



PowerSynchro Transmission Systems Operation Testing & Adjusting

Models

***TH336, TH337,
TH406, TH407,
TH414, TH514,
TH417***

S/N TDE00100 & After
S/N TDF00100 & After
S/N TBX00100 & After
S/N TBY00100 & After
S/N TBZ00100 & After
S/N TBW00100 & After
S/N TBT00100 & After

31200562

Original
October 27, 2008

Important Safety Information

Most accidents that involve product operation, maintenance and repair are caused by failure to observe basic safety rules or precautions. An accident can often be avoided by recognizing potentially hazardous situations before an accident occurs. A person must be alert to potential hazards. This person should also have the necessary training, skills and tools to perform these functions properly.

Improper operation, lubrication, maintenance or repair of this product can be dangerous and could result in injury or death.

Do not operate or perform any lubrication, maintenance or repair on this product, until you have read and understood the operation, lubrication, maintenance and repair information.

Safety precautions and warnings are provided in this manual and on the product. If these hazard warnings are not heeded, bodily injury or death could occur to you or to other persons.

The hazards are identified by the "Safety Alert Symbol" and followed by a "Signal Word" such as "DANGER", "WARNING" or "CAUTION". The Safety Alert "WARNING" label is shown below.



The meaning of this safety alert symbol is as follows:

Attention! Become Alert! Your Safety is Involved.

The message that appears under the warning explains the hazard and can be either written or pictorially presented.

Operations that may cause product damage are identified by "NOTICE" labels on the product and in this publication.

Caterpillar cannot anticipate every possible circumstance that might involve a potential hazard. The warnings in this publication and on the product are, therefore, not all inclusive. If a tool, procedure, work method or operating technique that is not specifically recommended by Caterpillar is used, you must satisfy yourself that it is safe for you and for others. You should also ensure that the product will not be damaged or be made unsafe by the operation, lubrication, maintenance or repair procedures that you choose.

The information, specifications, and illustrations in this publication are on the basis of information that was available at the time that the publication was written. The specifications, torques, pressures, measurements, adjustments, illustrations, and other items can change at any time. These changes can affect the service that is given to the product. Obtain the complete and most current information before you start any job. Caterpillar dealers have the most current information available.



When replacement parts are required for this product Caterpillar recommends using Caterpillar replacement parts or parts with equivalent specifications including, but not limited to, physical dimensions, type, strength and material.

Failure to heed this warning can lead to premature failures, product damage, personal injury or death.

Table of Contents

Systems Operation Section

Graphic Color Codes	4
Introduction	5
General Information	6
Location of Electrical Components	7
Location of Hydraulic Components	11
Electrical Input Components	13
Electronic Control Module	16
Electrical Output Components	18
Data Link	19
Electrical Schematic	19
Transmission Charge Pump	22
Modulating Valve (Transmission)	22
Solenoid Valves (Transmission)	22
Torque Converter	24
Transmission	26
Cooler (Hydraulic Oil)	36
Transmission Control (Shift Lever)	36
Transmission Power Flow	38
Hydraulic Schematic (Power Train System)	43
Configuration Parameters	46

Testing and Adjusting Section

Testing and Adjusting

Transmission Shift Rail - Calibrate	47
Transmission Fill - Calibrate	54
Torque Converter Stall - Test	61
Transmission Pressures - Test and Adjust	62

Index Section

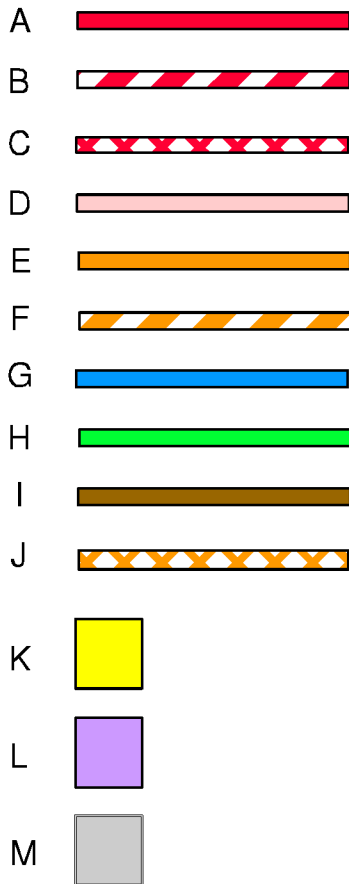
Index	69
-------------	----

Systems Operation Section

i01971789

Graphic Color Codes

SMCS Code: 4000



- (I) Brown Lubricating oil
- (J) Orange Crosshatch Second reduction in pilot, signal or torque converter oil
- (K) Yellow Moving or activated components
- (L) Purple Pneumatic pressure
- (M) Light Gray Surface color

Note: The information that is covered in this manual may not require all of the colors in Illustration 1.

Illustration 1

g01023555

- (A) Red High pressure oil
- (B) Red Stripes and White Stripes First pressure reduction
- (C) Red Crosshatch Second pressure reduction
- (D) Pink Third pressure reduction
- (E) Orange Pilot, signal or torque converter oil
- (F) Orange Stripes and White Stripes Reduced pilot, signal or torque converter oil
- (G) Blue Trapped oil
- (H) Green Tank, sump or return oil

i02075104

Introduction

SMCS Code: 4000



Illustration 2

This module discusses the features and operation of the power train. **The following Transmission arrangements are covered in this module:**

- 4 Speed 323-8993
- 5 Speed 323-8994

The power train for these machines has the following main components:

- Torque converter
- Transmission
- Front axle differential and rear axle differential
- Final drives for the front axle and final drives for the rear axle

i02120607

General Information

SMCS Code: 3000; 4000

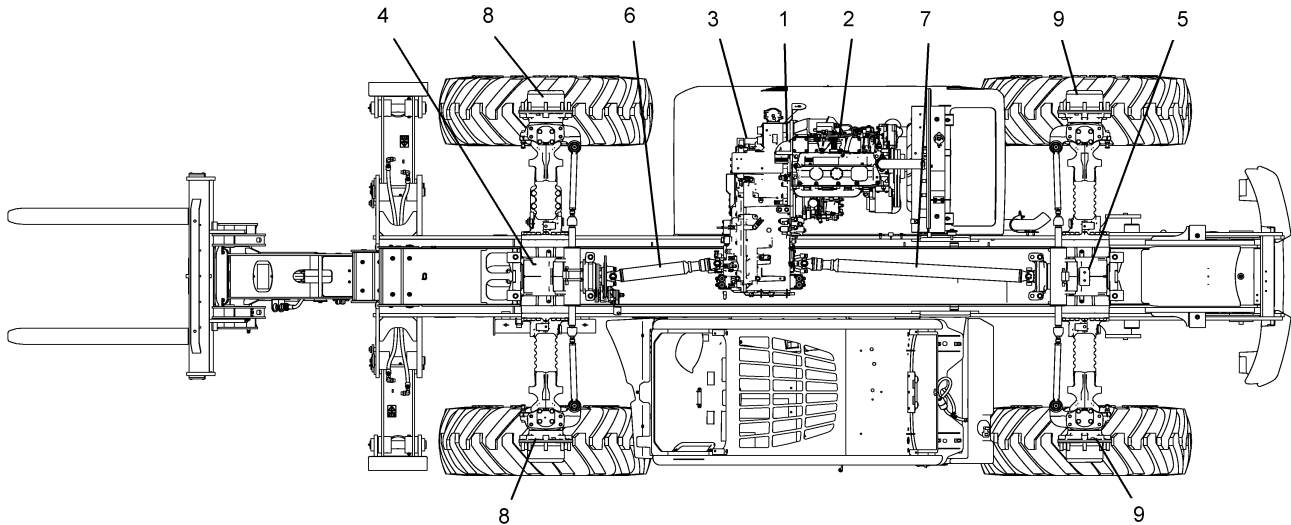


Illustration 3

(1) Torque converter
(2) Engine
(3) Transmission

(4) Front axle differential
(5) Rear axle differential
(6) Drive shaft (front axle)

(7) Drive shaft (rear axle)
(8) Final drive (front axle)
(9) Final drive (rear axle)

The power train consists of the following main components:

Torque converter (1) – The torque converter transfers power from engine (2) to transmission (3). The torque converter and the transmission are bolted as a unit to the flywheel housing on the engine.

Transmission (3) – The transmission has spur gears and helical gears that are in constant mesh on all shafts in order to provide a range of forward speeds and reverse speeds. The speed range and the direction (forward and reverse) are selected when the clutches and synchronizers lock specific gears to the shafts.

Front axle differential (4) and rear axle differential (5) – Power is directed to the differentials from the transmission via drive shafts (6) and (7). Each of the differentials has a ring gear and a pinion (bevel gear set) in order to provide the primary reduction. The differential for the front axle can be locked in order to improve traction on adverse ground conditions.

Final drives (8) for the front axle and final drives (9) for the rear axle – Power is transferred to the final drives for the front axle and to the final drives for the rear axle from differentials (4) and (5). The final drives in the front axle and in the rear axle have planetary gears. The planetary gears provide the secondary reduction.

The torque converter and the transmission have a common hydraulic system for operation, for lubrication, and for cooling. The transmission case and the hydraulic tank serve as an oil reservoir. Oil flow through the system is provided by a pump that is mounted on the casing for the transmission.

Machines are equipped with one of the following transmission arrangements:

- Powersynchro transmission arrangement with four speeds
- Powersynchro transmission arrangement with five speeds

Note: The five speed Powersynchro transmission is an option on some machines. Your machine may not have this option. The transmissions with five speeds and the transmissions with four speeds are identical except for the added components for the fifth speed. The Power Shuttle transmission is identical to the Powersynchro transmission with the exception of the mechanism for shifting the transmission.

Note: This machine must be serviced by a technician. The technician must be familiar with Caterpillar Electronic Technician (ET). A number of parameters can be installed and modified through the configuration screen. The configuration of the machine may appear as a interlock. See TESTING AND ADJUSTING, RENR5195, "ELECTRONIC CONTROL MODULE (ECM) - CONFIGURE" for information concerning the machine configuration.

The clutches and the synchronizers for the Powersynchro transmission are engaged by oil pressure. The oil pressure is controlled by solenoid valves that are mounted on the transmission.

- Position sensor for the shift rail (third gear and fourth gear)
- Position sensor for the shift rail (fifth gear)
- Electronic Control Module (ECM)
- Modulating valve
- Solenoid valves
- Transmission neutralizer override switch

i02121625

Location of Electrical Components

SMCS Code: 1400; 3030-PWT

The power train consists of the following electrical components:

- Transmission neutralizer switch
- Parking brake switch
- Service brake pressure switch
- Transmission direction control lever (Power Shuttle transmission)
- Transmission speed selector (Powersynchro transmission)
- Transmission oil temperature sensor
- Engine speed sensor
- Torque converter output speed sensor
- Transmission intermediate speed sensor
- Transmission output speed sensor
- Position sensor for the shift rail (first gear and second gear)

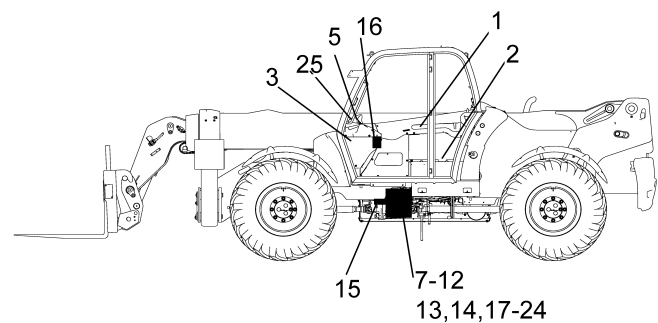
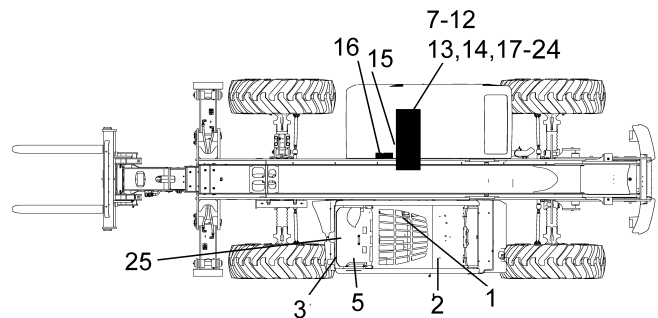


Illustration 4

- (1) Transmission neutralizer switch (on joystick)
- (2) Parking brake switch
- (3) Service brake pressure switch
- (5) Transmission speed selector (powersynchro transmission)
- (7) Transmission oil temperature sensor
- (9) Engine speed sensor
- (10) Torque converter output speed sensor
- (11) Transmission intermediate speed sensor
- (12) Transmission output speed sensor
- (13) Position sensor for the shift rail (first gear and second gear)
- (14) Position sensor for the shift rail (third gear and fourth gear)
- (15) Position sensor for the shift rail (fifth gear)
- (16) Electronic control module
- (17) Modulating valve
- (18) First gear (solenoid valve)
- (19) Second gear (solenoid valve)
- (20) Third gear (solenoid valve)
- (21) Fourth gear (solenoid valve)
- (22) Fifth gear (solenoid valve (if equipped))
- (23) Forward clutch solenoid valve
- (24) Reverse clutch solenoid valve
- (25) Transmission neutralizer override switch

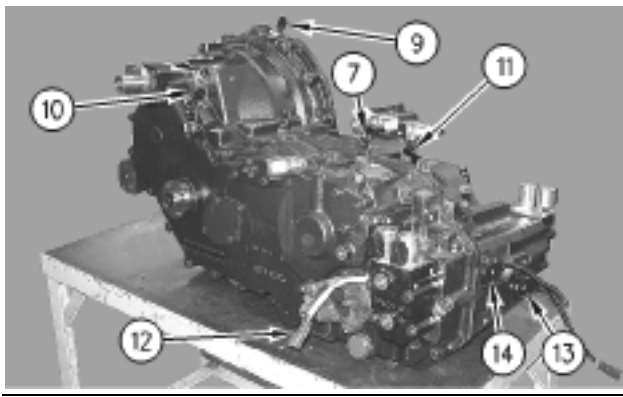


Illustration 5
Powersynchro Transmission (Four Speed)
(7) Transmission oil temperature sensor (Torque Converter outlet)
(9) Engine speed sensor
(10) Torque converter output speed sensor
(11) Transmission intermediate speed sensor
(12) Transmission output speed sensor
(13) Position sensor for the shift rail (first gear and second gear)
(14) Position sensor for the shift rail (third gear and fourth gear)

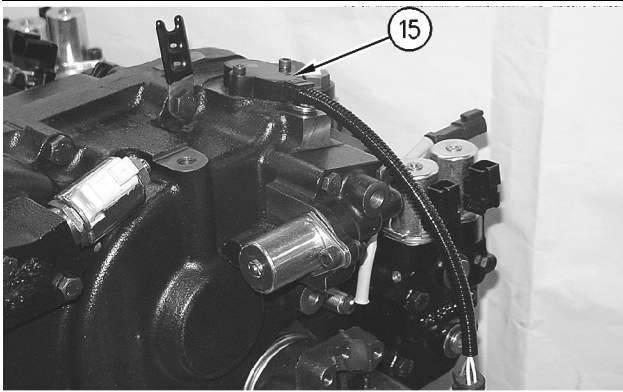


Illustration 6
g00890792
(15) Position sensor for the shift rail (fifth gear)

Transmission Neutralizer Switch

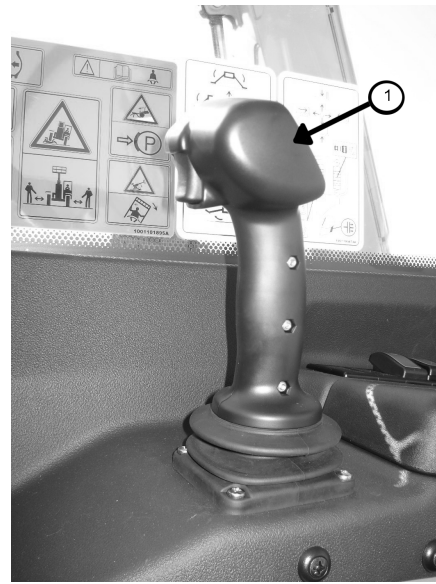


Illustration 7
The neutralizer switch is located on the top of the joystick lever. The neutralizer switch allows the operator to neutralize the transmission during transmission shifts.

Parking Brake Switch

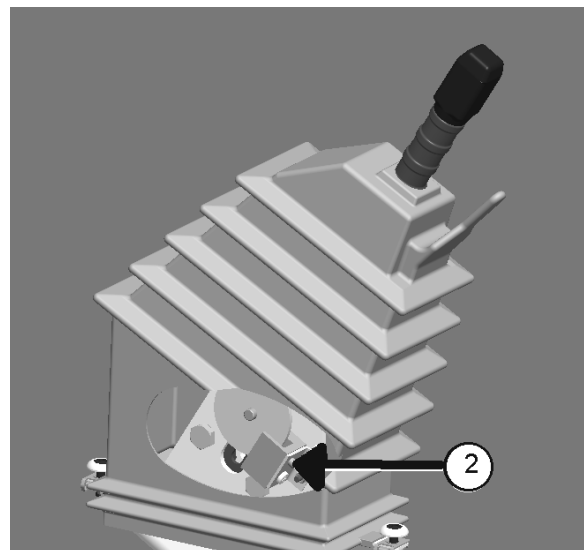


Illustration 8
Parking brake switch (2) is located inside the housing for the parking brake on the brake mechanism. The parking brake switch sends a signal to the ECM when the parking brake is applied.

Service Brake Pressure Switch

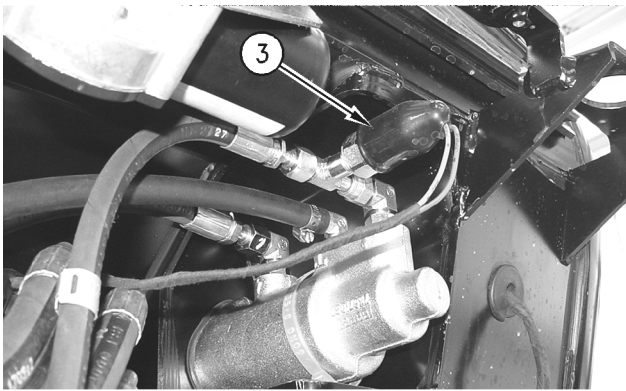


Illustration 9

g00903938

Service brake pressure switch (3) is located on the end of the brake cylinder. Remove the cover from the front of the cab in order to gain access to the service brake pressure switch. The service brake pressure switch sends a signal to the ECM in order to neutralize the transmission when the brakes are applied.

Transmission Speed Selector (Powersynchro Transmission)



Illustration 10

Lever (5) for the transmission speed selector is located on the left side of the steering column. The transmission speed selector sends a signal to the ECM in order to control the speed and direction of the machine.

Transmission Oil Temperature Sensor

Transmission oil temperature sensor (7) is located on the transmission housing next to the forward and reverse solenoids. Refer to Illustration 5. The transmission oil temperature sensor sends a signal to the ECM regarding the temperature of the transmission oil.

Engine Speed Sensor

Engine speed sensor (9) is located at the interface of the torque converter housing and the engine. Refer to Illustration 5. The engine speed sensor sends a signal to the ECM regarding the speed of the engine.

Torque Converter Output Speed Sensor

Torque converter output speed sensor (10) is located on the transmission housing in front of the torque converter. Refer to Illustration 5. The torque converter output speed sensor sends a signal to the ECM regarding the speed of the torque converter.

Transmission Intermediate Speed Sensors

The transmission intermediate speed sensors (11) are located on the transmission housing. Refer to Illustration 5. The transmission intermediate speed sensors send signals to the ECM regarding the speed of the transmission shafts.

Transmission Output Speed Sensor

Transmission output speed sensor (12) is located on the transmission housing above the yoke for the drive shaft to the front axle. Refer to Illustration 5. The transmission output speed sensor sends a signal to the ECM regarding the output speed of the transmission.

Shift Rail Sensors

The position sensors for the shift rails are located on the housing for the Powersynchro transmission. Refer to Illustration 5. The position sensors for the shift rails send signals to the ECM regarding the position of the shift rails.

Machines with four speeds are equipped with the following position sensors for the shift rails:

- Position sensor (13) for the shift rail (first gear and second gear)
- Position sensor (14) for the shift rail (third gear and fourth gear)

Machines with five speeds are equipped with the following position sensors for the shift rails:

- Position sensor (13) for the shift rail (first gear and second gear)
- Position sensor (14) for the shift rail (third gear and fourth gear)
- Position sensor (15) for the shift rail (fifth gear)

Electronic Control Module

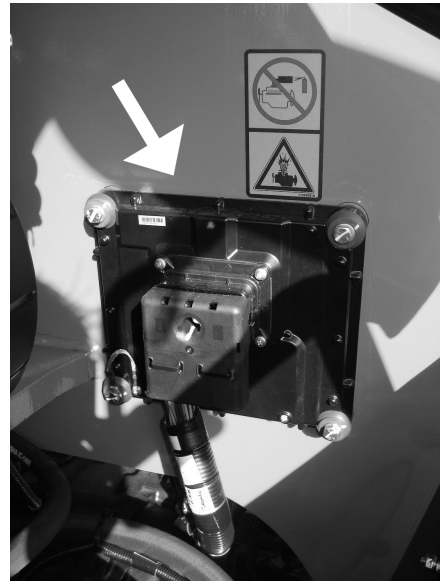


Illustration 11

Electronic control module (16) is mounted under the engine hood. The electronic control module is required for machines with Powersynchro transmission or the Power Shuttle transmission. The ECM controls the operation of the power train.

Modulating Valve for the Synchronizers

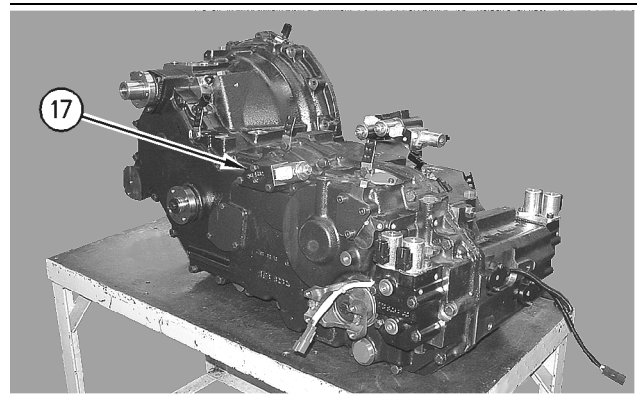


Illustration 12

g00947395

Modulating valve (17) for the powersynchro transmission is mounted on the front of the transmission. The modulating valve receives a signal from the ECM in order to control the oil pressure that is sent to the shift rails.

Solenoid Valves

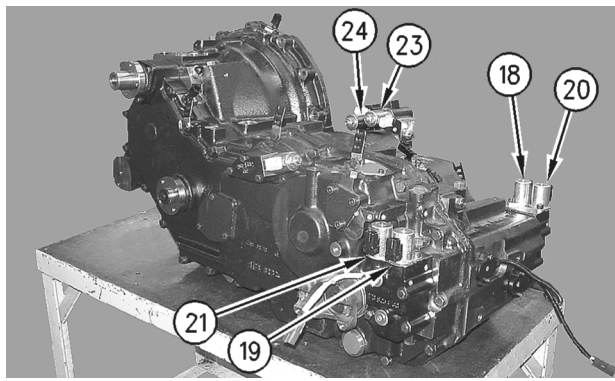


Illustration 13

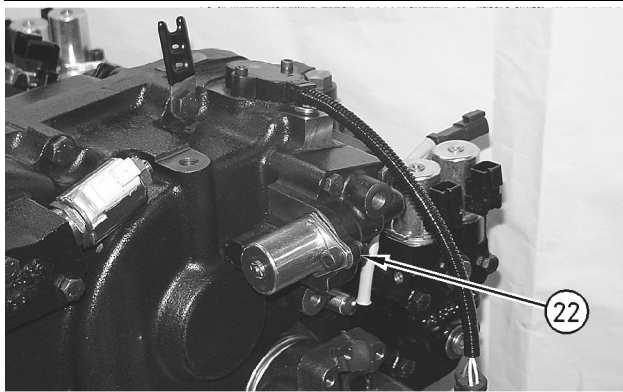


Illustration 14

g00947390

Powersynchro Transmission with Five Speeds

- (18) First gear (solenoid valve)
- (19) Second gear (solenoid valve)
- (20) Third gear (solenoid valve)
- (21) Fourth gear (solenoid valve)
- (22) Fifth gear (solenoid valve (if equipped))
- (23) Forward clutch (solenoid valve)
- (24) Reverse clutch (solenoid valve)

The solenoid valves receive signals from the ECM in order to control the oil that is sent to the transmission clutches and the shift rails.

Transmission Neutralizer Override Switch



Illustration 15

The transmission neutralizer override switch (25) is located on the left side of the dash panel. When the brakes are applied the transmission is neutralized in order to provide more hydraulic power to the implement system. The transmission neutralizer override switch may be used to prevent the transmission from neutralizing when the brakes are applied.

Reference: See Systems Operation/Testing and Adjusting, “Electrical Input Components” for more information on the electrical components.

i01925762

Location of Hydraulic Components

SMCS Code: 5050

The power train consists of the following hydraulic components:

- Transmission charge pump
- Torque converter
- Hydraulic oil cooler

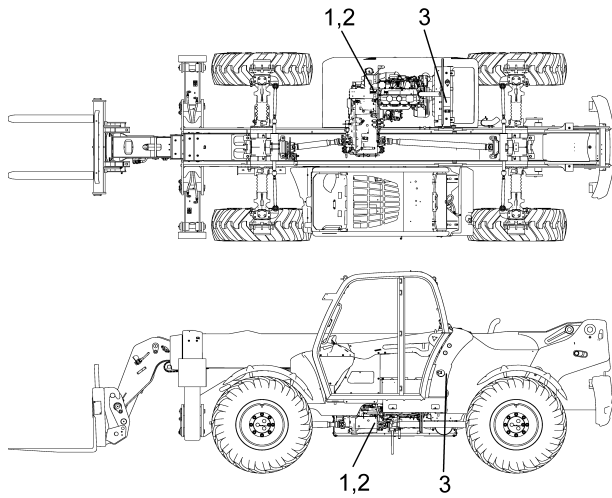


Illustration 16

- (1) Transmission charge pump
- (2) Torque converter
- (3) Hydraulic oil cooler

Transmission Charge Pump

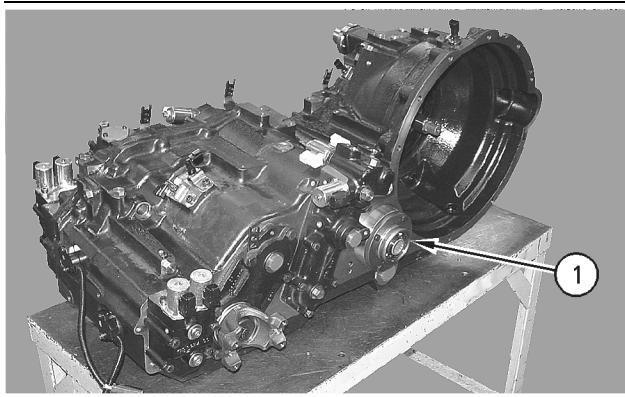


Illustration 17

g00884634

Transmission charge pump (1) is mounted on the rear of the transmission. The transmission charge pump supplies oil to the torque converter and the solenoid valves in the power train.

