CHAPTER 5

HYDRAULIC BRAKES

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CHAPTER 5

HYDRAULIC BRAKES

1. SCOPE. This Chapter applies to the operation and inspection of hydraulic brake systems.

2. INTRODUCTION. The information in this Chapter is intended to provide general information describing the operation of hydraulic brake systems and their major component parts in addition to providing a suggested inspection procedure to determine whether such systems and their component parts are functioning properly. Definitions appropriate to this Chapter are contained in Annex A of this Guide (Glossary of Brake Terminology).

3. GENERAL. Passenger cars, light trucks, and many medium duty vehicles are universally equipped with a hydraulic system for operation of the service brakes. In the hydraulic system, pressure applied to the brake application pedal forces fluid from the master cylinder reservoir through distribution lines to the individual wheel cylinders. Pistons in the wheel cylinders apply mechanical leverage to force the brake shoes against the brake drum to provide braking action.

a. Most Common Type of Hydraulic System prior to 1967. The major components of this basic hydraulic system include an application pedal, a single piston master cylinder assembly, fluid distribution lines (tubing or hoses), and individual wheel cylinder assemblies- Atypical hydraulic brake system is shown in Figure 5-1.

(1) This system generally utilizes drum-type brakes on all wheels and, prior to 1965, was not usually equipped with a self-adjusting mechanism. This system may also include a power-assist feature to supplement pressure applied manually to the system.

(2) The major disadvantage of this system is that a hydraulic failure anywhere in the system would, make it impossible to transmit forces from the brake pedal to the brakes, making the entire system inoperative.

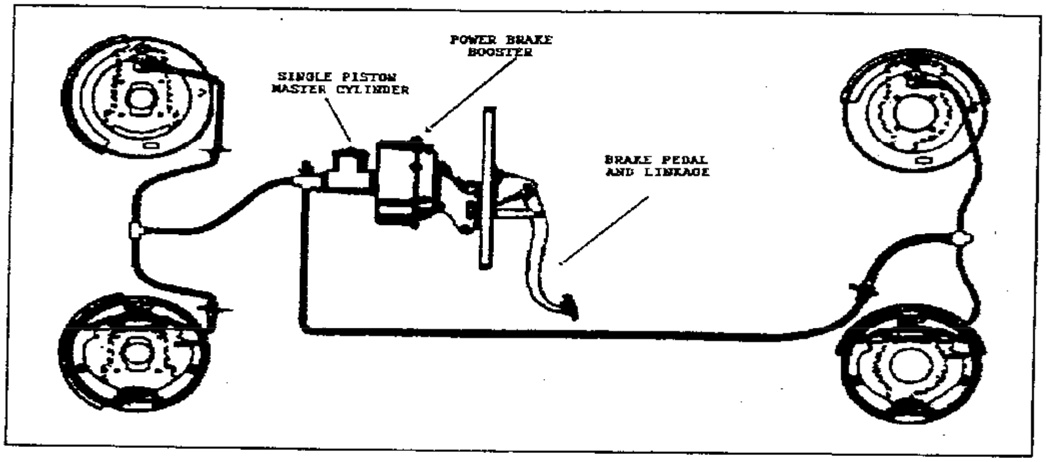

Figure 5-1. Hydraulic Brake System

b. Most Common Type of Hydraulic System in Present Use. Most vehicles manufactured after 1967 are equipped with a dual or split master cylinder assembly with brake fluid reservoirs, fluid distribution lines (tubing or hoses), and individual wheel cylinders/caliper assemblies. The majority of passenger cars and light trucks in current production are equipped with front disc and rear drum brakes. Additional components of dual brake systems include the pressure differential valve and switch (brake warning light), a proportioning valve and a metering valve. Many systems include power-assist features to supplement pressure applied manually to the system. A typical split hydraulic system is shown in Figure 5--2.

(1) The split system is designed to protect against a complete loss of braking action in the event of a failure of the hydraulic system.

(2) One part of the system actuates the front brakes and the other part actuates the rear brakes. The two independent hydraulic systems are separated by means of a split master cylinder.

(3) Hydraulic leakage or complete failure in one portion of the system cannot affect the other portion.

(4) Brake pedal travel increases when only one side of the system is operating and should alert the driver to a malfunction in the hydraulic system. A warning light on the instrument panel of most 1967 and later model vehicles will also alert the driver.

(5) Stopping distance may be increased with the defective condition since braking action is being applied to two wheels only.

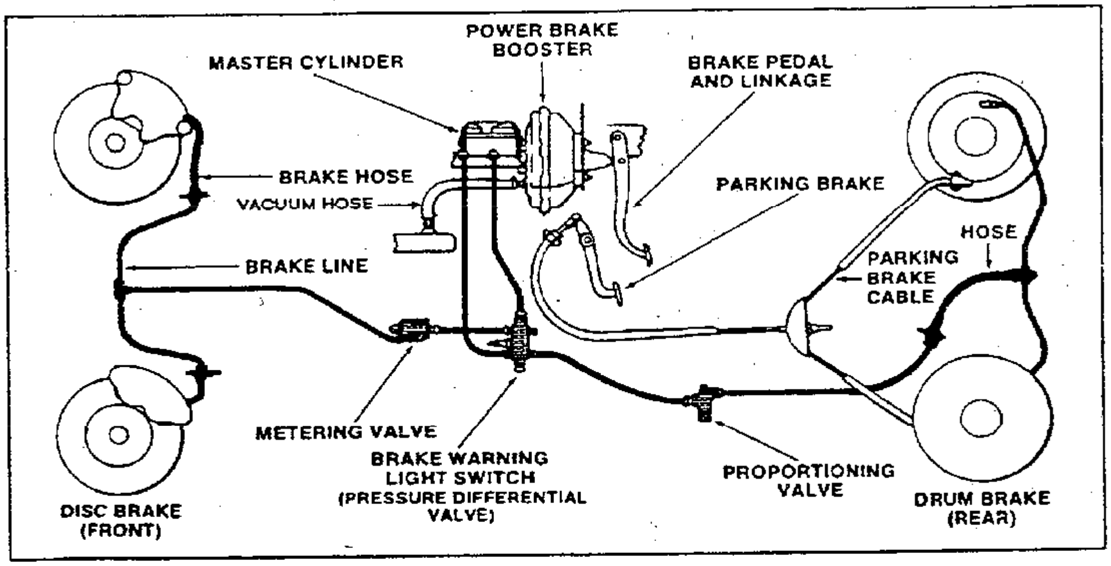

Figure 5-2. Split Hydraulic Brake System.

