After studying this chapter, you will be able to:

- Explain the basic purpose of a transmission.
- Identify the differences between manual and automatic transmissions.
- Describe the differences between automatic transmissions and automatic transaxles.
- Identify major automatic transmission and transaxle components.
- Explain the basic operation of an automatic transmission or transaxle.
- Trace the development of modern automatic transmissions and transaxles.

### Technical Terms

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Transmissions and Transaxles

Automatic transmissions and transaxes have been used for more than 60 years. They have been consistently modified and improved, evolving from early inefficient designs to the smooth-shifting, efficient units of today. Most modern transmissions and transaxes are controlled by an onboard computer and provide almost the same fuel economy as manual models. To service late-model automatic transmissions or transaxes, the technician must possess considerable knowledge and skill. This chapter will introduce you to the fundamentals of automatic transmissions and transaxes. The basic principles covered here will be expanded upon in later chapters.

The Purpose of Transmissions

All transmissions, whether manual or automatic, have the same basic purposes:
- To transmit power from the engine to the drive wheels when necessary.
- To disconnect the running engine from the drive wheels during gear changes and when the vehicle is not moving.
- To reverse the direction of power flow when the vehicle must be backed up.
- To multiply engine torque as needed.

In simplest terms, a transmission modifies engine torque and speed to match the vehicle's needs. For example, moving a vehicle from a stop requires a great deal of engine torque, or turning force. At low speeds, however, an engine produces relatively little torque. The transmission must multiply engine torque to get the vehicle moving. It does this by reducing speed to increase torque.

The relationship of the speed of the transmission's input shaft to the speed of its output shaft is called the gear ratio. The transmission uses a set of at least two gears that cause the output shaft speed to be much lower than the input shaft speed. This set of gears is called a reduction gear. Figure 1-1 shows a simple reduction gear.

At higher speeds, the vehicle does not require as much engine torque to keep it moving. The engine would be turning very fast if the transmission output speed remained slower than the input speed. High engine speed will cause poor fuel economy and rapid engine wear. Therefore, the transmission must be shifted into successively higher gears as vehicle speed increases. Shifting into higher gears changes gear ratios, so the speed of the output shaft approaches and eventually equals or exceeds the speed of the input shaft.

Most modern transmissions have at least four forward gears, with the highest gear being either direct drive or overdrive. A direct drive gear causes the input and output shafts to turn at the same speed. The overdrive gear causes the output shaft to turn faster than the input shaft. Figure 1-2. Overdrive allows the engine to turn at a relatively slow speed, increasing fuel economy and reducing engine wear.

Both manual and automatic transmissions can accomplish any of the previously mentioned jobs. There are many similarities between manual and automatic transmissions. All transmissions have a way of keeping the engine from stalling when the vehicle is stopped, all use gears and shafts to obtain different ratios, and all have a way to reverse the direction of vehicle travel. However, with a manual transmission, the gear selection decision must be made by the vehicle's operator. The driver slides the transmission gears in and out of engagement using a gearshift lever. The gears are milled in different combinations to achieve the desired gear ratios. The driver must also operate a manual clutch to connect and disconnect the engine from the transmission when stopping or changing gears.

With automatic transmissions, on the other hand, gear selection decisions are made by an automatic control system. Instead of a manual clutch to connect and disconnect the engine from the transmission, automatic transmissions use fluid couplings or torque converters to transfer power from the engine to the transmission. Automatic transmissions use planetary gearsets, which do not slide in and out of engagement. In operation, one of the gears in the gearset is locked in place. The remaining unlocked gears are driven by engine power and compose the input and output. Different gear ratios are achieved by different combinations of locked and unlocked gears. The gears are operated by holding members called clutches and bands. The clutches and bands are controlled by a hydraulic control system. Late-model automatic transmissions have hydraulic systems controlled by on-board computers. Vehicles with automatic transmissions are easier to drive than those with manual transmissions. They are also more durable for heavy-duty operation, such as trailer towing. The major differences between manual and automatic transmissions/transaxes are shown in Figure 1-3.

