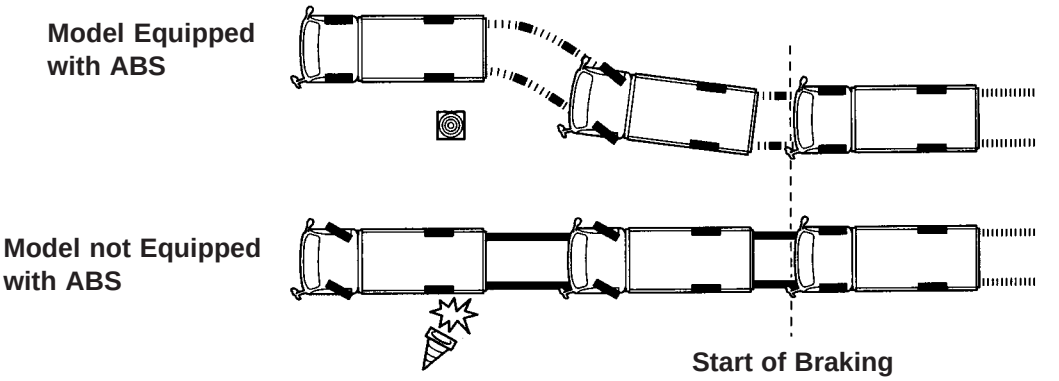
■ ABS AND BRAKE ASSIST FUNCTION

1. General

- The fundamental requirement for a vehicle to drive, turn, and stop is that the tires grip the road surface and realize their function. When braking suddenly, however, or when braking on snowy, wet, or other slippery road surfaces, the wheels may lock and the tires lose their grip even though the vehicle is still moving. The anti-lock brake system (ABS) detects the vehicle wheel speed when the brakes are applied on a slippery road surface, and uses computer control to regulate the brake fluid pressure supplied to each wheel. The ABS keeps the wheels from locking and secures adequate braking performance.

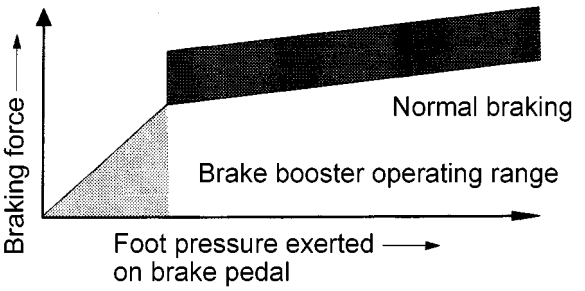


CAUTION

- The ABS cannot get tires to perform beyond what they are capable of doing. Even with antilock brakes equipped in your vehicle, you must watch your speed, maintain a safe distance between vehicles, and drive safely.
- In the following cases, anti-lock brakes may require a longer stopping distance than normal brakes.
  - When driving on a gravel road or a road with freshly fallen snow
  - When tire chains are mounted on the tires
  - When driving on a broken or uneven road surface
  - When driving on a rough road or a cobblestone road.
- Use of tires not of the designated size or of equipment not within specifications may adversely affect the ABS operation.
- After starting the engine or starting to drive, you may hear a motor noise when the computer initiates the ABS initial check; also, during the initial check, the brake pedal action may feel heavier than normal. These phenomena are both normal and do not represent a malfunction.