4. TYPES OF HYDRAULIC BRAKE SYSTEMS.

a. Drum-Type Brake Systems. Brake systems require a rotating and a nonrotating member. In a drum brake assembly, the drum is the rotating member and the brake shoes are the stationary member. The primary function of the drum brake system is to force the brake shoes against the rotating drum to provide the braking action. Drum-type brakes have been classified into numerous types, each given a name descriptive of its particular manufacturer. Drum-type brakes are generally classified as "servo" or "non-servo" types. Figure 5-3 illustrates a typical servo type brake and figure 5-4 illustrates a non-servo type brake, both equipped with automatic self-adjusters. Systems with drum-type brakes operate as follows:

(1) The brake shoes are anchored to a backing plate rigidly attached to the axle housing or wheel suspension unit and the drum rotates with the wheel. Fluid pressure forces the wheel cylinder pistons to move the brake shoes toward the rotating drum. As the brake shoe linings contact the drum, braking action is applied. Upon release of the hydraulic pressure, springs return the brake shoes to the unapplied position.

(2) All the brakes on a vehicle are designed to be applied equally since they normally receive the same hydraulic pressure. However, the amount of braking force upon a wheel is determined by the size of the wheel cylinders and/or the size of the brake drum and shoes.

(3) Full-servo brakes can be recognized by a single wheel cylinder at the top of the backing plate and by an anchor pin above the cylinder. The lower ends of the shoes are connected to each other by an adjuster link and are not anchored to the backing plate. The shoes float within the drum, pivoting on the single top anchor pin. The front shoe is called the primary shoe, and the rear shoe is called the secondary shoe. During forward braking, the rotation of the wheel wraps the, top of the primary shoe into the drum as the brakes are applied. This is called self-energizing action. The lower end of the primary shoe moves backward as the brakes are first applied and forces the lower end of the secondary shoe into the drum. This servo action of the primary on the secondary shoe causes the secondary shoe to also become self-energizing. The servo action of the primary and secondary shoes is reversed when the car is moving backwards.

(a) Most servo brakes are designed with self-adjusting mechanisms that automatically compensate for drum-to-lining clearance because drum brakes lack the inherent ability to self-adjust. One type operates as follows: When sufficient lining has been worn from the shoes, a self-adjuster lever picks up a tooth on the star wheel of the adjusting screw. When the brakes are operated while the vehicle is moving in reverse, the adjuster lever turns the star wheel slightly to reduce the shoe-to-drum clearance. The mechanism is designed to prevent over-adjustment. Figure 5-3 illustrates a selfadjusting mechanism on a full-servo brake.

(4) On non-servo brakes, only one shoe receives a self-energizing assist from the rotating drum, i.e., the front shoe when moving forward, the rear shoe when moving in reverse. Most non-servo brakes have the wheel cylinder mounted toward the top of the backing plate. In this application, the front shoe is called the <u>forward</u> shoe, and the rear shoe is called the <u>reverse</u> shoe. One end of each shoe bears against an anchor on the backing plate, the other bears against a wheel cylinder pushrod. A single anchor pin above the cylinder is not used as in full servo brakes. Non-servo brakes were used on older U.S. built cars and are found in combination with front discs on some late models.

(a) Self-adjusters are also used on non-servo brakes. Most of these self-adjusters also operate when the brakes are applied in reverse. The automatic adjuster moves the shoes out toward the drum as lining wear occurs, thus maintaining correct lining to drum clearance. Figure 5-4 illustrates a typical self-adjuster on a non-servo brake.

