

8. Construction and Operation of Main Components

Brake Actuator

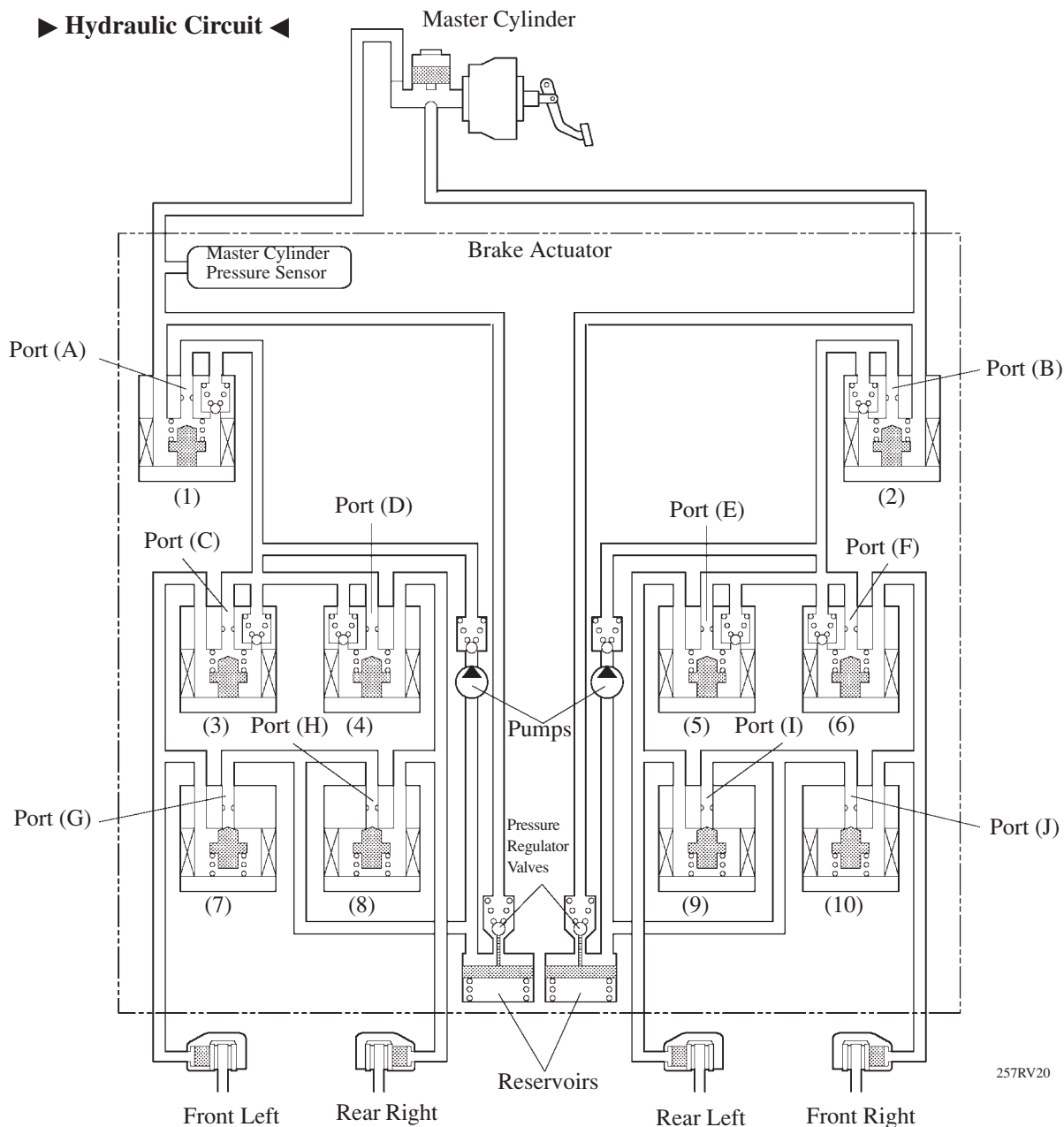
1) General

- A brake actuator with an integrated skid control ECU has been adopted.
- The orifice has been added in the solenoid valve of ABS brake actuator to reduce the pulsation of fluid which generates by opening and closing the valve. As a result of this, the operating sound has been reduced to achieve quietness.
- The brake actuator consists of 10 two-position solenoid valves, 2 pressure regulator valves, 1 pump motor, 2 reservoirs, and master cylinder pressure sensor.

The 10 two-position solenoid valves consists of the following:

- 2 master cylinder cut solenoid valves (linear type) [(1), (2)]
- 4 pressure holding solenoid valves [(3), (4), (5), (6)]
- 4 pressure reduction solenoid valves [(7), (8), (9), (10)]

