CHAPTER 6

VACUUM/AIR-OVER-HYDRAULIC BRAKES

REVISED FEBRUARY 2019

TABLE OF CONTENTS

THIS PAGE INTENTIONALLY LEFT BLANK

CHAPTER 6

VACUUM/AIR OVER HYDRAULIC BRAKES

1. SCOPE. This Chapter applies to the operation and inspection of vacuum/air over hydraulic brake systems.

2. INTRODUCTION. The information in this Chapter provides general information describing the operation of vacuum/air over hydraulic brake systems and their major component parts in addition to providing a suggested inspection procedure to determine whether the vacuum/air portion and the hydraulic portion of such systems are functioning properly and component pans are adequately maintained. Definitions appropriate to this Chapter are contained in Annex A.

3. SYSTEM DESCRIPTION AND OPERATION (Vacuum Over Hydraulic).

a. System. A hydraulic brake system which uses engine vacuum to assist in brake application is a "power brake" as defined in California Vehicle Code (VC) Section 480.

b. Operation. A vacuum over hydraulic brake system uses the force created by atmospheric pressure moving to balance engine vacuum, supplementing the manual force applied to the hydraulic system. Two of the three types of power booster units supplement manual pressure applied to_ the master cylinder and one type of unit boosts hydraulic pressure applied by the master cylinder to the wheel cylinders.

c. Types of Power Assisted Units. There are three basic types of, vacuum power brake units. The integral type as shown in Figure 6-1; the pedal-assist type as shown in Figure 6-2, and the pressure multiplier type as shown in Figure 6-3. They operate as follows:

(1) The integral type illustrated in Figure 6-1 supplements manual pressure to the master cylinder and is any type of power brake unit having the master cylinder assembly mounted directly on the vacuum chamber.

(2) The pedal-assist type power brake unit illustrated in Figure 6-2 applies force to the brake pedal linkage to supplement pressure applied manually to the master cylinder. The hydraulic master cylinder is independent of this type of power brake unit.

(3) The pressure multiplier type power brake unit illustrated in Figure 6-3, sometimes referred to as a low input-high output hydraulic power brake system, has a self-contained hydraulic cylinder known as a "slave" that works in conjunction with and is actuated by the master cylinder on the vehicle to boost hydraulic pressure to the wheel cylinders. This is essentially a two-stage hydraulic system in which the vacuum assist is applied to the input of second stage.

