14

Prerequisite: Chapters 1, 2, 3, and 4

CLUTCHES

OBJECTIVES

After reading this chapter, you should be able to:

- Outline the operating principles of a clutch.
- Identify the components of a clutch assembly.
- Explain the differences between centrifugal, pull-type, and push-type clutches.
- Describe the procedure for adjusting manual and self-adjusting clutches.
- Explain how to properly adjust the external linkage of a clutch.
- Describe the function of a clutch brake.
- Outline the procedures required to work safely around heavy-duty clutches.
- Troubleshoot a clutch for wear and damage.
- Identify some typical clutch defects and explain how to repair them.
- Outline the procedure for removing and replacing a clutch.
- Explain the difference between a three-pedal and a two-pedal clutch system.

KEY TERMS

adjusting ring
antirattle springs
AutoClutch
centrifugal clutch
clutch
clutch actuator
clutch brake
clutch brake squeeze
clutch free pedal
clutch pack
dampened discs
DM (datalink mechanical) clutch
free pedal
free travel
friction discs
Kwik-Adjust
Kwik-Konnect
launch phase
lockstrap
pull-type clutch
push-type clutch
release bearing
rigid discs
self-adjusting clutch
three-pedal system
throwout bearing
torque-limiting clutch brake
touch point
two-pedal system
two-piece clutch brake
Urge-to-Move
wear compensator
wet clutch

INTRODUCTION

Because of the rapid emergence of automated manual transmissions (AMTs) in truck chassis, clutches have undergone some changes in recent years. Or better said, the way clutches are actuated have undergone these changes. This means that any study of clutches today must include those used in automated three- and two-pedal systems. In what is known as the two-pedal systems that are common today, the clutch must be actuated mechanically, but managed by an electronic control unit (ECU). For example, a term that Eaton use for ECU-managed, mechanical actuation is DM, an acronym for *datalink mechanical*. Regardless of application, the role a clutch plays does not change that much whether it is in a mechanical standard transmission or an AMT.

14.1 CLUTCH FUNCTION

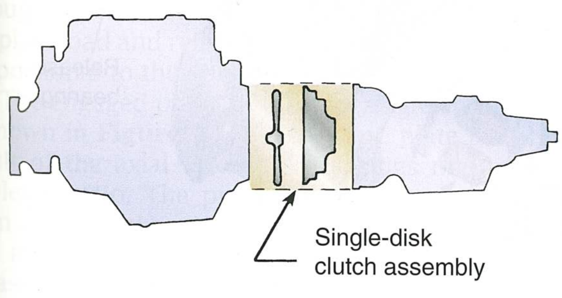
The function of a **clutch** is to transfer torque from engine flywheel to the transmission. At the moment of clutch engagement, the transmission input shaft may either be stationary, as when the truck is stationary, or rotating at a different speed than the flywheel, as in the case of upshifting or downshifting. At the moment the clutch fully engages, however, the flywheel and the transmission input shaft must rotate at the same speed.

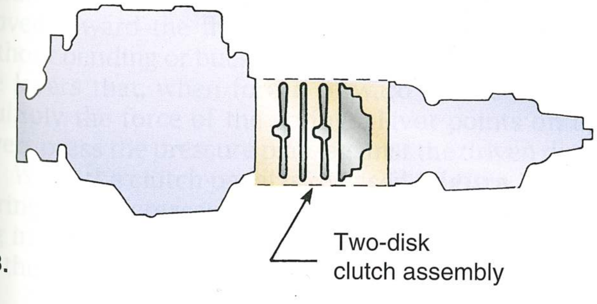
Torque transmission through a clutch is accomplished by bringing a rotating drive member connected to the engine flywheel into contact with one or more driven members splined to the transmission input shaft. Contact between the driving and driven members is established and maintained by both spring pressure and friction surfaces. Pressure exerted by springs on the driven members is unloaded by the driver by depressing the clutch pedal. This "releases" the clutch.

A clutch is equipped with one or two **friction discs**. These have friction surfaces known as facings (**Figure 14–1**). When the clutch pedal in the cab is depressed, the clutch pressure plate is drawn away from the flywheel, compressing the springs and freeing the friction disc(s) from contact with the flywheel friction surface. At this point, the clutch is disengaged and torque transfer from the engine to the transmission is interrupted.

As the clutch pedal is released, the pressure plate moves toward the flywheel, allowing the springs to clamp the disc(s) between the flywheel and the pressure plate. The discs are designed for moderate slippage as they are brought into contact with the rotating flywheel. This minimizes torsional (twisting) shock to the drivetrain components. As clutch-clamping pressure increases, the discs accept the full torque from the flywheel. At this point, engagement is complete, and engine torque is transferred to the transmission. Once engaged, a properly functioning clutch transmits engine torque to the transmission without slippage.