The ideal transmission will transmit engine power with no slipping. Slipping can be defined as failure to transmit all engine power to the other drive train components. In other words, a slipping transmission will lose both speed and torque between its input and output shafts. Early automatic transmissions were so inefficient and slipped so much that they were called “slush boxes.” Modern automatics are efficient and smooth. Except for first and reverse gears, modern automatic transmissions permit no slippage. They transmit as much engine power as manual transmissions. It is now possible for an automatic transmission to be more efficient than a manual. With an automatic transmission, there is no need to release the accelerator pedal during shifts, and then reaccelerate to maintain vehicle speed.

Transmissions and Transaxles

Until about 20 years ago, nearly all vehicles had a rear-wheel drive arrangement that used a transmission to transfer power to the rest of the driveline. The rear-wheel drive transmission transmits power in a straight line, from the front of the vehicle to the back. The differential and the final drive assembly are contained in a separate housing at the rear of the vehicle.

Today, most automobiles use front-wheel drive systems equipped with transaxes. Transmissions and transaxes perform the same function. The major differences include the arrangement of the parts and the fact that the differential and the final drive assembly (sometimes called the ring-and-pinion assembly) are an integral part of the transaxle. Transaxes have two output shafts, one for each wheel. These shafts are attached to the CV axles.

Engine power is transmitted sideways through a chain or gears at some point in the transaxle.

The advantages of transaxes include reduced weight and increased fuel economy. On trucks, however, weight and fuel economy are less of a factor than durability. The rear-wheel drive train is usually used on these vehicles. Therefore, it is important that both transmissions and transaxes be understood completely.

Four-wheel drive vehicles have a transfer case attached to the rear of the transmission. The transfer case sends power to the front wheels. Figure 1-4 illustrates the layouts of modern rear-wheel drive vehicles with automatic transmissions and front-wheel drive vehicles with automatic transaxes.

Automatic Transmission and Transaxle Development

The modern automatic transmission was not the result of a single invention. Some components used in automatic transmissions were developed long before the automobile itself. Planetary gear principles were known during the time of the Roman Empire and eventually appeared on the Ford Model T. Fluid couplings were used to drive machinery in 19th-century mills. The first automotive fluid couplings were used on English cars in the 1920s, and on Chrysler vehicles in the mid-1930s.

The 1938 Oldsmobile is widely considered the first car to have an automatic transmission. These early Oldsmobile Hydra-Matics had planetary gears operated by...
a hydraulic control system. However, they used a manual clutch in place of a fluid coupling. The clutch was used to engage the transmission when the vehicle was first started, after which the hydraulic system made all the shifts. Figure 1-5 shows this early design. In 1939 (1940 models), Oldsmobile introduced an updated version of this transmission, replacing the clutch with a fluid coupling. Cadillac began using this transmission in 1940. This was the first fully automatic hydraulic transmission. See Figure 1-6.

The first transmission to use a torque converter instead of a fluid coupling was the 1948 Buick Dynaflow, Figure 1-7. This transmission relied entirely on a complex torque converter with multiple stators and turbines for torque multiplication. Although the torque converter provided a much more efficient transfer of power than a fluid coupling, the Dynaflow had no gear changes, and the planetary gears were always in direct drive. The planetary gears were also used for manual low and reverse. The Dynaflow was smooth but extremely inefficient.

The first transmission that resembled modern transmissions was designed by Ford and Borg-Warner and offered in 1950. It used a torque converter and a hydraulic control system that automatically changed gears. The first models were two-speed types, while later designs had three speeds. A similar Borg-Warner transmission appeared on Studebakers. The Studebaker transmission, as well as one offered by Packard, contained the first version of the lockup torque converter, which eliminated slippage in certain gears. See Figure 1-8. The Studebaker automatic was the first to use a one-way clutch to obtain different gear ratios. At first, all automatic transmissions had cast iron cases. Aluminum bell housings and tailshaft housings were used on some Ford and Chrysler transmissions during the 1950s. The first transmission to use an all-aluminum case was the Chevrolet Turboglide installed in the 1958 models, Figure 1-9. The Chrysler Torqueflite followed in 1960. All automatics were being designed with aluminum cases by 1965. Around this time, simplified gear trains were introduced, some with only two forward gears. A late-1960s transmission might have fewer than half the parts of a comparable model produced ten years earlier.

