Study Unit

Clutches, Transmissions, and Drives

By

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Preview

This study unit focuses on the transmissions and related components used in motorcycle or ATV engines. In this study unit, you'll learn about the different types of gears that you may find in a motorcycle or ATV engine. You'll also understand how the primary drive and different clutch systems function in an engine. We'll then discuss how and why transmissions are used in motorcycle and ATV engines.

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

- Identify the different gears used in transmissions
- Calculate gear and drive ratios correctly
- Identify the functions of the primary drive systems
- Identify the different components that make up the primary drive systems
- Understand and identify the different clutch types
- Identify the different clutch release mechanisms
- Identify the different types of transmissions and shifting components
- Identify and understand the different types of final drive systems

Contents

Clutches, Transmissions, and Drives

INTRODUCTION

All motorcycles and ATVs use some type of a drive system to propel the vehicle. The primary drive, transmission, and final drive systems work together to transfer the power that's produced by the engine crankshaft to the rear wheels. To use the power made at the engine crankshaft, a motorcycle or ATV may use gears, belts, clutches, sprockets and a chain, or a combination of these items. Before we learn about the clutches, transmissions, and final drives used in motorcycles and ATVs, we must first understand some basic information related to gears and gear ratios.

Gears

A gear is simply one or more rotating levers. There are five primary purposes for using gears in engines:

1. To transmit power from one shaft to another
2. To change the direction of rotation
3. To increase torque, which results in a decrease in the revolutions per minute (rpm), or speed, of the gear; note that the force behind a moving gear is the torque of the drive system.
4. To increase rpm, which results in a decrease in torque
5. To properly time certain components in the engine such as engine balancers and camshafts on four-stroke engines

There are several basic types of gears used in an engine. Gears are also used in other areas of a motorcycle and ATV. Because you'll see many different types of gears, it's important that you can identify them and understand their purpose (Figure 1).

Spur Gear

A spur gear, or straight-cut gear, has teeth that are straight, which allows a tooth to mesh entirely with another spur gear tooth. The spur gear is the most common gear used in engines. The spur gear is the simplest gear to manufacture, is very durable under various strenuous loads, and, because of its simplicity, is the least expensive gear to manufacture. This type of gear also makes the most noise.

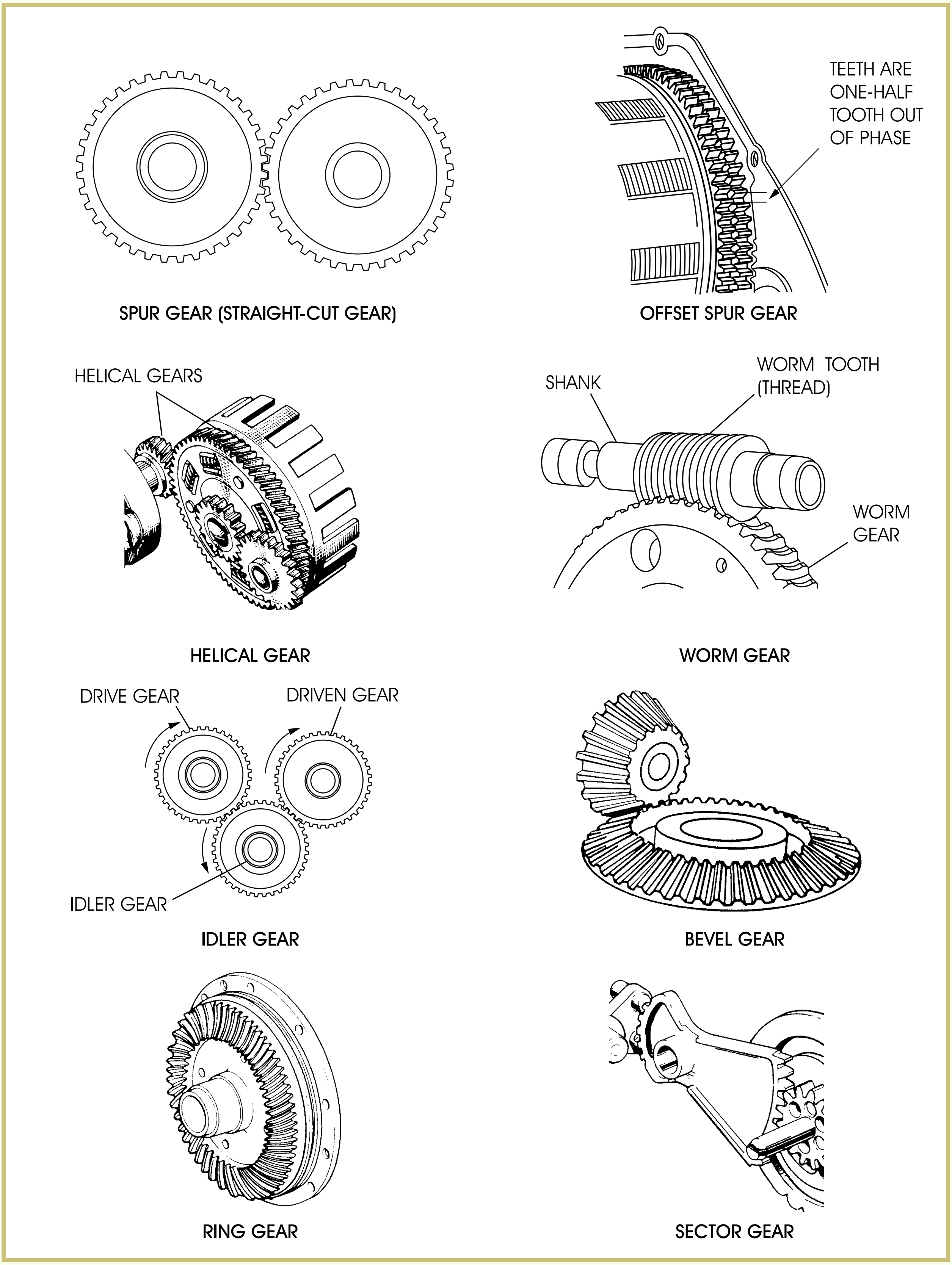


FIGURE 1—Different Types of Gears

Offset Spur Gear

An offset spur gear is essentially two spur gears which are attached side by side. The teeth of the offset spur gear are offset by ½ of a tooth. The gears are normally attached to one another by a rubber damper which allows the offset spur gear to engage its mating spur gear. The offset spur gear is used to reduce the amount of free movement between the teeth of two meshed gears. This is called *backlash*.

Helical Gear

A helical gear has teeth that are angled, which allows it to be much quieter than the spur gear. Unlike the spur gear, the teeth of two helical gears, when meshed, don't fully contact each other. The lack of full contact between the gears causes the gears to be quieter. When engaged and under load, helical gears create side loads which tend to force the gears to one side.

Worm Gear

A worm gear has teeth that are cut at an angle to be driven by a shank that has at least one complete tooth (thread) spiraled around the surface. A worm gear is used to connect nonparallel, nonintersecting shafts. A worm gear allows for a very high gear reduction ratio. Worm gears are most commonly found in speedometer and tachometer drives.

Idler Gear

An idler gear may have teeth which are cut in any of the types of configurations discussed in this study unit. An idler gear is a gear that's situated between a drive gear and a driven gear to transfer motion without a change of direction between the drive gear and driven gear. An idler gear won't change the gear ratio of the gear set. We'll discuss gear ratios later in this section of your study unit.

Bevel Gear

A bevel gear can be a spur bevel with straight-cut teeth or a spiral bevel with curved teeth. The bevel gear is used to transmit power at 90° angles. The bevel gear is the most common design found on the pinion gear (drive gear) of a final shaft-drive system and on some older camshaft drives. We'll discuss final drive systems later in this study unit.

Ring Gear

A ring gear is a metal wheel that has teeth around the inner edge of the gear. The ring gear is most commonly seen in the design of gears used for the final driven gear on shaft-drive final drive systems. The ring gear is normally used in conjunction with a bevel gear.

Sector Gear

A sector gear is a pie-shaped segment of a helical or spur gear. The sector gear is used in kickstart mechanisms and shift linkages. A sector gear allows partial movement of certain components.

Gear Ratios

Gear ratios are used to alter the speed of a rotating component to a useful rpm. A gear ratio is a numerical comparison of the number of revolutions of the drive gear as compared to one revolution of the driven gear. This is really more simple than it sounds. An example of a gear ratio would be 5 to 1, or, as stated in numerical terms, 5:1. This ratio states that the drive gear makes five revolutions for every one revolution of the driven gear (Figure 2). The formula used to determine gear ratios is

Gear ratio = (# of teeth on driven gear) ÷ (# of teeth on drive gear)

Gear ratio can also be expressed as

Gear ratio = (rpm of drive gear) ÷ (rpm of driven gear)

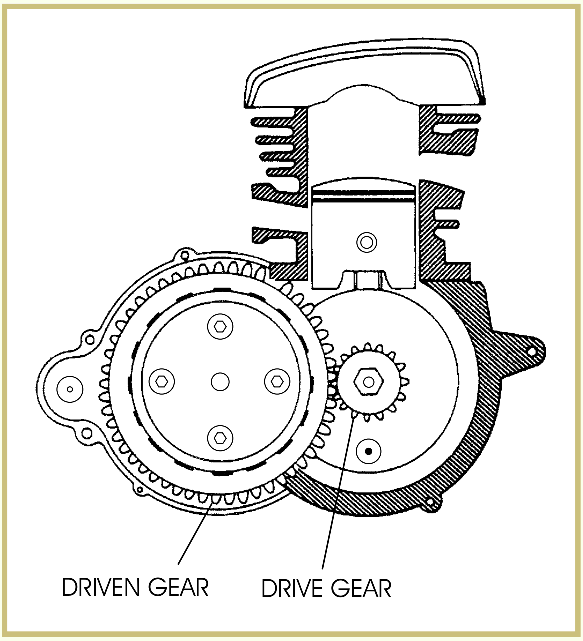


FIGURE 2—A drive and a driven gear are shown here. (Courtesy of American Suzuki Motor Corporation)

If you know the number of teeth on a gear, then you can determine the rpm ratio. Conversely, if you know the rpm, you can determine the number of teeth needed in a gear.

Let's try an example using one of these formulas to determine a gear ratio. If a driven gear has 40 teeth and a drive gear has 10 teeth, what's the gear ratio? You simply take the driven gear (40) and divide it by the drive gear (10) to get 4.

driven gear (40) ÷ drive gear (10) = 4

Therefore, these gears have a gear ratio of four to one, or 4:1. In other words, the drive gear rotates four times for every one revolution of the driven gear. In most cases, gear ratios are rounded off to a thousandth, so 4:1 would read 4.000:1.

Let's try another example. A crankshaft gear that has 25 teeth (we'll call this the drive gear) is turning at 5,000 rpm. It turns another attached shaft gear that has 50 teeth (let's call this the driven gear). How fast is the drive gear turning?

Since these gears have a 2:1 ratio, every time the crankshaft (drive) gear rotates twice, the driven shaft gear rotates once.

driven gear (50) ÷ drive gear (25) = 2

Now, calculate the speed of the driven gear with the following formula.

$$\frac{\text{Speed of drive gear}}{\text{Speed of driven gear}} = \frac{2}{1}$$

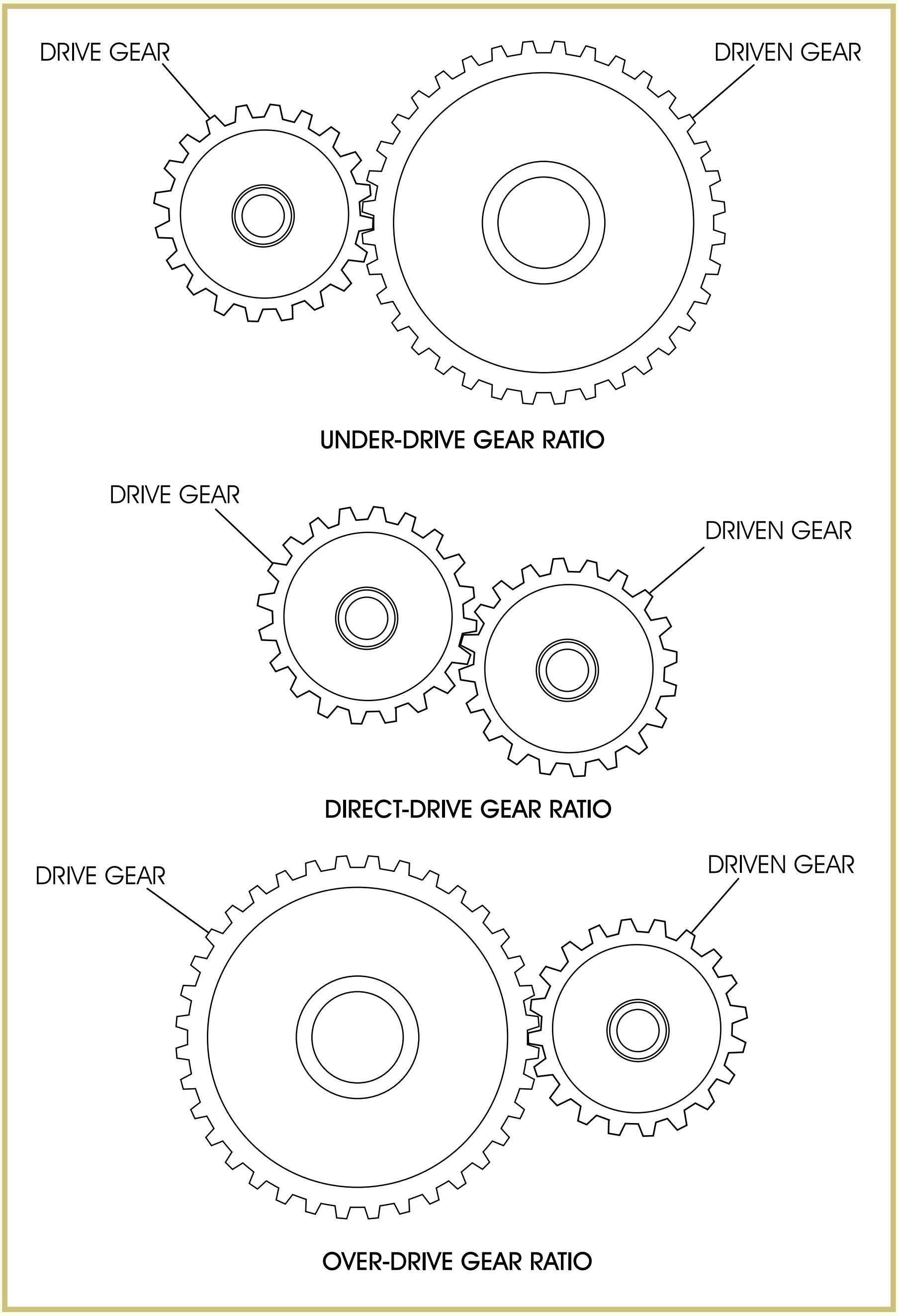
$$\frac{5000\text{ rpm}}{\text{Speed of driven gear}} = \frac{2}{1}$$

Speed of driven gear = 2500 rpm

Gear ratios can be categorized into one of three groups (Figure 3).

1. An *under-drive gear ratio* is a gear ratio that's greater than 1:1. In this situation, the drive gear always has less teeth than the driven gear. An under-drive gear ratio increases the torque output of the driven gear but decreases the rpm of the driven gear.
2. A *direct-drive gear ratio* is a gear ratio that's exactly 1:1. In this situation, the drive gear always has the same number of teeth as the driven gear. A direct-drive gear ratio won't change the torque or rpm of the driven gear.
3. An *over-drive gear ratio* is a gear ratio that's less than 1:1. In this situation, the drive gear always has more teeth than the driven gear. An over-drive ratio increases the rpm but also decreases the torque of the driven gear.

FIGURE 3—Gear Ratios



There are many different gear reductions used inside an engine. The proper gear reduction must be used to allow an engine to operate at its full potential. You'll find three types of ratios used in motorcycles and ATVs.

