Chapter One

Master Cylinder Training

BASIC BRAKE CONCEPTS

HEAT. When we talk about braking a car, we're talking about energy conversion: Converting the car's kinetic energy of motion into heat through friction. Most of this heat is generated in the brake drums or discs to be passed off to the atmosphere, but some of it is conducted through other brake parts. If the brakes are applied hard enough and often enough so that heat is generated faster than it can be absorbed and dissipated by the brakes, the condition known as "fade" happens. This high temperature loss of brake effectiveness can affect safety if the equipment is marginal due to thin drums (or rotors), inferior brake lining material or other deficiencies. High temperatures can also affect brake fluid, seals and other rubber parts if they are of inferior quality.

FRICTION. Since we depend on friction to convert the energy of motion into heat, there are some things we should understand about it. Friction is the resistance offered to the motion of one body rubbing on another. The amount of friction generated depends on several things:

a. Friction varies with the coefficient of friction of the materials in contact. In brakes this would be the materials used for the brake linings and the drums or rotors.

b. Friction varies with the area of the materials in contact. Brake linings must be of adequate size and contact the drum or rotor over the maximum area to be effective.

c. Friction is directly related to the amount of force pressing the two surfaces together.

While we need friction for braking, it's worth noting that it also produces wear, not only to the main braking surfaces, the linings and drums or rotors, but also to all moving parts in the brake system.

FLUIDS. A fluid principle important to brake operation is that liquids, such as brake fluid cannot be compressed, while gases are compressible (see Fig. 1). Any gas, such as air, in a hydraulic system will compress readily as pressure increases, thus reducing the amount of force that can be transmitted. This is why all air must be expelled from the hydraulic system for it to do an effective job. This is also why pure, quality brake fluid, free from elements that would vaporize at high temperatures, must be used.

Another important function of the brake fluid is to provide lubrication and protect parts in the hydraulic system against corrosion. Brake fluid must also be compatible with rubber parts in the system. That's why it is important to put nothing but clean, fresh, quality brake fluid in the brake system.

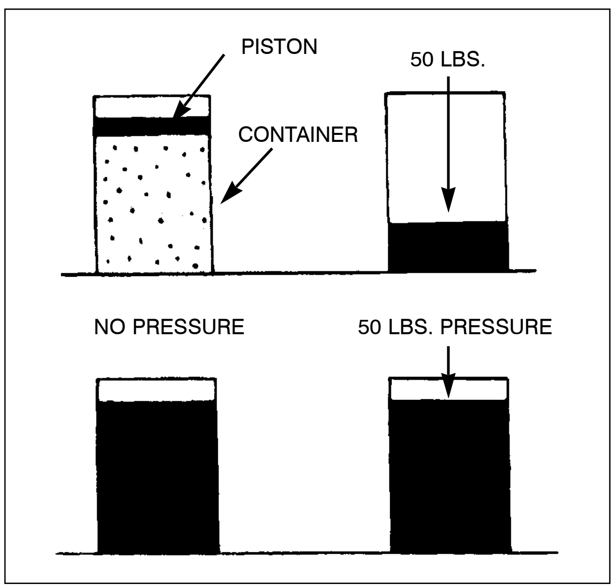


Fig. 1 - Fluid compressibility

HYDRAULICS. In automobile brakes, the force used to press the friction surfaces together is generated hydraulically, beginning with a foot pressing on the brake pedal. When pressure is applied to a fluid in a closed system, that pressure is transmitted, undiminished, in all directions to all parts of the system. Thus, if a pressure of 100 psi is generated in the master cylinder, that same pressure is transmitted to all wheel cylinders or calipers, regardless of how many there are or their location (see Fig. 2).

A definite relationship exists between force and piston area in a closed hydraulic system. If a force of 100 pounds is applied to a piston with an area of 1 square inch, a hydraulic pressure of 100 psi will be generated. Another piston in the same system with an area of 2 square inches will exert a force of 200 pounds. There is also a fixed relationship between motion or travel and the piston area. If the 1 square inch piston is moved 2 inches, then the 2 square inch piston will move only 1 inch.

AIR AND VACUUM. While air is to be avoided in the hydraulic system, it is quite useful in vacuum power brake operation. We live at the bottom of a sea of air that exerts a constant pressure on us. At sea level under normal atmospheric conditions this air pressure is 14.7 psi. If we remove part of the air (pull a vacuum) from a closed area on one side of a piston (or diaphragm), then a force will be exerted on the piston equal to pressure difference times the piston area. In power brakes, this force is used to boost the pressure of the push rod load in applying the brakes.

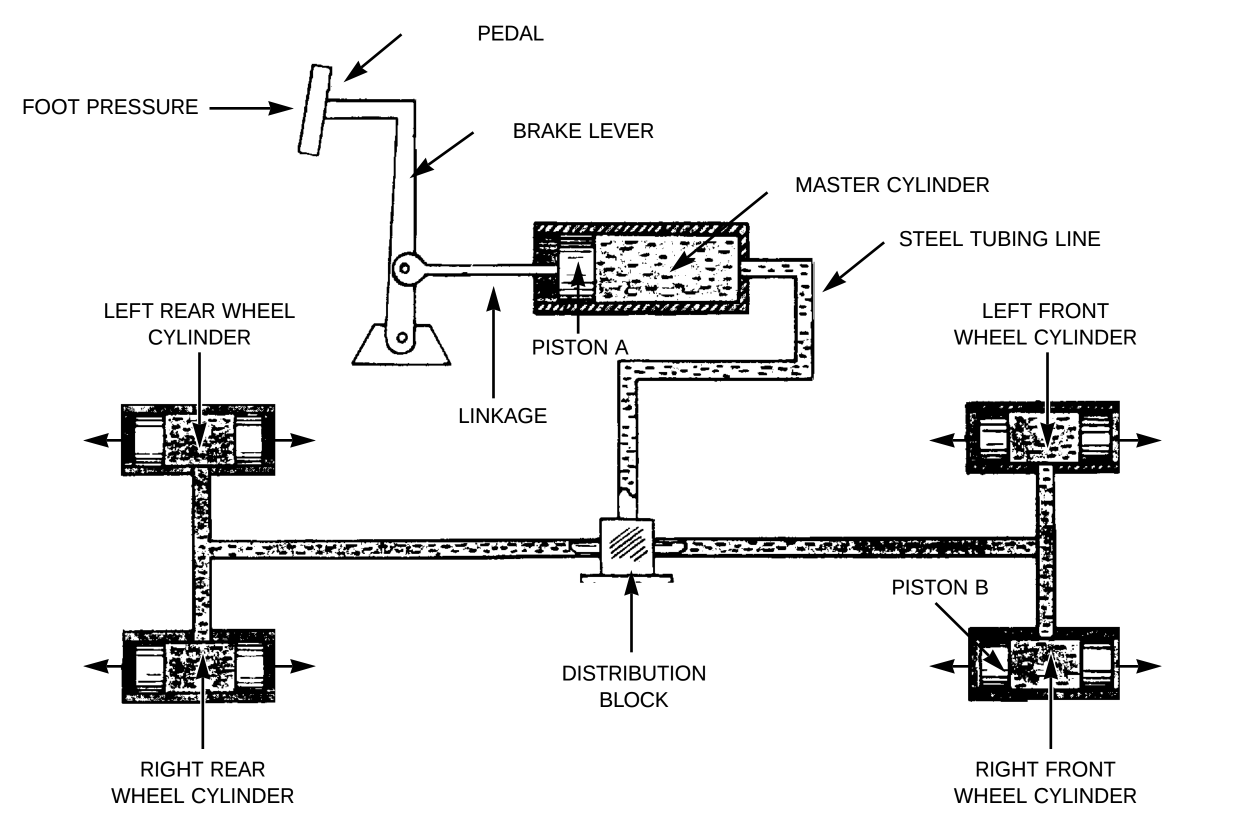


Fig. 2 - Pressure in a closed system

DUAL MASTER CYLINDERS. As its name implies, the dual master cylinder provides two separate and distinct pressure chambers in a single bore. In the illustrations that follow, the master cylinder is shown with the front chamber connected to the front brakes and the rear chamber to the rear brakes. In some cases, these connections may be reversed. Some cars may have a diagonal system. These alternate connections do not alter basic master cylinder operation, however.

When the brake pedal is depressed, force is transferred through the push rod to the master cylinder primary piston which moves forward. Under normal conditions, the combination of hydraulic pressure and the force of the primary piston spring moves the secondary piston forward at the same time. When the pistons have moved forward so that their primary cups move past the bypass holes, hydraulic pressure is built up and transmitted to the front and rear wheels (see Fig. 3) causing the brakes to be applied.

When the brakes are released, fluid is forced back through the lines to the master cylinder. However, the master cylinder pistons return to the released position faster than fluid can fill the chamber, thus tending to create a momentary vacuum. To compensate for this, fluid flows from the reservoirs through the compensating ports, through the compensating holes in the pistons and around the primary cups (Fig. 4).

NOTICE: In some late model master cylinders, the pistons do not have compensating holes (Fig. 5). Additional piston clearance is provided and other modifications made so that compensating flow is around the piston seal OD.

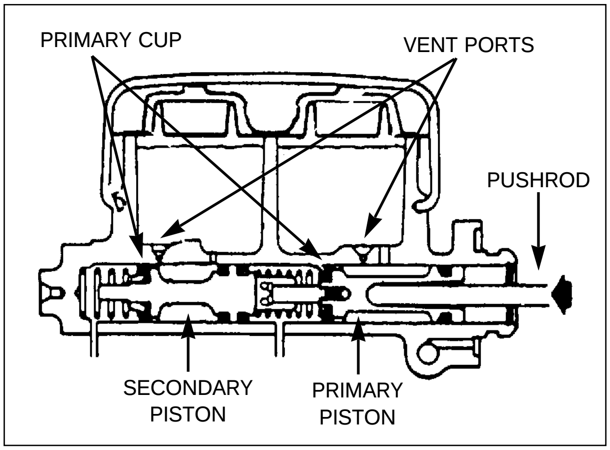


Fig. 3 - Brakes applied

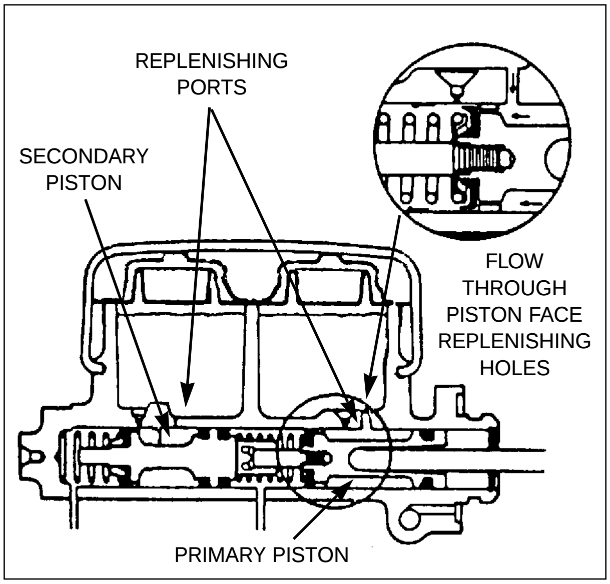


Fig. 4 - Start of brake release

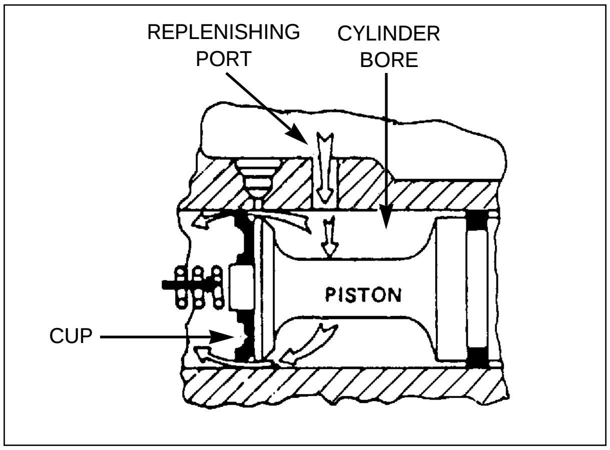


Fig. 5 - Fluid compensation

At the end of brake release, return pressure in the lines is greater than that in the master cylinder chambers. Fluid from the brake lines returns to the reservoirs through the bypass holes until pressure is equalized (Fig. 6).

In case of a failure in the rear brake line or system, the primary piston will move forward during brake apply, but will not build up hydraulic pressure. Only a negligible force is transferred to the secondary piston through the primary piston spring until the piston extension screw comes in contact with the secondary piston (Fig. 7). Then, push rod force is transmitted directly to the secondary piston and sufficient pressure is built up to operate the front brakes.

If there is a failure in the front line or system, both pistons will move forward when the brakes are applied, as under normal conditions. However, due to the front line failure, there is nothing to resist piston travel except the secondary piston spring. This permits the primary piston to build up only negligible pressure until the secondary piston bottoms in the cylinder bore (Fig. 8). Then, sufficient hydraulic pressure will be built up to operate the rear brakes.

With failure of either the front or rear system, increased pedal travel will result and greater pedal force will be required. Both of these effects should be noticeable to the driver but, as an added safety feature, a warning light switch is used in the system.

DUAL MASTER CYLINDER CONSTRUCTION VARIATIONS. The examples shown thus far have shown the cast iron master cylinder where the reservoir is integrally cast with the cylinder. To reduce vehicle weight, some new master cylinders have formed sheet metal or nylon reservoirs which are retained in the cylinder with rubber grommets. While these cylinders operate in a similar manner as the cast iron units, master cylinders with nylon reservoirs require a special fixture for pressure bleeding. If the reservoir were pressurized as is done for the cast iron units, there is the possibility that the reservoir could be distorted or broken.

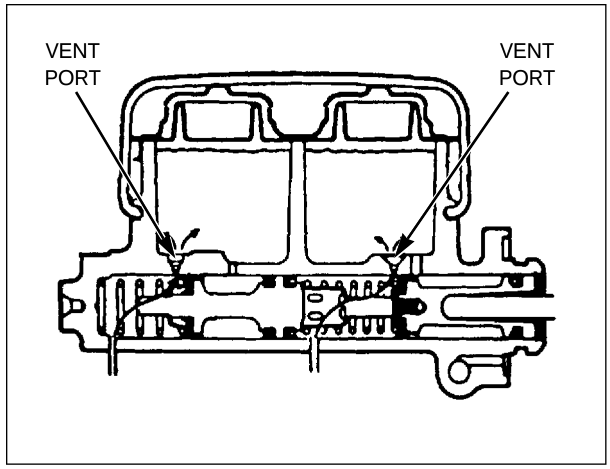


Fig. 6 - End of brake release

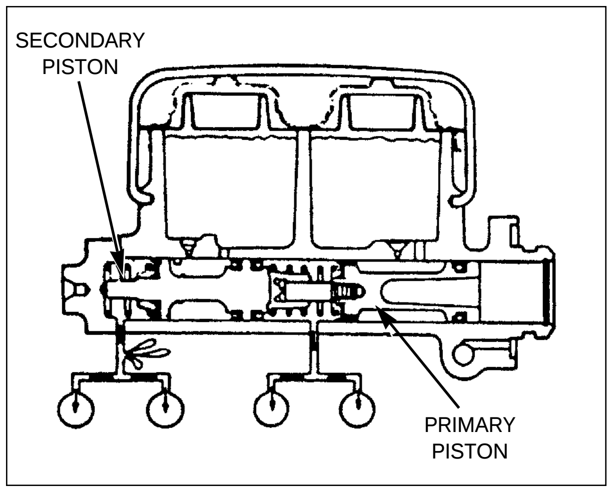


Fig. 7 - Rear line failure

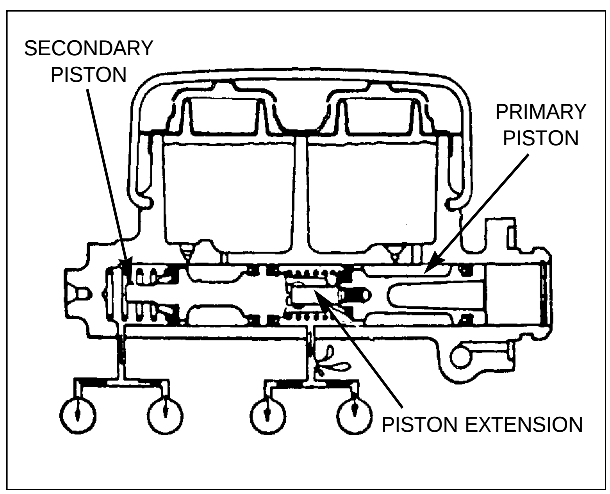


Fig. 8 - Front line failure

QUICK TAKE-UP MASTER CYLINDER. This master cylinder is designed for use in a diagonal split system. It incorporates the functions of the standard dual master cylinder plus a warning light switch and proportioners (Fig. 9). This master cylinder incorporates the quick take-up feature which provides a large volume of fluid to the wheel brakes at low pressure with initial brake application. The low pressure fluid quickly provides the displacement requirements of the system created by the seal retracting pistons in to the front calipers and retraction of rear drum brake shoes. The quick take-up feature of the master cylinder operates as follows (Figs. 9 &10):

1. With the initial brake application, more fluid is displaced in the primary piston low pressure chamber than in the high pressure chamber since the low pressure chamber has a larger diameter. The additional fluid is forced around the OD of the primary piston lid seal, into the high pressure chamber and on to the wheel brake units. Since equal pressure and displacement must be maintained in both primary and secondary systems, the primary piston moves a shorter distance to compensate for the larger volume of fluid moved from the low pressure area of the primary piston to the high pressure area.

