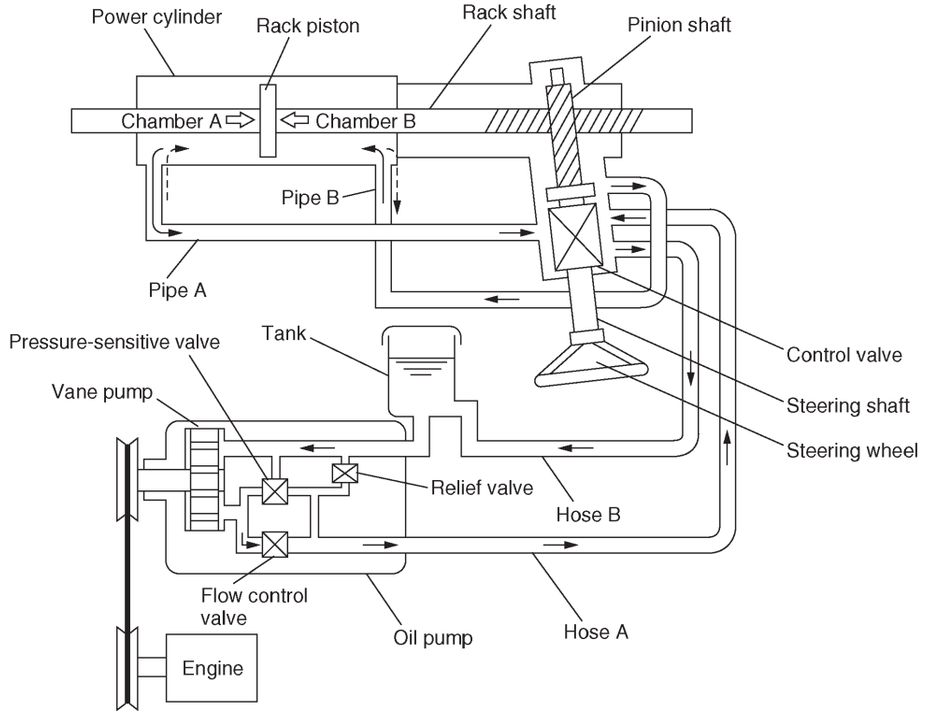
# 2. Power Steering System

## A: HYDRAULIC SYSTEM

- Oil pump is belt-driven from the engine to discharge oil under pressure.
- When the steering wheel is not being turned, the pressure-sensitive valve operates to drain oil, relieving the pressure in the pump.
- Oil under pressure is controlled by the oil pump in response to engine speed and is delivered to control valve via hose A.
- When the steering wheel is turned, control valve connected to the pinion shaft activates to form an oil flow circuit corresponding to the rotation direction of the steering wheel. Oil will then be delivered to chamber A or B via pipe A or B.
- Oil in chamber A or B acts on rack piston to produce the force required to move rack shaft to the left or the right. This helps reduce the effort required to operate the steering wheel.
- Movement of rack piston in turn causes oil in the other chamber to return to tank via pipe A or B, control valve and hose B.
- If the hydraulic system becomes inoperative, the steering shaft will then be connected to the pinion shaft mechanically via control valve. Thus, the steering shaft can act as one similar to a manual steering system to move the rack and pinion.
- To control the maximum oil pressure setting, relief valve is built into the oil pump to release excess oil pressure.

