# Section 5
# Governor



5

## GENERAL INFORMATION

**NOTE:** See Section 2 for Performance Control™ electronic governor service information.

Vanguard™ OHV V-Twin engines may be equipped for remote control, manual friction, or fixed speed adjustable governor controls.

### Remote Control and Manual Friction

Remote governor controls (supplied by the OEM) and manual friction governors (mounted on the engine) control engine speed by increasing or decreasing tension on the governor spring(s) to obtain the desired engine speed. Both controls, **Fig. 1**, provide speed control at all positions.

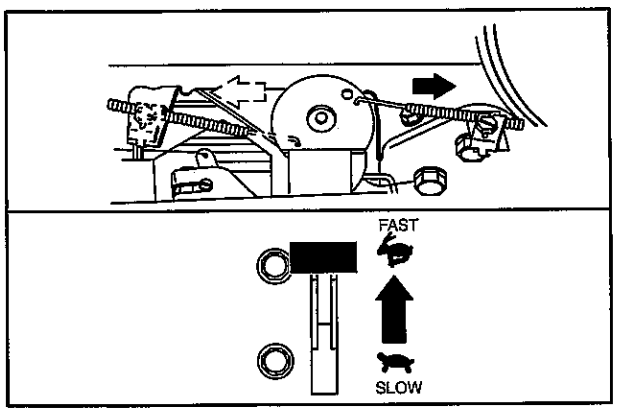



**Fig. 1**

### Fixed Speed Adjustable

The fixed speed adjustable governor, **Fig. 2** is used in applications where a constant speed is required, such as generator applications.

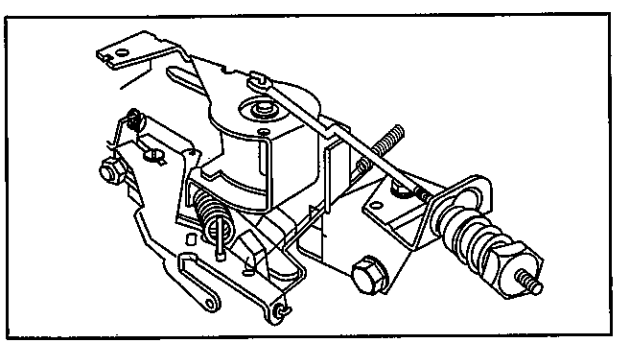


**Fig. 2**

### Governed Idle

OHV V-Twin engines equipped for manual friction or remote control have a governed idle system, **Fig. 3**. A throttle restrictor maintains the engine speed when a load is applied and the equipment control is in the SLOW position.

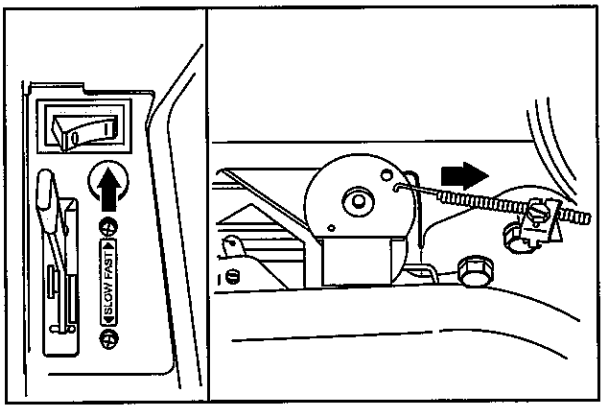



**Fig. 3**

## GOVERNOR CONTROLS

#### Remote Control Wire Travel

In order to make proper remote control adjustments, the remote control wire must have travel of **not less than 1-3/8" (35 mm)** (2) with controls mounted in equipment, **Fig. 4**. The dimension from the end of the cable casing to the wire at the end of its travel (1) is **2-1/8" (54 mm) minimum**.

Some control brackets are equipped with a plastic swivel for the control wire. The control wire has a 90º bend and snaps into the swivel. The length of the bend (3) should not exceed **1/4" (6 mm)**.

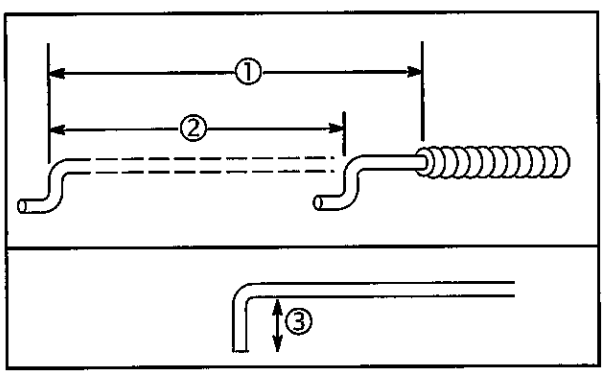



**Fig. 4**

## GOVERNORS

### All Models – Except 540000, 610000

#### Disassembly

Drain oil and remove engine from equipment. Remove spark plugs. Remove valve covers. Compress valve springs and remove push rods.

1. Disconnect governor link and spring (1) at carburetor, **Fig. 5**.
2. Disconnect governed idle spring (4, if equipped).

3. Loosen governor lever nut (3).
4. Remove governor lever (2) from shaft.

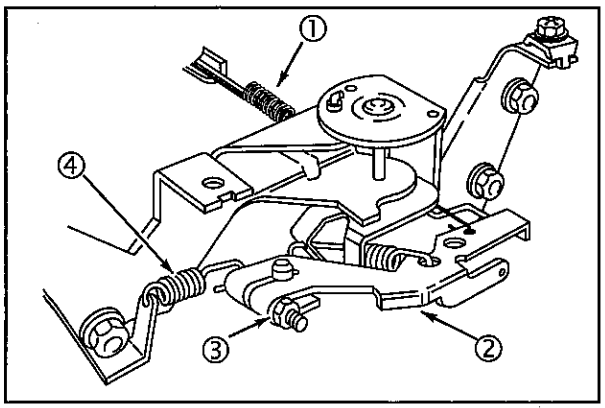



Fig. 5

5. Remove rust, nicks or burrs from crankshaft.
6. Remove oil fill tube and dipstick assembly.
7. Remove crankcase cover, **Fig. 6.**
8. Discard gasket and O-ring.

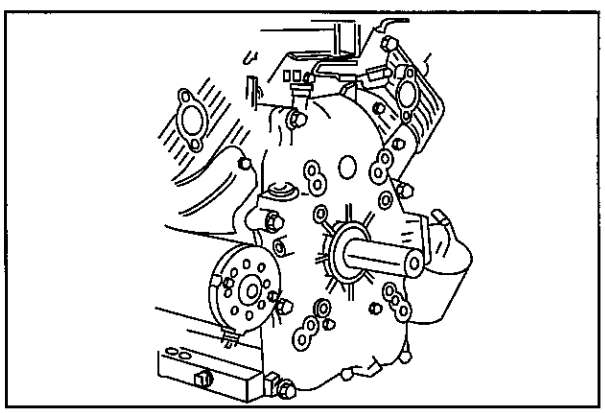


Fig. 6

### Inspect Governor

1. Governor spool (3) must move freely on PTO journal of camshaft, **Fig. 7**. Replace if spool sticks or bearing is damaged.
2. Flyweights (2) must move freely on hinge pins (1). Replace camshaft if hinge pins are loose or governor spool does not move freely on journal.

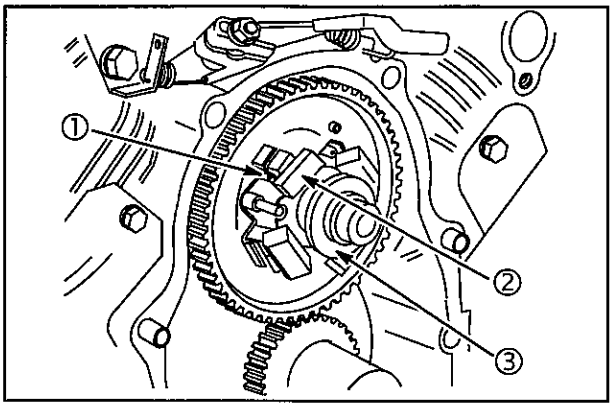



Fig. 7

### Remove Governor Shaft

1. Remove cotter pin (3) and collar (2). Discard cotter pin, **Fig. 8.**
2. Slide governor shaft (1) out of bushings (5).
3. Remove and discard seal (4).
4. Check governor shaft and bushings for wear or damage.

Replace as required.

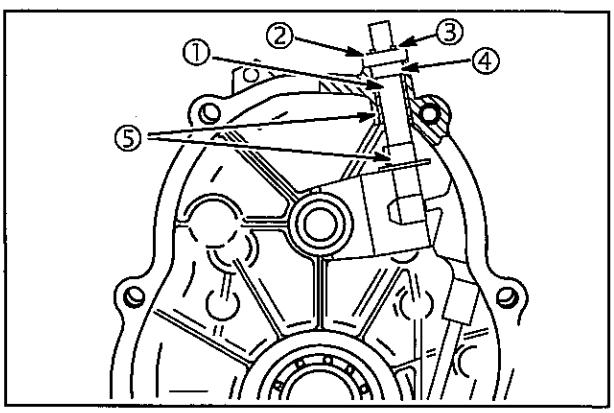



Fig. 8

### Replace Governor Shaft Bushings

1. Press out upper bushing (2) using Bushing Driver **#19204** (1), **Fig. 9.**
2. Lubricate new bushing with engine oil. Press in place with Bushing Driver **#19204.**

**NOTE:** Lower bushing is a slip fit. If bearing for lower bushing (3) is worn, the crankcase cover must be replaced.

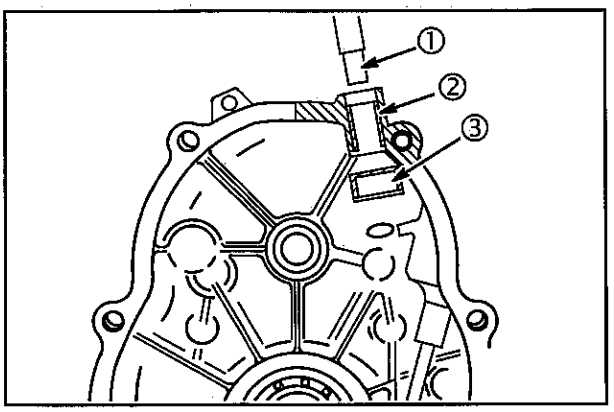



Fig. 9

### Install Governor Shaft

1. Assemble lower bushing to governor shaft with thrust flange (4) down, **Fig. 10.**
2. Slide shaft up through lower bearing and upper bushing.
3. Install new seal (3), collar (1) and cotter pin (2). Governor shaft must rotate freely.
4. Rotate governor shaft (arrow) so that paddle rests against camshaft bearing support (5).

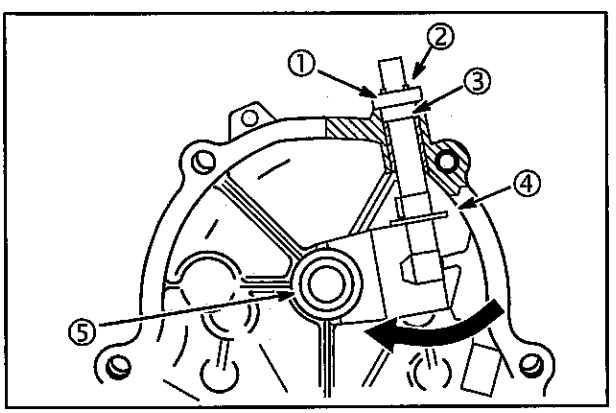



Fig. 10

### Assembly

1. Assemble governor spool to camshaft, **Fig. 11.**
   a. Make sure that spool (2) engages flyweights and slot on spool fits over locating pin (1).
   b. Install new O-ring (3) in cylinder.

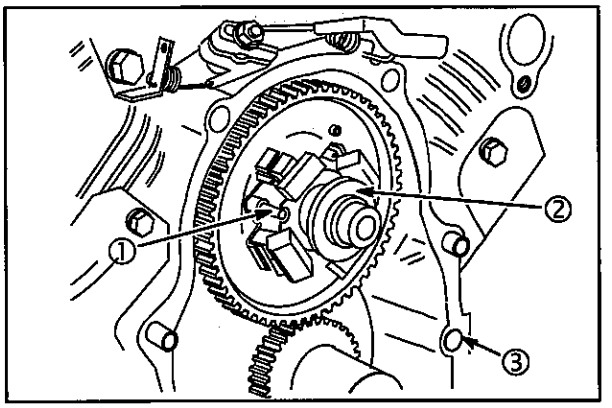



Fig. 11

2. Insert proper seal protector through oil seal.
3. Install crankcase cover or sump with new gasket. Torque screws in sequence shown to **150 in. lbs. (17 Nm), Fig. 12.**
4. Reinstall oil fill tube and dipstick assembly.

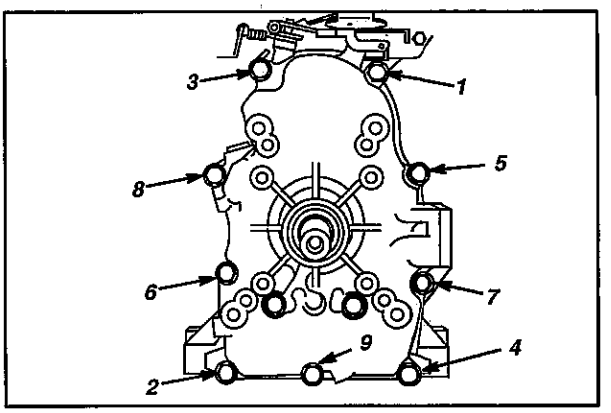



Fig. 12

5. Reassemble governor lever (6) to shaft, **Fig. 13.**
   a. Reassemble governor link and spring (5) at carburetor.
   b. Reassemble governed idle spring (4).

**NOTE:** DO NOT tighten nut (7) at this time.

6. Install push rods in their original position.
7. Compress valve spring with rocker arm. Insert push rod into rocker arm socket. Be sure push rods remain seated in recess in tappets.
8. Install valve covers with new gaskets and valve cover seals. Torque nuts to **25 in. lbs. (3 Nm).**

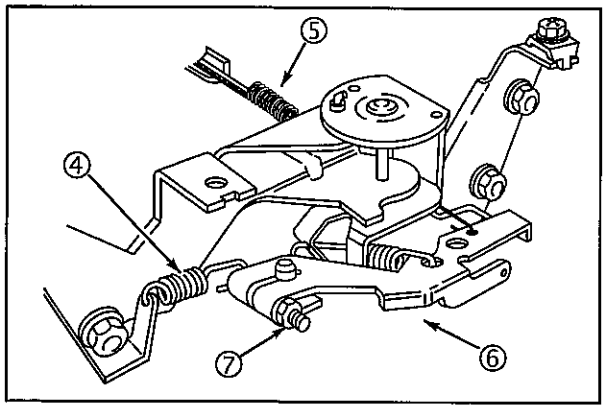



Fig. 13

9. Perform governor adjustments, see Trouble-shooting, Section 2.

**WARNING**

Static adjustment of the governor must be completed **BEFORE** starting or running engine!

- Failure to make static governor adjustments first could result in engine overspeeding and consequential engine damage, property damage or personal injury.

## Models 540000, 610000

### Disassemble Governor Gear

The governor gear (1) is located on the inside of the crankcase cover, **Fig. 14**.

Drain oil and remove engine from equipment. Remove spark plugs. Remove crankcase cover.

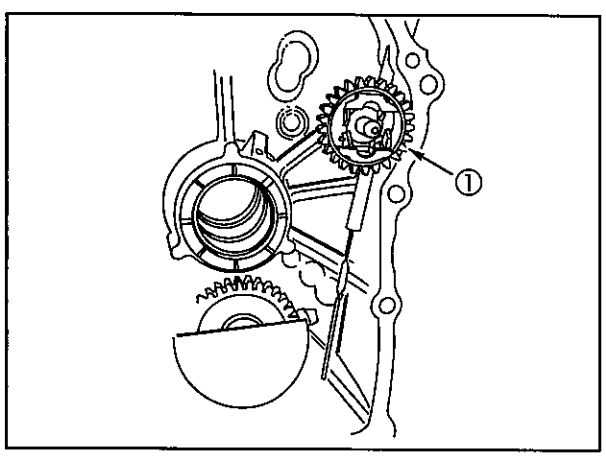



Fig. 14

1. The governor gear should spin freely and slide on the governor gear shaft. The flyweights (2), **Fig. 15,** must move freely on the hinge pins.
2. If necessary, remove the governor gear (1) from the crankcase cover with two screwdrivers (3). Remove the washer from under the governor gear.

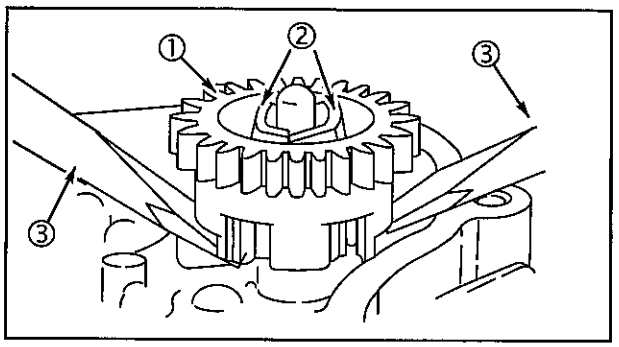



Fig. 15

### Inspect Governor Gear

1. Check the governor gear assembly for worn weights or weight pins. Inspect the governor cup, washer and gear for wear or damage.
2. Inspect the governor gear shaft (1) for wear or damage, **Fig. 16.**

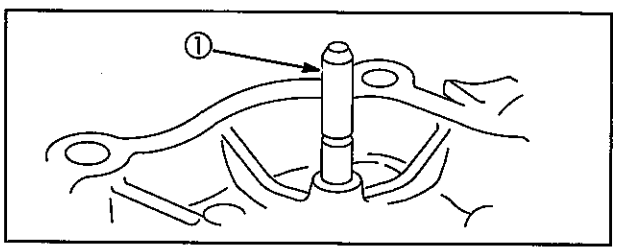



Fig. 16

Replace the crankcase cover if the shaft is worn, bent or otherwise damaged.

### Install Governor Gear

1. Install the washer and governor gear to the governor gear shaft.
2. Secure the governor gear assembly to the shaft with the retaining clip.
3. Place governor gear cup into the governor gear weights and push down into position on the governor gear shaft.

### Remove Governor Crank

1. Inspect the governor crank (2) for wear or damage, **Fig. 17.**

**NOTE:** Camshaft gear and cylinder block are cut away for clarity.

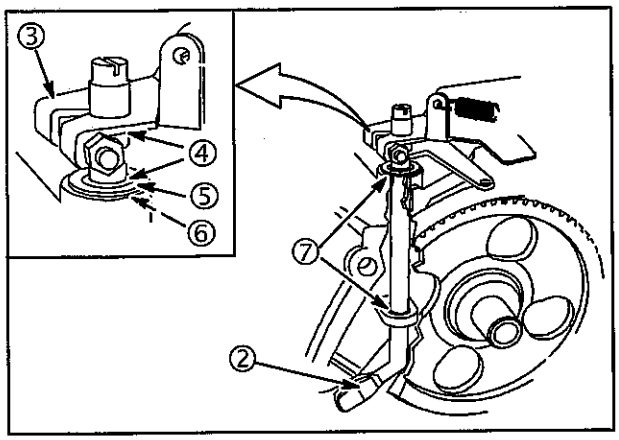



Fig. 17

2. If necessary remove the crank from the cylinder block. Mark the governor lever and the governor crank to aid in reassembly. Remove the governor lever from the crank (3). Remove the upper and lower retaining rings (4) and the washer (5). Slide the crank out of the bushings (7).

3. Replace the oil seal (6, under the washer). Replace worn or damaged components.

**NOTE:** Inspect the crank and the crank bushings. If the bushings are damaged or worn replace the cylinder block.

### Install Governor Crank

1. Insert the governor crank through the crank bushings and new seal. Install the washer and lower retaining ring.

2. Install the upper retaining ring and the governor lever. Align the marks on the governor lever and the governor crank.

# Section 6
# Cylinder Heads and Valves

## PARTS IDENTIFICATION

Compression testing information and procedure is described in Section 2 – TROUBLESHOOTING. **Fig. 1** shows the components of a typical V-Twin OHV Cylinder Head.

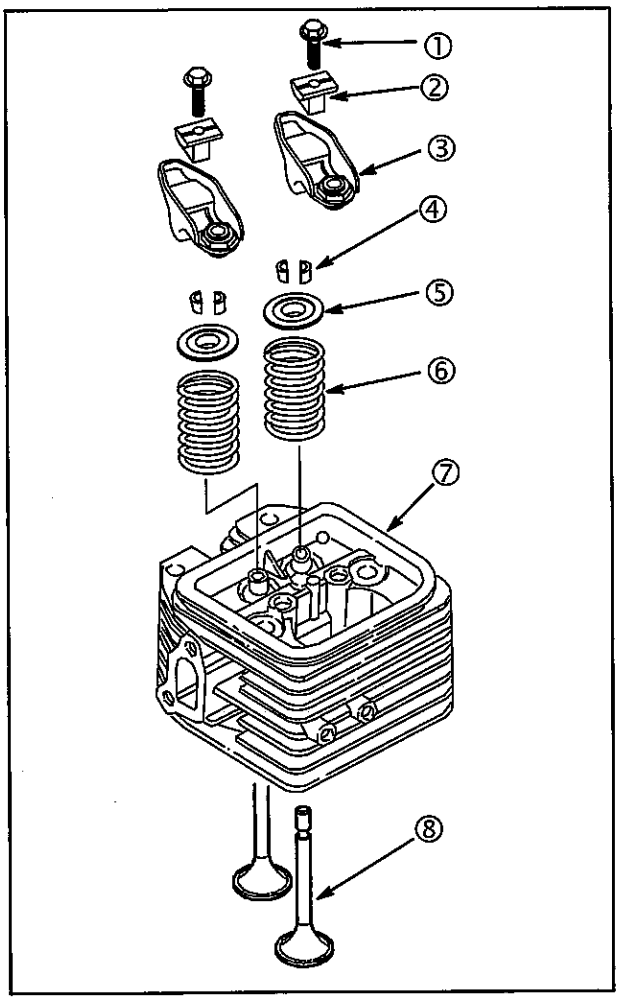



**Fig. 1**

1. Screw
2. Rocker Arm Support
3. Rocker Arm
4. Valve Spring Retainer Locks
5. Valve Spring Retainer
6. Valve Spring
7. Cylinder Head
8. Valve

### Rocker Arm Identification

Three different rocker arms have been used.

**Style 3:** (Current) Engines manufactured after date code 960331xx are equipped with a redesigned cylinder head, and stamped steel rocker arms (1), **Fig. 2**, with a separate rocker arm support (2) for each valve. The redesigned cylinder head, gasket and rocker arm assembly will not interchange with previous cylinder heads. The new cylinder head may be used on earlier V-Twins, but only as a complete assembly. Refer to date code when ordering parts.

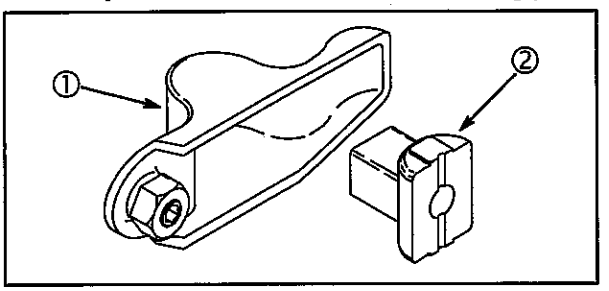



**Fig. 2**

**Style 2:** Engines manufactured before 960401xx but after 931031xx are equipped with cast aluminum rocker arms (3) with a rocker arm shaft, **Fig. 3**.

**Style 1:** Engines manufactured before date code 931101xx were equipped with stamped steel rocker arms (4) with a rocker arm shaft, **Fig. 3**.

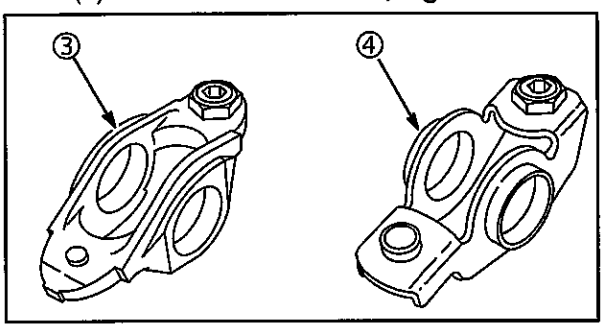



**Fig. 3**

## CYLINDER HEAD SERVICE

### Remove Cylinder Head

1. Remove two rocker studs (1) supports (2) and rocker arm assemblies (3), **Fig. 4** (current) or **Fig. 5** (early). Remove rocker arm shaft (4, early versions).
2. Remove push rods.

**NOTE:** Label push rods for reassembly in the original location.

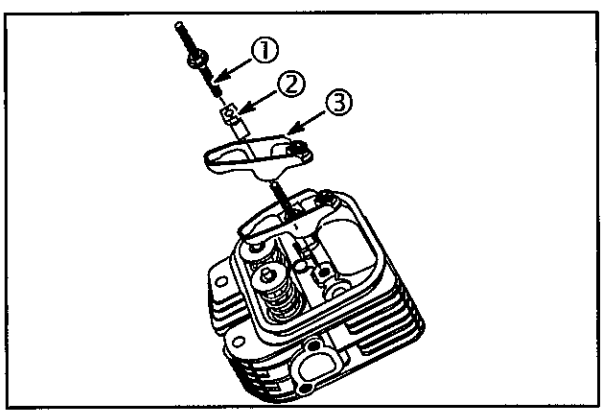



**Fig. 4**

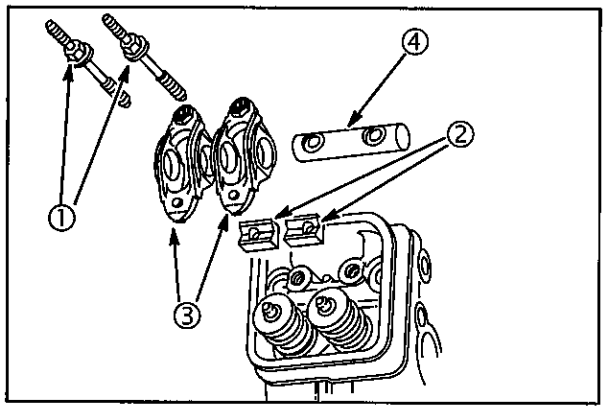



**Fig. 5**

3. Remove head bolts (5, 6, 7, 8) and cylinder head, **Fig. 6**. Discard cylinder head gasket.

**NOTE:** Engines manufactured before 940501xx were equipped with sealing washers under cylinder head bolts (5) and (6).

Repeat for other cylinder head.

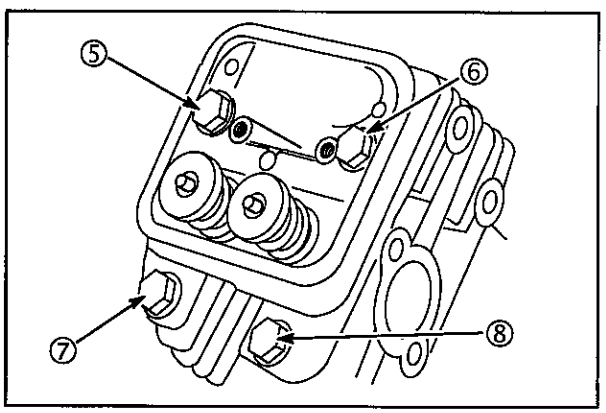



**Fig. 6**

## Disassembly

1. Thread rocker arm support screw into cylinder head a few turns.

**CAUTION**

**PREVENT EYE INJURY!**

- WEAR EYE protection when using Valve Spring Compressor.

**NOTE:** Place a shop rag or short section of rubber fuel line under valves inside combustion chamber to hold valve in place while compressing spring.

2. Compress valve spring and retainer with Valve Spring Compressor (3) **#19347, Fig. 7**.
3. Remove valve spring retainer locks (2).
4. Gradually release pressure on the valve spring compressor. Remove valve spring retainer and valve spring.
5. Remove intake and exhaust valves.

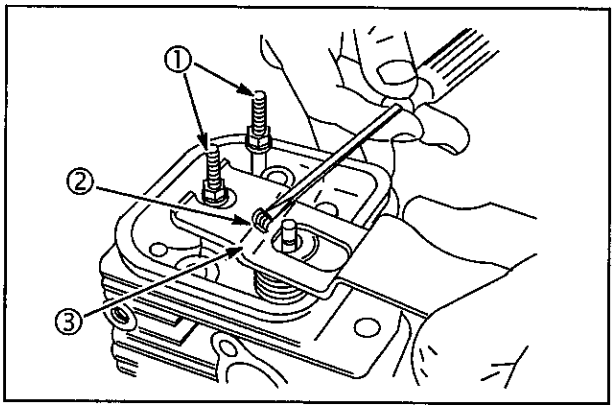



**Fig. 7**

6. Remove and discard valve stem seals, **Fig. 8**.

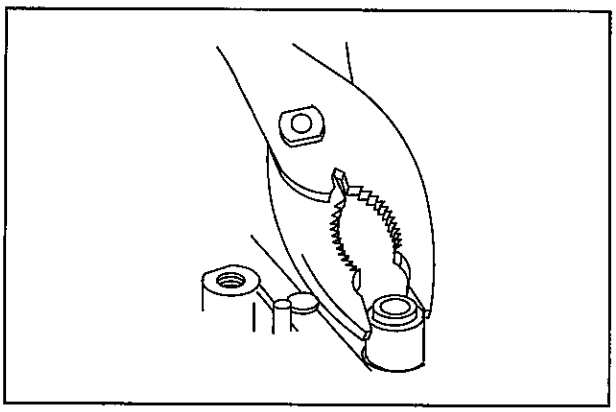


**Fig. 8**

## Inspect and Repair

1. Check cylinder head, **Fig. 9**.

**NOTE:** Be sure all gasket material is removed from surfaces before checking. Use a gasket scraper if necessary.

a. Inspect cylinder head for cracks or damage.

b. Use a surface plate or straight edge (1) and check cylinder head mounting surface for distortion.

Replace the cylinder head if the mounting surfaces are distorted more than **0.004" (0.1 mm)**.

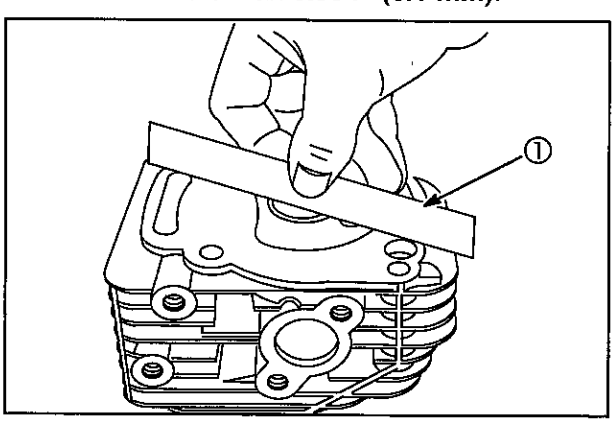



**Fig. 9**

• **CAUTION:** Do not resurface cylinder head mounting surfaces.

2. Check valve guide bushings for wear using Plug Gauge (2) **#19382, Fig. 10.** Replace valve guide if gauge enters guide **1/4" (6 mm)** or more.

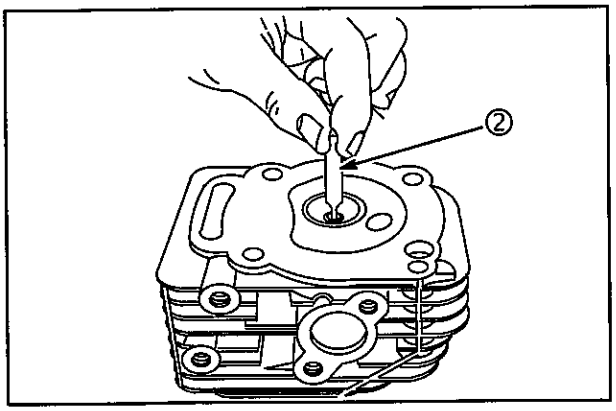



**Fig. 10**

**Replace Valve Guide**

1. Press out old valve guide (2) using Bushing Driver (1), **#19367, Fig. 11.**

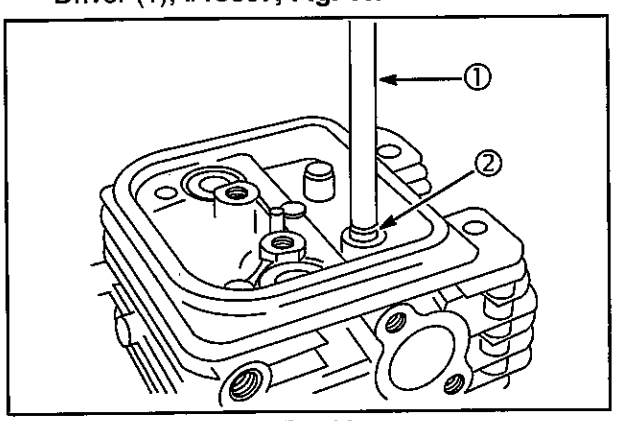



**Fig. 11**

2. Press in new valve guide (4) using Bushing Driver (3) **#19416, Fig. 12.** Press in until tool bottoms on valve guide bushing boss.

• **CAUTION:** Do not use hammer to install bushing.

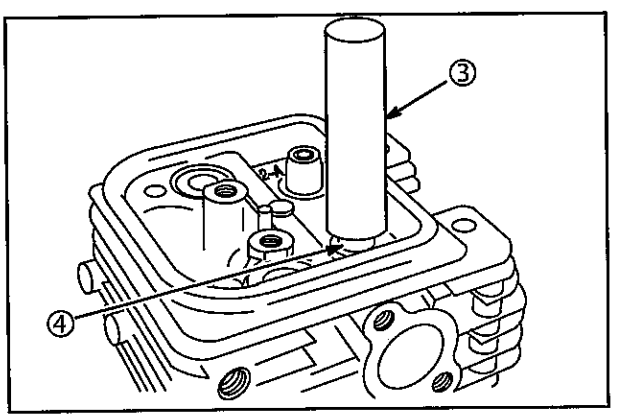



**Fig. 12**

3. Use Reamer Pilot Guide **#19345** (5) and Finish Reamer **#19444** (6) to ream new valve guide, **Fig. 13.**
   a. Use Stanisol® or kerosene to lubricate reamer.
   b. Ream through entire guide.
   c. Keep turning reamer CLOCKWISE when removing reamer.
   d. Flush out all chips.

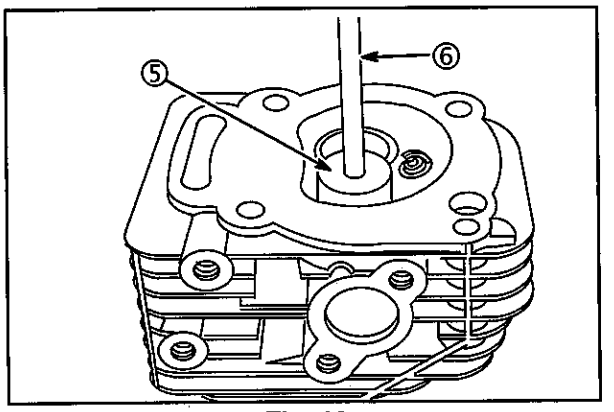



**Fig. 13**

**Reface Valves And Seats**

Valve seats can be reconditioned with Valve Seat Cutter Kit **#19237** and **#19343.**

If valve seat is wider than **3/64" (1.2 mm), Fig. 14,** use a narrowing cutter to ensure that contact area of valve seat is centered on face of valve, **Fig. 16.**

Use a **60°** cutter, **Fig. 14, top inset,** to narrow seat from bottom. Use a **15°** cutter, **Fig. 14, bottom inset,** to narrow seat from top.

**NOTE:** If valve seat is loose or cracked, replace cylinder head.

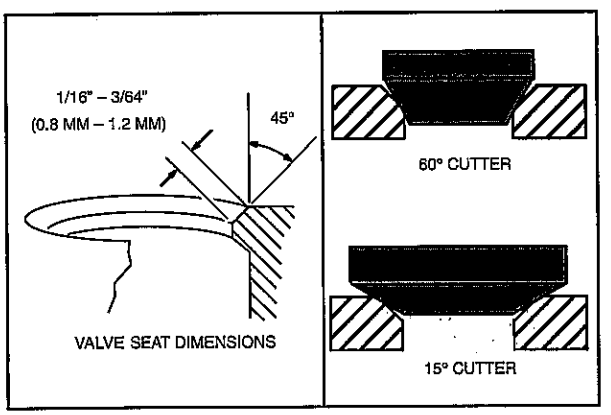



**Fig. 14**

1. Measure valve stem diameter approximately **1-1/2" (38 mm)** from end of valve, **Fig. 15.**

Replace valve if stem diameter is less than **0.233" (5.92 mm).**

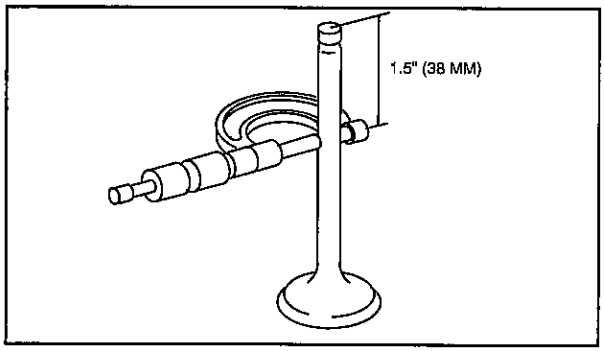



**Fig. 15**

2. Valve faces can be resurfaced to **45°**. See **Fig. 16** for dimensions for valves.
3. Lap the valves and seats with Valve Lapper **#19258** and Valve Lapping Compound **#94150.**

**NOTE:** In most instances it is more economical to replace the valves than to reface them.

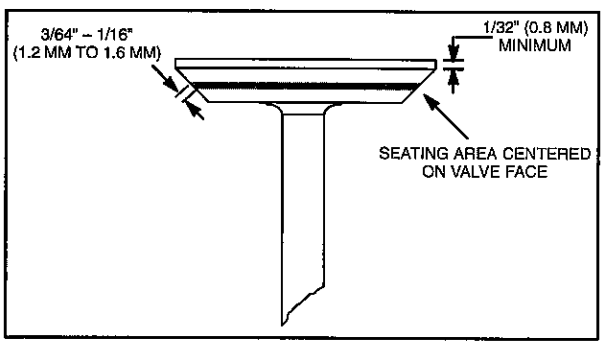



**Fig. 16**

## ASSEMBLY

1. Use Valve Guide Driver (1) **#19416** to install new valve stem seals (2), **Fig. 17.**
   a. Oil inner surface and lip of valve stem seal.
   b. Press seal on to valve guide bushing until it bottoms.