Torque Converter

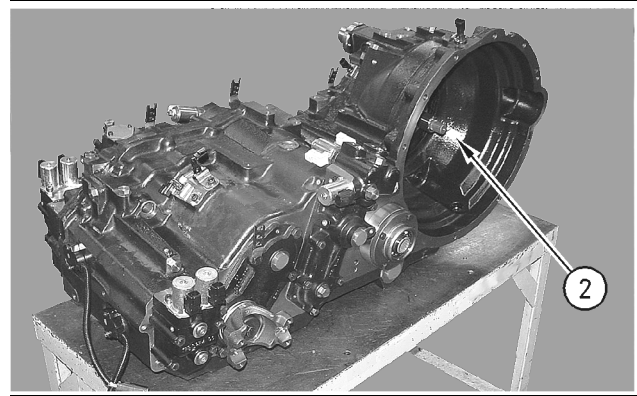


Illustration 18

g00908442

Torque converter (2) is located at the interface between the engine and the transmission. The torque converter hydraulically connects the engine to the transmission.

Hydraulic Oil Cooler

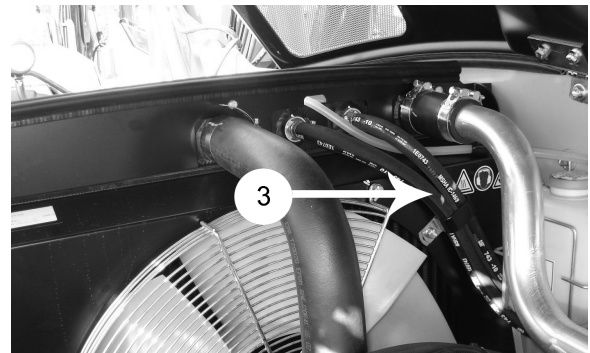


Illustration 19

Hydraulic oil cooler (3) is located inside the engine enclosure to the right of the transmission. The hydraulic oil cooler cools the hydraulic oil.

i01904225

Electrical Input Components

SMCS Code: 1435; 1907; 3175; 509T

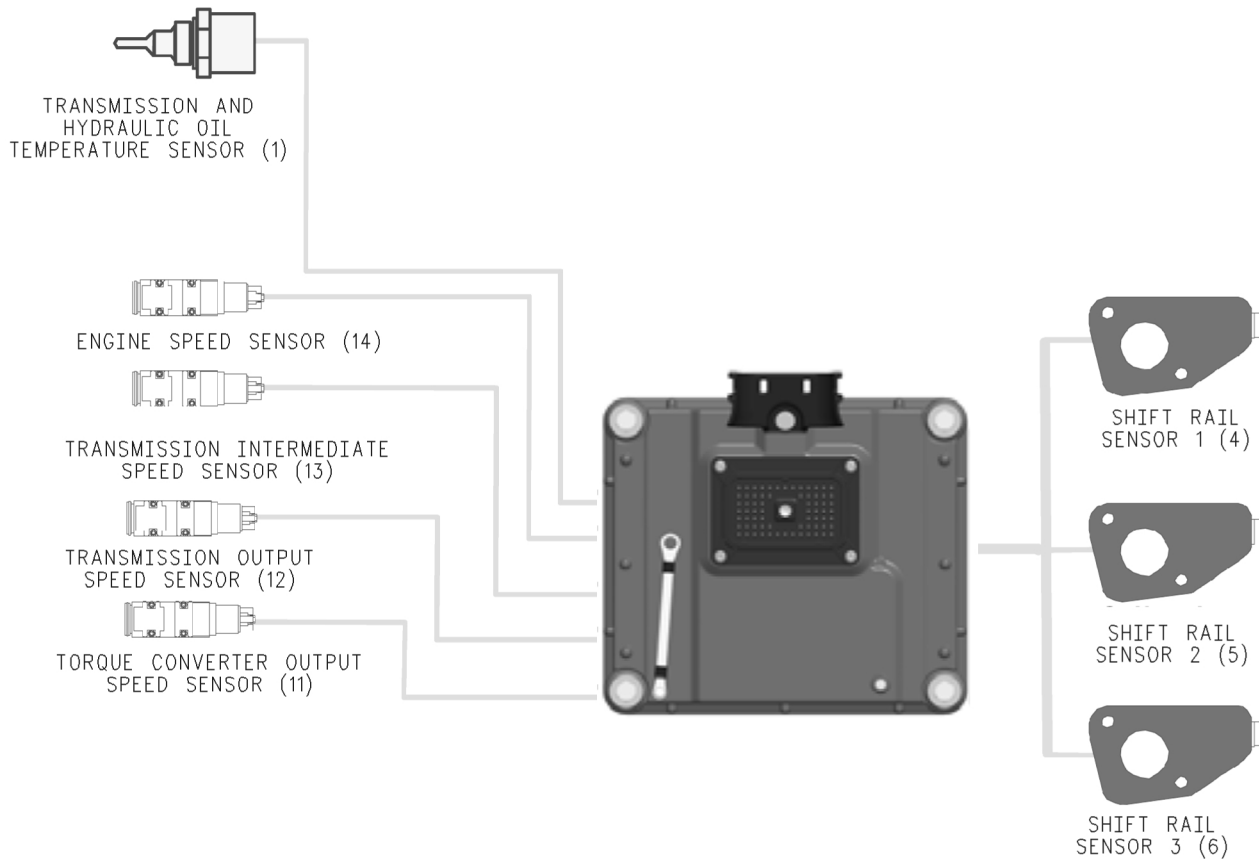


Illustration 20

Block Diagram of Input Components

Sensors

Sensors provide information to the ECM about changing conditions. The sensor signal changes proportionally to the changing conditions. The following type of sensor signals are recognized by the machine ECM.

Frequency – This type of sensor produces a signal that varies in frequency as the condition changes.

Pulse Width Modulated Sensor (PWM) – This type of sensor produces a digital signal with a duty cycle that varies as the condition changes. The frequency of this signal is constant.

Speed Sensors

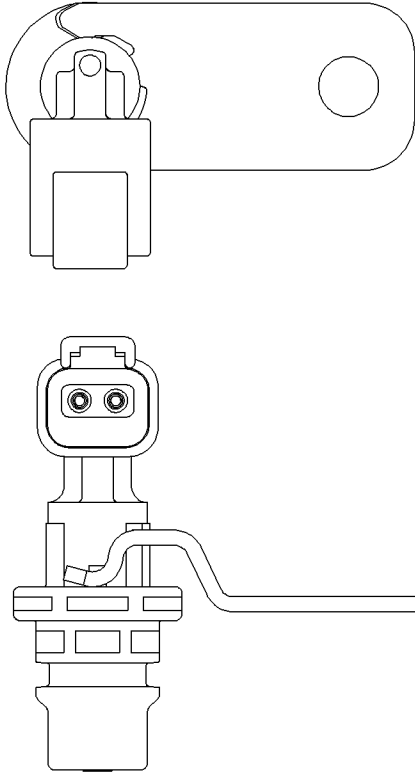


Illustration 21

g00899619

Engine Speed Sensor (Mechanical Engine)

The engine speed sensor (14) is used to measure the speed of the engine. The sensor is an input to the ECM. The sensor connects to contact 62 and contact 63.

Torque Converter Output Speed Sensor

The torque converter output speed sensor (11) is used in order to measure the speed at the output of the torque converter. The value that is measured is compared with the value of the engine speed signal from the engine speed sensor in order to calculate the ratio of the torque converter output speed. The sensor is an input to the ECM. The sensor connects to contact 60 and contact 61.

Transmission Intermediate Speed Sensor

The transmission intermediate speed sensor (13) is used in order to measure the intermediate shaft speed of the transmission. The sensor is an input to the ECM. The sensor connects to contact 18 and contact 52.

Transmission Output Speed Sensor

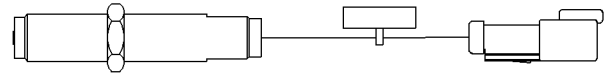
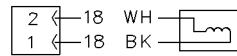


Illustration 22

g00899623

The transmission output speed sensor (12) is used in order to measure the output speed of the transmission. The value that is measured is used in order to control both upshifts and downshifts. The sensor is an input to the ECM. The sensor connects to contact 5 and contact 6.

Temperature Sensor (Transmission and Hydraulic Oil)

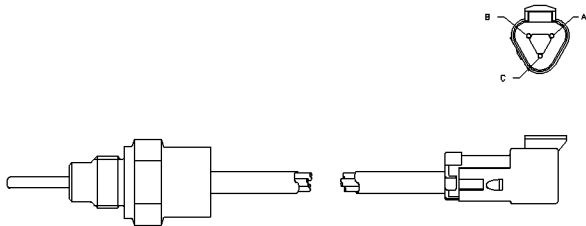


Illustration 23

g00991216

The hydraulic oil temperature sensor (1) is an input to the ECM. The sensor provides an input signal to the ECM. The sensor connects to the ECM through contacts 36 and 56.

Sensor (Shift Rail 1), Sensor (Shift Rail 2), and Sensor (Shift Rail 3)

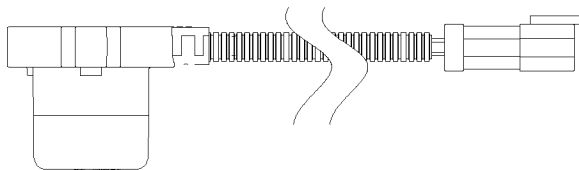


Illustration 24

g00901162

The sensors for the shift rails detect the position of the shift rails. The sensors send a signal to the ECM regarding the position of the rails. The ECM will determine if the transmission has been neutralized by the position of the rails. The sensors connect to the ECM through the following contacts: 29,30,31,55, and 68.

Switches

Switches provide an open signal, a ground signal, or a +battery signal to the inputs of the ECM. Switches are open or closed.

- When a switch is open, no signal is provided to the corresponding input of the ECM. This “no signal” condition is also called “floating”.
- When a switch is closed, a ground signal or a +battery signal is provided to the corresponding input of the ECM.

Switch (Parking Brake)

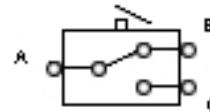


Illustration 25

The parking brake switch (9) tells the ECM that the operator has the parking brake lever in the PARK position. When the operator places the parking brake lever in the PARK position, the normally closed circuit is open and the normally open circuit is closed to ground. When the lever is NOT in the PARK position, the normally closed circuit is open and the normally open circuit is open. The switch connects to the ECM through a CAN signal sent from the Machine Controller.

Switch (Service Brake Pressure)

The service brake pressure switch (10) is used to monitor the pressure in the service brake system. The service brake pressure switch sends a signal to the ECM and the ECM neutralizes the transmission when the pressure reaches a set point. The ECM will engage the transmission when the pressure decreases below a set point. The switch is located on the brake cylinder. The switch connects to the ECM through a CAN signal sent from the Machine Controller.

i01904222

Electronic Control Module

SMCS Code: 7610

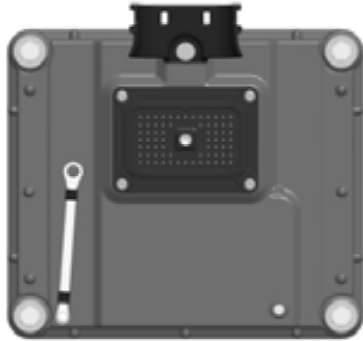


Illustration 26

Electronic Control Module (ECM)

The control is used for the powersynchro transmissions.

The electronic control module (ECM) makes decisions that are based on input information and memory information. After the ECM receives the input information, the ECM sends a corresponding response to the outputs. The inputs and outputs of the ECM are connected to the machine harness by a 70 contact connector (J1). The ECM is located on the right side of the machine inside the engine compartment. The ECM sends the information to the Caterpillar Electronic Technician on the CAN data link.

Note: The ECM is not serviceable. The ECM must be replaced if the ECM is damaged. Replace the ECM if a failure is diagnosed.

Inputs

The inputs describe the status of the machine systems. Two types of inputs exist. The inputs can be either a switch type or a sensor type. Switches provide an open, a ground, or a + battery signal to the inputs of the controller. Sensors (frequency, PWM or voltage) provide a changing signal to the sensor inputs of the controller. The inputs to the ECM are listed in table 1.

Outputs

The ECM responds to decisions by sending electrical signals to the outputs. The outputs can create an action or the outputs can provide information to the operator or the service technician. The outputs of the machine ECM are listed in table 1.

Input/Output

The CAN data link is used in order to provide a connection for the service tool for troubleshooting, testing, and calibrations. The data link is bidirectional. The data link allows the ECM to receive information. The data link allows the ECM to send information.

Table 1

Contact Description		
No.	Function	Type
1	permanent +Battery connection	+BATTERY
2	permanent -Battery connection	-BATTERY
3	switched connection to +Battery	KEY SWITCH
5	transmission output sp+	Differential Speed Sensor Input 1+
6	transmission output sp-	Differential Speed Sensor Input 1-
14	permanent +Batt connection	+BATTERY
15	permanent -Battery connection	-BATTERY
18	intermediate xmsn spd +	Differential Speed Sensor Input 2+
24	permanent +Batt connection	+BATTERY
25	permanent -Battery connection	-BATTERY
26	synchronizer solenoid 1 (HS / drive)	DRVR 1 HS
27	synchronizer solenoid 1 (LS / sense)	DRVR 1 LS
29	shift rail sensor 1	PWM/FREQ 4
30	shift rail sensor 2	PWM/FREQ 5
31	shift rail sensor 3	PWM/FREQ 6
32	synchronizer solenoid 2 (HS / drive)	DRVR 2 HS
33	synchronizer solenoid 2 (LS / sense)	DRVR 2 LS
34	synchronizer solenoid 3 (HS / drive)	DRVR 3 HS
35	synchronizer solenoid 3 (LS / sense)	DRVR 3 LS
36	xmsn 'bulk' oil temp sensor (passive)	ACTIVE/PASSIVE ANALOG IN 1 (AIN)
40	synchronizer solenoid 4 (HS / drive)	DRVR 4 HS
41	synchronizer solenoid 4 (LS / sense)	DRVR 4 LS

Contact Description		
No.	Function	Type
42	synchronizer solenoid 5 (HS / drive)	DRVR 5 HS
43	synchronizer solenoid 5 (LS / sense)	DRVR 5 LS
48	sync modulation solenoid (HS / drive)	DRVR 6 HS
49	sync modulation solenoid (LS / sense)	DRVR 6 LS
50	xmsn forward clutch (HS / drive)	DRVR 7 HS
51	xmsn forward clutch (LS / sense)	DRVR 7 LS
52	intermediate xmsn spd -	Differential Speed Sensor Input 2-
53	optional	CAN A Shield (CAN A SHIELD)
55	return for shift rail sensors	Sensor Return (VS_RETURN)
56	return for 'bulk' oil temp sensor	Sensor Return (VS_RETURN)
58	xmsn reverse clutch (HS / drive)	DRVR 8 HS
59	xmsn reverse clutch (LS / sense)	DRVR 8 LS
60	convertor output speed sensor+	Differential Speed Sensor Input 3+
61	convertor output speed sensor-	Differential Speed Sensor Input 3-
62	engine speed sensor+	Differential Speed Sensor Input 4+
63	engine speed sensor-	Differential Speed Sensor Input 4-
64	connection to CAN bus	CAN A+ (CAN_A_HI)
65	connection to CAN bus	CAN A- (CAN_A_LO)
68	sensor supply for shift rail sensors	SENSOR POWER 1 (VS_5_8_330MA)

The ECM responds to an active input only when all the necessary conditions are satisfied.
The connector contacts that are not listed are not used.

i01938988

Electrical Output Components

SMCS Code: 3155; 3174; 5479

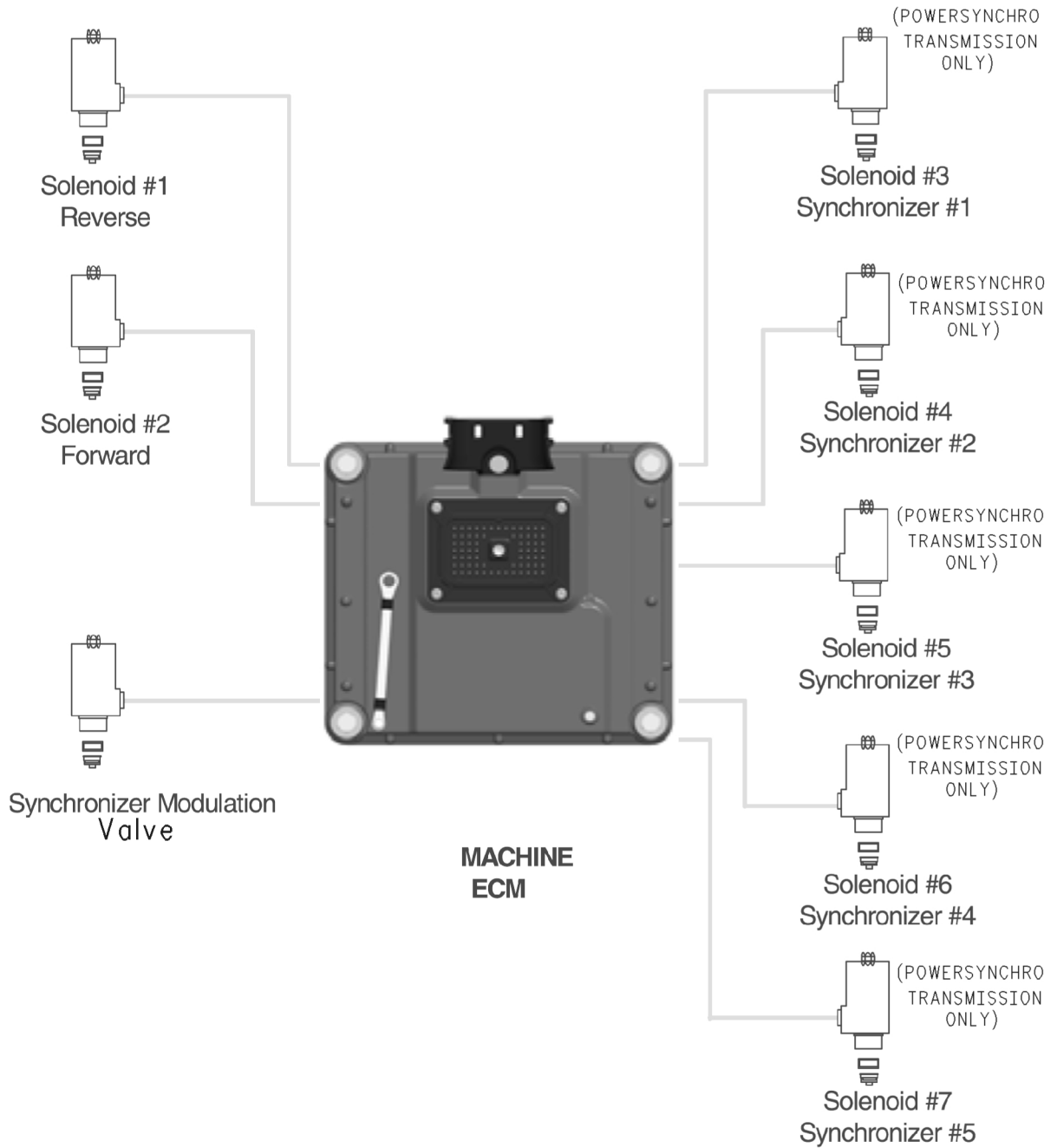


Illustration 27

Table 2

Solenoid	Function
Transmission Solenoid 1	This solenoid controls the reverse direction clutch.
Transmission Solenoid 2	This solenoid controls the forward direction clutch.
Transmission Solenoid 3	This solenoid engages the first synchronizer.
Transmission Solenoid 4	This solenoid engages the second synchronizer.
Transmission Solenoid 5	This solenoid engages the third synchronizer.
Transmission Solenoid 6	This solenoid engages the fourth synchronizer.
Transmission Solenoid 7	This solenoid engages the fifth synchronizer.

The transmission solenoids use a combination of proportional solenoids and on/off solenoids.

The directional solenoids are proportional solenoids. The proportional solenoids allow better shift modulation.

The speed or synchronizer solenoids will be on/off solenoids.

The synchronizer modulation valve aids in the shifting of the transmission.

Synchronizer Solenoids

- Solenoid Valve 3 (Synchronizer 1)
- Solenoid Valve 4 (Synchronizer 2)
- Solenoid Valve 5 (Synchronizer 3)
- Solenoid Valve 6 (Synchronizer 4)
- Solenoid Valve 7 (Synchronizer 5)

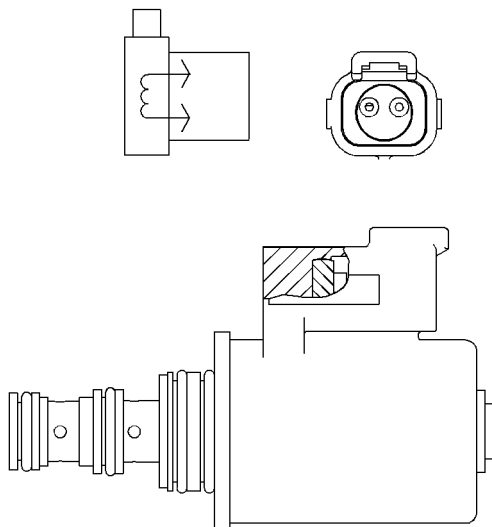


Illustration 28

g01009007

Directional Solenoids

- Solenoid Valve 1 (Reverse)
- Solenoid Valve 2 (Forward)
- Modulation Valve (Synchronizer)

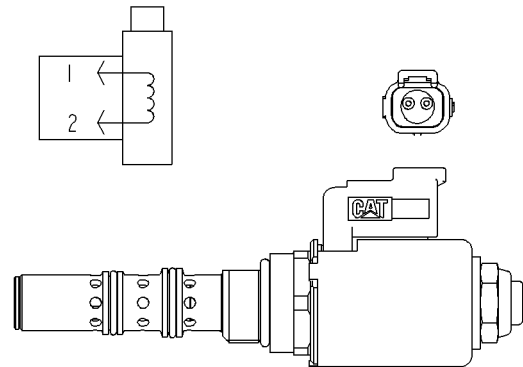


Illustration 29

g00899201

Data Link

CAN Data Link

The CAN Data Link is used in order to aid the transmission ECM with the control of the transmission.

i01904226

Electrical Schematic

SMCS Code: 7566-PWT

This is a simplified schematic of the power train system for the machine ECM. This schematic does not show all possible harness connectors. Always see the Electrical System Schematic in the Service Manual for the machine for an accurate schematic of a particular machine.