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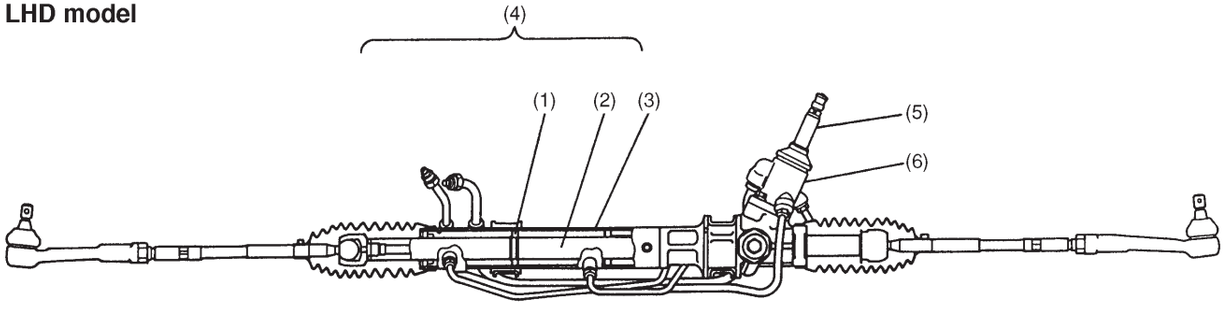
## B: GEARBOX ASSEMBLY

### 1. POWER CYLINDER

The gearbox is integrated with a built-in control valve and power cylinder. The rack shaft is used as a power cylinder piston and a rotary control valve is located in such a manner as to enclose the pinion shaft.

The control valve and power cylinder are connected to each other by two pipes through which hydraulic oil flows.

**LHD model**

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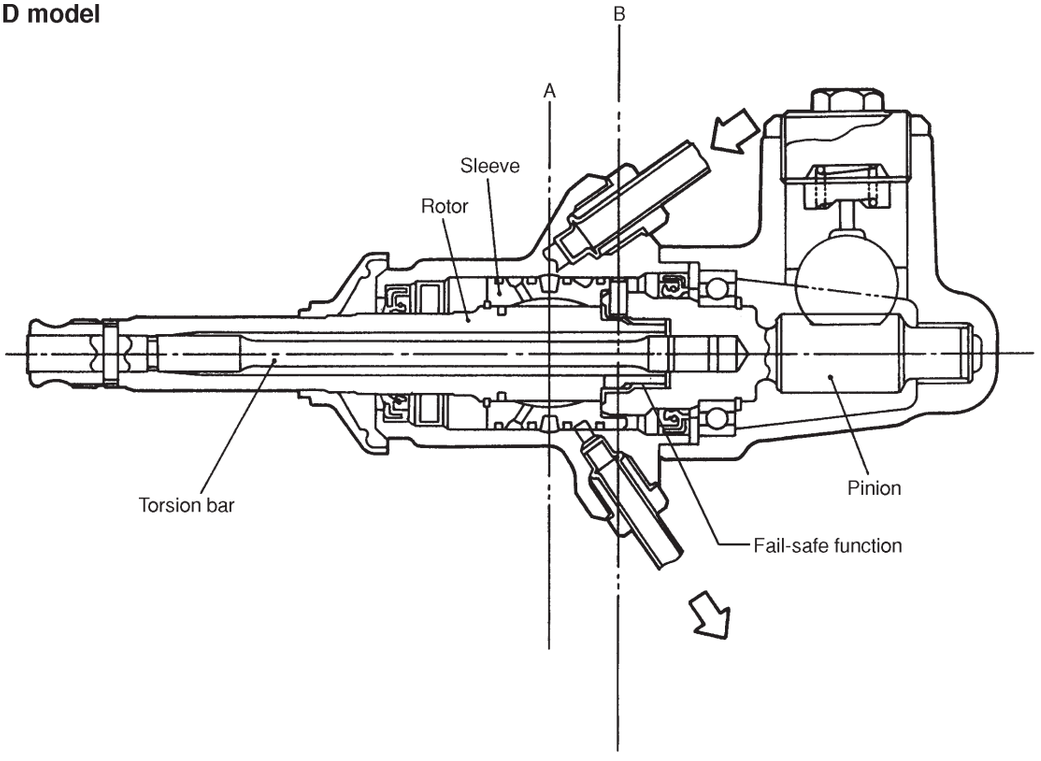
(1) Piston
(2) Rack shaft
(3) Cylinder
(4) Power cylinder
(5) Pinion shaft
(6) Control valve

