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CLUTCHES & AUTOMATIC TRANSMISSIONS

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MEC-158 EXAM PREVIEW

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Exam Preview:

1. According to the refence material, planetary gears are used in the Hydra-Matic 400 transmission as a basic means of multiplying the torque from the engine.
   a. True
   b. False
2. The Model 400 Hydra-Matic transmission is a fully automatic unit consisting of a three element torque converter and a compound planetary gearset. The compound planetary gearset gives ___ forward ratios and one reverse.
   a. 2
   b. 3
   c. 4
   d. 5
3. According to the reference material, with the engine operating at full throttle, the transmission in gear, and the vehicle standing still, the torque converter is capable of multiplying engine torque by approximately __:1
   a. 5
   b. 4
   c. 3
   d. 2
4. There are two types of clutch operating systems: mechanical and hydraulic. The hydraulic system is the most common; it moves the release lever by hydraulic pressure.
   a. True
   b. False

5. According to the reference material, the Hydra-Matic Model 400 uses an interred gear type of pump with its oil intake connected to a strainer assembly. The pressure regulator valve is spring-balanced to maintain line pressure at approximately __ psi at an idle.
    a. 30
    b. 50
    c. 70
    d. 90
6. According to the refence material, not all transmission fluids are the same. Before you add fluid, check the manufacturer's recommendations fast. The use of the wrong fluid will lead to early internal parts failure and costly overhaul.
    a. True
    b. False
7. According to the reference material, compressed air used for cleaning purposes should not exceed __ psi. Wear goggles and other appropriate protective equipment when you use compressed air.
    a. 15
    b. 30
    c. 45
    d. 60
8. According to the clutch malfunctions section of the reference material, which of the following problems causes the clutch disk to tend to continue turning with the engine and attempts to drive the transmission.
    a. Clutch pedal pulsation
    b. Grabbing
    c. Slipping
    d. Dragging
9. According to the reference material, for a regular Hydra-Matic Model 400 transmission, the fluid color should be ___ and clear. A burnt smell or brown coloration of the fluid is a sign of overheated oil from extra heavy use or slipping bands or clutch packs.
    a. Orange
    b. Yellow
    c. Pink
    d. Red
10. According to the refence material, noise may also come from a worn or dry pilot bearing. Such a bearing tends to "hum" when it is out of grease. This noise usually occurs when the vehicle is stationary, with the engine running, the transmission in gear, and the clutch disengaged.
    a. True
    b. False

CLUTCHES AND AUTOMATIC TRANSMISSIONS

This chapter provides information about the clutch and the automatic transmission to enable you to understand the operation of these units, to diagnose problems, and to prescribe corrective action. To obtain more detailed information on the operation and repair of specific units, refer to the specific manufacturer's maintenance and repair manual.

To make practical use of engine power, a coupling device, or clutch, is needed to connect and disconnect the engine from the drive line, as necessary. The clutch or torque converter provides for complete separation of power or at least slippage at an idle. The automatic transmission, like manual transmissions, matches load requirements of the vehicle to the power and speed of the engine.

CLUTCH SYSTEMS

It is important to briefly review the purpose of the clutch and also the various types of clutches. The clutch permits the operator to couple and uncouple the engine and transmission. When the clutch is in the coupling (or normal running) position, power flows through it from the engine to the transmission. If the transmission is in gear, power flows through to the vehicle wheels, so the vehicle moves. Essentially, the clutch enables the operator to uncouple the engine temporarily, so the gears can be shifted from one forward gear position to another or into reverse or neutral. The flow of power must be interrupted before the gears are shifted; otherwise, gear shifting is extremely difficult if not impossible.

The clutch assembly (fig. 7-1) contains a friction disk (fig. 7-2), or driven plate about a foot in diameter.

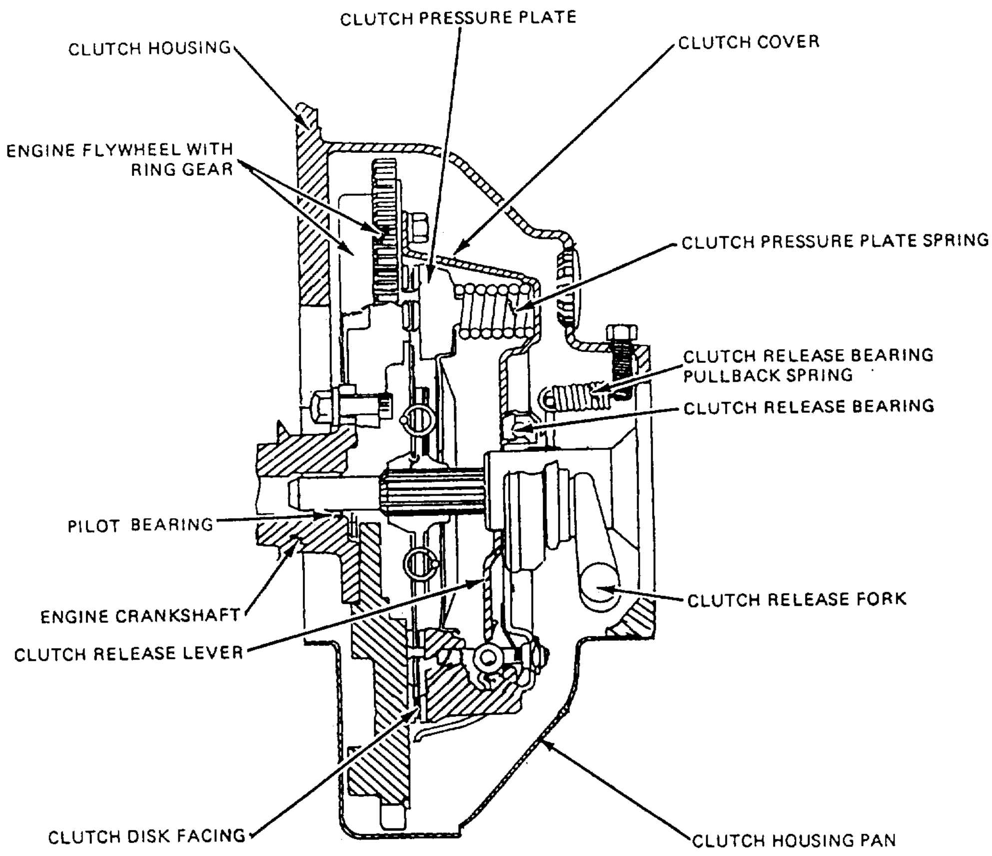

Figure 7-1.—Typical clutch assembly.

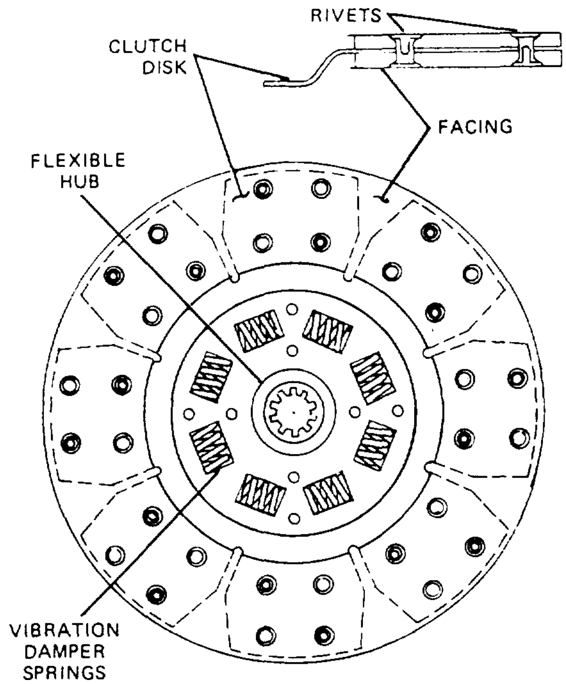

Figure 7-2.—Friction disk clutch with flexible center.

It also contains a spring arrangement and a pressure plate (fig. 7-3) for pressing the disk tightly against the face of the flywheel. The friction disk is splined to the clutch shaft. The splines consist of two sets of teeth: an internal set on the hub of the friction disk and a matching external set on the clutch shaft. They permit the friction disk to slide back and forth along the shaft but force the disk and the shaft to rotate together.

The flywheel, attached to the end of the engine crankshaft, rotates when the engine is running. When the clutch is engaged in the coupling position, the friction disk is held tightly against the flywheel by the pressure plate springs, so that it rotates with the flywheel. This rotary motion is carried through the friction disk and clutch shaft to the transmission.

To disengage (or uncouple) the clutch, the clutch operator presses the clutch pedal down. This causes the clutch fork to pivot so the clutch release bearing is forced inward. As the release bearing is moved inward, it operates the pressure plate release levers (fig. 7-4). The release levers take up the spring pressure and lift the pressure plate away from the friction disk. The friction disk is no longer pressed against the flywheel face, and the engine can run independently of the power train. Releasing the clutch pedal permits the clutch fork to disengage the release bearing, so the springs will again cause the pressure plate to force the friction disk against the flywheel face to rotate together.

There are two types of clutch operating systems: mechanical and hydraulic. The mechanical system is the most common and uses a rod type of linkage (fig. 7-5);

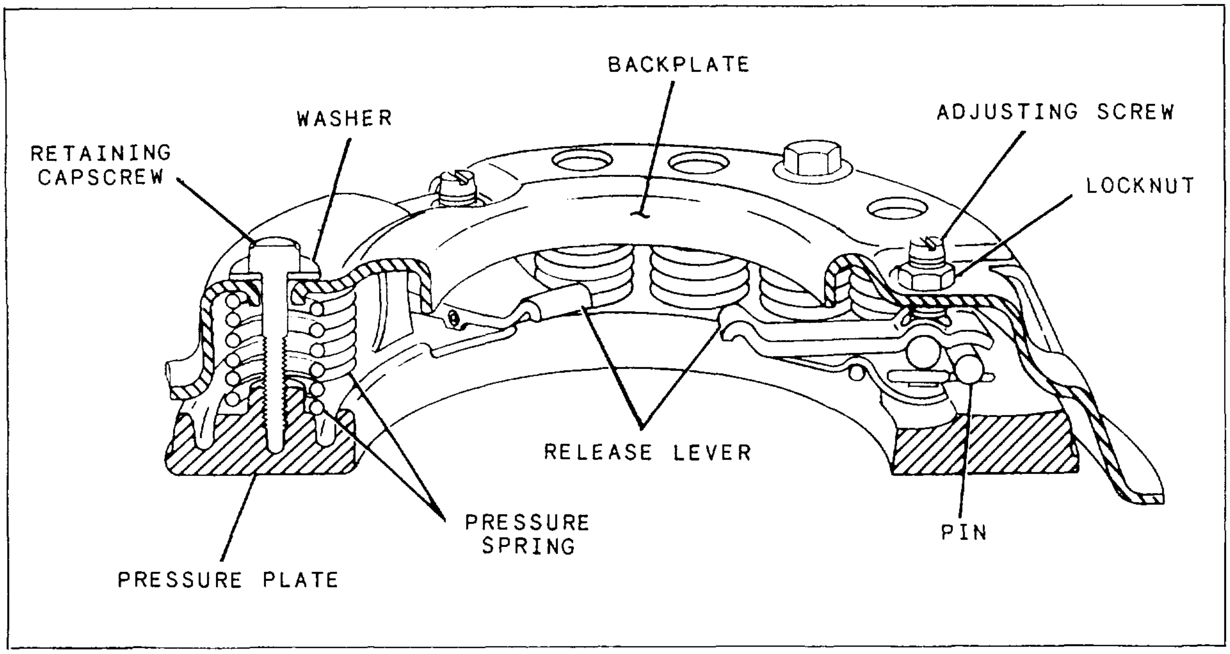

Figure 7-3.—Pressure plate and related parts.