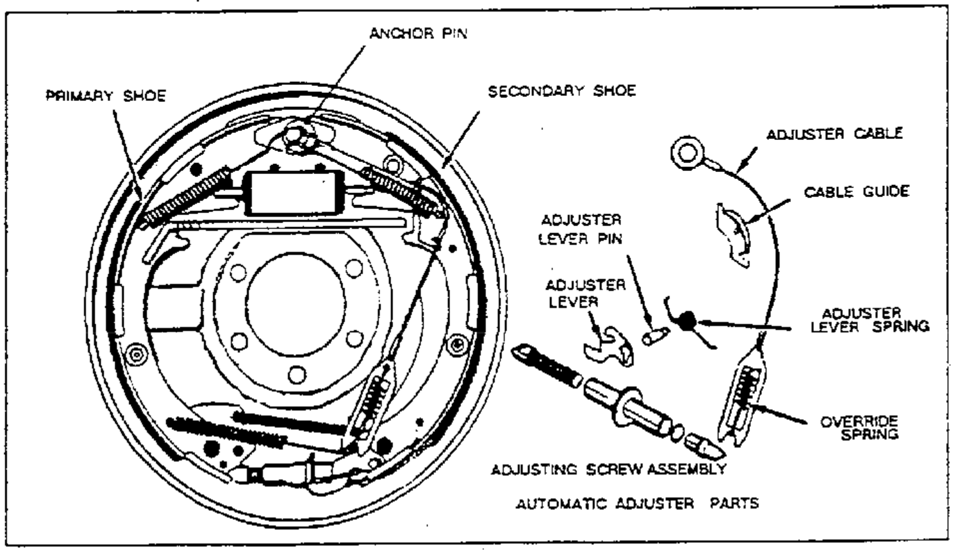

Fig. 5-3. Typical Full-Servo Drum Brake

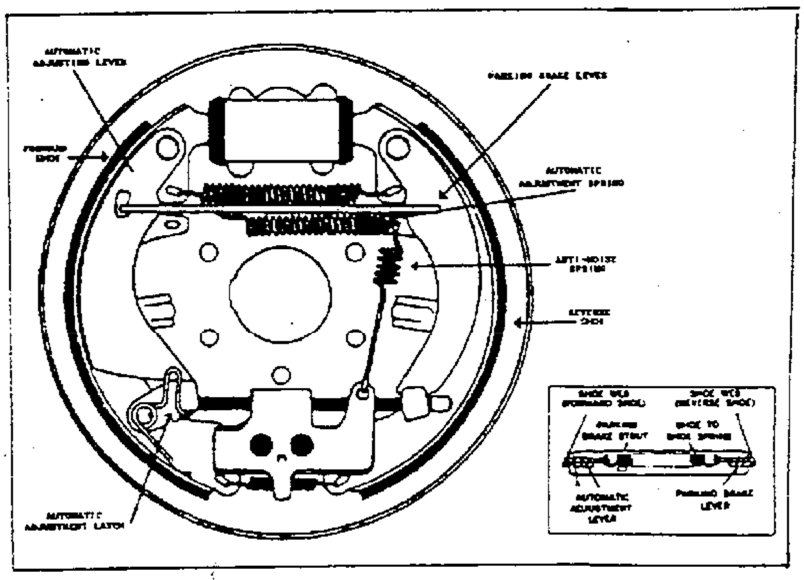

Fig. 5-4. Non-Servo Drum Brake

b. Disc-Type Brake Systems. Many modern vehicles with power-assisted systems utilize disc brakes either on the front wheels or on both front and rear wheels. The disc or rotor rotates and the caliper is stationary except for some lateral motion in the case of the floating caliper assembly. The caliper contains wheel cylinders and brake lining pads. Fixed caliper and 'floating caliper disc brake assemblies are shown in Figures 5-5 and 5-6. Systems with disc-type brakes operate as follows:

(1) The caliper, as its name implies, provides a gripping action on the rotor of a disc brake. The caliper may be compared to a vise, the movement of the pads representing the jaws of the vise while the caliper housing represents the base. As the jaws close on a rotating plate, the clamping action retards and finally stops the rotation as pressure is exerted by. the jaws.

(2) For strength, the caliper housing is a rather heavy casting. Its size and location enables the caliper to absorb some of the heat generated by the friction material and rotor.

(3) Brake pad assemblies fit into the caliper housing. Hydraulic force applied against the cylinder pistons moves the assembly in the caliper housing toward the rotor surfaces, bringing the vehicle to a stop. The release of hydraulic force allows the cylinder piston(s) to return to the released position. A brake pad assembly consists of friction material and a steel plate.

(4) To protect the inner surface of the rotor against foreign matter, a metal splash shield is often fastened to the spindle with a cap screw.

(5) The disc brake assembly may be further protected from water and contamination by a splash plate located at the inboard side. This may be compared to the backing plate of a drum brake. The wheel assembly protects the outboard side. Any liquid or foreign matter hitting the rotor surfaces tends to be discarded by centrifugal force as the rotors revolve.

(6) Since disc brakes are designed to provide a smaller operational area and are not self-energizing, correspondingly higher line pressures are required on full application. On vehicles equipped with front disc brakes and rear drum brakes, a proportioning valve is an important part of the system. It is installed in the hydraulic line to the rear (drum) brakes. Its function is to maintain the correct proportion between line pressure to the front and rear brakes and therefore provide a balanced vehicle braking

(7) On vehicles equipped with front disc brakes and-rear drum brakes, there are always separate fluid lines to the front and rear brakes. A residual check valve is installed in the hydraulic line between the` master cylinder and the rear brakes. This valve maintains the necessary residual pressure to the rear drum brakes without affecting the front disc brakes.

(8) Automatic adjustment of the brake pads is obtained by the piston movement past the seals as brake lining wear takes place. Clearance is continually controlled between the friction material and rotor assembly as the piston changes its position with respect to the seal. Parallelism and lateral run-out of the rotor must be within manufacturers' specifications to maintain the proper pedal reserve and prevent brake pulsation.

(9) Two basic types of rotors in use today are known as the solid disc rotor and the vented rotor. The solid disc rotor, as the name implies, has a disc made from a solid piece of metal. The vented rotor has two machined braking surfaces separated by ventilating fins. Both types function in basically the same manner, however, the vented rotor has a greater capacity to transfer and dissipate the heat generated by braking.

