MASTER TECHNICIANS SERVICE CONFERENCE 66-1

REFERENCE BOOK

SIXTY-SIX SERVICE PREVIEW

CHRYSLER CORPORATION

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It's always customer courting time

When it comes to *selling cars,* first impressions are mighty important. When it comes to *keeping customers,* second impressions are even more important. A new car that lives up to the owner's expectations in overall appearance, operation and performance is bound to make a favorable, lasting second impression.

No doubt about it, new-car announcement and delivery time represents a critical period in your dealership's courtship of new customers. Long after delivery, it's largely up to the service department and you Master Technicians to keep up the customer courtship that leads to satisfied customers and repeat sales.

Experience may be a great teacher, but tackling a service job on a new model without any advance knowledge of what's new or different can be a mighty risky business. So, give this reference book the once-over now and keep it handy for future use. And don't forget to keep your 1966 Service Manuals handy and use them anytime you're in doubt about a specification or procedure. Be prepared! It's always customer courting time in the service department.

TABLE OF CONTENTS:

BODY CHANGES AND SERVICE

One of the most obvious 1966 changes is the curved side glass on the Belvedere and Coronet models. Some of the other body features and changes aren't as readily apparent. Since you service technicians are primarily concerned with changes which affect service procedures and adjustments, the most significant body service highlights are covered in the paragraphs which follow.

BELVEDERE AND CORONET MODELS

The Coronet and Belvedere bodies are completely new for 1966. The curved side glass on these models means that just about everything inside the door and quarter trim panels is new this year. However, you won't have too many new things to learn about these models since they are similar in many ways to 1966 as well as 1965 Fury and Polara models.

FRONT DOOR GLASS

Coronet and Belvedere models use the same type of glass-operating mechanisms as the Fury and Polara models. However, the glass application and operating mechanism on hardtop and convertible doors is new this year. On Coronet and Belvedere models, the two-arm regulator has been replaced by a single-arm regulator. The glass guide and run channel design is also new on these models and quite similar to 1966 Fury and Polara models.

Fig. 1—Belvedere or Coronet 2-door hardtop glass mechanism

FRONT DOOR GLASS GUIDE

With the single-arm regulator, the front edge of the glass must lock into the guide channel so that the glass cannot tip as it is raised and lowered. The new front door glass guide design provides a more stable, rattle-free method of glass attachment and smooth operation of the new curved glass.

The front door glass weatherstrip is attached to the front edge of the glass instead of being attached to the glass channel. In other words, the weatherstrip slides up and down in the front guide channel instead of the glass sliding in the weatherstrip. Dacron-flocked shoes fit into channels formed in the glass guide. One pair of guide shoes is located near the top of the glass and a second pair is located near the bottom of the glass. These shoes virtually lock the glass into the glass guide so that the glass is well supported even when the window is partially lowered.

Fig. 2—The weatherstrip is attached to the glass

Both the guide shoes and the weatherstrip are locked in place by a plastic pin that goes through a hole in the front edge of the glass.

This design greatly simplifies servicing and replacement of the weatherstrip and the shoes.

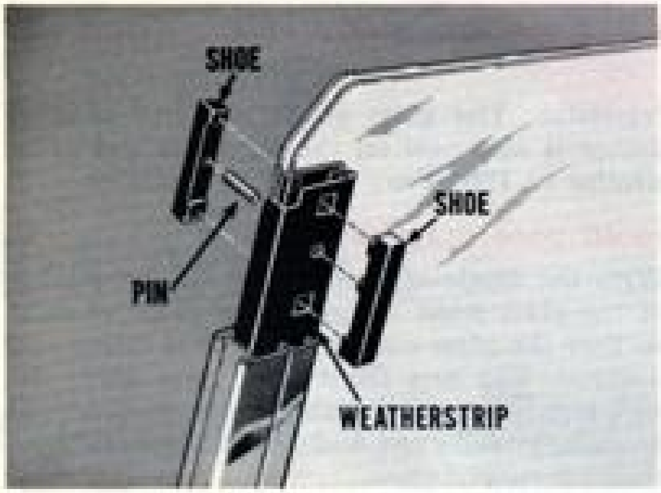


Fig. 3—Plastic pins attach the shoes and weatherstrip

You'll find this new glass guide and shoe design on the bigger models as well as the Belvederes and Coronets. As a matter of fact, the basic design as well as door and quarter glass adjustments on all models with curved side glass, with the exception of Imperial, are now the same or very similar.

CEMENTED-IN-TYPE REAR WINDOW

Early in 1966 model production, cemented-in rear window glass will be introduced in some of the longer wheelbase, two-door hardtop models. So, don't be surprised if you see a Fury, Polara, Monaco, or Newport without a rubber weatherstrip around the rear window glass. This new design came out too late to get into your service manuals but you'll get a service bulletin covering the cemented-in rear window. Be sure and read it before you tackle rear window replacement on one of these models. The following paragraphs will give you an idea of what's involved in servicing this type of rear window.

ADHESIVE CAULKING IS USED

An adhesive caulking material is used between the rear window glass and the fence of the rear window body opening instead of a rubber weatherstrip. The caulking material actually cures in place to form a very tough, rubber-like adhesive which cements the glass to the body fence.

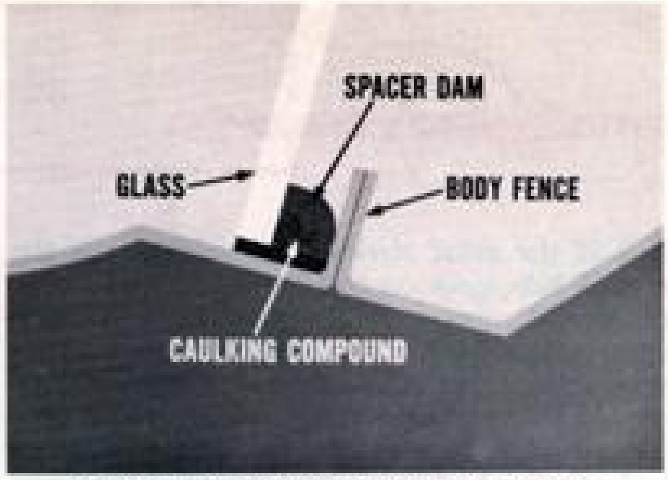


Fig. 4—Caulking forms a rubber-like adhesive

REAR WINDOW GLASS REMOVAL

To remove a rear window glass you must remove the interior garnish mouldings and the outside chrome mouldings. Since the adhesive caulking material literally vulcanizes itself to the glass and the body metal, the caulking material must be cut through before the glass can be removed. A two-foot length of steel music wire is used to cut the caulking material. One end of the wire is forced through the caulking material between the glass and the fence. Start at one of the lower corners of the rear window and push the wire through from inside the car. A short wooden handle is attached to each end of the music wire . . . a five- or six-inch length of a broom handle works nicely.

Fig. 5—Steel music wire used to cut caulking

With the aid of a helper, carefully cut through the caulking material by pulling the wire in a sawing motion. Once the caulking is cut all the way around the window, the glass is easily removed. If the original glass is to be reinstalled, remove all of the old caulking material using a razor blade or sharp cutting instrument. Use thinner or a rag dampened in toluene or thinner to remove all traces of caulking material.

CAUTION: Do not use an oil-base solvent. Any trace of oil on the glass will prevent proper adhesion of the caulking material.

USE THE CORRECT SIZE GLASS

The rear window glass used in an adhesive-caulked installation is *larger* than the glass used on models having a conventional rubber weatherstrip. The slightly smaller glass used with conventional weatherstrip will not work in the cemented-in application. The larger glass used for cemented-in application cannot be correctly installed using a rubber weatherstrip. *Be sure and use the correct size glass.*

RUBBER SPACERS FOR VERTICAL POSITIONING

A pair of rubber spacers are used to position the glass in the window opening. These spacers support the glass until the adhesive caulking compound cures. The two spacers are installed seventeen inches either side of the center of the glass opening.

Fig. 6—Rubber spacers support the glass

THERE'S A SPACER DAM, TOO

Another type of rubber spacer, called a spacer dam, provides a cushion between the glass and the body fence. It's called a dam because it keeps the adhesive caulking from squeezing out over the surface of the glass when the window is first installed.

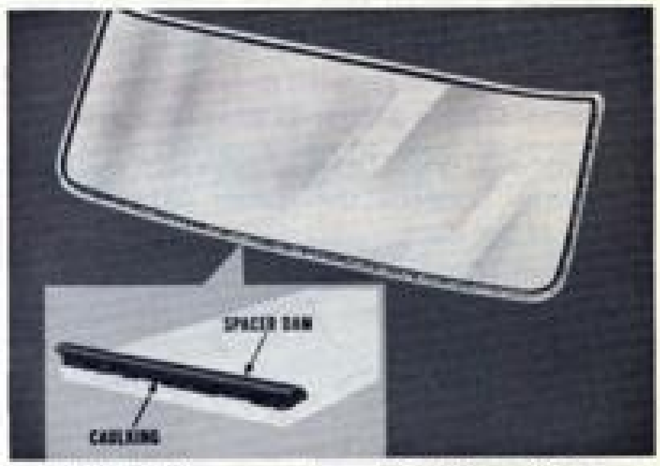


Fig. 7—The spacer dam retains the caulking

GLASS INSTALLATION HIGHLIGHTS

An installation kit will be available from the Parts Division. It will include two spacers, a length of rubber spacer dam material, a container of adhesive caulking and another of adhesive caulking primer. The following steps should be followed when installing a rear window glass:

- Make sure that all moulding retaining clips are in good condition and properly positioned. Clips must not be more than $\frac{1}{32}$-inch away from the body panel. If they are, they should be straightened or replaced *before* the glass is installed. They cannot be installed without removing the glass.
- Position the two rubber spacers 17 inches from the centerline of the window opening.
- Apply the spacer dam to the inside surface of the glass, $\frac{1}{4}$-inch from the edge.
- Carefully position the glass in the window opening. The spacer dam should rest against the fence and fold under, forming a cushion for the glass. The glass must overlap the fence along the top and side edges a minimum of about $\frac{5}{16}$-inch. If the glass is low, place waterproof shims under the rubber spacers to bring it up.
- Mark the exact position of the glass by applying a piece of masking tape across the edge of the glass and the body opening at each side of the glass. Then, slit the tape vertically and remove the glass.

- Remove the glass and clean the entire fence area using steel wool.
- Dampen a small pad with adhesive caulking primer and apply to the entire fence.

  CAUTION: Primer will damage paint and trim so confine primer to the fence area.

- Apply a ⅜-inch bead of adhesive caulking material between the spacer dam and the edge of the glass.
- Carefully install the glass in the body opening. Make sure the glass rests on the rubber spacers and check to make sure the tape on the glass lines up with the tape on the body.

  NOTE: Rubber suction cups, about the size of those used for car-top carriers, will help you hold and position the glass.

  Application of the adhesive and positioning of the glass must be accomplished quickly, since the working life of the adhesive is approximately 15 minutes.

- Press the glass lightly but firmly against the body fence to insure good adhesion. Then, use a fiber trimstick to level the caulking material and force it into the opening between the glass and the body.
- Use a light *spray* of cold water to test for water leaks. If leaks are encountered, apply additional caulking material to correct the leak. Water will not interfere with good adhesion, so you won't need to dry it.
- Leave at least one car window open and do not slam any car doors for at least one hour since the pressure could push the window out of its opening.

The foregoing information is intended to acquaint you with the service procedure used to remove or install a rear window glass. Tech suggests that you read your service bulletin on the subject before servicing a rear window.

MISCELLANEOUS BODY ITEMS

Needless to say there are many other body changes. Most of these affect appearance only and won't require any new service procedures or knowledge. However, there are a couple of items that may give you trouble if you aren't forewarned.

OUTSIDE FINISH MOULDING REMOVING TOOL

A new type of concealed windshield and rear window moulding retaining clip was introduced on some 1965 models. Removing these mouldings without damaging the moulding, the clips or the car finish could be a bit tricky . . . especially if you didn't understand how the clips worked. In Session No. 65-4, Tech explained how you could use a modified fiber trimstick to release these clips from the moulding. This same kind of moulding retaining clip is now used on all 1966 models except the Imperials, Valiants and Darts. A slick new tool that really simplifies removal of these mouldings has just been released. It's tool C-4009, Windshield and Rear Window Moulding Removing Tool.

Fig. 8—New windshield and rear window removing tool

DOOR WEATHERSTRIP ATTACHMENT

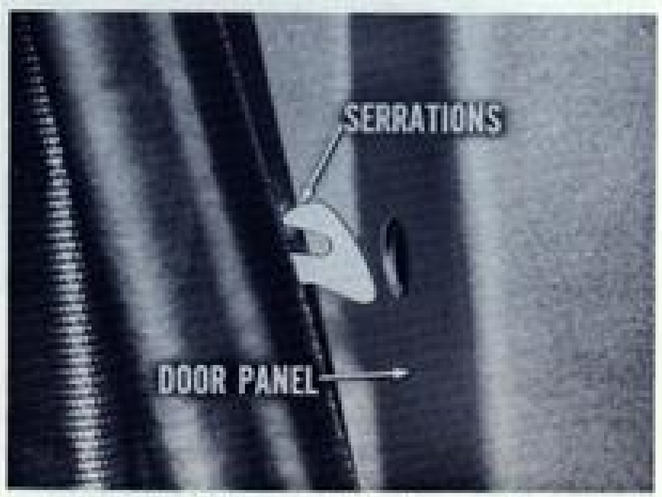


Fig. 9—Plastic clips retain the door weatherstrip

1966 models, except Imperial, Valiant and Dart, have the weatherstripping attached to the door instead of the door opening. Above the beltline the weatherstrip is cemented. Below the beltline the weatherstrip is retained by plastic fasteners spaced approximately 4 inches apart. The plastic clips are springy. When you push them into attachment holes in the door panel they compress and then spring open again. Tiny serrations grip the door panel, holding the weatherstrip securely in place.

TO RELEASE THE SPRING CLIPS

Don't try to remove a door weatherstrip without releasing the clips or you'll ruin the weatherstrip, break the clips, or both. All you have to do to release a clip from the door panel is push downward on the clip with a screwdriver or trimstick.

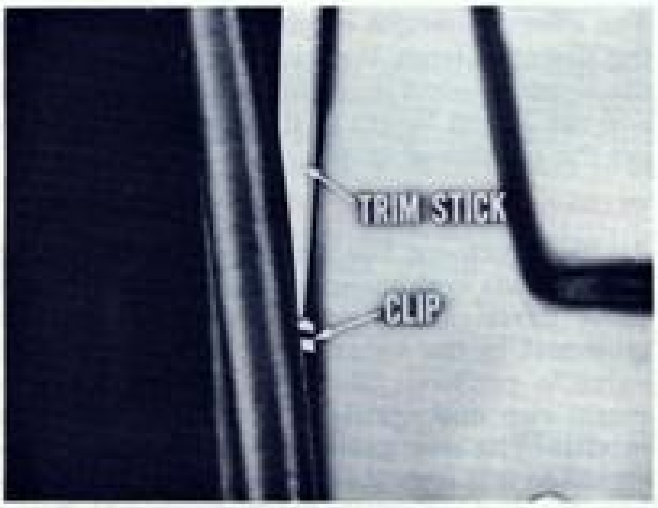


Fig. 10—Trimstick releases weatherstrip clip

Damaged or broken clips are easily replaced *provided* the clip hasn't been torn out of the weatherstrip. To replace a clip, carefully work the Tee-shaped end of the clip out of the weatherstrip and install a new one in its place.

INSIDE DOOR HANDLE REMOTE LINK ATTACHMENT

It's pretty obvious why the new inside door handles are unusually safe. Since you must pull the handle away from the door to open it, there is very little chance that anyone will accidentally open the door. But here's something that isn't quite so obvious. The remote-control link is attached to the remote control with a special spring-type retaining clip. The harder you push on the link to disconnect it, the tighter the clip grasps the link.

Since the link and clip are hidden behind the door inner panel where you can't see them, you'll have trouble figuring out how to release the clip. The accompanying illustration shows how a screwdriver can be used to spread the retaining clip and release the link.

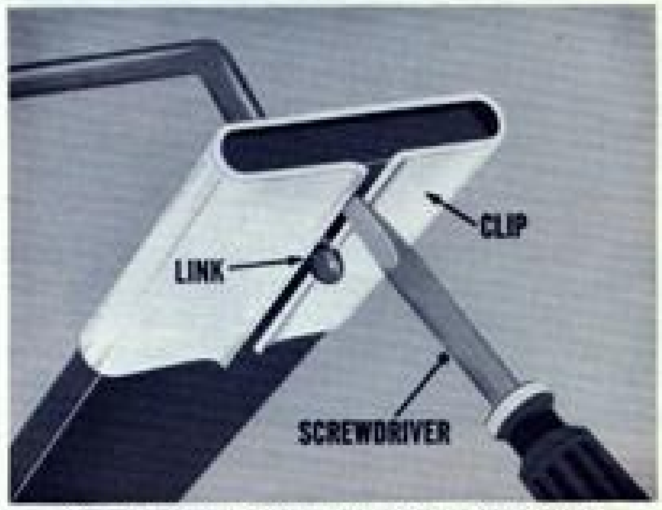


Fig. 11—Screwdriver releases link retaining clip

CORONET AND BELVEDERE WINDSHIELD WIPERS

By now you have probably noticed that the Coronets and Belvederes have parallel windshield wipers with the wiper motor in the engine compartment and the drive linkage on the passenger side of the firewall. There isn't much room to get at the linkage from inside the car; however, you can easily remove a motor for service if you know how.

Remove the stud nuts from the motor mounting studs. This will give you room enough to move the motor out and off the mounting studs. You can then easily remove the nut from the motor drive shaft and remove the crank arm and remove the wiper motor from the car.

CAUTION: Don't disconnect the drive from the linkage . . . remove the drive crank from the motor. It's much simpler to remove the crank from the motor than it is to remove the spring washer and clip from the drive assembly without loosening these parts. When you reassemble the crank arm to the motor, be sure the "DOUBLE-D" drive flats match the flats on the shaft and be sure and tighten the nut securely.

ENGINE AND CHASSIS HIGHLIGHTS

Although there are a number of important changes and improvements in the power train for 1966, there are no changes which should give you service technicians any problems. As a matter of fact, many of the changes, like simplification of transmission shift linkages, should make servicing chassis units easier.

THE ENGINE LINEUP

No major changes have been made in the basic design of our slant-six and V-eight engines. However, a couple of exciting new engines have been added. One of these is a new 440-cubic-inch engine; the other is a 426-cubic-inch hemi-head option.

NEW PISTON RING TOOL

The new 440 engine has a $4\frac{5}{16}$-inch bore. This calls for a new piston ring installing tool, C-4001. Although you probably won't be doing a ring job on a 440 engine real soon, it's a good idea to have the right tool available when you do need it.

TORQUE WRENCH ADAPTER

The Hemi-head engines have eight *special* stud nuts in the valve chamber. Correct tightening of these nuts is very important. On cast-iron Hemi-head engines the correct torque is 70-75 foot-pounds. On aluminum head Hemi-engines the correct torque is 60-65 foot-pounds.