1. Primary drive ratio
2. Transmission gear ratio
3. Final drive ratio

Primary Drive Ratio

The primary drive ratio is the gear reduction that's determined from the crankshaft to the clutch of the engine. When computing the primary drive ratio, the crankshaft output gear is considered to be the drive gear. The clutch has a gear attached to it and is considered the driven gear. For example, if a crankshaft gear has a tooth count of 41 and the clutch-attached gear has a tooth count of 89, the primary drive ratio is 89 (driven) divided by 41 (drive). The result (rounded off to the thousandth) is 2.171:1.

Transmission Gear Ratio

The transmission transmits power from the clutch, which is attached to the main shaft (drive side) of the engine, to the countershaft (driven side) of the engine. *Transmission gear ratios* are needed to allow for the many different power requirements needed. There may be as few as two to as many as six different transmission gear ratios used in a transmission. For example, a main shaft gear with 22 teeth and a countershaft gear with 28 teeth have a gear ratio of 1.273:1. This is determined by dividing the driven countershaft gear teeth (28) by the drive main shaft gear teeth (22) which results in a gear ratio of 1.273:1.

Final Drive Ratio

The final drive ratio transmits the power output of the transmission to the rear wheel. In this case, the transmission output shaft (in most cases this will be the countershaft) has a sprocket attached to it which drives the rear wheel through a roller chain. An example of a final drive ratio is an output shaft sprocket size of 16 teeth and a rear wheel sprocket size of 46 teeth. In this case, you would divide 46 by 16. The result of the ratio (rounded off to the thousandth) is 2.875:1.

Overall Gear Ratio

There's one other ratio that directly relates to the ratios that we just covered. This ratio is known as the overall gear ratio. This ratio compares the number of times the crankshaft turns to the turning of the rear wheel. This ratio gives us the numerical gear ratio from the crankshaft to the rear wheel. Generally this ratio is calculated with the transmission in its highest gear, but it can be calculated for any gear. The formula to calculate the overall ratio is

$$\text{Overall gear ratio} = (\text{primary}) \times (\text{transmission}) \times (\text{final drive})\ \text{ratio}$$

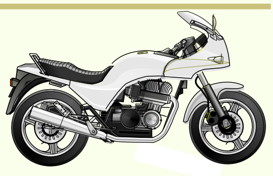
If we take the figures obtained in each of the examples above, we can calculate the overall gear ratio (rounded off to the thousandth) as follows:

$$2.171 \times 1.273 \times 2.875 = 7.946{:}1$$

This tells us that for every one revolution of the rear wheel, the crankshaft rotates 7.946 times.

As you can see, gears have a very important use in engines. Engines with high horsepower can use a lower gear ratio. Engines with a low horsepower rating require a higher gear ratio to allow for the full use of the available horsepower. An engine with a higher overall gear ratio won't have as much top speed capability but will reach its maximum available speed quicker than an engine that has a lower overall gear ratio.

Road Test 1



At the end of each section of *Clutches, Transmissions, and Drives*, 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. The _______ gear changes direction at 90°.
2. A gear ratio that has less teeth on its drive gear than it has on its driven gear is what type of gear ratio?

   ____
3. The _______ gear is the most commonly used gear on motorcycles.
4. A gear that's pie-shaped is known as a _______ gear.
5. A gear ratio that has the same number of teeth on its drive gear and its driven gear is what type of gear ratio?

   ____
6. If a crankshaft drive gear has 22 teeth and the clutch outer basket has 68 teeth, the ratio for this set of gears is _______.
7. A gear on a main shaft has 28 teeth and the countershaft has 33 teeth; the ratio for this set of gears is _______.
8. If the countershaft sprocket has 15 teeth and the rear wheel sprocket has 42 teeth, the ratio for this set of gears is _______.
9. By using the ratios from questions 6, 7, and 8, the overall gear ratio for this motorcycle or ATV is _______.
10. A gear ratio that has more teeth on its drive gear than it has on its driven gear is what type of gear ratio?

    ____

Check your answers with those on page 49.

PRIMARY DRIVES

All engines require a gear reduction system that's used to transfer the power from the crankshaft to the transmission, and then from the transmission to the rear wheel. The gear reduction system used for transferring the power from the crankshaft to the clutch is called the *primary drive.* As you've learned, gear reduction is necessary to allow the engine to remain in the appropriate range of rpm while maintaining various speeds at the rear wheel. In other words, we need a gear reduction system so that the engine crankshaft can turn at one speed while the rear wheel turns at another speed. A clutch system is needed to engage and disengage the power from the crankshaft to the transmission. Before we learn about the different types of clutches, we'll first discuss the types of primary drive systems found in today's motorcycle and ATV engines. A primary drive system transfers power from the crankshaft to the clutch by using gears, a chain, or a belt (Figure 4). These are the three basic methods of connecting the engine to the clutch and transmission.

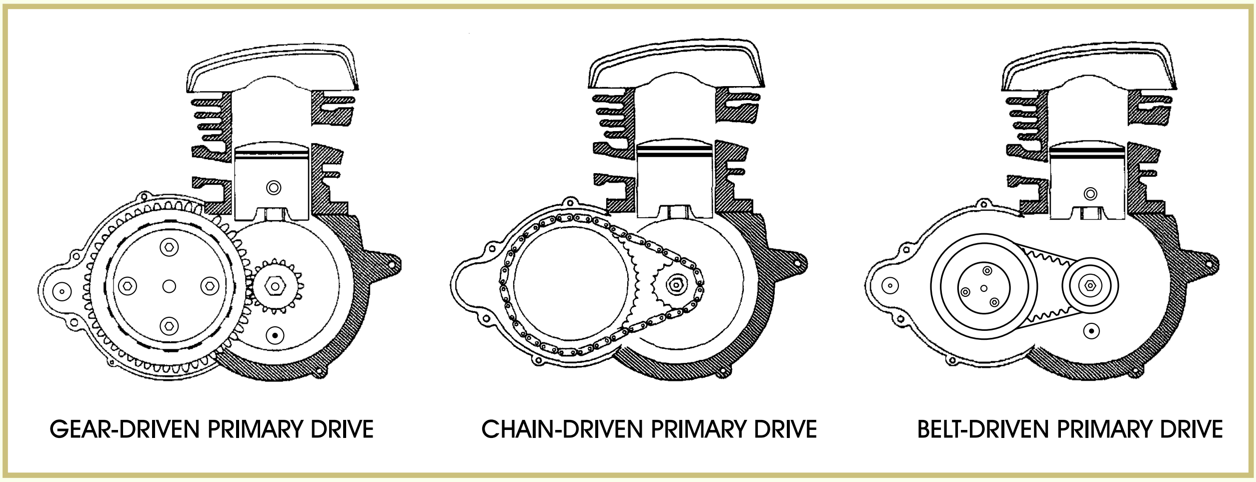


FIGURE 4—Primary Drives (Courtesy of American Suzuki Motor Corporation)

Gear-Driven Primary Drive

Most motorcycles and ATVs use a gear-driven primary drive system. This system uses either spur, offset spur, or helical gears to transfer power from the crankshaft to the clutch system. With a gear-driven primary drive system, the two gears turn in opposite directions because each gear is on a separate shaft. This makes the clutch turn in the opposite direction of the crankshaft. You must lubricate gear-driven primary drive systems to prevent excessive heat caused by the friction of the gears as they mesh together as the engine operates.

Chain-Driven Primary Drive

The chain-driven primary drive uses a chain and two gears or *sprockets* to transfer power from the crankshaft to the clutch system. Sprockets are the teeth on the periphery of a wheel or cylinder that engage the links of a chain. With a chain-driven primary drive, both sprockets turn in the same direction and use either a roller chain or a Hy-Vo chain design. The Hy-Vo chain design is the most commonly used as it's a much stronger design and quieter than the roller chain. You must keep chain-driven primary drive systems well lubricated.

Belt-Driven Primary Drive

The belt-driven primary drive system uses a toothed belt called a "Gilmer-type belt" and two pulleys with teeth attached to them. Just like the chain-driven primary drive system, the belt-driven type has both pulleys turning in the same direction. This type of primary drive is very quiet because it uses a belt instead of gears or a chain. Unlike the other primary drive systems, you must keep a belt-driven primary drive dry.

CLUTCH SYSTEMS

Now that we have a gear reduction system in place for the power at the crankshaft, there must be a way to interrupt that power flow when we need to stop the motorcycle or ATV. We also need a way to permit a gradual engagement of the motorcycle or ATV when you decide to have the machine move again. This power interruption is done using a clutch. As we mentioned earlier, the purpose of the clutch is to disconnect and connect the power of the crankshaft. The clutch is normally placed between the primary drive of the engine and the transmission. Clutch actuation can be divided into two different types: (1) manual clutch actuation, which is controlled by the rider and (2) centrifugal clutch actuation, which is controlled by the engine's rpm. There are three basic clutch designs used in engines:

1. Manual clutch
2. Centrifugal (also referred to as automatic) clutch
3. Variable-ratio clutch

We'll discuss these clutch designs next.

Manual Clutch

A manual clutch allows the rider to control the engagement and disengagement of the power flow from the crankshaft to the transmission. The manual clutch is the most conventional type of clutch used on motorcycles and ATVs. A manual clutch may be wet or dry. Both wet and dry clutches are extremely similar in design and function. The main difference between wet and dry clutches is the way they're cooled. A wet clutch operates in an oil bath to keep its components cool. The oil carries the heat generated by the clutch away from the clutch to help keep it cool. A dry clutch uses airflow to keep the clutch cool. There are two styles of manual clutches used: single-plate and multiplate. A single-plate clutch, which is very similar to the clutch system used for automobiles, is usually found in conjunction with a dry clutch. A multiplate clutch is the most conventional style of clutch found on motorcycles and ATVs. All manual clutches consist of the same basic components. We'll concentrate primarily on the multiplate manual wet clutch because dry clutches aren't as popular on motorcycles and ATVs.

Multiplate Manual Clutch

A multiplate clutch has as few as two plates and up to as many as twenty plates. By using more plates, the clutch can be made smaller in diameter while keeping the same amount (or more) of friction material for engagement purposes. Although terminology varies, all multiplate clutches have the same basic components (Figure 5).

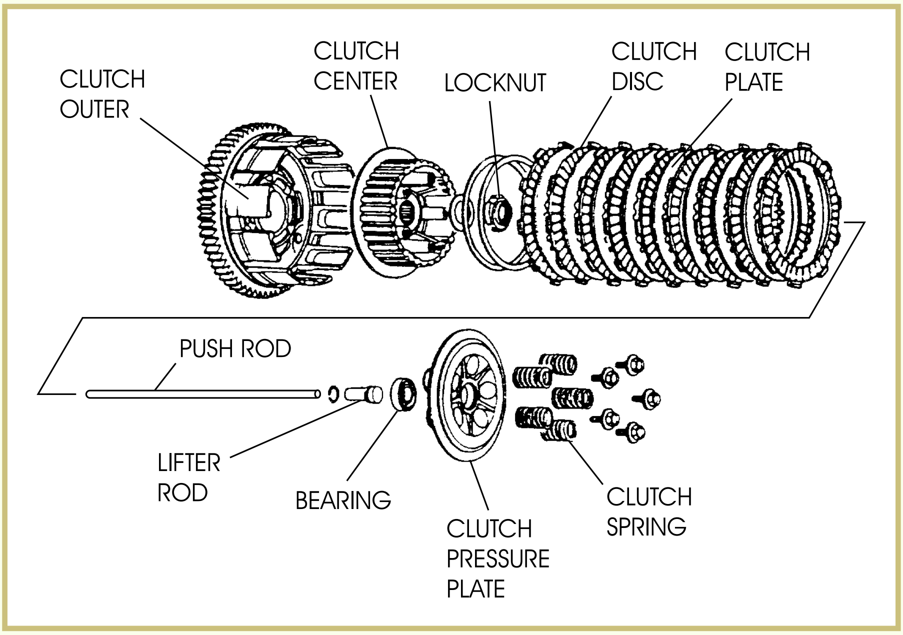


FIGURE 5—Multiplate Manual Clutch with Inner Pressure Plate (Copyright by American Honda Motor Co., Inc. and reprinted with permission)

- The clutch outer, which may also be called the *clutch basket*, contains all of the components of the clutch and has the driven gear for the primary drive attached to it. This component freewheels on the transmission main shaft and rotates whenever the engine is running. Most clutch outers use springs or rubber dampers to absorb excess power pulses so that the pulses aren't transmitted through the rest of the drive line. The clutch outer is driven by the engine and is tabbed (connected) to all of the clutch plates.

- The clutch center, which may also be called the inner clutch hub, is splined to the transmission main shaft and secured with a locknut. The clutch center has splines machined into it and is driven by the clutch plates. When the clutch plates rotate, the clutch center also rotates. The clutch center is connected directly to the transmission. The clutch center is tabbed to all of the clutch discs.
- Clutch discs transmit the power of the clutch outer to the clutch center and are normally made of a high-friction material. Clutch discs are also known as friction plates. The materials used to make friction plates are well-kept secrets by the makers of different clutches, but it's known that some of the materials used to produce friction discs are cork, neoprene, and Kevlar. These discs are connected to and driven by the clutch outer. Clutch discs have tabs on their outer edge that fit into the slots, or fingers, in the clutch outer. Like the clutch outer, the clutch discs rotate whenever the engine rotates. This being a wet clutch, the friction material is kept cool by the oil in the lubrication system. As the clutch friction material wears down, it begins to contaminate the oil in the transmission.
- Clutch plates are connected to and used to transfer the power from the clutch discs to the clutch center. When the clutch plates rotate, the transmission shaft also rotates.
- The clutch pressure plate applies pressure to the clutch plates and discs, which prevents the clutch from slipping. When pressed together, the clutch plates and discs form one unit and allow power to flow through them. The clutch pressure plate is pushed by the clutch release mechanism, which releases the pressure applied to the plates and discs to separate them from each other and to disengage the clutch.
- Clutch springs hold the clutch pressure plate firmly against the clutch plates and discs.
- The lifter rod applies pressure to the clutch pressure plate to release the clutch.
- The bearing reduces the friction of the lifter rod as it applies pressure to the clutch pressure plate.
- The push rod pushes the lifter rod, which in turn releases the clutch pressure plate. Push rods may be installed through the main shaft as illustrated in Figure 5 or they may be attached to the outside of the clutch.

