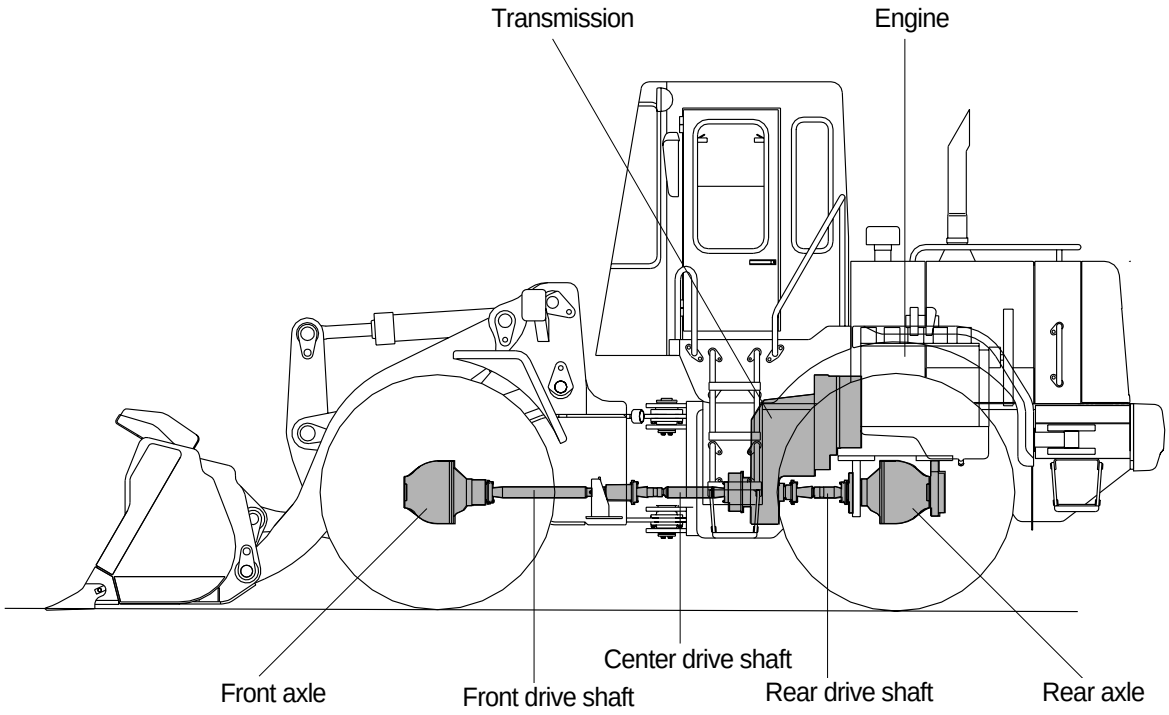
SECTION 3 POWER TRAIN SYSTEM

GROUP 1 STRUCTURE AND FUNCTION

1. POWER TRAIN COMPONENT OVERVIEW



The power train consists of the following components:

Transmission
Front and rear drive shafts
Front and rear axles

Engine power is transmitted to the transmission through the torque converter.

The transmission is a hydraulically engaged four speed forward, three speed reverse countershaft type power shift transmission. A drum type parking brake is located on the front of the transmission output shaft.

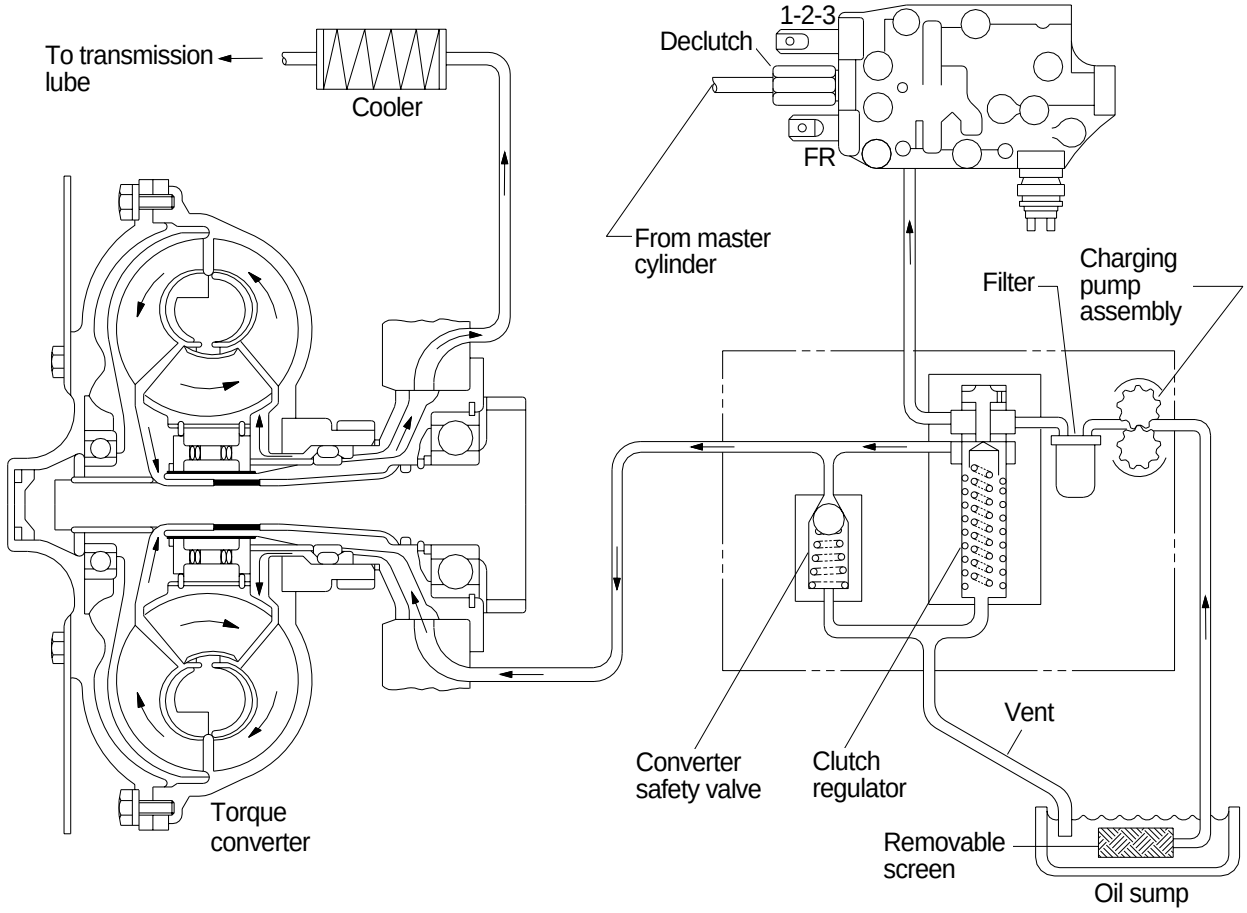
The transmission outputs through universal joints to two drive shaft assemblies. The front drive shaft is a telescoping shaft which drives the front axle. The front axle is mounted directly to the loader frame. The front axle is equipped with limited slip differential.

The rear axle is mounted on an oscillating pivot. The rear axle is equipped with limited slip differential.

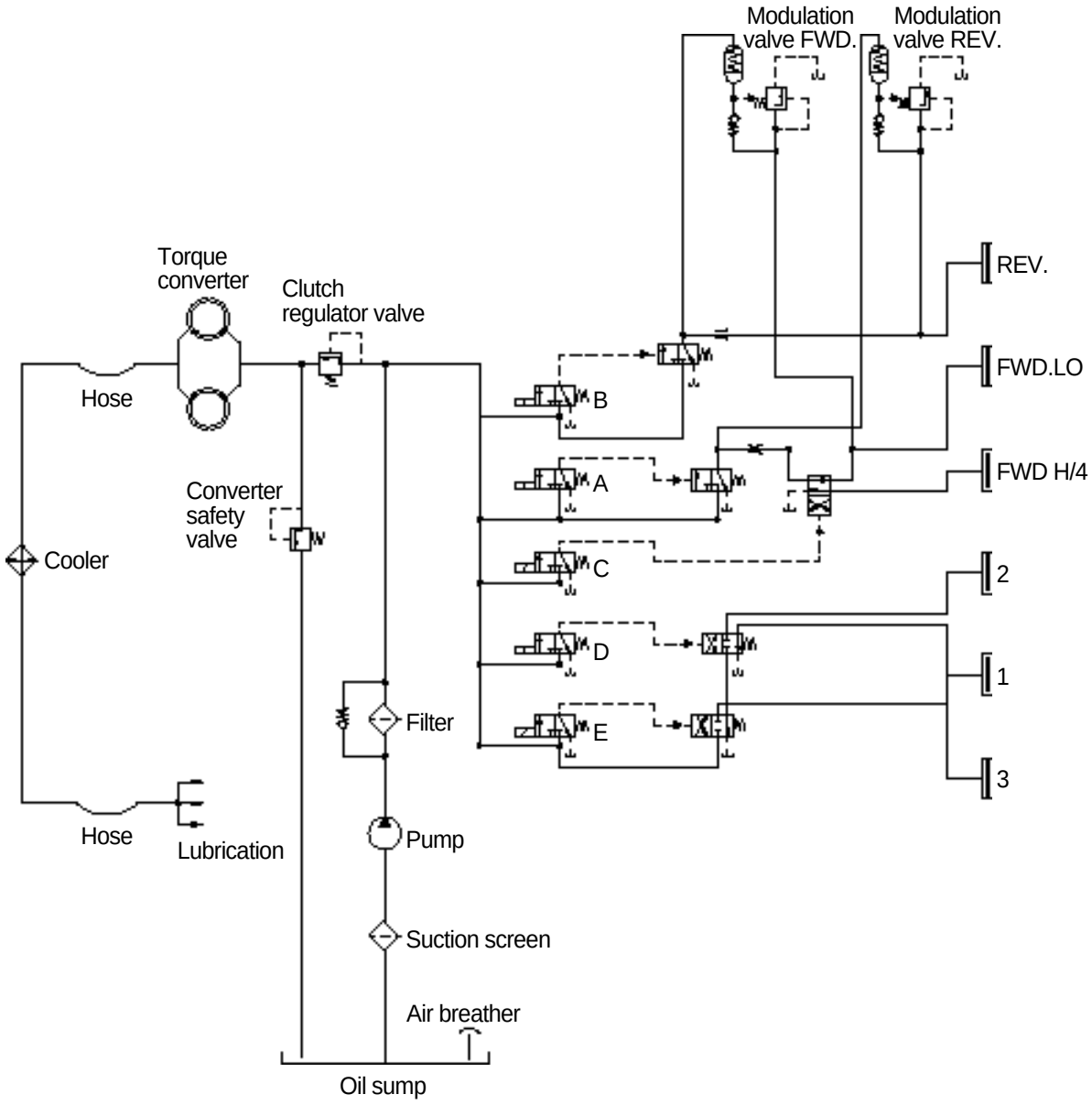
The torque transmitted to front axle and rear axle is increased by the pinion gear and ring gear of differential. It then passes from the differential to the sun gear shaft(axle shaft of final drive).

