Module 4

Braking system

Factors governing braking

Four basic factors determine the braking power of a system. The first three factors govern the generation of friction: pressure or force against the friction materials, coefficient of friction, and frictional contact surface.

Pressure : The amount of friction generated between moving surfaces in contact with each other depends in part on the pressure exerted on the surfaces. For example, if you slowly increase the downward pressure on the palm of your hand as you move it across a desk, you will feel a gradual increase in friction

Coefficient of Friction : The amount of friction generated between two surfaces is expressed as a coefficient of friction (COF). The COF is determined by dividing the force required to pull an object across a surface by the weight of the object.

Frictional Contact Surface: The third factor is the amount of surface area that is in contact. Simply put, bigger brakes stop a car more quickly than smaller brakes used on the same car.

Heat Dissipation: Any braking system must be able to effectively handle the heat created by friction within the system.

HYDRAULIC BRAKE SYSTEM

A hydraulic system (Figure 50–4) uses brake fluid to transfer pressure from the brake pedal to the pads or shoes. This transfer of pressure is reliable and consistent because liquids are not compressible . That is pressure applied to a liquid in a closed system is transmitted by that liquid equally to every other part of that system. Apply a force of 100 pounds per square inch (psi) (690 kPa) through the master cylinder and you can measure 100 psi (690 kPa) anywhere in the lines and at each wheel where the brakes operate.

Hydraulic Brake System Components

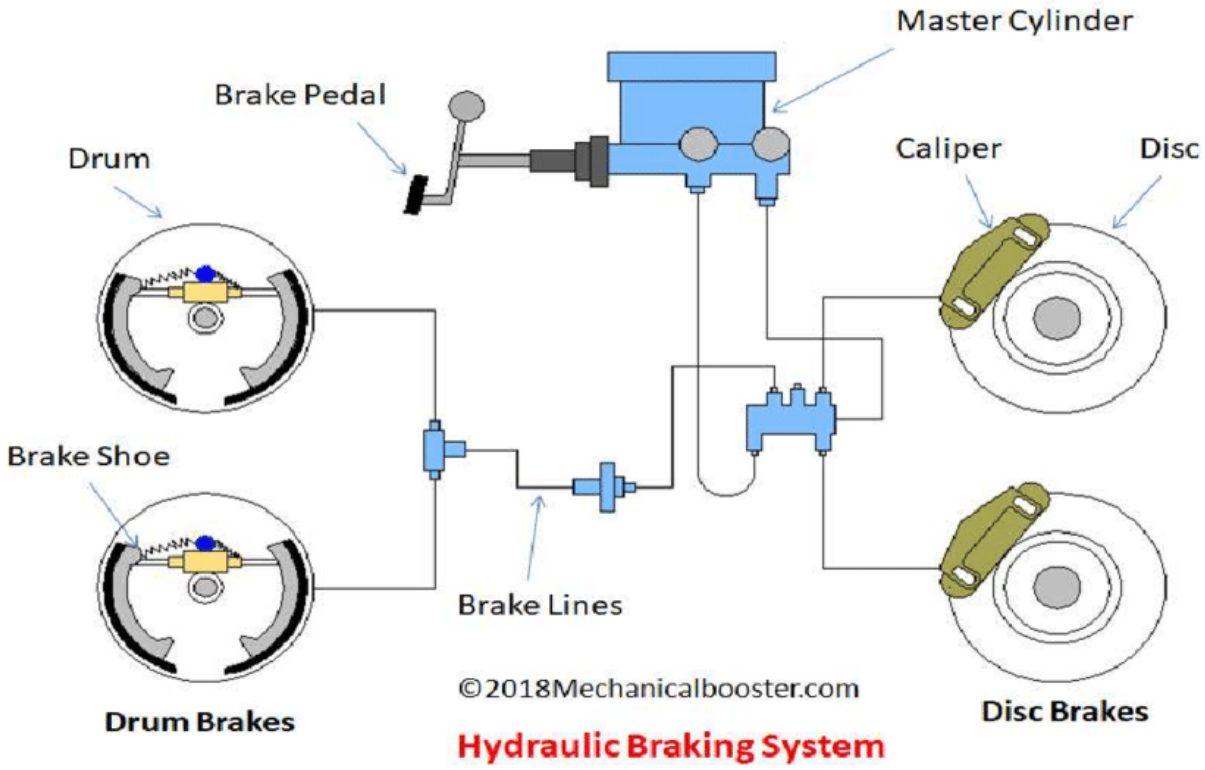
The following sections describe the major components of a hydraulic brake system

Brake Fluid

Brake fluid is the lifeblood of any hydraulic brake system. It is what makes the system operate properly. Brake fluid is specially blended to perform a variety of functions.

Brake Pedal

The brake pedal is where the brake's hydraulic system gets its start. When the brake pedal is depressed, force is applied to the master cylinder. On a basic hydraulic brake system (where there is no power assist), the force applied is transmitted mechanically. As the pedal pivots, the force applied to it is multiplied mechanically



Master Cylinders

The master cylinder (Figure 50–9) transmits the pressure on the brake pedal to each of the four wheel brakes to stop the vehicle. It changes the driver's mechanical pressure on the pedal to hydraulic the pistons in the drum brake wheel cylinders and/or disc brake calipers can move, and they move outward to force the brake shoes or pads against the rotating brake drums and/or rotors.