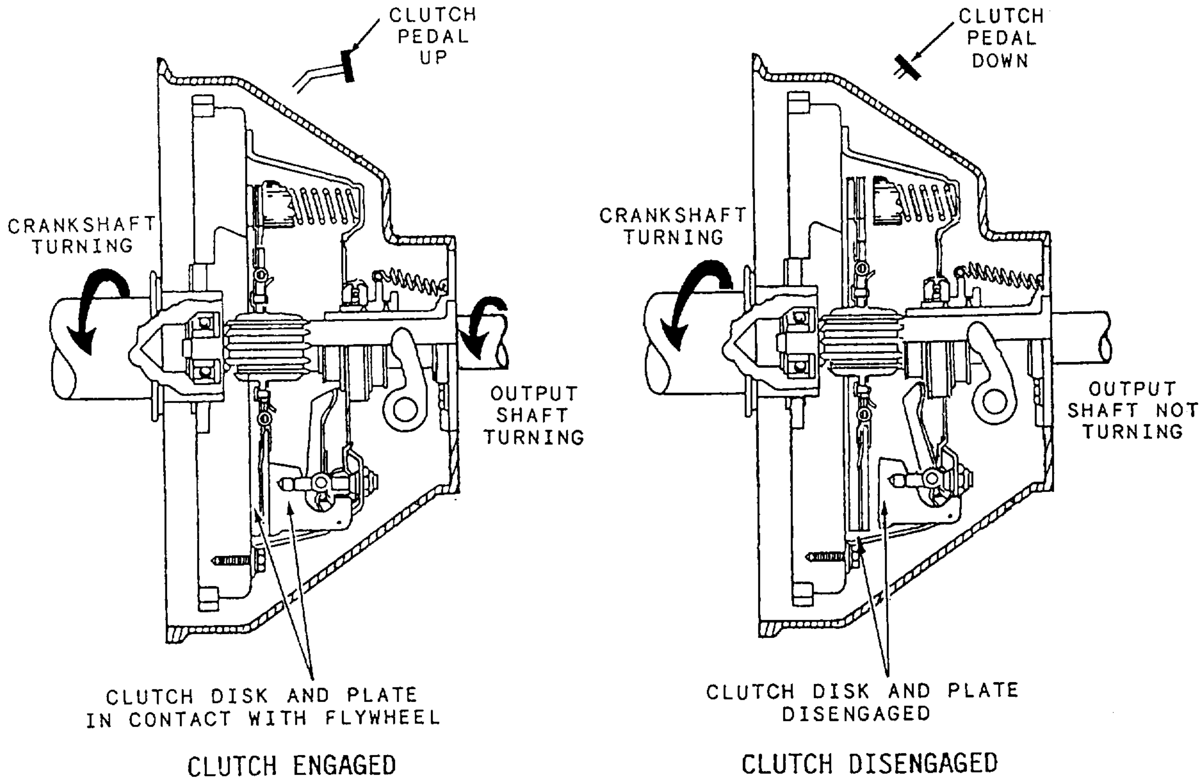

Figure 7-4.—Clutch operation.

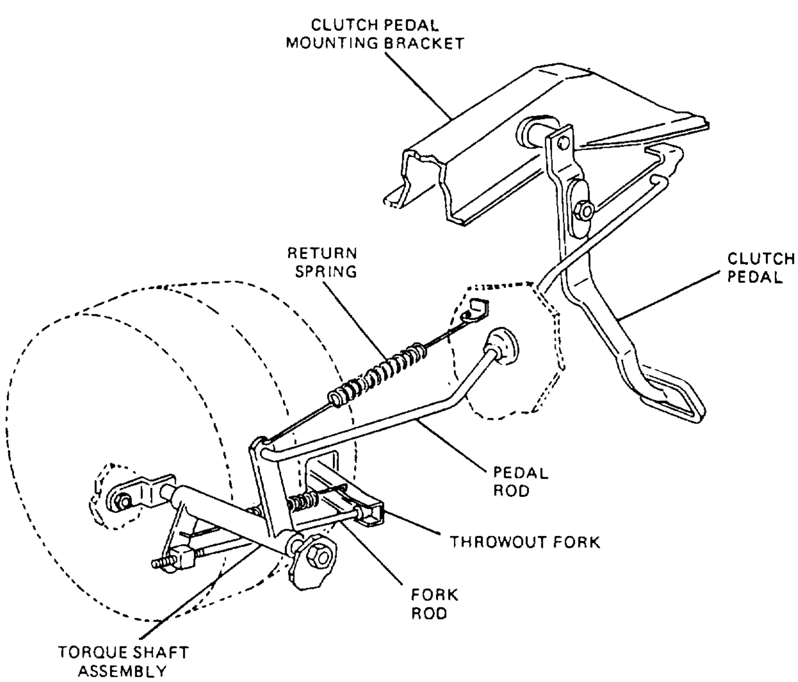

Figure7-5.—Mechanical clutch operating systems (rod type of linkage).

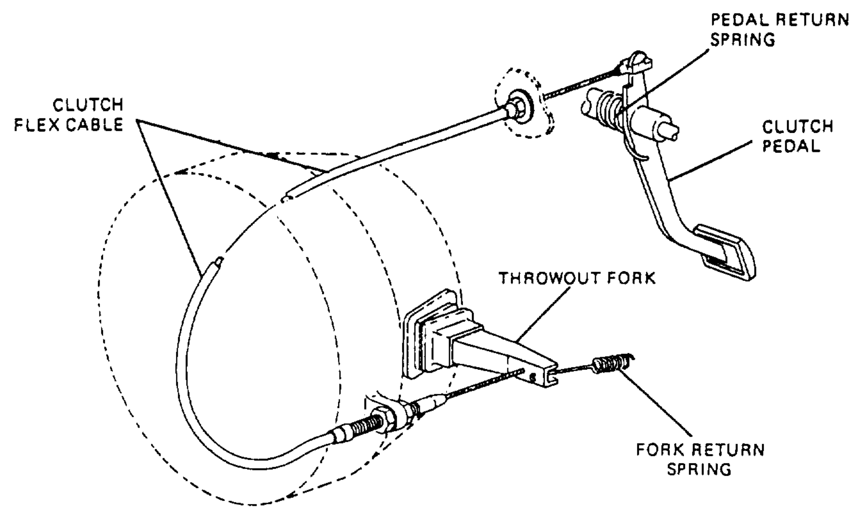

Figure 7-6.—Mechanical clutch operating systems (cable type of linkage).

other mechanical systems use a flexible type of cable (fig. 7-6). These systems are normally found in automotive applications. The hydraulic operating system (fig. 7-7) moves the release lever by hydraulic pressure. Depressing the clutch pedal creates pressure in the clutch master cylinder, actuating the slave cylinder which, in turn, moves the release arm and disengages the clutch. Hydraulic types of clutch operating systems are normally found in heavy construction equipment where extreme pressure is required to operate the clutch.

Most automotive and construction equipment clutches work on the same principle and are similar in

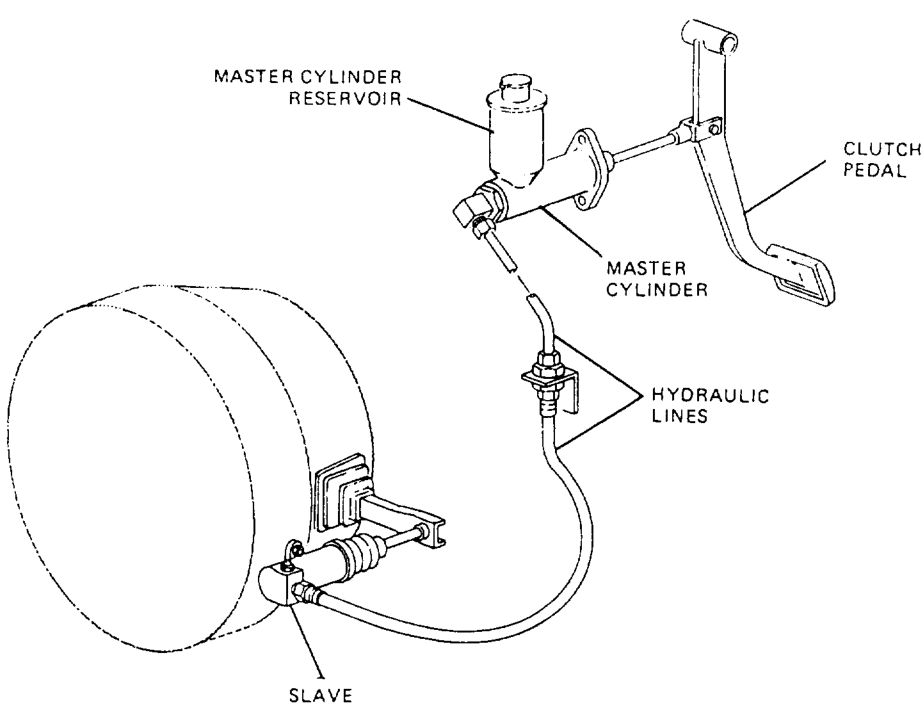

Figure 7-7.—Hydraulic clutch operating system.

construction. The differences are mainly in pressure plate assemblies, linkages, and overall size.

Of the different types of clutch assemblies, the one shown in figure 7-8 is known as the plate clutch. The plate clutch is a simple clutch with two plates and one disk, clamped between the two plates. Another type (fig. 7-9) is the double-disk clutch. The driving members of the single-disk clutch consist of the flywheel and driving (pressure) plate. The driven member consists of a single disk splined to the clutch shaft and faced on both sides with friction material. When the clutch is fully engaged, the driven disk is firmly clamped between the flywheel and the driving plate by the pressure of the pressure plate springs, and a direct, nonslipping connection between the driving and driven members of the clutch is formed. In this position, the driven disk rotates the clutch shaft to which it is splined. The clutch shaft is connected to the driving wheels through the power train.

The double-disk clutch is substantially the same as the single-disk clutch described in the section above, except that an additional driven disk and intermediate driving plate are added.

For more basic information concerning clutches refer to your Construction Mechanic 3&2 TRAMAN NAVEDTRA 10644-G1.

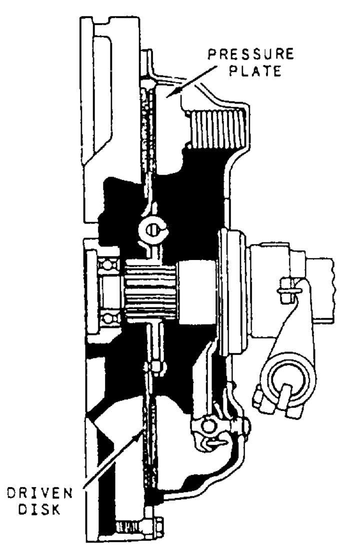

Figure 7-8.—Single-disk clutch assembly.

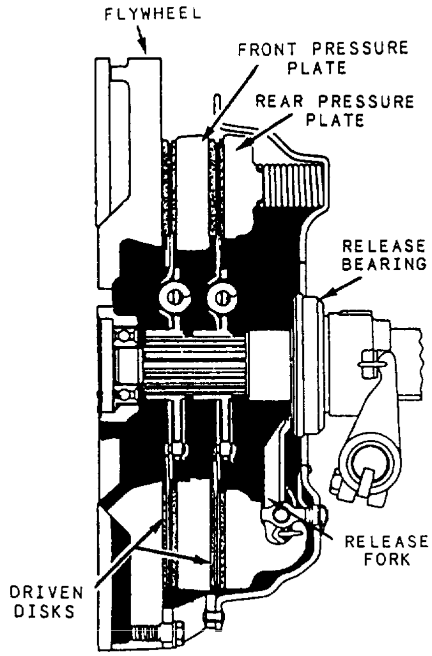

Figure 7-9.—Doubledisk clutch assembly.

CLUTCH MALFUNCTIONS

The information given in this section is general and may be applied to nearly every type of clutch you are likely to encounter. Refer to the manufacturer's repair manuals for problems not listed here.

The most common symptoms of clutch malfunctions are dragging, slipping, and noise. Improper adjustment is one condition that leads to clutch problems. You should always adjust the clutch according to the manufacturer's specifications. An improperly adjusted clutch can cause clutch slippage and hard shifting.

Dragging

This condition results when the clutch disk does not completely disengage from the flywheel or pressure plate when the clutch pedal is depressed. As a result, the clutch disk tends to continue turning with the engine and attempts to drive the transmission.

Dragging may be caused by any of the following conditions:

1. Excessive free travel in the clutch linkage.
2. The clutch disk binding on the transmission input shaft.
3. A warped or damaged pressure plate.

4. Improper adjustment of the pressure plate release lever. (Some pressure plates require this adjustment before the part is installed.)

To correct clutch dragging, adjust the free travel. Make this adjustment according to the manufacturer's specifications. If the problem is not corrected with this adjustment, you may need to remove the clutch for repairs or replacement.

Slipping

Because of heat generation, slipping of the clutch (while it is engaged) can severely damage the clutch disk facings. The contact surfaces on the pressure plate and the flywheel may also be damaged. If a clutch is allowed to continue to slip, complete clutch failure may result. Clutch slipping is most obvious when you are just starting out from a dead stop or upon sudden acceleration in a low gear. Slipping will be very noticeable in a vehicle with a heavy load.

Causes of clutch slippage include incorrect clutch pedal free travel, binding in the clutch linkage, and "riding the clutch." If the free travel is insufficient, there is a tendency for the release bearing to contact the release levers, even though the operator's foot is off the clutch pedal. As a result, the clutch disk may not be clamped tightly between the flywheel and the pressure plate. Readjustment of the pedal free travel will solve this problem. If you do not adjust the free travel at once, the release bearing, as well as the clutch disk, will wear rapidly.

If a binding condition exists in the clutch linkage, the pedal will be reluctant to return when it is released. So again, you may encounter clutch slippage. To solve this problem, "free up" the linkage that is binding by simply lubricating or aligning the clutch linkage. If this fails to correct the problem, you may have to remove the clutch for further inspection and repair.

"Riding the clutch" is an operator problem whereby the operator steadily drives with a foot on the clutch pedal. As a result, the pedal may be partially depressed and cause clutch slippage. If this form of operator abuse is suspected, contact the transportation supervisor. The problem should be corrected through proper operator training.

