MADISA CAT

Previous Screen

Service Information System

924F

Welcome: p230tav

Product: WHEEL LOADER
Model: 924F WHEEL LOADER 5NN00801
Configuration: 924F Wheel Loader 5NN00001-UP (MACHINE) POWERED BY 3114 Engine

SETEMBRO 1994

Systems Operation
924F WHEEL LOADER AND IT24F INTEGRATED TOOLCARRIER POWER TRA
Media Number -SENR6725-00 **Publication Date -19/09/1994** **Date Updated -12/10/2001**

Systems Operation

SMCS - 3168

RUTHZIL TRATOR COMERCIAL DE PEÇAS LTDA 11 97083-6812 ROLANDO CITRANGULO

General Information

Reference: For Specifications with illustrations, refer to SENR6724, 924F Wheel Loader and IT24F Integrated Toolcarrier Power Train. If the Specifications in SENR6724 are not the same as listed in the Systems Operation and the Testing And Adjusting, look at the print date on the cover of each module.

Use the Specifications listed in the module with the latest date.

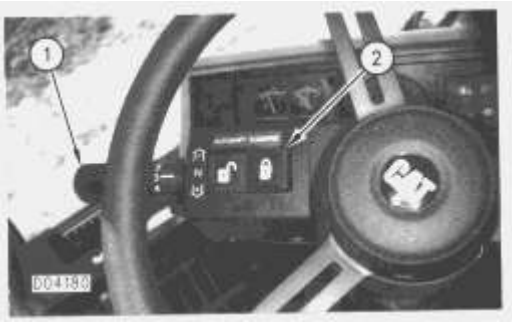
Power from the diesel engine is sent from the flywheel to the torque converter. The torque converter is splined to the engine flywheel and fastened to the transmission by bolts. Power flows directly from the torque converter to the transmission input shaft.

The transmission output shaft transfers power through the drive shafts and universal joints to the front and rear differentials. The bevel gear and pinion of each differential sends the power through the differentials and sun gear shafts to the final drives. Axle shafts transmit the power from the final drives to the wheels. An integral parking brake is mounted on the front of the transmission.

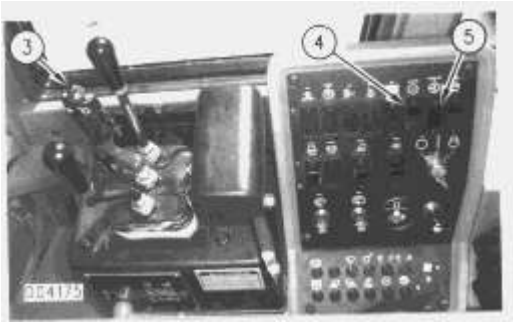
The transmission is a four speed forward and three speed reverse power shift transmission. The transmission is a constant mesh countershaft type and has six clutches that are engaged hydraulically and released by spring force.

There is a neutralizer switch activated by the brake pedals. When either brake pedal is depressed, the clutches in the transmission are disengaged. This allows the engine rpm, and thereby the hydraulic pump output to be increased without moving the transmission shift lever to the NEUTRAL position.

There is also a neutralizer lockout switch (5), which when in the ON position, overrides the neutralizing function of the brake pedals. A light on the dash indicates when the neutralizer lockout is activated.



Transmission Controls
(1) Control lever (for speed and direction selection). (2) Neutral lock.



Right Side Console
(3) Downshift switch. (4) Autoshift switch. (5) Neutralizer lockout switch.

Machine Equipped With Autoshift

The machine direction is changed manually by the operator with transmission control lever (1). The transmission will automatically shift up to the highest speed selected on the transmission control lever. Transmission control lever (1) is a dual function lever. Gear (speed) selection is made by twisting the lever. FORWARD or REVERSE selection is made by moving the lever toward the front or back.

Autoshift switch (4) allows either manual or autoshift operation.

Switches in the transmission control indicate to the Electronic Transmission Control the direction and speed selected by the operator. The Electronic Transmission Control energizes solenoids on the transmission control valve to engage the correct clutches for the direction and speed selected. The transmission control lever can be locked in NEUTRAL with neutral lock (2).

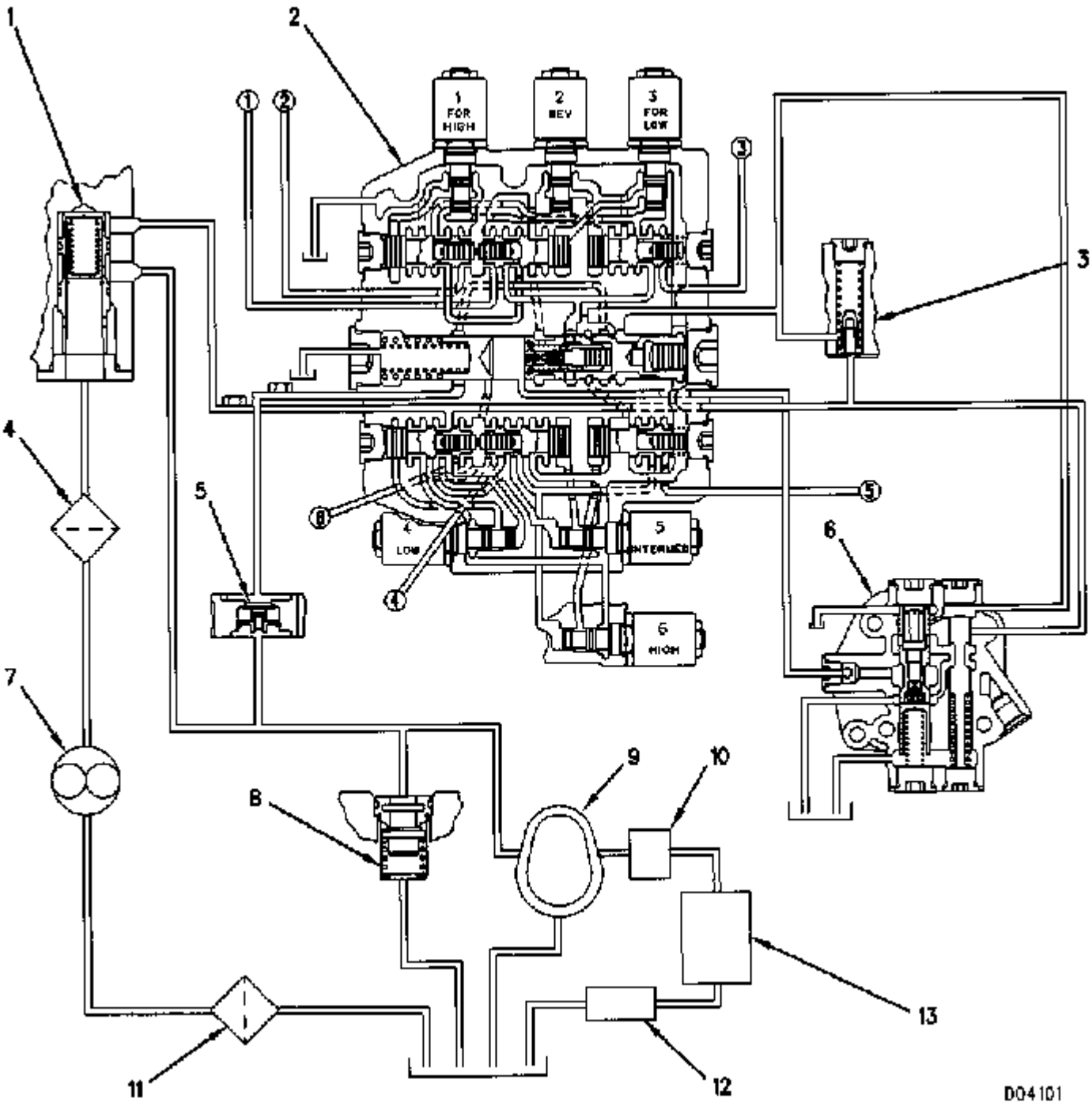
Downshift switch (3) is located on the lift control lever. The downshift switch is used to downshift the transmission manually one speed at a time.

Machines Without Autoshift

Direction and speed are changed manually by the operator with the transmission control lever which is mounted on the left side of the steering column. Transmission control lever (1) is a dual function lever with speed selection made by twisting the lever and FORWARD or REVERSE selection made by moving the lever toward the front or back.

Switches in the transmission control lever directly energize solenoids on the transmission control valve to engage the correct clutches for the speed and direction selected. The transmission control lever can be locked in NEUTRAL with neutral lock (2).

Transmission Hydraulic System



Transmission Hydraulic System Schematic
(1) Flow control valve. (2) Transmission control valve. (3) Differential valve. (4) Transmission oil filter. (5) Converter back flow check valve. (6) Dump valve group. (7) Transmission and torque converter oil pump. (8) Torque converter inlet relief valve. (9) Torque converter. (10) Converter outlet relief valve. (11) Suction screen and magnet. (12) Transmission lubrication. (13) Oil cooler.

The transmission hydraulic system consists of suction screen and magnet (11), transmission and torque converter oil pump (7), filter (4), flow control valve (1), converter back flow check valve (5) [part of transmission control valve (2)], transmission control valve (2), differential valve (3) [part of transmission control valve (2)], dump valve group (6), torque converter (9), torque converter inlet relief valve (8), converter outlet relief valve (10), and oil cooler (13).

NOTE: Machines equipped with the Low Speed Transmission Arrangement do not have converter outlet relief valve (10).

The bottom of the transmission case provides the oil sump. One positive displacement single section gear type pump (7) supplies oil to the power train hydraulic system. Oil is supplied to the pump inlet cavity through cast in passages in the transmission case and cover. Before reaching the pump, the oil flows through suction screen and magnet (12).

Pressurized oil exits the pump outlet cavity and flows to externally mounted transmission filter (4). From the transmission filter, the oil flows to flow control valve (1) located in the transmission case. Flow control valve (1) sends 23 liter/min (6 U.S. gpm) of oil to transmission control valve (2) and supplies torque converter (9) with the remainder of the oil.

Spools in transmission control valve (2) send oil to engage the correct clutches for the speed and direction selected. To make the machine move, one directional clutch (FORWARD LOW, FORWARD HIGH, or REVERSE) and one speed clutch (FIRST, SECOND, or THIRD) must be engaged.

Return oil from the control valve can enter the torque converter circuit through converter back flow check valve (5) [part of transmission control valve (2)]. Converter back flow check valve (5) prevents higher pressure from the torque converter charging circuit from entering control valve (2) when the control valve pressure is low during a shift.

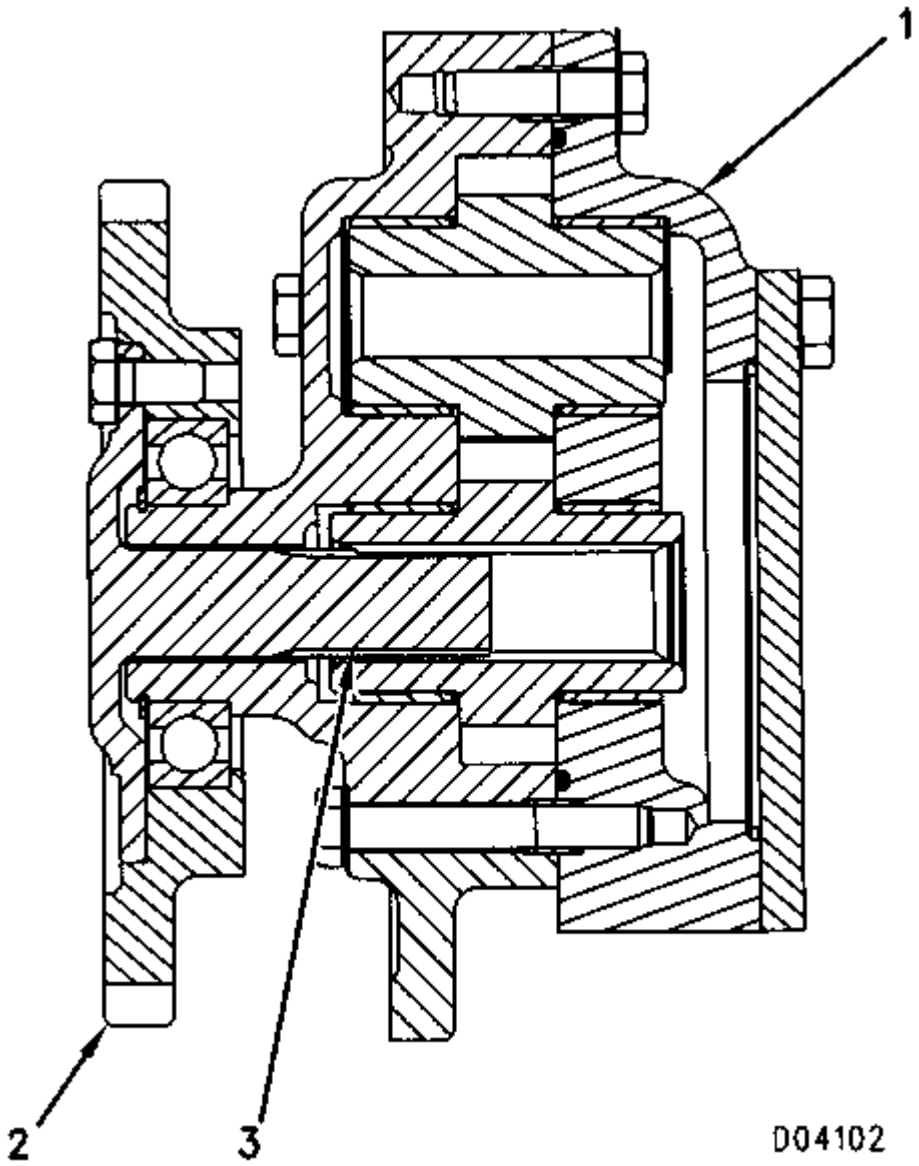
Torque converter inlet relief valve (8) limits torque converter inlet pressure to a maximum of 895 kPa (130 psi). Torque converter inlet relief valve (8) is installed in the transmission case below control valve (2). The control valve must be removed to obtain access to the torque converter inlet relief valve.

The outlet oil from the torque converter flows through converter outlet relief valve (10) to maintain 275 ± 35 kPa (40 ± 5 psi) in the torque converter. Oil then flows to oil cooler (13) which is located in the bottom tank of the radiator. The oil from the oil cooler provides lubrication and cooling to the transmission. The lubrication oil is transmitted down each transmission shaft to lubricate and cool the bearings, gears, and clutches.

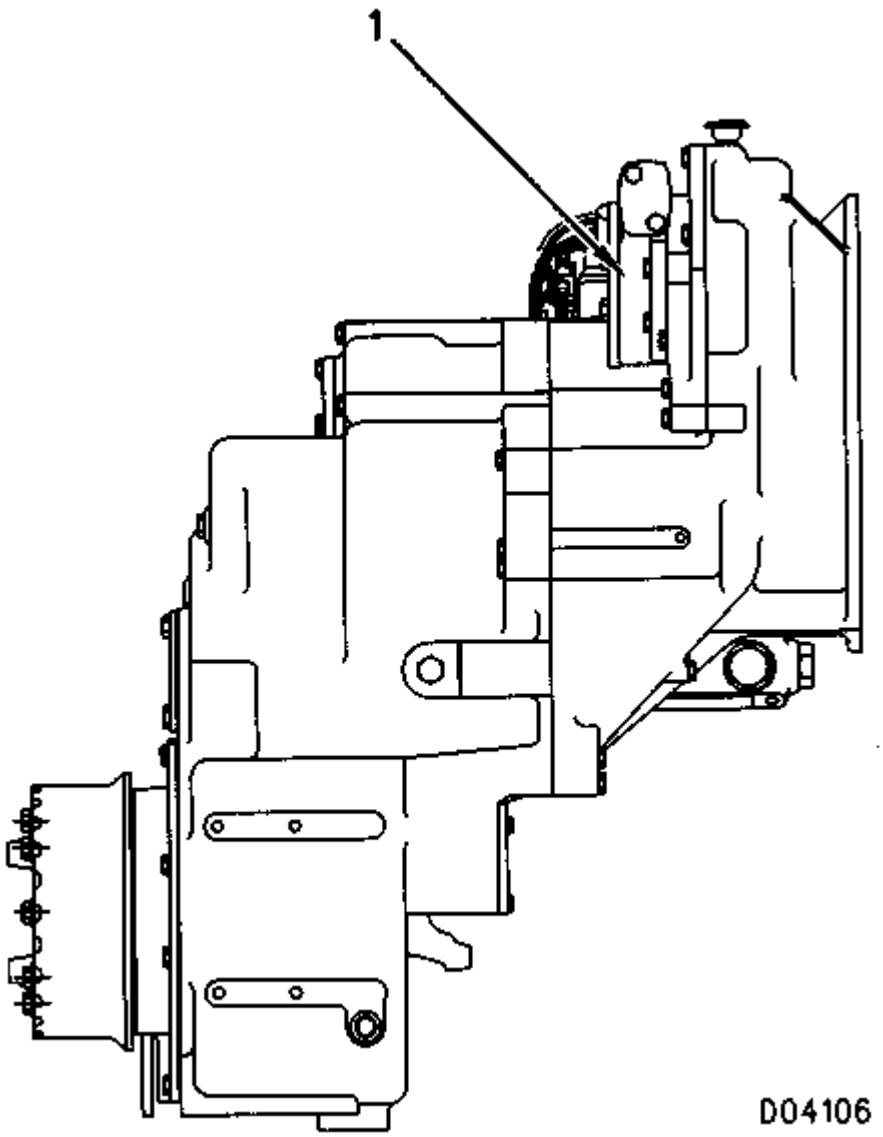
The converter outlet relief valve is located in the transmission case at the outlet to the oil cooler.

All oil passages are inside the transmission case and the transmission control valve body except for external lines to and from oil filter (4) and external lines to and from oil cooler (13).

Torque Converter And Transmission Pump And Filter



Transmission And Torque Converter Oil Pump
(1) Transmission and torque converter oil pump. (2) Gear. (3) Shaft.



Transmission And Torque Converter Oil Pump Location
(1) Transmission and torque converter oil pump.

Transmission and torque converter oil pump (1) is a positive displacement, single section gear type pump. The pump is bolted to the transmission cover. The implement and steering pumps are mounted on and driven by the transmission and torque converter pump.

A pump drive gear fastened to the torque converter impeller drives gear (2). Gear (2) is fastened to splined shaft (3) which drives the pump.

The externally mounted oil filter has a bypass valve. If there is a restriction in the oil filter or if the viscosity of the oil is very high, the bypass valve in the filter housing will open.

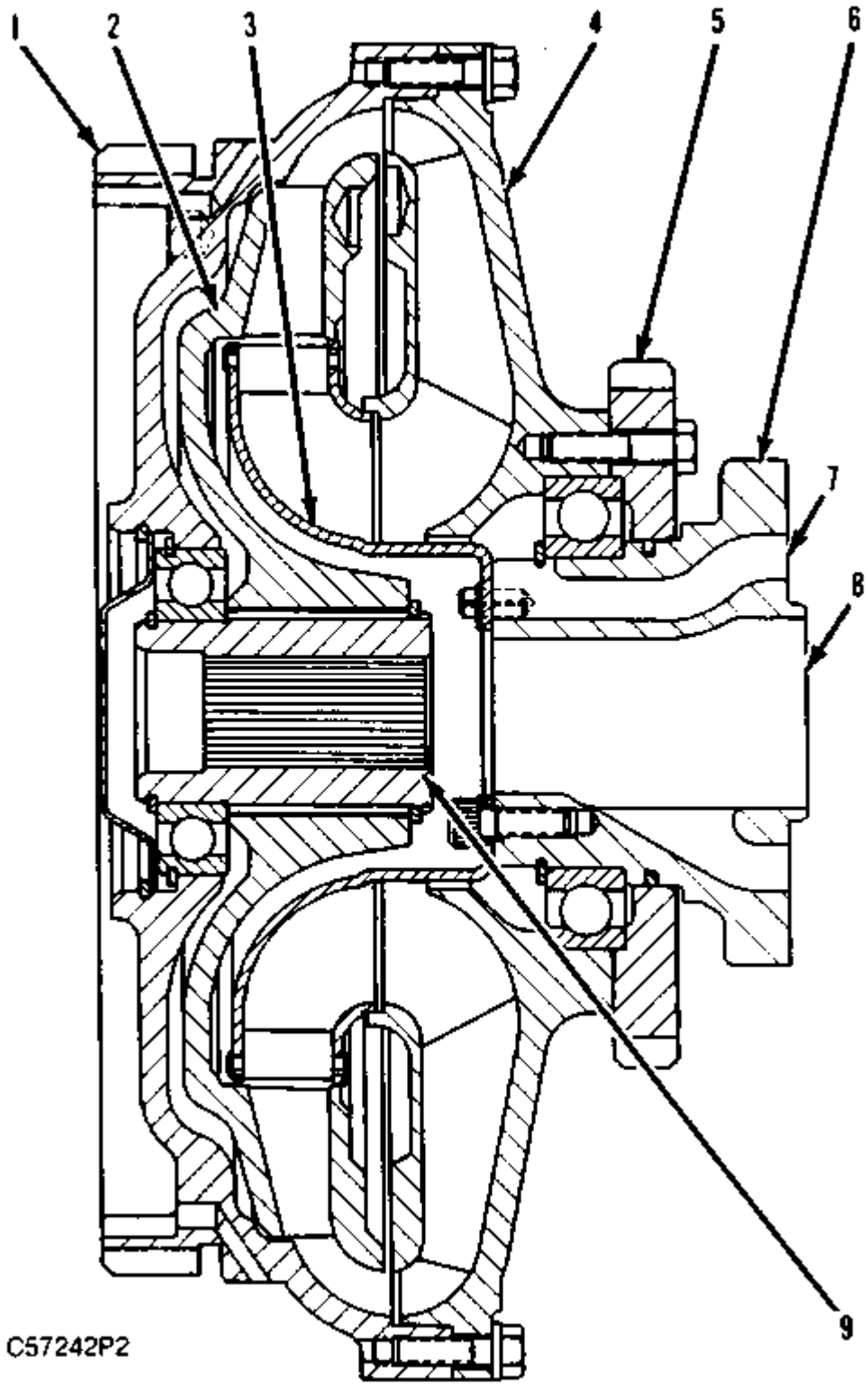
If the inlet pressure to the oil filter is 172 ± 12 kPa (25 ± 2 psi) greater than the outlet pressure, the bypass valve will open. When the oil does not go through the filter element, the debris in the oil will cause damage to other components in the hydraulic system.

