16.7 – 18.6N·m).

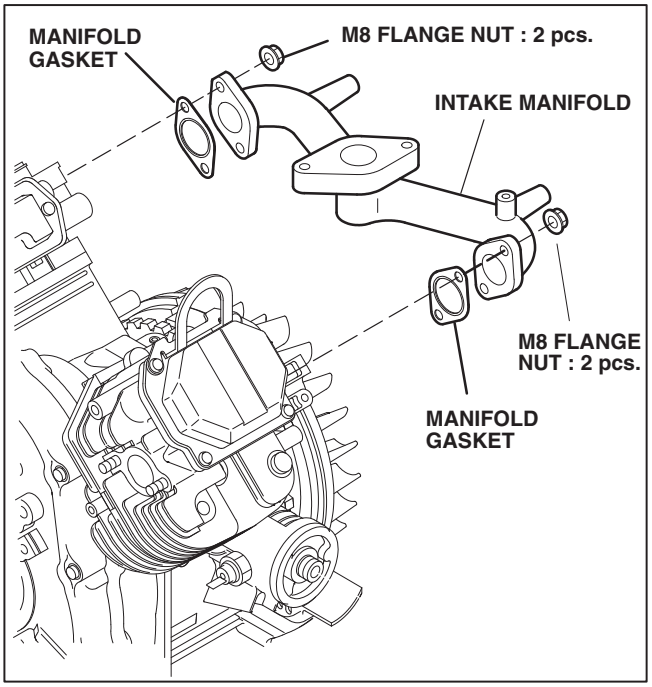


FIGURE 6-14.

Flywheel

1. Remove the M18 nut and washers from the tapered end of the crankshaft.

2. Place woodruff key in the keyway of crankshaft.

3. Wipe off oil and grease thoroughly from the crankshaft and flywheel center hole.

4. Install flywheel to crankshaft and tighten flywheel nut with spring washer and washer. Tighten the flywheel nut to the specified torque.

   Torque the M18 nut between 61.5 and 68.7 ft/lbs (83.3 – 93.1N·m).

Ignition Coils, Cylinder Baffles

1. Install the ignition coils onto crankcase. Finger-tighten the M6 bolts and washers.

2. Using a feeler gauge, adjust the gap between the coil and flywheel between 0.012 – 0.021" (0.3 – 0.5mm).

3. Tignten bolts the the specified torque.

   Torque the (2) M6 bolts between 5.1 and 6.5 ft/lbs (6.9 – 8.8N·m).

4. Connect wiring from the stop diodes to the primary terminals on the ignition coils (Figure 6-15).

5. Secure wires with cable ties and route wire bundles between the number 2 cylinder and the oil filter housing.

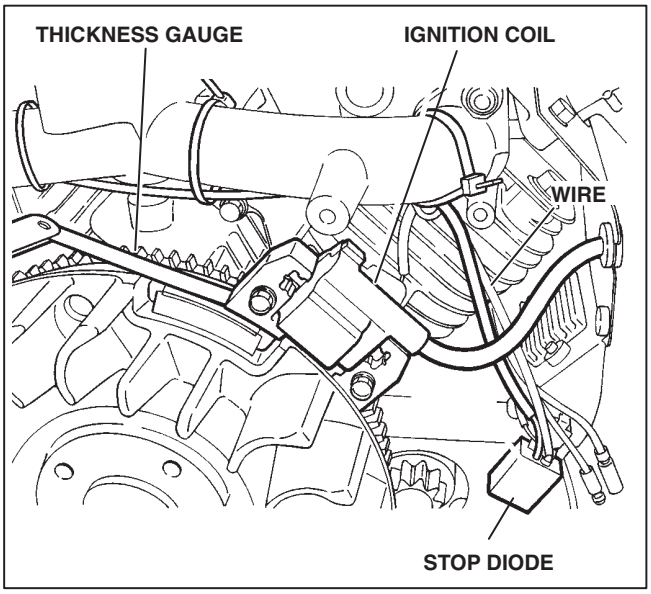


FIGURE 6-15.

6. Replace all four cylinder baffles secured with M6 flange bolts. (Refer to Figure 5-5.)

Carburetor

1. Place a new gasket onto the intake manifold and install carburetor. Tighten the bolts to the specified torque.

   Torque the (2) M8 flange bolts between 12.3 and 13.7 ft/lbs (16.7 – 18.6N·m).

