BRAKE SYSTEMS

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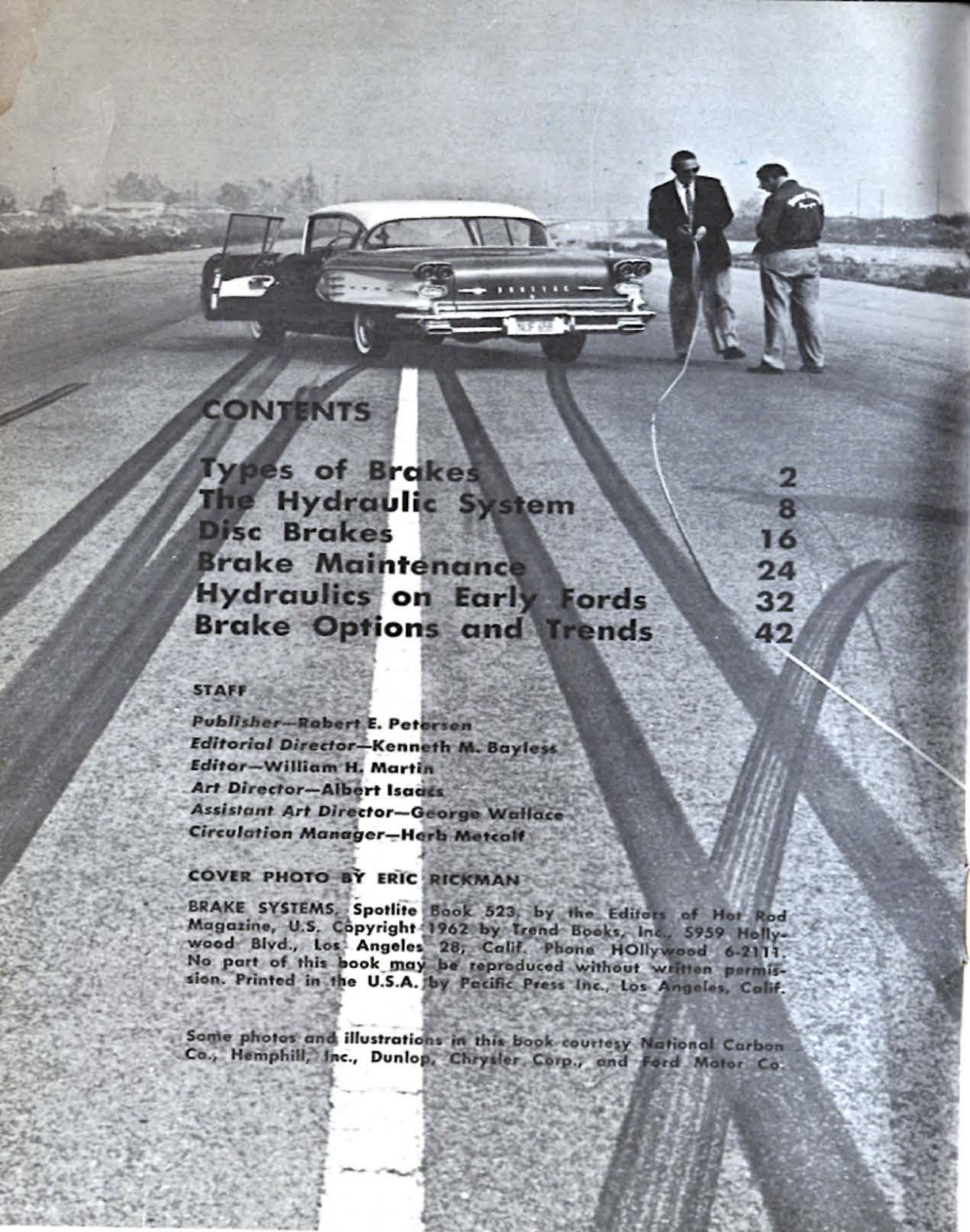
BY THE EDITORS OF *HOT ROD* MAGAZINE



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INTRODUCTION

EVER since the first vehicle was designed to transport man from one point to another, he has made incessant attempts to make such transportation more efficient. Unfortunately, during these attempts, the accent has been upon getting there ever faster and more comfortably rather than on stopping once the destination has been reached. And as often heard at the scene of an accident, it isn't the wreck that hurts, it's the sudden stop.

This apparent oversight on the part of engineers and designers of things that move people is a reasonable one, especially if viewed from the point of economics. Why build something costly if the mass isn't demanding it? Fortunately, however, while the majority of the motoring public has never paid more than a casual interest in automotive braking systems and related problems, the industry has. In 1955, for instance, the average American car had an average shipping weight of 20.5 pounds per square inch of brake lining area, the actual figures varying from 16.4 to 25.2 pounds per square inch of lining area. These figures are really appalling when you consider the average foreign sports and touring car ratio of that time was down around 10.8 pounds per square inch of lining area. Highly specialized racing cars even approached a ratio of 6 to 1. As ridiculous as these figures tend to make the American car, rest assured that something has and is being done, at least partially, to alleviate the problem. Engineers at the automotive companies and their contemporaries in brake systems manufacturing plants have for many years been cognizant of the necessity of proper brakes on the huge hulks of iron and steel that ply the nation's highways. The fact that they have done a great deal is apparent in the multitude of brake options now offered, usually as taxi and police specials. Unfortunately, automotive designers too often dictate styles not too compatible with engineering reason, so the average car still does not have a really good brake system in stock form.

Along with these strides toward better and safer decelerating devices for automobiles, brake systems manufacturers have produced a number of new materials suitable for brake application. New ideas are being formulated constantly and for the most part finding their way into some kind of testing program for proper evaluation. Disc brakes are becoming more and more common through invaluable information gleaned from such devices on aircraft with high landing speeds and loads and general racing car application. Friction materials are more diversified, as are materials for drums, shoes, etc. The advent of the space age has of itself necessitated the finding of better ways to control this abundant speed.

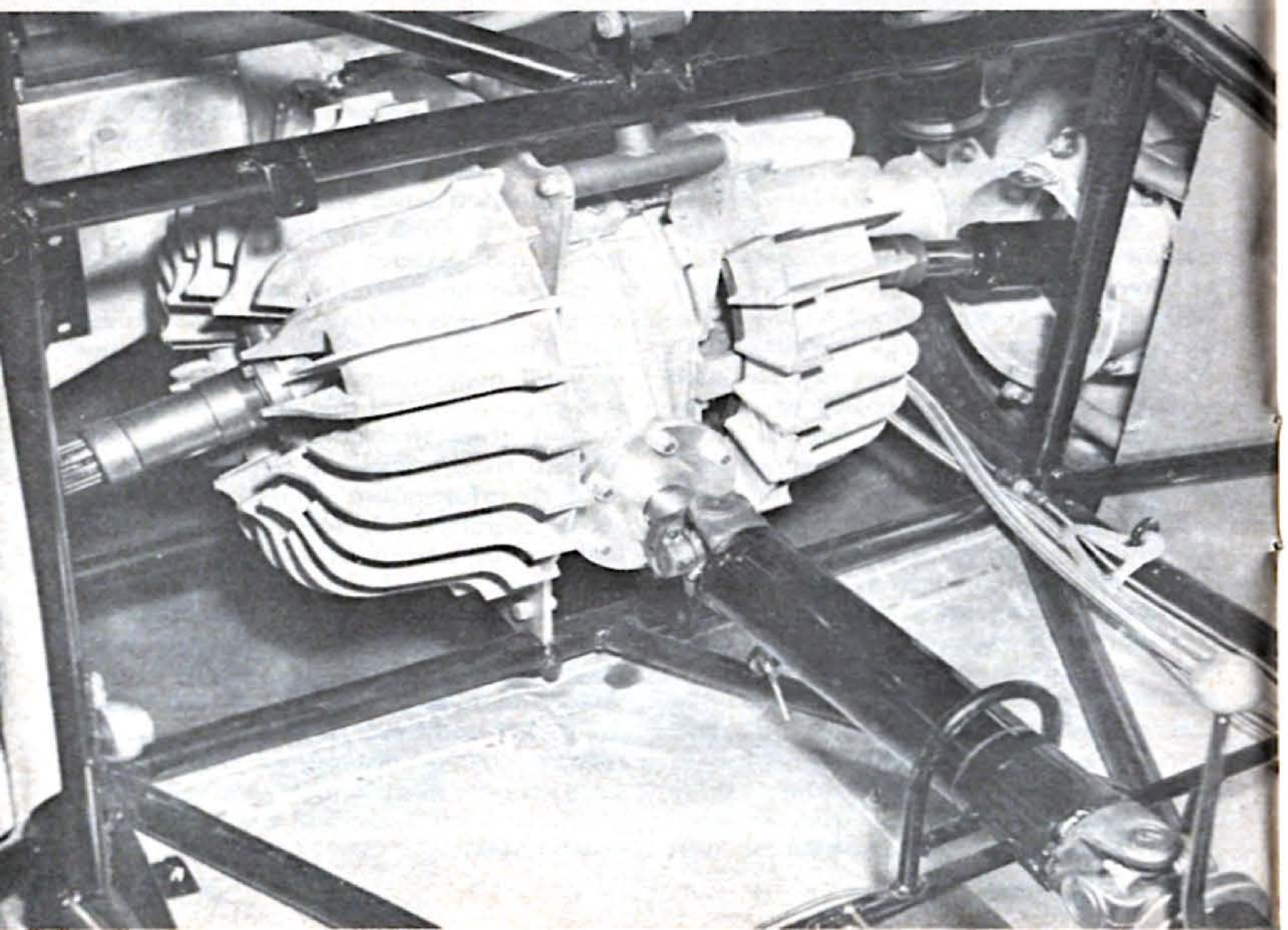
And thus the need for this book. Within these pages we hope to contain enough information to make even the most admitted novice or the professional race car builder more aware of what brakes really are, what they must do, and how they do it. Maintenance of the common hydraulic systems, both shoe and disc, will be discused, as will special installations of brakes now popular in hot rodding. In short, combining the knowledge of how to make a car go with how to make one stop will make a truely well rounded hot rodder of most anyone.

TYPES OF BRAKES

BEFORE we can really discuss brakes, we must consider a definition of them. Actually, as applied to automobiles, we may assume that the brake absorbs energy from an intentional application of friction. The energy absorbed is turned into heat that is dissipated to the atmosphere through the brake assembly. More simply put, brakes use controlled friction.

As we stated in the introduction to this book, brakes of some sort have been attached to wheeled vehicles since the first of time. We don't have any proof to back up this statement, but the first cave man may have learned from experience that brakes were necessary. All early engine propelled cars used brakes, but on the rear wheels only. These were considered good enough, and so they were for many years. Truthfully, some of the rather erratic and unpredictable actions of early braking systems would have made them a real hazard on the front wheels. Of course, the quest for performance and speed led to the inclusion of front wheel brakes. The first front wheel brakes showed up on the British Phoenix racing cars of 1908 and were shortly followed by the Italian Isotta-Fraschini in 1910 and the Scottish Argyle in 1911. Still, braking systems were something less than ideal, and four-wheel systems remained relatively unpopular until after WW I.

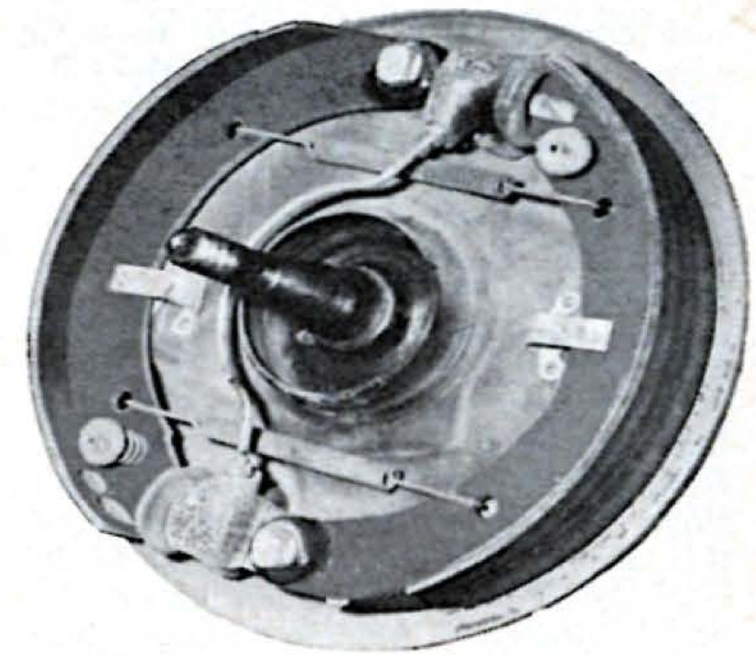
Considered by some to be the epitome of efficient braking, inboard mounted shoe brakes with large heat dissipating finned alloy muffs cast over quality steel linings.



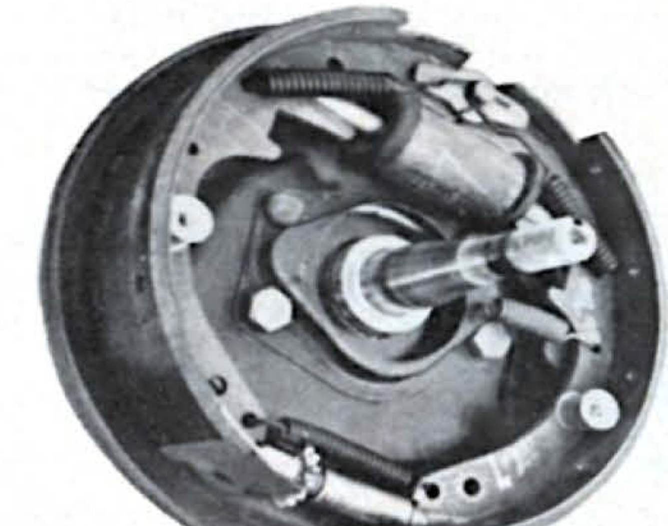
The Argyle cars used one of the better mechanical brake designs from the genius of a Frenchman named Henri Perrot. After the Great War, an American named Vincent Bendix acquired the patents to the Perrot system in the U.S., subsequently leading to the development of the famous Bendix brake. Buick was the first big auto manufacturer in this country to use the four wheel system on production cars.

While the four wheel systems were being turned into relatively finicky mechanical layouts, a Californian named Malcolm Lockheed was busy designing a different method. This first appeared on the 1921 Duesenberg race cars in the form of four wheel hydraulically actuated external contracting band brakes. The external contracting band type of brake was to become obsolete eventually, but the idea is still applied as a parking brake on some cars. The big achievement of Lockheed was the introduction of hydraulics to braking. The use of hydraulic forces to apply the necessary friction was a great stride toward uniformity and simplicity in brake operation. In fact, the use of a mechanical system except in specialized cases is now considered impractical. By 1939, all major American car builders were using the hydraulic system.

To avoid confusion, let us keep this inspection of brakes to the more modern hydraulically operated service units, the word service referring specifically to the regular foot operated brake as opposed to the hand or foot operated emergency brake. In this respect, we will deal with internal expanding shoe and disc brakes only.



As used on the Chrysler products, the two leading shoe brake takes advantage of self-energizing effect to the fullest.



In 1949 Ford products switched to the Bendix "Duo-Servo" type brake. Ratchet strut assembly at bottom transmits brake force from leading to the second shoe.

Internal expanding shoe brakes consist of two or more non-rotating segments, or shoes, faced with a friction material. When the foot pedal is pushed, hydraulic pressure is exerted on the shoes through the wheel brake cylinders, forcing them outward and into contact with the drum. In most cases, the drum is integral with the hub. The wheel is usually fastened directly to the drum and hub. In some cases, especially in many race car applications, the brake drum may be remote from the hub but still connected through a common shaft. Such drum mountings are usually referred to as being "inboard." But no matter where the drum is located, the effect is the same: friction between the fixed shoes (really the shoe friction material) and the rotating drum slows the drum. The effectiveness of this action (slowing of the car) is directly dependent on such things as pedal pressure, vehicle weight, car speed, design and condition of shoes and drums, etc.

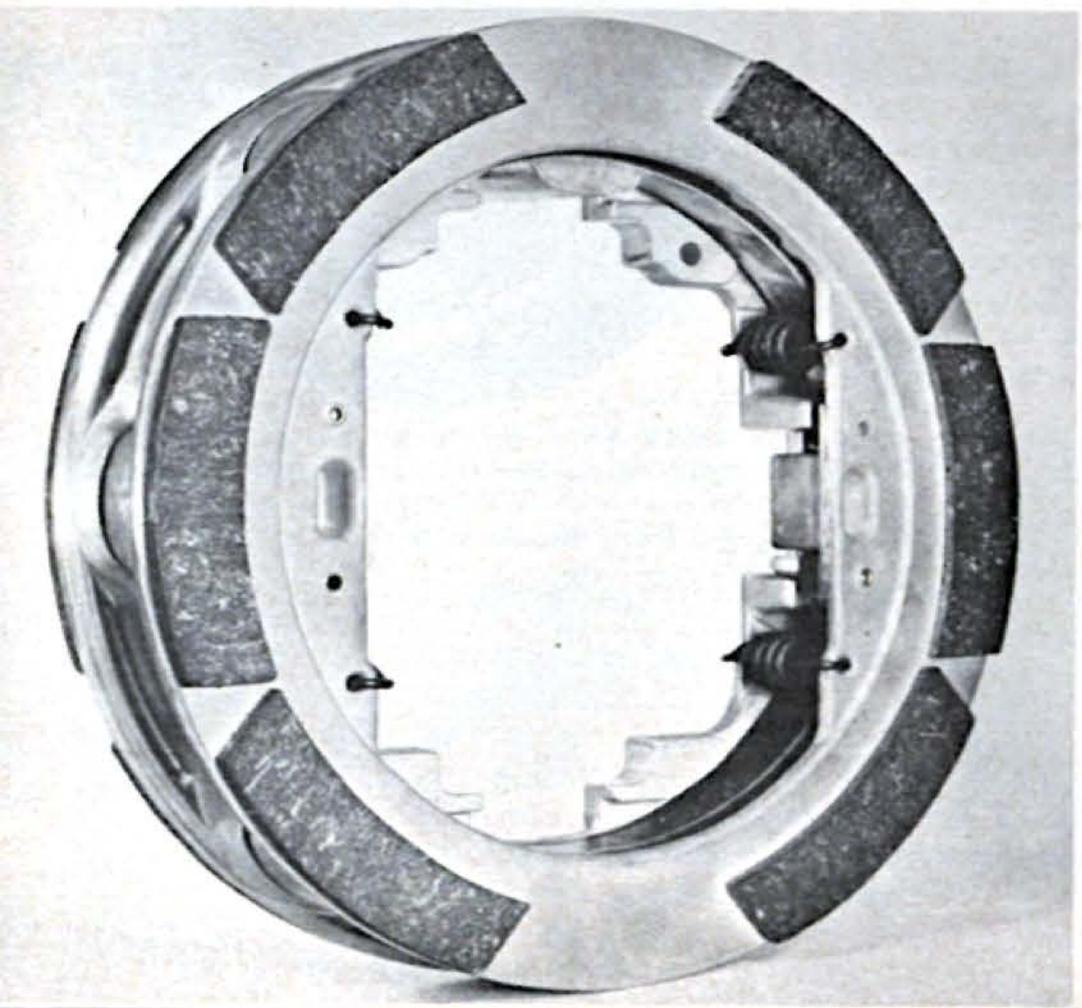
In addition to the drum and shoes, internal expanding brake types also contain one or more hydraulic wheel slave cylinders, one or more brake shoe anchors, return springs, and a method of adjusting the clearance between the drum and shoes. All of the non-rotating parts are located by the backing plate, a round plate vertically mounted to the stationary rear axle housing or front spindle. In addition to mounting the parts that comprise the brake, the backing plates keep the drum and operating mechanisms reasonably free from mud, water, dirt, etc. The backing plate also absorbs all of the braking torque. In the simplest designs, the wheel cylinder is bolted at the top of the backing plate so that the axis of the cylinder is almost horizontal. This cylinder has two pistons and seal or cup assemblies that are separated by a light compression spring. The outer ends of the pistons have slots or spherical seats to position the upper ends of the shoes. The bottom ends of the shoes are pivotally mounted by anchor bolts to the bottom of the backing plate. A strong tension spring is attached to both shoes near the top to keep the shoes pulled together, or toward each other and away from the drum, when not in use. Each shoe contacts an adjusting eccentric, the adjustment being necessary to reduce normal clearance between friction material on the shoes and the drum during normal wear. The hub and drum assembly is mounted on one or more bearings and is bolted either to the spindle or to the rear driving axle.

When the brake pedal is pressed, brake fluid enters the wheel cylinder under pressure, forcing the two pistons apart. The hydraulic pressure within the cylinder does the forcing, overcoming the tension spring pressure. The pistons in turn push the shoes toward the drum. The bottom ends of the shoes pivot about the centers of the anchor bolts. When the brake pedal is released, hydraulic pressure in the system drops to nearly zero and the tension or return springs pull the shoes away from the drum.

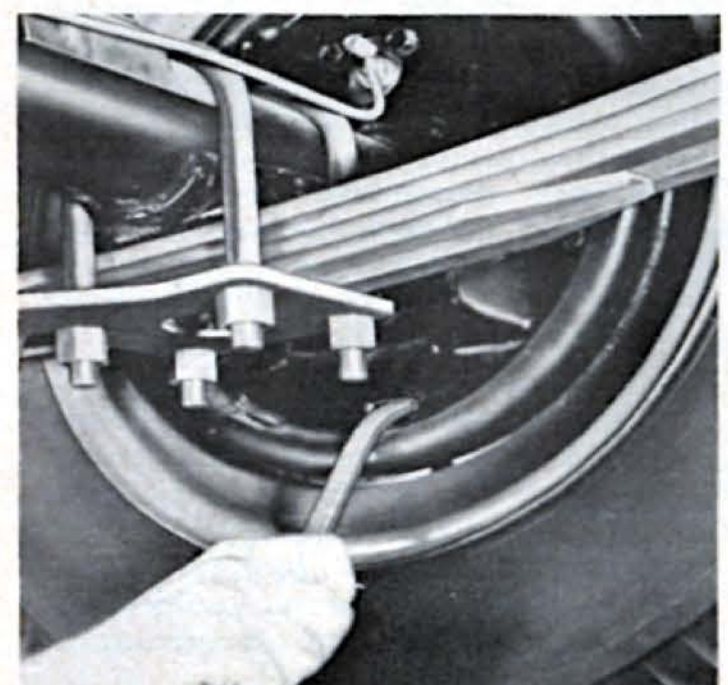
In the two shoe design just mentioned, the shoes are opposite each other and cover an approximate area each of 120 degrees drum circumference. Quite obviously, as the brakes are used over a period of time, the drum and the friction material on the shoes wear, increasing the clearance between them. Thus the need for the adjusting eccentrics.

In the automotive brake systems, the shoes that face toward the front of the car are called the primary or leading shoes. The units that face to the rear are referred to as being secondary or trailing. When the car moves forward and the brakes are applied, the friction on the leading shoe attained by brake pedal pressure is increased since the shoe tries to lean into the drum. This is called the self-energizing effect. The opposite happens to the trailing shoe, which tries to push away from the drum. When braking in reverse, the secondary shoe becomes the self-energizing shoe and vice versa. This system has been used by Lockheed designs on several cars, including Fords, Mercurys and some models of Lincoln from '39 through '48. The system is simple, trouble-free and dependable.

This self-energizing effect brings up an interesting point, mainly that the



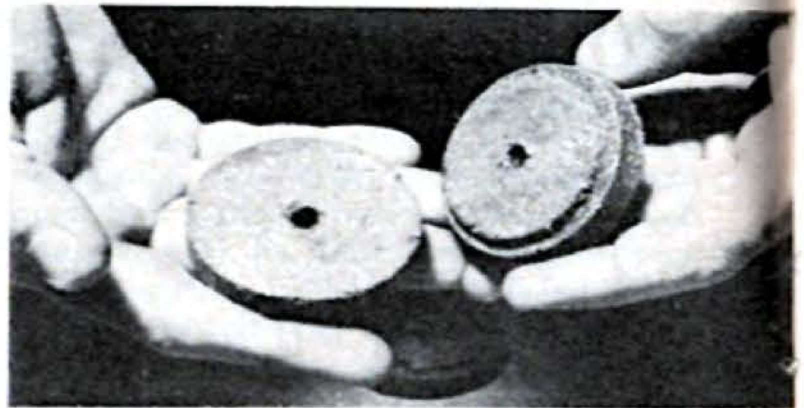
Introduced on the '53 Chrysler Imperials, the Ausco-Lambert disc brake used an outward expanding double-disc assembly with an automatic wear adjustment. This unit used small steel balls in inclined ramps and centrifugal force to provide a superior self-energizing effect. Pedal pressure was small without boost.



The Lincoln brake drum used during mid-1950's had cast-iron friction surface and steel center section. Heavy outer springs help to control drum distortion. Photo at the left shows a typical ratchet brake adjusting mechanism being contacted through backing plate by tool.

effectiveness of the self-energizing shoe is usually about twice that of the trailing shoe. Consequently, the lining on the leading shoe is shorter than that on the secondary shoe, and thicker. The front shoe is doing more work and will wear faster. The problem here is to equalize as much as possible the braking forces between the two shoes, thus the difference in shoe lining. In addition, the wheel hydraulic cylinders are usually step-bored, with the piston actuating the secondary slightly larger than that moving the leading shoe. The disadvantage of such a system is extra loading of the wheel bearings when the brakes are used. This loading is directly proportional to the braking force differential between the primary and secondary shoes, the diameter of the brake drum and the location of the brake assembly in relation to the bearings.

Rather common on foreign cars and used for some years in the U.S. by the Chrysler Corporation is the two leading shoe system. This layout takes full advantage of the self-energizing effect in that each shoe is a primary or leading shoe connected at its toe to its own cylinder. The cylinders are located 180 degrees from each other at the top and bottom of the backing plate. The front shoe is operated by the top cylinder, the bottom cylinder operates the back shoe. Each shoe then becomes applicable to the self-energizing effect, since it faces the direction of drum rotation. Linings on both shoes are identical. The two cylinders are joined by a common hydraulic line that keeps each cylinder pressure constant with the other. The heel of each shoe is pivotally anchored, but instead of being close together as before, the anchors are diametrically opposed. Adjustments are through eccentrics or ratchets. This arrangement is usually found only on the front brakes in American cars. As can be readily seen, the twin leading shoe type brake takes maximum advantage of the self-energizing effect which in turn



Disc brakes of the Goodyear-Halibrand type use small circular friction pads commonly called pucks. These pads are not greatly affected by heat or water.

means less pedal pressure and less strain on the front wheel bearings. But then, the disadvantages are quick heat build-up under extreme or prolonged use which may mean fade. The tendency to lock or grab is greater if water, dirt, etc., happens to get between the shoe and the drum, but this isn't a major problem. Three and four leading shoe designs have been tried but aren't common.

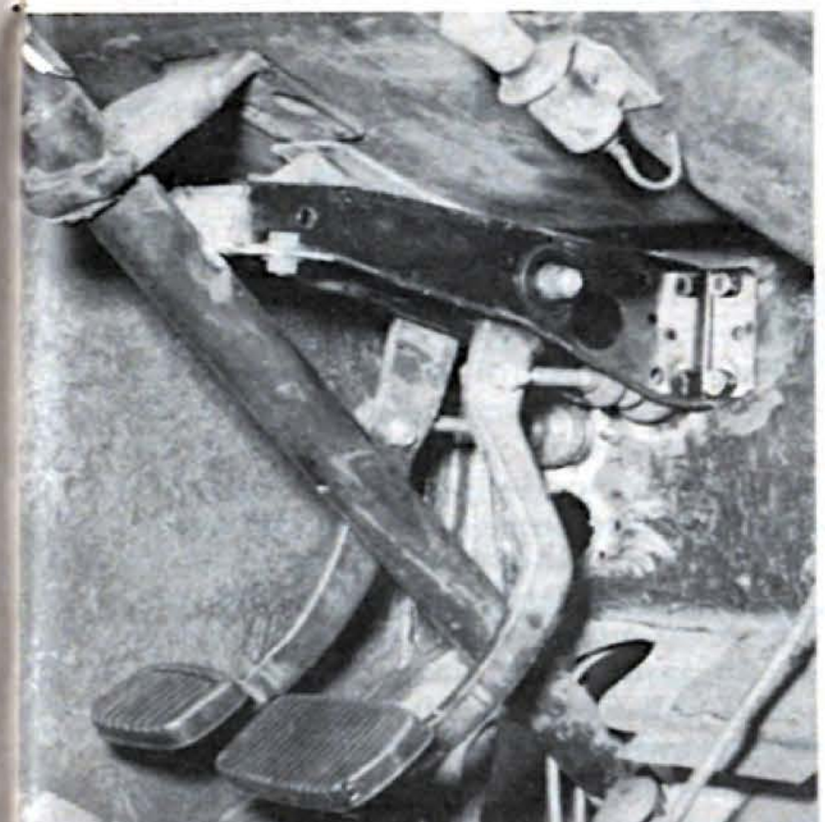
As opposed to the two leading shoe design is the two trailing shoe system. Not common in cars, the system is similar to the two leading shoe arrangement, but there is no self-energizing effect with its consequent easy or lighter pedal pressure. The pedal pressure for a given action is about four times greater on this type of arrangement, and usually necessitates a servo or booster unit incorporated in the hydraulic system somewhere between the master and wheel cylinders. As might be imagined, the advantages of this system are several. There is no grabbing or pulling, as possible with the leading shoe arrangement; the rate of lining wear is only about one-quarter that of the leading shoe system; temperature is less than the leading shoe type and oil or dirt doesn't greatly alter the effectiveness of the braking power. Even with the inherent problems of the trailing shoe system, the advantages just mentioned have made the system

desirable for gruelling long distance racing cars of some types, and in fact, the system was used on the Mark VII Jaguars. The Jags had a servo motor in the system.