Correct maintenance recommendations must be followed to make sure that the element does not become full of debris and stop the flow of clean oil to the hydraulic system. The filter is mounted on the right rear of the transmission case.

Torque Converter

The torque converter connects the engine to the transmission. This connection between the engine and the transmission is a hydraulic connection. There is no direct mechanical connection between the engine and the transmission.

The torque converter uses oil to send torque from the engine to the transmission. When the machine is working against a load, the torque converter can multiply the torque from the engine and send a higher torque to the transmission.



Torque Converter
(1) Housing. (2) Turbine. (3) Stator. (4) Impeller. (5) Gear (pump drive). (6) Carrier. (7) Outlet passage. (8) Inlet passage. (9) Hub.

The oil for the operation of the torque converter comes from the oil pump for the transmission. The oil pump is driven by gear (5). The oil flows to a flow control valve in the transmission case where the oil flow is divided.

Oil is directed to the transmission circuit and to the torque converter circuit. The torque converter inlet oil pressure is controlled by the torque converter inlet relief valve. The converter inlet relief valve is mounted in the transmission case below the transmission control valve. The relief valve limits the maximum pressure to torque

converter to 895 kPa (130 psi). The torque converter inlet relief valve protects the torque converter from high pressure due to cold oil or some other restriction in the torque converter or cooler circuit.

Housing (1) is connected to the engine flywheel with splines. Impeller (4) and gear (5) for the oil pump are connected to the rotating housing. These components turn with the engine flywheel at engine speed.

Stator (3) is connected to carrier (6) which is fastened to the transmission cover. The stator does not turn.

Turbine (2) is connected to the hub (9) by splines. Hub (9) is connected to the transmission input shaft by splines.

Oil from the hydraulic controls of the transmission flows into the torque converter through inlet passage (8) in carrier (6) to impeller (4). The rotation of the impeller gives force to the oil.

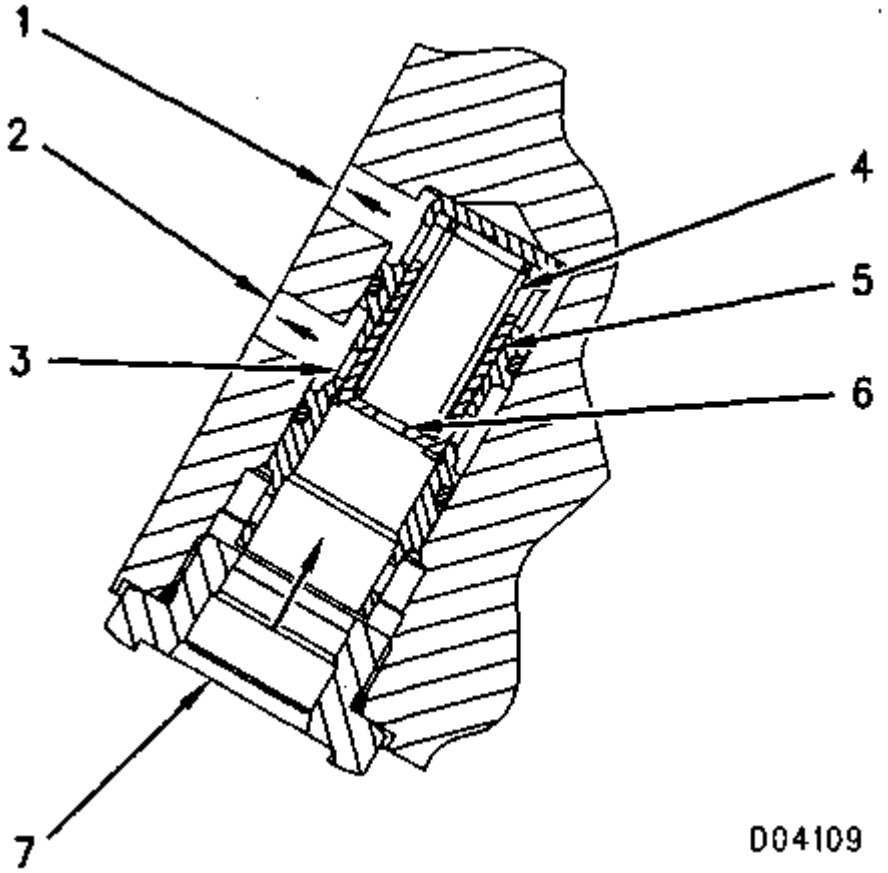
Impeller (4) [which turns with rotating housing (1) at engine speed] makes the oil go toward the outside of the impeller, around the inside of housing (1), and against the blades of turbine (2). The force of the oil that hits the turbine blades causes turbine (2) and hub (9) to turn. This sends torque to the input shaft of the transmission. At this point in time, the torque given to the turbine by the force of the oil from the impeller cannot be more than the torque output of the engine to the impeller.

After the oil hits the turbine blades, the oil goes toward the inside of turbine (2). As the oil goes from the turbine, it moves in a direction opposite the direction of impeller rotation. Stator (3) causes the oil to change direction and go back into impeller (4) in the direction of rotation.

The force of the oil from the stator can now add to the torque output from the engine to the impeller. This extra force can give an increase to the torque output of the engine to the turbine. The larger the difference between the speeds of the impeller and the turbine, the larger the amount of force of the oil from the stator.

Since it is the load on the machine that changes the speed of the turbine, the higher the load, the larger the difference in the speeds of the impeller and the turbine. It is the different loads on the machine that control the amount of torque multiplication that the force of the oil from the stator can add. Torque multiplication of the torque converter is at maximum when the torque converter is at stall (output shaft rpm at zero). Oil from outlet passage (7) flows to the converter outlet relief valve and then to the oil cooler and to the transmission lubrication system.

Flow Control Valve



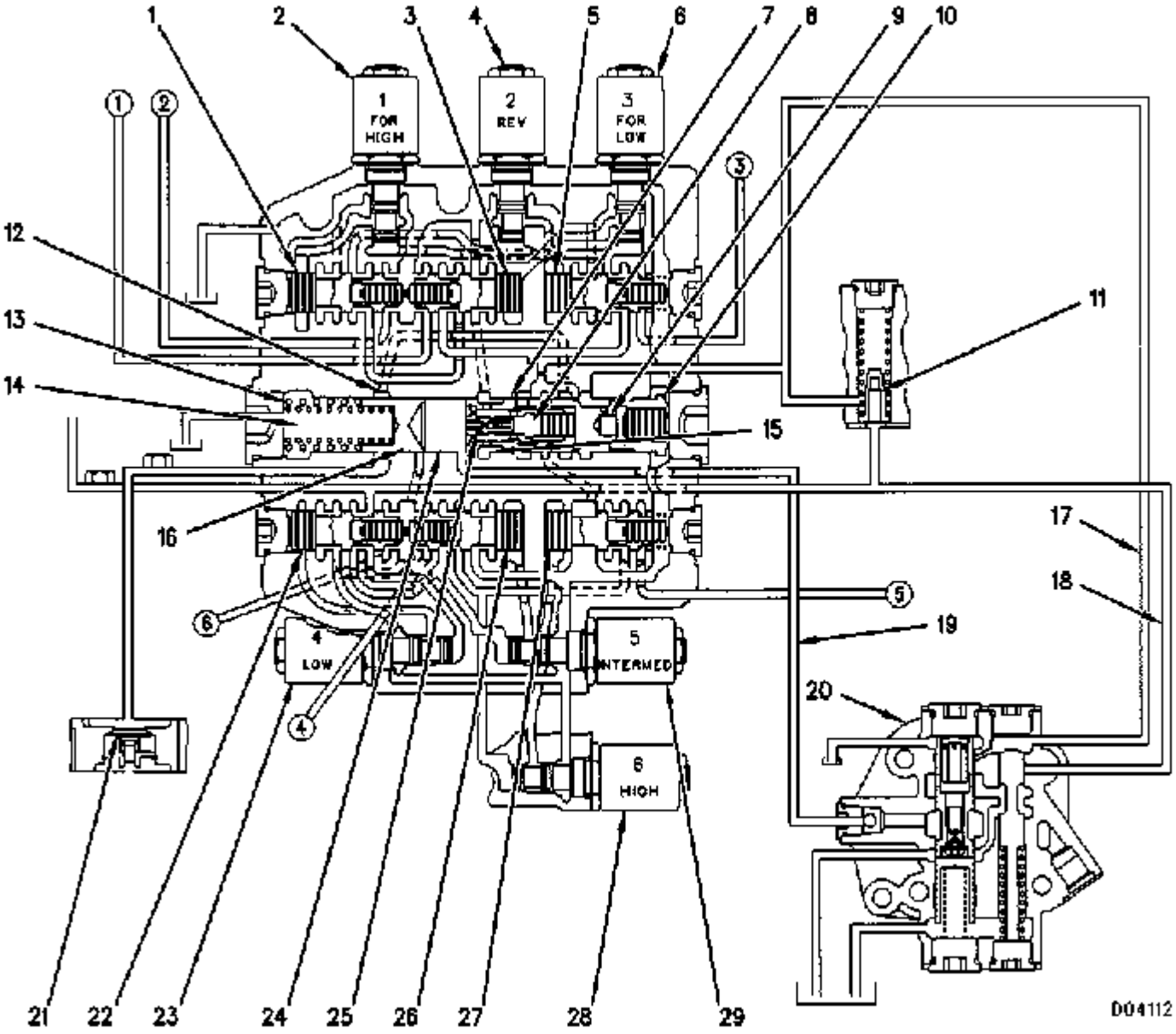
Flow Control Valve
(1) Passage to transmission control. (2) Passage to converter. (3) Port holes to converter. (4) Spring. (5) Piston. (6) Orifice. (7) Passage from filter.

The function of the flow control valve is to limit the flow of oil to the transmission control to 23 liter/min (6 U.S. gpm) and direct the remaining flow to the converter circuit. The result of this controlled flow requirement is to provide a constant clutch fill time through the entire engine speed range.

The flow across orifice (6) to passage (1) to the transmission controls remains constant because spring (4) exerts a constant force on piston (5) creating a constant differential pressure across orifice (6). Piston (5) directs remaining flow to the converter circuit by metering on port holes (3) to converter.

The flow control valve is located in the transmission case beneath the transmission controls. The flow control valve is under the fitting in the return line from the filter.

Transmission Control Group



Components Of The Transmission Control Valve
(1) Selector spool and slug (FORWARD HIGH). (2) No. 1 (FORWARD HIGH) solenoid. (3) Selector spool and slug (FORWARD LOW). (4) No. 2 (REVERSE) solenoid. (5) Selector spool and slug (REVERSE). (6) No. 3 (FORWARD LOW) solenoid. (7) Check valve. (8) Check valve slug cavity. (9) Modulating relief valve slug cavity. (10) Modulating relief valve. (11) Differential poppet. (12) Passage. (13) Load piston springs. (14) Load piston spring cavity. (15) Passage. (16) Load piston. (17) Passage. (18) Passage. (19) Passage. (20) Dump valve. (21) Converter back flow check valve. (22) Selector spool and slug (FIRST SPEED). (23) No. 4 (FIRST SPEED) solenoid. (24) Load piston cavity. (25) Screen orifice. (26) Selector spool and slug (SECOND SPEED). (27) Selector spool and slug (THIRD SPEED). (28) No. 6 (THIRD SPEED) solenoid. (29) No. 5 (SECOND SPEED) solenoid.

Introduction

The transmission hydraulic control valve is mounted to the top right side of the transmission case. Inlet oil from the transmission pump goes through the externally mounted transmission oil filter and then back to the flow control valve located in the transmission case below the transmission controls. The flow control valve sends 23 liter/min (6 U.S. gpm) of oil to the transmission control valve and supplies the torque converter with the rest of the oil.

The main components of the transmission control valve are solenoid valves (2), (4), (6), (23), (28), and (29); selector spools and slugs (1), (3), (5), (22), (26), and (27); differential poppet (11); converter back flow check

valve (21); load piston (16); modulating relief valve (10); check valve (7); and dump valve (20).

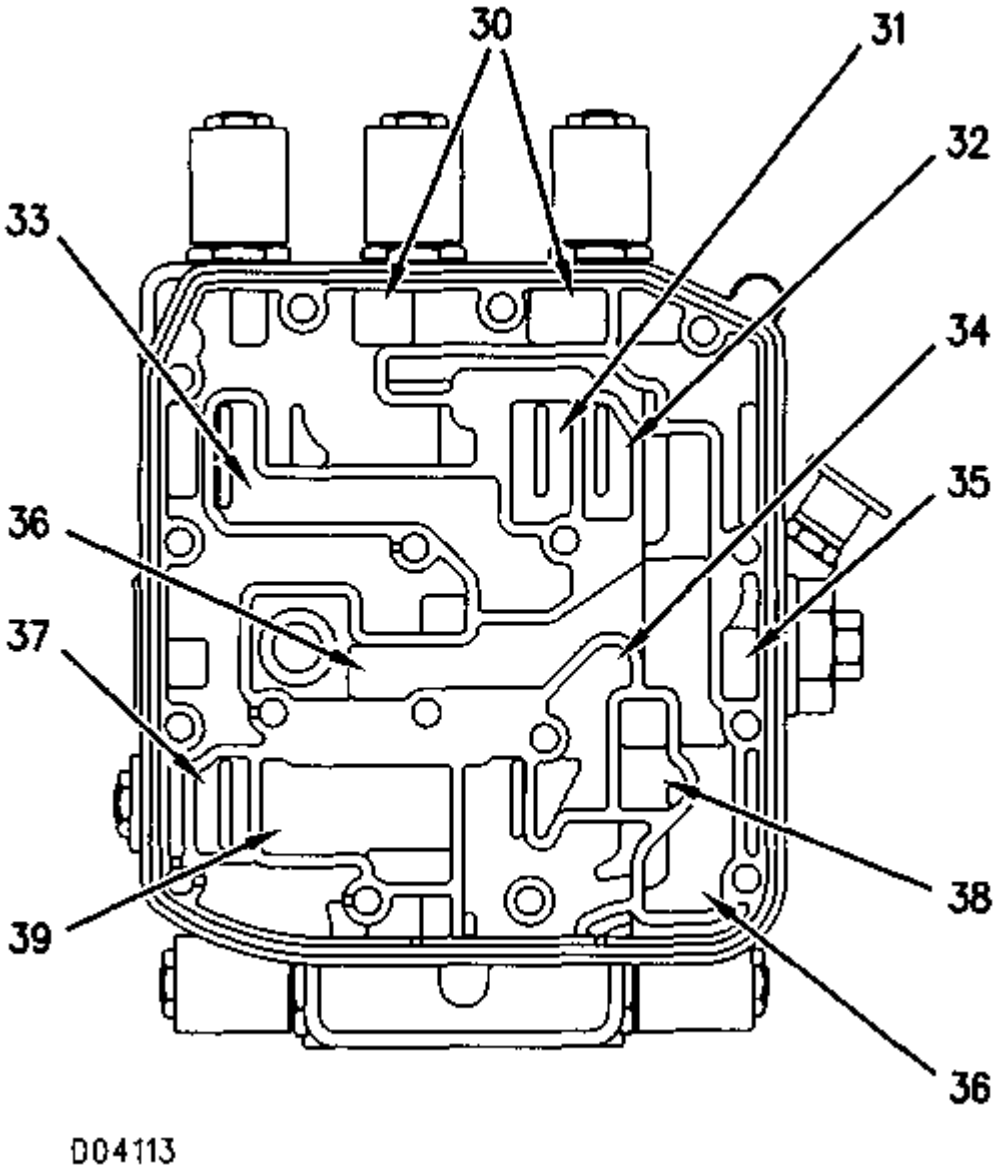
The function of each of these components is explained in the chart that follows.

Component Function Chart	
Component	**Function**
Solenoid Valves (2), (4), (6), (23), (28), (29)	Directs P1 or P2 oil to the selector spools to keep the selector spools in either the engaged or disengaged position.
Selector Spools (Speed Clutches) (22), (26), (27)	Routes P1 oil to FIRST, SECOND, and THIRD SPEED clutches.
Selector Spools (Directional Clutches) (1), (3), (5)	Routes P2 oil to FORWARD HIGH, FORWARD LOW, and REVERSE clutches.
Differential Poppet (11)	Maintains P1 pressure 345 kPa (50 psi) higher than P2.
Converter Backflow Check Valve (21)	Prevents excessive flow in the converter circuit from dumping into the load piston spring cavity during a shift.
Modulating Relief Valve (10)	Works with load piston (16) to provide a controlled pressure rise in the clutches and to control P2 pressure. Sends excess oil to the torque converter.
Load Piston (16)	Works with modulating relief valve (10) to provide a controlled pressure rise in the clutches and to control P2 pressure.
Check Valve (7)	Senses low P2 pressure during a shift and moves right opening load piston cavity (24) to drain. Closes after clutch fill and allows modulating relief valve (10) to complete a controlled pressure rise.
Dump Valve (20)	Rapidly removes pressure oil in load piston cavity (24) during a shift to allow load piston (16) to fully reset.

Each clutch has a solenoid and a selector spool and slug. When a solenoid is activated, the solenoid plunger is shifted. This directs oil through the solenoid valve to the selector spool. The oil pressure shifts the selector spool, which then directs oil to the selected clutch.

The following chart gives the combination of the solenoids energized and the clutches engaged for each FORWARD and REVERSE speed.

Machine Range/Direction	Solenoids Energized	Clutches Engaged
1-F	3,4	1,6
2-F	3,5	1,4
3-F	3,6	1,5
4-F	1,6	2,5
N	-	-
1-R	2,4	3,6
2-R	2,5	3,4
3-R	2,6	3,5



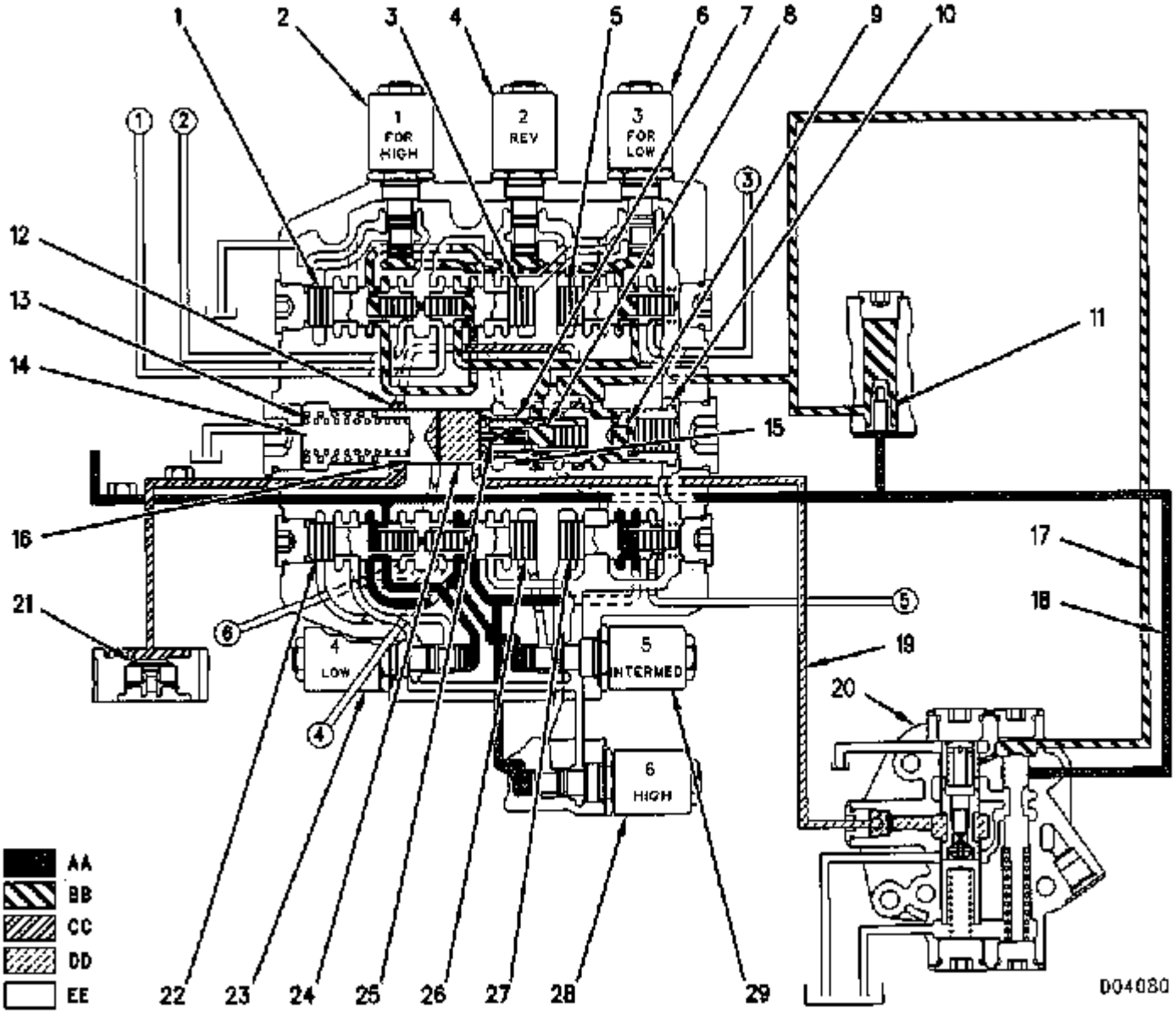
Control Valve Manifold (Viewed From The Bottom)
(30) Drain. (31) No. 1 (FORWARD LOW) clutch. (32) No. 2 (FORWARD HIGH) clutch. (33) No. 3 (REVERSE) clutch. (34) No. 4 (SECOND SPEED) clutch. (35) Load piston drain. (36) Torque converter (from flow control valve). (37) No. 5 (THIRD SPEED) clutch. (38) Supply (from flow control valve). (39) No. 6 (FIRST SPEED) clutch.