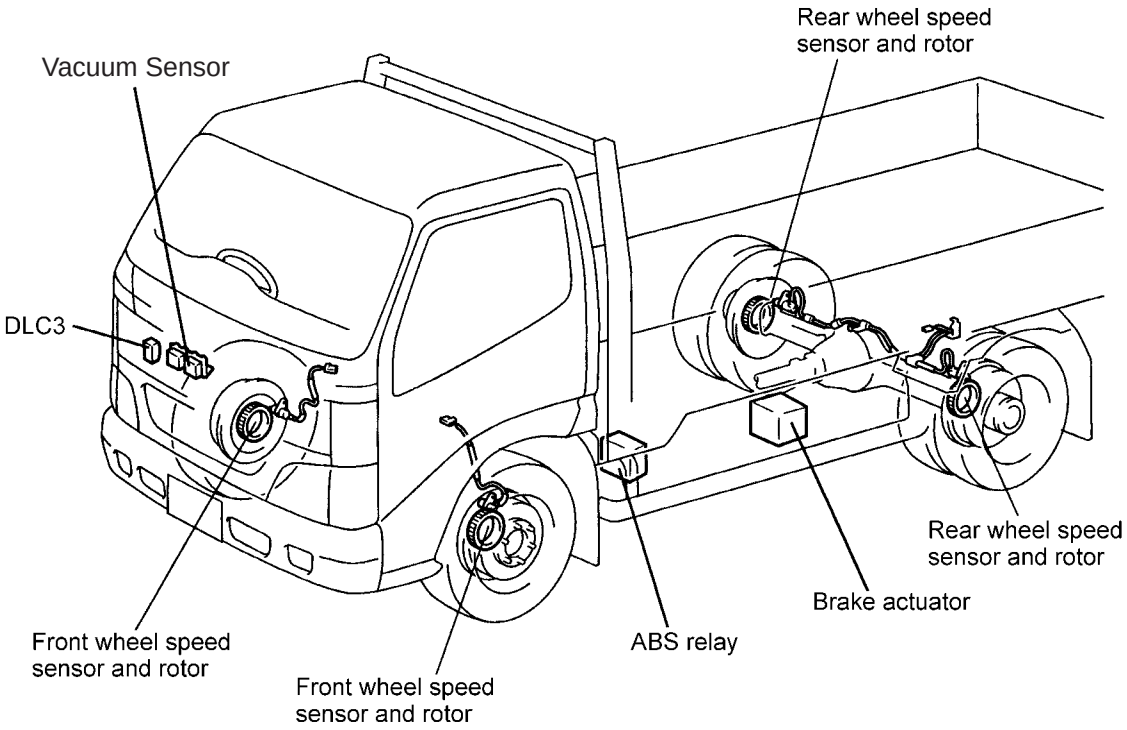
2. Overview of Brake Assist Function

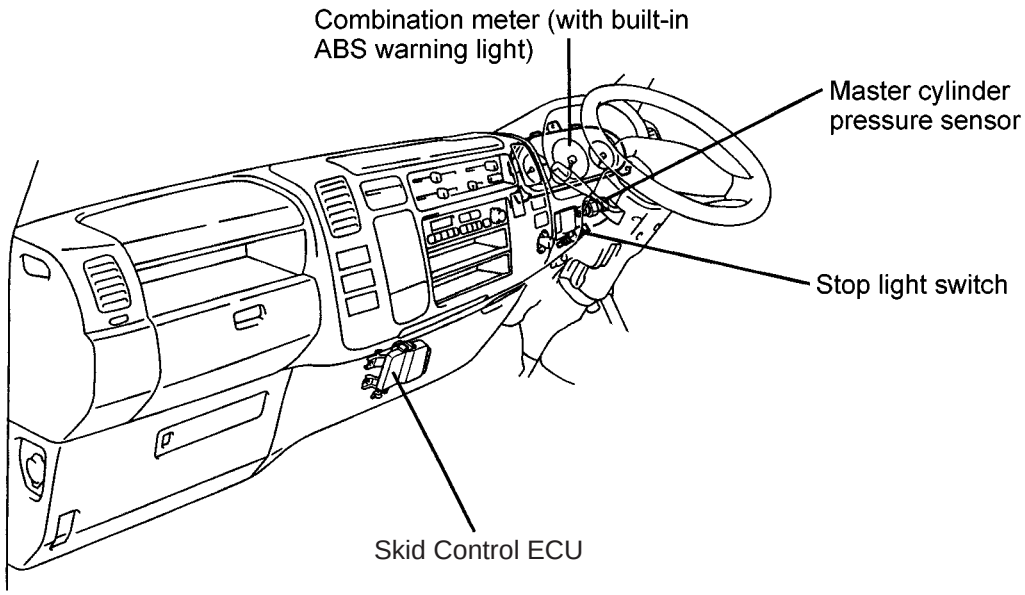
- This function is activated when the brake booster boosting effect deteriorates or its servo action is used up for whatever reason. The purpose of the function is to pressurize the brake fluid and secure the required braking performance.



3. System Components

- The ABS is a 4-sensor, 4-channel system that independently controls the brake fluid pressure applied to each wheel.
- The brake assist function is controlled by signals from a vacuum sensor and master cylinder pressure sensor, which were added to a conventional ABS.
- A fail safe function is activated in the event of a system malfunction, and a full range of diagnostic functions were provided for serviceability.





▶ Main System Components and Functions ◀

Wheel speed sensor	Detects the speed of each wheel and inputs the data into the skid control ECU.
Master cylinder pressure sensor	Detects the master cylinder pressure and inputs the data into the skid control ECU.
Vacuum sensor	Detects the pressure in the brake booster constant-pressure chamber and inputs the data into the skid control ECU.
Stop light switch	Detects brake pedal operation and inputs the data into the skid control ECU.
Brake warning light	Warns the driver of malfunction in the brake assist function (combined brake fluid low level warning, PKB light, and vacuum loss warning)
ABS warning light	Warns the driver of malfunction in the ABS.
Brake actuator	Controls the brake fluid pressure applied to each wheel according to signal output by the skid control ECU.
ABS solenoid relay	Supplies power to the brake actuator solenoid valve.
ABS motor relay	Supplies power to the brake actuator pump motor.
Skid control ECU	Outputs control signals to the brake actuator according to signals received from the wheel speed sensor, master cylinder pressure sensor, and vacuum sensor.

4. Construction and Operation

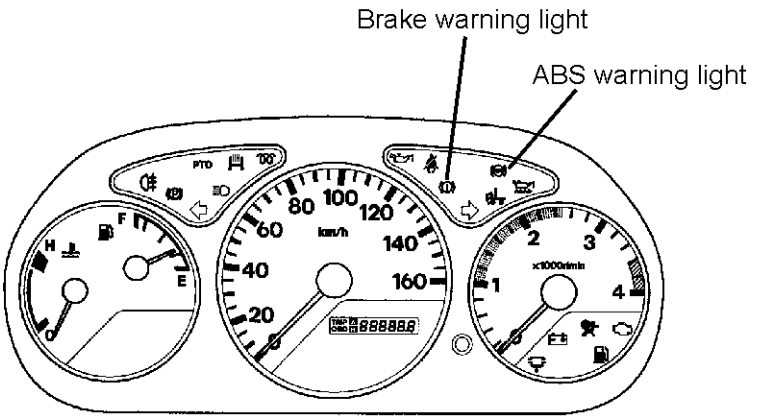
[1] Warning Lights

1) ABS Warning Light

When the ABS malfunctions, the ABS warning light comes on to warn the driver. Also, the diagnosis codes for the ABS and the brake assist function are displayed. To confirm that the warning light bulb has not burnt out, the light comes on for 3 seconds when the ignition switch is turned on and then goes out.

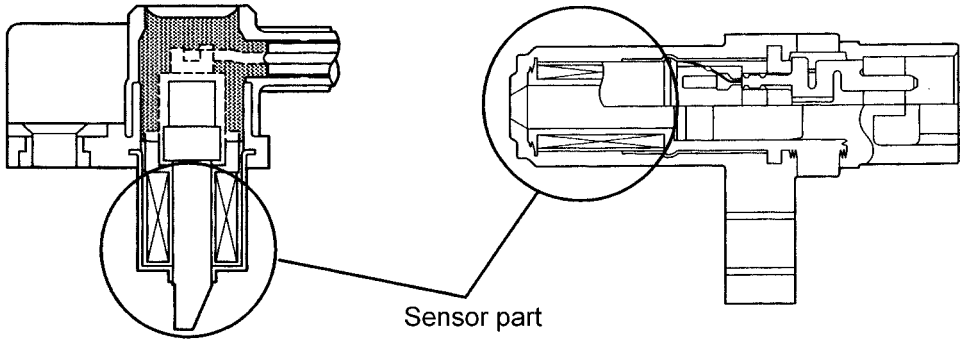
2) Brake Warning Light

The warning light comes on when the parking brake is normally engaged, when the brake fluid level is too low, when the brake booster pressure drops off, or when the brake assist function stops working. To confirm that the warning light bulb has not burnt out, the light comes on for 3 seconds when the ignition switch is turned on and then goes out.



