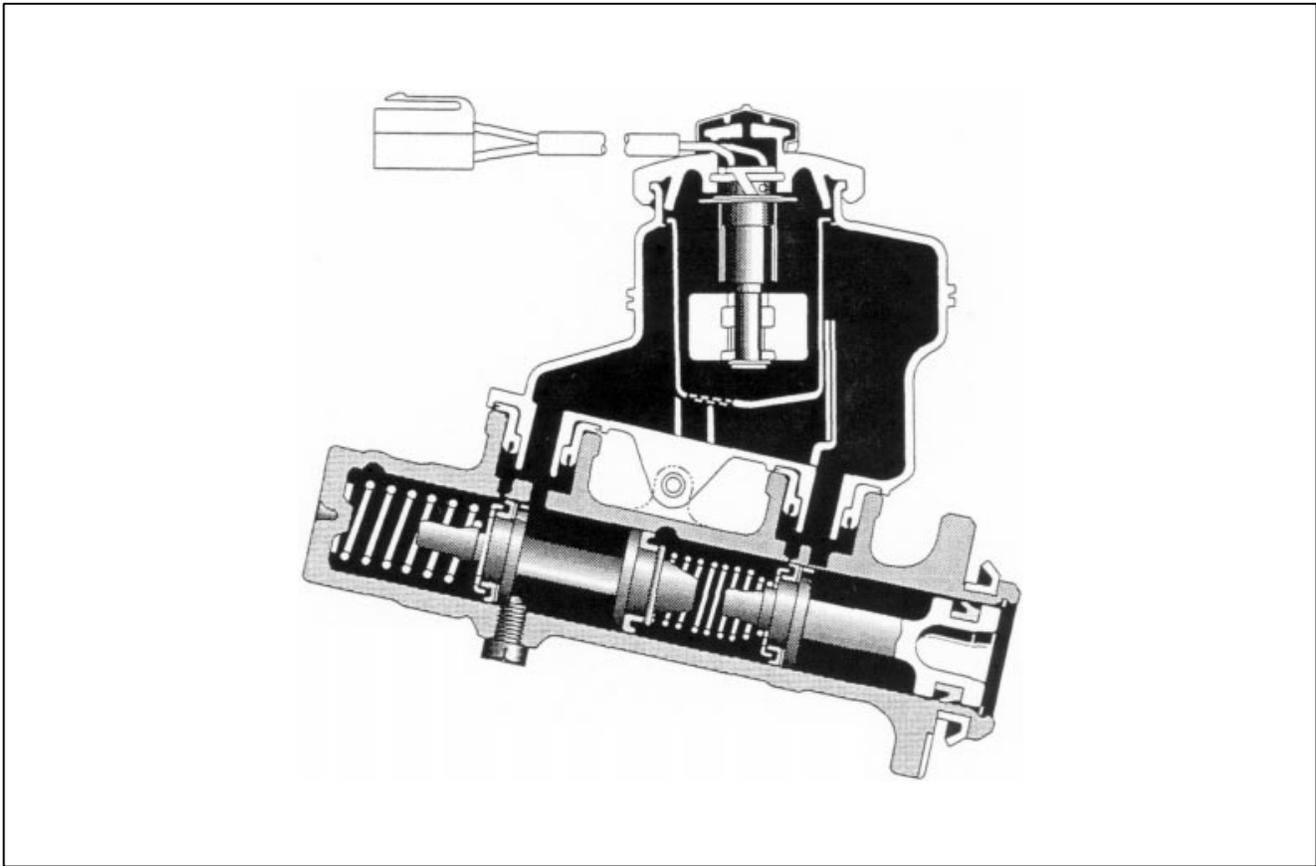


Section 2

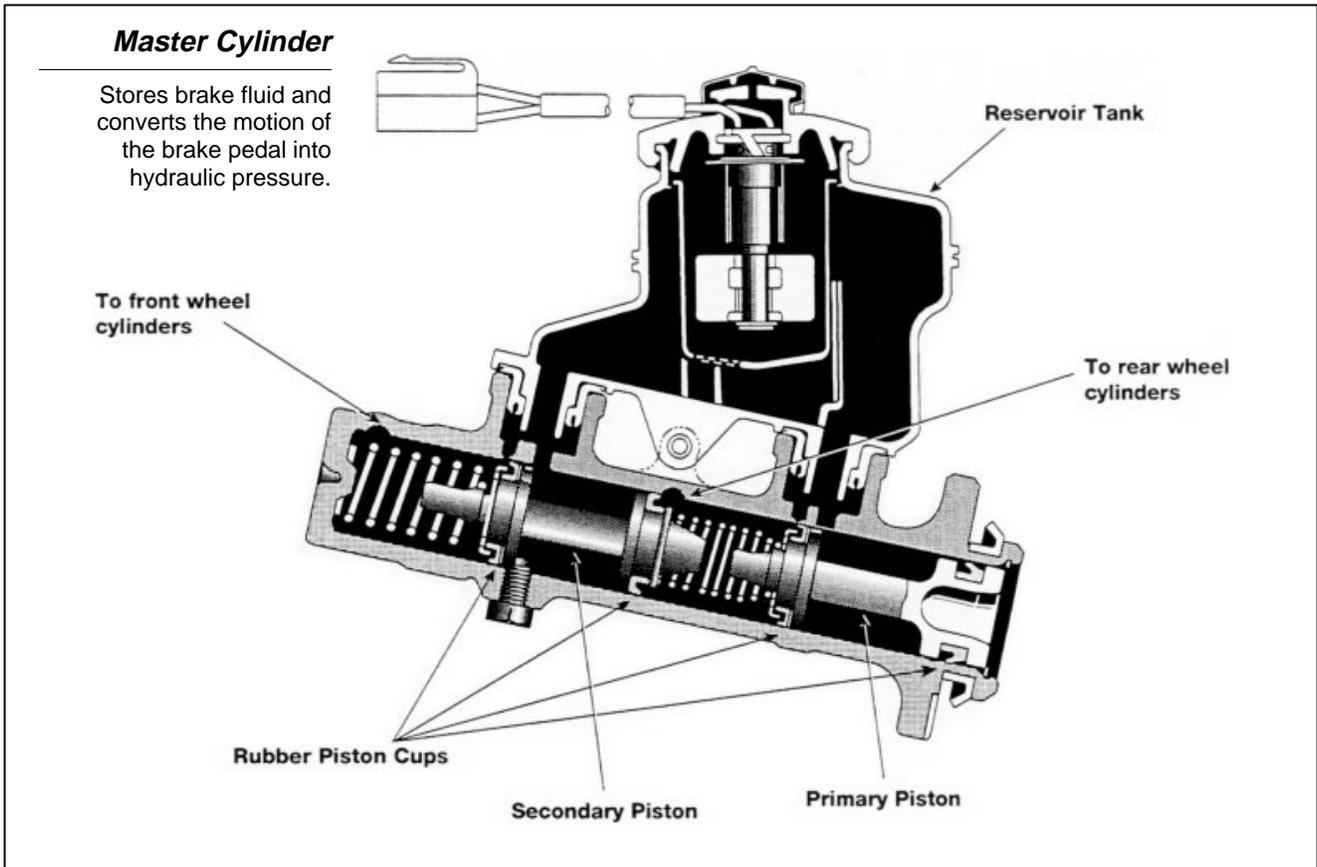
MASTER CYLINDER



- Lesson Objectives**
1. Explain the difference between conventional and diagonal split piping system and their application.
 2. Describe the function of the compensating port of the master cylinder.
 3. Explain the operation of the residual check valve on the drum brake circuit of the master cylinder.
 4. Explain the safety advantage of having two hydraulic circuits in the master cylinder.
 5. Describe the difference between the Portless and Lockheed master cylinders.

Master Cylinder The master cylinder converts the motion of the brake pedal into hydraulic pressure. It consists of the reservoir tank, which contains the brake fluid; and the piston and cylinder which generate the hydraulic pressure.

The reservoir tank is made mainly of synthetic resin, while the cylinders are made of cast iron or an aluminum alloy.