The torque of the sun gear is increased by a planetary mechanism and is transmitted through the planetary hub to the wheel.

HYDRAULIC SCHEMATIC



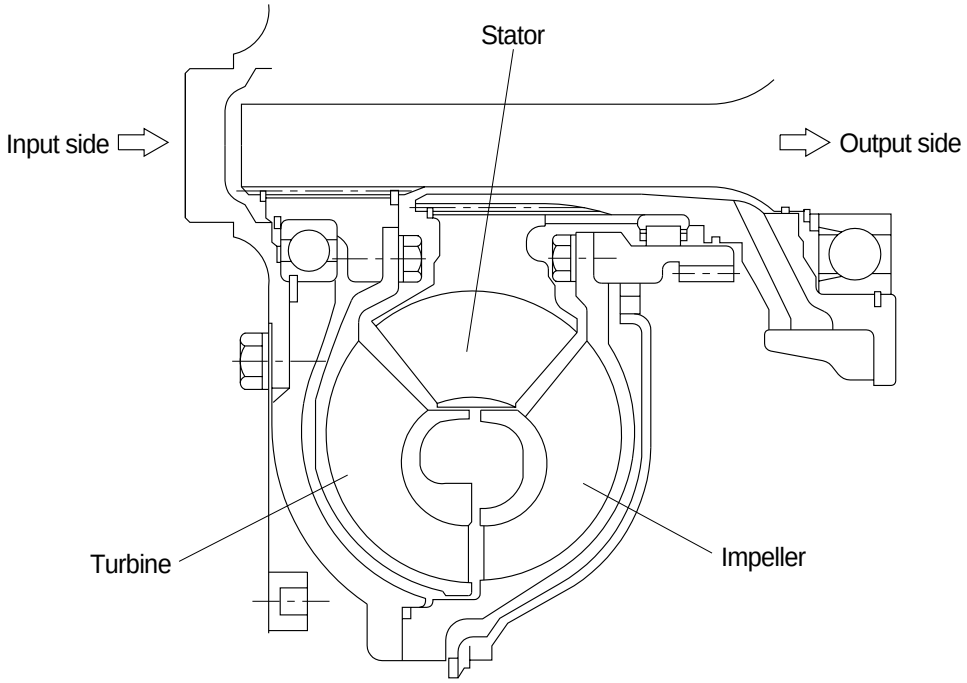
HYDRAULIC CIRCUIT



	Forward				Reverse			Neutral		
	1	2	3	4	1	2	3	1	2	3
B					X	X	X			
C				X						
A	X	X	X	X						
E	X	X			X	X		X	X	
D	X				X			X		

X : Solenoid activated

2. TORQUE CONVERTER



Torque converter is a stemless transmitting system to transmit engine power by means of hydraulic force. As usual, this system(torque converter) is consisting of three elements(impeller wheel, turbine wheel, stator wheel).... the impeller wheel connected to input shaft, the turbine wheel connected to output shaft and the stator wheel(guide bland) fixed to the housing.

The above impeller wheel and turbine wheel face each other and also, the stator wheel is located between these two elements. These three elements are enclosed in the oil filled housing.

As the impeller wheel is turned by the engine, centrifugal force causes oil to strike the turbine wheel at high velocity and forces it to turn.

The stator is provided to change the direction of oil flow after it has gone through the turbine wheel and send it back to the impeller wheel. At that time, reaction torque is caused and this is added to the torque of turbine wheel. As a result, the output torque is increased to several times of engine torque.

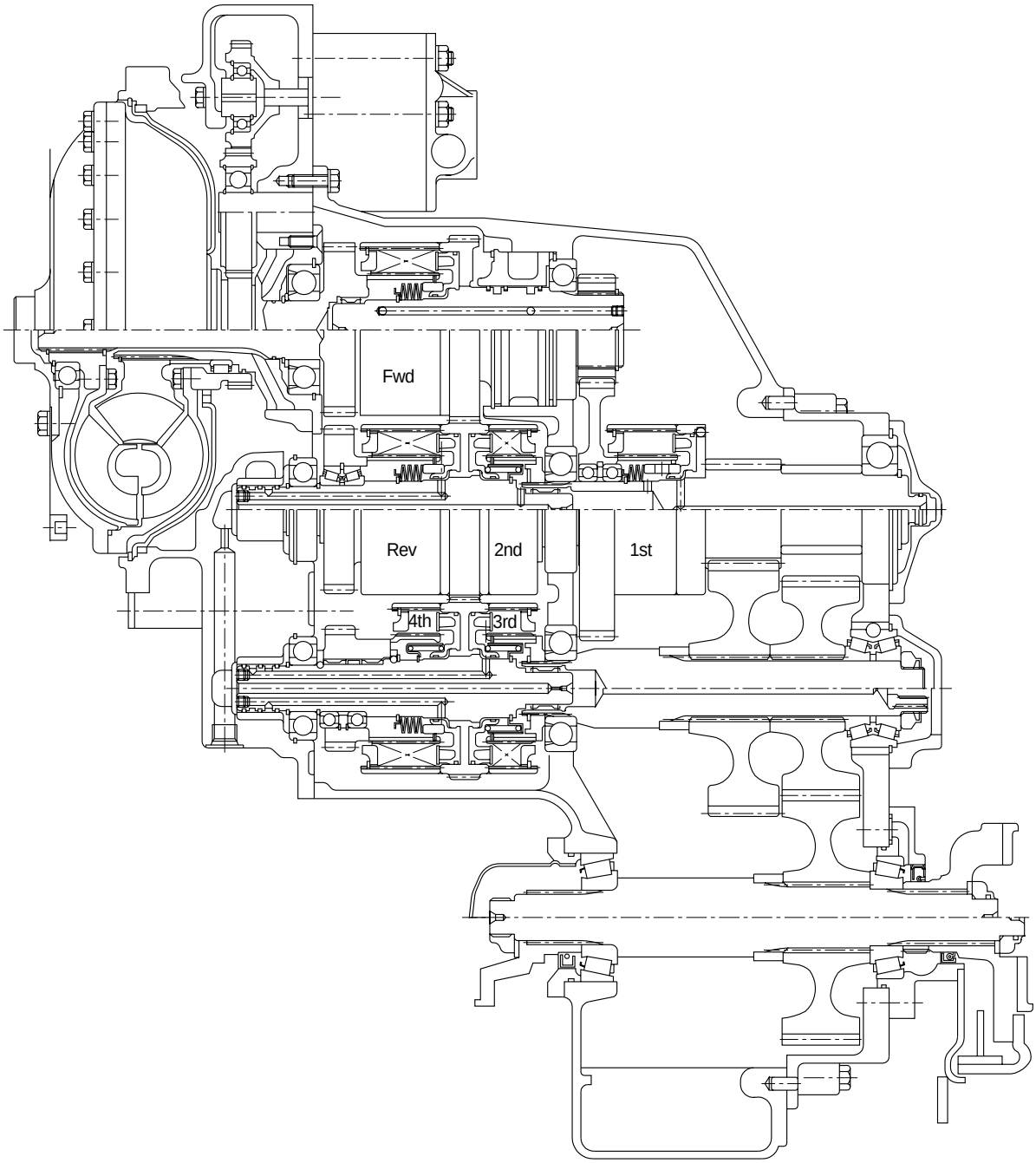
The output torque becomes the largest when the output shaft is stopped(the torque of output shaft at that time is called the stalling torque). When the load on the output side decreases, the reaction torque also decreases and, in contrast with this, the output speed increases.

As explained the above, the torque converter has the working to change output torque automatically in accordance with strength of load.

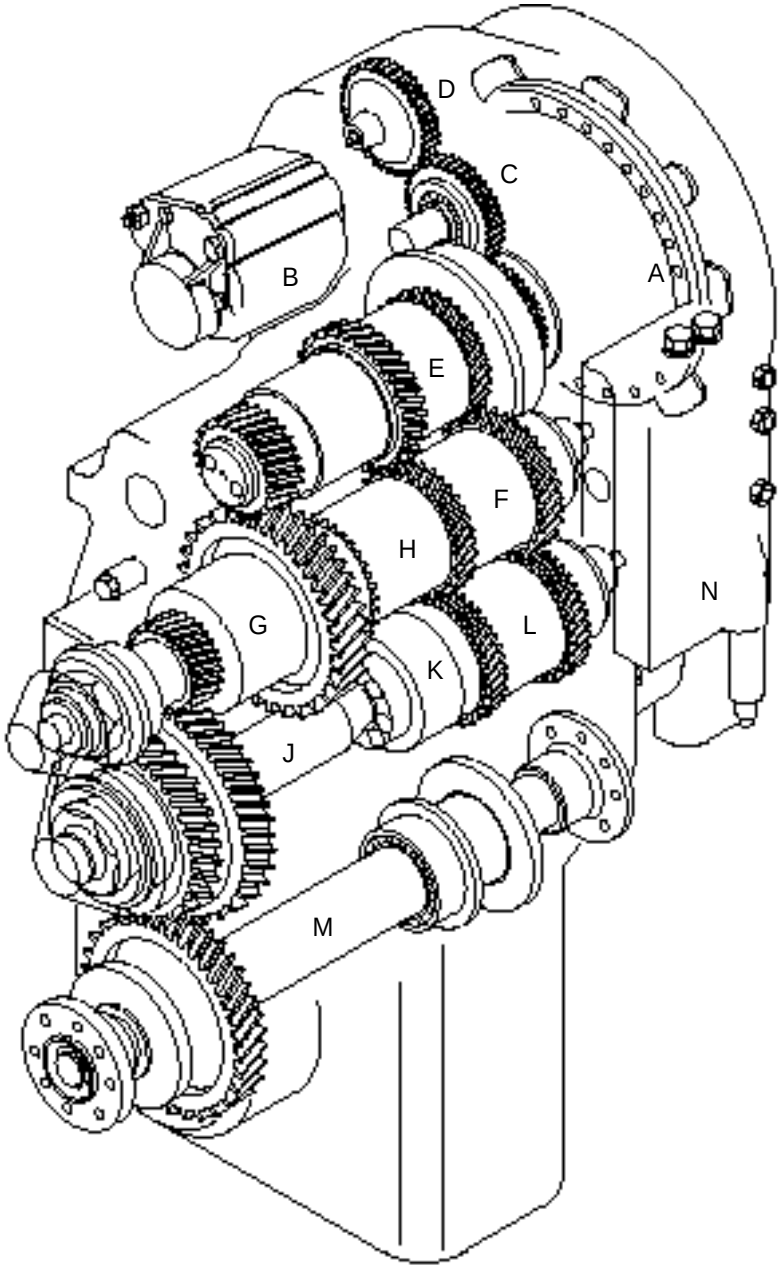
Besides, transmitting of torque is done by oil and that results it is possible to slip between the engine side(output side) and at the same time, mechanical shock can be absorbed.

