4L60-E

HYDRA-MATIC

CONTENTS

PREFACE

The Hydra-matic 4L60-E Technician's Guide is primarily intended for automotive technicians that have some familiarization with an automatic transaxle or transmission. Other persons using this book may find this publication somewhat technically complex if additional instruction is not provided. Since the intent of this book is to explain the fundamental mechanical, hydraulic and electrical operating principles, some of the terminology used is specific to the transmission industry. Therefore, words commonly associated with a specific transaxle or transmission function have been defined as either throughout this publication or in the Glossary at the end of this book.

The Hydra-matic 4L60-E Technician's Guide is intended to assist technicians during the service, diagnosis and repair of this transmission. However, this book is not intended to be a substitute for other General Motors service publications that are normally used on the job. Since there is a wide range of repair procedures and technical specifications specific to certain vehicles and transmission models, the proper service publication must be referred to when servicing the Hydra-matic 4L60-E transmission.

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INTRODUCTION

The Hydra-matic 4L60-E Technician's Guide is another Powertrain publication from the Technician's Guide series. These publications provide in-depth technical information that is useful when learning or teaching the fundamental operations of a transaxle or transmission. This book is designed to graphically illustrate and explain the function of the mechanical, hydraulic, and electrical systems that make up the Hydra-matic 4L60-E transmission. The information contained in this book was developed to be useful for both the inexperienced and experienced technician. The inexperienced technician will find the explanations of the basic operating characteristics of this transmission as valuable when learning the function of each component used in this transmission. The experienced technician will find that this book is a valuable reference source when diagnosing a problem with the vehicle.

In the first section of this book entitled "Principles of Operation", exacting explanations of the major components and their functions are presented. In every situation possible, text describes component operation during the apply and release cycle as well as situations where it has no effect at all. The descriptive text is then supported by numerous graphic illustrations which further emphasize the operational theories presented.

The second major section entitled "Power Flow", blends the information presented in the "Principles of Operation" section into the complete transmission assembly. The transfer of torque from the engine through the transmission is graphically displayed on a full page while a narrative description is provided on a facing half page. The opposite side of the half page contains the narrative description of the hydraulic fluid as it applies components or shifts valves in the system. Facing this partial page is a hydraulic schematic that shows the position of valves, checkballs, etc., as they function in a specific gear range.

The third major section of this book displays the "Complete Hydraulic Circuit" for specific gear ranges. Foldout pages containing fluid flow schematics and two dimensional illustrations of major components graphically display hydraulic circuits. This information is extremely useful when tracing fluid circuits for learning or diagnosis purposes.

The "Appendix" section of this book provides additional transmission information regarding lubrication circuits, seal locations, illustrated parts lists and more. Although this information is available in current model year Service Manuals, its inclusion provides for a quick reference guide that is useful to the technician.

Production of the Hydra-matic 4L60-E Technician's Guide was made possible through the combined efforts of many staff areas within the General Motors Powertrain Division. As a result, the Hydra-matic 4L60-E Technician's Guide was written to provide the user with the most current, concise and usable information available with regards to this product.

HOW TO USE THIS BOOK

First time users of this book may find the page layout a little unusual or perhaps confusing. However, with a minimal amount of exposure to this format its usefulness becomes more obvious. If you are unfamiliar with this publication, the following guidelines are helpful in understanding the functional intent for the various page layouts:

- Read the following section, "Understanding the Graphics" to know how the graphic illustrations are used, particularly as they relate to the mechanical power flow and hydraulic controls (see Understanding the Graphics page 6).

- Unfold the cutaway illustration of the Hydra-matic 4L60-E (page 8) and refer to it as you progress through each major section. This cutaway provides a quick reference of component location inside the transmission assembly and their relationship to other components.

- The Principles of Operation section (beginning on page 9A) presents information regarding the major apply components and hydraulic control components used in this transmission. This section describes "how" specific components work and interfaces with the sections that follow.

- The Power Flow section (beginning on page 41) presents the mechanical and hydraulic functions corresponding to specific gear ranges. This section builds on the information presented in the Principles of Operation section by showing specific fluid circuits that enable the mechanical components to operate. The mechanical power flow is graphically displayed on a full size page and followed by a half page of descriptive text. The opposite side of the half page contains the narrative description of the hydraulic fluid as it applies components or moves valves in the system. Facing this partial page is a hydraulic schematic which shows the position of valves, checkballs, etc., as they function in a specific gear range. Also, located at the bottom of each half page is a reference to the Complete Hydraulic Circuit section that follows.

- The Complete Hydraulic Circuits section (beginning on page 67) details the entire hydraulic system. This is accomplished by using a foldout circuit schematic with a facing page two dimensional foldout drawing of each component. The circuit schematics and component drawings display only the fluid passages for that specific operating range.

- Finally, the Appendix section contains a schematic of the lubrication flow through the transmission, disassembled view parts lists and transmission specifications. This information has been included to provide the user with convenient reference information published in the appropriate vehicle Service Manuals. Since component parts lists and specifications may change over time, this information should be verified with Service Manual information.

HOW TO USE THIS BOOK

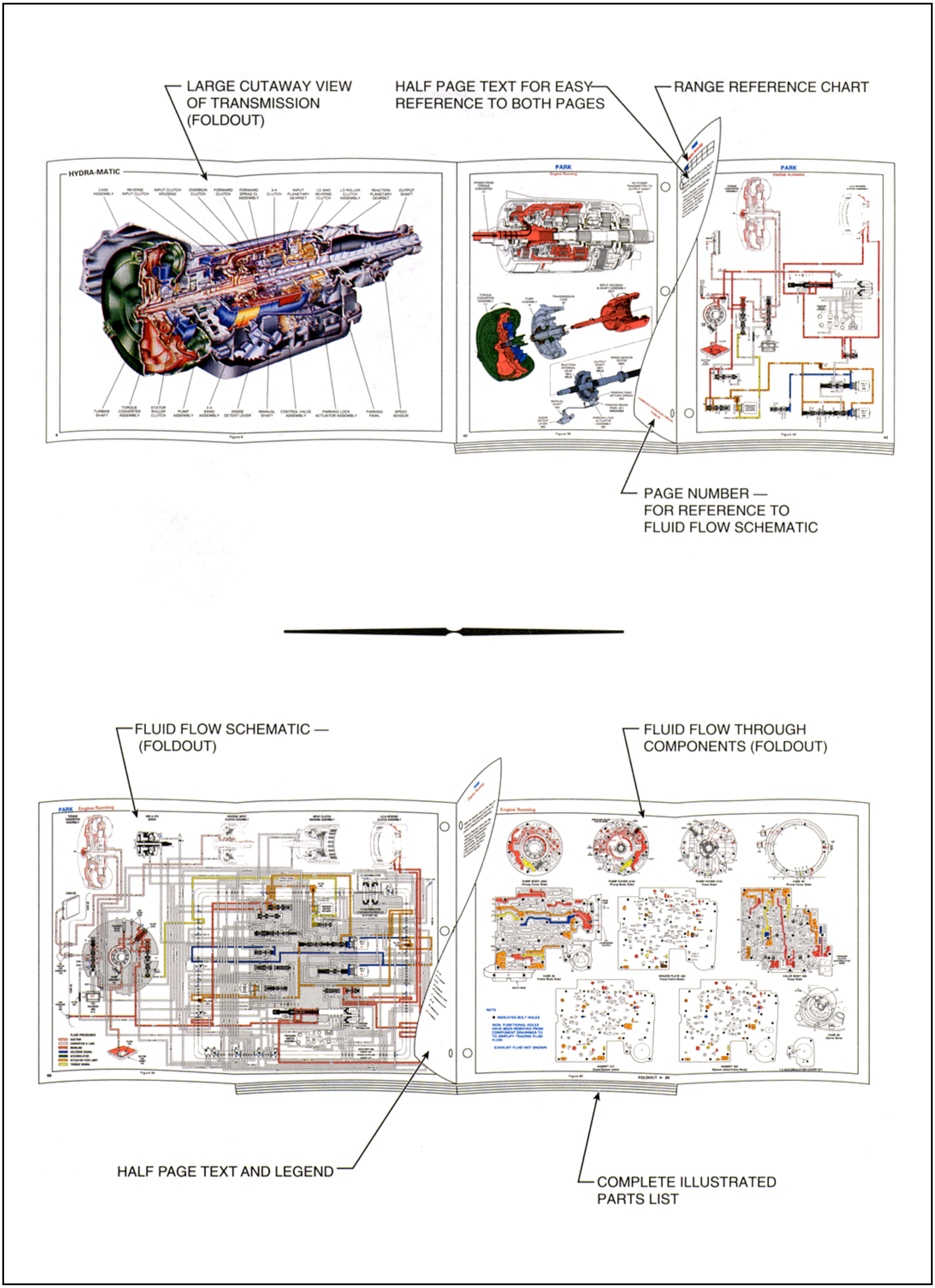


Figure 1

UNDERSTANDING THE GRAPHICS

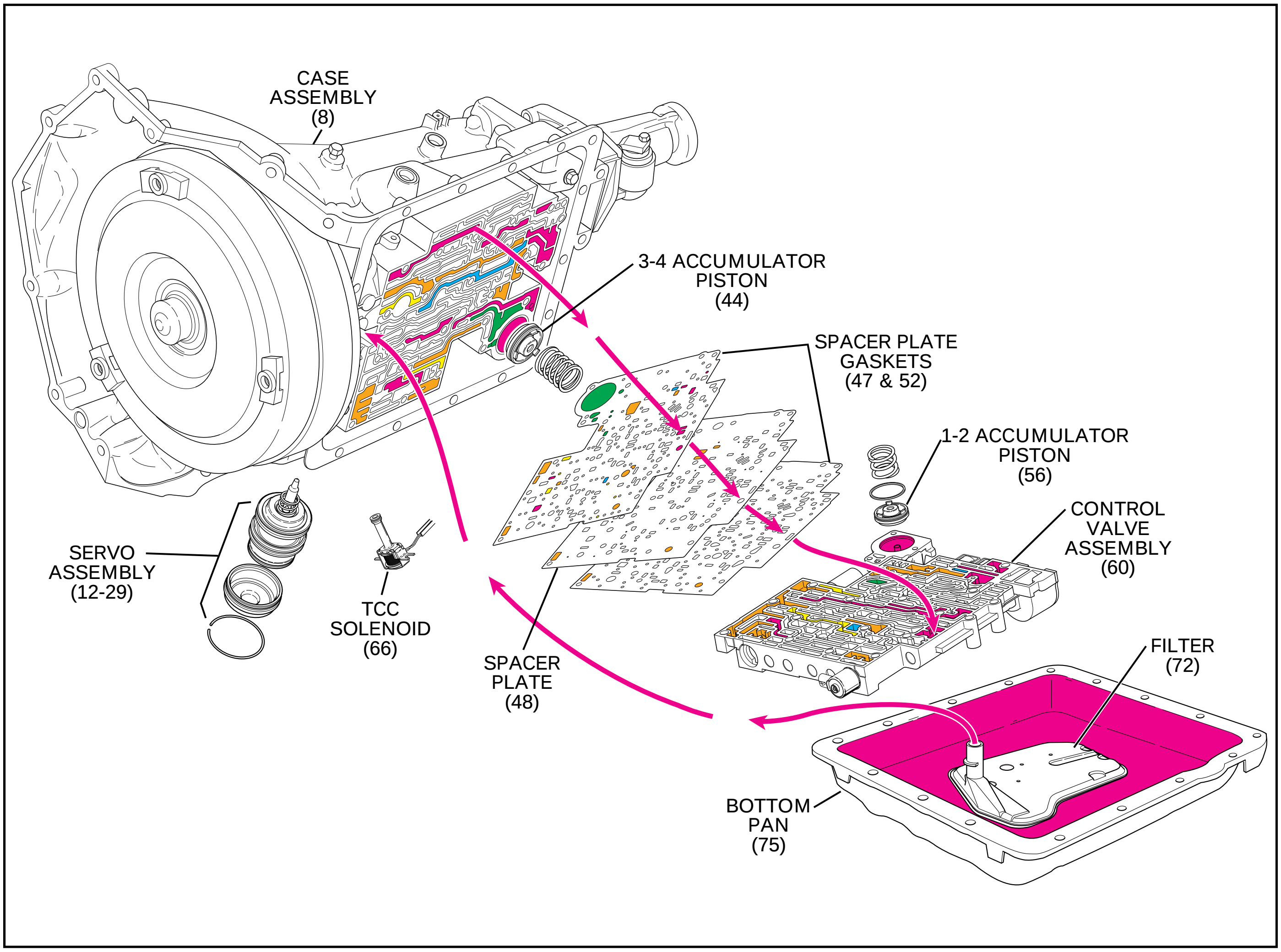


Figure 2

The flow of transmission fluid starts in the bottom pan and is drawn through the filter, main case valve body, transmission case and into the oil pump assembly. This is a general route for fluid to flow that is more easily understood by reviewing the illustrations provided in Figure 2. However, fluid may pass between these and other components many times before reaching a valve or applying a clutch. For this reason, the graphics are designed to show the exact location where fluid passes through a component and into other passages for specific gear range operation.

To provide a better understanding of fluid flow in the Hydra-matic 4L60-E transmission, the components involved with hydraulic control and fluid flow are illustrated in three major formats. Figure 3 provides an example of these formats which are:

- A three dimensional line drawing of the component for easier part identification.

- A two dimensional line drawing of the component to indicate fluid passages and orifices.

- A graphic schematic representation that displays valves, checkballs, orifices and so forth, required for the proper function of transmission in a specific gear range. In the schematic drawings, fluid circuits are represented by straight lines and orifices are represented by indentations in a circuit. All circuits are labeled and color coded to provide reference points between the schematic drawing and the two dimensional line drawing of the components.

- Figure 4 (page 7A) provides an illustration of a typical valve, bushing and valve train components. A brief description of valve operation is also provided to support the illustration.

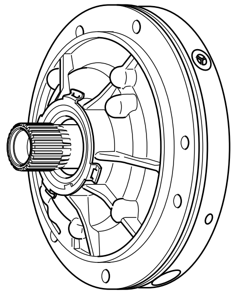
- Figure 5 (page 7A) provides a color coded chart that references different fluid pressures used to operate the hydraulic control systems. A brief description of how fluid pressures affect valve operation is also provided.

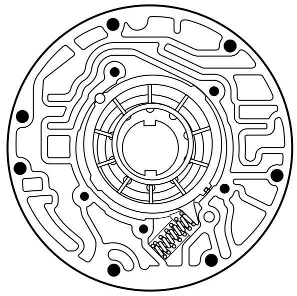
UNDERSTANDING THE GRAPHICS

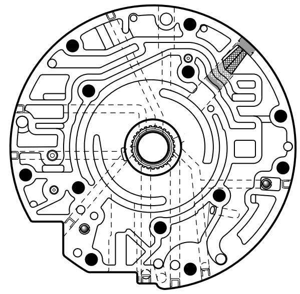
OIL PUMP ASSEMBLY (4)

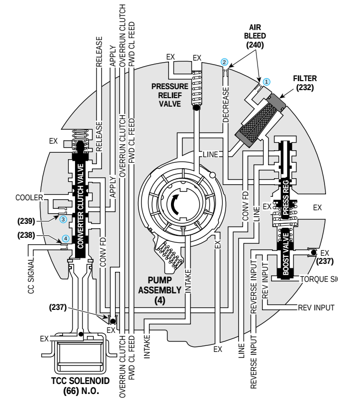
PUMP BODY (200)

PUMP COVER (215)









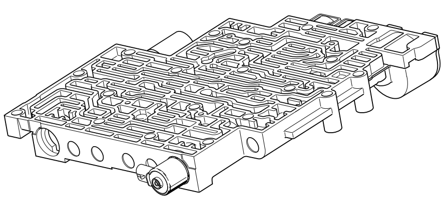
THREE DIMENSIONAL

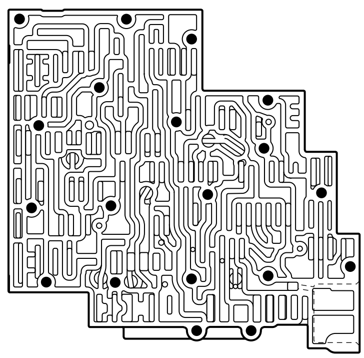
TWO DIMENSIONAL

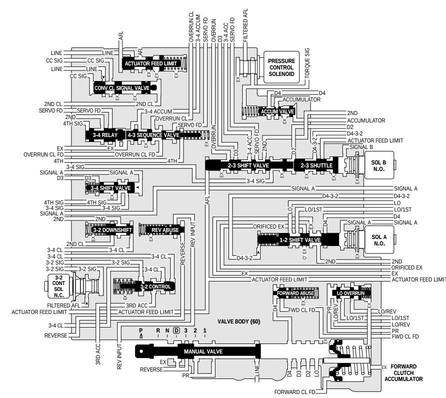
GRAPHIC SCHEMATIC REPRESENTATION

CONTROL VALVE BODY ASSEMBLY (60)

CASE SIDE







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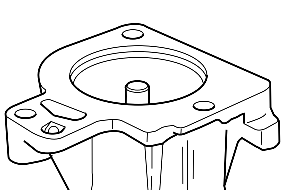
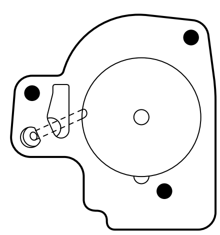
TWO DIMENSIONAL

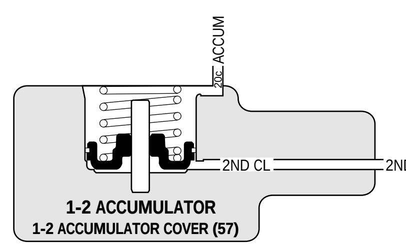
GRAPHIC SCHEMATIC REPRESENTATION

1-2 ACCUMULATOR COVER (57)

CASE SIDE







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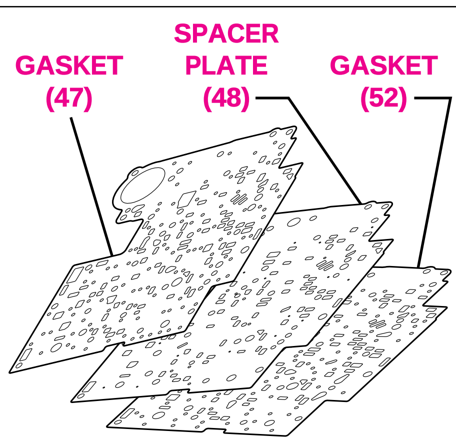
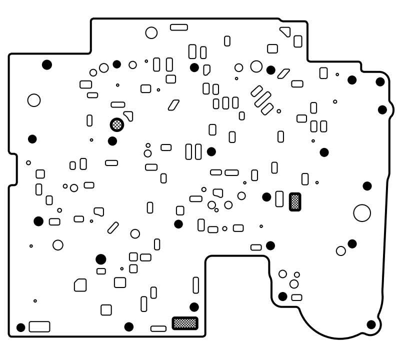
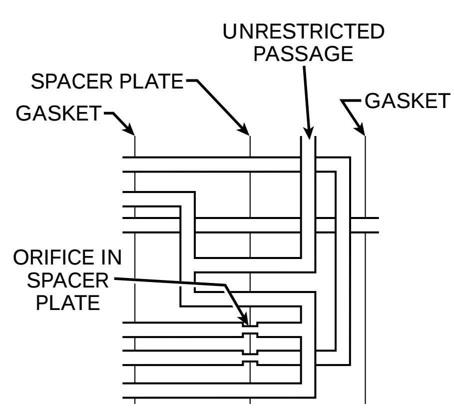
GRAPHIC SCHEMATIC REPRESENTATION



VALVE BODY SIDE





THREE DIMENSIONAL

TWO DIMENSIONAL

GRAPHIC SCHEMATIC REPRESENTATION

Figure 3

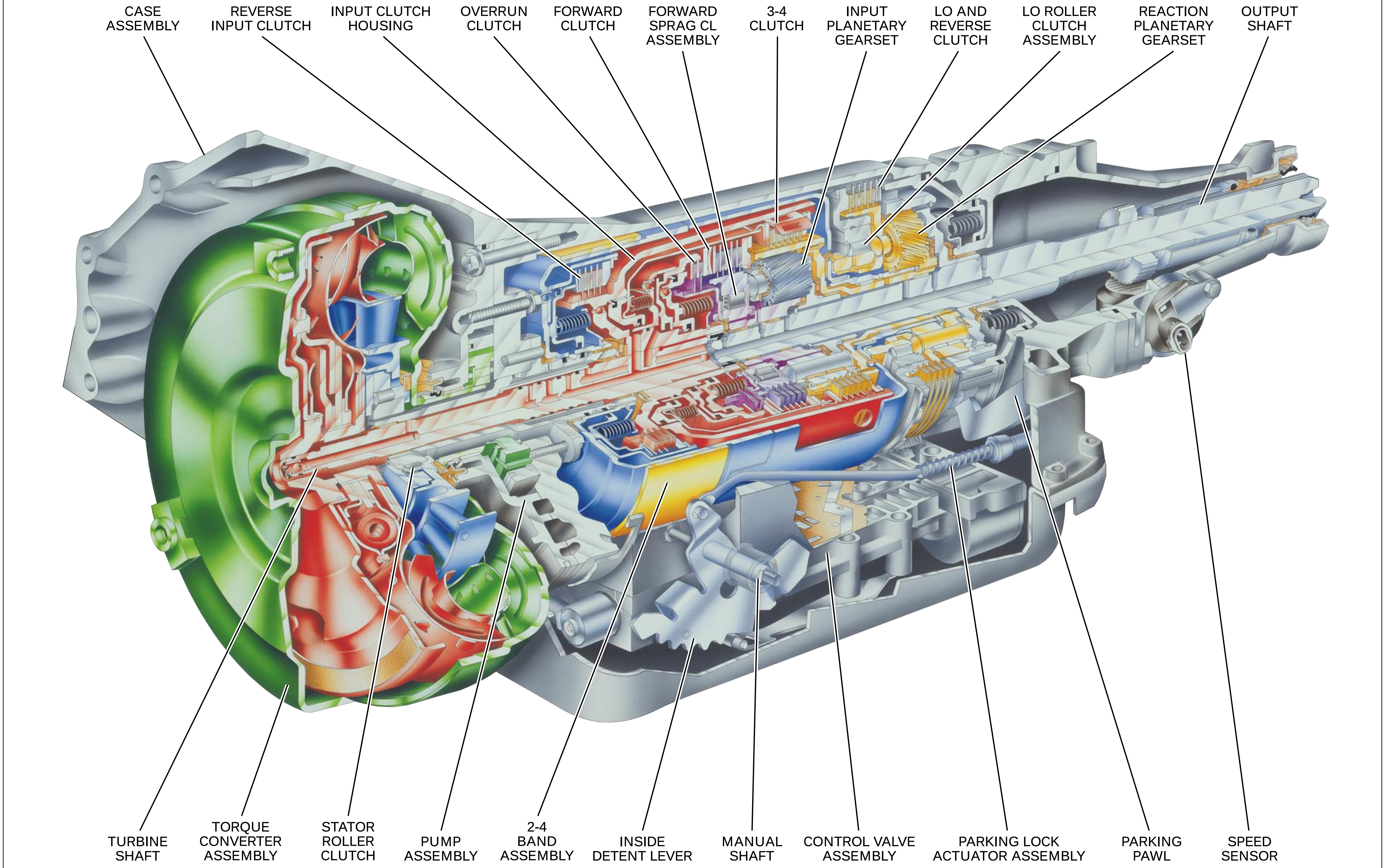

CASE ASSEMBLY
REVERSE INPUT CLUTCH
INPUT CLUTCH HOUSING
OVERRUN CLUTCH
FORWARD CLUTCH
FORWARD SPRAG CL ASSEMBLY
3-4 CLUTCH
INPUT PLANETARY GEARSET
LO AND REVERSE CLUTCH
LO ROLLER CLUTCH ASSEMBLY
REACTION PLANETARY GEARSET
OUTPUT SHAFT
TURBINE SHAFT
TORQUE CONVERTER ASSEMBLY
STATOR ROLLER CLUTCH
PUMP ASSEMBLY
2-4 BAND ASSEMBLY
INSIDE DETENT LEVER
MANUAL SHAFT
CONTROL VALVE ASSEMBLY
PARKING LOCK ACTUATOR ASSEMBLY
PARKING PAWL
SPEED SENSOR

Figure 6

GENERAL DESCRIPTION

The Hydra-matic 4L60-E is a fully automatic, four speed, rear wheel drive transmission. It consists primarily of a four-element torque converter, two planetary gear sets, various clutches, an oil pump, and a control valve body.

The four-element torque converter contains a pump, a turbine, a pressure plate splined to the turbine, and a stator assembly. The torque converter acts as a fluid coupling to transmit power smoothly from the engine to the transmission. It also hydraulically provides additional torque multiplication when required. The pressure plate, when applied, provides a mechanical "direct drive" coupling of the engine to the transmission.

The two planetary gear sets provide the four forward gear ratios and reverse. Changing of the gear ratios is fully automatic and is accomplished through the use of various electronic powertrain sensors that provide input signals to the Powertrain Control Module (PCM). The PCM interprets these signals to send current to the various solenoids inside the transmission.

By using electronics, the PCM controls shift points, shift feel and torque converter clutch apply and release, to provide proper gear ranges for maximum fuel economy and vehicle performance.

Five multiple-disc clutches, one roller clutch, a sprag clutch, and a brake band provide the friction elements required to obtain the various ratios with planetary gear sets.

A hydraulic system (the control valve body), pressurized by a vane type pump provides the working pressure needed to operate the friction elements and automatic controls.

Several electronic solenoids and sensors in the powertrain work in conjunction with the vehicle's PCM to control various shift points, shift feel and converter clutch apply and release.

EXPLANATION OF GEAR RANGES

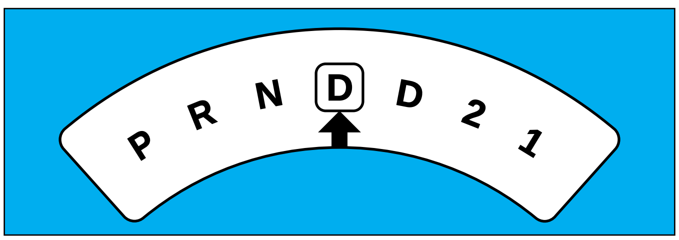


Figure 8

The transmission can be operated in any one of the seven different positions shown on the shift quadrant (Figure 8).

P – Park position enables the engine to be started while preventing the vehicle from rolling either forward or backward. For safety reasons, the vehicle's parking brake should be used with the transmission in the "Park" position. Since the output shaft is mechanically locked to the case through the parking pawl and reaction internal gear, Park position should not be selected until the vehicle has come to a complete stop.

R – Reverse enables the vehicle to be operated in a rearward direction.

N – Neutral position enables the engine to start and operate without driving the vehicle. If necessary, this position should be selected to restart the engine while the vehicle is moving.

D – Overdrive range should be used for all normal driving conditions for maximum efficiency and fuel economy. Overdrive range allows the transmission to operate in each of the four forward gear ratios. When operating in the Overdrive range, shifting to a lower or higher gear ratio is accomplished by depressing the accelerator or by manually selecting a lower gear with the shift selector.

The transmission should not be operated in Overdrive range when pulling heavy loads. Typically these conditions put an extra load on the engine, therefore the transmission should be driven in a lower manual gear selection for maximum efficiency.

D – Manual Third should be used when driving conditions dictate that it is desirable to use only three gear ratios. These conditions include towing a trailer or driving on hilly terrain. Automatic shifting is the same as in Overdrive range for first, second and third gears except the transmission will not shift into Fourth gear.

2 – Manual Second gear range prevents the transmission from operating in any gear other than second. This allows the transmission to start moving the vehicle in second gear which may be helpful under slippery conditions such as snow or ice. Manual Second also provides additional engine compression braking by not allowing the transmission to shift above second gear.

Note: Some vehicle applications will downshift into first gear when the transmission is in Manual Second under heavy throttle conditions at low speed.

1 – Manual First can also be selected at any vehicle speed, however, the transmission will not shift into first gear until vehicle speed slows to below approximately 48 to 56 km/h (30 to 35 mph). Above this speed the transmission will remain in second gear. Manual First is particularly beneficial for maintaining maximum engine braking when descending steep grades.

MAJOR MECHANICAL COMPONENTS

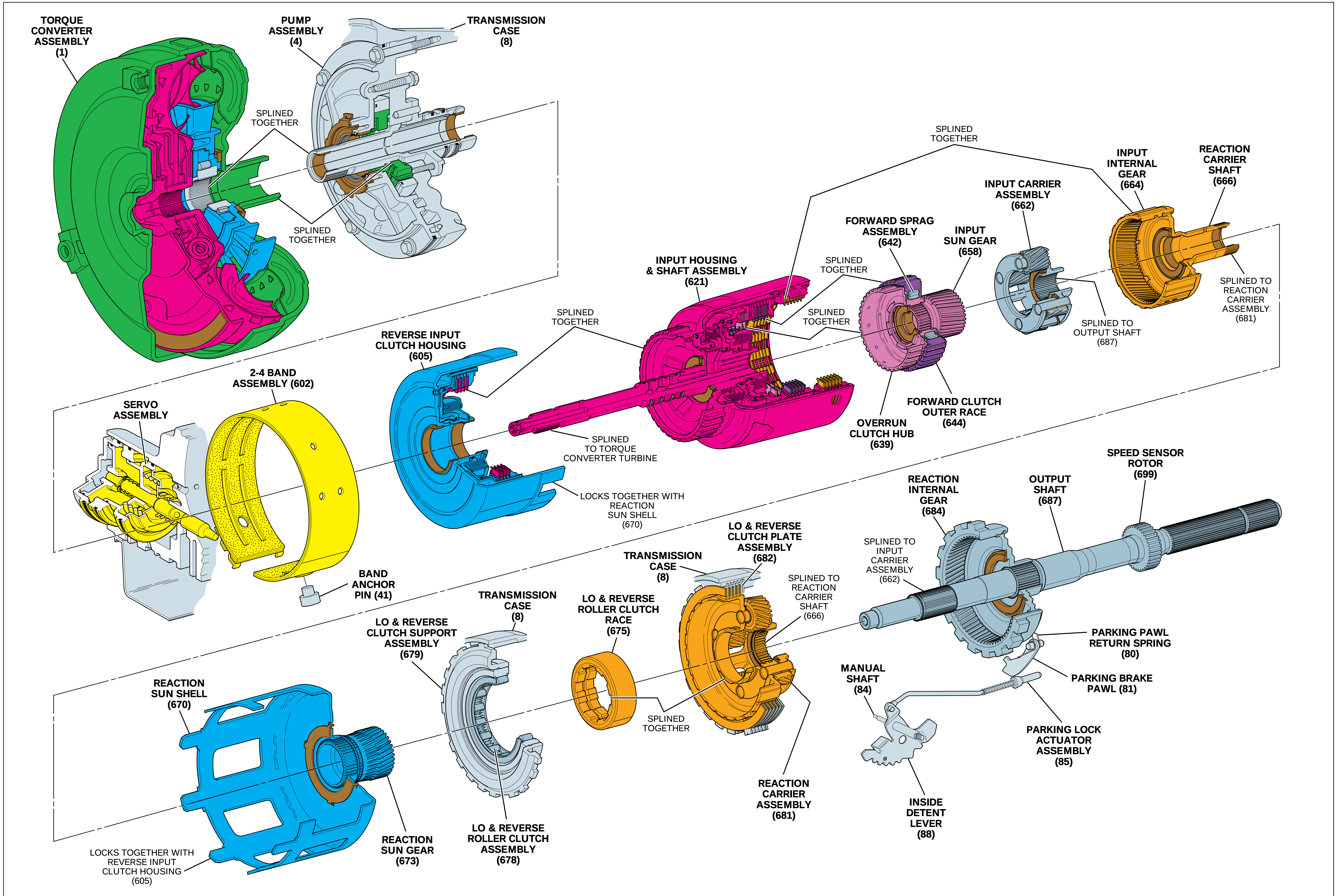


Figure 9

COLOR LEGEND

MAJOR MECHANICAL COMPONENTS

The foldout graphic on page 10 contains a disassembled drawing of the major components used in the Hydra-matic 4L60-E transmission. This drawing, along with the cross sectional illustrations on page 8 and 8A, show the major mechanical components and their relationship to each other as a complete assembly. Therefore, color has been used throughout this book to help identify parts that are splined together, rotating at engine speed, held stationary, and so forth. Color differentiation is particularly helpful when using the Power Flow section for understanding the transmission operation.

The color legend below provides the "general" guidelines that were followed in assigning specific colors to the major components. However, due to the complexity of this transmission, some colors (such as grey) were used for artistic purposes rather than based on the specific function or location of that component.

- Components that are stationary. Examples: Case (8), Oil Pump Assembly (4), Lo & Reverse Clutch Support (679), Extension Housing (31).
- Components that rotate at engine speed. Examples: Torque Converter Cover and Pump, and the Oil Pump.
- Components that rotate at turbine speed. Examples: Converter Turbine, Pressure Plate, Turbine Shaft and Input Housing Assembly (621).
- Components that rotate at transmission output speed and other components. Examples: Reaction Internal Gear (684), Output Shaft (687), Speed Sensor Rotor (699), Forward Sprag Assembly (642), and Lo & Reverse Roller Clutch Assembly (678).
- Components such as the Stator in the Torque Converter (1), Reverse Input Housing (605) and Reaction Sun Shell (670).
- Components such as the Reaction Carrier Assembly (681) and Input Internal Gear (664).
- Components such as the Overrun Clutch Hub (639) and Input Sun Gear (658).
- All bearings, bushings, gaskets and spacer plates.
- All seals

COLOR LEGEND

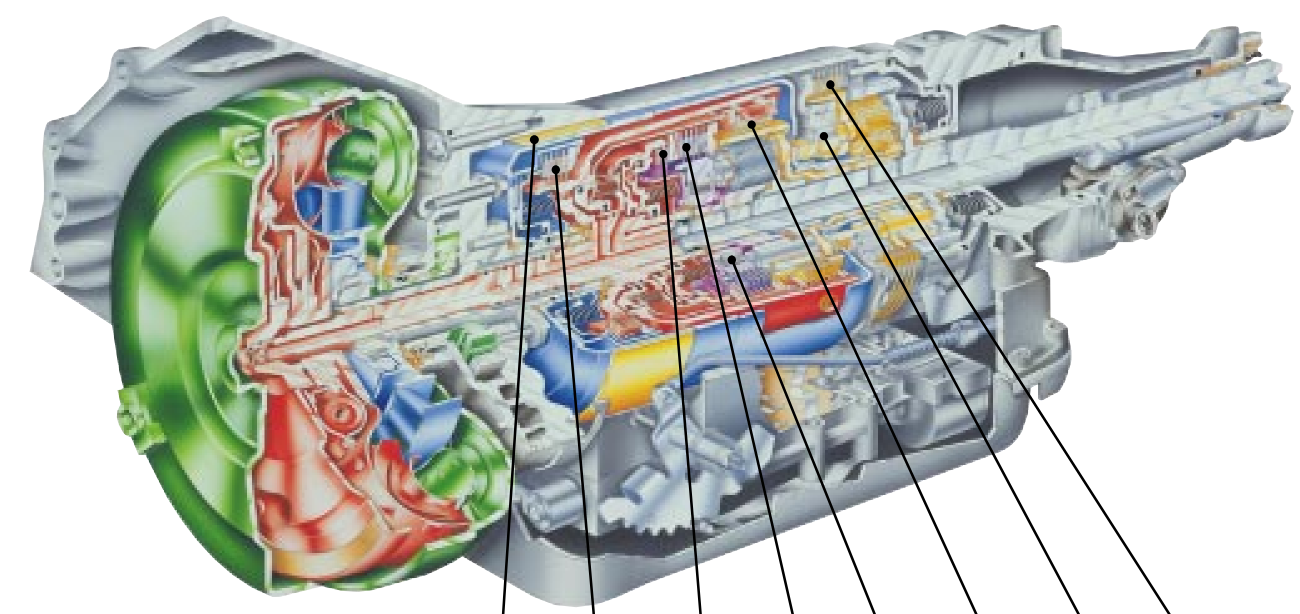
APPLY COMPONENTS

The Range Reference Chart on page 11, provides another valuable source of information for explaining the overall function of the Hydra-matic 4L60-E transmission. 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. 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 transmission 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.

RANGE REFERENCE CHART



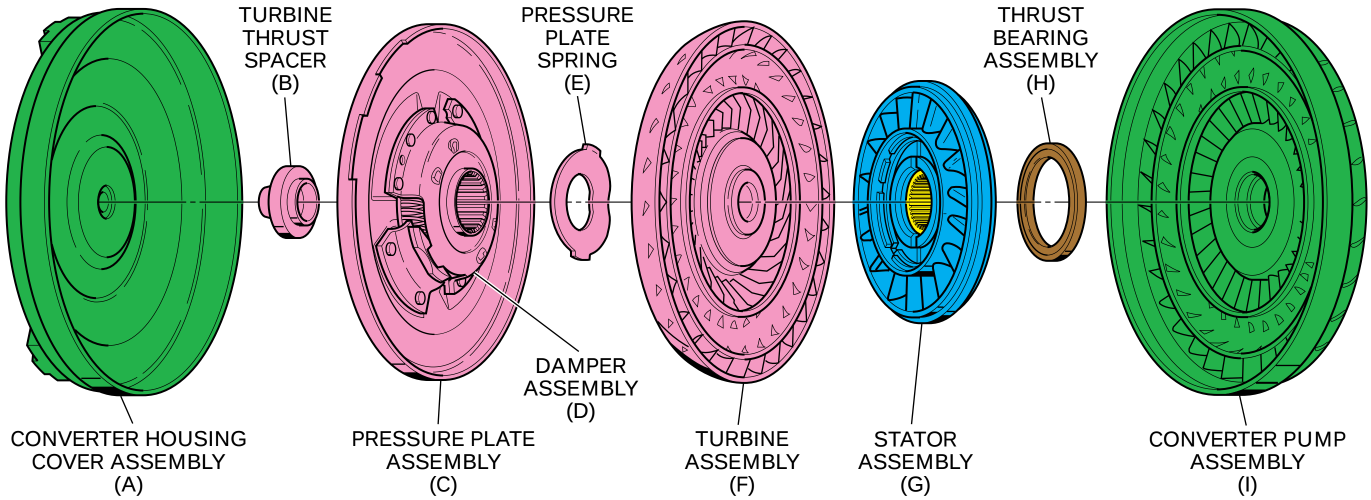
RANGE	GEAR	SHIFT SOLENOIDS "A"	SHIFT SOLENOIDS "B"	2-4 BAND	REVERSE INPUT CLUTCH	OVERRUN CLUTCH	FORWARD CLUTCH	FORWARD SPRAG CL. ASSEMBLY	3-4 CLUTCH	LO ROLLER CLUTCH	LO/REV. CLUTCH
PARK		ON*	ON*								APPLIED
REVERSE		ON*	ON*		APPLIED						APPLIED
NEUTRAL		ON*	ON*								
D	1st	ON	ON				APPLIED	HOLDING		HOLDING	
	2nd	OFF	ON	APPLIED			APPLIED	HOLDING			
	3rd	OFF	OFF				APPLIED	HOLDING	APPLIED		
	4th	ON	OFF	APPLIED			APPLIED		APPLIED		
D	1st	ON	ON				APPLIED	HOLDING		HOLDING	
	2nd	OFF	ON	APPLIED			APPLIED	HOLDING			
	3rd	OFF	OFF			APPLIED	APPLIED	HOLDING	APPLIED		
2	1st	ON	ON			APPLIED	APPLIED	HOLDING		HOLDING	
	2nd	OFF	ON	APPLIED		APPLIED	APPLIED	HOLDING			
1	1st	ON	ON			APPLIED	APPLIED	HOLDING		HOLDING	APPLIED
	2nd	OFF	ON	APPLIED		APPLIED	APPLIED	HOLDING			

* SOLENOID "A" & "B" OPERATION AND THE SHIFT VALVE POSITIONING IN P.R.N. RANGES ARE A FUNCTION OF THE INPUT TO THE SOLENOIDS FROM THE VSS. UNDER NORMAL OPERATING CONDITIONS THE SOLENOIDS ARE ON IN P,R,N.

NOTE: A MANUAL SECOND - FIRST GEAR CONDITION IS ONLY AVAILABLE ON SOME MODELS. OTHERWISE, THIS CONDITION IS ELECTRONICALLY PREVENTED.

Figure 10

TORQUE CONVERTER



TORQUE CONVERTER:
The torque converter (1) is the primary component for transmittal of power between the engine and the transmission. It is bolted to the engine flywheel (also known as the flexplate) so that it will rotate at engine speed. The major functions of the torque converter are:

- to provide a fluid coupling for a smooth conversion of torque from the engine to the mechanical components of the transmission.
- to multiply torque from the engine which enables the vehicle to achieve additional performance when required.
- to mechanically operate the transmission oil pump (4) through the converter hub.
- to provide a mechanical link, or direct drive, from the engine to the transmission through the use of the torque converter clutch (TCC), or pressure plate (C).

The torque converter assembly consists of the following five main sub-assemblies:

- a converter housing cover assembly (A) which is bolted to the engine flywheel and is welded to the converter pump assembly (I).
- a converter pump assembly (I) which is the driving member.
- a turbine assembly (F) which is the driven or output member.
- a stator assembly (G) which is the reaction member located between the converter pump and turbine assemblies.
- a pressure plate assembly (C) splined to the turbine assembly to provide a mechanical direct drive when appropriate.

CONVERTER PUMP ASSEMBLY AND TURBINE ASSEMBLY
When the engine is running the converter pump assembly acts as a centrifugal pump by picking up fluid at its center and discharging it at its rim between the blades (see Figure 12). The force of this fluid then hits the turbine blades and causes the turbine to rotate. The turbine shaft is splined to the converter turbine to provide the input to the transmission. As the engine and converter pump increase in RPM, so does the turbine assembly and turbine shaft. However, with the pressure plate released, turbine speed does not equal engine speed due to the small amount of slip that occurs in a fluid coupling.

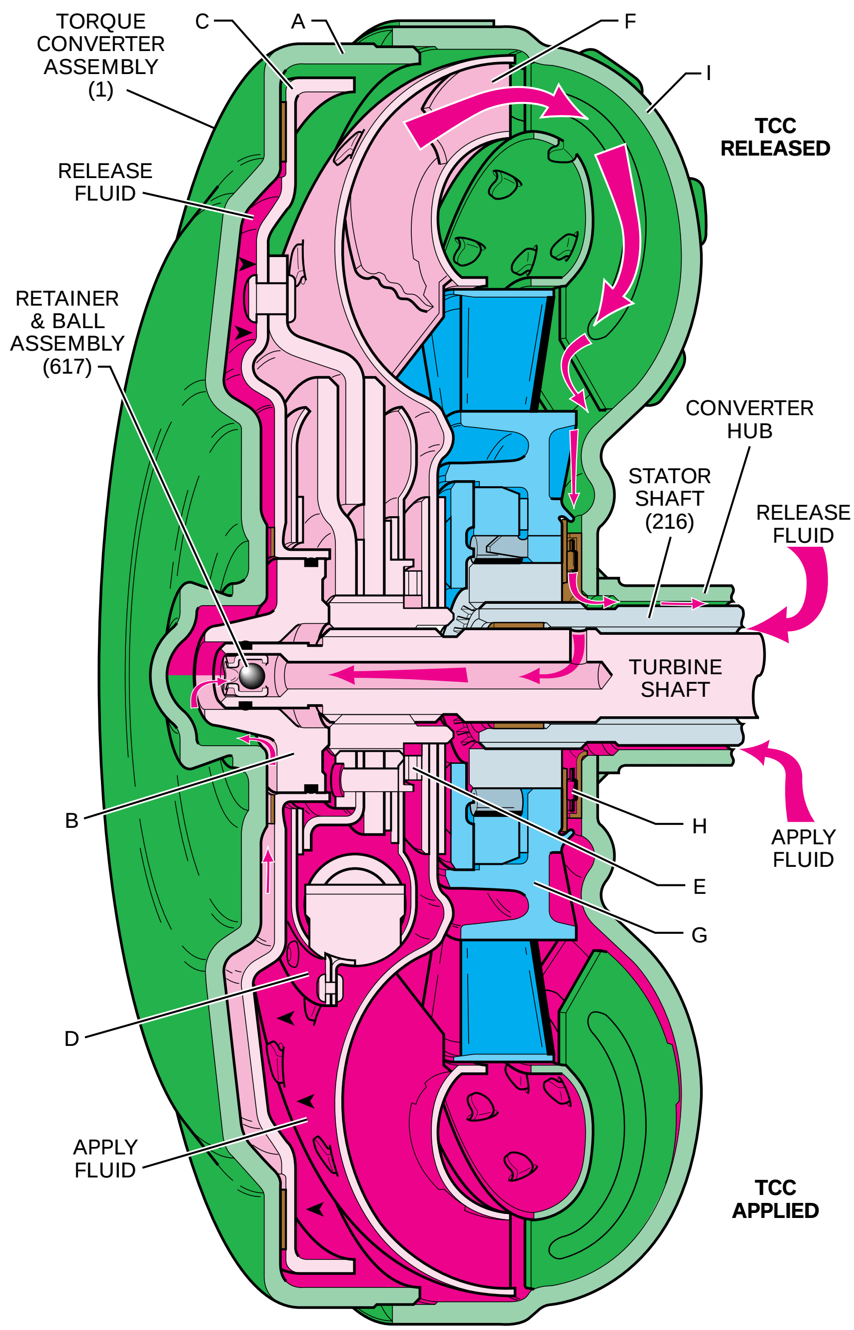


Figure 11

PRESSURE PLATE, DAMPER AND CONVERTER HOUSING ASSEMBLIES

The pressure plate is splined to the turbine hub and applies (engages) with the converter cover to provide a mechanical coupling of the engine to the transmission. When the pressure plate assembly is applied, the small amount of slippage that occurs through a fluid coupling is eliminated, thereby providing a more efficient transfer of engine torque to the transmission and drive wheels. The bottom half of the cutaway view of the torque converter in Figure 11 shows the pressure plate in the apply position while the top half shows the released position. Refer to Torque Converter Release and Apply on pages 56 and 57 for an explanation of hydraulic control of the torque converter clutch.

To reduce torsional shock during the apply of the pressure plate to the converter cover, a spring loaded damper assembly (D) is used. The damper assembly is splined to the turbine assembly and the damper's pivoting mechanism is attached to the pressure plate assembly. When the pressure plate applies, the pivoting mechanism allows the pressure plate to rotate independently of the damper assembly up to approximately 45 degrees. The cushioning effect of the damper assembly springs aid in reducing converter clutch apply feel and irregular torque pulses from the engine or road surface.

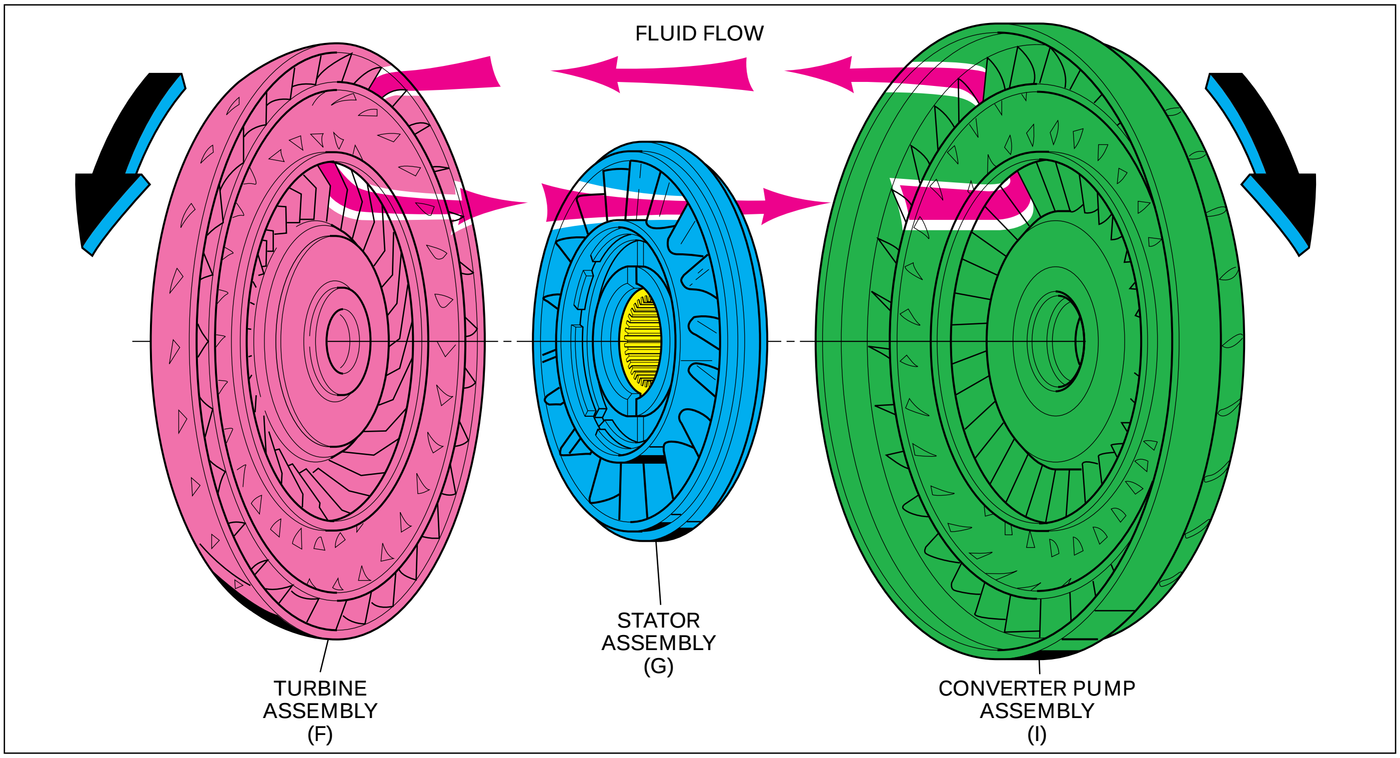


Figure 12

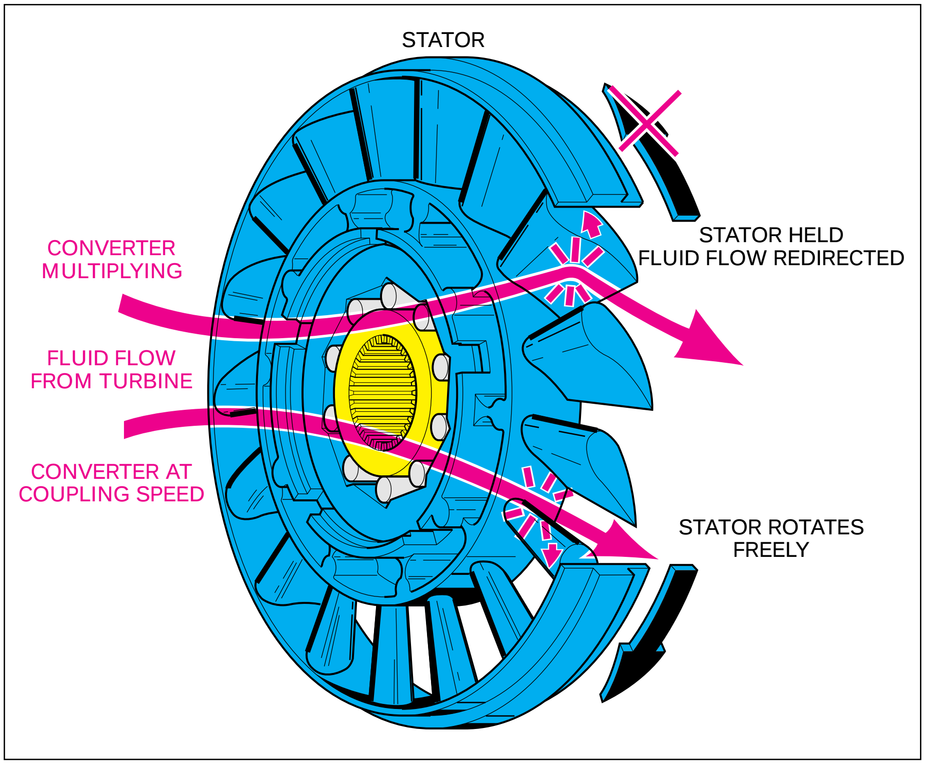


Figure 13

STATOR ASSEMBLY

The stator assembly is located between the pump assembly and turbine assembly and is mounted on a roller clutch. The roller clutch is a type of one-way clutch that prevents the stator from rotating in a counterclockwise direction. The function of the stator is to redirect fluid returning from the turbine which assists the engine in turning the converter pump assembly, thereby multiplying torque.

At low vehicle speeds, when greater torque is needed, fluid from the turbine hits the front side of the stator blades (converter multiplying torque). The roller clutch prevents the stator from rotating in the same direction as the fluid flow, thereby redirecting the fluid and increasing the fluid force on the pump assembly. Fluid from the converter pump then has more force to turn the turbine assembly and multiply engine torque.

As vehicle speed increases, centrifugal force changes the direction of fluid leaving the turbine such that it hits the back side of the stator blades (converter at coupling speed). When this occurs, the stator overruns the roller clutch and rotates freely. Fluid is no longer redirected and torque is no longer multiplied.

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APPLY COMPONENTS

The “Apply Components” section is designed to explain the function of the hydraulic and mechanical holding devices used in the Hydra-matic 4L60-E transmission. 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, often react to a hydraulically “applied” component by mechanically “holding” or “releasing” another member of the transmission. This interaction between the hydraulically and mechanically applied components is then explained in detail and supported with a graphic illustration. In addition, this section shows the routing of fluid pressure to the individual components and their internal operation when the component applies or releases.

The sequence in which the components in this section have been discussed coincides with their physical arrangement inside the transmission. This order closely parallels the disassembly sequence used in the Hydra-matic 4L60-E Unit Repair Section located in Section 7 of the appropriate Service Manual. It also correlates with the components shown on the Range Reference Charts that are used throughout the Power Flow section of this book. The correlation of information between the sections of this book helps the user to more clearly understand the hydraulic and mechanical operating principles for this transmission.

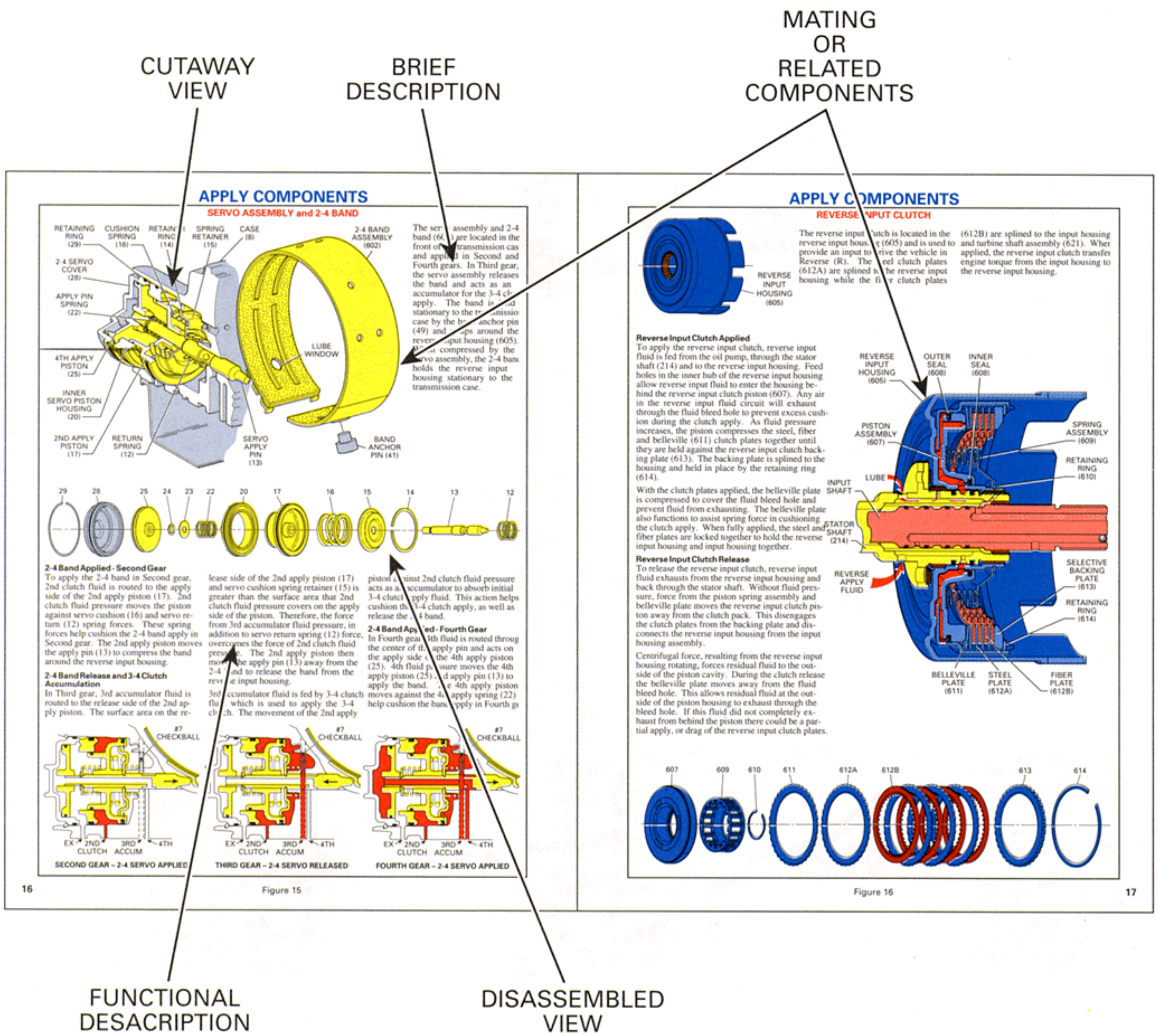
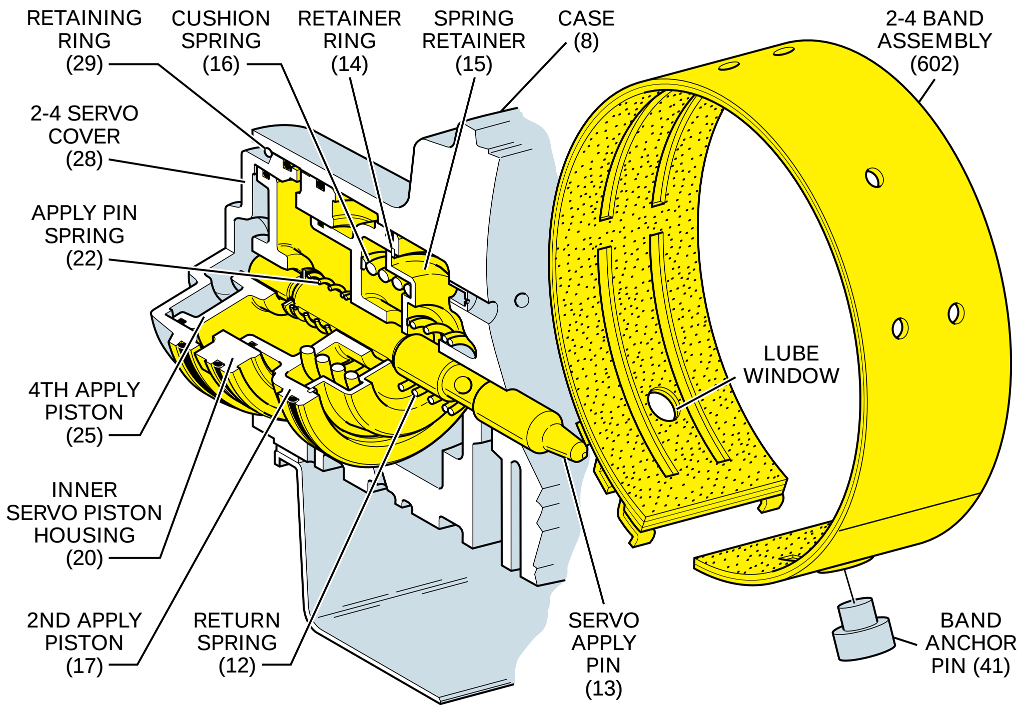


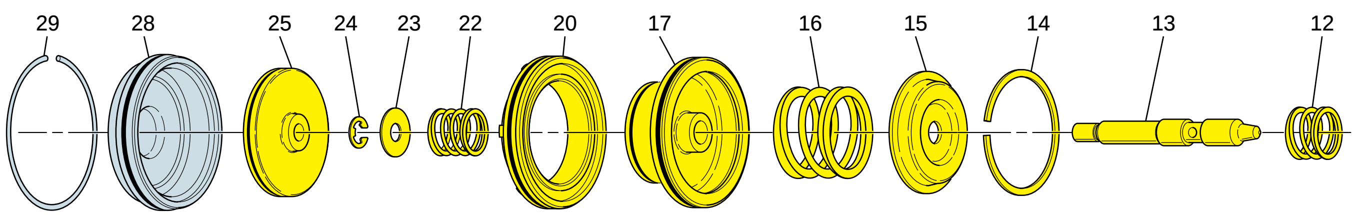
Figure 14

APPLY COMPONENTS

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.



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.

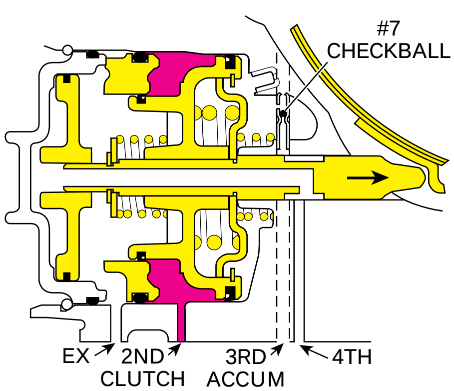
2-4 Band Release and 3-4 Clutch Accumulation

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.

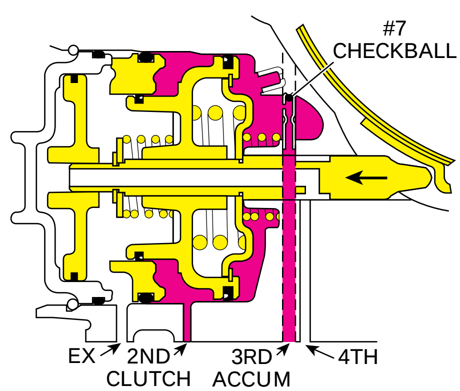
3rd accumulator fluid is fed by 3-4 clutch fluid which is used to apply the 3-4 clutch. The movement of the 2nd apply piston against 2nd clutch fluid pressure acts as an accumulator to absorb initial 3-4 clutch apply fluid. This action helps cushion the 3-4 clutch apply, as well as release the 2-4 band.

2-4 Band Applied - Fourth Gear

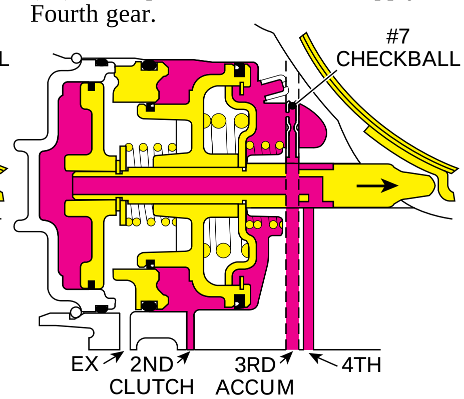
In Fourth gear, 4th fluid is routed through the center of the apply pin and acts on the apply side of the 4th apply piston (25). 4th fluid pressure moves the 4th apply piston (25) and apply pin (13) to apply the band. The 4th apply piston moves against the 4th apply spring (22) to help cushion the band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



SECOND GEAR – 2-4 SERVO APPLIED



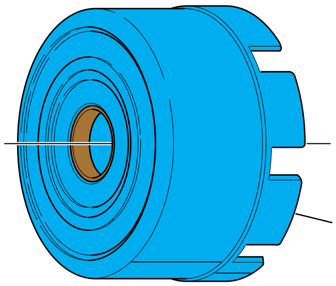
THIRD GEAR – 2-4 SERVO RELEASED



FOURTH GEAR – 2-4 SERVO APPLIED

Figure 15

REVERSE INPUT CLUTCH



The reverse input clutch is located in the reverse input housing (605) and is used to provide an input to drive the vehicle in Reverse (R). The steel clutch plates (612A) are splined to the reverse input housing while the fiber clutch plates (612B) are splined to the input housing and turbine shaft assembly (621). When applied, the reverse input clutch transfers engine torque from the input housing to the reverse input housing.

Reverse Input Clutch Applied

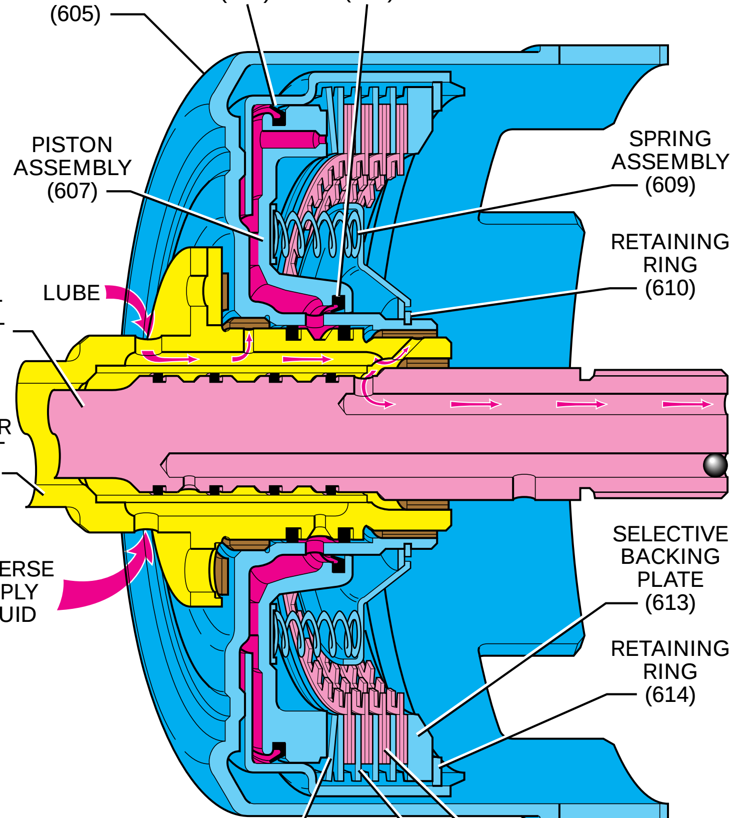
To apply the reverse input clutch, reverse input fluid is fed from the oil pump, through the stator shaft (214) and to the reverse input housing. Feed holes in the inner hub of the reverse input housing allow reverse input fluid to enter the housing behind the reverse input clutch piston (607). Any air in the reverse input fluid circuit will exhaust through the fluid bleed hole to prevent excess cushion during the clutch apply. As fluid pressure increases, the piston compresses the steel, fiber and belleville (611) clutch plates together until they are held against the reverse input clutch backing plate (613). The backing plate is splined to the housing and held in place by the retaining ring (614).

With the clutch plates applied, the belleville plate is compressed to cover the fluid bleed hole and prevent fluid from exhausting. The belleville plate also functions to assist spring force in cushioning the clutch apply. When fully applied, the steel and fiber plates are locked together to hold the reverse input housing and input housing together.

Reverse Input Clutch Release

To release the reverse input clutch, reverse input fluid exhausts from the reverse input housing and back through the stator shaft. Without fluid pressure, force from the piston spring assembly and belleville plate moves the reverse input clutch piston away from the clutch pack. This disengages the clutch plates from the backing plate and disconnects the reverse input housing from the input housing assembly.

Centrifugal force, resulting from the reverse input housing rotating, forces residual fluid to the outside of the piston cavity. During the clutch release the belleville plate moves away from the fluid bleed hole. This allows residual fluid at the outside of the piston housing to exhaust through the bleed hole. If this fluid did not completely exhaust from behind the piston there could be a partial apply, or drag of the reverse input clutch plates.



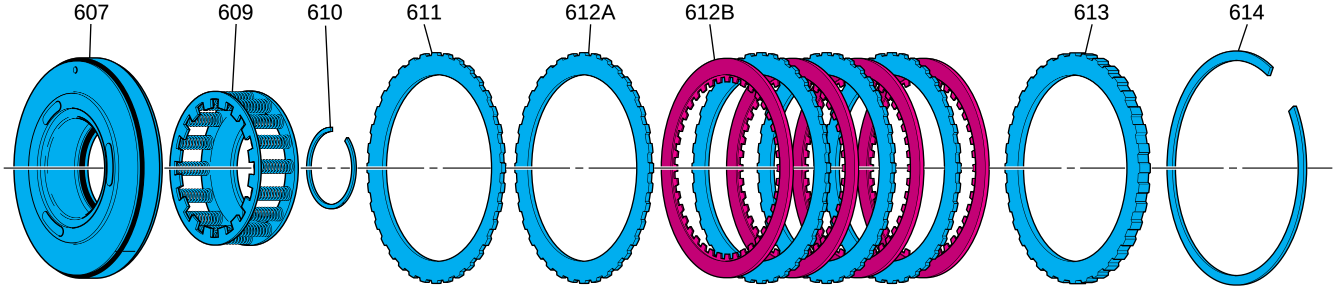
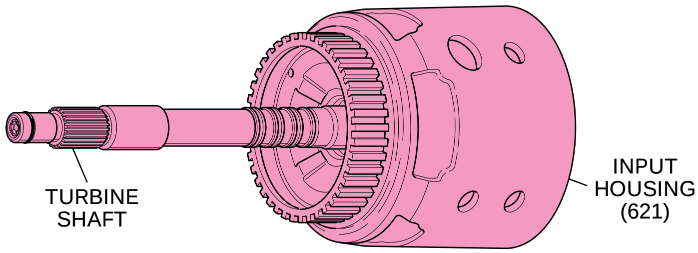


Figure 16

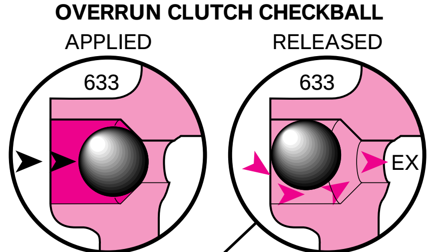
APPLY COMPONENTS

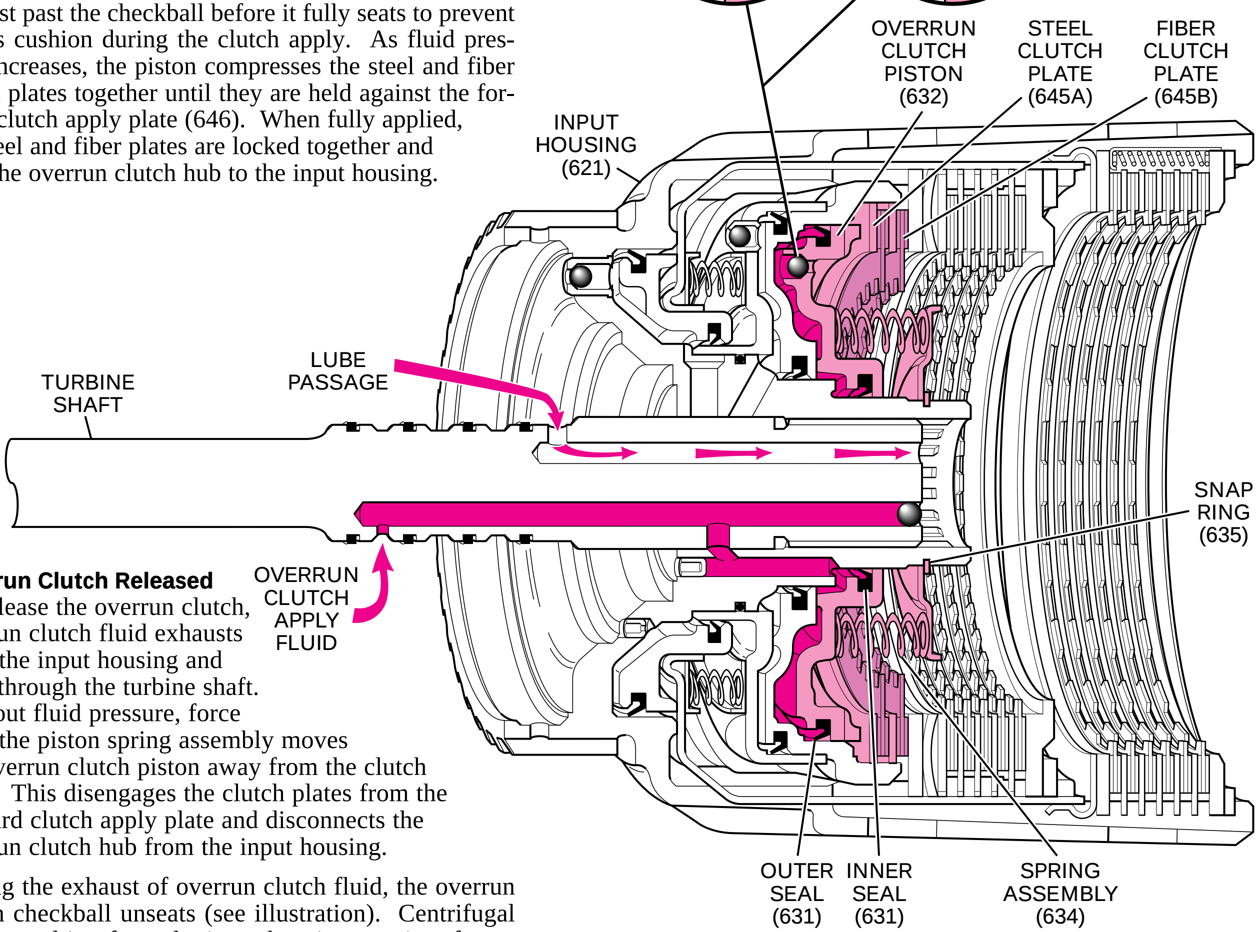
OVERRUN CLUTCH



The overrun clutch assembly is located in the input housing and turbine shaft assembly (621) and is only applied in the Manual Gear ranges. The steel clutch plates (645A) are splined to the input housing while the fiber clutch plates (645B) are splined to the overrun clutch hub (639). When applied, the overrun clutch plates force the overrun clutch hub to rotate at the same speed as the input housing. This prevents the forward sprag clutch from being overrun during coast conditions, thereby providing engine compression braking to slow the vehicle.