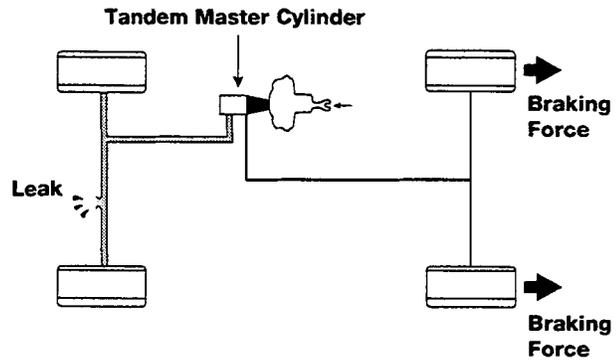
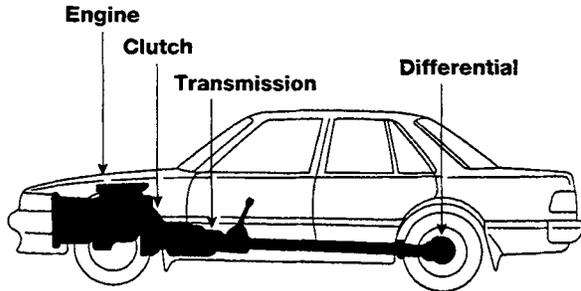


Tandem Master Cylinder The tandem master cylinder has two separate hydraulic chambers. This creates in effect two separate hydraulic braking circuits. If one of these circuits becomes inoperative, the other circuit can still function to stop the vehicle. Stopping distance is increased significantly, however, when operating on only one braking circuit. This is one of the vehicles' most important safety features.

Conventional Piping On front-engine rear-wheel-drive vehicles, one of the chambers provides hydraulic pressure for the front brakes while the other provides pressure for the rear.

Conventional Piping for Front Engine Rear Drive

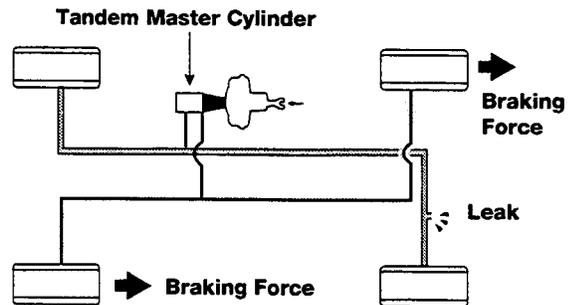
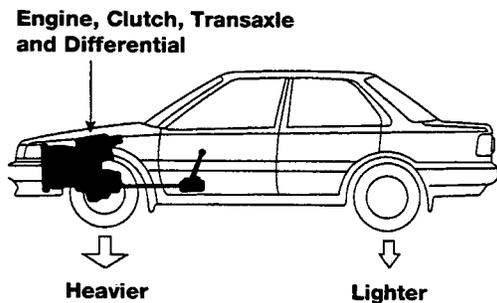
When one circuit fails the other remains intact to stop the vehicle.