[2] Front and Rear Wheel Speed Sensors and Rotors

The front wheel speed sensors are installed on the steering knuckle and the sensor rotors on the front axle hubs, and the rear wheel speed sensors are installed on the rear housing end and the sensor rotors on the rear axle hubs.



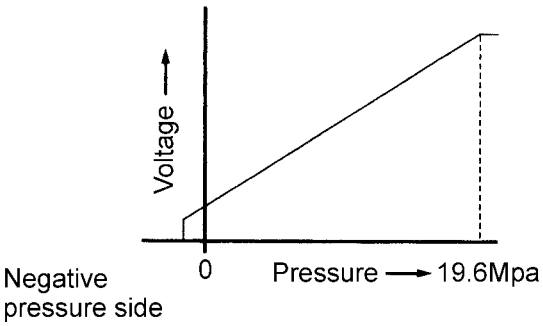
Front Wheel Speed Sensor Cross Section **Rear Wheel Speed Sensor Cross Section**

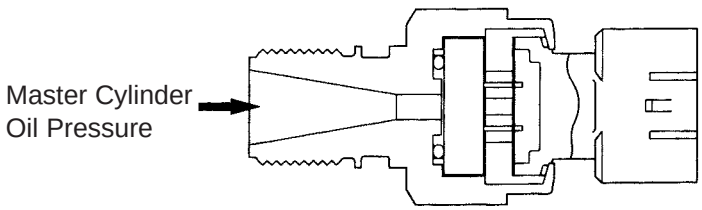
[3] Vacuum Sensor

The vacuum sensor is installed in the vacuum piping, and its output characteristics vary in proportion to the pressure.

[4] Master Cylinder Pressure Sensor

The master cylinder pressure sensor is installed in the master cylinder, and its output characteristics vary in proportion (2) the pressure.

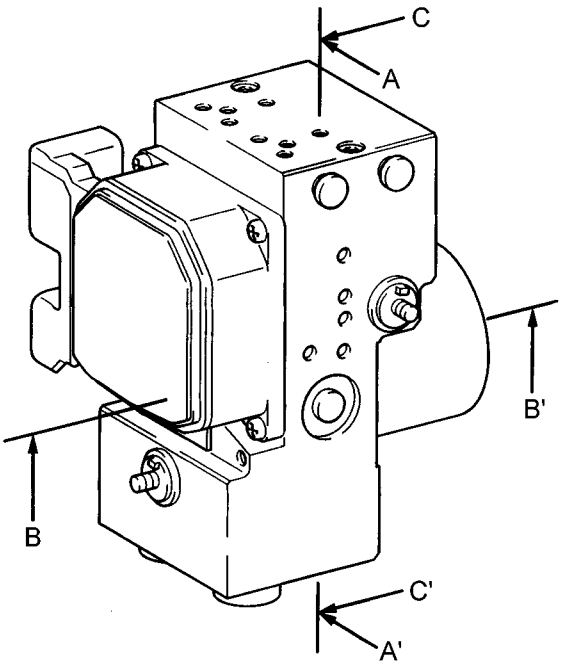




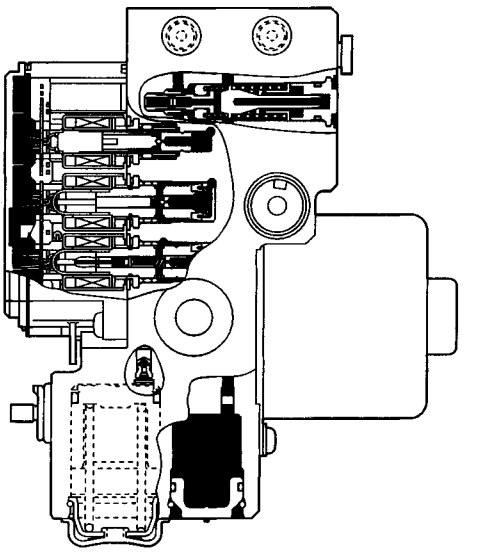
Output Characteristics **Master Cylinder Pressure Sensor Cross Section**

[5] Brake Actuator

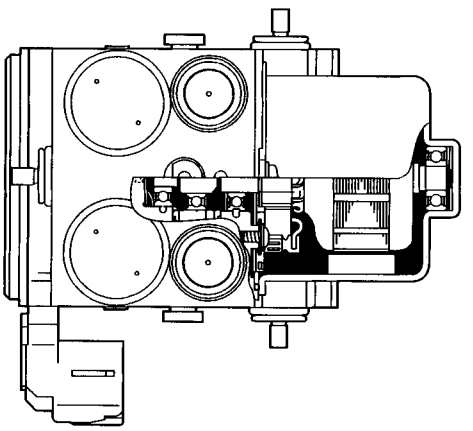
The brake actuator is comprised of 2 master cylinder cut solenoid valves, 2 reservoir cut solenoid valves, 4 pressure holding solenoid valves, 4 pressure reducing solenoid valves, 2 pressure regulating valves, a pump, and a reservoir. It controls the wheel cylinder oil pressure according to control signals from the skid control ECU.