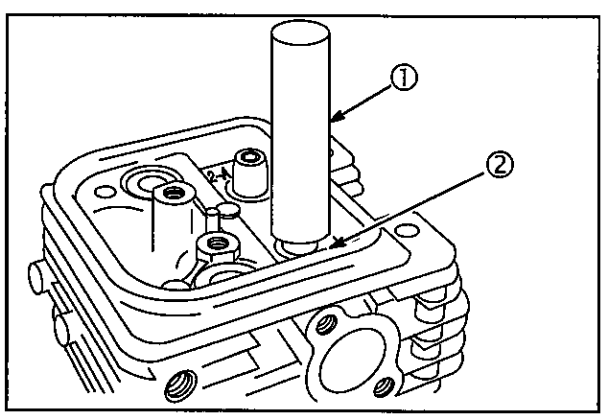



**Fig. 17**

2. Install valves, **Fig. 18.**

**NOTE:** Lightly coat valve stems with Valve Guide Lubricant **#93963** before installing valves. Be sure valve guide lubricant is not on valve face, seat or end of valve stem.

3. Install springs and valve spring retainers over valve stems.

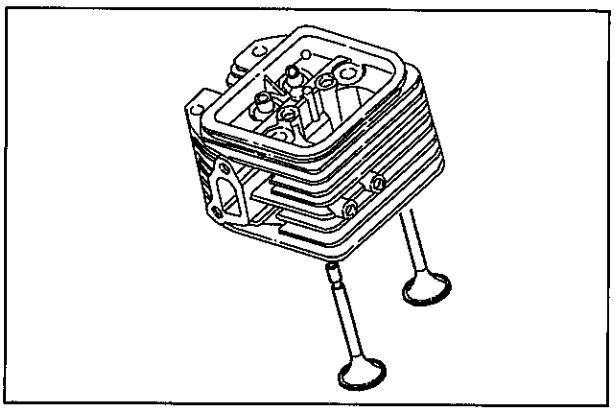
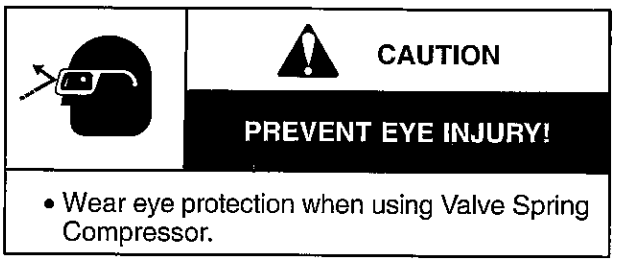


**Fig. 18**

**NOTE:** Place a shop rag or short section of rubber fuel line under valves inside combustion chamber to hold valve in place while compressing spring.




4. Temporarily install rocker studs (3) in cylinder head.
5. Compress valve spring and retainer with Valve Spring Compressor **#19347** (5). Install the valve retainer locks (4), **Fig. 19.**

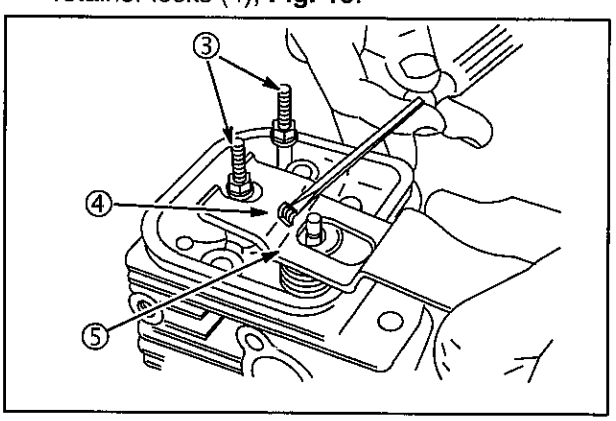



**Fig. 19**

6. Make sure the retainer locks are seated into the valve stem groove and valve retainer. Gradually release pressure on the valve spring compressor.

Repeat procedure for other valve. Remove rocker studs.

## Install Cylinder Heads

1. Install cylinder head with NEW gasket, **Fig. 20.**

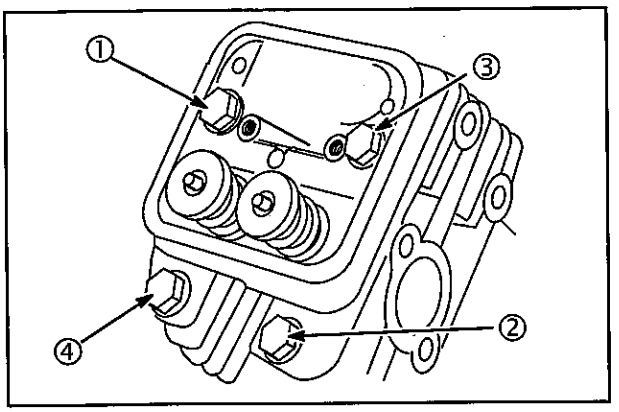



**Fig. 20**

**NOTE:** Engines manufactured BEFORE 940501xx were equipped with sealing washers under #1 and #3 cylinder head bolts.

2. Lubricate threads of head bolts with Valve Guide Lubricant **#93963.**
3. Torque bolts in the sequence shown, **Fig. 20,** to **165 in. lbs. (19 Nm).**

**NOTE: Models 540000, 610000** torque to **350 in. lbs. (40 Nm).**

## Install Rocker Arms

***Current Style***

1. Lubricate rocker arm supports (2) with clean engine oil.
2. Assemble rocker studs (1), rocker arm supports and rocker arms (3) to cylinder head, **Fig. 21.** Torque studs to **100 in. lbs. (11 Nm).**

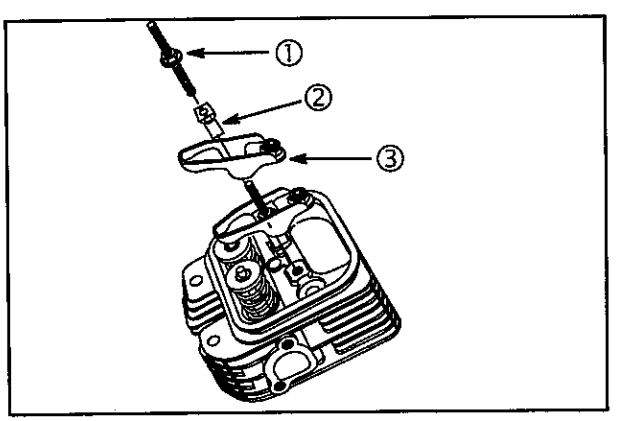



**Fig. 21**

***Early Style***

**NOTE:** Rocker shaft support (3) holes are offset. Install with holes facing ends of rocker shaft, **Fig. 22.**

1. Lubricate rocker arms (4) and shaft (2) with clean engine oil.
2. Assemble rocker arms, shaft, supports and studs (1) and install on cylinder head, **Fig. 22.** Torque studs to **140 in. lbs. (16 Nm).**

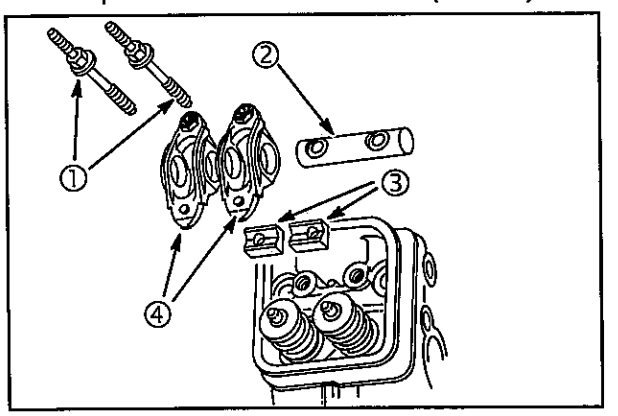



**Fig. 22**

## Install Push Rods

**NOTE:** All models **except 540000, 610000** – Exhaust valve push rods are aluminum. **Models 540000, 610000** – All push rods are aluminum.

1. Compress valve spring (3) with rocker arm (2) and insert push rod (1) into rocker arm socket, **Fig. 23.**

**NOTE:** Seat push rods into recess in tappets.

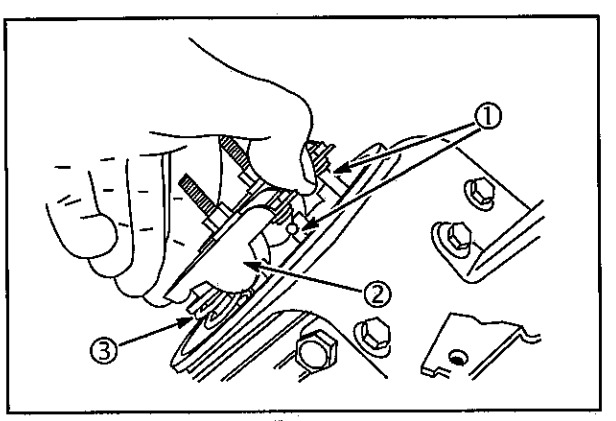



**Fig. 23**

2. Repeat for No. 2 cylinder.
3. Adjust valve clearance. See Section 1.

# Section 7
# Starters

## GENERAL INFORMATION

The starter motor uses a gear engagement method, similar to an automotive starter. When the starter motor is activated, the pinion gear engages a ring gear attached to the engine flywheel and cranks the engine. Three starter motors are used on Vanguard™ V-Twin engines, **Figs. 1-3**.

### Nylon Pinion

The starter motor shown in **Fig. 1** has a nylon pinion gear and is used only on flywheels equipped with an aluminum ring gear. These starters use either a C-ring or roll pin to retain the pinion gear. The flywheel ring gear is replaceable.

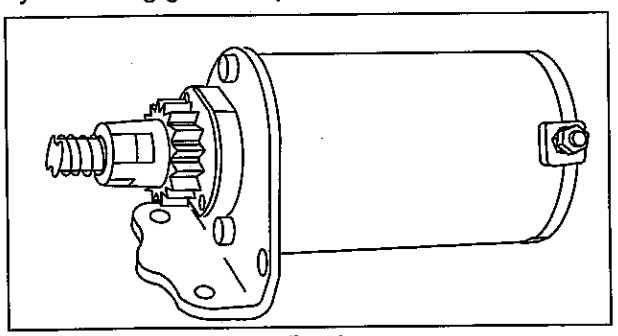


**Fig. 1**



### Steel Pinion

The starter motor shown in **Fig. 2** has a steel pinion gear and is used only with flywheels equipped with a steel ring gear. The flywheel ring gear is NOT replaceable.

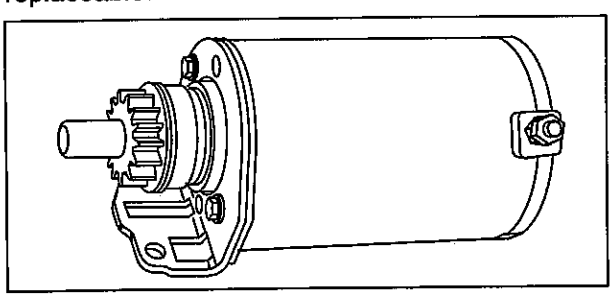


**Fig. 2**

### Solenoid Shift

The starter motor in **Fig. 3** uses a solenoid to engage the flywheel, and is equipped with a steel ring gear. The flywheel ring gear is NOT replaceable.

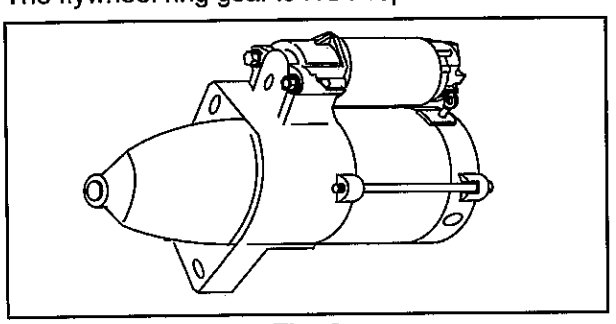


**Fig. 3**

## STARTER DRIVE SERVICE

***Except Models 540000, 610000***

The nylon pinion starter drives use either the C-ring retainer, **Fig. 4** or the roll pin retainer, **Fig. 5**. The steel pinion starter drive is shown in **Fig. 6**. When the starter motor is activated, the pinion gear should engage the flywheel ring gear and crank the engine. If it does not, inspect the helix and the pinion gear for freedom of operation.

Inspect the pinion gear (1) for damaged teeth. The gear must move freely on helix (2), **Figs. 4, 5 or 6.**

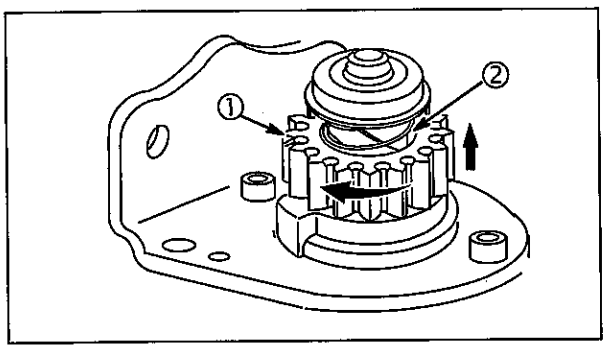



**Fig. 4**

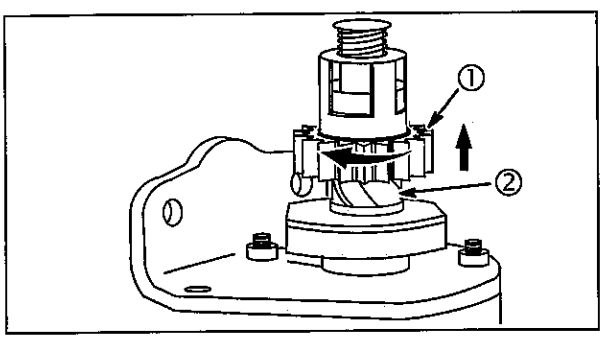



**Fig. 5**

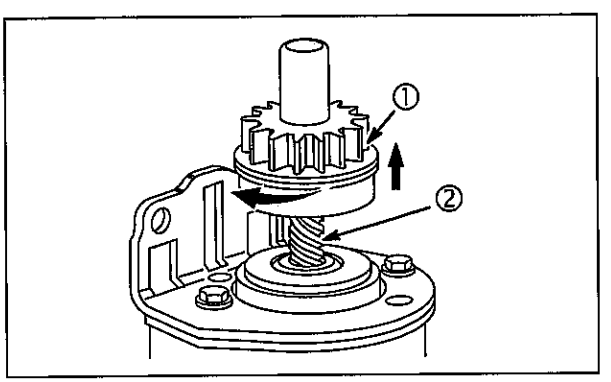



**Fig. 6**

## C-Ring Style

### Disassemble

**CAUTION**

**PREVENT EYE INJURY!**

- Wear eye protection when removing C-ring.

1. Place the counterbored side of C-ring Remover **#19436** (2) over retainer. Align drive pins (1) with open end of C-ring, **Fig. 7.**

**NOTE:** If retainer (3) has a notch (4) as shown, DO NOT align drive pins with notch. If necessary, rotate notch away from open end of C-ring.

2. While applying pressure, turn knurled knob clockwise until C-ring pops off. Discard C-ring.
3. Remove retainer, return spring, spring washer, pinion gear, and starter clutch.

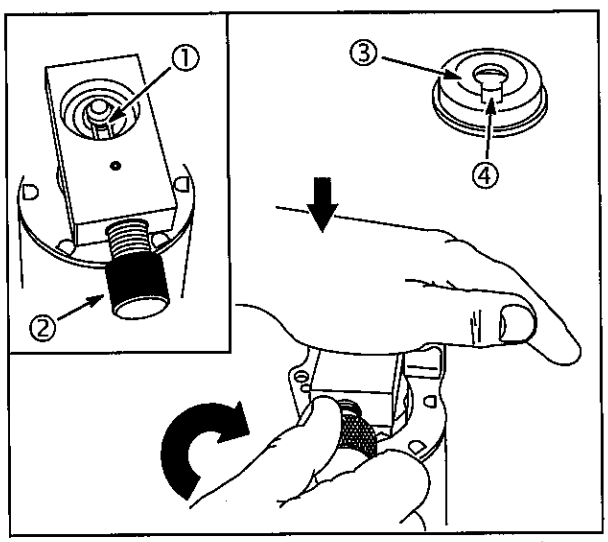



**Fig. 7**

### Assemble

1. Assemble clutch drive (1) to starter shaft. Rotate clutch until it drops into place, **Fig. 8.**
2. Install pinion gear (5) with beveled side of teeth up. Then install return spring (4) making sure spring is in recess of starter gear.
3. Install spring washer (3) with concave side up. Install retainer (2).

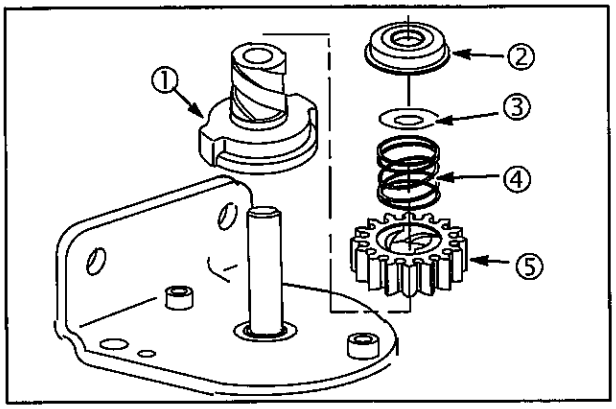



**Fig. 8**

4. Place C-ring (8) over chamfered end of shaft. Align one of the slots (7) of C-ring Installer **#19435** (6) with open end of C-ring, **Fig. 9.**
5. Press or drive C-ring on until it snaps into groove in shaft.

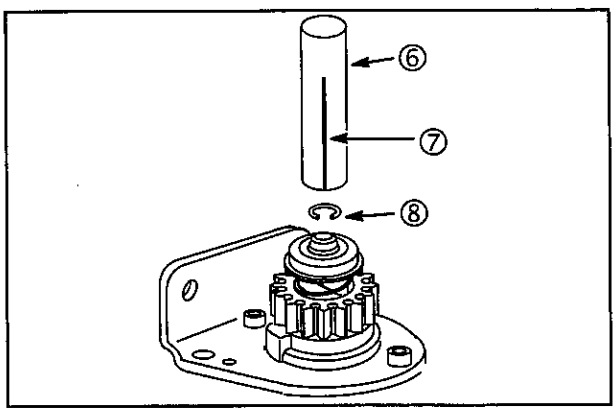



**Fig. 9**

## Roll Pin Style

### Disassemble

1. Place starter drive retainer on support block, **Fig. 10.**

**NOTE:** See Section 13, Appendix, for support block dimensions.

2. Drive out roll pin with a **5/32" (4 mm)** pin punch. Discard roll pin.
3. Remove retainer, washer, pinion gear, and starter clutch.

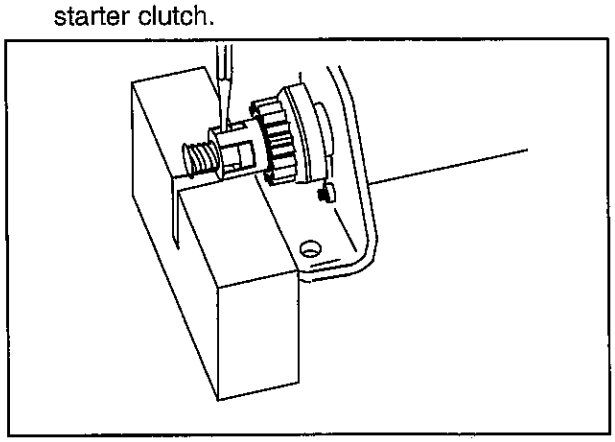


**Fig. 10**

### Assemble

1. Assemble clutch drive (5) to starter shaft. Rotate clutch until it drops into place, **Fig. 11**.
2. Install pinion gear (4) with beveled side of teeth UP.
3. Install washer (3) and retainer (1).
4. Install NEW roll pin (2).

**NOTE:** Slot in roll pin should face up.

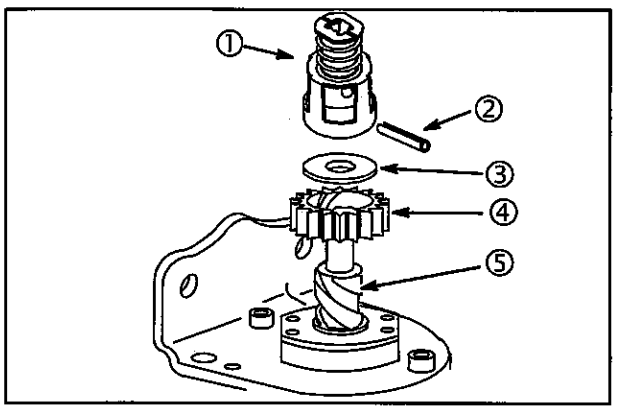



**Fig. 11**

7

## Steel Pinion Style

### Disassemble

1. Grasp end of rubber dust cover (1) and pull to remove, **Fig. 12.**
2. Push down on upper spring retainer (3) to expose retaining ring (2) on shaft.
3. Use a small screw driver and pry off retaining ring. Discard retaining ring.
4. Remove upper spring retainer, spring (4), lower spring retainer (5), pinion gear (6) and clutch (7).

### Inspect

Check pinion gear for damaged or worn teeth. Rubber bottom of pinion is part of clutch. Check for wear or damage. Check clutch for wear.

If clutch rubber inside of pinion gear is worn or damaged, pinion gear will slip when starter is engaged.

### Assemble

1. Lubricate helix (8) with a light coat of grease.
2. Assemble clutch and pinion gear to shaft.
3. Assemble lower spring retainer with OPEN END UP.
4. Install spring.
5. Install upper spring retainer with OPEN END UP.
6. Compress spring. Install NEW retaining ring to shaft.
7. Compress retaining ring with pliers to ensure that it is seated properly in groove in shaft.
8. Pull up on upper spring retainer until retaining ring snaps into groove in upper spring retainer.
9. Push dust cover down until it snaps into groove in lower spring retainer.

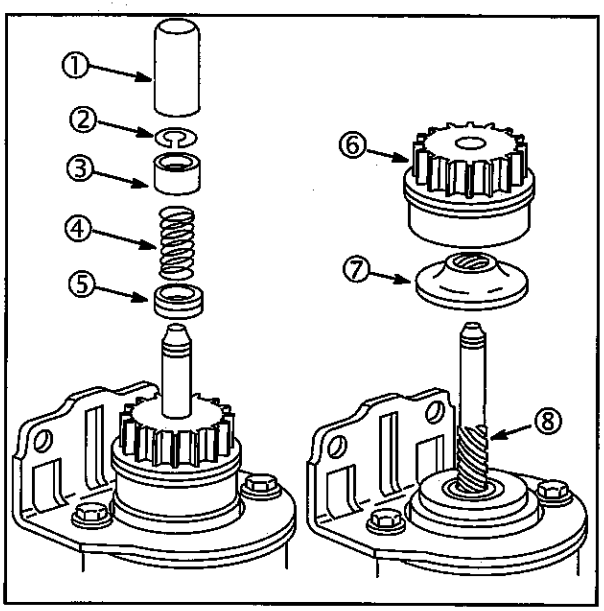



**Fig. 12**

## STARTER MOTOR SERVICE

***Except Models 540000, 610000***

### Disassemble

**CAUTION:** DO NOT clamp motor housing in a vise or strike with a hammer. Starter motors contain ceramic magnets that could be broken or cracked if the housing is damaged.

The disassembly and inspection procedure of the two starter motors is similar. Where a procedure or specification is different, those differences will be shown. See **Fig. 13** (radial compression brush spring) or **Fig. 14** (axial compression brush spring) for exploded view of the two starter motors. Scribe a mark on drive end cap and starter housing for alignment purposes when reassembling.

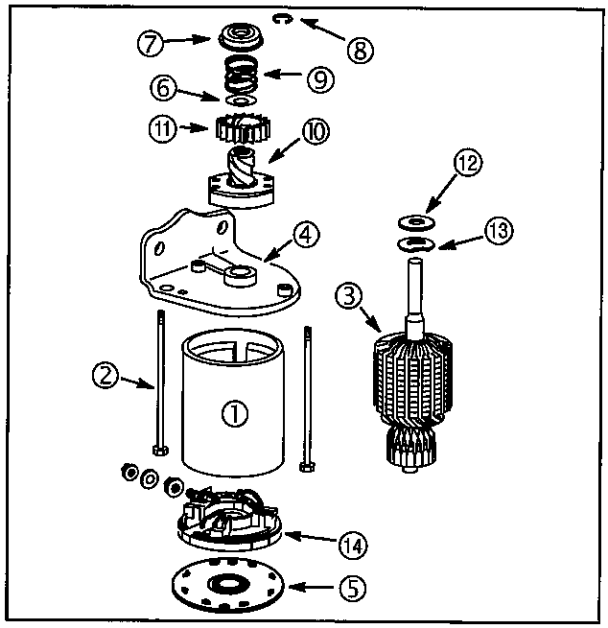



Fig. 13

1. Remove pinion gear assembly.
2. Remove thru bolts (2) and drive end cap (4).

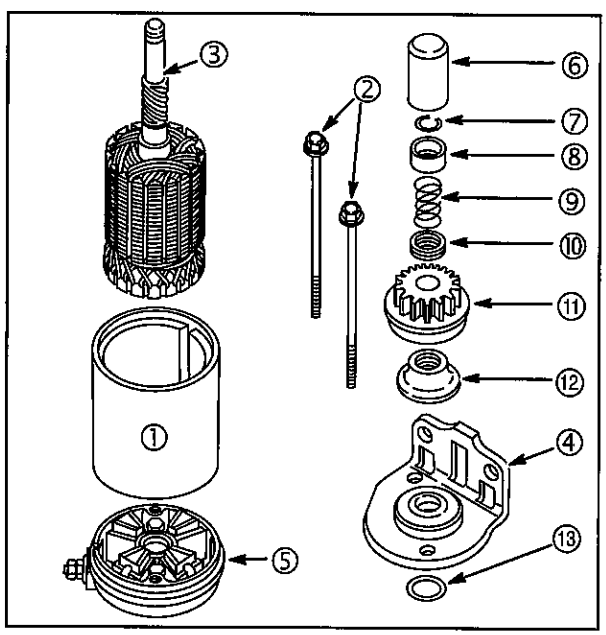



Fig. 14

3. Hold the armature (3) and commutator end cap (5) against a work surface while sliding housing (1) off the armature, **Fig. 15.**

**NOTE:** This allows the brush retainer to remain assembled to commutator for inspection of brush-to-commutator contact.

4. Remove end cap and brush retainer with brushes. Replace end cap if bushing is worn or damaged.

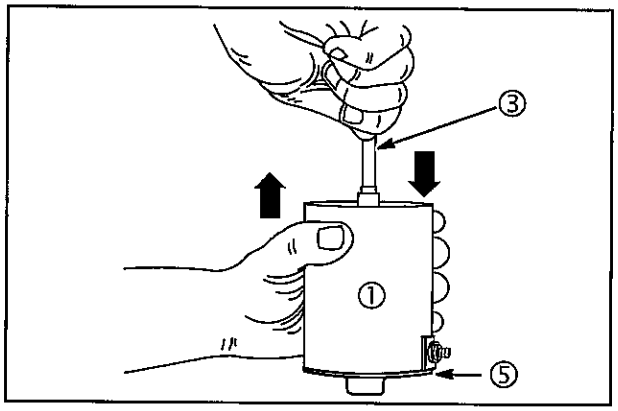



Fig. 15

## Inspect Armature Commutator

The armature commutator shown in **Fig. 16 (A)** can be cleaned with fine sandpaper. DO NOT use emery cloth. The commutator can be machined a diameter of NO LESS THAN **1.230" (31.24 mm)**.

Slots between commutator bars should be cleaned as shown in **Fig. 16 (A)** after sanding or machining.

Check the armature for shorts with a growler.

**NOTE:** The style armature commutator shown in **Fig. 16 (B)** cannot be machined.

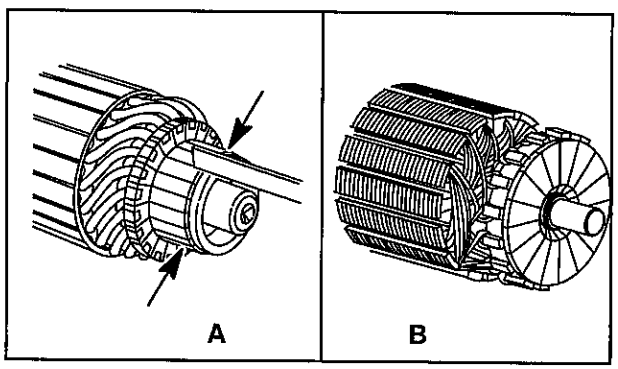



Fig. 16

## Inspect Brushes

Check the brushes for proper seating, weak brush springs, dirt, oil or corrosion. Brush springs should be strong enough to ensure good brush contact with armature. Replace the brushes if worn to **1/4" (6 mm)** (1) or less **Fig. 17 (A)**, or **1/8" (3 mm)** (2) or less, **Fig. 17 (B)**. Lengths of new brushes (3) are shown for reference.

Verify that the brushes are not sticking in their holders.

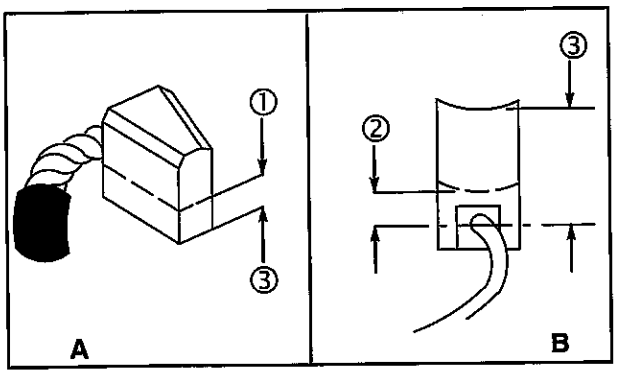



Fig. 17

## Replace Brushes

Three different brush end caps are used. Refer to **Fig. 18** for radial flat coil spring end caps.

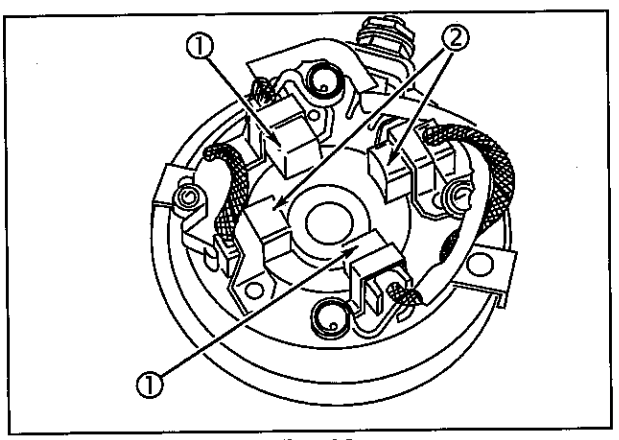



Fig. 18

Refer to **Fig. 19** for radial compression spring end caps.

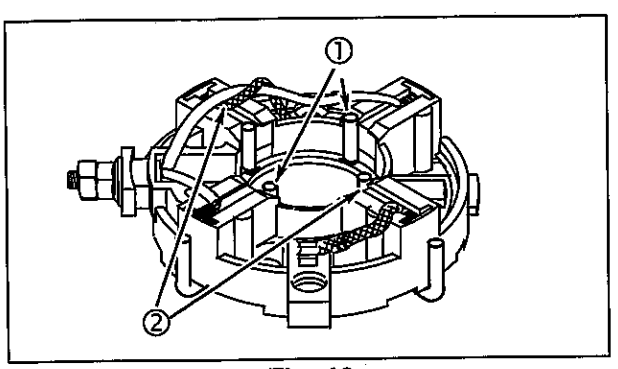



Fig. 19

Refer to **Fig. 20** for axial compression spring end caps and for the correct location of positive brushes (1), negative brushes (2), brush leads and wire routing. Note order of assembly for insulators, washers and screws or nuts.

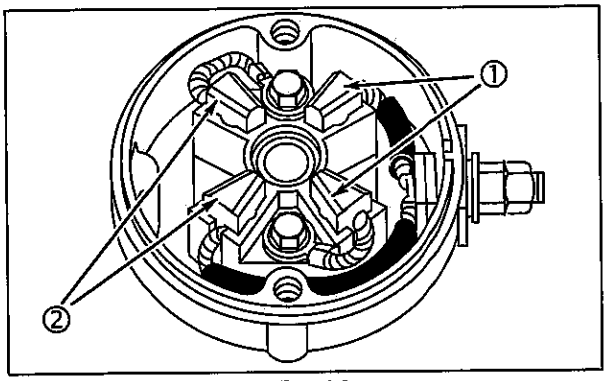



Fig. 20

## Assemble End Cap

**NOTE:** When all parts have been inspected, lightly lubricate bearings in both end caps with #20 oil.

### *Radial Flat Coil Brush Spring*

1. Assemble armature to brush end cap before installing brushes.
2. Install brush in holder.
3. Position coil spring over tab (1), **Fig. 21**.
4. While holding spring on tab, use a screwdriver and bend spring clockwise and position over end of brush.
5. Push spring down firmly over tab.
6. Repeat for remaining brushes.

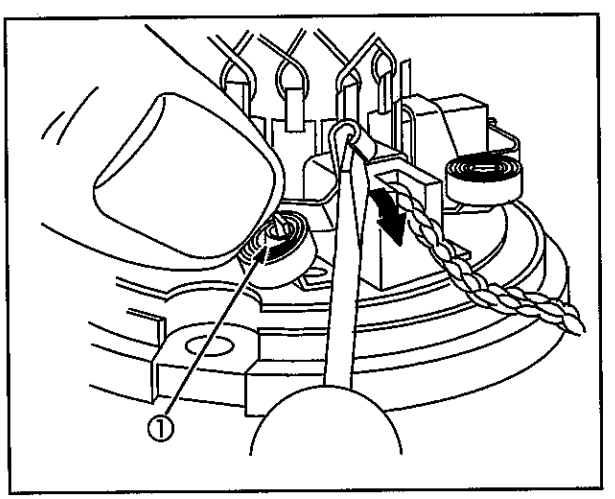



Fig. 21

### *Radial Compression Brush Spring*

End caps with radial compression type springs require 4 brush retainers (1) to hold brushes clear of armature commutator, **Fig. 22.**

Brush retainers can be made from Part **#26634** control wire or similar material. The retainer is U shaped, with two legs **1/2" (13 mm) high** (2), **3/4" (19 mm) long** (3), **Fig. 22**, inset.

1. Install brush spring and brush into holder.
2. Compress brush and spring. Install retainer.
3. Repeat for remaining brushes.

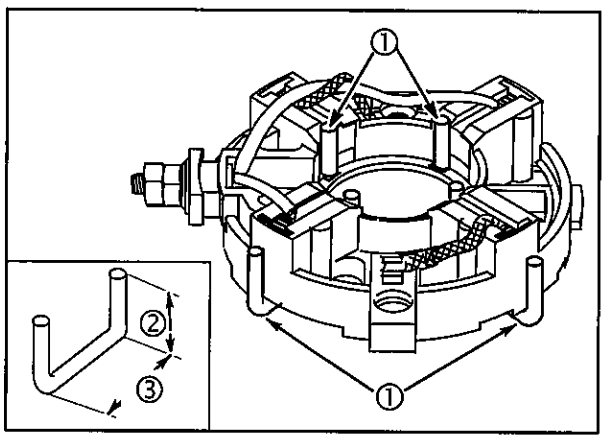



**Fig. 22**

***Axial Compression Brush Spring***

Use a brush retainer to hold brushes in place while assembling the armature to the end cap.