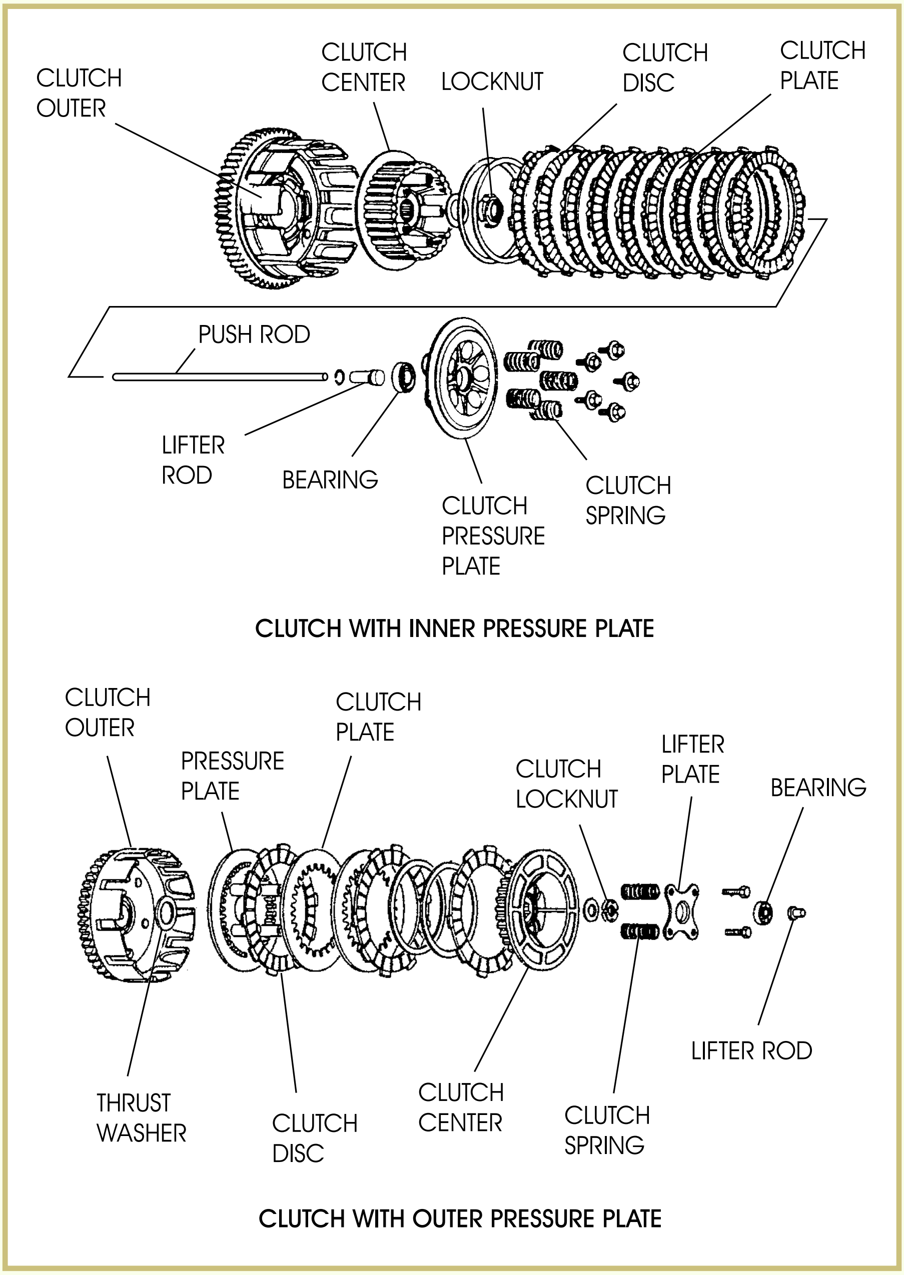
Single-Plate Manual Clutch

The single-plate manual clutch uses the same basic components as the multiplate clutch. As the name implies, the main difference between the two clutches is that the single-plate manual clutch uses only a single friction plate. This type of clutch is used on BMW motorcycles.

Manual Clutch Release Mechanisms

Clutch release mechanisms are used to disengage the power flow from the engine to the transmission. Clutches are designed to have an inner pressure plate or an outer pressure plate (Figure 6).

FIGURE 6—Multiplate Manual Clutch with Inner or Outer Pressure Plate (Copyright by American Honda Motor Co., Inc. and reprinted with permission)



When the clutch is disengaged, the release mechanism pushes against the clutch pressure plate. This pressure separates the clutch drive plates from the driven plates. The clutch must be engaged gradually to prevent a sudden grabbing of the clutch which will cause the motorcycle or ATV to lurch forward. There are seven common manual clutch release mechanisms:

- Rocker arm
- Ball and ramp
- Rack and pinion
- Lever
- Cam
- Screw
- Hydraulic

All but the hydraulic release mechanism use a cable that's attached to the handle bar to activate them. The hydraulic method uses hydraulic fluid in place of the cable.

Multiplate Manual Clutch Operation

A clutch is either engaged or disengaged (Figure 7). The following paragraphs describe each of these conditions.

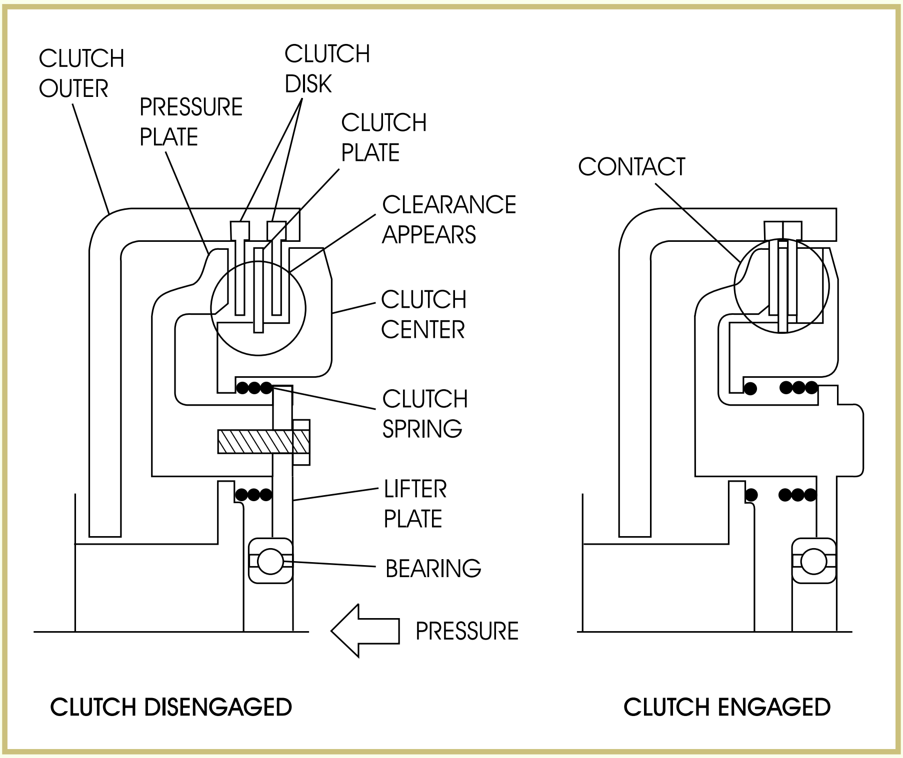


FIGURE 7—Clutch Operation (Copyright by American Honda Motor Co., Inc. and reprinted with permission)

Engaged. When the transmission is shifted into gear and the clutch lever is gradually released, the clutch discs and clutch plates become caught between the pressure plate and the clutch center. This now prevents the clutch from slipping and the power of the crankshaft is completely transmitted to the rear wheel.

Disengaged. When the clutch lever is pulled, the clutch push rod pushes against the clutch lifter rod. The clutch lifter rod applies pressure to the clutch pressure plate, resulting in a gap between the clutch discs and clutch plates. This separates the power of the crankshaft from the rear wheel and allows the clutch to slip.

Centrifugal Clutch

The centrifugal clutch (Figure 8) is among the simplest clutch designs and uses the engine's rpm to engage and disengage the crankshaft power to and from the engine's final drive. Since this clutch system relies on the engine for engagement, there's no need for a handlebar-mounted clutch lever. The centrifugal clutch uses weights and springs to determine the rpm's necessary to disengage and engage the clutch. When the engine rpm's are high enough to overcome the tension of the springs, centrifugal force throws the weights outward against the clutch drum to engage the crankshaft with the clutch outer. In many ATVs, this type of clutch is often used in conjunction with a manual multiplate clutch, as shown in Figure 9. The combination of these two clutch systems allows the engine to remain in gear while idling to allow the rider to come to a complete stop without having the engine stall.

Variable-Ratio Clutch

Variable-ratio clutch systems (Figure 10) are often seen on motorscooters and also may be found on some ATVs. Although named a "variable-ratio clutch," this system is actually a transmission system that provides a variable drive ratio between the engine and the rear wheel. Power is never actually disengaged as it would be in a true clutch. The variable-clutch system consists of a drive pulley which is attached to the engine crankshaft and a driven pulley that's attached to a shaft which may also incorporate a centrifugal clutch. The two pulleys are connected by a drive belt. Many variable-ratio clutch systems also have a final gear reduction between the driven pulley and the rear wheel to provide an extra increase in torque when needed.

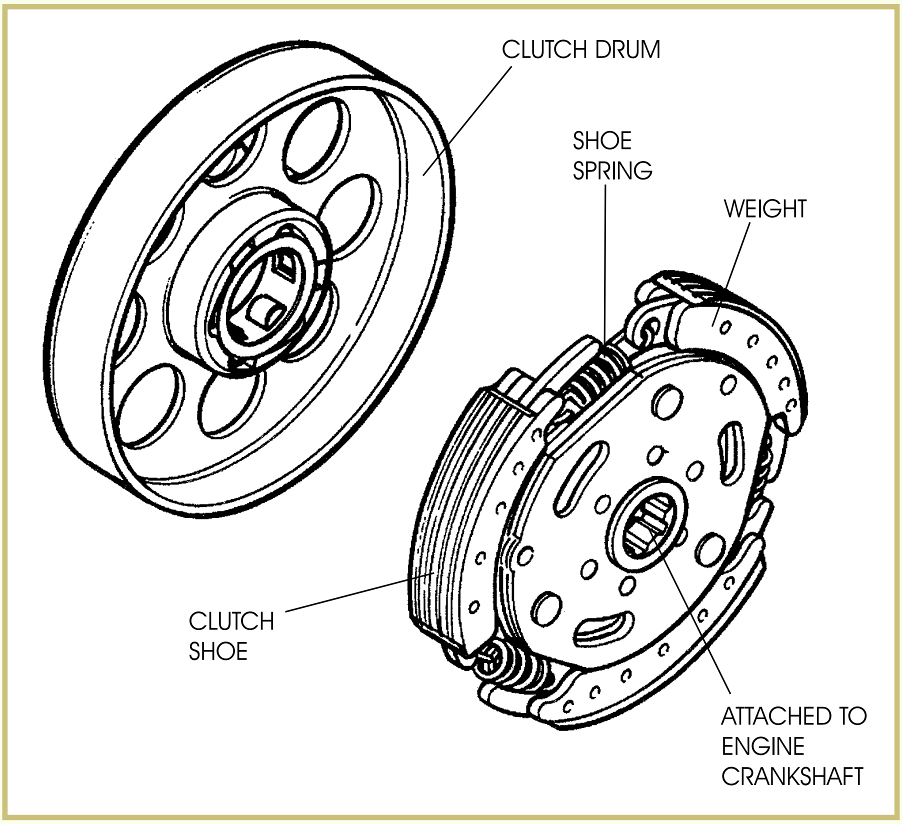


FIGURE 8—A Centrifugal Clutch (Copyright by American Honda Motor Co., Inc. and reprinted with permission)

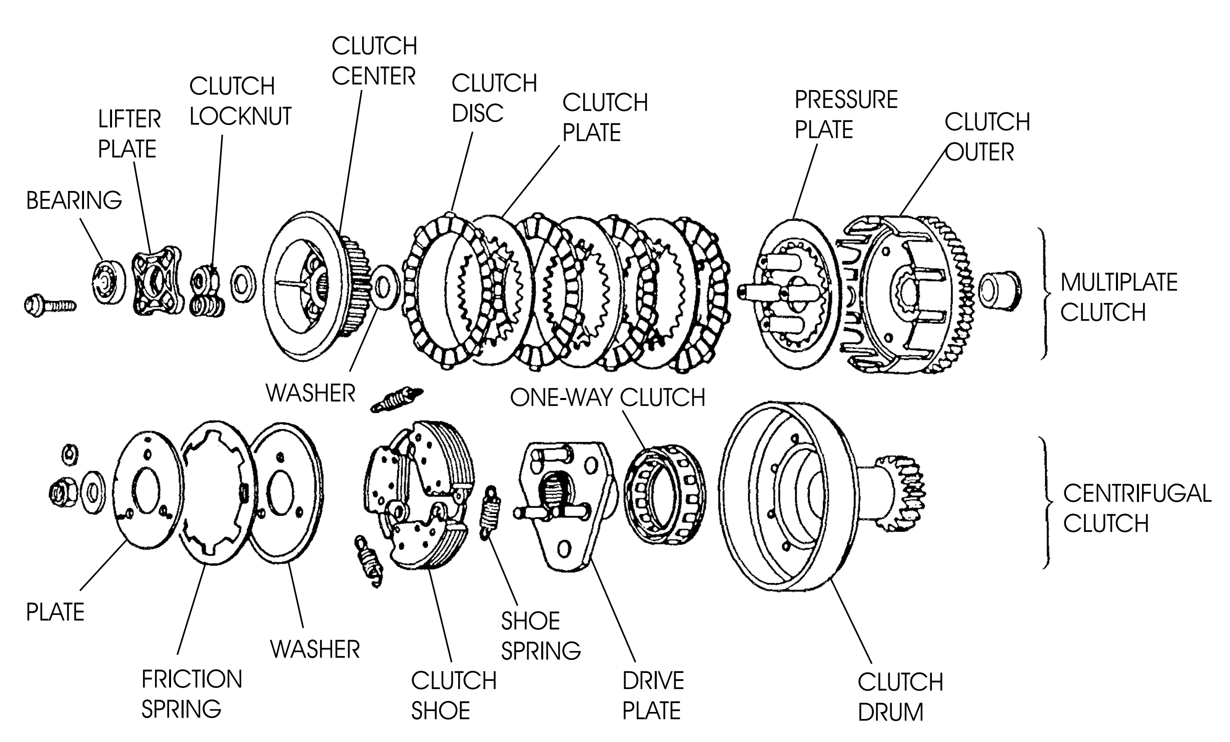


FIGURE 9—Multiplate and Centrifugal Clutch (Copyright by American Honda Motor Co., Inc. and reprinted with permission)

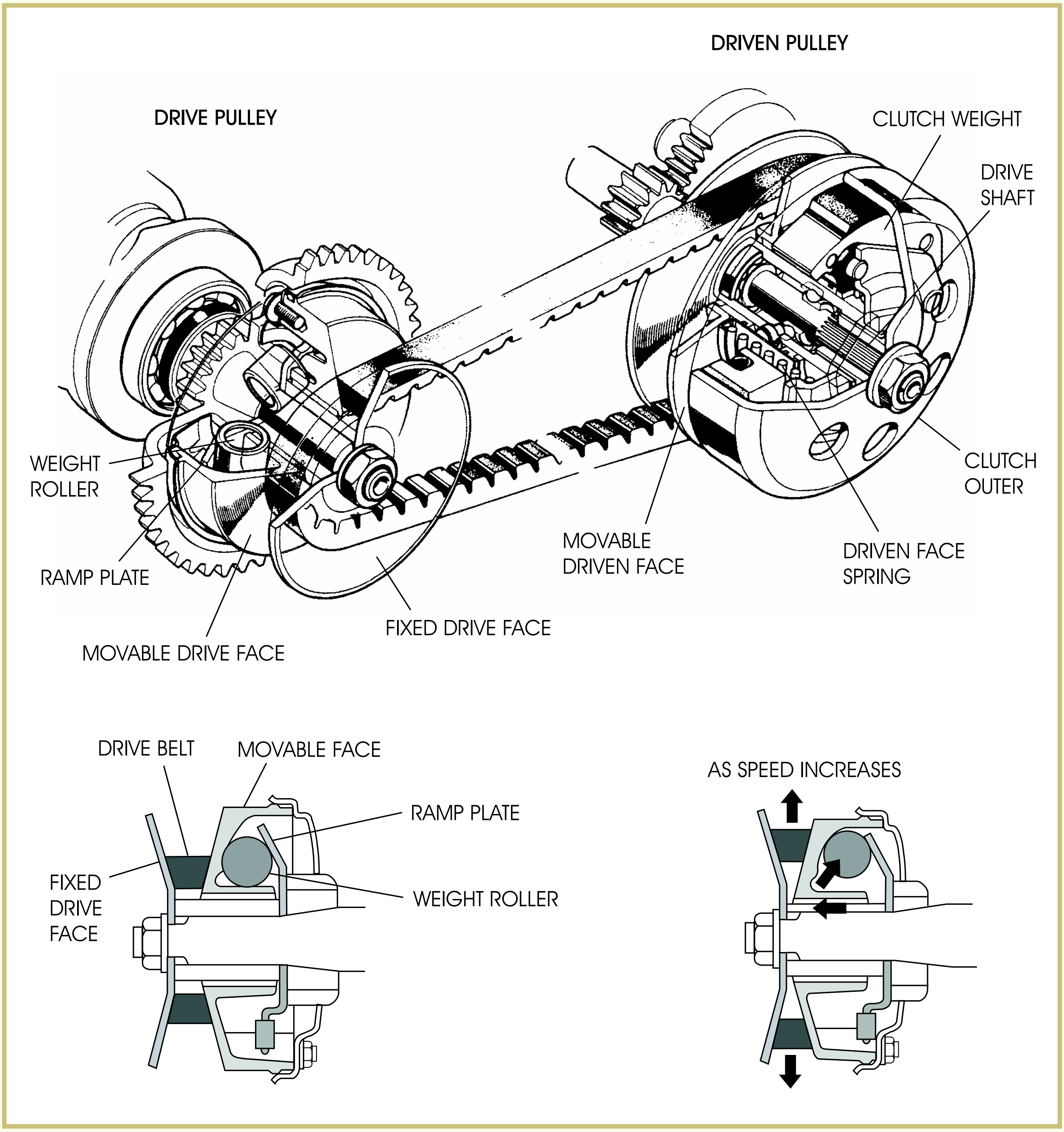


FIGURE 10—Variable-Clutch Operation (Copyright by American Honda Motor Co., Inc. and reprinted with permission)

Variable-Clutch Drive Pulley Operation

The drive pulley consists of a fixed and a movable face. The movable face has the capability to slide towards the drive face. There's also a ramp plate incorporated in the drive pulley which pushes weight rollers against the drive face. As engine speed increases, centrifugal force pushes the weight rollers outward. This force pushes the movable face toward the fixed face, which in turn pushes the drive belt upward toward the top of the drive pulley. This reduces the drive ratio by forcing the drive belt to ride on a pulley of larger diameter. As the engine speed decreases, the belt is pulled back into the drive pulley, which increases the drive ratio by allowing the belt to ride on a pulley of smaller diameter.

