5 BRAKING SYSTEM

5.1 INTRODUCTION

Steering system as well as braking system contribute to safe operation of an automobile. We know that safety of passengers in a moving vehicle depends upon a good brake system. Now-a-days vehicles have much higher maximum speeds as compared to olden days. So, brake system of fast running vehicles must be very effective to avoid accidents and for good controlling of vehicles. *Brakes are expected to stop a moving vehicle in shortest time and distance.* For this reason, the brakes must be well designed and regular inspection, adjustment and repair is required.

5.2 REQUIREMENTS OF A GOOD BRAKING SYSTEM

A good braking system must fulfil the following requirements.

1. The fast running vehicle should be stopped in shortest distance and time.
2. The brakes should be equally effective on good and bad roads.
3. Brakes should work equally good in all weathers.
4. Pedal effort applied by the driver for braking should be less.
5. It should have less wearing parts and little maintenance.
6. Steering geometry should not be disturbed, when brakes are applied.
7. There should be minimum sound when brakes are applied and should not pull the vehicle to either side.
8. In case of emergency there should be an independent parking brake system.

5.3 PURPOSE OF BRAKES

It is very much known that braking system is very important component of a vehicle. The running vehicle is not only safely-stopped but also controlled by using brakes.

Brakes play an important role to control the vehicle. Also safety of passengers depends upon the good brake system. So, brake system must be very effective and efficient to stop the vehicle in shortest time and distance without giving any jerk and strain to driver.

5.4 BRAKING ACTION

Braking action is the use of a controlled force to stop the running vehicle. When brakes are applied, a friction force is developed which retard the vehicle. In this way kinetic energy is converted into heat energy. Brakes must stop the vehicle in shortest distance and time. Therefore brakes must retard the vehicle at a faster rate than the engine can accelerate it. For this, brakes must be designed to control greater power than that developed by engine. Fig. 5.1 shows a rough comparison between horse power developed by engine and controlled by brakes.

According to the purpose, the brakes may be classified as the service or primary brakes or foot brakes and the hand brakes or parking or secondary brakes. The service brakes are the main brakes used to stop the vehicle while in motion.

Parking brakes are meant to hold the vehicle on a slope.

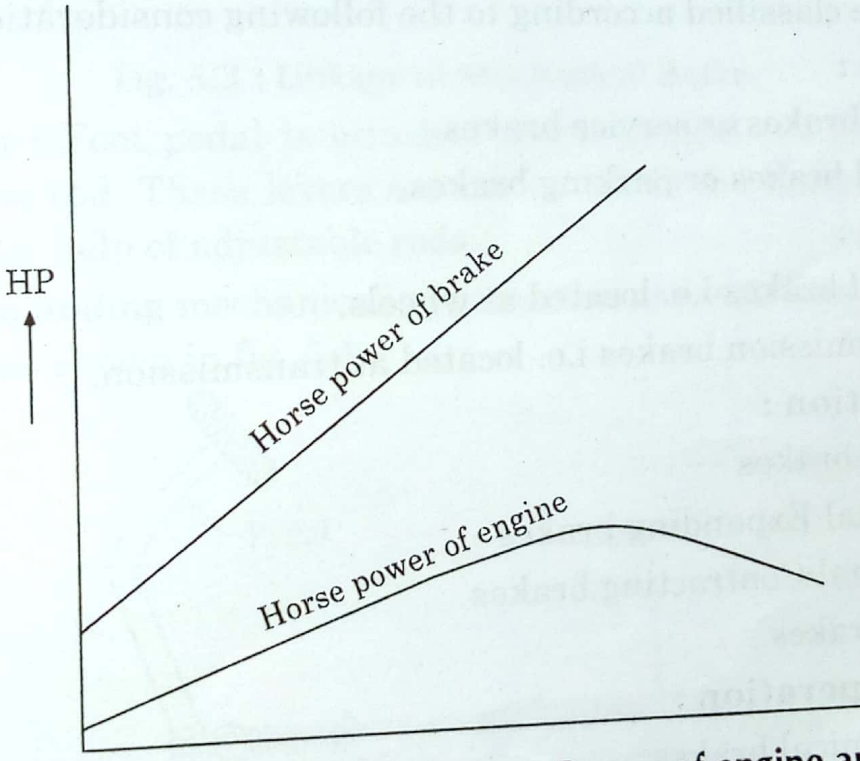

Fig. 5.1 : Rough Comparison of Horse Power of engine and brake

5.5 PRINCIPLE OF BRAKES

Principle of brake is to apply resistance which retard the running vehicle and ultimately stop it. This resistance is provided in the form of friction by brakes. In a running vehicle, fuel energy is converted into kinetic energy but while braking, this kinetic energy is converted into heat energy by means of friction produced between brake-lining and brake-drum. The retarding force or force of friction between linings and drum depends upon the co-efficient of friction for the two material and the force exerted on the shoes by the brake mechanism.

$F = \mu R$

F = Force of friction

μ = Co-efficient of friction

R = Normal reaction

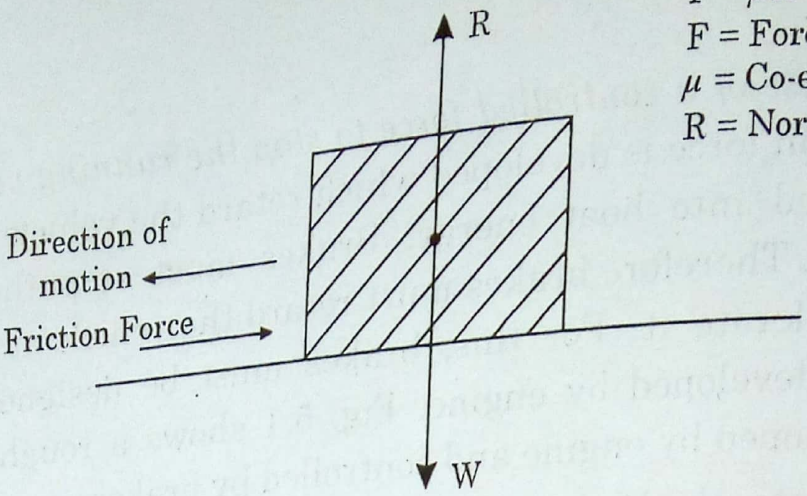

Fig. 5.2 : Simple representation of Law of Friction

5.6 TYPES OF BRAKES

Brakes can be classified according to the following considerations :

1. **Purpose :**
   - (*i*) Foot brakes or service brakes.
   - (*ii*) Hand brakes or parking brakes.
2. **Location :**
   - (*i*) Wheel brakes i.e. located at wheels.
   - (*ii*) Transmission brakes i.e. located at transmission.
3. **Construction :**
   - (*i*) Drum brakes
     - Internal Expanding brakes
     - External Contracting brakes
   - (*ii*) Disc brakes
4. **Mode of operation :**
   - (*i*) Mechanical brakes
   - (*ii*) Hydraulic brakes
   - (*iii*) Vacuum brakes
   - (*iv*) Air brakes
   - (*v*) Electric brakes.