Grabbing

Occasionally, you may encounter a clutch that grabs or chatters, no matter how evenly or gradually you try to engage it. If the linkage operates satisfactorily and the engine and clutch mountings are not loose, you may have to remove the clutch assembly from the vehicle to cure the trouble. The probable causes are loose, glazed, oily, or greasy disk facings; binding of the disk on the clutch shaft; broken or otherwise defective pressure plate springs; or a broken or otherwise defective pressure plate.

A careful inspection of all clutch parts should reveal any defective items. In any case, replace any damaged parts and rebuild the clutch as specified by the manufacturer. In most cases, it is best that you install the clutch as a unit which includes replacing the clutch disk, pressure plate, release bearing, pilot bearing and resurfacing the flywheel. Replacing the complete assembly prevents the need for rework

Clutch Noises

A noisy clutch may be caused by a number of conditions. Most of these conditions can be corrected only after you have removed the assembly from the vehicle. Start your inspection by noting whether or not the noise occurs when the clutch is engaged or disengaged. Do this with the engine idling since the noise is likely to be most apparent at this time.

To begin with, when you have the clutch disengaged, you may discover that the noise coming from the clutch is due to lack of lubrication or to defects in the assembly. For instance, a dry or binding release bearing is likely to squeal when it is placed in operation. If it does, you will usually need to replace the bearing. On some vehicles, however, provisions are made for lubricating this bearing. If so, you can generally lubricate or replace the bearing without removing the clutch assembly. Still, you may need to remove the transmission and the lower cover from the flywheel housing to get to the bearing. However, it usually pays for you to go a little further and inspect the entire clutch assembly if you must remove the transmission for any reason.

Noise may also come from a worn or dry pilot bearing. Such a bearing tends to "whine" when it is out of grease. This noise usually occurs when the vehicle is stationary, with the engine running, the transmission in gear, and the clutch disengaged. To remedy this, replace the bearing and make sure it is properly lubricated if it is not a prepacked bearing.

Still other clutch noises may occur when you have the clutch disengaged. Any one of several conditions can be responsible for noisy operation. For example, the clutch disk may be loose on the transmission shaft (disk hub loose on shaft splines). If this is the case, depending on the amount of wear, you may have to replace the input shaft and the clutch disk. Another condition involving noise and necessitating disk replacement is loose or weak torsional springs surrounding the disk hub. You may also find that the antirattle springs on the pressure plate assembly are weak and require replacement. A hose or misaligned transmission will cause noisy clutch operation. You can easily correct this by loosening the transmission, shifting it into proper alignment, and retightening it.

Stiff Clutch Pedal

A stiff clutch pedal or a pedal that is hard to depress is likely to result from lack of lubricant in the clutch linkage, from binding of the clutch pedal shaft in the floorboard seal, or from misaligned linkage parts that are binding. In addition, the overcenter spring (on vehicles so equipped) may be out of adjustment, Also, the clutch pedal may be bent so that it rubs on the floorboard and is hard to operate. To correct these conditions, you must realign, readjust, or lubricate the parts, as required.

Clutch Pedal Pulsation

Movement felt on the clutch pedal or operating lever when the clutch is being disengaged is called clutch pedal pulsation. These pulsations are noticeable when a slight pressure is applied to the clutch pedal. This is an indication of trouble that could result in serious damage if not immediately corrected Several conditions could cause these pulsations. One is misalignment of the engine and transmission.

If the engine and transmission are not in line, detach the transmission and remove the clutch assembly. Check the clutch housing alignment with the engine and crankshaft. At the same time, check the flywheel for wobble. A bent crankshaft flange or an improperly seated flywheel produces clutch pedal pulsations. After the flywheel is properly seated, check it using a dial indicator. If the crankshaft flange is bent, the crankshaft must be remachined or replaced.

Other causes of clutch pedal pulsations include uneven release lever adjustments, warped pressure plate, or a warped clutch disk. If the clutch disk or pressure plate is warped, it should be replaced.

It would be impractical to list every possible clutch problem and its remedy for repair in this training manual. Table 7-1 lists other possible clutch problems and their corrective action. Consult the manufacturer's operation and repair manual before making adjustments to any clutch system.

AUTOMATIC TRANSMISSIONS

Automatic transmissions (fig. 7-10) are found in all types of automotive and construction equipment. The

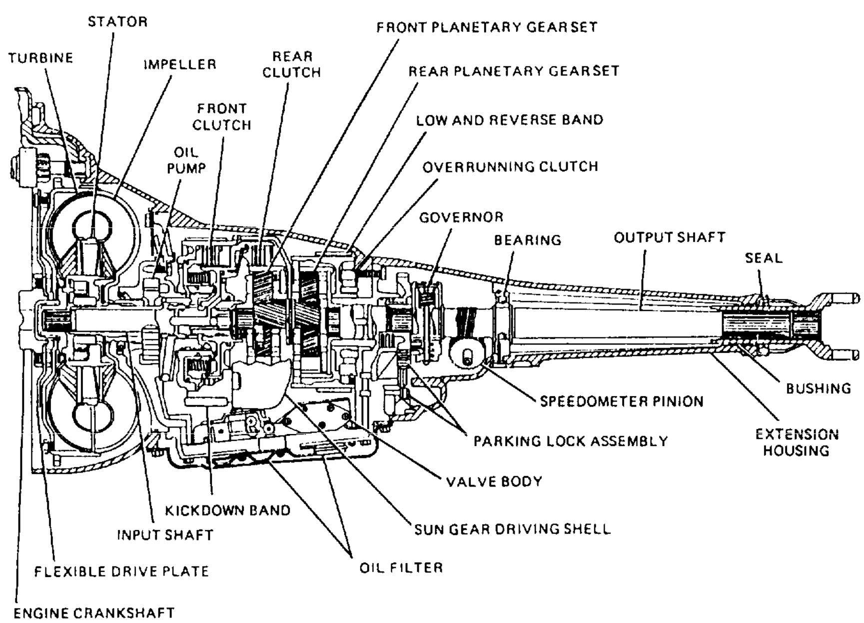

Figure 7-10.—Typical automatic transmission, cross-sectional view.

Table 7-1.—Clutch Assembly Troubleshooting Chart

PROBLEM	REMEDY
Clutch fails to release	
1. wrong linkage adjustment	1. readjust clutch linkage
2. broken linkage	2. repair linkage
3. pilot bearing is seized on the transmission input shaft	3. replace pilot bearing
4. broken release levers on pressure plate	4. replace pressure plate
5. broken clutch release cable	5. replace cable
the following is for hydraulic clutch operating systems	
6. low or no hydraulic fluid in the clutch master cylinder	6. repair the master cylinder
7. faulty clutch slave cylinder	7. rebuild or replace master cylinder
8. broken hydraulic lines	8. repair or replace hydraulic lines
Slipping Clutch	
1. excessive free play in clutch linkage	1. readjust clutch linkage
2. clutch drive plate worn	2. replace drive plate
3. diaphram spring broken	3. replace pressure plate
4. clutch plate is oil soaked	4. replace the clutch plate
5. drive plate is overheated	5. let the plate cool and recheck adjustment
6. warped pressure plate	6. replace pressure plate
Grabbing clutch	
1. broken engine mounts	1. repair or replace engine mounts
2. clutch plate facing charred or oil soaked	2. replace clutch plate
3. broken damper springs in the clutch plate	3. replace clutch plate
4. worn splines on transmission input shaft	4. replace the transmission shaft
5. flywheel or pressure plate is warped	5. reface flywheel or replace the pressure plate
6. cracked or broken release bearing collar	6. replace collar
Noisy, clutch engaged; transmission in neutral	
1. clutch plate damper springs worn or broken	1. replace clutch disk
2. clutch release arm spring loose or missing	2. replace spring
3. clutch linkage loose	3. repair and readjust
Noisy, when clutch is engaged and disengaged	
1. worn release bearing	1. replace release bearing
2. clutch linkage or assist springs are not properly lubricated..	2. lubricate linkage and springs
3. release arm is installed improperly	3. remove and reinstall
4. release bearing is loose on the release lever	4. remove and reinstall
Clutch pedal is hard to depress or does not return when disengaged	
1. faulty clutch pressure plate	1. replace pressure plate
2. jammed or binding clutch linkage	2. repair, lubricate, and readjust clutch linkage
3. broken or weak clutch return spring	3. replace return spring
4. binding clutch release cable	4. replace cable
the following is for hydraulic clutch operating systems	
5. faulty clutch master cylinder	5. rebuild or replace master cylinder

purpose of the automatic transmission is the same as standard transmissions-to match the load requirements of a vehicle to the power and speed of the engine. Changing the gear ratio automatically is controlled by throttle position, shift control lever position, and vehicle speed. It relieves the operator of the responsibility of selecting the best possible gear ratio for each condition and makes driving easier and safer.

Many different models of automatic transmissions are manufactured today. Automotive applications usually have three speeds forward and one reverse. More recently the automotive industry has added a lockup clutch to the torque converter, and on some models, an overdrive gear. Automatic transmissions for material handling and construction equipment will normally have a lower gear ratio, be considerable y larger, and may have over six speeds forward and more than one reverse gear.

Whatever the case and regardless of design or construction, all automatic transmissions have the following six basic systems that enable them to function:

1. A torque converter or fluid coupling
2. A hydraulic system
3. A planetary gearset (usually more than one)
4. One or more spool valves used to direct fluid flow
5. Multidisk clutch packs or lockup bands
6. A control valve or a combination of control valves

In automatic transmissions, these systems all serve the same purposes. For this reason, we will only discuss one type of automatic transmission in this TRAMAN. If you want information on a specific type, use the manufacturer's maintenance and repair manual for that unit.

TURBO HYDRA-MATIC MODEL 400

The Model 400 Hydra-Matic transmission (fig. 7-1 1) is a fully automatic unit consisting of a three element torque converter and a compound planetary

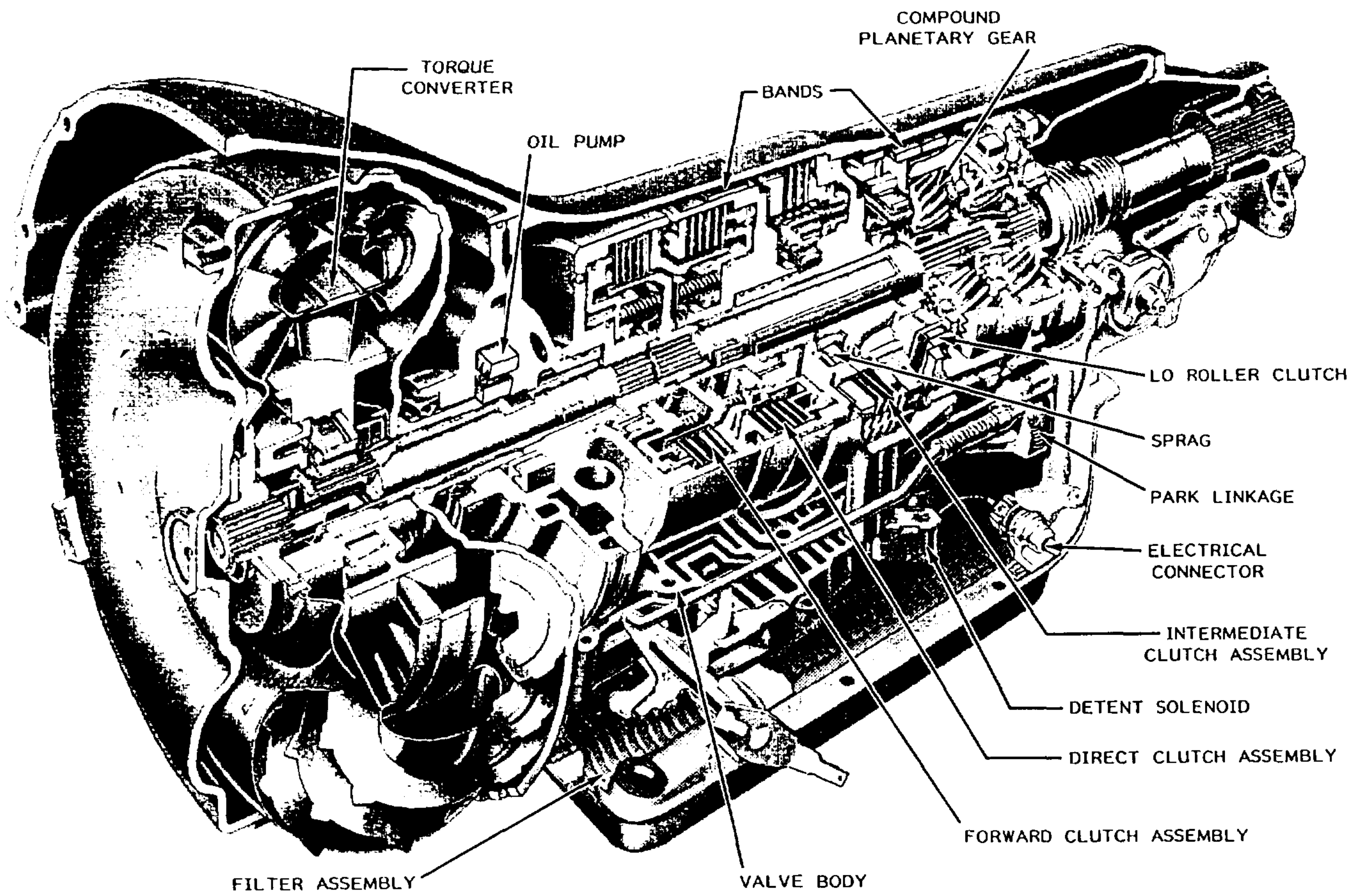

Figure 7-11.—Cutaway view of Model 400 Hydra-Matic transmission.

gearset. Three multiple-disk clutches-one sprag, one roller clutch, and two bands–provide the reaction elements required to obtain the desired function of the compound planetary gearset.