The Chrysler Corporation reintroduced the lockup torque converter in 1977. It was controlled by hydraulic pressure, and the lockup clutch applied only in third gear. Later lockup torque converters were operated electrically or electronically. Lockup clutches were applied in all gears but first and reverse.

In the early 1960s, a few vehicles, such as the Corvair, Volkswagen, and Porsche, used rear engines and were equipped with transaxes. A few imported front-wheel drive cars had transaxes. However, the front-wheel drive automatic transaxle was unknown in the United States until the introduction of the 1966 Oldsmobile Toronado. The Toronado’s engine was mounted longitudinally (facing forward), and its transaxle used a conventional cast iron differential bolted to the transmission case. In 1976,
Honda and Nissan introduced the first transverse (side-facing) engine and transaxle combinations sold in the U.S. By 1980, all domestic manufacturers were producing front-wheel drive cars with transaxles. At present, almost all passenger cars use front-wheel drive and a transaxle. Many modern transaxles use a belt and pulley mechanism to change gear ratios. These transaxles are called continuously variable transaxles, or CVTs.

The first attempt to use electricity to control the transmission was made in 1963, with the introduction of an electric passing gear solenoid on the Pontiac Tempest, Figure 1-10. Electric passing gears were used on other transmissions during the 1960s, and some electrically operated lockup torque converters were used during the 1970s. When the first computerized engine controls were introduced, the transmission was often equipped with pressure switches to tell the computer when the transmission was in high gear. During the 1980s, the power of on-board computers increased to the point that they could apply the converter clutch. Later they were able to control transmission shifting and internal pressures. Early electronic transmissions were simply updated hydraulic models, with only a few functions being performed by the computer and the output solenoids. Modern transmissions and transaxles are fully controlled by the computer.

Fluid Coupling/Torque Converter

Fluid couplings and torque converters are fluid-filled units installed between the engine’s crankshaft and the transmission. They consist of two sets of blades. One set of blades is driven by the engine, and the other set of blades is connected to the transmission’s input shaft. The blade set connected to the engine is called the impeller, and the blade set connected to the input shaft is called the turbine. See Figure 1-13. A hydraulic pump in the transmission forces fluid into the converter. Inside the converter, the fluid is spun by the impeller blades. As the fluid is thrown from the impeller blades, it strikes the turbine blades. See Figure 1-14. Power is transmitted from the impeller to the turbine through the fluid. When the vehicle is stopped, the fluid from the impeller continues to strike the turbine, but the fluid allows enough slippage between the impeller and the turbine to prevent engine stalling.
The fluid coupling was widely used on early automatic transmissions. Fluid couplings, however, slip excessively and are very inefficient at transmitting power at high speeds. Therefore, fluid couplings have been replaced by torque converters. In addition to an impeller and a turbine, a torque converter uses a device called a stator. The stator redirects the fluid to reduce slipping, Figure 1-15. All transmissions made since the 1960s use torque converters.

Modern transmissions are equipped with lockup torque converters. These torque converters are equipped with an internal clutch called a converter lockup clutch. The converter lockup clutch locks the transmission input shaft to the converter cover. The clutch is applied to lock the turbine to the cover. Since the input shaft is attached to the turbine, slipping is eliminated. The lockup clutch is disengaged at low speeds to prevent engine stalling.

Automatic transaxles have at least one hollow shaft. The solid shaft can turn inside the hollow shaft to permit power transfer to each side of the vehicle. See Figure 1-18.

**Planetary Gears**

Planetary gears are used in all automatic transmissions and transaxles. The term planetary comes from the resemblance of the gear assembly to the solar system. The basic planetary gear consists of a central sun gear surrounded by planet gears that are housed in a planet carrier. A ring gear with internal teeth surrounds the sun and planet gears. Figure 1-19 shows the main parts of a planetary gear assembly. The advantage of the planetary gear is that the gears remain in mesh at all times. This prevents gear clash when shifting. Different gear ratios can be obtained by holding or driving different parts of the planet gear assembly. Simple planet gears can be combined into more complex units, such as the one shown in Figure 1-20. Complex planetary gear sets are used to obtain many gear ratios.