5.7 MECHANICAL BRAKE

The brakes which are operated mechanically by means of levers, linkages, pedals, cams and bell cranks etc. are known as mechanical brakes. Mechanical brakes were employed in olden days but now hydraulic and other type of braking system have taken its place. Also some large trucks and articulated trailers employ such type of

brakes. Such type of brakes are also employed in parking brakes. Fig. 5.3 shows the layout of mechanical brake system.

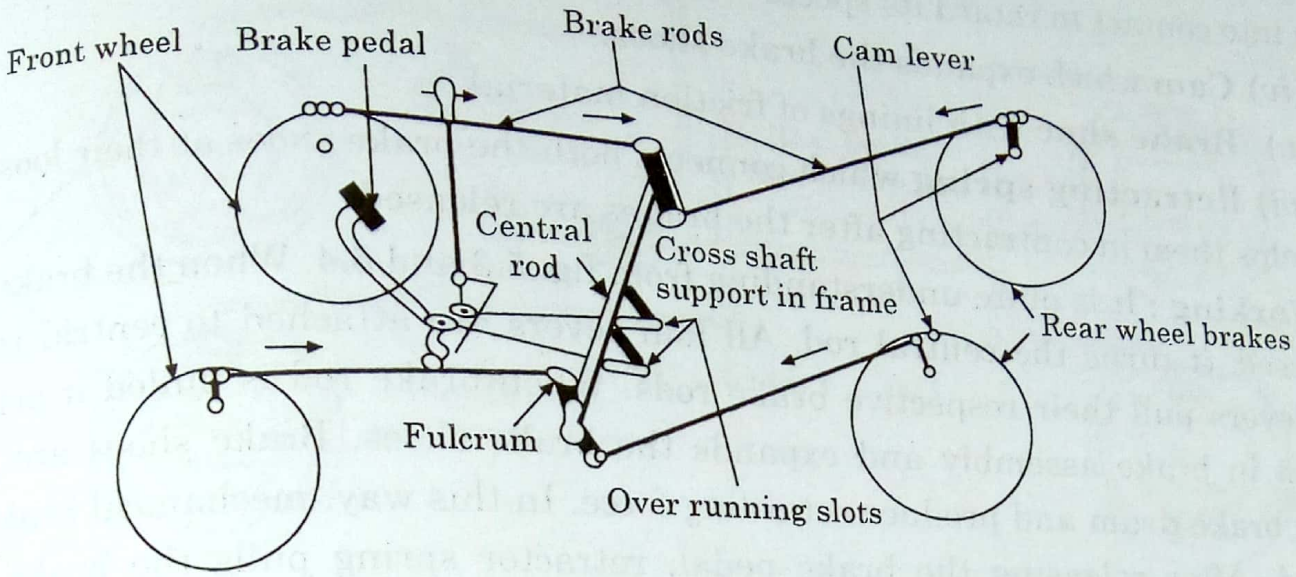

Fig. 5.3 : Linkage of Mechanical Brake

Construction : Foot pedal is attached to the central rod and four levers are fixed to this central rod. These levers are connected to the brake mechanism of all four wheels with the help of adjustable rods.

An internal expanding mechanically operated brake usually consists of following main components as shown in fig. 5.4.

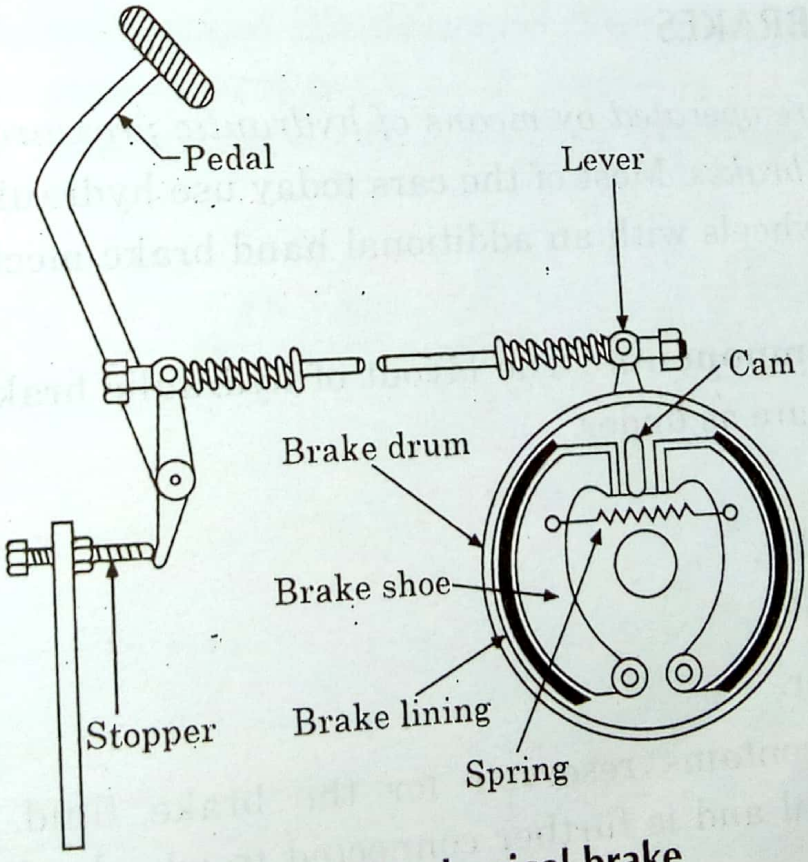

Fig. 5.4 : Mechanical brake

(*i*) **Brake pedal** to operate the brakes.

(*ii*) **Links and levers** to provide mechanical connections.

***(iii)* Brake drum** which moves with road wheel. The expanding brake shoes come into contact to retard its speed.

***(iv)* Cam** which expands the brake shoes.

***(v)* Brake shoe** with linings of friction material.

***(vi)* Retracting spring** which connects both the brake shoes at their loose ends and helps them in contracting after the brakes are released.

