Study Unit

Four-Stroke Engine Lower-End Inspection

By

Ed Abdo

Preview

Lower-end disassembly is the process of removing, inspecting, and possibly replacing engine parts and components located below the cylinders. You may need to disassemble an engine to make needed repairs, or you may perform a disassembly as the second major step in a complete engine rebuild—the first step being the top-end disassembly that we covered previously.

This study unit introduces you to the procedures used to disassemble motorcycle and ATV four-stroke engine lower-end assemblies. You'll start by learning the important preliminary steps you must complete before starting the engine disassembly process. Then, you'll learn a simple procedure to disassemble almost all four-stroke engines. We'll illustrate this procedure with real engine examples. Throughout the disassembly discussion, we'll identify the special tools used in the process, and we'll review the function of certain engine components. In addition, this study unit covers the reassembly procedures and the procedures to reinstall an engine into the frame.

When you complete this study unit, you'll be able to

- Identify the various components in a four-stroke engine lower-end assembly
- Describe the procedures used to disassemble the lower end of a four-stroke engine
- Identify the special tools used to disassemble a four-stroke engine lower-end assembly
- Identify the various inspections that should be conducted on a lower-end assembly
- Inspect the various parts of a transmission for damage and wear
- Diagnose basic engine problems based on their symptoms
- Describe the procedures used to reassemble the lower end of a four-stroke engine
- Describe the procedures used to install an engine into a chassis
- List the steps to take before starting up an engine following a major rebuild
- Describe the procedure for breaking in a rebuilt engine

Contents

Four-Stroke Engine Lower-End Inspection

INTRODUCTION

The lower end of a four-stroke engine occasionally needs repair. For this reason, it's important to understand how to disassemble the engine right down to the crankshaft. It's also important to know how to inspect the engine, do any necessary repair work, and reassemble the engine correctly. In this study unit, you'll find a step-by-step description of what to do, when to do it, and how to do it.

We've used a Kawasaki GPZ 500S and a Suzuki LT 250S ATV as the models for most of our illustrations in this study unit. Other four-stroke motorcycles and ATVs will vary somewhat, but the basic principles of disassembly, repair, and reassembly remain the same.

Repair of the lower-end assembly always requires that the engine be removed from the chassis. Therefore, be sure the malfunctioning component is located in the lower-end assembly before you remove the engine from its chassis and disassemble it. After all, you wouldn't want to go to all that effort only to find out that repairing the failure didn't require all that work.

Repair Procedures

The procedures in this study unit are general in nature and not intended to be used for actual disassembly and repair. Their purpose is to familiarize you with the types of activities you'll encounter. Always refer to the appropriate motorcycle or ATV service guide for maintenance information. The service guide contains all the information to do the job correctly, including detailed instructions for the specific make and model of motorcycle or ATV, special tools, and service tips. Above all, the service guide contains the appropriate safety information. In this study unit, we'll list the necessary procedures to disassemble, inspect, repair, and replace worn parts in single- and twin-cylinder four-stroke engines. Many of the procedures will apply to all motorcycle and ATV four-stroke engines that you'll work on.

In your last study unit, we discussed the procedures for removing the engine from the chassis of a motorcycle and ATV. Because the disassembly of the lower end of many four-stroke engines also requires the removal of the top end, we'll begin the disassembly process with the engine out of the frame and the top-end assembly removed.

As mentioned before, be sure the motorcycle or ATV is clean before you begin any disassembly work. A water-soluble degreaser can be purchased at an auto-supply store or motorcycle shop. Use the degreaser according to the manufacturer's directions. Remember that dirt or foreign particles can cause serious problems if allowed to get into the engine's internal working parts.

Common Lower-End Engine Failures

In the lower-end engine assembly, malfunctions commonly occur with the engine seals, crankshaft and connecting rod bearings, and transmissions. Following are brief descriptions of these potential trouble areas. Being alert to the possibility of problems in one section of an engine, while you're performing repairs on another section, will help you become a better motorcycle and ATV technician.

Leaking Engine Seals

A leaking oil seal sometimes requires that the engine's lower end be disassembled. Always verify that the replacement of the faulty oil seal requires complete disassembly before tearing down the lower end. You can do this by referring to the instructions in the appropriate service manual before you begin the work.

Worn Crankshaft Bearings

Crankshaft bearings are used to mount the crankshaft assembly into the crankcase. Bearing failure is indicated by a rough, growling sound. Use a *mechanic's stethoscope* to help pinpoint the location of a bad bearing. Bad bearings may cause excessive up and down movement of the crankshaft, or worse, prevent the crankshaft from rotating. Excessively worn bearings can sometimes *seize*, meaning they rotate with great difficulty or lock-up completely.

Worn Connecting Rod Bearings

Connecting rod bearings allow the connecting rod(s) to pivot freely when the crankshaft turns. Symptoms of bad connecting rod bearings are indicated by an engine that

- Knocks
- Starts, but runs roughly and vibrates
- Can't be rotated manually (It's seized up.)

Any of these symptoms necessitate the disassembly, inspection, and repair of the lower end of the engine.

Transmission Problems

Transmission problems are indicated by

- Difficulty with shifting or inability to shift at all
- Unusual growling or clunking sounds
- Jumping out of gear

Because most motorcycle and ATV four-stroke engines and transmissions use a common *casting*, or crankcase, the procedure for separating the engine and transmission case is similar. Any suspected transmission malfunction should be checked out while you have the crankcase open.

Let's get started with four-stroke motorcycle and ATV engine lower-end component disassembly, inspection, and repair. We've included clutch repair procedures, even though access to the clutch doesn't require the disassembly of the lower end or removal of the engine from the chassis, because the four-stroke engine clutch assembly is susceptible to wear and failures.

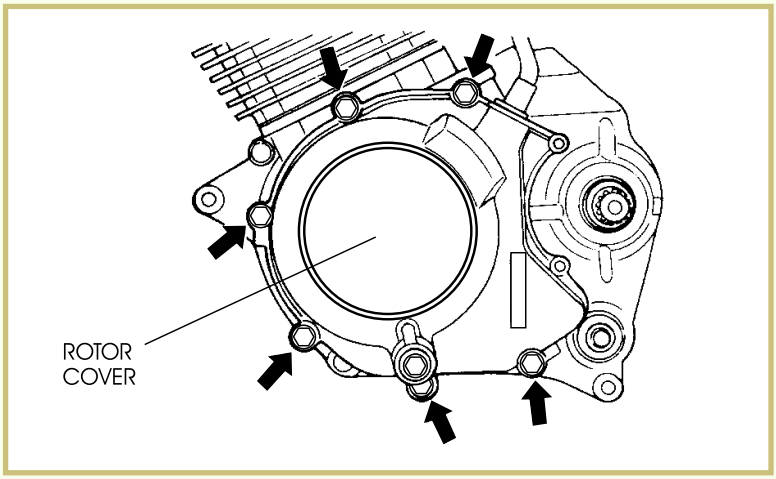
FOUR-STROKE ENGINE LOWER-END DISASSEMBLY

Because we've already discussed the removal of the engine and top-end disassembly procedures, we'll begin this section with the engine already out of the frame and the top end removed. We'll provide a step-by-step method of disassembly, as we've done previously, to assist with our explanation of the four-stroke lower-end disassembly procedures.

Our example, for illustrative purposes, will again be a single-cylinder Suzuki LT 250S ATV, which uses a vertically split crankcase assembly. We'll also explain, when needed, the different procedures used when disassembling a multicylinder model that uses a horizontally split crankcase assembly. However, you'll see that many of the procedures are identical when disassembling both vertical and horizontal crankcase four-stroke engines.

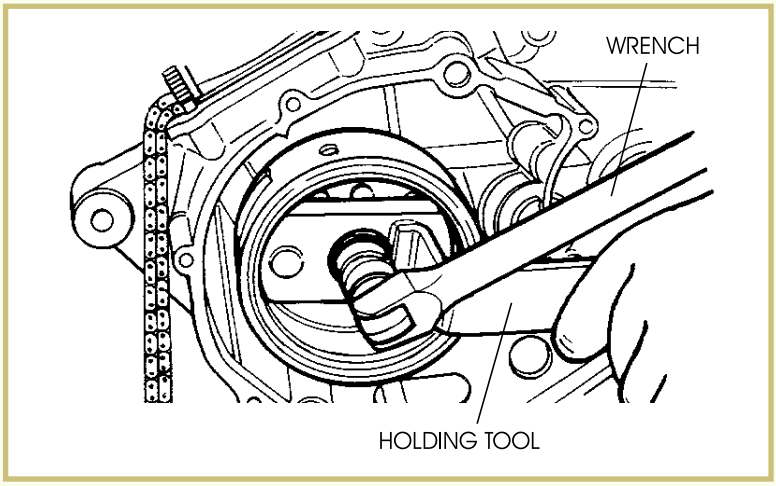
Removing the Rotor and Electric Starter

1 Remove the rotor cover. The cover mounting fasteners have arrows pointing to them in the figure. Many rotor covers contain the electrical charging system stator, so you should be careful when handling this component. Although not all rotor covers contain oil, you should proceed with caution, as there may be some residual oil in this area of the engine, even if you have previously drained the oil.



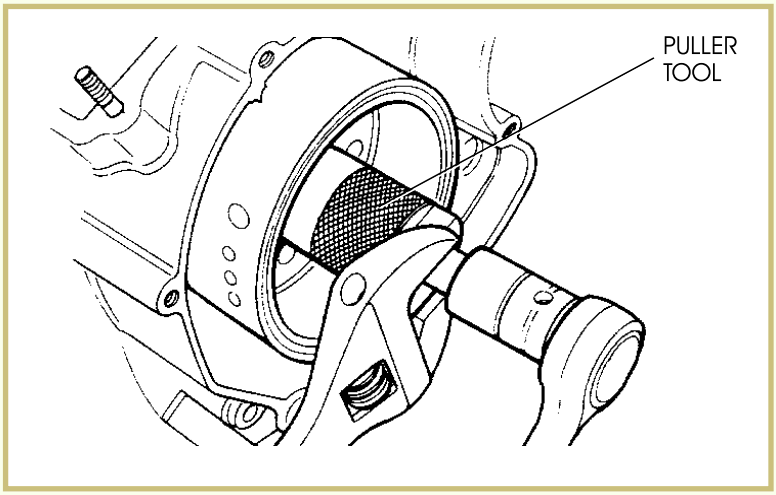
(Courtesy of American Suzuki Motor Corporation)

2 Remove the rotor nut or bolt. A special holding tool is often needed to keep the rotor from turning while removing the rotor attaching fastener. Don't attempt to improvise. Use the recommended tool. If you don't, you risk damaging expensive electrical parts in the rotor. Above all, don't try to pry the rotor with a screwdriver, and don't hit it with a hammer! Inexperienced mechanics soon learn that rotors must be handled with care, as they're easily damaged.



(Courtesy of American Suzuki Motor Corporation)

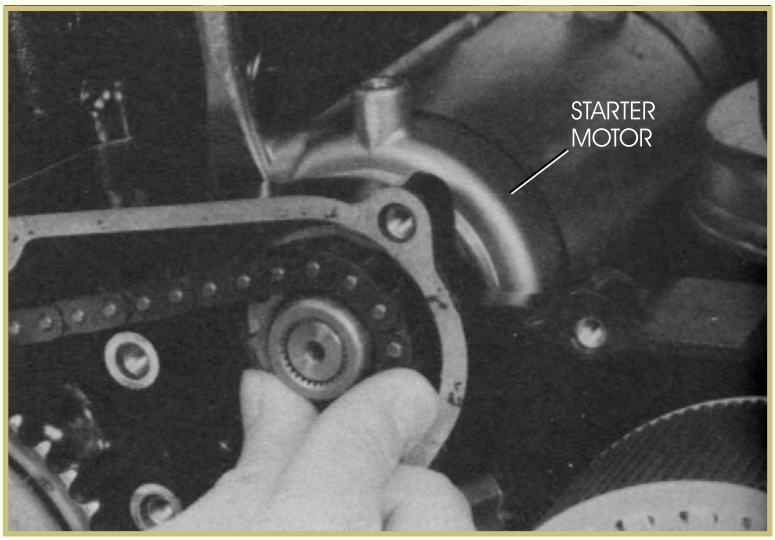
3 Remove the rotor (or flywheel), using a *rotor puller*, or *flywheel puller*. It's also a good idea to remove the *Woodruff key* from the crankshaft. Place all these parts together and put them aside until you're ready to reinstall the rotor.



(Courtesy of American Suzuki Motor Corporation)

4 If the engine has an electric starter motor, remove the mounting bolts that hold it in place. Starter motors are normally located behind the rotor or flywheel. Some starter motors use gears, while others use a chain, as shown in the figure at the right.

5 Remove the motor from the engine case.

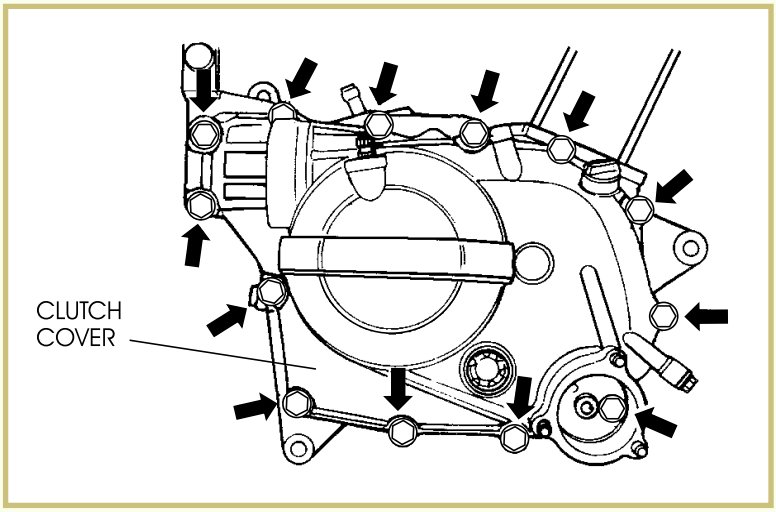


(Courtesy Kawasaki Motor Corp., U.S.A.)

Removing the Clutch and Related Components

The clutch and related components are located on the opposite side of the engine. Disassemble them next.

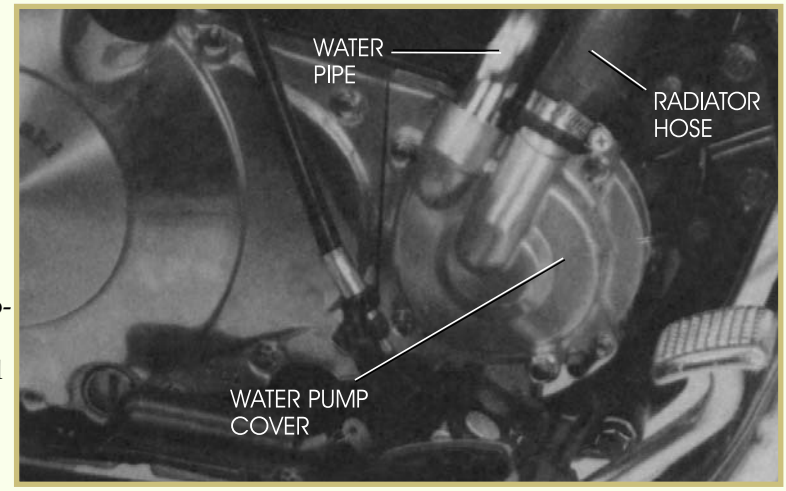
1 Remove the clutch cover. Sometimes many fasteners are used to attach this cover, as indicated by the arrows in the illustration.



(Courtesy of American Suzuki Motor Corporation)

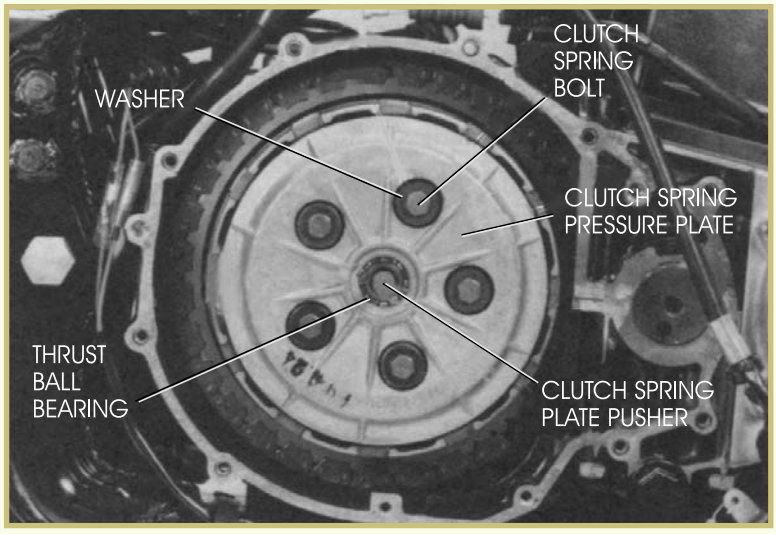
2 If you're working on a liquid-cooled engine, remove the water pump. Some water pumps are integrated into the clutch cover, while others are a separate component altogether.

Note: Before proceeding, check the model you're working on to determine where the clutch springs are located. If located *outside* the pressure plate, follow steps 3 and 4. If located inside the pressure plate, reverse steps 3 and 4.