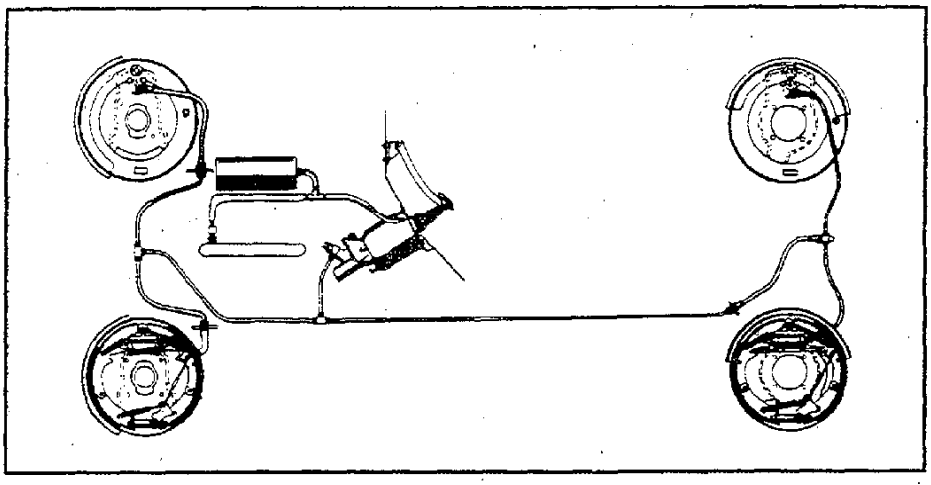

Figure 6-1. Typical Integral Type Power Brake Installation

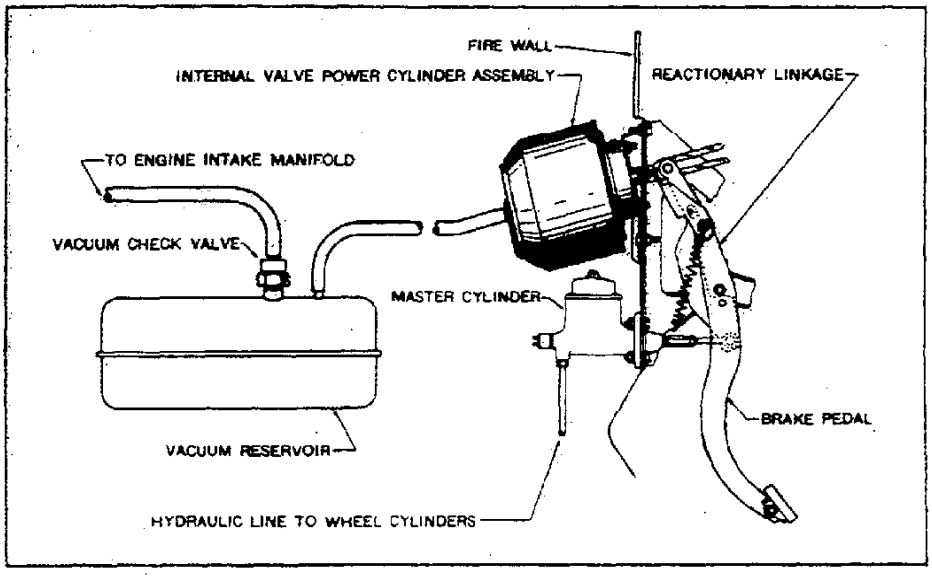

Fig. 6-2. Typical Pedal-Assist Type Installation

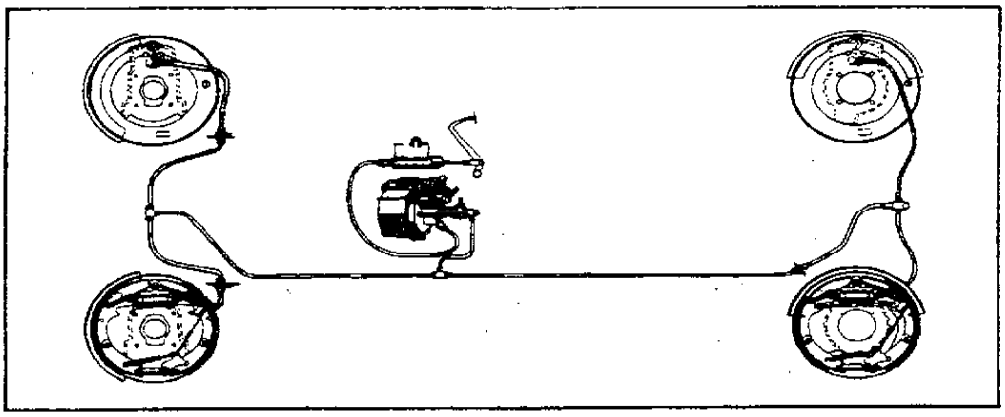

Fig. 6-3. Typical Pressure Multiplier Type Installation

4. COMPONENT PARTS (Vacuum Over Hydraulic).

a. Hydraulic Portion of a Vacuum Over Hydraulic System. The component parts of the hydraulic portion of a vacuum over hydraulic brake system are essentially the same as those contained in a straight hydraulic system. They are listed in Chapter 5 of this guide.

b. Vacuum Portion of a Vacuum Over Hydraulic System. The major components of a vacuum over hydraulic brake system are shown in Figures 6-1 through 6-3. Additional components sometimes used are vacuum gauges, warning devices, check valves, and vacuum reservoirs.

5. INSPECTION PROCEDURES.

a. Preliminary Requirements. Inspect the hydraulic portion of a vacuum over hydraulic system as outlined in Chapter 5.

b. Vacuum System Check. Stop the engine. Deplete the vacuum reserve by several applications of the brake pedal. This will cause pedal movement to stiffen, and pedal travel will seem to be shorter as the vacuum assist is depleted. With no vacuum in the system, depress the pedal with moderate force. When the pedal reaches a steady position, hold it there, start the engine, and observe the pedal action.