Working : It is quite understanding from fig. 5.3 and 5.4. When the brake pedal is pressed, it turns the central rod. All four levers are attached to central rod. So, these levers pull their respective brake rods. When brake rod is pulled it activates the cam in brake assembly and expands the brake shoes. Brake shoes are forced against brake drum and produce retarding force. In this way, mechanical brakes are operated. After releasing the brake pedal, retractor spring pulls the brake shoes back.

Use : Mechanical brakes are used in some large trucks and articulated trailers. Parking brakes of the vehicles are also mechanical type brakes. These parking brakes are operated by hands. For example, hand brakes in Maruti vehicles are internal expanding type mechanical brakes.

5.8 HYDRAULIC BRAKES

Brakes which are operated by means of hydraulic pressure or fluid pressure are known as hydraulic brakes. Most of the cars today use hydraulic brakes operated by foot on all the four wheels with an additional hand brake mechanically operated on the rear wheels.

Layout and Components : The layout of hydraulic brake is given in fig. 5.5. Its main components are as under.

1. Brake pedal,
2. Master cylinder,
3. Fluid reservoir,
4. Wheel cylinder.

Master cylinder contains reservoir for the brake fluid. Master cylinder is operated by brake pedal and is further connected to wheel cylinders in each wheel through steel pipes.

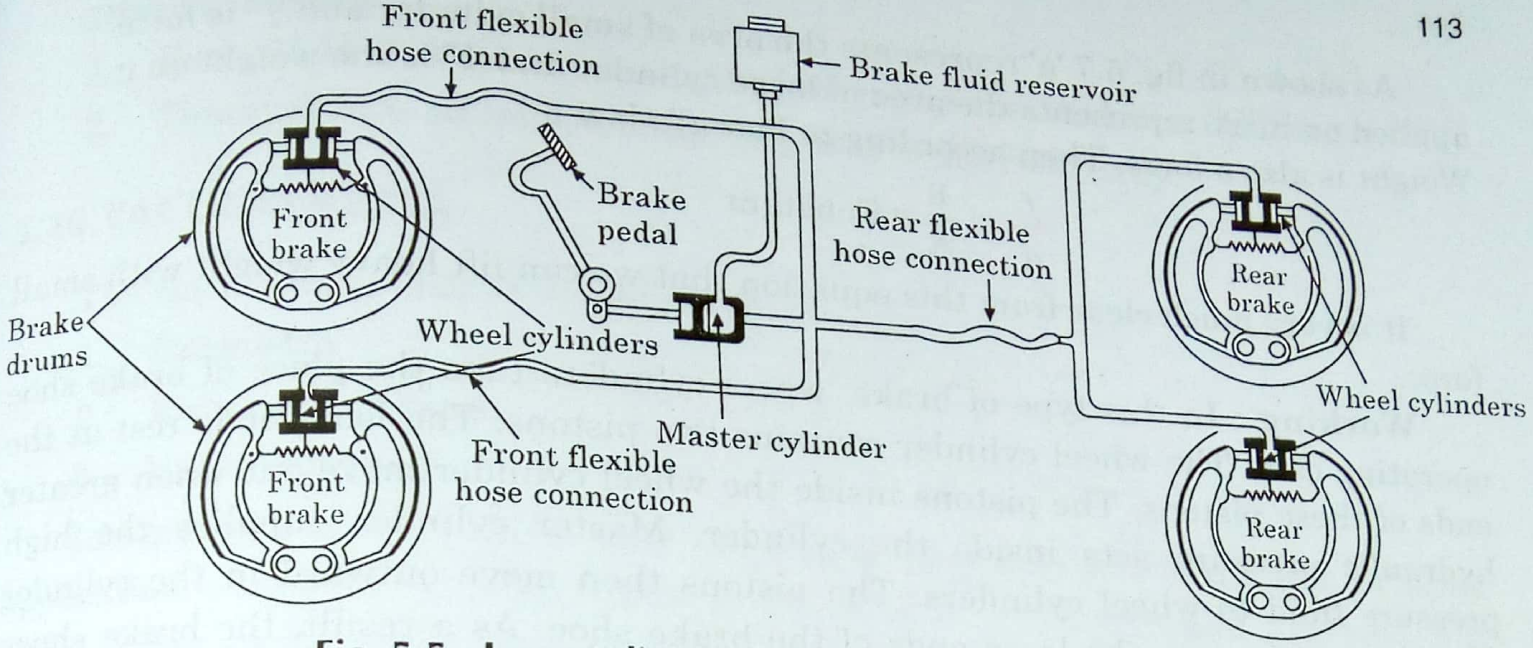

Fig. 5.5 : Layout diagram of Hydraulic brake system

Principle : Master cylinder is the main component of hydraulic brake system which contains reservoir for the brake fluid. Fluid pressure is involved in this type of brakes. So, hydraulic brake acts according to the principle of 'Pascal's Law' which states that *pressure applied to a liquid in a closed vessel is equally transmitted in all directions.*

It is important to understand the pressure. Pressure is the ratio of external applied force (F) to the area of cross-section (A). According to Pascal's law, pressure is transmitted equally in all direction. Its application can be easily understood from fig. 5.6.