Dual-Piston Master Cylinders

. A pushrod is connected to a piston inside the cylinder, and hydraulic fluid is in front of the piston. When the pedal is pressed, the piston is pushed forward. The fluid transmits the force of the piston to all the inner surfaces of the system. Only he pistons in the drum brake wheel cylinders and/or disc brake calipers can move, and they move outward to force the brake shoes or pads against the rotating brake drums and/or rotors.

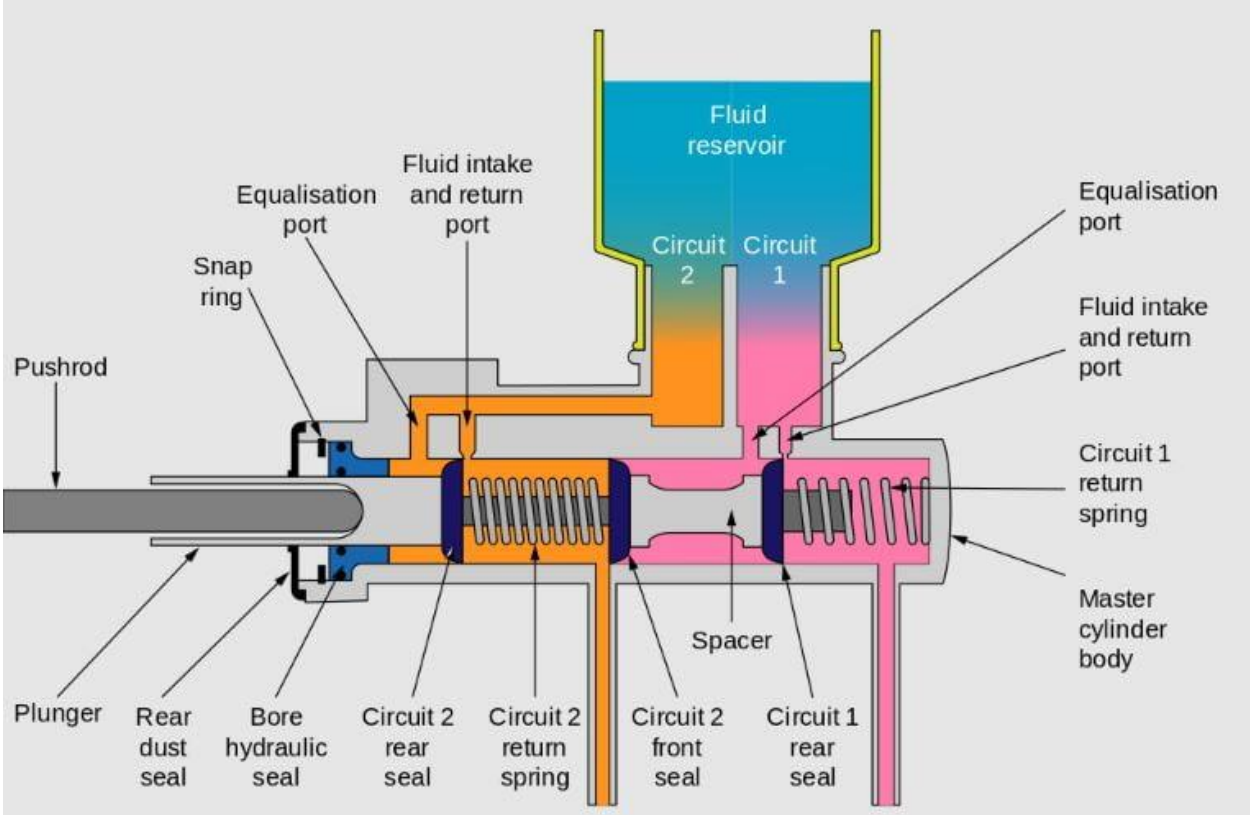
Master Cylinder Construction

A single cylinder bore contains two piston assemblies (Figure 50–13). The piston assembly at the rear is the primary piston, and the one at the front is the secondary piston. Each piston has a return spring in

front of it. There is a cup seal in front of each piston and a cup or seal at the rear of each piston. The seals retain fluid in the cylinders and prevent seepage between the cylinders. Inside the cylinder are two spool-shaped pistons. The piston has a head on one end and a groove for an O-ring seal on the other end. The seal seats against the cylinder wall and keeps fluid from leaking past the piston. The smaller diameter center of the piston is the valley or spool area, which lets fluid get behind the head of the piston. Each master cylinder piston works with a rubber cup seal, which fits in front of the piston head. The cup has flexible lips that fit against the cylinder walls to seal fluid pressure ahead of the piston head. The cup lip also can bend to let fluid get around the cup from behind. When the brakes are applied, pressure in front of the cup forces the lip tightly against the cylinder wall, enabling it to hold very high pressure. The lip of a cup seal is always installed toward the pressure to be contained or away from the body of the piston. The cup seals in only one direction.