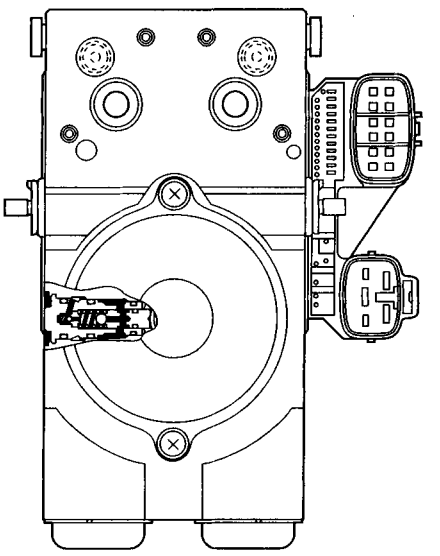
Brake Actuator External Appearance



A-A' Cross Section

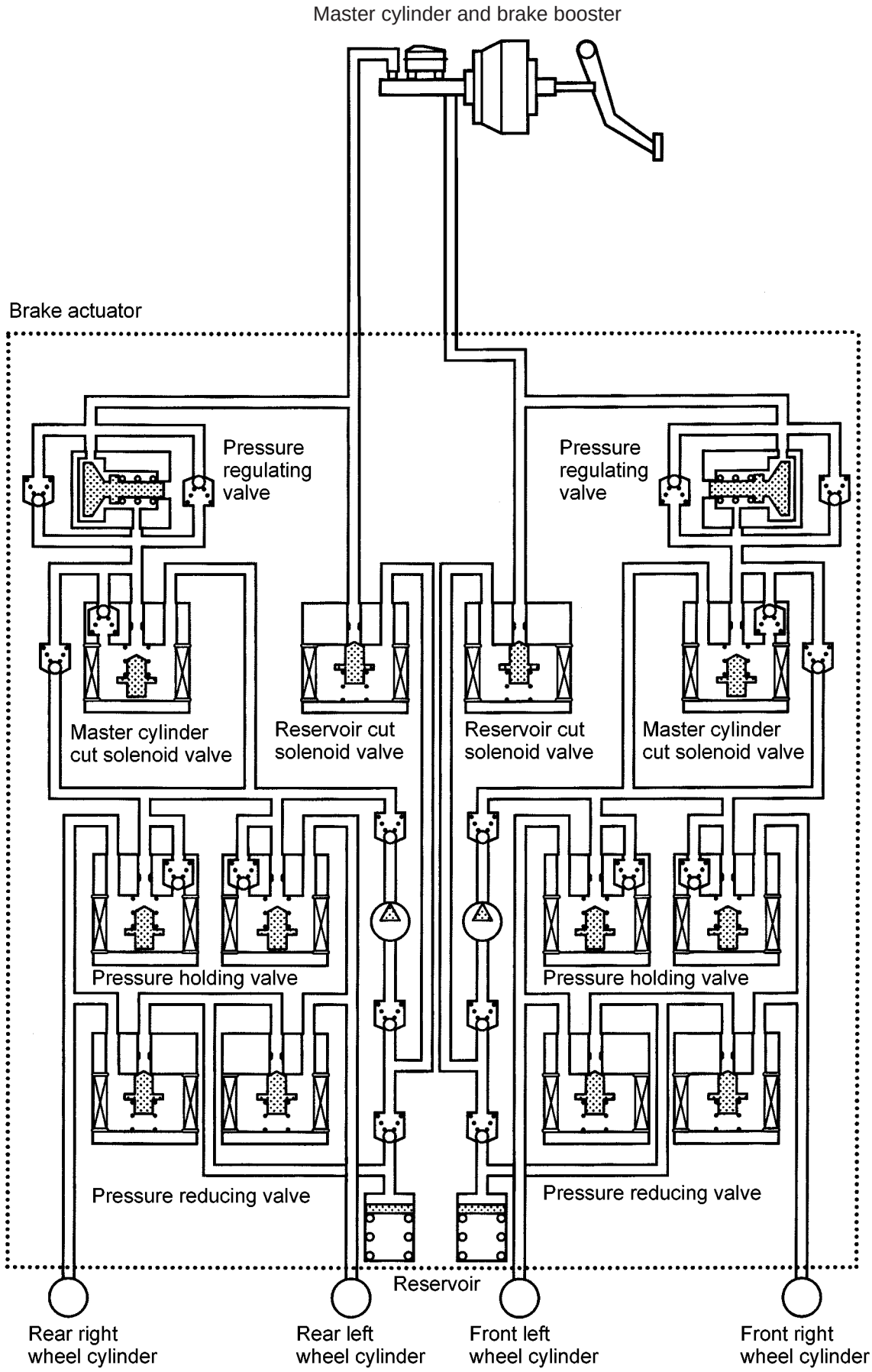


B-B' Cross Section



C-C' Cross Section

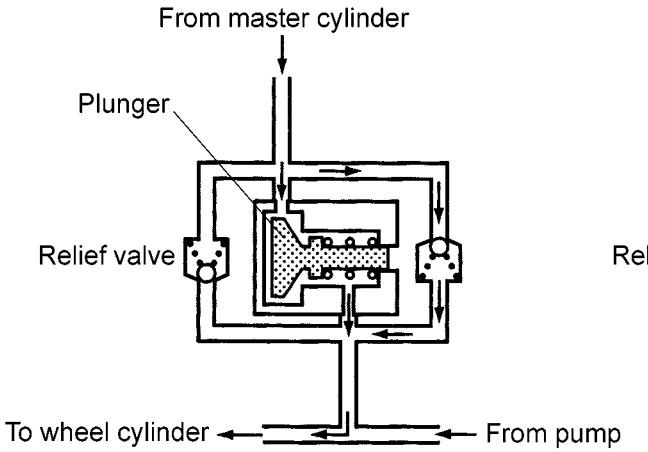
▶ Piping Layout ◀



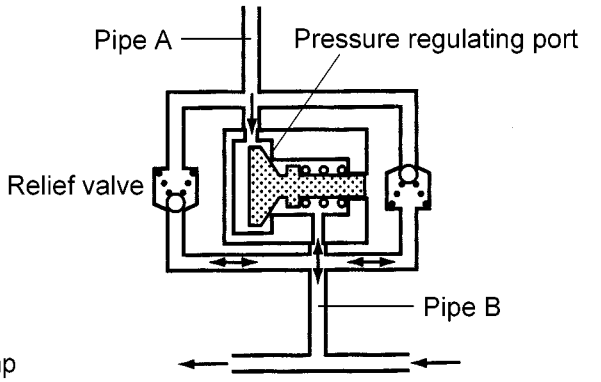
CH

1) Pressure regulating valve

When the braking force assist control (high G force assist control) is working under normal driving conditions, the action of the pressure regulating valve adjusts the pressure applied to the wheel cylinders. When brake fluid is supplied from the pump, the pressure regulating port is opened or closed so that the pressure upstream (pipe A) and downstream (pipe B) from the plunger is balanced by the valve spring force. The wheel cylinder pressure is raised above the master cylinder pressure, and then it is adjusted again to the prescribed pressure for the master cylinder pressure, accompanying the action of the relief valve.



During normal operation



During brake line pressurizing control

2) Master cylinder cut and reservoir cut solenoid valves

Open or close during brake line pressure control according to control signals from the skid control ECU, switching brake fluid routes.

3) Control solenoid valve

Opens or closes according to control signals from the skid control ECU, switching brake fluid routes. Two solenoid valves are used in combination to switch between pressure increasing, pressure holding, and pressure reducing modes.