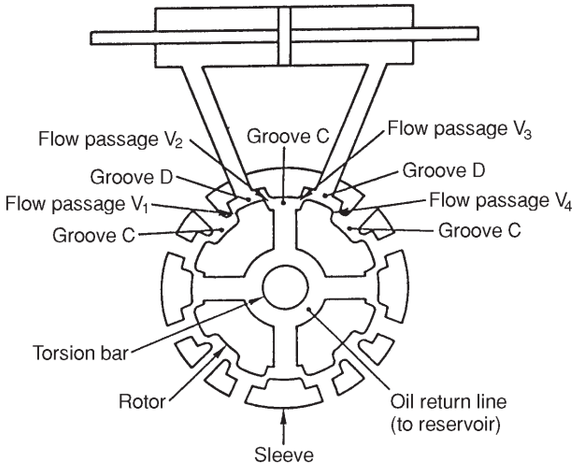
## 2. CONTROL VALVE

The control valve consists of a rotor (which rotates together with the steering shaft), a pinion (which is connected to the rotor and torsion bar), and a sleeve (which rotates together with the pinion). Oil grooves C and D are located in the rotor and sleeve to form oil flow passages $V_1$ through $V_4$.

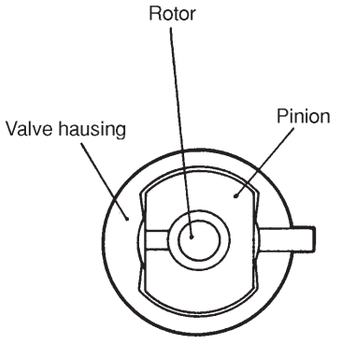
The pinion and rotor are meshed with adequate clearance. They utilize a fail-safe design.

**LHD model**




Cross-section view A of oil passage switching circuit




Fail-safe function
Cross-section view B

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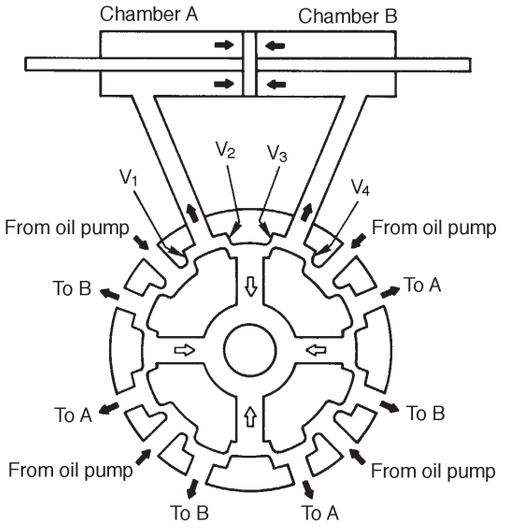
● Operating principle

When the torsion bar twists in relation to the steering force, a relative rotational displacement occurs between the rotor and sleeve. This displacement changes the cross-sectional area of oil passages $V_1$, $V_2$, $V_3$ and $V_4$, which in turn switches oil passages and controls oil pressure.

● When no steering force is applied:
The rotor and sleeve are held at the neutral position. Oil passages $V_1$, $V_2$ and $V_3$, which are formed by valve grooves C and D are open equally. Under this condition, oil delivered from the oil pump returns to the oil reservoir so that neither oil pressure builds up nor does the power cylinder activate.

**LHD model**




When no steering force is applied.