Dimensions for the brush retainer in **Fig. 23** are:

(1) – 7/8" (22 mm)
(2) – 2" (51 mm)
(3) – 1" (25 mm)
(4) – 1" (25 mm)
(5) – 1/4" (6 mm) radius
(6) – 2-1/2" (64 mm)

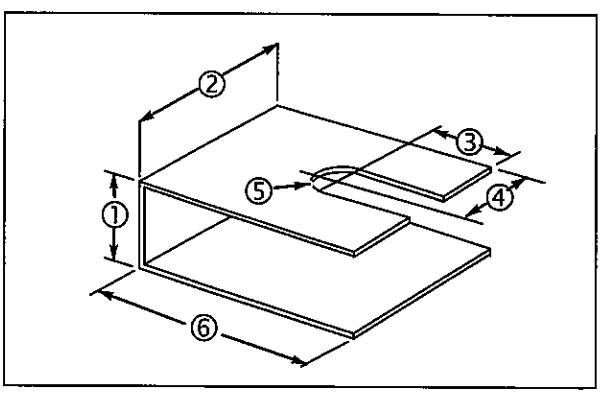



**Fig. 23**

1. Install positive (7) and negative (8) brushes with beveled edge UP in position shown, **Fig. 24.**

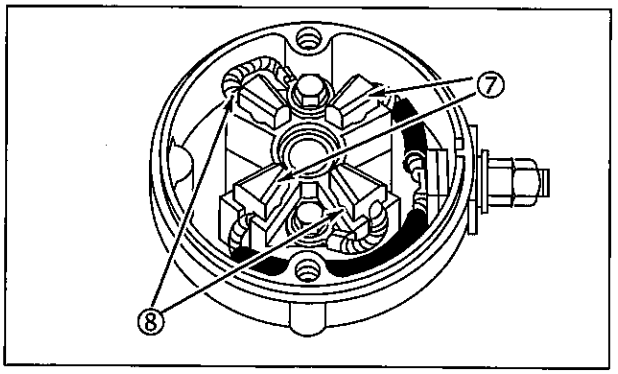



**Fig. 24**

2. Compress brushes and springs. Assemble brush retainer to end cap, **Fig. 25.**

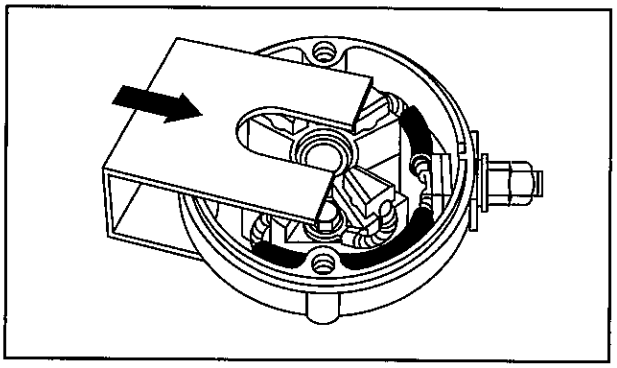


**Fig. 25**

## Assemble Armature

When all parts have been inspected, lightly lubricate bearings(1) in both end caps with **#20** oil, **Fig. 26.**

1. Install spacer (2) to armature shaft (if equipped).
2. Assemble armature to brush end cap.
3. Remove brush retainer(s).

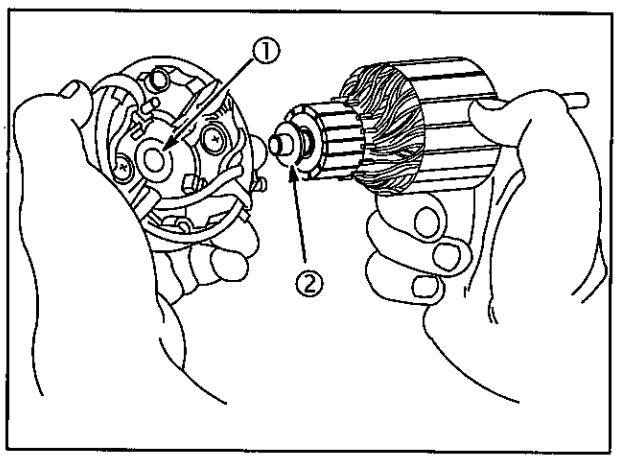



**Fig. 26**

## Assemble Housing

The starter housing (1) has a large notch (3) which indexes over the insulated terminal, **Fig. 27.**

1. Push down on armature and brush end cap.
2. Slide starter housing (1) over armature (2), aligning notch with insulated terminal.

**NOTE:** Use care to prevent damage to magnets in starter housing.

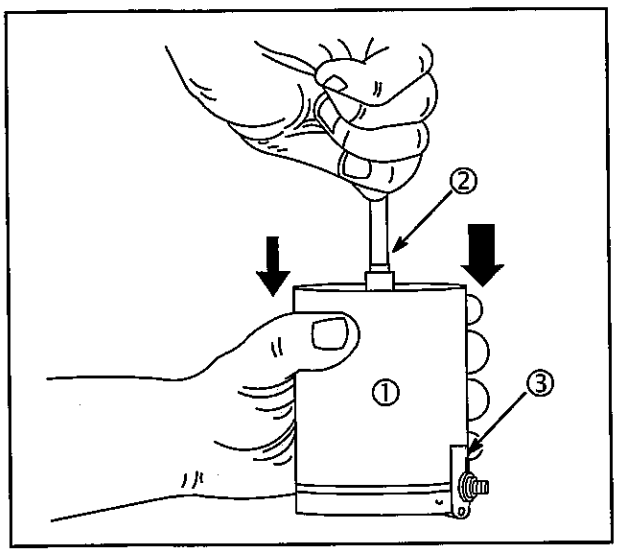



**Fig. 27**

7

## Install Drive End Cap

1. Assemble spacer washer (1) and spring washer (2, if equipped) to armature shaft, **Fig. 28**.
2. Assemble drive end cap (4) to armature shaft.
3. Align mark on end cap with mark on housing.
4. Install thru bolts (3). Torque to **50 in. lbs. (6 Nm)**.
5. Spin armature to check for binding. Correct any binding.
6. Install starter drive.

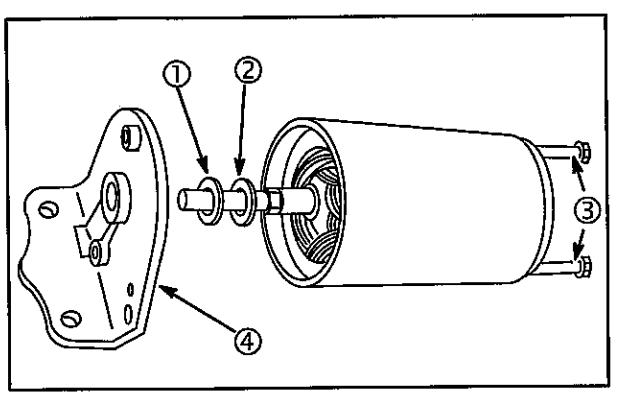



**Fig. 28**

# STARTER MOTOR SERVICE

***Models 540000, 610000***

## Remove Starter Solenoid

1. Remove nut and field coil wire from stud terminal.
2. Remove solenoid mounting nuts and solenoid
3. Lift solenoid to disengage drive lever from plunger, **Fig. 29**.

**NOTE:** Hold starter in vertical position with drive housing side DOWN when removing and installing solenoid.

**Fig. 29**

## Install Starter Solenoid

4. Engage flats on plunger (1) with fork in drive lever (2) and assemble solenoid to starter, **Fig. 30**. Torque nuts to **70 in. lbs. (8 Nm)**.
5. Install field coil wire and nut. Torque nut to **90 in. lbs. (10 Nm)**.

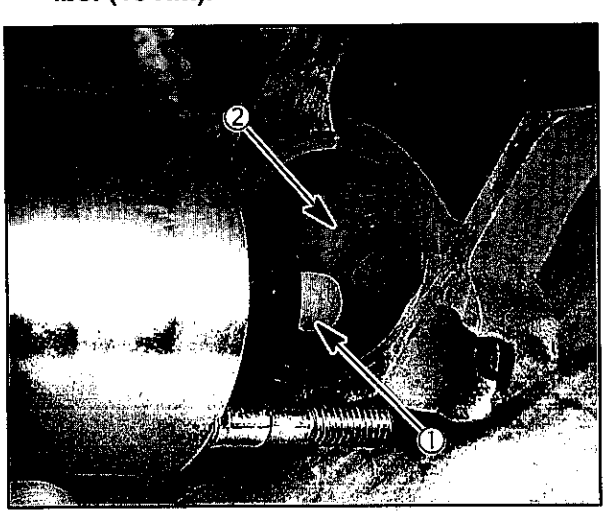



**Fig. 30**

## Pinion Gear

Pinion gear replacement requires complete starter motor disassembly. A thorough inspection of all components should be performed at that time.

### *Disassemble Starter*

For ease of disassembly and assembly, clamp drive end housing in a vise as shown, **Fig. 32**.

**NOTE:** Do not damage drive housing or mounting surface.

1. Remove solenoid.
2. Remove starter thru bolts.
3. Remove brush end cap, **Fig. 31**.

**NOTE:** To prevent losing brush springs, do not remove brush retainer (1) until starter housing has been removed from drive end cap, **Fig. 31**.

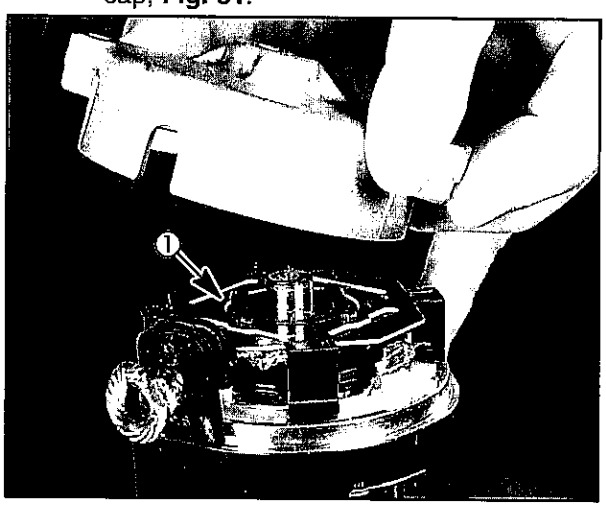



**Fig. 31**

4. Remove starter housing from drive end cap, **Fig. 32**.

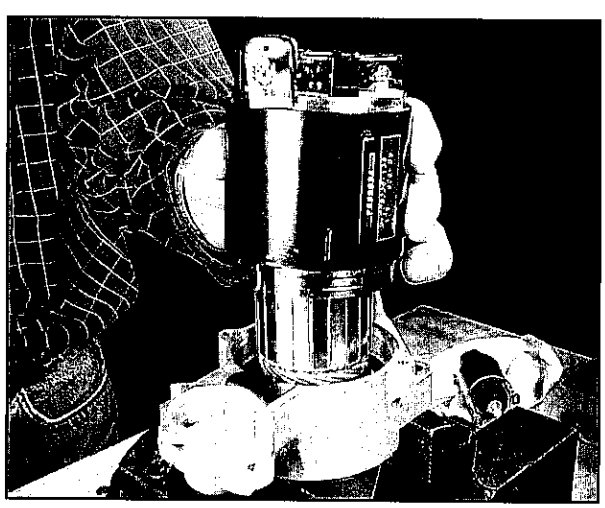


**Fig. 32**

5. Remove armature and pinion gear with drive lever from drive end cap, **Fig. 33**.

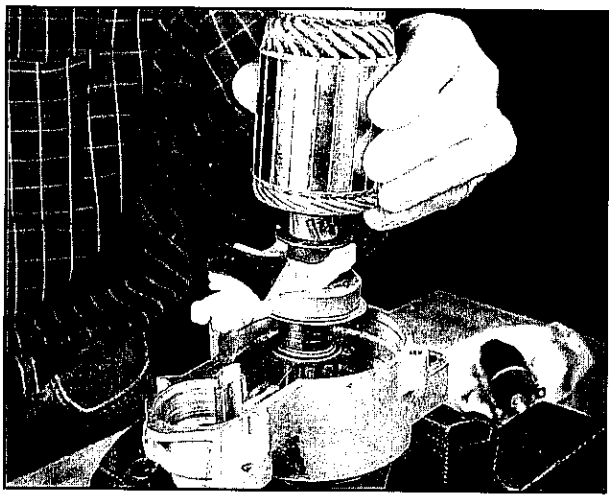


**Fig. 33**

6. Remove spacer from armature shaft.
7. Use a 14 mm Carburetor Socket **#19458** to drive retainer from C-ring, **Fig. 34**. Remove and discard C-ring and retainer.

**NOTE:** Always use a new C-ring and retainer.

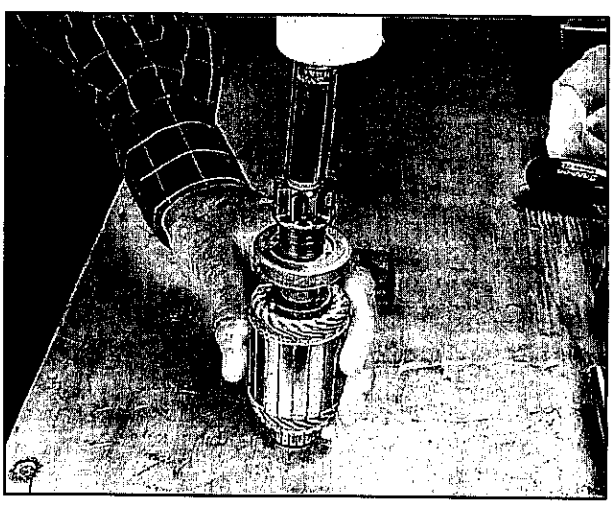


**Fig. 34**

8. Remove pinion gear and clutch assembly, **Fig. 35**.

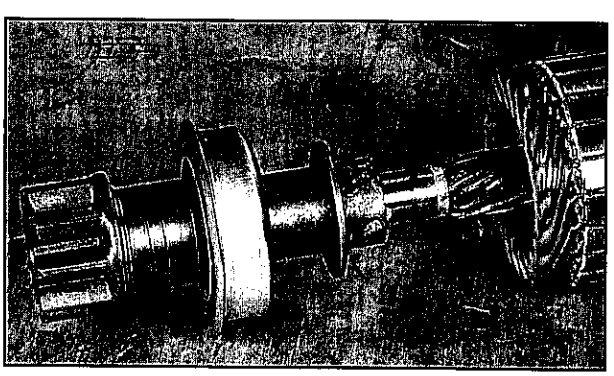


**Fig. 35**

Clean and inspect helix. If helix is damaged, replace starter. Inspect bearing journals on armature shaft for wear or damage. If bearing journals are worn or damaged, replace starter.

**NOTE:** Bearings in drive and brush end cap are not replaceable.

### *Inspect Armature Commutator*

The armature commutator may be cleaned with fine sandpaper (#300 – 500 grit). DO NOT use emery cloth.

Commutator may be machined to **no less than 1.063" (27 mm), Fig. 36.**

Slots between commutator bars should be cleaned with a hack saw blade after cleaning or machining.

The armature should be checked for shorts with a growler.

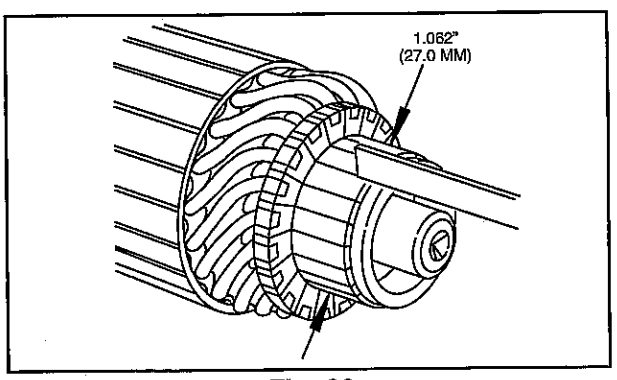



**Fig. 36**

### *Inspect Brushes*

Minimum brush dimension (1) is **1/4" (6 mm).** If brushes are worn less than specification, replace the starter housing, **Fig. 37.**

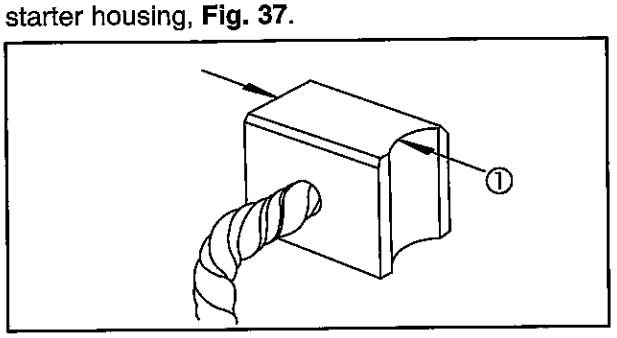



**Fig. 37**

Use digital multimeter and check for continuity between field coil wire and brushes shown, **Fig. 38.**

The following test will be made with the meter in the ⊣◀ ))) (Diode Test) Position.

1. Attach either meter test lead to field coil wire (2).
2. Contact first one, then other brush with other test lead as shown.
   a. Meter should indicate continuity (continuous tone).
   b. Replace starter housing if meter does not indicate continuity.

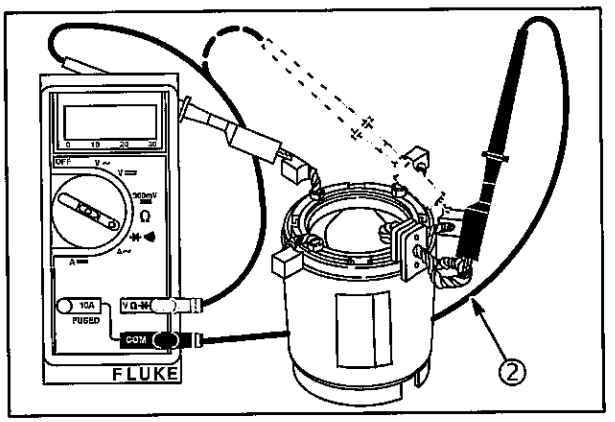



**Fig. 38**

3. Attach either test lead to starter housing, **Fig. 40.**

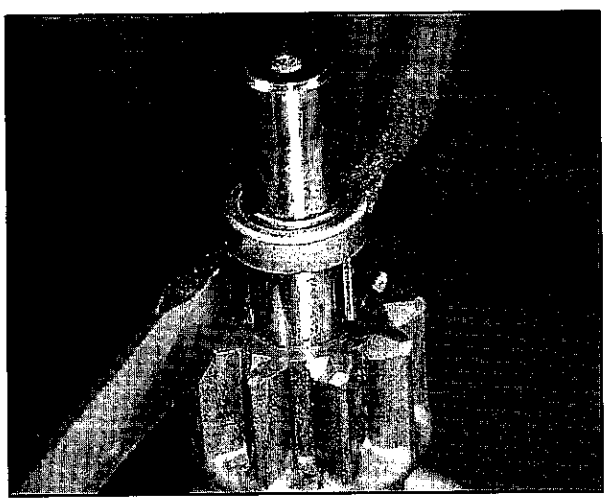


**Fig. 39**

4. Contact first one, then the other brush with other test lead as shown.
   a. Meter should indicate continuity (continuous tone).
   b. Replace starter housing if meter does not indicate continuity.

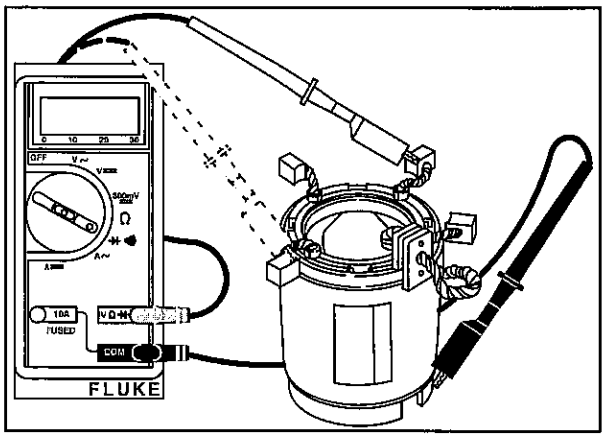



Fig. 40

***Assemble Pinion Gear***

1. Lubricate helix with a light coat of grease. Assemble pinion gear and clutch.
2. Assemble new retainer to shaft.
3. Install new C-ring.
4. Pry up on retainer until C-ring snaps into groove in retainer, **Fig. 39**.
5. Assemble spacer to armature shaft, **Fig. 41**.

**NOTE:** Lip (1) on spacer must face bearing in drive end cap.

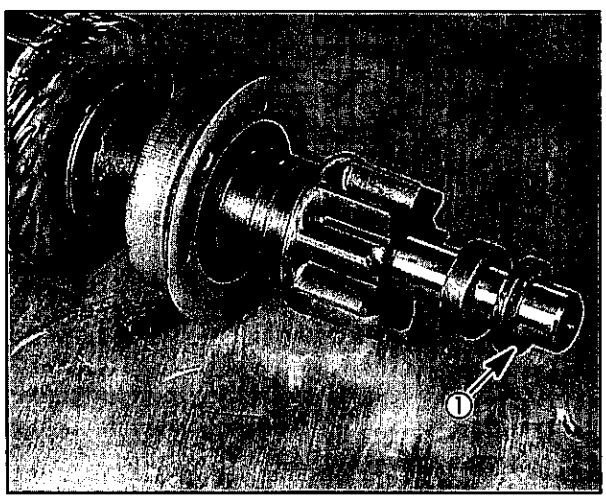



Fig. 41

***Assemble Starter***

1. Assemble drive lever (2) to pinion (1). Install armature and drive lever into drive housing (3), **Fig. 42**.

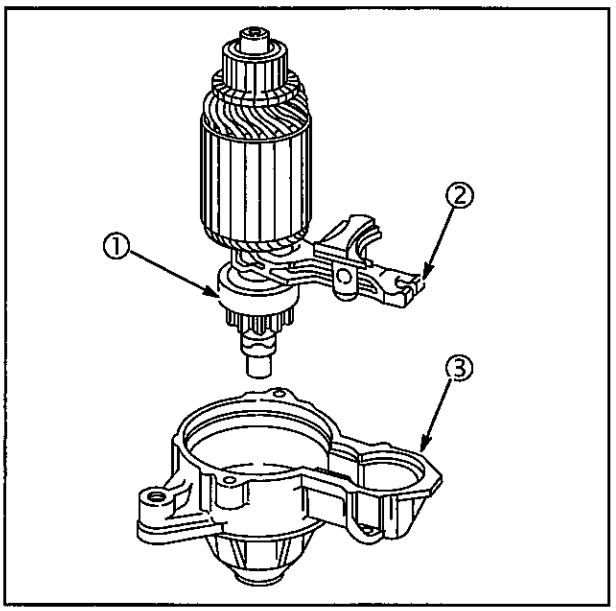



Fig. 42

2. Assemble starter housing to drive housing, engaging notch in housing with tab on drive lever support, **Fig. 43**.

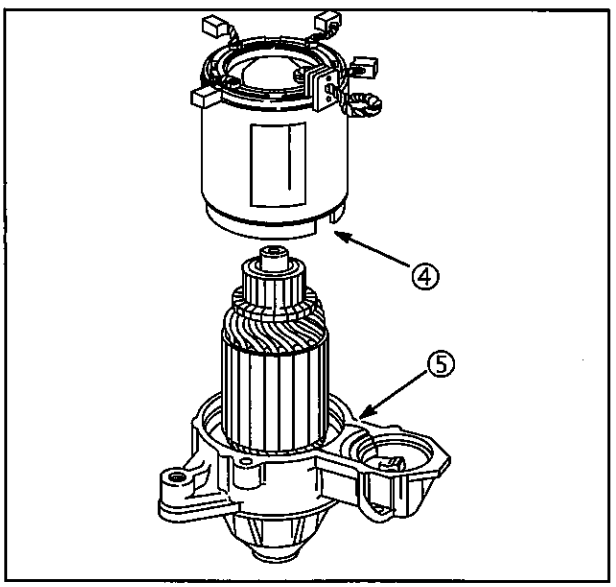



Fig. 43

3. Install brush holder, inserting tabs on brush holder (6) into starter housing slots (7), **Fig. 44**.

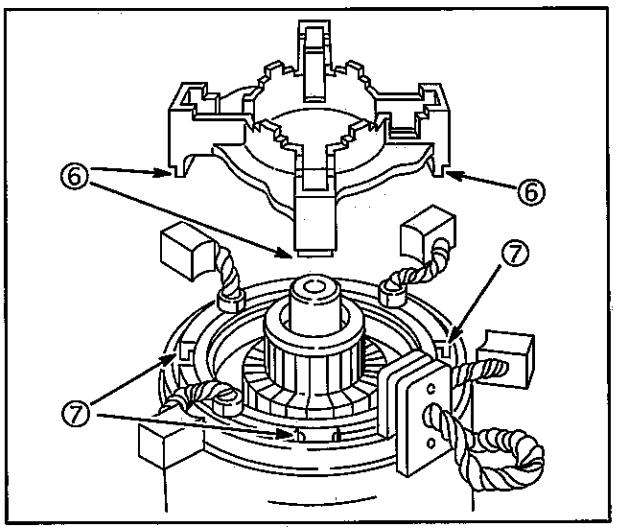



Fig. 44

4. Insert brushes into brush holder, **Fig. 45**.

5. Compress springs with needle nose pliers and insert spring behind brushes.

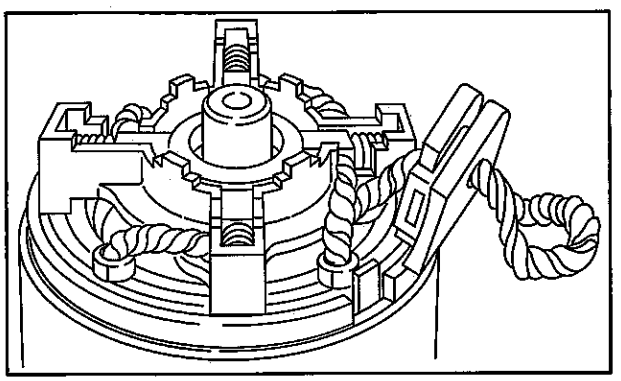


Fig. 45

6. Install brush retainer plate (7), **Fig. 46**.

7. Assemble rubber seal to starter housing. Be sure notch in rubber seal (8) is inserted over tab on housing (9).

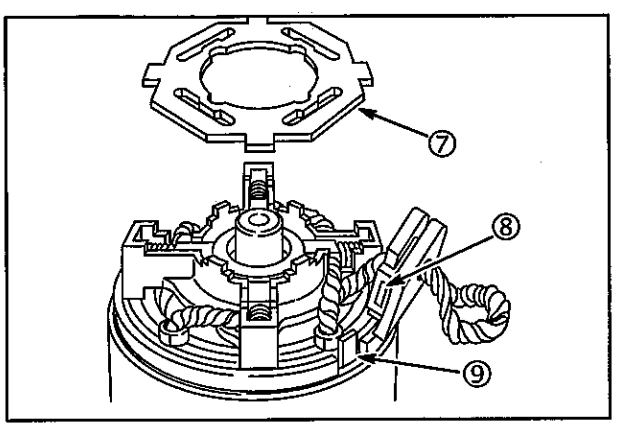



Fig. 46

8. Install end cap, **Fig. 47**. Torque thru bolts to **70 in. lbs. (8 Nm)**.

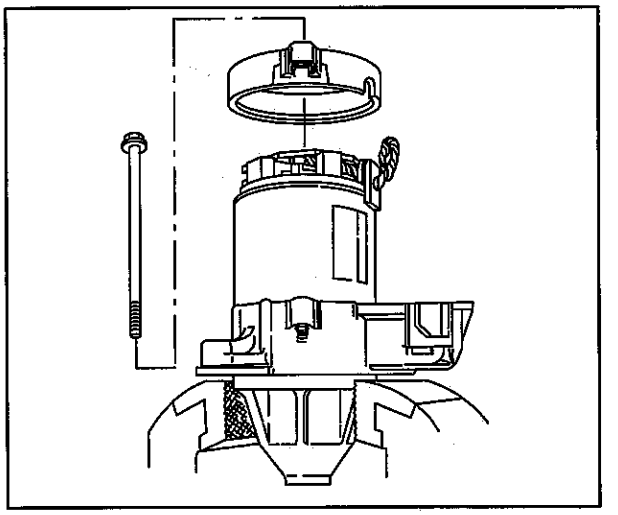


Fig. 47

9. Install solenoid, see "Starter Solenoid."

## RING GEAR SERVICE

**NOTE: Ring gear is not replaceable on models 540000, 610000.**

1. Mark center of rivets holding the ring gear (1) to flywheel (4), **Fig. 48**, with a center punch.

2. Drill out rivets using a **#13** drill bit.

3. Remove ring gear and clean mounting surface.

4. Attach new gear to flywheel using four screws (2) and lock nuts (3) provided with gear. Tighten nuts and screws securely.

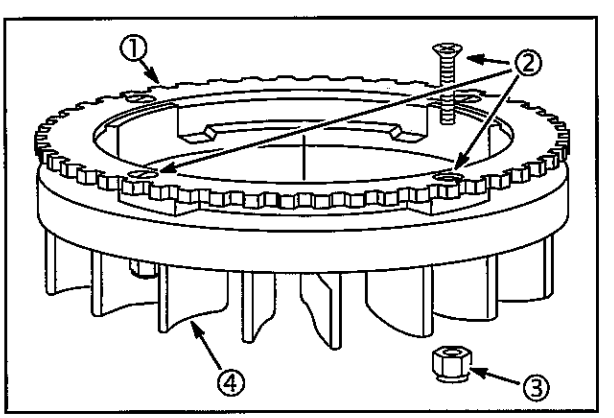



Fig. 48

## REWIND STARTER IDENTIFICATION

Two rewind starters are used on V-Twin engines. The rewind starter components (including the starter and cup) are NOT INTERCHANGEABLE between starters. **Figure 49** shows how to identify the rewind starters.

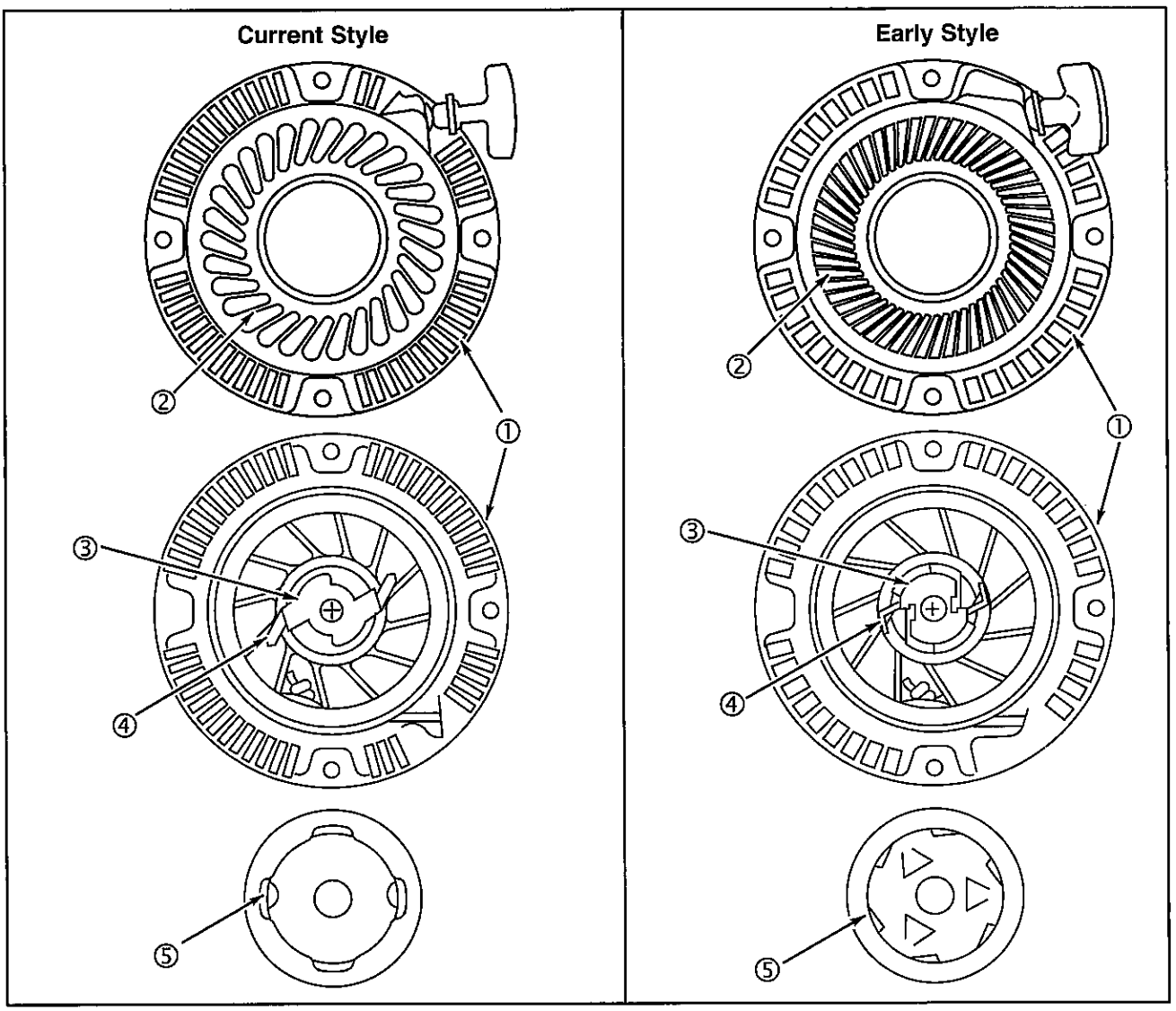



**Fig. 49**

1. Rewind Starter.
2. Air Inlet Slots – larger on current starters.
3. Retainer – nylon on current starters, metal on early starters.
4. Starter Dogs – nylon on current starters, metal on early starters.
5. Starter Cup – large notches on current starters, small notches on early starters.

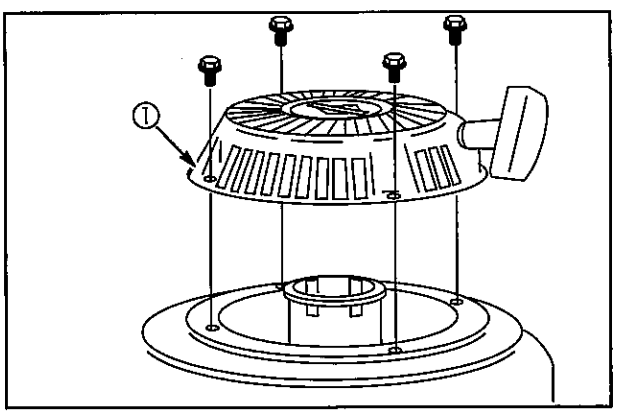



**Fig. 50**

## REWIND STARTER SERVICE

### Remove Rewind Starter

1. Remove four screws and rewind starter (1), **Fig. 50**.

## Replace Rope

### *Remove Rope*

1. Pull rope out partially. Tie a temporary knot (4), **Fig. 51**.
2. Remove insert (1) from rope handle (2). Pull knot out of rope insert.
3. Untie knot. Remove insert and handle from rope.
4. Pull rope (3) out as far as it will go.
5. While holding rewind pulley, grasp knot with a pair of needle nose pliers and pull rope out of pulley.
6. Slowly release spring tension on pulley until pulley stops turning.

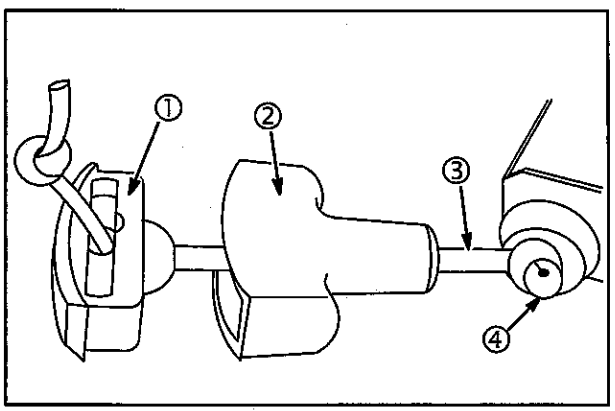



**Fig. 51**

### *Install Rope*

**NOTE:** Cut replacement rope to **80" (203 cm).**

1. After cutting rope, heat end with an open flame. Wipe with a rag to prevent unraveling.
2. Tie a figure eight knot at one end of rope, **Fig. 52**.

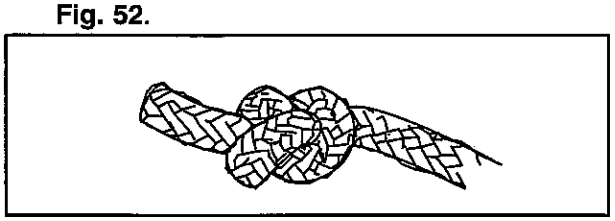


**Fig. 52**

3. Rotate pulley COUNTERCLOCKWISE (arrow) six complete turns, **Fig. 53**.
4. Rotate pulley CLOCKWISE just until rope hole in pulley (2) is in line with starter housing eyelet (1).
5. Hold pulley in this position.

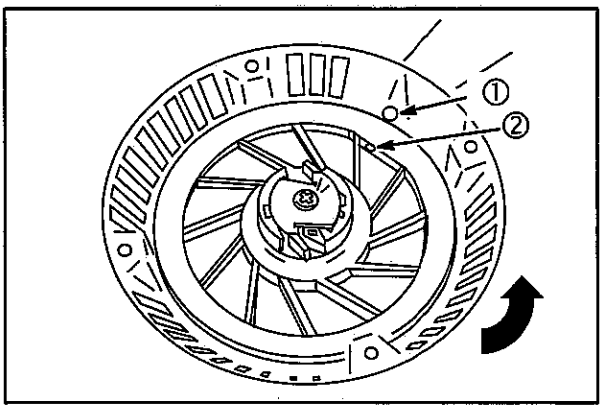



**Fig. 53**

6. Insert rope through pulley and eyelet in housing, **Fig. 54**.
7. Pull rope until knot is seated.
8. While holding pulley, tie a temporary knot part way out on rope.
9. Let pulley and spring slowly rewind pulling rope into temporary knot.