2. As the low pressure displacement requirements are met, pressure will increase in the primary piston low pressure chamber until the spring-loaded ball check valve in the quick take-up valve opens. This allows fluid to flow into the reservoir.

3. After the quick take-up phase of the cycle is completed, the pistons function in the same manner as in a conventional dual master cylinder.

4. With release of the brakes, the master cylinder springs will return the master cylinder pistons faster than fluid can flow back through the systems. This would tend to create a vacuum in both the low pressure and high pressure chambers of the pistons if proper compensation were not provided.

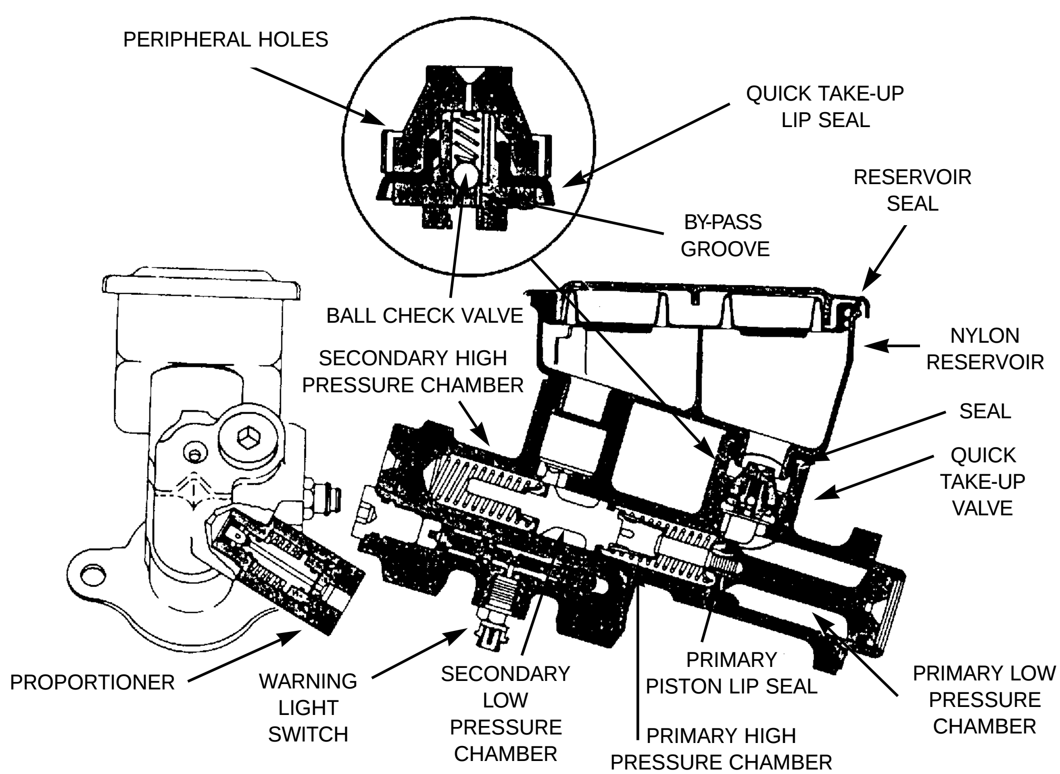


Fig. 9 - Quick take-up master cylinder

5. The primary piston is compensated by fluid flowing from the reservoir through the small periphery holes of the quick take-up lip seal through the compensating port and into the low and high pressure chambers of the primary piston. The secondary piston is compensated by fluid flowing from the reservoir through the compensating port and low pressure chamber, into the high pressure chamber.

6. In a conventional dual bore master cylinder, expansion and contraction of brake fluid is handled by fluid passing directly from the master cylinder bore, through the bypass hole and compensating port, to the reservoir. The secondary piston in the quick take-up master cylinder functions in this same manner. However, the primary piston must work through the quick take-up valve, thus a bypass groove is used to account for the fluid flow from or to the primary piston chambers.

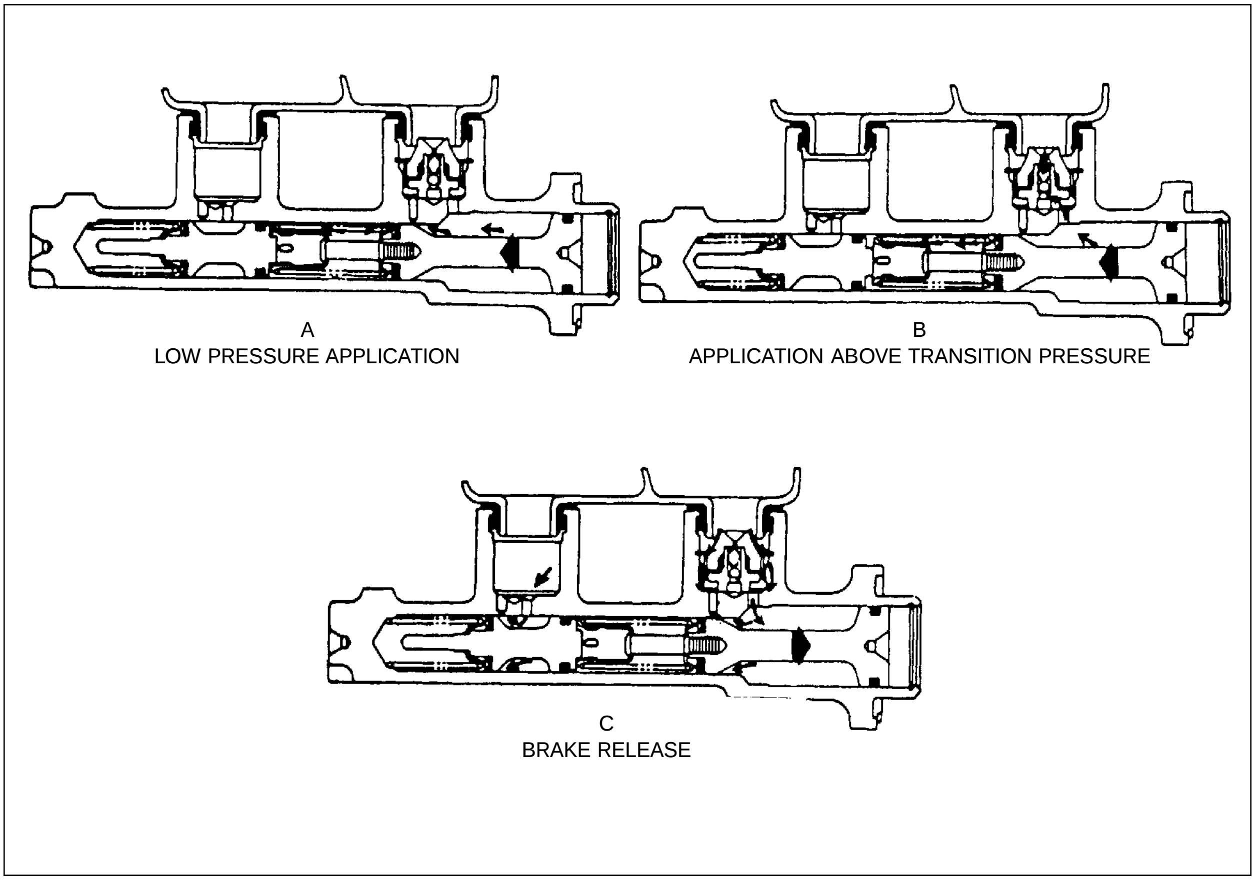


Fig. 9 - Quick take-up operation

Chapter Two

Caliper Training

DISC BRAKE OPERATION

1. The DISC brake differs from drum brakes in the use of a disc or rotor. The disc is bolted to and revolves with the wheel hub. The disc may be solid or slotted for improved cooling.

2. The brake CALIPER generally houses one or two pistons. Others have up to four pistons. The three piston setup uses two small pistons on one side of the disc and a larger one on the opposite side. Most four piston arrangements incorporate two pistons of equal size on each side of the disc.

3. The caliper is bolted to the spindle, on some models (see Fig. 1). Brake friction pads are so arranged that when hydraulic pressure is built up behind the pistons, the pads will be forced against the disc, providing braking effort (see Fig. 2).

4. Another type of caliper uses a single piston on one side only. This caliper is free to slide sideways to allow brake pads to align with disc. This is also known as a floating caliper (see Fig. 3).

5. Pistons, which can be constructed from cast iron, aluminum, or plastic are fitted to the caliper cylinders with the outer ends resting against friction pads. Rubber boots exclude the entry of dirt and moisture.

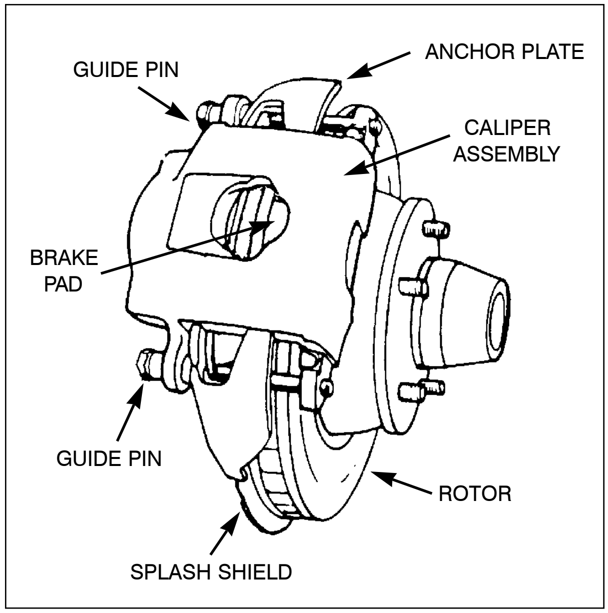


Fig. 1
Typical front wheel disc brake. Disc brake has excellent cooling characteristics, making it highly resistant to brake "fade."

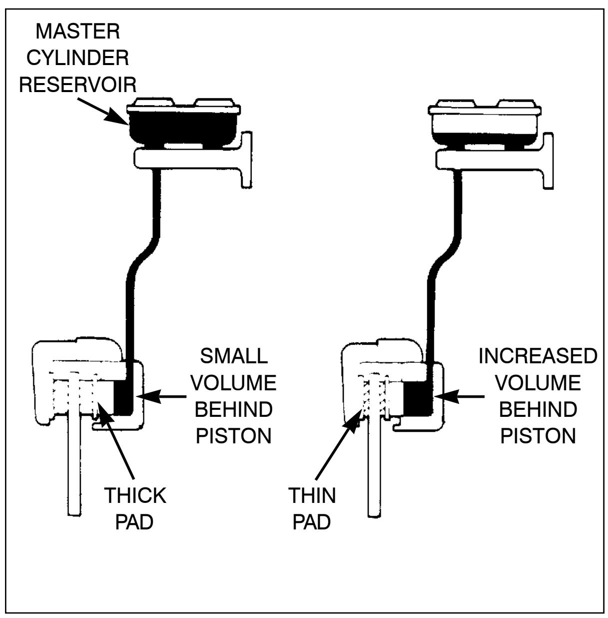


Fig. 2 - worn pads cause lower reservoir level.

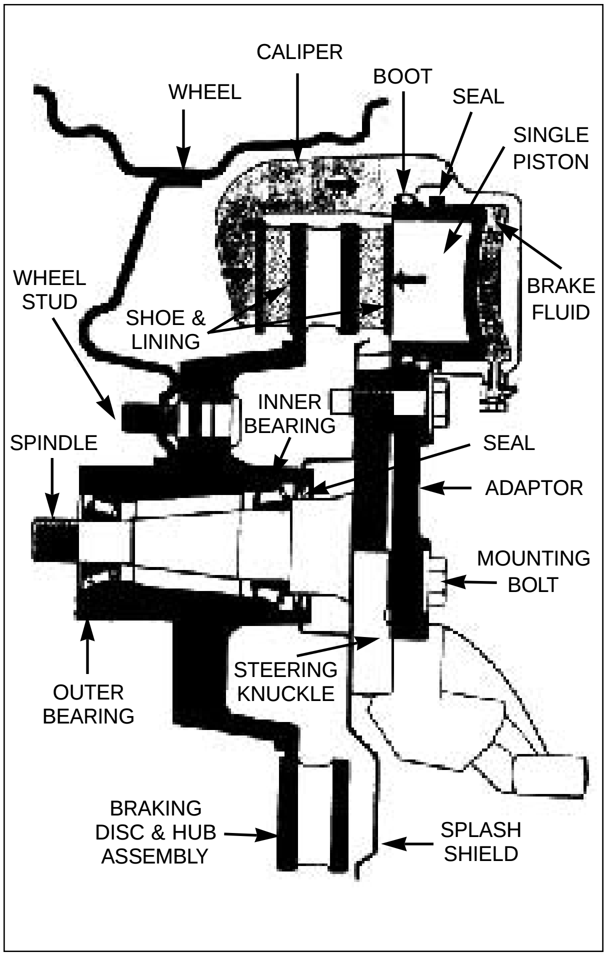


Fig. 3
Cross section of disc brake, showing caliper construction. This is a single piston, sliding (floating) caliper setup. (Dodge)

6. One design allows the brake pads to drag VERY LIGHTLY against the rotating disc at all times. Another type operates with only a minimal pad to disc clearance (about .005 in. or 0.13 mm).

7. A hydraulic line from the master cylinder leads to one side of the caliper. The other side will receive pressure through a crossover (external) line or bypassing the fluid internally through the casting (see Fig. 4 & 5).

8. The caliper piston operates against a snug seal ring snapped into a groove in the cylinder wall. When the brake is applied, the piston moves outward. In so doing, it stretches the seal to one side. When brake pressure is released, the seal returns to its normal position. This seal "roll" action pulls the piston back around .005 in. (0.13 mm), providing a small amount of pad (lining)-to-disc clearance. As the lining pads wear, the piston moves out through the seal, automatically keeping the proper pad to disc clearance.

