STEERING SYSTEM

67U10X-501

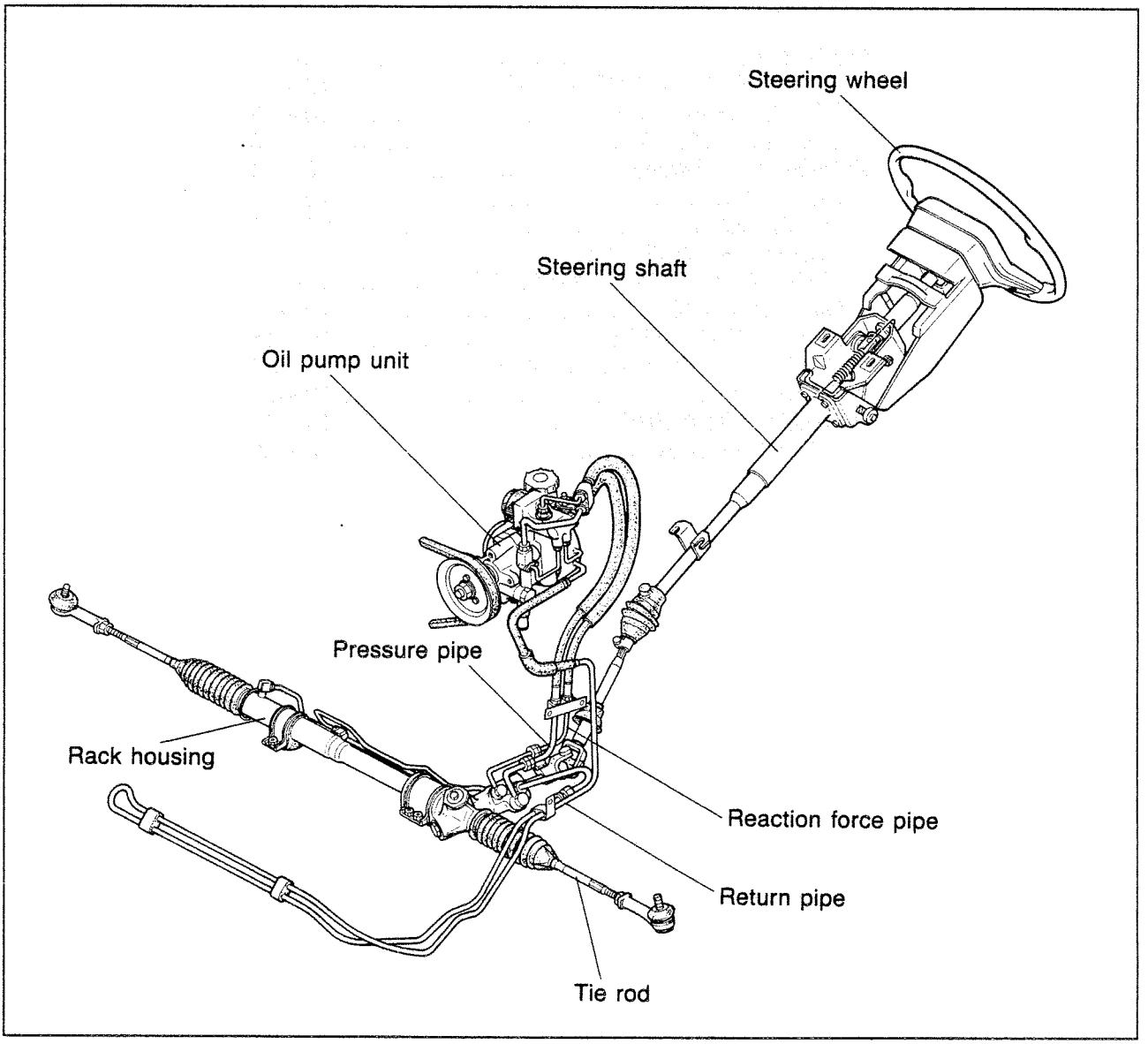
OUTLINE

OUTLINE OF CONSTRUCTION

1. The steering gear box has been changed from a ball-and-nut type to a rack-and-pinion type.
2. Vehicle speed and steering angle sensing power steering is adopted.
3. Tilt steering is a new feature. The steering wheel can be tilted about 5 degrees.
4. The control unit has a self-diagnostic capability for the electrical steering components.

57G10X-501

STRUCTURAL VIEW



67U10X-503

SPECIFICATIONS

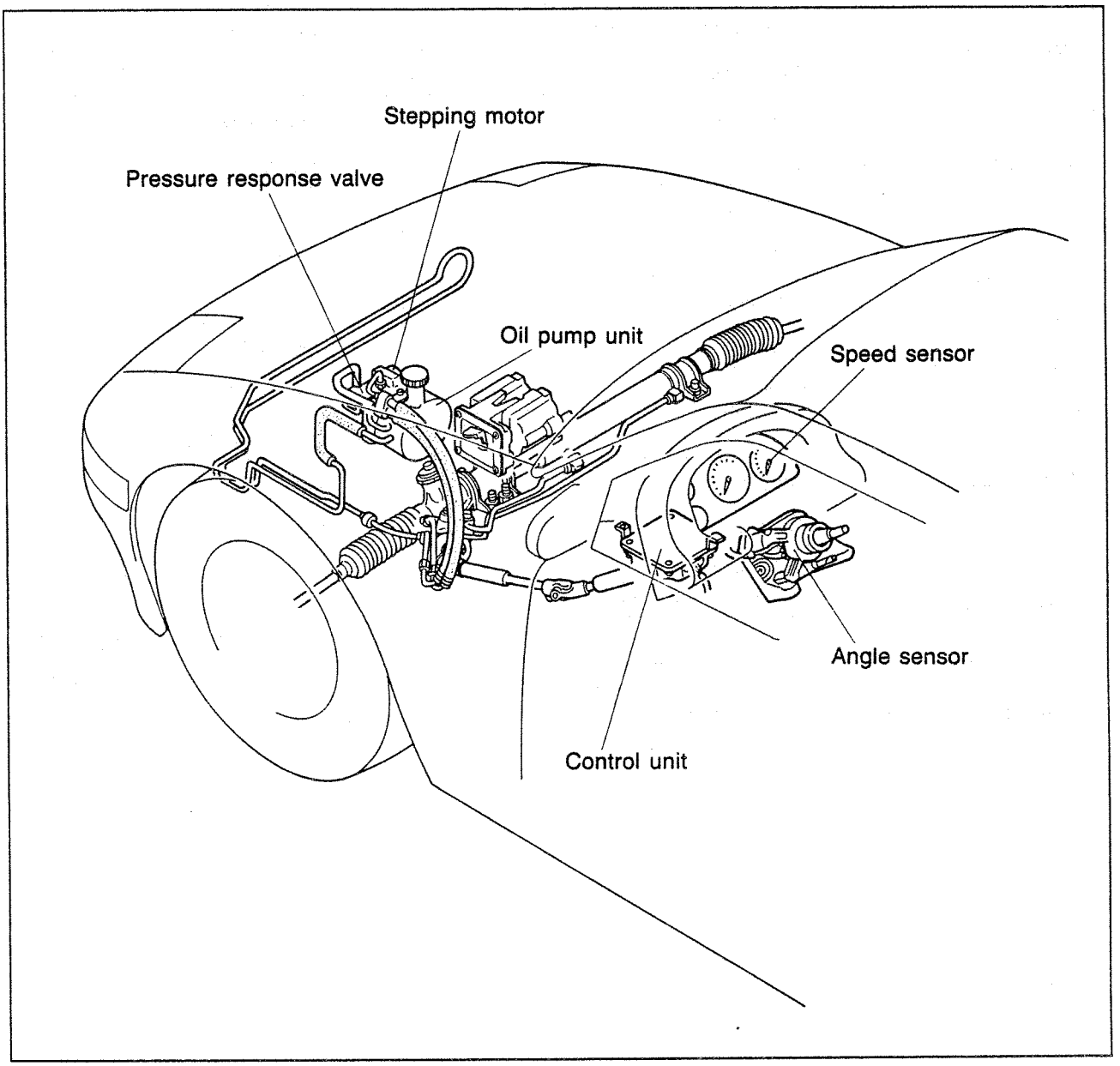
Item	Type	Manual steering	Power steering
Steering wheel	Outer diameter mm (in)	380 (14.96)	
	Turns lock to lock	3.6	2.7
Steering shaft and joints	Shaft type	Collapsible	
	Joint type	Cross joints (2)	
	Tilt angle degree	5	
Steering gear	Type	Rack and pinion	
	*Steering ratio	20.0	15.2
Maximum steering angle	Inner	36° ± 2°	
	Outer	32° ± 2°	
Wheel alignment	Toe-in mm (in)	3 ± 3 (0.12 ± 0.12)	
	Camber angle	22' ± 30'	
	Caster angle	4°40' ± 45'	
Power steering fluid	Capacity liter (US quarts, Imp quarts)	———	0.80 (0.85, 0.70)
	Type	———	ATF type F (M2C33-F)

57G10X-502

* Steering ratio: the turning angle of the tires relative to the turning angle of the steering wheel.

POWER STEERING

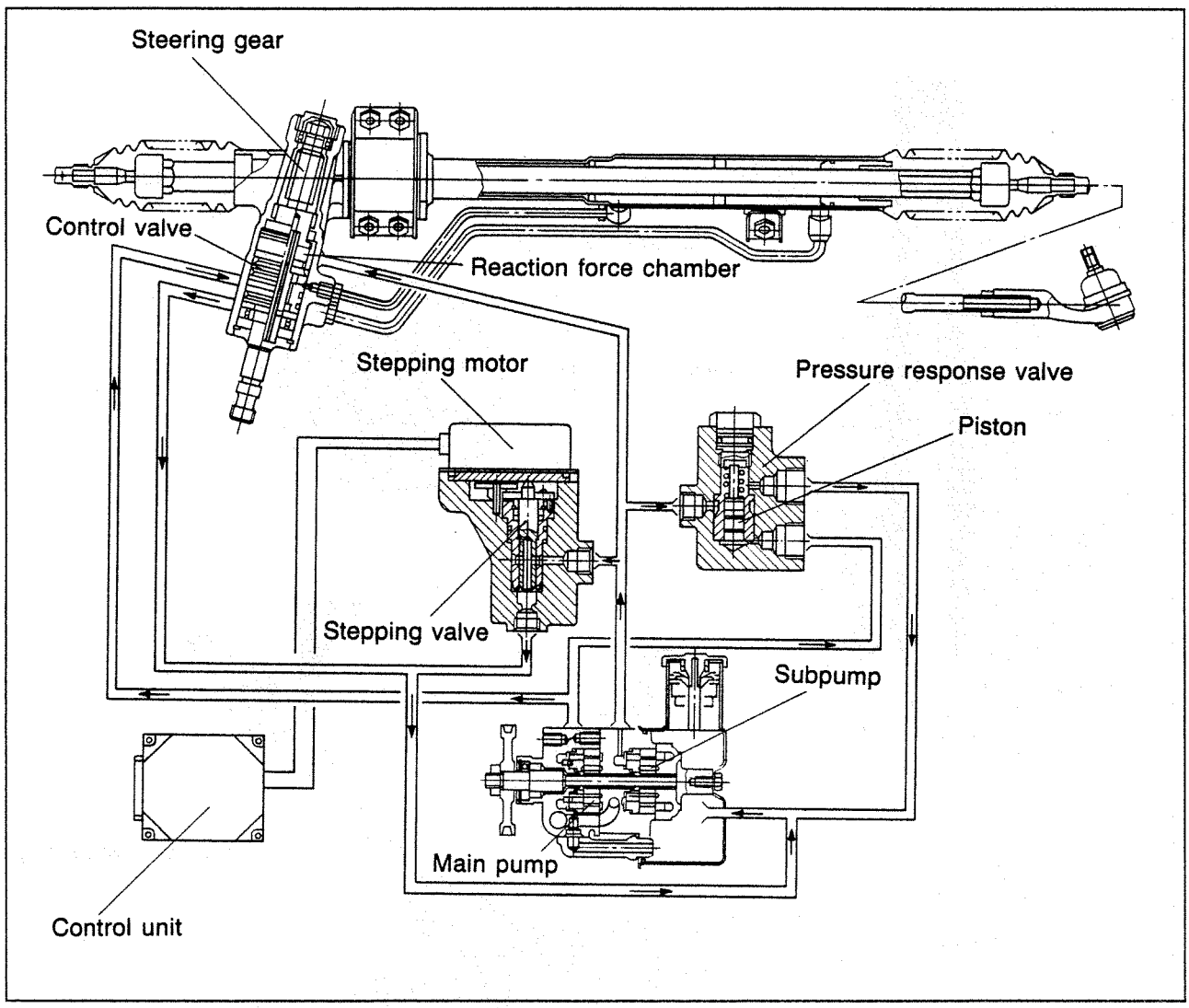
OUTLINE



67U10X-505

This power steering system changes its steering assist power according to vehicle speed, steering wheel turning angle and road resistance.
When the vehicle is stopped or running at low speed, more power assistance is provided and less effort is required of the driver.
When the vehicle speed is high, less power assistance is provided and more driver effort is required. More effort is required at high speeds as the steering angle increases.
With these functions, the system provides the driver with a rigid, stable, yet easy- handling feeling. The required steering effort is decided according to the oil pressure applied to the reaction force chamber in the steering gear housing. The oil pressure to the reaction force chamber is controlled by the vehicle speed signal and the steering wheel turning angle signal. This is done by means of the control unit and the stepping motor. Oil pressure to the reaction force chamber is also controlled by the pressure response valve according to road resistance.

