

STEERING SYSTEM

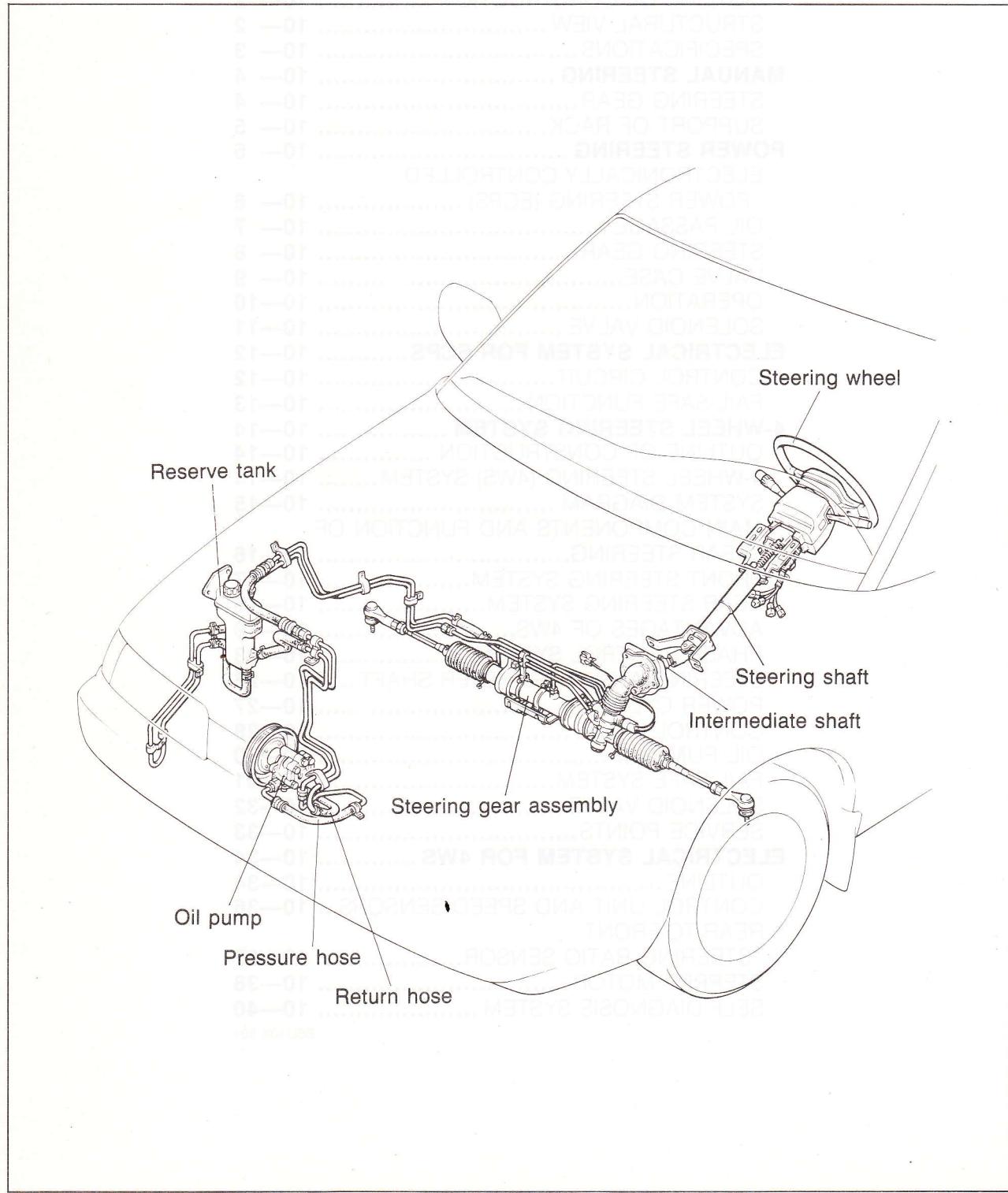
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OUTLINE

OUTLINE OF CONSTRUCTION

1. The steering gear box is the same rack and pinion type used in the previous model.
2. Two types of power steering control are available. One is an engine speed sensing type as used previously, and the other is an electronically controlled type.
3. A new 4-wheel steering system is used in which the rear wheels turn in conjunction with the steering angle of the front wheels to provide superior steerability.

STRUCTURAL VIEW



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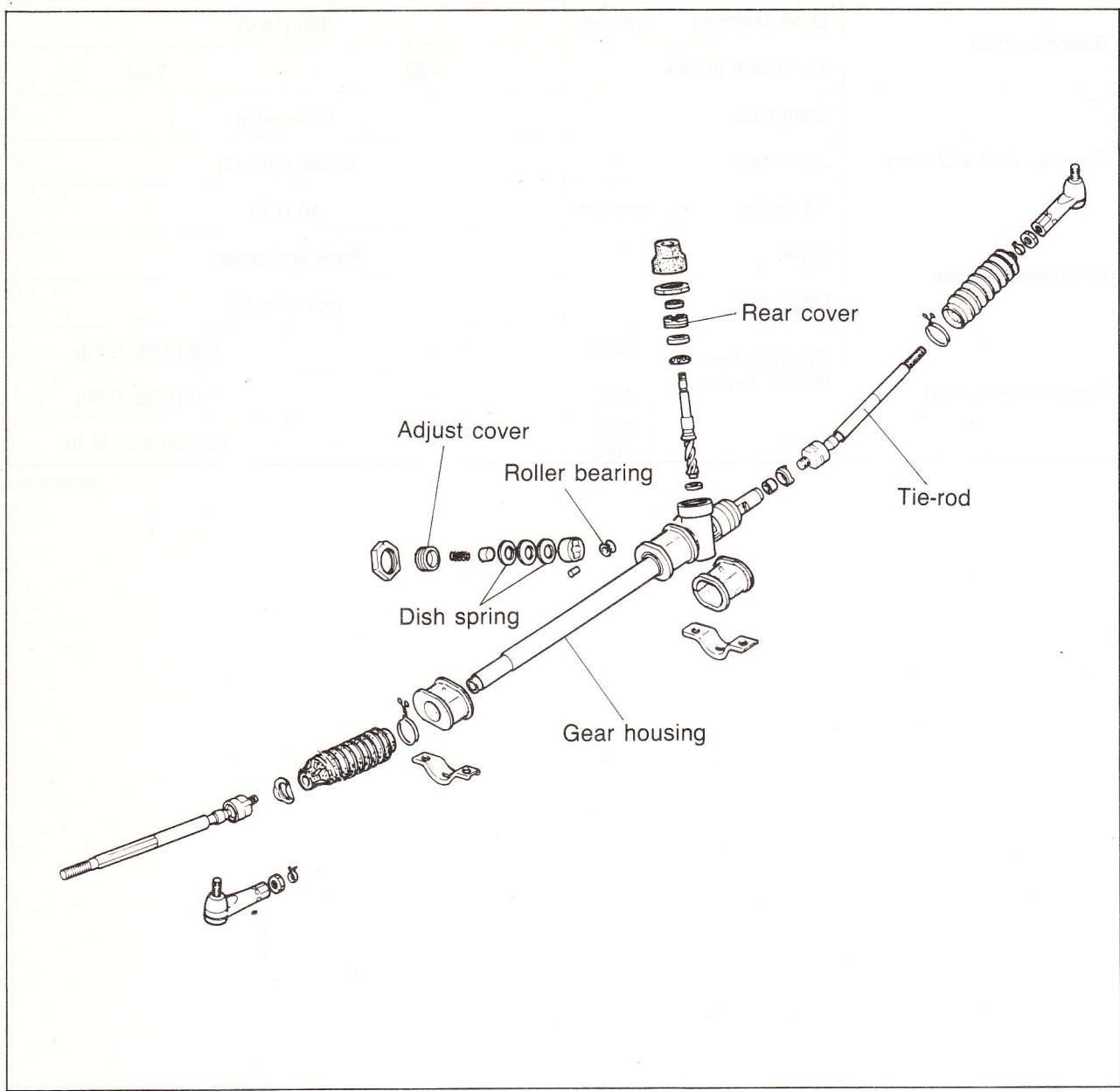
SPECIFICATIONS

Item	Type	Manual steering	Power steering
Steering wheel	Outer diameter mm (in)	380 (15.0)	
	Turns lock to lock	4.32	2.93
Steering shaft and joints	Shaft type	Collapsible	
	Joint type	Cross joints (2)	
	Tilt stroke mm (in)	40 (1.6)	
Front steering gear	Type	Rack and pinion	
	Gear ratio	(∞) (infinite)	
Power steering fluid	Capacity liter (US qt, Imp qt)	2WS —	0.9 (0.95, 0.79)
	4WS	—	1.0 (1.06, 0.88)
	Type	2WS 4WS —	Dexron II or M III

86U10X-503

MANUAL STEERING

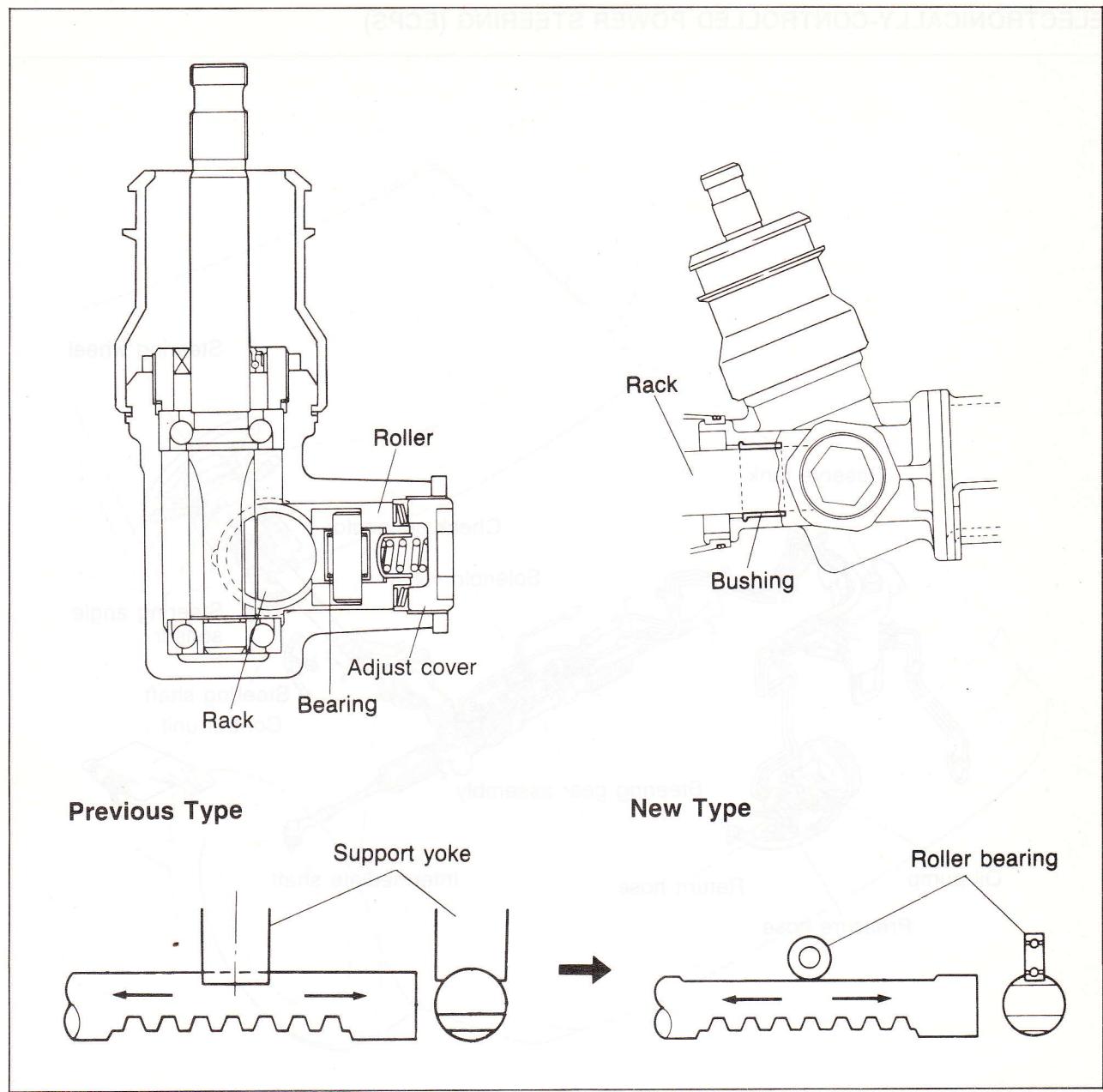
STEERING GEAR



86U10X-504

The steering gear is a constant gear ratio type. The pinion gear is supported by a roller bearing. The support of the rack is changed from a support yoke to a roller bearing.

SUPPORT OF RACK



86U10X-505

The method for support of the rack is changed.

Previous method

- The rack was supported by a support yoke.

New method

- The rack is supported by a roller bearing.
- A newly established bushing is used for additional support.

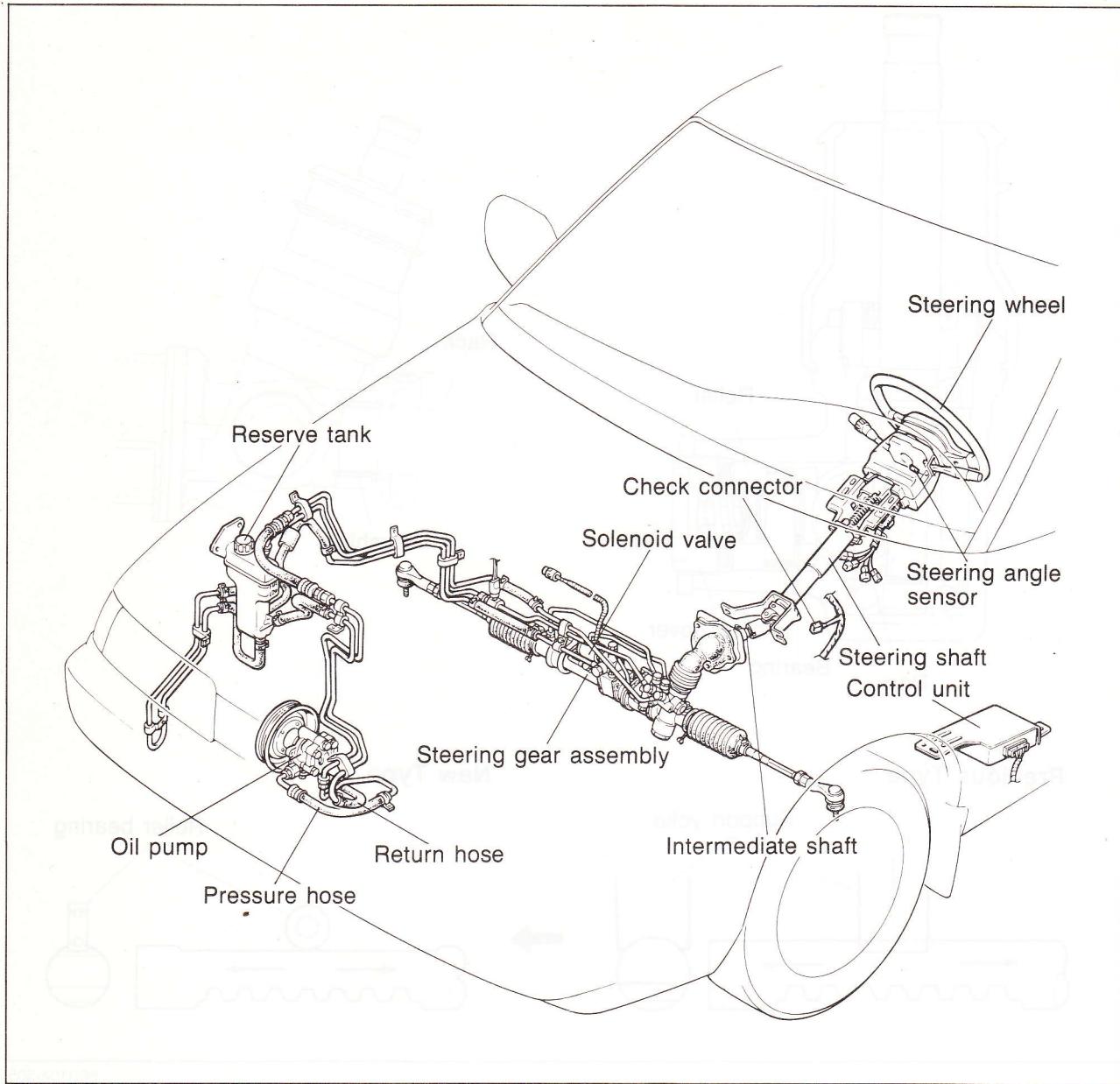
Advantages of new method

1. Smoother steering feel, as sliding contact is changed to rolling contact.
2. Improvement of rack wear resistance, as the rack is supported by the bearing.
3. Less noise and steering wheel vibration, as the rack is firmly supported by the bushing.

