Study Unit

Harley-Davidson Maintenance

By

Ed Abdo

About the Author

Edward Abdo has been actively involved in the motorcycle and ATV industry for over 25 years. He received factory training from Honda, Kawasaki, Suzuki, and Yamaha training schools. He has worked as a motorcycle technician, service manager, and Service/Parts department director.

After being a chief instructor for several years, Ed is now the Curriculum Development Manager for the Motorcycle Mechanics Institute in Phoenix, Arizona. He is also a contract instructor and administrator for American Honda's Motorcycle Service Education Department.

Preview

In this study unit, you'll learn about the engine design, drive system, and maintenance procedures as they pertain to the Harley-Davidson V-twin motorcycle. Included in this study unit is a brief history of this motorcycle, and an explanation of the current basic engine design, primary drive, clutch, and final drive system. Also included is a section covering the transmissions found on this increasingly popular motorcycle.

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

- Identify the different engine designs used by Harley-Davidson
- Identify the engine components specific to the V-twin engine
- Describe how the direct-drive transmission operates on the V-twin motorcycle
- Understand how the drive systems operate on the V-twin motorcycle

Contents

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INTRODUCTION

The American V-twin motorcycle has been around for a long time—since the early 1900s—and includes many different brands. Because of their popularity, when most people hear the words "American V-twin," they automatically assume that you're referring to a Harley-Davidson motorcycle. There are, however, a variety of foreign manufacturers building V-twins in the United States, such as Honda and Kawasaki, as well as American companies, such as Polaris.

In this study unit, we'll discuss many of the aspects of the V-twin motorcycle including engine design, drive systems, and maintenance procedures. Before we get too involved discussing the current model design, we'll give you a brief history of a legendary American motorcycle manufacturer, the Harley-Davidson Motor Company.

HISTORY OF THE HARLEY-DAVIDSON MOTOR COMPANY

The Harley-Davidson Motor Company was founded in 1903 by William S. Harley and Davidson family members William, Walter, and Arthur. These four men started their company in a small tool shed in Milwaukee, Wisconsin. Today, their story has become a legend among motorcycle enthusiasts.

The Early Years (1903–1929)

The first Harley-Davidson motorcycle was a belt-driven, bicycle-based model with a 3 hp single-cylinder engine. This motorcycle lacked suspension and had an engine that was based on a French design. There was no clutch or transmission (it was a true direct drive), and lubrication of the moving engine parts was provided solely by gravity! In 1906, the company increased the horsepower of this motorcycle from 3 to 4 by increasing the cylinder bore.

The first Harley-Davidson V-twin was offered publicly in 1907, in response to the multicylinder models offered from the companies Thor, Indian, and other marquees that are no longer in business. The first versions of this motorcycle used what were known as "suction valves," which used the suction created by the movement of the piston. Because this design was impractical, later V-twins used mechanically operated spring valves.

In 1912, the first chain-driven model Harley-Davidson was offered. In 1915, the company introduced the first 3-speed transmission as well as the first Harley with a headlight. The 1920 Harley-Davidson sport model had a horizontally-opposed twin-cylinder engine (similar to the BMW Boxer). This engine boasted 584 cc of displacement and came with a fully enclosed chain drive system. In 1922, two new V-twin engines were introduced—the 986 and 1208 cc. In 1926, a 348 cc single-cylinder overhead-valve engine was introduced. This engine had a 73 mm bore and 82.5 mm stroke. A special overhead-valve speedway racing model called the "Peashooter" was also introduced in 1926.

The longest-running (in production years) Harley-Davidson engine design was the 45 cubic-inch twin-cylinder "Flathead" (Figure 1). This engine was built between 1929 and 1974. When the company offered three different 45 cubic-inch models in 1929, it indicated that they were serious about this bike! This engine model was called the Flathead because there were no moving parts in the head; the moving parts were all in the cylinder block. This engine design is widely known as a side-valve engine design.

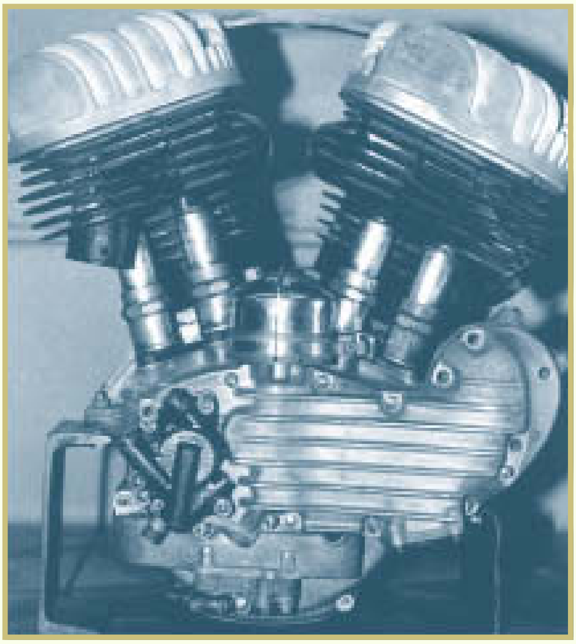
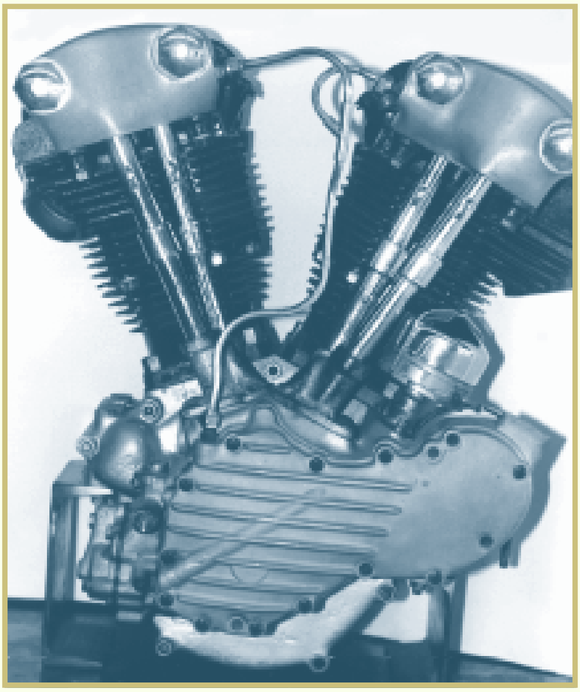


FIGURE 1—The Flathead engine has no moving parts in the head. The Flathead was built for 45 consecutive years, making it the longest-produced American-made motorcycle engine.

The Middle Years (1930-1949)

In the 1930s, the flathead engine design was so popular and successful that the company offered it in a larger displacement—the 74 cubic-inch (1200) cc engine. The year 1936 brought to the motorcycling world an engine that used a valve rocker box. This 61 cubic-inch engine design looked like knuckles and was nicknamed "Knucklehead" (Figure 2). The Knucklehead was Harley-Davidson's first overhead-valve twin-cylinder engine, and was so successful that its basic concept still serves Harley-Davidson today with the "Evolution" engine.

FIGURE 2—The knucklehead engine has a valve rocker box on the engine that looks like knuckles. This was Harley-Davidson's first overhead-valve V-twin cylinder engine.



From 1936 to 1941, an 80 cubic-inch side-valve twin engine was also produced. The factory recommended this engine, initially designated the "ULH," for sidecar work. The company decided not to continue this model after World War II, most likely because of the popularity of the Knucklehead. A 74 cubic-inch overhead-valve engine was introduced in 1941, and was identical, apart from its displacement, to the highly popular 61 cubic-inch model. The 74 cubic-inch model was produced in limited quantities during World War II, and in only slightly larger batches in 1946 and 1947. After the war, the side-valve engines were replaced by a new 1206 cc overhead-valve engine. In 1947, a new 125 single-cylinder two-stroke engine came out; however, the bike never completely fulfilled the lightweight demands of Harley-Davidson dealers.

The panhead engine design (Figure 3) was first produced for the 1948 model year. It superseded the Knucklehead because of its lighter weight, increased power, and better oil passage. The knucklehead engine design was all iron, whereas the panhead engine design (produced through 1965), had numerous aluminum top-end parts. The Panhead got its name because of the shape of the rocker covers, which resemble a pan. In 1949, the Hydra-Glide fork was introduced. This was a hydraulically-dampened telescopic fork.

FIGURE 3—The Panhead engine superseded the Knucklehead engine because of its light weight, power, and better oiling system.

The Modern Years (1950–Today)

The Harley-Davidson model K was introduced in 1952. This model featured rear suspension and a combination foot shift and hand clutch. This model is considered the father of the Sportster. The Sportster was introduced in 1957 and was successful beyond the manufacturer's wildest dreams! Larger by 10 cubic inches than the original model K, the 55 cubic-inch machine boasted overhead valves. In only its second year of production, an increase in performance was obtained through higher compression, larger valves, and aluminum tappets. The Sportster set the stage for the XLCH model. Some say that the "CH" in "XLCH" stood for "competition hot" and style became as important as speed. The staggered, short dual exhausts first seen in 1962 have become classic Sportster equipment.

Also developed during this modern period of design was the XR750, Harley-Davidson's flat-track racing engine (Figure 4). Electric starting was introduced in 1965 on the Panhead (which received rear suspension in 1953). And a motor known as the "Shovelhead" made its debut in 1966. The Shovelhead got its name because of the space in the center of the rocker box and because the rocker box looks like an upturned shovel. This engine lasted 18 years until 1984 and was made in 76 and 80 cubic-inch designs. Harley-Davidson introduced the "Evolution" engine design (Figure 5) in the new Softail lineup for the 1984 model year. The Evolution engine uses an aluminum alloy, whereas past engine designs used primarily iron.

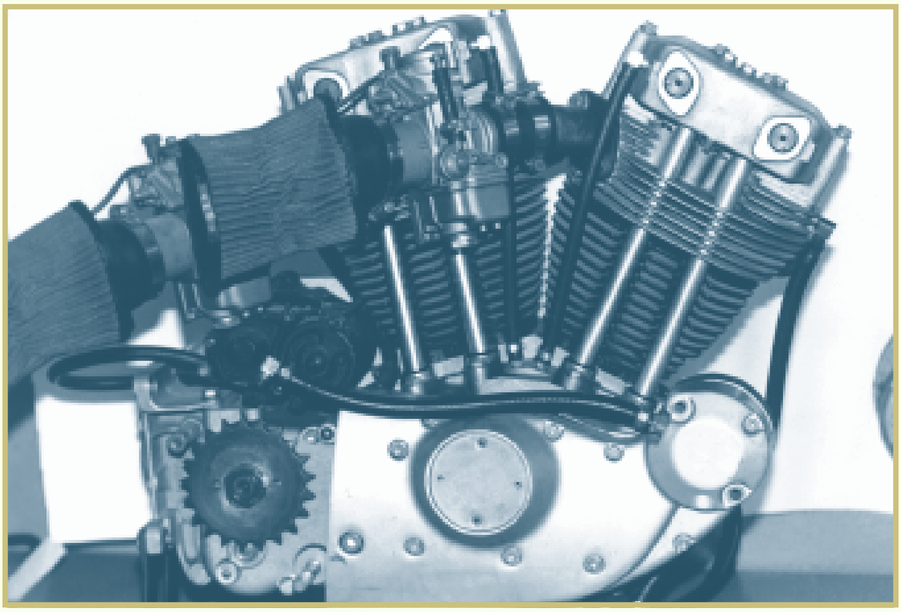


FIGURE 4—The XR750 was designed as Harley-Davidson's flat-track engine.

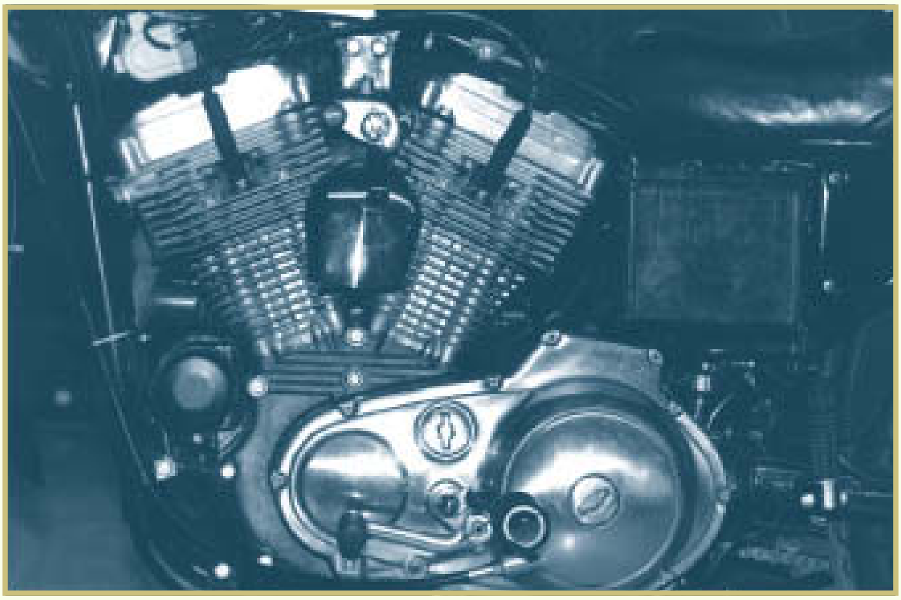


FIGURE 5—The Evolution engine was introduced in 1984 and is still used today.