Overrun Clutch Applied
To apply the overrun clutch, overrun clutch fluid is routed through the turbine shaft and into the input housing behind the overrun clutch piston (632). Overrun clutch fluid pressure seats the overrun clutch checkball (633), which is located in the overrun clutch piston, and moves the piston to compress the overrun clutch spring assembly (634). Any air in the overrun clutch fluid circuit will exhaust past the checkball before it fully seats to prevent excess cushion during the clutch apply. As fluid pressure increases, the piston compresses the steel and fiber clutch plates together until they are held against the forward clutch apply plate (646). When fully applied, the steel and fiber plates are locked together and hold the overrun clutch hub to the input housing.





Overrun Clutch Released
To release the overrun clutch, overrun clutch fluid exhausts from the input housing and back through the turbine shaft. Without fluid pressure, force from the piston spring assembly moves the overrun clutch piston away from the clutch pack. This disengages the clutch plates from the forward clutch apply plate and disconnects the overrun clutch hub from the input housing.

During the exhaust of overrun clutch fluid, the overrun clutch checkball unseats (see illustration). Centrifugal force, resulting from the input housing rotating, forces residual overrun clutch fluid to the outside of the piston housing and past the unseated checkball. If this fluid did not completely exhaust from behind the piston there could be a partial apply, or drag of the overrun clutch plates.

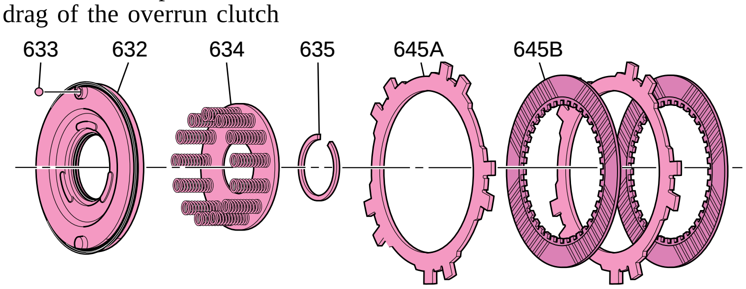
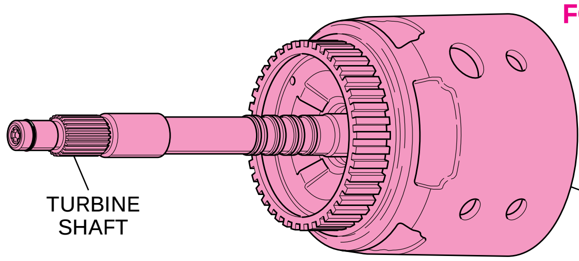


Figure 17

APPLY COMPONENTS

FORWARD CLUTCH

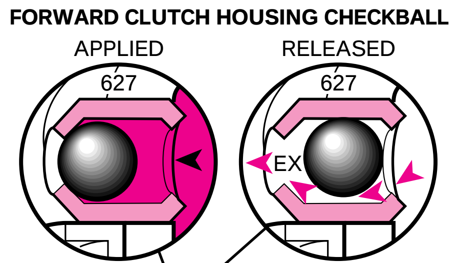


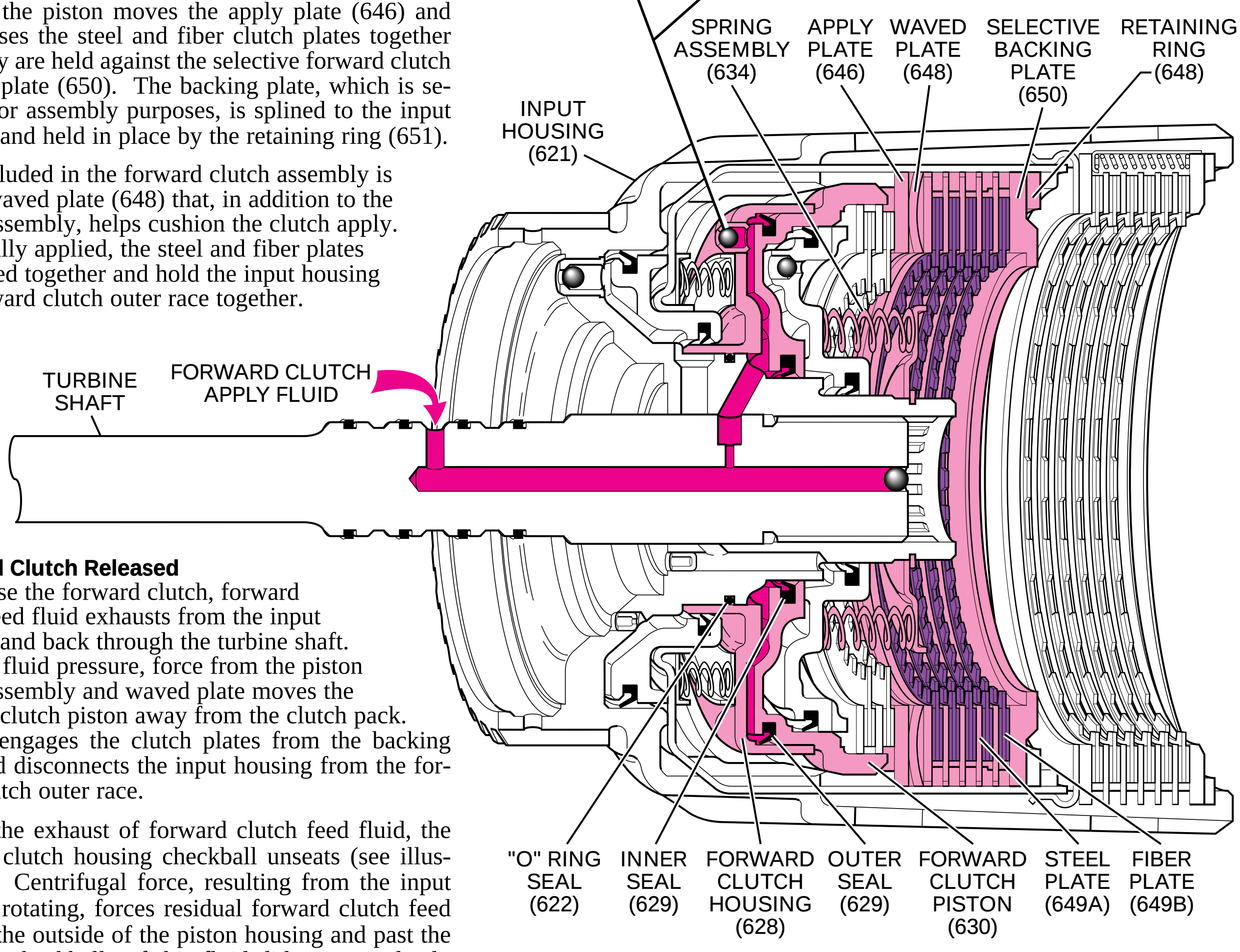
The forward clutch assembly is located in the input housing and turbine shaft assembly (621) and is applied in all forward drive ranges. The steel clutch plates (649A) are splined to the input housing while the fiber clutch plates (649B) are splined to the forward clutch outer race (644). When applied, the forward clutch plates transfer engine torque from the input housing to the forward clutch outer race and forward sprag clutch assembly.

Forward Clutch Applied

To apply the forward clutch, forward clutch feed fluid is routed through the turbine shaft and into the input housing behind the forward clutch piston (630). Forward clutch feed fluid pressure seats the forward clutch housing checkball, which is located in the forward clutch housing (627), and moves the piston to compress the piston spring assembly (634). Any air in the forward clutch feed fluid circuit will exhaust past the checkball before it fully seats to prevent excess cushion during the clutch apply. As fluid pressure increases, the piston moves the apply plate (646) and compresses the steel and fiber clutch plates together until they are held against the selective forward clutch backing plate (650). The backing plate, which is selective for assembly purposes, is splined to the input housing and held in place by the retaining ring (651).

Also included in the forward clutch assembly is a steel waved plate (648) that, in addition to the spring assembly, helps cushion the clutch apply. When fully applied, the steel and fiber plates are locked together and hold the input housing and forward clutch outer race together.





Forward Clutch Released

To release the forward clutch, forward clutch feed fluid exhausts from the input housing and back through the turbine shaft. Without fluid pressure, force from the piston spring assembly and waved plate moves the forward clutch piston away from the clutch pack. This disengages the clutch plates from the backing plate and disconnects the input housing from the forward clutch outer race.

During the exhaust of forward clutch feed fluid, the forward clutch housing checkball unseats (see illustration). Centrifugal force, resulting from the input housing rotating, forces residual forward clutch feed fluid to the outside of the piston housing and past the unseated checkball. If this fluid did not completely exhaust from behind the piston there could be a partial apply, or drag of the forward clutch plates.

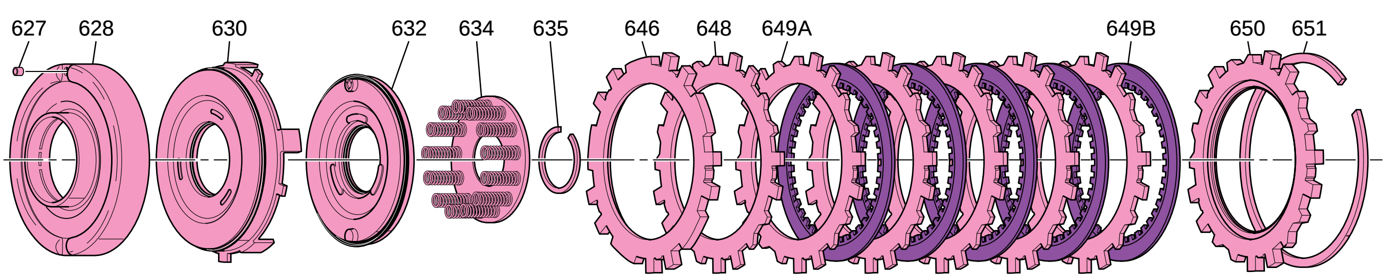
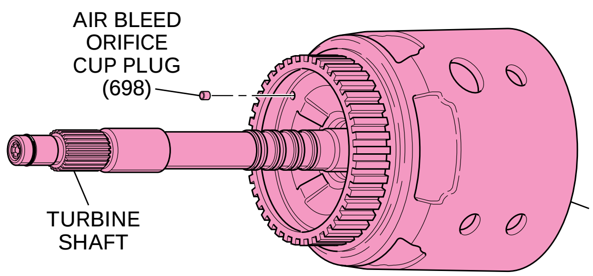


Figure 18



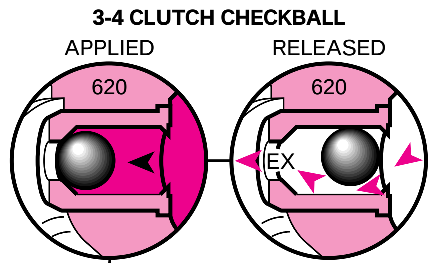
3-4 CLUTCH

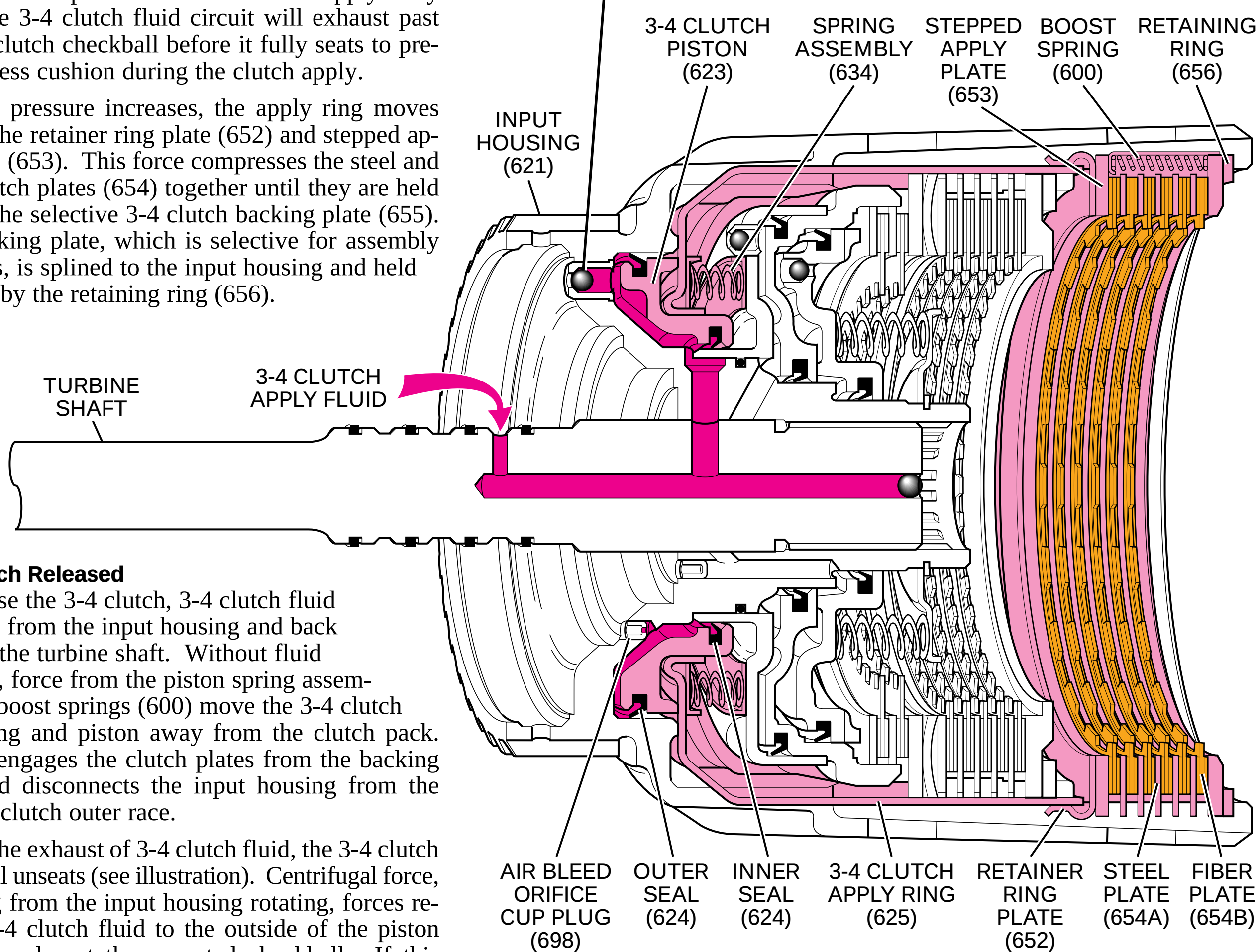
The 3-4 clutch assembly is located in the input housing and turbine shaft assembly (621) and is applied in Third and Fourth gears. The steel clutch plates (654B/C) are splined to the input housing while the fiber clutch plates (654A) are splined to the input internal gear (664). When applied, the 3-4 clutch plates transfer engine torque from the input housing to the input internal gear.

3-4 Clutch Applied

To apply the 3-4 clutch, 3-4 clutch fluid is routed through the turbine shaft and into the input housing behind the 3-4 clutch piston (623). 3-4 clutch fluid pressure seats the 3-4 clutch checkball (620), which is located in the input housing, and moves the piston against the 3-4 clutch apply ring (625). The apply ring compresses the 3-4 clutch spring assembly (626) which helps cushion the 3-4 clutch apply. Any air in the 3-4 clutch fluid circuit will exhaust past the 3-4 clutch checkball before it fully seats to prevent excess cushion during the clutch apply.

As fluid pressure increases, the apply ring moves against the retainer ring plate (652) and stepped apply plate (653). This force compresses the steel and fiber clutch plates (654) together until they are held against the selective 3-4 clutch backing plate (655). The backing plate, which is selective for assembly purposes, is splined to the input housing and held in place by the retaining ring (656).





3-4 Clutch Released

To release the 3-4 clutch, 3-4 clutch fluid exhausts from the input housing and back through the turbine shaft. Without fluid pressure, force from the piston spring assembly and boost springs (600) move the 3-4 clutch apply ring and piston away from the clutch pack. This disengages the clutch plates from the backing plate and disconnects the input housing from the forward clutch outer race.

During the exhaust of 3-4 clutch fluid, the 3-4 clutch checkball unseats (see illustration). Centrifugal force, resulting from the input housing rotating, forces residual 3-4 clutch fluid to the outside of the piston housing and past the unseated checkball. If this fluid did not completely exhaust from behind the piston there could be a partial apply, or drag of the 3-4 clutch plates.

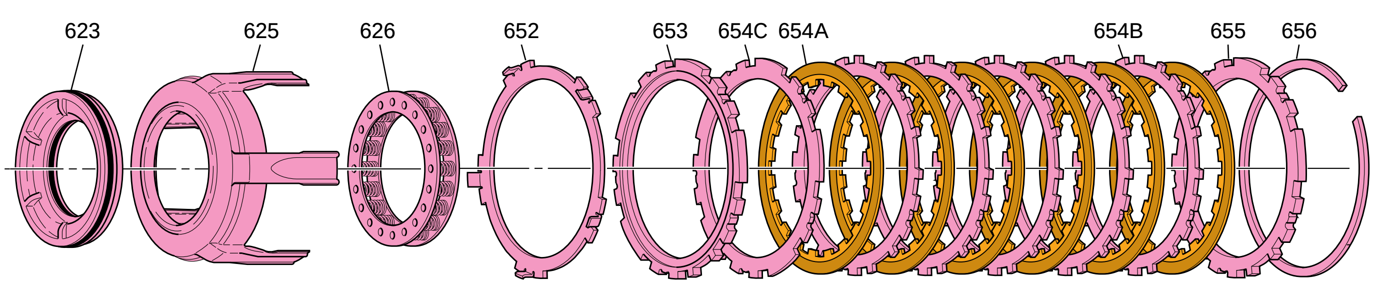
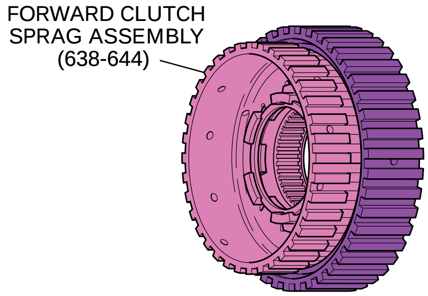


Figure 20

APPLY COMPONENTS

FORWARD SPRAG CLUTCH ASSEMBLY

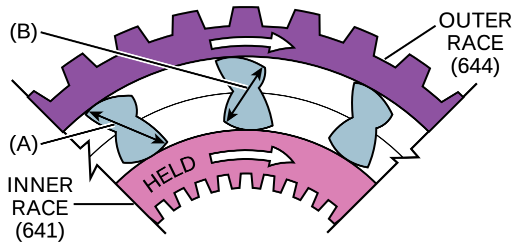


The forward sprag clutch assembly (642) is located between the forward clutch race (644) and the sprag race & retainer assembly (641). The sprag race and retainer is connected to both the overrun clutch hub (639) and input sun gear while the forward clutch race is splined to the forward clutch plates. The sprag clutch is a type of one-way clutch that transfers engine torque from the forward clutch to the input sun gear during acceleration in First, Second and Third gears in Overdrive Range. When the throttle is released in these gear ranges the sprag clutch is overrun to allow the vehicle to coast freely.

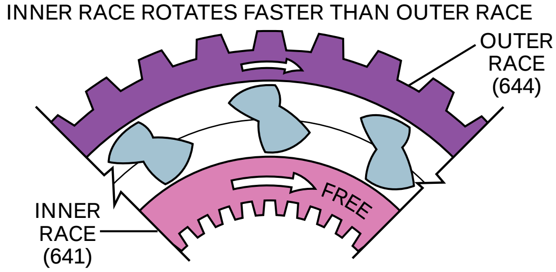
Forward Sprag Clutch Holding

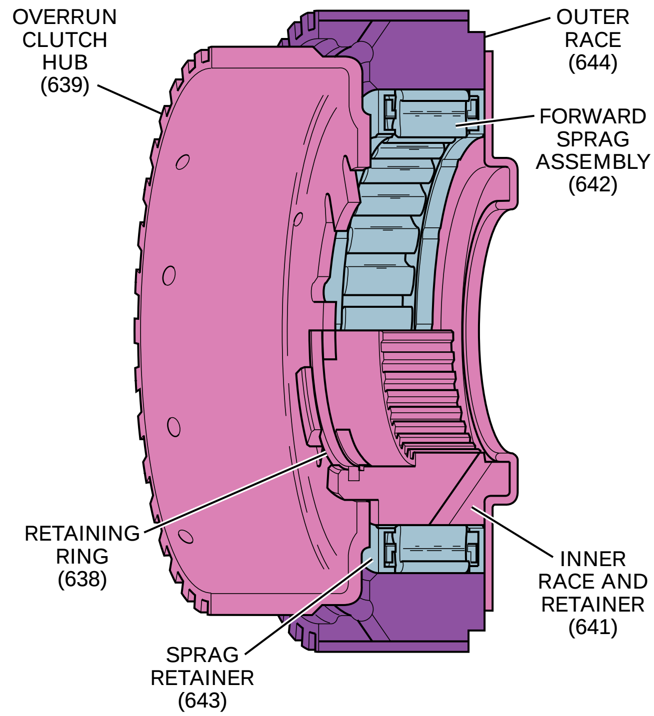
When the forward clutch is applied, engine torque is transferred to the forward clutch race (644) which functions as the outer race for the sprag assembly. The rotation of the outer race pivots the sprags toward their long diagonals. The length of the long diagonal (distance A) is greater than the distance between the outer race and inner race (641). This causes the sprags to "lock" between the inner and outer races and transfer engine torque from the forward clutch race to the inner race and input sun gear (658).

SPRAG CLUTCH HOLDING
OUTER RACE DRIVING THE INNER RACE



SPRAG CLUTCH RELEASED
INNER RACE ROTATES FASTER THAN OUTER RACE





Forward Sprag Clutch Released

The sprag clutch releases when the sprags pivot toward their short diagonals. The length of the short diagonals (B) is less than the distance between the inner and outer sprag races. This occurs when power flow drives the input sun gear and sprag race and retainer assembly faster than the forward clutch drives the forward clutch race (644). During acceleration the sprag clutch is overrun only in Fourth gear.

Coast Conditions

The sprag clutch is also overrun during coast conditions, or deceleration, in the following gear ranges:

- Overdrive Range - First, Second and Third Gears
- Manual Third - First and Second Gears
- Manual Second - First Gear

During coast conditions, power from vehicle speed drives the input sun gear faster than engine torque drives the forward clutch race (644). In this situation, the sprag race and retainer assembly (641), which is splined to the sun gear, overruns the sprag clutch and allows the vehicle to coast freely.

Overrun Clutch Applied

When the overrun clutch is applied (see range reference chart) it holds the overrun clutch hub and sun gear together. These components are then forced to rotate at the same speed as the input housing. This prevents the input sun gear from being driven faster than the forward clutch race (644). During coast conditions when the throttle is released, power from vehicle speed is then transferred back to the torque converter and engine compression slows the vehicle.

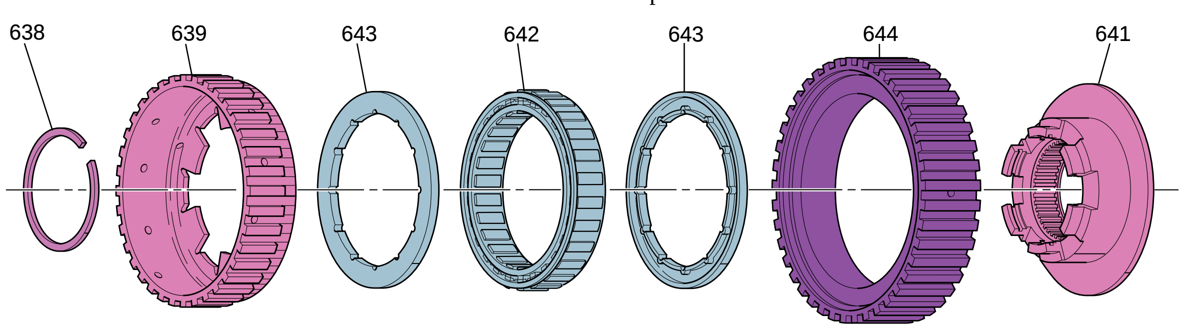
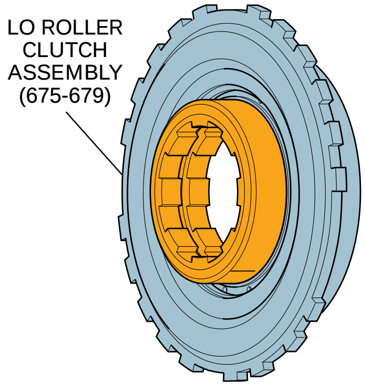


Figure 20

APPLY COMPONENTS

LO ROLLER CLUTCH

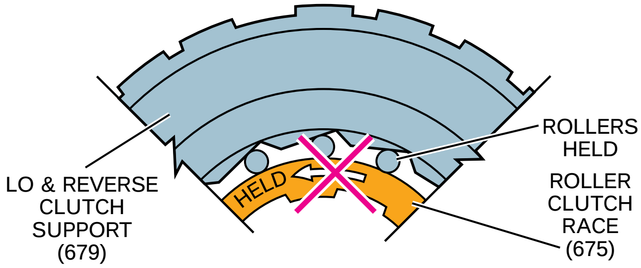


The lo roller clutch (678) is a type of one-way clutch used to prevent the reaction carrier assembly (681), reaction carrier shaft (666) and input internal gear (664) from rotating in a counterclockwise direction. The roller clutch is located between the lo & reverse clutch support (679) and the lo roller clutch race (675). The lo roller clutch support functions as the outer cam for the roller clutch and is splined to the transmission case. The roller clutch race (675) is splined to the reaction carrier assembly (681) and functions as the roller clutch inner race.

Roller Clutch Holding

The roller clutch is holding during acceleration in First gear. When accelerating in First gear, the reaction carrier assembly and inner race (675) attempt to rotate counterclockwise. This action causes the rollers to roll up the ramps on the outer cam and wedge between the inner race and outer cam. With the rollers wedged and the lo and reverse clutch support held stationary to the transmission case, the reaction carrier assembly is also held stationary.

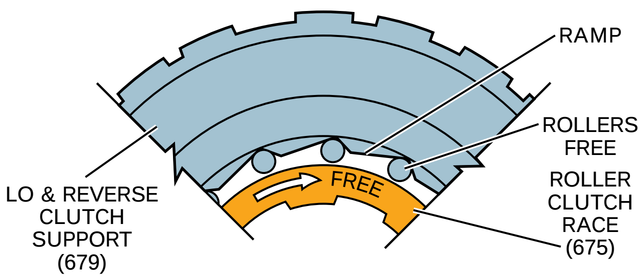
ROLLER CLUTCH HOLDING

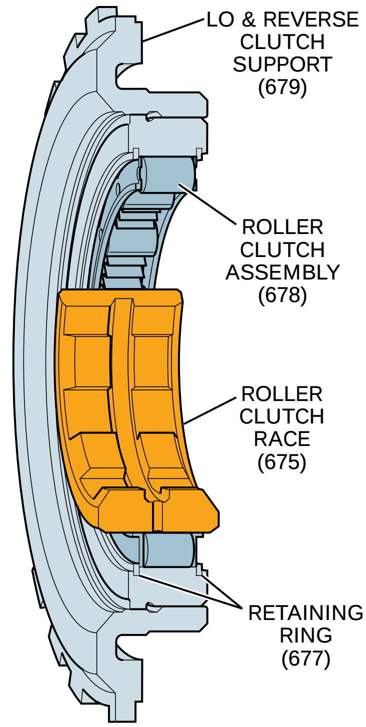


Roller Clutch Released

The roller clutch is overrun by the reaction carrier assembly and inner race when the throttle is released during First gear operation with the selector lever in Overdrive, Manual Third and Manual Second. When the throttle is released, power flow from vehicle speed drives the reaction carrier assembly and inner race in a clockwise direction. The inner race moves the rollers down the ramp, overruns the rollers and rotates freely in a clockwise direction.

ROLLER CLUTCH RELEASED





Lo and Reverse Clutch Applied

In Manual First - First Gear, the lo and reverse clutch is applied to hold the reaction carrier assembly stationary to the transmission case. The lo and reverse clutch prevents the reaction carrier and inner race from rotating clockwise and overrunning the roller clutch when the throttle is released. Power flow is then transferred back through the transmission gear sets and to the torque converter, allowing engine compression to slow the vehicle. The lo and reverse clutch is also applied in Reverse to provide the necessary power flow to obtain Reverse.

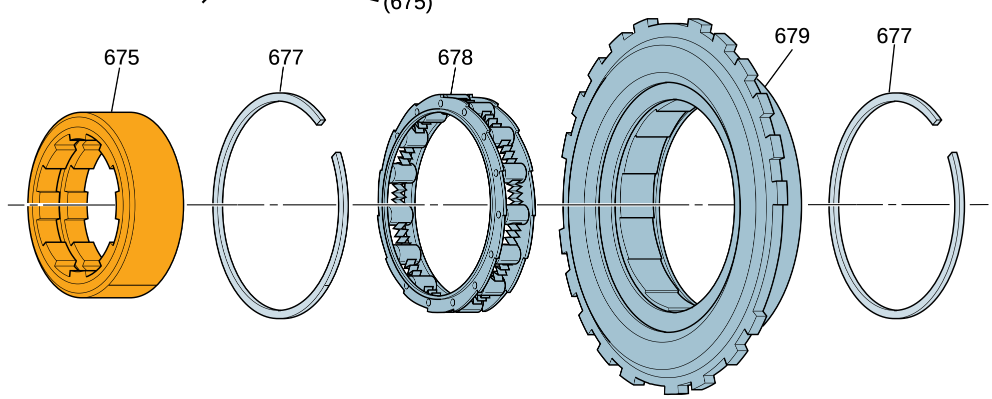
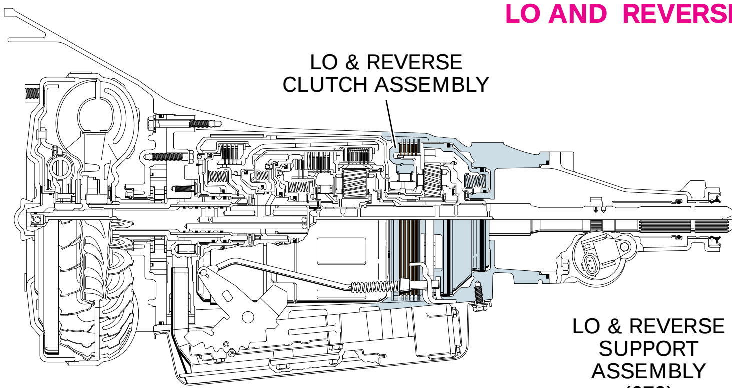


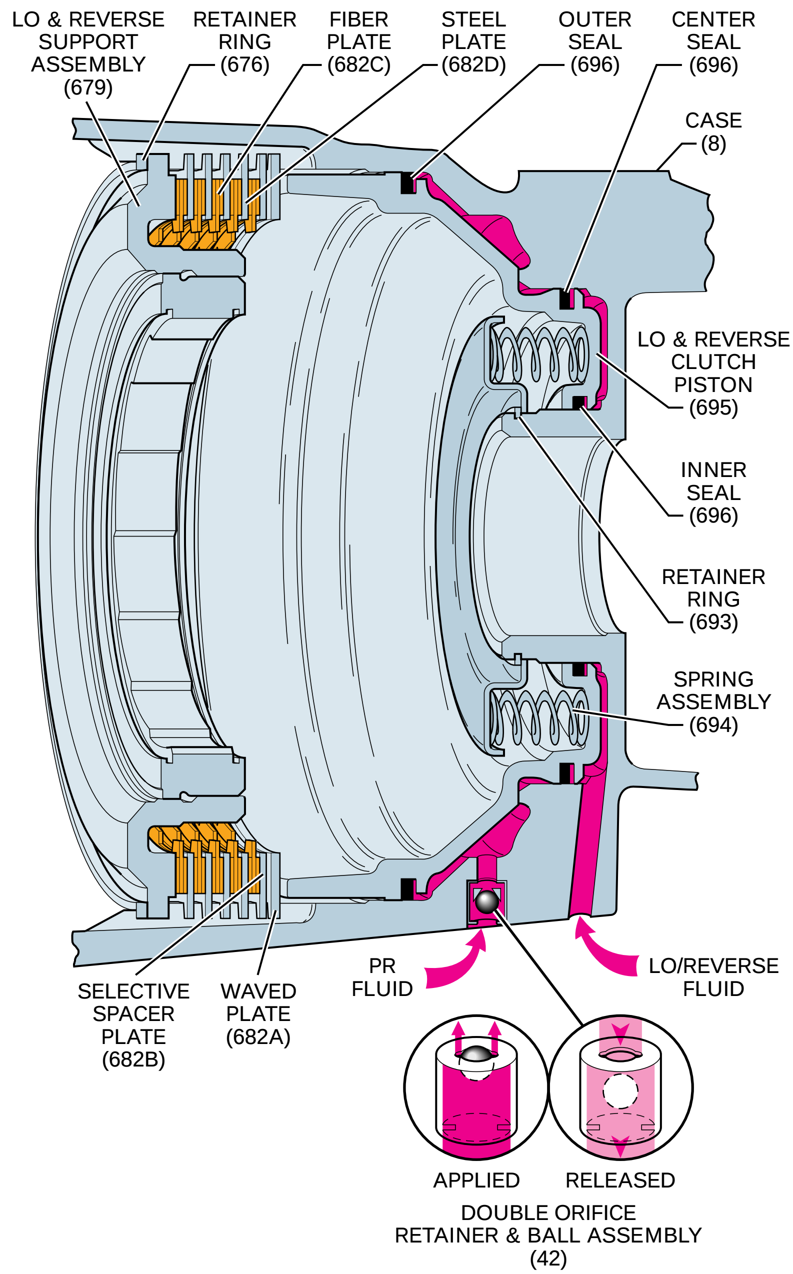
Figure 21

APPLY COMPONENTS

LO AND REVERSE CLUTCH



The lo and reverse clutch assembly is located in the rear of the transmission case and is applied in Park, Reverse and Manual First - First Gear. The steel clutch plates (682A,B,D) are splined to the transmission case while the fiber clutch plates (682C) are splined to the reaction planetary carrier (681). When applied, the lo and reverse clutch plates hold the reaction planetary carrier stationary to the transmission case.



Lo and Reverse Clutch Applied

To apply the lo and reverse clutch, two different fluids are routed to the lo and reverse clutch piston (695). In Manual First, lo/reverse fluid is routed to the inner area of the clutch piston. In Park and Reverse, PR fluid is routed to the outer area of the lo and reverse clutch piston, in addition to lo/reverse fluid acting on the inner area of the piston, to provide a greater holding capacity of the clutch. Fluid pressure moves the piston to compress the lo and reverse clutch piston spring assembly (634). PR fluid seats the PR checkball and is orificed to the piston to help control the clutch apply. Also included in the forward clutch assembly is a steel waved plate (682A) that, in addition to the spring assembly, helps cushion the clutch apply. As fluid pressure increases, the piston compresses the steel and fiber clutch plates together until they are held against the lo and reverse support assembly (679), which is also splined to the transmission case. The spacer plate (682B) is selective for assembly purposes.

Lo and Reverse Clutch Released

To release the lo and reverse clutch, apply fluid pressure exhausts from the behind the lo and reverse clutch piston. When exhausting, PR fluid unseats the PR checkball (42) for a quick exhaust. Without fluid pressure, force from the piston spring assembly and waved plate moves the lo and reverse clutch piston away from the clutch pack. This disengages the clutch plates from the lo and reverse clutch support, thereby allowing the reaction carrier assembly to rotate freely.

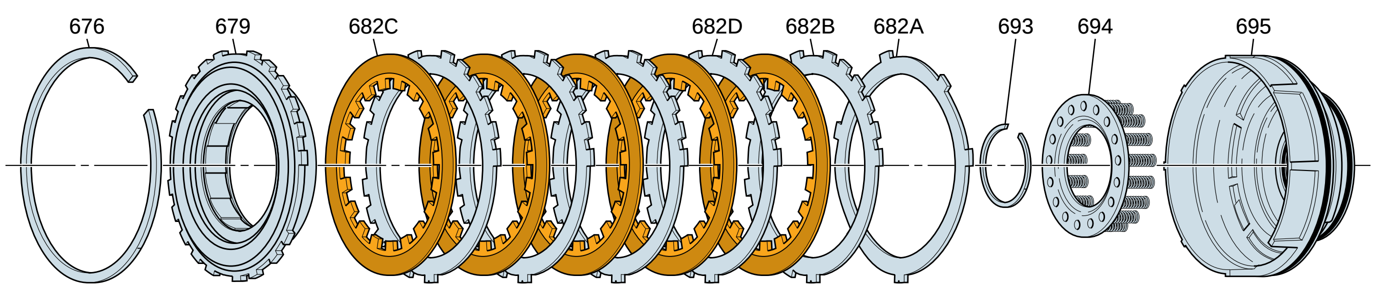
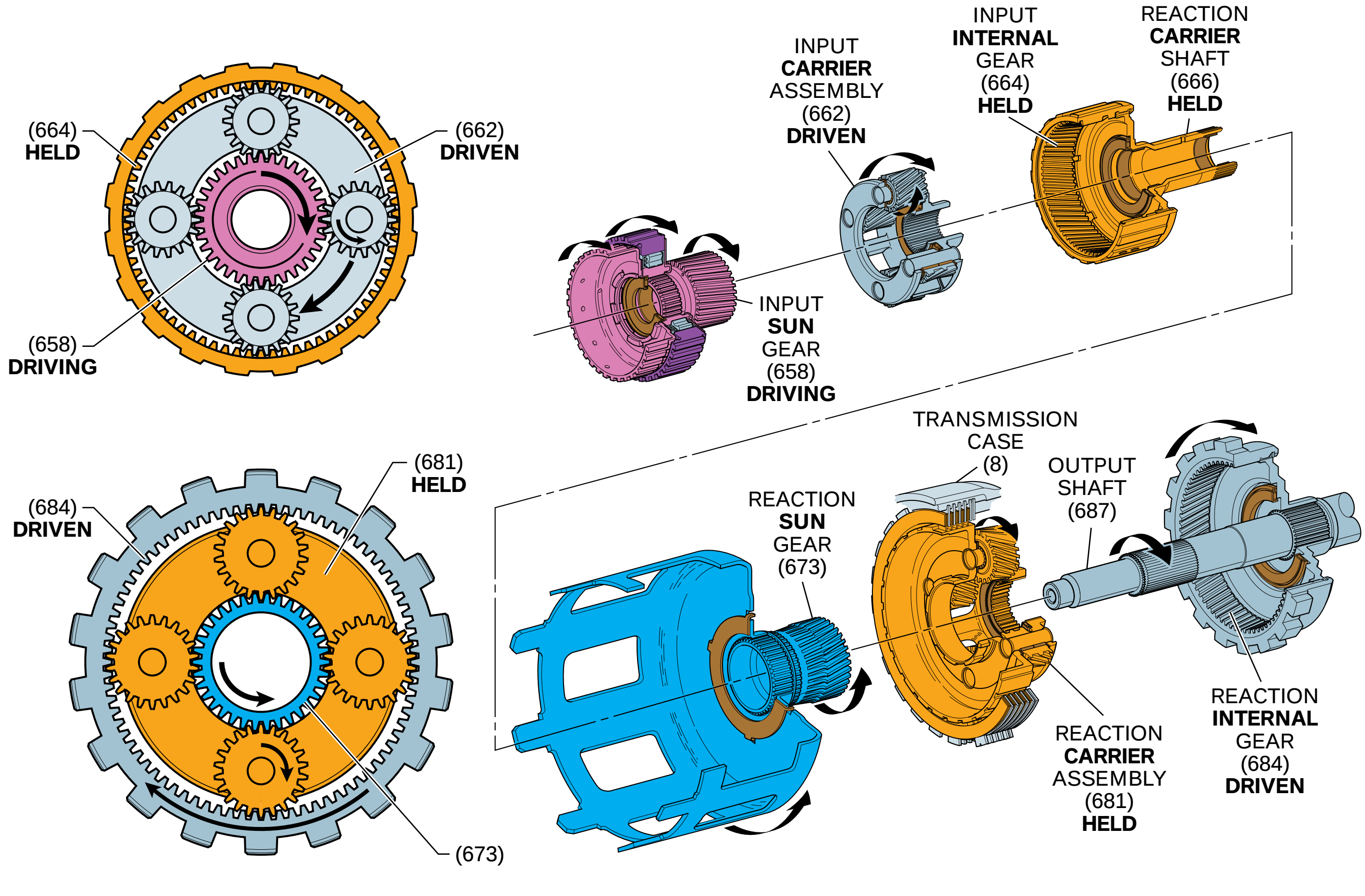


Figure 22

PLANETARY GEAR SETS

REDUCTION - FIRST GEAR



REDUCTION - SECOND GEAR

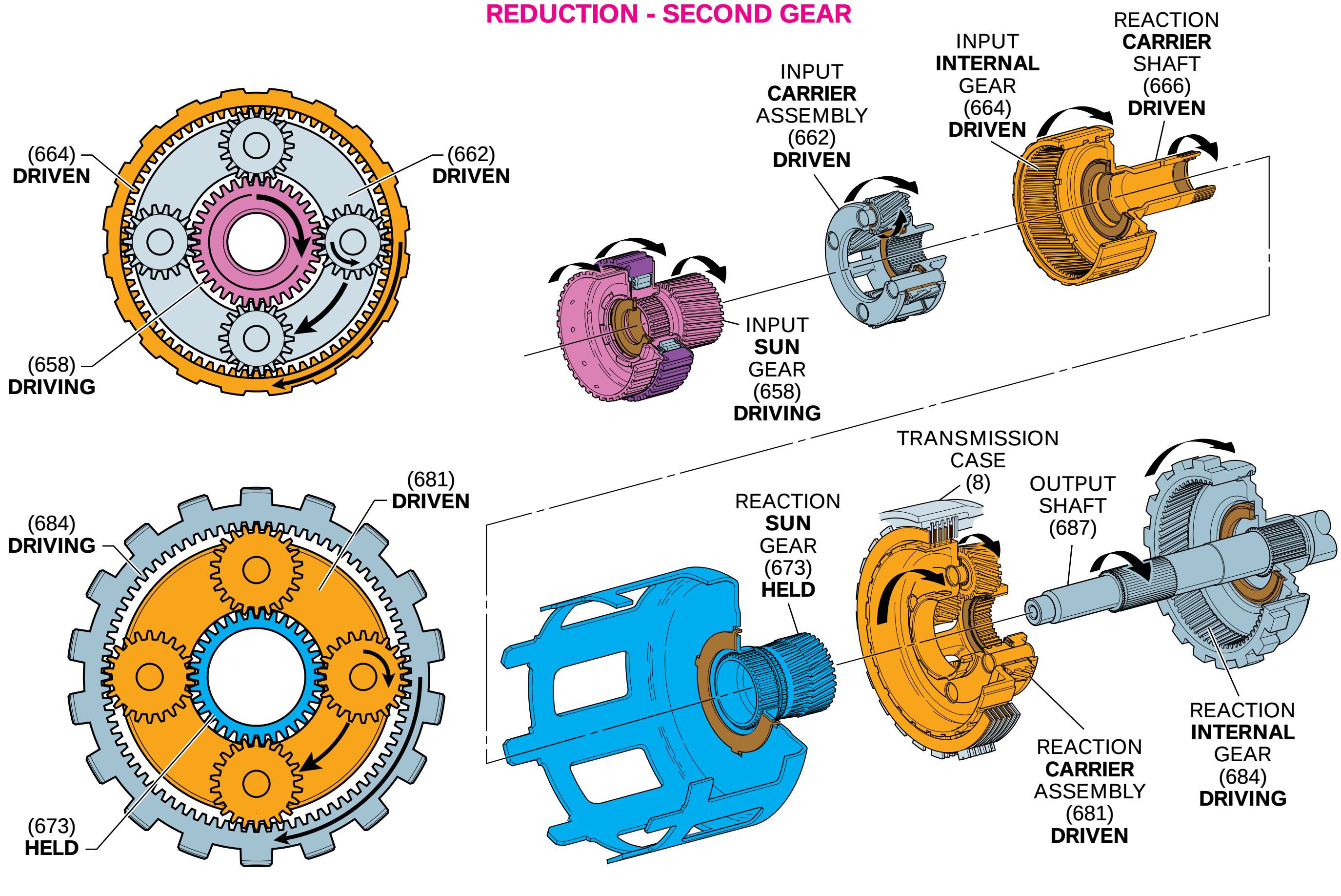
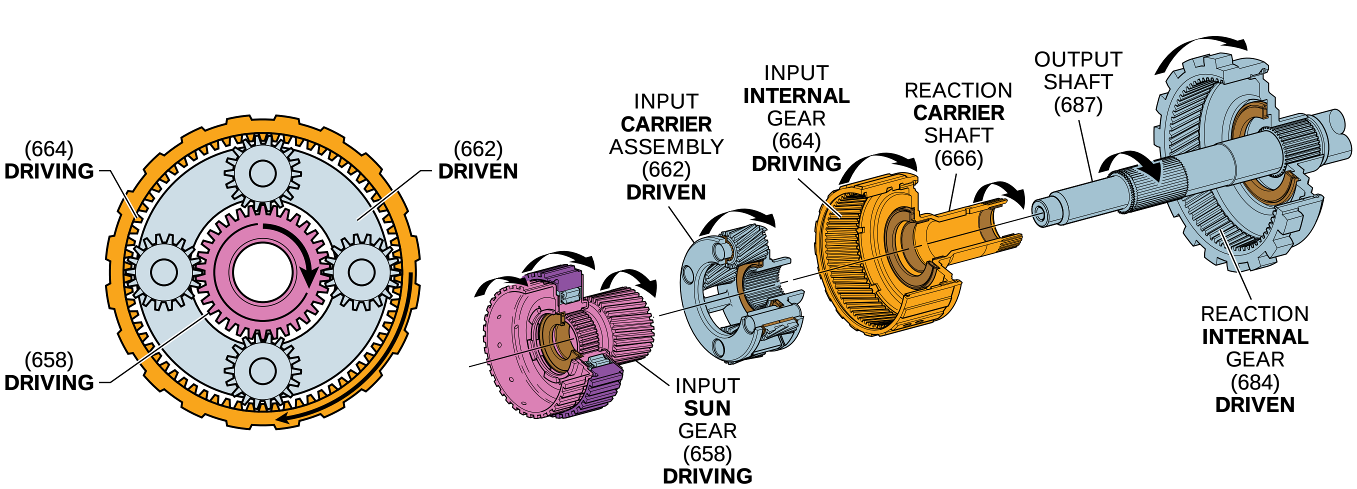


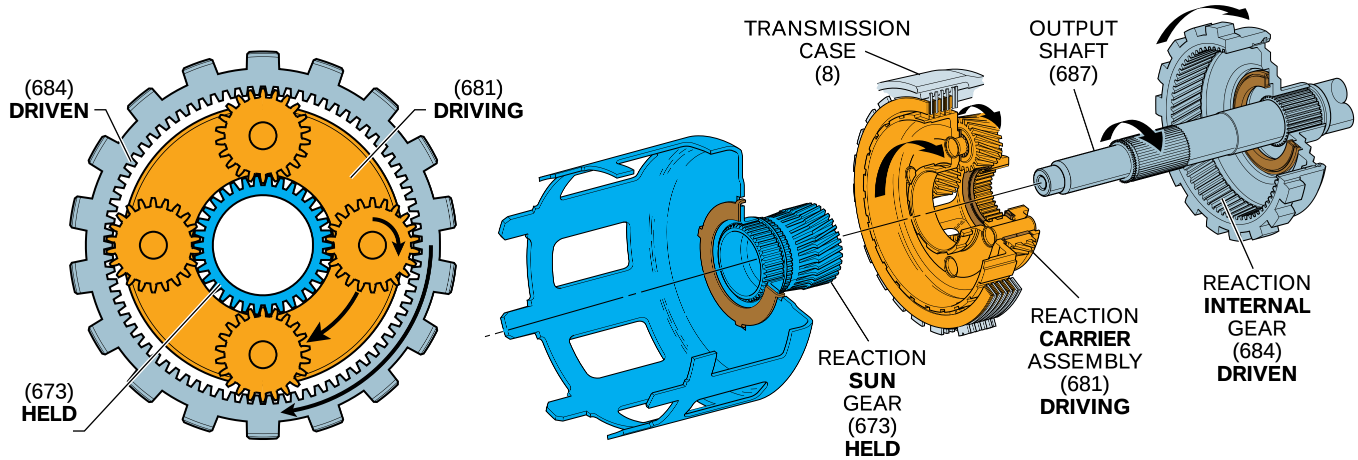
Figure 23

PLANETARY GEAR SETS

DIRECT DRIVE - THIRD GEAR



OVERDRIVE - FOURTH GEAR



REDUCTION - REVERSE

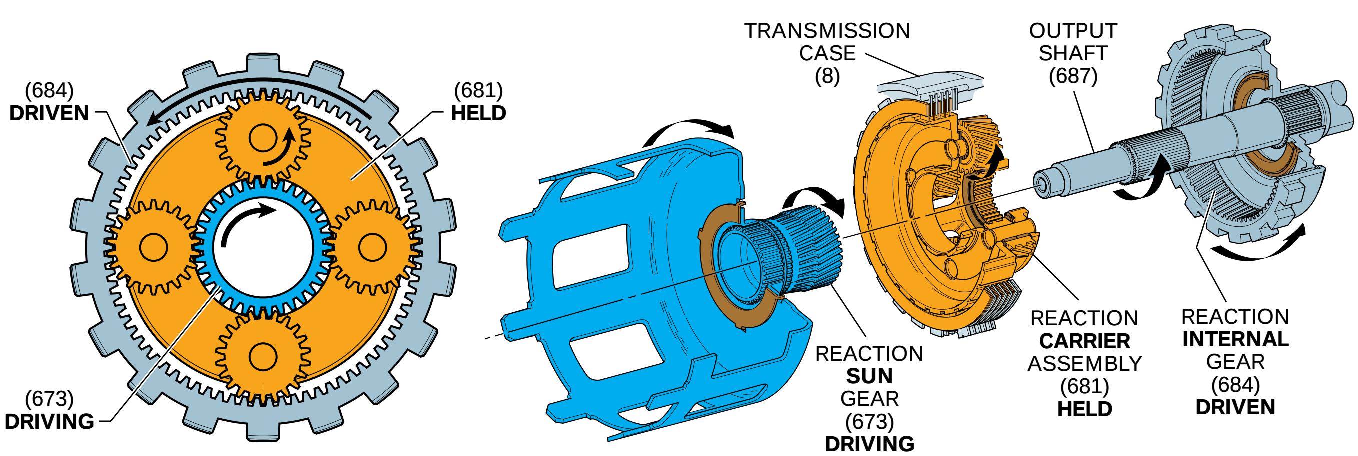


Figure 24

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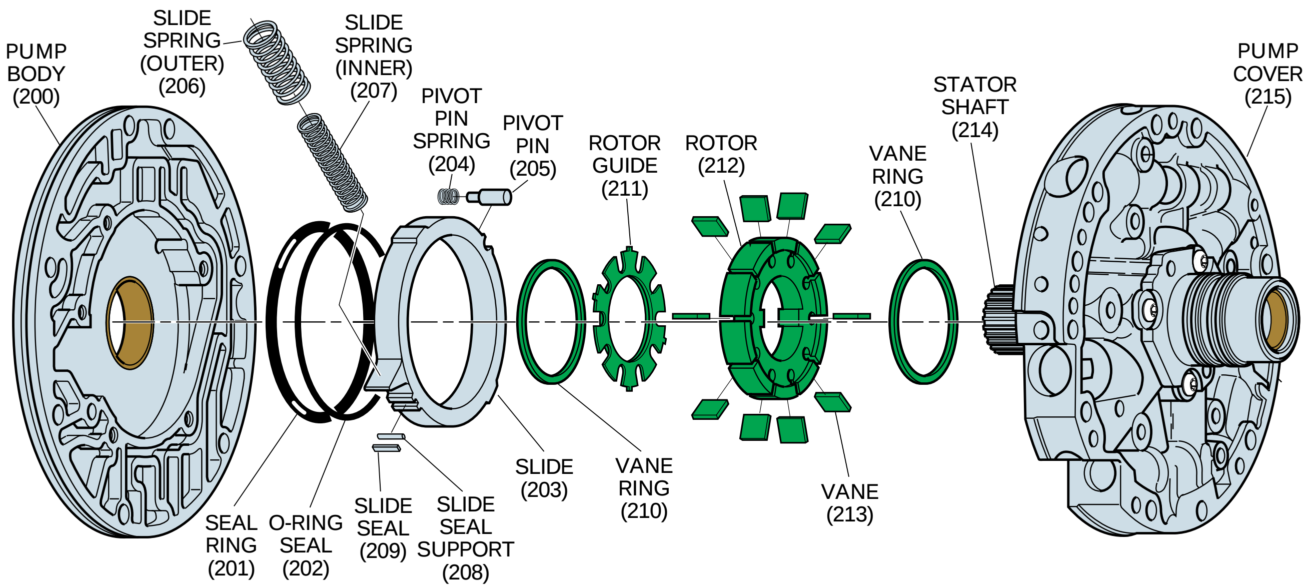
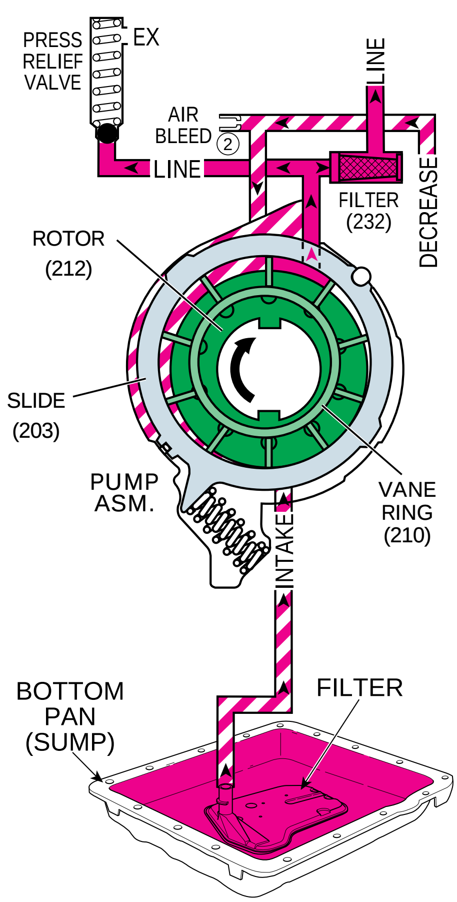
The previous section of this book describes the operation of the mechanical components used in the Hydra-matic 4L60-E transmission. In this section, a detailed description of the individual components used in the hydraulic system will be presented. These hydraulic control components apply and release the clutches, band and accumulators that provide for the automatic shifting of the transmission.





OIL PUMP ASSEMBLY

The oil pump assembly (4) contains a variable displacement vane type pump located in the oil pump body (200). The oil pump rotor (212) is keyed to the torque converter pump hub. Therefore, when the engine is running the converter pump hub drives the rotor at engine speed. As the oil pump rotor and the oil pump vanes (213) rotate, the area between the vanes increases and fluid volume is positively displaced, thereby creating a vacuum at the pump intake port. The vacuum force allows atmospheric pressure acting on the fluid in the bottom pan to prime the pump and pressurize the hydraulic system.

Fluid from the transmission bottom pan is drawn through the oil filter assembly (72) and into the oil pump intake fluid circuit. This fluid is forced into the oil pump through the intake port and rotates around the oil pump slide (203) to the pump outlet port. As the fluid rotates around the slide, the volume between the pump vanes decreases before reaching the outlet port. Decreasing the volume pressurizes the fluid and forces the fluid into the line pressure fluid circuit. This fluid is directed to the pressure regulator valve and becomes the main supply of fluid to the various components and hydraulic circuits in the transmission.

Figure 25

HYDRAULIC CONTROL COMPONENTS

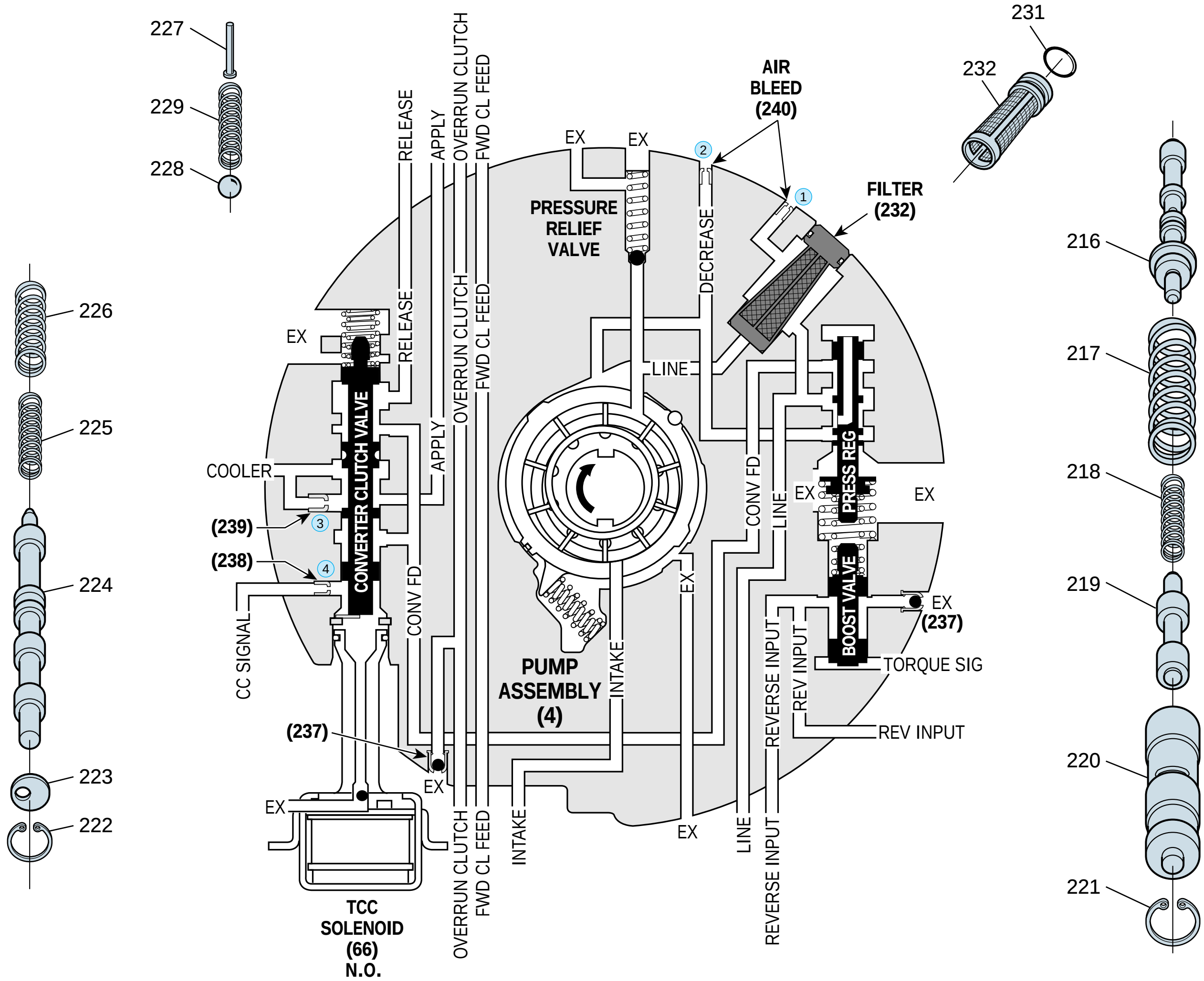
COMPONENTS LOCATED IN THE OIL PUMP ASSEMBLY

Torque Converter Clutch Solenoid
The Powertrain Control Module (PCM) controls the TCC solenoid to apply and release the converter clutch. The TCC solenoid is a normally open, ON/OFF solenoid that, when energized (ON), initiates the converter clutch apply. Refer to the Electronic Component Section for a complete description of the TCC solenoid.

Torque Converter Clutch Apply Valve (224)
Controlled by the TCC solenoid state and converter clutch signal fluid pressure, it directs converter feed fluid pressure to either the release or apply side of the converter clutch. The TCC apply valve also directs fluid into the cooler fluid circuit. The valve is held in the release position (as shown) by spring force when the TCC solenoid is OFF. With the TCC solenoid ON, converter clutch signal fluid pressure increases and moves the valve into the apply position against spring force.

Pressure Regulator Valve (216)
Regulates line pressure in relation to vehicle operating conditions (see page 29 on Pressure Regulation). The pressure regulator valve is biased by torque signal fluid pressure, pressure regulator spring (217) force, line pressure routed to the end of the valve, and reverse input fluid pressure acting on the boost valve in Reverse. Line pressure is routed through the valve and into both the converter feed and decrease fluid circuits.

Boost Valve (219)
Torque signal fluid pressure moves the boost valve against the isolator spring (218). The isolator spring then exerts the force from torque signal fluid pressure to the pressure regulator valve. Therefore, line pressure increases as throttle position and engine torque increase. Also, reverse input fluid pressure acting on the boost valve increases the operating range of line pressure when the transmission is in Reverse.



Pressure Relief Ball (228)
The pressure relief ball and spring (229) prevent line pressure from exceeding approximately 2240 to 2520 kPa (320 to 360 psi). Above this pressure, line fluid pressure moves the ball against spring force and exhausts until line pressure decreases sufficiently.

Retainer and Checkball Assemblies (237)
These two assemblies are located in the reverse input and overrun clutch fluid circuits. Their function is to allow air to escape from the fluid circuit when fluid pressure increases during clutch apply. Also, when the clutch releases the ball unseats and allows air into the circuit to displace the exhausting fluid.

Orifice Cup Plugs (238-240)
Various orifice cup plugs are located in the oil pump cover (215) to provide fluid flow control in the transmission's hydraulic system.

Figure 26

PRESSURE REGULATION

PRESSURE REGULATION

The main components that control line pressure are the pressure control solenoid and pressure regulator valve. The fluid pressure required to apply the clutches and band varies in relation to throttle position and engine torque. At the pressure regulator valve, line pressure is regulated in response to the following:

- torque signal fluid pressure routed from the pressure control solenoid (PCS) (this fluid pressure is proportional to engine torque - see page 40). Torque signal fluid pressure moves the boost valve (219) against the pressure regulator isolator spring (218) which acts against the pressure regulator valve.
- pressure regulator spring force.
- line pressure acting on the end of the pressure regulator valve.
- reverse input fluid pressure acting on the boost valve in Reverse.

The pressure regulator valve routes line pressure into both the converter feed and decrease fluid circuits. Converter feed fluid is routed to both the torque converter and cooler fluid circuits. Decrease fluid pressure moves the oil pump slide against the force of the pump slide springs (outer - 206, inner - 207). Decrease fluid pressure and the position of the pump slide constantly vary in relation to torque signal fluid pressure and engine torque as controlled by the pressure regulator valve.

Minimum Pressure Regulation

When engine torque is a minimum, the PCS regulates torque signal fluid pressure to a minimum. During these conditions, line pressure acting on the end of the pressure regulator valve moves the valve against spring force and torque signal fluid pressure to a point where line pressure enters both the converter feed and decrease fluid circuits. Decrease fluid pressure moves the pump slide (203) against spring force and toward the center of the pump body, causing the slide to partially cover the pump intake port. This increases the concentricity between the pump slide and rotor which decreases the vacuum affect on the fluid, thereby decreasing line pressure.

Maximum Pressure Regulation

When engine torque is a maximum, the PCS regulates torque signal fluid pressure to a maximum. Maximum torque signal fluid pressure moves the boost valve against the isolator spring to increase the force on the pressure regulator valve. This moves the pressure regulator valve to block line pressure from entering the decrease fluid circuit. With lower decrease fluid pressure, pump slide spring force moves the slide against the side of the pump body. This decreases the concentricity between the slide and rotor which increases the vacuum affect on the fluid. In this position line pressure is a maximum. The output of the oil pump continuously varies between these minimum and maximum points depending on vehicle operating conditions.

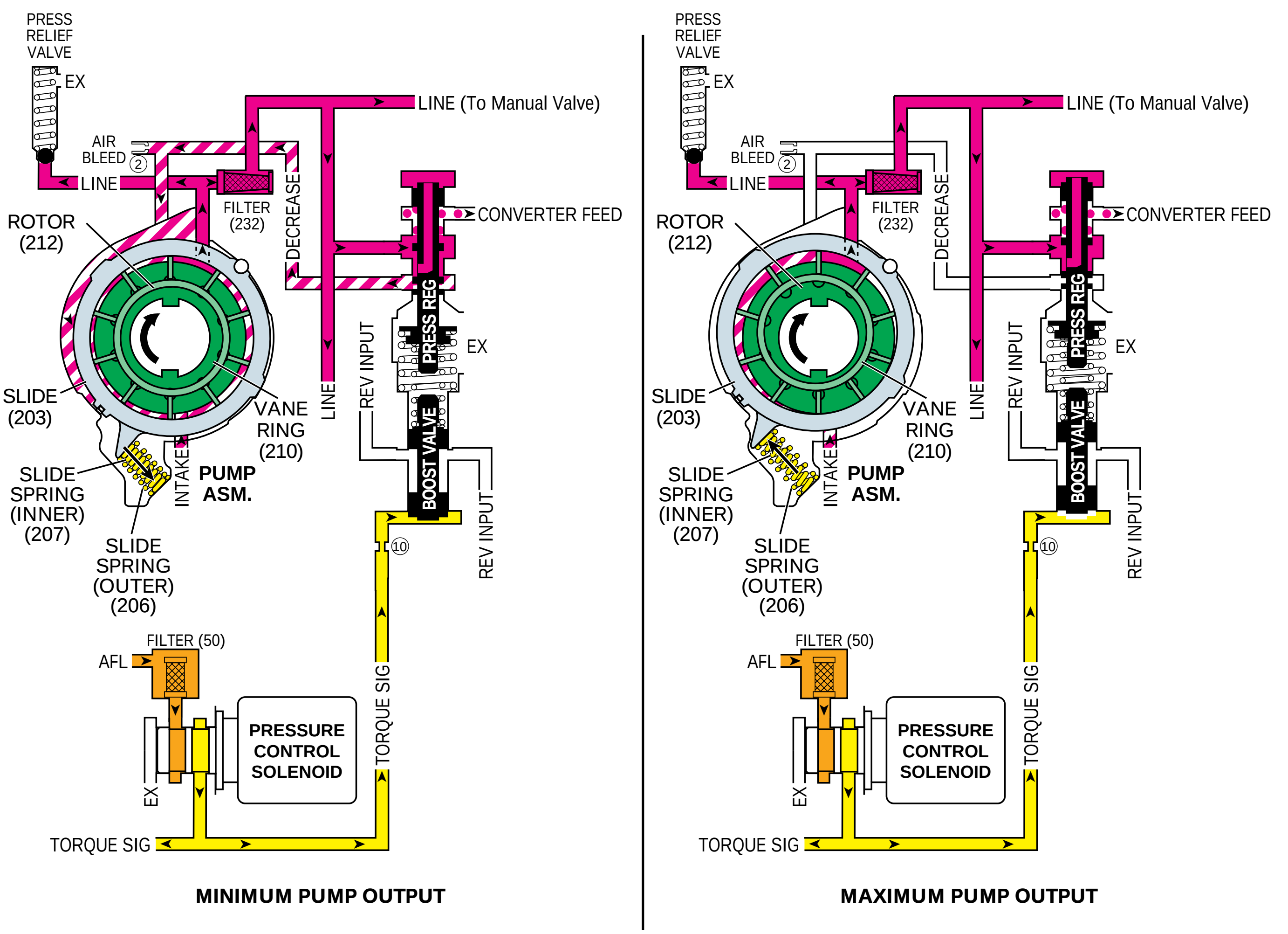


Figure 27

COMPONENTS LOCATED IN THE VALVE BODY

3-4 Shift Valve (385)
Biased by signal "A" fluid pressure from shift solenoid "A", spring force and D3 fluid pressure, the 3-4 shift valve controls the routing of 3-4 signal fluid. To obtain Fourth gear, signal "A" fluid pressure moves the valve against spring force and directs 3-4 signal fluid into the 4th signal fluid circuit. However, in Manual Third, D3 fluid assists spring force and holds the valve against signal "A" fluid pressure to prevent Fourth gear under any conditions. In the downshifted position, the 4th signal fluid circuit is open to an exhaust past the valve.

3-2 Downshift Valve (389)
The 3-2 downshift valve helps control the 2-4 band apply rate during a 3-2 downshift. During the downshift, 3-4 clutch fluid pressure holds the valve against spring force before exhausting. This allows 2nd fluid to quickly fill the 2nd clutch fluid circuit for a faster 2-4 band apply.

Reverse Abuse Valve (387)
The reverse abuse valve provides a faster apply of the reverse input clutch when throttle position is greater than idle. During these conditions, reverse fluid pressure increases and moves the valve against spring force. Reverse fluid can then quickly fill the reverse input fluid circuit. This bypasses the control of the reverse input orifice (#17) for a faster clutch apply.

3-2 Control Solenoid (394)
The 3-2 control solenoid is normally closed and controls the timing between the 3-4 clutch release and the 2-4 band apply during a 3-2 downshift. This is done through the use of pulse width modulation (duty cycle operation). The solenoid's duty cycle is controlled by the PCM in relation to vehicle operating conditions and regulates actuator feed limit (AFL) fluid into the 3-2 signal fluid circuit.

3-2 Control Valve (391)
The 3-2 control valve regulates the exhaust of 3rd accumulator fluid into the 3-4 clutch fluid circuit during a 3-2 downshift. This regulation is controlled by 3-2 signal fluid pressure from the 3-2 control solenoid. 3-2 signal fluid pressure moves the valve against spring force to open exhausting 3rd accumulator fluid to the 3-4 clutch fluid circuit. The amount the valve is opened to exhaust 3rd accumulator fluid controls the 3-2 downshift timing.

Manual Valve (340)
The manual valve is supplied line pressure from the pressure regulator valve and is mechanically linked to the gear selector lever. When a gear range is selected, the manual valve directs line pressure into various circuits by opening and closing fluid passages. The fluid circuits fed by the manual valve include Reverse, PR, D4, D3, D2 and lo.

Pressure Control Solenoid (377)
Controlled by the PCM through a duty cycle operation, the pressure control solenoid (PCS) regulates AFL fluid pressure into the torque signal fluid circuit. Torque signal fluid pressure is regulated in response to engine torque and other vehicle operating conditions. Torque signal fluid pressure is routed to the boost valve to increase line pressure and to the accumulator valve to help control shift feel.

Actuator Feed Limit Valve (374)
The AFL valve directs line pressure into the AFL fluid circuit. Spring force acting on the valve limits AFL fluid pressure to a maximum of approximately 795 kPa (115 psi). When line pressure is above this value, orificed AFL fluid pressure moves the valve against spring force to block line pressure, thereby providing the limiting action. AFL fluid is routed to the shift solenoids, pressure control solenoid, 3-2 control solenoid and the 2-3 shift valve train.