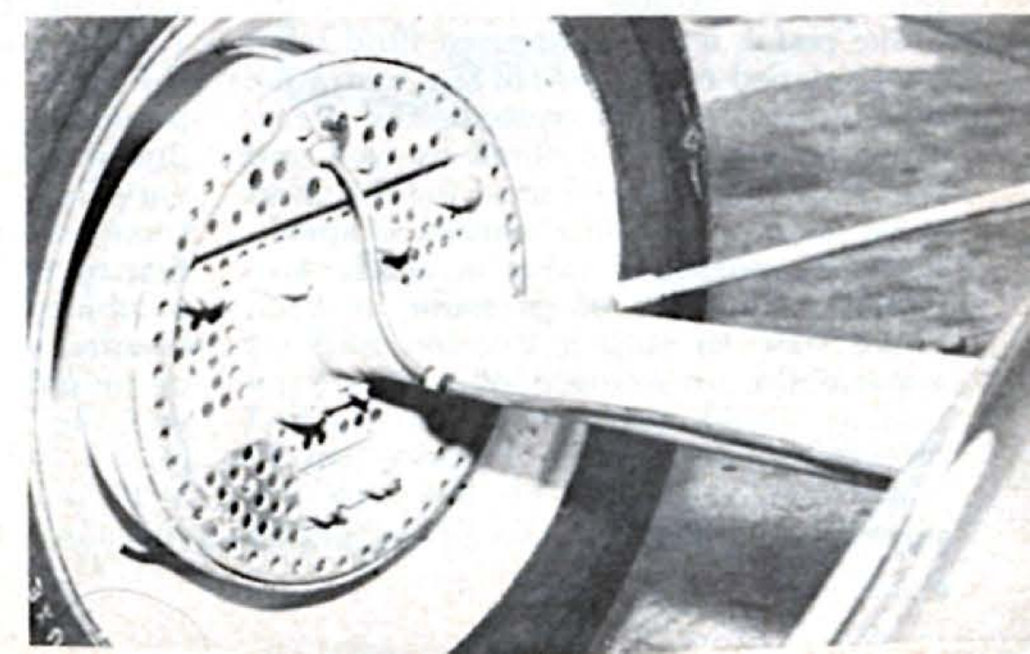
The Bendix "Duo-Servo" system makes use of the principle wherein the frictional force of one shoe helps apply frictional force to another shoe. In this type of system only one wheel cylinder is used and it is mounted near the top of the backing plate. The shoes are anchored at the top of the backing plate *above* the cylinder and when not in use the shoes are pulled against the anchor by a tension spring. A link between the bottoms of the shoes is necessary, a function performed by an adjusting strut assembly. A tension spring keeps the bottoms of the shoes in contact with the strut and also acts as a lock for the adjustment screw.

When the brake pedal is pressed, the shoes expand to the drum. Forward rotation of the drum gives the leading shoe a self-energizing effect. The leading shoe transmits some of this self-energizing effect to the back shoe through the adjusting strut assembly, making the back shoe also a leading shoe. However, the back shoe receives more actual pressure than the front shoe, consequently is susceptible to greater lining wear. Additionally, the back shoe usually has a smaller or shorter lining to help lessen wheel bearing load. This type of system is desirable from a marked decrease in pedal pressure standpoint, and to some extent is "floating" or "self-centering."

The above-mentioned hydraulic braking systems are the most commonly found on the average car. In a later chapter we shall discuss the disc brake, a system that is fast finding acceptance on most race cars under certain conditions and may in time be a common production item on family autos. ■



Swinging brake and clutch pedals from late model cars easily fit older vehicles, like the Model A, with minimum mount problems.



A brake's effectiveness comes from controlled heat and friction. Drilled back plates exit heated air.

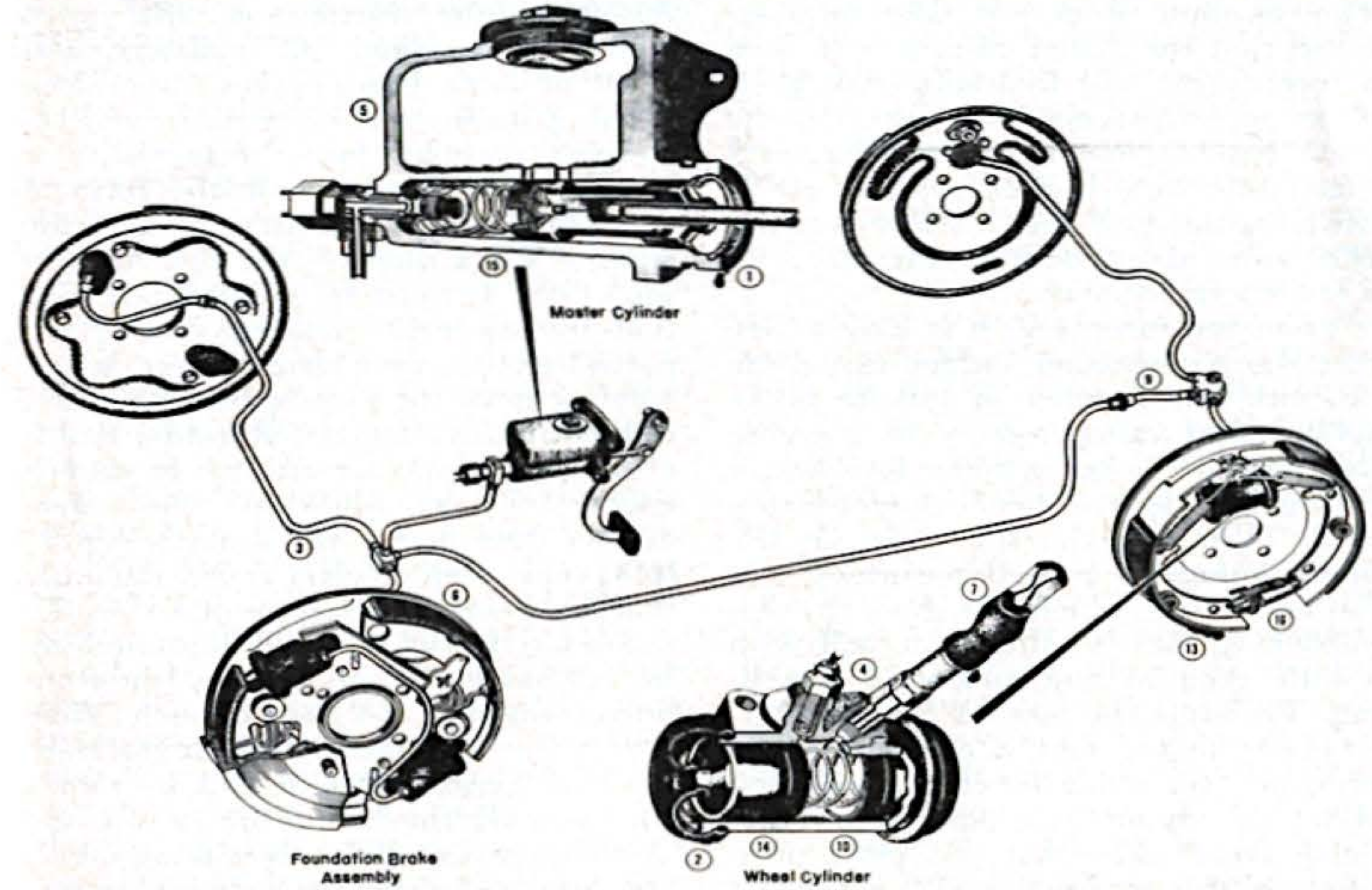
THE HYDRAULIC SYSTEM

THE FIRST chapter pointed out the braking system insofar as the individual and collective wheel assemblies are concerned. But no matter what kind of brake shoe system is used; no matter what the friction material or brake drum composition might consist of, the shoes must be placed into contact with the drums to do any good. Therefore, the hydraulic system.

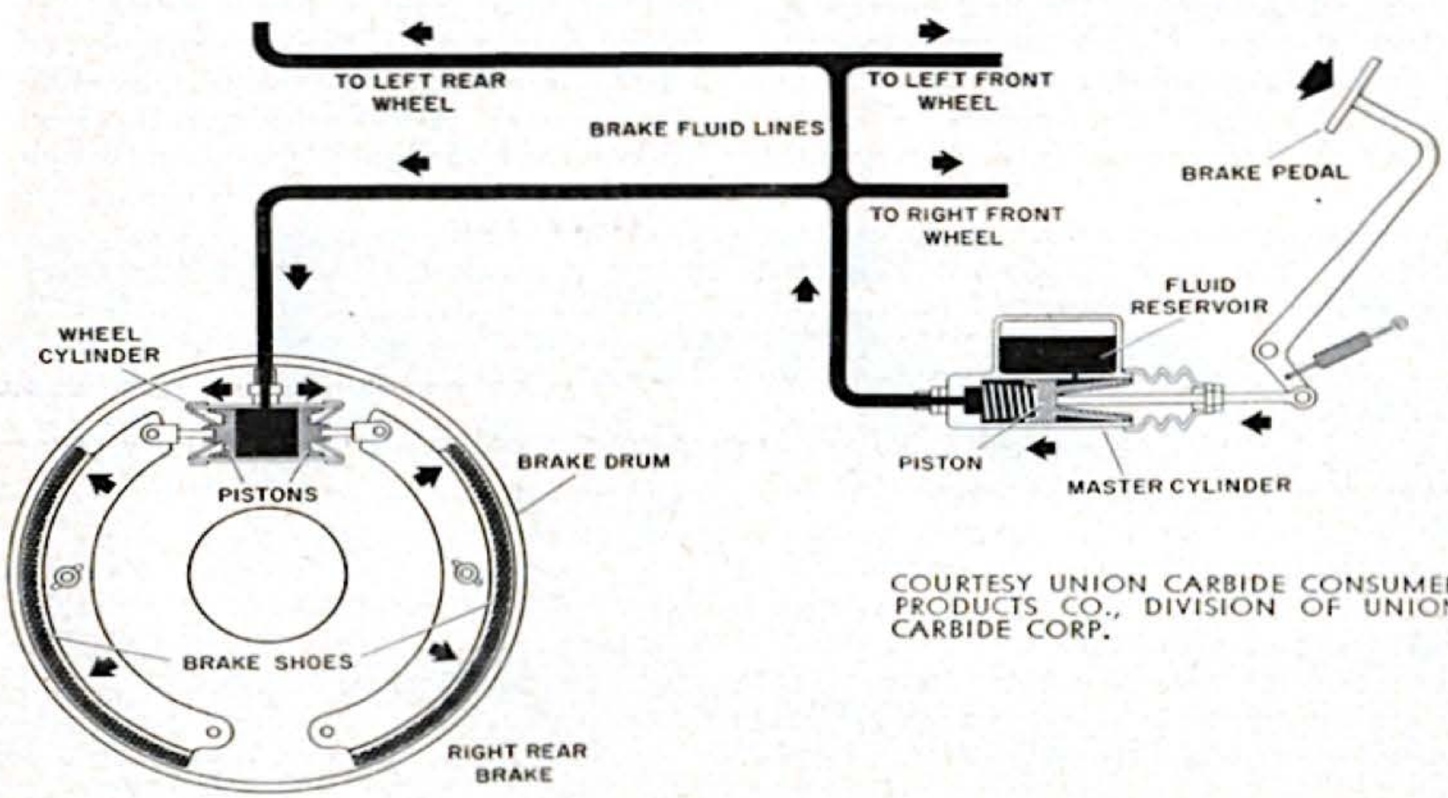
We won't spend time on the mechanical linkage system used on cars of past decades, for the plain and simple reason that such a system is merely a matter of rods, threaded ends and pivot arms. They either do or don't work. They're either in adjustment or out.

To talk about the hydraulic system, we should first realize that most hydraulic systems use oil of one compound or another. For all practical purposes, most liquids are relatively incompressible at the pressures and temperatures that crop up in the automobile braking system. In a closed hydraulic system of any sort, if one cubic inch of fluid in the master cylinder is pushed on by the brake pedal, a like amount of fluid must be displaced in the rest of the hydraulic system. In the auto system, the clearance between brake shoes at rest and the drum provide the area for the fluid to be displaced to, in a manner of speaking. Of course, it takes a really tremendous amount of pressure at each brake shoe to stop a two-ton hulk of automobile, an amount of pressure no human could provide if he pushed directly on the master cylinder piston. Therefore, the laws of leverage are placed into effect at the brake pedal.

The brake pedal is basically a pendulum affair, with a large foot pad at one end. The other end is secured by some portion of the body or frame structure and is free to swing fore and aft only. Slightly below (or above, whichever the case may be) is the connection between the pedal arm and the master cylinder via a piston rod. Through this leverage principle, applying just a few pounds of force at the pedal is multiplied to much more pressure at the master cylinder and several thousand pounds of pressure at the wheel cylinders. For example, suppose the brake pedal arm is 10 inches long from the pivot point to the foot pad. From the center of the pivot point to the center of the bolt attaching master cylinder rod and pedal arm together is one inch. The lever advantage is a strong 10 to 1, so 65 pounds of force on the brake pedal will figure out to be 650 pounds at the master cylinder piston. Now, if the master cylinder bore is just one inch, the hydraulic line pressure will be the area of the master cylinder piston (.7854 square inches) multiplied by the force applied to the piston, or 500.5 pounds per square inch. On cars produced since 1950, the line pressure may vary from 350 psi up (65 pounds initial force) with power brake boosters giving figures often three times greater. The combined mechanical leverage and hydraulic advantage thus forms a ratio of roughly 80 to 1 between the pedal and the brake shoes. So, if the driver pushes on the brake pedal to the tune of 65 pounds, the radial pressure of the shoes on the drums is 5200 pounds.



Typical hydraulic brake system showing cutaways of master and wheel cylinders. Note the front double leading and rear 'Duo-Servo' shoe assemblies.



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How the hydraulic system works. Hydraulic pressure is equal at all points.

This example does not take into account that the actual efficiency of such a mechanical and hydraulic linkage is closer to 90 percent than 100. On the other hand, remember from Chapter I that (since most braking systems use at least one leading shoe) self-energizing effect just about doubles the effect of a non-energized shoe.

From the foregoing, it is easy to see that the enterprising rodder can come up with any number of infinite brake actions and ratios merely by varying the pedal-to-master cylinder leverage or master cylinder-to-wheel cylinder piston area. Then too, the substance on the brake lining as a friction surface and the method in which the shoes are applied may also be altered at will with a little thought and junk yard searching. Through the use of "step-bored" wheel cylinders and a constant pedal pressure (65 pounds being considered about maximum for a panic-stop situation), we could either put more pressure on the trailing or non-energized shoe to equalize shoe pressure, or more pressure on the leading shoe to take more advantage of the self-energizing effect and get lighter pedal pressures. The average American car has a front-to-rear braking effectiveness of about 65-35 percent respectively. A very light 2000-pound street rod might have more weight on the rear wheels, for instance, and thus the above ratio might prove too much on the front, not enough on the rear. A 60-40 ratio is about right for a front-engined car, 55-45 for rear-engined. Among many special car builders it is felt that the braking ratio between the front and rear wheels should be such that the front wheels are still a bit short of skidding when the rear wheels are on the point of skidding. This ratio depends on the leverage to the brakes, shoe design, anchorage, shoe lining friction, and weight distribution and weight transfer during braking.

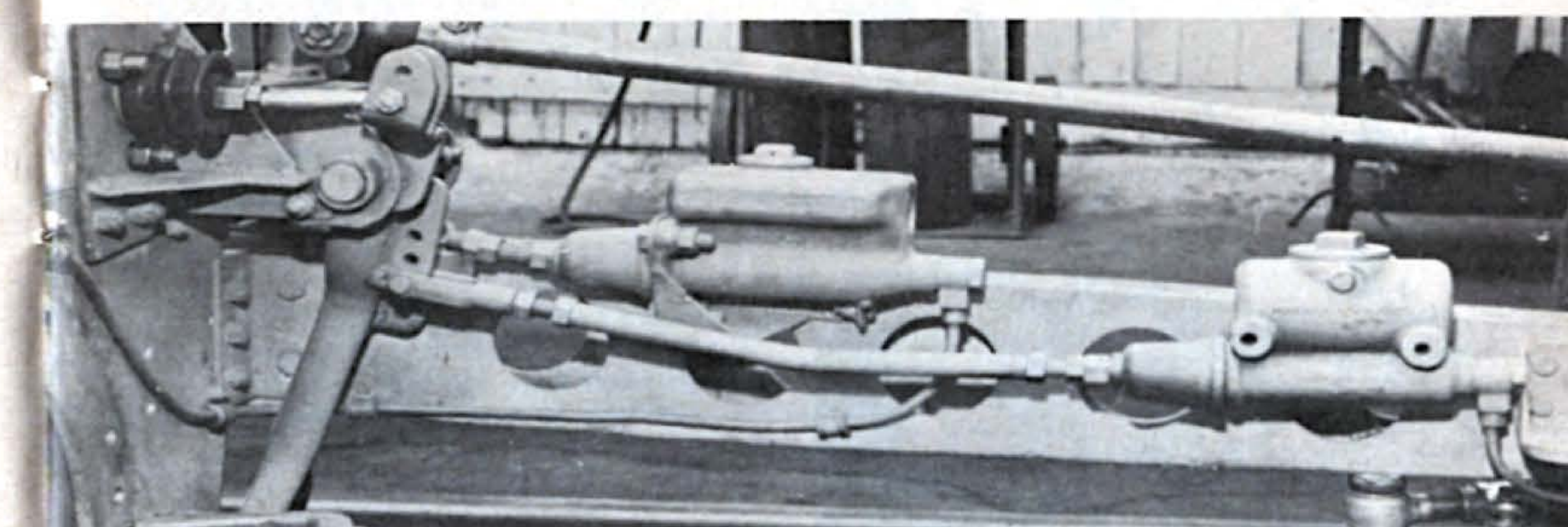
If the 2000-pound rod has about a 50-50 weight distribution, like most Chevy V8 engined '32 roadsters, and 1940 or later Ford brakes have been fitted, it means that more braking effectiveness may be built in to the rear systems. This could be in the form of step-bored wheel cylinders to give the leading shoes more of the self-energizing effect. It must be pointed out here that by arbitrarily bolting various car parts together one cannot hope to always achieve the best in braking. Most of the time an average hot rodder builds a car in this manner and never experiences any real difficulty, but then, neither does he tax the braking system to its maximum efficiency. One example that has been cropping up of late is the use of late model rear ends in something like a Model A coupe. Usually, the front brakes are off a '40 Ford or such. They are of the aforementioned single leading shoe type. The rear end is from a Chevy or Oldsmobile of the 1950's, and no thought is made as to braking ratios, etc. All of a sudden the rodder may find the rear wheels locking up for no apparent reason. There is a reason of course, and this is because the late model rear end has brakes designed for a 4000-pound car. The rod weighs about 2000 pounds. Add to this that the front brakes were designed for a car weighing about 3000 pounds. So what's the skinney? Well, one of two courses of action is needed; either make the wheel cylinders in the rear brakes smaller or transfer to Bendix brakes for the front. Utilizing the Bendix units seems to be the best, since they were used on some Lincoln cars up to '48 and will bolt right on the other Ford product spindles. Remember that this is still only an approximation of the real thing and a little figuring of weight distribution and ratios is necessary to get the top job.

In the event that you have a mechanical system and for some reason or other can't change to hydraulics, don't feel all is lost. You can do the same kind

of adjusting and experimenting with mechanical brakes and come up with reasonable results. Just be prepared to keep a constant check on the system and know that adjustment is almost always necessary. In the mechanical system, a cam takes the place of the wheel cylinder, and by playing around with operating arm lengths you can get a variety of pedal and shoe pressures.

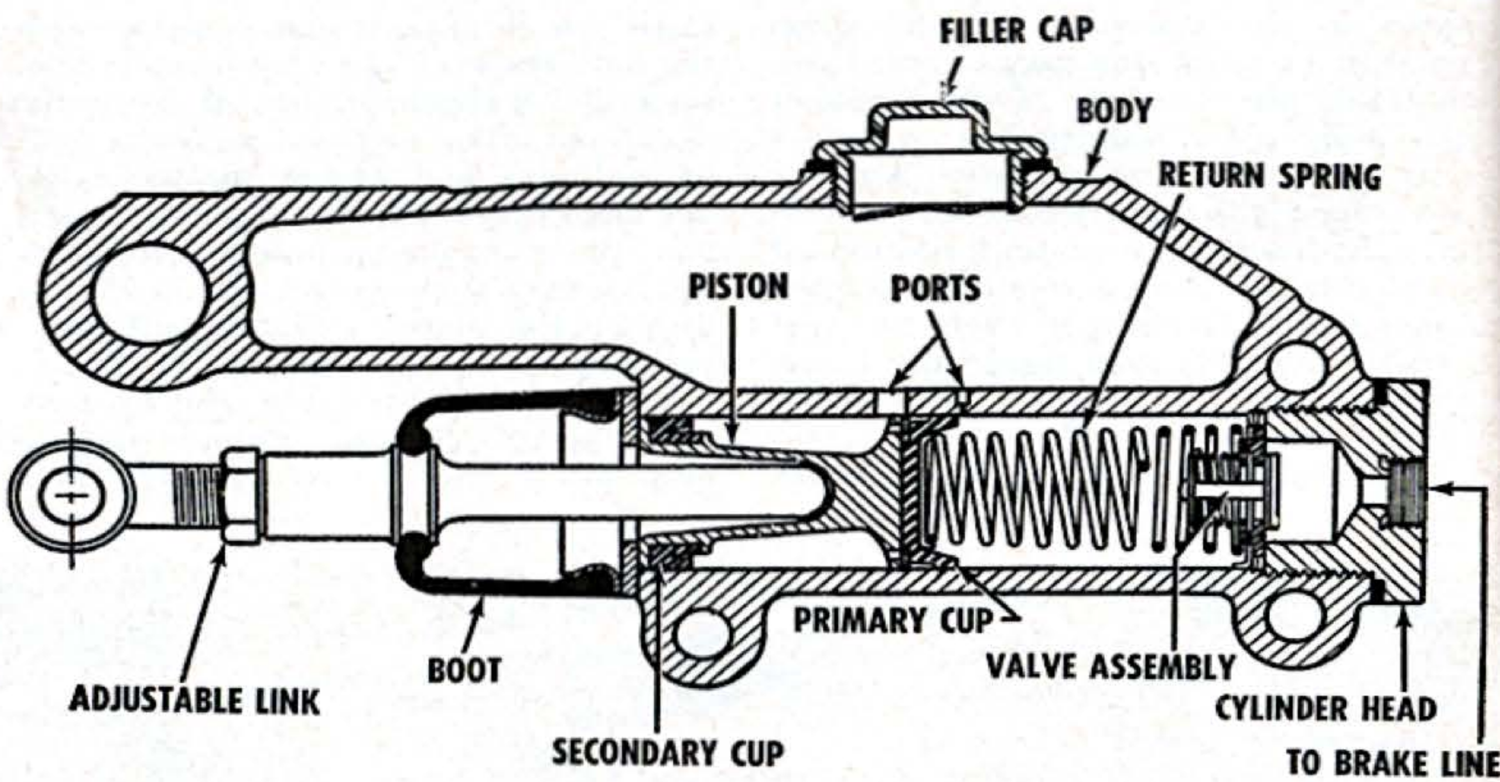
One of the greatest advantages to the hydraulic automobile brake system is that in a fluid system any pressure variation anywhere in the entire system is instantaneous and exactly equal everywhere. If one brake shoe happens to be closer to a drum than all the rest, it will touch the drum first when the brakes are used. But, it won't really do anything drastic until all the other shoes in the system reach the same point of pressure. It's easy to see, then, that this one property of fluids makes extremely close adjustments in a hydraulic system unnecessary. Another advantage is that there is no lost motion in a hydraulic system and routing of the hydraulic lines is relatively simple. Lines should be clamped every two feet or so, preferably well inside the frame structure out of the way of possible flying rocks and the like.

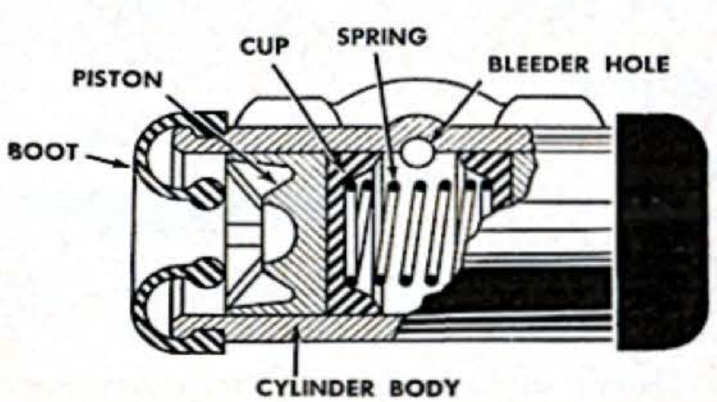
The real heart of the hydraulic brake system is the master cylinder, primarily because all action in the entire system depends upon this one item. Back in the "old" days, many a rodder or average motorist cussed the engineers for placing the brake mechanism directly to a major frame structure. Usually somewhere under the floor, the brake pedals bolted to a part of the frame and connected by a rod to the master cylinder. Inevitably, the master cylinder was skillfully hidden away beneath a cross-member or such and was most difficult to service. Since the early '50's the practice has become virtually universal to use "swinging" pedals and firewall mounted master cylinders. This makes checking the level of the master cylinder fluid an under-the-hood operation. In such installations, the master cylinder usually is integral in one housing with the fluid reservoir. In very recent years, since the widespread use of hydraulic clutch operating mechanism, brake master cylinder and clutch master cylinder have been sharing a common reservoir. It is common practice in some foreign cars such as the Austin-Healey to keep the master cylinder and reservoir separated. In a typical American master cylinder assembly, the cylinder and reservoir housing is made from a close grain alloyed cast iron. The bore



Individual cylinders for the front and rear brakes allow minute ratio adjustments.

is machined to precise measurements and precision honed. The cylinder head screws into the end of the housing bore opposite the pedal side. The bore is located below the reservoir and inside the bore is a piston, usually made of aluminum alloy or brass. This piston has a primary and a secondary seal (or cup), the primary seal acting to keep fluid from leaking from the pressure side of the piston. The secondary seal keeps fluid from leaking from the pedal end of the bore. The piston is relieved between the ends much like a sewing thread spool so that fluid can flow freely about it. The piston end facing the brake pedal has a conical hole in it to locate the actuating rod coming from the pedal. The other end of the piston (toward the cylinder head) has some little holes drilled in it so that communicating passages exist between both sides of the piston crown. A piston return spring is fitted between the cylinder head and the piston crown. In the cylinder head there is a two-way inlet-outlet valve assembly and a threaded hole that takes the line fitting. Two ports connect the reservoir with the cylinder. The smaller of the two is just barely uncovered by the primary cup when the brakes are released and serves as a vent to relieve pressure build-up in the cylinder. This is the reason for an atmosphere vent in the reservoir. The large port is located behind the piston crown and allows the fluid to pass into the cylinder around the annular space





Simple cut-aways of the master and wheel cylinders show how hydraulic fluid is controlled by piston and seals in cylinders.

between the piston ends. When the brake pedal is mashed, the piston moves in closing off the small port between cylinder and reservoir. The fluid in the rest of the cylinder is then under direct pressure. Mash harder and the pressure causes the poppet valve in the cylinder head to open and pressure is forced into the brake lines. When the pedal is released the return springs between the brake shoes pull the shoes together and force the fluid from the wheel cylinders back up the lines into the master cylinder. The returning fluid closes the inlet valve in the cylinder head and pressure is put on a disc—which serves as a seat for the valve and for the piston return spring, forcing the disc and valve assembly off its seat. The fluid can now flow back into the cylinder. When the pressure on the disc falls below the pressure of the piston return spring (which is inside the cylinder, remember), the disc and valve assembly returns to its seat. During the time that the pedal is being released, brake fluid can't enter the cylinder from the line fast enough due to flow restrictions around the valve.

Here's where the little holes drilled in the piston crown come in. Fluid from the reservoir and the area behind the piston crown can flow through these holes upon demand as a sort of pressure equalizer. After the piston is back at rest position, additional fluid coming into the cylinder from the line can pass directly into the reservoir through the

Constant research is being carried on in brake systems, creating such things as Auto-Mate Saf-T-Brak which holds car from creeping, releases when throttle is pressed.

relief port, which is now uncovered. The piston return spring keeps the outlet valve disc seated at line pressures below 10 to 15 psi. This pressure stays in the lines and wheel cylinders to keep air from getting into the system in the case of small breaks or leaks. The valve assembly is normally made of brass while the springs are usually cadminum plated steel wire.

The cups in the master and wheel cylinders are made of tough, flexible, non-porous synthetic rubber compounds which make them rather impervious to chemical actions. The cupped end of the unit always faces the pressure, and as this pressure increases it merely tends to force the cup tighter to the cylinder bore walls.

If you've had any experience with automobiles at all, then you've heard it said time and again that the two greatest enemies of the master cylinder (and in effect, the entire system) are water and dirt. And for a good reason. Since the reservoir is vented to the open air, condensation water can form on the walls above the fluid level when temperature and humidity conditions vacillate. The specific gravity of water is greater than the brake fluid, so it naturally seeps to the bottom of the reservoir and eventually through the ports into the bore. Since the fluid and the water both have an oxygen content, the cast iron cylinder bore is thus susceptible to corrosion and eventual scoring of the primary cup. As for dirt, this can be avoided by really cleaning the area around the reservoir filler cap before inspection, and then carefully removing and replacing the cap. Wear of the master cylinder bore due to either of these conditions will usually show up as increased pedal pressure; necessity to pump the pedal; or under prolonged pedal pressure the pedal slowly creeps to the floor. There's a leak in the cylinder or somewhere in the lines or wheel cylinders. Normally, the master cylinder will show signs of an approaching bad brake condition in advance of the lines or wheel cylinders.

