ASE 2 - Automatic Transmission & Transaxle

Module 4
Apply Devices
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Module 4 – Apply Devices

Acknowledgements .................................................................................................. 2
Introduction ........................................................................................................ 4
Objectives ........................................................................................................... 4
  Lesson 1. Basic Hydraulics ................................................................................. 5
  Clutches ........................................................................................................... 7
  Driving ............................................................................................................. 8
  Servos ............................................................................................................. 10
  Holding .......................................................................................................... 12
  Mechanical Clutches ...................................................................................... 13
  Range Reference Chart .................................................................................. 15
  Seals and O-rings .......................................................................................... 16
Introduction

The Apply Devices section explains the function of the hydraulic and mechanical holding devices used in automatic transmissions. Some of these apply components, such as clutches and bands, are hydraulically “applied” and “released” in order to provide automatic gear range shifting. Other components, such as a roller clutch or sprag clutch are mechanical and often react to a hydraulically applied component by mechanically holding or releasing another member of the transmission

Objectives

NATEF Area II.

1. Research applicable vehicle and service information, such as transmission/transaxle system operation, vehicle service history, service precautions, and technical service bulletins.

2. Inspect and replace external seals and gaskets.

3. Inspect servo bore, piston, seals, pin, spring, and retainers; determine necessary action.
Lesson 1. Basic Hydraulics

Pascal's Law

In the seventeenth century, Pascal, a French scientist, discovered the hydraulic lever. In laboratory experiments he proved that force and motion could be transferred by means of a confined liquid. Experimenting with weights and pistons of varying size, Pascal also found that mechanical advantage or force multiplication could be obtained in a pressure system and that the relationships between force and distance were exactly the same as with a mechanical lever. From the data Pascal collected, he formulated a law, which states:

Pressure on a confined fluid is transmitted equally in all directions and acts with equal force on equal areas.

So the basic idea behind any hydraulic system is very simple: Force that is applied at one point is transmitted to another point using an incompressible fluid. The fluid is almost always an oil of some sort. The force is almost always multiplied in the process. The picture below shows the simplest possible hydraulic system:

![Figure 4-1](image)

In this drawing, two pistons (red) fit into two glass cylinders filled with oil (light blue) and connected to one another with an oil-filled pipe. If you apply a downward force to one piston (the left one in this drawing), then the force is transmitted to the second piston through the oil in the pipe. Since oil is incompressible, the efficiency is very good – almost all of the applied force appears at the second piston.

The neat thing about hydraulic systems is that it is very easy to add force multiplication (or division) to the system. If you know how gears work, then you know that trading force for distance is very common in mechanical systems. In a hydraulic system, all you do is change the size of one piston and cylinder relative to the other, as shown here:
Hydraulic Multiplication

The piston on the right has a surface area nine times greater than the piston on the left. When force is applied to the left piston, it will move nine units for every one unit that the right piston moves, and the force is multiplied by nine on the right-hand piston.

To determine the multiplication factor, start by looking at the size of the pistons. Assume that the piston on the left is 2 inches in diameter (1-inch radius), while the piston on the right is 6 inches in diameter (3-inch radius). The area of the two pistons is \( \pi r^2 \). The area of the left piston is therefore 3.14, while the area of the piston on the right is 28.26. The piston on the right is 9 times larger than the piston on the left. What that means is that any force applied to the left-hand piston will appear 9 times greater on the right-hand piston. So if you apply a 100-pound downward force to the left piston, a 900-pound upward force will appear on the right. The only catch is that you will have to depress the left piston 9 inches to raise the right piston 1 inch. One thing you always want to remember is you don't get anything for free, if you want lifting power you give up stroke.
Clutches

Multiple Disk
Most multiple disk clutches are constructed by using some or all of the following components, apply clutch pistons, pressure plates, wavy plates, steel clutch plates, fiber clutch plates, backing plates, checkballs, return springs and returned spring assemblies.

Apply clutch piston
Apply clutch piston is the hydraulic device that has seals and/or gaskets that apply pressure to the multiple disk clutch assembly.

Pressure plate
The pressure plate is a heavy steel plate that provides a clamping surface for the multiple plate clutch. It can be installed in either the front or the back of the clutch assembly.

Wavy plates
Wavy plates are used to give a cushioned apply of the clutch assembly. They are steel plates that are wavy instead of flat.

Steel clutch plates
Steel clutch plates are flat steel plates in a multiple clutch assembly.

Fiber plates
Fiber plates are flat steel plates lined with a friction material in a multiple clutch assembly.

Backing plates
Backing plates are thick steel plates that the whole clutch assembly pushes against and they are very thick steel plates that are the farthest away from the piston.

Checkballs
Checkballs are balls that control oil flow in and out of the clutch assembly.

Return springs and returned spring assemblies
Return springs and returned spring assemblies are the springs or assemblies that return the piston to its resting position to give a complete release.
Driving

Figure 4-3,

Figure 4-4,
2nd Clutch

The 2nd clutch assembly (617-627), located between the driven sprocket support (609) and the input clutch assembly (631-659), is applied or "ON" during Second, Third and Fourth Gear Ranges as well as Manual Third and Manual Second Gear Ranges.