4) Reservoir

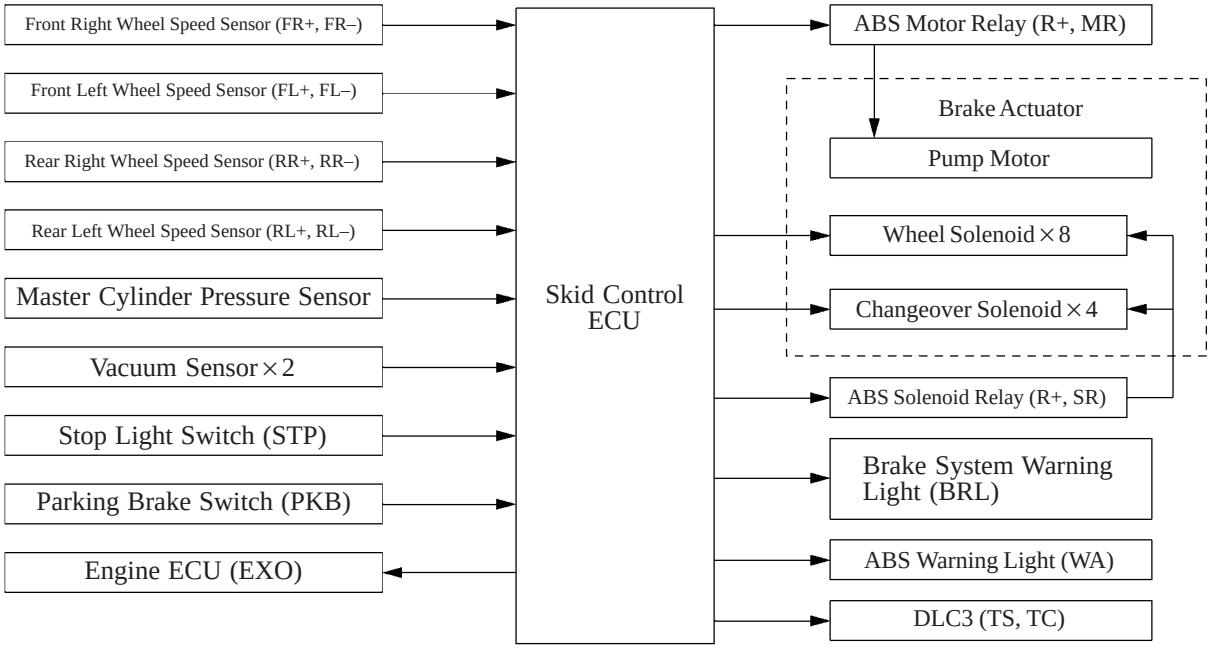
Stores brake fluid from the wheel cylinders when the control solenoid valves are operating in pressure reducing mode.

5) Pump

Driven by cam on the end of shaft inside pump motor; pumps up brake fluid stored in the reservoir according to signals from the skid control ECU.

[6] Skid Control ECU

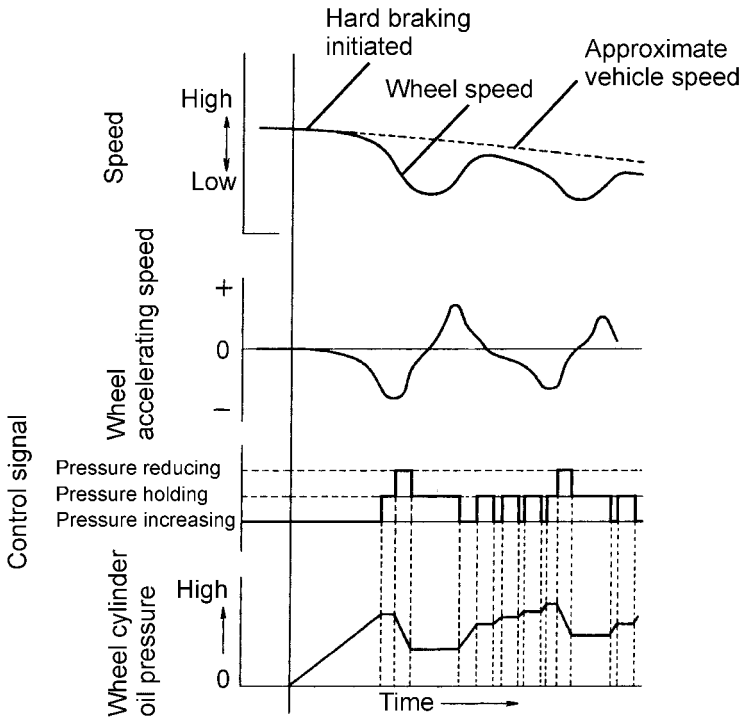
Outputs control signals to brake actuator according to signals from the various sensors.
Equipped with an initial check function and a system diagnosis function for serviceability.



219CH06

1) Wheel speed control

The skid control ECU uses signals from the four wheel speed sensors to compute the rotating or accelerating speed of each wheel independently and determine if any of the wheels are slipping. Depending on the conditions determined, the ECU outputs control signals to the brake actuator solenoid valves, activating the desired operational mode (pressure increasing, pressure holding, or pressure reducing mode).



2) Initial check function

Electrically checks the operation of each brake actuator solenoid valve and motor in sequence after the ignition switch is turned on and the vehicle reaches a speed of about 6km/h. During the initial check, the motor in the brake actuator will emit an operating sound. This is normal and does not indicate a malfunction. The initial check will not run if the brake pedal is depressed, but it will start as soon as the brake pedal is released.

3) Diagnostic functions

a. System trouble warning function

The ABS warning light in the combination meter comes on to warn the driver when there is a malfunction in the skid control ECU signal system.

b. Diagnosis display function

In diagnosis mode, the diagnosis results can be read from the ABS warning light flashing pattern.