In this study unit, we'll discuss certain engine, transmission, and drive components that are specific to the V-twin motorcycle. Many areas of repair of the V-twin motorcycle such as chassis, brakes, and electrical systems have already been covered in previous study units. We've repeated some of this information to serve as a review for you as you learn about some of the specific engine and transmission features found on the V-twin motorcycle.

V-TWIN MOTORCYCLE ENGINE DESIGN

An air-cooled, four-stroke V-twin motorcycle engine (Figure 6) is a group of assembled parts that are designed to change heat energy (the burning of fuel) into useful mechanical energy (the movement of the motorcycle). In other words, the engine provides the power that's needed to turn the rear wheel of the motorcycle. Although we've discussed it in an earlier study unit, it's important that you know and understand the principles of how the four-stroke internal-combustion engine operates so that you can become a good motorcycle technician. Knowing this information will give you a better understanding of why the motorcycle engine performs the way it does.

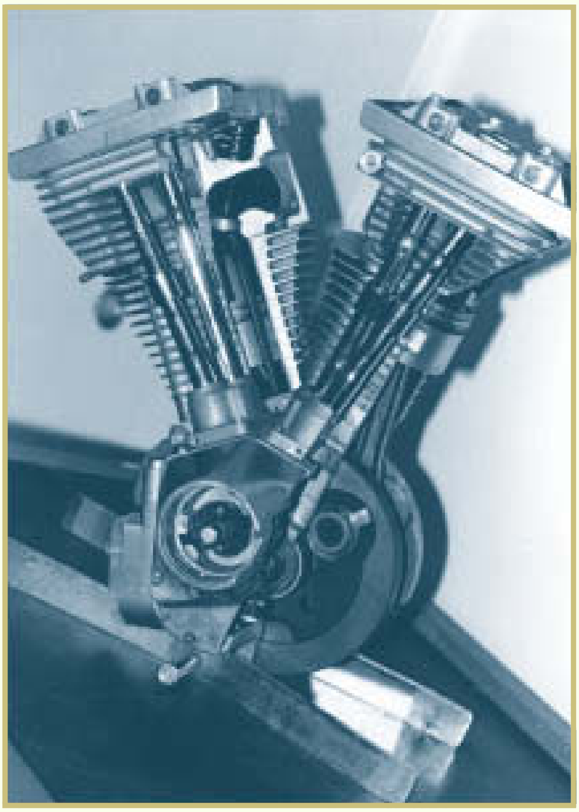


FIGURE 6—This picture shows some of the many components that make up a four-stroke air-cooled V-twin motorcycle engine.

Four-Stroke Engine Combustion

As we've mentioned, the combustion of the four-stroke engine changes chemical energy into heat energy. This is done by compressing the air and fuel mixture into a small space and by taking advantage of its expansion as it's heated. The air and fuel mixture is compressed by the piston and ignited by a spark plug, which burns the air and fuel mixture. This burning is known as *rapid oxidation* and is actually a chemical reaction that takes place very quickly. During this process, the fuel and oxygen in the air combine to form new molecules. These combustion molecules are carbon dioxide (CO_2) and water (H_2O). While the fuel and oxygen molecules are converting, they lose some of their internal energy. This energy is released as heat. This heat then causes an increase in the pressure inside the cylinder's combustion chamber, which then forces the piston downward. There are three phases involved in the internal engine combustion process—combustion lag, active combustion, and post combustion.

Combustion Lag

The first phase of combustion occurs as the piston compresses the air and fuel mixture. During this compression, the spark plug ignites a small portion of the air and fuel mixture and a ball of fire spreads outward and begins to consume the remaining mixture. The burning inside the cylinder is a chain reaction that spreads throughout the combustion chamber. Before the chain reaction is completed, there's a short period of slow burning in the combustion chamber. This slow burning process is known as *combustion lag*.

Active Combustion

The second phase of combustion occurs as the initial lag is overcome and the chain reaction begins to speed outward in the combustion chamber. A rapid temperature and pressure build-up occurs as the charge is consumed. The chain reaction of burning molecules accelerates and the chemical conversion causes heat to be quickly released. This increase in heat causes the pressure in the combustion chamber to increase dramatically. This phase is known as *active combustion.*

Post Combustion

The third phase of combustion occurs as the piston begins moving downward. At this time, most of the charge has been consumed so the remaining burning doesn't contribute much towards producing more power. As the piston continues its downward movement, the volume inside the combustion chamber increases. This increase in volume allows the pressure to drop and the remaining power to be absorbed by the piston. The combustion chamber and cylinder eliminate the spent gases and start the next cycle of fresh air and fuel mixture burning. This phase is known as the *post-combustion* phase.

Other Combustion Factors

Next we'll discuss the factors that influence the combustion process and engine performance. The compression ratio of a four-stroke engine is a major factor in engine performance. For example, if you increase the compression ratio, you can, in many cases, increase the power output of the engine. The *compression ratio* is the difference in the volume of air when the piston is at bottom dead center (BDC) compared to the volume of air trapped when the piston is at top dead center (TDC). *Volumetric efficiency* is the measurement of how much air is actually being taken in by the engine, compared to how much it can hold according to the size of the cylinder. A four-stroke V-twin engine motor with a high compression ratio may not be as powerful as it could be if it has a low volumetric efficiency. This is because the cylinder isn't completely packed with a charge of air and fuel to create enough heat during compression.

The combustion process and engine performance are also affected by the size (or displacement) of the engine. *Engine displacement* is determined by the diameter of the cylinder and the distance the piston moves when traveling from BDC to TDC. The diameter of the engine cylinder is called the *bore*. How far the piston travels from BDC to TDC is called the *stroke*. By knowing the bore and stroke of a V-twin motorcycle engine, you can determine the engine's displacement. For engine displacement examples or a more in-depth explanation, refer to your previous study unit entitled *Motorcycle and ATV Engine Configurations.*

Four-Stroke Engine Operation

As we've also discussed in past study units, there are four operations that are required for the engine to run. They are intake, compression, power, and exhaust (Figure 7).

Intake

The intake stroke is the first downward movement of the piston while the intake valve is open. At this time, a fuel and air mixture is pulled into the combustion chamber. The intake stroke takes place when the piston moves from TDC to BDC. This creates a vacuum (suction) in the cylinder chamber, which in turn draws air and fuel past the open intake valve.

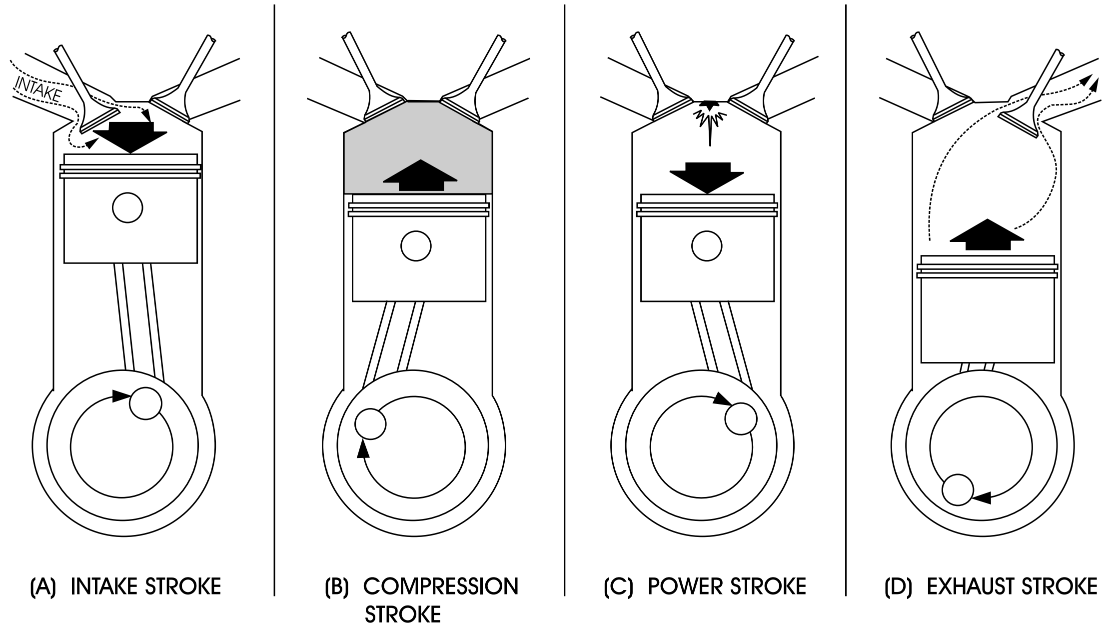


FIGURE 7—This illustration shows the four piston strokes in the sequence needed to complete one cycle of operation. An engine runs by repeatedly completing this cycle. (Courtesy Kawasaki Motor Corp., U.S.A.)

Compression

The compression stroke occurs as the piston moves upward in the cylinder and pressurizes the air and fuel mixture in the combustion chamber. During this stroke, both the intake and exhaust valves are in their closed position. This process allows the upward movement of the piston to compress the trapped air and fuel mixture.

Power

The power stroke occurs as the piston is moving downward again in the cylinder. As the piston approaches TDC, a spark plug is used to ignite the compressed air and fuel mixture. This begins the power stroke. As the air and fuel mixture burns, it expands very quickly, causing a tremendous amount of pressure and heat. This pressure forces the piston down into the cylinder, transmitting power to the crankshaft.

Exhaust

The exhaust stroke takes place as the piston returns upward into the cylinder while the exhaust valve is open. At this time, the previously burned gases are pushed from the engine into the exhaust system. This leaves the cylinder combustion chamber empty and prepares it for the start of another four-stroke cycle.

Each stroke of the four-stroke engine moves the crankshaft one-half of a complete revolution. To complete one full cycle, the crankshaft must make two complete revolutions, or rotate 720°. The intake, compression, power, and exhaust strokes repeat and continue during the operation of the four-stroke engine.

The crankshaft has a *flywheel assembly*, which is a large, round, disc-shaped weight. It's intended to help keep the engine spinning during the three non-power-producing strokes of the four-stroke engine. Because there's only one power stroke for every two crankshaft revolutions, the inertia produced by the crankshaft flywheel assembly aids in smoothing abrupt crankshaft movement during the power stroke. The flywheels that are used on large-displacement, V-twin four-stroke motorcycle engines are large to keep the engine running smoothly.

Four-Stroke Engine Components

The four-stroke V-twin engine design allows for the greatest amount of engine displacement in the smallest overall area. For a long time, Harley-Davidson engines were 45° air-cooled four-stroke V-twin designs, with both rods sharing the same crankshaft pin; one rod was forked to allow the other rod inside it (Figure 8). Now, Harley-Davidson also has an engine that's of the liquid-cooled variety that uses a 60° V-twin engine.

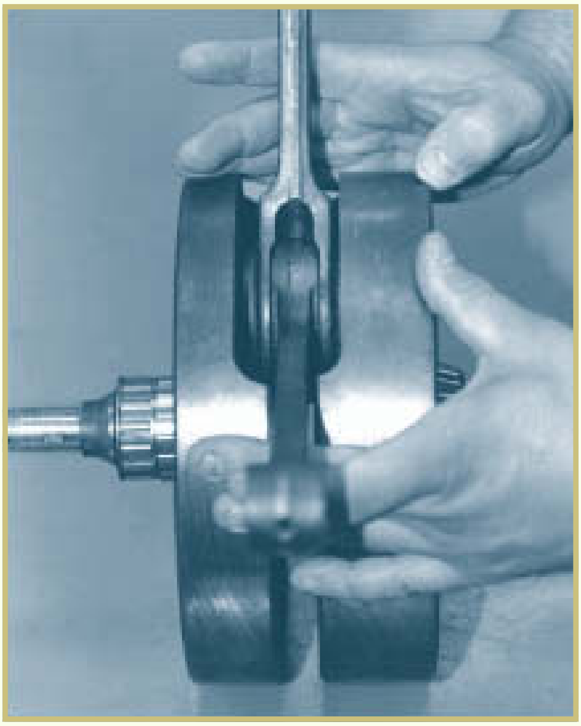


FIGURE 8—A forked connecting rod is used in this engine design.