2nd Clutch Apply

To apply the 2nd clutch, 2nd clutch apply fluid is fed through the driven sprocket support (609) to the inner hub of the 2nd clutch housing (617). Feed holes in the hub allows 2nd clutch apply fluid to enter the 2nd clutch housing (617) behind the 2nd clutch piston (620); seats the retainer and ball assembly (618) and moves the piston to compress the apply ring & release spring assembly (621). The piston continues to move, compressing the 2nd clutch wave plate (623), until the 2nd clutch apply plate (716), 2nd clutch reaction plates (625) and 2nd clutch plate assemblies (624) are held against the backing support ring plate (626). When fully applied, the 2nd clutch provides the power to the gear sets (672 & 675) through the: waved plate (623); (steel) tapered apply reaction plate (716); (steel) reaction plates (625) external teeth splined to the 2nd clutch housing (617); and, the 2nd clutch plate assemblies (624) internal teeth splined to the hub on the input housing assembly (631-659).

2nd Clutch Release:

To release the 2nd clutch assembly (621-627), 2nd clutch apply fluid pressure exhausts through the apply passages in the inner hub of the 2nd clutch housing (617) and driven sprocket support (609). In the absence of fluid pressure, the apply ring & release spring assembly (621) move the 2nd clutch piston (620) and releases the 2nd clutch reaction plates (625 & 716) and 2nd clutch plate assemblies (624) from contact with the backing support ring plate (626).

During the release of the 2nd clutch fluid, the retainer & ball assembly (618), located in the 2nd clutch housing (617), unseats. Centrifugal force, resulting from the rotation of the 2nd clutch housing (617), unseats the checkball and forces residual 2nd clutch fluid to the outside of the piston housing and through the unseated retainer & ball assembly (618). If this fluid did not completely exhaust from behind the piston, there could be a partial apply, or drag, of the 2nd clutch plates.
Servos

Servo Assembly and 2-4 Band

The servo assembly and 2-4 band (602) are located in the front of the transmission case and applied in Second and Fourth gears. In Third gear, the servo assembly releases the band and acts as an accumulator for the 3-4 clutch apply. The band is held stationary to the transmission case by the band anchor pin (49) and wraps around the reverse input housing (605). When compressed by the servo assembly, the 2-4 band holds the reverse input housing stationary to the transmission case. No upshift in 1st gear could be caused by a worn or damaged 2-4 band or if the band anchor pin is not engaged.

2-4 Band Applied - Second Gear

To apply the 2-4 band in Second gear, 2nd clutch fluid is routed to the apply side of the 2nd apply piston (17). 2nd clutch fluid pressure moves the piston against servo cushion (16) and servo return (12) spring forces. These spring forces help cushion the 2-4 band apply in Second gear. The 2nd apply piston moves the apply pin (13) to compress the band around the reverse input housing.
2-4 Band Release and 3-4 Clutch Accumulation

In Third gear, 3rd accumulator fluid is routed to the release side of the 2nd apply piston. The surface area on the release side of the 2nd apply piston (17) and servo cushion spring retainer (15) is greater than the surface area that 2nd clutch fluid pressure covers on the apply side of the piston. Therefore, the force from 3rd accumulator fluid pressure, in addition to servo return spring (12) force, overcomes the force of 2nd clutch fluid pressure. The 2nd apply piston then moves the apply pin (13) away from the 2-4 band to release the band from the reverse input housing. 3rd accumulator fluid is fed by 3-4 clutch fluid which is used to apply the 3-4 clutch. The movement of the 2nd apply piston against 2nd clutch fluid pressure acts as an accumulator to absorb initial 3-4 clutch apply fluid. This action helps cushion the 3-4 clutch apply, as well as release the 2-4 band.

![Figure 4-7, 2-4 Band Applied - Fourth Gear](image)

2-4 Band Applied - Fourth Gear

In Fourth gear, 4th fluid is routed through the center of the apply pin and acts on the apply side of the 4th apply piston (25). 4th fluid pressure moves the 4th apply piston (25) and apply pin (13) to apply the band. The 4th apply piston moves against the 4th apply spring (22) to help cushion the band apply in Fourth gear.

![Figure 4-8, 2-4 Band Applied - Fourth Gear](image)
Holding

Single Wrap Bands

The Manual 2-1 band assembly is a single wrap band it is held stationary in the transmission case by the band anchor pin and wraps around the direct clutch housing assembly.

When compressed by the manual 2-1 band servo assembly, the band holds the direct clutch housing. This provides engine compression braking in Manual First or Manual Second.

The Low and Reverse Band Assembly multi wrap band that is applied when the gear selector is in either Reverse or Manual First. The low and reverse band assembly is held stationary to the case by two band anchor pins and wraps around the reaction carrier assembly.