Converter Clutch Signal Valve (380)
The CC signal valve controls the routing of line pressure into the CC signal fluid circuit. 2nd clutch fluid pressure opens the valve in Second, Third and Fourth gears to direct line pressure into the CC signal fluid circuit.

3-4 Relay Valve (384) and 4-3 Sequence Valve (383)
These valves are used mainly to control the 4-3 downshift timing. The valves direct various fluids into different fluid circuits depending on the gear range. Spring force acting on the 4-3 sequence valve tends to keep the valves in the downshifted position. In Fourth gear, 4th signal fluid pressure moves both valves against spring force and into the upshifted position (see Overdrive Range: 4-3 Downshift on page 58).

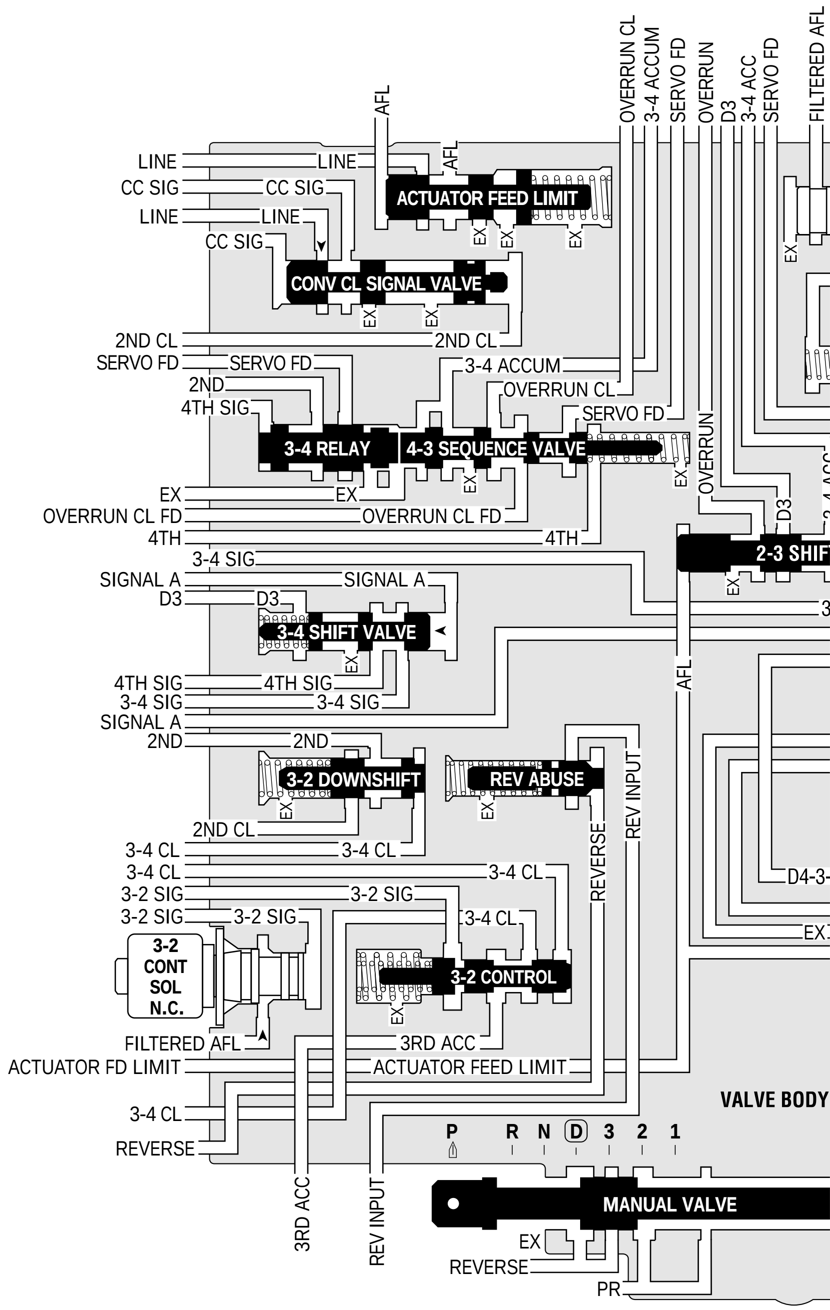
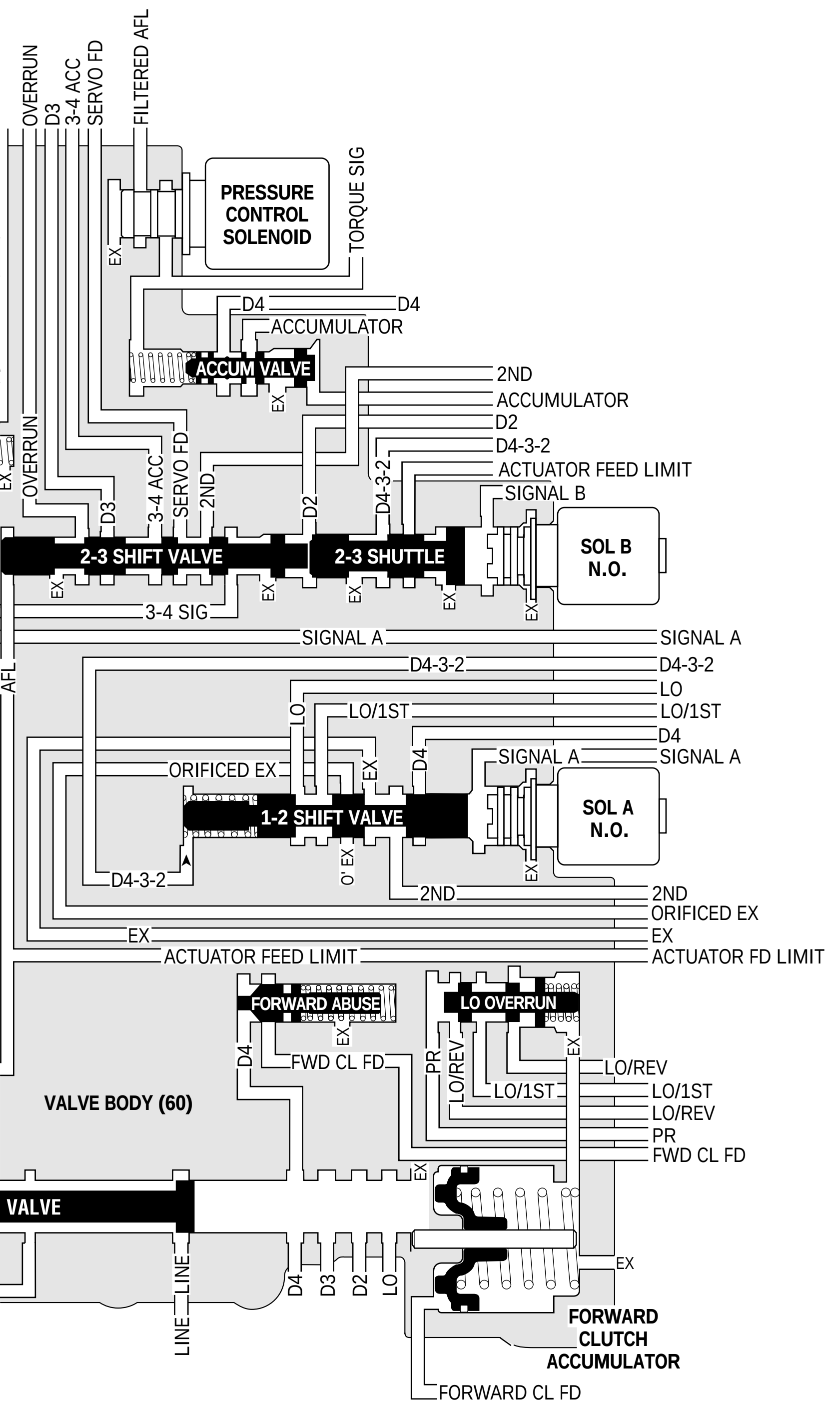


Figure 28

COMPONENTS LOCATED IN THE VALVE BODY

Accumulator Valve (371)
The accumulator valve is biased by torque signal fluid pressure, spring force and orificed accumulator fluid pressure at the end of the valve. The valve regulates D4 fluid into accumulator fluid pressure in relation to engine torque, as determine by torque signal fluid pressure. Accumulator fluid pressure is used to control shift feel during the 1-2 and 3-4 shifts. During the 1-2 and 3-4 upshifts, the valve regulates the exhaust of accumulator fluid to help control shift feel.



Shift Solenoid "B" (367)
Located at the end of the 2-3 shuttle valve, shift solenoid "B" is a normally open, ON/OFF type solenoid controlled by the PCM. The solenoid is used to control solenoid signal fluid pressure at the end of the 2-3 shuttle valve and the positioning of 2-3 shift valve train. When de-energized, the solenoid is open and solenoid signal fluid exhausts through the solenoid. When energized, the solenoid is closed and blocks solenoid signal fluid from exhausting, thereby creating solenoid signal fluid pressure at the end of the 2-3 shuttle valve.

2-3 Shift Valve (368) and 2-3 Shuttle Valve (369)
The 2-3 shift valve train responds to AFL fluid pressure acting on the 2-3 shift valve and solenoid signal fluid pressure from shift solenoid "B" at the 2-3 shuttle valve. Also, in Manual Second and Manual First gear ranges, D2 fluid pressure is routed between the two valves. D2 fluid pressure keeps the 2-3 shift valve in the downshifted position to prevent the transmission from upshifting above Second gear regardless of shift solenoid states. The valve train controls the routing and exhausting of various fluids to obtain the appropriate gear range as determined by the PCM or gear selector lever.

Shift Solenoid "A" (367)
Located at the end of the 1-2 shift valve, shift solenoid "A" is a normally open, ON/OFF type solenoid controlled by the PCM. The solenoid is used to control signal "A" fluid pressure and the positioning of both the 1-2 shift valve and the 3-4 shift valve. When de-energized (OFF), the solenoid is open and signal "A" fluid exhausts through the solenoid. When energized (ON), the solenoid is closed and blocks signal "A" fluid from exhausting, thereby creating signal "A" fluid pressure at the 1-2 and 3-4 shift valves.

1-2 Shift Valve (366)
The 1-2 shift valve is biased by signal "A" fluid pressure, spring force and D432 fluid pressure. The valve position depends on the shift solenoid states. Shift solenoid "A" controls signal "A" fluid pressure and shift solenoid "B" controls the 2-3 shuttle valve position and D432 fluid pressure. The 1-2 shift valve directs D4 fluid into the 2nd fluid circuit to upshift the transmission to Second gear. The valve also routes lo fluid into the lo/1st fluid circuit in Manual First - First Gear. The exhaust past the valve is an annulus exhaust in which exhausting fluid, either 2nd fluid or lo/1st fluid, flows around the valve land and through the valve body.

Forward Abuse Valve (357)
The forward abuse valve provides a faster apply of the forward clutch when throttle position is greater than idle. During these conditions, D4 fluid pressure increases and moves the valve against spring force. D4 fluid can then quickly fill the forward clutch feed fluid circuit. This bypasses the control of the forward clutch accumulator orifice (#22) for a faster clutch apply.

Lo Overrun Valve (361)
In Reverse, PR fluid moves the valve against spring force and fills the lo/reverse fluid circuit. In Manual First, the lo overrun valve regulates lo/1st fluid pressure into the lo/reverse fluid circuit. This regulation is biased by spring force and orificed lo/reverse fluid pressure acting on the valve.

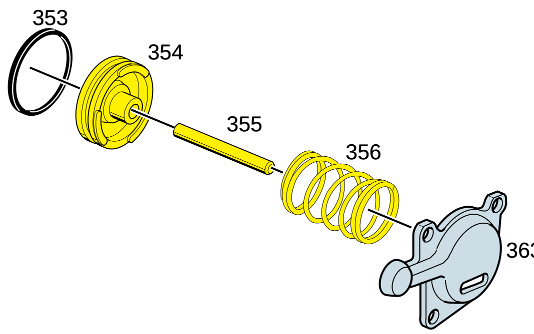
Forward Clutch Accumulator
Forward clutch accumulator spring force absorbs the initial increase in forward clutch feed fluid pressure to cushion the forward clutch apply. Refer to page 32 for a complete description of accumulator function.

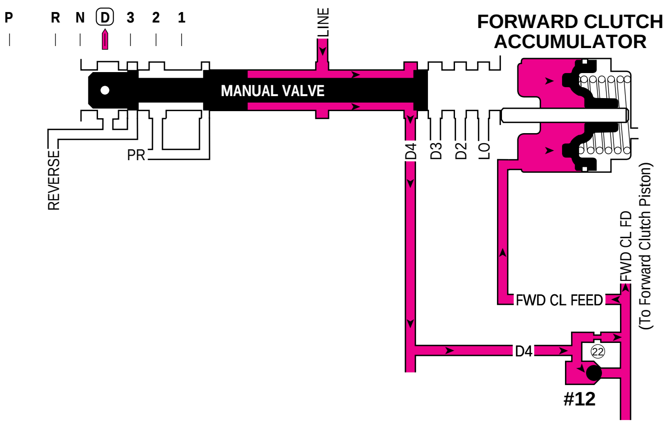
Note: Refer to the 'Power Flow' and 'Complete Hydraulic Circuit' sections for a detailed explanation of each components operation in a specific gear range. Also, refer to the 'Electronic Components' section for a detailed description of each electronic component.

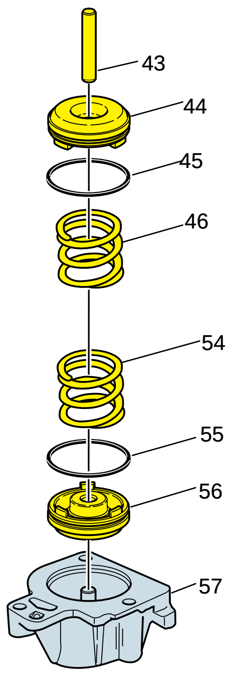
ACCUMULATORS

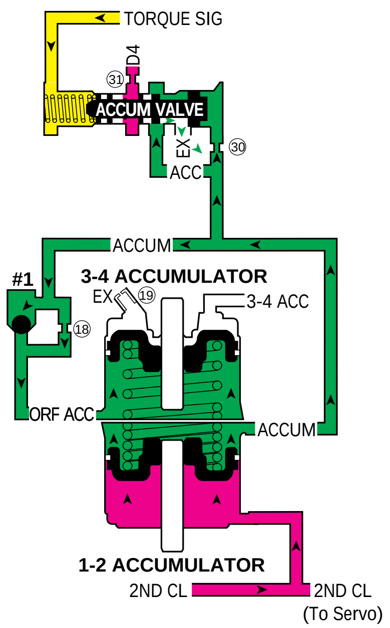
General Function
In the Hydra-matic 4L60-E transmission, accumulators are used to control shift feel during the apply of the forward clutch, 2-4 band (in both Second and Fourth gears) and 3-4 clutch. An accumulator is a spring loaded device that absorbs a certain amount of apply fluid pressure to cushion the apply of a clutch or band. Apply fluid pressure directed to an accumulator piston opposes a spring force, and an accumulator fluid pressure (except in the forward clutch accumulator), to act like a shock absorber.

During the apply of a clutch or band, apply fluid pressure builds up rapidly when the friction element begins to hold. As the fluid pressure increases, it also moves the accumulator piston against spring force and accumulator fluid pressure. Without an accumulator in the apply fluid circuit, the rapid buildup of fluid pressure would cause the clutch or band to apply very quickly and possibly create a harsh shift. However, accumulator spring force and accumulator fluid pressure absorb some of the initial apply fluid pressure to allow a more gradual apply of the clutch or band.









EXAMPLE: 1-2 UPSHIFT

FORWARD CLUTCH ACCUMULATOR
The forward clutch accumulator is located in the valve body (350) and helps control the garage shift feel into a forward drive range from Park, Reverse or Neutral. Forward clutch feed fluid pressure that applies the forward clutch is also routed to the forward clutch accumulator piston (354). Forward clutch feed fluid pressure moves the accumulator piston against spring force (356) as the clutch begins to apply. This action absorbs some of the initial increase of clutch apply fluid pressure to cushion the forward clutch apply.

1-2 and 3-4 ACCUMULATOR ASSEMBLIES
Accumulator Valve Function
The 1-2 and 3-4 accumulator assemblies help cushion the 2-4 band apply rate. These assemblies use an accumulator fluid pressure to assist spring force. Accumulator fluid pressure is regulated by the accumulator valve (371) in relation to torque signal fluid pressure. The pressure control solenoid (PCS) is controlled by the PCM and regulates torque signal fluid pressure in relation to engine torque, throttle position and other vehicle operating conditions.

When engine torque is a maximum, a greater apply pressure is required to prevent the band from slipping during apply and hold the band against the reverse input housing. When engine torque is a minimum, the band requires less apply force and a slower apply rate. The regulating action of the accumulator valve compensates for these various operating conditions by increasing accumulator fluid pressure as engine torque and torque signal fluid pressure increase.

1-2 Accumulator Assembly
The 1-2 accumulator assembly is used to control the apply feel of the 2-4 band in Second gear. The assembly is located between the spacer plate (48) and 1-2 accumulator cover (57) and consists of a piston (56), spring (54) and apply pin.

Upshift Control
During a 1-2 upshift (as shown in Example), 2nd clutch fluid is routed to both the servo assembly and the 1-2 accumulator assembly. The rapid buildup of fluid pressure in the 2nd clutch fluid circuit strokes the accumulator piston against spring force and accumulator fluid pressure. This action absorbs some of the initial buildup of 2nd clutch fluid pressure and provides a time delay to cushion the 2-4 band apply.

As 2nd clutch fluid pressure moves the accumulator piston, some accumulator fluid is forced out of the 1-2 accumulator assembly. This fluid pressure is routed back to the accumulator valve. The increase in accumulator fluid pressure acting on the end of the accumulator valve moves the valve against spring force and torque signal fluid pressure. This blocks D4 fluid and regulates the exhaust of the excess accumulator fluid pressure past the accumulator valve and through an exhaust port. This regulation provides additional control for the accumulation of 2nd clutch fluid and apply of the 2-4 band.

Figure 29

Downshift Control
2nd clutch fluid pressure exhausts from the 1-2 accumulator assembly during a 2-1 downshift. As spring force and accumulator fluid pressure move the 1-2 accumulator piston against exhausting 2nd clutch fluid, the accumulator valve regulates more D4 fluid into the accumulator fluid circuit. This regulation controls the rate at which accumulator fluid fills the 1-2 accumulator and the rate at which 2nd clutch fluid exhausts from the accumulator.

3-4 ACCUMULATOR ASSEMBLY
The 3-4 accumulator assembly is located in the transmission case and consists of a piston (44), piston spring (46) and piston pin (43). The 3-4 accumulator assembly is the primary device for controlling the apply feel of the 2-4 band in Fourth gear.

The 3-4 accumulator assembly functions similar to the 1-2 accumulator assembly. During a 3-4 upshift the 3-4 accumulator absorbs the initial increase of 3-4 accumulator fluid pressure to control the 2-4 band apply.

3-4 Accumulator Checkball (#1)
During a 4-3 downshift, accumulator fluid seats the #1 checkball and is orificed into the orificed accumulator fluid circuit. This orifice (#18) controls the increase of orificed accumulator fluid pressure and the movement of the 3-4 accumulator piston against exhausting 3-4 accumulator fluid.

2-3 UPSHIFT ACCUMULATION (Figure 29A)
During a 2-3 upshift, the 2-4 band releases as the 3-4 clutch applies. To accomplish this, 3-4 clutch fluid that applies the 3-4 clutch is also routed into the 3rd accumulator fluid circuit. 3rd accumulator fluid pressure is used to release the band while 3-4 clutch fluid pressure is used to apply the 3-4 clutch. 3rd accumulator fluid pressure is routed to the 2-4 servo and moves the 2nd apply piston against spring force and 2nd clutch fluid pressure to release the band. This action functions as an accumulator for the 3-4 clutch by absorbing some of the initial increase in 3-4 clutch fluid pressure.

2-4 SERVO ASSEMBLY

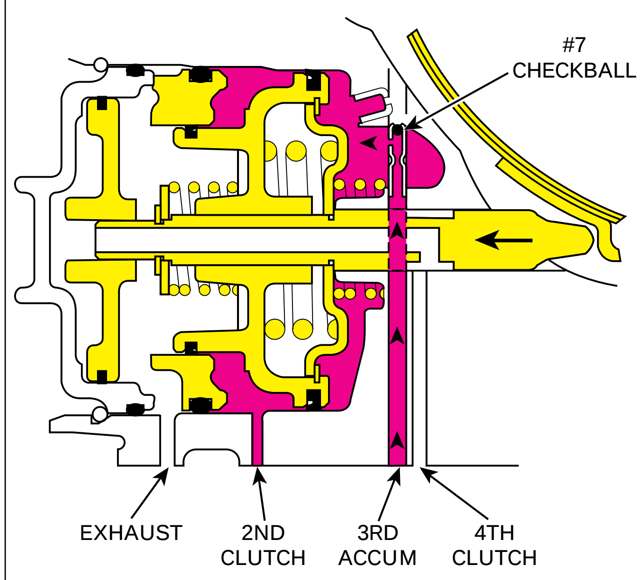


Figure 29A

CHECKBALL LOCATION AND FUNCTION

#1 3-4 ACCUMULATOR
Located in the transmission case, the 3-4 accumulator checkball helps control the flow of accumulator fluid to the 3-4 accumulator. When the ball is seated, accumulator fluid is forced through the #18 orifice. This action helps control the 2-4 band release during a 4-3 downshift.

#2 3RD ACCUMULATOR
Located in the valve body, the 3rd accumulator checkball directs exhausting 3rd accumulator fluid through orifice #12 and to the 3-2 control valve. This helps control the 2-4 band apply during a 3-2 downshift. During a 3-4 upshift, 3-4 clutch fluid unseats the ball for a quick feed into the 3rd accumulator fluid circuit.

Note: Some models do not include orifice #12 in the spacer plate. For these models, all exhausting 3rd accumulator fluid is routed to the 3-2 control valve.

#3 REVERSE INPUT
Located in the valve body, the reverse input checkball controls the reverse input clutch apply when engine speed is at idle. During these conditions, all reverse fluid feeding the reverse input fluid circuit is routed to the ball, seats the ball, and is forced through orifice #17. This slows the flow of reverse fluid to cushion the reverse input clutch apply. When the reverse input clutch releases, exhausting reverse input fluid unseats the ball for a quick exhaust of fluid.

#4 3-4 CLUTCH EXHAUST
Located in the valve body, this checkball helps control the 3-2 downshift. Exhausting 3-4 clutch and 3rd accumulator fluids seat the ball and are forced through orifice #13. This helps control the 3-4 clutch release rate and 2-4 band apply. During a 3-4 upshift, 3-4 signal fluid unseats the ball for a quick feed into the 3-4 clutch fluid circuit.

#5 OVERRUN CLUTCH FEED
Located in the valve body, it routes either overrun fluid or D2 fluid into the overrun clutch feed fluid circuit while blocking the other fluid circuit. Overrun clutch feed fluid feeds the overrun clutch fluid circuit in the Manual gear ranges to apply the overrun clutch.

#6 OVERRUN CLUTCH CONTROL
Located in the valve body, the #6 checkball helps control the overrun clutch apply rate. Overrun clutch feed fluid pressure seats the ball and is forced through orifice #20. This orifice slows the flow of overrun fluid to cushion the overrun clutch apply. When the overrun clutch releases, overrun clutch feed fluid unseats the ball for a quick exhaust.

#7 3RD ACCUMULATOR EXHAUST
Located in the transmission case, it unseats when 3rd accumulator fluid exhausts from the 2-4 servo to prevent residual fluid pressure from accumulating. Also, before 3rd accumulator fluid pressure seats the ball during a 2-3 upshift, any air in the circuit exhausts past the ball.

#8 1-2 UPSHIFT
Located in the valve body, the 1-2 upshift checkball helps control the 2-4 band apply during a 1-2 upshift. During the upshift, 2nd fluid pressure seats the ball and is forced through the #16 orifice. This orifice slows the flow of 2nd fluid to help cushion the band apply. When the band releases during a 2-1 downshift, exhausting 2nd clutch fluid unseats, and exhausts past, the 1-2 upshift checkball.

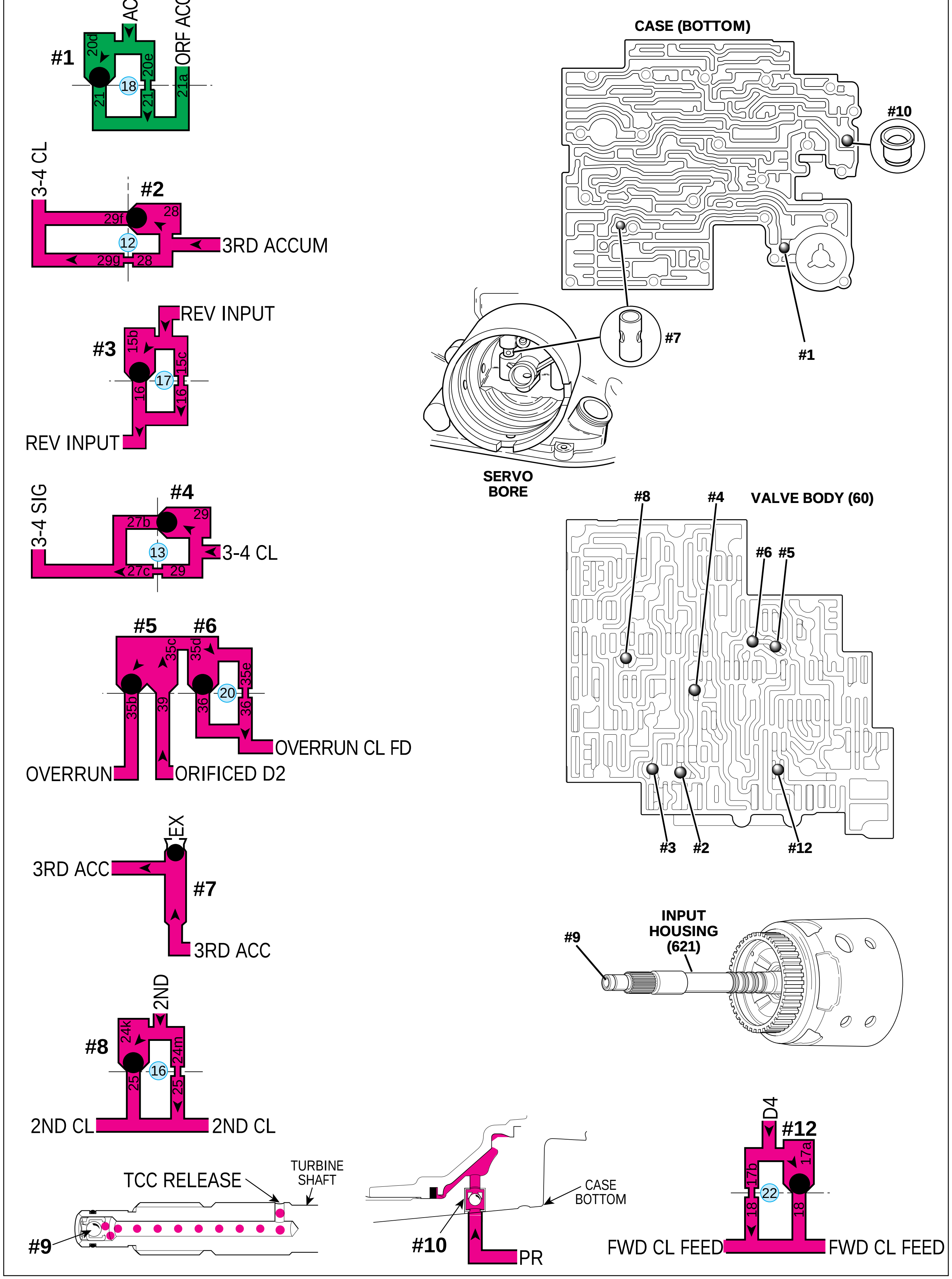
#9 TCC APPLY
Located in the end of the turbine shaft, the #9 checkball is a retainer and ball assembly that helps control the converter clutch apply feel. As the converter clutch applies, exhausting release fluid seats, and is orifice around the checkball. This action slows the exhaust of release fluid to control the converter clutch apply feel. When the converter clutch is released, release fluid pressure unseats the checkball and flows freely past the ball to keep the pressure plate disconnected from the converter cover.

#10 LO/REVERSE CLUTCH APPLY
Located in the transmission case, the #10 checkball is a retainer and ball assembly that helps control the lo and reverse clutch apply feel. During the clutch apply, PR fluid pressure seats, and is orificed around the checkball. This orifice slows the increase of PR fluid pressure at the clutch piston to cushion the apply feel. When the clutch releases, exhausting PR fluid unseats the checkball for a quick exhaust.

#12 FORWARD CLUTCH ACCUMULATOR
Located in the valve body, it helps controls the forward clutch apply when engine speed is at idle. During these conditions, all D4 feeding the forward clutch feed fluid circuit is routed to the ball, seats the ball, and is forced through orifice #22. This slows the increase of forward clutch feed fluid pressure to cushion the forward clutch apply. When the forward clutch releases, exhausting forward clutch feed fluid unseats the ball for a quick exhaust of fluid.

HYDRAULIC CONTROL COMPONENTS

CHECKBALL LOCATION AND FUNCTION



ELECTRICAL COMPONENTS

The Hydra-matic 4L60-E transmission incorporates electronic controls that utilize a Powertrain Control Module (PCM). The PCM gathers vehicle operating information from a variety of sensors and control components located throughout the powertrain (engine and transmission). The PCM processes this information for proper control of the following:

- transmission shift points - through the shift solenoids,
- transmission shift feel - by adjusting line pressure with the pressure control solenoid,
- TCC apply and release timing - through the TCC solenoid, and
- the 3-2 downshift - through the pulse width modulated 3-2 control solenoid.

Electronic control of these transmission operating characteristics provides for consistent and precise shift points and shift quality based on the operating conditions of both the engine and transmission.

FAIL-SAFE MODE

"Fail-safe" mode is an operating condition when the transmission will partially function if a portion of the electronic control system becomes disabled. For example, if the wiring harness becomes disabled, the PCM commands the fail-safe mode which causes the electronic solenoids to default to OFF. The following changes occur when the transmission is operating in the fail-safe mode.

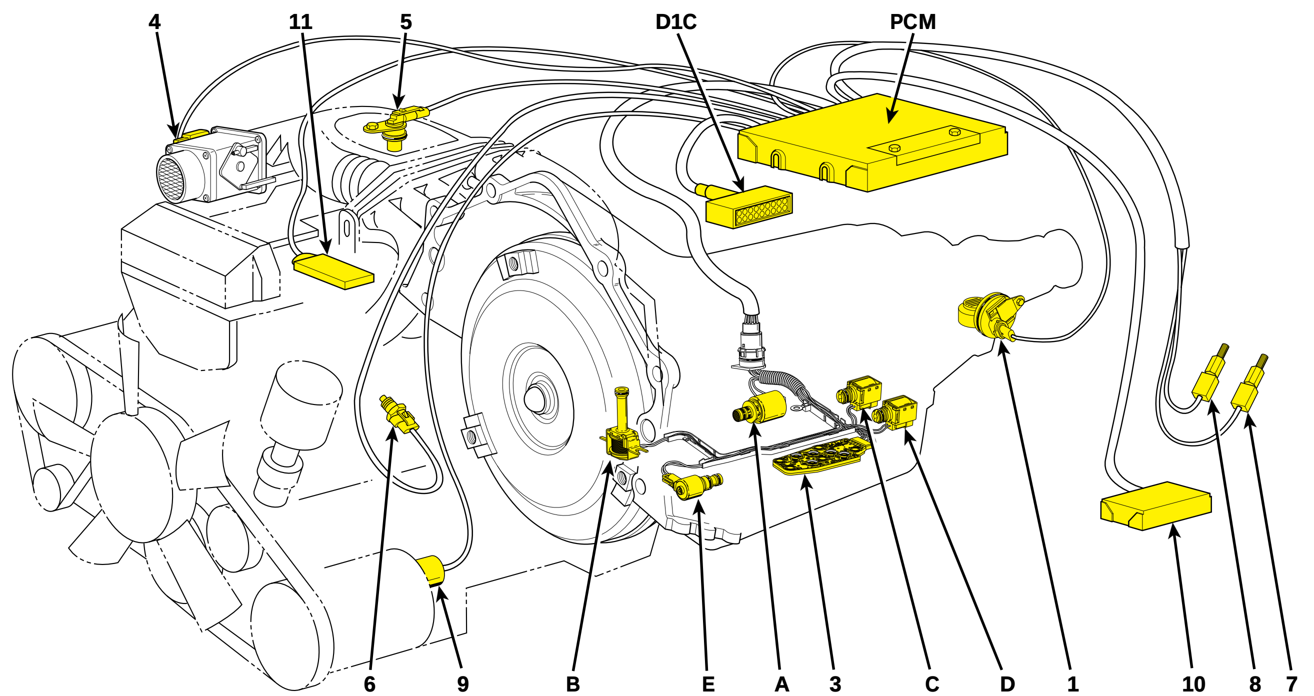
- the pressure control solenoid is OFF, increasing line pressure to a maximum to prevent any clutch or band slippage,
- the TCC solenoid is OFF, preventing converter clutch apply,
- the 3-2 control solenoid is OFF, providing a faster 3-2 downshift, and
- both shift solenoids are OFF.

With both shift solenoids OFF, the transmission will operate in Third gear when the selector lever is in the Overdrive position. However, with the Hydra-matic 4L60-E transmission the driver has some flexibility in gear selection during fail-safe mode. Changing gears during fail-safe mode is accomplished by moving the gear selector lever as follows:

Gear Selector Lever Position	**Transmission Gear Operation**
Overdrive Range (D)	Third gear
Drive Range (D)	Third gear
Manual Second (2)	Second gear
Manual First (1)	Second gear
Reverse (R)	Reverse
Park, Neutral (P,N)	Park, Neutral

The downshift to First gear in Manual First is controlled electronically for safety and durability reasons. This means that the PCM must electronically command both shift solenoids to be ON to obtain First gear.

NOTE: This section of the book contains "general" information about electrical components that provide input information to the PCM. Since some of this input information varies between vehicle application, it is important that the appropriate General Motors Service Manual is used during repair of diagnosis of the transmission.



INPUTS

INFORMATION SENSORS

1. VEHICLE SPEED SENSOR
2. TRANSMISSION FLUID TEMPERATURE SENSOR
3. FLUID PRESSURE SWITCH ASSEMBLY (PSA)
4. THROTTLE POSITION SENSOR (TPS)
5. ENGINE SPEED SENSOR
6. ENGINE COOLANT TEMPERATURE SENSOR
7. BRAKE SWITCH
8. 4 WHEEL DRIVE LOW SWITCH
9. AIR CONDITIONING REQUEST
10. CRUISE CONTROL INFORMATION
11. MANIFOLD ABSOLUTE PRESSURE SENSOR

ELECTRONIC CONTROLLERS

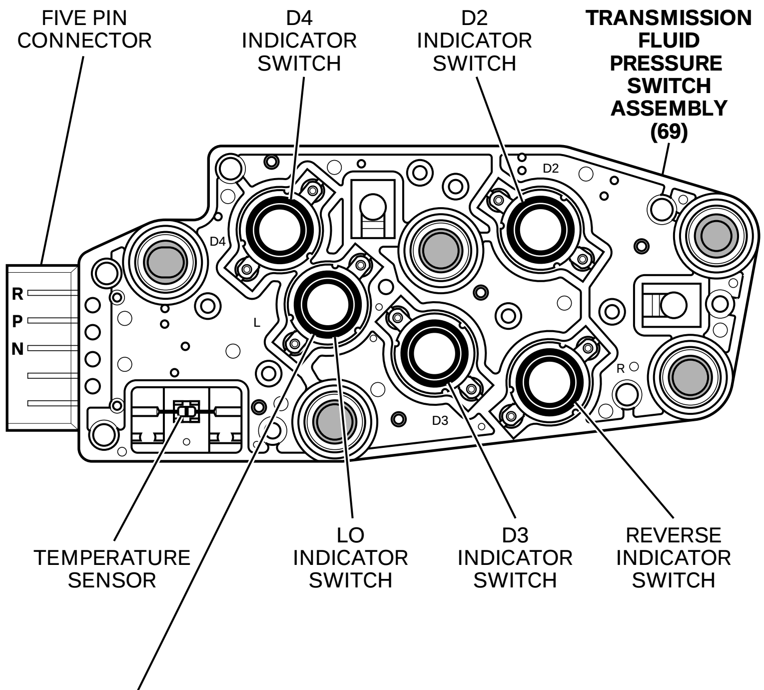
- POWERTRAIN CONTROL MODULE (PCM)

OUTPUTS

ELECTRONICALLY CONTROLLED TRANSMISSION COMPONENTS

A. PRESSURE CONTROL SOLENOID
B. TORQUE CONVERTER CLUTCH SOLENOID
C. SHIFT SOLENOID "A" (1–2/3–4 SHIFT)
D. SHIFT SOLENOID "B" (2–3 SHIFT)
E. 3–2 CONTROL SOLENOID

Figure 31

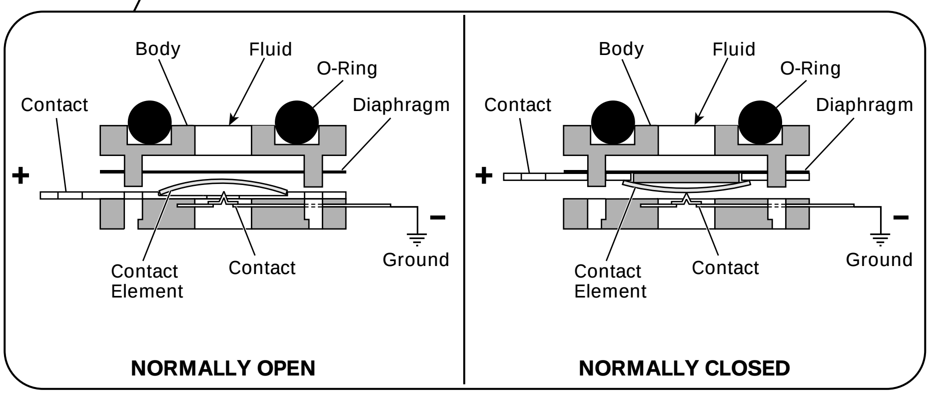


PRESSURE SWITCH ASSEMBLY

The transmission fluid Pressure Switch Assembly (PSA) is attached to the valve body and is used to signal the manual valve position to the PCM. Various fluids are routed to the PSA depending on the manual valve position. These fluids open and close the fluid pressure switches in the PSA to provide a signal to the PCM indicating the gear range position of the manual valve. The combination of opened and closed switches determines the voltage measured at each of the three pins in the PSA electrical connector. An open circuit measures 12 volts while a grounded circuit measures 0 volts. The electrical schematic and chart below show the PSA circuitry used to signal the manual valve position.

Normally Open Fluid Pressure Switch

The D4, Lo, and Reverse fluid pressure switches are normally open and electrical current is stopped at these switches when no fluid pressure is present. Fluid pressure moves the diaphragm and contact element until the contact element touches both the positive contact (+) and the ground contact (⏚). This creates a closed circuit and allows current to flow from the positive contact, through the switch and to ground.



Normally Closed Fluid Pressure Switch

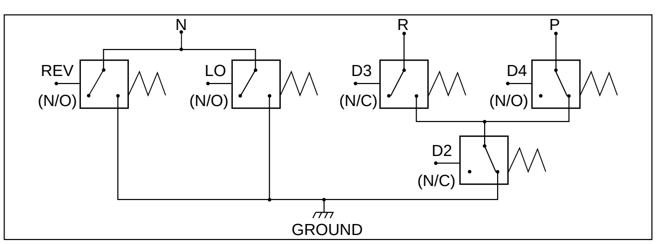
The D2 and D3 fluid pressure switches are normally closed and electrical current is free to flow from the positive contact to the ground contact when no fluid pressure is present. Fluid pressure moves the diaphragm to disconnect the positive and ground contacts. This opens the switch and stops current from flowing through the switch.

Example

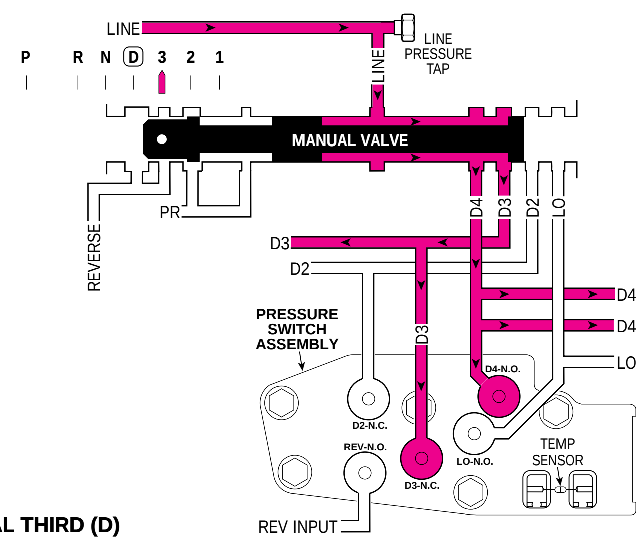
The hydraulic and electrical schematics below are shown in the Drive Range (Manual Third) position (D or 3). D4 fluid pressure closes the D4 fluid pressure switch and D3 fluid pressure opens the D3 fluid pressure switch. With the D2 switch normally closed, pins N and P measure 0 volts while pin R measures approximately 12 volts. This combination signals the PCM that the manual valve is in the Manual Third position.

RANGE INDICATOR	OIL PRESSURE					TRANSMISSION CONNECTOR		
	REV	D4	D3	D2	LO	PIN N	PIN R	PIN P
PARK						12	0	12
REVERSE	■					0	0	12
NEUTRAL						12	0	12
Ⓓ		■				12	0	0
D		■	■			12	12	0
2		■	■	■		12	12	12
1		■	■	■	■	0	12	12

■ OIL PRESSURE PRESENT — EXPECTED VOLTAGE READINGS

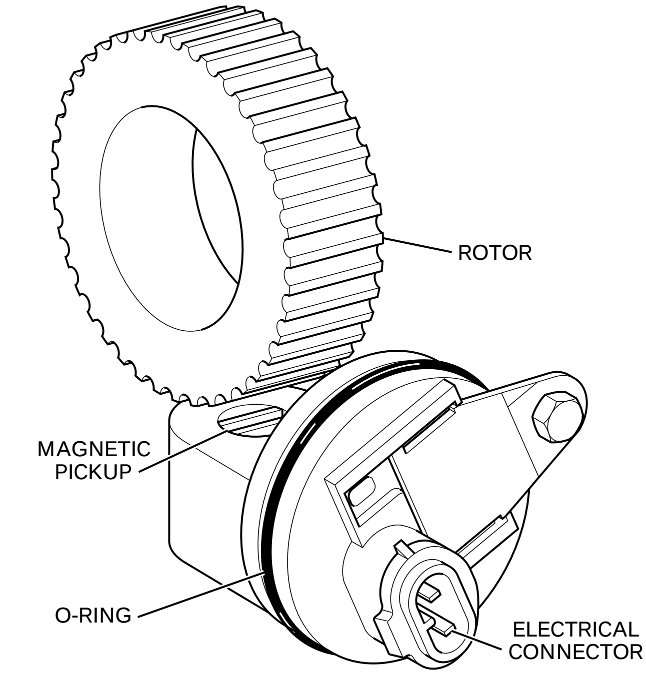


SWITCH LOGIC (N/O) - NORMALLY OPEN



EXAMPLE: MANUAL THIRD (D)

Figure 32



VEHICLE SPEED SENSOR

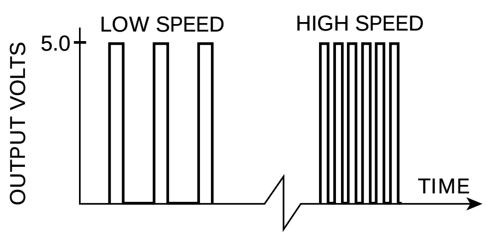


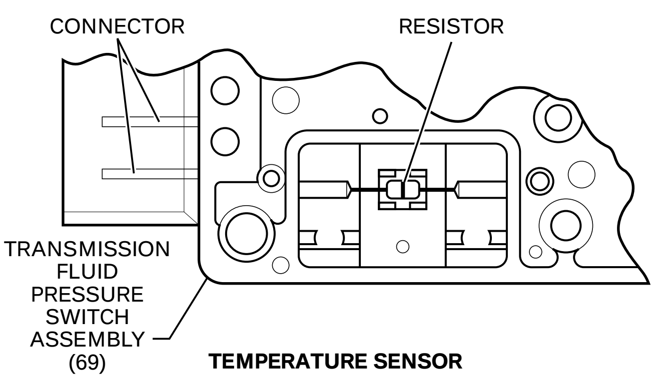
FIGURE A: CONDITIONED SIGNAL

VEHICLE SPEED SENSOR (VSS)

The vehicle speed sensor is a magnetic inductive pickup that relays information relative to vehicle speed to the PCM. In two wheel drive (2WD) applications, the VSS is located on the transmission extension housing (31), opposite the speed sensor rotor. The speed sensor rotor is attached to the transmission output shaft and rotates with the output shaft at transmission output speed. The speed sensor rotor has 40 serrations, or teeth, cut into it's outside diameter.

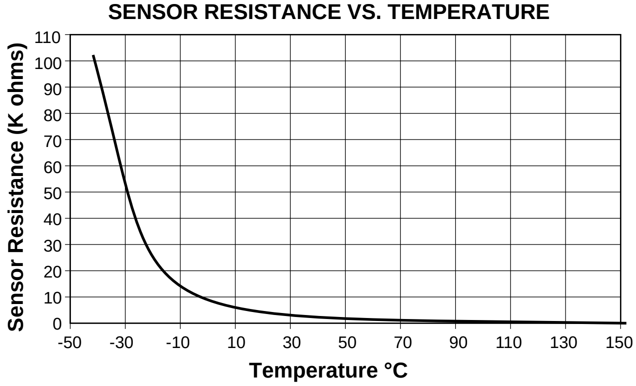
The VSS consists of a permanent magnet surrounded by a coil of wire. As the output shaft and speed sensor rotor rotate, an alternating current (AC) is induced in the coil of wire from the teeth on the rotor passing by the magnetic pickup on the VSS. Whenever the vehicle is moving the VSS produces an AC voltage proportional to vehicle speed. This AC signal is sent to the digital ratio adaptor converter (DRAC) where it is converted to a direct current (DC) square wave form. The DC signal is then sent to the PCM and interpreted as vehicle speed. As vehicle speed increases and more rotor teeth pass by the magnetic pickup on the VSS in a given time frame, the frequency of the DC signal sent to the PCM increases. The PCM interprets this increase in frequency as an increase in vehicle speed (see Figure A).

Note: On four wheel drive (4WD) applications the VSS is located on the transfer case.



TEMPERATURE SENSOR

SENSOR RESISTANCE VS. TEMPERATURE



TRANSMISSION FLUID TEMPERATURE SENSOR

The temperature sensor is a negative temperature coefficient thermistor (temperature sensitive resistor) that provides information to the PCM regarding transmission fluid temperature. The temperature sensor is a part of the pressure switch assembly (PSA) which is attached to the valve body and submersed in fluid in the transmission bottom pan. The internal electrical resistance of the sensor varies in relation to the operating temperature of the transmission fluid (see chart). The PCM sends a 5 volt reference signal to the temperature sensor and measures the voltage drop in the circuit. A lower fluid temperature creates a higher resistance in the temperature sensor, thereby measuring a higher voltage signal.

The PCM measures this voltage as another input to help control TCC apply and line pressure. The PCM inhibits TCC apply until transmission fluid temperature reaches approximately 29°C (84°F). Also, when fluid temperatures exceed 135°C (275°F), the PCM commands TCC apply at all times in Fourth gear, as opposed to having a scheduled apply. Applying the TCC reduces fluid temperatures created by the fluid coupling in the converter.

Figure 33

ELECTRICAL COMPONENTS EXTERNAL TO THE TRANSMISSION

THROTTLE POSITION SENSOR (TPS)

The TPS is a potentiometer mounted to the throttle body that provides the PCM with information relative to throttle angle (accelerator pedal movement). The PCM provides a 5 volt reference signal and a ground to the TPS and the sensor returns a signal voltage that changes with throttle valve angle. This signal varies from less than 1.0 volt at minimum throttle to nearly 5.0 volts at wide-open throttle. The PCM uses this information to modify fuel control, shift patterns, shift feel and TCC apply and release timing. In general, with greater accelerator pedal travel and higher TPS voltage signal, the following conditions occur:

- The PCM delays upshifts or initiates a downshift (through the shift solenoids) for increased acceleration.
- The PCM increases line pressure (through the pressure control solenoid) to increase the holding force on the clutches and/or band.
- The PCM keeps the TCC released during heavy acceleration. The TCC is also released during minimum acceleration.

ENGINE COOLANT TEMPERATURE (ECT) SENSOR

The ECT sensor is a negative temperature coefficient resistor (temperature sensitive resistor) mounted in the engine coolant stream. Low coolant temperature produces high resistance in the sensor while high coolant temperature produces low resistance. With respect to transmission operation, the PCM monitors the voltage signal from the sensor, which is high at low coolant temperatures, to prevent TCC apply when coolant temperature is below approximately 20°C (68°F).

ENGINE SPEED SENSOR

The PCM monitors engine speed as RPM through the ignition module for gasoline engines. For diesel engine applications, a separate engine speed sensor is used to monitor engine speed from the crankshaft. This information is used to help determine shift patterns and TCC apply and release timing.

BRAKE SWITCH

The brake switch is a normally closed switch when the brake pedal is in the released position. When the brake pedal is depressed, the switch is open and the PCM commands TCC release.

AIR CONDITIONING (A/C) SWITCH SIGNAL

When the A/C cycling switch closes, the PCM is signaled that the A/C compressor is ON. The PCM uses this information to adjust transmission line pressure, shift timing and TCC apply timing.

CRUISE CONTROL INFORMATION

The PCM monitors input signals from the cruise control switch to alter shift patterns when the cruise control is engaged. Depending on application, the PCM alters the shift pattern to require a time limit to be met between the 3-2/2-3 shifts and the 4-3/3-4 shifts. This time limit prevents the transmission from upshifting to quickly after downshifting when the cruise control is engaged.

FOUR WHEEL DRIVE (4WD) LOW SWITCH

With 4WD applications, the VSS is located on the transfer case. The 4WD Low switch signals the PCM that the vehicle is operating in 4WD Low. The PCM then multiplies transfer case output speed signal by the transfer case ratio in low range to determine the transmission output shaft speed. The PCM uses this information to provide earlier upshifts and prevent an overspeed condition when operating in 4WD low.

MANIFOLD ABSOLUTE PRESSURE (MAP) SENSOR

The MAP sensor measures changes relative to intake manifold pressure which results from changes in engine load and speed. These changes are converted to a voltage output which is monitored by the PCM in order to adjust line pressure and shift timing.

ASSEMBLY LINE DIAGNOSTIC LINK (ALDL)

The ALDL is a multi-terminal connector wired to the PCM that is located under the vehicle dash. The ALDL can be used to diagnose conditions in the vehicle's electrical system, PCM and the transmission's electrical components. Refer to the appropriate General Motors Service Manual for specific electrical diagnosis information.

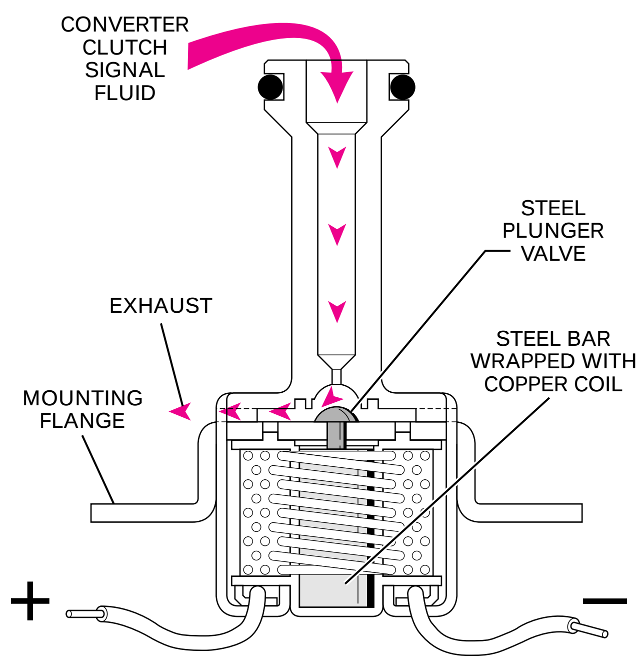
TORQUE CONVERTER CLUTCH SOLENOID

The TCC solenoid is a normally open, ON/OFF solenoid that the PCM controls to apply and release the converter clutch. When de-energized, converter clutch signal fluid pressure holds the valve and plunger away from the exhaust port. This allows converter clutch (CC) signal fluid to exhaust through the solenoid. Without CC signal fluid pressure at the end of the converter clutch apply valve, spring force holds the valve in the release position.

When vehicle operating conditions are appropriate for TCC apply, the PCM provides a ground for the TCC solenoid electrical circuit. Electrical current flows through the coil assembly in the solenoid which creates a magnetic field. The magnetic field moves the plunger and valve to block the exhaust port and prevent CC signal fluid from exhausting through the solenoid. CC signal fluid pressure increases at the converter clutch apply valve and moves the valve into the apply position against spring force.

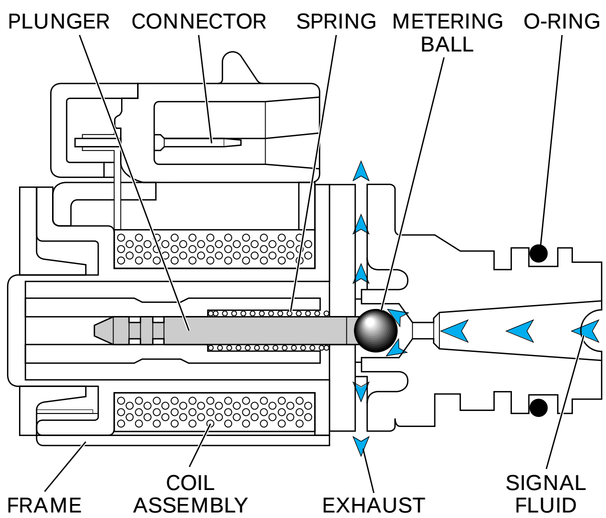
Under normal operating conditions, the converter clutch only applies in Fourth gear when in Overdrive range or Third gear when in Manual Third gear range. However, at high speeds under heavy throttle conditions, the PCM will command TCC apply in Third gear when in Overdrive range. Also, when transmission fluid temperature is above approximately 135°C (275°F), the TCC is applied all of the time in Fourth gear to help reduce transmission fluid temperatures. Other conditions that cause the PCM to change the operating state of the TCC solenoid include:

- The TCC is released when the brake pedal is depressed.
- The TCC is released under minimum and maximum throttle conditions.
- TCC apply is prevented until engine coolant temperature is above approximately 20°C (68°F).
- TCC apply is prevented until transmission fluid temperature is above approximately 29°C (84°F).

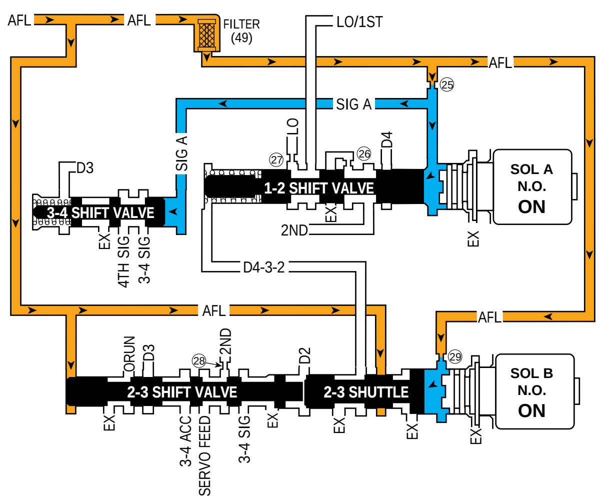


TORQUE CONVERTER CLUTCH SOLENOID (NORMALLY OPEN)

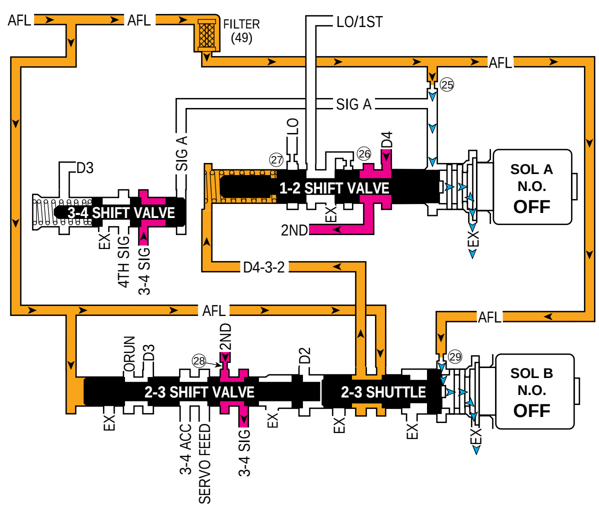
Figure 34



SHIFT SOLENOID (OFF)



EXAMPLE A: PARK/REVERSE/NEUTRAL/& FIRST GEAR



EXAMPLE B: THIRD GEAR

SHIFT SOLENOIDS

The Hydra-matic 4L60-E transmission uses two identical, normally open, electronic shift solenoids (“A” and “B”) to control upshifts and downshifts in all forward gear ranges. These shift solenoids work together in a combination of ON and OFF sequences to control the positions of the 1-2 shift valve, 2-3 shift valve train and 3-4 shift valve. The PCM monitors numerous inputs to determine the appropriate solenoid state combination and transmission gear for the vehicle operating conditions. The following table shows the solenoid state combination required to obtain each gear:

GEAR	SOLENOID “A”	SOLENOID “B”
Park, Reverse, Neutral	ON	ON
First	ON	ON
Second	OFF	ON
Third	OFF	OFF
Fourth	ON	OFF

Shift Solenoid De-energized (OFF)

The shift solenoids are OFF when the PCM opens the path to ground for the solenoid’s electrical circuit. When OFF, solenoid signal fluid pressure (blue color) moves the metering ball and plunger against spring force, away from the fluid inlet port. Solenoid signal fluid is then open to an exhaust port located on the side of the solenoid.

Shift Solenoid Energized (ON)

To energize the shift solenoids, the PCM provides a path to ground for the solenoid’s electrical circuit. Electrical current passing through the coil assembly in the solenoid creates a magnetic field that magnetizes the solenoid core. The magnetized core repels the plunger which seats the metering ball against the fluid inlet port. With the ball seated, solenoid signal fluid is blocked from exhausting, thereby creating fluid pressure in the solenoid signal fluid circuit.

Shift Solenoid “A”

Located at the end of the 1-2 shift valve, shift solenoid “A” controls the position of the 1-2 and 3-4 shift valves. The solenoid is fed solenoid signal “A” fluid by the actuator feed limit fluid (AFL) circuit through orifice #25. When energized (Example "A"), the solenoid blocks signal “A” fluid from exhausting, thereby creating pressure in the signal “A” fluid circuit. Signal “A” fluid pressure holds the 1-2 shift valve against spring force (downshifted position) in Park, Reverse, Neutral and First gears. In Fourth gear, D432 fluid pressure assists spring force to keep the 1-2 shift valve in the upshifted position against signal “A” fluid pressure. Also, signal “A” fluid pressure holds the 3-4 shift valve in the upshifted position against spring force.

When shift solenoid “A” is de-energized in Second and Third gears (Example "B"), signal “A” fluid exhausts through the solenoid. Spring force holds the 1-2 shift valve in the upshifted position and the 3-4 shift valve in the downshifted position.

Shift Solenoid “B”

Located at the end of the 2-3 shuttle valve, shift solenoid “B” controls the position of the 2-3 shift valve train. The solenoid is fed solenoid signal fluid by the AFL fluid circuit through orifice #29. When energized by the PCM (Example "A"), solenoid signal fluid pressure holds the 2-3 shift valve train in the downshifted position against AFL fluid pressure acting on the 2-3 shift valve.

When de-energized [Third and Fourth gears (Example "B")], solenoid signal fluid exhausts through the solenoid. This allows AFL fluid pressure acting on the 2-3 shift valve to move the shift valve train into the upshifted position. In Manual Second, D2 fluid pressure holds the 2-3 shift valve in the downshifted position against AFL fluid pressure regardless of shift solenoid “B” state.

Note: The feed orifices (#25 and #29) between the AFL and solenoid signal fluid circuits are smaller than the exhaust ports through the solenoids. This prevents fluid pressure buildup in the solenoid signal fluid circuits at the end of the shift valves when the shift solenoids are OFF.

Figure 35

3-2 DOWNSHIFT CONTROL SOLENOID

The 3-2 downshift control solenoid is a normally closed, pulse width modulated (PWM) solenoid used to control the 3-2 downshift. During a 3-2 downshift, the 2-4 band is applied as the 3-4 clutch releases. The timing between the 3-4 clutch release and 2-4 band apply must be varied depending on vehicle speed and throttle position (see downshift timing below). The 3-2 control solenoid regulates AFL fluid into the 3-2 signal fluid circuit. 3-2 signal fluid pressure controls the 3-2 control valve to provide for these varying requirements and achieve a precise control of the 3-2 downshift.

The PCM operates the 3-2 control solenoid at a frequency of 50 hz (cycles per second). This means that the solenoid is pulsed with electrical current 50 times per second. The amount of time the solenoid is energized during each cycle is referred to as the solenoid's duty cycle. Figure A shows an example of a 70% duty cycle. A 70% duty cycle means that during each cycle (1/50 of a second) the solenoid is energized 70% of the time (see inset in Figure A).

The 3-2 control solenoid operates on a negative duty cycle. This means that the ground (negative or low) side of the solenoid circuit is controlled by the PCM. The solenoid is constantly fed 12 volts to the high (positive) side and the PCM controls the length of time the path to ground for the electrical circuit is closed (duty cycle). When the PCM closes the solenoid ground circuit, current flows through the solenoid and the ground circuit is at a low voltage state (0 volts and solenoid energized).

Solenoid De-energized

When the solenoid is OFF, no current flows to the solenoid coil (duty cycle = 0%). Spring force holds the plunger and metering ball against the fluid inlet port to block AFL fluid from entering the 3-2 signal fluid circuit. The 3-2 signal fluid circuit is open to an exhaust through the solenoid. With the 3-2 signal fluid circuit empty, spring force holds the 3-2 control valve open.

Solenoid Energized

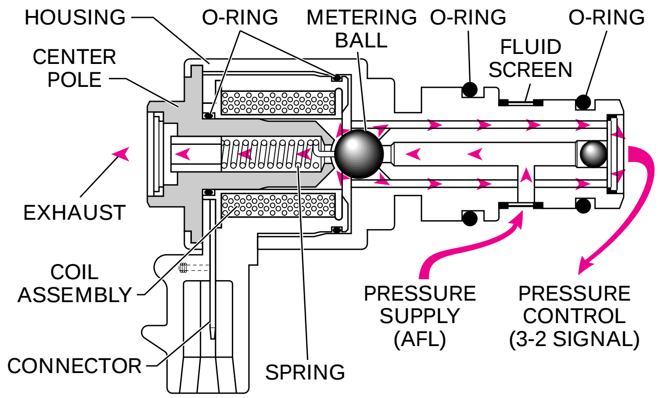
The position of the metering ball is controlled by the amount of current flowing through the solenoid coil. Current flowing through the solenoid coil, which is controlled by the solenoid's duty cycle, creates a magnetic field that magnetizes the solenoid core. When the core is magnetized it attracts the metering ball, moving the ball and plunger against spring force to block the exhaust port. A higher duty cycle means more current flowing through the coil and a greater magnetic field force. This greater force seats the ball further against the exhaust port, thereby increasing 3-2 signal fluid pressure.

3-2 Downshift Timing

The PCM operates the 3-2 control valve at approximately a 90% duty cycle when the transmission is in Second, Third and Fourth gears. In all other gear ranges, the solenoid is OFF and the duty cycle is 0%. During a 3-2 downshift, the solenoid duty cycle is decreased to control the exhaust of 3rd accumulator fluid through the 3-2 control valve. The value of the duty cycle during the downshift is related to vehicle speed - the lower the speed, the lower the duty cycle (see Figure B).

A lower solenoid duty cycle corresponds to lower 3-2 signal fluid pressure which allows spring force to keep the 3-2 control valve open farther. This provides a faster exhaust of 3rd accumulator fluid through the 3-2 control valve. However, this exhausting fluid creates a pressure backup in the 3-4 clutch fluid circuit due to the #4 checkball and #13 orifice. This delays the 3-4 clutch release at lower speeds for proper shift timing.

At higher vehicle speeds, the solenoid duty cycle during the shift is greater and 3-2 signal fluid pressure is increased. Under these conditions, 3-2 signal fluid pressure closes the 3-2 control valve further against spring force, thereby slowing the exhaust of 3rd accumulator fluid into the 3-4 clutch fluid circuit. This prevents the pressure backup in the 3-4 clutch fluid circuit and allows the 3-4 clutch to release faster for proper shift timing.



3-2 DOWNSHIFT CONTROL SOLENOID

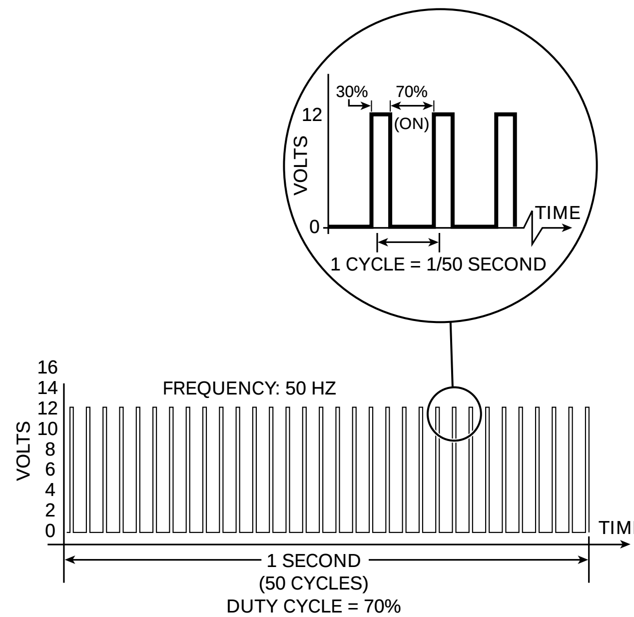


FIGURE A: 3-2 DOWNSHIFT CONTROL SOLENOID NEGATIVE DUTY CYCLE

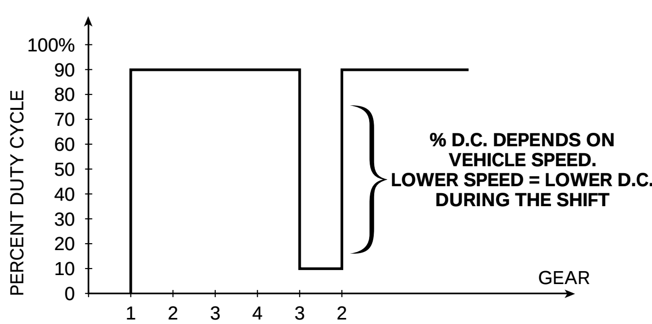


FIGURE B: 3-2 DOWNSHIFT TIMING

PRESSURE CONTROL SOLENOID

The Pressure Control Solenoid (PCS) is a precision electronic pressure regulator controlled by the PCM at approximately 292.5 Hz (cycles per second). The PCS regulates actuator feed limit (AFL) fluid into torque signal fluid pressure. The PCM controls this regulation by varying the electrical current flowing to the PCS.

Duty Cycle and Current Flow

The amount of current directed to the PCS is controlled by the solenoid's duty cycle. Similar to the pulse width modulated 3-2 control solenoid, the duty cycle represents the percent time current is flowing through the solenoid coil during each cycle. As duty cycle increases, the amperage in the coil increases. The high frequency of the PCS acts to smooth the pulses created by the duty cycle energizing and de-energizing the PCS.

The duty cycle and amount of current flow to the PCS are mainly affected by throttle position. Duty cycle and current flow are inversely proportional to throttle angle; as throttle angle increases, the duty cycle is decreased by the PCM which decreases current flow to the PCS. Current flow to the PCS creates a magnetic field force that moves the solenoid armature toward the push rod and against spring force. Note that AFL fluid flows through the restrictor to assist spring force in creating a dashpot for the armature to move against.

The PCM operates the PCS on a positive duty cycle. This means that the high (positive) side of the PCS electrical circuit at the PCM controls the PCS operation. The PCM always provides a ground path for the circuit and continually adjusts the PCS duty cycle depending on vehicle and transmission operating conditions. A positive duty cycle is measured as approximately 12 volts on the positive side of the PCS when it is energized. Figure B shows an example of a 40% positive duty cycle.

Fluid Regulation

At minimum throttle (idle), duty cycle is a maximum (approximately 40%) and current flow approaches 1.0 amp. This increases the magnetic field in the solenoid coil. The magnetic field force moves the armature toward the push rod and against the spring. In this position AFL fluid exhausts through the variable bleed exhaust port between the armature and spool valve sleeve. With AFL fluid exhausting, spool valve spring force holds the spool valve in the closed position blocking AFL fluid from feeding the torque signal fluid circuit. Also, torque signal fluid is open to the exhaust port through the spool valve sleeve. Therefore, torque signal fluid pressure is a minimum and line pressure is a minimum. Remember that torque signal fluid pressure controls line pressure at the pressure regulator valve.

At maximum throttle, the solenoid's duty cycle is a minimum (approximately 0% - always de-energized) and current flow approaches 0.0 amps. This decreases the magnetic field in the solenoid coil and spring force acting on the armature moves the armature against the spool valve sleeve, thereby closing the variable bleed exhaust. With the variable bleed exhaust closed, AFL fluid pressure acting on the spool valve increases and moves the valve fully against the spool valve spring force. The AFL fluid circuit is then completely open to feed the torque signal fluid circuit and the torque signal fluid exhaust through the spool valve sleeve is closed. This provides maximum torque signal fluid pressure and maximum line pressure.

Under normal operating conditions between minimum and maximum throttle positions, the PCM varies the duty cycle between approximately 40% and 0% respectively. The changes in duty cycle varies the current flow to the PCS between approximately 1.0 and 0.0 amps. This varies the opening of the variable bleed exhaust between the armature and spool valve sleeve to regulate torque signal fluid pressure (see Figure C). If the electrical system becomes disabled for any reason, current flow to the solenoid is 0.0 amps and the PCS will regulate maximum torque signal fluid pressure. This creates maximum line pressure to prevent any apply components form slipping until the condition can be corrected.

The 4L60-E PCM programming also allows for adjustments in line pressure based on the changing characteristics of the transmission components. This process is referred to as Adaptive Learning and is used to assure consistent shift patterns and increase transmission durability. As transmission apply components wear and shift overlap time (time required to apply a clutch or band) increases, the PCM adjusts line pressure to maintain the originally calibrated shift timing. This is done by changing torque signal fluid pressure through the PCS control. *Note: Adaptive learning control is not used on all shifts and varies depending on application.*

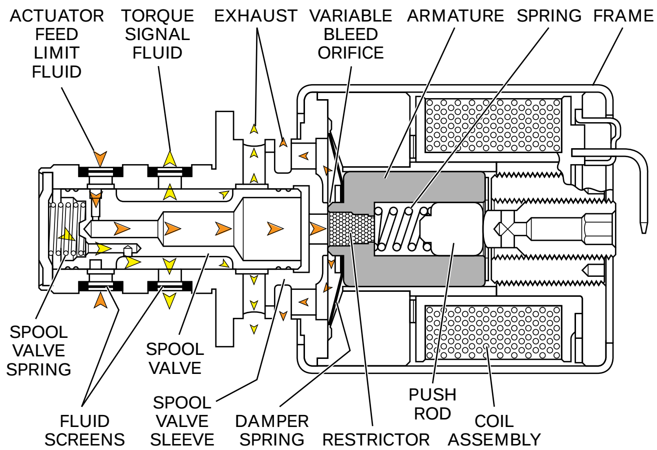


FIGURE A: PRESSURE CONTROL SOLENOID

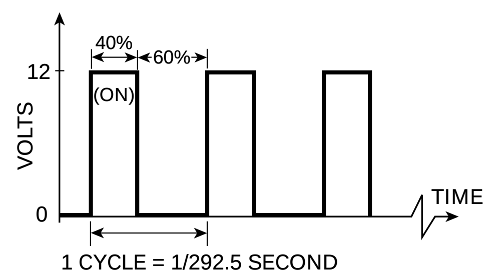


FIGURE B: PRESSURE CONTROL SOLENOID POSITIVE DUTY CYCLE

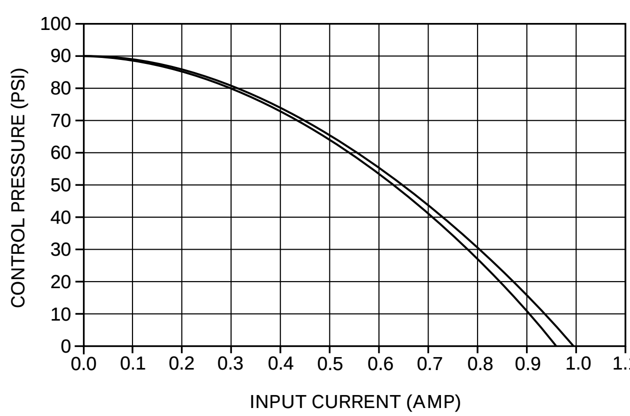


FIGURE C: PRESSURE CONTROL SOLENOID CURRENT FLOW

Figure 37

The purpose of this section is to describe how torque generated by the engine is transferred through the Hydra-matic 4L60-E transmission and to the vehicle's drive shaft. The information that follows describes the mechanical, electrical and hydraulic operation of the transmission while in each specific gear range. This section builds upon previously covered information. Therefore, if the operation of a certain component is unclear, refer to the previous sections of this book for individual component explanations.

