

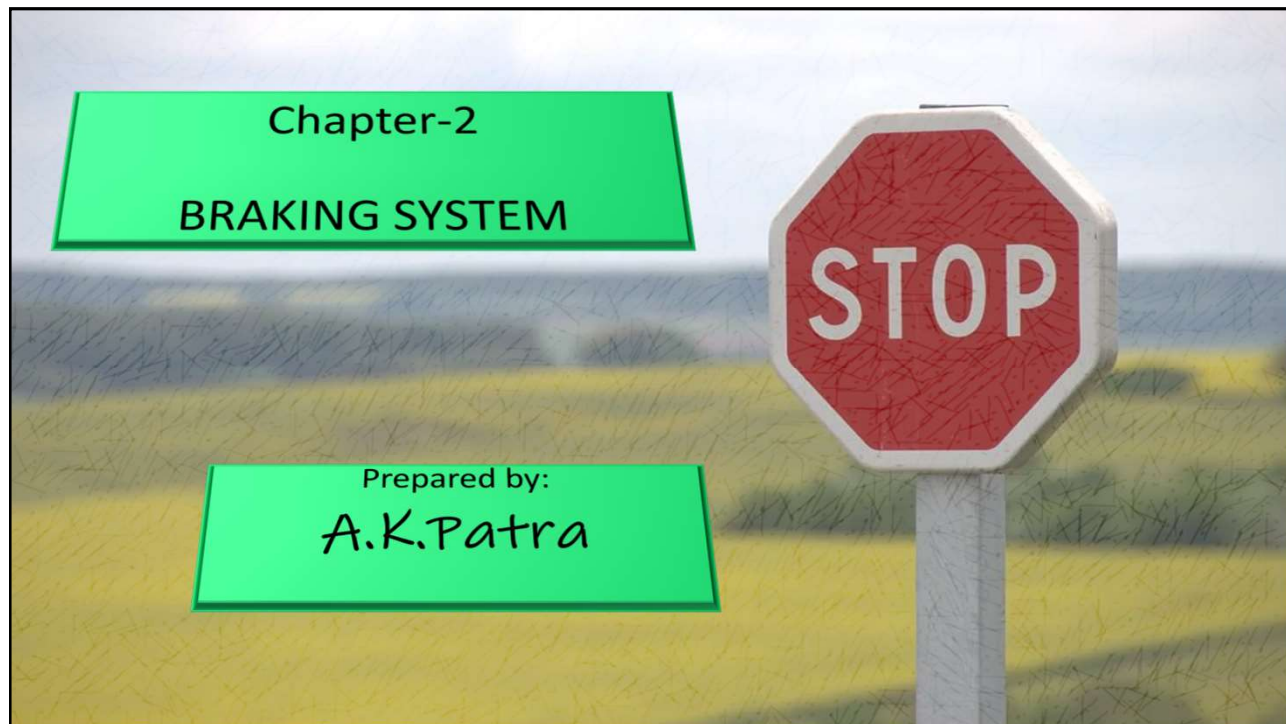
LECTURE NOTES ON

AUTOMOBILE ENGINEERING & HYBRID VEHICLES

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Braking Systems In Automobiles

- ☛ Braking is the mechanism in the motor vehicle which is used to slowing down and stopping the vehicle to rest in the **shortest possible distance**.
- ☛ So a brake is a mechanical device that inhibits motion by **absorbing energy** from a moving system.
- ☛ Brakes are used for slowing or **stopping** a moving vehicle, wheel, axle, or to prevent its motion, most often accomplished by means of friction.
- ☛ It is also used to **control** the vehicle to be retained when descending a hill.
- ☛ The brake system takes the **kinetic energy** of your moving vehicle and converts it to **thermal energy** through friction.

Need of Braking System:

- ☞ To stop the moving vehicle to rest in shortest possible distance.
- ☞ To de-accelerate the moving vehicle.
- ☞ For control the vehicle while descending along the slope.
- ☞ As a precaution for accidents, it stops where and when required.
- ☞ To prevent the vehicle from any damage due to road conditions.
- ☞ To park the vehicle and held it in stationary position without the presence of driver.