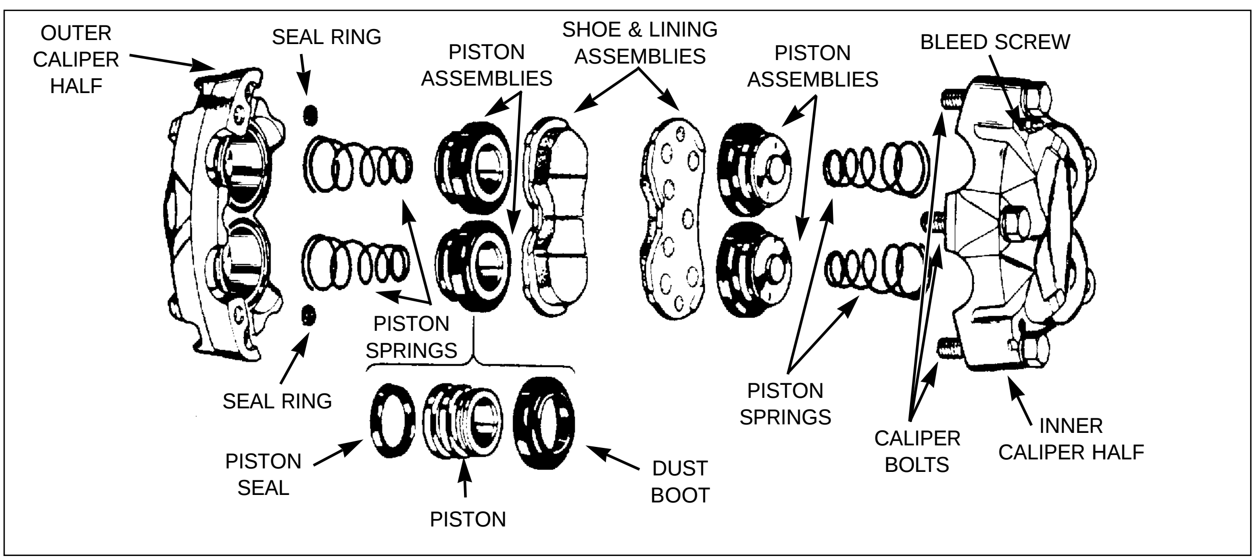


Fig. 4 - Two-piece disc brake caliper, using four pistons. (Bendix)

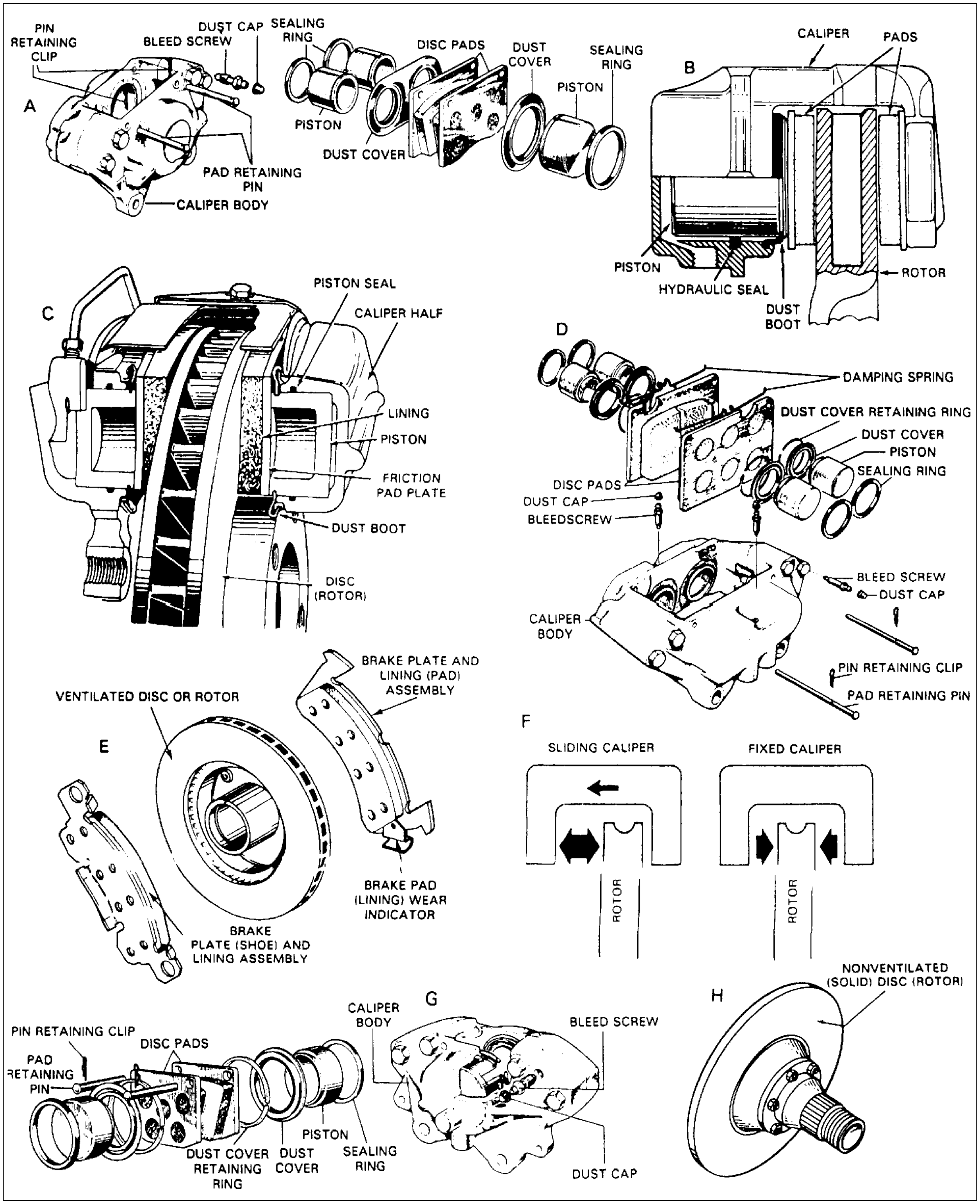


Fig. 5
Various disc brake assemblies. A - Three piston. B - Single piston caliper. C - Cross section showing relationship of caliper to disc or rotor. D - Four piston caliper. E - Ventilated disc and inboard and outboard brake plate and lining assembly. Note pad (lining) wear indicator. When pad is worn, indicator strikes disc, making noise to warn driver. F - Sliding and fixed caliper braking action. G - Dual (two) piston caliper. H - Solid or nonventilated disc. (Delco, EIS, Girling)

PHENOLICS - WHY?

1. **What are phenolics?**

   A phenol-formaldehyde resin combined with 80% glass fiber to provide a high performance, low cost material. Phenolic materials are light weight, heat resistant, dimensionally stable at elevated temperatures and will not corrode or rust when exposed to harsh environments.

2. **What other automotive applications use phenolic materials?**

   The most popular use is in distributor caps and rotors. Phenolic materials are also widely used in torque converters and their most recent automotive application is for pulleys on the new Serpentine belt system.

3. **I've always used metal caliper pistons. Why should I use phenolic pistons?**

   Phenolic brake pistons offer many advantages over their aluminum and steel counterparts. Foremost among these is the fact that (1) phenolic pistons thermally insulate the brake fluid from the heat generated by the friction of pad against rotor. This thermal insulation greatly reduces the possibility of brake failure resulting from fluid boil. In addition, phenolic pistons (2) resist corrosion due to moisture and road salt, (3) improve fuel economy because of their light weight and low drag, and (4) cost less than their metal counterparts.

4. **Who uses phenolic caliper pistons?**

   90% of all Ford cars and light trucks now come with phenolic brake pistons, and 100% of Chrysler production is equipped with phenolics. GM is starting to use phenolics also.

5. **What about brake problems with mid-70s Chrysler cars?**

   The phenolic piston has long been blamed for brake problems with mid-1970 Chrysler cars. Brake experts now know that these problems were caused by poor dust boost design and incorrect piston diameters.

6. **Can I mix a phenolic and steel piston on opposing front calipers?**

   Yes, however, you should follow OE procedures whenever possible. Of greater concern is piston quality. All phenolic pistons are produced by OE approved sources and meet new car standards for safe performance, service life and quality assurance.

7. **Sometimes when I work with a phenolic piston, it chips.**

   Special caution should be used when these front disc brake calipers require service to avoid any unnecessary piston replacement. Do not use a screwdriver or any similar tool to pry piston into or out of the bore to prevent piston chipping or scuffing. Do not replace pistons for cosmetic irregularities or small chips between the piston boot grooves and shoe face.

FRICTION FACTS (Brake Linings)

1. Because of today's demands on braking, a quality product is not only needed, it is expected.

2. Freeway traffic, mountain roads, bad weather conditions, heavy stop and go traffic, panic stops and down-sized vehicles create demands on today's braking systems.

3. Key friction material terms to be familiar with:

    a. *Coefficient of friction,* also called friction effectiveness is a unit of measurement that can be expressed in many ways. It is the distance it takes to stop a vehicle. It is also expressed as required application pressure or developed torques under certain conditions. The coefficient of friction involves several variables. Various car weights and speeds alter stopping distances.

    b. Road surface conditions alter stopping distances.

    c. Different linings give different stopping results. Superior or quality linings stop a vehicle in a shorter distance.

       In addition, the friction coefficient should be constant and it should be sufficiently high to ensure comfortable braking. Comfortable braking means the slowing of a vehicle safely, smoothly and quietly.

    d. *Heat fade* is the ability of the friction material to maintain its effectiveness at higher temperatures.

    e. *Fade resistance* is the ability of the friction material to maintain its effectiveness at elevated temperatures.

    f. *Moisture* or *water recovery* is the ability of the lining to regain its original stopping power as it dries.

4. The three types of lining:

    a. *Semi-metallic* is a type of friction material that utilizes steel fibers and sponge ore for structural strength and reinforcement.

    b. *Asbestos organic* is a type of friction material that has asbestos fibers as its primary reinforcement ingredient.

    c. *Asbestos-free organic* can be made up of glass fibers, steel fibers and other composites as its primary ingredients.

5. Three basic ingredients of brake pads:

    a. *Asbestos*—a foundation of organic linings. This is used to attain required friction levels while adding strength and wear resistance to the lining.

       Asbestos free friction material uses various combinations of natural and synthetic fibers as principal ingredients. This type of lining performs well under most conditions. However, asbestos could create a health risk and is becoming obsolete.

    b. *Resin binders* are extremely important and must be high quality to assure proper binding of the formulation to keep the lining in tact.

    c. *Friction modifiers* are used to raise or decrease the friction levels of the lining as required to keep braking performance.

6. Friction material is fastened to the metal shoe or disc plate in three ways:

    a. *Bonding* is when the friction material is actually glued to the metal.

    b. *Riveted segments* are actually riveted to the metal.

c. Integrally molding is a process where holes are punched into the metal plate, the plate is placed in a mold, then filled with friction material.

   Then under pressure the assembly is formed. High temperature adhesives hold the friction material securely on the metal.

7. Important points about brake noise:

   a. High friction linings tend to be noisier

   b. Bonded linings tend to be noisier than riveted linings.

   c. Noise can be evident under special conditions such as extreme heat or cold.

   d. Most noises are not caused by friction materials...most likely it comes from loose hardware, disc or shoe vibration, wear sensors, or metal-to-metal contact.

8. Lining integrity is the ability of the friction material to resist cracking, checking and even chucking off the shoe or plate.

9. There are three categories of friction material:

   a. Competitive or low-priced
      - Usually flexible and bonded to a brake shoe.
      - May contain large amounts of rubber filler and briefly cured in rolls.
      - Probably provide 10,000 to 20,000 miles before replacement is required.

   b. Standard or medium-priced
      - Semi-rigid often with wire backing.
      - Tend to have better fade and recovery characteristics than competitive linings.
      - May be bonded or riveted.

   c. Premium linings (the best)
      - Rigid and fully cured.
      - Contain best raw materials.
      - May be bonded or riveted.
      - Under normal use can expect 35,000 or more miles.

10. Balanced braking is the equal distribution of vehicle weight on the brake system. To achieve balance braking:

    a. Always replace brake parts according to O.E. specifications (i.e. semi-metallic pads should replace semi-metallic pads).

    b. Always use the same brand linings on both the front and rear wheels.

    c. Unbalanced braking effects wear life, fade and recovery characteristics.

    d. Always replace brake linings as a set. Never separate to ensure equal braking.

11. Benefits of premium linings:

    a. Better fit to drum.

    b. Longer wear life.

    c. Better recovery.

    d. Less break in time.

    e. Structural integrity.

    f. Smooth and balanced braking.

    g. Minimum noise factors.

    h. More economical in long term.

Organic materials are manufactured with disc pads, drum brakes, and brake blocks and are used on heavy equipment for most automotive applications. Some of the metallics were developed in the late 1960's for use on police cars and taxis. Today they are used on front brake systems of all automobiles offering better resistance and reduced noise.

BRAKE FLUID INFORMATION

Dot #3 -
95% of all vehicles - mineral based.

Dot #3 & 4 -
Brake fluids are hygroscopic (absorbs moisture).

Dot #5 -
5% of all vehicles - silicone based.

Mixing -
NO, first sign is brake failure and silicone lumps in reservoir.

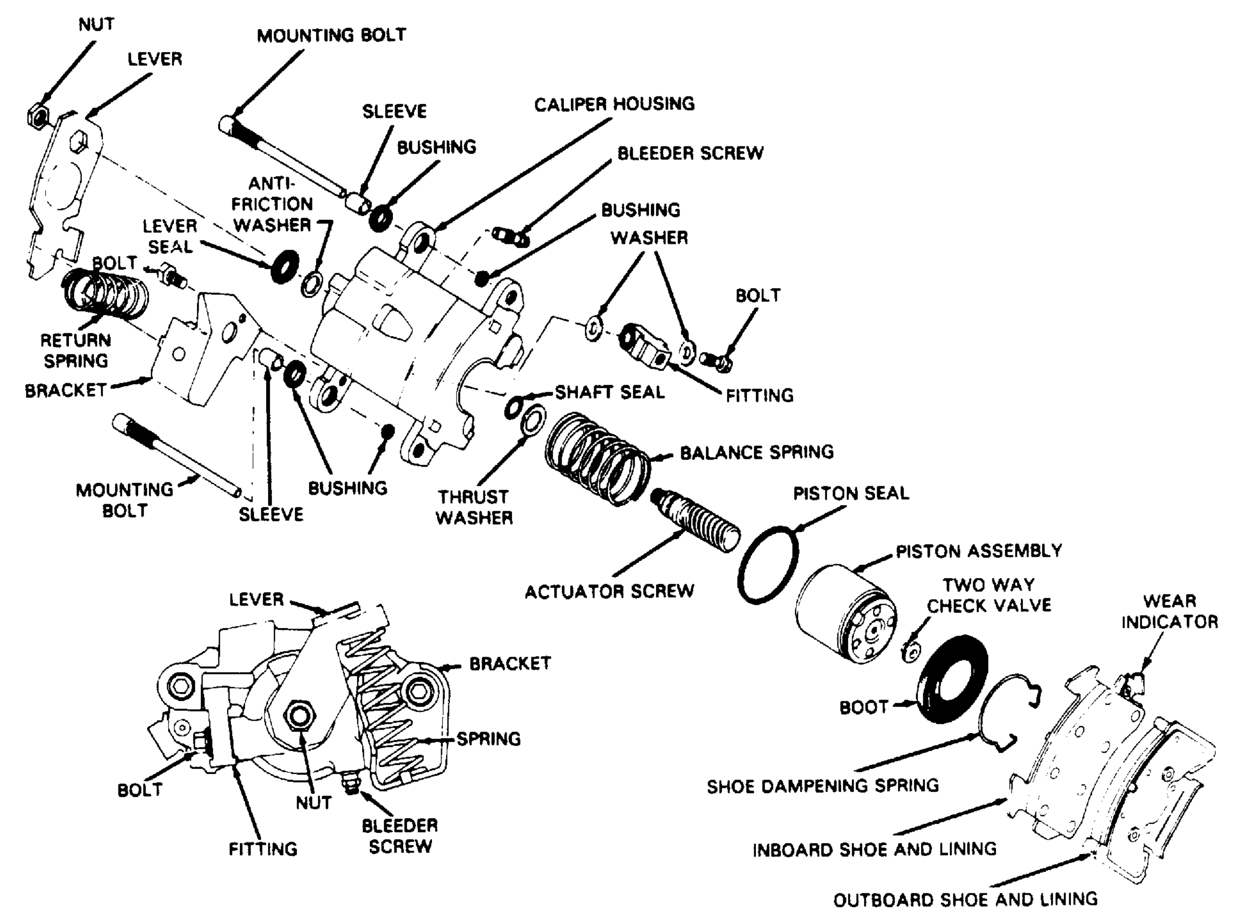


Fig. 6 - Exploded view of a rear caliper using an integral parking brake arrangement.