Diagonal Split Piping On front-engine front-wheel-drive vehicles, however, extra braking load is shifted to the front brakes due to reduced weight in the rear. To compensate for hydraulic failure in the front brake circuit with the lighter rear axle weight, a diagonal brake line system is used. This consists of one brake system for the right front and left rear wheels, and a separate system for the left front and right rear wheels. Braking efficiency remains equal on both sides of the vehicle (but with only half the normal braking power) even if one of the two separate systems should have a problem.

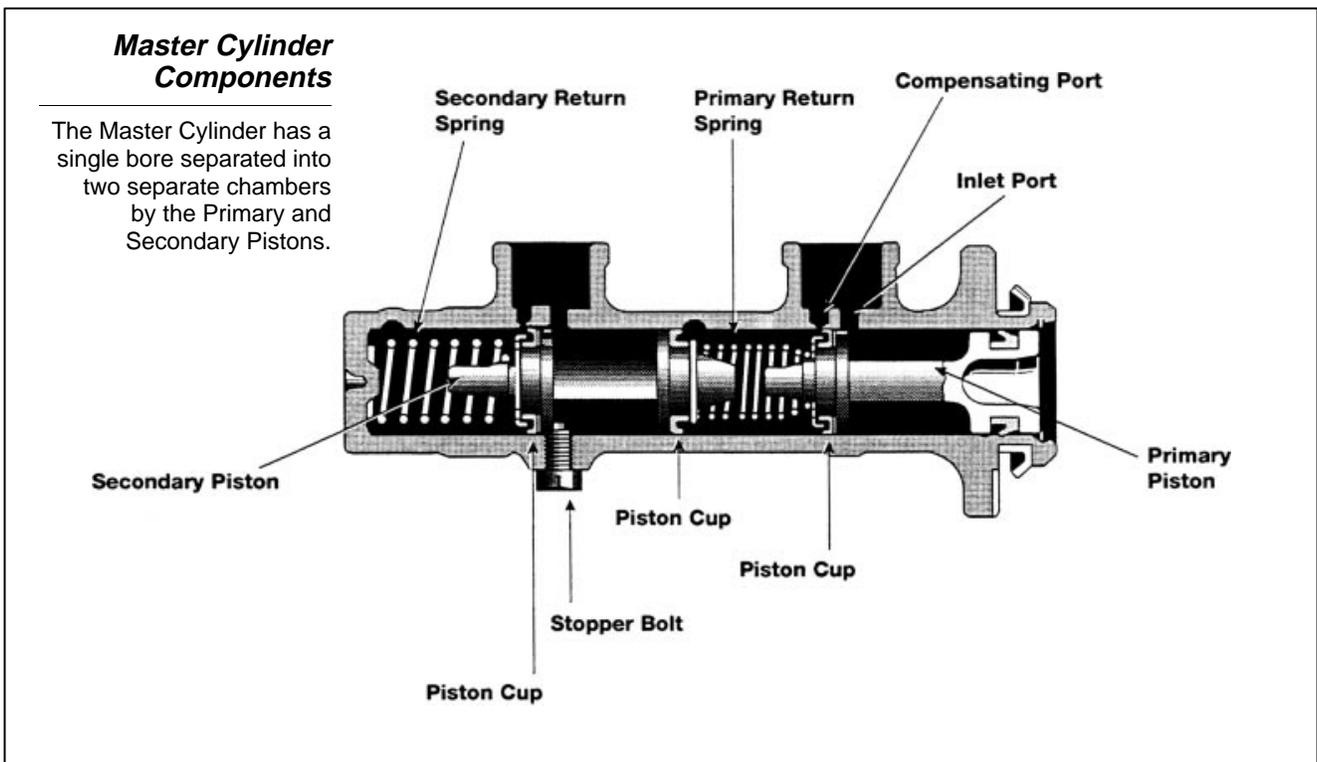
Diagonal Piping for Front Engine Front Drive

Improves braking efficiency if one circuit fails by having one front wheel and one rear wheel braking.



Construction The Master Cylinder has a single bore separated into two separate chambers by the Primary and Secondary Pistons. On the front of the master cylinder Primary Piston is a rubber Piston Cup, which seals the Primary Circuit of the cylinder. Another Piston Cup is also fitted at the rear of the Primary Piston to prevent the brake fluid from leaking out of the rear of the cylinder.

At the front of the Secondary Piston is a Piston Cup which seals the Secondary Circuit. At the rear of the Secondary Piston the other Piston Cup seals the Secondary Cylinder from the Primary Cylinder. The Primary Piston is linked to the brake pedal via a pushrod.



Normal Operation When the brakes are not applied, the piston cups of the Primary and Secondary Pistons are positioned between the Inlet Port and the Compensating Port. This provides a passage between the cylinder and the reservoir tank.