XMSN
CONTROLLER
MODULE

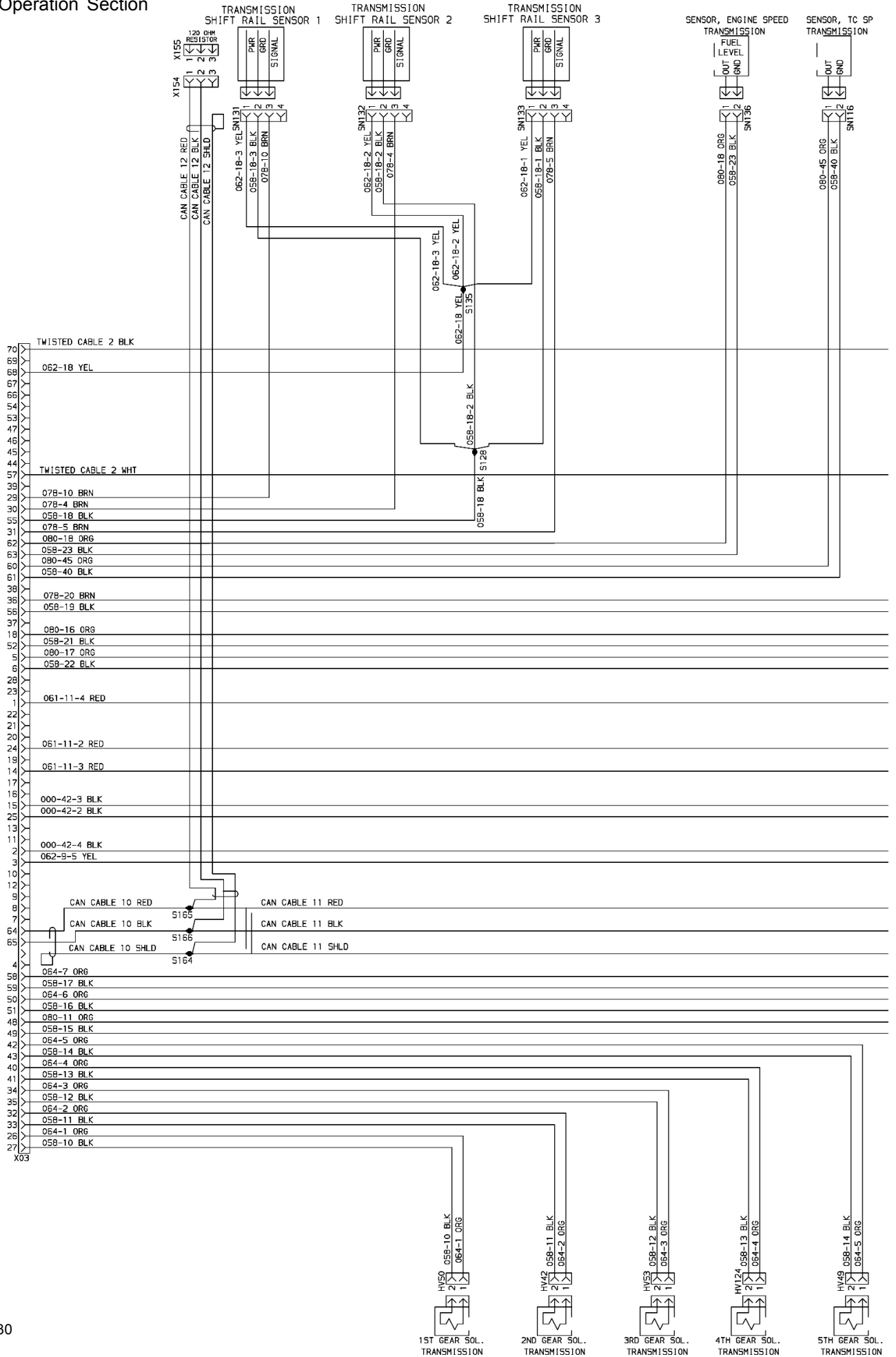
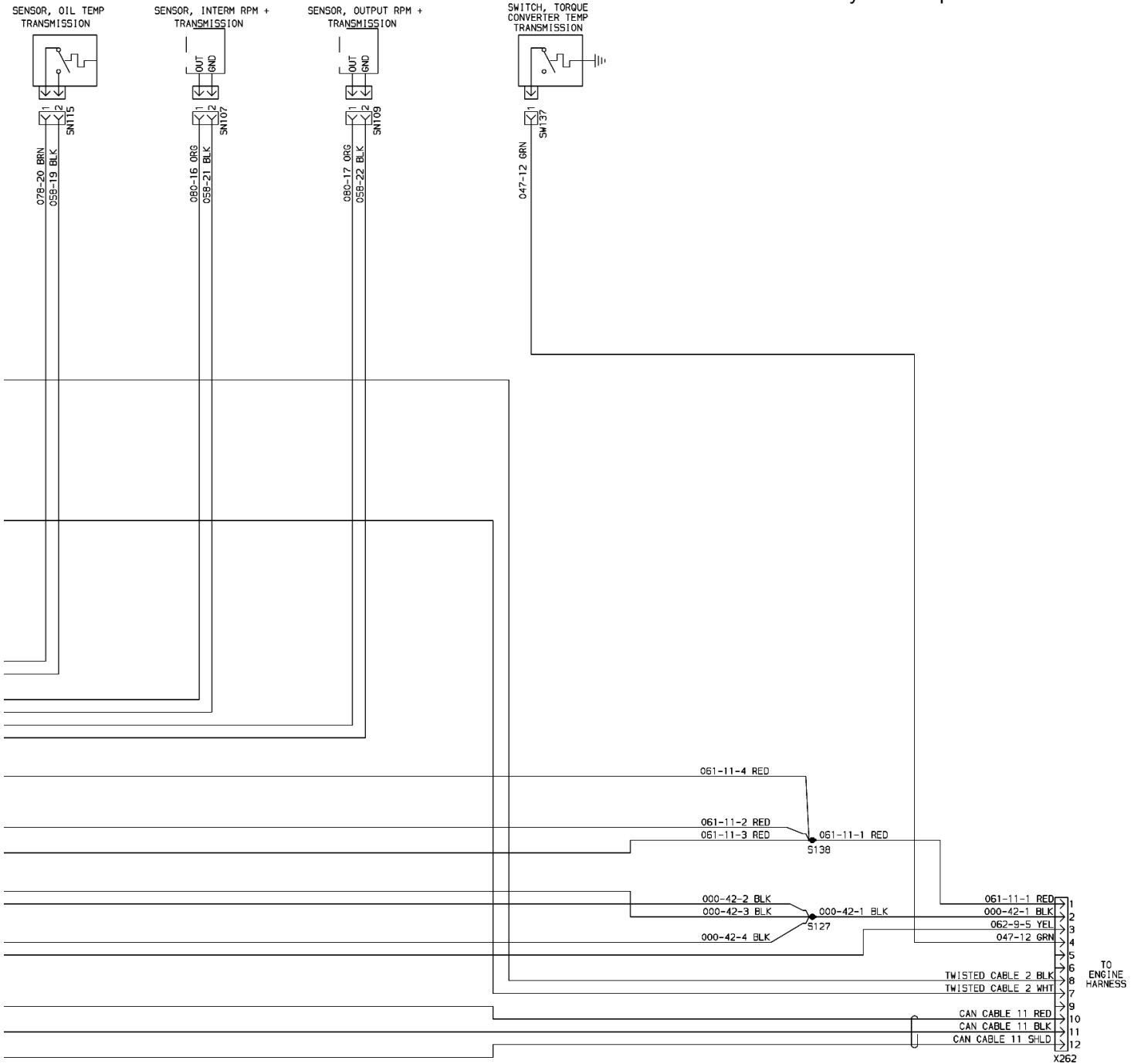
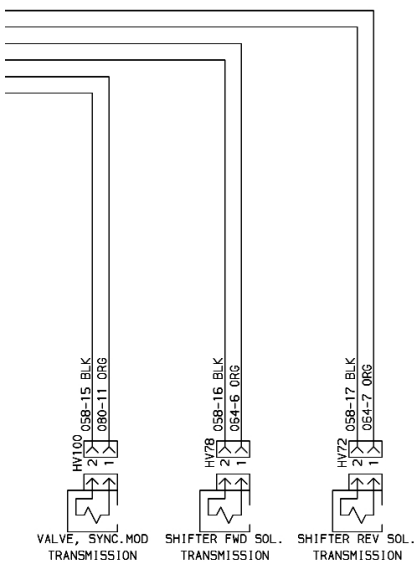


Illustration 30



TRANSMISSION
HARNESS
1001093378



i01897249

Transmission Charge Pump

SMCS Code: 3066

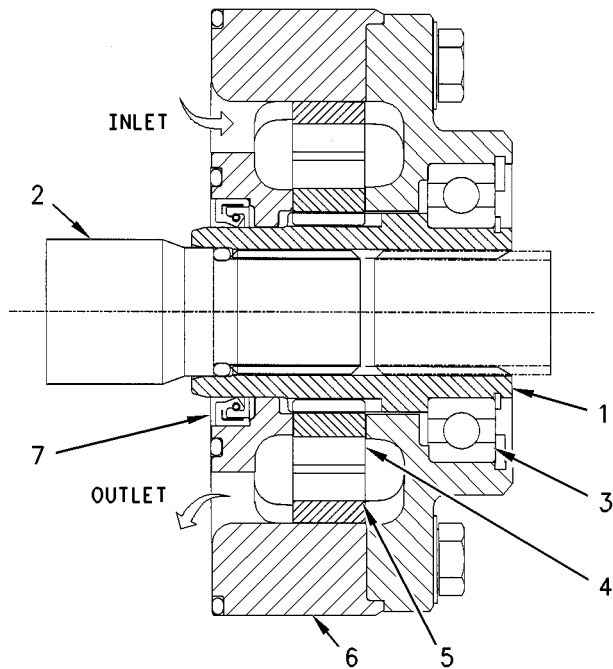


Illustration 31

g00889728

- (1) Sleeve
- (2) Pump drive shaft (transmission)
- (3) Ball bearing
- (4) Rotor
- (5) Ring Gear
- (6) Housing
- (7) Seal

The charge pump for the torque converter and the transmission is a crescent type gear pump that is driven by the pump drive shaft of the transmission. The clearances between the components within the charge pump are very small in order to keep losses in efficiency to a minimum.

The charge pump consists of the following main components:

Sleeve (1) – The sleeve is splined to pump drive shaft (2) of the transmission. The sleeve which has external tangs rotates with the pump drive shaft on ball bearing (3).

Rotor (4) – Tangs on the outside of sleeve (1) drive the ring gear.

Ring Gear (5) – Rotor (4) is meshed with the rotor. As the rotor and the ring gear rotate inside housing (6), oil is drawn through the inlet. The oil is then forced past a crescent and out of the outlet.

Crescent (not shown) – Ring gear (5) is offset from rotor (4), and the teeth of these components only mesh on one side of the pump. The crescent separates the ring gear and the rotor on the other side of the pump. The pump creates oil flow from the inlet port to the outlet port by trapping oil in the spaces between the rotor, the teeth on the ring gear and the crescent.

Seal (7) – The seal prevents oil from escaping between rotating sleeve (1) and housing (6).

i01876669

Modulating Valve (Transmission)

SMCS Code: 3073

The modulating valve that is used for controlling the clutches and the synchronizer solenoids is a proportional pressure reducing valve. The valve reduces the system pressure in an inverse proportion to the current that is supplied to the valve solenoid. When no current is supplied, the outlet port is connected to the tank and the supply is cut off. The valve is pilot operated. The force of the solenoid acts on a small pilot stage. This force allows the main control spool to be hydraulically operated. The relatively low force of the solenoid is magnified in order to enable a relatively large flow through the valve.

Note: The maximum oil pressure that will flow through the valve is always reduced. The valve reduces the system pressure by about 150 kPa (22 psi).

i02121680

Solenoid Valves (Transmission)

SMCS Code: 3030; 5479

The transmission solenoids are a combination of proportional solenoids and on/off solenoids.

The transmission direction control will energize the solenoids in order to control the direction of the output shaft. The transmission direction control also energizes the solenoids in order to control the speeds in the powersynchro transmission.

Reference: See Systems Operation/Testing and Adjusting, “Location of Electrical Components” for more information on the location of the solenoids.

The solenoids control the following functions on the machine:

- Forward/Reverse Clutches
- Gear Selection (powersynchro transmission)
- Fifth Gear Selection (if equipped)

Directional Solenoids

The directional solenoids are proportional solenoids. The proportional solenoids allow better directional clutch pressure modulation as the solenoids are energized in order to achieve smooth gear changes.

Speed or Synchronized Solenoids

The speed solenoids or synchronized solenoids are on/off solenoids. The speed solenoids and the synchronized solenoids are used on the powersynchro transmission in order to control the output direction and gear.

Torque Converter

SMCS Code: 3101

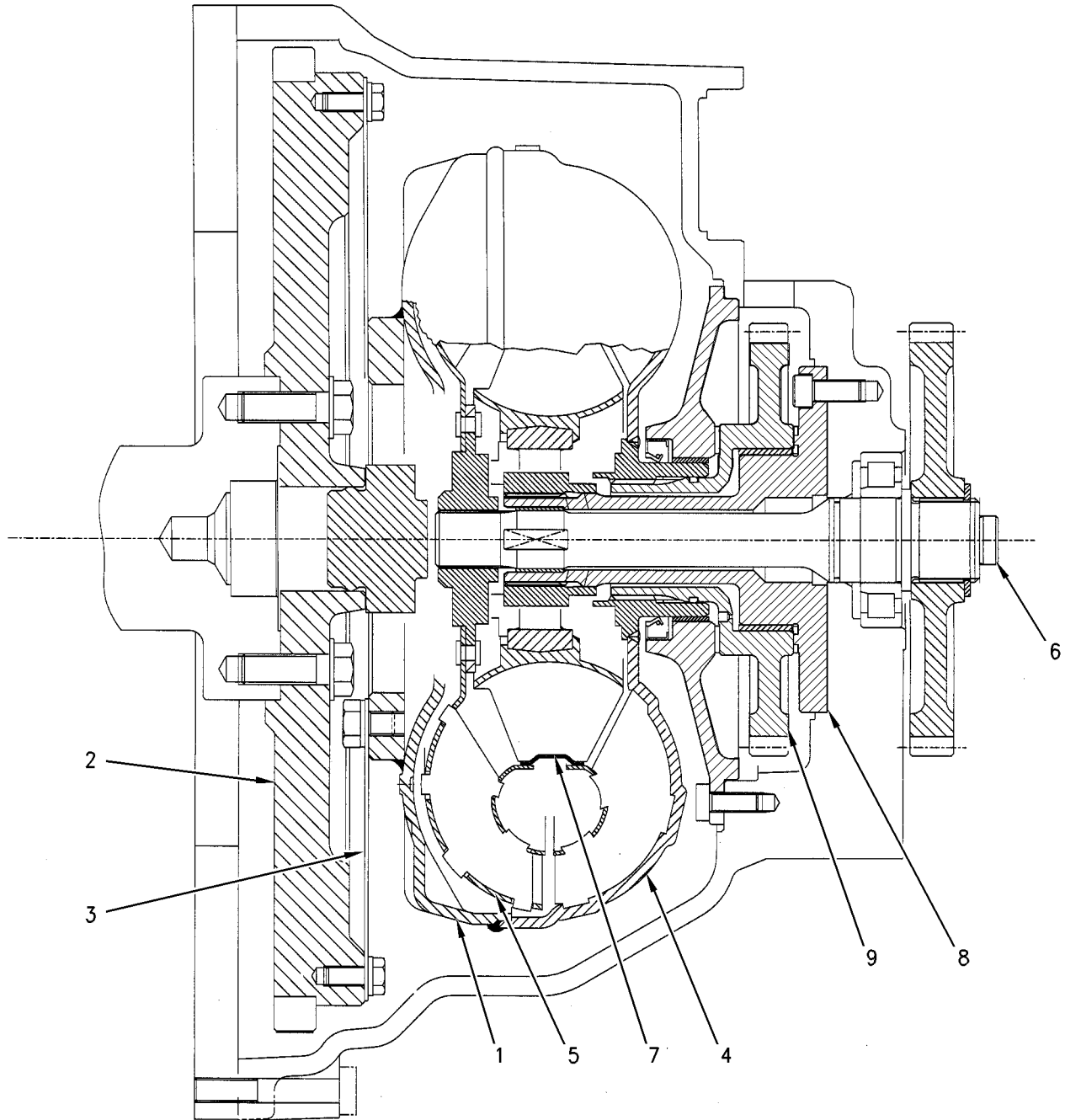


Illustration 32

g00889374

- | | | |
|---------------------|------------------------------|------------|
| (1) Housing | (4) Impeller | (7) Stator |
| (2) Engine flywheel | (5) Turbine | (8) Sleeve |
| (3) Drive plate | (6) Transmission input shaft | (9) Gear |

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

Torque Converter

When the machine works against a load, the torque converter can multiply the torque from the engine in order to send a higher torque to the transmission. The oil for the operation of the torque converter is supplied by the charge pump for the transmission. Refer to Systems Operation/Testing and Adjusting, "Transmission Charge Pump" for further information.

The torque converter has the following main components:

Housing (1) – The housing is connected to engine flywheel (2) through drive plate (3).

Impeller (4) – The impeller, which is connected to housing (1), rotates with engine flywheel (2) at engine speed. When the housing and the impeller turn, oil is directed toward the outside of the impeller and against the blades of turbine (5).

Turbine (5) – The force of the oil that contacts the turbine blades causes the turbine and input shaft (6) for the transmission to rotate. The rotation of the input shaft provides power to the transmission.

Stator (7) – The stator is splined to sleeve (8) which is bolted to the torque converter casing. Oil is directed back to impeller (4) through the stator vanes which causes the torque to increase.

Gear (9) – The gear which is splined to impeller (4) rotates at engine speed in order to supply power to the fan drive shaft.

Transmission

SMCS Code: 3030

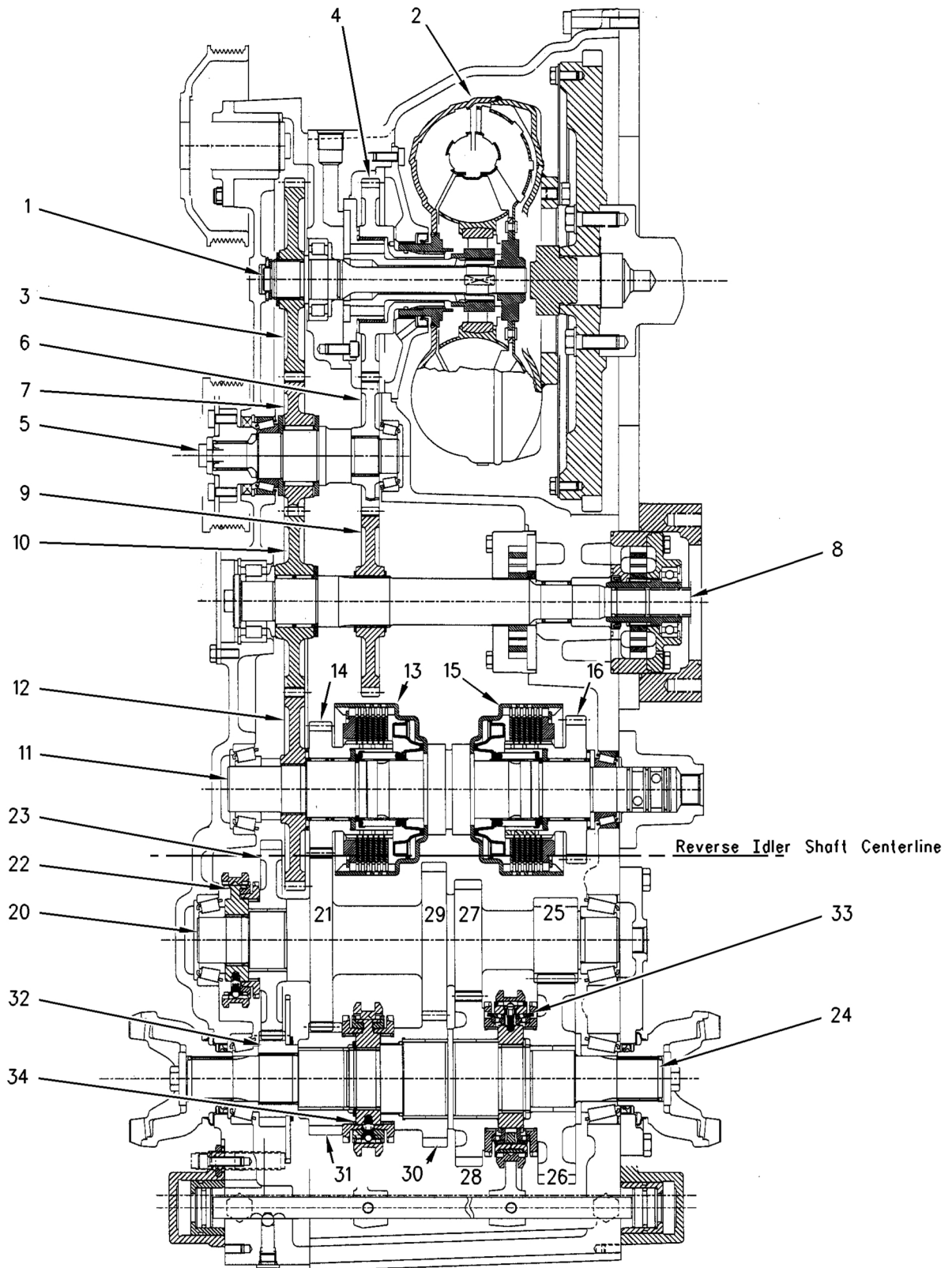


Illustration 33

- | | | |
|----------------------------|---------------------------------|--|
| (1) Input shaft | (13) Forward clutch | (25) First gear |
| (2) Torque Converter | (14) Forward primary gear | (26) First gear |
| (3) Gear | (15) Reverse clutch | (27) Second gear |
| (4) Gear | (16) Reverse primary gear | (28) Second gear |
| (5) Fan drive shaft | (17) Reverse idler shaft | (29) Third gear |
| (6) Gear | (18) Gear | (30) Third gear |
| (7) Gear | (19) Gear | (31) Fourth gear |
| (8) Pump drive shaft | (20) Countershaft | (32) Fifth gear |
| (9) Gear | (21) Fourth gear | (33) Synchronizer (first/second speeds) |
| (10) Gear | (22) Synchronizer (fifth speed) | (34) Synchronizer (third speed and fourth speed) |
| (11) Forward/Reverse shaft | (23) Fifth gear | |
| (12) Input drive gear | (24) Output shaft | |

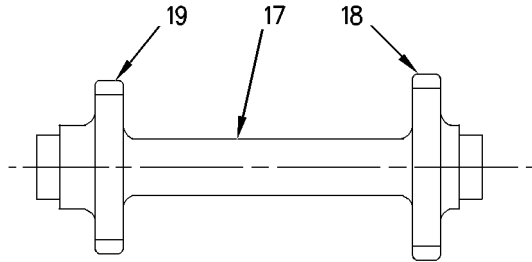


Illustration 34 g00886748
Reverse Idler Shaft (Shown Outside of the Transmission for Clarity)

Note: The transmission that is shown in Illustration 39 is a transmission with five speeds. The fifth gear (23) is removed when the machine has only four speeds. Also, synchronizer (22) is replaced by a spacer, and fifth gear (32) is replaced by a spacer.

The transmission consists of the following main components:

Input shaft (1) – Power from torque converter (2) is transferred to the input shaft which causes the input shaft to rotate. Gear (3) is splined to the input shaft, and gear (4) rotates freely on the input shaft at the engine speed.

Intermediate Idler shaft (5) - The shaft (5) is splined to gear (6) which meshes with gear (4) on the input shaft. Power is transferred from gear (4) to gear (6) in order to cause the shaft (5) to rotate. Gear (7) meshes with gear (3) on the input shaft. Power is transferred from gear (3) to gear (7) in order to cause gear (7) to rotate on the shaft (5). A needle bearing is located between gear (7) and the shaft (5) in order to allow the gear to rotate independently of the shaft (5).

Pump drive shaft (8) – Gear (9) that is on the pump drive shaft for the implement pump is driven by gear (6) on the fan drive shaft. Gear (9) is splined to the pump drive shaft in order to provide drive to the pump drive shaft. Power is transferred from gear (7) to gear (10) that rotates on the pump drive shaft. The pump drive shaft rotates at engine speed. A needle bearing is located between gear (10) and the pump drive shaft in order to allow the gear to rotate independently of the pump drive shaft.

Forward/Reverse shaft (11) – Input drive gear (12) that is splined to the forward/reverse shaft meshes with gear (10) on the pump drive shaft. Power is transferred from gear (10) to the forward/reverse shaft via input drive gear (12).

Forward clutch (13) – When the forward clutch is engaged, forward primary gear (14) is locked to the forward/reverse shaft. When the forward clutch is not engaged, forward primary gear (14) can rotate freely on two needle bearings on the forward/reverse shaft. Refer to “Clutch Operation” for more information on the operation of the forward clutch.

Reverse clutch (15) – When the reverse clutch is engaged, reverse primary gear (16) is locked to the forward/reverse shaft. When the reverse clutch is not engaged, reverse primary gear (16) can rotate freely on two needle bearings on the forward/reverse shaft. Refer to “Clutch Operation” for more information on the operation of the reverse clutch.

Reverse idler shaft (17) – Gear (18) on the reverse idler shaft meshes with reverse primary gear (16). When reverse clutch (15) is engaged, power from the reverse primary gear is transferred to the reverse idler shaft via gear (18). The power in the reverse idler shaft is transferred to gear (19).

Countershaft (20) – Forward primary gear (14) and gear (19) mesh with fourth gear (21) on the countershaft. If the forward clutch is engaged, power is transferred from the forward primary gear to the fourth gear on the countershaft. The reverse idler shaft will rotate freely in this case. If the reverse clutch is engaged, power is transferred from gear (19) to the fourth gear on the countershaft. Forward primary gear will rotate freely in this case. The countershaft has four gears that are integral to the shaft, a fifth gear (if equipped) that rotates on two needle bearings, and a synchronizer (if equipped). When the synchronizer (22) is engaged, fifth gear (23) is locked to the countershaft.

Output shaft (24) – The countershaft and the output shaft have the following gear sets that are in constant mesh:

- First gear (25) on the countershaft with first gear (26) on the output shaft
- Second gear (27) on the countershaft with second gear (28) on the output shaft
- Third gear (29) on the countershaft with third gear (30) on the output shaft
- Fourth gear (21) on the countershaft with fourth gear (31) on the output shaft
- Fifth gear (23) (if equipped) on the countershaft with fifth gear (32) (if equipped) on the output shaft

The required gear ratio is selected by locking the specific gear sets to the respective shafts by engaging one of the following synchronizers:

- Synchronizer (33) for the first/second speed that is on the output shaft
- Synchronizer (34) for the third/fourth speed that is on the output shaft
- Synchronizer (22) (if equipped) for the fifth speed that is on the countershaft

Refer to Systems Operation/Testing and Adjusting, “Transmission Power Flow” for information on the clutches and the synchronizers that are engaged for each speed.

Clutch Operation

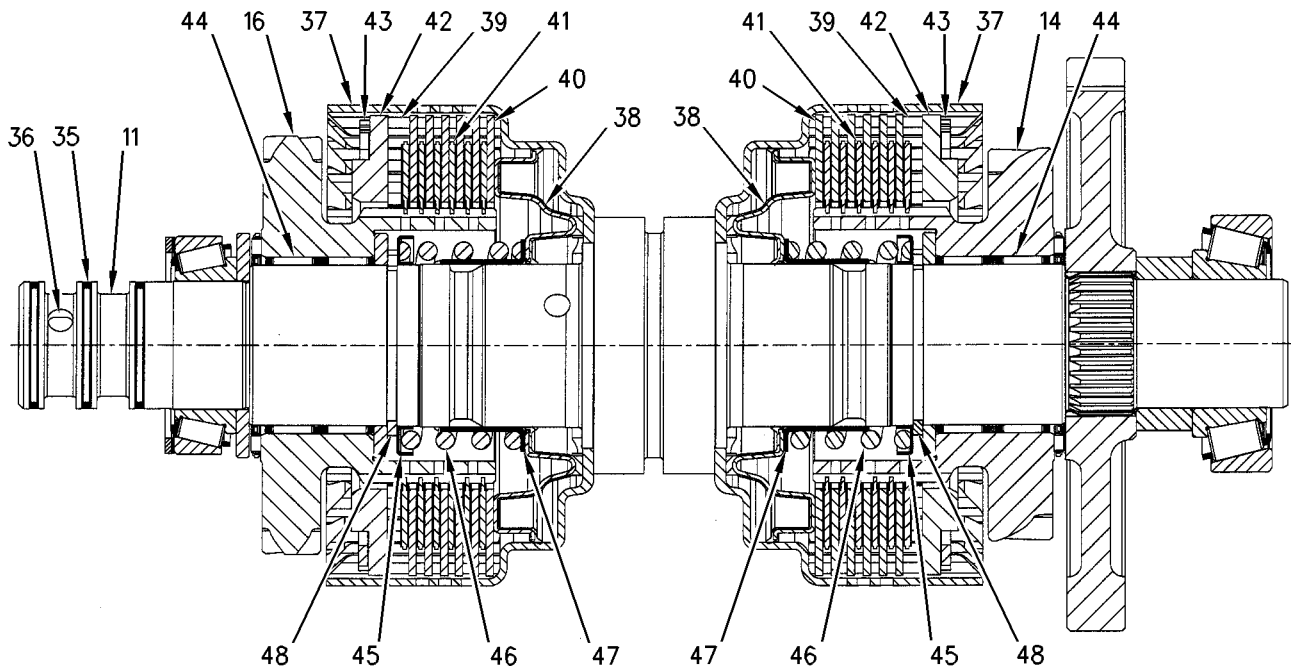


Illustration 35

g00886075

(11) Forward/reverse shaft
(14) Forward primary gear
(16) Reverse primary gear
(35) Seal rings
(36) Control oil passage
(37) Drum shaft assembly

(38) Clutch piston
(39) Clutch pack
(40) Outer discs
(41) Inner discs
(42) Backing plate
(43) Snap ring

(44) Needle bearings
(45) Spring
(46) Needle bearings
(47) Spring retainer
(48) Circlip

The two clutches on the forward/reverse shaft operate in an identical manner. **The forward clutch and the reverse clutch have the following main components:**

Seal rings (35) – Three seal rings are located on the end of forward/reverse shaft (11). Control oil is connected to each clutch through a series of passages which are formed in the housings of the torque converter and the transmission. Control oil is connected to a control oil passage (36) in the forward/reverse shaft. The control oil is prevented from leaking by seal rings (35).