Pump oil from the flow control valve enters the transmission control valve through passage (38).

Oil from the transmission control valve is sent through passages (31), (32), (33), (34), (37), and (39) in the manifold to passages in the transmission case to the appropriate clutches for the speed and direction selected.

Oil from the flow control valve for the operation of the torque converter flows through passage (36) and the transmission case to the torque converter. Converter inlet relief valve and converter back flow check valve both open into passage (36).

Operation



Engine Running (Transmission In NEUTRAL)
(1) Selector spool and slug (FORWARD HIGH). (2) No. 1 (FORWARD HIGH) solenoid. (3) Selector spool and slug (FORWARD LOW). (4) No. 2 (REVERSE) solenoid. (5) Selector spool and slug (REVERSE). (6) No. 3 (FORWARD LOW) solenoid. (7) Check valve. (8) Check valve slug cavity. (9) Modulating relief valve slug cavity. (10) Modulating relief valve. (11) Differential poppet. (12) Passage. (13) Load piston springs. (14) Load piston spring cavity. (15) Passage. (16) Load piston. (17) Passage. (18) Passage. (20) Dump valve. (21) Converter back flow check valve. (22) Selector spool and slug (FIRST SPEED). (23) No. 4 (FIRST SPEED) solenoid. (24) Load piston cavity. (25) Screen orifice. (26) Selector spool and slug (SECOND SPEED). (27) Selector spool and slug (THIRD SPEED). (28) No. 6 (THIRD SPEED) solenoid. (29) No. 5 (SECOND SPEED) solenoid. (AA) P1 Speed clutch pressure. (BB) P2 Direction clutch pressure. (CC) P3 Converter inlet pressure. (DD) Load piston pressure. (EE) Drain.

Engine Running (Transmission In Neutral)

NOTE: In the above illustration, all passages with no pattern are open to drain.

When the engine is started, oil from the oil pump flows through the oil filter and back to the flow control valve in the transmission case. The flow control valve directs 23 liters (6 U.S. gpm) of oil to the transmission control valve and allows the rest of the oil to go to the torque converter circuit.

Oil at P1 pressure from the flow control valve goes through the transmission control valve to differential poppet (11); speed clutch solenoids (23), (28), and (29); speed clutch selector spools and slugs (22), (26), and (27); and

through passage (18) to dump valve (20) (see Dump Valve for a description of dump valve operation).

The P1 oil enters the slug cavities of the speed selector spools and maintains the selector spools in the clutch disengaged position. When the pressure in the P1 circuit reaches approximately 345 kPa (50 psi), differential poppet (11) opens. Oil through differential poppet (11), which maintains a 345 kPa (50 psi) difference between P1 and P2 pressures, flows to modulating relief valve (10); directional clutch solenoids (2), (4) and (6); and directional clutch spools and slugs (1), (3), and (5), where the oil enters the slug cavities of the directional clutch selector spools and maintains the selector spools in the clutch disengaged position.

Oil in the P2 circuit also enters modulating relief valve slug cavity (9), check valve slug cavity (8), and flows through screen orifice (25) to load piston cavity (24). Oil in the P2 circuit also flows through passage (17) to dump valve (20) (see Dump Valve for a description of dump valve operation).

The increasing P2 pressure in check valve slug cavity (8) moves check valve (7) to the left closing off passage (15) and load piston cavity (24) to drain.

The increase in P2 pressure is also felt in modulating relief valve slug cavity (9). When P2 pressure reaches the initial setting of modulating relief valve (10), the modulating relief valve moves left against load piston (16) and load piston springs (13) until the passage to the P3 (torque converter) circuit is open. This lets excess oil go to the P3 circuit, which is open to drain through passage (12) and load piston spring cavity (14).

As the oil pressure increases in load piston cavity (24), the pressure moves load piston (16) to the left against load piston springs (13). The pressure in the load piston cavity also acts against modulating relief valve (10) moving it slightly to the right reducing the flow to the torque converter circuit. The pressure continues to rise in load piston cavity (24) moving load piston (16) to the left against load piston springs (13).

The movement of modulating relief valve (10) and load piston (16) continues until load piston (16) moves far enough left until it is metering load piston cavity flow to drain and modulating relief valve (10) is metering excess pump flow to the P3 circuit. At this time, load piston (16) and load piston springs (13) working with modulating relief valve (10) are controlling the pressure of P2 oil. Pressure in the system will be limited by the final spring force on load piston.

Differential poppet (11) maintains P1 pressure at 345 kPa (50 psi) above P2 pressure.

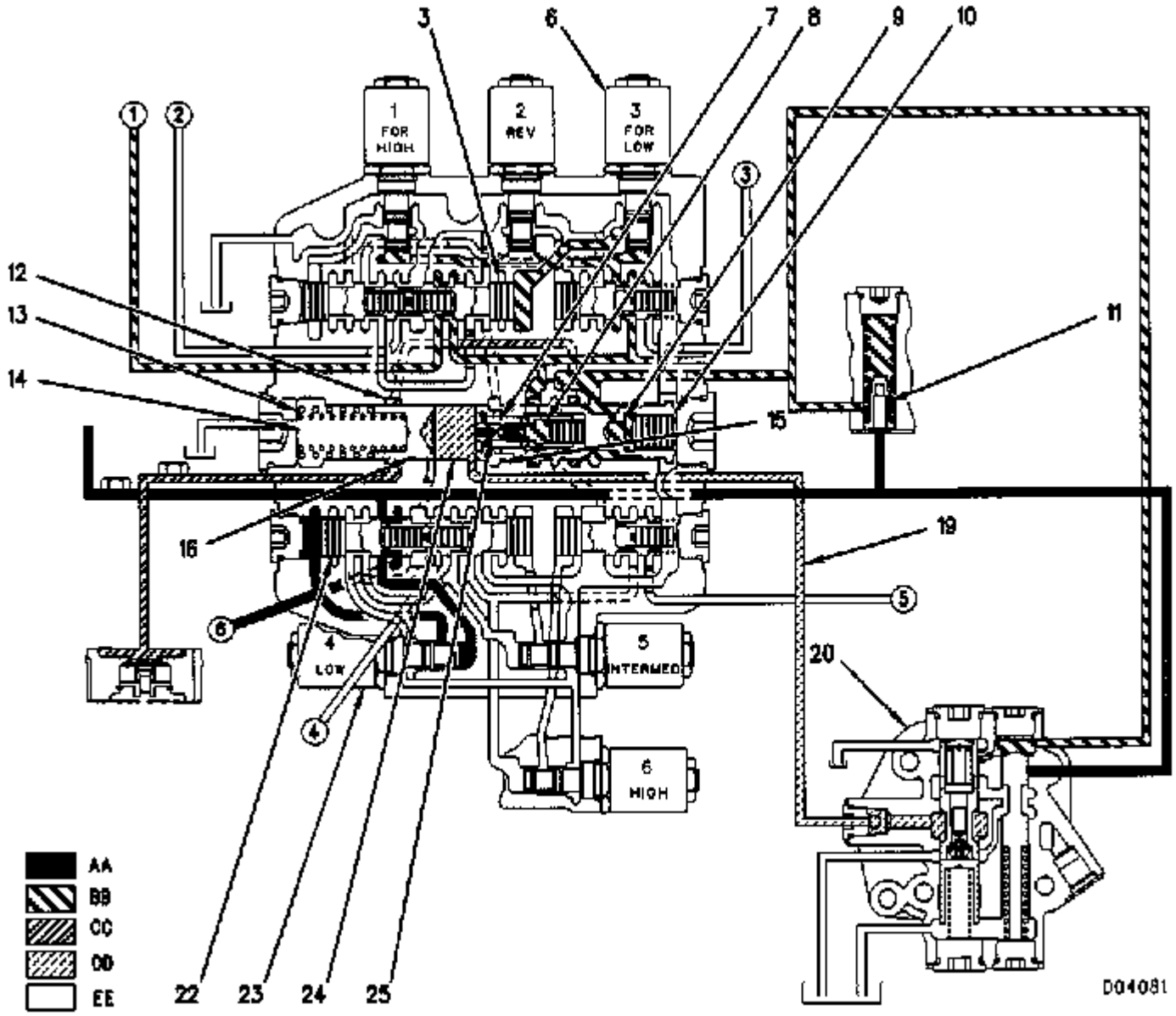
With the transmission in NEUTRAL, none of the solenoids are shifted, therefore pressure oil is not directed to any clutch.

Converter Back flow Check Valve

During the first 65% of the stroke of load piston (16), the oil being relieved to the converter circuit by the modulating relief valve (10) is connected to drain through passage (12) and load piston spring cavity (14). This allows modulating relief valve (10) to begin modulation from a 310 kPa (45 psi) initial setting.

The function of converter back flow check valve (21) is to stop the excess flow in the 550 kPa (80 psi) converter circuit from also dumping into the load piston spring cavity causing a high initial setting of the modulating relief valve.

Engine Running (Neutral To First Speed Forward)



Engine Running (NEUTRAL To FIRST SPEED FORWARD)
(3) Selector spool and slug (FORWARD LOW). (6) No. 3 (FORWARD LOW) solenoid. (7) Check valve. (8) Check valve slug cavity. (9) Modulating relief valve slug cavity. (10) Modulating relief valve. (11) Differential poppet. (12) Passage. (13) Load piston springs. (14) Load piston spring cavity. (15) Passage. (16) Load piston. (19) Passage. (20) Dump valve. (22) Selector spool and slug (FIRST SPEED). (23) No. 4 (FIRST SPEED) solenoid. (24) Load piston cavity. (25) Screen orifice. (AA) P1 Speed clutch pressure. (BB) P2 Direction clutch pressure. (CC) P P3 Converter inlet pressure. (DD) Load piston pressure. (EE) Drain.

NOTE: In the above illustration, all passages with no pattern are open to drain.

When the transmission selector lever is moved to FIRST SPEED FORWARD, No. 3 (FORWARD LOW) solenoid (6) and No. 4 (FIRST SPEED) solenoid (23) are energized.

Selector spool (22) for the FIRST SPEED clutch receives oil through No. 4 solenoid (23) and moves to the right directing oil to the FIRST SPEED clutch. Full flow 23 L/min (6 gpm) is available for the FIRST SPEED clutch fill. During clutch fill, P1 pressure drops below 345 kPa (50 psi) and the spring closes differential poppet (11). Selector spool (3) for the FORWARD LOW clutch does not move until the speed clutch has filled because differential poppet (11) is closed and blocks flow to the P2 (directional) circuit.

With differential poppet (11) closed, the pressure in the P2 (directional) circuit begins to drop. Check valve (7) senses the lower pressure and moves to the right to open load piston cavity (24) to drain through passage (15) in modulating relief valve (10) and a passage in the valve body. When the P2 pressure drops below 1034 kPa (150

psi), dump valve (20) rapidly dumps the remaining pressure in the load piston cavity to drain through passage (19) (see Dump Valve for a description of dump valve operation). With the pressure in load piston cavity (24) dumping to drain, springs (13) move load piston (16) all the way to the right until it is touching modulating relief valve (10). Modulating relief valve (10) has also moved to the right and blocks the passage to the P3 circuit.

With load piston (16) moved to the right, passage (12) in the P3 circuit is opened to drain through load piston spring cavity (14). This insures low back pressure for modulating relief valve (10) so that modulation can start at the initial setting.

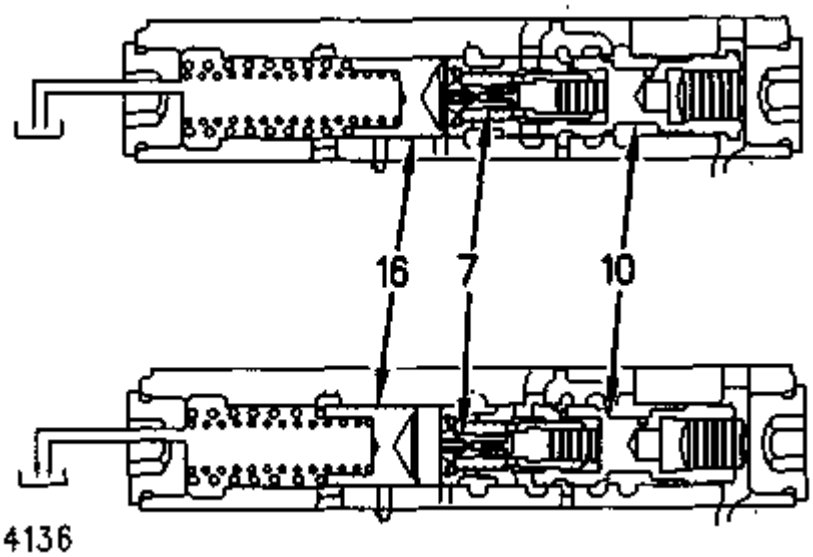
At this time the FIRST SPEED clutch has filled and P1 pressure begins to increase. Differential poppet (11) opens when the pressure reaches 345 kPa (50 psi) and oil flows to the P2 circuit.

Selector spool (3) for the FORWARD LOW clutch receives oil through No. 3 solenoid (6) and moves to the left directing oil to the FORWARD LOW clutch which begins to fill.

Oil in the P2 circuit also flows to dump valve (20), modulating relief valve slug cavity (9), check valve slug cavity (8), and through screen orifice (25) to load piston cavity (24).

When the FORWARD LOW clutch is full of oil, the pressure in the P2 circuit starts to increase. This pressure increase is felt in check valve slug cavity (8) and moves check valve (7) to the left which closes load piston cavity (24) to drain. Dump valve (20) also closes off passage (19) from load piston cavity to drain (see Dump Valve for a description of dump valve operation). The pressure increase is also felt in modulating relief valve slug cavity (9). When the pressure in the directional clutch circuit reaches the initial setting of the modulating relief valve, the modulating relief valve has moved to the left until the passage to the P3 circuit is open. This lets excess oil go to the P3 circuit, which is still open to drain through passage (12) and load piston spring cavity (14).

The pressure, felt by the modulating relief valve, is also felt in check valve slug cavity (8). Screen orifice (25) in check valve (7) controls the rate of flow to load piston cavity (24). As the pressure increases in load piston cavity (24), load piston (16) moves to the left. The movement of load piston (16) to the left compresses springs (13) causing an increase in pressure in load piston cavity (24). This pressure in the load piston cavity also acts against modulating relief valve (10) moving it slightly to the right reducing the flow to the torque converter circuit. The pressure continues to rise in load piston cavity (24) moving load piston (16) farther to the left against load piston springs (13). The modulating relief valve also continues to move very slightly to the right further restricting flow to the torque converter circuit.

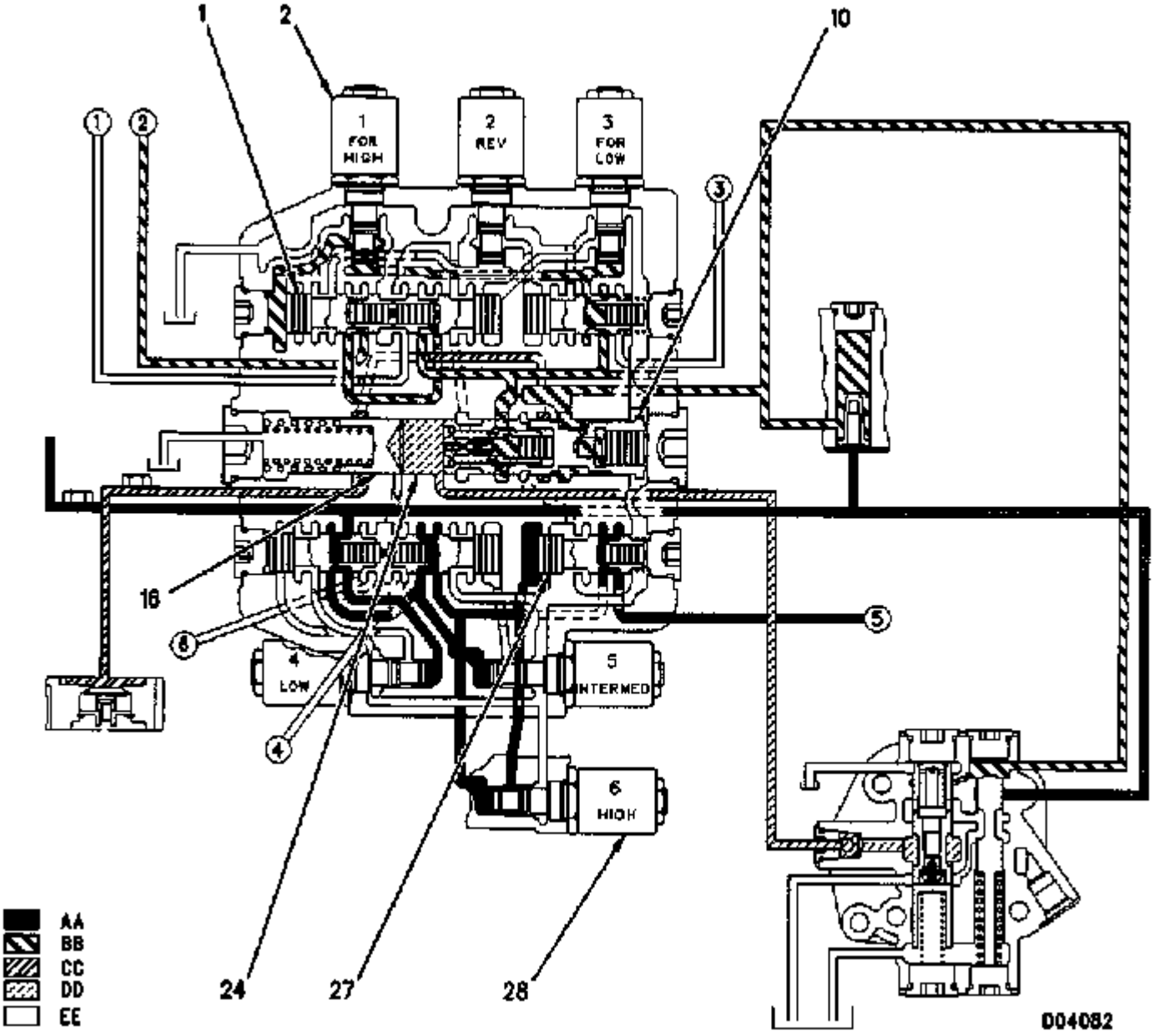


Load Piston And Modulating Relief Valve Positions At Dump (Top) And At Start Of Modulation (Bottom)
(7) Check valve. (10) Modulating relief valve. (16) Load piston

This movement of the modulating relief valve and the load piston causes the clutch pressure to increase gradually. This gradual increase in pressure is known as modulation.

After about 2/3 of total load piston movement, the load piston has moved far enough to close off passage (12), closing off P3 to drain through load piston spring cavity (14). The load piston movement to the left stops when the load piston moves to the drain passage. At this time, modulation stops. As oil comes through screen orifice (25) to load piston cavity (24), oil goes out the drain passage. This keeps load piston (16) in position without any further movement. Load piston (16) and load piston springs (13) working with modulating relief valve (10) are controlling the pressure of P2 oil. Pressure in the system will be limited by the final spring force on load piston. At this time, the modulating relief valve meters excess oil flow to the torque converter circuit.

Engine Running (Transmission in Fourth Speed Forward)



Engine Running (Transmission in FOURTH SPEED FORWARD)
(1) Selector spool and slug (FORWARD HIGH) (2) No. 1 (FORWARD HIGH) solenoid. (10) Modulating relief valve. (16) Load piston. (24) Load piston cavity. (27) Selector spool and slug (THIRD SPEED). (28) No. 6 (THIRD SPEED) solenoid. (AA) P1 Speed clutch pressure. (BB) P2 Direction clutch pressure. (CC) P3 Converter inlet pressure. (DD) Load piston pressure. (EE) Drain.

NOTE: In the above illustration, all passages with no pattern are open to drain.

When the transmission selector lever is in FOURTH SPEED FORWARD, No. 1 (FORWARD HIGH) solenoid (2) and No. 6 (THIRD SPEED) solenoid (28) are engaged.