Classification of Braking System

1. On the Basis of Frictional Braking Contact:

- Internal expanding brakes (e.g.-drum brakes)
- External contracting brakes(e.g.- Disc brakes)

2. On the Basis of Application:

- Foot or service brakes
- Hand or parking brakes

3. On the Basis of Brake Force Distribution

- Single acting brakes
- Dual acting brakes

4. On the Basis of Number of Wheels:

- Two wheel brakes
- Four wheel brakes

5. On the Basis of Method Of Braking Contact:

- Internal Expanding Brakes
- External Contracting Brakes

6. On the Basis of Power Transmission

- Direct Acting Brakes
- Geared Brakes

7. On the Basis of Power Unit:

- Cylinder brakes
- Diaphragm brakes

8. On the Basis of Power Source

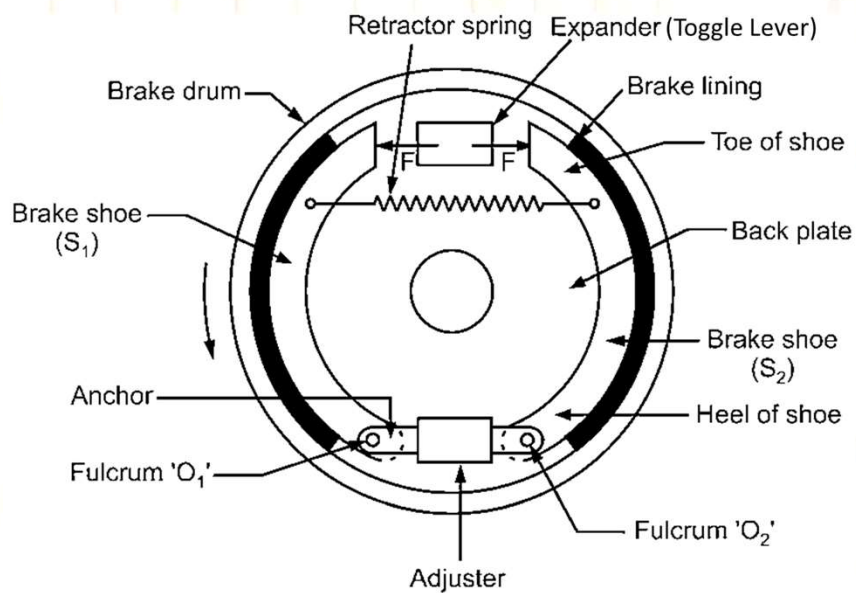
- Mechanical braking system
- Hydraulic braking system
- Air or pneumatic braking system
- Vacuum braking system
- Magnetic braking system
- Electric braking system

Mechanical Brake

Construction:

- ☞ A drum brake is a brake that uses **friction** caused by a set of shoes or pads that press outward against a rotating cylinder-shaped part called a brake drum.
- ☞ A brake drum is a **cylindrical drum** that is attached to the inside of a car's wheel, and so rotates at the same speed as the wheel.
- ☞ The drum surrounds a set of **brake shoes** that are coated in materials that generate friction called **brake lining**.
- ☞ Each brake shoe is hinged at one end by an **anchor pin**, the other end is operated by some means so that the brake shoe expand outwards.

- ✿ **Refracting spring** keeps the brake shoes into position when the brakes are not applied.
- ✿ The drum encloses the entire mechanism to keep out dust and moisture.
- ✿ The shoe are generally mounted to rub against the inside surface of the drum to form an **internal expanding brake**.



Working of Mechanical Brakes:

- 🚗 When the brake pedal is pressed, the cam turns by means of brake linkage.
- 🚗 When the cam or toggle lever turns, the shoe expands outwards against the inner surface of the brake drum.
- 🚗 The brake linings rub against the drum generating friction and so slowing the car down and thus stop its motion.
- 🚗 The entire mechanical linkage between the brake pedal and the shoes operates to transmit pedal force to the brake shoes, and to multiple that force through leverage to produce effective braking forces against the drum.
- 🚗 However, drum brakes can be susceptible to heat generation, which can have an adverse effect on braking performance.

Advantages Of Mechanical Brake:

- i. They are **self energizing** braking system means they are designed to operate by itself.
- ii. Drum brakes can provide **more braking force** than an equal diameter disc brake.
- iii. It is **cheaper** than the disc braking system.
- iv. A slightly lower frequency of **maintenance** due to better corrosion resistance compared to disks.