(1) If the vacuum system is operating properly, the pedal will fall away slightly under foot pressure and less pressure will be required to hold the pedal in an applied position.

(2) If no action of the brake pedal is felt, it is an indication that the vacuum system is not functioning.

c. Check Valve and Vacuum Reserve Check.Check the vacuum reserve and check valve by starting the engine. With the brakes unapplied, run engine at a medium speed for at least 20 seconds, then release the accelerator and apply the brakes.

(1) If there is no vacuum assist for one or more applications, or if the vacuum gauge reading drops, the check valve is defective, or there is a defect in the system which causes a vacuum loss (Section 26452 and 26522 VC). Vacuum loss through the brake booster system can cause rough engine idle, or in severe cases, engine stalling at idle throttle. (These symptoms can have other causes, however).

(2) If the vacuum system is not functioning,continue with the visual inspection of component parts described in Paragraph j.If this inspection does not reveal a condition that would interfere with operation of the vacuum system, an internal malfunction is indicated. Removal and/or disassembly of the unit may be required to determine the malfunction.This step is not appropriate for an on-the-road inspection.

d. Vacuum Piping and Air Cleaner. Check the condition of the vacuum piping and the air cleaner. Leaks and restrictions, collapsed hose and tubing, hose worn down to any fabric, loose hose clamps, and air cleaner clogging are conditions of inadequate maintenance (Section 26453 VC).

e. Vacuum Leakage and Low Vacuum Warning Device Test. This test can be conducted only on vehicles equipped with vacuum gauges or to which a vacuum gauge can be connected. If a gauge is installed for these tests, ensure that it is installed between the vacuum check valve and the vacuum booster unit. Otherwise, only manifold vacuum will be read, and the gauge will drop to zero as soon as the engine is stopped.

(1) Stop the engine and observe any loss of vacuum reserve as indicated by the vacuum gauge. Any drop in vacuum should not exceed 3 inches in one minute. The absence, malfunction or incorrect installation of the check valve is indicated by rapid fall-off of vacuum after the engine stops (Sections 26453 and 26522 VC).

(2) Apply the brakes and observe any loss of vacuum as indicated by the vacuum gauge.Leakage of vacuum greater than 3 inches in one minute indicates inadequate maintenance (Section 26453 VC).

(3) Deplete the vacuum reserve in the system by slow, repeated applications of the brake pedal. Observe the vacuum gauge reading when the low vacuum warning device operates. When a vehicle is required to be equipped with a low vacuum warning device, the device must begin operation when the vacuum drops to 8 inches of mercury or less (Section 26521 VC).

(4) To check the vacuum measurement, start the engine and observe the vacuum test gauge. Failure of the vacuum to reach at least 15 inches indicates a defective system and is a violation of Section 26453 VC. (Vacuum measurements will be lower at altitudes above sea level because of the decrease in atmospheric pressure).

f. Vacuum Gauge Test. The test for vacuum gauge accuracy can be conducted only on vehicles to which test gauges can be connected.

(1) Install the test gauge. Start the engine and build the vacuum reserve to the maximum. Compare the test gauge and vehicle gauge readings.

(2) A vacuum gauge which has an error of 10% or more or is not legible (at night, check for illumination) is in violation of Section 26520 VC.

g. Breakaway Brakes. Disconnect the vacuum hoses between the motor vehicle and the towed vehicle.

(1) Check the motor vehicle to determine that it will have sufficient service brakes to stop after breakaway of the towed vehicle (Section 26304(b) VC).

(2) Check to see that trailer brakes are applied and determine if they will hold the vehicle stationary for at least 15 minutes (Section 26304(b) VC).

h. Vacuum Trailer Brake Adjustment (Actuator Reserve). Measure the brake chamber pull-rod stroke as follows:

(1) Apply the service brakes and place a reference mark on the brake chamber pull-rod.