► Hydraulic Circuit ◀

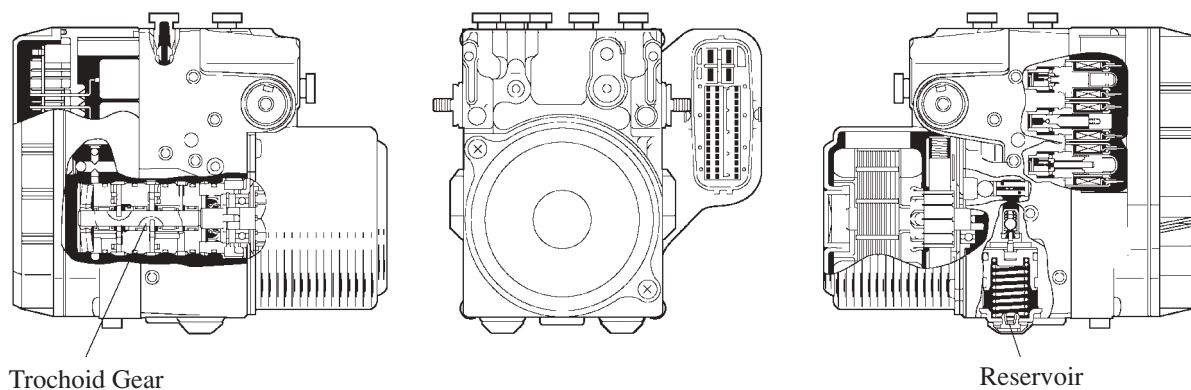


► Function of Main Components ◀

Component		Function
(1), (2)	Master Cylinder Cut Solenoid Valve (Linear Type)	To effect the respective brake controls of the Brake Assist, TRC, and VSC system, a combination of the ON/OFF conditions of the master cylinder cut solenoid valve is used to appropriately vary the fluid pressure.
(3), (4), (5), (6)	Pressure Holding Valve	Each wheel cylinder contains a pressure holding solenoid valve and a pressure reduction solenoid valve. A combination of the ON/OFF conditions of the respective valves is used in order to change the increase mode, holding mode, or the reduction mode during the operation of the ABS, TRC and VSC system.
(7), (8), (9), (10)	Pressure Reduction Valve	
Master Cylinder Pressure Sensor		The master cylinder pressure sensor converts the brake fluid pressure that the master cylinder applies to the brake actuator into an electrical signal and sends it to the skid control ECU. The skid control ECU can thus monitor the brake fluid pressure that is applied to the brake actuator in accordance with this signal.
Reservoir		While effecting the reduction mode during the operation of the ABS, TRC, and VSC system, the reservoir stores the brake fluid that has returned from the wheel cylinders. It also functions as an accumulator.
Pump		Pumps the brake fluid that is stored in the reservoir and returns it to the master cylinder. While effecting the increase mode during the operating of the Brake Assist, TRC and VSC system, the pump operates in order to apply brake fluid pressure to the wheel cylinders.
Pressure Regulator Valve		Regulates the pressure of the fluid supplied to the pump, and closes the pressure passage between the master cylinder and the pump when the brake pedal is depressed.

2) Pump and Reservoir

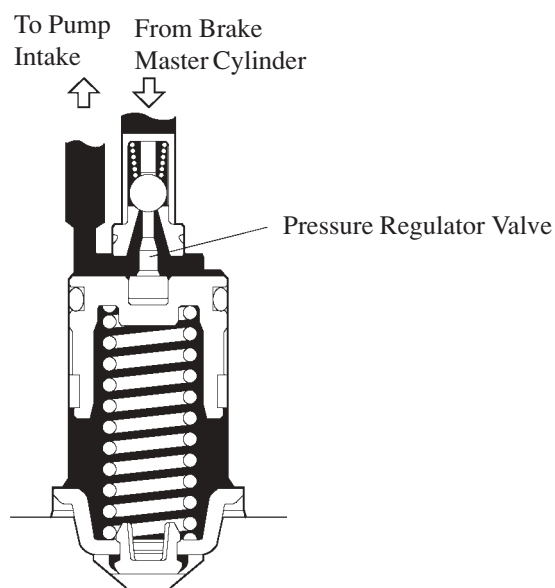
- The trochoid gear type pump has been newly adopted, to reduce operating noise.



Actuator for VSC

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- The pressure regulator valve has been adopted in the reservoir for the purpose of regulating the pressure of the fluid to be supplied to the pump and to close the passage between the pump and the master cylinder during braking.

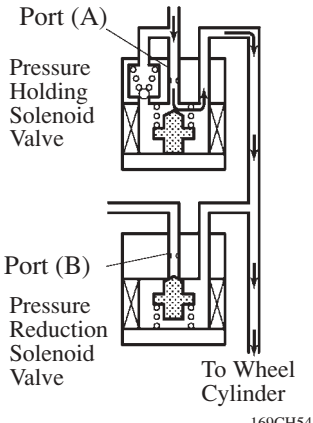
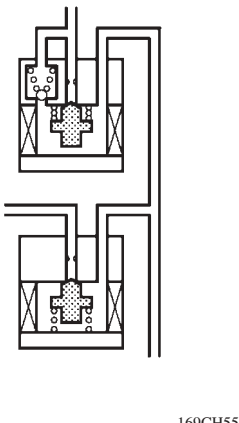
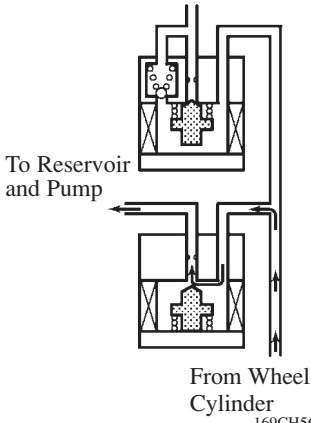


Reservoir Cross Section

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ABS with EBD Operation

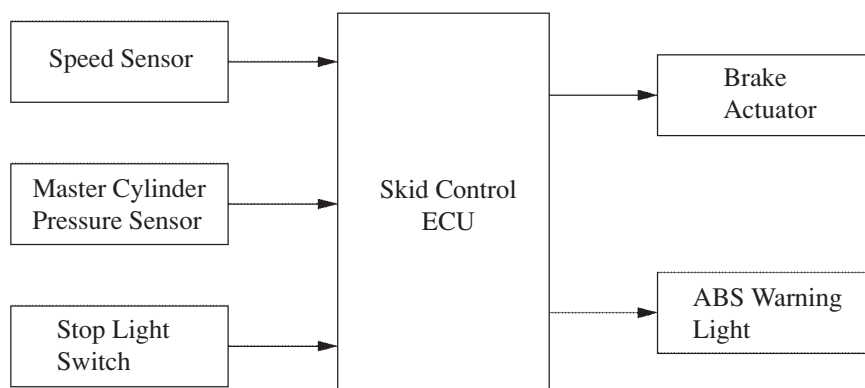
Based on the signals received from the 4 wheel speed sensors and yaw rate & deceleration sensor, the skid control ECU calculates each wheel speed and deceleration, and checks wheel slipping condition. According to the slipping condition, the ECU controls the pressure holding solenoid valve and pressure reduction solenoid valve in order to adjust the fluid pressure of each wheel cylinder in the following 3 modes: pressure reduction, pressure holding, and pressure increase modes.

Not Activated	Normal Braking	—	—
Activated	Increase Mode	Holding Mode	Reduction Mode
Hydraulic Circuit	 <p>Port (A) Pressure Holding Solenoid Valve</p> <p>Port (B) Pressure Reduction Solenoid Valve</p> <p>To Wheel Cylinder</p> <p>169CH54</p>	 <p>169CH55</p>	 <p>To Reservoir and Pump</p> <p>From Wheel Cylinder</p> <p>169CH56</p>
Pressure Holding Valve (Port A)	OFF (Open)	ON (Close)	ON (Close)
Pressure Reduction Valve (Port B)	OFF (Close)	OFF (Close)	ON (Open)
Wheel Cylinder Pressure	Increase	Hold	Reduction