Fig. 12—You must calculate the correct torque reading

Torque Wrench Adapter, C-4005 makes it easy to tighten these special stud nuts to the specified torque. Of course, the added 2-inch length of the adapter increases the leverage of the torque wrench so you must use a corrective factor to obtain the correct torque value. All you have to do is multiply the recommended torque specification by the effective length of your torque wrench and divide by the combined length of the torque wrench and adapter.

The *effective length* of your torque wrench is the distance from the pivot in the handle to the square socket drive at the other end. Just add the 2-inch length of the adapter to that to get the *combined length.*

CRANKCASE VENTILATOR VALVE ATTACHMENT

An improvement has been made in attaching the slant-six crankcase ventilation valve to the valve cover. It consists of a special rubber grommet in the valve cover to hold the vent valve in position. The grommet replaces the metal cup and spring clip used on previous models. The new grommet attachment is designed to improve sealing and control oil seepage. To inspect the valve, simply pull it out of the grommet. *Do not* remove the grommet from the valve cover.

NEW ENGINE MOUNTS

There has been a change in the design and location of the engine mounts that affects all eight-cylinder models *except* Valiants, Darts and Imperials. The new 45-degree shear-type front engine mounts are located lower and closer to the centerline of the engine. This change has several desirable effects. Bringing the mounts closer together tends to soften the roll or lateral rocking motion of the engine. Letting the engine roll easily reduces the amount of engine vibration transmitted to the passenger compartment at engine idle speeds.

Perhaps even more important, the new mounts are tuned to absorb objectionable suspension vibrations.

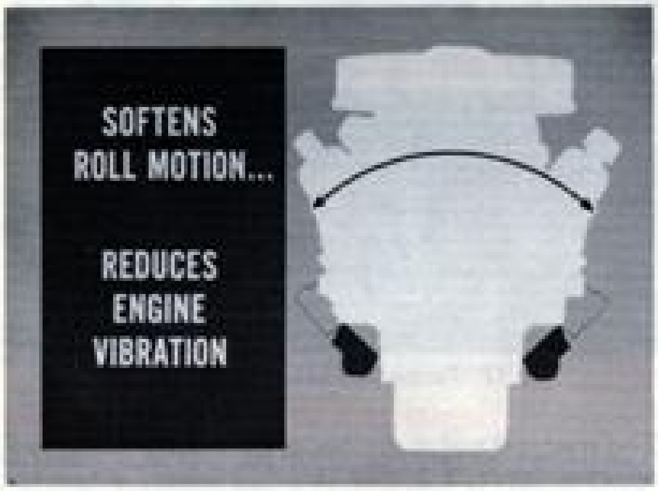


Fig. 13—New shear-type front engine mounts

WIDE-BLADE DISTRIBUTOR ROTORS

When the new slant-six distributor cap with wide inserts was introduced a few years back, a new narrow-bladed rotor was also introduced. Eight-cylinder models continued to use a wide-blade distributor rotor. Don't be surprised when you find a wide-blade distributor rotor in a 1966 slant-six. From now on, the wide-blade rotor will be used on both sixes and eights.

TORQUEFLITE TRANSMISSION

Extensive changes have been made in the TorqueFlite transmissions and the shift linkages. Most of these changes were brought about by the elimination of the rear pump and the addition of the internally actuated parking sprag.

THE CASE OF THE MISSING REAR PUMP

Some customers are bound to ask you about the elimination of the rear pump, so let's think about its purpose for a minute. As you know, when a car is pushed or towed, the rear pump is driven by the rear wheels instead of the engine. That means a rear pump supplies hydraulic pressure for push-starting and lubrication for towing with the rear wheels turning.

Greatly improved engine reliability and startability have minimized the importance of push-starting. Besides, very few owners care to have their cars damaged by pushing. In other words, the push-start feature is no longer very important to most owners. Here's something that *is* important. If you are going to tow a 1966 car equipped with TorqueFlite, pick up the rear of the car or disconnect the drive shaft.

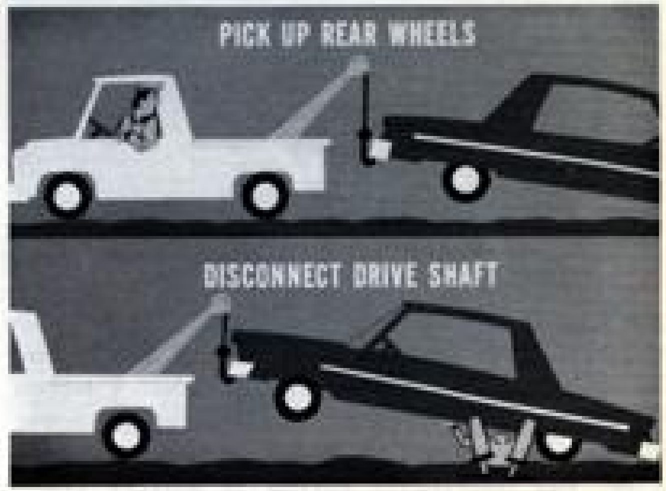


Fig. 14—1966 TorqueFlite towing precautions

TORQUEFLITE TOOLS AND SERVICE

Eliminating the rear pump brought about several related changes. Because of the hydraulic circuit changes, the new TorqueFlites have a new hydraulic system and a new valve body. As a result of these and other changes, new service procedures and new special tools are required. For example, new adapters are needed for installing the front pump bushing to the correct depth. Adapter SP-5118 is needed for the A-727 and Adapter SP-5117 for the A-904. Replacing the rear pump with an output shaft support calls for a new Adapter, SP-5124, to install the overrunning clutch cam on an A-727. In other words, be sure and refer to your 1966 service manuals and familiarize yourself with the new essential service tools before you start overhauling a '66 model TorqueFlite.

THE NEW PARK-LOCK MECHANISM

The locking sprag is now actuated by an internal sprag rod. The sprag rod is connected to the manual valve lever through an overtravel spring device . . . we'll explain why the overtravel spring is needed in a minute.

There is a bullet-shaped cam device at the rear end of the sprag rod. When it's pulled

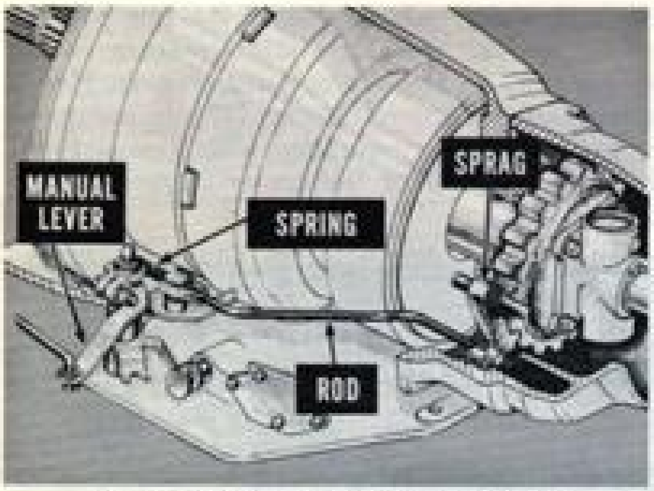


Fig. 15—Parking lock actuating mechanism

into position between the locking lever and the reaction plug, the cam action moves the locking lever into engagement with a notch in the park-lock gear. If the locking lever doesn't line up with a notch in the park-lock gear, the overtravel spring is simply compressed. This keeps spring pressure on the sprag rod until the locking lever does line up with notch in the gear.

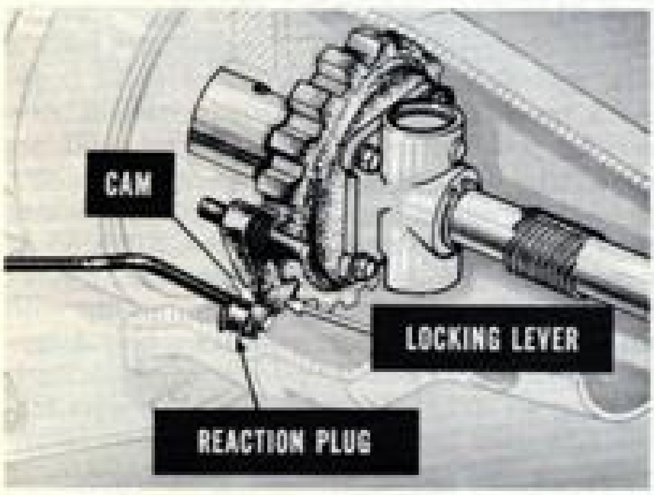


Fig. 16—Cam action actuates the locking lever

TORQUEFLITE COLUMN SHIFT

The column shift linkage has been greatly simplified. The detenting at the lower end of the steering column has been eliminated. To compensate for the elimination of this detenting, a much stiffer detent spring is used in the new valve body. So, watch it when you disassemble a new valve body or you may find the detent ball zooming into orbit.

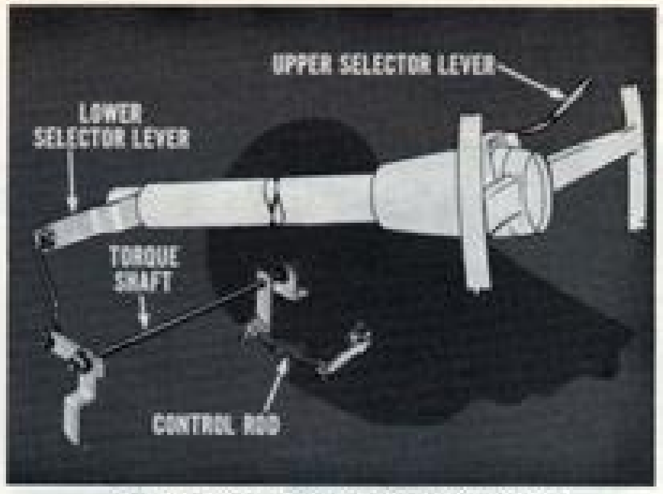


Fig. 17—TorqueFlite column shift linkage

The manual valve is now actuated by an upper selector lever, a lower selector lever, a torque shaft and a single control rod which replaces the two shift cables used on last year's models. Gating to prevent accidental shifting into REVERSE or PARK is still retained at the upper end of the steering column. Incidentally, this gating arrangement made it practical to eliminate the reverse blocker valve. The reverse blocker was necessitated by the push-button control which had no external gating.

TORQUEFLITE CONTROL ROD ADJUSTMENT

Control rod adjustment is simplicity itself! Loosen the control rod swivel clamp screw until the control rod is loose in the swivel. Put the gearshift selector lever in PARK. Move the manual control lever into the PARK detent. That's the last detent when you move

Fig. 18—TorqueFlite control rod adjustment

the lever rearward. Then, tighten the swivel clamp screw and that's all there is to shift linkage adjustment!

CONSOLE SHIFT LINKAGE

On TorqueFlite models with console shift, there's no gating between neutral and drive. However, you *must* push the release button in the top of the shift knob to get into "1", "2", "REVERSE", or "PARK". You must also push the release button in the shift knob to get *out of* reverse. This is a good safety arrangement because it prevents accidental shifts into "REVERSE" or "PARK". It also prevents you from accidentally bumping the shift lever out of "PARK".

CONSOLE SHIFT LINKAGE ADJUSTMENT

On the console as well as the column-shift models, the linkage adjustment is made with the gearshift selector lever and the manual valve control lever in "PARK". On Valiant and Dart models, the control rod is adjusted by loosening the adjusting lever at the lower end of the torque shaft. On other models, the adjustment is made at the swivel clamp located at the manual valve lever.

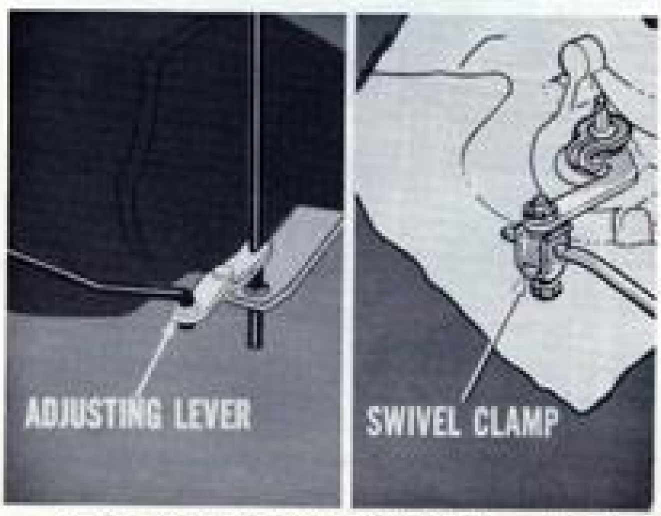


Fig. 19—Adjusting lever and swivel clamp detail

CONSOLE SHIFT RELEASE BUTTON ADJUSTMENT

When the console shift release button is assembled it should be adjusted so that it extends about 1/32-inch above the shift knob. This adjustment is made by loosening the set screw in the knob. Then, with the shift lever in neutral, turn the release button clockwise until the serrated surface of the button is approximately 1/32-inch above the shift knob. Tighten the set screw. If the button is not threaded far enough onto the shift cable, it may be difficult or impossible to shift out of the NEUTRAL-DRIVE range.

Fig. 20—Console shift release button adjustment

—FOUR-SPEED MANUAL TRANSMISSION—

The four-speed manual transmission was covered in MTSC Session 65-11 and no major changes have been made since that Tech Kit was released. One change should be called to your attention.

SELECTIVE-FIT SHIFTER SHAFTS

The one-two shifter is a selective fit. You will recall that if an "A" shifter does not provide a good fit between the one-two shifter and the reverse shifter, a "B" or perhaps a "C" shifter should be tried. In other words, three dimensionally different one-two shifters were available. In 1966 only two one-two shifters will be serviced . . . an "A" and a "B".

FOUR-SPEED TRANSMISSION SHIFT MECHANISM

A completely new four-speed manual transmission shift mechanism is offered in 1966. This new mechanism has a positive reverse lockout device that is released manually by lifting the Tee-handle below the shift knob. Lifting the Tee-handle releases a lockout pin and lets you move the shift lever sideways to get into reverse.

You can easily make a simple alignment tool which will help you adjust the shift control rods correctly. The alignment tool is used to lock the new gearshift mechanism in neutral while you adjust the three control rods. The alignment tool can be made from any metal stock. It is 1/16-inch thick, 5/8-inch wide and about 2 3/8 inches long.

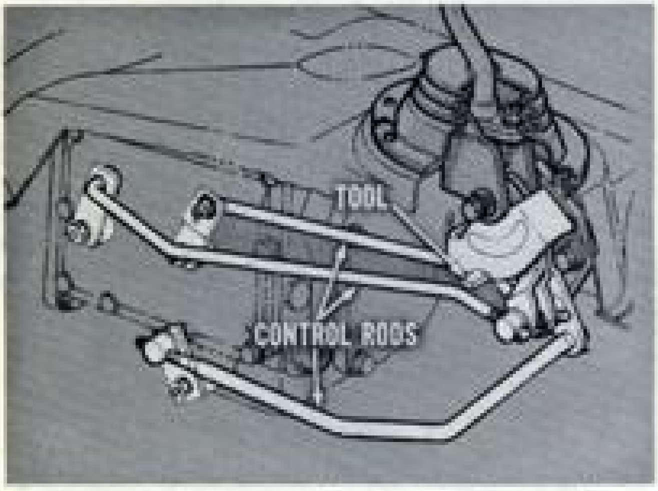


Fig. 21—Tool locks shift mechanism in neutral

Shift the transmission into "NEUTRAL" and then disconnect all three control rods from the transmission shift levers. Insert the alignment tool, as shown, to lock the shift mechanism in neutral. Adjust each of the three control rods to obtain a "rattling good fit". When rod length is exactly right, the end of the rod may rub the hole in the lever as it is assembled. However, if the rod length is correct it will be loose in the lever hole after it is installed. This is what Tech calls, "a rattling good fit". The retaining clips and washers will eliminate the rattle when they're installed.

MISCELLANEOUS DRIVE-LINE ITEMS

Several new bushing and seal tools will be required to service the drive-line components of the 1966 models. Also, a unique new high-accuracy speedometer drive has been introduced this year. You'll find the service details in your service manuals but here are some of the highlights.

EXTENSION HOUSING BUSHING TOOL

You'll need the new Extension Housing Bushing Remover and Installer, C-3996, to service TorqueFlite and manual transmissions which have the sliding spline output shaft with small U-joint yoke. This new tool will remove the bushing easily without danger of damaging the extension housing. Perhaps even more important, this same tool will install the new bushing to the correct depth in the housing.

EXTENSION HOUSING SEAL TOOLS

You'll also need Seal Installer, C-3995, to service the transmission extension housing oil seal of six-cylinder models with TorqueFlite. This tool also services the seal used on manual transmissions with sliding spline and small U-joint yoke. To remove the seal on these same models, you'll need Seal Remover C-3994. As we said earlier, get acquainted with your 1966 service manuals and your 1966 essential service tools and make it easy on yourself in the coming year!

HIGH-ACCURACY SPEEDOMETER DRIVE

The new high-accuracy speedometer drive is entirely new for 1966. The number of teeth on both the output shaft worm gear and the pinion gear has been almost doubled. Also, a larger selection of pinion sizes is now available. The new pinions come in three different basic diameters.

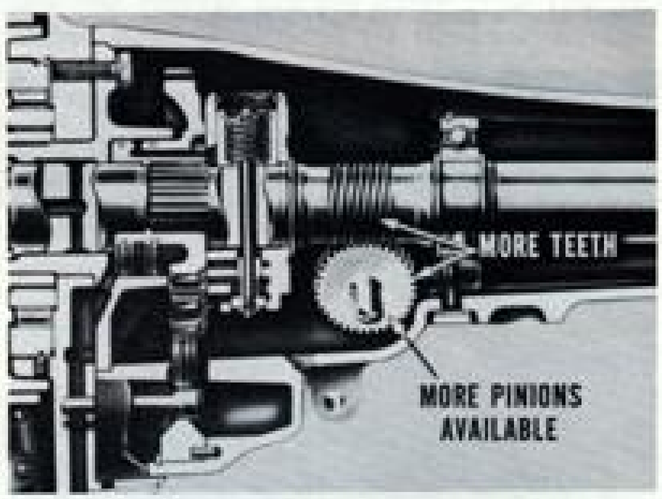


Fig. 22—High-accuracy speedometer gears

To simplify servicing or changing the new pinions, a new pinion adapter has been developed. The adapter adjusts the center-to-center distance between the output shaft worm gear and the pinion gear.

The new pinion drive adapter has an off-center bearing hole. This allows you to install the correct size pinion without installing a new adapter or changing any other parts. You simply put the proper pinion in place and turn

Fig. 23—The new adapter adjusts for different pinion diameters

Fig. 24—Adjustable pinion adapter

the adapter so that the range of teeth numbers at the bottom of the adapter match the number of pinion teeth.