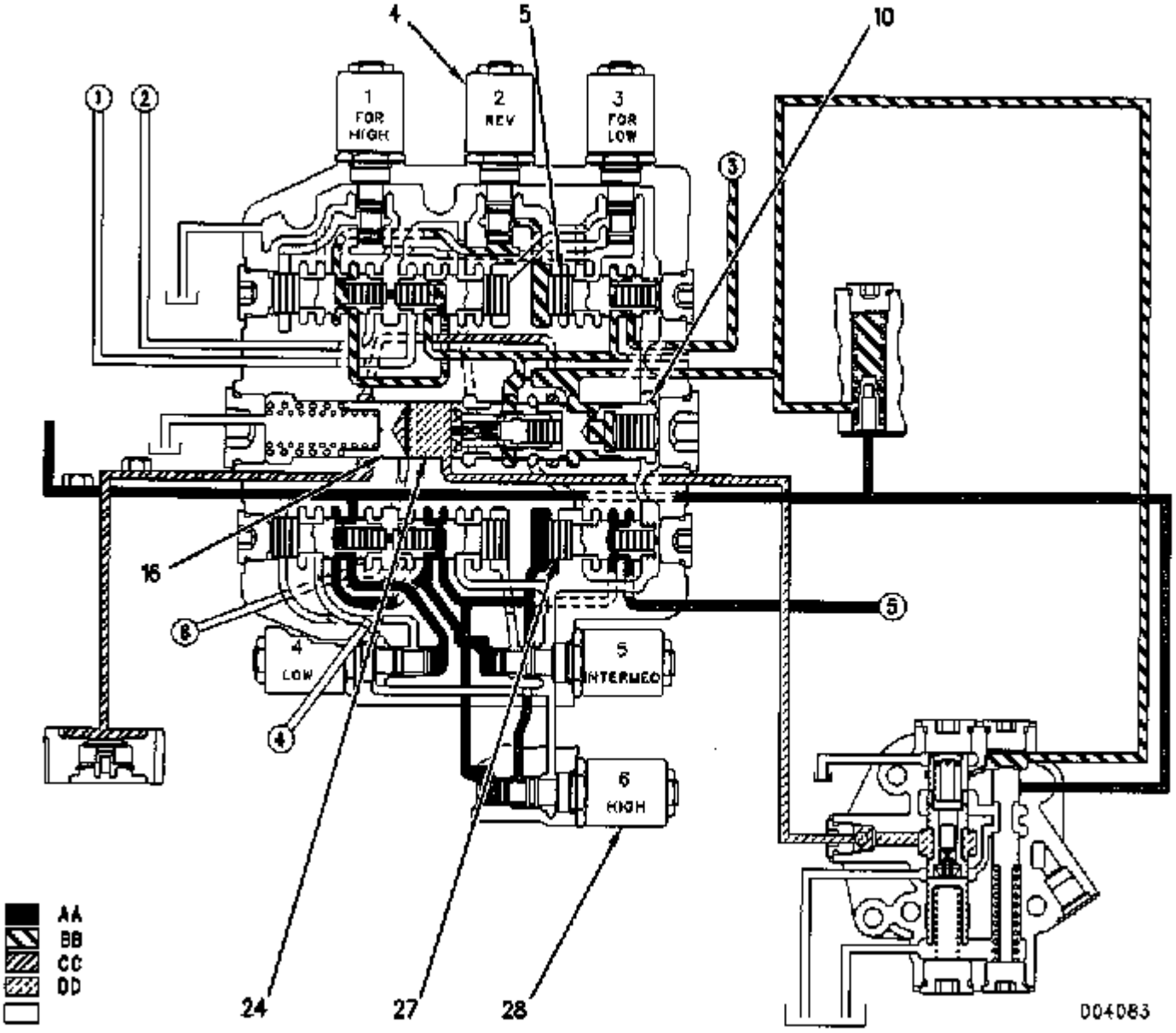
Pressure oil through the No. 6 solenoid has moved selector spool (27) for the THIRD SPEED clutch to the right. This allows P1 pressure oil to flow to and engage the THIRD SPEED clutch.

Pressure oil through the No. 1 solenoid (2) has moved selector spool (1) for the FORWARD HIGH clutch to the right. This allows P2 pressure oil to flow to the FORWARD HIGH clutch.

Modulation (as described in the text for NEUTRAL To FIRST SPEED FORWARD) has occurred. Modulating relief valve (10) has moved to the left and is metering oil to the torque converter circuit. Load piston (16) has also moved to the left where it is metering load piston cavity (24) pressure to drain.

P1 and P2 pressures are stabilized and the transmission is in steady state operation.

Engine Running (Transmission in Third Speed Reverse)



Engine Running (Transmission in THIRD SPEED REVERSE)
(4) No. 2 (REVERSE) solenoid. (5) Selector spool and slug (REVERSE). (10) Modulating relief valve. (16) Load piston. (24) Load piston cavity. (27) Selector spool and slug (THIRD SPEED). (28) No. 6 (THIRD SPEED) solenoid. (AA) P1 Speed clutch pressure. (BB) P2 Direction clutch pressure. (CC) P3 Converter inlet pressure. (DD) Load piston pressure. (EE) Drain.

NOTE: In the above illustration, all passages with no pattern are open to drain.

When the transmission selector lever is in THIRD SPEED REVERSE, No. 2 (REVERSE) solenoid (4) and No. 6 (THIRD SPEED) solenoid (28) are engaged.

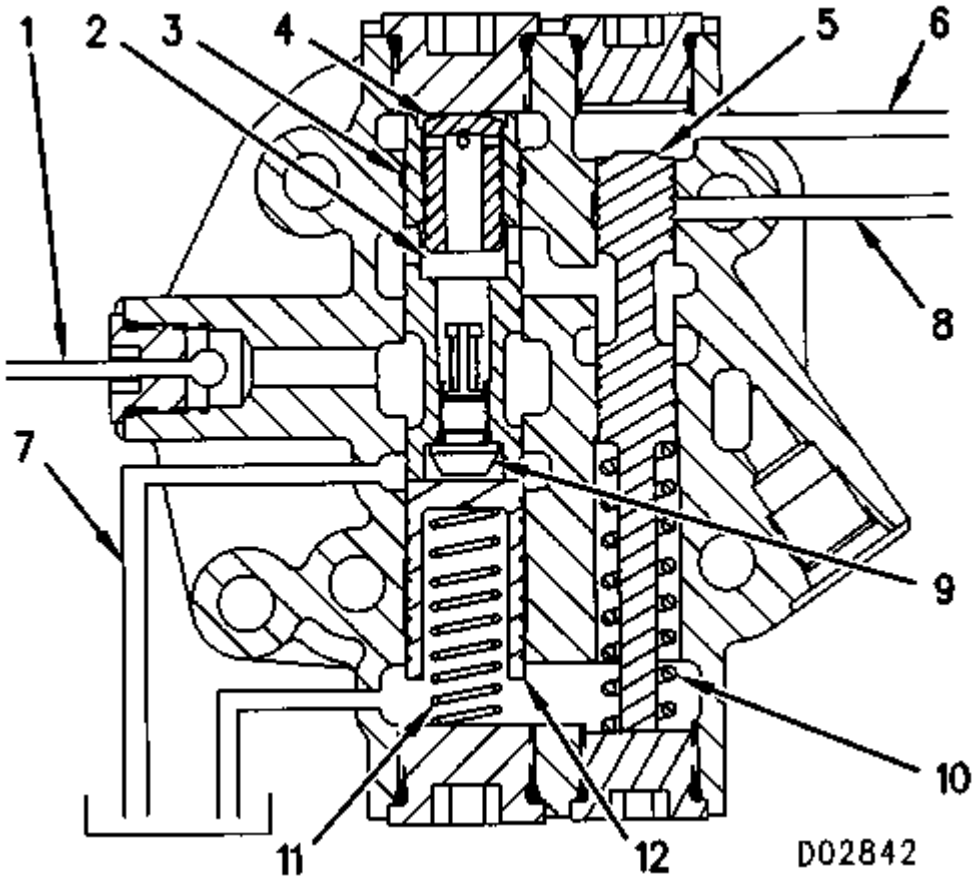
Pressure oil through the No. 6 solenoid has moved selector spool (27) for the THIRD SPEED clutch to the right. This allows P1 pressure oil to flow to and engage the THIRD SPEED clutch.

Pressure oil through No. 2 (REVERSE) solenoid (4) has moved selector spool (5) for the REVERSE clutch to the right. This allows P2 pressure oil to flow to the REVERSE clutch.

Modulation (as described in the text for NEUTRAL To FIRST SPEED FORWARD) has occurred. Modulating relief valve (10) has moved to the left and is metering oil to the torque converter circuit. Load piston (16) has also moved to the left where it is metering load piston cavity (24) pressure to drain.

P1 and P2 pressures are stabilized and the transmission is in steady state operation.

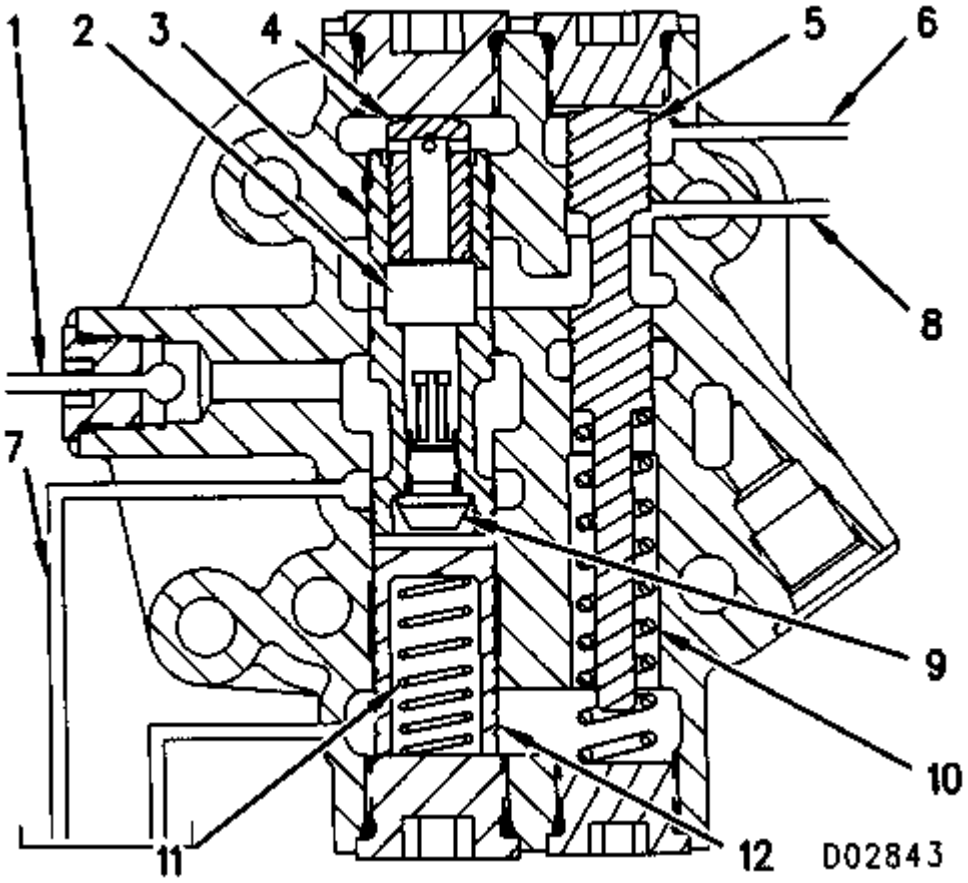
Dump Valve



Dump Valve (Normal Operation)
(1) Passage. (2) Slug cavity. (3) Spool. (4) Slug. (5) Spool. (6) Passage. (7) Drain passage. (8) Passage. (9) Orifice. (10) Spring. (11) Spring. (12) Piston.

The function of the dump valve is to assist in reducing pressure in the load piston cavity to allow the load piston to fully reset. This ensures full modulation of clutch pressure and smooth clutch engagement.

When the transmission is in gear, directional clutch pressure (P2) from the transmission control valve enters the dump valve through passage (6). This pressure moves spool (5) downward against spring (10). Load piston pressure (LP) enters the dump valve through passage (1). Speed clutch pressure (P1) from the transmission control valve, through passage (8) is blocked by spool (5). >>pg>> 32



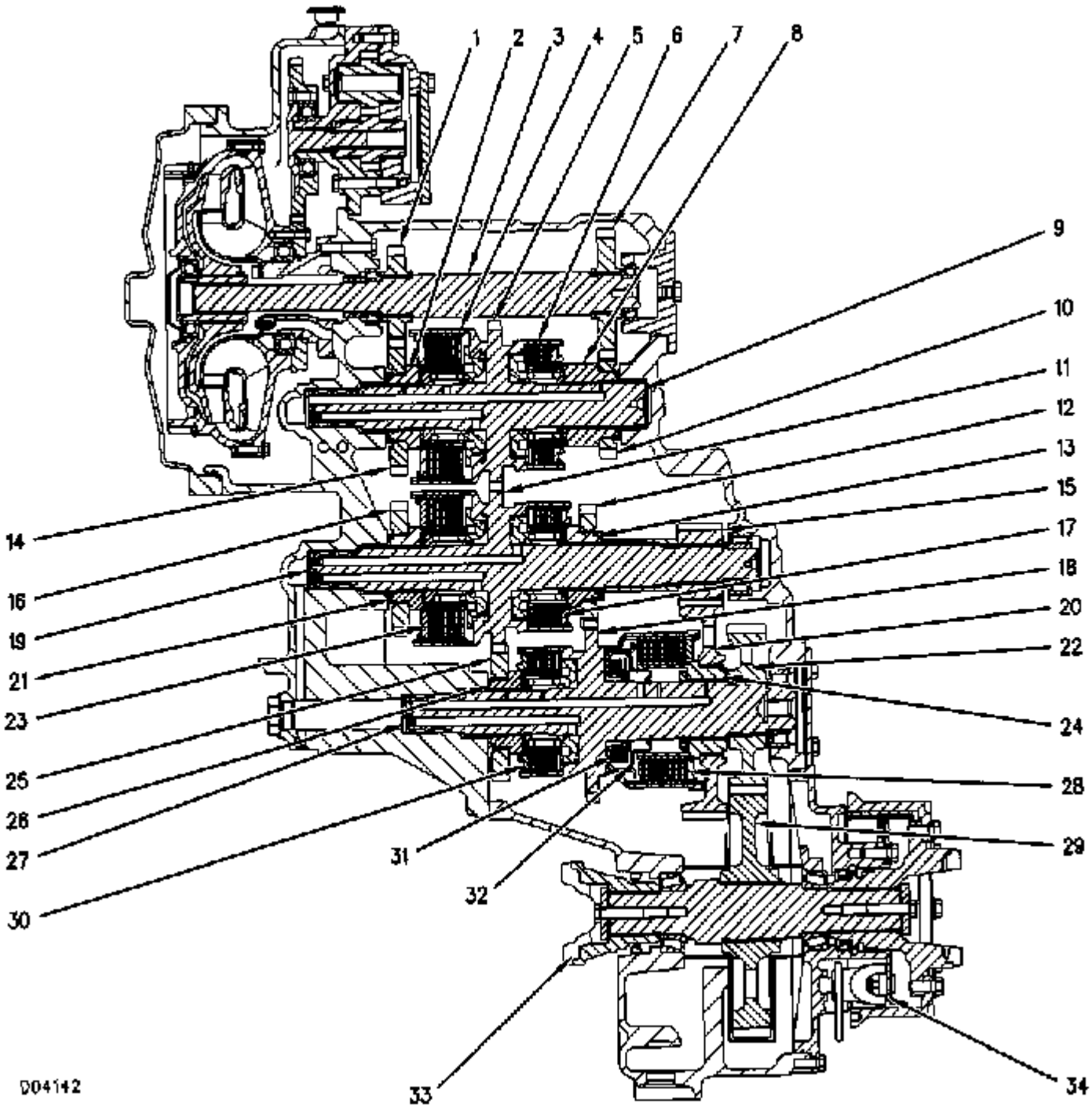
Dump Valve (During A Shift)
(1) Passage. (2) Slug cavity. (3) Spool. (4) Slug. (5) Spool. (6) Passage. (7) Drain passage. (8) Passage. (9) Orifice. (10) Spring. (11) Spring. (12) Piston.

When a shift of the transmission is made, directional clutch pressure (P2) drops. When directional clutch pressure drops below 1034 kPa (150 psi), spring (10) moves spool (5) upward against the reduced P2 pressure. This opens slug cavity (2) to P1 pressure through passage (8).

P1 pressure in slug cavity (2) moves spool (3) and piston (12) downward against spring (11). This opens LP pressure in passage (1) to drain through passage (7) causing P2 pressure to drop to a maximum of 310 kPa (45 psi) (initial pressure).

P1 pressure through orifice (9) also acts on spool (3) causing it to slowly move upward closing off LP flow from passage (1) to drain passage (7). Orifice (9) is sized to provide a delay in closing LP pressure to drain. When LP pressure is closed to drain, the modulating relief valve is allowed to perform its function. When P2 pressure rises to 1034 kPa (150 psi), spool (5) moves downward blocking P1 pressure from slug cavity (2) and opening slug cavity to drain. Spring (11) then pushes piston (12) upward until it contacts spool (3). This returns spool (3) to the reset position for the next shift.

Transmission



Transmission Components
(1) Gear. (2) Hub assembly. (3) Input shaft assembly. (4) No. 1 (FORWARD LOW) clutch. (5) Gear [part of shaft assembly (9)]. (6) No. 2 (FORWARD HIGH) clutch. (7) Gear. (8) Hub assembly. (9) Shaft assembly. (10) Gear. (11) Gear [part of shaft assembly (19)]. (12) Gear. (13) Hub assembly. (14) Gear. (15) Gear. (16) Gear. (17) No. 4 (SECOND SPEED) clutch. (18) Gear [part of shaft assembly (27)]. (19) Shaft assembly. (20) Gear. (21) Hub assembly. (22) Gear. (23) No. 3 (REVERSE) clutch. (24) Hub assembly. (25) Gear. (26) Hub assembly. (27) Shaft assembly. (28) No. 6 (FIRST SPEED) clutch. (29) Gear. (30) No. 5 (THIRD SPEED) clutch. (31) Wave spring. (32) Balance seal assembly. (33) Output shaft assembly. (34) Parking brake assembly.

The transmission is a constant mesh power shift transmission that has four forward speeds and three reverse speeds. The transmission has six clutches that are engaged hydraulically. Five of the clutches are disengaged by a coil spring. FIRST SPEED clutch (28) is disengaged by wave spring (31) and balance seal assembly (32).

Balance seal assembly (32) positively disengages FIRST SPEED clutch (28) and prevents the clutch from dragging during an over speed condition, such as coasting down a hill.

Balance seal assembly (32) and wave spring (31) assemble inside the clutch piston. When the FIRST SPEED clutch is not engaged, force from wave spring (31) and lube oil pressure between the clutch piston and balance seal assembly (32) combine to move and hold the clutch piston in the clutch disengaged position.

The transmission has five shafts: input shaft assembly (3), output shaft assembly (33), and three main gear carrying shafts. Input shaft assembly (3) is driven by the torque converter turbine. Shaft assembly (9) contains No. 1 (FORWARD LOW) clutch (4) and No. 2 (FORWARD HIGH) clutch (6). Shaft assembly (19) contains No. 3 (REVERSE) clutch (23) and No. 4 (SECOND SPEED) clutch (17). Shaft assembly (27) contains No. 5 (THIRD SPEED) clutch (30) and No. 6 (FIRST SPEED) clutch (28).

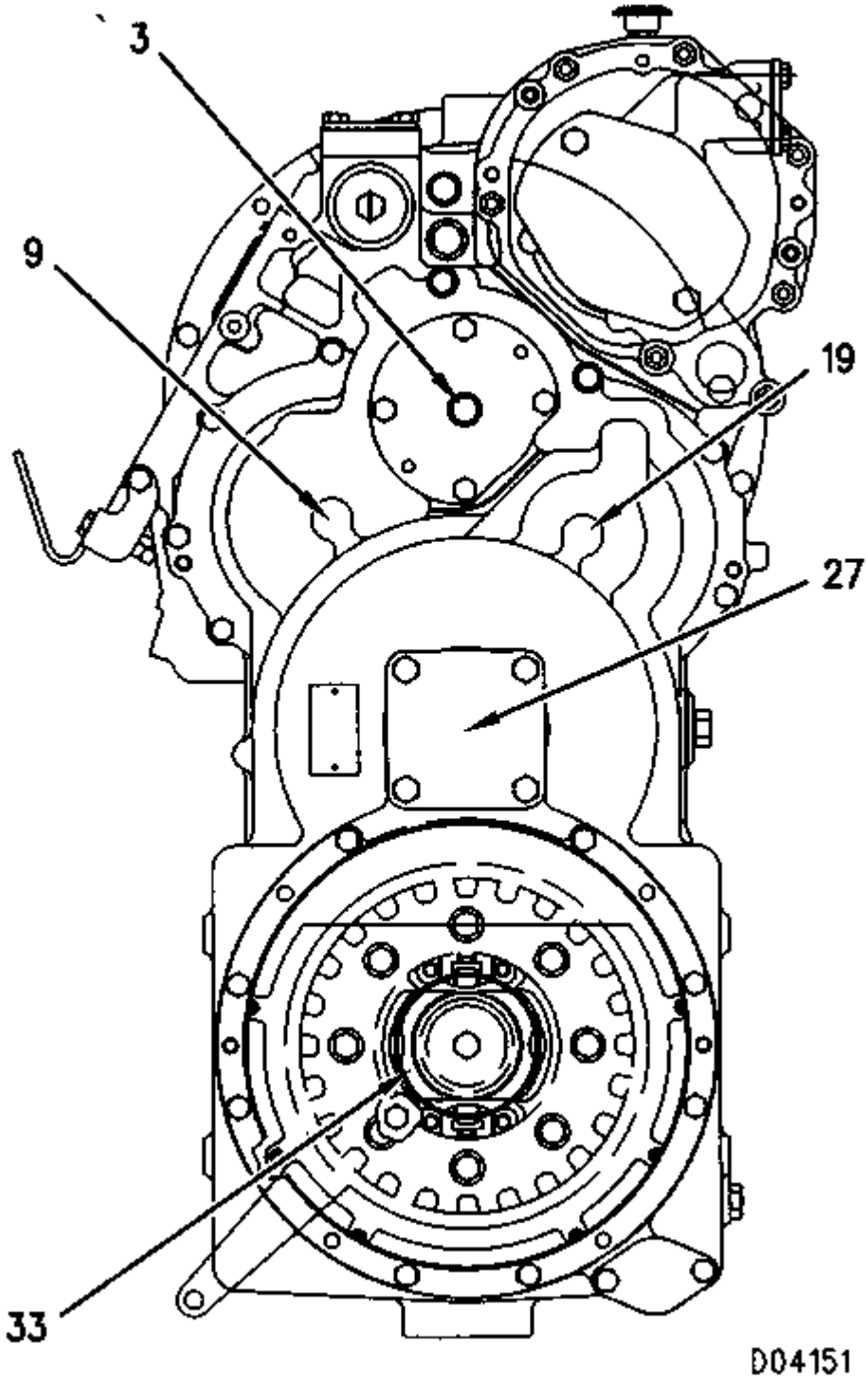
Each of the three clutch carrying transmission shafts have three internal oil passages. One passage is for carrying the oil for the lubrication and cooling of the clutches, bearings and gears. The other two passages are for carrying pressure oil for the engagement of the clutches on each shaft.