The material in this section is presented in the same order as the arrangement of the shift quadrants - a progression from Park to Manual First (P, R, N, D, D, 2, 1). The left hand, or even numbered pages, contain drawings of the mechanical components and power flow used in a specific gear range. Facing this page is a half page insert with a detailed explanation of the mechanical operation for that gear range. At the top of this insert is a range reference chart showing a summary of which components are applied in that gear range.

The right hand, or odd numbered pages, contain a simplified version of the Complete Hydraulic Circuit section (beginning on page 67). Facing this page is a half page of text with a detailed description of what is occurring hydraulically and electronically in that gear range. A reference to the corresponding Complete Hydraulic Circuit is located at the bottom of the half page, should more schematic information be desired.

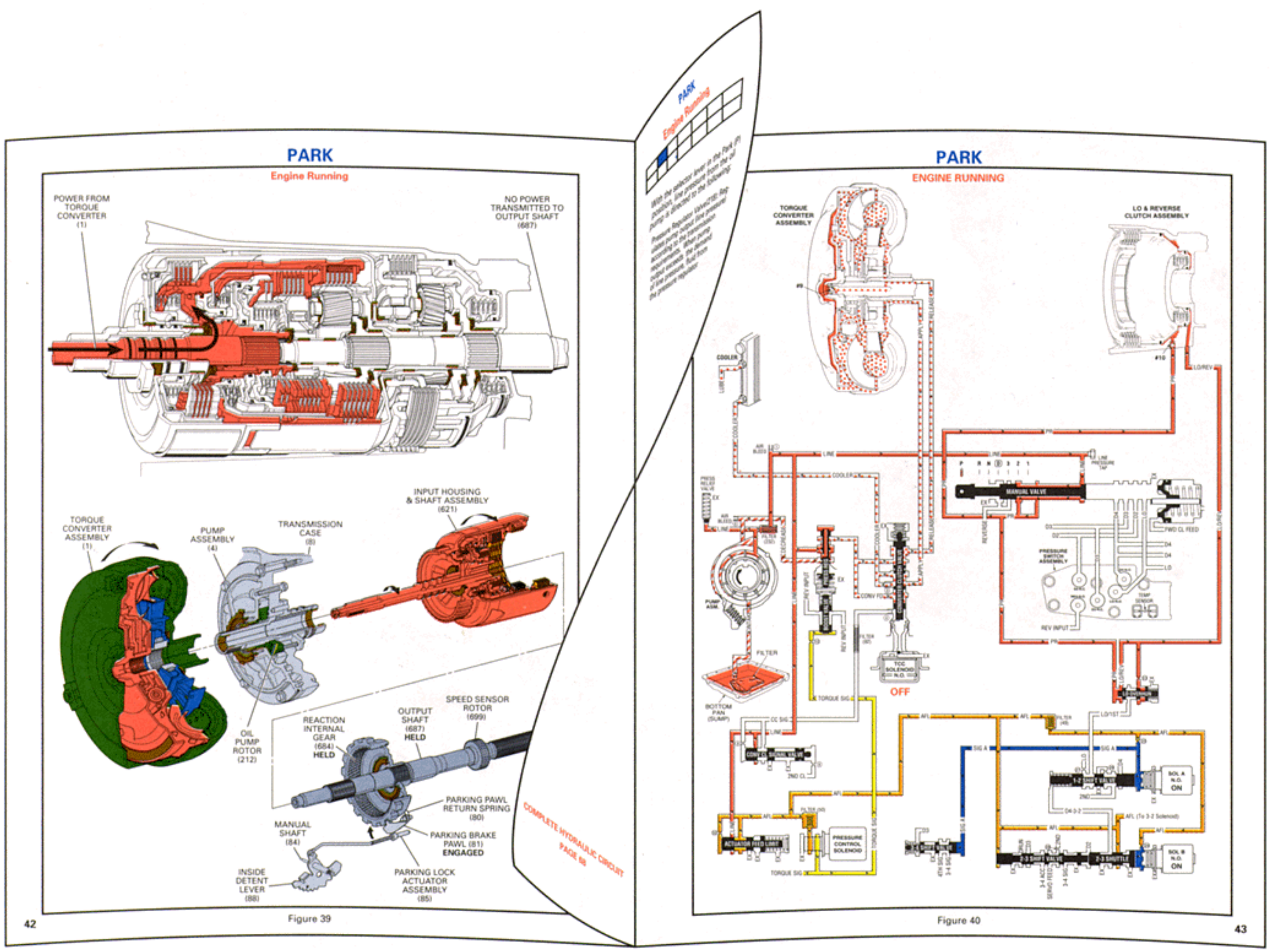


Figure 38

PARK

Engine Running

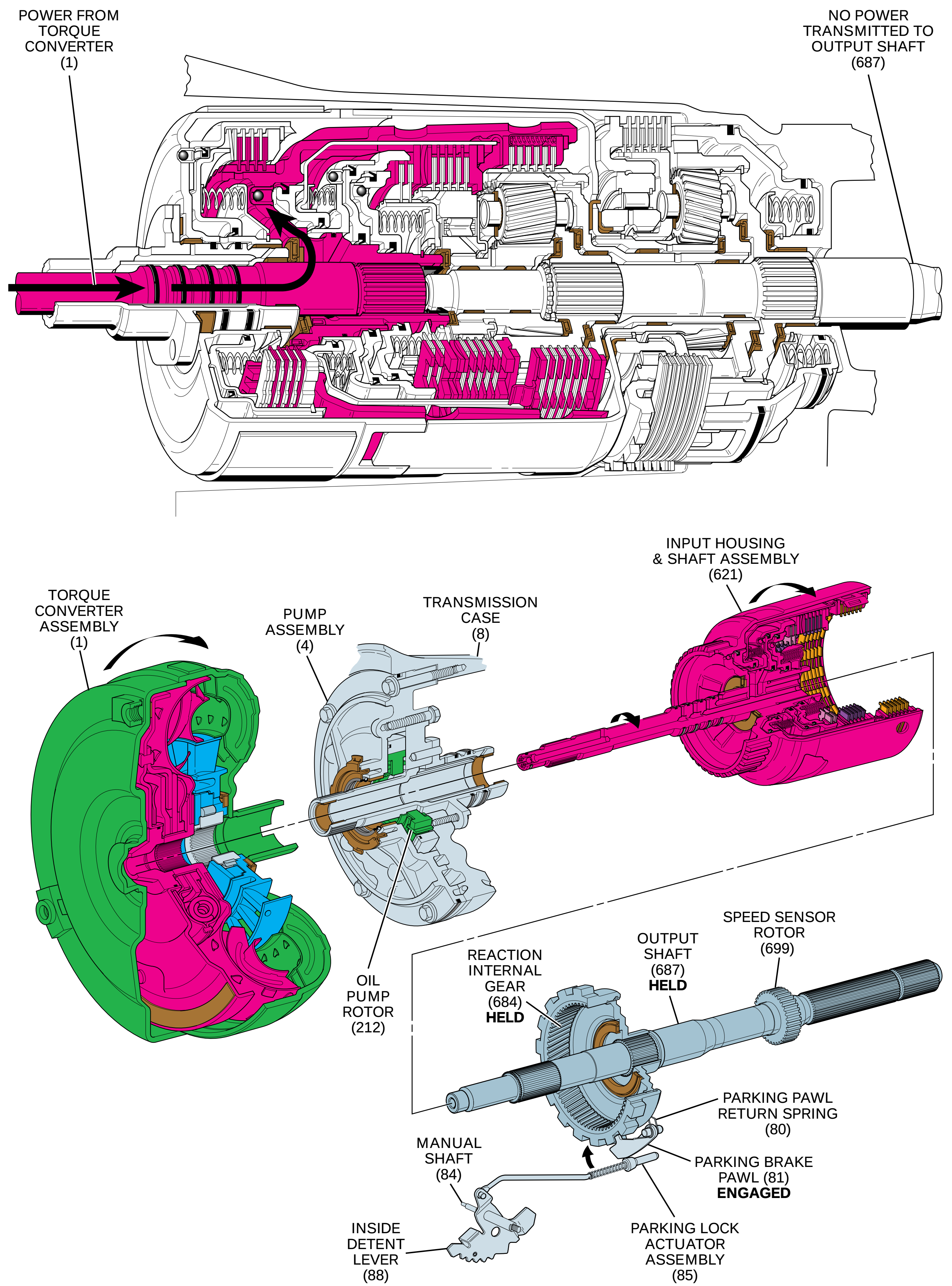


Figure 39

PARK

Engine Running

SHIFT "A" SOL	SHIFT "B" SOL	2-4 BAND	REVERSE INPUT CLUTCH	OVERRUN CLUTCH	FORWARD CLUTCH	FORWARD SPRAG CL. ASSEMBLY	3-4 CLUTCH	LO-ROLLER CLUTCH	LO-REV CLUTCH
ON	ON								APPLIED

The Hydra-matic 4L60-E automatic transmission requires a constant supply of pressurized fluid to cool and lubricate the components throughout the unit. It also requires a holding force be applied to the bands and clutches to obtain the various gear ranges. The oil pump and valve body assemblies provide for this pressurization and distribution of fluid.

- The torque converter assembly (1) is connected to the engine through the engine flywheel and rotates at engine speed.
- The oil pump rotor (212) is keyed to the torque converter pump hub and is also driven at engine speed.
- The fluid circulating inside the converter creates a fluid coupling that drives the converter turbine.
- The turbine shaft, connected to the input housing (621), is driven by the converter turbine.
- The input housing contains three separate multiple disc clutches: The overrun clutch, forward clutch and the 3-4 clutch. All three clutches are released and power flow is terminated at the input housing.

Lo and Reverse Clutch Applied

- The lo and reverse clutch plates (682) are applied and hold the reaction carrier (681) stationary to the transmission case (8). However, with power flow terminated at the input housing the lo and reverse clutch has no affect on transmission operation in Park.

Parking Pawl Engaged

- The manual shaft (84) and manual valve (340) are in the Park position (P). The parking lock actuator assembly (85) engages the parking brake pawl (81) with the lugs on the reaction internal gear (684).
- The reaction internal gear is splined to the output shaft (687) and both components are held stationary by the parking pawl. With the output shaft held, the vehicle is prevented from moving.

Note: The transmission manual linkage must be adjusted correctly so the indicator quadrants in the vehicle correspond with the inside detent lever in the transmission. Refer to the appropriate General Motors service manual for the proper manual linkage adjustment procedure. Also, the vehicle should be completely stopped before selecting Park range or internal damage to the transmission could occur.

PARK

Engine Running

When the engine is running, the oil pump draws fluid from the bottom pan, through the oil filter assembly and into the oil pump. This fluid is pressurized by the oil pump and directed into the line fluid circuit.

Pressure Regulation

- Line pressure from the oil pump assembly is directed to the pressure regulator valve where it is regulated in response to torque signal fluid pressure, spring force and line pressure acting on the end of the valve.
- Excess line pressure at the pressure regulator valve is fed into the decrease fluid circuit. Decrease fluid is routed back to the oil pump slide to help control pump output.
- Line pressure is also directed to the pressure relief ball, line pressure tap, manual valve, converter clutch signal valve and actuator feed limit (AFL) valve.
- Line pressure is routed through the AFL valve and into the AFL fluid circuit. AFL fluid is routed to the shift solenoids, pressure control solenoid, 3-2 control solenoid and the 2-3 shift valve train.

Note: Refer to Neutral range on page 47A for a description of the shift solenoid and shift valve operation in Park, Reverse and Neutral.

- The pressure control solenoid regulates AFL fluid into torque signal fluid pressure. The PCM controls this regulation in relation to throttle position and other vehicle operating conditions.
- In all gear ranges, torque signal fluid pressure from the pressure control solenoid is directed to the boost valve and accumulator valve.

Converter Clutch Circuit

- Line pressure is blocked by the converter clutch signal valve and the converter clutch signal fluid circuit is empty.
- The normally open TCC solenoid is OFF.
- Line pressure enters the converter feed fluid circuit at the pressure regulator valve and is routed to the converter clutch apply valve.
- Spring force holds the converter clutch apply valve in the release position. Converter feed fluid is routed through the valve and into the release fluid circuit.
- Release fluid pressure unseats the TCC apply checkball (#9) in the turbine shaft and is routed between the converter cover and pressure plate. This fluid pressure keeps the converter clutch released and fills the converter with fluid.
- Fluid exits the converter in the apply fluid circuit, flows through the converter clutch apply valve and enters the cooler fluid circuit.
- Cooler fluid flows through the transmission fluid cooler in the radiator and into the lubrication circuits throughout the transmission. Refer to page 92 for a complete drawing of the lubrication circuit.

Lo and Reverse Clutch Applies

- Line pressure is routed through the manual valve and into the PR (Park/Reverse) fluid circuit.
- PR fluid pressure seats the lo/reverse checkball (#10) and is orificed to the outer area of the lo and reverse clutch piston.
- PR fluid is also routed to the lo overrun valve. PR fluid pressure moves the valve against spring force and enters the lo/reverse fluid circuit.
- Lo/reverse fluid is routed to the inner area of the lo and reverse clutch piston. This fluid pressure, in addition to PR fluid pressure acting on the outer piston area, applies the lo and reverse clutch.
- All fluid circuits at the pressure switch assembly (PSA) are empty and the PSA signals the PCM that the manual valve is in either the Park or Neutral position.

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Page 68

PARK

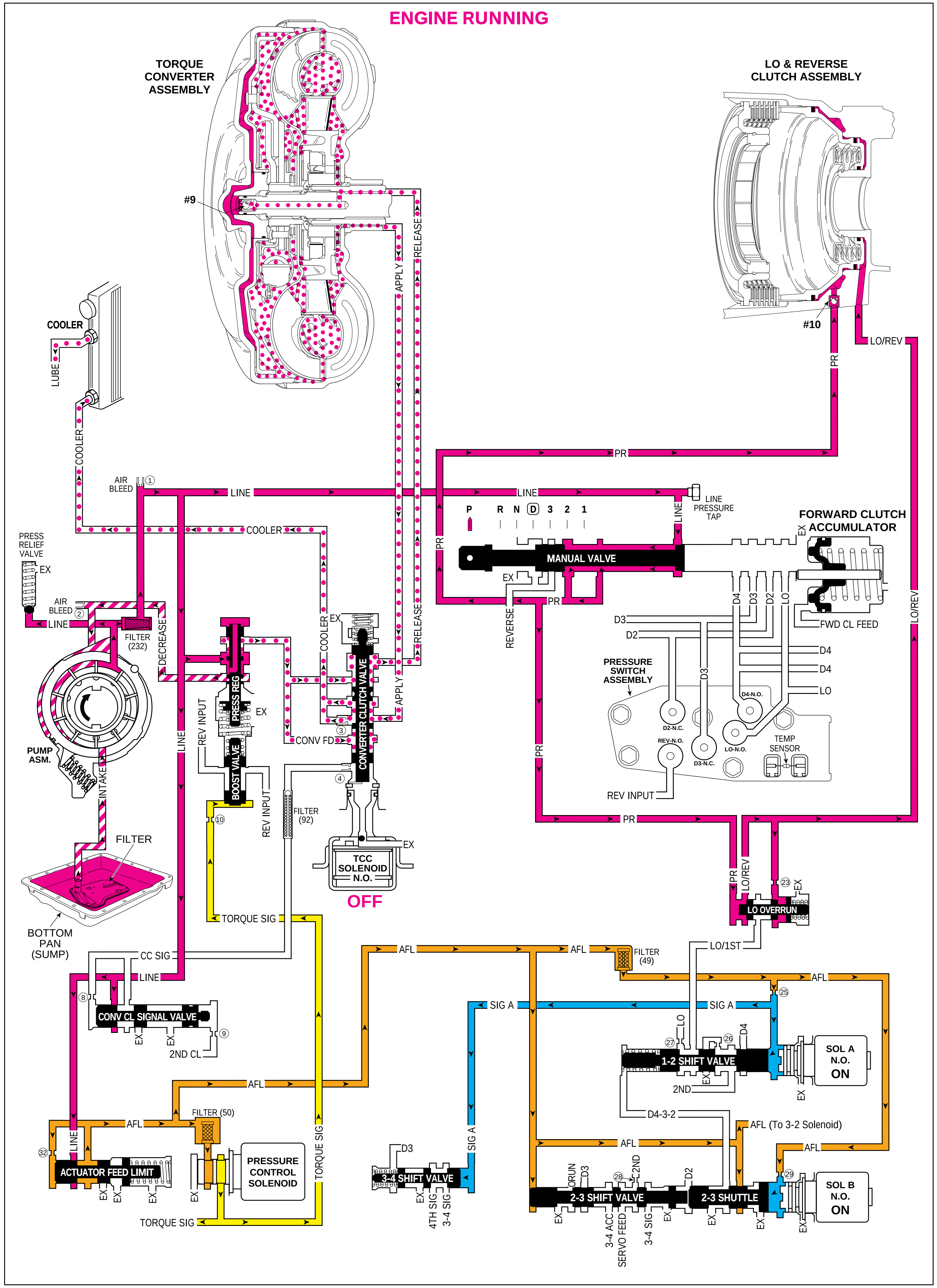

Figure 40

REVERSE

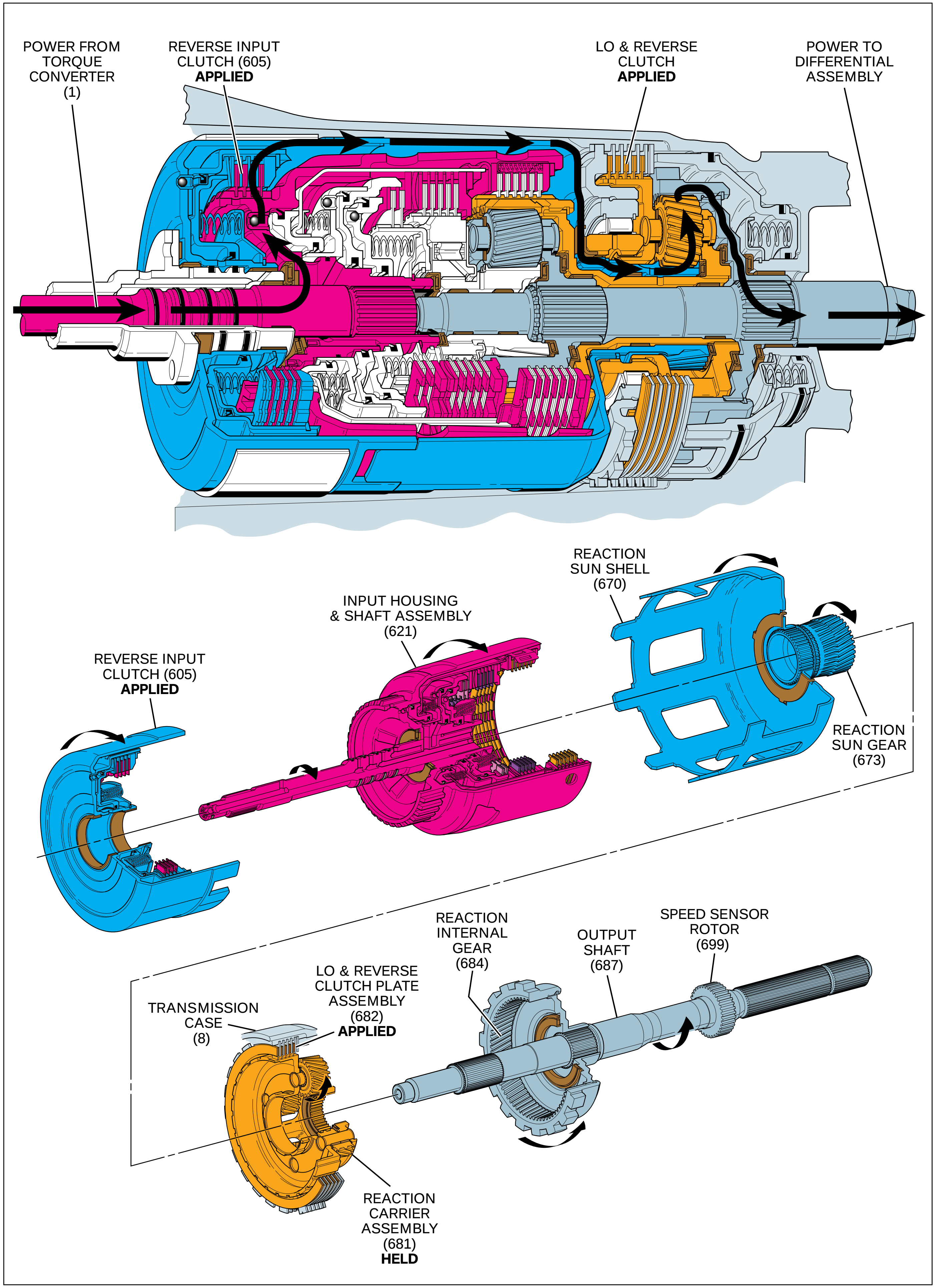

Figure 41

REVERSE

SHIFT "A" SOL	SHIFT "B" SOL	2-4 BAND	REVERSE INPUT CLUTCH	OVERRUN CLUTCH	FORWARD CLUTCH	FORWARD SPRAG CL. ASSEMBLY	3-4 CLUTCH	LO-ROLLER CLUTCH	LO-REV CLUTCH
ON	ON		APPLIED						APPLIED

In Reverse (R), torque from the engine is transmitted to the turbine shaft and input housing in the same manner as Park range. The reverse input clutch is applied to transfer engine torque to the reaction planetary gear set and obtain Reverse.

- The manual shaft (84) and manual valve (340) are in the Reverse (R) position. The parking pawl (81) is disengaged from the reaction internal gear (684) and the output shaft (687) is free to rotate.

- All clutches in the input housing (621) are released, as in Park, preventing power flow from reaching the input planetary gear set.

Reverse Input Clutch Applied

- The reverse input clutch plates (612) are applied and connect the reverse input clutch housing (605) to the input housing. Engine torque is transferred from the input housing, through the clutch plates, and to the reverse input clutch housing.

- The reverse input clutch housing is connected to the reaction sun shell (670) and torque is transferred to the sun shell.

- The reaction sun gear (673) is splined to the reaction sun shell and is driven clockwise by the sun shell.

Lo and Reverse Clutch Applied

- As in Park range, the lo and reverse clutch plates (682) are applied and hold the reaction carrier (681) stationary to the transmission case. This also holds the reaction carrier shaft (666) and input internal gear (664) stationary.

- The reaction sun gear drives the reaction carrier pinion gears in a counterclockwise direction.

- The reaction carrier pinion gears drive the reaction internal gear in a counterclockwise direction.

- The reaction internal gear is splined to and drives the output shaft (687) counterclockwise to obtain Reverse and a gear reduction of approximately 2.3:1.

- The input carrier assembly (662), splined to the output shaft, also rotates but has no affect in Reverse with all other clutches released.

Coast Conditions

- When the throttle is released in Reverse, power from vehicle speed is transferred back through the transmission gear train to the engine. This action allows engine compression to slow the vehicle.

REVERSE

When the gear selector lever is moved to the Reverse (R) position the manual valve also moves and line pressure enters the reverse fluid circuit, in addition to the PR fluid circuit.

Lo and Reverse Clutch Remains Applied

- PR and lo/reverse fluid pressures continue to act on the lo and reverse clutch piston. This keeps the lo and reverse clutch applied in Reverse (see note below).

Reverse Input Clutch Applies

- Reverse fluid pressure seats the reverse input checkball (#3) and is orificed into the reverse input fluid circuit. This orifice (#17) controls the reverse input clutch apply when engine speed is approximately at idle.
- Reverse input fluid is routed through the boost valve and seats the air exhaust checkball located in the oil pump.
- Reverse input fluid pressure is directed to the reverse input clutch piston to apply the reverse input clutch.
- Reverse fluid also acts on the reverse abuse valve. At engine speeds above idle, reverse fluid pressure increases and moves the valve against spring force. This allows reverse fluid to feed the reverse input fluid circuit quickly, thereby bypassing the control of orifice #17.
- Reverse input fluid closes the normally open reverse fluid pressure switch in the pressure switch assembly (PSA). The PSA signals the PCM that the manual valve is in the Reverse position.

Pressure Regulation

- The pressure control solenoid continues to regulate actuator feed limit (AFL) fluid into the torque signal fluid circuit in relation to throttle position and other vehicle operating conditions.
- Torque signal fluid pressure continues to act on the boost valve to control line pressure. Also, reverse input fluid pressures acts on the boost valve to assist torque signal fluid pressure force and increase the operating range of line pressure.

Note: The hydraulic and electrical systems in Reverse operate in the same manner as Park (P) range except as described above. In each of the following gear ranges, most of the explanation is limited to the changes from the range on the previous page. If a component or circuit is not explained, it functions similar to the previous range. However, some explanations are repeated for clarity and continuity.

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REVERSE

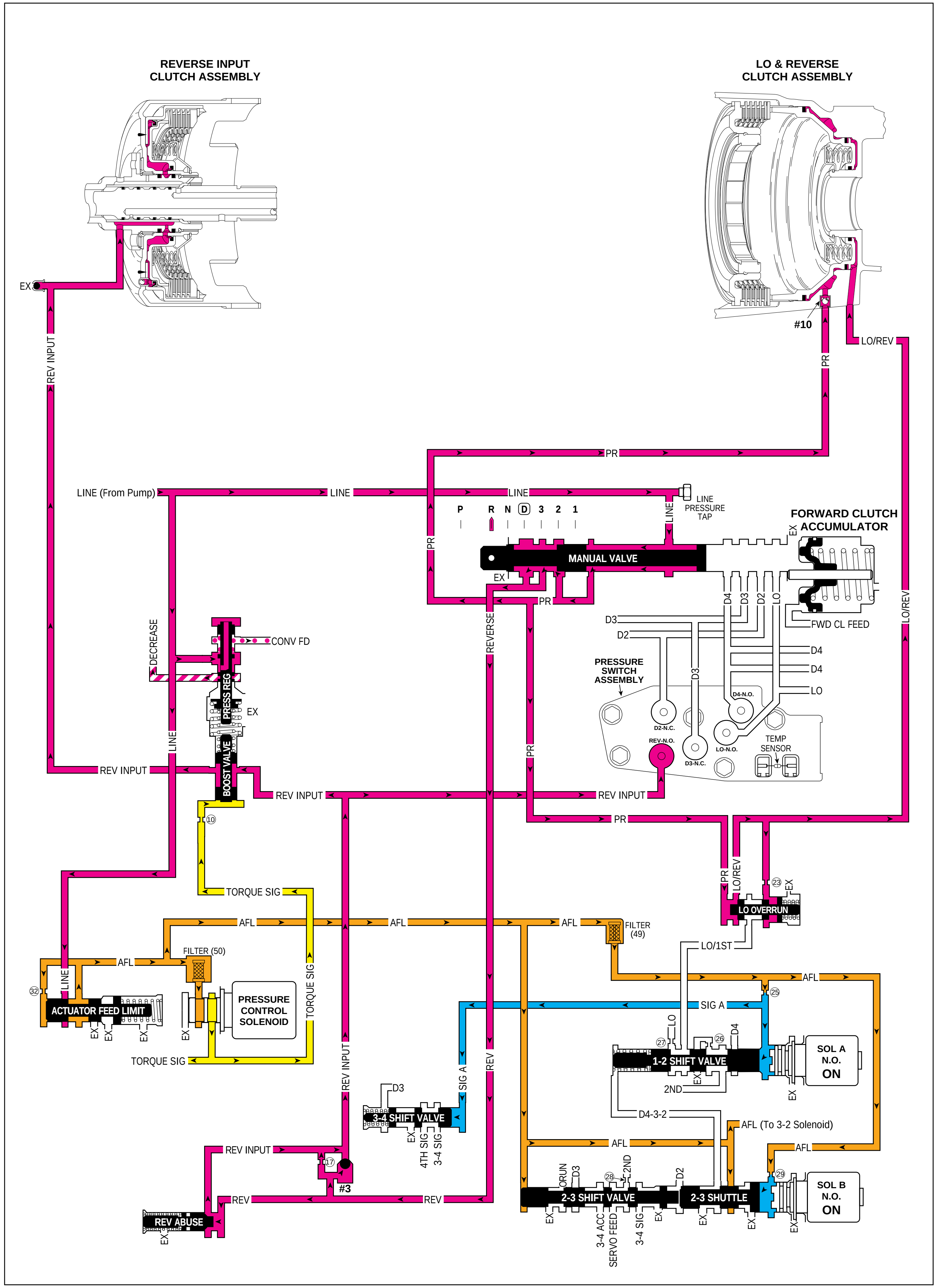

Figure 42

NEUTRAL

Engine Running

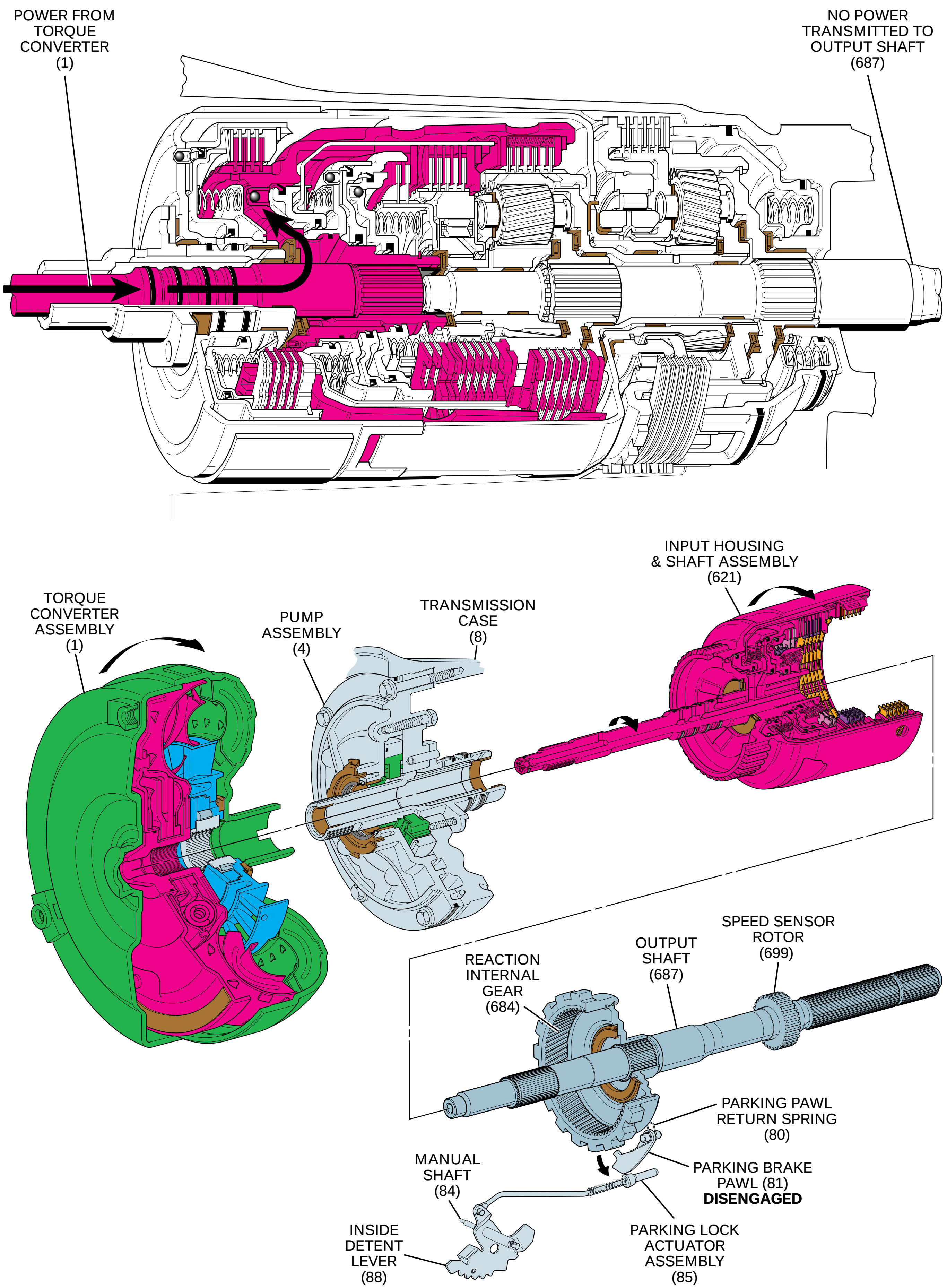

Figure 43

NEUTRAL

Engine Running

SHIFT "A" SOL	SHIFT "B" SOL	2-4 BAND	REVERSE INPUT CLUTCH	OVERRUN CLUTCH	FORWARD CLUTCH	FORWARD SPRAG CL. ASSEMBLY	3-4 CLUTCH	LO-ROLLER CLUTCH	LO-REV CLUTCH
ON	ON								

Power flow in Neutral is the same as in Park range.

- The turbine shaft and input housing assembly (621) are driven at converter turbine speed.
- All clutch packs in the input housing assembly are released and power flow is terminated at the input housing.

Lo and Reverse Clutch Released

- Unlike Park range, the lo and reverse clutch plates (682) are released in Neutral. However, this does not affect the mechanical power flow.

Parking Lock Pawl Disengaged

- The parking lock actuator (85) is disengaged from the parking brake pawl (81).
- The parking pawl return spring (80) moves the parking brake pawl away from the lugs on the reaction internal gear (684).
- The reaction internal gear and output shaft (687) are free to rotate. This allows the vehicle to roll freely when the transmission is in Neutral.
- Neutral range may be selected to start the engine when the vehicle is standing still or moving down the road.

NEUTRAL
Engine Running

When the gear selector lever is moved to the Neutral (N) position, the manual valve also moves and blocks line pressure from entering any other fluid circuits. In this position, reverse and PR fluids are open to an exhaust past the end of the valve.

Reverse Input Clutch Releases

- Reverse input fluid pressure, which was fed by reverse fluid, exhausts from the reverse input clutch piston. This releases the reverse input clutch plates.
- Reverse input fluid also exhausts from the boost valve and pressure switch assembly (PSA). The PSA signals the PCM that the manual valve is in either the Park or Neutral position.
- Exhausting reverse input fluid unseats the reverse input checkball (#3) for a quick exhaust through the reverse fluid circuit.
- Reverse fluid also exhausts from the reverse abuse valve and spring force closes the valve.

Lo and Reverse Clutch Releases

- PR fluid exhausts from the outer area of the lo and reverse clutch piston. Exhausting PR fluid unseats the lo and reverse clutch checkball (#10) for a quick exhaust.
- PR fluid exhausts from the lo overrun valve and spring force closes the valve. Lo/reverse fluid exhausts through the valve, into the lo 1st fluid circuit, through the 1-2 shift valve, into the lo fluid circuit and past the manual valve.
- With both PR and lo/reverse fluids exhausted, the lo and reverse clutch plates are released and the transmission is in Neutral.

Shift Solenoid Operation in Park, Reverse and Neutral

- Both normally open shift solenoids are energized (ON). The solenoids block solenoid signal fluid from exhausting, thereby creating fluid pressure in these solenoid signal fluid circuits.
- Signal "A" fluid pressure holds the 1-2 shift valve in the downshifted position against spring force.
- Solenoid signal fluid holds the 2-3 shift valve train in the downshifted position against AFL fluid pressure acting on the 2-3 shift valve.
- In Park, Reverse and Neutral the normally closed 3-2 control solenoid is de-energized and blocking AFL fluid.

Note: With the manual valve blocking line pressure, the shift solenoid states do not affect transmission operation in Park, Reverse and Neutral. In Park, Reverse and Neutral the shift solenoids are shown energized, as in First gear. This is the normal operating state when the vehicle is stationary or at low vehicle speeds.

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NEUTRAL
ENGINE RUNNING

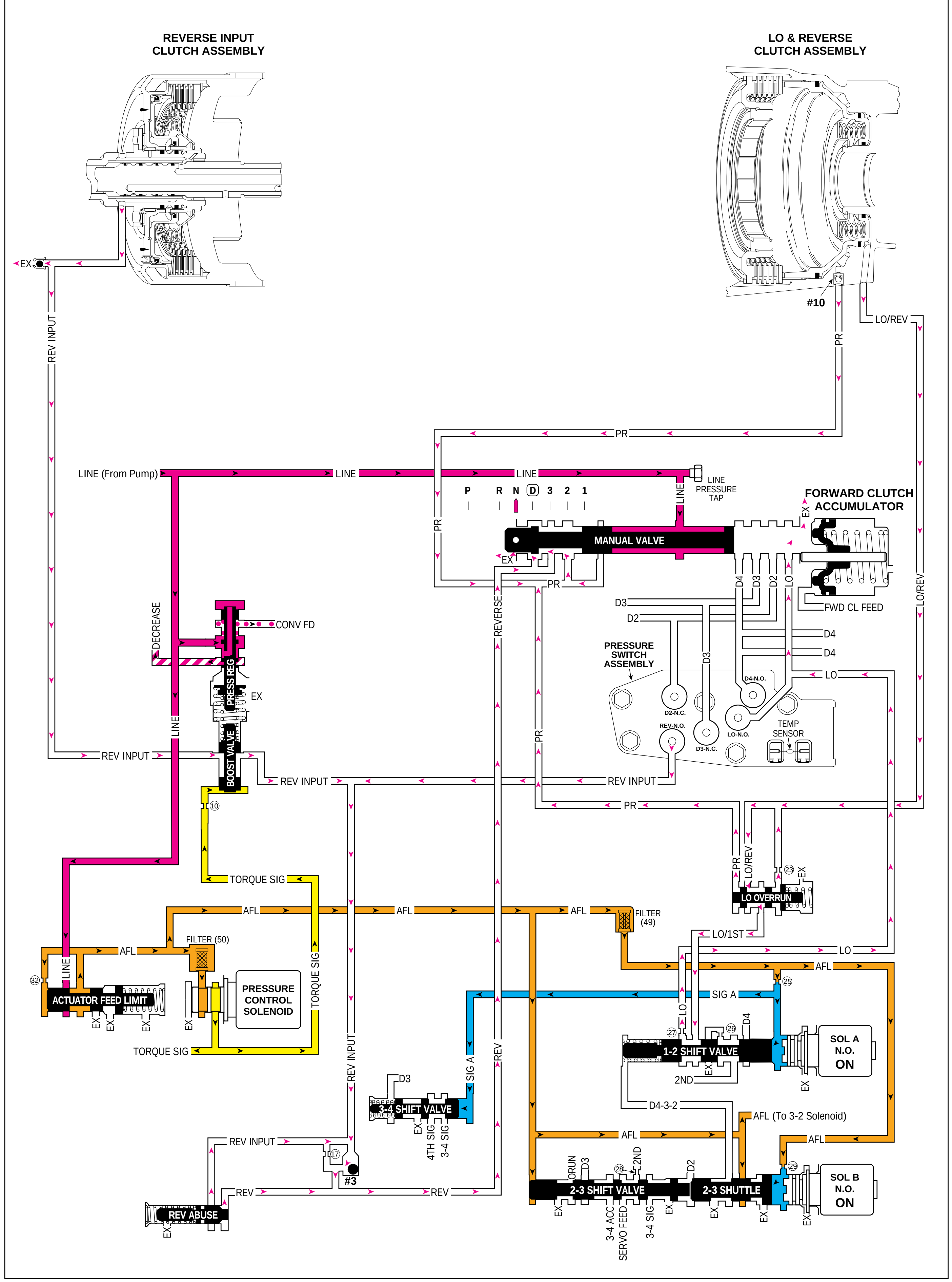

Figure 44

OVERDRIVE RANGE - FIRST GEAR

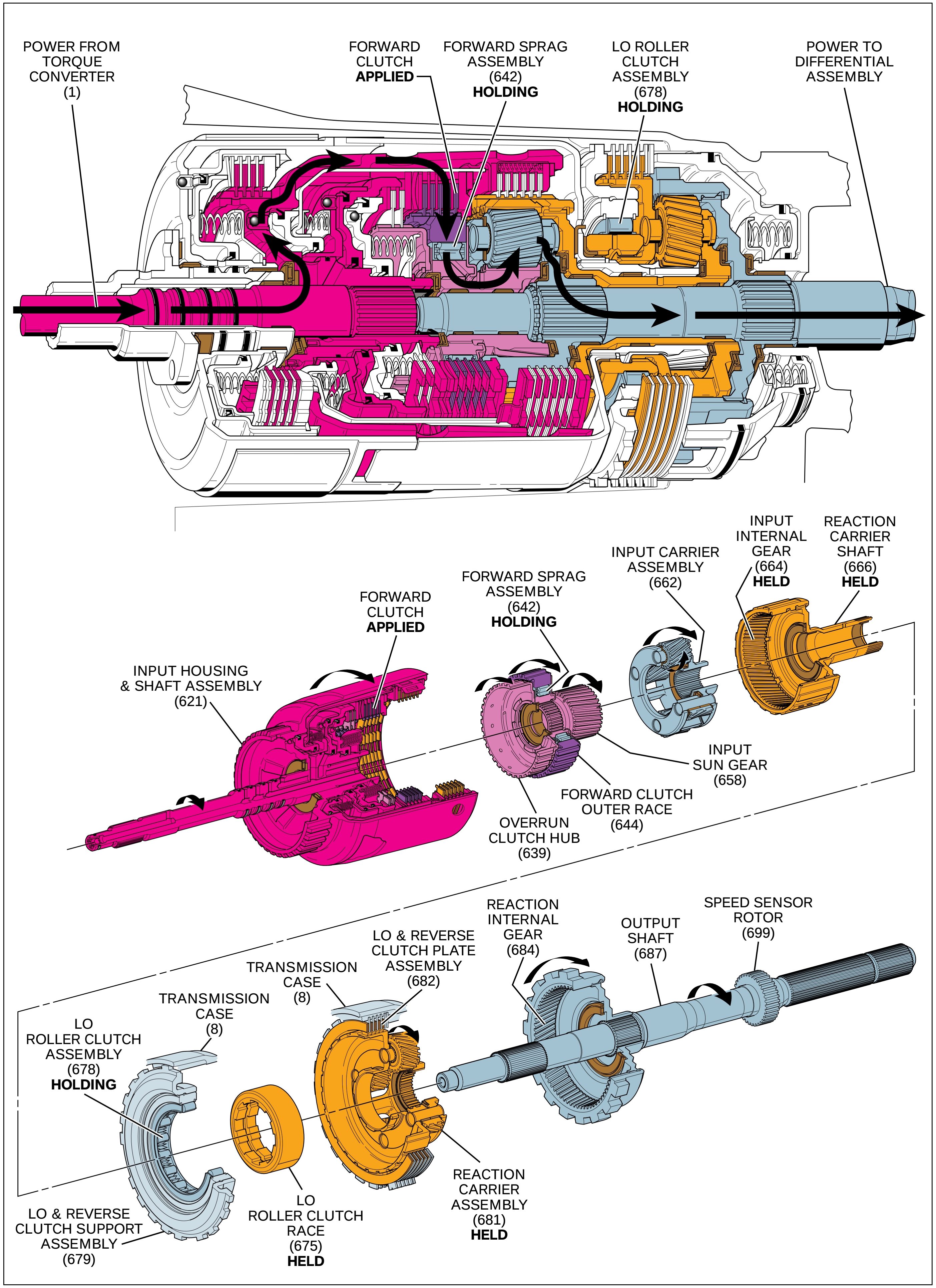

Figure 45

OVERDRIVE RANGE - FIRST GEAR

SHIFT "A" SOL	SHIFT "B" SOL	2-4 BAND	REVERSE INPUT CLUTCH	OVERRUN CLUTCH	FORWARD CLUTCH	FORWARD SPRAG CL. ASSEMBLY	3-4 CLUTCH	LO-ROLLER CLUTCH	LO-REV CLUTCH
ON	ON				APPLIED	HOLDING		HOLDING	

In First gear, torque from the engine is multiplied through the torque converter and transmission gear train to the vehicle's drive shaft. The planetary gears operate in reduction to achieve a First gear starting ratio of approximately 3.06:1.

- The manual shaft (84) and manual valve (340) are in the Overdrive position (D).
- Engine torque is transferred from the torque converter to the input housing assembly (621) in the same manner as during Park, Reverse and Neutral.

Forward Clutch Applied
- The forward clutch is applied in all forward gear ranges. The forward clutch plates (649) transfer engine torque from the input housing to the forward clutch outer race (644).

Forward Sprag Clutch Driving
- The sprag clutch (642), located between the forward clutch outer race and the sprag retainer and race assembly (641), locks and drives the sprag retainer and race assembly.
- The sprag retainer and race assembly is splined to and drives the input sun gear (658).
- The input sun gear drives the input carrier pinion gears counterclockwise.

Lo Roller Clutch Holding
- The input carrier pinion gears attempt to drive the input internal gear (664) and reaction carrier shaft (666) counterclockwise. The reaction shaft then attempts to drive reaction carrier assembly (681) counterclockwise.
- The lo roller clutch (678) is located between the lo and reverse clutch support assembly (679) (which is splined to the case) and the reaction carrier assembly. With the reaction carrier attempting to rotate counterclockwise, the roller clutch locks and prevents the reaction carrier, reaction carrier shaft and input internal gear from rotating.
- The input carrier pinion gears, rotating counterclockwise on their pins, walk clockwise around the stationary input internal gear. This action drives the input carrier assembly (662) clockwise.
- The input carrier assembly is splined to and drives the output shaft (687) clockwise in a First gear reduction of approximately 3.06:1.
- As a result of the output shaft rotating, the reaction internal gear (684), reaction carrier pinion gears, reaction sun gear (673), reaction sun shell (670), and reverse input clutch housing (605) all rotate but do not affect the transmission's mechanical power flow.

Coast Conditions
- When the throttle is released in Overdrive Range - First Gear and engine RPM decreases, power from vehicle speed drives the output shaft and input carrier (662) faster than engine torque is driving the forward clutch outer race (644). This allows the input carrier pinion gears to drive the input sun gear (658) clockwise faster than the forward clutch outer race. This causes the sprag race and retainer assembly to overrun the sprag clutch and allow the vehicle to coast freely without engine compression slowing the vehicle.
- Also during coast conditions, the reaction internal gear drives the reaction carrier pinion gears. This drives the reaction carrier clockwise and overruns the lo roller clutch.

When the gear selector lever and manual valve are moved to the Overdrive position Ⓓ, line pressure fills the D4 fluid circuit.

- D4 fluid pressure is routed to the pressure switch assembly (PSA) where it closes the normally open D4 fluid pressure switch. With the D4 switch closed, the PSA signals the PCM that the manual valve is in the Overdrive position.

Forward Clutch Applies

- D4 fluid pressure seats the forward clutch accumulator checkball (#12) and is orificed into the forward clutch feed fluid circuit. This orifice (#22) helps control the forward clutch apply when engine speed is approximately at idle.
- Forward clutch feed fluid pressure acts on the forward clutch piston to apply the forward clutch plates.
- As the forward clutch applies, forward clutch feed fluid pressure moves the forward clutch accumulator piston against spring force. This action absorbs some of the initial increase of forward clutch feed fluid pressure to cushion the forward clutch apply.
- D4 fluid pressure is also routed to the forward abuse valve. At engine speeds above idle, D4 fluid pressure increases and moves the abuse valve against spring force. This allows D4 fluid to fill the forward clutch feed fluid circuit quickly and bypass the control of orifice #22 for applying the forward clutch.

Shift Solenoid “A” and 1-2 Shift Valve

- Actuator feed limit (AFL) fluid continues to feed the signal “A” fluid circuit through orifice #25.
- The normally open shift solenoid “A” remains ON, as in Park, Reverse and Neutral, and blocks signal “A” fluid from exhausting through the solenoid.
- Signal “A” fluid pressure holds the 1-2 shift valve in the downshifted position against spring force. In this position the valve blocks D4 fluid in preparation for a 1-2 upshift.
- Signal “A” fluid pressure also holds the 3-4 shift valve in the upshifted position against spring force.

Shift Solenoid “B” and 2-3 Shift Valve Train

- AFL fluid continues to feed the solenoid signal fluid circuit through orifice #29.
- The normally open shift solenoid “B” remains ON and blocks solenoid signal fluid from exhausting.
- Solenoid signal fluid pressure holds the 2-3 shift valve train in the downshifted position against AFL fluid pressure acting on the 2-3 shift valve. In this position the 2-3 shuttle valve blocks AFL fluid from entering the D432 fluid circuit.

Accumulator System

- D4 fluid is regulated into accumulator fluid pressure by the accumulator valve. This regulation is biased by spring force, torque signal fluid pressure and orificed accumulator fluid.
- Accumulator fluid fills both the 1-2 and 3-4 accumulators in preparation for the 1-2 and 3-4 upshifts respectively.
- D4 fluid is also routed through an orifice cup plug (#24) and into the lubrication circuit at the rear of the transmission.

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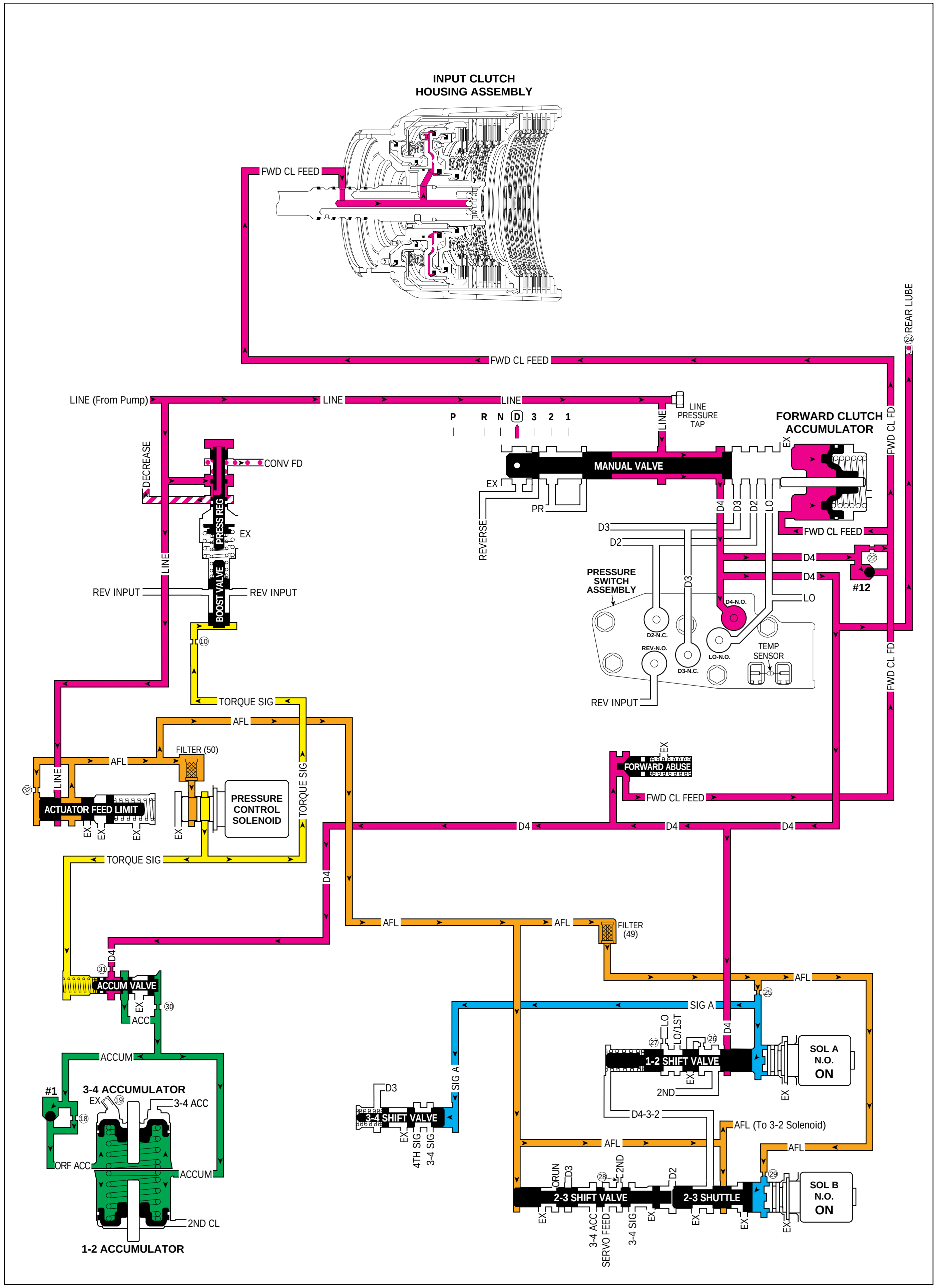

Figure 46

OVERDRIVE RANGE - SECOND GEAR

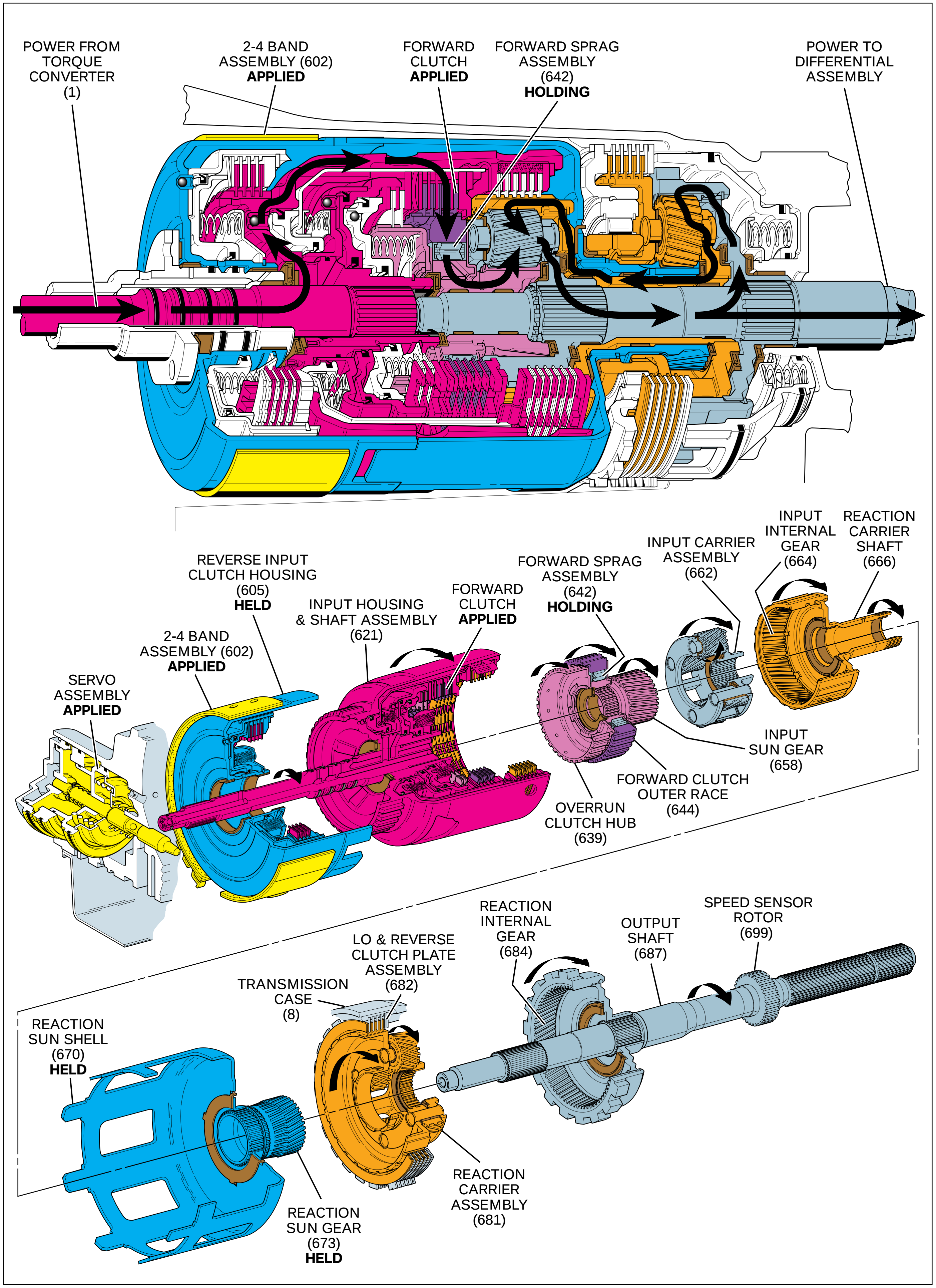

Figure 47

OVERDRIVE RANGE - SECOND GEAR

SHIFT "A" SOL	SHIFT "B" SOL	2-4 BAND	REVERSE INPUT CLUTCH	OVERRUN CLUTCH	FORWARD CLUTCH	FORWARD SPRAG CL. ASSEMBLY	3-4 CLUTCH	LO-ROLLER CLUTCH	LO-REV CLUTCH
OFF	ON	APPLIED			APPLIED	HOLDING			

Input signals from the various engine and transmission information sensors are continually monitored by the Powertrain Control Module (PCM). As vehicle speed increases, the PCM processes this information to determine the precise moment to shift the transmission into Second gear. In Second gear, the planetary gear sets operate in reduction at a gear ratio of approximately 1.63:1.

Forward Sprag Clutch Driving

- The forward clutch (649) is applied and the forward sprag clutch (642) is driving as in First gear to transfer engine torque to the input sun gear (658) and input carrier pinion gears.

- The input carrier assembly (662) is driven clockwise by the input carrier pinion gears walking around the input internal gear (664) as in First gear. This action drives the output shaft (687) and the reaction internal gear (684).

2-4 Band Applied

- The 2-4 band (602) is applied and holds the reverse input clutch housing (605) stationary to the transmission case.

- The reverse input clutch housing and the reaction sun gear (673) are splined to the reaction sun shell (670). With the 2-4 band applied, the sun shell and reaction sun gear are also held stationary.

- The reaction internal gear rotates with the output shaft and drives the reaction carrier pinion gears in a clockwise direction.

- The reaction carrier pinion gears walk clockwise around the stationary reaction sun gear and drive the reaction carrier assembly (681).

- The reaction carrier shaft (666) and input internal gear (664) are driven clockwise by the reaction carrier assembly.

- The input internal gear drives the input carrier pinions, input carrier and output shaft in a second reduction to achieve the Second gear ratio of approximately 1.63:1.

Coast Conditions

- Similar to Overdrive Range - First Gear, the forward sprag clutch is overrun when the throttle is released. This action allows the vehicle to coast freely in Overdrive Range - Second Gear.

OVERDRIVE RANGE - SECOND GEAR

The PCM continually receives input signals from the vehicle speed sensor (VSS), throttle position sensor (TPS) and other vehicle sensors. The PCM processes these inputs to determine the precise moment to de-energize (turn OFF) shift solenoid “A” and shift the transmission into Second gear.

2-4 Band Applies

- Shift solenoid “A” is de-energized and signal “A” fluid exhausts through the normally open solenoid. Spring force moves the 1-2 shift valve into the upshifted position.
- AFL fluid continues to feed the signal “A” fluid circuit through orifice #25. However, because the exhaust through the solenoid is larger than orifice #25, fluid pressure does not increase in the signal “A” fluid circuit.
- D4 fluid flows through the upshifted 1-2 shift valve and fills the 2nd fluid circuit.
- 2nd fluid pressure seats the 1-2 upshift checkball (#8) and is routed through orifice #16 to fill the 2nd clutch fluid circuit. This orifice helps control the apply rate of the 2-4 band during a 1-2 upshift.
- 2nd clutch fluid pressure is routed to the 2-4 servo. This fluid pressure moves the 2nd apply piston against servo cushion and servo return spring forces to apply the 2-4 band and obtain Second gear.

1-2 Shift Accumulation

- 2nd clutch fluid pressure is also routed to the 1-2 accumulator where it moves the 1-2 accumulator piston against spring force and accumulator fluid pressure. This action absorbs initial 2nd clutch fluid pressure to cushion the 2-4 band apply.
- Some accumulator fluid is forced out of the 1-2 accumulator as 2nd clutch fluid moves the accumulator piston. This fluid is routed back to the accumulator valve.
- Accumulator fluid orificed to the end of the accumulator valve moves the valve against spring force and torque signal fluid pressure. This action regulates the exhaust of excess accumulator fluid for additional control of the band apply.
- 2nd fluid and 2nd clutch fluid are both blocked by the 3-2 downshift valve which is held in the closed position by spring force.
- 2nd fluid is blocked by the 3-4 relay valve in preparation for the upshift to Fourth gear.
- 2nd fluid is also routed through the downshifted 2-3 shift valve and into the servo feed fluid circuit. Servo feed fluid is blocked by both the 3-4 relay valve and the 4-3 sequence valve.
- Signal “A” fluid pressure also exhausts from the 3-4 shift valve and spring force moves the valve into the downshifted position.
- In Second gear the PCM operates the normally closed 3-2 control solenoid at approximately a 90% duty cycle. This opens the solenoid and AFL fluid fills the 3-2 signal fluid circuit.
- 3-2 signal fluid pressure closes the 3-2 control valve against spring force.

Torque Converter Clutch

- 2nd clutch fluid is also routed to the converter clutch (CC) signal valve. 2nd clutch fluid pressure opens the valve and line pressure fills the CC signal fluid circuit. CC signal fluid is routed to the TCC solenoid and converter clutch apply valve.
- The TCC solenoid is de-energized and CC signal fluid exhausts through the normally open solenoid. Orifice #4 in the cup plug is smaller than the exhaust through the TCC solenoid. This prevents fluid pressure from building up at the end of the TCC apply valve and spring force keeps the valve in the release position.

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OVERDRIVE RANGE - SECOND GEAR

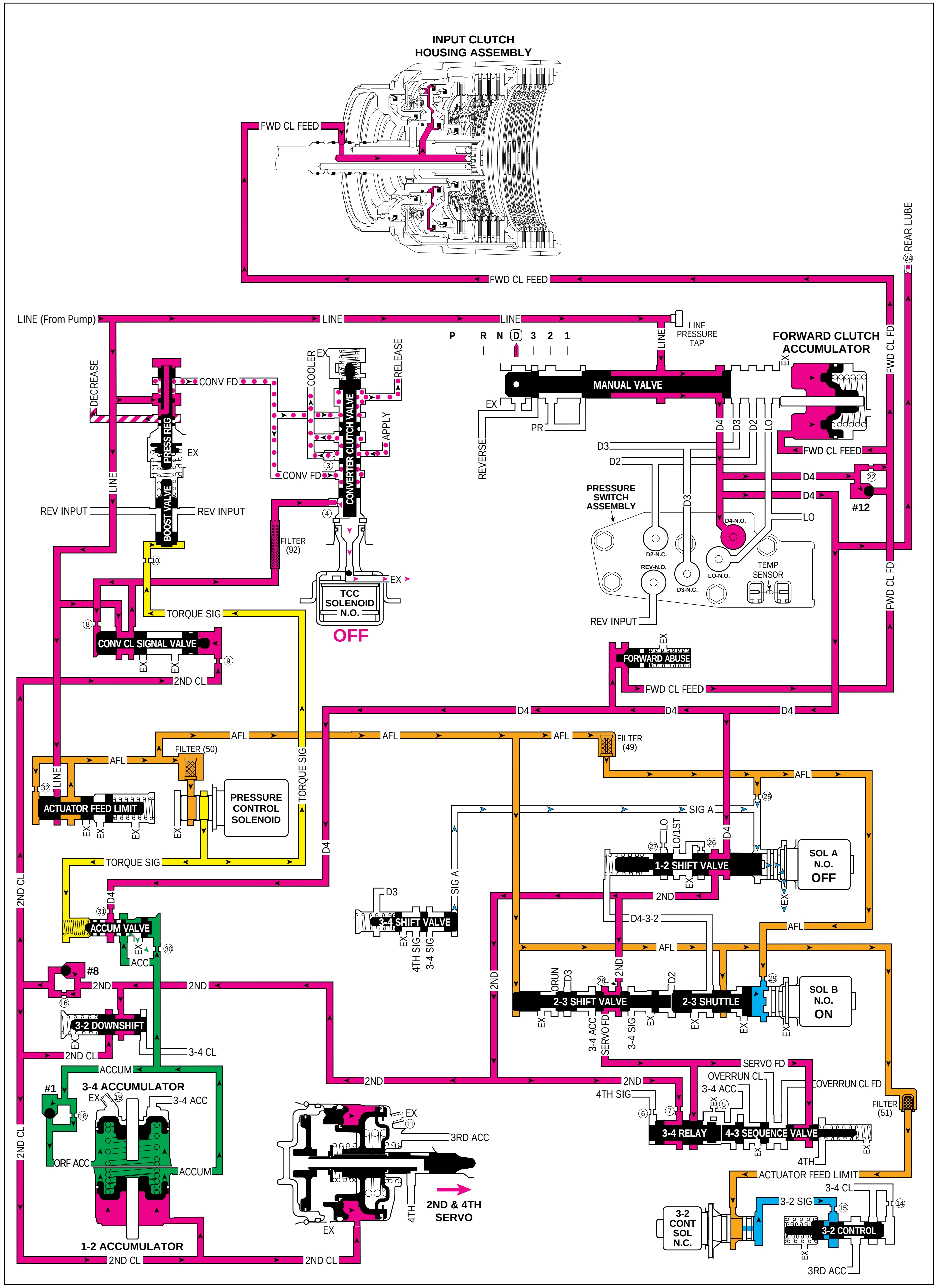

Figure 48

OVERDRIVE RANGE - THIRD GEAR

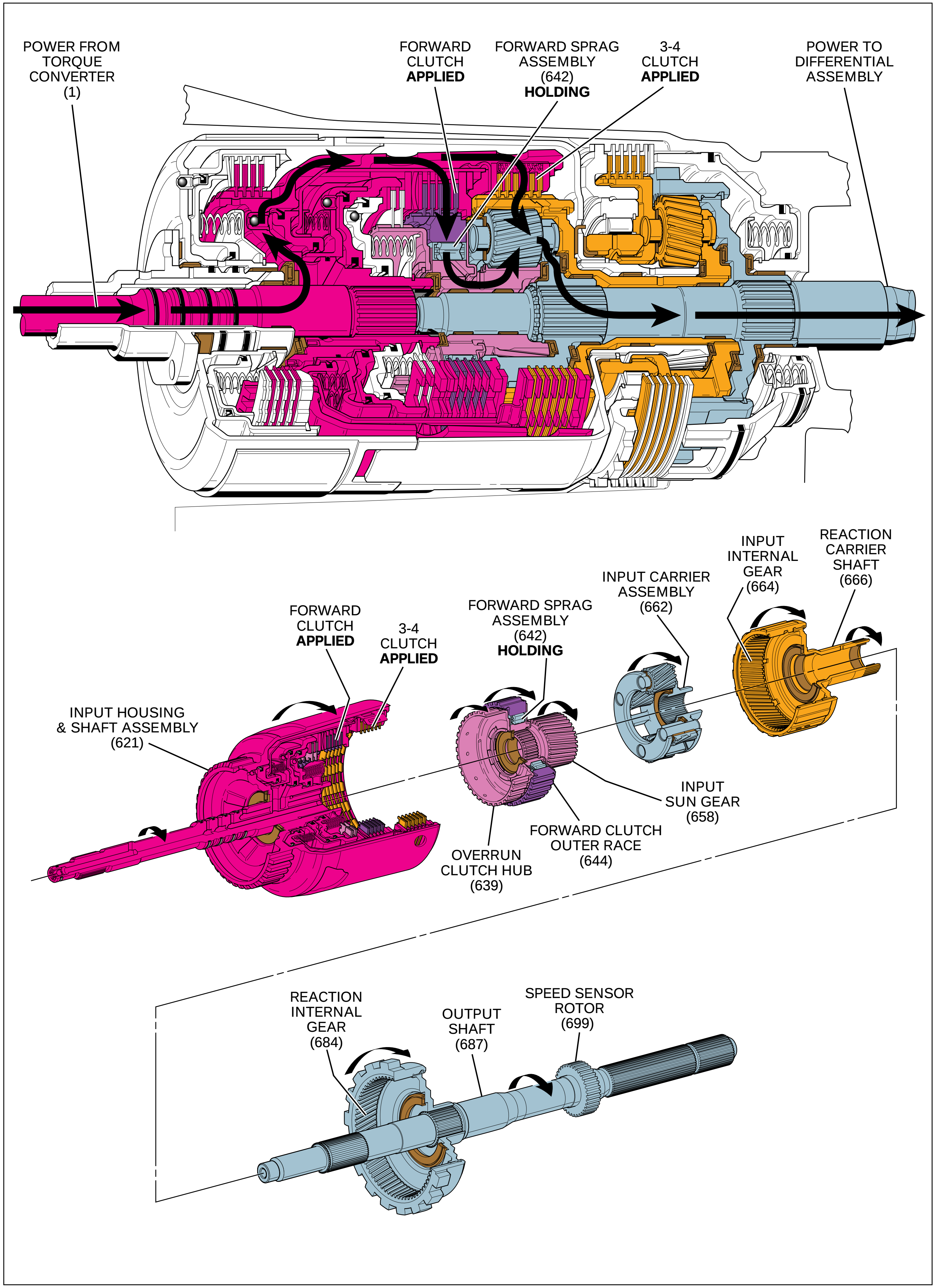

Figure 49

OVERDRIVE RANGE - THIRD GEAR

SHIFT "A" SOL	SHIFT "B" SOL	2-4 BAND	REVERSE INPUT CLUTCH	OVERRUN CLUTCH	FORWARD CLUTCH	FORWARD SPRAG CL. ASSEMBLY	3-4 CLUTCH	LO-ROLLER CLUTCH	LO-REV CLUTCH
OFF	OFF				APPLIED	HOLDING	APPLIED		

As vehicle speed increases further, the PCM monitors the various information sensors to determine the precise moment to shift the transmission into Third gear. In Third gear, both planetary gear sets, input and reaction, rotate at the same speed and provide a 1:1 direct drive gear ratio between the converter turbine and output shaft.

- Engine torque is transmitted to the input sun gear (658) in the same manner as First and Second gears. The forward clutch (649) is applied and the forward sprag clutch (642) is driving the input sun gear.

2-4 Band Released
- The 2-4 band (602) is released and the reverse input clutch housing (605) is free to rotate. The reaction sun shell (670) and reaction sun gear (673) are also free to rotate.

3-4 Clutch Applied
- The 3-4 clutch plates (654) are applied and transfer engine torque from the input housing (621) to the input internal gear (664).

- Both the input internal gear and the input sun gear are driven at the same speed. The input carrier pinion gears are splined to these components and act as wedges to drive the input carrier assembly (662).

- The input carrier drives the output shaft (687) at converter turbine speed to achieve direct drive in Third gear.

- The reaction internal gear (684) is driven by the output shaft. Also, the reaction carrier shaft (666) is driven by the input planetary gear set and drives the reaction carrier assembly (681). With the reaction carrier and reaction internal gear rotating at the same speed, the pinion gears act as wedges and drive the reaction sun gear (673) at the same speed. As a result, the entire gear set rotates as one unit at converter turbine speed.

Coast Conditions
- As in First and Second gears when the throttle is released, power from vehicle speed drives the input sun gear (658) faster than engine torque drives the forward clutch outer race (644). This action causes the forward sprag clutch inner race (641) to overrun the sprag clutch (642) and allow the vehicle to coast freely.

OVERDRIVE RANGE - THIRD GEAR

The PCM continues to monitor input signals from the VSS, TPS and other vehicle sensors to determine the precise moment to upshift the transmission into Third gear. This upshift is initiated by de-energizing shift solenoid "B".