BRAKES, REAR AXLE AND STEERING

You'll find some changes and additions in the brake, rear axle and steering departments, too. In addition, all cars except Imperial will use a cross-and-roller universal joint at both the front and rear. The Imperial will retain the two-piece shaft and center bearing. Some models will be equipped with an inertia yoke at the front while others will have a rubber-isolated propeller shaft at the rear. Universal joint angularity specifications have been modified slightly, so follow the latest service manual and bulletin information.

Needless to say we can't cover every change in one reference book. Besides, the information will be easier to digest if Tech feeds it to you session-by-session in the remaining eleven issues of the Master Technicians Service Conference. He plans an early release on disc brakes and several other interesting subjects, so be on the lookout for them.

HEATERS AND ACCESSORIES

Several changes have been made in the heaters for the 1966 models. New power seat mechanisms have been introduced and reclining seats will be offered. You probably won't run into these accessory changes and additions every day, but this serviceman's preview wouldn't be complete without at least mentioning them.

BELVEDERE AND CORONET HEATER

These models now have a ram-type, fresh-air vent on the driver's side of the car. This left-side ventilator is independent of the heater and has its own separate cable control.

The right-side fresh-air ventilator is part of

Fig. 25—Belvedere-Coronet vent for driver's side

the heater assembly. The vent control door directs fresh air into the car when it's open. When the vent is closed, it feeds fresh air into the heater.

The new Coronet-Belvedere heater is the blend-air type. The heater core is always hot. Outlet air temperature is controlled by the position of the temperature control door. Correct heater-defroster position is very important because the three door positions, "HEAT", "DEFROST" and "OFF", are covered in only about 90 degrees of door movement.

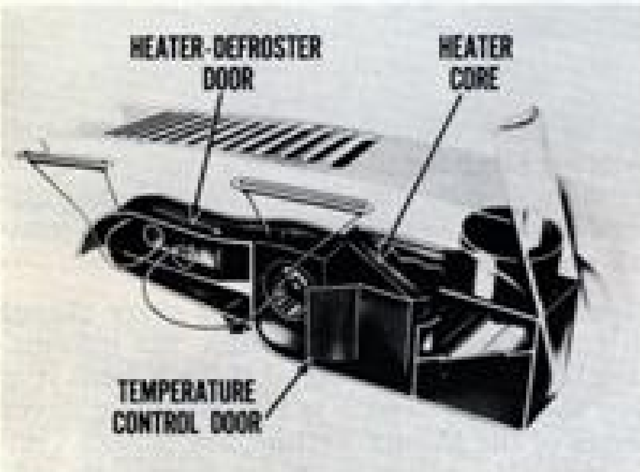


Fig. 26—Belvedere-Coronet heater control doors

Correct adjustment of the heater-defroster door is easy if you use Bowden Cable Locator Tool SP-5163. This special tool holds the heater-defroster crank arm in the correct position while you clip the control cable to its bracket. Incidentally, you'll find the Bowden

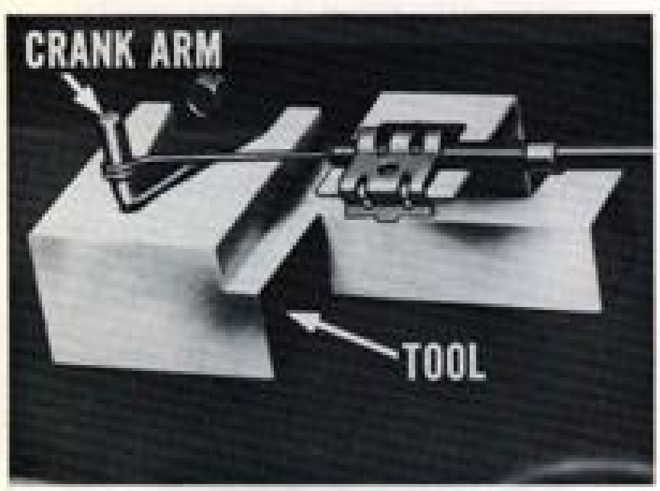


Fig. 27—Heater-defroster door adjusting tool

cable clip removing and installing tool, SP-5162, is worth its weight in time and tempers saved when adjusting control cables that are held in place by a spring clip. Be sure and get acquainted with this handy little tool. You'll wonder how you ever got along without it!

CHRYSLER REAR-SEAT HEATER

The Chrysler rear-seat heater is a combination heater, defroster, and defogger. It's a recirculating system having its own two-speed blower, its own heater core and its own vacuum-controlled water flow valve.

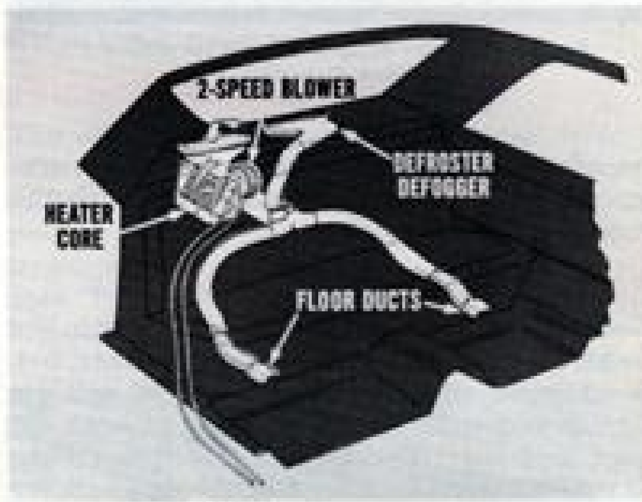


Fig. 28—Chrysler rear-seat heater

The rear-seat heater is entirely independent of the front compartment heater and has its own controls. One of the controls is an electric switch which controls the blower. Blower positions are . . . OFF . . . LOW . . . HIGH.

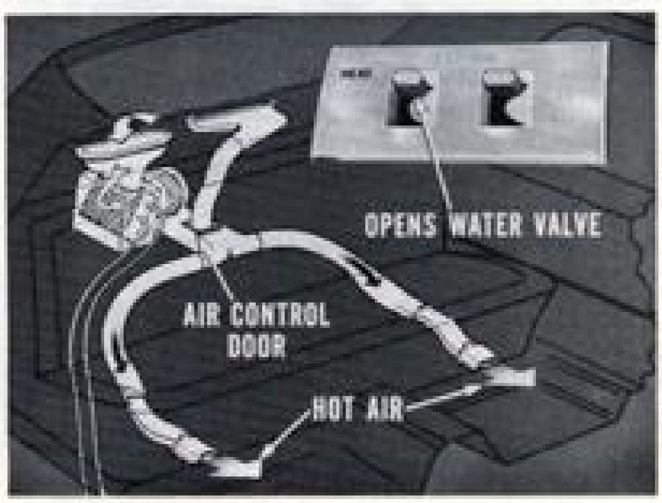


Fig. 29—Rear-seat heater, heating air flow

The other control is a vacuum switch. It controls both the water valve in the engine compartment and the air control door at the heater assembly.

When the vacuum switch is on HEAT, a vacuum actuator opens the water valve and sends hot water to the heater core. A second vacuum actuator moves the air control door so that heated air is directed downward and out through floor-level discharge ducts on either side of the rear seat.

When the vacuum switch is set for DEFROST, the water valve actuator opens the water valve, sending hot water to the heater core. The air door actuator directs hot air upward and out through the package shelf duct to defrost the rear window.

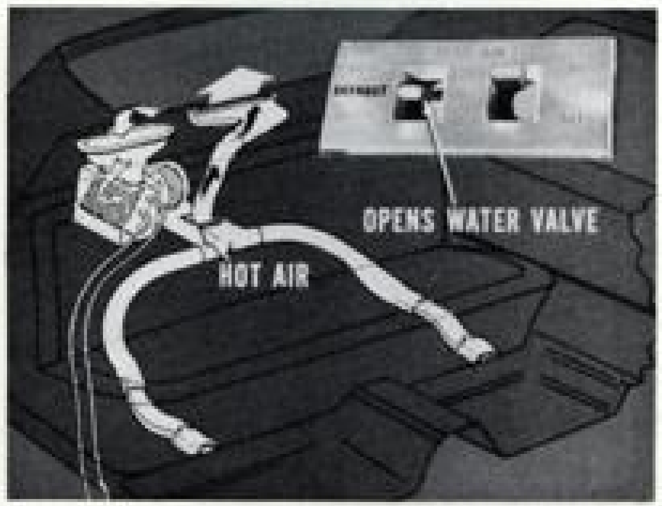


Fig. 30—Rear-seat heater, defrosting air flow

In warm weather you may want defogging without heat. When the vacuum switch is flipped to DEFOG, the vacuum actuator in the engine compartment closes the water flow valve. The actuator at the air control door directs unheated air upward and out through the defroster outlet.

SIX-WAY POWER SEATS

A new six-way power seat adjuster is offered this year. Horizontal movement of the seat is controlled by a rack-and-pinion mechanism. New gearing in the rack and pinion is designed to provide quieter operation. Screw jacks at the front and rear provide the up-and-down, as well as the tilt adjustment of the seat. This design reduces the free-play in the adjuster mechanism and minimizes chucking motion of the seat.

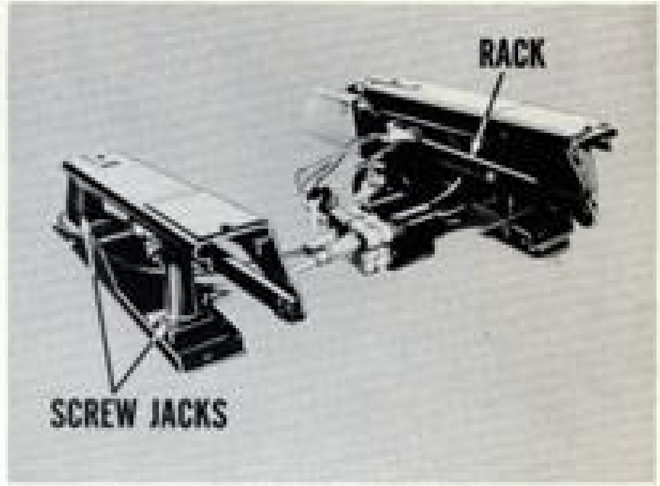


Fig. 31—New six-way power seat mechanism

RECLINING SEATS

Two new reclining seats are offered this year. They both operate something like cylinder-type storm-door closers. This design permits the front-seat passenger to adjust the seat-back through an angle of approximately 45 degrees. It also allows rear-seat passengers in two-door hardtop models to unlock the mechanism by pushing the rear seat-back forward. This, of course, makes it easy for rear-seat passengers to get out of the car. One of the reclining seat options has an adjustable headrest, the other does not.

IMPERIAL AUTOMATIC BEAM CHANGER

The automatic beam changer is completely new for 1966. The phototube is mounted on top of the instrument panel. The knob located at the rear of the unit permits the driver to adjust the dimming distance . . . within reasonable limits. Special tool C-4008 is required to obtain proper aiming of the phototube unit.

A PARTING WORD FROM TECH

This preview of the 1966 models doesn't begin to cover every new feature and all the changes in service procedures. However, it should give you a better idea of what to look for in the new models.

We'll be back with additional information in coming Master Tech sessions. In the meantime, give your customers and the sixty-six models the best of care again this year.

MASTER TECHNICIANS SERVICE CONFERENCE 66-2

REFERENCE BOOK

DISC BRAKES

CHRYSLER CORPORATION

PLYMOUTH · DODGE
CHRYSLER · IMPERIAL

STOP!

That's what our customers expect when they push the brake pedal. And, that's what they get: a safe, stable stop every time. Even after a panic stop, the car is in its own lane, instead of being slewed around crosswise to the road.

In keeping with the tradition of providing the best braking systems in the automobile industry, Chrysler Corporation is offering, as optional equipment, caliper-type disc brakes on some 1966 models. Specifically, the Valiant, Dart, Barracuda, Fury, Polara, Monaco and all Chryslers have disc options in their lines.

Tech predicts that you'll enjoy working on disc brakes. And, as they become better known to the buying public as the safest, most dependable brakes available, there is little doubt that you'll be seeing more and more of them.

This reference book describes the operation of the two disc brake systems available in 1966. (One system for the smaller cars, another for the larger cars.) Although the principles of operation of the two systems are very similar, there are some structural differences that vary servicing procedures. For instance, replacement of shoes on either of the units is very simple, and takes only a few minutes. But, there is a different procedure for each type that you'll want to know about.

The book contains some other tips on service procedures, so be sure to look it over carefully and add it to your reference book library.

INDEX

THIS BUSINESS OF STOPPING

There isn't much doubt that the best safety device on any automobile, old or new, is a careful, skilled driver. Even the most carefully designed car can become a thing of danger in the wrong hands. On the other hand, the most careful and highly skilled driver has to rely upon the dependability of all the components of his car to keep him and his passengers safe.

A SPRAG BRAKE

A few thousand years ago, a man with a name something like Ogachuk Gug discovered that a round wheel was a mighty handy gadget for transporting dinosaur steaks back to the cave. It was tough going on the uphill grades, but it was almost as tough going downhill, until he discovered that a log sprag worked fine as a method of preventing a runaway wagon.

FRICTION SHOES

A few thousand years later, Wells Fargo was using a friction-type brake to control the speed of the Overland Stage. Some of those old trails covered some mighty rough country, and the horses needed help to hold the stage from running away down the side of a mountain. The driver stepped on a pedal and a shoe rubbed a wheel rim to help slow the stage.

SELF-POWERED VEHICLES

As the world progressed into the age of the automobile, the need for more powerful brakes soon became evident. Vehicles were heavier, and they moved faster. In a few short years, the brake shoe was moved from the outer wheel rim to the inside of an auxiliary rim attached to the wheel, the forerunner of our modern drum-type brake. In the mid-thirties, hydraulic power was added to the drum brake system, providing more stopping power.

THE CHRYSLER RECORD

The cars of Chrysler Corporation have always had a very good reputation in the brake department. Among the more notable systems were our Total Contact Safe Guard, Center Plane, Three Platform and the currently used Servo-Contact brakes. In every case, Chrysler met the need for safe, dependable straight-line stopping. There's no question that our cars have led the industry.

HEAVIER DEMANDS

A recent survey proved that there is an automobile for every 2⅓ people in America. And, these automobiles are on the move. Every year more people travel more miles, and at higher speeds. The cars are heavier, and they're very often loaded down with vacation gear. A three-hundred horsepower engine is no longer unusual. With all this additional "GO" power, it follows that we also need more "WHOA" power.

HOW MUCH BRAKE POWER?

How much braking power is needed in an automobile? Consider the amount of power required to accelerate a car from a standstill to 60 miles an hour in, say, 15 seconds. Let's assume, for illustration, that it takes 100 horsepower. Now, after the car is moving at 60 miles per hour, it will take an additional 100 horsepower to bring it to a standstill in 15 seconds. As you know, you seldom have 15 seconds to stop. Again for illustration, let's assume that the stopping time is 5 seconds—one-third of the acceleration time. Horsepower is a measurement of work done in a given period of time, and the brakes must do the same amount of work that the engine did, but in one-third of the time. This means that the horsepower requirement is tripled. The brakes exert 300 horsepower in stopping the car.

HEAT ENTERS THE PICTURE

In stopping an automobile, the brake drums and linings absorb a lot of mechanical energy and convert it to heat. For example, stopping a 4,000-pound car from a speed of 60 miles an hour develops about 620 BTU. That's enough heat to raise the temperature of the drums about 170 degrees. Repeated brake applications, such as might be encountered in mountainous country, multiply the heat load. Unless this heat is dissipated rapidly, the linings may deteriorate, the drums become distorted and, in extreme cases, the brake fluid may boil.

DISSIPATION PROBLEMS

Way back when we had 30-inch wheels, getting rid of the heat generated by the brakes wasn't much of a problem. First of all, there wasn't as much heat to get rid of. And, the wheels and drums were well exposed to the air. The heat problem became more severe with the introduction of new suspension systems, which required that the drums be almost encased by the wheels. To add to the problem, more and more sheet metal was installed around the wheels, reducing the flow of air around the drums. Bigger tires, smaller wheels and higher speeds also presented brake heat difficulties, which in turn cause brake fade.

ENTER DISC BRAKES

With the introduction of disc brakes, the heat dissipation problem is greatly reduced. A major portion of the disc is exposed to the air to throw off accumulated heat. The opposing action of the shoes on the disc eliminates distortion. The absence of distortion permits the use of much greater application force and special lining material with stable friction characteristics, which simply means that the gripping ability of the linings is not affected by temperature extremes.

A GOOD BATH DOESN'T HURT

Even though the discs are exposed to road splash and dirt, the braking efficiency is not affected. Centrifugal force throws most of the water and mud off the disc, and high lining application force and temperature quickly dries the disc and pads. In addition, the pads clean the disc, even when the brakes are not applied. In the unit used on Valiant, Dart and Barracuda, there is only about five-thousandths of an inch clearance between the pads and the disc. In the other unit, the pads actually ride lightly against the disc. (A spring behind each piston applies just enough force to keep the pads in light contact, without causing any noticeable drag or lining wear.)

Fig. 1—Discs are self-cleaning

WHY ONLY IN FRONT?

One of the first questions usually asked about our disc brake system is, "Why are discs used only on the front wheels?" As you know, when the brakes are applied, especially in a sudden stop, much of the car weight is thrown forward. So, most of the tire-to-road friction is at the front wheels, where the weight is, and where the most braking power is needed. If an equal amount of braking power were applied to the rear wheels, with less weight on them, they would have a strong tendency to slide, probably resulting in an uncontrolled skid.

Fig. 2—Most weight is on front wheels

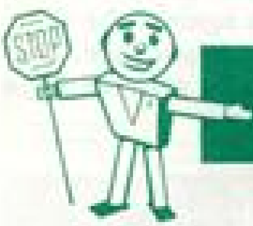
PARKING BRAKES

Another very good reason for using drum brakes on the rear wheels is that drums provide an excellent mechanical parking brake. It would be very difficult to obtain equal results from disc brakes through mechanical linkage.

THE COST FACTOR

It's obvious that disc brakes are more expensive to build than drum brakes. There are four cylinders and pistons per wheel, and the manufacturing tolerances are very close. Since most of the braking force is applied at the front wheels, it would be highly uneconomical to use discs at the rear wheels. Any additional braking power at the rear wheels just wouldn't be worth the extra cost.

Fig. 3—Drum brakes for parking



DISC BRAKE OPERATION

There are two different disc brake systems available in 1966. The Kelsey-Hayes-type system is used on the Valiant, Dart and Barracuda. The other unit, a Budd type, is used on the Fury, Polara, Monaco and Chrysler. Although they are structurally different, the operation of the calipers is very similar.