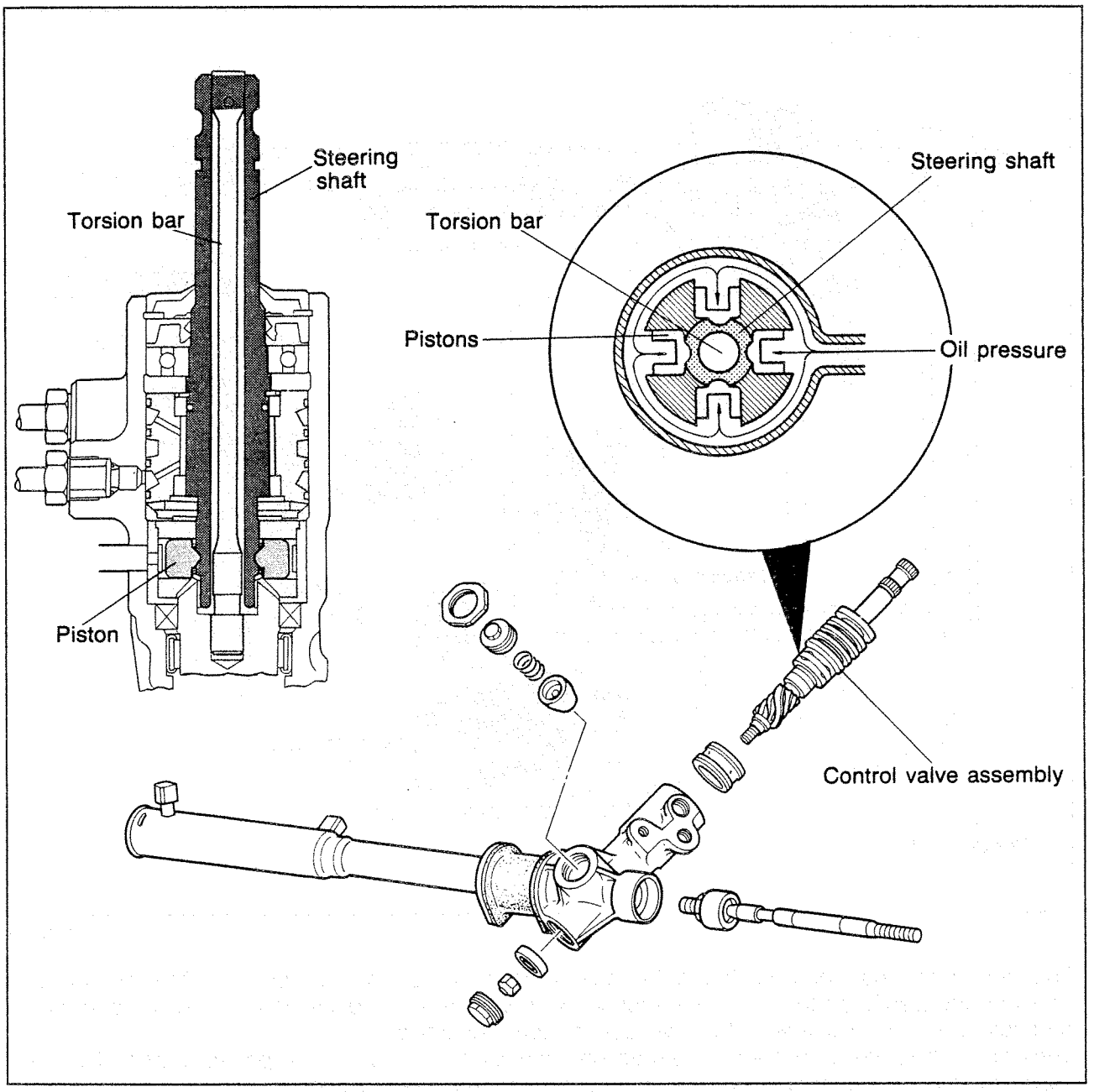
OIL PASSAGE



67U10X-529

The oil from the main pump is led to the rack housing through the control valve. The oil moves the rack bar and also is led to the pressure response valve. Here oil moves the piston which controls the hydraulic pressure activated within the reaction force chamber.
The oil from the sub-pump is led to the reaction force chamber, pressure response valve and stepping valve (rotated by the stepping motor), thus changing the steering effort.

STEERING GEAR AND REACTION FORCE CHAMBER



67U10X-506

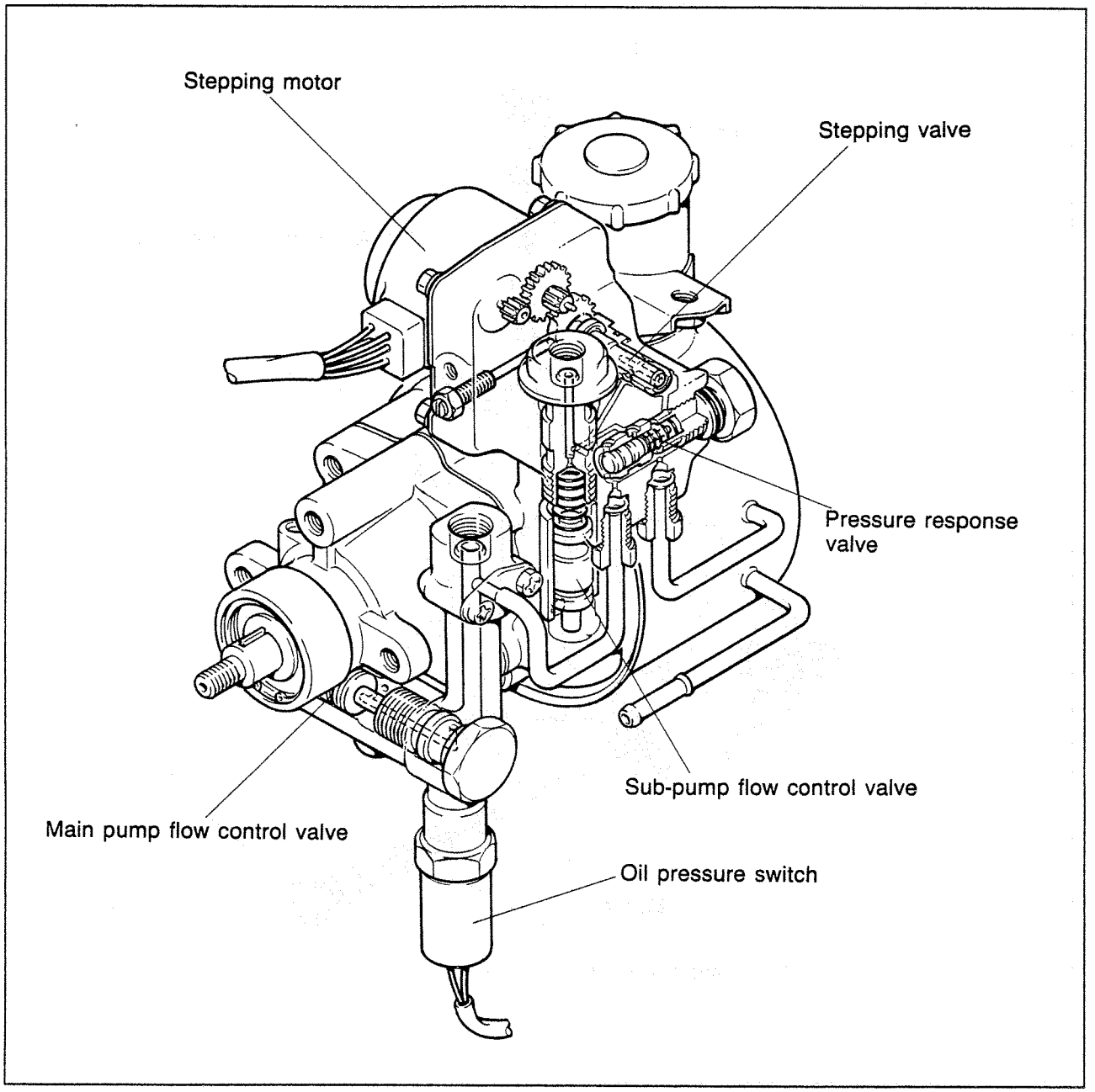
This rack-and-pinion type of steering gear construction is basically the same as that of the 323 and 626, except that a new reaction force chamber has been provided at the lower part of the control valve. The reaction force chamber has been added in order to change the driver's steering effort according to driving conditions.

Inside the reaction force chamber there are four small pistons which push against the steering shaft; hydraulic pressure is led to each piston from a sub-pump.

During low-speed driving when the hydraulic pressure becomes low, the pressure upon the steering shaft is reduced, and the torsion bar can be twisted easily so, the required steering effort becomes small.

During high-speed driving when the hydraulic pressure becomes high, each piston exerts pressure upon the steering shaft, and the required steering effort to twist the torsion bar becomes large.

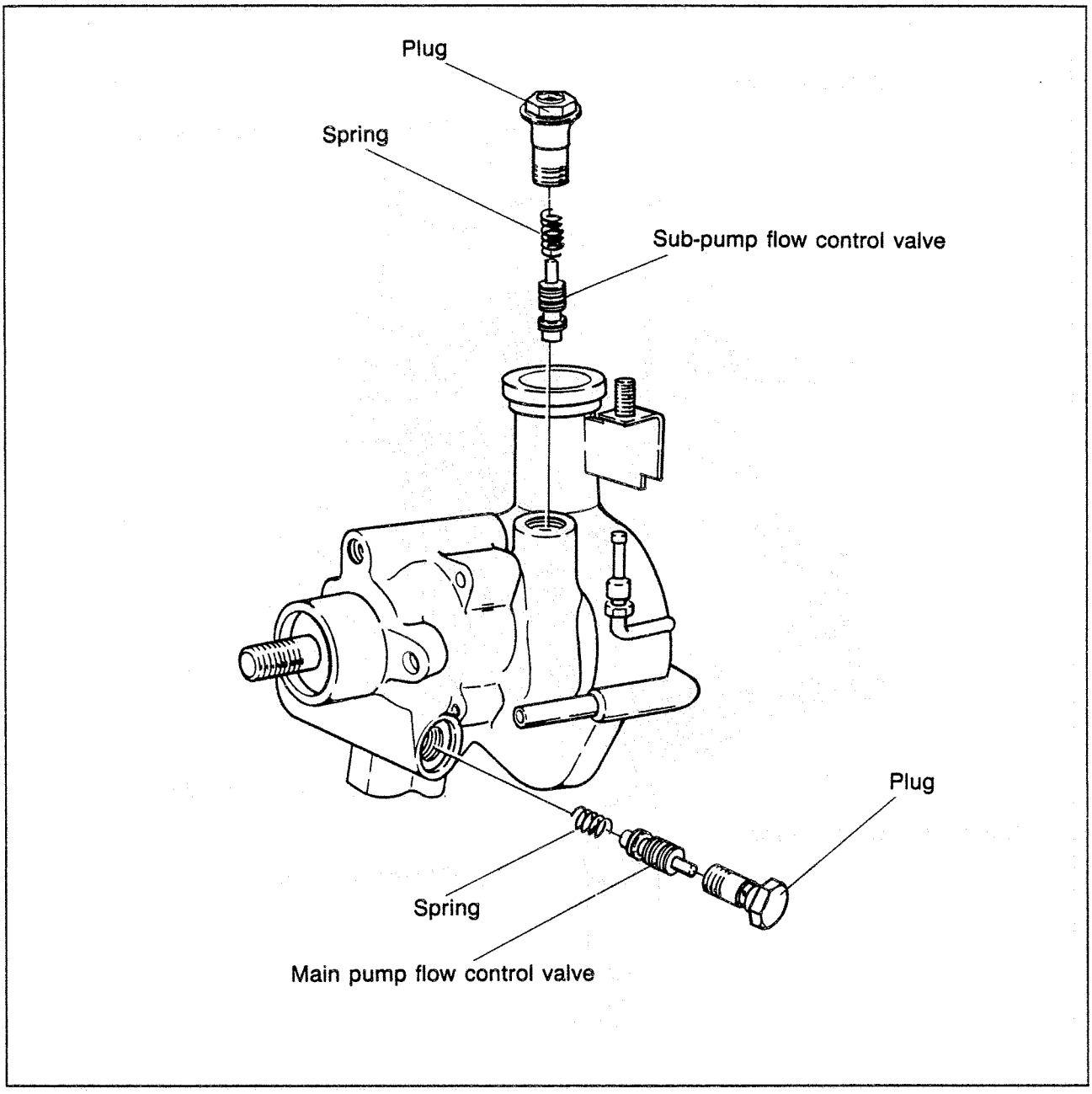
OIL PUMP UNIT



67U10X-507

A stepping motor, stepping valve and pressure response valve are provided at the upper part of the oil pump unit.
Inside, there are a vane-type main pump and sub-pump, as well as a flow control valve to regulate the amount of discharge of these two pumps.
The stepping valve controls the oil pressure of the sub-pump path by being driven by the geared stepping motor.
The stepping motor adjusts according to the signal received from the control unit.
The pressure response valve controls the oil pressure of the sub-pump path by opening or closing the oil passage.