**Holding Members**

Holding members are the units that hold or drive the various parts of the planetary gear assembly to drive the vehicle. Holding members consist of friction material, which is similar to that used on manual clutches or brake shoes, bonded to a metal backing. Clutches and bands are the most common holding members. Clutches are a series of flat, ring-shaped plates.
They are applied (pressed together) by a hydraulically operated clutch piston, or apply piston. The clutch plates are alternately splined, and applying them holds two parts together. One set of plates is lined with friction material and the other set is bare steel. Clutches are commonly used to deliver engine power to the planetary gears, and hold parts of the gear assembly to the case. The entire assembly of clutch plates, the apply piston, and related components is called a clutch pack. A typical clutch pack is shown in Figure 1-21.

Bands wrap around drums (cylindrical transmission parts) to hold them stationary. The band is tightened against the drum by a hydraulic piston called a servo, which is operated by hydraulic pressure. Figure 1-22 shows a band, servo, and related linkage.

Another type of holding member is the one-way clutch, Figure 1-23. A one-way clutch is a mechanical device that allows the central hub to turn in one direction, but causes it to lock up when it tries to turn in the opposite direction. One-way clutches are always used in combination with other holding members to hold or drive parts of the planetary gearsets.

Case and Housings

The case is the main support for the other transmission or transaxle parts. It also contains passages to deliver pressurized fluid between various parts of the transmission. Modern cases are made of aluminum that is cast into the proper shape. After casting, the case is machined where necessary to form mating surfaces for the other components. Oil passages are then drilled in the case where necessary. Bushings may be pressed into the case at wear points. Figure 1-24 shows two common transmission and transaxle cases. On most modern vehicles, the housings around the torque converter and the output (or tail) shaft are cast as an integral part of the case. When used, separate bell housings (housing around the torque converter) and tailshaft housings are bolted to the case.

Oil Pans

All transmissions or transaxes contain one or more oil pans. The main purpose of the oil pan is as a storage place for extra transmission fluid. Airflow over the oil pan helps remove heat from the fluid. Some oil pans contain a
magnet to trap the metal particles produced as the transmission components wear. Oil pans are usually made of sheet metal. A few pans are made of cast aluminum.

Bushings and Bearings

Bushings and bearings allow parts to move against each other with minimal friction. **Bushings,** Figure 1-25, provide a sliding contact with the moving part and require good lubrication. They are installed where rotating part passes through a stationary part or two rotating parts are in contact with each other.

**Ball bearings** or **roller bearings** provide a rolling contact for reduced friction. Bearings are usually used where there is a heavy load, such as the output shaft, or an internal part that is subjected to high pressure. **Thrust bearings** are used in other places where parts are rotating in relation to each other under heavy pressures. A **thrust washer** separates moving parts, but it is made of a single piece of flat metal. Some thrust washers are available in different thicknesses and are used to adjust transmission shaft back-and-forth movement, or **endplay.** Typical roller bearings, thrust bearings, and washers are shown in Figure 1-26.

Hydraulic Pump and Pressure Regulator

The hydraulic pump provides all the hydraulic pressure used in the automatic transmission or transaxle. An extension at the rear of the torque converter drives the pump on transmissions. A separate shaft attached to the converter is often used to drive transaxle oil pumps. Whenever the engine is running, the converter is turning and causing the pump to turn. Therefore, whenever the
engine is running, the pump is producing pressure. There are several types of hydraulic pumps. These will be discussed in a later chapter. The hydraulic pump draws transmission fluid from the bottom or side oil pan, which is usually called the sump. The pump pressurizes the fluid for use by the other hydraulic system components, Figure 1-27. Modern transaxles with two oil pans may have more than one pump. In systems that contain three pumps, a three-gear scavenger pump removes the fluid from the bottom pan and pumps it into the side pan. The primary and secondary pumps pick up the oil from the side pan and pump it to the other hydraulic system components. On very old vehicles, a pump was installed on the output shaft and it produced pressure only when the vehicle was moving. Output shaft pumps are no longer used.

The pressure regulator is installed in the outlet line from the pump and controls overall transmission pressures, usually called line pressures. If the pump output becomes too great, the pressure regulator valve opens, dumping oil back into the oil pan. Once the pressure returns to normal, the valve closes. A pressure regulator is shown in Figure 1-28. The pressure regulator may be installed in the pump housing or in the valve body.

