SINCE 1901

Indian™

MOTORCYCLE

POWERPLUS™ 100 ENGINE SERVICE MANUAL

OFFICIAL FACTORY MANUAL

INDIAN POWERPLUS™ 100 ENGINE SERVICE PROCEDURES

Introduction

This manual provides service procedures for the Indian POWERPLUS® 100 engine. There are nine sections including sections that cover Troubleshooting and Maintenance in addition to Engine Disassembly and Assembly.

The Engine Removal and Installation section contains sub-sections that concentrate on removing chassis components and engine accessory items in preparation for performing in-chassis repairs from rocker box to cylinder and piston replacement. If a complete rebuild is required, the remaining sub-sections provide procedures for removing the complete engine assembly from the chassis and reinstalling it.

At the back of the manual are sections covering specifications and special tool requirements. The Specifications section provides assembly clearances and wear limits as well as fastener torque values and specified sealants. The Required Tools section identifies special tools that are readily available from JIMS® Machining. In addition, there are drawings for fabricating or modifying tools for use in servicing the engine.

Component and Systems Description

The Indian POWERPLUS® 100 engine is a four-cycle two-cylinder engine with a 45-degree "V" configuration. Its large bore and stroke give it a displacement of 100 cubic inches. The design is also traditional, carrying forward the characteristic "round" cylinders found in early Indian Chief motorcycles.

The engine is standard equipped with a carburetor and electronic ignition system.

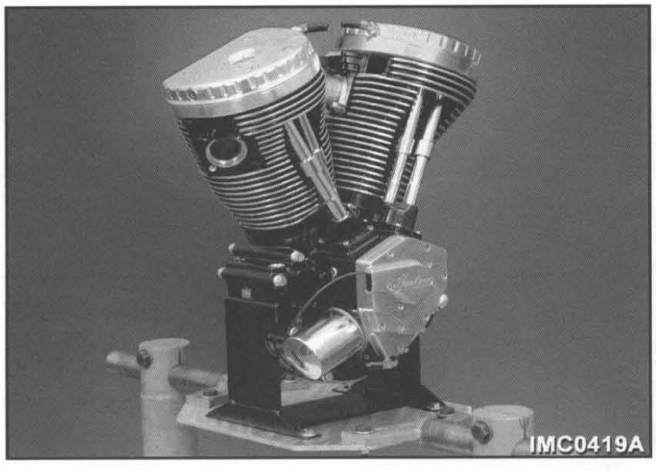

Figure 1— Indian POWERPLUS™ engine

The piston connecting rods are a fork-and-blade style connected to a common crank pin joining two flywheels. The crank pin is set between the pinion shaft flywheel to the right and the sprocket shaft flywheel to the left. The sprocket shaft drives the compensator sprocket in the primary case at the left side of the motorcycle. The sprocket shaft carries the alternator rotor, between the engine crankcase and the compensator. The pinion shaft drives the camshaft, oil pump and breather valve through gearing at the right side of the engine.

The camshaft actuates the intake and exhaust valves through a valve train that includes roller lifters, pushrods and rocker shaft assemblies. The roller lifters, following the cam lobes, raise the pushrods and rocker arms to open the intake and exhaust valves at the appropriate times in the intake and exhaust cycles.

The lubrication system incorporates a gerotor-type oil pump located at the front of the cam housing. The pump, which is driven by a worm gear fitted on the pinion shaft, provides positive lubrication to the engine. At the rear of the cam housing is a full-flow spin-on type filter to screen the lubricating oil as it circulates through the system.

The ignition system with an electronic module and timing sensor controls output to the spark plugs in the cylinders. The ignition rotor, attached to the end of the pinion shaft, in combination with the sensor in the ignition cover, provides the "trigger" signal for the electronic ignition system.

Component Locations

The following views identify the location of major chassis and engine-related parts and accessories referenced in this manual.

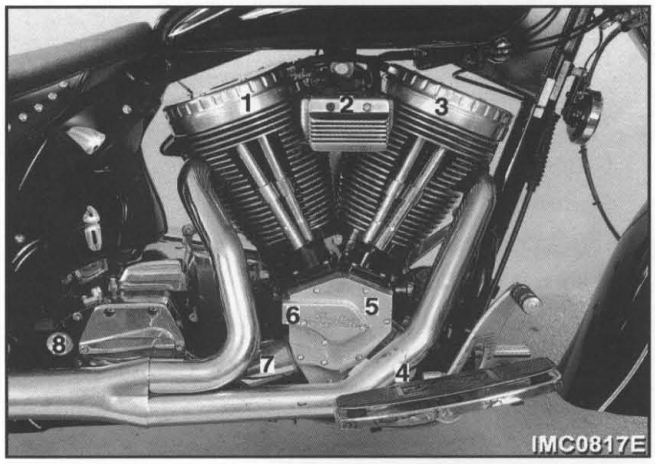

Figure 2 — Indian Chief Motorcycle (right side)

1. Rear cylinder
2. Ignition coil and upper engine support
3. Front cylinder
4. Oil pump
5. Cam cover
6. Ignition cover
7. Oil filter
8. Oil filler and dipstick

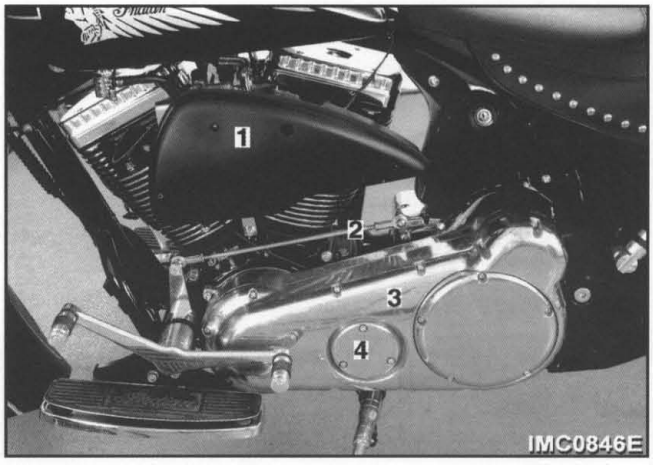

Figure 3 — Indian Chief Motorcycle (left side)

1. Air cleaner housing
2. Transmission shift control
3. Outer primary housing
4. Access cover

Troubleshooting

Symptom-Related Diagnostics

Carburetor

Carburetor floods:

- Excessive pumping of throttle while starting
- Fuel valve (petcock) left open while bike is parked

Electrical system

Alternator charge rate is below normal:

- Low battery voltage
- Loose or corroded connections
- Excessive periods of idling or low-speed riding

Alternator does not charge:

- Engine ground wire loose or broken
- Loose or broken wires in charging circuit
- Voltage regulator not grounded

Engine

Engine knocks or pings:

- Incorrect fuel
- Incorrect spark plugs
- Incorrect ignition timing

Engine overheats:

- Insufficient air reaching the cylinders from slow operation
- Insufficient oil supply
- Oil not circulating due to restricted lines, filter or fittings
- Heavy carbon depositing from lugging the engine
- Incorrect ignition timing

Engine starts but runs irregularly or misses:

- Battery low on charge
- Spark plugs in bad condition, have improper gap or are partially fouled
- Incorrect spark plugs
- Spark plug cables in bad condition and shorting
- Damaged wire or loose connection at battery terminals or at coil
- Damaged wire insulation causing short circuit
- Fuel system clogged by water or dirt
- Fuel vent system plugged

Engine starts hard:

- Battery low on charge
- Spark plugs in bad condition, have improper gap or are partially fouled
- Incorrect spark plugs
- Spark plug cables in bad condition and shorting
- Damaged wire or loose connection(s) at one of the battery terminals or at the coil
- Carburetor not adjusted correctly
- Improper engine oil
- Incorrect ignition timing
- Fuel tank vent plugged or fuel line closed off
- Fuel system clogged by water or dirt

Engine turns over but does not start:

- Fuel tank empty
- Fuel valve (petcock) in OFF position
- Fuel valve or fuel filter clogged
- Discharged battery or loose battery terminal connections
- Fouled spark plugs
- Engine flooded with fuel from overuse of enrichener
- Throttle held open when enrichener was used
- Spark plug cable connections loose or in bad condition
- Loose or corroded wire or cable connection(s) at coil or battery

Engine vibrates excessively or seems to vibrate:

- Swingarm pivot shaft bolts loose
- Front engine mount bolts loose
- Rear engine mount bolts loose
- Broken frame
- Belt badly worn
- Wheels and/or tires damaged
- Vehicle not properly aligned
- Top engine mount loose or broken

Spark plugs foul repeatedly:

- Incorrect spark plugs
- Fuel mixture too rich
- Enrichener used too much

Starter does not operate or does not turn engine over:

- Engine stop switch in OFF position
- Ignition switch not in ON position
- Discharged battery or loose or corroded connections
- Connector to starter loose

Lubrication system

Oil does not return to oil tank:

- Insufficient amount of oil in system
- Oil lines or fittings clogged
- Oil filter clogged
- Inoperative oil pump

Oil leaks from cases, pushrod covers and/or hoses:

- Loose parts
- Imperfect seal at gaskets, pushrod cover, washers, etc.
- Restricted oil return line to tank
- Restricted crankcase vent

Basic Engine Tests

The cylinder leakage and compression checks are basic engine tests that will help determine the overall mechanical condition of the engine and identify problems that can prevent the engine from delivering peak performance.

Cylinder leakage test

With the cylinder leakage test, air pressure is applied to the cylinder. A drop in pressure indicates a leak.

Run the engine to attain normal operating temperature. Stop the engine.

Clean the area around the spark plug and remove the spark plug.

Position the piston, in the cylinder being tested, at top dead center (TDC).

Remove the air filter and set the throttle and choke in the wide-open position.

Place the transmission in 5th gear and engage the rear brake to prevent the engine from turning over.

Using a cylinder leakdown tester, follow the manufacturer's instructions to perform a leak test on the cylinder. Listen for air escaping at the following locations:

- Exhaust pipe — indicates a defective exhaust valve
- Head gasket — indicates defective head gasket, cylinder head surface or cylinder surface
- Carburetor — indicates defective intake valve

Air escaping through the valves may indicate incorrect pushrod length. Check that the correct size pushrods are installed in each location.

Engine compression test

The engine compression test provides a quick method to uncover engine faults.

Run the engine to attain normal operating temperature. Stop the engine.

Clean the areas around the spark plugs and remove the spark plugs.

Remove the air filter and set the throttle and choke in the wide-open position.

Install a compression gauge in the cylinder being tested.

Have an assistant crank the engine at least four complete compression strokes and record the compression readings. Repeat the test on the second cylinder, and compare the readings.

If the highest readings from both cylinders are within specification, 137-183 psi, the engine compression is satisfactory. If the engine compression is not to specification, the cause may be one of the following:

- Worn Piston Rings — If compression is low on the first stroke, increases on successive strokes, but never achieves specification, the piston rings may be worn. Add a tablespoon of heavy oil into the cylinder and crank the engine to distribute the oil. Repeat the compression test. If the compression readings increase considerably, the rings are worn.
- Faulty Valve Seating — If compression is uniformly low on all strokes, the valves may not be seated properly. Add a tablespoon of heavy oil into the cylinder and crank the engine to distribute the oil. Repeat the compression test. If the compression readings remain approximately the same, the valves are not seated properly. Check that the correct size pushrods are installed in each location.
- Head Gasket Leak — If compression is uniformly low on all strokes, the head gasket may be leaking.

Maintenance

Maintenance Schedule

Primary Service (at 500 miles, 5,000 miles and every 10,000 miles thereafter)	Change engine oil and replace oil filter. Clean tappet screen.
Interval Service (at 2,500 miles and every 5,000 miles thereafter)	Change engine oil and replace oil filter.
Renewal Service (at 10,000 miles and every 10,000 miles thereafter)	Replace spark plugs. Change engine oil and replace oil filter.

Engine Maintenance Procedures

It is essential to keep clean, fresh oil in the engine at all times. More frequent oil changes are necessary when:

- The motorcycle is ridden hard.
- The air temperature is very hot or very cold.
- Idling for extended periods of time.
- Two-up riding.
- Mountain riding.
- Dusty conditions.

Indian motorcycles are supplied with 20W-50 V-Twin Motorcycle oil in their engines. This oil is formulated for the rigors of air-cooled motorcycle engines and will provide maximum protection. **Indian Motorcycle does not recommend the addition of mystery oils to the basic 20W-50 Motorcycle product.**

Each oil manufacturer produces products chemically designed which contain detergents, polymers and anti-wear agents to name a few. All these chemicals are balanced to not assault the other. Addition of such oil additives may create an imbalance and the outcome is unknown.

Changing Engine Oil

Tools required:

3/4" wrench

Drain pan

Procedure:

Warm the oil to operating temperature.

The oil drain plug is located in the bottom of the oil tank at the left rear corner.

Place the drain pan under the drain plug. Remove the plug using a 3/4" wrench.

When all the oil has drained from the tank, replace the drain plug.

Remove the oil tank filler cap.

Pour 3 quarts of Indian 20W-50 motorcycle oil into the oil tank.

Return the oil tank filler cap.

Oil Filter Replacement

Tools required:

Drain pan

Oil filter wrench

Procedure:

The oil filter is located at the rear of the crankcase on the right side of the engine.

From the right side of the bike, remove the oil filter using a proper sized oil filter wrench.

Inspect the filter-seating surface of the engine. Make sure the old filter gasket is not attached to the engine crankcase. Clean any dirt or debris from the seating surface and surrounding area.

Replace the filter with an Indian-approved part (#96-021). Apply a thin film of oil to the filter threads and to the gasket of the new filter.

Screw the filter into the filter mount until the gasket contacts the seating surface. Torque another 1/2-3/4 of a revolution.

Engine oil should be checked when warm and the motorcycle is vertical. The oil level should be between the high and low marks on the dipstick. Add oil if necessary.

Cleaning the Tappet Screen

Tools required:

1/4" hex bit

Torque wrench

Procedure:

The tappet screen provides coarse filtering of engine oil before reaching the hydraulic tappets. The tappet screen cap is located on the right side of the engine, at the top front of the crankcase just above the oil pump.

Remove the cap using a 1/4" hex bit.

Then, remove the spring and screen from the bore.

Clean the screen with a suitable oil removal product. Inspect the screen for any metal chips. Chips may be removed with brake clean, carburetor clean, etc. If chips cannot be removed, replace the screen with a new part (#01-185).

Sequence of assembly is as follows:

1. Screen, opening to the bottom
2. Spring
3. O-ring and cap (Inspect the O-ring before assembly.)

Using a torque wrench and 1/4" hex bit, tighten the cap to 8-12 foot-pounds.

Spark Plug Replacement

Tools required:

13/16" hex socket

Pliers

Torque wrench

Procedure:

Gently pull the spark plug caps away from the spark plugs. Be very careful to not separate the caps from the wires while pulling.

Clean the spark plug area of the cylinder heads with compressed air.

Remove the old spark plugs using a 13/16" hex socket.

Gap new NGK BPR5ES spark plugs (#05-002) at 0.038 inch.

Apply a small quantity of anti-seize to the spark plug threads.

Install the new spark plugs in the cylinder heads. Using a torque wrench and 13/16" socket, tighten the plugs to 18 foot-pounds.

Tighten the threaded caps located on the spark plugs with a pair of pliers.

Connect the spark plug wires to the spark plugs.

Engine Removal and Installation

Tools required:

5/32" hex bit

3/16" hex bit

1/4" hex bit

3/8" hex bit

1/2" socket/wrench

9/16" socket/wrench

3/4" socket/wrench

1-1/2" socket

Drain pan

Engine stand, 1006T (available from JIMS®)

Flat-blade screwdriver, medium

Phillips screwdriver

Oil filter wrench

Torque wrench

Removing Chassis Components and Engine Accessories

Using a 3/16" hex bit, remove the two screws attaching the seat to the frame.

Disconnect the battery cables (negative cable first) at the battery terminals.

Remove the screw at the rear of the instrument panel using a 5/32" hex bit. Remove the Phillips head screw in the speedometer housing and remove the instrument panel.

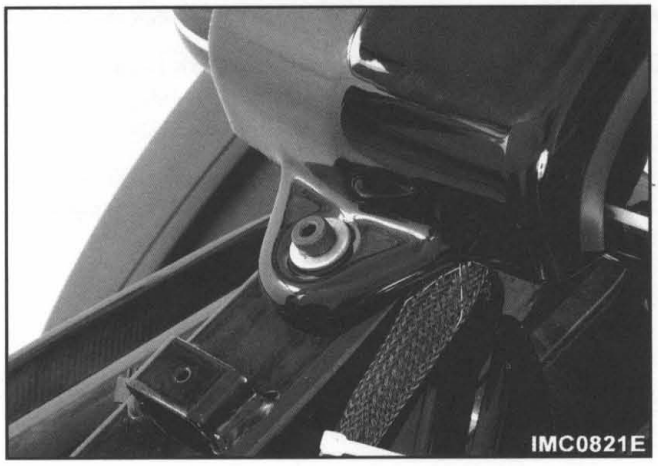

Figure 4 — Instrument panel rear retaining screw

Figure 5 — Speedometer housing retaining screw

Drain the fuel from the fuel tanks into a suitable container and then disconnect and remove the vent and crossover tubes.

Using a 3/16" hex bit, remove the two bright-finish mounting screws at the bottom front of the fuel tanks. Then, using a 1/2" wrench, remove the mounting screws at the top center and front of the tanks. Remove the tanks.

WARNING: Gasoline is flammable and explosive. Work in a well-ventilated area when draining gasoline and drain it into an approved container for gasoline storage. Failure to follow this warning could result in an explosion and/or fire which may cause serious personal injury and/or death and damage to the motorcycle.

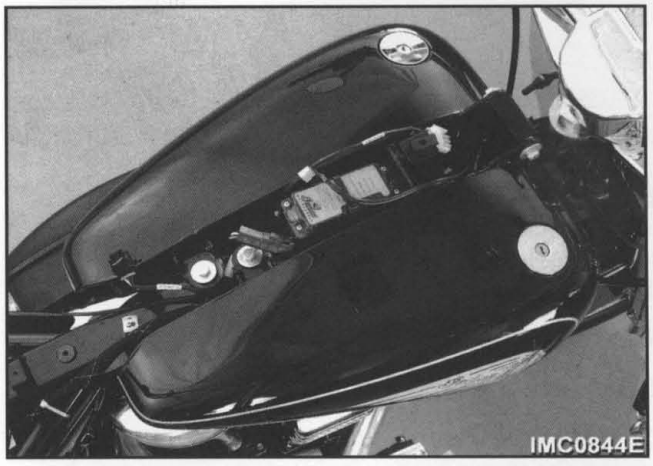

Figure 6 — Fuel tank mounting screws

Remove the fairings at each side of the rear swing arm stanchion.

Figure 7 — Removing fairings

Remove the screws securing the air cleaner housing to the upper engine-mounting bracket and remove the air cleaner as an assembly from the carburetor.

Figure 8 — Air cleaner housing mounting screws

Disconnect the choke- and throttle-control cables, loosen the clamp at the intake manifold and remove the carburetor.

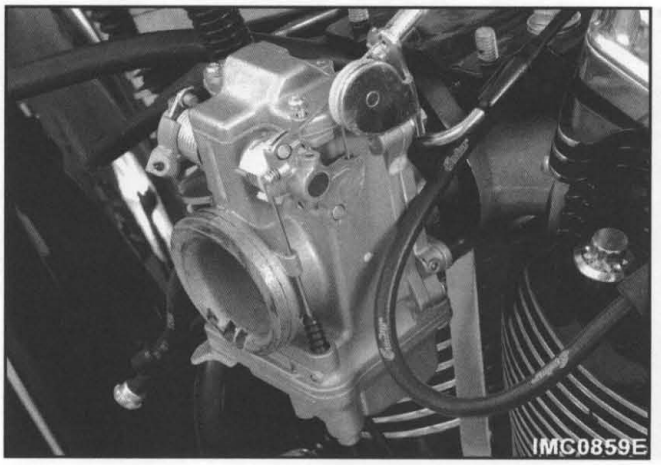

Figure 9 — Carburetor mounting

Disconnect the ignition wires from the spark plugs.

Remove the upper support bracket from the intake manifold and the frame. The ignition coil can remain attached to the bracket.