3. TRANSMISSION

1) TYPICAL CROSS SECTION



2) TRANSMISSION LAYOUT



A	Torque converter	F	Reverse clutch	K	3rd clutch
B	Charge pump assembly	G	1st clutch	L	4th clutch
C	Pump drive idler gear	H	2nd clutch	M	Output shaft
D	Pump drive gear	J	Idler shaft	N	Control valve assembly
E	Forward clutch				

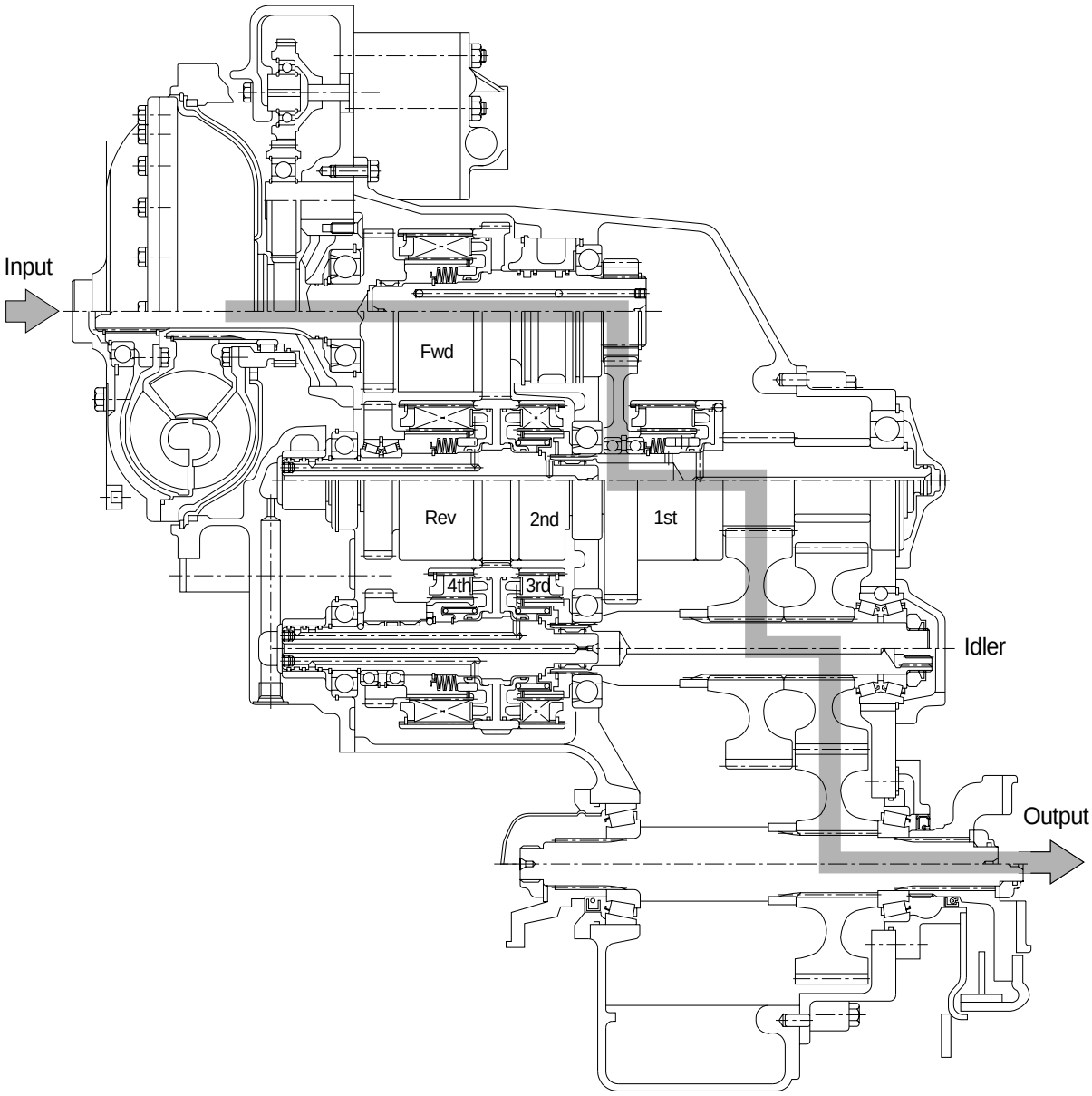
3) OPERATION OF TRANSMISSION

(1) Forward

① Forward 1st

In 1st forward, FWD clutch and 1st clutch are engaged.

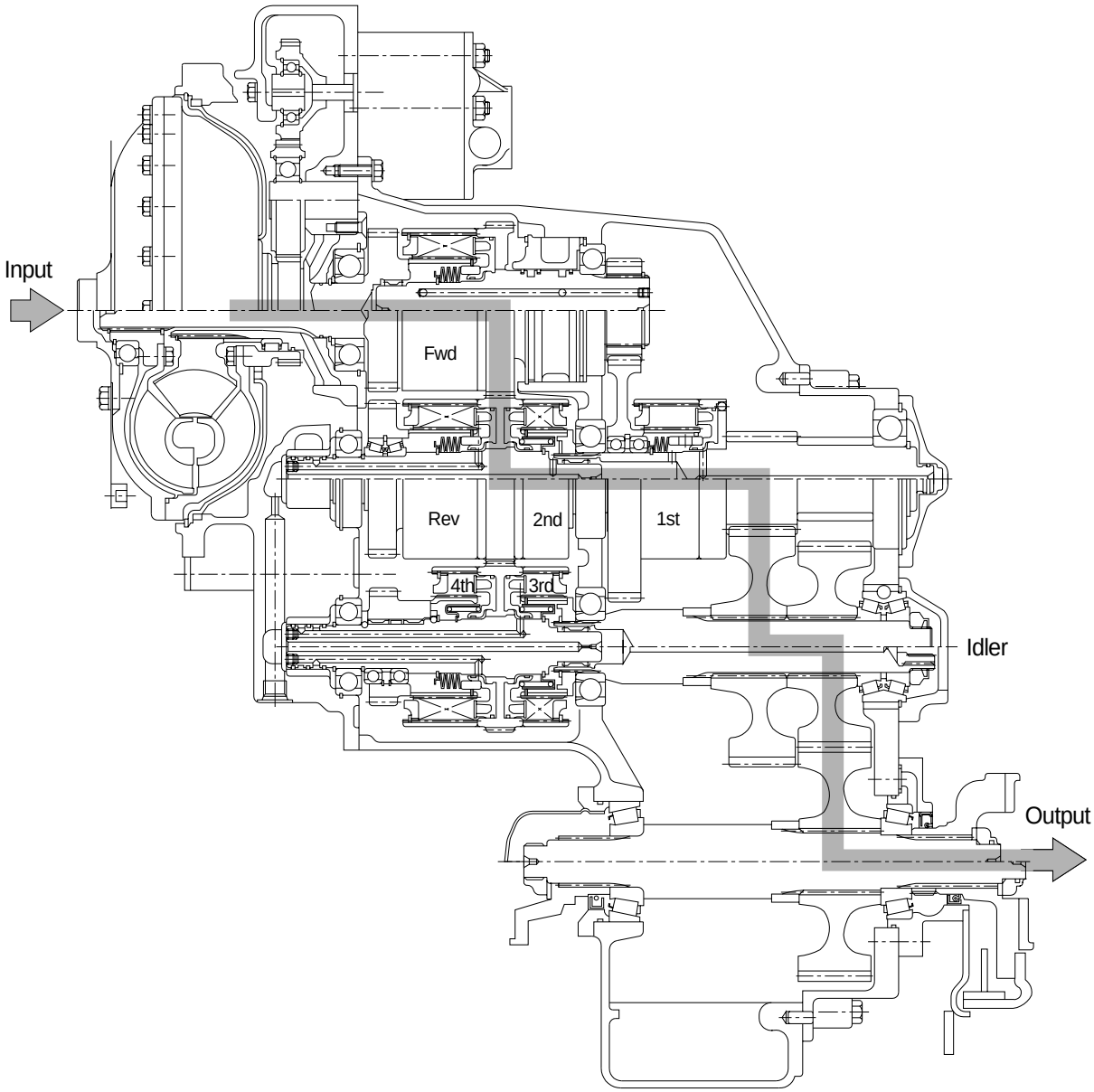
FWD clutch and 1st clutch are actuated by the hydraulic pressure applied to the clutch piston.



② **Forward 2nd**

In 2nd forward, FWD clutch and 2nd clutch are engaged.