Governor Lever, Control Solenoid

1. Attach governor rod and rod spring between the governor lever and carburetor throttle lever. Insert the governor lever on governor lever shaft (Figure 6-16). Finger-tighten the M6 locking bolt, washer and square nut.

2. Reinstall the speed and choke linkage mounting bracket and secure with (3) M6 flange bolts.

3. Attach one end of the governor spring on the speed control link and the other end on the fifth hole of the governor lever (Figure 6-17).

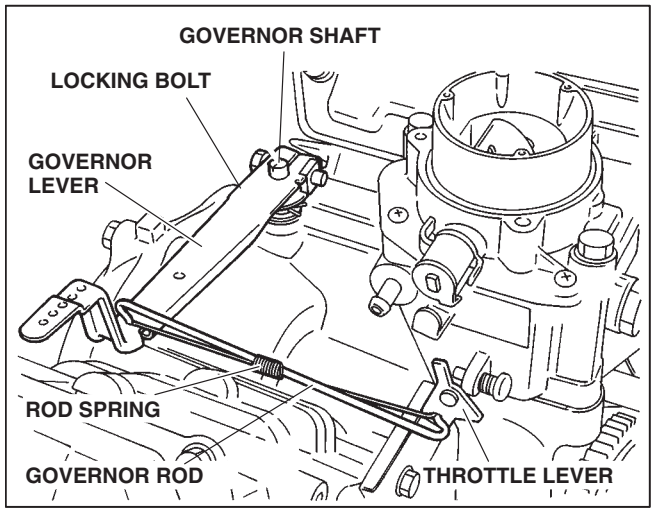


FIGURE 6-16.

4. Attach the choke control rod and the return spring between the choke control lever (on carburetor) and the choke control link (Figure 6-17).

5. Replace the speed control solenoid to the gear case cover.

Adjust Governor

1. Push the speed control lever clockwise to the high speed position and tighten the nut.

2. Make sure the governor lever is pulled by the governor spring and the carburetor valve is fully open.

3. Turn governor shaft counterclockwise all the way and tighten lock bolt to secure the lever on the shaft (Figure 6-18).

Follow the adjustment procedures for the carburetor in *Section 6 of the Operator's Manual.*

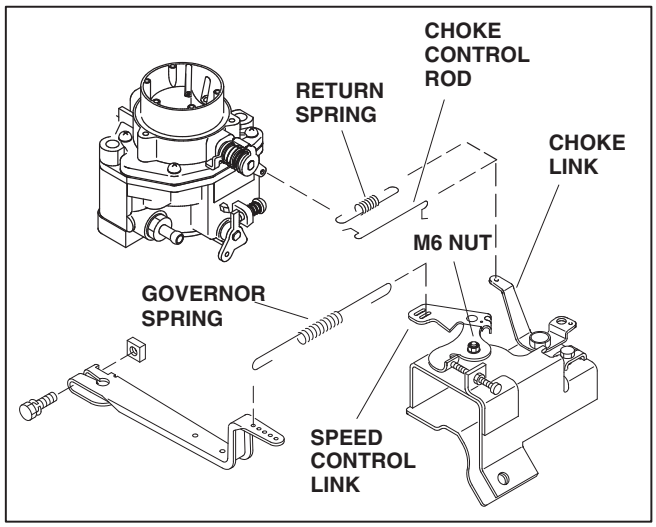


FIGURE 6-17.

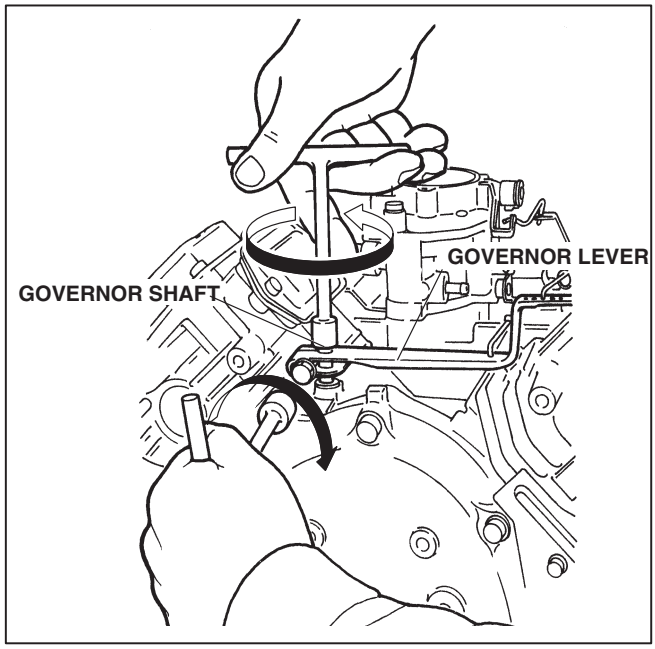


FIGURE 6-18.