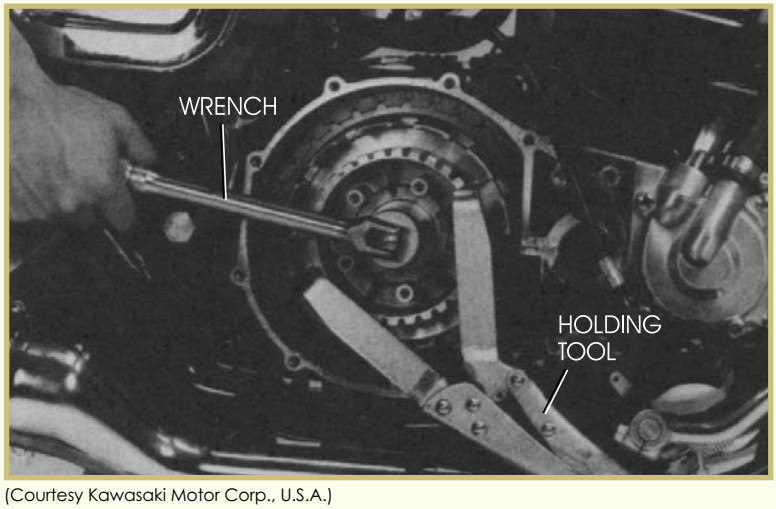
(Courtesy Kawasaki Motor Corp., U.S.A.)

3 Loosen and remove the clutch spring bolts. Remove the springs and the pressure plate.



(Courtesy Kawasaki Motor Corp., U.S.A.)

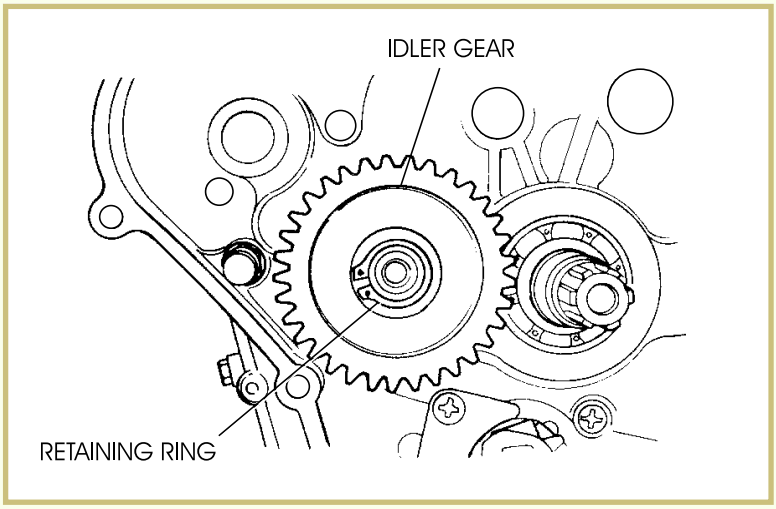
4 Attach a holding tool to the clutch inner hub, and remove the clutch nut using a wrench.



(Courtesy Kawasaki Motor Corp., U.S.A.)

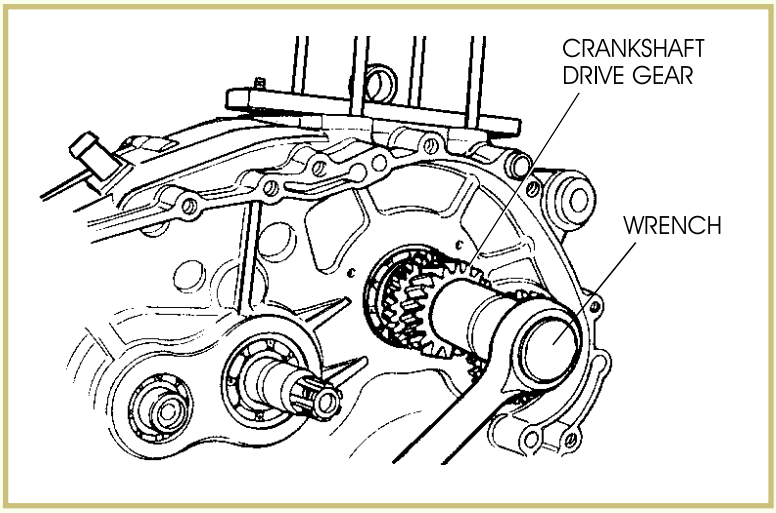
5 Remove each of the friction discs and clutch plates as well as the clutch inner and outer hubs.

6 Remove all idler gears.



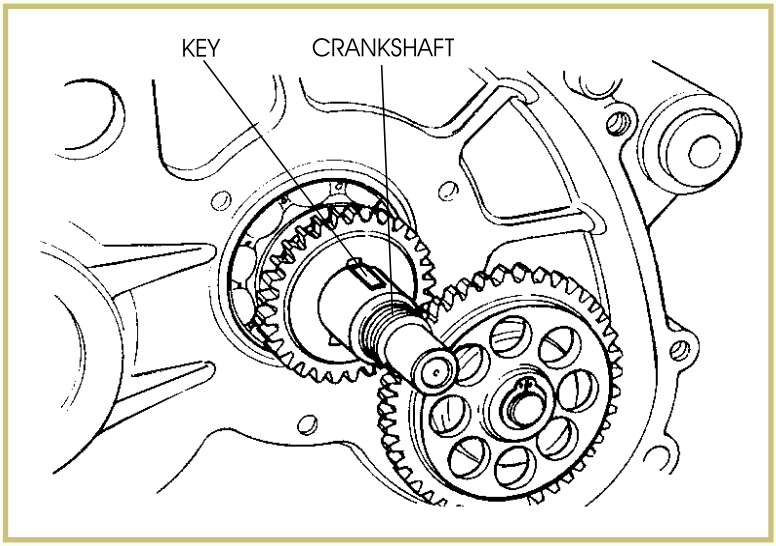
(Courtesy of American Suzuki Motor Corporation)

7 Remove the crankshaft drive gear holding nut using the holding tool to prevent the crankshaft from turning.



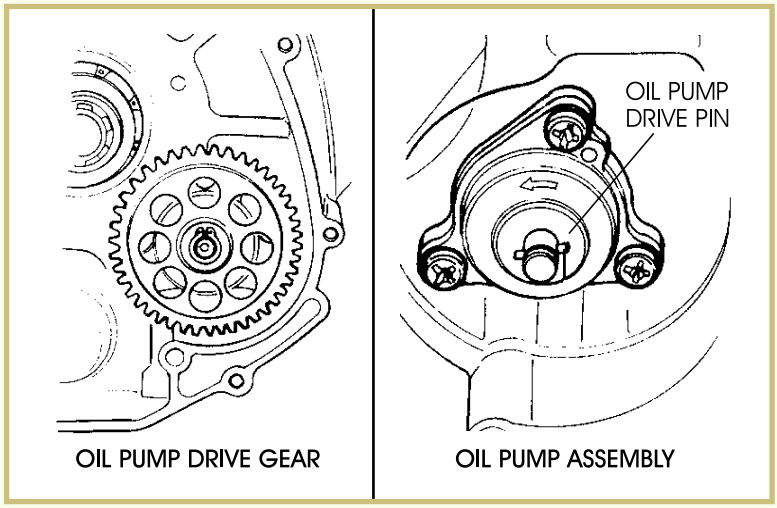
(Courtesy of American Suzuki Motor Corporation)

8 Remove the primary drive gear and its key.



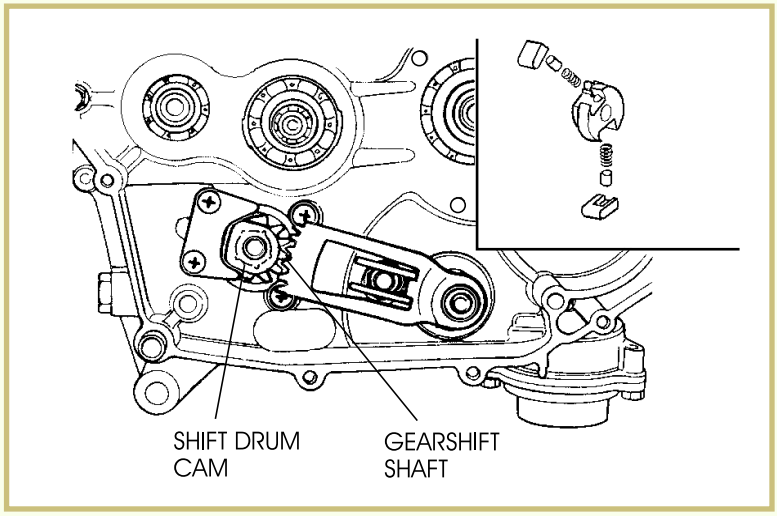
(Courtesy of American Suzuki Motor Corporation)

9 Remove the oil pump drive gear and the oil pump assembly. Be careful not to lose the oil pump drive pin.



(Courtesy of American Suzuki Motor Corporation)

10 Remove the gearshift shaft and its associated parts from the engine cases.



(Courtesy of American Suzuki Motor Corporation)

Separating the Crankcase and Removing Components

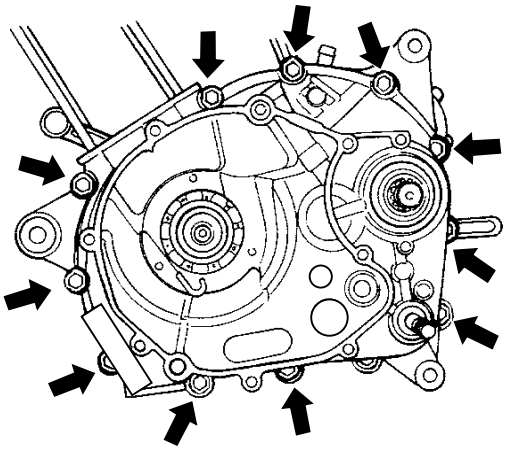
We're now able to separate the crankcase halves to expose the crankshaft and the transmission. We'll describe separating a vertical crankcase as well as a horizontal crankcase.

Vertical Crankcase Separation

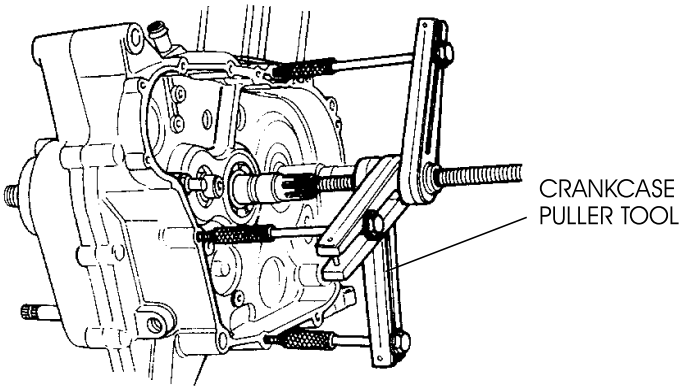
With the vertical crankcase engine design, it's mandatory that the top end of the engine be removed before the engine crankcase halves can be separated. This is because the cylinder and cylinder head are attached to both sides of the crankcase assembly.

Note: The illustrations used in the following example procedure are courtesy of American Suzuki Motor Corporation.

1 Remove the crankcase securing bolts, as indicated by the arrows in the illustration.

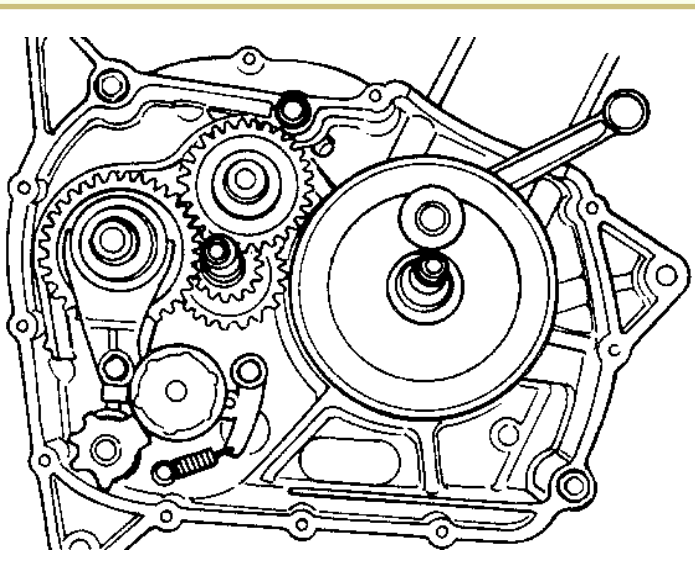


2 Separate the crankcase using a special puller tool similar to the one shown in this figure.



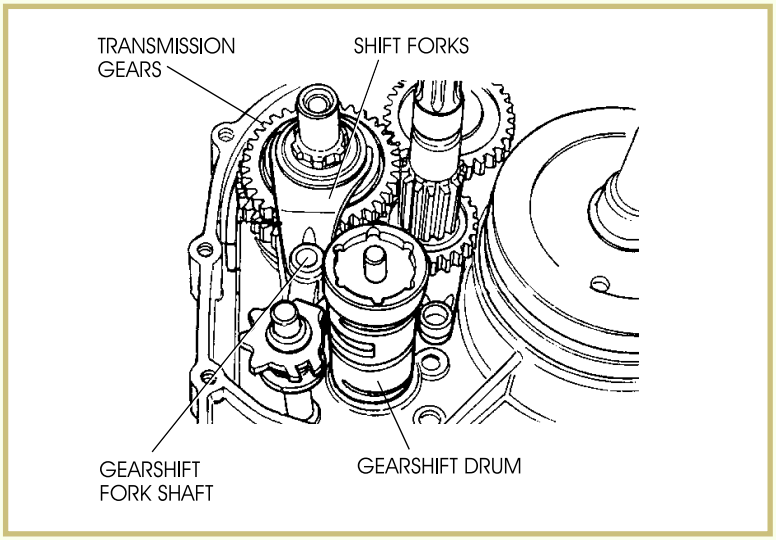
3 Pull the cases apart, using extreme care. Notice that separating the engine case exposes the crankshaft and transmission gears, which remain in one side of the crankcase. On most models, washers are used to align both the crankshaft and the gears.

4 Note the position of each spacer. The engine *must* be reassembled with these spacers in their original position to ensure correct alignment of the crankshaft and gears.



5 Remove the transmission by removing the gearshift fork shaft, as well as the cluster of transmission gears, shift forks, and the gearshift drum. Be careful not to misplace any transmission parts!

6 Remove the crankshaft using a crankshaft pulling tool.

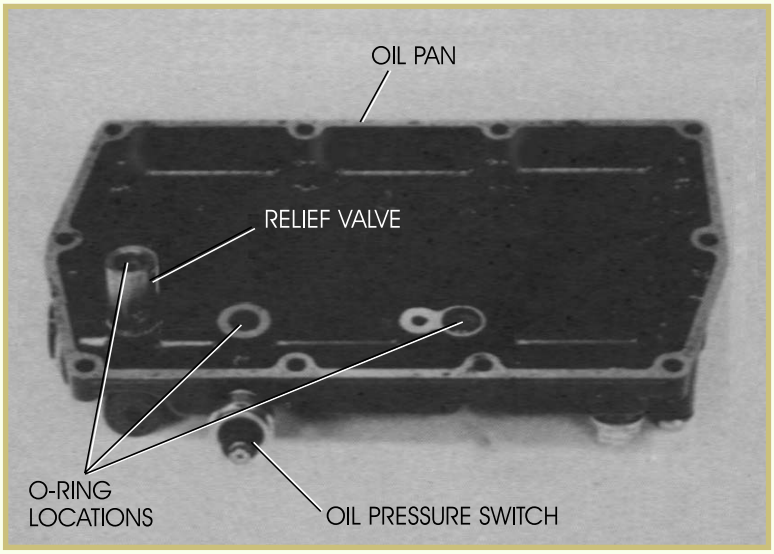


Horizontal Crankcase Separation

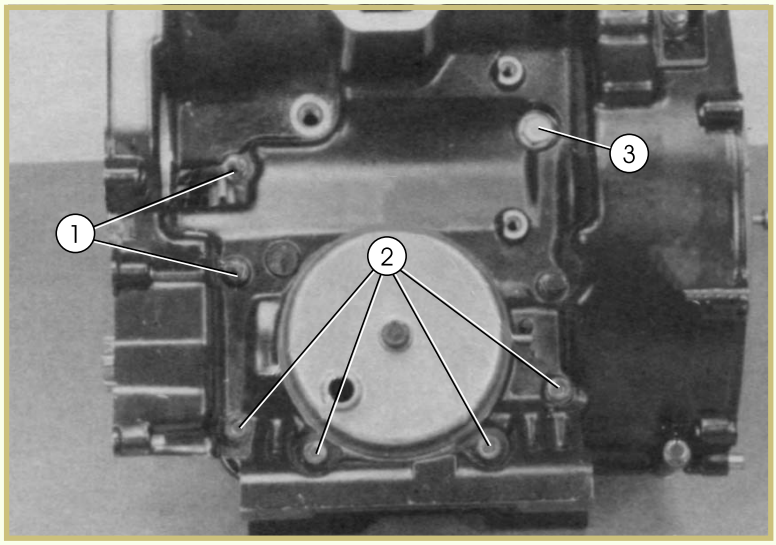
With the horizontal crankcase engine design, you aren't required to remove the top-end components unless you're going to remove the crankshaft assembly. This is because the cylinder and cylinder head are attached to only one crankcase half (usually the top half). If, for example, the transmission requires repair, it's not necessary to remove the top end of the engine in most cases. If you don't have to remove the top-end components, you'll save you a considerable amount of rebuild time.

Note: The illustrations used in the following example procedure are courtesy of Kawasaki Motor Corporation.

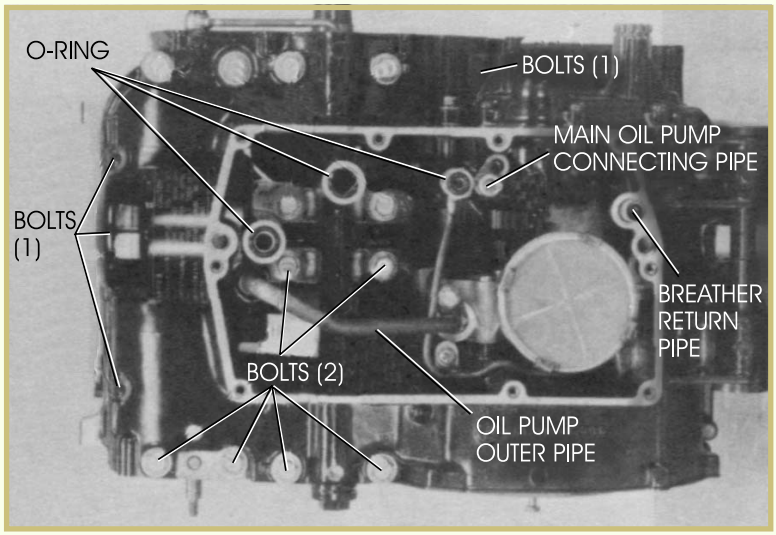
1 Remove the oil pan. Notice the O-rings when taking the oil pan off the bottom crankcase.