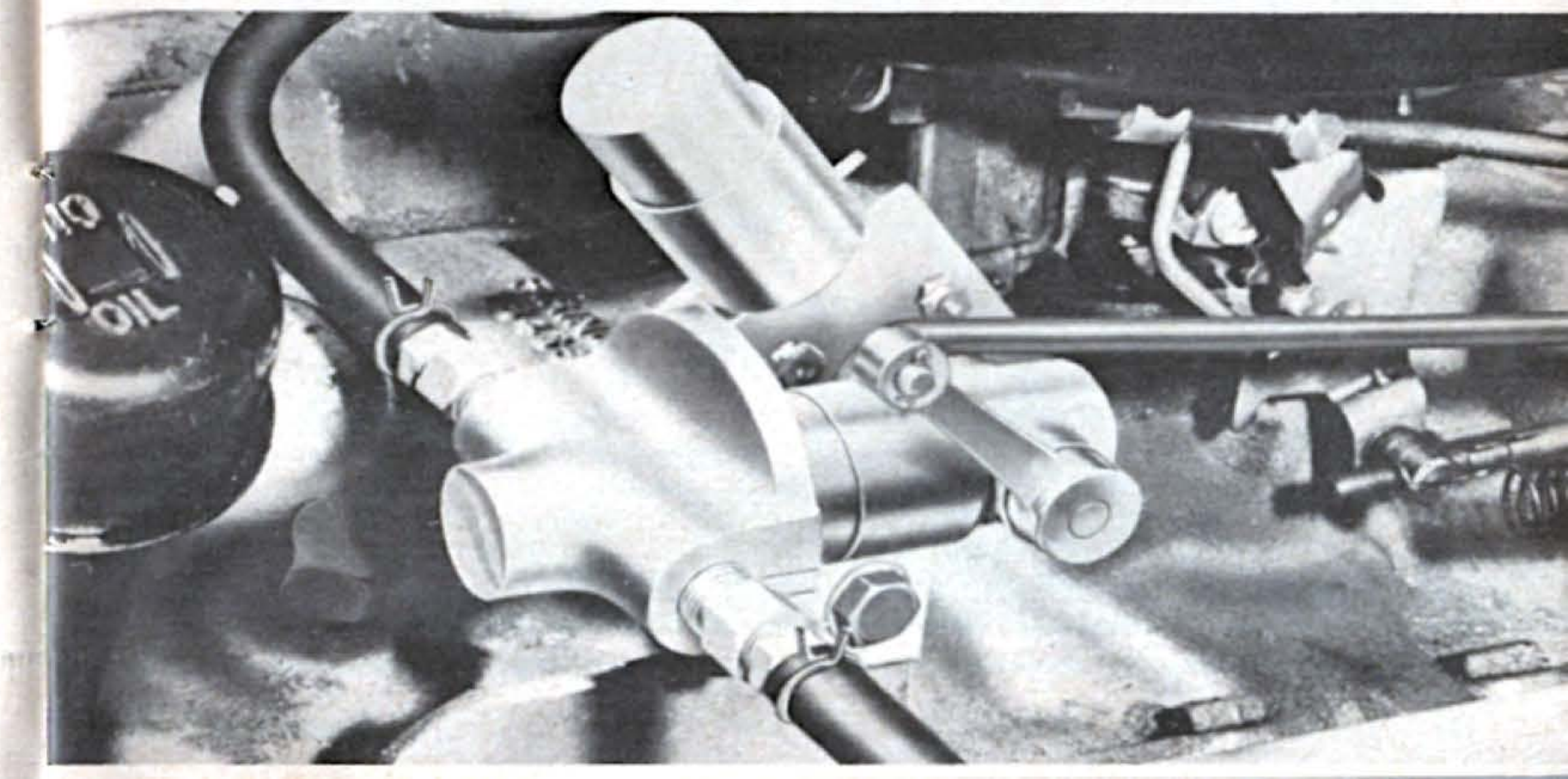
Continuing our inspection of the hydraulic system, we will note in most cases a brass fitting screwed into the master cylinder. The line then fits into this fitting. Normally a two- or three-way fitting, one side will contain the stoplight switch which deserves mention. The fitting is normally secured to the cylinder by a hollow bolt that lets fluid go to the connecting line(s). A pressure tight seal is effected between the bolt head, both sides of the fitting and the master cylinder by concentric rings machined into the fitting and copper gaskets. Make absolutely sure every time this fitting is removed that all areas are extra clean and new gaskets fitted before the fitting is replaced. The stoplight switch will have two electrical connections on it; one for input current and the other for current to the lights. Next in the sequence are the lines. It seems that 99 percent of the special cars built have the brake lines run much too close to the exhaust pipe(s). Suffice it to say that the lines should be as far away as possible, and shielded from flying debris.

The rigid lines of a car's brake system are seamed steel tubing with an inside diameter of ⅛- to 3/16-inch. Right here and now is where the boys are separated from the men. Never, never use copper for brake lines. We could go into a long discussion upon the properties of the two metals, but just for the sake of simplicity let us state that copper is for the birds as brake lines. It will crack under certain conditions and will tend to swell more than steel under the high pressures in a hydraulic system. On the other hand, just because a tubing has a copper look to it doesn't mean it is. Some brake line tubing is coated with copper, so to make sure just check a freshly cut end. The steel color will be unmistakable. And while we're talking about lines, be it known that lines should be free of kinks and flattened spots that might restrict flow. Forget the out-dated slip-on ferrule type end fittings unless you're absolutely forced into using them. Flared connections are much the best and a flaring tool costs very little at the corner hardware store.

At the fore and aft ends of the brake lines will be found flexible hoses connecting to the wheel cylinders. Two hoses will be used at the front and usually just one hose at the rear. As for hose, just be sure and buy a good brand and install it in such a manner that it doesn't get sawed off by flailing shocks, steering apparatus, springs, etc.

Well, we're finally down to the wheel cylinder. In its most common form it consists of a plain open-ended bore, a couple of pistons, cups, a compression spring, two openings and a couple of flexible boots to keep out dirt, dust, mud, etc. The cylinder itself is made of a close-grained alloyed cast iron like the master cylinder. Suitable mounting bosses are provided to bolt it to the backing plate. The bore is machined to exacting standards and lapped to a high polish. Cups are much the same as in the master cylinder and rest in the same position relative to pressure. The pistons are normally made from aluminum alloy and the outer ends are made to accept the ends of the brake shoes or the strut that transmits pressure to the shoe. Between the two cups is located a light compression spring that keeps the cups in contact with the pistons when pressure is released. There are two openings in the cylinder bore to the outside. One goes to the brake line hose, the other to a threaded bleeder fitting. This bleeder fitting is used to release air trapped in the system. The cylinder's operation is simple: when pressure is applied the two pistons separate, causing the brake shoes to come into contact with the drum. When the pressure is released, the tension springs on the shoes pull the pistons toward each other, forcing the fluid back up the lines and into the master cylinder. This, in a nutshell, is the hydraulic system. ■

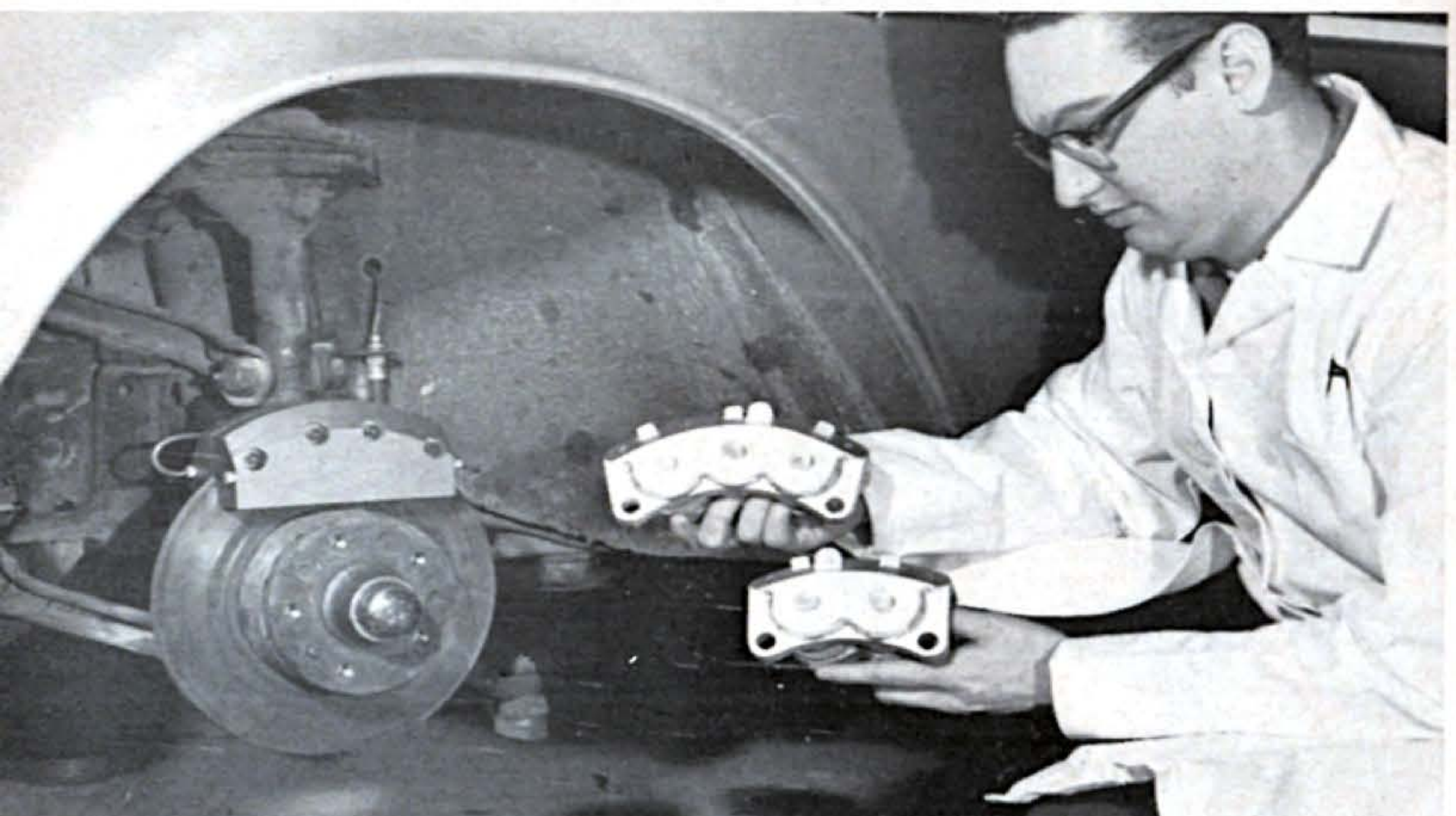
The Hemphill Automatic Brake system uses this vacuum-operated "brain." Single rod to accelerator allows brakes to be applied in emergency by lifting foot from throttle.



DISC BRAKES

IN THE simplest of explanations, the disc brake may be likened to a clutch assembly. The basic principle of braking—friction—is retained, but it is achieved in a slightly different way which has its advantages and, possibly, disadvantages.

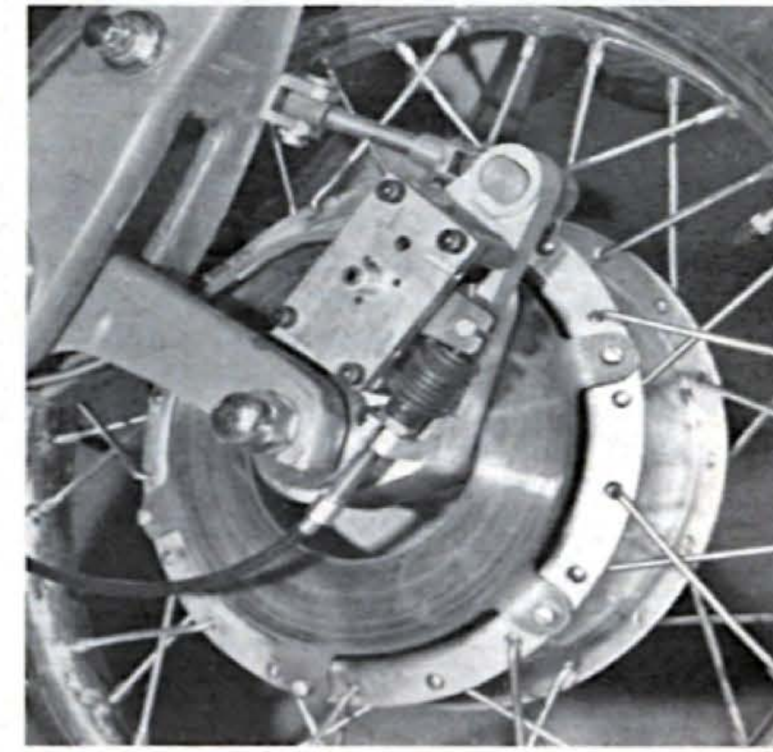
Discs first became popular with the majority of people in the U.S. after their introduction on aircraft. The early units that appeared toward the end of the '40's and early '50's were generally of the single disc variety although overall design and operation was closely akin to their aircraft counterparts. The chief advantage of the disc brake is in its ability to resist fade, this property due a great deal to the ease with which the friction biscuits or "pucks" may be cooled by normal air and air circulated by the rotating disc. Another advantage is a greatly increased friction area compared to like-sized drum units and in some cases the units may even prove to be lighter than their drum counterparts. This weight comparison is especially true of American cars, but there have been European cars fitted with drum brakes actually lighter than discs. Dimensional stability of disc brakes is also very good, remaining relatively unaffected by widely varying temperature conditions. One of the disadvantages of discs is that slack bearings let the disc move axially and tend to push the pads away. This problem is negated by careful attention to bearings, something a conscientious rodder should do anyway.



Frank Airheart inspects patterns and new Airheart disc brake on Rambler test car.

New Airheart disc brake for karts is small, has been used on lightweight Formula Junior racers.

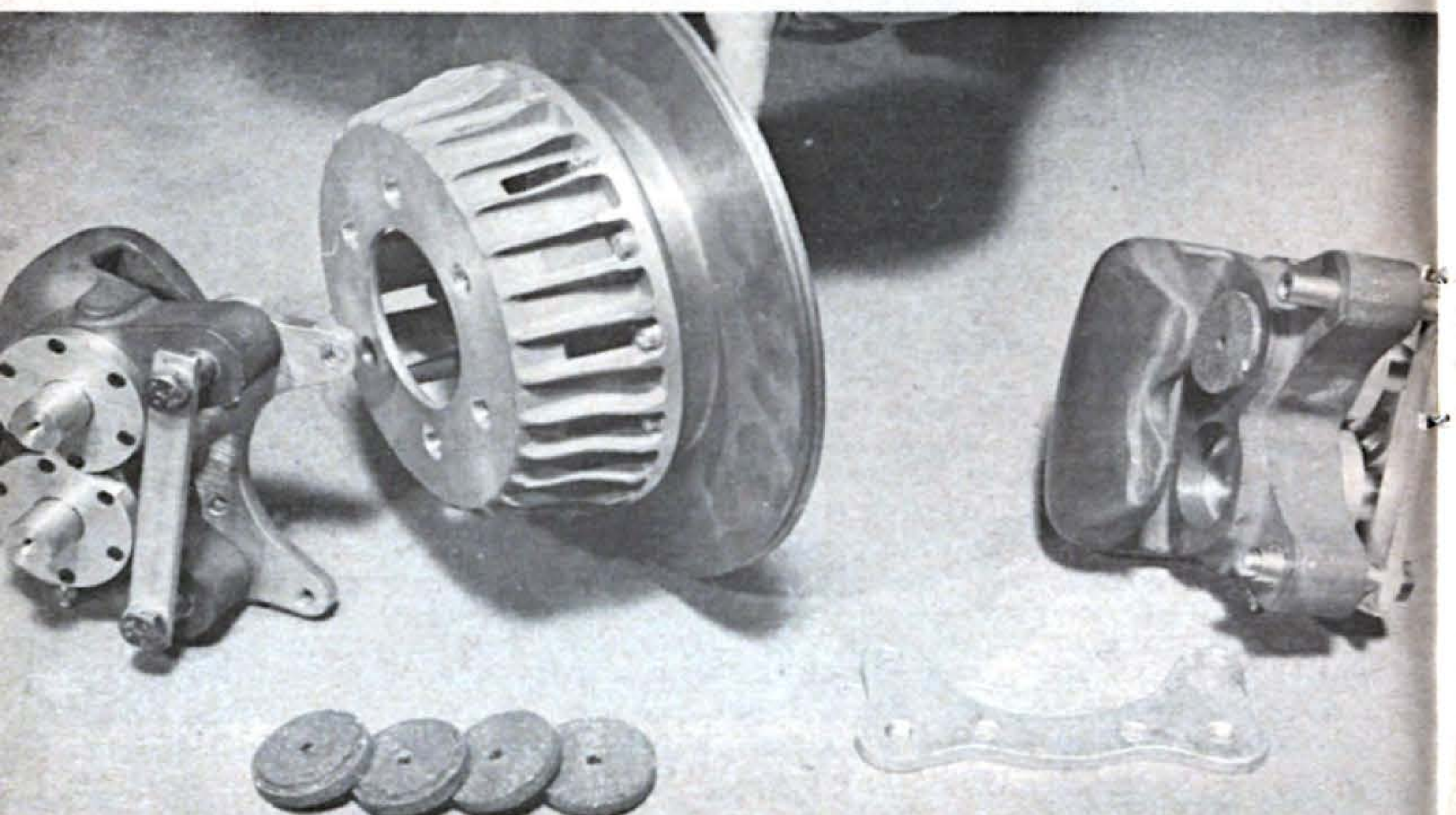
Another Airheart disc, this time on front motorcycle wheel. Caliper mounts in the center of the disc.

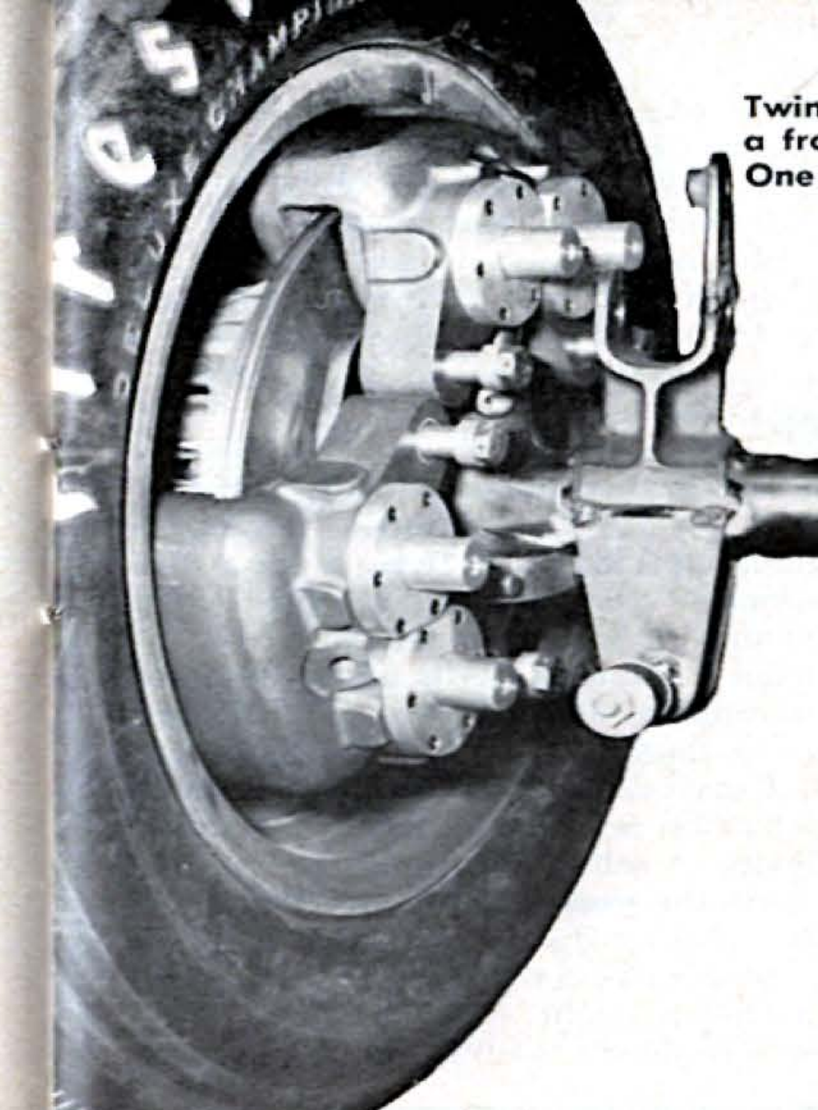


Searching our memory, we can recall only two American cars using disc brakes as production equipment. One was the no longer built Crosley and the other the Chrysler Imperial back around 1953. The Crosley units were made by Goodyear based upon Hawley designs. These units had a rotating steel disc as a part of the hub assembly. A single hydraulic cylinder was used on the inboard side of the disc with a back-up pad on the other side. The single piston and the back-up pad both had a friction face that contacted the disc upon demand. The cylinder housing was of the "floating" type (axially) and when the brakes were applied, the piston would move toward the disc. Upon contact with the disc, the piston would stop and the whole cylinder assembly would move, bringing the stationary pad toward the piston and squeeze the disc. At release of the brake pressure, return springs inside the cylinder separated the pads and the disc. This system proved to be very good despite its limited size. In fact, it was a relatively "soft" pedal pressure system and was some 40 percent lighter than the then current drum assembly.

The Goodyear type brake was refined until the disc was moved further away or inboard from the wheel. This placed it more in the open airstream for cooling and naturally upped performance. The disc brake so common in the U.S. during the mid-fifties was a combination of ideas from Goodyear and Ted Halibrand. Ted makes a number of specialty items for racing cars, the best known being alloy wheels and quick-change differential cases. Some of Ted's early brakes were of the two-spot design and found quick popularity among the racing fraternity, especially sprint and Indy builders. On these units, the discs were of a Meehanite iron casting, selected because of its extreme density and uniformity. A special cage assembly of aluminum mounted to the front or rear hubs became the mounting agent for the 7/16-inch disc. The disc was placed well inboard of the wheel, enough so a fresh blast of air could get to it. The wheel cylinder housing was of a magnesium alloy casting that held two 2⅛-inch diameter pistons with ⅝-inch thick friction material on their surfaces. Two back-up pads were on the opposite side of the housing. The unit floated axially on two locating bolts. As before, the pistons pushed out to meet the disc, then the whole housing slid in until the outer and inner friction pads were in compression against the disc. More recently, Halibrand came up with a triple spot caliper designed to meet just about any type of use. In general construction and design it was the same as the twin spot, however, the disc was (and still is) available in steel or polished chrome as well as Meehanite. Master cylinder design and pressure was experimented with by both Halibrand and individual builders and special brake fluid with a very high boiling point is now used. It was found that although the discs and nearby assembly parts tended to be cooled by the rotating disc and the general airstream, some limited instances had cropped up where the brake fluid was boiling. Investigation proved these cases to be attributed to shrouded lines, etc., thus the new fluid. The three-spot brakes were first introduced in 1956 and had a much better effectiveness than the double units (on heavy cars). Halibrand has since discontinued the triple spot and is back to the double and single spots. They have been found to be more than adequate for race cars, and a new midget spot is now available. This little unit has 1½-inch pucks and is great for lightweight midgets, sports cars and dragsters. Steel discs are recommended for dragster spot installations.

Various components that make up Halibrand-Goodyear disc. Alloy cage bolts to hub.

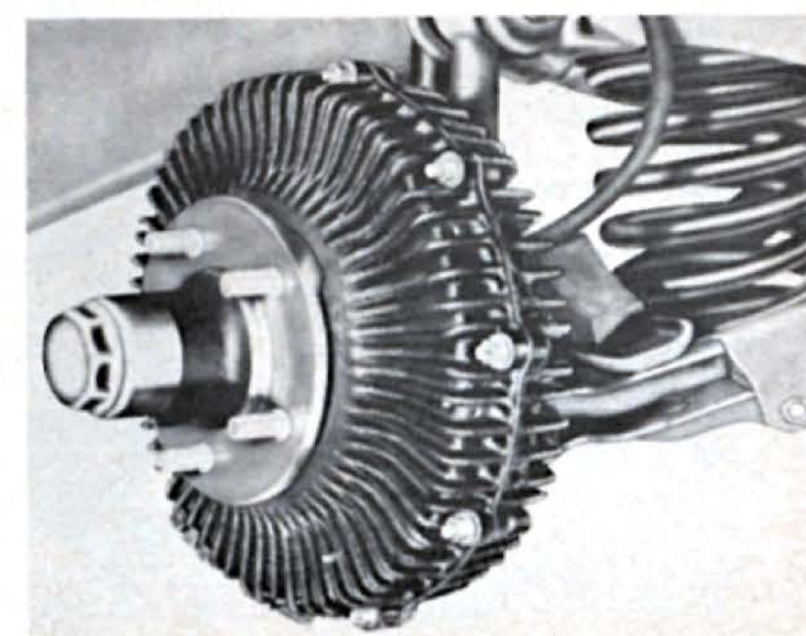




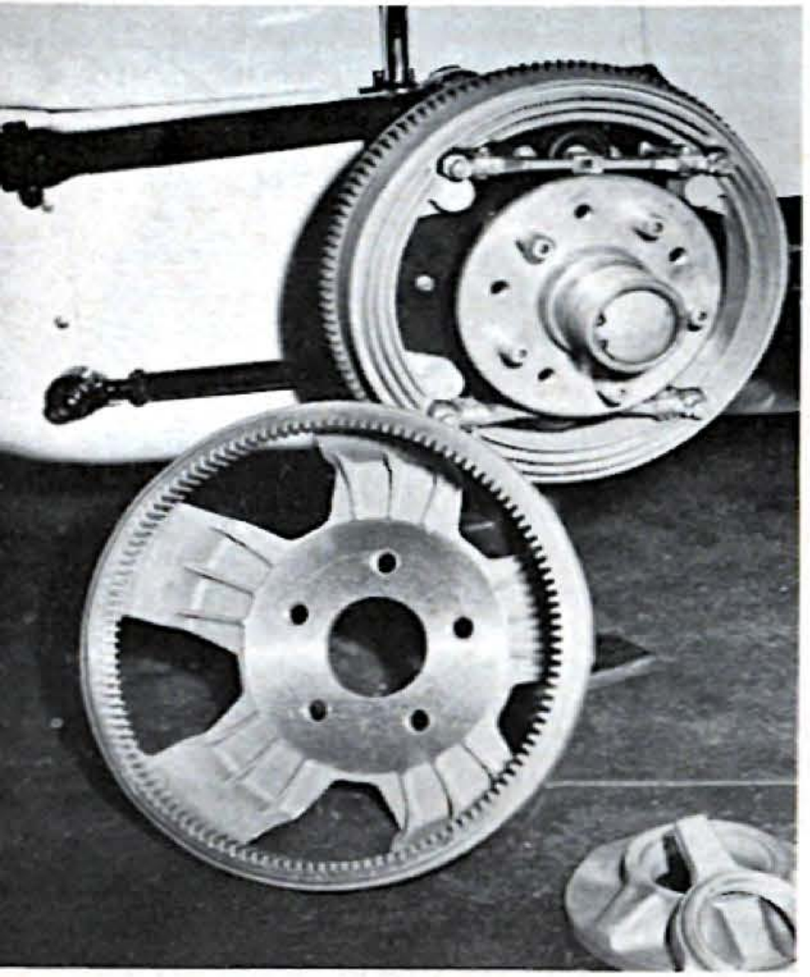
Twin Halibrand double-spot units bolted to a front axle provide extreme stopping pressure. One caliper set and disc weigh about 21 pounds.

It must be pointed out when talking about disc brakes that the disc design will and does use forces far in excess of its drum counterparts. In disc brakes, all pressure ends up as a strong compressive force and with such installations, the ratio of lining area to vehicle weight does not become so important as with drum units. Main reason for this difference is that a drum will take just so much force and heat until it distorts. The only limiting factor in discs is the breaking point of the materials. In the case of American disc brake designs, no servo motors or boosters are necessary, the required pressure being gained through mechanical leverage. There is a wide variety of friction materials available, from soft through very hard and for all types of service.