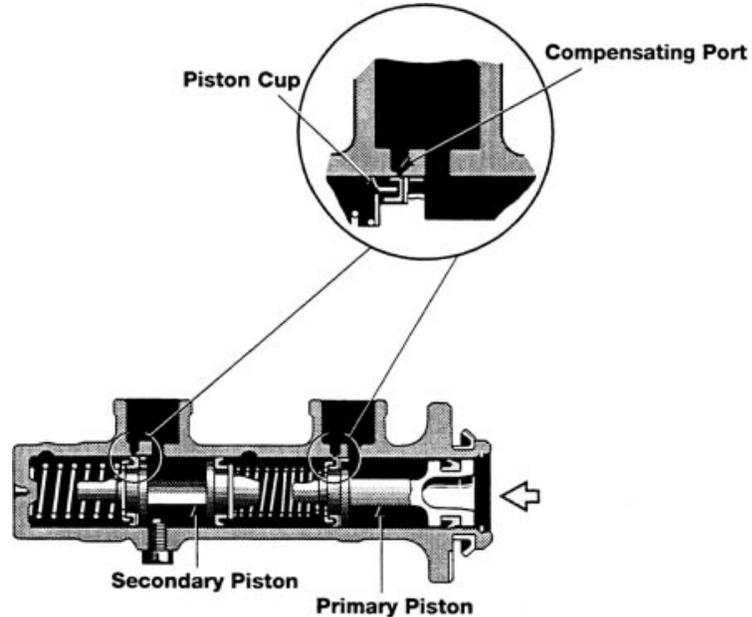
The Secondary Piston is pushed to the right by the force of Secondary Return Spring, but prevented from going any further by a stopper bolt.

When the brake pedal is depressed, the Primary Piston moves to the left. The piston cup seals the Compensating Port blocking the passage between the Primary Pressure Chamber and the Reservoir Tank. As the piston is pushed farther, it builds hydraulic pressure inside the cylinder and is applied or transmitted to the wheel cylinders in that circuit. The same hydraulic pressure is also applied to the Secondary

Piston. Hydraulic pressure in the Primary Chamber moves the Secondary Piston to the left also. After the Compensating Port of the Secondary Chamber is closed, fluid pressure builds and is transmitted to the secondary circuit.

Brake Application

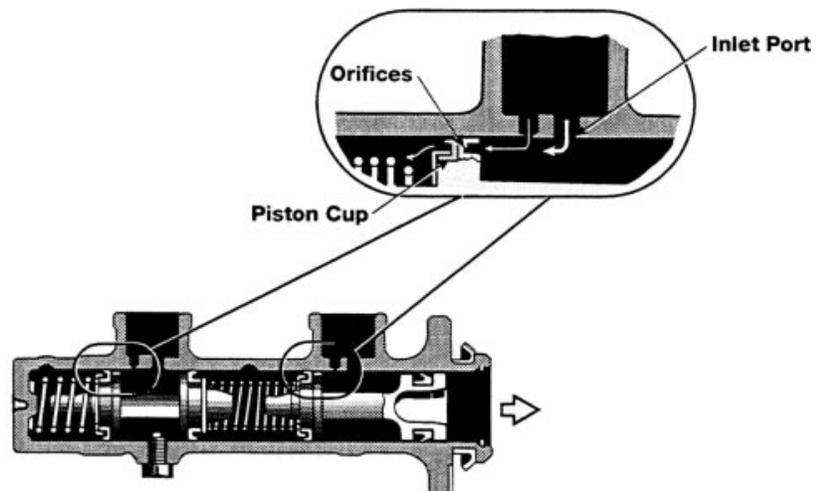
As the piston cup passes the compensating Port pressure begins to increase in the hydraulic circuit.



When the brake pedal is released, the pistons are returned to their original position by hydraulic pressure and the force of the return springs. However, because the brake fluid does not return to the master cylinder immediately, the hydraulic pressure inside the cylinder drops momentarily. As a result, the brake fluid inside the reservoir tank flows into the cylinder via the inlet port, through small holes provided at the front of the piston, and around the piston cup. This design prevents vacuum from developing and allowing air to enter at the wheel cylinders.

Brake Release

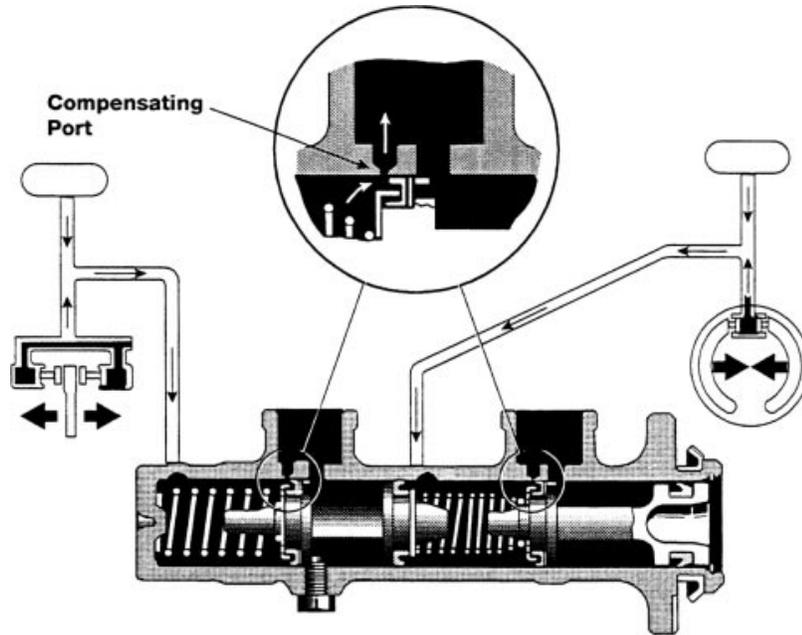
Brake fluid inside the reservoir tank flows into the cylinder via the inlet port, through small holes provided at the front of the piston, and around the piston cup.