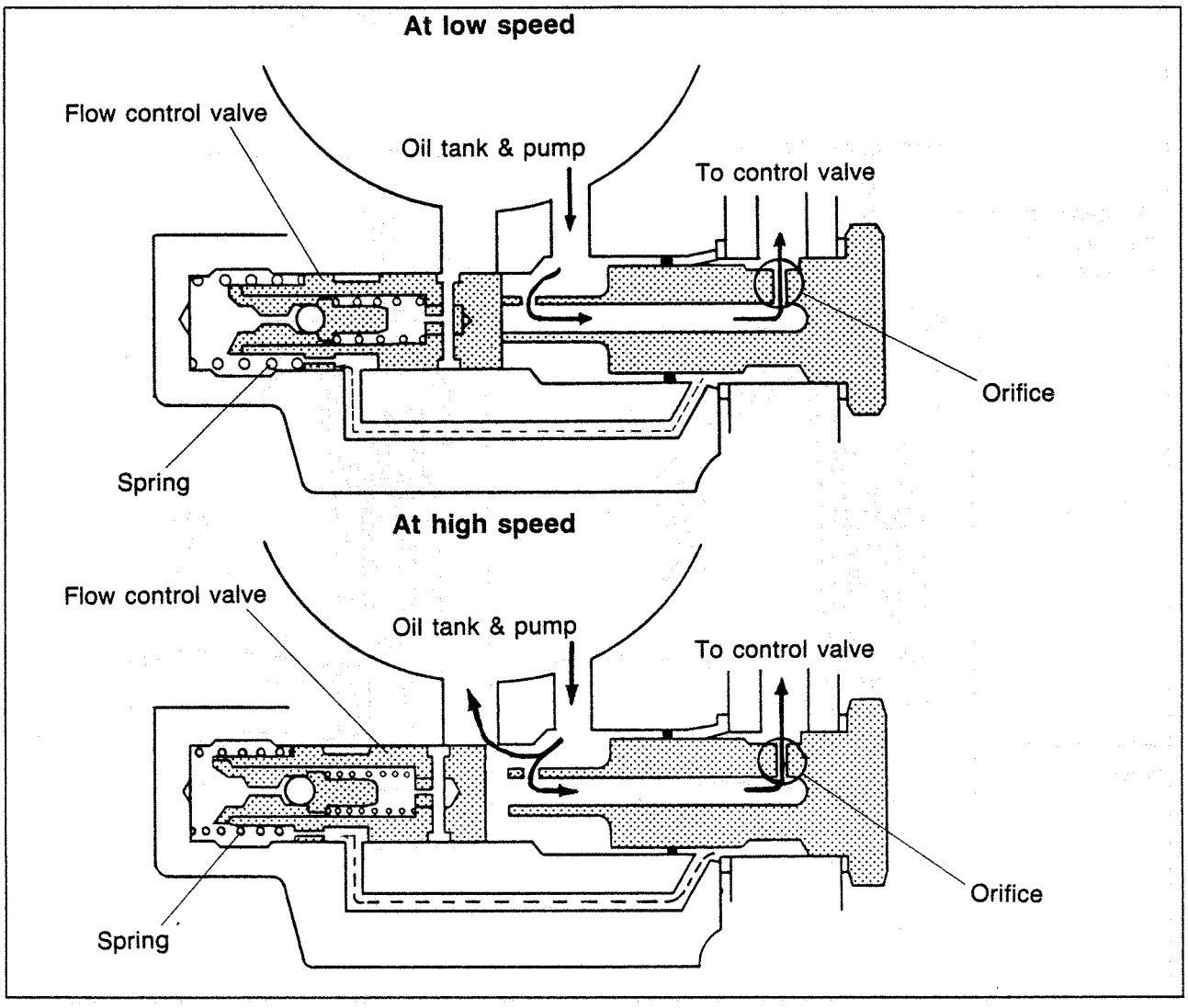
Flow Control Valve



67U10X-508

Flow control valves for main pump and sub-pump maintain a flow of fluid at 5.5 liters/min (1.43 US gal/min, 1.21 Imp gal/min) for main pump, 2.0 liters/min (0.52 US gal/min, 0.44 Imp gal/min) for sub-pump to the control valve of the steering gear. It allows excessive fluid to return to the suction side of the oil pump unit.

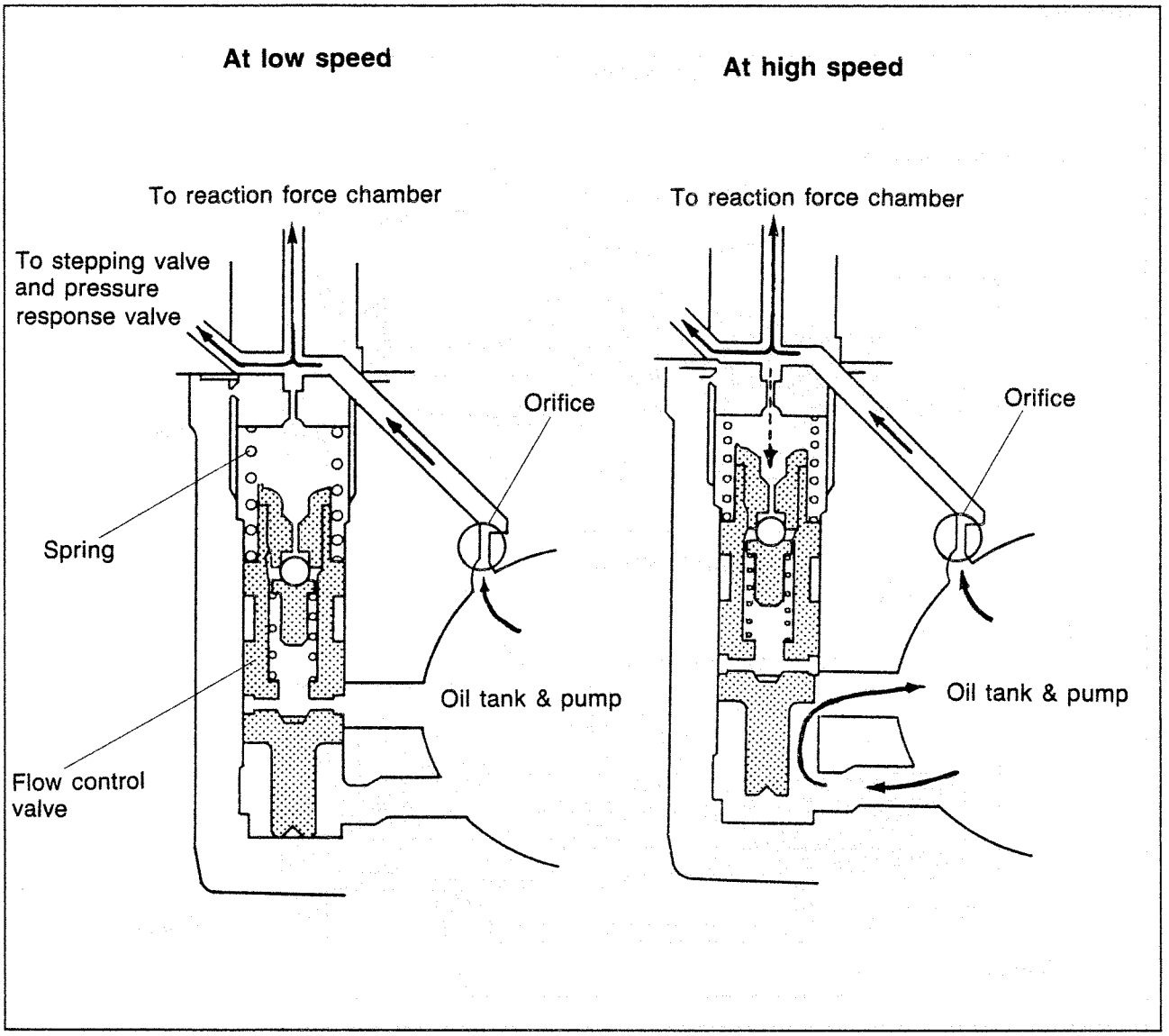
Operation



67U10X-509

Main pump flow control

1. At low speed:
   Oil discharged from the main pump flows into the rack housing through the flow control valve and control valve.
2. At high speed:
   When pump speed increases, the discharge pressure becomes higher, and a hydraulic pressure difference develops with the orifice to the control valve as the boundary.
   The hydraulic pressure prior to passage through the orifice becomes higher than the hydraulic pressure after passage through the orifice.
   The hydraulic pressure prior to passage through the orifice is applied to the right side of the flow control valve, and hydraulic pressure after passage through the orifice is applied to the left side of the flow control valve.
   When the hydraulic pressure difference before and after the orifice becomes great, the flow control valve is forced to move to the left by depressing the spring. By this action, oil escapes to the suction side of the pump.
   In this way, the flow of excess oil to the power steering gear control valve is prevented.

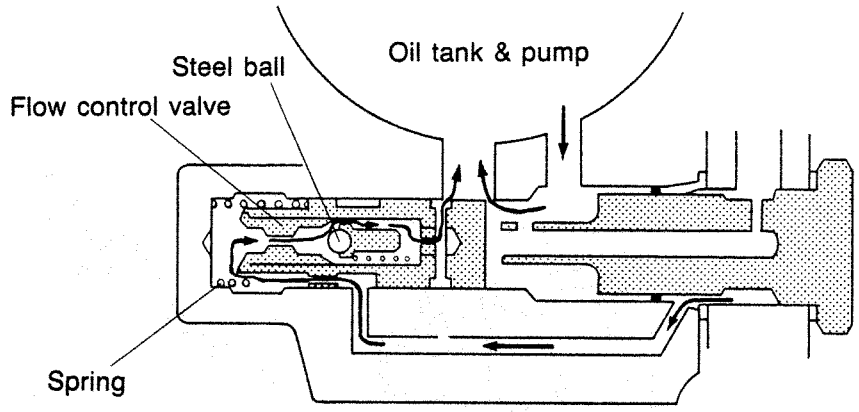


57G10X-503

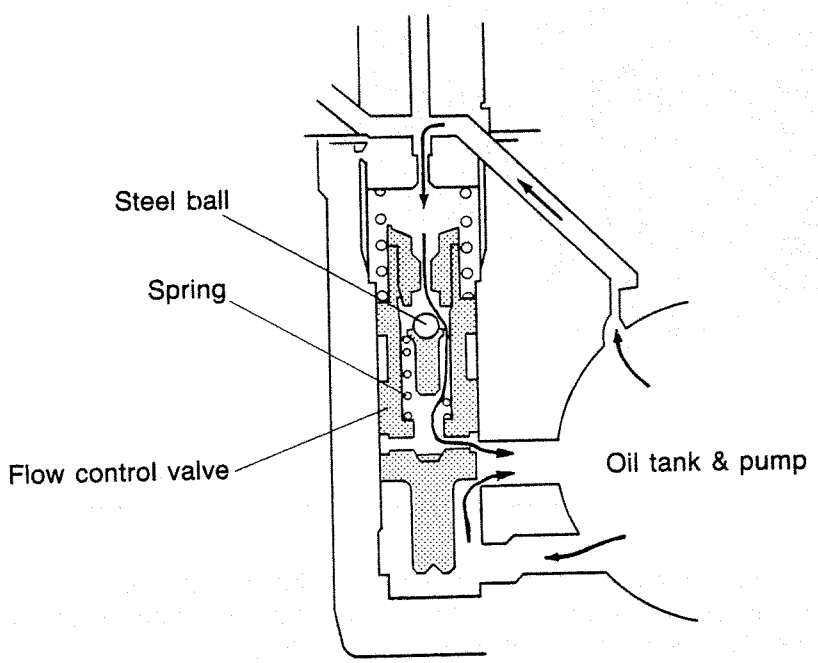
Sub-pump flow control

1. At low speed:
   Oil discharged from the sub-pump flows into the reaction force chamber through the orifice.
2. At high speed:
   When the pump speed increases, the discharge pressure becomes higher. A hydraulic pressure difference also develops with the orifice as the boundary.
   The hydraulic pressure prior to passage through the orifice becomes higher than the hydraulic pressure after passage through the orifice.
   The hydraulic pressure prior to passage through the orifice is applied to the lower side of the control valve. Hydraulic pressure after passage through the orifice is applied to the upper side of the control valve.
   When the difference of hydraulic pressures before and after the orifice becomes great, the flow control valve is forced to move upward by depressing the spring, and discharged oil escapes to the suction side of the pump.
   In this way, the flow of excess oil to the reaction force chamber is prevented.