2-4 Band Releases
- Shift solenoid "B" is de-energized by the PCM and solenoid signal fluid exhausts through the solenoid.
- Actuator feed limit (AFL) fluid continues to feed solenoid "B" through orifice #29. However, because orifice #29 is smaller than the exhaust through the solenoid, fluid pressure does not increase at the 2-3 shuttle valve.
- AFL fluid pressure acting on the 2-3 shift valve moves the 2-3 shift valve train into the upshifted position.
- Orificed 2nd fluid is routed through the upshifted 2-3 shift valve and into the 3-4 signal fluid circuit.
- 3-4 signal fluid unseats the 3-4 clutch exhaust checkball (#4) and fills the 3-4 clutch fluid circuit. 3-4 clutch fluid unseats the 3rd accumulator checkball (#2) and fills the 3rd accumulator fluid circuit.
- 3rd accumulator fluid seats the 3rd accumulator exhaust checkball (#7) and acts on the release side of the 2nd apply piston in the 2-4 servo. 3rd accumulator fluid pressure assists servo return spring force to move the piston and apply pin against 2nd clutch fluid pressure. This action releases the 2-4 band.
- 3-4 signal fluid is also directed to the 3-4 shift valve where it is blocked in preparation for the upshift to Fourth gear.

3-4 Clutch Applies
- 3-4 clutch fluid is directed to the 3-4 clutch piston to apply the 3-4 clutch plates and obtain Third gear.
- With 3-4 clutch fluid feeding the 3rd accumulator fluid circuit, the movement of the 2nd apply piston in the 2-4 servo acts as an accumulator for the 3-4 clutch apply.
- The PCM continues to operate the 3-2 control solenoid at approximately a 90% duty cycle and 3-2 signal fluid pressure holds the 3-2 control valve closed against spring force.
- 3-4 clutch fluid and 3rd accumulator fluid are blocked by the closed 3-2 control valve in preparation for a 3-2 downshift.
- 3-4 clutch fluid pressure is also routed to the 3-2 downshift valve where it moves the valve against spring force. This opens the valve in preparation for a 3-2 downshift.
- With the 2-3 shift valve train in the upshifted position, servo feed fluid exhausts through the 2-3 shift valve, into the 3-4 accumulator fluid circuit and through an orificed exhaust past the 3-4 relay and 4-3 sequence valves.
- AFL fluid is routed through the 2-3 shuttle valve and fills the D432 fluid circuit. D432 fluid assists spring force at the 1-2 shift valve.

Torque Converter Clutch
- The PCM will apply the converter clutch in Overdrive Range - Third Gear only under heavy throttle at high speeds. Refer to page 56B for an explanation of TCC apply.

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OVERDRIVE RANGE - THIRD GEAR

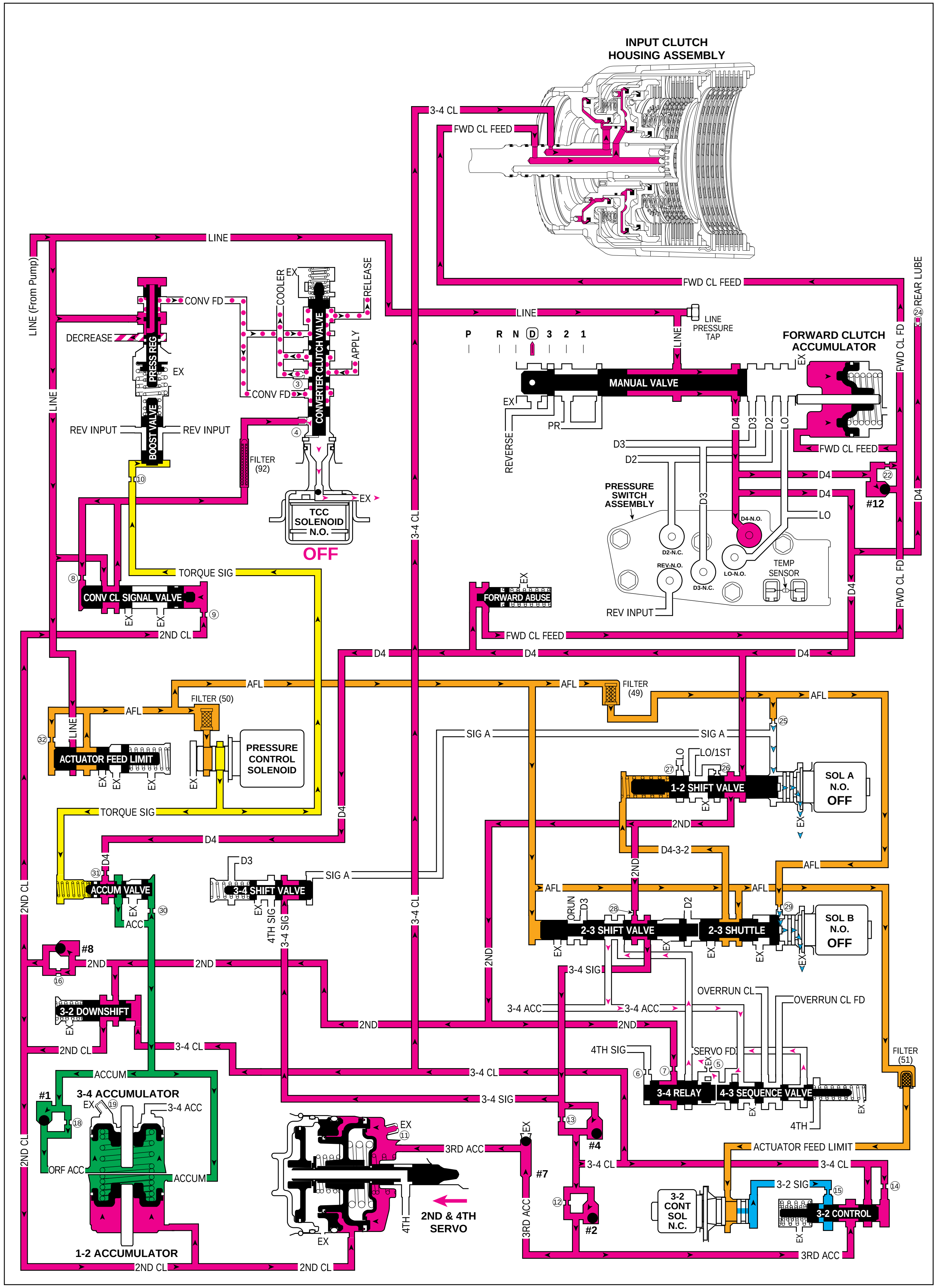

Figure 50

OVERDRIVE RANGE - FOURTH GEAR

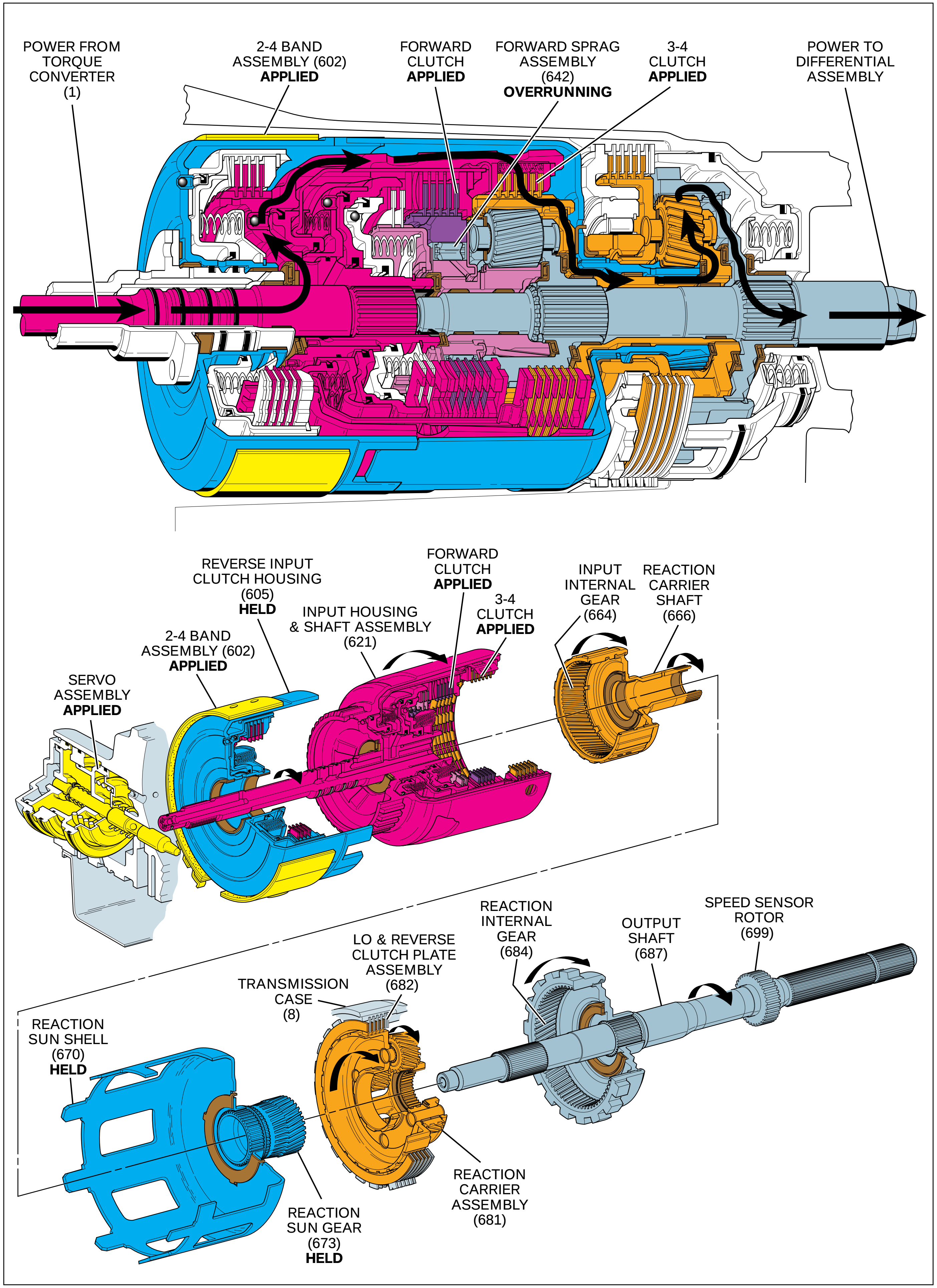

Figure 51

OVERDRIVE RANGE - FOURTH GEAR

SHIFT "A" SOL	SHIFT "B" SOL	2-4 BAND	REVERSE INPUT CLUTCH	OVERRUN CLUTCH	FORWARD CLUTCH	FORWARD SPRAG CL. ASSEMBLY	3-4 CLUTCH	LO-ROLLER CLUTCH	LO-REV CLUTCH
ON	OFF	APPLIED			APPLIED		APPLIED		

To maximize engine efficiency and fuel economy, an Overdrive gear ratio of approximately .73:1 is used. This allows the vehicle to maintain a given road speed with less engine output speed.

- The 3-4 clutch plates (654) remain applied in Fourth gear to transfer engine torque from the input housing (621) to the input internal gear (664) and reaction carrier shaft (666).

2-4 Band Applied

- The 2-4 band (602) is applied and holds the reverse input clutch housing (605) stationary to the transmission case.
- The reaction sun shell (670) is splined to the reverse input clutch housing and the reaction sun gear (673) is splined to the sun shell. Both the sun shell and reaction sun gear are held stationary as a result of the 2-4 band being applied.
- The reaction carrier shaft drives the reaction carrier assembly (681) clockwise.
- The reaction carrier pinion gears rotate clockwise on their pins as they walk clockwise around the stationary reaction sun gear.
- The reaction carrier pinion gears drive the reaction internal gear (684) and output shaft (687) in an overdrive gear ratio of approximately .73:1.

Forward Sprag Clutch Overrunning

- The output shaft drives the input carrier assembly (662), input pinion gears and input sun gear (658) faster than the forward clutch is driving the forward clutch outer race (644). This allows the forward clutch inner race to overrun the forward sprag clutch (642). As a result, the forward clutch and forward sprag clutch are ineffective in Fourth gear.

Converter Clutch Applied

- When operating conditions are appropriate, the TCC is applied in Fourth gear. With the TCC applied there is a mechanical link between the engine and transmission and turbine speed equals engine speed (see page 12).

Coast Conditions

- In Fourth gear, neither the forward sprag clutch nor the lo roller clutch are used to transfer engine torque during acceleration. Therefore, there are no elements to overrun and allow the vehicle to coast freely when the throttle is released. This causes engine compression braking to slow the vehicle. However, because of the Overdrive gear ratio, engine compression braking is not as noticeable by the driver in Fourth gear as in the manual gear ranges.

OVERDRIVE RANGE - FOURTH GEAR

When vehicle operating conditions are appropriate, the PCM energizes shift solenoid “A” to initiate the shift from Third to Fourth gear.

2-4 Band Applies

- Shift solenoid “A” is energized and blocks signal “A” fluid from exhausting through the solenoid. This creates pressure in the signal “A” fluid circuit.
- D432 fluid pressure from the 2-3 shuttle valve assists spring force to hold the 1-2 shift valve in the upshifted position against signal “A” fluid pressure.
- Signal “A” fluid pressure moves the 3-4 shift valve against spring force and into the upshifted position.
- 3-4 signal fluid is routed through the 3-4 shift valve and fills the 4th signal fluid circuit.
- 4th signal fluid pressure moves the 3-4 relay and 4-3 sequence valves against spring force and into the Fourth gear position.
- 2nd fluid flows through the 3-4 relay valve and fills the servo feed fluid circuit.
- Servo feed fluid is routed through the 4-3 sequence valve and into the 4th fluid circuit.
- 4th fluid is routed through the center of the servo pin and acts on the apply side of the 4th apply piston. 4th fluid pressure moves the 4th apply piston against the apply pin spring force acting on the release side of the 4th apply piston. This action moves the apply pin to apply the 2-4 band and obtain Fourth gear.

2-4 Band Accumulation

- Servo feed fluid is also routed through the 2-3 shift valve and into the 3-4 accumulator fluid circuit.
- 3-4 accumulator fluid is blocked by the 3-4 relay and 4-3 sequence valves and is also routed to the 3-4 accumulator.
- 3-4 accumulator fluid pressure moves the 3-4 accumulator piston against spring force and orificed accumulator fluid. This action absorbs initial band apply fluid pressure to cushion the band apply. Some orificed accumulator fluid is forced out of the 3-4 accumulator.
- Accumulator fluid forced from the 3-4 accumulator unseats the 3-4 accumulator checkball and is exhausted back to the end of the accumulator valve. This fluid pressure, in addition to spring force and torque signal fluid pressure, regulates the exhaust of excess accumulator fluid past the valve to help control the 2-4 band apply feel.

Torque Converter Clutch

- When operating conditions are appropriate the PCM will energize the TCC solenoid to apply the converter clutch in Fourth gear. Figure 52 shows the TCC solenoid ON and the converter clutch applied.
- Refer to page 56B, Converter Clutch Applied, for a complete description of converter clutch apply.

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OVERDRIVE RANGE - FOURTH GEAR

(TORQUE CONVERTER CLUTCH APPLIED)

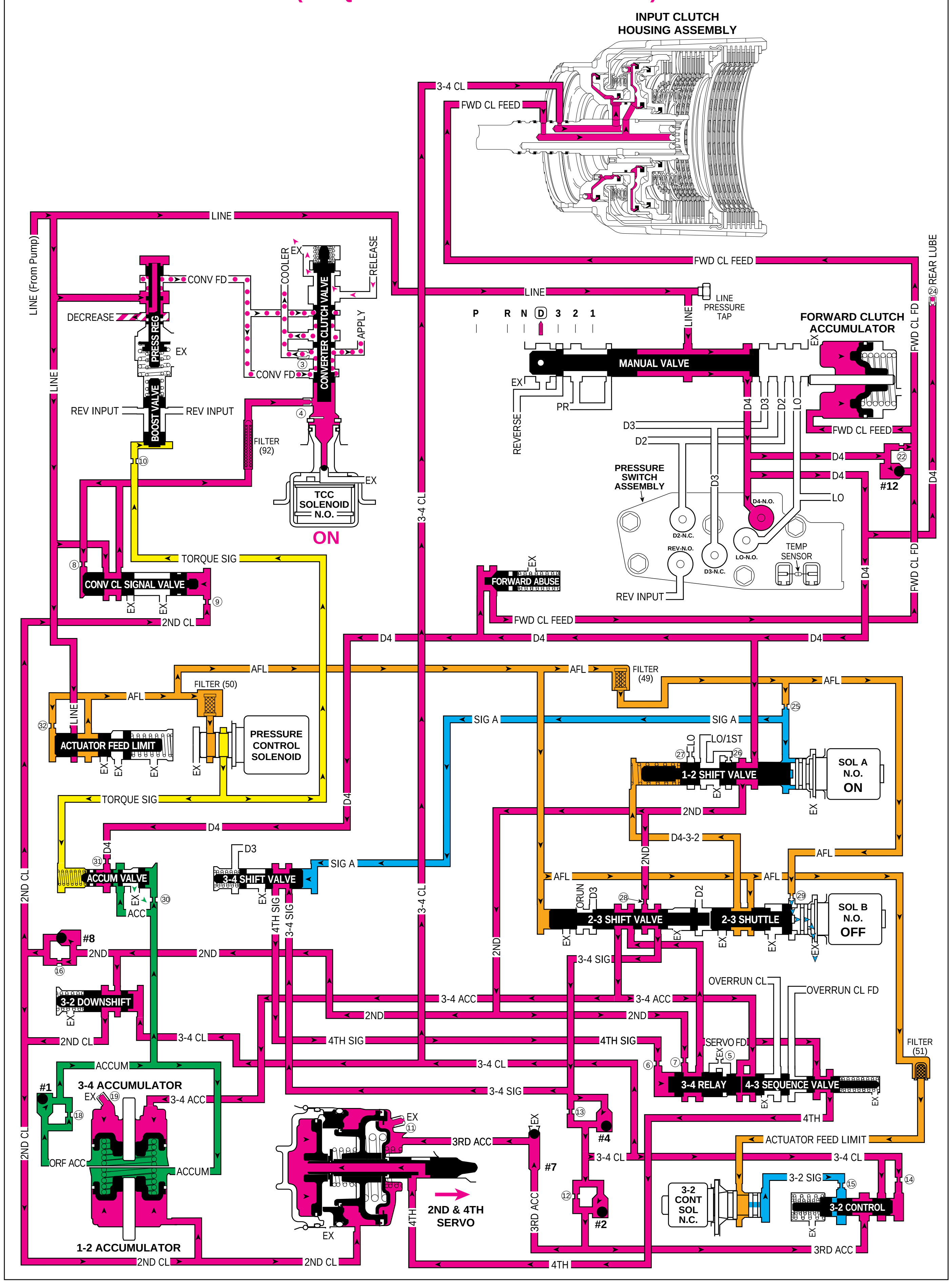

Figure 52

OVERDRIVE RANGE - FOURTH GEAR

(TORQUE CONVERTER CLUTCH RELEASED)

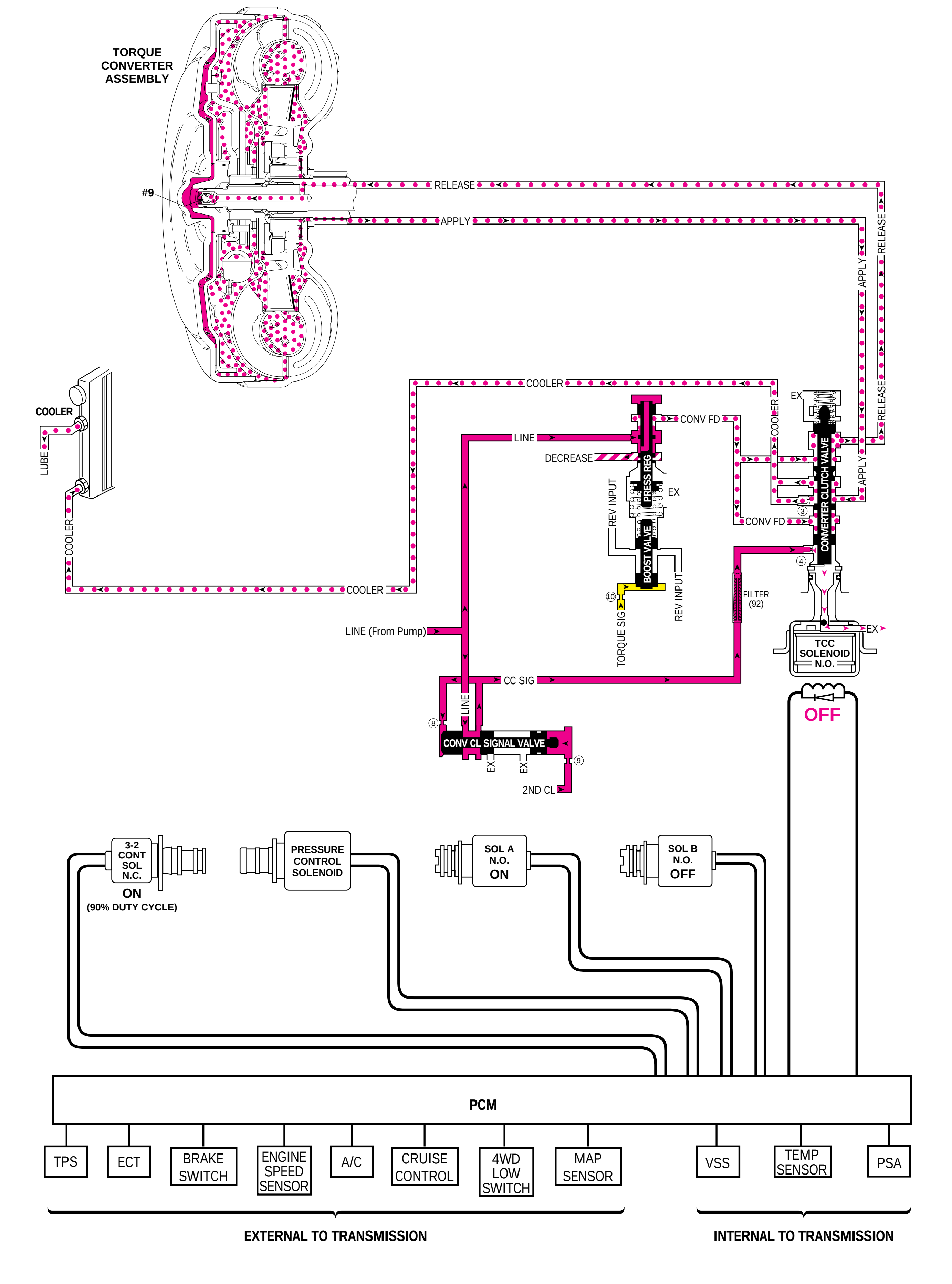

Figure 53

OVERDRIVE RANGE - FOURTH GEAR

(Torque Converter Clutch Released)

Under normal vehicle operating conditions the converter clutch is released and the converter is multiplying torque in First, Second and Third gears. In Fourth gear the converter may or may not be applied depending on the various inputs to the Powertrain Control Module (PCM). These inputs are both internal and external to the transmission and include the following:

- Vehicle Speed Sensor (VSS)*
- Transmission Fluid Temperature Sensor*
- Pressure Switch Assembly (PSA)*
- Throttle Position Sensor (TPS)
- Engine Speed
- Engine Coolant Temperature (ECT) Sensor
- Brake Switch
- 4WD Low Switch
- Air Conditioning (A/C) Request
- Cruise Control Information
- Manifold Absolute Pressure (MAP) Sensor

**Internal to the transmission*

When the converter clutch is released, as determined by the PCM, the converter clutch hydraulic and electrical systems operate as follows:

- The normally open converter clutch solenoid is de-energized and open.
- Converter clutch (CC) signal fluid exhausts through the solenoid. Orifice #4 is smaller than the exhaust through the solenoid, thereby preventing a fluid pressure buildup at the end of the converter clutch apply valve.
- Spring force holds the converter clutch apply valve in the release position.
- Converter feed fluid from the pressure regulator valve is routed through the converter clutch apply valve and into the release fluid circuit.
- Release fluid is routed between the turbine shaft and stator shaft and through the center of the turbine shaft. This fluid unseats the TCC apply checkball (#9) in the end of the turbine shaft and flows between the converter cover and pressure plate. Release fluid pressure keeps the converter clutch pressure plate released from the converter cover and fills the converter with fluid.
- Fluid exits the converter from between the stator shaft and converter hub in the apply fluid circuit.
- Apply fluid is routed through the converter clutch apply valve and into the cooler fluid circuit.
- Cooler fluid flows through the transmission fluid cooler in the radiator and into the lubrication fluid circuit. Refer to page 92 for a complete description of the lubrication fluid circuits throughout the transmission.

Note: Refer to the Electronic Components Section for a complete description of the electrical inputs to the PCM that control the converter clutch apply and release.

OVERDRIVE RANGE - FOURTH GEAR
(Torque Converter Clutch Applied)

The Powertrain Control Module (PCM) continually monitors and receives input signals from various electrical devices both internal and external to the transmission. The PCM processes these signals and determines the precise moment to apply the converter clutch. These input signals include the following:

- Vehicle Speed Sensor (VSS)*
- Transmission Fluid Temperature Sensor*
- Pressure Switch Assembly (PSA)*
- Throttle Position Sensor (TPS)
- Engine Speed
- Engine Coolant Temperature (ECT) Sensor
- Brake Switch
- 4WD Low Switch
- Air Conditioning (A/C) Request
- Cruise Control Information
- Manifiold Absolute Pressure (MAP) Sensor

**Internal to the transmission*

The PCM energizes the converter clutch solenoid when vehicle operating conditions are appropriate for converter clutch apply. This causes the following changes in the transmissions hydraulic system:

- The normally open TCC solenoid closes and blocks converter clutch signal fluid from exhausting through the solenoid.
- Converter clutch signal fluid pressure moves the converter clutch apply valve against spring force and into the apply position.
- Converter feed fluid is routed through the converter clutch apply valve and into the apply fluid circuit. At the same time, the release fluid circuit is open to an exhaust port past the valve.
- Apply fluid flows between the converter hub and stator shaft to maintain fluid pressure in the converter. This fluid pressure applies the pressure plate against the converter cover to obtain TCC apply.
- As the pressure plate applies, release fluid exhausts from between the converter cover and pressure plate. This fluid seats the TCC apply checkball (#9) and is orificed around the ball. Release fluid then flows through the turbine shaft, between the stator shaft and turbine shaft, and past the converter clutch apply valve. The #9 checkball and orifice controls the exhaust rate of release fluid and the converter clutch apply rate.
- With the converter clutch apply valve in the apply position, the cooler fluid circuit is fed by converter feed fluid through an orifice cup plug (orifice #3).
- The following conditions either prevent TCC apply or cause TCC release (refer to the Electronic Components Section for a complete description):
  - When engine coolant temperature is below approximately 20° C (68° F).
  - When transmission fluid temperature is below approximately 29° C (84° F).
  - When throttle position is at a minimum or maximum.
  - When the brake pedal is depressed.

Note: When transmission fluid temperature is above approximately 135° C (275° F), the PCM will operate in 'hot mode' and command TCC apply at all times when the transmission is in Fourth gear.

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OVERDRIVE RANGE - FOURTH GEAR

(TORQUE CONVERTER CLUTCH APPLIED)

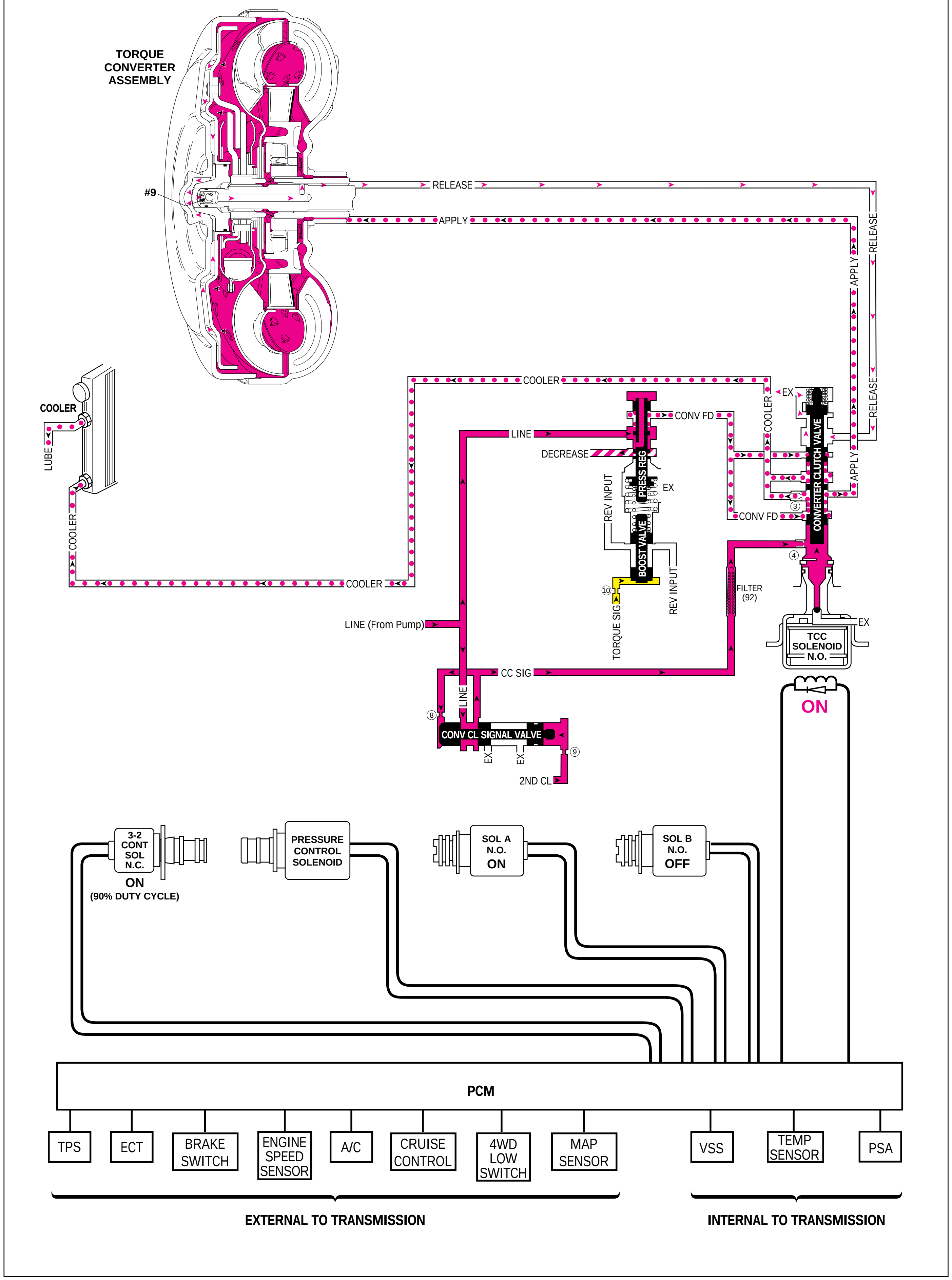

Figure 54

OVERDRIVE RANGE - 4-3 DOWNSHIFT

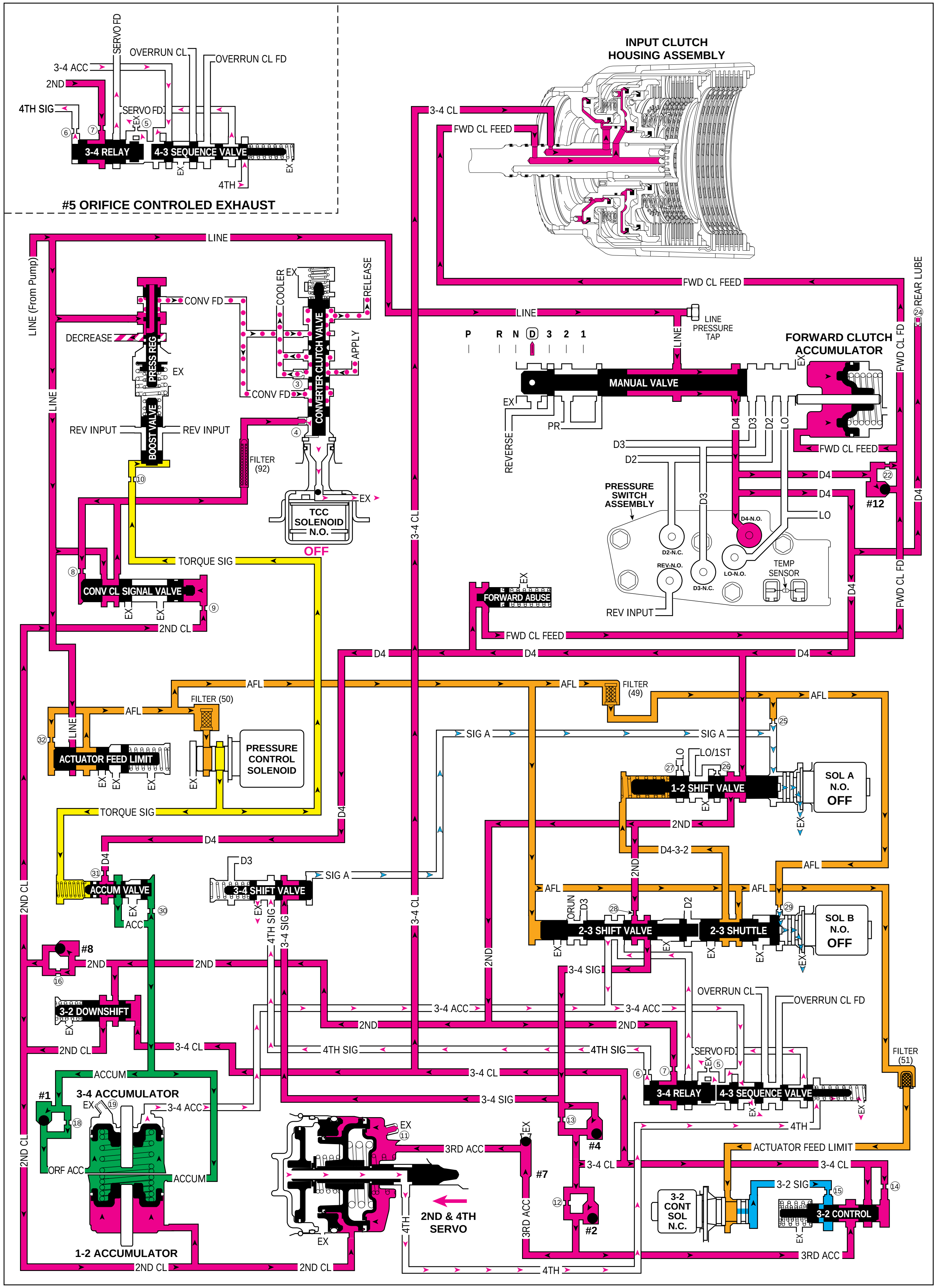

Figure 55

OVERDRIVE RANGE - 4-3 DOWNSHIFT
(Torque Converter Clutch Released)

A forced 4-3 downshift in Overdrive Range is achieved by increasing the percentage of accelerator pedal travel (throttle position) when the transmission is operating in Fourth gear. A 4-3 downshift can also occur when the vehicle is decelerating during coast conditions (minimum throttle). Remember that the PCM controls the pressure control solenoid to vary line pressure in relation to throttle position and other vehicle operating conditions.

The PCM initiates a 4-3 downshift by de-energizing shift solenoid “A”, causing the following changes to occur in the transmission’s hydraulic system:

- Shift solenoid “A” is OFF and signal “A” fluid exhausts through the solenoid.

2-4 Band Releases

- Signal “A” fluid exhausts from the 3-4 shift valve and spring force moves the valve into the downshifted position.
- 3-4 signal fluid is blocked by the downshifted 3-4 shift valve and 4th signal fluid exhausts past the valve.
- 4th signal fluid exhausts from the 3-4 relay valve and 3-4 accumulator fluid moves the 3-4 relay into the Third gear position. This blocks 2nd fluid from feeding the servo feed fluid circuit and opens the 3-4 accumulator fluid circuit to an orificed exhaust (#5). Because the exhaust is orificed, 3-4 accumulator fluid pressure momentarily holds the 4-3 sequence valve against spring force (see inset in Figure 55).
- As shown in the inset, exhausting 3-4 accumulator fluid and spring force acting on the 4-3 sequence valve regulates the exhaust of 4th fluid past the end of the valve. The release of the 2-4 band is initiated with 4th fluid exhausting.
- When exhausting 3-4 accumulator fluid pressure decreases sufficiently, spring force will move the 4-3 sequence valve into the Third gear position (as shown in Figure 55). This opens 3-4 accumulator fluid to a quick exhaust past the 4-3 sequence valve. This also opens the 4th fluid circuit completely to exhaust past the 4-3 sequence valve.
- 4th fluid exhausts from the 4th apply piston in the servo assembly. Apply pin spring force moves the 4th apply piston and apply pin to release the band and shift the transmission into Third gear.

Accumulator Circuit

- 3-4 accumulator fluid also exhausts from the 3-4 accumulator piston.
- Spring force and orificed accumulator fluid pressure move the 3-4 accumulator piston into the Third gear position.
- Accumulator fluid seats the 3-4 accumulator checkball (#1) and fills the orificed accumulator fluid circuit through orifice #18. The rate at which accumulator fluid fills the 3-4 accumulator and 3-4 accumulator fluid exhausts from the accumulator helps control the 2-4 band release.
- The accumulator valve regulates D4 fluid into the accumulator fluid circuit in response to spring force and torque signal fluid pressure. This regulation also helps control the 2-4 band release.

Converter Clutch Releases

- The PCM releases the converter clutch before initiating a 4-3 downshift if it is applied in Fourth gear. Refer to TCC Released on page 56A for a complete description of converter clutch release.

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OVERDRIVE RANGE - 3-2 DOWNSHIFT

As with a 4-3 downshift, a forced 3-2 downshift occurs when throttle position is increased or when the vehicle decelerates during coast conditions. The PCM initiates a 3-2 downshift by energizing shift solenoid “B”.

3-4 Clutch Releases

- Shift solenoid “B” is energized and blocks solenoid signal fluid from exhausting. This creates solenoid signal fluid pressure which moves the 2-3 shift valve train into the downshifted position against AFL fluid pressure acting on the 2-3 shift valve.
- AFL fluid is blocked by the 2-3 shuttle valve and the D432 fluid circuit is open to an exhaust past the valve.
- 2nd fluid fills the servo feed fluid circuit through the 2-3 shift valve and the 3-4 signal fluid circuit is open to an exhaust past the valve.
- 3-4 clutch fluid exhausts from the 3-4 clutch piston to release the 3-4 clutch plates. Exhausting 3-4 clutch fluid pressure seats the 3-4 clutch exhaust checkball (#4), flows through orifice #13 and exhausts through the 3-4 signal fluid circuit. This orifice helps control the release of the 3-4 clutch and the 2-4 band apply (see downshift timing below).

2-4 Band Applies

- 3rd accumulator fluid, which was fed by 3-4 clutch fluid, exhausts from the 2nd apply piston in the 2-4 servo. Exhausting 3rd accumulator fluid seats the 3rd accumulator checkball (#2), flows through orifice #12 and exhausts through the 3-4 clutch and 3-4 signal fluid circuits. 3rd accumulator fluid also exhausts through the 3-2 control valve (see downshift timing below).

Note: Orifice #12 opposite the #2 checkball is not found on all models. For these models, all of the exhausting 3rd accumulator fluid is routed to the 3-2 control valve.

- When 3rd accumulator fluid exhausts from the 2-4 servo, 2nd clutch fluid pressure moves the 2nd apply piston and apply pin to apply the 2-4 band.
- 3-4 clutch fluid exhausts from the 3-2 downshift valve and spring force moves the valve into the Second gear position (as shown in Figure 56). Before spring force overcomes exhausting 3-4 clutch pressure, 2nd fluid feeds the 2nd clutch fluid circuit through the valve. This increased supply of 2nd clutch fluid is needed at the 2-4 servo to apply the 2-4 band. Routing 2nd fluid through the 3-2 downshift valve bypasses the control of orifice #16 at the #8 checkball. *Remember that this checkball and orifice are used to help control the 2-4 band apply during a 1-2 upshift.*

Downshift Timing

- The PCM varies the 3-2 control solenoid’s duty cycle to regulate AFL fluid into the 3-2 signal fluid circuit. The lower the vehicle speed, the lower the solenoid duty cycle during the shift.
- A lower solenoid duty cycle corresponds to lower 3-2 signal fluid pressure which allows spring force to keep the 3-2 control valve open farther. This provides a faster exhaust of 3rd accumulator fluid through the 3-2 control valve. However, this exhausting fluid creates a pressure backup in the 3-4 clutch fluid circuit due to the #4 checkball and #13 orifice. This delays the 3-4 clutch release at lower speeds for proper shift timing. *Refer to the page 39 on the 3-2 control solenoid for a complete description of the solenoid operation.*
- At higher vehicle speeds, the solenoid duty cycle during the shift is greater and 3-2 signal fluid pressure is increased. Under these conditions, 3-2 signal fluid pressure closes the 3-2 control valve further against spring force, thereby slowing the exhaust of 3rd accumulator fluid into the 3-4 clutch fluid circuit. This decreases the pressure backup in the 3-4 clutch fluid circuit and allows the 3-4 clutch to release faster for proper shift timing.

Torque Converter Clutch

- If the converter clutch is applied in Third gear it will release prior to downshifting to Second gear. The PCM keeps the TCC solenoid de-energized and the converter clutch released In Second gear.

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OVERDRIVE RANGE - 3-2 DOWNSHIFT

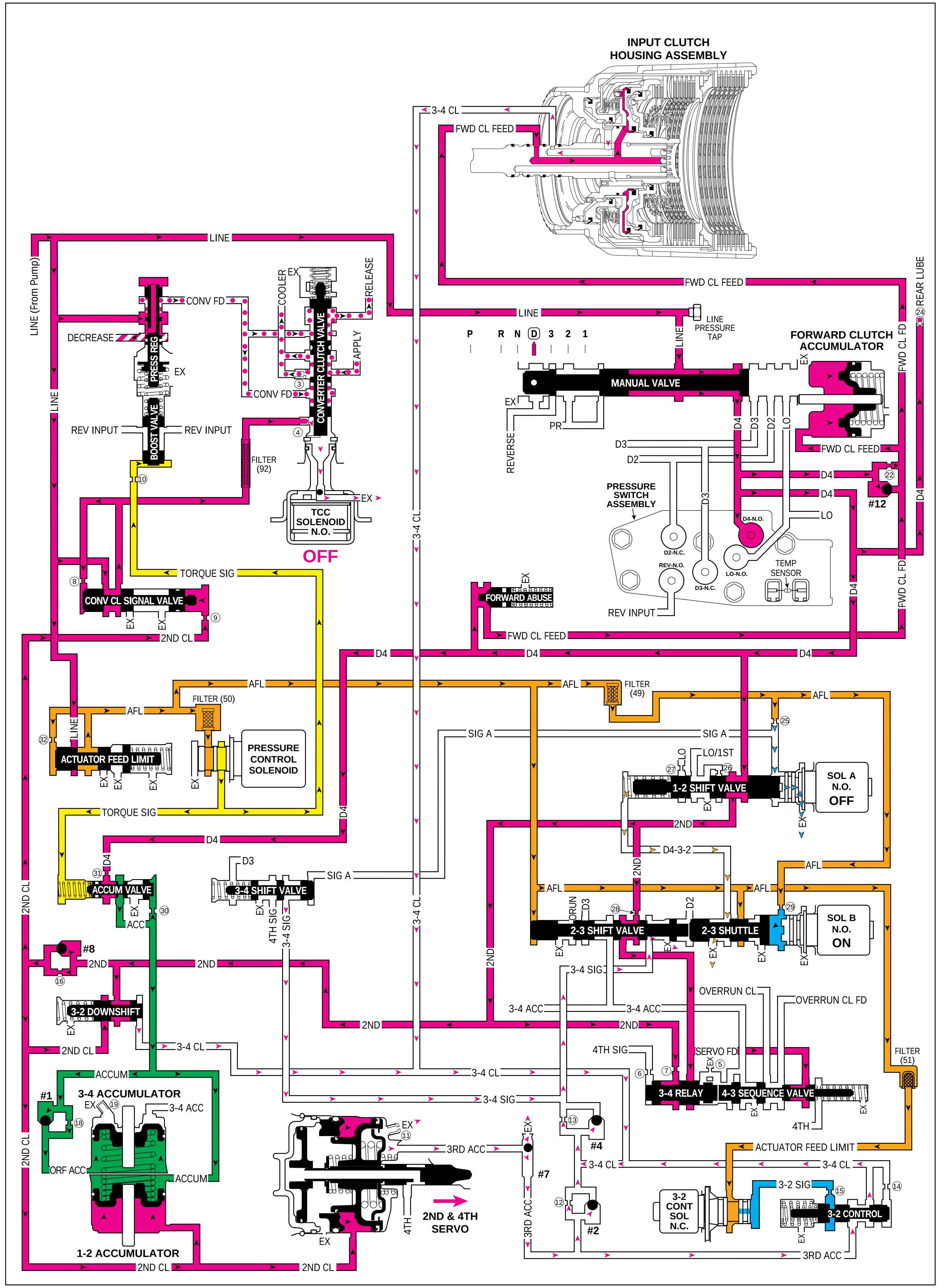

Figure 56

MANUAL THIRD - THIRD GEAR

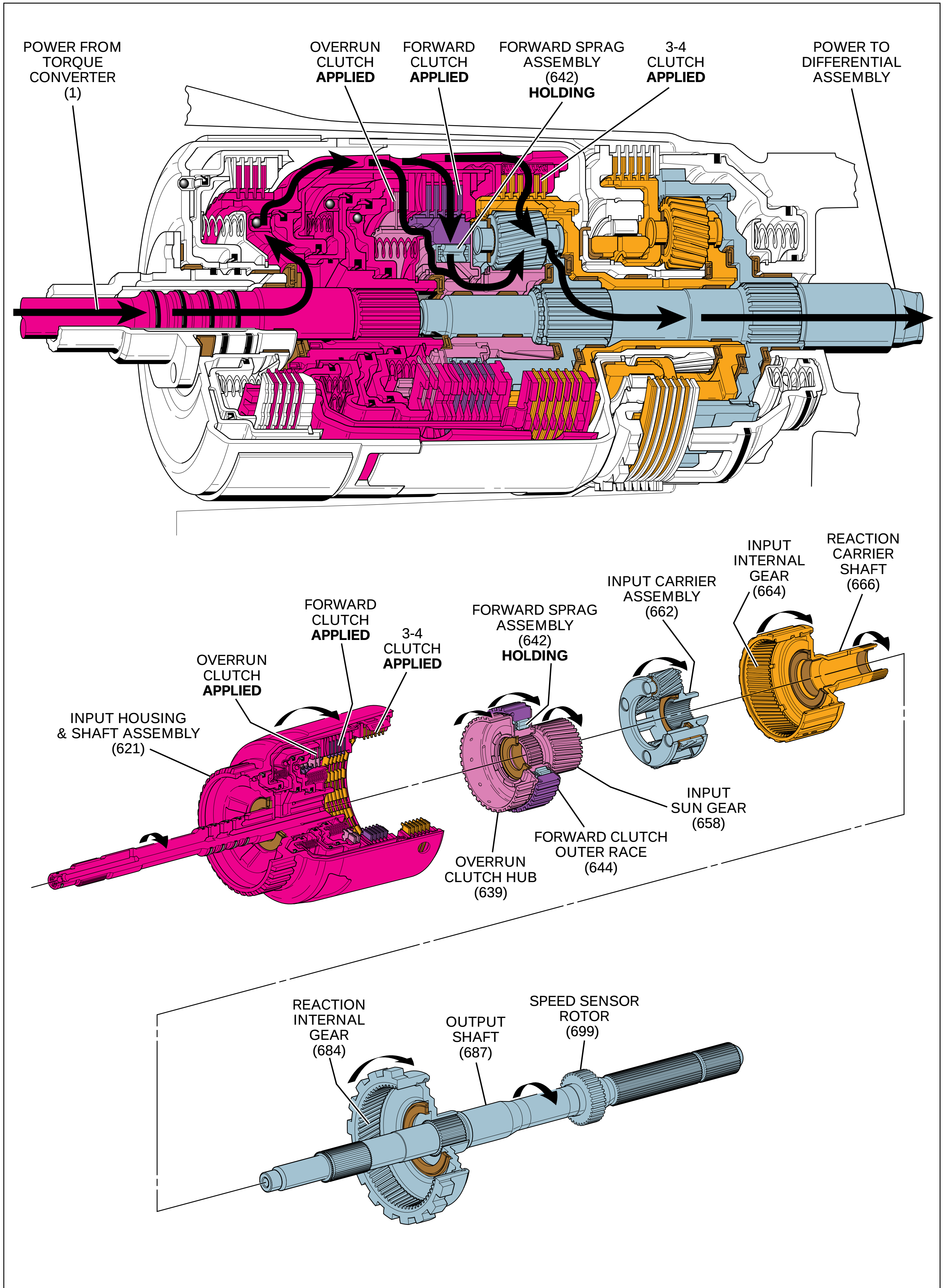

Figure 57

MANUAL THIRD - THIRD GEAR

SHIFT "A" SOL	SHIFT "B" SOL	2-4 BAND	REVERSE INPUT CLUTCH	OVERRUN CLUTCH	FORWARD CLUTCH	FORWARD SPRAG CL. ASSEMBLY	3-4 CLUTCH	LO-ROLLER CLUTCH	LO-REV CLUTCH
OFF	OFF			APPLIED	APPLIED	HOLDING	APPLIED		

Manual Third (D or 3) is available to the driver when vehicle operating conditions make it desirable to use only three gear ratios. These conditions include towing a trailer or driving on hilly terrain.

In Manual Third the transmission is prevented from upshifting into Fourth gear. Otherwise, upshifts and downshifts between First, Second and Third gears are the same as in Overdrive range. If the transmission is in Fourth gear when Manual Third is selected the transmission will immediately downshift into Third gear.

- Power Flow from the engine to the input housing assembly (621) is the same as in all other gear ranges.

Overrun Clutch Applied

- The overrun clutch plates (645) are applied and connect the input housing with the overrun clutch hub (639).

- The overrun clutch hub is connected to the forward clutch outer race (644) and input sun gear (658).

- The overrun clutch plates transfer engine torque to the input sun gear. The forward sprag clutch (642) is holding as in Overdrive Range - Third Gear to assist the overrun clutch in transferring engine torque to the input sun gear.

- Power Flow from the input sun gear to the output shaft (687) is identical to Overdrive Range - Third Gear (refer to page 52A).

Coast Conditions

- With the overrun clutch applied, power from vehicle speed is prevented from overrunning the forward sprag clutch when the throttle is released. This power is transferred back through the overrun clutch and to the engine, thereby allowing engine compression to slow the vehicle when the throttle is released.

Manual Third - First and Second Gears

- Transmission power flow in First and Second gears in Manual Third is identical to the power flow in Overdrive Range. The overrun clutch is released and the forward sprag clutch overruns when the throttle is released during coast conditions, allowing the vehicle to coast freely.

When driving conditions are such that only two gear ratios are desired, or if increased engine compression braking is needed, the Manual Second gear selector position should be selected.

Note: The power flow arrows in the top half of Figure 57 are shown during acceleration. During deceleration the power is transferred from the output shaft to the engine.

MANUAL THIRD - THIRD GEAR
(from Overdrive Range - Fourth Gear)

Transmission operation in Manual Third is similar to the operation in Overdrive Range. The transmission upshifts and downshifts normally between First, Second and Third gears. However, in Manual Third the transmission is prevented, both electronically and hydraulically, from operating in Fourth gear. Also, the overrun clutch is applied in Manual Third - Third Gear to provide engine compression braking. The following information explains the unique changes in Manual Third. Refer to page 58A, Overdrive Range: 4-3 Downshift, for a complete description of a 4-3 downshift.

- The gear selector lever, selector shaft and manual valve are moved to the Manual Third (D) position.
- Line pressure is routed through the manual valve and fills the D3 fluid circuit.

Fourth Gear Prevented

- D3 fluid pressure is routed to the 3-4 shift valve to assist spring force and hold the 3-4 shift valve in the downshifted position.
- 3-4 signal fluid is blocked by the 3-4 shift valve and 4th signal fluid exhausts past the valve. This releases the 2-4 band and hydraulically prevents Fourth gear.
- D3 fluid is also routed to the pressure switch assembly (PSA) and opens the normally closed D3 fluid pressure switch. The PSA signals the PCM that the manual valve is in the Manual Third position.
- With the PSA signalling Manual Third, the PCM de-energizes shift solenoid "A" and signal "A" fluid exhausts through the solenoid. This electronically prevents Fourth gear.

Overrun Clutch Applies

- D3 fluid is routed through the 2-3 shift valve and fills the overrun fluid circuit.
- Overrun fluid pressure seats the overrun clutch feed checkball (#5) against the empty D2 fluid circuit, seats the overrun clutch control checkball (#6), and is orificed (#20) into the overrun clutch feed fluid circuit.
- Overrun clutch feed fluid pressure assists spring force and moves the 3-4 relay and 4-3 sequence valves into the Third gear position against the exhausting 4th signal fluid. Overrun clutch feed fluid flows through the 4-3 sequence valve and fills the overrun clutch fluid circuit.

Note: Overrun clutch feed fluid pressure immediately closes the 4-3 sequence valve against exhausting 3-4 accumulator fluid. This provides a quick exhaust of 4th fluid past the 4-3 sequence valve, unlike a forced 4-3 downshift where the initial exhaust of 4th fluid is regulated by the 4-3 sequence valve (see inset on page 58).

- Overrun clutch fluid is routed to the overrun clutch piston to apply the overrun clutch plates.

Torque Converter Clutch

- The PCM de-energizes the converter clutch solenoid and the TCC releases before downshifting from Fourth to Third gear. The PCM will re-apply the TCC in Manual Third - Third Gear at approximately the same vehicle speeds as in Overdrive Range - Fourth Gear. However, since Fourth gear is prevented, the converter clutch applies with the transmission operating in Third gear in Manual Third.

Manual Third - First & Second Gears (Overrun Clutch Released)

- Shift solenoid "B" is energized in First and Second gears and the 2-3 shift valve train is in the downshifted position. In this position, the 2-3 shift valve blocks D3 fluid from feeding the overrun fluid circuit and overrun fluid exhausts past the valve. This prevents overrun clutch apply and engine compression braking in Manual Third - First and Second Gears.

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MANUAL THIRD - THIRD GEAR

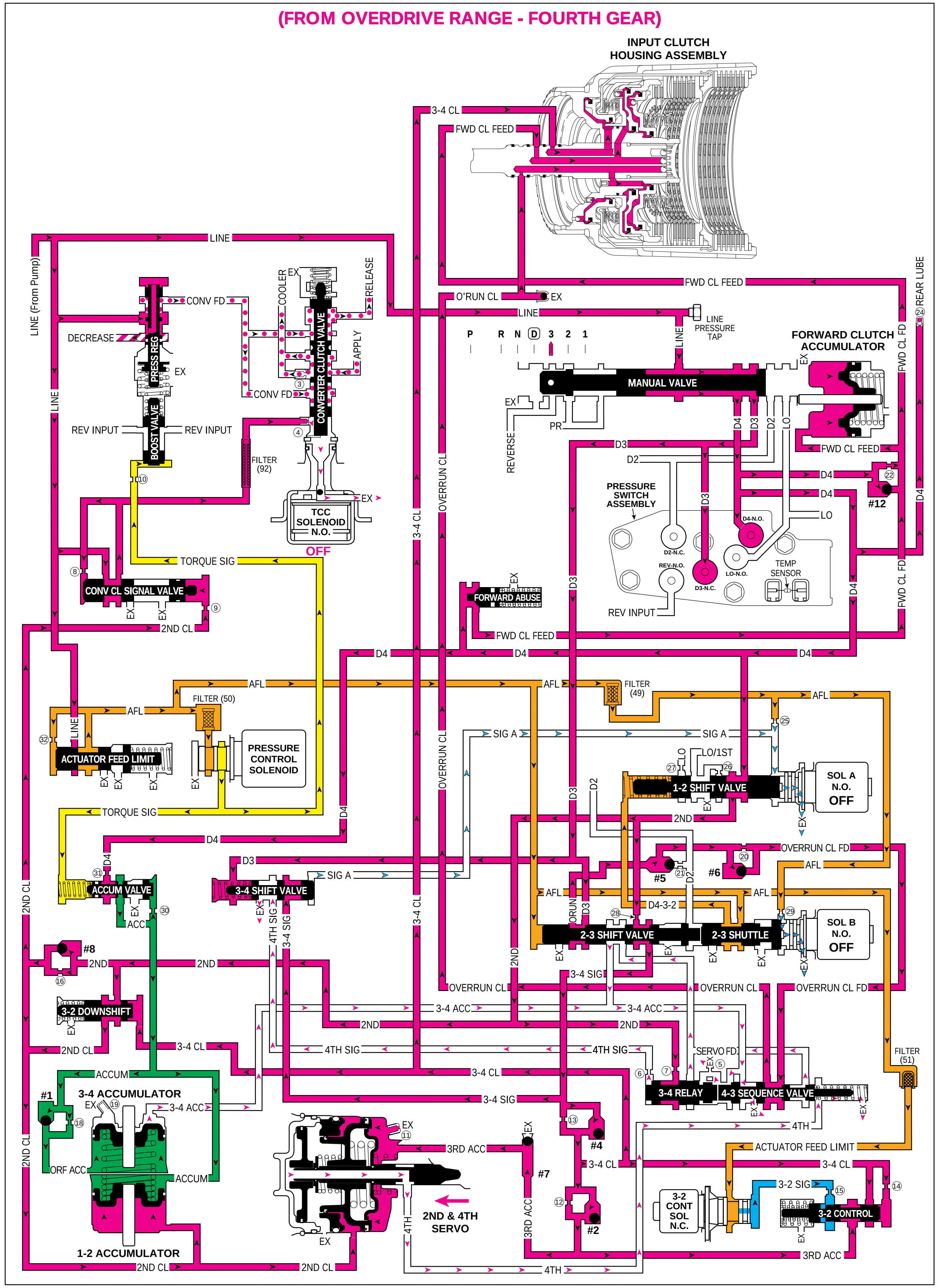

Figure 58

MANUAL SECOND - SECOND GEAR

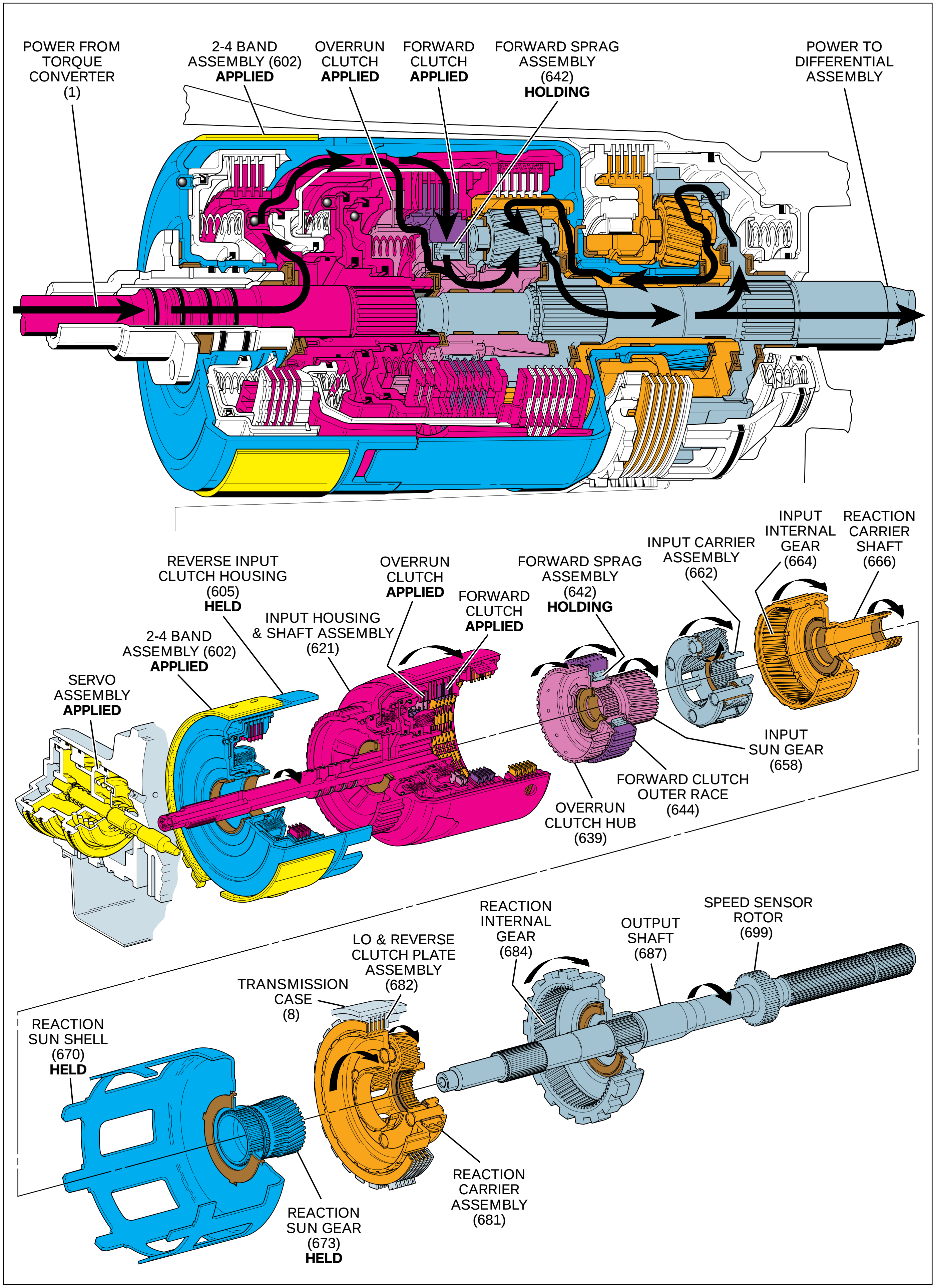

Figure 59

MANUAL SECOND - SECOND GEAR

SHIFT "A" SOL	SHIFT "B" SOL	2-4 BAND	REVERSE INPUT CLUTCH	OVERRUN CLUTCH	FORWARD CLUTCH	FORWARD SPRAG CL. ASSEMBLY	3-4 CLUTCH	LO-ROLLER CLUTCH	LO-REV CLUTCH
OFF	ON	APPLIED		APPLIED	APPLIED	HOLDING			

Manual Second gear range is available to the driver when vehicle operating conditions make it desirable to use only two gear ratios. These conditions include descending a steep grade when increased engine compression braking is needed, or to retain Second gear when ascending a steep grade for additional engine performance. The transmission immediately shifts into Second gear when Manual Second is selected regardless of vehicle speed (see Note below).

- Power flow from the engine to the input housing (621) is the same as in all other gear ranges.

Overrun Clutch Applied

- The overrun clutch plates (645) are applied, as in Manual Third - Third Gear, and connect the input housing with the overrun clutch hub (639).
- The overrun clutch hub is connected to the forward clutch outer race (644) and input sun gear (658).
- The overrun clutch plates transfer engine torque to the input sun gear. The forward sprag clutch (642) is holding as in Overdrive Range to assist the overrun clutch in transferring engine torque to the input sun gear.
- Power Flow from the input sun gear to the output shaft is identical to Overdrive Range - Second Gear (refer to page 50A).

Coast Conditions

- Similar to Manual Third - Third Gear, the overrun clutch plates hold the overrun clutch hub and input sun gear to prevent the sprag clutch from overrunning when the throttle is release. This allows engine compression to slow the vehicle during coast conditions.

Manual Second - First Gear

Note: First gear in the Manual Second gear selector position is only available on some models at low speeds and under heavy throttle.

- The overrun clutch remains applied in Manual Second - First Gear to provide engine compression braking.
- The power flow arrows in Figure 59 are shown during acceleration. During coast conditions, when engine compression braking slows the vehicle, power flow is transferred from the output shaft to the engine.

MANUAL SECOND - SECOND GEAR
(from Manual Third - Third Gear)

When Manual Second (2) is selected, the transmission only operates in Second gear and is prevented from operating in First, Third and Fourth gears *(see note below)*. The transmission will immediately shift to Second gear when Manual Second is selected. This allows the transmission to begin moving the vehicle in Second gear to reduce the torque to the drive axle and reduce tire slippage on ice and snow. Figure 60 and the following information explain what is unique to the Manual Second gear range. Refer to page 58B, Overdrive Range: 3-2 Downshift, for a complete description of the downshift from Third to Second gear.

- The gear selector lever, selector shaft and manual valve are moved to the Manual Second (2) position.
- Line pressure is routed through the manual valve and fills the D2 fluid circuit.

Third and Fourth Gears Prevented
- D2 fluid is routed to the pressure switch assembly (PSA) and opens the normally closed D2 fluid pressure switch. The PSA signals the PCM that the manual valve is in the Manual Second position.
- The PCM immediately changes the shift solenoid states to a Second gear operation. Shift solenoid "A" is OFF and shift solenoid "B" is ON. This electronically prevents First, Third and Fourth gears *(see note below).*
- D2 fluid pressure is also routed between the 2-3 shuttle and 2-3 shift valves. D2 fluid pressure keeps the 2-3 shift valve downshifted against AFL fluid pressure regardless of shift solenoid "B" state. This hydraulically prevents Third and Fourth gears.
- Solenoid signal fluid pressure from shift solenoid "B" keeps the 2-3 shuttle valve downshifted against D2 fluid pressure. This blocks AFL fluid and opens the D432 fluid circuit to an exhaust past the valve.

Overrun Clutch Remains Applied
- D3 fluid is blocked by the downshifted 2-3 shift valve and overrun fluid exhausts past the valve.
- Before overrun fluid exhausts, D2 fluid seats the overrun clutch feed checkball (#5) against the overrun fluid circuit and feeds the overrun clutch feed fluid circuit. This provides a continuous supply of fluid to the overrun clutch fluid circuit to keep the overrun clutch applied in both Second and First gears in Manual Second *(see note below)*.

First Gear Prevented *(see note below)*
- The prevention of First gear is controlled electronically by the PCM through shift solenoid "A". The PCM keeps shift solenoid "A" de-energized regardless of vehicle operating conditions when the PSA signals Manual Second gear range. This keeps signal "A" fluid exhausted and spring force holds the 1-2 shift valve in the upshifted position.

Pressure Regulation
- The PCM output signal to the pressure control solenoid increases the operating range of torque signal fluid pressure in Manual Second. This provides increased line pressure for the additional torque requirements during engine compression braking and increased engine loads.

Note: A 2-1 downshift is available on some applications during heavy throttle conditions at lower speeds.

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MANUAL SECOND
(FROM MANUAL THIRD - THIRD GEAR)

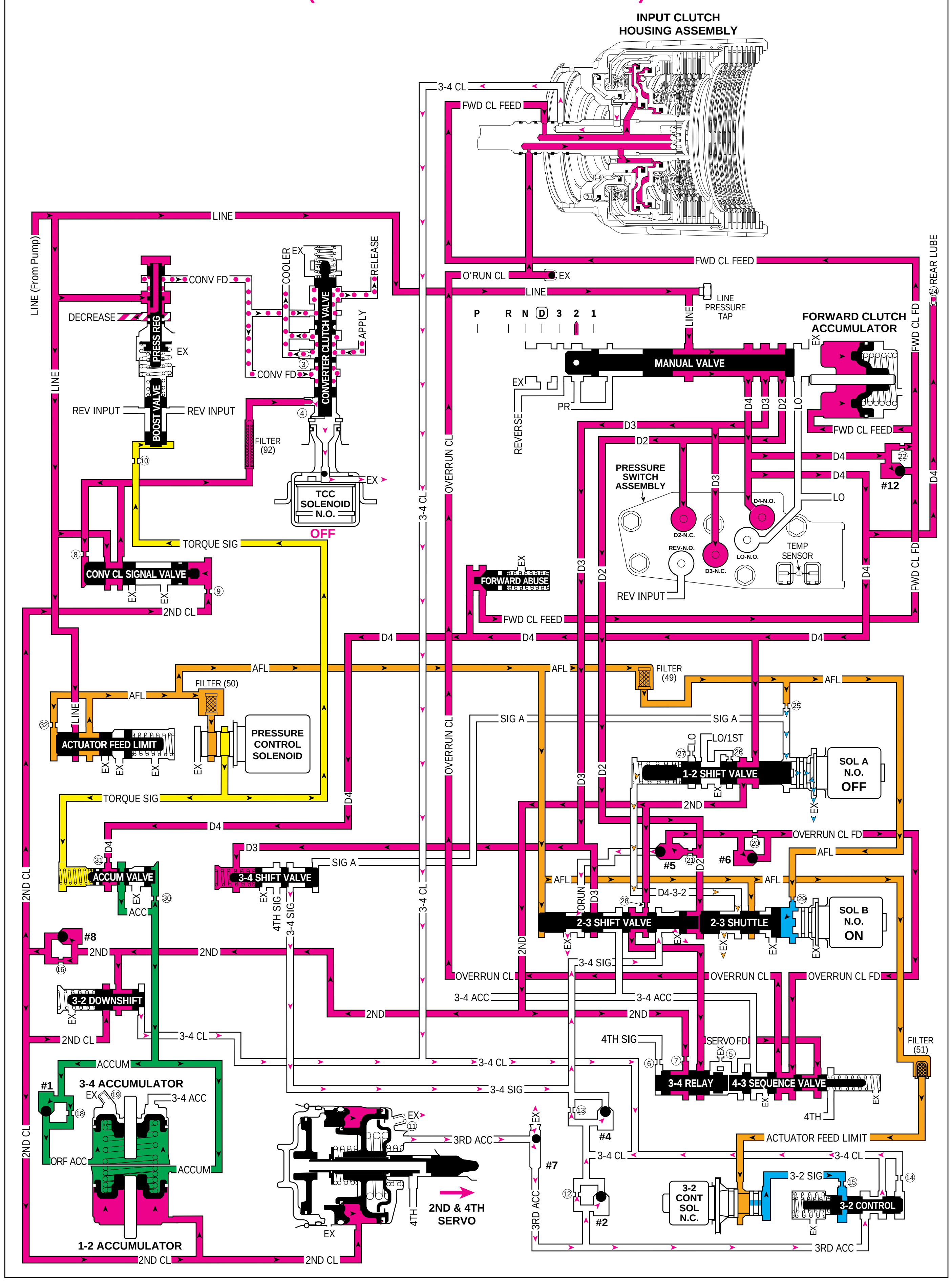

Figure 60

MANUAL FIRST - FIRST GEAR

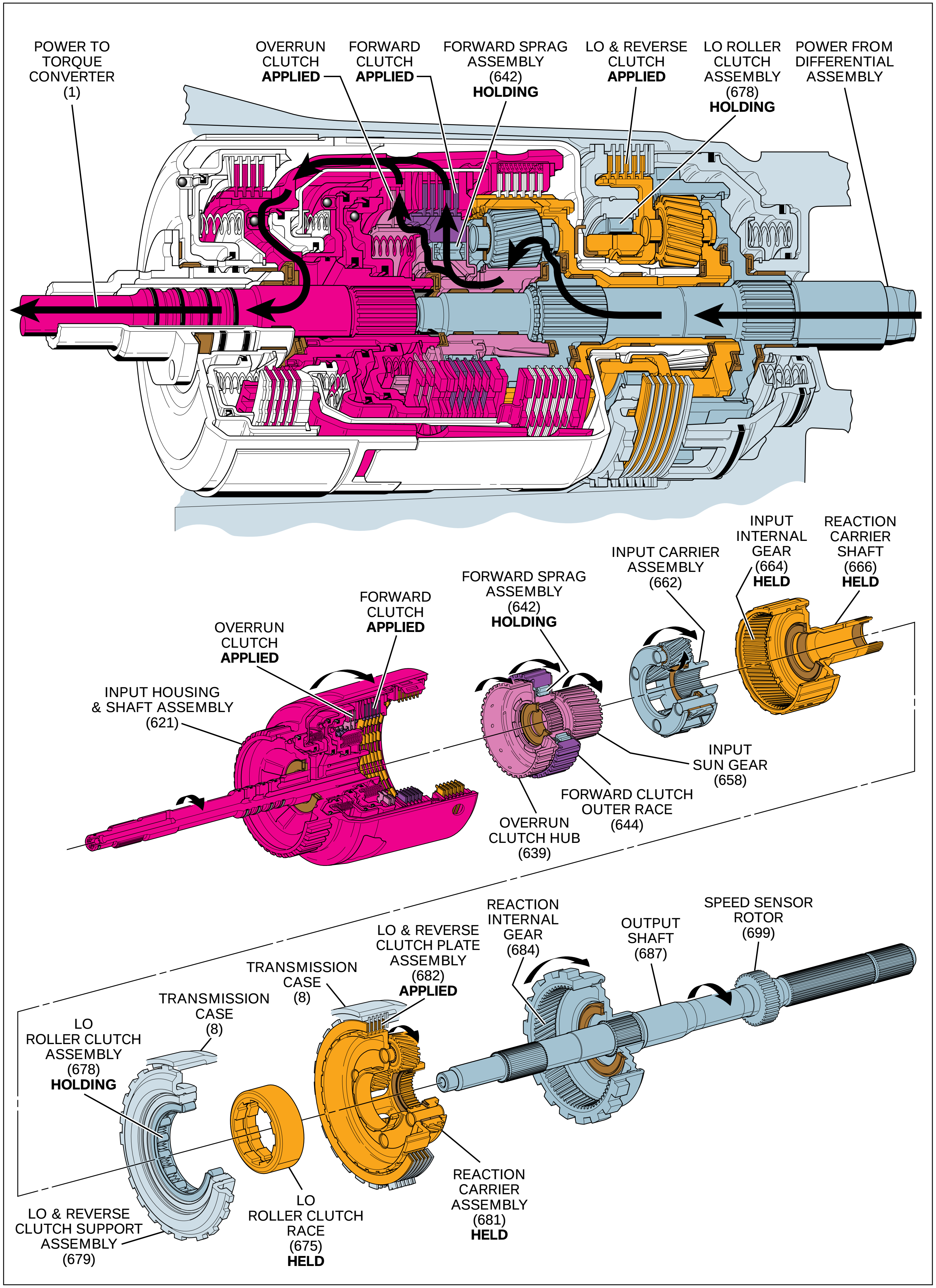

Figure 61

MANUAL FIRST - FIRST GEAR

SHIFT "A" SOL	SHIFT "B" SOL	2-4 BAND	REVERSE INPUT CLUTCH	OVERRUN CLUTCH	FORWARD CLUTCH	FORWARD SPRAG CL. ASSEMBLY	3-4 CLUTCH	LO-ROLLER CLUTCH	LO-REV CLUTCH
ON	ON			APPLIED	APPLIED	HOLDING		HOLDING	APPLIED

Manual First is available to the driver when vehicle operating conditions require maximum engine compression to slow the vehicle, or maintain maximum transfer of engine torque to the vehicle drive shaft.