Chapter Three

Power Brake Booster Training

SINGLE DIAPHRAGM VACUUM POWER BRAKES. The single diaphragm power head uses engine intake manifold vacuum and atmospheric pressure to provide power assist to the brake system master cylinder. The unit is composed of the vacuum power head and the hydraulic master cylinder. The vacuum power head consists essentially of a housing separated by a large diaphragm which is connected to the power piston assembly. An air valve mechanism controls the application and release of the brakes. The unit operates as follows:

A line from the engine intake-manifold is connected to the vacuum check valve (39) (Fig. 1) in the front housing (37) of the power brake. This check valve is to prevent loss of vacuum when manifold vacuum falls below that stored in the power brake system.

At the released position (Fig. 1) the air valve (12) is seated on the floating control valve (13). The air under atmospheric pressure, which enters through the filter elements (15) in the tube extension of the power piston, is shut off at the air valve (12). The floating control valve is held away from the valve seat (18) in the power piston (10). The vacuum, which is present at all times in the space (6) to the left of the power piston is free to evacuate any existing air on the right side (9) of the power piston. This air is drawn through two small passages (19) in the power piston, over the valve seat (18) in the power piston, and then through the power piston into the space at the left of the power piston (6). It is then drawn through the check valve to the vacuum source.

In this position, there is vacuum on both sides of the power piston, and the power piston (10) is held against the rear housing by the power piston

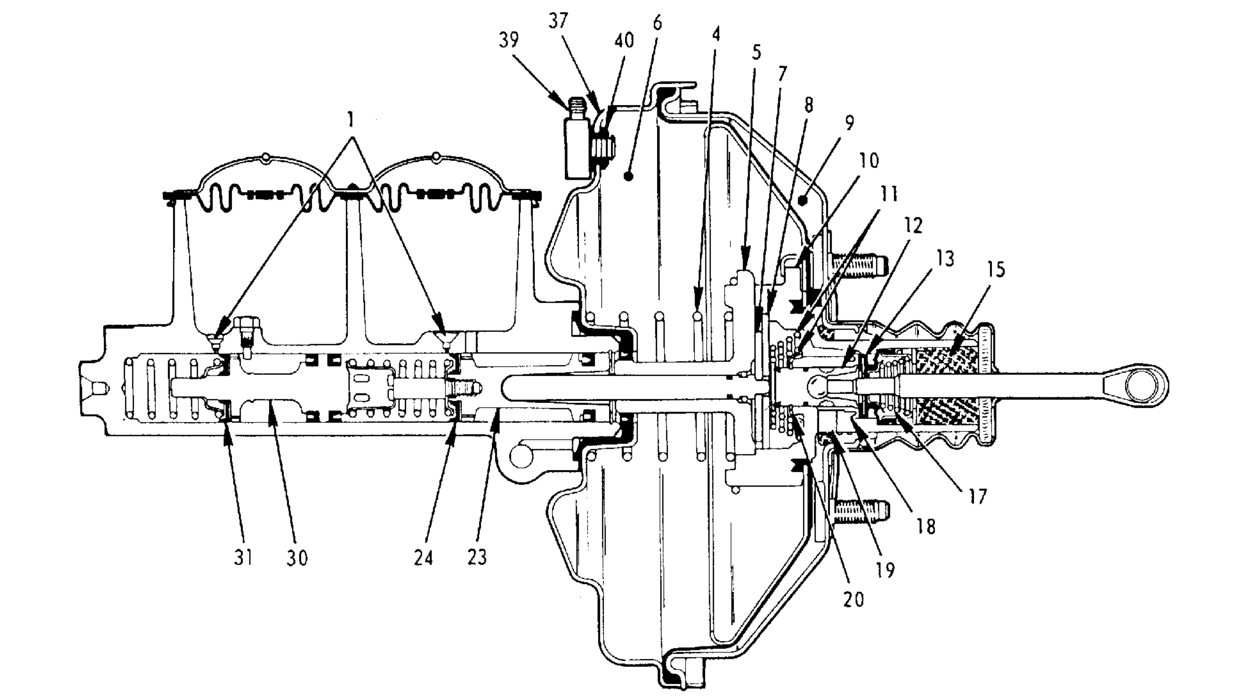


Fig. 1 - Single diaphragm power brake - released

return spring (4). At rest, the hydraulic reaction plate (7) is held against the reaction retainer (5). The reaction levers (8) are held back against the hydraulic reaction plate (7) by the air valve springs (11) (some units use only one spring). The air valve springs hold the air valve (12) back, so that its retaining ring (20) rests against the power piston (10).

The floating control valve assembly (13) is held against the air valve seat by the floating control valve spring (17).

As the brake pedal is depressed (Fig. 2) the pushrod (16) carries the air valve (12) away from the floating control valve (13). The floating control valve will follow until it is in contact with the raised annular seat (18) in the power piston (10). When this occurs, the vacuum is shut off in the space (9) to the right of the power piston. Air, under atmospheric pressure, rushes through the air filters (15) and travels past the seat of the air valve (12) and through two passageways (19) into the space (9) to the right of the power piston. Since there is still vacuum on the left side of the power piston (6) the force of the air at atmospheric pressure on the right of the piston will force the power piston (10) to travel to the left.

As the power piston (10) travels to the left, the piston rod (35) moves also to actuate the master cylinder and apply the brakes.

As pressure builds up on the end of the piston rod (35) the hydraulic reaction plate (7) is moved off its seat on the reaction retainer (5) and presses against the reaction levers (8). The levers, in turn, swing about their pivots and bear against the end of the air valve (12) and push rod (16) assembly. In this manner, approximately 20% of the load on the hydraulic master cylinder piston (23) is transferred back through the reaction system to the brake pedal. This gives the operator a feel, which is proportional to the degree of brake application.

When the desired pedal pressure is reached, the power piston (10) moves to the left until the floating control valve (13) which is still seated on seat (18) of the power piston (10), again seats on the air valve (12). Then, both air and vacuum are shut off to the space (9) to the right of the diaphragm. The power brake will now remain stationary, until either more pressure is applied or pressure is released at the brake pedal. Reaction force is transmitted through the levers (8) back to the brake pedal.

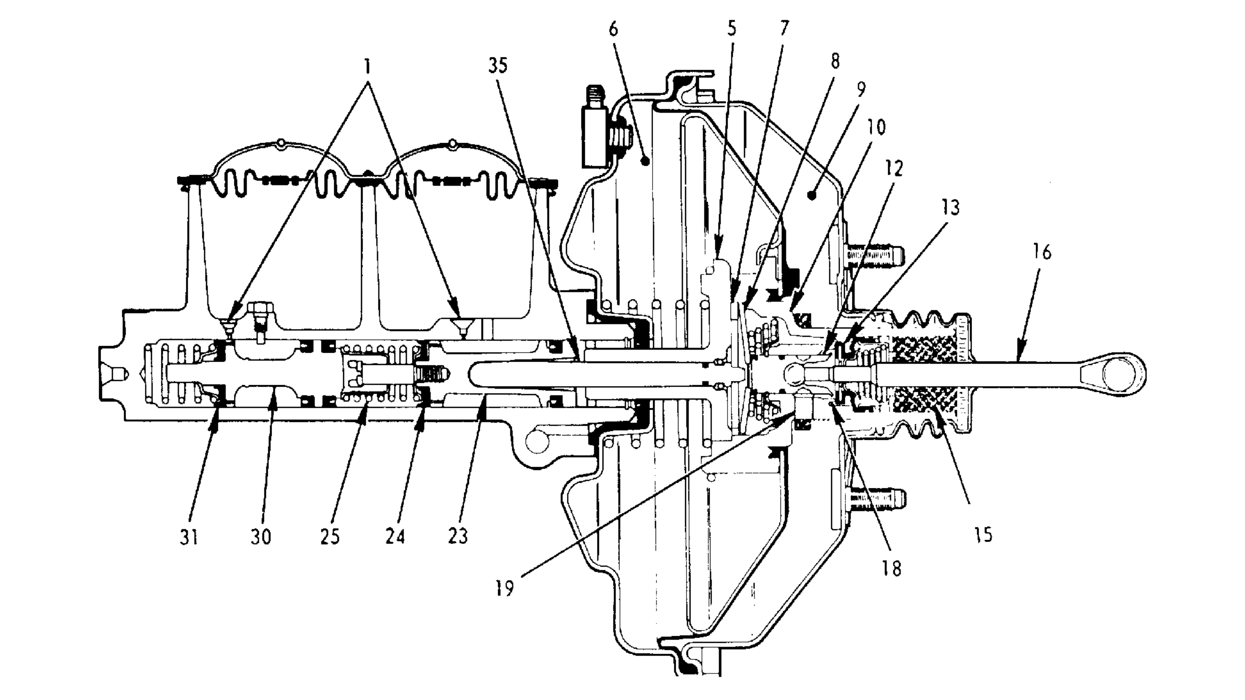


Fig. 2 - Single diaphragm power brake - applied

As the pressure at the pedal is released, the air valve springs (11) force the air valve (12) back until its retaining ring (20) rests against the power piston (10). As it returns, the air valve (12) pushes the floating control valve (13) off its seat (18) on the power piston (10).

TANDEM VACUUM POWER BRAKES. The tandem power brake is similar to the single diaphragm unit except that it has a divided housing with a diaphragm and power piston in each section. The power pistons are connected together in tandem or series to provide additional boost without increasing the power head diameter. Operation of the tandem unit is as follows:

In the released position (Fig. 3), operation of the tandem power brake is the same as the single diaphragm unit except as follows:

Vacuum in space (52), pulled through the check valve (62) in the front housing (25), is also pulled from space (51) through passage (60). With the air valve (7) seated against the floating control valve (8), atmospheric air pressure is shut off from entering the unit. Since the air valve holds the floating control valve off the power piston seat (47), vacuum is also pulled through passage (57) from space (49) and through passage (61) from space (50).

When the brake pedal is depressed (Fig. 4), action in the tandem power brake is the same as in the single diaphragm unit, except as follows:

Movement of the air valve (7) and the seating of the floating control valve (8) on the power piston seat (47) admits air, not only to space (49) through passage (57), but also to space (50) through passage (61). With vacuum still present in both spaces (51 and 52), operating force is applied to both diaphragms (14 and 21), and both power pistons (4 and 6).

Operating force is transmitted from the power pistons to the master cylinder through the piston retainer (19) and piston rod (27). A reactionary force is applied to the reaction disc (18) which contacts the reaction piston (17).

Action of the tandem power brake in the holding position is the same as for the single diaphragm unit, except as follows:

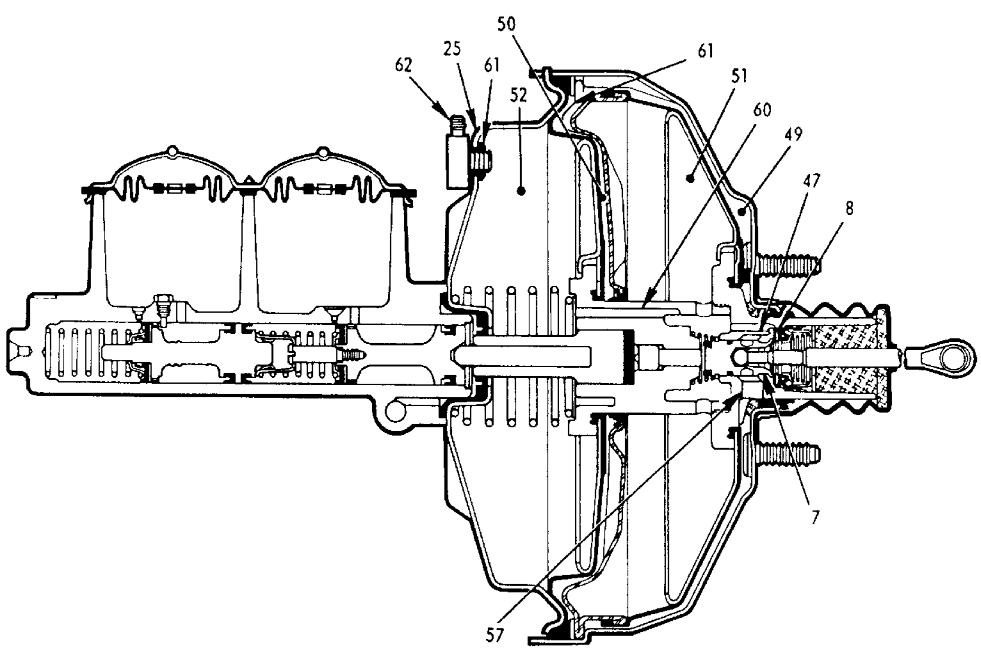


Fig. 3 - Tandem power brake - released

With the floating control valve (8) seated on both the air valve (7) and the power piston seat (47), air and vacuum are shut off to the space (49 and 50) to the right of both diaphragms, resulting in the stationary or holding action.

The force applied to the master cylinder is transmitted back through the piston rod (27) and retainer (19) to the rubber reaction disc (18). The reaction disc is compressed and extruded into the cavity where the reaction piston (17) is installed. A fraction of the total force is transferred to the reaction piston and, through the air valve (7), to the push rod. The reaction bumper (58) is a noise control device that will contact the secondary power piston only during maximum assist brake applications.

Operation of the tandem power brake when releasing is the same as for the single diaphragm unit except as follows:

Return action of the air valve (7) in seating against the floating control valve (8) and moving the floating control valve off the power piston seat (47), allows vacuum to be pulled from space (49) through passage (57). Simultaneously, vacuum is pulled from space (50) through passage (61).

Thus, vacuum is present on both sides of power pistons and the return spring (1) moves the pistons back against the rear housing.

VACUUM FAILURE - ALL TYPES. In case of vacuum source interruption to either the single diaphragm or the tandem power brakes, enough vacuum is available in the power brake to make about three power assisted stops. If the vacuum check valve should fail, or if the vacuum stored in the unit is exhausted, it is still possible to operate the power brake by purely mechanical effort. However, the pedal force required for the manual application of either the single diaphragm or the tandem power brake is considerably greater than with power assist.

In the single diaphragm power brake, push rod force is transferred through the air valve (12), reaction levers (8), reaction plate (7) and piston rod (35) to the master cylinder.

In the tandem power brake, push rod force is transferred through the air valve (7) to the secondary power piston (6) and the reaction piston (17), which in turn conduct the force through the retainer (19) to the piston rod (27) and on to the master cylinder.

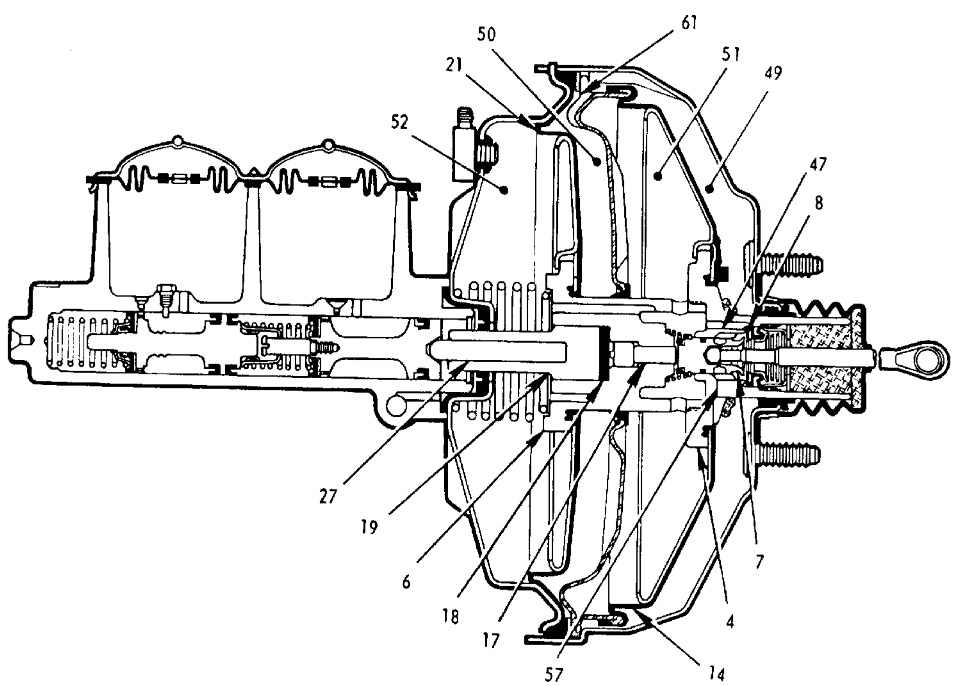


Fig. 4 - Tandem power brake - applied

Chapter Four
ABS Training

4.1 What is ABS?

Anti-Lock Brake System (ABS) is a combination of vehicle hardware and software that work together to maintain steering control and vehicle stability during hard braking.

