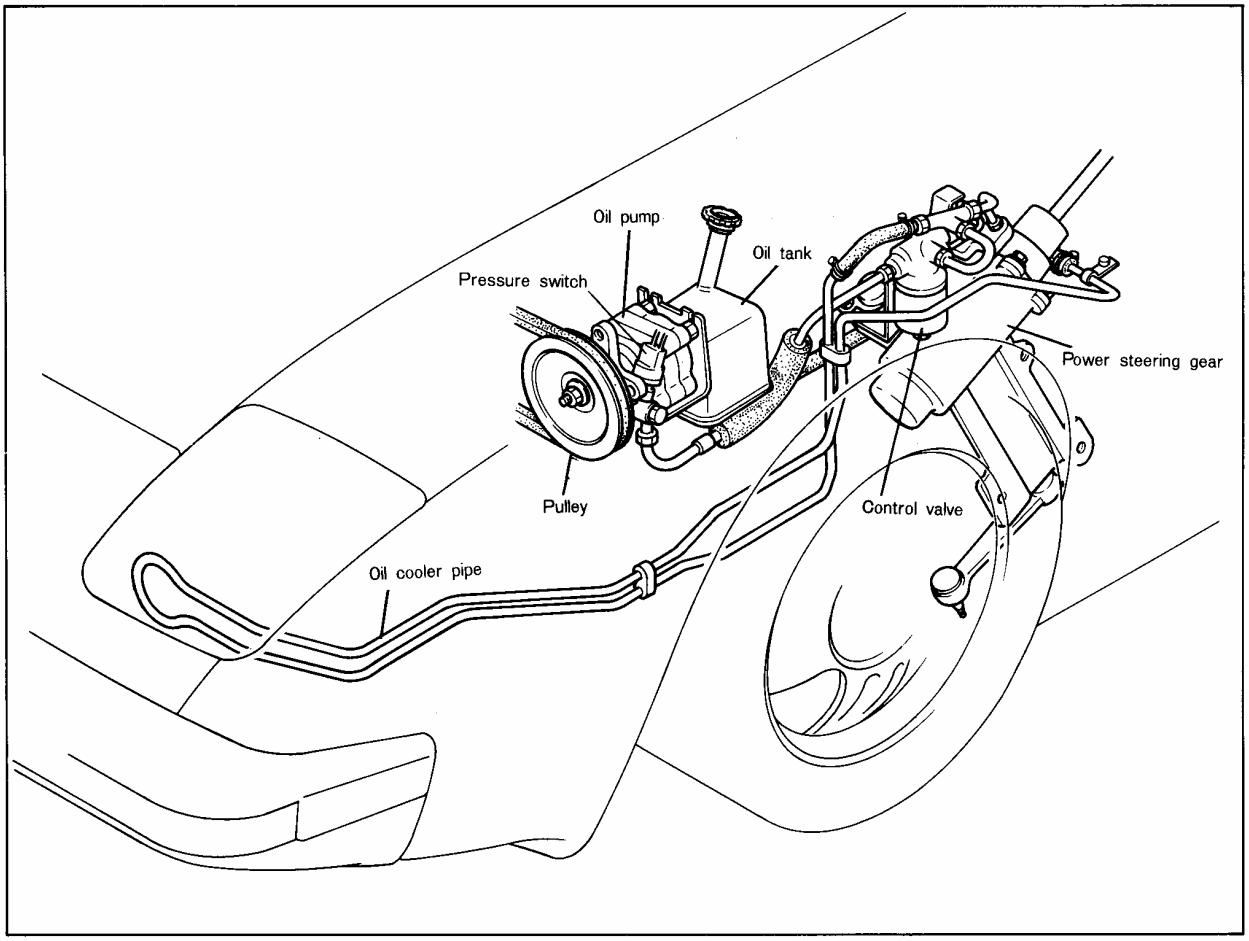
POWER STEERING

STRUCTURAL VIEW



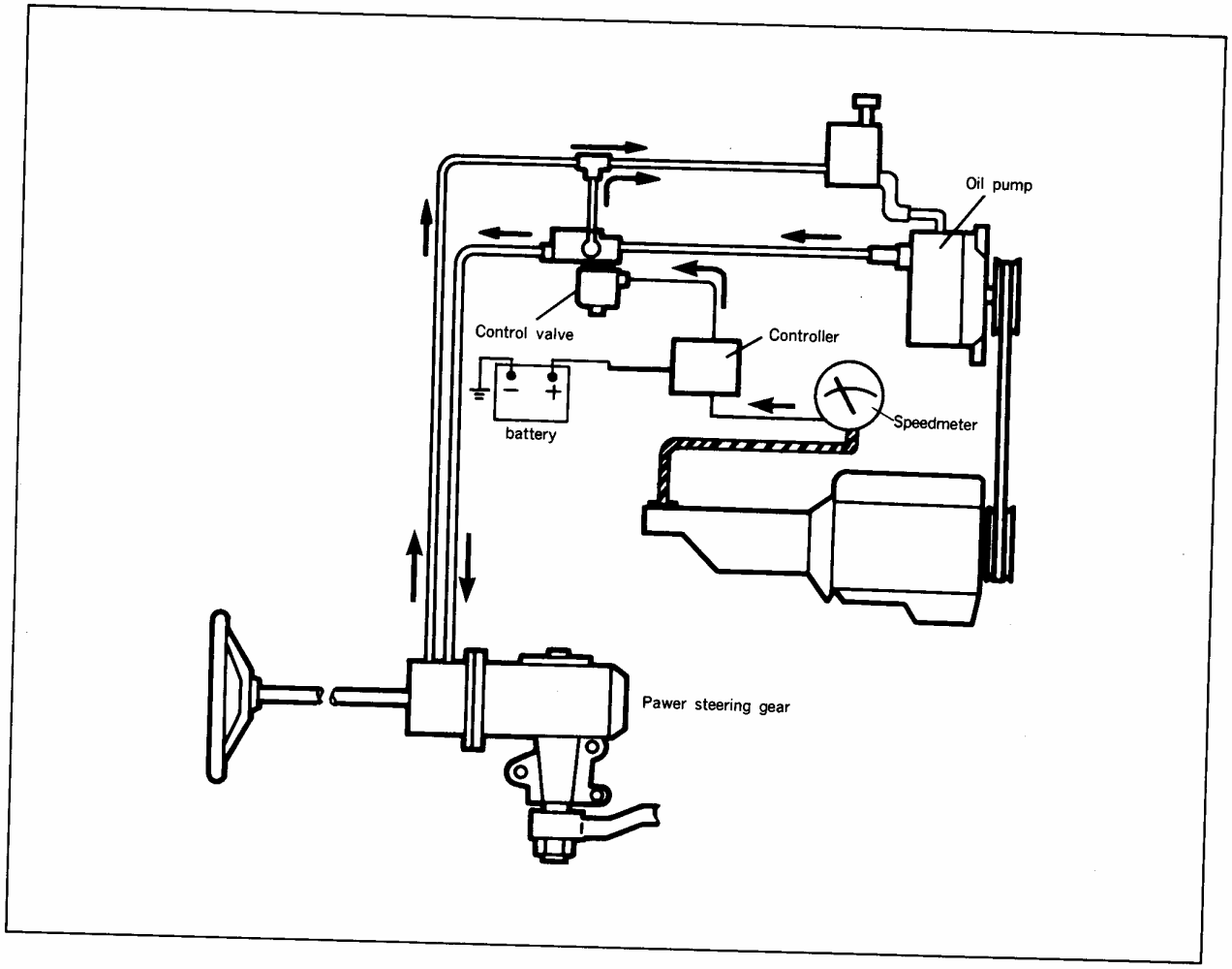
SPECIFICATIONS

Item		
Steering wheel	Outer diameter	380 mm (14.96 in)
	Lock to lock	3.0
Steering and linkage	Gear type	Ball nut type
	Gear ratio	15.83 : 1
	Shaft type	Regular type
Oil pump	Constant discharge	6.5 ± 0.5 liters/min. (1.69 ± 0.13 U. S. gallon, 397 ± 31 cu. in)
	Constant pressure	$7{,}000\ ^{+500}_{-250}$ kPa ($995\ ^{+71}_{-35}$ lb/in^2)
	Oil pump rpm	600 ~ 6,500 rpm
	Oil capacity	0.8 liters (0.21 U. S. gallon, 48.82 cu. in)
	Oil	ATF Type F (M2C33F)

SPEED-SENSING STEERING SYSTEM

OUTLINE

This system detects the vehicle speed by a vehicle-speed sensor located within the speedometer. Pulse signals are transmitted from the vehicle-speed sensor to a controller, these pulse signals are converted to electric current which activates the electromagnetic plunger incorporated within a solenoid, the constant discharge flow from the oil pump is regulated by a control valve which varies the supply flow to the steering gear, lightening the required steering effort at low speed and increasing it appropriately at high speed, and thereby suitable steering power is provided according to the vehicle speed.