Figure 10 — Removing upper support bracket

Using a 9/16" wrench, remove the nuts retaining the exhaust pipe at the front and rear cylinder heads. It may be necessary to remove the heat shield(s) to gain access to the mounting nuts.

Figure 11 — Exhaust manifold retaining nuts

Using a 1/2" wrench, remove the two bolts retaining the muffler bracket to the frame. Remove the exhaust pipe assembly.

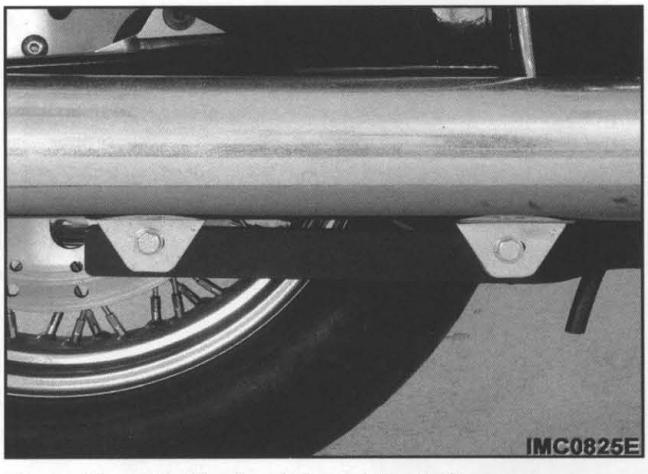

Figure 12 — Muffler bracket retaining bolts

With the above components removed, repairs to the rocker arm/shaft assemblies, cylinder heads, cylinders, pushrods and lifter assemblies, including gasket replacement can be done in chassis as needed. Refer to the following sections for the applicable procedures:

- Rocker Box Procedures
- Pushrod and Tube Removal and Installation
- Cylinder Head Procedures
- Cylinder and Piston Assembly Procedures

Engine Removal

If the engine is to be removed from the chassis, complete all of the steps listed under Removing Chassis Components and Engine Accessories. Then, continue with the steps below.

Place a drain pan under the drain plug at the bottom of the primary chain housing. Remove the plug using a 3/4" wrench and allow the oil to drain from the housing. When completely drained, replace the plug and tighten.

Place a drain pan under the engine drain plug. Remove the plug using a 3/4" wrench and drain the oil from the crankcase. When completely drained, replace the plug and tighten.

Remove the oil filter with an oil filter wrench.

Disconnect the shift rod from the transmission lever using a 3/16" hex bit.

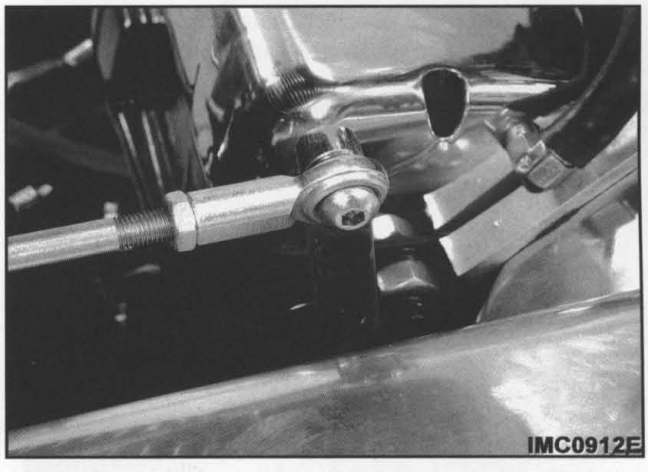

Figure 13 — Transmission shift rod

Using a 5/16" hex, remove the left footrest mounting screws and remove the footrest and clutch pedal assembly from the frame.

Remove the right footrest from the frame using a 5/16" hex bit. Position and secure the footrest with master cylinder attached out-of-way. It is not necessary to remove the brake master cylinder or disconnect the line.

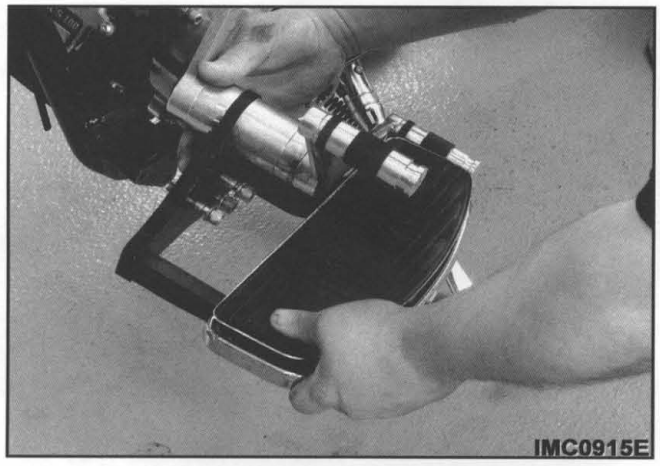

Figure 14 — Removing left footrest assembly

Using a 3/16" hex bit, remove the 15 screws at the perimeter of the outer primary housing. Remove the outer housing. Remove the rubber seal from the housing and inspect it. Discard the seal if it is distorted or damaged.

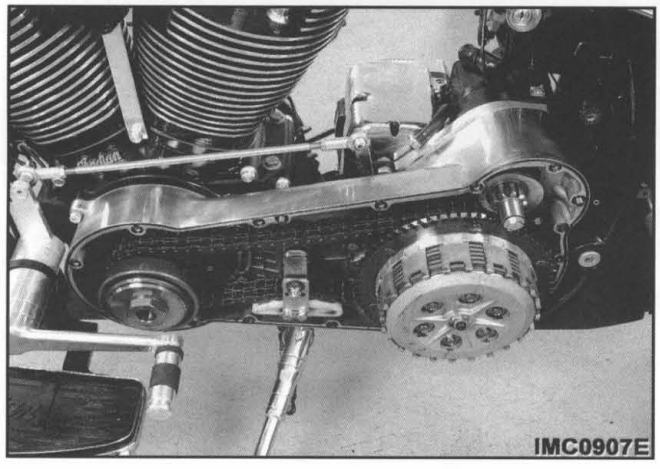

Figure 15 — Outer primary housing removed

Loosen the chain adjuster using a 9/16" socket and slide the adjuster down to provide maximum slack in the chain.

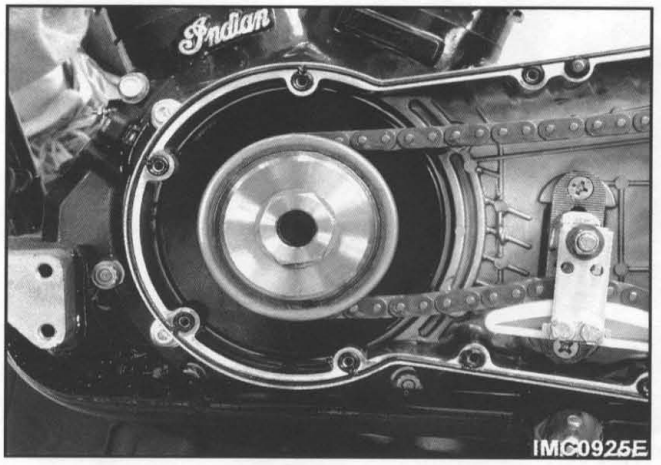

Figure 16 — Compensator sprocket and chain adjuster

Using a 1-1/2" socket, remove the compensator retaining nut and remove the assembly from the sprocket shaft.

Using a 9/16" socket, remove the four primary housing-to-engine mounting screws.

NOTE: The two inner screws are locked by tabbed washers. Bend the tabs back to unlock.

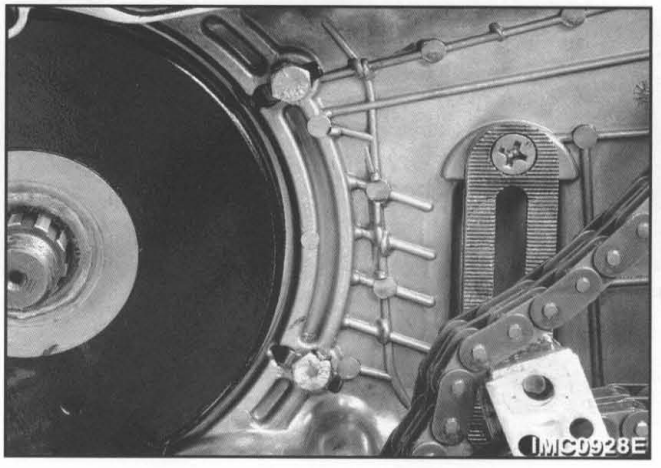

Figure 17 — Primary housing mounting screws

Disconnect the electrical leads from the oil pressure switch, ignition module and the alternator stator and position them out-of-way.

Figure 18 — Electrical leads to oil pressure switch and stator

Remove the breather clamps and hoses from the fittings at the breather valve and the bottom of the cam cover. Disconnect the oil supply line at the oil pump.

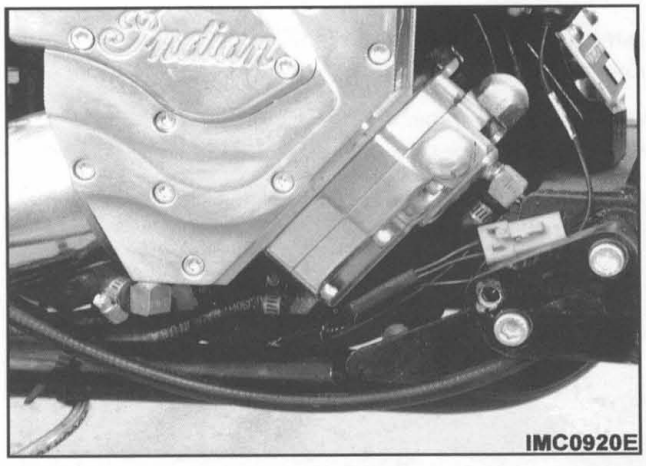

Figure 19 — Breather hoses and oil line

Using a 3/16" hex bit, remove the engine nameplate covering the front engine mounting bolts.

Remove the front and rear engine mounting bolts using a 9/16" socket.

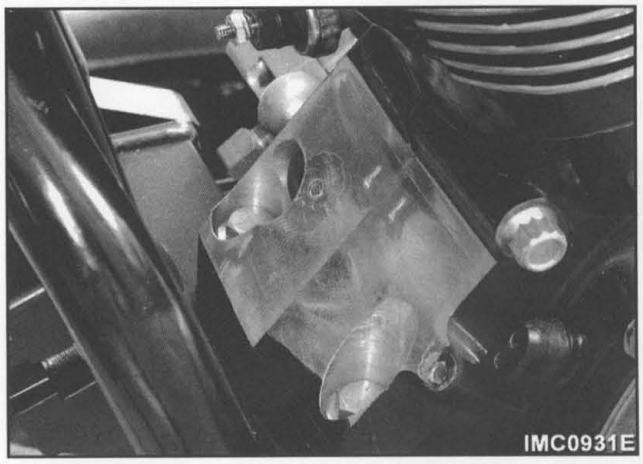

Figure 20 — Front engine mounting bolts

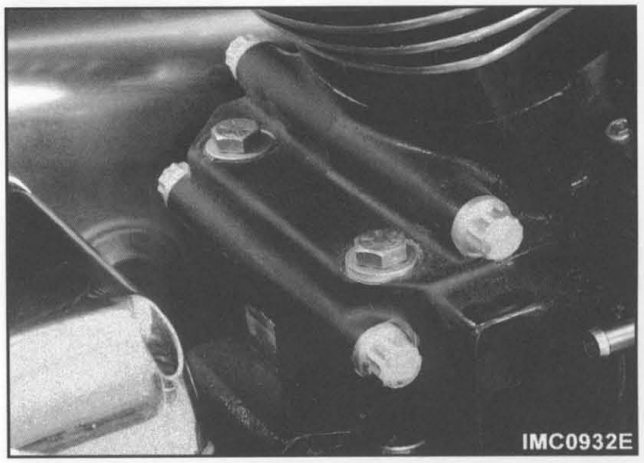

Figure 21 — Rear engine mounting bolts

Lift the engine from the chassis and mount it in an engine stand, JIMS® 1006T, for disassembly and repair.

Engine Installation

Install a new rubber O-ring in the groove on the engine-to-primary housing mounting flange on the crankcase.

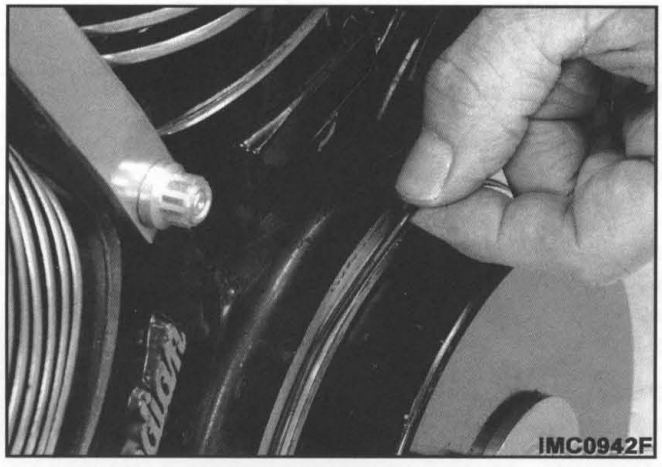

Figure 22 — Installing O-ring on crankcase

Apply black RTV sealant to the inner seal surface on the primary housing.

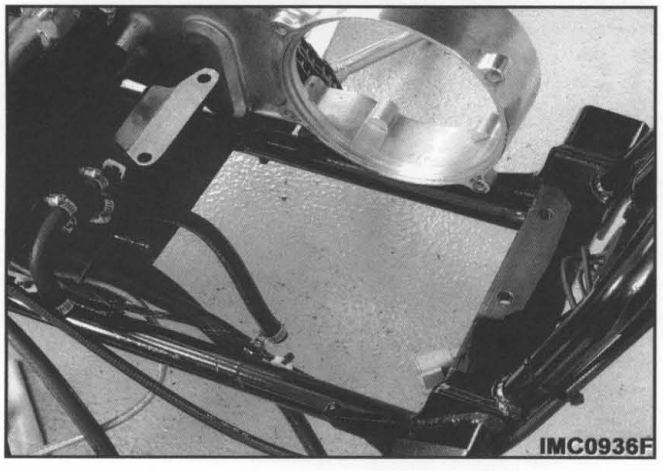

Figure 23 — Inner primary housing seal surface

Place the engine in position over the frame mounting pads making sure the sealing surfaces of the engine and primary housing are properly aligned.

Apply a thin coat of blue threadlock to the threads of the four engine mounting bolts. Then, loosely install the bolts. Do not tighten the bolts at this time.

Apply a thin coat of blue threadlock to the four inner primary housing-to-engine mounting screw threads. Install the screws and tabbed lockwashers, using a 1/4" hex bit. Tighten the screws to 16-18 foot pounds and bend the washer tabs up to lock the screws in place.

Using a 9/16" socket and torque wrench, tighten the four engine mounting bolts to 35-38 foot-pounds.

Adjust the primary chain as follows:

- Move the adjuster up to the top notch and check for slack by pressing down on the chain in the top span.
- If the chain cannot be depressed to the specified 5/16" slack, move the adjuster down to a position where the specified slack is reached. Tighten the adjuster to specification.

Install a new rubber seal and install the outer primary housing and retaining screws using a 3/16" hex bit. Tighten the screws to 8-10 foot-pounds.

Place the right footrest assembly in position on the frame. Install the mounting screws using a 5/16" hex bit and tighten the screws to specification. Install the left footrest and clutch assembly in the same manner.

Apply blue threadlock to the shift rod screw. Connect the shift rod at the transmission using a 3/16" hex bit. Tighten the screw to 13-19 foot-pounds.

Install the breather hoses and clamps on the fittings at the breather valve and the bottom of the cam cover.

Connect the electrical leads to the oil pressure switch, ignition module and the alternator stator.

Remove the access cover in the outer primary housing using a 3/16" hex bit. Fill the housing with 30 ounces of Indian primary oil. Replace the cover and tighten the screws to 8-10 foot-pounds.

Apply a thin coat of engine oil to the gasket and install a new oil filter.

Remove the fill-tube cap and fill the oil tank with 3 quarts of Indian 20W-50 engine oil. Replace the cap.

Installing Chassis Components and Engine Accessories

Place the upper support bracket in position and install the bracket-to-frame bolt using a 3/4" socket and torque wrench. Tighten the bolt to specification.

Install the upper support bracket-to-intake manifold screws, using a 9/16" socket. Tighten the screws to specification.

Connect the ignition wires from the coil to the spark plugs.

Inspect the rubber carburetor-mounting collar, clamp and flange on the intake manifold for damage.

Place the carburetor throttle bore flange in position in the rubber-mounting collar and secure it with the clamp. Connect the choke- and throttle-control cables.

Place the air cleaner in position on the carburetor. Install the two screws attaching the assembly to the upper engine support bracket using a 9/16" socket. Tighten the screws to specification.

Position the fairing at each side of the rear swing arm stanchion and install the retaining screws using a 3/16" hex bit. Tighten the screws to specification.

Place the left fuel tank in position at the side of the upper frame tube and install the two top retaining screws and washers using a 1/2" socket. Tighten the screws to specification. Install the bottom front retaining screw and bright-finish collar using a 3/16" hex bit. Tighten the screw to specification.

Repeat the above step to install the right fuel tank.

Install the fuel crossover, vent lines and clamps. Tighten the clamps securely.

Connect the fuel line from the shutoff valve on the right tank to the carburetor.

Position the instrument panel over the fuel tanks and secure the panel with the Phillips head screw in the speedometer bezel and the socket head screw at the rear of the panel. Using a 5/32" hex bit, tighten the rear screw to specification.

Reconnect the battery positive cable and then the negative cable to the battery terminals.

Position the seat on the frame and using a 3/16" hex bit, install the two screws attaching the seat to the frame. Tighten the screws to specification.

Engine Disassembly and Assembly

The procedures covered under Disassembly and Assembly can be done as separate operations with the engine mounted in-chassis or as a complete rebuild with the engine removed from the chassis.

If a complete rebuild is being done, remove the engine from the chassis and mount it in an engine stand, JIMS® 1006T. If a repair involves a specific operation being done in-chassis, find the appropriate procedure(s) in this section and proceed.

Tools required:

Engine stand, 1006T (available from JIMS®)

Rocker Box Procedures

The following procedures apply for both the front and rear rocker boxes.