14–1 The clutch uses (A) one; or (B) two friction discs to couple the engine to the transmission.





TWO- AND THREE-PEDAL SYSTEMS

The engaging and disengaging of a clutch may be an action controlled by the driver or one managed by the transmission management electronics. Automated transmissions (see Chapter 20) are widely used today. When a clutch is used in an automated transmission, its function does not change but control of it is moved from the driver to the shift electronics. In studying clutches in this chapter, when clutch packs used in automated transmissions are referenced, the following terms are used:

- **Three-pedal system**: automated transmission that uses a driver actuated clutch pedal. The driver is required to use the clutch pedal to break torque when stopping or starting or as an option.
- **Two-pedal system**: automated transmission system with no clutch pedal (the "pedals" refer to the accelerator and brake pedal). The clutch is actuated mechanically either by using a **clutch actuator** or by using a centrifugal clutch (both are discussed late in this chapter).

14.2 CLUTCH COMPONENTS

A clutch assembly is illustrated in **Figure 14–2**. Clutch components can be divided into two basic groups: driving and driven members.

FIGURE 14–2 An angle-spring clutch pack with two spring dampened discs

DRIVING MEMBERS

The driving members of a clutch are the cover assembly (contains the pressure plate) and, if the clutch has two friction discs, an intermediate plate. Although it is not part of the clutch pack, the engine flywheel drives the clutch assembly and should be inspected and serviced whenever work is performed on the clutch.

Flywheel

The flywheel may either be flat faced or use a pot design (**Figure 14–3**). The flywheel must be precisely perpendicular to the crankshaft with almost no runout (as little as 0.005 inch/0.127 mm). The surface of the flywheel that contacts the friction discs is machined smooth and should be dry of lube oil or grease.

Clutch Cover

The clutch cover assembly is constructed of cast steel, cast iron, or stamped steel (**Figure 14–4**). Cast cover assemblies provide maximum ventilation and heat dissipation and are often used on heavy-duty Class 8 trucks. Stamped steel clutch covers tend to be used on lighter-duty trucks.

FIGURE 14–3 (A) Some clutches are installed on flat-faced flywheels; and (B) others are installed in pot flywheels.