Main pump flow control valve



Sub-pump flow control valve



57G10X-508

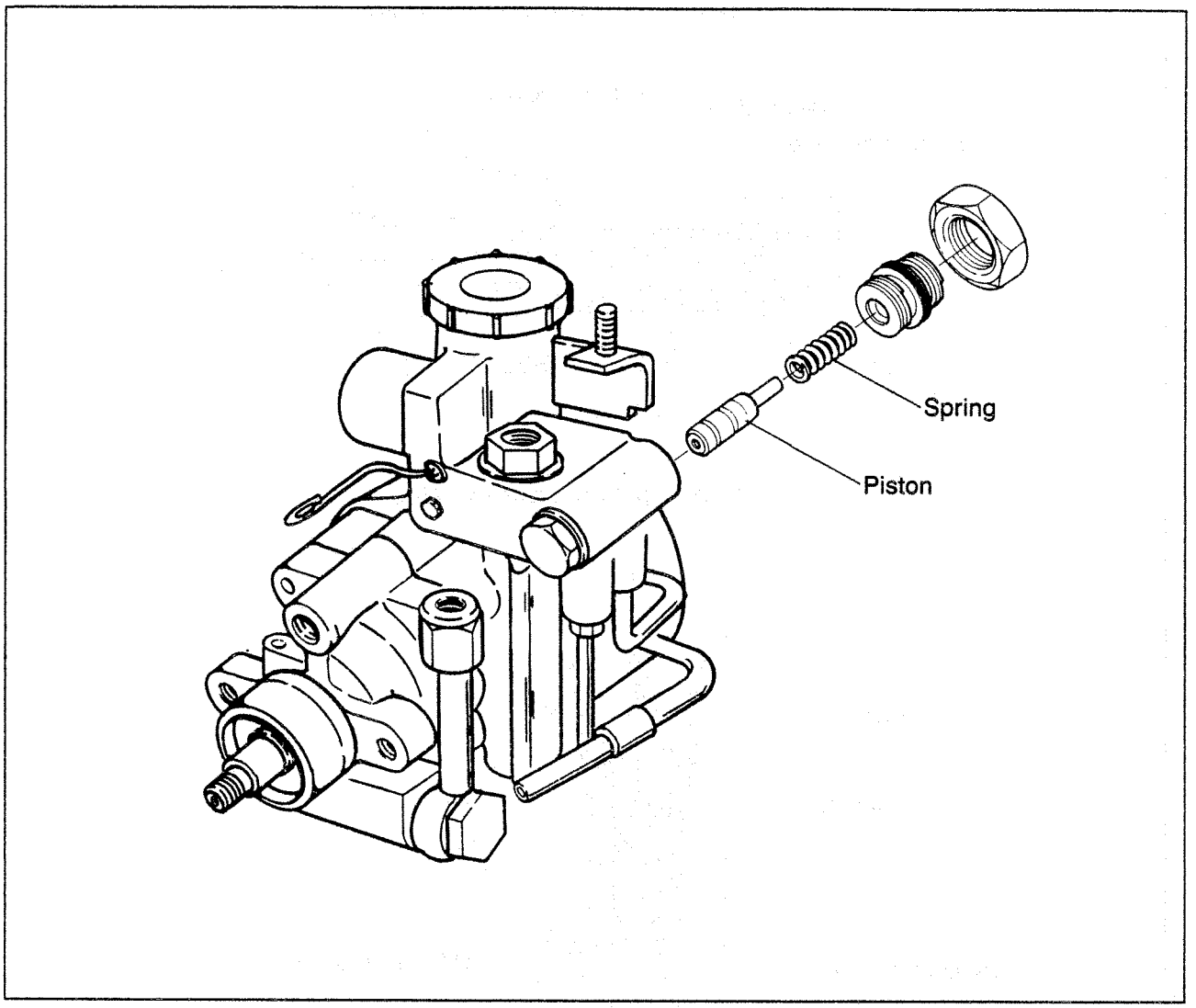
Relief pressure control

Main pump flow control valve:
If the wheels are held at the stops during steering, the pressure of the hydraulic system increases infinitely. The pressure of oil discharged from the oil pump is constantly pressing the steel ball. When the pressure becomes greater than the set load of the relief spring, the pressure relief valve functions.

Sub-pump flow control valve:
If for some reason clogging occurs in the sub-pump path, the oil pressure in the sub-pump path rises. This high oil pressure pushes the steel ball, allowing the oil flow into the oil tank.

Relief pressure:
Main pump flow control valve: 7,848 kPa (80 kg/cm^2, 1,137 psi)
Sub-pump flow control valve: 3,924 kPa (40 kg/cm^2, 569 psi)

Pressure Response Valve



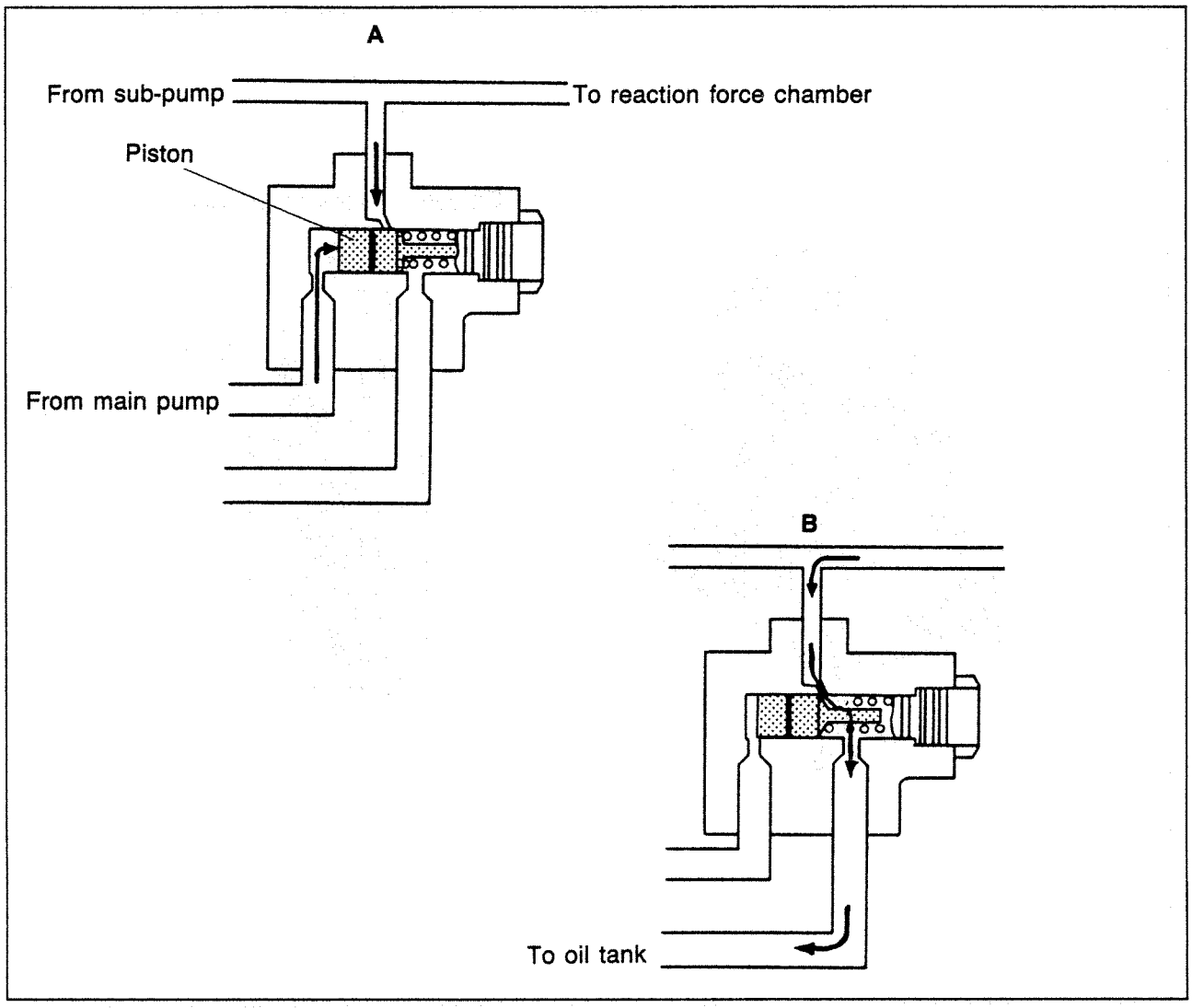
67U10X-512

The pressure response valve is installed at the upper part of the oil pump unit.
This valve, controlled by main pump pressure, functions to control the hydraulic pressure applied to the reaction force chamber (at the lower part of the steering gear).

The objectives of the installation of the pressure response valve are as described below:
When the road resistance is small, such as on a snow-covered road, the required steering effort is reduced to let the driver sense that there is little road resistance. When the road resistance is high, the opposite is true.
In other words, this valve compensates to give a more natural steering wheel response (such as you might get with normal steering) in situations like an icy road, gravel road, etc.

Changes of the hydraulic pressure (from the main pump) applied to the pressure response valve occur in response to changes in the road surface resistance.
When the road surface resistance is high, a greater force is required in order to turn the tires. For this reason, hydraulic pressure within the rack housing increases, and hydraulic pressure in the main pump path becomes higher.
On the other hand, when the road surface resistance is low a lesser force is required to turn the tires. In this situation, hydraulic pressure in the main pump path becomes lower.

Operation



67U10X-513

When hydraulic pressure in main pump path is high (illustration A)

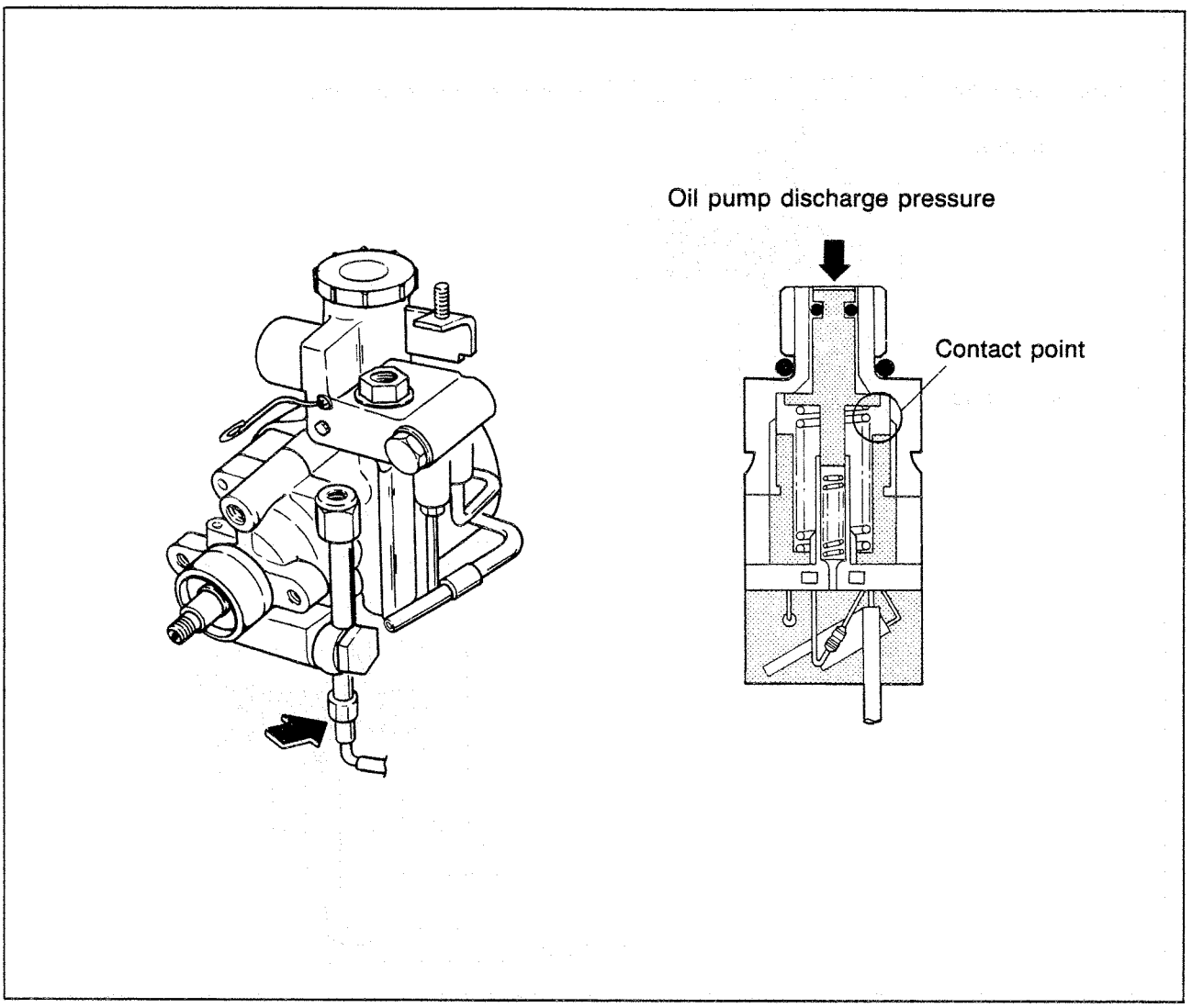
When the hydraulic pressure is high, the piston within the pressure response valve is pushed to the right. As a result, the passage from the sub-pump to the oil tank closes.

As a result, the hydraulic pressure within the reaction force chamber increases, and the steering effort of the steering wheel becomes greater.

When hydraulic pressure in main pump path is low (illustration B)

When the hydraulic pressure is low, the piston within the pressure response valve is pressed to left by spring force, thus opening the passage from the reaction force chamber to the oil tank. As a result, the hydraulic pressure within the reaction force chamber does not increase and the steering effort of the steering wheel becomes less.