For the past several years Airheart Products, Inc., has been engaged in development work on a highly specialized disc brake application. Their ideas are for a relatively low-cost unit adaptable to most any vehicle and especially suitable for late model production cars with small wheels. The latest unit is designed to fit inside a 12-inch wheel or over a 12½-inch disc. This gives a wide range of use for a single unit, something heretofore rather uncommon. The Airheart prototypes presently in production stages are of the opposed operating piston design. That is, they have pistons and friction material on each side of the disc. When pressure is applied to the system, each piston moves toward the disc equally, thus the entire housing does not slide back and forth on pillars. The plans call for single, double and triple spots



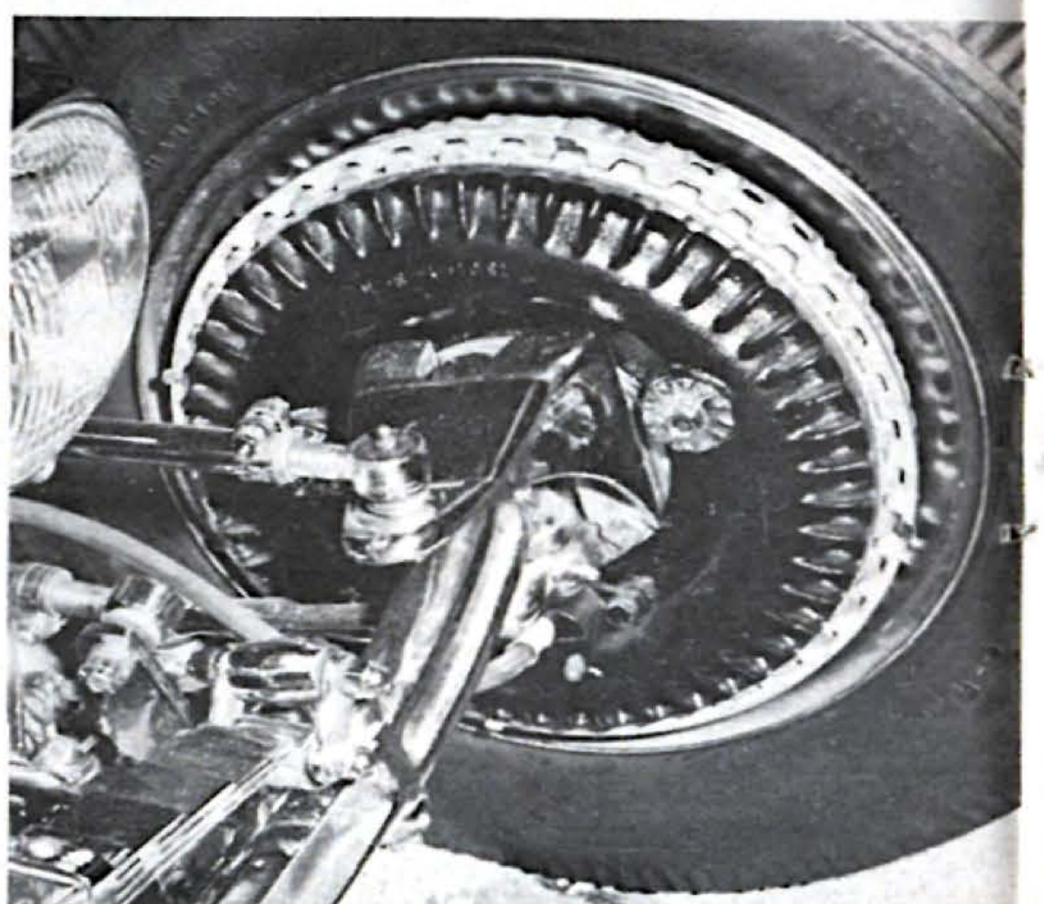
Fully assembled, the Chrysler self-energizing disc brake has a finned housing to help dissipate heat.



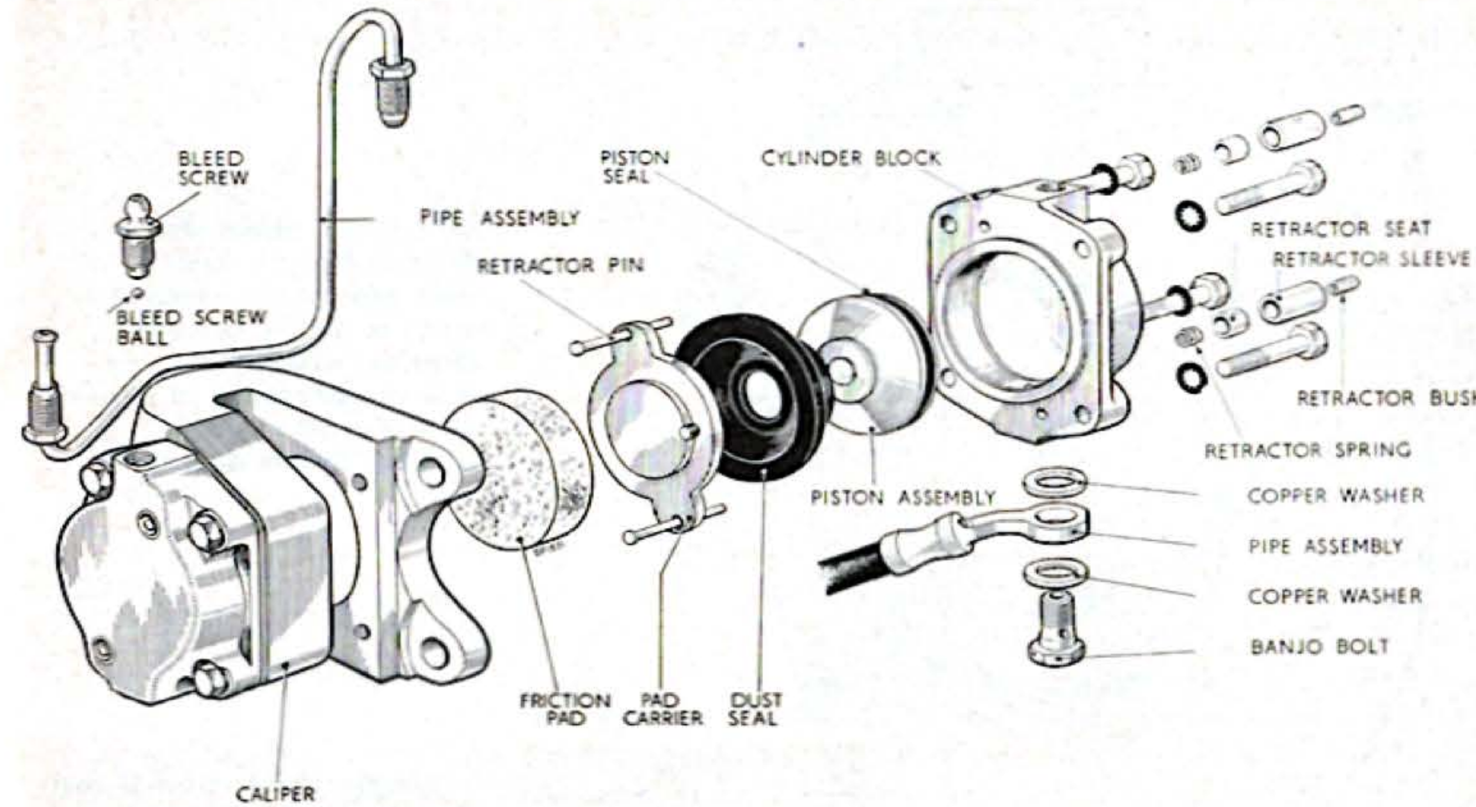
to be placed on the market. Actually, this is a bit confusing, since the single spot really has two operating pistons, the double has four pistons and the triple has six pistons and pucks. The Airheart units will have puck diameters of 1¾ inches and a piston pressure of around 900 pounds, to be determined by pedal leverage.

The big difference in the Airheart design is the caliper and its piston return device. The cylinder body is of aluminum alloy that weighs some two pounds; this counts all the inside goodies minus the friction pads. A major advantage of the newly designed housing is a minimum of deflection under high piston and line pressure. But even so, the very small amount of deflection is offset by the piston return device. A self-adjusting mechanism that keeps the pads a cool .015-inch from the rotating disc at rest, the device is so built that no matter how much body deflection might arise, the same clearance is always maintained. This insures

Mounted on a Kurtis sports car, Catton disc has serrations in edge of drum to drive like serrations on disc which rotates behind ribbed alloy wheel backing plates.



Kinmont discs from Cragar were popular on special rods during early 1950's. Now out of production, the brakes are considered something of a collector's item by many builders.

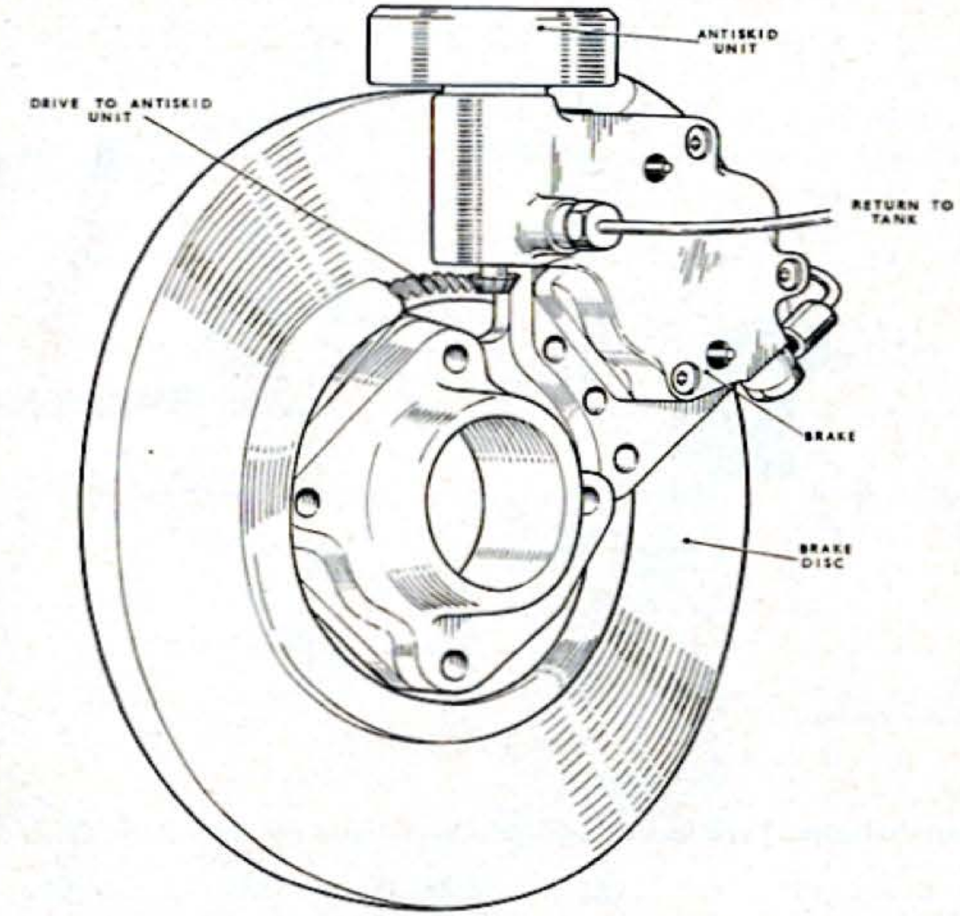


An exploded view of the Dunlop caliper. Two balanced pistons squeeze into the disc.

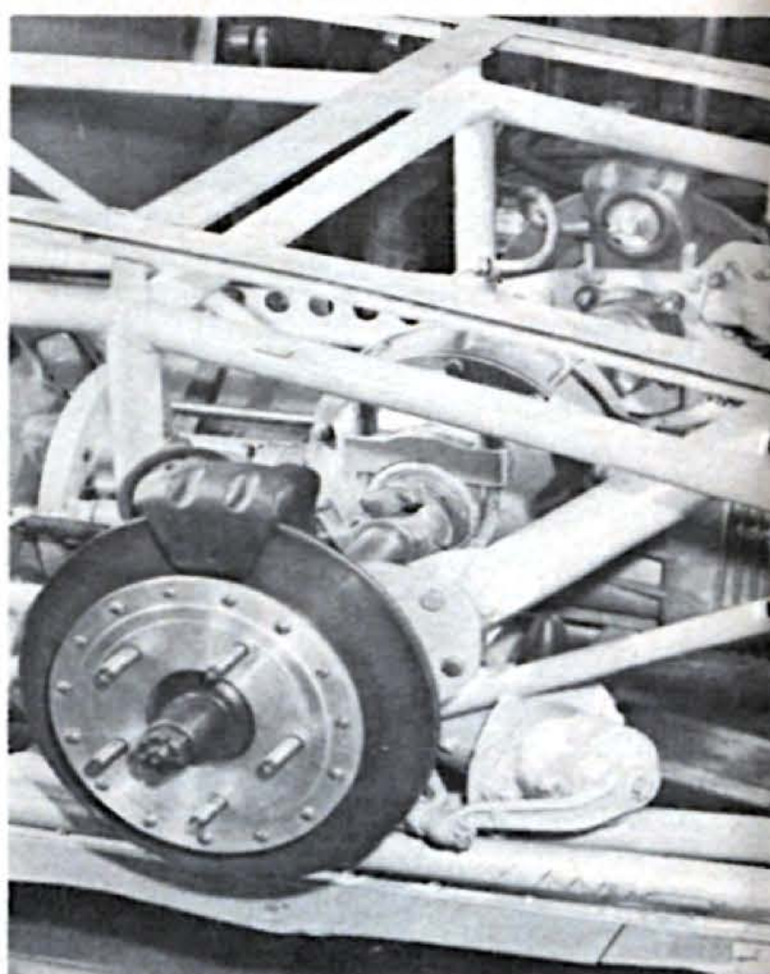
a cooler running and much more efficient system. In fact, Airheart has run tests where the metal disc actually melted under the extreme heat, but the brake still functioned properly and the cylinder fluid didn't boil.

The Airheart design may be marketed soon and will be available for everything from big passenger cars through race cars to karts and even motorcycles. Like some of the British disc brakes, the Airheart units feature integral fluid passages between opposing cylinders and individual bleeder taps taken off the top of the cylinder bore to make maintenance relatively simple. Discs are scheduled to be Meehanite or ductile iron castings.

In foreign countries, England leads the way in use and development of the disc brake. The British Lockheed, Girling and Dunlop units are the most common in Europe, being used successfully on everything from milk trucks to race cars. All these designs are similar to the initial Goodyear-Halibrand spots, except that they use hydraulic cylinders and pistons on both sides of the housing or "caliper" (like the Airheart). In the Dunlop brake, both Mark I and Mark II, the caliper wraps around the disc and looks nearly the same on both sides. Only one piston is used in each side, being balanced by a single hydraulic line. The friction pads are somewhat larger than the small round "pucks" used in American designs and are kept at a rest position of from .008 to .010 clearance from the disc by retractor pins which act as return springs. In addition, these pins provide a self-adjusting mechanism that keeps the above clearance constant throughout the life of the friction pads. There are also two common types of Girling brakes. They look a great deal like the Dunlop items to the untrained eye, incorporating the same wrap-around caliper design. Two pistons are used, one opposite the other and the later design has internal porting between the separate housing for hydraulic fluid balance between the pistons. The British Lockheed brake is made in two general sizes, type M for medium duty on cars weighing around 3100 pounds.



This illustration shows a Maxaret anti-skid unit mounted integrally with a single cylinder Dunlop disc brake. Hydraulic pressure in brake is released slightly as disc slows or stops.



Single Halibrand-Goodyear spots were adapted to a deDion rear end made of early Ford parts on this Bonneville Streamliner.

Type H is a heavy duty option built for cars weighing over 3100 pounds. Like the other two English brakes, the Lockheed uses balanced pistons straddling the disc. An internal balance system keeps the pistons in tune.

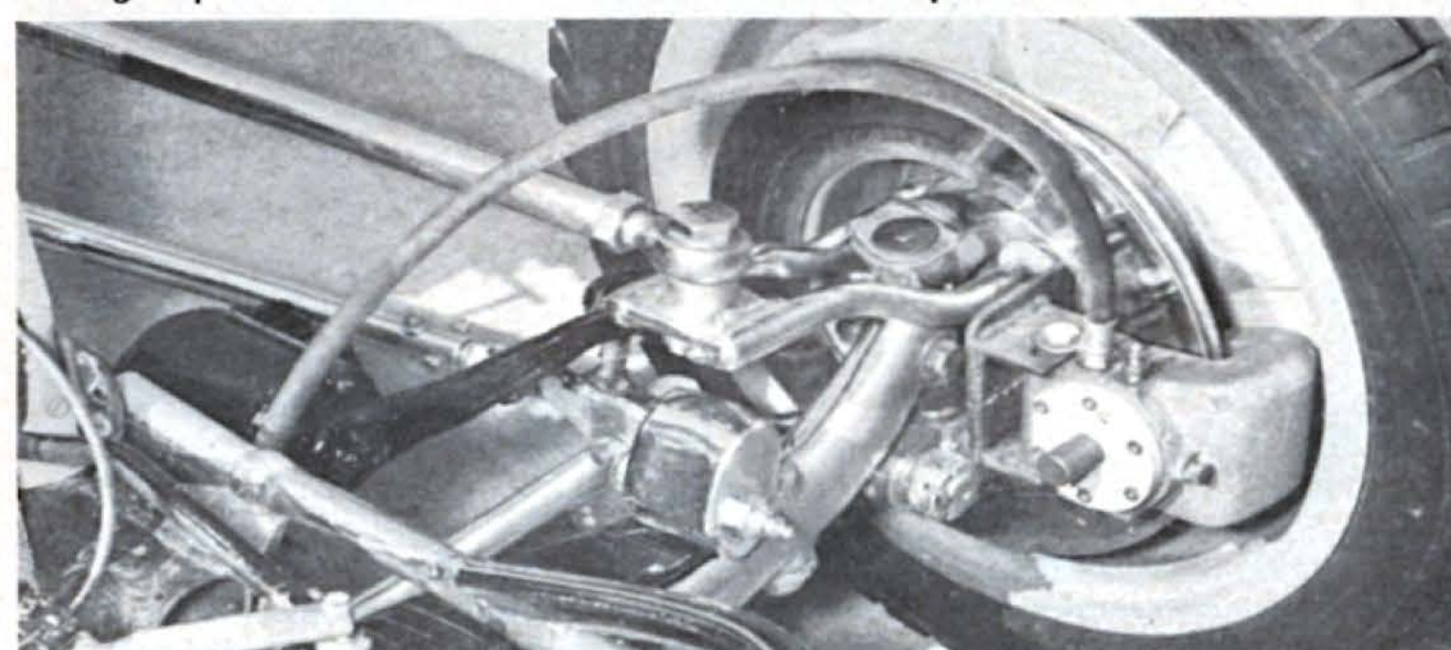
There are a great number of these English disc brake systems presently in the U.S., primarily because of their widespread use on such cars as Jaguar, Austin-Healey, MG, Triumph, etc. They make a relatively inexpensive conversion and parts are readily available. On the *Hot Rod Magazine* experimental street roadster XR-6, some problem was experienced in finding front wheels for the Volkswagen front end assembly. Special sports car builder Bill Devin was told about the problem and he recommended using the entire hub and brake assembly from the front of a Triumph TR-3 sports car. A very little machine work on the hub for different bearings and the hub slid right onto the VW spindle. A small mounting bracket was built from the former VW backing plate mounts for Girling calipers and the job was complete. Thirteen-inch four-bolt pattern Corvair-Buick Special-Falcon wheels bolted right on but they hit the calipers. The Girling calipers have since been replaced by the new small-space calipers being built by Airheart. Cost of the two hubs and brake items ran to just over $60 off a wrecked TR-3.

The use of discs in preference to drum brakes is strictly up to the builder. Each does a specific job, and usually does the job adequately. Design restrictions during the past several years on U.S. cars will undoubtedly force some consideration of disc brakes as original equipment. This is especially true when you consider that a good drum brake needs some area—area it is being squeezed out of by smaller and smaller wheels.

Right now might be a good time to consider brake mounting. On cars having independent suspension at the front, rear or both ends, inboard or outboard brake mounting may be considered. Actually, the problem is one of sprung versus unsprung weight. If the massive drum brake, or for that matter the disc brake, is mounted outboard, its sheer weight tends to magnify every road irregularity. On independent suspensions the brakes may be mounted inboard, but then the problem of cooling arises. About the only successful inboard mounting of front brakes was on some Lancia and Mercedes-Benz racing cars. This is an expensive and difficult operation, so let's assume that the average builder will just consider inboard mounting at the rear. It isn't too hard a job, but the heat generated by the differential assembly tends to raise the operating temperatures rather high. Then, too, the possibility of oil from the rear end or transmission is always there to think about. Both of these items will cause worry with a drum braking system, but not nearly so much with disc brakes.

Whatever the problems that your own individual installation might propose, it is certainly worthwhile checking into using discs. Their initial cost might be higher than you'd like to go, but consider their qualities well and then make your decision. Whichever way you go, just make sure the brakes are in tip-top shape all the time. You can't afford not to. ■

A single-spot mounted ahead of the Ford axle and spindles on a dirt-track race car.



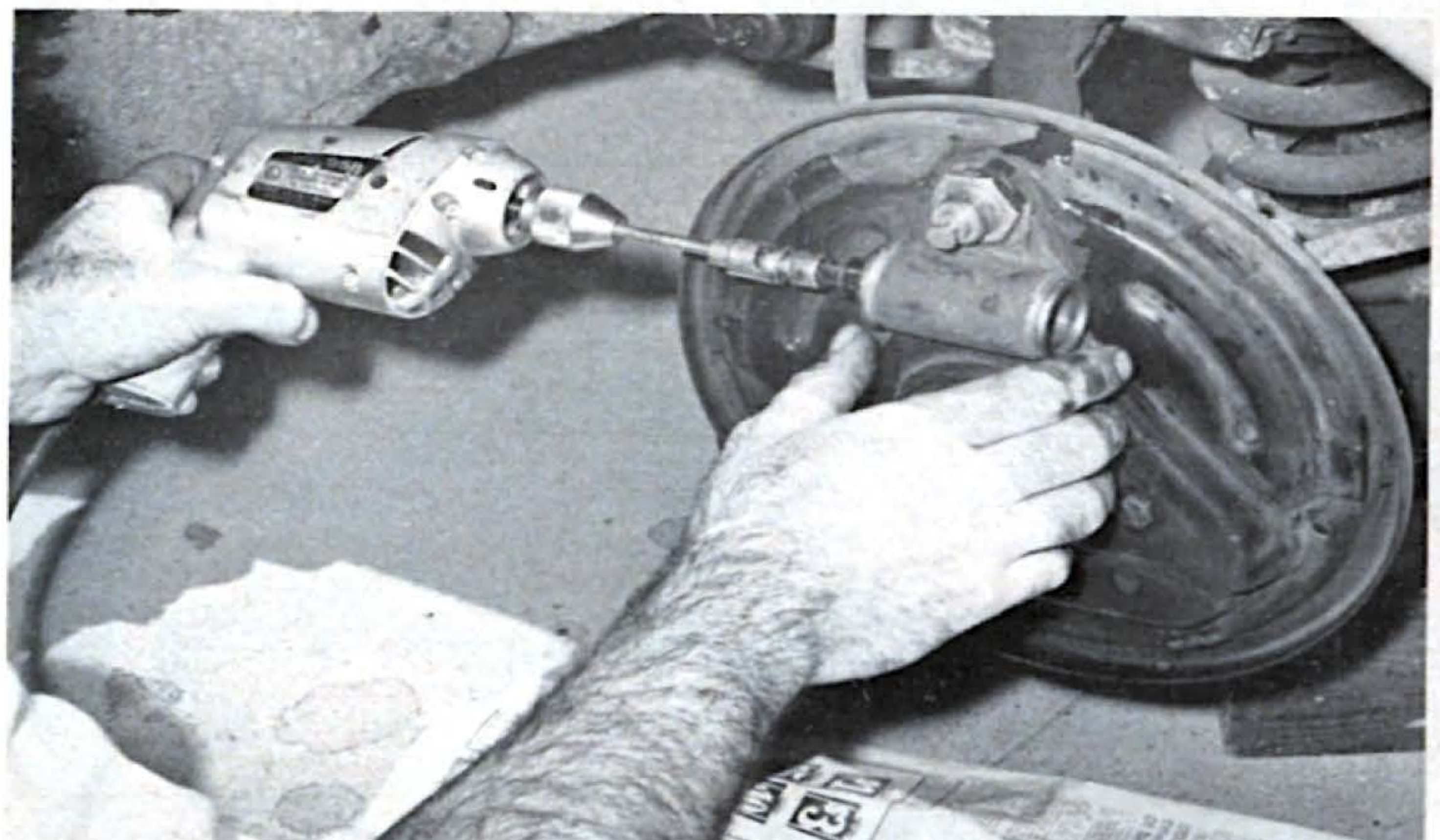
BRAKE MAINTENANCE

ALL the automotive engineering and know how in the world; all the most expensive and exotic construction materials; all the advantages of this rapid technological age are useless where your brakes are concerned if they are not cared for properly.

Unfortunately, the average auto owner tends to treat the brakes with a lackadaisical attitude, preferring to spend normal up-keep time and money on the paint job, upholstery, etc. And the brakes respond by acting like fair weather friends. When the sun is out, they're at least acceptable, but when the weather is bad and the chips are down, they're nowhere to be found. You may be just such an average motorist, or on the other hand you may be a brake specialist. Either way, we'll pass along some mighty helpful basic information on keeping your car's "binders" in tip-top shape.

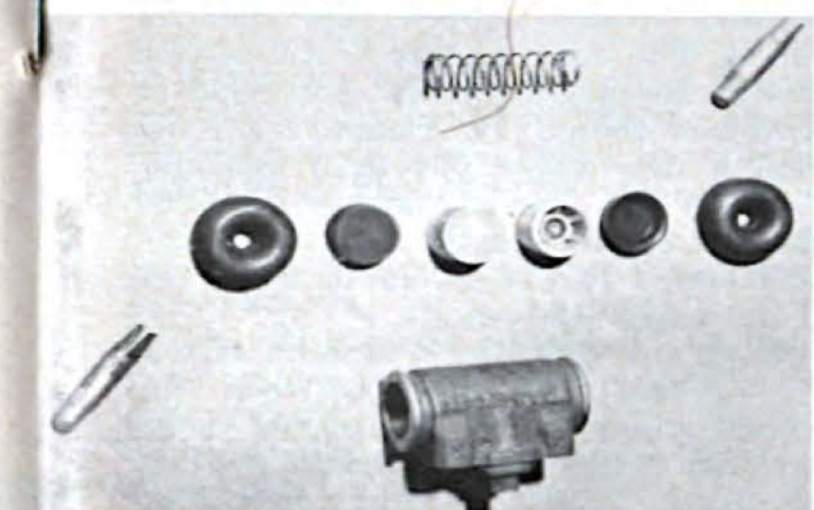
SHOE BRAKES

Generally speaking, the wear experienced in the hydraulic brake system is directly proportional to the amount of work done. Nose to the grindstone,



Proper brake maintenance and rebuilding usually starts with wheel assemblies. When honing cylinders, proper technique described in text must be followed for best job.

and all that bit. In order of wear, we find it most often necessary to repair and adjust first the shoes and lining, brake drums, master cylinder, and finally the wheel cylinders. Seldom do the brake lines (hoses excepted) need to be repaired or replaced unless they are subjected to extremely rough use. Just the same, a smart rodder keeps a close tab on the lines, especially at the end fittings.



Wheel cylinder rebuild kit contains spring, boots, cups and pistons. Struts and cylinder bodies are not included.

Wear of the individual wheel cylinder bores and pistons goes hand in hand with the travel the pistons do. This is under normal conditions and does not take into account foreign materials like dirt and water. As was pointed out by HRM's Racer Brown way back in 1955, the wear of such cylinders can thus be calculated with at least a reasonable degree of accuracy. For discussion purposes, let's again assume an area ratio of one inch for the master cylinder bore and one inch for the wheel cylinder bores. The first inch or so of pedal travel in an average system will be taken up by free play before any real pressure is accumulated at the master cylinder. After the pressure is begun, suppose it requires another 2 to 2½ inches before the brakes are fully applied. Again, with a mechanical advantage of 10 to 1, every 2½ inches of pedal travel under pressure will give a master cylinder piston movement of ¼-inch. With the one-inch bore diameter and ¼-inch stroke, .196 cubic inches of fluid have been forced into the lines and wheel cylinders. On an average car with four wheel brakes and everything else normal and equal, the wheel cylinder piston will move .032-inch which is 1/8th the distance traveled by the master cylinder and 1/80th that traveled by the pedal. This ratio will remain about the same, although the average system in good adjustment will not have this much travel. From this travel figure it might be assumed that the wheel cylinders require considerably less maintenance than the master cylinder, but everything works out to be about even. In actual practice, wear may not enter into the picture very much at all, but the wheel cylinders will often require more attention than the master cylinder. The tell-tale traces of something wet on the backing plates usually indicate leaking wheel cylinders (or perhaps a loose hose fitting or ruptured hose).

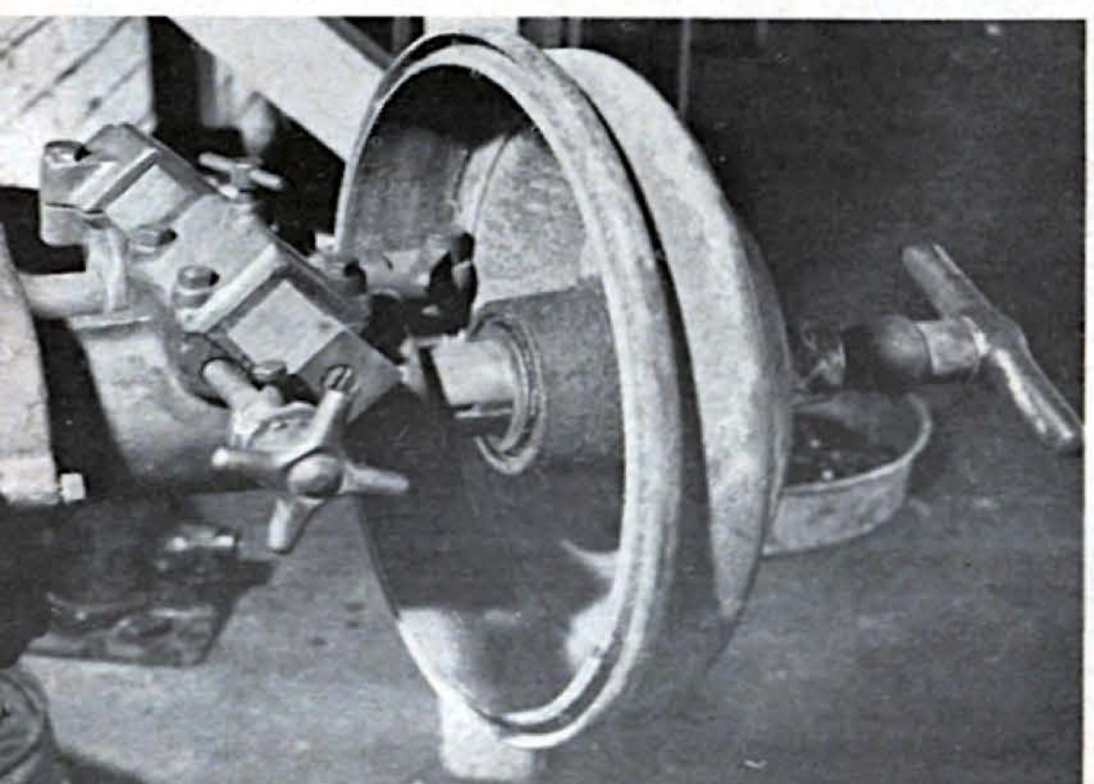
It is the basic cause of economics that leads most rodders to rebuild the wheel and master cylinder units on their car. New items are available, and often the cost is relatively low considering the possibility of making an error in such a critical automotive system. Either way you go, with new or rebuilt equipment, it won't hurt to know how the repair job is handled.