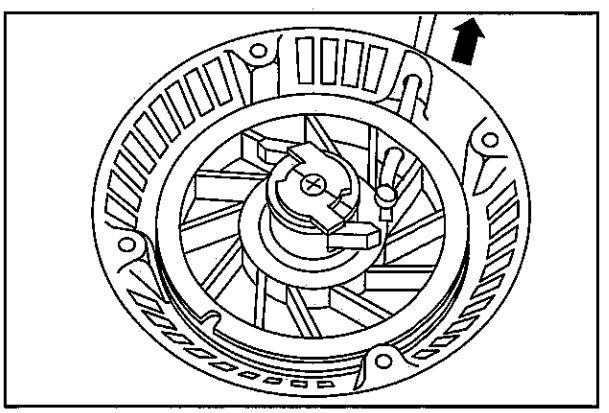


**Fig. 54**

10. Insert rope (4) through starter rope handle (3) and handle insert (2), **Fig. 55**.
11. Tie knot on end of rope.
12. Pull knot (1) into rope insert and pull insert into rope handle.
13. Untie temporary knot (5) and slowly let rope rewind into starter.
14. Operate starter to check for smooth operation.

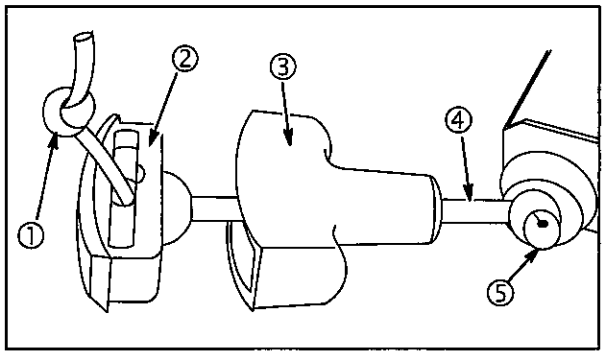



Fig. 55

## Replace Pulley and Spring

***Current Style***

**CAUTION**

**PREVENT EYE INJURY!**

- Wear eye protection when working on starter pulley and spring.
- Pulley and spring is serviced as an assembly. DO NOT remove spring from pulley.

1. Remove rope.
2. Remove shoulder screw (1) and retainer (2), **Fig. 56**.
3. Lift out dogs (3) and dog springs (4).

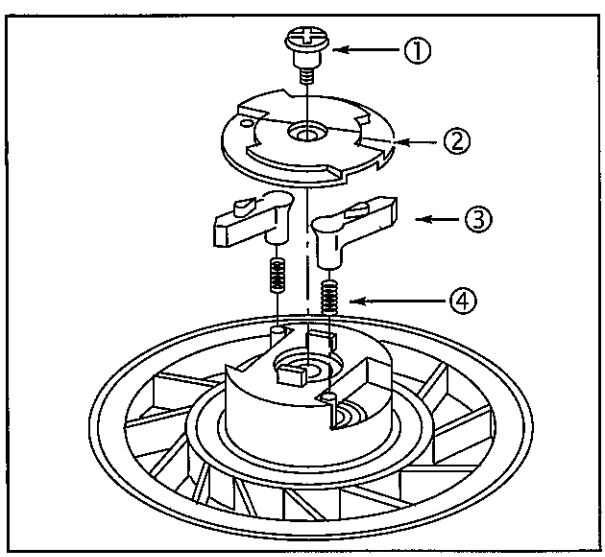



Fig. 56

4. Rotate pulley CLOCKWISE until pulley disengages spring.
5. Carefully lift out pulley with spring, **Fig. 57**.

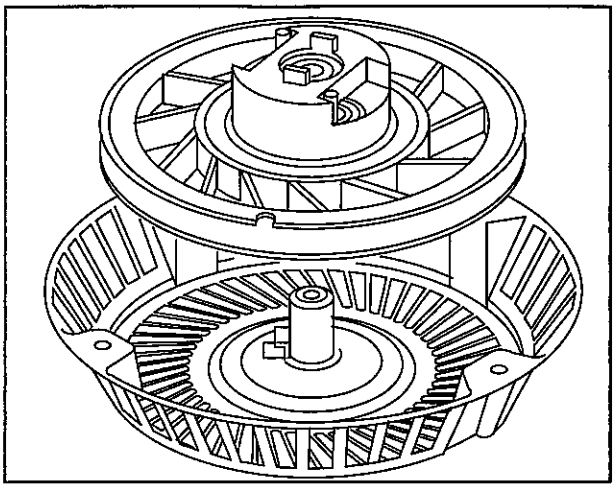


Fig. 57

***Inspect Starter Housing and Pulley***

Inspect pulley for wear, cracks, rough edges or burrs in pulley groove (2) and wear on center hole (1), **Fig. 58**. Replace pulley if damaged or worn.

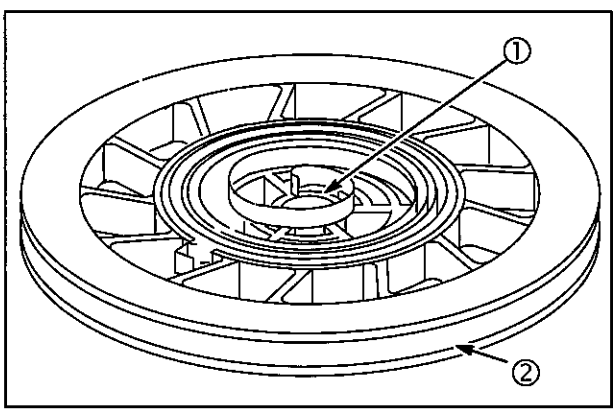



Fig. 58

Inspect starter housing for wear or sharp edges at rope eyelet (4), center pivot post (5), and inner spring anchor (3) tab, **Fig. 59**. Replace housing if worn or damaged.

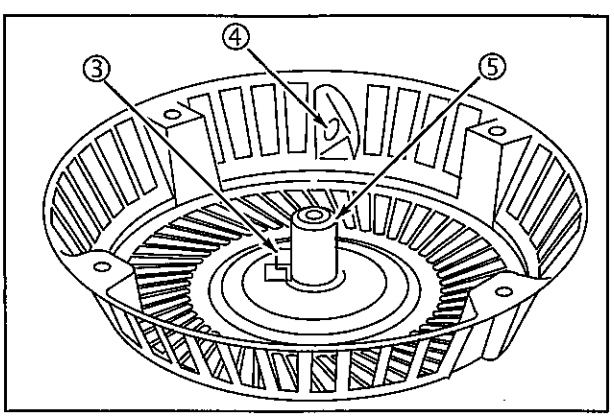



Fig. 59

### *Assemble Pulley To Housing*

1. Lay starter housing on work bench.
2. Assemble starter pulley (1) and spring assembly to center pivot post (2) in housing, **Fig. 60.**

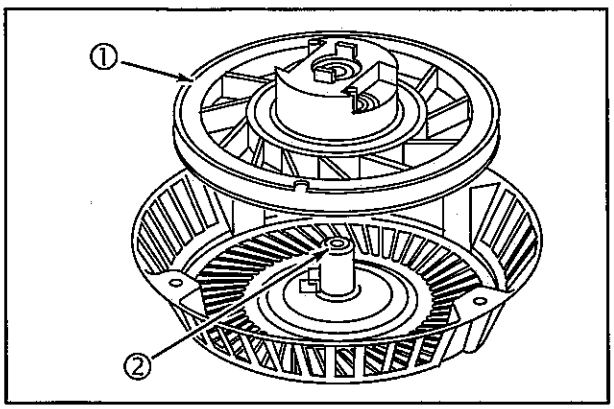



**Fig. 60**

3. Rotate pulley COUNTERCLOCKWISE until slight resistance is felt, indicating that spring is engaged in spring tab in housing, **Fig. 61.**

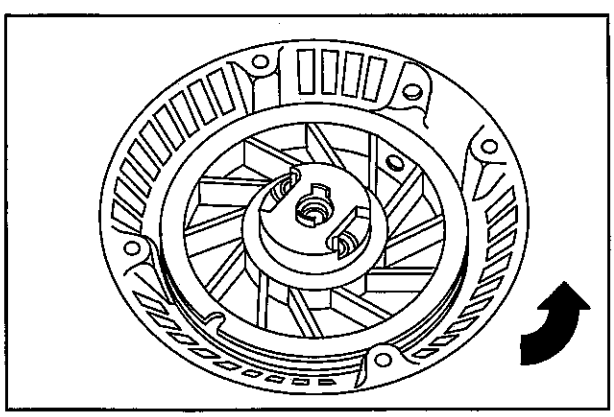


**Fig. 61**

### *Install Dogs, Dog Springs, Retainer Assembly*

1. Position springs (3) over posts in pulley (1). Install dogs (2), **Fig. 62.**

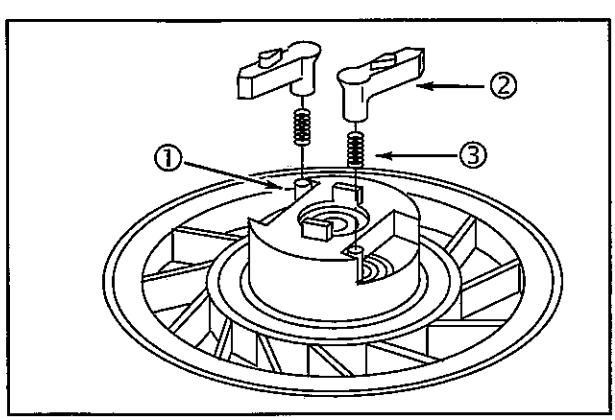



**Fig. 62**

2. Install retainer making sure that slots (4) in retainer (6) engage tabs (7) on pulley, **Fig. 63.**
3. Hold retainer down, compressing dog springs and install retainer screw (5). Torque screw to **70 in. lbs. (8 Nm).**
4. Install rope.

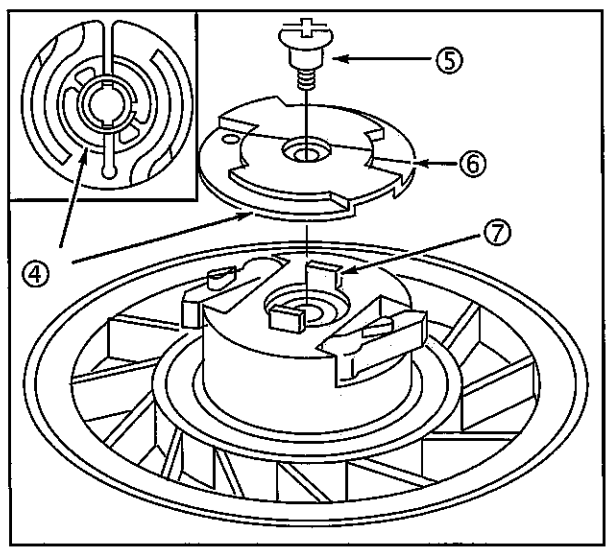
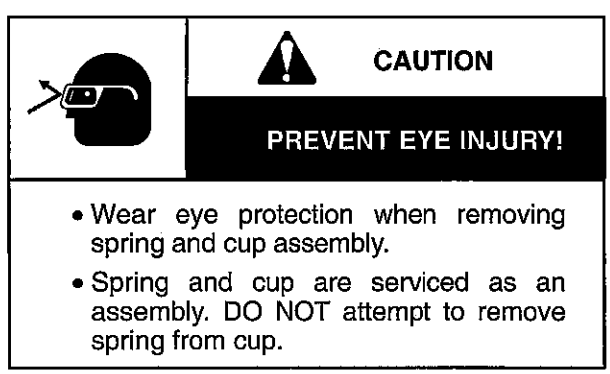



**Fig. 63**

## Replace Pulley and Spring

### *Early Style*




1. Remove rope.
2. Remove shoulder screw (1), small washer (2), retainer (3), brake spring (4) and large washer (5), **Fig. 64.**

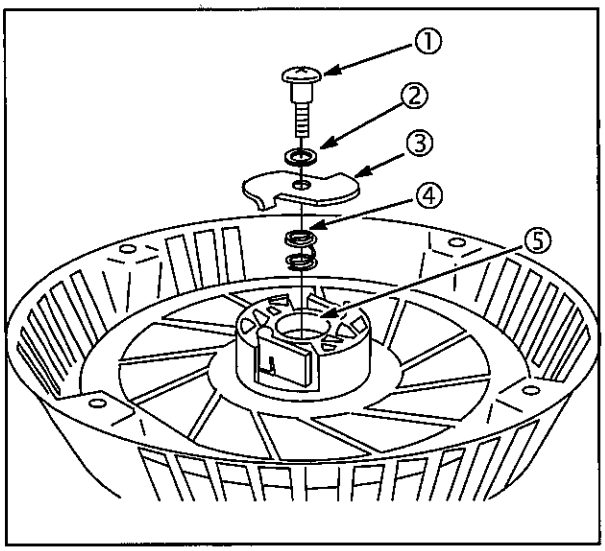



Fig. 64

3. Lift out dogs (6) and dog springs (7).
4. Rotate pulley (8) until it disengages spring.
5. Carefully lift out pulley, **Fig. 65**.

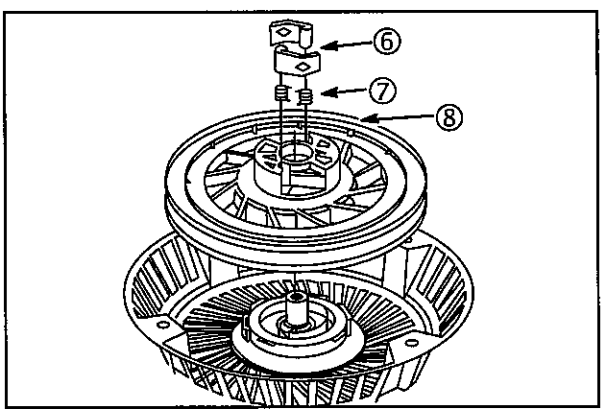



Fig. 65

The starter spring and cup will normally remain as an assembly in starter housing.

6. Remove spring and cup assembly (9) from starter housing, **Fig. 66**.

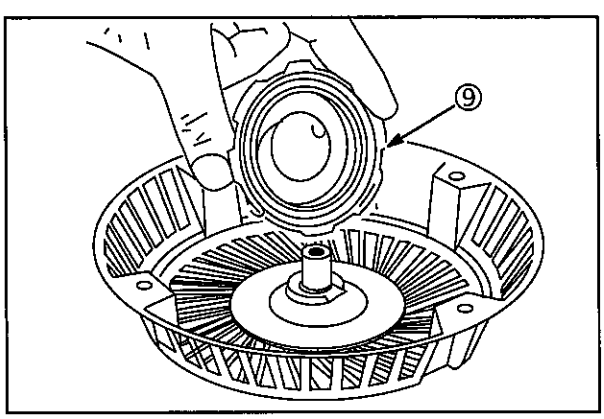



Fig. 66

***Inspect Spring, Starter Housing and Pulley***

Inspect pulley for cracks, rough edges (1) or burrs in pulley groove, wear on spring cup lugs (2), and wear on center hole (3), **Fig. 67**. Replace pulley if damaged or worn.

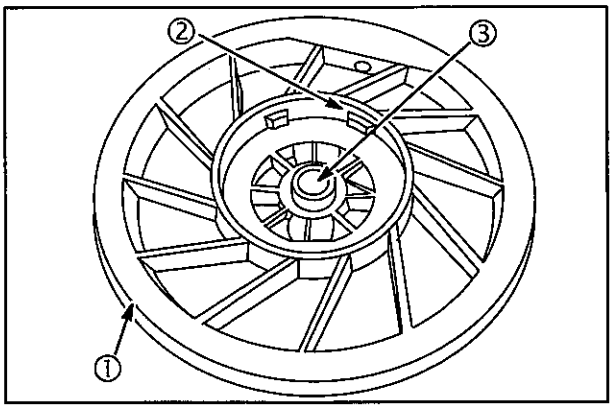



Fig. 67

Inspect starter housing for wear and sharp edges at rope eyelet (5), center pivot post (4), and at inner spring anchor (6), **Fig. 68**. Replace if worn or damaged.

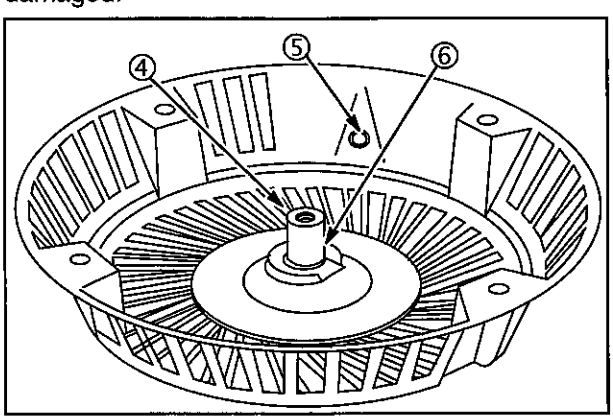



Fig. 68

***Install Spring, Cup Assembly and Pulley In Starter Housing***

1. Place spring and cup assembly in pulley with outer end of spring tab (2) between two wide lugs in pulley (1) and spring cup projections (3) next to the two wide lugs, **Fig. 69**.

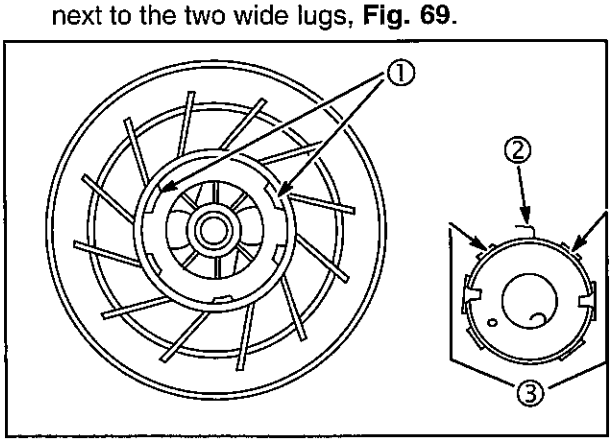



Fig. 69

7

2. Note location of spring tab (5) and location of spring anchor (4) on center post of starter housing.

3. Lower starter housing onto pulley and spring assembly, **Fig. 70.**

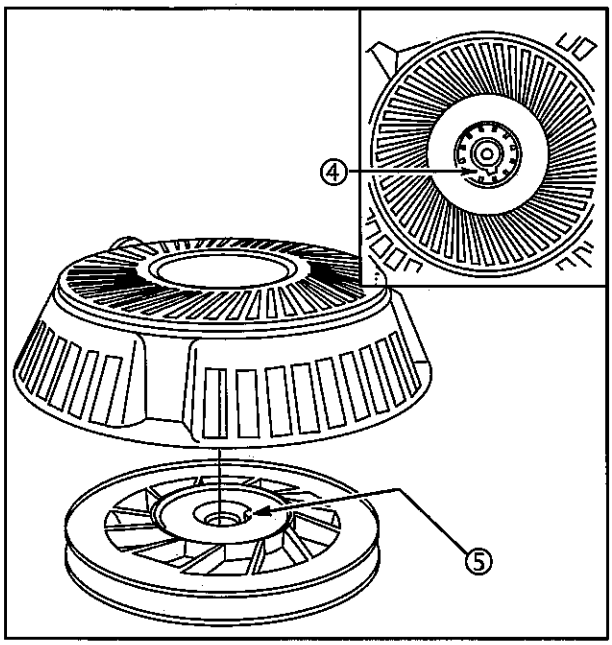



**Fig. 70**

4. Invert assembly, rotate pulley counterclockwise until inner spring tab engages spring anchor, **Fig. 71.**

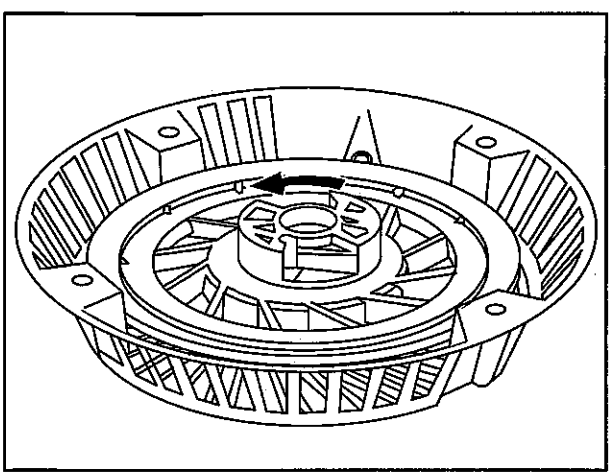


**Fig. 71**

***Install Dogs, Dog Springs, Retainer Assembly***

1. Install dogs (2) and dog springs (1) in pulley, **Fig. 72.**

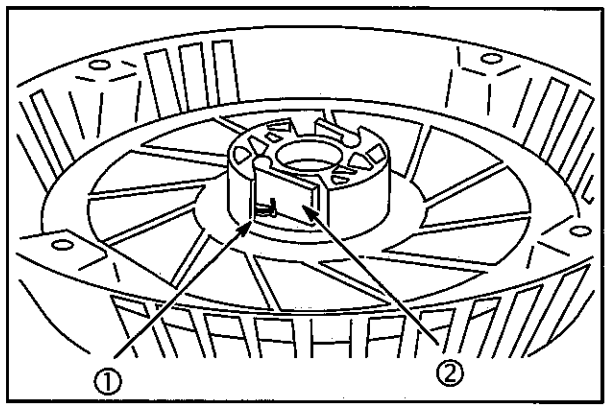



**Fig. 72**

2. Place large washer (7), brake spring (6) and retainer (5) on pulley, **Fig. 73.**
3. Place small washer (4) on shoulder screw (3). Install screw and washer in center pivot post.
4. Position tabs of retainer inside dogs. Torque screw to **70 in. lbs. (8 Nm).**
5. Install rope.

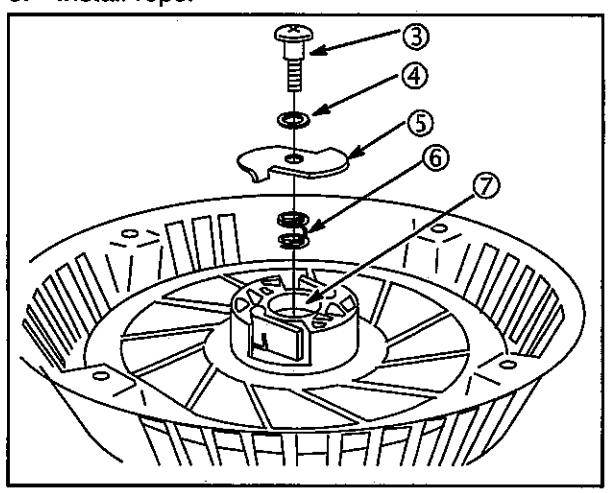



**Fig. 73**

## Install Rewind Starter

1. Install rewind starter on blower housing and install screws (1) finger tight, **Fig. 74.**
2. Pull rope to engage dogs in starter cup.
3. While holding rope, tighten screws to **60 in. lbs. (7 Nm).**

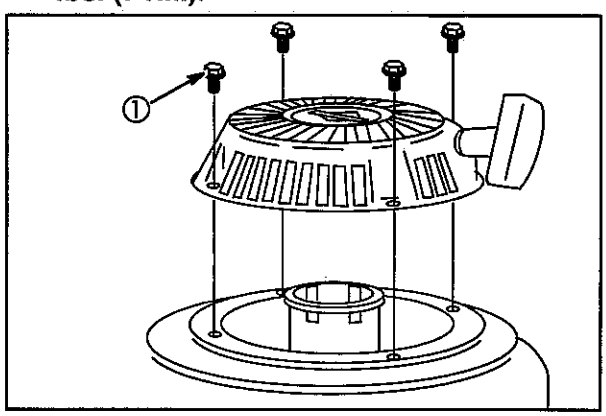



**Fig. 74**

# Section 8
# Lubrication Systems

## GENERAL INFORMATION

Briggs & Stratton Vanguard™ OHV V-Twins use a full pressure lubrication system with an oil filter. The gear driven oil pump (1) draws oil from a screened oil pickup (2) in the sump and pumps the oil through the oil filter (3). The lubrication systems shown are:

Horizontal Crankshaft Engines, **Fig. 1.**

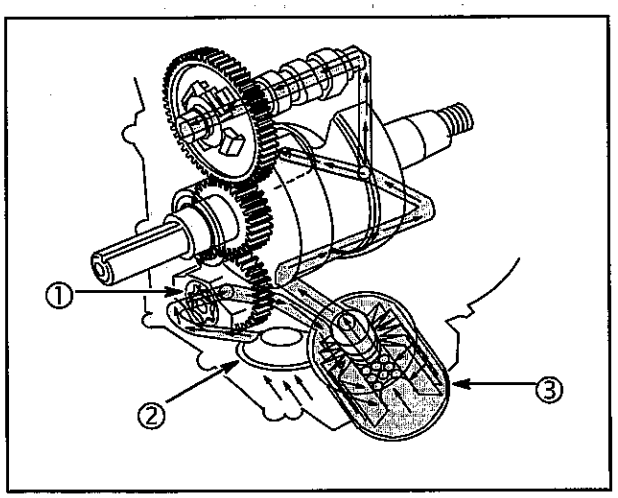



**Fig. 1**

Vertical Crankshaft Engines, **Fig. 2.**

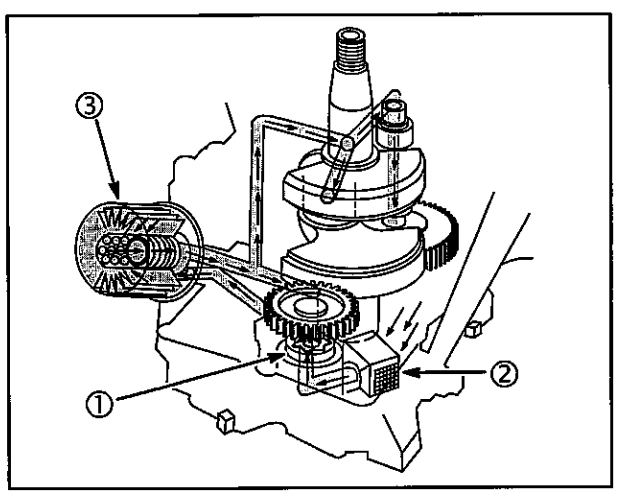



**Fig. 2**

Filtered oil flows through oil galleries in the sump and is distributed to the main bearings, connecting rod bearings and camshaft bearings. Engine oil pressure will vary with oil viscosity, ambient air temperature differences, operating temperatures and engine load. Follow the oil recommendations in Section 1.

A pressure relief valve limits the maximum oil pressure in the system.

An optional oil pressure switch is available. The switch may be used to activate a warning device if oil pressure drops below approximately **5 psi (0.3 Bar)**. The warning device and wiring is supplied by the OEM.

## Crankcase Breather Identification

Vanguard™ engines utilize a breather valve to control and maintain a vacuum in the crankcase. The breather vents crankcase vapors through the air cleaner.

***Models 290000 – 351000***

The breather is located on the valley between the cylinders.

Two styles of breathers are used, **Fig. 3.** The current style breather (left) uses a reed valve (1) to maintain crankcase vacuum. Early style breathers (right) contain a fiber disc type valve (2).

**NOTE:** The early breather mounting screw (3) used a washer (4) and O-rings that are not used on the current screw (5). The screws and breathers are NOT interchangeable.

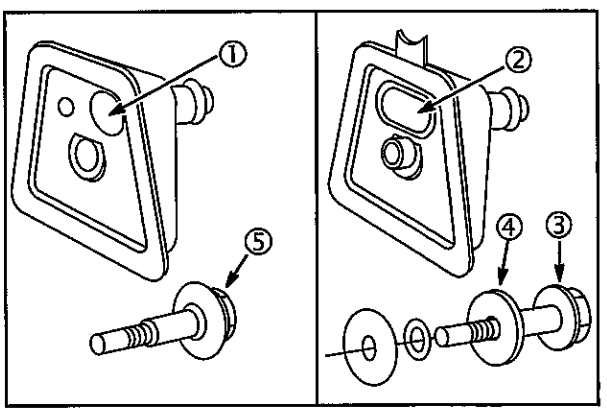



**Fig. 3**

***Models 380000, 540000, 610000***

The breather is located in the valve cover of the number 2 cylinder, **Fig. 4.** The breather uses a reed valve to maintain crankcase vacuum. The reed valve is replaceable.

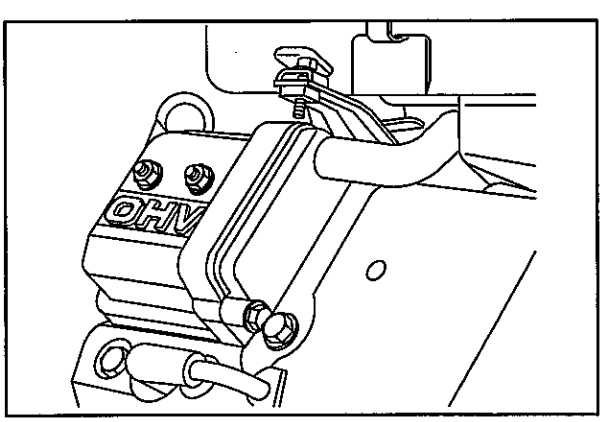



**Fig. 4**

## CRANKCASE BREATHER SERVICE

**Models 290000 – 351000**

Remove the air cleaner assembly.

Remove breather assembly (1). Discard gasket (2), **Fig. 5**.

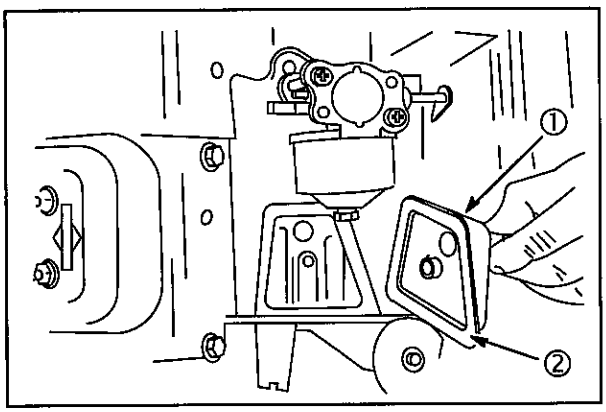



**Fig. 5**

### *Checking Reed Valve Breather*

The reed valve is spring loaded and must make a complete seal around the vent hole (1) in breather body, **Fig. 6**. Check to see that reed valve is not deformed.

**CAUTION:** Do not use force on the reed valve.

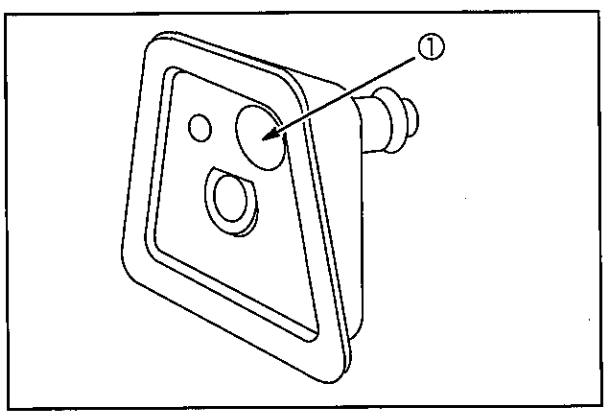



**Fig. 6**

### *Checking Fiber Disc Breather*

If the fiber disc valve (3) is stuck or binding, the breather assembly (1) must be replaced. A **0.045" (1.14 mm)** wire gauge (2) should not enter the space between the fiber disc valve and body, **Fig. 7**.

**CAUTION:** Do not use force on the fiber disc.

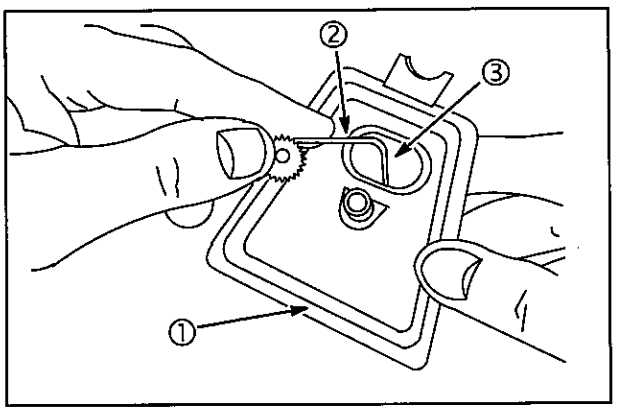



**Fig. 7**

### *Install Reed Valve Breather*

1. Place breather (2) on gasket (3), **Fig. 8**.
2. Assemble large O-ring (1) onto mounting screw.
3. Install screw. Torque to **30 in. lbs. (3 Nm)**.

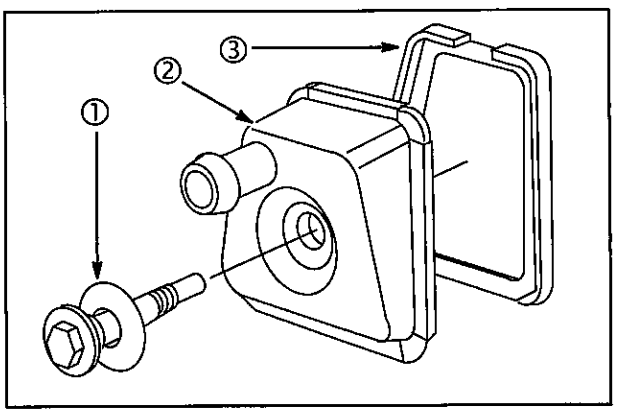



**Fig. 8**

### *Install Fiber Disc Breather*

1. Place breather on gasket.
2. Place large O-ring (1) on breather, **Fig. 9**.
3. Assemble washer (3) and small O-ring (2) to screw.
4. Install screw. Torque to **30 in. lbs. (3 Nm)**.

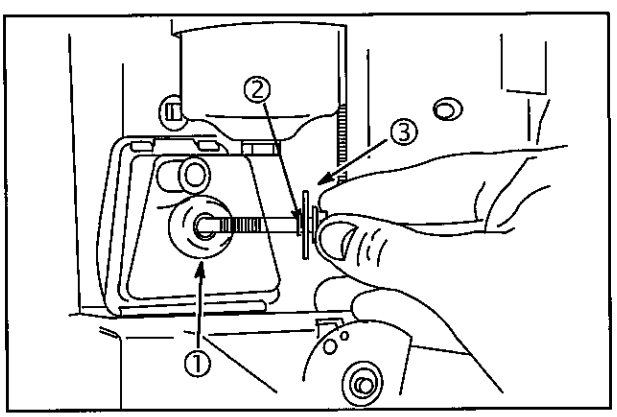



**Fig. 9**

Remove two screws. Separate breather assembly from valve cover, **Fig. 10.**

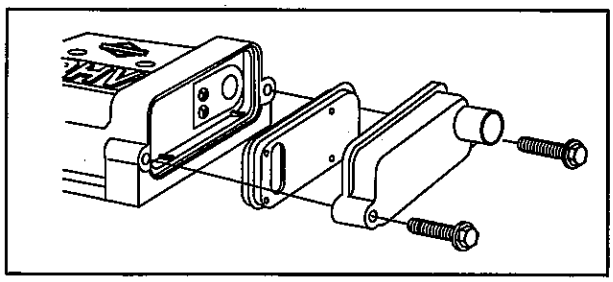


**Fig. 10**

### *Checking Breather*

1. Remove two screws, reed stop and reed valve.
2. Place reed valve on flat surface.
3. Check reed valve for distortion with feeler gauge, **Fig. 11.**

Replace reed valve if the maximum distortion exceeds **0.010" (0.25 mm).**



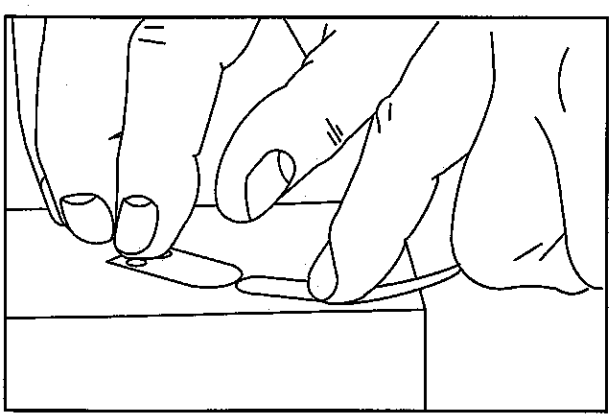


**Fig. 11**

Check reed stop height in the following manner.

4. While holding mounting surface of reed stop on flat surface, use the following drills to check reed stop height, **Fig. 12.**
5. Use **#29** drill as GO gauge.
6. Use **#24** drill as NO-GO gauge.

Replace reed stop if not to specification.