Tools required:

3/16" hex bit

1/4" hex bit

Torque wrench

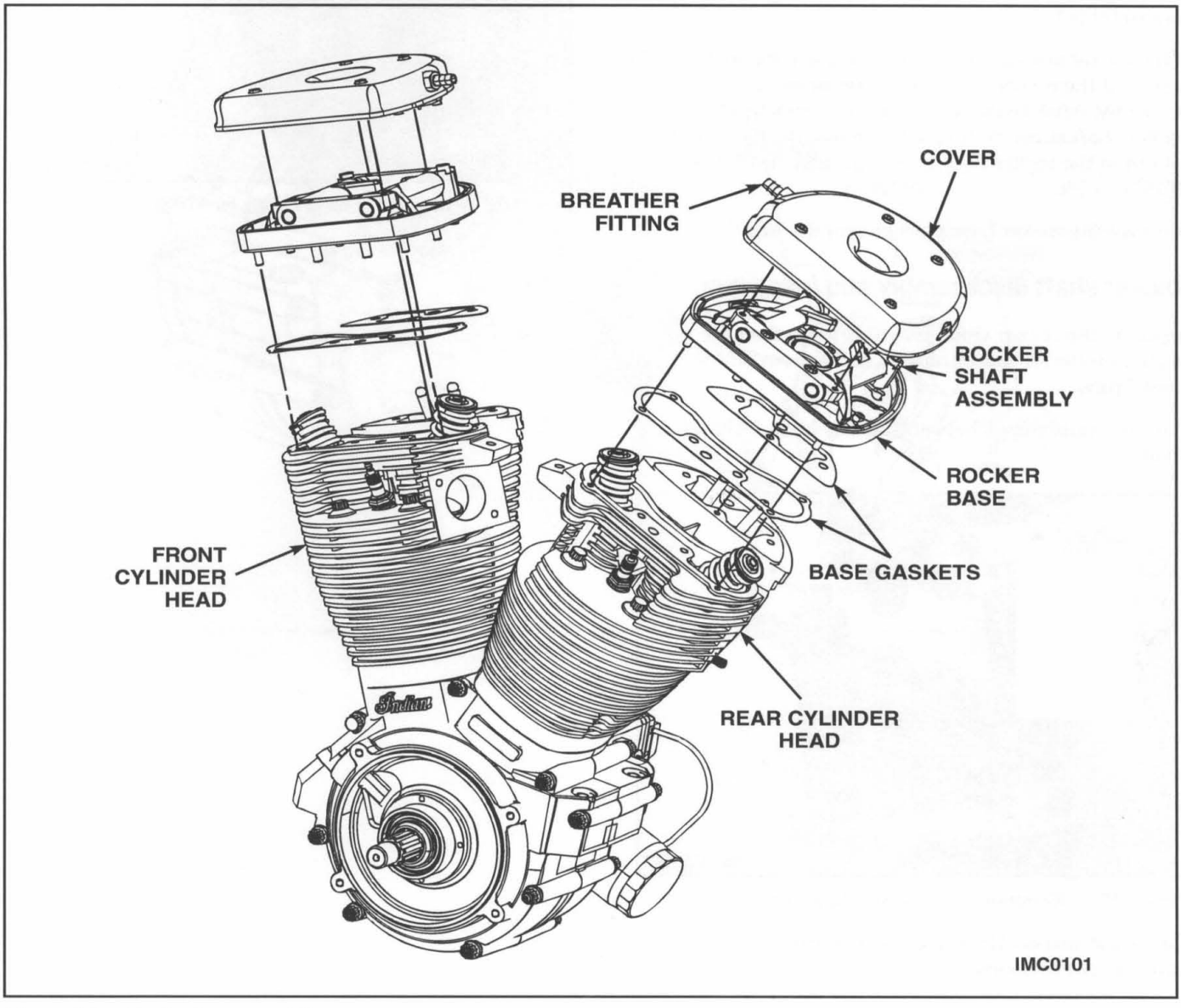

Figure 24 — Rocker box assemblies

Removal

Using a 3/16" hex bit, remove the four screws retaining the rocker cover.

Remove the cover and then remove the two O-ring seals from the rocker base.

Inspect the O-ring seals. Discard any damaged O-rings.

Using a 1/4" hex bit, remove the mounting screws from the left and right rocker-shaft support brackets.

If servicing the rocker arms, turn the sprocket shaft to move the pushrods upwards and loosen the brackets from the rocker base. Then, remove the rocker assembly from the base and inspect the rocker arm shafts and bushings for wear. Replace components as necessary. (Skip this step if the rocker arms are not being serviced and the rocker box is being removed as an assembly.)

If the rocker arms are not being serviced, the rocker box base and the rocker arms can be removed as an assembly. After removing the four screws from the rocker shaft support brackets, remove the five screws retaining the rocker base to the cylinder head using a 3/16" hex bit.

Remove the rocker base gaskets and discard them.

Rocker shaft disassembly and inspection

Separate the rocker shaft assembly from the base by prying on the support brackets to lift them off the dowel pins.

Pull the support brackets and rocker arms from the shafts.

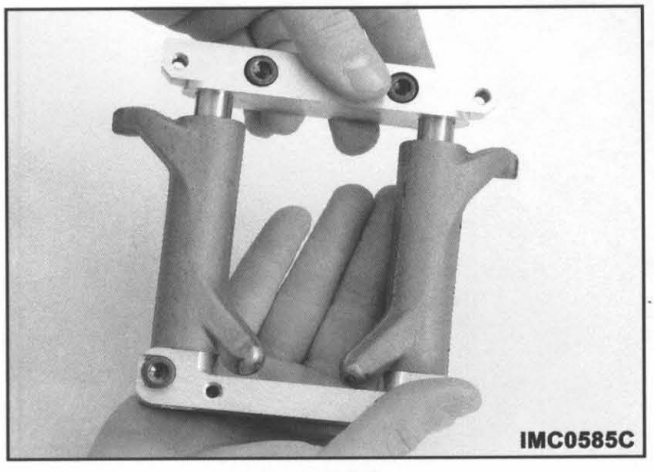

Figure 25 — Removing rocker shaft supports

Clean and inspect the shafts, rocker arms, bushings and support brackets:

- Check the rocker arms, shafts and support brackets for cracks, nicks or other damage. Check the contact pads for wear.
- Check the bushings for unusual wear and pitting. Measure bushing bore diameters (see Specifications). Replace as required.
- Measure the shaft diameters at contact points and the bores of the support brackets. Replace if out of specification.

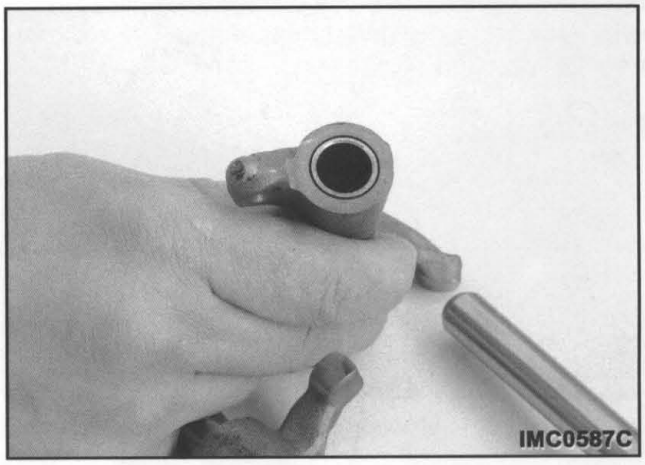

Figure 26 — Inspecting rocker shaft bushings

Rocker shaft assembly

Apply clean engine oil to the rocker shafts and insert them into the rocker arms. The notched end of the shafts must be positioned at the pushrod end of the arms, where they interlock with the mounting screws in the right side support bracket.

Slide the slotted end of the shafts into the right support bracket and align the slots with the mounting screw holes. Slide the left support bracket onto the other end of the shafts.

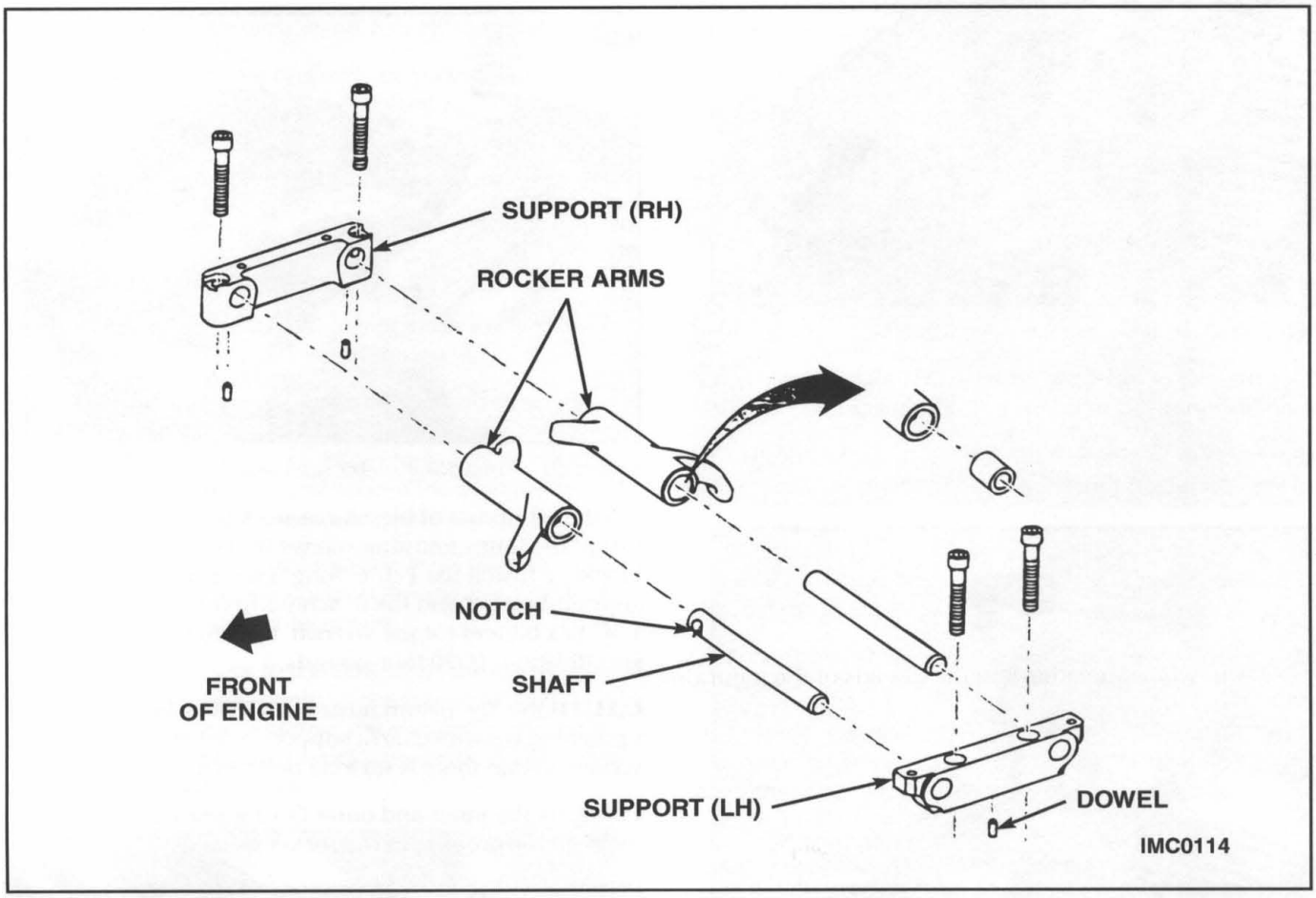

Figure 27 — Rocker shaft assembly

Installation

Install new rocker base gaskets on the cylinder head.

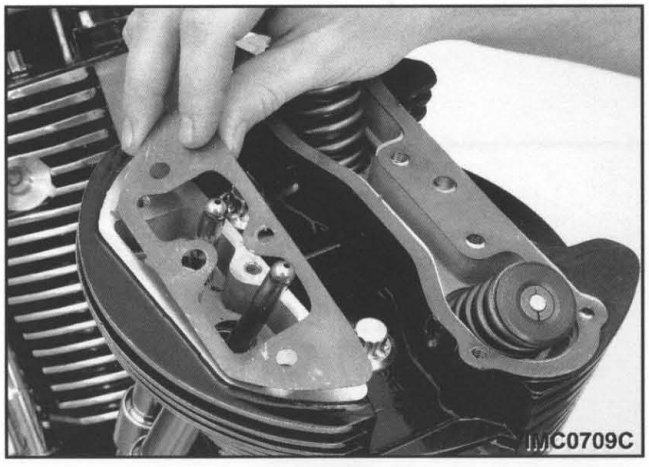

Figure 28 — Installing rocker base gaskets

Place the rocker box base (or base and rocker shaft assembly) in position on the cylinder head.

Apply a thin coat of blue threadlock to the mounting screws and install the five screws in the base.

Figure 29 — Installing rocker base

Using a 3/16" hex bit and torque wrench, tighten the screws to specification, 8-12 foot-pounds.

If removed for service, place the rocker shaft assembly in position on the base. Make sure that the three dowel pins are in place and that the slots in the rocker shafts are properly aligned with the mounting screw holes in the right support bracket.

Figure 30 — Installing rocker shaft assembly

Apply a thin coat of blue threadlock to the screws and install the four mounting screws in the support brackets. Install the 1-3/4" long screws in the left support bracket and the 2" screws in the right. Using a 1/4" hex bit and torque wrench, tighten the screws to specification, 16-20 foot-pounds.

CAUTION: The piston must be at TDC when tightening the rocker arm support bracket mounting screws so that there is no load on the valve springs.

Lubricate the inner and outer O-ring seals and place them on the grooves in the rocker base.

Place the rocker cover in position on the rocker base with the breather fittings facing inward. Apply a thin coat of blue threadlock to the four screws and install them in the cover. Using a 1/4" hex bit and torque wrench, tighten the screws to specification, 8-12 foot-pounds.

Pushrod and Tube Removal and Installation

Tools required:

Small flat-blade screwdriver

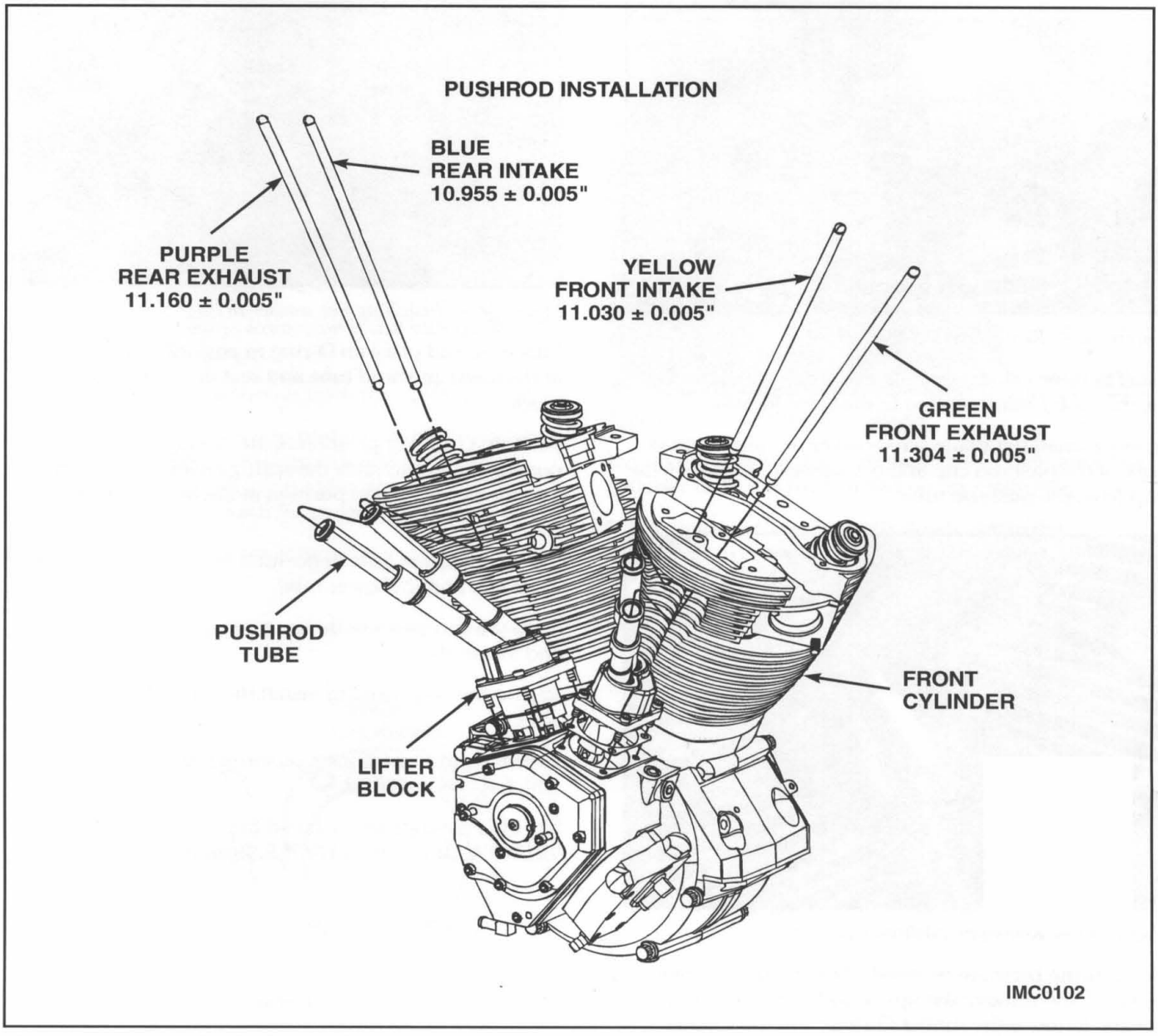

Figure 31 — Pushrod and tube assemblies

Removal

Remove the pushrods from the bores in the cylinder head. Be sure to note the location of each pushrod as it is removed.

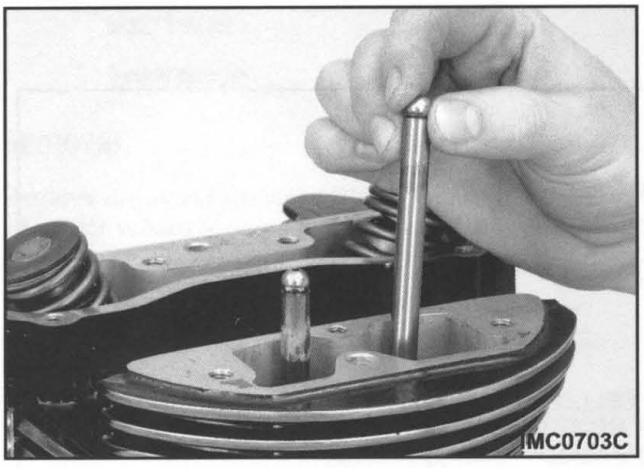

Figure 32 — Removing pushrods

NOTE: If the color codes are not visible, mark the pushrods for reinstallation in the same location.

Insert a small flat-blade screwdriver in the slot at the base of the pushrod clip and pry upward to remove the clip from the pushrod tube.

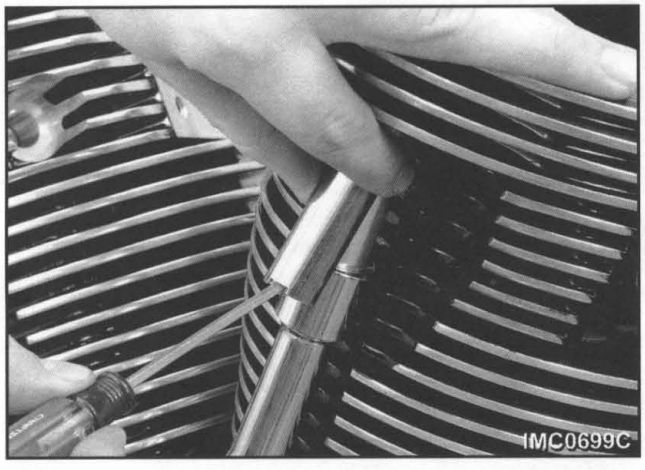

Figure 33 — Removing pushrod tube clip

With spring pressure released, slide the spring cover upward and remove the upper and lower pushrod covers. Remove the rubber O-rings and the washer from the tube seat in the lifter block.

Inspect the O-rings and washer and discard if damaged.

Remove the second pushrod tube repeating the above steps.

Installation

Place the flat washer in position on the tube seat of the lifter block.

Figure 34 — Installing flat washer in lifter block

Lubricate and place an O-ring in position at the bottom of the lower pushrod tube and seat the tube in the lifter block.

Place an O-ring in position at the top of the upper pushrod tube and slide the spring cover, spring, flat washer and O-ring in position at the lower end of the upper tube.

Install the upper tube in position between the cylinder head seat and the lower tube.

Slide the spring cover down to compress the spring and install the clip.

Repeat the procedure to install the second pushrod tube.

Lubricate and install each pushrod into the bore from which it was removed.

NOTE: Pushrods are installed in the order, GREEN, YELLOW, BLUE and PURPLE, from front to rear.

Cylinder Head Procedures

The following procedures apply for both the front and rear cylinder heads.