The torque converter smoothly couples the engine to the planetary gear through oil and hydraulically y provides additional torque mulitplication when required. The torque converter consists of a pump (driving member), a turbine (driven member), and a reaction member, known as a stator.

The compound planetary gearset gives three foward ratios and one reverse. Changing of the gear ratios is fully automatic in relation to vehicle speed and load.

Planetary Gears

Planetary gears are used in the Hydra-Matic 400 transmission as a basic means of multiplying the torque from the engine. The name is derived from the physical arrangement of the gears. They are always in mesh and thus cannot “clash” like other gears that go in and out of mesh. The gears are so designed so several teeth are in mesh or in contact at one time. This distributes the forces over several teeth at one time for greater strength. Because the shafts generally used with planetary gear trains can be arranged on the same centerline, a compact system can be obtained.

A planetary gear train consists of a center or sun gear, an internal or ring gear, and a planetary carrier assembly which includes and supports the smaller planet gears or pinions (fig. 7-12). A planetary gearset can be used to increase speed increase torque, reverse the direction of rotation, or function as a coupling for direct drive. Increasing the torque is known as operating in reduction because there is always a decrease in the speed of the output member proportional to the increase in the output of torque. This means that with a constant input speed, the output torque increases as the output speed decreases.

Reduction can be obtained in several ways. In a simple reduction, the sun gear is held stationary, and the power is applied to the internal gear in a clockwise direction. The planetary pinions rotate in a clockwise direction and “walk” around the stationary sun gear, thus rotating the carrier assembly clockwise in reduction (fig. 7-13).

Direct drive results when any two members of the planetary gear train rotate in the same direction at the same speed. In this condition, the pinions do not rotate on their pins but act as wedges to lock the entire unit together as one rotating assembly.

To obtain reverse, restrain the carrier from turning freely and power is applied to either the sun or the internal gear. This causes the planet pinions to act as idlers, thus driving the output member in the opposite

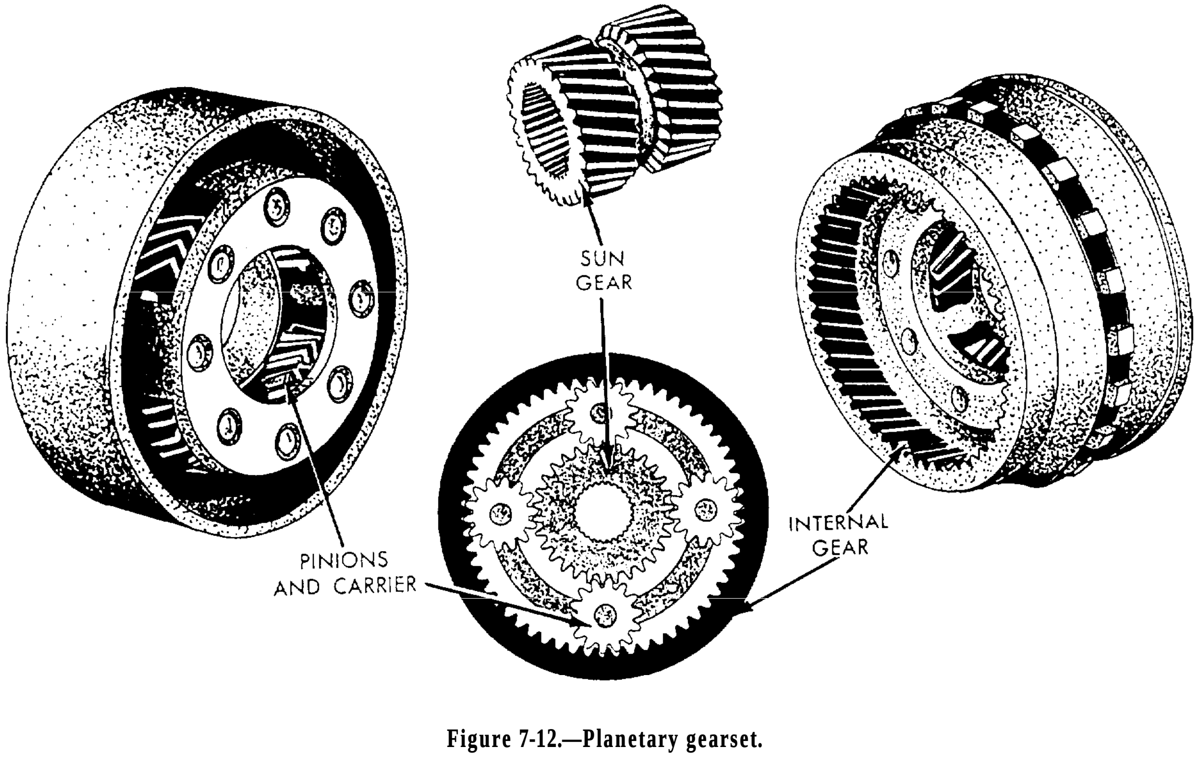

Figure 7-12.—Planetary gearset.

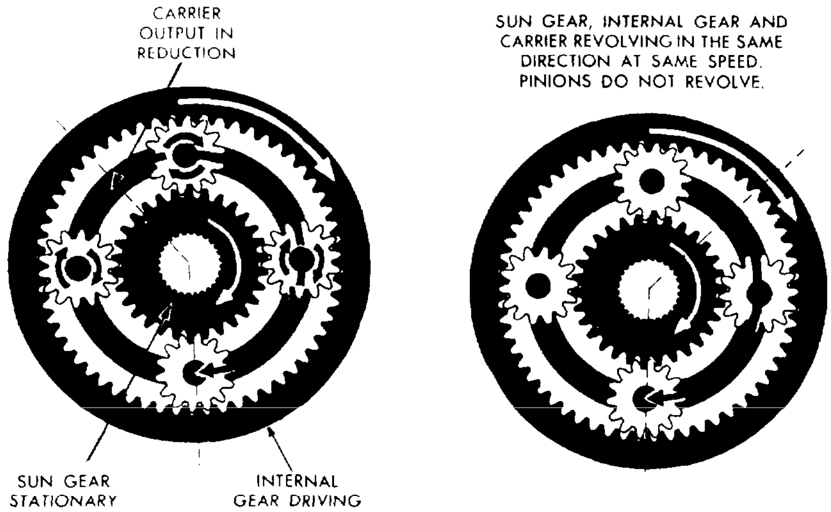

Figure 7-13.—Simple reduction-direct drive.

direction (fig. 7-14). In both cases, the output member is turning in the opposite direction of the input member.

Coupling ((Torque Converter Operation)

The automatic transmission is coupled to the engine through a torque converter. The torque converter is used with the automatic transmission because it does not have to be manually disengaged by the operator each time the vehicle is stopped. The cushioning effect of the fluid coupling within the torque converter allows for shifting without interruption of engine torque application.

The torque converter serves two primary functions. First, it acts as a fluid coupling to connect engine power smoothly through oil to the transmission gear train. Second, it multiplies the torque from the engine when additional performance is desired.

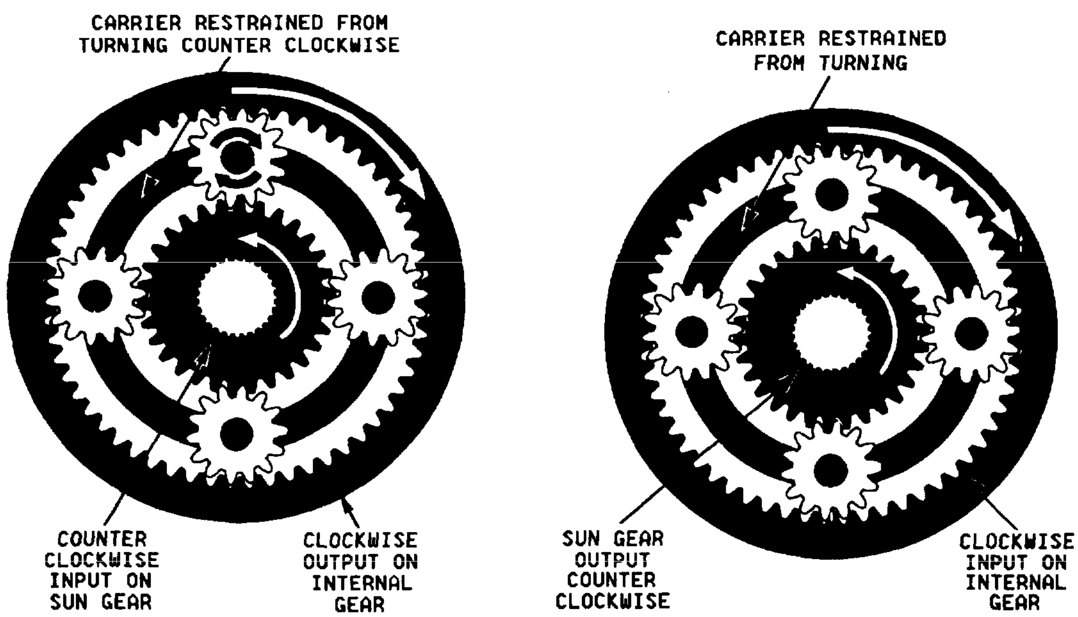

Figure 7-14.—Reverse drive.

The torque converter, as shown in figure 7-15, consists of the pump (driving member), the turbine (driven or output member), and the stator (reaction member). The converter cover is welded (some maybe bolted) to the pump to seal all three members in an oil-filled housing. The converter cover is bolted to the engine flex-plate which is bolted directly to the engine crankshaft. The converter pump is, therefore, mechanically connected to the engine and turns at engine speed whenever the engine is operating.

When the engine is running and the converter pump is spinning, it acts as a centrifugal pump, picking up oil at the center and discharging this oil at its rim between the blades. The shape of the converter pump shells and blades causes this oil to leave the pump, spinning in a clockwise direction toward the blades of the turbine. As the oil strikes the turbine blades, it imparts a force to the turbine, causing it to turn. Figure 7-16 shows the torque converter in the coupling stage. When the engine is idling and the converter is not spinning fast, the force of the oil is not great enough to turn the turbine with any efficiency. This allows the vehicle to stand in gear with the engine idling. As the throttle is opened and the pump speed is increased, the force of the oil increases and the engine power is more efficiently transmitted to the turbine member and the gear train. After the oil has imparted its force to the turbine, the oil follows the contour of the turbine shell and blades so that it leaves the center section of the turbine spinning counterclock-wise.

Because the turbine member has absorbed the force required to reverse the direction of the clockwise spinning of oil, it now has greater force than is being delivered by the engine. The process of multiplying

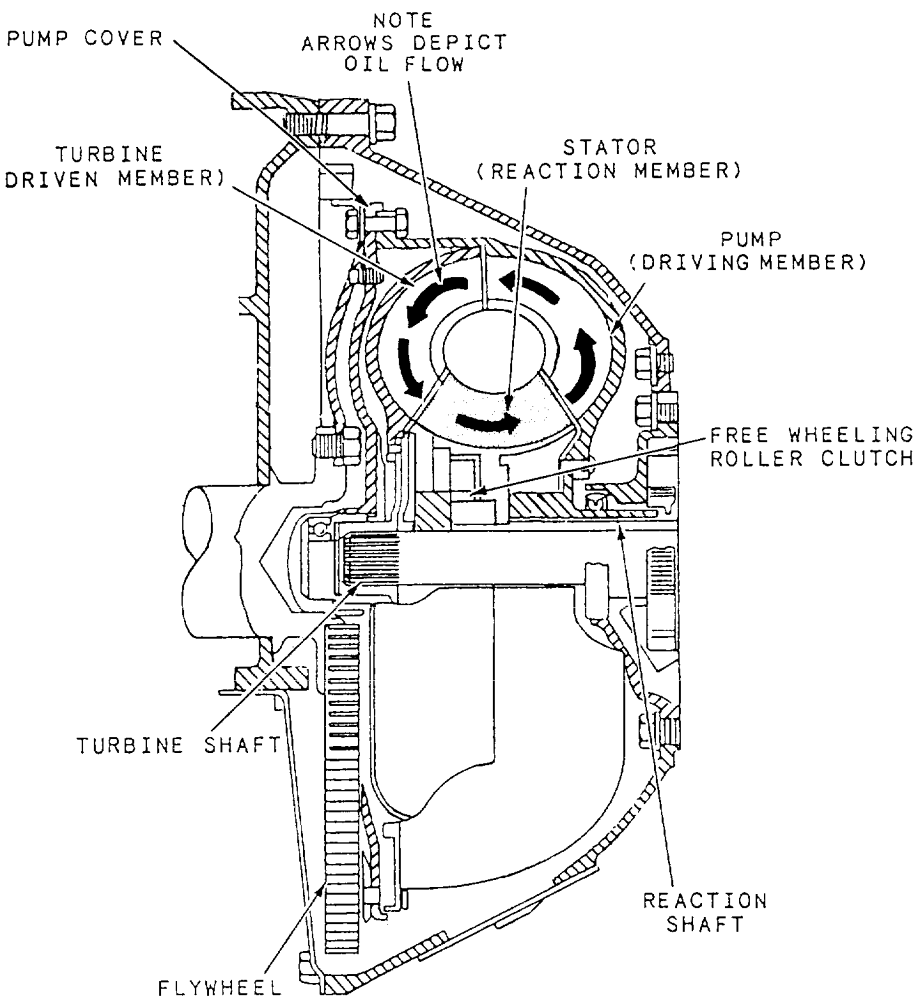

Figure 7-15.—Torque converter, partial cutaway view.