THE PARTS

The basic disc brake assembly consists of a hub and disc assembly, a caliper assembly, four pistons and two shoes. The disc is bolted to the hub, and is serviced as an assembly only. The caliper assembly, containing the pistons and shoes, bolts to the steering knuckle and steering knuckle arm, and straddles the

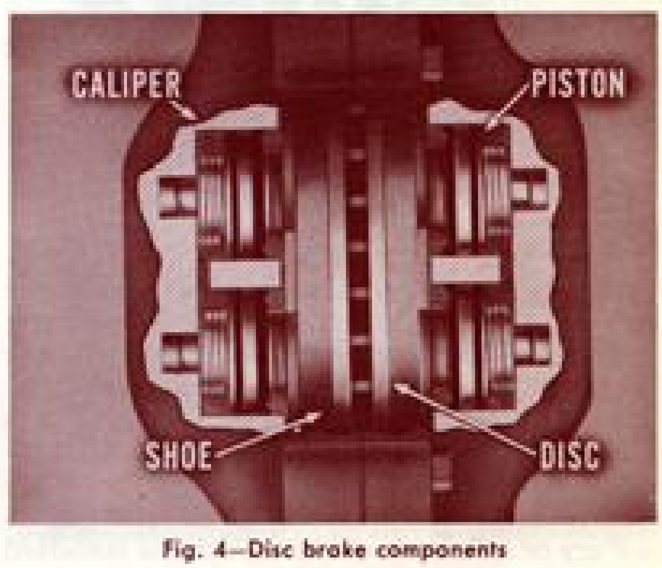


Fig. 4—Disc brake components

disc. The wheels are deep-dished to clear the caliper. The disc has radial ventilating louvers cast between the two contact surfaces. The louvers help to dissipate the extreme heat generated during brake applications.

The high-friction, organic linings are bonded to the steel shoes. There is no provision for adjusting the shoes, since they are self-adjusting. Although the lining area is much smaller than drum-type linings, disc brake linings usually last much longer.

A SQUEEZE PLAY

When the brakes are applied, the pistons force the shoe and lining assemblies against each side of the disc, squeezing it like a clamp or vise. There is an equal force against each side of the disc, so the disc is not distorted by the application, even when the temperature is high, as after repeated applications. Because there is little or no clearance between the shoes and disc when the brakes are not applied, the braking action is instantaneous. The extra-large piston area provides extremely high application force.

Fig. 5—Shoes clamp on the disc

THE HYDRAULICS

Basically, the hydraulics of disc brakes are exactly the same as drum brakes. The master cylinder piston forces the brake fluid into the wheel cylinders and against the wheel pistons. But, in the disc brake systems, each caliper has four large pistons, so the fluid requirement is much larger, and the forces are higher for a given pressure. As an example, on a Fury or a Polara equipped with the standard drum-type brakes, each front shoe is operated by a single piston with a diameter of 1.375 inches, or an effective area of 1.485 square inches. If the pressure in the brake lines is 1,000 psi, the force each shoe exerts against the drum is 1,485 pounds. On the same cars equipped with disc brakes, each shoe is operated by two pistons of 2.368 inches diameter, or an effective area of 4.404 square inches per piston.

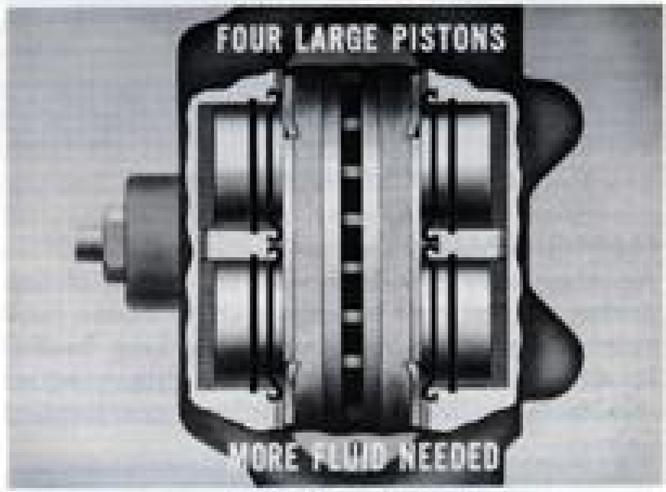


Fig. 6—Higher fluid requirements

If the same pressure of 1,000 psi were introduced into this system, each piston would exert a force of 4,404 pounds against the shoe, for a total force of 8,808 pounds per shoe. This means that each disc would be gripped by a total force of 17,616 pounds!

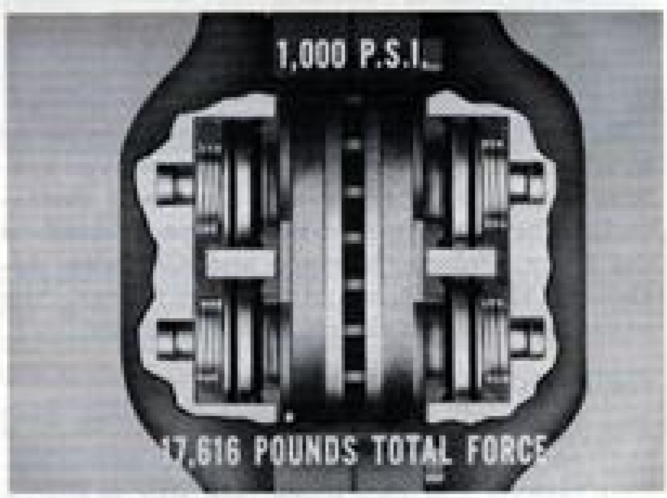


Fig. 7—More force for same pressure

RESIDUAL VALVE

In a drum brake system, the residual valve has a very important function. The residual pressure keeps the wheel cylinder cups against the cylinder wall, so no dirt or moisture can enter the system. But, most important, the residual valve makes it possible to pump the brakes when the linings have worn somewhat. Here's how it works.

When the brake pedal is pressed, the master cylinder piston forces the fluid in the cylinder through the residual valve and into the lines. As the pedal is released, the shoe return springs in the wheels force the fluid back out of the wheel cylinders and lines and back into the master cylinder. The residual valve maintains from 12 to 18 psi in the lines by closing when the line pressure drops to the valve capacity. If the brake pedal is pumped, the fluid return will be delayed by the residual valve, and the master cylinder will be refilled from the reservoir, through the compensating port. On the next pedal stroke, this fluid will also be forced into the lines, building up the pedal height.

THE VALVE HAS BEEN MOVED

The residual valve has been relocated for disc brake systems. Residual pressure is highly undesirable in the disc brake calipers. Because of the large diameter of the pistons, and since there are no return springs in the calipers, residual pressure would cause a heavy brake drag. For example, if there were 18 psi residual pressure in the front wheel cylinders of a Fury or Polara equipped with discs, the shoes would exert 320 pounds of force on each disc. However, residual pressure is still necessary for the drum brakes at the rear wheels. So, the valve is located between the "T" connection and the brake line to the rear wheels.

Fig. 8—Residual pressure would cause drag

DIFFERENCES IN THE SYSTEMS

KELSEY-HAYES

The Kelsey-Hayes-type unit, used on the Valiant, Dart and Barracuda, has $1\frac{5}{8}$-inch-diameter pistons. Each lining has $8\frac{1}{2}$ square inches of braking surface. The rear wheels have 10-inch brakes, with $1\frac{3}{4}$-inch-wide linings. Fourteen-inch wheels are used with this disc brake system.

When the brakes are applied, the four pistons press the shoes against either side of the disc. The square piston seals, in the walls of the cylinders, move slightly with the pistons. When the brakes are released, the elasticity of the seals pulls the pistons back away from the shoes about five thousandths of an inch.

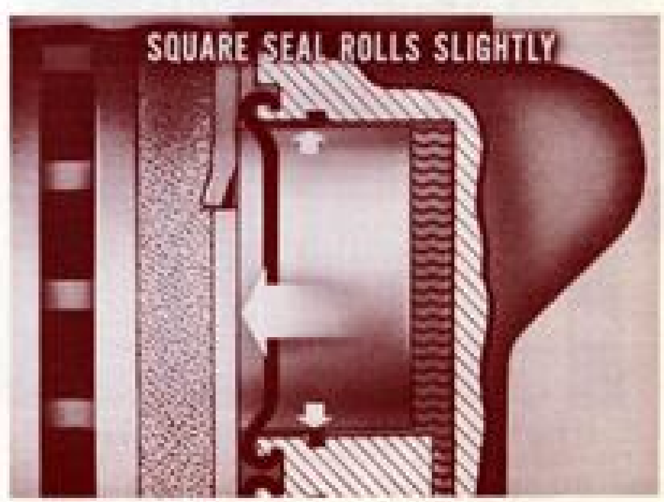


Fig. 9—The piston rolls the seal

This allows any small amount of lateral run-out in the disc to tap the shoes away from the contact surfaces, providing the running clearance. Anti-rattle springs in the caliper splash shield hold the shoes in the unapplied position. Two small ears on the ends of the shoes support them in the caliper. The ears ride on notches, called bridges.

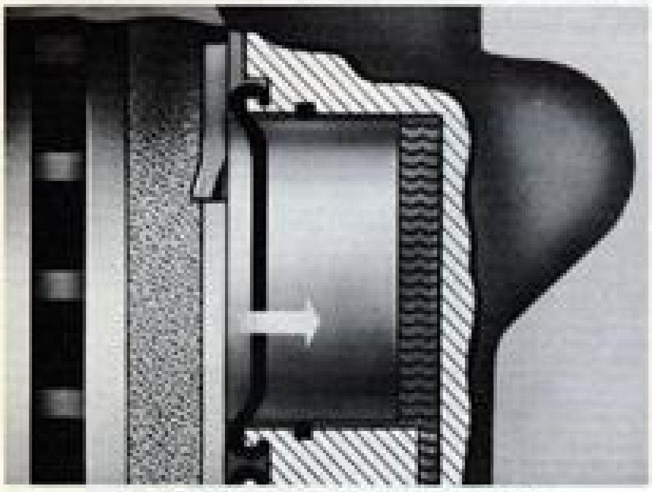


Fig. 10—The seal pulls the piston back

THE PISTONS

The pistons in this unit are cup-shaped, with the open end contacting the shoes. The cup-shaped construction minimizes the transfer of heat from the shoes to the fluid. Otherwise, the fluid could get hot enough to boil, creating bubbles, which would cause a spongy brake pedal.

Fig. 11—Hollow pistons don't conduct heat

THE HYDRAULICS

Probably the first thing you'll notice about the hydraulic system is the extra capacity of the master cylinder reservoir. The four large cylinders in each caliper need a lot of fluid as the linings wear down.

Fig. 12—A bigger fluid supply

THERE'S ANOTHER VALVE

Another difference that will be immediately apparent, in the Kelsey-Hayes-type unit, is a second valve. It's called a proportioning valve, and it's located after the residual valve in the line to the rear brakes. Its purpose is to provide maximum braking at all four wheels before any wheel begins to slide, under any road conditions. It performs this function by regulating the hydraulic pressure to the rear wheel cylinders during heavy brake applications.

Fig. 13—Valve limits rear cylinder pressure

WEIGHT DISTRIBUTION

During light brake applications, hydraulic pressure seldom exceeds 300 psi. Under these light braking conditions, the weight differential between front and rear wheels is much less than during heavy applications, so a larger percentage of the braking force can be applied to the rear wheels without fear of sliding the rear wheels. However, as brake application increases in intensity, more weight is thrown onto the front wheels, and correspondingly less on the rear wheels. So, the greatest force must be applied to the front wheels. And, although the piston area in the disc front brakes is much greater than in the rear drum brakes, remember that the discs have a much smaller lining area.

Fig. 14—Weight distribution is important

THE PRESSURE LIMIT

To demonstrate the function of the proportioning valve, let's assume some braking applications of different intensities. First, a light application, with up to 300 psi line pressure from the master cylinder. This would be typical of a gradual stop at an intersection in a residential area. As mentioned before, there isn't much weight differential between front and rear wheels, so equal pressure is supplied to all four wheels.

A traffic light that changes unexpectedly presents a good example of a moderately heavy brake application, with perhaps 600 psi line pressure from the master cylinder. This puts a higher percentage of the car weight on the front wheels, so the braking force required at the rear wheels will be proportionately less than at the front. The proportioning valve al-

Fig. 15—Moderately heavy stop

lows only 450 psi to the rear cylinders, even though the caliper cylinders get the full 600 psi.

When that crazy driver pulls out of a stop street without looking, you have to really clamp down on the stoppers. Again, the weight shift is greater, so the braking proportion changes, too. Let's say you're standing on the pedal, and producing 900 psi master cylinder pressure. You sure don't want that much pressure at the rear wheel cylinders, so the proportioning valve cuts it down to 600 psi.

Fig. 16—A panic stop

OVER 300 PSI, REDUCES 50%

As you can see by the examples given, at pressures of 300 psi or less, the proportioning valve doesn't do a thing for us. When pressures go higher than 300 psi, the valve allows the 300 to the rear cylinders, but anything greater than that amount is reduced by 50%, as shown in the following chart.

LINE PRESSURE	REAR PRESSURE
300	300
500 (300 + 200)	400 (300 + 100)
700 (300 + 400)	500 (300 + 200)
900 (300 + 600)	600 (300 + 300)

INTER-CYLINDER SUPPLY

Even though there are four large cylinders in each caliper assembly, there is a single hydraulic feed line to the bottom cylinder in the inner half of each caliper. The top cylinder in the inner half is supplied through a cored passage in the casting. The cylinders in the outer caliper half are supplied through a transfer tube from the inner half.

Fig. 17—Tube supplies outer caliper half

SERVICE INSTRUCTIONS AND PRECAUTIONS

SERVICING KELSEY-HAYES

Disc brake linings on the Valiant, Dart and Barracuda should be replaced when they are worn to the point where the combined thickness of the shoe and lining is $\frac{3}{16}$-inch or less. Inspection and replacement of the shoes is very simple. Just remove the front wheel and the caliper splash shield anti-rattle spring assembly. You should be able to measure the shoe and lining thickness while they're in the caliper. If not, simply pull them out of the caliper for measurement.

Fig. 18—Time to replace linings

WARNING SIGNAL

When a Valiant, Dart or Barracuda has accumulated a lot of mileage, the customer may complain of a scraping noise when the brakes are applied. The noise is probably caused by signal tabs in the brake shoe. They are stamped into the shoe to act as a signal to the driver

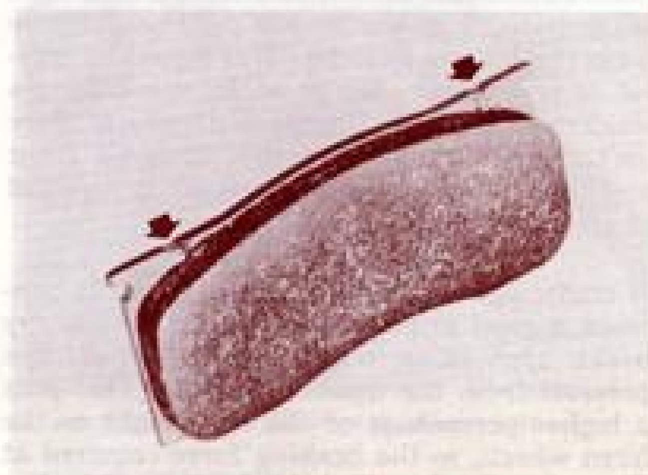


Fig. 19—Tabs signal worn out shoes

when the linings are worn down to the danger point. When the brakes are applied, the tabs contact the disc to produce the scraping sound. This won't affect the braking or harm the disc, provided the linings are changed within a short length of time.

LINING REPLACEMENT

To replace the linings in the Kelsey-Hayes unit, remove the wheel and the caliper splash shield anti-rattle assembly and pull the worn linings out through the splash shield opening. You'll find that two pairs of pliers make it a little easier to grip the shoes. Always inspect the caliper carefully for signs of fluid leakage.

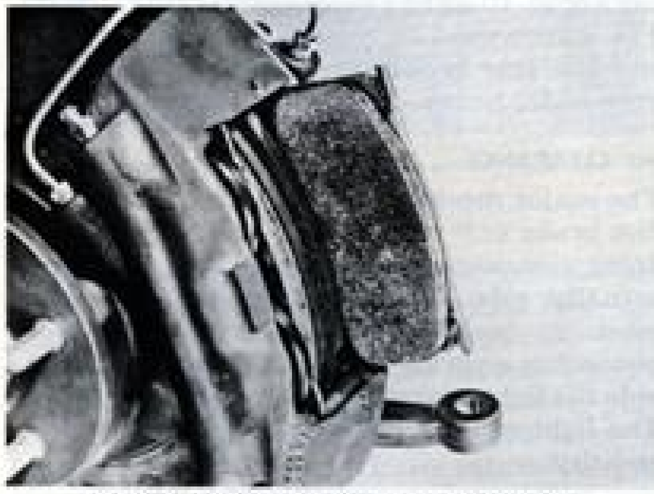


Fig. 20—Shoe replacement is an easy job

You may need to remove the caliper for seal replacement. To install the new shoe and lining assemblies, force all four pistons back into their bores and simply drop the new shoes into the caliper through the splash shield opening.

DRAIN SOME FLUID

As the brake linings wear down, it takes more fluid to fill the cylinders. Since there are four large cylinders at each front wheel, and there is about 3/8-inch difference between the thickness of a worn lining and that of a new lining, you can see that a lot of fluid can be added to the reservoir during the lining wear period. When you try to force the caliper pistons back into their bores, this extra fluid has no place to go. So, before installing new linings, drain most of the fluid from the master cylinder reservoir. Just be mighty careful not to get any dirt in the reservoir. When the new shoes are installed and you have a firm pedal, refill the reservoir with *new* brake fluid.

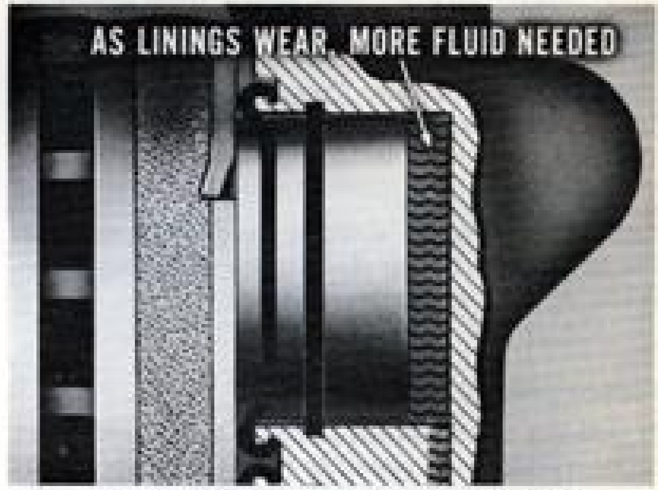


Fig. 21—Fluid level should be checked often

Fig. 22—Make room for fluid in the calipers

BLEEDING

The bleed screw on Valiant, Dart and Barracuda disc brakes is located at the top of the

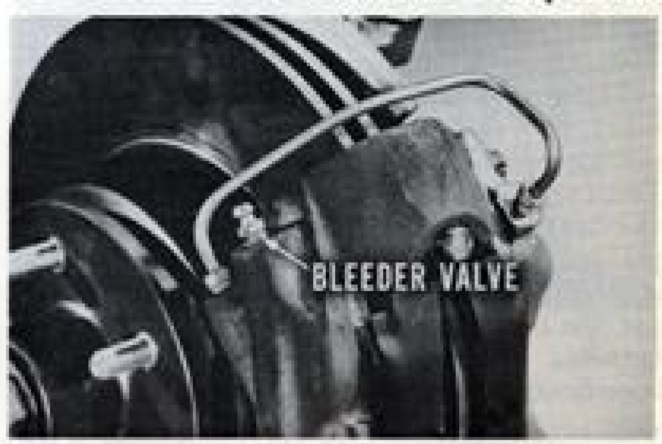


Fig. 23—Remove the wheel to bleed caliper

outer caliper half, so you'll have to remove the wheel to bleed the calipers. And, don't forget that you'll have to add more fluid on disc-brake cars than on drum-brake cars. Our present pressure bleeding tank adapters are not compatible with the "piggy back" reservoir, but a new adapter cover is currently being developed to handle both disc brake systems.