After the piston has returned to its original position, fluid returns from the wheel cylinder circuit to the reservoir through the Compensating Port.

Fluid Return

Fluid returns to the reservoir tank through the compensating port.

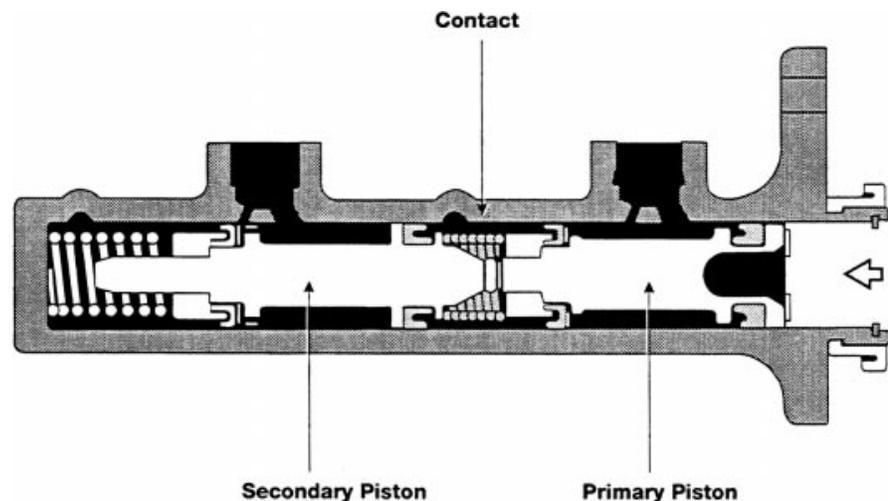


Fluid Leakage In One of the Hydraulic Circuits

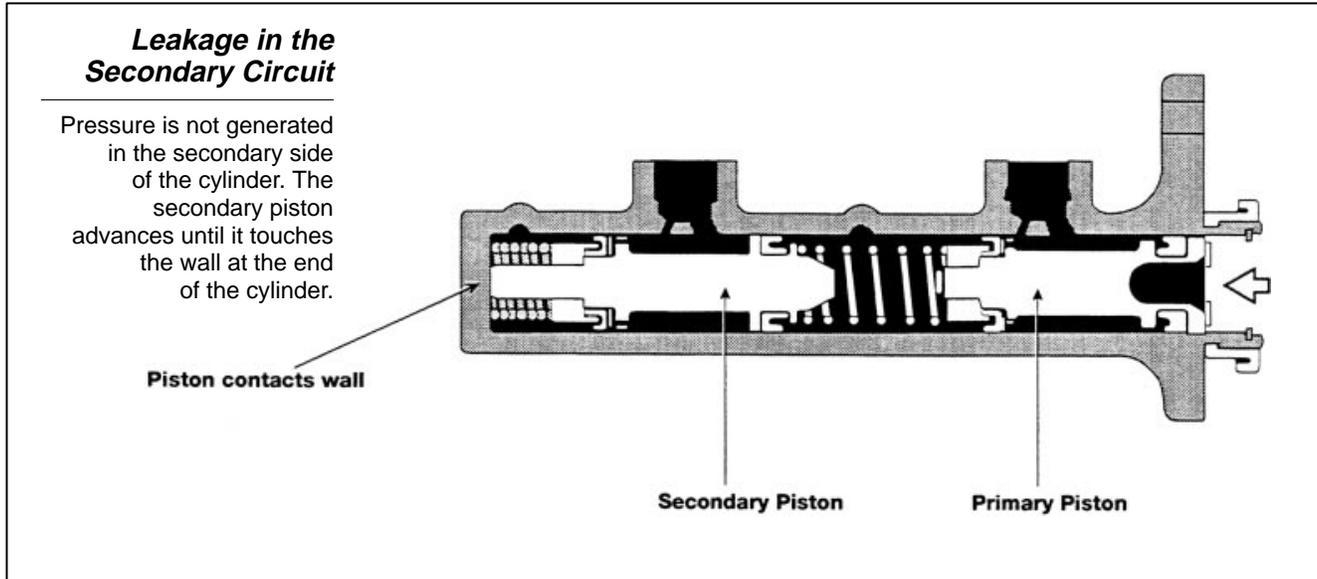
When fluid leakage occurs in the primary side of the master cylinder, the Primary Piston moves to the left but does not create hydraulic pressure in the primary pressure chamber. The Primary Piston therefore compresses the Primary Return Spring, contacting the Secondary Piston and directly moving the Secondary Piston. The Secondary Piston then increases hydraulic pressure in the Secondary Circuit end of the master cylinder, which allows two of the brakes to operate.

Leakage In Primary Circuit

The primary piston compresses the return spring, contacts the secondary piston, and manually moves it.