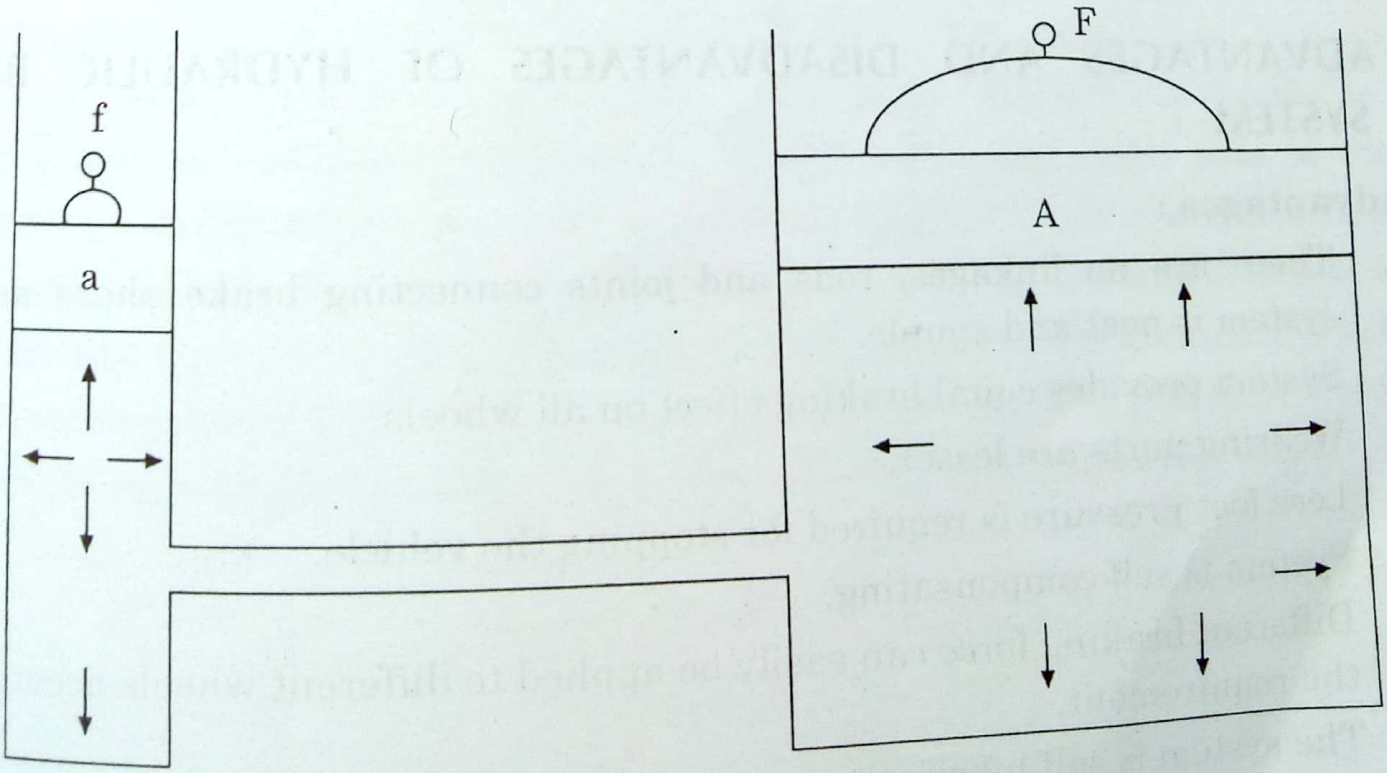

Fig. 5.6 : Hydraulic Principle

As shown in fig. 5.7 'a' represents the area of small cylinder and 'f' is force applied on it. 'A' represents the area of large cylinder and 'F' is the weight on it. Weight is also a force. Then according to Pascal's law :

$$\frac{f}{a} = \frac{F}{A} = \text{Constant}$$

It is very much clear from this equation that we can lift heavy weight with small force.

Working : In this type of brake, wheel cylinders take the place of brake shoe operating cam. The wheel cylinder contains two pistons. The loose ends rest at the ends of these pistons. The pistons inside the wheel cylinder move out when greater hydraulic pressure acts inside the cylinder. Master cylinder supplies the high pressure fluid to wheel cylinders. The pistons then move outward in the cylinder exerting pressure on the loose ends of the brake shoe. As a result, the brake shoes are expanded outward and come into contact with the brake drum. In this way brakes are applied.

When the brake pedal is released, the retracting spring closes the brake shoes which push the wheel cylinder's pistons inwards. Inward going wheel cylinder's pistons develop back pressure and force back the fluid into the master cylinder. In this way brakes are released.

Main components of hydraulic brake system are wheel cylinder and master cylinder. To understand the complete working of hydraulic brake we have to understand the working of wheel cylinder and master cylinder along- with their construction. So wheel cylinder and master cylinder are discussed separately.

5.9 ADVANTAGES AND DISADVANTAGES OF HYDRAULIC BRAKE SYSTEM

Advantages :

1. There are no linkages, rods and joints connecting brake shoes as such system is neat and simple.
2. System provides equal braking effect on all wheels.
3. Wearing parts are lesser.
4. Less foot pressure is required for stopping the vehicle.
5. System is self compensating.
6. Different braking force can easily be applied to different wheels according to the requirement.
7. The system is self lubricating.

Disadvantages :

1. Even slight leakage of air into the braking system makes it useless.
2. This system is suitable for applying brakes intermittently.

5.10 VACUUM BRAKE

The main components of vacuum brake are :

1. Exhauster
2. Vacuum Reservoir
3. Vacuum booster.

In vacuum brakes, suction from the engine inlet manifold is utilised for brake application. A piston or diaphragm is operated in a cylinder and provided with suitable linkage for brake application. There are two types of vacuum brakes :

1. **Suspended air type :** In this type both sides of the piston are exposed to atmosphere when brakes are in released position. For applying brakes engine vacuum is applied on one side of the piston. Thus operating the linkage.

2. **Suspended vacuum type :** In this type both sides of the piston are subjected to engine vacuum in the brakes released position. To apply brakes, one side is exposed to atmosphere which provide the pressure difference and desired force on the piston to operate the linkage. This is preffered over first type because this is comparatively more rapid in action.

Construction : As shown in the fig. 5.7, vacuum reservoir is connected through a non-return valve to the inlet manifold between carburettor and the engine. Vacuum reservoir is also connected to servo cylinder on both sides of the piston. Left side of piston is connected through the control unit and right side is directly connected. Control unit also contains a piston to which two valves are attached. The upper valve controls the connections between the atmosphere and left side of the piston in the servo cylinder. The lower valve controls the connection between vacuum reservoir and left side of the servo cylinder piston. The piston in the control unit itself is actuated by the brake pedal through the master cylinder.