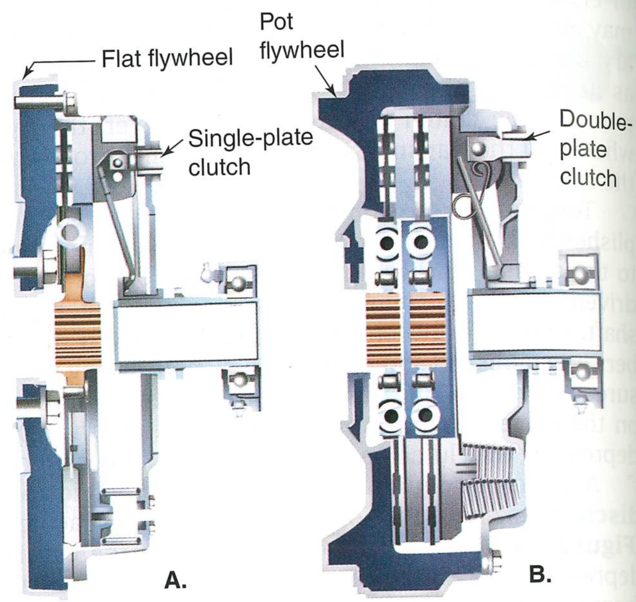
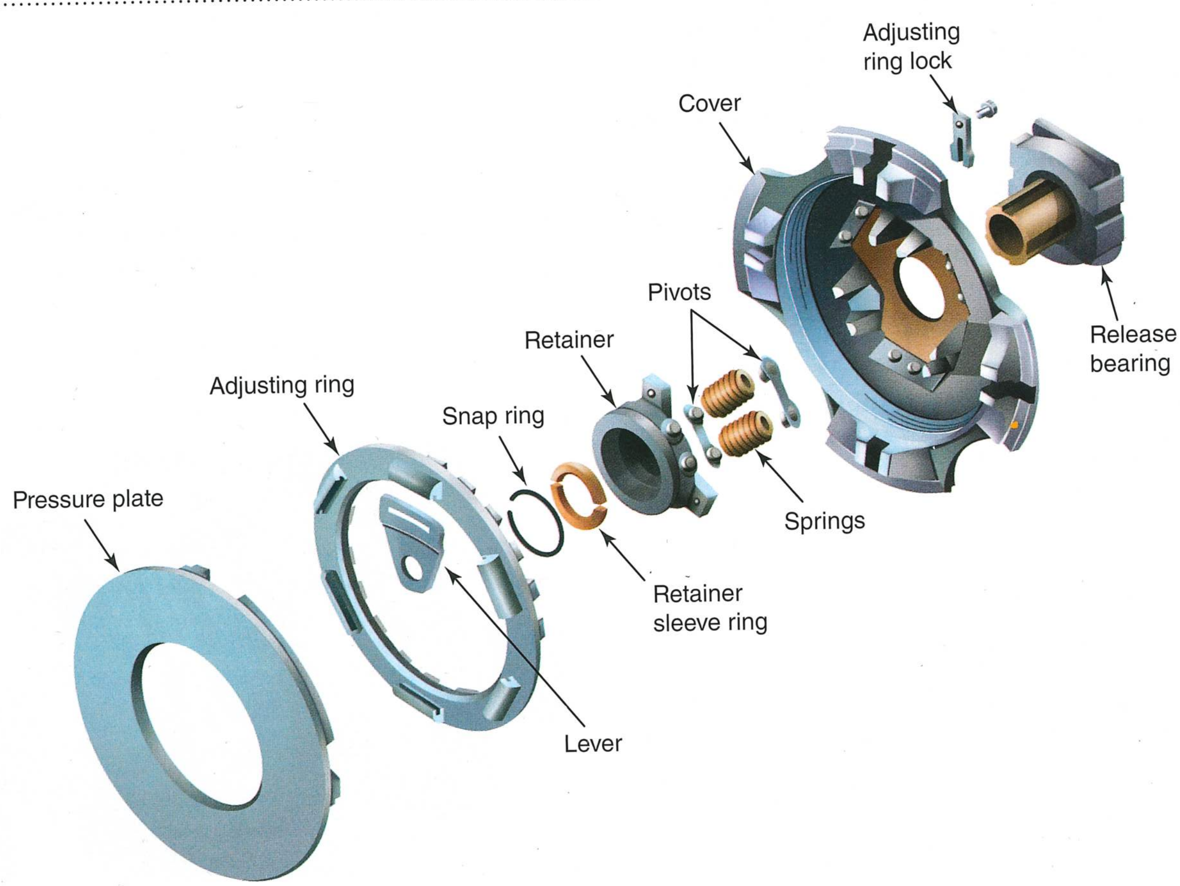


FIGURE 14–4 Exploded view of an angle-spring clutch assembly. The outside of the adjusting ring is threaded and turns in the clutch cover plate to adjust the clutch.



The clutch cover is bolted to the flywheel and rotates with it. The clutch cover contains the pressure plate, which is fitted to the cover with the pressure springs. Most truck clutch cover assemblies contain the levers that move the pressure plate back and forth, thereby making and breaking contact with the friction discs.

Pressure Plate

The clutch pressure plate is machined smooth on the side facing the driven disc (or discs). The pressure plate mounts on pins or lugs on the clutch cover and is free to slide back and forth on these pins or lugs. When the clutch pedal is released, spring pressure is applied to the pressure plate, clamping the friction discs to the flywheel with enough linear force to prevent slippage.

Pressure Springs and Levers

Pressure springs are located between the clutch cover and the pressure plate. Both coil spring and diaphragm spring designs are used.

Clutches with Coil Springs. Most clutch designs use multiple coil springs to force the pressure plate against the driven discs. In some clutches, coil springs are positioned perpendicular to the pressure plate and are equally spaced around the perimeter of the cover.

Other clutches use fewer coil springs and angle them between the cover and a retainer (**Figure 14–5**).

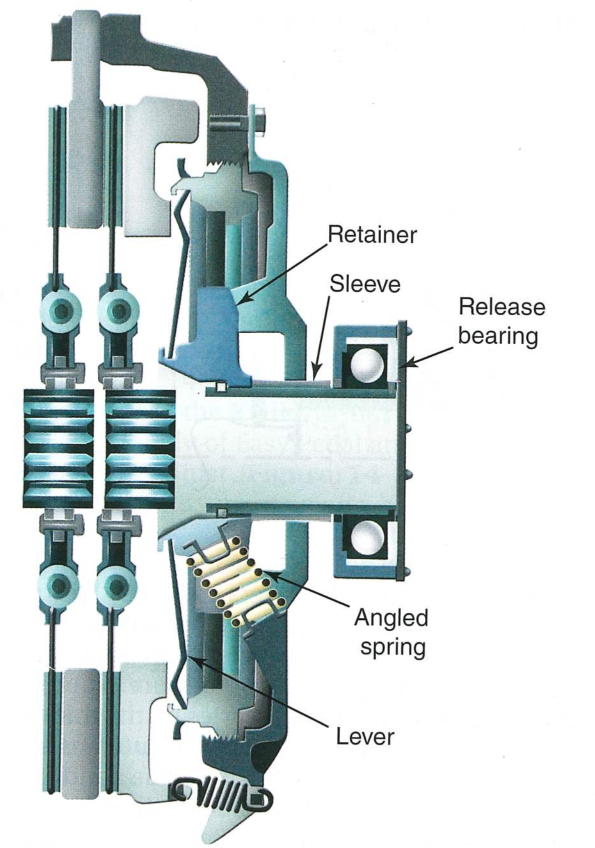
Angle-spring designs require 50 percent less clutch pedal effort. They also provide a constant plate load regardless of the thickness or wear on the friction facings of the driven discs.