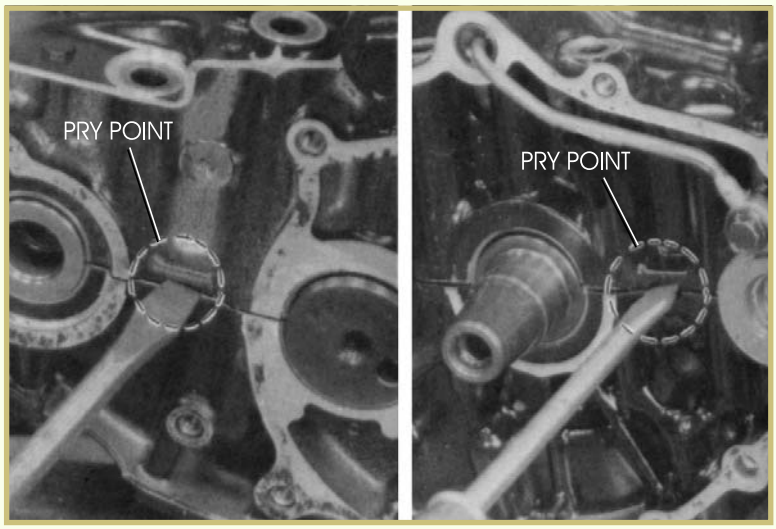
2 Remove the crankcase securing bolts from the upper crankcase, in the order indicated in the illustration.



3 Turn the engine over and remove the lower crankcase fasteners. Remove bolts labeled 1 first, then remove bolts labeled 2.

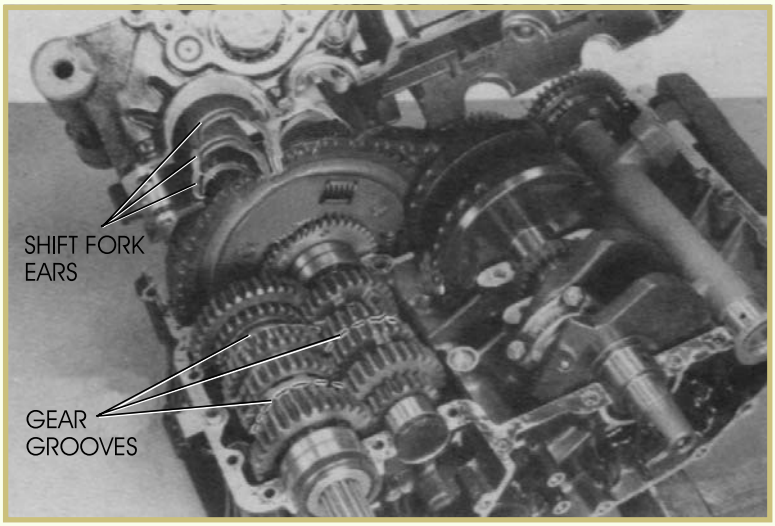


4 Separate the crankcase halves. With most horizontal crankcase designs, there are pry points to assist you, as shown in the illustration. Pry points ease the crankcase separation process considerably.



5 Pull the cases apart, using extreme care. Notice that separating the engine case exposes the crankshaft and transmission gears.

Note: As you separate the crankcases, notice that the crankshaft and transmission remain in the upper crankcase half, while the shifting forks and shifting mechanism stay intact in the lower crankcase half.



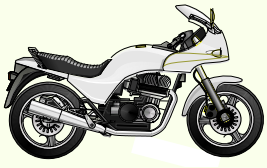
6 Note the position of each spacer. On most models, washers or spacers are used to align both the crankshaft and the gears. The engine must be reassembled with these spacers in their original position to ensure correct alignment of the crankshaft and gears.

7 Remove the transmission by removing the cluster of transmission gears.

8 Remove the forks and gearshift drum from the lower crankcase.

9 Remove the crankshaft by simply lifting it out of the crankcase half.

Road Test 1



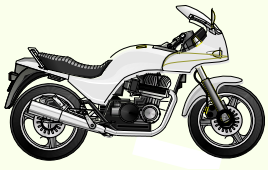
At the end of each section of *Four-Stroke Engine Lower-End Inspection*, you'll be asked to check your understanding of what you've just read by completing a "Road Test." Writing the answers to these questions will help you review what you've learned so far. Please complete *Road Test 1* now.

1. *True or False?* The cylinder head and cylinder must be removed before separating the crankcase halves on the vertical crankcase engine design.

2. *True or False?* The proper procedure for separating a horizontal set of engine crankcase halves is to pry the cases apart at specified points.

(Continued)

Road Test 1



3. The last component to be removed from the engine crankcase halves is the _____.
4. Electric starter motors are connected to the engine by either a _____ or _____.
5. Many rotor covers contain the _____, so care should be taken when handling this cover.

Check your answers with those on page 49.

FOUR-STROKE ENGINE LOWER-END INSPECTION

Now that all the components have been removed from the separated crankcases, it's time to inspect each one individually to check for damage or wear. Depending on the reason for disassembly, you might think that you should look only for a particular problem while the engine is completely apart. This is far from true! While the engine is disassembled, you should carefully inspect all components. Because complete disassembly of the engine isn't common practice, it's important not only to ensure that the job is done right the first time, but also to ensure that no existing problems or soon-to-be problems are present. We'll begin this discussion by inspecting the components that are attached to the crankcases.

Inspecting Engine Crankcases

The engine crankcases should be closely inspected for cracks, loose-fitting bearings, and worn-out fastener-anchoring points. If there are stripped bolt holes, they may be repaired using a special process that reconditions the hole. Two popular options are the Heli-Coil and the Time-Sert. These are available at your local hardware store or tool supplier.

Inspecting and Replacing Engine Seals

Engine seals are located on all shafts that rotate and are exposed to the outside atmosphere on a four-stroke engine (Figure 1). Inspect all seals to verify that they're in good condition. Ensure they're the right size and that they fit on the shafts properly. Inspect the seal lips for tears or rough surfaces. The rubber must be *live*. That is, the lip of the seal must be soft and springy. Most seals have a small coil spring which fits on the outer side of the seal lip. Be sure this spring is in place.

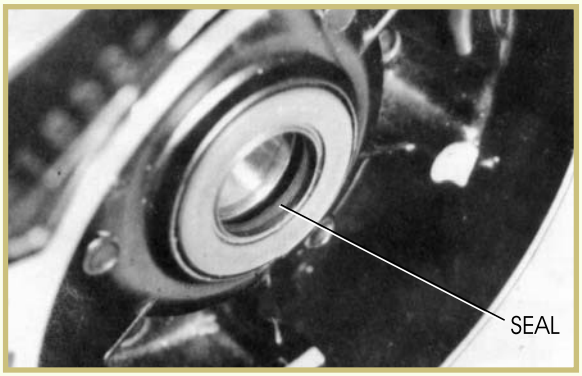


FIGURE 1—A Typical Engine Seal (Courtesy of American Suzuki Motor Corporation)

Remove bad seals by tapping them out, using a drift, or prying them using a seal removal tool. If you remove a seal, replace it with a new seal. Don't try to reinstall the old one. New seals are tapped into place with a mallet or a special seal installation tool. Be sure the new seal is installed evenly in the hole. Incorrect fitting of a seal allows oil leaks. Be sure to install the seal into the case properly. Normally, the manufacturer's identification number is on the side away from the bearing to be sealed.

Some engine seals are located on the inside of the crankcase cavity. These seals can be replaced only when the crankcase halves are separated. Therefore, it's always a good idea to install new seals whenever you have the crankcase opened. New seals are installed when any doubt exists about the condition of the old seals. New seals are also installed when bearings are replaced.

Inspecting and Replacing Engine Bearings

The most popular bearing found in a motorcycle or ATV engine is the ball bearing. You can inspect the play of the bearing inner race by hand while it's still mounted in the crankcase (Figure 2). You can also rotate the inner race by hand and inspect it for any abnormal noise or lack of smooth operation. Visually inspect the races, balls, or rollers. If they show signs of wear, chips, cracks, or damage to the hard bearing surface, you must replace them.

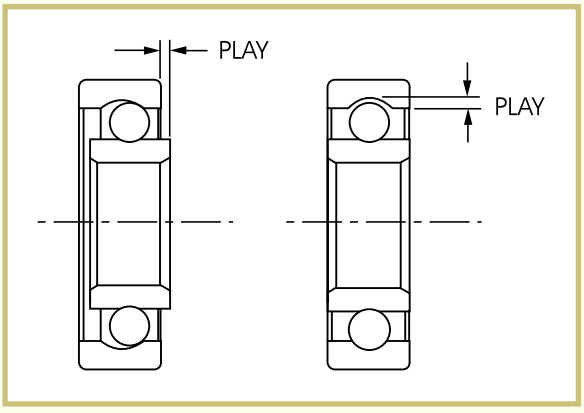


FIGURE 2—Check for play in ball bearing. (Courtesy of American Suzuki Motor Corporation)

Replace the bearing if there's any doubt that it's not in good condition. To replace most bearings, first remove the old bearings. Removal of crankcase ball bearings sometimes requires heating the case. The best method is to place the case on a hot plate. This expands the aluminum and allows the bearings to be pressed or tapped out. Heating the cases ruins the seals—another reason why they should be replaced.

To install new bearings, cool the bearings in a refrigerator freezer to shrink the bearing metal. Heat the case to expand the case metal, before installing the bearing in the case.

Ball bearings are held in the case by an *interference*, or very tight, fit. Placing cool bearings into a warm case ensures easy installation, as well as a snug fit, when both have returned to normal temperature. This is because the cooled bearings expand as they warm up, and the warmed case shrinks as it cools down.

The other popular bearing found in the four-stroke engine is the plain bearing. This bearing is used in most horizontal crankcase engines. Plain bearings are also used in some vertical crankcase engines that use a single-piece crankshaft, as a crankshaft journal support bearing, or as a multipiece connecting rod bearing. Most are color coded to describe the size of the bearing (Figure 3).

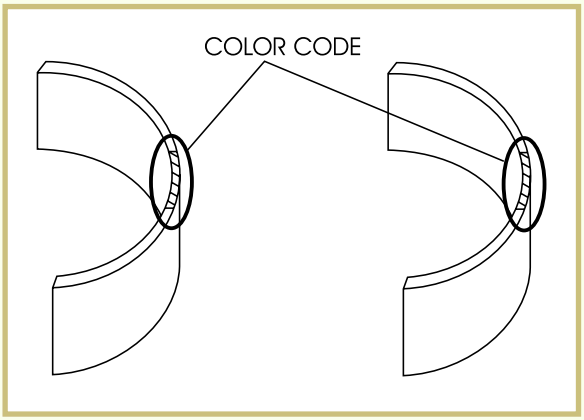


FIGURE 3—Color codes are used on plain bearings to identify the size of the bearing. (Copyright by American Honda Motor Co., Inc. and reprinted with permission)

Plain bearings are measured for the amount of oil clearance they have, using a fine plastic string called *plastigage*. Plastigage is long and has a very small diameter. To use plastigage, thoroughly clean and dry the surfaces to be measured. Place a piece of the string on each bearing inside surface. Then reinstall the crankcase halves and torque them to the factory specification. You can now take the crankcase halves apart and measure the amount of oil clearance that the bearing has (Figure 4). You should also inspect the plain bearing visually for signs of wear (Figure 5).

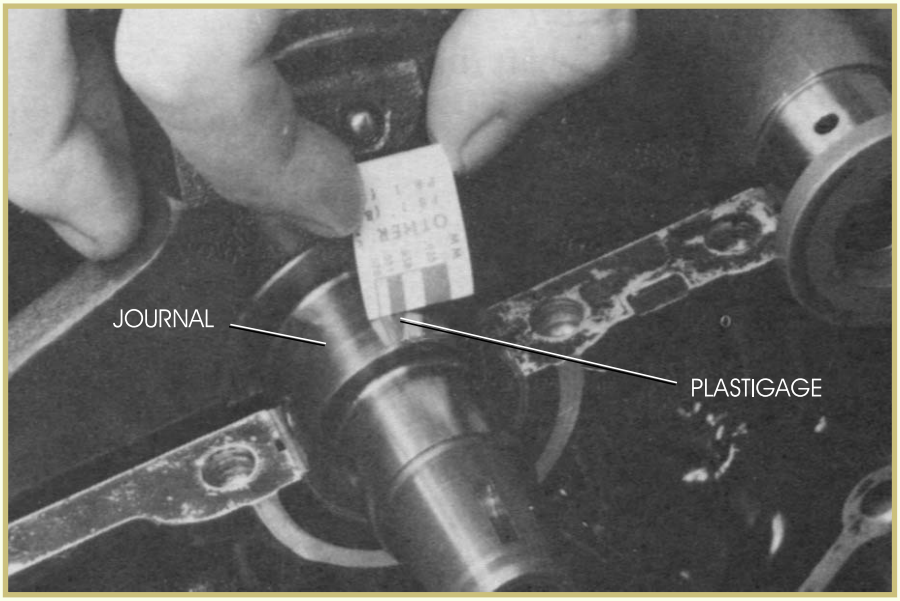


FIGURE 4—Measure the crankshaft journal with plastigage. (Courtesy Kawasaki Motor Corp., U.S.A.)

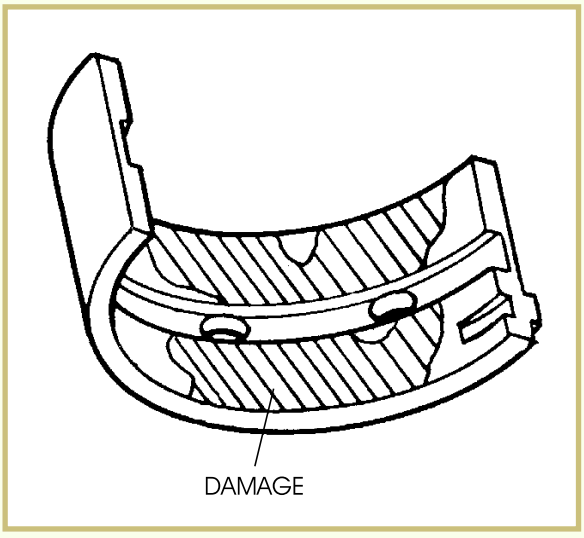


FIGURE 5—Inspect the plain bearing for damage. (Copyright by American Honda Motor Co., Inc. and reprinted with permission)

Inspecting the Oil Pump

The oil pump used in most four-stroke motorcycles and ATVs is the rotor type oil pump. To inspect this type of pump, disassemble and clean the parts of the pump and set the inner and outer rotors into the pump body properly. Measure the body clearance and tip clearance using a feeler gauge (Figure 6). If all measurements are within specification, reassemble the oil pump in the reverse order of disassembly.

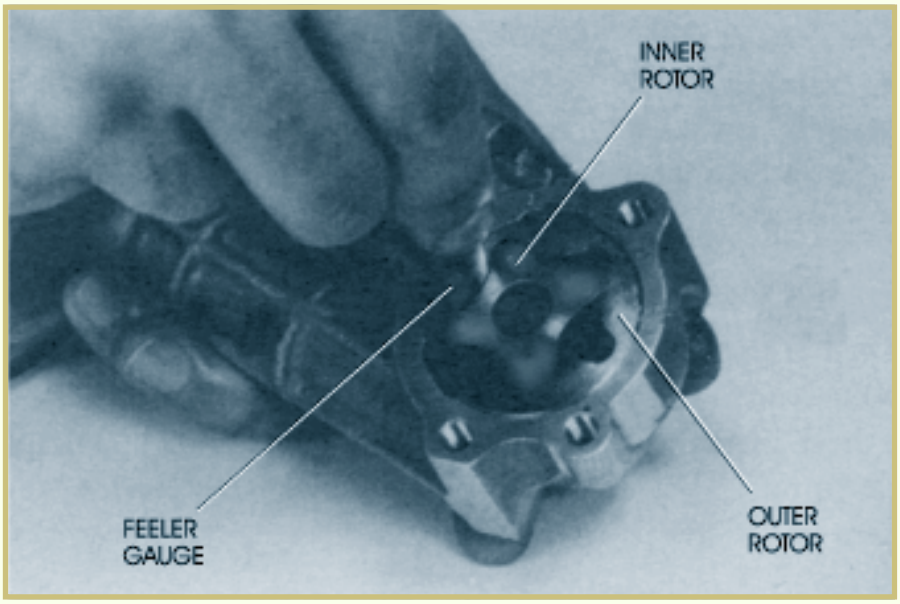


FIGURE 6—Use a feeler gauge to check for clearance between the oil pump rotor inner housing and outer housing. (Courtesy Kawasaki Motor Corp., U.S.A.)

Inspecting the Clutch

Although lower-end engine disassembly isn't required to remove the clutch, the clutch must be removed to disassemble the lower end. Because the clutch is among the most common engine components to wear out or fail, we'll review the inspection and repair of the common multiplate wet clutch.

When you take the clutch springs out, you should compare the length of the used springs with the length of a new spring, if one is available. If the old springs are shorter, they should be replaced. Most service manuals have specifications for correct spring length. They're measured using a Vernier caliper.

The most popular choice for measuring the thickness of the clutch friction and steel plates is the Vernier caliper. All of the plates must be measured individually. The clutch plates should also be checked for warpage. Lay each plate on a flat surface and attempt to run a feeler gauge under the edge. If the feeler gauge slips in anywhere under the edge, the plate is warped and must be replaced.