Master Cylinder Operation

The vent port in the bottom of the reservoir is located just ahead of the piston cup. Fluid flows from the reservoir into the pressure chamber in front of the piston cup. The replenishing port is located above the valley area of the piston behind the piston head. The O-ring seal on the piston keeps the fluid from leaking out the rear of the cylinder. The return spring in front of the piston and cup returns the piston when the brakes are released When the driver depresses the brake pedal, the pushrod pushes the piston forward. As it moves forward, the piston pushes the cup past the vent port. As soon as the vent port is covered, fluid is trapped ahead of the cup. The fluid, which is under pressure, goes through the outlet lines to the wheel brake units to apply the brakes. When the driver releases the brake pedal, the return spring forces the piston back to its released position. As the piston moves back, it pulls away from the fluid faster than the fluid can flow back from the brake lines to the pressure chamber. This creates a low pressure ahead of the piston. The piston must rapidly move back to the released position so it can be ready for another forward stroke if necessary. The low-pressure area must be filled with fluid as the piston moves back. A path for fluid flow is provided by the valley area, past the primary cup protector washer and through several small holes in the head of the piston, or by having enough clearance between the piston head and the cylinder bore. Fluid flows through the piston or around the lip of the cup and into the chamber ahead of the piston. This flow quickly relieves the low-pressure condition. The fluid that flows from the valley area to the pressure chamber must be replaced. When the piston is fully returned to its released position, the space in front of it is full of fluid. The piston cup again seals off the head of the piston. In the meantime, the fluid from the rest of the system has begun to flow back to the high-pressure chamber. If this pressure is not released, the brakes would not release. The returning fluid flows back to the reservoir through the vent port. The vent port is covered by the piston cup at all times, except when the piston is released.



Residual Pressure Check Valve

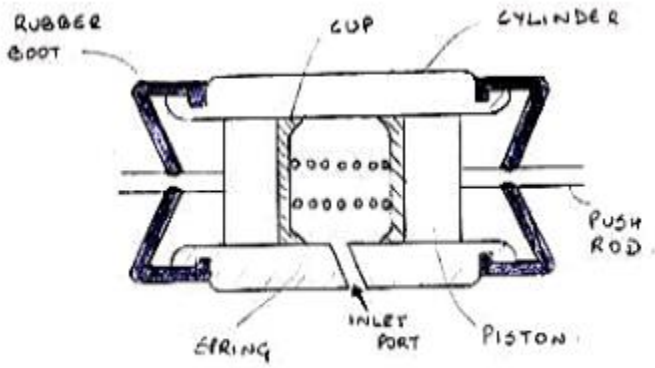
The pressure chamber in a master cylinder for some drum brake systems may have an additional part called a residual pressure check valve. This valve can be installed in the pressure chamber or the outlet line of the master cylinder.

Split Hydraulic Systems

Most late-model vehicles have a diagonally split hydraulic system. If there is a hydraulic failure in the brake lines served by the master cylinder's secondary piston, both pistons will move forward when the brakes are applied, but there is nothing to resist piston travel except the secondary piston spring. This lets the primary piston buildup only a small amount of pressure until the secondary piston bottoms in the cylinder bore. Then the primary piston will build enough hydraulic pressure to operate the brakes served by this half of the system. In case of a hydraulic failure in the brake system served by the primary piston, the piston will move forward when the brakes are applied but will not buildup hydraulic pressure. Very little force is transferred to the secondary piston through the primary piston spring until the piston extension screw comes in contact with the secondary piston. Then, pushrod force is transmitted directly to the secondary piston and enough pressure is built up to operate its brakes.

Wheel cylinder

Wheel cylinders convert hydraulic pressure from the master cylinder into a mechanical force at the brakes . The wheel cylinder bore is filled with fluid. When the brake pedal is depressed, additional brake fluid is forced into the cylinder. The additional fluid moves the cups and pistons outward. This piston movement forces the brake shoes outward to the contact drum and thus applies the brakes. Piston stops prevent the fluid leakage or air from getting into the system when the pistons move to the end of their bores.



Wheel Cylinder

Metering Valve

A metering valve (hold-off valve) in the front brake line holds off pressure going from the master cylinder to the front disc calipers. This delay allows pressure to buildup in the rear drums first. When the rear brakes begin to take hold, the hydraulic pressure builds to the level needed to open the metering valve . When the metering valve opens, line pressure is high enough to operate the front discs. This process provides for better balance of the front and rear brakes. It also prevents lockup of the front brakes by keeping pressure from them until the rear brakes have started to operate. The metering valve has the most effect at the start of each brake operation and all during light braking conditions

Proportioning Valve

The self-energizing action of the delayed response rear drum brakes can cause them to lock the rear wheels at a lower hydraulic pressure than the front brakes. The proportioning valve (balance valve) is used to control rear brake pressures, particularly during hard stops. When the pressure to the rear brakes reaches a specified level, the proportioning valve overcomes the force of its spring-loaded piston, stopping the flow of fluid to the rear brakes. By doing so, it regulates rear brake system pressure and adjusts for the difference in vehicle load. This is accomplished by turning the valve on or off. When the vehicle is not loaded, hydraulic pressure is reduced to the rear brakes.