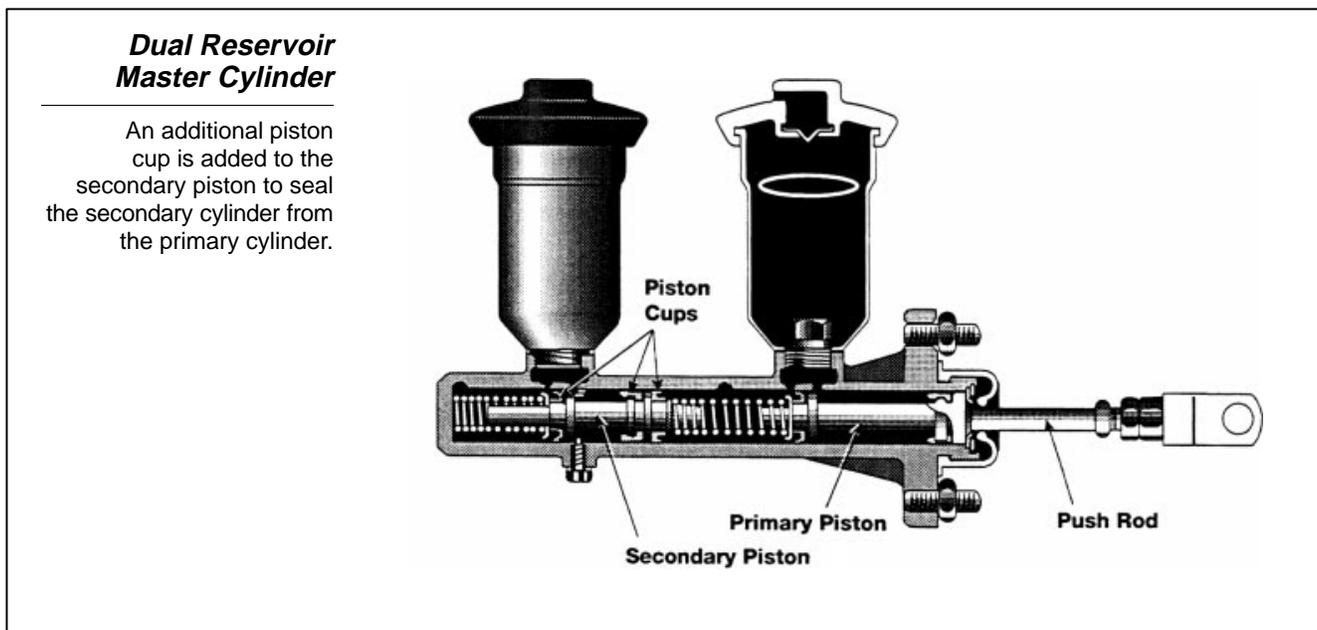
When fluid leakage occurs on the secondary side of the master cylinder, hydraulic pressure in the Primary Chamber easily forces the Secondary Piston to the left compressing the return spring. The Secondary Piston advances until it reaches the far end of the cylinder.



When the Primary Piston is pushed farther to the left, hydraulic pressure increases in the rear (primary) circuit or pressure chamber of the master cylinder. This allows one half of the brake system to operate from the rear Primary Pressure Chamber of the master cylinder.

Separated Reservoir Tank

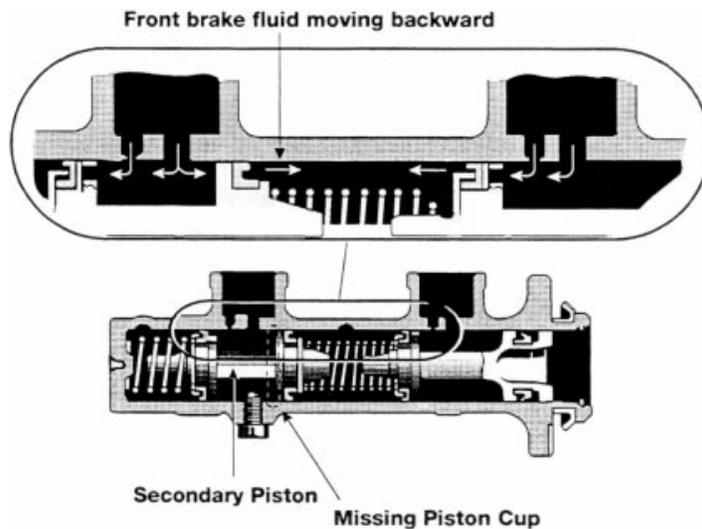
The master cylinder we have been covering so far has only two piston cups on the Secondary Piston and a single fluid reservoir. A third piston cup is added to the Secondary Piston of master cylinders having separate fluid reservoirs for the primary and secondary chambers.



The third piston cup is located between the front and rear piston cup of the secondary piston and seals the Secondary Chamber from the Primary Chamber. When the brakes are released after brake application, the master cylinder pistons return faster than the fluid can, momentarily creating low pressure (vacuum) in the Primary Chamber. It is the job of the third piston cup to prevent fluid passage between the Secondary Chamber and the Primary Chamber. If the piston cup were missing or worn, fluid passing the third piston cup would fill the Primary Reservoir and deplete the Secondary Reservoir. If left unchecked, the Secondary Reservoir would empty allowing air into the secondary hydraulic circuit.

Role of the Second Piston Cup of the Secondary Piston

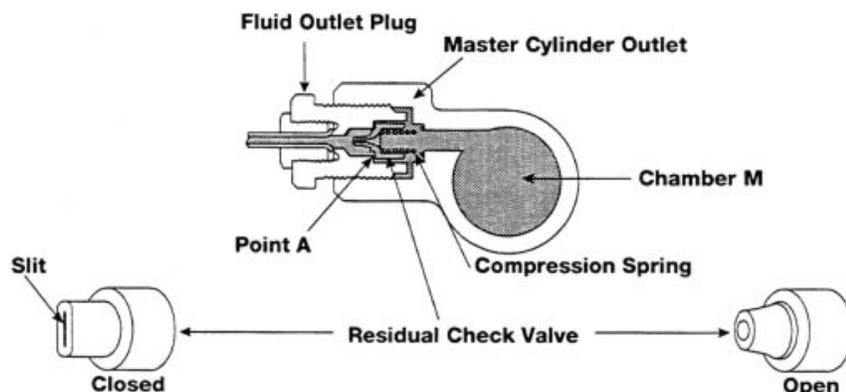
Prevents transfer of fluid from the front tank to the rear tank.