Disadvantages Of Mechanical Brake:

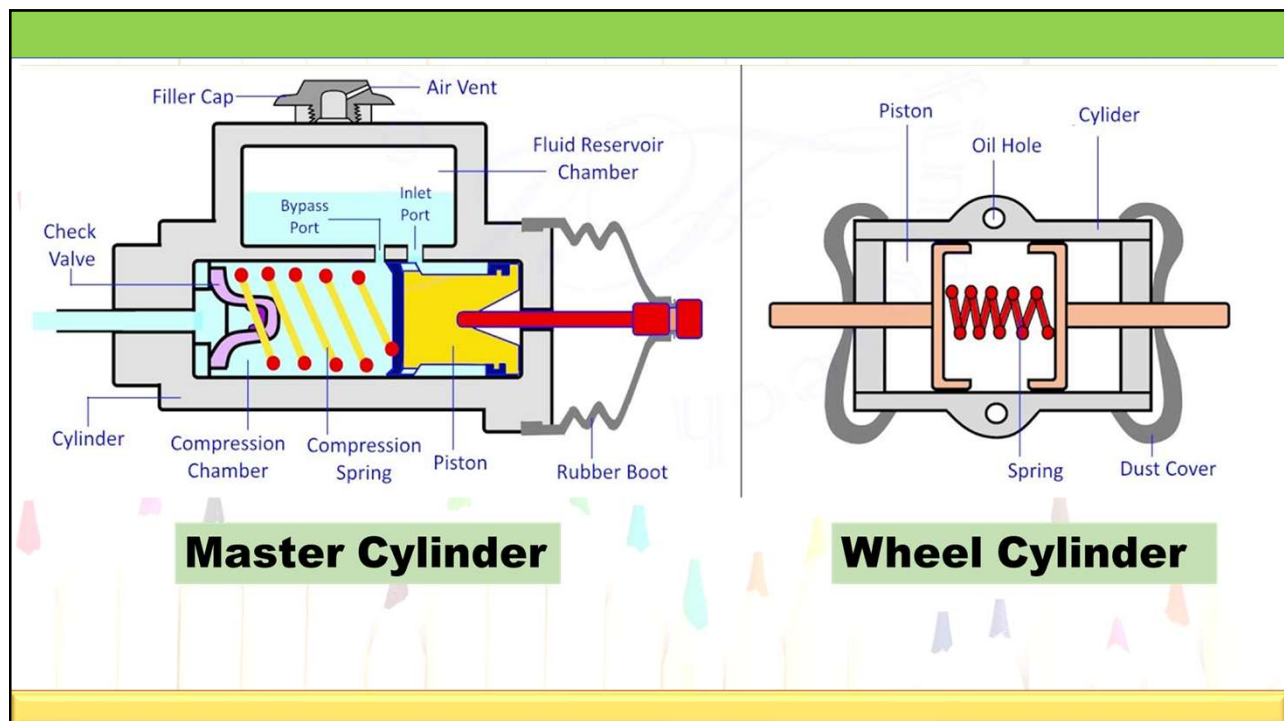
- i. Heating problem: Since the friction area is totally covered by lining, so heat is developed during the friction is not allowed to go out in the atmosphere. This may reduces the braking efficiency of the vehicle. i.e.- **Poor heat dissipation**
- ii.Excessive brake drum heating can cause the brake fluid to **vaporize**.
- iii.The drum brakes will not work properly if it gets **wet** in water. This is because water takes longer time to come out from the drum and the **water reduces the friction** in between the brake lining and drum.
- iv.Under hard braking, the diameter of the drum increases slightly due to **thermal expansion**, the driver must press the brake pedal farther.
- v.Maintenance of drum brakes is more **time-consuming**, compared to disc brakes.

Hydraulic Brake

- ☞ A hydraulic braking system in automobiles is the brake operating system which uses fluid for their operation. It is highly efficient braking system.
- ☞ This system is based upon **Pascals principle**, which states that, “Pressure at any point in a static fluid is equal in all directions”.
- ☞ Here the pedal force is transmitted to the brake shoe by means of a confined liquid through a system of force transmission.
- ☞ The force applied to the pedal is multiplied and transmitted to all the brake shoe by a force transmission system.

Construction:

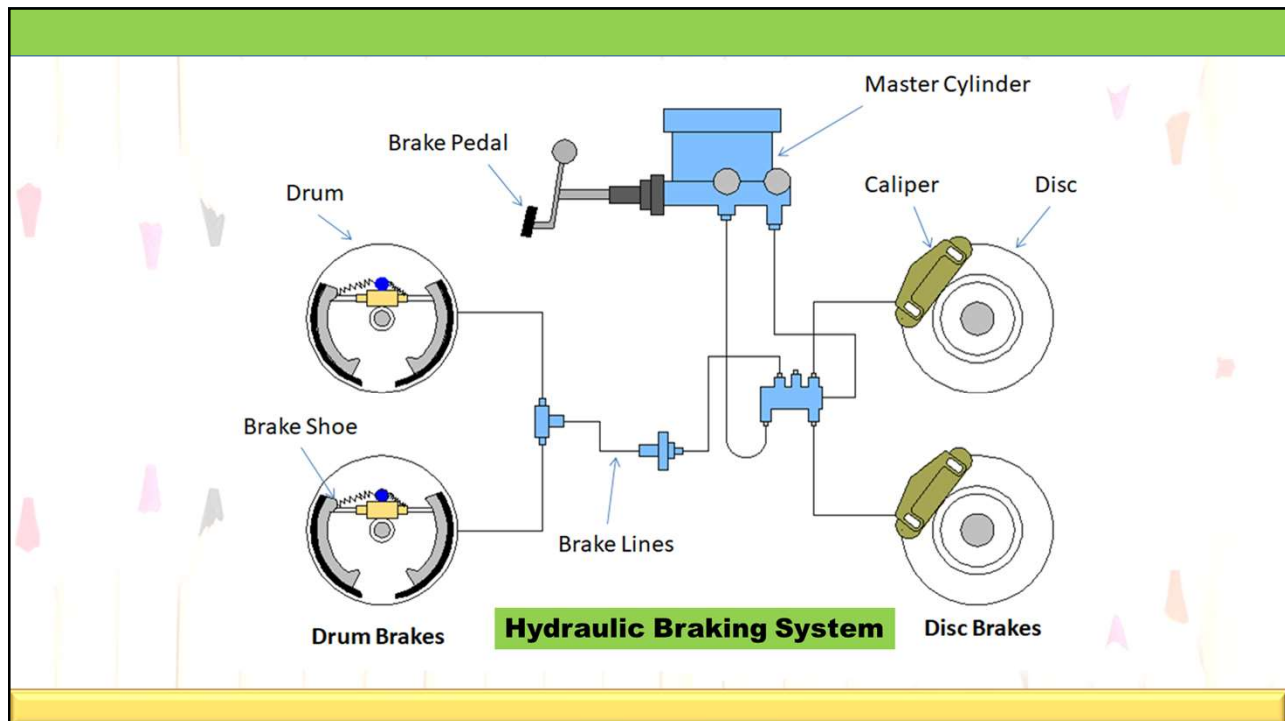
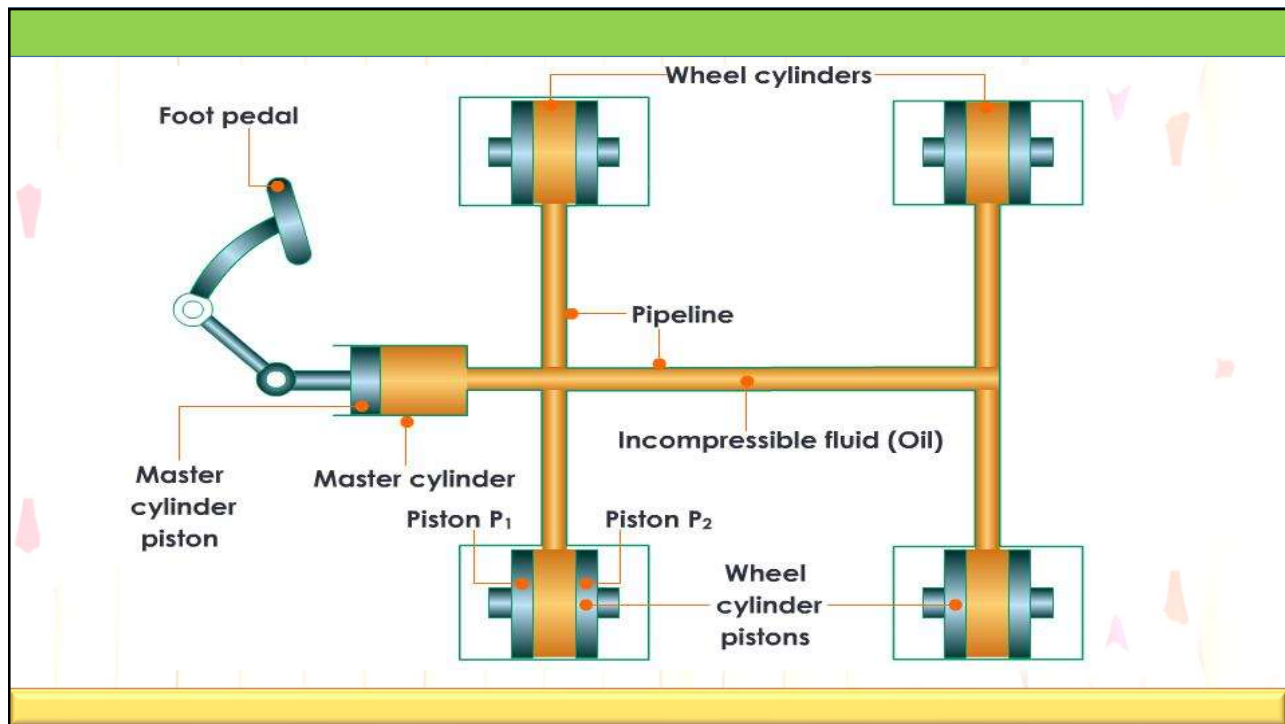
- It is essentially consists of two main component: **Master cylinders** and **Wheel cylinders**.
- The master cylinder is the heart of the hydraulic braking system consists of piston, oil & return spring.
- When the driver presses the pedal, the piston presses the oil inside the master cylinder.
- The oil reservoir is connected to the master cylinder which maintains the oil quantity inside the system.
- Return spring is used to maintain pressure on the piston therefore when the driver releases the brake pedal, the piston comes to its original position.