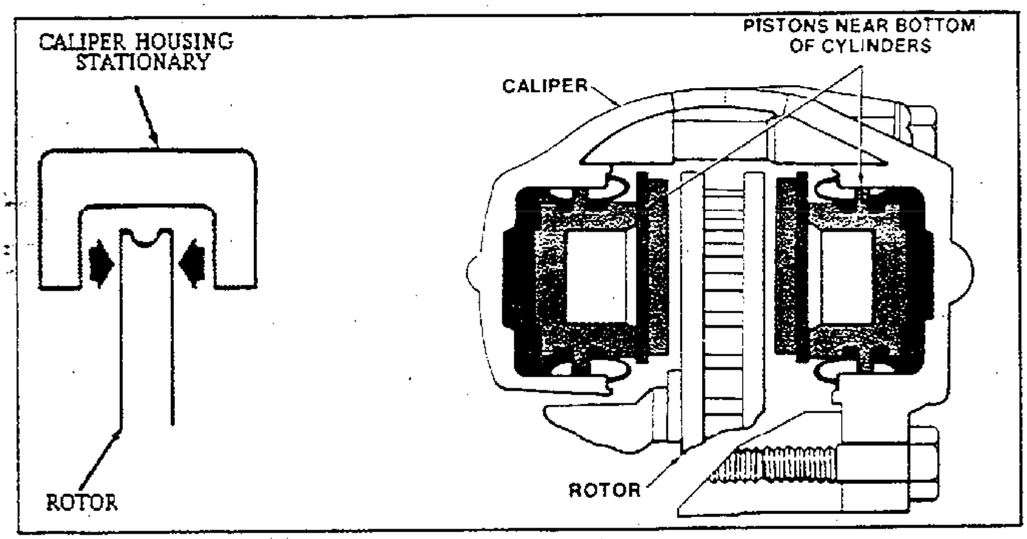

Fig. 5-5. Fixed Caliper Disc Brake

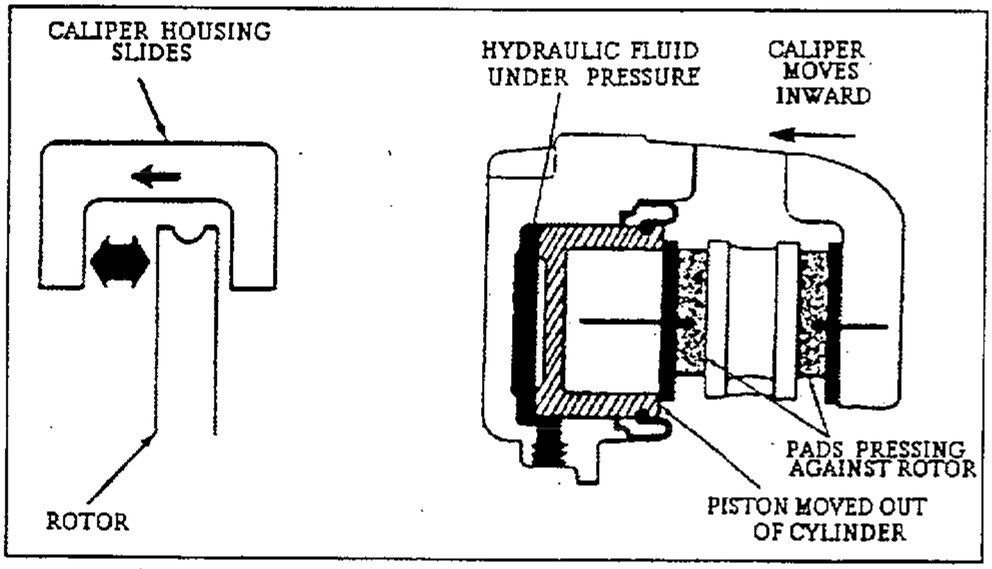

Fig. 5-6. Floating Caliper Disc Brake

5. COMPONENT PARTS.

a. Hydraulic Brake System Components. The components of a hydraulic system include the-application pedal, master cylinder assembly, brake fluid, fluid distribution lines (tubing or hoses), and individual wheel cylinders or caliper assemblies. Additional components may consist of a pressure differential valve and switch (brake warning light), a proportioning valve and metering valve. The system may also include a power-assist feature such as a vacuum or hydraulic booster to supplement pressure applied manually to the system.

b. Single System Master Cylinder. The master cylinder is a simple hydraulic pump operated by the brake pedal through a link or push rod. A typical master cylinder consists of a cylinder, a piston with a primary and secondary cup, a residual pressure check valve, a return spring and a fluid reservoir. A single system master cylinder is shown in Figure 5-7 and operates as follows:

(1) When, force is applied to the brake pedal, the force is multiplied by the pedal lever and transmitted through the push rod or link to the master cylinder piston. The piston converts the force into hydraulic fluid pressure.

(2) Hydraulic fluid under pressure is forced through the check valve and hydraulic lines into the wheel cylinders to expand the shoes against the drums. When the brake pedal is released, the brake shoe return springs force the fluid through the hydraulic lines and residual check valve back into the master cylinder.

(3) The compensating port is reopened when the master cylinder piston reaches the full release position. When the brake pedal is released quickly, the master cylinder piston may return faster than the fluid from the wheel cylinders. If this happens, fluid from the reservoir enters the cylinder through the inlet port to keep the chamber ahead of the piston full of fluid.

(4) As the cylinder pistons return to the fully released position, the excess fluid in the system is returned to the fluid reservoir through the compensating port.

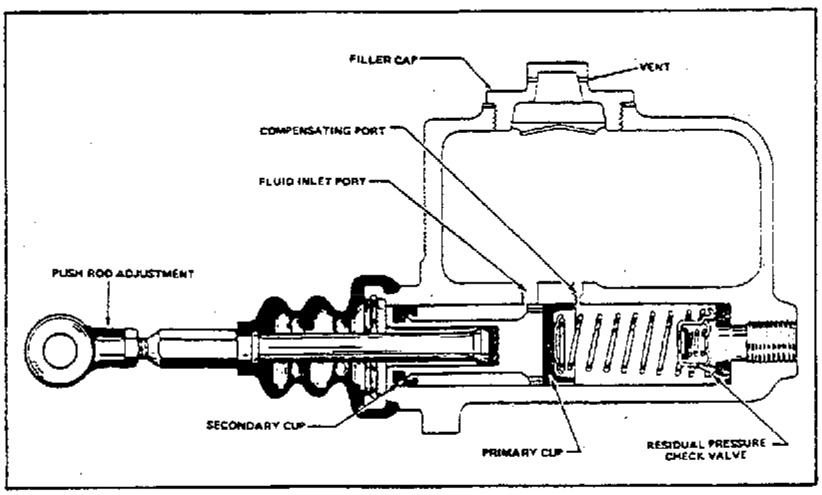

Fig. 5-7. Single System Master Cylinder

c. Dual System Master Cylinder. The dual or split master cylinder contains two separate hydraulic brake circuits. The individual brake systems may be designed to divide the systemm front and rear, or diagonally. If a brake fluid leak develops in` one circuit, the other circuit still provides limited stopping capability. Figure 5-8(a) illustrates a typical dual master cylinder used with vehicles equipped with drum-type brakes and Figure 5-8(b) illustrates a typical dual master cylinder used with vehicles equipped with disc-type brakes. These cylinders operate as follows:

(1) As the brake pedal is depressed under normal operating conditions, it forces. the primary piston forward to cover the primary compensating

port. At this time, the primary chamber is sealed and direct hydraulic pressure is transmitted to the secondary piston.

(2) As the brake pedal continues to travel, the secondary piston covers the compensating port. Further application of the brake pedal develops the pressure required to apply the brake components.

(3) Should a leak develop in the primary circuit, the brake system would not be rendered inoperative. During the applications of the brakes, the primary piston would continue to move forward, unable to build pressure due to the malfunction. Approximately halfway through its maximum stroke, the primary piston contacts the secondary piston. Further application of the brake would force the secondary piston forward to develop pressure in the secondary system, which would allow for braking action to take place in two wheels.

(4) Should a leak develop in the secondary circuit, braking for the other two wheels would still be available. The primary piston would move forward and cover the primary compensating port as before. Because of the rupture in the secondary circuit, the secondary or floating piston would be moved to its extreme stop by the force of the return spring. Further application of the brake would develop enough pressure in the primary circuit to apply the brakes connected to this circuit, therefore allowing the vehicle to maintain some stopping ability.