Initially developed as a special option for top-of-the-line models, today's ABS units are compact, easy to service, inexpensive and widely available. Now every major automotive manufacturer offers some form of ABS vehicle control that provides safe, maximum braking under all weather conditions and road surfaces.

INTEGRAL AND NON-INTEGRAL

There are basically two types of Anti-Lock (or AntiSkid) Brake Systems–Integral and Non-Integral. **INTEGRAL** systems incorporate the power unit (pump and accumulator), master cylinder, and control valve mechanism into one hydraulic unit. An external microprocessor and individual wheel sensors complete the system. The Teves Mark II system (Fig. 1) is an example of an integral unit.

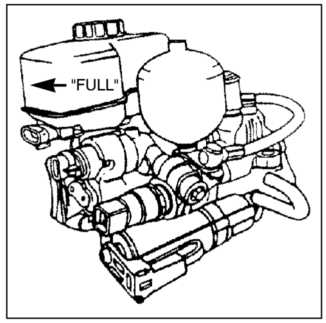


Fig. 1

The other type of ABS is referred to as **NON-INTEGRAL** or **ADD-ON.** The non-integral system incorporates ABS components into the standard brake system. Added to the power brake unit, master cylinder, and calipers are a microprocessor (computer module), modulator valve, and speed sensor(s). A lateral accelerator

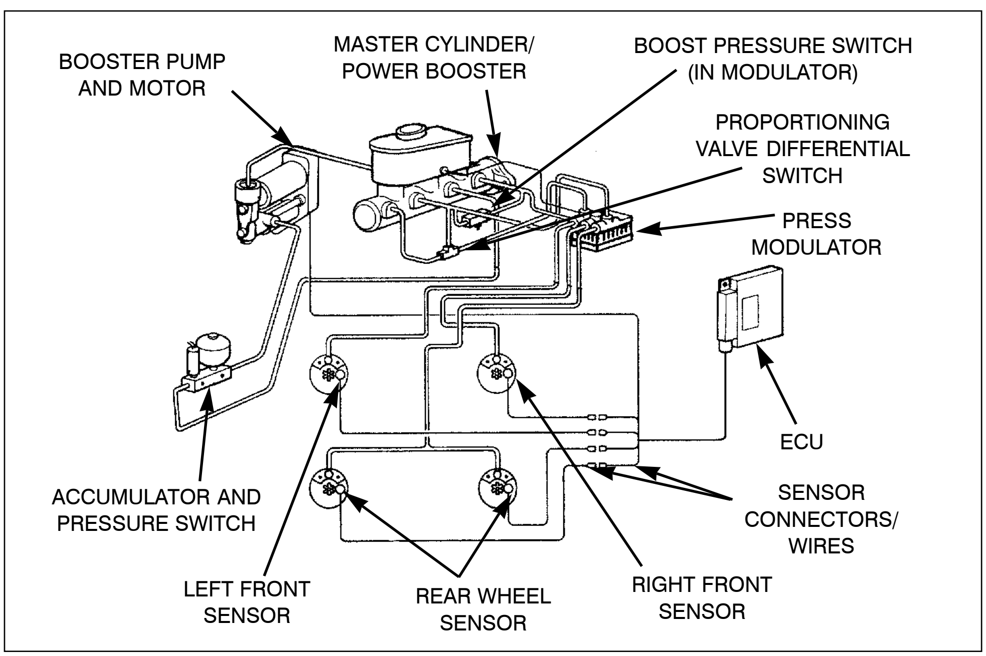


Fig. 2

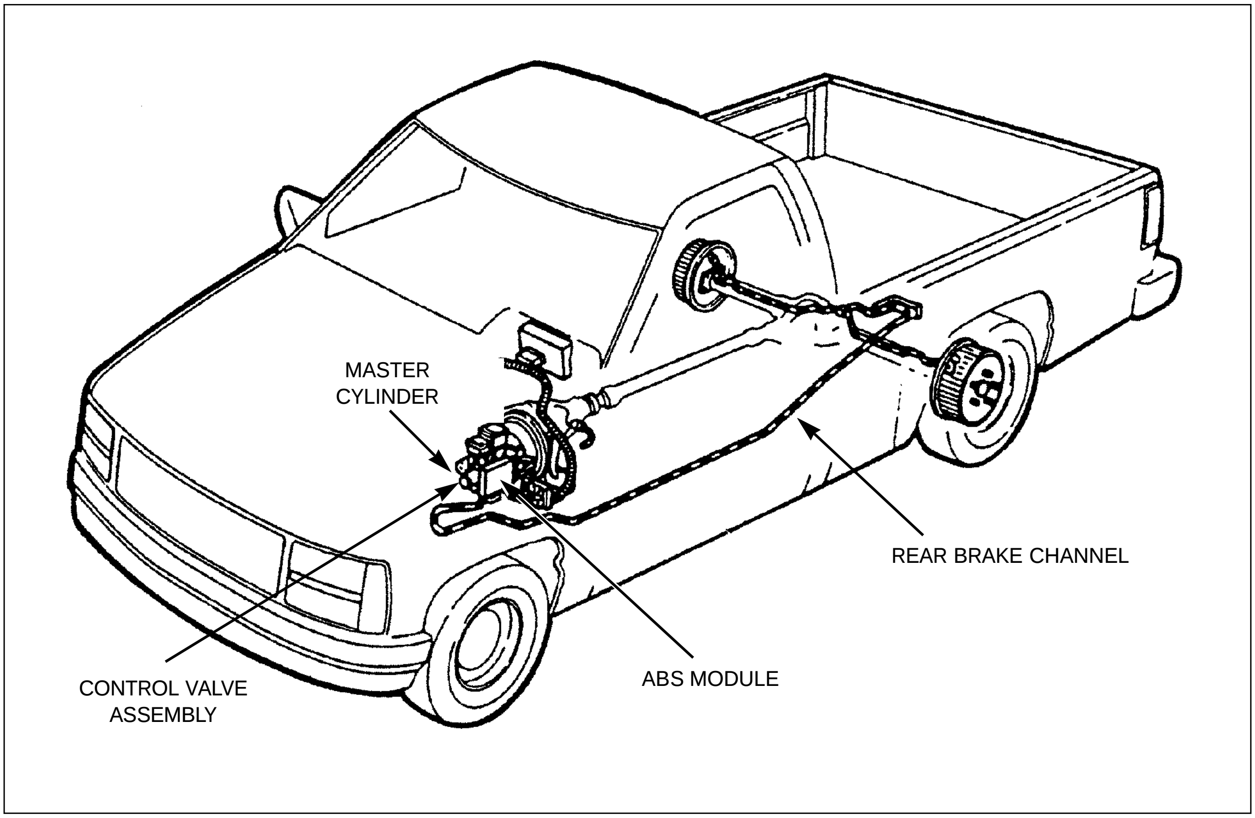


Fig. 3

switch, measuring side "G" forces, can also be a part of this system. Because of its lower cost, vehicle manufacturers are designing add-on systems for the majority of the future vehicle population. The typical components used in a non-integral system are shown in Fig. 2.

FOUR, THREE, OR SINGLE CHANNEL

Non-integral ABS systems are grouped by the number of wheel sensors used in the system. On some applications, each wheel is equipped with its own speed sensor. This type of system is referred to as a four wheel or four channel system. A variation of this system has a separate wheel speed sensor for each front wheel but uses a common speed sensor for both rear wheels. Known as a three channel system, the rear axle speed sensor is mounted in the differential or transmission and reads the combined or average speed of both rear wheels. This type of setup saves the cost of an additional sensor and reduces the complexity of the system by allowing both rear wheels to be controlled simultaneously.

The last non-integral variation is the single channel or rear-wheel only ABS system. Used on many rear-wheel drive pickups and vans, Ford's version is called Rear Anti-Lock Brakes (RABS) while GM and Chrysler call theirs Rear Wheel Anti-Lock (RWAL). A typical installation of a single channel system is shown in Fig. 3.

In this system the front wheels have no speed sensors. Only a single speed sensor, mounted in the differential or transmission, monitors both rear wheels. Rear-wheel anti-lock systems are typically used on applications where vehicle loading can affect rear wheel traction, which is why it's used on pickup trucks and vans.

4.2 How ABS Works

ABS improves vehicle control through a blending of computer technology, modern electronics and standard brake components. Sensors constantly monitor the rotating speed of each wheel or the rear axle. These sensors are connected to the ABS control module. The signals sent from each sensor are constantly compared to stored parameters by the control module.

In a hard braking situation, the control module can detect a slowing or lock-up of each sensor equipped wheel or axle and instantly pulse the braking force up to 15 times a second. This process “pumps” the brakes, avoiding wheel lock-up while allowing the wheels to continue to turn. All the driver does is keep his foot on the pedal and continue to steer. After the need for ABS control passes, the system returns to normal braking.

YOU CAN DO IT!

Many repair technicians are turning away ABS equipped vehicles because they perceive these systems as too complex, too tough to diagnose, or requiring special tools and repair skills. What these technicians don’t realize is that the same brake components they’ve worked on for years still do the job of stopping the vehicle. It’s simply the addition of the ABS unit and its components that make the system special.

Service technicians had the same reaction when ECM controlled vehicles first appeared. What we quickly learned was that 80% of the driveability problems were still engine related. The same will hold true for ABS systems. Proper training to recognize and understand the differences between ABS systems and how they function will be necessary, and some special test equipment and reference material will be needed. But experienced technicians knowledgeable in brake systems, will have little difficulty diagnosing and repairing ABS.

ABS COMPONENTS AND OPERATION

Basic brake components such as calipers, pads, rotors, wheel cylinders, and drums are still there. The ABS components include wheel speed sensors, an electronic control module, and a hydraulic modulator assembly that includes electrically-operated solenoid valves.

THE HEART OF THE SYSTEM

Everything starts with the wheel speed sensors. Wheel sensors consist of a magnetic pickup and a toothed sensor ring or a slotted collar. In some applications, the sensor is an integral part of the wheel bearing and hub assembly. In others, the sensor ring(s) may be mounted on the axle hub behind the brake rotor, on the brake rotor itself, inside the brake drum, on the transmission

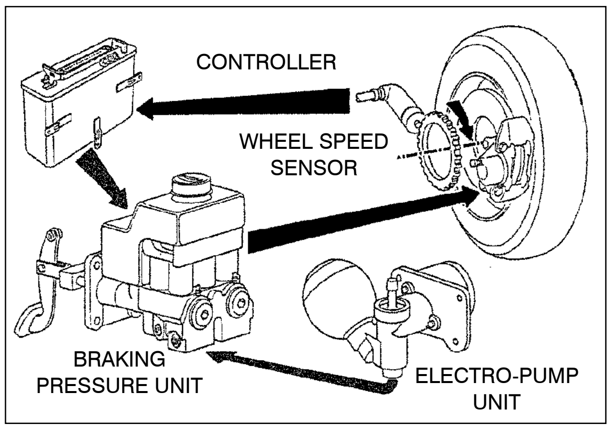


Fig. 4

tailshaft or inside of the differential on the pinion shaft. As the wheel turns, teeth on the sensor ring move through the pickup’s magnetic field inducing voltage in the pickup’s windings. The number of voltage pulses generated indicate the speed of the wheel or vehicle. The frequency of these pulses are converted into a digital signal by the ABS control module. Some typical wheel speed sensors are shown in Fig. 5.

THE BRAINS OF THE SYSTEM

The ABS control module is the nerve center of the ABS system. Usually a separate unit located under the hood, some older systems integrated ABS control information into other electronics such as the body control or suspension computer. Today's modern ABS control module receives inputs from the wheel speed sensors and a brake pedal switch. When it detects a difference in the deceleration rate between one or more wheels while braking, it cycles the ABS solenoid valves in the hydraulic modulator assembly to prevent wheel lockup. Like any other electronic module, the ABS module is vulnerable to damage caused by electrical overloads, static electricity, impacts and extreme temperatures. This block diagram (Fig. 6) shows how ABS system components interface with the internal components of the control module.

TYPICAL WHEEL SPEED

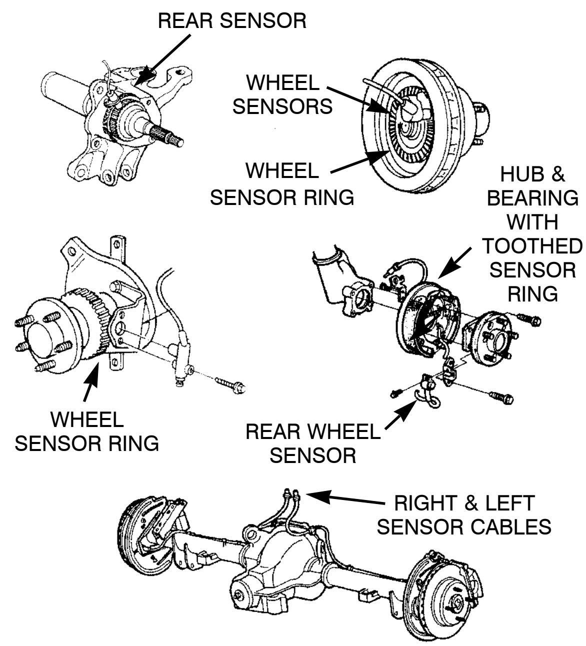


Fig. 5

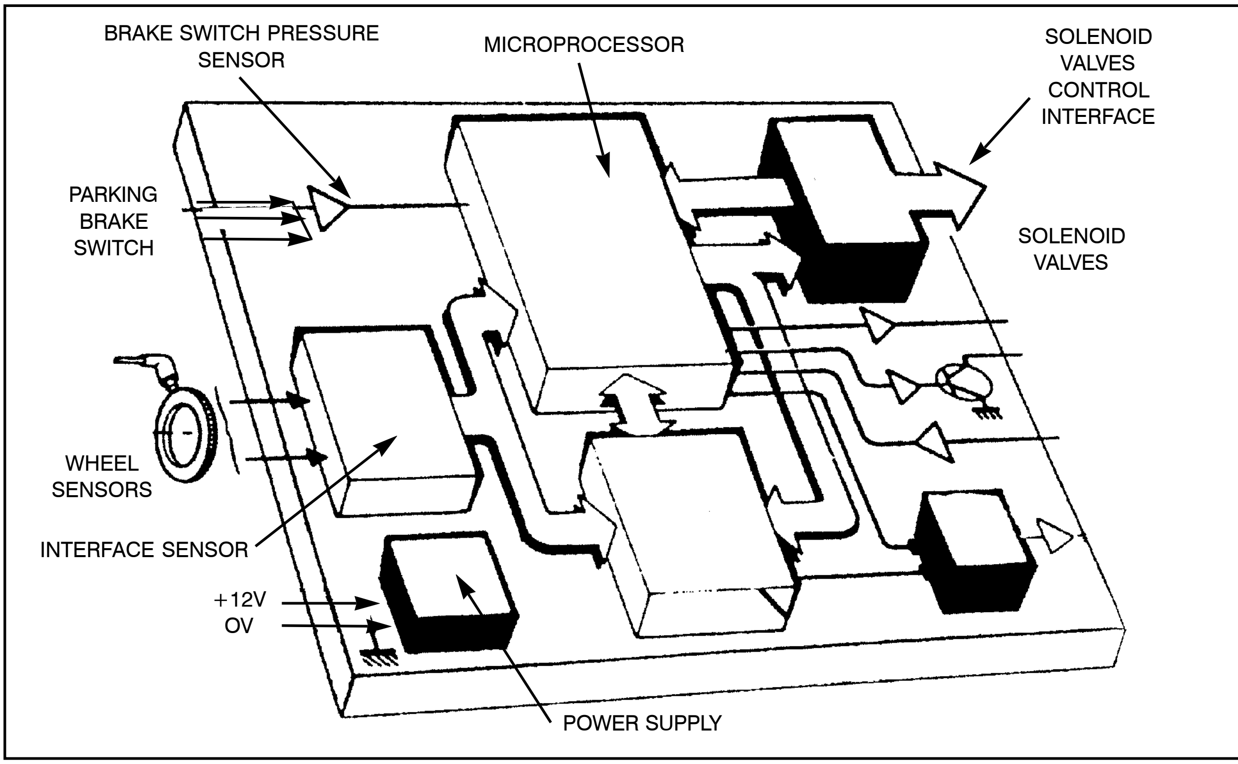


Fig. 6

THE MUSCLE IN THE SYSTEM

The hydraulic modulator contains a valve block and ABS solenoid valve for each brake circuit. The exact number of valves per circuit and their configuration depend on the application. Some use a pair of on-off solenoid valves for each brake circuit while others use a single valve that can operate in more than one position.