(2) Using a rule, measure from a fixed point on the face of the chamber to the reference mark on the pull-rod.

(3) Release the brakes and measure from the same fixed point on the actuator to the reference mark on the pull-rod.

(4) If the pull-rod travel is more than 3 inches, the brake is out of adjustment (Section 26453 VC).

6. SYSTEM DESCRIPTION AND OPERATION (Air Over Hydraulic).

a. System. A hydraulic brake system which uses the force of compressed air to assist in brake application is a "power brake" as defined Section 480 VC. The air over hydraulic brake system is an "airbrake" as defined in Section 108 VC.

(1) Air over hydraulic brake systems are required to be equipped with all safety devices required on vehicles equipped with straight airbrakes, except the emergency stopping system otherwise required under Section 26508 VC.

(2) Vehicles with an air over hydraulic brake system may tow trailers which are equipped with full air brake systems, supplied and operated through the air portion 6f the vehicle braking system.

b. Operation (Air Portion). The air portion of an air over hydraulic brake system uses the force of air pressure to supplement manual pressure on the hydraulic system.

(1) The basic air system is very simple, requiring only a source of compressed air, a valve to control the amount of air applied, and a means of converting the force of compressed air into hydraulic force to apply the brakes.

(a) Compressed air is generated by a compressor driven by the engine. Air is stored in reservoirs.

(b) The treadle valve or control valve is a foot operated valve that admits compressed air into the air-hydraulic boosters.

(c) The air-hydraulic boosters-convert the force of compressed air pressing against a piston diaphragm into hydraulic force to apply the brake shoes to the brake drums or the brake pads to the rotors to slow or stop the vehicle.

(d) Vehicles complying with Federal Motor Vehicle Safety Standard (FMVSS) No. 121 for split air systems are equipped with a single dual-chamber treadle valve designed to apply front and rear wheel brakes from separate hydraulic reservoirs and hydraulic boosters.

(2) Other valves, and devices such as air dryers, may be added to make the brake system operate more efficiently and safely.

c. Most Common Type of Air Over Hydraulic System Prior to 1975. The major components of this basic air over hydraulic system include an application pedal, an air compressor, air reservoir(s), a single-piston master cylinder assembly, and one air over hydraulic booster. A typical air over hydraulic brake system is shown in Figure 6-4.

(1) This system generally utilizes drum-type brakes on all wheels and, prior to 1965, was not usually equipped with a self-adjusting mechanism.

(2) The major disadvantage of single systems of the type shown in Figure 6-4 is that a hydraulic failure anywhere in the system causes total service brake failure, leaving the driver with only the emergency stopping system, if equipped, or the parking brake system as a backup means of stopping the vehicle.