POWER STEERING

ROAD TO TROPICUS

ELECTRONICALLY-CONTROLLED POWER STEERING (ECPS)



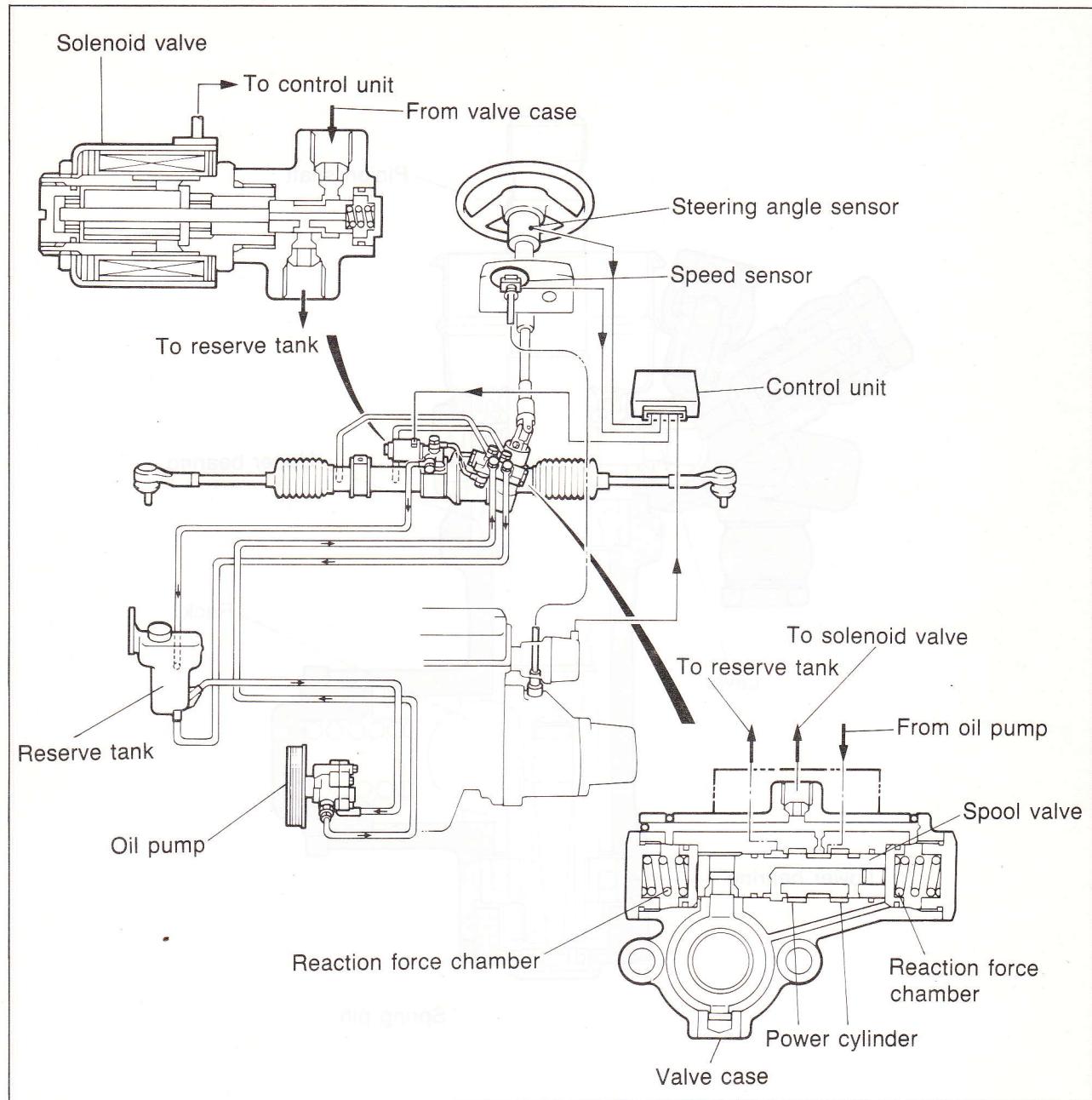
86U10X-506

This power steering system changes steering assistance 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 also 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 control unit and solenoid valve control oil pressure to the reaction force chamber based on the vehicle speed signal and the steering wheel turning angle signal.

OIL PASSAGE

RAWD DRAWINGS

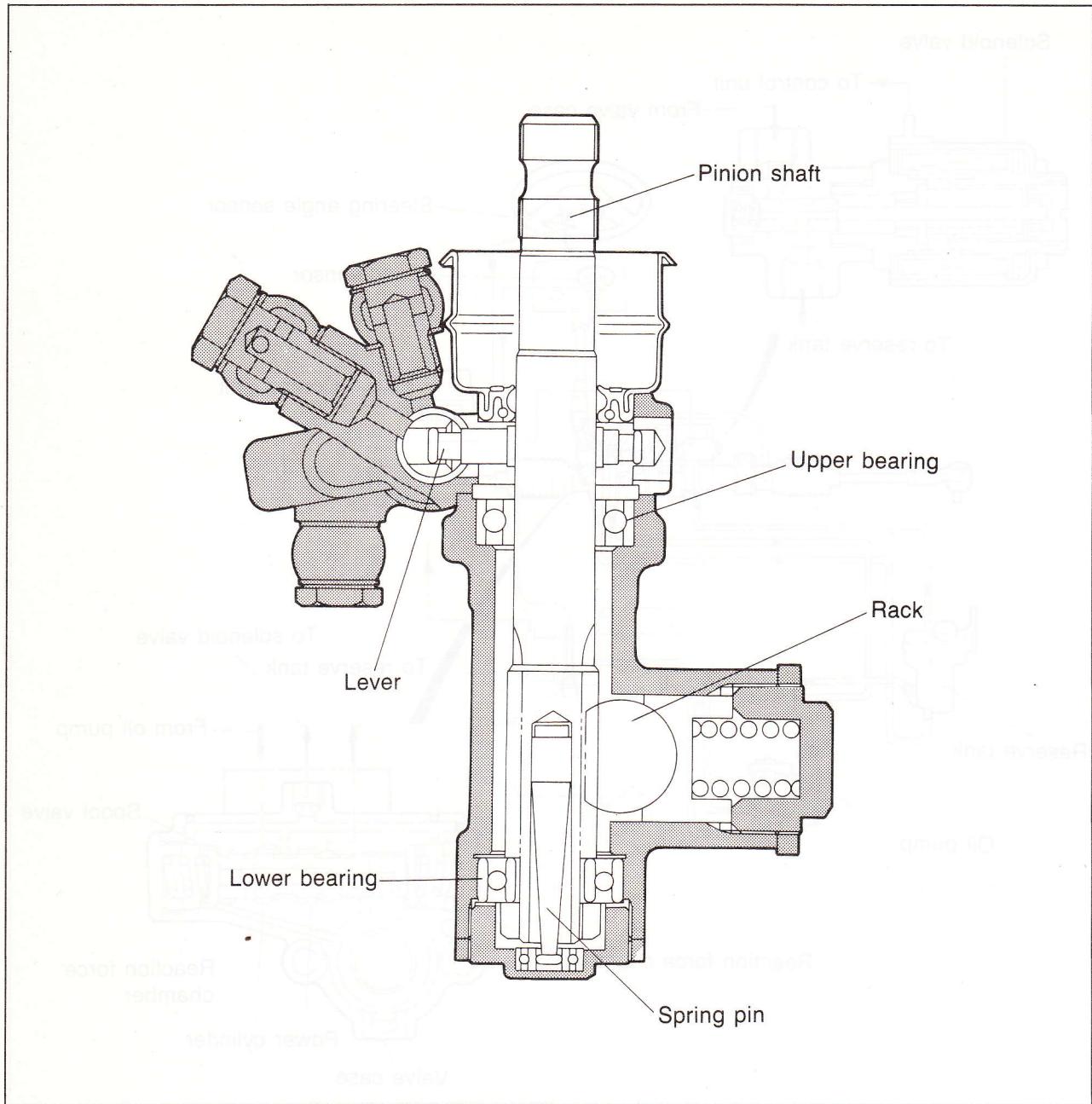


86U10X-507

The oil from the pump is led to the valve case. In the valve case, the oil flows to the reaction force chambers and through an orifice to the solenoid valve. The oil is fed to the reserve tank or power cylinder according to movement of the spool valve. The solenoid valve controls the oil flow to the reserve tank.

STEERING GEAR

86U10X-508



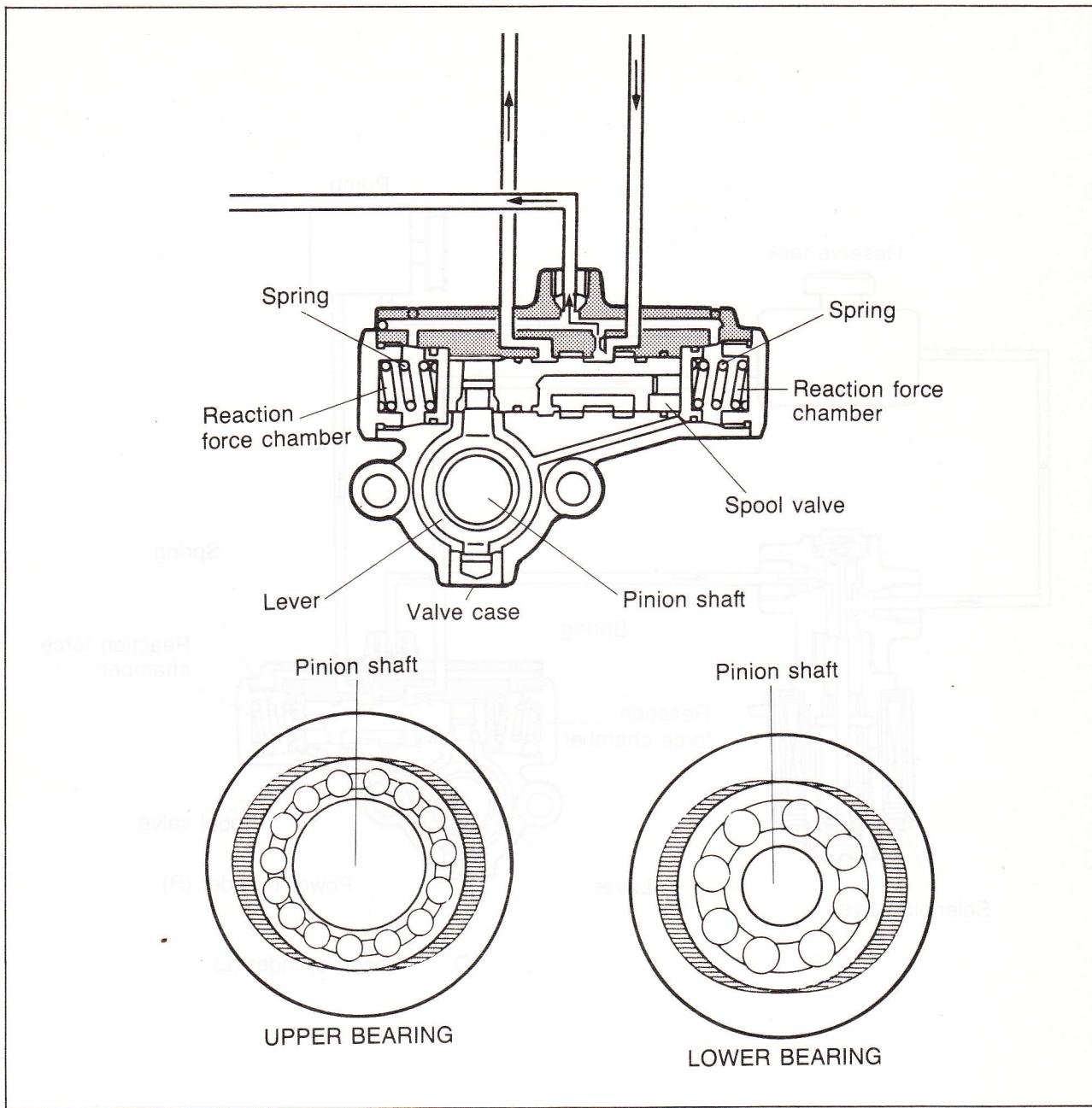
86U10X-508

Spool valve type power steering, which is basically the same as that of the 323, is used. Two bearings (upper and lower) are used to support the pinion shaft and allow it to move side-to-side in the case.

A spring pin is installed on the bottom of the pinion shaft to return it to the neutral position.

VALVE CASE

HOTARABO



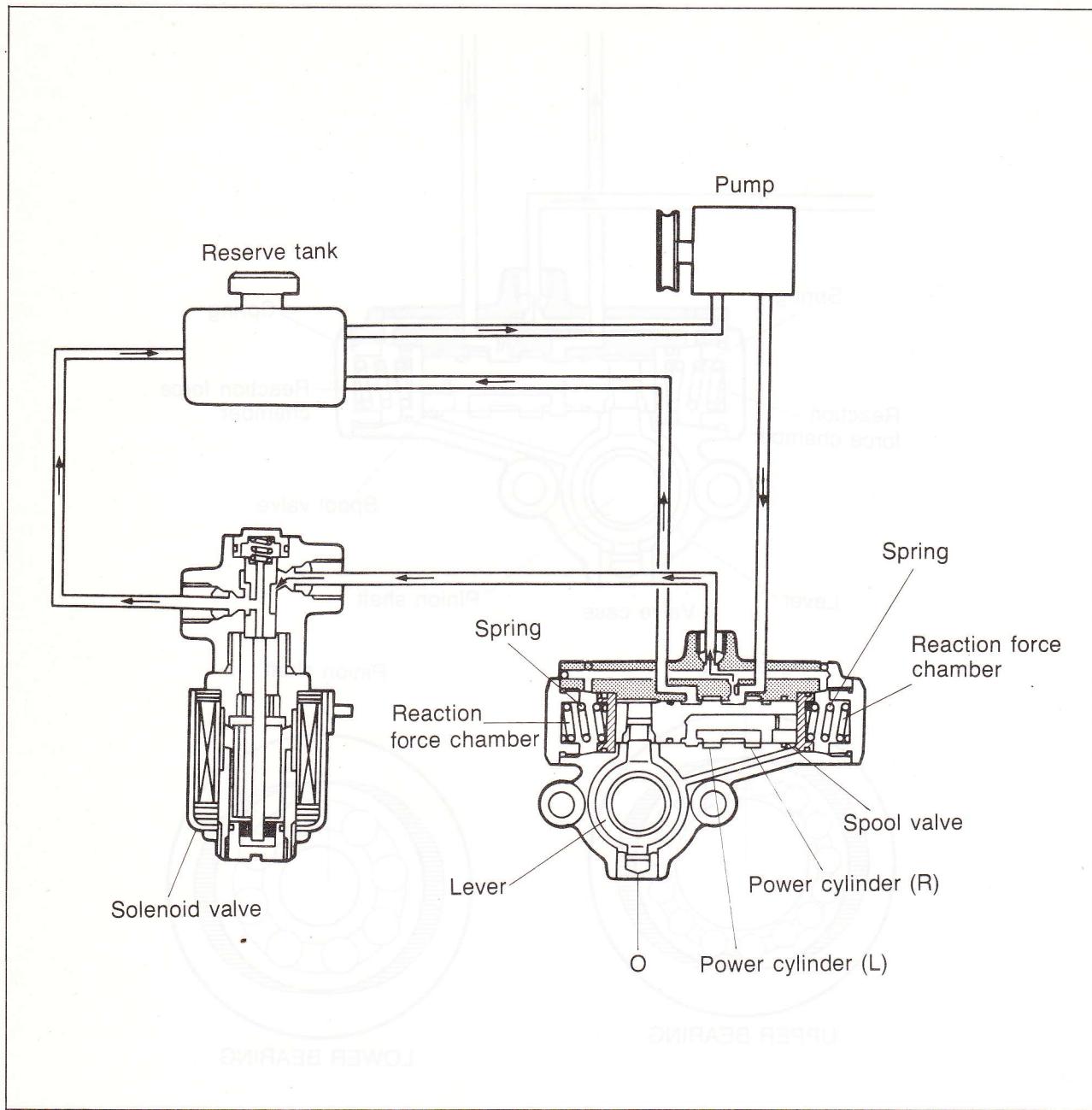
86U10X-509

The control valve consists of the valve case, spool valve, lever, reaction force chamber, spring, and pinion.

The valve is connected to the pinion shaft by the lever, and kept in the neutral position by the springs and oil pressure in the reaction force chambers.

OPERATION

ROAD BYWAY



86U10X-510

When the pinion moves, the lever pivots at point O. Consequently, the spool valve is moved, overcoming the spring pressure and oil pressure in the reaction force chamber.

During low-speed driving, when oil pressure in the reaction force chamber is low, the spool valve moves easily and the required steering effort is low.

At higher speeds, the oil pressure of the reaction force chambers increase, the spool valve moves with difficulty, and the required steering effort increases.

The spool valve's freedom of movement is, therefore, in proportion to the oil pressure in the reaction force chambers.

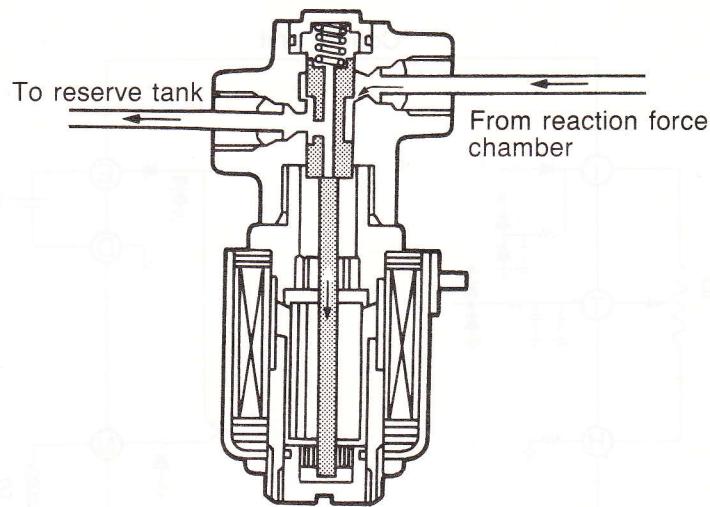
The oil pressure in the reaction force chambers is controlled by the solenoid valve.