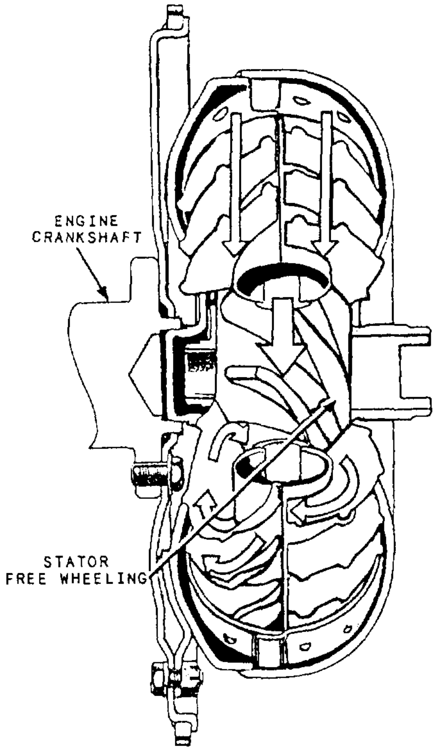

Figure 7-16.—Torque converter in fluid coupling stage.

engine torque through the converter has begun. If the counterclockwise spinning oil was allowed to continue to the section of the pump member, the oil would strike the blades of the pump in a direction that would hinder its rotation and cancel any gains obtained in torque. To prevent this, a stator assembly is added (fig, 7- 17).

The stator is located between the pump and the turbine and is mounted on a one way or roller clutch which allows it to rotate clockwise but not

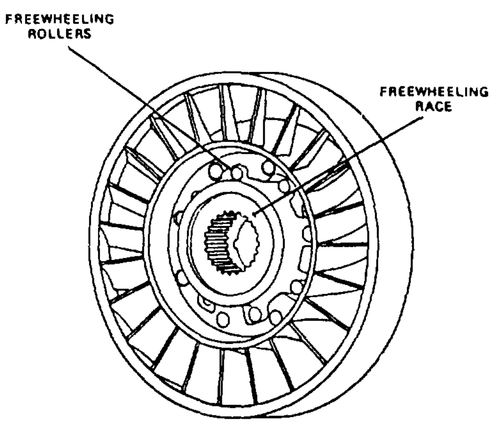

Figure 7-17.—Stator assembly.

counterclockwise. The purpose of the stator is to redirect the oil returning from the turbine and change its direction of rotation back to that of the pump member. The energy of the oil is then used to assist the engine in turning the pump. This increases the force of the oil, driving the turbine, and as a result, multiplying the torque. The force of the oil flowing from the turbine to the blades of the stator tends to rotate the stator counterclockwise, but the one way roller clutch prevents this from happening.

With the engine operating at full throttle, the transmission in gear, and the vehicle standing still, the torque converter is capable of multiplying engine torque by approximately 2:1. As turbine and vehicle speed increase, the direction of the oil leaving the turbine changes (fig. 7-18). The oil flows against the rear side of the stator vanes in a clockwise direction. Since the stator is now impeding the smooth flow of oil, its roller clutch automatically releases, and the stator revolves freely on its shaft. Once the stator becomes inactive, there is no further multiplication of engine torque within the converter. At this point, the converter is merely acting as a fluid coupling as both the converter pump and the turbine are turning at the same speed or at a 1:1 ratio.

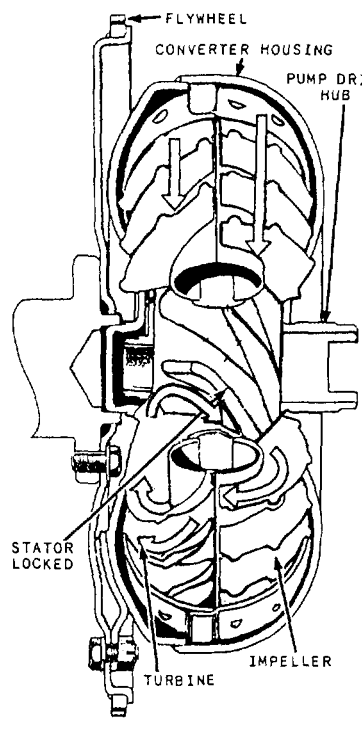

Figure 7-18.—Torque converter in torque multiplication stage.

Hydraulic System Operation

The hydraulic system shown in figure 7-19 has the following five basic functions.

1. The planetary holding devices are all actuated by hydraulic pressure from hydraulic slave systems (fig. 7-20).
2. It keeps the torque converter charged with fluid at all times.
3. The shifting pattern is controlled by the hydraulic system by switching hydraulic line pressure to programmed shifting devices according to vehicle speed and load.
4. It circulates the oil through a remote oil cooler to remove excess heat that is generated in the transmission and torque converter.

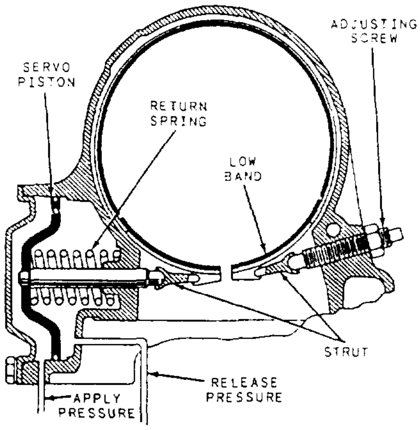

Figure 7-20.—Lockup band actuated by hydraulic pressure.

5. The hydraulic system provides a constant supply of lubricating oil to all critical wearing surfaces of the transmission.

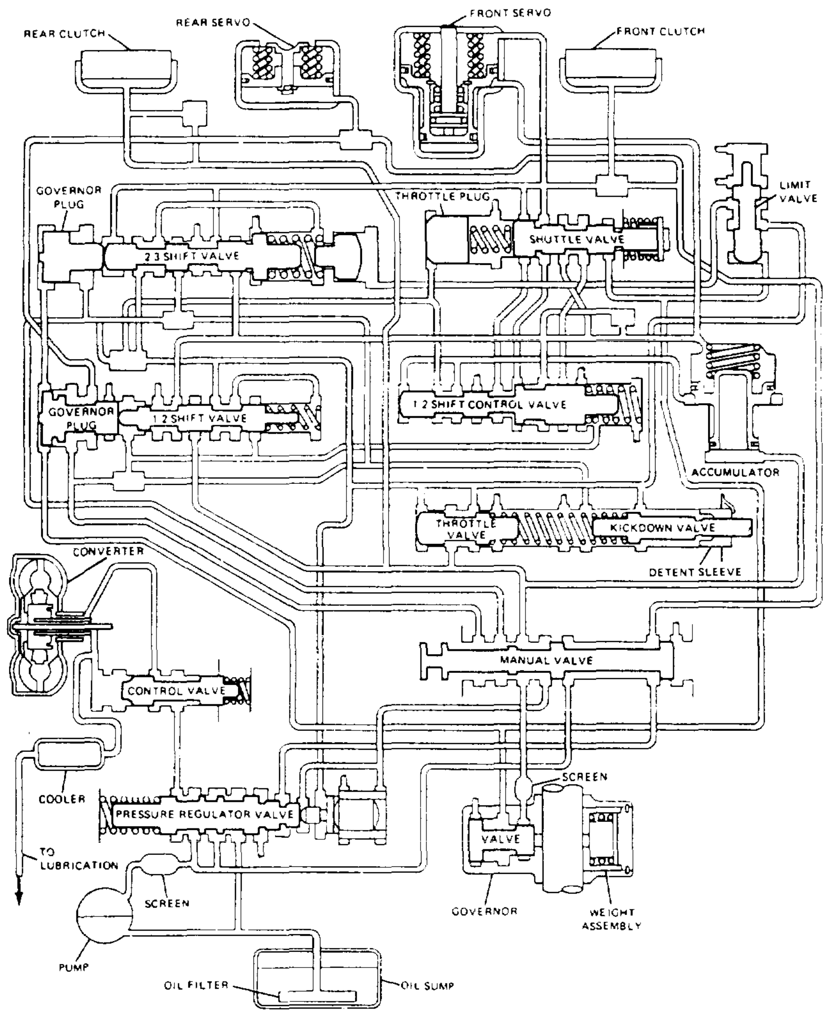

Figure 7-19.—Typical hydraulic schematic of a three-speed automatic transmission.

A hydraulic system requires a source of clean hydraulic fluid and a pump to pressurize the fluid. The Hydra-Matic Model 400 uses an interred gear type of pump (fig. 7-21) with its oil intake connected to a strainer assembly. The oil is drawn through the strainer from the transmission sump. The pump drive gear is geared or keyed to the driven member of the torque converter; therefore, whenever the engine is in operation, the pump is functioning. As the pump drive gear rotates, it rotates the pump driven gear causing the oil to be lifted from the sump into the oil pump. As the pump gears turn, oil is carried past the crescent section of the pump. Beyond the crescent, the gear teeth begin to come together again forcing the oil out of the pump and into the hydraulic system under pressure. At this point, the oil is delivered to the pressure control system.

Oil pressure is controlled by the pressure regulator valve. As the pressure builds, oil is directed through an orifice to the top of the pressure regulator valve. When the desired pressure is reached, the valve moves down against the spring, thus opening a passage to feed the 'converter. When the converter is tilled, oil returning from it is directed to the transmission cooler in the engine radiator. As the pressure continues to increase, the pressure regulator valve moves to expose a port that directs excess oil to the suction side of the pump. The pressure regulator valve is spring-balanced to maintain line pressure at approximately 70 psi at an idle.

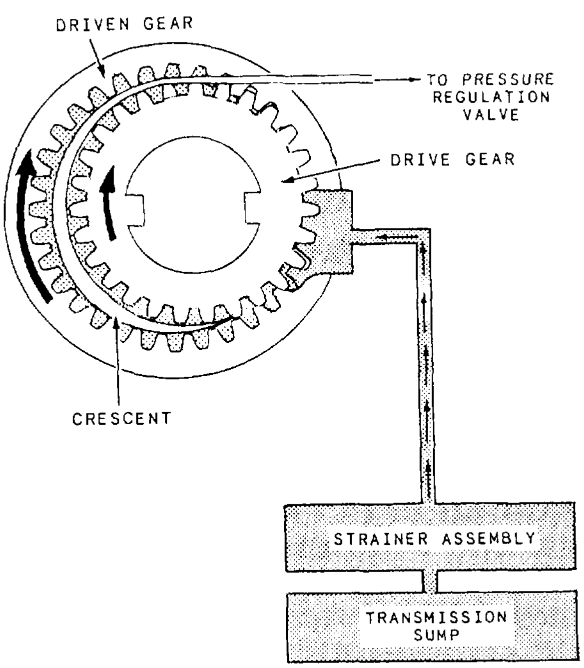

Figure 7-21.—Internal gear type of pump assembly.

When the transmission selector valve is moved to the D position, the manual valve moves to allow line pressure to be delivered to the forward clutch pack. The oil enters the small area first to provide a smooth initial takeup. The larger area is then filled gradually by oil metered through an orifice to provide the final holding force required

With the forward clutch applied, the mechanical connection for torque transmission between the turbine shaft and the main shaft has been provided. The LO roller clutch assembly becomes effective as a result of the power flow through the compound planetary gearset, and the transmission is in first gear, ready for the vehicle to start moving. As the vehicle begins to accelerate and first gear reduction is no longer required, the transmission automatically shifts to second gear. The vehicle speed signal for the shift is supplied by the transmission governor which is driven by the output shaft. The governor assembly consists of a regulating valve, a pair of primary weights, a pair of secondary weights, the secondary springs, the body, and the driven gear. The governor weights are so arranged that the secondary weights act only on the regulating valve. Because the centrifugal force varies with weight and speed, small changes in output shaft rpm at low speed result in small governor pressure changes. To give even greater change in pressure, the primary weights add force to the secondary weights. As the primary weight moves out at greater vehicle speed, it finally reaches a stop and is no longer effective. From this point on, only the secondary weights and secondary springs are used to apply the force to the governor valve.