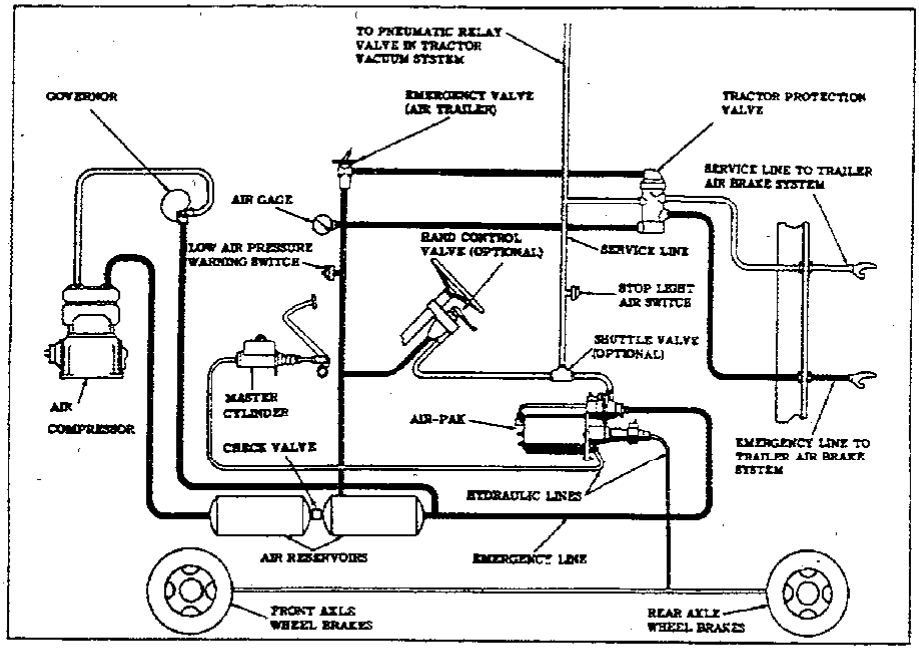

Fig. 6-4. Air Over Hydraulic Brake System - Before FMVSS 121

d. Most Common Type Air Over Hydraulic System in Present Use. Most vehicles equipped with air brake systems and manufactured after March 1, 1975 are required to be equipped with a dual air system and dual air over hydraulic boosters in compliance with FMVSS 121. A typical split air over hydraulic system is shown in Figure 6-5.

(1) The split service brake system consists of two air over hydraulic boosters actuated by a single control. It is designed so that a rupture or leakage-type failure of a pressure component (air and/or hydraulic) in a single booster will not impair the operation of the other booster.

(2) One booster actuates the front. brakes and the other booster actuates the rear brakes. Some hydraulic brake systems are split diagonally, rather than front and rear. The two air over hydraulic boosters are independent of each other.

(3) 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. Stopping distance may be increased with the defective condition since braking action is being applied to half of the system only.

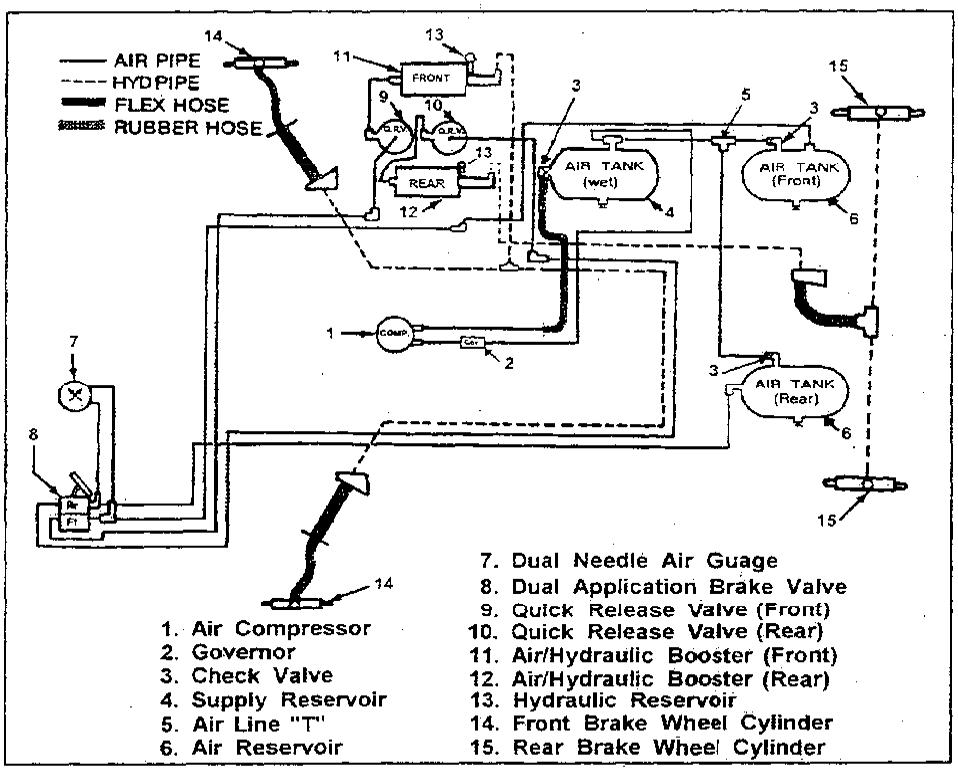

Fig. 6-5. Air Over Hydraulic Brake System - Meeting FMVSS 121

e. Description (Air Over Hydraulic Booster). The essential difference between the straight hydraulic brake system and the air over hydraulic brake system lies in the air over hydraulic booster. Figure 6-6 illustrates a typical air over hydraulic booster which is comprised basically of three interconnected units:

(1) An air reservoir which stores compressed air so there will always be an ample supply available for immediate use in the air portion of the booster. The reservoir is equipped with a drain valve for draining contaminants and condensation, as well as a means to drain air to check the double check valve in the air system.