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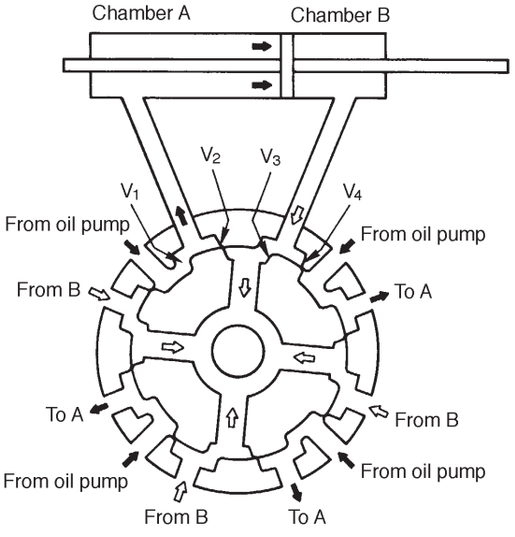
● When steering force is applied:
When the steering wheel is turned to the right, for example, oil passages $V_1$ and $V_3$ open while oil passages $V_2$ and $V_4$ nearly close.
At this point, oil under pressure in chamber A increases in response to the throttle position of oil passages $V_2$ and $V_4$ so that the rack piston moves to the right. Oil in chamber B, on the other hand, is discharged through oil passage $V_3$ returning to the oil reservoir.

**LHD model**




When steering force is applied.

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● Fail-safe function

If oil pressure fails to build up due to a broken oil pump drive belt, torque is transmitted from the valve rotor to the pinion by way of the fail-safe function.

## C: OIL PUMP & TANK

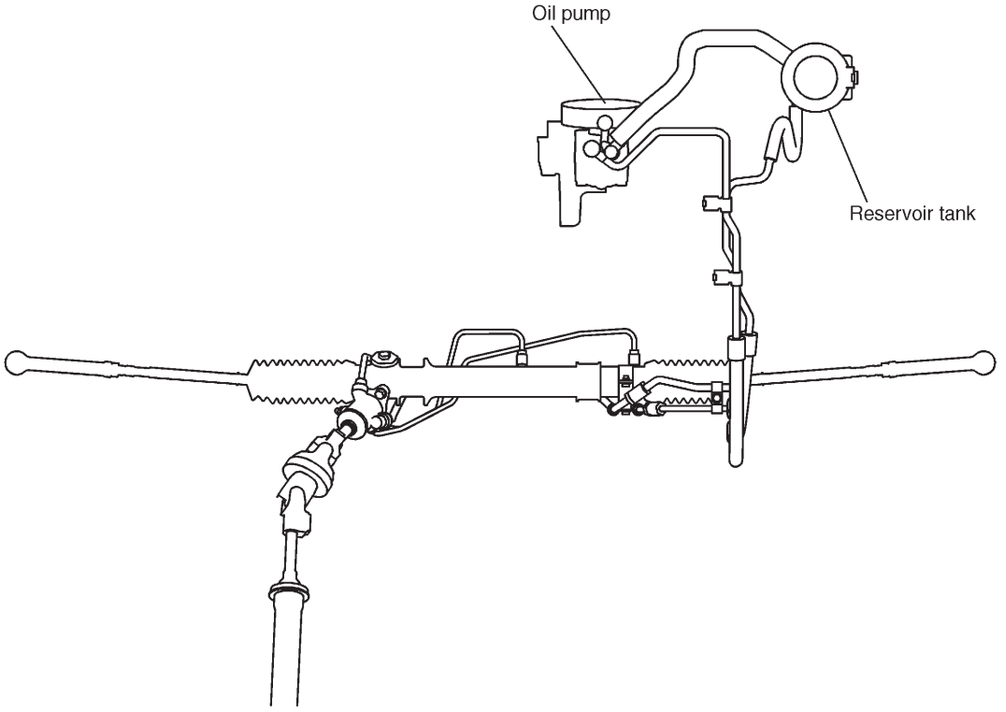
The oil pump is belt-driven from the engine.

The reservoir tank is mounted on the body.

The oil pump is the vane type.

The oil pump incorporates the flow control valve, pressure-sensitive valve, and relief valve that control the flow rate and pressure of the oil.

- The flow control valve controls the flow rate of discharged oil corresponding to an engine speed.
- The pressure-sensitive valve helps to decrease the pressure in the pump when the steering wheel is not being turned.
- The relief valve relieves the pressure when the pressure in the system becomes too high such as when the steering wheel is turned all the way.