Hydraulic Control System

The hydraulic control system is a set of hydraulic parts and passages that perform the following functions:

- Applies and releases the holding members to obtain the needed gear ratios at any vehicle speed and throttle position.
- Controls system pressures for proper shift feel and long holding member life as loading and acceleration vary.
- Keeps transmission fluid flowing to the torque converter, transmission cooler, and lubricating system.

The major component of the hydraulic control system is the valve body, which contains the control valves and related springs. The valve body also contains the manual valve, which is connected by linkage to the shift lever in the passenger compartment. Moving the manual valve directs pressure to other parts of the hydraulic system. The valve body may also contain accumulators, check balls, and spacer plates. A typical valve body is shown in Figure 1-29. Other parts of the hydraulic system include governor valves, throttle linkage, band servos, clutch apply pistons, and the passages that connect them. Some of these passages and parts may be located in the transmission case.

Most modern transmissions and transaxles use an electronic control system to operate the hydraulic components. An on-board computer processes information from input sensors. It then uses this information to operate solenoids and other output devices installed in the transmission or transaxle to control pressure flow through the hydraulic system. See Figure 1-30. Figure 1-31 illustrates the input and output devices used with a typical electronically controlled transmission. The construction and operation of hydraulic and electronic control components will be discussed in detail in later chapters.

Gaskets and Seals

Gaskets and seals are used to keep fluid from leaking out of the transmission or transaxle and to keep pressure from leaking internally. Gaskets are used where major components are joined together. For example, a gasket is used to seal the oil pans to the case. Gaskets are also used in the valve body and where the front pump and extension housing are attached to the case. See Figure 1-32.
Seals are used at moving parts, such as the torque converter, drive shaft, and various internal rotating parts. They are also used as sliding pressure seals at the band servos and clutch apply pistons. Figure 1-33 shows a servo seal. Some seals are used to seal stationary parts. These seals are usually called O-rings.

A seal ring is a special type of seal that prevents leaks in pressure passages between parts that rotate in relation to each other. Figure 1-34. For example, oil pressure from the valve body may be directed through a stationary support to a rotating clutch drum. Seal rings keep the pressure from being lost.

Manual Linkage and Throttle Linkage

To provide drive input, two types of linkage are used. The manual linkage connects the shift lever to the manual valve inside the transmission or transaxle. The linkage can be a cable or a series of rods and levers. Cables are commonly used on modern vehicles. Figure 1-35 shows a commonly used manual linkage arrangement. The shifter is mounted on the steering column or on a center console. In the Park position, the manual linkage operates a park lock inside the transmission or transaxle. The park lock is a lever that engages a toothed wheel on the output shaft, Figure 1-36. When the park lock is engaged, the vehicle cannot roll. Throttle linkage connects the engine’s throttle plate to the transmission’s throttle valve. On some transmissions, throttle linkage is used to apply extra pressure for a forced downshift (or passing gear). On other transmissions and transaxles, the throttle linkage controls all shift speeds. On some older cars, a vacuum modulator controlled shift speeds. Vacuum modulators are still used on a few vehicles. Most modern throttle linkage is cable operated, Figure 1-37. On newer vehicles, the computer controls shift speeds and throttle linkage has been eliminated.

Transmission Fluid

Transmission fluid is a combination of petroleum oils and various additives. It is pressurized by the pump and used to operate the hydraulic system. Since the transmission fluid splashes on the holding members, it contains additives that help the holding members to grip when they are applied. Transmission fluid also lubricates gears, bearings, and moving parts. Some transmission parts are lubricated by fluid under pressure. Other components depend on splash lubrication. Transmission fluid also carries away heat and helps seal in pressure.

There are several types of transmission fluid used in modern vehicles. Proper fluid is important to transmission and transaxle operation. At one time, almost all automatic transmissions and transaxles used the same type of fluid. Today, however, many domestic and imported vehicles use special fluids. Never add transmission fluid to any automatic transmission or transaxle without first finding out what type of fluid should be used. Some manufacturers allow the use of a common fluid, such as Dexron III, if a special friction modifier is added to the fluid.
Transmission Fluid Cooler

Transmission and transaxle operation causes the fluid to get very hot. This heat must be removed to keep the fluid from breaking down and to keep the holding members from becoming so hot that they begin to slip and burn.