CONSTRUCTION OF MAJOR PARTS

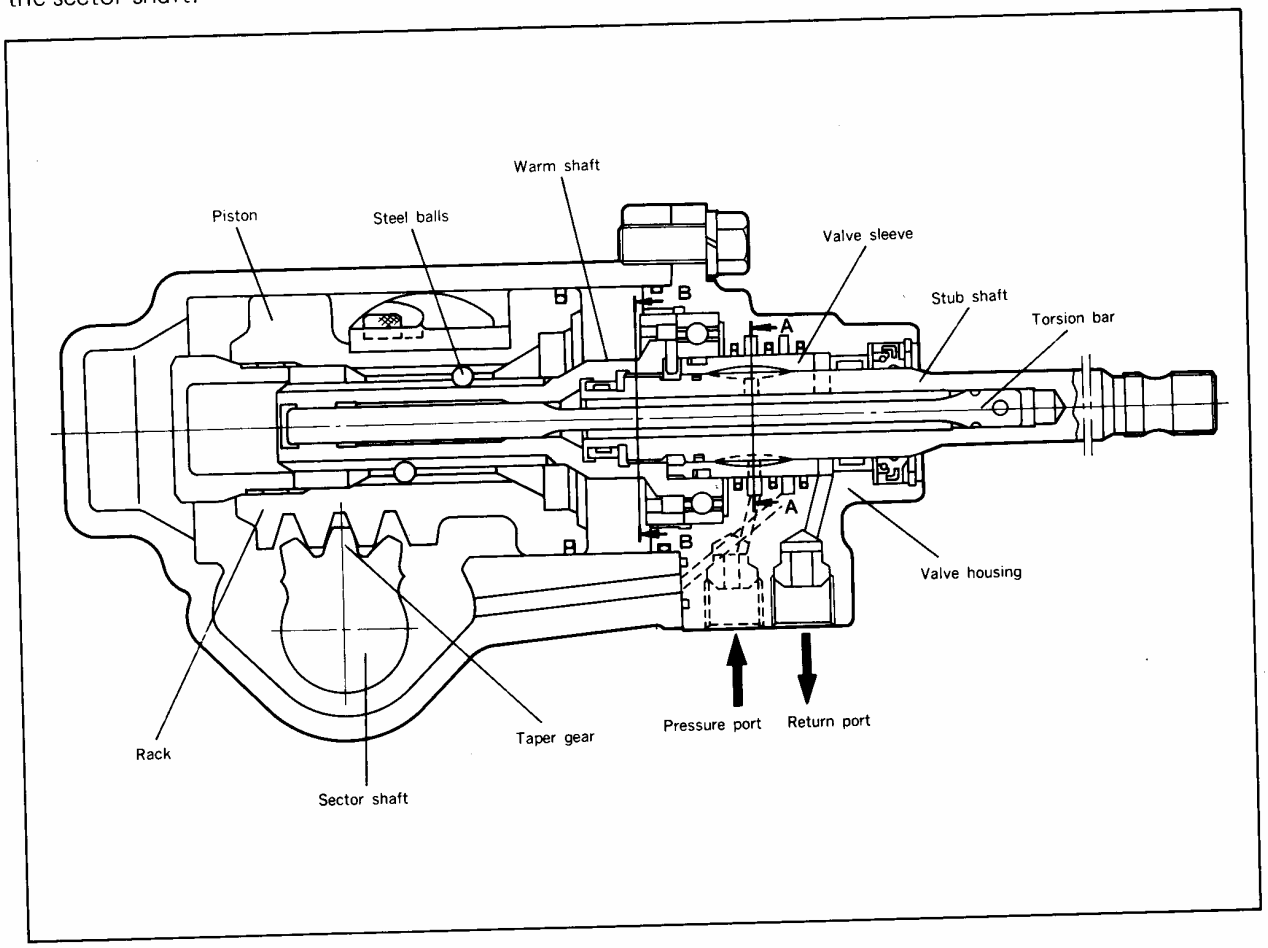
POWER STEERING CONSTRUCTION

The power steering system described here in is a rotary-valve type ball-screw integral power steering system. The system consists of the steering gear section, the power cylinder section, the control valve section, and the reaction section.

The steering gear section is of the same construction as the ball-screw manual steering, and is composed of a worm shaft, a piston (ball nut), sector shaft, etc.
When the steering wheel is turned, the movement is transmitted via the steering shaft, stub shaft, and torsion bar to turn the worm shaft. (In the manual steering system the rotational force is transmitted directly to the worm shaft from the stud shaft.) The balls then cause the piston to move in the worm shaft's axial direction. The piston rack engages the sector shaft, thus causing the sector shaft to turn as the piston moves. The rotation of the steering wheel is thus transmitted to the steering link via the pitman arm mounted to the end of the sector shaft, making steering possible.

The worm shaft is a male screw and the piston is a female screw. They are both quench-hardened and then precision cut to give their screw grooves a special cross-sectional shape. A number of steel balls are interposed between the two parts, and these steel balls roll in the grooves and recirculate via the ball tube mounted to the piston.

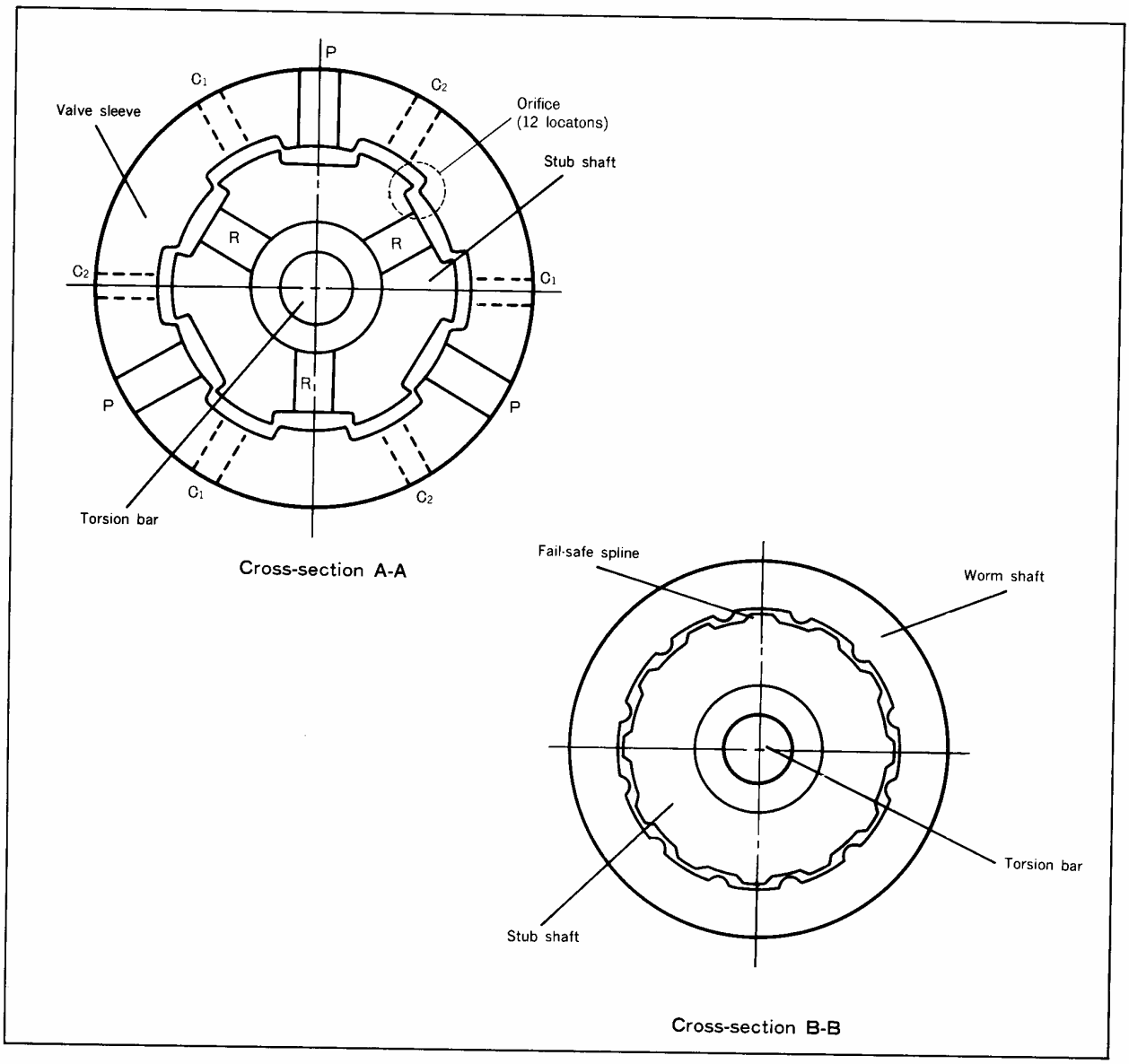
The taper gear tooth surfaces are tapered 4.5° with respect to the sector shaft center axis, and this angle results in perfect meshing of the piston rack. The reason for tapering the tooth surfaces 4.5° is to ajust the meshing of the piston rack and the sector shaft taper gear. The meshing of the rack and taper gear can be easily adjusted by tightening or loosening the adjusting screw located at the top of the sector shaft.