A typical ABS solenoid consists of a wire coil with a movable core and a return spring. When current from the ABS control module energizes the coil, it pulls on the movable core. Depending on how the solenoid is constructed, it either opens or closes the valve. When the control current is shut off, the solenoid snaps back to its normal or rest position.

Some solenoids are “multi-position” valves that open to an intermediate position when a certain level of current is applied, then fully open or close when additional current is applied. This design (Fig. 7) found in Bosch units, allows a single solenoid to perform the same functions as two or even three open and shut solenoids. ABS solenoids in the modulator are used to open and close passageways between the master cylinder and the individual brake circuits. This allows brake pressure to be held, released and reapplied

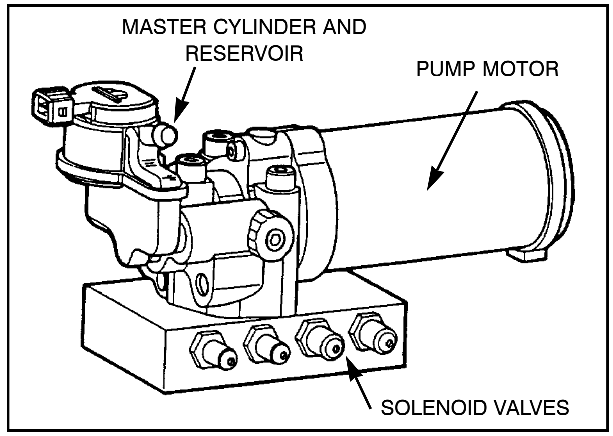


Fig. 7

to prevent wheel lockup during hard braking. The diagram below (Fig. 8) represents control valves used on the Kelsey-Hayes RWAL system and the Delco VI system.

ELECTRONIC CO-PILOT ON BOARD

From a safety perspective, perhaps the greatest benefit of most ABS systems is their fail-safe nature. In the event of failure of any ABS component, the main braking system continues to function. Anti-Lock capability is lost, but the

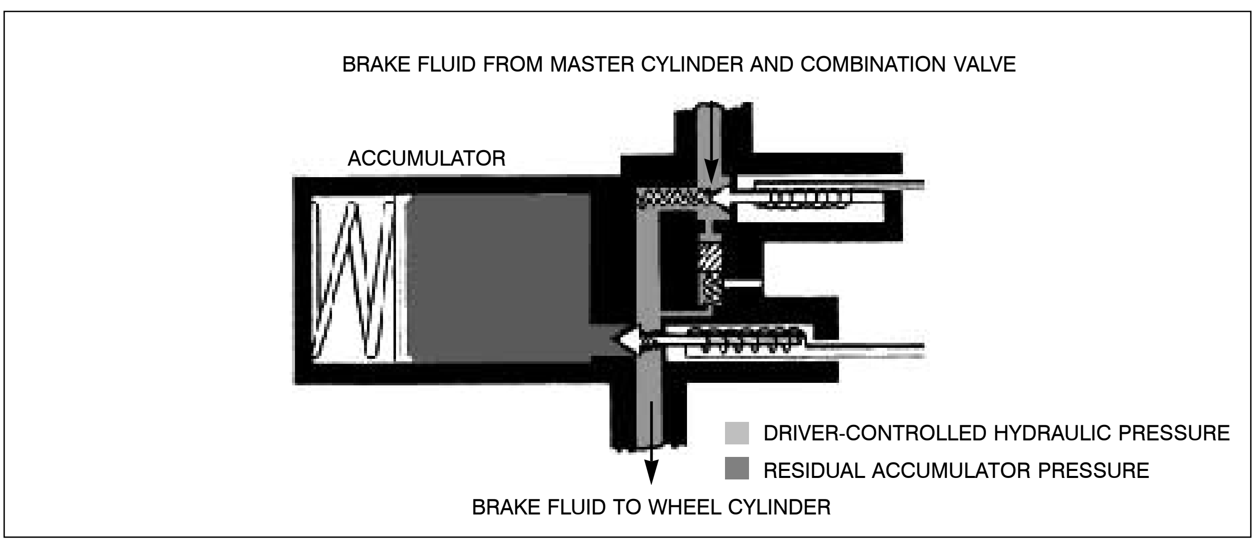
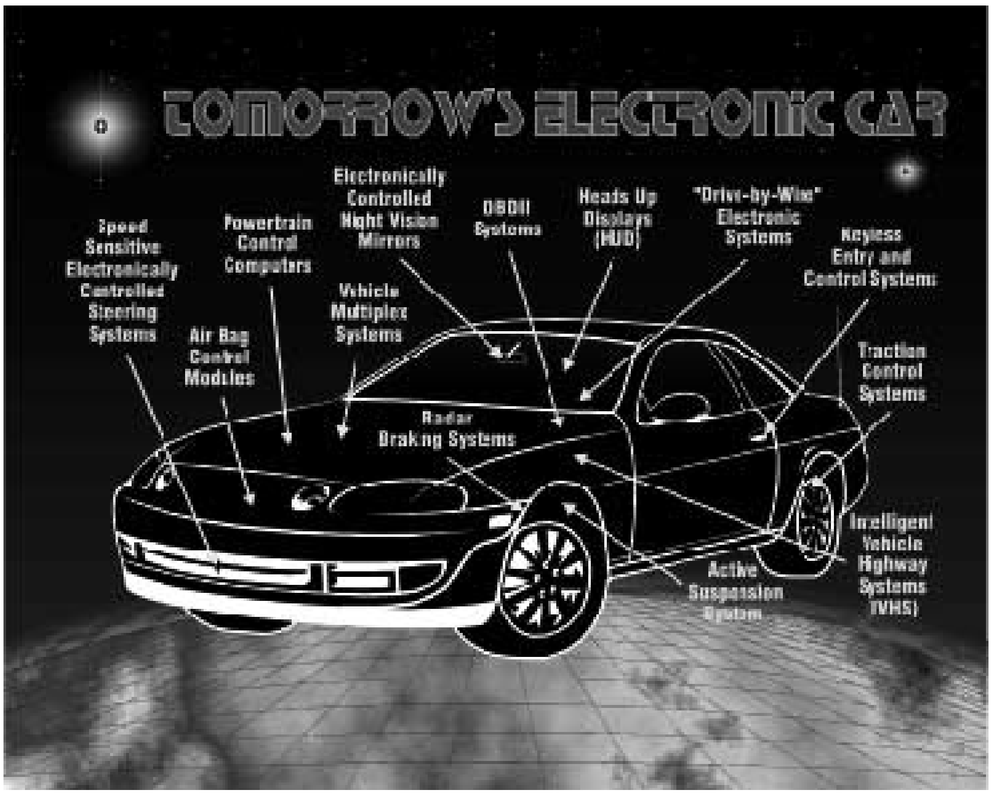


Fig. 8

driver will still be able to stop the vehicle in a normal manner.

The safety and control ABS provides is being extended to other areas of vehicle control. Traction control is becoming a common option on today's vehicles. Future vehicles will increase this safety envelope by providing electronic control over every area of vehicle performance and handling. Today we have Anti-Lock brakes, tomorrow the total package of vehicle control and stability dynamics will be combined into a single system. No matter what the electronic co-pilot is, you can do the job now.



4.3 System Groups

The major groups or suppliers of ABS units on the market today are AC-Delco, Allied Signal Automotive, Robert Bosch, Kelsey-Hayes and Teves.

AC-DELCO

ABSVI - The Delco Moraine ABS VI is one of the newest designs and is rapidly expanding to all GM vehicles. The reason for this is that ABS VI was designed with low cost and serviceability in mind from the beginning. Setting the standard for self-diagnosis, this unit keeps track of which of the 60 possible codes are set and how often. Serviceability and readily available parts will make it a hit with the aftermarket and repair shops.

TEVES

MKII - The Teves MKII integral ABS system was used in different forms by Ford, GM and some imports. One of the first units on the market, the system was complex, needed special test equipment and required a technician that understood the variations between different applications.

MKIV - The Teves MKIV is the non-integral replacement for the Teves II system. Using this design is a big advantage for manufacturers because it allows the use of standard vacuum boosters and a conventional master cylinder. It can also be upgraded to include traction control. The combination of simplicity and low-cost provide manufacturers an ABS system for all production lines.

KELSEY-HAYES

Kelsey-Hayes offers a number of units that cover passenger and light truck applications. RWAL provides rear wheel ABS for 2 and 4 wheel drive vehicles, and 4WAL provides four wheel ABS for vans and light trucks. Both units are non-integral designs that utilize conventional brake boosters and master cylinders.

RWAL - The RWAL unit (RABS is the Ford version) was designed specifically for applications where rear wheel traction varies with vehicle loading. This ABS system uses a single sensor located in the differential or transmission for both rear wheels. A new variation of RWAL used on Dodge trucks is FWAL.

4WAL - The 4WAL system is designed to provide ABS control over all four wheels. 4WAL relies on wheel sensors at each wheel or separate sensors for each front wheel and one common sensor for both rear wheels, depending on the application.

ALLIED SIGNAL AUTOMOTIVE

Allied Signal has been a supplier of ABS systems to the industry for many years. Its early models were both integral and non-integral designs that shared the same basic technology. However, its three newest systems are all lighter and less complicated than their predecessors.

BENDIX III - The first of these designs is the Bendix III unit. This non-integral, four channel, four solenoid system is 30 percent lighter than the Bendix 6 and 10 it replaces. It also uses far less and simpler components. This unit is currently available on Chrysler, Dodge and Plymouth passenger cars.

ABX-4 - The ABX-4 was introduced on the Chrysler Neon. This non-integral system is the simplest, least expensive and most compact ABS unit Bendix has yet designed. Like all non-integral systems, the ABX-4 consists of an electronic control module, a hydraulic control unit, an ABS relay box and four independent wheel sensors. One of this system’s unique features is that it provides system messages instead of numeric codes. Retrieving these messages require Chrysler’s DRB or similar scan tool.

MECA II - The third system, Mecatronic II, is currently used in Europe on the Ford Mondeo and domestically on the Ford Contour and Mercury Mystique. The Mecatronic II is a four channel, non-integral add-on ABS system, however, the control module is mounted on the HCV. An added feature is a unique traction control that uses braking to control wheel spin below 31 MPH and throttle control above 31 MPH.

ROBERT BOSCH

BOSCH 2S, 2U - The BOSCH 2 system in different forms has been used on a variety of domestic and import vehicles. The Bosch 2 system was used on Corvettes from 1986 to 1989. The 2U unit was used by GM on their full-sized passenger vehicles starting in 1991. The 2S MICRO was used on 90 and 91 Corvettes and other GM vehicles, and since 1992 has incorporated traction control, which they market as Acceleration Slip Regulation. All of the Bosch 2 variations are non-integral designs.

BOSCH III - The Bosch III unit was used by both GM and Chrysler on their luxury vehicles and is their only integral ABS design.

BOSCH 5 - This system is standard equipment on 1995 Corvettes and Porsche 911, Carrerra 4, and an option on two-wheel drive Carrerras equipped with Automotive Brake Differential. The Bosch 5 system is a non-integral, four-channel unit using separate solenoid valves for each brake circuit. The unit also provides traction control for both vehicles although by different techniques.

Chapter Five

Troubleshooting & Bench Bleeding

5.1 Master Cylinder, Caliper & Power Brake Booster

Squeal or chatter	Erratic braking	Brakes pull	Brakes drag	Brakes grab	Pedal vibrates	Pedal sinks to floor	Spongy pedal	Hard pedal	Excessive play in pedal	← SYMPTOMS PROBABLE CAUSES
						●	●		●	Low fluid level
					●		●		●	Air in hydraulic system
●	●	●	●						●	Brakes need adjustment
	●	●		●				●		Brake fade due to overheating
●								●		Grease or fluid on brake linings
		●						●		Brake linings glazed
								●		Brakes wet
			●					●		Faulty vacuum booster
								●		Brake linkage binding
					●		●		●	Weak flexible hoses
	●	●			●					Loose or worn wheel bearings
	●	●								Loose or worn front end parts
		●								Front wheels out of alignment
	●	●								Loose disc brake caliper
●	●				●					Warped brake disc
●	●				●					Eccentric brake drum
		●				●		●	●	Faulty wheel cylinder
			●			●		●	●	Faulty master cylinder
			●							Weak or broken retracting springs
	●	●		●						Scored brake drums
●										Dirt in brake mechanism
		●	●					●		Clogged or kinked brake lines
		●	●					●		Disc brake caliper piston frozen

5.2 Bench Bleeding Instructions

You MUST bench bleed the master cylinder before installing it OR WARRANTY WILL BE VOID.

It is very difficult to bleed all of the air out of the master cylinder after it is installed on the vehicle. It is necessary to bleed the unit before it is installed.

Follow these steps:

1. Clamp the mounting flange of the replacement master cylinder in a bench vise. Do not clamp on the body of the master cylinder as this could damage and void the warranty.

2. Install bleeder tubes supplied with the master cylinder into the outlet ports.

3. Fill master cylinder reservoir with clean brake fluid and hold the ends of the bleeder tubes under the fluid level.

4. Use a wooden dowel or similar device to slowly push the master cylinder piston in about one inch, then slowly release the piston.

5. Wait 15 seconds and repeat step four (including the waiting period) until you no longer see any air bubbles in the reservoir.

6. Install the replacement master cylinder on the vehicle.

5.3 ABS Diagnosis & Repair

This section is divided into two parts. The first provides general guidelines and helpful tips for the removal, installation, and testing of ABS components. The second part gives more specific information for some of the major ABS systems. All information is provided as a guide only and is not intended to replace manufacturers service manuals and procedures. If the service technician or installer does not have access to the proper tools and service manuals, or does not have the proper training or experience, the services of a qualified technician should be used.

Guidelines & Installation Tips

WHERE TO BEGIN

It is critical that you keep the work area clean when working with hydraulic brake components. Dirt or other contaminants cannot be allowed to enter any of the brake components. Before installing the replacement unit, you must take the following steps. Failure to observe these precautions can lead to misdiagnosis and possibly damage the replacement ABS unit.

1. Find out what caused the original ABS unit to fail.

2. Fix whatever caused the failure.

3. When handling ABS control modules, use extreme care to avoid damage from static electricity.

4. Do not remove the ABS unit from its shipping carton until you are ready to install the unit.

5. Do not allow dirt or fluids to contaminate the ABS electrical harness connections.

6. Do not remove sealing labels or protectors until unit is installed on vehicle.

7. The entire brake system must be flushed using only DOT 3 or recommended fluid according to OE instructions before operation of the replacement ABS unit.

REMOVING THE ORIGINAL UNIT

1. Before disconnecting power to the ABS system, record any stored codes using the appropriate scan tool and OE recommended procedure.

2. Before disconnecting any hydraulic lines, deplete system pressure by depressing brake pedal 40 or more times with ignition off until a firm pedal is obtained.

3. Disconnect the battery ground terminal to avoid risk of short circuit and electrical damage.

4. Clean the area around the ABS unit hydraulic lines to prevent contamination of the brake system when lines are removed and to protect the replacement unit.

5. Remove original unit following recommended OE service procedures.

6. Thoroughly flush the entire brake system before installing replacement unit.

INSTALLING THE REPLACEMENT UNIT

1. Remove the replacement ABS unit from its carton and place the original unit in that carton to assure proper core credit upon return.