Cylinder Heads

Cylinder heads on the typical V-twin engine may be made of cast iron or aluminum (Figure 9). The V-twin engine cylinder heads that are made today are made of aluminum. Air is used to cool the cylinder heads. These heads have large fins that aid in heat dissipation. Modern Harley-Davidson cylinder head designs use both a round combustion chamber as well as an egg-shaped chamber (Figure 10). As we discussed in an earlier study unit, cylinder heads are designed to

- Create sufficient turbulence within the combustion chamber. The shape of the combustion chamber creates turbulence. Turbulence is essential to keep the air and fuel mixture well-atomized, which is needed to complete combustion.
- Create a squish area. Within the combustion chamber, the squish area also helps create turbulence and forces the combustible mixture towards the spark plug, which increases the efficiency of the engine.
- Eliminate restrictions when the air and fuel flows through valve ports.

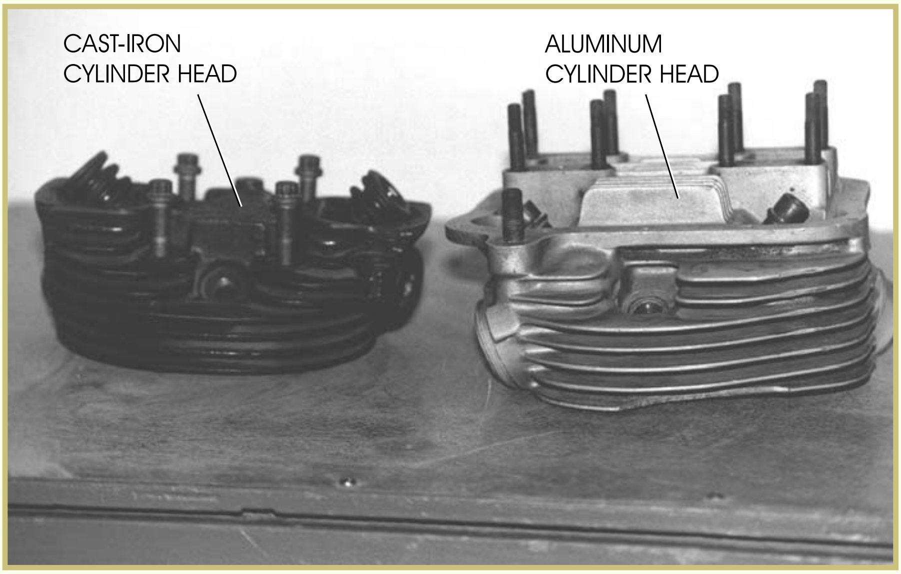


FIGURE 9—Even though it's physically smaller, the cast-iron cylinder head is heavier than the aluminum cylinder head.

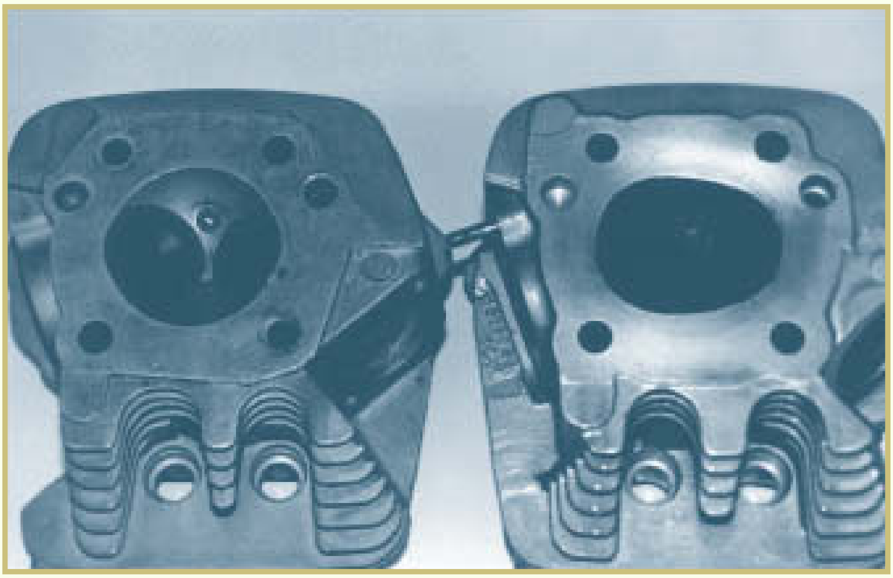


FIGURE 10—This photo shows two different combustion chamber designs used in V-twin air-cooled engines. The egg-shaped chamber is more efficient than the round chamber, because the shape helps force the fuel charge into the spark plug area.

Cylinders

The modern V-twin cylinder assembly is usually made of aluminum with a liner of cast iron or steel that's poured into the cylinder (Figure 11). These liners have a cylinder finish that's designed to create a good piston-ring seal while providing sufficient oil for lubrication.

FIGURE 11—An aluminum cylinder has a liner made of cast iron or steel.

Pistons and Rings

In a properly sized cylinder, the piston fits snugly and transfers combustion power directly to the connecting rod and indirectly to the crankshaft. The typical Harley-Davidson pistons have valve pockets machined in the top to provide adequate clearance for the intake and exhaust valves to open (Figure 12). The piston rings in the V-twin four-stroke engine perform two important functions—they seal the cylinder to trap the power of combustion, and prevent the oil that's used to lubricate the piston from entering the combustion chamber.

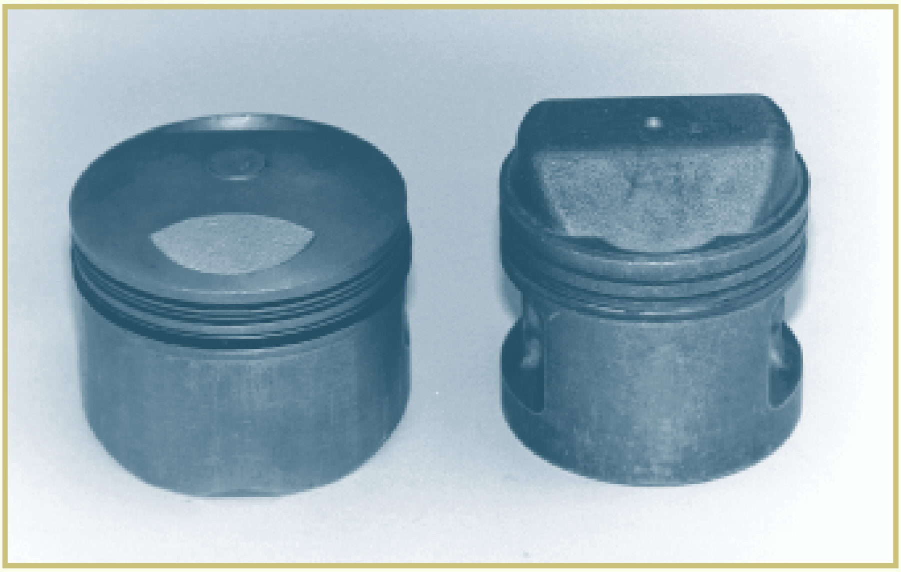


FIGURE 12—Two different V-twin pistons are shown here. The pistons have pockets machined into them to prevent contact with the valves.

Rocker Arms / Valve Train

Rocker arms (Figure 13) are used to open the intake and exhaust valves. The valve tappet and guide assembly consist of a tappet and roller. The hydraulic tappet contains a plunger and cylinder, plus a check valve, which allows the unit to pump itself full of engine oil to take up any excess clearance in the valve train. The up and down motion produced by the revolving cam is transmitted to the valve by the push rod (Figure 14) and rocker arm. When the tappets are functioning properly, the assembly operates with minimal tappet clearance. The units automatically compensate for heat expansion to maintain a zero clearance condition.

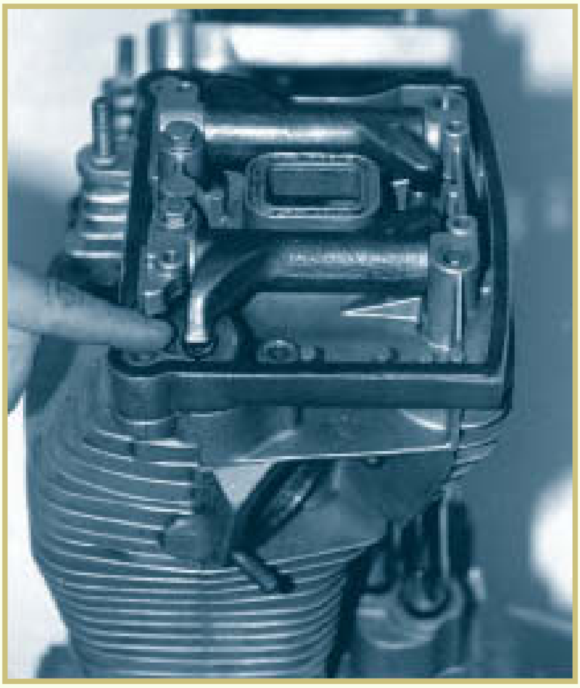


FIGURE 13—A V-twin Engine Rocker Arm

FIGURE 14—The push rod has an adjuster built into it for finer adjustments to the hydraulic-valve lifter system.

Engine Crankcases and Crankshaft

The gear case is located behind the timing cover on the right side of a V-twin motorcycle engine crankcase assembly. The gear case contains a series of gears, which transmit engine power to the camshaft, ignition timing device, and to the oil pump. Figure 15 shows a cutaway view of a V-twin engine that shows this area in greater detail. This area of the crankcase is lubricated with engine oil through a breather valve from the engine crankcase. The vertically split crankcase supports the crankshaft, cylinders, and cylinder head assemblies.

The crankshaft changes the reciprocating (up and down) motion of the piston into rotating motion, which turns the gears to produce movement of the motorcycle. The piston is connected to the crankshaft by the wrist pin and connecting rod (Figure 16).

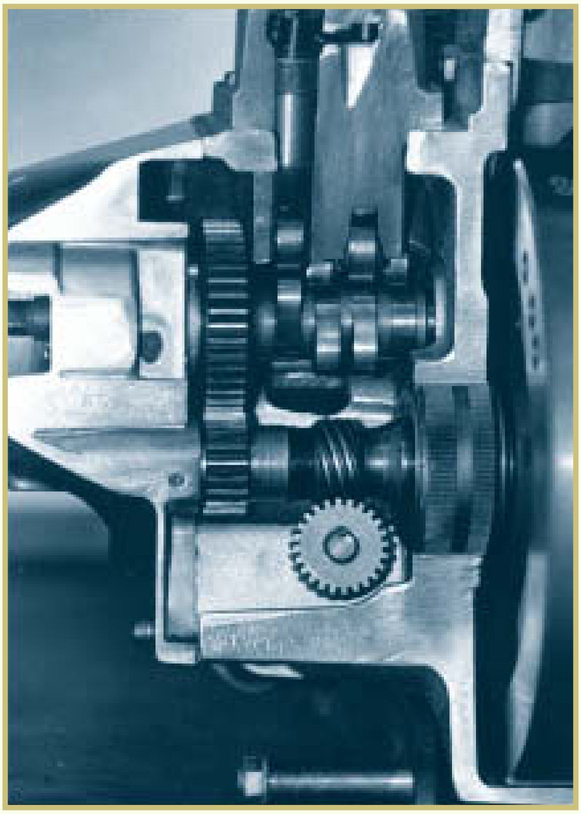


FIGURE 15—This cutaway view shows some of the gears and engine components found in the gear case of a V-twin engine.