CAUTION: Always discard fluid drained from the hydraulic system during the bleeding operation. It must never be re-used.

PROPORTIONING VALVE TEST

If you get a rear wheel slide on a Valiant, Dart or Barracuda, it's possible that the proportioning valve is not reducing the pressure to the rear wheel cylinders. You can check the valve operation with gauge set C-4007, consisting of two 1000-psi gauges with high-pressure hoses and two "T" connectors.

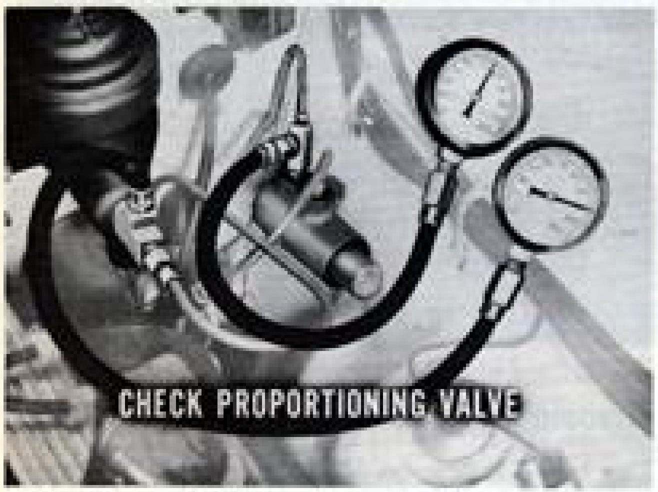


Fig. 24—Proportioning valve must reduce pressure

Install one "T" and gauge between the master cylinder and the master cylinder line. The other "T" and gauge goes between the proportioning valve outlet and the rear brake line. Draft someone to help you, and have him push the brake pedal hard enough to produce 800 psi on the master cylinder gauge. With the master cylinder gauge holding steady at 800 psi, the proportioning valve gauge should read between 540 and 560 psi. If it's outside the specification, replace the valve.

You may have difficulty getting 800 psi at the master cylinder gauge if the gauge hose is full of air. If so, bleed both of the gauge hoses at the gauge end to remove the air. Remember, air is compressible, and the master cylinder piston stroke is not very long. And, you can't pump up the pressure in the master cylinder gauge, because there is no residual valve in the master cylinder. When you're finished with the test, cap the gauge hoses to keep the fluid from draining out, so you won't need to bleed them on the next job.

BUDD TYPE

The Budd-type unit, which is optional on the Fury, Polara, Monaco and all the Chryslers, has 2.368-inch-diameter pistons. Each lining has about 10 square inches of braking surface. The wheels used on these cars are 15-inch 6K, and the rear brakes are 11 inches, with 2½-inch-wide, heavy-duty police linings.

NO CLEARANCE

The major mechanical difference between this disc brake unit and the Kelsey-Hayes-unit is lining clearance. In the Budd unit, the linings actually ride lightly against the disc, even when no braking pressure is applied. Each piston has a spring behind it. The springs provide the light contact between linings and disc. The light contact helps to keep the disc clean and dry.

Fig. 25—Shoes keep the disc clean

THE PISTONS

The pistons used in the Budd unit are narrow, with a piston guide on the inner end to prevent them from "cocking" in the cylinder. The piston seal groove is in the piston itself, rather than in the cylinder, as in the other unit. There's a heat insulator pad on the outer end of the piston to prevent braking heat from reaching the brake fluid.

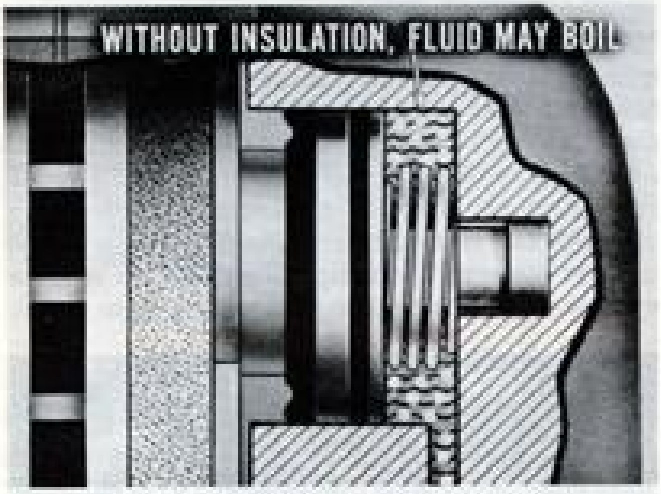


Fig. 26—Insulator keeps the piston cool

THE HYDRAULICS

There is no external transfer tube to feed fluid to the cylinders in the outer caliper half. Instead, the fluid transfer is through cross-over passages cast into the caliper halves. There's an "O" ring seal at each of the cross-over passages to prevent leakage. The bleed screw is located at the top of the inner caliper half, so it's accessible without removing the wheel.

Fig. 27—Passage supplies fluid to outer-half

ONLY ONE VALVE

You won't find a proportioning valve on these larger cars. That's because the rear wheel cylinders are only ⅞-inch in diameter, as compared to 2.368 inches in the calipers. With the area proportion between front and rear wheel cylinders, we can use the same hydraulic pressure all the way around. The system does have a residual valve, though. It's located under the left side of the car, near the front edge of the front door.

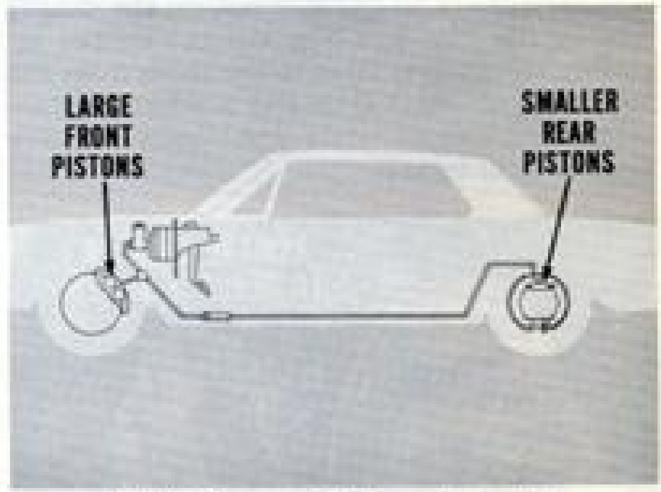


Fig. 28—No proportioning valve needed

LINING INSPECTION

If the disc brake linings on a Fury, Polara, Monaco or Chrysler are worn down to 1/32-inch, it's time to replace them. To check for lining wear, simply raise the front of the car and remove the wheel. The linings are visible through the top of the caliper.

Fig. 29—Maximum lining wear

LINING REPLACEMENT

To replace the linings on these cars, you'll have to remove the caliper from the disc. However, there's no need to break into the hydraulic system unless inspection shows the need for further repairs. First, remove the anti-rattle spring from the caliper and shoes. Then, remove the two caliper attaching bolts from the steering knuckle and steering knuckle arm.

Lift the caliper assembly off the disc, but be very careful not to put a strain on the caliper tube or the flex line. Support the caliper assembly solidly and remove the shoes from the housing. The steering tie rod is a handy place to lay the caliper while you check for any signs of fluid leakage.

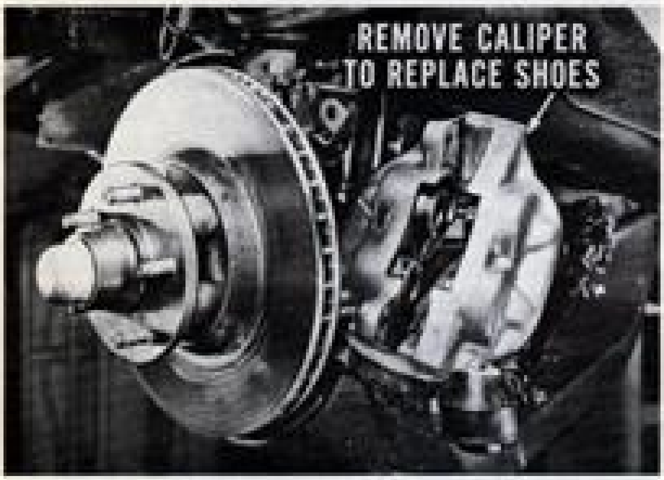


Fig. 30—It's not necessary to open hydraulic lines

SPECIAL TOOL NEEDED

A special tool, C-3992, is used to compress the caliper pistons when the new shoe and lining assemblies are being installed. First, place the new shoe in position in the caliper. Then, insert the compression tool between the lining

Fig. 31—Forces pistons back into the bores

faces and turn the knob to force the pistons back into their bores.

NOTE: Be sure to drain some of the fluid from the master cylinder to make room for the fluid in the caliper cylinders.

With the tool in place, slide the caliper down over the disc. As the caliper slides into position, the disc will force the compression tool out from between the linings. Install the two attaching bolts and tighten them at 70 to 80 foot-pounds. Install the anti-rattle spring through the shoe tabs and snap it into place in the grooves in the caliper. Refill the master cylinder and make sure you have a firm pedal.

Fig. 32—The disc forces the tool out

GENERAL SERVICE INFORMATION

SEAT NEW LININGS

When new linings have been installed in either type of disc brake, the car may have a tendency to pull to one side or the other during the first few brake applications, because of small variations in the linings. If you make a few quick stops from about 40 miles an hour, the linings will seat themselves and eliminate the pull.

DON'T REFACE DISCS

If you suspect that a disc has a lot of lateral runout, or "wobble", check it with a dial indicator. Maximum allowable runout is .0025 inch on the Kelsey-Hayes disc and .005 inch on the Budd disc. If runout exceeds these specifications, the hub and disc assembly must be replaced. DO NOT ATTEMPT TO REFACE A DISC

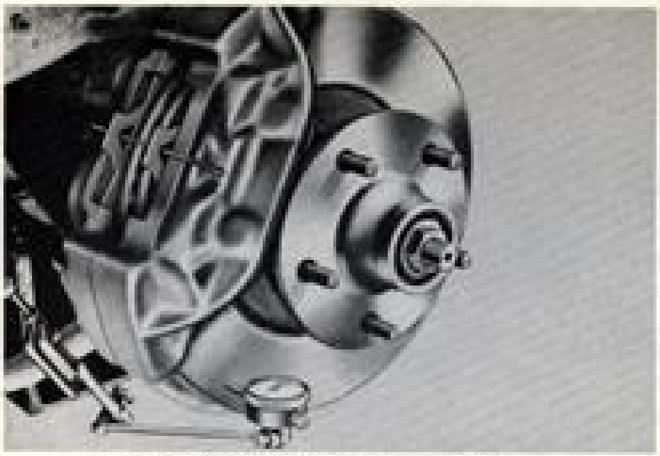


Fig. 33—Check lateral runout of disc

BEARING SERVICE

It is not possible to remove the wheel and hub as an assembly. If you have to service front wheel bearings, you must first remove the wheel to gain access to the caliper. After the caliper is removed, then the hub and disc are removed as an assembly.

Fig. 34—Remove wheel first

OTHER SPECIAL TOOLS

There are two other special tools in addition to the proportioning valve gauges (C-4007) and the piston compression tool (C-3992). A piston remover, C-3999, is used on the Kelsey-Hayes unit to remove the pistons from the caliper. It's very difficult to get the pistons out without the tool, since the square seal rolls with the piston and grips it. The other tool, C-3993, is a caliper cylinder hone, which is used on both units. If a cylinder gets a light scratch, the seal might be damaged, causing a leak. The hone will clean up the scratch, but you should never remove more than .002 inch from the cylinder. Always install the hone baffle to avoid damaging the stones when they hit the bottom of the bore.

Fig. 35—Used on Valiant, Dart and Barracuda

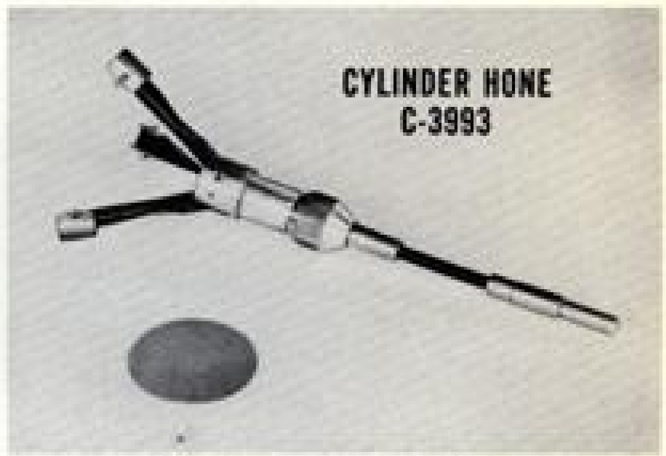


Fig. 36—Cylinder hone for both calipers

BRAKE FLUID

There are many brake fluids on the market with a variety of specifications. They are not all compatible with Chrysler Corporation brake systems. So, play it safe. Use only Chrysler-approved HiTemp brake fluid, with an SAE 70R3 rating.

POWER ASSIST

The Fury, Polara, Monaco and Chrysler disc brake installations include a dual diaphragm power booster as standard equipment. A single diaphragm power booster is optional with the Valiant, Dart and Barracuda disc brakes. Service on these two boosters is very well covered in your 1966 Service Manual.

MASTER TECHNICIANS SERVICE CONFERENCE 66-3

REFERENCE BOOK

ELECTRICAL FUNDAMENTALS

CHRYSLER CORPORATION

PLYMOUTH • DODGE
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We are beginning to suspect that automotive electricity is here to stay! Every model year new electrical options, units and circuits are introduced which make driving safer, more comfortable, or more convenient. No doubt about it, our car's electrical systems are becoming increasingly sophisticated and circuits are becoming increasingly complicated. There's a lot more to electrical service these days than tracing a wire in search of a loose connection or short.

You don't have to be an electrical engineer to do a top-notch job of servicing electrical circuits and units. However, a certain amount of *practical theory* will help you understand modern electrical circuits, units and accessories so that you'll be much better prepared to diagnose and correct electrical troubles. A working knowledge of electrical fundamentals will also help you keep pace with new electrical circuits and units as they are introduced on future models.

TABLE OF CONTENTS

THE BEHAVIOR OF ELECTRICITY AND MAGNETISM

At one time or another, most of us have been exposed to some basic education on the fundamentals of electricity and magnetism. However, remembering these fundamentals is like remembering algebra or a foreign language . . . it's apt to slip away from you unless you use it regularly. Unless you are a practicing electrical service technician, the chances are that you're a bit rusty on the fundamentals of electricity and magnetism. Reading the following pages will help you rub off the rust and refresh your memory on the nature and behavior of electricity and magnetism.

BASIC ELECTRICITY

Electricity is an invisible force which behaves according to definite rules and produces predictable results and effects. Although we have learned to produce, store, use and measure electricity, no one knows just what electricity is. In recent years, scientists have developed the electron theory to explain the nature of electricity. It explains more thoroughly than any other theory, the *behavior* of electricity and magnetism. However, it is difficult to understand because electrons can't be seen or easily illustrated.

ELECTRON THEORY vs. WATER ANALOGY

As a service technician you are more concerned with the actual behavior of electricity than you are with theories. If you understand how electricity is supposed to behave in a circuit or unit you'll be well equipped to recognize out-of-line conditions when electricity misbehaves. The electron theory is a highly scientific way of explaining the behavior of electricity. The flow and behavior of electricity can also be explained by comparing it with the flow of water. In fact, comparing water flow with electrical flow is undoubtedly the easiest and quickest way to explain volts, amps and ohms. For one thing, when we use water flow to explain electrical flow we are using something you can see to explain something invisible. So, we'll stick to the water analogy . . . comparing the behavior of water with the behavior of electricity.

Fig. 1—The electron theory explains electricity

Fig. 2—Water flow helps explain electrical flow

VOLTAGE IS PRESSURE

A storage battery and a water tower have a lot in common . . . they both provide pressure. The battery is a source of electrical pressure and the water tower supplies water pressure. In other words, voltage is simply electrical pressure. And, it's voltage that pushes electricity through the wires in a circuit just as pressure pushes water through the pipes in a plumbing system.

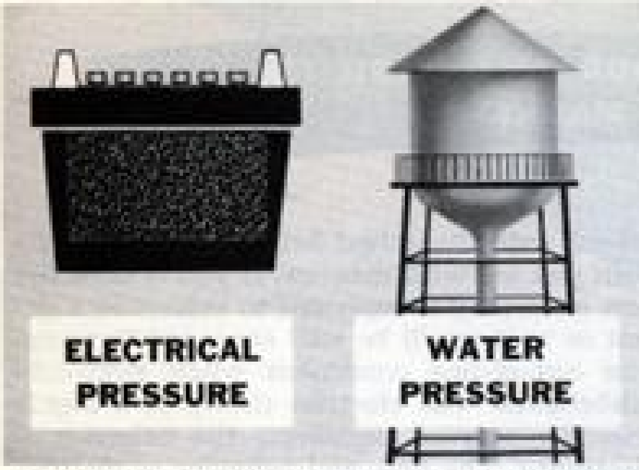


Fig. 3—Both a battery and water tower provide pressure

AMPERAGE IS FLOW

The flow of electricity and water can also be compared. An electric current is the movement or flow of electricity through a circuit just as water flow is the movement of water through a pipe.

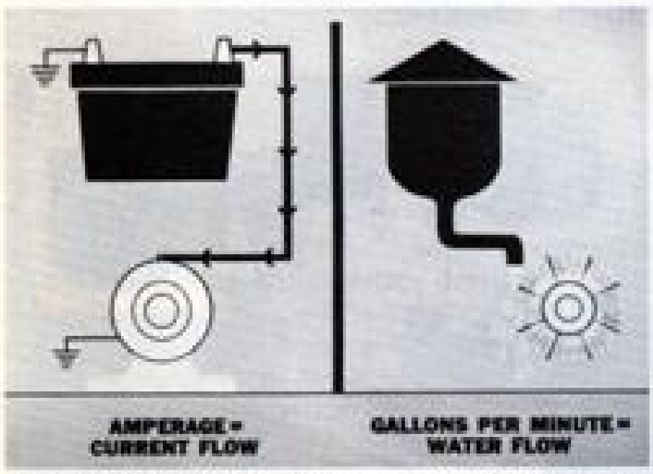


Fig. 4—Amperage and gallons per minute measure flow

Amperage is the electrical unit that tells you how much current is flowing through the wires of a circuit. Just as gallons-per-minute is the measure of the rate of water flow, amperage is the measure of rate of current flow. When a current of one ampere is flowing through a wire it means that a definite amount of electricity is moving through that wire each second of each minute. If the flow in another wire is six amperes, it means that six times as much current is flowing in the second wire.