Under normal operating conditions in Manual First the transmission is prevented from upshifting past First gear. When Manual First is selected while operating in either Second, Third, or Fourth gears, the transmission may not immediately downshift into First gear. Vehicle speed must be below approximately 52 km/h (33 mph) before the transmission will downshift into First gear. Above this speed, the transmission will operate in a Manual First - Second Gear condition until vehicle speed decreases sufficiently.

The transfer of engine torque through the transmission during acceleration is similar to Overdrive Range - First Gear. Refer to Page 48A for a complete description of mechanical power flow during acceleration. When decelerating with the throttle released, engine compression braking is accomplished by applying the lo and reverse clutch.

Note: Figure 61 shows the transfer of engine torque during deceleration with the throttle released, and engine compression braking slowing the vehicle. Power is transferred from the vehicle's drive shaft, through the transmission components and to the engine.

Overrun Clutch Remains Applied

- The overrun clutch plates (645) are applied and prevent the forward sprag clutch (642) from overrunning when the throttle is released.

Lo and Reverse Clutch Applied

- The lo and reverse clutch plates (682) are applied in Manual First - First Gear. The lo and reverse clutch holds the reaction carrier assembly (681) stationary to the transmission case.

- With the reaction carrier held stationary, the lo roller clutch (678) is prevented from being overrun when the throttle is released. Without an element to overrun during coast conditions, (either the sprag clutch or roller clutch), engine compression slows the vehicle when the throttle is released.

MANUAL FIRST - FIRST GEAR
(from Manual Second - Second Gear)

The downshift to First gear is controlled electronically by the PCM. The PCM will not energize shift solenoid "A" to initiate the 2-1 downshift until vehicle speed is below approximately 48 to 56 km/h (30 to 35 mph). Above this speed, the transmission will operate in a Manual First - Second Gear condition until vehicle speed slows sufficiently. In Manual First, as in Manual Second, the transmission is electronically and hydraulically prevented from operating in Third or Fourth gears. Figure 62 and the following text describes the downshift from Manual Second - Second Gear to Manual First - First Gear.

- The selector lever, selector shaft and manual valve are in the Manual First position.
- Line pressure is routed through the manual valve and fills the lo fluid circuit.
- Lo fluid is routed to the pressure switch assembly (PSA) and closes the normally open lo fluid pressure switch. The PSA signals the PCM that the manual valve is in the Manual First position.

2-4 Band Releases

- When vehicle speed is below approximately 48 to 56 km/h (30 to 35 mph), the PCM energizes shift solenoid "A". This closes the solenoid and blocks signal "A" fluid from exhausting.
- Signal "A" fluid pressure moves the 1-2 shift valve against spring force and into the downshifted position. This opens 2nd fluid to an orificed annulus exhaust through the 1-2 shift valve. This orifice (#26) helps control the 2-4 band release rate.
- 2nd clutch fluid exhausts from the 2nd apply piston in the 2-4 servo. Servo return and servo cushion spring forces move the apply piston and apply pin to release the 2-4 band.
- 2nd clutch fluid exhausts from the 1-2 accumulator piston. Spring force and accumulator fluid pressure move the accumulator piston into the First gear position.
- 2nd clutch fluid also exhausts from the 3-2 downshift and converter clutch signal valves. Exhausting 2nd clutch fluid unseats the 1-2 upshift checkball (#8) for a quick exhaust into the 2nd fluid circuit.
- 2nd fluid exhausts from the 3-4 relay valve and servo feed fluid exhausts from the 4-3 sequence valve. Exhausting servo feed fluid is routed through the downshifted 2-3 shift valve and into the 2nd fluid circuit.

Overrun Clutch Remains Applied

- D2 fluid continues to feed the overrun clutch feed fluid circuit at the overrun clutch feed checkball (#5). This maintains overrun clutch apply in Manual First - First Gear.

Lo and Reverse Clutch Applies

- Lo fluid is orificed through the 1-2 shift valve and fills the lo/1st fluid circuit. This orifice (#27) helps control the lo and reverse clutch apply rate.
- Spring force holds the lo overrun valve open and lo/1st fluid is routed through the valve to fill the lo/reverse fluid circuit.
- Lo/reverse fluid is routed to the lo and reverse clutch piston. This fluid pressure applies the lo and reverse clutch and, in addition to the overrun clutch, provides engine compression braking in Manual First - First Gear.

Pressure Regulation

- As in Manual Second, the PCM output signal to the pressure control solenoid increases the operating range of torque signal fluid pressure in Manual First. This provides increased line pressure for the torque requirements during engine compression braking and increased engine loads.

COMPLETE HYDRAULIC CIRCUIT
Page 90

MANUAL FIRST - FIRST GEAR

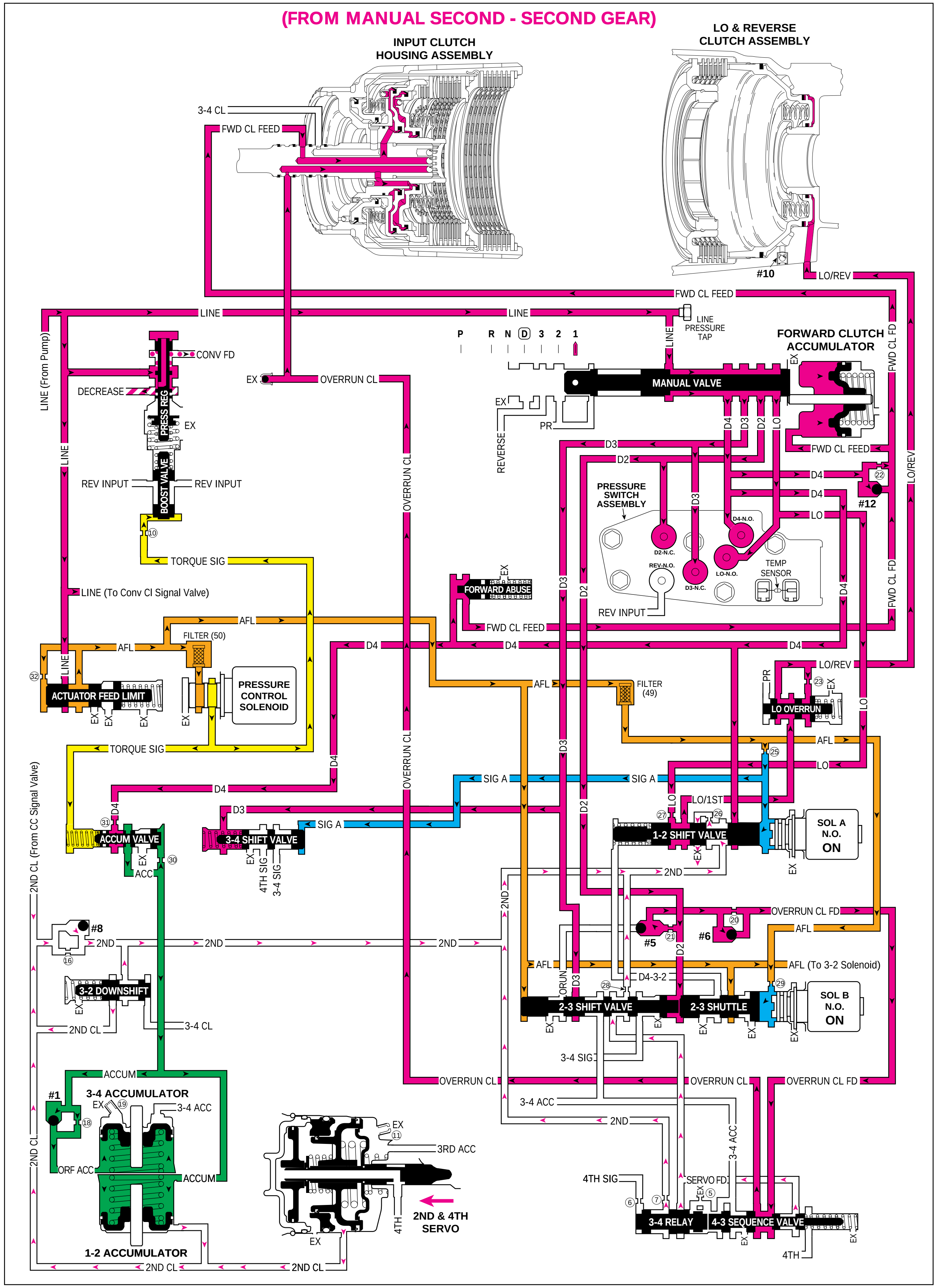

Figure 62

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The hydraulic circuitry of the Hydra-matic 4L60-E transmission is better understood when fluid flow can be related to the specific components in which the fluid travels. In the Power Flow section, a simplified hydraulic schematic was given to show what hydraulically occurs in a specific gear range. The purpose was to isolate the hydraulics used in each gear range in order to provide the user with a basic understanding of the hydraulic system.

In contrast, this section shows a complete hydraulic schematic with fluid passages active in the appropriate component for each gear range. This is accomplished using two opposing foldout pages that are separated by a half page of supporting information.

The left side foldout contains the complete color coded hydraulic circuit for the given gear range along with the relative location of valves, checkballs and orifices within specific components. A broken line is also used to separate components such as the pump, valve body and case to assist the user when following the hydraulic circuits as they pass between them. Also, the numbers shown in the circuits at the broken lines reference specific holes and orifices in the spacer plate on the right hand foldout. The half page of information facing this foldout identifies the components involved in this gear range and a description of how they function.

The right side foldout shows a two-dimensional line drawing of the fluid passages within each component. The active fluid passages for each gear range are appropriately colored to correspond with the hydraulic schematic used for that range. The half page of information facing this foldout identifies the various fluid circuits with numbers that correspond to the circuit numbers used on the foldout page.

PASSAGE A IS LOCATED IN THE PUMP BODY (LIGHT GREY AREA)
PASSAGE B IS LOCATED IN THE VALVE BODY (LIGHT GREY AREA)
PASSAGE C IS LOCATED ON THE SPACER PLATE (DASHED LINE)
PASSAGE D IS LOCATED IN CASE (WHITE AREA)
PASSAGE E IS LOCATED IN THE ACCUMULATOR HOUSING (LIGHT GREY AREA)

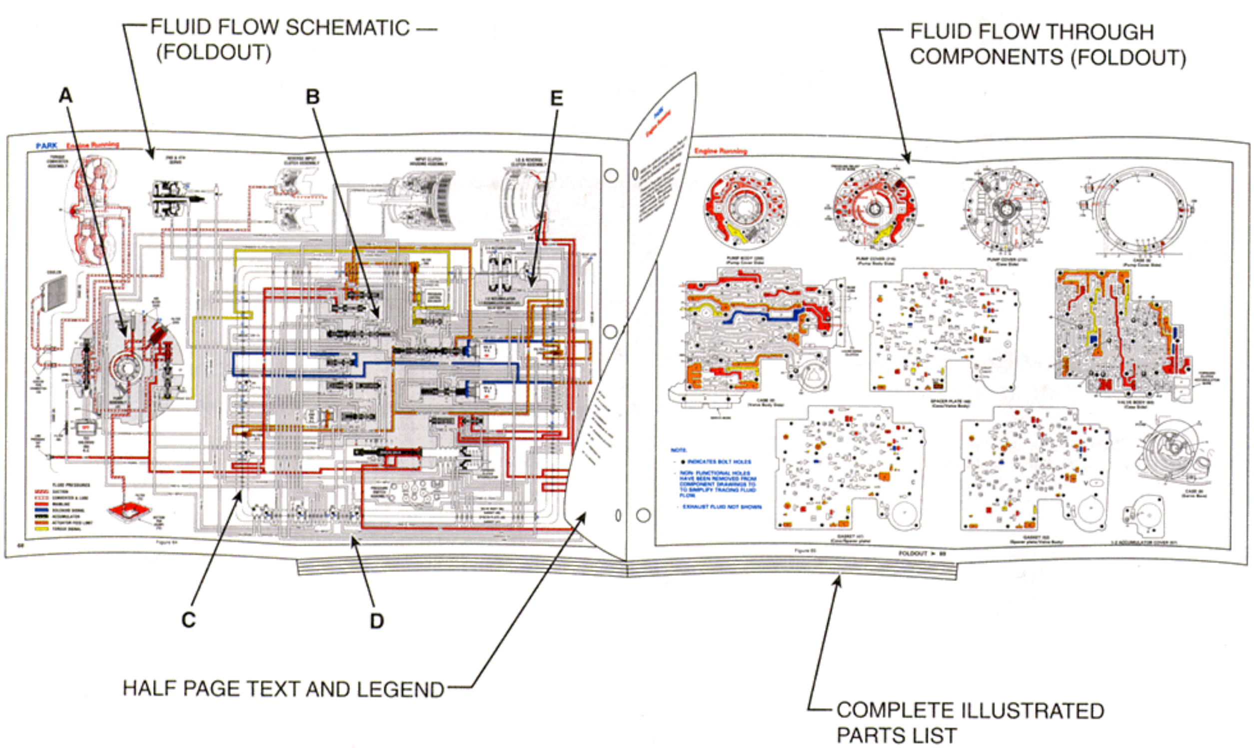


Figure 63

PARK Engine Running

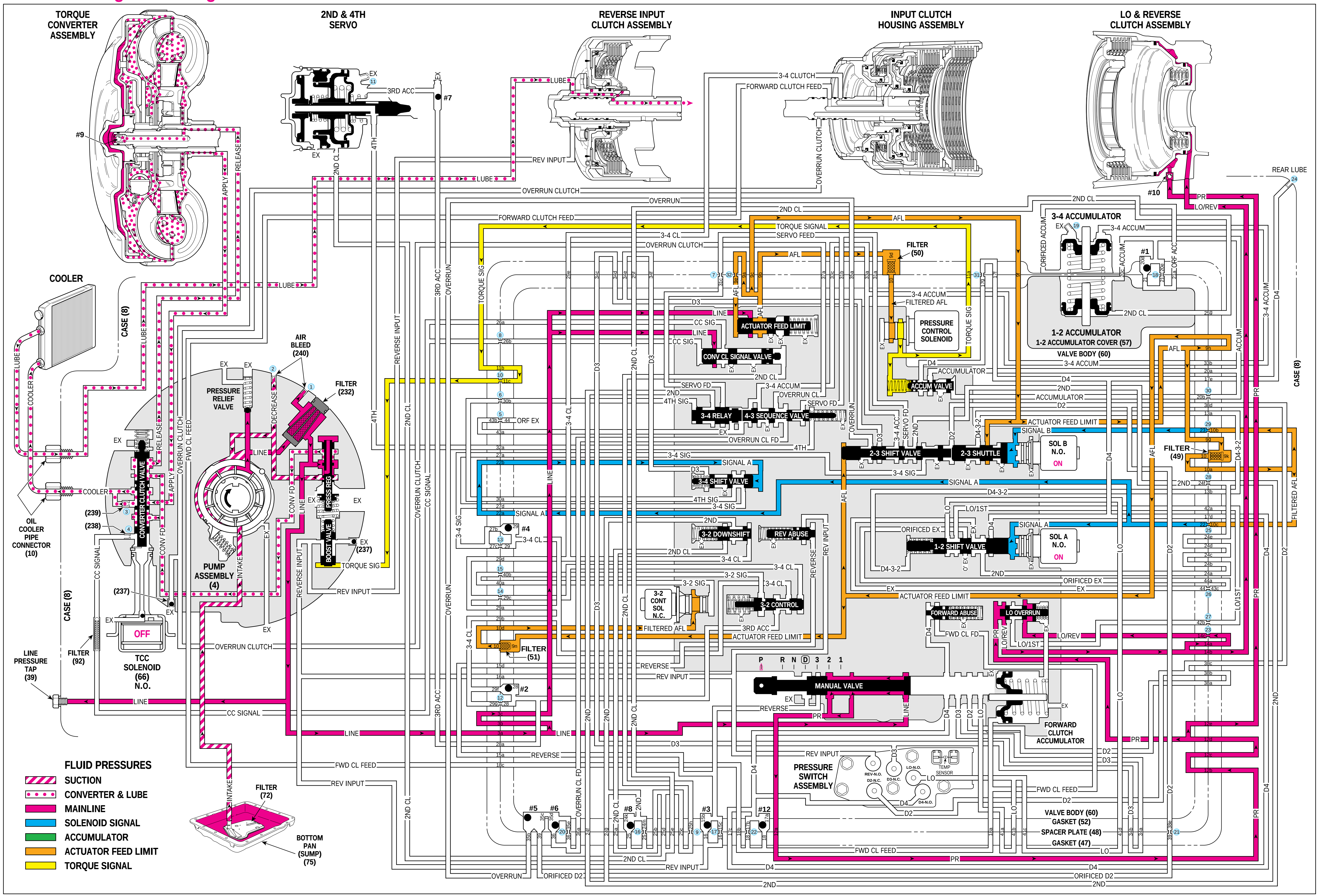
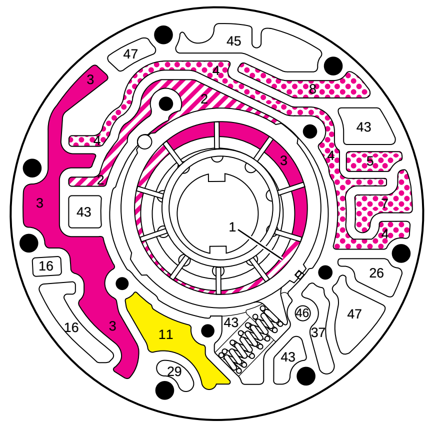
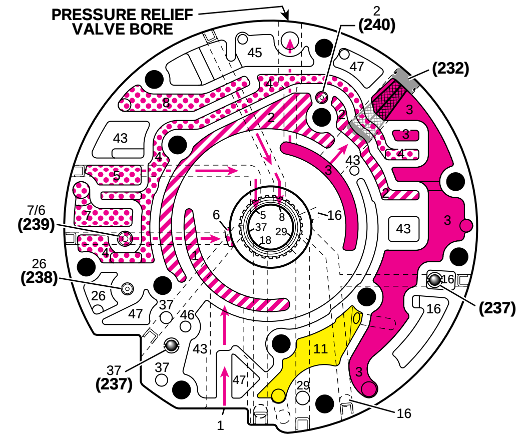


Figure 64

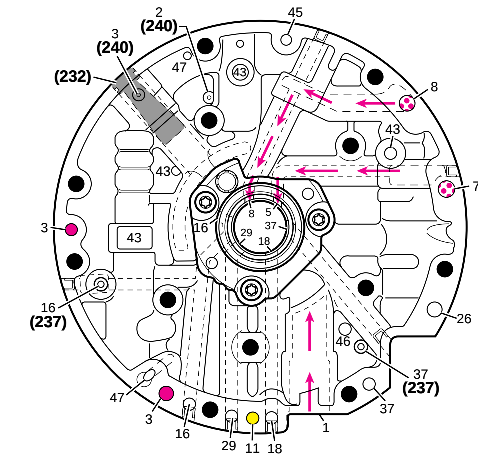
PARK Engine Running



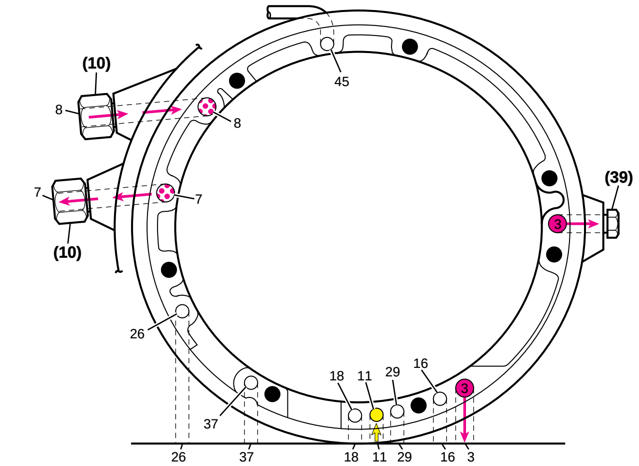
PUMP BODY (200)
(Pump Cover Side)



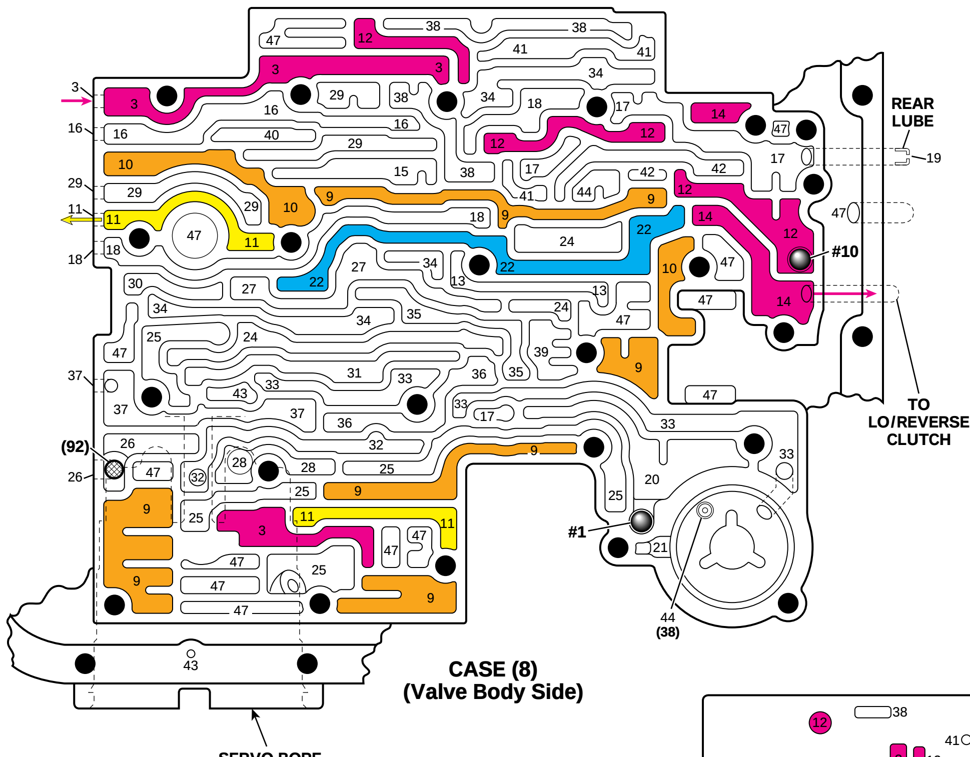
PUMP COVER (215)
(Pump Body Side)



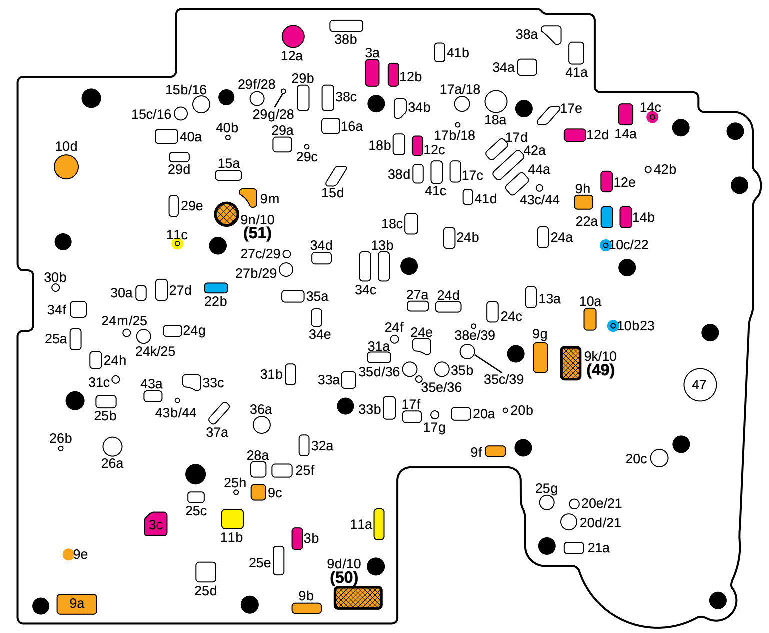
PUMP COVER (215)
(Case Side)



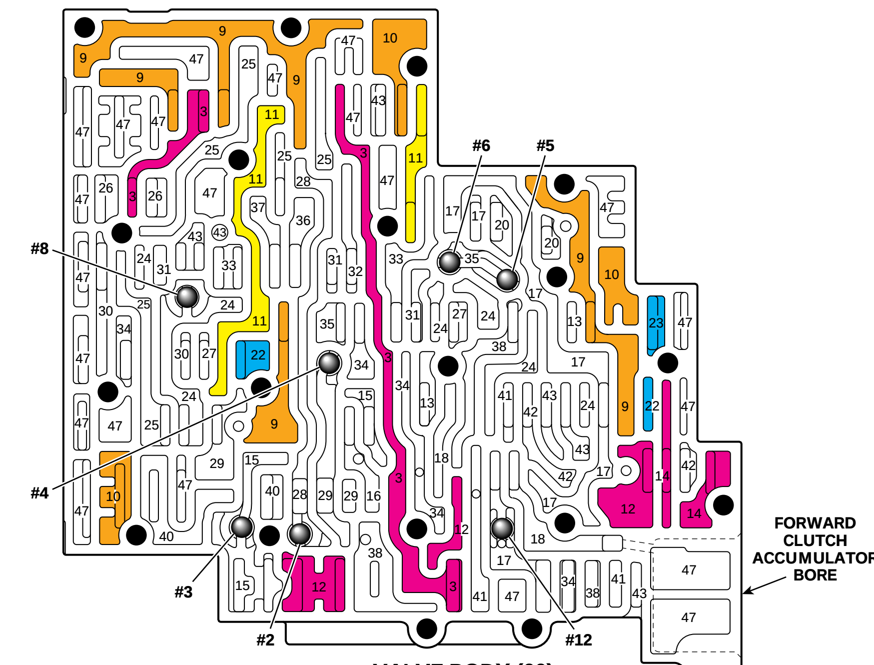
CASE (8)
(Pump Cover Side)



CASE (8)
(Valve Body Side)



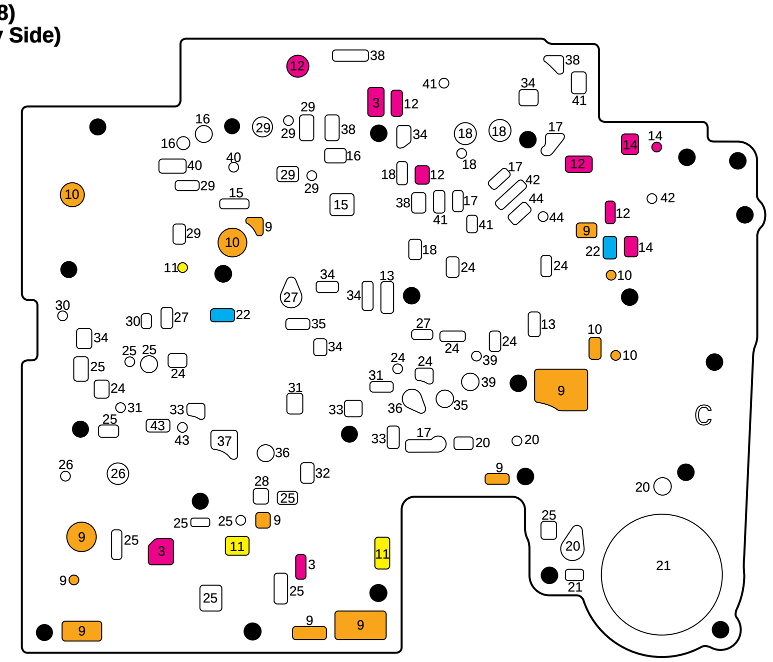
SPACER PLATE (48)
(Case/Valve Body)



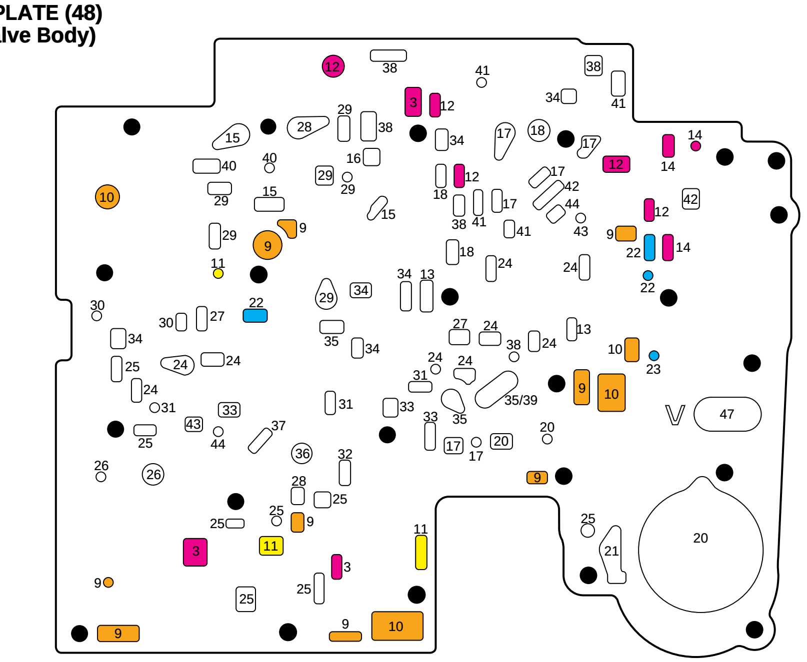
VALVE BODY (60)
(Case Side)

NOTE:

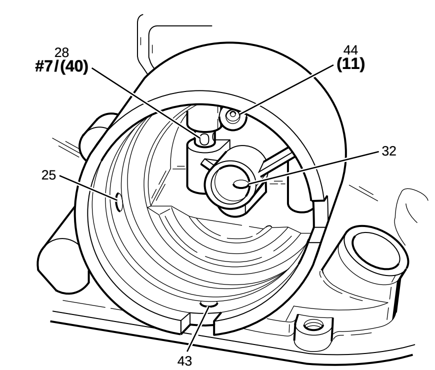
- ● INDICATES BOLT HOLES
- NON- FUNCTIONAL HOLES HAVE BEEN REMOVED FROM COMPONENT DRAWINGS TO TO SIMPLIFY TRACING FLUID FLOW.
- EXHAUST FLUID NOT SHOWN



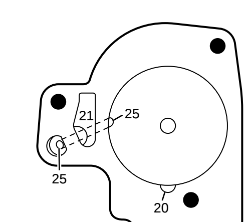
GASKET (47)
(Case/Spacer plate)



GASKET (52)
(Spacer plate/Valve Body)



CASE (8)
(Servo Bore)



1-2 ACCUMULATOR COVER (57)

Figure 65

REVERSE

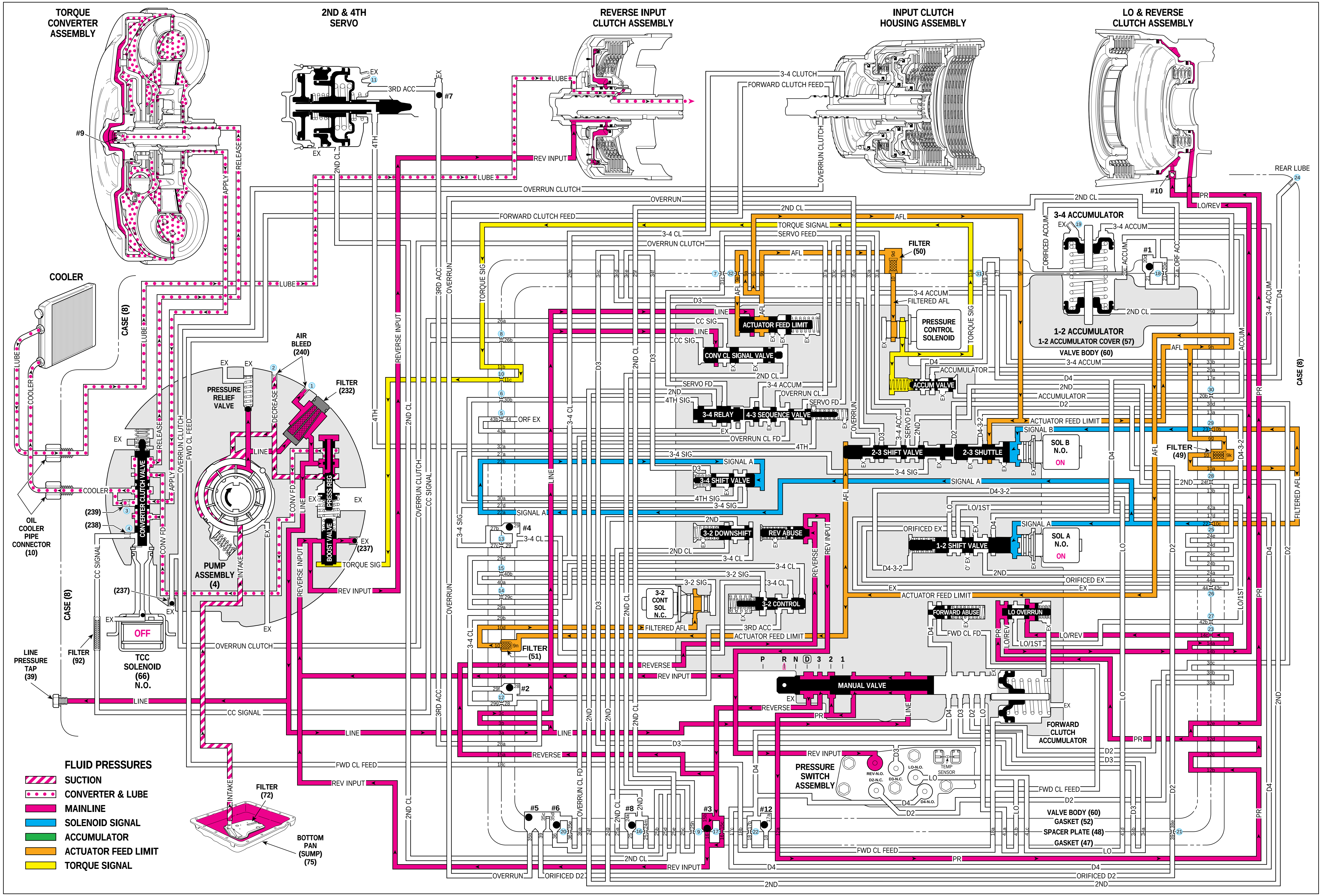
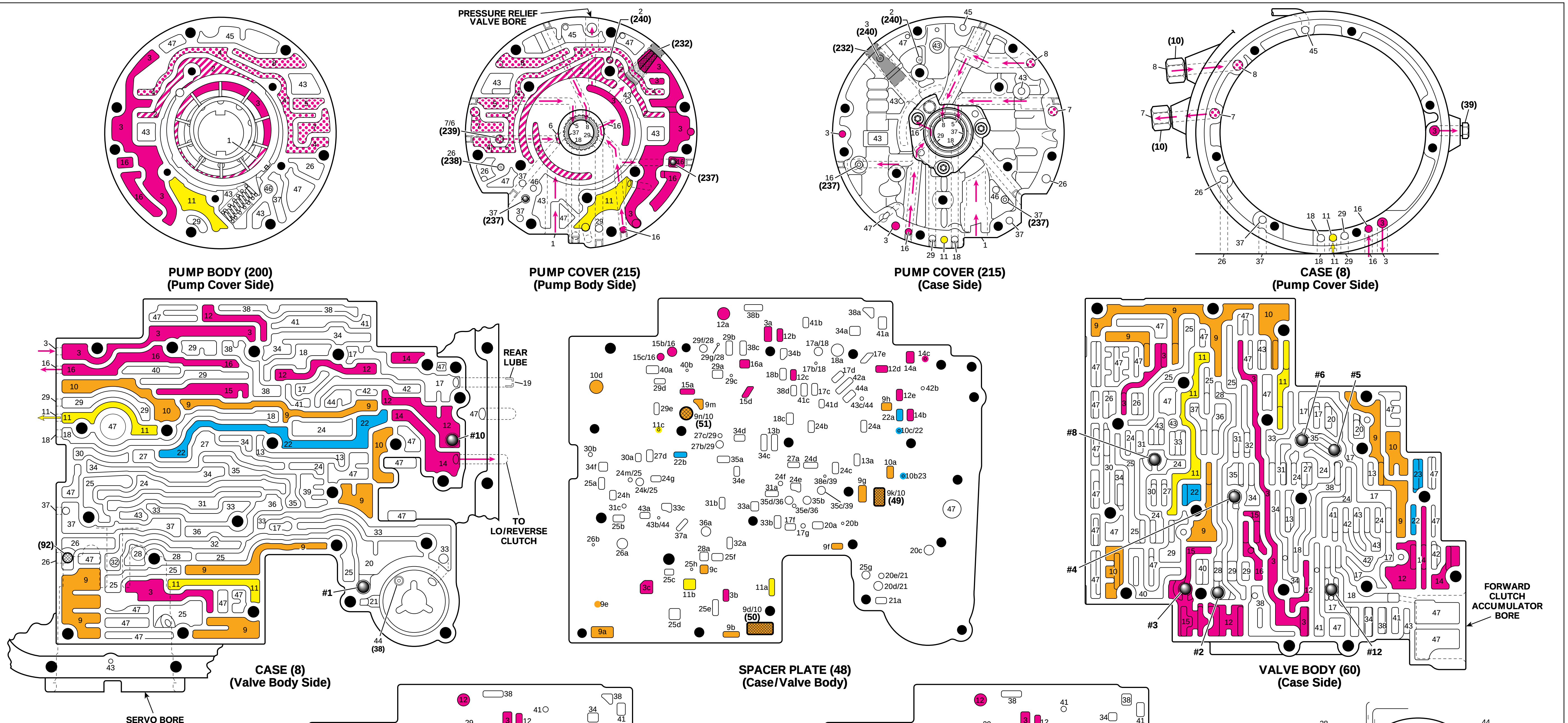
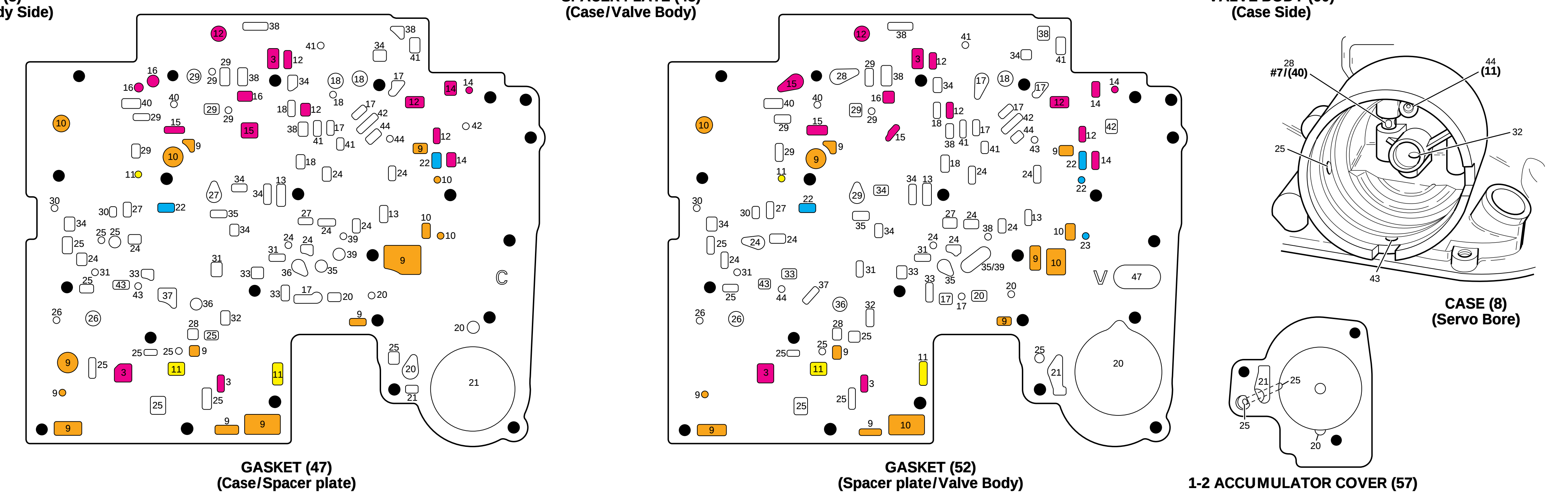


Figure 66

REVERSE





NOTE:

- ● **INDICATES BOLT HOLES**
- **NON- FUNCTIONAL HOLES HAVE BEEN REMOVED FROM COMPONENT DRAWINGS TO TO SIMPLIFY TRACING FLUID FLOW.**
- **EXHAUST FLUID NOT SHOWN**

Figure 67

NEUTRAL Engine Running

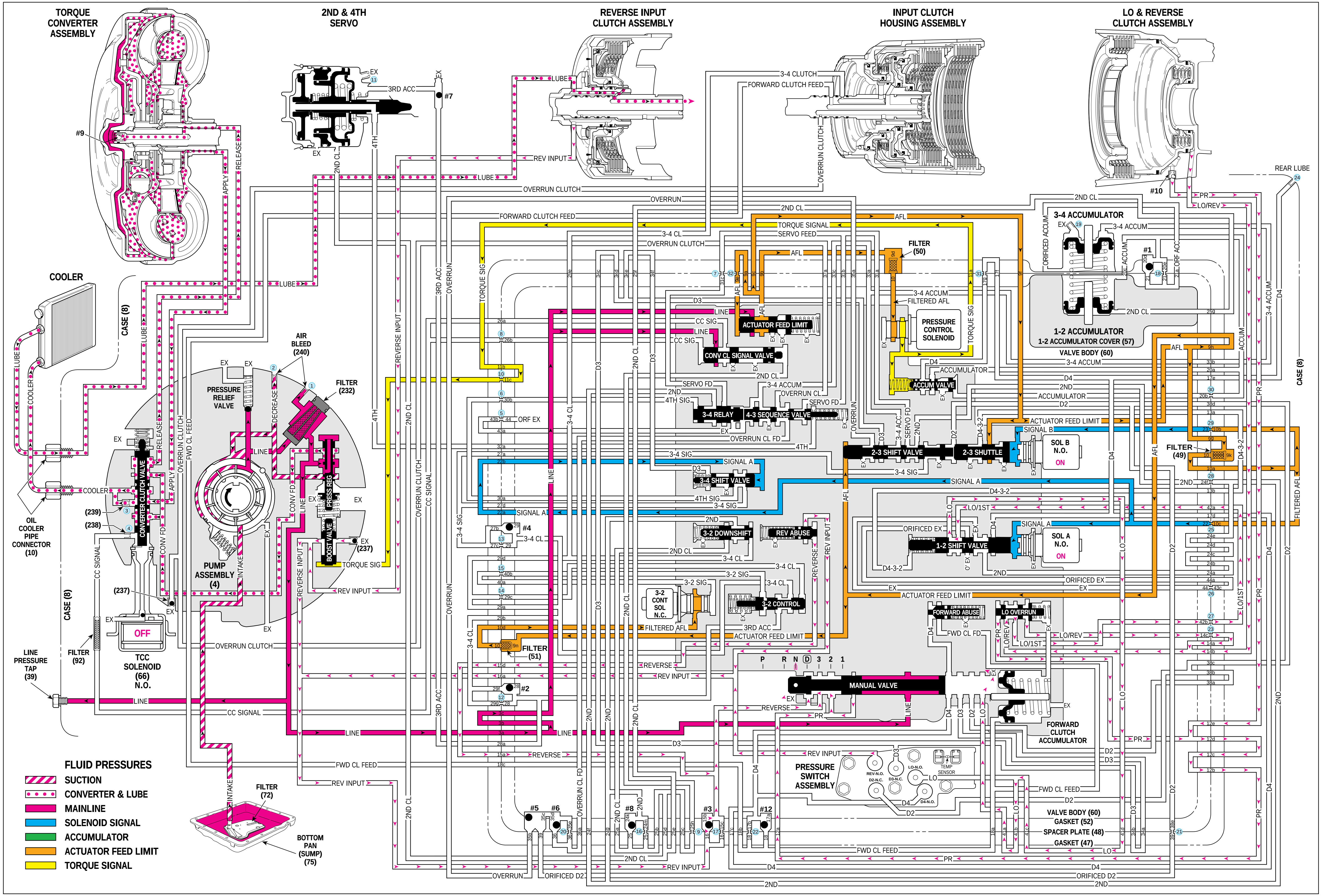
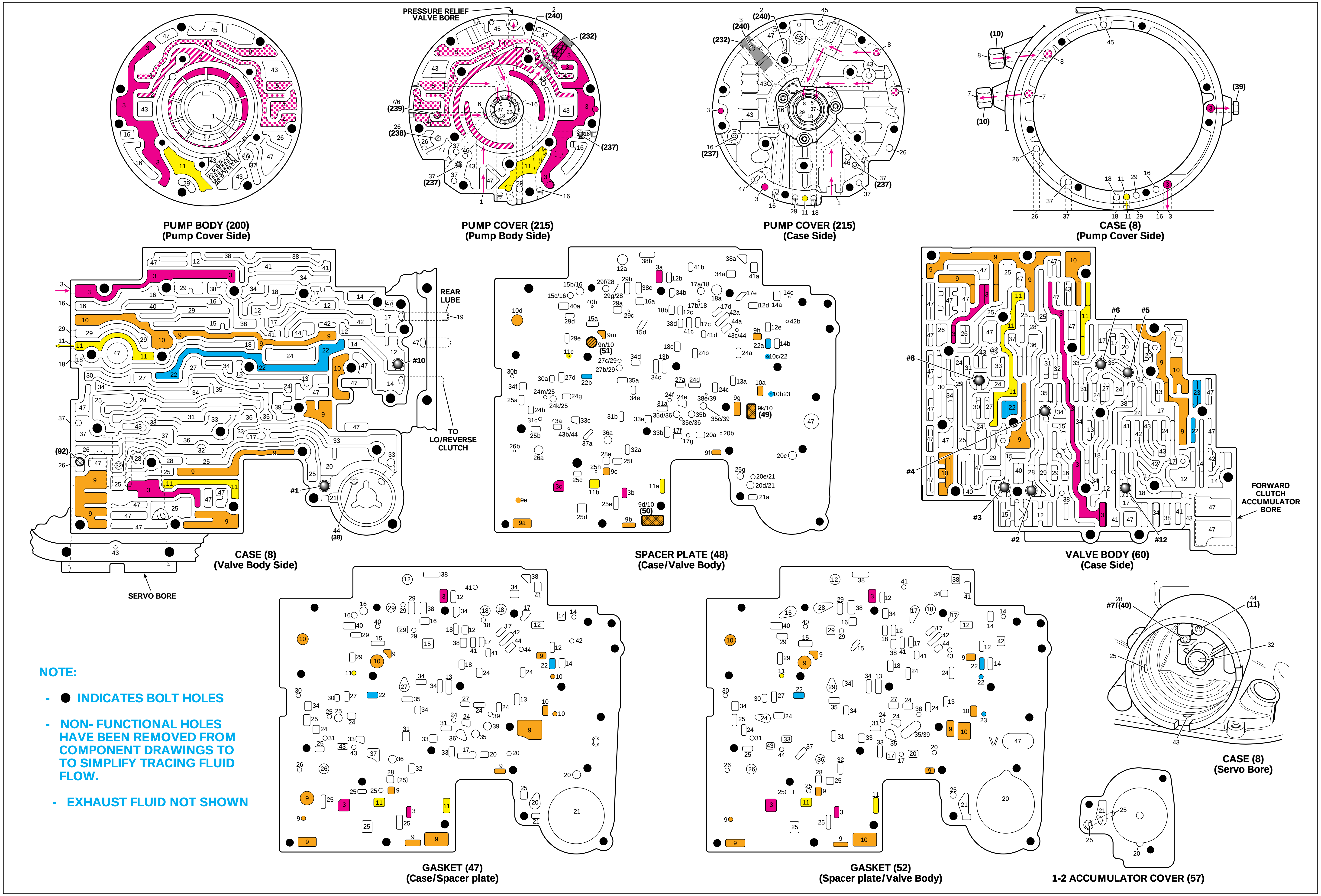


Figure 68



NOTE:

- ● INDICATES BOLT HOLES
- NON- FUNCTIONAL HOLES HAVE BEEN REMOVED FROM COMPONENT DRAWINGS TO TO SIMPLIFY TRACING FLUID FLOW.
- EXHAUST FLUID NOT SHOWN

Figure 69

OVERDRIVE RANGE - FIRST GEAR

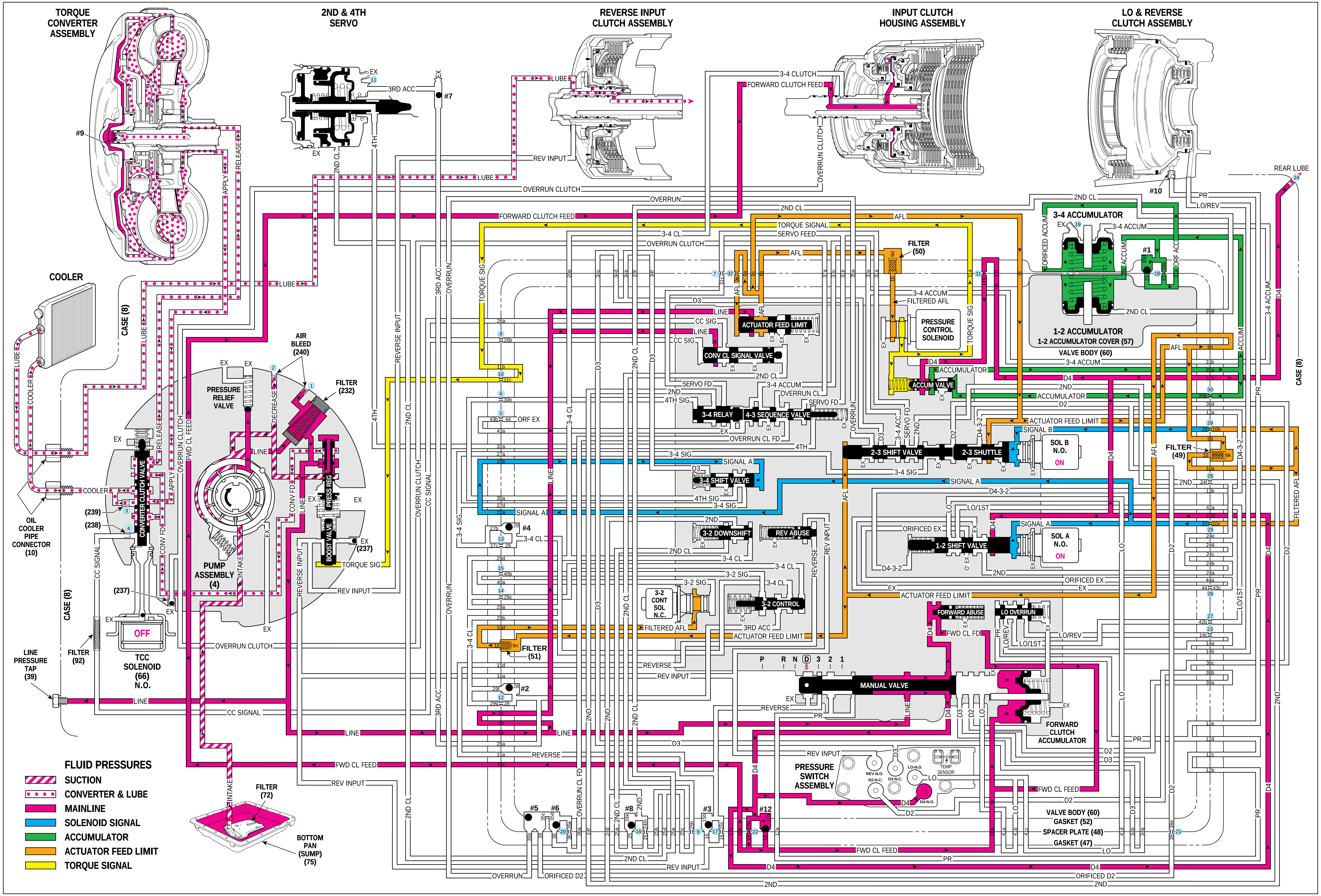
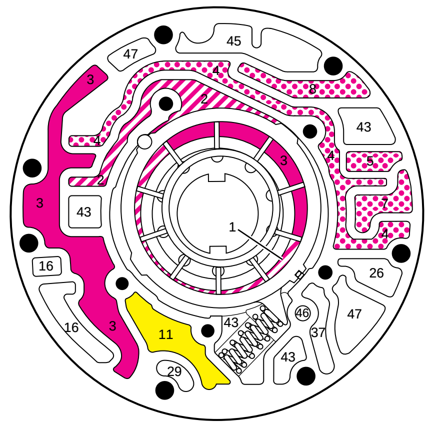
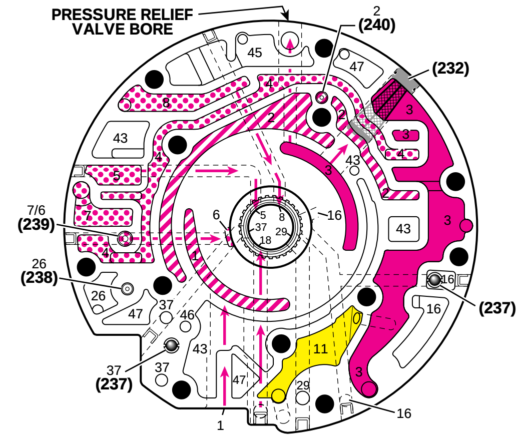


Figure 70

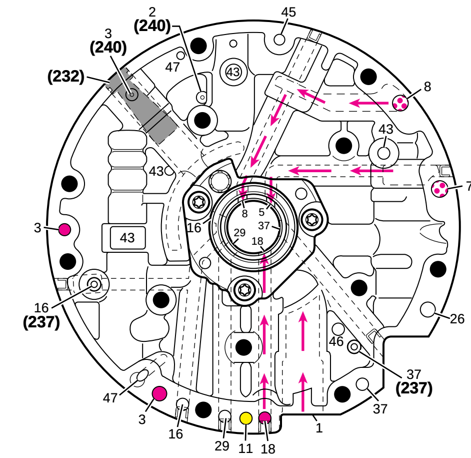
OVERDRIVE RANGE - FIRST GEAR



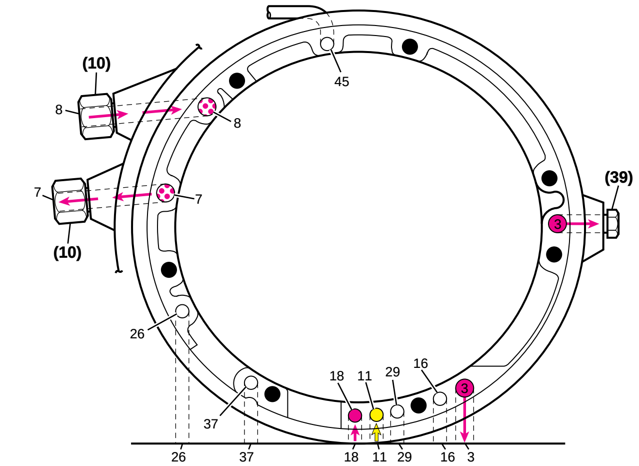
PUMP BODY (200)
(Pump Cover Side)



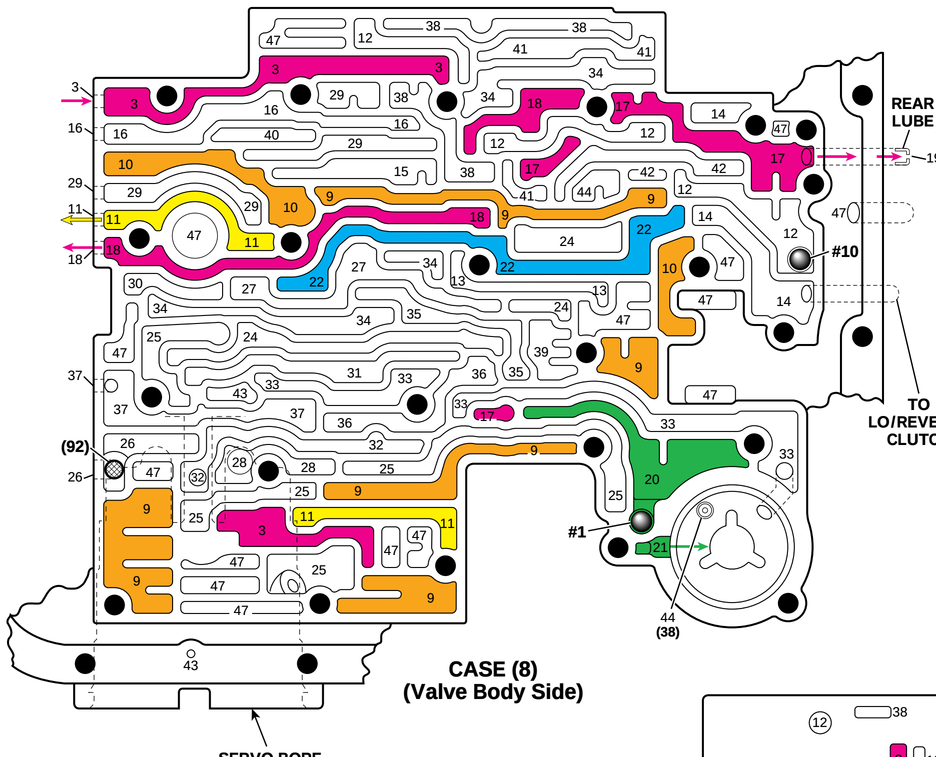
PUMP COVER (215)
(Pump Body Side)



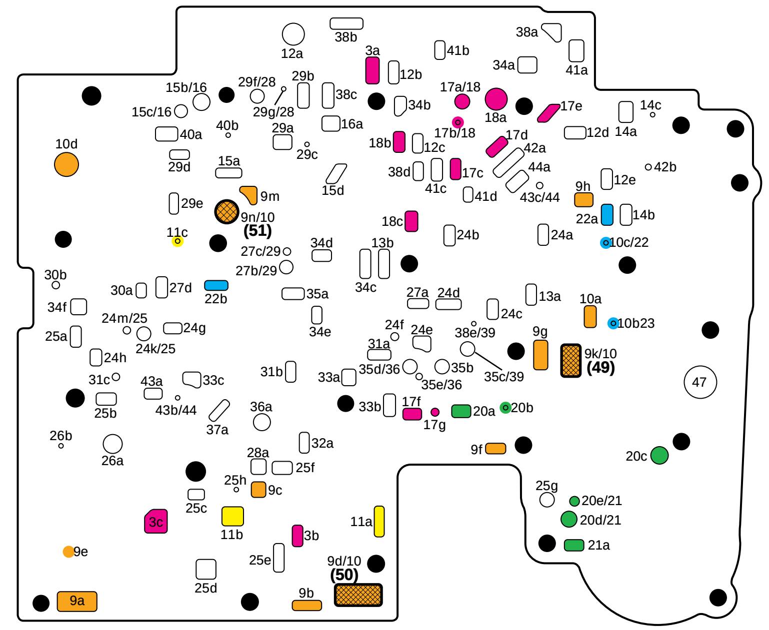
PUMP COVER (215)
(Case Side)



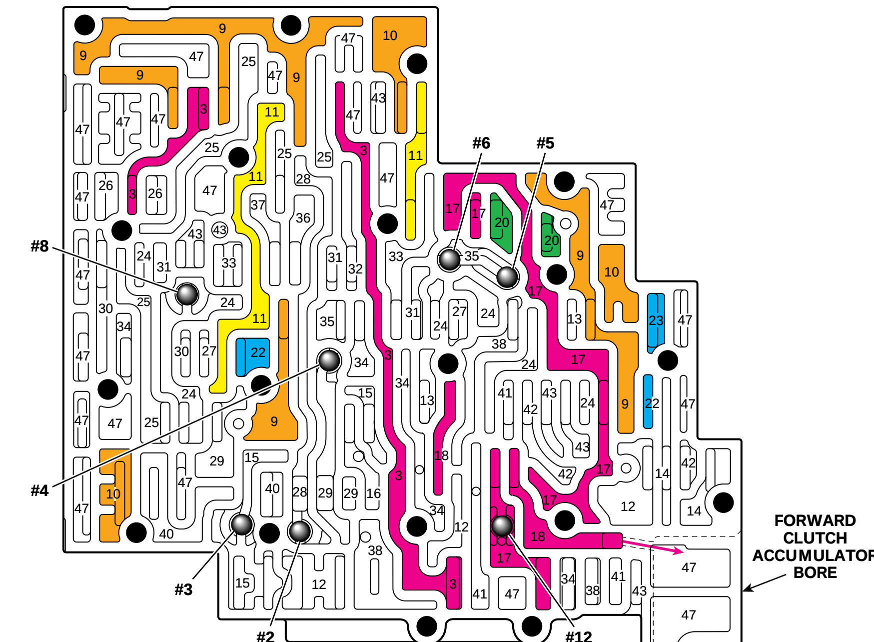
CASE (8)
(Pump Cover Side)



CASE (8)
(Valve Body Side)



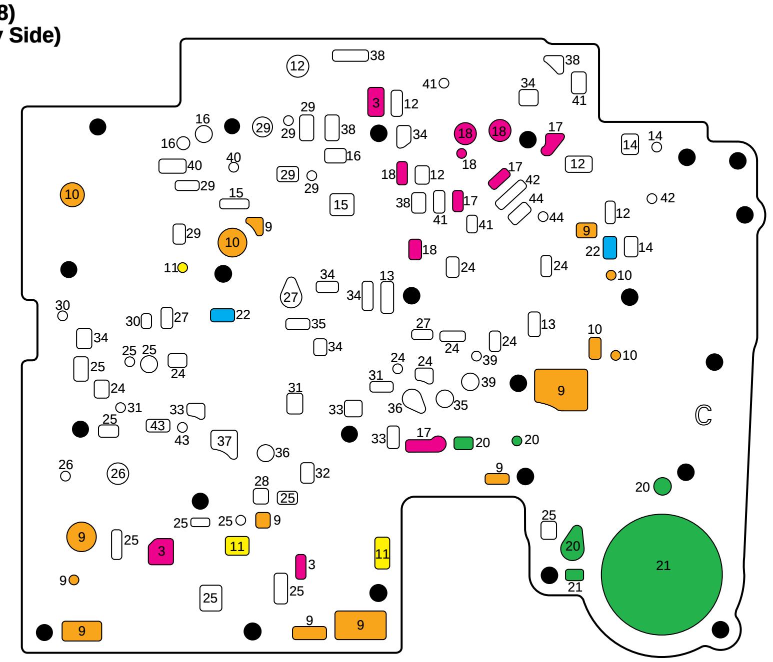
SPACER PLATE (48)
(Case/Valve Body)



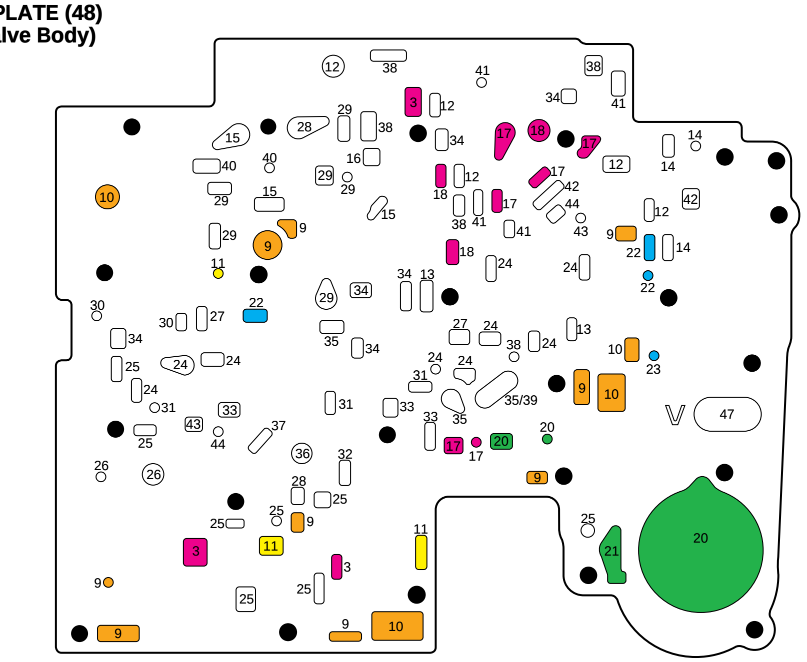
VALVE BODY (60)
(Case Side)

NOTE:

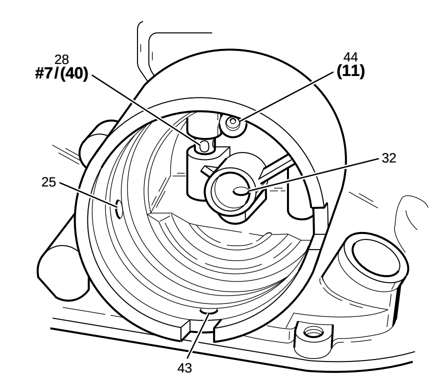
- ● INDICATES BOLT HOLES
- NON- FUNCTIONAL HOLES HAVE BEEN REMOVED FROM COMPONENT DRAWINGS TO TO SIMPLIFY TRACING FLUID FLOW.
- EXHAUST FLUID NOT SHOWN



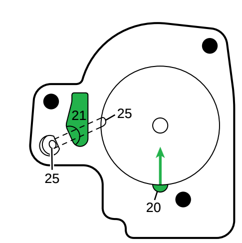
GASKET (47)
(Case/Spacer plate)



GASKET (52)
(Spacer plate/Valve Body)



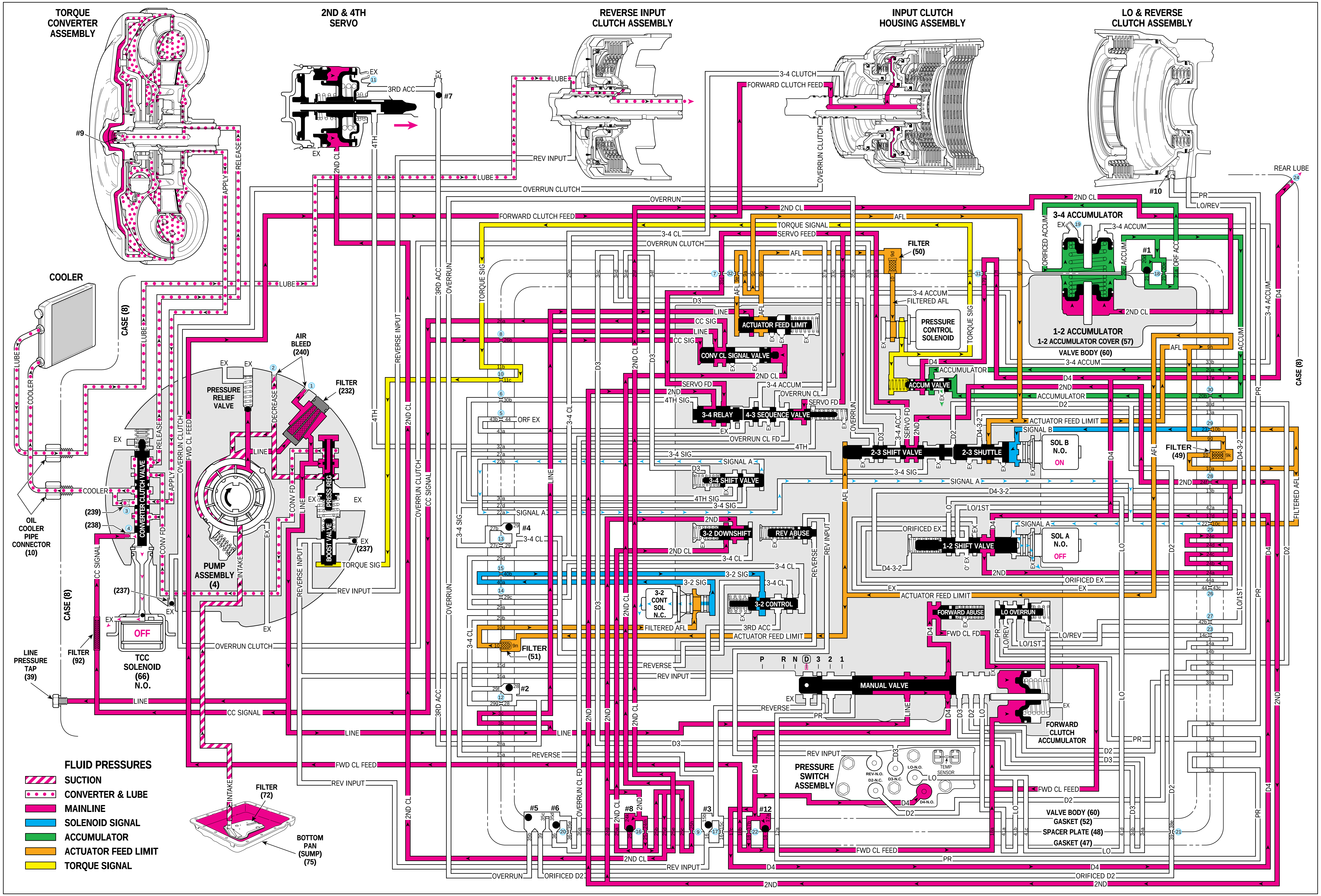
CASE (8)
(Servo Bore)



1-2 ACCUMULATOR COVER (57)

Figure 71

OVERDRIVE RANGE - SECOND GEAR

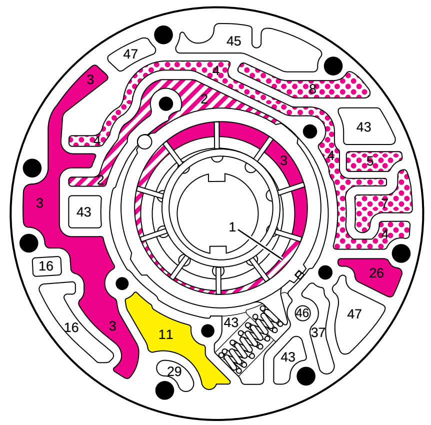


FLUID PRESSURES

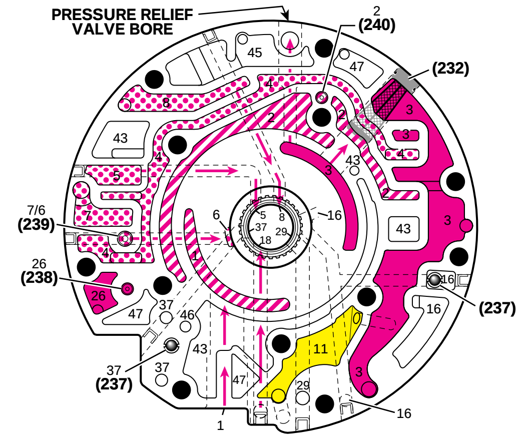
- SUCTION
- CONVERTER & LUBE
- MAINLINE
- SOLENOID SIGNAL
- ACCUMULATOR
- ACTUATOR FEED LIMIT
- TORQUE SIGNAL