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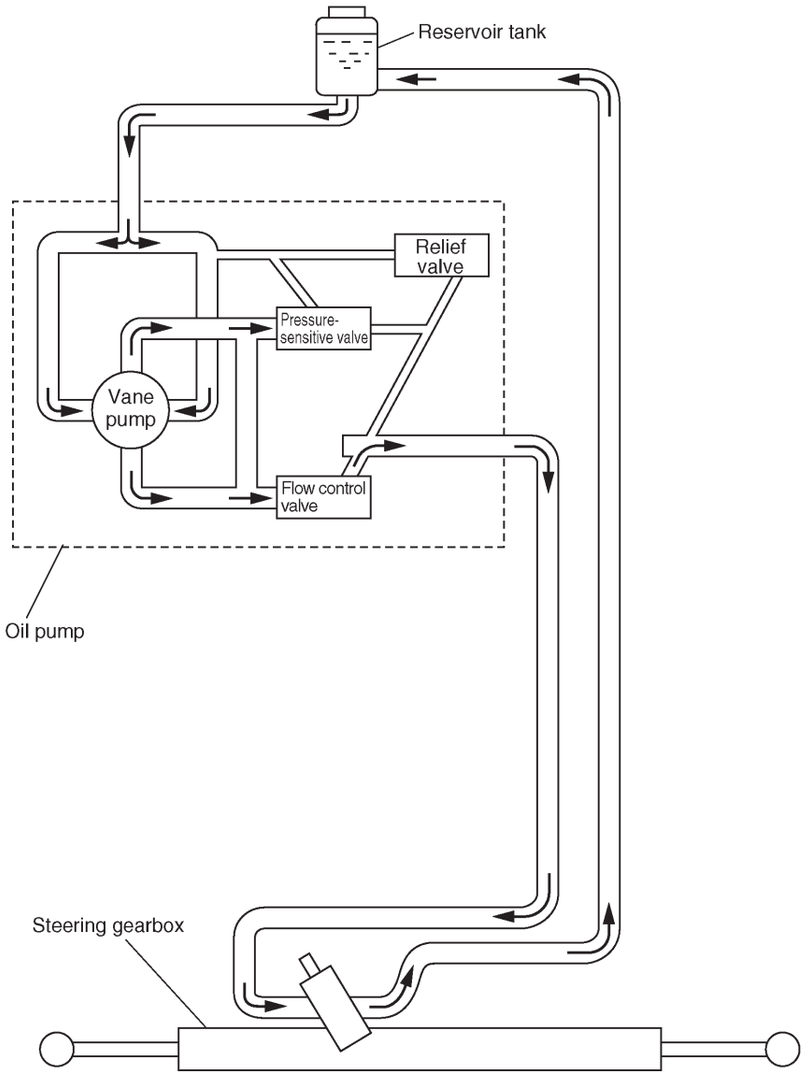
Reservoir tank
Relief valve
Pressure-sensitive valve
Vane pump
Flow control valve
Oil pump
Steering gearbox

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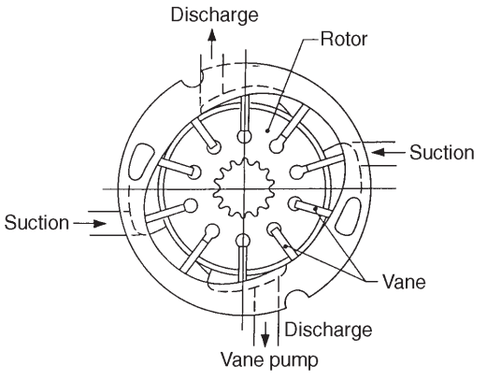
## 1. VANE PUMP

The vane pump consists of a rotor, cam rings, and ten vanes.