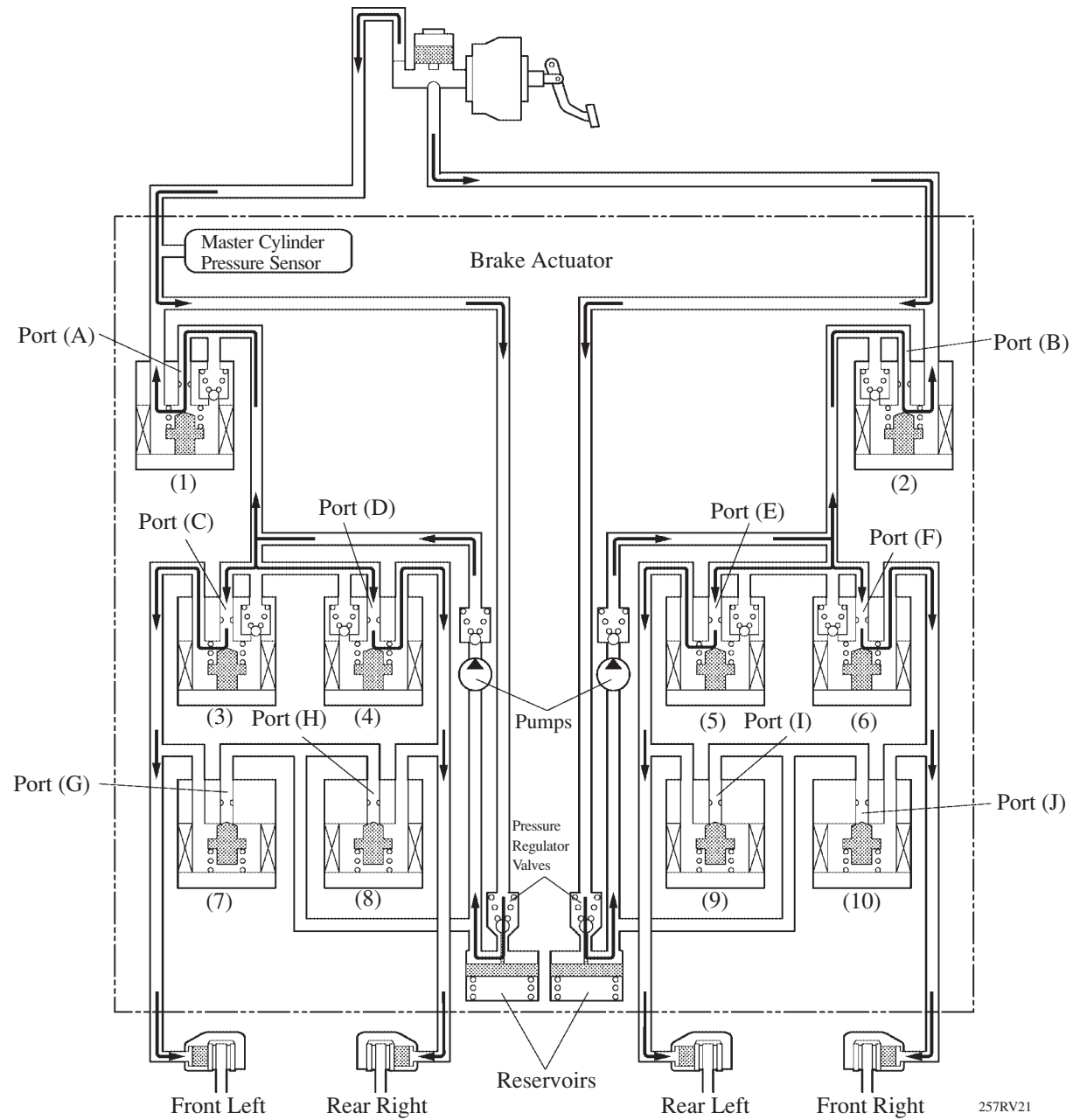
Brake Assist Operation

In the event of emergency braking, the skid control ECU detects the driver's intention based on the speed of the pressure increase in the master cylinder determined by the pressure sensor signal. If the ECU judges the need for the additional brake assist, the fluid pressure is generated by the pump in the actuator and directed to the wheel cylinder to apply a greater fluid pressure than the master cylinder.

► System Diagram ◀



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Brake Assist Activated

Item		Brake Assist Not Activated	Brake Assist Activated
(1), (2)	Master Cylinder Cut Solenoid Valve	OFF (Open)	ON*
	Port: (A), (B)		
(3), (4), (5), (6)	Pressure Holding Solenoid Valve	OFF (Open)	OFF (Open)
	Port: (C), (D), (E), (F)		
(7), (8), (9), (10)	Pressure Reduction Solenoid Valve	OFF (Close)	OFF (Close)
	Port: (G), (H), (I), (J)		

*: The solenoid valve controls the hydraulic pressure between “open” through “close” according to the operating condition by adjusting continually.