Inspect the clutch basket and clutch center grooves. Ensure the grooves are smooth so the prongs of both the driving and driven plates fit properly. Inspect the clutch basket bearing or bushing for excessive wear. The bearing should be replaced if the clutch housing has excessive wobble when placed on the shaft.

Inspecting and Measuring the Single-Piece Crankshaft

A single-piece crankshaft can be inspected and measured after the connecting rods have been removed (Figure 7). Before disassembly, mark the location of the connecting rods and their big-end caps, to ensure that the rods are reassembled in their original position. Remove the connecting rod big-end cap nuts, and take off the rod and cap with the bearing inserts attached (Figure 8). The connecting rods will normally have size and weight code letters or numbers stamped in them for information purposes.

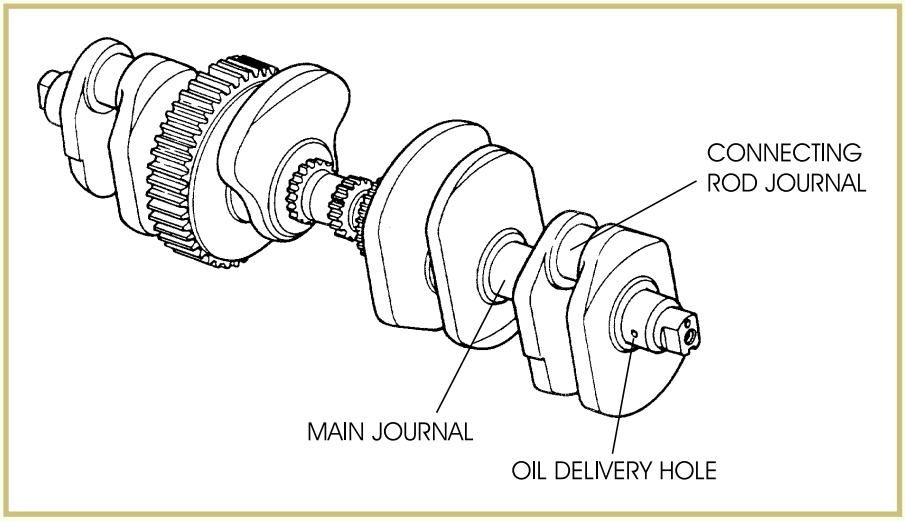


FIGURE 7—A Single-Piece Multicylinder Crankshaft (Copyright by American Honda Motor Co., Inc. and reprinted with permission)

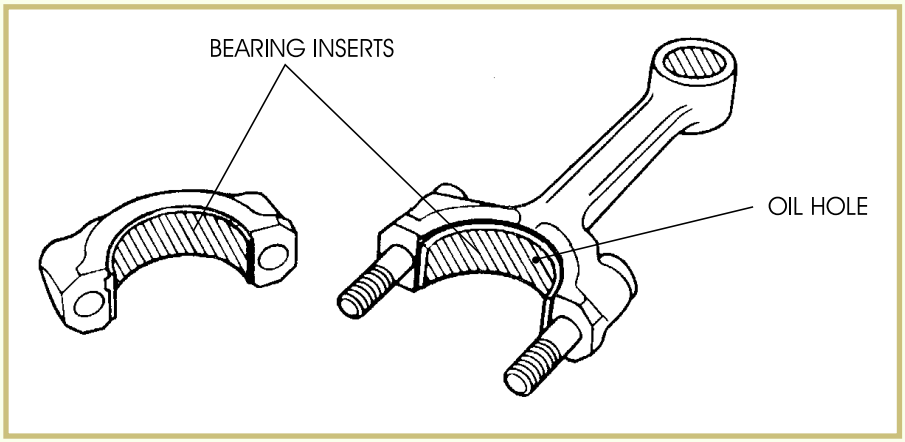


FIGURE 8—Bearing Inserts in a Two-Piece Connecting Rod (Copyright by American Honda Motor Co., Inc. and reprinted with permission)

Measure the crankshaft and connecting rod journals with a micrometer and check your measurements with the factory specification given in the appropriate service manual (Figure 9). Also check for crankshaft run-out (Figure 10). Single-piece crankshafts used in motorcycles and ATVs aren't normally rebuildable and, therefore, need to be replaced if the measurements aren't within factory specifications.

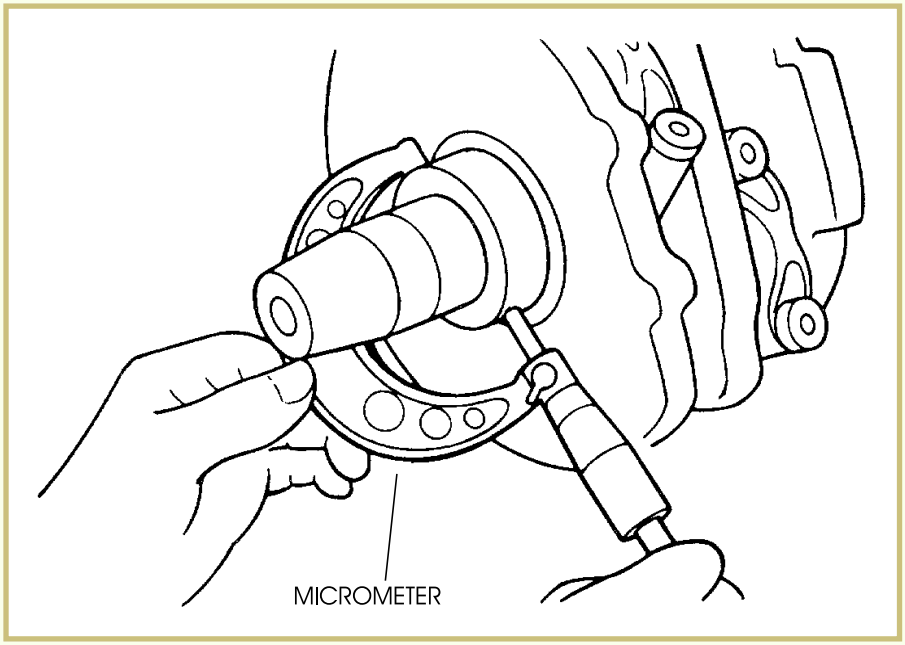


FIGURE 9—Use a micrometer to measure crankshaft journals. (Copyright by American Honda Motor Co., Inc. and reprinted with permission)

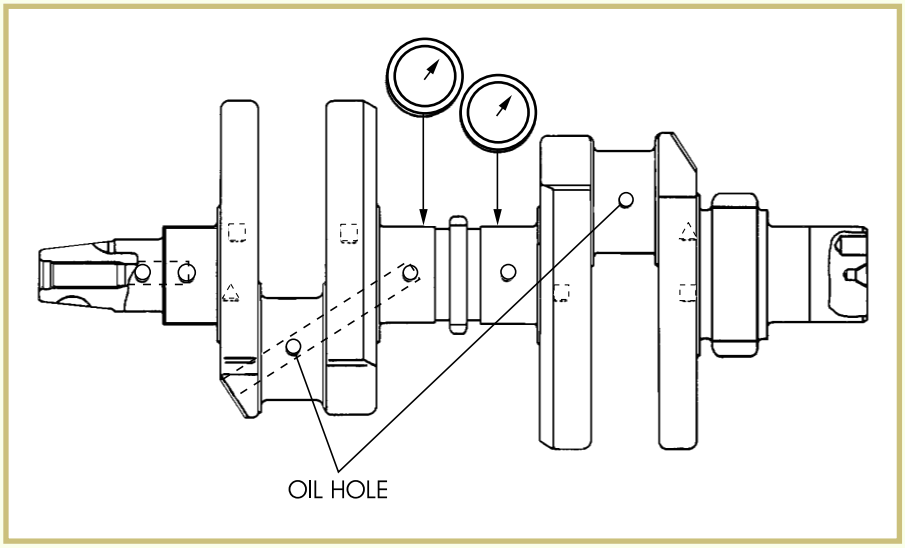


FIGURE 10—Check for crankshaft run-out. Note the oil holes that feed the connecting rods. (Courtesy Kawasaki Motor Corp., U.S.A.)

Inspecting and Measuring the Multipiece Crankshaft

Multipiece crankshafts are normally rebuildable. Multipiece crankshaft connecting-rod lower bearings are usually of the roller type and are replaced as one unit. The unit consists of rollers, cage, and crank pin (Figure 11). Many times the connecting rod is also a part of this replacement unit.

Replacement of the connecting-rod lower-bearing unit requires that the flywheels be separated. Before separating the flywheels, measure their overall width at a point on each side of the crank pin. Use a micrometer for this measurement. Careful measurement is necessary to ensure the correct replacement of the spacers used to align the

crankshaft in the crankcase. The flywheels must be exactly the same dimensions when reassembled as when they were disassembled (as per manufacturer's specifications).

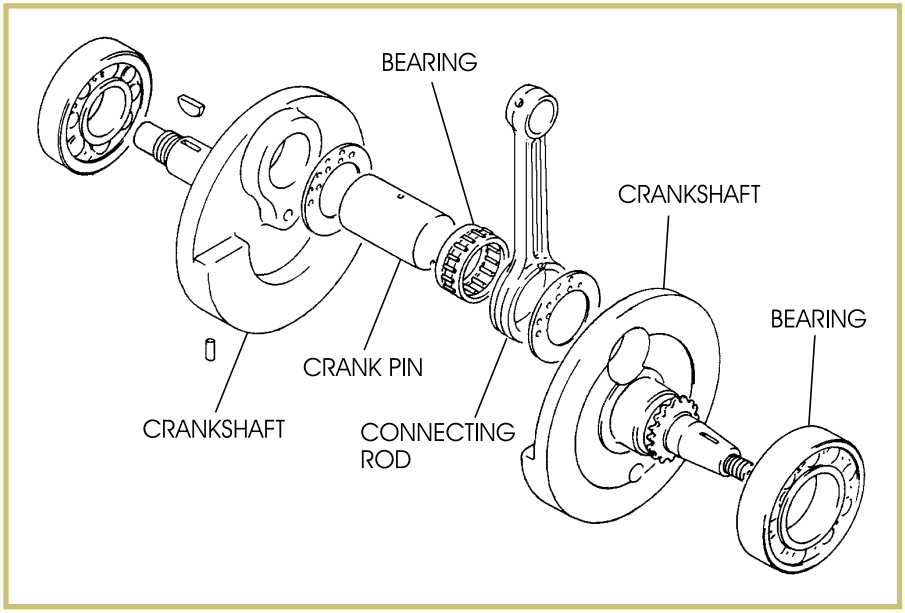


FIGURE 11—Exploded View of a Multipiece Crankshaft
(Courtesy of American Suzuki Motor Corporation)

To separate the crankshaft flywheels, it's best to use a hydraulic press and special tools. The special tools are strong steel inserts that are placed between the flywheels to hold one of them securely in position. You then apply pressure to the crank pin to force it out of the securely held flywheel. Next, remove the rod and bearings and press the crank pin out of the other flywheel in the same way. Crank pins are pressed free from the outside to the inside. Press toward the opposite flywheel.

To replace a crank pin, carefully align it so that it can be pressed into one of the flywheels. Make sure it fits squarely before you attempt to press it in. It should be perpendicular to the center of the hole in the flywheel. Lubricate the rod and bearings and install them next. Then align the other flywheel and press it onto the crank pin in the same way. Be sure to replace the connecting-rod spacers (crank pin washers) before you press the flywheels together. A final alignment of the flywheels ensures that the axles will run absolutely true in the axle bearings. The center of each flywheel axle must remain perpendicular to the center of the connecting rod at all times.

Alignment requires the use of a special tool called a *crankshaft alignment jig* (Figure 12). Place the crankshaft in this jig and rotate it. A dial indicator is positioned against the axle surface. Rotating the crankshaft shows any misalignment of the crankshaft halves on the dial indicator.

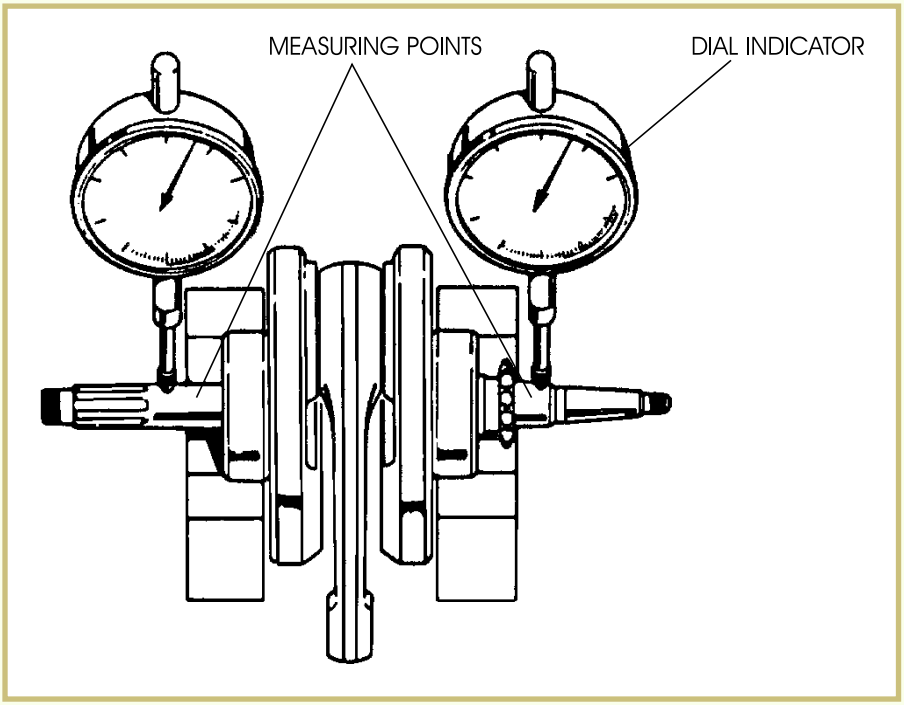


FIGURE 12—Checking Alignment of a Multipiece Crankshaft with a Crankshaft Alignment Jig
(Copyright by American Honda Motor Co., Inc. and reprinted with permission)

Figure 13 shows correctly aligned crankshaft halves as well as misaligned ones. Sometimes the crankshaft must be realigned (trued) because, as it turns in the alignment jig, the two flywheels don't spin in a true circle. To correct this, one or both crank halves must be moved so they revolve around a true center. The higher of the lopsided crankshaft flywheels should be tapped gently with a mallet. Brace the lower flywheel on a firm surface as you tap the higher wheel. This should cause both wheel shafts to align. When doing this, remember to

- Use light taps
- Use caution
- Don't use a steel hammer
- Don't hit over the crank pin hole in the flywheel

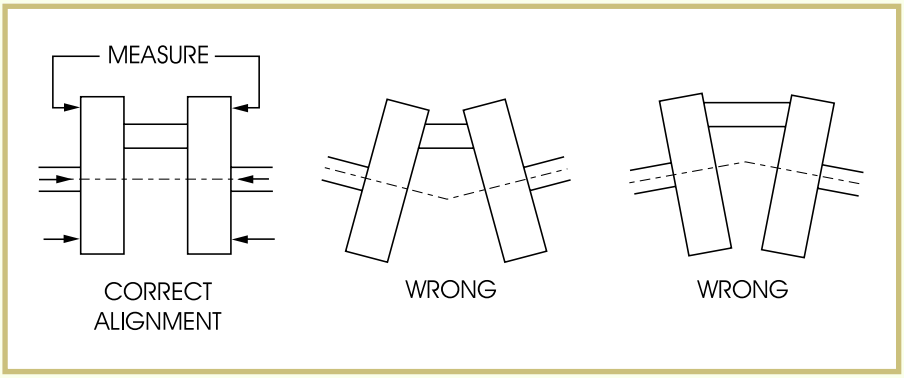


FIGURE 13—Aligned and Misaligned Crankshaft Halves

Check the alignment in the crankshaft alignment jig with each adjustment until the dial indicators show that the axles are in proper alignment.

Disassembling the Transmission

The transmission gear cluster was removed from the crankcase assembly in the last section. Now we'll disassemble, inspect, and reassemble the gears and other transmission components found in a four-stroke engine.

When taking the gears off the transmission shaft, always keep track of the disassembled parts by stacking them, or slipping them onto a long screwdriver or piece of wire (Figure 14). Don't expand the *retaining rings* any more than necessary for removal. To remove a retaining ring, expand it and pull it off using the gear behind it. Always replace retaining rings that have been removed from a transmission shaft. After removal, they're generally spread too far out to be useful again. To remove the transmission bearings, it may be necessary to use a bearing puller (Figure 15).

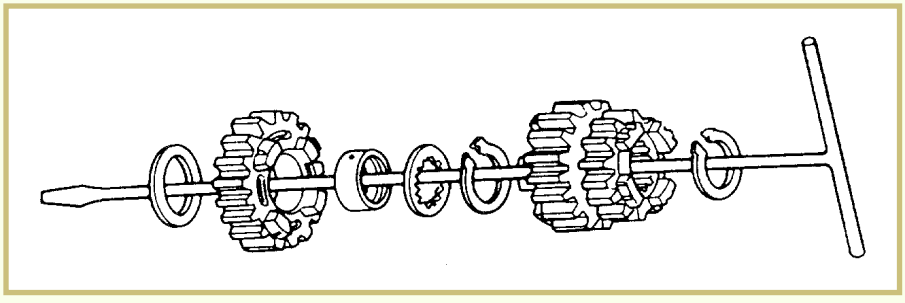


FIGURE 14—Keep track of all transmission pieces while you disassemble them. (Copyright by American Honda Motor Co., Inc. and reprinted with permission)

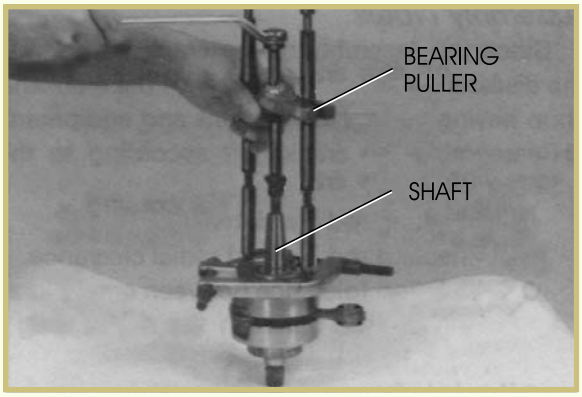


FIGURE 15—A bearing puller is often needed to remove a bearing from a shaft. (Courtesy Kawasaki Motor Corp., U.S.A.)