(2) An air cylinder which receives air when the footbrake is depressed and actuates a piston, one part of which is pushed into the hydraulic cylinder.

(3) A hydraulic cylinder which stores brake fluid and displaces the fluid through the hydraulic lines into the wheel cylinders or calipers when pressure is applied by the air cylinder piston.

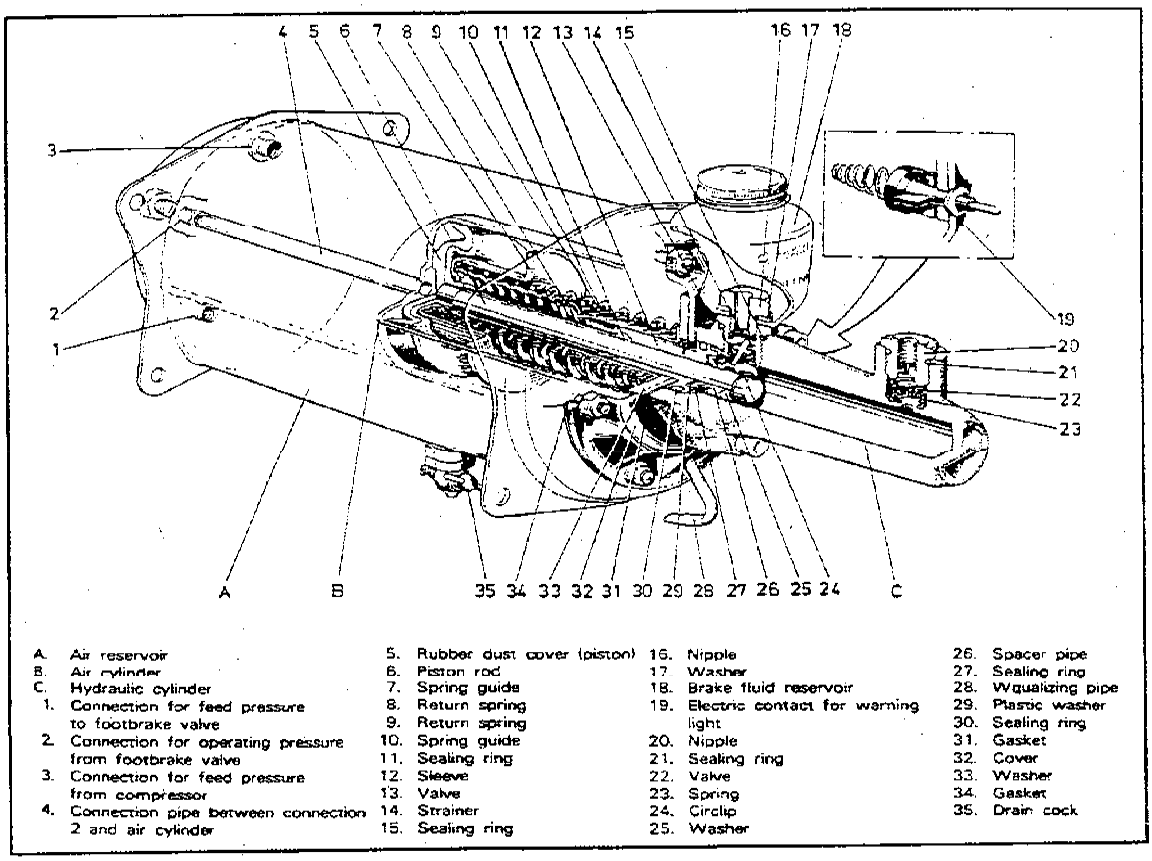

Fig. 6-6 Typical Air Over Hydraulic Booster

f Operation - Brakes Applied. Figure 6-7 illustrates the hydraulic booster with brakes applied and operates as follows:

(1) When the brake pedal is depressed, compressed air is supplied to the air line leading into the air cylinder of the air over hydraulic booster at a pressure corresponding to the amount of foot pressure applied to the pedal. This causes the piston and piston rod to move forward in the hydraulic cylinder.