Variable-Clutch Driven Pulley Operation

Because the belt remains constant in length, the driven pulley reacts to the drive pulley by allowing the drive belt to be pulled in toward the center of the driven face. By doing this, the diameter of the belt on the driven face decreases at higher engine speeds. When the engine speed decreases and the belt is pulled back into the drive pulley, the driven face spring moves the movable driven face towards its resting and original position. This pushes the drive belt back to the circumference of the driven pulley.

In the operations described above, the reduction ratio automatically varies as the engine speed changes without the need to manually shift to change gear ratios. When the engine is running at lower engine speeds the gear ratio is high, which allows for greater torque. As engine speed increases, the drive ratio becomes lower between the driven and drive pulleys.

Sprag Clutch

Another type of clutch used in different areas of the motorcycle is the sprag or “one-way” clutch (Figure 11). This type of clutch is used with some primary drive systems as well as some electric starting systems and prevents damage to the starter motor when the engine engages. The sprag clutch allows a portion of the clutch to slip when under high-stress situations such as rapid downshifting, when used in conjunction with the primary drive, or when trying to use the electric starter and the engine backfires. This prevents the loss of traction that can occur as a result of extreme compression-braking forces within the engine. By allowing the clutch to slip, the rear wheel has better traction and won’t “hop” during compression-braking forces. On motorcycles and ATVs that have a centrifugal clutch system, a sprag clutch may be used to provide some engine braking when the centrifugal clutch is disengaged. This gives the rider better control when bringing the machine to a stop or going down hills.

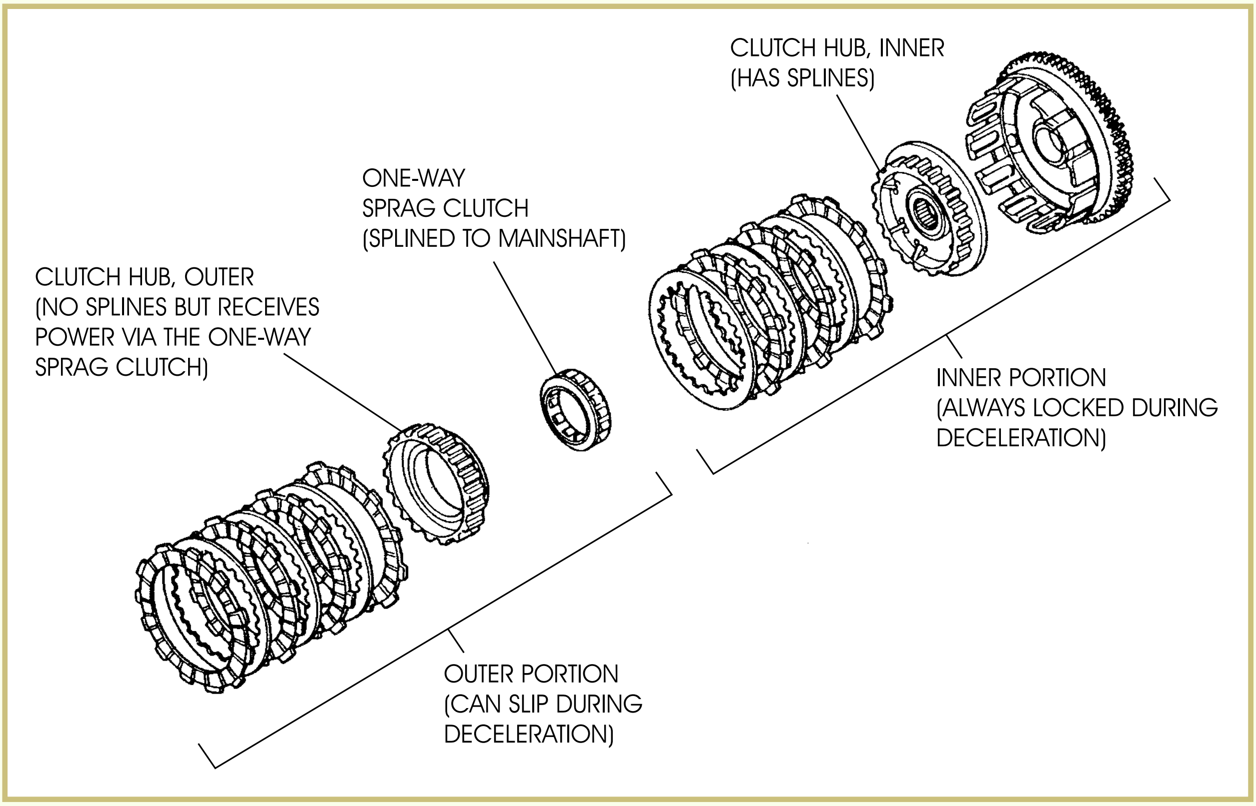
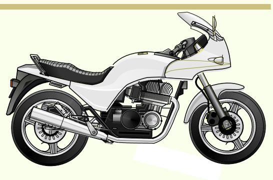


FIGURE 11—A Sprag Clutch (Copyright by American Honda Motor Co., Inc. and reprinted with permission)

Road Test 2



1. What are the names of the three types of primary drive systems that may be found on motorcycles and ATVs?

____

2. What component is used to engage and disengage the power flow from the engine to the transmission?

____

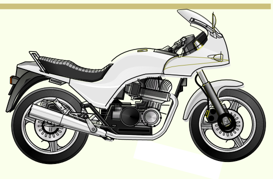
3. The _______ clutch is the most widely used clutch on motorcycles and ATVs.

4. The _______ clutch is used mostly on motorscooters and also on some ATVs.

5. When the _______ primary drive system is used, the crankshaft rotates in the opposite direction as the clutch.

(Continued)

Road Test 2



6. What clutch release mechanism doesn't use a cable to actuate it?

____

7. The _______ clutch is both a clutch and a transmission.

8. Which type of clutch is often used in conjunction with a manual multiplate clutch in many ATVs?

____

9. What component of a manual clutch is normally made of a high-friction material?

____

Check your answers with those on page 49.

SERVICE AND REPAIR OF CLUTCHES

Servicing and repairing clutch components are two of the jobs you'll need to perform frequently as a technician. Because clutches are engaged and disengaged each time the transmission gears are shifted, clutch components have a tendency to wear. Additionally, the clutch parts perform the difficult job of locking the power output of the engine to the transmission and then to the drive wheel.

We can't overemphasize the importance of correctly servicing clutch components. Proper adjustment of the release lever, cable, release rod, spring pressure, and so forth determines how long a clutch performs satisfactorily. Because you can't properly adjust parts which need repairing, this section of your study unit is divided into two sections. The first section covers how to correctly adjust the various parts of the clutch assembly. The second section covers the repair of clutch parts.

Common Clutch Problems

You'll find two common clutch problems with any of the previously mentioned clutches in this study unit. The first problem is a clutch that slips. Clutch slippage occurs when the clutch doesn't have the ability to transfer all of the engine's power flow. This problem may be caused by improper adjustment, weak clutch springs, or worn clutch plates.

The second common problem you may find with a clutch is known as clutch drag. Clutch drag occurs when the clutch is unable to fully disengage. Clutch drag is evident when the engine power can't be disengaged from the rear wheel. An example of this condition is when you squeeze the clutch lever and the motorcycle or ATV still tries to move forward. Possible causes of this condition include warped or binding clutch plates, a worn clutch outer or clutch center, improper clutch adjustment, or a worn release mechanism.

Clutch Adjustment

Most clutch problems originate from an improperly adjusted clutch. Whenever there's an indication of a clutch problem, it's very important to verify that the clutch is adjusted properly. In most cases, a simple adjustment solves either a slipping or a dragging clutch. Most manual clutches use a clutch cable to link the handlebar lever to the clutch release mechanism which is attached to the engine. Most motorcycles and ATVs that have a clutch cable also have a clutch cable length adjuster and a clutch release adjuster—both of which you can use to properly adjust the clutch.

The cable length adjuster is used to adjust the play in the cable. The manufacturer has the correct specification for the lever in the service manual or the owner's manual. You can adjust the amount of play in the cable simply by turning the adjuster in or out.

The clutch release adjuster is used to verify that there's a proper amount of clutch rod movement for correct disengagement. Once properly adjusted, you shouldn't need to further adjust the release adjuster. Because there are many different types of adjusters and each has a specific method of adjustment, you'll need to refer to the manufacturer's service manual for the correct procedure. For any adjustments thereafter, you'll need to remove excess slack from the clutch cable as it stretches.

The next portion of this study unit concentrates on the service and repair of wet multiplate manual clutches primarily because they're the most popular clutch used. Before proceeding, we suggest that you review our discussion on the manual multiplate clutch system components so that you'll have a picture in your mind of how a clutch works as you continue with this lesson on clutch repair. In that section of the study unit, you learned about the various internal clutch parts and how they work. In this lesson, we'll be working with the entire clutch assembly, including parts such as the clutch handlebar lever and clutch cable.

Multiplate Manual Clutch Adjustment

The proper sequence for clutch adjustment is

1. Adjust the release mechanism at the engine.
2. Adjust the cable play at the clutch lever.

As discussed before, clutches that drag (don't fully disengage) prevent smooth shifting of transmission gears; clutches that slip (don't fully engage) won't transmit all available engine power to the transmission. Sometimes either one of these conditions can be corrected by making simple clutch adjustments.

These problems may be caused by

- Not enough cable movement at the handlebar lever
- Improper cable adjustment
- Improper release rod adjustment
- Improper spring tension

These problems may be interrelated. The following items must be checked to ensure correct adjustment of each part (Figure 12).

Lever Movement. You should be sure that the clutch lever on the handlebar isn't bent and has as much movement as it was designed to have. You should also be sure that the lever doesn't contact the handlebar grip before the inner clutch cable has been pulled to its maximum extension.

Improper Cable Adjustment. You must adjust the cable so that it has $1/16$ inch to $3/16$ inch play, that is, so that the lever on the handlebar can be depressed $1/16$ inch to $3/16$ inch *before* the pressure of the clutch spring resisting release can be felt. Take the measurement from where the cable attaches to the handlebar lever. Adjust the cables by turning the adjuster at either end of the cable. Turn the adjuster "in" for more play and "out" for less play. If the play is measured out at the end of the clutch lever, the measurement should be from 1″ to 1 $1/4$″.

Improper Release Rod Adjustment. The release rod adjustment must allow enough play in the release rod to allow the springs to expand, but not too much play or the rod won't move far enough to relieve the pressure from the clutch plates. To adjust the release rod, you must first disconnect the clutch cable from the release rod lever located on the engine cover case. Next, you must adjust the release rod screw so that pressure is applied against the springs. Then you must readjust the adjustment screw to allow for the manufacturer's recommended play of the release rod lever. You should be able to move the end of the release rod lever $1/32$ to $1/16$ inch from fully open before the clutch spring pressure resists the lever movement.

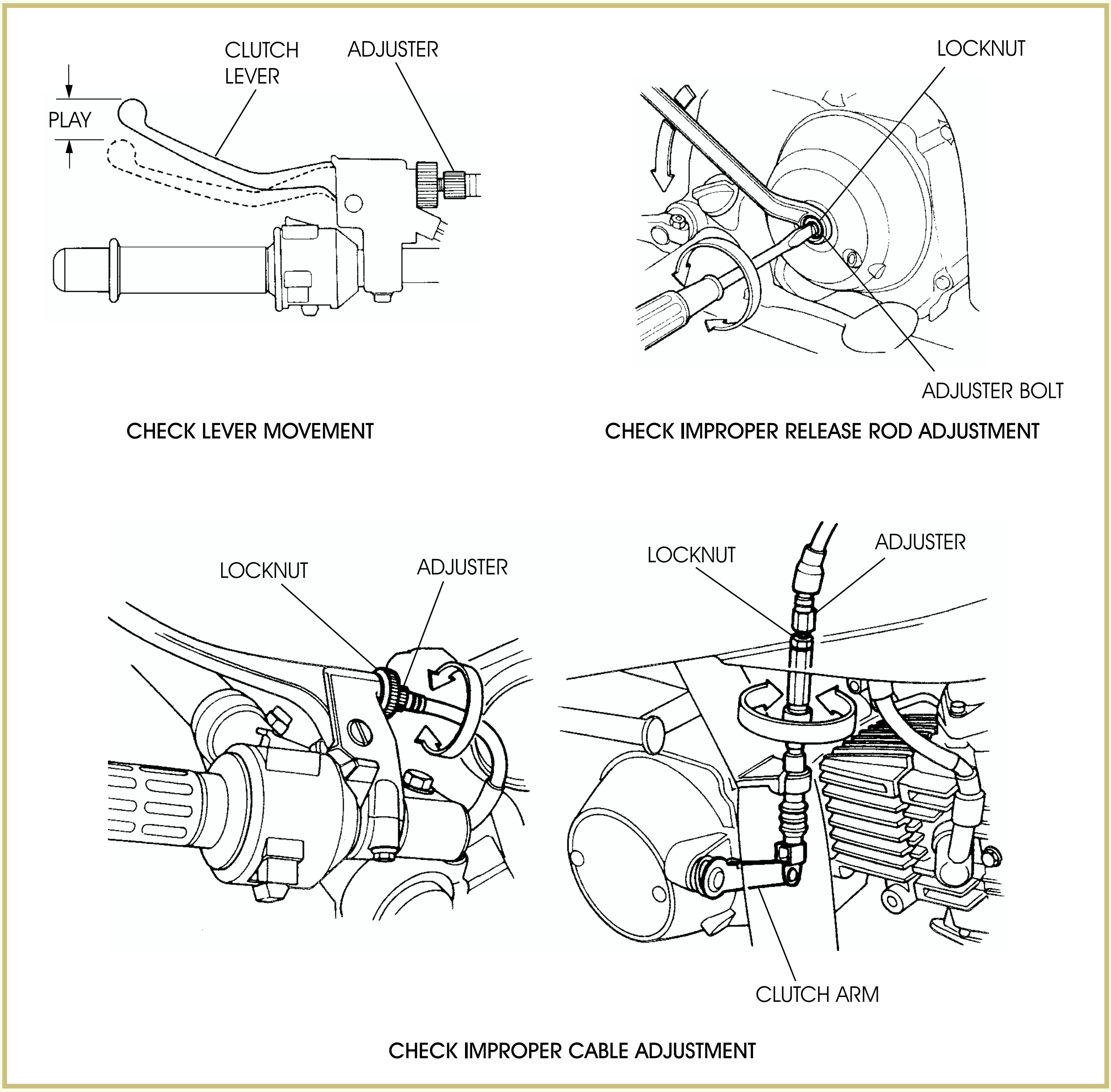


FIGURE 12—Clutch Adjustment (Copyright by American Honda Motor Co., Inc. and reprinted with permission)

Multiplate Manual Clutch Repair

The major multiplate manual clutch components (Figure 5) that can be repaired include the

- Clutch outer (clutch basket)
- Clutch center (clutch hub)
- Clutch plates and discs
- Clutch springs
- Clutch bearings

Clutch Basket Repair

One problem you'll encounter with the clutch basket is indentations that are worn into the housing by the drive plates. Using Figure 5 as a reference, note that the clutch basket (clutch outer) contains several grooves. These grooves are designed to allow the clutch friction plates (clutch discs) to move away from the metal clutch plates when the clutch is released.