Combination Valves

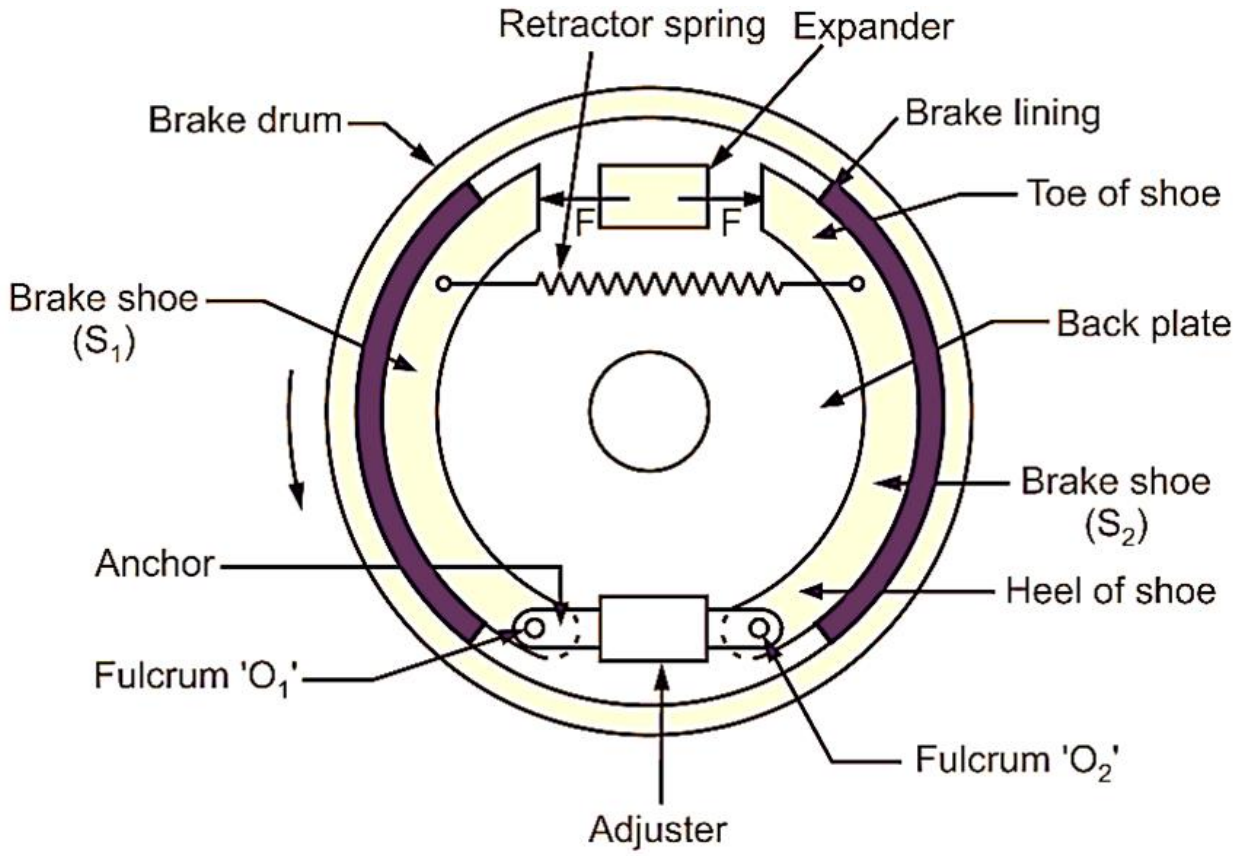
Most older cars and trucks have a combination valve in their hydraulic system. This valve is simply a single unit that combines the metering and proportioning valves with the pressure differential valve. Combination valves are described as three-function or two function valves, depending on the number of functions they perform in the hydraulic system.

Pressure differential switch

A wide variety of electrical and electronic components are found in a brake system, especially with ABS. These include the warning lamp switch operation of a pressure differential valve and the electrical switches to operate the parking brake warning light, hydraulic failure warning lamp, as well as sensors to indicate low brake fluid level.

DRUM BRAKES

Drum brake operation is fairly simple. The most important feature contributing to the effectiveness of the braking force supplied by the drum brake is the brake shoe pressure or force directed against the drum . With the vehicle moving in either the forward or reverse direction with the brakes on, the applied force of the brake shoe pressing against the brake drum increasingly multiplies itself (called self-energizing) because the brake's anchor pin acts as a brake shoe stop and prohibits the brake shoe from its tendency to follow the movement of the rotating drum. The result is a wedging action between the brake shoe and brake drum. The wedging action combined with the applied brake force creates a self-multiplied brake force.



Drum Brake Components

The backing plate provides a foundation for the brake shoes and associated hardware . The plate is secured and bolted to the axle flange or spindle.

Wheel Cylinders : Wheel cylinders convert hydraulic pressure from the master cylinder into a mechanical force at the brakes

Brake Shoes and Linings : The shoe rim is welded to the web to provide a stable surface for the lining. The web thickness might differ to provide the stiffness or flexibility needed for a specific application

Shoe Return Springs : Return springs can be separately hooked into a link or a guide or strung between the shoes.

Shoe Anchors : There are various types of shoe anchors such as the fixed nonadjustable type, self-centering shoe sliding type, or on some earlier models, adjustable fixed-type providing either an eccentric or a slotted adjustment.

Drums: Modern automotive brake drums are made of heavy cast iron (some are aluminum with an iron or steel sleeve or liner) with a machined surface inside against which the linings on the brake shoes generate friction when the brakes are applied.