▶ Diagnosis Codes ◀

DTC No.	Detection Item	DTC No.	Detection Item
11	Open circuit in ABS solenoid relay circuit	31	Right front wheel speed sensor signal malfunction
12	Short circuit in ABS solenoid relay circuit	32	Left front wheel speed sensor signal malfunction
13	Open circuit in ABS motor relay circuit	33	Right rear wheel speed sensor signal Malfunction
14	Short circuit in ABS motor relay circuit	34	Left rear wheel speed sensor signal malfunction
21	Open or short circuit in right front solenoid circuit	41	Low battery voltage
22	Open or short circuit in left front solenoid circuit	46	Malfunction in master cylinder pressure sensor
23	Open or short circuit in right rear solenoid circuit	49	Open circuit in stop light switch circuit
24	Open or short circuit in left rear solenoid circuit	51	• Pump motor is locked • Open circuit in pump motor ground
25	Open or short circuit in SMC circuit	65	Malfunction in vacuum sensor
27	Open or short circuit in SRC circuit	66	Malfunction in exhaust retard prevention signal circuit

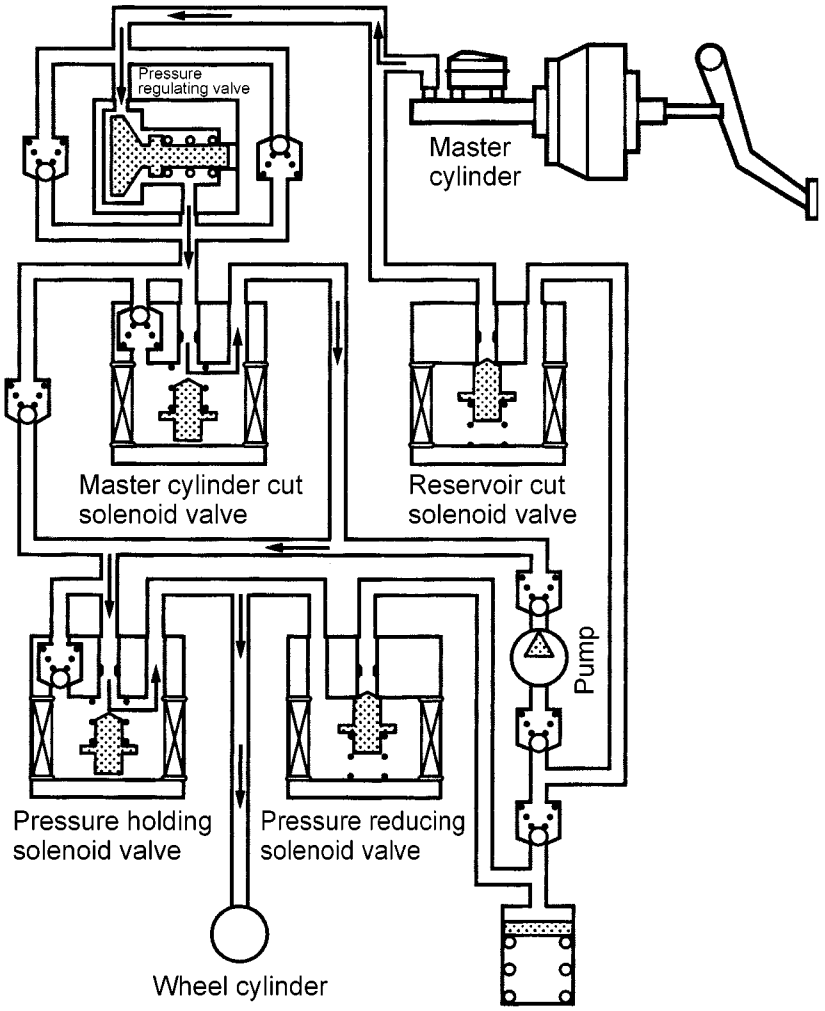
4) Fail safe function

Turns off solenoid relay supplying power to the brake actuator (and illuminates warning light) when there is a malfunction in the skid control ECU signal system, brake actuator system, or the skid control ECU unit. The normal braking function is secured at this time even though the ABS is not operating.

[7] System operation

1) During normal braking

When the master cylinder oil pressure rises, brake fluid is supplied from the pressure regulating valve to the master cylinder cut solenoid valve to the pressure holding solenoid valve to the wheel cylinder.



Brake fluid route (During normal braking)

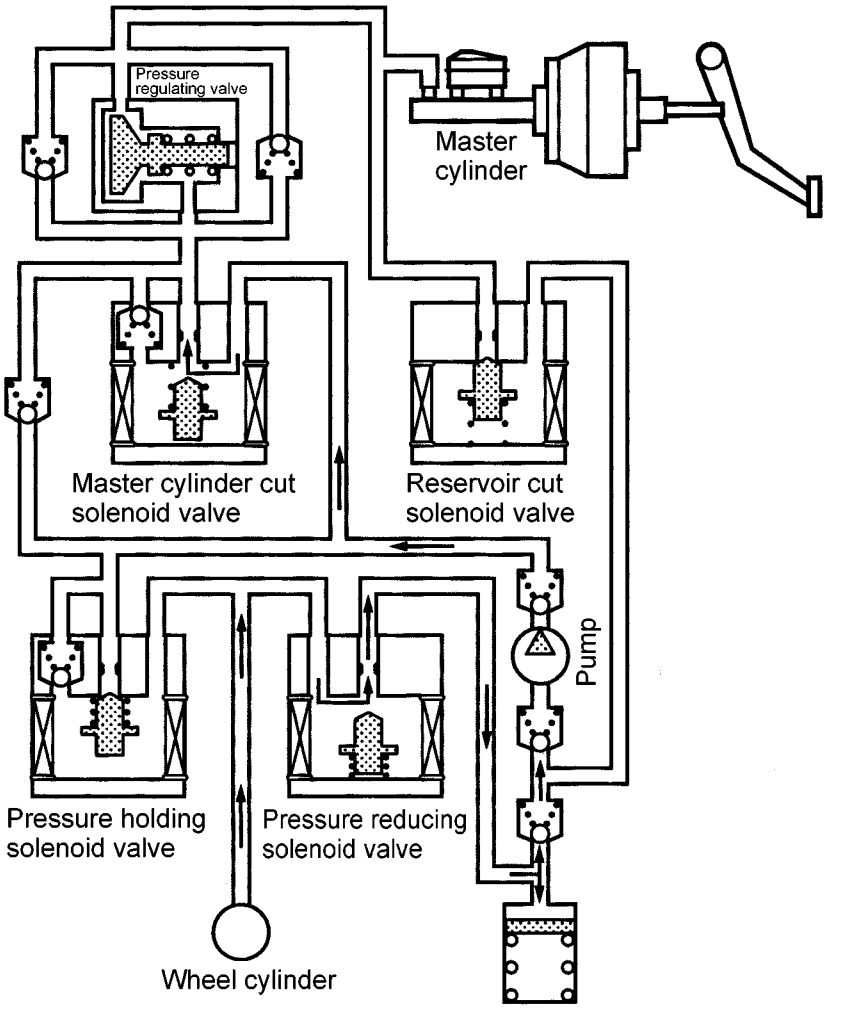
▶ Valve Operation ◀

	Control signal	Port status
Pressure regulating valve	—	Open
Master cylinder cut solenoid valve	OFF	Open
Reservoir cut solenoid valve	OFF	Closed
Pressure holding solenoid valve	OFF	Open
Pressure reducing solenoid valve	OFF	Closed