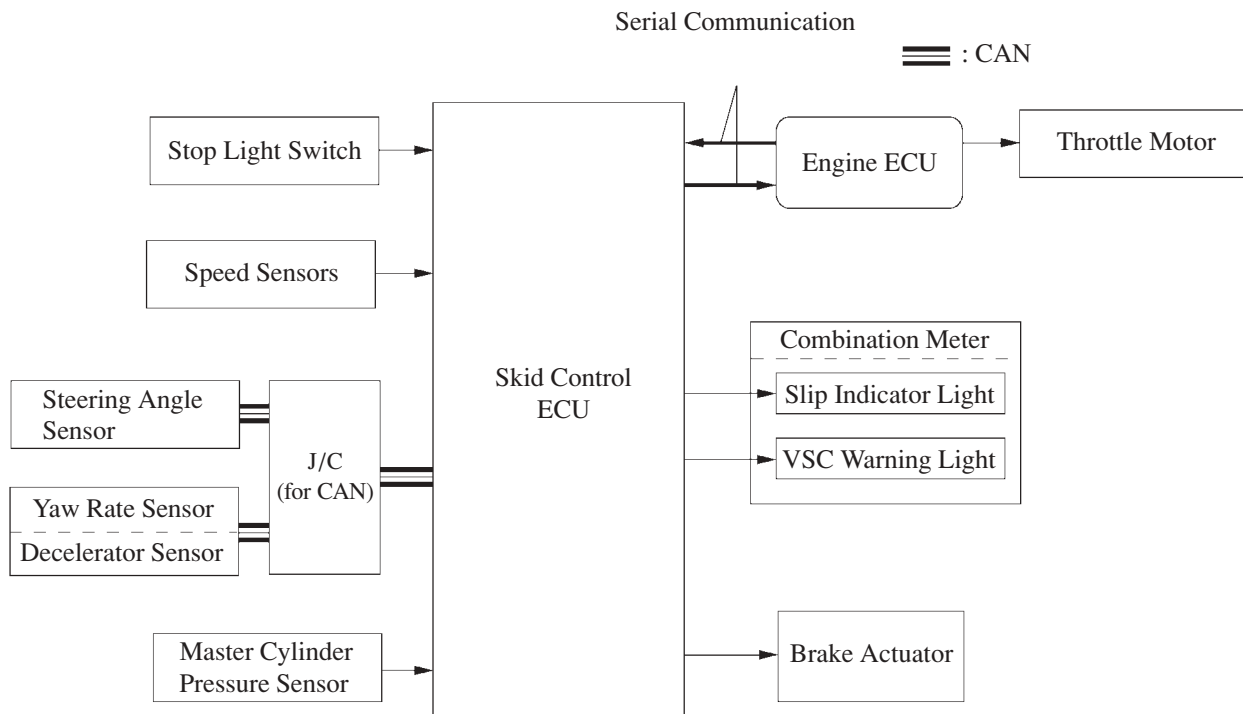
TRC Operation

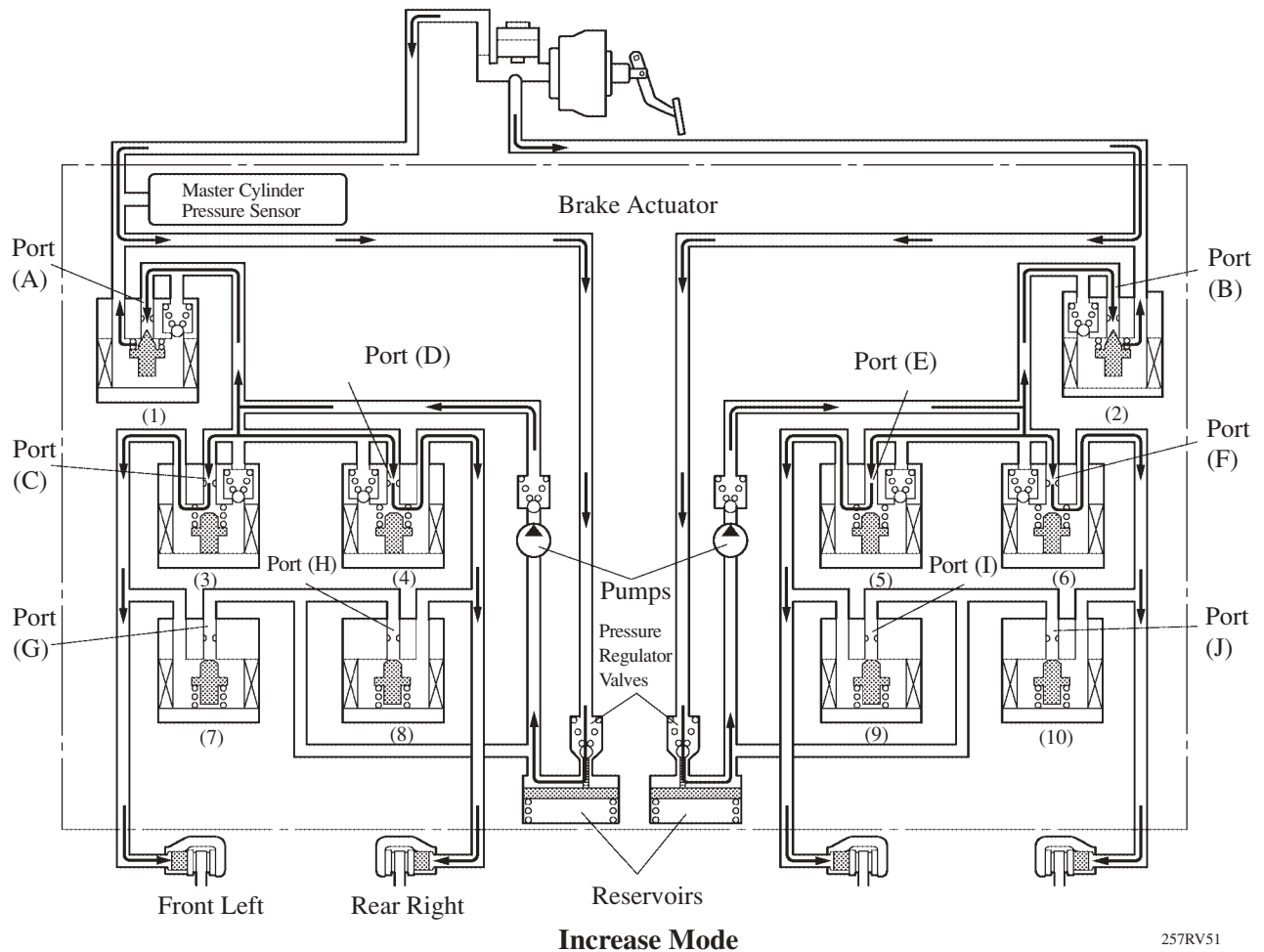
The fluid pressure generated by the pump is regulated by the master cylinder cut solenoid valve to the required pressure. Thus, the wheel cylinders of the drive wheels are controlled in the following 3 modes: pressure reduction, pressure holding, and pressure increase modes, to control the slippage of the drive wheels.

The diagram below shows the hydraulic circuit in the pressure increase mode when the TRC system is activated.

The pressure holding solenoid valve and the pressure reduction solenoid valve are turned ON/OFF according to the ABS operation pattern described on the previous page.

► System Diagram ◀





Item			TRC not Activated	TRC Activated		
				Increase Mode	Holding Mode	Reduction Mode
(1), (2)	Master Cylinder Cut Solenoid Valve		OFF (Open)	ON*	ON*	ON*
	Port: (A), (B)					
Front Brake	(3), (6)	Pressure Holding Solenoid Valve	OFF (Open)	OFF (Open)	OFF (Open)	ON (Close)
		Port: (C), (F)				
	(7), (10)	Pressure Reduction Solenoid Valve	OFF (Close)	OFF (Close)	OFF (Close)	ON (Open)
		Port: (G), (J)				
	Wheel Cylinder Pressure		—	Increase	Holding	Reduce
Rear Brake	(4), (5)	Pressure Holding Solenoid Valve	OFF (Open)	OFF (Open)	ON (Close)	ON (Close)
		Port: (D), (E)				
	(8), (9)	Pressure Reduction Solenoid Valve	OFF (Close)	OFF (Close)	OFF (Close)	ON (Open)
		Port: (H), (I)				
	Wheel Cylinder Pressure		—	Increase	Holding	Reduce