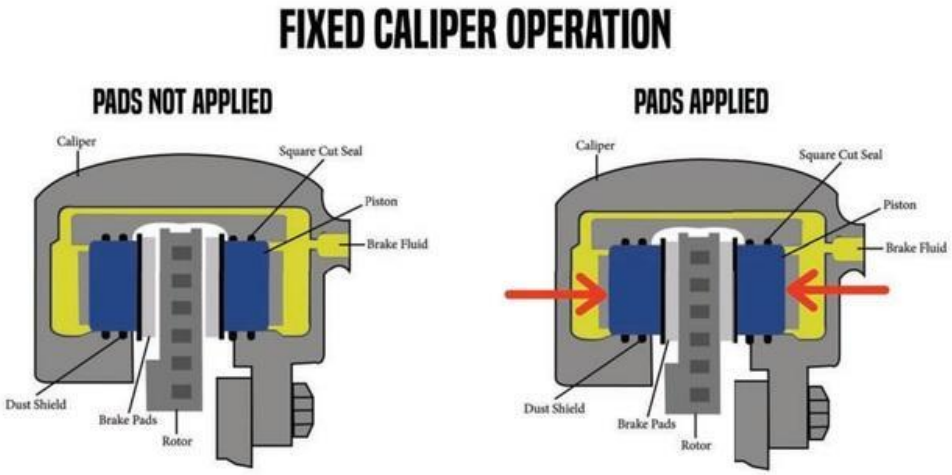
DISC BRAKES

The disc brakes used today are typically of two basic designs: fixed caliper (Figure 52–2) or floating caliper. There is also a sliding caliper, but its design is very similar to the floating caliper (Figure 52–3). The A disc brake assembly. A fixed caliper assembly. A floating caliper. only difference is that sliding calipers slide on surfaces that have been machined smooth for this purpose, and floating calipers slide on special pins or bolts. The disc brake, regardless of its design, consists of a hub and rotor assembly, a caliper assembly, and the brake pads.

TYPES OF CALIPER ASSEMBLY

1) **Fixed Caliper Disc Brakes**

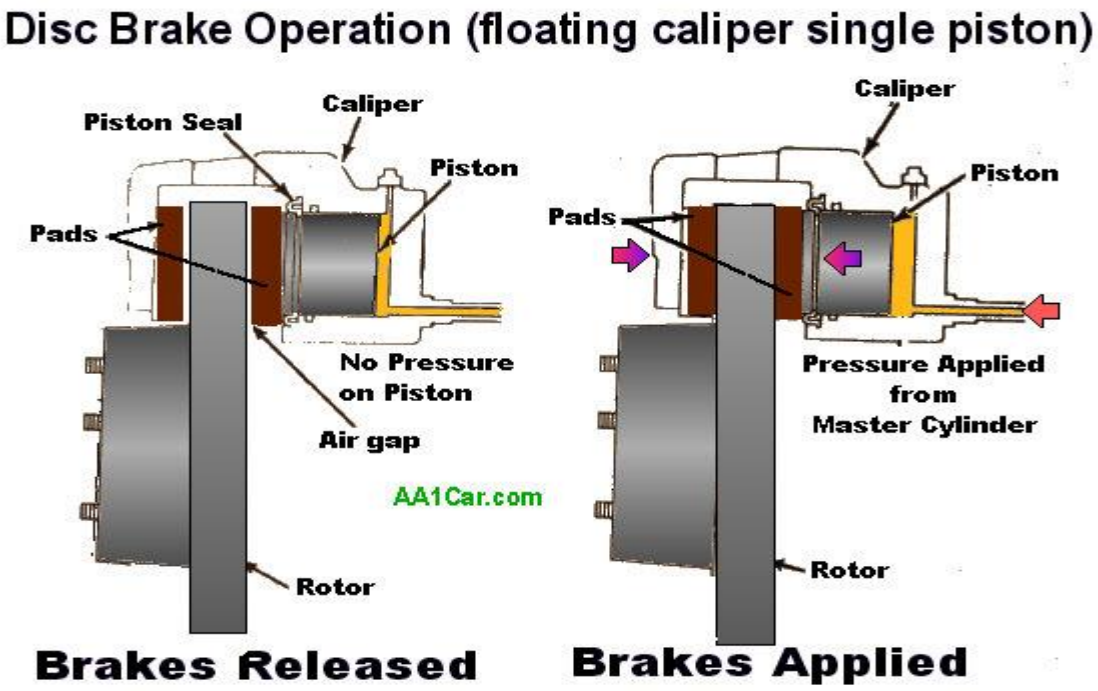
Fixed caliper disc brakes have a caliper assembly that is bolted in a fixed position and does not move when the brakes are applied. The pistons in both sides of the caliper come inward to force the pads against the rotor . Fixed calipers typically have two to six pistons based on the size of the brake and the performance of the vehicle. Fixed calipers may be one or a two-piece design. Also called a monobloc caliper, one-piece designs are made from a single piece of aluminum to reduce weight. Two-piece calipers are bolted together and are less expensive than one-piece calipers. Fluid passages may be machined into the caliper body or external transfer tubes (steel brake lines) route fluid to both sets of pistons.



2) **Floating Caliper Disc Brakes**

A typical floating caliper disc brake is a one-piece casting that has one hydraulic cylinder and a single piston. The caliper is attached to the spindle anchor plate with two threaded locating pins . A Teflon

sleeve separates the caliper housing from each pin and the caliper slides back and forth on the pins as he brakes are actuated. When the brakes are applied, hydraulic pressure builds in the cylinder behind the piston and seal. Because hydraulic pressure exerts equal force in all directions, the piston moves evenly out of its bore.