Inspecting the Transmission

When inspecting the transmission components, always inspect each component carefully. For example, if you find a burnt shift fork, check the gear and the shift drum for damage as well.

Check each gear for damage or excessive wear. Inspect all the gear dogs or slots for wear or damage as well. Measure the inside diameter of the gear (unless it's a splined gear) with an inside micrometer and compare the measurement with the specification in the service manual (Figure 16).

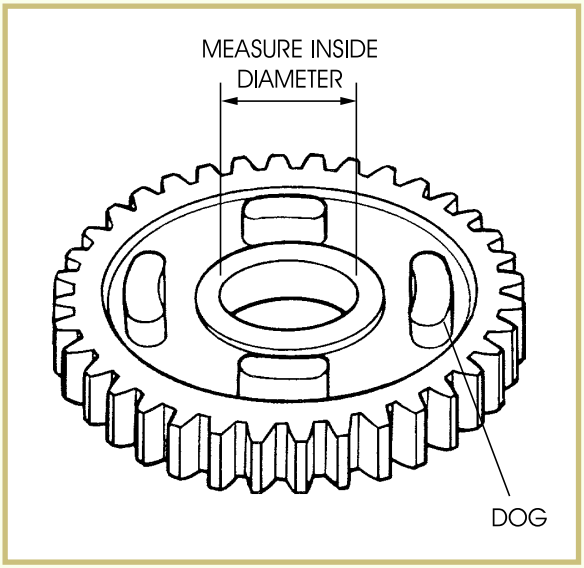


FIGURE 16—Measure the inside diameter of transmission gears. (Copyright by American Honda Motor Co., Inc. and reprinted with permission)

The shifting fork groove surfaces can be measured with a Vernier caliper. A shift fork can also be placed in the shifting fork groove of the sliding gear to be measured for the proper clearance (Figure 17).

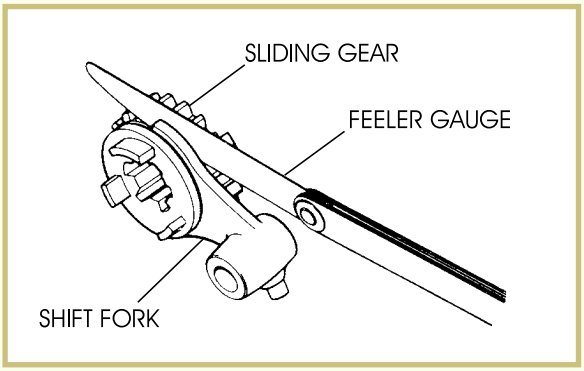


FIGURE 17—Check for proper shift fork to gear clearance. (Courtesy of American Suzuki Motor Corporation)

Inspect any gear bushings for wear or damage and measure the inside and outside dimensions to verify that they're within specification (Figure 18).

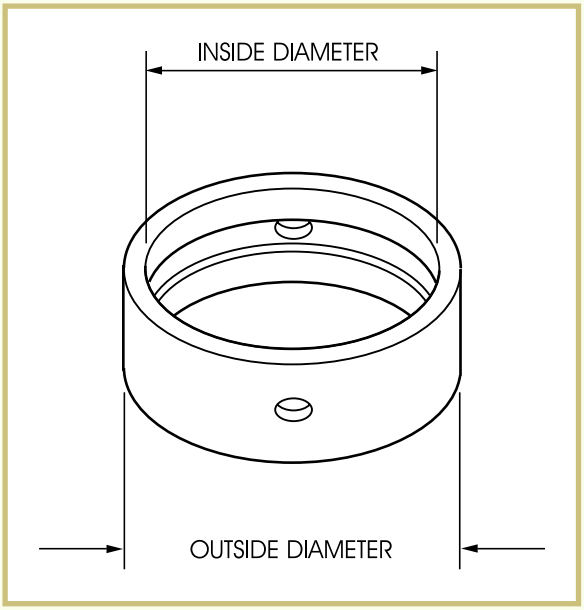


FIGURE 18—Measure both the inside and outside diameters on a transmission bushing. (Copyright by American Honda Motor Co., Inc. and reprinted with permission)

Carefully inspect the main shaft and counter shaft at their splined grooves, as well as their sliding surfaces, for abnormal wear or damage. Measure the shafts for proper dimensions, and compare to the specified sizes given in the service manual for the motorcycle or ATV that you're working on (Figure 19).

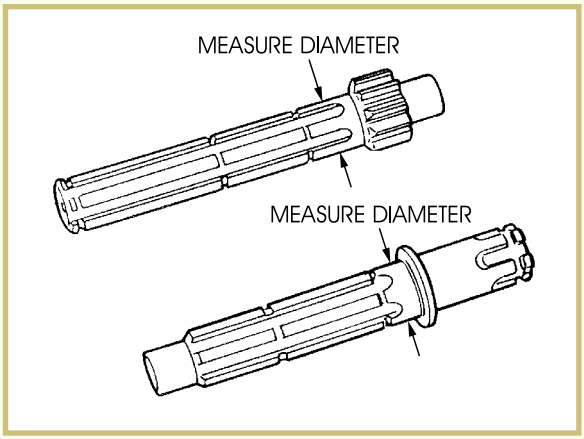


FIGURE 19—Measure both transmission shafts with a micrometer. (Copyright by American Honda Motor Co., Inc. and reprinted with permission)

The shifting drum is a critical component of the transmission that's often overlooked. Check the shifting fork guide grooves for damage such as a small chip or scoring (Figure 20). Also inspect the bearing in which the shift drum rotates. Many shifting problems relate to a faulty shift drum.

Next, inspect the shifting fork. Although transmission problems aren't very common with most modern motorcycles and ATVs, when a problem does occur, the shift fork is most likely to be damaged. Check the shift fork for deformation, abnormal wear, size, and straightness. Measure the fork at the locations shown in Figure 21 and compare them to the factory specifications.

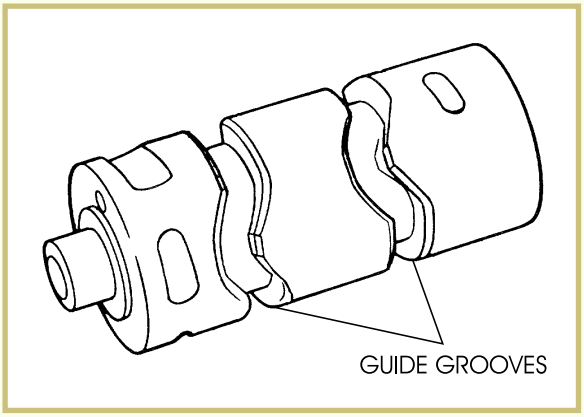


FIGURE 20—Inspect the shift drum guide grooves. (Copyright by American Honda Motor Co., Inc. and reprinted with permission)

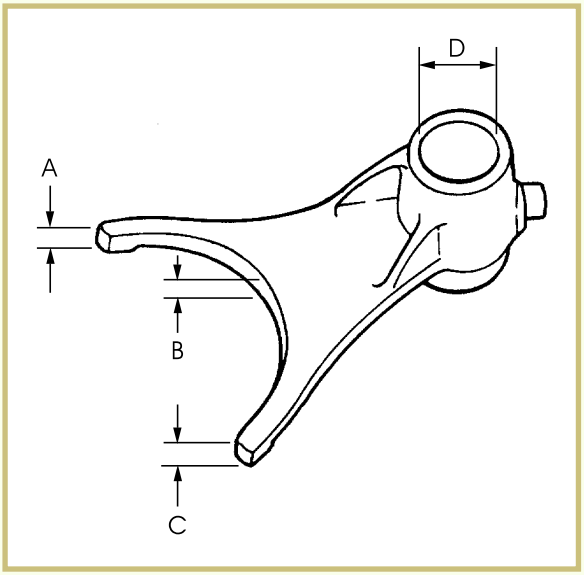


FIGURE 21—Measuring Points on a Shift Fork (Copyright by American Honda Motor Co., Inc. and reprinted with permission)

Assembling the Transmission

Before assembling the transmission, be sure that all parts are cleaned. Apply a molybdenum disulfide grease (molylube) to all sliding surfaces of each shaft before beginning the assembly process. This ensures adequate initial lubrication in the transmission. Reassemble all the transmission gears in the proper position on the appropriate shaft. All service manuals have an exploded view of the transmission that assists with the assembly of the transmission gears, bushings, thrust washers and retaining rings.

Bushings have oil holes that allow oil to flow to the gears. They must be properly aligned (Figure 22).

When you install the thrust washers, be sure that the chamfered side faces away from the thrust load side of the gear. Also align the snap ring with one of the grooves of the spline (Figure 23). If the retaining ring rotates easily in the groove, replace it as it won't properly seat and may come out, causing serious transmission failure at the most inappropriate time!

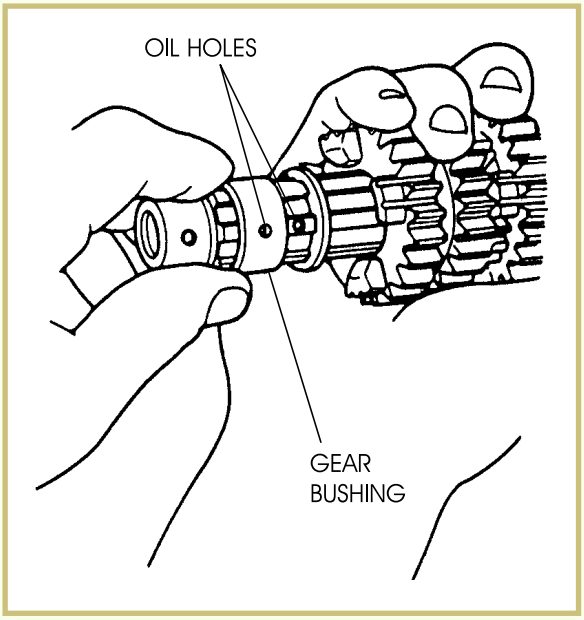


FIGURE 22—Proper Alignment of the Transmission Gear Bushing and Oil Holes (Copyright by American Honda Motor Co., Inc. and reprinted with permission)

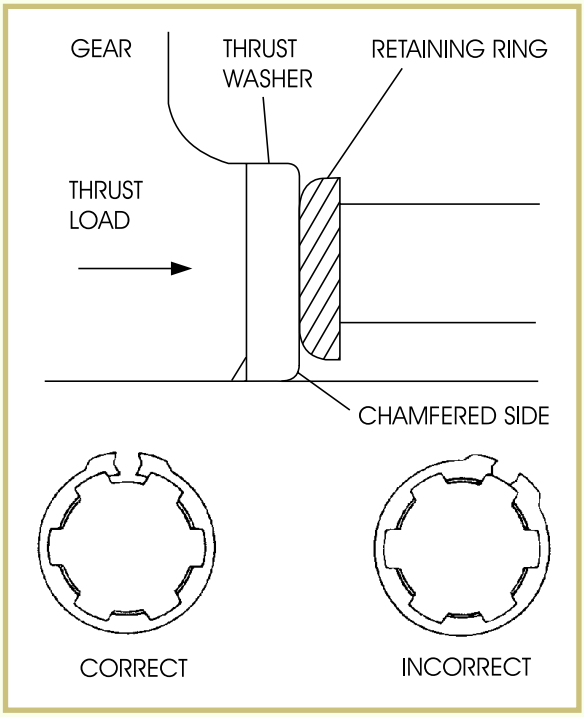


FIGURE 23—Proper Installation of a Transmission Retaining Ring (Copyright by American Honda Motor Co., Inc. and reprinted with permission)

Some gears have a *lock washer system* that uses a splined washer and a lock washer that's engaged as shown in Figure 24.

Shift forks are marked for their proper location. A fork marked with *L* is placed on the left side of the transmission. A fork marked with *C* is the center shift fork; the fork marked *R* is the right side shift fork.

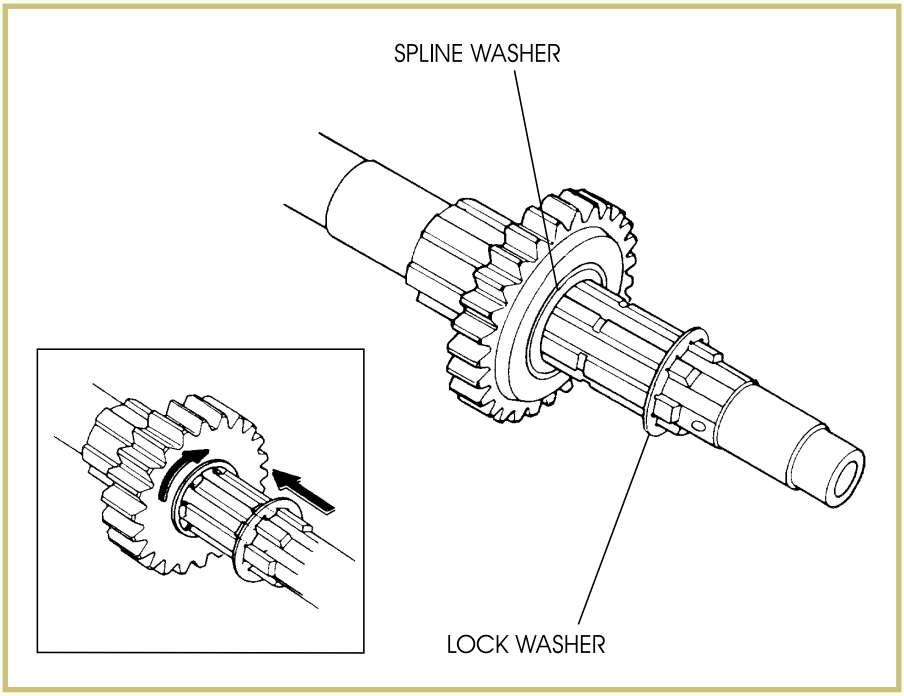


FIGURE 24—A lock washer system is sometimes used to keep the gears in place. (Copyright by American Honda Motor Co., Inc. and reprinted with permission)

After the transmission is properly assembled, it must be placed into the crankcase as an assembly. In a vertical crankcase engine design, the transmission should be lubricated with engine oil while rotating the shafts (Figure 25). In a horizontal crankcase engine design, set the gears and shafts back into the appropriate crankcase as shown in Figure 26. Figure 26 also illustrates the measuring of *gear backlash*, a measurement used to verify that the transmission gears are meshing properly with the mating gear.

We've already discussed how transmissions function in motorcycle and ATV engines. Now that we've taken one apart and put it back together, let's compare the symptoms of problems in a transmission with what we suspect is wrong. Because each part in the transmission does a certain job, when a failure occurs, you can usually tell which part is at fault by the symptoms. Following is a description of some common transmission malfunctions, hints on how to recognize them, and suggestions for the most likely component at fault.

Difficult shifting. When difficult shifting occurs between gears, while the motorcycle is moving, and it's been determined that the clutch isn't at fault, the cause is usually a bent or burnt shift fork. A damaged shift fork no longer fits properly in the grooves of the gear. This problem requires replacement of the shift fork. Replacement of the sliding gear to which the shift fork is attached is also necessary, as well as the gear with which the sliding gear is engaged. Shift forks usually fail when put under extreme loads, such as shifting without using the clutch or forcing the transmission into gear while it's still under a load. If a shift fork is bent or burnt, it is visually noticeable by gouging or a discoloration on the shift fork ears. Difficult shifting can

also be caused by a seized gear on a transmission shaft. This problem is generally caused by a lack of proper lubrication.