The angle-spring clutch illustrated in Figure 14–5 operates under indirect pressure. Three pairs of coil springs are located away from the pressure plate rather than directly on it. Spring load is applied through a series of six levers. In this clutch design, the plate load and release bearing load are not directly proportional to the spring load.

The engaged position of a new angle-spring clutch is shown in **Figure 14–6A**. Pressure plate load is the result of the axial load of the springs multiplied by the lever ratio. The pressure springs are positioned at an angle to the center line of the clutch with each end attached to the flywheel ring (cover) and the release sleeve retainer. As the release sleeve retainer—including the release sleeve and release bearing—is moved toward the flywheel, the springs pivot freely without bending or buckling. Connected to the retainer are levers that, when forced forward by the retainer, multiply the force of the springs. Pivot points on the levers press the pressure plate against the driven discs.

When the clutch pedal is released (**Figure 14–6B**), spring load increases but axial load decreases, resulting in reduced pedal effort. The plate load is defined by the axial spring force multiplied by the lever ratio.

FIGURE 14–5 The coil springs in this clutch are angled between the cover and a retainer. Levers multiply the spring force against the pressure plate.

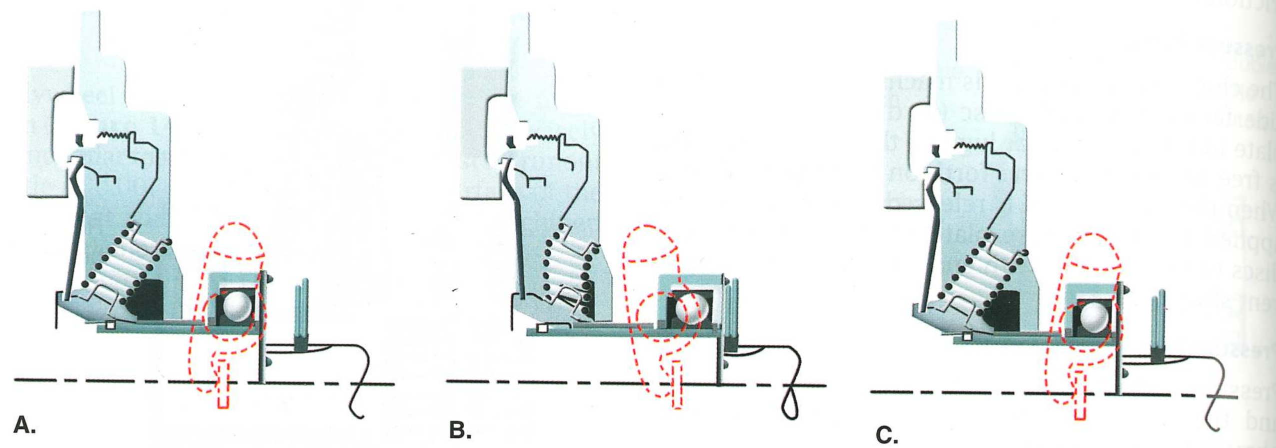


Axial spring force changes with release bearing movement but not in direct proportion to the spring load.

When friction facings wear (**Figure 14–6C**), spring load reduces but axial load remains constant. As the clutch wears, the release sleeve assembly moves toward the flywheel, and the pressure springs elongate, reducing their tension. The axial spring force, however, remains essentially constant. This means that pressure plate force remains constant throughout the life of the clutch. When the clutch is adjusted to compensate for friction facing wear, the pressure plate position does not move, but the rotating **adjusting ring** moves the levers toward the transmission, pushing the release sleeve and bearing assembly in that direction also. This reestablishes the internal spring position to the original setting for continued clutch use.