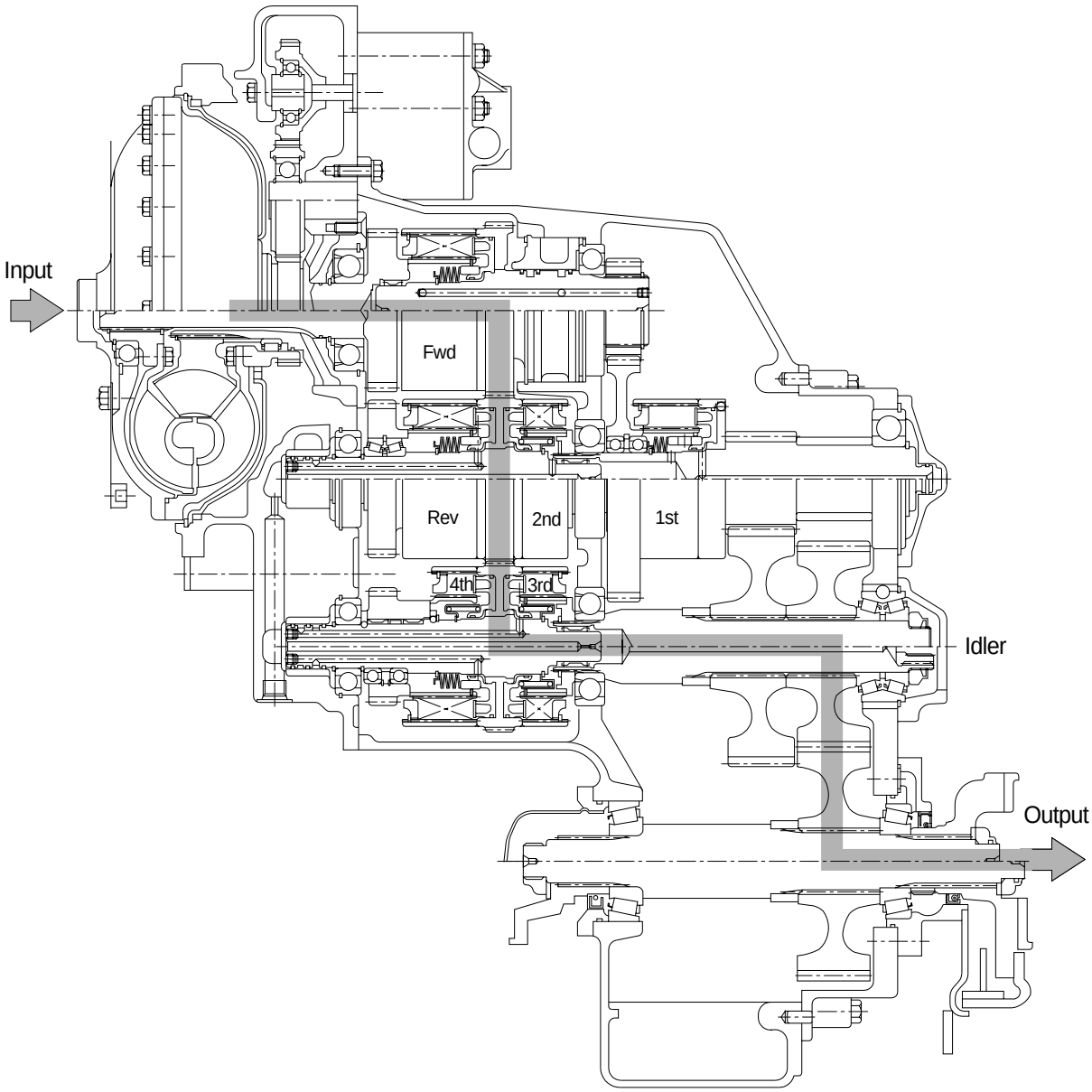
FWD clutch and 2nd clutch are actuated by the hydraulic pressure applied to the clutch piston.



③ **Forward 3rd**

In 3rd forward,FWD clutch and 3rd clutch are engaged.

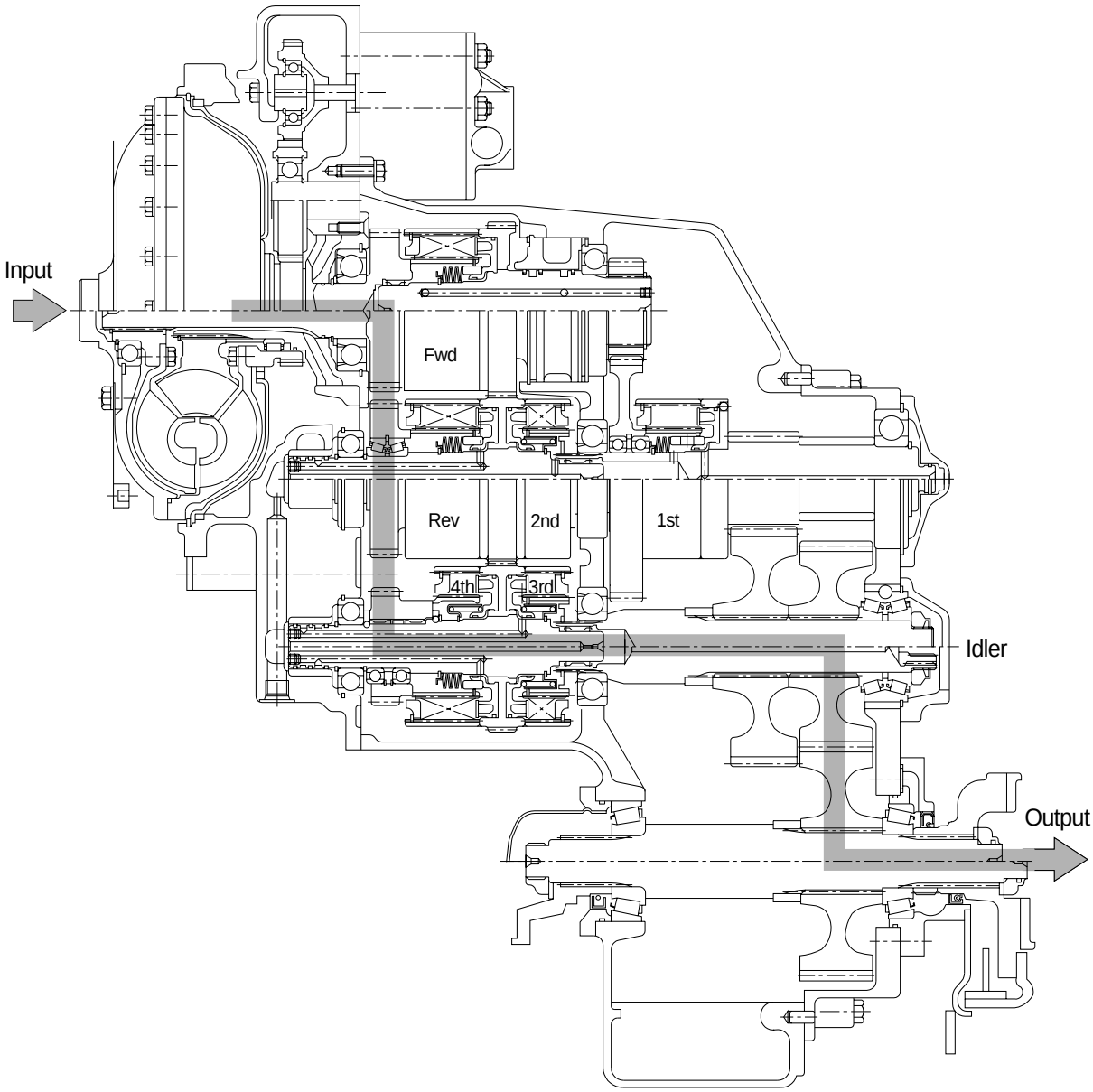
FWD clutch and 3rd clutch are actuated by the hydraulic pressure applied to the clutch piston.



④ **Forward 4th**

In 4th forward, 4th clutch and 3rd clutch are engaged.

4th clutch and 3rd clutch are actuated by the hydraulic pressure applied to the clutch piston.

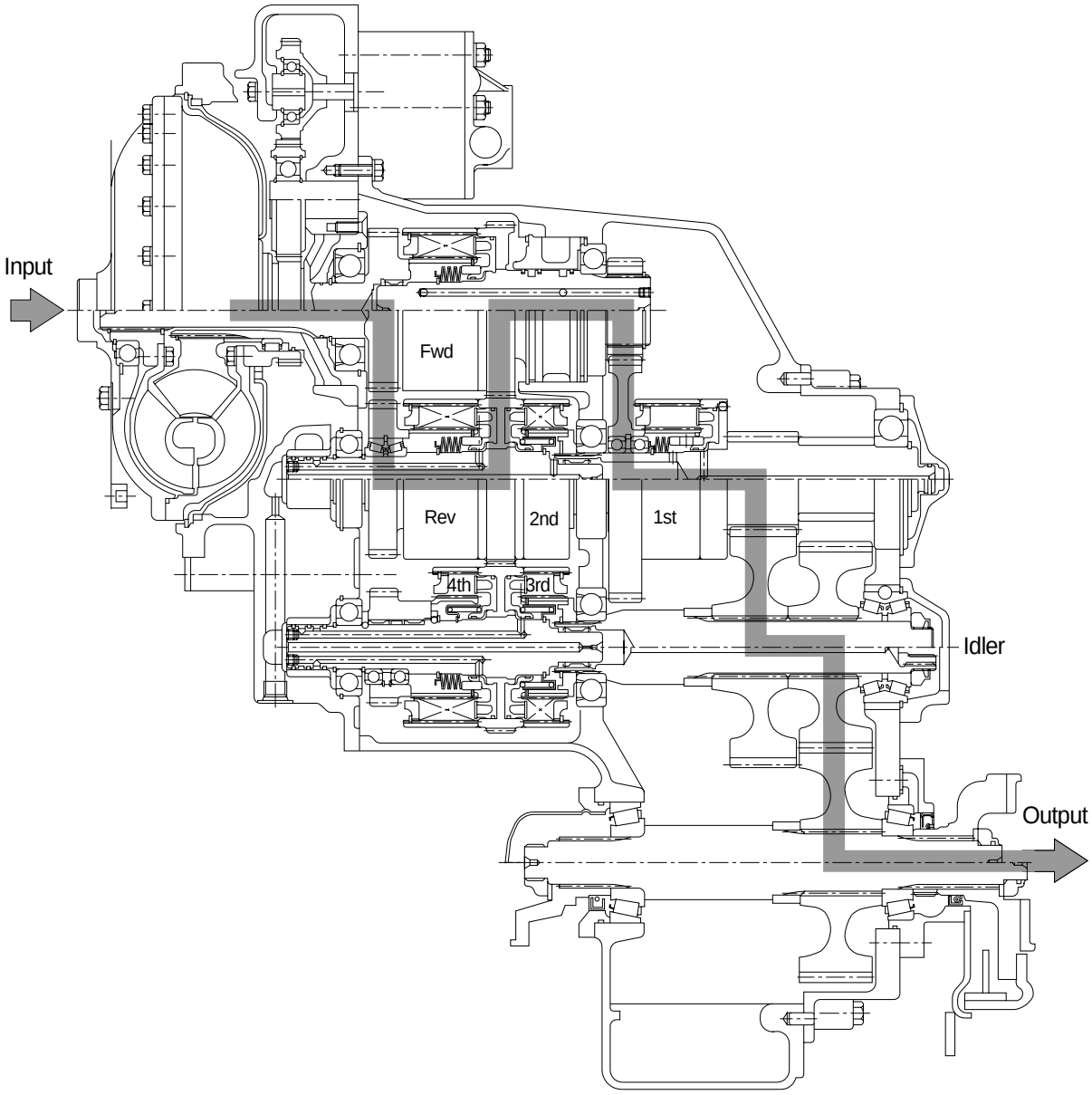


(2) Reverse

① Reverse 1st

In 1st reverse, REV clutch and 1st clutch are engaged.