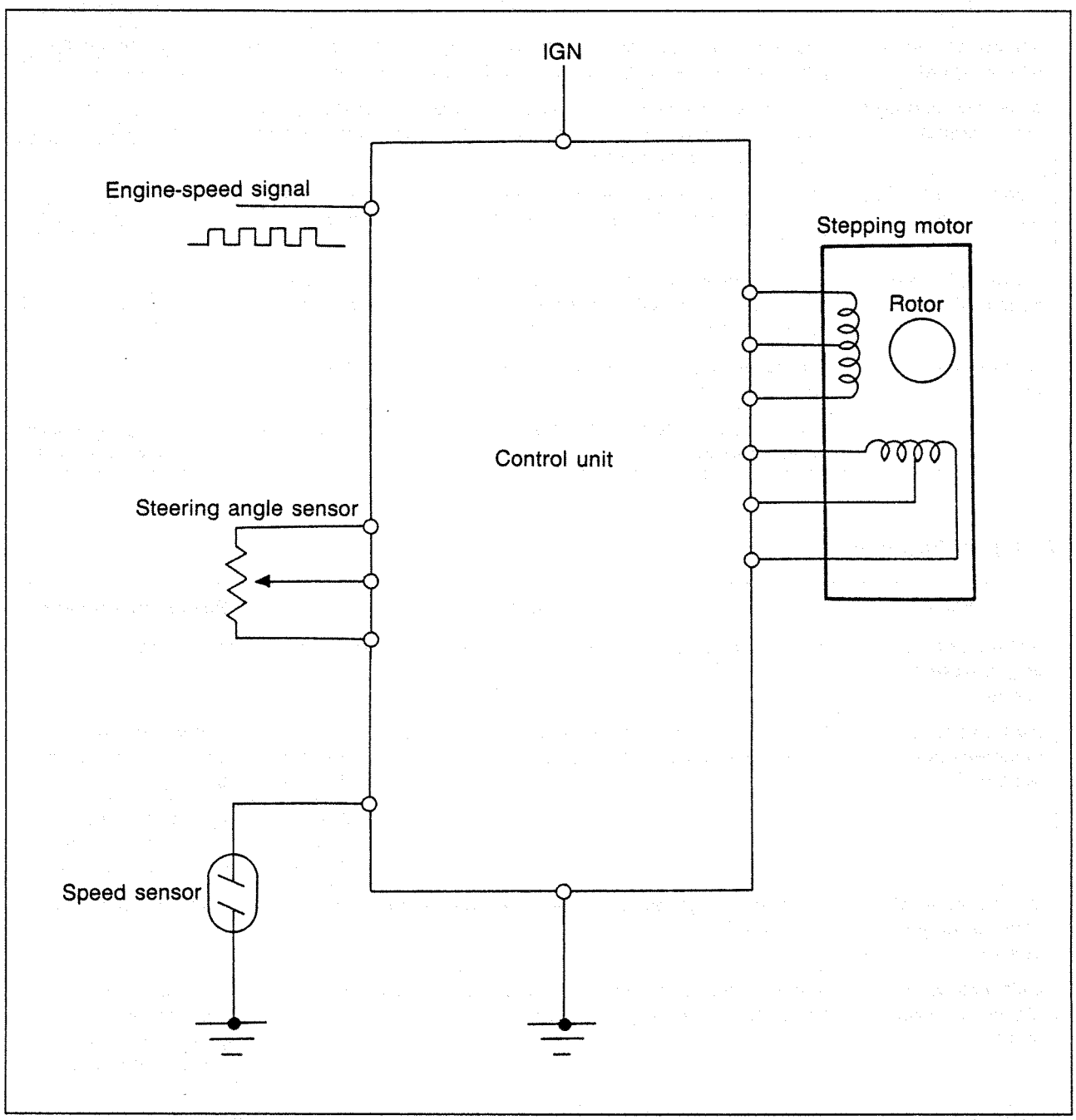
Pressure Switch



67U10X-514

The pressure switch detects the operational pressure of the power steering system. This switch sends a signal to the idle-up system to increase engine speed when the pump discharge pressure is more than 3,041 - 3,826 kPa (31 - 39 kg/cm^2, 441 - 555 psi).

ELECTRICAL SYSTEM
Control Unit



67U10X-515

The control unit detects the signals from the speed sensor, steering-angle sensor, and engine-speed sensor. Based upon these signals, the control unit regulates hydraulic pressure by rotating the stepping motor. This rotation changes the opening degree of the stepping valve.
The control unit also includes a fail-safe function. If, for any reason, no signal is sent from the vehicle speed sensor, the signal from the engine speed sensor would be detected, and the hydraulic pressure would be regulated based upon that signal. Therefore, the appropriate steering wheel effort would be provided.

Self-diagnosis function

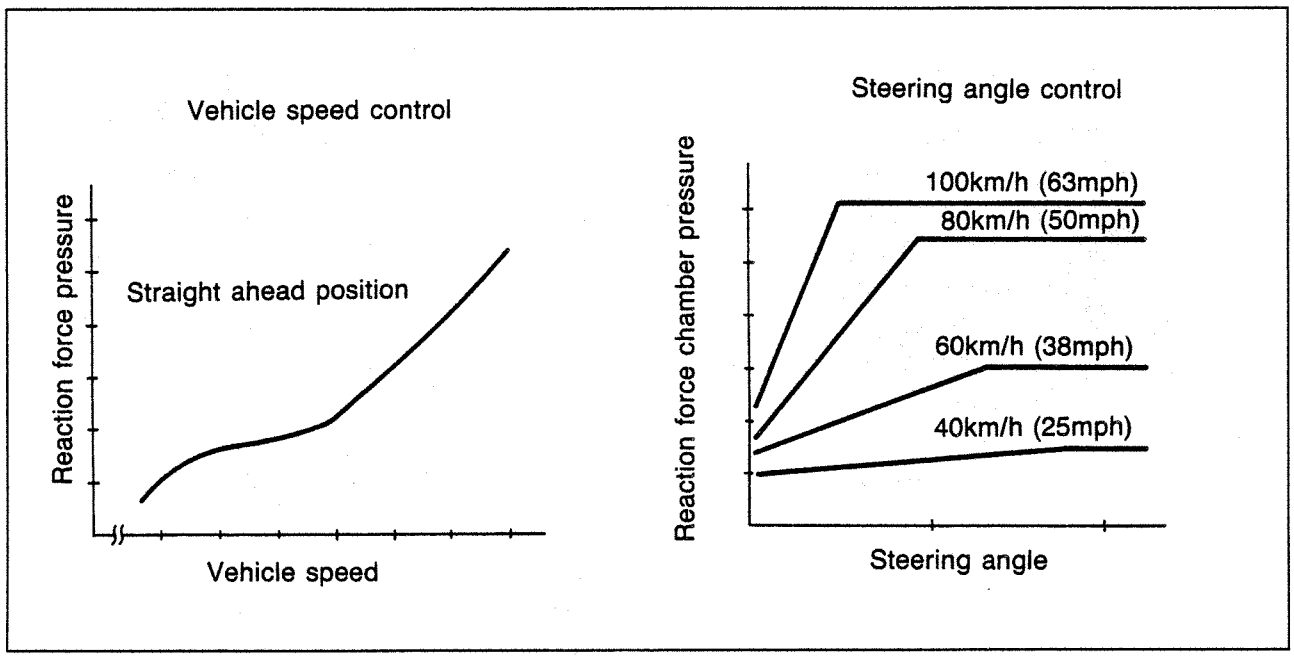
Fault	Condition	Buzzer signal
Abnormal engine-speed signal	The buzzer sounds when vehicle-speed signal is input but no engine speed signal is input (short circuit, broken wire, etc.)	
Abnormal stepping motor signal	The buzzer sounds when the stepping motor does stepping not respond to the signal from the control unit (broken wires or short circuit in coils or harnesses).	
Abnormal steering sensor signal	The buzzer sounds 60 seconds after broken wire or short circuit occurs to sensors or harnesses when vehicle speed is over 40 km/h (25 mph)	
Abnormal speed sensor signal	In case broken wires or short circuits occur to sensors or harnesses, the buzzer sounds 60 seconds after the engine speed signal of 2,200 rpm continues for 18 seconds.	
Abnormal control unit	The buzzer sounds if the micro-computer malfunctions and cannot control the system.	
	And the buzzer sounds when there are circuit troubles other than micro-computer.	

Fail-safe function

Fault	Description		Power steering effect
Malfunction of engine-speed sensor	Vehicle-speed signal is input but engine-speed signal is not input		Normal control
Malfunction of vehicle-speed sensor	No vehicle-speed signal but engine-speed signal of more than 2,200 rpm received for over 18 seconds	Below 80 km/h (50 mph)	Steering effort adjust to as if vehicle speed 80 km/h (50 mph)
		Above 80 km/h (50 mph)	Steering effort maintained as if at vehilce speed when failure occurred.
Malufunction of steering-angle sensor	No steering angle signal is input when vehicle speed is over 40 km/h (25 mph).		Vehicle speed control only
Malfunction of stepping motor input	Abnormal signal caused by damage, disconnection, short-circuit, etc. of stepping motor circuit		Power supply to stepping motor cancelled and steering effort adjusted to as if vehicle speed 80 km/h (50 mph)
Malfunction of control unit	Control unit malfunction		Power supply to stepping motor cancelled and steering effort adjusted to as if vehicle speed 80 km/h (50 mph)

57G10X-504

Steering control unit- control function

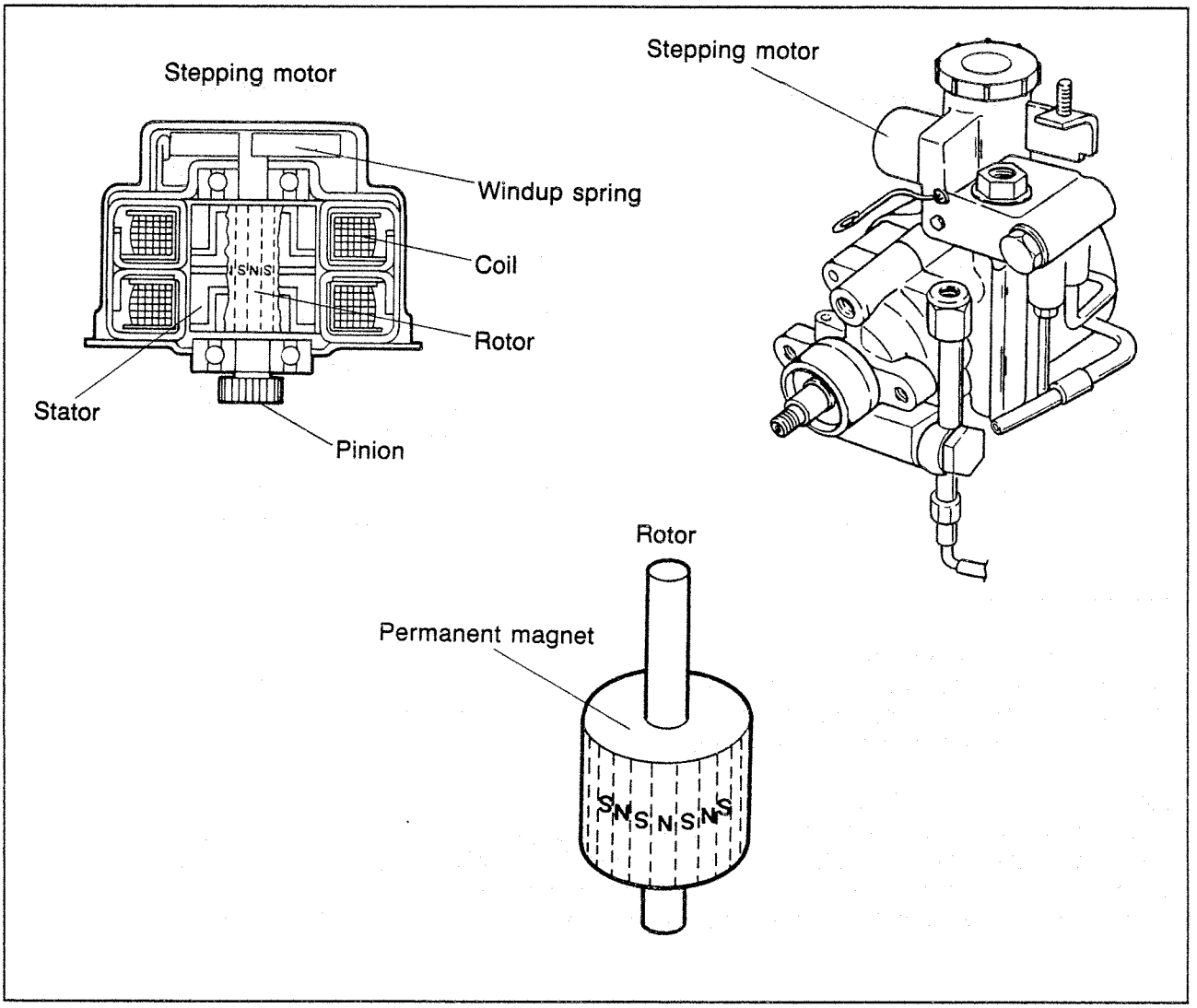


57G10X-505

Vehicle speed control function...
The control unit uses information from the vehicle speed sensor to regulate the turning angle of the stepping motor. This motor functions to control the hydraulic pressure applied to the reaction force chamber according to the vehicle speed.

Steering angle control function...
The control unit uses information from the steering angle sensor to regulate the turning angle of the stepping motor. This motor also functions to control hydraulic pressure applied to the reaction force chamber according to the turning angle of the steering wheel.
This control system functions when the vehicle speed is above 40 km/h (25 mph).