Drum shaft assembly (37) – Each clutch pack is installed in a drum shaft assembly which has internal splines. A section of the bore of drum shaft assembly is smooth in order to allow operation of clutch piston (38).

Clutch pack (39) – The clutch packs consist of outer discs (40) with external splines on the outer diameter and inner discs (41) with internal splines on the inner diameter. The outer discs are made from steel and the inner discs (friction) are made from steel and a paper based material. An outer disc is installed first against clutch piston (38), and an inner disc is then installed. The external splines on the outer disc engage with corresponding splines in drum shaft assembly (37). The discs are stacked alternately until six inner discs and six outer discs are installed. The discs are held in position by backing plate (42) and snap ring (43).

The hub of forward primary gear (14) and the hub of reverse primary gear (16) have external splines which engage with the internal splines of inner discs (41). The inner discs and the primary gears which run on needle bearings (44) are free to increase in speed and free to rotate in the opposite direction to the outer discs provided that there is no oil pressure in that specific clutch.

Clutch piston (38) – When the clutch is engaged, control oil pressure is transmitted into the area behind the clutch piston. The oil pressure forces the clutch piston and clutch discs (40) and (41) against backing plate (42) in order to form a solid connection. The drive can then be transmitted from drum shaft assembly (37) to the hub of forward primary gear (14) or reverse primary gear (16).

Spring (45) – The spring is located on spring guide (46) between spring retainer (47) and clutch piston (38). The spring is held under compression by circlip (48). The spring force is used to move clutch piston (38) away from clutch discs (40) and (41) in order to disengage the clutch. Oil from behind the clutch piston flows back through control oil passage (36) when the clutch is disengaged.

When pressure is relieved from the clutch, drum shaft assembly (37) can rotate with outer discs (40) at a different speed to the forward primary gear (14) or reverse primary gear (16) and inner discs (41). Also, when pressure is relieved from the clutch, the drum shaft assembly can rotate with the outer discs in the opposite direction to the forward primary gear or reverse primary gear and the inner discs.

Operation of the Synchronizers

The synchronizer for the first speed and second speed, and the synchronizer for the third speed and fourth speed are two-way synchronizers. The synchronizer assemblies and the shift rails are operated by solenoids. Each of these synchronizers can lock one of two output gears to the output shaft at a time. The synchronizer for the fifth speed can only lock the fifth gear to the countershaft. All three of the synchronizers are actuated with forks and a shift rail. The shift rails have a steel ball and spring detents in order to hold the NEUTRAL position and the GEAR positions. The first/second synchronizer use a double clutch. The third/forth synchronizer and the fifth synchronizer use a single cone clutch. The synchronizer assemblies are all strut type. The following text explains the operation of the synchronizer assemblies.

Synchronizer for the First Speed and Second Speed

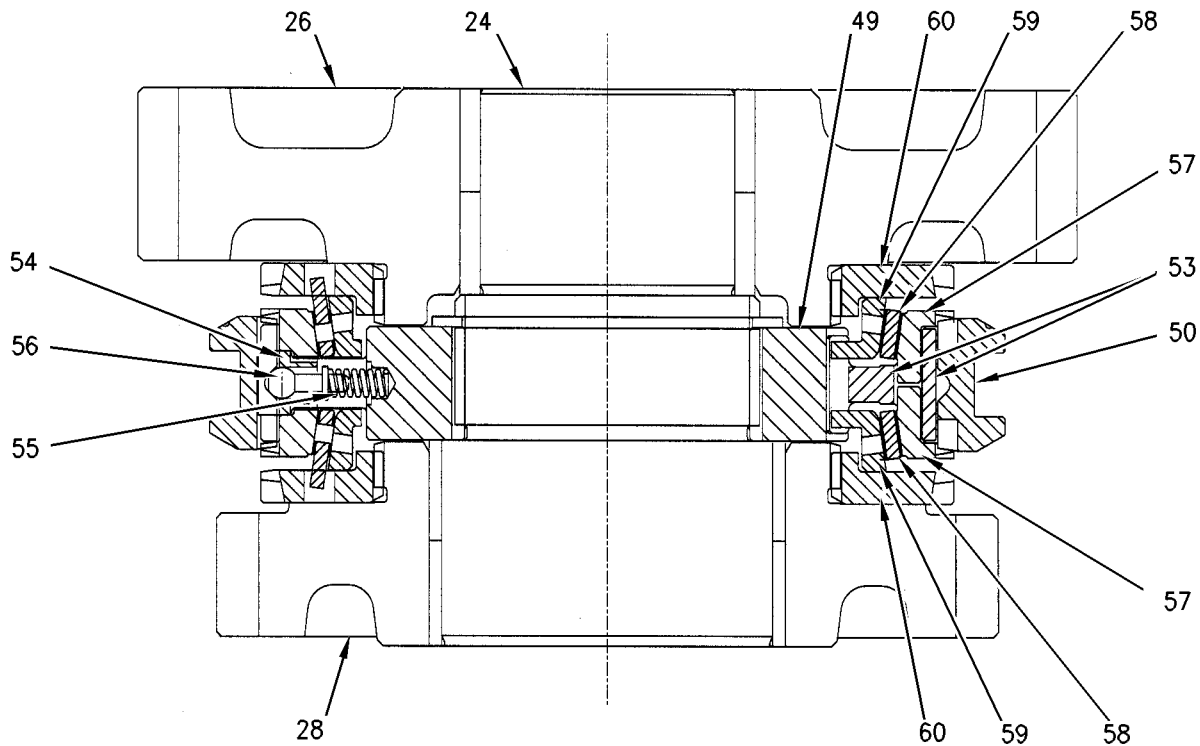


Illustration 36

g00886407

Synchronizer for the First/Second speed

- | | | |
|-------------------|-----------------------|--------------------|
| (24) Output shaft | (53) Connecting block | (58) Friction ring |
| (26) First gear | (54) Strut | (59) Inner cone |
| (28) Second gear | (55) Spring | (60) Plate |
| (49) Hub | (56) Detent pin | |
| (50) Sleeve | (57) Outer cone | |

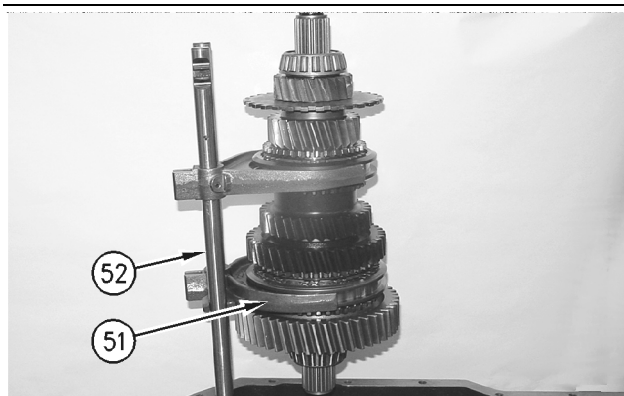


Illustration 37

g00887427

Output Shaft (Shown Outside of the Transmission for Clarity)

- (51) Fork
- (52) Shift rail

The synchronizer contains the following main components:

Hub (49) – The hub is splined to output shaft (24). The outer radius of the hub also has splines.

Sleeve (50) – Splines on the internal radius of the sleeve are interlocked with the splines on the outer radius of hub (49). A groove around the circumference of the sleeve provides a location for fork (51) which is attached to shift rail (52).

Connecting blocks (53) – Three connecting blocks are located between hub (49) and sleeve (50). The connecting blocks are positioned around the sleeve at 120 degree intervals. The connecting blocks connect the inner cone to the outer cone.

Struts (54) – Three struts are also located between hub (49) and sleeve (50). Each strut is positioned directly opposite one of the connecting blocks (53). Each of the three struts have a spring (55) and detent pin (56). The head of the detent pin sits in a groove on the inside of sleeve (50).

Two outer cones (57) – Each outer cone sits in a circular channel on the side of hub (49). The outer cones are driven by lugs which engage in slots in the hub. The outer cones also have teeth on the circumference which can engage with the internal teeth of the sleeve.

Two friction rings (58) – Each friction ring which sits between the inner cone and the outer cone (57) can rotate independently of the cones. The friction ring drives the plate (60) via lugs.

Two inner cones (59) – Each inner cone sits inside friction ring (58) and interlocks with connecting blocks (53) to the outer cones.

Two Plates (60) – Each plate (60) fits over an inner cone (59), a friction ring (58) and an outer cone (57). The location lugs of friction rings (58) are interlocked with the alignment slots of the adjacent plate (60). Each plate (60) is also splined with an output gear that is on the output shaft.

When the synchronizer is not engaged, the following components rotate with the output gear:

- Plate (60)
- Friction ring (58)

When the synchronizer is not engaged, the following components rotate with the output shaft:

- Hub (49)
- Inner cone (59)
- Outer cone (57)
- Connecting blocks (53)
- Strut (54)
- Detent pins (56)
- Springs (55)
- Sleeve(50)

When a transmission speed is selected the solenoid on the gear valve is switched on. Oil flows into the actuator at the opposite end of the shift rail. The shift rail (52) moves in a direction that is parallel to the output shaft. Fork (51), which is attached to the shift rail, exerts a force on sleeve (50) and the sleeve begins to move toward the output gear. As sleeve (50) moves toward output gear detent pins (56) are dragged by the groove in sleeve (50). This causes struts (54) to move until the struts contact outer cone (57). The modulating valve drops the pressure initially. The pressure then ramps up to a predetermined level. When the surfaces of the struts and the surfaces of the cones come together outer cone (57) will rotate by half a tooth. The chamfers of the teeth on sleeve (50) contact the chamfers of the teeth on outer cone (57). The force on sleeve (50) is now transmitted to the cones by these tooth chamfers. Further movement of sleeve (50) is blocked by the interaction of the synchronising torque and the indexing torque of the chamfers on the tooth. The friction that is created causes the speed of the output gear and the speed of output shaft (24) to become equal. Zero synchronising torque will result if the speed of the output gear is equal to the speed of the output shaft. The chamfers on the teeth are now able to rotate outer cone (57) by half a tooth. Sleeve (50) will then move up over the teeth on the outer cone and up to plate (60). The teeth on sleeve (50) will engage with the teeth on plate (60). This action will fix the output gear to output shaft (24). Sleeve (50) rides over the top of detent pins (56) so that no force is transmitted to struts (54).

The pressure to the clutch is controlled by a proportional pressure reducing valve. When the synchronizer is engaged, the output gear is locked to the output shaft. **Power flows through the system components in the following order:**

- Output gear
- Synchronizer
- Output shaft

Synchronizer for the Third Speed and Fourth Speed

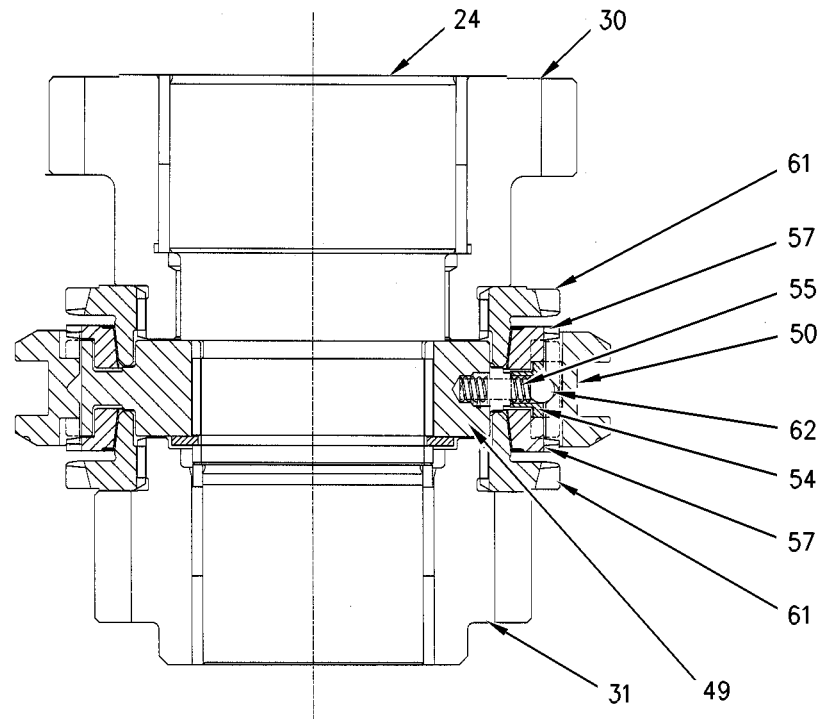


Illustration 38

g00888146

Synchronizer for the Third/Fourth Speed

(24) Output shaft
(30) Third gear
(31) Fourth gear
(49) Hub

(50) Sleeve
(54) Strut
(55) Spring
(57) Outer cone

(61) Plate
(62) Steel ball

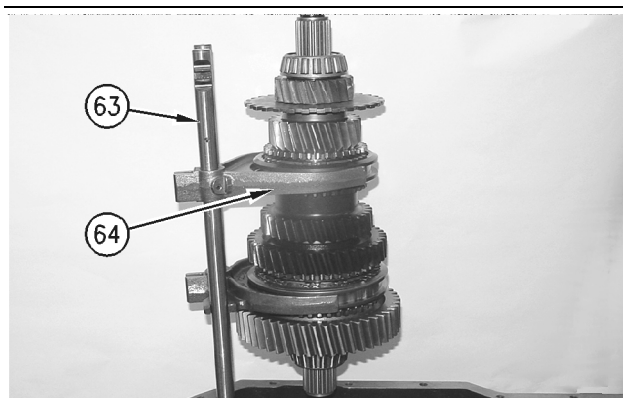


Illustration 39

g00888421

Output Shaft (Shown Outside of the Transmission for Clarity)

(63) Shift rail
(64) Fork

The synchronizer for the third/fourth speed has the following components that operate in the same way as the synchronizer for the first/second speed:

- Sleeve (50)
- Strut (54)
- Springs (55)
- Outer cone (57)
- Hub (49)

The synchronizer for the third/fourth speed has the following components that operate in a different way to the synchronizer for the first/second speed:

The synchronizer for the third/fourth speed operates on the same principles as the synchronizer for the first/second speed, but it does not include all of the same components. The components that are not used in the synchronizer for the third/fourth speed are the friction rings and the connecting blocks.

Plates (61) – The plate (61) for the third speed is splined to third gear (30) on output shaft (24). The plate (61) for the fourth speed is splined to fourth gear (31) on output shaft (24). The plates (61) have an inner cone that is machined into the inner circumference of the plates (61). The plates (61) also have teeth around the outer circumference.

When third speed or fourth speed is selected, shift rail (62) moves in a direction that is parallel to the output shaft. Fork (63), which is attached to the shift rail, exerts a force on sleeve (50) in order to initiate the engagement of the synchronizer. The synchronizer for the third speed and fourth speed operates in the same way as the synchronizer for the first/second speed. The frictional force that is required to equalize the speed of the output shaft and the speed of the output gear is produced between outer cone (57) and the inner cone on plate (61).

Steel balls (62) – The three steel balls will operate in the same way as the detent pins on the synchronizer for the first/second speed. The steel balls sit in a groove on the inside of outer ring (50). This action causes the struts to move.

Synchronizer for the Fifth Speed (If Equipped)

The synchronizer for the fifth speed operates on the same principles as the synchronizer for the third/fourth speed. However, the synchronizer for the fifth speed has the following differences to the synchronizer for the third/fourth speed:

- The fifth speed cannot be selected manually.
- The fifth gear is engaged and disengaged automatically when the transmission is in fourth gear.
- The synchronizer for the fifth speed operates on one side instead of two sides.
- The synchronizer operates on the countershaft instead of the output shaft.
- The actuator is held hydraulically in the DISENGAGED position.

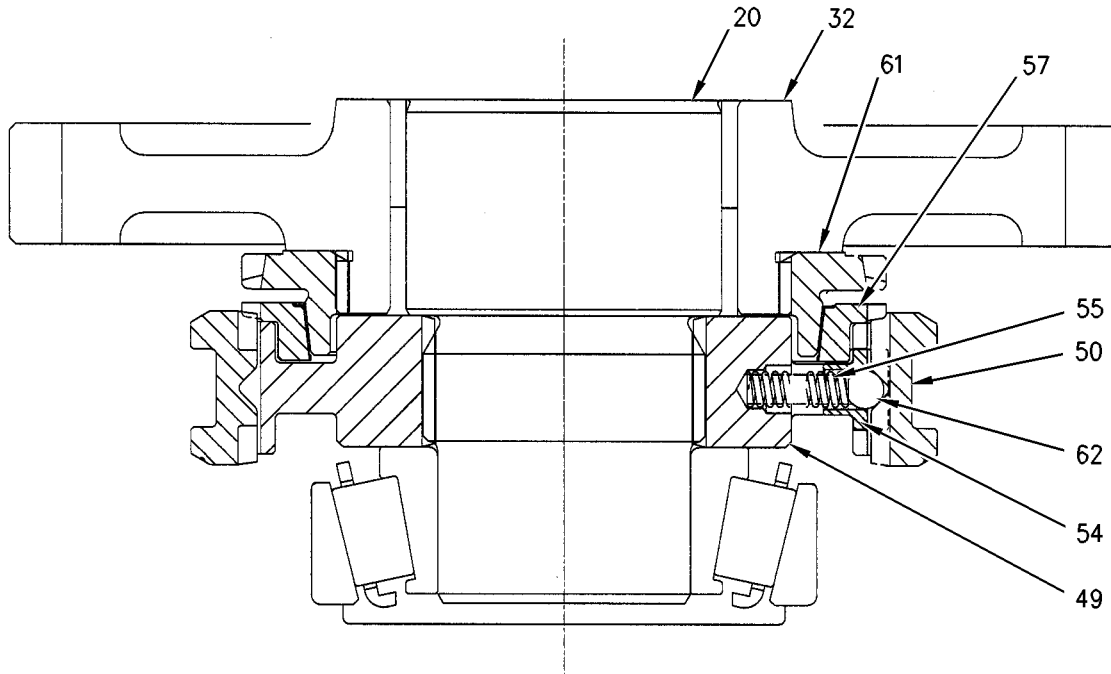


Illustration 40
Synchronizer for the Fifth Speed

g00886408

- | | | |
|-------------------|-------------|-----------------|
| (20) Countershaft | (50) Sleeve | (57) Outer cone |
| (32) Fifth gear | (54) Strut | (61) Plate |
| (49) Hub | (55) Spring | (62) Steel ball |

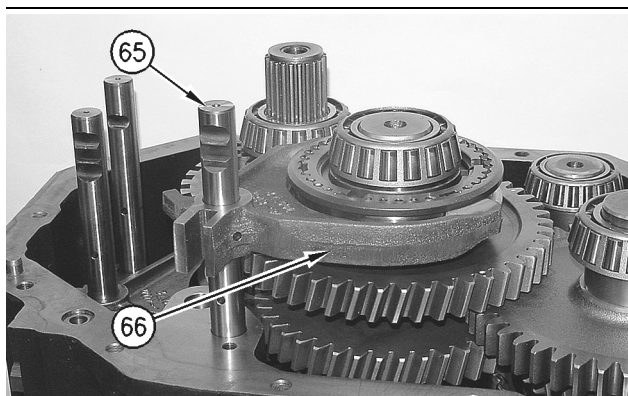


Illustration 41
(65) Shift rail
(66) Fork

g00888072

The synchronizer for the fifth speed operates in the same way as the top half of the synchronizer for the third/fourth speed. The synchronizer for the fifth speed is only able to lock the fifth gear to the shaft.

The fifth speed is automatically selected by the machine when the output shaft reaches a set speed. Shift rail (65) and forks (66) move outer ring (50) in order to engage the synchronizer, and the fifth gear is then locked to the countershaft. **Power is transferred through the system components in the following order:**

- Countershaft
- Synchronizer for the fifth speed
- Fifth gear on the countershaft
- Fifth gear on the output shaft
- Output shaft

Limits

Several limits have been incorporated into the control system of the transmission. The limits prevent damage to the power train. The limits also prevent overspeed of the engine.

- Transmission shifting through the gears will be prevented when the torque converter has stalled.

- When a direction change from fourth gear forward or fifth gear forward is received, this will be limited. The ECM will change down the gears to third gear in order to reach a suitable speed before changing direction.
- Shifting down causing engine overspeed will be limited. Once the speed drops the shift will be allowed.
- The ECM will allow directional changes at any speed in third gear. Excessive numbers of directional changes at any speed in third gear is limited. Excessive numbers of directional changes at any speed in third gear could damage the integrity of the system.
- The machine has a downshift inhibitor in order to prevent the engine from over-speeding. The ECM will detect the current speed. The ECM will stop the operator from selecting a lower gear while the machine is coasting down a hill.
- The machine has a inhibitor on shifting for protection from rollback in order to prevent the machine from rolling back between shifts on a slope if the torque converter is near a stall. If the transmission output speed and the torque converter ratio fall below the limit, the ECM will not allow a downshift. The ECM will shift to the requested gear when the limit has passed.

i01775101

Cooler (Hydraulic Oil)

SMCS Code: 1374

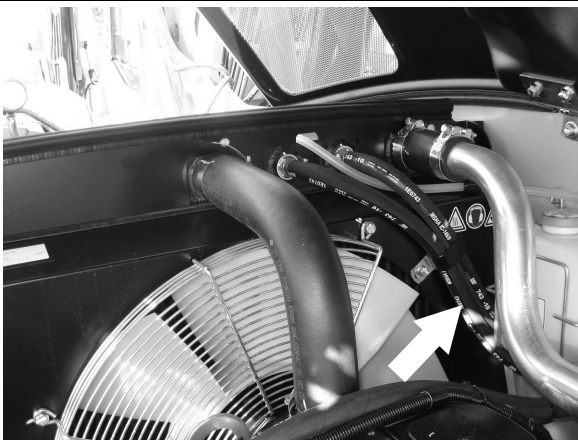


Illustration 42

Oil from the torque converter flows into the hydraulic oil cooler. The cooled oil then flows into the transmission housing.

Refer to Systems Operation/Testing and Adjusting, "Location of Hydraulic Components" for the location of the oil cooler.

Transmission Control (Shift Lever)

SMCS Code: 3065

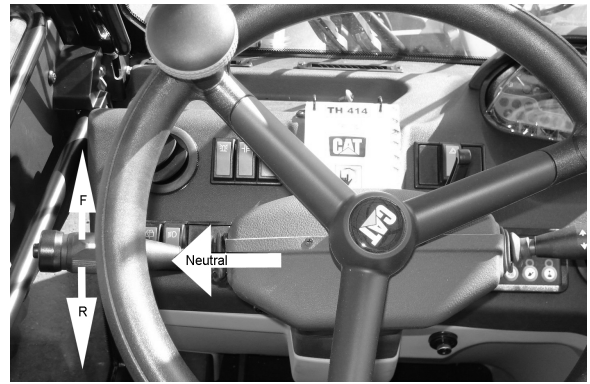


Illustration 43

The transmission direction control is a sealed, nonserviceable unit which is mounted to the steering column. Movement of the control lever energizes solenoid valves for the direction clutches of the transmission.

The control lever has the following positions:

- FORWARD (F)
- NEUTRAL (N)
- REVERSE (R)

The control lever is pushed upward in order to travel in a forward direction and the control lever is pulled downward in order to travel in a reverse direction.

The transmission control lever sends a signal to the machine ECM. The ECM interprets the signal as either forward, neutral or reverse.

The transmission control lever needs to be in NEUTRAL position before the engine will start.

When the ECM detects the transmission control lever in the REVERSE position the ECM energizes the back up alarm.

When the control lever is in the NEUTRAL position a switch in the control group is closed and this completes a circuit between the engine start switch and the start relay. The switch opens when the control lever is in any other position which will prevent the engine from being started.

When the control lever is in the REVERSE position, a switch in the control closes. This activates the backup alarm and warning light of the machine.

A switch that is located below the parking brake control is open in order to prevent the power to the transmission control if the parking brake is not fully disengaged.

A pressure switch that is located in the service brake line is connected in series with a switch that is located on the dash panel. When the switch on the dash panel is in the ON position, the application of the service brake prevents the power supply to the transmission control which neutralizes the transmission. This control is intended for use with a machine that is equipped with a work tool. The control ensures that full engine power is available for operating the hydraulics when the machine is held stationary with the service brake.

Powersynchro Transmission

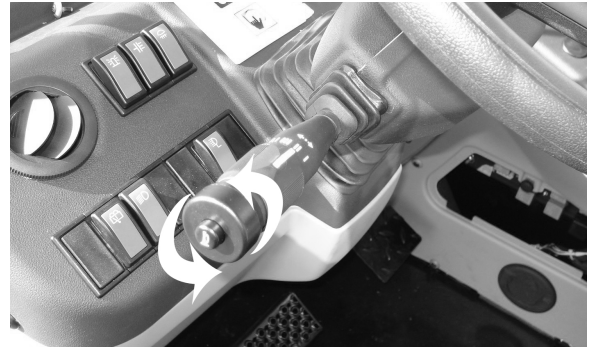


Illustration 44

On machines with a powersynchro transmission, the required transmission speed is selected by rotating the barrel of the control lever. The corresponding solenoid valve on the transmission is energized in order to select the desired transmission speed.

The following transmission speeds are available when the control lever is in the FORWARD position:

- First speed
- Second speed
- Third speed
- Fourth speed

Your machine may also be equipped with an automatic fifth speed. Machines that are equipped with this feature will automatically shift into fifth speed when the appropriate ground speed is reached. Fifth speed cannot be manually selected by the operator.