Residual Check Valve The Residual Check Valve is located in the master cylinder outlet to the rear drum brakes. Its purpose is to maintain about 6 to 8 psi in the hydraulic circuit. When the brakes are released the brake shoe return springs force the wheel cylinder pistons back into the bore. Without the Residual Valve the inertia of fluid returning to the master cylinder may cause a vacuum and allow air to enter the system. In addition to preventing a vacuum, the residual pressure pushes the wheel cylinder cup into contact with the cylinder wall.

Master Cylinder Residual Check Valve

Maintains about 6 to 8 psi in the hydraulic circuit to prevent air from entering.



Portless Master Cylinder

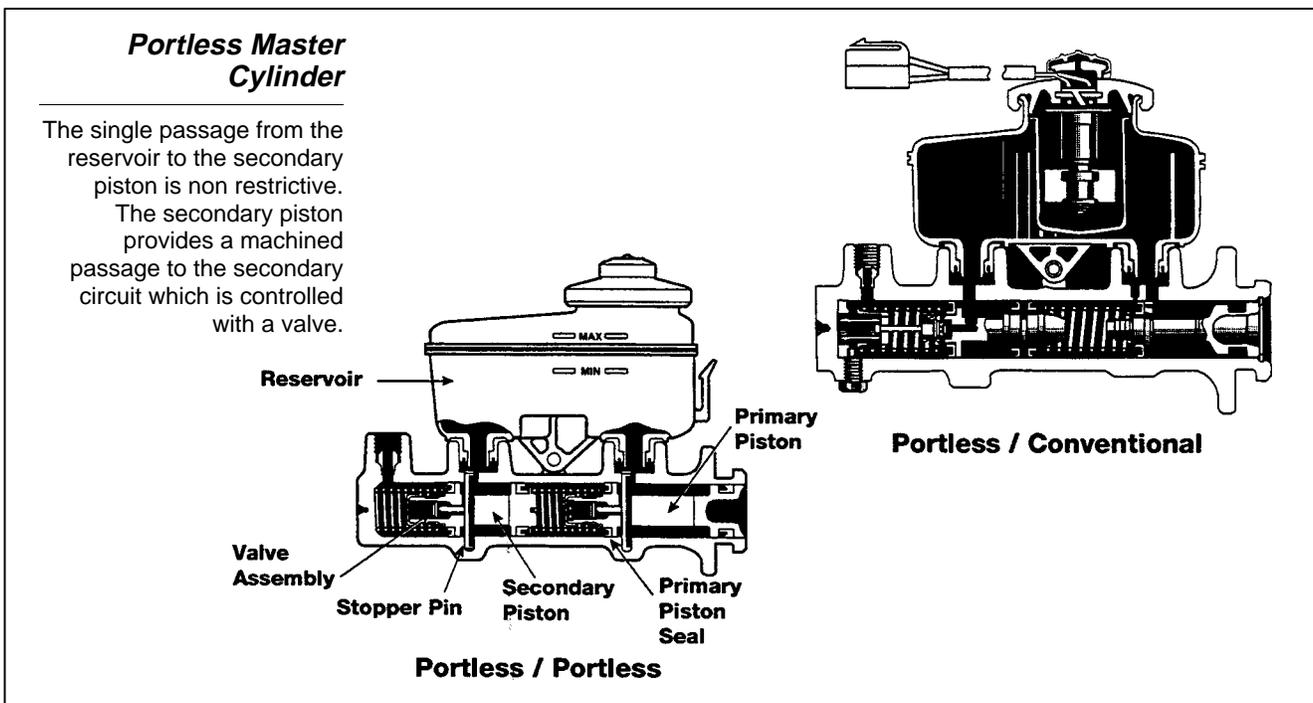
The master cylinder design discussed up to this point has been the conventional compensating port and inlet port type used on most brake systems. A new style master cylinder is used on late model vehicles equipped with ABS and ABS/TRAC (Traction Control).

Initially introduced on the 1991 MR2 and Supra, which were rear wheel drive vehicles, the front piston has a port-less design. The single passage from the reservoir to the secondary piston is non-restrictive. The secondary piston provides a machined passage to the secondary circuit which is controlled with a valve. The valve is spring loaded to seal the piston passage however, a stem attached to the valve holds it from contact with the piston in the "at rest" position. When the brakes are applied the valve closes, sealing the passage and pressure is built in the secondary circuit. The front piston controls pressure to the rear brake calipers.

The master cylinder on the 1997 Camry and Avalon incorporates another master cylinder portless design. In this design a spring loaded valve seals the passage in the piston however, in the "at rest" position, a stem attached to the valve contacts the piston retaining pin and unseats the valve.

Three types of master cylinders are available on the 1997 Camry and Avalon depending on the brake system options.

1. Non ABS Brake System - Conventional primary and secondary master cylinder.
2. ABS Brake System - Portless secondary and conventional primary master cylinder.
3. ABS and TRAC Brake System - Portless secondary and Portless primary master cylinder.