Rebuilding kits (wheel cylinders) usually contain everything but the cylinder housing, so take the various pieces out and use them for paper weights. Right off the bat the most important part of the entire job is at hand, that of honing or lapping the bore. Clean everything first in trichlorethylene, Bendix "Metalclean" or some such cleaner. Lapping equipment probably won't be handy, but it does give the best finish to the bore. As a secondary measure the hone will do. Honing should be done with the stone and cylinder bore liberally bathed in cutting oil during this process. First, select a medium-fine grit hone and turn it at about 400 rpm. Work the hone back and forth the entire length of the bore leaving a cross-hatched looking surface. These apparent "scratches" should have a laced look with the lines intersecting at about a 45 degree angle. Use the medium-fine stone until all traces of scoring or marking are gone. Now, fit the hone with the finest grit stones available and after washing the cylinder clean of the finer grit residue, repeat the honing procedure until the bore takes on a uniform semi-polished look. If the score or corrosion marks can't be taken out by honing, throw the unit away and start over.

After all the honing is finished, the important job of cleaning up the bore remains. Hot water and lots of soapsuds applied with a stiff bristle brush (like a bottle brush) will float out any honing operation particles that remain. Don't use cleaning solvent or the like for this cleaning up, since it doesn't do the job. Dry off the cleaned cylinder with an air hose and put the repair kit parts in. Follow the included instructions in the kit to a 'T' and all will be well. Basically the same procedure is used on the open-end master cylinders.

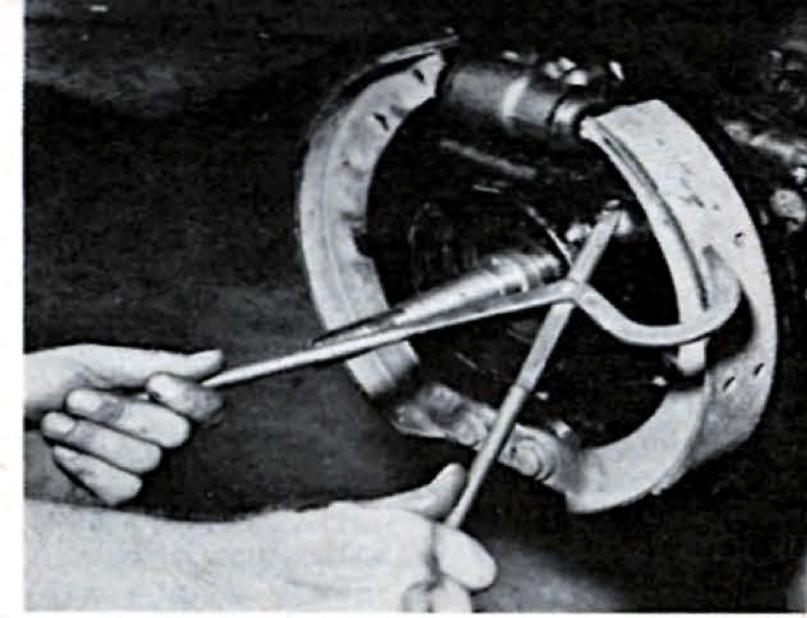
If you have step-bored or blind-end wheel cylinders, just be content to buy new replacements. Hones don't have the reputation of getting all the way down a one-way alley and making a perfectly true job at the ends. Before installing the rebuilt cylinders on the backing plates, check the bleeder valves. The critical place is the conical seat in the cylinder body. Any nicks or scratches should be cleared up, and then a new valve put in if possible. The way this bleeder passage is drilled into the cylinder at the top, no air can be trapped in the system if all is OK at the valve seat point.

If at any time the hydraulic system is "broken" anywhere between the wheel cylinders and the master cylinder, the system will probably have to be "bled." This "bleeding" procedure is a simple one. If any air is trapped in the system (usually due to some part or other being worked on necessitating disconnecting a hydraulic line) this air may be let out through the



The best maintenance and rebuilding won't give good brakes if drum is distorted or scored badly. Best advice is to take drums to brake specialist for inspection and turning, if necessary. Discard drums that have been turned excessively or show cracks.

A very handy tool to have if brakes are to be worked on is special brake shoe tension spring pliers. Ordinary pliers may be used, but be careful.



bleeder valves located in each wheel cylinder. If you have a "bleeder tank" handy or can borrow one from an auto shop, great. This tank will be of the pressure type, and will be partially filled with brake fluid. A coupling at the end of a length of hose will screw into the opening where the master filler cap goes. With 20 to 25 pounds of air in the tank, the brake fluid is forced into the master cylinder. Starting at the bleeder valve farthest from the master cylinder, slowly open the valve with a wrench until fluid is emitted. Usually air in the system will cause the fluid to come out in a spurting manner. When all spurting ceases and no bubbles appear in the fluid (which has been caught in a container), close the bleeder valve. Repeat the procedure at each wheel working from the farthest cylinder to the nearest to the master cylinder. When all air is removed, take off the bleeder tank. Open one bleed valve and work the pedal until the master cylinder fluid level is below the reservoir top from ½ to ¾-inch. Close the bleed valve and replace the filler cap.

A second and more common method of bleeding is referred to as the "buddy" system. Fill the reservoir to the top with fluid. Have someone work the brake pedal until fluid will have entered the system. Bleed the system as before, using the master cylinder piston for system pressure. Have your buddy pump up the brake pedal until some pressure is felt. Open the bleed valve at the wheel and after the initial pressure (and trapped air) is released, close the valve. This may be repeated several times at each wheel bleeder until the lines are clear. During this operation, the man working the pedal should not pump it while the bleed valve is open. Check on the level of the fluid in the master cylinder and keep it up to prevent air from entering the system from that point.

After the system has been bled, the brake pedal should have a firm or solid feel. If it is soft or spongy, then the bleeding job wasn't too good, so start again. Our own experience with jobs that weren't right has been to have a grabbing and/or spongy condition arise until finally there are no brakes at all after some operation.

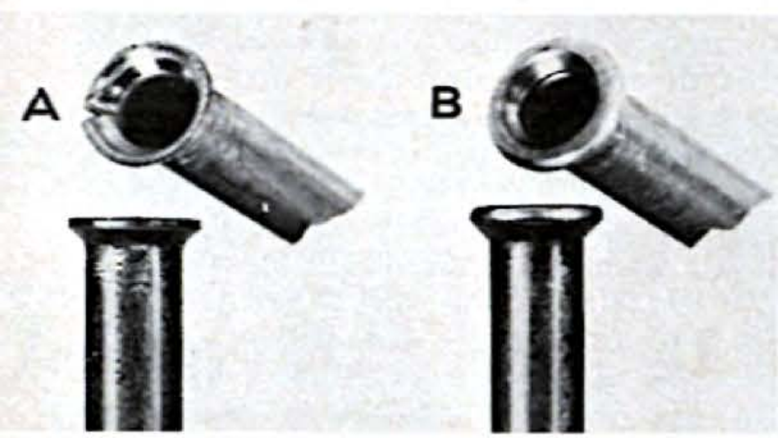
Incidentally, when filling the master cylinder, every caution should be taken to assure absolute cleanliness so that dirt or other matter won't get into the system. And a word about fluid. There are various grades of brake fluid, designed for all kinds of work. This might be heavy-duty fluid for trucks, or something specially formulated for high altitudes. In any case, select the best fluid for your job. In an emergency, a 50-50 mixture of alcohol and castor oil may be used if some suitable neutralizer is added to counteract the actions of any free acid in the solution. If absolutely necessary, water will work. But if water is ever used, be sure the system is *thoroughly* cleaned at the very first opportunity. Don't ever use a mineral or petroleum base product for brake fluid! These compounds contain chemicals that will attack the parts in the system and render them useless.

It is the brake shoe lining material that takes the most beating in modern brakes and consequently is the part of the brake system that normally requires the most attention. Brake linings usually require replacement somewhere between 20,000 to 50,000 miles, depending upon hardness of the lining material, weight of car, type of use, type of brakes, etc. A heavy car used for a lot of mountain driving will require harder linings and will often require them more often than a car driven in town at moderate speeds. At any rate, re-lining isn't too difficult a job.

Removing the drums is done at the front by taking off the spindle nut and taking the entire drum-hub assembly off the spindle bolt. At the rear, the drums usually pull right away from the axle flange, but in the case of pre-1949 Ford products, good luck! These bears are held on by a tapered fit, a half-moon key and a nut. Remove the nut and use an extra-large puller to get the drum off. If it can't be removed, just know that a cutting torch will do the job and a new drum is needed. When you replace the drum, a little threaded fastening (fancy term for bolt) anti-seize compound on the tapered axle ends will stop this problem next time.

Assuming that the wheel cylinders won't be taken off, be careful when removing the brake shoes. A special pliers is made to remove the tension spring(s) between the shoes, but in a pinch regular pliers will do with care. A good precaution at this stage is to blow off the exposed brake assembly with air to cut down the possibility of dirt, etc., from getting into the wheel cylinder. Do not remove the rubber dust caps from the wheel cylinders if they are not to be rebuilt at this time.

Check the drums to see if they are scored, out of round, etc. Fastest and most inexpensive methods of working on the drums we have found is to trundle them off to the nearest brake specialist and have the work done there. They know the proper tolerances and will do the job at a most reasonable fee, often for as little as a dollar a drum. Incidentally, it isn't the brake shoe rivets that wear grooves in the drums, it's dirt, and other foreign objects that enter the assembly and get lodged in the little rivet cavities. While working on the drums, don't keep anything with a distortion greater than ⅛ of an inch. This will keep you from having a drum that is thick in places and thinner in others, a condition which will lead to eventual cracking and failure. Also check the drums for cracks, and especially to see that they haven't been turned down before. If they have been turned previously, make sure that turning them again will not make them dangerously thin.



Single flanged hydraulic line (A) may crack and cause eventual system failure. Better method is double flange (B) which has superior strength.

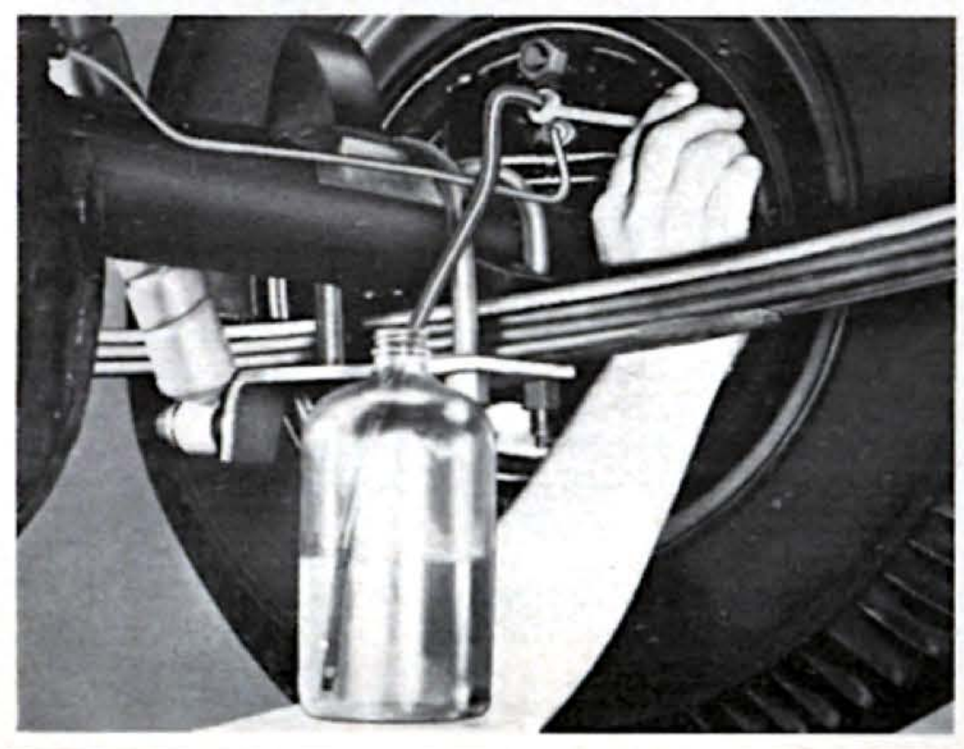
One-man brake bleeding job is simplified by use of pressurized brake bomb.

Back to the shoes. First, make darn sure of what kinds of lining should be used. This is dictated by type of use, weight of car, etc., and any reputable brake shop will have good recommendations. Don't use too cheap a lining, but on the other hand, just because a lining is expensive doesn't mean it is what you need.

You can get two general kinds of linings, bonded and riveted. Bonded linings use a super adhesive that is impervious to heat, water, etc., and will outlast riveted linings on an average of two to one. This is because riveted linings require replacement when the rivets start contacting the drum. Thus, only about half the thickness of riveted lining is ever used. With bonded units you can go clear to the shoe itself, if necessary. A "soft" lining will normally be selected, because of its better resistance to fade and softer pedal pressures. Whatever lining is used, you may purchase the complete re-lined shoe (usually on a trade-in basis) at your local parts store.

Should you want to reline your own riveted shoes you may. Replacement linings are readily available. Punch out the old rivets and discard the old lining. If the shoes are in good condition, set the new linings in place and secure with the proper type of rivets. Make sure the new rivets are snugged up good and tight (not tight enough to break the linings), and above all, make sure the new lining is in the same position as the old. In the instance where brake relining material comes in a long length cut to your specs, just clamp the proper lengths to your shoes with C clamps or the like and drill and countersink the necessary rivet holes.

Always grind the linings to match the drum bore for correct and complete surface contact. In some instances, manufacturers of special lining specify special clearances which must be closely set up. When the linings are fitted to the drums, replace them where they belong, making sure you don't have a



Air trapped in hydraulic system is bled through small taps at each wheel cylinder. Catch fluid in container for future use. Start at farthest cylinder, work toward the master cylinder.

trailing shoe in a leading shoe spot and vice versa.

Adjustment of shoe brakes is necessary if they are to work properly. This isn't necessary with the new self-adjusting units but not all of us have "little men" keeping a constant check on the shoe-drum clearances.

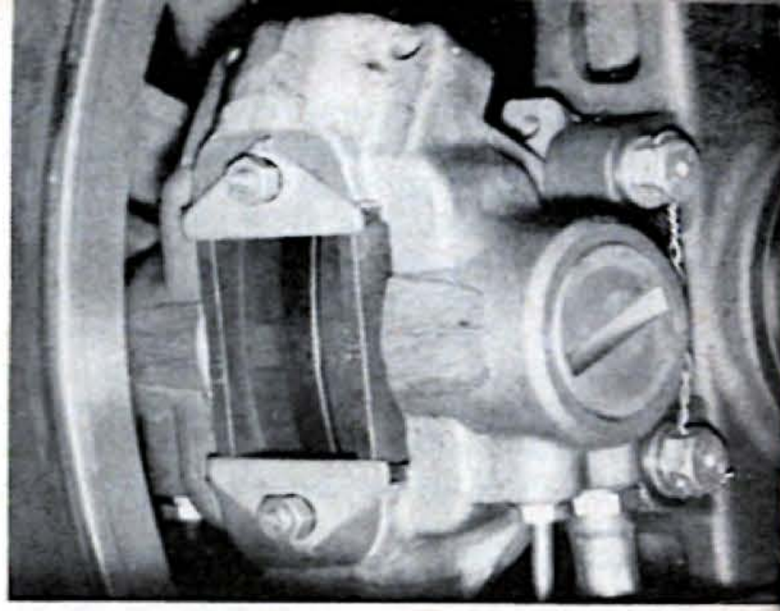
Most systems will have little slots either in the drums or backing plates where a feeler gauge may be slipped between the ends of the shoes and the drums. Clearances checked every five to seven thousand miles should be set at around .012. Check the manufacturer's recommendation here. Adjustments are made on the ratchet assemblies by special spoon tools and, on pre-'49 Fords, with a wrench.

Keep about one inch free travel in the brake pedal unless otherwise specified. This will assure that you don't have a constant pressure in the system and, besides, it will keep you from mashing your nose against the windshield on panic stops!

Handbrake adjustment should be made in the usual cable system so that at rest the rear shoes do not drag, but when engaged the brakes will hold the car. Some Chrysler products have an emergency brake connected to the drive train. This is a simple method of providing a parking brake, but just don't go around yanking on the parking brake handle while the car is moving. You might find yourself with a driveshaftless vehicle.

SPOT BRAKES

Maintenance of disc brakes is usually relegated to keeping a check on the friction material and making sure that everything is working properly. Follow the procedures outlined before for keeping tabs on the system as a whole, and little more is necessary with discs. Since the spot brakes now on the market all incorporate self-adjusting mechanism, checking the clearance between puck and disc is not a normal procedure. Most units have a method whereby you can watch the wear of the friction material. When it becomes necessary, just change pucks or pads. On the new Girling and Dunlop units the pads may be changed without removing the caliper, but on the British Lockheed, Halibrand and Airheart units the calipers must be removed from their rigid mounting to remove the worn material and insert fresh pads or pucks.



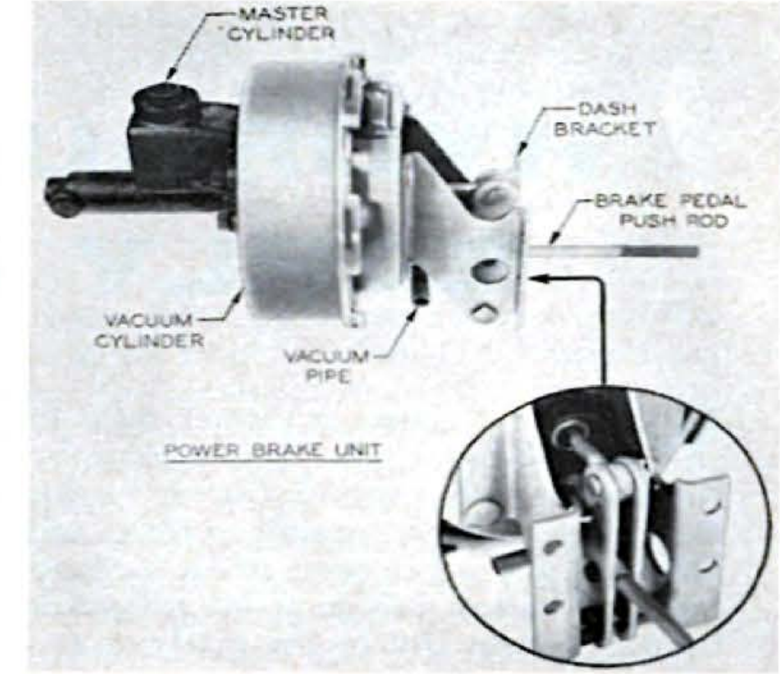
Brake pads in Girling and Dunlop disc brakes may be checked at a glance, changed by removing two triangle tabs.

POWER BRAKES

In essence, the power brake (or more properly, the brake booster) was originally designed to help in the Herculean job of stopping some of the big barges coming out of Detroit with inadequate brakes. The poor driver would have been required to take a course in leg muscle building before owning such a car were it not for the power options. On a light car this system is not entirely necessary, although it makes light brake pedal pressures even lighter. On a heavy car, the power brake helps beef up the driver's pedal pressure to give a big push on the individual shoes. On an average power system the driver supplies about ⅓ of the pressure used. Thus, using the ratio discussed previously, 65 pounds of pressure on the pedal of a normal system would give a line pressure of about 408 psi. With the aid of a power system this pressure jumps to a tremendous 1224 psi. You can imagine that the wear and fade of the lining material will be greater, even with "hard" linings.

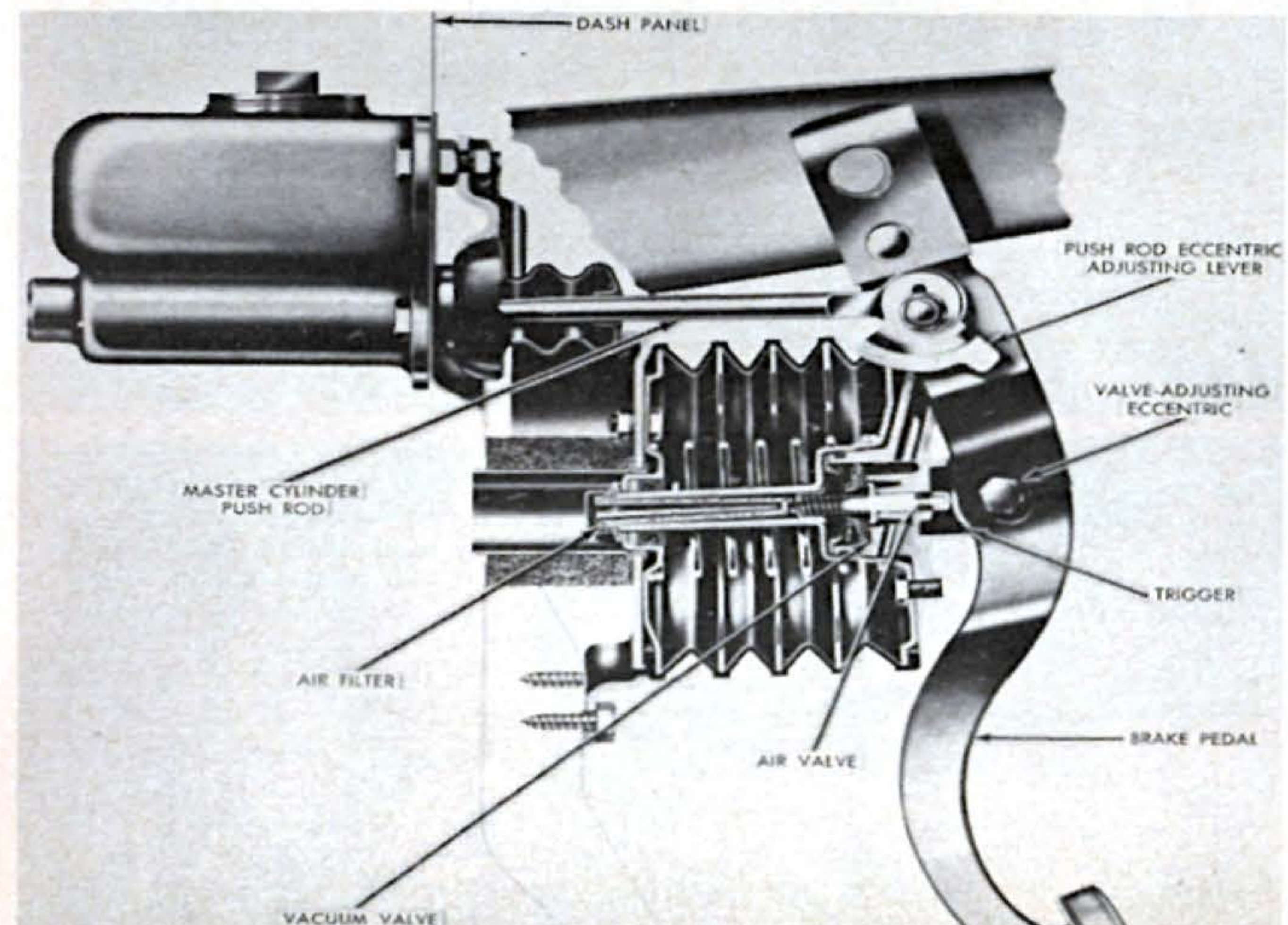
The two most general types of boosters in present use are of the vacuum-suspended variety. One contains a power cylinder with two pistons, a slave cylinder and a control valve. The other has a diaphragm chamber and a spring-loaded diaphragm with two valves. Manifold vacuum supplies the "power".

Maintenance of the power brake booster itself should be left up to a professional, because of the myriad operations involved. In the event it becomes absolutely necessary to overhaul the power booster the procedures outlined by the individual booster manufacturers should be followed to the letter. March, 1958 *Hot Rod Magazine* has an excellent article on general power brake maintenance. ■



Delco-Moraine power brake from Pontiac is easily adaptable to other automobiles.

Bellows type power brake such as used on Ford shows basic simplicity of design.

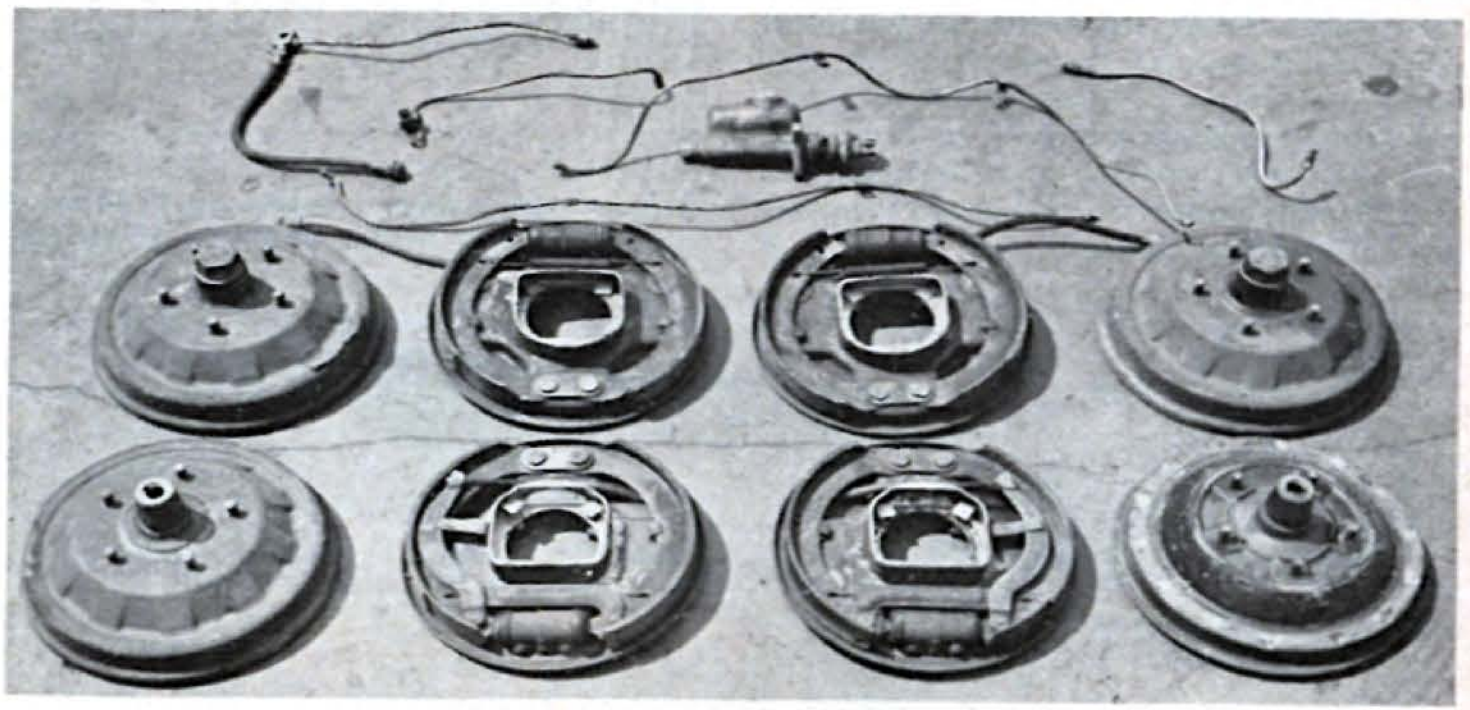


HYDRAULICS on EARLY FORDS

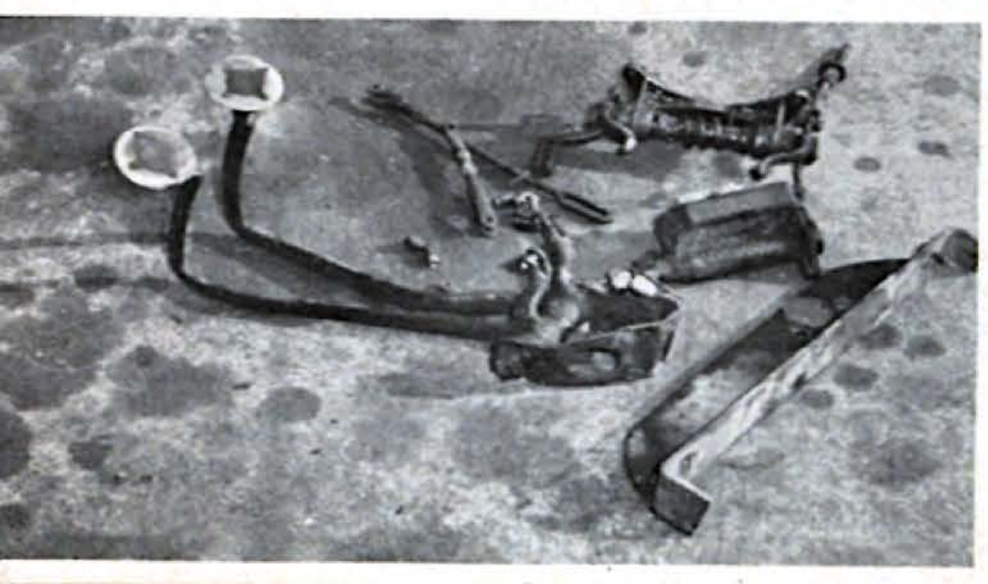
WE ONCE knew a farmer back in the Midwest who would come by our farm nearly every Saturday on his way to town. It was uphill to town and downhill the other way, with a sharp turn and narrow bridge about 100 yards from the house. Out by the mail box was a large blackjack tree with a trunk that looked like it had been through the wars. Well, every Saturday, as sure as taxes, this farmer would start on the return home and come down the hill by our house lickety-split. He had an old Model T and the brakes weren't what you'd call exceptional. Since he had to be going fairly slow to make the bend, he had to do a little improvising as far as stopping was concerned. Nearing the house, he'd hang the right side wheels in the sandy barrow pit. This would do a fair to middlin' job, but his final and constant hope was the tree. So he'd just whap it a good one. Hard on the T and the tree, but it worked.