Clutches with Diaphragm Springs. Clutches equipped with a diaphragm or Belleville spring assemblies are often used in medium-duty trucks. Like coil spring-equipped clutches, diaphragm and Belleville spring clutches operate under indirect pressure using a retainer and lever arrangement to exert pressure on

FIGURE 14–6 Clutch operation: (A) In the engaged position, pressure plate load (3,200 lb./1,450 kg) is the result of the axial load (500 lb./225 kg) of the spring load multiplied by the lever ratio; (B) when the clutch is released, spring load increases but the release bearing load reduces to 420 lb./190 kg, which results in the reduced pedal effort; (C) when facings wear, spring load reduces but axial load remains at 500 lb./225 kg and maintains 3,200 lb./1,450 kg of plate load.



the pressure plate. The levers may also be referred to as *fingers* or *tapered fingers.* As with angle-spring clutches, the result is low release bearing load and constant pressure plate load. Pressure plate load on the friction material surface varies by the thickness of the diaphragm spring. This type of clutch uses either a single disc or multiple discs with the addition of an intermediate plate. It can also be designed either as a push-type or pull-type clutch. The actual design used is determined by the clutch linkage/vehicle design, space requirements inside the vehicle, and the torque load required from the clutch assembly.

In the diaphragm clutch assembly shown in **Figure 14–7**, the clutch cover assembly is bolted directly to the engine flywheel. The clutch cover assembly drives the pressure plate by means of drive straps.

In a push-type clutch, pressing the clutch pedal moves the release bearing toward the engine flywheel. As the clutch's diaphragm spring fingers are depressed, the pressure plate retracts from contact with the driven disc(s) and the clutch is disengaged.

When the clutch pedal is released, the release bearing and clutch diaphragm spring fingers move away from the engine flywheel. The diaphragm Belleville spring exerts pressure through its levers to the pressure plate. This results in the driven disc(s) being *locked up* between the friction surfaces of the pressure plate and the engine flywheel in the single disc type.

Torque flow through a multiple disc assembly is the same as with a coil spring or angle-spring type. The pressure plate diaphragm Belleville spring exerts pressure through the rear disc to the intermediate plate and to the forward disc onto the flywheel friction face. This locks the clutch assembly together.

On a conventional direct pressure clutch, as the friction facings wear, pressure plate load loss occurs as a result of spring elongation. A diaphragm clutch that uses a Belleville spring design maintains the

FIGURE 14–7 Diaphragm clutch operation: (A) new, engaged position; (B) released position; (C) worn, engaged position