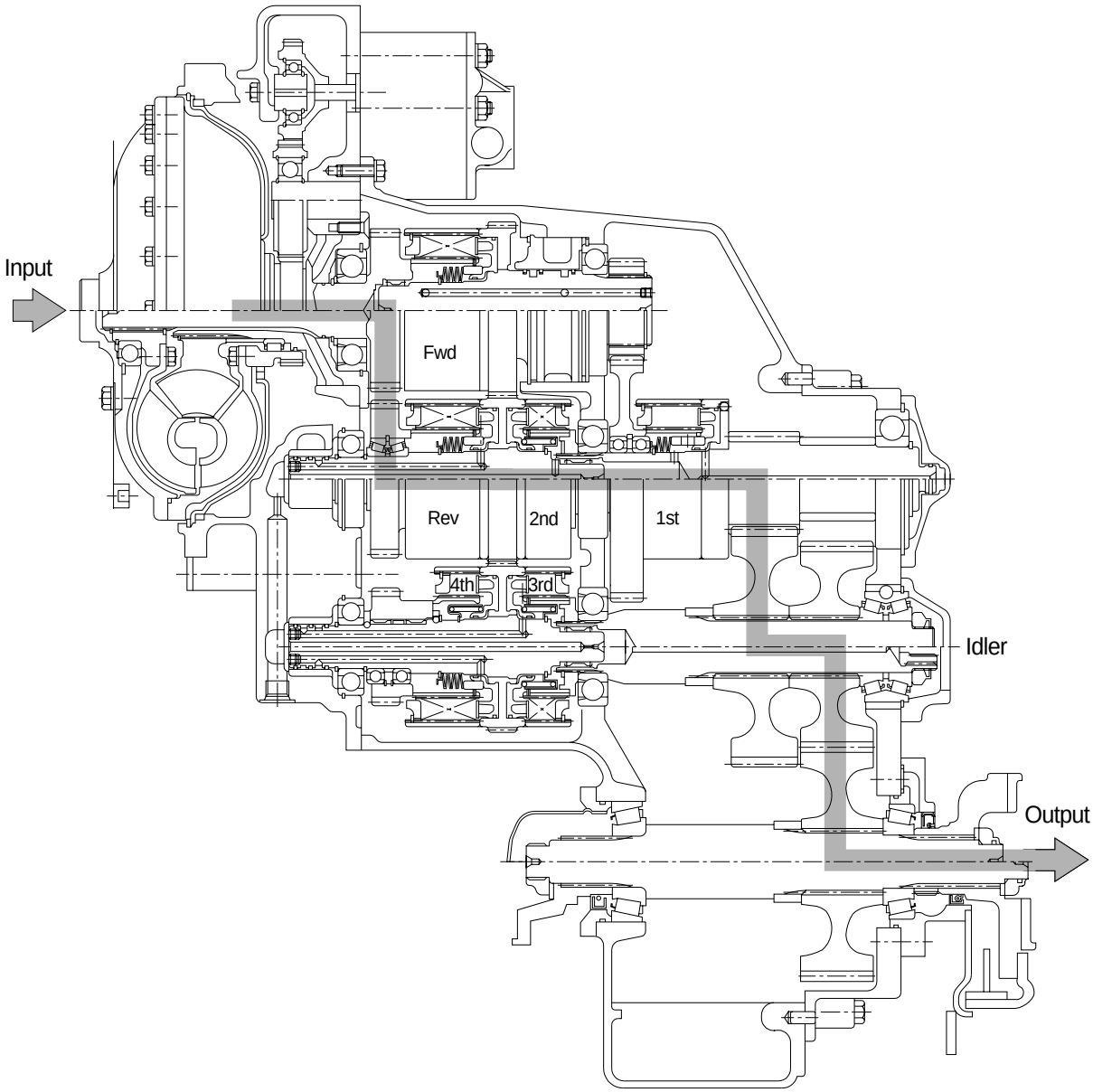
REV clutch and 1st clutch are actuated by the hydraulic pressure applied to the clutch piston.



② **Reverse 2nd**

In 2nd reverse, REV clutch and 2nd clutch are engaged.

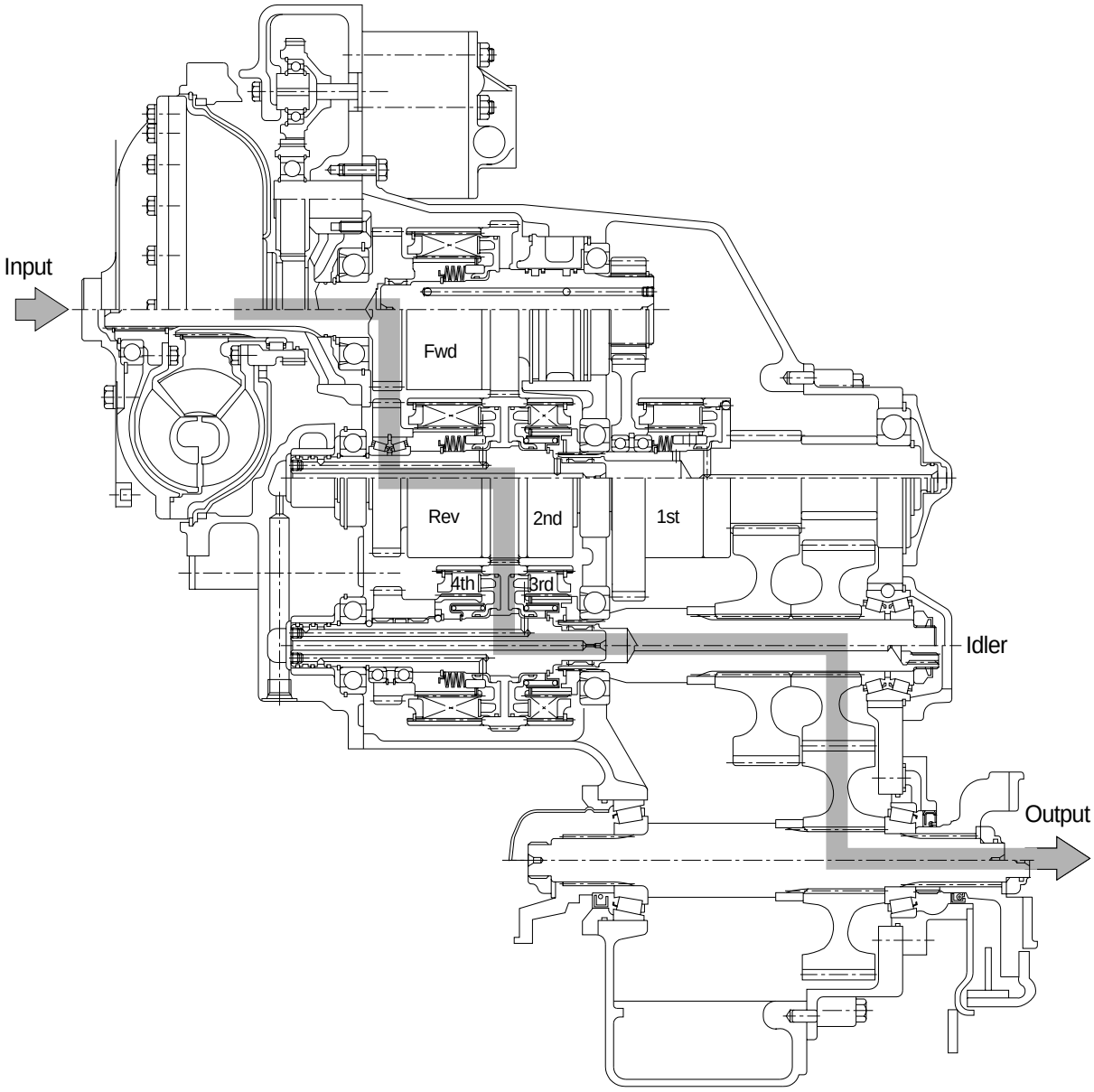
REV clutch and 2nd clutch are actuated by the hydraulic pressure applied to the clutch piston.



③ **Reverse 3rd**

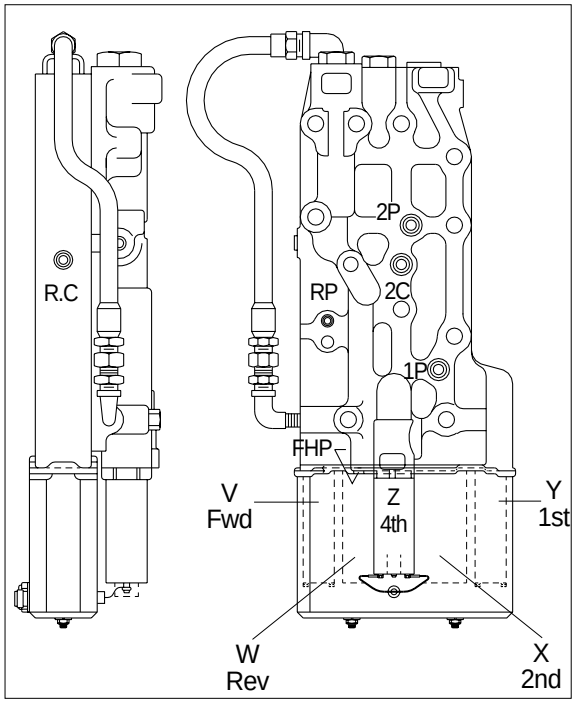
In 3rd reverse, REV clutch and 3rd clutch are engaged.

REV clutch and 3rd clutch are actuated by the hydraulic pressure applied to the clutch piston.



4) ELECTRIC SOLENOID CONTROL

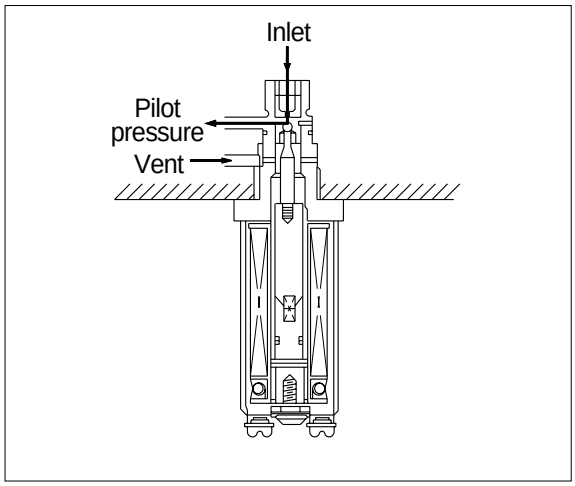
Direction & speed	Solenoids energized	Clutches pressurized
Forward 1st	V X Y	Forward & 1st
Forward 2nd	V X	Forward & 2nd
Forward 3rd	V	Forward & 3rd
Forward 4th	V Z	4th & 3rd
Reverse 1st	W X Y	Reverse & 1st
Reverse 2nd	W X	Reverse & 2nd
Reverse 3rd	W	Reverse & 3rd



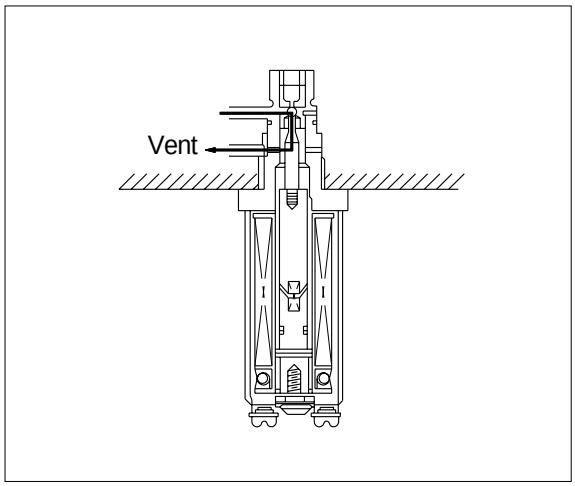
Pilot and clutch pressure check points

1P 1st pilot
2P 2nd pilot
2C 2nd clutch
4P(FHP) 4th clutch
RP reverse pilot
RC reverse clutch

· **Energized**



· **De-energized**



5) EGS FUNCTIONAL DESCRIPTION

(1) Definition of terms

① **Selecting UP :**
Rotate the shift lever away from the driver. This movement is spring returned.