Tools required:

1/4" hex bit

1/2" wrench

1/2" 12-point socket

Brass hammer

Torque wrench

Valve guide tool, 34731-84 (available from JIMS®)

Valve guide tool handle, 34740-84 (available from JIMS®)

Valve spring compressor tool, 96600-36B (available from JIMS®)

Valve spring tester, 1090 (available from JIMS®)

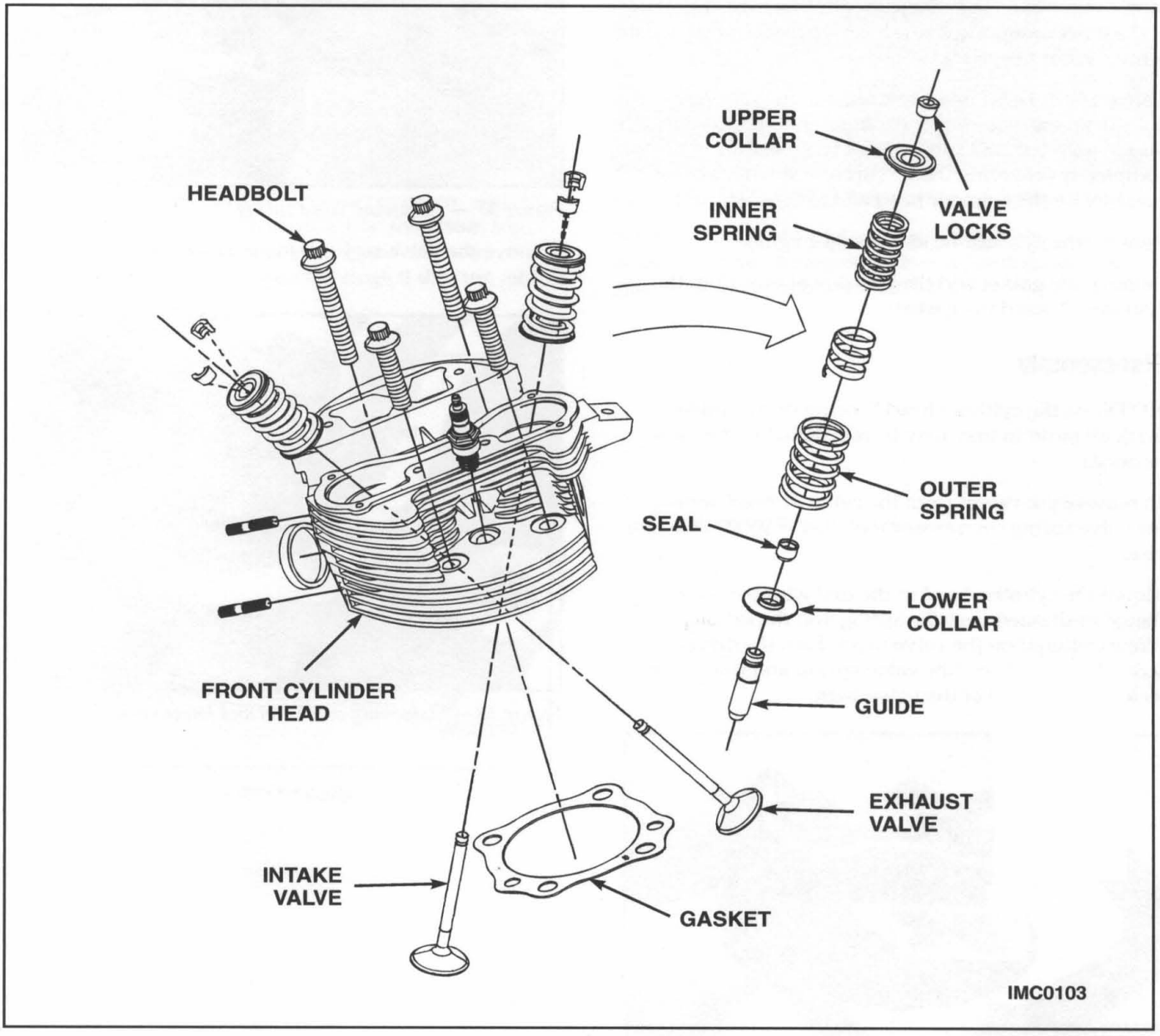

Figure 35 — Cylinder head assembly

Removal

Remove the rocker box assembly (see Rocker Box Procedures).

Using a 1/2" wrench, remove the bolt from the support bracket and carburetor flange at the intake manifold.

Loosen the 12-point nut securing the support bracket to the crankcase and remove the bracket.

Using a 1/4" hex bit, remove the outer intake manifold mounting screws from each cylinder head. Then, loosen the two inner mounting screws and remove the intake manifold. (The intake manifold flange is slotted at the inner mounting screw locations so removal of the screws is not necessary.)

Using a 1/2" 12-point socket, remove the four head bolts from the cylinder studs. In removing the bolts, loosen each bolt 1/4 turn at least twice before completely removing them. This will slowly release pressure on the cylinder head and avoid distortion.

Remove the cylinder head from the engine.

Remove the gasket and the two dowel pins from the cylinder. Discard the gasket.

Disassembly

NOTE: As the cylinder head is being disassembled, mark all parts so they may be reinstalled in the same location.

To remove the valves from the cylinder head, mount the valve spring compressor tool, JIMS® 96600-36B, in a vise.

Mount the cylinder head in the tool with the collar flange positioned over the spring and the driving screw centered on the valve head. Turn the driving screw in to compress the valve spring and remove the locks from the top of the valve stem.

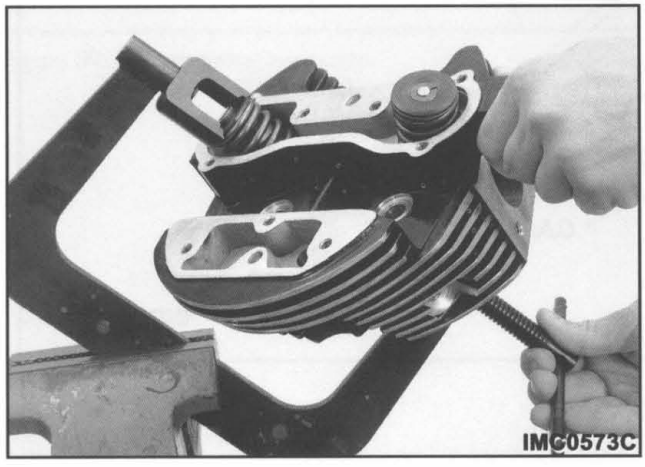

Figure 36 — Removing valves from cylinder head

Turn the driving screw out to release pressure on the spring and remove the cylinder from the tool.

Remove the upper collar and spring set from the top of the head. Pull the valve out from the bottom.

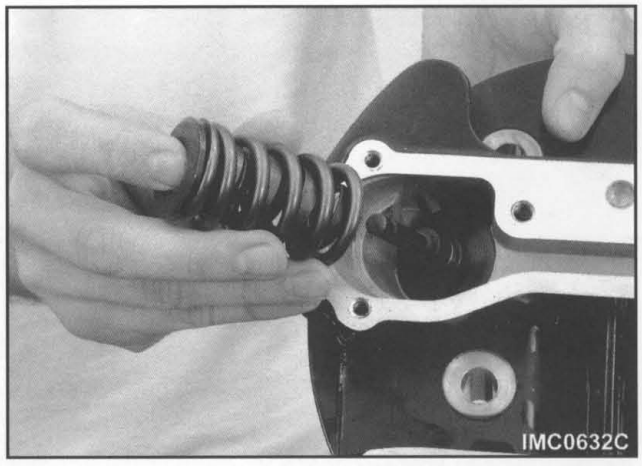

Figure 37 — Removing valve spring

Remove the valve seal and lower collar from the valve guide.

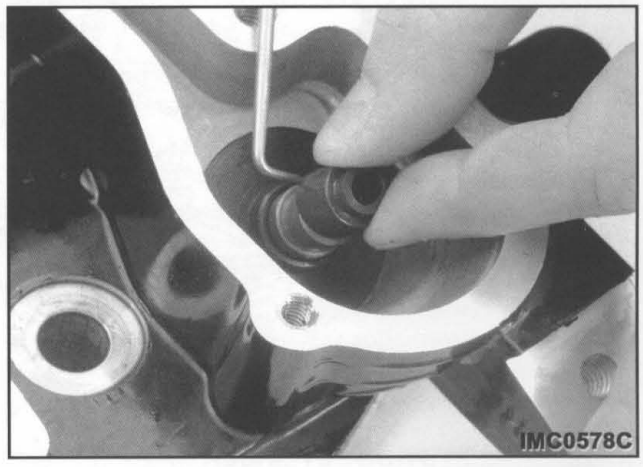

Figure 38 — Removing valve seal and lower spring collar

If the valve guide is to be removed, use valve guide tool, JIMS® 34740-84, and a hammer to drive the guide out from the head.

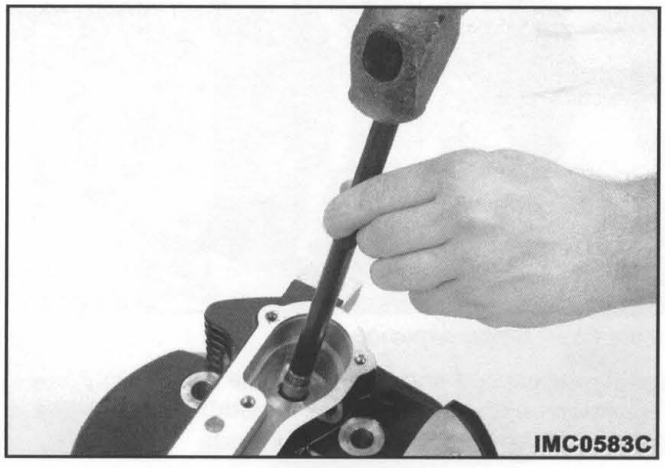

Figure 39 — Removing valve guide

Cleaning and inspection

Clean the cylinder head and all associated parts including valves with a suitable non-flammable solvent. Scrape the carbon buildup from any parts using care to avoid damage. Flush with solvent to remove all traces of dirt and debris, making sure that all ports, passages, bores and threads are thoroughly clean. Dry parts with compressed air.

Inspect the valve stems and faces for wear and damage. Also, inspect the valve guides and valves seats.

Measure the following to ensure that wear limits are not exceeded (see Specifications):

- Cylinder head flatness (gasket surface)
- Valve seat width
- Valve stem protrusion from cylinder head
- Valve-to-guide clearance

If removed from the cylinder head, also measure clearances for valve guides and valve seat inserts. Check against specifications.

Refinish the valves, valve seats and guides. Replace parts if required.

Measure valve spring pressure using a spring tester, JIMS® 1090. Replace springs if not within specification.

Assembly

If removed, start the valve guide into the guide bore in the cylinder head. Using an arbor press and valve guide tools, JIMS® 34731-84 and 34740-84, press the guide into the head until it is properly seated.

Ream the bore of the new guides to the following specified diameters, then finish hone and thoroughly clean the bores.

- Intake guide bore diameter, 0.3108–0.3128"
- Exhaust guide bore diameter, 0.3115–0.3128"

Recut the valve seats, removing only enough material so the seats are concentric with the new finished guides. Both intake and exhaust seats should be cut to 45° with nominal seat widths of 0.052" (intake) and 0.059" (exhaust) respectively. To change the seat width to bring it within specification, or raise or lower the seat, cut the lead or trail angles as specified below. Cutting the lead angle will raise and narrow the seat. Cutting the trail angle will lower and narrow the seat.

- **Intake valve seats**
  Lead angle — 60°
  Seat angle — 45°
  Trail angle — 30°
  Seat width — 0.041-0.063" (0.052" nominal)
- **Exhaust valve seats**
  Lead angle — 52°
  Seat angle — 45°
  Trail angle — 30°
  Seat width — 0.048-0.070" (0.059" nominal)

Insert the valves and check valve stem runout and protrusion. Runout should not exceed 0.002" and protrusion should be within 2.065-2.069" from the cylinder head.

Apply a small amount of lapping compound to the valve faces and finish lapping the seats and faces. Remove the valves and thoroughly clean all parts, using care to ensure that no residue remains.

Install the lower collar and stem seal on the valve guide. Lubricate the valve stem with clean engine oil and insert the appropriate valve into the guide from the bottom of the cylinder head.

NOTE: The intake and exhaust valves are different sizes. The diameter of the intake valve is larger than the exhaust valve. Be sure that each is installed in the correct location.

Place the inner and outer springs and upper collar in position over the valve stem and guide. Then, mount the cylinder head in the valve spring compressor tool, JIMS® 96600-36B.

Turn the driving screw in to compress the spring and install the valve locks in the grooves at the top of the valve stem. Turn the driving screw out slowly to release pressure on the spring, making sure that the locks remain in position.

Remove the cylinder head from the tool and repeat the procedure to install the remaining valve.

Installation

Install the two dowel pins in the cylinder and install a new head gasket, making sure the "fire ring" is facing upward.

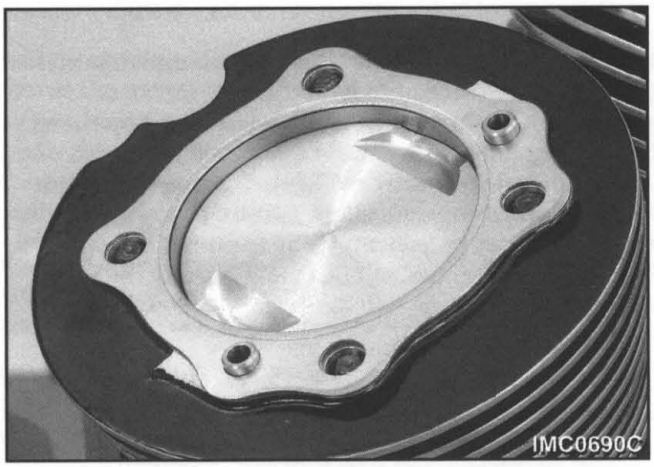

Figure 40 — Installing cylinder head gasket

Place the correct cylinder head in position on the cylinder. Front and rear cylinder heads are different and are marked with an "F" or "R" for identification.

Apply a light coating of oil to the threads of the head bolts and loosely install the two short and two long head bolts at the proper locations.

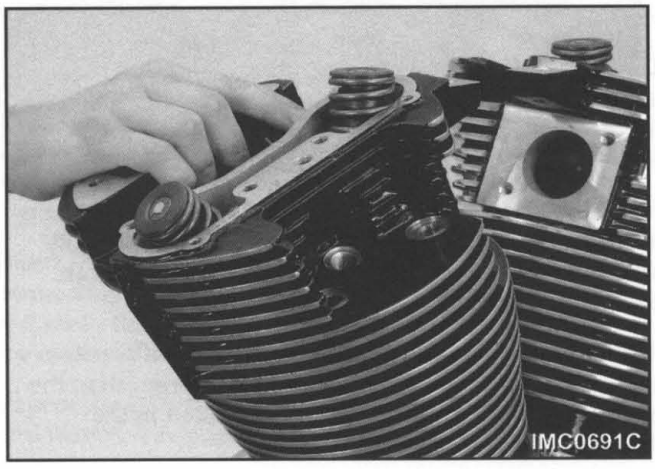

Figure 41 — Installing cylinder head

Using a 1/2" 12-point socket and torque wrench, tighten the head bolts incrementally in three steps following a diagonal cross-head pattern:

Stepped Torque Sequence

1 - Finger tight in sequence
2 - 5 foot pounds in sequence
3- 14 foot pounds in sequence
4 - ¼ turn +/- 2 degrees in sequence

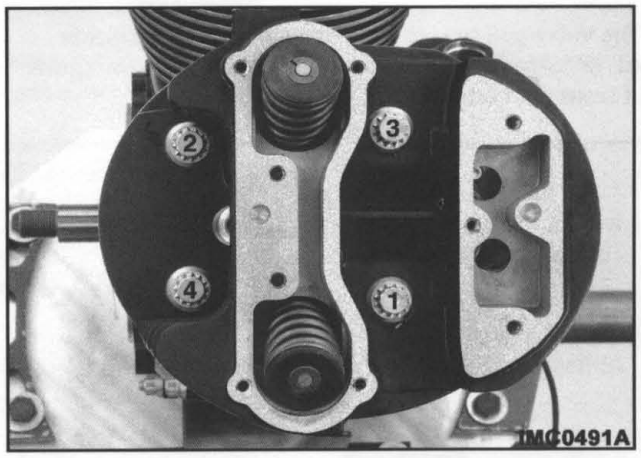

Figure 42 — Torque sequence

Install new gaskets and then place the intake manifold in position on the cylinder heads. Install the mounting screws and tighten to 16-20 foot-pounds.

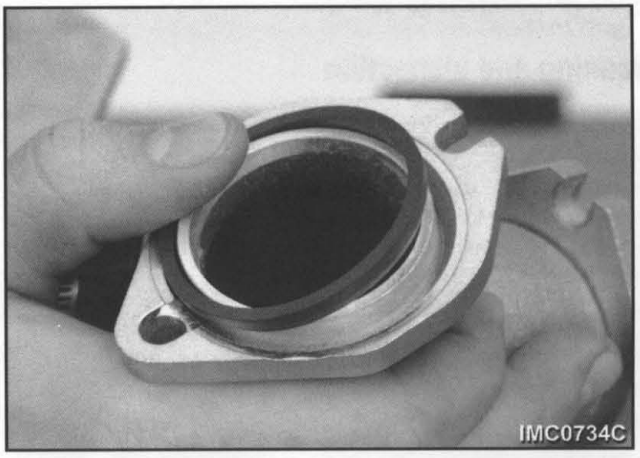

Figure 43 — Installing intake manifold gaskets

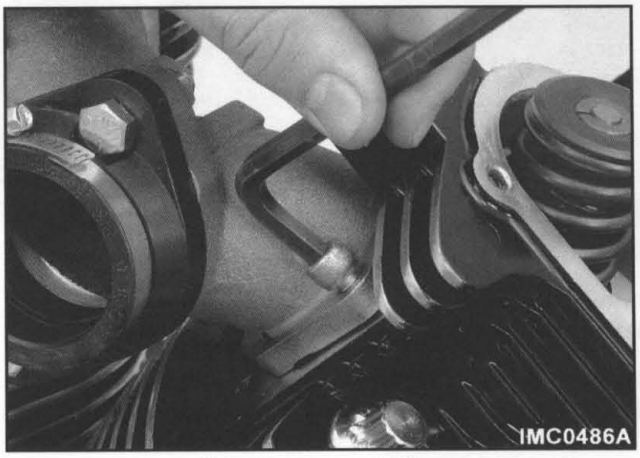

Figure 44 — Installing intake manifold

Install the support bracket between the manifold and the crankcase. Tighten the bolts and nut to 16-20 foot-pounds.

Install the rocker box assembly (see Rocker Box Procedures).

Cylinder and Piston Assembly Procedures

Tools required:

Dental pik, 2361 (available from JIMS®)

Piston lock ring tool (available from JIMS®)

- Driver, 96780-58A-2 (requires modification)
- Collar, 96781-72-2 (requires modification)

Refer to the SPECIAL TOOL REQUIREMENTS section for tool modification prints.

Piston ring compressor, 1236 (available from JIMS®)

Piston ring expander, 1235 (available from JIMS®)

Protective tubes for cylinder studs

Rod alignment tool, 1010 (available from JIMS®)

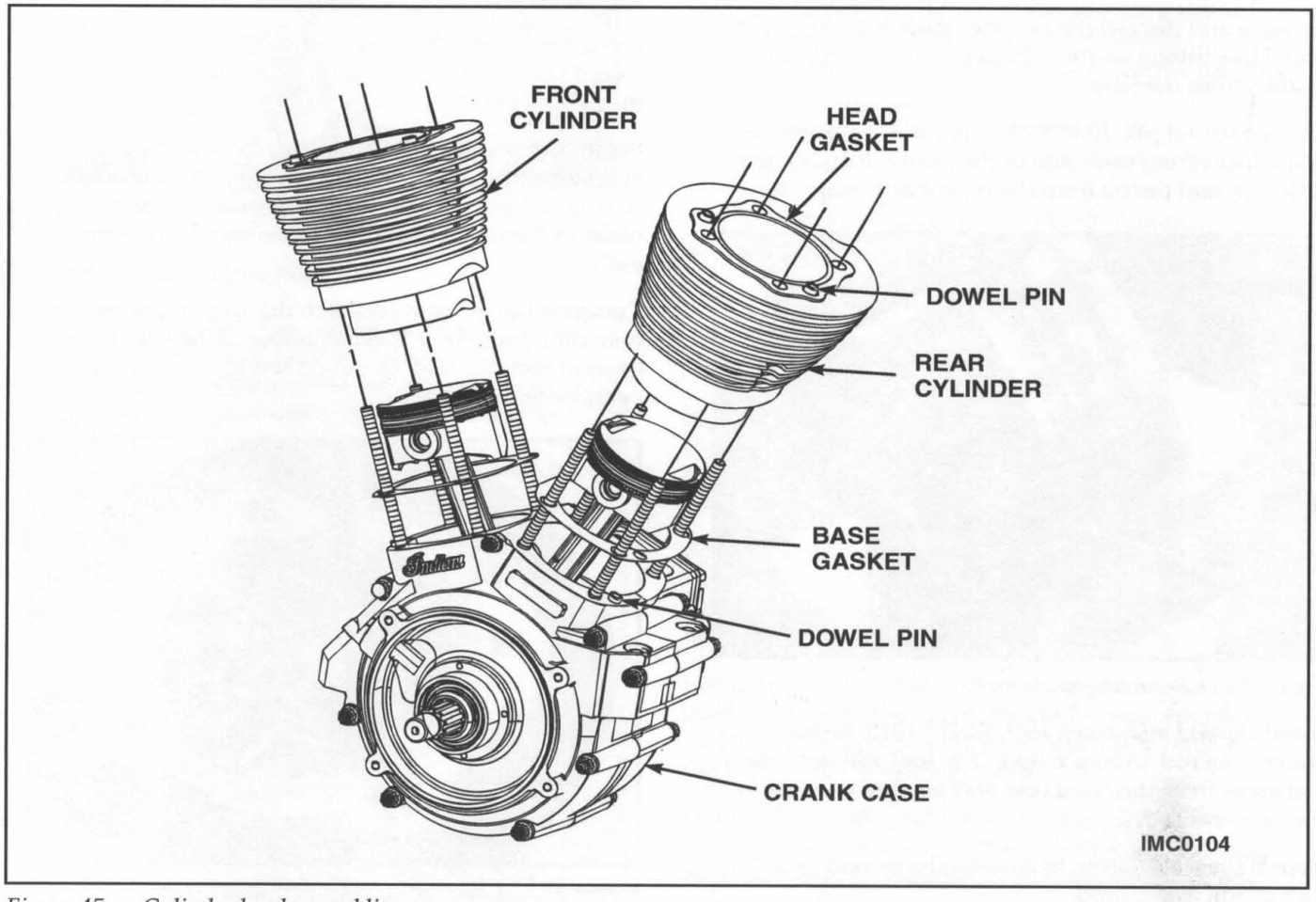

Figure 45 — Cylinder head assemblies

Cylinder and piston removal

Remove the cylinder heads (see Cylinder Head Procedures).