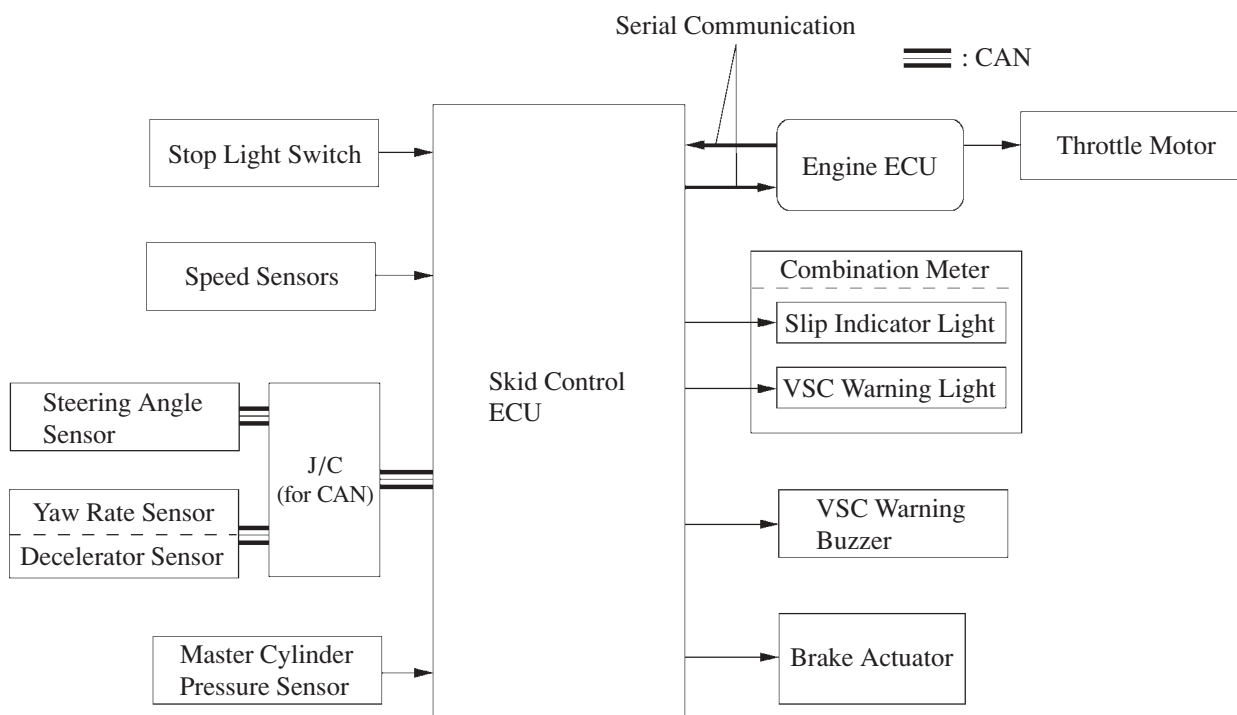
*: The solenoid valve controls the hydraulic pressure between “open” through “close” according to the operating condition by adjusting continually.

VSC Operation

1) General

The VSC system, by way of solenoid valves, controls the fluid pressure that is generated by the pump and applies it to the brake wheel cylinder of each wheel in the following 3 modes: pressure reduction, pressure holding, and pressure increase modes. As a result, the tendency to front wheel skid or rear wheel skid is controlled.

► System Diagram ◀



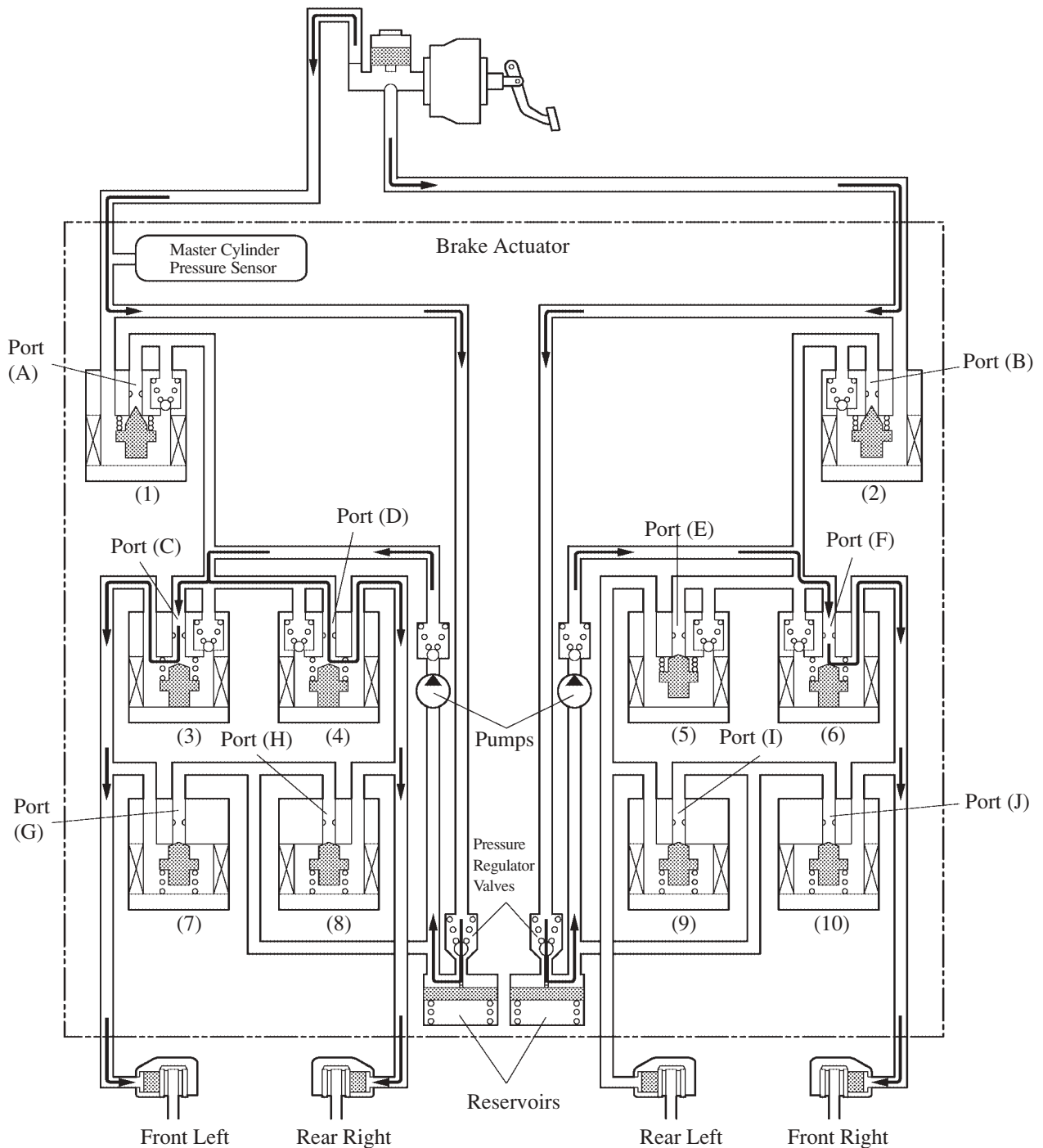
2) Front Wheel Skid Control (Turn to the Right)

In the front wheel skid control, the brakes of the front wheels and the rear wheel of the inner circle of the turn are applied.