For the power cylinder section the inside of the steering gear box has been worked into a cylinder, and inside this there is a piston with the added function of a ball nut, thus making this a double-acting power cylinder.

The control valve section is a four-port, three-position open center type rotary valve, and it is composed of a valve sleeve and a stub shaft.
The valve sleeve and the stub shaft fit together with an appropriate amount of clearance so that they can both turn. There are six grooves running up and down the inside of the valve sleeve and the outside of the stub shaft in the axial direction; this provides orifices in 12 locations and oil passages are provided in each of the balance positions to allow oil to flow to the pressure port (P), return port (R), and left and right cylinders (C_1, C_2). There is a notch in the end of the sleeve into which a pin press-fit into the worm shaft fits to allow the worm shaft and the sleeve to turn as a unit.

The reaction section consists of a torsion bar. One end of the torsion bar is secured to the worm shaft by a special press-fitting method and the other end is secured to the stub shaft with a pin. Although the stub shaft and the worm shaft are relatively displaced when the torsion bar is twisted, the amount of displacement is limited by the contact of the stub shaft fail-safe spline against the worm shaft fail-safe spline.

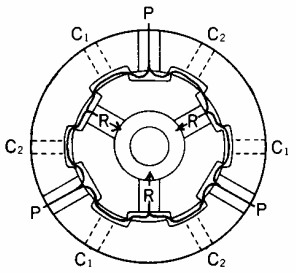


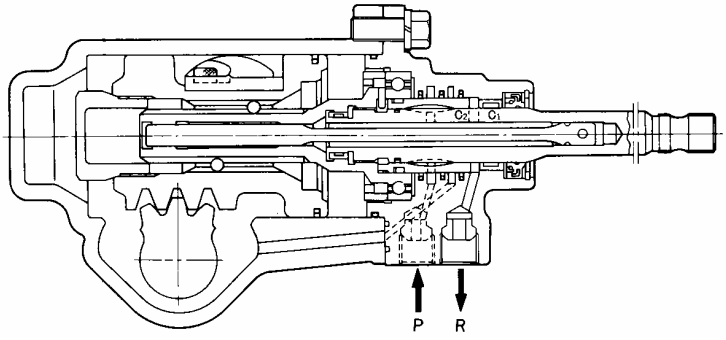
POWER STEERING OPERATION

DURING NEUTRAL (STRAIGHT-AHEAD DRIVING)

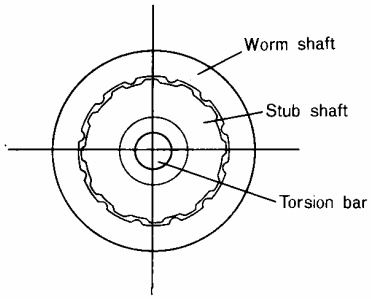
Illustrates the operation during neutral. The oil supplied from the pump flows from the pressure port through the circular groove inside the valve housing and into the three oil passages provided in the valve sleeve in the axial direction. However, because all of the orifice gaps are the same size and the resistance is equal throughout the circuit, the oil flows through the three oil passages provided in the stub shaft in the radial direction and through the clearance between the stub shaft and the torsion bar, and then once again out of the return port via the three oil passages provided in the stub shaft in the radial direction.

Therefore, there is no difference in the operating pressures applied to the left and right cylinders and the piston does not move.