(2) The piston rod washer then breaks contact with the valve pin in port #1 and the valve closes. which prevents brake fluid from returning to the brake fluid reservoir.

(3) As air pressure from the footbrake valve increases, the piston rod continues to be forced forward by the piston. Hydraulic pressure increases as the piston rod is pressed further into the hydraulic cylinder.

(4) In the outlet of the hydraulic cylinder (port #2), there is a residual pressure check valve which maintains a small residual pressure in the hydraulic lines between the booster cylinder and' the wheel cylinders or calipers at each wheel.

(5) The pressure in the hydraulic cylinder is in proportion to the pressure in the air cylinder.

(6) An electrical contact is built into the air cylinder. If the piston stroke is excessive due to a leakage in the hydraulic system, a weak spring or excessive air pressure, the spring guide washer presses against the spring for the electric contact, and activates a warning light on the drivers instrument panel.

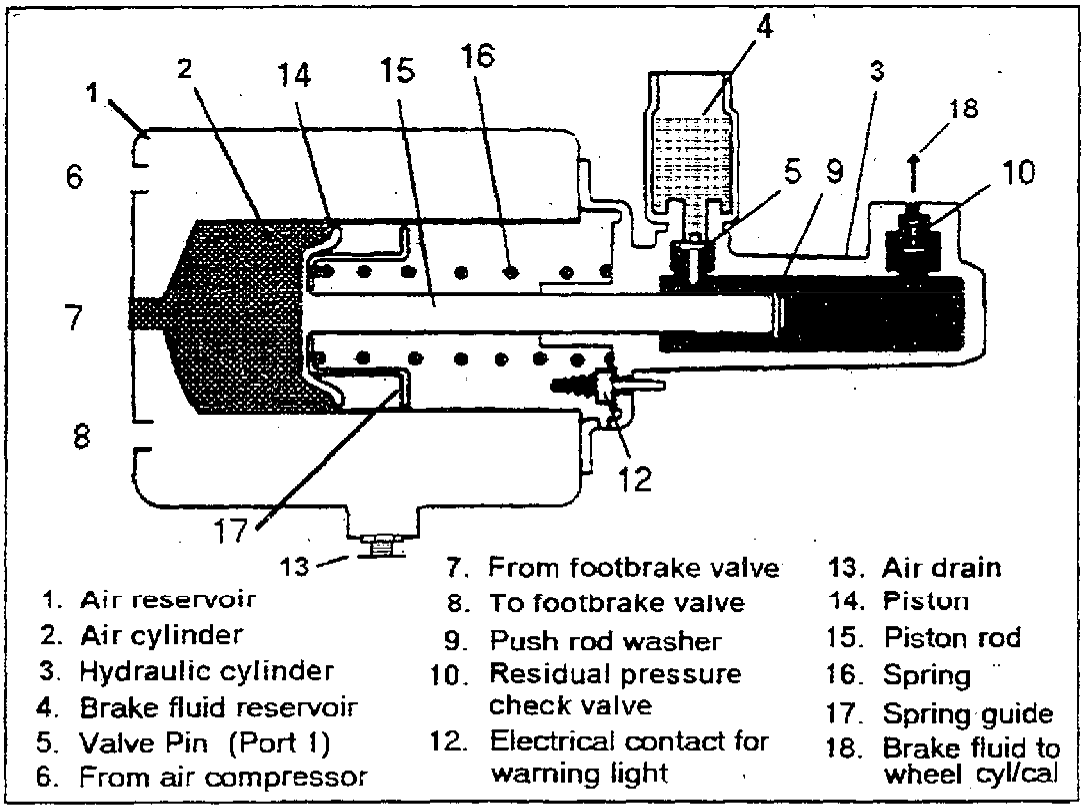

Fig. 6-7. Air Over Hydraulic Booster - Brakes Applied

g Operation - Brakes Released. Figure 6-8 illustrates the hydraulic booster (with brakes released) which operates as follows:

(1) When the footbrake is released, air is evacuated from the air cylinder through the quick release valve and footbrake valve'.