The following transmission speeds are available when the control lever is in the REVERSE position:

- First speed
- Second speed
- Third speed

i02138787

Transmission Power Flow

SMCS Code: 3030

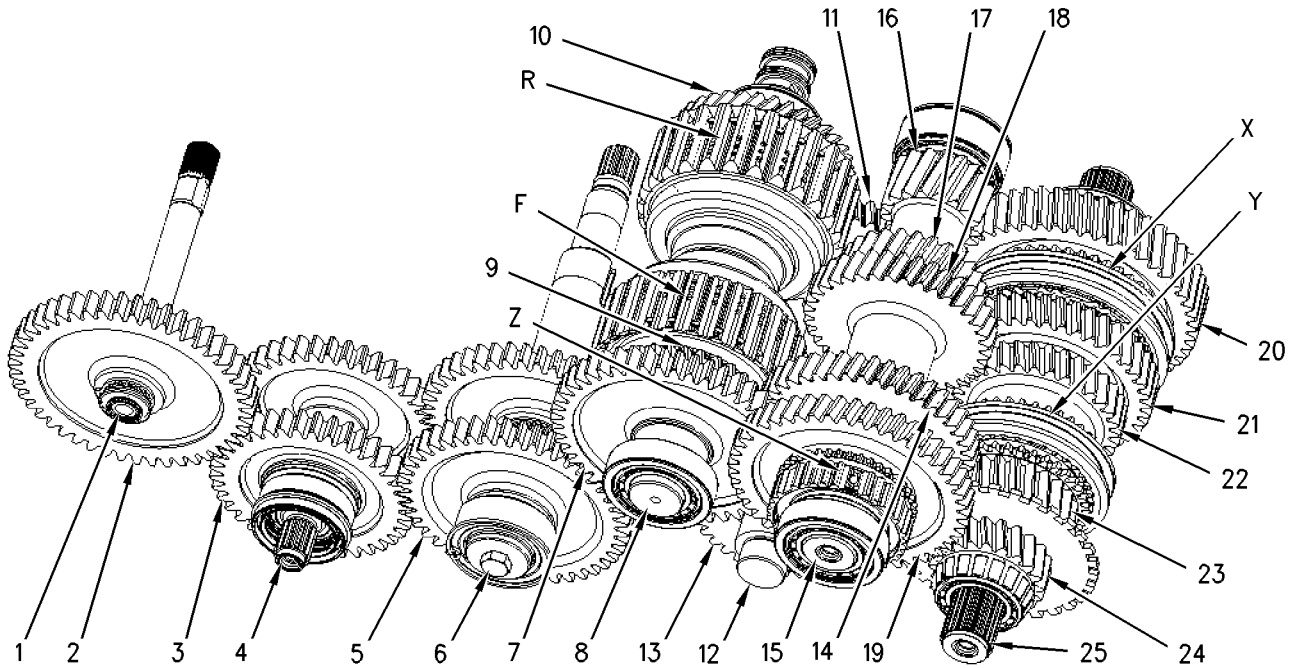


Illustration 45

g01007675

- | | | |
|---------------------------|---------------------------------|---|
| (1) Input shaft | (12) Reverse idler shaft | (23) Fourth gear (output shaft) |
| (2) Gear | (13) Gear | (24) Fifth gear (output shaft) |
| (3) Gear | (14) Fourth gear (countershaft) | (25) Output shaft |
| (4) Fan drive shaft | (15) Countershaft | (F) Forward clutch |
| (5) Gear | (16) First gear (countershaft) | (R) Reverse clutch |
| (6) Pump drive shaft | (17) Second gear (countershaft) | (X) Synchronizer for the first speed and second speed |
| (7) Input drive gear | (18) Third gear (countershaft) | (Y) Synchronizer for the third speed and fourth speed |
| (8) Forward/Reverse shaft | (19) Fifth gear (countershaft) | (Z) Synchronizer for the fifth speed |
| (9) Forward primary gear | (20) First gear (output shaft) | |
| (10) Reverse primary gear | (21) Second gear (output shaft) | |
| (11) Gear | (22) Third gear (output shaft) | |

Table 4 and Table 5 show the engagements of the clutches and the synchronizers for different speed selections.

Table 3

FORWARD DIRECTION	
Selected Speed	Engaged Clutches and Synchronizers
Neutral	None
First Speed Forward	Forward clutch (F) and synchronizer (X) with first gear (20)
Second Speed Forward	Forward clutch (F) and synchronizer (X) with second gear (21)
Third Speed Forward	Forward clutch (F) and synchronizer (Y) with third gear (22)
Fourth Speed Forward ⁽¹⁾	Forward clutch (F) and synchronizer (Y) with fourth gear (23)
Fifth Speed Forward (if equipped) ⁽¹⁾	Forward clutch (F) and synchronizer (Z) with fifth gear (19)

⁽¹⁾ Forward direction only

Table 4

REVERSE DIRECTION	
Selected Speed	Engaged Clutches and Synchronizers
Neutral	None
First Speed Reverse	Reverse clutch (R) and synchronizer (X) with first gear (20)
Second Speed Reverse	Reverse clutch (R) and synchronizer (X) with second gear (21)
Third Speed Reverse	Reverse clutch (R) and synchronizer (Y) with third gear (22)
Fourth Speed Reverse (Power Shuttle Transmission)	Reverse clutch (R) and synchronizer (Y) with third gear (23)

Examples of Power Flow Through the Transmission

First Speed Forward

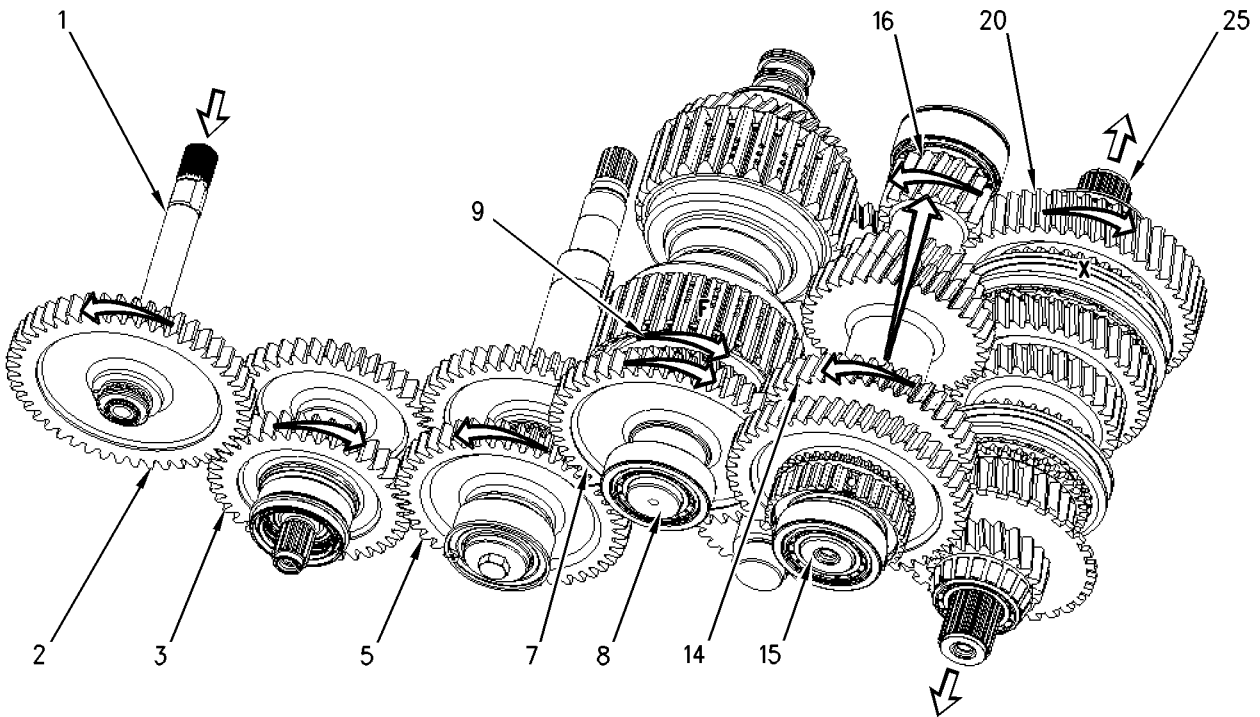


Illustration 46

g00886981

When first speed forward is selected, synchronizer (X) locks first gear (20) to output shaft (25). Also, forward clutch (F) is hydraulically actuated in order to lock forward primary gear (9) to forward/reverse shaft (8).

Power will flow through components in the following order:

- Input shaft (1)
- Gear (2)
- Gear (3)
- Gear (5)
- Input drive gear (7)
- Forward/Reverse shaft (8)
- Forward clutch (F)
- Forward primary gear (9)
- Fourth gear (countershaft) (14)
- Countershaft (15)
- First gear (countershaft) (16)
- First gear (output shaft) (20)
- Synchronizer (X)
- Output shaft (25)

Second Speed Reverse

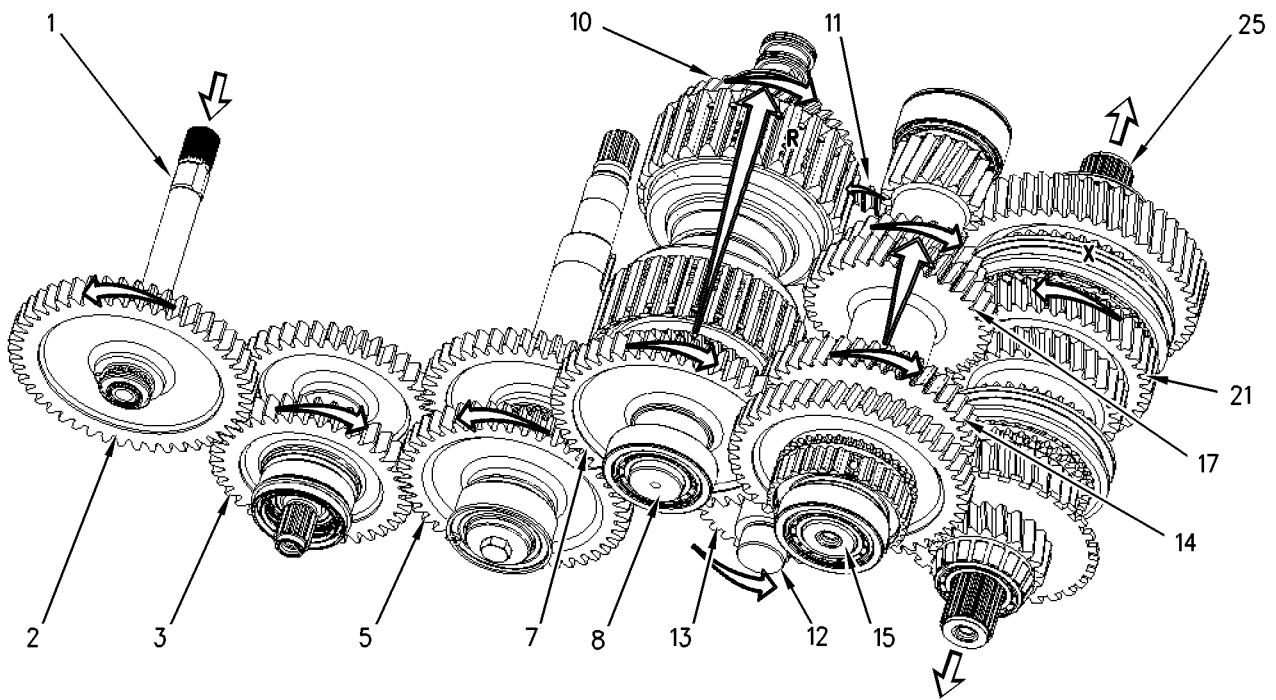


Illustration 47

g00886984

When second speed reverse is selected, synchronizer (X) locks second gear (21) to output shaft (25). Also, reverse clutch (R) is hydraulically actuated in order to lock reverse primary gear (10) to forward/reverse shaft (8).

Power will flow through components in the following order:

- Input shaft (1)
- Gear (2)
- Gear (3)
- Gear (5)
- Input drive gear (7)
- Forward/Reverse shaft (8)
- Reverse clutch (R)
- Reverse primary gear (10)
- Gear (11)
- Reverse idler shaft (12)
- Gear (13)
- Fourth gear (countershaft) (14)
- Countershaft (15)
- Second gear (countershaft) (17)
- Second gear (output shaft) (21)
- Synchronizer (X)
- Output shaft (25)

Fifth Speed Forward (If Equipped)

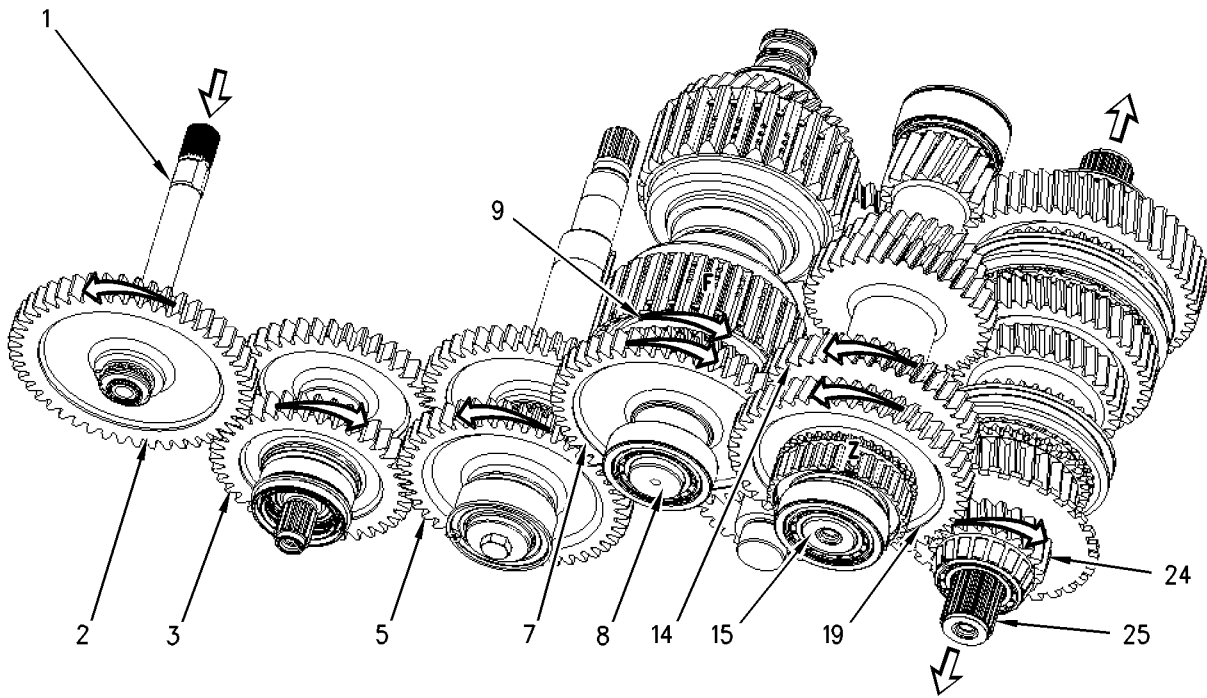


Illustration 48

g00886983

When fifth speed forward is selected, synchronizer (Z) locks fifth gear (19) to countershaft (15). Also, forward clutch (F) is hydraulically actuated in order to lock forward primary gear (9) to forward/reverse shaft (8).

- Fifth gear (countershaft) (19)
- Fifth gear (output shaft) (24)
- Output shaft (25)

Power will flow through components in the following order:

- Input shaft (1)
- Gear (2)
- Gear (3)
- Gear (5)
- Input drive gear (7)
- Forward/Reverse shaft (8)
- Forward clutch (F)
- Forward primary gear (9)
- Fourth gear (countershaft) (14)
- Countershaft (15)
- Synchronizer (Z)

i02121712

Hydraulic Schematic (Power Train System)

SMCS Code: 3030; 5050

Neutral (Powersynchro Transmission)

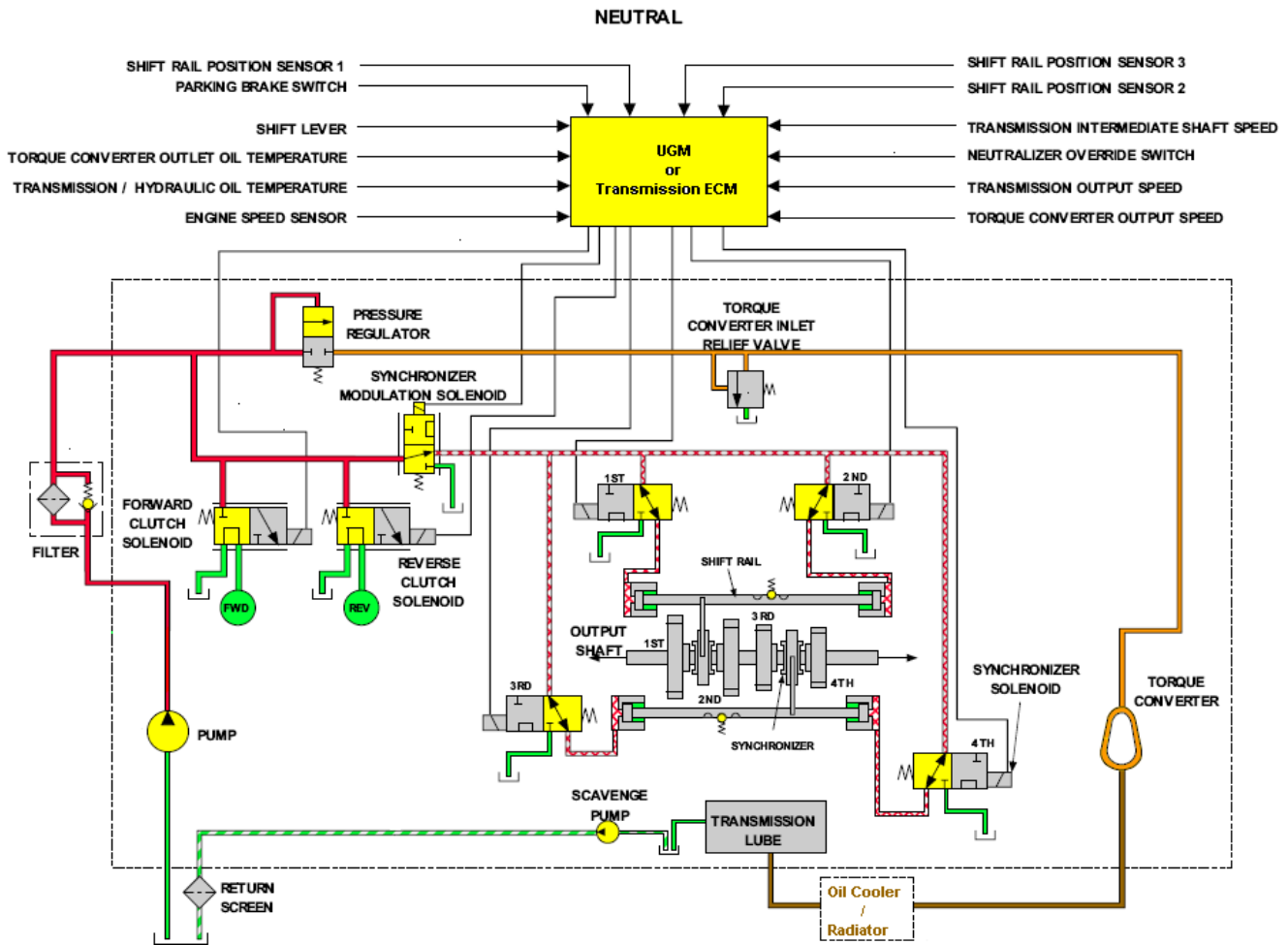


Illustration 49

The Powersynchro transmission uses “ON/OFF” Synchronizer solenoids that are controlled by the Machine “ECM” in order to move the shift rails. The synchronizers in the transmission are then activated in order to select the appropriate gear. The modulation of the pressure that is sent to the Synchronizer solenoids is controlled by the Synchronizer Modulation Solenoids.

Neutral into First Gear (Start of shift)

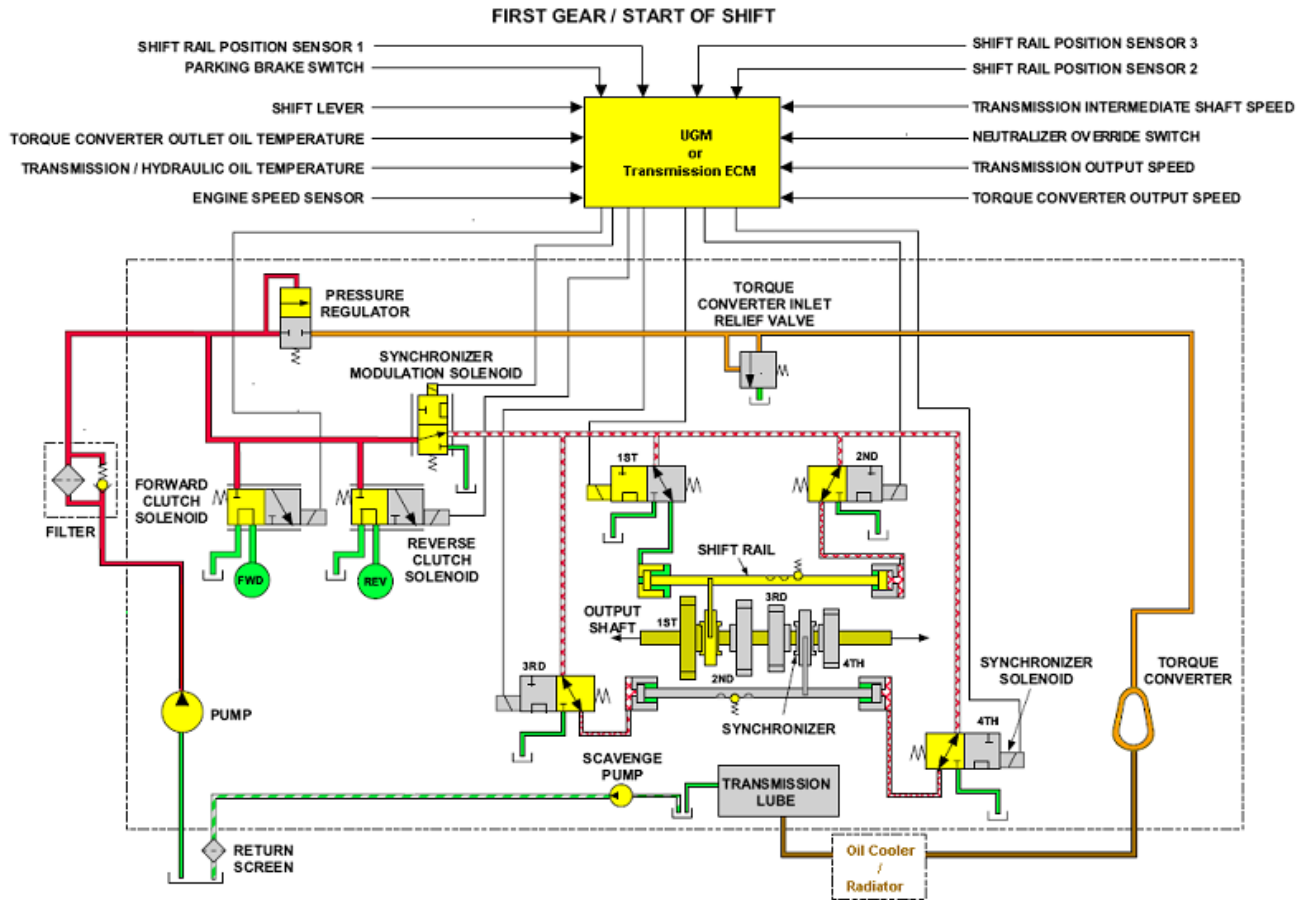


Illustration 50

When you are shifting into a gear, the sensors for the shift rail will check in order to ensure that the shift rails are in the neutral position. The modulation valve for the synchronizer is energized and the pressure is dropped to approximately 455 kPa (66 psi) in order to limit the speed of the movement of the synchronizer. The appropriate synchronizer for the solenoid is energized in order to direct the oil to the end of the shift rail. The oil will then flow to the tank.

The modulation valve for the synchronizer begins to ramp up the pressure to a set value which starts moving the shift rail and the synchronizer toward the appropriate gear. When the Machine "ECM" detects the appropriate ratio between the intermediate shaft speed and the output shaft speed, the synchronizer for the modulation valve is de-energized. Full pressure on the opposite end of the shift rail pushes the synchronizer in order to engage the gear to the shaft.

Neutral Into First Gear (End of Shift) (FORWARD)

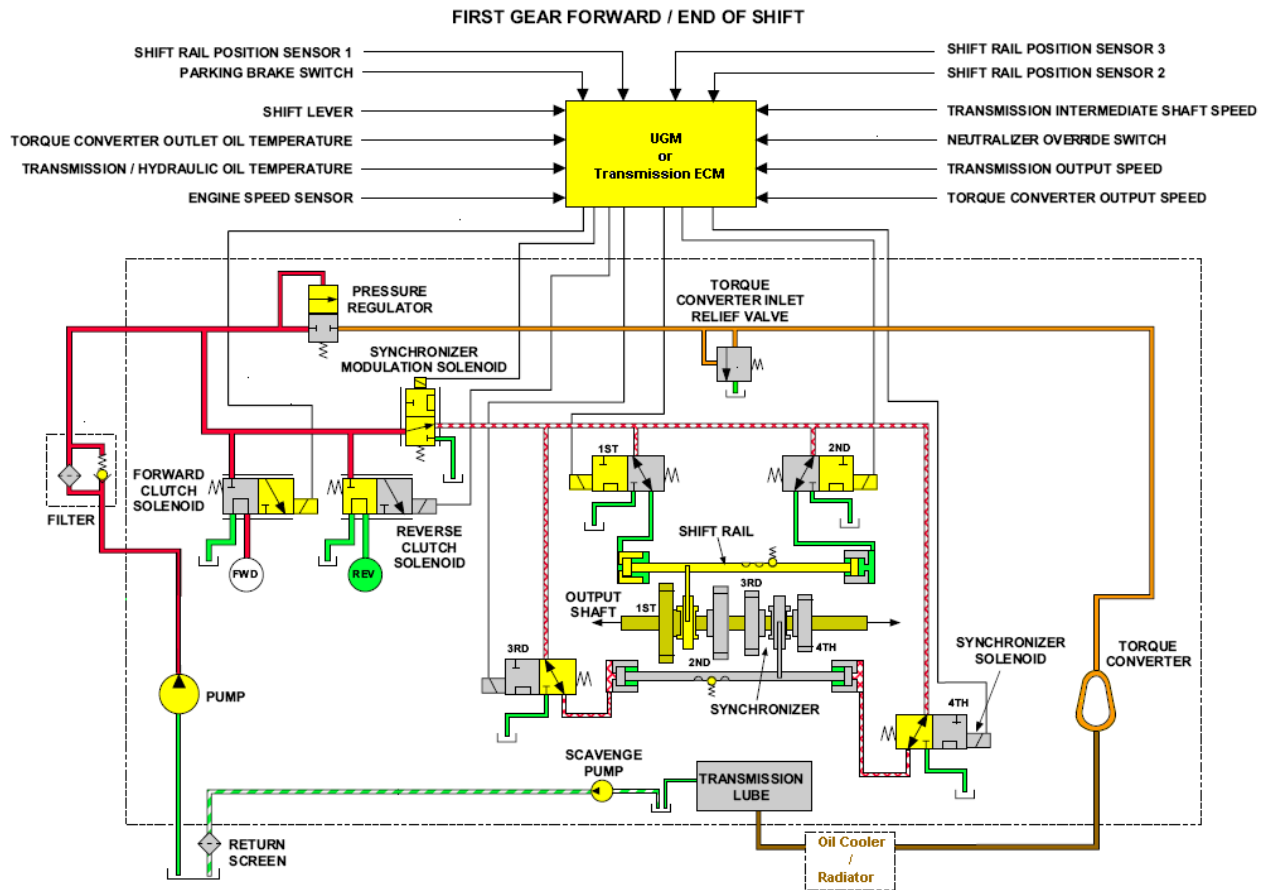


Illustration 51

The position sensor detects the position of the shift rail. When the shift rail is in the ENGAGED Position, the solenoid for the synchronizer that is on the opposite end of the same shift rail is energized. The oil that is on that end of the shaft is sent to the tank. The gear is kept in the engaged position by the spring and ball detents that are in the synchronizers.