OHMS MEASURE RESISTANCE

Electrical resistance is just that . . . resistance to the flow of an electric current. For example, a small wire offers more resistance to the flow of electricity than a large wire of the same material. In much the same way, a small pipe in a water system offers more resistance to the flow of water than a large pipe.

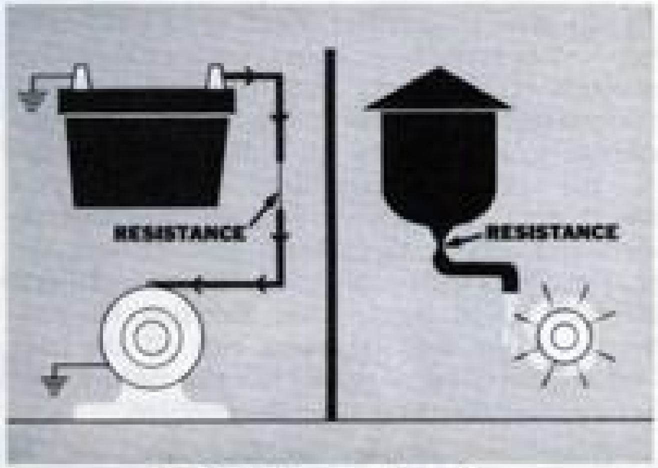


Fig. 5—Resistance reduces flow

The ohm is a unit of measurement which indicates the amount of resistance offered to the flow of an electrical current. The amount of current flowing through a wire depends on the electrical pressure or voltage pushing the current and the amount of resistance in the wire. Wires or conductors which let the current flow easily have low resistance and wires which slow down or limit the flow of current have high resistance.

Wire size is only one of the things that affects the amount of resistance in a circuit. The length of a wire and the material from which the wire is made also affect resistance. Short wires offer less resistance than long wires and good conductor materials offer less resistance than poor conductors. Metals like copper, aluminum and silver are used in electrical circuits because they are very good conductors, having very low resistance.

AN INSULATOR IS SIMPLY HIGH RESISTANCE

Resistance is the only difference between good conductors and good insulators. Any material which is a very poor conductor could be called an insulator. In other words, an insulator is simply a material which offers enough resistance to prevent the flow of electricity.

OHM'S LAW

Ohm's Law is the most fundamental equation in electrical science. It very accurately defines the relationship between volts, amps and ohms. Ohm's Law states that voltage equals amperage times the resistance in ohms. This simply means that one volt will push one ampere of current through one ohm of resistance. Since Ohm's Law is an equation, it can be written three different ways so that if you know any two facts about a circuit you can calculate the third or unknown fact by using one of the following equations:

Voltage = Amperage x Resistance

Amperage = Voltage ÷ Resistance

Resistance = Amperage ÷ Voltage

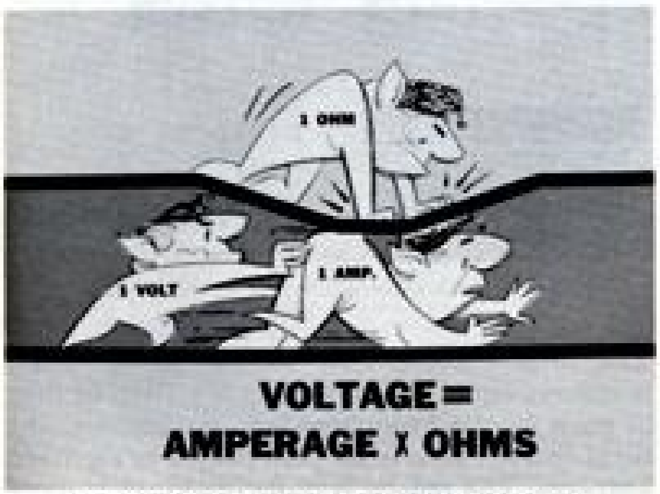


Fig. 6—Ohm's Law defines electrical behavior

A CIRCUIT IS AN ELECTRICAL PATH

Batteries and alternators apply electrical pressure and cause an electric current to move through a circuit from the high-pressure side to the low-pressure side. But there must be a complete circuit or electrical path made up of wires or other conductors or a current will not flow. If a wire is broken or disconnected, current stops. Circuits are not all alike and electricity does not behave exactly the same in different types of circuits. Therefore, it is important for you to understand the basic kinds of circuits found in an automobile and the way the volts, amps and ohms behave in these circuits.

A SIMPLE CIRCUIT

The easiest way to explain the basic circuits is to use a battery, some wire and electric lamps which serve as resistance units. In the simplest kind of circuit, current flows from the battery, through a lamp and back to the battery to complete the circuit. Most automotive circuits have more than one lamp or resistance unit and aren't quite this simple.

CURRENT FLOW IN A SERIES CIRCUIT

In a series circuit, two or more lamps or resistance units are connected so that there is only one continuous path for current flow. Since, in a series circuit, all of the current must flow through each of the resistance units, the current flow is always the same everywhere in the circuit. This is always true regardless of how many resistance units you connect in series.

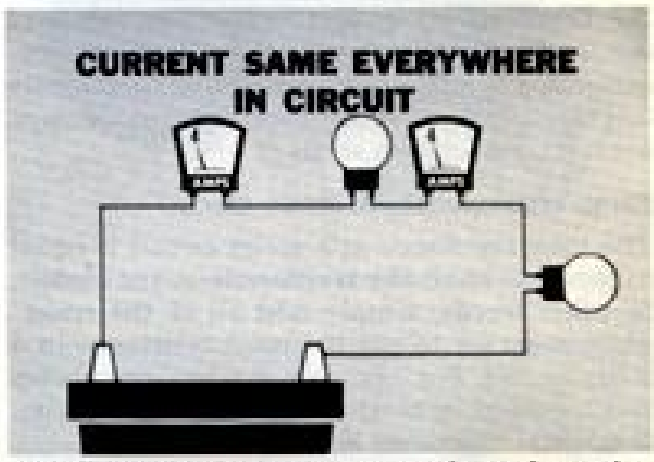


Fig. 7—A series circuit means one continuous flow path

The important thing to remember is that in a series circuit there is only one path for current flow. If you remember this, you'll have no trouble recognizing a series circuit when you see it in a wiring diagram.

VOLTAGE DROP IN A SERIES CIRCUIT

Electrical pressure is always reduced by resist-

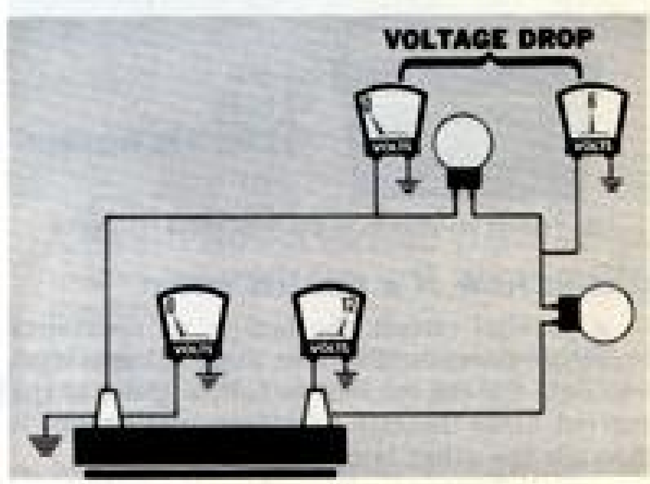


Fig. 8—A voltage drop means a voltage difference

ance in a circuit. This reduction in electrical pressure is usually referred to as voltage drop. Voltage drop is simply the difference between the voltage at one point in a circuit and the voltage at another point in the same circuit.

Incidentally, if you were to connect two twelve-volt lamps in series to a twelve-volt battery, the lamps would glow dimly. That's because neither lamp would get a full twelve volts. If both lamps were the same candlepower, the voltage drop across each lamp would be the same . . . six volts. But, six volts wouldn't push enough current through the circuit to make the lamps glow with full brilliance. On the other hand, if you connected two six-volt lamps in series to a twelve-volt battery, each lamp would get six volts and produce its full candlepower rating. Normally, car lamps are not connected in series.

TOTAL RESISTANCE IN A SERIES CIRCUIT

The total resistance in a series circuit is equal to the sum of all the resistances in the circuit. In other words, simply add all of the resistances together to get the total resistance in a series circuit. For example, if a one-ohm lamp and a two-ohm lamp are connected in series, their total resistance is three ohms.

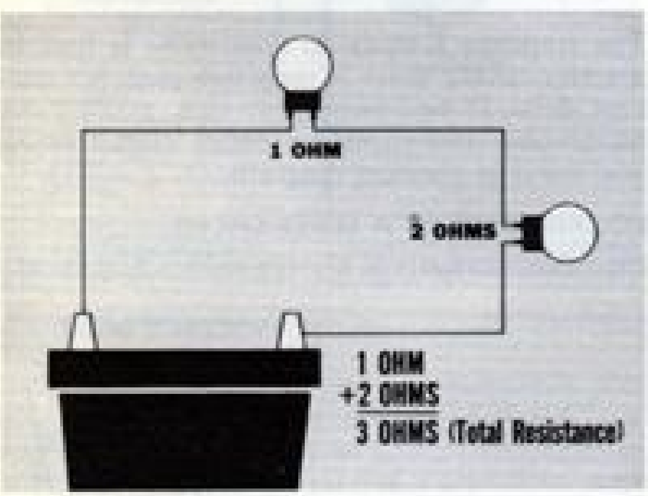


Fig. 9—Add resistances to get total series resistance

CURRENT FLOW IN A PARALLEL CIRCUIT

In a parallel circuit the lamps, or resistance units, are connected so that there is more than one path for the current to follow. Part of the current flows through one lamp and part of it through the other lamp.

Let's suppose that a one-ohm lamp and a two-ohm lamp are connected in parallel to a twelve-volt battery. You can use Ohm's Law to figure out that in this twelve-volt system, twelve-amperes will flow through the lamp having one-ohm resistance but only six-amperes will flow through the two-ohm lamp. Unlike a series circuit, the current flow is not the same in all parts of a parallel circuit.

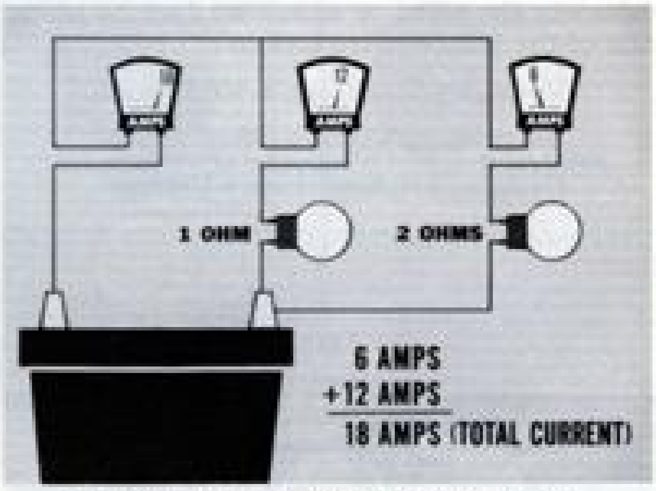


Fig. 10—Total current flow in a parallel circuit

The total current flow in a parallel circuit is always equal to the sum of the current flow in each of the branches. In our example, the total current flow is six plus twelve or eighteen amperes. The reason is quite obvious . . . more current can flow through two paths than can flow through one path.

VOLTAGE IN A PARALLEL CIRCUIT

When two resistance units are connected in parallel, the same voltage is applied to each resistance. If two twelve-volt lamps are connected in parallel, the voltage applied to each lamp and the voltage drop across each lamp will be twelve volts. Lamps are normally connected in parallel rather than in series so that each lamp produces full rated candlepower and continues to provide light even if a lamp in another branch of the circuit is burned out or turned off.

RESISTANCE IN A PARALLEL CIRCUIT

The total resistance in a parallel circuit is always less than even the smallest resistance in the circuit. This is explained by the fact that there is less resistance to current flow when two paths are provided than there is when only one of these paths is available.

There are several ways to calculate the total resistance in a parallel circuit. One practical way to find the total resistance offered by two resistances in parallel is to multiply the two resistances and then divide this product by the sum of the same two resistances. Let's take that a bit slower using a circuit having a two-ohm lamp and a four-ohm lamp in parallel. The accompanying circuit illustration with its resistance calculations clearly explains that the total resistance of two-ohms and 4-ohms in parallel is 1⅓ ohms. Note that the total resistance is less than either of the individual resistances.

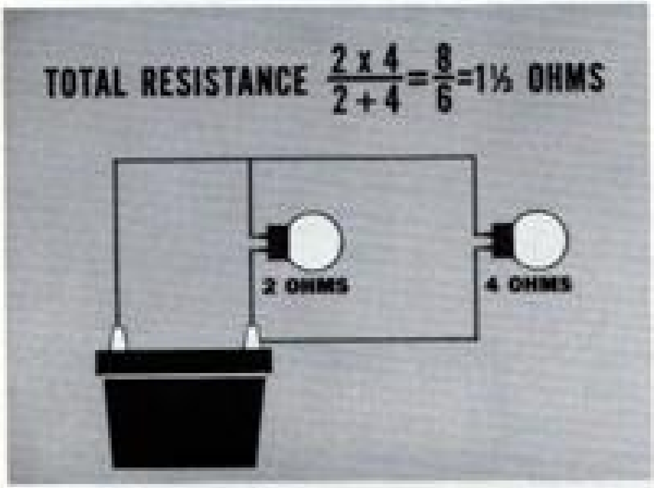


Fig. 11—Total resistance in parallel circuit

We will discuss the electrical measuring instruments and the measurement of voltage and amperage as soon as we have covered some basic facts about magnetism.

MAGNETISM AND MAGNETS

If it weren't for magnetism, electrical energy would have very few practical applications. Magnetism is essential to the operation of the alternator, the ignition coil and the starter. As a matter of fact, the lights and the cigar lighter are the only electrical automotive units we can think of that operate without magnetism.

THE NATURE OF MAGNETISM

Magnetism, like electricity, can be explained most readily in terms of what it does and the way it acts. The simplest type of magnet is a permanent bar magnet. Lines of force leave the magnet at the north pole and enter again at the south pole. The magnetic field is all of the space, outside of the magnet, containing lines of magnetic force. If a bar magnet is bent into the shape of a horseshoe, the magnetic field becomes stronger because the distance between the north and south poles is greatly reduced and the lines of force are more concentrated.

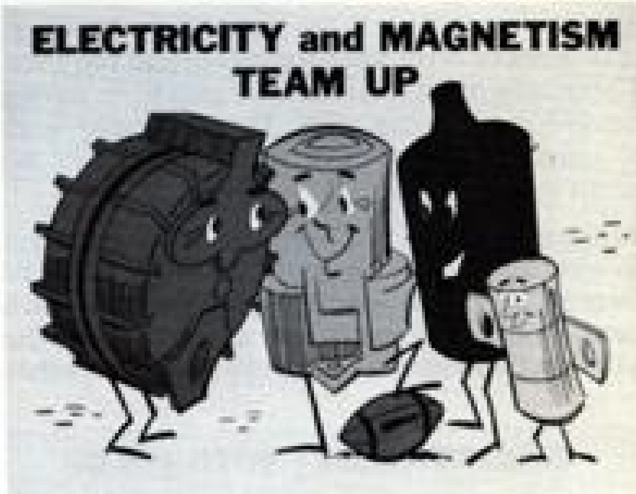


Fig. 12—These units need electricity and magnetism

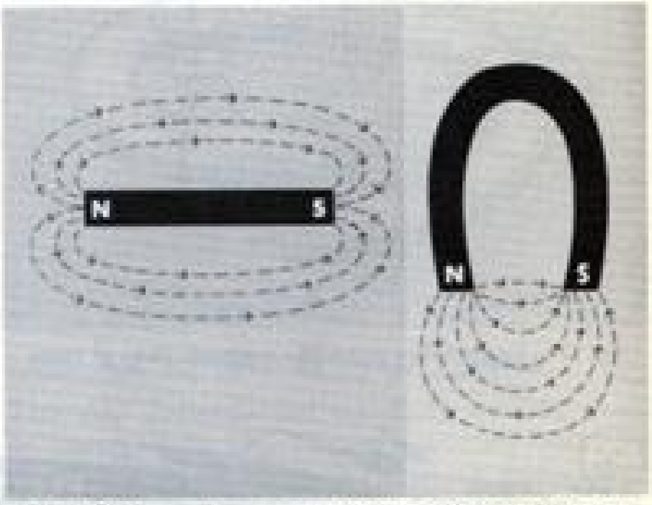


Fig. 13—Horseshoe magnet field is more concentrated

QUICK FACTS ABOUT MAGNETISM

- Unlike magnetic poles attract each other and like magnetic poles repel each other. A north pole attracts the south pole of another magnet but repels the north pole of another magnet.
- Magnetic lines of force pass through all materials and there is no known insulator against magnetism.
- Magnetic lines pass easily through materials that can be magnetized, such as iron or steel.

They pass much less readily through air or across an "air gap".

- Hard steel alloys are used in permanent magnets because they retain high magnetic strength when they are magnetized.

CURRENT FLOW CREATES MAGNETISM

Whenever a current flows through a wire, magnetic lines of force are created around the wire. These lines of force are small concentric circles formed around the wire. These circular lines of magnetic force have no polarity . . . no north or south pole.

Suppose we form a wire into a loop and send an electric current through the wire. Lines of force will form around the wire but now each circular line of force leaves at one side of the wire loop and enters at the other side. In other words, the lines of force all pass through the center of the wire loop. This action creates a weak electromagnet having north and south poles. The magnetic lines all leave the inside of the loop at the north pole, flow around the outside of the loop and reenter at the south pole . . . just like a bar magnet.

A PRACTICAL ELECTROMAGNET

A practical electromagnet has many turns of wire wound around a soft iron core. The more turns of wire, the more lines of magnetic force and the stronger the electromagnet. The soft iron core is a good "magnetic conductor" and helps concentrate the lines of force to increase the strength of the magnetic field. Increasing the amount of current flowing in the windings of the electromagnet also increases the strength of the magnetic field.