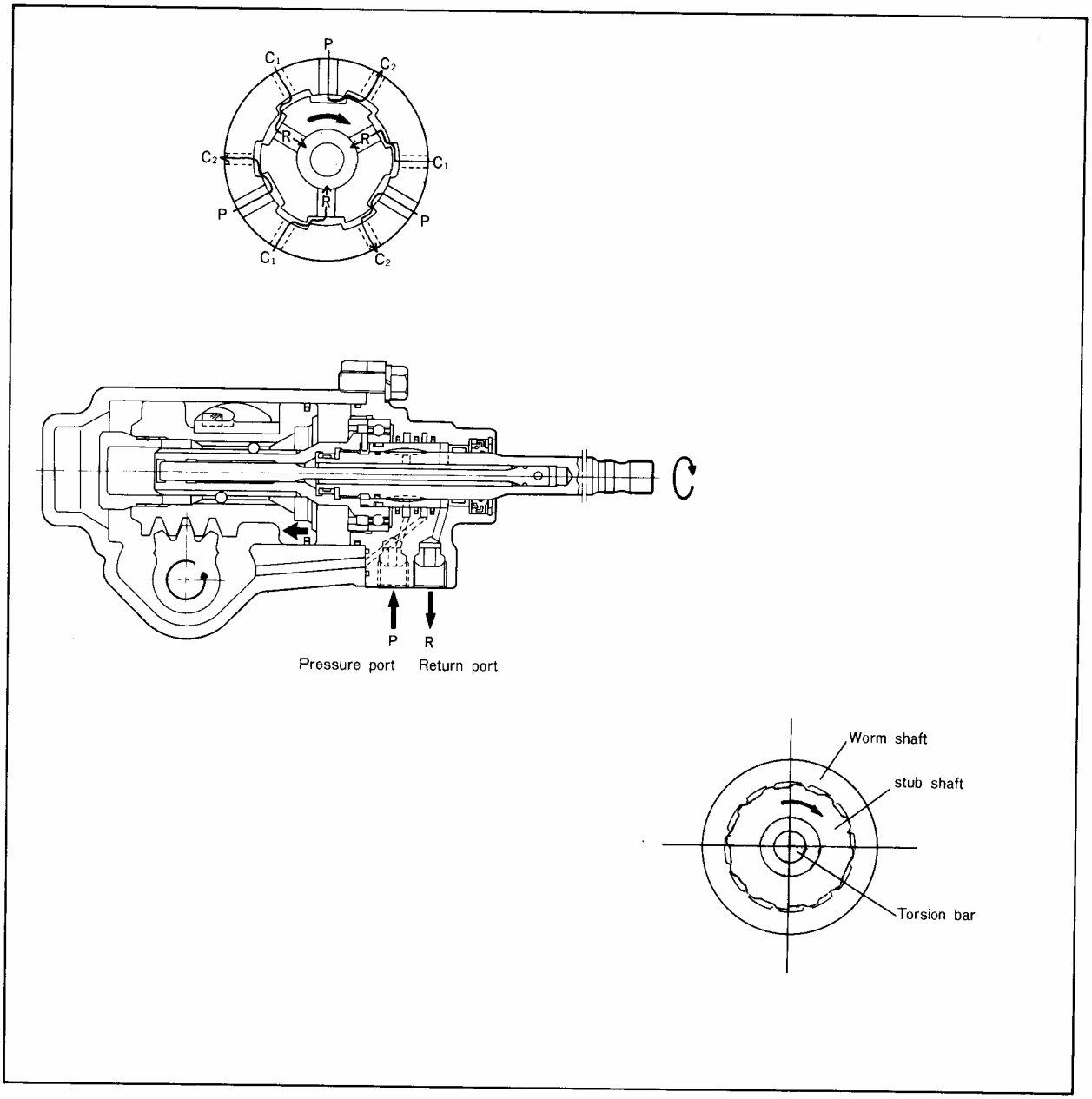
Pressure port Return port



WHEN TURNING

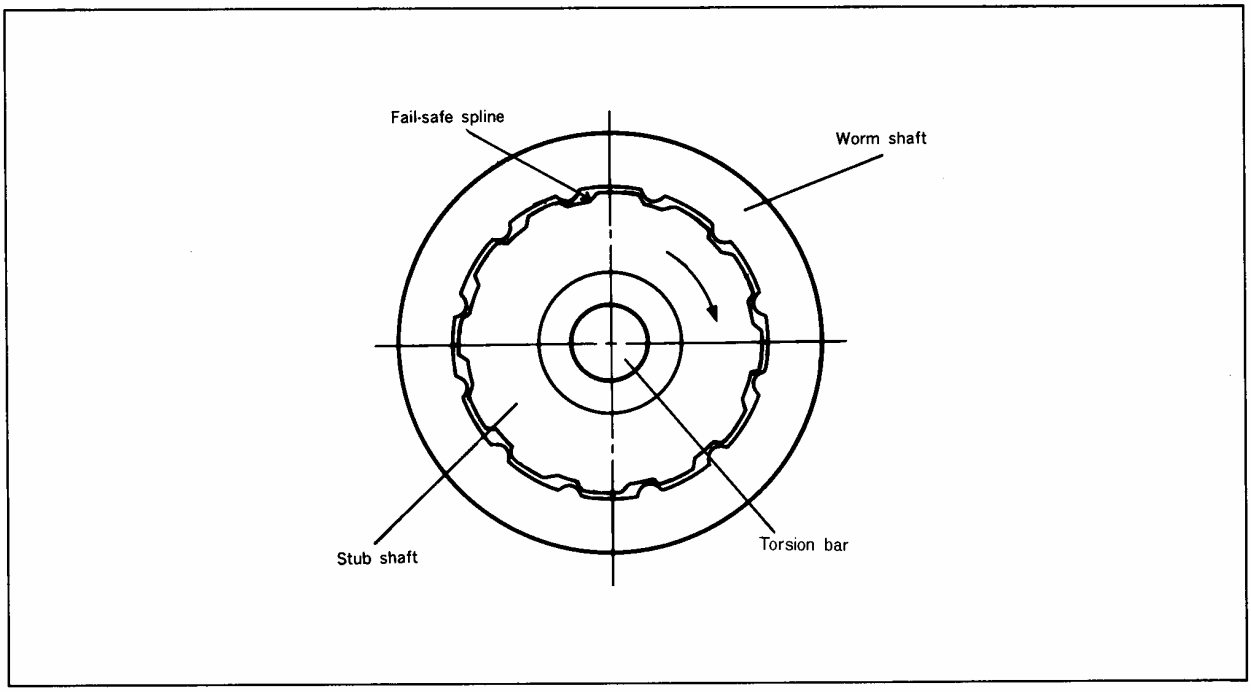
When the steering wheel is turned to the right, for example, because the reaction force of the tires work on the worm shaft via the link, the pitman arm, the sector shaft, the piston, etc., the torsion bar twists and the stub shaft turns to the right with respect to the worm shaft. Because the sleeve and the worm shaft are a single unit, the openings of the orifices for the right-turn direction become smaller and the flow of oil out of the return port is limited, thus increasing the pressure in the right cylinder circuit. The piston, therefore, is forced to move to the left, and accompanying this movement of the piston, the rotational force of the sector shaft is supplemented.

When the piston moves, the twisted torsion bar returns to the neutral condition and the relative displacement which appeared between the valve sleeve and the stub shaft also returns to the neutral condition. In this way, when the steering wheel is turned at a certain speed to a desired angle, the tires connected via the sector shaft, pitman arm, link, etc., will turn at a corresponding speed to a corresponding position. In addition, the reaction force of the torsion bar causes the stub shaft to return to the neutral position, and this force is also transmitted to the steering wheel to give the driver an appropriate steering feel.



MANUAL STEERING

Even if there is no pressure because the engine is stopped or in the event of a pump malfunction, oil leakage, or any other reason, manual steering will still be possible because the stub shaft fail-safe spline is in contact with the fail-safe spline of the worm shaft.



OIL PUMP

EXPLANATION OF OPERATION OF OIL PUMP

Construction and operation of oil pump assembly

This oil pump is the vane pump type, and is united with the oil reservoir. A flow-control valve and relief valve are included.

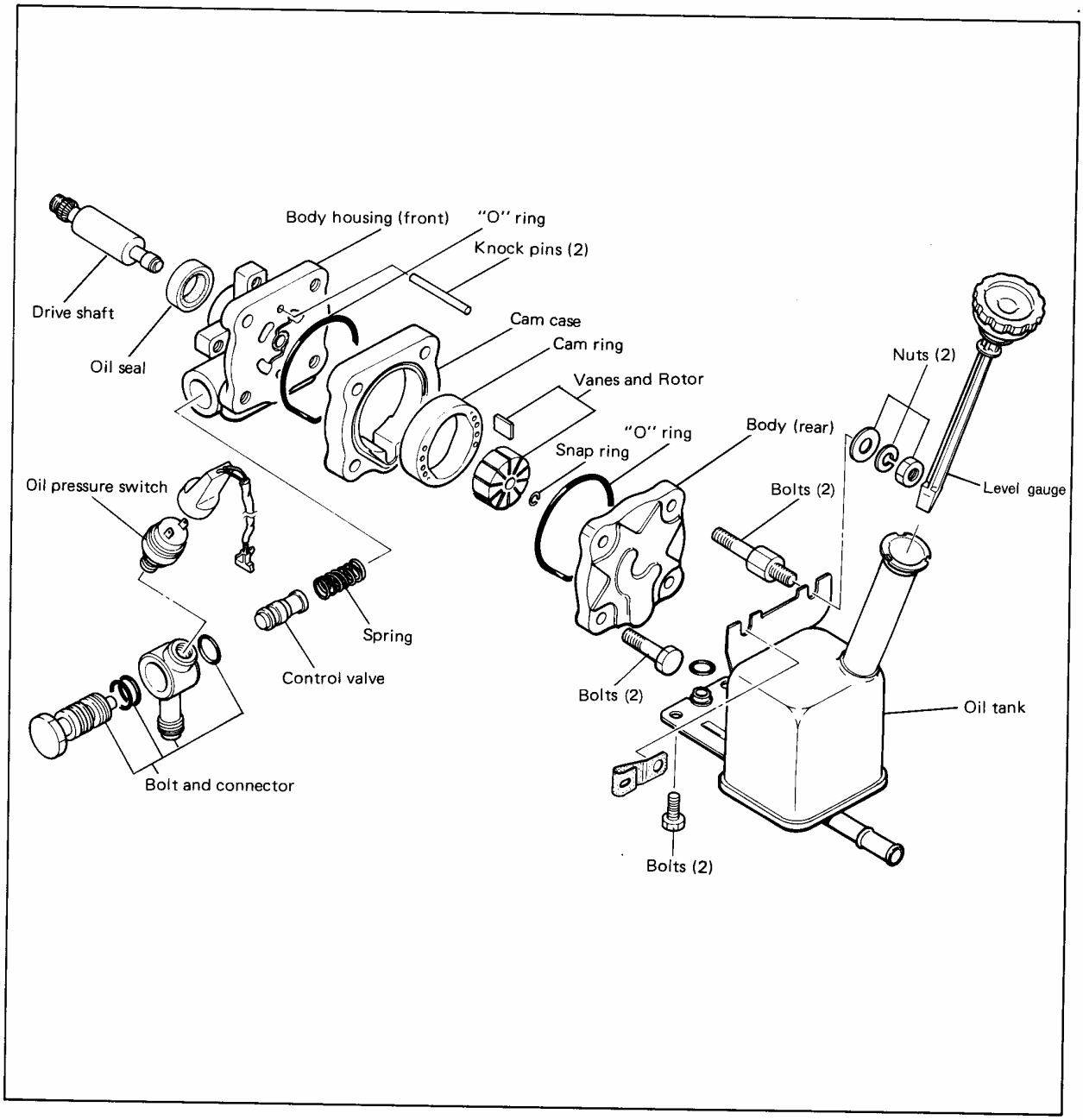
There is a hydraulic pressure switch for idle-up at the pump discharge connector.