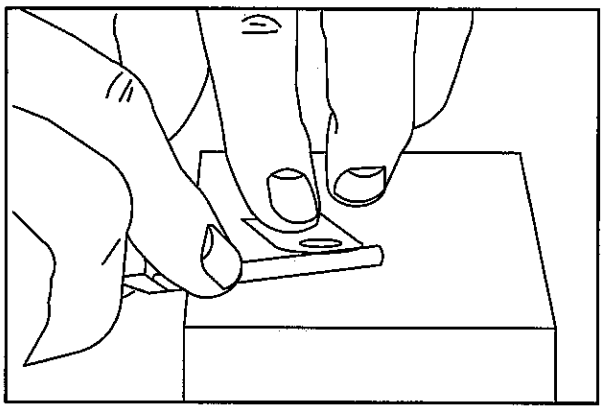


**Fig. 12**

### *Install Breather*

1. Assemble reed valve and reed stop to breather body, **Fig. 13.** Tighten screws securely.

**NOTE:** Holes in reed and reed stop are offset. Assemble so that holes are aligned.

2. Assemble baffle and cover to valve cover with new gasket.
3. Torque screws to **30 in. lbs. (3 Nm).**

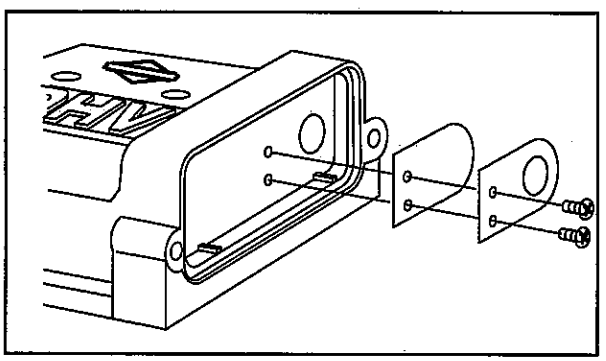


**Fig. 13**

### *Inspect Breather Tube*

Check breather tube(s) (1) for cracks, holes or hardening, **Fig. 14.** Replace if damaged.

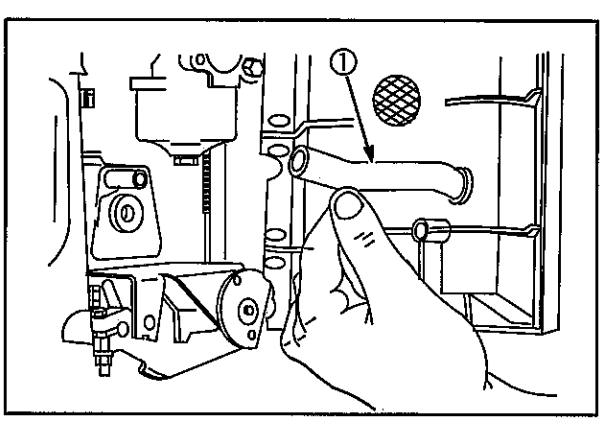



**Fig. 14**

**Models 540000, 610000**

1. Remove two screws (6) and breather cover (5), **Fig. 15.**
2. Lift off the outer baffle (4).
3. Remove the reed valve assembly (3) and O-ring.
4. Remove the inner baffle (2) from the valve cover (1).

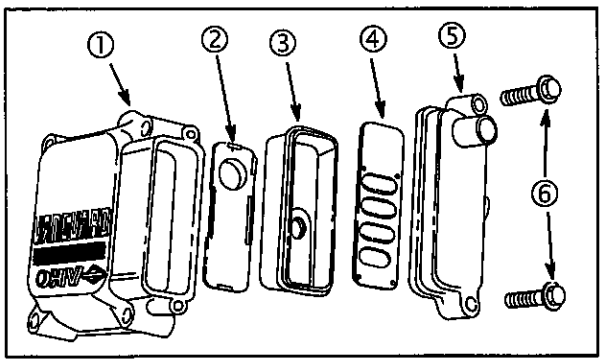



**Fig. 15**

***Check Breather***

Check for loose rivets and for damage to the reed valve, reed stop and housing. If any of the components are worn or damaged, or if the reed valve does not lay flat over the opening, replace the assembly.

***Install Breather***

**NOTE:** For correct alignment, the breather components have one corner that is a sharper radius than the others. DO NOT force components into an incorrect position.

1. Install the inner baffle with raised edges facing OUT.
2. Install the reed valve assembly into the valve cover, reed valve facing out.
3. Install the O-ring over the reed valve assembly. Use fingertips to seat the O-ring into the valve cover.
4. Position the outer baffle into the breather cover with the 3 bosses facing OUT.
5. Install the breather cover and baffle onto the valve cover.
6. Reinstall screws.

## Oil Pump

***Inspect***

Inspect pump drive gear (2) for worn or chipped teeth. Inspect inner pump rotor (4), outer pump rotor (1), housing (3) and crankcase cover or sump for scoring or wear. Replace as required.

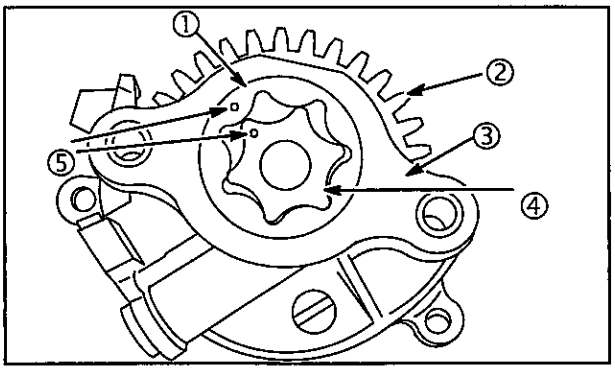



**Fig. 16**

***Assemble Oil Pump***

Lubricate rotors with oil. Install in pump with dimples aligned (5), **Fig. 16.**

## Oil Fill Tube and Dipstick

***All Models – Except 540000, 610000***

The oil fill tube (3) and the dipstick (1) are equipped with O-rings (2) and/or a grommet (4) for proper sealing, **Fig. 17.**

**NOTE:** A leak at the seal between the tube and sump, or at the seal at the upper end of the dipstick, can result in a loss of crankcase vacuum and a discharge of oil or smoke through the muffler.

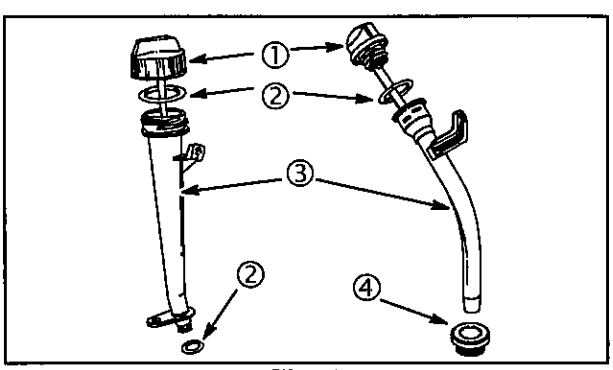



**Fig. 17**

*Models 540000, 610000*

For proper sealing on these models, the oil fill cap (5) has an O-ring, the dipstick has a grommet (6), **Fig. 18.**

**NOTE:** The oil dipstick tube (7) is not removeable/ serviceable on these models. If damaged replace the crankcase cover.

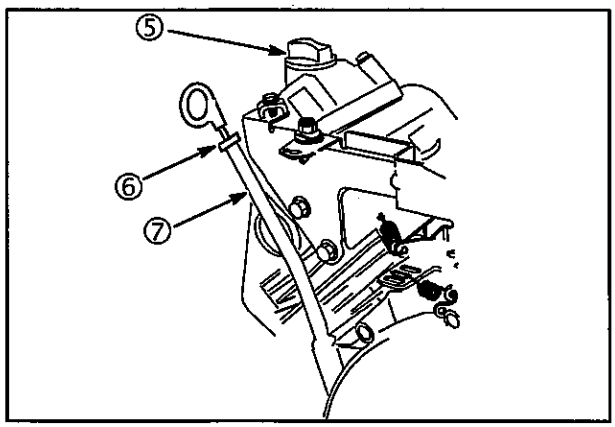



**Fig. 18**

8

# Section 9
# Cylinders and Crankcase Covers/Sumps

## Inspect and Measure

1. Check cylinder for cracks, stripped threads or broken fins. Check cylinder bores for damage or scoring.

2. Check cylinder head mounting surface for distortion with a straight edge, **Fig. 1.**

Replace the cylinder if the mounting surfaces are distorted more than **0.004" (0.1 mm)**.

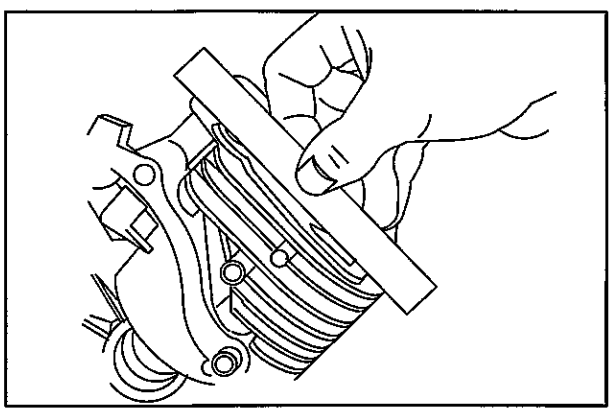


**Fig. 1**



3. Use Telescoping Gauge **#19404** (1) and Dial Caliper **#19199** to check cylinder bores for wear. Measure cylinder bore at 6 points as shown, **Fig. 2.** Measure each cylinder bore at 90º angles near the top (2), middle (3) and bottom (4) of piston ring travel as shown.

If cylinder bore is worn more than **0.003" (0.076 mm)** or more than **0.0015" (0.038 mm)** out-of-round, it must be resized.

**NOTE:** If cylinder bores are within specification and show no signs of scoring or damage, new piston rings may be installed providing the cylinder bores are reconditioned to restore the proper crosshatch finish. Correct cylinder bore finish ensures proper lubrication and piston ring break in.

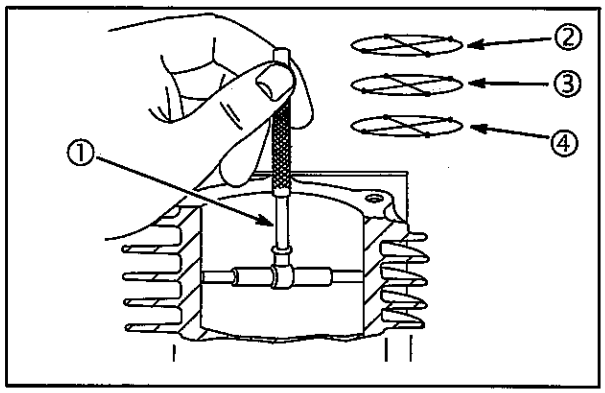



**Fig. 2**

## Resizing Cylinder

Verify the available piston oversize(s) for the engine being worked on. Resize the cylinder to exactly that dimension over the standard bore size. If this is done accurately, the oversize rings and pistons will fit correctly, maintaining proper clearances.

Cylinders should be resized with a good quality hone such as Briggs & Stratton Tool **#19205.** Contact your Briggs & Stratton source of supply for more information. Use the stones and lubrication recommended by the hone manufacturer to produce the correct cylinder finish.

**NOTE:** Automatic transmission fluid is an acceptable honing oil. Another acceptable honing oil can be made by mixing 4 parts 30 weight oil with 1 part kerosene.

If a boring bar is used, a hone must be used after the boring operation to produce the proper cylinder crosshatch finish.

Honing can be done with a variable speed 1/2", portable drill and a honing fixture. See Section 13 for dimensions to make your own honing fixture.

1. Use crankcase cover mounting screws (2) to fasten cylinder to a honing fixture (1), **Fig. 3 (A).**
2. Clamp honing fixture and cylinder securely in a vise at a convenient work height. Place hone drive shaft in chuck of portable drill and tighten.
3. Cut a wood block and place inside cylinder to prevent hone from extending further than **3/4 – 1" (19 – 25 mm)** below cylinder bore.
4. Place hone in middle of cylinder bore. Tighten adjusting knob with finger until stones fit snugly against cylinder wall. DO NOT FORCE. Connect drive shaft to hone. Be sure that cylinder and hone are centered and aligned with drive shaft and drill spindle.

**NOTE:** Recondition the cylinder bores to restore the crosshatch finish whenever new piston rings are installed to a cylinder that is within specification. Be careful not to hone the cylinder oversize or it will be necessary to resize the cylinder.

Lubricate hone as recommended by hone manufacturer. The recommended drill speed is **300 – 700 RPM** and **40 - 60 strokes per minute.** Because cylinder bores normally wear only in the area of ring travel (3), the cylinder bore will be round above and below ring travel area, **Fig. 3 (B).** Start drill and, as hone spins, move it up and down (7) at the bottom of the cylinder bore (4). Gradually increase the length of the strokes until hone travels full length of cylinder bore (8), but no more than **3/4 – 1" (19 – 25 mm)** above or below (6) cylinder bore, **Fig. 3 (C).** Lubricate hone frequently to prevent build up on stones.

As cutting tension decreases, stop hone and tighten adjusting knob following hone manufacturer's recommendations. Check cylinder bore frequently.

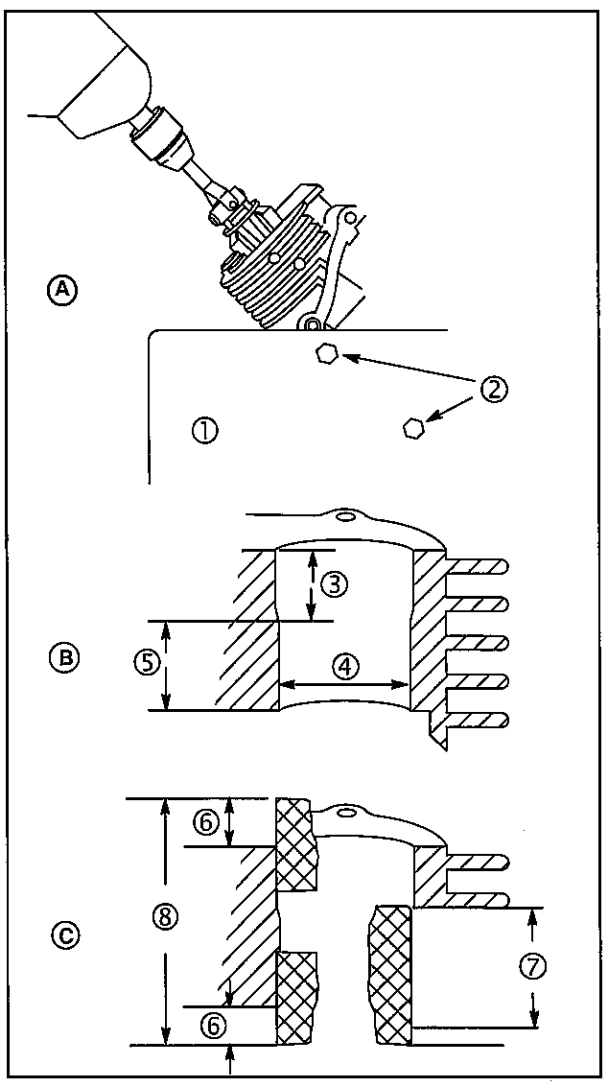



**Fig. 3**

## Finishing

Finishing stones are used after the cylinder bore has been resized to within **0.0015" (0.04 mm)** of the desired size or when reconditioning a cylinder bore. The finishing stones will produce the correct crosshatch finish necessary for proper lubrication. The correct crosshatch angle is approximately **45º** (1), **Fig. 4.**

Recondition the cylinder bores to restore the finish when new piston rings are to be installed in a cylinder that is within specification. Do not to hone oversize or it will be necessary to resize the cylinder.

**NOTE:** To produce the proper crosshatch finish use a drill speed of approximately **200 RPM** and **40 - 60 strokes per minute.** Lubricate hone liberally to prevent build up on finishing stones.

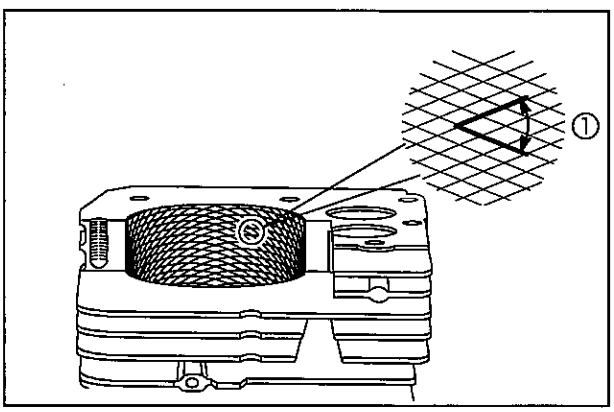



**Fig. 4**

## Cleaning

**CAUTION:** Honing grit is highly abrasive and will cause rapid wear to all the internal components of the engine unless it is completely removed. The entire cylinder and crankcase MUST be THOROUGHLY cleaned after honing.

First wash the cylinder and crankcase carefully in a solvent such as kerosene or commercial solvent. Then thoroughly wash cylinder and crankcase using a stiff brush with soap and hot water. Rinse thoroughly with hot running water. Repeat washing and rinsing until all traces of honing grit are gone.

**NOTE:** When cylinder and crankcase have been thoroughly cleaned, use a clean white rag or napkin to wipe the cylinder bore. If honing grit is present it will appear as a gray residue on rag. If any honing grit is evident, re-wash and rinse entire cylinder and crankcase and check again. When there is no trace of honing grit on rag, the cylinder has been properly cleaned. Oil the cylinder bore to prevent rusting.

## ENGINE BEARINGS

### Mag Bearing – After 970430xx

#### Check

1. Check magneto bearing for damage. Check for wear at several locations using plug gauge **#19219 (1)** or appropriate measuring tools, **Fig. 5.** If plug gauge is not available see reject dimension in Section 13.
2. Replace bearing if damaged or worn.

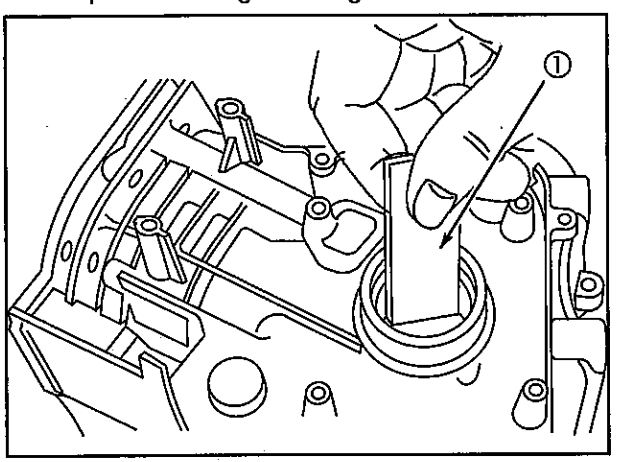



**Fig. 5**

#### Remove

1. Remove the oil seal.
2. Insert Bushing Driver **#19450** (1) into bearing from oil seal side, **Fig. 6.**
3. Place a reference mark (2) on driver to indicate proper depth when installing new bearing.

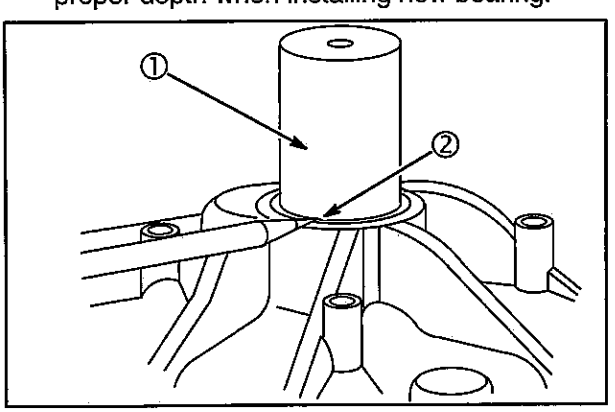



**Fig. 6**

4. Place cylinder on Cylinder Support **#19227** with large opening facing bearing.
5. Press out bearing with bushing driver (1), **Fig. 7.**

#### Install

1. Place cylinder on Cylinder Support **#19227** with large opening facing bearing, **Fig. 7.**
2. Align oil holes in bearing with oil holes in cylinder.
3. Press in new bearing to correct depth with bushing driver (1).

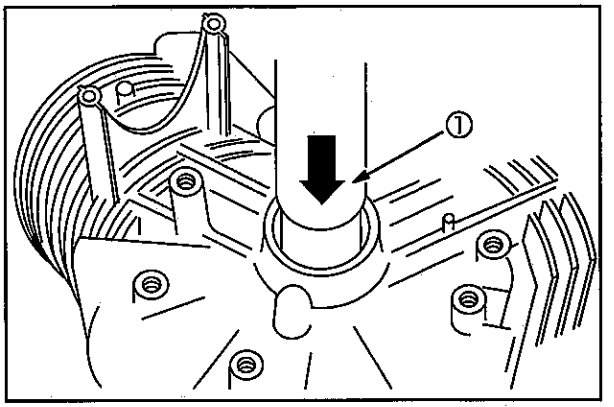



**Fig. 7**

4. Stake bearing in top notch (2) with **1/8"** round pin punch to prevent bearing from turning, **Fig. 8.**

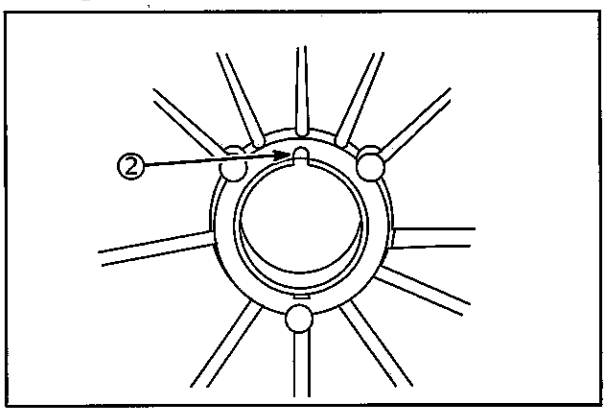



**Fig. 8**

5. Install new oil seal with sealing lips facing in. Use Cylinder Support **#19227.** Press oil seal until flush with cylinder.

### Mag Bearing – Before 970501xx

#### Check

1. Check magneto bearing for damage. Check for wear at several locations using **#19380** plug gauge or appropriate measuring tools, **Fig. 9.** If plug gauge is not available see reject dimension in Section 13.
2. Replace bearing if damaged or worn.

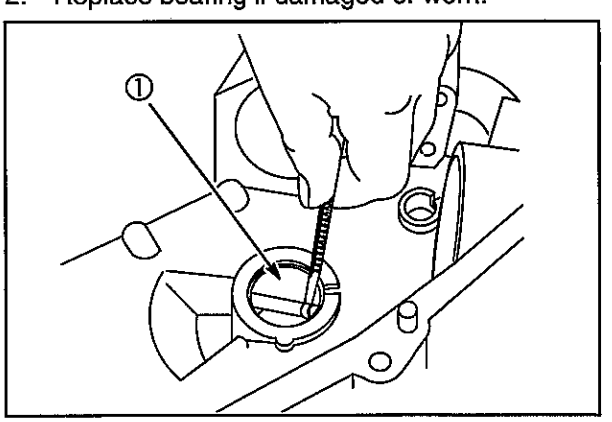



**Fig. 9**

Insert Bushing Driver **#19349** into bearing from oil seal side. Place a reference mark on driver to indicate proper depth of bushing when installing new bearing, as shown, **Fig. 6.**

**Remove**

The magneto bearing has a roll pin installed in the oil gallery to prevent the bearing from turning.

1. Drive roll pin (2) into oil gallery using a **3/16"** punch (1), **Fig. 10.**
2. Place cylinder on Cylinder Support **#19227** with large opening facing bearing.
3. Press out bearing with Bushing Driver **#19349.**

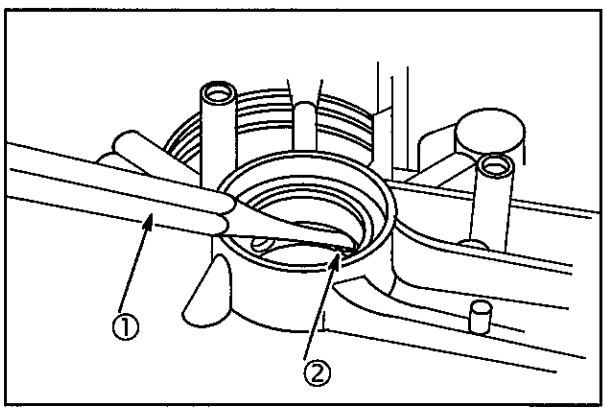



**Fig. 10**

**Install**

1. Place cylinder on Cylinder Support **#19227** with large opening facing bearing.
2. Align oil holes in bearing with oil holes in cylinder.
3. Press in new bearing to correct depth with Bushing Driver **#19349** (3), **Fig. 11.**

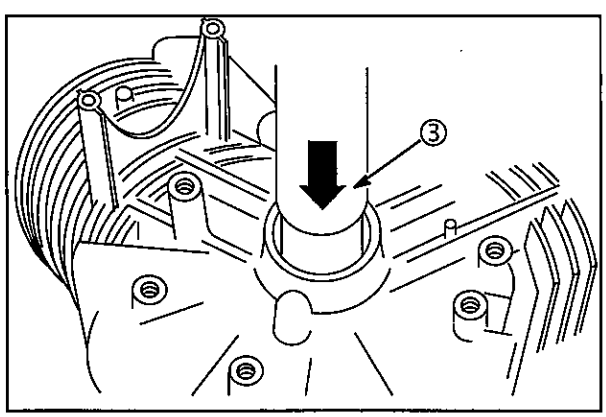



**Fig. 11**

4. Grind off the taper (5), approximately **1/8" (3 mm)** (4), from one end of new roll pin as shown, **Fig. 12.**
   a. Quench pin in water periodically to prevent loss of temper.
   b. Remove all burrs and clean thoroughly.

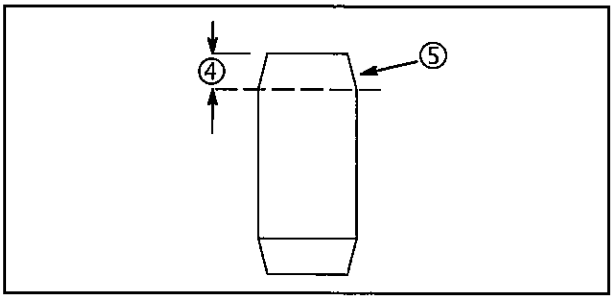



**Fig. 12**

5. Place TAPERED end of new roll pin in the bearing oil hole.
6. Use Roll Pin Driver **#19344** to install new roll pin, **Fig. 13.** Drive in new roll pin until tool bottoms.
7. Use Cylinder Support **#19227** and press oil seal until flush with cylinder.

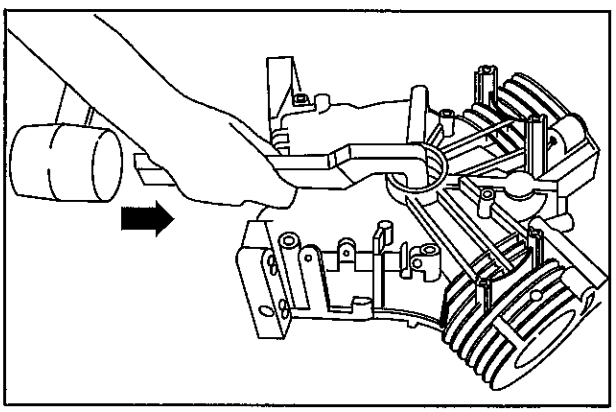


**Fig. 13**

## PTO Ball Bearing

**Check**

Ball bearings must rotate freely, **Fig. 14.** If any rough spots are felt replace the ball bearing.

- **CAUTION:** Crankcase cover bearings are usually damaged during removal from the crankcase. Do not re-use crankcase cover bearings.

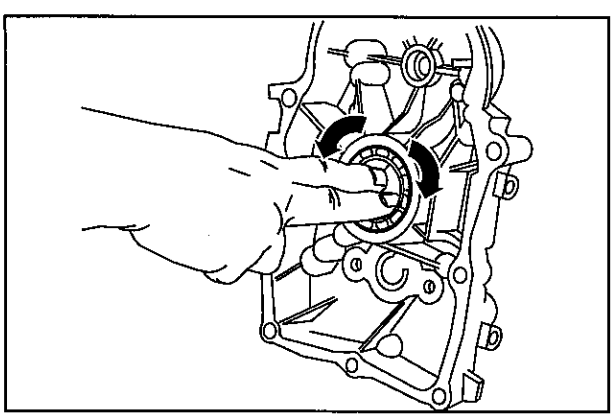


**Fig. 14**

The following tools are recommended to replace the ball bearing, **Fig. 15.**

(1) Washer **#224061**

(2) Puller Screw **#19318**

(3) Pilot **#19396**

(4) Driver **#19401**

(5) Support **#19440**

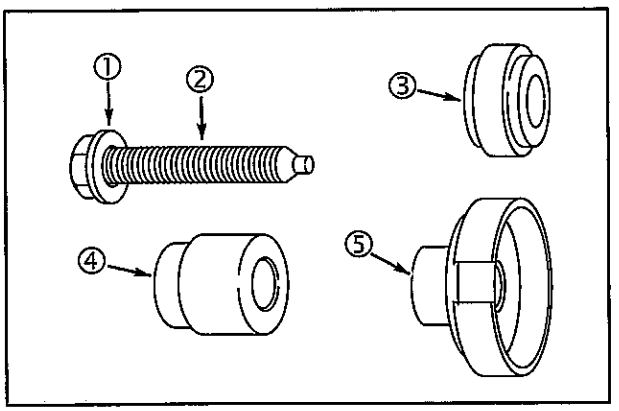



**Fig. 15**

### Remove

1. Assemble washer (1), to puller screw (2). Insert through large end of driver (4), **Fig. 16.**
2. Place open side of support (5), over ball bearing.
3. Insert screw with driver through ball bearing and thread into support. Continue tightening screw until ball bearing is removed.

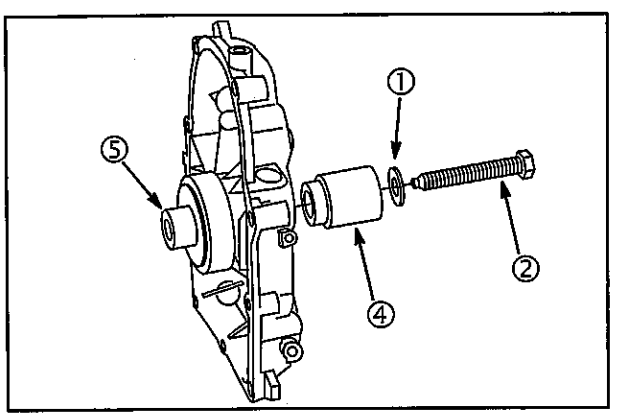



**Fig. 16**

### Install

Lubricate outside diameter of ball bearing before installing.

1. Place ball bearing on to Support **#19440**, **Fig. 17.**
2. Assemble washer (1), to puller screw (2).
3. Insert screw (2) and washer (1) through pilot (3) and thread into support (5). Tighten screw until bearing is seated.
4. Use Cylinder Support **#19227** and press oil seal until flush with crankcase cover.

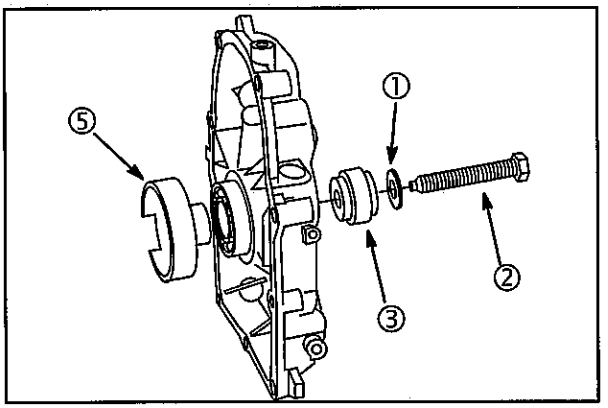



**Fig. 17**

## PTO Plain Bearing

Replace the sump if the PTO bearing is scored or if Plug Gauge **#19380** (1), enters bearing. Try gauge at several locations in bearing, **Fig. 18.**

If plug gauge is not available, measure the bearing ID at several points. Replace the cover or sump if the bearing if the ID exceeds **1.381" (35.07 mm) (Model 540000 – 1.777" (45.12 mm))** at any point.

## Oil Seal

When installing new PTO oil seal, use **1-7/8" (47.6 mm)** side of Cylinder Support **#19227**. Press in seal until it is **1/16" (1.5 mm)** below mounting surface.

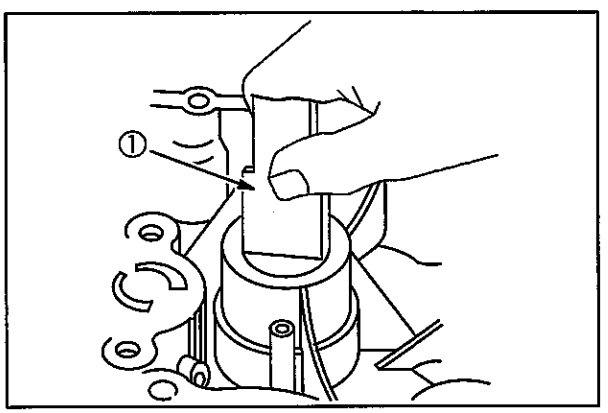



**Fig. 18**

## Camshaft Bearings

Use Plug Gauge **#19384** to check magneto side cam bearing. Use Plug Gauge **#19386** to check PTO side cam bearing. Plug gauge should not enter bearing. If plug gauges are not available, see reject sizes in Section 13. If cam bearings are worn, cylinder or crankcase cover must be replaced.

# Section 10
# Crankshafts and Camshafts

## INSPECT CRANKSHAFT

Inspect crankshaft threads (1) and keyways (2, 8), **Fig. 1**. Replace crankshaft if threads or keyways are damaged or worn. Check magneto (3) and PTO (7) journals for scoring. Measure journals for wear. Replace crankshaft if journals are scored, or worn past reject sizes listed in Section 13.

Check oil galleries (4) for blockage or obstructions.

Inspect timing gear (6). Replace timing gear if teeth are damaged or worn.

Measure crankpin (5) for wear.

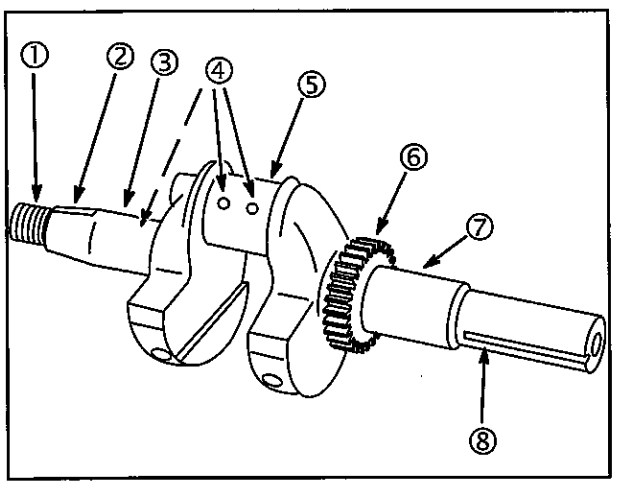



**Fig. 1**

Crankshaft crankpin may be re-ground for **0.020"** undersize connecting rods when available. See IPL for part number. Accurately measure and grind the crankpin diameter (A), throw (T) and fillet radius (R), **Fig. 2**. Discard any crankshaft that is worn beyond reject specifications listed in Section 13.

Complete instructions are included with undersize connecting rods.

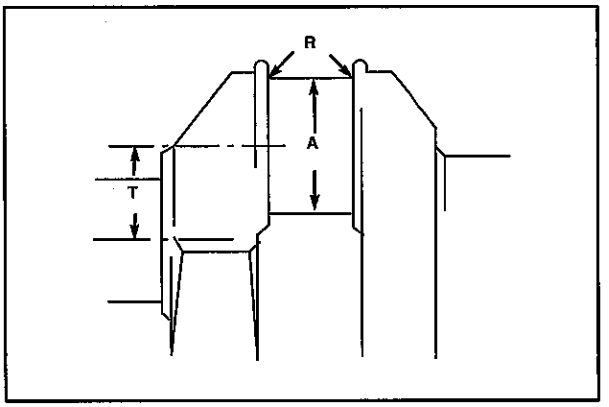



**Fig. 2**

## INSPECT FLYWHEEL

Check flywheel keyway (1) for damage. Replace flywheel if it has cracks, broken fins or keyway damage, **Fig. 3**.

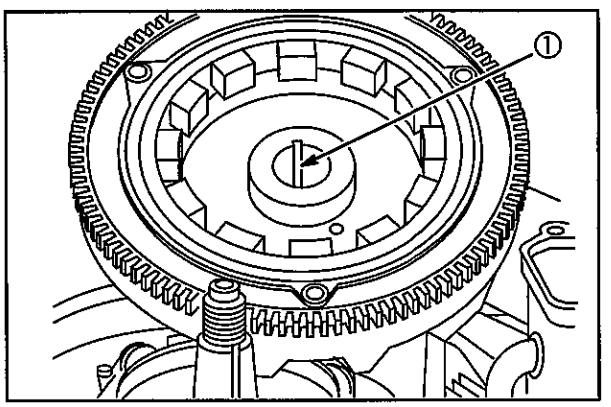



**Fig. 3**

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## INSPECT CAMSHAFT

Inspect gear teeth (4), lobes (9, 10), compression release balls (7) and camshaft bearing journals (6, 11) for wear and nicks, **Fig. 4.**

Camshaft journal and lobe reject sizes are shown in specifications page in Appendix. Replace cam gear if not to specification.

Governor spool (2) must move freely on PTO journal (6) of camshaft. Flyweight (12) must move freely on pivot (8). Make sure flyweight spring (5) is not stretched. Governor weights (3) must move freely on hinge pins (1). Make sure hinge pins are not loose.

If parts are worn or damaged replace camshaft assembly.