Also, depending on whether the brake is ON or OFF and the condition of the vehicle, there are circumstances in which the brake might not be applied to the wheels even if those wheels are targeted for braking.

The diagram below shows the hydraulic circuit in the pressure increase mode, as it controls the front wheel skid condition while the vehicle makes a right turn.

The pressure holding solenoid valve and the pressure reduction solenoid valve are turned ON/OFF according to the ABS operation pattern.



Increase Mode

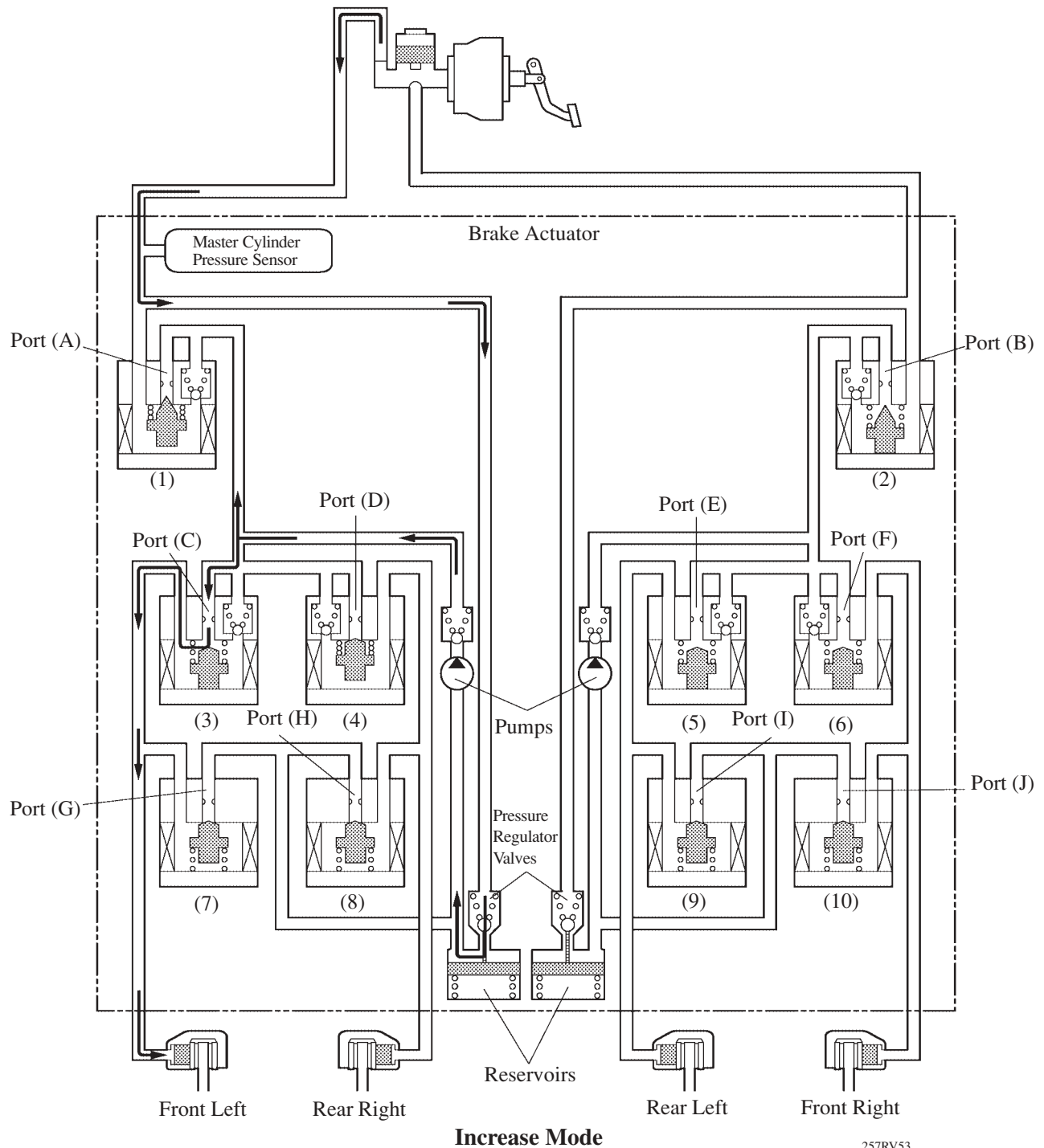
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Item			VSC not Activated	VSC Activated		
				Increase Mode	Holding Mode	Reduction Mode
(1), (2)	Master Cylinder Cut Solenoid Valve		OFF (Open)	ON	ON	ON
	Port: (A), (B)					
Front Brake	(3)	Pressure Holding Solenoid Valve	OFF (Open)	OFF (Open)	ON (Close)	ON (Close)
		Port: (C)				
	(6)	Pressure Holding Solenoid Valve	OFF (Open)	OFF (Open)	ON (Close)	ON (Close)
		Port: (F)				
	(7)	Pressure Reduction Solenoid Valve	OFF (Close)	OFF (Close)	OFF (Close)	ON (Open)
		Port: (G)				
	(10)	Pressure Reduction Solenoid Valve	OFF (Close)	OFF (Close)	OFF (Close)	ON (Open)
		Port: (J)				
	Wheel Cylinder Pressure	Right	—	Increase	Holding	Reduce
		Left	—	Increase	Holding	Reduce
Rear Brake	(4)	Pressure Holding Solenoid Valve	OFF (Open)	OFF (Open)	ON (Close)	ON (Close)
		Port: (D)				
	(5)	Pressure Holding Solenoid Valve	OFF (Open)	ON (Close)	ON (Close)	ON (Close)
		Port: (E)				
	(8)	Pressure Reduction Solenoid Valve	OFF (Close)	OFF (Close)	OFF (Close)	ON (Open)
		Port: (H)				
	(9)	Pressure Reduction Solenoid Valve	OFF (Close)	OFF (Close)	OFF (Close)	OFF (Close)
		Port: (I)				
	Wheel Cylinder Pressure	Right	—	Increase	Holding	Reduce
		Left	—	—	—	—

3) Rear Wheel Skid Control (Turn to the Right)

In rear wheel skid control, the brake of the front wheel of the outer circle of the turn is applied. As an example, the diagram below shows the hydraulic circuit in the pressure increase mode, as it controls the rear wheel skid condition while the vehicle make a right turn.