When compressed by the low and reverse band servo assembly, the band holds the reaction carrier stationary in the case. This creates a reverse gear ratio and also prevents the low gear clutch from overrunning during coast conditions.
Mechanical Clutches

Sprag Clutches

Figure 4-11,

A sprag assembly is shown in the holding and released positions. When holding, the rotation of the outer race pivots the sprags towards their long diagonals.

The length of the long diagonal is greater than the distance between the outer race and inner race. This causes the sprags to lock between the inner and outer races and transfer torque from the outer forward sprag clutch face to the inner sprag clutch race and to the input sun gear.

The sprag clutch is released when the sprag pivots toward their short diagonal. The length of the short diagonals is less than the distance between the inner and outer sprag races. This occurs when the powerflow drives the input retainer assembly faster than the forward Roller Clutches clutch race.
**2nd Roller Clutch:**

The 2nd roller clutch, located between the driven sprocket support and reverse clutch housing, holds the reverse clutch housing whenever the transaxle is operating in Second gear.

**2nd Roller Clutch Assembly Holding (the reaction sun gear):**

The 2nd clutch assembly has fiber plates with internal teeth splined to the 2nd roller clutch cam, and steel plates that are splined to the case. The 2nd roller clutch inner race is part of the reverse clutch housing (454), which rotates in the opposite direction of engine rotation during First gear operation. When the 2nd clutch applies, internal teeth on the 2nd clutch fiber plates hold the 2nd roller clutch cam stationary. The reverse clutch housing is then prevented from rotating in a direction opposite to engine rotation because the rollers are forced to wedge between the inner race and lowest part of the cam ramps. When the 2nd roller clutch is mechanically locked up, it holds the reaction sun gear and shell assembly through the reverse clutch housing. This arrangement directs power flow to the reaction carrier assembly in Second gear.

**2nd Roller Clutch Assembly Released:**

The 2nd roller clutch assembly releases whenever the 2nd clutch releases, or its rollers "overrun" (freewheel). An overrunning condition occurs whenever the transaxle operates in Third gear where the 2nd clutch is not used for power flow through the gear sets. While operating in Third gear, the reverse clutch housing rotates in the direction of engine rotation. When this occurs, the rollers are forced to rotate in the opposite direction which disengages the inner race from the outer cam. The rollers freewheel when this condition occurs. Roller clutch damaged, not holding can cause no Overdrive range second/slips in second.

**Note:** Manual second will be available.
### Range Reference Chart

**Figure 4-13,**

<table>
<thead>
<tr>
<th>RANGE</th>
<th>GEAR</th>
<th>1-2, 3-4 SOLN. VALVE</th>
<th>2-3 SHIFT SOLN. VALVE</th>
<th>4TH CLUTCH</th>
<th>REVERSE BAND</th>
<th>2ND CLUTCH</th>
<th>3RD CLUTCH</th>
<th>3RD SPRAG CLUTCH</th>
<th>INPUT CLUTCH</th>
<th>2/1 BAND</th>
<th>1/2 SUPPORT ROLLER CLUTCH</th>
<th>FORWARD BAND</th>
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*APPLIED OR HOLDING WITH NO LOAD (NOT TRANSMITTING TORQUE)*

ON = SOLENOID ENERGIZED
OFF = SOLENOID DE-ENERGIZED
@ = THE SOLENOID’S STATE FOLLOWS A SHIFT PATTERN WHICH DEPENDS UPON VEHICLE SPEED, THROTTLE POSITION AND SELECTED GEAR RANGE.

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The Range Reference Chart provides another valuable source of information for explaining the overall function of any transmission or transaxle. This chart highlights the major apply components that function in a selected gear range, and the specific gear operation within that gear range. Included as part of this chart is the same color reference to each major component that was previously discussed. If a component is active in a specific gear range, a word describing its activity will be listed in the column below that component. The row where the activity occurs corresponds to the appropriate transaxle range and gear operation. An abbreviated version of this chart can also be found at the top of the half page of text located in the Power Flow section. This provides for a quick reference when reviewing the mechanical power flow information contained in that section.

Seals and O-rings

Static seal
Static seal is a seal used between two parts that do not move in relationship to each other.

Dynamic seal
A dynamic seal is a seal that is used between two parts that do move in relationship to each other this movement is either rotating or reciprocating up-and-down motion.

A positive seal
A positive seal is a seal that prevents all fluid from leaking between two parts.

Non-positive seal
Non-positive seal is a seal that allows a controlled amount of fluid to leak from between two parts.

These components are sealed with rings seals. Rings seals fit onto a groove shaft. The outside diameter of the ring, slide against the walls of a bore into which a shaft is inserted. Most rings seals of the transmission are placed near pressurize fluid outlets on rotating shaft helped to retain pressure. Ring seals are made of cast-iron, nylon, or Teflon.

Three major type of rubber seals are used in automatic transmissions: the o-ring, the lip seal, and the square cut seal.

O-rings are seals with a circular cross-section.

Square cut seal are similar to O-ring however the square cut seal can withstand more axial movement that 0-ring can.

Lip seals are used to seal parts that have axial or rotational movement.