SOLENOID VALVE

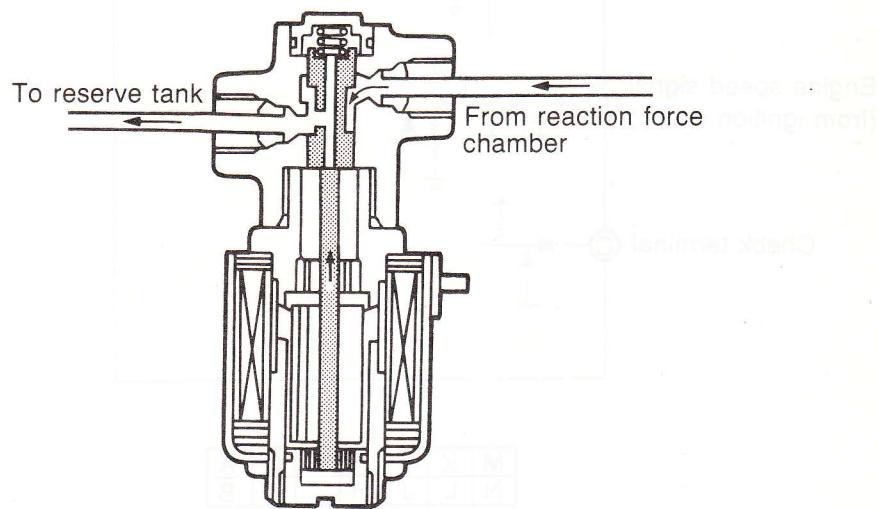
VALVE FOR METAYER JAGUAR XJ6

FLUID CONTROL

At high-speed



At low-speed



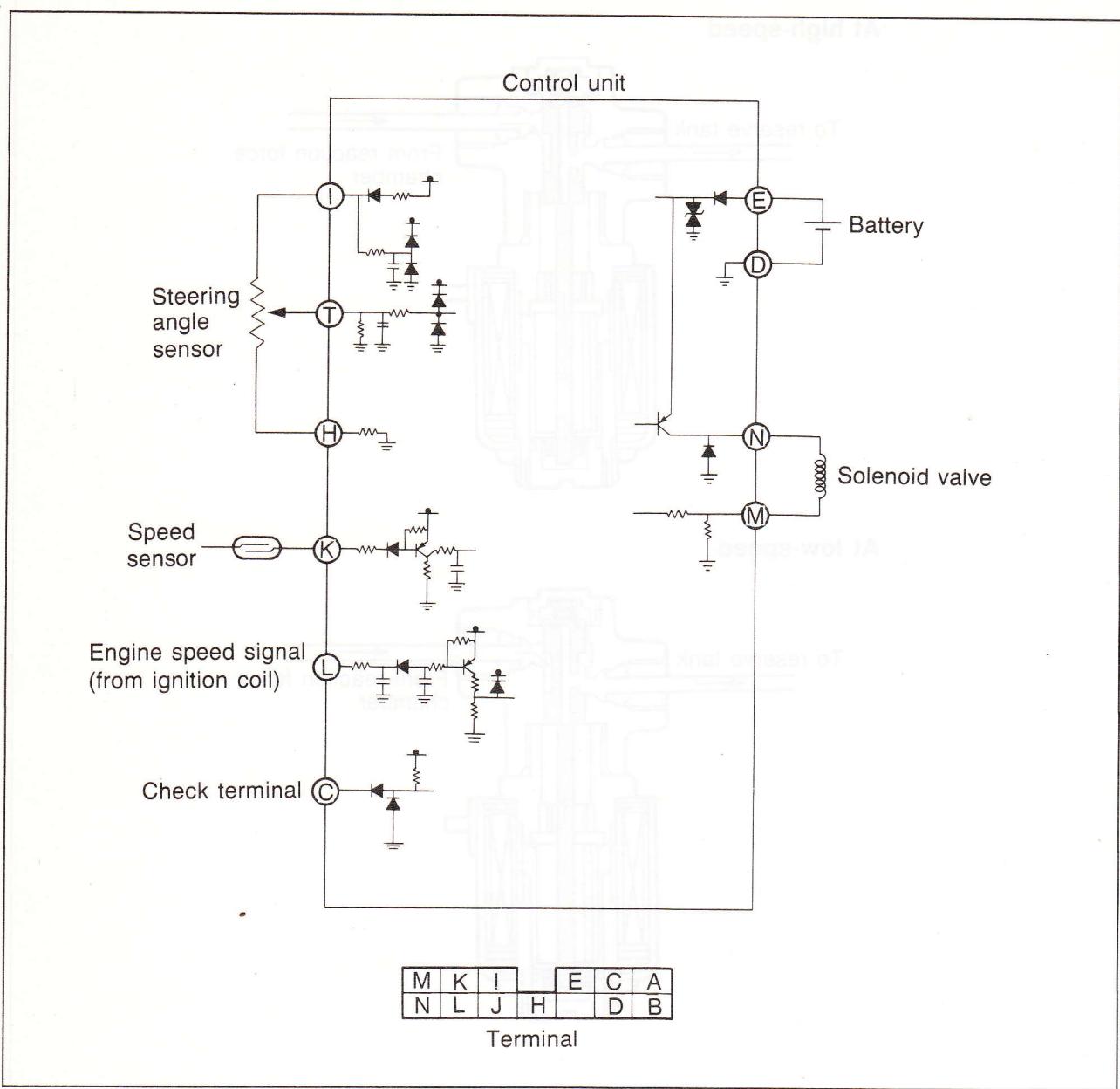
86U10X-511

The reaction force chamber oil pressure is controlled by the solenoid valve. When a large electrical current is sent from the control unit to the solenoid valve, the rod moves and compresses the spring. As a result of this, the passage from the reaction force chamber to the tank becomes larger. The reaction force chamber oil pressure then decreases, and the steering effort is lower.

When a small electrical current is sent from the control unit to the solenoid valve, the force with which the rod compresses the spring is less, and the passage between the reaction force chamber and the tank is smaller. As a result, the reaction force chamber oil pressure increases, and the steering effort is greater.

ELECTRICAL SYSTEM FOR ECPS

CONTROL CIRCUIT



86U10X-512

The control unit receives signals from the steering angle sensor, speed sensor, and ignition coil (engine speed). Based on these signals, the control unit calculates the amount of current needed to properly control solenoid valve operation.

Since the control unit has fail-safe and self-diagnosis functions, if incorrect or no signals are received from the sensors, the unit makes a judgment and regulates valve current to maintain appropriate steering operation.

FAIL-SAFE FUNCTION

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Failure point	Evaluation	Reaction to failure
Solenoid valve	Open or short circuit	Fixed control
Vehicle-speed signal	If the below occur simultaneously for over 10 sec., a failure is judged. ① Vehicle speed zero ② Engine speed over 500 rpm ③ Fluctuation of steering angle signal	Power steering control fixed at 80 km/h (49.6 mph) setting
	Changes over 60 km/h (37.2 mph) in 1 sec.	
Steering-angle signal	If the below occur simultaneously for over 10 sec., a failure is judged. ① Vehicle speed above 35 km/h (21.7 mph) ② Steering wheel angle above 140°	Power steering controlled only by vehicle speed

86U10X-513

Steering effort is controlled by the oil pressure regulated by the solenoid valve. The amount of the solenoid valve opens is controlled by the current flowing through its solenoid coil. Thus, steering effort is controlled by the current.

The amount of current is determined according to steering angle and vehicle speed. For explanation of self-diagnosis function, refer to Section 10 of the Workshop Manual.

4-WHEEL STEERING SYSTEM

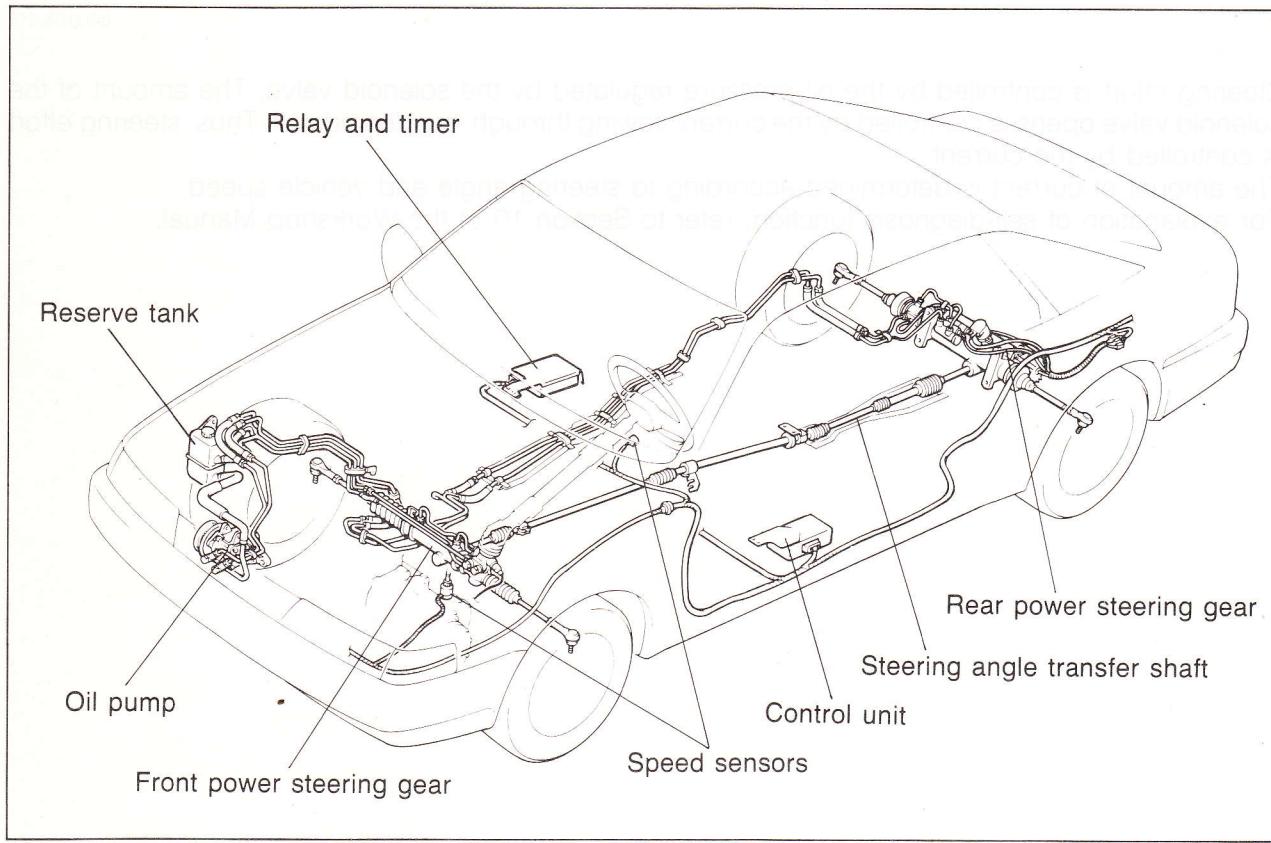
MOTORINFORTEA-JALR

OUTLINE OF CONSTRUCTION

Since the 4-wheel steering (4WS) system performs the function of steering the rear wheels according to steering wheel angle and vehicle speed, it has the following advantages over ordinary 2-wheel steering (2WS) systems in which only the front wheels are steered.

- 1) Improved straight-ahead driving stability at high speeds
- 2) Greater control during lane change
- 3) Better balance during cornering
- 4) Greater responsiveness and precision of steering wheel operation
- 5) Superb parking ability

4-WHEEL STEERING (4WS) SYSTEM

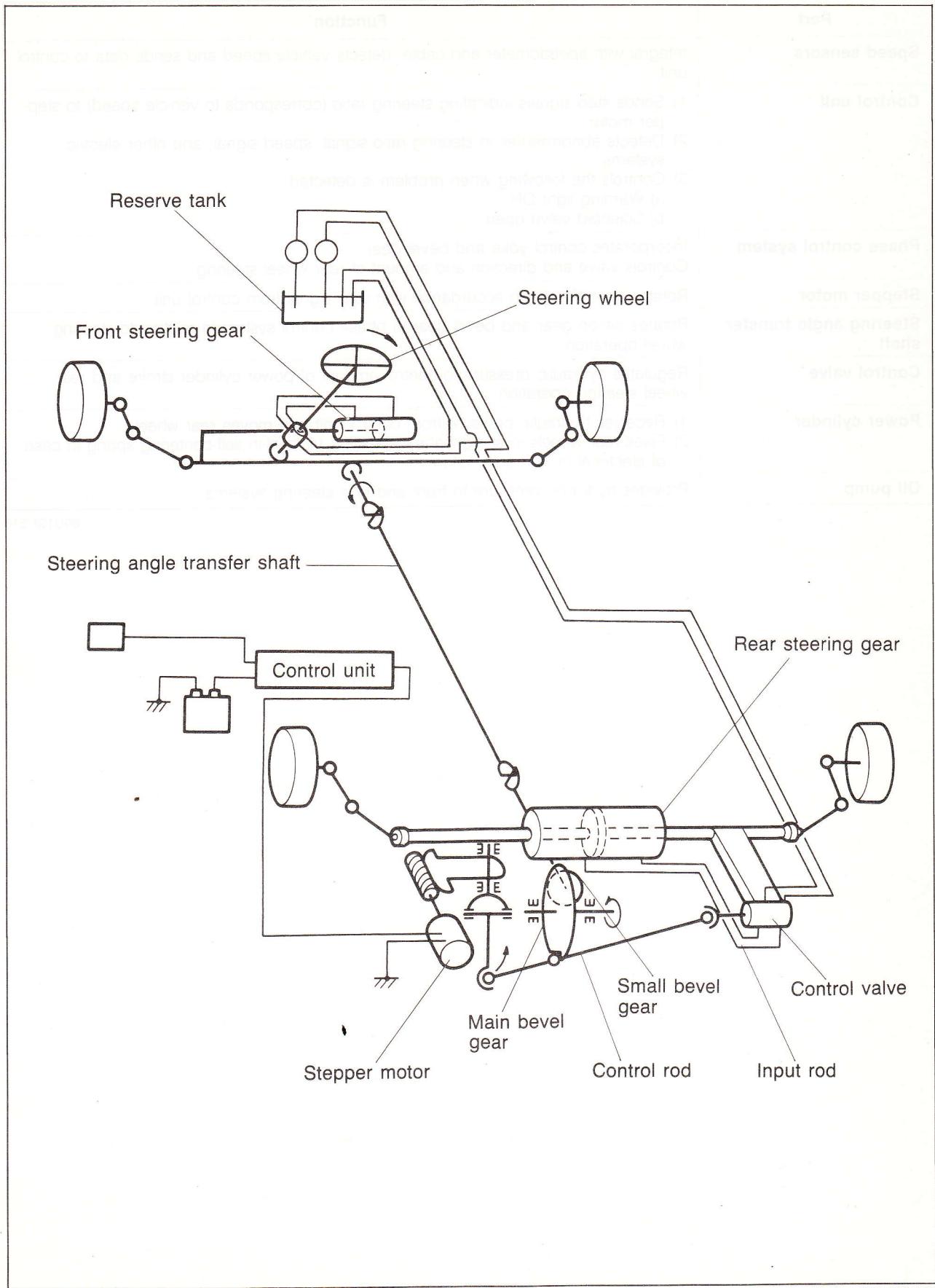


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This system consists of a hydraulically-assisted front power steering which performs the main steering function, and an electronically-controlled, hydraulically-assisted rear power steering which operates rear wheel steering according to steering wheel angle and vehicle speed.

An important safety feature is that the rear power steering gear returns and fixes the rear wheels in the straight-ahead position by a built-in self centering spring. This allows the vehicle to be steered as though it had conventional 2WS in the event of an electrical or hydraulic failure of the rear steering system.

SYSTEM DIAGRAM



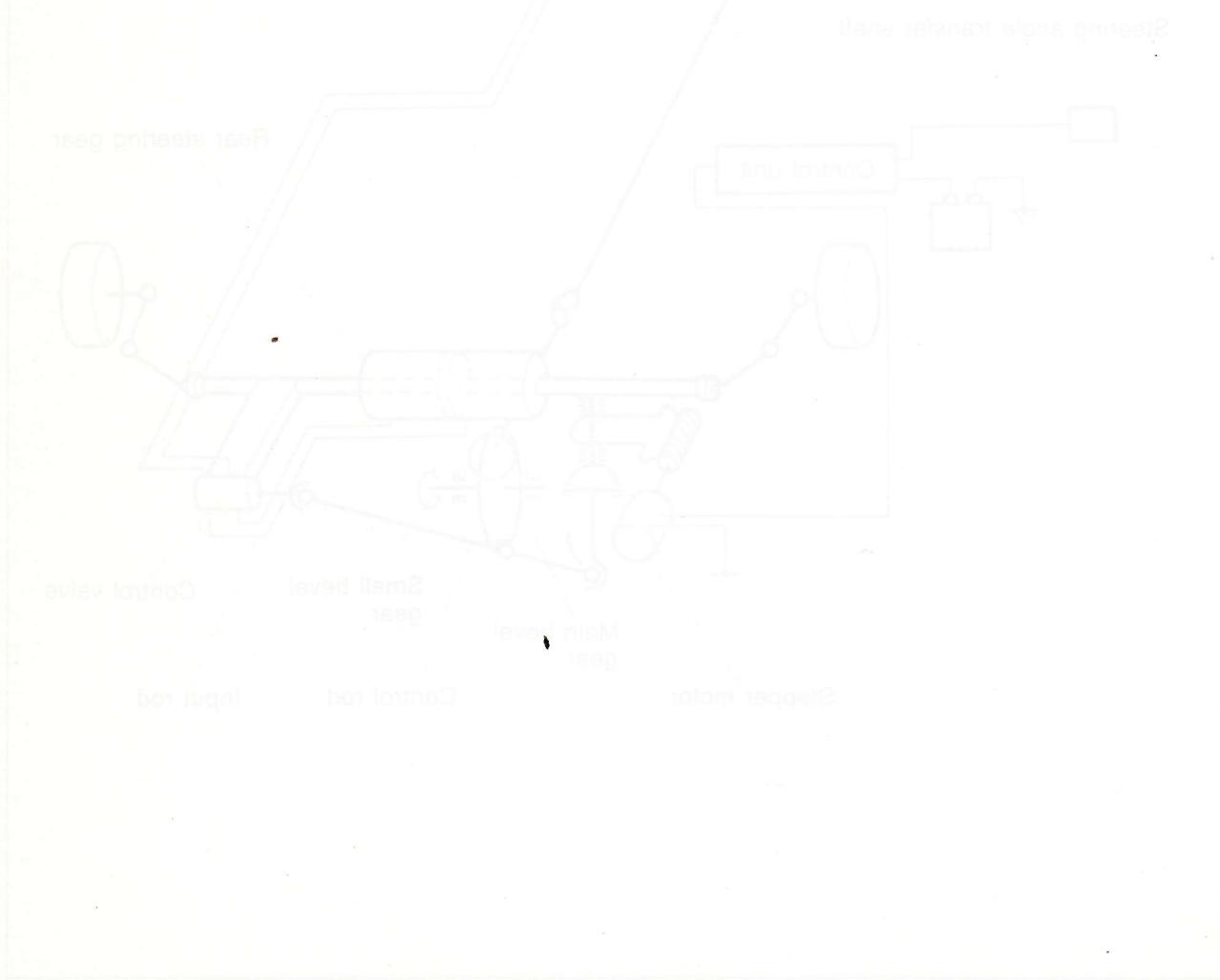
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MAIN COMPONENTS AND FUNCTION OF REAR STEERING