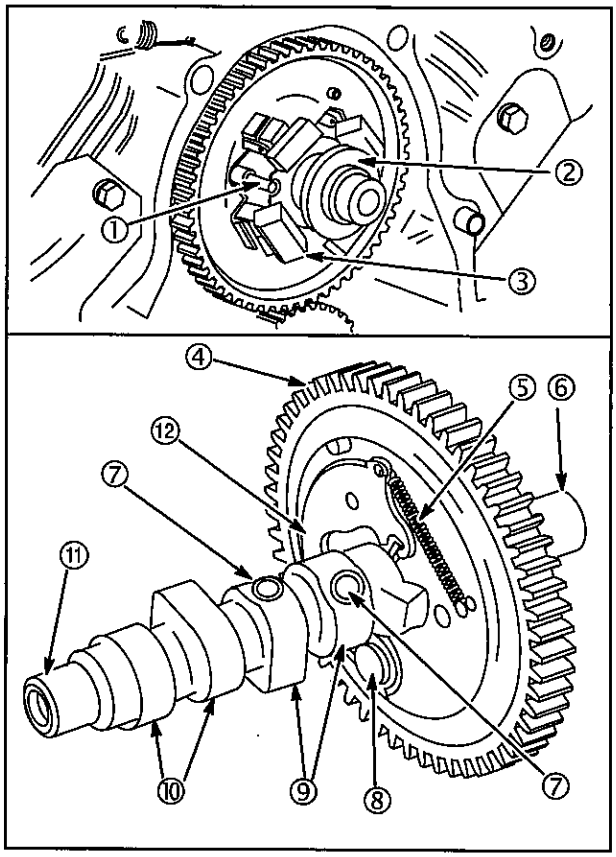


**Fig. 4**

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# Section 11
# Pistons, Rings and Connecting Rods

## GENERAL INFORMATION

Install new piston rings whenever the engine is disassembled for major servicing or overhaul, providing that cylinder bores are within specification.

1. Remove any carbon or ridge at the top of the cylinder bore. This will prevent breaking the rings when removing the piston and connecting rod from the engine.

2. Remove the connecting rod cap. Push the piston and connecting rod out through the top of the cylinder.

3. Measure cylinder bores before checking pistons and rings. If cylinder bores require re-sizing it is not necessary to check pistons and rings, since a new oversized piston assembly will be used.

Resize a cylinder bore if it is more than **0.003" (0.08 mm)** oversize, or **0.0015" (0.04 mm)** out of round.

## Disassemble

1. Remove piston rings using Ring Expander **#19340** (1), **Fig. 1**.

2. Remove oil control ring coil expander and oil control rings.

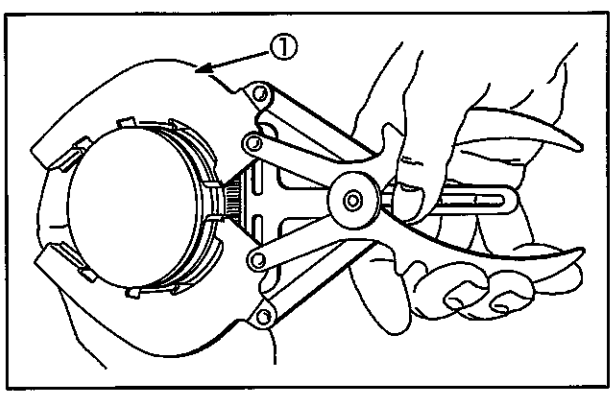


**Fig. 1**

3. Disassemble piston from connecting rod, **Fig. 2**.

   a. Remove piston pin locks (2).

   b. Piston pin is a slip fit in piston and connecting rod.

Keep pistons and connecting rods together as an assembly. Do not mix.

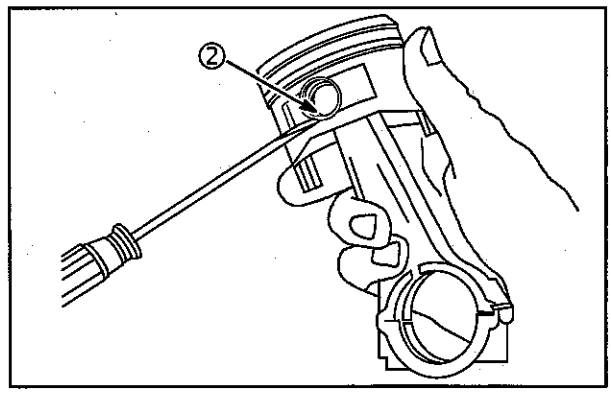


**Fig. 2**

## Inspect Piston and Piston Rings

**NOTE:** If the cylinder is not going to be resized and the piston shows no signs of scoring, the piston should be checked.

1. Check side clearance of ring grooves using a feeler gauge and NEW piston rings (3), **Fig. 3**. Replace the piston if the ring groove is worn beyond specification.

Side Clearance Reject Dimension:

**All Except Models 540000, 610000**

- Compression Rings – **0.004" (0.10 mm)**
- Oil Rings – **0.008" (0.20 mm)**

**Models 540000, 610000**

- Top Compression Ring – **0.009" (0.23 mm)**
- Center Compression Ring – **0.006" (0.15 mm)**
- Oil Rings – **0.004" (0.10 mm)**

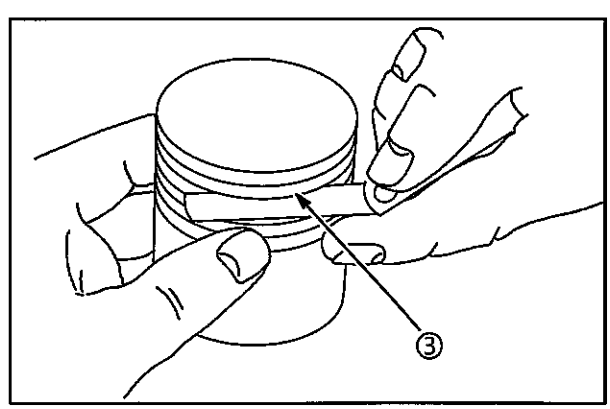


**Fig. 3**

2. Check ring end gap, **Fig. 4**. Clean carbon from end of rings and insert approximately **1" (25 mm)** into cylinder.

End Gap Reject Dimension

**All Except Models 540000, 610000**

- All Rings – **0.030" (0.76 mm)**

**Models 540000, 610000**

- Top Compression Ring – **0.030" (0.76 mm)**
- Center Compression Ring – **0.030" (0.76 mm)**
- Oil Rings – **0.040" (1.0 mm)**

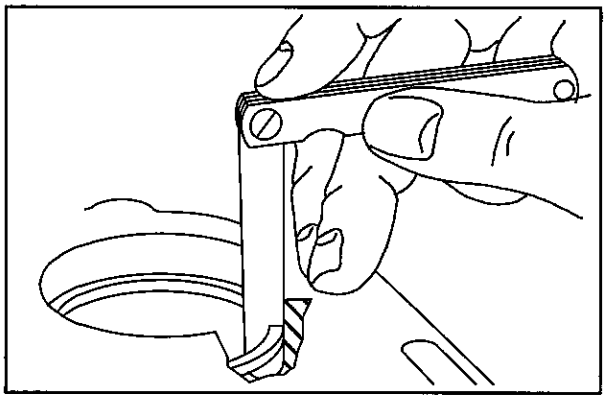

**Fig. 4**

3. Check piston pin bore, **Fig. 5**. Replace piston if worn beyond reject dimension or **0.0005" (0.01 mm)** out of round.

***Piston Pin Bore Reject Dimension***

- Models 290000 – 351000 – **0.674" (17.12 mm)**
- Model 380000 – **0.711" (18.06 mm)**
- Model 540000 – **0.828" (21.03 mm)**

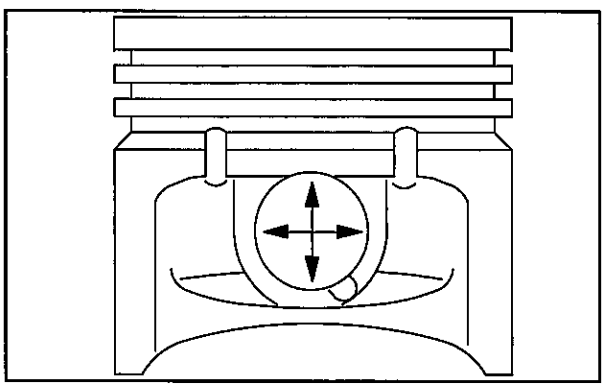

**Fig. 5**

## Inspect Piston Pin and Connecting Rod

1. Measure piston pin, **Fig. 6**. Replace pin if worn beyond reject dimension or **0.0005" (0.01 mm)** out of round.

**Piston Pin Reject Dimension:**

- Models 290000 – 351000 – **0.672" (17.07 mm)**
- Model 380000 – **0.708" (17.98 mm)**
- Model 540000 – **0.826" (20.98 mm)**

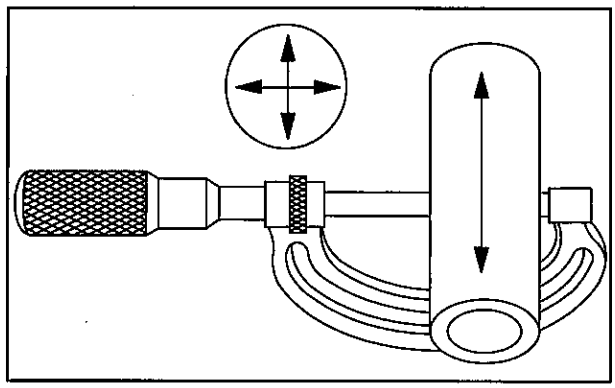

**Fig. 6**

2. Check connecting rod bearings, **Fig. 7**.

**NOTE:** Undersize (**0.020"**) connecting rods are available for use on a reground crankpin journal on some engines. See IPL for availability. If crankpin bearing is scored or worn replace the connecting rod.

***Piston Pin Bearing (1) Reject Dimension***

- Models 290000 – 351000 – **0.674" (17.12 mm)**
- Model 380000 – **0.711" (18.06 mm)**
- Model 540000 – **0.828" (21.03 mm)**

***Crankpin Bearing (2) Reject Dimension***

- All Except Model 540000 – **1.461" (37.12 mm)**
- Model 540000 – **1.658" (42.11 mm)**

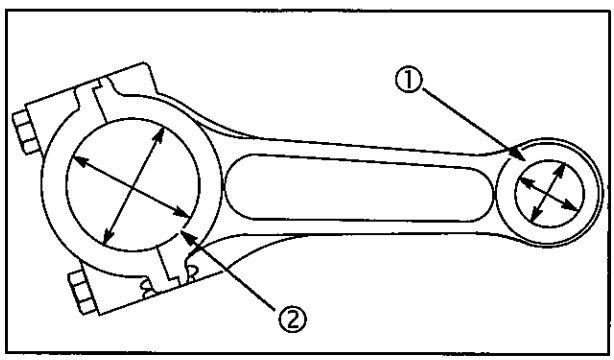


**Fig. 7**

## Assemble Piston and Connecting Rod

1. Lubricate parts with engine oil. Assemble #1 piston to connecting rod, **Fig. 8**.
2. Arrow, notch or casting mark on piston must face flywheel side, inset **Fig. 8**.
   - The designation "OUT 1" or the number "1" on the connecting rod must face PTO side (opposite arrow on piston).
   - Install piston pin locks with needle nose pliers.

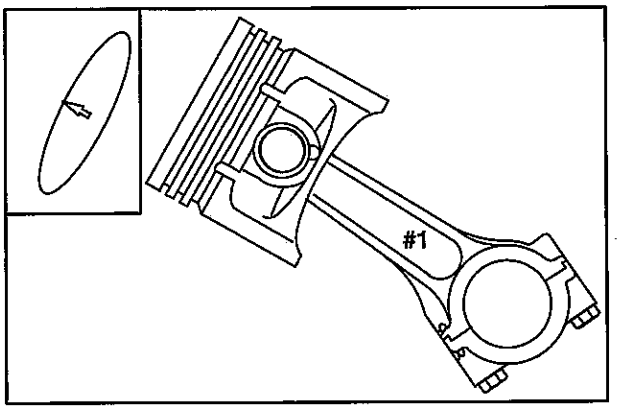


Fig. 8

3. Lubricate parts with engine oil. Assemble #2 piston and connecting rod, **Fig. 9**.
   - Arrow, notch or casting mark on piston must face flywheel side.
   - The designation "OUT 2" or the number "2" on the connecting rod must face PTO side (opposite arrow on piston).
4. Install piston pin locks with needle nose pliers.

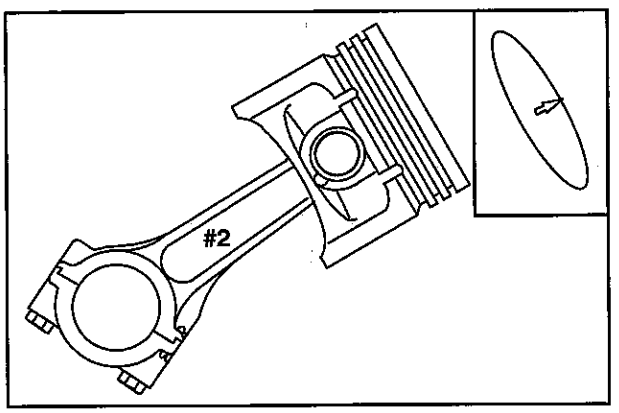


Fig. 9

## Assemble Piston Rings to Piston

Install rings in order shown, **Fig. 10**. Use Piston Ring Expander, **#19340** when installing center (2) and top (1) compression rings.

1. Install oil ring expander (4).
   a. Install lower scraper ring (5).
   b. Install upper scraper ring (3).
2. Install center compression ring (2) with ID mark (6) up.
3. Install top compression ring (1) with ID mark (6) up.

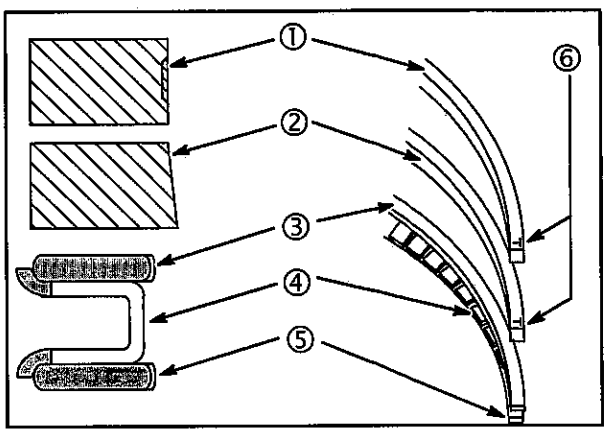


Fig. 10

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# Section 12
# Engine Assembly



12

## Install Crankshaft

Lubricate mag bearing and lips of oil seal with engine oil. Install crankshaft, **Fig. 1.**

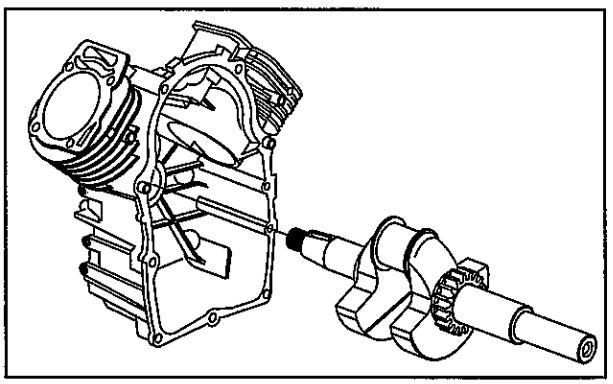

**Fig. 1**

## Install Piston and Connecting Rods

**NOTE:** Install #1 piston and connecting rod first.

1. Oil piston rings and piston skirt. Compress rings with Piston Ring Compressor **#19070 (2), Fig. 2.**
   a. Place piston and ring compressor upside down on bench with projections (1) on compressor facing up.
   b. Tighten ring compressor until rings are fully compressed.
   c. Loosen ring compressor slightly so the compressor can be rotated on the piston skirt while holding connecting rod.

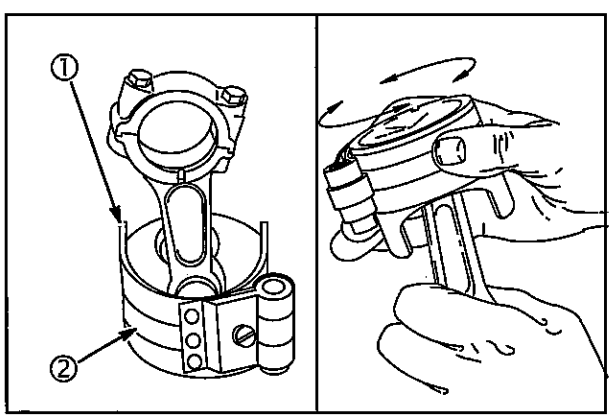


**Fig. 2**

2. Lubricate cylinder bores and crankpin. Rotate crankshaft until it is at bottom of stroke.
3. Install #1 piston with notch or offset casting mark (3) toward the FLYWHEEL SIDE of the engine (4), **Fig. 3.** Push piston down by hand until connecting rod is seated on crankpin.

**NOTE:** The words "OUT-1" (5) on #1 connecting rod must be facing PTO side of engine (6).

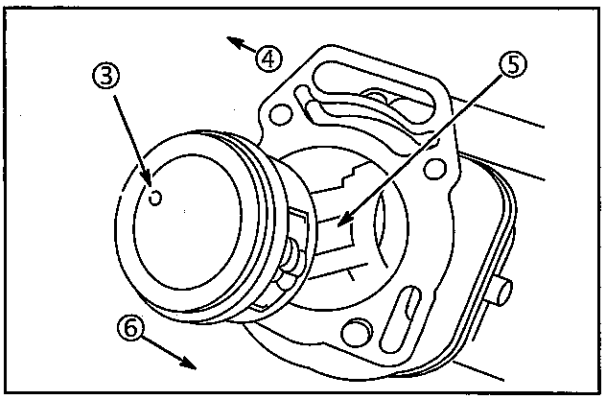


**Fig. 3**

4. Assemble connecting rod cap to rod with match marks aligned, **Fig. 4.** Torque screws to **115 in. lbs. (13 Nm).**

**NOTE:** Models **540000, 610000 – 125 in. lbs. (14 Nm).**

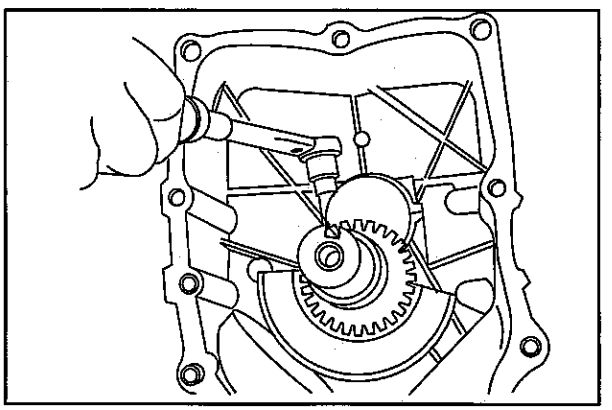

**Fig. 4**

5. Rotate crankshaft **two revolutions** to check for binding. Connecting rod should also be free to move sideways on crankpin.
6. Repeat for #2 cylinder.

**NOTE:** The words "OUT-2" on #2 connecting rod must face PTO side.

**CAUTION:** Failure to use a torque wrench can result in loose connecting rod screws causing breakage, or overtightened connecting rod screws, causing scoring.

## Install Camshaft

1. Lubricate tappets, camshaft journals and lobes with engine oil. Assemble timing gear to crankshaft.
2. Install tappets.

3. Align timing marks on camshaft and crankshaft timing gear. Install camshaft, **Fig. 5**.
4. Assemble governor spool (2) to camshaft (except Models **540000, 610000**).
   a. Install new O-ring (3) in cylinder.
   b. Make sure that spool engages flyweights and slot on spool fits over locating pin (1).

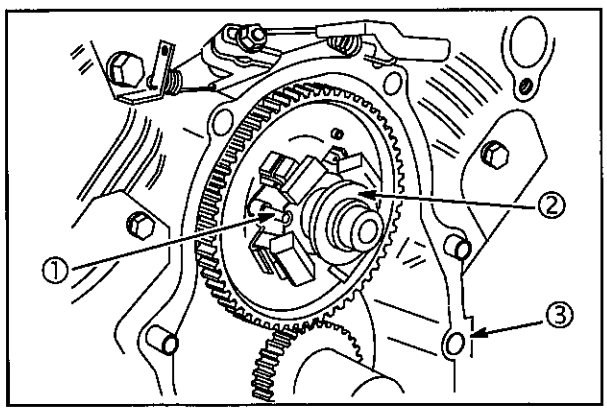


**Fig. 5**

## Install Oil Pump

### *Horizontal Crankshaft*

1. Install a new O-ring (5) to the pickup tube and screen assembly (4). Install the pickup tube assembly to the oil pump (2), **Fig. 6**.
2. Install oil pump assembly and gear baffle (1), to crankcase. Use new O-rings (3) under the screws.

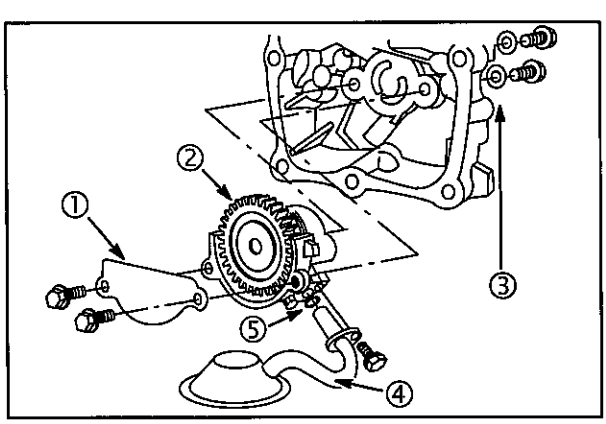


**Fig. 6**

### *Vertical Crankshaft*

1. Make sure the oil pickup screen (3) is clean and in position.
2. Place new O-rings (1) on the screws (2). Install to sump, **Fig. 7**.

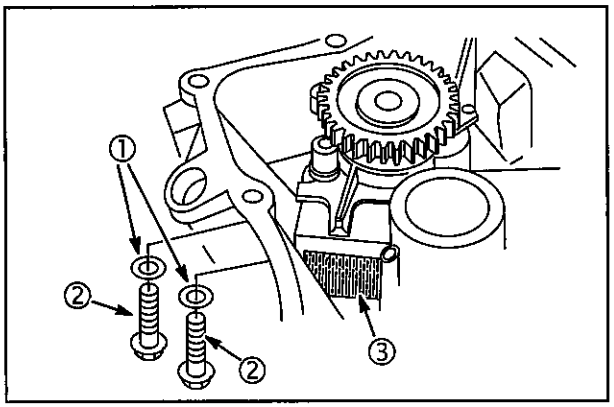


**Fig. 7**

## Install Crankcase Cover or Sump

1. Lubricate PTO and camshaft bearing.
2. Rotate governor shaft so that paddle rests against camshaft bearing support, **Fig. 8**.
3. Insert proper seal protector through oil seal.

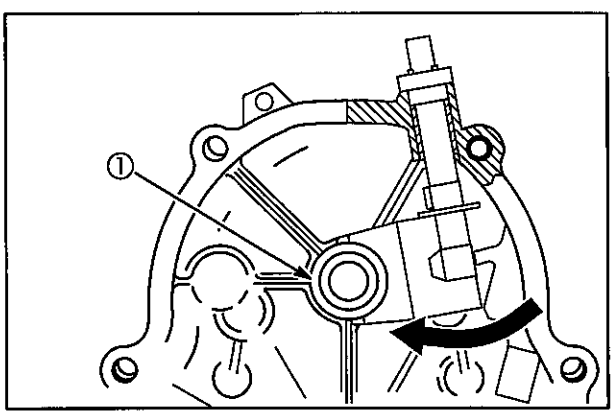


**Fig. 8**

4. Install crankcase cover or sump with new gasket. Torque screws in sequence, **Fig. 9**, to **150 in. lbs. (17 Nm).**

**NOTE:** Models **540000, 610000 – 200 in. lbs. (23 Nm).**

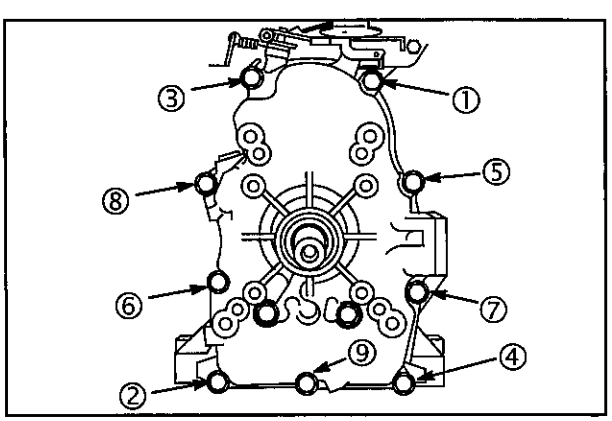


**Fig. 9**

5. Check crankshaft end play. End play should be **0.003 – 0.015" (0.08 – 0.40 mm).**

Crankshaft end play is adjusted by adding or removing a thrust washer. Thrust Washer Kit **#807625** contains shims with the following thickness; **0.039" (1.0 mm), 0.049" (1.25 mm)** and **0.059" (1.5 mm)**. The thrust washer is installed on the PTO side of the crankshaft next to the timing gear.

## Install Cylinder Heads

1. Install cylinder head with new gasket, **Fig. 10.**

**NOTE:** Engines manufactured before 940501xx were equipped with sealing washers under #1 and #3 cylinder head bolts.

2. Lubricate threads of head bolts with Valve Guide Lubricant **#93963.**

3. Torque bolts in sequence shown to **165 in. lbs. (19 Nm).**

**NOTE:** Models 540000, 610000 – **350 in. lbs. (40 Nm)**

4. Insert push rods into recess in tappets.

**NOTE:** All Models **except 540000, 610000** – Exhaust valve push rods are aluminum. Models **540000, 610000** – All push rods are aluminum.

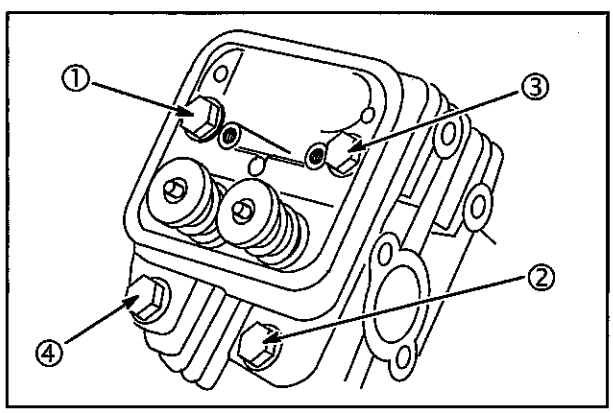


**Fig. 10**

## Install Rocker Arms

***Current Style***

1. Lubricate rocker arm supports (2) with clean engine oil.

2. Assemble rocker studs (1), rocker arm supports and rocker arms (3) to cylinder head, **Fig. 11.**

3. Torque studs to **100 in. lbs. (11 Nm).**

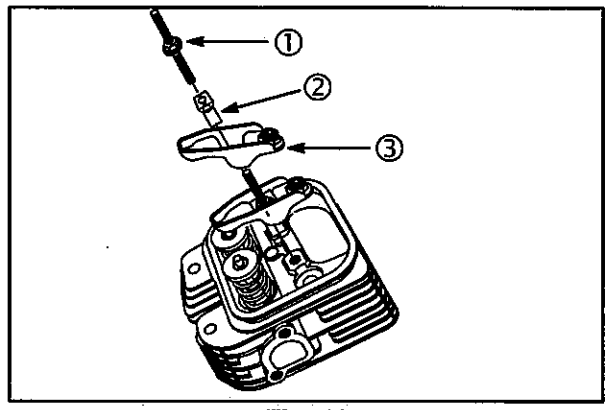


**Fig. 11**

***Early Style***

**NOTE:** Rocker shaft support (3) holes are offset. Install with holes facing ends of rocker shaft, **Fig. 12.**

1. Lubricate rocker arms (4) and shaft (2) with clean engine oil.

2. Assemble rocker arms, shaft, supports and studs (1) and install on cylinder head, **Fig. 12.**

3. Torque studs to **140 in. lbs. (16 Nm).**

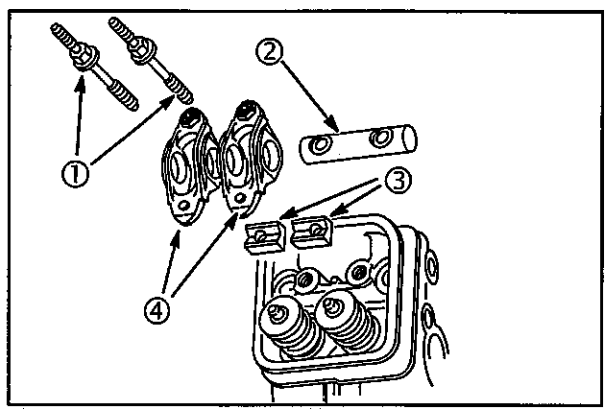


**Fig. 12**

## Install Push Rods

1. Compress valve spring (3) with rocker arm (2) and insert push rod (1) into rocker arm socket, **Fig. 13.**

**NOTE:** Be sure push rods remain seated in recess in tappets.

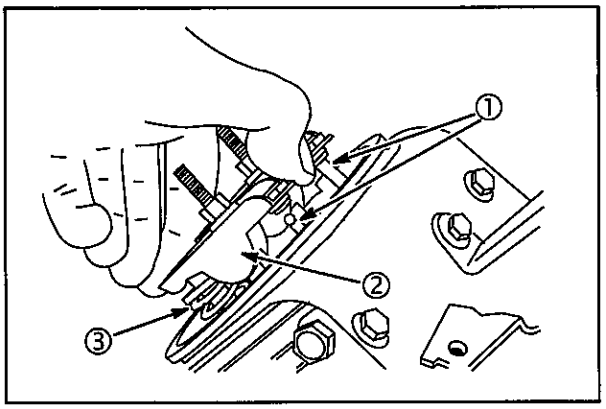


Fig. 13

2. Install valve covers with new gaskets and valve cover seals (6), **Fig. 14**. Torque nuts (7) to **25 in. lbs. (3 Nm)**.

**NOTE:** Models **540000, 610000 – 70 in. lbs. (8 Nm)**

3. Repeat for No. 2 cylinder.
4. Adjust valve clearance. See Section 1.

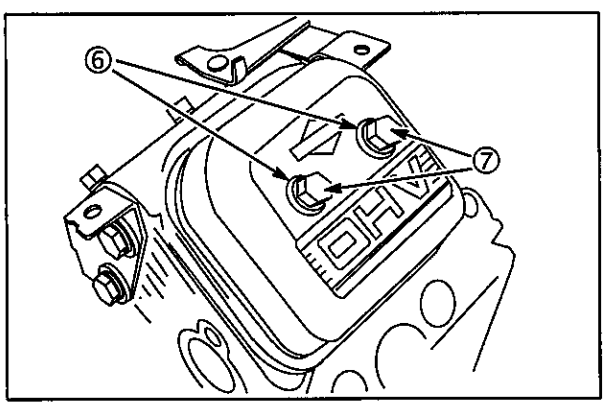


Fig. 14

## Install Starter Motor, Breather, Alternator

1. Install back plate (1), **Fig. 15**. Torque screws to **65 in. lbs. (7 Nm).**
2. Install alternator (2). Torque screws to **20 in. lbs. (2 Nm).**

**CAUTION:** Route alternator wire(s) behind starter motor. DO NOT pinch wires.

3. Install starter motor (3). Torque screws to **140 in. lbs. (16 Nm).**
4. Install breather, **Models 290000 – 350000**. Torque screws to **30 in. lbs. (3 Nm).**

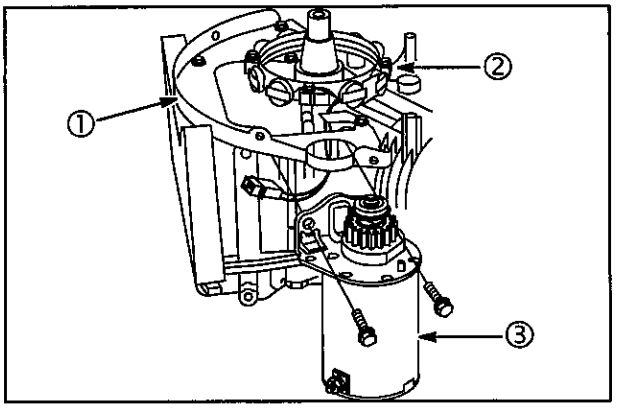


Fig. 15

## Install Flywheel

**All models except Engines with POWERLINK™**

**CAUTION:** Clean flywheel and crankshaft taper. Remove ALL oil, dirt and grease.

1. Assemble flywheel to crankshaft and align keyways.
2. Insert flywheel key into crankshaft.

## Torque Flywheel Nut

**Models 290000, 303000, 540000, 610000**

1. Install starter hub (if equipped), washer and flywheel nut.
2. Place Flywheel Strap Wrench **#19433** (1) around outer rim of flywheel, **Fig. 16.**
3. Use torque wrench (2) to torque flywheel nut to **125 ft. lbs. (175 Nm)**. Models 290000, 303000 and 150 ft. lbs. (203 Nm). Models 540000 and 610000.

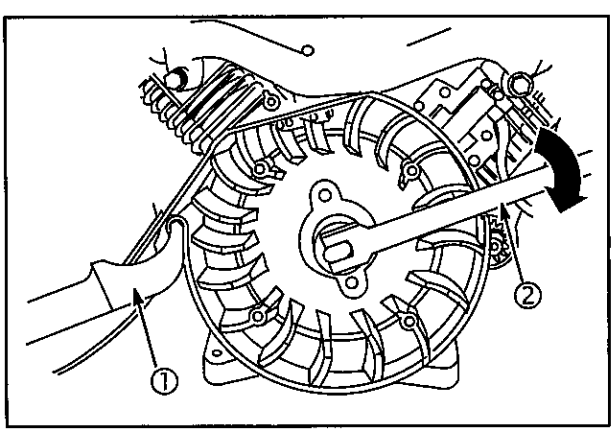


Fig. 16

**Models 350000, 380000**

1. Install washer and flywheel nut.
2. Assemble Flywheel Holder **#19321** (2) to retainer, **Fig. 17**.
3. Use a torque wrench (1) and 30 mm socket (3) to torque flywheel nut to **125 ft. lbs. (175 Nm).**
4. Install starter hub and screw (if equipped). Torque to **35 ft. lbs. (48 Nm)**.

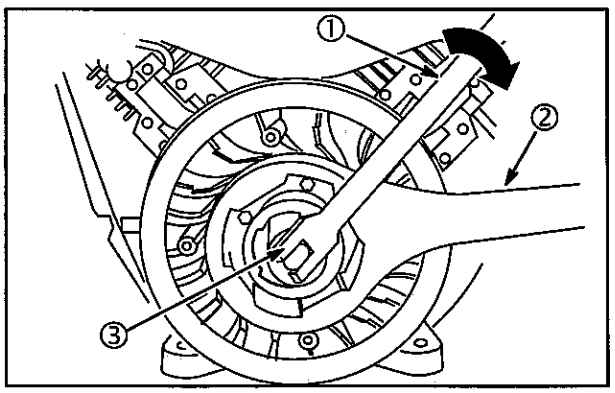


**Fig. 17**

## Install Fan

**Models 350000, 380000**

1. Align boss on back of fan (5) with notch (3) in flywheel, **Fig. 18.**

**NOTE:** Engines manufactured after date code 030430xx use a specially balanced crankshaft and balanced fan which has no boss. This fan can be mounted in any direction on the flywheel. Do not interchange fans or crankshafts manufactured before 030501xx with newer components.

2. Align cut out in retainer (6) with cut out in fan.
3. Torque screws (7) to **150 in. lbs. (17 Nm).**

**NOTE:** Models **540000, 610000** torque screws to **90 in. lbs. (10 Nm).**

4. If equipped, install rewind starter hub (2) and starter hub screw (1).

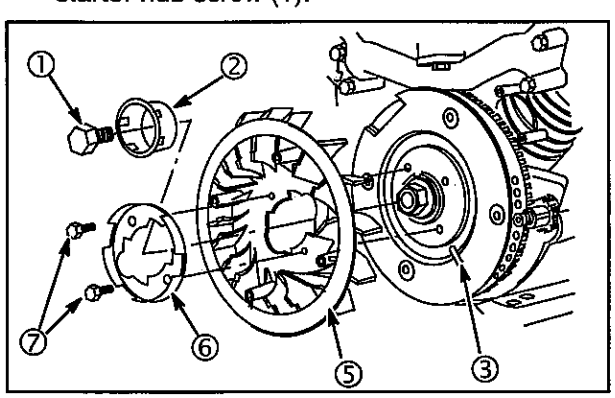


**Fig. 18**

## Install Flywheel – Engines with PowerLink™

**NOTE:** Before installing flywheel make sure the flywheel magnets are free of debris.

**WARNING**

**AVOID HAND/FINGER INJURY.**

- The flywheel magnets are VERY POWERFUL and can rapidly pull the flywheel to the engine.
- Be certain the puller screw (1) is set to AT LEAST the height it was at when the flywheel was removed from the engine.