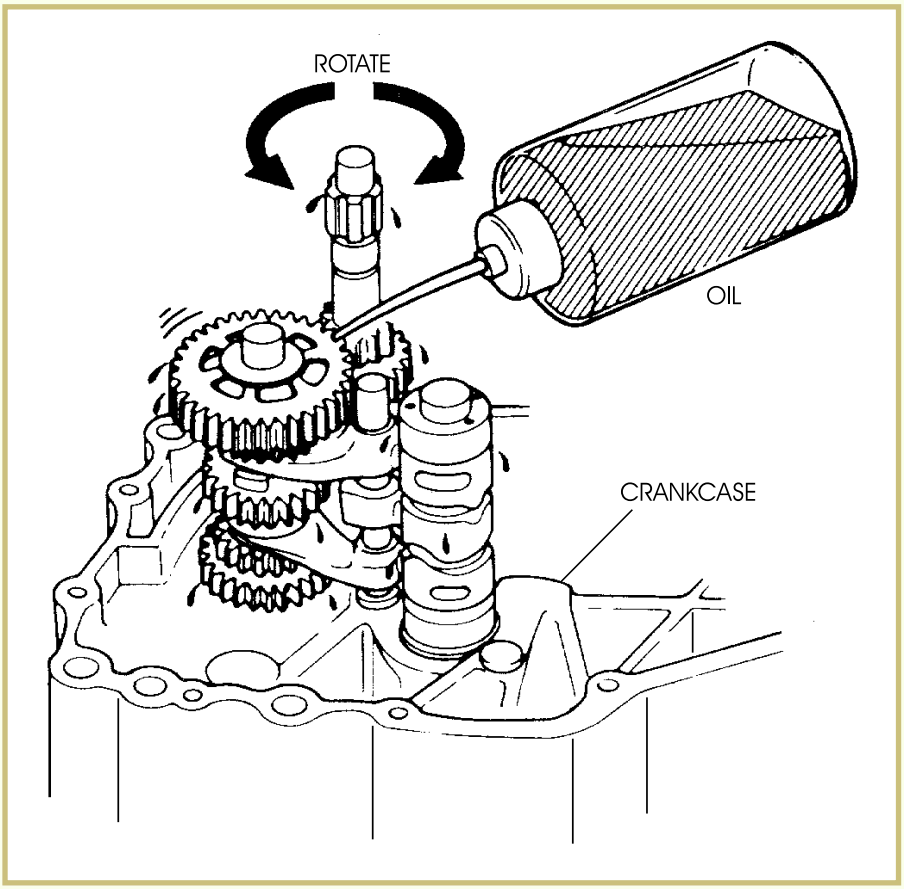


FIGURE 25—When installing the transmission into the crankcase, lubricate it while rotating the shafts. (Copyright by American Honda Motor Co., Inc. and reprinted with permission)

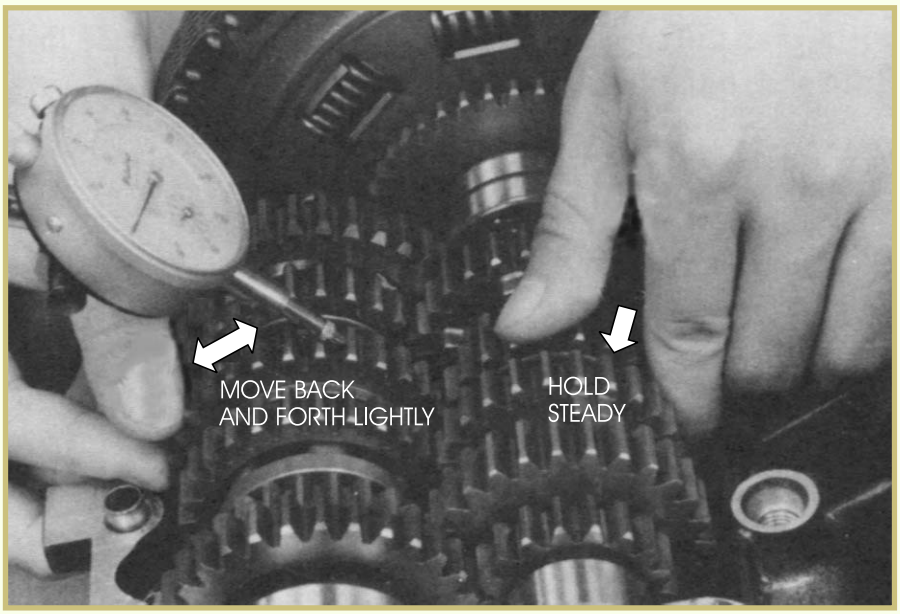


FIGURE 26—Measuring Gear Backlash (Courtesy Kawasaki Motor Corp., U.S.A.)

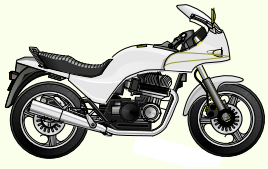
Inability to shift gears. Sometimes you'll find a machine that shifts into one gear, but not into the next. This problem is often caused by the shift return spring, which returns the shifting lever to its original position. Repair is usually possible by replacing the spring and, in most cases, won't require the complete disassembly of the engine. The spring is usually attached to the shift shaft assembly and is located behind or near the clutch assembly.

Strange sounds. A low growling sound when the motorcycle or ATV is in gear and rolling usually indicates a bearing failure. When a bearing failure occurs, it may cause a transmission shaft to move slightly out of position. When this occurs, the gears don't mesh together properly and produce a low growling noise. In these cases, not only the bearing needs replacement, but many times the gears may also need to be replaced.

Clunking noises. Another characteristic sound that indicates a transmission problem is an excessive clunking sound when the engine is in a particular gear while under a load. More often than not, this indicates broken teeth on one or more gears. This warrants a complete inspection of all transmission components, as the broken teeth normally damage other parts in the transmission.

Jumping out of gear. A transmission that jumps out of gear is usually caused by worn dogs or slots on the transmission gears. Gear dogs and slots are used to lock the two gears together. When dogs and slots become excessively rounded, the gears tend to slip out the holes when the engine rpm increases. Thus, the engine *jumps* out of gear. The gears, as well as the shift forks, need replacement in this case. The shift forks become damaged due to the excessive pressure they encounter.

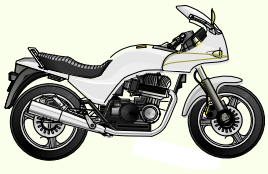
Road Test 2



1. *True or False?* The shift fork is the most likely transmission component to fail.
2. A _____ is used to disassemble the multipiece crankshaft.
3. The proper measuring tool to check for the thickness of the clutch friction plates is a _____.
4. *True or False?* Single-piece crankshafts on four-stroke motorcycle and ATV engines are usually reconditioned when worn out of specification.

(Continued)

Road Test 2



5. Most horizontal crankcase engine designs allow you to leave the _____ and _____ in place while separating the crankcase halves.

6. What's usually the cause of a transmission that's jumping out of gear?

_____

7. If a shift fork is visually worn or damaged, what other parts, if any, should be inspected?

_____

8. A low growling sound, when the motorcycle or ATV is in gear and rolling, normally indicates what type of engine failure?

_____

Check your answers with those on page 49.

FOUR-STROKE ENGINE REASSEMBLY PROCEDURES

Reassembly of the lower end is done in the reverse order of disassembly and isn't difficult when you follow proper procedures. Before you begin reassembling the bottom end of any engine, be sure to thoroughly clean every part with a cleaning solvent. When you're prepared to begin the assembly process, be sure to stay organized and keep the engine components separated. This will make your job more efficient. As we've done in previous sections, we'll assemble the example engines in steps. Keep in mind that these procedures are general in nature and not intended to be used for actual assembly. Always refer to your service guide for specific steps and detailed information.

Installing the Crankshaft

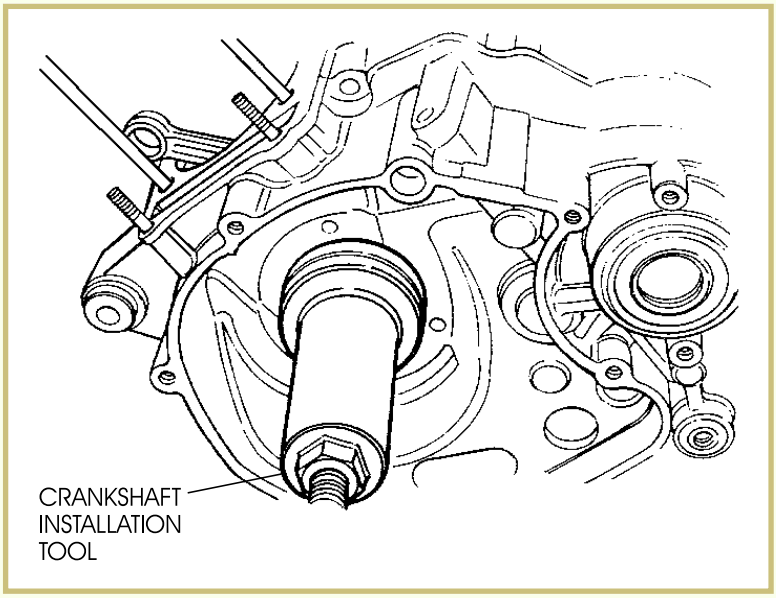
Crankshaft installation is slightly different on a vertical crankcase design compared to a horizontal design. Therefore, we'll explain each procedure separately.

Vertical Crankcase Crankshaft Installation

Crankshafts used in vertical crankcases are usually of a multipiece design.

1 Install the assembled crankshaft into the proper crankcase using any special crankshaft installation tools required by the motorcycle or ATV manufacturer. Never attempt to fit the crankshaft into the crankcase by hitting it with a hammer. Always use the special tools indicated in your service guide; otherwise, accuracy of the crankshaft alignment may be affected.

2 Lightly coat all moving parts of the crankshaft with engine oil.



(Courtesy of American Suzuki Motor Corporation)

Horizontal Crankcase Crankshaft Installation

Because most crankshafts used in horizontal crankcase engine designs are single-piece units, you must install the connecting rod(s) onto the crankshaft before installing the crankshaft into the crankcase.

Note: The illustrations used in the following example procedure are copyrighted by American Honda Motor Co., Inc. and reprinted with permission.

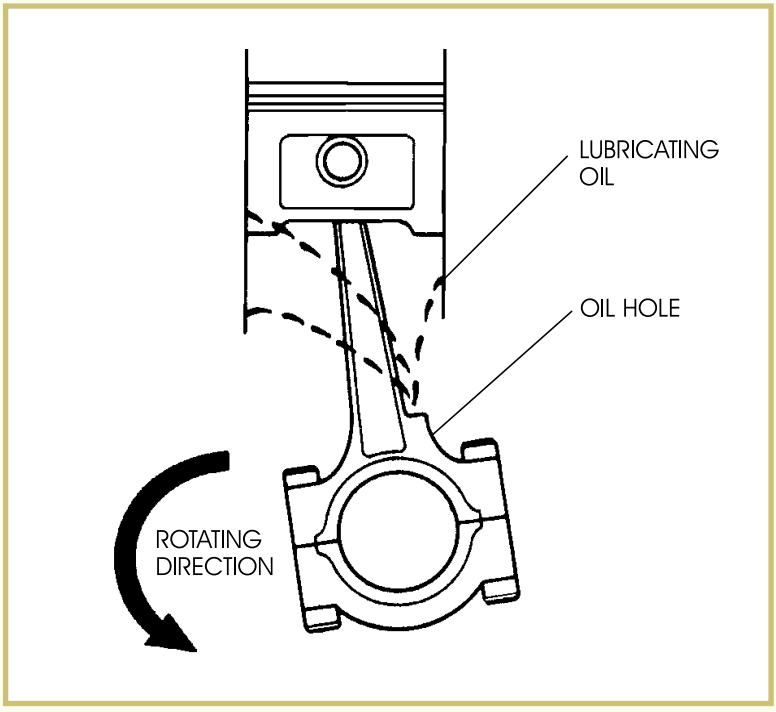
1 Choose the correct connecting-rod bearings.

2 Coat the inside of the bearing surface with a 50/50 mixture of moly lube and clean engine oil.

3 If the connecting rod uses an oil hole, install the connecting rod so the hole is behind the crankshaft rotating direction as illustrated in the figure.

4 Install the bearing caps and connecting rods on the correct crankshaft connecting rod journal.

5 Oil the threads of the connecting rod bolts and nuts to ensure the bolts are tightened evenly.



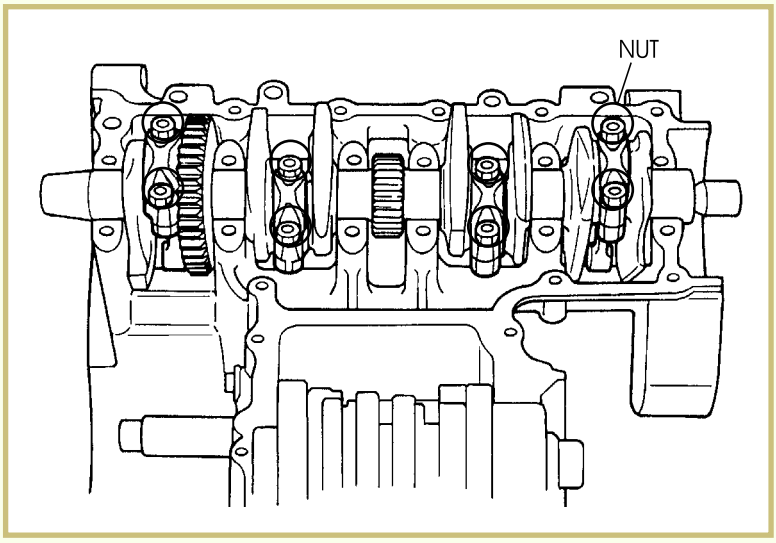
(Copyright by American Honda Motor Co., Inc. and reprinted with permission)

6 Tighten the nuts to the specified torque and make sure the rods turn freely after torquing, without binding. Sometimes the connecting rod nuts are torqued after the crankshaft is installed in the crankcase. Check your service manual for this information.

7 Install the cam chain on its sprocket, if the sprocket is located in the middle of the crankshaft.

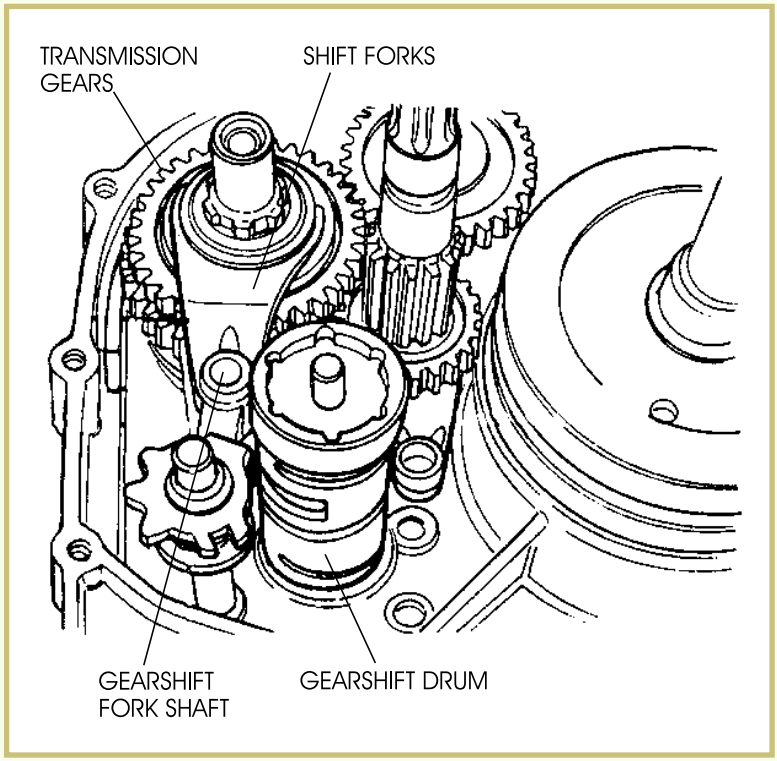
8 Lubricate the plain bearings and pre-lube the crankshaft journals. This ensures a proper amount of lubrication at the bearings when the engine is started for the first time.

9 Install the crankshaft into the appropriate crankcase half. Tighten the connecting rod nuts to the specified torque, if you haven't done so already (Step 6). The figure shows a four-cylinder crankshaft as it looks after installation, and points to one of the connecting rod nuts on the crankshaft.



Installing the Transmission, Balancer, and Other Components

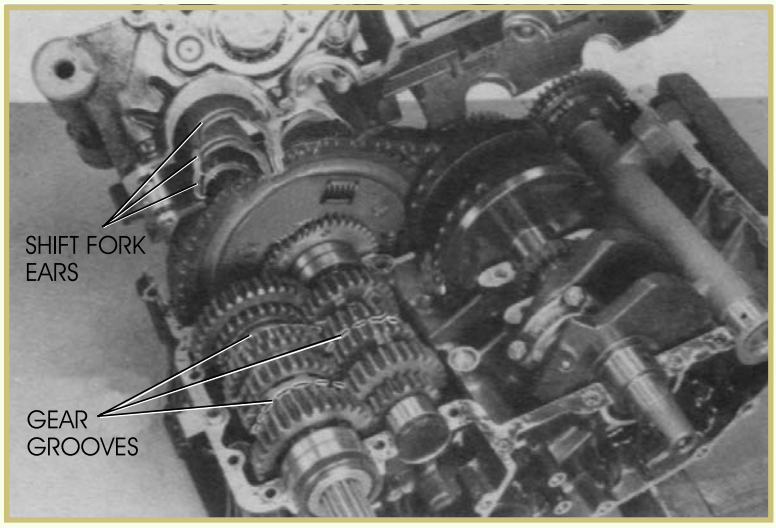
1 Install the transmission into the crankcase as a single unit. This includes the main shaft, counter shaft, shift drum, and shift forks, in most cases.



(Courtesy of American Suzuki Motor Corporation)

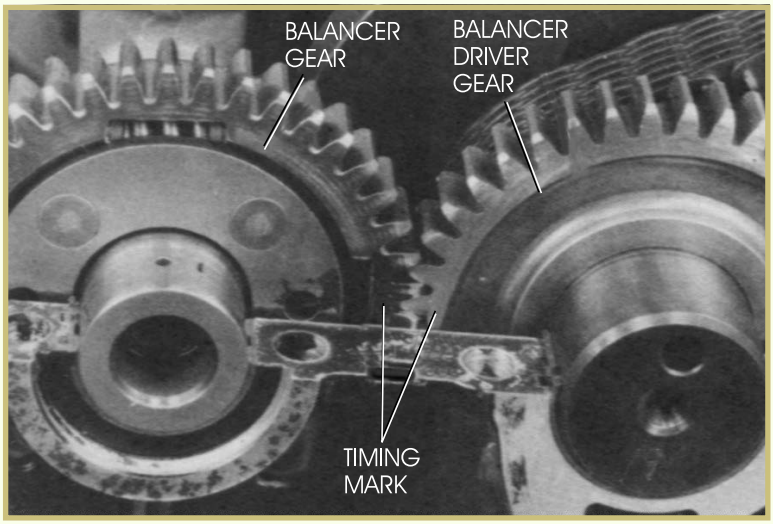
2 Note that some horizontal crankcases contain the shift drum and forks in one crankcase half, while the transmission gears are located in the other.

3 Lubricate all moving components after they're installed in the crankcase half. Also, make sure the transmission is in the neutral position and all shafts rotate freely.



(Courtesy Kawasaki Motor Corp., U.S.A.)