Because the small ears or "prongs" on the friction plates are used to lock the plates in these grooves, and power from the engine is applied to the prongs from the grooves, an indentation eventually appears in the clutch housing grooves where the prongs press against the edges of the grooves. This condition may be seen in Figure 13. When these indentations form, they have a tendency to hold the prongs of the friction plates and prevent the plates from separating when the clutch is released—thus continuing to transmit engine power to the transmission when the clutch is released. In many cases, the only solution is to replace the clutch housing. However, if the indentations aren't too deep, you could file the grooves smooth using a flat file and then recut the grooves. When doing this, you must be sure that the edge of the groove is smooth and faces at a 90° angle to the clutch plate prongs. This allows more prong surface to contact the edge of the groove and delays future wear, reducing the need for further repair.

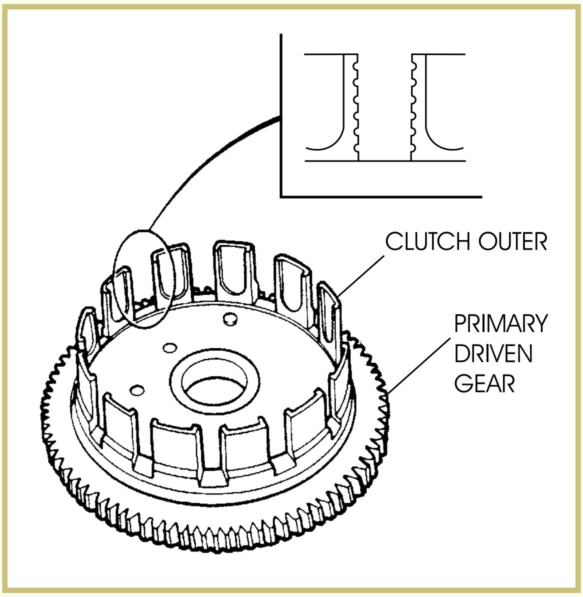


FIGURE 13—Clutch Damage (Copyright by American Honda Motor Co., Inc. and reprinted with permission)

Clutch Center Repair

Problems in the clutch center (or inner clutch hub) are essentially the same as problems involving the clutch basket. Repairs are usually done for the same reason—to provide the largest and smoothest possible area for the prongs of the clutch plates to seat on or slide over. The grooves of the clutch center tend to develop indentations similar to those that develop on the grooves of the clutch housing. As with the clutch basket, if these indentations aren't too deep, the grooves can be filed smooth with a file.

Clutch Plates and Disc Repair

Repairs to clutch plates and discs depend a great deal on the motorcycle model you're repairing. Generally, clutch plates and discs need replacement when they don't perform satisfactorily or don't meet factory specifications. As a general rule, clutch plates are replaced when they're warped beyond the manufacturer's specifications; clutch discs are replaced when they're worn beyond their service limit thickness.

Clutch Spring Repair

Clutch springs must apply equal pressure to both the drive and driven clutch plates. These springs aren't normally adjustable, but when worn will apply unequal pressure to the clutch plates, which may cause the clutch to slip. This spring tension problem is corrected by replacing the clutch springs. After replacing springs, you should perform a final adjustment of the clutch push rod to be certain it has the proper amount of play.

Clutch Bearing Repair

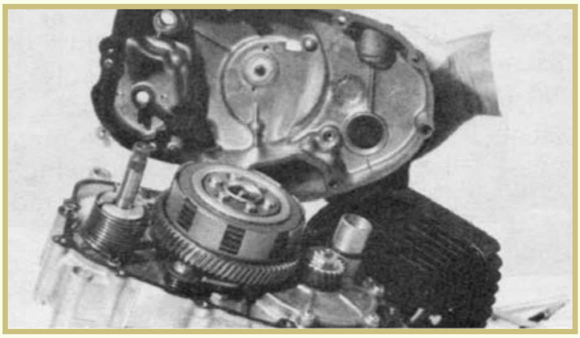
You should recall that the function of the clutch bearing is to reduce the friction between the clutch lifter rod and the clutch pressure plate when the clutch is disengaged and engine power isn't being transmitted to the transmission. Clutch bearings may be of the ball bearing, roller bearing, or bushing type. Each type of bearing eventually becomes worn and needs replacing. In many cases, to replace the bearing, you'll have to completely disassemble the clutch components because the bearing is in the centermost part of the clutch. This is discussed in greater detail later in this study unit.

An Example Repair of a Typical Multiplate Manual Clutch

In the following paragraphs, we'll step through the disassembly and repair of a typical motorcycle clutch. 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, service tips, and above all—it contains the appropriate safety information. Although it's not necessary in most models, we've removed the engine from the chassis in this example to better illustrate the procedures.

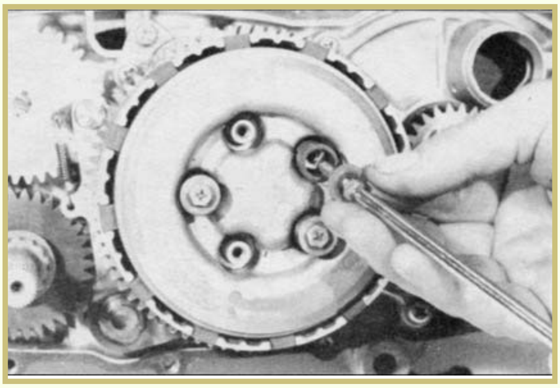
1 Drain the oil from the transmission and clutch cover case.

2 Remove the screws securing the clutch cover case and lift off the cover case.



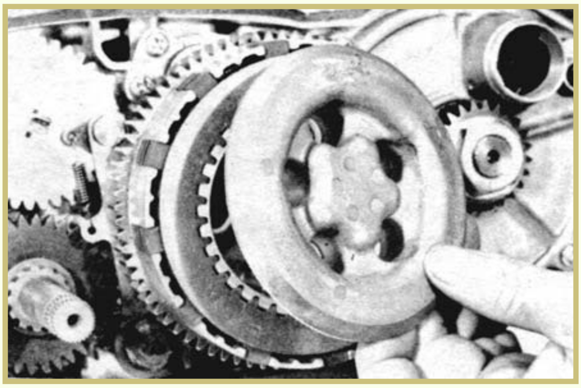
3 Remove the screws securing the clutch springs. Compare the length of the old springs with the length of a new spring. Replace the old springs if they're shorter.

Note: Most service manuals have specifications for correct spring length which are measured using a vernier caliper.

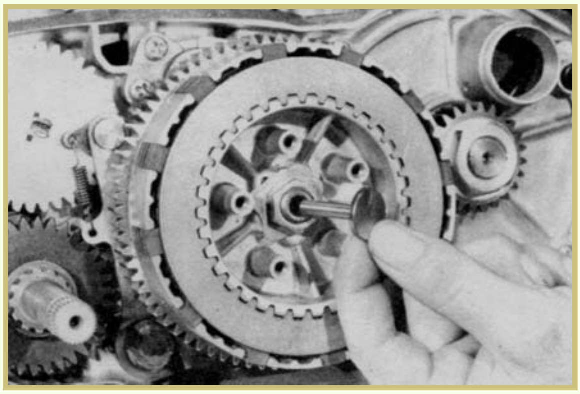


4 Lift the pressure plate.

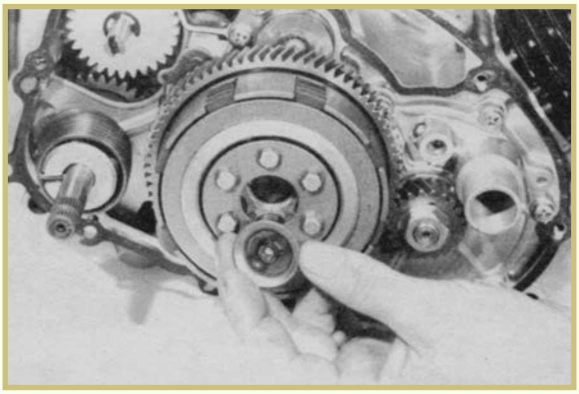
Note: Some models have the springs located inside the pressure plate, and on these models steps 3 and 4 would be reversed.



5 Pull the lifter rod from the hollow transmission input shaft.



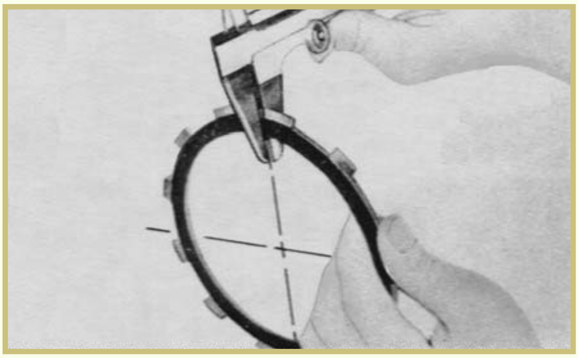
Note: Not all clutches use the same method of attaching the lifter rod. This illustration shows an example of another type of release rod mechanism. The release rod bearing is in the mechanic's hand in this illustration. The bearing fits into the hole in the center of the clutch and presses against the spring retainer when the clutch is disengaged.



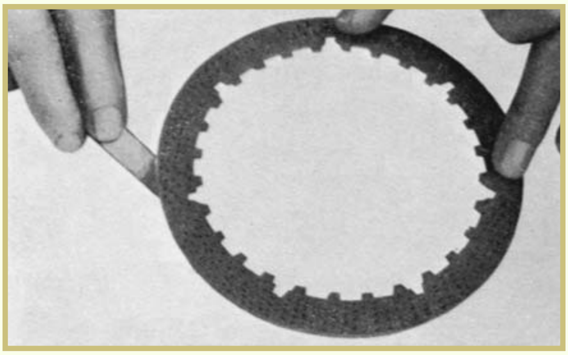
6 Remove each of the friction discs and clutch plates and inspect them for wear.

7 Measure the clutch friction plates to be sure they're the correct thickness.

Note: When clutch friction plates become worn they can become too thin, causing the clutch to slip. The service manual for your particular model of motorcycle will tell you how thick the clutch plates should be. The most popular choice for measuring the thickness of the clutch friction and steel plates is the vernier caliper. Each plate must be measured individually.



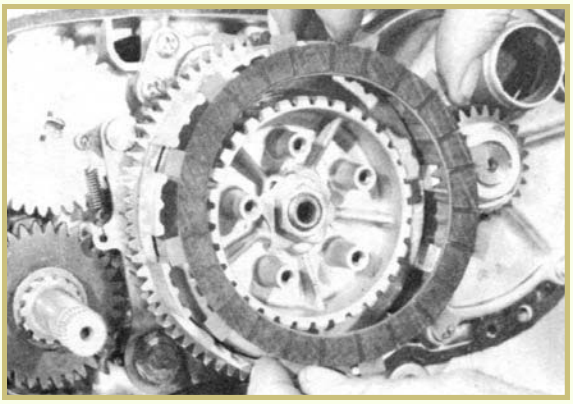
8 Check the clutch plates for warpage by putting each plate on a flat surface and running a feeler gauge under the edge. If the feeler gauge slips in anywhere under the edge, the plate is warped and must be replaced.



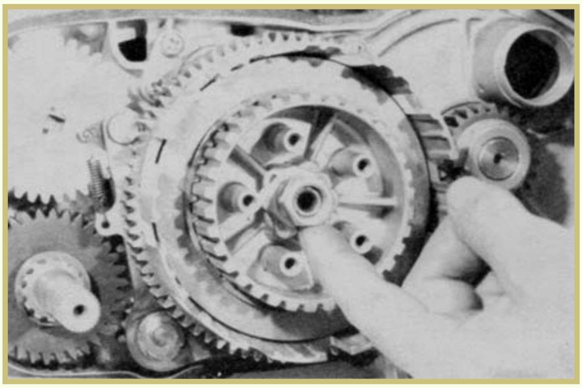
9 Inspect the clutch basket and clutch center grooves. Be sure the grooves are smooth so that the prongs of both the driving and driven plates fit properly.

Note: You can make a clutch center holding tool by welding a steel rod to an old clutch plate.

10 Place the plate over the clutch center to keep it from turning. Remove the nut securing the clutch center. Remove the clutch center and housing.

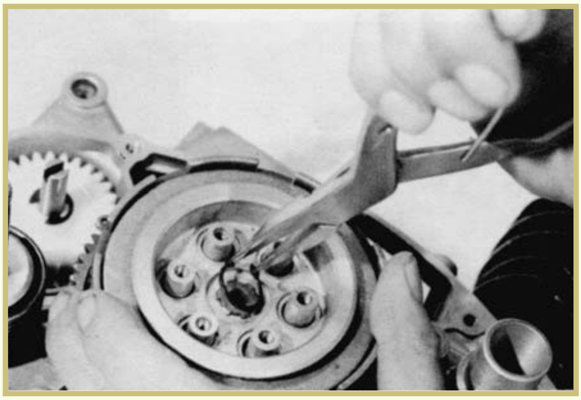


Note: Some motorcycles and ATV engines secure the clutch to the transmission input shaft with a retaining ring.



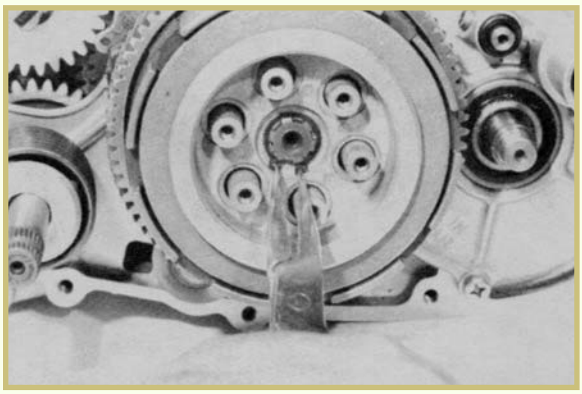
11 Remove the clutch using retaining-ring pliers or other appropriate tool.

12 Inspect the clutch basket bearing or bushing for excessive wear. If the clutch housing has excessive wobble when placed on the shaft, replace the bearing.



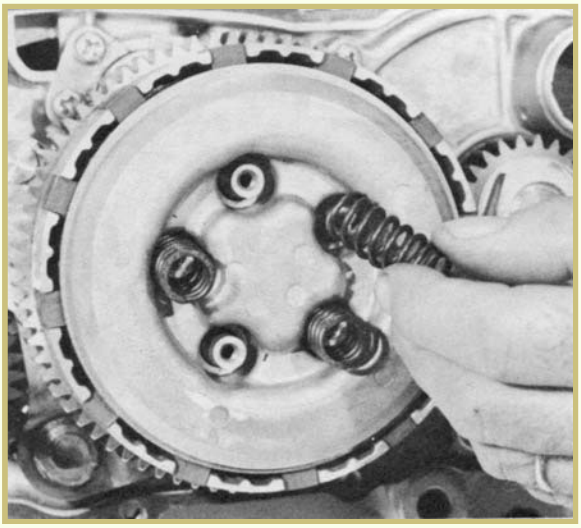
13 Reassemble the unit by placing the bearing (or bushing), spacers, housing, and clutch center on the transmission main shaft. Secure with the nut and bend the lock washer against the flat part of the nut, or replace the retaining ring.