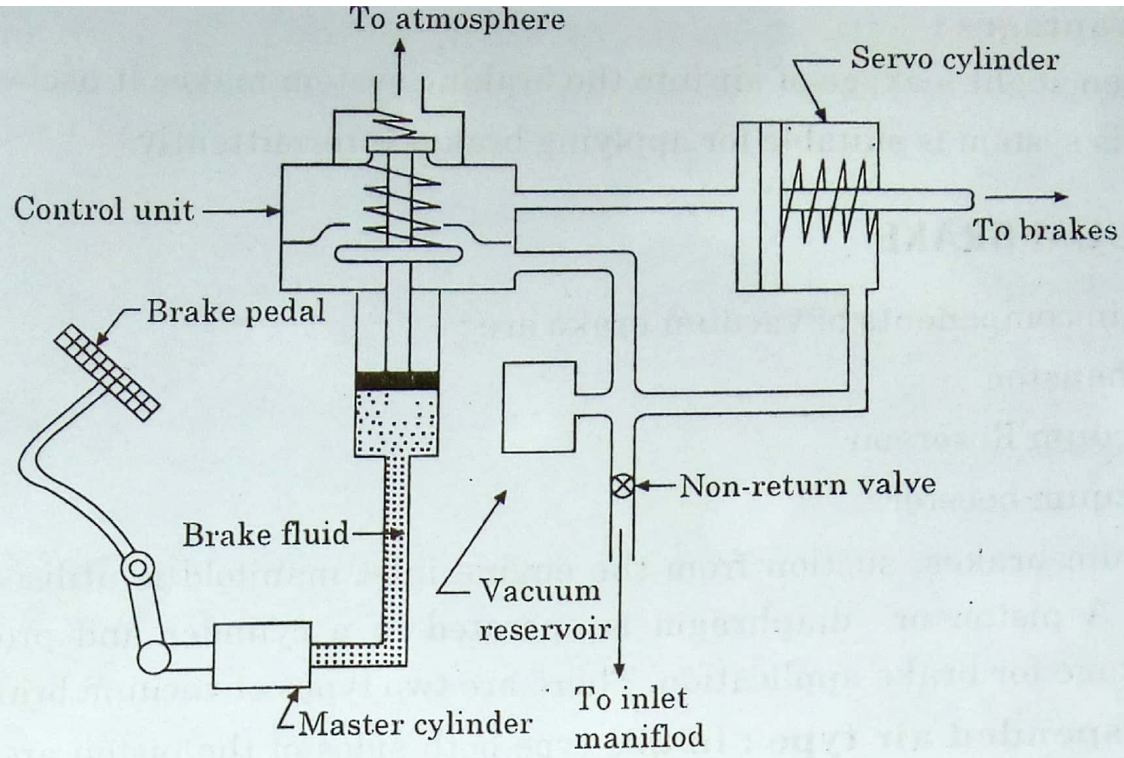

Fig. 5.7 : Vacuum brake

Working : When the brake pedal is pressed to apply the brakes, the pressure of the brake fluid pushes the piston in the control unit up, thereby closing the lower valve and opening the upper valve. Thus left side of servo piston is exposed to atmospheric pressure, whereas vacuum acts on the right side.

This causes the servo piston to move towards right side. This movement is utilized to apply the brakes in the wheels through some linkage.

Advantages :

Force to be exerted by the driver is reduced because the braking effort is supplied by the engine vacuum.

5.11 AIR BRAKING SYSTEM

Main parts of an Air Braking System are :

1. Air filter/suction strainer
2. Compressor
3. Unloader valve
4. Air Reservoir
5. A brake valve/control valve
6. Pressure gauge
7. Safety valve/relief valve
8. Brake chambers
9. Low pressure indicator

10. Stop light switch
11. Air bottle for supplying air for the inflation of tyre
12. A quick release valve
13. Limiting pressure valve

Layout : Fig. 5.8(*a*) shows the layout of air braking system. The air is sucked through the air filter by the compressor and is sent to the reservoir. When the pressure inside the reservoir reaches a predetermined value the unloader valve prevents any further rise of pressure. When the pressure drops to a pre determined value the unloader valve opens and pressure is again built up.

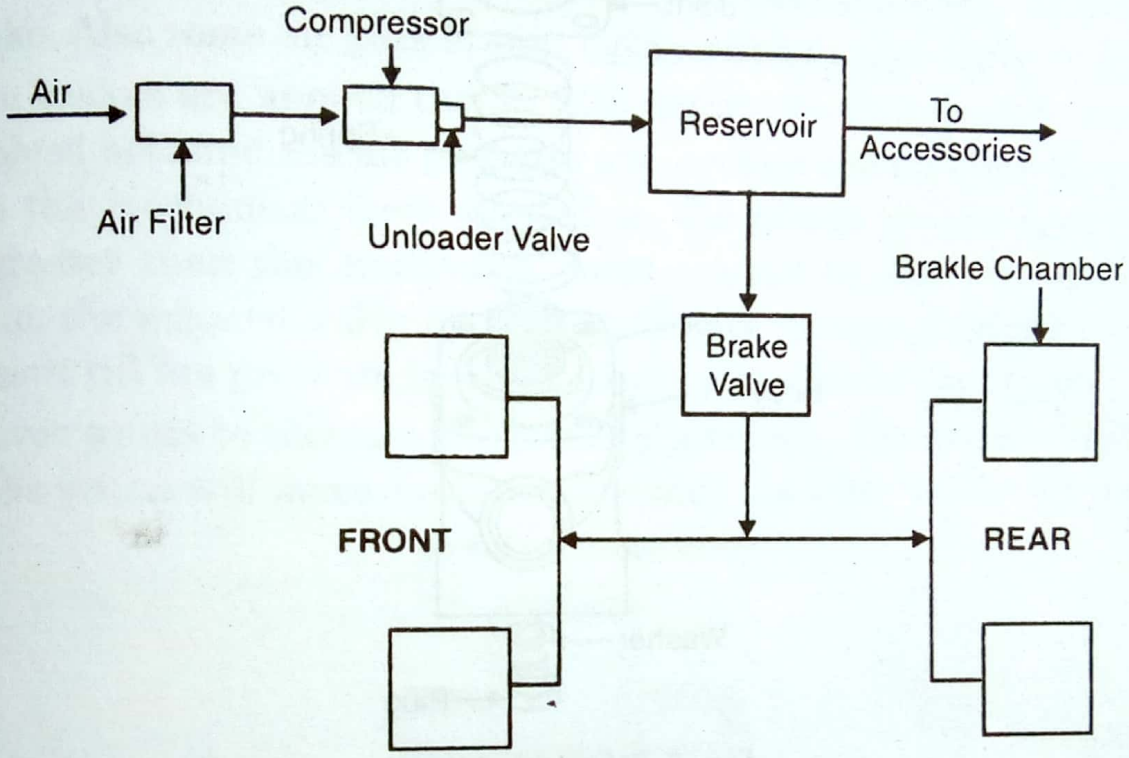

Fig. 5.8(a) : Layout of air brake system

When the foot pedal is pressed for applying brakes, the compressed air from the reservoir pass through the brake valve and acts against the diaphragm in brake chambers [See Fig. 5.8(e)]. There are separate air brake chambers for each wheel. The diaphragms are connected to brake rods. The brake rods operate the brake shoe cams which in turn expands the shoes to apply the brakes.