To accomplish this, the transmission fluid is pumped through metal lines to a transmission fluid cooler in the vehicle’s radiator. In the cooler, the fluid gives up its heat to the engine coolant and then returns to the transmission. This is because the torque converter produces most of the heat generated by the transmission, especially at low speeds.

Transmission Fluid Filter

All transmissions and transaxles produce some metal shavings and particles of friction material as they wear. Additionally, transmission fluid breaks down from heat and age. The transmission fluid filter catches and removes these impurities as the fluid passes through it. Some filters are fine mesh screens. Most filters, however, are made of felt or filtration paper enclosed in a metal or plastic housing. The filter is always installed on the suction side of the pump so it can remove impurities before they reach the pump and other hydraulic system components. The filter is located in the bottom of the transmission or transaxle so it is always covered by transmission fluid. A few transmissions have two filters, Figure 1-39. A few transaxles have two filters. Filters should be changed as part of periodic transmission or transaxle maintenance.

Automatic Transmission Operation

The following is a brief discussion of how an automatic transmission operates. The principles discussed here will be explained in more detail in later chapters.

When the engine is running and the transmission is in Park or Neutral, the pump produces pressure to keep the torque converter filled. No holding members are applied, and no power reaches the planetary gears. The converter impeller turns the turbine and input shaft, but the power stops at the planetary gears. In Park, the parking gear holds the output shaft stationary.

When the transmission is placed in Drive, oil flows through the manual valve to one or more holding members. The holding members apply, causing the planetary gears to connect the input and output shafts. Engine power goes through the converter impeller, through the turbine and input shaft, and into the planetary gears. It exits the planetary gears and tries to turn the output shaft. If the brakes are applied, the turbine, input shaft, and gears do not move. Fluid from the impeller striking the turbine creates friction and heat, which is removed by the cooler in the radiator. Once the vehicle starts moving, the planetary gears reduce input shaft speed and increase torque to get the vehicle moving.

As vehicle speed increases, the hydraulic control system moves various valves to change which holding members are applied. This changes the rotation of the planet gears and shifts the transmission into a higher gear. Power continues to flow through the torque converter, input shaft, planetary gears, and output shaft.

As vehicle speed continues to increase, other valves move to obtain higher gears until the transmission is at its highest gear ratio. At some point, the control system applies the lockup clutch for increased fuel economy. With the lockup clutch applied, the impeller and turbine turn at the same speed.
When the vehicle is brought to a stop, the control system again moves various valves to lower the gear ratios to match vehicle speed and engine load. The control system releases the converter lockup clutch as the vehicle approaches the completely stopped position.

In Reverse, the manual valve sends pressure to the proper holding members. They apply and hold the planetary gears to place the transmission in Reverse. Power goes through the planetary gears. The planetary gears reverse the direction of rotation before delivering power to the output shaft.

Hybrid Vehicle Drivetrain Operation

Hybrid vehicles use more than one source of energy for propulsion. A hybrid gas-electric vehicle uses both an internal combustion engine and an electric motor-generator. The motor-generator is installed between the engine and the transmission or transaxle. Some vehicles have two motor-generators. Depending on driving conditions and the type of hybrid, the vehicle can be moved by the engine only, the motor-generator only, or both the engine and the motor-generator.

Figure 1-40 shows a motor-generator installed in a transmission case. A stationary field winding is attached to the engine block and a rotor is attached to the engine crankshaft. A large, high-voltage battery is installed in the vehicle body. An electronic control system operates the motor-generator for maximum efficiency. The motor-generator can crank the engine, eliminating the need for starter and flywheel gears. When the internal combustion engine is running, the motor-generator can produce electricity to recharge the hybrid’s batteries and power its electrical circuits. Some hybrid vehicles do not have a reverse gear, and the motor-generator runs in reverse to back up the vehicle. An overrunning clutch keeps the engine from turning backward when the vehicle is in reverse.

The two major classes of hybrid vehicles are full hybrids and mild hybrids. The motor-generator on a full hybrid moves the vehicle as long as the battery is charged above a certain preset level. The battery charge falls below this level, the engine starts and propels the vehicle while recharging the battery.