- The master cylinder is connected by tubing to the wheel cylinders at each of the four wheel and this system is **filled** with the liquid under light pressure when the brakes are not in operation.
- The liquid is known as **brake fluid** and is usually a mixture of glycerine and alcohol or caster oil, denatured alcohol and some additives.
- Each wheel brake consists of a cylinder brake drum which is mounted on the inner side of the wheel and revolves with it. And two brake shoes which are mounted inside the brake drums do not rotate.
- The shoes are fitted with a heat and wear resisting brake lining on their surfaces.
- The brake pedal is connected to the master cylinder piston by means of a piston rod.

Working Of Hydraulic Brake System:

- When the driver presses the brake pedal, the piston presses the oil inside the master cylinder.
- Oil flows from the master cylinder to wheel cylinder through a pipeline thus increasing the pressure of the fluid in the entire hydraulic system. (**Pascal's Law**)
- This pressure is conducted instantaneously to the wheel cylinders on each of the four brakes, where it forces the wheel cylinder piston outwards.
- Due to piston movement, brake shoes expand inside the brake drum. Therefore due to friction between shoes & brake drum, the wheel stops.



- When the driver releases the brake pedal the master cylinder piston returns to its original position due to the return spring pressure.
- Thus the fluid pressure in the entire system drop to its original low value, which allows retracting springs on wheel brake to pull the break shoes out of the contact with the brake drums into their original position.
- This causes the wheel cylinder Pistons also to come back to their original inward position dos the brakes are released

Advantages Of Hydraulic Brake

- i. Less efforts required
- ii. Equal braking effort to all the four wheels.
- iii. It is a self-lubrication system hence no external lubrication is required.
- iv. High mechanical advantage.
- v. Simple Construction & Smooth Operation
- vi. Losses due to friction are very less.

Disadvantages Of Hydraulic Brake

- i. The braking system fails if there is any leakage in the brake lines.
- ii. The brake shoes are liable to get ruined if the brake fluid leaks out.