② **Selecting DOWN :**
Rotate the shift lever towards the driver. This movement is spring returned.

③ **Selecting FORWARD :**
Push the shift lever away from the driver. The forward position is a stable shift lever position.

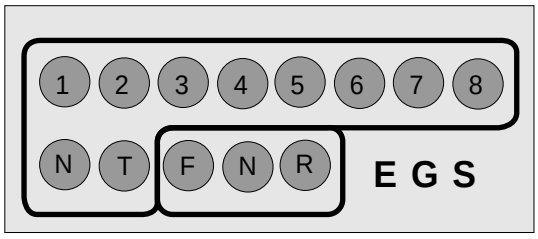
④ **Selecting REVERSE :**
Pull the shift lever towards the driver. The reverse position is a stable shift lever position.

⑤ **Selecting NEUTRAL :**
Place the shift lever in the center position. The neutral position is a stable shift lever position.

⑥ **Selecting DECLUTCH :**
Connect input wire 14 to ground.

⑦ **Requesting KICK DOWN :**
Push the kick down button mounted on the top of the shift lever.

(2) Display arrangement



Lamps 1-4 : Indicate the selected lever position / direction(color).
Indicate the selected transmission gear / direction(color).
Lamp N : ON if the transmission is placed in neutral.
Lamp T : Used in self diagnostic modes and for fault signalling.
Lamp S/8 : Used to indicate "standstill" or a possible speed sensor problem.

During the initialization phase after power up, both the N and T lamp are ON. Also when the EGS controller is malfunctioning both lamps are ON or blink simultaneously.

※ All lamps can have different functions in the diagnostic modes.

(3) Connector pin designations

Below table lists the function of each EGS connector pin.

Pin	Function
1	Battery plus
2	Battery ground
3	Neutral start solenoid(on in neutral)
4	CV solenoid 1
5	CV solenoid 2
6	CV forward solenoid
7	CV reverse solenoid
8	Warning lamp
9	Not used
10	Speed sensor input HOT
11	Speed sensor input GND
12	Speedometer output
13	CV forward HI/LO(splitter) solenoid
14	Declutch input
15	Not used(internally connected with kick down button)

CV : control valve

(4) Selftest functions

The EGS has special circuitry to help verifying its operation.

Three selftest modes are built into the EGS control programs :

- INPUT TEST
- SPEED SENSOR TEST + LAMP TEST
- OUTPUT TEST

① Selftest mode invocation

Below table lists what conditions must be satisfied during POWER UP to get into a specific selftest mode.

Leaving the selftest mode is done by switching OFF the power of the EGS.

Selftest mode	To enter mode
Input test	FWD & UP
Speed sensor test	REV & UP
Output test	FWD & DOWN

② Selftest operation

Selftest operation is described in **Electrical system**, SECTION 2.

(5) Functional description

① Selftest of NEUTRAL

At power up, regardless of the shift lever position, the EGS selects neutral. All transmission outputs are switched off. The neutral start output is switched on only if the shift lever is placed in the neutral position.

Neutral is selected by moving the shift lever to the center stable position.

Alternatively, neutral can be selected by connecting EGS input wire 14 to ground.(See declutch feature).

② EGS in NEUTRAL

While in neutral, lamp N is ON.

In order to leave neutral you must make sure EGS input wires 14 is not grounded.

FORWARD is selected by moving the shift lever to the forward position.

REVERSE is selected by moving the shift lever to the reverse position.

At startup, no outputs are activated. When forward or reverse is selected, but the vehicle speed is too high(above 1000 rpm), neutral remains selected and the warning lamp is switched on. If the vehicle speed is low(below 800 rpm), the selected direction is engaged in 2nd gear. If vehicle speed is between these 2 values, neutral 2nd is selected for 1 second in order to slow down the machine before the direction is engaged.

If the sensor indicates **standstill**, the S-led lights up GREEN.

③ EGS in FORWARD

In forward, lamps 1-4 light up GREEN indicating the selected lever position.

Upon selection of forward from neutral, 2nd gear forward is selected. However, if before neutral was selected, 1st gear was obtained due to a shift lever downshift, 1st gear will be engaged.

An UPSHIFT is made by moving the shift lever to the UP position and then returning it to the center position(spring returned).

Holding the lever in the UP position, gives subsequent upshifts 1.5 seconds spaced in time.

When the speed sensor indicates **standstill** (S-led on), only 1st and 2nd gear can be selected.
If the sensor fails when driving in a gear higher than 2nd, the gear remains engaged.
Downshifts will be granted, upshifts will be ignored if the gear exceeds or equals 2nd gear.

A DOWNSHIFT is made by moving the shift lever to the DOWN position and then returning it to the center position(spring returned).

Holding the lever in the DOWN position, gives subsequent downshift 1.5 seconds spaced in time.

④ **EGS in REVERSE**

In reverse, lamps 1-3 light up ORANGE indicating the selected lever position.

Upon selection of reverse from neutral, 2nd gear reverse is selected. However, if before neutral was selected, 1st gear was obtained due to a shift lever downshift, 1st gear will be engaged.

An UPSHIFT is made by moving the shift lever to the UP position and then returning it to the center position(spring returned).

Holding the lever in the UP position, gives subsequent upshifts 1.5 seconds spaced in time.
When the speed sensor indicates **standstill**(S-led on), only 1st and 2nd gear can be selected.
If the sensor fails when driving in a gear higher than 2nd, the gear remains engaged.
Downshifts will be granted, upshifts will be ignored if the gear exceeds or equals 2nd gear.

A DOWNSHIFT is made by moving the shift lever to the DOWN position and then returning it to the centre position(spring returned).

Holding the lever in the DOWN position, gives subsequent downshift 1.5 seconds spaced in time.

⑤ **Quick shifts**

When repeatedly pushing shift lever to the UP or DOWN position and back to the center position(hold it more than 0.1 second UP/DOWN), the selected lever position alters faster than when holding the lever to get sequential shifts.

The transmission however **creeps** towards the selected lever position one gear at a time with 1.5 second interval between shifts.

This is indicated by a blinking lamp indicating the engaged transmission gear position.

⑥ **Downshift protection**

When a downshift is requested, but the vehicle is driving too fast and danger for overspeeding exists, the request is stored, but not executed. The warning lamp switches on, indicating the driver he has to slow down in order to get the requested shift.
The fact that the downshift is not granted is also displayed on the EGS. The led corresponding to the current gear is blinking, the led corresponding to the requested gear is on.

⑦ Direction changes

If while driving in one direction, the opposite direction is elected, depending on the vehicle speed and the gear the transmission is currently in, a different direction change action is made.

The new gear after a direction change is 2nd gear, except if 1st gear was obtained due to a shift lever downshift. In this case, 1st gear will be selected after the direction change. This gear is referred to as the **fwd-rev gear**.

If the current gear does not exceed the fwd-rev gear, fwd-rev gear and the new direction is engaged if the vehicle speed is not too high. If the vehicle speed is too high, the old direction remains engaged.

If the current gear exceeds the fwd-rev gear, a check is made on the modulation speed.
(This speed is the maximum speed at which a direction change is acceptable)

In this application, the maximum speed is 11.7㎞/h. If the modulation speed is not exceeded, the new direction is engaged(same gear for maximum deceleration), followed by a downshift to the fwd-rev gear after a small delay.

If the modulation speed is exceeded, the EGS will make successive downshifts until one of the previous conditions is met.

After the direction clutch engagement, eventual upshifts are delayed for 3 seconds, in order to make sure that the modulation time completely elapsed before the upshift occurs.

※ **If the transmission is in 2nd gear and a direction change is requested, but the vehicle speed exceeds the modulation index, a downshift is made to 1st gear. This will cause hard braking. As soon as the vehicle speed drops below the modulation index, the direction is inverted and 2nd gear is selected.**

⑧ Declutch function

When wire 14(brake pedal switch) is connected to ground, the transmission is put in neutral when the vehicle speed is below 5㎞/h and the transmission is in first or 2nd gear. When the brake pedal is released, or when the vehicle speed increases and exceed this limit, normally the shift lever selected direction is reengaged. An exception to this is described in point ⑩.
Automatic shifting in neutral.

⑨ Kick down function

The kick down is only functional when driving in 2nd gear.

If the kick down is pressed, a downshift to first gear is made if no risk for overspeeding the transmission exists.
If a direction change is requested, 2nd gear is selected.
If in first gear, the vehicle speed exceeds 5㎞/h, an automatic upshift to 2nd gear is made.

⑩ Automatic shifting in neutral

In order to prevent transmission overspeeding while driving in neutral, the EGS automatically shifts to a gear position that suits best the current vehicle speed.

If the shift lever is placed in the same direction it was in before neutral was selected, the direction clutch is engaged in the gear the EGS shifted to in neutral.
If the shift lever is placed in the opposite direction to what it was in before neutral was selected, a reversal procedure is engaged as described in ⑦ Direction changes.

However, if the vehicle after being stopped is again driving(neutral being selected all the time), the vehicle must slow down(speed < 1000 rpm) in order to get drive again.

⑪ Speedometer output

Output wire 12 generates pulses for controlling the speedometer. The amount of pulses is 26.27 pulses per km/h. See wiring diagram for installation of speedometer.