OIL PUMP (VANE PUMP)

This pump is composed of a rotor, cam ring, and 10 vanes.

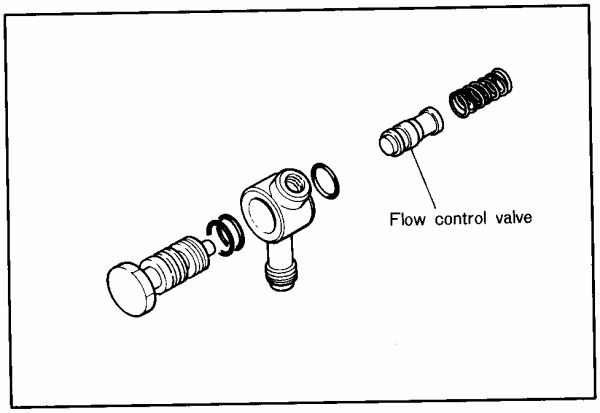
When the rotor turns, centrifugal force causes the vanes, located in the grooves of the rotor, to be forced out radially and pressed against the inner wall of the cam ring.

The tips of the vanes move against the oval inner wall of the cam ring; oil passes through the oval grooves, enters the chamber formed by the rotor, cam ring and vanes, and is continuously discharged.

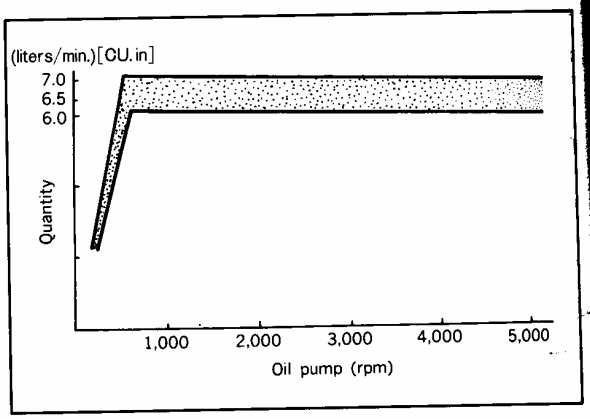


FLOW CONTROL VALVE

The flow control valve is located in the pump housing.

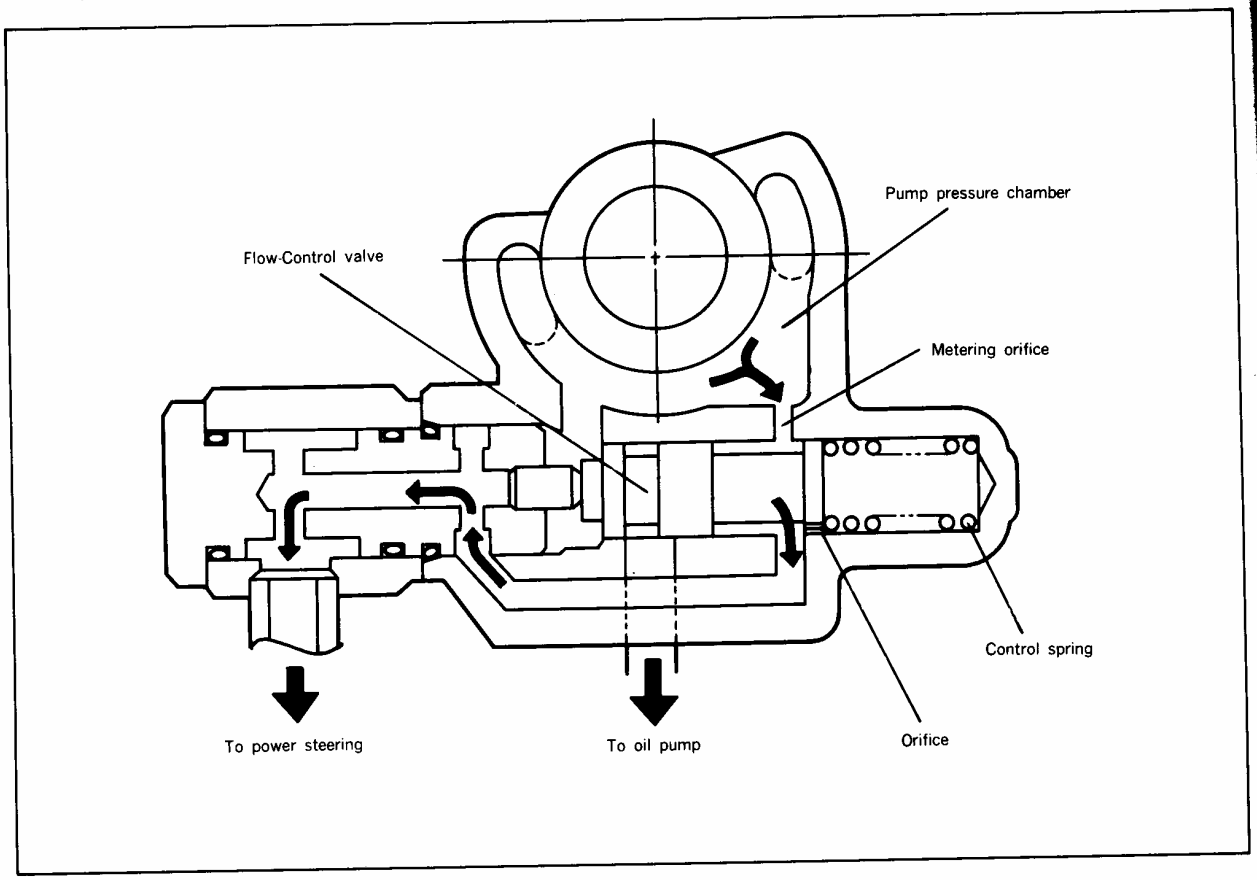


The characteristics of the flow control valve.

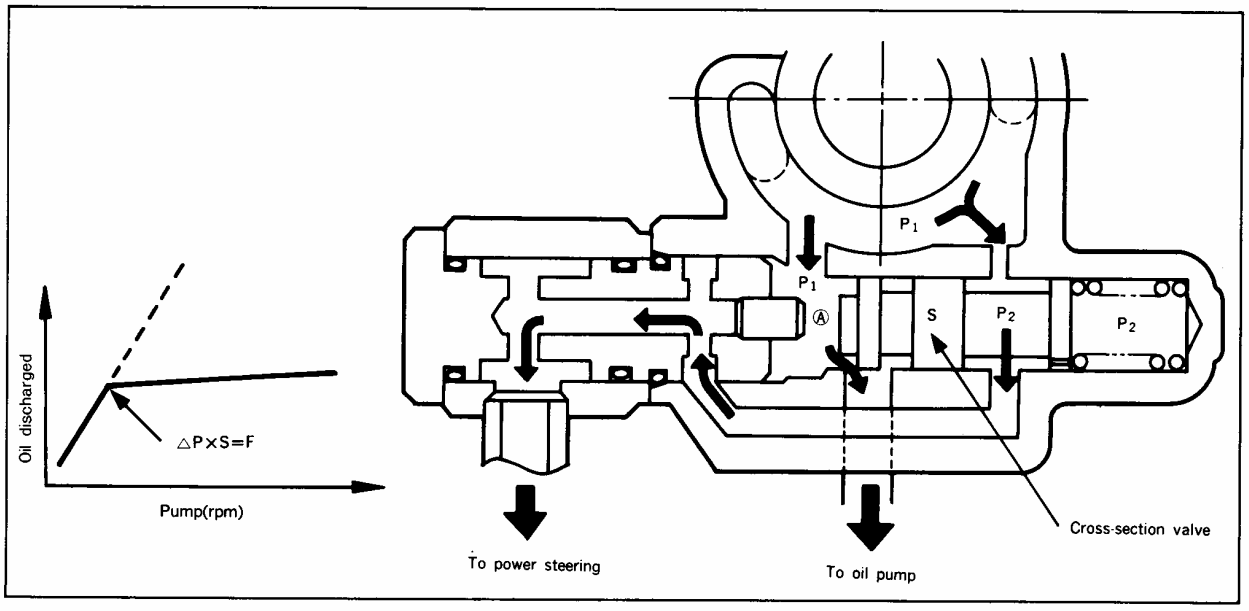


Flow Control Valve Operation

The oil discharged by the oil pump is sent to the pump pressure chamber, passes through the metering orifice, then through the control valve, and is supplied to the power steering.