When the pedal is released the brake valve returns to the off position, cutting off supply of air to the reservoir and at the same time, opening a valve which allows the air operating in the brake chambers to escape and the brakes are released. A safety valve/relief valve and pressure gauge are fitted to the reservoir. The valve is for safety purpose and pressure gauge indicates the pressure inside the reservoir.

Description of Main Parts of Air Brake System

1. **Air filter :** *Air filters are used to prevent dust, dirt and any type of foreign particle to enter inside the system.* It is mounted on chassis. It has a drain plug for

removing dust which is filled inside the filter. See Fig. 5.8(*b*) Air enters through the inlet passage, passes through filter lement and flows out through outlet passage. Any foreign particle or dust particles deposit in the bottom from where it is removed by opening the drain plug.

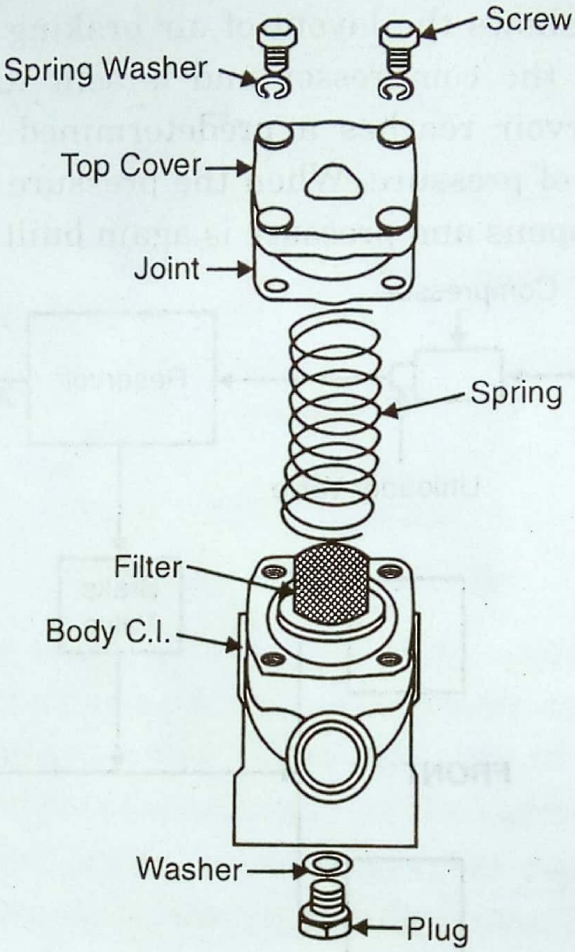

Fig. 5.8(*b*) : Air Filter

2. Compressor : *An air compressor receives air from atmosphere, increases its pressure and delivers it to the reservoir. This high pressure air is supplied through pipe lines to the reservoir.*

3. Unloader Valve : This valve is mounted between compressor and Air reservoir. *The function of this valve is to control the pressure of air inside the reservoir.* This valve releases the air to the atmosphere which is suppled by compressor so that the reservoir may not have excess of air than predetermined limit.

4. Air Reservoir : *It stores the compressed air in such a way that there is always an ample supply of air available when required in braking operation.* It also stores the air which is also used for various other accessorries like horn, to run wiper motor etc. Total volume of air reservoir may be 20-25 litre.

5. Brake Valve : *This valve controls the intensity of braking in an air pressure system.* It consists of

(*i*) Spring loaded hollow piston (*ii*) Inlet valve
(*iii*) Exhaust valve (*iv*) Exhaust port
(*v*) Piston return spring (*vi*) Bleed hole
(*vii*) Graduating spring (*viii*) Stop light switch.

When the driver presses the brake pedal for applying the brakes, the piston is pushed down against the force of graduating spring and thus the graduating spring is being pressed. The driver feels the intensity of braking due to this spring force. As the piston moves in downward direction the exhaust valve gets closed and the inlet valve opens, thereby, allowing the air to enter the brake chambers at each wheels to apply the brake. Also some air goes to stop light switch to glow the stop lights.

When the brakes are applied the air also enters the chambers under the piston through the bleed hole and the air pressure also acts on the bottom side of the piston and balances the mechanical force applied on the piston by the driver. If the air pressure is greater than the mechanical force applied by the driver, the piston is again lifted up, the exhaust valve opens and the air escapes through exhaust valve and exhaust port till the pressure is balanced on both sides of the piston.

If the driver wants to increase the braking intensity, the brake pedal is pressed further and the piston will move down due to which the inlet valve will open further

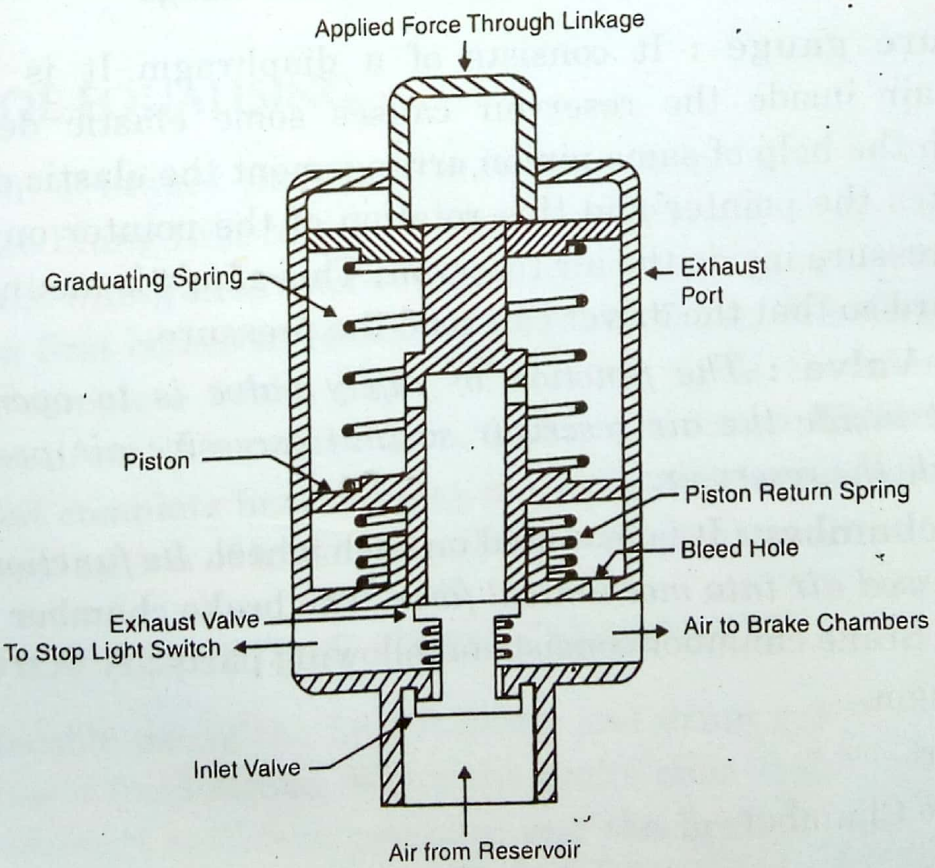

Fig. 5.8(c) :Brake Valve

and more air will enter the chamber. On the other hand if the driver wants to decrease the braking intensity he will release slight amount of the pedal hard and