Figure 72

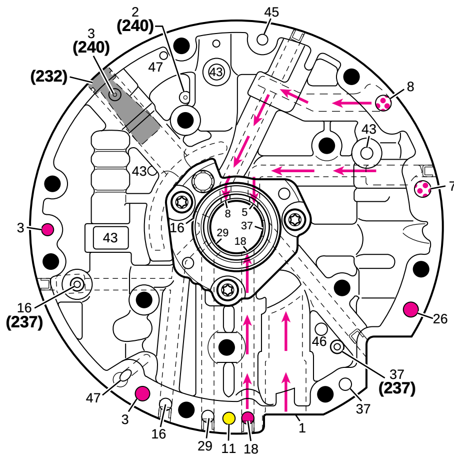
OVERDRIVE RANGE - SECOND GEAR



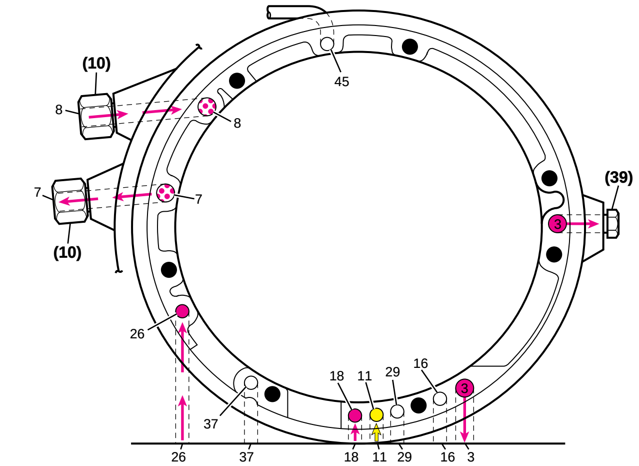
PUMP BODY (200)
(Pump Cover Side)



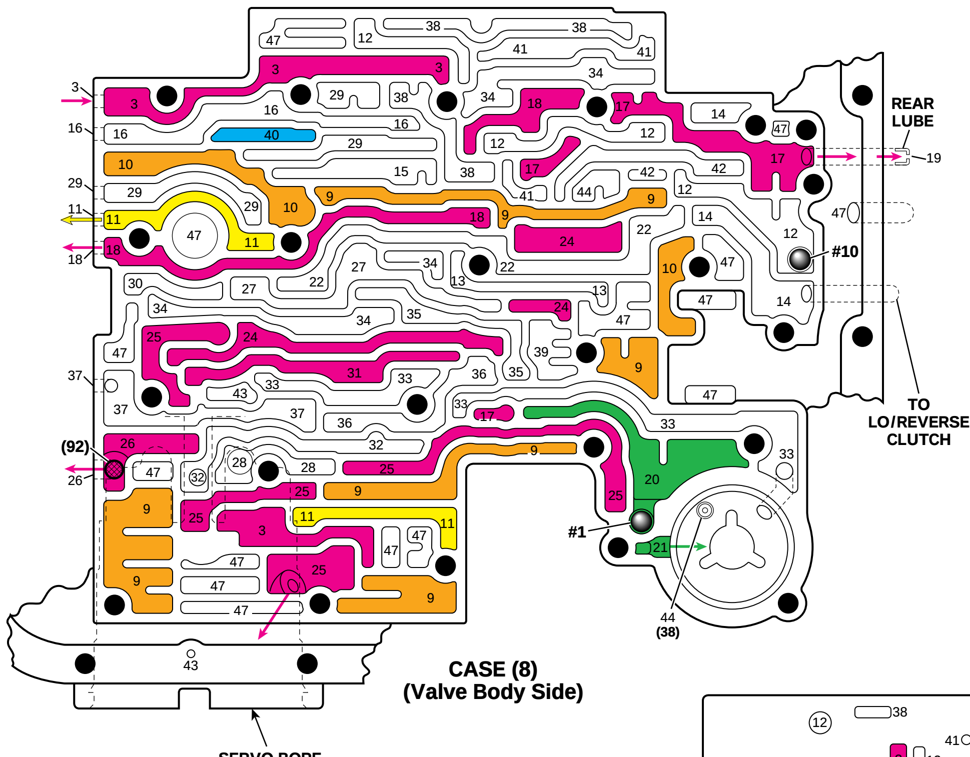
PUMP COVER (215)
(Pump Body Side)



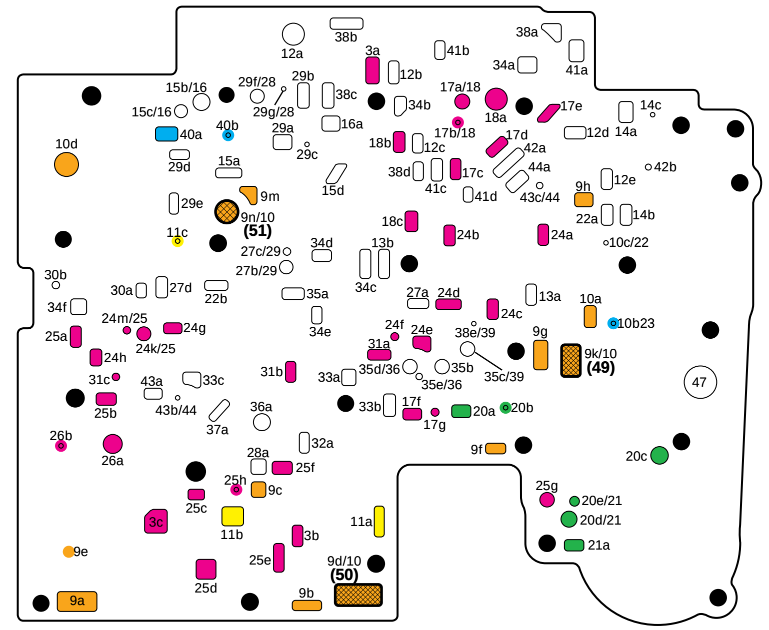
PUMP COVER (215)
(Case Side)



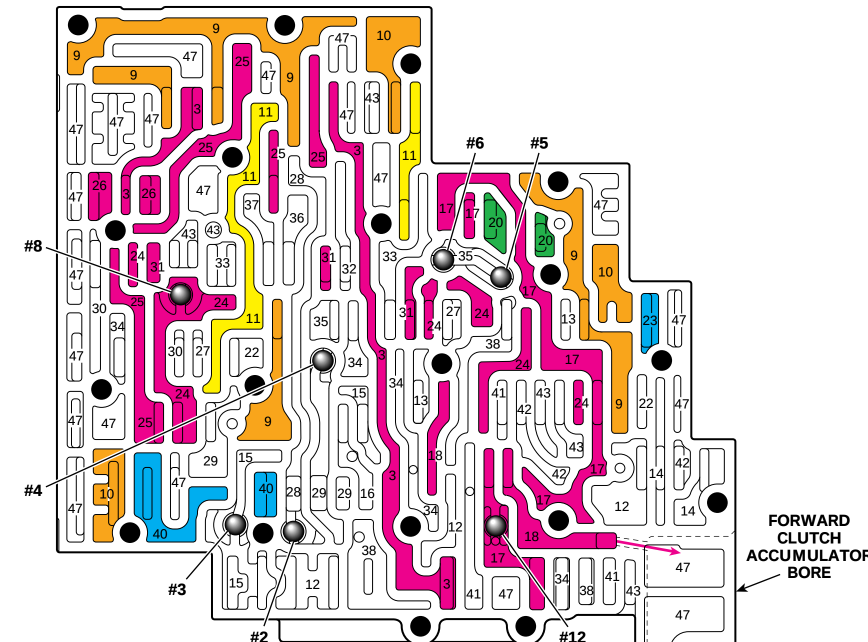
CASE (8)
(Pump Cover Side)



CASE (8)
(Valve Body Side)



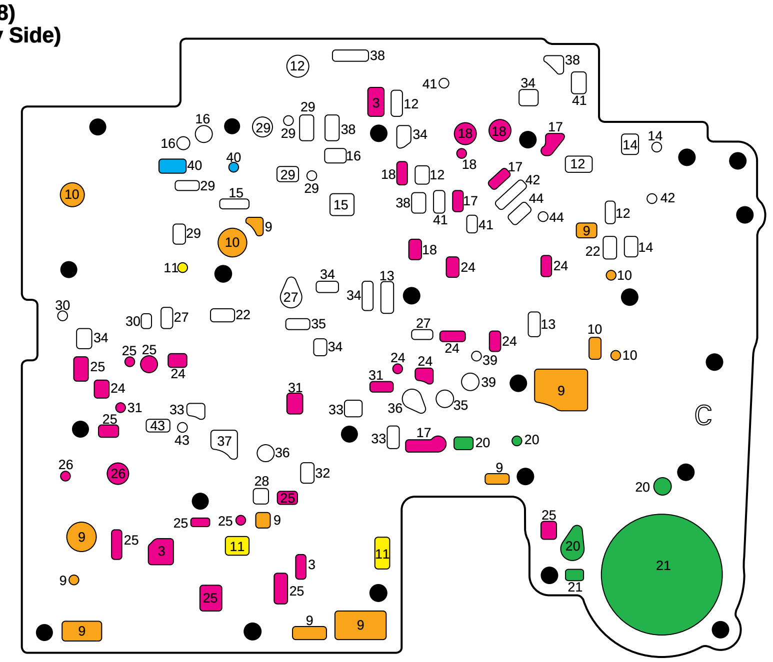
SPACER PLATE (48)
(Case/Valve Body)



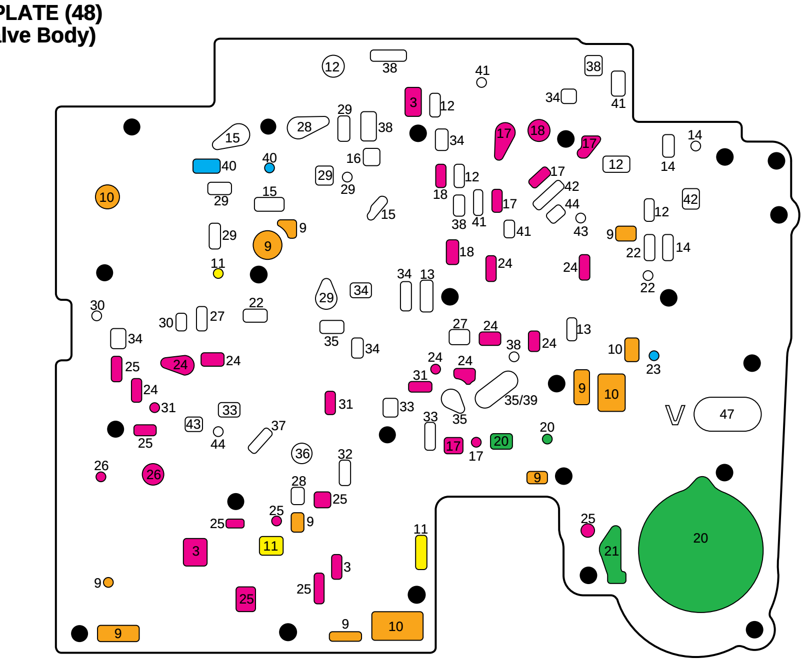
VALVE BODY (60)
(Case Side)

NOTE:

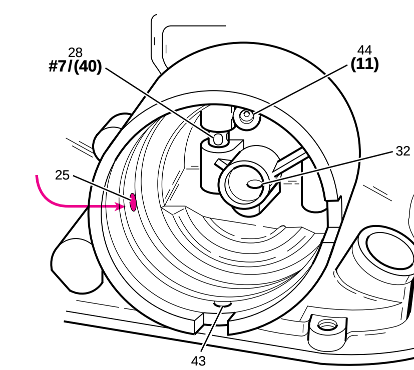
- ● INDICATES BOLT HOLES
- NON- FUNCTIONAL HOLES HAVE BEEN REMOVED FROM COMPONENT DRAWINGS TO TO SIMPLIFY TRACING FLUID FLOW.
- EXHAUST FLUID NOT SHOWN



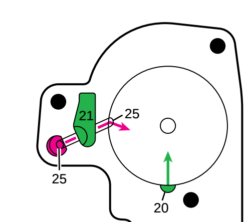
GASKET (47)
(Case/Spacer plate)



GASKET (52)
(Spacer plate/Valve Body)



CASE (8)
(Servo Bore)



1-2 ACCUMULATOR COVER (57)

Figure 73

OVERDRIVE RANGE - THIRD GEAR

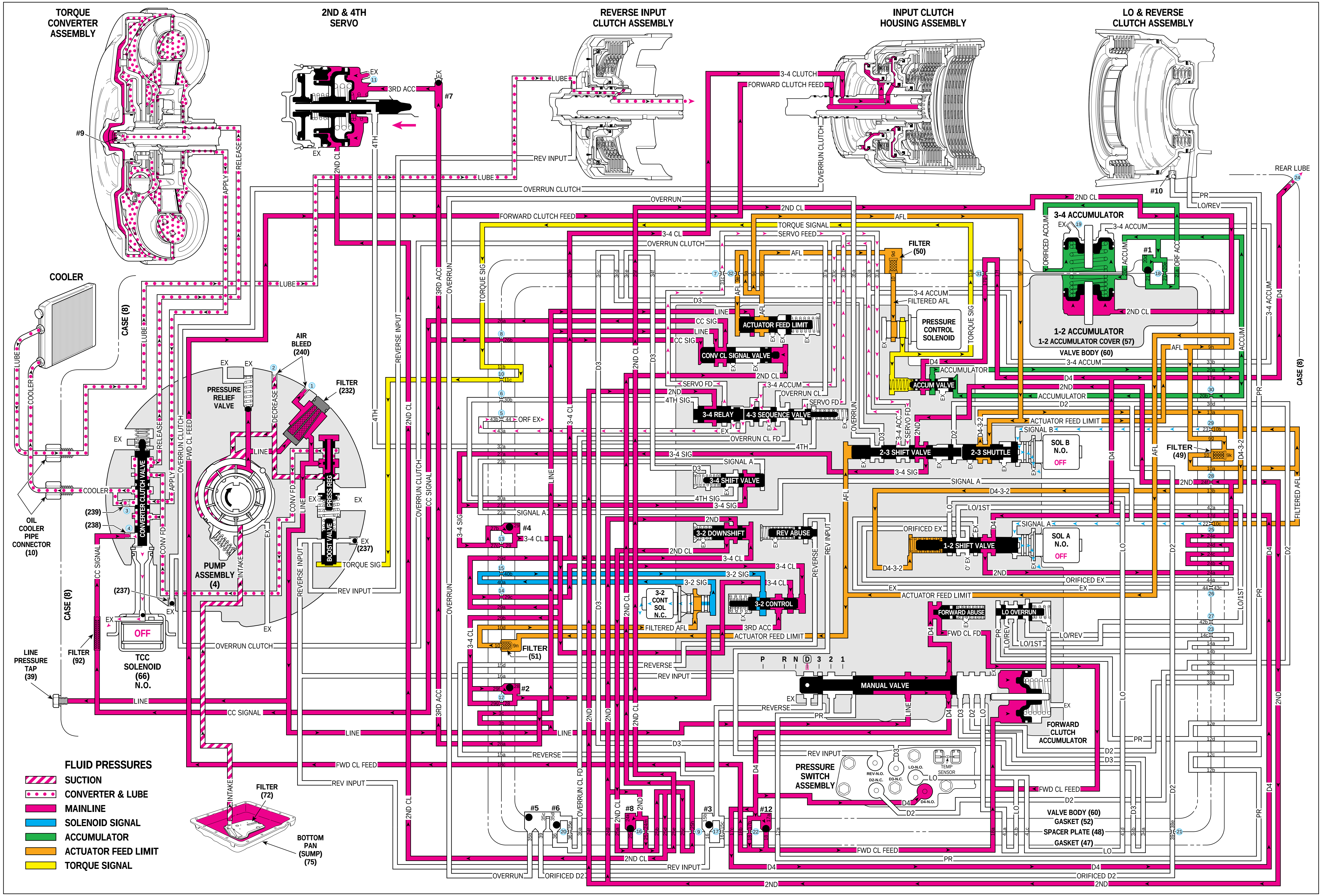
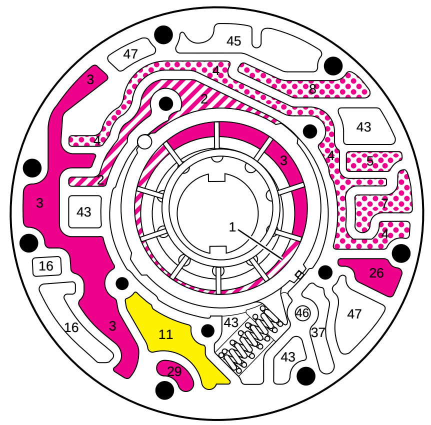
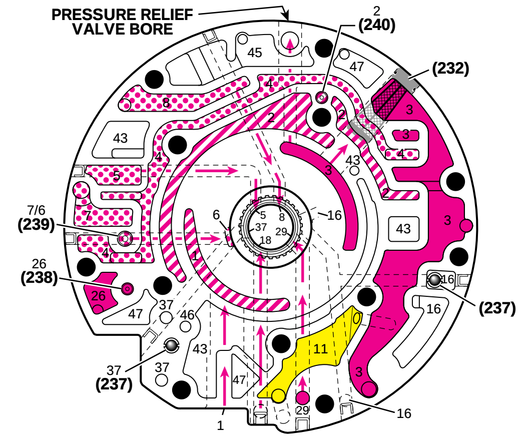


Figure 74

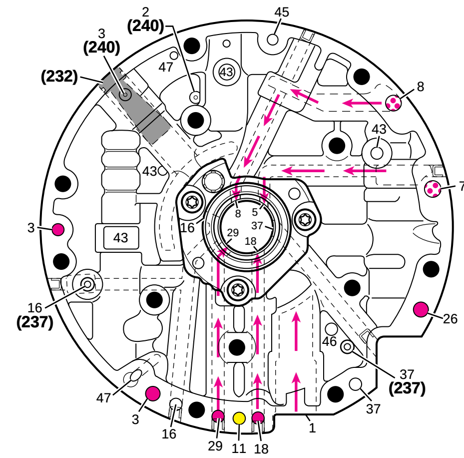
OVERDRIVE RANGE - THIRD GEAR



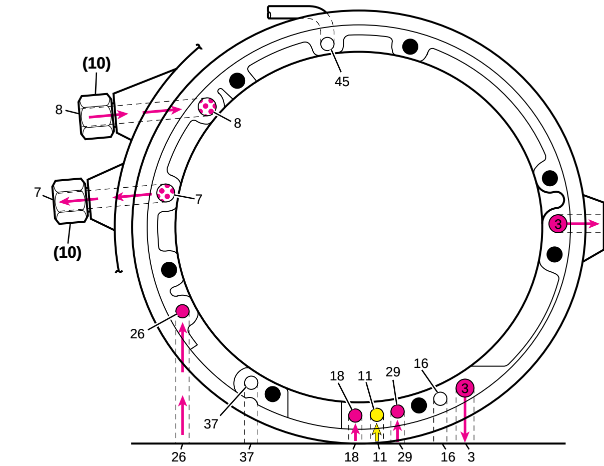
PUMP BODY (200)
(Pump Cover Side)



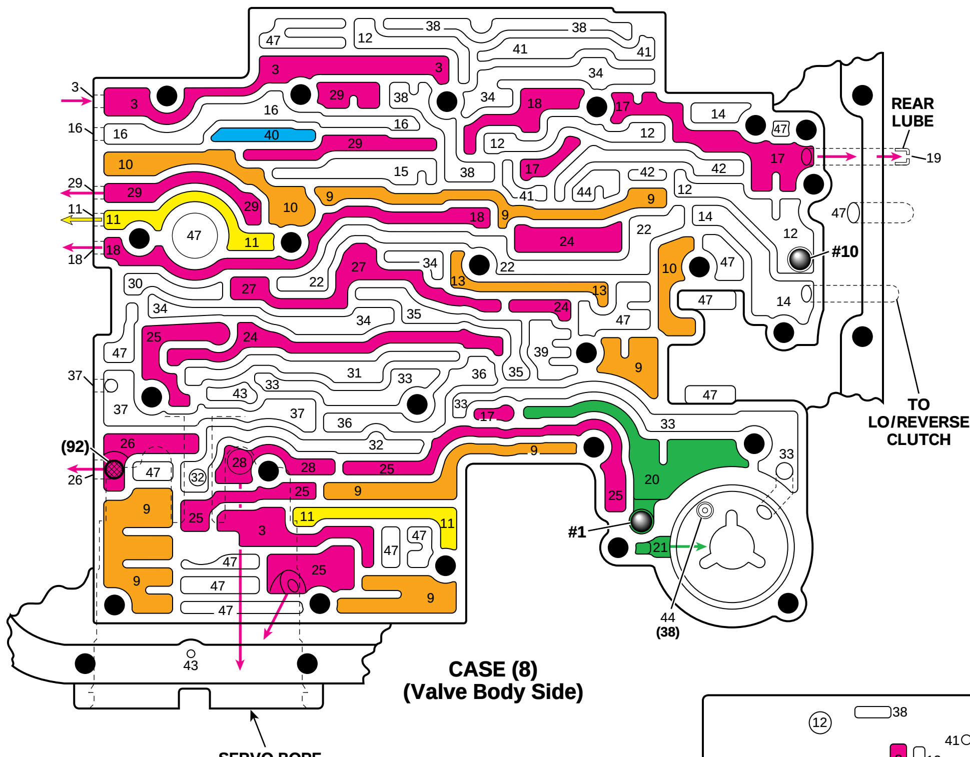
PUMP COVER (215)
(Pump Body Side)



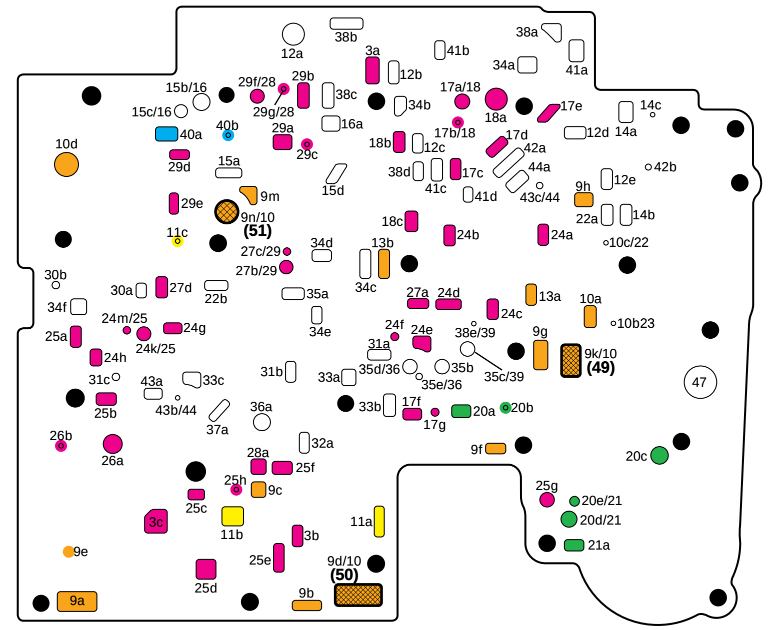
PUMP COVER (215)
(Case Side)



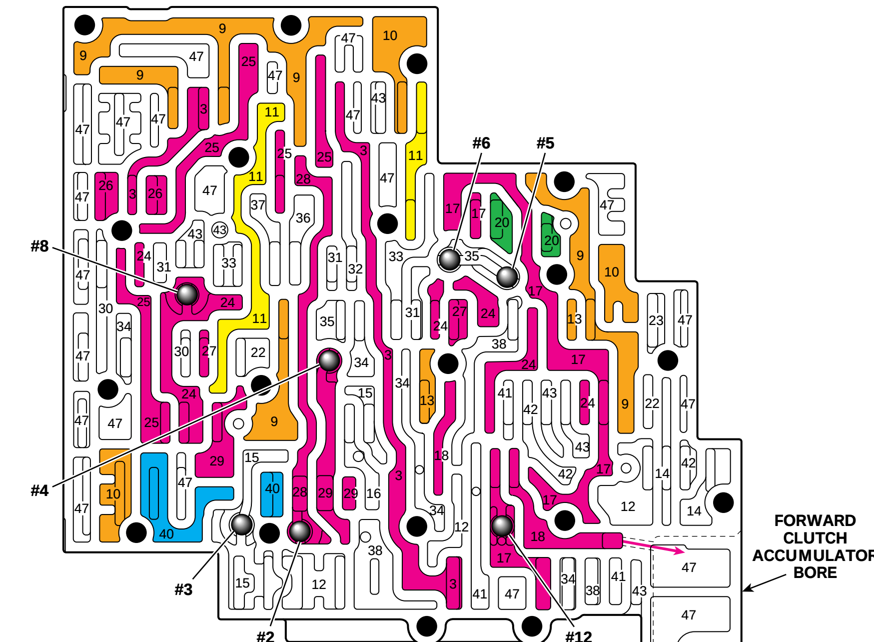
CASE (8)
(Pump Cover Side)



CASE (8)
(Valve Body Side)



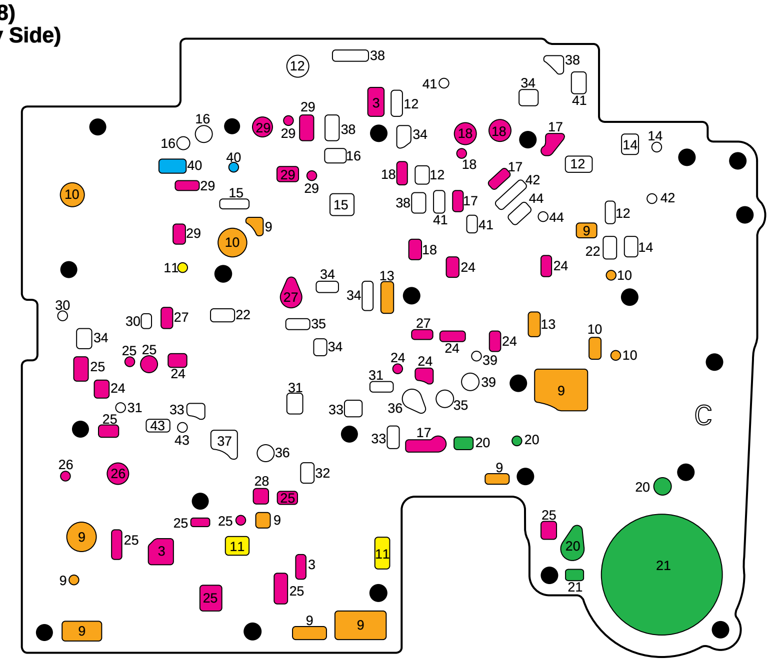
SPACER PLATE (48)
(Case/Valve Body)



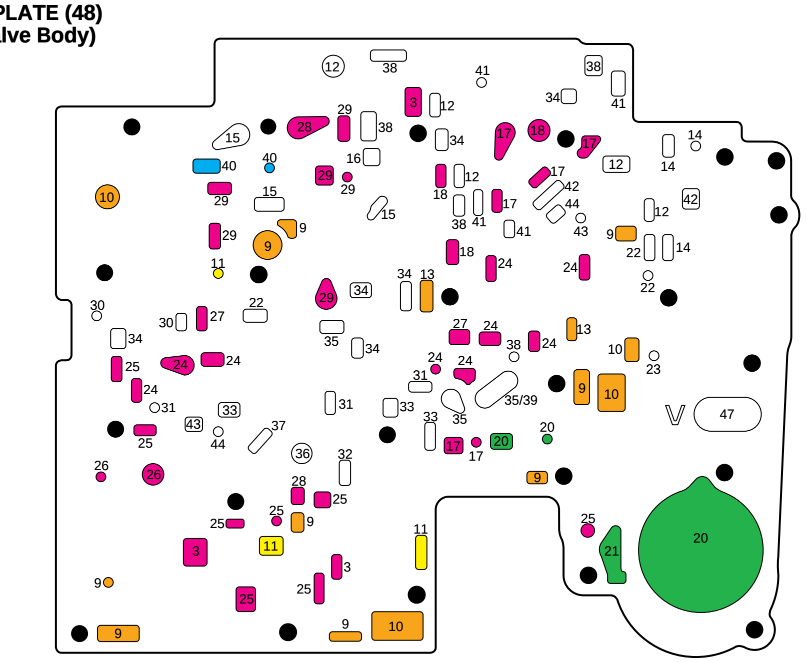
VALVE BODY (60)
(Case Side)

NOTE:

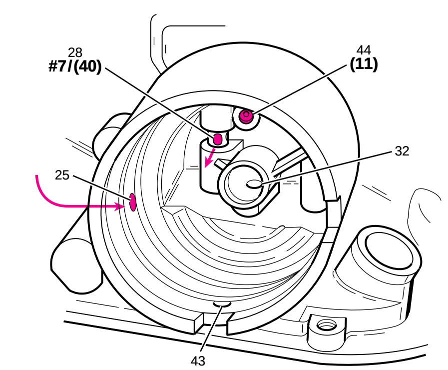
- ● INDICATES BOLT HOLES
- NON- FUNCTIONAL HOLES HAVE BEEN REMOVED FROM COMPONENT DRAWINGS TO TO SIMPLIFY TRACING FLUID FLOW.
- EXHAUST FLUID NOT SHOWN



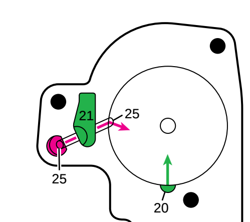
GASKET (47)
(Case/Spacer plate)



GASKET (52)
(Spacer plate/Valve Body)



CASE (8)
(Servo Bore)



1-2 ACCUMULATOR COVER (57)

Figure 75

OVERDRIVE RANGE - FOURTH GEAR (Torque Converter Clutch Applied)

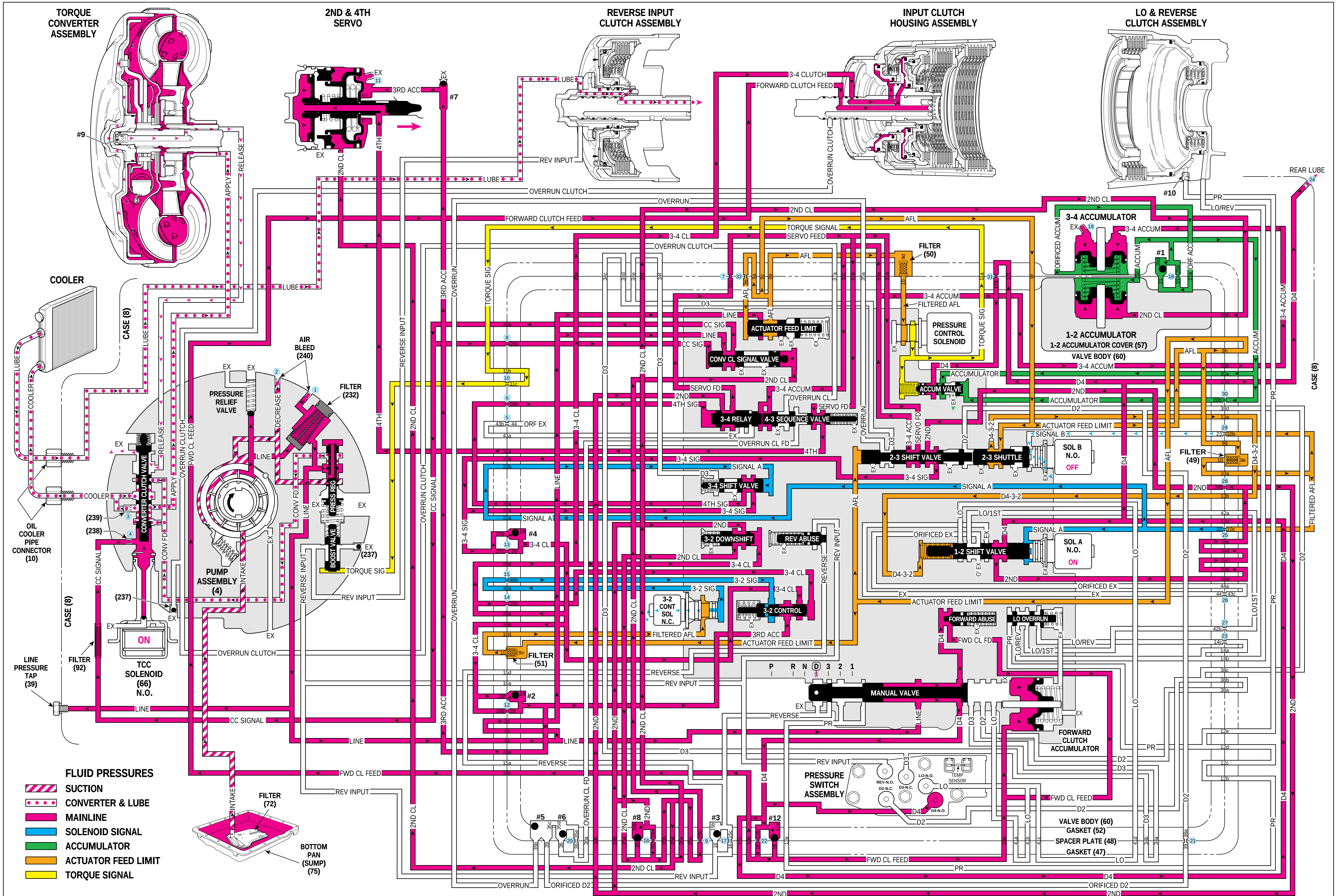
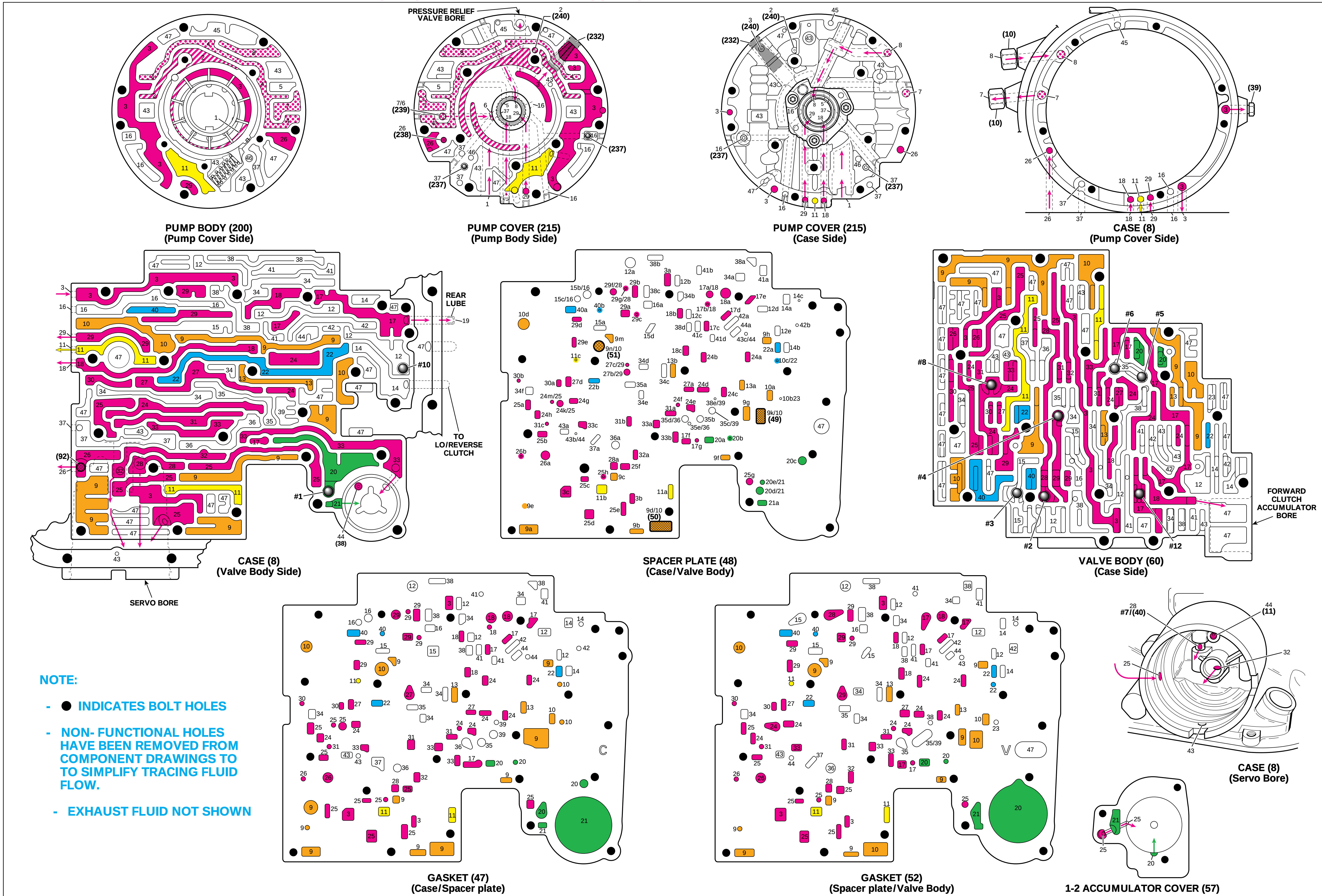


Figure 76

OVERDRIVE RANGE - FOURTH GEAR (Torque Converter Clutch Applied)



NOTE:

- ● INDICATES BOLT HOLES
- NON- FUNCTIONAL HOLES HAVE BEEN REMOVED FROM COMPONENT DRAWINGS TO TO SIMPLIFY TRACING FLUID FLOW.
- EXHAUST FLUID NOT SHOWN

Figure 77

OVERDRIVE RANGE - 4-3 DOWNSHIFT (Torque Converter Clutch Released)

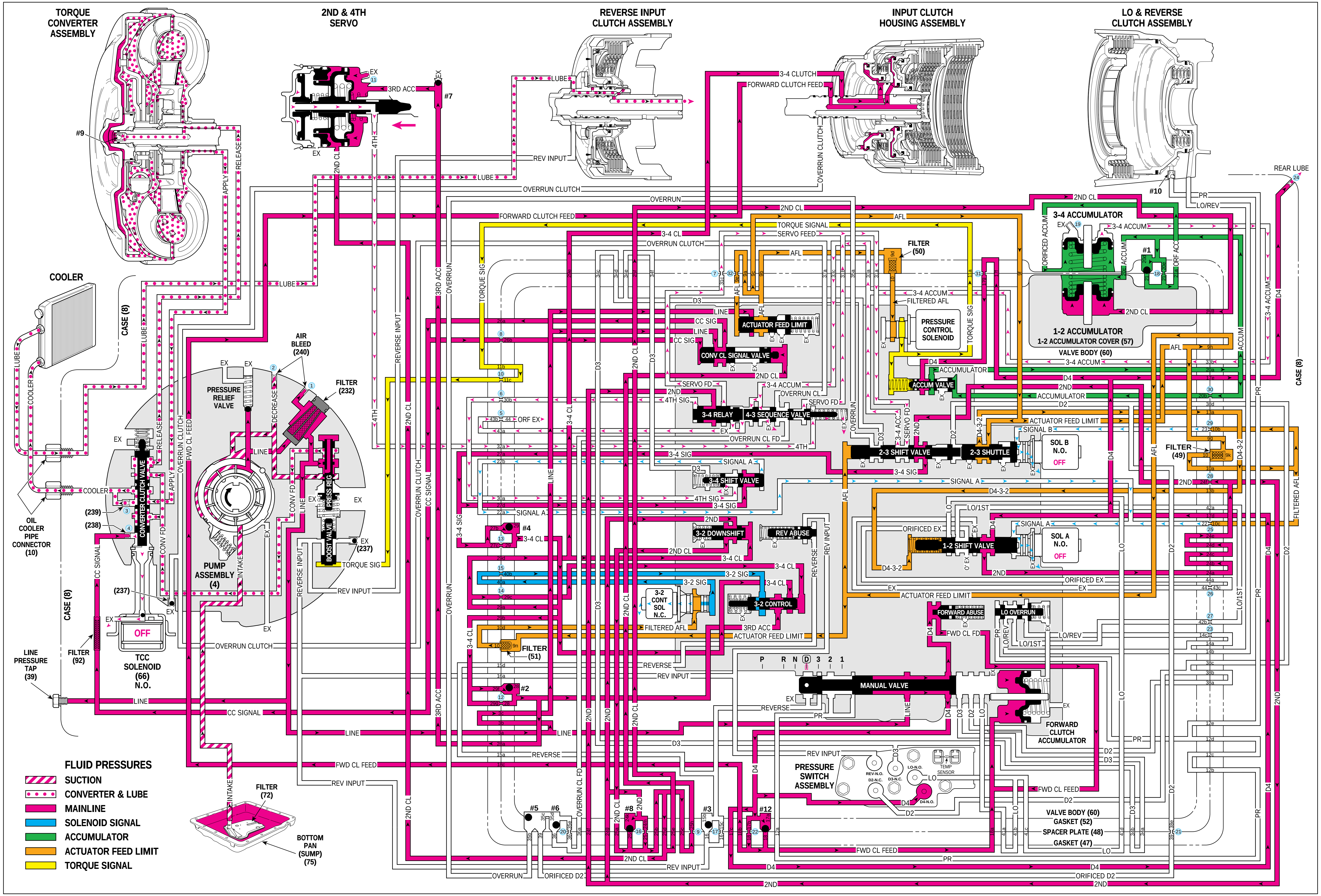
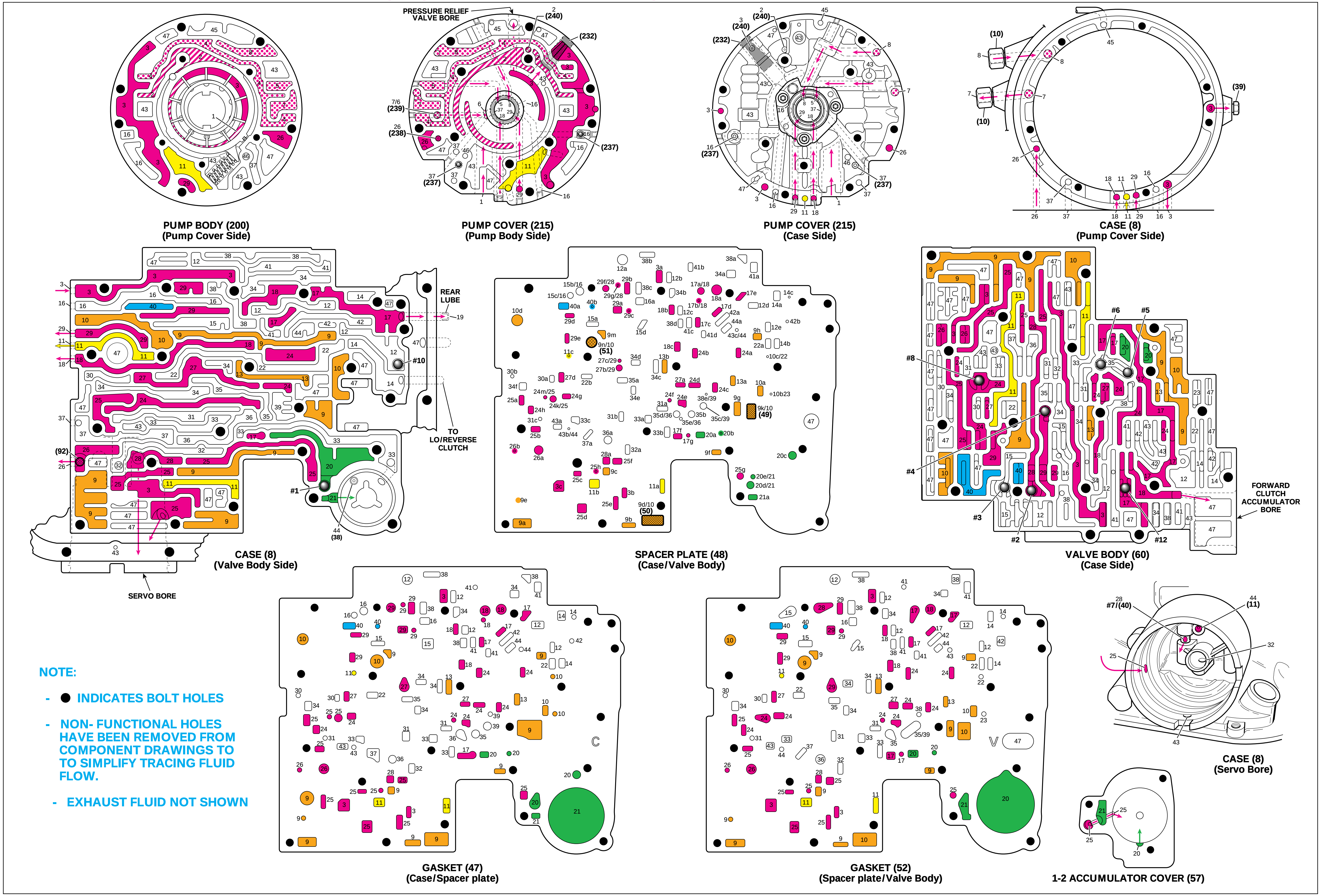


Figure 78

OVERDRIVE RANGE - 4-3 DOWNSHIFT (Torque Converter Clutch Released)



NOTE:

- ● INDICATES BOLT HOLES
- NON- FUNCTIONAL HOLES HAVE BEEN REMOVED FROM COMPONENT DRAWINGS TO TO SIMPLIFY TRACING FLUID FLOW.
- EXHAUST FLUID NOT SHOWN

Figure 79

OVERDRIVE RANGE - 3-2 DOWNSHIFT

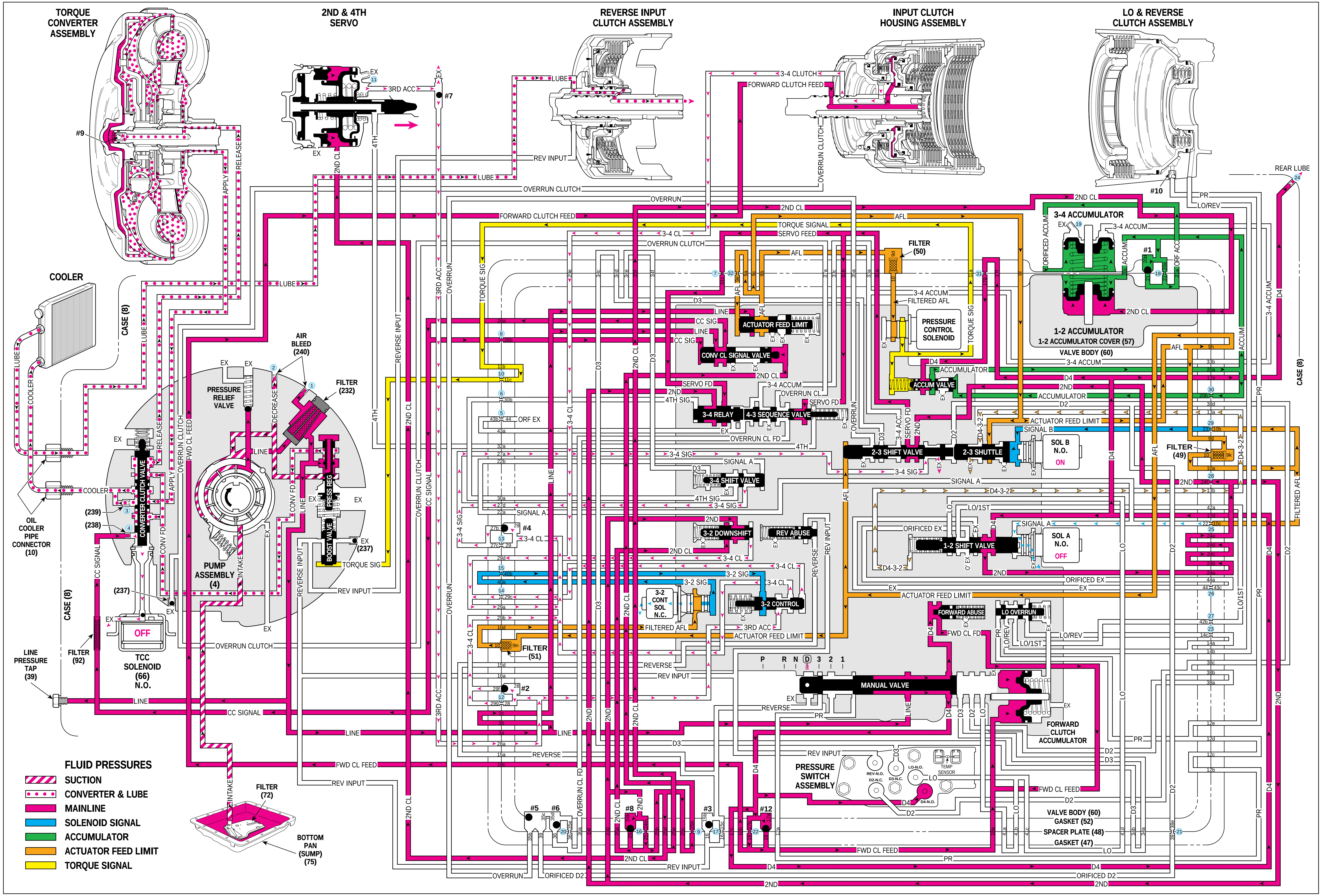
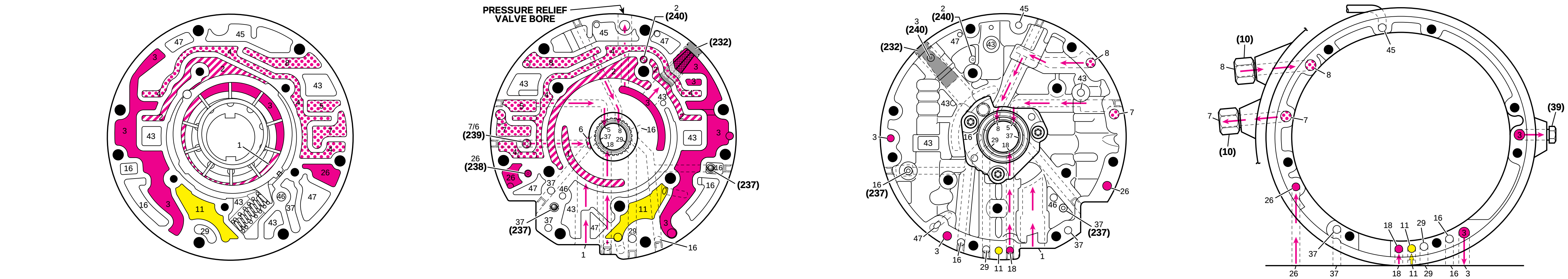


Figure 80

OVERDRIVE RANGE - 3-2 DOWNSHIFT

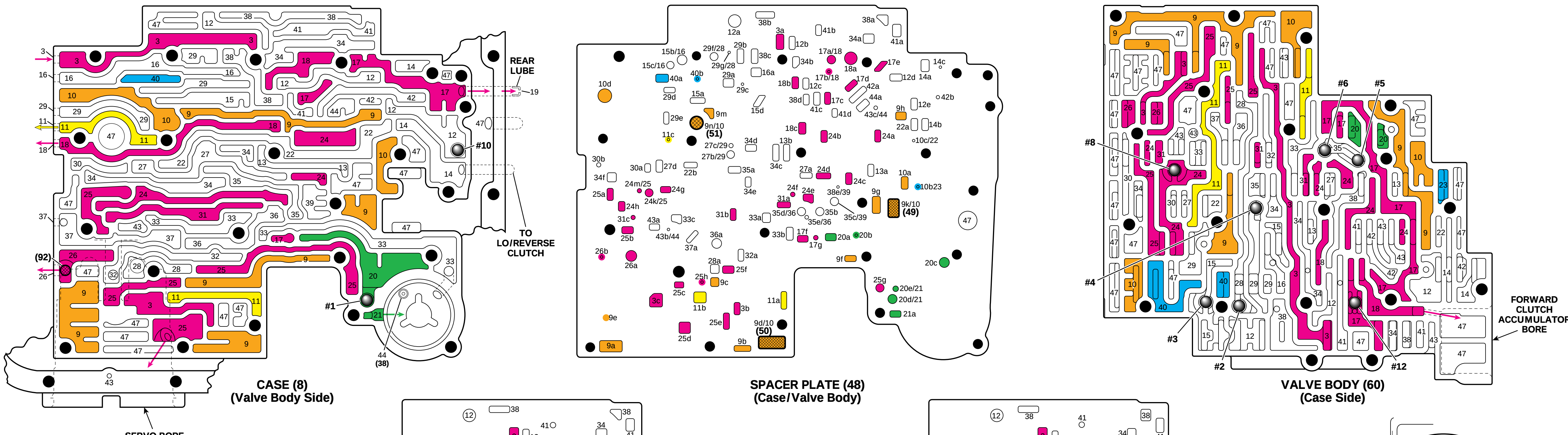


PUMP BODY (200)
(Pump Cover Side)

PUMP COVER (215)
(Pump Body Side)

PUMP COVER (215)
(Case Side)

CASE (8)
(Pump Cover Side)



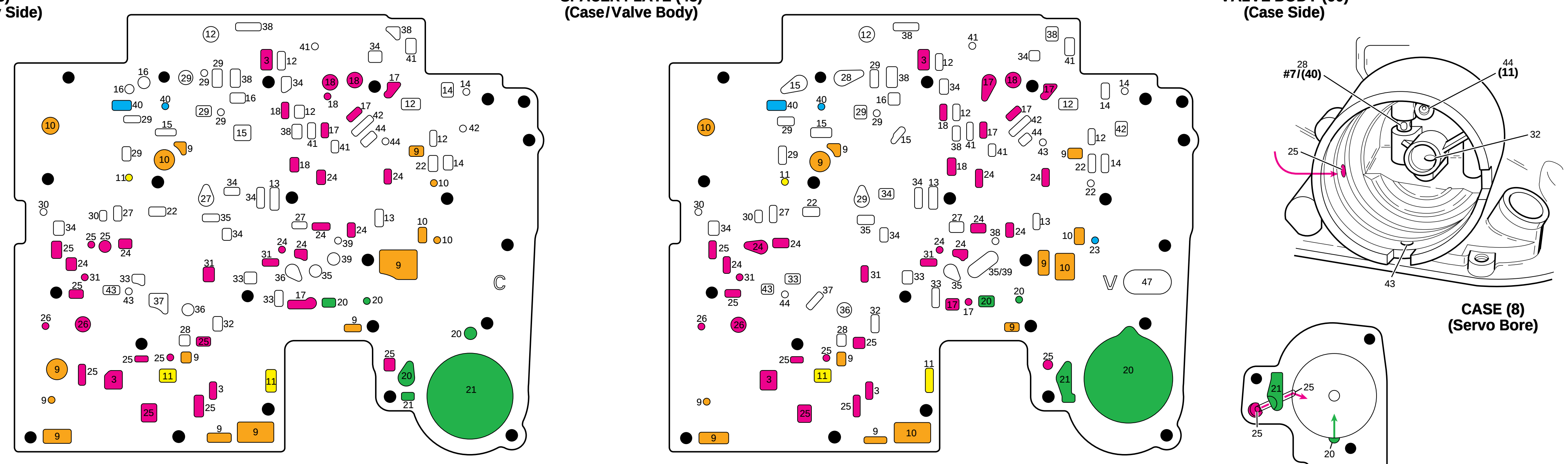
CASE (8)
(Valve Body Side)

SPACER PLATE (48)
(Case/Valve Body)

VALVE BODY (60)
(Case Side)

NOTE:

- ● INDICATES BOLT HOLES
- NON- FUNCTIONAL HOLES HAVE BEEN REMOVED FROM COMPONENT DRAWINGS TO TO SIMPLIFY TRACING FLUID FLOW.
- EXHAUST FLUID NOT SHOWN



GASKET (47)
(Case/Spacer plate)

GASKET (52)
(Spacer plate/Valve Body)

CASE (8)
(Servo Bore)

1-2 ACCUMULATOR COVER (57)

Figure 81

MANUAL THIRD - THIRD GEAR (from Overdrive Range - Fourth Gear)

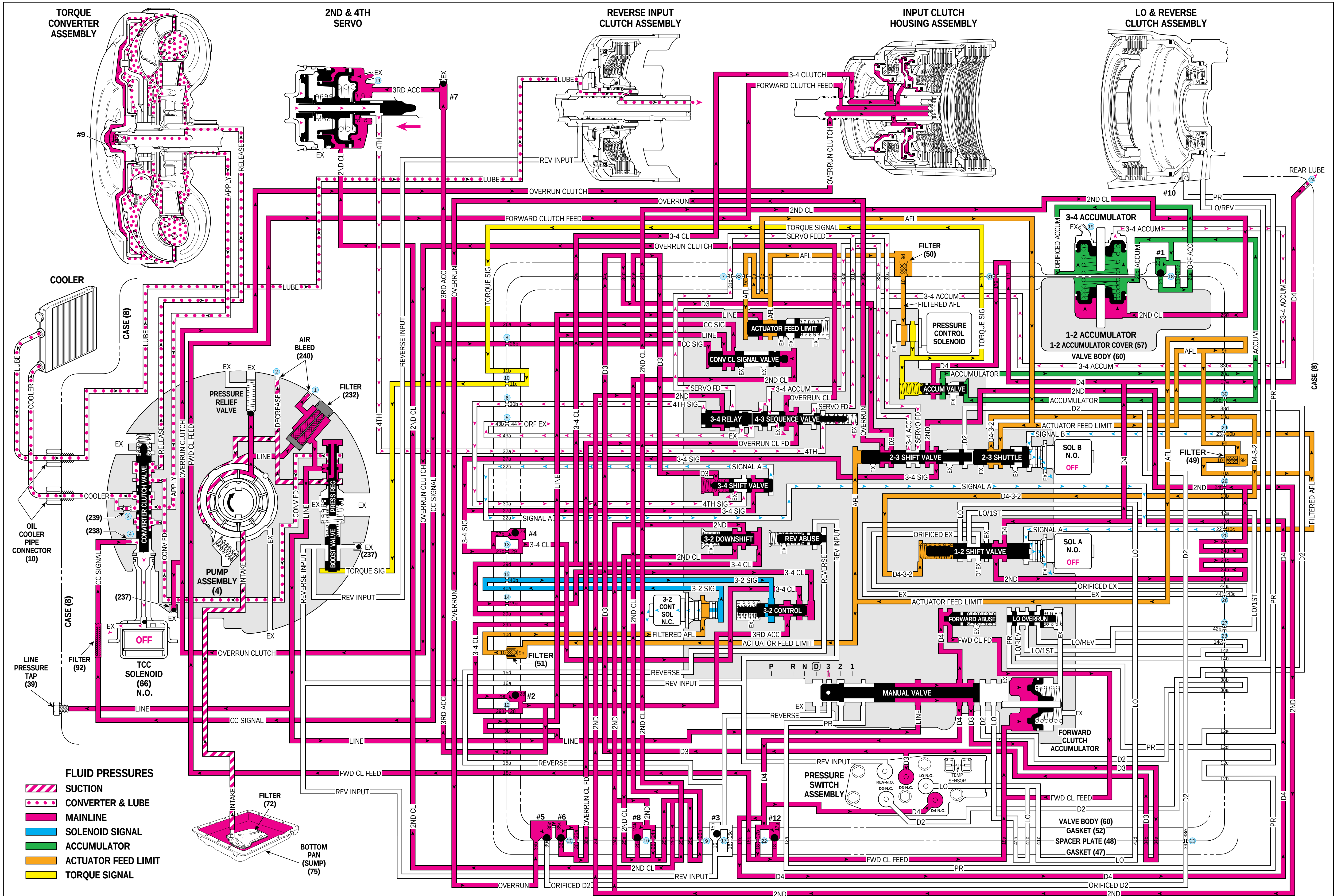
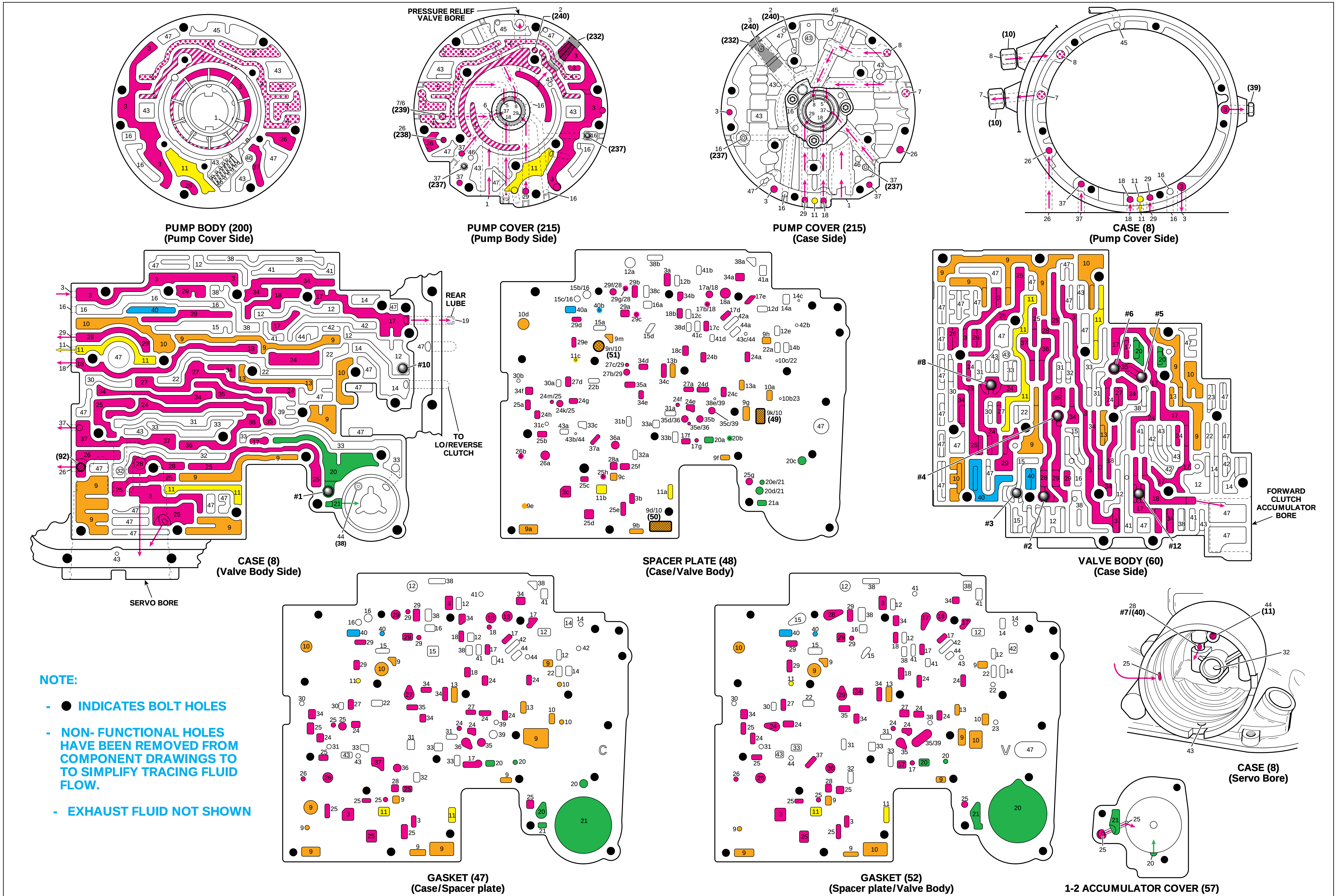


Figure 82



NOTE:

- ● INDICATES BOLT HOLES
- NON- FUNCTIONAL HOLES HAVE BEEN REMOVED FROM COMPONENT DRAWINGS TO TO SIMPLIFY TRACING FLUID FLOW.
- EXHAUST FLUID NOT SHOWN

Figure 83

MANUAL SECOND - SECOND GEAR (from Manual Third - Third Gear)

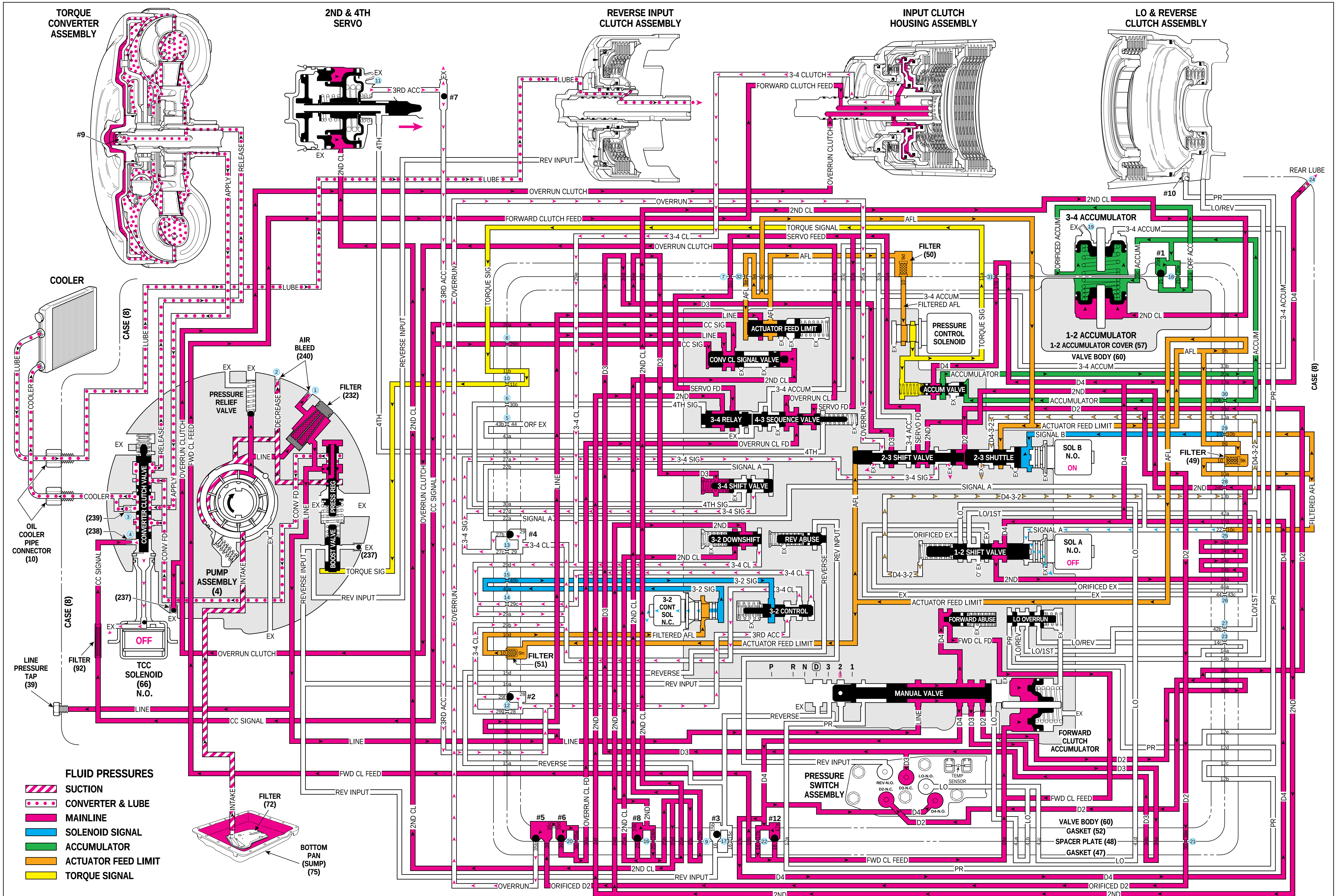
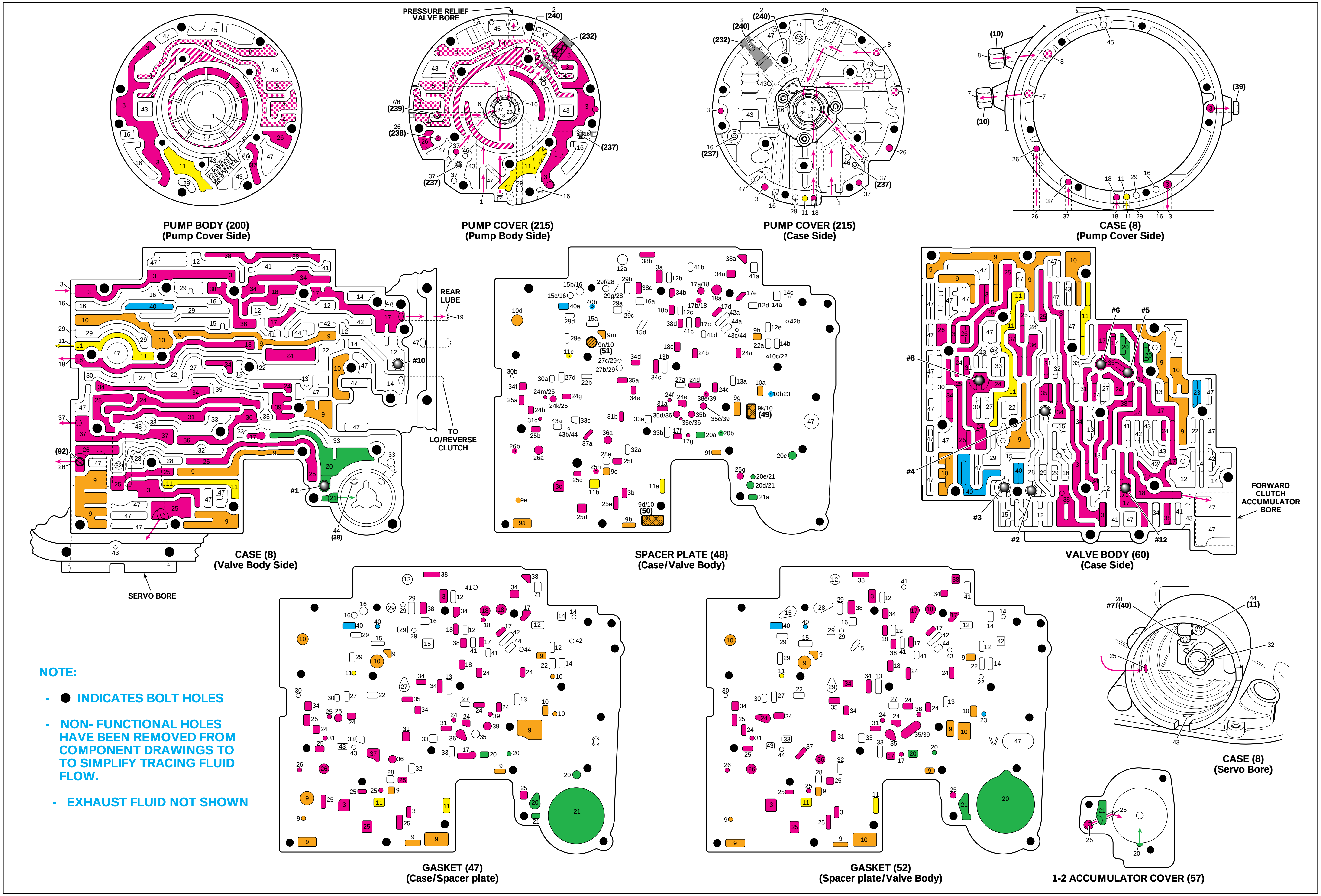


Figure 84

MANUAL SECOND - SECOND GEAR



NOTE:

- ● INDICATES BOLT HOLES
- NON- FUNCTIONAL HOLES HAVE BEEN REMOVED FROM COMPONENT DRAWINGS TO TO SIMPLIFY TRACING FLUID FLOW.
- EXHAUST FLUID NOT SHOWN

Figure 85

MANUAL FIRST - FIRST GEAR (from Manual Second - Second Gear)