Note: On some models which use a retaining ring to secure the clutch to the shaft, you may need to install the clutch plates before installing the retaining ring.



14 Reinstall the clutch plates, spacers, release rod, and pressure plate.

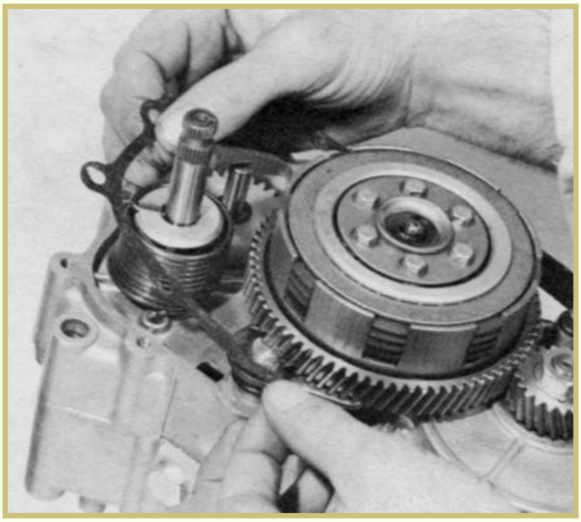
15 Install the springs and secure with screws. (If the new clutch plates are to be installed, they must first be soaked in the same oil that will be used in the clutch case.)



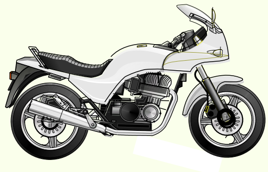
16 Reinstall the new gaskets, any O-rings, and the clutch cover. (Always install a new clutch cover gasket. Don't try to reuse the old gasket.)

17 Install the cover case screws and release rod lever.

18 Fill the engine with oil and check the cable adjustments.



When working on an engine with a clutch problem, you'll first have to decide if the problem is due to improper adjustment or if a component part needs to be replaced. If the problem is one of adjustment only, the situation is easily rectified. However, if the problem is due to worn internal components, you'll need to replace them, as adjusting the parts won't completely solve the problem if parts are excessively worn. It's a good idea to always check for an adjustment problem before you take a clutch apart to prevent any unnecessary disassembly work.



Road Test 3

1. *True or False?* A clutch that won't fully disengage can be the cause of a motorcycle or ATV that has a tendency to creep even though the clutch lever is fully depressed.

2. *True or False?* Worn-out clutch springs can cause a clutch to slip.

3. What is the proper sequence for correct clutch adjustment?

   ____

   ____

4. The two most common problems found in clutches are _______ and _______.

5. The proper measuring tool to check for the thickness of the clutch friction plates is a _______.

6. *True or False?* A grooved clutch basket can be repaired by filing it smooth.

7. Clutch plates need to be replaced when they become _______ beyond factory specifications.

8. What must be done *before removing* the clutch cover to prevent oil from spilling?

Check your answers with those on page 49.

TRANSMISSIONS

Now that you understand how and why primary drive systems and clutches are used on motorcycles and ATVs, we can move on to our discussion about engine transmissions. All motorcycles and ATVs require a method of transmitting the power from the engine to the rear wheel. Transmissions are used to change the speed of the machine while keeping the engine within its usable power band. A transmission consists of shafts and gears which are arranged to provide different gear ratios to the rear wheel. Transmissions allow the rider to increase and decrease the wheel speed while maintaining a constant engine speed.

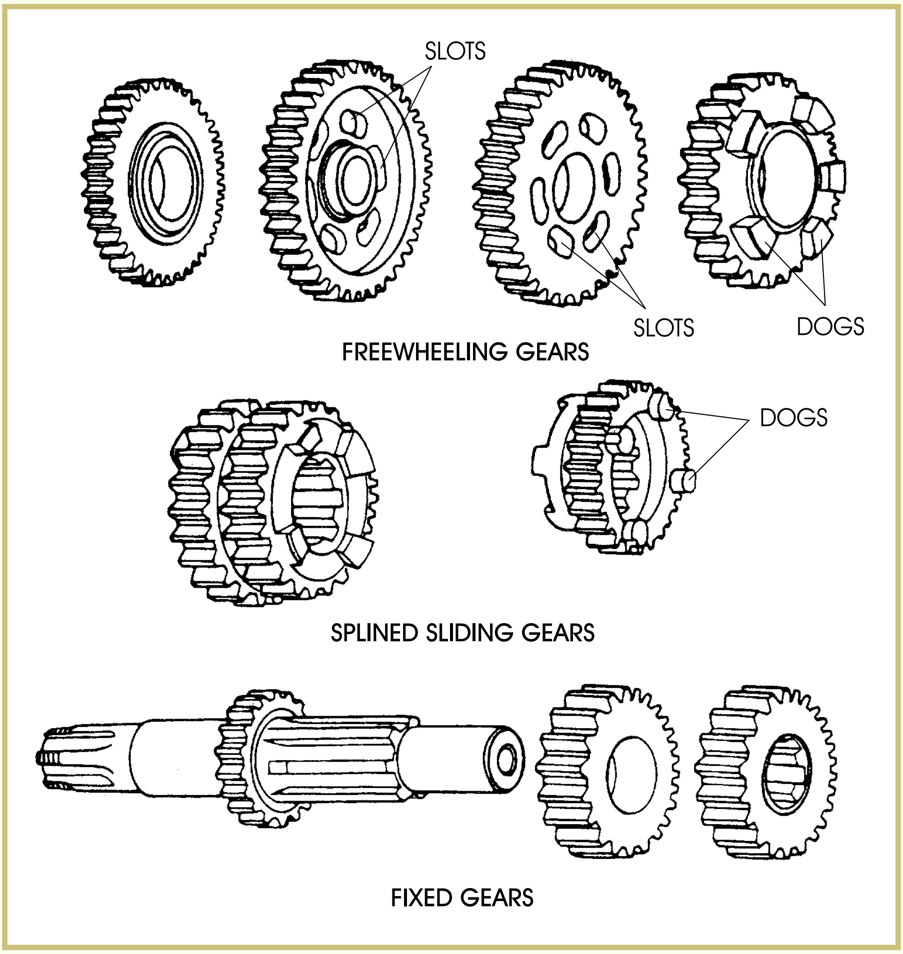
Transmission types vary from one manufacturer to another. However, if you can understand the basic principles of how the most popular transmissions operate, you'll be on your way to becoming a first-class motorcycle and ATV technician. In this lesson we're going to help you get a thorough understanding of how transmissions work.

In its simplest form, a transmission consists of a centrifugal clutch-attached to the crankshaft (input shaft). A belt or chain will be connected between the clutch and the rear wheel via a pulley or belt. As the engine speed increases, the clutch activates and propels the rear wheel. This type of transmission is an example of a single-speed transmission, which isn't the most efficient system available.

Transmission Gears

Most transmissions contain a combination of gears. The gears that may be found in a transmission include fixed gears, freewheeling gears, and sliding gears (Figure 14).

FIGURE 14—Transmission Gears (Courtesy of American Suzuki Motor Corporation)



Fixed Gears

A fixed gear is one that doesn't move on the shaft to which it's attached. Fixed gears are attached to a shaft in one of three ways. The gear may be machined as part of the shaft, splined to the shaft, or pressed onto the shaft. A fixed gear rotates at shaft speed.

Freewheeling Gears

A freewheeling gear moves freely on its shaft and is usually held in place by retaining rings. A freewheeling gear doesn't have to rotate at shaft speed and has slots or protrusions (called dogs) on its sides which allow the gear to engage a sliding gear. For a constant-mesh transmission to operate correctly, there must be a freewheeling gear opposed to a fixed or sliding gear on the opposite shaft. Constant-mesh transmissions are discussed a little later in this study unit.

Sliding Gears

A sliding gear is one that can slide across the axis of the shaft. A sliding gear is splined to the shaft and rotates at shaft speed. The purpose of this type of gear is to engage and disengage transmission gears. Sliding gears are moved left or right across the axis of the shaft by a shift fork (Figure 15). A sliding gear has dogs on its sides that are designed to engage a freewheeling gear.

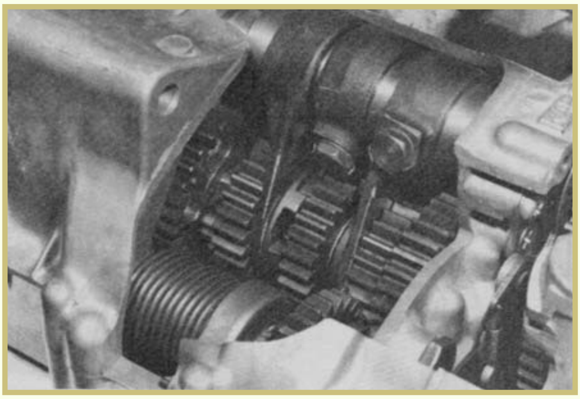
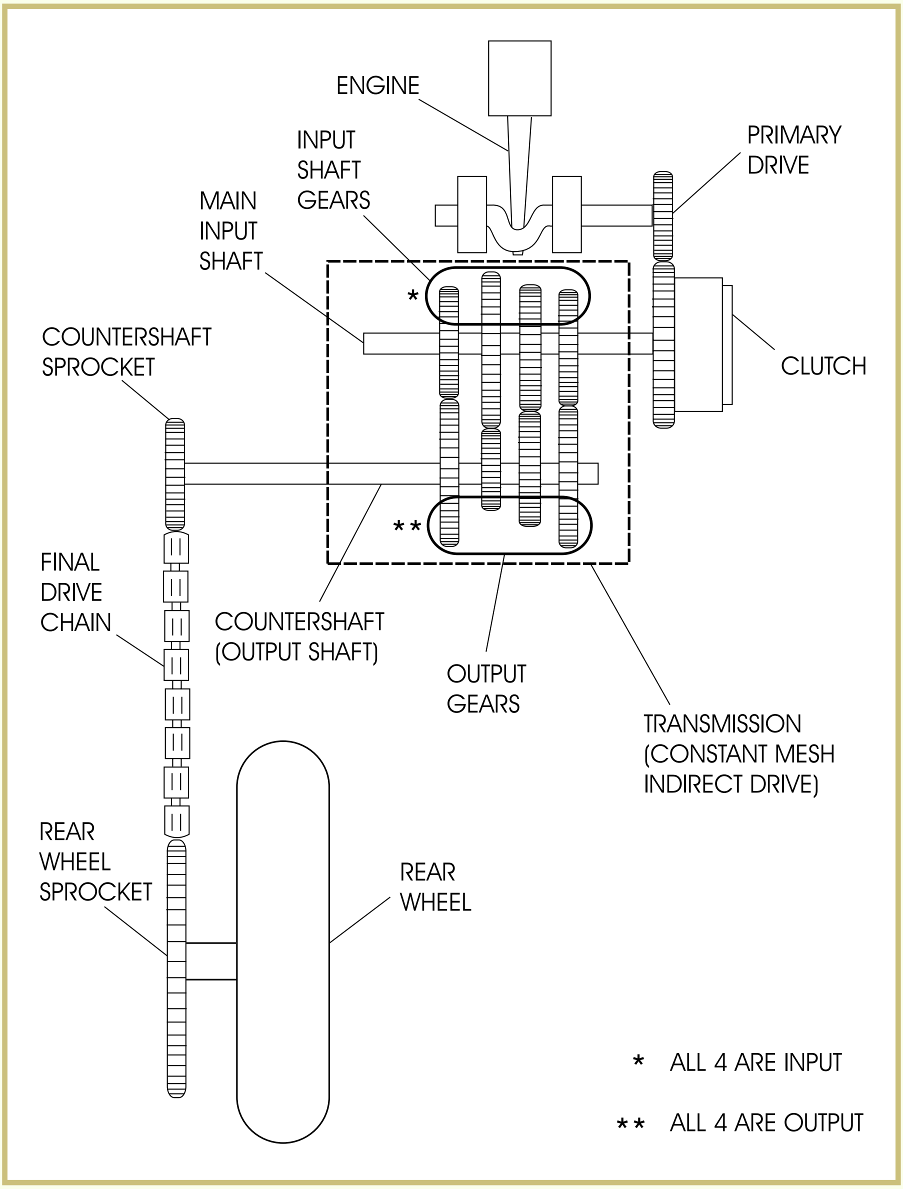


FIGURE 15—A shift fork must be straight to fit between the gears.

Constant-Mesh Transmissions

The most common transmission design is the constant-mesh transmission design (Figure 16). With a constant-mesh transmission, the teeth of all gears mesh with their mate on the opposing shaft at all times. The most common gears used in a typical constant-mesh transmission are spur (straight-cut) gears. There are two types of constant-mesh transmissions—indirect drive and direct drive.

FIGURE 16—A Typical Drive Shaft with a Constant-Mesh Indirect-Drive Transmission



Indirect-Drive Transmissions

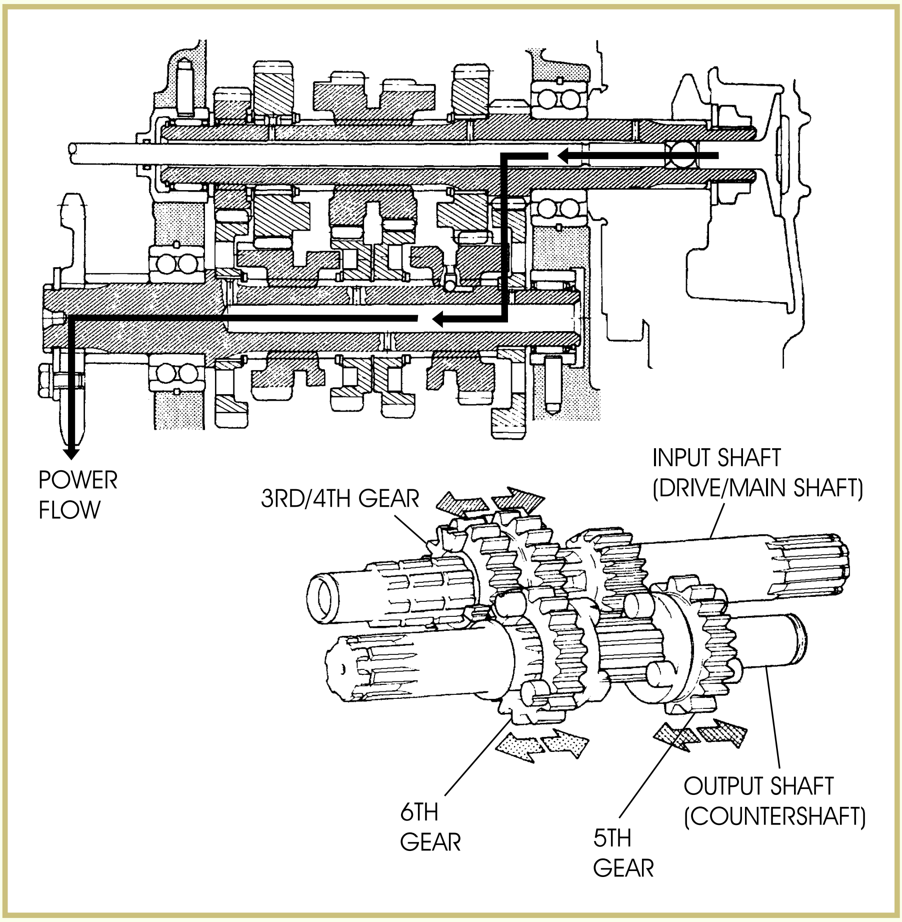
Indirect-drive transmissions have power entering on one shaft and exiting from another shaft on a different axis (Figure 17). The main, or drive, shaft of an indirect-drive transmission is splined to the clutch center. Power is transmitted through the clutch to the main shaft. The main shaft rotates opposite the countershaft. Power flow generally exits on the countershaft. The transmission countershaft turns the countershaft sprocket which is connected to the rear wheel.

The following facts apply to indirect-drive transmissions.

- All gears on the main shaft are drive gears.
- The smallest gear on the main shaft is a fixed gear and is part of low gear. The largest gear on the main shaft is part of high gear.