the piston will move up due to which the exhaust valve opens and the air escapes through exhaust port till a balancing force is there on the piston. When the brake pedal is released completely, there is not any mechanical pressure on the piston. Hence, the air lifts up the piston and opens the exhaust valve and shuts off the inlet valve. Now there is no connection between reservoir and brake valve. So brake shoes are released.

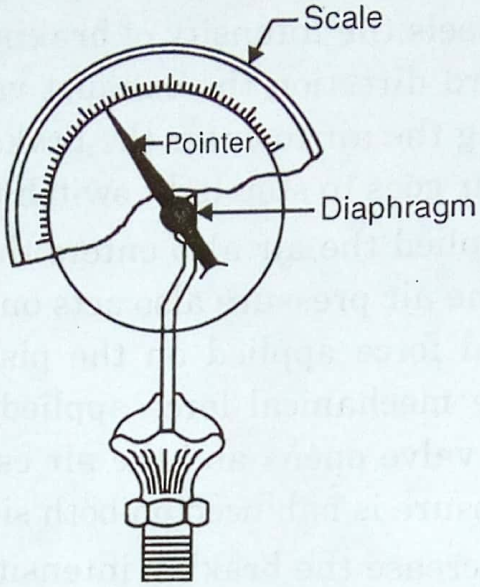

Fig. 5.8(*d*) : Diagram Pressure Gauge

6. Pressure gauge : It consists of a diaphragm. It is connected to the reservoir. The air inside the reservoir causes some elastic deformation of the diaphragm. With the help of same pinion arrangement the elastic deformation of the diaphragm rotates the pointer and this rotation of the pointer on the dial gives us the reading of pressure inside the air reservoir. This gauge is mounted in front of the drivers dash board so that the driver can read the pressure.

7. Safety Valve : *The function of safety valve is to open if excessive air pressure is built inside the air reservoir so that excessive air pressure should not damage or explode the reservoir.*

8. Brake chamber : It is mounted on each wheel. *Its function is to convert the energy of compressed air into mechanical force.* The brake chamber generally used is diaphragm type. Brake chamber consists of following parts :

(*i*) Diaphragm
(*ii*) Inlet port
(*iii*) Pressure Chamber
(*iv*) Spring
(*v*) Push rod.

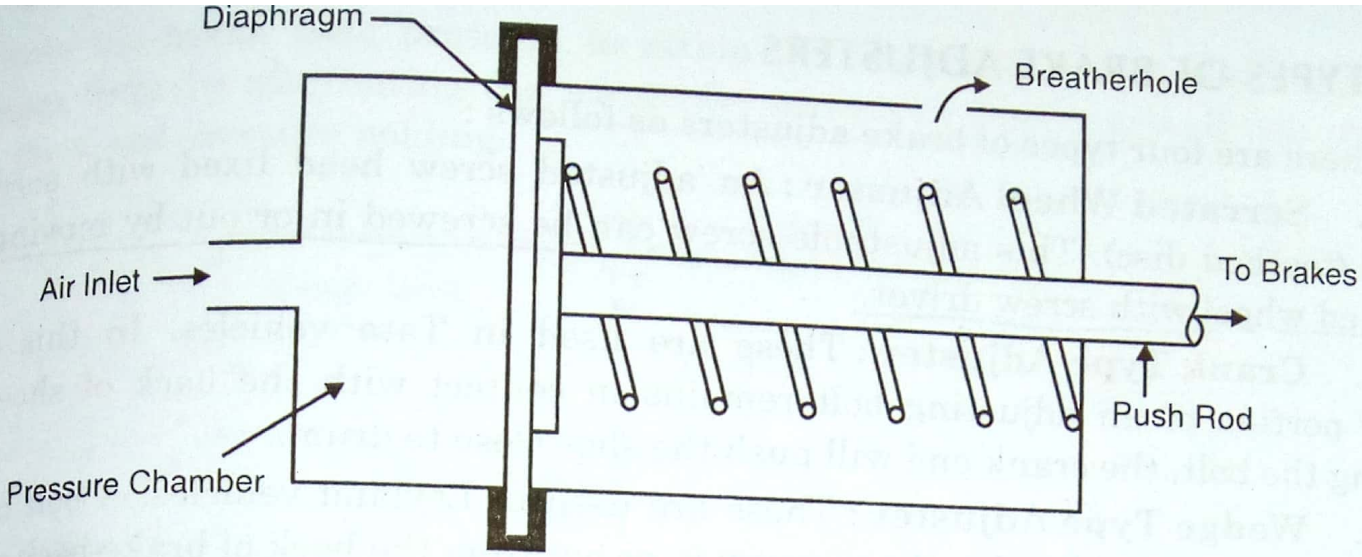

Fig. 5.8(e) : Brake Chamber (Single Diapragm)

The return spring holds the push rod against the diaphragm where as seal prevents the passage of dust and dirt. The spring is located over the push rod.

When the compressed air from brake valve enters the pressure chamber, it pushes the diaphragm thereby pushing the rod which actuates the cam of the brake shoes. Thus the brakes are applied. When brake pedals are released, there is no compressed air and thus the diaphragm comes to its original position due to spring pressure.

5.12 BRAKE SHOE EQUALISING

On application of brakes the piston moves out of cylinder and pushes apart the brake shoes. Brake lining first comes in contact with brake drum. It is observed that top portion of brake lining first comes in contact with brake drum and then the rest. So the top portion first comes in contact with brake drum. It wears out quickly. For efficient braking complete brake lining area with equal thickness must come in contact with brake drum. After some time, brakes are not so efficient.

To ensure that complete braking area of shoe comes in contact with brake drum immediately on application of brakes, equilising rods are used.