(2) With the release of air pressure, the piston rod inside the air cylinder is forced by spring pressure back to the released position.

(3) The piston rod washer on the piston rod contacts the valve pin in port #1, which opens the valve. As the valve pin opens, brake fluid returns to the brake fluid reservoir through port #1.

(4) Brake fluid from the lines and wheel cylinders or calipers can return through the residual pressure check valve in port #2 and into the hydraulic cylinder and brake fluid reservoir.

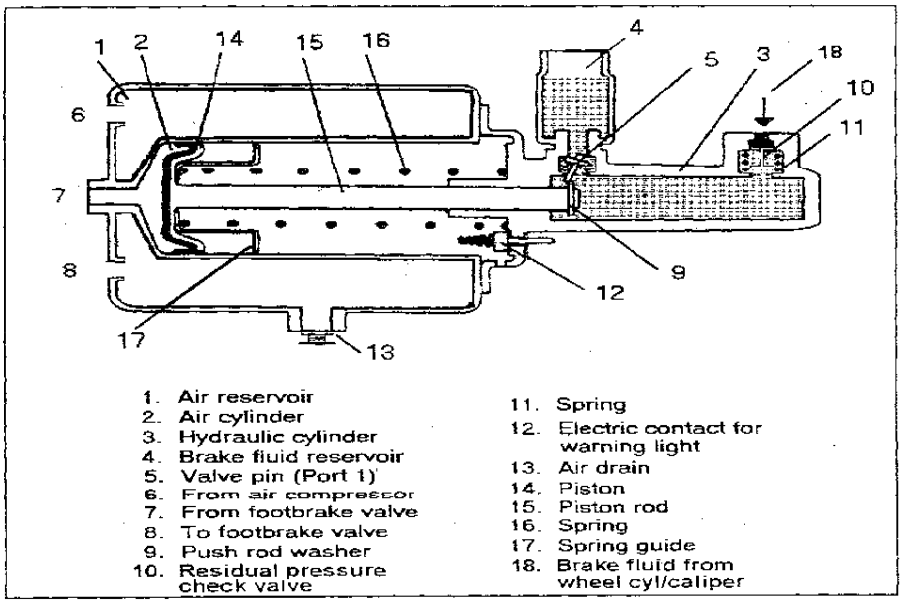

Fig. 6-8. Air Over Hydraulic Booster - Brakes Released

7. COMPONENT PARTS.

a. Air Portion of an Air Over Hydraulic System. The component parts of the air portion of an air over hydraulic brake system are essentially the same as those contained in a straight air system. They are listed in Chapter 3 of this manual.

b. Hydraulic Portion of an Air Over Hydraulic System. The component parts of the hydraulic portion of an air over hydraulic is brake system are essentially the same as those contained in a straight hydraulic system. hey are listed in Chapter 5 of this manual.

8. INSPECTION PROCEDURES.

a. Air System Check. Inspect the air portion of the system as outlined in Chapter 3.

b. Hydraulic System Check. inspect the hydraulic portion of the system as outlined in chapter 5. c. Brake Adjustment.

(1) Pre FMVSS 121. On vehicles manufactured prior to March 1, 1975, and equipped with a power cylinder cluster activated by hydraulic application, brake adjustment can be checked by depressing the brake pedal with a heavy foot-force (150 lbs.) and measuring travel in the power cylinder cluster. Travel of the push rod or of the rod-type gauge on the power cylinder cluster from the fully released to the fully applied position which exceeds 75% of the manufacturer's specified maximum stroke is an indication of improper maintenance (Section 26453 VC).

(2) FMVSS 121. Brake adjustment on vehicles manufactured in compliance with FMVSS 121 and not equipped with a power cylinder booster may he checked as outlined in Chapter 5.