- All gears on the countershaft are driven gears.
- The largest gear on the countershaft is part of first gear. The smallest gear on the countershaft is part of high gear.

FIGURE 17—Indirect-Drive Transmission (Courtesy Kawasaki Motor Corp., U.S.A.)



Direct-Drive Transmissions

With a direct-drive transmission, the power flow enters on one shaft and leaves on another shaft of the same axis, instead of a different axis as found with the indirect-drive transmission. Top or high gear with the direct-drive transmission always has a ratio of 1:1, hence the name, "direct-drive." This type of transmission was widely used on older European motorcycles as with many older American-made motorcycles. The direct-drive transmission is often housed in a separate gearbox which isn't a part of the actual engine. Currently, the direct-drive transmission is found only on certain American-made motorcycles of the V-twin variety (Harley Davidson). There's a study unit that covers this type of motorcycle specifically, and we'll further study the direct-drive type of transmission in that study unit.

Dual-Range Transmissions

Another type of transmission, the dual-range transmission (also known as a *subtransmission*), is found in some dual-purpose motorcycles and widely found on ATVs. This type of transmission is a two-speed (high and low), auxiliary transmission that's placed into the power flow between the transmission output side and the final drive system. Usually, a dual-range transmission has a manual shifting arrangement. The dual range allows a trail bike to be on-road or off-road, and a touring motorcycle to have fast acceleration for city driving (low range) as well as a high range for long trips.

Shifting Transmission Gears

When you move the gearshift lever on a constant-mesh transmission, you're also moving mechanical connections which are linked to certain gears within the transmission. Each movement of the shift lever locks one set of gears into position, and this set of gears is then engaged. At the same time, all other gears within the transmission are disengaged. Thus, shifting gears is the way you control the position of gears in the transmission and select different gear ratios that best suit the riding conditions. There are several different components that make up the gear-shifting mechanism used on motorcycle and ATV transmissions. Later in this study unit, we'll look at some of them more closely.

The shifting sequence for a transmission is

1. Your foot moves the shift lever which is attached to a shift linkage.
2. The shift linkage moves a shifting mechanism.
3. The shifting mechanism moves a shift fork which in turn moves a sliding gear to engage and disengage the transmission gear.

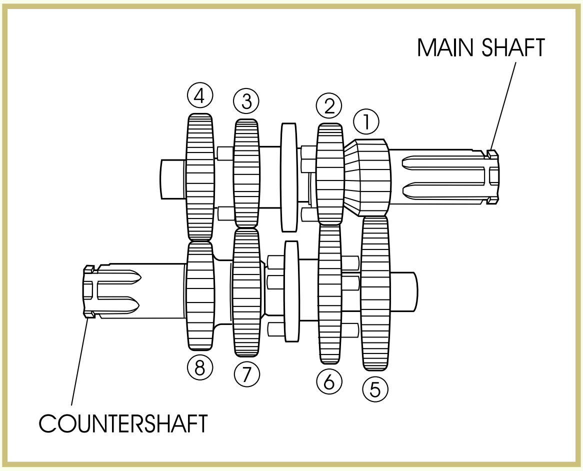
Let's trace the power flow through a typical four-speed indirect-drive transmission. Although the gear arrangement and number of gears vary greatly in engines used for motorcycles and ATVs, the power flow of indirect-drive transmissions is similar to that of the following example.

Indirect-Drive Transmission Power Flow

Neutral

Let's begin with the gear selection where there's no power transmitted to the rear wheel—neutral. Using Figure 18 as a reference, let's find out why power can't be delivered when the gears are in this position.

FIGURE 18—Neutral Gear



- Gear #1 is a fixed gear and turns with the main shaft. It meshes with gear #5 on the countershaft, causing it to spin. Because gear #5 is a freewheeling gear, no power is transmitted to the countershaft.
- Gear #2 is also a freewheeling gear, so power can't be transmitted to sliding gear #6 when the main shaft rotates.
- Gear #3 is a sliding gear and turns with the main shaft. It meshes with freewheeling gear #7, so power can't be transmitted in this position.
- Gear #4 is a freewheeling gear and can't transmit power to fixed gear #8 when arranged in this neutral position.

If you could see inside the transmission with the engine running and the gears in this neutral position, you would see the main shaft and gears #1 and #3 turning gears #5 and #7 with no rotation of the countershaft.

First Gear

Comparing Figure 18 (neutral gear) with Figure 19, you'll notice that gear #6, a sliding gear, has moved to the right. This gear change from neutral to first gear connects freewheeling gear #5 with sliding gear # 6, which is splined to the countershaft. By following the arrow, you can trace the power flow from the main shaft and gear #1 to gear #5 and #6, and through the countershaft which is now rotating to transmit power in first or "low" gear ratio.

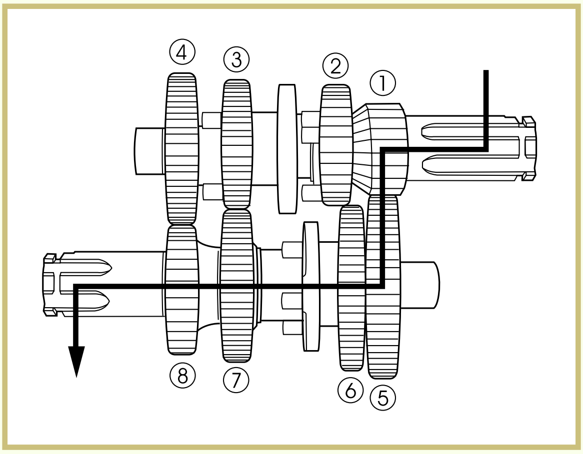


FIGURE 19—First Gear

Second Gear

Shifting from first gear into second gear causes two major changes in the arrangement of the gears. When comparing Figure 19 to Figure 20 you'll notice that sliding gear #6 has moved to the left, out of engagement with gear #5. Also, sliding gear #3 has moved to the right, into engagement with freewheeling gear #2. You can trace the power flow in the figure by following the solid line arrow from the main shaft and gear #2 to gear #6 (a sliding gear), which transmits power and rotation to the countershaft.

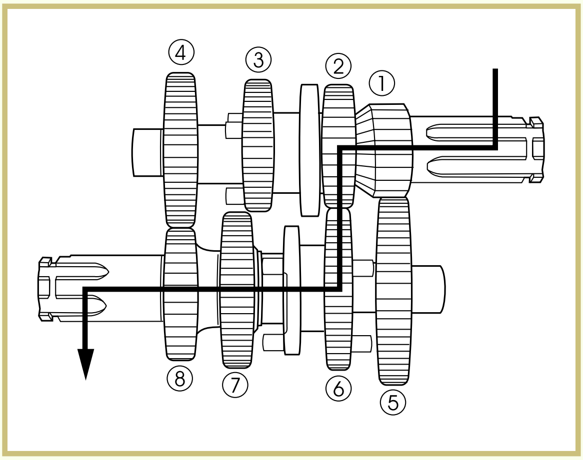
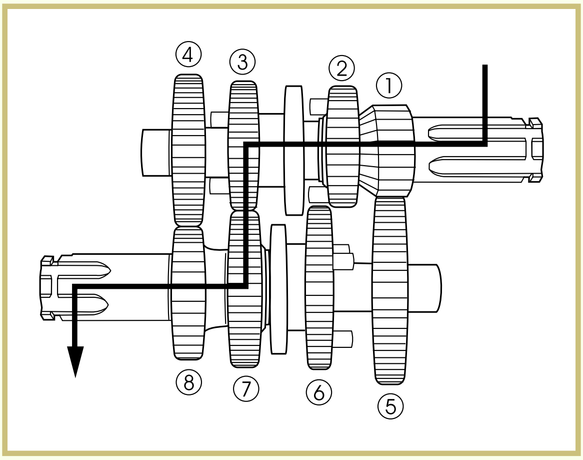


FIGURE 20—Second Gear

Third Gear

In Figure 21, notice that in shifting from second gear to third gear, sliding gear #3 has moved to the left, out of engagement with gear #2, and now meshes with gear #7. Also notice that sliding gear #6 has moved to the left to lock freewheeling gear #7 to the countershaft. As the arrow indicates, power flows through the main shaft and gear #3 (splined) into gear #7 and through the countershaft.

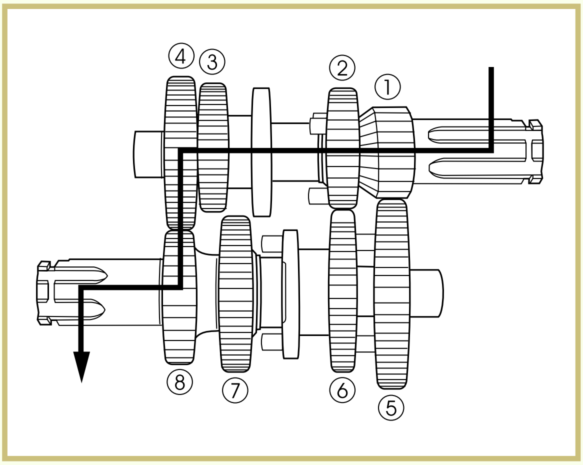
FIGURE 21—Third Gear



Fourth Gear

In a four-speed transmission, fourth gear is also called top gear or high gear. In Figure 22, notice that in shifting from third gear to fourth gear, gear #6 has shifted to the right, out of engagement with gear #7. Also notice that sliding gear #3 has moved to the left to connect with free-wheeling gear #4. As the arrow indicates, power now flows through the main shaft and gears #3 and #4 into gear #8 (a fixed gear) and out through the countershaft to the final drive system. Final drive systems are covered later in this study unit.

FIGURE 22—Fourth Gear



Shifting Mechanisms

Manufacturers of motorcycles and ATVs use many different mechanical systems to change the internal transmission gears from one gear ratio to another. Let’s look at how the most common shifting mechanisms work. Once you gain an understanding of these mechanisms, learning how the variations operate is easy.

The most common shifting mechanism in a constant-mesh transmission uses a component called a *shift drum* along with shift forks (Figure 23). You'll recall that shift forks fit into the grooves of sliding gears and allow movement to the right or left on the transmission shaft. Now let's learn what makes them move.

FIGURE 23—Shift Drum

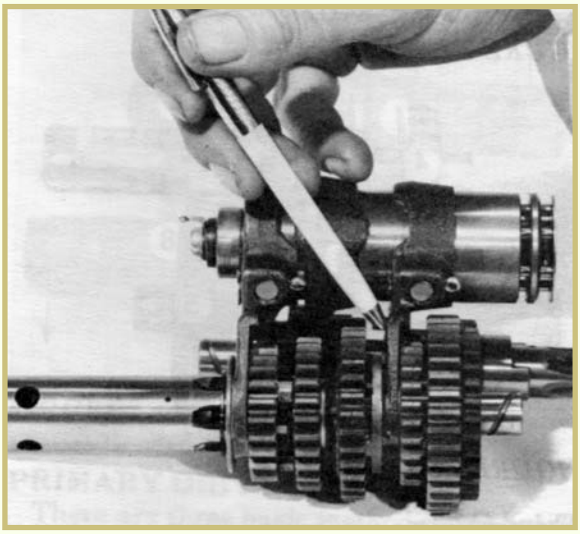


Figure 24 shows an entire shifting-mechanism assembly. When the rider's foot moves the change pedal (shift lever) downward, gearshift arms A and B move forward. The prongs on the end of gearshift arm B pull on the gearshift drum pins, which causes the shift drum to rotate forward.

Notice the machined grooves (slotted guides) in the shift drum. If you locate the shift forks, you'll notice that their cam follower pins fit into the machined grooves. When the shift drum rotates, the machined grooves cause the shift forks to move in a timed sequence to the right or to the left to engage and disengage the sliding gears.

When the rider shifts to a higher gear ratio by moving the change pedal upward, the gearshift arms rotate the shift drum in the opposite direction. This motion causes the shift forks to move the gears into engagement with the gear selected by the rider.

Shift detents (called a *shift drum stopper lever* in the illustration) are used to help in locating the next gear as the shift drum rotates. There are different variations of shift detents used within transmissions, but they all serve the same purpose.

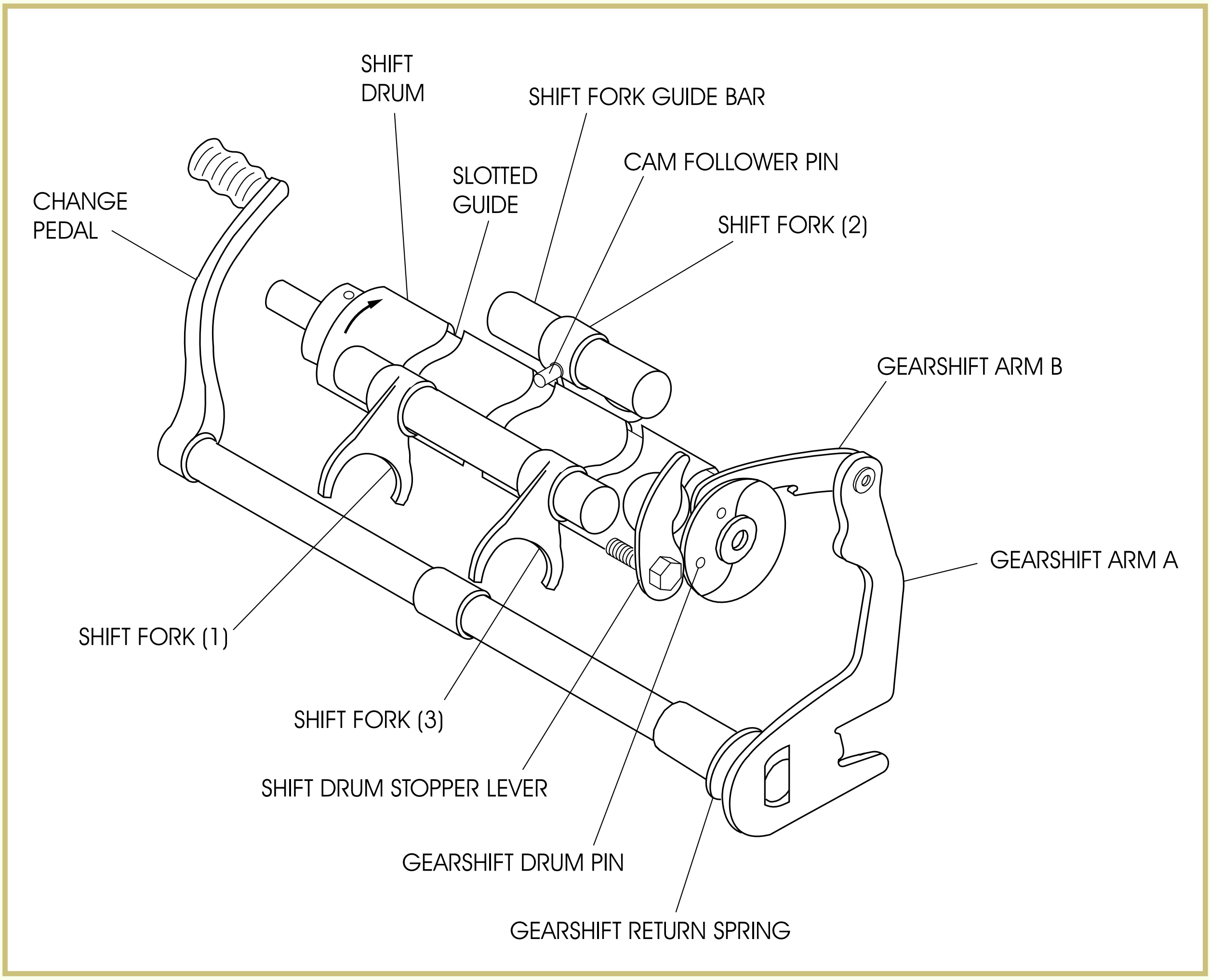


FIGURE 24—Shift Mechanism

Transmission Problem Symptoms

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. The following paragraphs discuss some common malfunctions of a transmission and how you can recognize them.