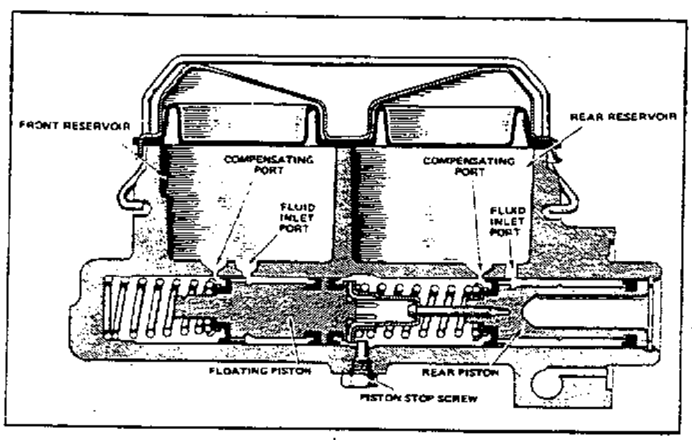

Fig. 5-8(a). Dual System Master Cylinder Used With Drum Brakes

d. <u>Hydraulic Brake Fluid</u>. Brake fluid is a specially blended liquid which provides a means of transmitting hydraulic pressure between the master cylinder and the brake wheel cylinders or calipers.

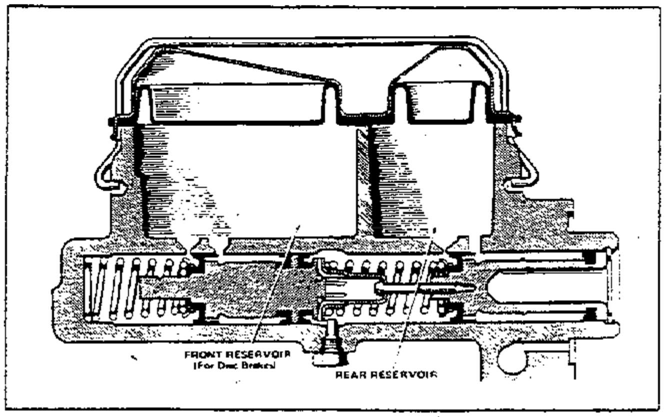

Fig. 5-8(b). Dual Master Cylinder Used With Disc Brakes

(1) Brake fluid is one of the most important parts of the hydraulic brake system since it ties all of the hydraulic brake system components together into an integral operating unit. Federal laws require that brake fluid must meet SAE (Society of Automotive Engineers) specifications. Do not reuse brake fluid and do not use brake fluid that does not meet SAE specifications.

(2) The State of California, through regulations of the Department of Food and Agriculture contained in Title 4 of the California Code of Regulations, 'requires that brake fluid conform to the current specifications of the National Highway Traffic Safety Administration, United States Department of Transportation.

(3) As a result of use, brake fluid becomes contaminated and loses some of its original qualities. It is good practice to bleed the brake system until all old fluid is removed when performing major brake work. Old fluid should be bled from the system and replaced with new brake fluid if any of the hydraulic system parts are corroded or the fluid is discolored or dirty. If any of the rubber parts of the hydraulic system are soft or swollen, old fluid should be removed, and the hydraulic system should be flushed with alcohol and refilled with new brake fluid. All cups and seals also should be replaced.

(4) Brake fluid must have the following characteristics:

(a) Viscosity (free flowing at all temperatures).

(b) High boiling point (remain liquid at highest operating temperatures).

(c) Noncorrosive (must not attack metal or rubber parts).

(d) Water tolerance (must be able to absorb and retain moisture that collects in the system).

(e) Lubricating ability (must lubricate piston and cups to reduce wear and internal friction).

(f) Low freezing point (must not freeze even at lowest operating temperatures).

e. Hydraulic Tubes and Hoses. Hydraulic tubes and hoses form the link . between the master cylinder and the wheel cylinders or calipers. They transmit the hydraulic fluid under pressure from the master cylinder to the wheel cylinders.

(1) Hydraulic hoses provide a flexible link between the brakes (or axle) and the vehicle frame or body. Hoses must be able to withstand high fluid pressures without expansion and must be free to flex during suspension spring deflection and wheel turns without damaging the hose.

(2) Most hydraulic brake tubes are made of double-walled, welded steel tubing, coated to prevent rust and corrosion. The tube ends are double flared or have a chamfer-type flare to guard against leakage.

f. Wheel Cylinders. There are several different types of wheel cylinders used with drum brakes. Figure 5-9 illustrates a double piston, straight bore wheel cylinder which is the type most commonly used -on. automobiles and light trucks. Wheel cylinders operate as follows:

(1) Wheel cylinders convert hydraulic pressure supplied by the master cylinder into a mechanical force that pushes the brake shoes against the drums.

(2) Inside the wheel cylinder are two pistons that are. moved in opposite directions by hydraulic pressure and which, at the same time, push the shoes against the drum. The shoe links are connected directly to the shoes. Rubber piston cups fit tightly in the cylinder bore against each piston to prevent the escape of brake fluid. There is a light spring between the cups to keep them in position against the pistons. The open ends of the cylinder are fitted with rubber boots to keep out foreign matter.

(3) When the pedal (pressure) is released, spring tension on the brake linkage and spring pressure against the master-cylinder piston force

the piston to move back in its cylinder. Fluid now flows from the wheel cylinders back to the master cylinder. The tension of the brake shoe return springs forces the brake shoes away from the brake drums, pushing the wheel cylinder pistons inward. Fluid is thus returne d from the wheel cylinders

to the master cylinder. However, some systems have pressure trapped in the lines by the check valve at the end of the master cylinder.

(4) As the pressure drops, the check valve closes, trapping a few pounds of pressure in the lines and wheel cylinders. This pressure has the purpose of keeping the wheel cylinders from leaking and also of reducing the chances of air leaking into the system.