⑫ Warning lamp

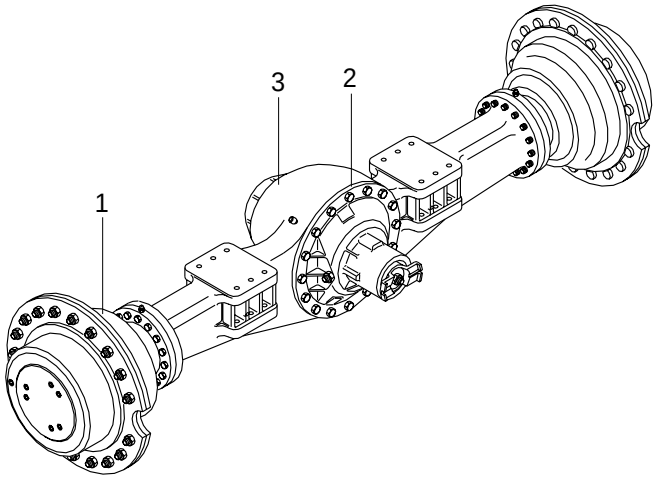
Output wire 8 is activated to indicate the driver has to slow down in order to get the requested situation.
Some situation where this lamp is switched on :
to indicate downshift protection during a direction change sequence EGS drives too fast during startup.

4. AXLE

1) OPERATION

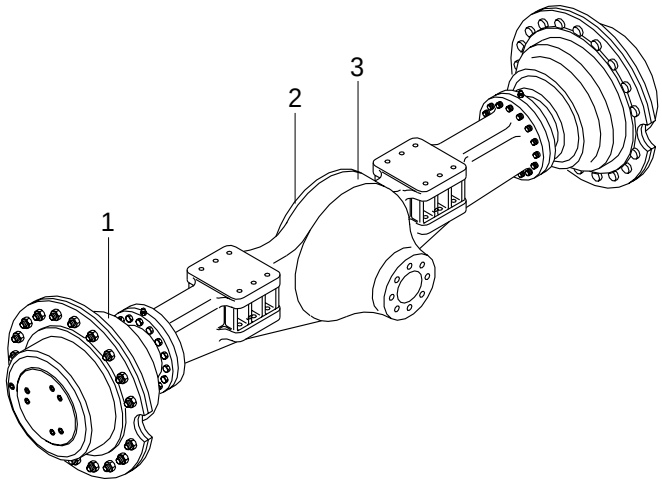
- The power from the engine passes through torque converter, transmission and drive shafts, and is then sent to the front and rear axles.
- Inside the axles, the power passes from the bevel pinion to the bevel gear and is sent at right angles. At the same time, the speed is reduced and passes through the both differentials to the axle shafts. The power of the axle shafts is further reduced by planetary-gear-type final drives and is sent to the wheels.

(1) Front axle



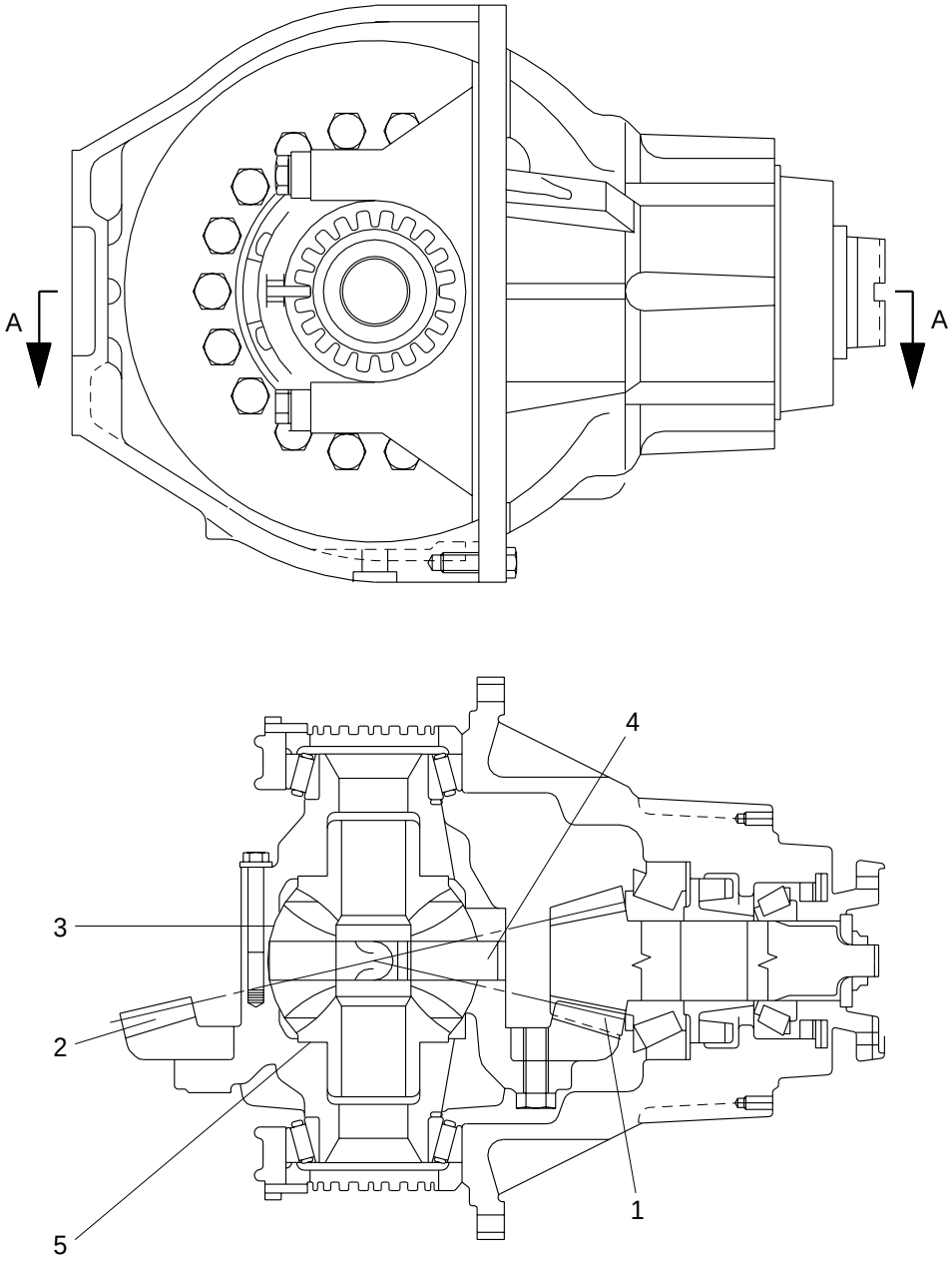
1 Final drive 2 Front differential 3 Front axle

(2) Rear axle



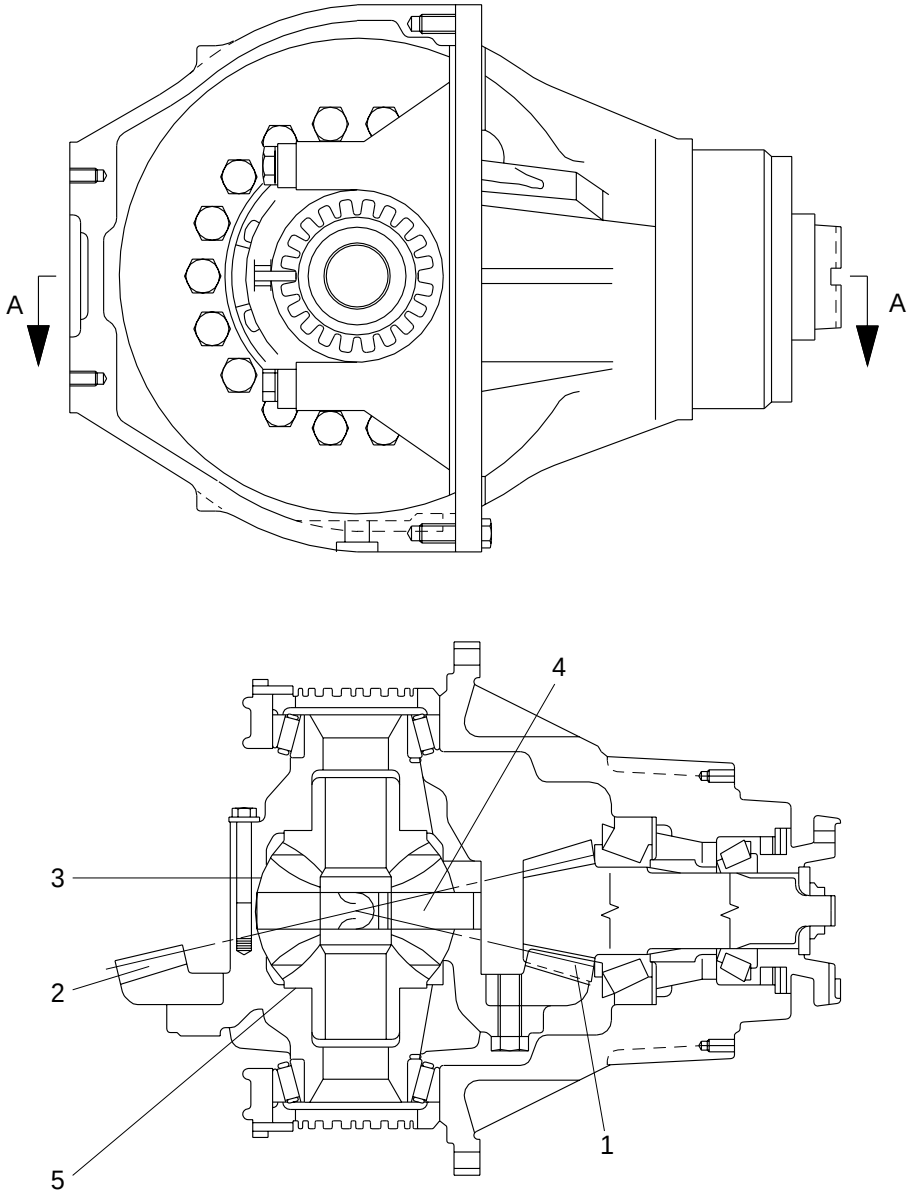
1 Final drive 2 Rear differential 3 Rear axle

2) SECTION OF FRONT DIFFERENTIAL



1	Bevel pinion	3	Sun gears	5	Side gear(differential)
2	Bevel gear	4	Shaft		

3) SECTION OF REAR DIFFERENTIAL



1	Bevel pinion	3	Sun gears	5	Side gear(differential)
2	Bevel gear	4	Shaft		

4) DIFFERENTIAL

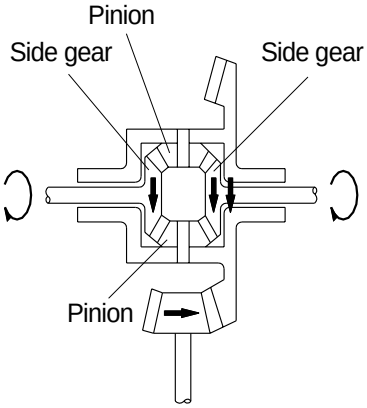
(1) Description

When the machine makes a turn, the outside wheel must rotate faster than the inside wheel. A differential is a device which continuously transmits power to the right and left wheels while allowing them to turn a different speeds, during a turn.