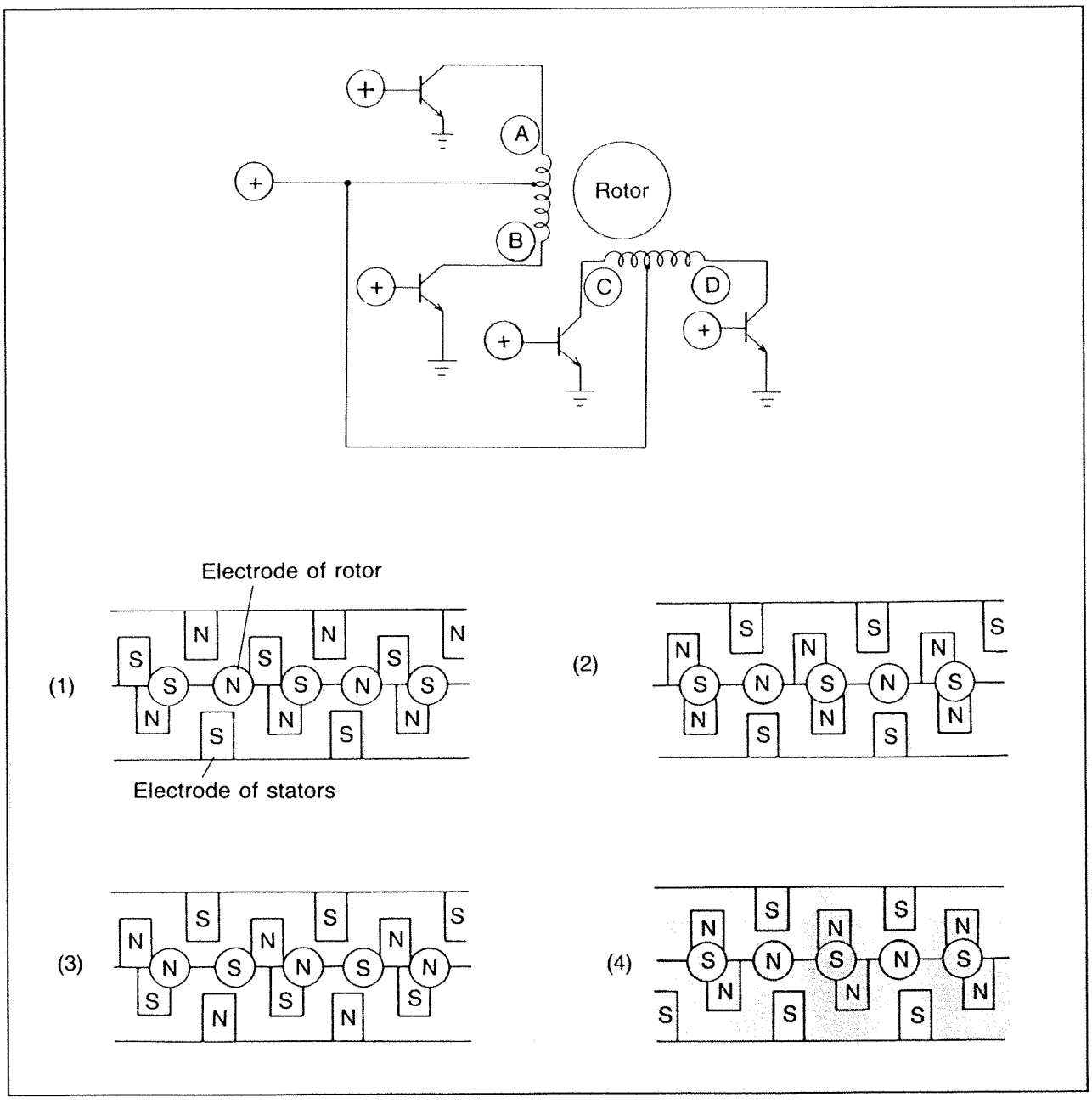
Stepping Motor



67U10X-519

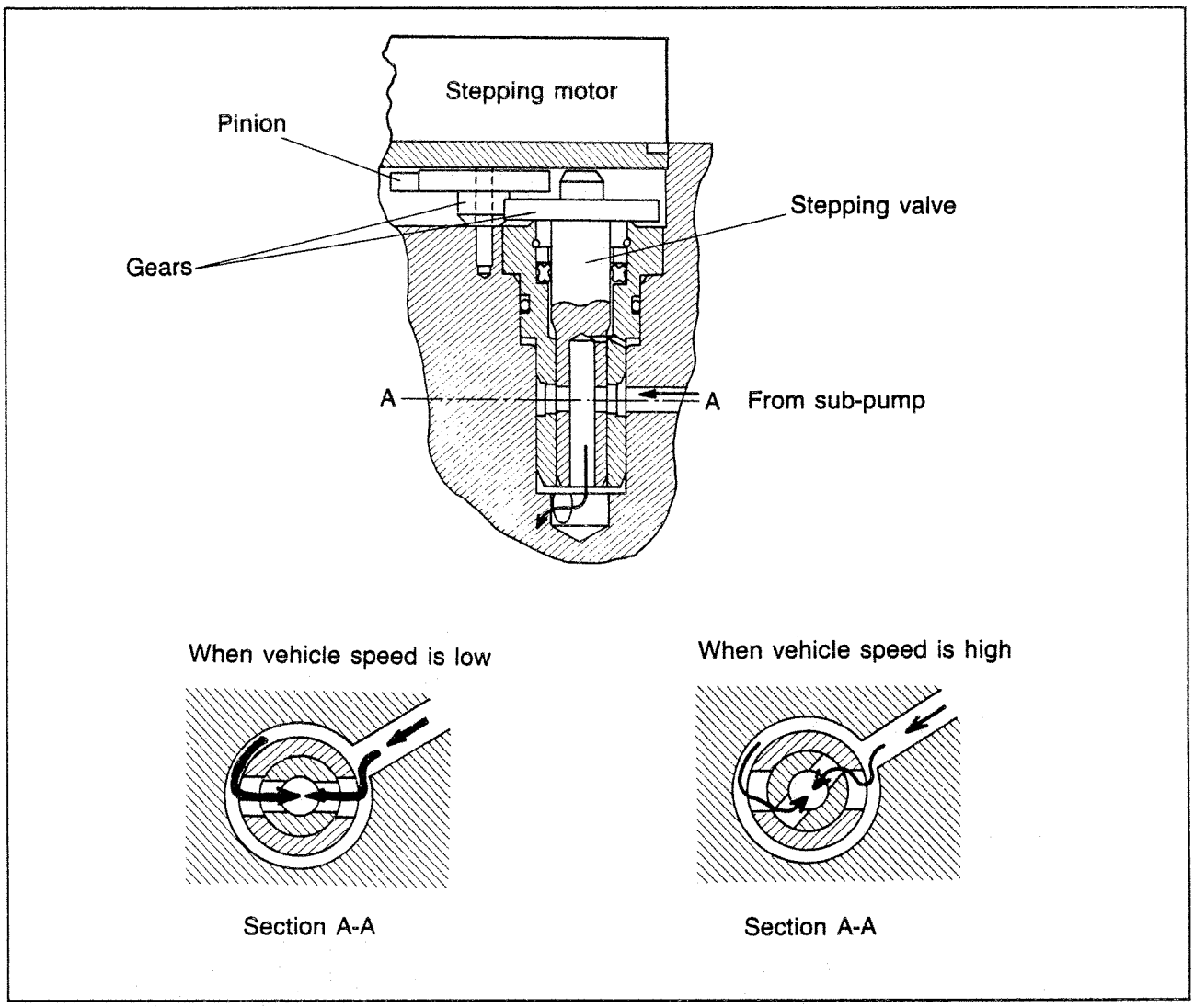
The stepping motor is composed of a coil, a stator, a wind-up spring, and a rotor composed of a permanent magnet. This motor is located at the upper part of the oil pump unit.
The coil is 4 layers of coiled wire and is separated into two (upper and lower) parts within the stepping motor.
The rotor is unified with the shaft and has 12 N poles and 12 S poles. At one end of the shaft is a pinion which drives the stepping valve. At the other end is the wind-up spring.
If power is lost to the stepping motor, the wind-up spring functions to close the oil passage by rotating the stepping valve.

Operation



1. When there is power to coils (A) and (C) in the circuit, the rotor stops in the condition shown in illustration (1).
2. Then, when the power to coil (A) stops and power is provided to coils (B) and (C), the poles of the lower stator of the upper part change from S to N. The result is that the S poles are attracted and the rotor turns in the left direction shown in illustration (2).
3. When (in the condition 2. above) power to coil (C) stops and power is provided to coils (B) and (D), the poles of the upper stator of the lower part change from N to S. The result is that the rotor turns further to the left as in illustration (3).
4. When (in the condition 3. above) power to coil (B) stops and power is provided to coils (A) and (D), the poles of the lower stator of the lower part change from N to S. The result is that the rotor turns further to the left as in illustration (4).
5 As described in 1. to 4. above, the rotor rotates as a result of the switching of the power supply in sequence to coils (A) to (D). The turning angle for each time is 7.5°.

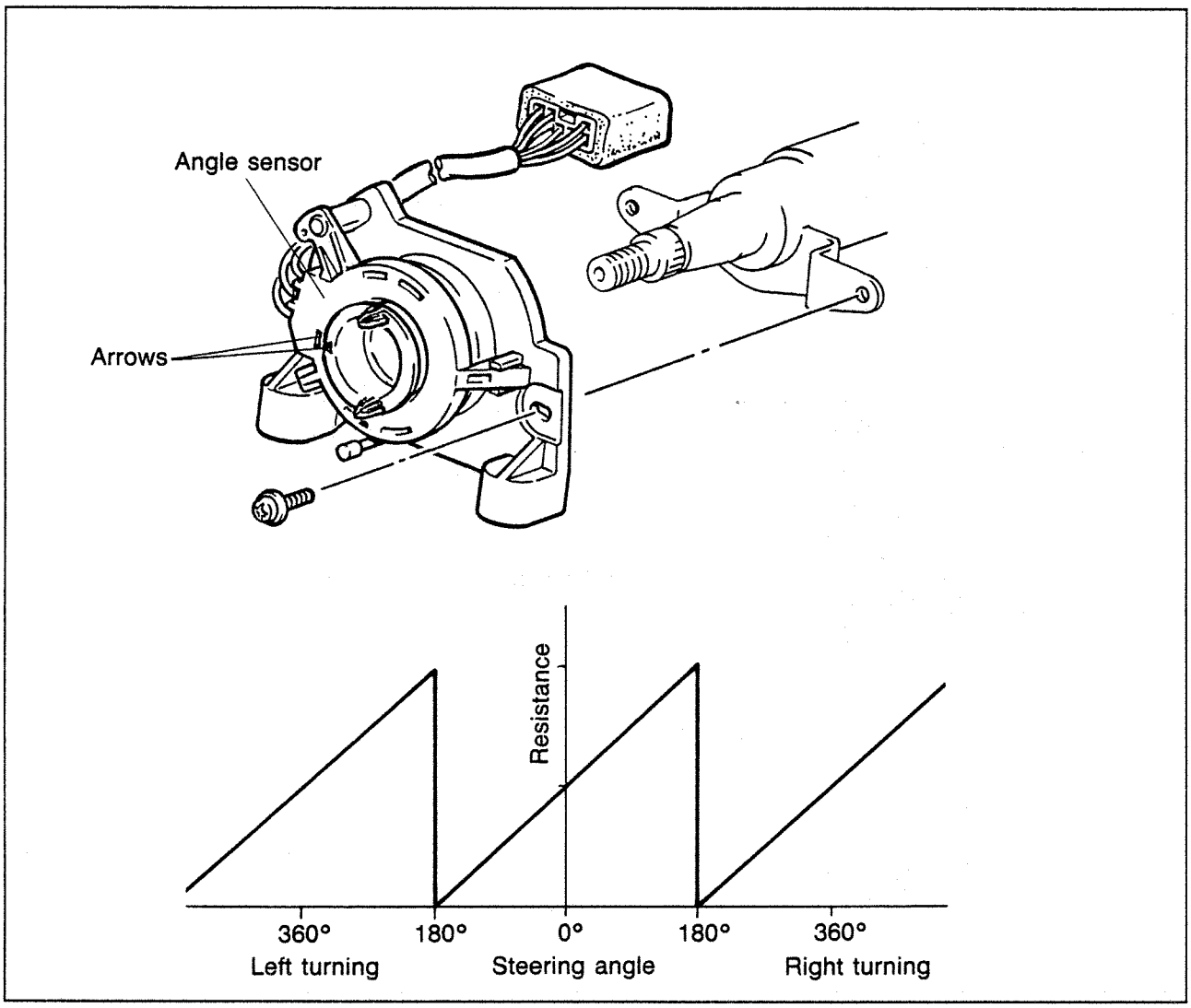
Stepping Valve



67U10X-521

The stepping valve is driven, via two gears, by the stepping motor. The turning angle of the stepping motor is reduced 1/10 by the gears, and this is transmitted to the stepping valve.
The stepping valve adjusts the sub-pump system hydraulic-circuit pressure. This adjusted pressure is led to the reaction force chamber.