3)Sliding Caliper Disc Brakes

With a sliding caliper assembly, the caliper slides or moves sideways when the brakes are applied. As mentioned previously, in operation, these brakes are almost identical to the floating type. But unlike the floating caliper, the sliding caliper does not float on pins or bolts attached to the anchor plate. It has angular machined surfaces at each end that slide in mating machined surfaces on the anchor plate. This is where the caliper slides back and forth. Some sliding calipers use a support key to locate and support the caliper in the anchor plate . The caliper support key is inserted between the caliper and the anchor plate. A worn support key may cause tapered brake pad wear. Always inspect the support keys when replacing brake pads. Also make sure they are lubricated when reassembling the unit.

HYDRAULIC SYSTEM BLEEDING(PROCDURE)

`Step 1: Get the Right Brake Fluid.
Step 2: Mount the Car and Remove the Tires.
Step 3: Loosen the Bleeder Screw.
Step 4: Check the Brake Fluid Level.
Step 5: Cover the Screw Opening with Tubing.
Step 6: Get an Assistant to Engage the Brake Pedal.

Step 7: Repeat on Each Brake.

Power Brakes

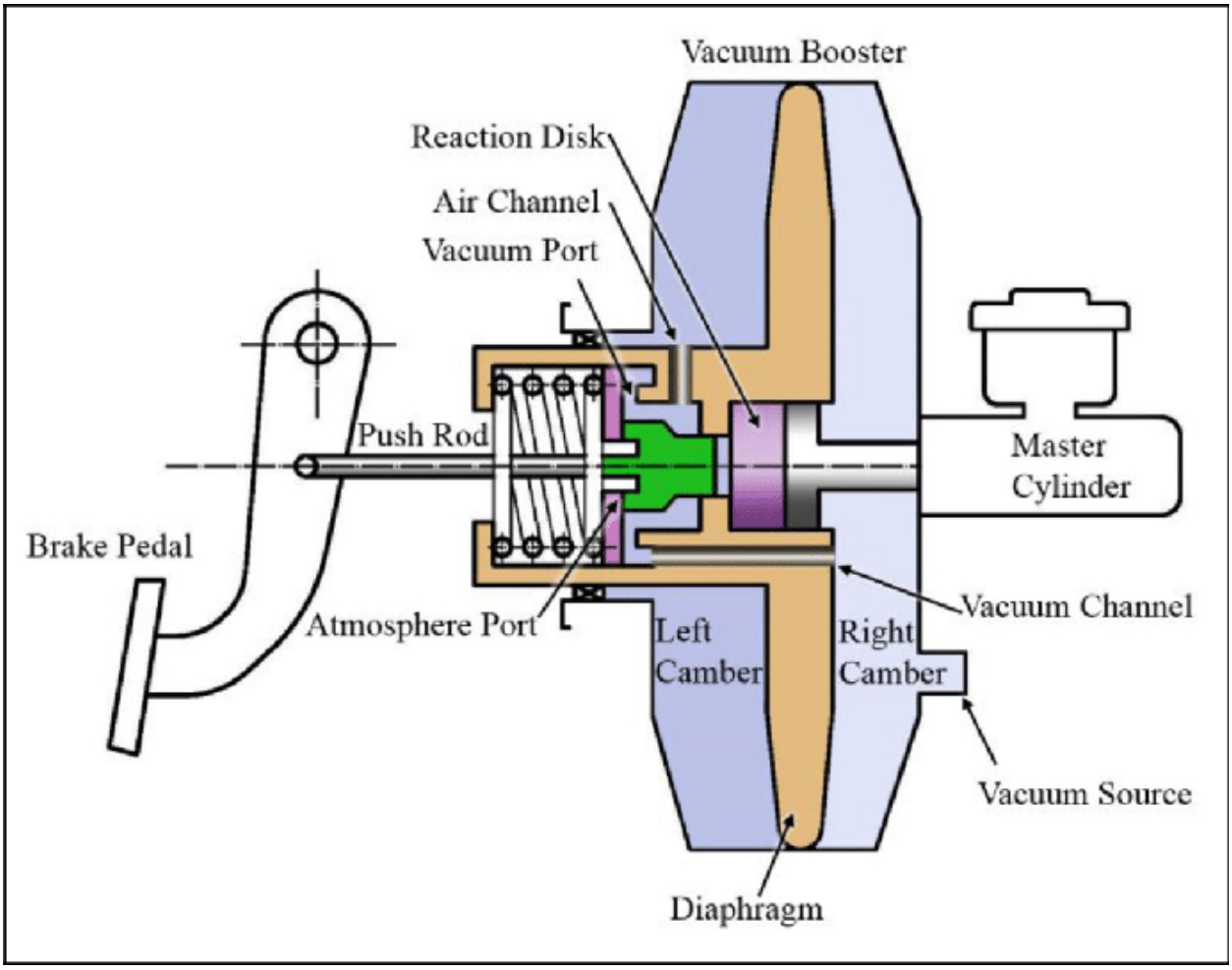
Power brakes are nothing more than a standard hydraulic brake system with a booster unit located between the brake pedal and the master cylinder to help activate the brakes. Three basic types of power-assist mechanisms are used. The first is vacuum assist. These systems use engine vacuum, or sometimes vacuum pressure developed by an external vacuum pump, to help apply the brakes. The second type of power assist is hydraulic assist.