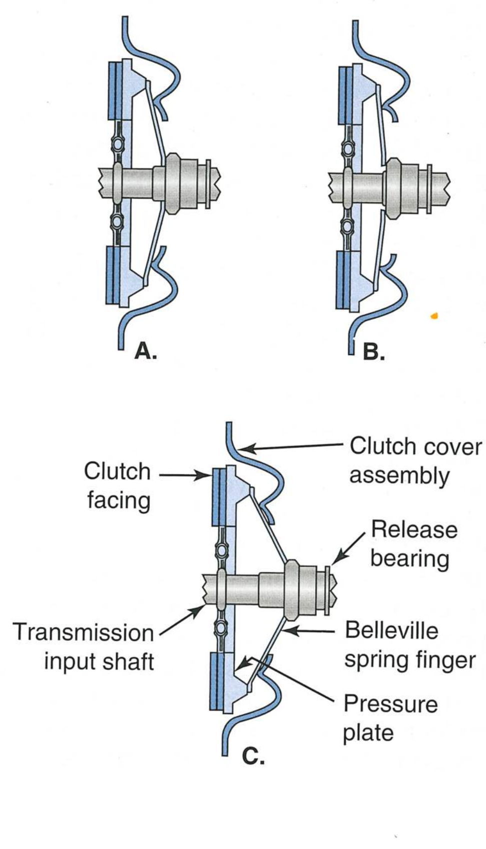


FIGURE 14–11 Components of a pull-type clutch

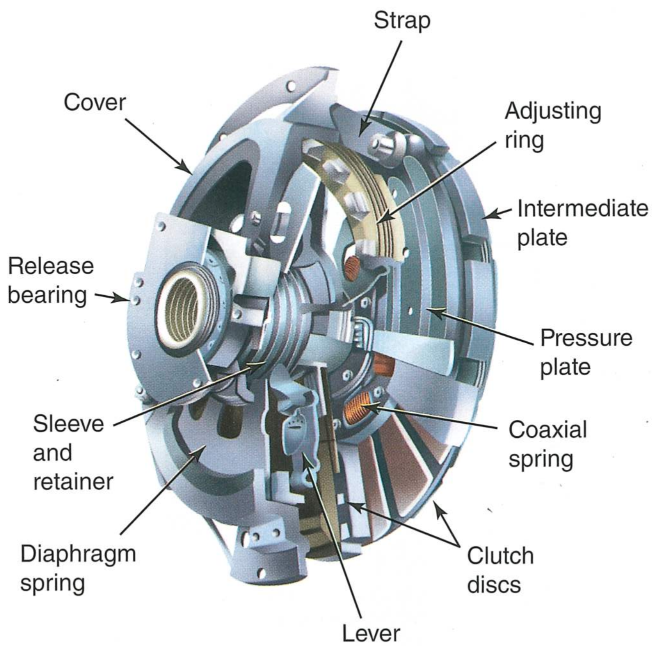
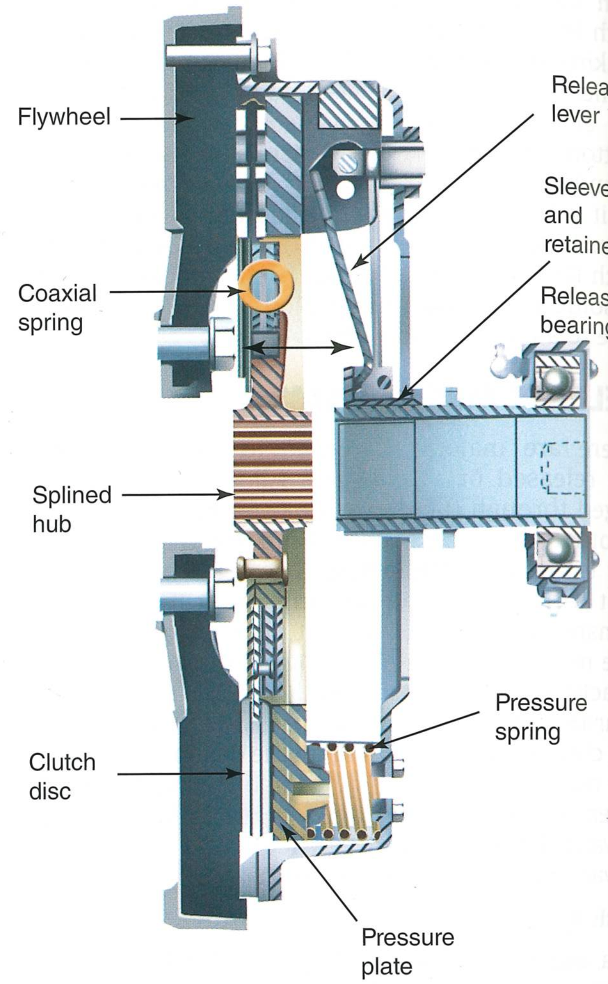


FIGURE 14–12 Cutaway of a Lipe single-plate, pull-type clutch



disengaging the clutch. When the clutch pedal is released, spring pressure forces the pressure plate forward against the clutch disc and the release bearing, sleeve, and retainer return to their original position. Pull-type clutches are used in both medium- and heavy-duty applications and are adjusted internally.

Centrifugal Clutches

Eaton introduced heavy-duty **centrifugal clutches** with their UltraShift AMT. **AutoClutch** is a 15½-inch, two-friction plate clutch pack usually faced with ceramic material. This UltraShift is a two-pedal system. Its centrifugal clutch uses centrifugal force resulting from an increase in engine revs to engage. It drops out of lock (disengages) when the engine spools down. AutoClutch uses a ball-and-ramp engagement hub that occupies no more space than a standard heavy-duty clutch pack. The assembly uses a standard bell housing. In addition, AutoClutch has a built-in inertia brake that speeds up automated upshifts by acting as a clutch brake, and the transmission electronics are designed to message the engine electronics to drop rpm to time downshifts.