4 Time the balancers by matching the balancer gear alignment mark with the mark on the crankshaft gear, as shown in the figure. Many four-stroke motorcycle and ATV engines have these balancers for the smoothing of crankshaft pulses.



(Courtesy Kawasaki Motor Corp., U.S.A.)

5 Depending on the exact four-stroke engine bottom end that you're assembling, you may need to install other components, such as an oil pump, primary drive chains or gears, drive shaft components, idler gears, and electrical components. By following the procedures in the appropriate service manual, you won't forget to install any lower-end engine component.

Closing the Crankcase

Now that you've reinstalled the transmission and related components, you can proceed with closing the crankcase.

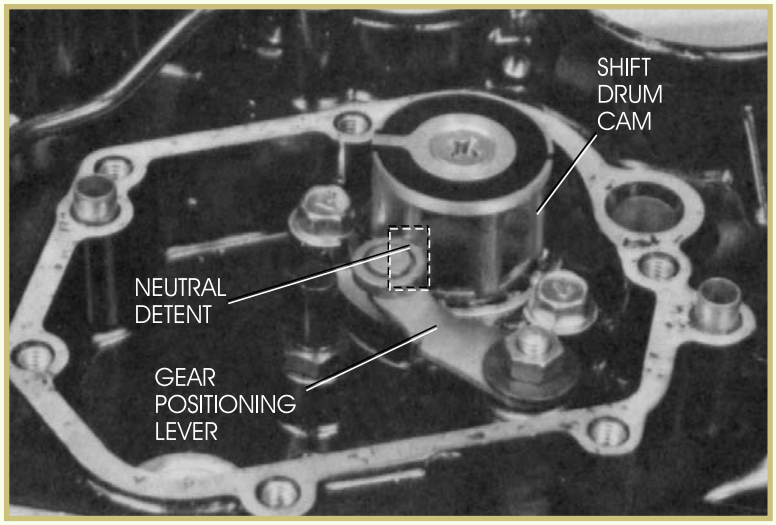
1. Before reassembling the crankcase halves, ensure that all old gaskets or crankcase sealant have been properly removed.
2. Renew the surface joint sealing material, using gaskets or crankcase sealing compound, as the manufacturer recommends. Use crankcase sealant sparingly, as excess sealant may get into the engine and cause problems.
3. Install any dowel or alignment pins and O-rings on the crankcase half into which the transmission and crankshaft are installed.
4. Check that all shafts rotate freely.
5. Install the crankcase halves together and tighten the crankcase fasteners in the proper sequence, as instructed in the appropriate service manual. Be sure to torque the fasteners properly. Note that all case fasteners aren't the same length. When inserting case fasteners, be sure each screw is in its proper hole. It's very easy to break the aluminum case if you insert too long a fastener into a hole. You can also strip the threads if you install a screw or bolt that's too short.
6. After the crankcase fasteners have been properly tightened, again make sure that all shafts rotate freely. If there's abnormal resistance in any shaft, try to free the shafts by tapping on the shaft with a plastic hammer. If there's still excessive resistance,

the crankcase must be disassembled to locate the resistance problem. A common problem, in this instance, is a misplaced spacer or thrust washer.

Installing Clutch Side Components

Now that the crankcase is assembled, it's time to install the external components. We'll begin by installing the external shifting components.

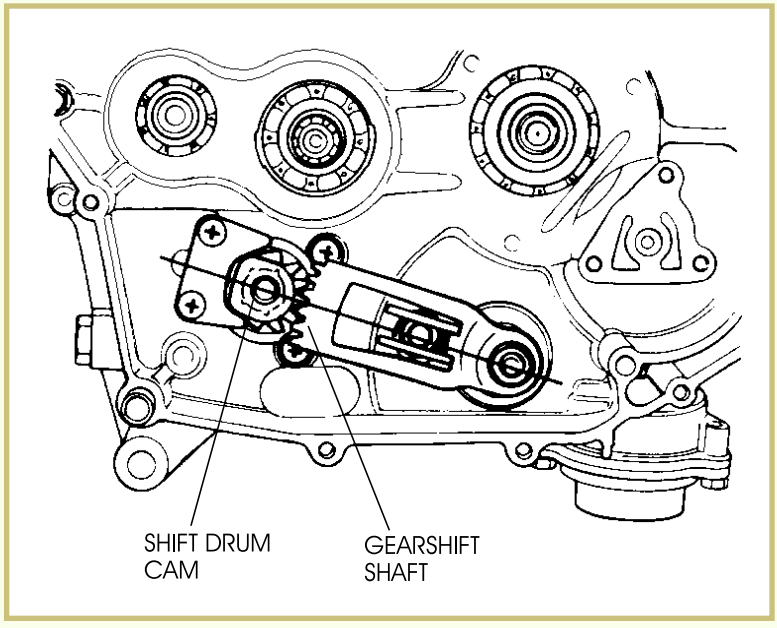
1 Assemble the gear positioning lever, neutral detent, and shift drum cam, if so indicated by your service guide.



(Courtesy Kawasaki Motor Corp., U.S.A.)

2 Install the gear shift shaft. Be sure to fit the shift shaft return spring correctly or the transmission won't shift properly. The figure shows the proper positioning of the shift shaft on our four-stroke engine ATV example. Match the center teeth of the gear on the gear shift shaft with the center teeth on the shift drum cam, as shown.

3 Apply engine oil to the sliding surfaces of the crankcase, outer rotor, inner rotor, and the shaft, to ensure proper lubrication when the engine is first started after assembly is complete.

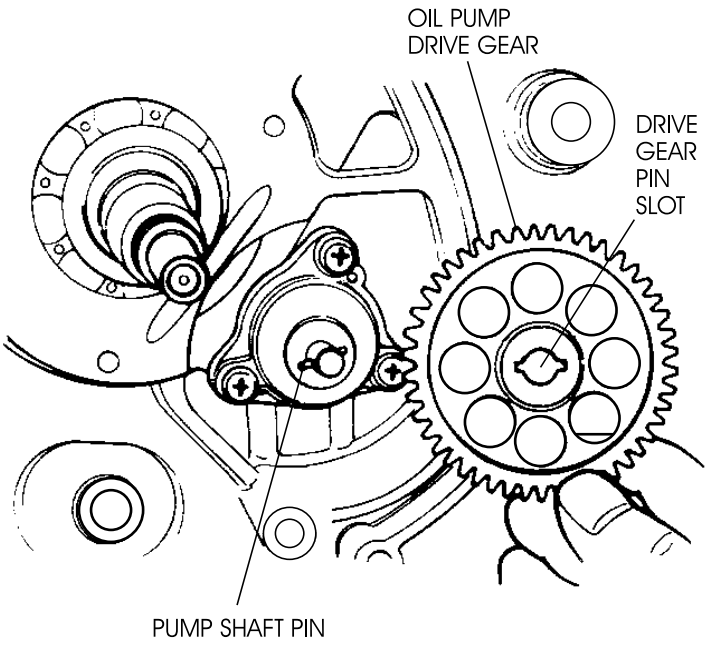


(Courtesy of American Suzuki Motor Corporation)

4 Install the oil pump. When installing the oil pump drive gear, align the pin on the pump shaft with the slot in the gear as shown in the figure.

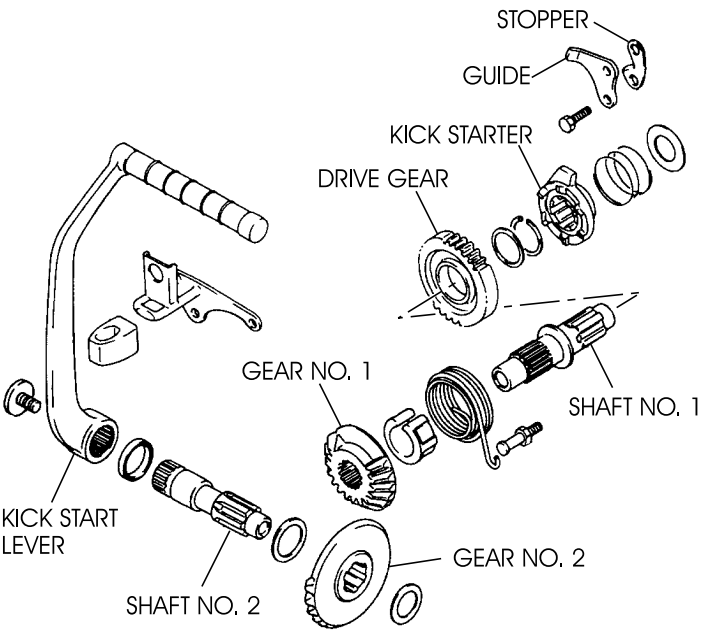
5 Install the primary drive gear, making sure the key is properly aligned with the gear key way slot.

6 Tighten the gear retaining fastener to the proper torque specification.



(Courtesy of American Suzuki Motor Corporation)

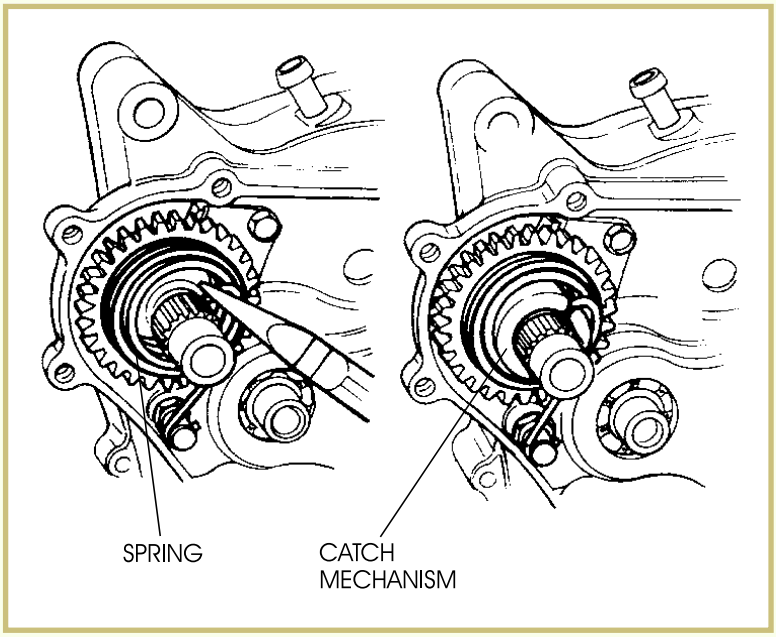
7 Install the kick starter mechanism components, except for the kick start lever. Check your service manual for an exploded view of all the kick starter components, such as the one shown in the figure.



KICK STARTER COMPONENTS

(Courtesy of American Suzuki Motor Corporation)

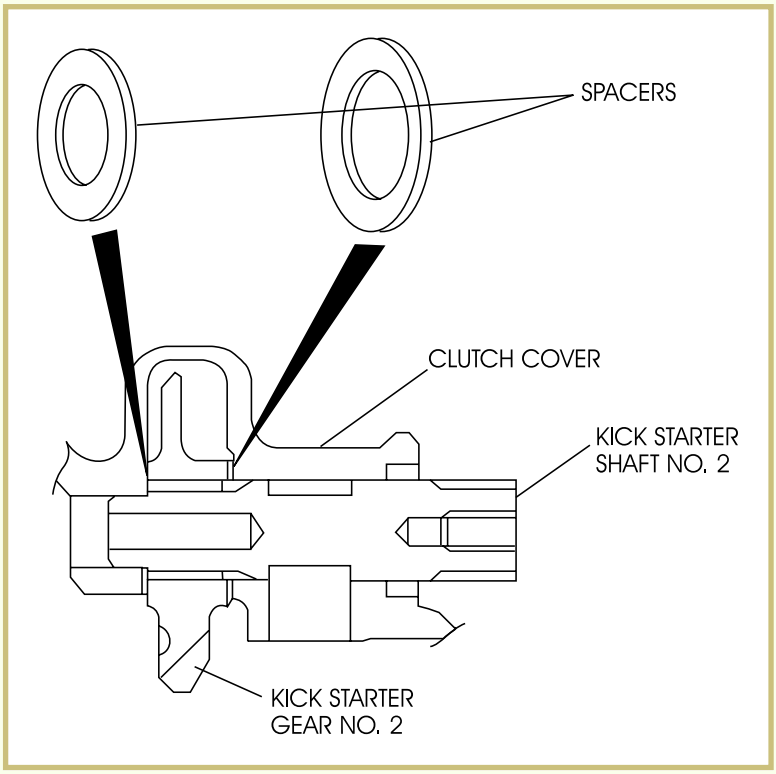
8 Ensure that the kick starter catch mechanism and spring are in good condition and installed properly.



(Courtesy of American Suzuki Motor Corporation)

9 Ensure that all spacers are in their correct places. The kick starter won't function properly if the spacers aren't installed properly.

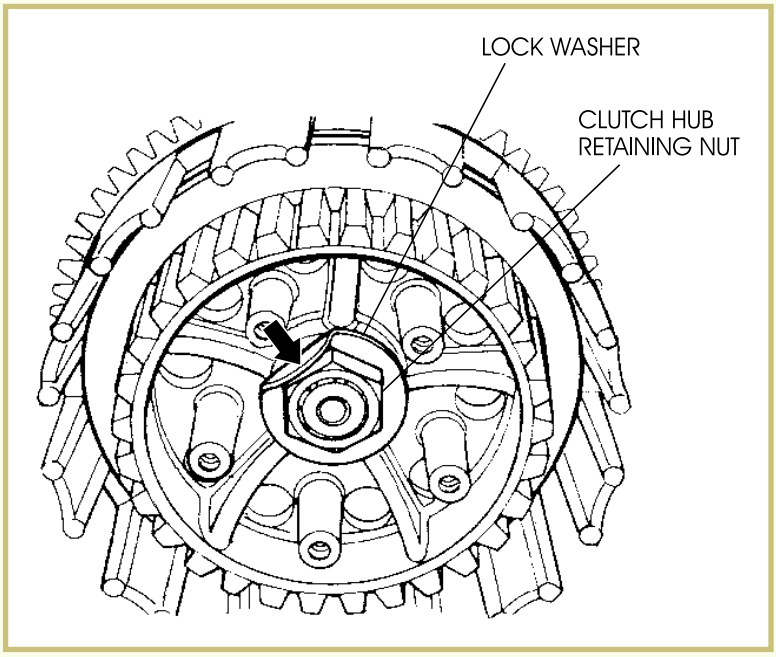
10 Install the cylinder assembly before installing the clutch. This prevents possible damage to the piston if the engine rotates when you tighten the clutch holding nut.



(Courtesy of American Suzuki Motor Corporation)

11 Install and tighten the clutch hub retaining nut. Be sure to lock it properly, by bending the tongue of the lock washer as shown in the figure.

12 Insert the clutch friction and metal plates one at a time.

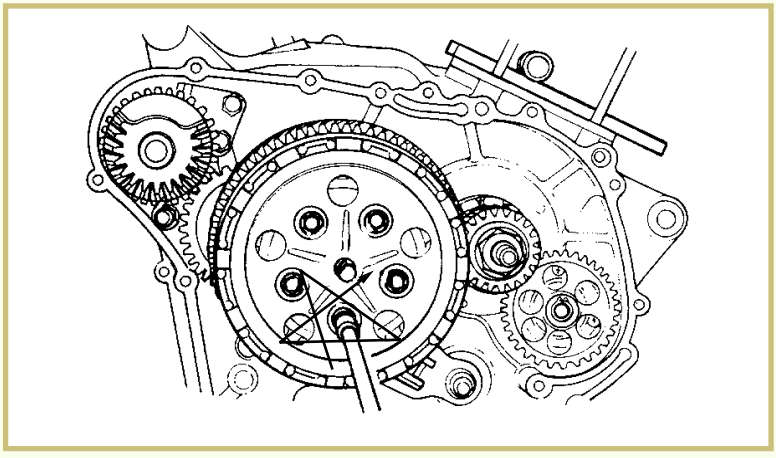


(Courtesy of American Suzuki Motor Corporation)

13 Install the clutch spring bolts in a diagonal or crisscross pattern, as shown in the figure.

14 Replace the cover gasket.

15 Install the clutch cover and tighten the cover fasteners.

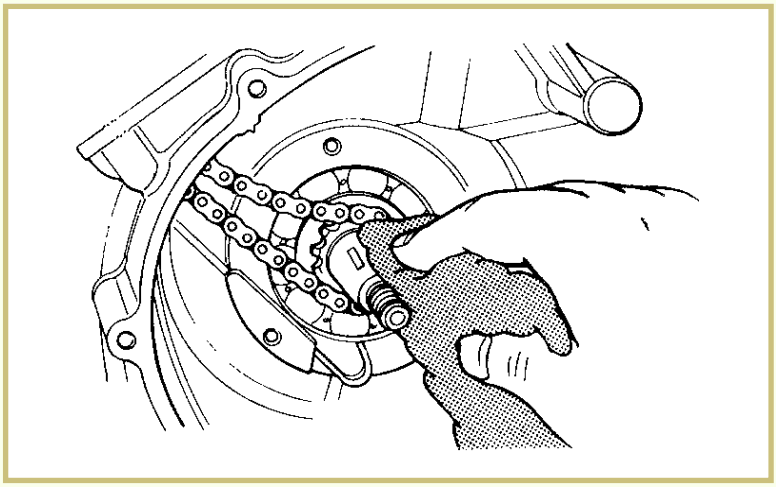


(Courtesy of American Suzuki Motor Corporation)

Assembling Rotor Side Components

1 Install the cam chain.

2 Thoroughly clean the tapered portion of the crankshaft, as shown in the figure, to allow for a tight fitting rotor.

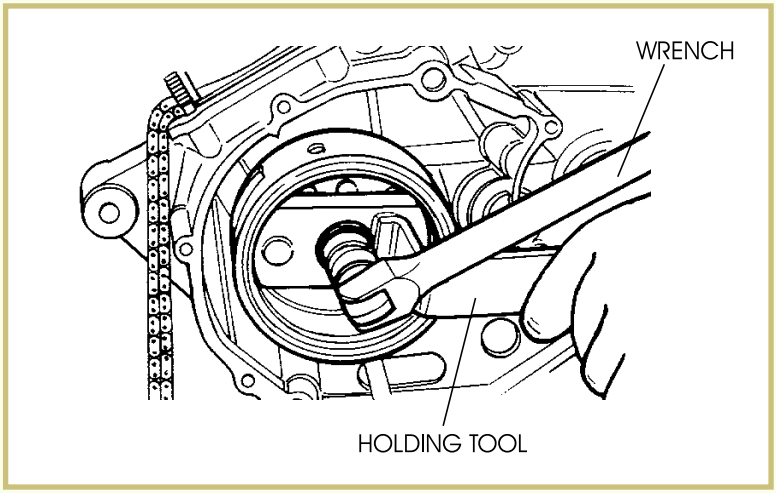


(Courtesy of American Suzuki Motor Corporation)

3 Install the rotor and tighten the fastener to the specified torque, using the special rotor holding tool to prevent movement.