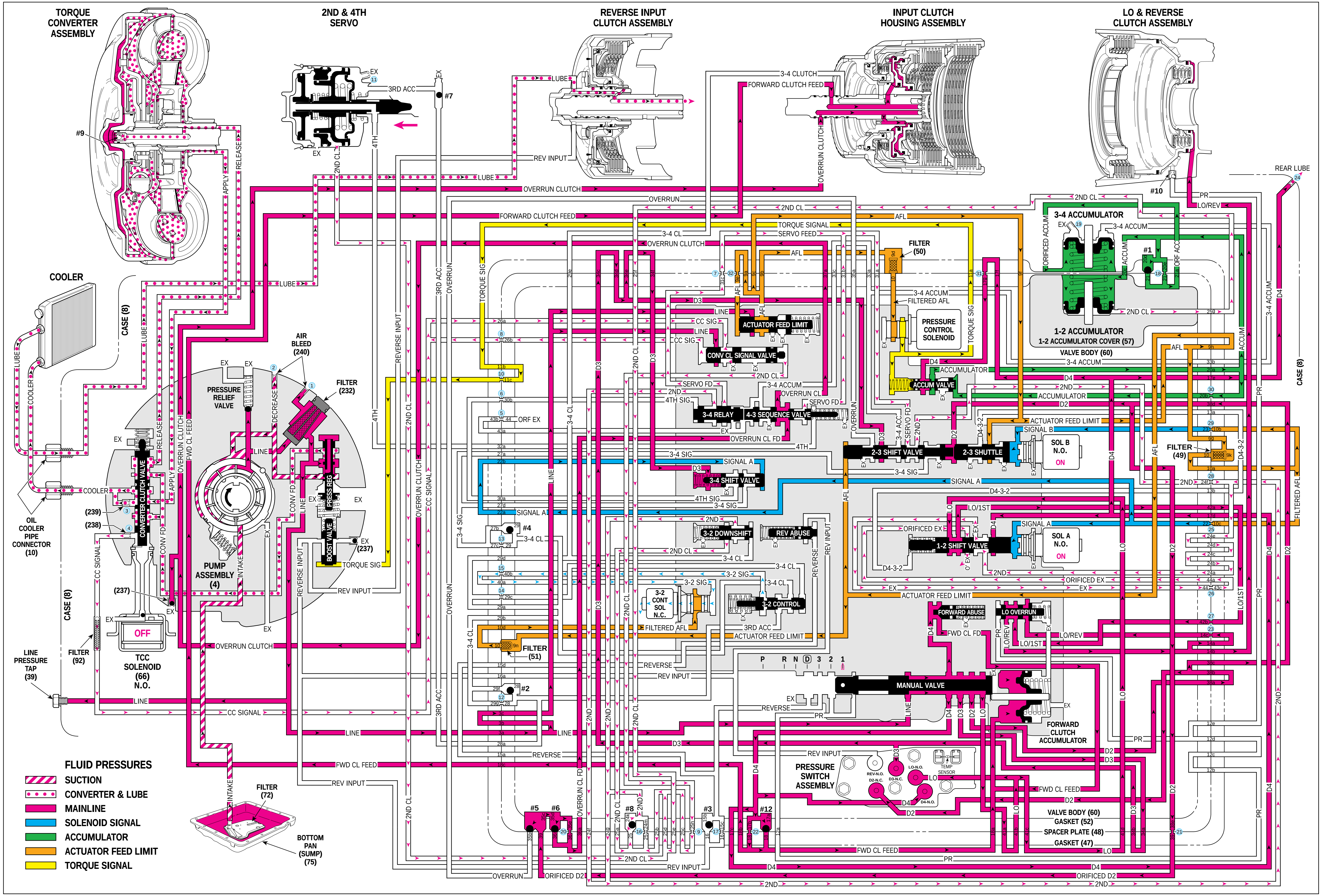
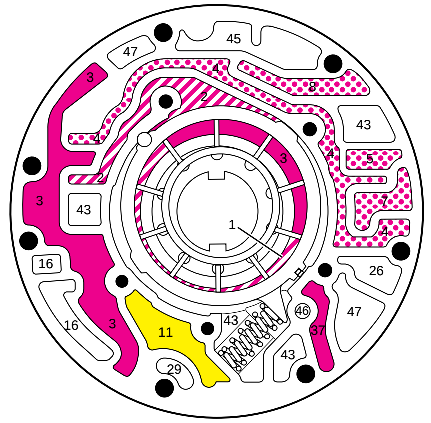
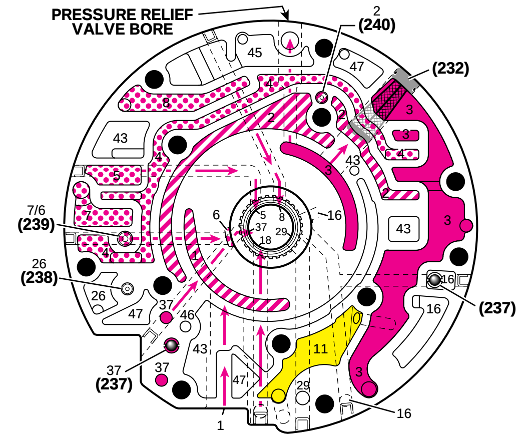


Figure 86

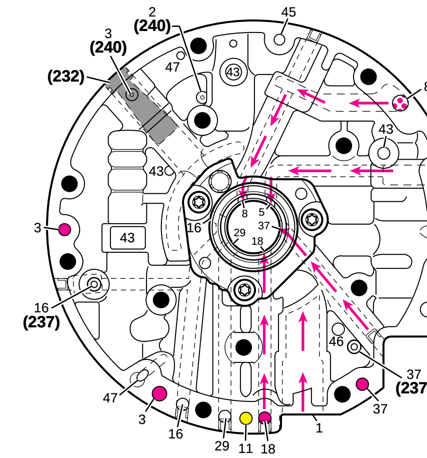
MANUAL FIRST - FIRST GEAR



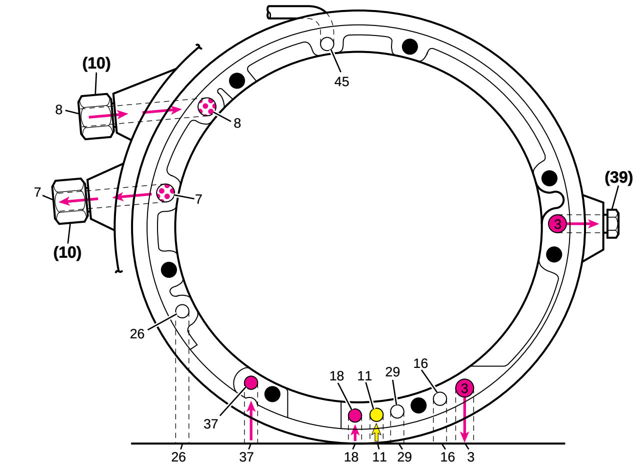
PUMP BODY (200)
(Pump Cover Side)



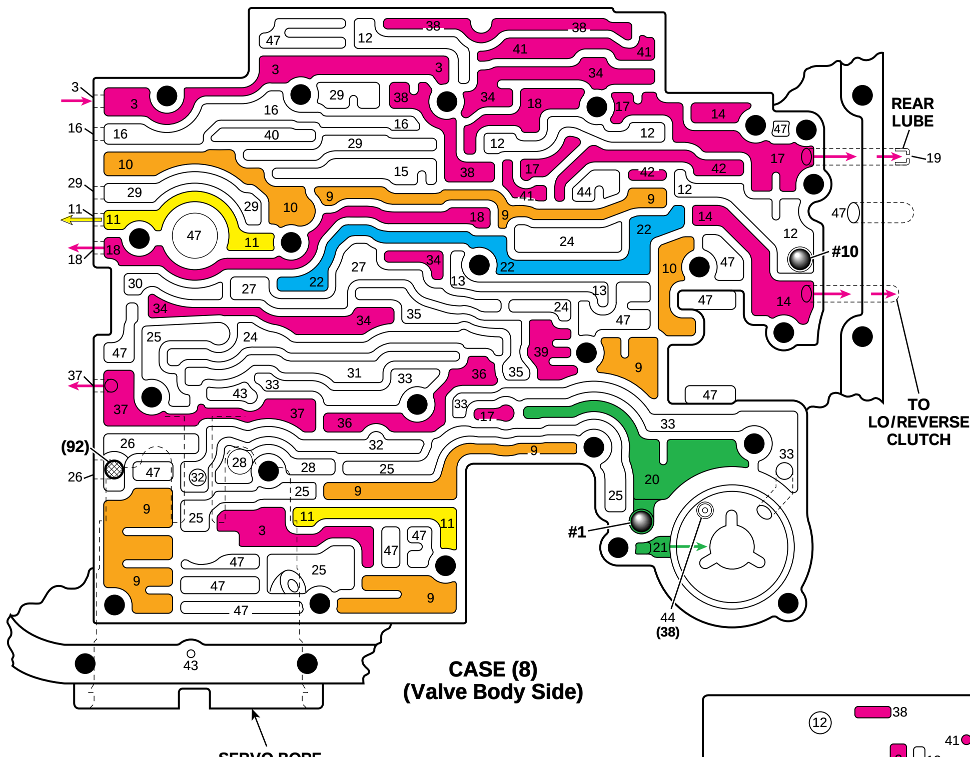
PUMP COVER (215)
(Pump Body Side)



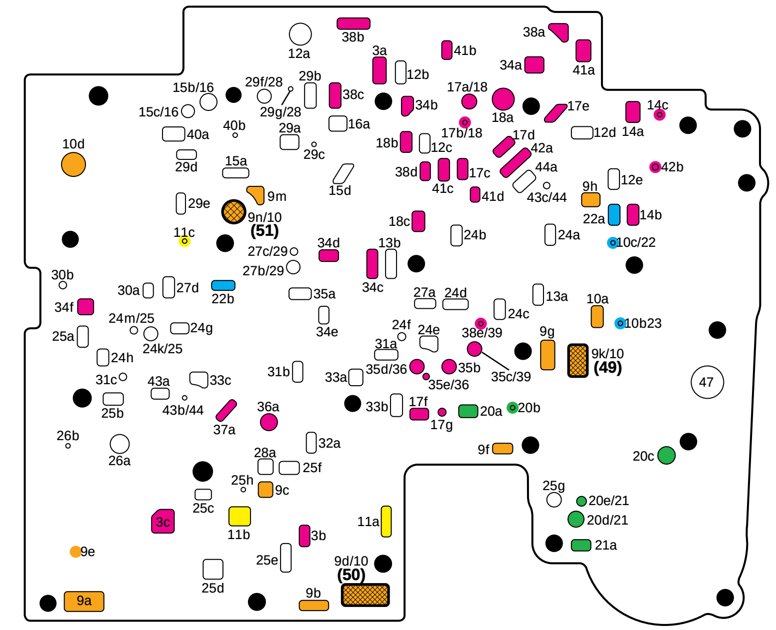
PUMP COVER (215)
(Case Side)



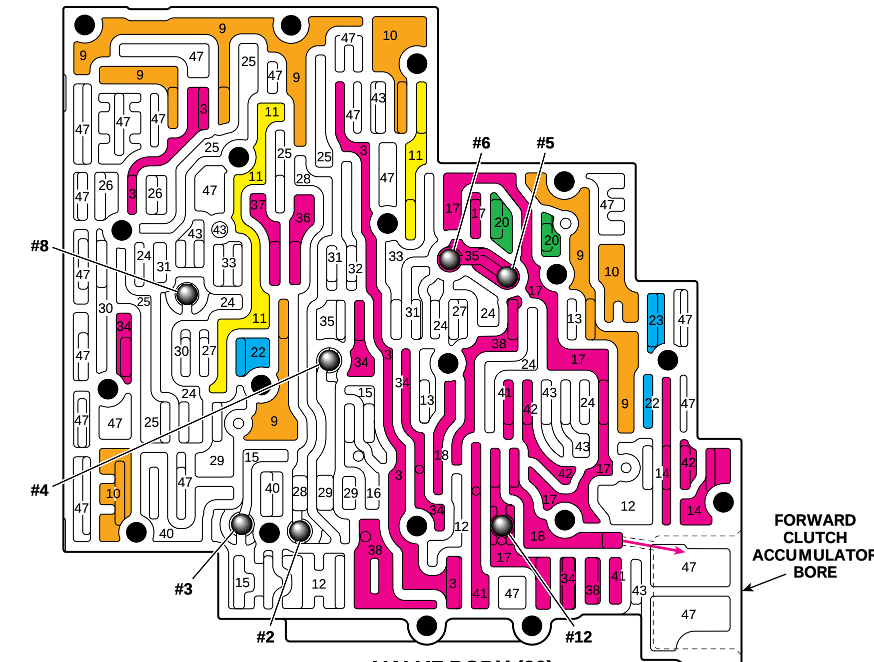
CASE (8)
(Pump Cover Side)



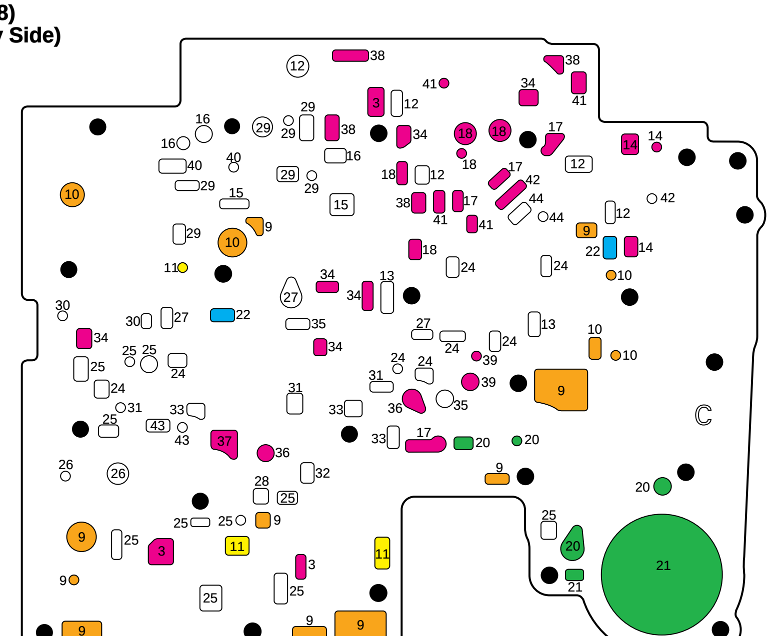
CASE (8)
(Valve Body Side)



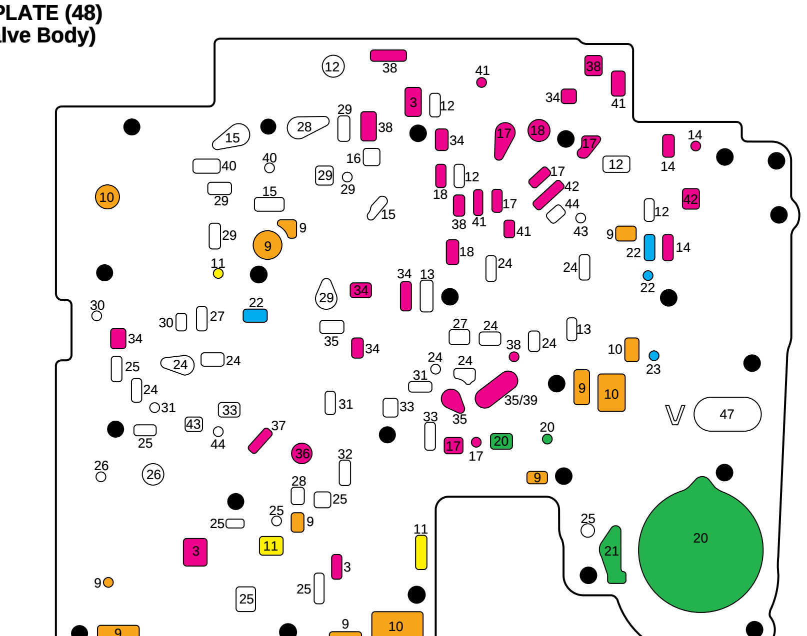
SPACER PLATE (48)
(Case/Valve Body)



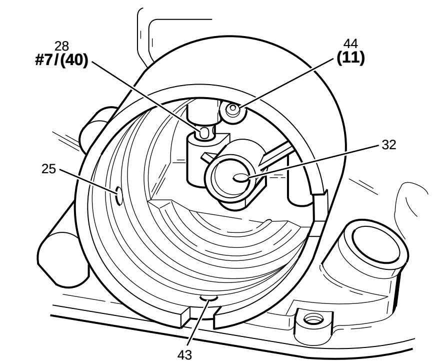
VALVE BODY (60)
(Case Side)



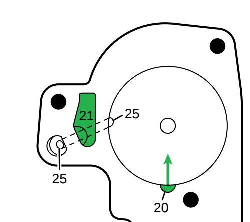
GASKET (47)
(Case/Spacer plate)



GASKET (52)
(Spacer plate/Valve Body)



CASE (8)
(Servo Bore)



1-2 ACCUMULATOR COVER (57)

NOTE:

- ● INDICATES BOLT HOLES
- NON- FUNCTIONAL HOLES HAVE BEEN REMOVED FROM COMPONENT DRAWINGS TO TO SIMPLIFY TRACING FLUID FLOW.
- EXHAUST FLUID NOT SHOWN

Figure 87

COOLER AND LUBRICATION CIRCUITS

To maintain proper transmission fluid temperature, the fluid is routed to the transmission fluid cooler located in the vehicle radiator. After the fluid is cooled it is routed back to the transmission and into the lubrication fluid circuit. Lube fluid is routed through the oil pump assembly, into the turbine shaft and down the center axis of the transmission. This fluid is routed into the various clutch packs and onto the planetary gear sets to cool and lubricate the various components.

The rear of the transmission is lubricated by D4 fluid feeding the rear lube fluid circuit through an orifice cup plug (#24). Rear lube fluid is routed into the transmission case extension housing (31) to cool and lubricate the bushings and components in the housing.

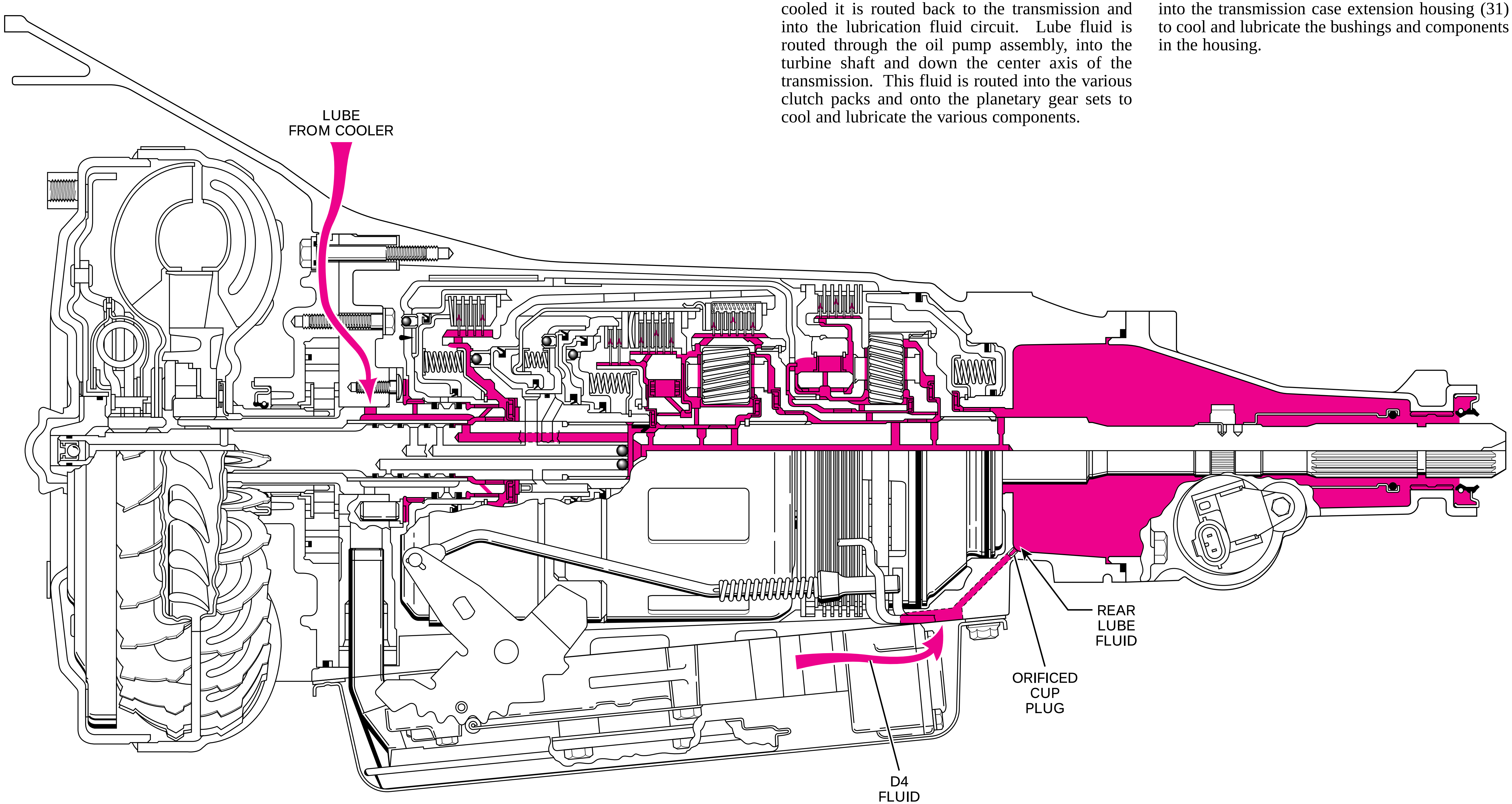
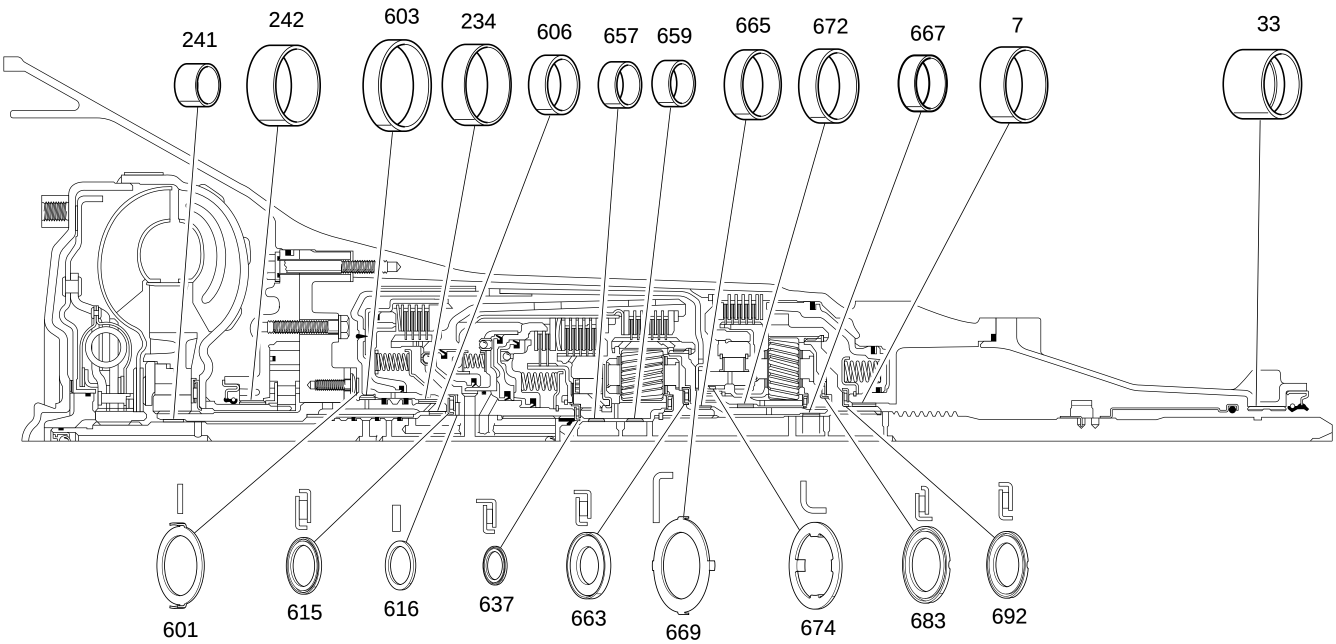


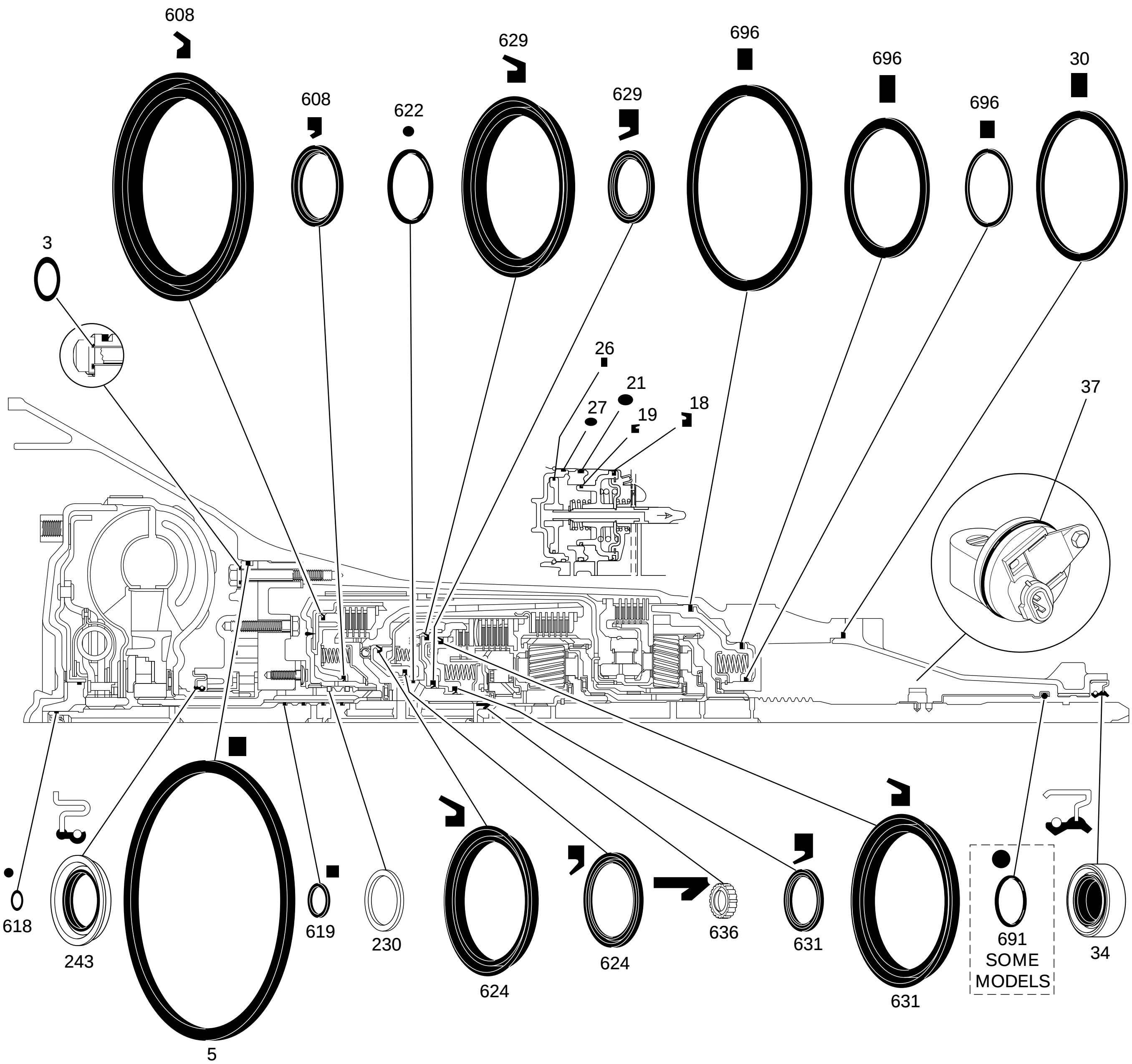
Figure 88



7 BUSHING, CASE
33 BUSHING, CASE EXTENSION
234 BUSHING, STATOR SHAFT (FRONT)
241 BUSHING, STATOR SHAFT (REAR)
242 BUSHING, OIL PUMP BODY
601 WASHER, THRUST (PUMP TO DRUM)
603 BUSHING, REVERSE INPUT CL. (FRONT)
606 BUSHING, REVERSE INPUT CLUTCH (REAR)
615 BEARING ASSEMBLY, STATOR SHAFT/ SELECTIVE WASHER
616 WASHER, THRUST (SELECTIVE)
637 BEARING ASSEMBLY, INPUT SUN GEAR
657 BUSHING, INPUT SUN GEAR (FRONT)
659 BUSHING, INPUT SUN GEAR (REAR)
663 BEARING ASSEMBLY, THRUST (INPUT CARRIER TO REACTION SHAFT)
665 BUSHING, REACTION CARRIER SHAFT (FRONT)
667 BUSHING, REACTION CARRIER SHAFT (REAR)
669 WASHER, THRUST (REACTION SHAFT/SHELL)
672 BUSHING, REACTION SUN
674 WASHER, THRUST (RACE/REACTION SHELL)
683 BEARING ASSEMBLY, THRUST (REACTION CARRIER/ SUPPORT)
692 BEARING., REACTION GEAR SUPPORT TO CASE

RH0212-4L60-E

Figure 89



3 O-RING, PUMP TO CASE BOLT
5 SEAL, OIL (PUMP TO CASE)
18 RING, OIL SEAL (2ND APPLY PISTON - OUTER)
19 RING, OIL SEAL (2ND APPLY PISTON - INNER)
21 SEAL, O-RING
26 RING, OIL SEAL (4TH APPLY PISTON - OUTER)
27 SEAL, O-RING (2-4 SERVO COVER)
30 SEAL, CASE EXTENSION TO CASE
34 SEAL ASSEMBLY, CASE EXTENSION OIL
37 SEAL, O-RING (ITSS TO CASE EXTENSION)
230 RING, OIL SEAL (STATOR SHAFT)
243 SEAL ASSEMBLY, OIL
608 SEALS, REVERSE INPUT CLUTCH (INNER AND OUTER)
618 SEAL, O-RING (TURBINE SHAFT/ SELECTIVE WASHER)
619 RING, OIL SEAL (SOLID)
622 SEAL, O-RING INPUT TO FORWARD HSG.
624 SEAL, 3RD AND 4TH CL. (INNER AND OUTER)
629 SEAL, FORWARD CLUTCH (INNER AND OUTER)
631 SEAL, OVERRUN CLUTCH (INNER AND OUTER)
636 SEAL, INPUT HOUSING TO OUTPUT SHAFT
691 SEAL, OUTPUT SHAFT
696 SEAL, TRANSMISSION (LO AND REVERSE CLUTCH –OUTER, CENTER, INNER)

RH0211-4L60-E

Figure 90

ILLUSTRATED PARTS LIST

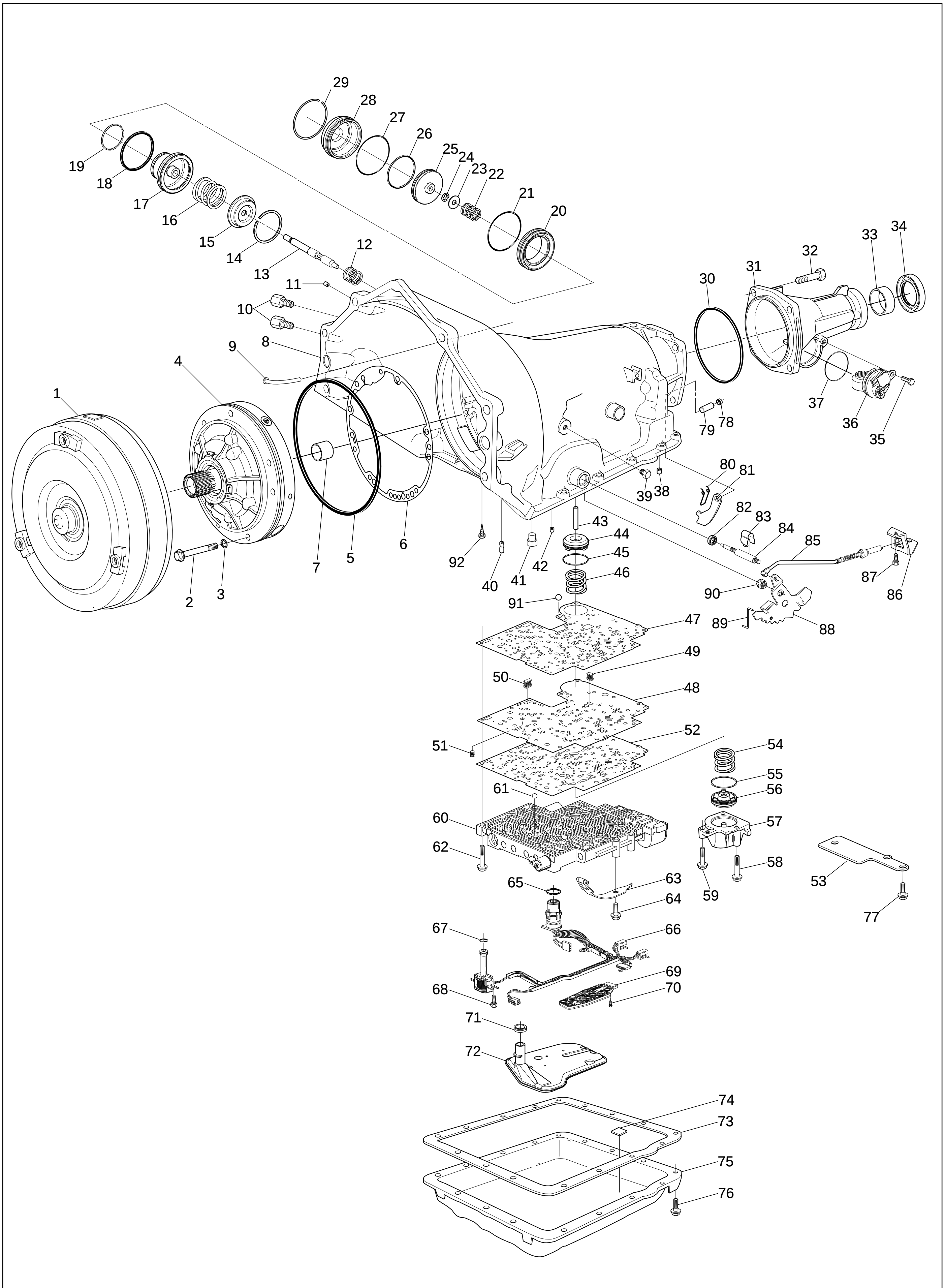
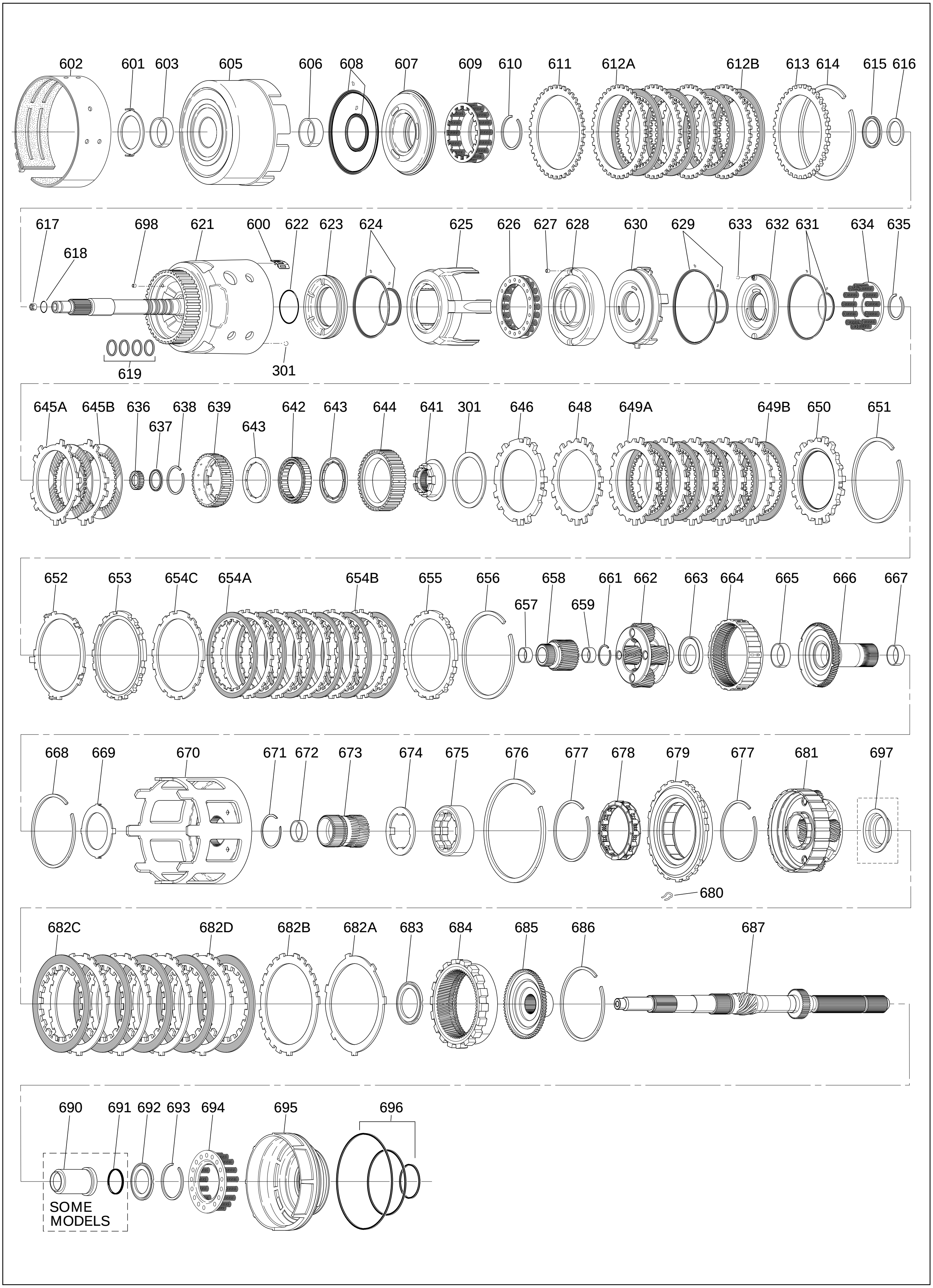

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92

Figure 91

ILL. NO.	DESCRIPTION
1	TORQUE CONVERTER ASSEMBLY
2	BOLT, PUMP TO CASE
3	O-RING, PUMP TO CASE BOLT
4	PUMP ASSEMBLY, OIL
5	SEAL, OIL (PUMP TO CASE)
6	GASKET, PUMP COVER TO CASE
7	BUSHING, CASE
8	CASE, TRANSMISSION
9	VENT ASSEMBLY, TRANSMISSION
10	CONNECTOR, OIL COOLER PIPE
11	PLUG, CASE SERVO
12	SPRING, SERVO RETURN
13	PIN, 2ND APPLY PISTON
14	RING, RETAINER (2ND APPLY PISTON)
15	RETAINER, SERVO CUSHION SPRING
16	SPRING, SERVO CUSHION
17	PISTON, 2ND APPLY
18	RING, OIL SEAL (2ND APPLY PISTON - OUTER)
19	RING, OIL SEAL (2ND APPLY PISTON - INNER)
20	HOUSING, SERVO PISTON (INNER)
21	SEAL, O-RING
22	SPRING, SERVO APPLY PIN
23	WASHER, SERVO APPLY PIN
24	RING, RETAINER (APPLY PIN)
25	PISTON, 4TH APPLY
26	RING, OIL SEAL (4TH APPLY PISTON - OUTER)
27	SEAL, O-RING (2-4 SERVO COVER)
28	COVER, 2-4 SERVO
29	RING, SERVO COVER RETAINING
30	SEAL, CASE EXTENSION TO CASE
31	EXTENSION, CASE
32	BOLT, CASE EXTENSION TO CASE
33	BUSHING, CASE EXTENSION
34	SEAL ASSEMBLY, CASE EXTENSION OIL
35	BOLT, SPEED SENSOR RETAINING
36	SPEED SENSOR, INTERNAL TRANSMISSION
37	SEAL, O-RING (ITSS TO CASE EXTENSION)
38	PLUG, TRANSMISSION CASE (ACCUM. BLEED)
39	PLUG, PRESSURE
40	RETAINER AND BALL ASSEMBLY, 3RD ACCUM.
41	PIN, BAND ANCHOR
42	RETAINER AND BALL ASM. (DOUBLE ORIFICE)
43	PIN, ACCUMULATOR PISTON
44	PISTON, 3-4 ACCUMULATOR
45	RING, OIL SEAL (3-4 ACCUMULATOR PISTON)
46	SPRING, 3-4 ACCUMULATOR
47	GASKET, SPACER PLATE TO CASE
48	PLATE, VALVE BODY SPACER
49	SCREEN, SHIFT SOLENOIDS
50	SCREEN, PRESSURE CONTROL SOLENOID
51	SCREEN, 3-2 CONTROL SOLENOID
52	GASKET, SPACER PLATE TO VALVE BODY
53	PLATE, SPACER PLATE SUPPORT
54	SPRING, 1-2 ACCUMULATOR
55	RING, OIL SEAL (1-2 ACCUMULATOR)
56	PISTON, 1-2 ACCUMULATOR
57	COVER AND PIN ASSEMBLY, 1-2 ACCUMULATOR
58	BOLT, ACCUMULATOR COVER
59	BOLT, ACCUMULATOR COVER
60	VALVE ASSEMBLY, CONTROL BODY
61	CHECKBALL
62	BOLT, VALVE BODY
63	SPRING ASSEMBLY, MANUAL DETENT
64	BOLT, MANUAL DETENT SPRING
65	SEAL, WIRING HARNESS PASS-THRU CONNECTOR O-RING
66	SOLENOID ASSEMBLY, WIRING HARNESS
67	SEAL, O-RING (SOLENOID)
68	BOLT, HEX WASHER HEAD (SOLENOID)
69	SWITCH ASSEMBLY, TRANSMISSION PRESSURE
70	BOLT, PRESSURE SWITCH ASSEMBLY
71	SEAL, FILTER
72	FILTER ASSEMBLY, TRANSMISSION OIL
73	GASKET, TRANSMISSION OIL PAN
74	MAGNET, CHIP COLLECTOR
75	PAN, TRANSMISSION OIL
76	SCREW, TRANSMISSION OIL PAN
77	BOLT, SPACER PLATE SUPPORT
78	PLUG, STEEL CUP
79	SHAFT, PARKING BRAKE PAWL
80	SPRING, PARKING PAWL RETURN
81	PAWL, PARKING BRAKE
82	SEAL, MANUAL SHAFT
83	RETAINER, MANUAL SHAFT
84	SHAFT, MANUAL
85	ACTUATOR ASSEMBLY, PARKING LOCK
86	BRACKET, PARKING LOCK
87	BOLT, PARKING LOCK BRACKET
88	LEVER, INSIDE DETENT
89	LINK, MANUAL VALVE
90	NUT, HEX HEAD
91	NO. 10 CHECKBALL
92	SCREEN, TCC

Figure 92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682C
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SOME
MODELS

Figure 93

ILL. NO.	DESCRIPTION
600	SPRING ASM., 3-4 CLUTCH BOOST (5)
601	WASHER, THRUST (PUMP TO DRUM)
602	BAND ASSEMBLY, 2-4
603	BUSHING, REVERSE INPUT CL. (FRONT)
605	HOUSING AND DRUM ASSEMBLY, REVERSE INPUT CLUTCH
606	BUSHING, REVERSE INPUT CLUTCH (REAR)
607	PISTON ASM., REVERSE INPUT CLUTCH
608	SEALS, REVERSE INPUT CLUTCH (INNER AND OUTER)
609	SPRING ASM., REVERSE INPUT CLUTCH
610	RING, REVERSE INPUT CLUTCH SPRING RETAINER
611	PLATE, REVERSE INPUT CLUTCH (BELLEVILLE)
612A	PLATE ASM., REVERSE INPUT CLUTCH (STEEL)
612B	PLATE, REVERSE INPUT CLUTCH (FIBER)
613	PLATE, REVERSE INPUT CLUTCH BACKING (SELECTIVE)
614	RING, REVERSE INPUT CL. RETAINING
615	BEARING ASSEMBLY, STATOR SHAFT/ SELECTIVE WASHER
616	WASHER, THRUST (SELECTIVE)
617	RETAINER AND BALL ASM., CHECK VALVE
618	SEAL, O-RING (TURBINE SHAFT/ SELECTIVE WASHER)
619	RING, OIL SEAL (SOLID)
620	RETAINER AND CHECKBALL ASSEMBLY
621	HOUSING AND SHAFT ASSEMBLY, INPUT
622	SEAL, O-RING INPUT TO FORWARD HSG.
623	PISTON, 3RD AND 4TH CLUTCH
624	SEAL, 3RD AND 4TH CL. (INNER AND OUTER)
625	RING, 3RD AND 4TH CLUTCH (APPLY)
626	SPRING ASSEMBLY, 3RD AND 4TH CLUTCH
627	RETAINER AND BALL ASSEMBLY, FORWARD CLUTCH HOUSING
628	HOUSING, FORWARD CLUTCH
629	SEAL, FORWARD CLUTCH (INNER AND OUTER)
630	PISTON, FORWARD CLUTCH
631	SEAL, OVERRUN CLUTCH (INNER AND OUTER)
632	PISTON, OVERRUN CLUTCH
633	BALL, OVERRUN CLUTCH
634	SPRING ASSEMBLY, OVERRUN CLUTCH
635	SNAP RING, OVERRUN CLUTCH SPRING RETAINER
636	SEAL, INPUT HOUSING TO OUTPUT SHAFT
637	BEARING ASSEMBLY, INPUT SUN GEAR
638	SNAP RING, OVERRUN CL. HUB RETAINING
639	HUB, OVERRUN CLUTCH
641	RETAINER AND RACE ASSEMBLY, SPRAG
642	FORWARD SPRAG ASSEMBLY
643	RETAINER RINGS, SPRAG ASSEMBLY
644	RACE, FORWARD CLUTCH (OUTER)
645A	PLATE ASSEMBLY, OVERRUN CLUTCH (STEEL)
645B	PLATE, OVERRUN CLUTCH (FIBER)
646	PLATE, FORWARD CLUTCH (APPLY)
648	PLATE, FORWARD CLUTCH (WAVED)
649A	PLATE ASSEMBLY, FORWARD CLUTCH (STEEL)
649B	PLATE, FORWARD CLUTCH (FIBER)
650	PLATE, FORWARD CLUTCH BACKING (SEL.)
651	RING, FORWARD CLUTCH BACKING PLATE RETAINER
652	PLATE, 3-4 CLUTCH RING RETAINER
653	PLATE, 3-4 CLUTCH APPLY (STEPPED)

ILL. NO.	DESCRIPTION
654A	PLATE ASSEMBLY, 3RD AND 4TH CLUTCH (FIBER)
654B	PLATE, 3-4 CLUTCH (STEEL)
654C	PLATE, 3-4 CLUTCH (STEEL)
655	PLATE, 3-4 CLUTCH BACKING (SEL.)
656	RING, 3-4 CLUTCH BACKING PLATE RETAINER
657	BUSHING, INPUT SUN GEAR (FRONT)
658	GEAR, INPUT SUN
659	BUSHING, INPUT SUN GEAR (REAR)
661	RET., OUTPUT SHAFT TO INPUT CARRIER
662	CARRIER ASSEMBLY, INPUT (COMPLETE)
663	BEARING ASSEMBLY, THRUST (INPUT CARRIER TO REACTION SHAFT)
664	GEAR, INPUT INTERNAL
665	BUSHING, REACTION CARRIER SHAFT (FRONT)
666	SHAFT, REACTION CARRIER
667	BUSHING, REACTION CARRIER SHAFT (REAR)
668	RING, REACTION SHAFT/INTERNAL GEAR RETAINER
669	WASHER, THRUST (REACTION SHAFT/SHELL)
670	SHELL, REACTION SUN
671	RING, REACTION SUN GEAR RETAINER
672	BUSHING, REACTION SUN
673	GEAR, REACTION SUN
674	WASHER, THRUST (RACE/REACTION SHELL)
675	RACE, LO ROLLER CLUTCH
676	RING, LO AND REVERSE SUPPORT TO CASE RETAINER
677	RING, LO AND REVERSE RETAINER (ROLLER ASSEMBLY/CAM)
678	CLUTCH ASSEMBLY, LO ROLLER
679	SUPPORT ASM., LO AND REVERSE CLUTCH
680	SPRING, TRANSMISSION (LO AND REVERSE CLUTCH SUPPORT RETAINER)
681	CARRIER ASSEMBLY, REACTION
682A	PLATE, LO AND REVERSE CLUTCH (WAVED)
682B	PLATE, SPACER LO AND REVERSE CLUTCH (SELECTIVE)
682C	PLATE ASSEMBLY, LO AND REVERSE CLUTCH (FIBER)
682D	PLATE, LO AND REVERSE CLUTCH (STEEL)
683	BEARING ASSEMBLY, THRUST (REACTION CARRIER/ SUPPORT)
684	GEAR, INTERNAL REACTION
685	SUPPORT, INTERNAL REACTION GEAR
686	RING, REACTION GEAR/SUPPORT RETAINER
687	SHAFT, OUTPUT
690	SLEEVE, OUTPUT SHAFT
691	SEAL, OUTPUT SHAFT
692	BRG., REACTION GEAR SUPPORT TO CASE
693	RING, LO AND REVERSE CLUTCH RETAINER
694	SPRING ASSEMBLY, LO AND REVERSE CLUTCH
695	PISTON, LO AND REVERSE CLUTCH
696	SEAL, TRANSMISSION (LO AND REVERSE CLUTCH – OUTER, CENTER, INNER)
697	DEFLECTOR, OIL (HIGH OUTPUT MODELS ONLY)
698	PLUG, ORIFICED CUP
699	ROTOR, INTERNAL TRANSMISSION SPEED SENSOR

Figure 94

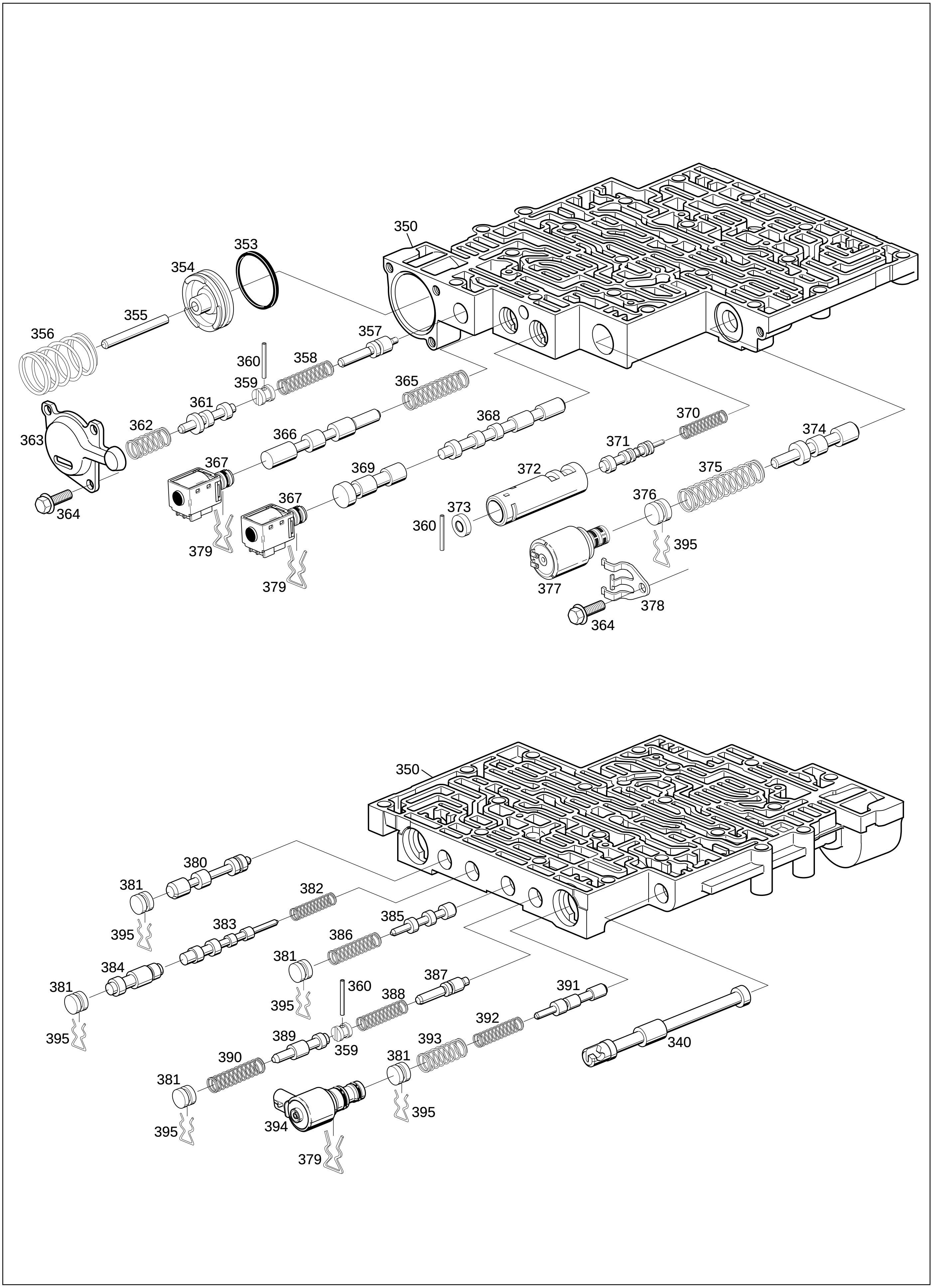
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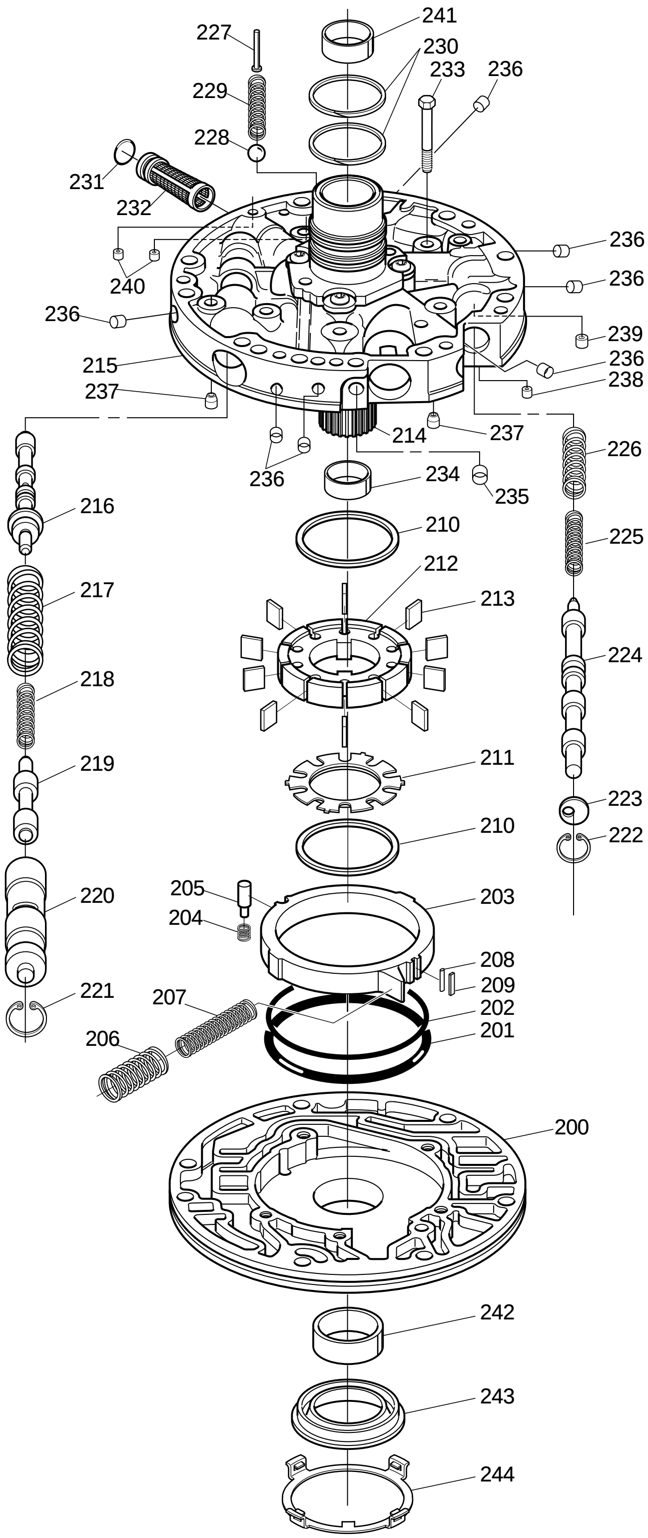
Figure 95

340 VALVE, MANUAL
350 VALVE ASSEMBLY, CONTROL BODY
353 SEAL, FORWARD ACCUMULATOR OIL
354 PISTON, FORWARD ACCUMULATOR
355 PIN, FORWARD ACCUMULATOR
356 SPRING, FORWARD ACCUMULATOR
357 VALVE, FORWARD ABUSE
358 SPRING, FORWARD ABUSE VALVE
359 PLUG, BORE
360 PIN, COILED SPRING
361 VALVE, LOW OVERRUN
362 SPRING, LOW OVERRUN VALVE
363 COVER, FORWARD ACCUMULATOR
364 BOLT, FORWARD ACCUMULATOR COVER
365 SPRING, 1-2 SHIFT VALVE
366 VALVE, 1-2 SHIFT
367A SHIFT SOLENOID A (1-2/3-4)
367B SHIFT SOLENOID B (2-3)
368 VALVE, 2-3 SHIFT
369 VALVE, 2-3 SHUTTLE
370 SPRING, ACCUMULATOR VALVE
371 VALVE, ACCUMULATOR
372 SLEEVE, ACCUMULATOR VALVE
373 PLUG, BORE
374 VALVE, ACTUATOR FEED LIMIT
375 SPRING, ACTUATOR FEED LIMIT VALVE
376 PLUG, BORE
377 PRESSURE CONTROL SOLENOID
378 RETAINER, PRESSURE CONTROL SOLENOID
379 RETAINER, SOLENOID
380 VALVE, CONVERTER CLUTCH SIGNAL
381 PLUG, BORE
382 SPRING, 4-3 SEQUENCE VALVE
383 VALVE, 4-3 SEQUENCE
384 VALVE, 3-4 RELAY
385 VALVE, 3-4 SHIFT
386 SPRING, 3-4 SHIFT VALVE
387 VALVE, REVERSE ABUSE
388 SPRING, REVERSE ABUSE VALVE
389 VALVE, 3-2 DOWNSHIFT
390 SPRING, 3-2 DOWNSHIFT VALVE
391 VALVE, 3-2 CONTROL
392 SPRING, 3-2 CONTROL VALVE
393 SPRING, BORE PLUG
394 3-2 CONTROL SOLENOID
395 RETAINER, BORE PLUG

Figure 96



ILL. NO.	DESCRIPTION
200	BODY, PUMP
201	RING, OIL SEAL (SLIDE TO WEAR PLATE)
202	SEAL, O-RING (SLIDE SEAL BACK-UP)
203	SLIDE, PUMP
204	SPRING, PIVOT PIN
205	PIN, PIVOT SLIDE
206	SPRING, PUMP SLIDE (OUTER)
207	SPRING, PUMP SLIDE (INNER)
208	SUPPORT, PUMP SLIDE SEAL
209	SEAL, PUMP SLIDE
210	RING, PUMP VANE
211	GUIDE, ROTOR
212	ROTOR, OIL PUMP
213	VANE, PUMP
214	SHAFT, STATOR
215	COVER, PUMP
216	VALVE, PRESSURE REGULATOR
217	SPRING, PRESSURE REGULATOR VALVE
218	SPRING, PRESSURE REGULATOR ISOLATOR
219	VALVE, REVERSE BOOST
220	SLEEVE, REVERSE BOOST VALVE
221	RING, OIL PUMP REVERSE BOOST VALVE RETAINING
222	RING, OIL PUMP CONVERTER CLUTCH VALVE RETAINING
223	VALVE, STOP
224	VALVE, CONVERTER CLUTCH
225	SPRING, CONVERTER CLUTCH VALVE (INNER)
226	SPRING, CONVERTER CLUTCH VALVE (OUTER)
227	RIVET, PRESSURE RELIEF BOLT
228	BALL, PRESSURE RELIEF
229	SPRING PRESSURE RELIEF
230	RING, OIL SEAL (STATOR SHAFT)
231	SEAL, OIL PUMP COVER SCREEN
232	SCREEN, OIL PUMP COVER
233	BOLT, M8 X 1.25 X 40 (COVER TO BODY)
234	BUSHING, STATOR SHAFT (FRONT)
235	PLUG, OIL PUMP COVER (FWD CLUTCH FEED)
236	PLUG, OIL PUMP COVER
237	RETAINER AND BALL ASSEMBLY, CHECK VALVE
238	ORIFICE, CONVERTER CLUTCH SIGNAL (CUP PLUG)
239	ORIFICE, OIL COOLER (CUP PLUG)
240	PLUG, CUP ORIFICE
241	BUSHING, STATOR SHAFT (REAR)
242	BUSHING, PUMP BODY
243	SEAL ASSEMBLY, OIL
244	RETAINER, FRONT HELIX

Figure 97

BASIC SPECIFICATIONS

Transmission Type

4L60-E = 4: Four Speed
L: Longitudinal Mount
60: Product Series
E: Electronically Controlled

Automatic Overdrive with a Torque Converter Clutch Assembly

Curent Engine Range

2.5L to 5.7L Gasoline
6.2L Diesel

Transmission Drive

Rear Wheel Drive
4-Wheel Drive
All Wheel Drive

Control Systems

Shift Pattern – Solenoid Control
Shift Quality – Variable Bleed Solenoid
Pulse Width Modulated Solenoid
(For 3-2 Downshifts Only)
Torque Converter Clutch – Solenoid Control

Additional transmission and engine sensors are provided depending on transmission/powertrain application.

Gear Ratios

1st:	3.059
2nd:	1.625
3rd:	1.000
4th:	0.696
Rev:	2.294

Maximum Engine Torque

475 Nm (350 LB-FT)

Maximum Gearbox Torque

910 Nm (670 LB-FT)

The maximum torque limits are only to be used as a guide and may not be applicable under certain conditions.

Maximum Shift Speed

1-2	6,000 RPM
2-3	6,000 RPM
3-4	4,600 RPM

The maximum shift speed allowed in each engine application must be calculated.

Maximum Gross Vehicle Weight

3,900 Kg (8,600 LB)

Transmission Fluid Type

Dexron® IIE

Converter Sizes Available

245 mm and 298 mm (Reference)

Converter Bolt Circle Diameters

For 245 mm Converter – 247.65 mm (Reference)
For 298 mm Converter – 273.05 mm (Reference)

Converter Stall Torque Ratio Range

For 245 mm Converter – 1.63 to 2.70
For 298 mm Converter – 1.84 to 2.34

Converter 'K' Factor Range

For 245 mm Converter – 122 to 240
For 298 mm Converter – 100 to 140

Not all 'K' Factors are applicable across the range of Converter Stall Torque Ratios.

Transmission Fluid Capacities (Approximate)

245 mm Converter	**298 mm Converter**
Dry: 7.9L (8.4 QTS)	Dry: 10.6L (11.2 QTS)

Transmission Weight

245 mm Converter	**298 mm Converter**
Dry: 65.4 Kg (144.30 LB)	Dry: 70.5 Kg (155.70 LB)
Wet: 72.4 Kg (159.55 LB)	Wet: 80.5 Kg (176.16 LB)

Transmission Packaging Information**

Engine Mounting Face to Rear of Case
593.50 mm (Reference - Less Extension)

Overall Length
Current Minimum: 756.20 mm (Reference)
Current Maximum: 778.30 mm (Reference)

Case Extension Lengths
Determined by Customer Requirements
Current Minimum: 162.70 mm (Reference)
Current Maximum: 184.80 mm (Reference)

Current Converter Housings Available
245 mm (Small Style Bell)
298 mm (Large Style Bell)

Two-Piece Case Assembly
Bell Housing with Main Body
Case Extension

7 Position Quadrant

(P, R, N, D, D, 2, 1) / (P, R, N, D, 3, 2, 1)

Pressure Taps Available

Line Pressure

Manufacturing Location

Toledo, Ohio

* All dimensions shown are nominal.

Information may vary with application. All information, illustrations and specifications contained in this brochure are based on the latest product information available at the time of publication approval. The right is reserved to make changes at any time without notice.

HYDRA-MATIC PRODUCT DESIGNATION SYSTEM

The product designation system used for all Hydra-matic transaxles and transmissions consists of a series of numbers and letters that correspond with the special features incorporated in that product line. The first character is a number that designates the number of forward gear ranges available in that unit. For example: 4 = four forward gear ranges.

The second character is a letter that designates how the unit is mounted in the vehicle. When the letter "T" is used, it designates that the unit is transversely mounted and is used primarily for front wheel drive vehicles. The letter "L" designates that it is longitudinally mounted in the vehicle and it is used primarily for rear wheel drive vehicles. The letter "M" designates that the unit is a manual transaxle or transmission but not specific to a front or rear wheel drive vehicle application.

The third and fourth characters consists of a set of numbers, (i.e. "60"), that designate the transaxle or transmission "Series" number. This number signifies the relative torque capacity of the unit.

The fifth character designates the major features incorporated into this unit. For example, the letter "E" designates that the unit has electronic controls.

By using this method of classification, the HYDRA-MATIC 4L60-E is a 4-speed, longitudinally mounted, 60 series unit.

HYDRA-MATIC 4L60-E

HYDRA-MATIC	4	L	60	E
	Number of Speeds:	Type:	Series:	Major Features:
	3	T - Transverse	Based on Relative Torque Capacity	E - Electronic Controls
	4	L - Longitudinal		A - All Wheel Drive
	5	M - Manual		HD - Heavy Duty
	V (CVT)			

GLOSSARY OF TECHNICAL TERMS

Accumulator: A component of the transmission that absorbs hydraulic pressure during the apply of clutch or band. Accumulators are designed to control the quality of a shift from one gear range to another.

Adaptive Learning: Programming within the PCM that automatically adjusts hydraulic pressures in order to compensate for changes in the transmission (i.e. component wear).

Applied: An apply component that is holding another component to which it is splined or assembled with. Also referred to as "engaged".

Apply Components: Hydraulically operated clutches, servos, bands, and mechanical one-way roller or sprag clutches that drive or hold members of a planetary gear set.

Apply Plate: A steel clutch plate in a clutch pack located next to the (apply) piston.

Backing Plate: A steel plate in a clutch pack that is usually the last plate in that clutch assembly (farthest from the clutch piston).

Band: An apply component that consists of a flexible strip of steel and friction material that wraps around a drum. When applied, it tightens around the drum and prevents the drum from rotating.

Brake Switch: An electrical device that provides signals to the Powertrain Control Module (PCM) based on the position of the brake pedal. The PCM uses this information to apply or release the torque converter clutch (TCC).

Centrifugal Force: A force that is imparted on an object (due to rotation) that increases as that object moves further away from a center/point of rotation.

Checkball: A spherical hydraulically controlled component (usually made of steel) that either seals or opens fluid circuits. It is also referred to as a check valve.

Clutch Pack: An assembly of components generally consisting of clutch plates, an apply plate and a backing plate.

Clutch Plate: A hydraulically activated component that has two basic designs: (1) all steel, or (2) a steel core with friction material bonded to one or two sides of the plate.

Control Valve Body: A machined metal casting that contains valve trains and other hydraulically controlled components that shift the transmission.

Coupling Speed: The speed at which a vehicle is traveling and no longer requires torque multiplication through the torque converter. At this point the stator free wheels to allow fluid leaving the turbine to flow directly to the pump. (See torque converter)

De-energize(d): To interrupt the electrical current that flows to an electronically controlled device making it electrically inoperable.

Direct Drive: A condition in a gear set where the input speed and input torque equals the output speed and output torque. The gear ratio through the gear set is 1:1.

Downshift: A change in a gear ratio where input speed and torque increases.

Duty Cycle: In reference to an electronically controlled solenoid, it is the amount of time (expressed as a percentage) that current flows through the solenoid coil.

Energize(d): To supply a current to an electronically controlled device enabling it to perform its designed function.

Engine Compression Braking: A condition where compression from the engine is used with the transmission to decrease vehicle speed.

Exhaust: The release of fluid pressure from a hydraulic circuit. (The words exhausts and exhausting are also used and have the same intended meaning.)

Fail-Safe Mode: A condition whereby a component (i.e. engine or transmission) will partially function even if its electrical system is disabled.

Fluid: In this publication fluid refers primarily to transmission fluid.

Fluid Pressure: A pressure that is consistent throughout a given fluid circuit.

Force: A measurable effort that is exerted on an object (component).

Freewheeling: A condition where power is lost through a driving or holding device (i.e. roller or sprag clutches).

Friction Material: A heat and wear resistant fibrous material bonded to clutch plates and bands.

Gear: A round, toothed device that is used fortransmitting torque through other components.

Gear Range: A specific speed to torque ratio at which the transmission is operating (i.e. 1st gear, 2nd gear etc.).

Gear Ratio: Revolutions of an input gear as compared to the revolutions of an output gear. It can also be expressed as the number of teeth on a gear as compared to the number of teeth on a gear that it is in mesh with.

Hydraulic Circuit: A fluid passage which often includes the mechanical components in that circuit designed to perform a specific function.

Input: A starting point for torque, revolutions or energy into another component of the transmission.

Internal Gear: The outermost member of a gear set that has gear teeth in constant mesh with planetary pinion gears of the gear set.

Land (Valve Land): The larger diameters of a spool valve that contact the valve bore or bushing.

Line Pressure: The main fluid pressure in a hydraulic system created by the pump and pressure regulator valve.

Manual Valve: A spool valve that distributes fluid to various hydraulic circuits and is mechanically linked to the gear selector lever.

Orifice: A restricting device (usually a hole in the spacer plate) for controlling pressure build up into another circuit.

Overdrive: An operating condition in the gear set allowing output speed to be higher than input speed and output torque to be lower than input torque.

Overrunning: The function of a one-way mechanical clutch that allows the clutch to freewheel during certain operating conditions of the transmission.

Pinion Gears: Pinion gears (housed in a carrier) that are in constant mesh with a circumferential internal gear and centralized sun gear.

Planetary Gear Set: An assembly of gears that consists of an internal gear, planet pinion gears with a carrier, and a sun gear.

Powertrain Control Module (PCM): An electronic device that manages most of the electrical systems throughout the vehicle.

Pressure: A measurable force that is exerted on an area and expressed as kilopascals (kPa) or pounds per square inch (psi).

Pulse Width Modulated (PWM): An electronic signal that continuously cycles the ON and OFF time of a device (such as a solenoid) while varying the amount of ON time.

Race (Inner or Outer): A highly polished steel surface that contacts bearings or sprag or roller elements.

Reduction (Gear Reduction): An operating condition in the gear set allowing output speed to be lower than input speed and output torque to be higher than input torque.

Residual Fluid Pressure: Excess pressure contained within an area after the supply pressure has been terminated.

Roller Clutch: A mechanical clutch (holding device) consisting of roller bearings assembled between inner and outer races.

Servo: A spring loaded device consisting of a piston in a bore that is operated (stroked) by hydraulic pressure to apply or release a band.

Spool Valve: A round hydraulic control valve often containing a variety of land and valley diameters.

Sprag Clutch: A mechanical clutch (holding device) consisting of “figure eight” like elements assembled between inner and outer races.

Throttle Position: The travel of the throttle plate that is expressed in percentages and measured by the throttle position sensor (TPS).

Torque: A measurable twisting force expressed in terms of Newton- meters (N·m), pounds feet (lbs. ft.) or pounds inches (lbs. in.).

Torque Converter: A component of an automatic transmission, (attached to the engine flywheel) that transfers torque from the engine to the transmission through a fluid coupling.

Variable Capacity Pump: The device that provides fluid for operating the hydraulic circuits in the transmission. The amount of fluid supplied varies depending on vehicle operating conditions.

ABBREVIATIONS

AC - Alternating Current
A/C - Air Conditioning
ACC or ACCUM - Accumulator
AFL - Actuator Feed Limit
ALDL - Assembly Line Diagnostic Link
AMP - Amperage
ASM - Assembly

°C - Degrees Celsius
CC - Converter Clutch
CL - Clutch
CONT - Control
CONV - Converter

DC - Direct Current
D.C. - Duty Cycle
DRAC - Digital Ratio Adaptor Converter
D2 - Drive 2 (circuit)
D3 - Drive 3 (circuit)
D4 - Drive 4 (circuit)
D432 - Drive 432 (circuit)

ECM - Electronic Control Module
ECT - Engine Coolant Temperature
EX - Exhaust
°F - Degrees Fahrenheit
FD - Feed
FWD - Forward

Hz - Hertz

KM/H - Kilometers per Hour
kPa - KiloPascals

MAP - Manifold Absolute Pressure
MPH - Miles per Hour

NC - Normally Closed
N·m - Newton Meters
NO - Normally Open

ORF - Orificed
ORUN - Overrun

PCM - Powertrain Control Module
PCS - Pressure Control Solenoid
PR - Park Reverse (circuit)
PSA - Pressure Switch Assembly
PRESS REG - Pressure Regulator
PSI - Pounds per Square Inch

REV - Reverse
RPM - Revolutions per Minute

SEL - Selective
SIG - Signal
SOL - Solenoid
TCC - Torque Converter Clutch
TPS - Throttle Position Sensor
TRANS - Transmission or Transaxle

V - Volts
VSS - Vehicle Speed Sensor

2WD - 2 Wheel Drive
4WD - 4 Wheel Drive

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