If, at this time, as a result of the amount of oil passing through the metering orifice, a pressure difference ($\Delta P = P_1 - P_2$) occurs before or after, and the oil amount increases, (ΔP) will also increase. (When the oil pump rpm increases and the discharge amount increases, this pressure difference (ΔP) overcomes ($\Delta P \times S \geqq F$) the initial reaction (F) of the control spring, moving the flow-control valve to the right, and the passage which passes through the pressure chamber (A) to the pump inlet port expands, thus maintaining the flow supplied to the control valve at a constant amount.

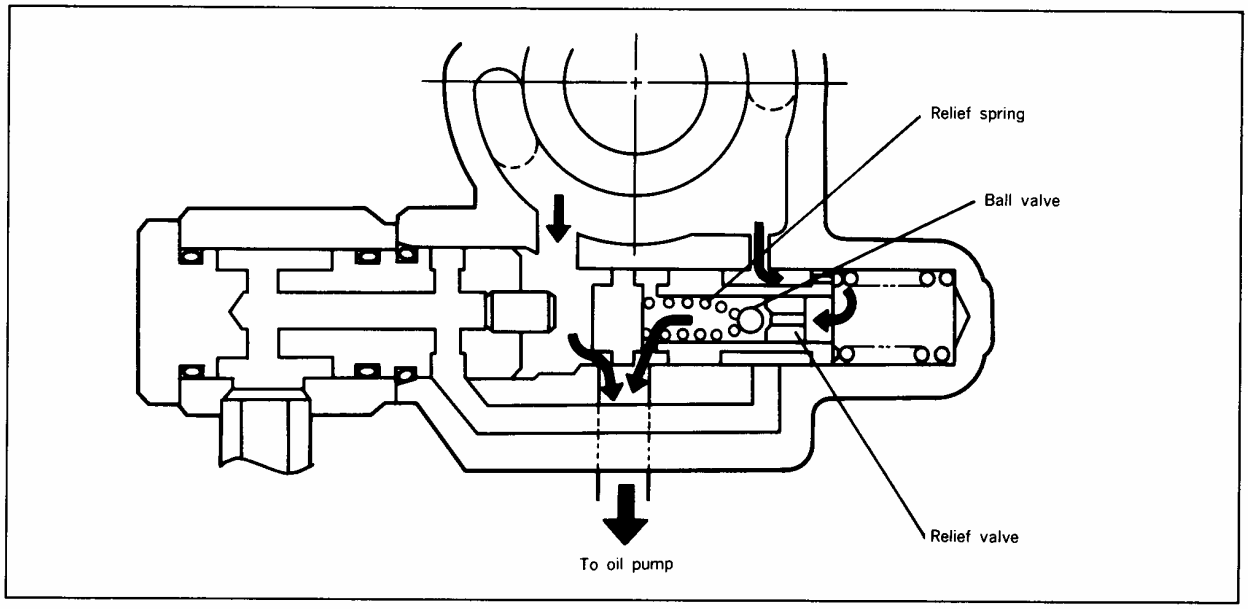


RELIEF VALVE

This valve is designed to regulate the maximum oil pressure. It is composed of a relief valve, ball valve, and relief spring, and is located within the flow-control valve.

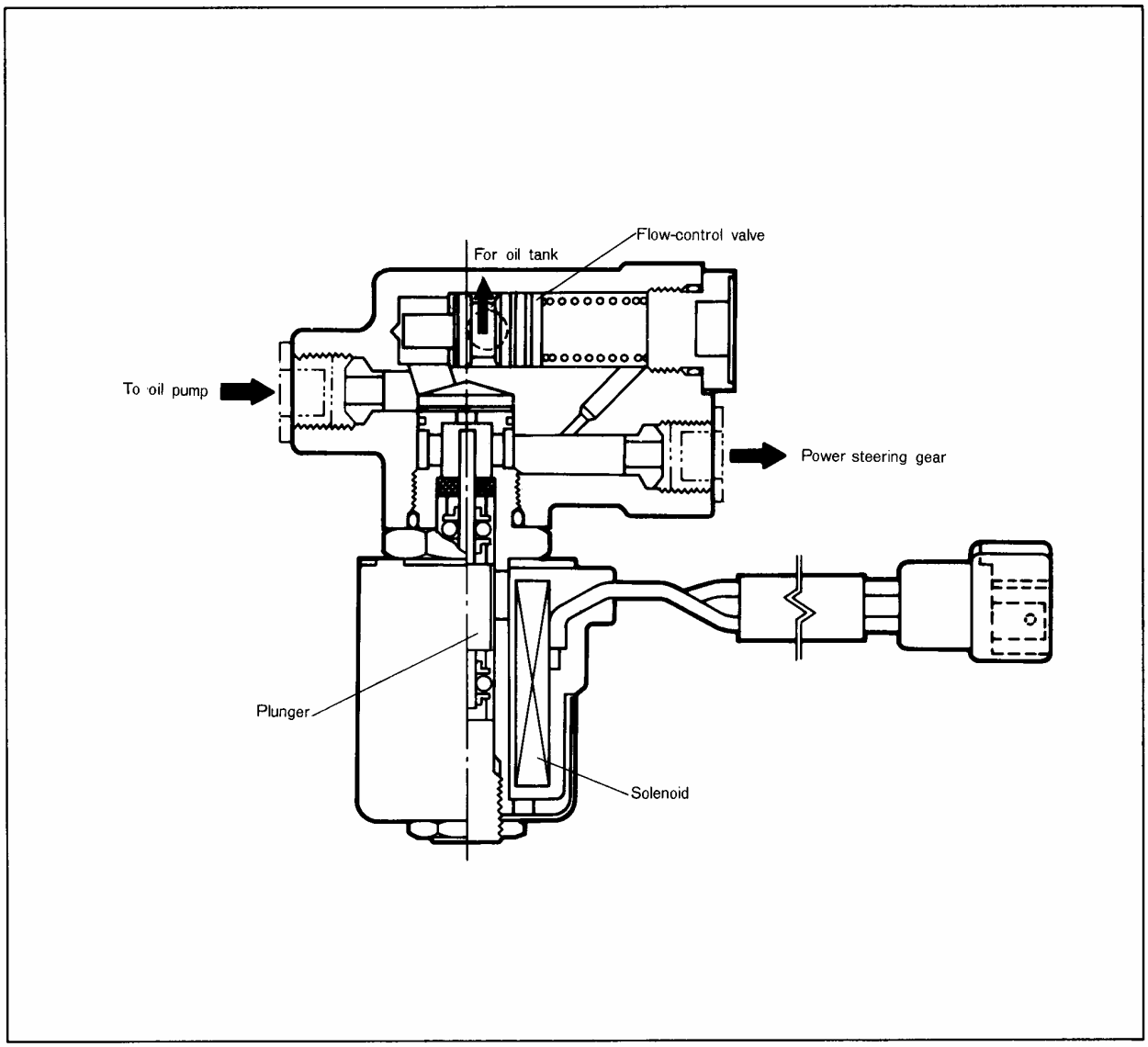
When the system oil pressure reaches the specified value, the ball valve opens, and a portion of the oil passes through the orifice and is discharged to the pump inlet port.