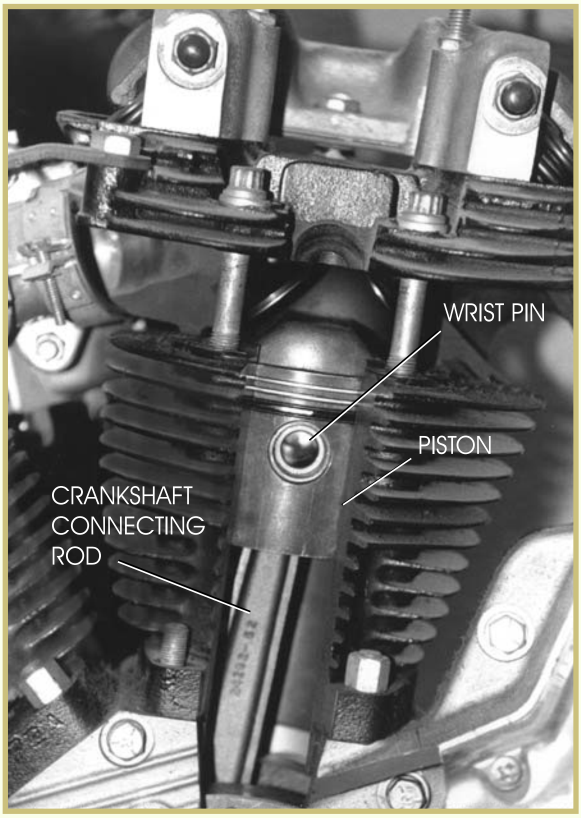
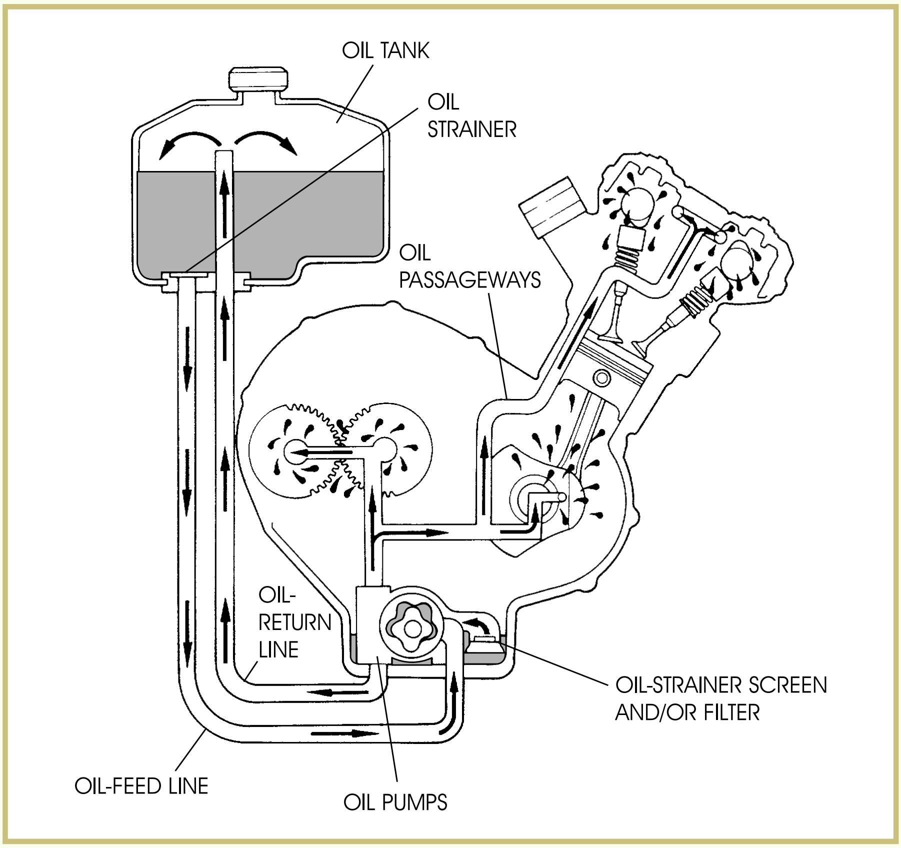


FIGURE 16—The piston is shown attached to the crankshaft connecting rod.

Dry-Sump Engine Lubrication System

Most V-twin motorcycles use a dry-sump engine lubrication system. The components in a typical dry-sump lubrication system are the oil tank, oil feed line, oil pumps, engine oil passageways, and oil return line (Figure 17). In this system, an oil filter is attached to the engine to keep the oil that enters the engine as clean as possible. In this type of lubrication system, there are essentially two oil pumps. One pump acts as an oil pressure feed and the other acts as an oil return pump. Oil in the oil tank is gravity-fed to the pressure feed side of the oil pump. The pump forces oil through oil passageways in the engine. The oil is under pressure and lubricates the internal moving engine components, which would be otherwise damaged from the heat created by friction from the moving components. Also, the oil that's thrown off from pressure-fed parts lubricates other internal engine components. This method of lubrication is called *splash lubrication*. The excess oil collects in the sump and returns to the oil storage tank via the oil return pump.

FIGURE 17—Compnents of a Dry-Sump Four-Stroke Engine Lubrication System
(Copyright by American Honda Motor Co., Inc. and reprinted with permission.)



Advantages

One advantage of the dry-sump lubrication system is that the engines that use this system give the oil a better place to cool because they store the oil in a separate storage tank away from the hot engine. An anti-leak check valve prevents the oil in the oil tank from leaking back to the sump and filling it with oil. What would happen if this check valve were to malfunction? A condition called *wet sumping* would occur. If the oil in the oil tank fills the engine sump it would cause the engine to smoke excessively, possibly to the point of damaging the spark plugs! Such problems occur because engine crankcases aren't designed to contain large amounts of oil. This is why dry-sump systems have separate storage tanks for the oil.

Lubrication System Maintenance

Changing the oil and oil filter on a regular basis is the only maintenance required in a dry-sump lubrication system. The general steps used to prepare the motorcycle for an oil change, change the oil, and change the filter are

1. Run the engine until its normal engine temperature is obtained.
2. Remove the drain plug that's attached to the oil tank or oil tank drain hose and let the oil completely drain from the oil tank into an approved container.
3. Carefully remove and discard the oil filter.
4. Use a clean, lint-free cloth/shop rag to clean the area around where the filter attaches.
5. Lubricate the gasket of a new oil filter with the same engine oil that you'll be using to fill the oil tank.
6. Reinstall the oil filter onto the engine.
7. Be sure to tighten the oil filter to the manufacturer's specifications (usually ¼ to ½ turn after the gasket surface makes contact with the filter mounting surface).
8. Reinstall the oil tank drain plug and tighten properly.
9. Pour the specified amount of engine oil into the oil tank. The manufacturer will have suggestions for the type of oil that should be used in the engine for different weather and riding conditions. This information can be found in the model's service or owner's manual.
10. Start the engine and carefully check for oil leaks at all points of the oiling system where components were removed and replaced.
11. Run the engine to allow it to warm up.
12. Turn off the engine and add oil to the tank.
13. With the motorcycle in the upright position, check the oil level and add oil to the tank if the engine oil dipstick shows that the oil level is low. Be sure to avoid overfilling the oil supply tank. The tank requires air space for heat expansion as the oil heats up.

Carburetors

The carburetor is positioned between the intake valve and the air filter. You've learned that basic carburetor operation occurs because of the negative pressure that results from the downward motion of the piston during the intake stroke. As the air passes through the carburetor venturi, the venturi creates an increase in velocity and a drop in pressure. To review how carburetors operate, refer to your study unit on *Fuel Systems.*

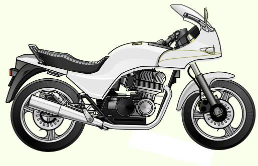
CV Carburetor Operation

The modern V-twin motorcycle uses a constant velocity (CV) carburetor, which is usually gravity-fed. CV carburetors use a fuel-enrichment system for cold starting. The CV carburetor on most of these machines is equipped with an accelerator pump. The accelerator pump system uses sudden throttle openings to quickly inject fuel into the carburetor venturi. This provides extra fuel for smoother acceleration.

CV Carburetor Adjustments

Since the V-twin motorcycle uses only one carburetor to feed the air and fuel mixture into the engine, external adjustments include only an idle adjustment. The idle adjustment entails adjusting a simple external adjusting screw. The low-speed fuel mixture screw is preset and shouldn't be tampered with once it has been properly set to the manufacturer's specification which can be found in the appropriate service manual.

Road Test 1



At the end of each section of *Harley-Davidson Maintenance*, 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 combustion in a four stroke engine changes _______ energy into _______ energy.
2. Most air-cooled V-twin motorcycles use a/an _______ sump lubrication system.
3. The three phases of the internal combustion process in their order of occurrence are _______, _______, and _______.
4. A/An ______ prevents oil drainage from the oil tank back into the engine.
5. Fuel is _______ -fed to the V-twin motorcycle carburetor.
6. The modern V-twin motorcycle uses a _______ type carburetor.

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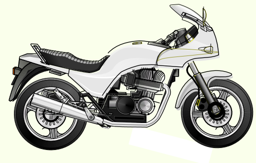
Road Test 1



7. *True or False?* By increasing the compression ratio of an engine, you'll usually increase the power output.

8. The four strokes of the engine used in the American V-twin in order of occurrence are _______, _______, ______, and _______.

Check your answers with those on page 47.

V-TWIN MOTORCYCLE DIRECT-DRIVE TRANSMISSIONS

This section of your study unit provides you with information specific to V-twin motorcycle transmissions. We'll also review some general information on transmissions, including theory of operation, component identification, and direct-drive power flow.

A transmission gives us the ability to shift gears, which allows for increases in rear wheel speed without overworking the engine. Both 4-speed and 5-speed V-twin motorcycles use a direct-drive transmission system. A direct-drive 4-speed or 5-speed transmission case contains a series of gears on different shafts, which are powered by the engine primary drive system. The transmission in this style of motorcycle may be separate from, or combined with, the engine assembly. A gear shifter is used to shift the transmission into the desired ratios by sliding shifting forks that move the gears into and out of mesh along the main shaft and countershaft.

Direct-Drive Transmissions

With a constant-mesh direct-drive transmission, the power from the engine enters on one shaft and leaves on another shaft of the same axis. As you probably remember, "constant mesh" means that each gear on one shaft has a matching gear on the opposing shaft. In other words, the gears are meshed with each other at all times.

With a direct-drive transmission, top (or high) gear 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 and current V-twin motorcycles.

Direct-Drive Transmission Components

Although we've discussed most of these items in previous study units, it's important for you to know about each of the components of a transmission, so we'll review this information next.

Fixed Gears

Fixed gears can't move on the shaft to which they're attached. These gears will be attached to a shaft in one of three ways—machined as part of the shaft, splined to the shaft, or pressed onto the shaft. A fixed gear always rotates at the same speed as the shaft it's attached to. In a diagram or in text, fixed gears are normally abbreviated as "FX."

Sliding Gears

Sliding gears slide across the axis of the shaft to which they're attached. Since sliding gears are splined to the shaft, they rotate at shaft speed. The purpose of this type of gear is to engage and disengage transmission gears. A shift fork moves a sliding gear left or right across the axis of the shaft. A sliding gear has dogs on its sides, which are designed to engage freewheeling gears. Sliding gears will normally be abbreviated as "S."

Freewheeling Gears

Freewheeling gears rotate freely on the shaft to which they're attached. Freewheeling gears are usually held in place by retaining rings. A freewheeling gear doesn't have to rotate at shaft speed and has slots or protrusions (also known as dogs) on its side to allow for engagement with a sliding gear. For a constant-mesh transmission to operate correctly, there must be a freewheeling gear meshing with a sliding gear or fixed gear on the opposite shaft. Freewheeling gears will normally be abbreviated as "FW."

Main Drive Gears

Main drive gears are designed to ride on bearings and are mounted on the main shaft. There are two different types of main drive gears—one is used on the 5-speed transmission while the other is found on the 4-speed transmission.

5-speed main drive gear. The final drive sprocket (or pulley) is connected to the 5-speed main drive gear. When the transmission is in any gear other than fifth (or top) gear, this main drive gear is driven by a gear on the countershaft. While in top gear, it's locked to the main shaft by a sliding gear, which is also attached to the main shaft.

4-speed main drive gear. In the 4-speed transmission, the main drive gear is attached directly to the clutch and slides over the main shaft. As with its 5-speed counterpart, when the transmission is in any gear other than fourth (top) gear, the main drive gear is driven by a gear on the countershaft.

Main Shaft

The main shaft in a direct-drive transmission is connected to the clutch. Both rotate at the same speed. The main shaft rotates whenever the engine is running and the clutch is engaged.

Countershaft

The countershaft is used to transfer the power coming into the main shaft to the main drive gear. The countershaft rotates only when the transmission is engaged, and rotates at the speed that the engaged gear-set ratio permits.

Shift Drum

The shift drum controls the movement of sliding gears using shift forks. The shift forks have pins that set into grooves. The grooves are machined into the drum and allow the gears to slide from side-to-side to move them into and out of transmission engagement. The shift drum is rotated by a shifting mechanism that's operated by a shift lever on the left side of the motorcycle.

Cam Plate

A cam plate (Figure 18) is used on 4-speed direct-drive transmissions. This plate operates under the same principle as the shift drum. The difference between a cam plate and a shift drum is that the cam plate is a flat plate with grooves machined into it which are used to guide the shift forks, whereas the shift drum is a round drum.