A speed clutch and a direction clutch must both be engaged to send power through the transmission. The speed and direction of the machine must be selected manually by the operator.

Machine Range/Direction	Solenoids Energized	Clutches Engaged
1-F	3,4	1,6
2-F	3,5	1,4
3-F	3,6	1,5
4-F	1,6	2,5
N	-	-
1-R	2,4	3,6
2-R	2,5	3,4
3-R	2,6	3,5

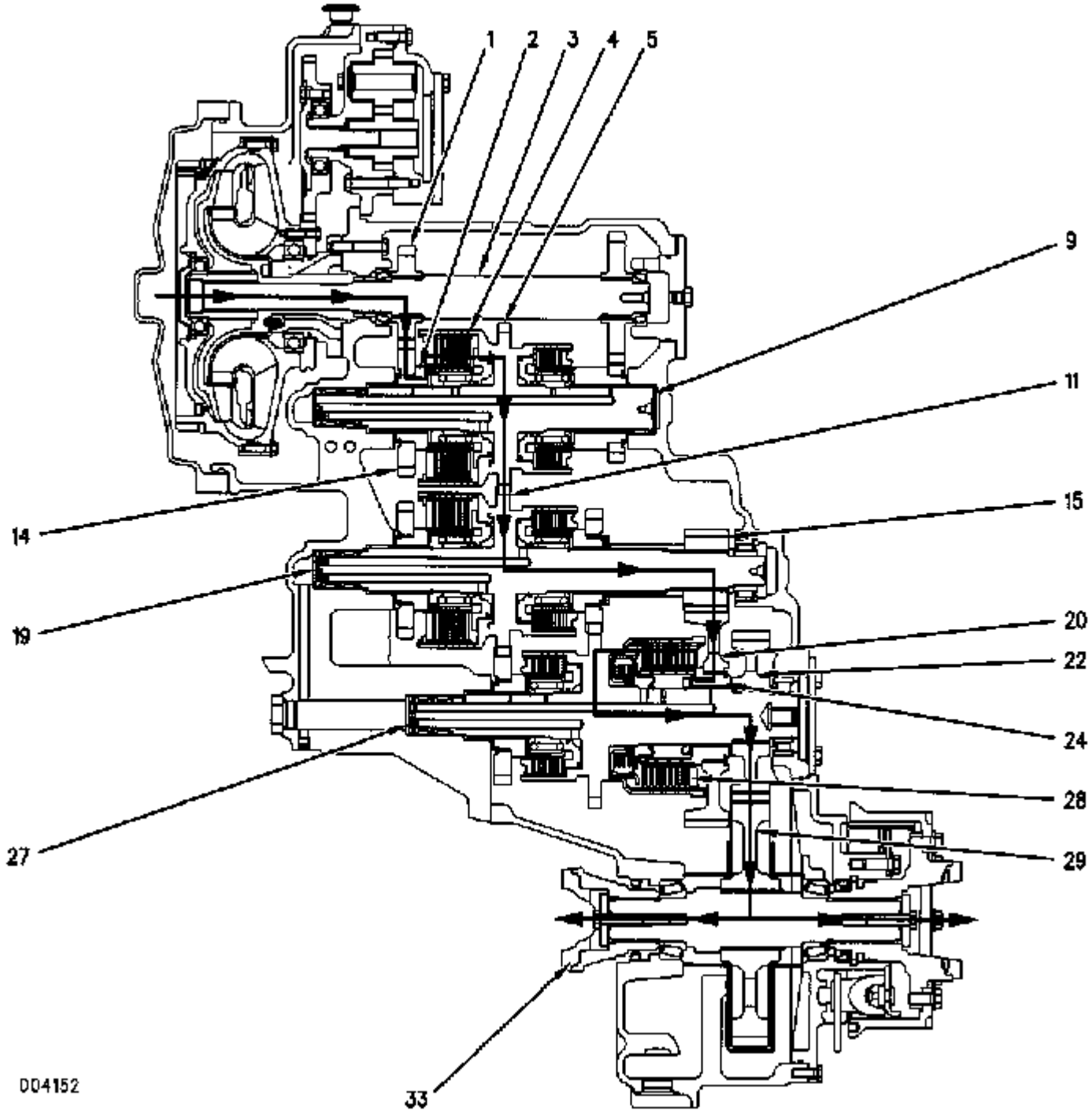
The chart gives the combination of the solenoids energized and the clutches engaged for each FORWARD and REVERSE speed.

Parking brake assembly (34) is mounted to the transmission case. The parking brake drum is fastened to the transmission output shaft. See SENR6729 and SENR6730 for additional information on the parking brake.



Transmission Shaft Locations
(3) Input shaft assembly. (9) Shaft assembly (FORWARD LOW and FORWARD HIGH clutches). (19) Shaft assembly (REVERSE and SECOND SPEED clutches). (27) Shaft assembly (THIRD SPEED and FIRST SPEED clutches). (33) Output shaft assembly.

First Speed Forward



Power Flow In FIRST SPEED FORWARD
(1) Gear. (2) Hub assembly. (3) Input shaft assembly. (4) No. 1 (FORWARD LOW) clutch. (5) Gear [part of shaft assembly (9)]. (9) Shaft assembly. (11) Gear [part of shaft assembly (19)]. (14) Gear. (15) Gear. (19) Shaft assembly. (20) Gear. (22) Gear. (24) Hub assembly. (27) Shaft assembly. (28) No. 6 (FIRST SPEED) clutch. (29) Gear. (33) Output shaft assembly.

When the transmission is in FIRST SPEED FORWARD, No. 1 clutch (4) and No. 6 clutch (28) are engaged. Torque from the engine is transferred through the torque converter to input shaft assembly (3). Gear (1) is splined to input shaft assembly (3) and is in mesh with and turns gear (14).

Gear (14) is splined to and turns hub assembly (2). Torque is transferred from input shaft assembly (3) through gear (1) and gear (14) to hub assembly (2). With No. 1 clutch (4) engaged, torque is transferred from hub assembly (2) through the engaged No. 1 clutch to shaft assembly (9).

Gear (5) is part of shaft assembly (9). Gear (5) is in mesh with and turns gear (11). Gear (11) is part of shaft assembly (19). Torque is transferred from shaft assembly (9) through gear (5) and gear (11) to shaft assembly (19).

Gear (15) is splined to shaft assembly (19). Gear (15) is in mesh with and turns gear (20) which is splined to hub assembly (24). Torque is transferred from shaft assembly (19) through gear (15) and gear (20) to hub assembly (24). With No. 6 clutch (28) engaged, torque is transferred from hub assembly (24) through the engaged No. 6 clutch to shaft assembly (27).

Gear (22) is splined to shaft assembly (27) and is in mesh with and turns gear (29). Gear (29) is splined to output shaft assembly (33). Torque is transferred from shaft assembly (27) through gear (22) and gear (29) to output shaft assembly (33).

Second Speed Forward

When the transmission is in SECOND SPEED FORWARD, No. 1 clutch (4) and No. 4 clutch (17) are engaged. Torque from the engine is transferred through the torque converter to input shaft assembly (3). Gear (1) is splined to input shaft assembly (3) and is in mesh with and turns gear (14).

Gear (14) is splined to and turns hub assembly (2). Torque is transferred from input shaft assembly (3) through gear (1) and gear (14) to hub assembly (2). With No. 1 clutch (4) engaged, torque is transferred from hub assembly (2) through the engaged No. 1 clutch to shaft assembly (9).

Gear (5) is part of shaft assembly (9). Gear (5) is in mesh with and turns gear (11). Gear (11) is part of shaft assembly (19). Torque is transferred from shaft assembly (9) through gear (5) and gear (11) to shaft assembly (19).

With No. 4 clutch (17) engaged, torque is transferred from shaft assembly (19) through the engaged No. 4 clutch to hub assembly (13). Gear (12) is splined to hub assembly (13) and is in mesh with and turns gear (18). Gear (18) is part of shaft assembly (27). Torque is transferred from hub assembly (13) through gear (12) and gear (18) to shaft assembly (27).

Gear (22) is splined to shaft assembly (27) and is in mesh with and turns gear (29). Gear (29) is splined to output shaft assembly (33). Torque is transferred from shaft assembly (27) through gear (22) and gear (29) to output shaft assembly (33).

Third Speed Forward

When the transmission is in THIRD SPEED FORWARD, No. 1 clutch (4) and No. 5 clutch (30) are engaged. Torque from the engine is transferred through the torque converter to input shaft assembly (3). Gear (1) is splined to input shaft assembly (3) and is in mesh with and turns gear (14).

Gear (14) is splined to and turns hub assembly (2). Torque is transferred from input shaft assembly (3) through gear (1) and gear (14) to hub assembly (2). With No. 1 clutch (4) engaged, torque is transferred from hub assembly (2) through the engaged No. 1 clutch to shaft assembly (9).

Gear (5) is part of shaft assembly (9). Gear (5) is in mesh with and turns gear (11). Gear (11) is part of shaft assembly (19) and is in mesh with and turns gear (25). Gear (25) is splined to hub assembly (26). Torque is transferred from shaft assembly (9) through gear (5), gear (11), and gear (25) to hub assembly (26).

With No. 5 clutch (30) engaged, torque is transferred from hub assembly (26) through the engaged No. 5 clutch to shaft assembly (27).

Gear (22) is splined to shaft assembly (27) and is in mesh with and turns gear (29). Gear (29) is splined to output shaft assembly (33). Torque is transferred from shaft assembly (27) through gear (22) and gear (29) to output shaft assembly (33).

Fourth Speed Forward

When the transmission is in FOURTH SPEED FORWARD, No. 2 clutch (6) and No. 5 clutch (30) are engaged. Torque from the engine is transferred through the torque converter to input shaft assembly (3). Gear (7) is splined to input shaft assembly (3) and is in mesh with and turns gear (10).

Gear (10) is splined to and turns hub assembly (8). Torque is transferred from input shaft assembly (3) through gear (7) and gear (10) to hub assembly (8). With No. 2 clutch (6) engaged, torque is transferred from hub assembly (8) through the engaged No. 2 clutch to shaft assembly (9).

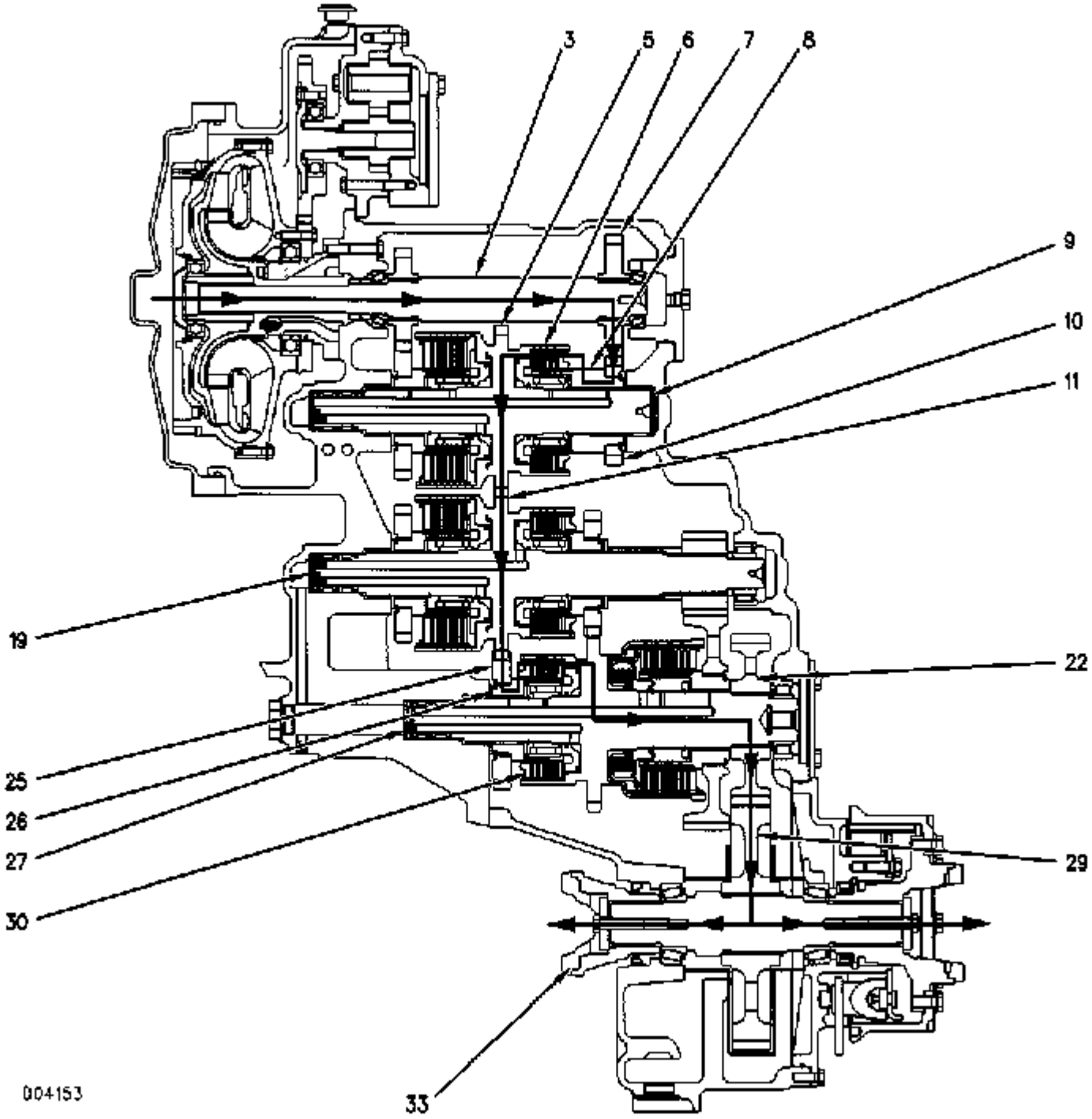
Gear (5) is part of shaft assembly (9). Gear (5) is in mesh with and turns gear (11). Gear (11) is part of shaft assembly (19) and is in mesh with and turns gear (25). Gear (25) is splined to hub assembly (26). Torque is transferred from shaft assembly (9) through gear (5), gear (11), and gear (25) to hub assembly (26).

With No. 5 clutch (30) engaged, torque is transferred from hub assembly (26) through the engaged No. 5 clutch to shaft assembly (27).

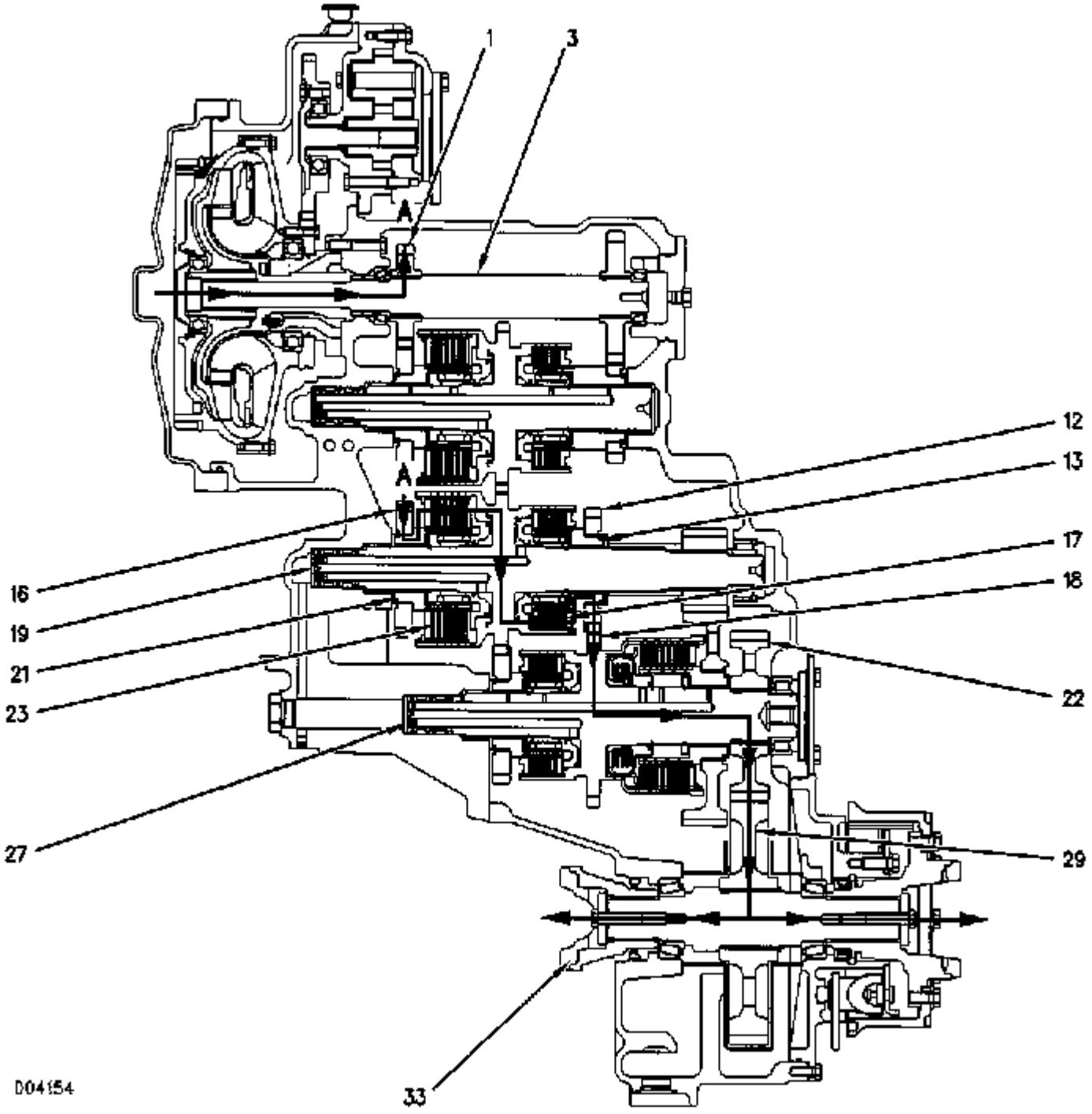
Gear (22) is splined to shaft assembly (27) and is in mesh with and turns gear (29). Gear (29) is splined to output shaft assembly (33). Torque is transferred from shaft assembly (27) through gear (22) and gear (29) to output shaft assembly (33).