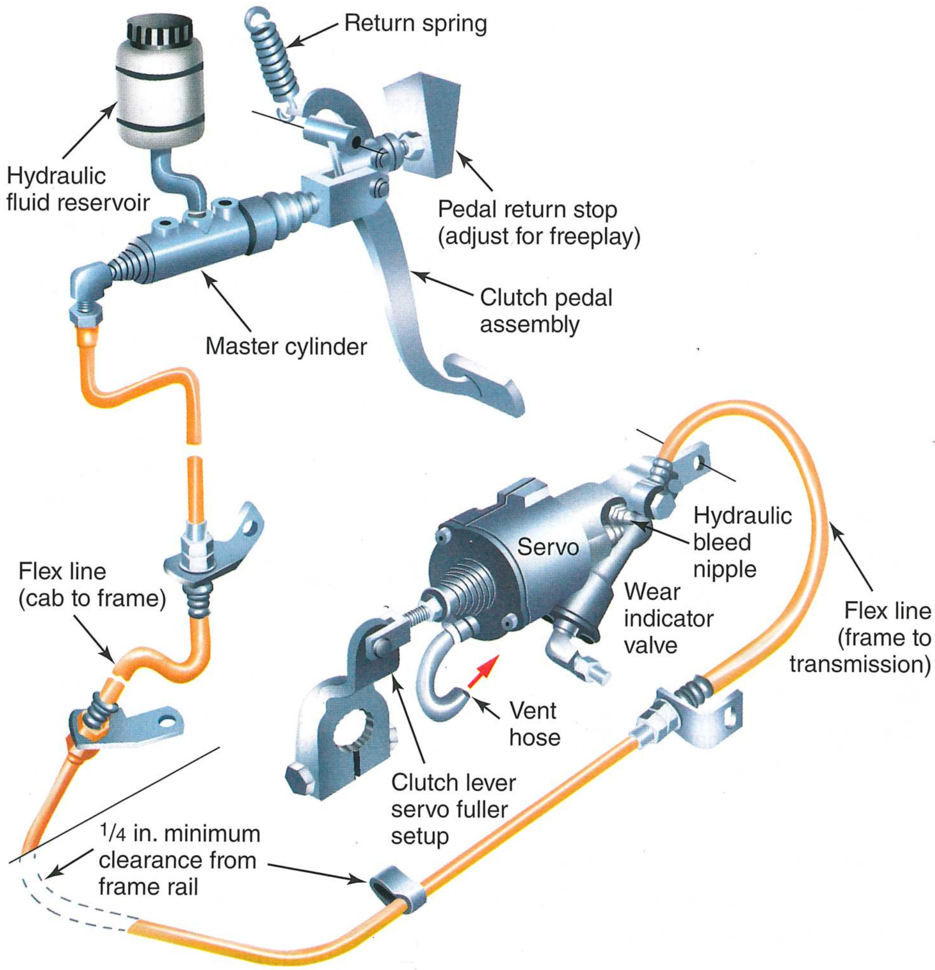
CLUTCH BRAKES

Most pull-type clutches have a component not found on push-type clutches: a **clutch brake**. The clutch brake is a disc with friction surfaces on either side; it is mounted on the transmission input shaft splines between the release bearing and the transmission (**Figure 14–13A**). Its purpose is to slow or stop the transmission input shaft from rotating to allow gears to be engaged without clashing (grinding) from a neutral-to-first or neutral-to-reverse shift. This can greatly extend transmission life. Clutch brakes are used only on nonsynchronized transmission systems.

Only 70 to 80 percent of clutch pedal travel is needed to fully disengage the clutch. The last ½ to 1 inch (12 to 25 mm) of pedal travel is used to engage the clutch brake. When the pedal is fully depressed, the fork squeezes the release bearing against the clutch brake, which forces the brake disc against the transmission input shaft bearing retainer (**Figure 14–13B**). The friction created by the clutch brake facing stops the rotation of the input shaft and countershaft. This allows the transmission gears to mesh without clashing. Eaton currently manufactures two types of clutch brake:

- Torque limiting
- Kwik-Konnect

FIGURE 14–21 Components used in one type of hydraulic clutch circuit



those that use clutch actuators to engage and disengage the unit. The DM clutch is one option that is used with the Eaton UltraShift transmission; it should not be confused with the AW wet clutch.

A DM clutch module used with an UltraShift transmission is a 15.5-inch (394 mm) twin plate mechanical clutch that is integrated with the UltraShift transmission. The UltraShift transmission is a two-pedal system so the DM clutch module requires no clutch pedal and linkage. Dry metallo-ceramic friction facings are typically used in DM clutches.

DM OPERATION

Because the UltraShift transmission is a two-pedal system, there is no driver-actuated clutch pedal. This eliminates the adjustment and maintenance associated with driver-actuated clutch release systems. The UltraShift DM is centrifugal clutch that relies on centrifugal force generated by its rotational speed to bring it into full engagement. During idle, the clutch is disengaged. As engine speed increases, a **touch point** is reached somewhere between 750 and 850 rpm. The touch point occurs when the clutch departure (gap) is taken up. Beyond the touch point rpm, clamping load begins to generate, meaning that the clutch engages and transfers engine torque to the transmission input shaft.

Engine speed is controlled by a combination of transmission and engine controller logic during launch of the truck to provide a smooth start. The clutch continues to generate additional clamping load as engine speed increases. Full clutch clamping force is achieved at approximately 1,350 rpm. The **launch phase** occurs between the touch point rpm (750–850 rpm) and the rpm (around 1,350 rpm) at which full clamp load is achieved. When the vehicle is brought to a stop, engine and transmission logic are used to modulate clutch friction disc clamping pressure until full disengagement occurs at approximately 800 rpm.