Difficulty Shifting

When you need excessive clutch lever pressure to shift gears, it may indicate either a clutch problem or a transmission problem. If the clutch is at fault, you'll notice symptoms such as grinding gears when you shift into low or first gear. As we discussed earlier, in most cases if the clutch is at fault, a simple adjustment will solve the problem. If the transmission is at fault, you'll notice difficult shifting between other gears while the motorcycle is moving. This problem may indicate a bent shift fork or seized gear on the transmission shaft. When a shift fork is damaged, it will no longer fit properly in the grooves of the gear. To fix this problem, you'll need to disassemble the engine and replace the shift fork. When a gear has seized on the transmission shaft, the problem is usually caused by a lack of proper lubrication. As with the shift fork, you'll also need to disassemble the engine to repair the problem.

Inability to Shift Gears

Occasionally you'll find a machine that shifts into one gear, but won't shift into the next gear. This problem is often caused by the shift return spring which returns the shifting lever to its original position. You can usually repair this problem by replacing the spring. The spring is usually located near the clutch assembly. In most cases, you won't need to completely disassemble the engine to repair the problem.

Strange Sounds

Occasionally you'll have customers who will complain of strange sounds coming from the transmission of their motorcycle or ATV. Unusual sounds may range from a low growl to a high-pitched whine. Below we'll describe the most common noises which indicate a transmission problem. Any unusual noise which is coming from the transmission of a machine will require you to disassemble and carefully inspect for worn or broken parts.

Constant growling sound. A low growling sound usually indicates a bearing failure. When a bearing fails, it may cause a transmission shaft to move slightly out of position. When this occurs, the gears don't mesh properly and produce a low growling noise. In these cases, not only will you need to replace the bearing, but you'll most likely need to replace the gears as well.

Clunking noises. An excessive clunking sound when the engine is in a particular gear while under a load usually indicates broken teeth on one or more gears. In this case, you'll need to completely disassemble and inspect all of the transmission components.

Jumping Out of Gear

When dogs and slots become too rounded, the gears will tend to slip out of the holes when the engine rpm increases, and the engine "jumps out of gear." The shift forks may also become damaged from the excessive pressure they encounter as the transmission jumps out of gear. Therefore, when a transmission is jumping out of gear, you'll need to replace the gears, the shift forks, and the shift drum.

Starting Systems

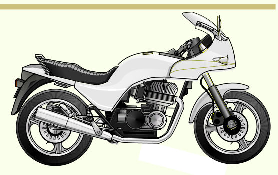
A motorcycle or ATV may be started by a kickstart lever or an electric starter. We'll discuss both of these types of starting systems, which will complete our discussion of transmissions.

Electric Starting System

An electric starting system uses an electric motor which uses a gear or a chain to turn either the main shaft, countershaft, or crankshaft. Electric starting systems work much like the starting system on a car, which makes them very popular.

Kickstarting System

Many motorcycles and ATVs have an engine kickstarting system that's actually a part of the transmission. Kickstarting systems fall into one of two categories—primary drive or direct drive. In general, when a kickstarter is used, a lever is depressed which activates a mechanism that turns a gear. This gear rotates another gear that's either attached directly to the primary drive system or to the main shaft. The difference between these two types of starting systems is that the primary-drive system attaches directly to the primary drive and has the ability to start the engine in any gear as long as the clutch lever is pulled in. The direct-drive system is attached to the main shaft and the engine will start (using the kickstart lever) only if it's in neutral and the clutch lever is released. Once the starter gear rotates, the engine turns over and has the ability to start.



Road Test 4

1. The _______ transmission is the most common type of transmission found in motorcycle and ATV engines today.

2. The type of gear normally used with constant-mesh transmission is a _______ gear.

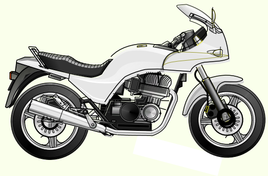
3. A _______ gear is a gear that can't move on the shaft that it's attached to.

4. For a constant-mesh transmission to operate correctly, there must be a _______ gear opposed to a fixed or sliding gear on the opposite shaft.

5. A _______ is used to move a sliding gear.

(Continued)

Road Test 4



6. A _______ transmission has the power flow enter on one shaft and leave from another shaft on the same axis.

7. Why are transmissions used in motorcycle and ATV engines?

____

____

8. When an engine is in a gear selection where there's no power being transmitted to the rear wheel, it's considered to be in _______.

9. The smallest gear on the main shaft of an indirect-drive transmission is the _______ gear.

10. The _______ rotates opposite of the main shaft in an indirect-drive transmission.

Check your answers with those on page 49.

FINAL DRIVE SYSTEMS

Now you should have a good understanding of how power is transferred from the crankshaft to the clutch and through the transmission. Next, we'll discuss the final drive system, which is a gear reduction system that takes the power from the transmission and allows it to flow to the rear wheel. There are three types of final drive systems—chain, belt, and shaft.

Chain-Driven Final Drives

The chain-driven final drive system is the most common system found on motorcycles and ATVs. A chain-driven final drive consists of two sprockets, one attached to the countershaft of the transmission and one attached to the rear wheel. A chain is used to connect the sprockets. By using a chain final drive we can easily change gear ratios simply by replacing the existing sprockets with different sized sprockets. The sprockets and chain in a chain-driven final drive system wear out over time and require frequent maintenance to make them last. The drive chain also needs to be serviced more often than any other final drive parts. The correct adjustment and proper lubrication of the final drive chain help prolong the life of the chain as well as the sprockets. There are two common ways to check for a chain that's excessively worn.

1. Try to lift the chain at various points around the rear sprocket. At a point midway between the top and bottom of the sprocket, try to pull the chain away from the sprocket. If you can pull the chain so that one-third of the sprocket tooth shows below the chain, the chain or sprocket should be replaced.
2. Lay the chain on a flat surface and measure the length of the chain when it's compressed (pushed together) to its shortest length. Pull the chain to stretch it out as far as possible. If the chain stretches in excess of $\frac{1}{4}$ inch per foot, it should be replaced.

The chains used on chain final drive systems are composed of pin links and roller links (Figure 25). Pin links are composed of two plates and two pins. Roller links are composed of two plates, two bushings, and two rollers. The links are connected together by a master link or are considered to be an endless chain and have no master link. Many chains used on motorcycles and ATVs are O-ring chains that use O-rings in between the bushings and plates to help protect the chain and also to keep lubrication inside the roller.

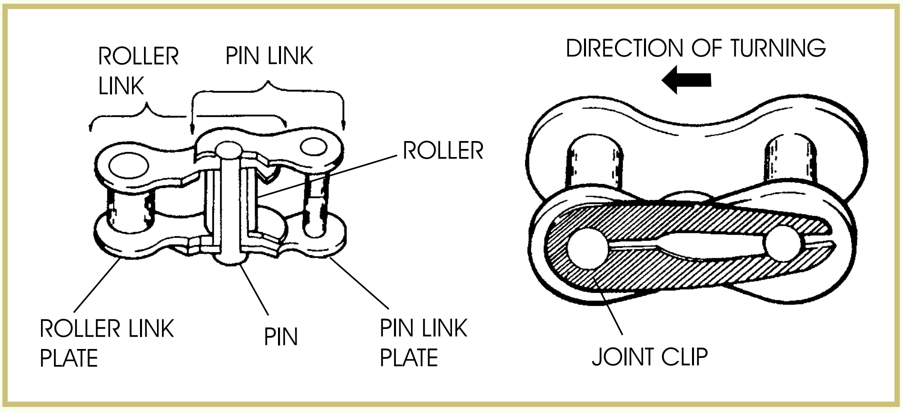
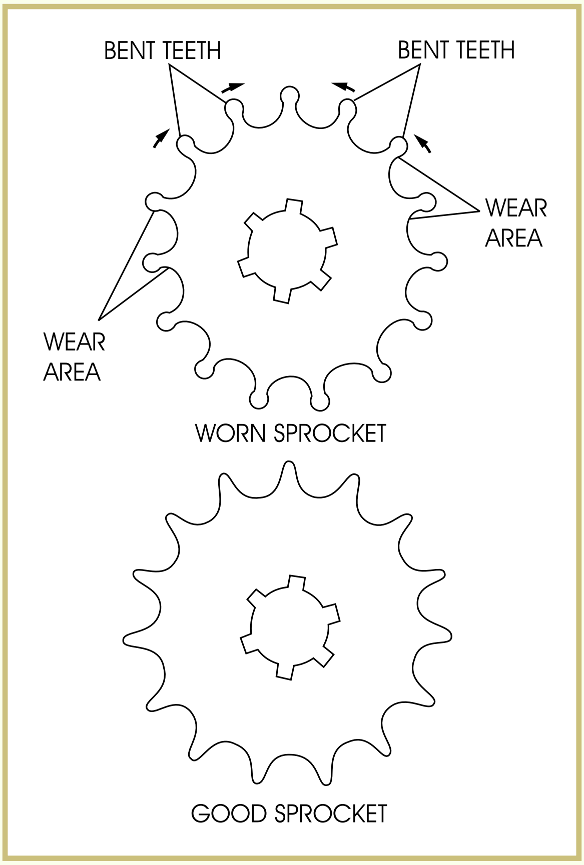


FIGURE 25—Drive Chain Link and Master Link
(Image courtesy of Yamaha Motor Corporation, U.S.A.)

The sprockets on chain final drive systems are flat metal plates with teeth around the outside edges. The chain fits around the sprockets with the teeth of the sprockets fitting into the open spaces between the rollers of the chain. Worn sprockets will ruin a chain. Sprocket wear is visible and the condition of a sprocket can be judged by comparing it to a new one (Figure 26).

FIGURE 26—Sprocket Wear



Belt-Driven Final Drives

Belt-driven final drive systems are used on a few select models of motorcycles. These systems use a "Gilmer-type" belt that has teeth molded into it that mesh with a pair of toothed pulleys. The belt requires no lubrication and must be kept clean and dry. This system has certain maintenance requirements such as proper alignment of the belt and pulleys. Belt tension is extremely critical with this type of final drive system.

Shaft-Driven Final Drives

Although it has the least mechanical efficiency, a shaft-driven final drive system is the best system available for a final drive. These systems are strong, clean, and require virtually no maintenance. Shaft drives are the least likely final drive system to have a failure, and will most likely last longer than the machine on which they're used when they're properly maintained. There are many parts to the shaft-driven final drive system, as illustrated in Figure 27. The shaft-driven final drive system is becoming more and more popular on ATVs because the complete system is self-contained and won't wear out as quickly as a chain or belt system.

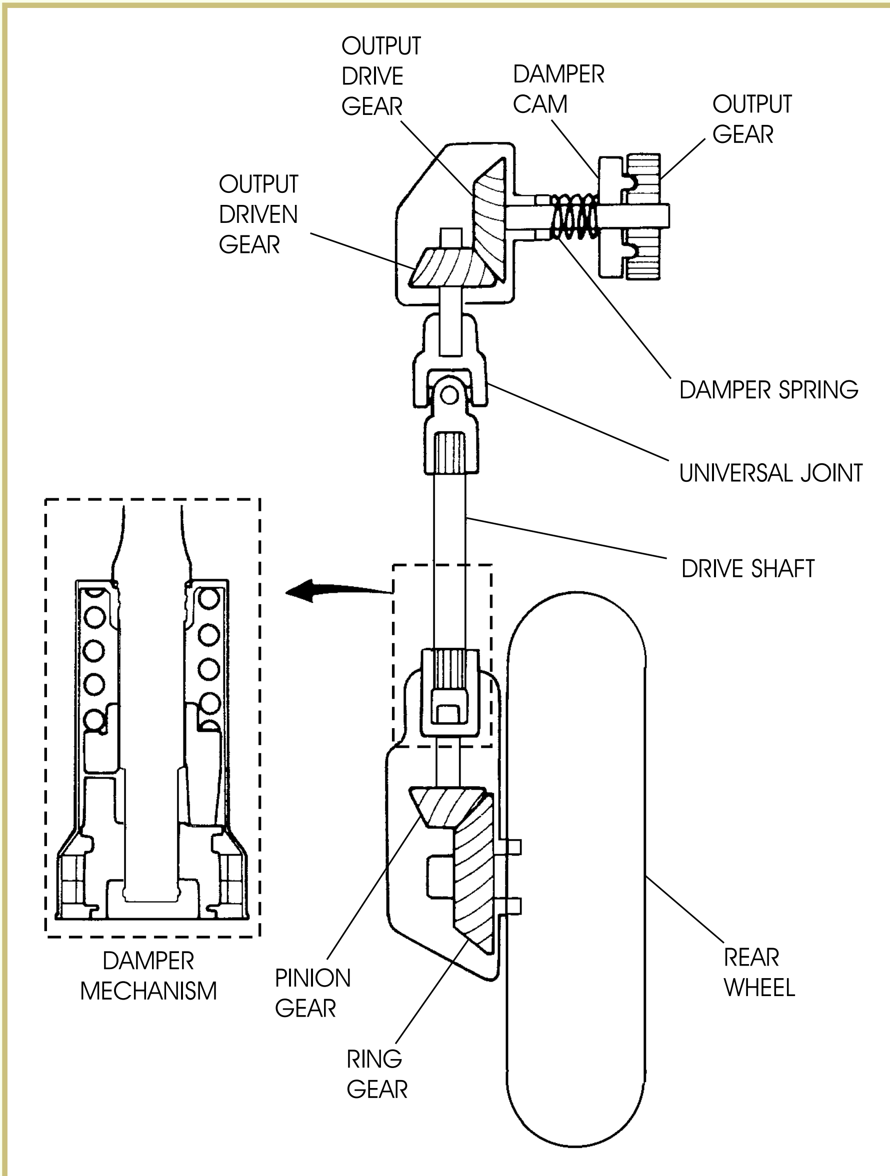
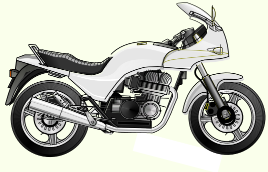


FIGURE 27—Shaft Final Drive (Copyright by American Honda Motor Co., Inc. and reprinted with permission)



Road Test 5

1. The three types of final drive systems found on motorcycles and ATVs are the _______, _______, and the _______ final drives.

2. The _______ final drive is the most complex final drive system found on motorcycles and ATVs.

3. The belt final drive system uses a _______ -type belt that has teeth molded into it.

4. Chains need frequent _______ because they move at high speed and transmit the power of the engine.

5. Some chains have _______ in between the bushings and plates to help protect the chain and also to keep lubrication inside of the roller.

Check your answers with those on page 50.

Road Test Answers

1

1. bevel
2. Under-drive
3. spur or straight-cut
4. sector
5. Direct-drive
6. 3.091:1
7. 1.179:1
8. 2.800:1
9. 10.204:1
10. Over-drive

2

1. Gear, chain, and belt
2. Clutch
3. manual
4. variable-ratio
5. gear-driven
6. Hydraulic
7. variabl- ratio
8. Centrifugal clutch
9. Clutch disc (or friction disc)

3

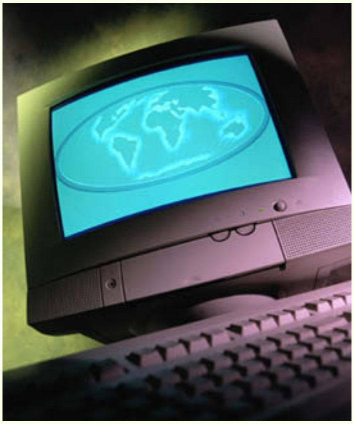
1. True
2. True
3. Adjust the release mechanism, then adjust the clutch free play.
4. drag, slippage
5. vernier caliper
6. True
7. warped (or worn)
8. Drain the oil.

4

1. indirect-drive
2. spur or straight-cut
3. fixed
4. freewheeling
5. shift fork
6. direct-drive
7. To change the speed of the machine while keeping the engine in its usable power band
8. neutral
9. low (or first)
10. countershaft

5

1. chain, belt, shaft
2. shaft
3. Gilmer
4. lubrication
5. O-rings



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