Turn the sprocket shaft until both pistons are positioned at mid-stroke in the cylinders.

Pull the cylinder from the crankcase and studs. Use care as the piston is pulled from the cylinder so that the piston does not fall hard against the studs. It may be easier if a second technician, using a sprocket wrench, holds the crankshaft from turning and catches the piston as it drops from the cylinder.

Remove and discard the cylinder gasket. Then, place protective tubing on the cylinder studs to protect the pistons from damage.

Using a dental pik, JIMS® 2361, pry out the piston pin spiral locks from each side of the piston. Remove the wrist pin and piston from the connecting rod.

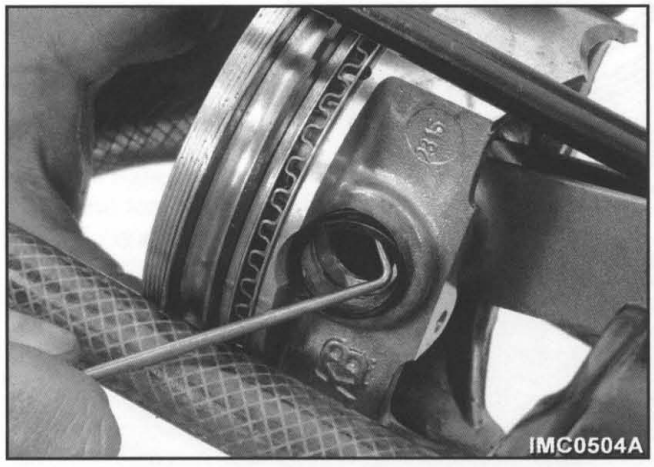

Figure 46 — Removing spiral lock

Insert the rod alignment tool, JIMS® 1010, in the connecting rod wrist pin bore. The tool will hold the rod away from the crankcase and prevent damage to the case and rod.

Repeat the above steps to remove the second cylinder and piston, if required.

Cylinder inspection

Check that the cylinder gasket surfaces are free from burrs and scratches.

Check the cylinder-to-cylinder head and cylinder-to-crankcase gasket surfaces for flatness.

Lay a straightedge across each surface and use a feeler gauge to measure any gaps between the straightedge and the surface.

Compare the feeler gauge measurement to the flatness limit (see Specifications). If either surface is not within specification, replace the cylinder and piston.

Use a dial indicator to measure the cylinder bore and record the readings. This procedure will determine if the cylinder bore is worn or out-of-round.

Beginning approximately 0.5 inch from the top of the cylinder, measure along the top ring path. Take front-to-rear and side-to-side measurements. Repeat the measurement procedure for the center and bottom ring paths.

Compare the measurements to the specified standard bore dimension (see Specifications). If the bore is worn beyond specification, or out-of-round, replace the cylinder and piston.

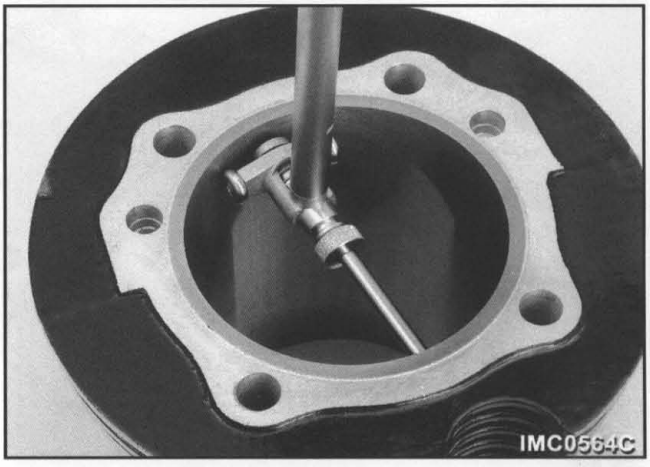

Figure 47 — Checking cylinder bore dimensions

Piston inspection and ring replacement

Use a carbon scraper to remove excessive carbon deposits from the pistons. Take care to avoid scratching the pistons.

Use an appropriate solvent to clean any remaining carbon from the pistons. Blow-dry the pistons with compressed air.

Inspect the pistons for cracks, grooves and burnt spots. Check the wrist pins for pitting and scoring.

Inspect the wrist pin bushing in the connecting rods for wear or damage. Check that wrist pin-to-bushing clearance is within specification (see Specifications). Replace worn parts as required.

Check that the wrist pin-to-piston clearance is within specification (see Specifications). Replace worn parts as required.

Check that the ring gaps of all piston rings are within specifications (see Specifications). Use the piston top surface to square each ring in the cylinder when measuring ring gaps. Replace the rings if the ring gap is not within specification.

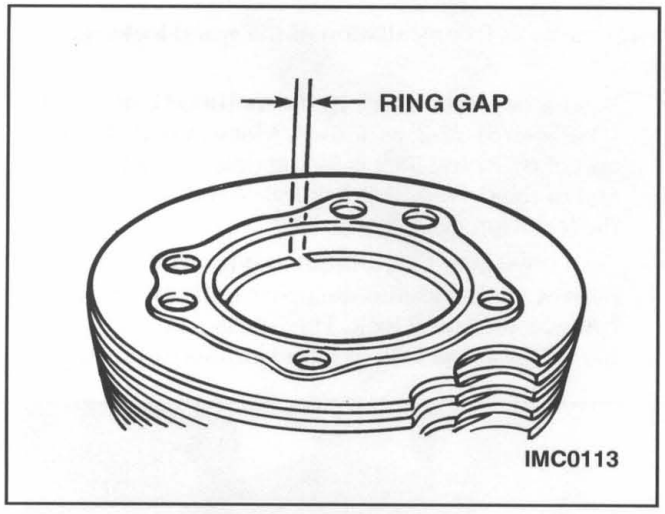

Figure 48 — Checking piston ring gap

Check the side clearance for each piston ring. Replace the rings, the piston, or both if the ring side clearance is not within specification (see Specifications).

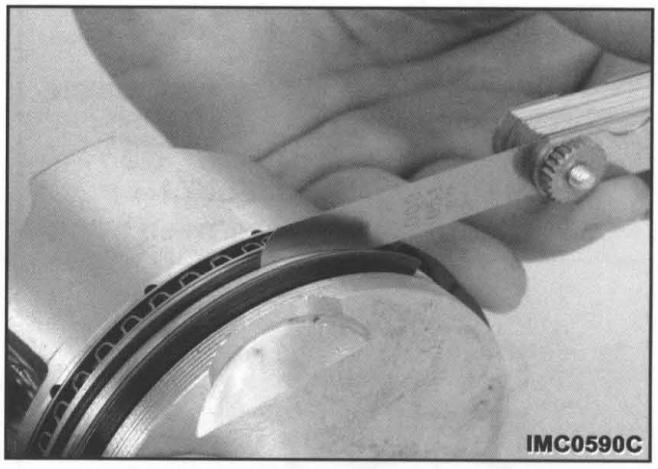

Figure 49 — Checking side clearance, piston ring to land

When installing the piston rings, stagger the ring gaps as shown in the illustration. Do not position any ring gaps in-line with the wrist pin ends.

Install the second compression ring with the dot facing upwards.

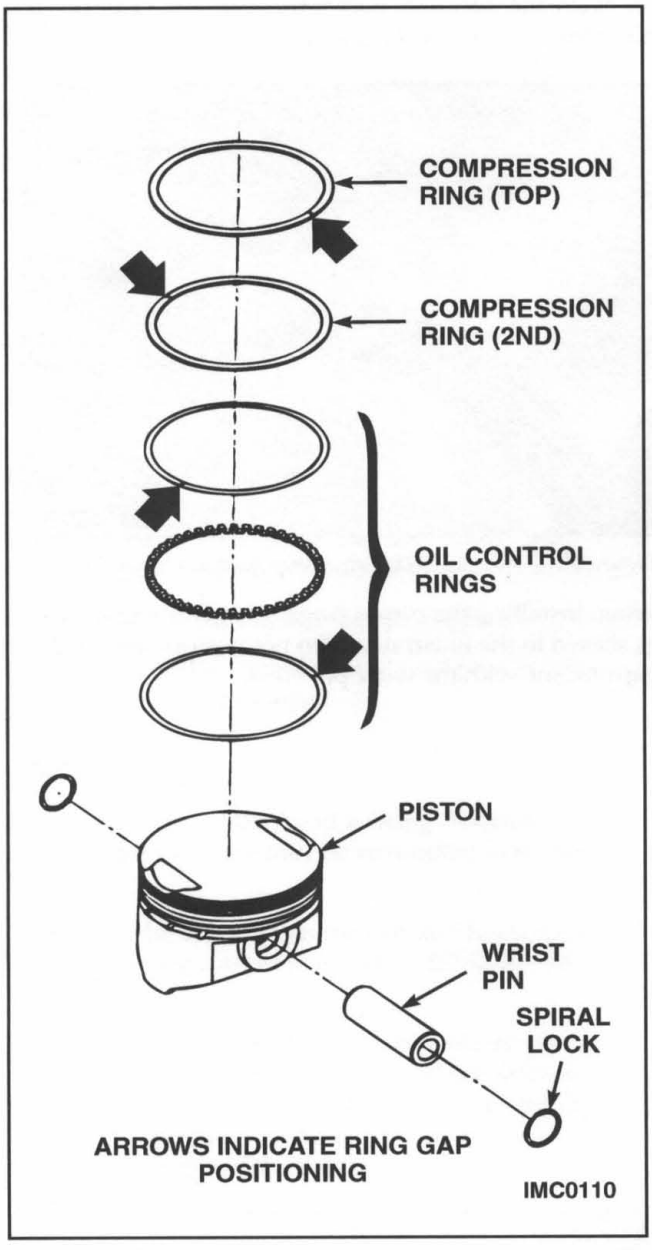

Figure 50 — Positioning ring gaps

Piston and cylinder installation

Place protective sleeves on the cylinder studs to protect the pistons and rings from damage during installation.

Remove the rod alignment tool from the connecting rod and lubricate the wrist pin and connecting rod with clean engine oil. Place the piston in position on the connecting rod with the notched skirt facing the middle of the engine. Then, install the wrist pin.

Figure 51 — Installing piston and wrist pin

Setup the tools for installation of the spiral locks as follow:

- Place a new spiral lock in the modified collar tool, JIMS® 96781-72-2, as shown. Make sure the split end of the spiral lock is facing down. Use the back end of the driver, JIMS® 96780-58A-2, to position the lock ring in the collar tool.
- Turn the driver tool around and insert the long narrow shaft end into the collar until the shoulder contacts the spiral lock. The tool is now ready to install the spiral lock in the piston wrist pin bore.

Figure 52 — Spiral lock installation tool setup

Insert the tool into the piston and wrist pin and drive the spiral lock into place in the piston pin bore.

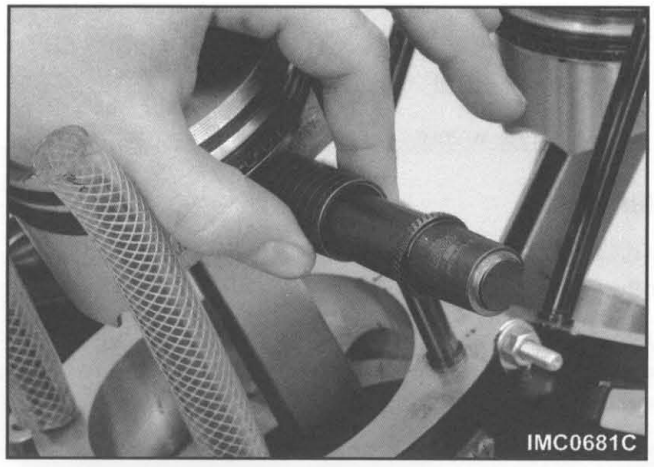

Figure 53 — Installing a spiral lock

Repeat the procedure to install the spiral lock on the opposite side of the piston.

Remove the protective sleeves from the cylinder studs.

Make sure the dowel pin is in position on the crankcase and install the cylinder base gasket. Different gaskets are used for the front and rear cylinders. Refer to the illustration to identify each for proper installation.

Lubricate the cylinder bore, pistons and rings with clean engine oil.

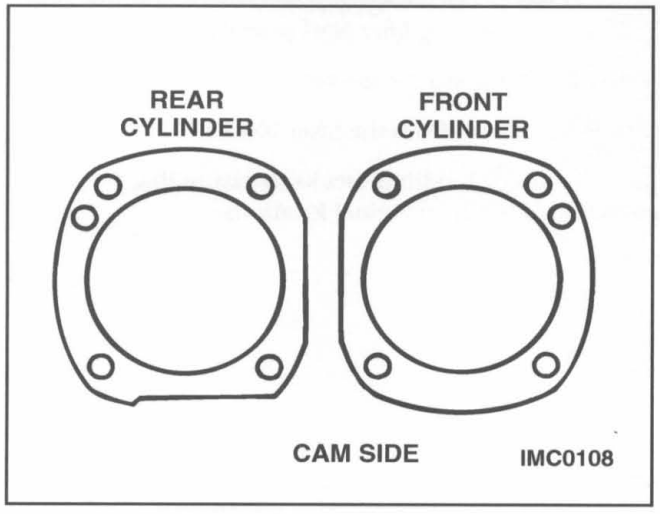

Figure 54 — Cylinder gasket locations

Install a piston ring compressor tool, JIMS® 1236, on the piston.

With the piston positioned at mid-stroke, install the cylinder over the piston. Use a sprocket shaft socket to hold the crankshaft from turning during cylinder installation.

Figure 55 — Installing the cylinder

Remove the piston ring compressor and then push the cylinder until it is fully seated on the crankcase.

While holding the cylinder(s) down, rotate the crankshaft to ensure there is no interference and that the rings are properly seated.

Wipe the cylinder clean and install the cylinder head (see Cylinder Head Procedures).

Repeat the above procedure for the second cylinder.

Alternator Rotor/Stator Removal and Installation

Tools required:

5/32" hex bit

Torque wrench

Removal

Remove the alternator rotor from the sprocket shaft. The rotor is held in place by the force of the integral magnets.

Using a 5/32" hex bit, remove the four socket head screws retaining the stator to the sprocket side of the crankcase.

Push the stator connector through the housing flange and remove the stator.

Installation

Lubricate the stator connector and the crankcase bore. Insert the stator connector into its bore in the flange on the sprocket side of the crankcase and press the connector into position.

Apply a thin coating of blue threadlock to the four socket head screws.

Place the stator in position against the case and install the mounting screws. Using a 5/32" hex bit and torque wrench, tighten the screws to specification, 8-10 foot-pounds.

Make sure the stator electrical leads are pressed against the crankcase. If not positioned properly, the leads can come in contact with the rotor and be damaged.

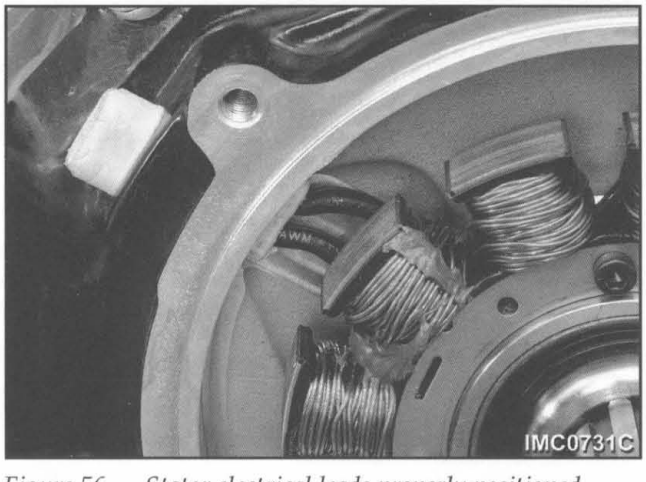

Figure 56 — Stator electrical leads properly positioned against crankcase

Lifter Block Removal and Installation

Tools required:

3/16" hex bit

Torque wrench

Removal

Remove the rocker box assembly, pushrods and tubes following the procedures in this guide.

Using a 3/16" hex bit, remove the four mounting screws from each lifter block and remove the front and rear lifter assemblies from the crankcase.

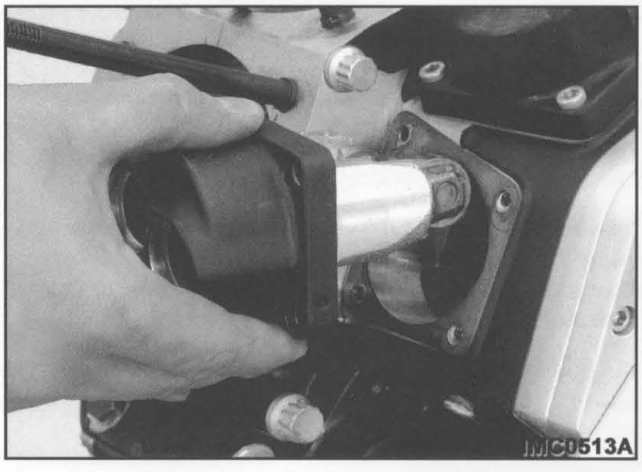

Figure 57 — Removing lifter block assembly

Remove and discard the gaskets.

Remove the lifters from the lifter blocks.

Mark the lifters and lifter blocks to assure that they are reassembled in their original locations.

Cleaning and inspection

Clean the lifter blocks with a suitable oil removal product.

Inspect the lifters and lifter blocks for wear or damage. Replace any lifters and lifter blocks that are damaged or show excessive wear.

Clean the lifter roller with an oil-free cleaning solution.

If a lifter is not working properly, or you think that there is dirt in a lifter, replace the lifter.

Place the lifters in a covered container filled with clean engine oil. Store the lifters in this manner until they are reinstalled on the engine.

Installation

Place a new gasket in position on the crankcase. Make sure that the gasket is properly positioned.

Place the rear lifter block assembly in position at the top of the crankcase. Install the tappet-block alignment pins, JIMS® 33443-84, in the lifter block. Install one in the screw hole nearest the oil hole in the block and the other in the screw hole diagonally across from the first.

NOTE: The front and rear blocks (marked with an "F" and "R" respectively) are not interchangeable and must be installed in the correct locations.

Apply blue threadlock to the threads of the mounting screws and install the screws in the two open holes, using a 3/16" hex bit. Remove the alignment pins and install the two remaining mounting screws. Tighten the screws to 8-12 foot-pounds.