On a mild hybrid, the engine moves the vehicle. During operation, the mild hybrid’s engine shuts off during coasting, braking, and complete stops. When the driver presses the accelerator pedal, the motor-generator restarts the engine. When the engine starts, it begins turning the motor-generator, which then functions as an alternator to recharge the vehicle’s battery.

Future Transmissions

Transmission technology is always advancing, and some entirely new concepts are being developed. The following section discusses transmissions that may appear in future vehicles.

Toroidal or Infinitely Variable Transmission (IVT)

Figure 1-41 shows an infinitely variable transmission (IVT), also known as a toroidal transmission, that is currently being used in Asia. This type of transmission may eventually be installed in vehicles made for American and European roads. The IVT consists of a set of movable discs that rotate between drive and driven races. Varying the angle of the discs varies the speed ratio between the drive and driven races. Since sending power through the discs reverses the direction of rotation, a second set of movable discs are installed behind the driven race. The driven race powers a final output race through the discs. This again reverses power flow so that power exits the transmission in the same direction as it entered. The combination of ratios between the two sets of discs results in the final transmission ratio.

The angles of the movable discs are varied by servos that are operated by the transmission’s hydraulic system. An on-board computer monitors and adjusts the hydraulic system outputs based on inputs from engine and road speed sensors.
Electronically Shifted Manual Transmission

Many modern manual transmissions operate without a clutch pedal. Electronically operated devices control clutch operation and gear selection. The driver moves a slider, or “paddle,” that sends signals to an onboard computer. The computer controls solenoids or motors to shift gears and also applies and releases the clutch. On some vehicles with this type of transmission, the clutch pedal is used only to start moving the vehicle from rest. Other vehicles with electronically shifted manual transmissions have no clutch pedal at all.

The transmission controls now in use can be connected to the engine and anti-lock brake computers. The computers could provide fully automatic shifting. Some manufacturers are working on automatic versions of manual transmissions. A few of these designs are being used in large trucks, usually with a torque converter replacing the manual clutch.

Summary

Manual and automatic transmissions have the same basic purposes. They must connect and disconnect the engine and drive wheels, multiply engine power as dictated by vehicle speed and load, and provide a way to reverse the direction of power flow.

Manual and automatic transmissions have many similarities. Major differences are that automatic transmissions use of a torque converter instead of a clutch, planetary gears instead of sliding gears, and a hydraulic control system that makes shifting decisions for the driver. Modern automatic transmissions and transaxes are almost as efficient as manual models. Transmissions and transaxes differ only in the layout of parts and the fact that the transaxle contains the final drive assembly and the differential.

The modern automatic transmission has been gradually refined over the years. The first automatic transmission was introduced more than 60 years ago. Over the years, automatic transmissions with torque converters, simplified gear trains, and aluminum cases were developed and placed in service. Lockup torque converters, transaxes, and electronic control systems have been introduced and gradually perfected during the last 20 years.

Fluid couplings and torque converters are fluid-filled devices that contain a turbine and a set of turbine blades driven by the engine. In automatic transmissions, a fluid coupling connects the engine to the torque converter, simplifying gear changes. Gear change logic is determined by the vehicle speed, engine speed, and throttle position.

DCT, one transmission contains the odd-numbered gears (first, third, and fifth) and the other transmission contains even-numbered gears (second and fourth). A reverse gear is built into one of the transmissions. To save space, the two transmissions and clutches are combined into a single unit. Hollow shafts allow each transmission to transfer power without interfering with the other transmission.

Operation depends on alternately applying and releasing the clutches, and engaging gears before the clutch is applied. For instance, when the vehicle is accelerating in first, power flows through the clutch and first gear of the odd-gear transmission. While power is traveling through the odd-gear transmission, second gear of the even-gear transmission has been engaged, but is not yet delivering power. To shift to second, the odd-gear transmission clutch disengages and the even-gear transmission clutch engages. Power then flows through the clutch and second gear of the even-gear transmission. Meanwhile, third gear of the odd-gear transmission is engaged for the next shift.

The vehicle powertrain computer controls gear selection and clutch application sequence. This results in fast, smooth shifts, with no gear clash or interruption in power flow. The powertrain module is programmed to give the best shift pattern at various throttle openings. DCT fuel efficiency is about 15% better than that of a torque converter automatic.