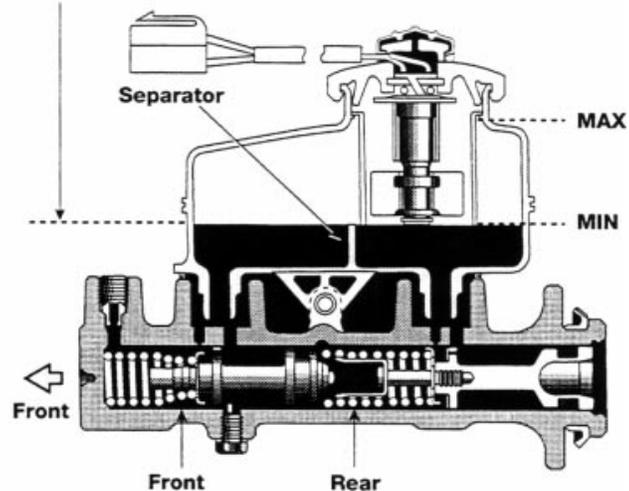
Reservoir Tank The amount of the brake fluid inside the Reservoir Tank changes during brake operation as Disc Brake Pads wear. A small hole in the reservoir cap connects the reservoir to the atmosphere and prevents pressure fluctuation, which could result in air being drawn into the hydraulic circuit.

A tandem master cylinder having a single reservoir tank has a separator inside that divides the tank into front and rear as shown below. The two-part design of the reservoir ensures that if one circuit fails due to fluid leakage, the other circuit will still be available to stop the vehicle.

Single Fluid Reservoir Tank

A separator inside divides the tank into front and rear parts to ensure that if one circuit fails the other will still have fluid.

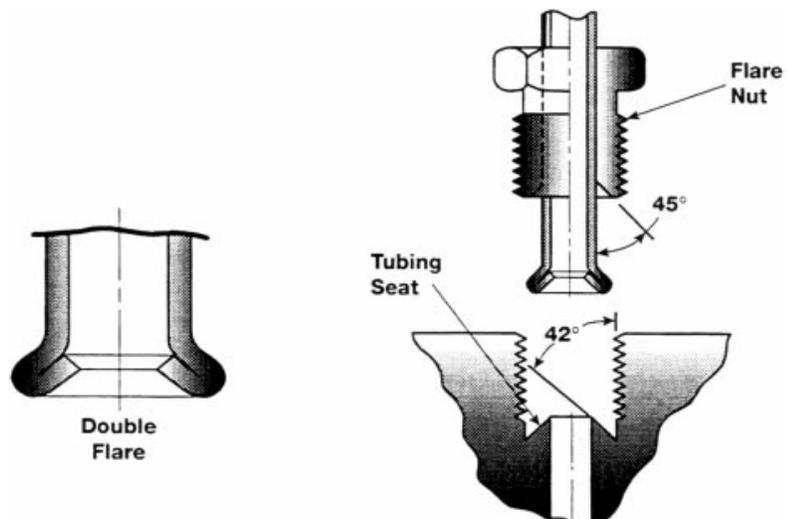
Fluid level if one of the circuits is leaking



Brake Tubing Brake hydraulic components are connected by a network of seamless steel tubes and hoses. Brake tubing is made of copper plated steel sheets rolled at least two times and brazed into a single piece and plated with tin and zinc for corrosion resistance. It is produced in different lengths and pre-bent for the specific model applications. Each end is custom flared in a two step process and fitted with a flare nut.

Double Flare Tubing

The tapered seats and double flare tube provide a compression fitting to seal the connection.

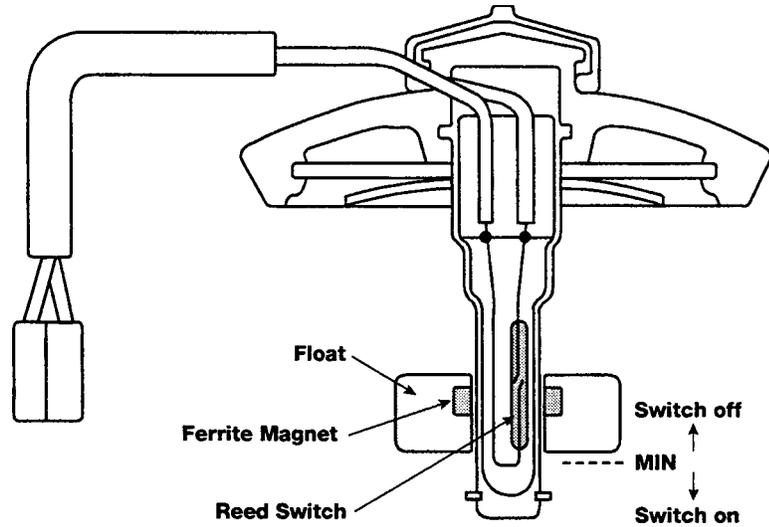


Brake Fluid Level Warning Light Switch

The brake fluid level warning switch is located on the reservoir cap or in some models, is wired within the reservoir body. It normally remains off when there is an appropriate amount of fluid. When the fluid level falls below the minimum level, a magnetic float moves down and causes the switch to close. This activates the red brake warning lamp to warn the driver.

Brake Fluid Level Warning Switch

If fluid level falls below the minimum level, a magnetic float moves down and turns the switch on.



A typical brake warning lamp electrical circuit is shown below. It also turns ON when the parking brake is applied.

Brake Warning Light Electrical Circuit

Low brake fluid level or parking brake light turn on.