When the rotor rotates, the vane located in each groove of the rotor is radially swung out by centrifugal force and pressed against the cam ring. The tip of the vane slides along the inner oval wall of the cam ring so that oil is delivered to the chamber formed by the rotor, cam ring and vane by way of a pea-shaped groove. Oil from the chamber is discharged into the oil circuit via the discharge port.

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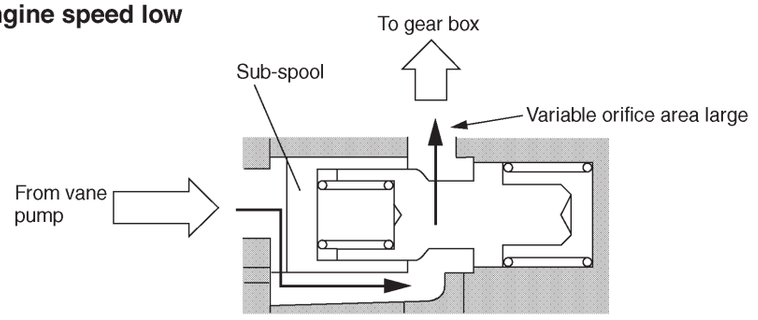
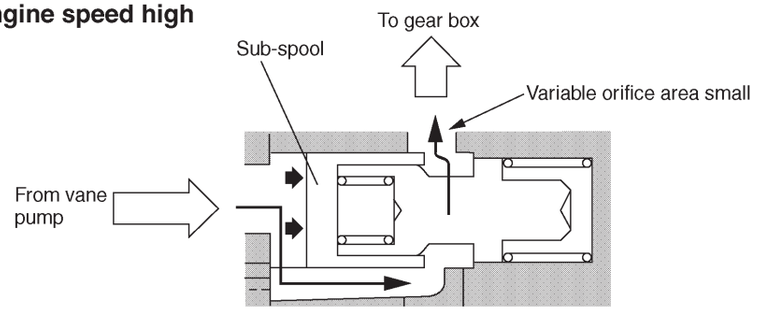
## 2. FLOW CONTROL VALVE

● The flow control valve consists of a sub-spool which is pushed to the right by the fluid pressure as the pump discharge rate becomes higher with the engine speed increase. When the sub-spool is shifted to the right, some area of the variable orifice is covered by the spool, thus the discharge rate being reduced.

**Engine speed low**




**Engine speed high**

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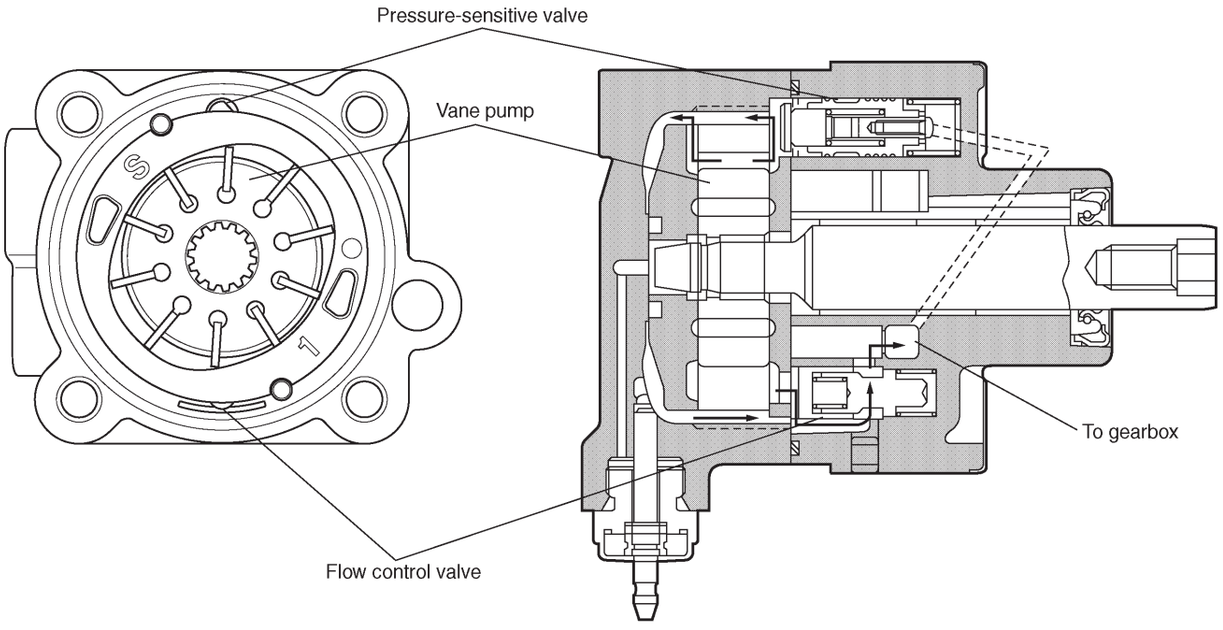
### 3. PRESSURE-SENSITIVE VALVE