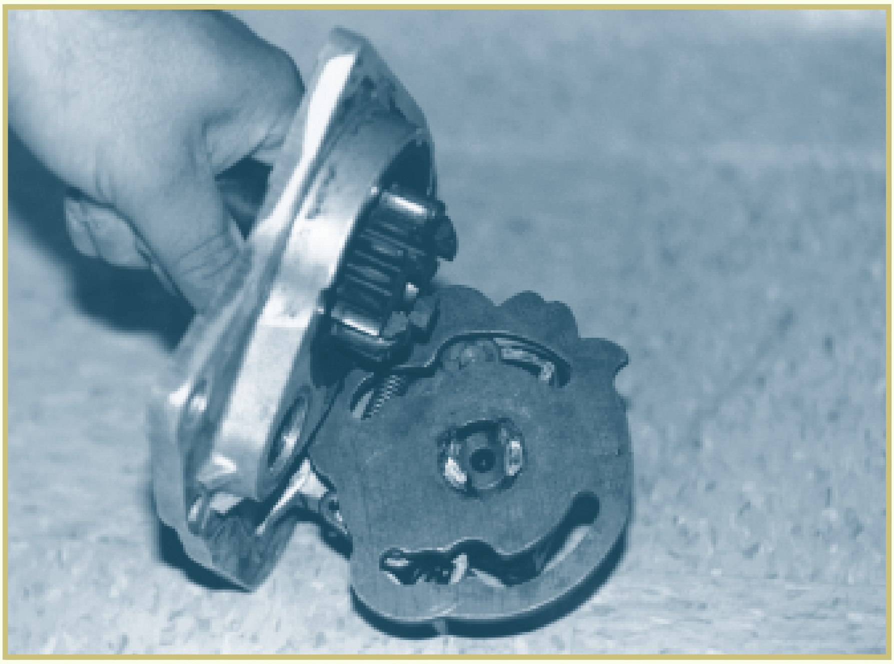


FIGURE 18—The 4-speed direct-drive transmission uses a cam plate to move the shifting forks to engage and disengage the transmission.

Direct-Drive Transmission Theory of Operation

With a direct-drive transmission, the rear wheel rotates in the same direction as the engine when a primary chain or belt is used. To accomplish this, the transmission must allow the power from the engine to come into one shaft, make any necessary gear ratio changes, and then transmit the power to the rear wheel without reversing rotation. This is the purpose of direct-drive transmissions.

In a direct-drive transmission, the power from the engine enters on the main shaft from the primary drive and is transferred to the countershaft, which determines the gear ratio for the lower gears. The power is transferred from the countershaft through the main drive gear, which directs the power through the main shaft. The drive sprocket is splined to the main drive gear, which as mentioned earlier, fits on the main shaft. The drive sprocket rides on bearings on the 5-speed direct-drive transmission. On the 4-speed system, the drive sprocket is attached directly to the main shaft. In top gear, the main shaft is directly connected to the main drive gear and power doesn't flow through the countershaft. Instead, power flows directly from the engine's primary drive system to the rear wheel.

Direct-Drive Transmission Power Flow (5-Speed)

You should now have a basic understanding of the theory of operation of a direct-drive transmission and its component parts. Next, we'll discuss the power flow in a 5-speed direct-drive transmission (Figure 19).

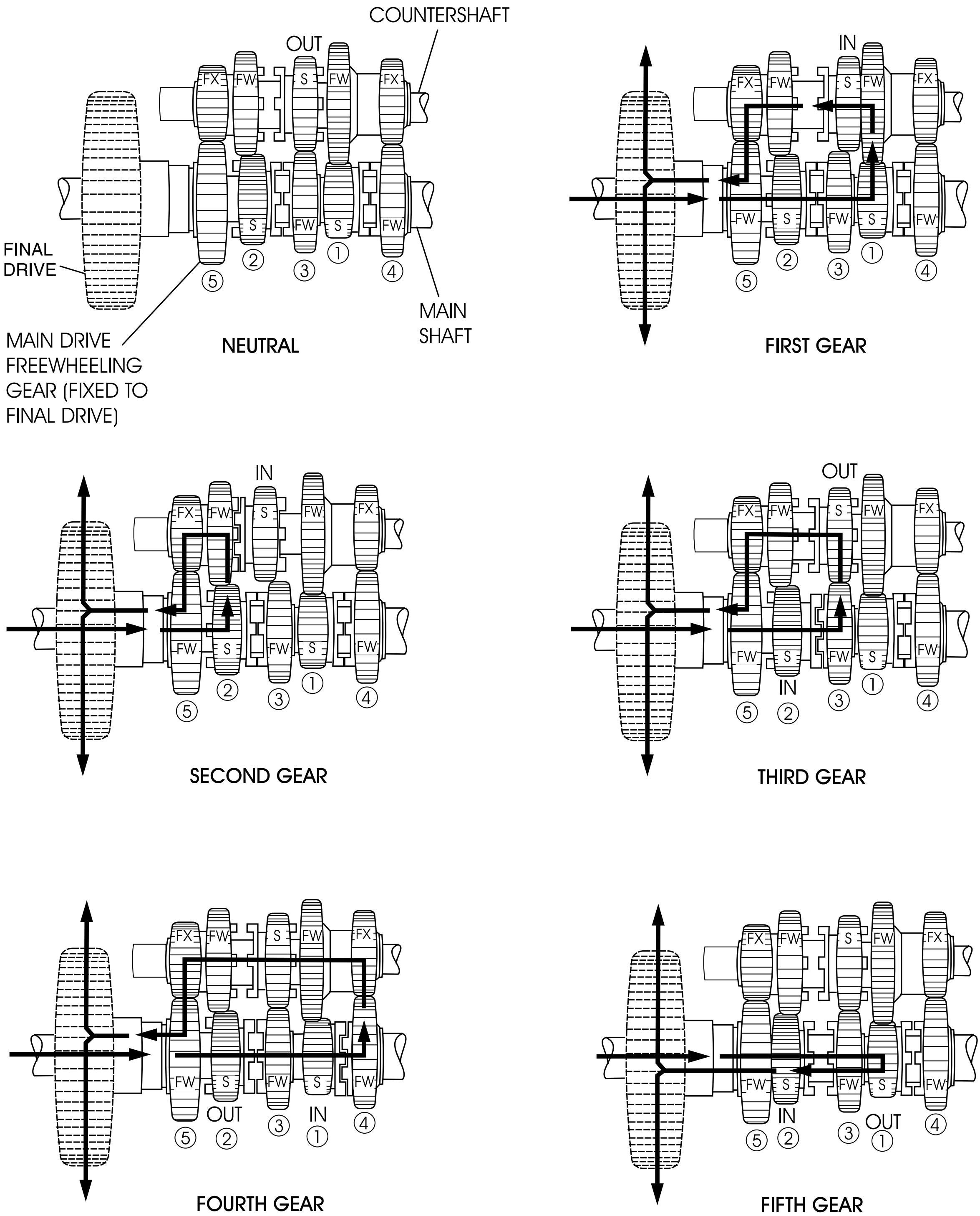


FIGURE 19—This illustration shows a five-speed direct-drive transmission.

Neutral

When the 5-speed direct-drive transmission is in the neutral position, the shift drum places the sliding gears in a position so that the dogs on the sliding gears cannot engage with any dogs or slots on the gears adjacent to them. If the clutch is engaged while the engine is running, the two sliding gears on the main shaft (1st and 2nd) will rotate with the clutch. Thus, the two countershaft gears opposing the rotating main shaft gears will also rotate. However, since a freewheeling gear must oppose a sliding or fixed gear in a constant-mesh transmission, the countershaft won't rotate in this transmission position.

First Gear

When the transmission is shifted into 1st gear, the shift drum slides the shift fork that's attached to the sliding 3rd gear on the countershaft into freewheeling 1st gear. Since 1st gear on the main shaft is also a sliding gear, this motion attaches the countershaft to the main shaft. The fixed 5th gear on the countershaft will make the main drive gear rotate, delivering power to the final drive pulley.

Second Gear

When the transmission is shifted into second gear, the shift drum slides the countershaft, sliding 3rd gear out of the countershaft freewheeling 1st gear and into the countershaft freewheeling 2nd gear. This attaches the countershaft to the main shaft (as the main shaft 2nd gear is also a sliding gear). The transmission is fully engaged now at a slightly higher gear ratio than when it was in first gear. Output is realized through the countershaft fixed 5th gear again, delivering power to the final drive.

Third Gear

When the transmission is shifted into third gear, the shift drum must do two things at one time. Second gear must be disengaged by moving the countershaft sliding 3rd gear away from countershaft freewheeling 2nd gear, while the main shaft sliding 2nd gear slides into the main shaft freewheeling 3rd gear. Since 3rd gear on the countershaft is a sliding gear, this again attaches the main shaft and countershaft, but now in the third gear position. This drives the final drive through the countershaft 5th gear and out the main drive gear.

Fourth Gear

When the transmission is shifted into 4th gear, the sliding 2nd gear on the main shaft is disengaged from the main shaft freewheeling 3rd gear just as the main shaft 1st sliding gear attaches itself to the main shaft freewheeling 4th gear. Countershaft 4th gear is a fixed gear and the countershaft and main shaft complete the power flow once again to the main drive gear.

Fifth Gear

For our final gear, the main shaft sliding 1st gear is disengaged from main shaft 4th gear while the sliding 2nd gear on the main shaft is slid into the main drive gear. This in turn connects the main drive gear directly to the main shaft, which allows power to be delivered directly from the clutch (attached to the main shaft) to the final drive pulley.

Direct-Drive Transmission Power Flow (4-Speed)

Many V-twins also use a 4-speed direct-drive transmission which is similar in design to a 5-speed, but has some operating differences. Next we'll explain the power flow of the 4-speed transmission. One of the differences between the 4- and 5-speed direct-drive transmission is that the 4-speed only needs two sliding gears as opposed to the 5-speed, which needs three sliding gears. Also, as Figure 19 and Figure 20 show, the main drive gear in a 4-speed direct-drive transmission is attached directly to the clutch instead of the final drive sprocket or pulley as on the 5-speed system.

Neutral

When the 4-speed direct-drive transmission is in the neutral position, the shift plate places the two sliding gears in a position so that their dogs can't engage with any dogs or slots on the gears adjacent to them. If the clutch is engaged while the engine is running, the countershaft rotates with the clutch. Therefore, the main shaft gear opposing the rotating countershaft gear (main shaft 3rd freewheeling) will rotate as well. The final drive does not rotate in this transmission position.

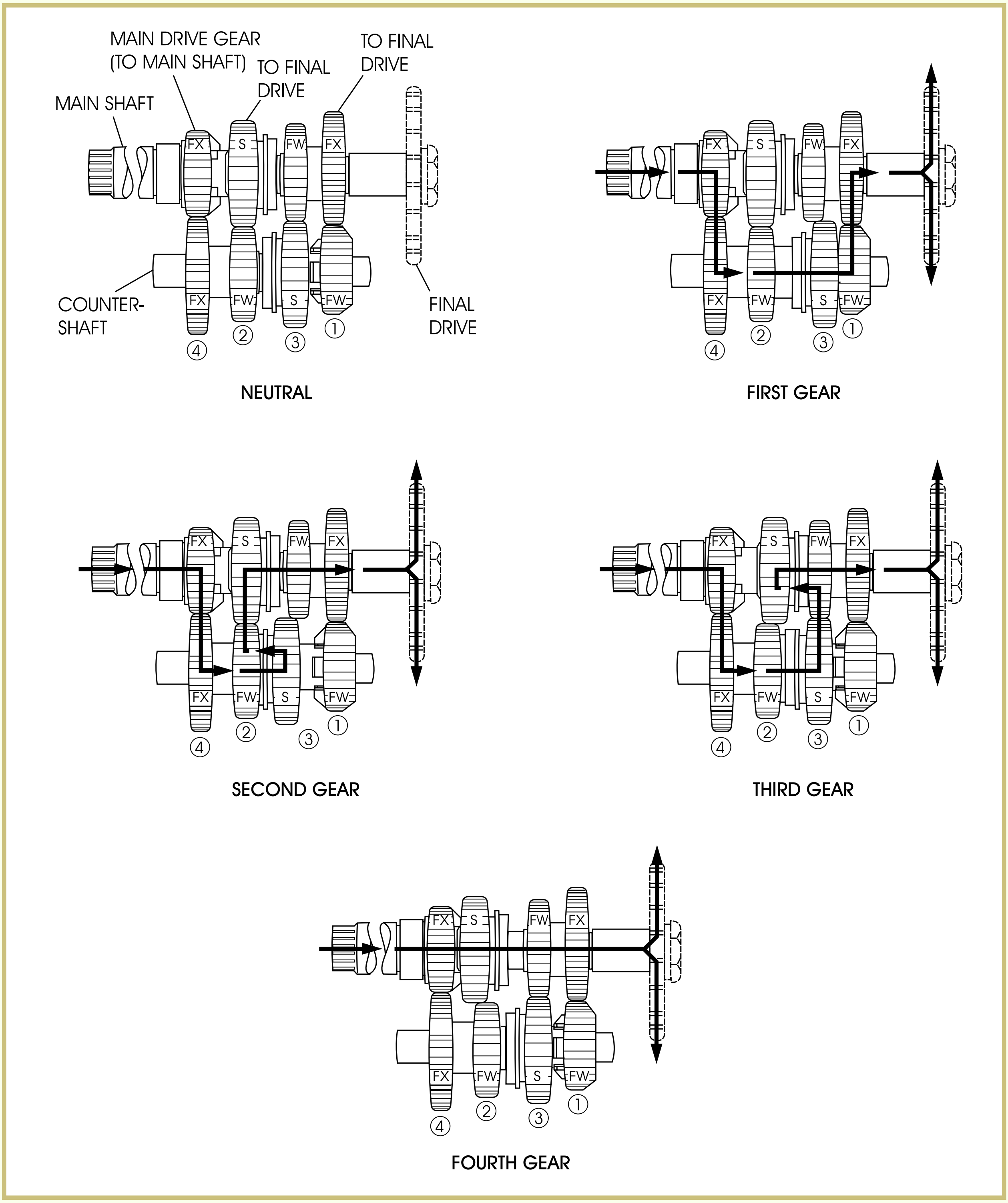


FIGURE 20—This illustration shows a four-speed direct-drive transmission.