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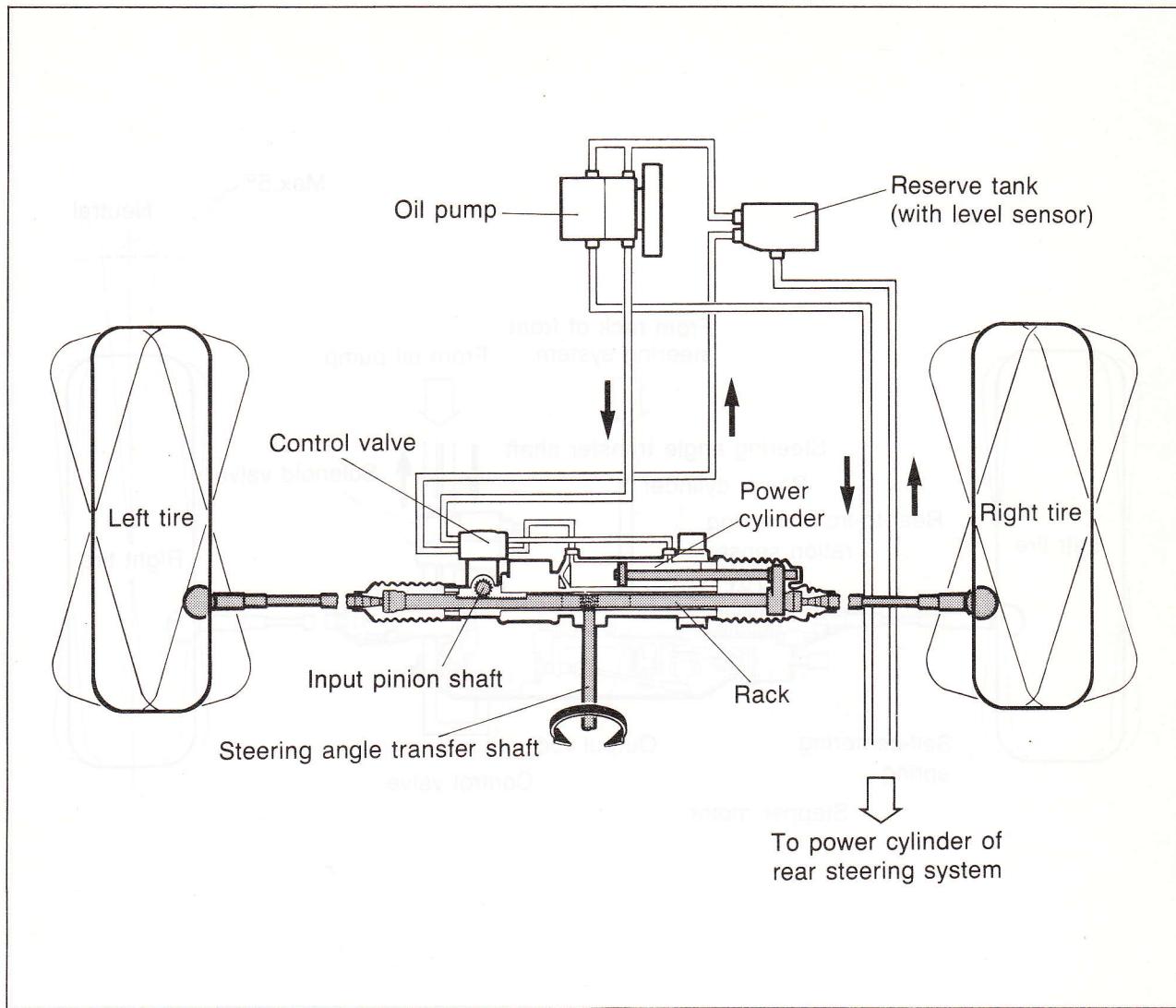
Part	Function
Speed sensors	Integral with speedometer and cable; detects vehicle speed and sends data to control unit
Control unit	<ol style="list-style-type: none"> 1) Sends step signals indicating steering ratio (corresponds to vehicle speed) to stepper motor 2) Detects abnormalities in steering ratio signal, speed signal, and other electric systems 3) Controls the following when problem is detected: <ol style="list-style-type: none"> a) Warning light ON b) Solenoid valve open
Phase control system	Incorporates control yoke and bevel gear Controls valve and direction and amount of rear wheel steering
Stepper motor	Rotates control yoke in accordance with step signal from control unit
Steering angle transfer shaft	Rotates pinion gear and bevel gear in phase control system in relation to steering wheel operation
Control valve	Regulates hydraulic pressure to control amount of power cylinder stroke and rear wheel steering operation
Power cylinder	<ol style="list-style-type: none"> 1) Receives hydraulic pressure from control unit and moves rear wheels 2) Fixes rear wheels in straight-ahead position by built-in self-centering spring in case of electrical or hydraulic failure
Oil pump	Provides hydraulic pressure to front and rear steering systems

86U10X-515



FRONT STEERING SYSTEM

MITSUBISHI FUSO TRUCK & BUS

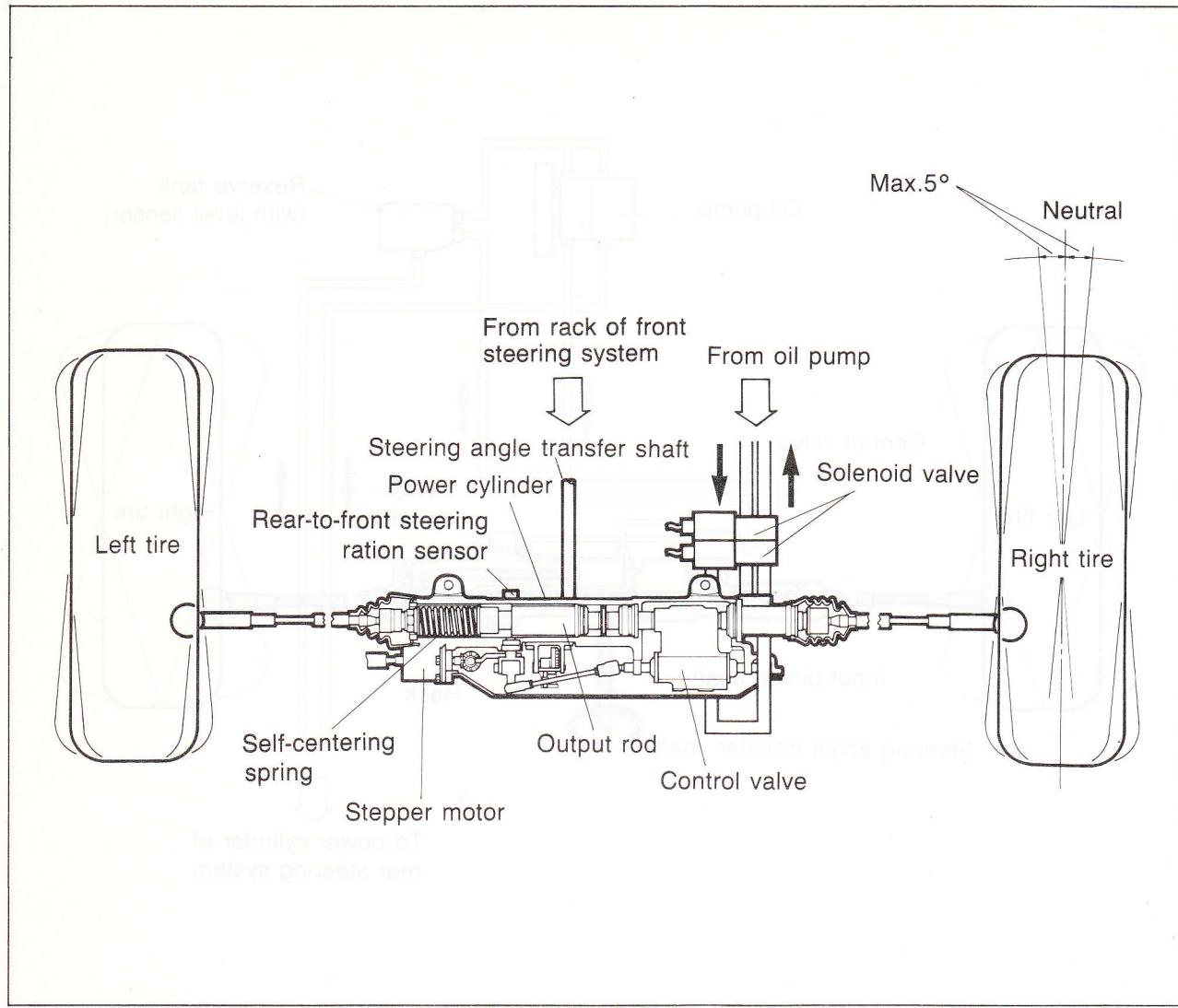


86U10X-516

This is an ordinary rack and pinion power steering system in which the steering efforts of the driver are hydraulically assisted. This system consists of a steering wheel, an input pinion shaft connected to the steering wheel by a steering shaft, a rack, an oil pump, and a control valve. A steering angle transfer shaft for controlling the rear steering system is geared to the rack and connects with the phase control system of the rear steering system.

REAR STEERING SYSTEM

МЕТУВА ОМИРЕТС ТИОРИ



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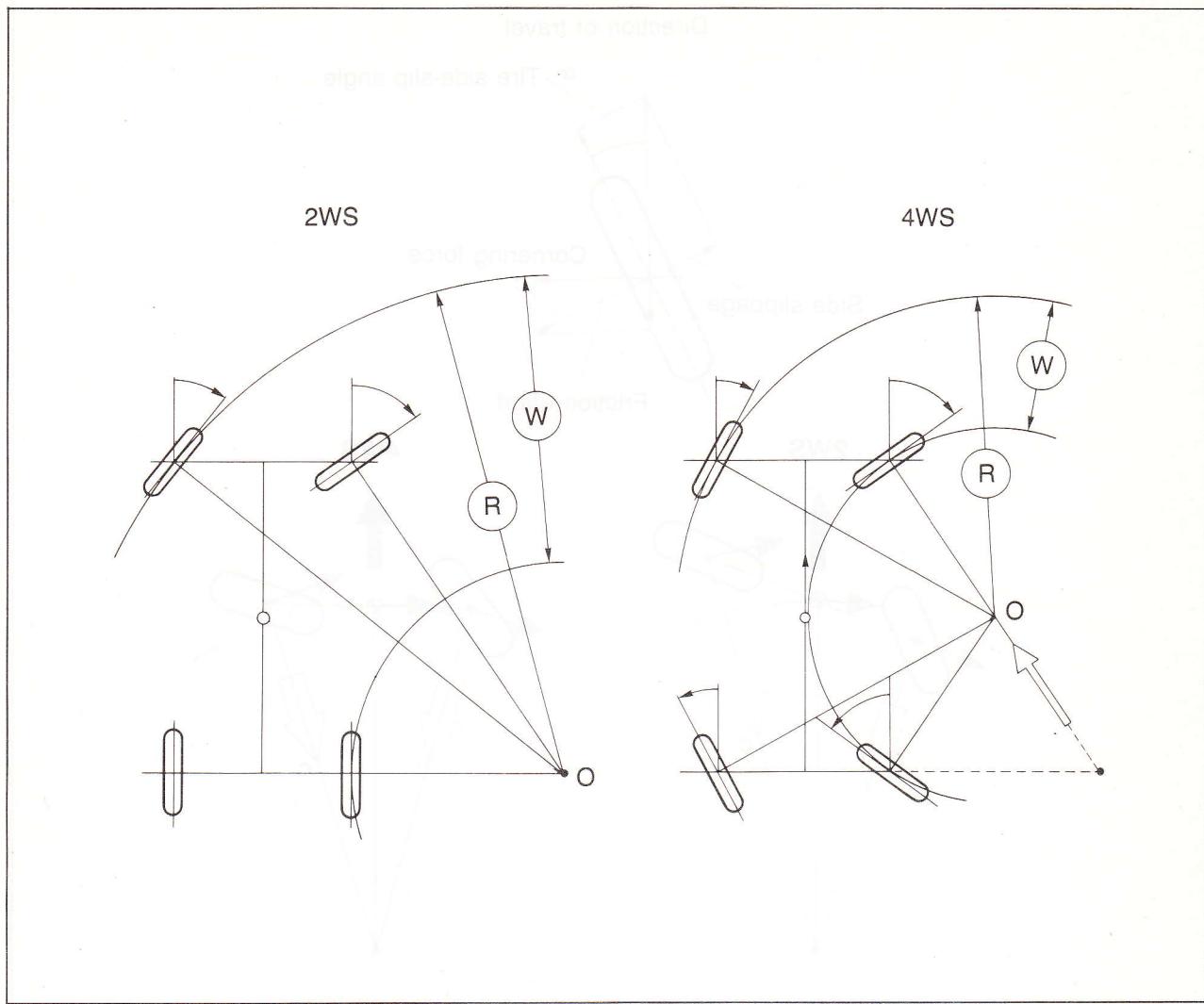
This is a hydraulically-assisted power steering system which is electronically controlled according to steering wheel angle and vehicle speed. This system consists of a steering angle transfer shaft, speed sensors, control unit, stepper motor, phase control system, control valve, oil pump, and power cylinder and output rod.

As a fail-safe system, the rear steering system is equipped with a self-centering spring which fixes the output rod in the straight-ahead position if hydraulic pressure to the power cylinder is lost. Also incorporated is a solenoid valve which cuts off the hydraulic pressure if there is a system electrical failure.

ADVANTAGES OF 4WS

Low-speed turning

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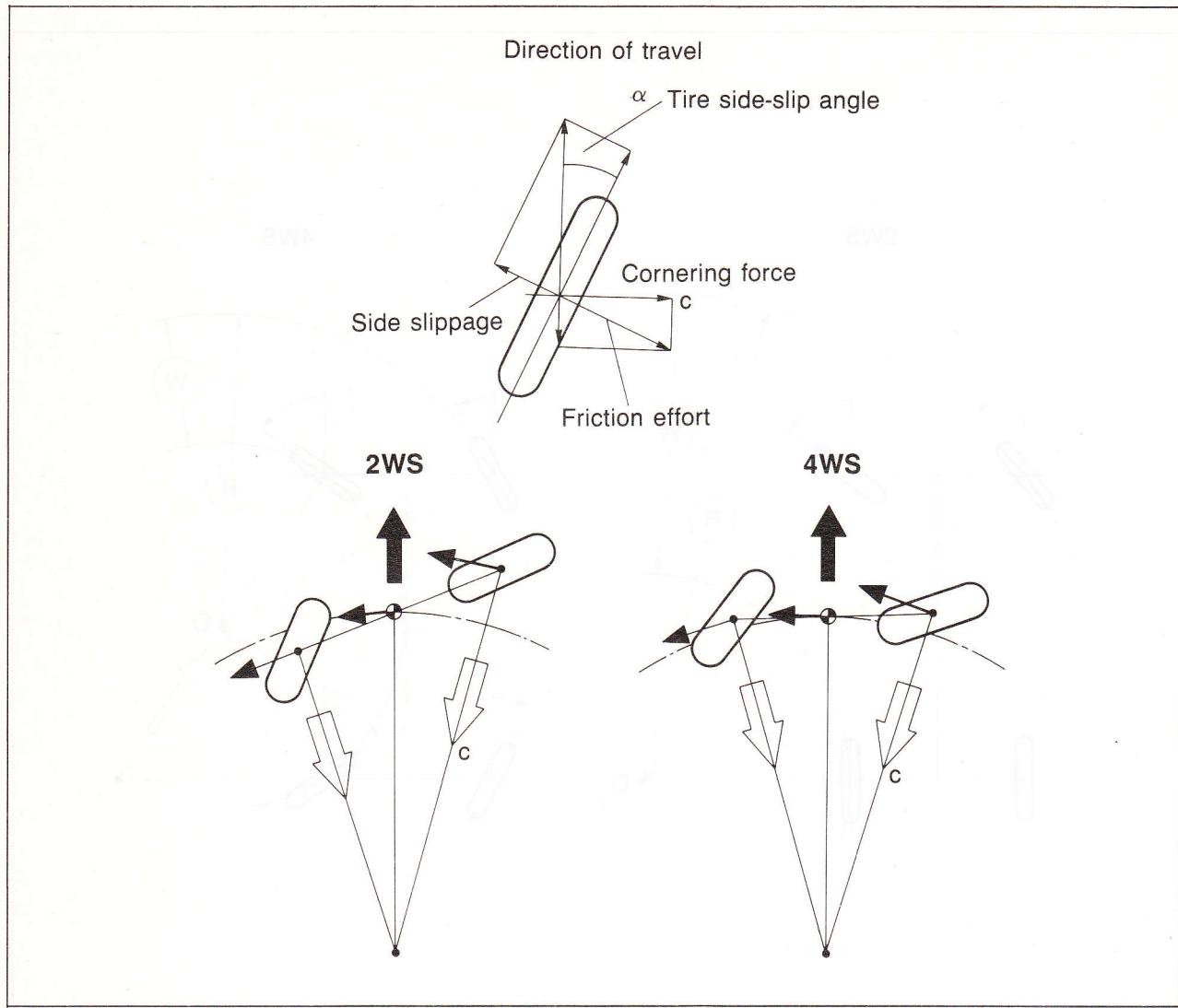
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For 2WS vehicles turning at low speed, the center of the turn is point O (the extended line of the rear axle shaft). The minimum turning radius is shown by line R.

If the front and rear wheels are steered in opposite phases, the change in location of point O makes it possible for the minimum turning radius and inner/outer wheel difference (W) to be lessened; thus, improving the turning capability during small-radius turns.