Since trees may be hard to come by in your neighborhood, perhaps you will want to invest in a set of hydraulic brakes, especially if you have a pre-1939 Ford. It's a great investment, a relatively inexpensive one, and the saving on front end wear and tear is tremendous.

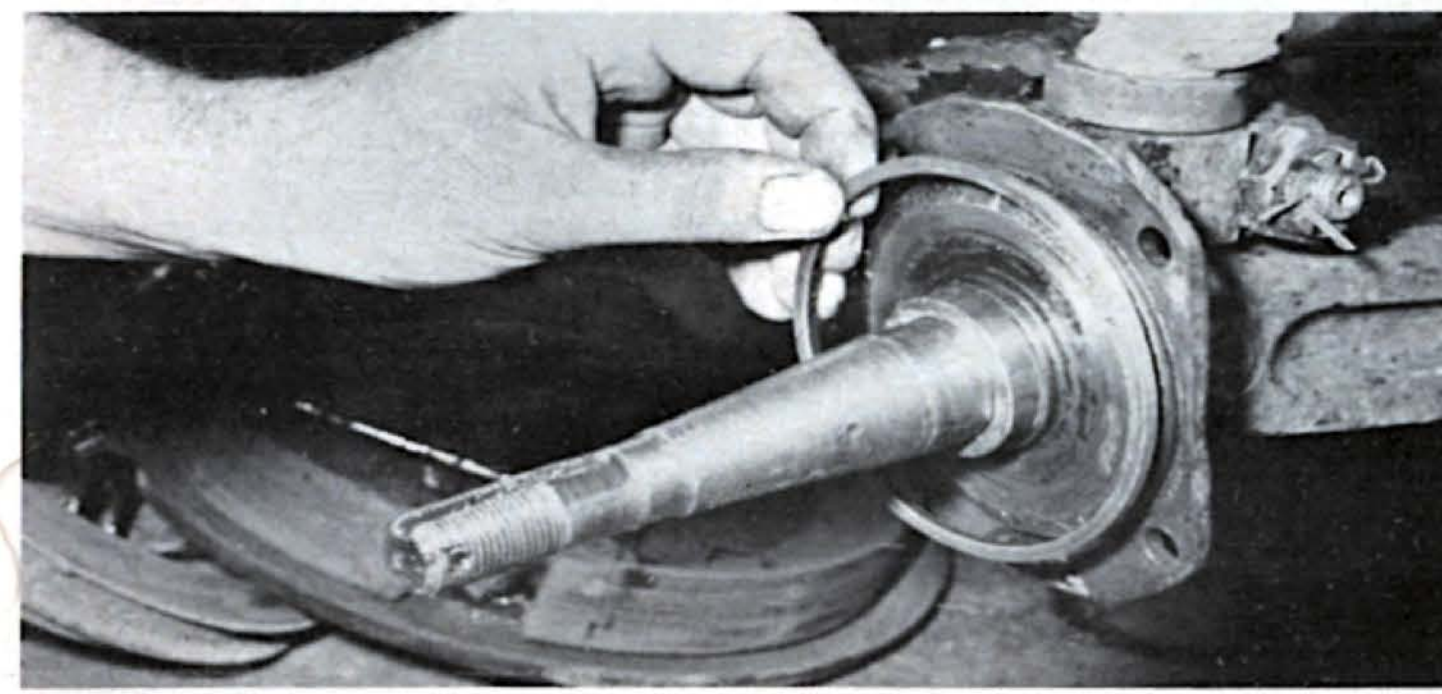
Starting with the easiest first, if you have a 1935 through 1938 Ford, the problem of hydraulics is primarily one of bolting on pieces. You can pick up the necessary parts at any wrecking yard for a song and sing it yourself. All that is needed is the front brake assemblies (backing plates, shoes, wheel cylinders, hubs), the rear brake assemblies (same as front), the steel hydraulic lines and the master cylinder. Supposing the whole kit and kaboodle from a '47 Ford is bought. First, either replace or rebuild the master and wheel cylinders. This will insure that you have top notch equipment. Next, buy new brake hoses, two for the front and one for the rear. Check the steel lines for cracks and re-



Virtually all that is needed to convert your early (pre-'39) Ford to hydraulic brakes are the parts shown here from '39-'48 Ford products. Replace or rebuild worn parts.



These parts were used to get hydraulics in an 'A', were later discarded for swing pedals. Note mechanical linkage.

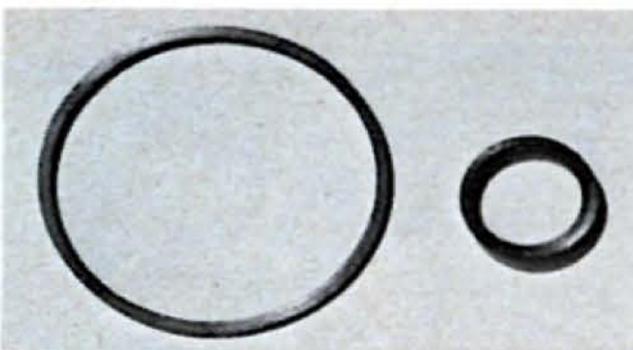


Large center positioning hole in hydraulic backing plates is larger than early brakes. Spacer ring must be used.

In place with spacer ring, holes in backing plate and early spindle mis-align. Use a rat-tail file to align.

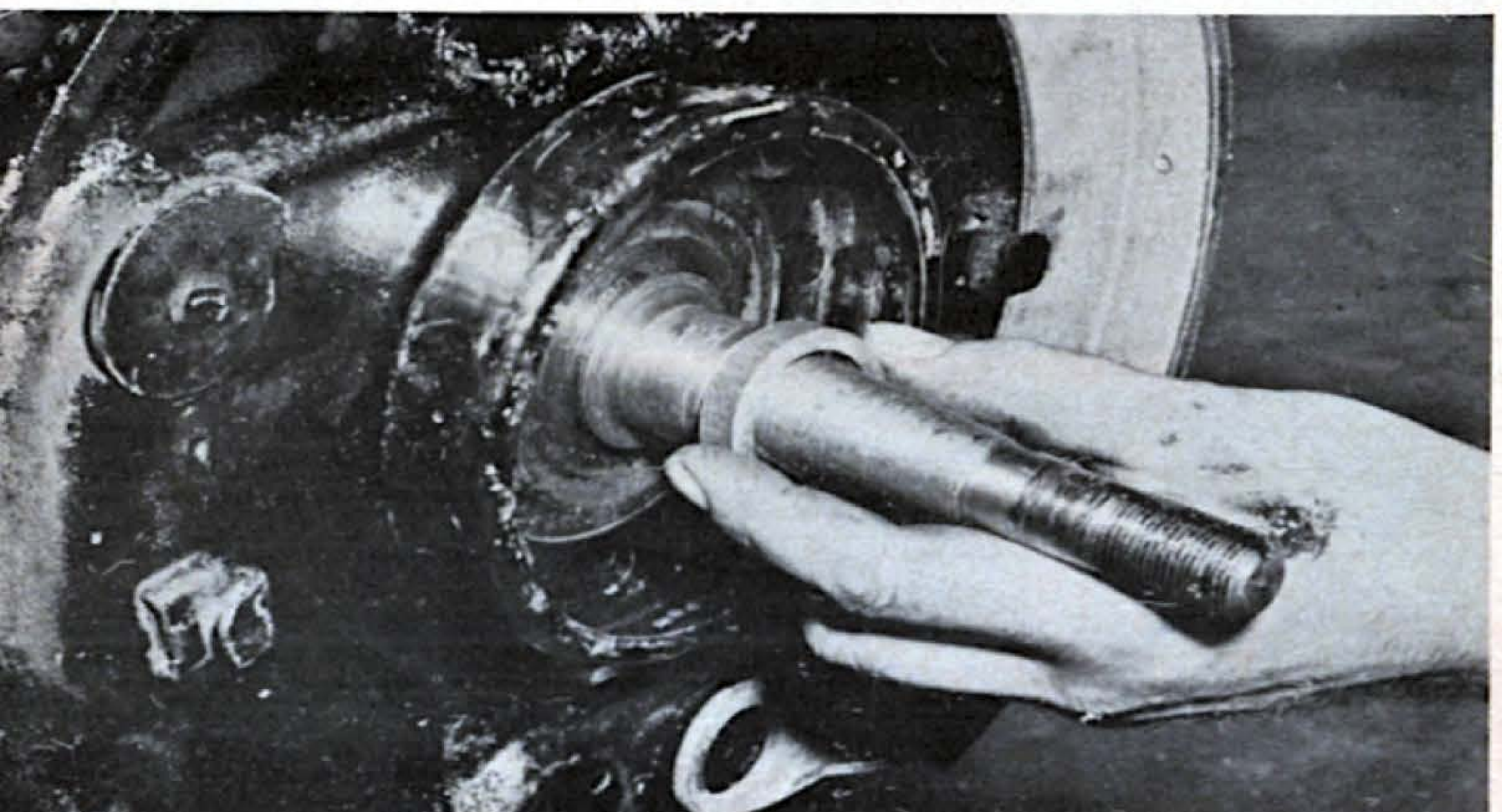
place if necessary. Remove the mechanical system presently on the car, including everything from the hubs through the shoes to the rods connecting brakes to the brake pedal. You can leave the mechanical cross shaft that bolts to the center crossmember in place if you want to. Hooking up the master cylinder is a chore that requires building support brackets. These brackets may be simple or elaborate, welded or bolted to the frame. Just be sure the cylinder is mounted so the connecting rod is in a straight line with its actuating mechanism. Keep the cylinder away from the exhaust and not too close to the ground where it could be knocked around. If you happen to want to use the entire cylinder/brake pedal assembly from a '39 or later Ford, this assembly can be substituted on the '35 through '38 frame rather easily. Locate the pedal assembly and bolt to the X crossmember in the same place the original pedals mounted. Cut the crossmember for clearance of the master cylinder which is directly behind. Don't forget a hole in the floorboard to service the cylinder.

If you want to retain the original pedals and a portion of the mechanical linkage, locate the master cylinder behind or ahead of the cross shaft at a convenient point. The determining factor here is the little cross shaft brackets that transfer pedal motion to fore or aft



Two spacers needed to put hydraulics on early Fords are available through most speed shops or obsolete parts dealers.

Small spacer is needed to space inner front wheel bearing and provide a seat for the seal. Grease baffle secures the large ring.

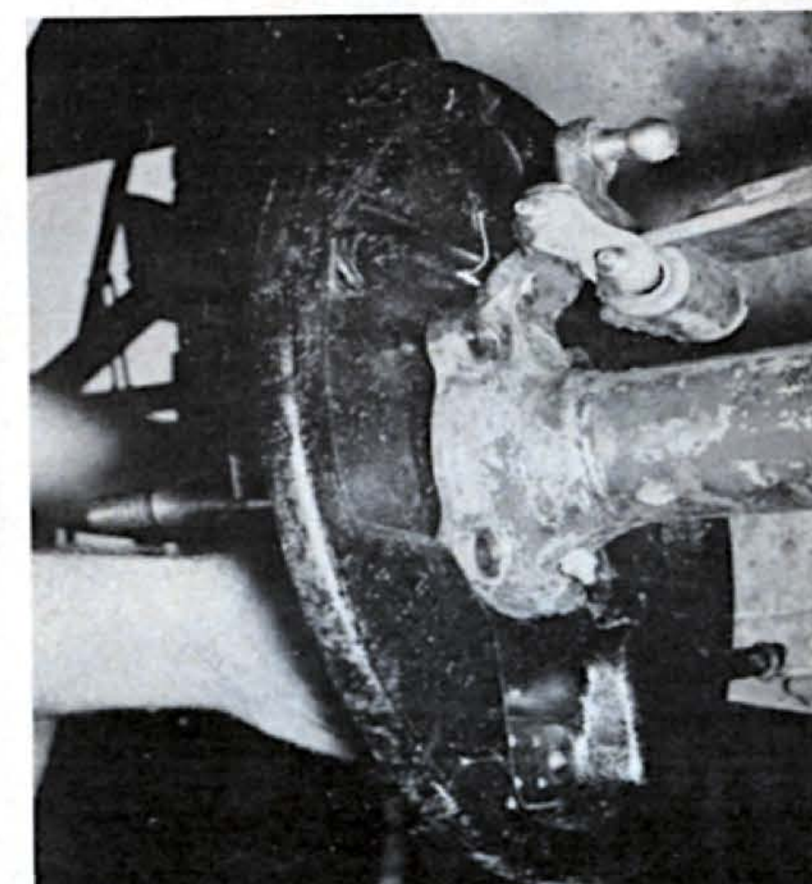


motion. Again, keep everything lined up and above all, make sure the master cylinder brackets are strong and do not flex.

The individual wheel brake assemblies will bolt to the front spindles and rear hubs with no major problems. (We might note that many rodders feel it necessary to exchange the entire suspension system to make use of hydraulics. In some cases, early bodies have even been fitted to late chassis just for this reason. Seems a lot of trouble for such a small amount of work necessary to make the conversion.) Fit new hoses from the wheel cylinders over to the frame, preferably near a line drawn vertically from the axle or spring. Make sure that all shock and steering linkage will be missed, and drill a hole in the frame just slightly larger than the end of the brake hose. The frame end of the hose has a round, thin flange about one-half inch from the end and a slot on two edges about one-fourth inch from the end. With the hose in position, the flange keeps it from going into the frame hole, and a U-shaped keeper on the inside of the frame keeps it snug. Brake lines may be positioned and secured on the frame much the same as they were on the '39 or later Ford. Most times the lines will prove slightly long, except for the line between the front two hoses and possibly the line between the rear wheels. If the lines

Hydraulic backing plates hit spring hangers on 'A' rear end, must be notched slightly for perfect clearance.

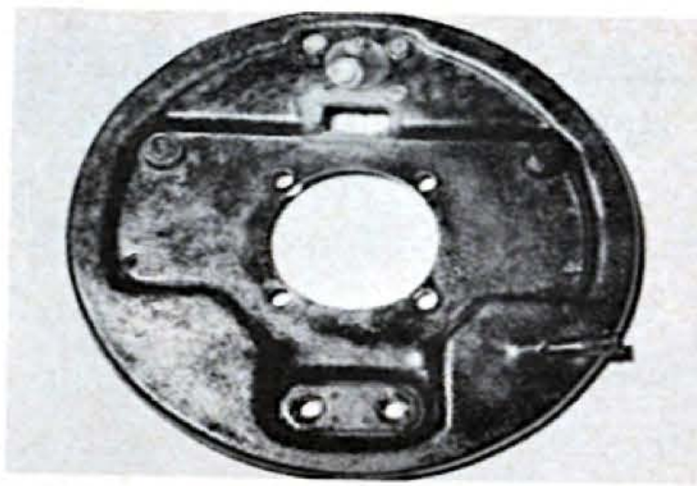
Master cylinder in this '32 is operated by original mechanical pedals via tab welded to bottom of brake pedal. Installation is neat.



are too long, take out your little tubing cutter and flanger and shorten accordingly. Any number of ways of getting the line to the rear end are used. The one seen most is by running a rigid line from the master cylinder aft to just ahead of the axle. This line is inside the lower lip of the frame. A hose connects the line to a T fitting on the axle housing about eight inches from a backing plate. Rigid lines then run across the top of the housing to each cylinder. Another method commonly used is a rigid line from each cylinder up the outsides of the radius rod to the front of the driveshaft. A hose connects the lines to the master cylinder. Mount the hubs and you're in business.

On '34 and older Fords (excluding 'T's), the problems are a bit more difficult, but still minor. First, contact any good speed shop and buy a hydraulic conversion kit. There are any number of kits available, but all you will need (assuming you have bought the complete hydraulic system mentioned above in a wrecking yard) are two steel rings that look like piston rings, two smaller adaptor rings that slide over the spindle bolts and two shims. Pull off the hydraulic system as above. For a neat looking installation, the front king pin sockets may be sawed off. When the mechanical linkage is removed, two sockets remain on the tops of the king pins and serve no useful purpose, so

Notch for clearance is cut just under wheel cylinder. This isn't necessary on '32 or later Ford rear ends.



If original Houdaille type shocks are to be replaced by tubes, original shock linkage mounts may be cut from top of the Model A rear end.

junk them if you wish. The two large ring spacers are slid over the 'A' spindle backing plate registers. They are just the thickness of the backing plates and 3/16-inch wide to make up the difference between the center hole diameter of 'A' backing plates and '39 or later backing plates. With the backing plates in position, note that the bolt-up holes in the hydraulic plates are spaced slightly wider than the 'A' spindle holes. A small rattail file alleviates this problem. Position the grease baffle and bolt everything up. The baffle keeps the spacer ring in place. Naturally you've re-shod the shoes with good friction material and rebuilt or replaced the wheel cylinders. Next, replace the 'A' grease seal ring on the spindle. The new ring is used to space the new hub bearing for correct drum clearance and for the new drum grease seals. Incidentally, on any hydraulic switch-over, always be sure that new hub grease seals are used where needed.

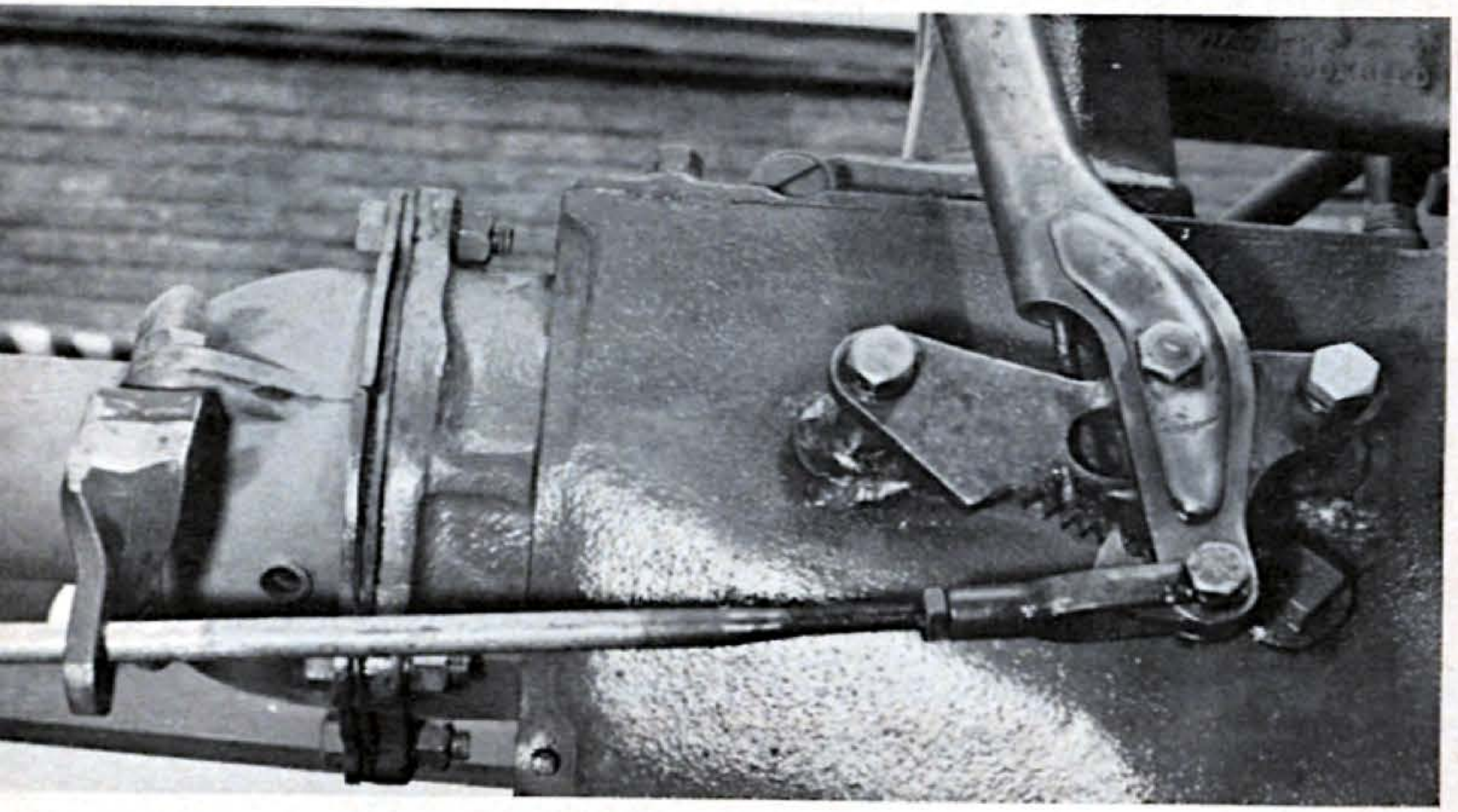
On the rear, a shim is required on each tapered axle end to space the drum the right distance from the backing plate. These shims are quite small and are a part of the average kit. The backing plates will bolt right up to the rear axle housings *after* a little clearance work has been done. First, the Houdaille type shock mount/spring hanger on the rear end will hit the backing plate. The area in question is

One method of line installation uses rigid line between rear wheels, flex hose to frame rail and rigid line.

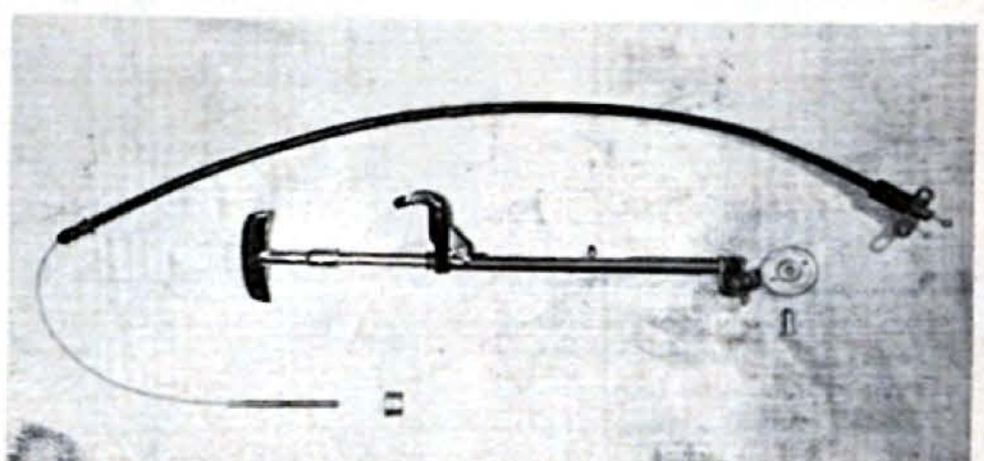
Mechanical linkage cross-shaft may be retained, hooked to master cylinder. Make sure all braces are strong and welded well.

just over one inch wide, a half-inch high and just below the wheel cylinder. Cut a notch at this point for clearance and everything is kosher. The brake line might interfere here, so if you are not going to use the stock shock links, cut them off. If they are to be retained, file a depression in the top of the spring hanger to the back side of the shock mount for the brake line to snuggle into. Now bolt on all the jazz and connect up the lines. '32-'34 cars don't have backing plate clearance problems.

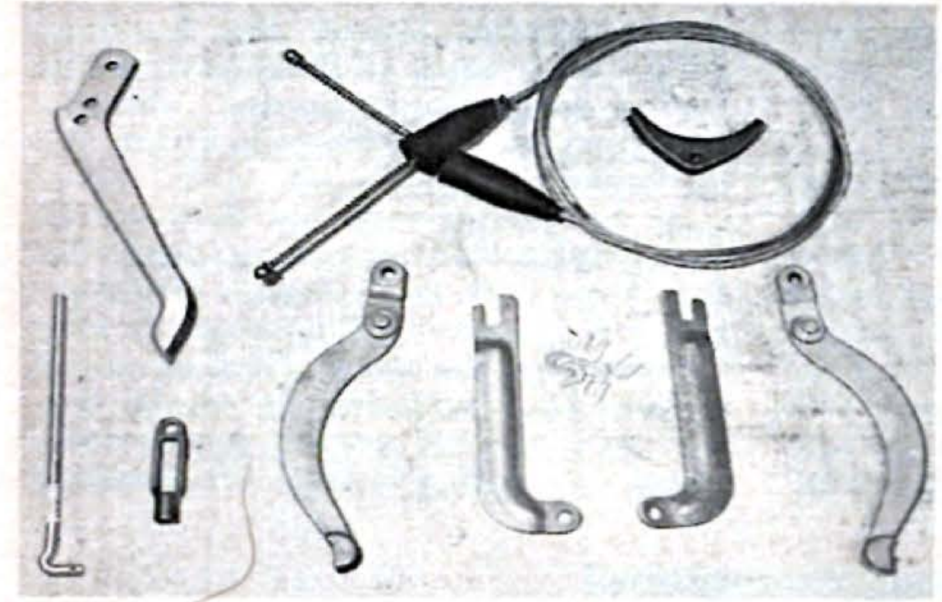
As before, master cylinder location is up to you. However, a couple of pedal arrangements are available. On the 'A', let's assume that the old four-banger is to be discarded. Well, since the pedals connect to the transmission, there goes that. A small diagonal brace from the crossmember to the frame side rail will serve to mount the hydraulic pedal assembly, and brackets must be made for the master cylinder. On '32 through '34 Fords, the original pedals and mechanical cross shaft may be used as on



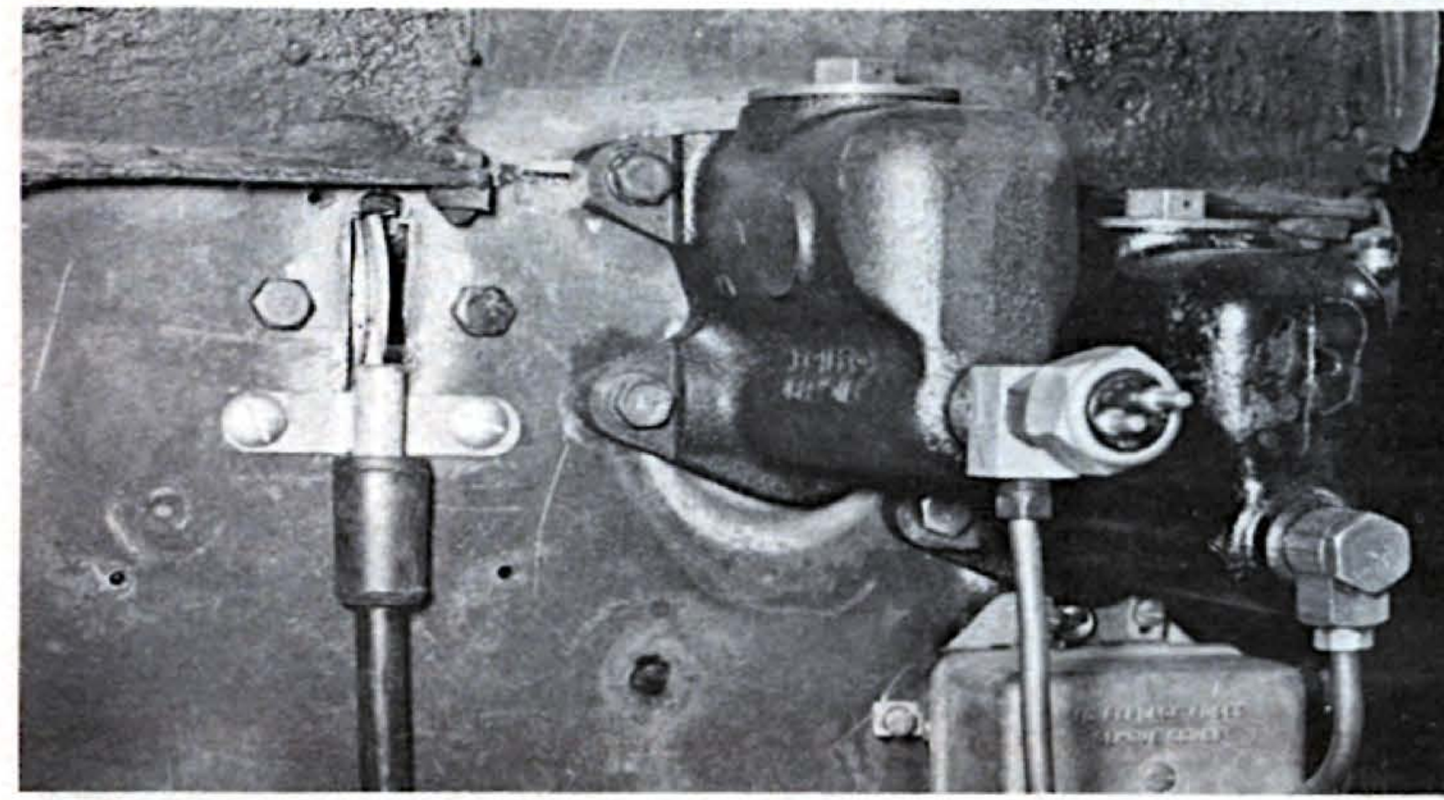
Mechanical emergency brake handle from 'A' may be welded to later Ford case, hooked up to work.