The power from the drive shaft passes through bevel pinion and is transmitted to the bevel gear. The bevel gear changes the direction of the motive force by 90°, and at the same time reduces the speed. It then transmits the motive force through the differential to the axle gear shaft.

(2) When driving straight forward

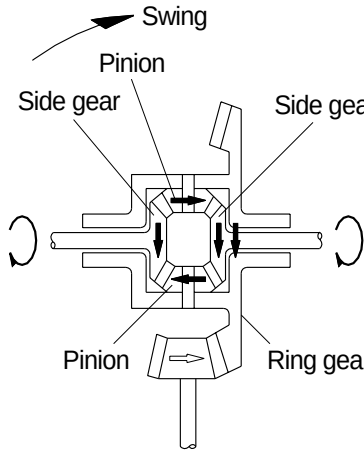
When the machine is being driven straight and the right and left wheels are rotating at the same speed, so the sun gear inside the differential assembly do not rotate, therefore the power is equally transmitted to the left and right axle gear shaft.



(3) When turning

When turning, the rotating speed of the left and right wheels is different, so the pinion gear and side gear inside the differential assembly rotate in accordance with the difference between the rotating speed of the left and right wheels.

The power of the carrier is then transmitted to the axle gear shafts.



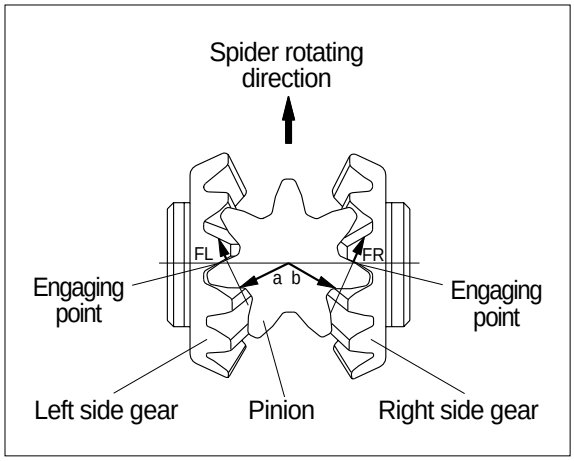
4) TORQUE PROPORTIONING DIFFERENTIAL

(1) Function

① Because of the nature of their work, 4-wheel-drive loaders have to work in places where the road surface is bad.
In such places, if the tires slip, the ability to work as a loader is reduced, and also the life of the tire is reduced.
The torque proportioning differential is installed to overcome this problem.
In structure it resembles the differential of an automobile, but the differential pinion gear has an odd number of teeth. Because of the difference in the resistance from the road surface, the position of meshing of the pinion gear and side gear changes, and this changes the traction of the left and right tires.

(2) Operation

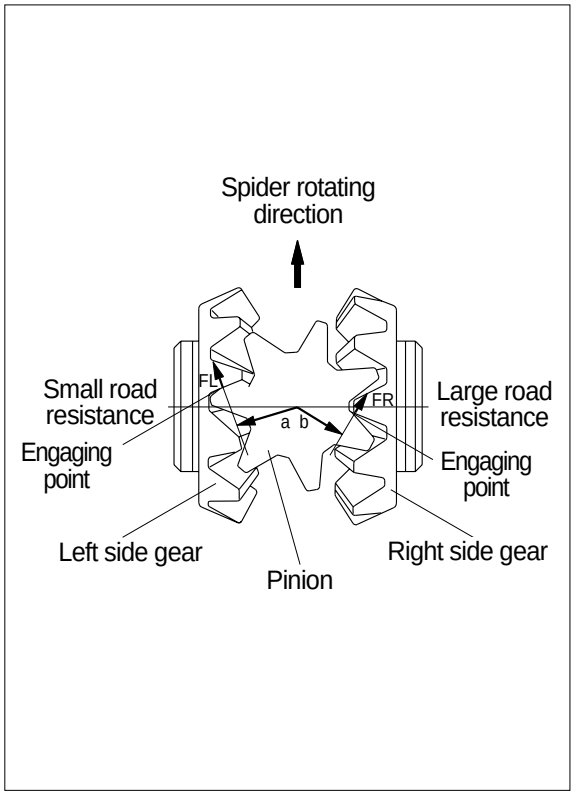
① **When travelling straight(equal resistance from road surface to left and right tires)**
Under this condition, the distances involving the engaging points between right and left side gears and pinion-a and b-are equal and the pinion is balanced as FL×b=FR×a. Thus, FL=FR, and the right and left side gears are driven with the same force.



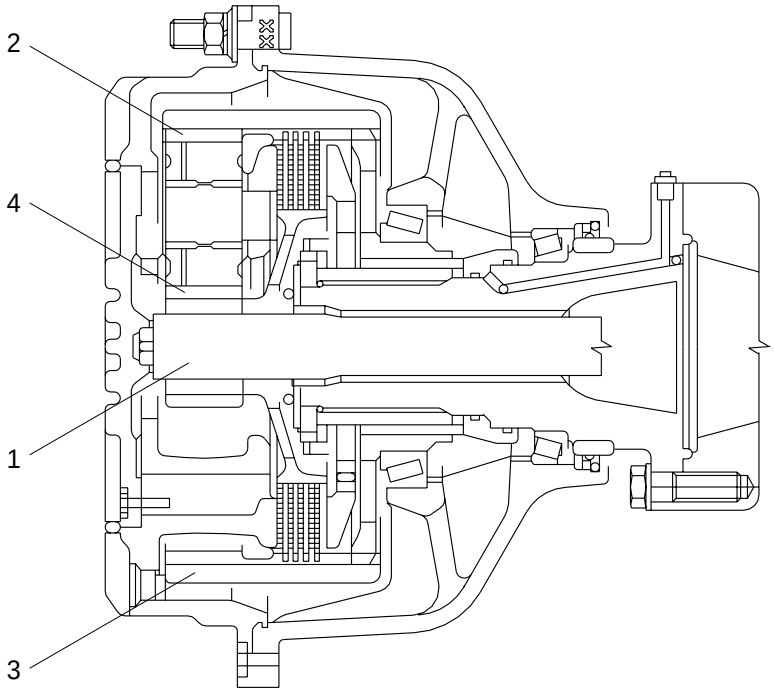
② **When travelling on soft ground (resistance from road surface to left and right tires is different)**

If the road resistance to the left wheel is smaller, the left side gear tends to rotate forward, and this rotation changes the engaging points between the side gears and pinion. As a result, the distances involving the engaging points becomes a>b. The pinion now is balanced as FL ×b=FR×a, where FL>FR. The right side gear is driven with a greater force than the left side gear. The torque can be increased by up to about 30% for either side gear.

The pinion therefore does not run idle and driving power is transmitted to both side gears until the difference between road resistance to the right and left wheels reaches about 30%.



6) FINAL DRIVE(front & rear)

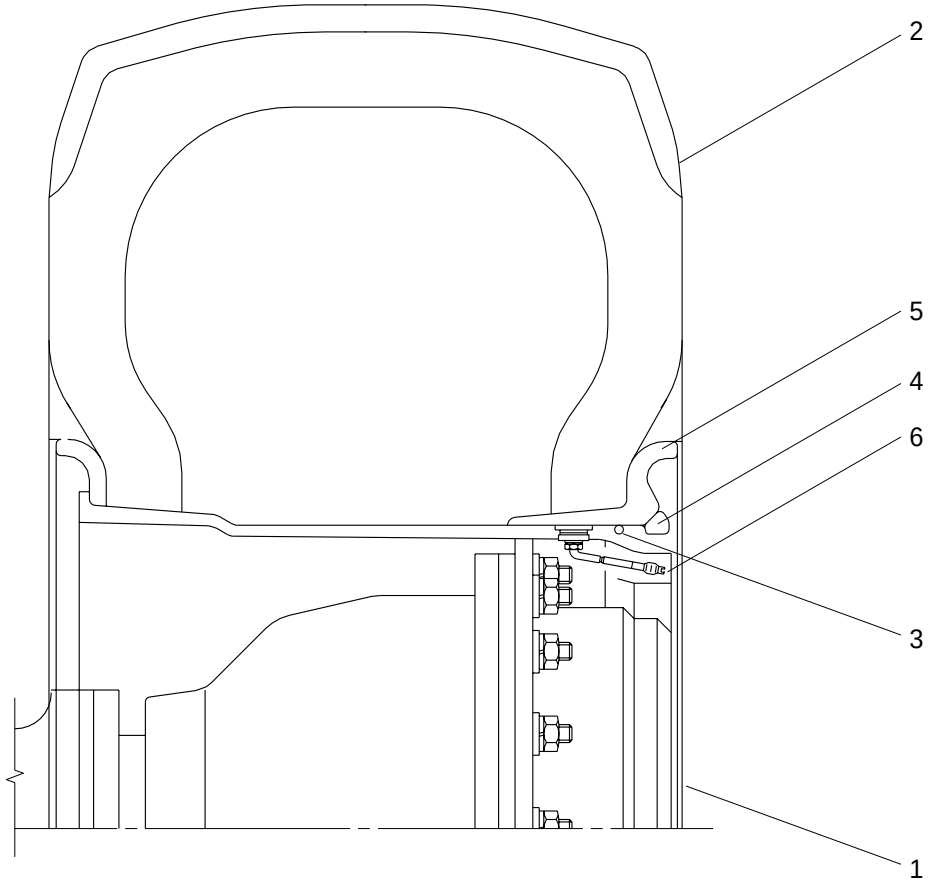


1 Axle shaft 2 Planetary gear 3 Rear gear
4 Sun gear

(1) To gain a large drive force, the final drive uses a planetary gear system to reduce the speed and send drive force to the tires.

(2) The power transmitted from the differential through axle shaft(1) to sun gear(4) is transmitted to planetary gear(2). The planetary gear rotates around the inside of a fixed ring gear(3) and in this way transmits rotation at a reduced speed to the planetary carrier.
This power is then sent to the wheels which are installed to the planetary carriers.

5. TIRE AND WHEEL



1) The tire acts to absorb the shock from the ground surface to the machine, and at the same time they must rotate in contact with the ground to gain the power which drives the machine.

2) Various types of tires are available to suit the purpose. Therefore it is very important to select the correct tires for the type of work and bucket capacity.

1	Wheel rim	2	Tire	3	O-ring
4	Lock ring	5	Side ring	6	Valve assembly