Neutral

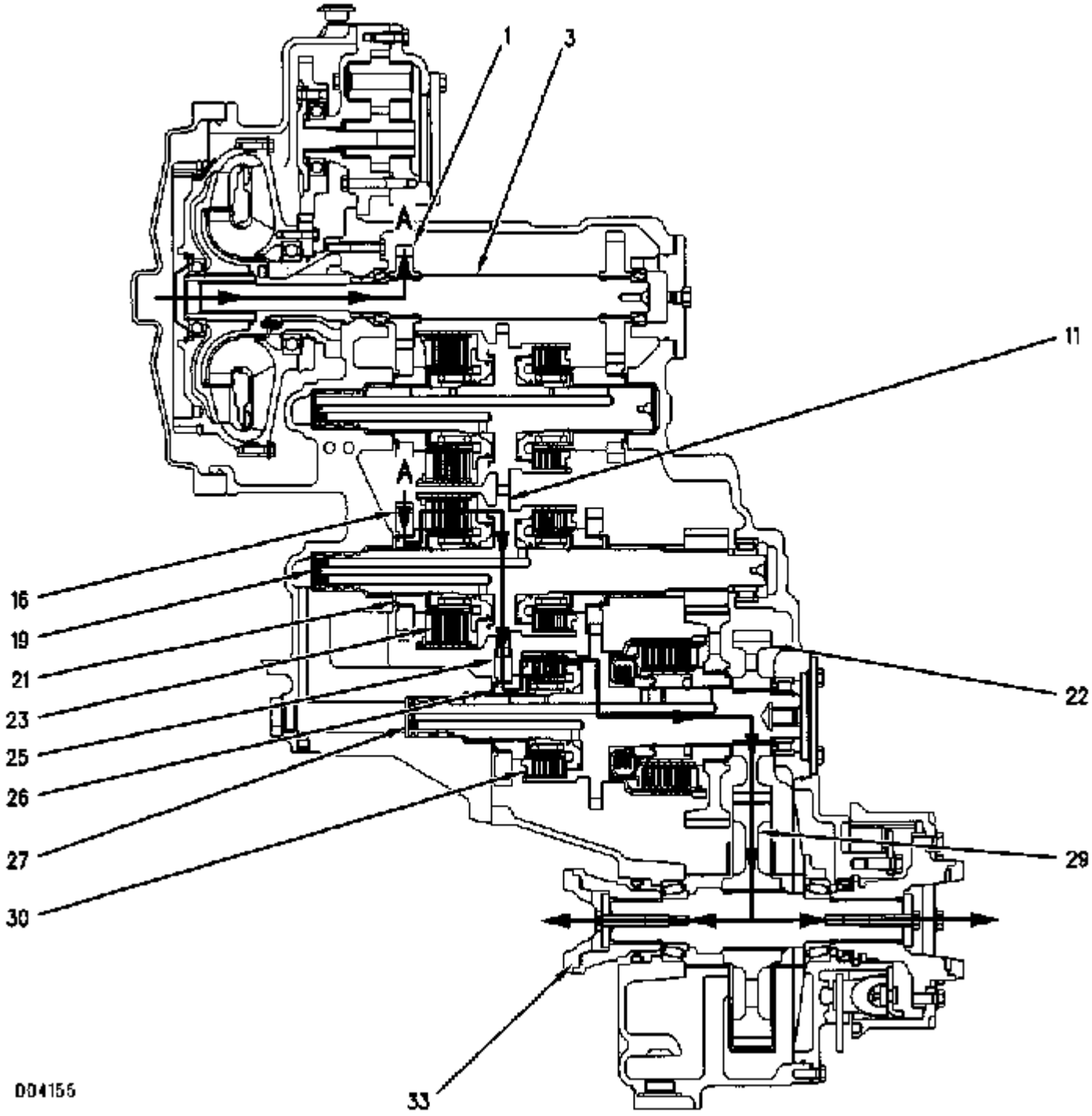
When the transmission is in NEUTRAL, there are no clutches engaged. Torque from the engine is transferred through the torque converter to input shaft assembly (3). Since No. 1 (FORWARD LOW) clutch (4), No. 2 (FORWARD HIGH) clutch (6), or No. 3 (REVERSE) clutch (23) are not engaged, there is no torque transfer from input shaft assembly (3) to either shaft assembly (9) or shaft assembly (19).



Power Flow In FOURTH SPEED FORWARD
(3) Input shaft assembly. (5) Gear [part of shaft assembly (9)]. (6) No. 2 (FORWARD HIGH) clutch. (7) Gear. (8) Hub assembly. (9) Shaft assembly. (10) Gear. (11) Gear [part of shaft assembly (19)]. (19) Shaft assembly. (22) Gear. (25) Gear. (26) Hub assembly. (27) Shaft assembly. (29) Gear. (30) No. 5 (THIRD SPEED) clutch. (33) Output shaft assembly.



Power Flow In SECOND SPEED REVERSE
(1) Gear. (3) Input shaft assembly. (12) Gear. (13) Hub assembly. (16) Gear. (17) No. 4 (SECOND SPEED) clutch. (18) Gear [part of shaft assembly (27)]. (19) Shaft assembly. (21) Hub assembly. (23) No. 3 (REVERSE) clutch. (22) Gear. (27) Shaft assembly. (29) Gear. (33) Output shaft assembly.



Power Flow In THIRD SPEED REVERSE
(1) Gear. (3) Input shaft assembly. (11) Gear [part of shaft assembly (19)]. (16) Gear. (19) Shaft assembly. (21) Hub assembly. (22) Gear. (23) No. 3 (REVERSE) clutch. (25) Gear. (26) Hub assembly. (27) Shaft assembly. (29) Gear. (30) No. 5 (THIRD SPEED) clutch. (33) Output shaft assembly.

First Speed Reverse

When the transmission is in FIRST SPEED REVERSE, No. 3 clutch (23) and No. 6 clutch (28) are engaged. Torque from the engine is transferred through the torque converter to input shaft assembly (3). Gear (1) is splined to input shaft assembly (3) and is in mesh with and turns gear (16).

Gear (16) is splined to and turns hub assembly (21). Torque is transferred from input shaft assembly (3) through gear (1) and gear (16) to hub assembly (21). With No. 3 clutch (23) engaged, torque is transferred from hub

assembly (21) through the engaged No. 3 clutch to shaft assembly (19).

Gear (15) is splined to shaft assembly (19). Gear (15) is in mesh with and turns gear (20) which is splined to hub assembly (24). Torque is transferred from shaft assembly (19) through gear (15) and gear (20) to hub assembly (24). With No. 6 clutch (28) engaged, torque is transferred from hub assembly (24) through the engaged No. 6 clutch to shaft assembly (27).

Gear (22) is splined to shaft assembly (27) and is in mesh with and turns gear (29). Gear (29) is splined to output shaft assembly (33). Torque is transferred from shaft assembly (27) through gear (22) and gear (29) to output shaft assembly (33).

Second Speed Reverse

When the transmission is in SECOND SPEED REVERSE, No. 3 clutch (23) and No. 4 clutch (17) are engaged. Torque from the engine is transferred through the torque converter to input shaft assembly (3). Gear (1) is splined to input shaft assembly (3) and is in mesh with and turns gear (16).

Gear (16) is splined to and turns hub assembly (21). Torque is transferred from input shaft assembly (3) through gear (1) and gear (16) to hub assembly (21). With No. 3 clutch (23) engaged, torque is transferred from hub assembly (21) through the engaged No. 3 clutch to shaft assembly (19).

With No. 4 clutch (17) engaged, torque is transferred from shaft assembly (19) through the engaged No. 4 clutch to hub assembly (13). Gear (12) is splined to hub assembly (13) and is in mesh with and turns gear (18). Gear (18) is part of shaft assembly (27). Torque is transferred from hub assembly (13) through gear (12) and gear (18) to shaft assembly (27).

Gear (22) is splined to shaft assembly (27) and is in mesh with and turns gear (29). Gear (29) is splined to output shaft assembly (33). Torque is transferred from shaft assembly (27) through gear (22) and gear (29) to output shaft assembly (33).

Third Speed Reverse

When the transmission is in THIRD SPEED REVERSE, No. 3 clutch (23) and No. 5 clutch (30) are engaged. Torque from the engine is transferred through the torque converter to input shaft assembly (3). Gear (1) is splined to input shaft assembly (3) and is in mesh with and turns gear (16).

Gear (16) is splined to and turns hub assembly (21). Torque is transferred from input shaft assembly (3) through gear (1) and gear (16) to hub assembly (21). With No. 3 clutch (23) engaged, torque is transferred from hub assembly (21) through the engaged No. 3 clutch to shaft assembly (19).

Gear (11) is part of shaft assembly (19) and is in mesh with and turns gear (25). Gear (25) is splined to hub assembly (26). Torque is transferred from shaft assembly (19) through gear (11), and gear (25) to hub assembly (26).

With No. 5 clutch (30) engaged, torque is transferred from hub assembly (26) through the engaged No. 5 clutch to shaft assembly (27).

Gear (22) is splined to shaft assembly (27) and is in mesh with and turns gear (29). Gear (29) is splined to output shaft assembly (33). Torque is transferred from shaft assembly (27) through gear (22) and gear (29) to output shaft assembly (33).

Transmission Lubrication

All clutches, gears, and bearings in the transmission are lubricated by pressure oil. After the oil has been cooled by the oil cooler, it flows back to the transmission case where internal passages carry the oil to a passage in each clutch carrying transmission shaft. Drilled cross-holes carry the oil to the bearings, clutches, and gears.

Transmission Electrical System

Standard machines without Autoshift

The main components of the transmission electrical system are the transmission control group, six solenoid valves, and transmission neutralizer switch. There is also a neutralizer lockout switch, and a switch in the parking brake linkage to sound the parking brake alarm.

The transmission control group is a non-serviceable, environmentally sealed unit. The transmission control group is mounted on the steering column and allows the operator to select a speed range by rotating the control lever and a direction by moving the control lever forward or backward. By twisting and/or moving the lever, switches are selected to energize the appropriate transmission solenoids.

When the control lever is in NEUTRAL, a switch in the control group is closed to complete the circuit from the key switch to the start relay, which allows the machine to be started with the key.

When the control lever is moved to REVERSE, a switch in the control group is closed, which activates the backup alarm.

The solenoids are installed in the transmission control valve body. The solenoids are two position-three way and are normally open to drain. When energized, the solenoid plunger moves to direct pressure oil to the clutch selector spool.

The transmission neutralizer switch is located on the left brake pedal linkage. When either brake pedal is depressed, the power to the transmission solenoids is interrupted, thereby neutralizing the transmission.

The neutralizer lockout switch is located on the dash of the machine. When the switch is in the ON position, depressing the brake pedals will no longer neutralize the transmission. An indicator light on the dash is lit when the switch is in the ON position.

A switch on the parking brake linkage lights an indicator light on the dash when the parking brake is engaged. If the transmission is put in gear while the parking brake is engaged, a switch in the transmission control group opens and sounds an audible alarm.

For a complete electrical schematic of the 924F, see SENR6735, 924F Wheel Loader Electrical System Schematic.

For a complete electrical schematic of the IT24F, see SENR6737, IT24F Integrated Toolcarrier Electrical System Schematic.

Machines equipped with Autoshift

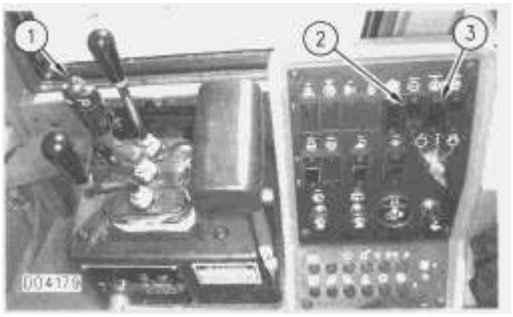
The main components of the transmission electrical system are the Autoshift switch, transmission control group, electronic control module, six solenoid valves, transmission neutralizer switches, and transmission neutralizer lockout switch.

Transmission Electronic Control Module (ECM)

The electronic control module (ECM) for the transmission is located in the cab, behind the operator seat. The main function of the ECM is to shift the transmission. The ECM receives operator input from the transmission control group to shift the transmission to the desired speed and direction.

The ECM also controls engine starting and the back-up alarm. The ECM will not allow the engine to be started unless the direction control switch is in the neutral position. The back-up alarm is activated any time the direction control switch is in the reverse position.

The ECM has built-in system diagnostics to detect faults in the transmission system. The ECM sends fault codes to the Computerized Monitoring System (CMS) for display. For information on troubleshooting the transmission ECM, see SENR5751, Electronic Transmission Control System.



Right Side Console
(1) Downshift switch. (2) Autoshift switch. (3) Transmission neutralizer lockout switch.

Autoshift switch (2) turns the automatic shift feature ON or OFF. When the switch is in the ON position, the transmission will automatically upshift or downshift. The transmission will not automatically upshift to a speed higher than selected by the operator. There is no automatic downshift from second speed to first speed.

Downshift switch (1) is located on the lift control lever. The downshift switch is a momentary contact switch that will downshift the transmission one speed each time the switch is depressed.

Transmission Neutralizer

Transmission neutralizer switch (3) is located on the left brake pedal linkage. When either brake pedal is depressed, the power to the transmission solenoids is interrupted, thereby neutralizing the transmission.

The neutralizer lockout switch is located on the dash of the machine. When the switch is in the ON position, depressing the brake pedals will not neutralize the transmission. An indicator light on the dash is lit when the switch is in the ON position.

Transmission Control Group



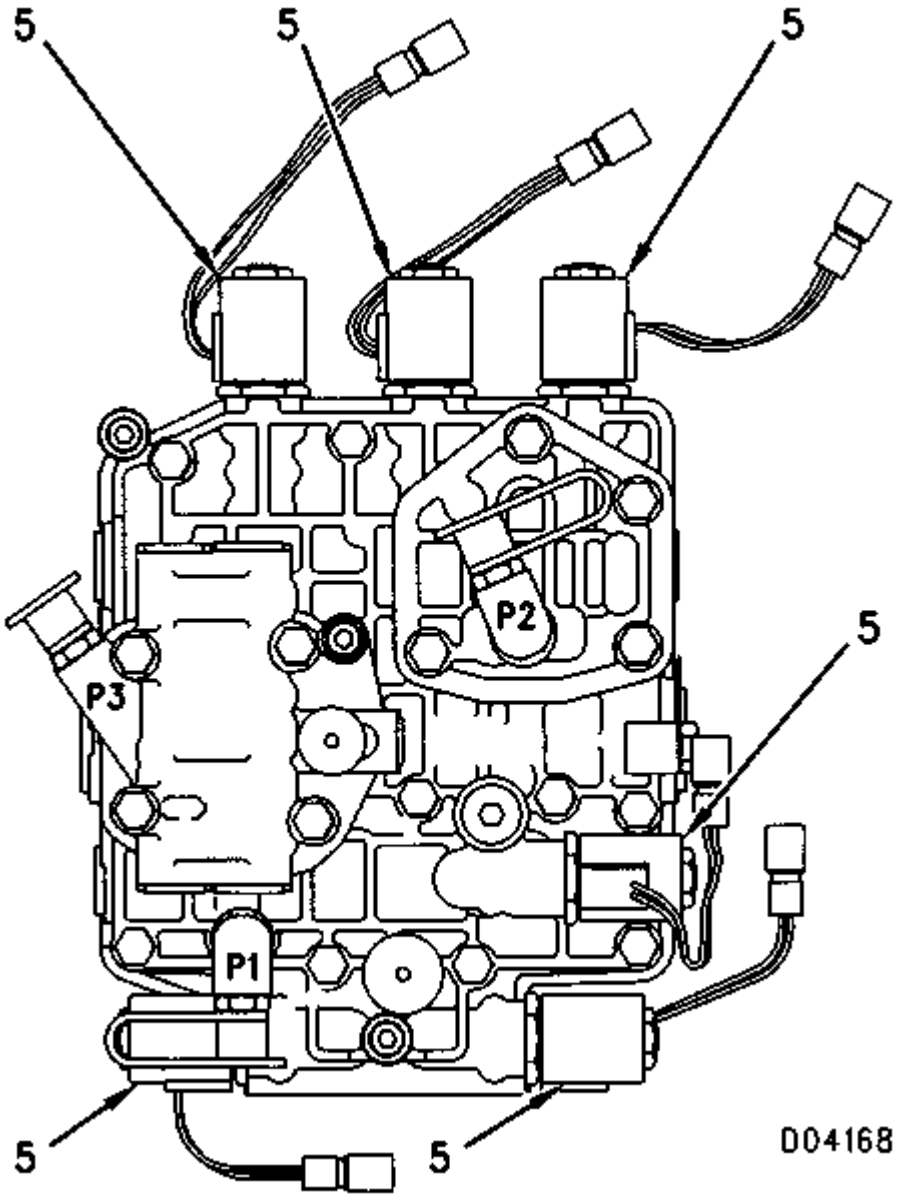
Cab
(4) Transmission control group.

The transmission control group is a sealed unit. The control group is mounted on the steering column and allows the operator to select a speed range by rotating the control lever, and a direction by moving the lever forward or backward.

The transmission control group contains switches that tell the electronic transmission control what direction and speed the operator has selected.

If the transmission control group is not in neutral when the key is turned ON, the control must be returned to neutral before a direction can be selected.

Solenoid valves

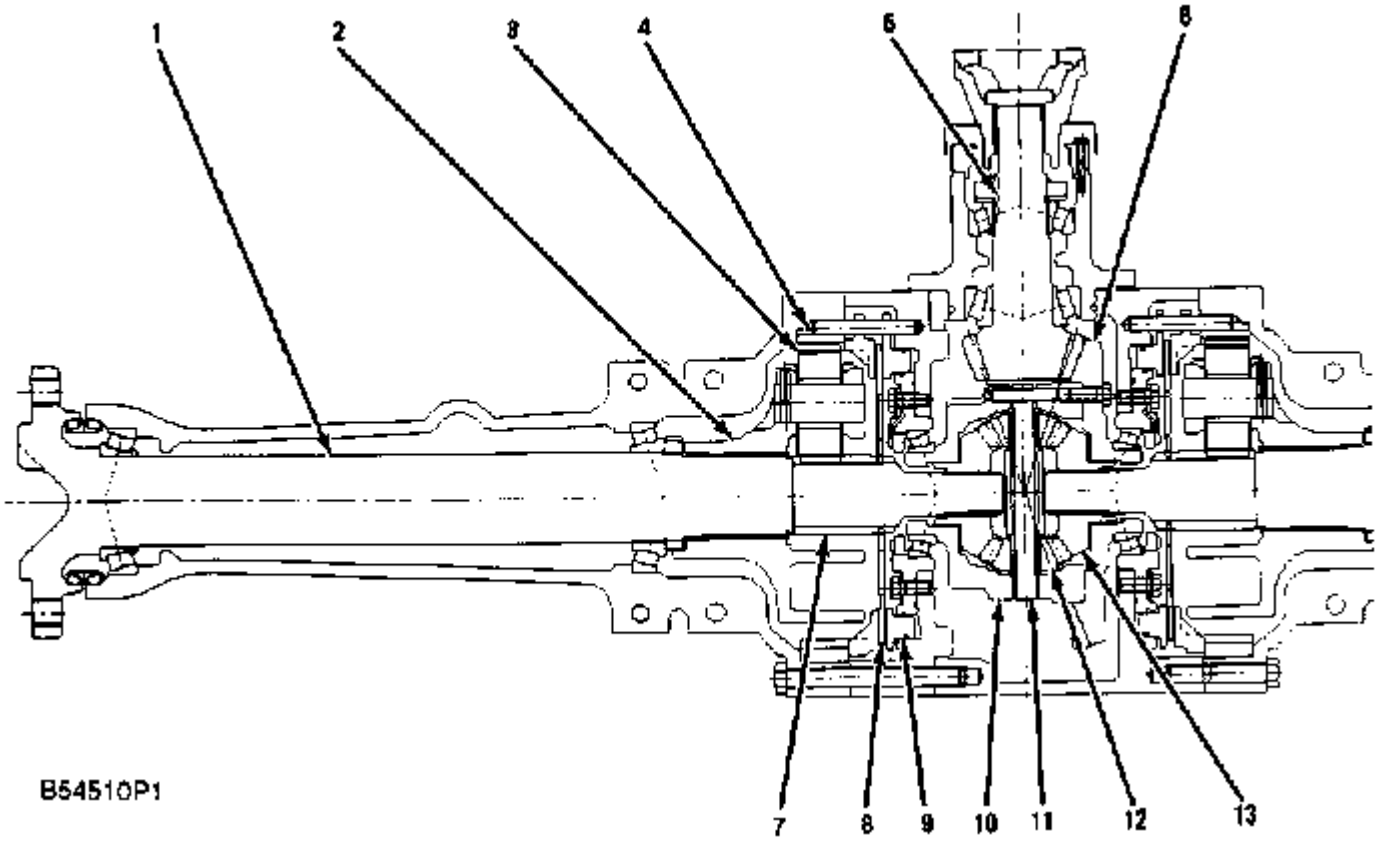


Transmission Hydraulic Control Valve
(5) Solenoid valve.

Solenoid valves (5) are installed in the transmission hydraulic controls. The solenoid valves are two position-three way and are normally open to drain. When energized, the solenoid valve spool moves to direct pressure oil

to one end of a transmission control valve spool. The transmission control valve spool directs pressure oil to a clutch.

Front And Rear Axle Groups



(1) Axle shaft. (2) Carrier. (3) Planet gear. (4) Ring gear. (5) Bevel pinion. (6) Bevel gear. (7) Sun gear. (8) Brake disc. (9) Brake piston. (10) Differential case. (11) Shaft. (12) Pinion. (13) Side gear.

The front and rear axle groups incorporate the pinion and bevel gear set, the differential, the final drives, and the disc brakes. While the front and rear axle housings are slightly different, the internal components and operation are identical. A No-SPIN differential is available in the rear axle group.

Power from the transmission output shaft is transferred to the front and rear axle groups by the drive shafts. The power enters the axle groups through bevel pinion (5). Bevel pinion (5) turns bevel gear (6) which is fastened to differential case (10).

Power is transferred through the differential by pinions (12) and side gears (13) to the final drives. The main components of the final drives are carrier (2), planet gears (3), ring gear (4), and sun gear (7). Each final drive has the same components. The final drives cause the last speed reduction and torque increase in the drive train.

Sun gear (7) is splined into side gear (13) of the differential. Ring gear (4) is pressed into the axle housing. Three planet gears (3) are mounted in carrier (2). Carrier (2) has internal splines into which the splines of axle shaft (1) fit.

As sun gear (7) is driven by the differential, planet gears (3) are forced to revolve around the inside of ring gear (4). The movement of the planet gears (3) around ring gear (4) causes carrier (2) and axle shaft (1) to rotate. This transfers power to the rim and tire which bolts to the flange on axle shaft (1).

NOTE: For axle group adjustments see SENR6724, 924F Wheel Loader and IT24F Integrated Toolcarrier Power Train Specifications.