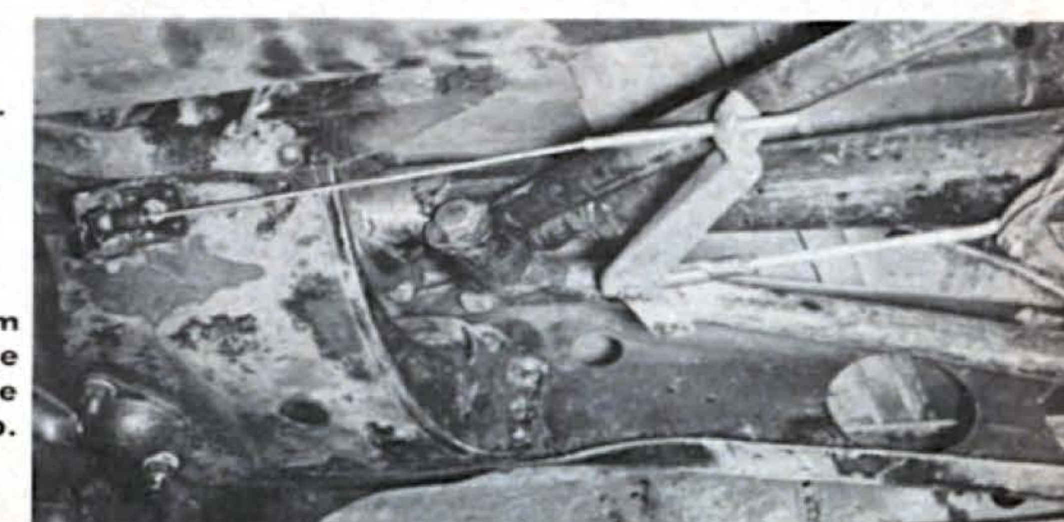
T handle emergency brake and initial cable from post-'49 Fords may be modified to fit older Ford cockpits.



These emergency brake parts from '39 through '48 Ford make final connection at the rear wheels simple.



With T handle mounted in cab of model A, slot is cut in firewall for cable, roller.



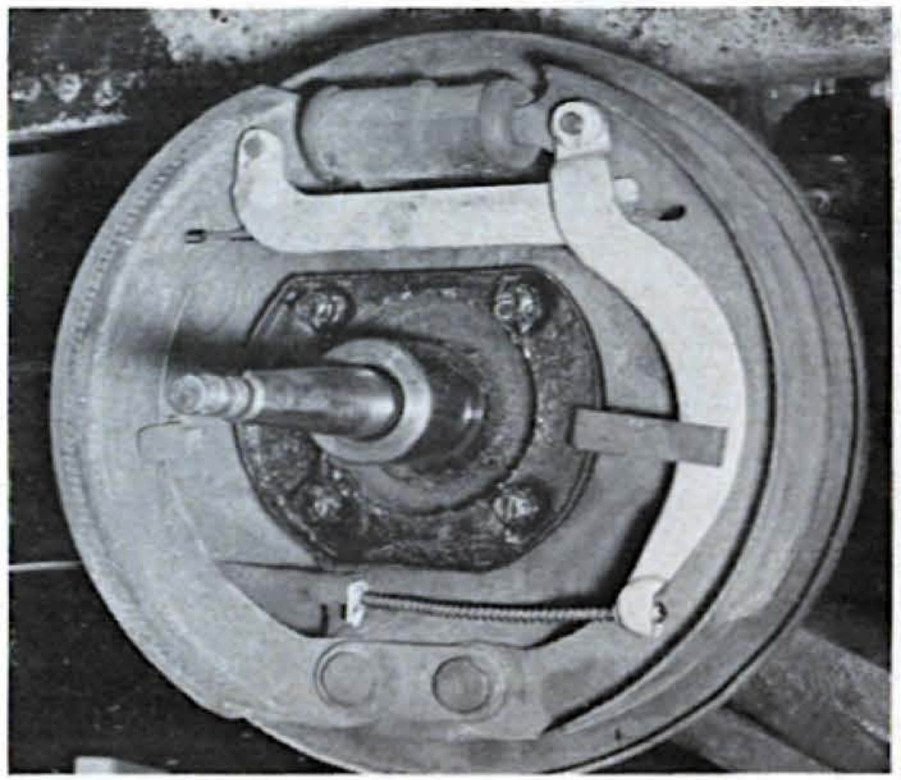
Mechanical leverage arm of final emergency brake unit hooks to T handle initial cable for neat job.

the '35 through '38 cars. Or, the later pedals may be fitted with some minor crossmember cutting for master cylinder clearance.

As a reminder, it isn't necessary that the entire system be completely from a Ford. If you figure you want a better master cylinder-to-wheel cylinder piston area ratio, shop around for the needed part. It can be installed just as the Ford unit. Pedals can also be swapped with minor location work. In some instances, the use of a rather remote master cylinder is popular. Usually this is off an early Chevy truck or Buick and merely uses a longer than normal actuating link between the master cylinder and the brake pedal.

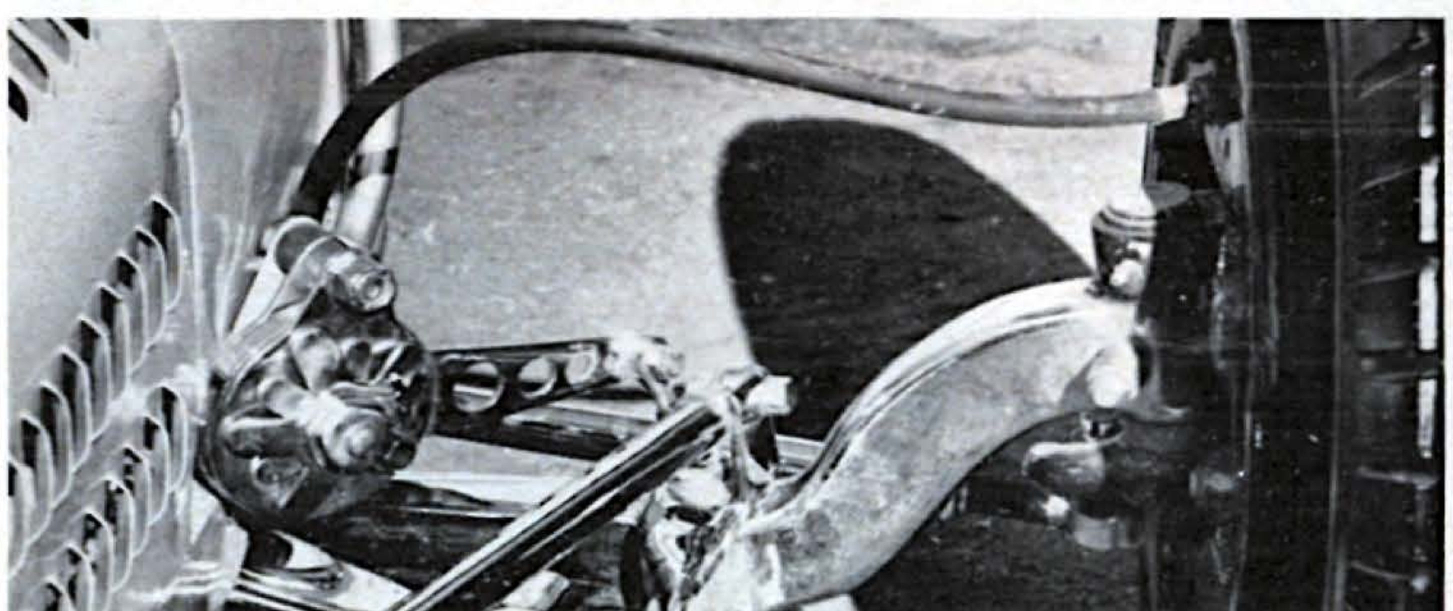
As for swinging pedals, they are almost predominant in rodding circles today. Even here, two methods of mounting are common. The most popular conversion is the use of Ford overhead pedals. They bolt directly to the firewall with a brace running to the dashboard. A bit of trimming and welding and they will fit almost any rod. Just position where you want them on the firewall and mark the mounting bolt holes and the one or two larger linkage holes (depending upon whether you elect to use hydraulic clutch, mechanical clutch linkage, or automatic trans). Drill the holes and mount the pedals and master cylinder. With such pedals you'll probably have to make a set of rigid brake lines. Several speed equipment builders have cataloged specially made swinging pedal assemblies, among them Moon Equipment Co. and Cannon Equipment Co. Similar to the production car items, they are more austere in design and feature a firewall support only. They are made in a number of designs, but the most popular seems to be the ones using the single hydraulic clutch/brake master cylinder reservoir from new Chevy and GMC trucks.

So there you are. Properly installed and maintained you will never have to go hunting that tree. ■

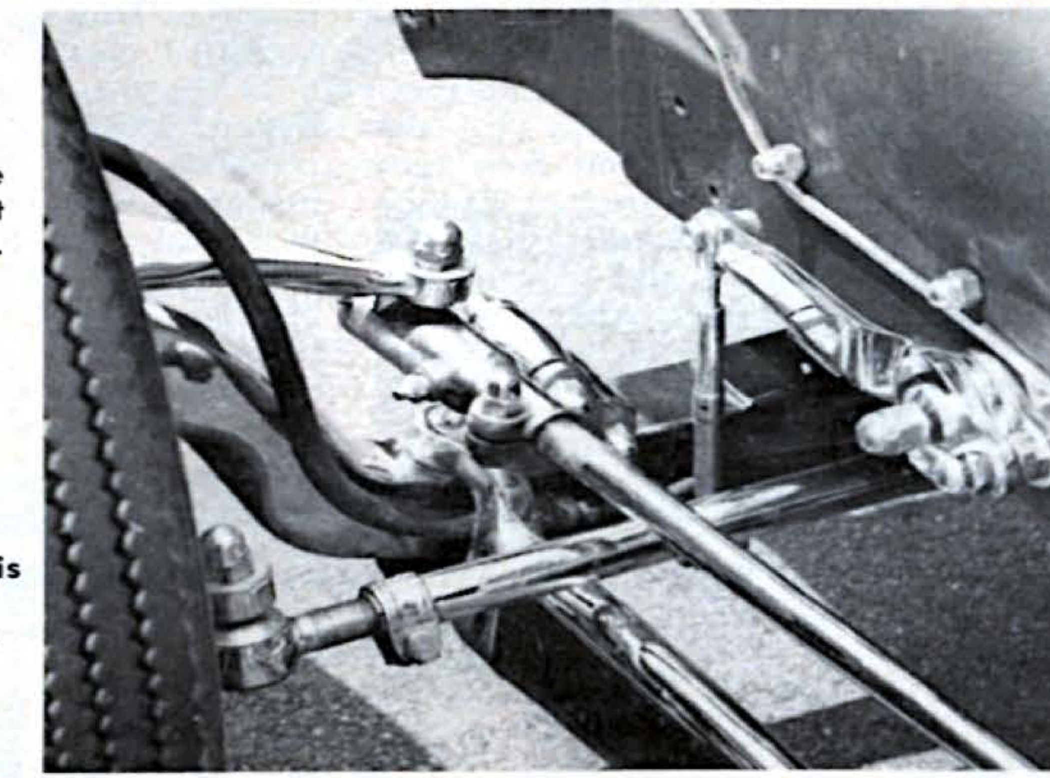


Rear shoes contact drums when emergency brake handle is pulled causing two arms to push shoes apart at top.

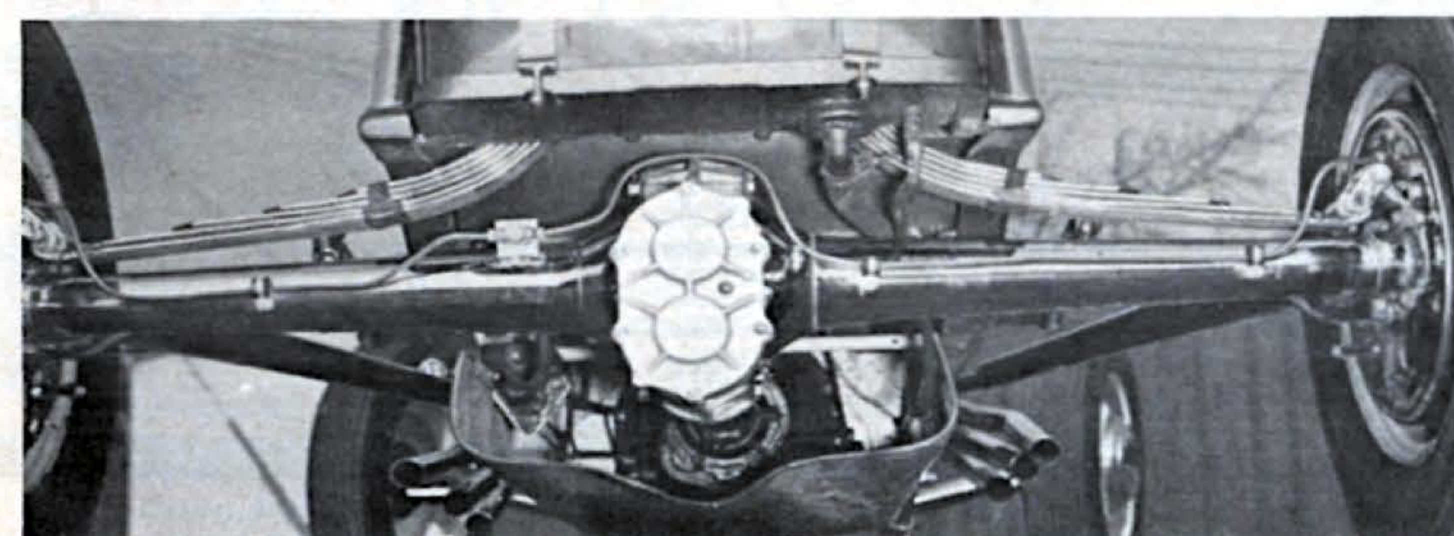
Front end of track roadster is good example of front brake hose mounted out of way of flailing suspension.



Street rod clears brake hose by mounting it behind dropped axle.



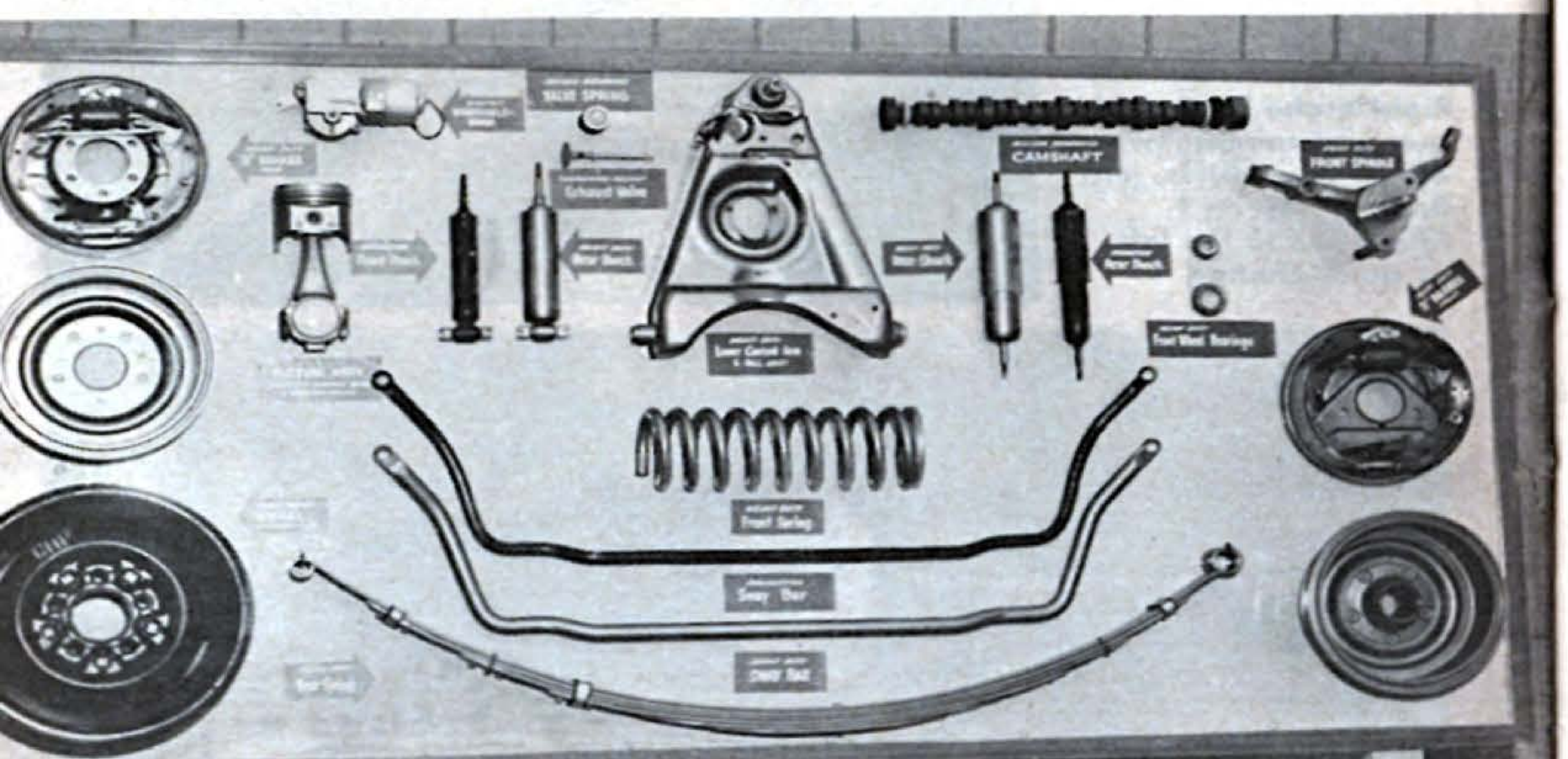
Rigid brake lines on this rear end connect two wheel assemblies, join flexible hose in T fitting just to the left of quick-change.



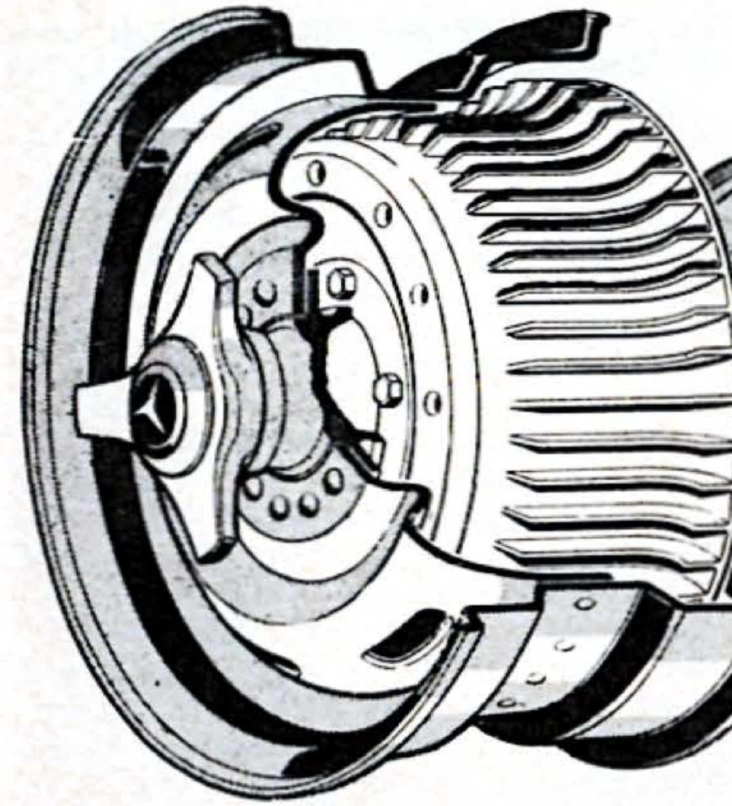
BRAKE OPTIONS and TRENDS

IT IS OFTEN argued that the automotive industry isn't doing anything about brakes, that brake design and application has not kept pace with general auto advancements. Actually, such accusations are really quite irrational and have little foundation in fact. Consider, for example, the braking advancements introduced constantly by the European auto builders on their race cars. The road race courses of Europe provide the manufacturers with an excellent test track for their new ideas. And these ideas aren't hidden in some great dark vault as the property of some particular company, either. While the English definitely lead in the development of the disc brake, other European companies have perfected the drum brake system. Before they quit racing, the Mercedes-Benz team introduced a braking device on their sports cars that had the industry buzzing. A large flat portion of the body just behind the driver would quickly lift on hydraulic struts upon demand and the resulting wind resistance served remarkably well to slow the car, even in critical areas. Some skeptics claimed that the air turbulence caused by the big flaps would play havoc with cars following closely, but apparently these attitudes were soon dispelled.

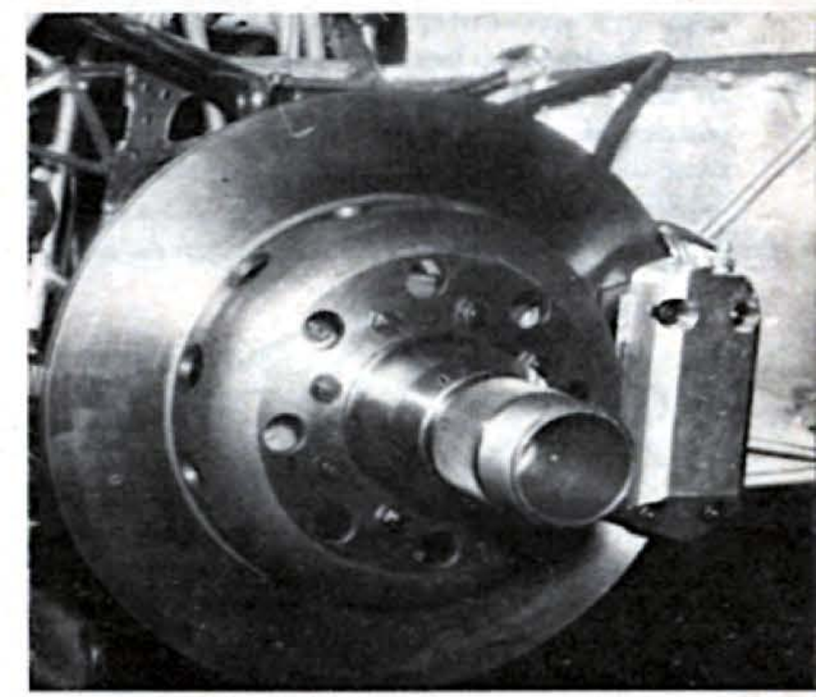
In America, the past six or seven



Nearly every U.S. car has optional equipment which includes speed goodies but stresses heavy duty handling components like springs, brakes. Mercury items shown.



Brake in the '55 Mercedes-Benz 300 SL used huge 12-inch finned alloy drums and big twin leading shoes.



Even Italian racing cars have switched to discs, like the type 63 Maserati shown with English Girling units fitted.

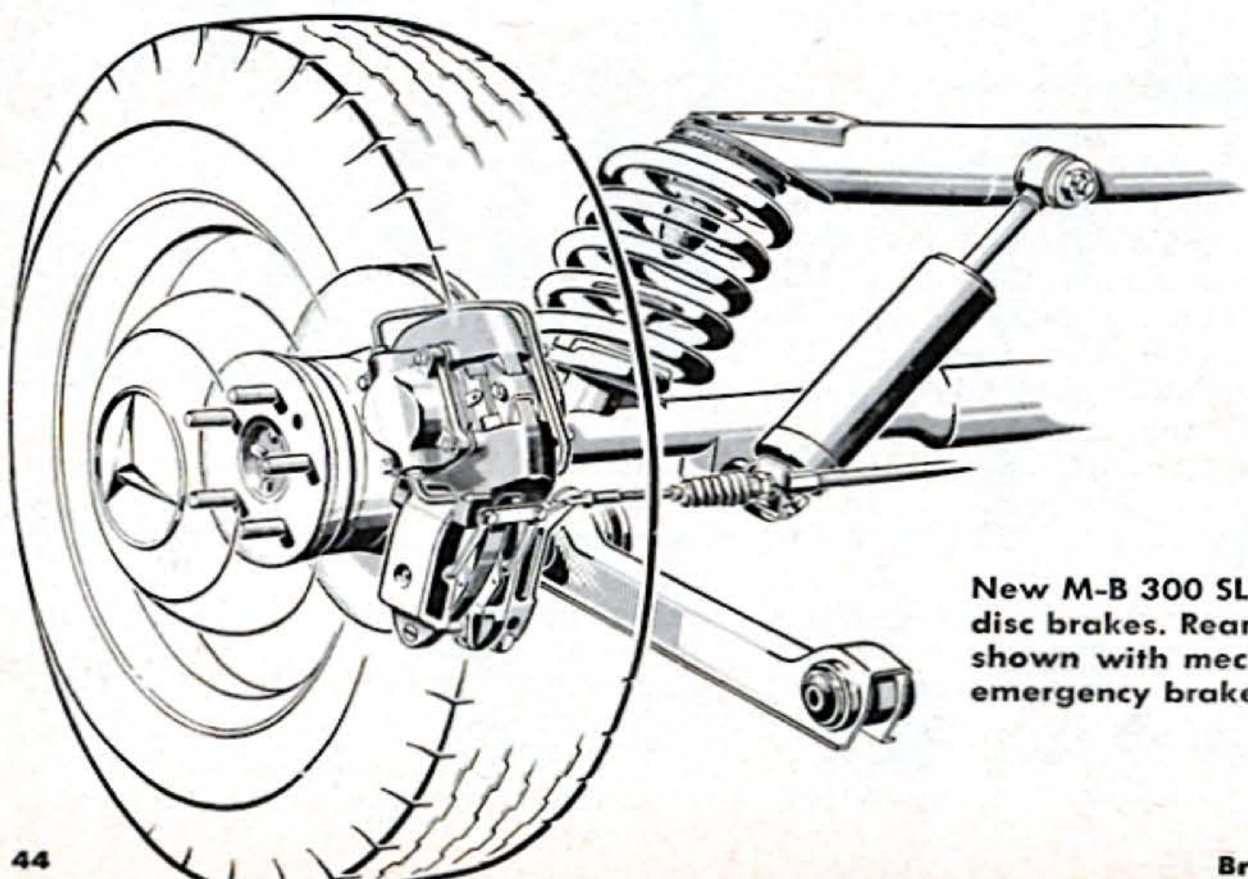
years might well be referred to as the "performance years." During this time the U.S. auto industry has awakened to the strong national desire for nice looking cars that will *perform*. The general clamor for bigger and better cars with a wide range of performance options has brought results, not so much in the top speed of the cars but in their operation up to around 115 mph. The average car is much quicker and definitely more agile. The aspect of this growth most often overlooked is the brakes. What goes must stop, and no one is more cognizant of this truth than the car builders. Virtually every manufacturer now has an optional performance package available to the prospective buyer, one part of the package being heavy duty brakes of some sort.

The biggest problem the designer of high performance braking systems faces is one of available space. He must work with material already at hand. It isn't economically feasible to design optional brakes that need 15-inch wheels for a car that comes standard with 13-inch wheels. In some rare cases larger wheels are a part of the kit, but only when the optimum brake efficiency cannot be arranged with the standard wheels. Two of the problems that must be licked are brake fade and stability. Fade occurs when the temperature of the linings gets too high (and you can actually set the brakes on fire if they are put to excessively severe use) or the drums distort. The distortion problem hasn't been too great of late. Of course the system must be balanced so that the brakes don't grab or force the car to veer when the brakes are applied, and the braking torque must be absorbed back through the brake mechanism into the chassis. For the most part, heavy-duty brake optional equipment can be ordered when you buy a new car. If not, you usually may purchase same and install it yourself.