Figure 58 — Positioning lifter block assembly with alignment pins

Repeat the process to install the front lifter block assembly.

Oil Pump Removal and Installation

Remove the tappet screen plug using a 1/4" hex bit. Then, remove the spring and tappet screen. Inspect the screen for damage and discard if necessary.

Loosen the oil pump mounting screws with a 1/4" hex bit and remove the six screws.

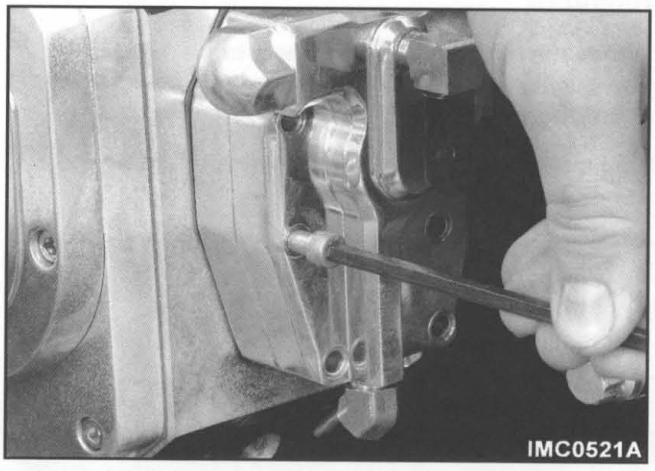

Figure 59— Removing the oil pump

Remove the oil pump and gasket from the crankcase. Discard the gasket.

Clean and inspect the oil pump for wear and/or damage. Rebuild or replace the pump if necessary.

Place a new gasket on the oil pump-mounting surface and place the pump in position on the crankcase. Turn the crank assembly if necessary to seat the pump.

Apply blue threadlock to the threads of the six mounting screws and install the screws using a 1/4" hex bit. Tighten the screws to 8-12 foot-pounds.

Install the tappet screen, open end down, into the tappet screen bore above the oil pump. Install the spring, O-ring and plug. Using a 1/4" hex bit, tighten the plug to 8-12 foot-pounds.

Ignition Cover Housing/Rotor Removal and Installation

Tools required:

1/8" hex bit

3/16" hex bit

Procedure

Remove the two ignition cover housing mounting screws using a 3/16" hex bit. Remove the cover and discard the gasket.

Using a 1/8" hex bit, remove the screw retaining the rotor and remove the rotor.

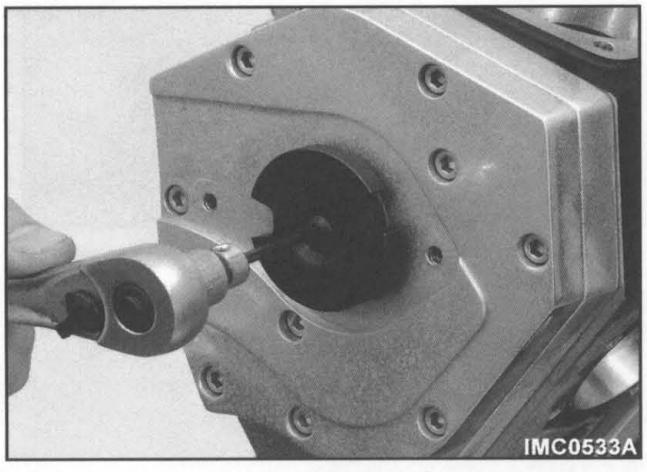

Figure 60 — Removing the ignition rotor

Inspect the leads and connector for the sensor sealed in the cover. If damaged, repair or replace as necessary.

Position the rotor on the end of the pinion shaft with the alignment pin in the shaft slot. Apply blue threadlock to the threads of the retaining screw and install the screw using a 1/8" hex bit. Tighten the screw to 6-8 foot-pounds.

Place a new gasket in position and install the ignition cover housing. Apply blue threadlock to the threads of the cover screws and install the screws. Tighten the screws to 8-12 foot-pounds.

Cam, Breather Valve and Pinion Gear Removal and Installation

Tools required:

3/16" hex bit

Cam cover puller (to be fabricated — see Required Tools section)

Mainshaft sprocket locknut wrench, 94660-37A (available from JIMS®)

Pinion gear installer/puller (available from JIMS®)

- Screw, 96830-51-2
- Puller, 96830-51-3

Rod alignment tool, 1010 (available from JIMS®)

Small hammer and drift

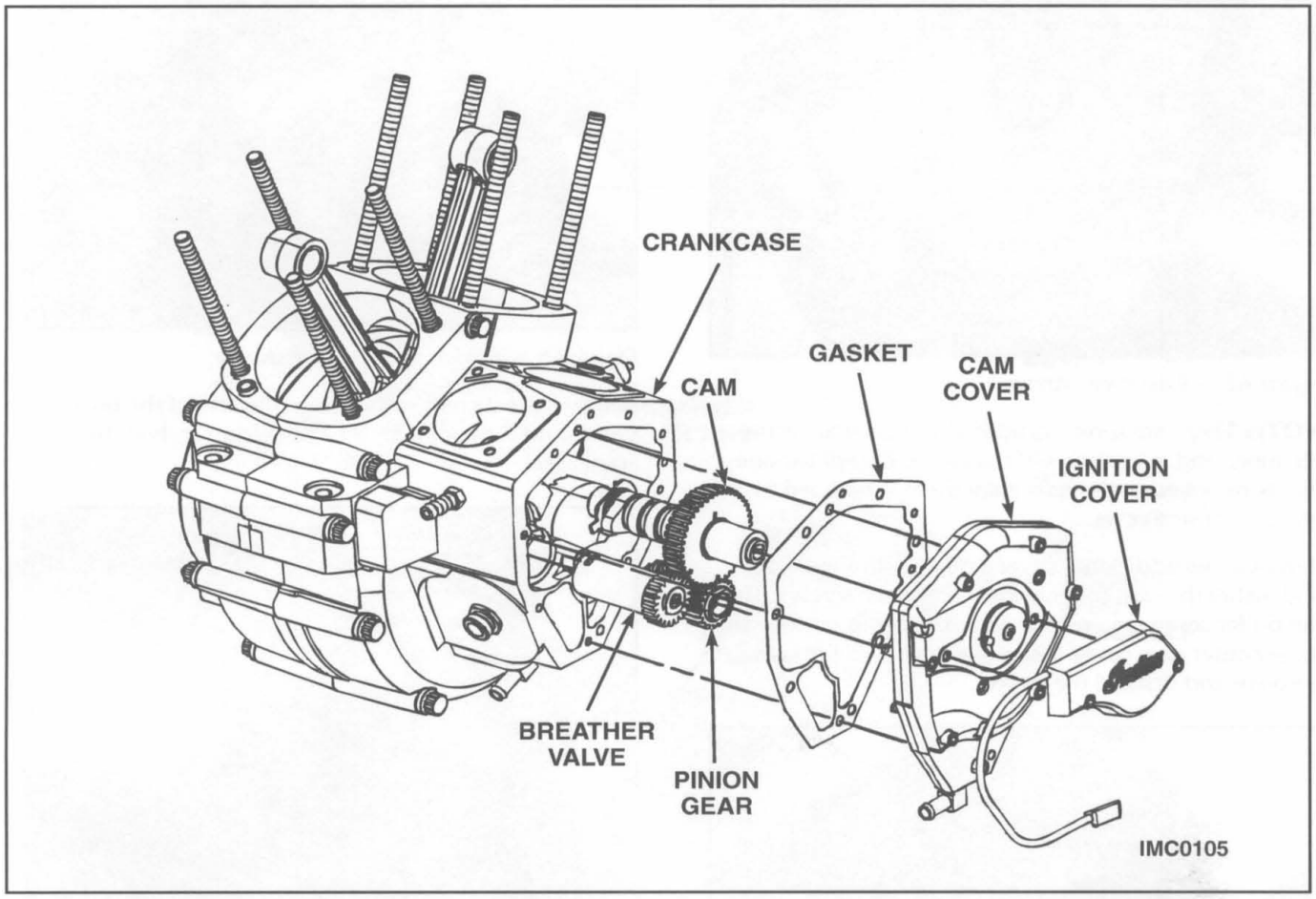

Figure 61 — Cam assembly

Removal

Remove the rocker box assemblies, pushrods and tubes, lifter block assemblies and ignition cover and rotor following procedures covered earlier in this section.

Remove the seven perimeter screws attaching the cover to the crankcase.

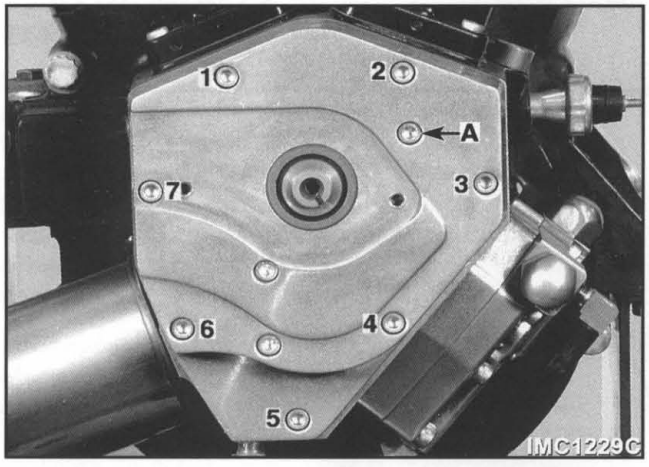

Figure 62 — Cam cover screws

NOTE: There are three additional screws that secure the inner and outer parts of the cover. Except for one that is removed in the next step, there is no need to remove these screws.

Remove one additional cover screw (A in Figure 62) and install the cam cover puller with three screws. Turn the puller screw against the pinion shaft to remove the inner/outer cam cover assembly from the crankcase. Remove and discard the gasket.

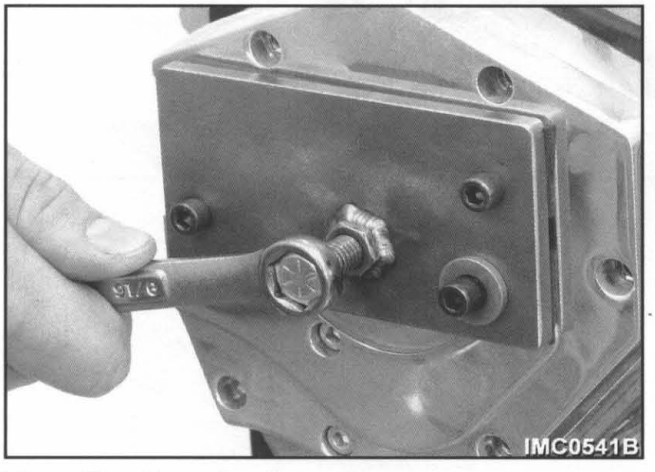

Figure 63 — Removing the cam cover

NOTE: If the engine is not being disassembled and only the breather valve or cam is to be removed, then align the timing marks on the gears before removing the breather valve or cam. This will make installation easier.

Pull the cam assembly, shim and thrust washer from the camshaft bearing bore.

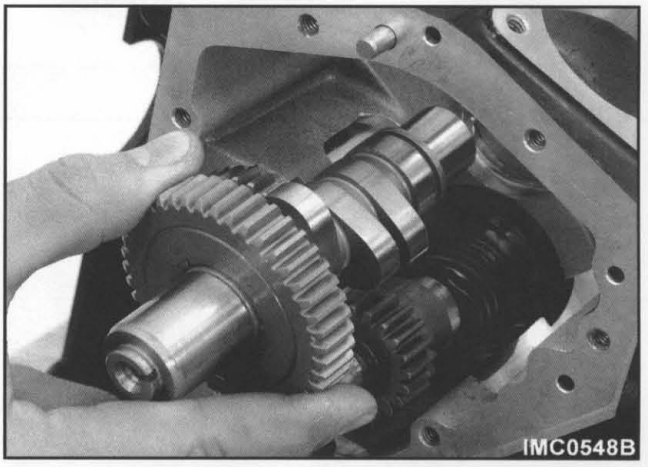

Figure 64 — Removing the cam assembly

Remove the thrust washer from the end of the breather valve, and then remove the valve from its bore in the crankcase.

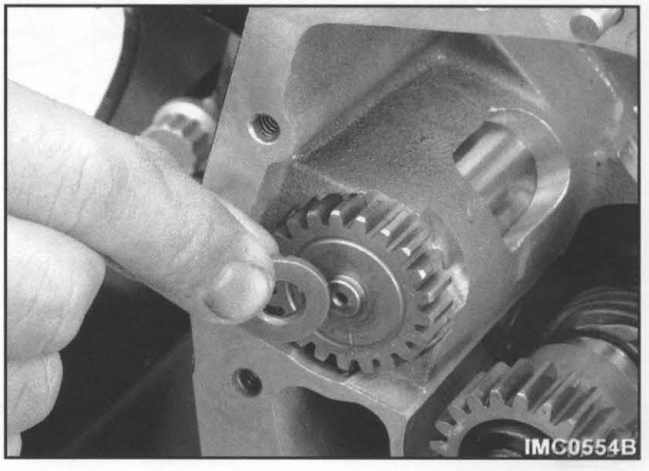

Figure 65 — Removing the breather valve thrust washer

To remove the pinion gear nut, the crankshaft must be locked in position. Use a mainshaft sprocket locknut wrench, JIMS® 94660-37A, to keep the crank assembly from turning or insert a rod alignment tool, JIMS® 1010, into the connecting rod wrist pin bore if the engine is disassembled.

Use the pinion gear nut socket, JIMS® 94555-55A, to loosen and remove the nut.

NOTE: The pinion gear nut is a left-hand thread. To remove, turn the nut in a clockwise direction.

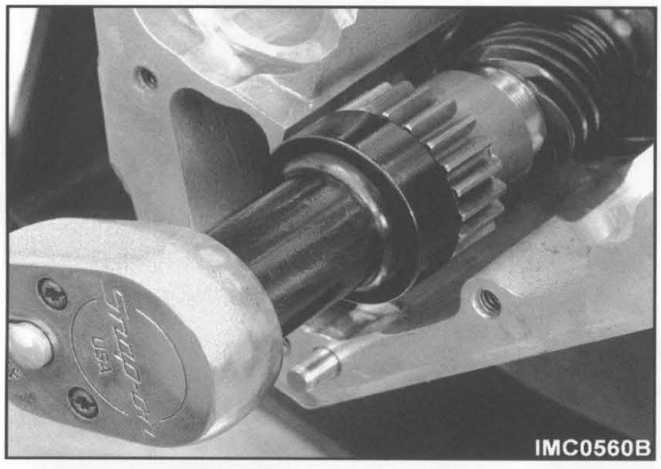

Figure 66 — Removing the pinion gear nut

To remove the pinion gear, install the pinion nut puller and screw, JIMS® 96830-51-3 and 96830-51-2, as shown. Remove the gear from the pinion shaft.

Figure 67 — Removing the pinion gear

Use a small hammer and drift to drive out the key from the pinion shaft. Then, remove the spacer and oil pump drive gear.

Clean and inspect the components and replace as necessary.

Installation

Install the inner key, oil pump gear, spacer, and outer key and pinion gear on the pinion shaft.

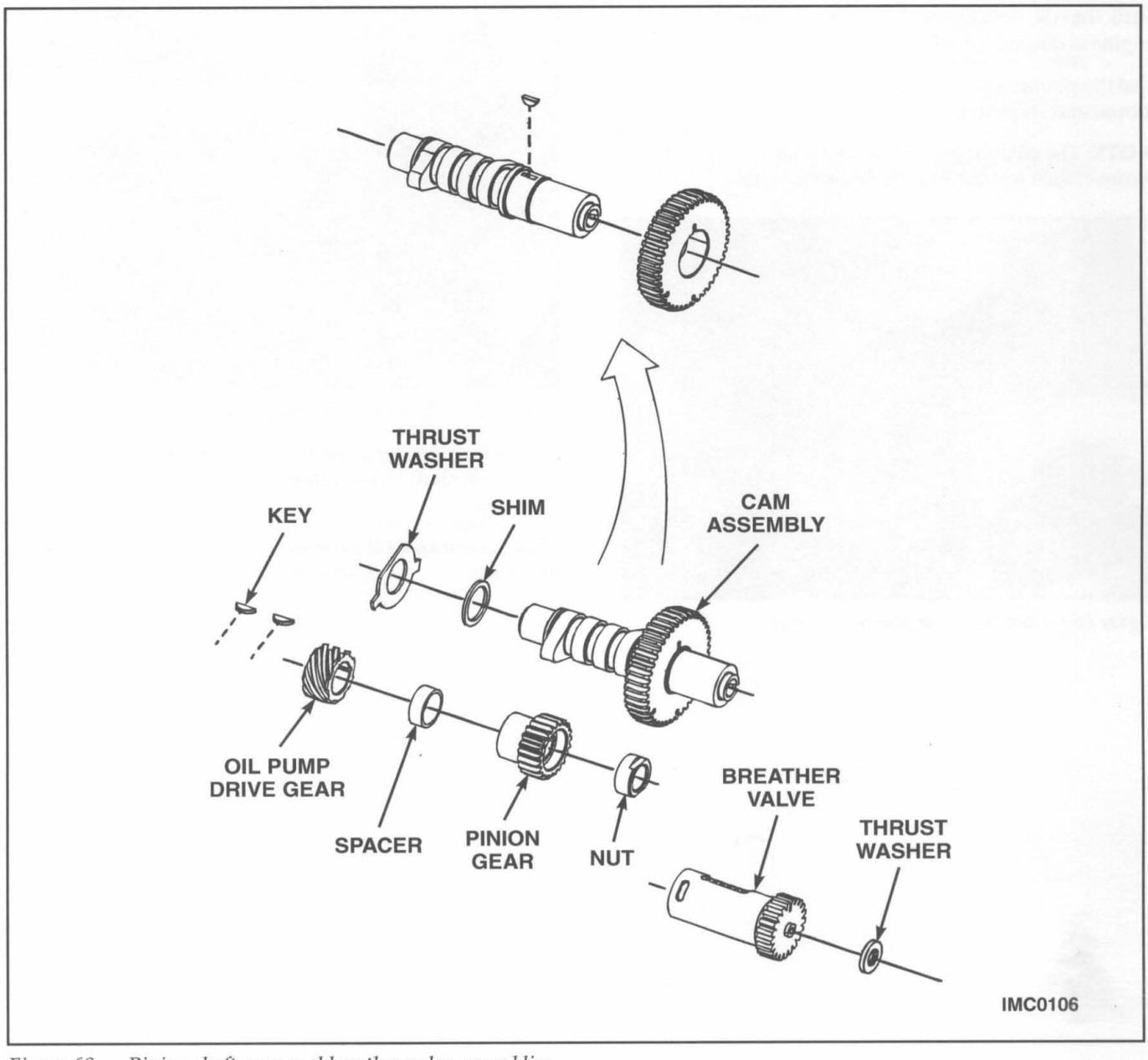

Figure 68 — Pinion shaft, cam and breather valve assemblies

Apply a thin coating of red threadlock to the threads on the pinion shaft. Install the nut on the pinion shaft and using the pinion gear nut socket, JIMS® 94555-55A, tighten the nut to 40 foot-pounds. Use a sprocket shaft socket or rod alignment tool, JIMS® 1010, inserted through the connecting rod wrist pin bore to keep the shaft from turning.

NOTE: The pinion gear nut is a left-hand thread. To install, turn the nut in a counterclockwise direction.

Install the shim and thrust washer on the camshaft. Install the thrust washer with the beveled side facing the inside of the case and the flat edge facing the rear lifter block mounting hole.

Lubricate the pilot bearing in the crankcase and the end of the camshaft. Align the timing marks on the pinion and camshaft gears and install the camshaft into the pilot bearing.

Lubricate the breather valve and install the valve in its bore in the crankcase.

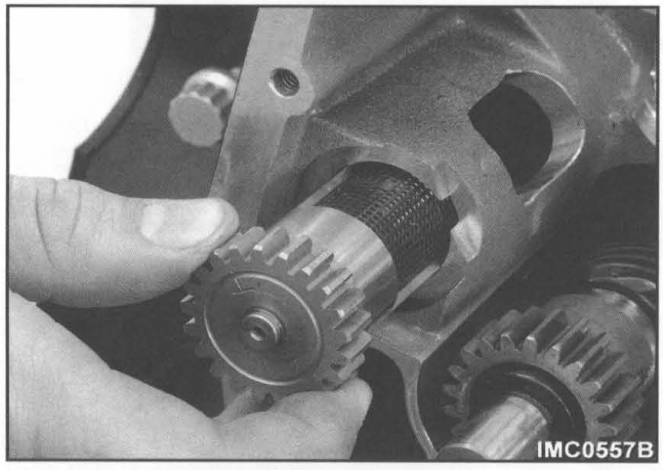

Figure 69 — Installing the breather valve

Make sure that the timing marks of the valve and camshaft gears are properly aligned.