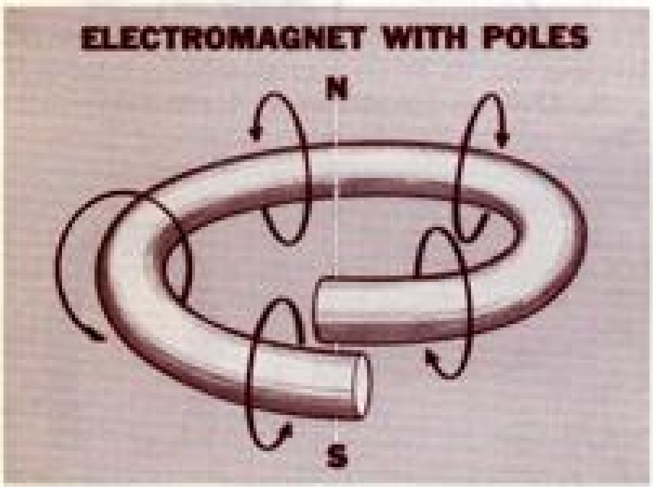


Fig. 14—Current flow produces magnetic lines of force

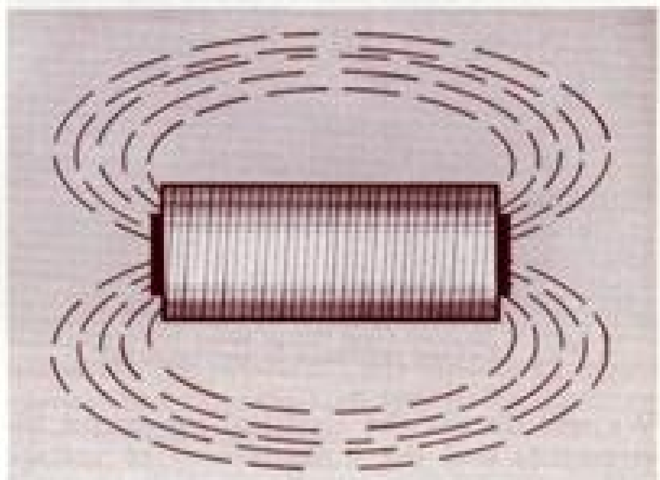


Fig. 15—An electromagnet with an iron core is stronger

It takes both electricity and magnetism to generate a voltage, make an electric motor run and turn low voltage into high voltage for the ignition system. Understanding how an alternator changes torque into electricity, how a starting motor changes electricity into torque and how an ignition coil steps up voltage will help you do a better job of diagnosing trouble in these units and their circuits.

GENERATING A VOLTAGE

In a generator or alternator, mechanical energy is changed into electrical energy. The basic principle of generating a voltage is the same for generators and alternators.

ELECTROMAGNETIC INDUCTION

Earlier we explained that a magnetic field is created around a wire when current passes through the wire. This action can be reversed. When a magnetic field is moved so that its lines of force cut across a wire or conductor, a voltage is generated in the conductor. This can be demonstrated by connecting the conductor to a lamp so that the lamp will light when the field is moved rapidly across the conductor.

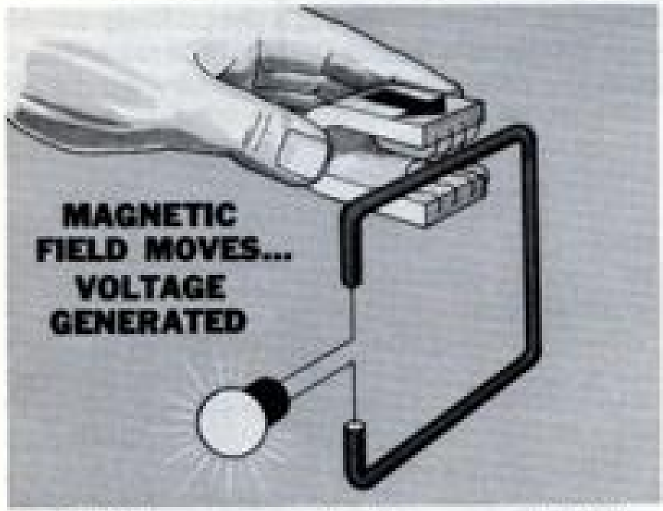


Fig. 16—Voltage generated by electromagnetic induction

When a voltage is generated by magnetic lines of force cutting across a conductor, the process is called *electromagnetic induction.* It doesn't make any difference whether the field and lines of force move across the conductor or the conductor moves across the field. As long as there is relative motion between the two, a voltage will be induced in the conductor. In an alternator, the field moves and the conductor is stationary. In a generator, the conductor moves and the field is stationary.

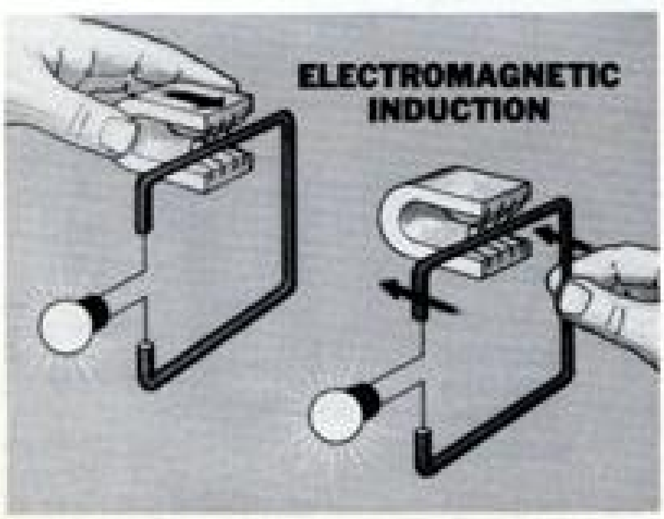


Fig. 17—Relative movement induces the voltage

A SIMPLE ALTERNATOR

In an alternator, a magnet is rotated inside of the stationary conductor so that lines of force cut across the conductor. A voltage is induced in the stationary conductor . . . called a *stator.* The rotating magnet is called the *rotor.*

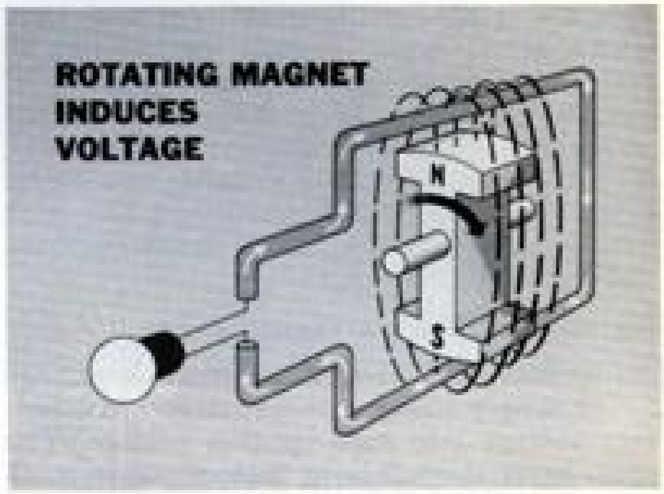


Fig. 18—An alternator has stationary conductor windings

The direction of the current flow produced in our simple alternator changes every half-revolution. When the north pole of the rotor is at the top, the voltage induced in the stator will cause the current to flow in one direction. When the south pole reaches the top, the voltage will cause the current to flow in the opposite direction. Thus the direction of current flow reverses every half-revolution. That's why it's called an alternating current.

CHANGING AC CURRENT TO DC CURRENT

The AC (alternating current) output must be changed to DC (direct current) before it can be used to charge the battery and supply the other circuits found in present-day cars. Six integrally mounted rectifiers are used to change the output of Chrysler-built alternators from AC current to DC current. A complete explanation of how these rectifiers change alternating current to direct current is too lengthy to cover in this session. However, you will find it interesting and helpful to understand how a rectifier works.

A rectifier is a one-way electrical valve. It allows current to flow in only one direction. When a rectifier is connected into the output circuit of an alternator, current will flow through the rectifier in only one direction.

When the direction of the current tries to reverse, no current will flow through the rectifier. As a result, we get one-way or direct current which does not reverse or alternate its direction of flow.

THE IGNITION COIL

Although magnetic lines of force and electricity are invisible, it isn't too difficult to understand how *moving* magnetic lines of force induce a voltage in a conductor. Since an ignition coil doesn't have any moving parts, it's a bit more difficult to visualize how an ignition coil works. Read slowly and bear with us as we explain and illustrate how an ignition coil delivers high voltage.

THE IGNITION COIL'S A TRANSFORMER

An ignition coil does not generate a voltage . . . it simply changes or transforms low battery voltage into high ignition voltage. You must know the following facts about induced voltage before you can understand how an ignition coil works:

- Increasing the speed at which magnetic lines of force cut across a conductor increases the voltage induced in the conductor.
- The greater the number of turns of wire cut by the moving lines of magnetic force, the greater the voltage induced in these turns of wire.

The foregoing facts apply to induced voltages . . . generators, alternators and ignition coils.

Fig. 19—Increasing speed or windings increases voltage

TWO SETS OF WINDINGS PER IGNITION COIL

An ignition coil has two sets of windings. The primary winding has fewer turns of relatively heavy wire and is connected to the battery through a switch . . . the ignition contacts. The secondary winding has many more turns of fine wire and is connected to a circuit leading to the spark plugs. Both the primary and secondary windings are wound on the same soft iron core. When the ignition contacts are closed, current flow through the primary windings produces a strong magnetic field around both the primary and the secondary windings.

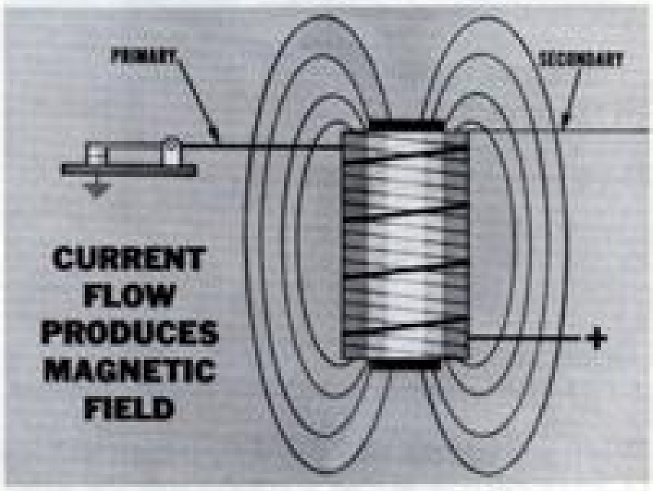


Fig. 20—An ignition coil has two sets of windings

WHEN THE CONTACTS OPEN

When the ignition contacts open, current flow through the primary windings stops. The magnetic field collapses and literally shrinks back into the iron core of the coil. The movement of the collapsing lines of force is very real and very rapid. It is the movement of the collapsing lines of force which induces a volt-

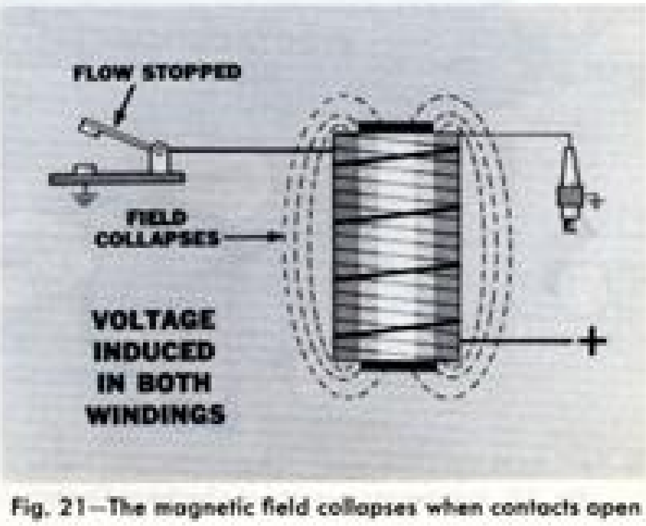


Fig. 21—The magnetic field collapses when contacts open

age in both the primary and the secondary windings of the coil.

Since there are thousands of turns of fine wire in the secondary windings, the voltage induced in these windings is very high. Since there are far fewer turns in the primary winding, the voltage induced is much lower.

Although the voltage induced in the primary windings is much lower than in the secondary, it may reach several hundred volts. This is great enough to arc across the ignition contacts as they open and burn them.

THE CONDENSER PROTECTS THE CONTACTS

The condenser is connected in parallel across the ignition contacts. It absorbs and stores the current flow caused by the voltage induced in the primary when the field collapses. By the time the condenser is fully charged, the space between the contacts is wide enough to prevent the induced voltage in the primary windings from pushing a spark across the gap between the contacts.

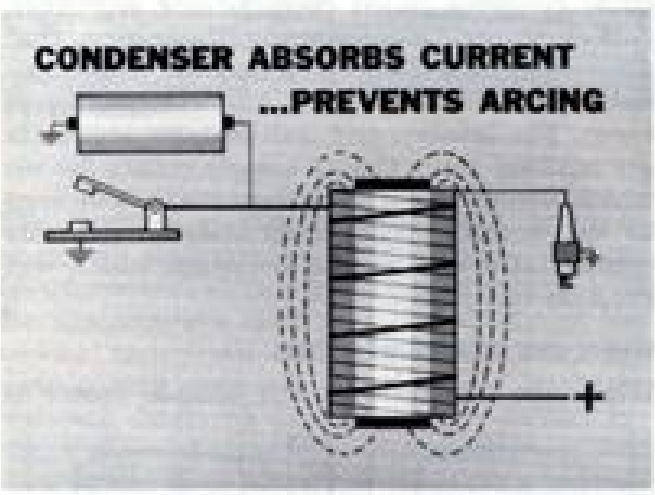


Fig. 22—The condenser is connected in parallel

CONDENSER INCREASES IGNITION VOLTAGE

The condenser does something even more important than protecting the ignition contacts . . . it helps the coil produce even higher ignition voltage. That's why a car won't start or run without a good condenser. Here's what the condenser does to step up voltage.

When the contacts open, the condenser stops current flow in the primary windings very rapidly. This in turn speeds up the collapse of the magnetic field, increasing the speed at which the lines of force cut across the secondary windings. By increasing the speed at which the magnetic field collapses, the condenser increases the induced secondary voltage.

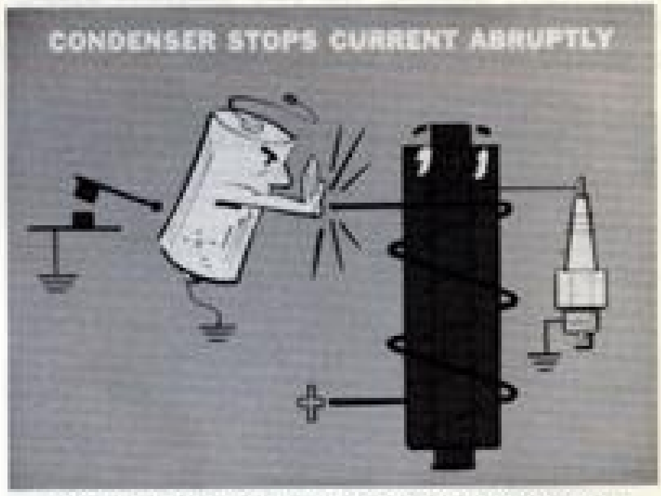


Fig. 23—The condenser increases ignition voltage

THE ELECTRIC STARTING MOTOR

The electric starting motor did more than anything else to put the little woman in the driver's seat. No doubt about it, electric starters contributed greatly to the popularity of motor cars. So, let's take time to explain how an electric motor works.

Fig. 24—The starter helped make cars popular

MAGNETS MAKE A MOTOR RUN

An electric motor is simply an electromagnetic device that turns electrical energy into mechanical energy . . . and it's all done with magnets. If you bring the north pole of one magnet close to the south pole of another magnet, magnetic attraction will finish the job of pulling the two magnets together. If you put the two like poles of two magnets together, the like magnetic poles will repel each other, pushing the two magnets apart. Electric motors operate on the principle of magnetic attraction and repulsion.

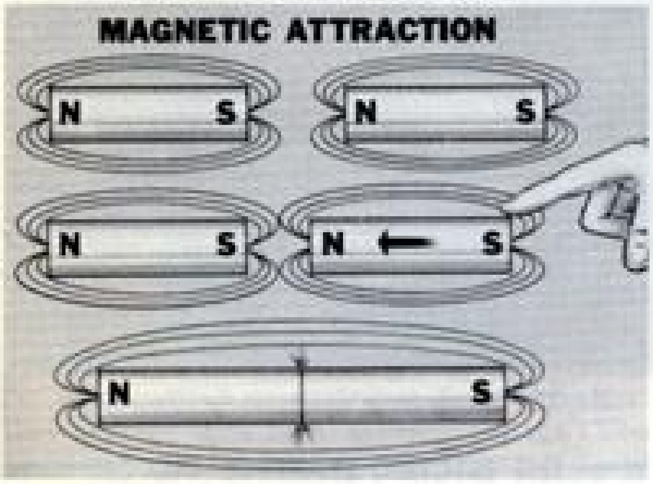


Fig. 25—Magnetic attraction can produce motion

In order to use the principle of magnetic attraction to obtain rotary motion, a bar magnet and horseshoe magnet can be used instead of two bar magnets. If we put a bar magnet in the field of a horseshoe magnet, the bar magnet will turn until the poles of the two magnets line up. This gives us rotary motion, but a motor that will turn only part of a revolution isn't very practical.

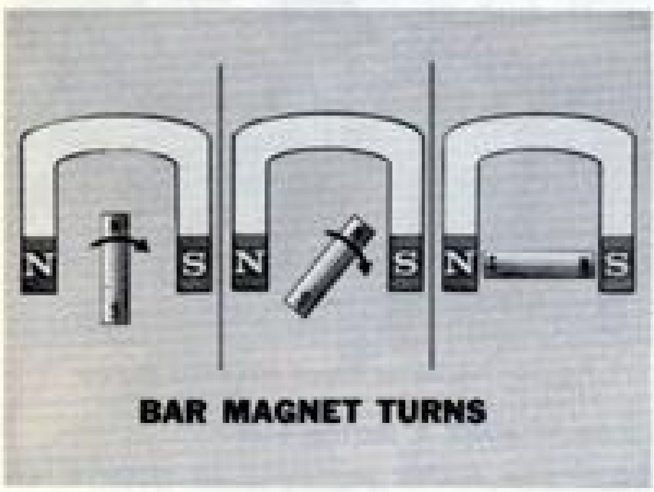


Fig. 26—Magnet rotates until poles line up

LET'S USE AN ELECTROMAGNET

In a very simple electric motor an electromagnet is used in place of the permanent bar magnet. The horseshoe magnet can be either an electromagnet or a permanent magnet. To simplify things, we'll use a permanent horseshoe magnet.