High-speed turning and cornering

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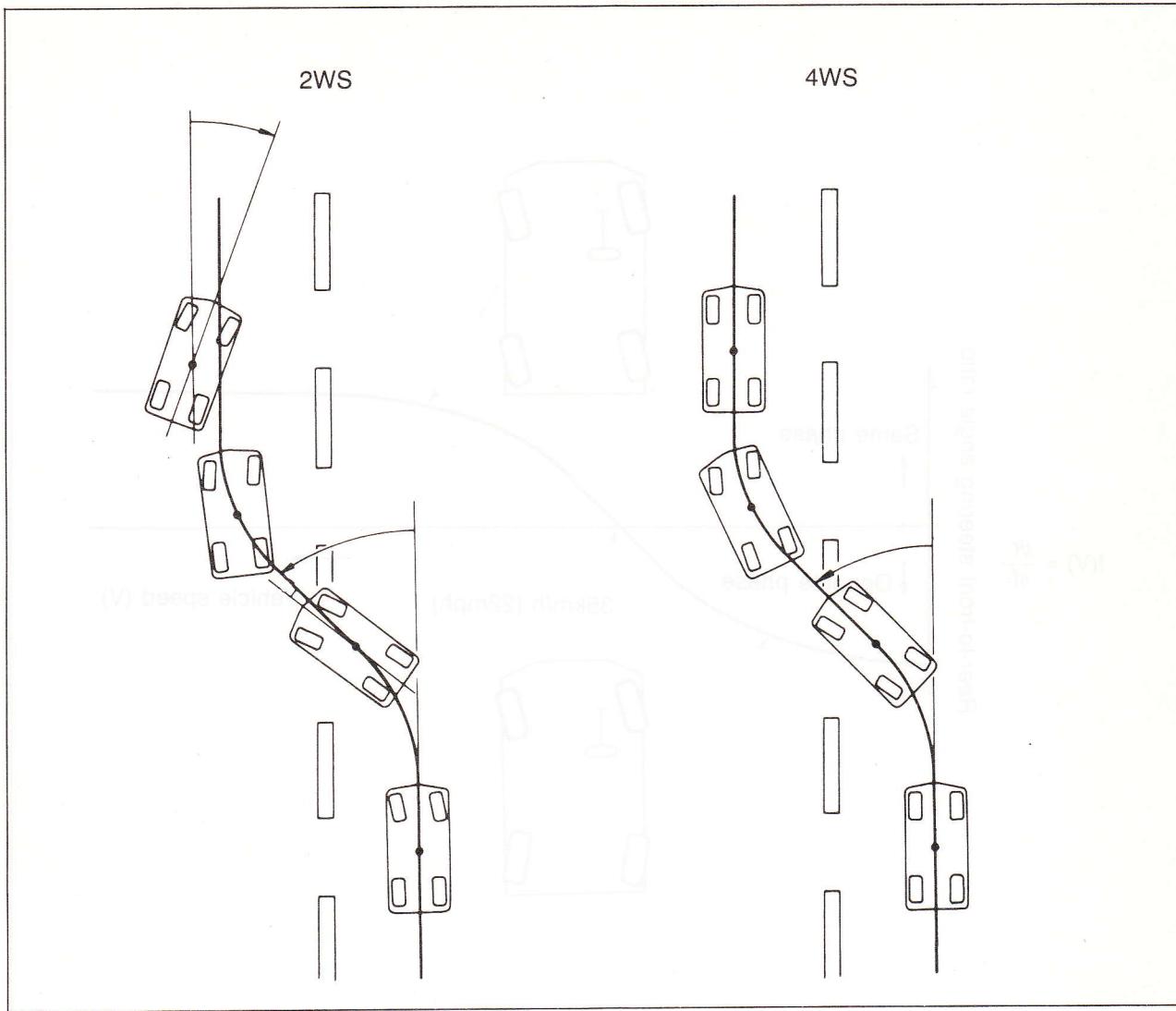


86U10X-519

The centrifugal force acting upon the vehicle body increases with high-speed turning and cornering. As a result, a greater cornering force (C) is necessary, and the side-slip angle (α) of the tires is increased. Ordinarily, when a 2WS vehicle turns or corners under high-speed conditions, the side-slip angle of the tires is increased as the driver turns the steering wheel, with the result that the vehicle's rear end yaws to a great extent and the side-slip angle of the rear tires becomes greater. For 4WS vehicles, the rear wheels are steered in the same phase as the front wheels, with the result that there is reduced yawing of the rear end, and there is a corresponding reduction of the yawing time of the vehicle's rear end.

Lane change

2WD 100R to 100L 0.0002 to 0.0001 bus in uomA



86U10X-520

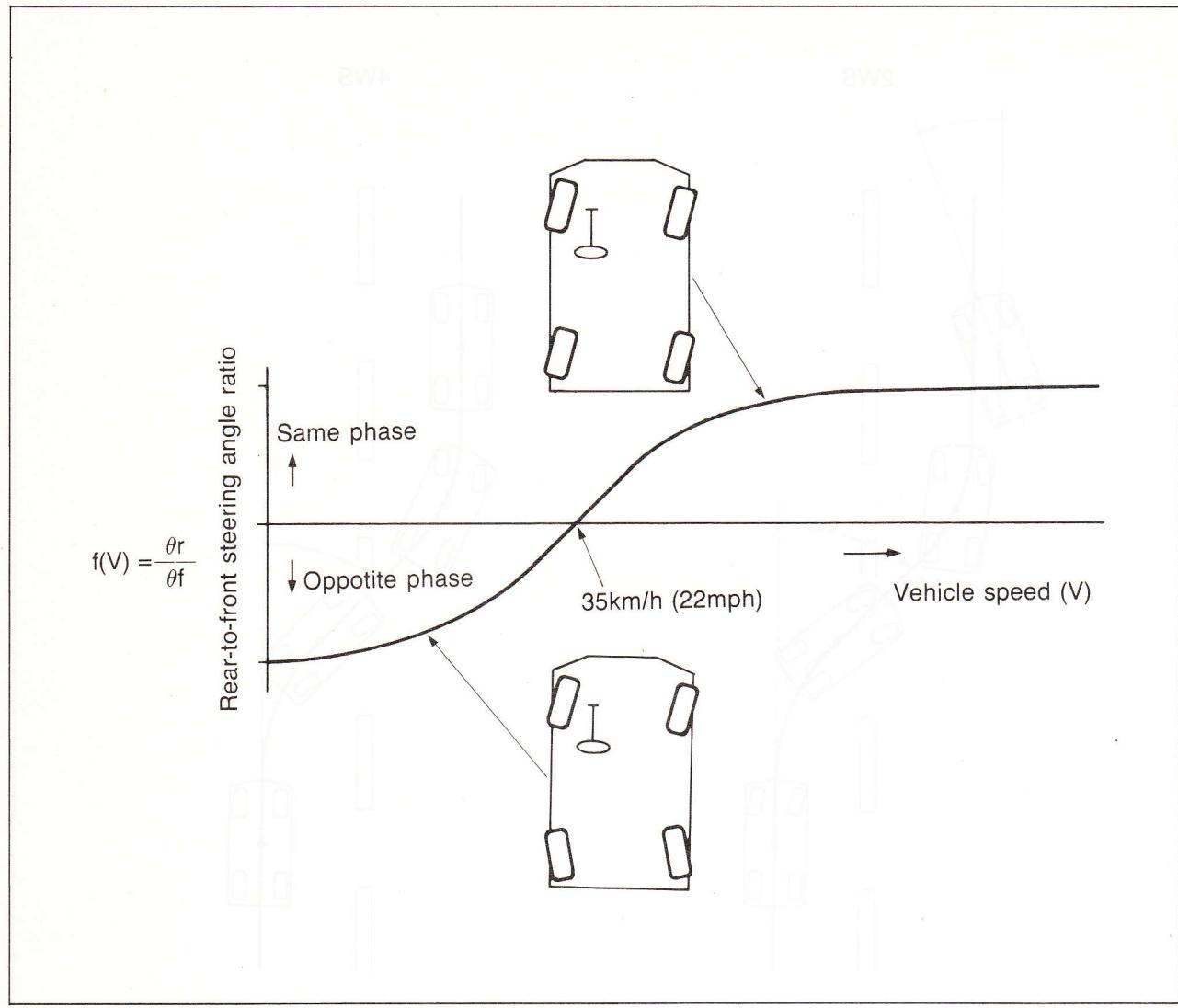
As a result of the 4WS characteristics described, when the 4WS vehicle makes, for example, a lane change, there is the difference (shown in the illustrations above) of the path of the 4WS vehicle and the 2WS vehicle. This is because the length of time of rear end yawing and attitude change are less for the 4WS vehicle.

Moreover, such factors as cornering balance, steering wheel response, and steering precision are better for the 4WS vehicle.

The relationship between vehicle speed, steering wheel angle, and angle of the rear wheels is described on the following page.

Amount and Direction of Steering Angle of Rear Wheels

86U10X-521



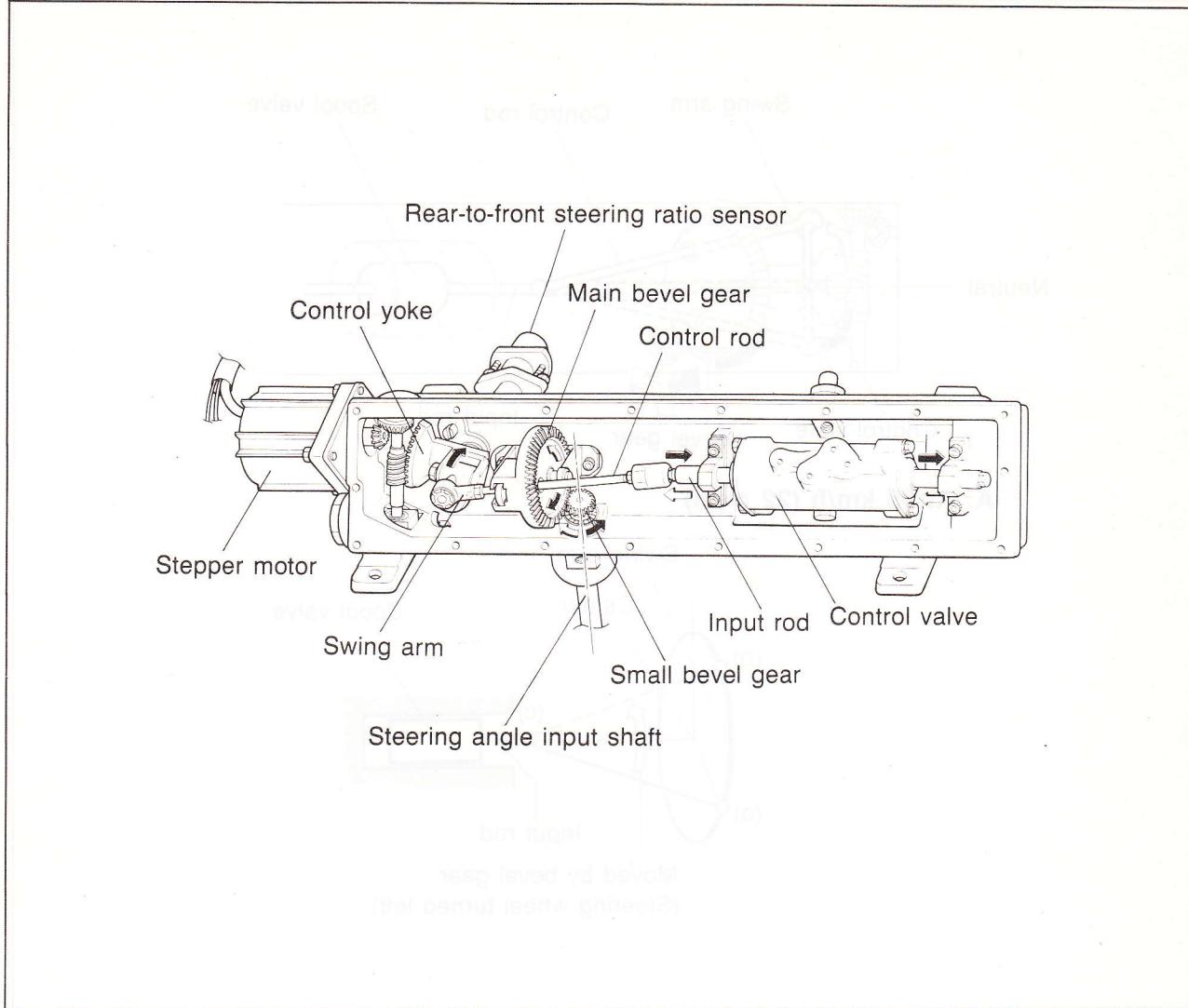
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Rear-to-front steering angle ratio (r/f) is decided by the control unit according to vehicle speed. The general characteristics are as follows.

Under 35 km/h (22 mph) the rear wheels are steered in the opposite direction as the front wheels, at 35 km/h (22 mph) the rear wheels point straight-ahead as in 2WS, and at speeds over 35 km/h (22 mph) they are steered in the same direction as the front wheels.

The maximum steering angle of the rear wheels is 5°.

PHASE CONTROL SYSTEM

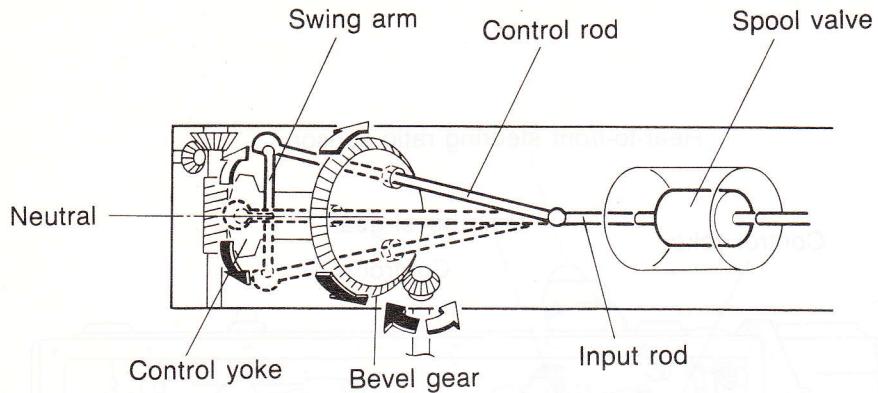


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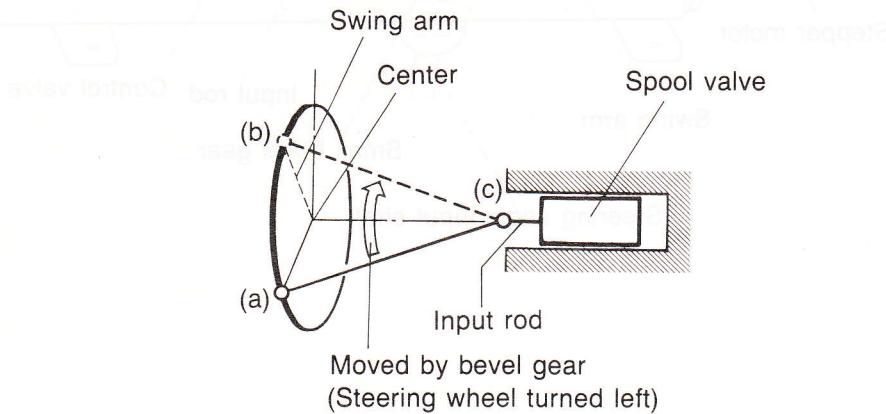
The phase control system functions to control the steering amount and direction of the rear wheels as mentioned before. It consists of a stepper motor which controls the steering ratio, a control yoke, a swing arm, a main bevel gear engaged to the steering angle input shaft through a small bevel gear, and a control rod connected to a control valve.

Operation

METER 20FTWOD BEARS



A: At 35 km/h (22 mph)



86U10X-523

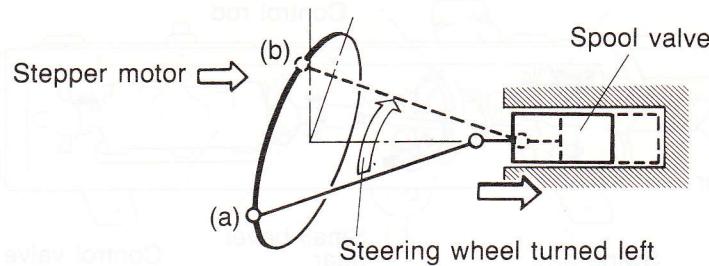
Assuming that the swing arm is a disc, the connection of the input rod and control rod (c) is at the disc center line.

The disc moves the end of the control rod (a) in relation with the turning angle of the steering wheel.

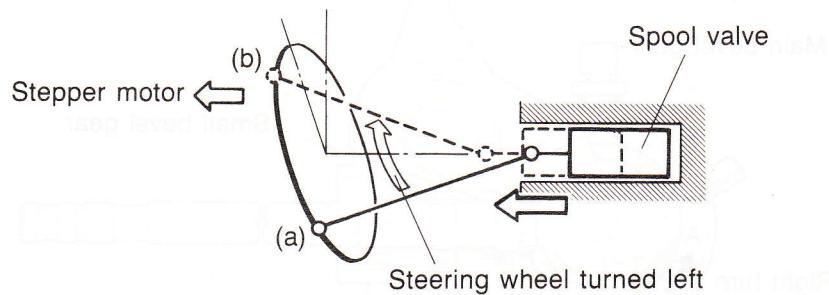
At 35 km/h (22 mph)

The disc and the input rod are at a right angle as shown in Fig. A. At this time, if the steering wheel is turned to the left, the disc turns and the control rod is moved from point (a) to point (b). The control rod moves in the reverse direction if the steering wheel is turned to the right. There is, however, no movement of the spool valve. Therefore, the rear wheels remain in the straight-ahead position.

B:At more than 35 km/h (22 mph)



C:At less than 35 km/h (22 mph)



86U10X-524

At more than 35 km/h (22 mph)

The position of the disc is changed by the stepper motor as shown in Fig. B, resulting in an angle change between the disc and input rod. (The degree of angle change is in relation to vehicle speed.) At this time, when the steering wheel is turned to the left, the control rod is again moved from point (a) to point (b). When this happens, the spool valve is moved toward the right. As a result, the rear wheels are turned to the left (same phase) when the steering wheel is turned to the left. The opposite happens when the steering is turned to the right.

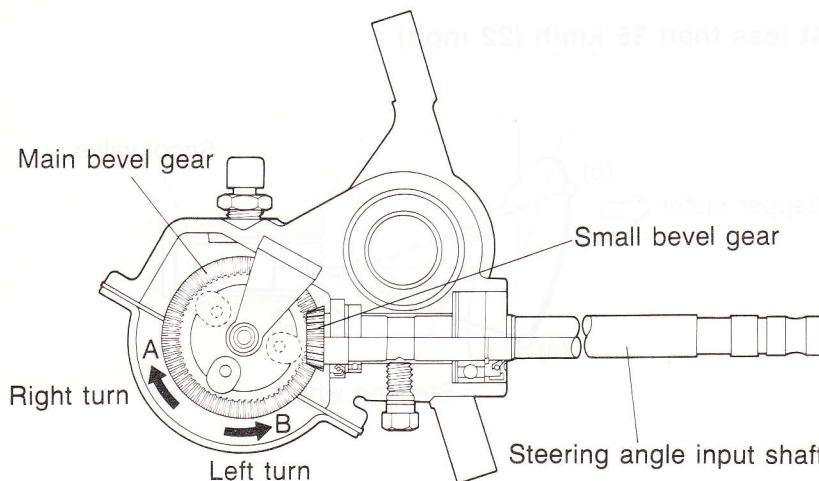
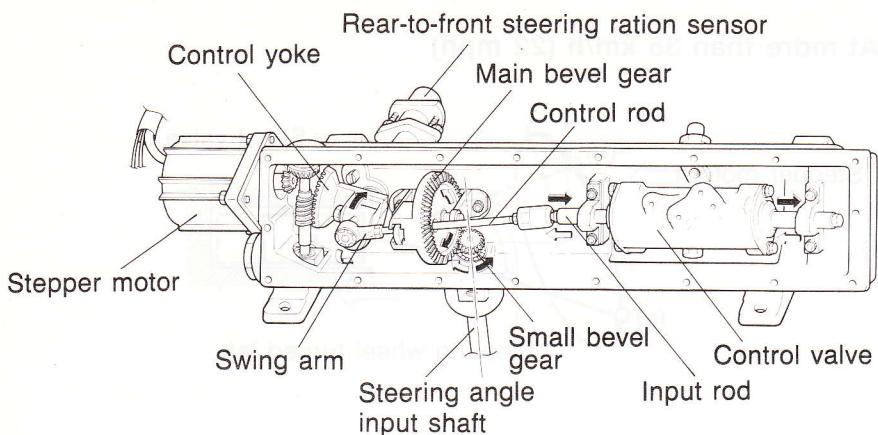
At less than 35 km/h (22 mph)

The position of the disc is changed by the stepper motor as shown in Fig. C, so that the angle is opposite that in Fig. B.