When this happens, the flow-control valve moves to the right because the pressure at its right side decreases as a result of the orifice's contraction effect, and thus almost all of the oil discharged from the pump is caused to escape to the pump inlet port.



CONTROL VALVE CONSTRUCTION

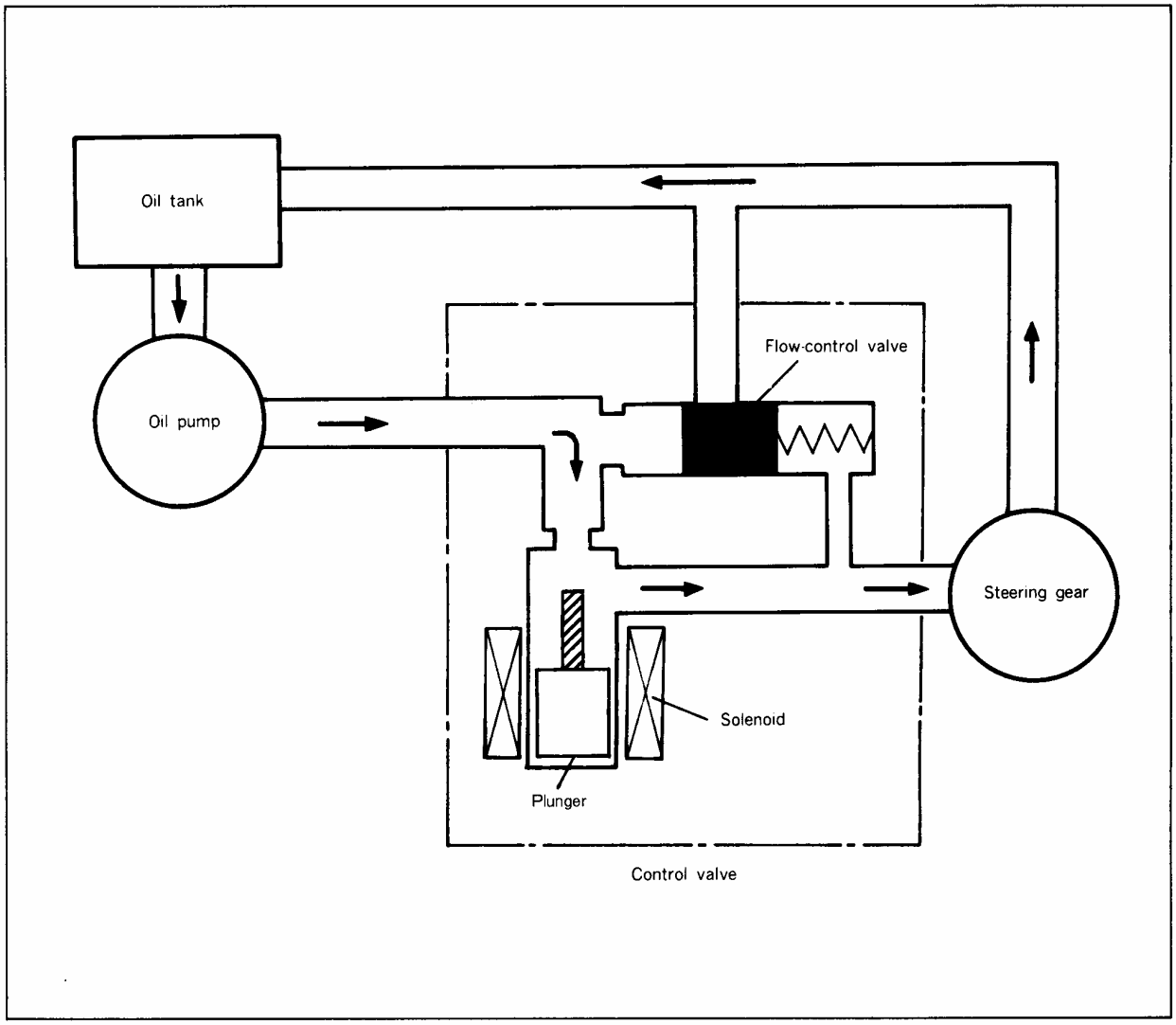
The amount of flow from the oil pump is controlled by the rod activated by the solenoid, and this regulated flow is supplied to the power steering gear.



CONTROL VALVE OPERATION

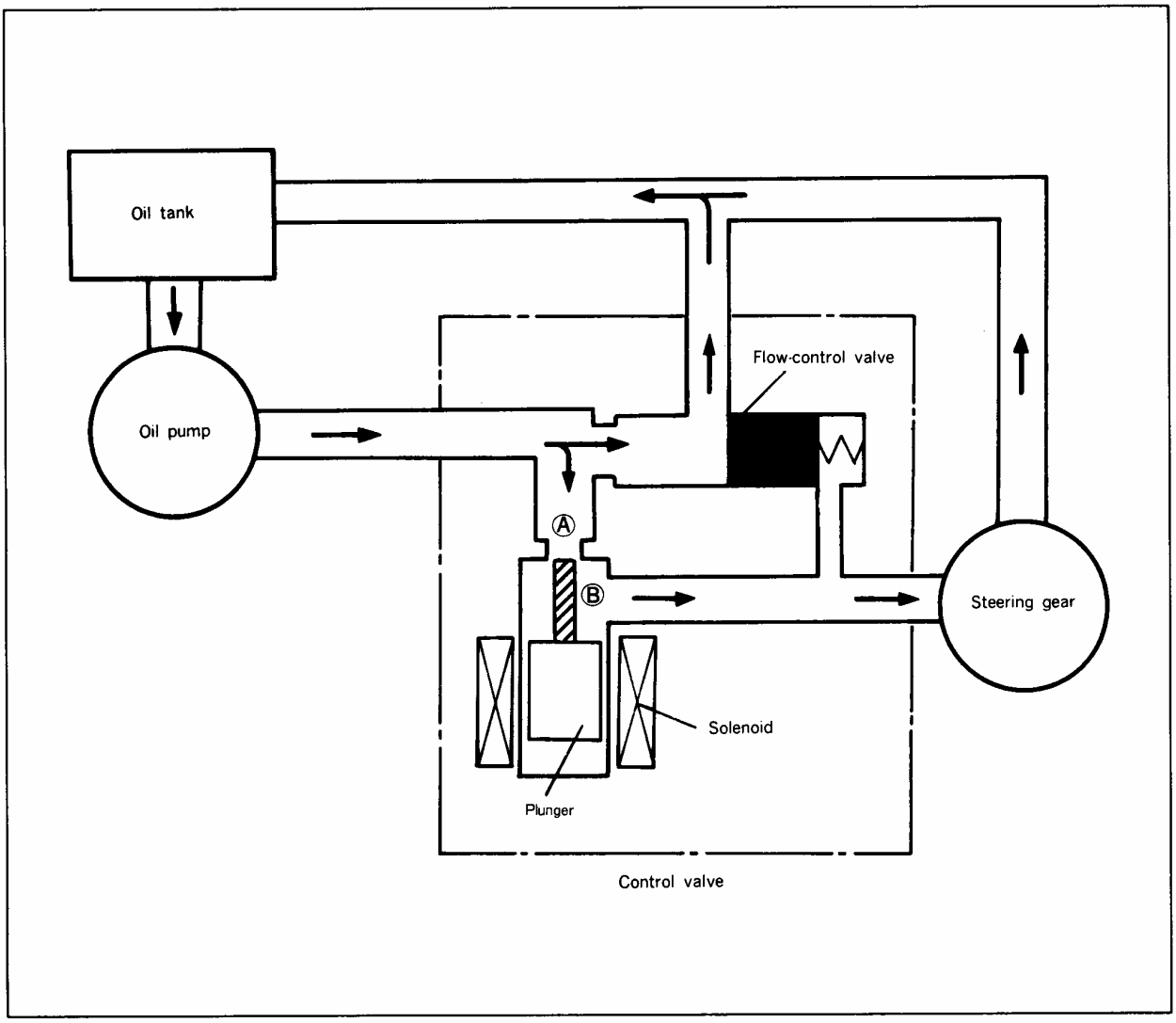
AT LOW SPEED

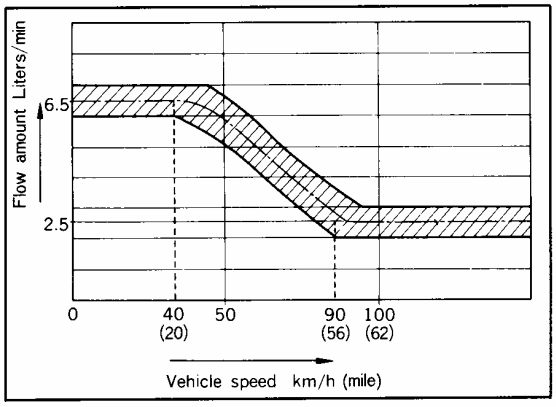
With the electromagnetic plunger of the solenoid at the lower side and the opening wide, almost all of the oil discharged from the oil pump is supplied to the power steering gear after passing through the orifice.