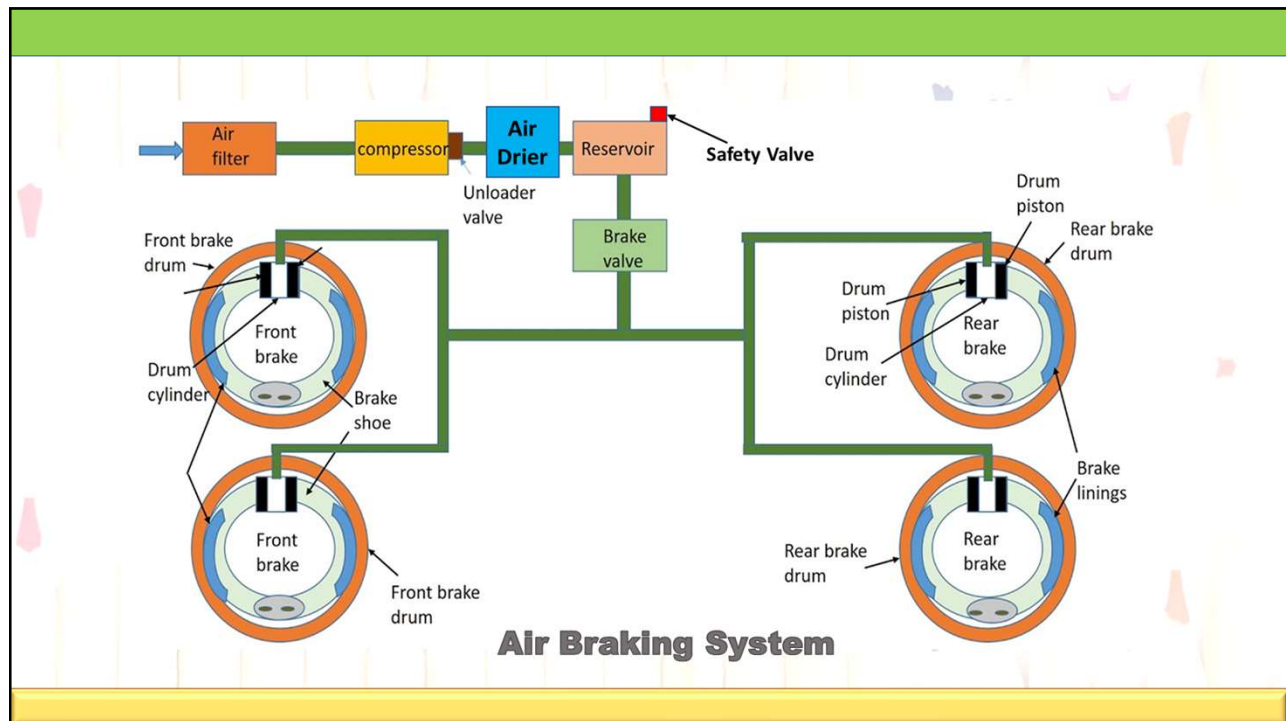
Difference between hydraulic and mechanical brakes

Sr. No.	MECHANICAL BRAKES	HYDRAULIC BRAKES
1	Brakes are Less Powerful	Brakes are more Powerful
2	External Lubrication Require	No External Lubrication is required as it is a self-lubrication system.
3	More efforts are required to an operator to apply Brake	Less effort is required for an operator to apply Brake.
4	Less costly	It is costlier.
5	Friction Losses are more	Friction losses are less

Air Brake or Pneumatic Brake

- It is the types of braking system in which atmospheric air through **compressors** and valves is used to transmit brake pedal force from brake pedal to the final drum or disc rotor.
- This system consists of an air filter, air compressor, air drier, a brake valve, unloader valve, a pressure gauge and a safety valve.
- The air compressor, governor, pressure gauge, safety valve and the reservoir constitute the compressing and the control units where as the rest of them are termed as application units.
- The compressed air available on the vehicle is also used for the operation of additional assemblies of the vehicle such as horn, with shield wipers etc.

- 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 break.
- Each of the brake chamber is connected to the brake pedal, and an air filter is also fitted between the brake valve and reservoir.



Working Of Air Brake System:

- ☛ When the driver starts the engine, the brake compressor starts as it is driven by the engine which in turn starts compressing the atmospheric air.
- ☛ This compressed air with optimum pressure is sent to the compressed air reservoir which always has some amount of air stored from the previous cycle.
- ☛ The compressor sends the compressed air to the reservoirs which are connected to the brake valve.
- ☛ Brake valve consists of **three** passages: Air intake, Exhaust and Brake chamber.
- ☛ The lines of tubing from the brake valve extend to the front and rear brake chambers.

- ☛ When the driver presses the brake pedal, the exhaust valve of the triple valve closes and air intake valve opens up which in turn gives passage to the compressed air from the reservoir to pass through the brake lines of the system.
- ☛ This compressed air flowing through the brake lines is then transferred to the brake cylinder which has piston inside it.
- ☛ When the compressed air applies pressure over the piston inside the brake chamber, the piston moves away from its original position which converts this pneumatic energy into mechanical energy.
- ☛ On the wheel end of the brake cylinder, brake drums are placed inside which there is a housing of the mechanical actuator like springs or slacks having brake pads at its outer end.

- ☛ Due to the movement of piston, because of the pressure applied by the compressed air, The mechanical actuator inside the brake drum expands which in turn pushes the brake pads in an outward direction in order to make frictional contact with the rotating drum lines.
- ☛ With this frictional contact between brake pads and rotating drum lines brakes are applied to the wheels in order to stop or decelerate the vehicle.
- ☛ Air brakes are mainly used in heavy vehicles like busses and trucks because hydraulic brakes fails to transmit high brake force through greater distance and also pneumatic brakes generates higher brake force than hydraulic brake which is the need of the heavy vehicle.
- ☛ The chances of brake failure is less in case of pneumatic brakes as they are usually equipped with a reserve air tank which comes in action when there is a brake failure due to leakage in brake lines.