At this time, when the steering wheel is turned to the left, the control rod is moved from point (a) to point (b), and the spool valve is moved to the left.

As a result, the rear wheels are turned to the right (opposite phase) when the steering wheel is turned to the left, and left when turned to the right.

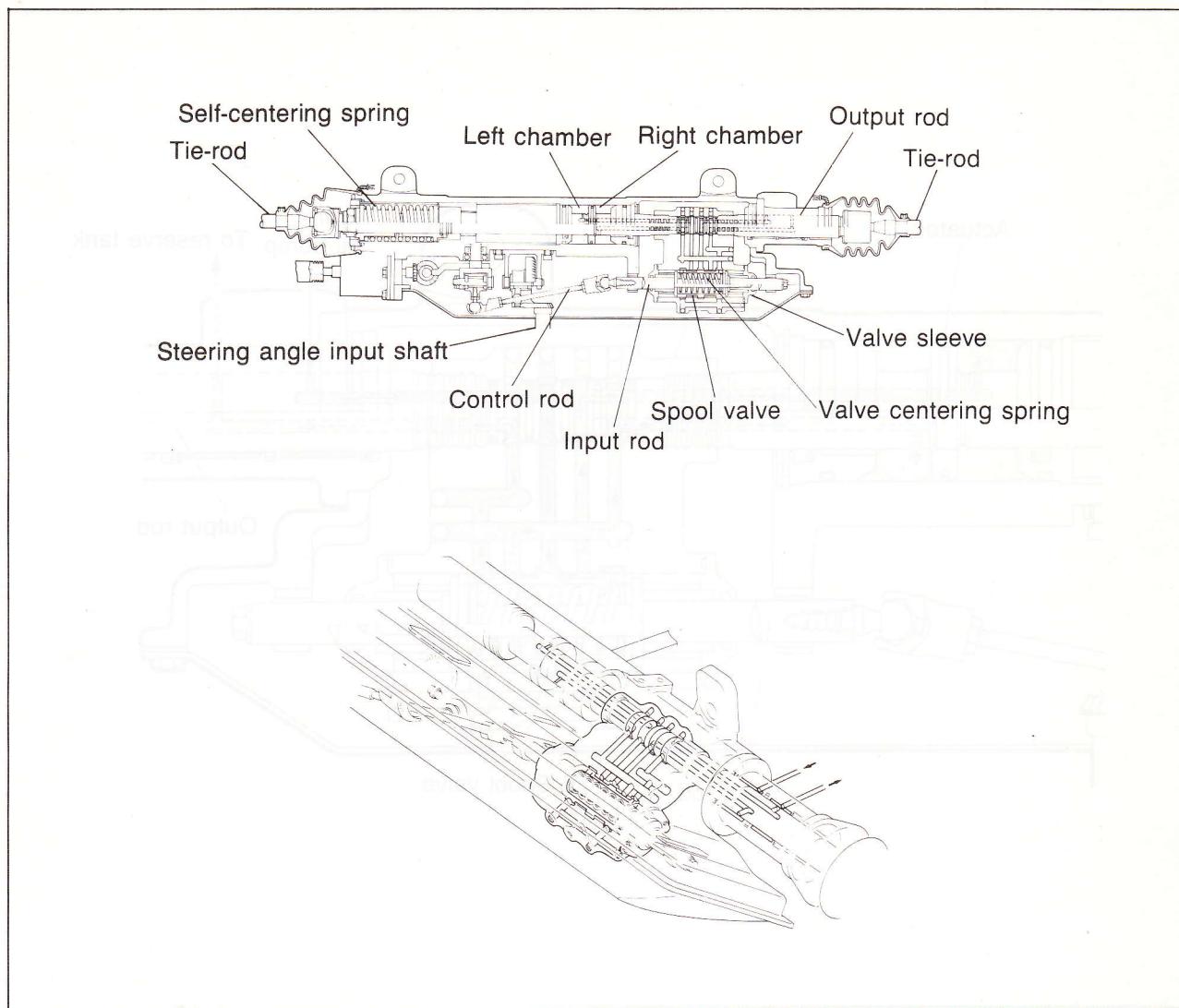
STEERING ANGLE TRANSFER SHAFT



86U10X-525

With the rotation of the steering wheel, the steering angle input shaft rotates the main bevel gear through the small bevel gear in the phase control system. The main bevel gear moves in direction A during right turns, and in direction B during left turns as shown in the figure. The control rod, which passes through the main bevel gear, moves in the same direction. The amount and direction of movement of the control valve input rod (connected to the control rod) is controlled by the control yoke angle which changes according to vehicle speed.

POWER CYLINDER



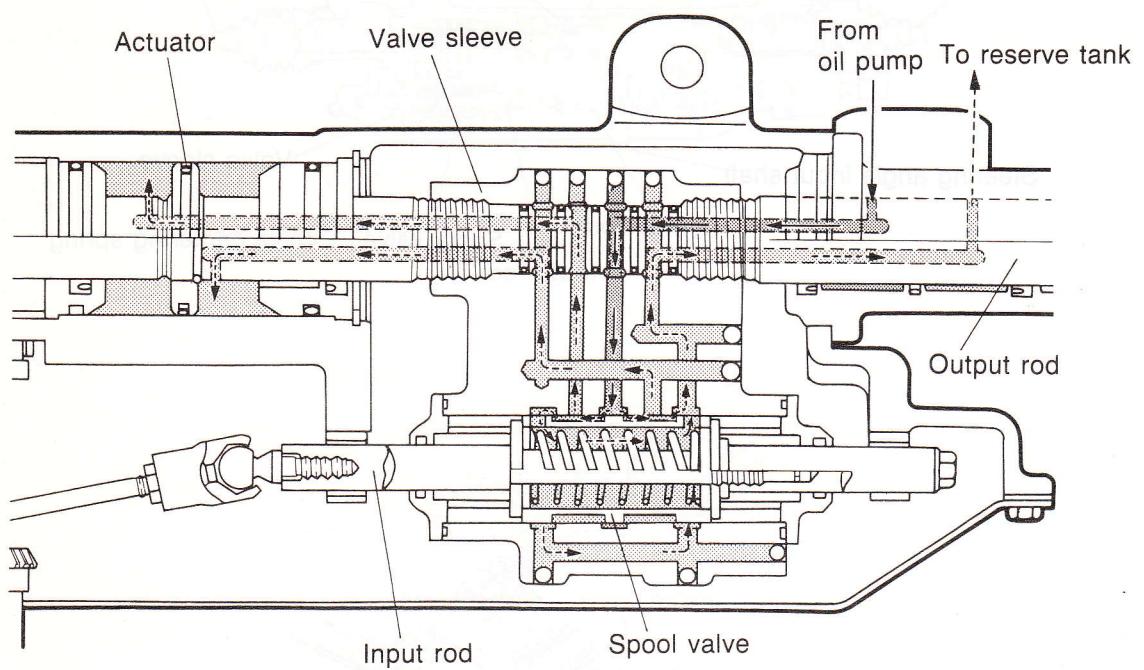
86U10X-526

The action of the control valve input rod is transmitted to the spool valve according to the front steering operation. The displacement of the spool to the valve sleeve causes difference in oil pressure between the right and left chambers in the power cylinder. The difference of pressure overcomes the load of the output rod and causes it to move. The valve sleeve, combined with the power rod, is moved by an amount and in the direction corresponding to the movement of the input rod. Then, the tie-rods, connected to the output rod, develop the steering action of the rear wheels.

The self-centering spring maintains or returns the output rod to the straight-ahead position if there is a failure in the hydraulic or electrical systems.

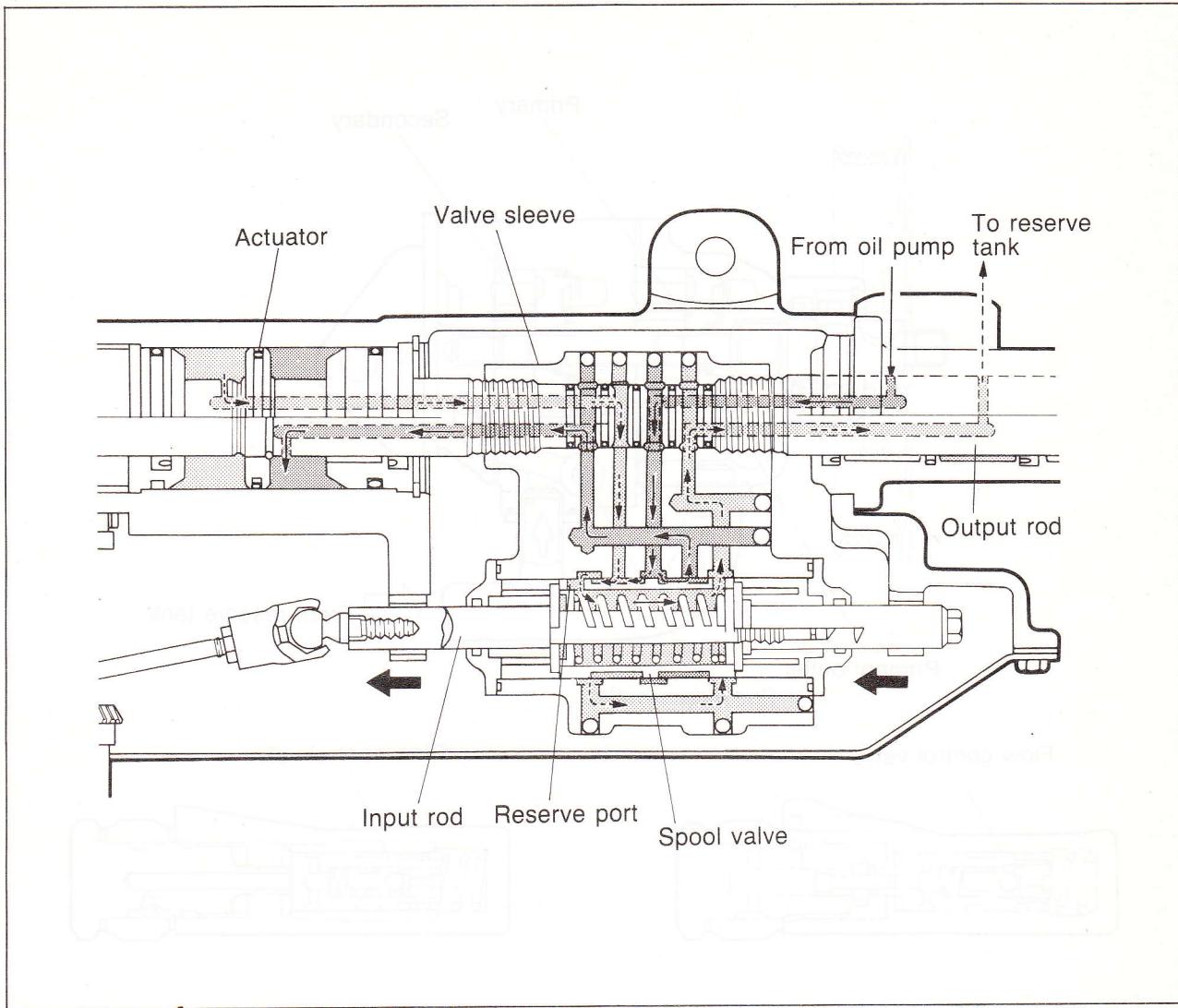
CONTROL VALVE

POWER CYLINDER



86U10X-527

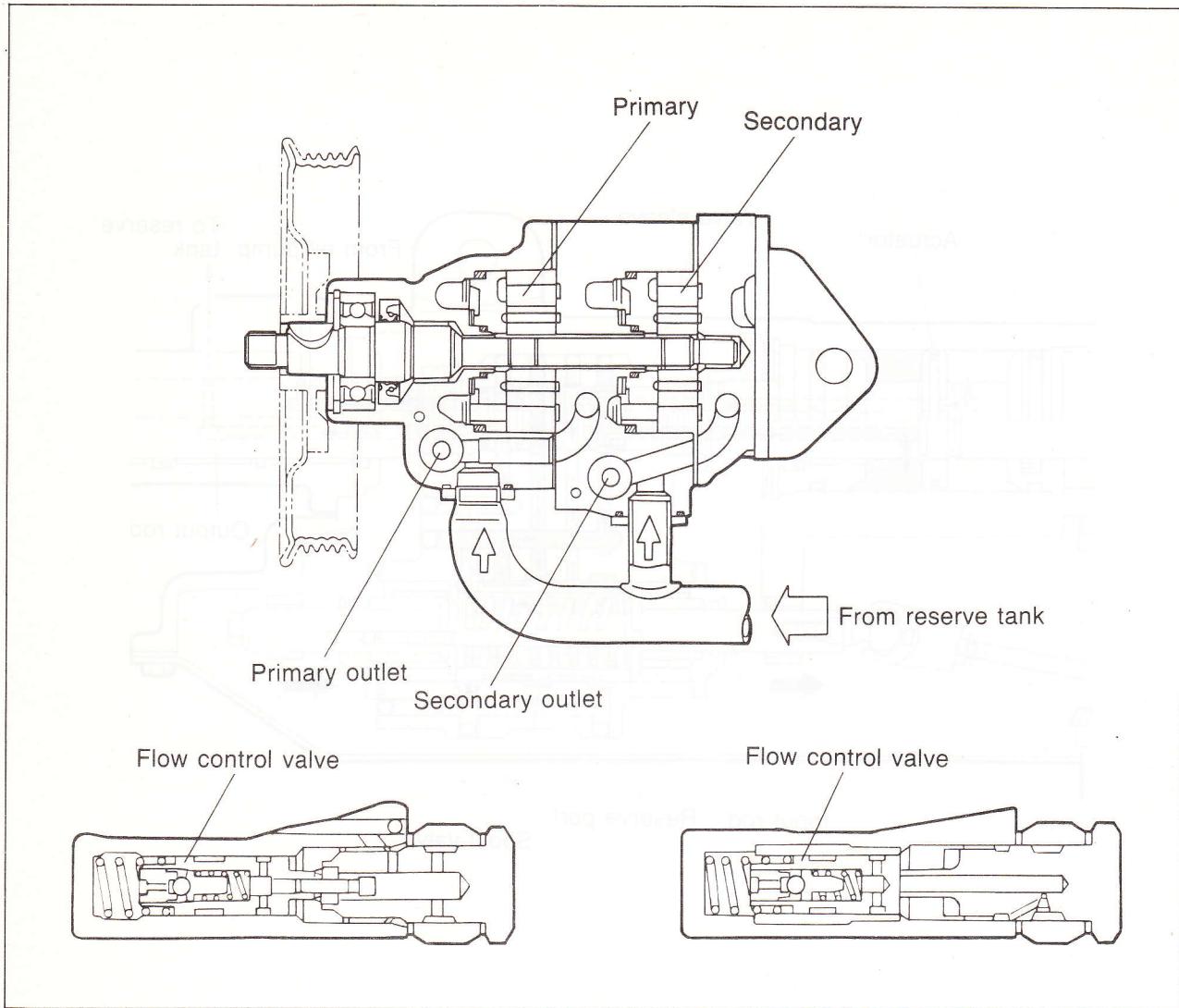
The main parts of the control valve are the input rod, spool valve, valve sleeve, and the output rod. When the control valve input rod is stationary, the spool valve is in the neutral position of the valve sleeve. Oil pressure from the power steering oil pump passes by the spool valve and returns to the pump reserve tank. Oil also flows to both sides of the actuator, holding the output rod in position; not allowing the rear steering angle to change.



86U10X-528

When the control valve input rod moves to the left it also moves the spool valve to the left. The output rod does not move at this time due to the load on the rear wheels and the action of the self-centering spring. As the spool valve moves it opens the ports, allowing oil pressure from the pump to flow to the right side of the actuator and oil to flow from the left side of the actuator to the reserve tank. This pressure difference causes the output rod (and valve sleeve) to move to the left, turning the rear wheels to the right.