4 Install the electric starter motor, if one is used. The starter motor is either gear or chain driven.

5 Install the rotor cover. Remember that most rotors have a line that marks the proper ignition timing.



(Courtesy of American Suzuki Motor Corporation)

Bench Testing

It's good practice to verify that all components move freely and properly before continuing engine reassembly. Turn the crankshaft over to make sure it moves freely. Shift the engine into every gear to ensure there are no apparent problems inside the engine. It would be frustrating to find a problem in the crankcase after you've completely reassembled the engine and installed it into the chassis. This completes the procedures for assembling the lower end.

Top-End Assembly Review

Before we can install the engine back into the chassis, the top end must be replaced on the vertical crankcase design four-stroke engine. You may recall that the top-end components on a horizontal design crankcase can stay attached to the crankcase.

We'll briefly review the steps to install the top end of the four-stroke motorcycle and ATV engine. Refer to the *Four-Stroke Engine Top-End Inspection* study unit for a more detailed explanation of the top-end assembly procedures.

Installing the Piston Rings

Recall that the piston rings have markings on them, indicating which side of the ring faces the top of the piston crown. Piston rings should be installed so their end gaps are 120° apart.

Installing the Piston

Place a clean rag over the base of the cylinder to prevent foreign objects from falling into the crankcase. Install the piston pin through the piston, making sure the piston directional arrow is facing in the correct direction. Always install new piston pin retaining rings.

Installing the Cylinder

Before installing the cylinder, clean all surfaces to remove old gasket material. Lightly oil and compress the piston rings. Lower the cylinder over the piston, then remove any ring compressors, if they're being used. Make sure you pull the cam chain out of the crankcase cavity, to prevent the chain from being caught between the cylinder and the crankcase. Push the cylinder down tightly to the crankcase joint. Install the cam chain tensioner guide into the cylinder, as well as the cylinder head alignment pins. To complete the installation procedure for the cylinder, install the cylinder head gasket onto the top of the cylinder.

Installing the Cylinder Head

Place the cylinder head on the cylinder and secure it by torquing the four outside bolts, as well as the cylinder head base fasteners. Remember to tighten the fasteners in a diagonal or crisscross pattern.

Installing the Camshaft

Timing of the camshaft's position in relation to the crankshaft's position is done by aligning specific marks. One of the main pieces of information you must have for every four-stroke engine is the exact location of the timing marks. Once you have that information, your job is to align the marks. These marks may be letters, dots, dashes, or simple lines. Normally the marks appear on the alternator rotor and the cam chain sprocket. As a result of its positioning, the rotor can be used to indicate the position of the crankshaft. In the case of camshaft timing marks, put the chain over the sprocket with the sprocket in the position where its timing mark on the sprocket aligns with the mark on the cylinder head. Then insert the camshaft into the sprocket and rotate the camshaft until it fits into the sprocket properly.

Recall that we previously explained the methods used for timing the camshaft to the crankshaft on the two most popular engine designs used in the motorcycle and ATV industry: the single overhead cam (SOHC) and the double overhead cam (DOHC) designs. Because camshaft installation is slightly different between these designs, refer to the *Four-Stroke Engine Top-End Inspection* study unit to review the specifics.

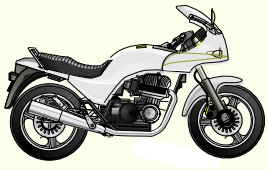
Installing the Cam Chain Tensioner

Mount the cam chain tensioner onto the cylinder and install the tensioner spring into the tensioner assembly. Tighten the spring holder bolt.

Checking Valve Clearance

Usually, you check the valve clearance after engine reassembly. This is done to ensure that they're within the specifications given in the service manual. Because the valve clearances might have been changed by the reconditioning and lapping procedures, the clearances should be measured and compared to the manufacturer's specifications. If a valve clearance is too small, it needs to be adjusted. In all motorcycle and ATV engines, the valves can be adjusted to correct the clearance. The valve clearance is normally checked when the cylinder is at the top-dead-center (TDC) position. At this position on the compression stroke, both the intake and exhaust valves for the cylinder should be completely closed. The actual adjustment procedure for the four-stroke motorcycle and ATV valves is discussed in detail in a later study unit, when we discuss maintenance procedures of the motorcycle and ATV.

Road Test 3



1. It's sometimes necessary to use a special tool to install a _____ in a vertically split crankcase engine.

2. The _____ is installed into the crankcase as a unit.

3. After installing the cam chain, what should be done to the crankshaft to allow for a tight fitting rotor?

   _____

4. Suppose that after the crankcase fasteners have been properly tightened, you find abnormal resistance in a shaft. How should you try to free the shaft before disassembling the crankcase?

   _____

5. *True or False?* All crankcase fasteners are the same length.

6. *True or False?* The top end of the engine must be removed before disassembly of most horizontal crankcase engine designs.

7. What should be done to the plain bearing surface of a multipiece connecting rod before assembling it onto the crankshaft?

   _____

8. Before installing the crankcase halves together, what components should you check to verify that they move freely?

   _____

Check your answers with those on page 49.

FOUR-STROKE ENGINE INSTALLATION

In the *Four-Stroke Engine Top-End Inspection* study unit, we removed the engine from the frame before we began the disassembly of our example engines, a Suzuki LT 250S ATV and a Kawasaki GPZ 500S. We first disassembled the top end of the engines and then proceeded with the disassembly, inspection, and reassembly of the lower end of the engines. We discussed the disassembly and assembly procedures for a single overhead cam (SOHC) vertical split engine design as well as a double overhead cam (DOHC) horizontal engine design. These two types of engine designs are the most popular engines used on motorcycles and ATVs. The only variable is the number of cylinders that the engines use.

Now that the engines are assembled, they're ready to be installed back into the frame and prepared for final assembly and startup. As we've done in past sections, we'll complete our explanation of installing the four-stroke engine into the chassis using example procedures.

Installing the Engine into the Chassis

It's best to have a clean and well prepared *rolling chassis* before you begin installing the engine back into the frame. A rolling chassis is a motorcycle or ATV that's assembled completely, except for the body work and engine.

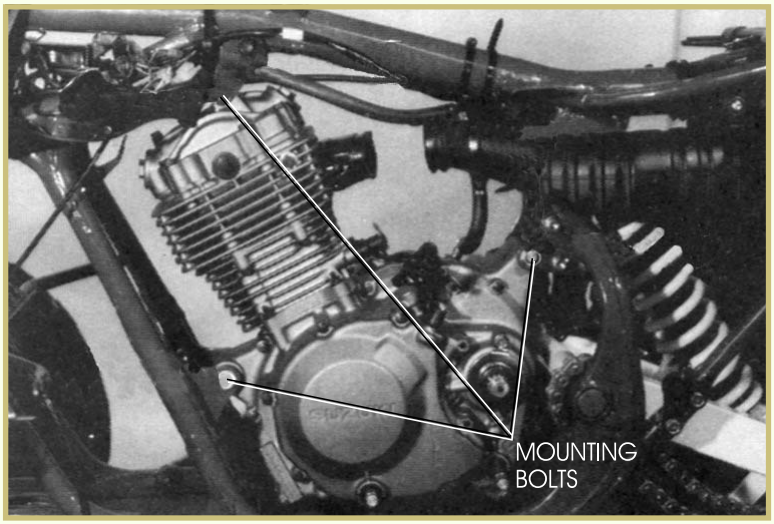
1 Clean the complete chassis thoroughly, after removing all necessary hardware.

2 Get at least one assistant to help you put the engine in the frame. Due to the weight of the engine, an assistant can be a big help as you align the engine mounting points on the engine and the frame.

3 After positioning the engine in the frame, put a jacking device under the engine to help keep it in place. This also makes it easier to install the mounting hardware.

4 After the engine is in place, install the mounting hardware. The service manual normally has an exploded view of the mounting hardware to help you correctly install all the pieces.

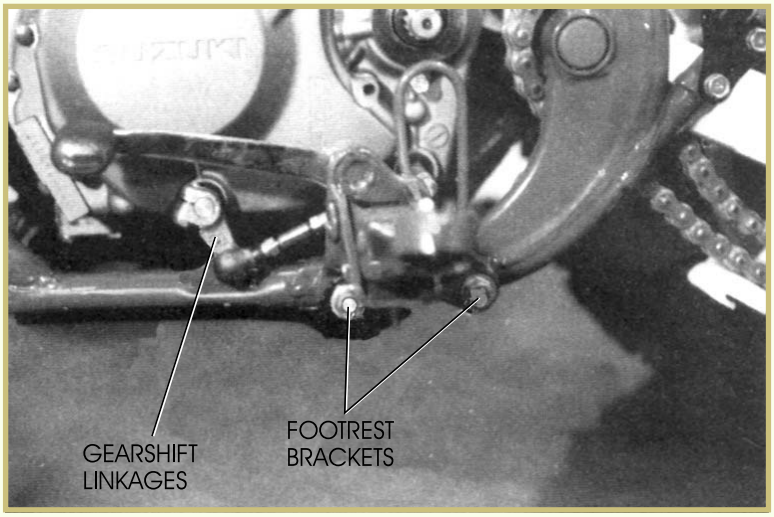
5 Tighten the engine mounting bolts to the proper torque specifications given in the service manual.



(Courtesy of American Suzuki Motor Corporation)

Installing Chassis and Body Components

1 Install the gear shift linkage and footrest brackets that were removed to take the engine out of the frame.

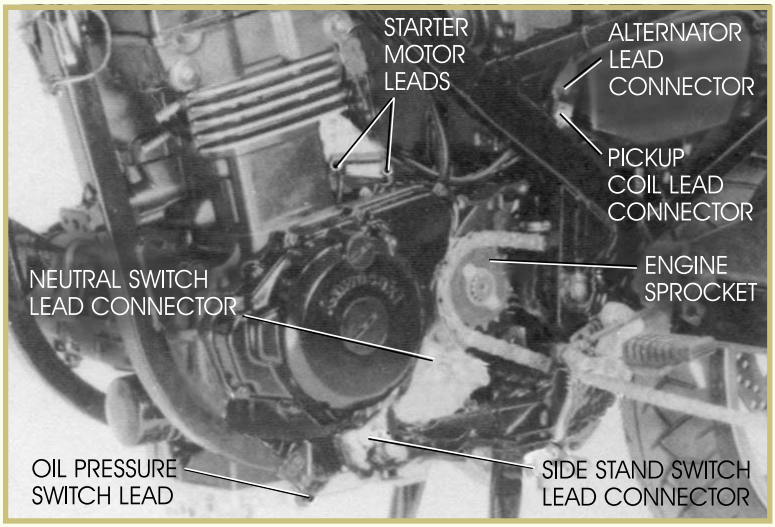


(Courtesy of American Suzuki Motor Corporation)

2 Reconnect the electrical connectors.

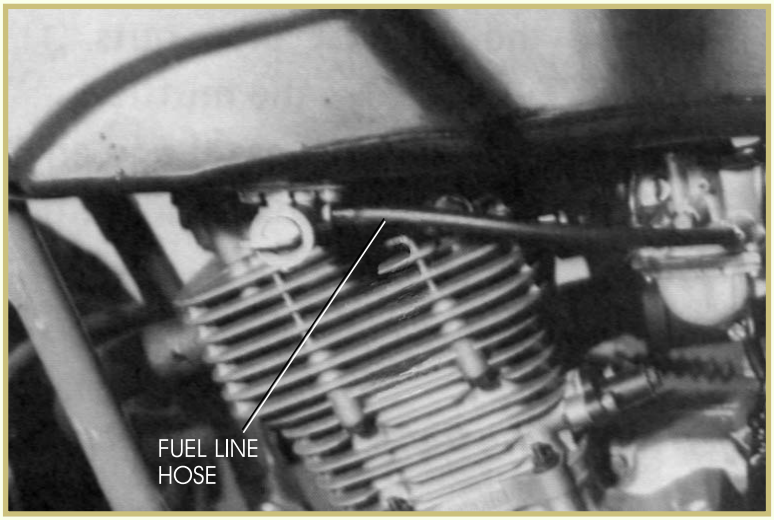
3 Install the sprocket and drive chain.

4 Reconnect the exhaust pipe, radiator, coolant lines, carburetor, air box, control cables, spark plug wires and any other electrical connections, as well as components that were not previously connected or installed. The appropriate service manual informs you of the proper order of assembly for these parts. Follow the sequence in the service manual closely, as the manufacturer knows the correct and most efficient manner to assemble the engine and its related components back onto the chassis.



(Courtesy Kawasaki Motor Corp., U.S.A.)

5 Install all body parts and hoses that were removed, including the fuel tank and all fuel hose connections. Now our motorcycle and ATV are both ready for final preparation prior to engine startup.



Courtesy of American Suzuki Motor Corporation

Final Preparation for Engine Startup

Final preparation steps must be taken before attempting to start the engine in our motorcycle or ATV. Complete the following steps.

1. Check all fasteners to verify that all nuts and bolts are properly tightened.
2. Verify that all electrical components are properly installed.
3. Fill the engine with the correct amount of engine oil and check for any obvious leaks.
4. If the motorcycle is liquid-cooled, fill the radiator and inspect for any obvious leaks around the hoses or connectors.
5. Check that the engine rotates properly by engaging the kick starter or turning the engine over using the electric starter motor.
6. Rotate the engine without starting it, to help pump oil to all vital components. This ensures proper lubrication at these points before the engine is started.
7. Turn on the fuel petcock to verify that fuel is flowing to the carburetor.

Starting the Engine

It's finally time to start the engine!

1. Start the engine. The engine should start within 10 seconds of attempting to electric start it or within 5 to 10 kicks of the kick starter. If it doesn't start, verify that all connectors are attached. Then try again. Once started, let the engine idle or keep it running as close to idle as you can.
2. As the engine is warming up, check for any leaking fluids in and around the engine unit.
3. Shut the engine off and wait for it to cool to room temperature.
4. Top off the coolant on a liquid-cooled engine and verify that the engine oil is at its proper level.

Breaking-In the Engine

Most manufacturers recommend that a new (or reconditioned) engine be properly broken-in to ensure that all components are sealing and meshing together properly. During the assembly process, it's recommended that you use the best possible materials and original equipment manufactured parts. Even so, it's still necessary to allow the parts to break-in before subjecting the engine to maximum stress. The future reliability, as well as the performance of the engine, depends on a proper break-in procedure. This includes extra care and restraint during the early life of the reconditioned engine. The general rules are as follows.

1. For off-road machines, such as ATVs and dirt bikes, keep the engine at less than ½ throttle for the first ten hours of engine operation.
2. For street bikes, keep the engine operation at less than ½ throttle for the first 600 miles.
3. After the initial time period or mileage has been reached, replace the engine oil and filter. This will remove any contamination from the break-in process. The machine can now be subjected to the normal riding habits of the rider.

Road Test 4

1. How long should the engine be run at less than ½ throttle for proper break-in of an ATV?

2. How long should the engine be run at less than ½ throttle for proper break-in of a street motorcycle?

3. Why should a newly reconditioned engine be broken-in?

4. After rebuilding an engine, what should you check for while the engine is warming up?

5. Why should the engine be rotated for a period of time before attempting to start it?

6. What can be placed under the engine to keep it steady, while you install the mounting fasteners?

Check your answers with those on page 49.

Road Test Answers

1

1. True
2. True
3. crankshaft
4. chain, gear
5. charging system stator

2

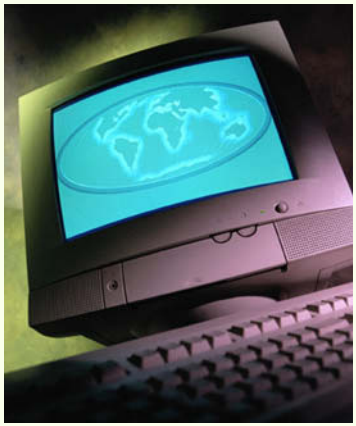
1. True
2. hydraulic press
3. Vernier caliper
4. False
5. cylinder, cylinder head
6. Worn dogs or slots on gears
7. Sliding gear that the shift fork activates, opposing gear
8. Faulty transmission bearing

3

1. crankshaft
2. transmission
3. It should be thoroughly cleaned.
4. Tap on the shafts.
5. False
6. False
7. Lubricate it with a 50/50 mixture of moly lube and clean engine oil.
8. All rotating shafts

4

1. 10 hours
2. 600 miles
3. To allow parts and components to mesh together and seal properly
4. Fluid leaks
5. To allow the oil to be pumped to the critical lubrication points
6. A jacking device



ONLINE EXAMINATION

For the online exam, you must use this

EXAMINATION NUMBER:

03301200

When you're confident that you've mastered the material in your studies, you can complete your examination online. Follow these instructions:

1. Write down the eight-digit examination number shown in the box above.
2. Click the **Back** button on your browser.
3. Click the **Take an Exam** button near the top of the screen.
4. Type in the eight-digit examination number.