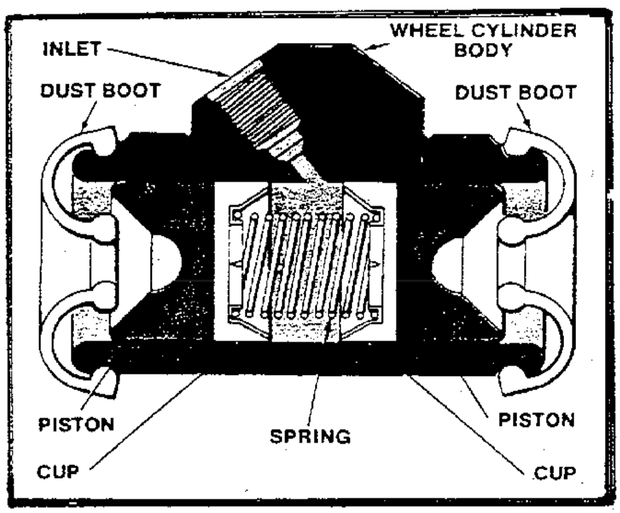

Fig. 5-9. Typical Double-piston, Straight-bore Wheel Cylinder

g. <u>Proportioning Valve</u>. A proportioning valve is used on most vehicles equipped with front disc and rear drum brakes. This valve is installed in the line to the rear drum brakes. Figure 5-10 illustrates a typical proportioning valve, which operates as follows:

(1) During high deceleration stops, a percentage of the vehicle's rear. weight is transferred to the front wheels. The resultant loss of weight on the rear wheels contributes to early rear wheel lockup.

(2) The proportioning valve is' designed to reduce the hydraulic pressure to the rear drum brakes during heavy brake applications and improves front-to-rear braking balance.

(3) The proportioner does not operate during normal brake stops (slow deceleration). Fluid normally flows into the proportioner, through the space between the piston center hole and valve stem, through the stop plate and out to the rear brakes. The spring loads the piston so that it rests against the stop plate for normal brake pressures.

Pressure developed within the valve pushes against the large end of the piston and when sufficient enough to overcome the spring load, moves the piston to the left (in the illustration). The piston "contacts" the spherical stem seat and starts proportioning by restricting pressure through the valve.

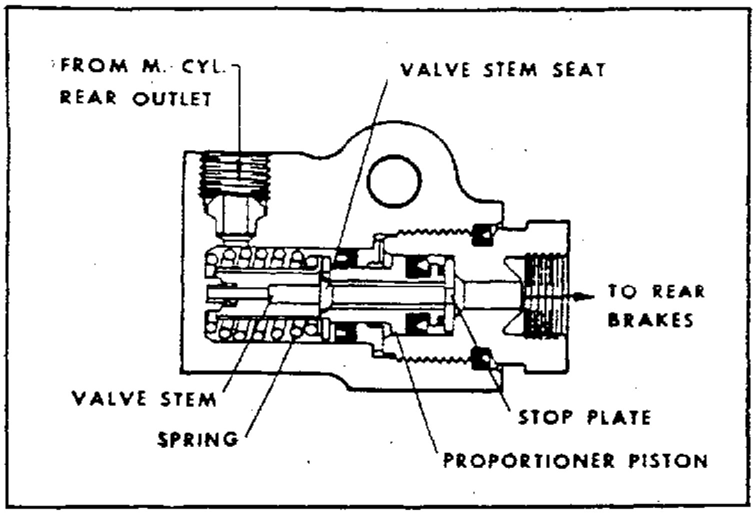

Fig. 5-10. Proportioning Valve

h. Metering Valve. This valve is installed in the front brake line between the master cylinder and the front disc brakes. The function of the metering valve is to improve braking balance, particularly during light brake applications. Figure 5-11 illustrates a typical metering valve, which operates as follows:

(1) The valve holds off excessive front disc braking until the shoes of the rear drum brakes contact the drums. Thus, the rear brake shoes move outward to contact the drums at the same time that the pads in the front disc brakes contact the rotor.

(2) With the brakes released, the metering valve allows free flow of brake fluid through the-valve. When the brakes are applied, the metering valve stem moves to the left (in the illustration), and at low pressure (approximately 75 to 135 psi), the stem is in a sealing position with the metering valve seal lip, shutting off any additional hydraulic pressure to

the front disc brakes until the shoes of the rear drum brakes come in contact with the drums.

(3) The metering valve stem continues to the left as pressure is increased enough to overcome the spring, allowing hydraulic pressure through the valve to the front brakes.

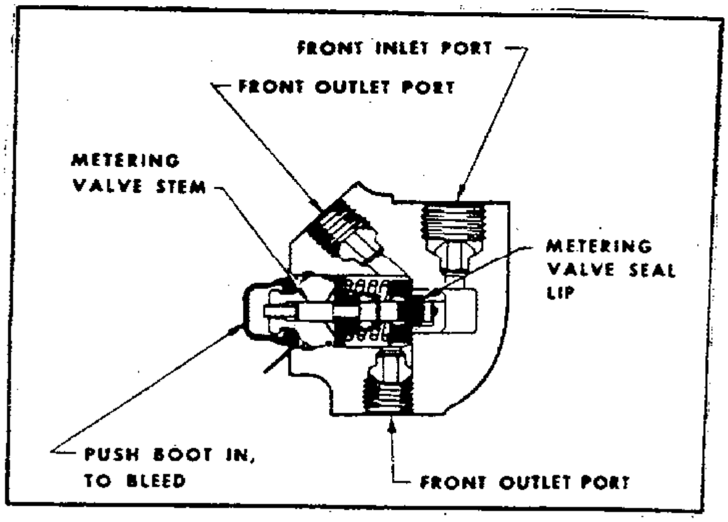

Fig. 5-11. Metering Valve

i. Brake Warning Light Switch. Along with dual master cylinders which are required by Federal Motor Vehicle Safety Standards, most new vehicles are equipped with a pressure differential switch and a brake warning light. The switch lights a telltale light on the dashboard to notify the driver that a failure has occurred in some part of the hydraulic system. Figure 5-12 illustrates a typical brake warning light switch, which operates as follows:

(1) Pressure differential switches vary in functional details, but generally are activated by a pressure differential between the two systems (front and rear brakes or in the split diagonal system,right-front, left-rear and left-front, right-rear brakes).

(2) The switch consists of a free-floating piston and a trigger mechanism which closes an electrical circuit if the piston is displaced from its center position. Equal hydraulic line pressure to the front brakes and to the rear brakes keeps the piston centered. Should the pressure be reduced on one side of the piston while higher pressure exists on the other side, the piston moves from its center position, actuating the electrical switch and illuminating the brake warning light on the dashboard.