2) During hard braking (during ABS operation)

a. Pressure reducing mode

When the wheels are about to lock, signals from the skid control ECU close the pressure holding solenoid valve and open the pressure reducing solenoid valve. This causes brake fluid to pass through the pressure reducing solenoid valve and flow into the reservoir, reducing the pressure applied to the wheel cylinder. While the ABS is in operation, the skid control ECU continually outputs control signals to the pump, which pumps the brake fluid back into the master cylinder.



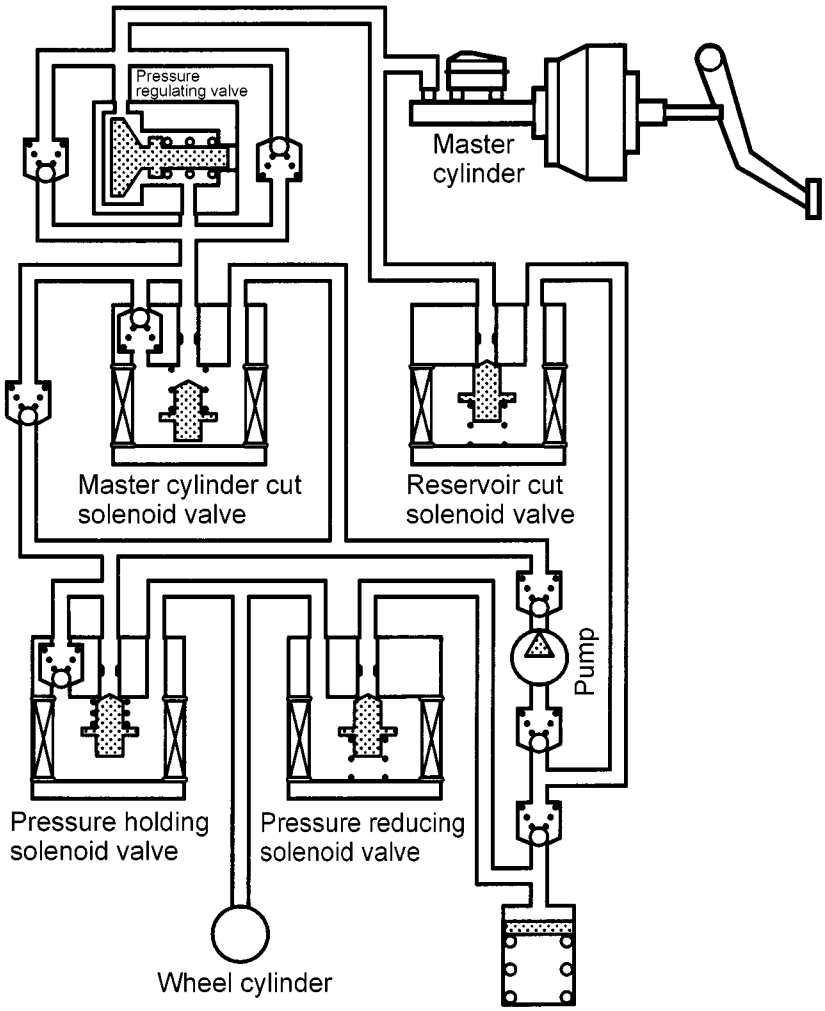
Brake fluid route (Pressure reducing mode)

▶ Valve Operation ◀

	Control signal	Port status
Pressure regulating valve	—	Open
Master cylinder cut solenoid valve	OFF	Open
Reservoir cut solenoid valve	OFF	Closed
Pressure holding solenoid valve	ON	Closed
Pressure reducing solenoid valve	ON	Open

b. Pressure holding mode

When the wheel cylinder pressure has risen or dropped to the required pressure, signals from the skid control ECU simultaneously close the pressure holding solenoid valve and pressure reducing solenoid valve. This cuts off the oil channels on the master cylinder side and the reservoir side, maintaining the oil pressure applied to the wheel cylinder.



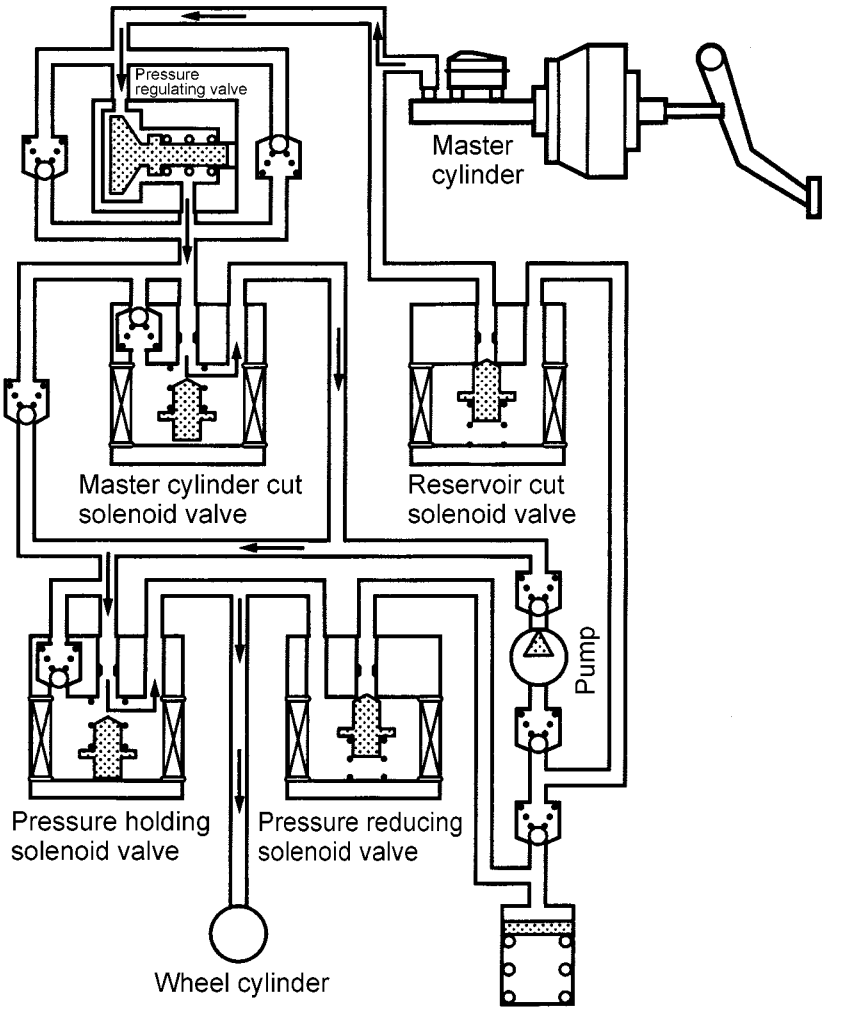
Brake fluid route (Pressure holding mode)