Drive oil pressure is fed to the governor. This, in turn, is regulated by the governor valve and gives a governor pressure that is proportional to vehicle speed. To initate the shift from first to second gear, governor oil pressure is directed to the end of the 1-2 shift valve. It acts against the spring pressure holding the valve in the closed position, blocking drive oil. As vehicle speed and governor pressure increase sufficiently to overcome spring force, the 1-2 valve opens, allowing drive oil to flow into the intermediate clutch passage and through an orifice to apply the intermediate sprag effectively which shifts the transmission into second gear. Further increases in vehicle speed and governor pressure will cause the transmission to shift to third gear.

The operation of the 2-3 shift valve is similar to the 1-2 shift valve operation. Springs acting on the valve tend to keep the shift valve closed while governor pressure attempts to open the valve. When speed and governor pressure become great enough to open the 2-3 shift valve, intermediate clutch oil passes through the shift valve and enters the direct clutch, thus shifting the transmission into third gear. Oil pressure to the direct clutch piston is applied only to the small inner area in third gear.

When the accelerator is released and the vehicle is allowed to decelerate to a stop, the transmission automatically downshifts 3-2 and 2-1. This results from the decrease in governor pressure as the vehicle slows and the springs closing the shift valves in sequence.

In this system, shifts would always take place at the same vehicle speeds when the governor pressure overcomes the force of the springs on the shift valves. When you accelerate under a heavy load or for maximum performance, it is desirable to have the shifts occur at higher vehicle speeds. To make the transmission shift at higher vehicle speeds with greater throttle opening, variable oil pressure, called modulation pressure is used. Modulator pressure is regulated by engine vacuum which is an indicator of engine load and throttle setting. The engine vacuum signal is provided to the transmission by the vacuum modulator which consists of an evacuated metal bellow, a diaphram, and springs. These are so arranged that, when installed, the bellows and one spring apply a force that acts on the modulator valve to increase modulator pressure. Engine vacuum and the other spring act in the opposite direction to decrease modulator pressure which results in low-engine vacuum and gives a high-torque signal and high modulator pressure. High-engine vacuum gives a low-torque signal and low modulator pressure.

Modulator pressure is directed to the 1-2 regulator valve which regulates modulator pressure to a lesser pressure that is proportional to modulator pressure. his tends to keep the 1-2 shift valve in the closed or downshift position. Modulator pressure is also directed to the 2-3 modulator valve to apply a variable force proportional to modulator pressure. This tends to hold the 2-3 shift valve in a the closed or downshift position. The shifts can now be delayed to take place at higher vehicle speeds with heavy throttle operation.

Line pressure is controlled in D (drive) range so that it will vary with torque input to the transmission. Since torque input is a product of engine torque and converter ratio, modulator pressure is directed to a pressure regulator boost valve to adjust the line pressure for changes in either engine torque or converter ratio.

To regulate modulator pressure, and, in turn, line pressure with the torque converter torque ratio that decreases as vehicle speed increases, governor pressure is directed to the modulator valve to reduce modulator pressure with increases in vehicle speed. In this way, line pressure is regulated to vary with torque input to the transmission for smooth shifts with sufficient capacity for both heavy and light acceleration.

The 1-2 shift feel and the durability of the intermediate clutch are dependent on the apply pressure that locks the clutch pack. At minimum or light throttle operation, the engine develops a small amount of torque and as a result, the clutch requires less apply pressure to engage or lock. At heavy throttle, the engine develops a great amount of torque which requires a higher apply pressure to lock the clutch pack. If the clutch locks too quickly, the shift will be too agressive. If it locks too slowly, it will slip excessively and eventually burn and ruin the clutches due to the heat created by the slippage.

Automatic Transmission Service

Automatic transmission service can be easily divided into the following three parts: preventive maintenance, troubleshooting, and major overhaul. Before you perform any maintenance or repairs on an automatic transmission, consult the maintenance manual for instructions and proper specifications.

PREVENTIVE MAINTENANCE.— Normal preventive maintenance includes:

1. Checking the transmission fluid daily
2. Adjusting the shifting and kickdown linkages
3. Adjusting lockup bands
4. Changing the transmission fluid and filter at recommended service intervals (Example: 15,000 miles or yearly for heavy or severe service)

Checking the Fluid.— The operator is responsible for first echelon's (operator's) maintenance. They should not only be trained to know how to look for the proper fluid level but also to know how to look for discoloration of the fluid and debris on the dip stick. Fluid levels in automatic transmissions are almost always checked at operating temperature. This is important to know since the level of the fluid may vary as much as three-fourths of an inch between hot and cold. The fluid color should be pink and clear. The color varies due to the type of fluid. (Example: construction equipment using OE-10 will not have color to it but still should be clear.) A burnt smell or brown coloration of the fluid is a sign of overheated oil from extra heavy use or slipping bands or clutch packs. The unit should be sent to the shop for inspection for possible trouble.

CAUTION

Not all transmission fluids are the same. Before you add fluid, check the manufacturer's recommendations fast. The use of the wrong fluid will lead to early internal parts failure and costly overhaul.

Overfilling the transmission can result in fluid foaming and the fluid being driven out through the vent tube. The air that is trapped in the fluid is drawn into the hydraulic system by the pump and distributed to all parts of the transmission. This situation will cause air to be in place of oil and, in turn, cause slow application and burning of clutch plates and facings. Slippage occurs, heat results, and failure of the transmission follows.

Another possible, but remote, problem is water, indicated by the fluid having a "milky" appearance. A damaged fluid cooling tube in the radiator (automotive) or a damaged oil cooler (construction) could be the problem. The remedy is simple. Pressure test the suspected components and repair them as required. After reassembly, refill the transmission with fresh fluid.

Linkage and Band Adjustment.— The types of linkages found on an automatic transmission are gear shift selection and throttle kickdown. The system can be a cable or a series of rods and levers. Whichever the type, they do not normally present a problem, and preventive maintenance usually involves only a visual inspection and lubrication of the pivot points of linkages or the cable. Adjustment of these linkages should only be done according to manufacturer's specifications.

If an automatic transmission is being used in severe service, the manufacturer may suggest periodic band adjustment. Lockup bands are always adjusted to the manufacturer's specifications after an overhaul. Bands are adjusted by loosening the locknut and tightening down the adjusting screw to a specified value. Then the band adjusting screw is backed off a specified amount of turns and the locking nut is tightened down. Not all bands are adjustable. For example, the General Motors turbo Hydra-Matic Model 400 does not have a band adjustment. If the band is worn to the point where it cannot perform its function, you should replace it.

Fluid Replacement.— The Naval Construction Force (NCF), the COMCBPAC/COMCBLANTINST 11200.1 series, recommends maintenance be performed according to the manufacturer's specifications. These recommendations vary considerably for different makes and models. When you change automatic transmission fluid, read the repair manual first.

Service intervals depend on the type of use the transmission receives. In the NCF, because of the operating environment, more than a few of our vehicles are subjected to severe service. Severe service includes the following: hot and dusty conditions, constant stop and go driving (taxi service), trailer towing, constant heavy hauling, and around the clock operations (contingency). Any CESE operating in these conditions should have its automatic transmission fluid and falter changed on a regular schedule, based on the manufacturer's specifications for severe service.

Draining the transmission can be done in three ways. By removing the drain plug, loosening the dip stick tube, or by removing the oil pan. Have the vehicle on level ground or on a lift and let the oil drain into a proper catchment device.

CAUTION

Oil drained from automatic transmissions contains heavy metals and is considered hazardous waste and should be disposed of according to local naval station instructions.

Once the oil is drained, remove the pan completely for cleaning. By paying close attention to any debris in the bottom of the pan, you may able be to detect a possible problem. The presence of a high number of metal particles could indicate serious internal problems. Clean the pan; set it aside. All automatic transmissions have a filter or a screen located in the oil pan. The screen is cleanable; the falter is a disposable type and should always be replaced when removed. These are retained in different ways: retaining screws, metal retaining clamps, or O rings made of neoprene. Clean a screen with solvent and use low pressure air to blow-dry it. Do not use rags to wipe a screen dry as it tends to leave lint behind that will be ingested into the transmission hydraulic system. Any screen with a hole in it or any screen that is abnormally hard to clean should be replaced.

Draining the oil from the oil pan of the transmission does not remove all of the oil: the process is completed by draining the oil from the torque converter. To do this, remove the torque converter cover and remove the drain plug if the converter is so equipped. (Most modern automotive torque converters do not have a drain plug. Special draining instructions may be found in the manufacturer's repair manuals. Before performing this operation, clear it with your maintenance supervisor.)

Refilling the Transmission.— Reinstall the transmission oil pan, the oil plug, and fill tube. Fill the transmission with the fluid prescribed by the manufacturer to the proper level. With the brakes applied, start the engine and let it idle for a couple of minutes. Move the gear selector through all positions several times, allowing the fluid to flow through the entire hydraulic system to release any trapped air. Return the selector lever to park or neutral and recheck the fluid level. Bring the fluid to the proper level. Run the vehicle until the operating temperature has been reached, and check for leaks in the process. At operating temperature, recheck the fluid and adjust the level, as necessary.

CAUTION

Overfilling an automatic transmission will cause foaming of the fluid. This condition prevents the interred working parts of the automatic transmission from being correctly lubricated and causes slow actuation of the bands and clutches. Eventual burning of the clutches and bands results. DO NOT OVERFILL AN AUTOMATIC TRANSMISSION.

TROUBLESHOOTING.— Good troubleshooting practices save a lot of time and money for the Navy. If you know what you are doing when you troubleshoot an automatic transmission, you should be able to pinpoint the problem before you remove it from the vehicle. In some cases, you may be able to make the repairs without removing the transmission.

Next, before troubleshooting the transmission, make sure the engine is in good running condition. An engine that is not operating properly will not allow the transmission to function normally.

Locate the transmission serial number (fig. 7-22). This is important for finding the correct troubleshooting information and in obtaining repair parts.

The information (table 7-2) included here will assist you in locating and correcting the troubles that could develop in the Turbo Hydra-Matic Model 400 series automatic transmission, a type found throughout the NCF in M-1008, M-1009, and M-1010 series trucks.

NOTE

A malfunction may have more than one probable cause. Complete all the tests and inspections for each cause to find the correct cause.

Keep in mind that it is impossible to list each and every malfunction and its possible corrective action in this training manual. The problems listed are the most common. If you have a problem occurring in your transmission that is not listed here, see your supervisor for advice.

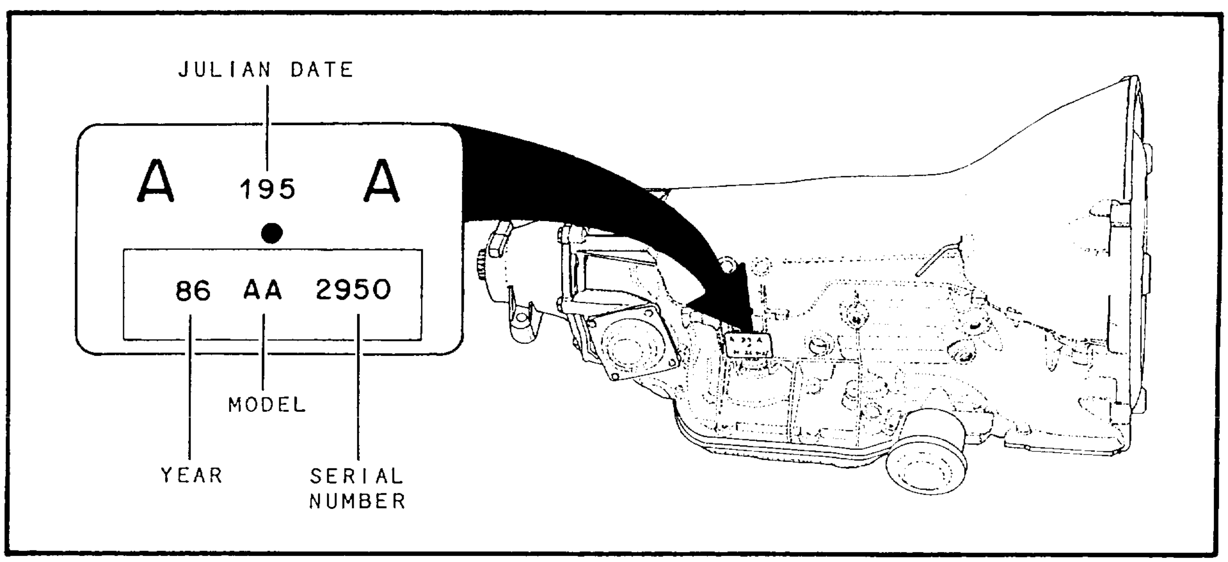

Figure 7-22.—Typical example of the data plate location on an automatic transmission.