VACUUM ASSISTED BRAKE

All vacuum-assisted units are similar in design. They generate application energy by opposing engine vacuum to atmospheric pressure. A piston and ylinder, flexible diaphragm, or bellows use this energy to provide braking assistance. All modern vacuum-assist units are vacuumsuspended systems. This means the diaphragm inside the unit is balanced using engine vacuum until the brake pedal is depressed. Applying the brake allows atmospheric pressure to unbalance the diaphragm and allows it to move generating application pressure. Vacuum boosters may be single diaphragm or tandem diaphragm. The unit consists of three basic elements combined into a single power unit.

Operation

When the brakes are applied, the valve rod and plunger move to the left in the power diaphragm. This action closes the control valve's vacuum port and opens the atmospheric port to admit air through the valve at the rear diaphragm chamber . With vacuum in the rear chamber, a force develops that moves the power diaphragm, hydraulic pushrod, and hydraulic piston or pistons to close the compensating port or ports and force fluid under pressure through the residual check valve or valves and lines into the front and rear brake assemblies.



Hydraulic Brake Boosters

Decreases in engine size, plus the continued use of engine vacuum to operate other engine systems, such as emission control devices, led to the development of hydraulic-assist power brakes. These systems use fluid pressure, not vacuum pressure, to help apply the brakes. They are mostly found on diesel engines and other engines that have low vacuum. Fluid pressure from the power-steering pump provides the power assist to the brakes. The power brake booster is located between the cowl and the master cylinder. Hoses connect the power-steering pump to the booster assembly. The power-steering pump provides a continuous flow of fluid to the brake booster whenever the engine is running. Three flexible hoses route the power-steering fluid to the booster. One hose supplies pressurized fluid from the pump. Another hose routes the pressurized fluid from the booster to the power-steering gear assembly. The third hose returns fluid from the booster to the power-steering pump.

Operation

When the brake pedal is depressed, the pedal's pushrod moves the master cylinder's primary piston forward. This causes the lever assembly of the booster to move a sleeve forward to close off the holes

leading to the open center of the spool valve. A small additional lever movement moves the spool valve into the spool valve bore. The spool valve then diverts some hydraulic fluid into the cavity behind the booster piston building up hydraulic pressure that moves the piston and a pushrod forward. The output pushrod moves the primary and secondary master cylinder pistons that apply pressure to the brake system. When the brake pedal is released, the spool and sleeve assemblies return to their normal positions. Excess fluid behind the piston returns to the power-steering pump reservoir through the return line. After the brakes have been released, pressurized fluid from the power-steering pump flows into the booster through the open center of the spool valve and back to the powersteering pump.

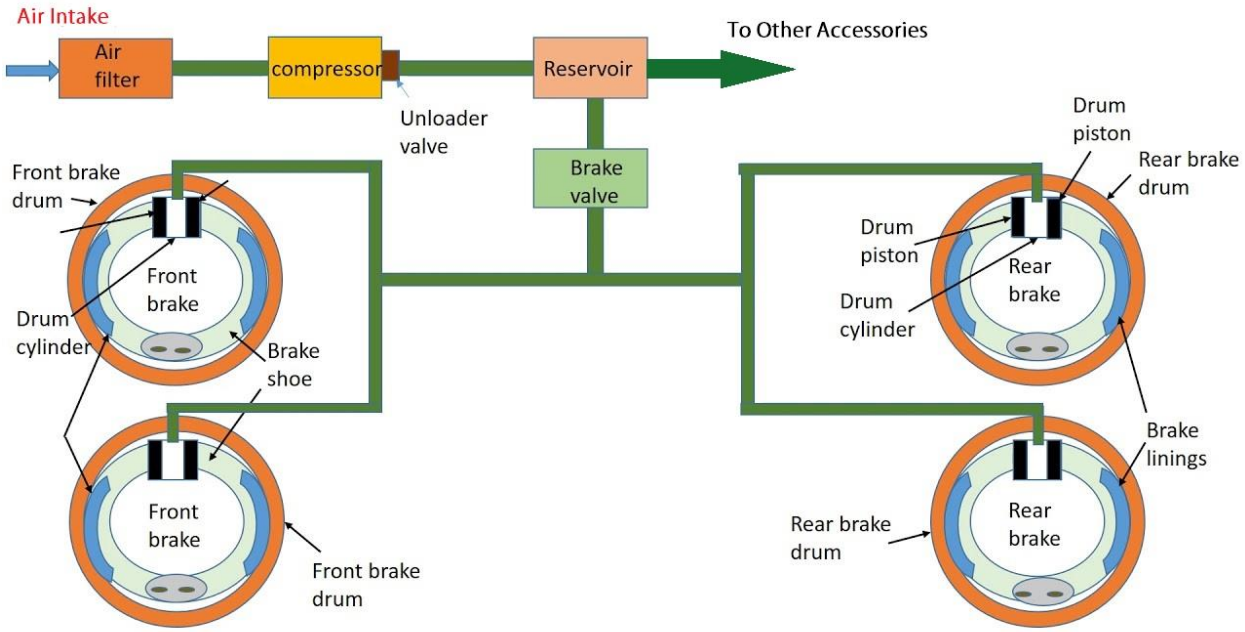
AIR BRAKE COMPONENTS AND WORKING

Introduction To Air Brake :

An air brake or, more formally, a compressed air brake system, is a type of friction brake for vehicles in which compressed air pressing on a piston is used to apply the pressure to the brake pad needed to stop the vehicle. Air brakes are used in large heavy vehicles, particularly those having multiple trailers that must be linked into the brake system, such as trucks, buses, trailers, and semi-trailers in addition to their use in railroad trains.