(3) The switch piston, equipped with o-ring seals, floats in a neutral position, held in place by springs of equal force at each end, as long as the fluid pressures on each side of the switch are the same. If these pressures should become unequal, as would be the case with partial failure, the piston will be forced to the low pressure side, making electrical contact and causing the warning light to come on while the brakes are applied.

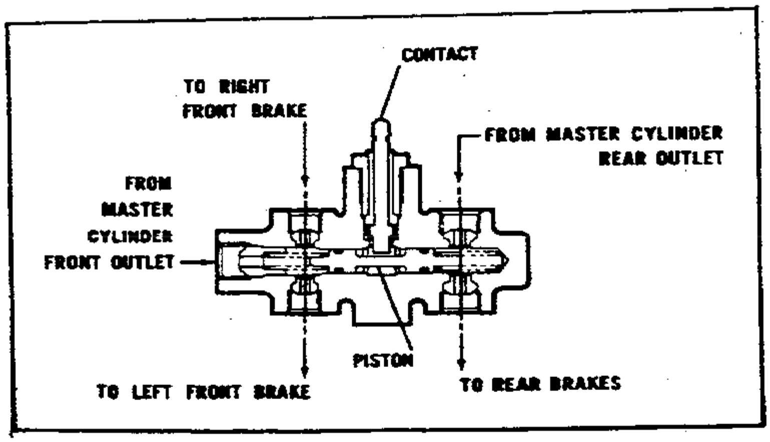

Fig. 5-12. Brake Warning Light Switch

j. Combination Valve. Many vehicles manufactured after 1970, equipped with front disc brakes and rear drum brakes, have a combination valve in the hydraulic system. The valve is installed between the master cylinder and the front and rear brake system. Figure 5-13 illustrates a typical combination valve,, which operates as follows:

(1) Since the brake combination valve assembly incorporates the metering valve, failure warning switch, and proportioner, it functions in the same manner as the components did before they were combined into one assembly. The resulting "four-in-one" combination in one assembly eliminates six tube nuts and three formed brake lines, thus reducing potential leak points.

6. PRELIMINARY INSPECTION PROCEDURES.

a. Safety Precautions. Ensure that all persons are out from under the vehicle or combination of vehicles. Block the wheels. With the engine running, release all brakes, and instruct the driver to apply or release the brakes only as directed.

b. Depth of Inspections. Each inspection must be in sufficient detail to determine (as a minimum) the following:

(1) If the system is properly installed and maintained.

(2) If the system functions as required.

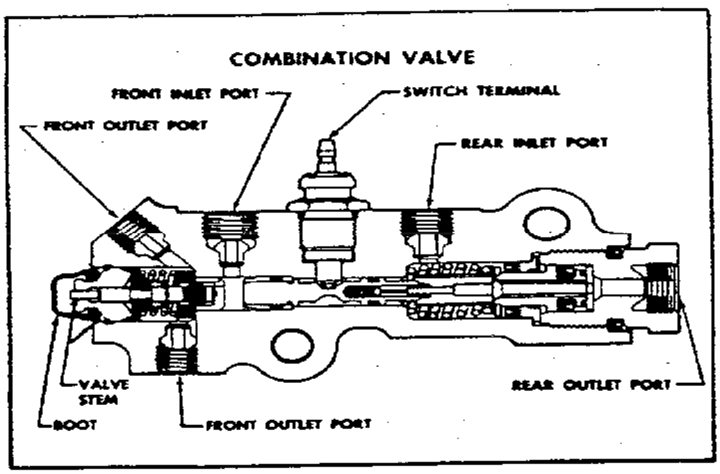

Fig. 5-13. Combination Valve

7. INSPECTION PROCEDURE.

a. The following inspection procedures are offered as a guide, to assist in ensuring a complete inspection of a braking system. The basic inspection applies regardless of the type of braking system installed on the vehicle.

b. The remainder of the inspection depends upon the particular type of power-assist the vehicle is equipped with-.

8. BASIC INSPECTION.

a. Visual Inspections. Conduct a visual inspection of the brake system as follows to determine if the brakes are maintained in good condition and good working order (Section 26453 VC).

(1) Remove master cylinder cap(s) and check the fluid level. The fluid should be within 1/4-inch to 1/2-inch from the top of the reservoir (both reservoirs of a dual system master cylinder). The vent hole(s) in the caps should be clear and unrestricted, and the gasket should not be torn or damaged.

(a) In brake systems which use drum-type brakes, master cylinder reservoir fluid level drop is not directly related to brake wear. Periodic level check is necessary since slight reservoir loss may be expected.

(b) In disc brake systems, fluid level drop is directly related to brake pad wear. Since disc brake pads or shoes have no retracting springs, master cylinder fluid level will drop as pads wear.

(2) Inspect the master cylinder for leaks at the hydraulic line connections and at the push rod end.

(3) Check pedal linkage for excessive wear or looseness and signs of interference at frame members or with other parts. Also check for loose locknuts and condition of pedal return spring (if used).

(4) Inspect outsides of backing plates, brake drums, and inner walls. of tires for stains and dampness which would indicate leakage of hydraulic brake fluid.

(5) Inspect tube and hose connections for stains around fittings or wet spots around hoses which indicate fluid leakage.

(6) Inspect all brake hoses for cracks, weathering, and leaks.

(7) Inspect front wheel brake hoses for worn spots indicating contact with the wheels.

(8) Turn the steering wheel to maximum left and right turns and inspect to ensure that hoses do not contact wheels and are not placed in tension.

(9) Inspect all brake lines between the master cylinder and wheels for leaks, kinks, dents, damaged fittings and/or hold-down clips.

(10) Inspect the wheel brake assembly. This check can be conducted by removing a wheel or wheel and brake drum. Wheels and drums should be removed only when proper tools are available and the condition of the brake system indicates a need for such inspection. (This check is not appropriate for on-highway inspections or departmental terminal inspections).