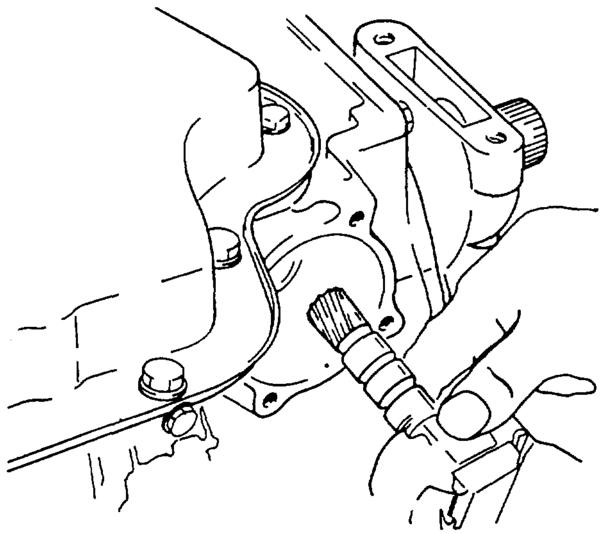

Figure 7-23.—Removing the governor assembly.

TRANSMISSION OVERHAUL.—Because of the complexity of automatic transmissions, the need for special tools, and personnel skills, overhauling these major components is usually done at a Construction Equipment Department located at a Construction Battalion Center. Overhaul of automatic transmissions is not a job for an inexperienced person. If the job must be performed in the field, it is recommended that only a highly capable mechanic be assigned to this type of work NCIC, Port Hueneme, Calif., and NCTC, Gulfport, Miss., both offer training in automatic transmission overhaul as part of the 12 week CM-C-1 advance course.

The following disassembly instructions apply to the General Motors Turbo Hydra-Matic Model 400 series automatic transmission. This type of transmission is commonly found in CESE throughout the NCF and in many public works stations. It is likely to be in manufacture for years to come.

Before preceding with automatic transmission disassemble y or reassembly, get the applicable repair instructions and have them on hand. READ THIS INFORMATION !!!!! Incorrect disassembly procedures can lead to severe parts damage, causing unnecessary equipment downtime. Have a workplace away from the main CM shop. A dust-free air-conditioned room is the best, but this is not always available. Obtain the cleanest work space possible! Have on hand any special tools needed for the job, such as snap ring pliers, torque wrenches, or special pullers. It is also a good idea to have an air compressor available for test purposes and for blowdrying individual parts.

CAUTION

Compressed air used for cleaning purposes should not exceed 30 psi. Wear goggles and other appropriate protective equipment when you use compressed air.

Clean the outside of the transmission and drain out as much fluid as possible. Remove the torque converter and set it aside for separate cleaning and testing. Place the transmission on the workbench and remove the governor (fig. 7-23). Next, remove the oil pan, oil filter, and intake pipe (fig. 7-24). The type of debris found in the bottom of the oil pan is indicative of the type of internal damage you may find in the transmission. Remove the vacuum modulator and valve (fig. 7-25);

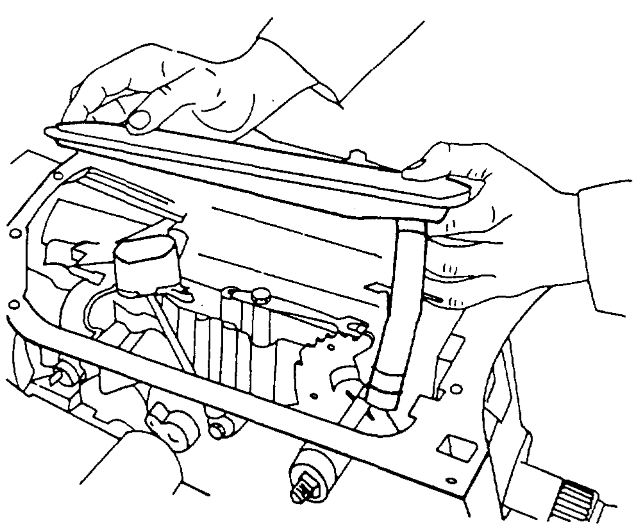

Figure 7-24.—Removing the filter assembly.

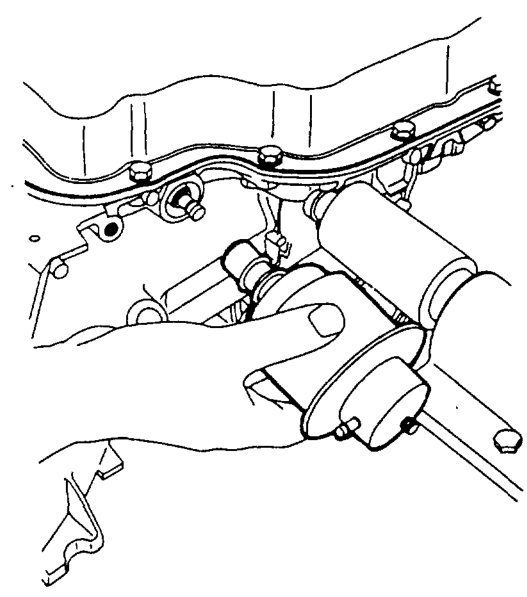

Figure 7-25.—Removing the vacuum modulator.

Table 7-2.-Turbo Hydra-Matic Model 400 Troubleshooting List

PROBLEM	POSSIBLE CAUSE
1. No drive in drive range	1. Low or no oil in the transmission 2. Linkage improperly adjusted 3. Low oil pressure 4. Defective control valve 5. Forward clutch inoperative
2. Oil pressure too high or low	1. Defective vacuum modulator 2. Defective pressure regulator 3. Defective oil pump 4. Governor inoperative 5. Modulator valve sticking 6. Leaking vacuum lines
3. 1-2 shift, full throttle only	1. Faulty detent valve or detent solenoid 2. Vacuum lines leaking 3. 1-2 spool valve in valve body is sticking
4. First speed only, no 1-2 shift	1. Faulty governor, or governor drive gear 2. Intermediate clutch not operating properly 3. Governor feed channel is blocked 4. Faulty control valve assembly
5. First and second speeds only, no 2-3 shift	1. Faulty detent switch 2. Detent solenoid sticking open 3. 1-2 spool control valve body sticking 4. Control valve body spacer-plate-to-cover gasket leaking or incorrectly installed 5. Defective direct clutch
6. Drive in neutral	1. Manual linkage improperly adjusted 2. Forward clutch not releasing
7. No drive or slipping in reverse	1. Low or no oil in the transmission 2. Manual linkage out of adjustment 3. Faulty control valve assembly 4. Direct clutch slipping or inoperative 5. Forward clutch slipping or inoperative 6. Defective reverse or low lockup band
8. Slips in all gear selections	1. Low or no oil in the transmission 2. Clogged transmission oil filter 3. Vacuum modulator valve is sticking 4. Forward clutch is slipping

Table 7-2.—Turbo Hydra-Matic Model 400 Troublesbooting List–Contiued

PROBLEM	POSSIBLE CAUSE
9. Slips 1-2 shift	1. Low oil pressure 2. Rear servo accumulator unserviceable 3. 1-2 accumulator unserviceable 4. Defective intermediate clutch 5. Improperly positioned pump to case gasket
10. Rough 1-2 shift	1. Incorrect oil pressure 2. Valve body assembly loose on transmission case 3. Intermediate clutch ball in valve body not functioning 4. Faulty 1-2 accumulator assembly
11. Slips 1-2 shift	1. Low oil level 2. Incorrect oil pressure 3. Defective direct clutch 4. Modulator valve damaged
12. Slips 2-3 shift	1. Low oil level 2. Direct clutch defective 3. Modulator valve defective or inoperative 4. Pump pressure regulator valve or booster valve damaged 5. Transmission case leaking between channels
13. Rough 2-3 shift	1. Vacuum modulator defective 2. Valve body pressure regulator is inoperative 3. Faulty rear servo accumulator assembly
14. No engine braking lst gear	1. Pressure regulator or boost valve is stuck 2. Manual valve is stuck 3. Rear band inoperative or damaged 4. Check ball missing from case
15. No engine braking in 2nd gear	1. Front band inoperative or damaged
16. No part throttle downshift	1. Low oil pressure 2. Faulty detent valve 3. 2-3 shift valve sticking
17. No detent downshift	1. 2-3 shift valve sticking 2. Sticking detent valve

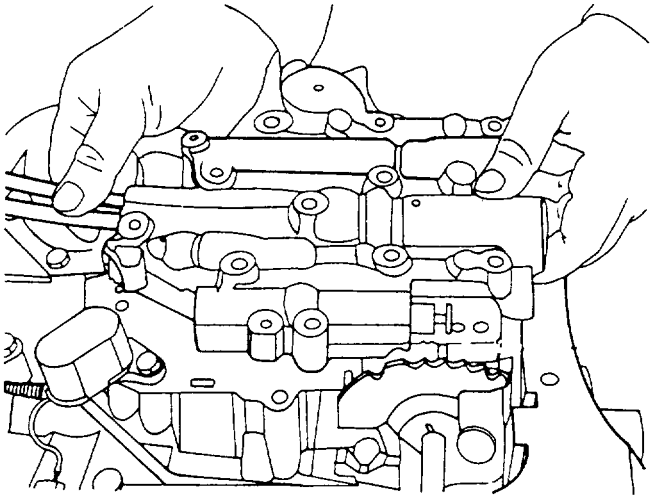

Figure 7-26.—Removing the control valve assembly.

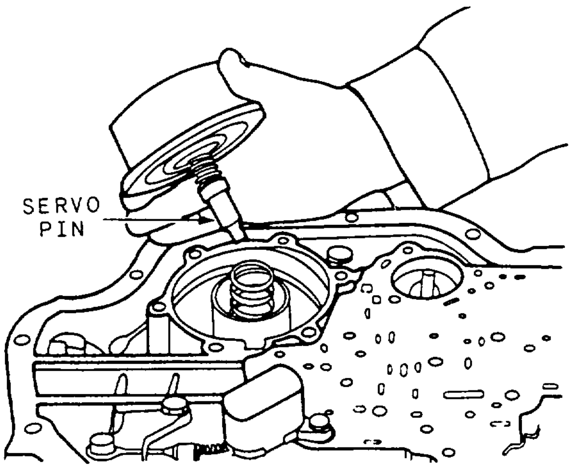

Figure 7-27.—Removing the rear servo assembly.

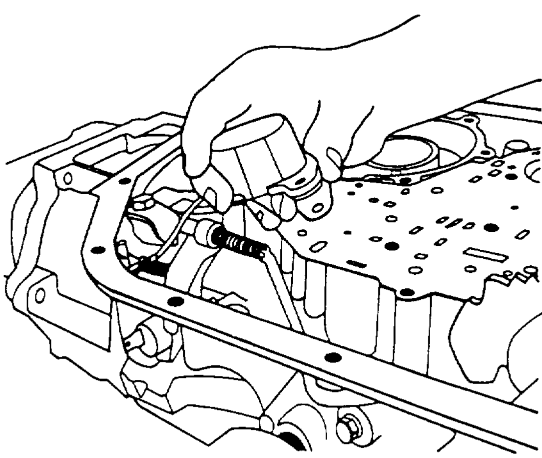

Figure 7-28.—Removing the pressure switch/detent solenoid.

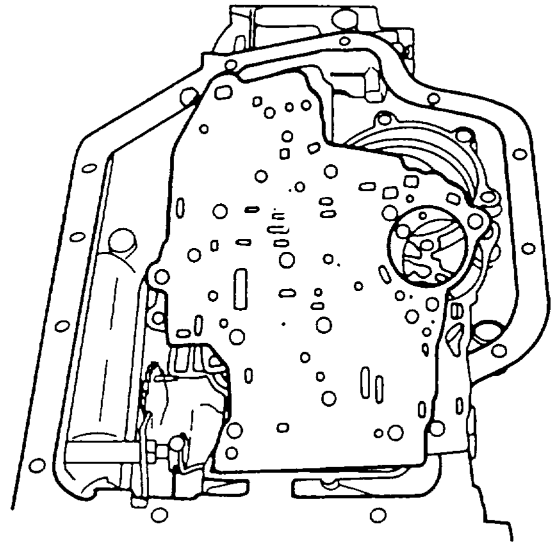

Figure 7-29.—Removing the control valve spacer. (The check balls are here.)

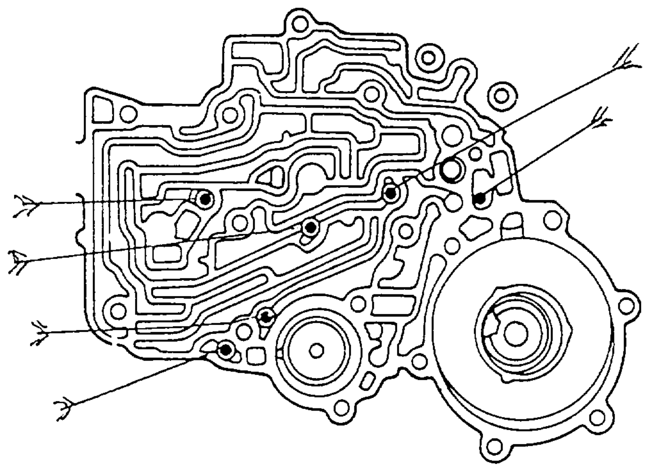

Figure 7-30.—Location of the six check balls in the transmission body.