Construction Of Air Brakes :

he air brake system consists of a two-stage air-compressor driven by the crankshaft or gearbox shaft. It takes air from the atmosphere, compresses it, and delivers to the air reservoir through an un-loader valve. Where the pressure of the reservoir reaches the maximum degree, the unloader valve opens to the atmosphere. Then the compressed air is directed into the atmosphere directly. Each of the four wheels fitted with brake chambers consists of a diaphragm, and which the air pressure is applied and pushes it. This force operates the cam actuating lever and applies the brake. Each of the brake chambers is connected to the brake pedal, and the air filter is also fitted between the brake valve and reservoir.



Air Brake Components and their Functions

Air compressor

- It is used to build-up and maintain air pressure.
- The function of the air compressor is to build up and maintain air pressure required to operate air brakes and air-powered accessories.
- A compressor is designed to pump air into a reservoir which results in pressurized air.
- The compressor is driven by the vehicle's engine, either by belts and pulleys or shafts and gears.
- The compressor is in constant drive with the engine. Whenever the engine is running, so is the compressor.

Reservoir

- he reservoir is used to store the compressed air. Reservoirs are pressure-rated tanks, which hold a supply of compressed air until required for braking or operating auxiliary air systems.
- They must store a sufficient volume of air to allow several brake applications if the engine stops or the compressor fails.
- The number and size of the reservoirs on a vehicle will depend on the number of brake chambers and their size, along with the parking brake configuration.

Safety Valve

- A safety valve protects reservoirs from becoming over-pressurized and bursting if the governor malfunctioned and did not place the compressor in the unloading stage.
- The valve consists of a spring-loaded ball that will allow air to exhaust from the reservoir into the atmosphere. The valve's pressure setting is determined by the force of the spring

Foot valve.

- Foot Valve is used to draw compressed air from reservoirs when it is needed for braking.
- This foot-operated valve applies air to operate the brakes.
- The amount of air delivered to the brakes is regulated by the driver according to the distance the treadle or brake pedal is depressed. Releasing it exhausts air in the service brakes through its exhaust port.
- The distance the treadle of the foot valve is depressed by the driver determines the air pressure that will be applied, but the maximum application will not exceed the pressure in the reservoir. Releasing the foot valve treadle releases the brakes.
- When the driver applies the brakes, depressing the treadle partway, the foot valve will automatically maintain the application air pressure without the driver having to adjust the pressure of his foot on the treadle.
- Releasing the treadle allows the application air to be released through the exhaust ports into the atmosphere. Air treadles are spring-loaded, producing a different "feel" from hydraulic brake applications.

(v) Brake chamber.

- Brake chamber is used to transfer the force of compressed air to mechanical linkages.
- Service-brake chambers convert compressed air pressure energy into mechanical force and movement, which apply the vehicle's brakes.
- A brake chamber is a circular container divided in the middle by a flexible diaphragm.
- Air pressure pushing against the diaphragm causes it to move away from the pressure, forcing the push rod outward against the slack adjuster.
- The force exerted by this motion depends on air pressure and diaphragm size. If a leak occurs in the diaphragm, air is allowed to escape, reducing the effectiveness of the brake chamber.
- A brake chamber is usually mounted on the axle, near the wheel that is to be equipped for braking.

(vi) Brake Assembly

- Brake assembly includes brake chamber and slack adjuster mounted on the backing–plate because of the steering action.
- A brake chamber is usually mounted on the axle, near the wheel that is to be equipped for braking.

- Air pressure is fed through an inlet port. The air pushes against the diaphragm and the pushrod.
- The pushrod is connected by a clevis and pin to a crank arm–type lever called a “slack adjuster”.
- This converts the pushing motion of the pushrod from the brake chamber to a twisting motion of the brake camshaft and S–cams.
- When the air is exhausted, the return spring in the brake chamber returns the diaphragm and pushrod to the released position.

Working of Air Braking System :

When the brake pedal is pushed the brake valve opens and compressed air is allowed into the brake chamber.

The brake valve consists of three passages.

1. Air intake

2. Exhaust

3. Brake chamber

When the brake pedal is pressed the exhaust passage will be closed and Air intake passage open and compressed air goes back to the chamber. During return stroke the exhaust passage opens while intake closes and used air goes to the atmosphere. This system fitted with an emergency mechanical brake, which can be used when air supply fails the air brake system, which is called an air-assisted hydraulic braking system.

Working principle:

As shown in the figure, in the air brakes the compressed air (around 700 kPa) is used to actuate the brake mechanism. The figure shows the complete layout of the Air Brake System. It consists of Air filter, unloading valve, Air compressor, Air reservoir, Brake valve, and 4 numbers brake chamber. The compressor takes atmospheric air through the air filter and compresses the air. This air is stored under pressure in the air reservoir. From this reservoir air goes to various accessories of the vehicle which operates on compressed air. Part of the air goes to the brake valve. The control of the brake valve is done by a driver who controls the intensity of braking according to an emergency.

Pedal Depressed: When the brake pedal is depressed, compressed air from the reservoir is transmitted through pipes equally in all directions to the brake chambers through brake valve which further applies the brake.

Pedal Released: When the driver releases the brake pedal, the master cylinder piston returns to its original position due to return spring, and the pressure is dropped. It releases brake shoes from brake drum to their: original position and brakes are released.