5.13 BRAKE SHOE ADJUSTING (SHOE CLEARANCE)

After considerable use of the brake, lining and drum get worn off, as the wheel cylinder piston has a fixed stroke. When the brake shoe and drum get worn off, the brake shoe cannot exert sufficient pressure and the brakes start slipping. This gap between brake shoe lining and drum is called shoe clearance. To adjust the clearance between brake drum and shoe, brake adjusters are used.

5.14 TYPES OF BRAKE ADJUSTERS

There are four types of brake adjusters as follows :

1. **Serrated Wheel Adjuster :** An adjusted screw head fixed with serrated wheel (toothed disc). This adjustable screw can be screwed in or out by moving the serrated wheel with screw driver.

2. **Crank Type Adjuster :** These are used in Tata vehicles. In this case, crank portion of an adjusting bolt remains in contact with the back of shoe. On turning the bolt, the crank end will push the shoe close to drum.

3. **Wedge Type Adjuster :** These are used in Leyland vehicles. A bolt called wedge has a tapered head and can screw in or out from the back of brake-back-plate. While screwing in, the wedge pushes apart two links which in turn push the brake shoes out.

4. **Snail And Cam Type Adjuster :** These are widely used in small vehicles. In this type a cam rests against the back of shoe. The outer end of cam is square or hexagonal shaped. This cam can be turned by a spanner from the back of brake plate. The more the cam is pressed against shoe, the more the shoe will expand.

5.15 ANTILOCK BRAKE SYSTEM

Antilock braking system (ABS) is an automobile safety system which allows the wheels of a motor vehicle to maintain tractive contact with the road surface according to driver inputs while braking. It prevents the wheels from locking up and avoids uncontrolled skidding. It generally offers improved vehicle control and decreases stopping distances on dry and slippery surfaces. An antilock braking system consists of following components :

1. Electronic control unit (controller) (ECU),
2. Speed sensors (one at each wheel),
3. Solenoid valves (hydraulic) on each brake circuit,
4. Master cylinder,
5. Wheel brake cylinder.

The speed sensor constantly monitors the r.p.m. of each wheel and sends the information to the ECU. When the ECU senses that any wheel is about to lock up, it sends command to the solenoid valve unit to stop and reduce the build up of brake pressure until the danger of lock up has been reduced. The brake pressure again builds up so that the wheel is not 'under-braked'. During such automatic brake control, it is necessary to detect the stability or unstability of the wheel motion constantly and the wheel must be kept in the slip range. ABS calculates the slip rates of the wheel depending upon the vehicle speed and wheel speed and then

controls the brake fluid pressure to attain the desired slip rate, with maximum braking force by alternating the successive phases of pressure built up, pressure reduction and pressure holding.

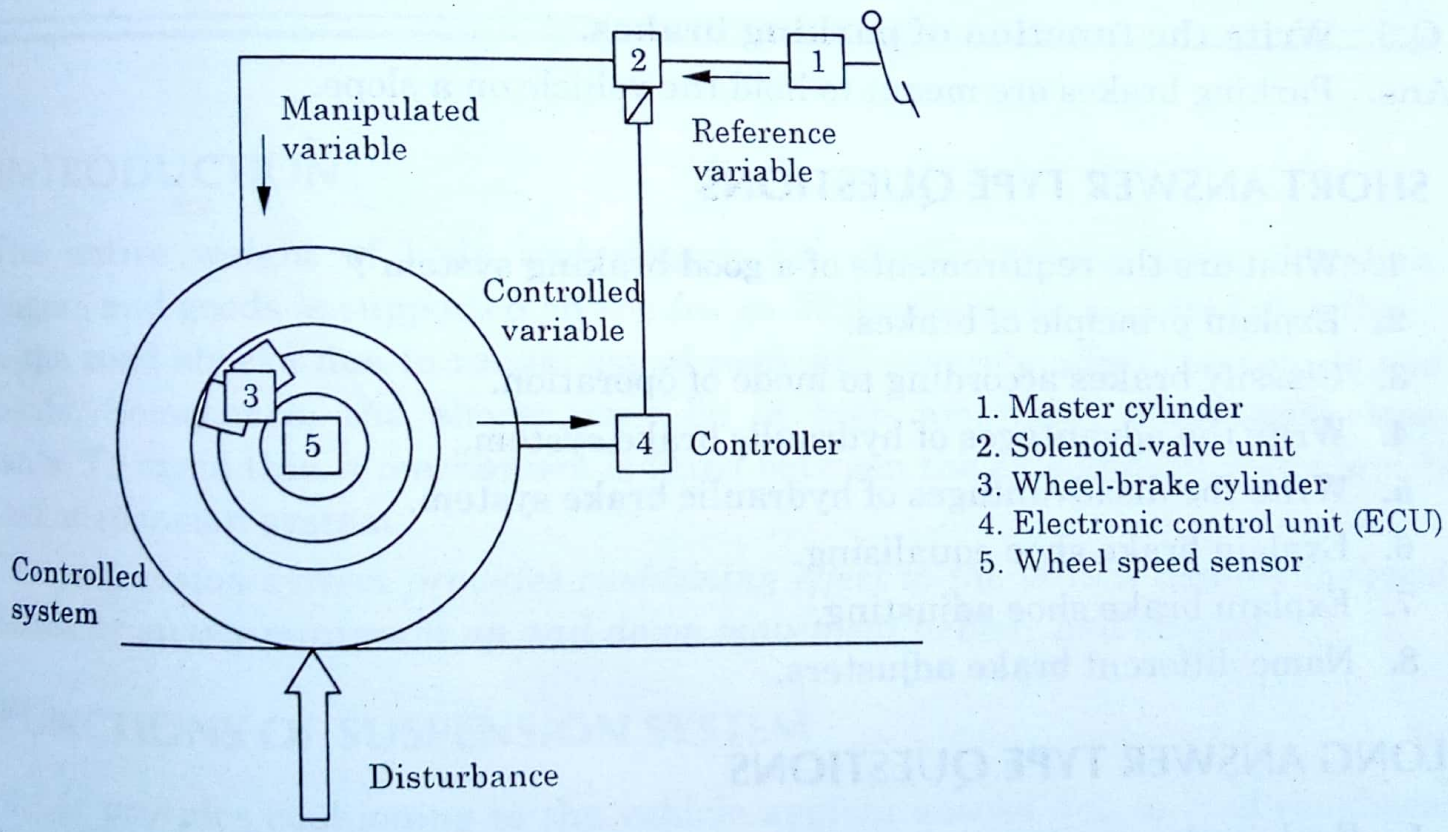

Fig. 5.9 : Antilock Braking System