As in front wheel skid control the pressure holding solenoid valve and the pressure reduction solenoid valve are turned ON/OFF according to the ABS operating pattern.

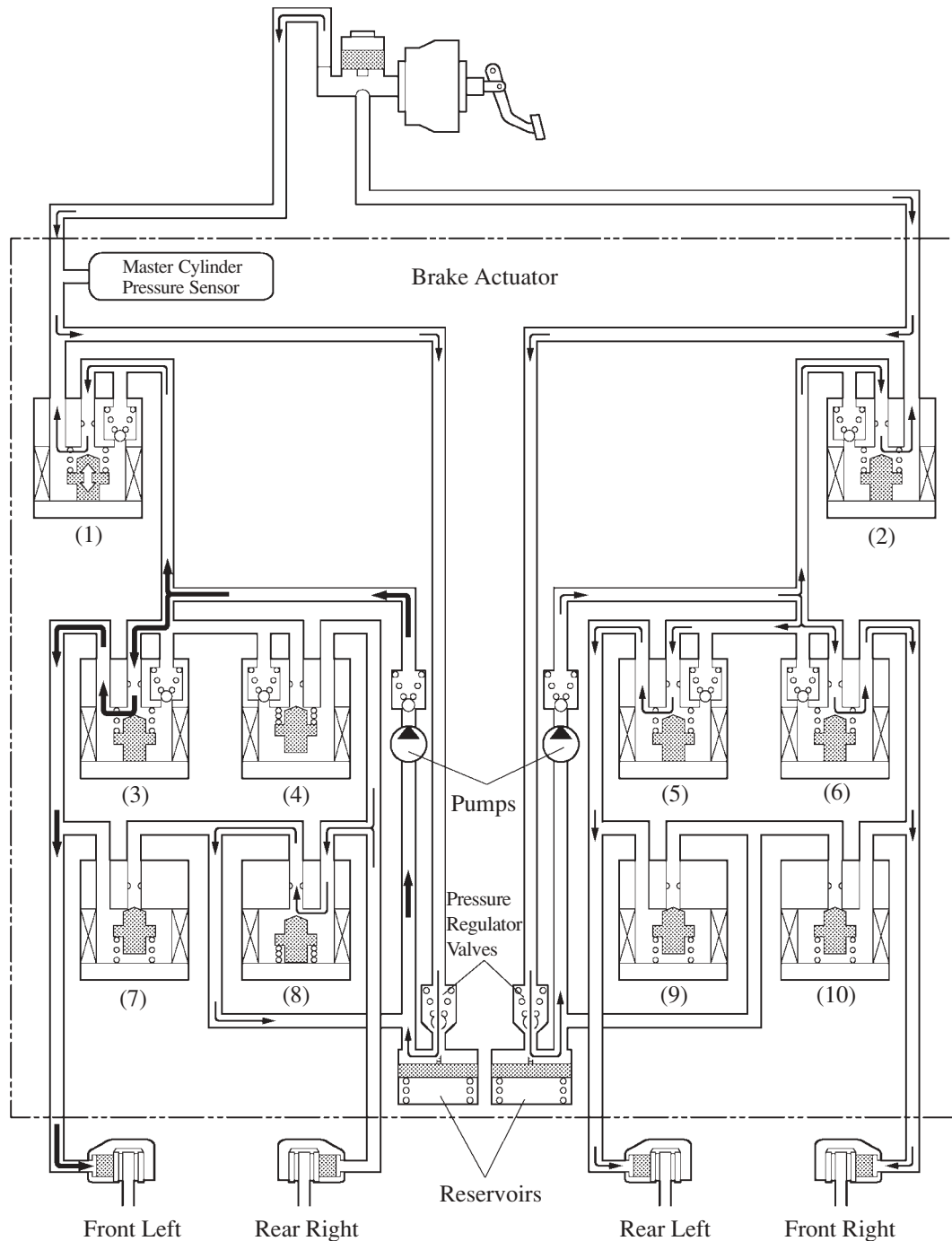


Item			VSC not Activated	VSC Activated		
				Increase Mode	Holding Mode	Reduction Mode
(1)	Master Cylinder Cut Solenoid Valve		OFF (Open)	ON (Close)	ON (Close)	ON (Close)
	Port: (A)					
(2)	Master Cylinder Cut Solenoid Valve		OFF (Open)	OFF (Open)	OFF (Open)	OFF (Open)
	Port: (B)					
Front Brake	(3)	Pressure Holding Solenoid Valve	OFF (Open)	OFF (Open)	ON (Close)	ON (Close)
		Port: (C)				
	(6)	Pressure Holding Solenoid Valve	OFF (Open)	OFF (Open)	OFF (Open)	OFF (Open)
		Port: (F)				
	(7)	Pressure Reduction Solenoid Valve	OFF (Close)	OFF (Close)	OFF (Close)	ON (Open)
		Port: (G)				
	(10)	Pressure Reduction Solenoid Valve	OFF (Close)	OFF (Close)	OFF (Close)	OFF (Close)
		Port: (J)				
	Wheel Cylinder Pressure	Right	—	—	—	—
		Left	—	Increase	Holding	Reduce
Rear Brake	(4)	Pressure Holding Solenoid Valve	OFF (Open)	ON (Close)	ON (Close)	ON (Close)
		Port: (D)				
	(5)	Pressure Holding Solenoid Valve	OFF (Open)	OFF (Open)	ON (Close)	ON (Close)
		Port: (E)				
	(8)	Pressure Reduction Solenoid Valve	OFF (Close)	OFF (Close)	OFF (Close)	OFF (Close)
		Port: (H)				
	(9)	Pressure Reduction Solenoid Valve	OFF (Close)	OFF (Close)	OFF (Close)	OFF (Close)
		Port: (I)				
	Wheel Cylinder Pressure	Right	—	—	—	—
		Left	—	—	—	—

4) Control During Cornering Braking (Turn to the Right)

During cornering braking, the pressure holding valve (3) and the pressure reduction valve (7) are inactive. However, because the pump is operating, the brake fluid pressure in the left front wheel cylinder increases. At the same time, the pressure holding valve (4) and the pressure reduction valve (8) turn ON and OFF in the pressure increase, pressure holding, and pressure reduction modes, in order to control the brake fluid pressure applied to the right rear wheel cylinder.

The master cylinder cut solenoid valve (2) regulates the master cylinder fluid pressure applied to the right front wheel cylinder and the left rear wheel cylinder. Because the pressure holding valves (5) and (6) and the pressure reduction valves (9) and (10) are inactive at this time, the master cylinder fluid pressure acts on the right front wheel cylinder and the left rear wheel cylinder.