(a) Measure the brake lining thickness. For passenger cars, the Motor Vehicle Manufacturers' Association of the United States, Inc. recommends more than 1/32-inch of lining above the rivets on riveted shoes, and above the shoes on bonded linings (or to the wear. indicator if lining is so marked) measured at the shoe center. For commercial motor vehicles, the Commercial Vehicle Safety Alliance (CVSA) requires drum brakes to have a lining thickness of not less than 3/16 inch for a shoe with a continuous strip of lining or 1/4 inch for a shoe with two pads, or to wear indicator if lining is so marked. Hydraulic disc and electric brakes require more than 1/16 inch lining thickness, measured at the shoe center.

(b) Inspect the brake lining for grease soaking, faulty riveting, imbedded foreign particles, cracking, and missing pieces.

(c) Inspect brake drums for cracks and excessive wear.

(d) Inspect hydraulic wheel cylinders for fluid leaks. The rubber boots should be pulled back to determine if brake fluid has collected between the boot and piston. The actual presence of fluid, other than mere dampness, indicates a, fluid leak.

(e) Inspect condition of brake shoe return and hold-down springs.

(f) Inspect the automatic adjuster for free movement and proper alignment of the star wheel and pawl. Misalignment of the pawl and star wheel, and rust or other conditions which interfere with freee turning of the adjuster may render the automatic adjustment feature inoperative.

(g) Inspect disc brake calipers for damage, leakage, loose or damaged mounting bolts, and for loose or missing shoe retaining pins or clips.

(h) Inspect brake shoes or disc brake pad linings for proper thickness. There must be more than 1/16-inch of lining above the, rivets on riveted pads, and above the pads on bonded linings (or to the wear indicator if so marked) measured at the shoe center. Inspect for contamination with grease, brake fluid, or other material. Check lining for security on shoe or pad..

(i) Inspect the rotor disc for thickness variations (parallelism), side-to-side wobble (lateral run-out), excessive ridges, grooves, or cracks.

b. Basic Functional Inspection. Check the brake system as follows to determine if the brakes function properly and are maintained in good condition and good working order (Section 26453 VC).

(1) Firmly depress brake pedal several times to ascertain if it operates freely without locking or binding.

(2) Inspect the brake failure warning light. Apply the parking brake and start the engine. The warning light should illuminate with the ignition switch in the "on" or "start" position. Release the parking brake. The brake warning light should no longer be illuminated. (Dual or split systems only.)

(3) Inspect hydraulic brake pedal free play. A minimum amount of free play should exist, enough to make sure the piston is fully returned and does not block the master cylinder compensating port (except on certain vehicles without a separate pedal return spring).

(a) Depress the brake pedal slowly until it can be depressed no further.

(b) If pedal pressure builds up, drops off sharply, and builds up sharply as it is being depressed, it indicates that a piston is sticking in one or more wheel cylinders or that one of the hydraulic lines is partially blocked. Such blocking would be more likely to occur in a flexible hose due to flaking or separation of inner layers.

(4) Inspect the pedal reserve. The distance that the pedal travels to operate the brakes for a safe stop is just one indication of the condition of the brake system. The total distance that the pedal can travel from its free position to its limit of travel is the <u>total pedal travel</u>. Figure 5-14 illustrates pedal travel and height.

(a) With the vehicle stopped and the engine running on vehicles equipped with power brakes, apply approximately 150 lbs. force to the brake pedal and observe if pedal moves, slowly downward. (on vehicles equipped with a hydraulic booster, apply normal pedal pressure not to exceed 60 lbs.).

(b) The distance that the pedal travels, from its <u>free height</u> to its <u>depressed</u> <u>height</u> should not be more than 80 percent of its total pedal travel. This means that there must always be 20 percent or more of the total travel left in reserve.

(c) If the brake pedal "floor boards", check the system by rapidly pumping the pedal several times to determine if a reserve can be built up.

(d) If the reserve does not build up, it is an indication that the master cylinder cup has failed or a' brake adjustment or brake relining is needed. A "spongy" pedal indicates air in the lines.

(5) Inspect for external leakage. If a pedal reserve is present, hold the pedal down hard for a period of one minute. If, instead of remaining stable, the pedal moves down, lessening the reserve, it is an indication that the hydraulic system is leaking fluid.

(6) Inspect for internal leakage. After holding the brake pedal down hard, lessen foot pressure without completely releasing the pedal. Then depress the pedal again gradually with light foot pressure. If the reserve gradually

fades under light foot pressure, hydraulic fluid may be leaking past the master cylinder primary cup lip causing pressure to. be dissipated within the cylinder. If this should be the case, no external leak would be noticed, since the fluid would remain in the master cylinder.

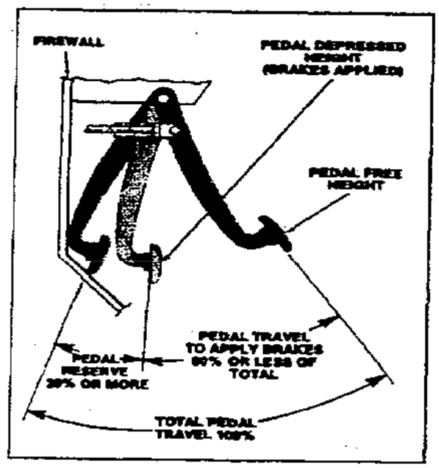

Fig. 5-14. Pedal Travel Showing Free Height, Depressed Height, and Reserve.

(7) Inspect for dragging brakes. If after repeated brake applications (not pumped) the pedal reserve increases and brakes at all wheels begin to drag, it indicates a blocked master cylinder compensating port, due to a swollen primary cup, lack. of necessary pedal lash, or dirt in the system.

c. <u>Vacuum Booster System Functional Inspection</u>. (See Chapter 6 for additional information on vacuum-assisted systems.)

(1) Vacuum Booster System Operation:

(a) Stop the engine, then depress the brake pedal several times to eliminate all vacuum in system.

(b) Depress the pedal with light pressure (30 lbs.).

(c) While maintaining this pressure on the pedal, start the engine and observe if the pedal moves downward slightly (which 'indicates that the vacuum booster is working) when engine starts.

(2) Vacuum Reserve:

(a) Run the engine to build full vacuum, shut the engine off, make one full brake application.

(b) There must be sufficient vacuum reserve to permit one full brake application after engine shutoff.