2. Use grounding wrist strap to protect unit from static electricity damage.

3. Follow OE recommended installation procedures and any enclosed instructions.

4. Flush and bleed the ABS system using OE recommended brake fluid from a fresh sealed container.

NOTE: Under normal driving conditions the ABS system should be flushed every 2 years or whenever any brake system component is replaced, whichever occurs first. Always use OE approved fluid from a fresh sealed container.

TESTING THE ABS SYSTEM

1. Using suitable test equipment, follow recommended OE testing procedures before operating the vehicle.

2. If pedal action does not feel normal, repeat the entire bleeding and test procedure.

3. Road test the vehicle after verifying that all systems function properly and that there are no error codes.

While it is not difficult to service ABS components, you must remove, install and test the replacement unit as described by service manuals specific to your vehicles.

ABS CHECKLIST

Tips for trouble-free installation. Do the following when installing the replacement unit.

DID YOU:

- Retrieve and record any stored codes before disconnecting electrical power?
- Determine and correct what caused the original ABS unit to fail?
- Depressurize brake system by depressing brake pedal 40 or more times with key off?
- Clean area around ABS hydraulic fittings and electrical connectors?
- Flush entire brake system using approved brake fluid before installing replacement unit?
- Follow OE service procedures and all enclosed guidelines for ABS unit removal and installation?
- Follow OE testing procedures before operating vehicle?
- Road test vehicle to verify all systems are functioning correctly?

Failure to perform these checks and procedures will lead to incorrect installation and premature system failure.

Road Testing

Pedal action must be firm and normal before moving the vehicle. Do not drive the vehicle if codes are stored or pedal action is not normal.

First put the vehicle through a series of moderate braking actions. If the system functions normally, then run a series of hard stops at low speed (attempt wheel lock).

If moderate braking produces pedal pulsation or if hard braking produces wheel pull, then stop the vehicle. With the ignition "off," remove the brake fuse (check the owner's manual for location). Repeat the road test.

If pulsation or pull persists, check for a mechanical problem in the brake system. Make any necessary repairs.

Reinstall the brake fuse. Repeat the road test. If the problem returns, refer to a suitable service manual for diagnostic troubleshooting.

DELCO MORAINE III

Depressurizing the System

Always depressurize the system before performing any service operations including a check of the brake fluid level. Use only new DOT 3 brake fluid from a sealed container. DO NOT use fluid from an open container that may be contaminated with water. DO NOT use DOT 5 brake fluid.

- To depressurize the system, turn OFF the ignition. FIRMLY apply and release brake pedal 40 or more complete strokes. A noticeable change in brake pedal feel (hard pedal) will occur when the accumulator is completely discharged. Be sure ignition is off during procedure.

- Clean and remove reservoir cover and fill to correct level. Replace cover securely.

NOTE: Do not turn the ignition on after depressurizing the system unless specifically instructed to do so in a service procedure.

Bleeding Front Wheels

This procedure requires two persons unless a pressure or vacuum bleeder is available. DO NOT turn ignition on.

- Begin with the right front wheel caliper.

- Attach a bleeder hose to the bleeder valve and submerge the opposite end in a clean container partially filled with brake fluid.

- Slowly depress the brake pedal.

- Open the bleeder valve. To assist in removing trapped air, tap LIGHTLY on the caliper with a rubber mallet.

- Close bleeder valve.

- Release brake pedal.

- Check fluid level and add as necessary.

- Repeat the procedure until the brake pedal feels firm and no air bubbles are present in the bleeder hose.

Bleeding Rear Wheels

- Turn the ignition to the RUN position without starting the engine. Allow the pump motor to run to pressurize the accumulator. The pump motor will shut off when fully charged. Turn the ignition OFF if the pump motor runs for more than 60 seconds. Refer to the vehicle service manual to troubleshoot the problem.

- Begin with the right rear caliper.

- Attach bleeder hose to bleeder valve and submerge the opposite end in a clean container partially filled with brake fluid.

- Open the bleeder valve.

- With the ignition ON, slowly depress the brake pedal part way, until brake fluid begins to flow from the bleeder hose. (DO NOT press the brake pedal fully during this step). The pump motor may engage during this step, which is normal. Allow the brake fluid to flow for 15 seconds. To assist in removing trapped air, tap LIGHTLY on the caliper with a rubber mallet.

- Close the bleeder valve and release the brake pedal.

- Repeat this procedure until no air is visible in bleeder hose.

- Add brake fluid to the rear chamber of the reservoir to approximately 1 inch below the full mark.

- Repeat the process on the left rear caliper.

- Test drive the vehicle.

DELCO MORAINE ABS VI

System Preparation

Before bleeding the brakes, the front and rear displacement cylinder pistons must be returned to the topmost position (motor rehome). The motor rehome function cannot be performed if any current Diagnostic Trouble Code (DTC) is present. If DTC's are present, the system must first be repaired and the DTC cleared before proceeding with motor rehome procedure. Refer to the manufacturer's ABS service manual for further information.

Obtain and Clear Codes

- Start the engine and allow it to run for at least 10 seconds with brake pedal NOT applied. This will allow the ABS system to initialize itself.

- Make sure the ABS indicator lamp is OFF after about 3 seconds. If not, refer to service manual.

- Repeat this procedure one more time.

- Perform the motor rehome sequence (see manufacturer's ABS service manual for details on procedure).

Manual Bleeding

Use only new DOT 3 brake fluid from a sealed container. DO NOT use fluid from an open container that may be contaminated with water. DO NOT use DOT 5 brake fluid.

- Clean and remove reservoir cover and fill to correct level. Replace cover securely.

- Bleeding sequence: right rear, left rear, right front, left front.

- Attach a bleeder hose to the bleeder valve and submerge the opposite end in a clean container partially filled with brake fluid.

- Open bleeder valve.

- Slowly depress brake pedal.

- Close bleeder valve and slowly release brake pedal.

- Wait 5 seconds.

- Repeat the process at each wheel in the appropriate sequence including the five second wait, until the brake pedal feels firm and no air bubbles are present in the bleeder hose. Check brake fluid level periodically during bleeding sequence.

- Test drive the vehicle only after pedal action is firm and normal.

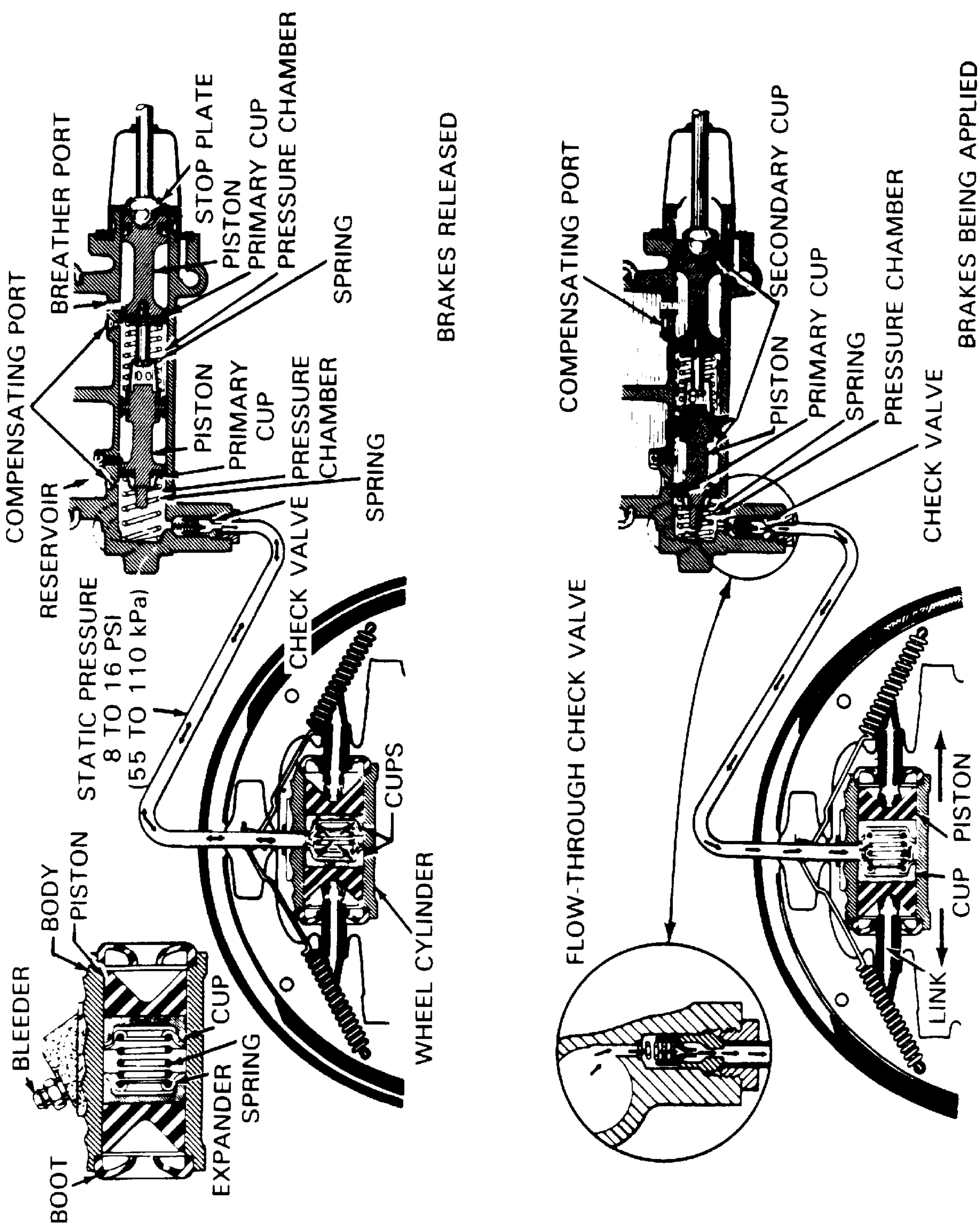
ABS PRECAUTIONS AND SERVICE TIPS

- Change brake fluid every two years or when ABS service is required.
- Use approved brake fluid from a sealed (new) container. DO NOT use silicone brake fluids in ABS equipped vehicles. Refer to master cylinder lid or service manual for specific fluid type.
- Never overfill fluid reservoir. Always refer to service manual or owner's manual for specific filling instructions.
- Never open a bleeder valve or loosen a hydraulic line while ABS is pressurized. The accumulator must be depressurized according to individual manufacturer's repair instructions.
- Never push caliper/wheel cylinder pistons back in their housing without opening the bleeder valve first. Unless bleeder is opened contaminated fluid will be forced back through system and may cause ABS components to fail.
- Never disconnect/reconnect any electrical connectors or components while ignition key is on. Disconnect ALL on-board computers while using electrical welding equipment.
- When installing entertainment or transmitting devices on ABS equipped vehicles, do not tap into ABS wiring or locate antenna or wiring near ABS control unit or its wiring harness.
- Do not tap on speed sensors. Striking components can cause demagnetization or polarization, affecting the accuracy of signal return to ABS control unit.
- Do not overtighten wheel lug nuts. Rotor/drum damage may occur which can lead to inaccurate wheel speed readings.
- Do not mix tire size. Increasing tire width is acceptable as long as the height on all four wheels is identical. NOTE: using a space-saver tire can set fault code or shut down ABS control.
- Check sensor to ring air gap, if applicable, if removed or replaced.
- Check speed sensor components for grease, dirt or metal filings.
- Check ABS for codes set when turning wheels during wheel/brake service. Spirited driving habits such as wheel spin or wheels leaving ground contact can set ABS codes.
- Make sure system is properly bled and inspect entire brake system before road testing vehicle.