The axle groups contain the service brakes. Brake disc (8) is splined to sun gear shaft (7) and rotates at sun gear speed. When the brakes are applied, the cavity behind brake piston (9) is pressurized and the brake piston clamps brake disc (8) between the piston and the brake reaction plate.

Differential Group

A differential divides or causes a balance of the power which is sent to the wheels. When one wheel turns slower than the other, as in a turn, the differential lets the inside wheel go slower in relation to the outside wheel. The differential still sends the same amount of torque to each wheel.

Operation

Straight Forward or Reverse

When the machine moves in a straight direction with the same amount of traction under each drive wheel, the same amount of torque on each axle holds the pinions so they do not turn on the spider.

Bevel pinion (5) turns bevel gear (6). Bevel gear (6) turns case (10). Case (10) turns shaft (11). Shaft (11) turns side gears (13) through pinions (12). Pinions (12) do not turn on the shaft. The side gears turn final drive sun gears (7). The same amount of torque is sent through the final drives to each wheel.

This gives the same effect as if both drive wheels were on one axle shaft.

Forward or Reverse Turn

When the machine is in a turn, the inside wheel has more resistance to turn than the outside wheel. This resistance causes different torques on the opposite sides of the differential. It is easier for the outside wheel to turn than it is for the inside wheel. The outside wheel starts to turn faster than the inside wheel.

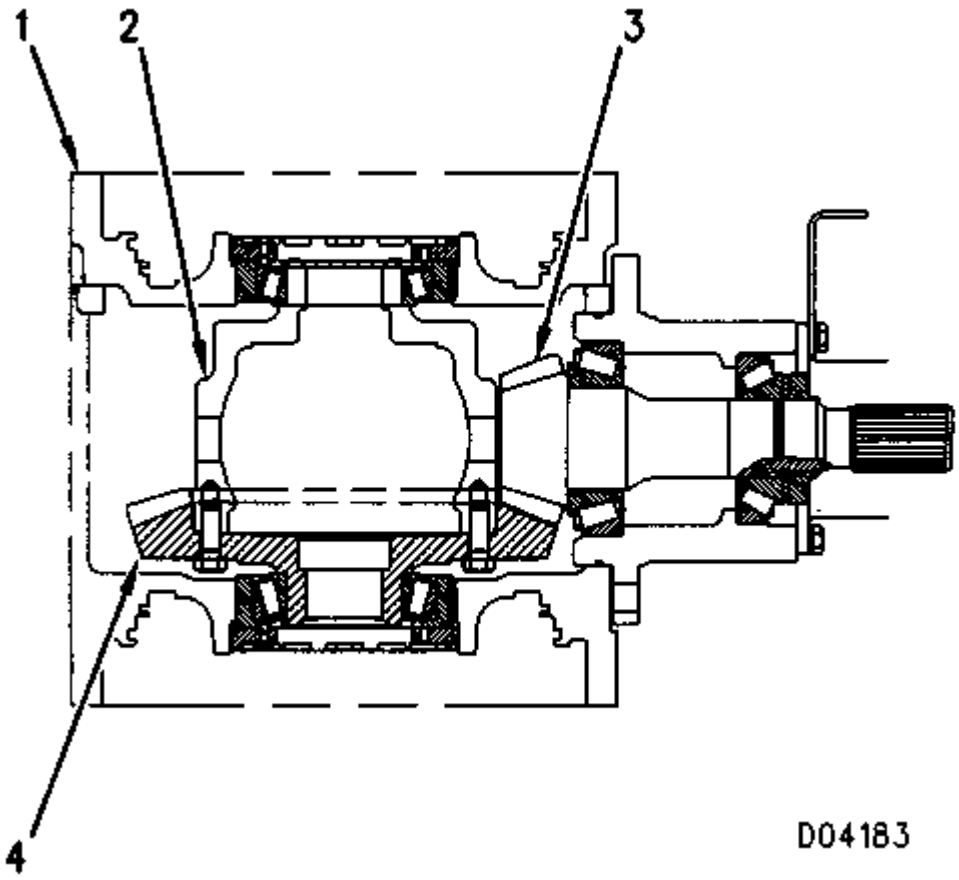
Bevel pinion (5) turns bevel gear (6). Bevel gear (6) turns case (10). Case (10) turns shaft (11). Shaft (11) turns side gears (13) through pinions (12). Since it takes more force to turn one side gear than it does the other, pinions (12) turn around shaft (11). As the pinions turn, they move around the side gears. This lets the outside wheel turn faster than the inside wheel.

The same amount of torque is sent through the final drives to both the inside and outside wheels. This torque is only equal to the amount needed to turn the outside wheel.

Loss of Traction (Wheel Slippage)

When one wheel has more traction than the other, the operation of the differential is the same as in a turn. The same amount of torque is sent to both wheels. This torque is only equal to the amount needed to turn the wheel with the least resistance.

NoSPIN Differential Group



NoSPIN Differential Group (Typical)
(1) Axle housing. (2) NoSPIN differential and case. (3) Bevel pinion. (4) Bevel gear.

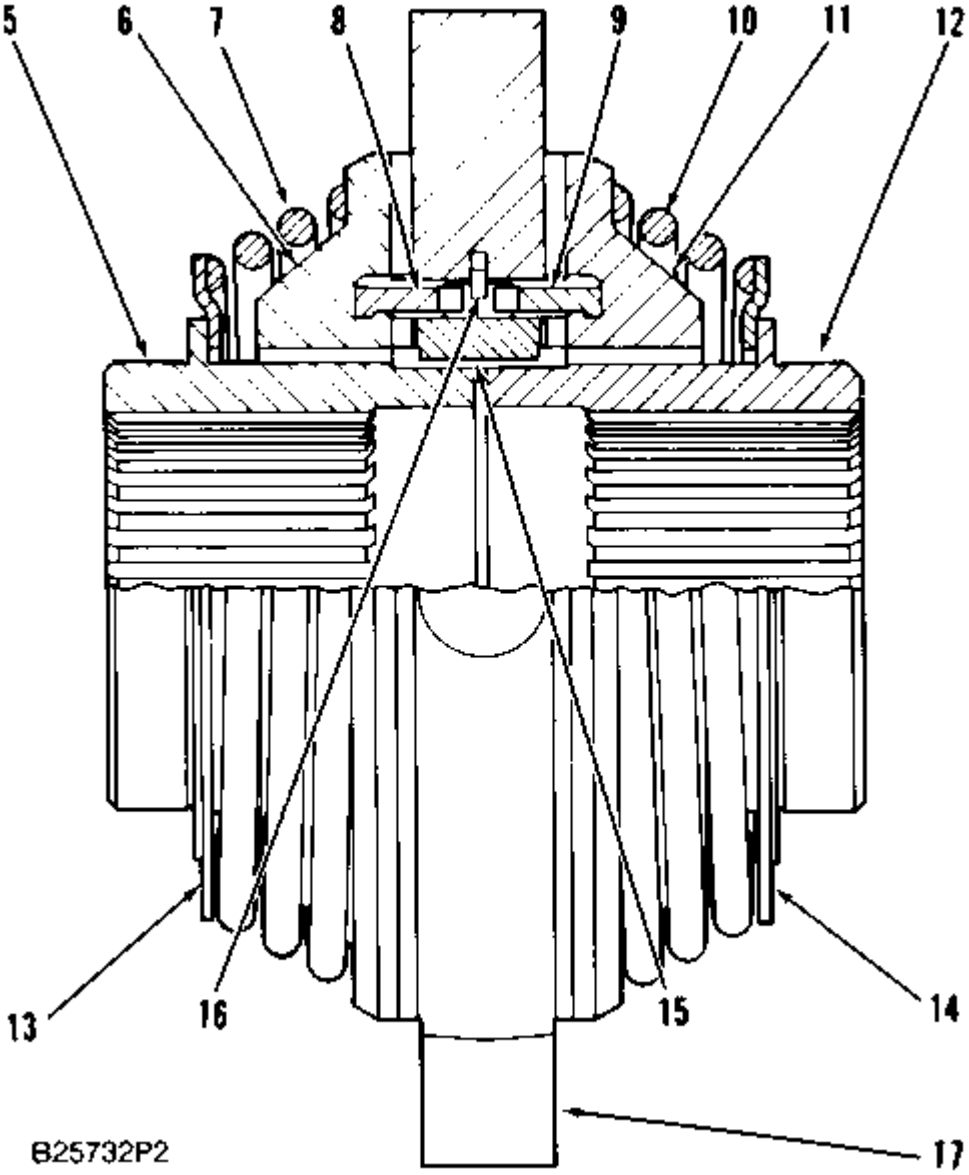
The NoSPIN differential is a locking type differential designed to deliver power to both wheels of an axle when ground slip conditions are encountered on one wheel and disengage one side when good traction conditions require overrun, such as the outside wheel in a turn. The NoSPIN differential group is a direct replacement for the standard differential. It is available only in the rear axle group.

When the speeds of the wheels are the same, the NoSPIN differential sends the same amount of torque to each wheel. When the speeds of the wheels are different, the NoSPIN differential sends the torque to the wheel that turns slower. A difference in the speeds of the wheels is caused by a turn.

The NoSPIN differential lets a wheel (axle) turn faster than the speed of the bevel gear by not engaging it with the bevel gear. For example: During a turn with power, the outside wheel (axle) is not engaged with the bevel gear and turns faster while the inside wheel axle is engaged with the bevel gear and turns at the same speed as the bevel gear. The inside wheel gives the power which moves the machine through the turn.

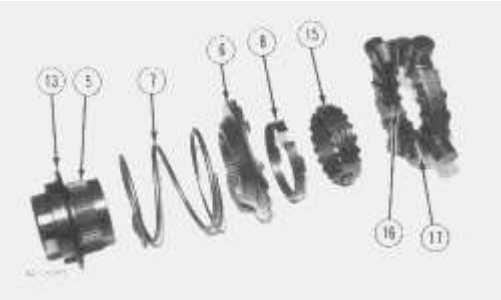
The NoSPIN differential is the same on one side of spider (17) as it is on the other side (symmetrical). The NoSPIN has two springs (7) and (10), two side gears (5) and (12), two driven clutches (6) and (11), two holdout rings (8) and (9), a center cam (15), a snap ring (16) and a spider (17).

The inside splines of side gears (5) and (12) are connected to the sun gears for the final drives. The outside splines of the side gears are connected to the inside splines of drive clutches (6) and (11). The side gears send the power through the sun gears to the final drives.



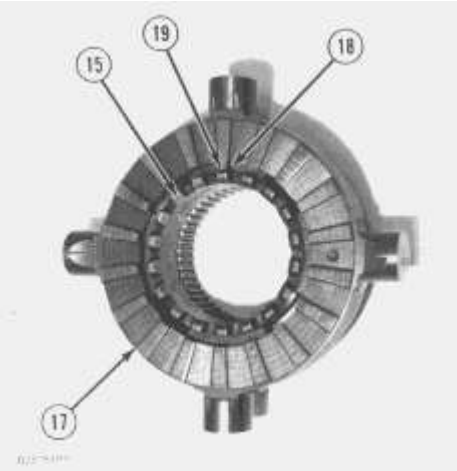
NoSPIN Differential (Typical)
(5) Side gear. (6) Driven clutch. (7) Spring. (8) Holdout ring. (9) Holdout ring. (10) Spring. (11) Driven clutch. (12) Side gear. (13) Spring retainer. (14) Spring retainer. (15) Center cam. (16) Snap ring. (17) Spider.

Spider (17) is fastened to the differential case and turns at the speed of bevel gear (4). The spider has clutch teeth on both sides. The spider also has one long tooth. The long tooth is spider key (19). Center cam (15) fits inside the spider and is held in position by snap ring (16). The center cam is turned by spider key (19) which fits inside notch (18). Spider key (19) pushes on either side of notch (18). The direction of the machine, forward or reverse, controls which way the spider turns and which side of notch (18) gets the force.



NoSPIN Differential (Left Side Disassembled)
(5) Side gear. (6) Driven clutch. (7) Spring. (8) Holdout ring. (13) Spring retainer. (15) Center cam. (16) Snap ring. (17) Spider.

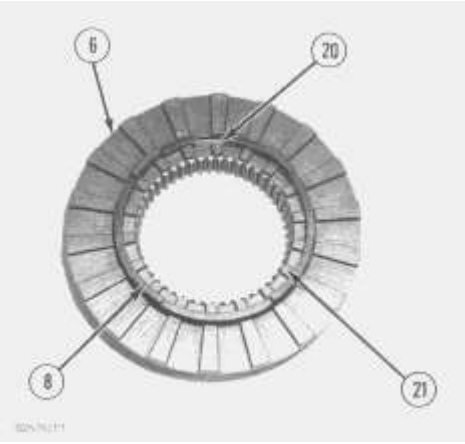
Springs (7) and (10) fit, between the side gears and spring retainers (13) and (14). The force of the springs holds the driven clutches against spider (17) and the side gears against the differential case.



Spider And Center Cam
(15) Center cam. (17) Spider. (18) Notch in center cam. (19) Spider key.

Driven clutches (6) and (11) are the same. Each driven clutch has a cam (21) which is part of the clutch. The teeth on the cam engage with the teeth of center cam (15). The teeth of the drive clutches engage with the teeth of spider (17). An annular (in the shape of a circle) groove is between the teeth of the driven clutches and the teeth of the cams.

Holdout rings (8) and (9) are the same. Each holdout ring fits in the annular groove between the teeth of the driven clutches and the teeth of the cams. The teeth of the holdout rings engage with the notches in the center cam. Notch (20) in the holdout ring engages with spider key (19). The spider key controls the movement of the holdout ring in relation to the spider. There is no connection, except friction, between the holdout rings and the driven clutches.



Clutch And Holdout Ring
(6) Driven clutch. (8) Holdout ring. (20) Notch in holdout ring. (21) Cam.

Operation Of NoSPIN Differential

When a wheel is made to turn faster than the speed of the bevel gear, the "clutch action" (the stopping of power to drive axle) of the NoSPIN differential will let this axle turn faster than the speed of the bevel gear.

The "clutch action" of the NoSPIN differential is as follows: If spider (17) turns, spider key (19) locates center cam (15) and the spider and the center cam turn at the speed of the bevel gear. The center cam turns holdout ring (8) and cam (21) at the speed of the bevel gear. The spider turns driven clutch (6) at the speed of the bevel gear. The driven clutch turns the side gear, axle and wheel at the speed of the bevel gear.

When the wheel is made to turn faster than the speed of the bevel gear, the teeth of center cam (15) work like ramps and the teeth of cam (21) move up the teeth of the center cam. This action causes driven clutch (6) to become disengaged (not engaged) with the spider.

The driven clutch pulls holdout ring (8) out of the grooves in the center cam. The friction between the holdout ring and driven clutch turns the holdout ring until notch (20) in the holdout ring engages with spider key (19). The holdout ring is now turned by the spider key at the speed of the bevel gear. The teeth of the holdout ring are now in a position so they can not engage the notches in the center cam.

The driven clutch and cam move around the holdout ring at a speed faster than the speed of the bevel gear. The holdout ring keeps the driven clutch and cam from being engaged (engagement) with the center cam and spider. The driven clutch, cam, axle shaft and wheel now turn freely.

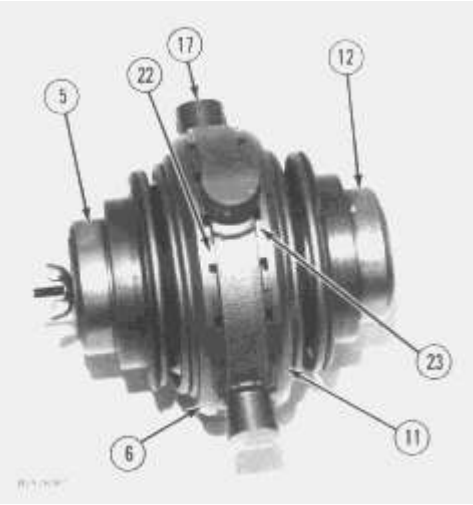
The opposite side clutch, cam and holdout ring are held engaged to the center cam and spider by spring (7) as long as the driven wheel turns slower.

When the speed of the wheel that is not engaged becomes slower and near the speed of the bevel gear, the resistance of the ground to the wheel causes the torque on this wheel to be in a small reverse direction. This causes the driven clutch and cam to turn in a direction opposite the direction of the bevel gear. The friction between the holdout ring and the driven clutch causes the holdout ring to move in a direction opposite the direction of the bevel gear. Notch (20) in the holdout ring moves away from spider key (19).

When the teeth of the holdout ring are in a position to engage the notches in center cam (15), the force of the spring causes the driven clutch and cam to move to the inside. The driven clutch pushes the holdout ring. The holdout ring now engages the center cam and is turned at the speed of the bevel gear. The teeth of cam (21) now engage the center cam and the teeth of the drive clutch engage the spider. At this time, both wheels are turned at the same speed.

NOTE: When both wheels are turned at the same speed they do not necessarily have equal torque. For example: When one wheel starts to turn faster on ice (tends to spin), both clutches engage and both wheels turn at the same speed. The wheel that is on ice will have less torque.

Straight Forward Operation



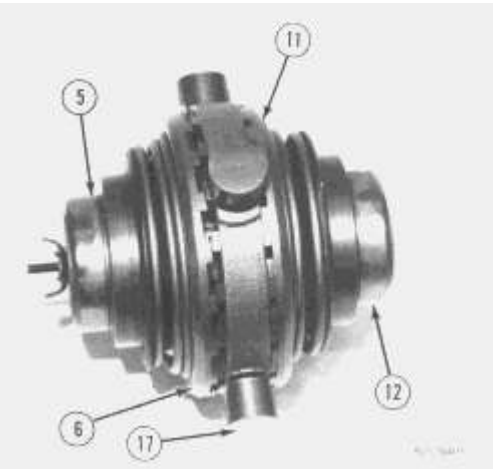
Straight Forward Operation
(5) Side gear. (6) Driven clutch. (11) Driven clutch. (12) Side gear. (17) Spider. (22) Teeth of the spider. (23) Teeth of the driven clutches.

When the machine has straight forward movement, teeth (22) on both sides of spider (17) are fully engaged with teeth (23) of driven clutches (6) and (11). The teeth of cams (21) are engaged with the teeth of center cam (15). The negative angle of the teeth on the clutches and spider, along with the force of springs (7) and (11), cams (21) and center cam (15), push together and the teeth engage.

In this condition, driven clutches (6) and (11) are fully engaged with spider (17). The driven clutches turn side gears (5) and (12) at the same speed as the bevel gear. The two side gears turn the axle shafts and wheels at the same speed as the bevel gear.

Forward Turn With Power

The travel of the outside wheel, during a turn, is at a longer distance than the travel of the inside wheel. When the machine turns with power, the NoSPIN differential lets the outside wheel turn faster than the speed of the bevel gear (to let the outside wheel have this longer travel) but does not let the inside wheel turn slower than the speed of the bevel gear. The inside wheel turns at the same speed as the bevel gear.



Forward Right Turn With Power
(5) Side gear. (6) Driven clutch. (11) Driven clutch. (12) Side gear. (17) Spider.

The teeth of the spider send the drive force to the inside driven clutch. The inside driven clutch turns the inside wheel at the same speed as the bevel gear and gives the power that is needed to move the machine through the turn.

The outside wheel is made to turn (by the traction of the road) at a speed faster than the speed of the bevel gear. This causes the driven clutch for the outside wheel to turn faster than the speed of the bevel gear. The movement of one wheel faster than the other wheel starts the "clutch action" of the NoSPIN differential.

The teeth of the cam for the driven clutch for the inside wheel are engaged with the teeth of center cam (15) and stay in the same position in relation to spider (17). The teeth of the inside drive clutch are engaged with the spider. The teeth on the other side of center cam (15) are used as ramps. The teeth on the cam for the driven clutch for the outside wheel move up the teeth of the center cam. This causes the outside driven clutch and cam to move away from the spider and center cam. The outside driven clutch and cam are not engaged with the spider and center cam.

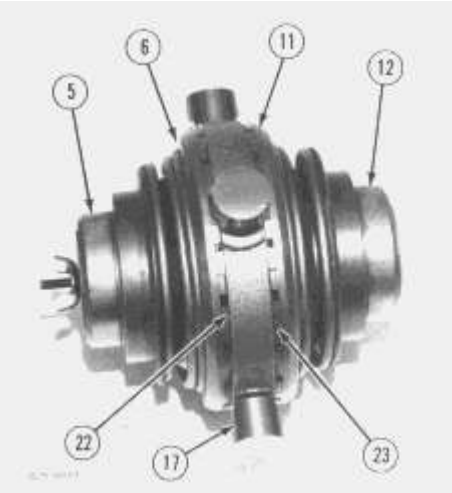
The driven clutch for the outside wheel can not be engaged with the spider until the speed of the outside wheel becomes slower and equal to the speed of the bevel gear. The holdout ring keeps the driven clutch and cam from being engaged with the spider and center cam until the machine moves in a straight direction. At this time the operation of the differential is the same as STRAIGHT FORWARD OPERATION.

Forward Turn With No Power

The operation of the NoSPIN differential is the same as for FORWARD TURN WITH POWER. The outside wheel is still made to turn faster (by the traction of the road) than the speed of the bevel gear. The inside wheel is turned at the speed of the bevel gear.

Straight Reverse Operation

When the machine moves in a straight reverse direction, teeth (22) on both sides of spider (17) are fully engaged with teeth (23) of driven clutches (6) and (11). Spider (17) turns in the opposite direction than it turns in straight forward. Since the spider turns in an opposite direction, teeth (22) of the spider push against the opposite face of teeth (23) of the driven clutches.