1. With pilot (2) installed to the crankshaft (3), place the flywheel with puller attached, onto the pilot, **Fig. 19.**
2. Align the flywheel keyway mark with the crankshaft key (4). Slowly loosen the flywheel puller screw (1) to lower the flywheel (5) into position over the stator. Be certain that the crankshaft key engages the flywheel keyway.

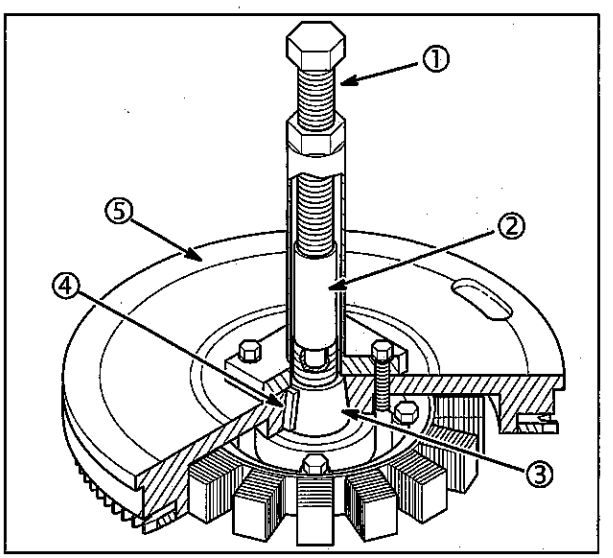


**Fig. 19**

3. Install the flywheel nut. Torque the flywheel nut to specification.
4. Reassemble the fan and fan retainer to the flywheel.
5. Connect the alternator wires to the regulator-rectifier.
6. Connect the POWERLINK™ harness to the inverter and install tamper-proof screws.
7. Retest system to ensure proper operation.

## Install Armatures

1. Assemble armature to engine, **Fig. 20.**
2. Install ground wire onto tab terminal on armatures.

**NOTE:** Mounting holes in armature are slotted. Push armature away from flywheel (arrow) as far as possible. Tighten either screw (4) to hold armature in place.

3. Repeat for second armature.
4. Adjust armature air gap. See Section 1.

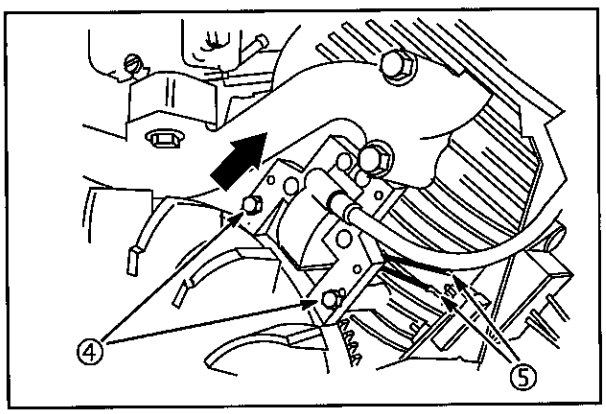


**Fig. 20**

## Install Control Bracket

1. Install cylinder shields (4) and valley cover (1), **Fig. 21.** Torque screws to **65 in. lbs. (7 Nm).**

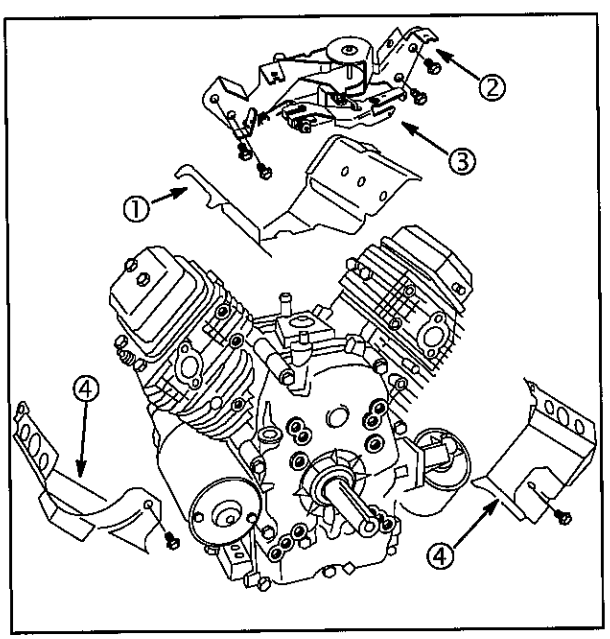


**Fig. 21**

2. Connect ground wire harness to stop switch terminal.
3. Assemble governor lever (3) to governor shaft. DO NOT tighten nut at this time.
4. Install governor control bracket (2). Torque screws to **140 in. lbs. (16 Nm).**

## Install Carburetor and Manifold

**Vertical Crankshaft**
**Models 290700, 303700, 350700**

***Current style: Fig. 22***

1. Assemble gaskets (1) and spacer (4) to manifold. Make sure that locating pin (2) on carburetor spacer fits in recess (3) in manifold.
2. Assemble carburetor onto mounting studs.

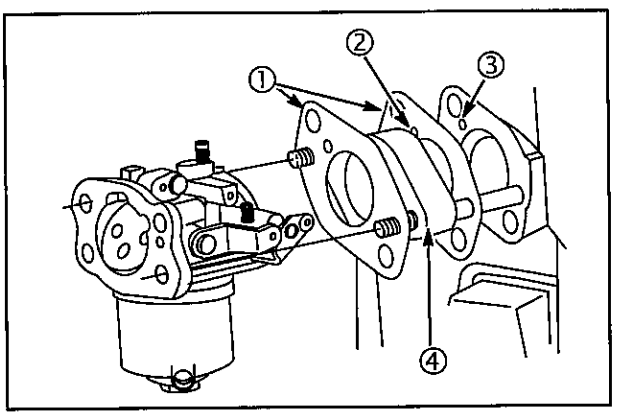


**Fig. 22**

***Early style: Fig. 23***

1. Insert carburetor mounting screws (5) through carburetor, gasket (1), spacer (4) and gasket (1).
2. Assemble carburetor to manifold.
   a. Make sure that locating pin on carburetor spacer (2) fits in recess in manifold (3).
   b. Torque screws to **65 in. lbs. (7 Nm).**

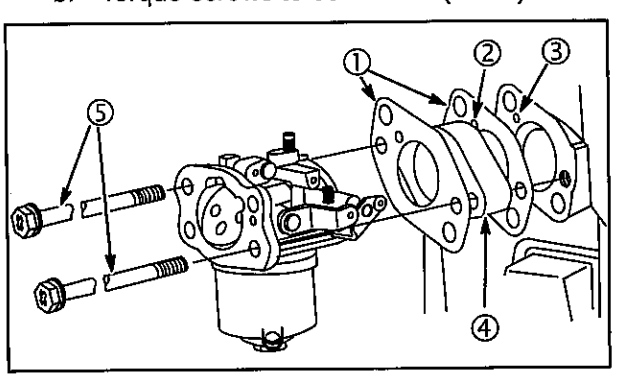


**Fig. 23**

**Models 351700, 380700**

1. Assemble gaskets (2) and spacer (1) to intake manifold.

2. Assemble carburetor onto mounting studs, **Fig. 24.**

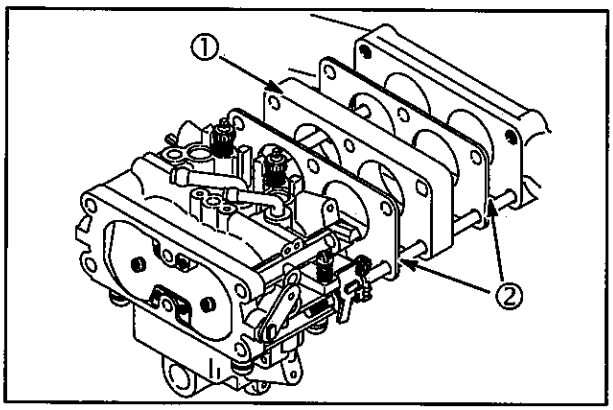


**Fig. 24**

**All Models**

1. Connect governor link (3) to throttle lever (1). Snap retainer (2) over link, **single barrel carburetor, Fig. 25, two barrel carburetor, Fig. 26.**

2. Install governor link spring (4) in loop on retainer.

**NOTE:** If the carburetor is equipped with an anti-afterfire solenoid, route the wire under the intake manifold and through the hole in #1 cylinder shield at this time.

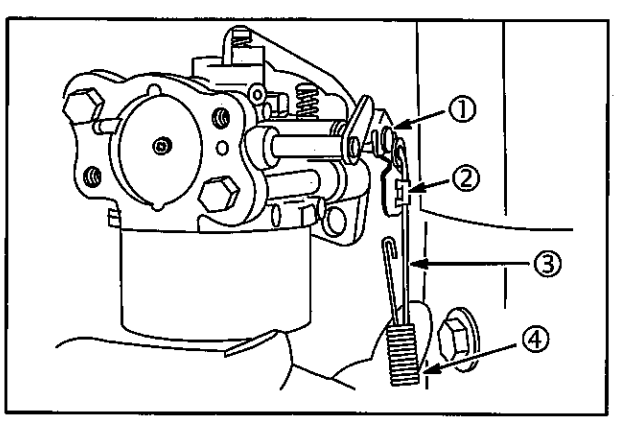


**Fig. 25**

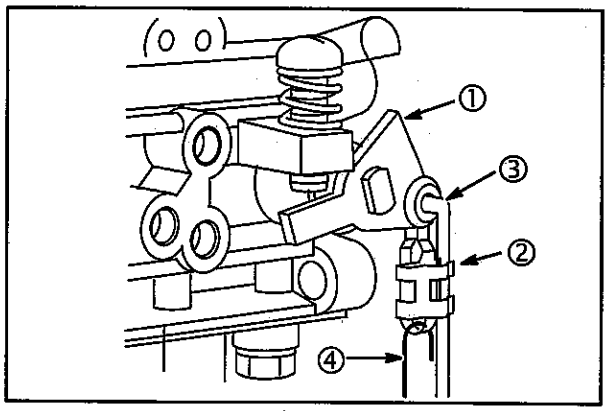


**Fig. 26**

3. Connect choke link (7) to choke lever and install choke control bracket (5), single barrel carburetor, **Fig. 27**, two barrel carburetor, **Fig. 28.** Torque screws (6) to **65 in. lbs. (7 Nm).**

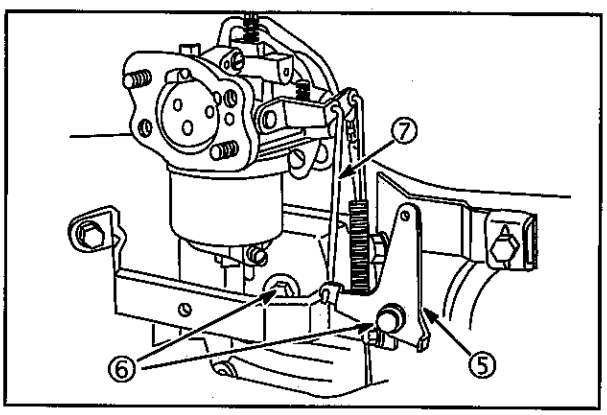


**Fig. 27**

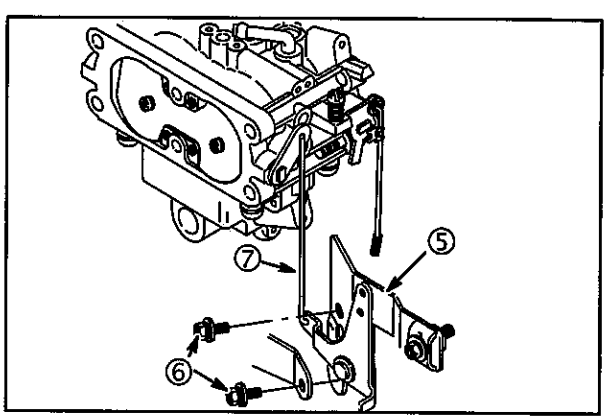


**Fig. 28**

4. Install fuel line and clamp.

**Horizontal Crankshaft**

**Models 290400, 303400, 350400**

1. Assemble gaskets (1), spacer (3) and carburetor to intake manifold, **Fig. 29.**

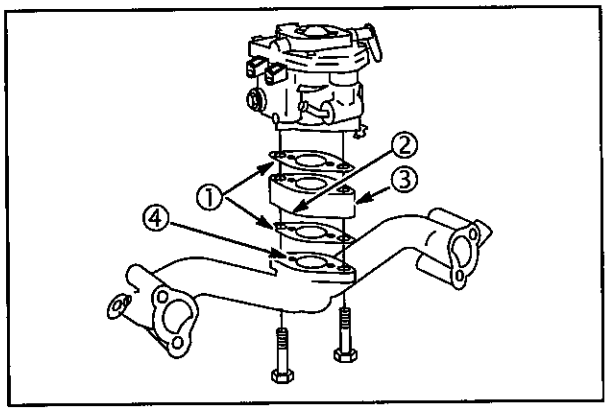


Fig. 29

a. Be sure locating pin (2) in spacer fits in recess (4) in manifold.
b. Torque screws to **65 in. lbs. (7 Nm)**.

2. Install new gaskets (5) and carburetor/manifold assembly (6) to cylinder heads, **Fig. 30**. Torque screws to **140 in. lbs. (16 Nm)**.

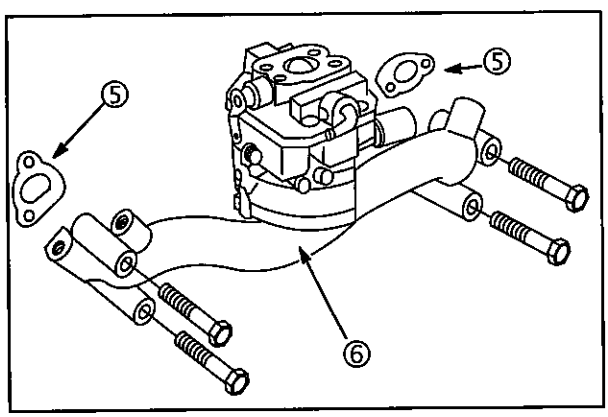


Fig. 30

3. Connect governor link (9) to throttle lever (7) and snap retainer (8) over link, **Fig. 31**.
4. Install governor link spring in loop on retainer.
5. Assemble choke link (6) to carburetor and choke lever and install choke bracket (10). Torque screws to **65 in. lbs. (7 Nm)**.
6. Install fuel line and clamp. Install fuel line at carburetor. Rotate fuel line clamp tabs horizontally to prevent interference with air cleaner base.

**NOTE:** If carburetor is equipped with anti-afterfire solenoid, route wire under intake manifold and through hole in #1 cylinder shield at this time.

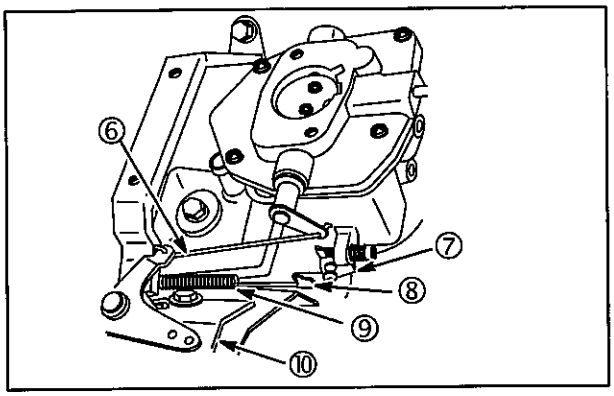


Fig. 31

**Models 351400, 380400, 540000, 610000**

1. Assemble intake elbow (1) and air cleaner elbow (5) to carburetor (3) with new gaskets (2, 4) **Fig. 32**.
2. Install air cleaner elbow gasket (4) with adhesive side toward air cleaner elbow and arrow up.

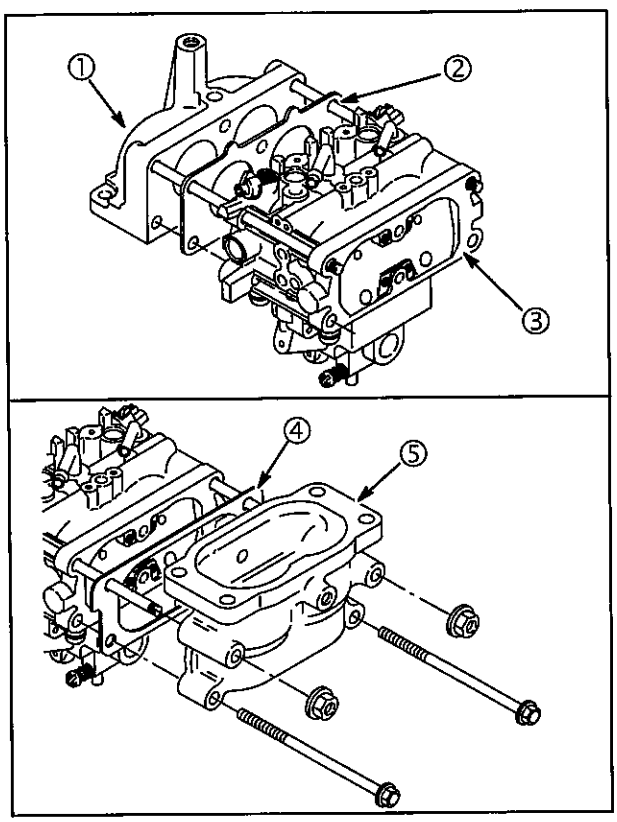


Fig. 32

12

3. Assemble choke link (6) to choke lever, **Fig. 33.**

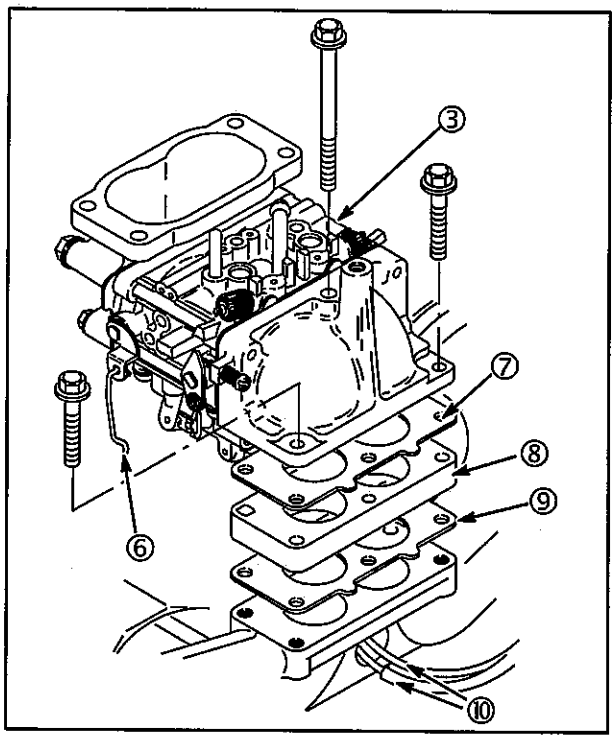


**Fig. 33**

4. Assemble carburetor (3), gasket (7), spacer (8) and gasket (9) to intake manifold.
5. Route both solenoid wires (10) through hole in intake manifold. Torque three screws to **65 in. lbs. (7 Nm).**
6. Install solenoid ground wire (11). Torque screw to **65 in. lbs. (7 Nm).**
7. Route long solenoid wire (12) under wire tie on manifold, then through hole in #1 cylinder shield, **Fig. 34.**

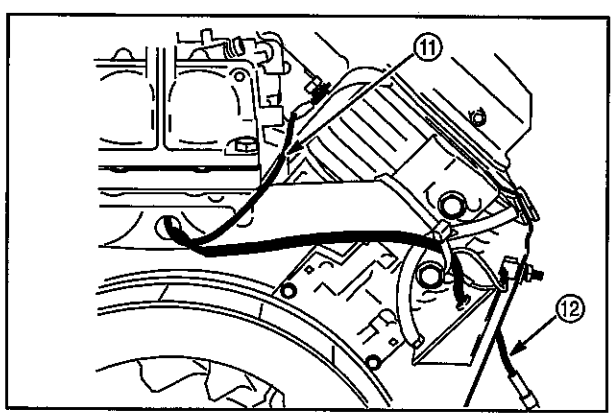


**Fig. 34**

8. Connect governor link (14) to throttle lever and snap retainer over link, **Fig. 35.**
9. Install governor link spring in loop on retainer.
10. Assemble choke link (13) to carburetor and choke lever. Install choke bracket (15). Torque screws to **65 in. lbs. (7 Nm).**
11. Install air cleaner elbow support. Torque screw to **65 in. lbs. (7 Nm).**

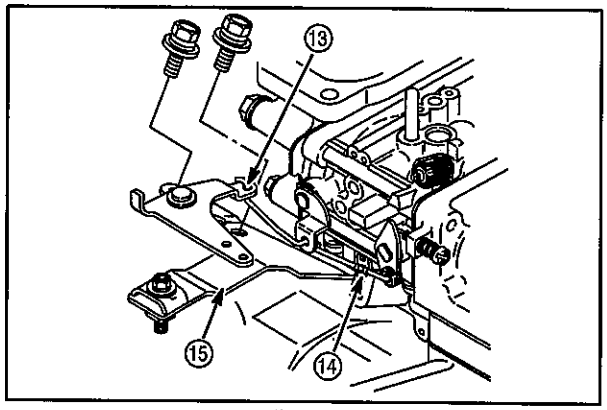


**Fig. 35**

## Install Blower Housing

1. Install blower housing (8), **Fig. 36.**
   a. Torque 6 mm screws to **65 in. lbs. (7 Nm).**
   b. Torque 8 mm screws to **140 in. lbs. (16 Nm).**
2. Install carburetor cover (9).
3. Install rotating screen (10).

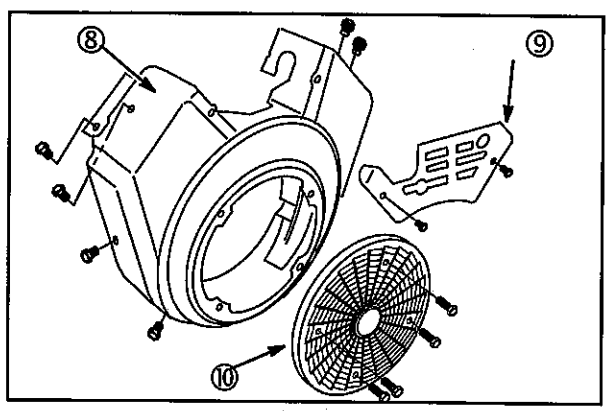


**Fig. 36**

## Install Air Cleaner

**Vertical Crankshaft**
**Models 290700, 303700, 350700**

***Current Style: (Round cartridge) Fig. 37.***

1. Install new air cleaner base gasket (6).
2. Guide breather tube (5) onto nipple on breather and install air cleaner base on carburetor mounting studs.
3. Install carburetor mounting nuts (2). Do not tighten nuts at this time.

4. Install breather deflector (4) and three screws (3). Torque nuts and screws to **65 in. lbs. (7 Nm)**.

Make sure air inlet tube (1) is installed correctly in air cleaner base.

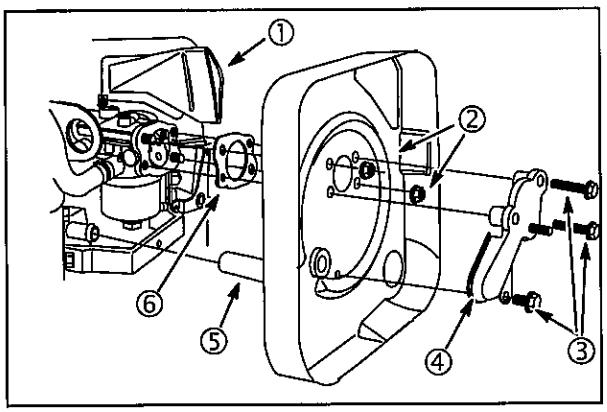


**Fig. 37**

***Early Style: (Square cartridge) Fig. 38.***

1. Insert mounting screws (2) through breather deflector, base (1) and gasket.
2. Guide breather tube onto breather nipple. Install mounting screws in carburetor. Do not tighten screws at this time.
3. Install two air cleaner bracket screws. Torque all four screws to **65 in. lbs. (7 Nm)**.

Make sure air inlet tube is installed correctly in air cleaner base.

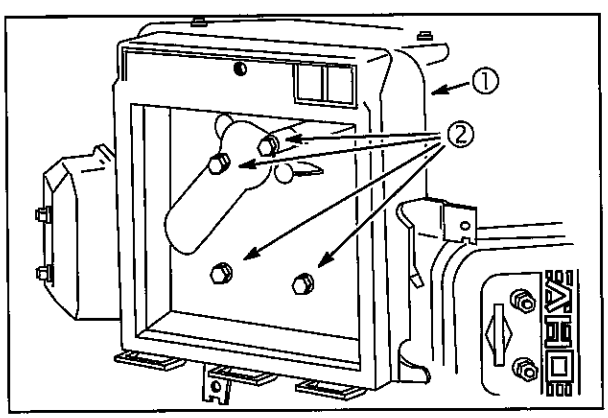


**Fig. 38**

**Models 351700, 380700**

1. Install new air cleaner mounting gasket with adhesive side toward air cleaner base, **Fig. 39.**
2. Guide breather tube onto breather nipple. Install air cleaner base on carburetor mounting studs.
3. Install carburetor shield (2).
4. Install nuts (3) and screws (1) finger tight.
5. Torque nuts and screws to **65 in. lbs. (7 Nm).**

Make sure air inlet tube is installed correctly to air cleaner base.

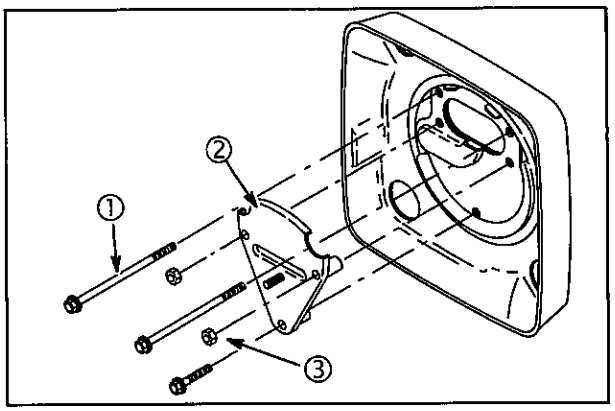


**Fig. 39**

**Horizontal Crankshaft**
**Models 290400, 303400, 350400**

***Current Style: (Round cartridge)***

1. Install new air cleaner base gasket.
2. Guide breather tube onto breather nipple. Install air cleaner base (1) on carburetor and support bracket, **Fig. 40.**

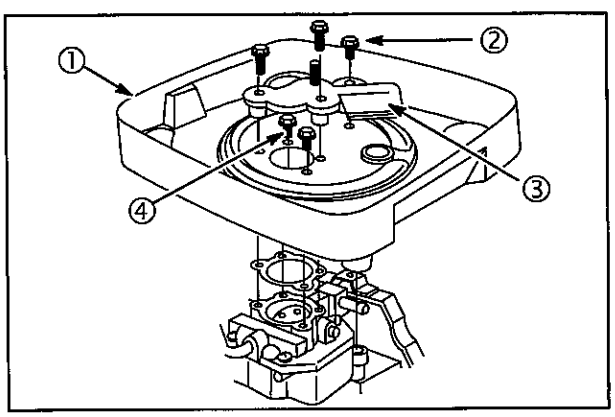


**Fig. 40**

3. Install two air cleaner base screws (4). Do not tighten at this time.
4. Install breather deflector (3) and three screws (2). Torque all screws to **65 in. lbs. (7 Nm).**

Make sure air inlet tube is installed correctly in air cleaner base.

***Early Style: (Square cartridge)***

1. Install new air cleaner base gasket.
2. Guide breather tube onto nipple on breather. Install air cleaner base (1) on carburetor and support bracket, **Fig. 41.**

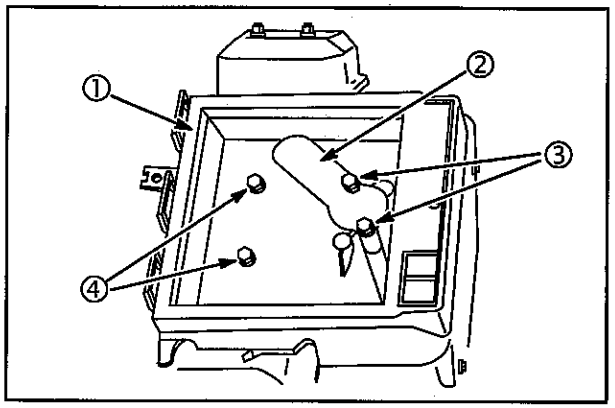


Fig. 41

3. Install breather deflector (2) and two screws (3). Do not tighten at this time.
4. Install two air cleaner support screws (4). Torque screws to **65 in. lbs. (7 Nm)**.

Make sure air inlet tube is installed correctly in air cleaner base.

**Models 351400, 380400**

1. Install new air cleaner mounting gasket (2) with adhesive side toward air cleaner base, **Fig. 42.**
2. Connect breather tube to air cleaner base and assemble air cleaner base to air cleaner elbow.
3. Install carburetor shield (1). Install five screws finger tight. Torque screws to **65 in. lbs. (7 Nm)**.

Make sure air inlet tube is installed correctly in air cleaner base.

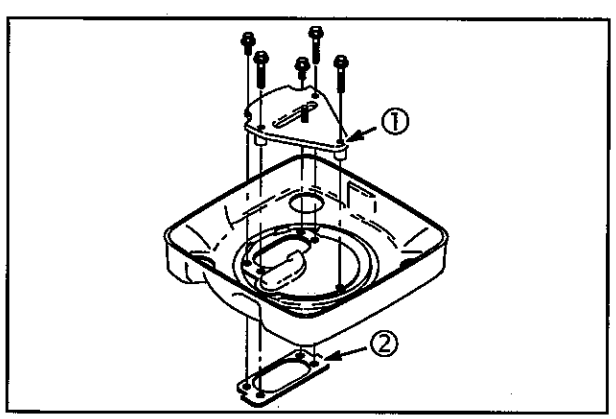


Fig. 42

**Models 540000, 610000**

1. Orient the air cleaner with the air inlet (2) facing UP. Tighten the air inlet hose clamp to **30 in. lbs. (3.4 Nm), Fig. 43.**

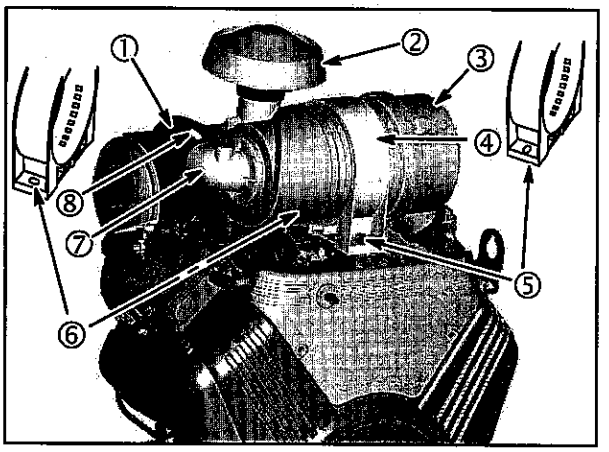


Fig. 43

2. With the outlet tube (7) to the LEFT, service cover (3) to the RIGHT, install the mounting band (4).

**NOTE:** The air cleaner is held in place by the mounting band. The mounting band has a TENSIONER ADJUSTING SLOT (5) that runs vertically and faces the front of the engine, the SIDE ADJUSTER SLOT (6) runs horizontally and faces the back.

3. Align the tabs on the inside of the mounting band with the slots on the outside of the air cleaner housing. Fasten the SIDE ADJUSTER SLOT first.
4. Push the mounting band closed and fasten the TENSIONER ADJUSTING SLOT. Tighten both mounting band screws to **200 in. lbs. (23 Nm)**.
5. Connect the air inlet hose (1) to the outlet tube (7). Tighten both hose clamps to **30 in. lbs. (3.4 Nm)**.

**NOTE:** The end of the air inlet hose with the white stripe connects to the outlet tube of the air cleaner. The white stripe (8) on the air inlet hose faces UP as shown.

## Final Engine Assembly

- Install muffler and exhaust manifold. Torque to **150 in. lbs. (17 Nm).**

**NOTE:** Models **540000, 610000** torque screws to **180 in. lbs. (20 Nm).**

- Install spark plugs. Torque spark plugs to **180 in. lbs. (20 Nm).**
- Install engine into equipment.
- Connect choke and throttle control cables.
- Install oil filter. Refill oil.
- Static-adjust engine governor (see below).

## Static Governor Adjustment

***Before Running Engine***

**WARNING**

**AVOID INJURY!** Complete the governor static adjustment BEFORE starting or running engine.

- Incorrect adjustment could result in engine overspeeding, causing engine damage, property damage or personal injury.
- Correct speed is found in the Service Engine Sales Manual Microfiche, MS-6225 or the Service Sales Manual, MS-4052.

1. Loosen governor lever nut. Push on governor lever (1) until throttle is wide open.

**CAUTION:** Do not bend governor link or distort governor lever.

2. Use a screwdriver (2) to rotate governor shaft COUNTERCLOCKWISE as far it will go, **Fig. 44.** Torque governor nut to **70 in. lbs. (8 Nm).**
3. Perform a dynamic governor adjustment per Section 1.