Advantages Of Air Brakes:

- i. This system used in heavy vehicles because they are more powerful than hydraulic or mechanical brakes.
- ii. It requires less brake effort and simplifies the chassis design.
- iii. The compressed air is used for purposes like tyre inflation; for horn, windscreen wipers etc.

Disadvantages Of Air Brakes:

- i. If there is any leakage in passage the entire system will be fail. Therefore sealing of of air is very difficult.
- ii. It is Noisy Operation and has high Maintenance Cost.

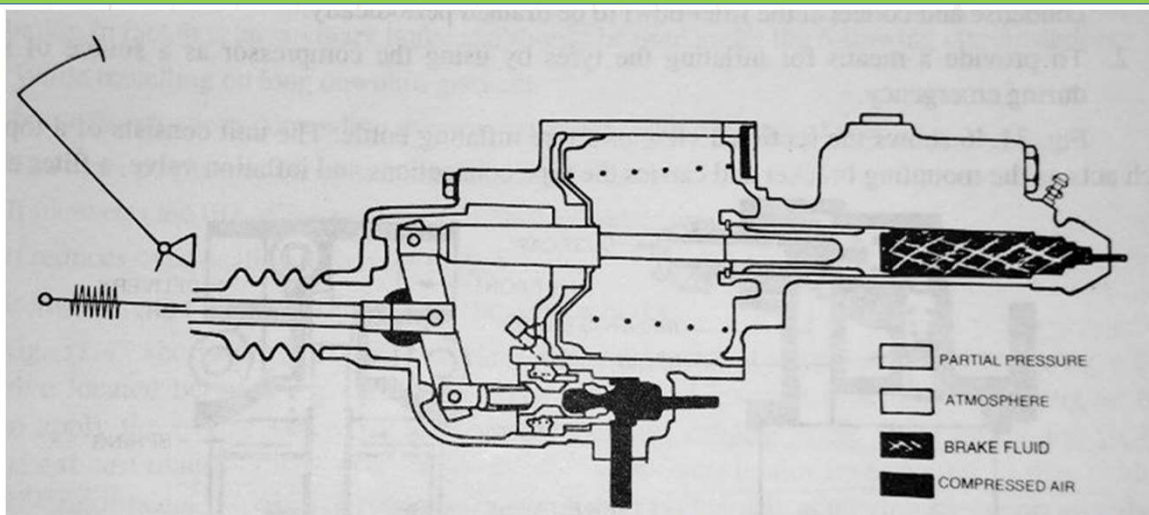
Air Assisted Hydraulic Brake

- ☞ In this type of braking system, the **air pressure is converted into hydraulic pressure**.
- ☞ Here the air power cylinder is **combined** with the hydraulic master cylinder and the reservoir.
- ☞ The conventional type hydraulic brakes are actuated by the air power with the help of this unit.
- ☞ The bore of the power cylinder is generally kept **four times** that of the masters cylinder.
- ☞ The ratio between the hydraulic pressure and the air pressure is maintained at **15:1**.
- ☞ Compressed air delivered by the air compressor incorporated in engine is used to assist the hydraulic brake system to increase brake efficiency.

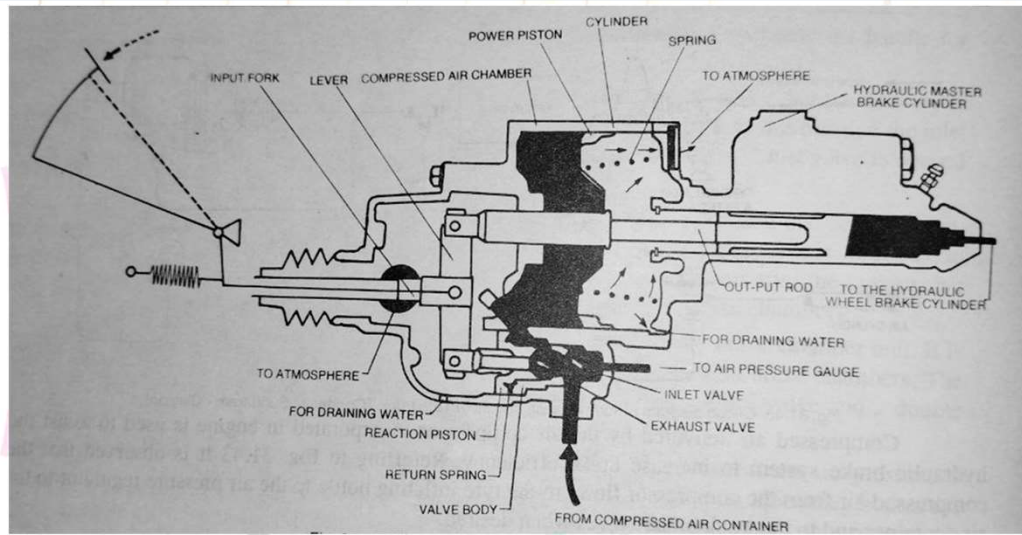
- ☞ The compressed air from the compressor flows to the **tyre inflating bottle** to the air pressure regulator to the air container and to the truck brake valves when desired.
- ☞ It will be seen that the piston of brake valve is held against the stop on the body by the return spring.
- ☞ The inlet valve is kept closed on its seat on the valve body in the existing pool remains open.
- ☞ The space behind the piston is connected to the atmosphere through the cross hole in the body and through the exhaust passage on the reaction piston and the reaction fork.