First Gear

When the transmission is shifted into first gear, the shift plate slides the shift fork, which is attached to the countershaft sliding 3rd gear, into freewheeling 1st gear on the countershaft. Since 1st gear on the main shaft is fixed to the final drive, this motion attaches the clutch and main drive gear through the countershaft to the final drive. This allows power to flow to the rear wheel by delivering power to the final drive sprocket or pulley.

Second Gear

When the transmission is shifted into second gear, the shift plate must slide the countershaft sliding 3rd gear out of the countershaft freewheeling 1st gear and into countershaft freewheeling 2nd gear. This attaches the countershaft to the final drive, as the main shaft 2nd gear is a sliding gear. Once again, the transmission is fully engaged, except that it's now at a slightly higher gear ratio.

Third Gear

When the transmission is shifted into third gear, the shift plate must do two things at one time, just as the 5-speed shift drum did earlier. Second gear must be disengaged by moving the countershaft sliding 3rd gear away from countershaft freewheeling 2nd gear, while at the same time, the main shaft sliding 2nd gear is slid into the main shaft freewheeling 3rd gear. Since 3rd gear on the countershaft is a sliding gear, this again attaches the final drive and countershaft, but now in the third gear position.

Fourth Gear

To shift into fourth gear, the sliding 2nd gear on the main shaft must be disengaged from the main shaft freewheeling 3rd gear and slide into the main drive gear. This in turn, connects the main drive gear directly to the main shaft, which allows power to be delivered directly from the clutch to the final drive pulley or sprocket.

Transmission Problem Symptoms

Since 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. Here are some common malfunctions of a transmission and how you can recognize them.

Difficult Shifting

When excessive clutch lever pressure is required to shift gears, it may indicate either a clutch problem or a transmission problem. If the clutch is at fault, the symptom of grinding gears when shifting into low or first gear will be evident. In most cases, if the clutch is at fault, a simple adjustment may solve the problem. When difficult shifting occurs between other gears while the motorcycle is moving, it's usually caused by a bent shift fork. When a shift fork has been damaged, it no longer fits properly in the grooves of the gear. This problem requires disassembly of the transmission and replacement of the shift fork. Difficult shifting can also be caused by a partially seized gear on a transmission shaft. This problem is generally caused by the lack of proper lubrication and, as with the shift fork, disassembly of the transmission is required to repair this type of condition

Inability to Shift Gears

Sometimes you'll find a machine that will shift 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. This problem can usually be repaired by replacing the spring and in most cases won't require the complete disassembly of the transmission. The spring is usually located near the clutch assembly.

Strange Sounds

Occasionally you'll have customers who will complain of strange sounds coming from the transmission of their motorcycle. Strange transmission sounds can range from a low growl to a high-pitched whine. Next we'll describe the most common noises that can usually be attributed to a problem with the transmission. Any unusual noise which is coming from the transmission will require you to disassemble and carefully inspect for and replace any worn or broken parts.

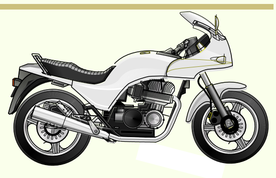
Constant growling sound. A low growling sound usually indicates a bearing failure. When a bearing failure occurs, it may cause a transmission shaft to move slightly out of position. When this occurs, the gears won't mesh properly and produce a low growling noise. In this case, not only does the bearing need replacing, but often the gears need replacing as well.

Clunking noises. Another characteristic sound which indicates a transmission problem is an excessive clunking sound when the engine is in a particular gear while under a load. Usually, this indicates broken teeth on one or more gears. This condition requires a complete disassembly as well as a complete inspection of all of the transmission components as broken teeth will normally damage other parts within the transmission.

Jumping Out of Gear

A transmission that jumps out of gear usually indicates that there are worn dogs or slots on the transmission gears. When dogs and slots become excessively rounded, the gears tend to slip out of the holes when engine rpm increases, causing the engine to jump out of gear. In this situation, the gears as well as the shift forks need replacing. The shift forks need to be replaced because they become damaged from the excessive pressure caused from the gear jumping out of gear.

Road Test 2



1. The transmission provides gear shifting to allow increases in speed without overworking the _______.

2. *True or False*? The 4-speed direct-drive transmission is identical in design to the 5-speed direct drive transmission except for the extra gear in the 5-speed system.

3. The _______-speed direct-drive transmission uses a shift drum to move the shift forks.

4. The _______-speed direct-drive transmission uses a cam plate to move the shift forks.

5. Define a constant-mesh transmission.

   ____

   ____

6. The letter "S" stands for which type of transmission gear?

   ____

7. A low growling sound in a transmission will usually indicate a _______ failure.

8. If you are working on a motorcycle that has a symptom of difficult shifting, what should you adjust first to try to correct the problem?

   ____

Check your answers with those on page 47.

V-TWIN MOTORCYCLE DRIVE SYSTEMS

As with any motorcycle, the V-twin motorcycle uses three systems to transmit the power made at the engine to the rear wheel. These systems are the primary drive system, the clutch system, and the final drive system.

Primary Drives

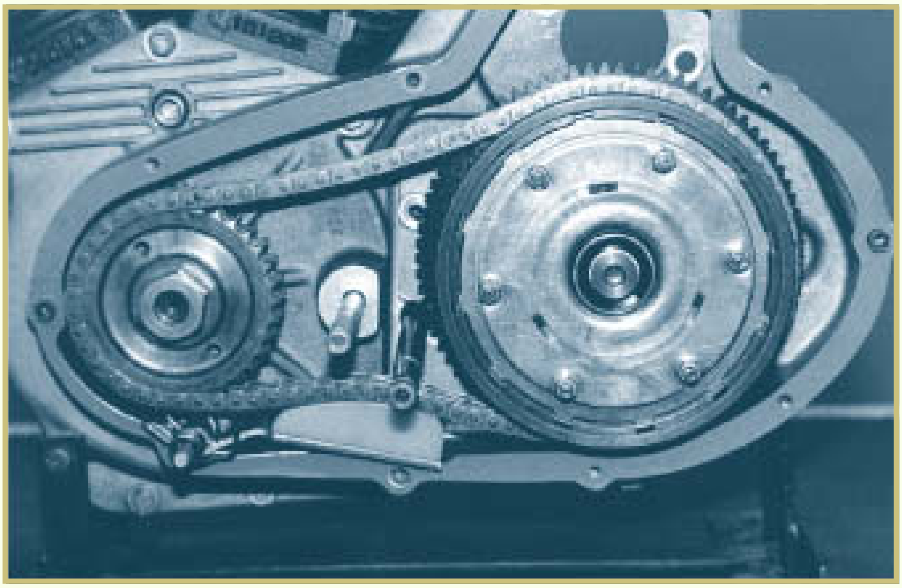
All motorcycle engines require a gear-reduction system that's used to transfer the power from the crankshaft to the transmission, and then from the transmission to the rear wheel. The gear-reduction system used for transferring the power from the crankshaft to the clutch is called the primary drive. As you already know, gear reduction is necessary to allow the engine to remain in the appropriate rpm range while maintaining various speeds at the rear wheel. In other words, we need gear reduction systems so that the engine can revolve at one speed, while the rear wheel turns at another speed. A clutch is needed to engage and disengage the power from the crankshaft to the transmission. Before we discuss and learn about the type of clutch used in V-twin motorcycles, we'll first discuss the types of primary drive systems found in this type of motorcycle engine.

There are two basic methods of connecting the engine to the clutch and transmission. A V-twin motorcycle primary drive system transfers power from the crankshaft to the clutch by using a chain or a belt.

Chain-Driven Primary Drive

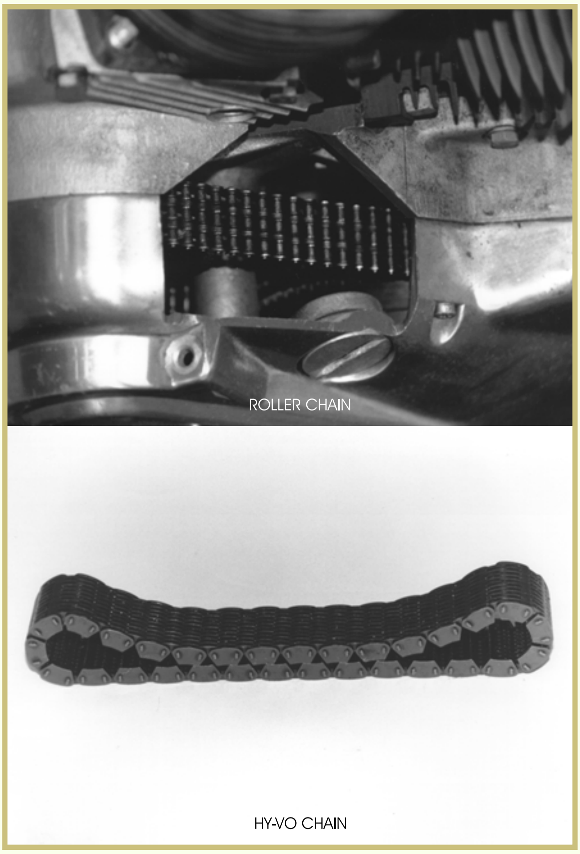
The chain-driven primary drive uses a chain and two sprockets (Figure 21) to transfer power from the crankshaft to the clutch. With a chain-driven primary drive, both sprockets turn in the same direction and use one of two different types of chain—roller or Hy-Vo (Figure 22). The Hy-Vo chain design is the most common type of primary drive, because its design is stronger and quieter than the roller chain.

FIGURE 21—The Chain-Driven Primary Drive



The chain-type primary-drive system found on the V-twin motorcycle must be checked for proper adjustment on a regular basis. There are normally two different chain play specifications—one for a hot engine and one for a cold engine. This is because of the expansion rate that's found in chains as well as how engine parts are affected by hot and cold temperatures. The cold play specification is larger than the hot play specification. You'll find that, as a chain wears, it stretches and generally has a tight spot at some point on the sprocket. As a result, you should always check for proper chain play at the tightest point of the chain. You can adjust primary chain tension by using the plastic shoe that's located in the primary chain case. The shoe is either raised to apply more tension, or lowered to apply less tension on the chain. This shoe can be seen on Figure 21 between the clutch and the crankshaft primary gear. The chain-type primary drive must be kept well-lubricated for proper operation. On the V-twin, lubrication is usually applied via the transmission.