▶ Valve Operation ◀

	Control signal	Port status
Pressure regulating valve	—	Open
Master cylinder cut solenoid valve	OFF	Open
Reservoir cut solenoid valve	OFF	Closed
Pressure holding solenoid valve	ON	Closed
Pressure reducing solenoid valve	OFF	Closed

c. Pressure increasing mode

When the master cylinder oil pressure needs to be increased rapidly, signals from the skid control ECU open the pressure holding solenoid valve and close the pressure reducing solenoid valve. This supplies brake fluid from the master cylinder to the wheel cylinder as during normal braking, causing the wheel cylinder oil pressure to rise. The speed at which the pressure increases is controlled by alternating between pressure increasing and pressure holding modes.



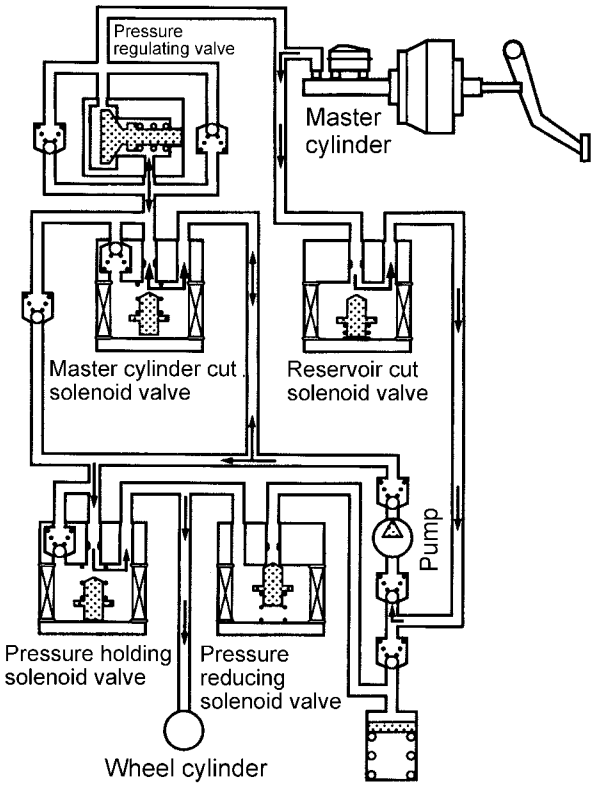
Brake fluid route (Pressure increasing mode)

▶ Valve Operation ◀

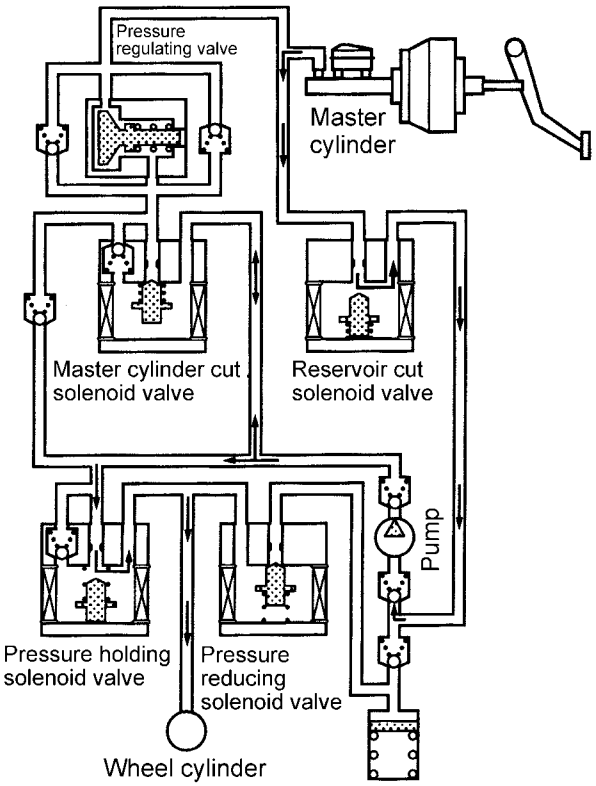
	Control signal	Port status
Pressure regulating valve	—	Open
Master cylinder cut solenoid valve	OFF	Open
Reservoir cut solenoid valve	OFF	Closed
Pressure holding solenoid valve	OFF	Open
Pressure reducing solenoid valve	OFF	Closed

3) During brake line pressurizing control

Control signals from the skid control ECU operate the various solenoid valves and the pump, sending the oil pressure generated by the pump to each wheel cylinder and producing pressures higher than the master cylinder pressure.



When brake booster vacuum pressure does not drop



When brake booster vacuum pressure drops

Brake fluid route (During brake line pressurizing control)

▶ Valve Operation ◀

	When brake booster vacuum pressure does not drop		When brake booster vacuum pressure drops	
	Control signal	Port status	Control signal	Port status
Pressure regulating valve	—	Closed	—	Open
Master cylinder cut solenoid valve	OFF	Open	ON	Closed
Reservoir cut solenoid valve	ON	Open	ON	Open

CH