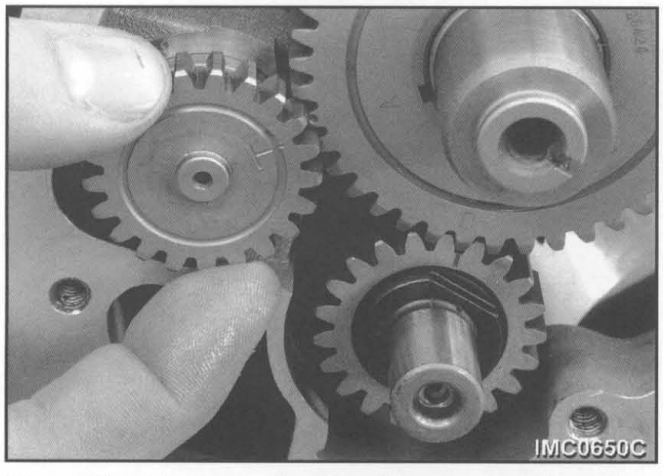

Figure 70 — Timing marks aligned between breather valve and camshaft gears

Lubricate and install the thrust washer on the breather valve gear. Lubricate the ends of the cam and pinion shafts.

Check that the two dowel pins are in place on the sealing surface of the crankcase. Place a new gasket on the crankcase.

Apply blue threadlock to the threads of the cam cover mounting screws. Install the cam cover and the seven screws around the perimeter of the cover. Make sure the one shorter screw is installed in the lower cam cover hole. Tighten the screws to 8-12 foot-pounds.

Check camshaft end play as follows:

- Slide the camshaft against the cam cover.
- Measure end play with a gap gauge inserted between the camshaft shoulder and shim at the pilot bearing end.
- If end play is not within specification, remove the cam cover and camshaft. Install a properly sized shim to bring the end play within specification and recheck.

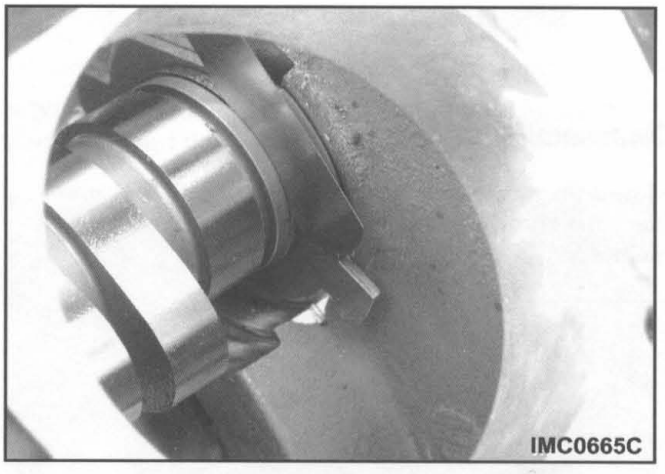

Figure 71 — Measuring camshaft end play

Crankcase Disassembly and Assembly

Tools required:

1/2" 12-point socket

Brass hammer

Cam bearing tool, 97272-80-1 (available from JIMS®)

Crank disassembly-removing tool, 1047-TP (available from JIMS®)

Drift

Flywheel rebuilding jig, 1071 (HD 09-1194) (available from JIMS®)

Motor sprocket shaft seal installation tool, 39361-69 (available from JIMS®)

Snap ring pliers

Sprocket shaft bearing installation tool set, 97225-55 (available from JIMS®)

Sprocket shaft holder, 1034 (available from JIMS®)

Torque wrench

Disassembly

Mount the sprocket shaft holder, JIMS® 1034, in a vise. Place the crankcase assembly, sprocket shaft down, in the holder.

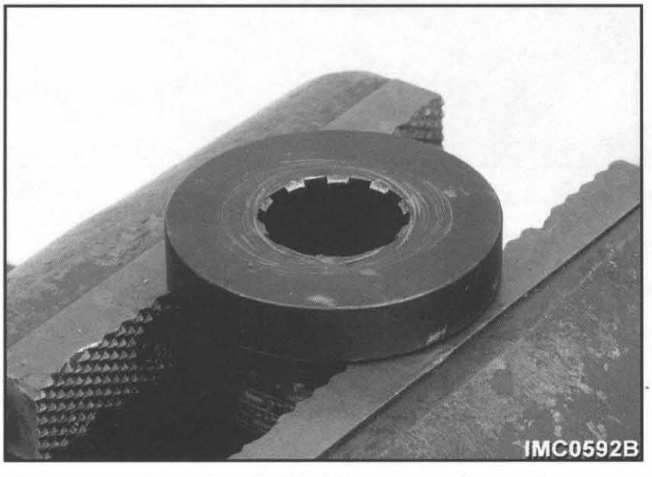

Figure 72 — Sprocket shaft holder mounted in a vise

Using a 1/2" 12-point socket, remove the seven bolts joining the left and right case halves. Three of the case bolts are locator bolts that must be driven out using a brass hammer and drift.

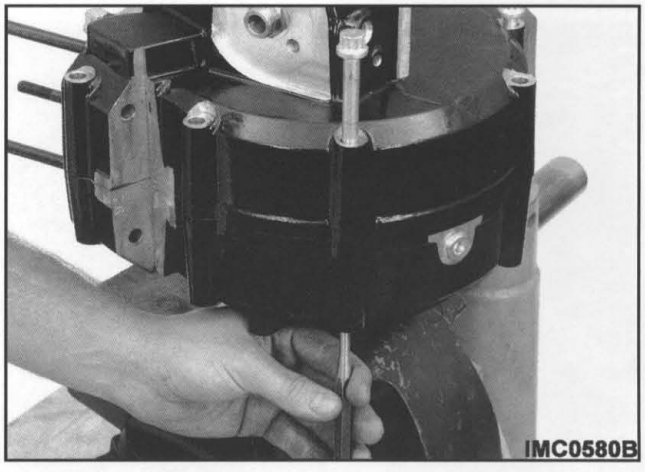

Figure 73 — Driving locator bolts from case

NOTE: Six are 5/16" through-bolts with nuts. The seventh, a 3/8" bolt, passes through the pinion-side case and is threaded into the sprocket-side case.

With the case bolts removed, tap the case with a brass hammer to separate the halves and lift the right case half (pinion side) off the assembly.

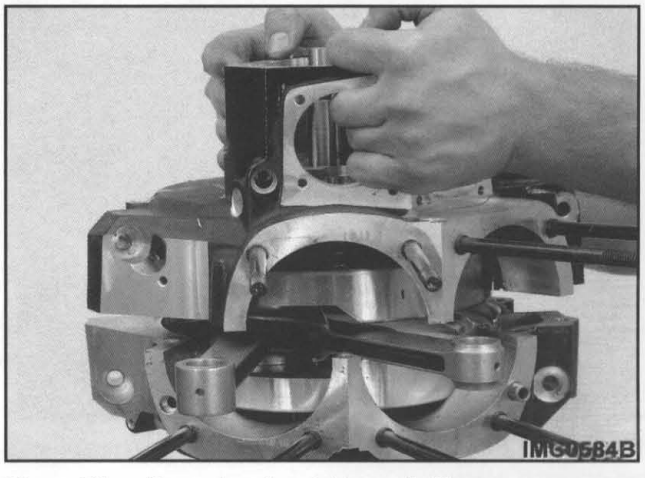

Figure 74 — Removing the right case half

Using suitable pliers, remove the snap ring retaining the pinion bearing and remove the bearing from the shaft.

Remove the left case half, flywheel and crank assembly from the holder.

Remove the sprocket shaft holder from the vise and mount the flywheel-rebuilding jig, JIMS® 1071, in the vise.

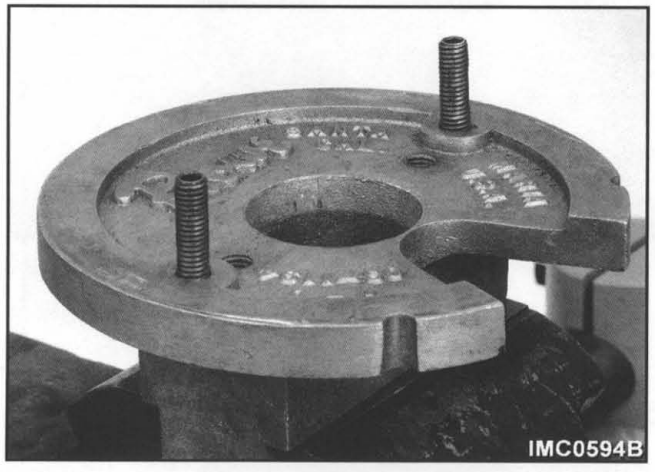

Figure 75 — Flywheel-rebuilding jig mounted in a vise

Mount the left case half, flywheel and crank assembly, pinion shaft facing down, on the rebuilding jig.

Install the crank disassembly/removing tool, JIMS® 1047-TP, on the left case half and tighten the mounting bolts.

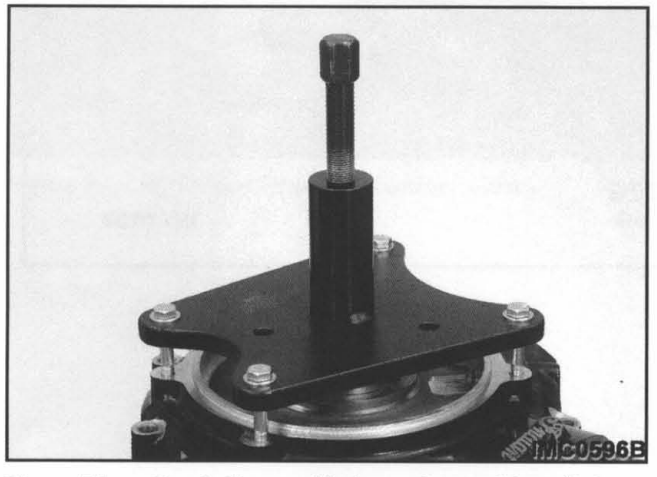

Figure 76 — Crank disassembly/removing tool installed on left case half

Turn the driving bolt until the case half separates from the sprocket shaft. Remove the case half and tool.

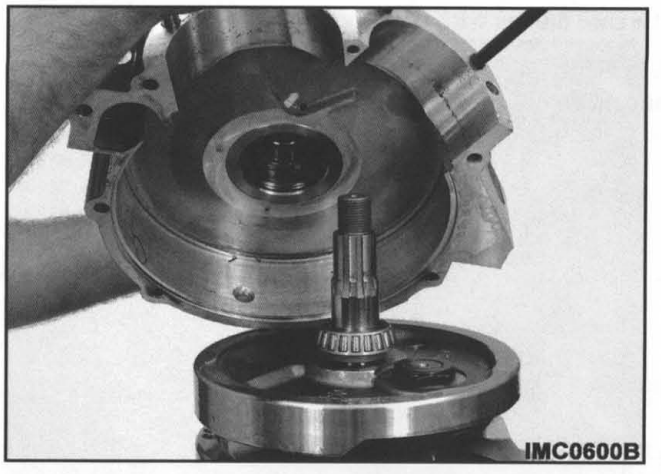

Figure 77 — Removing the left case half

Remove the flywheel and crank assembly from the rebuilding jig.

Cleaning and inspection

Clean the right and left case halves in a suitable cleaning solution to remove all oil, dirt and debris. Dry the case halves with compressed air.

Inspect the mating surfaces of the case halves for nicks and scratches, cracks or other damage. Repair or replace the case, if necessary.

Apply a thin coating of Teflon® thread dope to the drain plug and install the plug in the left case half, using a 5/16" hex bit. Tighten the plug to 18 foot-pounds.

Clean and inspect the bearings and races for wear or damage. Replace parts as required.

If removed, install the cam bearing in the right case half. Check that the bearing is fully seated in the case and that it is below the surface of the cam bearing housing.

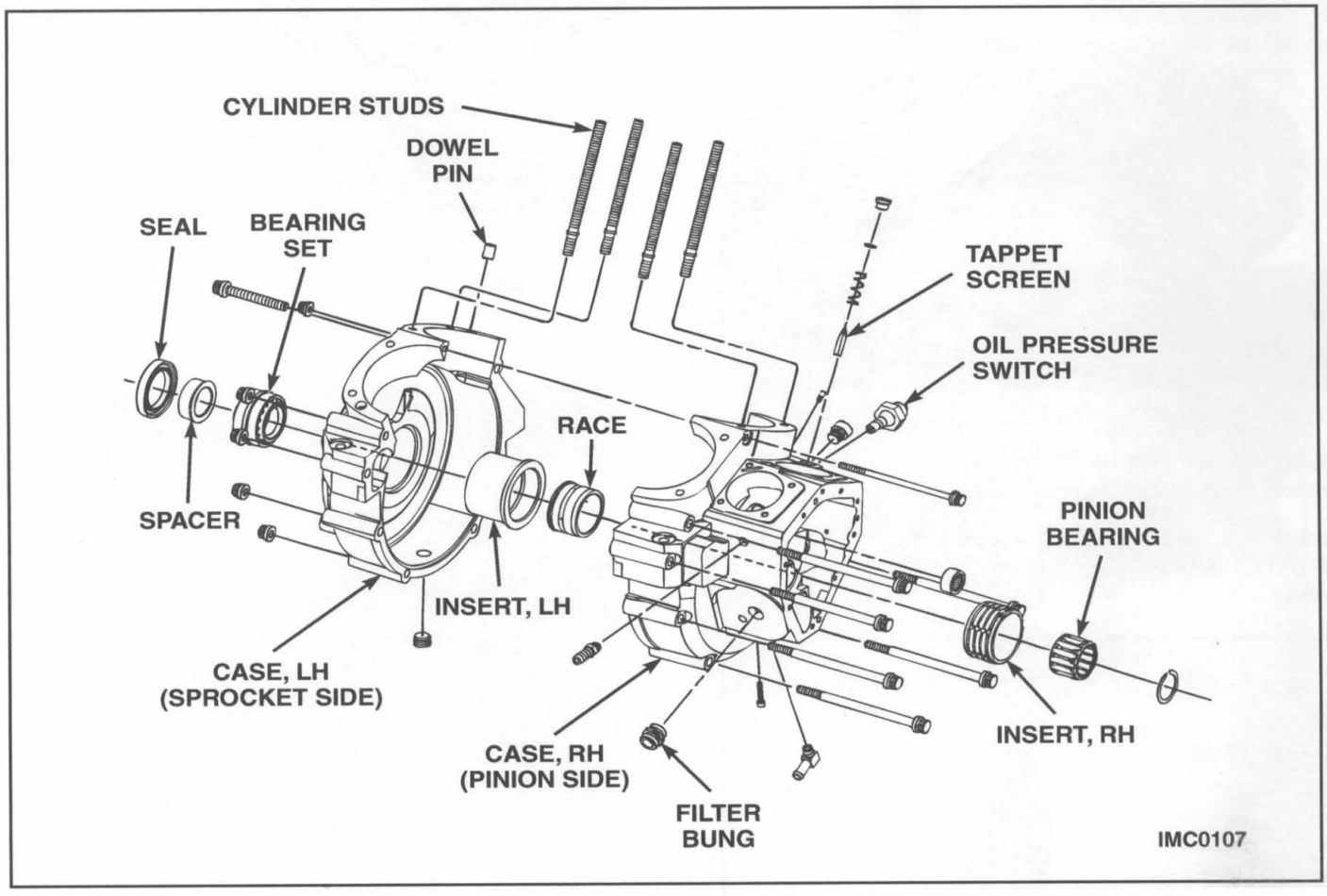

Figure 78 — Crankcase assembly

Assembly

Mount the flywheel-rebuilding jig, JIMS® 1071, in a vise.

Place the pinion side of the flywheel and crank assembly in the rebuilding jig. The sprocket side of the crankshaft assembly will be facing up.

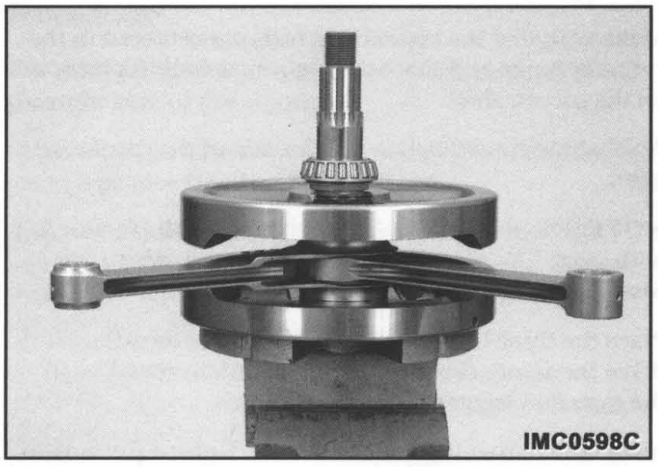

Figure 79 — Flywheel and crank assembly mounted in rebuilding jig

NOTE: Before reassembling the crankcase, the connecting rods must be aligned with the

male connecting rod positioned to the front cylinder and the female connecting rod to the rear cylinder.

Install the inner bearing spacer and race on the sprocket shaft. Lubricate the race.

Place the left case half in position on the sprocket shaft. Make sure that the connecting rods are properly positioned in the cylinder bores.

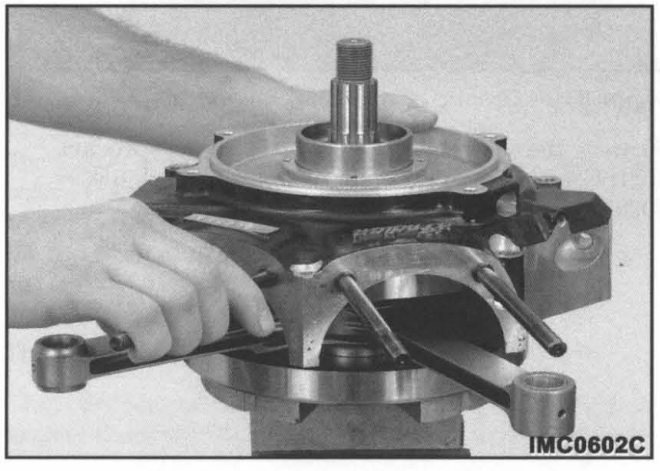

Figure 80 — Placing left case half on sprocket shaft

Install the outer bearing and spacer on the output shaft using the sprocket shaft bearing installation tool set, JIMS® 97225-55, and the mainshaft sprocket locknut wrench, JIMS® 94660-37A.

- Install the bearing installation tool on the sprocket shaft and turn the screw in until the bearing is snug against the case half.
- Position the locknut wrench on the bearing installation tool. Turn the wrench until the bearing is fully seated in the case.
- Remove the wrench and bearing installation tool.

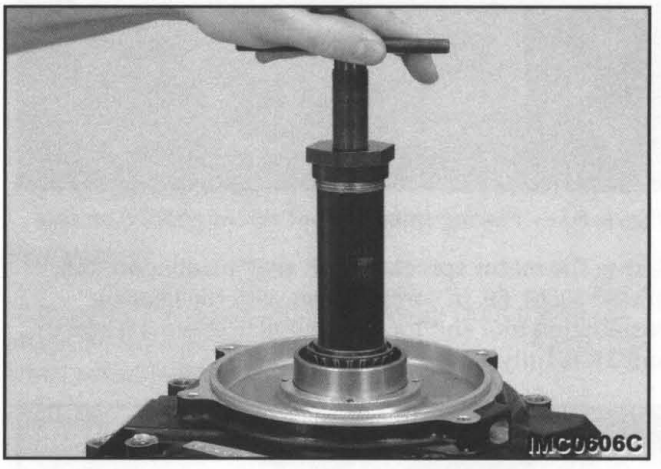

Figure 81 — Pressing bearing snug against case with tool 97225-55

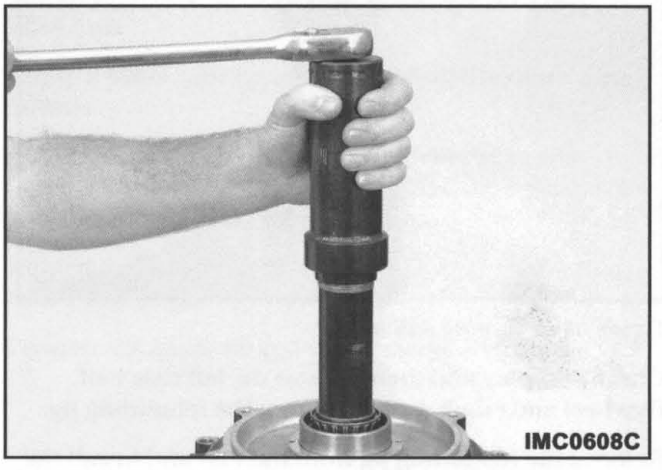

Figure 82 — Seating bearing in case with locknut wrench 94660-37A

Lubricate and install the sprocket shaft spacer and position the seal in the case. The seal must be positioned with the rounded edge facing outward, away from the case.