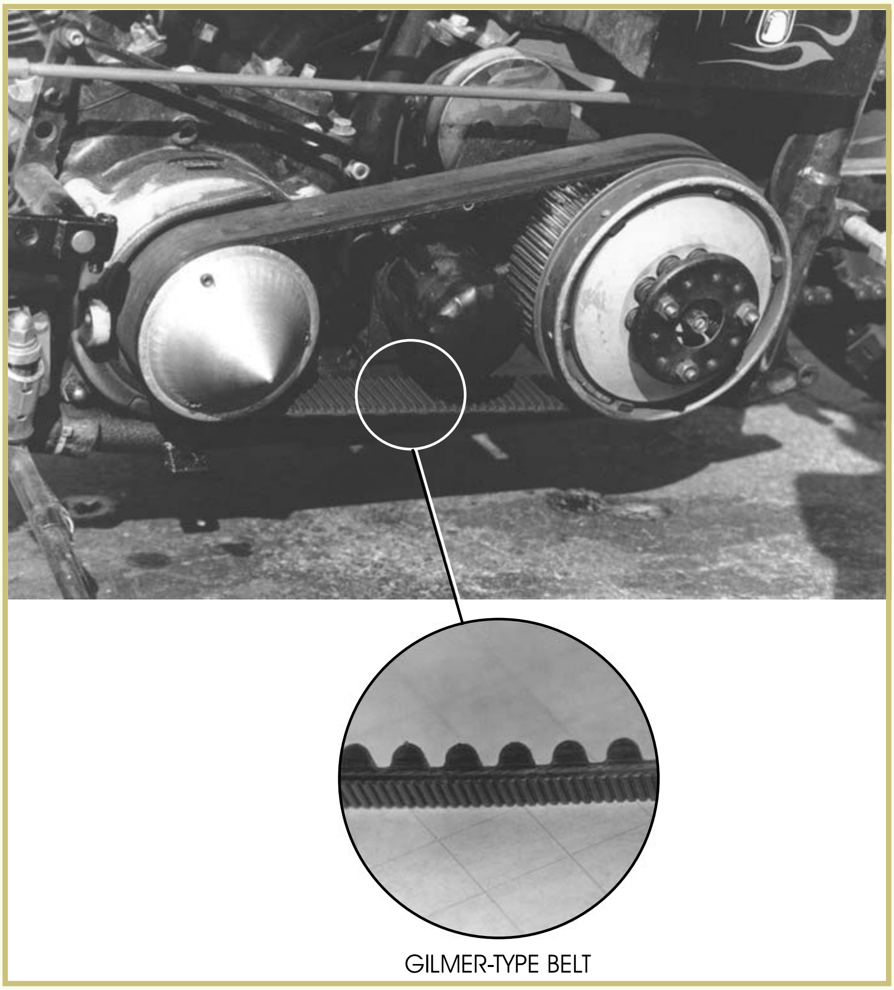
FIGURE 22—Roller and Hy-Vo primary drive chains are shown here.



Belt-Driven Primary Drives

The belt-driven primary drive system uses a toothed belt called a "Gilmer-type belt" and two pulleys with teeth attached to them (Figure 23). Just like the chain-driven primary drive system, the belt-driven type of drive has both pulleys turning in the same direction. This type of primary drive, because it uses a belt, is much quieter than gear-driven or chain-driven primary drives. Unlike the other primary drive systems however, the belt primary drive arrangement must be kept dry and therefore uses a dry clutch. The adjustment for this type of primary drive is very critical for proper operation. If the belt is too loose, it will seem like there's excessive play in the drive train and it will make excessive noise in the primary belt area. If the belt is too tight, the clutch will drag. Primary belt adjustment is accomplished by loosening the transmission mounting plate and prying on the crankcases with a heavy-duty screwdriver to increase the belt tension. While you're holding the screwdriver in place to maintain proper tension, tighten the transmission mounting bolts.

FIGURE 23—A Glimer-type belt has teeth in it and attaches between toothed pulleys.



Clutch System

The purpose of a clutch is to engage and disengage the power flow from the crankshaft to the transmission to start, stop, and shift transmission gears. The clutch used on the typical V-twin motorcycle is part of the primary drive system. The clutch is a wet multiplate manual clutch (or dry multiplate manual clutch if it's used with a belt-driven system). The clutch also has steel and fiber (friction) plates that are set alternately in the clutch outer shell. The clutch is located in the primary-side case, which contains the lubricant (for the wet clutch).

The friction plates in the clutch are made of a cork- or paper-based material (depending on the model and year), and are designed to drive the clutch outer shell. The steel plates are splined to the clutch hub, which is splined to the transmission, and uses a left-hand-threaded nut to attach it to the shaft. Usually, different steel plates are required for different types of friction plate materials. The steel plates should be used for the proper application as described by the appropriate service manual. The steel plates are called the drive plates while the friction plates are known as the driven plates.

The clutch outer shell is made up of pieces riveted together that contain the outer shell, the primary drive sprocket, and the electric starter gear. Some models even include the charging system rotor on the clutch outer shell. These clutches contain multiple coil springs or a diaphragm-type spring that applies pressure against the friction and steel plates to ensure a positive clutch engagement.

Clutch Lubrication

The primary chain-case lubricant (which again, is used to lubricate the clutch) should be changed in accordance with the manufacturer's recommendations. You can drain the lubricant into a suitable container by removing the drain plug at the bottom of the primary chain case. After draining the oil and installing the drain plug, you can refill the chain case through the clutch cover opening with the recommended amount of oil. When you have the correct amount of lubricant in the case, the lubricant is level with the bottom of the outer diameter of the diaphragm spring, or the lubricant overflows out of the oil level screw hole (depending on the model). Refilling the oil should be done when the motorcycle is standing in an upright and level position.

Clutch Adjustment

To obtain the maximum life from the clutch on a V-twin motorcycle, it's very important to perform the correct clutch adjustment procedure at every service interval. Also, if any clutch components are replaced during normal servicing, the clutch must be adjusted.

Clutch adjustment should be performed with the motorcycle at room temperature, since the clearance at the adjuster screw will increase as the power train temperature increases. If the clutch is adjusted while the engine is hot, clearance at the push rod bearing will be insufficient and clutch slippage will occur. The clutch cable adjuster is located midway between the clutch cable ends.

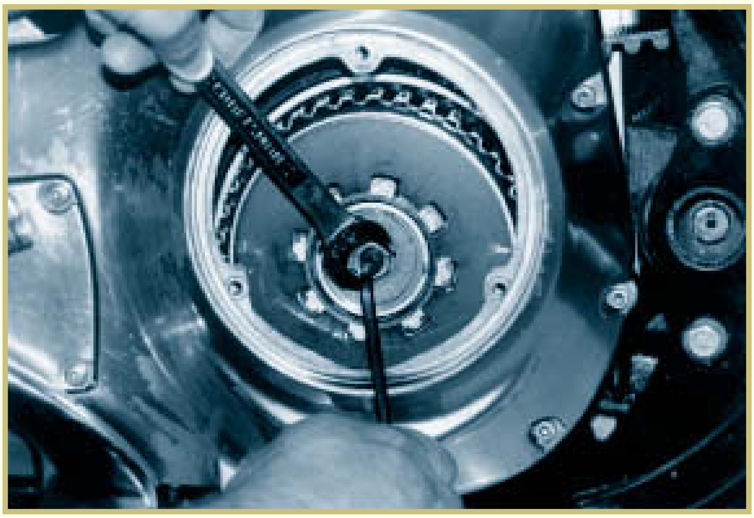
As with the previous study units, the procedures in this study unit are general in nature and not intended to be used for actual disassembly and repair. Their purpose is to familiarize you with the types of activities you'll encounter. Always refer to the appropriate motorcycle or ATV service guide for 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.

The following example steps will help you to understand how to adjust the clutch.

1 Loosen the lock nut and turn the adjuster in all the way to provide maximum play in the cable at the clutch lever.

2 Loosen the clutch adjuster screw lock nut (which is located under the clutch access plug) and turn the push rod adjusting screw inward (clockwise) to take up any of the play in the push rods.

3 Back out the adjusting screw ½ to 1 full turn and tighten the lock nut while holding the adjusting screw with an Allen wrench.



4 Pull the clutch lever in all the way (you may have to do this multiple times) to set the ball and ramp release mechanism.

5 Adjust the cable adjuster to provide $\frac{1}{16}$ - $\frac{1}{8}$ inch play at the clutch lever, then tighten the cable lock nut and return the adjuster boot over the adjuster.

Common Clutch Problems

There are two common clutch problems found with the V-twin multiplate manual clutch. The first 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. The clutch will slip if the rider releases the clutch lever and the motorcycle engine revs up without any power going to the rear wheel. This problem may be caused by improper clutch adjustment, a weak clutch spring, or worn clutch plates.

The second common problem that may be found with a clutch is known as clutch "drag." Clutch drag occurs when the clutch is unable to fully disengage. Clutch drag will be evident when the engine power can't be disengaged from the rear wheel. An example of this condition is when the clutch lever is squeezed in and the motorcycle is still trying to move forward. This condition may be caused by warped or binding clutch plates, a worn clutch outer shell or clutch hub, improper clutch adjustment, or a worn release mechanism.

Manual Clutch Operation

We'll now review the operation of a multiplate manual clutch as it's used on the V-twin motorcycle. It may also be helpful to review the material that was presented in the study unit *Clutches, Transmissions, and Drives*.

Clutch disengaged. When the clutch lever is pulled, the clutch push rod pushes against the clutch lifter rod. The clutch lifter 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.

Clutch engaged. When the transmission is shifted into gear, and the clutch lever is gradually released, the discs and 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 again completely transmitted to the rear wheel.

Final Drives

There are two common final drive systems used on V-twin motorcycles—chain and belt.

Chain Final Drives

The chain-driven final drive system is commonly found on V-twin motorcycles. As we discussed in earlier study units, a chain-driven final drive consists of two sprockets. One sprocket is attached to the output shaft of the transmission and one is attached to the rear wheel. A chain is used to connect the sprockets. With a chain-driven final drive system, you can replace the sprockets with other different-sized sprockets to provide a wide range of gear ratios.

The sprockets and chain in a chain-driven system wear out over time. As a result, you'll need to frequently perform maintenance if you are to make them last their full life. The drive chain requires service more often than any of the other final drive components. The correct adjustment and proper lubrication of the drive chain will help prolong the life of the chain and sprockets. Chains need frequent lubrication because they move at high speed and transmit the power of the engine. Heat builds up from the friction of the chain moving over the sprockets. Lubrication is needed to help reduce the friction and heat. When properly lubricated, the life of the chain and sprocket will be extended.

As we've discussed previously, the chains used on chain final drive systems are composed of pin links and roller links. Pin links are composed of two plates and two pins, while 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 with no master link. Most chains used on V-twin motorcycles are O-ring chains that use O-rings between the bushings and plates to help protect the chain and to keep lubrication inside the roller.

The sprockets on chain final drive systems are flat metal plates with teeth around the outside edges. The chain fits around the sprocket with the teeth of each sprocket 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.

As we mentioned, the largest benefit of using the chain-type final drive system is the wide variety of available sprocket sizes that allow you to change the gear ratio for the final drive to match your riding conditions.

Chain maintenance. To properly lubricate the chain, first brush off any dirt and grime using a soft hand brush. Then lubricate the chain using a high-quality chain lubricant. It's important to lubricate the chain between the side plates and rollers to allow for maximum lubrication. To clean an excessively dirty chain, you must remove the chain from the motorcycle. To do this, you must locate and remove the spring clip on the chain master link, then press the master link from the side plate using a special tool which is available at most motorcycle dealership parts departments. Once removed, you'll need to soak and wash the chain thoroughly in a pan of solvent, such as kerosene. Be sure to wear eye protection when performing this procedure. After you've thoroughly cleaned the chain, you can remove it from the solvent and dry it using compressed air or wipe it clean and dry with a clean shop rag. If using compressed air to dry the chain, eye protection is a must. After the chain is clean and dry, you'll need to apply chain lubricant, wipe all excess lubricant from the chain surface, and then reinstall the chain onto the motorcycle.

Chain installation. To install the chain, place the transmission in neutral and connect one end of the chain onto the front sprocket. Feed the chain through the sprocket until the chain is on both the wheel and transmission sprockets. Connect the ends of the chain with a new master link, making sure that the spring clip open end trails the direction of chain travel (Figure 24). The clip must be installed correctly to prevent the chain from coming apart.

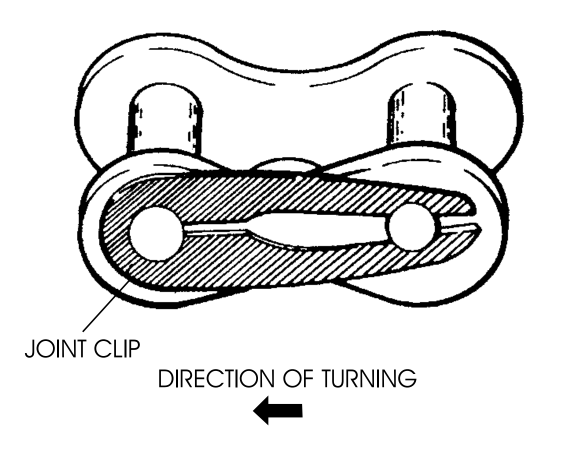


FIGURE 24—Be sure to install the master link in the proper direction or the clip can come off, causing the chain to come apart. (Image courtesy of Yamaha Motor Corporation, U.S.A.)

Chain adjustment. The chain must be adjusted on a regular basis as the chain wears. When checking the chain adjustment, you should place the motorcycle upright with the transmission in neutral and with the rider on the machine (Figure 25). A properly adjusted chain should have the specified "slack" (up and down movement) midway between the transmission sprocket and the rear wheel sprocket. The manufacturer will supply the specification in the service and owner's manual. You'll notice that different models require different amounts of chain slack. To adjust the chain, first loosen the axle nut, then turn the chain adjusting nuts clockwise to tighten the chain and counterclockwise to loosen the chain. Be sure to turn each adjusting nut an equal number of turns to keep the rear wheel in proper alignment with the chain. The rear axle must remain parallel with the swing arm pivot shaft. When you have completed the adjustment of the chain, tighten the axle nut to the manufacturer's specified torque. If the chain adjusters have reached their limit, proper chain adjustment can no longer be achieved and the chain will need to be replaced.