● The pressure-sensitive valve is exposed on its left end directly to the vane pump discharge pressure and on its right end to the fluid pressure which has just passed through the flow control valve and will be led to the gear box.

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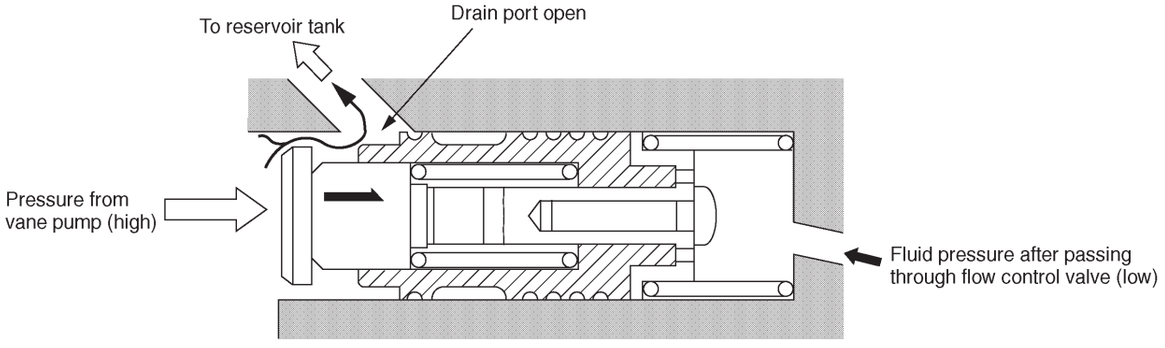
● When the steering wheel is not being turned, the fluid which has passed through the flow control valve is led to the gear box but returned to the reservoir tank without acting on the control valve in the gear box. Accordingly, the pressure does not build up.

For this reason, the vane pump discharge pressure acting on the left end of the pressure-sensitive valve assembly is higher than the pressure acting on the right end (the pressure just having passed through the flow control valve). This causes the pressure-sensitive valve assembly to move to the right. Accordingly, the drain port which has been closed by the outer spool is opened, the pressure inside the pump thereby being reduced.

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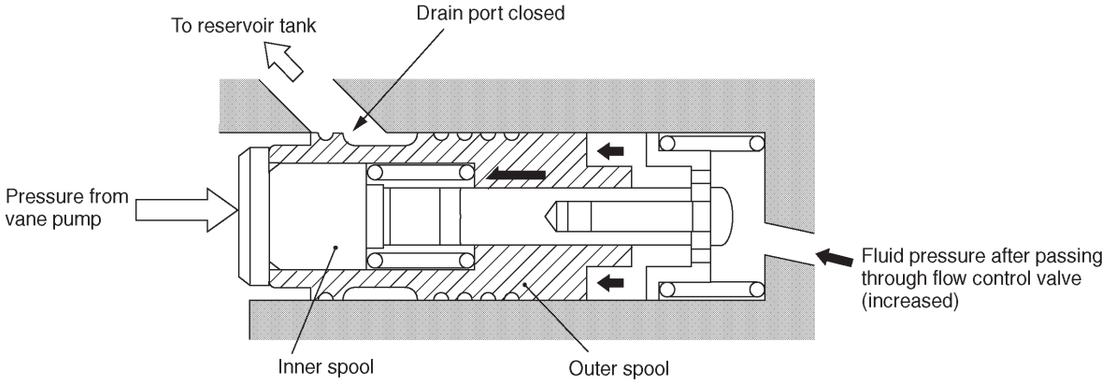
● When the steering wheel is turned, the fluid which has passed through the flow control valve and flown into the steering gear builds up its pressure, because it is used as a power source assisting the steering effort.