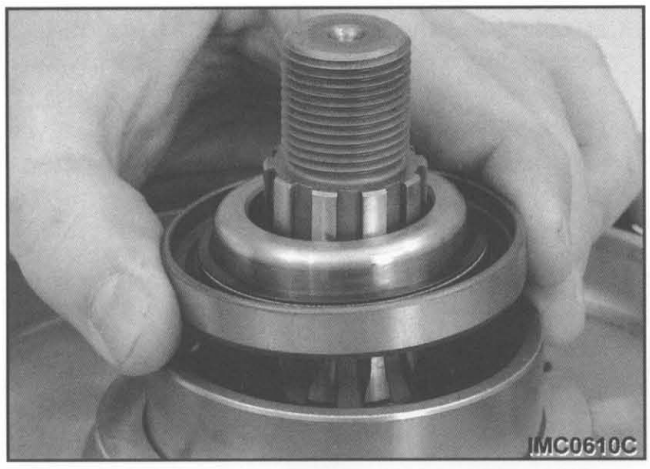

Figure 83 — Placing sprocket shaft seal in position on case

Using the motor sprocket shaft seal installation tool, JIMS® 39361-69, in combination with the bearing installation tool and locknut wrench, drive the seal in until it is fully seated in the case.

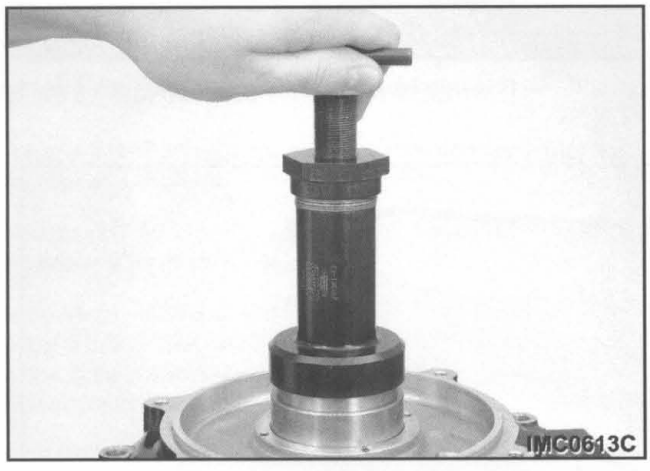

Figure 84 — Seating seal in case

Check end play and then remove the left case half, flywheel and crank assembly from the rebuilding jig.

Remove the rebuilding jig from the vise and install the sprocket shaft holder, JIMS® 1034, in the vise.

Position the left case half, flywheel and crank assembly in the holder, sprocket shaft down.

Lubricate the pinion shaft and install the pinion shaft bearing. Then lubricate the bearing.

Install the snap ring to retain the bearing.

Apply a bead of Loctite® 510 Gasket Eliminator to the case-mating surface.

Make sure that the connecting rods are centered in the cylinder bores and place the right case half in position on the pinion shaft.

Apply blue threadlock to the threads of the crankcase bolts.

NOTE: The six 5/16" bolts are through bolts retained with nuts. The shorter 3/8" bolt is threaded into the case.

Place the three locator bolts in the proper locations and drive them into the case with a brass hammer. Install the nuts and tighten to 18 foot-pounds.

Install the remaining bolts and nuts. Tighten the nuts to 18 foot-pounds.

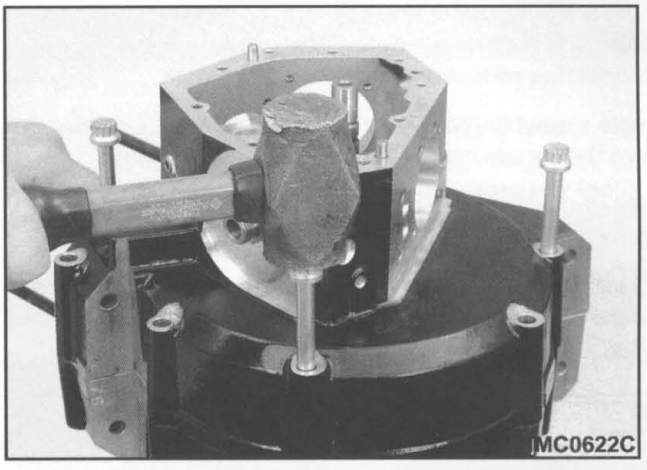

Figure 85 — Driving locator bolts into case

Remove the assembled crankcase from the sprocket shaft holder and mount it in an engine stand, JIMS® 1006T, for engine assembly.

Specifications

General

Engine type	4-cycle, 45-degree V
Number of cylinders	2
Bore and stroke	3.875 in x 4.25 in
Displacement	100 cu-in
Compression ratio	9.5:1
Horsepower	67.5 bhp at 5750 rpm
Torque	77.2 ft-lbs at 2300 rpm

Fits and Tolerances

Valve Rocker Box Assembly

Item	Standard Fit	Wear Limits
Rocker arm-to-bushing (press fit)	0.0040-0.0020 in	Less than 0.0020 in
Rocker arm shaft-to-bushing	0.0005-0.0020 in	Exceeds 0.0035 in
Rocker arm shaft-to-shaft supports	0.0010-0.0024 in	Exceeds 0.0035 in

Cylinder Head and Valves

Item	Standard Fit	Wear Limits
Cylinder head displacement range	81.1-83.1 cc	—
Cylinder head flatness (gasket surface)	0.003 in	0.005 in
Valve guide-to-cylinder head (press fit)	0.0028-0.0018 in	Less than 0.0018 in
Valve seat insert-to-cylinder head (press fit)	0.0050-0.0030 in	Less than 0.0030 in
Valve seats		
• Intake lead angle	60 deg	—
• Intake seat angle	45 deg	—
• Intake trail angle	30 deg	—
• Intake seat width	0.041–0.063 in	—
• Exhaust lead angle	52 deg	—
• Exhaust seat angle	45 deg	—
• Exhaust trail angle	30 deg	—
• Exhaust seat width	0.048–0.070 in	—
Valve stem diameter	0.3100–0.3102 in	—
Valve stem-to-face runout	0.002 in max	—
Valve stem protrusion (from cylinder head)	2.065-2.069 in	Exceeds 2.079 in
Valve-to-guide		
• Intake	0.0013-0.0022 in	Exceeds 0.0035 in
• Exhaust	0.0017-0.0026 in	Exceeds 0.0040 in
Valve springs		
• Free length	2.256 in	—
• Pressure, outer spring, compressed to 1.250 in	269 lbs	—
• Pressure, inner spring, compressed to 1.437 in	47.5 lbs	—

Cylinder and Piston Assembly

Item	Standard Fit	Wear Limits
Cylinder bore	3.8760–3.8765 in	0.002 in max Taper 0.003 in max out-of-round
Piston-to-cylinder	0.0025-0.0030 in	Exceeds 0.0060 in
Piston rings		
• Compression rings		
Gap	0.025-0.030 in	Exceeds 0.040 in
Side clearance (top)	0.001-0.003 in	Exceeds 0.0045 in
Side clearance (2nd)	0.0023-0.0033 in	Exeeds 0.0045 in
• Oil control ring		
Side clearance	0.003-0.006 in	Exceeds 0.0065 in
Wrist pin-to-piston	0.0005-0.0007 in	Exceeds 0.001 in
Wrist pin-to-connecting rod	0.0015-0.0020 in	Exceeds 0.0020

Oil Pump Assembly

Oil pressure (at normal operating temperature and 2000 rpm)	12-35 psi

Crankcase

Item	Standard Fit	Wear Limits
Breather valve gear end play	0.008-0.032 in	Exceeds 0.037 in
Camshaft bearing-to-crankcase (press fit)	0.0005-0.0010 in	Less than 0.0005 in
Camshaft-to-camshaft bearing	0.0005-0.0025 in	Exceeds 0.005 in
Camshaft end play	0.005-0.015 in	Exceeds 0.025 in
Sprocket shaft bearing cups-to-crankcase (press fit)	0.005-0.003 in	Less than 0.003 in
Pinion shaft bearing-to-crankcase (press fit)	0.001-0.002 in	Less than 0.001 in

Flywheel and Crank Assembly

Item	Standard Fit	Wear Limits
Connecting rod-to-crank pin	0.0004-0.0017 in	Exceeds 0.002 in
Pinion shaft-to-bearing	0.0004-0.0010 in	Exceeds 0.001 in
Sprocket shaft-to-bearing (press fit)	0.0005-0.0015 in	Less than 0.0005 in
Flywheel and crank assembly end play	0.001-0.005 in	Exceeds 0.006 in
Flywheel runout	0.002 in max TIR	

Ignition System

Spark plug gap	0.038 in

Fastener Torque Values

Part	Torque Value
Breather fitting (in rocker cover)	8-12 ft-lbs
Breather valve housing assembly screws	8-12 ft-lbs
Camshaft cover screws	8-12 ft-lbs
Crank pin nut	210 ft-lbs
Crankcase bolts	18 ft-lbs
Cylinder head bolts, new engine or new studs (step torque)	(Step 1) 8-10 ft-lbs
	(Step 2) 18-20 ft-lbs
	(Step 3) 33 ft-lbs
Cylinder head bolts, rebuilt engine or used studs (step torque)	(Step 1) 8-10 ft-lbs
	(Step 2) 18-20 ft-lbs
	(Step 3) 1/4 turn
Cylinder studs	8-12 ft-lbs
Exhaust studs	8-12 ft-lbs
Ignition housing mounting screws	8-12 ft-lbs
Ignition rotor screw	6-8 ft-lbs
Intake manifold screws	16-20 ft-lbs
Intake manifold support bracket	16-20 ft-lbs
Intake stud	10-12 ft-lbs
Lifter block mounting screws	8-12 ft-lbs
Oil drain plug	18 ft-lbs
Oil filter bung adapter	18 ft-lbs
Oil pressure sensor	8-12 ft-lbs
Oil pump mounting screws	8-12 ft-lbs
Pinion gear nut	40 ft-lbs
Pinion shaft nut	170 ft-lbs
Plug (in rocker cover)	8-12 ft-lbs
Rocker base mounting screws	8-12 ft-lbs
Rocker shaft support bracket screws	16-20 ft-lbs
Spark plugs	18 ft-lbs
Sprocket shaft nut	310 ft-lbs
Stator mounting screws	8-10 ft-lbs
Tappet screen plug	8-12 ft-lbs
Timing plug	8-12 ft-lbs
Valve cover screws	8-12 ft-lbs

Lubricants and Sealants

Assembly Lubricants and Sealants

Part	Specified Lubricant or Sealant
Breather valve housing assembly screw threads	Blue threadlock
Camshaft cover screw threads	Blue threadlock
Crank pin threads	Red threadlock
Crankcase bolts	Blue threadlock
Crankcase drain plug	Teflon® pipe dope
Crankcase joint (sprocket side-to-pinion side)	Loctite® 510 Gasket Eliminator®
Cylinder studs	Red threadlock
Exhaust stud threads	Red threadlock
Hose fittings, 90-degree (crankcase, cam cover, and oil pump)	Teflon® pipe dope
Ignition housing mounting screw threads	Blue threadlock
Ignition rotor screw threads	Blue threadlock
Lifter block mounting screw threads	Blue threadlock
Oil drain plug	Teflon® pipe dope
Oil filter bung adapter	Red threadlock
Oil pump mounting screw threads	Blue threadlock
Pinion shaft threads	Red threadlock
Rocker base mounting screw threads	Blue threadlock
Sprocket shaft threads	Red threadlock
Stator connector plug-to-case	Silicone seal
Stator mounting screw threads	Blue threadlock
Valve cover screw threads	Blue threadlock

Required Tools

Available Special Tools

Description	JIMS® Tool No.
Cam bearing tool (use with 33416-80-1)	97272-60
Cam cover puller ***(Fabricate locally)***	
Crank disassembly removing tool	1047-TP
Engine stand	1006T
Flywheel rebuilding jig	1071 (Rowe HD 09-1194)
Mainshaft sprocket locknut wrench	94660-37A
Motor sprocket shaft seal installation tool	39361-69
Pinion gear installer and puller	
• Screw	96830-51-2
• Puller	96830-51-3
Pinion gear nut socket	94555-55A
Piston lock ring tool	
• Driver ***(Requires modification)***	96780-58A-2
• Collar ***(Requires modification)***	96781-72-2
Piston ring compressor set	1236
Piston ring expander tool	1235
Race and bearing install tool handle (use with 97272-60)	33416-80-1
Rod alignment tool	1010
Sprocket shaft bearing installation tool	97225-55 (set)
• Main body (97225-55-1)	
• Slider (97225-55-3)	
• Nut (1026B)	
• Handle (1028)	
• Bearing and washers (1047-54)	
Sprocket shaft holder	1034
Tappet block alignment tool	33443-84
Valve guide tool (use with 34740-84 for installation)	34731-84
Valve guide tool handle (for removal)	34740-84
Valve spring compressor tool	96600-36B
Valve spring tester	1090

Tool Drawings

The following drawings provide dimensions for fabricating a cam cover puller and modifying JIMS® piston lock ring tools.

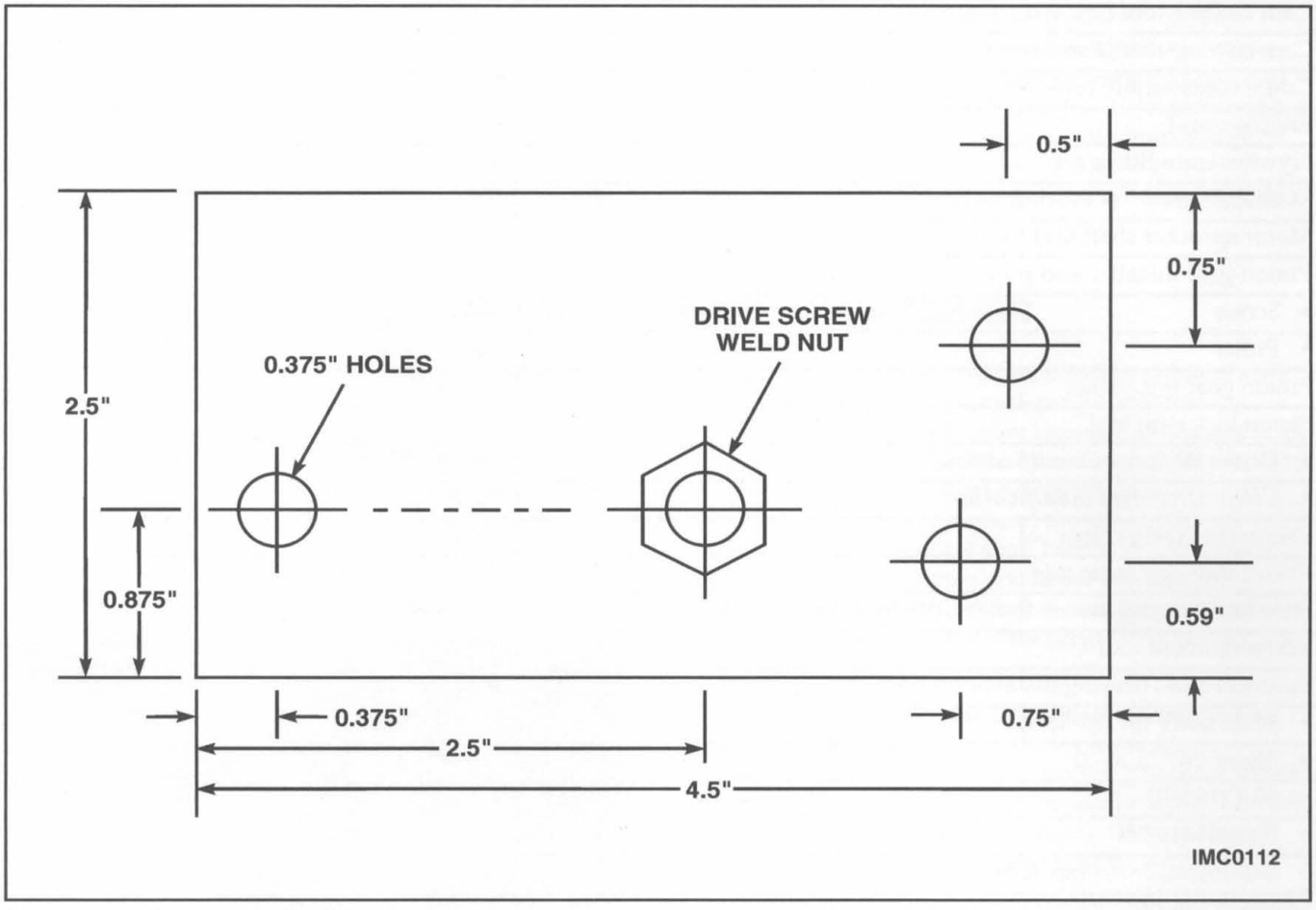

Figure 86 — Cam cover puller dimensions

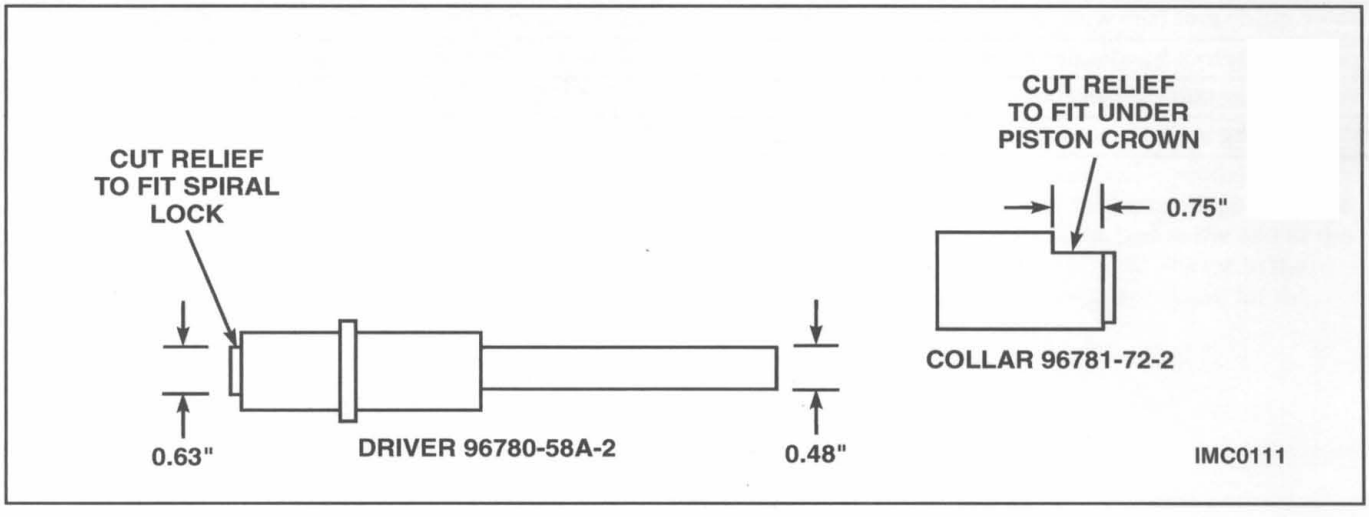

Figure 87 — Modification to JIMS® piston lock ring tools 96780-58A-2 and 96781-72-2