Working Of Air Assisted Hydraulic Brake:

- ☛ When the brake pedal is depressed by the driver, the input rod moves the lever forward.
- ☛ In this condition the pin joint at the power piston guide acts as a fulcrum the movement of the lever moves the reaction piston and the exhaust passage is closed.
- ☛ Further movement of the input rod opens the inlet valve and air pressure is admitted into the space behind the piston through the cross hole on the body.
- ☛ This air pressure forces the power piston to move and this effort is transmitted to the master cylinder through the output rod.
- ☛ The force acting on the master cylinder thus creates the hydraulic pressure required for the application of the brakes.



Brakes Not Applied



Brakes Applied

Vacuum Brakes

- ☛ It is the conventional type of braking system in which vacuum inside the brake lines causes brake pads to move which in turn finally stops or de-accelerate the vehicle.
- ☛ This effect can be obtained by exposing **one side** of the piston or diaphragm to the atmospheric pressure and the **other side** to a pressure **below** the atmospheric pressure.
- ☛ And it is the **potential difference** which is utilised to create the braking effect.
- ☛ The pressure below atmospheric is obtained by exhausting air from it. This is the principle of vacuum brakes.
- ☛ Vacuum brakes were **used** in old or conventional trains and are **replaced** with air brakes now days because of its less effectiveness and slow braking.
- ☛ Vacuum brakes are **cheaper** than air brakes but are less safe than air brakes.

- ✎ In a vacuum brake system, depressing the brake pedal opens a valve between the power cylinder, which contains a piston, and the intake manifold to which the power cylinder is connected.
- ✎ When you apply the brakes, air is exhausted from the cylinder head of the piston. At the same time, atmospheric pressure acts on the rear side of the piston to exert a powerful pull on the rod attached to the piston.
- ✎ When the brake valve is closed, the chamber ahead of the piston is shut off from the intake manifold and is opened to the atmosphere.
- ✎ The pressure is then the same on both sides of the piston; therefore, no pull is exerted upon the pull rod.
- ✎ The brakes are released and the piston returned to its original position in the power cylinder by the brake shoe return spring.



- ☛ In a vacuum suspended servo the air is fast exhausted from both sides of the piston in the large cylinder and during the application of a brake, the air is then admitted from the atmosphere to one side of the piston.
- ☛ The amount of air entering the cylinder is controlled by the driver.
- ☛ The piston of the cylinder moves under the pressure differential which in turn moves the hydraulic piston thus forcing the fluid into brake pipes into the whole cylinders.
- ☛ The vacuum is obtained from the inlet manifold of the engine.

- ☛ In this type of braking system a vacuum reserve tank is fitted between the servo and the engine.
- ☛ The tank and the servo are protected with the help of non return valves in order to enable them to hold some vacuum in case of failure of other components.
- ☛ The tank provides reserve of some vacuum which can be utilised for making number of stops in quick succession.

Advantages of Vacuum Braking System:

- i. It is simple in design.
- ii. The Vacuum Braking System is safety in usage.
- iii. This type of braking system is highly reliable. (Less chances of leakage)

Disadvantages of Vacuum Braking System:

- i. It is very difficult to find the leakages in Vacuum Braking System.
- ii. The initial cost of Vacuum Braking System is very high.

Application of Vacuum Braking System:

- i. It is used in Heritage Railway (UK).
- ii. The application of Vacuum Braking System can be found in Narrow Gauge Railway Central Europe.
- iii. It is also used in Railway of India.
- iv. Additionally, the Vacuum Brakes are used in Railway of Spoornet (South Africa) too.