Manual linkage connects the shift lever to the manual valve inside the transmission or transaxle. Throttle linkage connects the engine’s throttle plate to the transmission’s throttle valve and controls shift speeds.

Transmission fluid is made of oils and various additives. The fluid is pressurized, and it operates the holding members. It also lubricates moving parts, carries away heat, and helps seal internal parts. The proper fluid is important to transmission and transaxle operation.

To cool the transmission fluid, it is pumped from the torque converter to a cooler in the radiator. A few vehicles have direct-air coolers.

Automatic transmission operation varies from one gear to another. In Neutral and Park, no holding members are applied and the power flow stops at the planetary gears. In Drive or Reverse, holding members apply and cause the planetary gears to connect the input and output shafts. Engine power goes through the impeller, through the turbine and input shaft, and into the planetary gears. The hydraulic control system varies gear ratios by applying and releasing different holding members.

Review Questions—Chapter 1

Please do not write in this text. Write your answers on a separate sheet of paper.

1. One of the principal jobs of any transmission is to disconnect the engine from the ________ when the vehicle is not moving.

2. Which of the following gears should be selected to obtain the best acceleration from stop?
   (A) Reduction gear.  
   (B) Direct drive.  
   (C) Overdrive.  
   (D) Passing gear.

3. If the transmission output speed is more than the input speed, the transmission is in an ________ gear.

4. Which of the following gears should be selected to obtain the best fuel economy?
   (A) Reduction gear.  
   (B) Direct drive.  
   (C) Overdrive.  
   (D) Passing gear.

5. Briefly explain why placing an automatic transmission in drive with the brakes applied does not kill the engine.

6. Planetary gears are so named because they resemble the ________ system.

7. Clutches and bands are examples of ________.
8. The ______ serves as a storage place for extra transmission fluid.

9. ______ are used to adjust transmission shaft endplay.
   (A) Bushings
   (B) Shim packs
   (C) Thrust washers
   (D) None of the above.

10. The hydraulic pump is driven by the _____ whenever the engine is running.

11. The governor, oil passages, and servos are part of the _____ control system.

12. An on-board computer operates the _____ control system.

13. The _____ is a cable or a series of rods and levers that connect the shift lever to the manual valve.

14. Transmission fluid ______.
   (A) carries away heat produced in the transmission
   (B) helps the holding members grip when they are applied
   (C) helps seal in pressure
   (D) All of the above.

15. The transmission fluid filter is always located on the _____ side of the hydraulic pump.

**ASE-Type Questions—Chapter 1**

1. In any transmission, gears are used to do all the following except:
   (A) provide direct drive.
   (B) disconnect the engine and drive wheels.
   (C) reverse the vehicle.
   (D) provide overdrive.

2. Technician A says early transmissions were inefficient. Technician B says a slipping transmission is an efficient transmission. Who is right?
   (A) A only.
   (B) B only.
   (C) Both A and B.
   (D) Neither A nor B.

3. Which of the following materials is most commonly used to make modern transmission and transaxle cases?
   (A) Cast Iron.
   (B) Wrought Iron.
   (C) Magnesium.
   (D) Aluminum.

4. The planetary ring gear has _____ teeth.
   (A) internal
   (B) external
   (C) internal and external
   (D) no

5. Which of the following is not part of a clutch pack?
   (A) Apply piston.
   (B) Steel plates.
   (C) Servo.
   (D) Spline hub.

6. Technician A says bands are applied by servos. Technician B says bands wrap around drums. Who is right?
   (A) A only.
   (B) B only.
   (C) Both A and B.
   (D) Neither A nor B.

7. The modern transmission/transaxle case is made of _____.
   (A) cast iron
   (B) steel
   (C) plastic
   (D) aluminum

8. The hydraulic control system contains all the following components except:
   (A) governor.
   (B) parking lock.
   (C) accumulators.
   (D) valve body.

9. Technician A says gaskets seal moving parts. Technician B says that O-rings seal stationary parts. Who is right?
   (A) A only.
   (B) B only.
   (C) Both A and B.
   (D) Neither A nor B.

10. Available transmission oil cooler configurations include all of the following except:
    (A) in the radiator—factory installed.
    (B) in the radiator—aftermarket.
    (C) in front of the radiator—factory installed.
    (D) in front of the radiator—aftermarket.