OIL PUMP



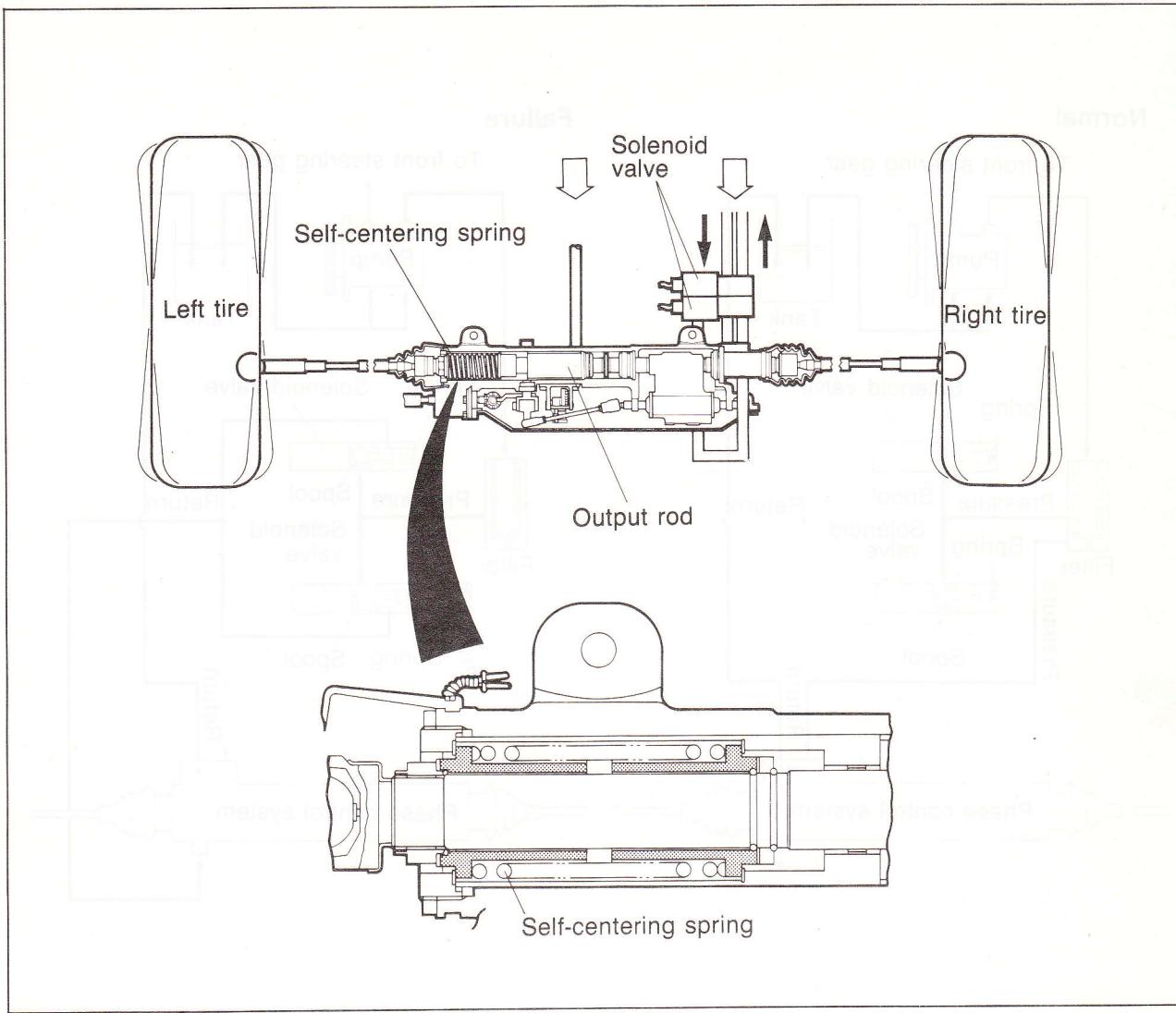
86U10X-529

The oil pump is a belt driven, vane type, tandem oil pump with a remote reserve tank. The pump construction is basically the same as that of the 626 2WS vehicle.

One section of the pump provides oil pressure to the front steering system and the other to the rear steering system. Both sections are equipped with flow control valves (shown in the figure above) for securing a constant oil flow.

FAIL-SAFE SYSTEM

2WS ELECTRIC POWER STEERING



86U10X-530

A fail-safe system is used for safety in the event of a system failure.

Function

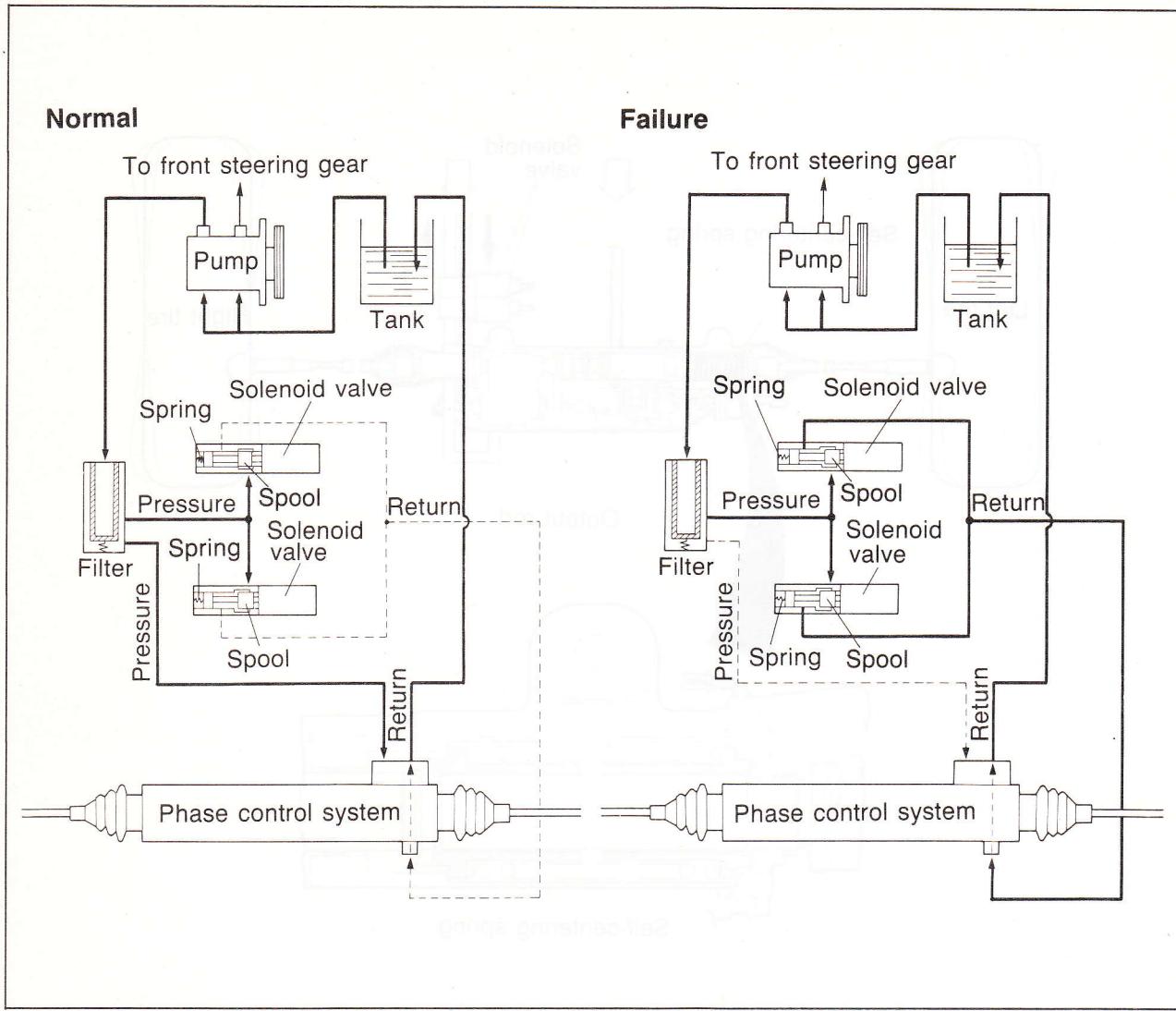
- 1) Ensures 2WS (rear wheels fixed in straight-ahead position) in case of an electrical or hydraulic system failure.
- 2) Provides warning to the driver via a warning light in the instrument panel in the event of an electrical failure.
- 3) An oil level sensor is provided in the reserve tank. The warning light warns the driver when the amount of oil falls below that required.
- 4) Mechanically ensures safety equal to that of a conventional 2WS system.

Oil pressure defects

The rear steering is locked in the straight-ahead position and 2WS is assured if there is a drop in the rear steering system oil pressure due to oil leakage, pump failure, or a broken drive belt. When there is no oil pressure acting on the output rod, the self-centering spring holds the rod centered in the power cylinder.

SOLENOID VALVE

MITSUBISHI TRACTOR



86U10X-531

The 4WS system has two solenoid valves for the electrical fail-safe system. The reason two valves are used is that if one fails the other works as a back-up. They operate as follows:

Normal

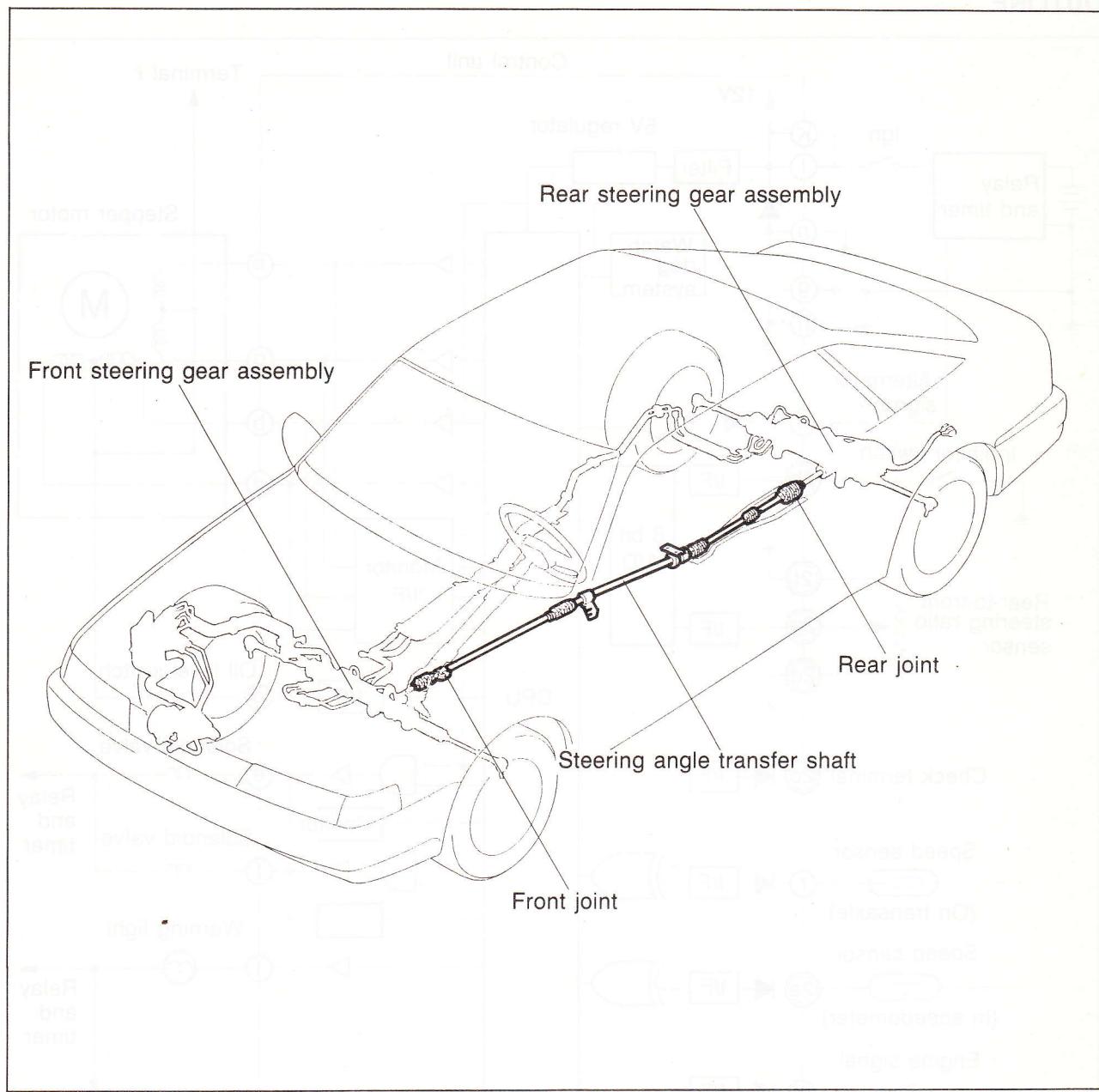
While the ignition switch is on, current passes through the coil and the plunger moves the spool; overcoming the force of the return spring. Since the hydraulic circuit between the pressure and return line in the valve is closed, normal pressure is generated in the power cylinder.

Failure

When the control unit detects an electrical failure and sends a failure signal to the solenoid valve, current to the coil is cut and the spool is returned by the return spring. As a result, the hydraulic circuit in the valve is opened and pressure in the power cylinder becomes zero.

If the control unit senses that the problem is intermittent, it cuts the voltage through the coil; the spool is returned by the return spring and the hydraulic circuit is opened.

SERVICE POINTS
Adjustment of Steering Angle Transfer Shaft



86U10X-539

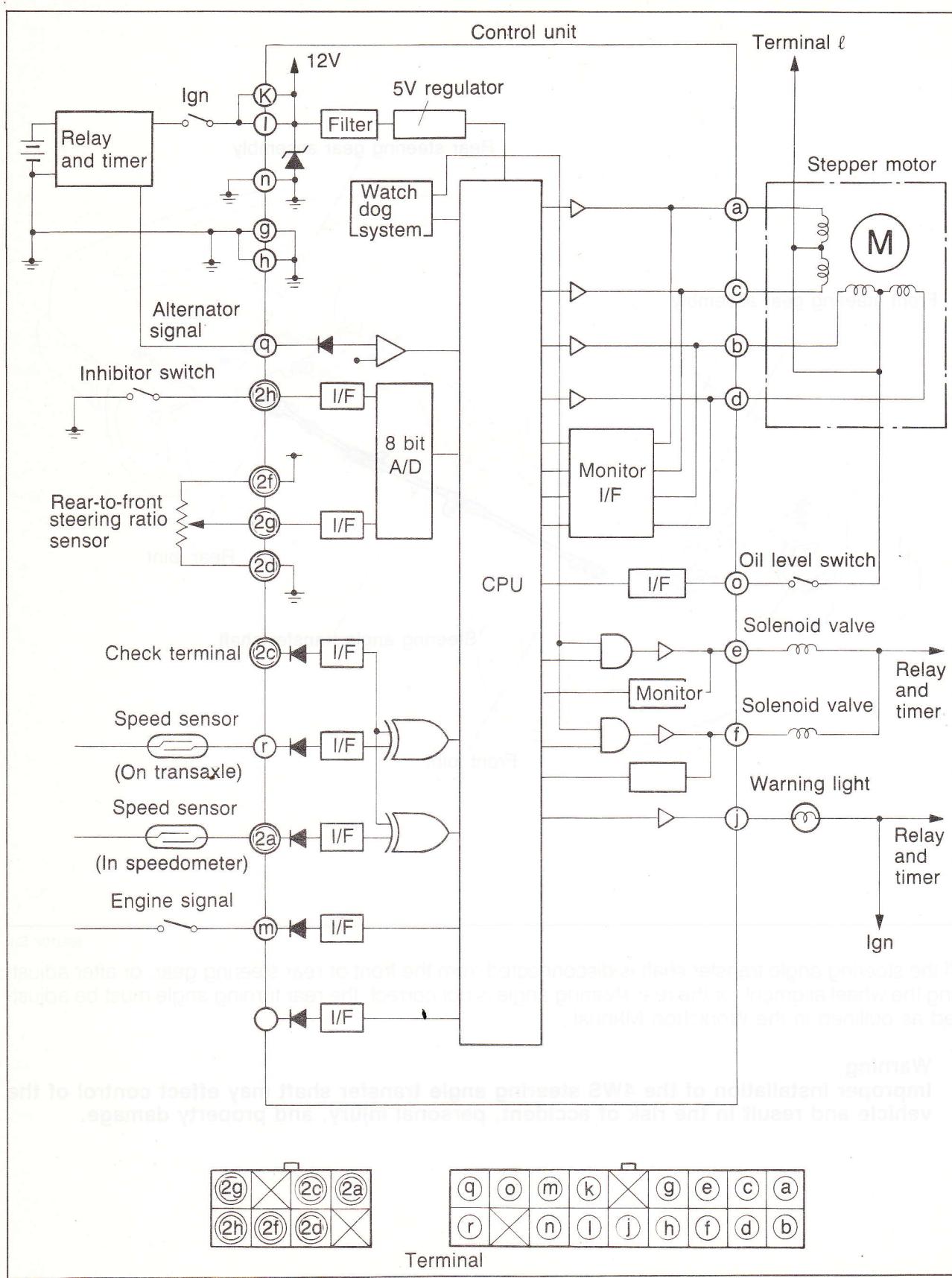
If the steering angle transfer shaft is disconnected from the front or rear steering gear, or after adjusting the wheel alignment, or the rear steering angle is not correct, the rear turning angle must be adjusted as outlined in the Workshop Manual.

Warning

Improper installation of the 4WS steering angle transfer shaft may effect control of the vehicle and result in the risk of accident, personal injury, and property damage.