REVIEW QUESTIONS

1. Which of the following clutch components is a driven member?
   a. clutch cover
   b. clutch friction disc
   c. intermediate plate
   d. pressure plate
2. Which of the following is not a part of the clutch cover assembly?
   a. pressure spring
   b. release lever
   c. pressure plate
   d. adapter ring
3. Which of the following clutch components is splined to the input shaft of the transmission?
   a. clutch friction disc
   b. pressure plate
   c. release bearing
   d. flywheel
4. What is the function of a *current* clutch brake used in a heavy-duty drivetrain?
   a. minimize gear clash during a neutral to first gear shift
   b. minimize gear clash during downshifts to all ratios
   c. minimize gear clash during upshifts to all ratios
   d. none of the above
5. Which of the following driving procedures will result in clutch or driveline damage?
   a. driving with a foot on the clutch pedal
   b. using the clutch as a brake to hold the truck on a hill and incline
   c. coasting downhill with the transmission in gear and the clutch disengaged
   d. all of the above
6. Which of the following could be a cause of poor clutch release?
   a. damaged drive pins
   b. worn clutch linkage
   c. worn release bearing
   d. all of the above
7. How often should a clutch be inspected and lubricated?
   a. every month
   b. every 6,000 to 10,000 miles (9700 to 16,000 km)
   c. any time the chassis is lubricated
   d. all of the above
8. When adjusting clutch linkage, Technician A says that pedal free travel should be about 1½ to 2 inches. Technician B says that free travel should be more than ½ inch measured at the release forks. Who is correct?
   a. Technician A only
   b. Technician B only
   c. both A and B
   d. neither A nor B
9. When servicing clutches, Technician A always wears an OSHA-approved particulate mask. Technician B uses compressed air to clean off clutch components before removing a clutch pack. Who is correct?
   a. Technician A only
   b. Technician B only
   c. both A and B
   d. neither A nor B
10. In the procedure required to perform a clutch replacement on a truck, which of the following steps should be performed first?
    a. Unbolt the clutch from the flywheel.
    b. Remove the clutch brake.
    c. Install a clutch alignment tool through the release bearing.
    d. Unbolt the transmission bell housing from the flywheel.
11. On which of the following types of flywheels would the center intermediate plate be driven by drive pins?
    a. flat flywheel
    b. pot flywheel
    c. torque converter
    d. all of the above
12. Failure analysis determines that the facing of a clutch disc has burst. Technician A says that the cause is the driver using the clutch as a brake. Technician B says that the problem might be the driver coasting downhill with the transmission in gear and the clutch disengaged. Who is correct?
    a. Technician A only
    b. Technician B only
    c. both A and B
    d. neither A nor B
13. When installing a 14-inch clutch, Technician A installs new drive pins in the flywheel. Technician B files the drive pin slots to ensure that proper clearances are met. Who is correct?
    a. Technician A only
    b. Technician B only
    c. both A and B
    d. neither A nor B
14. When regarding the operation of a typical 15½-inch clutch, which of the following components constantly rotates at engine rpm?
    a. rear clutch disc
    b. front clutch disc
    c. intermediate plate
    d. clutch brake

15. When inspecting the mating faces of a clutch bell housing, which of the following can be regarded as the critical wear area?
    a. at the 12 o'clock position
    b. at the 3 o'clock position
    c. between 2 o'clock and 10 o'clock counterclockwise
    d. between 3 o'clock and 8 o'clock clockwise
16. Which of the following adjustments is made on nonsynchronized transmissions only?
    a. pedal height
    b. total pedal travel
    c. clutch brake squeeze
    d. free travel
17. A driver complains of a hard clutch pedal. Technician A says that the problem may be damaged bosses on the release yoke assembly. Technician B says that the clutch linkage may be worn or damaged. Who is correct?
    a. Technician A only
    b. Technician B only
    c. both A and B
    d. neither A nor B
18. Technician A says that when the driver releases (disengages) the clutch while coasting downhill, the clutch may overheat. Technician B says that overheating may result when the driver rides the clutch pedal. Who is correct?
    a. Technician A only
    b. Technician B only
    c. both A and B
    d. neither A nor B
19. There are grooves worn in a clutch pressure plate. Technician A says that the clutch discs could be worn or damaged. Technician B says that the clutch pressure springs could be worn or damaged. Who is correct?
    a. Technician A only
    b. Technician B only
    c. both A and B
    d. neither A nor B
20. Which of the following should be used to remove minor heat discoloration from a clutch pressure plate?
    a. cleaning solvent with a nonpetroleum base
    b. ammonia
    c. emery cloth
    d. none of the above