AT HIGH SPEED

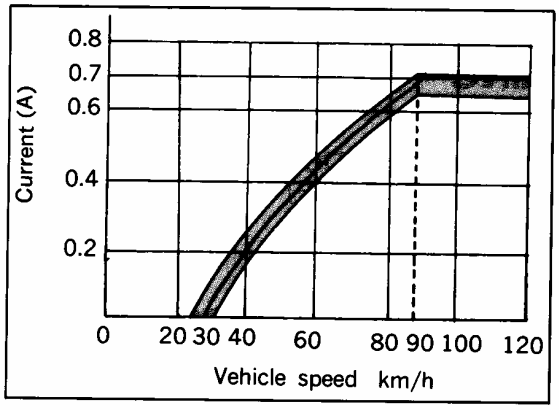
The solenoid is activated by signals from the controller, and the electromagnetic plunger moves to the upper side in response to the increase of the vehicle speed. At this time, a difference between the pressures of chamber A and chamber B occurs, the flow-control valve overcomes spring pressure and operates, the bypass passage opens, the oil is caused to bypass the tank, and the flow supplied to the power steering gear decreases.





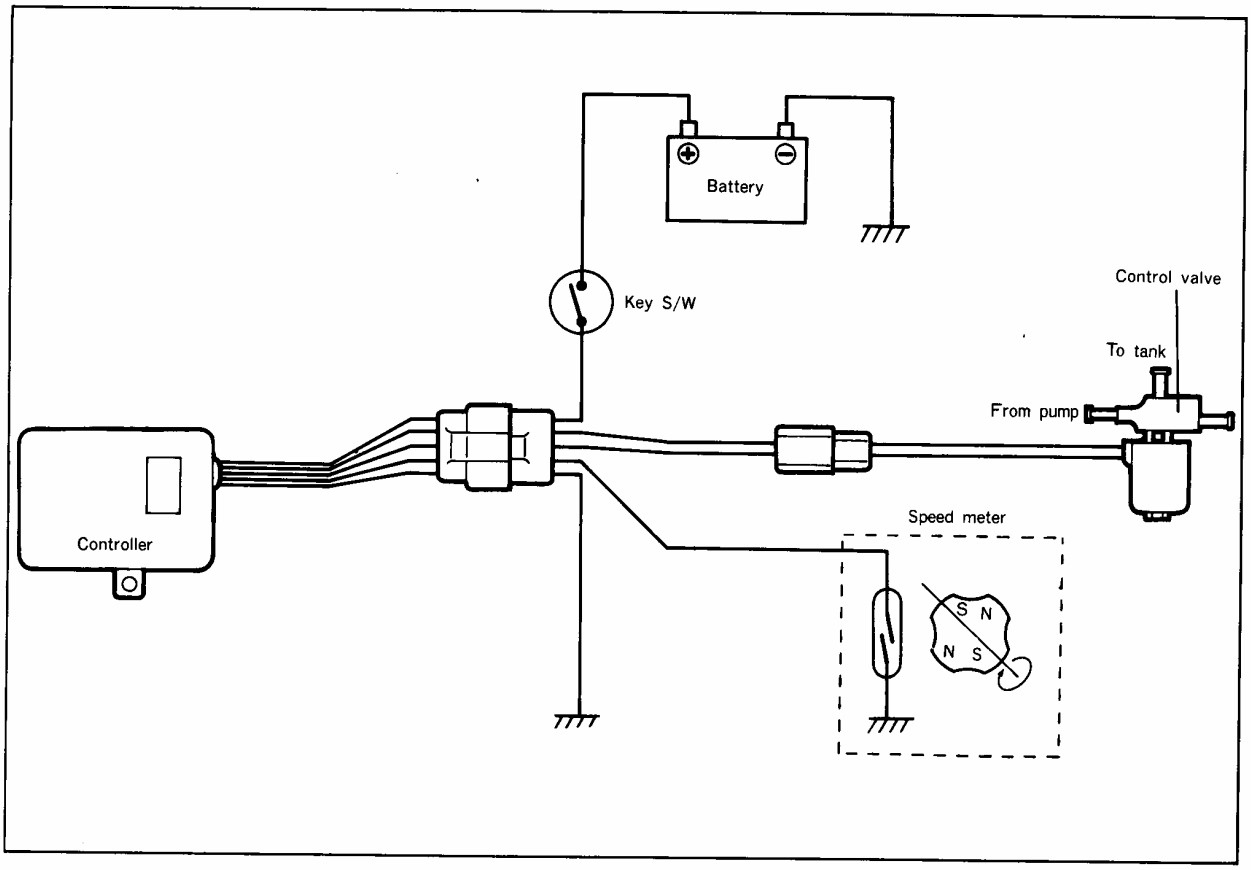
AT CONSTANT SPEED

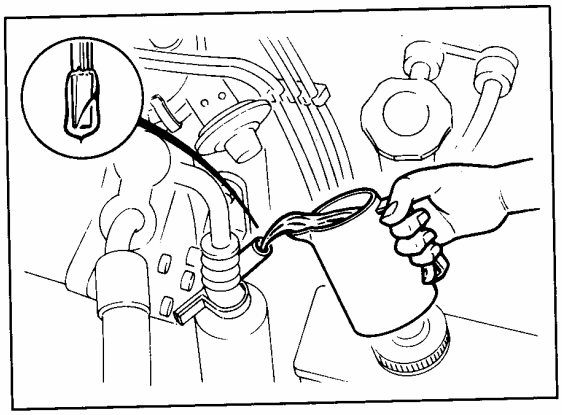
Changes from low speed to high speed or from high speed to low speed change continuously. The changes in the flow amount at various speeds are shown in the diagram at the left.



CONTROLLER

Pulse signals proportional to the vehicle speed from the vehicle-speed sensor are input and are converted to electric current to activate the control valve. Depending on the speed of the vehicle, the current flowing from the controller to the solenoid of the control valve is as shown in the figure at the left.





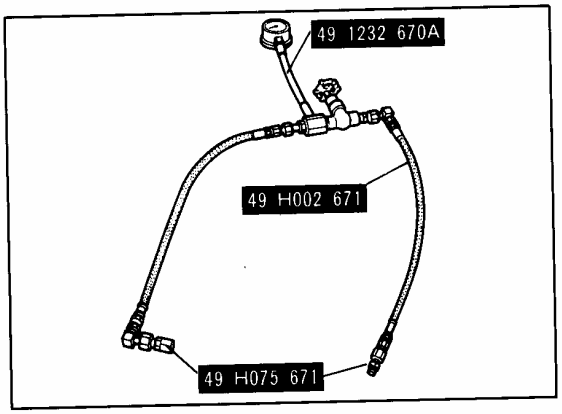
SERVICE POINTS OF POWER STEERING

FLUID LEVEL INSPECTION

Add ATF type F (M2C33F) metting specifications if necessary.

AIR BLEEDING

Procedures for air bleeding the power steering are included in the workshop manual.



PRESSURE INSPECTION

To check the hydraulic pressure of the pump, use the special gauge (49 H002 671, 49 H075 671 and 49 1232 670A), referring to the workshop manaul. The pressure should be 6,500 kPa (924 psi) at the engine revolution of 1,000 ~ 1,500 rpm and the fluid temperature of 50 ~ 60°C (122 ~ 140°F).