Angle Sensor

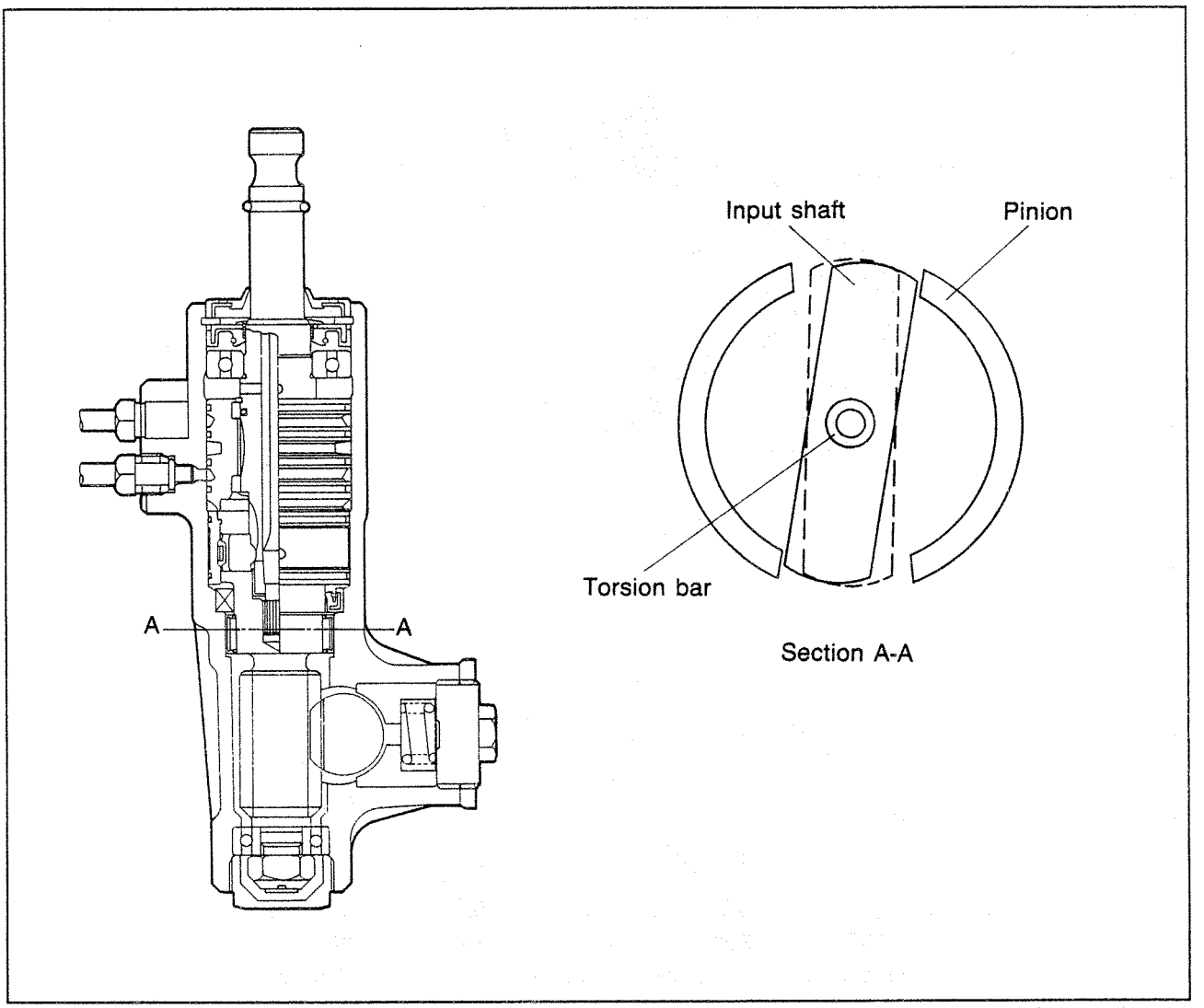


57G10X-506

The angle sensor is installed on the steering shaft and sends the steering wheel turning angle signal to the control unit.
The angle sensor has shared functions:
1. Cancellation of the turn-signal lever
2. Auto-adjusting suspension

Note
Align the arrow heads when installing this sensor.

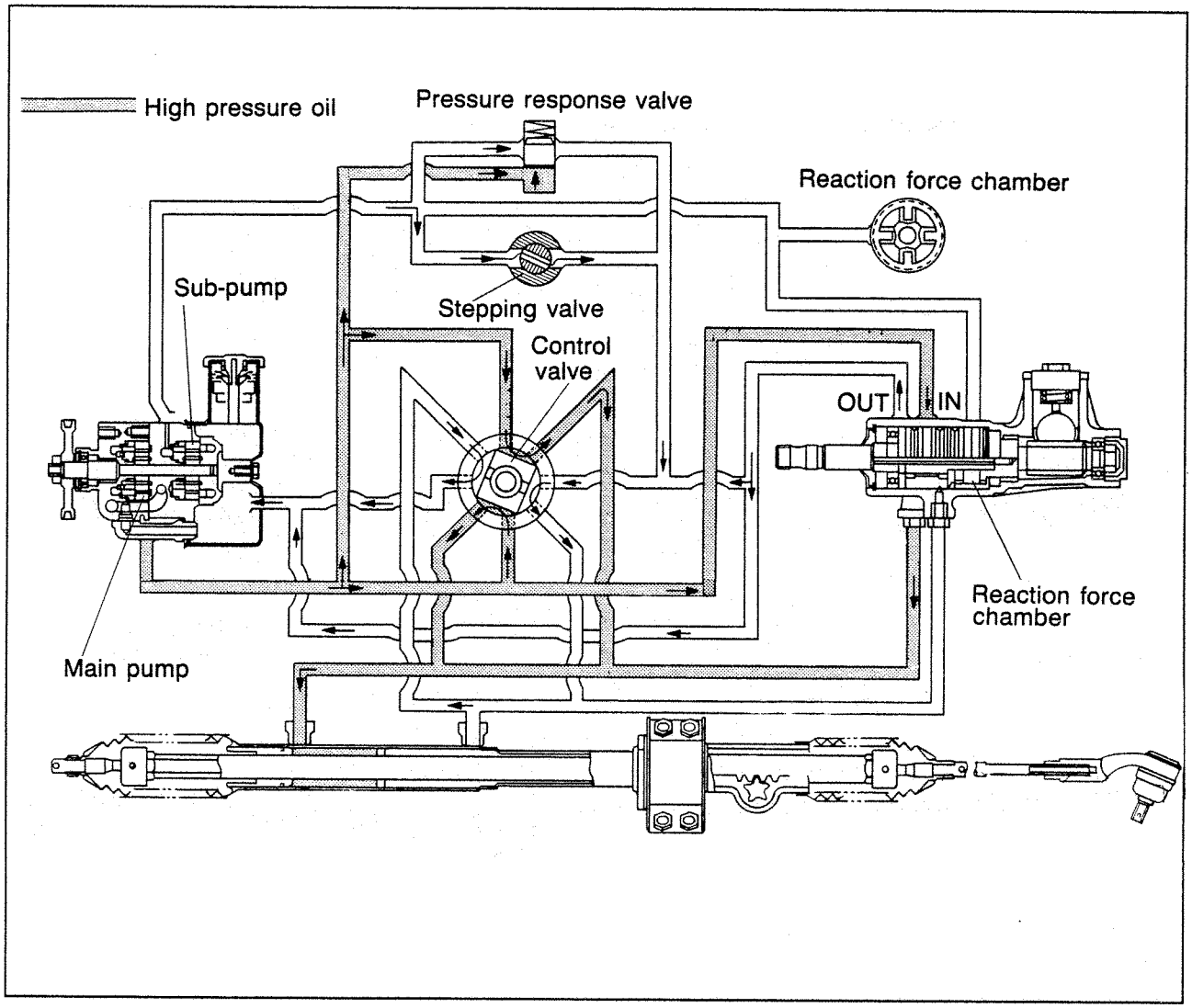
MANUAL STEERING CAPABILITY



67U10X-523

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 input shaft is in contact with the pinion.

OPERATION

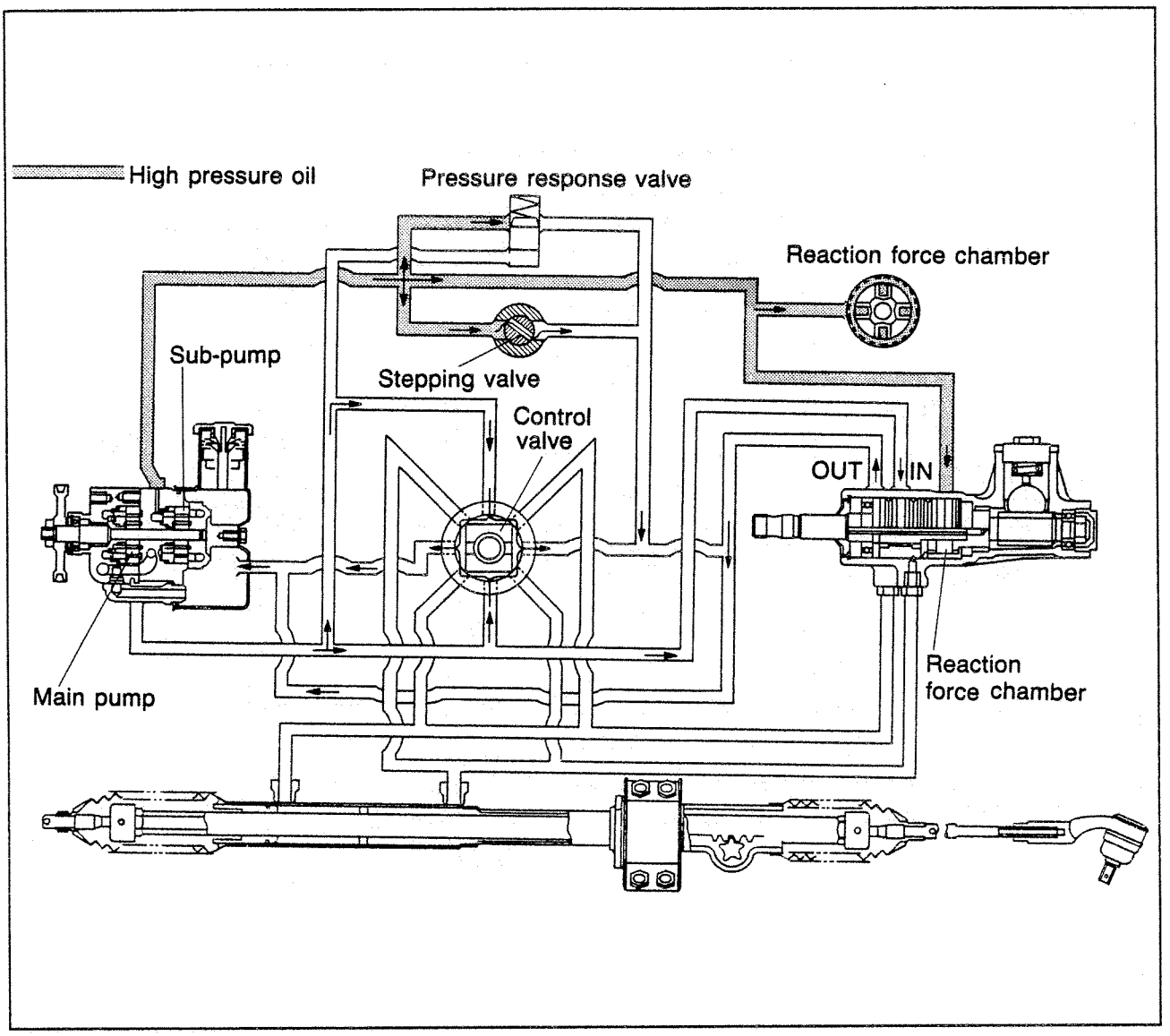


57G10X-507

When turning (to the left) at low speed...

For this power steering system, the effort required to turn the steering wheel has been reduced in order to make steering easier at times when the steering resistance is great, such as when moving the vehicle into a garage, etc.

1. When the steering wheel is turned to the left, the rack bar does not move immediately.
2. This is because there is road resistance transmitted from the tires, and also because the pinion is engaged with rack bar and does not follow the steering wheel angle.
3. Therefore, only the input shaft is rotated and the torsion rod directly connected to the input shaft is distorted.
4. At this time, a phase shift occurs between the input shaft and the valve sleeve.
5. Meanwhile, high-pressure oil flows into the right cylinder via the valve sleeve port.
6. Consequently, the rack bar is moved to the left, the wheels are turned to the left via the knuckle arm.
7. On the other hand, oil in the left cylinder is returned back to the oil tank.
8. The pressure response valve closes the sub-pump path due to rising oil pressure in the steering housing.
9. Because the stepping motor has fully opened the stepping valve, the hydraulic pressure in the reaction force chamber of the steering gear does not increases. As a result, the steering operation becomes lighter.