When a gear change is made, all energized solenoids for the synchronizer are de-energized. Oil is then sent to both ends of the shift rail and the shift rail is moved to the NEUTRAL Position. There is a double piston arrangement on each end of each shift rail. The smaller piston is used to push the shift rail into gear and the larger piston is used to shift that particular shift rail into neutral.

For example, the port for the small piston is blocked on the "in gear end" of the shift rail and the oil acts on the large piston. The oil on the other end of the shift rail is acting on the small piston. This imbalance pushes the shift rail to the Neutral Position. As the shift rail gets closer to the NEUTRAL Position, less oil acts on the large piston and more oil acts on the small piston. When neutral for that particular shift rail is attained, oil on both ends of the shaft acts on the small piston and the shaft stops moving. The spring and ball detents hold the shift rail in the NEUTRAL Position.

When the transmission control lever is placed into the NEUTRAL Position, only the direction clutch is disengaged and the synchronizers stay in gear.

i02161085

Configuration Parameters

SMCS Code: 1400

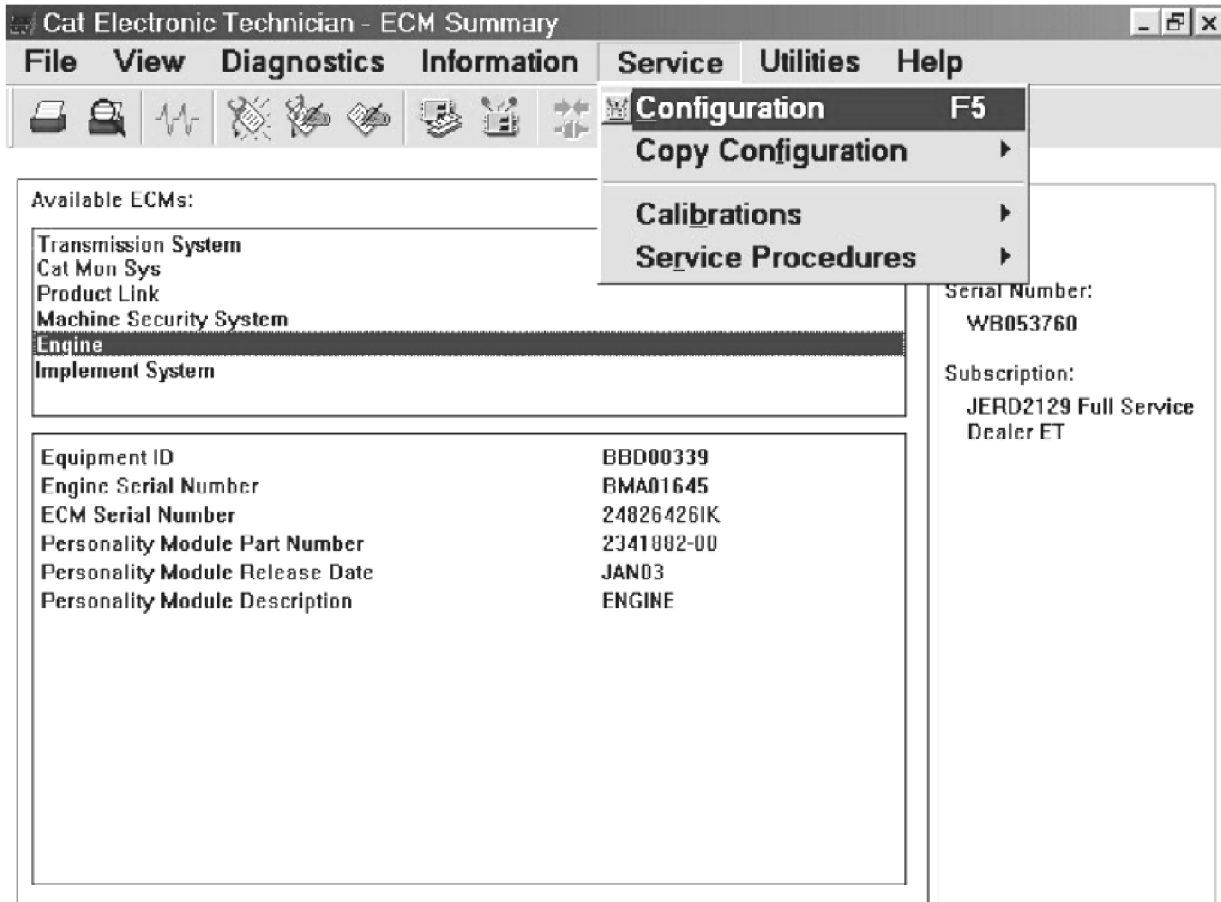


Illustration 52

g00993238

This is a summary screen.

Some parameters need to be configured for the machine to operate properly. The configuration screen for the ECM can be accessed by using the Cat Electronic Technician (ET). The configuration screen for each ECM is accessed from the above ECM summary screen by selecting "Configuration" from the "Service" drop-down menu.

Reference: Refer to the service manual module Testing and Adjusting, RENR5195, "Electronic Control Module (ECM) - Configure" for further instructions on configuring the ECM for your machine.

Testing and Adjusting Section

Testing and Adjusting

i02124721

Transmission Shift Rail - Calibrate

SMCS Code: 3030-524

This calibration procedure is for machines with the powersynchro transmission. The sensors detect the position of the shift rails and the sensors indicate to the machine ECM if the transmission is neutralized.

Machine Preparation



WARNING

Personal injury or death can result from sudden machine movement.

Sudden movement of the machine can cause injury to persons on or near the machine.

Prevent possible injury by performing the procedure that follows before working on the machine.

1. Move the machine to a smooth, horizontal location that is away from operating machines and away from personnel.
2. In order to prevent the drive wheel from turning during the test, put the machine in position against a solid, stationary object such as a loading dock. Engage the parking brake.
3. Permit only one operator on the machine. Keep all other personnel away from the machine or in the operator's sight.
4. Move the transmission control to the NEUTRAL position.
5. Lower the boom. If equipped, lower the work tool to the ground and stop the engine.
6. If the machine is in a confined area, ensure that exhaust gases are vented to the outside when the engine is operated.
7. Make sure that all the oil pressure is released before you perform any of the following procedures:

- Loosen any fitting, any hose, or any component.
- Tighten any fitting, any hose, or any component.
- Remove any fitting, any hose, or any component.
- Adjust any fitting, any hose, or any component.

Warming the Transmission Oil

Increase the transmission oil temperature to at least 35 °C (95 °F).

1. Apply the service brakes and start the engine.
2. Disengage the parking brake. Ensure that the switch that disables the transmission neutralizer control is in the OFF position. Refer to the Operation and Maintenance Manual, "Transmission Neutralizer Control".
3. Move the transmission control to the FOURTH SPEED position with the drive in the NEUTRAL position. Depress the accelerator pedal until the engine speed has reached high idle. The high idle speed is 2350 ± 25 (rpm).
4. Move the transmission control to the FORWARD position and stall the torque converter until the transmission oil temperature gauge in the cab reads 3/4 of the way to the red line.

Note: To ensure that the transmission oil does not get too hot, do not keep the torque converter in a full stall condition for more than 10 seconds.

5. Move the transmission control to the NEUTRAL position and continue to run the engine at high idle until the needle of the transmission oil temperature returns to the middle of the scale.

Calibrate the Shift Rail

Table 5

Required Tools		
Part Number	Description	Quantity
JEBD3003	Caterpillar Electronic Technician (ET)	1
171-4400	Communications Adapter II	1
207-6845	Adapter Cable As	1
160-0141	Adapter Cable As	1
9U-7400	Multitach Tool Group	1

The Caterpillar Electronic Technician service tool (ET) is used to access the calibration procedures. A message on the ET screen will give instructions that guide the user through the calibration procedure. Refer to the Manual that is provided with the ET for more information about ET.



Illustration 53
This is the location of the service connector that contains the CAT data link. The connector is located to the side and rear of the seat.

The transmission ECM is located under the engine hood.

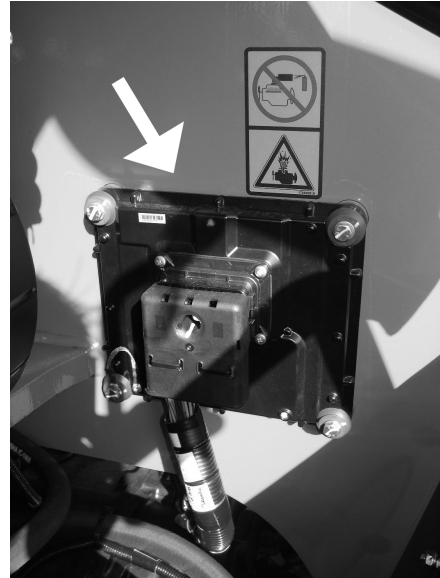


Illustration 54
This is the location for the transmission ECM.

The transmission shift rail calibration should be performed if any of the following items occur:

- The shifting is harsh or slow.
- Seasonal transmission fluid changes.
- Replacement of a rail sensor
- A sensor is repositioned.
- The transmission is removed or the transmission is replaced.
- An active error code

Note: The following information is an example of the calibration procedure. The actual calibration screens may vary as new versions of the software are released.

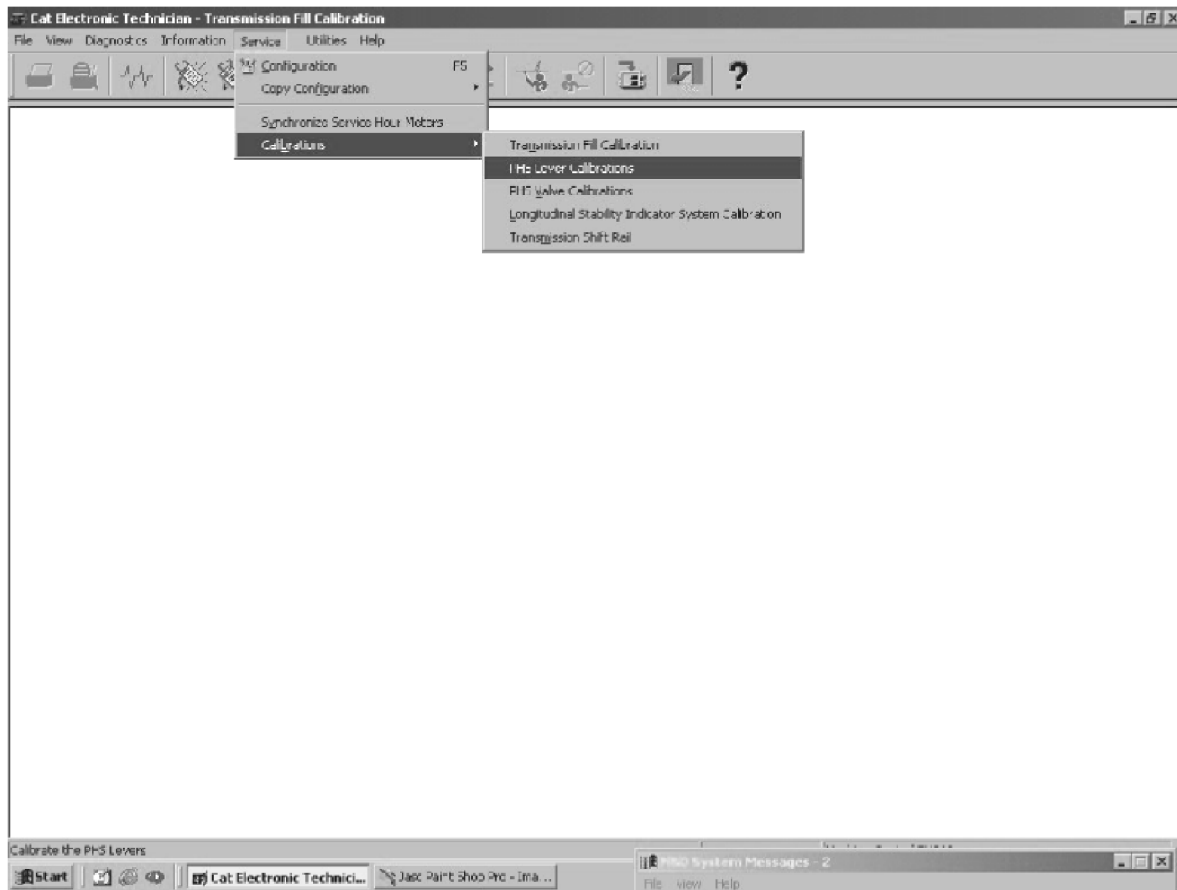


Illustration 55

g00931831

Note: Calibrate the position sensors for the transmission shift rail first if the machine is equipped with the powersynchro transmission.

To get to the calibration procedures for the transmission, you click on the “Service” menu. Click on “Calibration”. Click on the “Transmission Shift Rail”. The “Transmission Shift Rail” is the last item on the list. Next, the first calibration screen will appear.

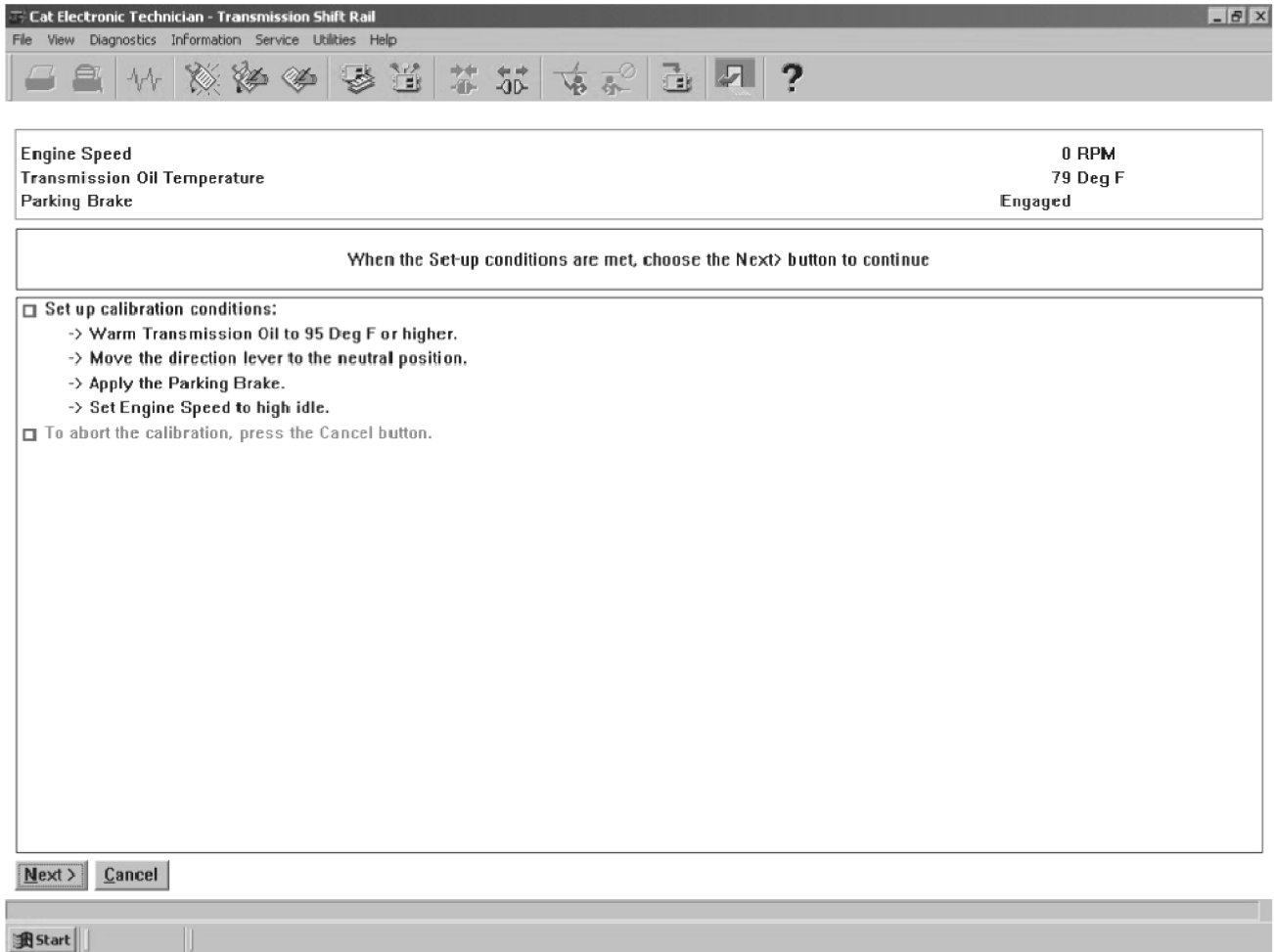


Illustration 56

g00927353

There are up to 3 position sensors for the shift rail in the automatic transmission. The shift rail position sensor sends an input to the machine ECM if the transmission is neutralized. 2 position sensors for the shift rail are used in the automatic transmission with four speeds. One rail sensor is for the one and two synchronizers. The second rail sensor is used for synchronizers three and four. The automatic transmission with five speeds has a third shift rail position sensor for the fifth speed.

After all of the conditions are met, click “Next” in order to continue with the calibration procedure.

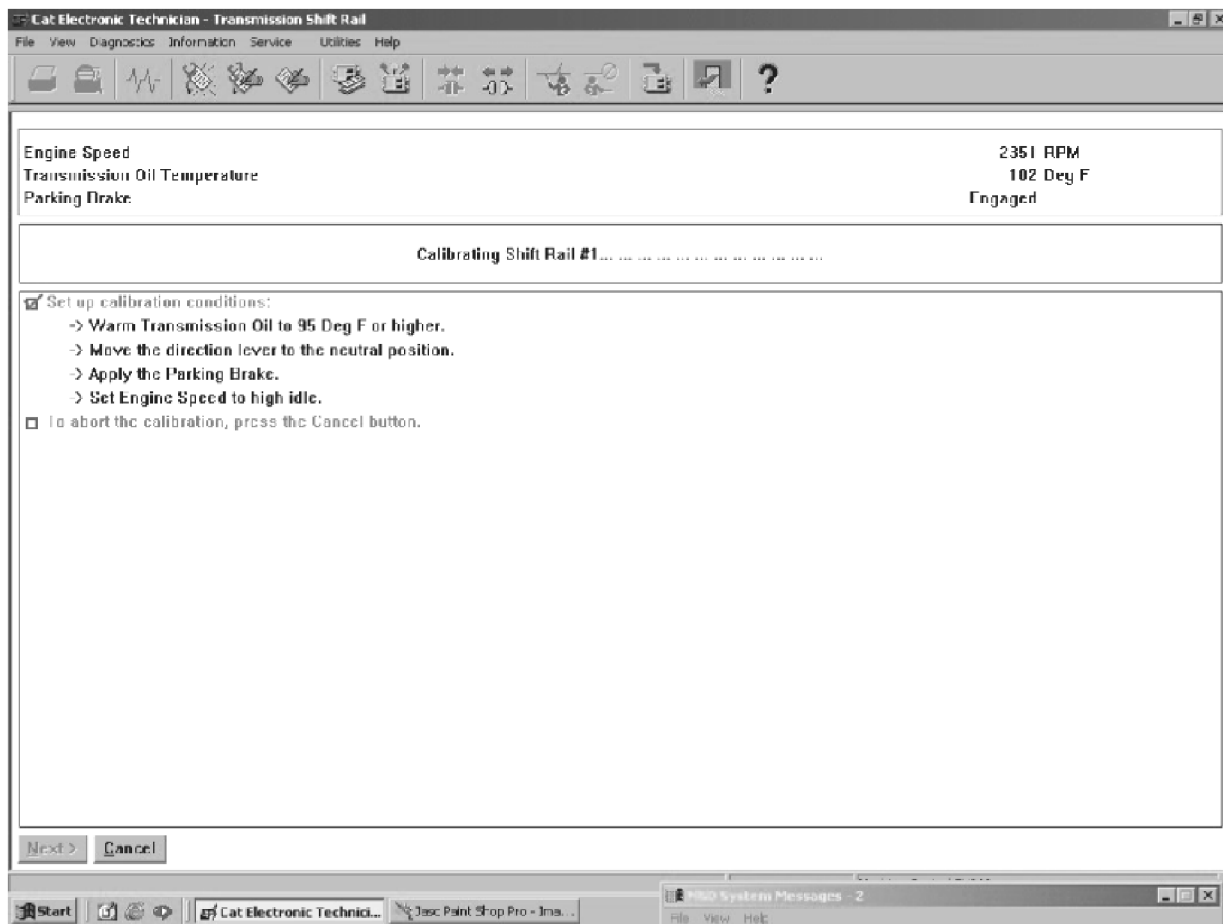


Illustration 57

g00931874

ET is calibrating the number one shift rail. If ET does not calibrate the number one shift rail successfully, ET will discontinue the calibration. A dialog box for the failure will appear on the screen. A fault error code will be displayed in the window. The error codes are listed in table 7. If a failure occurs ET will not try to calibrate the number two shift rail.

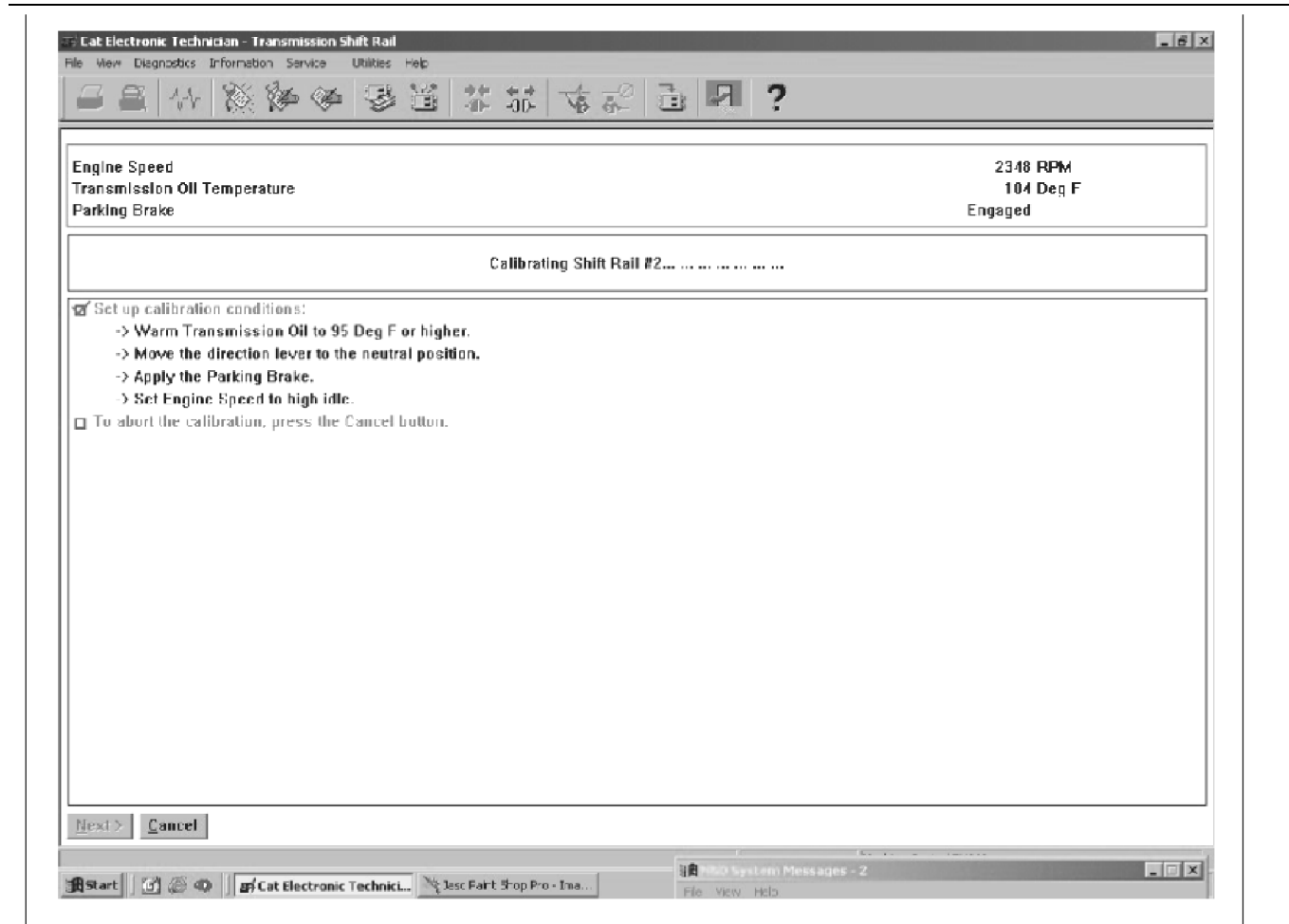


Illustration 58

g00931882

ET is now calibrating the number two shift rail. The shift rails two and three are calibrated automatically after the number one shift rail has been calibrated.