Blower Housing, Fuel Pump

1. Attach blower housing to crankcase and secure evenly with (8) M6 flange bolts.

2. Install fuel pump and mounting bracket onto the blower housing. Connect fuel hose to the carburetor and pulse hose to the crankcase.

Air Cleaner

1. Connect breather hose to air cleaner base.
2. Install air cleaner base onto carburetor.
3. Connect breather hose to #1 cylinder head.
4. Place air cleaner element along with urethane form onto base.
5. Install air cleaner cover and secure with knob.

Oil Pressure Switch and Oil Filter

1. Install oil pressure switch into the elbow connector on crankcase. Tighten to the specified torque.

   Torque the pressure switch between 4.3 and 7.2 ft/lbs (5.9 – 9.8N·m).

2. Apply a thin coat of oil to the rubber gasket on the oil filter canister. Hand-tighten about 3/4 turns after the gasket touches the crankcase.

   Torque the oil filter to approximately 9 ft/lbs (12.3N·m).

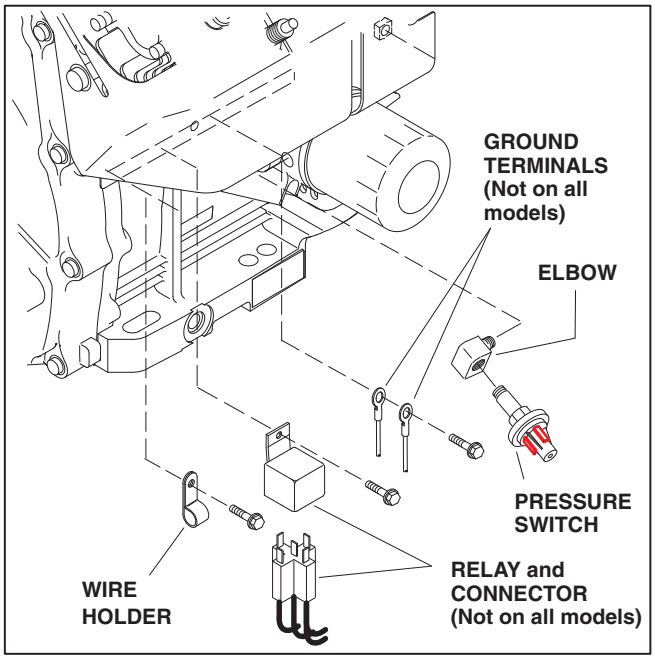


FIGURE 6-19.

Wiring

1. Attach the wire holder, relay and connector, and ground terminals to the engine crankcase under the #1 cylinder baffle. (See Figure 6-19.)
2. Route the ground wires and connector wires threw the wire holder.
3. Secure the wires to the intake manifold with cable ties.
4. Attach the spark plug wires onto each plug.
5. Route wire bundle up through the cable holder mounted on the Control Solenoid.

FINAL CHECKS

1. Check for loose bolts and nuts. Make sure all electric wiring connections are secure.
2. Reconnect the battery, (**+**) positive terminal first.
3. Connect the fuel supply hose to the supply.

   Note: To prevent fuel from flooding the carburetor, the valve must be closed when the engine is not running.

4. Refill engine oil and start the engine. After oil lubricates the oil passages and oil filter, turn off engine and recheck the oil level.

   ⚠CAUTION ***Starting the engine without oil will cause severe engine damage. Always keep the engine oil level between the Full and Add marks on the dipstick.***

   ⚠CAUTION ***Overcranking the engine can cause starter damage. Do not engage starter for longer than 30 seconds. If engine does not start, allow 5 minutes for starter to cool between cranking intervals.***

   ⚠WARNING ***Crankcase pressure can blow hot engine oil out the fill tube causing severe burns. Always stop the engine before removing the oil fill cap or the oil gauge.***

   NOTE: Total engine oil capacity is about 1.64 qt (1.55 L).
   Use "SE" (API classification) or higher grade engine oil.

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