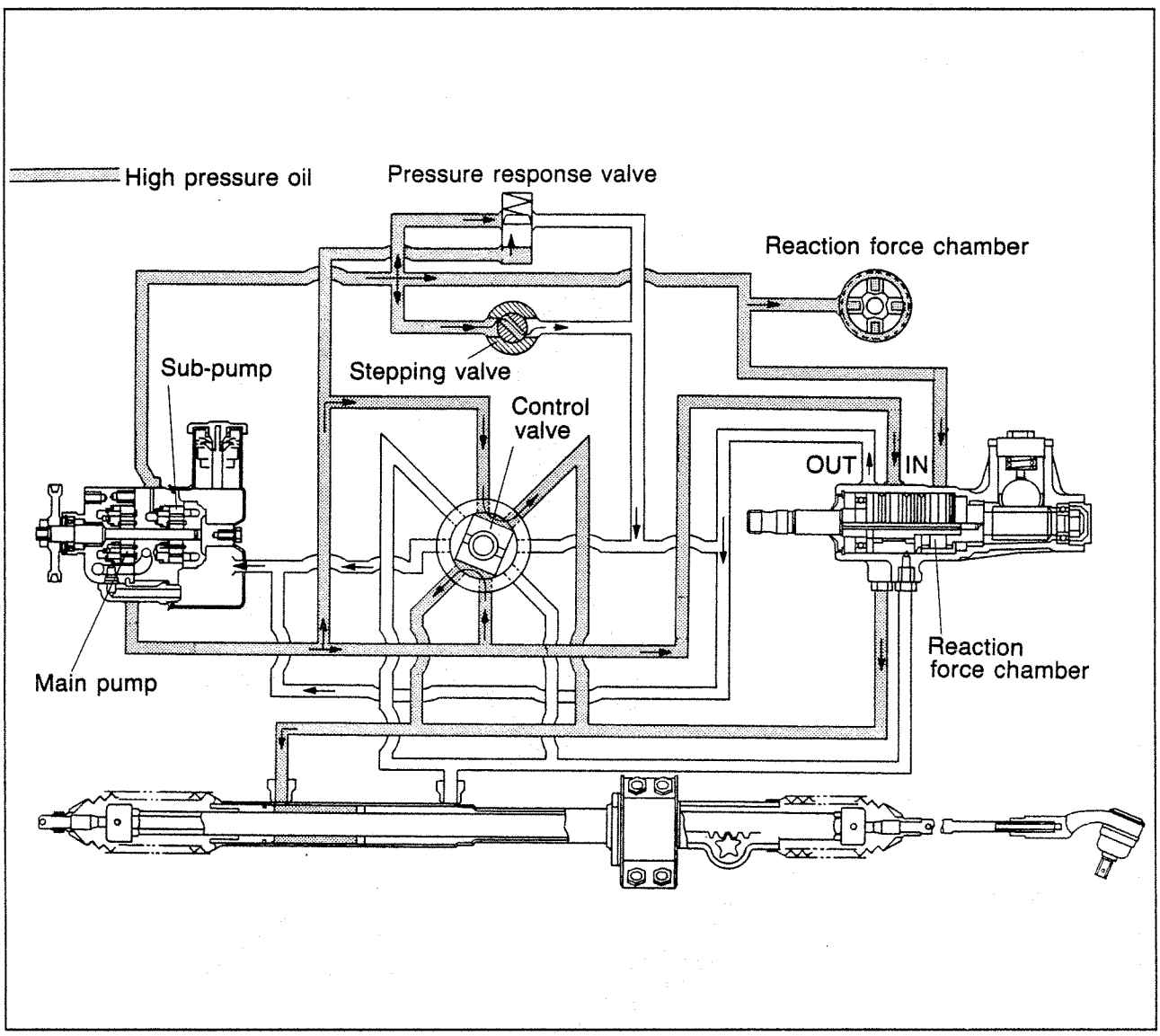


67U10X-525

During straight-ahead driving at medium or high speed...

In order to further improve handling stability at medium and high speeds while driving straight, steering wheel operation becomes heavier.

1. As a result of the vehicle-speed signal from the control unit, the stepping motor rotates the stepping valve, causing the oil passage to become more constricted. As a result hydraulic pressure in the passage from the sub-pump increases.
2. This causes the hydraulic pressure in the reaction force chamber of the steering gear to increase.
3. Because the four pistons in the reaction force chamber push against the input shaft of the steering shaft, operation of the steering wheel becomes heavy.



67U10X-526

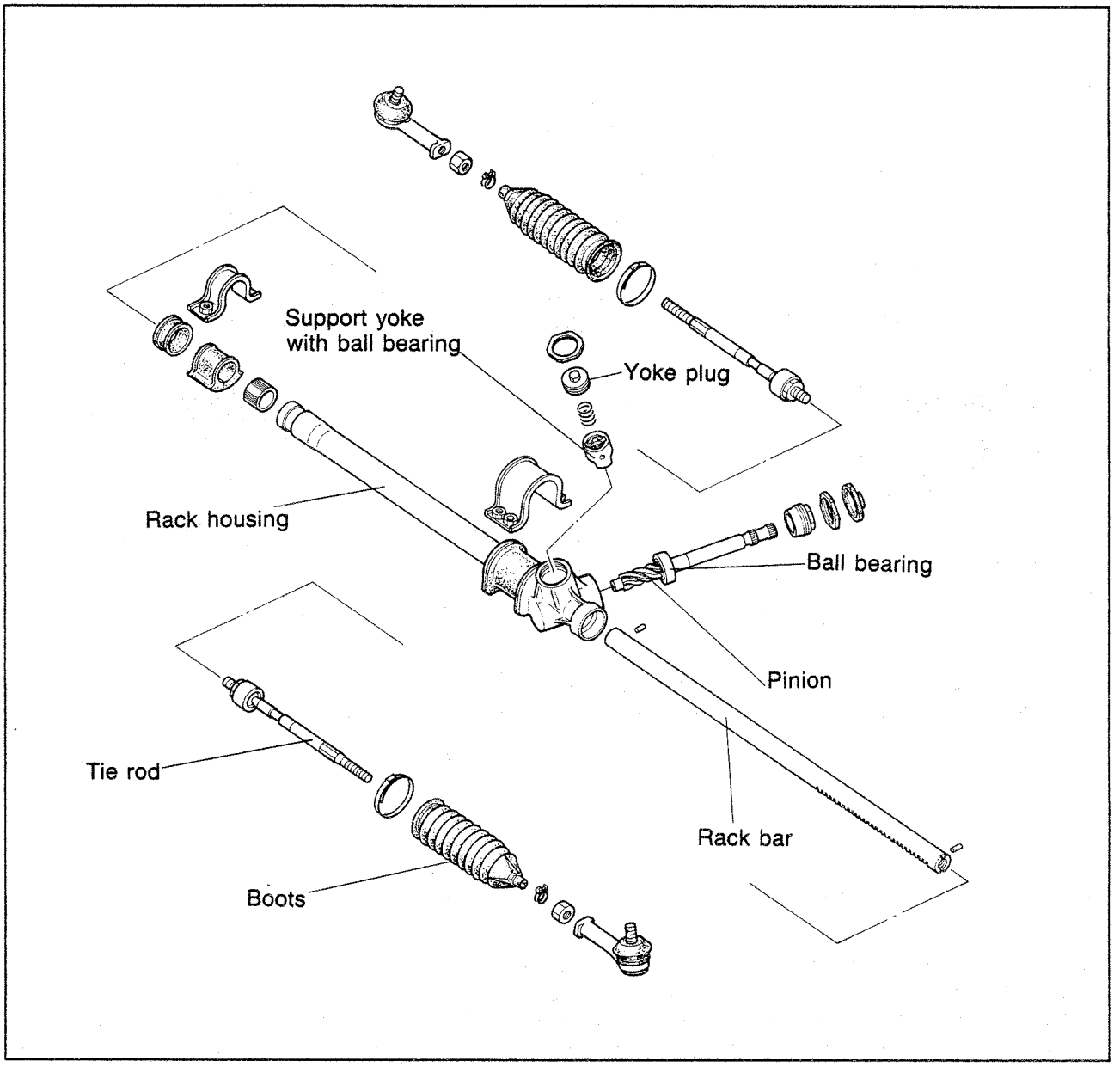
When turning (to the left) at medium or high speed...

During turning (to the left) at medium or high speed, the flow of oil is the same as during low-speed turning, except that the operation of the steering wheel is made heavier in order to prevent oversteering.

1. As a result of the vehicle-speed signal and steering-angle signal from the control unit, the stepping motor rotates the stepping valve, causing the oil passage to become more constricted. As a result, the hydraulic pressure in the passage from the sub-pump increases.
2. This causes the hydraulic pressure in the reaction force chamber of the steering gear to increase.
3. In addition, the hydraulic pressure in the passage to the main pump increases as a result of the increase of hydraulic pressure in the right cylinder of the steering housing during turning.
4. As a result, the hydraulic pressure in the reaction force chamber increases even further. Also, because the four pistons in the reaction force chamber push against the input shaft of the steering shaft, the operation of the steering wheel becomes heavy.

MANUAL STEERING

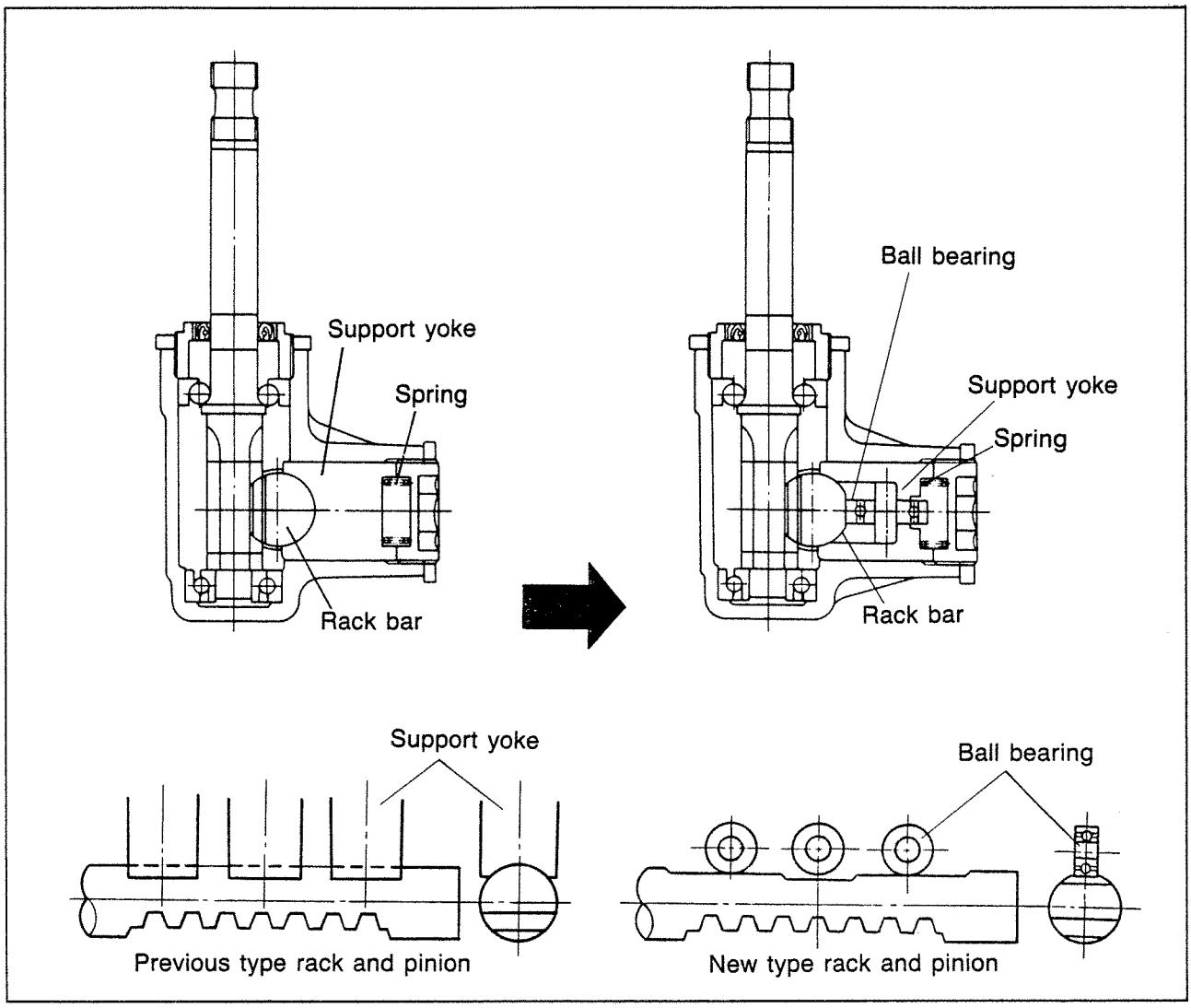
STEERING GEAR



67U10X-527

The steering gear is a constant-gear-ratio type. The pinion gear is supported by the two upper and lower ball bearings.
The method used for support of the rack bar has been changed from the system in which support was only by the support yoke (the method used for the 626 and 323) to a system in which support is by the support yoke and ball bearings.

Support of Rack Bar



67U10X-528

The method for support of the rack bar has been changed.

Previous method...
The entire part from the center of the rack bar (with the vehicle in the straight-ahead condition) to the end of the rack bar (with the vehicle being turned) was supported only by the support yoke.

New method...
The center part of the rack bar is supported by the support yoke (in the same way as the previous method), but the end of the rack bar is supported by ball bearings.

Advantages of the new method...
1. Improvement of transmission efficiency of steering effort, because sliding contact has changed to rolling contact.
2. Improvement of rack bar wear resistance, because twisting of the rack bar as it moves is eliminated.