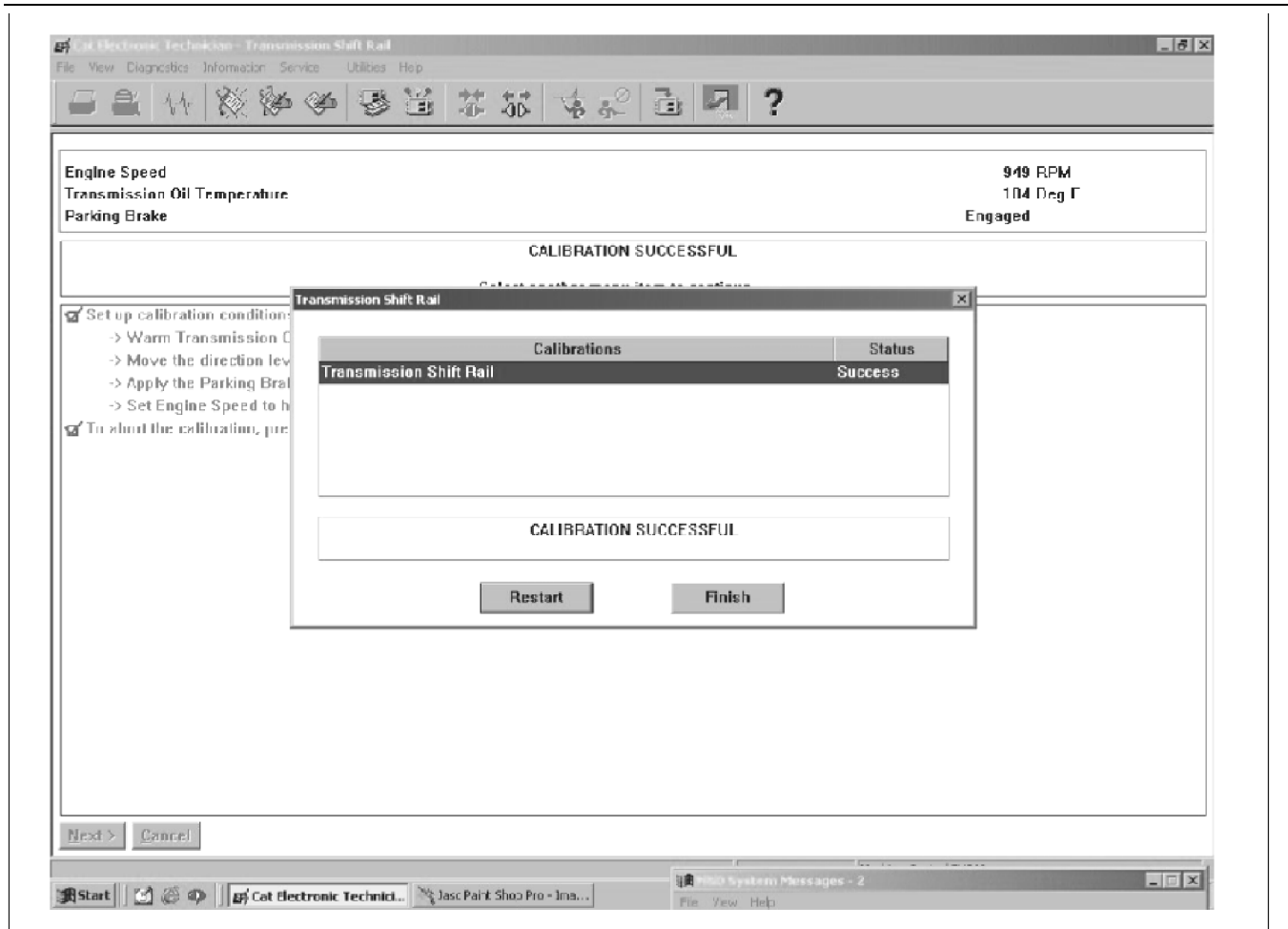


Illustration 59

g00931892

The calibration procedure was successful. A window will appear if a failure occurs. Data in the window will include an error code for the failure. The error codes are listed in table 7. After correcting the problem, the calibration is repeated by pressing the “Restart” button. You complete the process by clicking on the “Finish” button.

Note: Turn off the ignition key, after the calibration procedure is finished. Leave the key off for fifteen seconds. The new parameters are then stored in the ECM.

Table 6

TRANSMISSION SHIFT RAIL CALIBRATION ERROR CODES	
CODE	Cause
0002	Active diagnostic present
0006	Aborted by user
0009	Aborted by ECM
1012	Engine RPM incorrect
1018	Parking brake not engaged
101B	Machine speed not zero
101F	Direction lever not in NEUTRAL
1021	Transmission oil temperature too low
1022	Transmission oil temperature too high
108F	Shift rail readings inconsistent
1090	Shift rail maximum position out of range
1091	Shift rail detent position out of range
1092	Shift rail NEUTRAL position out of range

i02124714

Transmission Fill - Calibrate

SMCS Code: 3030-524

This calibration procedure is for calibrating the fill time for the forward clutch and the reverse clutch. This calibration procedure is done on the Power Shuttle and the Powersynchro transmissions.

Machine Preparation

WARNING

Personal injury or death can result from sudden machine movement.

Sudden movement of the machine can cause injury to persons on or near the machine.

Prevent possible injury by performing the procedure that follows before working on the machine.

1. Move the machine to a smooth, horizontal location that is away from operating machines and away from personnel.
2. In order to prevent the drive wheel from turning during the test, put the machine in position against a solid, stationary object such as a loading dock. Engage the parking brake.
3. Permit only one operator on the machine. Keep all other personnel away from the machine or in the operator's sight.
4. Move the transmission control to the NEUTRAL position.
5. Lower the boom. If equipped, lower the work tool to the ground and stop the engine.
6. If the machine is in a confined area, ensure that exhaust gases are vented to the outside when the engine is operated.
7. Make sure that all the oil pressure is released before you perform any of the following procedures:
 - Loosen any fitting, any hose, or any component.
 - Tighten any fitting, any hose, or any component.
 - Remove any fitting, any hose, or any component.
 - Adjust any fitting, any hose, or any component.

8. Install the 9U-7400 Multitach Tool Group or ET on the engine in order to enable an accurate measurement of the engine speed (rpm). Refer to Special Instruction, NEHS0605 for further information on the use of this equipment.

Warming the Transmission Oil

Increase the transmission oil temperature to at least 60 °C (140 °F).

1. Apply the service brakes and start the engine.
 2. Run the engine at Low Idle for 2 minutes. Then run the engine at High Idle for 2 minutes.
 3. Disengage the parking brake. Ensure that the switch that disables the transmission neutralizer control is in the OFF position. Refer to the Operation and Maintenance Manual, "Transmission Neutralizer Control".
 4. Move the transmission control to the FOURTH SPEED position with the drive in the NEUTRAL position. Depress the accelerator pedal until the engine speed has reached high idle. The high idle speed is 2350 ± 25 (rpm).
 5. Move the transmission control to the FORWARD position and stall the torque converter until the transmission oil temperature gauge in the cab reads 3/4 of the way to the red line.
- Note:** To ensure that the transmission oil does not get too hot, do not keep the torque converter in a full stall condition for more than 10 seconds.
6. Move the transmission control to the NEUTRAL position and continue to run the engine at high idle until the needle of the transmission oil temperature gauge returns to the middle of the scale.

Calibration Procedure

Table 7

Required Tools		
Part Number	Description	Quantity
JEBD3003	Caterpillar Electronic Technician (ET)	1
171-4400	Communications Adapter II	1
207-6845	Adapter Cable As	1
160-0141	Adapter Cable As	1
9U-7400	Multitach Tool Group	1

The Caterpillar Electronic Technician service tool (ET) is used to access the calibration procedures. A message on the ET screen will give instructions that guide the user through the calibration procedure. Refer to the Manual that is provided with the ET for more information about ET.



Illustration 60

This is the location of the service connector that contains the CAT data link. The connector is located to the side and rear of the seat.

The location for the machine ECM is under the engine hood.

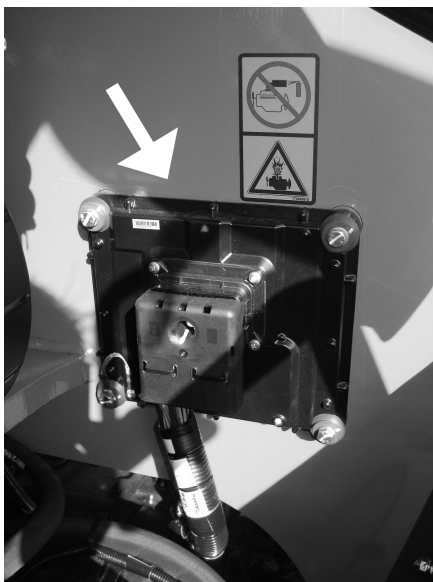


Illustration 61

This is the location for the machine ECM.

The transmission fill calibration should be performed if any of the following items occur:

- The shifting is harsh or slow.
- Seasonal transmission fluid changes.
- Replacement of a rail sensor
- A sensor is repositioned.
- The transmission is removed or the transmission is replaced.
- An active error code

Note: The following information is an example of the calibration procedure. The actual calibration screens may vary as new versions of the software are released.

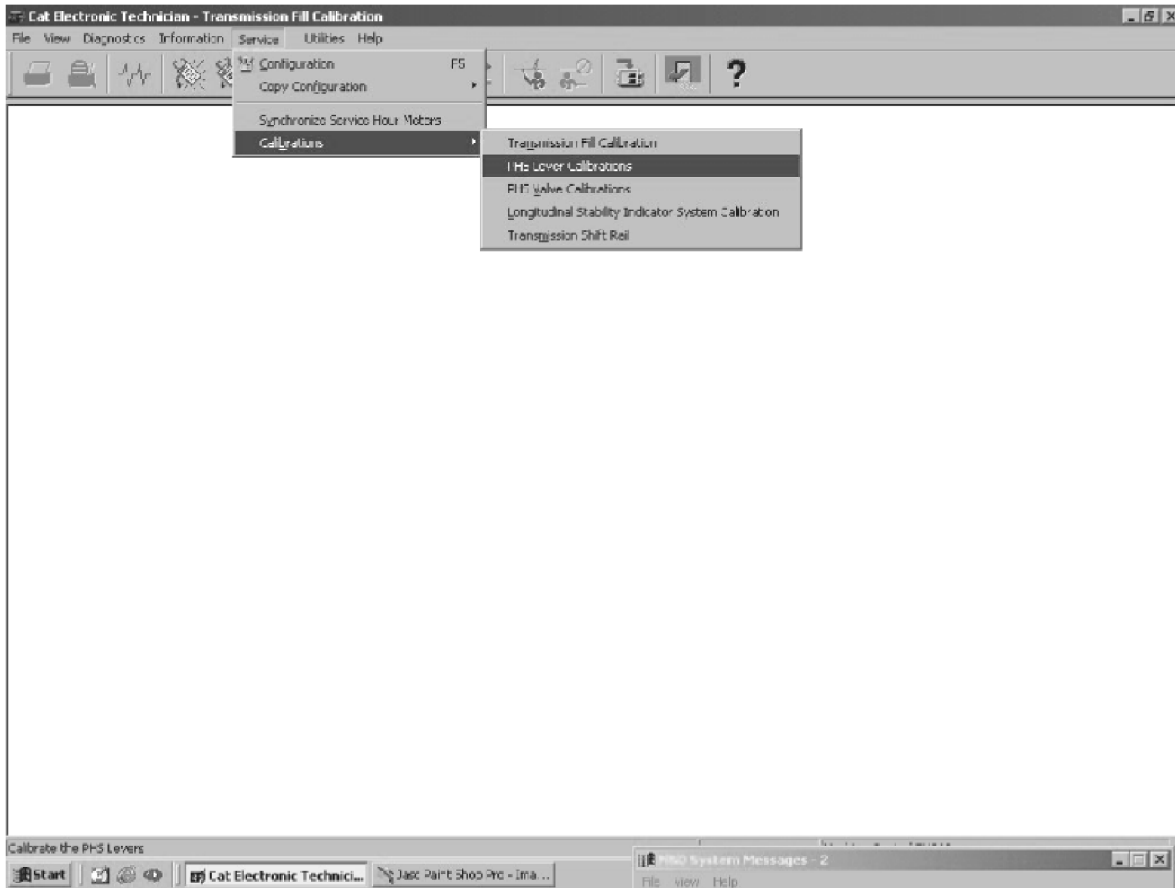


Illustration 62

g00931831

Note: Calibrate the position sensors for the transmission shift rail first if the machine is equipped with the powersynchro transmission.

Reference: For additional information about calibrating the position sensors for the transmission shift rail, refer to the Service Manual module Testing and Adjusting, “Transmission Shift Rail - Calibrate” for the machine that is being serviced.

To get to the calibration procedures for the transmission, you click on the “Service” menu. Click on “Calibration”. Click on the “Transmission Fill Calibrate”. The “Transmission Fill Calibrate” is the first item on the list. Next, the first calibration screen will appear.

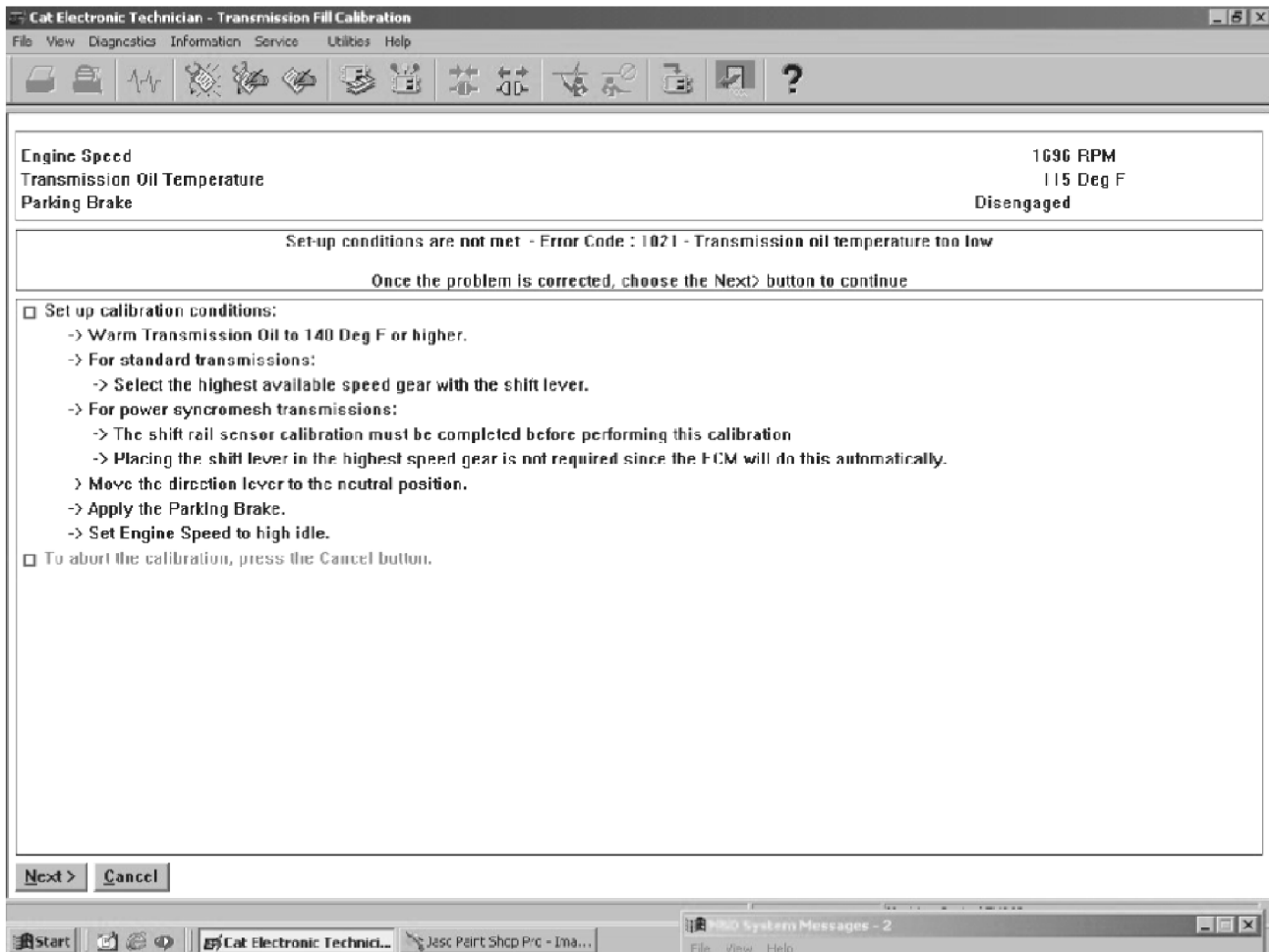


Illustration 63

g00932422

All requirements must be met in order to continue the calibration. The screen illustrates that all conditions are not met. In this particular case, the transmission oil temperature is too low.

Note: Both calibration procedures involve heating the transmission oil to a certain temperature and running the engine at high idle.

Follow the instructions on the ET screens in order to successfully complete the calibration procedure.

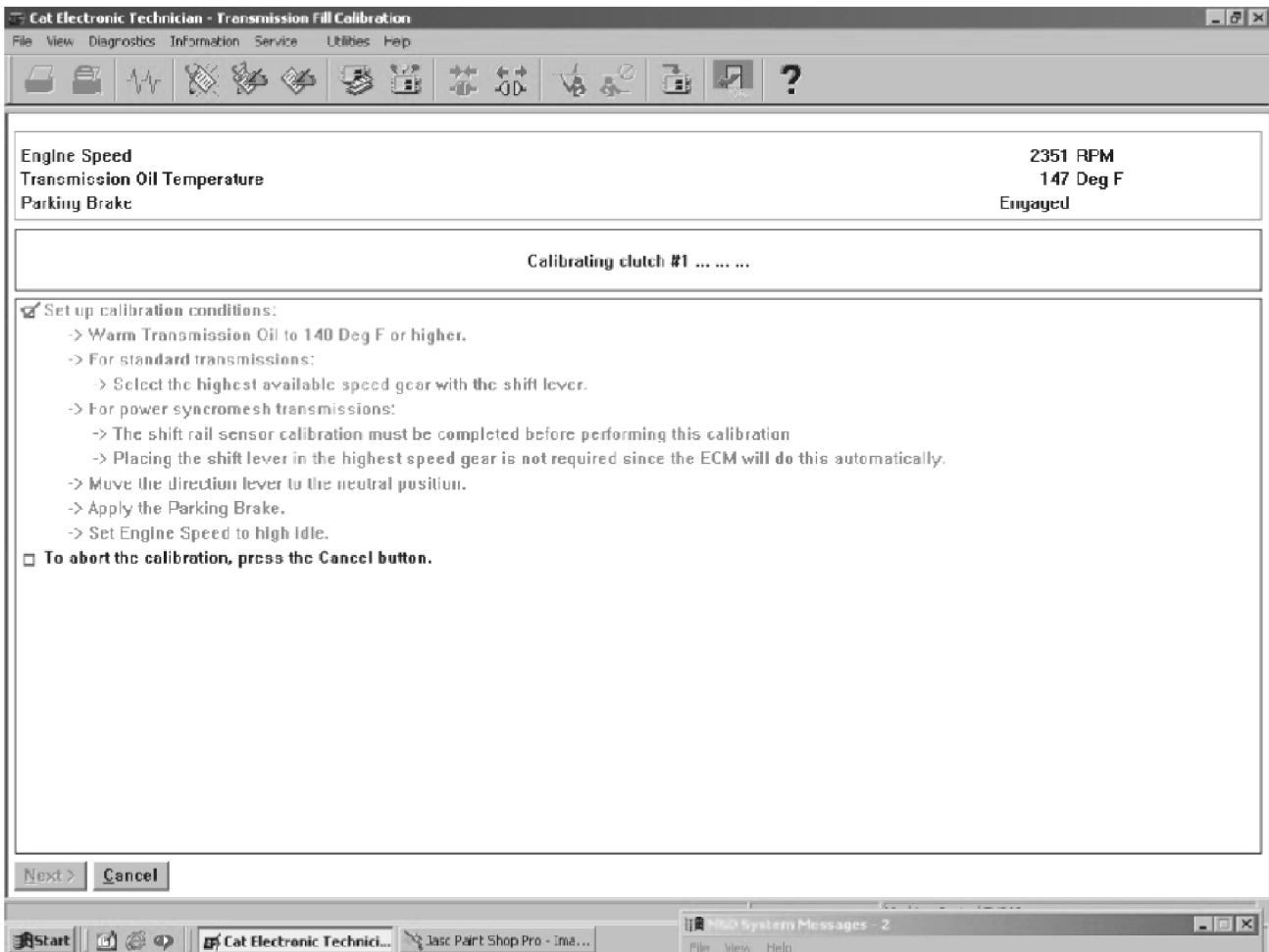


Illustration 64

g00932434

The number one clutch is the reverse clutch.

All the conditions have been met. ET is now calibrating the number one clutch. If ET does not calibrate the number one clutch successfully ET will discontinue the calibration. A dialog box for the failure will appear on the screen. A fault error code will be displayed in the window. The error codes are listed in table 9. If a failure occurs ET will not try to calibrate the number two clutch.

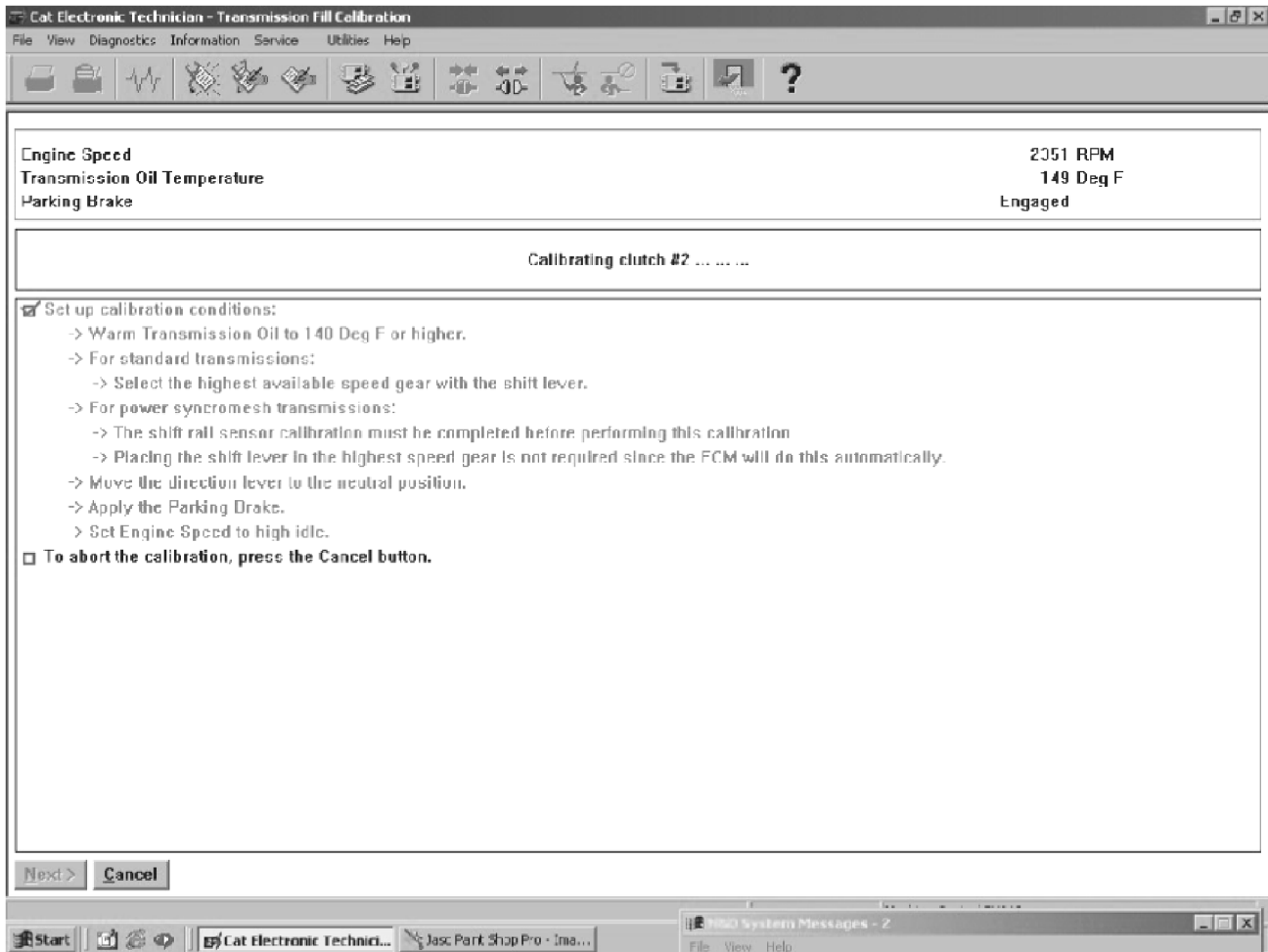


Illustration 65

g00932439

The number two clutch is the forward clutch.

The second clutch is calibrated automatically after the first clutch is calibrated.