Item			VSC Activated		
			Increase Mode	Holding Mode	Reduction Mode
(1)	Master Cylinder Cut Solenoid Valve		ON*1	ON*1	ON*1
(2)	Master Cylinder Cut Solenoid Valve		—*2	—*2	—*2
Front Brake	Wheel Cylinder Pressure	Right	—*3	—	—
		Left	Increase	—	—
Rear Brake	(4)	Pressure Holding Solenoid Valve	OFF (Open)	ON (Close)	ON (Close)
	(5)	Pressure Holding Solenoid Valve	—*1	—*1	—*1
	(8)	Pressure Reduction Solenoid Valve	OFF (Close)	OFF (Close)	ON (Open)
	(9)	Pressure Reduction Solenoid Valve	—*1	—*1	—*1
	Wheel Cylinder Pressure	Right	Increase	Holding	Reduce
		Left	—*3	—*3	—*3

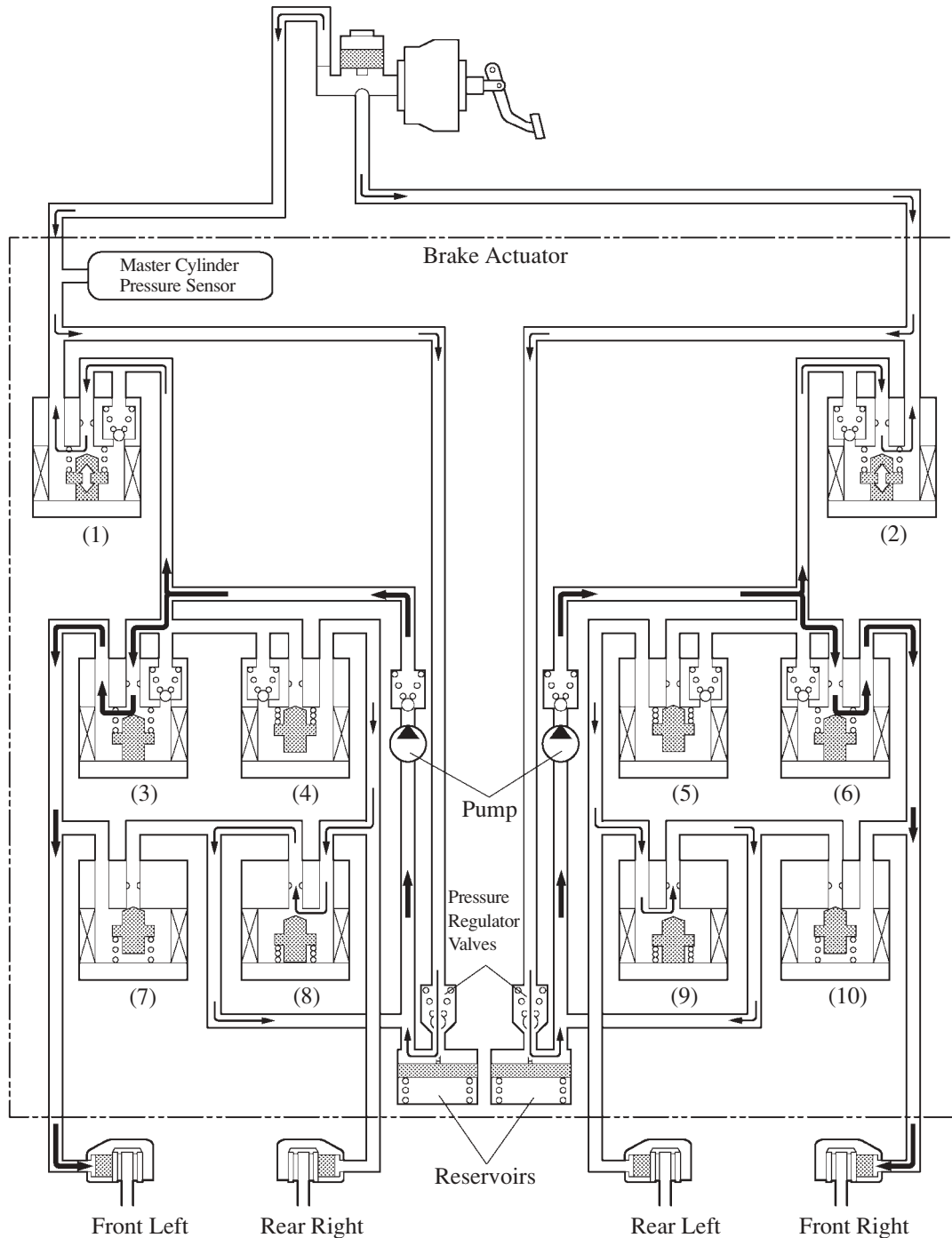
*1: The solenoid valve controls the hydraulic pressure between “open” through “close” according to the operating condition by adjusting continually.

*2: Indicates an inactive condition.

*3: The master cylinder pressure acts on it.

5) Control During High-Speed

During high-speed braking, the system turns ON/OFF (pressurization/depressurization) the pressure holding valves (4) and (5), and the pressure reduction valves (8) and (9) depend on the vehicle condition. Because the pressure holding valves (3) and (6) and the pressure reduction valves (7) and (10) are inactive (the pressure holding valves are ON and the pressure reduction valves are OFF) at this time, the pump increases the fluid pressure of braking force which correspond is to the fluid pressure reduced at the rear wheel cylinders, in the front wheel cylinder.



Item			VSC Activated		
			Increase Mode	Holding Mode	Reduction Mode
(1)	Master Cylinder Cut Solenoid Valve		ON*	ON*	ON*
(2)	Master Cylinder Cut Solenoid Valve		ON*	ON*	ON*
Front Brake	Wheel Cylinder Pressure	Right	Increase	—	—
		Left	Increase	—	—
Rear Brake	(4)	Pressure Holding Solenoid Valve	OFF (Open)	ON (Close)	ON (Close)
	(5)	Pressure Holding Solenoid Valve	OFF (Open)	ON (Close)	ON (Close)
	(8)	Pressure Reduction Solenoid Valve	OFF (Close)	OFF (Close)	ON (Open)
	(9)	Pressure Reduction Solenoid Valve	OFF (Close)	OFF (Close)	ON (Open)
	Wheel Cylinder Pressure	Right	Increase	Holding	Reduce
		Left	Increase	Holding	Reduce

*: The solenoid valve controls the hydraulic pressure between “open” through “close” according to the operating condition by adjusting continually.