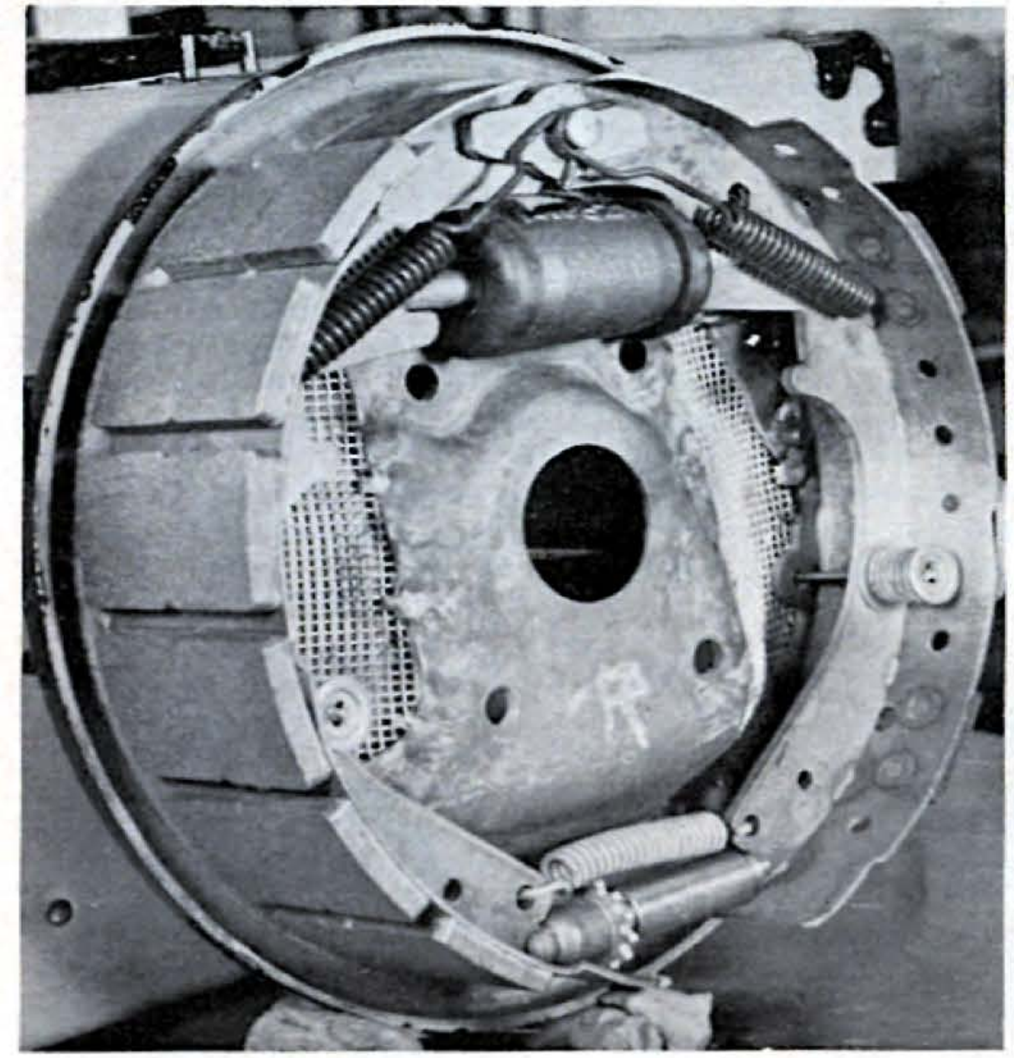
For the majority of production cars the heavy duty options consist of harder brake linings. These hard linings can operate at higher temperatures but normally require more pedal pressure, especially when they are cool. Metallic linings are presently offered by Chevrolet and promise to become more widespread in the near future. The Chevy units are made of a powdered iron composition that will give good braking up to around 1000 degrees. Competition Corvettes are equipped with these linings in addition to aluminum finned drums and backing plates with air scoops.

Pontiac offers special aluminum wheels and drums that are built by Kelsey-Hayes while the Chrysler Corporation has big 12-inch drums to replace their 11-inch standard items. Ford has available the Thunderbird and Lincoln drums that are a whopping three-inches wide.

One of the most interesting linings to come along in quite awhile is the new S. K. Wellman Co. "Velvetouch Metalik." Composition is primarily powdered iron and graphite. Both these elements have a high coefficient of friction, making them ideal for use as friction material. The average lining, and even some of the high performance optional lining, is in one strip per brake shoe. The "Metalik" lining comes in segments (to better absorb and pass off the heat) that are bonded to top quality shoes. Installing the Metalik shoes is the same as with any normal lining, but remember that these shoes have been very carefully pre-ground at the factory for most cars and will not need further

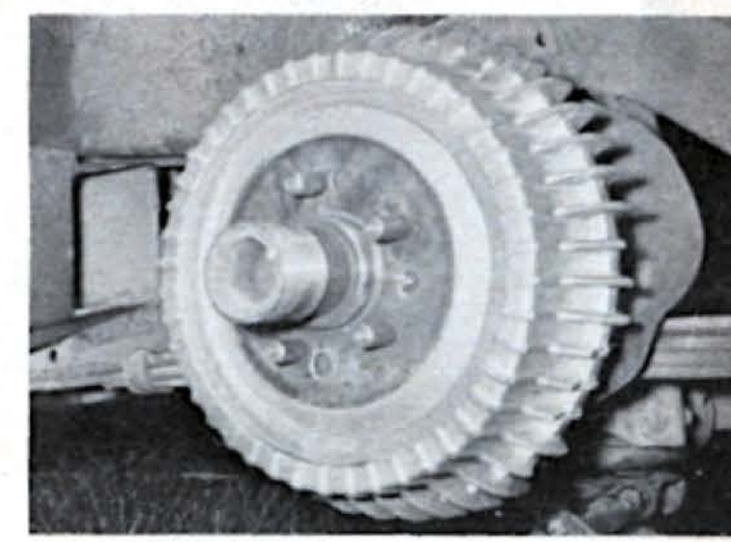


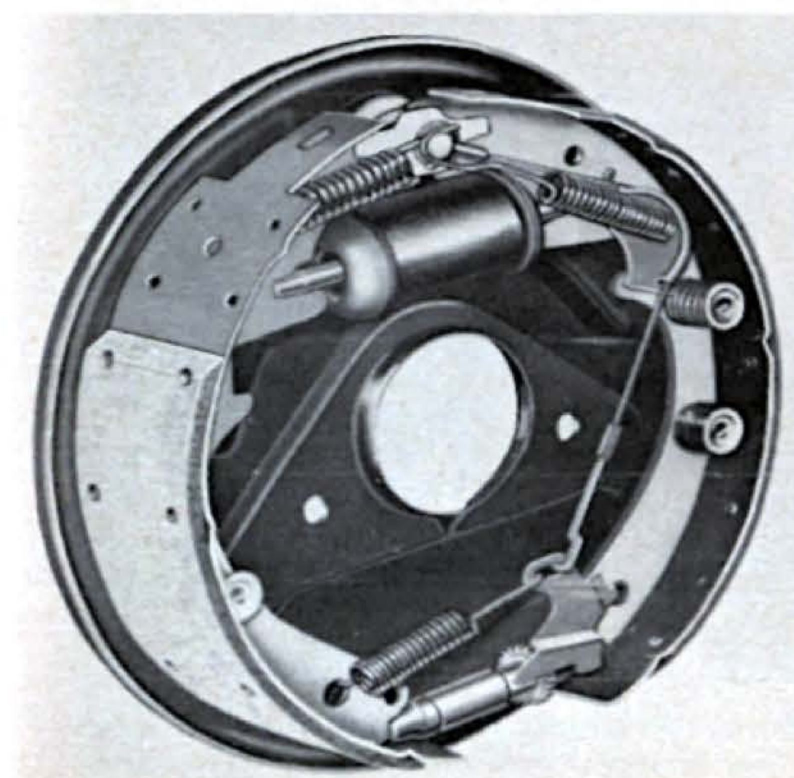
New M-B 300 SL cars have disc brakes. Rear brake is shown with mechanical emergency brake linkage.



'62 Corvette heavy duty brake equipment furnished as part of H-D chassis option RPO 687. Linings are sintered iron segments welded to shoes, 12 segments on secondary, 6 on primary. Note vented and screened backing plate to exit hot air trapped during braking process.

Earlier Corvette brakes had sintered linings, finned alloy drums, air scoops.



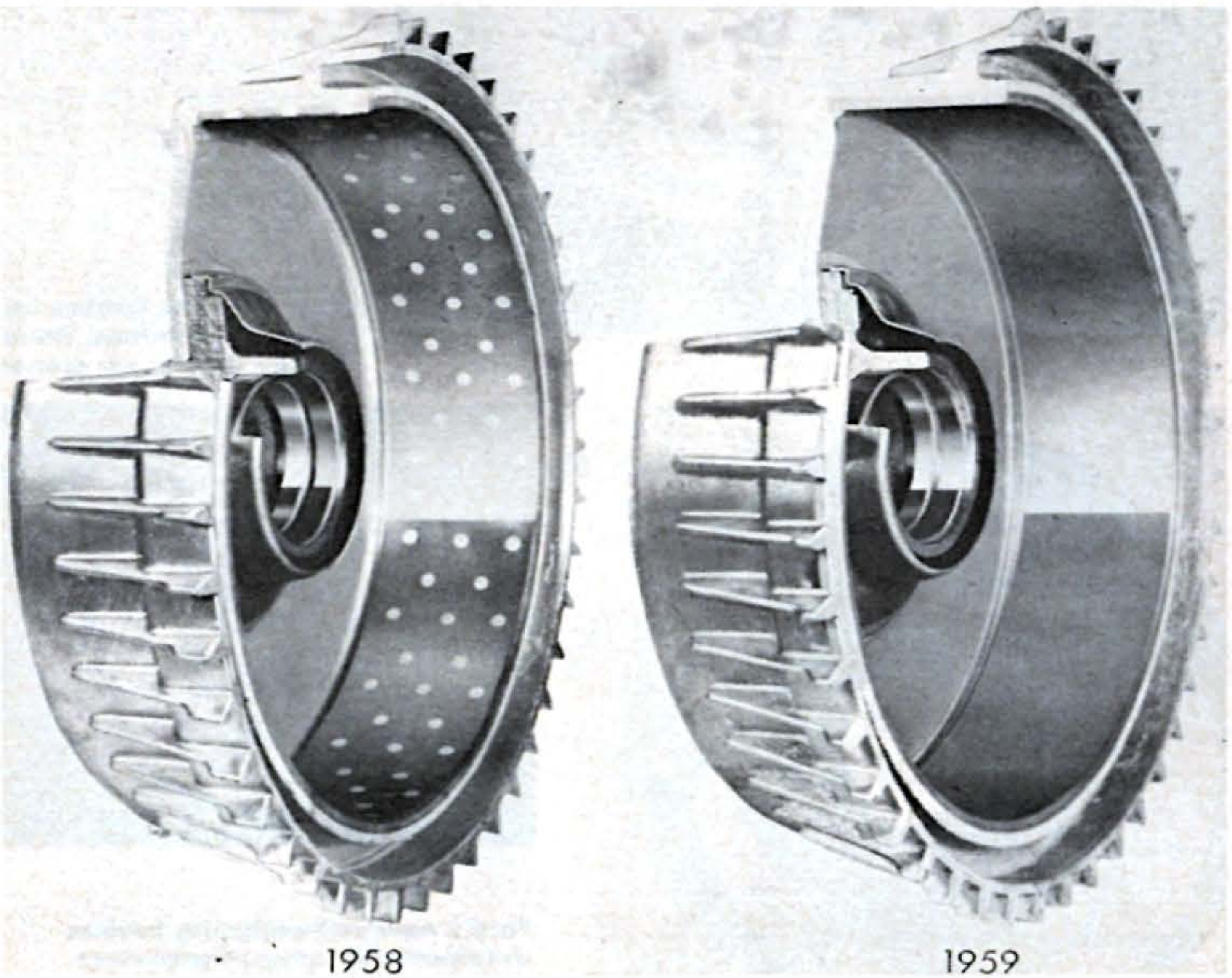


Ford's new self-adjusting brakes automatically adjust themselves in normal operation, meaning better brake efficiency for the average motorist.

fitting. Should the brake drums have been turned to quite an extent, it is recommended by the company that the shoe heel and toe minimum clearance be kept to .008. After installing the shoes, go out on a lonely road and make a minimum of 10 hard stops from at least 45 mph. This will seat the shoes and you're in like Flynn.

In addition to the better braking afforded by these metallic linings from Chevrolet and S. K. Wellman, you get a big double-plus for inclement weather operation. It is the normal practice to force cool air to the brakes by ducts and exit trapped hot air by drilling holes in the backing plates. Great for cooling the brakes, but water on average linings means nothings-ville for brakes. Water doesn't affect these metallic linings, even after total immersion for some time.

The increasing speeds of all classes of competition at the drag strips in the past two short years have led to several interesting developments in competition braking. Performance has jumped from an average terminal speed in dragsters from 150 to 170 mph. The big 2500 pound Gassers are up from 110 to 130 mph, and the stockers are bordering on 120 (Factory Experi-



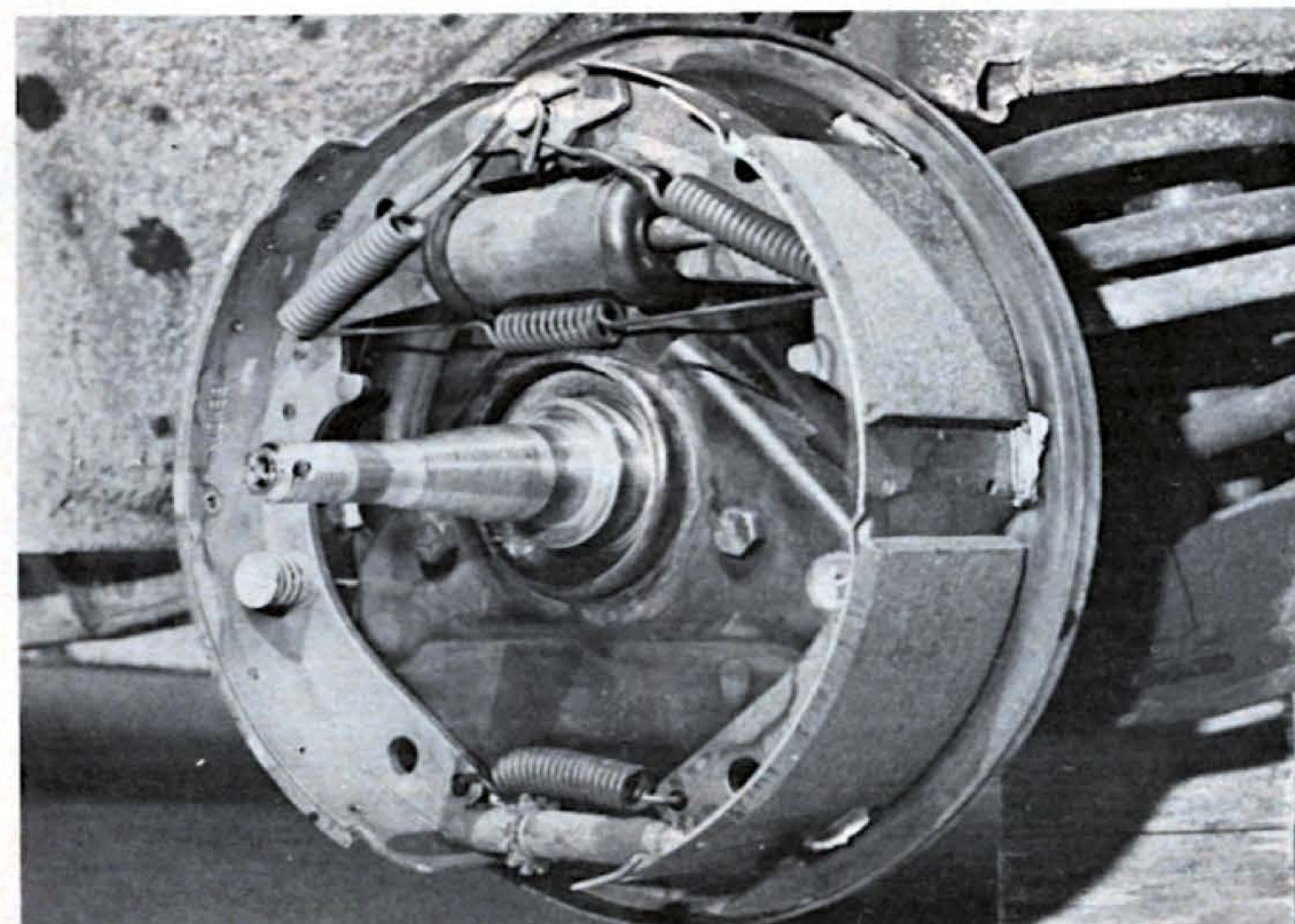
Buick modified their finned alloy brake drums in 1959 to do away with locating pegs, used a bonded edge overlap grip instead. Such drums can be adapted to other cars.

Made for Pontiac by Kelsey-Hayes, these special alloy wheels and brake drums do an excellent job of heat dissipation.

mental, that is). And, although it isn't always the car with the fastest top speed that wins the race, it is this car that has the biggest problem in stopping.

Drag chutes are almost universal across the nation, and allow the cars to decelerate rather rapidly. The use of chutes even allows the ultra-fast cars to run on strips that previously were too short for such times. The average chute in use now runs around 14 feet in diameter and is of either the round or triangle design. Virtually all are of the ring-slot nature. Chutes are being mounted on all types of cars, from AA Dragsters through stock cars, usually in earnest,

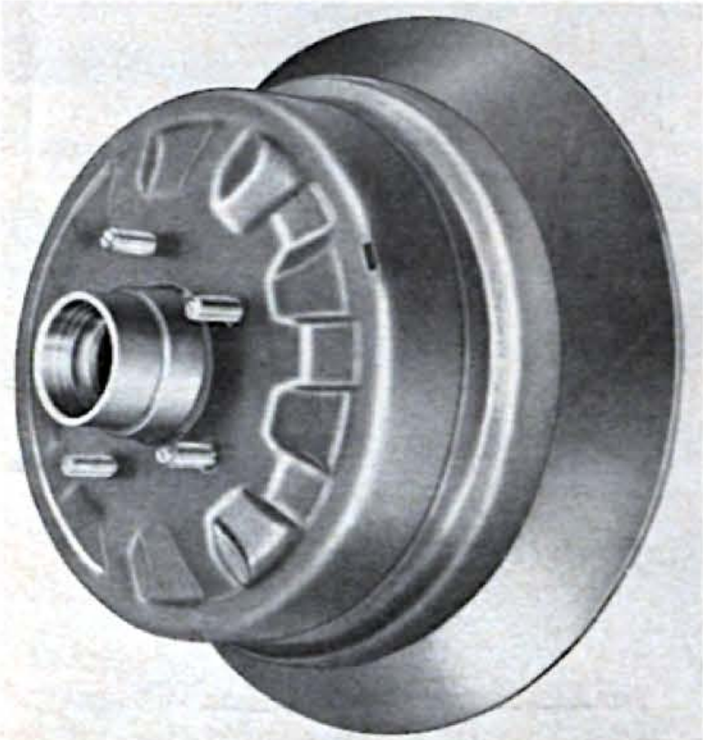
New Velvetouch Metalik bonded lining from S. K. Wellman Co. has segments of powdered iron and graphite.



but sometimes only in fun. But whatever the reason for their use, they must be selected with care and attached to the car properly. For a full run-down on chutes, be sure to check the '61 HOT ROD YEARBOOK for the vital information. Just one passing comment, the chute can't stop the car if it is packed improperly or isn't hooked securely. Too often we have witnessed a car careening off the end of a strip all because the driver had come to rely totally on the chute, and when it didn't work he then looked for brakes that just weren't there.

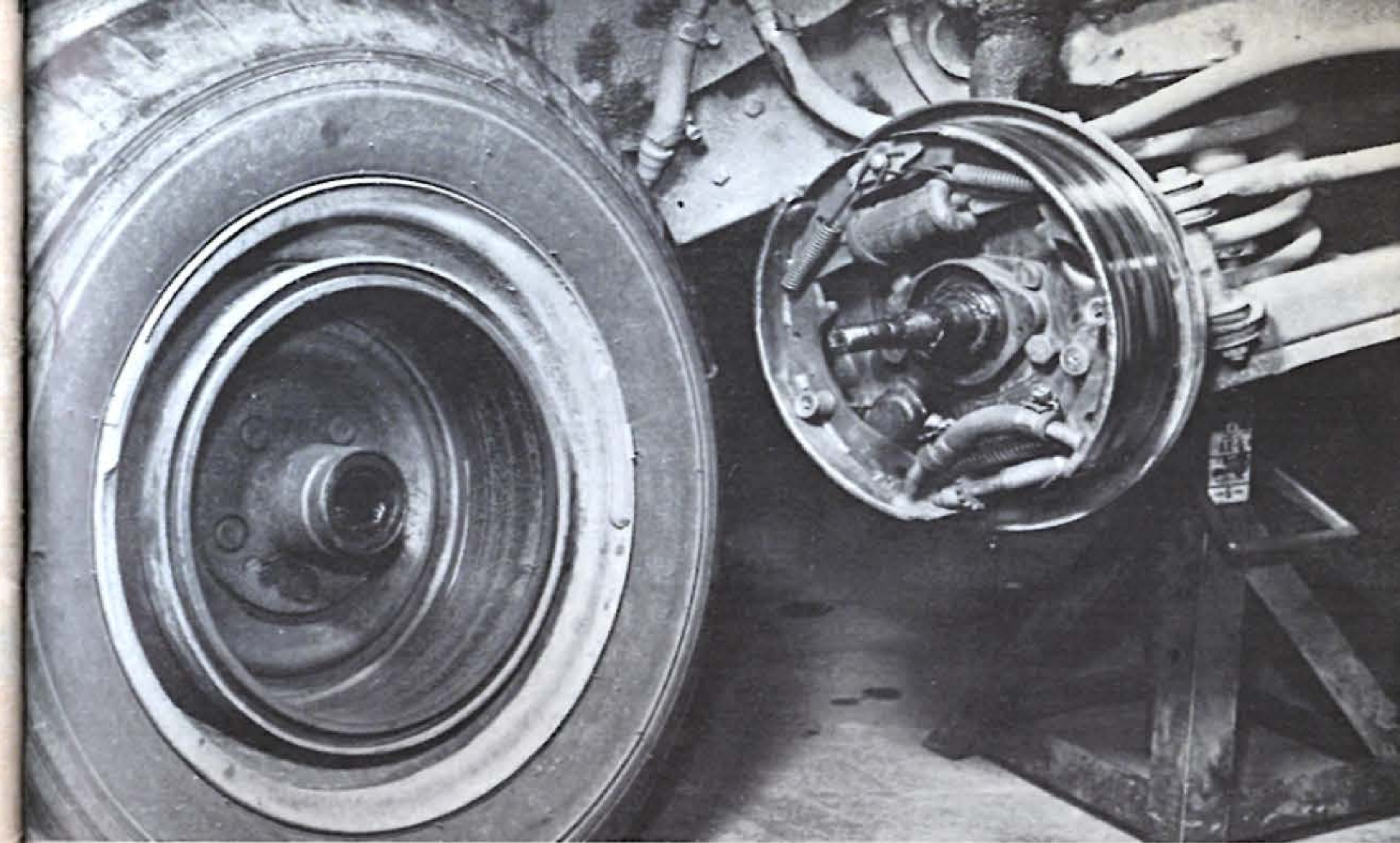
With the increased popularity of late model three-quarter and full-floating rear ends for modified drag cars has come the consequent advantage of bigger and better shoe brakes. These brakes usually prove more than adequate. In some cases, solid rear axles are used with either one or two spot brakes being selected. In the case of the lightweight dragsters, the single spot discs will do, but for heavier Gassers and Street Roadsters, etc., double spots are better. In-line pressure boosters have been tried, such as the Por-Del units, and many special road race builders are switching to a new flexible hydraulic line called Nylaflow. This line is extremely strong, having a breaking point well above stock steel line. It is flanged just like steel but seems to be impervious to cracking. With it, a person need only run a single line clear from the master cylinder all the way to the wheel cylinder. Since it is highly flexible, no more need for flex hoses.

Thus we close the book on brake systems, their operation and maintenance. We haven't been able to delve into the subject too deeply, for to do so would require a book many times larger than this. But we have passed along the high spots, the important information that will help you make your care *stop* as well as go. See you at the races! ■



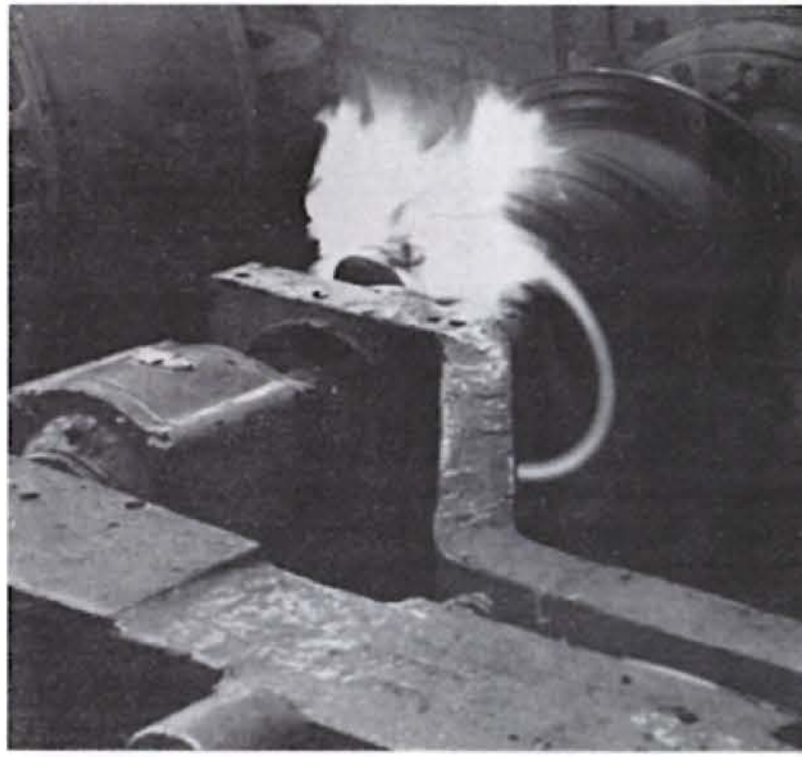
Late model Oldsmobiles use a steel flange pressed over the drum to help control drum distortion from heat.

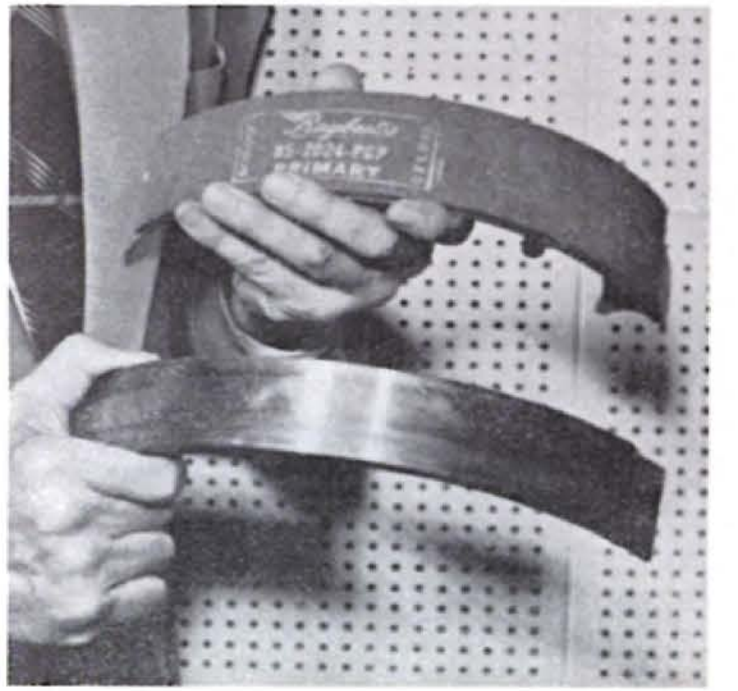
Velvetouch Metalik shoes are precision ground at factory, but if necessary minimum heel-toe clearance is .008-inch.



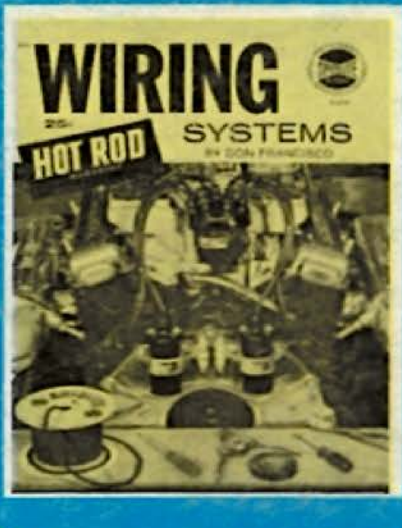
Raybestos introduced liquid cooled brakes in 1957, found that copper linings cooled by engine coolant lasted about three times longer than conventional linings.

During lab test, conventional brake burns when brakes stop simulated drum of 5000-pound car at 100 mph.





Standard brake lining, top, alongside Raybestos copper lining at bottom.

1 

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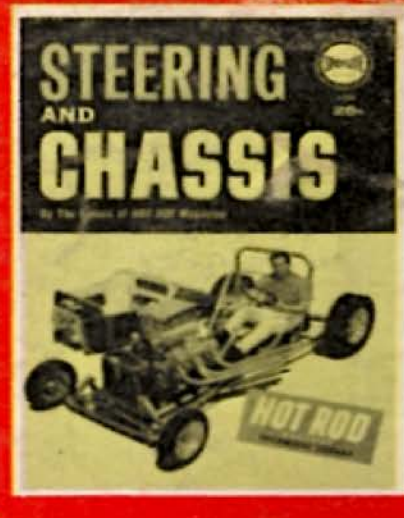
2 

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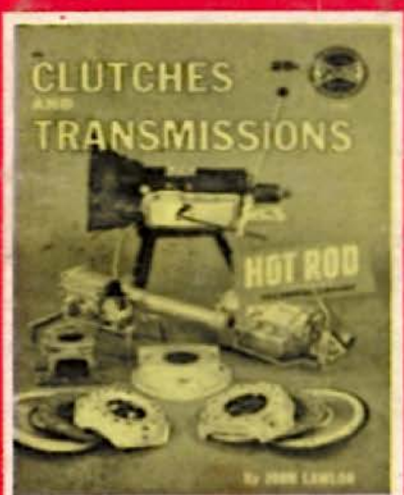
3 

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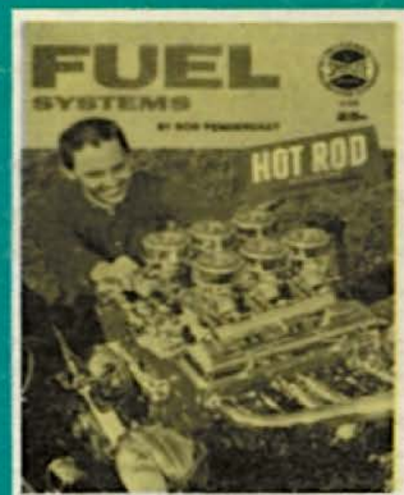
4 

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