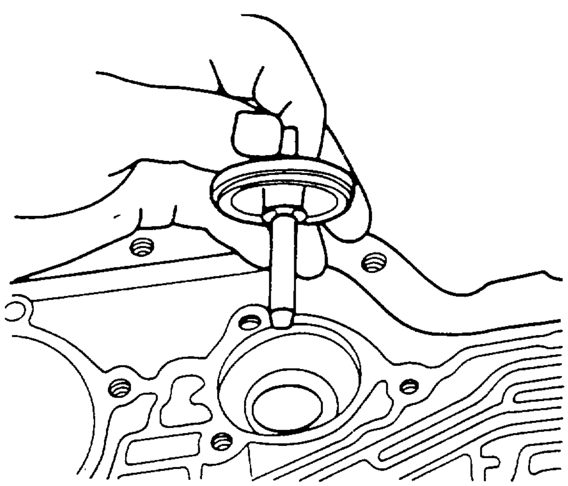

Figure 7-31.—Removing the front servo.

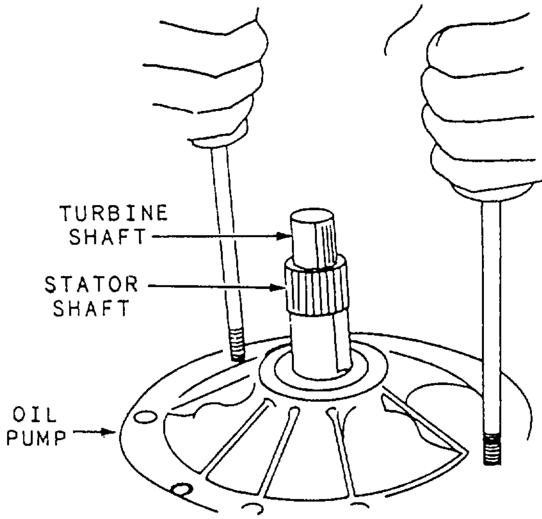

Figure 7-32.—Removing the pump assembly.

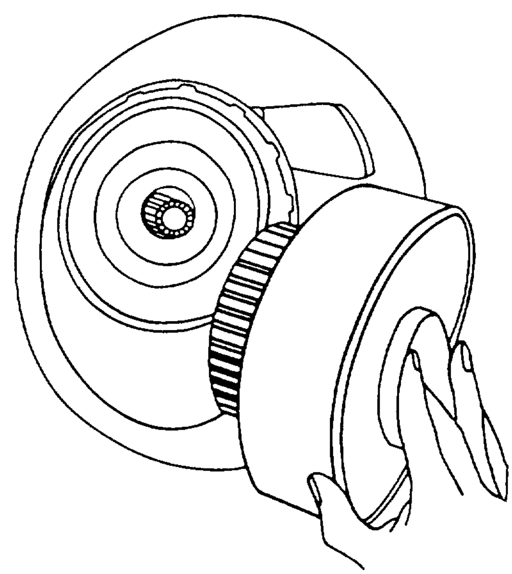

Figure 7-34.—Removing the direct clutch assembly.

this must be done before the valve body may be removed. Unbolt the control valve assembly and carefully lift it to free the governor pipes from the transmission case (fig. 7-26). Do not bend the governor pipes. Remove the rear servo assembly by taking out the six screws that attach it to the transmission body (fig. 7-27). Next, remove the pressure switch/detent solenoid by unclipping the wires and unbolting the device (fig. 7-28). (This varies to application.) Next, lift the control valve spacer away from the transmission body (fig. 7-29). Notice the position of the six check balls located in the transmission case (fig. 7-30); remove these with a magnet and retain them in a safe place for reinstallation during reassembly. Remove the front servo piston and servo piston spring from the case (fig. 7-31). If this item appears to be in satisfactory condition, do not disassemble it. After removing the bolts that retain the oil pump, use two slide hammers to remove the oil pump from the transmission housing (fig. 7-32). Set the pump aside for later attention. Next, grasp the turbine shaft and remove the forward clutch assembly from the transmission case (fig. 7-33). Figure 7-34 shows the direct clutch being removed from the transmission housing followed by the removal of the front band (fig. 7-35). Unclip the snap ring retaining the intermediate

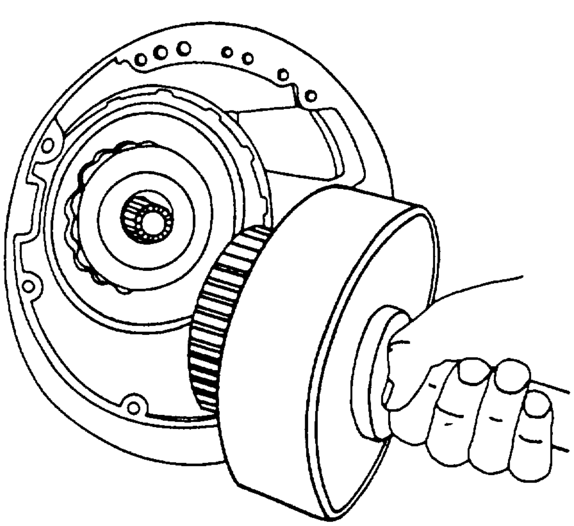

Figure 7-33.—Removing the forward clutch assembly.

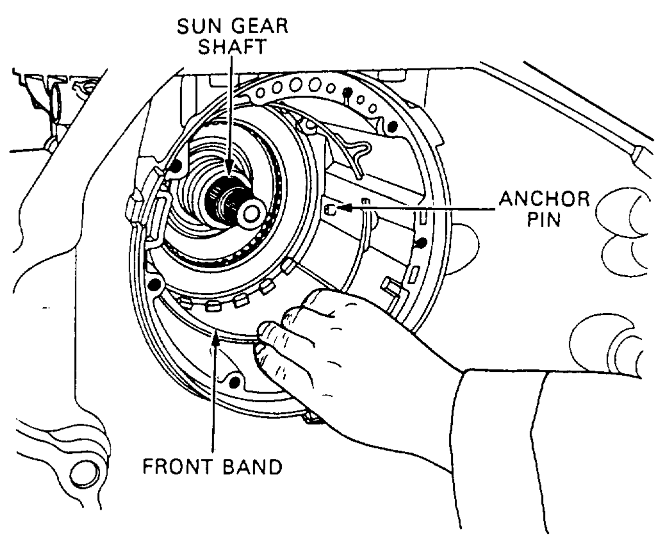

Figure 7-35.—Removing the front band.

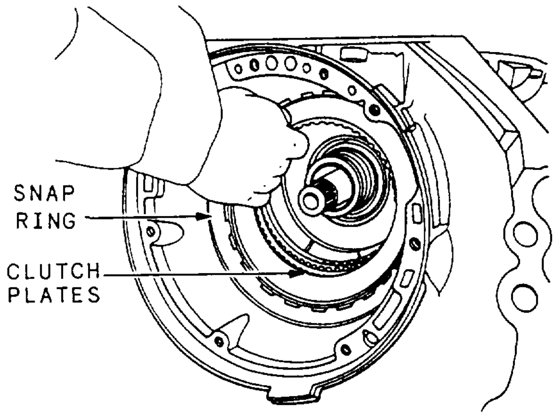

Figure 7-36.—Removing the intermediate backing plate and clutch plate.

clutch pack (fig. 7-36) and remove it. Remove the center support-to-case snap ring (fig. 7-37). At this point the center support bolt should be removed (fig. 7-38). A thin wall twelve point three-eighths inch socket is required to do this; no other tool will work This is a hollow bolt that is used as art oil supply passage for the intermediate clutch assembly. Place the transmission in a vertical position and extract the center support, gear assembly, and output shaft (fig. 7-39). Use care when doing this, the gearset is quite heavy. The rear unit selective washer, center support-to-case spacer, and the rear band may now be removed (fig. 7-40).

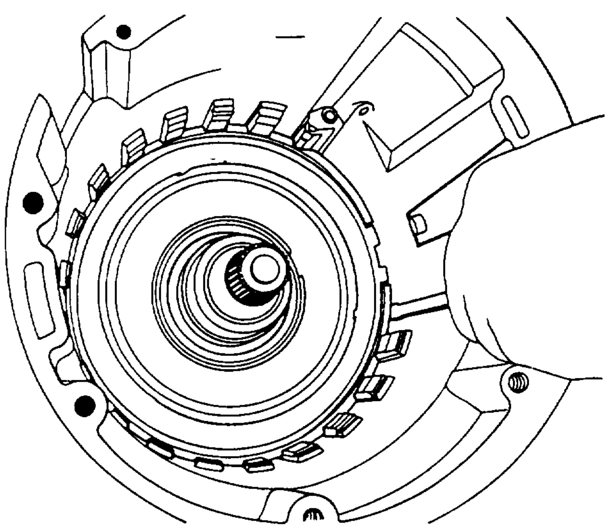

Figure 7-37.—Removing the center support snap ring.

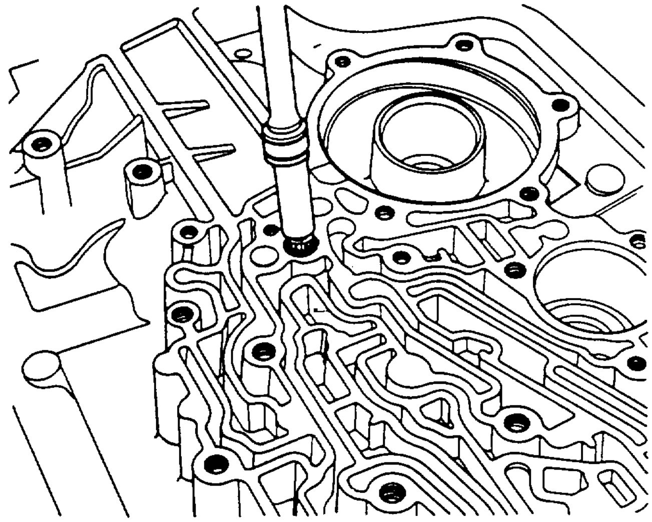

Figure 7-38.—Removing the center support bolt.

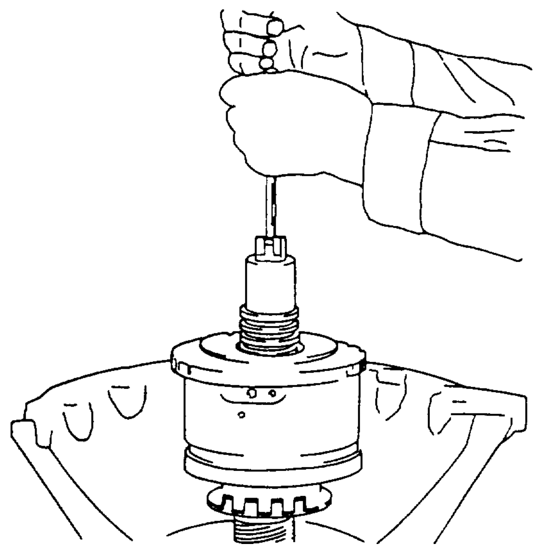

Figure 7-39.—Removing the center support and gear unit.

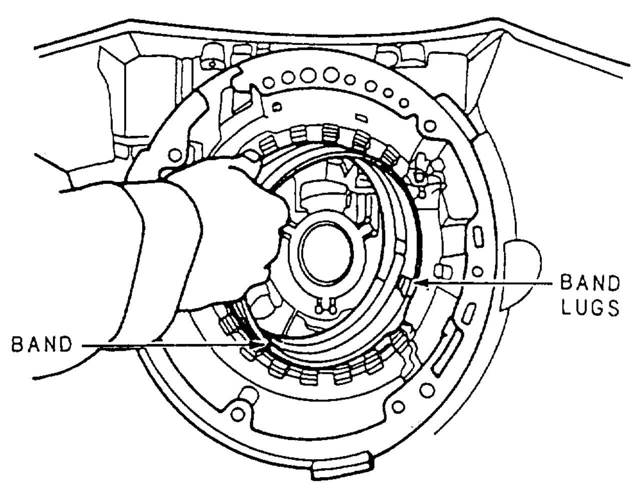

Figure 7-40.—Removing the rear band.

With the major components removed, the transmission case is ready to be thoroughly cleaned out and inspected for wear or damage.

All assemblies that have been removed from the transmission, such as the oil pump, clutch packs, valve body, servos, etc., should all be disassembled, inspected, and rebuilt to the manufacturer's specifications. Always replace all seals and gaskets before reassembly. Look for any worn thrust washers and replace them as required. Check the condition and proper operation of all vacuum or electronic devices connected to the unit. The automotive type of torque converter is usually a welded unit and can only be flushed out, usually with solvent, and pressure tested. If this type of torque converter proves to be the problem, replace it. Because of size and expense, construction equipment torque converters are made to be disassembled and repaired.

Remember, the instructions for disassembly given here are for one type of transmission and only of one model of that type. The information is only to give you an idea of the complexities involved in automatic transmission overhaul, not to make you an expert in this field. Be sure to check the transmission serial numbers to ensure you are getting the correct overhaul parts.

Aside from size and weight, construction equipment automatic transmissions are the same in many respects as automotive automatic transmissions and only specific instructions for that particular unit will be different. For these "specific" instructions, go to your technical library and check out the correct repair manual.

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