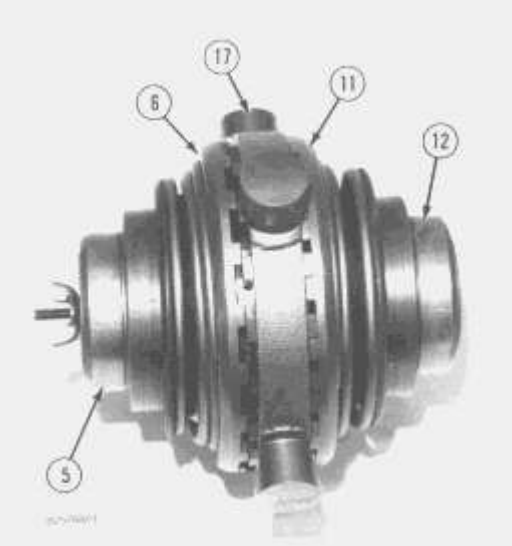


Straight Reverse
(5) Side gear. (6) Driven clutch. (11) Driven clutch. (12) Side gear. (17) Spider. (22) Teeth of the spider. (23) Teeth of the driven clutches.

The action of the differential is the same as it is in the STRAIGHT FORWARD DIRECTION.

Reverse Turn With Power

The action of the differential is the same as it is in the FORWARD TURN WITH POWER condition except spider (17) turns in the opposite direction.



Reverse Right Turn With Power
(5) Side gear. (6) Driven clutch. (11) Driven clutch. (12) Side gear. (17) Spider.

Reverse Turn With No Power

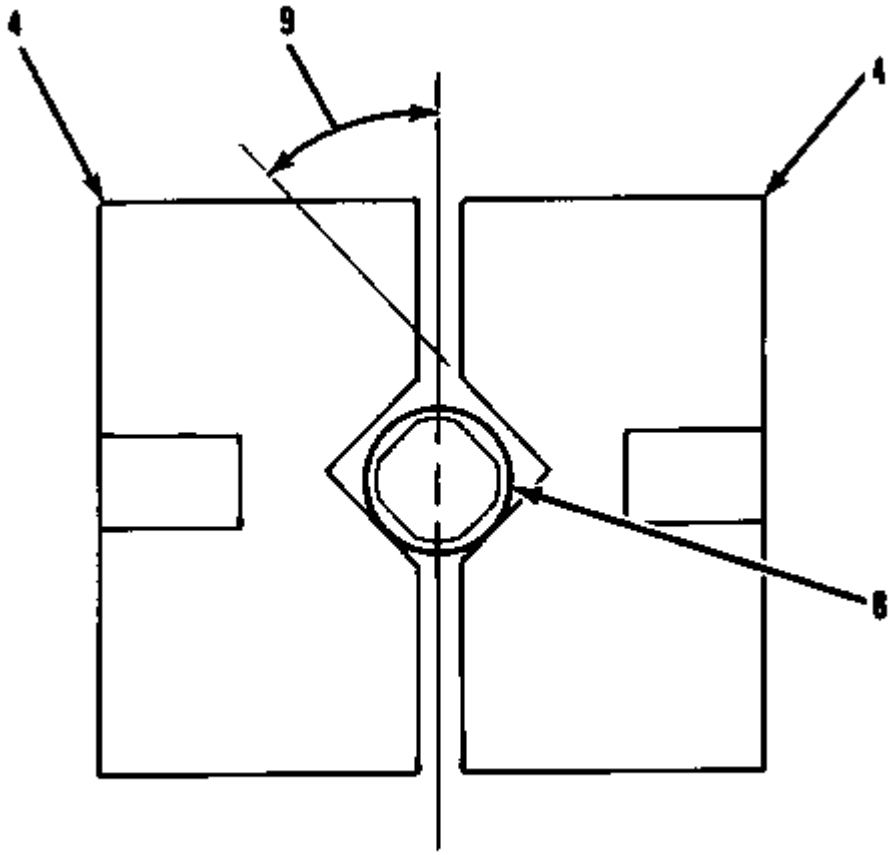
The operation of the NoSPIN differential is the same as for REVERSE TURN WITH POWER. The outside wheel is still made to turn faster (by the traction of the road) than the speed of the bevel gear. The inside wheel is turned at the speed of the bevel gear.

Limited Slip Differential Group [optional (front and rear)]

The Limited Slip Differential is a locking type differential and is designed to give equal power to both wheels until ground conditions between the left and right wheel have a pulling difference. The Limited Slip differential transfers lost power from the least traction side to the side with most traction.

The Limited Slip differential is a direct replacement for the standard differential. It is available in both the front and rear axle groups.

When the traction of the wheels are the same, the Limited Slip differential acts like the standard differential sending equal power to both wheels. In the event that one wheel starts to turn faster (lose traction) than the other; the internal forces present between shaft (8) and load rings (4) react on the 45° angle (9), pushing load rings (4) into clutch packs (3). This clutch pack torque limits the loss of traction to that wheel.

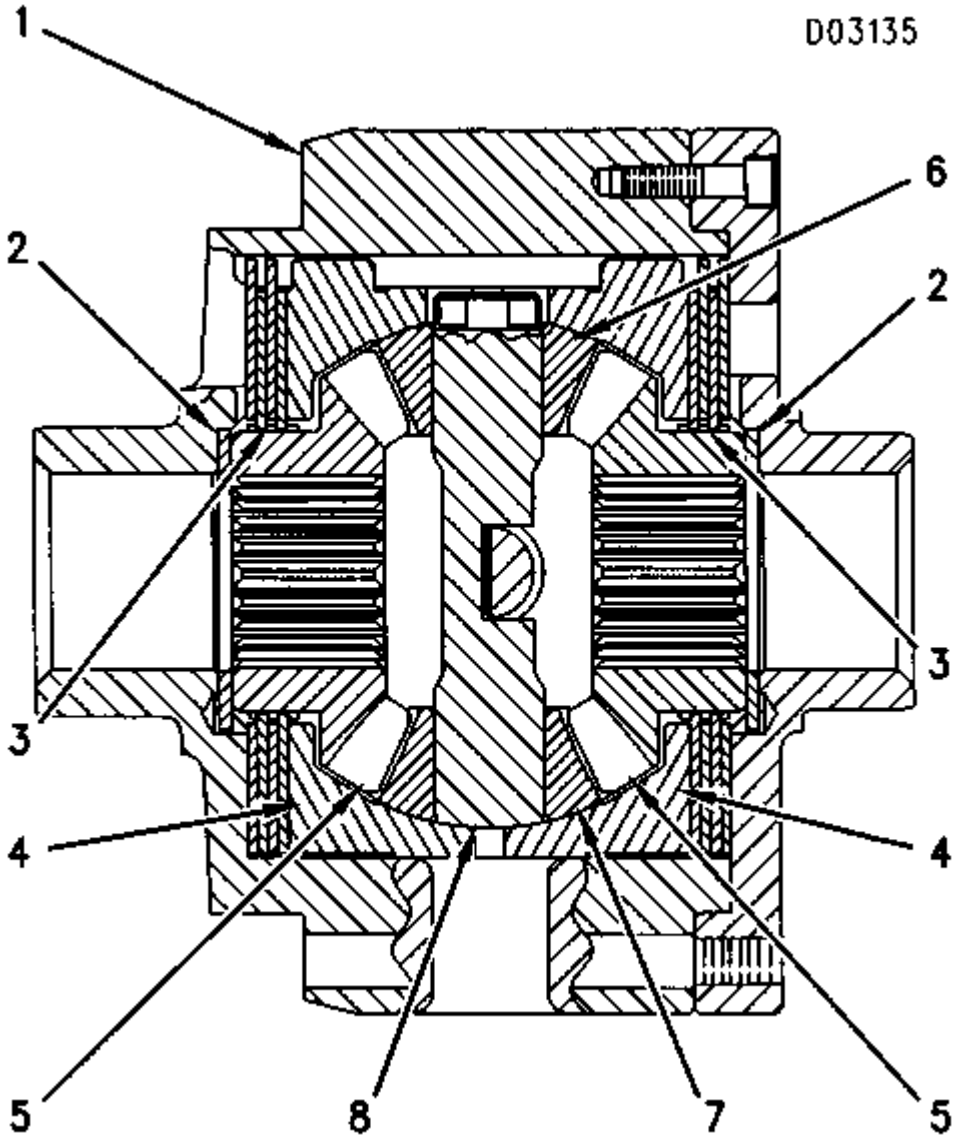


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Locking Ratio
(4) Load rings. (8) Pinion shaft. (9) 45° angle.

The locking effect is due to the internal friction of the differential. This is produced by two clutch packs (3) arranged symmetrically in the differential housing. In a standard differential, one wheel can be braked or held in position when the engine is running and a gear is engaged. The other wheel will turn correspondingly faster. In the limited slip differential, the above procedure would be more difficult due to clutch packs (3), and would become more difficult as power is increased.

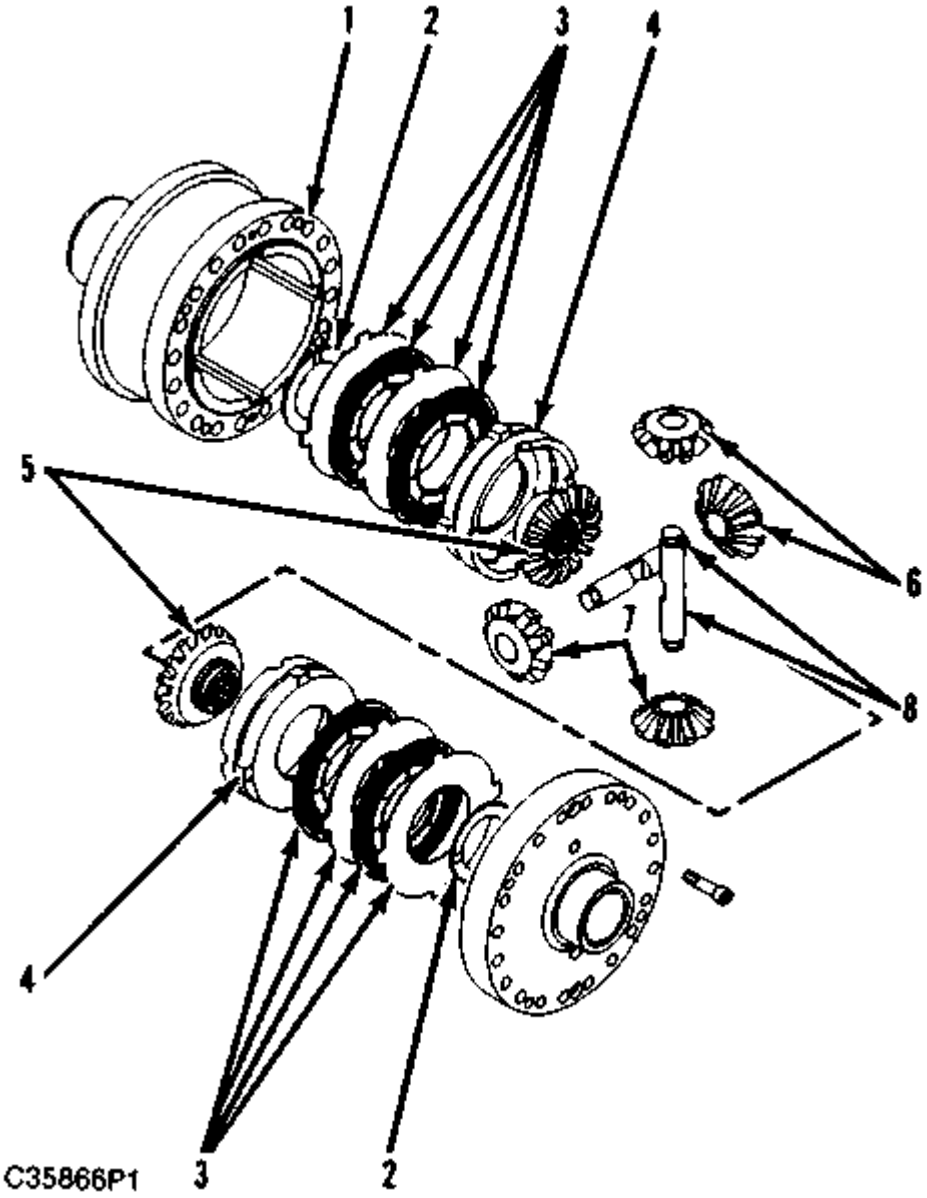
The Limited Slip differential is the same on one side of the two pinion shafts (8) as it is on the other side (symmetrical). The Limited Slip has two thrust washers (2), two clutch packs (3), two load rings (4), two bevel gears (5) and four side gears (7).



Limited Slip Differential
(1) Housing. (2) Thrust washer. (3) Clutch pack. (4) Load rings. (5) Side gears. (6) Pinion (gears). (7) Pinion (gears). (8) Pinion shafts.

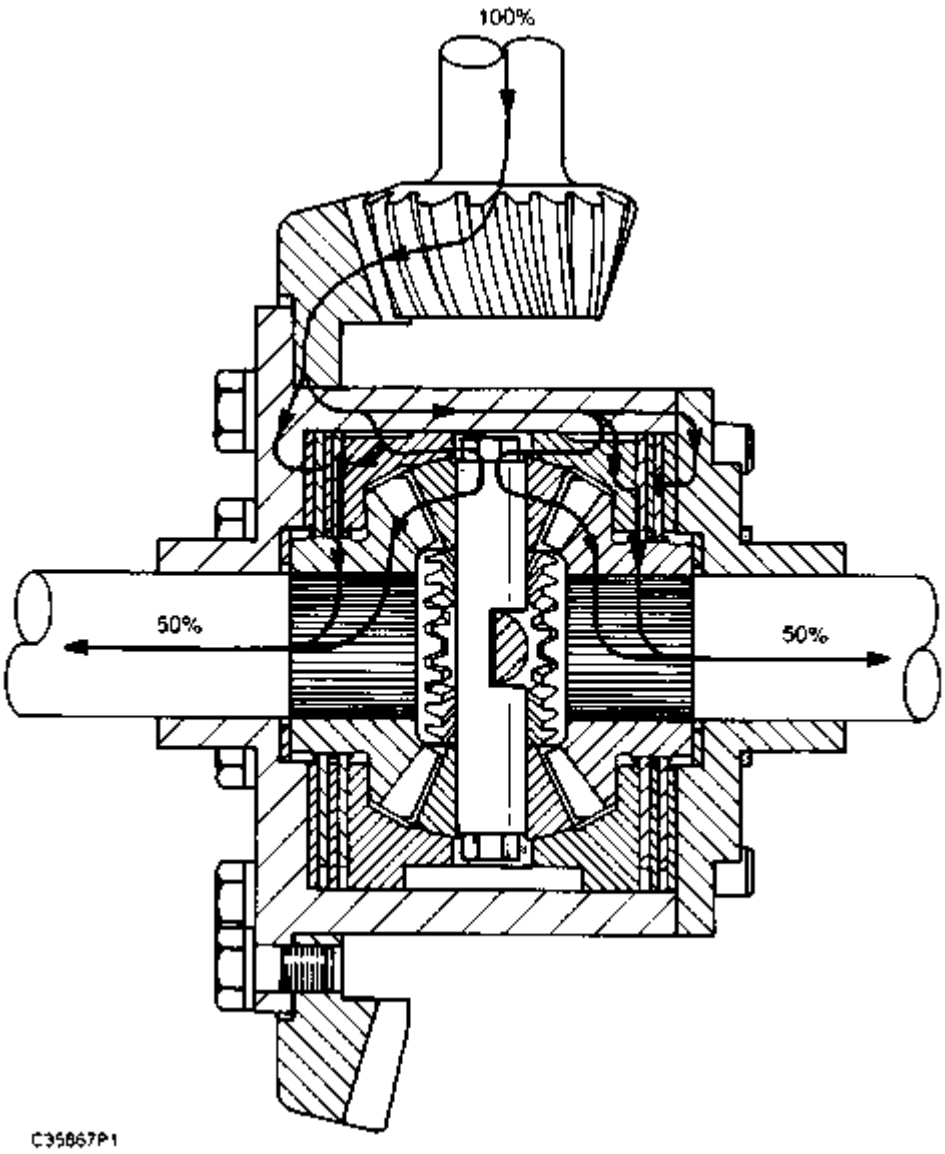
The inside splines of side gears (5) are connected to the sun gears for the final drives. The outside splines of side gears (5) are meshed with inner discs in clutch packs (3). The side gears send the power through the sun gears to the final drives.

Housing (1) is fastened to the bevel gear. Inside, housing (1) has groves to hold the outer discs that are in clutch pack (3). Also in the clutch pack are inner discs (splined to side gears) between the outer discs. Load ring (4) also fits in the same grooves and are held with the discs from moving radially. Side gear (5) fits into load rings (4), along with pinion shafts (8) that lay in the 45° notches in the load ring. Pinion (gears) (6) and (7) go on the pinion shafts.



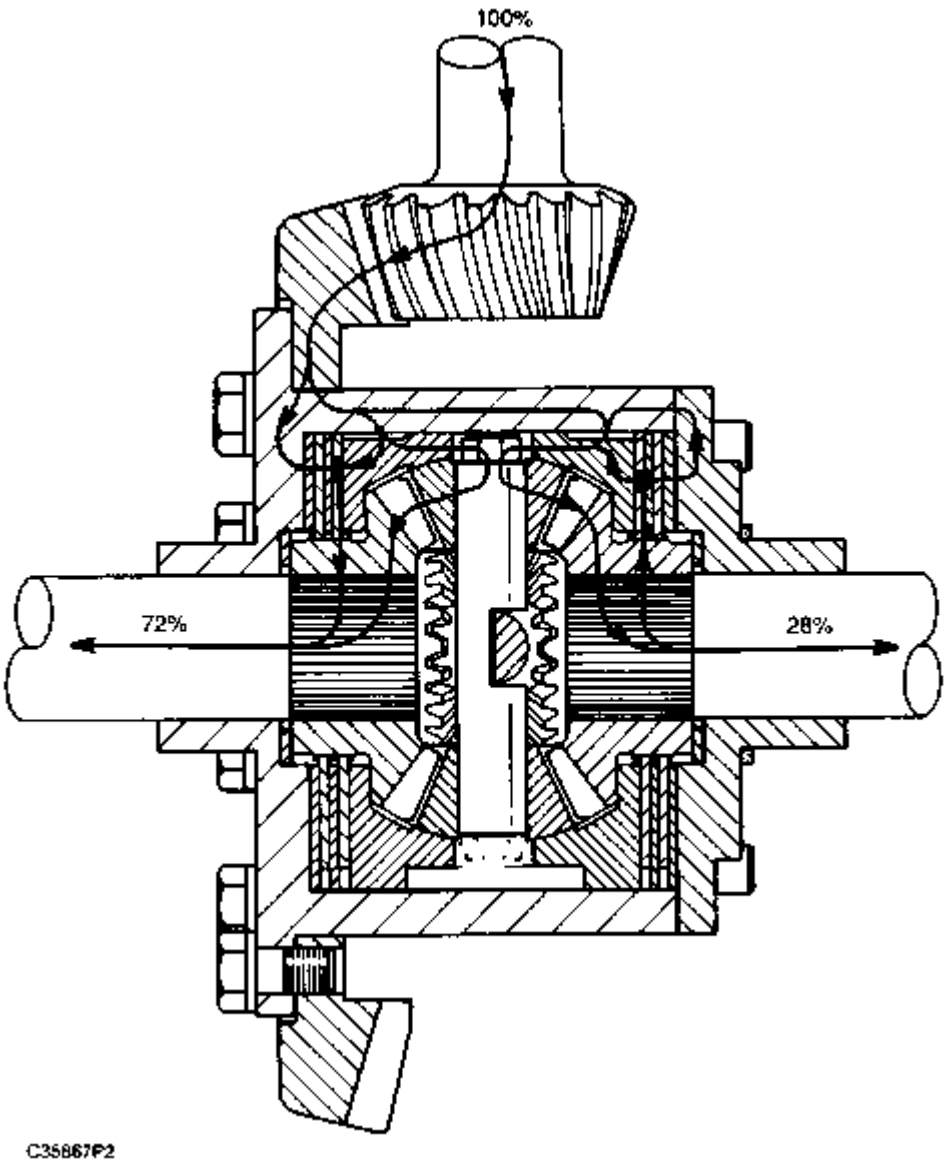
Limited Slip Differential (Disassembled)
(1) Housing. (2) Thrust washer. (3) Clutch pack. (4) Load rings. (5) Side gears. (6) Pinion (gears). (7) Pinion (gears). (8) Pinion shafts.

Limited Slip Differential Operation



Normal - No-slip Conditions

When the machine is in normal straight forward or reverse the limited slip differential acts the same as a standard differential with 50% of torque at each wheel.



Maximum Slipping Conditions

When one wheel starts to turn faster than the other; the clutch pack on the faster turning wheel is slipping, thus only 28% of the input torque is available at that wheel. And, 72% of input torque is available to the slower turning wheel. For example in a turn the inside tire provides 72% of the traction.

The advantage of a limited slip differential over a standard differential is evidenced by the torque difference.

A standard differential could only transfer the same torque from the slipping side to the opposite, while the limited slip differential can transfer 72/28 = 2.6 times the torque over the slipping side. So overall traction advantage would be 1 + 2.6/1 + 1 = 3.6/2 = 1.8 or 80% more traction for the limited slip differential in a slipping situation.

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