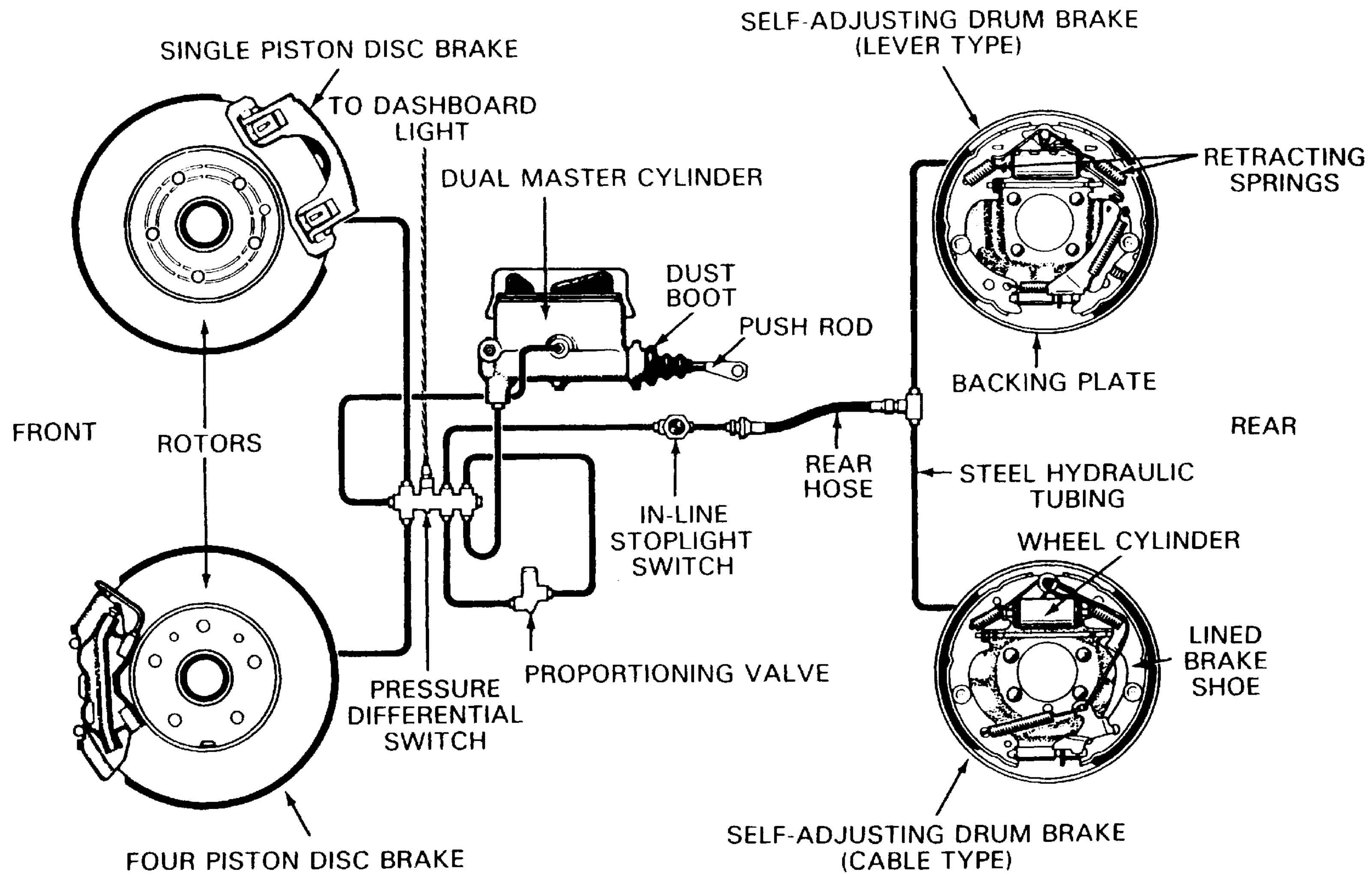
Chapter Six

Reference Pictures

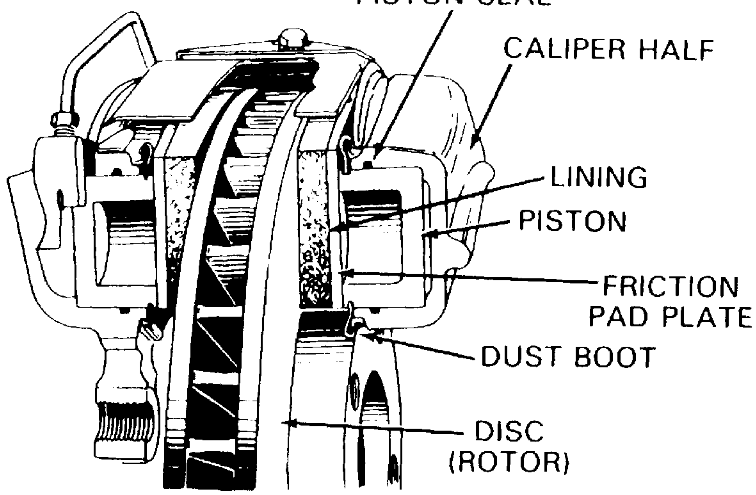
Brake System

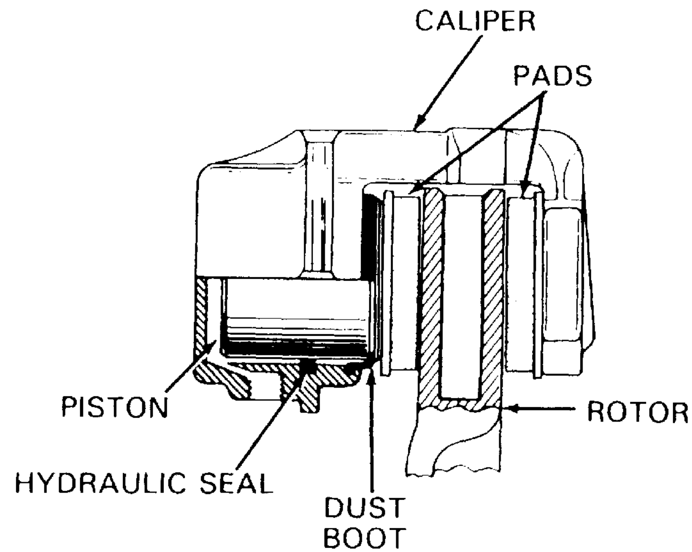


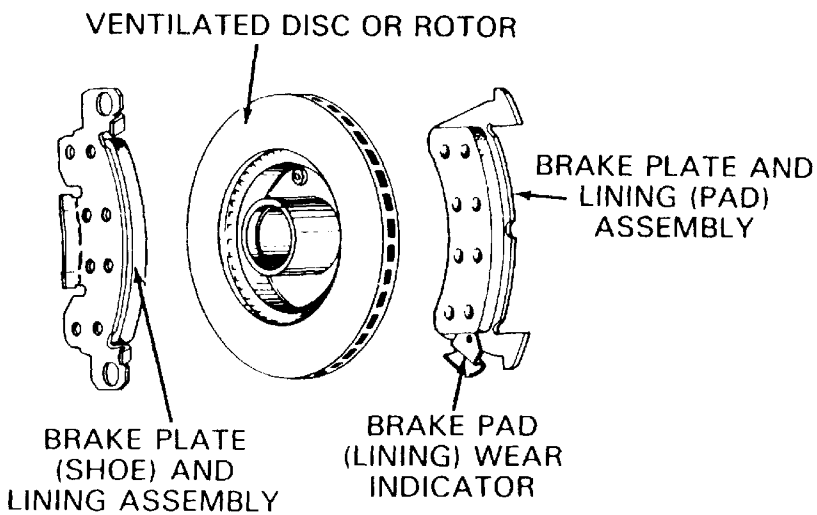
Complete Brake Service

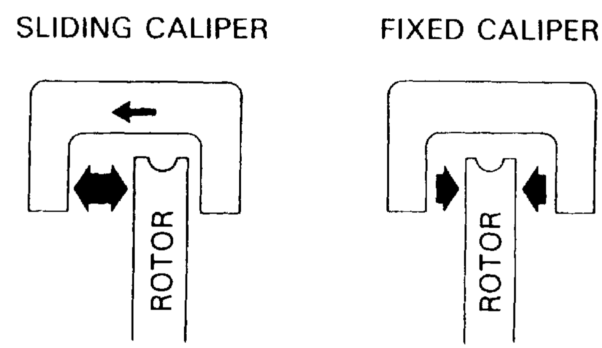


Disc Brakes

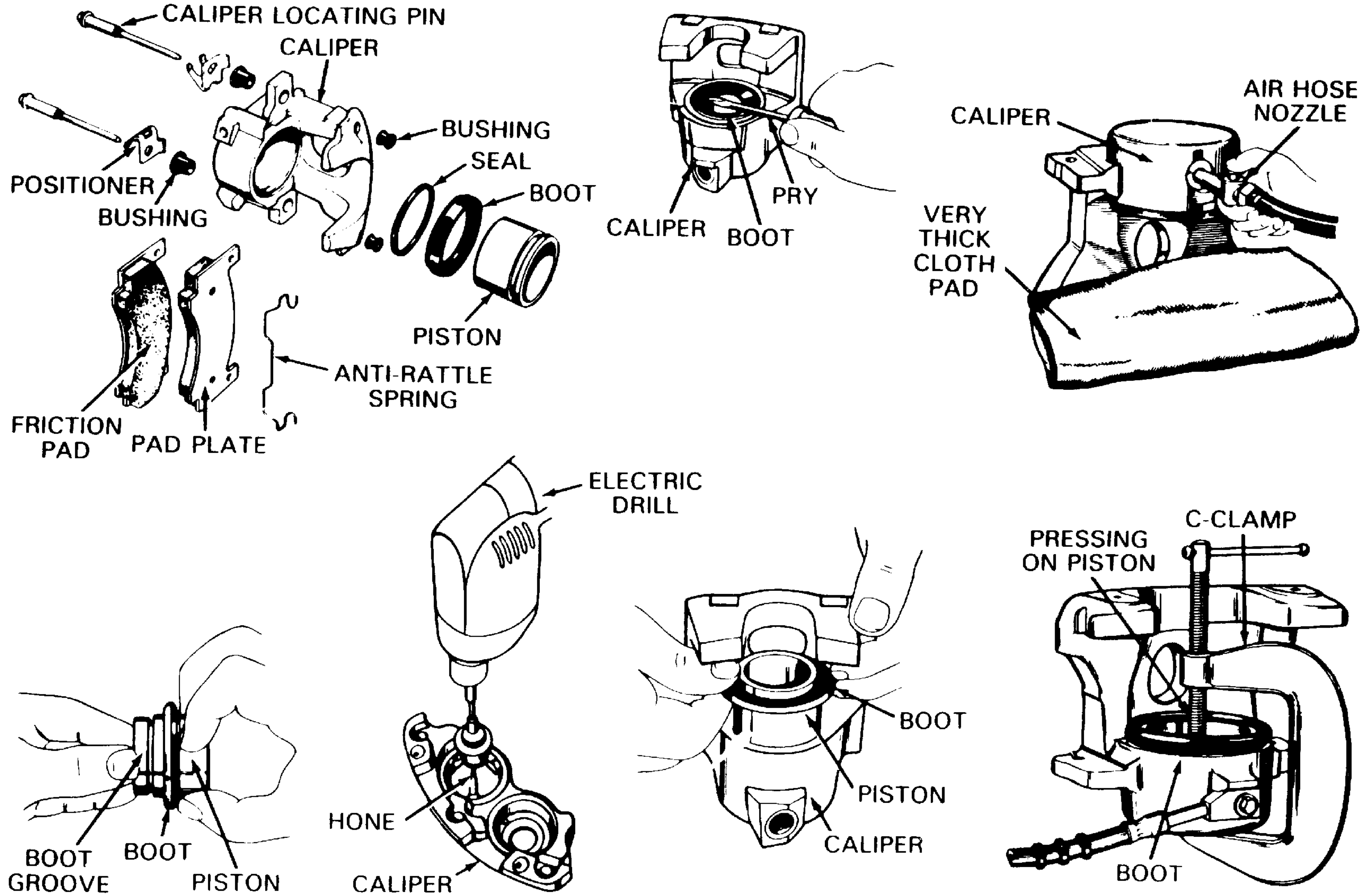

PISTON SEAL
CALIPER HALF
LINING
PISTON
FRICTION
PAD PLATE
DUST BOOT
DISC
(ROTOR)


CALIPER
PADS
PISTON
ROTOR
HYDRAULIC SEAL
DUST
BOOT

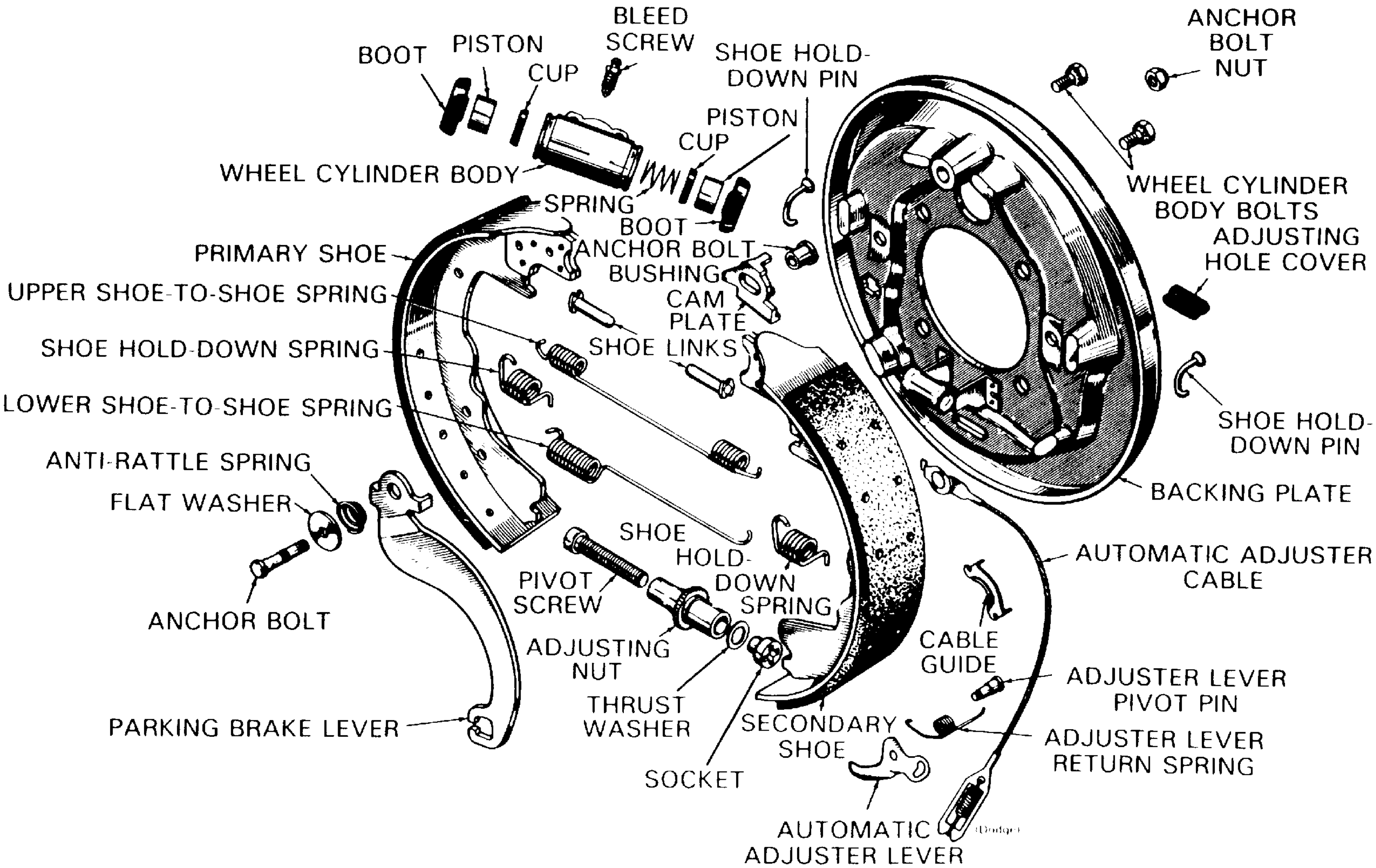

VENTILATED DISC OR ROTOR
BRAKE PLATE AND
LINING (PAD)
ASSEMBLY
BRAKE PLATE
(SHOE) AND
LINING ASSEMBLY
BRAKE PAD
(LINING) WEAR
INDICATOR


SLIDING CALIPER
FIXED CALIPER
ROTOR
ROTOR

Brake Caliper Service



Drum Brakes


BOOT
PISTON
CUP
BLEED SCREW
SHOE HOLD-DOWN PIN
PISTON
CUP
WHEEL CYLINDER BODY
SPRING
BOOT
ANCHOR BOLT
BUSHING
CAM PLATE
SHOE LINKS
PRIMARY SHOE
UPPER SHOE-TO-SHOE SPRING
SHOE HOLD-DOWN SPRING
LOWER SHOE-TO-SHOE SPRING
ANTI-RATTLE SPRING
FLAT WASHER
ANCHOR BOLT
PARKING BRAKE LEVER
SHOE HOLD-DOWN SPRING
PIVOT SCREW
ADJUSTING NUT
THRUST WASHER
SOCKET
SECONDARY SHOE
AUTOMATIC ADJUSTER LEVER
CABLE GUIDE
ANCHOR BOLT NUT
WHEEL CYLINDER BODY BOLTS
ADJUSTING HOLE COVER
SHOE HOLD-DOWN PIN
BACKING PLATE
AUTOMATIC ADJUSTER CABLE
ADJUSTER LEVER PIVOT PIN
ADJUSTER LEVER RETURN SPRING

Chapter Seven

Fast Facts

MASTER CYLINDERS & CALIPERS

A. Basic Function & Operation

1. Hydraulic principles
2. Single vs. dual system

B. Reasons for Failure

1. Nature of brake fluid (hygroscopic)
   a. Corrosion
   b. Contamination
2. Normal wear
3. External corrosion

C. Service & Sales Tips

1. Replace calipers in pairs
2. Work on one wheel at a time
3. Proper bleeding
   a. Bench bleed master cylinder
   b. System bleeding
4. Inspect brake lines
5. Troubleshooting procedures

D. Features of CARDONE Brake Products

1. Phosphate coating to ensure longer life
2. Bores refinished to OE microfinish for better performance
3. Caliper pistons refinished to OE microfinish
4. State-of-the-art rubber components
5. Bleeder kits and essential hardware included for easy installation
6. Complete, easy-to-read installation instructions in every box
7. Loaded calipers supplied with brake pads and all necessary hardware

E. Catalogs

1. Complete, up-to-date domestic and import coverage
2. Metal piston option for calipers
3. Complete information included

F. Add-On Sales

1. Brake fluid
2. Hoses / lines
3. Brake pads
4. Hardware kits
5. Tools (flare wrenches, torx-head sockets, etc.)

G. Core Policy

1. Return in original box
2. Damaged core deductions (see price sheets)

POWER BRAKE UNITS

A. Basic Function & Operation

1. Provide power assist when braking
2. Hydraulic & vacuum operated

B. Reasons for Failure

1. Normal wear
2. Contamination

C. Service & Sales Tips

1. Replace as a unit
2. Proper bleeding
3. Check vacuum line for gas, odor, or moisture
4. Check master cylinder for leaks

D. Features of CARDONE Brake Products

1. Broad domestic and import coverage
2. Meet or exceed OE specifications
3. Phosphate coating prevents rusts and gives "better-than-new" appearance
4. New piston cups and seals (when supplied with master cylinder)
5. New seals and filters
6. 100% computer tested
7. Backed with a limited lifetime warranty

ABS

A. Basic Function and Operation

1. Anti-Lock Brake System (ABS) is a combination of vehicle hardware and software that work together to maintain steering control and vehicle stability during hard braking.
2. The replacement market for ABS components is becoming more profitable every day. CARDONE pioneered this new market by being the first full-line remanufacturer of ABS components.

B. Reasons for Failure

1. Contaminated brake fluid
2. Sticking valves, corroded solenoids, or damaged electronic components
3. Bad grounds, voltage spikes
4. Faulty or misadjusted wheel sensors

C. Service and Sales Tips

1. Troubleshooting tips included in every unit
2. Record stored codes before disconnecting electrical power
3. Electronic modules, hydraulic control units, pumps and motors available

D. Features of CARDONE Anti-Lock Brake System Components

1. Built to meet stringent OEM specifications
2. Units are remanufactured in a clean-room environment to eliminate the possibility of unit contamination
3. All ABS components are full-function computer tested for internal and external leakage and performance
4. Troubleshooting diagnostic and installation guide included with every uni