The inner spool of the pressure-sensitive valve assembly is kept pressed to the right by the vane pump discharge pressure acting on its left end. In this condition, as the fluid pressure acting on the right end is increased by the steering operation, the outer spool is moved to the left, closing the drain port. Therefore, the pump internal pressure is increased, and a higher pressure required for assisting the steering effort is supplied to the gear box.

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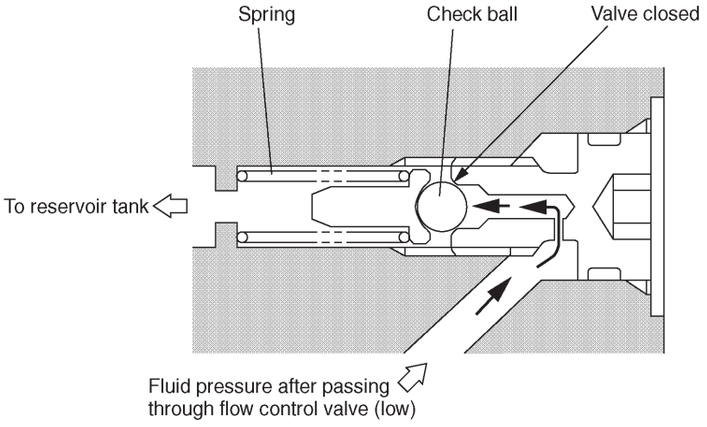
## 4. RELIEF VALVE

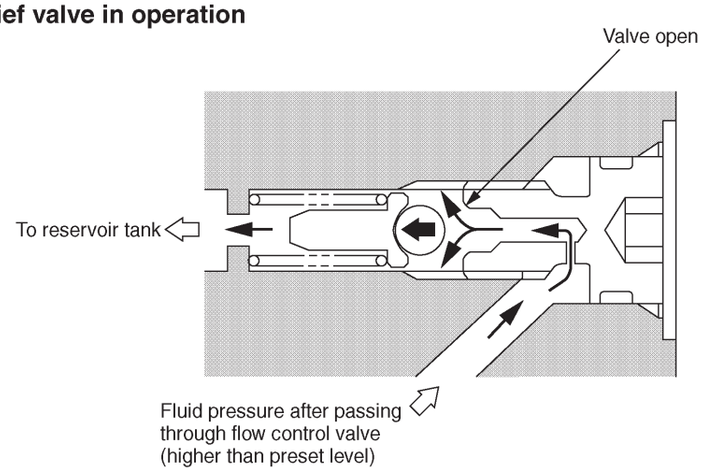
The relief valve is composed of a check ball and a tension spring. The check ball is exposed, on the right side, to the fluid pressure regulated by the flow control valve (fluid pressure supplied to the steering gear box). At the left side, it is subjected to the spring tension and normally closes the passage for the said fluid pressure.

If the pressure in that passage is increased abnormally high for some reason (for example, the steering wheel has been fully turned to its stopper) and overcomes the spring tension, the ball is pushed to the left, and the oil is drained into the reservoir tank, thus the pressure in the passage being relieved.

**Relief valve not in operation**




**Relief valve in operation**

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**MEMO**