ELECTRICAL SYSTEM FOR 4WS

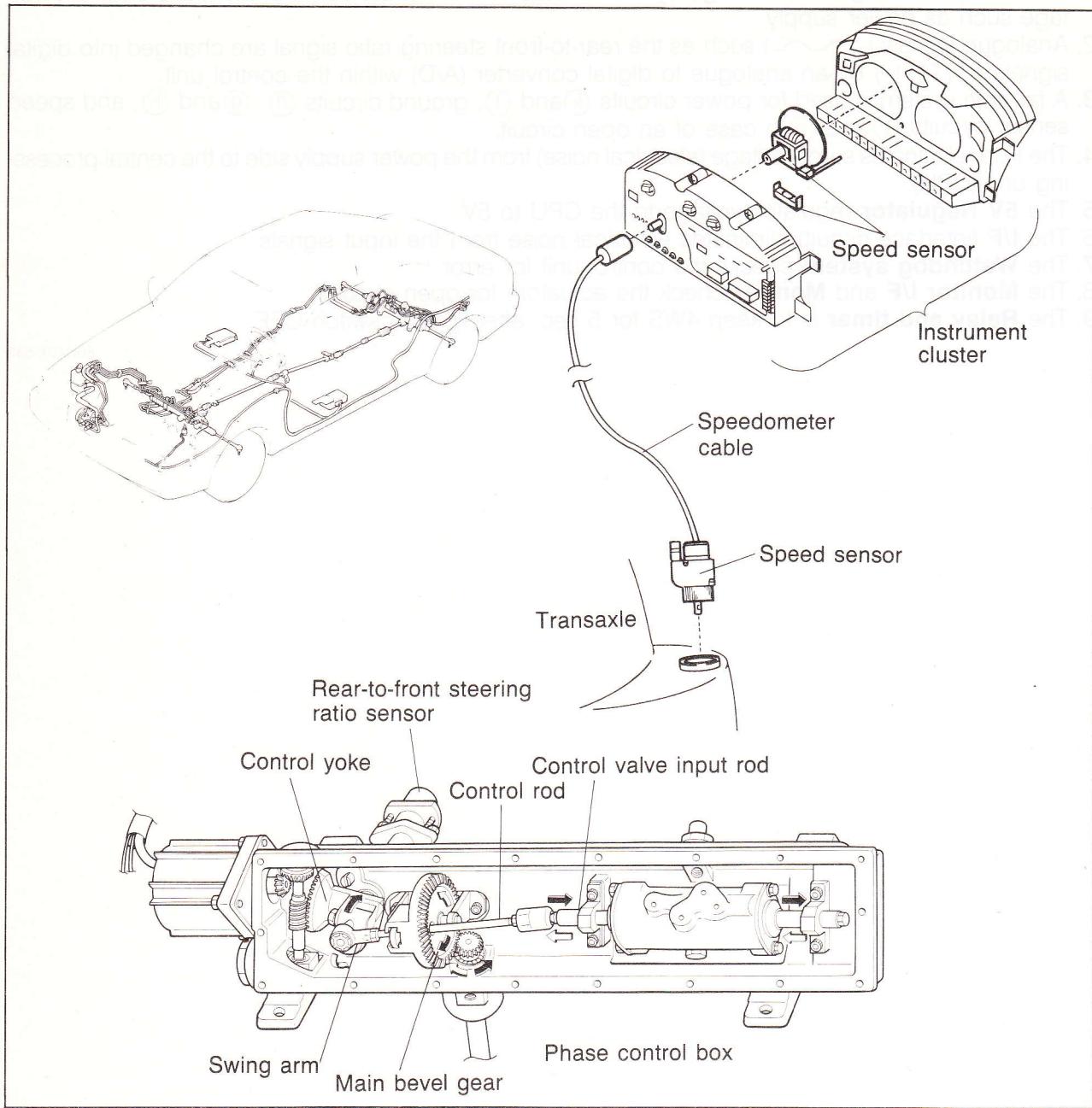
OUTLINE



1. All of the input signals—power, rear-to-front steering ratio, oil level, and gear position—are converted into electrical signals or voltage by the sensors and switches. Some of them are originally voltage such as power supply.
 2. Analogue signals (~~~~) such as the rear-to-front steering ratio signal are changed into digital signals (□□□□□) by an analogue to digital converter (A/D) within the control unit.
 3. A fail-safe system is used for power circuits (k) and (l), ground circuits (n), (g) and (h), and speed sensor circuits (r) and (s) in case of an open circuit.
 4. The Filter eliminates surge voltage (electrical noise) from the power supply side to the central processing unit (CPU).
 5. The **5V Regulator** regulates voltage to the CPU to 5V.
 6. The **I/F** (interface circuit) eliminates electrical noise from the input signals.
 7. The **Watchdog system** checks the control unit for error.
 8. The **Monitor I/F** and **Monitor** check the actuators for open circuits.
 9. The **Relay and timer** is to keep 4WS for 5 sec. after ignition switch OFF.

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CONTROL UNIT AND SPEED SENSORS



86U10X-533

Control unit

Based on signals from the rear-to-front steering ratio sensor and the speed sensor, the control unit operates the stepper motor to achieve the rear-to-front steering ratio and rear steering phase.

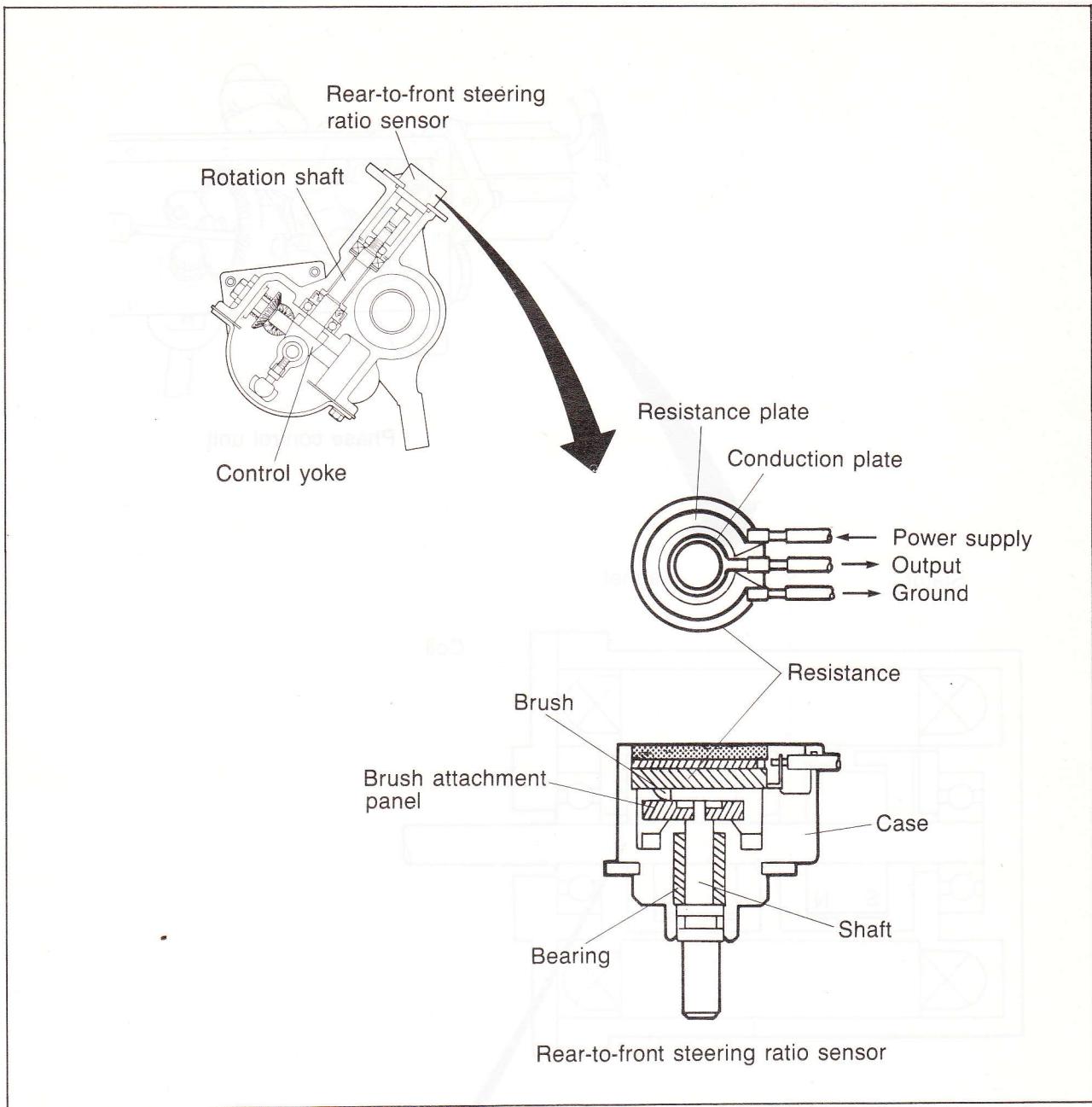
Speed sensors

The vehicle has two speed sensors; the main one inside the instrument cluster, and the other at the transaxle as a back-up.

The sensors detect speedometer cable rotation, and send signals to the control unit.

REAR-TO-FRONT STEERING RATIO SENSOR

ROTOM REPREZ



86U10X-534

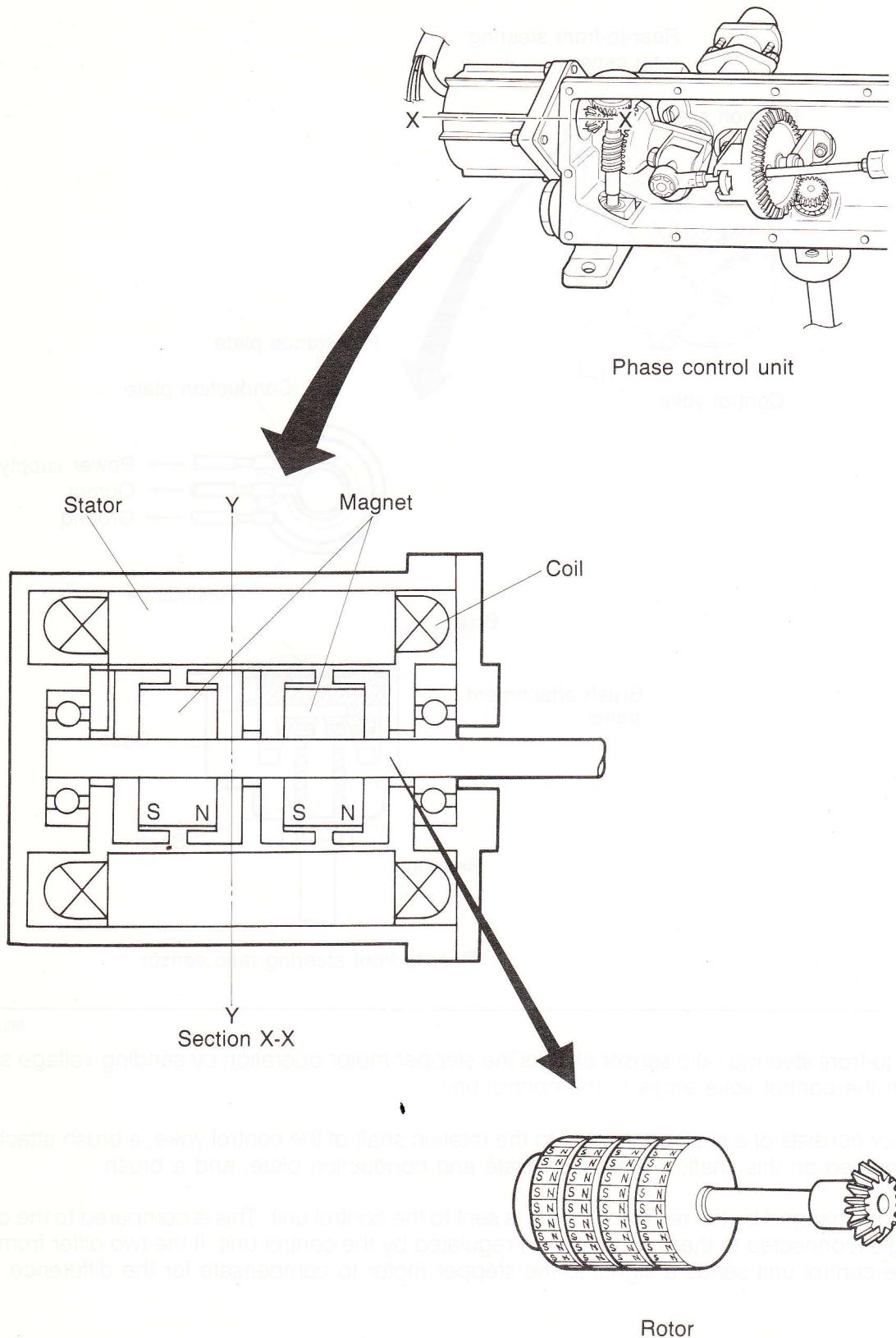
The rear-to-front steering ratio sensor checks the stepper motor operation by sending voltage signals based on the control yoke angle to the control unit.

The sensor consists of a shaft connected to the rotation shaft of the control yoke, a brush attachment panel mounted on this shaft, a resistance plate and conduction plate, and a brush.

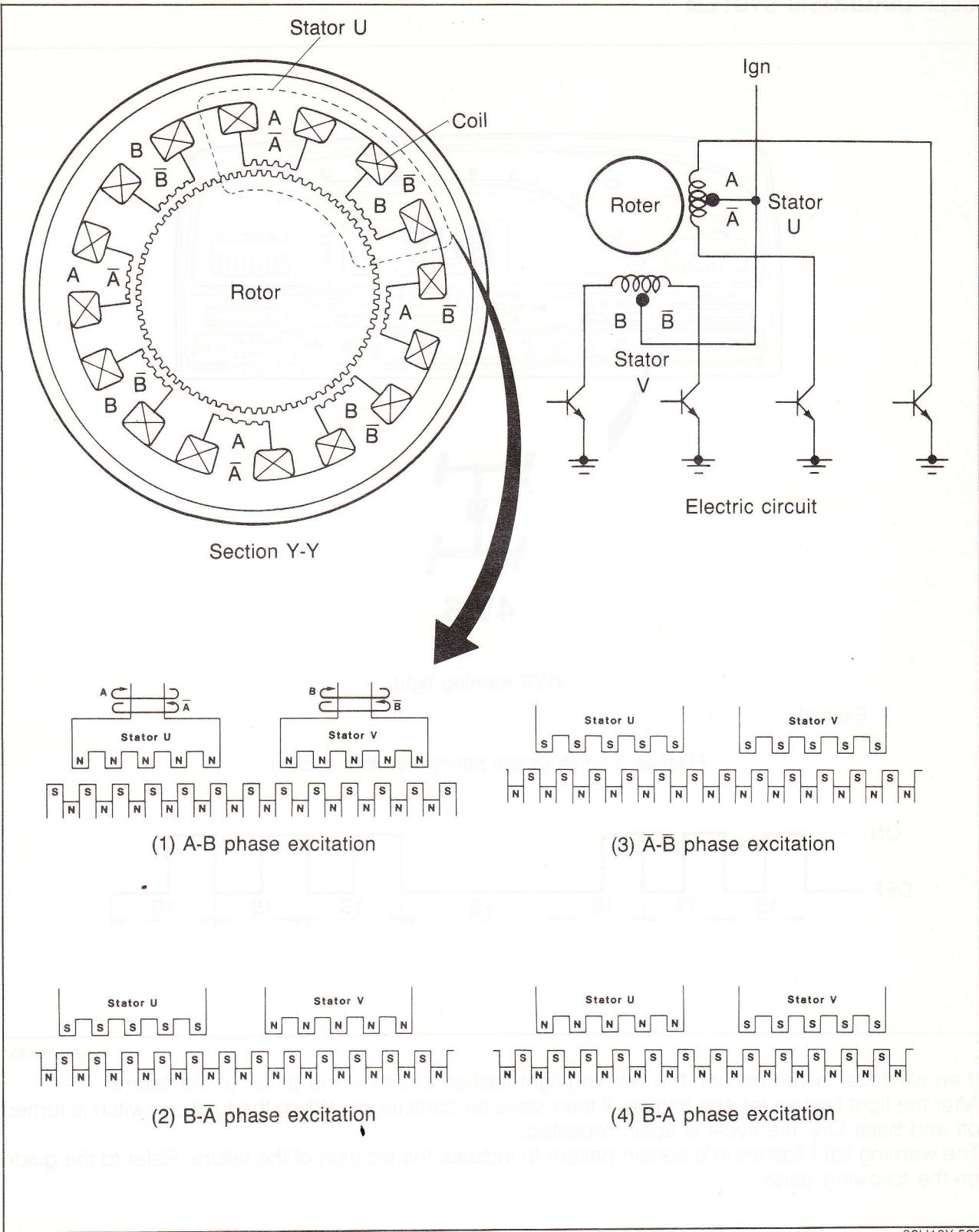
The voltage changed by the resistance plate is sent to the control unit. This is compared to the control yoke angle (connected to the stepper motor) regulated by the control unit. If the two differ from each other, the control unit sends a signal to the stepper motor to compensate for the difference.

STEPPER MOTOR

TRINAMIC GUITAR SURFACE THICK-OT-PAGE



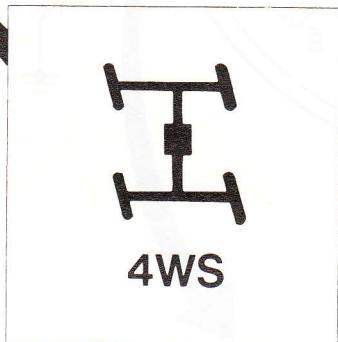
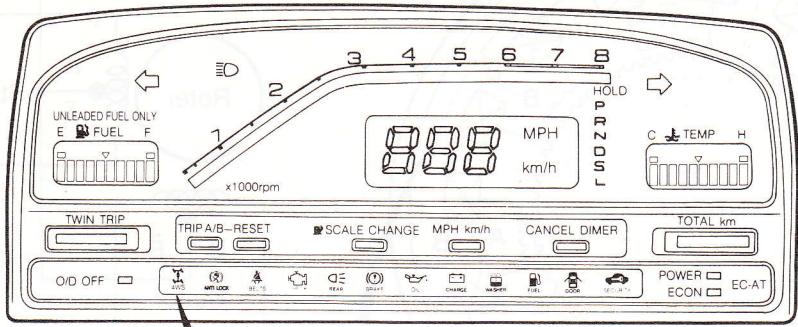
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The stepper motor consists of a coil, stator, and rotor with two magnets.

Current flowing to the coil magnetizes stator. The rotor rotates by the attracting or repelling of magnets. The rotor rotates clockwise when phase excitation is made (1) → (2) → (3) → (4), counterclockwise when (4) → (3) → (2) → (1).

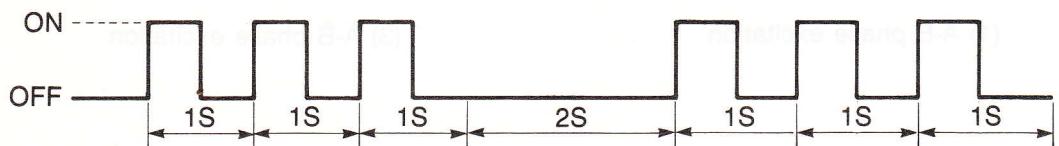
SELF-DIAGNOSIS SYSTEM



4WS warning light

Example:

Flashes 3 times (3 sec period between cycles)



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If an electrical failure occurs, the warning light flashes to inform the driver of the failure.

After the light flashes for one minute, it then stays on continuously. When the ignition switch is turned off and back ON, the cycle is again repeated.

The warning light flashes in a certain pattern to indicate the location of the failure. Refer to the guide on the following page.

Item		Check timing		Warning light	Reaction to failure
		Ign ON	Driving		
Speed sensor	Speed sensor in speedometer	—	*	Flashes 1 time (2 sec. period between cycles)	2WS
	Speed sensor on transaxle	—	*		
	Difference between above sensors	—	*		
Phase control system	Mis-stepping (Out of phase)	—	*	Flashes 2 times	
Solenoid valve	Wiring circuit	*	*	Flashes 3 times	
Stepper motor	Wiring circuit	*	*	Flashes 4 times	2WS
	Operation	—	*		
Rear-to-front steering ratio sensor	Output	*	*	Flashes 5 times	
	Standard position	*	*	Flashes 6 times	
Power steering fluid	Level	*	*	Flashes 7 times	
Control unit	Program	*	*	Flashes 8 times	4WS after computer reset
	Memory	*	*		
	Conversion from analogue to digital values	*	—		
	Computer error	*	*	OFF	
Power supply	Battery voltage	—	*	Stays ON	2WS

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Note

After repairing a failure, turn off the ignition switch to cancel the warning light operation.