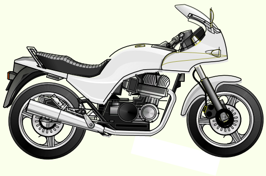
FIGURE 25—In this picture, the customer is sitting on the motorcycle while the technician checks for the proper chain slack.

Belt Final Drives

Belt final drive systems are used on many Harley-Davidson and other brands of V-twin motorcycles. As we mentioned earlier in this study unit, these systems use a Gilmer-type belt that has teeth molded into it which 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, including proper alignment of the belt and pulleys and proper belt tension, which is extremely critical with this type of final drive system.

To adjust the belt, first loosen the rear axle nut and after loosening the jam nuts, turn the belt adjuster bolts as needed to move the axle in or out. As with the chain final drive, turn each adjuster nut an equal number of turns to keep the wheel properly aligned. To move the axle forward, loosen the adjuster nuts an equal number of turns and tap lightly on the ends of the adjuster studs using a soft-tipped hammer. In most cases, to get the proper belt tension required by the manufacturer, a belt tension tool is required. This special tool is available from your local dealer. After verifying the belt tension, tighten the rear axle nut to the specified torque given by the manufacturer. On some models, you aren't required to loosen the axle nut to adjust the belt tension. The service or owner's manual will specify this when necessary.

Road Test 3



1. The clutch found on V-twin motorcycles is part of the _______ drive system.
2. On motorcycles that use a primary drive with a chain, what type of clutch design is used?

   ____

3. The clutch outer shell contains pieces that are _______ together.
4. The V-twin motorcycle has a primary drive system that uses a chain or _______ to transmit power from the crankshaft to the transmission.
5. Primary chain tension is adjusted by a shoe located in the _______.
6. *True or False?* The clutch outer shell may also include the charging system rotor as part of the component.
7. Which chain used in a primary drive system is the most common?

   ____

8. The friction plate material used in a clutch is made of a _______ or _______ material.
9. *True or False?* Adjustments to a clutch should be made while the engine is at its normal operating temperature.
10. *True or False?* When the clutch is engaged, the power of the crankshaft to the rear wheel is separated.

Check your answers with those on page 47.

V-TWIN MAINTENANCE

The reliability and longevity of any engine is dependent on the routine maintenance it receives. The valve trains on Harley-Davidson V-twins require specific and careful attention in order to run long and strong. First we'll discuss routine maintenance on engines like the Shovelhead and the Evolution; then we'll go over some points specific to Harley-Davidson chassis maintenance.

The first step in any tune up is to obtain the proper factory workshop manual for the motorcycle in question and follow it carefully. Now is a good time to put into practice all of the concepts and methods you learned in previous chapters.

The Shovelhead engine uses *hydraulic valve adjusters*, or *tappets*, much like those found in American automobiles. Although they're designed to maintain valve clearance, these adjusters encounter heat and wear and therefore require periodic adjustment.

Remember that the engine must be cold before you can set the valves. Begin the procedure for setting the valve clearance by removing the spark plugs. This makes it much easier to turn the engine over while you find top dead-center compression. You must have the piston on top dead-center compression before you set the valves.

Watch the rocker arms as you turn the engine over. If you have the piston at top dead-center and the intake valve is closed, you have the engine set correctly. Once you've determined that the cylinder you're concerned with is in the correct position, slide the pushrod covers out of the way to expose the adjusters. Loosen the adjuster lock nut on the pushrod, and turn the adjuster up until there's some up-and-down play in the pushrod. At this time, turn the adjuster down until you've removed all of the play. Look for the split in the lock nut; you can use it as a reference mark. (You may have to turn the lock nut in order to see the split.)

Turn the adjuster down four full turns. (This is the specification listed in the factory workshop manual.) You may choose to add another half-turn, which takes all of the play out of a well-used adjuster and lock nut assembly. At this point, tighten down the lock nut and repeat the procedure for the other valve's pushrod.

You need to be careful here, because the hydraulic tappet is full of oil and holding the valve off its seat. It will take several minutes for the valve spring to compress the oil out of the hydraulic tappet. After you've waited five minutes, repeat the process for the other cylinder, remembering to find top dead-center compression for that cylinder as well.

As long as you're inspecting the top end, it's a good idea to check the side-to-side clearance of the rocker arms. This clearance will manifest itself as a tapping or ticking noise that sounds very much like a loose valve. With the piston on top dead-center compression, try to slide the intake rocker arm back and forth. It should only have a .004-inch play. Aftermarket manufacturers make shims that allow you to set this clearance properly. Just make certain that you keep the rocker arm centered over the valve stem while you shim out the excess play.

Spark Plugs

As long as you have the spark plugs out for the valve adjustment, you should check their condition. Sooty, black plugs indicate a carburetion problem; while plugs with rounded center electrodes are ready for replacement. If your plugs are ready for replacement, make sure to gap them according to the factory specification. The gap should fall between .020-inch and .043-inch, depending on the year and model you're servicing. Also, make sure you have the correct heat range. Never replace the plugs found in the engine without checking whether or not the replacements are the correct type. Always go by what the manual specifies.

Carburetor

Harley-Davidson has been using Keihin carburetors for more than 12 years, and these have proven easy to tune given the proper maintenance. To begin the process, warm the bike up to operating temperature. Remove the air cleaner and check that the butterfly opens fully. If it doesn't, adjust the throttle cable. After adjusting the throttle cable, swing the handlebars from side-to-side to make sure there's sufficient free play. The engine should maintain the set idle speed as the bars move from side-to-side.

Now find the idle mixture screw. This is located on top of the carburetor under an aluminum anti-tamper cap that must be removed before the idle mixture can be adjusted. Drill a 1/8″ hole in it and thread a sheet metal screw into the hole. Use the sheet metal screw to pull out the anti-tamper cap. Be careful you don't drill the hole too deeply, or you'll damage the idle mixture screw. To prevent this from happening, wrap a piece of tape around the drill bit .100″ inch from the end of the bit. The position of the tape will indicate when you've drilled deeply enough.

Turn the idle mixture screw in or out until you achieve the highest idle. If the idle speed creeps above the speed listed in the manual, reset it with the idle stop-screw and readjust the mixture screw. You'll know that you've set the mixture screw properly if the idle speed drops when you turn the mixture screw in and out from your setting.

The correct setting should be very close to the one listed in the manual, somewhere between a half-turn and 1 ¼ turns out. If you find that the engine runs best with the mixture screw set at less than a half-turn, then the idle jet is too large. If you find the opposite is true, then the idle jet is too small. Of course, this will be the case only if the engine has been modified from stock or if there's some problem with it, such as bad rings or valves that aren't seating properly.

Replace the anti-tamper cap with a new one when you're finished with the carburetor. Drive it in carefully with a small ball peen hammer. Also, the air filter should be replaced if it's excessively dirty. Filters usually last for about 10,000 miles, but this figure varies according to riding conditions. If the bike is operated on dirt roads, the filter should be replaced more often.

Harley-Davidson makes an excellent replacement-filter kit under the "Screamin' Eagle" name. This filter is made of oil-pleated paper and catches dirt particles as small as five microns in size. Filters actually work better once they're a little dirty, and they can be washed and reused several times.

Oil Levels

The Harley-Davidson engine is much more sensitive to dirty oil than an automobile engine. HD engines contain rolling element bearings in the crank train, and dirt can ruin these bearings in short order. A car has plain bearings, and dirt often embeds itself in the soft bearing material without harming the journal. For this reason, Harley-Davidson engines should receive frequent oil and filter changes. The oil should be changed every 2,000 miles, while the filter should be with every oil change.

If you drain the oil and find that there's more than a quart in the crankcase, this is a signal that the oil pump has a bad check valve. The Harley-Davidson engine is of a dry sump design and, as such, contains an oil pump that draws oil out of the crankcase and back into the oil tank. Excess oil in the crankcase results in smoking and plug-fouling. The most common cause of "wet sumping" is a bad check ball.

Chassis

After you've serviced the engine, it's time to address the chassis. We've already talked about adjusting the final drive chain or belt, but you'll also need to check the brake pads for wear. Any pad worn unevenly or down to the wear indicators must be replaced immediately.

If the bike has hydraulic brakes, the fluid must be checked. Replace the fluid if it has been two years or longer since the last change, or simply top it off if the fluid is still clear. Be careful what kind of fluid you're adding. Some types aren't compatible. Check with the owner of the bike if you're in doubt. Failure to do so will necessitate a complete tear-down of the braking system.

Go over the rest of the bike. The cables should be lubed with a light oil, such as *ATF* or *3-In-1;* their free play should also be set to factory specifications. Check for frayed cables, especially at the levers. In addition, remove and lube the pivot bolts from the clutch and brake levers. You can improve the shifting dramatically with this simple exercise.

The tires should be checked next, as you pay special attention to the wear bars molded into the tread. If the wear bars are flush with the surface of the tire, then the tire is ready for replacement. Tire pressures are listed in the owner's manual and should be strictly adhered to. If the bike you're servicing has tires other than those it came with, you can find the recommended pressures from the manufacturer. The factory-recommended tire pressures generally apply for aftermarket tires as well.

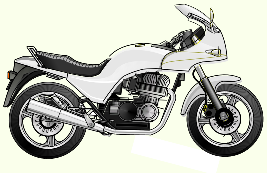
The level in the battery is very important, and any chassis tune-up is incomplete without a battery-servicing. Replace the electrolyte with distilled water. You may want to test the specific gravity with a hydrometer for a more complete picture of the battery condition. As you'll remember from past study units, the proper specific gravity should be between 1.275 and 1.30.

By virtue of their 45° V-twin engines, Harley-Davidson engines vibrate. This vibration causes bolts and nuts to loosen over time. Go over all external fasteners and check to see that they're properly torqued. A thread-locking compound is very useful in keeping bolts tight that frequently become loose. Make sure you thoroughly clean the threads of any bolt you treat with thread locker; this will help it perform properly.

Now check the fork seals for leakage. Fork oil that gets past the fork seal will often leak onto the brake caliper and cause a loss of braking power. Fork seals should be replaced as soon as possible to prevent dirt from getting into the fork and slider. Then, while you're inspecting the fork seals, check the front wheel and steering head for worn bearings.

You should know that Harley-Davidson motorcycles contain tapered wheel bearings in the front wheel that require more care than the sealed ball bearings found in Japanese bikes. Use lithium grease to lube these bearings. Heavy wheel-bearing grease will be squeezed out of the rollers as they rotate. However, make sure the bearing spacer is set correctly. A dial indicator set on the end of the axle in the front wheel should indicate .004″–.018″ of axial play. If that's not the measurement you get, you'll need to select one of three different-sized bearing spacers available from Harley-Davidson.

You've now completed a thorough maintenance check of a typical American V-twin motorcycle. Proper maintenance is essential in keeping any bike running well. It also contributes to the safety of the rider. Poorly maintained bikes are accidents waiting to happen.



Road Test 4

1. What's the first step in setting valve clearance?

   ____

2. *True or False?* Spark plugs with square-shaped center electrodes should be replaced.

3. What signifies that the idle jet is too small?

   ____

4. *True or False*? Filters only work well when they're *completely* clean.

Check your answers with those on page 47.

Road Test Answers

1

1. chemical, heat
2. Dry
3. combustion lag, active combustion, and post combustion
4. anti-leak check valve
5. Gravity
6. Constant Velocity (CV)
7. True
8. intake, compression, power, exhaust

2

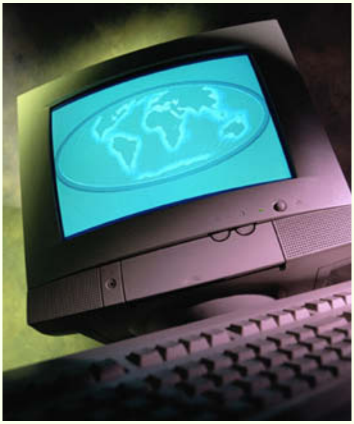
1. Engine
2. False
3. Five
4. Four
5. All gears within the transmission have a mate on the opposite shaft.
6. Sliding gear
7. Bearing
8. The clutch

3

1. Primary
2. Wet multiplate
3. Riveted
4. Belt
5. primary chain case
6. True
7. Hy-Vo
8. cork, paper
9. False
10. False

4

1. Remove the spark plugs
2. False
3. If you find that the engine runs best at higher than one turn
4. False



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