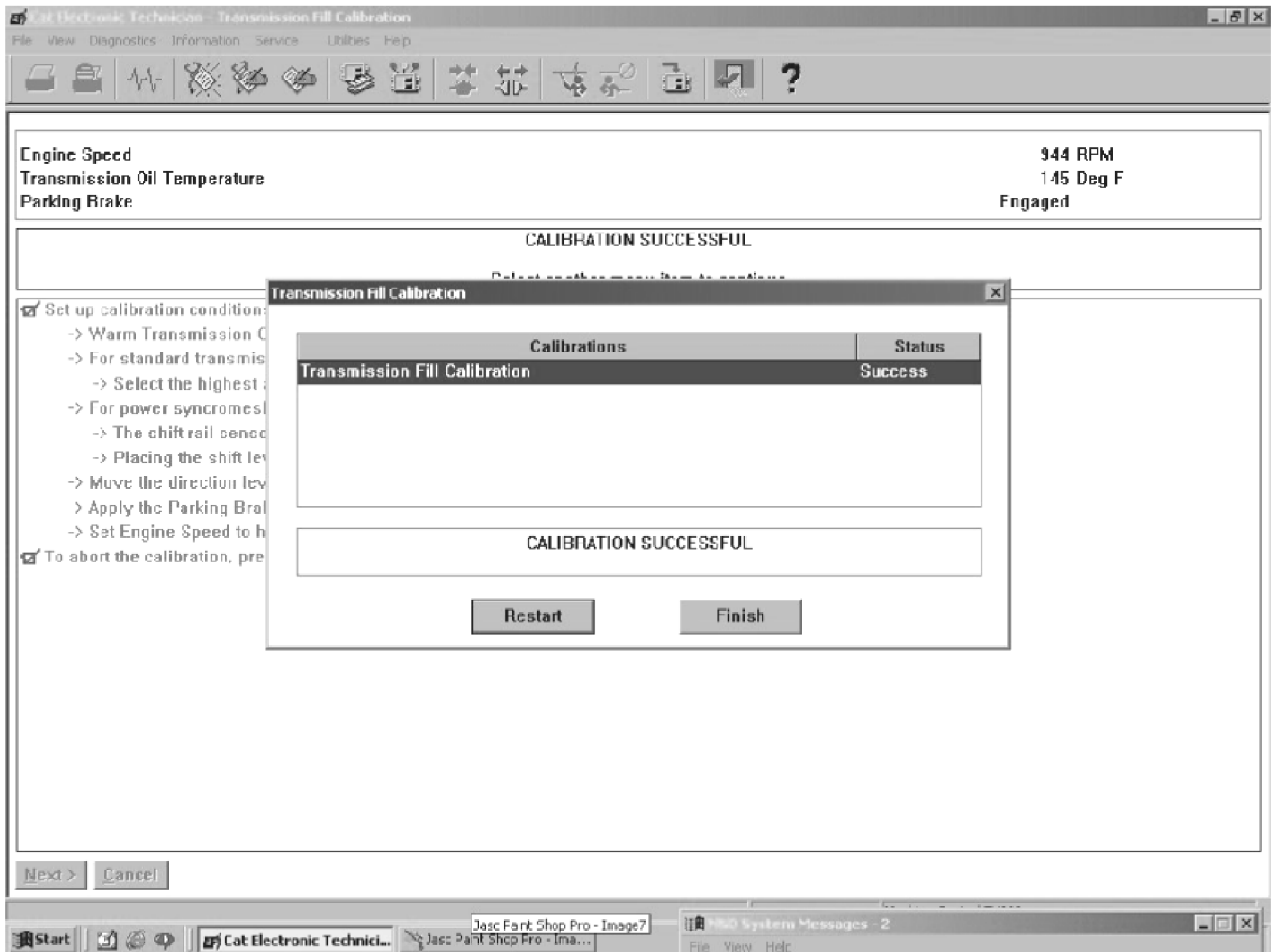


Illustration 66

g00932443

The calibration procedure was successful. A window will appear if a failure occurs. Data in the window will include an error code for the failure. The error codes are listed in table 9. After correcting the problem, the calibration is repeated by pressing the “Restart” button. You complete the process by clicking on the “Finish” button.

Note: Turn off the ignition key, after the calibration procedure is finished. Leave the key off for fifteen seconds. The new parameters are then stored in the ECM.

Table 8

TRANSMISSION FILL CALIBRATION ERROR CODES	
CODE	Cause
0002	Active diagnostic present
0006	Aborted by user
0009	Aborted by ECM
1012	Engine RPM incorrect
1018	Parking brake not engaged
101B	Machine speed not zero
101F	Direction lever not in NEUTRAL
1021	Transmission oil temperature too low

i02120212

Torque Converter Stall - Test

SMCS Code: 3101-081-V8

Introduction

The torque converter stall test is designed to test the engine, the torque converter and the drive train. The engine speed indicates whether the engine and the transmission are operating correctly under full load.

If the engine performance is correct and the torque converter stall speed is not correct, the problem is in the torque converter or in the transmission. To ensure that the engine performance is not responsible for the wrong torque converter stall speed, check the engine by other methods after the first test.

Note: Refer to Telehandlers Machine Systems Troubleshooting, RENR5195 for problems that involve the engine.

The service brakes must be applied when tests are performed. Check the operation of the brakes before you perform any tests.

Reference: See Systems Operation/Testing and Adjusting, "Torque Converter" for more information on the torque converter.

Required Tools

Table 10 provides a list of the tools that are required to carry out the stall test for the torque converter.

Table 9

Required Tools		
Qty	Part Number	Description
1	9U-7400	Multitach Tool Group

Test Procedure

NOTICE

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Refer to Special Publication, NENG2500, "Caterpillar Tools and Shop Products Guide" for tools and supplies suitable to collect and contain fluids on Caterpillar products.

Dispose of all fluids according to local regulations and mandates.

WARNING

When testing and adjusting the transmission and power train, move the machine to an area clear of obstructions, with safe exhaust ventilation for the exhausts. Sudden movement of the machine or release of oil under pressure can cause injury to persons on or near the machine. To prevent possible injury, do the procedure that follows before testing and adjusting the transmission and power train.

1. Move the machine to a smooth, horizontal location that is away from operating machines and away from personnel.
2. In order to prevent the drive wheel from turning during the test, put the machine in position against a solid, stationary object such as a loading dock. Engage the parking brake.
3. Permit only one operator on the machine. Keep all other personnel away from the machine or in the operator's sight.
4. Move the transmission control to the NEUTRAL position.
5. Lower the boom. If equipped, lower the work tool to the ground and stop the engine.
6. If the machine is in a confined area, ensure that exhaust gases are vented to the outside when the engine is operated.
7. Make sure that all the oil pressure is released before you perform any of the following procedures:
 - Loosen any fitting, any hose, or any component.
 - Tighten any fitting, any hose, or any component.
 - Remove any fitting, any hose, or any component.
 - Adjust any fitting, any hose, or any component.
8. Install the 9U-7400 Multitach Tool Group or ET on the engine in order to enable an accurate measurement of the engine speed (rpm). Refer to Special Instruction, NEHS0605 for further information on the use of this equipment.

Warming the Transmission Oil

In order to ensure that the transmission oil is at the normal operating temperature of 60° ± 10°C (140° ± 18°F), complete the following procedure:

1. Apply the service brakes and start the engine.

2. Run the engine for 2 minutes at Low Idle. Then, run the engine for 2 minutes at High Idle.
 3. Disengage the parking brake. Ensure that the switch that disables the transmission neutralizer control is in the OFF position. Refer to the Operation and Maintenance Manual, "Transmission Neutralizer Control".
 4. Move the transmission control to the FOURTH SPEED position with the drive in the NEUTRAL position. Depress the accelerator pedal until the engine speed has reached high idle. The high idle speed is 2350 ± 25 (rpm).
 5. Move the transmission control to the FORWARD position and stall the torque converter until the transmission oil temperature gauge in the cab reads 3/4 of the way to the red line.
- Note:** To ensure that the transmission oil does not get too hot, do not keep the torque converter in a full stall condition for more than 10 seconds.
6. Move the transmission control to the NEUTRAL position and continue to run the engine at high idle until the needle of the transmission oil temperature gauge returns to the middle of the scale.
 7. Repeat Step 5 and Step 6. Then follow the procedure for "Measurement of the Stall Speed" that is shown below.

Measurement of the Stall Speed

Test the torque converter stall according to the following procedure:

1. Apply the service brakes and start the engine.
2. Disengage the parking brake. Ensure that the transmission neutralizer switch on the instrument panel is in the OFF position.

Note: To ensure that the transmission oil does not get too hot, do not keep the torque converter in a full stall condition for more than 10 seconds. After the torque converter is stalled, move the transmission control to the NEUTRAL position and run the engine at half speed.

3. Move the transmission control to the FOURTH SPEED position with the drive in the NEUTRAL position. Depress the accelerator pedal until the engine speed has reached high idle. The high idle speed is 2350 ± 25 (rpm). Check that the water temperature gauge and the oil temperature gauge are showing the correct reading.

4. Move the transmission control to the FORWARD position and record the torque converter stall speed after 10 seconds. The torque converter temperature during the stall test should be $80^\circ \pm 10^\circ\text{C}$ ($176^\circ \pm 18^\circ\text{F}$). Refer to Table 11 for the correct stall RPM of the various power ratings for the available engines.

Table 10

Direct Drive Transmission Arrangement		
Engine	Power Rating	Stall RPM
C4.4 DITAAC	74.5 kW (100 hp)	2035 +/- 90
C4.4 ACERT	93.1 kW (125 hp)	2145 +/- 75

Note: The stall speeds are calculated by using number 2 diesel fuel.

5. If you must repeat the test, keep the transmission in neutral and wait for two minutes between tests.
6. After the test, operate the engine for five minutes at low idle in order to allow the temperature of the components to equalize.

i02112505

Transmission Pressures - Test and Adjust

SMCS Code: 3030-025-PX; 3030-081-PX;
3074-025-PX; 3074-081-PX

WARNING

When testing and adjusting the transmission and power train, move the machine to an area clear of obstructions, with safe exhaust ventilation for the exhausts. Sudden movement of the machine or release of oil under pressure can cause injury to persons on or near the machine. To prevent possible injury, do the procedure that follows before testing and adjusting the transmission and power train.

NOTICE

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Refer to Special Publication, NENG2500, "Caterpillar Tools and Shop Products Guide" for tools and supplies suitable to collect and contain fluids on Caterpillar products.

Dispose of all fluids according to local regulations and mandates.

Table 11

Required Tools		
Qty	Part Number	Description
1	9U-7400	Multitach Tool Group
1	8T-0855	Pressure Gauge (0 to 4,000 kPa (0 to 580 psi))
1	5P-4675	Adapter
1	6V-3966	Fitting
1	6V-4143	Coupler
1	177-7861	Hose As
1	6V-4142	Fitting
1	6V-4144	Coupler

Problems with the transmission may be caused by mechanical faults, electrical faults or hydraulic faults. The mechanical components and the electrical components must be in good condition and the components must operate properly. In addition, the correct operation of the transmission hydraulic system is critical. The transmission oil circulates through the system for operation, for lubrication, and for cooling.

To ensure the correct operation of the torque converter, the clutches, and the synchronizers in the transmission, the oil must be supplied in the correct quantity. Also, the oil must be regulated at the required temperature and the required pressures.

The operating temperatures and the operating pressures can be checked in order to help you identify problems when you are troubleshooting the system.

Note: If you have a power shuttle transmission, you only need to do the test points that are common to the manual transmission.

Test the transmission pressures according to the following procedures:

Pressure Test Points for the Powersynchro Transmission

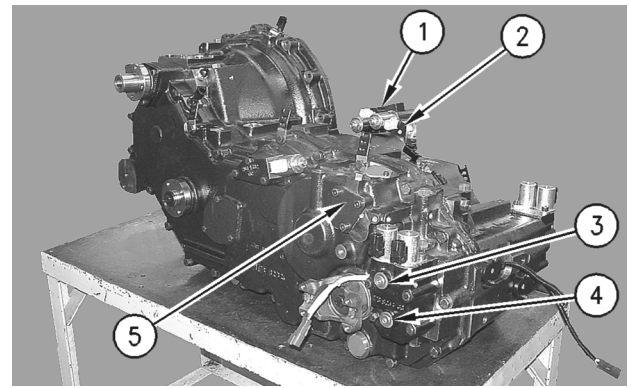


Illustration 67

- (1) Pressure test point (forward clutch)
- (2) Pressure test point (reverse clutch)
- (3) Pressure test point (synchronizer for the fourth speed)
- (4) Pressure test point (synchronizer for the second speed)
- (5) Pressure test point (synchronizer for the fifth speed)

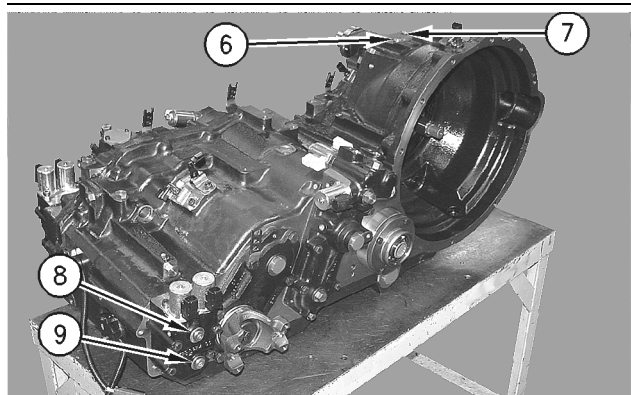


Illustration 68

g00888738

- (6) Pressure test point (regulated pump)
- (7) Pressure test point (torque converter inlet)
- (8) Pressure test point (synchronizer for the third speed)
- (9) Pressure test point (synchronizer for the first speed)

The test points for the synchronizers are for the powersynchro transmission. The remaining test points are able to be performed on both transmissions.

Oil Level Check

Pressure tests must be made with the oil in the transmission at the correct level and at the normal operating temperature. Use the following procedure to check the oil level:

1. Operate the machine until the oil in the transmission is at $30^{\circ} \pm 5^{\circ}\text{C}$ ($86^{\circ} \pm 9^{\circ}\text{F}$).
2. Operate the engine at low idle 950 rpm.
3. Check the level mark for the hydraulic oil system.
4. If necessary, add oil.

Torque Converter Inlet Pressure

Introduction

The pressure test for the torque converter inlet is designed to test the operation of the relief valve for the torque converter. If the pressure at the test point for the torque converter inlet is within the given parameters then it is likely that the relief valve for the torque converter is operating correctly. If the pressure at the test point is not within the given parameters refer to Telehandler Machine Systems Troubleshooting, RENR5195.

Test Procedure

Pressure gauges are used in the following test procedure.

1. Move the machine to a smooth, horizontal location that is away from operating machines and away from personnel.
2. Permit only one operator on the machine. Keep all other personnel away from the machine or in the operator's sight.
3. Move the transmission control to the NEUTRAL position.
4. Lower the boom. If equipped, lower the work tool to the ground.
5. Engage the parking brake and stop the engine.
6. Place wheel blocks in front of the wheels and behind the wheels.
7. If the machine is in a confined area, ensure that exhaust gases are vented to the outside when the engine is operated.
8. Install the 9U-7400 Multitach Tool Group or the Caterpillar Electronic Technician (ET) on the engine in order to enable an accurate measurement of the engine speed (rpm). Refer to Special Instruction, NEHS0605 for further information on the use of the 9U-7400 Multitach Tool Gp.

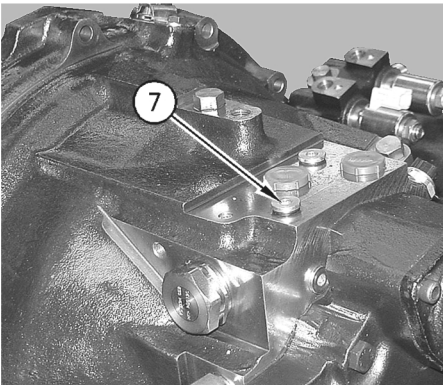


Illustration 69

Pressure Test Point for the Torque Converter Inlet

9. The torque converter inlet pressure can be tested at test point (7). Remove the plug from the test point. Use suitable fittings from Table 12 in order to install the 8T-0855 Pressure Gauge (0 to 4,000 kPa (0 to 580 psi)).
10. Start the engine and operate the engine at HIGH IDLE 2350 rpm.

11. The pressure should be 800 ± 100 kPa (116 ± 15 psi) when the engine is operating at 2350 rpm at a temperature of $25^\circ \pm 5^\circ\text{C}$ ($77^\circ \pm 9^\circ\text{F}$).

Note: This pressure is dependent on the oil temperature. A temperature range from 120°C (248°F) to -30°C (-22°F) will cause the inlet oil pressure to be from 500 kPa (73 psi) to 1100 kPa (160 psi).

12. Remove the fittings and install the plug that was removed from the test point.

Regulated Pump Pressure

Required Tools

Table 12 provides a list of the tools that are required to carry out the test for the regulated pump pressure.

Test Procedure

Pressure gauges are used in the following test procedure.

1. Move the machine to a smooth, horizontal location that is away from operating machines and away from personnel.
2. Permit only one operator on the machine. Keep all other personnel away from the machine or in the operator's sight.
3. Move the transmission control to the NEUTRAL position.
4. Lower the boom. If equipped, lower the work tool to the ground.
5. Engage the parking brake and stop the engine.
6. Place wheel blocks in front of the wheels and behind the wheels.
7. If the machine is in a confined area, ensure that exhaust gases are vented to the outside when the engine is operated.
8. Install the 9U-7400 Multitach Tool Group or ET on the engine in order to enable an accurate measurement of the engine speed (rpm). Refer to Special Instruction, NEHS0605 for further information on the use of this 9U-7400 Multitach Tool Gp.

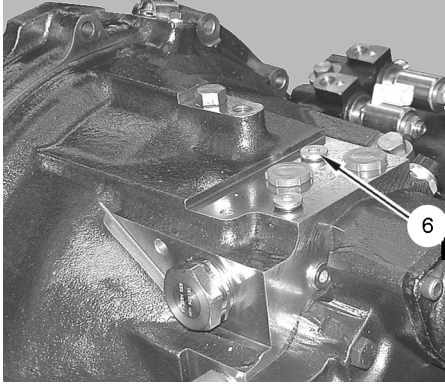


Illustration 70

Pressure Test Point for the regulated pump pressure

9. The regulated pump pressure can be tested at test point (6). Remove the plug from the test point. Use suitable fittings from Table 12 in order to install the 8T - 0855 Pressure Gauge (0 to 4,000 kPa (0 to 580 psi)).
10. Start the engine and operate the engine at 2350 rpm +100 or - 50.
11. The pressure should be 1625 ± 75 kPa (235 ± 11 psi) when the engine is operating at HIGH IDLE at a temperature of 80°C (176°F).
12. Remove the fittings and install the plug that was removed from the test point.

Operating Pressures of Clutches and Synchronizers

Introduction

The pressure tests for the clutches and synchronizers are designed to test the operation of the solenoid valves for the transmission. If the pressures at the test points are within the given parameters then it is likely that the solenoid valves for the transmission are operating correctly. If the pressures at the test points are not within the acceptable range refer to Telehandler Machine Systems Troubleshooting, RENR5195.

Test Procedure

Pressure gauges are used in the following test procedure.

1. Move the machine to a smooth, horizontal location that is away from operating machines and away from personnel.

2. Permit only one operator on the machine. Keep all other personnel away from the machine or in the operator's sight.
3. Move the transmission control to the NEUTRAL position.
4. Lower the boom. If equipped, lower the work tool to the ground.
5. Engage the parking brake and stop the engine.
6. Place wheel blocks in front of the wheels and behind the wheels.
7. If the machine is in a confined area, ensure that exhaust gases are vented to the outside when the engine is operated.
8. Install the 9U - 7400 Multitach Tool Group or the ET on the engine in order to enable an accurate measurement of the engine speed (rpm). Refer to Special Instruction, NEHS0605 for further information on the use of this 9U - 7400 Multitach Tool Gp.

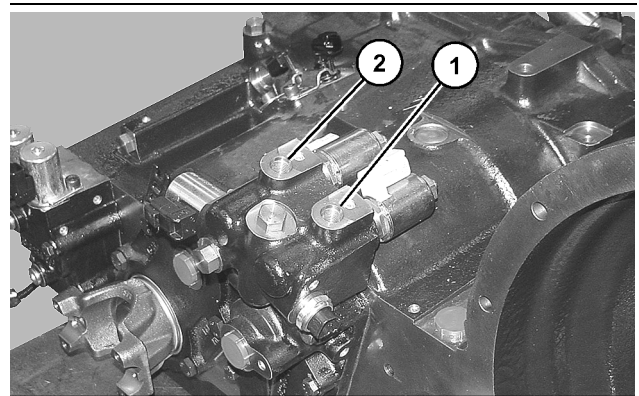


Illustration 71

g01075877

- (1) Pressure test point (forward clutch)
- (2) Pressure test point (reverse clutch)

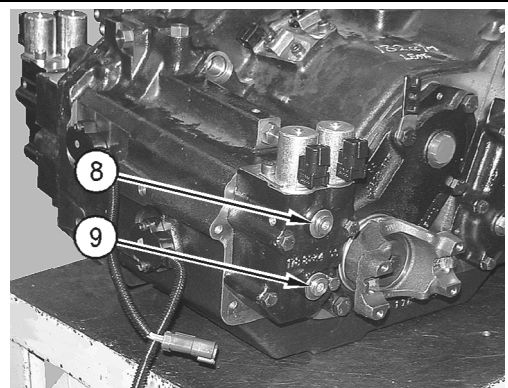


Illustration 72

- (8) Pressure test point (synchronizer for the third speed)
- (9) Pressure test point (synchronizer for the first speed)

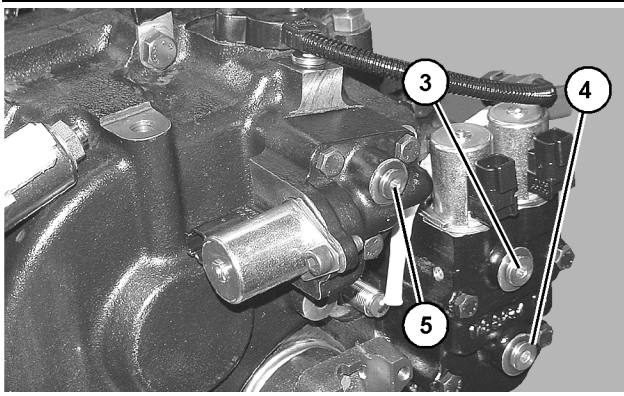


Illustration 73

g01075880

- (3) Pressure test point (synchronizer for the fourth speed)
- (4) Pressure test point (synchronizer for the second speed)
- (5) Pressure test point (synchronizer for the fifth speed)

Note: The test point for the fifth speed is shown for the optional five speed powersynchro transmission.

9. The operating pressures of clutches and synchronizers can be tested at the test points that are shown in Illustration 86, Illustration 87 and Illustration 88. Remove the plug from the desired test point. Use suitable fittings from Table 12 in order to install the 8T - 0855 Pressure Gauge (0 to 4,000 kPa (0 to 580 psi)).
10. Start the engine and operate the engine at LOW IDLE 950 RPM.
11. Place the machine into forward gear in order to test the forward clutch pressure. To test the pressure for the reverse clutch, place the transmission in reverse gear.
12. The correct oil pressures for each test point are shown in Table 13 and table 14.

Table 12

Clutch	Disengaged	Engaged
	Low Idle 950 RPM	Low Idle 950 RPM
Forward Clutch	10 ± 10 kPa (1.5 ± 1.5 psi)	1350 ± 100 kPa (195 ± 15 psi)
Reverse Clutch	10 ± 10 kPa (1.5 ± 1.5 psi)	1350 ± 100 kPa (195 ± 15 psi)

Table 13 is for both the power shuttle transmission and the powersynchro transmission.

Cycle through the first gear, the second gear, the third gear, the fourth gear and fifth gears for this test on the powersynchro transmission.

Table 13

Synchronizer	Disengaged	Engaged
	Low Idle 950 RPM	Low Idle 950 RPM
Synchronizer for the First Speed	1350 ± 100 kPa (195 ± 15 psi)	10 ± 10 kPa (1.5 ± 1.5 psi)
Synchronizer for the Second Speed	1350 ± 100 kPa (195 ± 15 psi)	10 ± 10 kPa (1.5 ± 1.5 psi)
Synchronizer for the Third Speed	1350 ± 100 kPa (195 ± 15 psi)	10 ± 10 kPa (1.5 ± 1.5 psi)
Synchronizer for the Fourth Speed	1350 ± 100 kPa (195 ± 15 psi)	10 ± 10 kPa (1.5 ± 1.5 psi)
Synchronizer for the Fifth Speed (if equipped)	10 ± 10 kPa (1.5 ± 1.5 psi)	1350 ± 100 kPa (195 ± 15 psi)

Table 14 pertains to the powersyncro transmission.

13. Remove the fittings and install the plug that was removed from the test point.

Index

C

Configuration Parameters.....	46
Cooler (Hydraulic Oil).....	36

D

Data Link.....	19
CAN Data Link.....	19

E

Electrical Input Components.....	13
Sensors.....	13
Switches.....	15
Transmission Control.....	16
Electrical Output Components.....	18
Directional Solenoids.....	19
Synchronizer Solenoids.....	19
Electrical Schematic.....	19
Electronic Control Module.....	16
Input/Output.....	16
Inputs.....	16
Outputs.....	16

G

General Information.....	6
Graphic Color Codes.....	4

H

Hydraulic Schematic (Power Train System).....	43
Neutral (Powersynchro Transmission).....	43
Neutral Into First Gear (End of Shift) (FORWARD).....	45
Neutral into First Gear (Start of shift).....	44

I

Important Safety Information.....	2
Introduction.....	5

L

Location of Electrical Components.....	7
Electronic Control Module.....	10
Engine Speed Sensor.....	9
Modulating Valve for the Synchronizers.....	10
Parking Brake Switch.....	8
Service Brake Pressure Switch.....	9
Shift Rail Sensors.....	10
Solenoid Valves.....	11
Torque Converter Output Sensor for the Temperature of the Oil.....	9

Torque Converter Output Speed Sensor.....	9
Transmission Intermediate Speed Sensors.....	10
Transmission Neutralizer Override Switch.....	11
Transmission Neutralizer Switch.....	8
Transmission Oil Temperature Sensor.....	9
Transmission Output Speed Sensor.....	10
Transmission Speed Selector (Powersynchro Transmission).....	9
Location of Hydraulic Components.....	11
Hydraulic Oil Cooler.....	12
Torque Converter.....	12
Transmission Charge Pump.....	12

M

Modulating Valve (Transmission).....	22
--------------------------------------	----

S

Solenoid Valves (Transmission).....	22
Directional Solenoids.....	23
Speed or Synchronized Solenoids.....	23
Systems Operation Section.....	4

T

Table of Contents.....	3
Testing and Adjusting.....	47
Testing and Adjusting Section.....	47
Torque Converter.....	24
Torque Converter Stall - Test.....	61
Introduction.....	61
Required Tools.....	61
Test Procedure.....	61
Transmission.....	26
Clutch Operation.....	29
Limits.....	35
Operation of the Synchronizers.....	30
Transmission Charge Pump.....	22
Transmission Control (Shift Lever).....	36
Powersynchro Transmission.....	37
Transmission Fill - Calibrate.....	54
Machine Preparation.....	54
Transmission Power Flow.....	38
Examples of Power Flow Through the Transmission.....	40
Transmission Pressures - Test and Adjust.....	62
Oil Level Check.....	64
Operating Pressures of Clutches and Synchronizers.....	66
Pressure Test Points for the Powersynchro Transmission.....	63
Regulated Pump Pressure.....	65
Torque Converter Inlet Pressure.....	64
Transmission Shift Rail - Calibrate.....	47
Machine Preparation.....	47

CATERPILLAR®