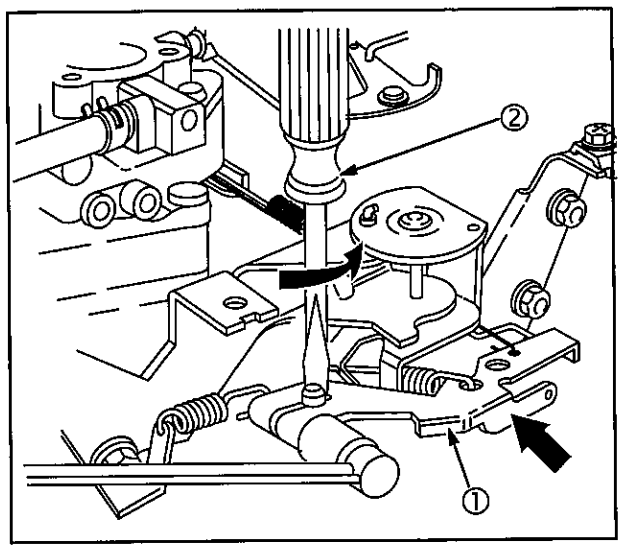


**Fig. 44**

12

# Section 13
# Engine Specifications



13

## Models 290000, 300000

### Common Specifications

**NOTE:** All dimensions in Inches (Millimeters)

| | |
|---|---|
| Armature Air Gap | 0.008 – 0.012 (0.20 – 0.30) |
| Crankshaft End Play | 0.002 – 0.030 (0.05 – 0.76) |
| Spark Plug Gap | 0.030 (0.76) |
| Valve Clearance – Measured Cold | |
| Intake | 0.004 – 0.006 (0.10 – 0.15) |
| Exhaust | 0.004 – 0.006 (0.10 – 0.15) |

### Dimensional Specifications

**NOTE:** All dimensions in Inches (Millimeters)

| *Description* | *Standard Dimension* | *Reject Dimension* |
|---|---|---|
| **Cylinder** | | |
| Bore | | |
| Models 290000 & 303000 | 2.677 – 2.678 (68.00 – 68.03) | 2.681 (68.10) |
| Out-of-round | | 0.002 (0.05) |
| Main Bearing | | |
| Before 970501100 | 1.182 – 1.183 (30.03 – 30.06) | 1.184 (30.08) |
| After 97043000 | 1.379 – 1.380 (35.02 – 35.06) | 1.383 (35.12) |
| Cam Bearing | 0.630 – 0.631 (16.00 – 16.03) | 0.633 (16.08) |
| **Cylinder Head** | | |
| Valve Guide | 0.2366 – 0.237 (6.01 – 6.02) | 0.238 (6.05) |
| Valve Stem– | | |
| Intake | 0.234 – 0.235 (5.95 – 5.96) | 0.233 (5.92) |
| Exhaust | 0.2338 – 0.234 (5.94 – 5.95) | 0.2327 (5.91) |
| **Crankcase Cover** | | |
| Main Bearing | 1.3795 – 1.380 (35.04 – 35.05) | 1.381 (35.07) |
| Cam Bearing | 0.7874 – 0.788 (20.0 – 20.02) | 0.789 (20.04) |
| **Crankshaft** | | |
| Crankpin | 1.4567 – 1.458 (37.00 – 37.03) | 1.455 (36.95) |
| Magneto Journal | | |
| Before 9705010 | 1.180 – 1.181 (29.98 – 30.00) | 1.179 (29.94) |
| After 97043000 | 1.376 – 1.378 (34.95 – 35.00) | 1.376 (34.95) |
| PTO Journal | 1.376 – 1.377 (34.95 – 34.98) | 1.375 (34.92) |
| Throw | 1.444 – 1.447 (36.66 – 36.74) | |
| **Camshaft** | | |
| Magneto Journal | 0.628 – 0.629 (15.95 – 15.97) | 0.627 (15.93) |
| PTO Journal | 0.785 – 0.7854 (19.94 – 19.95) | 0.7843 (19.92) |
| Lobes | | |
| Intake | 1.194 – 1.202 (30.33 – 30.53) | 1.191 (30.25) |
| Exhaust | 1.194 – 1.202 (30.33 – 30.53) | 1.191 (30.25) |
| **Connecting Rod** | | |
| Crankpin Bearing | 1.459 – 1.460 (37.06 – 37.08) | 1.461 (37.12) |
| Piston Pin Bearing | 0.6728 – 0.6732 (17.09 – 17.10) | 0.674 (17.12) |
| **Piston Pin** | 0.6720 – 0.6724 (17.07 – 17.08) | 0.6717 (17.06) |
| **Piston Pin Bearing (Piston)** | 0.6728 – 0.6732 (17.09 – 17.10) | 0.674 (17.12) |
| **Piston Rings** | | |
| End Gap – Top, Center & Oil | 0.008 – 0.016 (0.20 – 0.40) | 0.030 (0.76) |
| Side Clearance | | |
| Top & Center Rings | 0.002 – 0.003 (0.05 – 0.08) | 0.004 (0.10) |
| Oil Control Rings | 0.0045 – 0.006 (0.11 – 0.15) | 0.008 (0.20) |

## Torque Values

| *Description* | *Torque* |
|---|---|
| Air Cleaner Mounting | 90 in. lbs. (10 Nm) |
| Air Guide Mounting Screws | 90 in. lbs. (10 Nm) |
| Air Block Plate Mounting Screws | 30 in. lbs. (3 Nm) |
| Alternator | 20 in. lbs. (2 Nm) |
| Alternator Harness Clamp Screw | 90 in. lbs. (10 Nm) |
| Air Cleaner Base (to carburetor) | 65 in. lbs. (7 Nm) |
| Air Cleaner Support Bracket | 65 in. lbs. (7 Nm) |
| Armature | 25 in. lbs. (3 Nm) |
| Back Plate | 65 in. lbs. (7 Nm) |
| Blower Housing | 65 in. lbs. (7 Nm) |
| Breather | 30 in. lbs. (3 Nm) |
| Carburetor to Manifold | 65 in. lbs. (7 Nm) |
| Connecting Rod | 115 in. lbs. (13 Nm) |
| Crankcase Cover | 150 in. lbs. (17 Nm) |
| Cylinder Head | 165 in. lbs. (19 Nm) |
| Cylinder Shield | 65 in. lbs. (7 Nm) |
| Exhaust Manifold | 150 in. lbs. (17 Nm) |
| Fan Retainer | 150 in. lbs. (17 Nm) |
| Flywheel | 125 ft. lbs. (170 Nm) |
| Fuel Pump | 45 in. lbs. (5 Nm) |
| Governor Control Bracket | 140 in. lbs. (16 Nm) |
| Governor Lever Nut | 70 in. lbs. (8 Nm) |
| Intake Manifold | 140 in. lbs. (16 Nm) |
| Oil Pump | 65 in. lbs. (7 Nm) |
| Rewind Starter (to blower housing) | 65 in. lbs. (7 Nm) |
| Rocker Arm Lock Nut | 70 in. lbs. (8 Nm) |
| Rocker Arm Stud | |
| – Current Style | 100 in. lbs. (11 Nm) |
| – Early Style | 140 in. lbs. (16 Nm) |
| Spark Plug | 180 in. lbs. (20 Nm) |
| Starter Motor | 140 in. lbs. (16 Nm) |
| Valve Cover | 70 in. lbs. (8 Nm) |

## Model 350000

### Common Specifications

**NOTE:** All dimensions in Inches (Millimeters)

| | |
|---|---|
| Armature Air Gap | 0.008 – 0.012 (0.20 – 0.30) |
| Crankshaft End Play | 0.002 – 0.030 (0.05 – 0.76) |
| Spark Plug Gap | 0.030 (0.76) |
| Valve Clearance – Measured Cold | |
| Intake | 0.004 – 0.006 (0.10 – 0.15) |
| Exhaust | 0.004 – 0.006 (0.10 – 0.15) |

### Dimensional Specifications

**NOTE:** All dimensions in Inches (Millimeters)

| *Description* | *Standard Dimension* | *Reject Dimension* |
|---|---|---|
| **Cylinder** | | |
| Bore | 2.835 – 2.836 (72.00 – 72.03) | 2.841 (72.16) |
| Out-of-round | | 0.002 (0.05) |
| Main Bearing | | |
| Before 970501100 | 1.182 – 1.183 (30.03 – 30.06) | 1.184 (30.08) |
| After 97043000 | 1.379 – 1.380 (35.02 – 35.06) | 1.383 (35.12) |
| Cam Bearing | 0.630 – 0.631 (16.00 – 16.03) | 0.633 (16.08) |
| **Cylinder Head** | | |
| Valve Guide | 0.2366 – 0.237 (6.01 – 6.02) | 0.238 (6.05) |
| Valve Stem– | | |
| Intake | 0.234 – 0.235 (5.95 – 5.96) | 0.233 (5.92) |
| Exhaust | 0.2338 – 0.234 (5.94 – 5.95) | 0.2327 (5.91) |
| **Crankcase Cover** | | |
| Main Bearing | 1.3795 – 1.380 (35.04 – 35.05) | 1.381 (35.07) |
| Cam Bearing | 0.7874 – 0.788 (20.0 – 20.02) | 0.789 (20.04) |
| **Crankshaft** | | |
| Crankpin | 1.4567 – 1.458 (37.00 – 37.03) | 1.455 (36.95) |
| Magneto Journal | | |
| Before 9705010 | 1.180 – 1.181 (29.98 – 30.00) | 1.179 (29.94) |
| After 97043000 | 1.376 – 1.378 (34.95 – 35.00) | 1.376 (34.95) |
| PTO Journal | 1.376 – 1.377 (34.95 – 34.98) | 1.375 (34.92) |
| Throw | 1.444 – 1.447 (36.66 – 36.74) | |
| **Camshaft** | | |
| Magneto Journal | 0.628 – 0.629 (15.95 – 15.97) | 0.627 (15.93) |
| PTO Journal | 0.785 – 0.7854 (19.94 – 19.95) | 0.7843 (19.92) |
| Lobes | | |
| Intake | 1.194 – 1.202 (30.33 – 30.53) | 1.191 (30.25) |
| Exhaust | 1.194 – 1.202 (30.33 – 30.53) | 1.191 (30.25) |
| **Connecting Rod** | | |
| Crankpin Bearing | 1.459 – 1.460 (37.06 – 37.08) | 1.461 (37.12) |
| Piston Pin Bearing | 0.6728 – 0.6732 (17.09 – 17.10) | 0.674 (17.12) |
| **Piston Pin** | 0.6720 – 0.6724 (17.07 – 17.08) | 0.6717 (17.06) |
| **Piston Pin Bearing (Piston)** | 0.6728 – 0.6732 (17.09 – 17.10) | 0.674 (17.12) |
| **Piston Rings** | | |
| End Gap – Top, Center & Oil | 0.008 – 0.016 (0.20 – 0.40) | 0.030 (0.76) |
| Side Clearance | | |
| Top & Center Rings | 0.002 – 0.003 (0.05 – 0.08) | 0.004 (0.10) |
| Oil Control Rings | 0.0045 – 0.006 (0.11 – 0.15) | 0.008 (0.20) |

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## Torque Values

| *Description* | *Torque* |
|---|---|
| Air Cleaner Mounting | 90 in. lbs. (10 Nm) |
| Air Guide Mounting Screws | 90 in. lbs. (10 Nm) |
| Air Block Plate Mounting Screws | 30 in. lbs. (3 Nm) |
| Alternator | 20 in. lbs. (2 Nm) |
| Alternator Harness Clamp Screw | 90 in. lbs. (10 Nm) |
| Air Cleaner Base (to carburetor) | 65 in. lbs. (7 Nm) |
| Air Cleaner Support Bracket | 65 in. lbs. (7 Nm) |
| Armature | 25 in. lbs. (3 Nm) |
| Back Plate | 65 in. lbs. (7 Nm) |
| Blower Housing | 65 in. lbs. (7 Nm) |
| Breather | 30 in. lbs. (3 Nm) |
| Carburetor to Manifold | 65 in. lbs. (7 Nm) |
| Connecting Rod | 115 in. lbs. (13 Nm) |
| Crankcase Cover | 150 in. lbs. (17 Nm) |
| Cylinder Head | 165 in. lbs. (19 Nm) |
| Cylinder Shield | 65 in. lbs. (7 Nm) |
| Exhaust Manifold | 150 in. lbs. (17 Nm) |
| Fan Retainer | 150 in. lbs. (17 Nm) |
| Flywheel | 125 ft. lbs. (170 Nm) |
| Fuel Pump | 45 in. lbs. (5 Nm) |
| Governor Control Bracket | 140 in. lbs. (16 Nm) |
| Governor Lever Nut | 70 in. lbs. (8 Nm) |
| Intake Manifold | 140 in. lbs. (16 Nm) |
| Oil Pump | 65 in. lbs. (7 Nm) |
| Rewind Starter (to blower housing) | 65 in. lbs. (7 Nm) |
| Rocker Arm Lock Nut | 70 in. lbs. (8 Nm) |
| Rocker Arm Stud | |
| – Current Style | 100 in. lbs. (11 Nm) |
| – Early Style | 140 in. lbs. (16 Nm) |
| Spark Plug | 180 in. lbs. (20 Nm) |
| Starter Motor | 140 in. lbs. (16 Nm) |
| Valve Cover | 70 in. lbs. (8 Nm) |

## Model 380000

### Common Specifications

**NOTE:** All dimensions in Inches (Millimeters)

| | |
|---|---|
| Armature Air Gap | 0.008 – 0.012 (0.20 – 0.30) |
| Crankshaft End Play | 0.002 – 0.030 (0.05 – 0.76) |
| Spark Plug Gap | 0.030 (0.76) |
| Valve Clearance – Measured Cold | |
| Intake | 0.004 – 0.006 (0.10 – 0.15) |
| Exhaust | 0.004 – 0.006 (0.10 – 0.15) |

### Dimensional Specifications

**NOTE:** All dimensions in Inches (Millimeters)

| *Description* | *Standard Dimension* | *Reject Dimension* |
|---|---|---|
| **Cylinder** | | |
| Bore | 2.972 – 2.973 (75.50 – 75.52) | 2.976 (75.59) |
| Out-of-round | | 0.002 (0.05) |
| Main Bearing | | |
| Before 970501100 | 1.182 – 1.183 (30.03 – 30.06) | 1.184 (30.08) |
| After 97043000 | 1.379 – 1.380 (35.02 – 35.06) | 1.383 (35.12) |
| Cam Bearing | 0.630 – 0.631 (16.00 – 16.03) | 0.633 (16.08) |
| **Cylinder Head** | | |
| Valve Guide | 0.2366 – 0.237 (6.01 – 6.02) | 0.238 (6.05) |
| Valve Stem– | | |
| Intake | 0.234 – 0.235 (5.95 – 5.96) | 0.233 (5.92) |
| Exhaust | 0.2338 – 0.234 (5.94 – 5.95) | 0.2327 (5.91) |
| **Crankcase Cover** | | |
| Main Bearing | 1.3795 – 1.380 (35.04 – 35.05) | 1.381 (35.07) |
| Cam Bearing | 0.7874 – 0.788 (20.0 – 20.02) | 0.789 (20.04) |
| **Crankshaft** | | |
| Crankpin | 1.4567 – 1.458 (37.00 – 37.03) | 1.455 (36.95) |
| Magneto Journal | | |
| Before 9705010 | 1.180 – 1.181 (29.98 – 30.00) | 1.179 (29.94) |
| After 97043000 | 1.376 – 1.378 (34.95 – 35.00) | 1.376 (34.95) |
| PTO Journal | 1.376 – 1.377 (34.95 – 34.98) | 1.375 (34.92) |
| Throw | 1.444 – 1.447 (36.66 – 36.74) | |
| **Camshaft** | | |
| Magneto Journal | 0.628 – 0.629 (15.95 – 15.97) | 0.627 (15.93) |
| PTO Journal | 0.785 – 0.7854 (19.94 – 19.95) | 0.7843 (19.92) |
| Lobes | | |
| Intake | 1.224 – 1.232 (31.09 – 31.30) | 1.223 (31.06) |
| Exhaust | 1.194 – 1.202 (30.33 – 30.53) | 1.191 (30.25) |
| **Connecting Rod** | | |
| Crankpin Bearing | 1.459 – 1.460 (37.06 – 37.08) | 1.461 (37.12) |
| Piston Pin Bearing | 0.710 – 0.711 (18.03 – 18.06) | 0.711 (18.06) |
| **Piston Pin** | 0.7087 – 0.709 (18.00 – 18.01) | 0.7079 (17.98) |
| **Piston Pin Bearing (Piston)** | 0.710 – 0.711 (18.04 – 18.05) | 0.711 (18.06) |
| **Piston Rings** | | |
| End Gap – Top, Center & Oil | 0.008 – 0.016 (0.20 – 0.40) | 0.030 (0.76) |
| Side Clearance | | |
| Top & Center Rings | 0.002 – 0.003 (0.05 – 0.08) | 0.004 (0.10) |
| Oil Control Rings | 0.0045 – 0.006 (0.11 – 0.15) | 0.008 (0.20) |

## Torque Values

| *Description* | *Torque* |
|---|---|
| Air Cleaner Mounting | 90 in. lbs. (10 Nm) |
| Air Guide Mounting Screws | 90 in. lbs. (10 Nm) |
| Air Block Plate Mounting Screws | 30 in. lbs. (3 Nm) |
| Alternator | 20 in. lbs. (2 Nm) |
| Alternator Harness Clamp Screw | 90 in. lbs. (10 Nm) |
| Air Cleaner Base (to carburetor) | 65 in. lbs. (7 Nm) |
| Air Cleaner Support Bracket | 65 in. lbs. (7 Nm) |
| Armature | 25 in. lbs. (3 Nm) |
| Back Plate | 65 in. lbs. (7 Nm) |
| Blower Housing | 65 in. lbs. (7 Nm) |
| Breather | 30 in. lbs. (3 Nm) |
| Carburetor to Manifold | 65 in. lbs. (7 Nm) |
| Connecting Rod | 115 in. lbs. (13 Nm) |
| Crankcase Cover | 150 in. lbs. (17 Nm) |
| Cylinder Head | 165 in. lbs. (19 Nm) |
| Cylinder Shield | 65 in. lbs. (7 Nm) |
| Exhaust Manifold | 150 in. lbs. (17 Nm) |
| Fan Retainer | 150 in. lbs. (17 Nm) |
| Flywheel | 125 ft. lbs. (170 Nm) |
| Fuel Pump | 45 in. lbs. (5 Nm) |
| Governor Control Bracket | 140 in. lbs. (16 Nm) |
| Governor Lever Nut | 70 in. lbs. (8 Nm) |
| Intake Manifold | 140 in. lbs. (16 Nm) |
| Oil Pump | 65 in. lbs. (7 Nm) |
| Rewind Starter (to blower housing) | 65 in. lbs. (7 Nm) |
| Rocker Arm Lock Nut | 70 in. lbs. (8 Nm) |
| Rocker Arm Stud | |
| – Current Style | 100 in. lbs. (11 Nm) |
| – Early Style | 140 in. lbs. (16 Nm) |
| Spark Plug | 180 in. lbs. (20 Nm) |
| Starter Motor | 140 in. lbs. (16 Nm) |
| Valve Cover | 70 in. lbs. (8 Nm) |

## Models 540000, 610000

### Common Specifications

**NOTE:** All dimensions in Inches (Millimeters)

| | |
|---|---|
| Armature Air Gap | 0.005 – 0.007 (0.13 – 0.18) |
| Crankshaft End Play | 0.002 – 0.012 (0.05 – 0.30) |
| Spark Plug Gap | 0.020 (0.51) |
| Valve Clearance – Measured Cold | |
| Intake | 0.004 – 0.006 (0.10 – 0.15) |
| Exhaust | 0.004 – 0.006 (0.10 – 0.15) |

### Dimensional Specifications

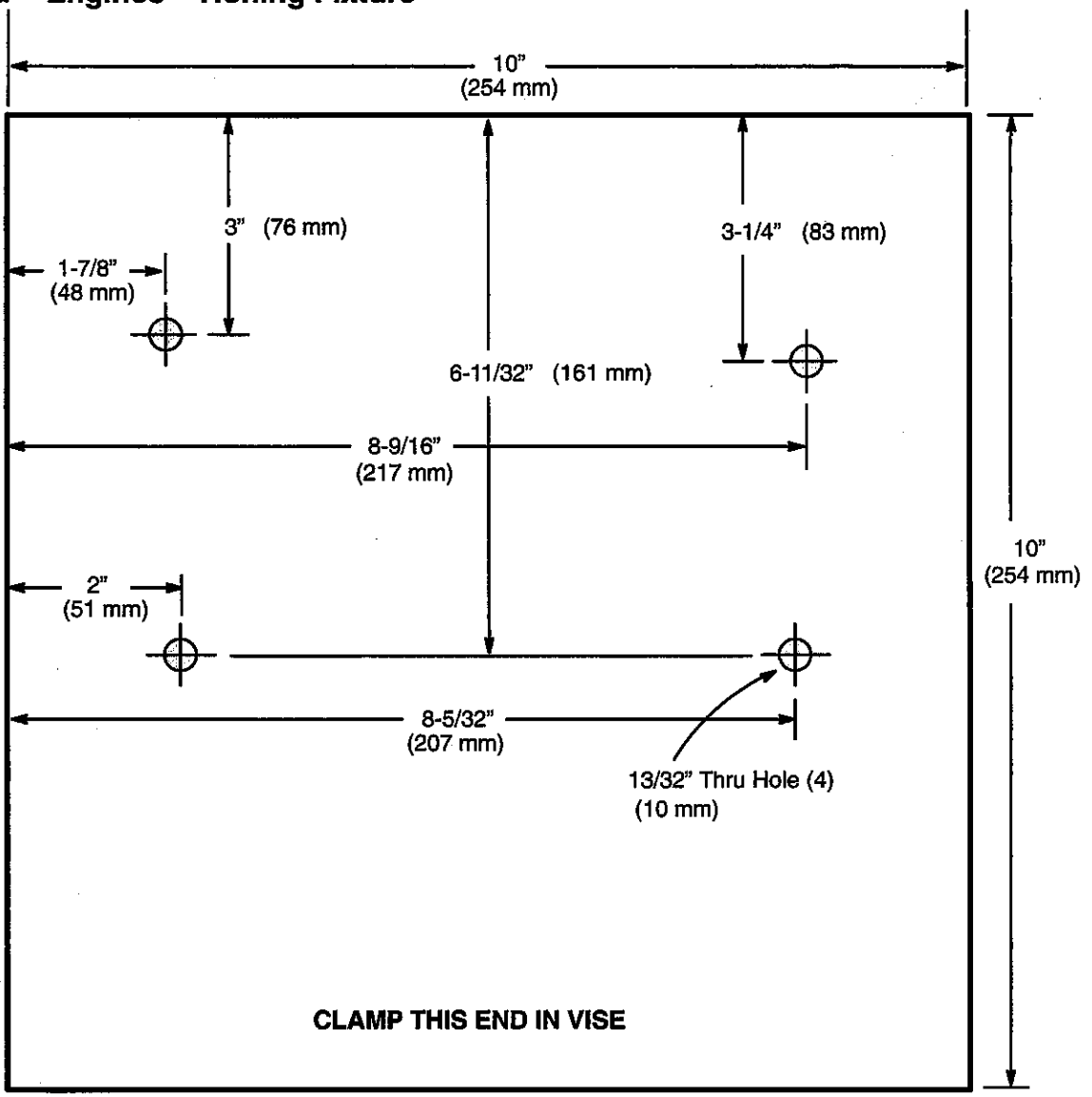
**NOTE:** All dimensions in Inches (Millimeters)

| *Description* | *Standard Dimension* | *Reject Dimension* |
|---|---|---|
| **Cylinder** | | |
| Bore | 3.366 (85.50) | 3.369 (85.57) |
| Out-of-round | | 0.002 (0.05) |
| Main Bearing | 1.775 (45.09) | 1.777 (45.12) |
| Cam Bearing | 0.630 – 0.631 (16.00 – 16.03) | 0.633 (16.08) |
| **Cylinder Head** | | |
| Valve Guide | 0.2366 – 0.237 (6.01 – 6.02) | 0.238 (6.05) |
| Valve Stem– | | |
| Intake | 0.234 – 0.235 (5.95 – 5.96) | 0.233 (5.92) |
| Exhaust | 0.2338 – 0.234 (5.94 – 5.95) | 0.2327 (5.91) |
| **Crankcase Cover** | | |
| Main Bearing | 1.3795 – 1.380 (35.04 – 35.05) | 1.381 (35.07) |
| Cam Bearing | 0.7874 – 0.788 (20.0 – 20.02) | 0.789 (20.04) |
| **Crankshaft** | | |
| Crankpin | 1.654 (42.01) | 1.6525 (41.97) |
| Magneto Journal | 1.771 (44.98) | 1.7695 (44.95) |
| PTO Journal | 1.771 (44.98) | 1.7695 (44.95) |
| **Camshaft** | | |
| Magneto Journal | 0.786 (19.96) | 0.7485 (19.93) |
| PTO Journal | 0.786 (19.96) | 0.7485 (19.93) |
| **Connecting Rod** | | |
| Crankpin Bearing | 1.656 (42.06) | 1.658 (42.11) |
| Piston Pin Bearing | 0.827 (21.01) | 0.828 (21.03) |
| **Piston Pin** | 0.8268 (21.00) | 0.8258 (20.98) |
| **Piston Pin Bearing (Piston)** | 0.827 (21.01) | 0.828 (21.03) |
| **Piston Rings** | | |
| End Gap | | |
| Top | 0.007 – 0.013 (0.20 – 0.35) | 0.030 (0.76) |
| Center | 0.013 – 0.021 (0.35 – 0.55) | 0.030 (0.76) |
| Oil | 0.007 – 0.057 (0.20 – 0.70) | 0.040 (1.00) |
| Side Clearance | | |
| Top | 0.003 (0.07) | 0.006 (0.15) |
| Center | 0.002 (0.05) | 0.004 (0.10) |
| Oil | 0.0015 (0.04) | 0.008 (0.20) |

## Torque Values

| *Description* | *Torque* |
|---|---|
| Air Cleaner Mounting | 190 in. lbs. (21 Nm) |
| Air Guide Mounting Screws | 90 in. lbs. (10 Nm) |
| Air Block Plate Mounting Screws | 90 in. lbs. (10 Nm) |
| Alternator | 35 in. lbs. (4 Nm) |
| Alternator Harness Clamp Screw | 90 in. lbs. (10 Nm) |
| Air Cleaner Base (to carburetor) | 65 in. lbs. (7 Nm) |
| Air Cleaner Support Bracket | 65 in. lbs. (7 Nm) |
| Armature | 35 in. lbs. (4 Nm) |
| Back Plate | 90 in. lbs. (10 Nm) |
| Blower Housing | 90 in. lbs. (10 Nm) |
| Breather | 45 in. lbs. (5 Nm) |
| Carburetor to Manifold | 90 in. lbs. (10 Nm) |
| Carburetor Intake Elbow to Carburetor | 90 in. lbs. (10 Nm) |
| Connecting Rod | 125 in. lbs. (14 Nm) |
| Crankcase Cover | 200 in. lbs. (23 Nm) |
| Cylinder Head | 350 in. lbs. (40 Nm) |
| Cylinder Shield | 90 in. lbs. (10 Nm) |
| Exhaust Manifold | 200 in. lbs. (23 Nm) |
| Flywheel | 150 ft. lbs. (203 Nm) |
| Flywheel Fan Screws | 90 in. lbs. (10 Nm) |
| Fuel Pump | 45 in. lbs. (5 Nm) |
| Governor Control Bracket | 200 in. lbs. (23 Nm) |
| Governor Lever Nut | 70 in. lbs. (8 Nm) |
| Ignition Armature | 30 in. lbs. (3 Nm) |
| Intake Manifold | 180 in. lbs. (20 Nm) |
| Oil Drain Plug | 180 in. lbs. (20 Nm) |
| Oil Pickup to Pump | 90 in. lbs. (10 Nm) |
| Oil Pressure Switch | 80 in. lbs. (9 Nm) |
| Oil Pump to Crankcase Cover | 90 in. lbs. (10 Nm) |
| Regulator Rectifier | 90 in. lbs. (10 Nm) |
| Rocker Arm Lock Nut | 70 in. lbs. (8 Nm) |
| Rocker Arm Stud | 100 in. lbs. (11 Nm) |
| Rotating Screen Screws | 100 in. lbs. (11 Nm) |
| Rotating Screen Studs | 125 in. lbs. (14 Nm) |
| Spark Plug | 180 in. lbs. (20 Nm) |
| Starter Motor | 140 in. lbs. (16 Nm) |
| Valve Cover | 70 in. lbs. (8 Nm) |

## Vanguard™ Engines – Honing Fixture




**Material: Wood 2" x 10" x 10" (51 mm x 254 mm x 254 mm)**

**Cylinder Mounting Hardware Fasteners Required:**

**4 @ Crankcase Cover Screws, 4 @ Flat Washers 3/8" (9.5 mm) I.D.**

## Starter Motor Support Block

A starter motor support block can be made from stock 1" (25.4 mm) thick as shown in **Fig. 1**. The dimensions for the block are:

1. 1" (25.4 mm)
2. 0.4" (10.2 mm)
3. 2" (51 mm)
4. 1" (25 mm)
5. 5" (127 mm)

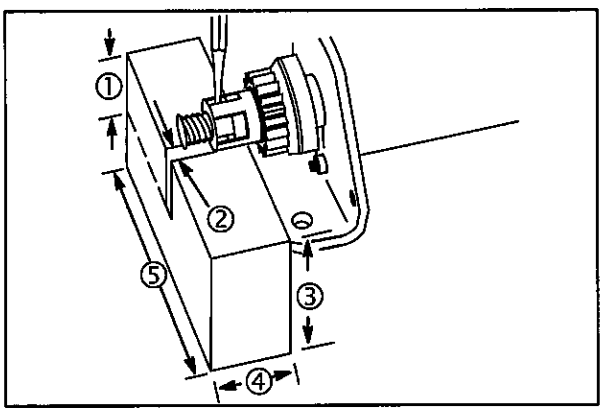



**Fig. 1**

## Starter Motor Test Bracket

A starter motor test bracket may be made from metal stock 1/4" (6.4 mm) thick steel as shown in **Fig. 2**. The dimensions for the test bracket are:

a. 4" (101.6 mm)
b. 2-1/4" (57.2 mm)
c. 3-1/2" (88.9 mm)
d. 2" (50.8 mm)
e. 10" (254 mm)
f. 1" (25.4 mm)
g. 3-1/2" (88.9 mm)

1. Drill two holes (1) 3/8" (9.5 mm) diameter for mounting starter.
2. Use a #7 drill to drill two holes (2) to mount Tachometer **#19200**. Tap holes for 1/4-20 screws.
3. Drill an extra hole (3) for mounting starter brackets.

- **CAUTION:** DO NOT clamp motor housing in a vise or strike with a hammer. Starter motors contain ceramic magnets that could be broken or cracked if the housing is damaged.

A growler or armature tester is available from an automotive parts supplier.

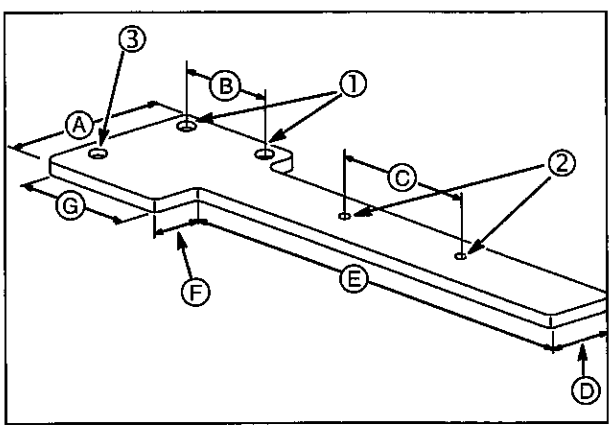



**Fig. 2**

| FUEL SYSTEM IDENTIFICATION | | |
|---|---|---|
| **Model** | **Fuel System Type** | **Color Code** |
| **290400** | Gravity | Yellow |
| **290400** | Pump | White |
| **294400** | Gravity | Pump |
| **294400** | Pump | None |
| **303400** | Gravity | Blue |
| **303400** | Pump | None |
| **350400** | Gravity | Blue |
| **350400** | Pump | None |

| CARBURETOR MAIN JETS | |
|---|---|
| **Model** | **Jet Number** |
| **351400** | Left cylinder (#1) #94<br>Right cylinder (#2) #98 |
| **351700** | Left cylinder (#1) #98<br>Right cylinder (#2) #100 |
| **380400** | Left cylinder (#1) #110<br>Right cylinder (#2) #114 |
| **380700** | Left cylinder (#1) #118<br>Right cylinder (#2) #116 |
| **405770** | #132 |
| **445770** | #140 |
| **540000**<br>**610000** | Left Cylinder #136<br>Right Cylinder #138<br>Secondary Upper<br>#120 (2 used)<br>Secondary Lower<br>#150 (2 used) |

| REFERENCE PRESSURES FOR GASEOUS FUELED ENGINES | |
|---|---|
| **Tank Pressure** | 90 psi minimum |
| **Secondary inlet under load** | 11 inches of water |
| **Secondary outlet under load** | 0 to slight vacuum |
| 1 psi = 16 ounces = 27.72 inches of water | |

| DIODE FAILURE DIAGNOSIS | | |
|---|---|---|
| **Switch ON** | **Switch OFF** | **Cause** |
| **Engine Runs on Only 1 Cylinder** | Shuts Off OK | 1 Closed Diode |
| **Engine Runs on Both Cylinders** | Only 1 Cylinder Shuts Off | 1 Open Diode |
| **Won't Run (No Spark)** | | 2 Closed Diodes |
| **Engine Runs on Both Cylinders** | Engine Won't Shut Off | 2 Open Diodes |

| CRANKSHAFT GRINDING DIMENSIONS<br>**NOTE:** Dimensions in Inches (Millimeters), **Fig. 3** | | | |
|---|---|---|---|
| **Model** | **Crankpin Diameter (Dim. A)** | **Throw (Dim. T)** | **Fillet Radius (Dim. R)** |
| **29/30** | 1.4567 – 1.4568 (37.00 37.03) | 1.30 (33.02) | 0.170 – 0.180 (4.32 – 4.57) |
| **350/351** | | 1.375 (34.93) | |
| **38** | | | |
| **54** | 1.654 (42.01) | 1.535 (39.00) | |
| **61** | 1.654 (42.01) | | |

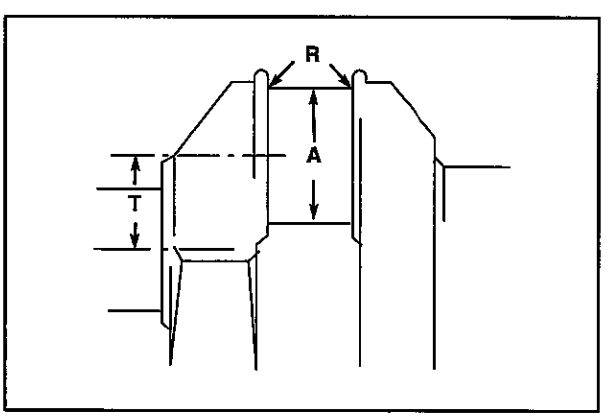



**Fig. 3**

## Drill Size – Decimal Equivalent (Inches)

| | | |
|---|---|---|
| 60 — 0.040 | *9/64* — 0.1406 | E, *1/4* — 0.250 |
| 59 — 0.041 | 27 — 0.144 | F — 0.257 |
| 58 — 0.042 | 26 — 0.147 | G — 0.261 |
| 57 — 0.043 | 25 — 0.1495 | *17/64* — 0.2656 |
| 56 — 0.0465 | 24 — 0.152 | H — 0.266 |
| 55 — 0.052 | 23 — 0.154 | I — 0.272 |
| 54 — 0.055 | *5/32* — 0.1562 | J — 0.277 |
| 53 — 0.0595 | 22 — 0.157 | K — 0.281 |
| *1/16* — 0.0625 | 21 — 0.159 | *9/32* — 0.2812 |
| 52 — 0.0635 | 20 — 0.161 | L — 0.290 |
| 51 — 0.067 | 19 — 0.166 | M — 0.295 |
| 50 — 0.070 | 18 — 0.1695 | *19/64* — 0.2969 |
| 49 — 0.073 | *11/64* — 0.1719 | N — 0.302 |
| 48 — 0.076 | 17 — 0.173 | *5/16* — 0.3125 |
| *5/64* — 0.0781 | 16 — 0.177 | O — 0.316 |
| 47 — 0.0785 | 15 — 0.180 | P — 0.323 |
| 46 — 0.081 | 14 — 0.182 | *21/64* — 0.3281 |
| 45 — 0.082 | 13 — 0.185 | Q — 0.332 |
| 44 — 0.086 | *3/16* — 0.1875 | R — 0.339 |
| 43 — 0.089 | 12 — 0.189 | *11/32* — 0.3438 |
| 42 — 0.0935 | 11 — 0.191 | S — 0.348 |
| *3/32* — 0.0938 | 10 — 0.1935 | T — 0.358 |
| 41 — 0.096 | 9 — 0.196 | *23/64* — 0.3594 |
| 40 — 0.098 | 8 — 0.199 | U — 0.368 |
| 39 — 0.0995 | 7 — 0.201 | *3/8* — 0.375 |
| 38 — 0.1015 | *13/64* — 0.2031 | V — 0.377 |
| 37 — 0.104 | 6 — 0.204 | W — 0.386 |
| 36 — 0.1065 | 5 — 0.2055 | *25/64* — 0.3906 |
| *7/64* — 0.1094 | 4 — 0.209 | X — 0.397 |
| 35 — 0.110 | 3 — 0.213 | Y — 0.404 |
| 34 — 0.111 | *7/32* — 0.2188 | *13/32* — 0.4062 |
| 33 — 0.113 | 2 — 0.221 | Z — 0.413 |
| 32 — 0.116 | 1 — 0.228 | *27/64* — 0.4219 |
| 31 — 0.120 | A — 0.234 | *7/16* — 0.4375 |
| *1/8* — 0.125 | *15/64* — 0.2344 | *29/64* — 0.4531 |
| 30 — 0.1285 | B — 0.238 | *15/32* — 0.4688 |
| 29 — 0.136 | C — 0.242 | *31/64* — 0.4844 |
| 28 — 0.1405 | D — 0.246 | *1/2* — 0.500 |

## English to Metric Conversion Table

| Fraction | Decimal | mm | Fraction | Decimal | mm |
|---|---|---|---|---|---|
| 1/64 | 0.0156 | 0.396 | 33/64 | 0.5156 | 13.096 |
| 1/32 | 0.0313 | 0.795 | 17/32 | 0.5313 | 13.495 |
| 3/64 | 0.0469 | 1.191 | 35/64 | 0.5469 | 13.891 |
| 1/16 | 0.0625 | 1.588 | 9/16 | 0.5625 | 14.288 |
| | | | | | |
| 5/64 | 0.0781 | 1.984 | 37/64 | 0.5781 | 14.684 |
| 3/32 | 0.0938 | 2.383 | 19/32 | 0.5938 | 15.083 |
| 7/64 | 0.1094 | 2.779 | 39/64 | 0.6094 | 15.479 |
| 1/8 | 0.1250 | 3.175 | 5/8 | 0.625 | 15.875 |
| | | | | | |
| 9/64 | 0.1406 | 3.571 | 41/64 | 0.6406 | 16.271 |
| 5/32 | 0.1563 | 3.970 | 21/32 | 0.6562 | 16.667 |
| 11/64 | 0.1719 | 4.366 | 43/64 | 0.6719 | 17.066 |
| 3/16 | 0.1875 | 4.763 | 11/16 | 0.6875 | 17.463 |
| | | | | | |
| 13/64 | 0.2031 | 5.159 | 45/64 | 0.7031 | 17.859 |
| 7/32 | 0.2188 | 5.558 | 23/32 | 0.7188 | 18.258 |
| 15/64 | 0.2344 | 5.954 | 47/64 | 0.7344 | 18.654 |
| 1/4 | 0.2500 | 6.350 | 3/4 | 0.7500 | 19.050 |
| | | | | | |
| 17/64 | 0.2656 | 6.746 | 49/64 | 0.7656 | 19.446 |
| 9/32 | 0.2813 | 7.145 | 25/32 | 0.7813 | 19.845 |
| 19/64 | 0.2969 | 7.541 | 51/64 | 0.7969 | 20.241 |
| 5/16 | 0.3125 | 7.938 | 13/16 | 0.8125 | 20.638 |
| | | | | | |
| 21/64 | 0.3281 | 8.334 | 53/64 | 0.8281 | 21.034 |
| 11/32 | 0.3438 | 8.733 | 27/32 | 0.8438 | 21.433 |
| 23/64 | 0.3594 | 9.129 | 55/64 | 0.8594 | 21.829 |
| 3/8 | 0.3750 | 9.525 | 7/8 | 0.8750 | 22.225 |
| | | | | | |
| 25/64 | 0.3906 | 9.921 | 57/64 | 0.8906 | 22.621 |
| 13/32 | 0.4063 | 10.320 | 29/32 | 0.9063 | 23.020 |
| 27/64 | 0.4219 | 10.716 | 59/64 | 0.9219 | 23.416 |
| 7/16 | 0.4375 | 11.113 | 15/16 | 0.9375 | 23.813 |
| | | | | | |
| 29/64 | 0.4531 | 11.509 | 61/64 | 0.9531 | 24.209 |
| 15/32 | 0.4688 | 11.908 | 31/32 | 0.9688 | 24.608 |
| 31/64 | 0.4844 | 12.304 | 63/64 | 0.9844 | 25.004 |
| 1/2 | 0.5000 | 12.700 | 1 | 1.0000 | 25.4000 |