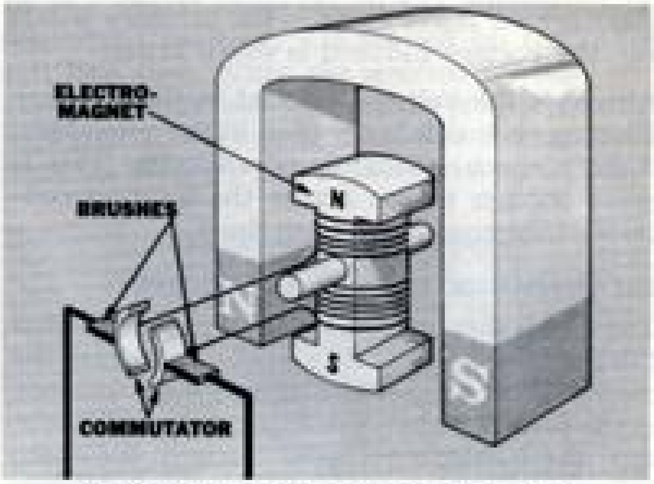


Fig. 27—The working parts of a simple motor

The windings of the electromagnet are connected to a battery through brushes and electrical contacts called *commutator segments.* Notice, in the accompanying illustration, that the brushes are stationary and the commutator segments turn when the electromagnet turns. The brushes and commutator segments are nothing more than a simple rotary switch which connects the electromagnet's windings to the battery. The electromagnet with its commutator is a simple *armature* which will keep on turning.

WHEN THE ARMATURE TURNS

When the armature of our simple motor is

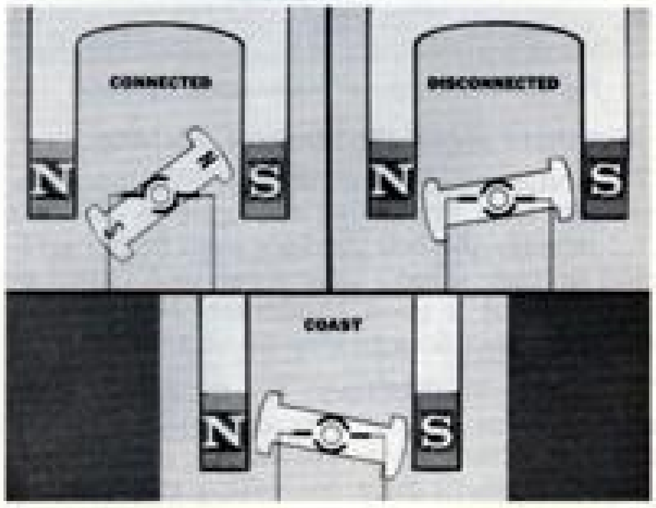


Fig. 28—The commutator disconnects the armature

connected to a battery, the armature will start to rotate. When the poles of the armature start to line up with the poles of the horseshoe magnet, the commutator is momentarily disconnected from the brushes. The armature's magnetic field is temporarily interrupted and the armature coasts past the point where the armature and horseshoe magnet poles line up.

Shortly after the poles of the armature coast past the poles of the horseshoe magnet, the commutator is reconnected to the brushes. The armature again becomes an electromagnet but now the magnetic polarity of the armature is reversed. The poles of the horseshoe magnet are now repelling instead of attracting the armature so it keeps on turning.

In our simple example, the magnetic poles repel each other for a quarter revolution and then attract each other for a quarter revolution. Then, the polarity of the armature is reversed and the poles repel each other for the next quarter revolution and attract each other for the final quarter revolution. Of course a starting motor has many more armature windings, more commutator segments, and an electromagnetic field in place of the horseshoe magnet. However, the basic principle remains the same.

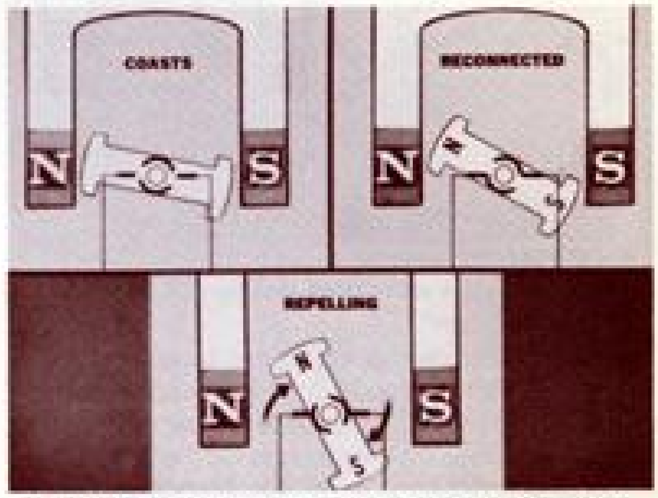


Fig. 29—The commutator reverses the polarity of the armature

ELECTRICAL MEASURING INSTRUMENTS

The basis of electrical diagnosis is accurate electrical measurements. The value of these measurements depends upon the accuracy of the instruments used and the ability of the service technician to connect and read his instruments correctly. In the final analysis, accurate diagnosis depends on the correct interpretation of accurate measurements. If you understand how electrical measuring instruments work you'll find it easy to understand how they must be connected and used when testing electrical circuits.

VOLTMETER CONSTRUCTION & CONNECTIONS

The basic working parts of ammeters, ohmmeters and voltmeters are the same or very similar. These instruments have a permanent horseshoe-type magnet, a pointer attached to a movable coil, and a graduated scale. However, the internal circuitry is quite different for each of these instruments. Voltmeters and ammeters differ primarily in the way the test leads are connected to the movable coil.

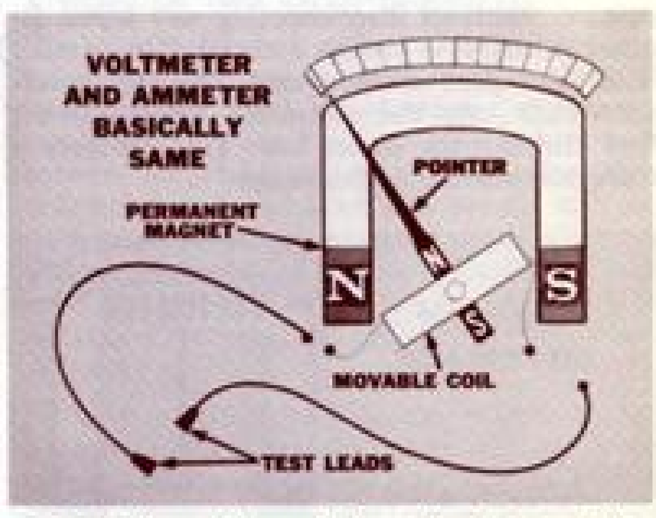


Fig. 30—The working parts of a voltmeter or ammeter

AN INSIDE LOOK AT A VOLTMETER

In a voltmeter, the windings of the movable coil are connected to the test leads through a high resistance. This resistance unit limits the amount of current flow through the meter.

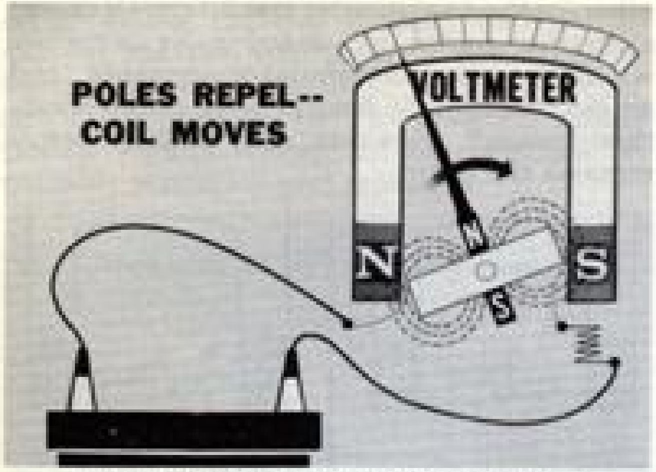


Fig. 31—Like poles repel and the coil moves

When a voltmeter is connected across a battery or circuit, current flow through windings of the movable coil produces a magnetic field. The north pole of this magnetic field is fairly close to the north pole of the horseshoe magnet. Since like poles repel, the coil and pointer move anytime current flows through the windings of the coil. The higher the voltage, the greater the current flow through the coil, the stronger the magnetic field around the coil and the greater the movement of the coil.

CONNECT A VOLTMETER ACROSS THE CIRCUIT

A voltmeter is always connected across a circuit . . . without disconnecting any wires. In other words, it is always connected in parallel with some part of the circuit. The high resistance built into the voltmeter keeps current flow through the meter low. This protects it from overheating and damage.

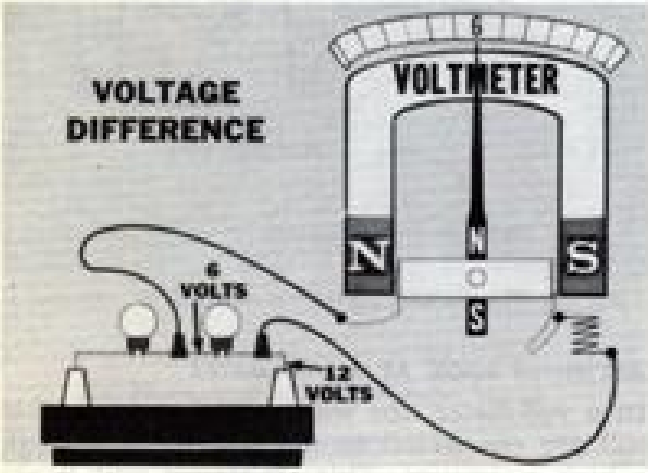


Fig. 32—Measuring the voltage difference between terminals

The voltmeter measures the *voltage difference* between the two terminals the meter leads are connected to. In other words, it measures the *voltage drop* between two points in the circuit.

If one voltmeter lead is connected to a terminal in a circuit and the other lead is connected to a good ground, the voltmeter will register the *voltage available* at that terminal. That's because it's actually measuring the voltage drop across the circuit from the terminal to the battery ground post.

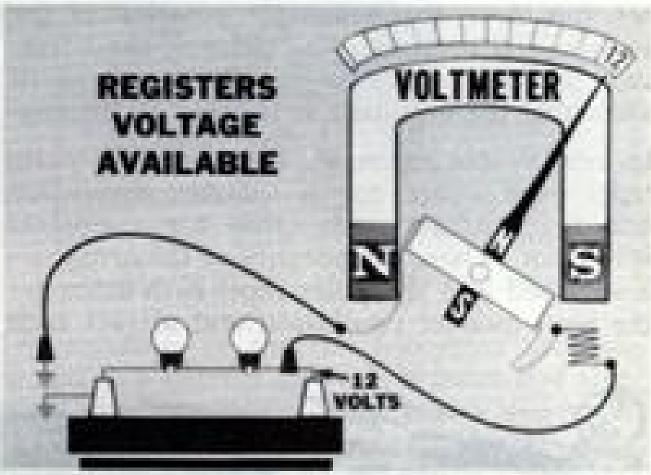


Fig. 33—Measuring the voltage available at a terminal

AMMETER CONSTRUCTION AND CONNECTIONS

Like a voltmeter, an ammeter has a permanent horseshoe magnet and a movable coil with pointer. However, its internal circuitry is entirely different.

AN INSIDE LOOK AT AN AMMETER

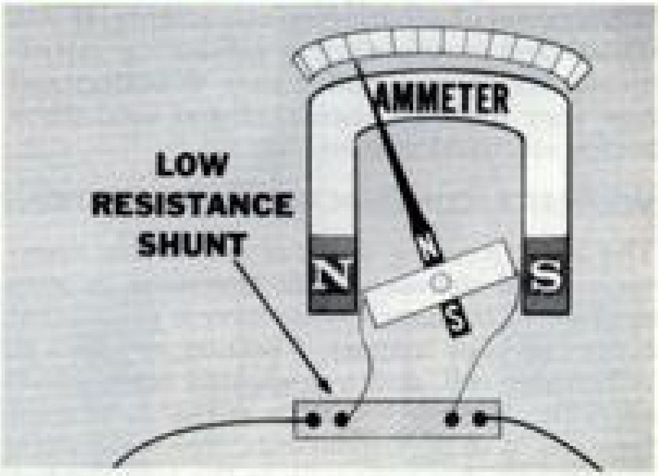


Fig. 34—Most of the current flows through the ammeter shunt

The movable coil windings of an ammeter are connected to the external test leads through a low-resistance shunt. The internal meter connections are made so that the movable coil is connected in parallel with the shunt. As a matter of fact, a shunt circuit is nothing more than a parallel circuit. When the ammeter is connected into a circuit, most of the current flows through the low resistance of the shunt and only a small amount flows through the movable coil.

CONNECT AN AMMETER IN SERIES

An ammeter must *always* be connected directly *into* the circuit . . . in series . . . so that all of the current flowing in the circuit you are testing will flow through the ammeter. That means you must disconnect at least one wire and break into a circuit in order to connect an ammeter correctly.

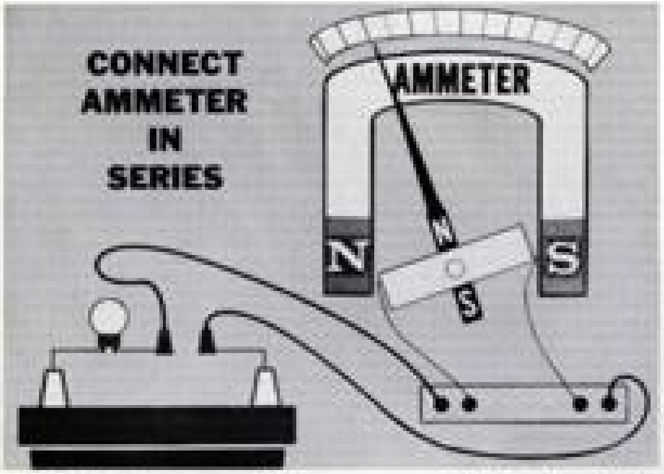


Fig. 35—An ammeter is always connected into the circuit

THE CIRCUIT MUST PROTECT THE AMMETER

Never connect an ammeter into a circuit unless there is enough resistance in the circuit you are testing to limit the amount of current flow through the meter. For example, suppose you connect an ammeter into a twelve-volt circuit having a lamp in it with a twelve-ohm resistance. Ohm's Law will tell you that the resistance of this lamp will let only one-ampere flow through the circuit. This couldn't damage an ammeter rated at one ampere or more. However, if the resistance was less than twelve ohms, the ammeter would have to have a capacity of more than one ampere. Just remember, the external circuit resistance must protect the meter . . . it doesn't have enough internal resistance to protect itself.

NEVER CONNECT AN AMMETER ACROSS A CIRCUIT

Never connect an ammeter the way you connect a voltmeter. If you connect an ammeter in parallel, across the circuit instead of in series, you'll fry it!

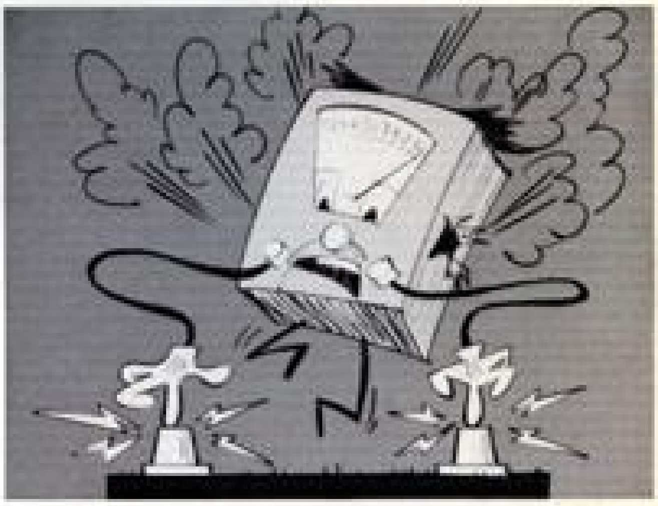


Fig. 36—Never connect an ammeter across a circuit

Connecting an ammeter across a circuit would let full battery voltage push too much current through the low resistance of the shunt. Too much current would also flow through the coil windings and damage them.

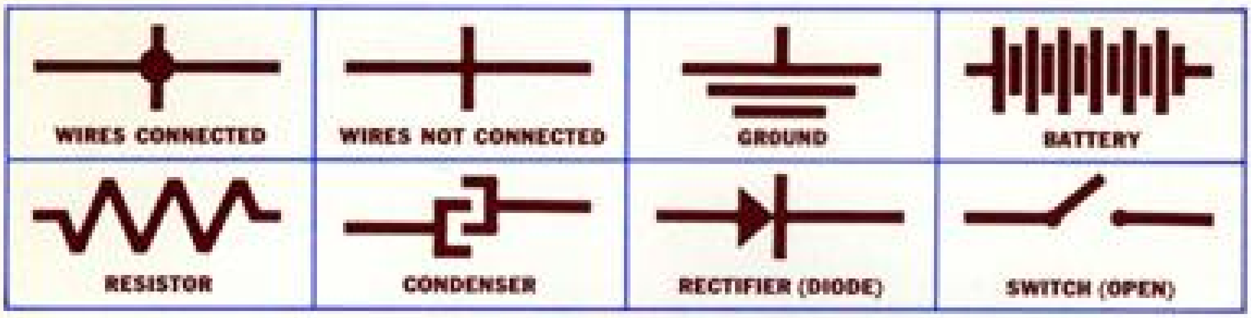
A WORD OR TWO ABOUT OHMMETERS

The ohmmeter is a delicate instrument used to obtain very precise resistance readings. It is frequently used by electronic servicemen but is used far less frequently by service technicians for checking automotive circuits. A voltmeter and ammeter will handle all common-type automotive circuit troubleshooting. Unless you want to measure the exact resistance of an electrical component, such as a resistance-type ignition cable, you won't need an ohmmeter.

In case you are curious, an ohmmeter is a voltmeter that has been carefully calibrated to read ohms. It has its own supply of electricity, usually small batteries mounted in the ohmmeter. These batteries have a known voltage and are used to send a "test" current through the electrical component being tested. An ohmmeter is never connected into or across a "hot" circuit. In other words, the circuit or electrical component being tested must be "dead" when using an ohmmeter.

WIRING DIAGRAM ELECTRICAL SYMBOLS

Commonly used electrical symbols are shown below to help you understand the average wiring diagram.



ELECTRICAL TERM DEFINITIONS

Alternating Current: Electrical current which continuously reverses its direction of flow at regular intervals.

Ammeter: An instrument used to indicate rate of electrical current flow in a circuit.

Ampere: A unit of the electrical flow rate.

Coil: A continuous winding arrangement of a conductor which combines the separate magnetic fields of all the winding loops to produce a single, stronger field.

Conductor: A path for electrical current flow.

Core: The metallic center section of a coil which serves to concentrate magnetic lines of force.

Current: The flow of electricity in a circuit.

Direct Current: Electrical current which flows continuously in one direction.

Electromagnet: A coil which produces a magnetic field when current flows through its windings.

Ground Circuit: The return side of an electrical circuit. Usually the frame or body of a single-wire automotive system.

Inductance: The reaction which produces voltage when a conductor passes through a magnetic field.

Load: An electrical device or resistance connected into a circuit.

Magnetic Field: The area surrounding the poles of a magnet which is affected by its attraction or repulsion forces.

Magnetic Lines of Force: Lines of magnetic influence which produce the magnetic field. Force lines are stronger and more concentrated at the magnetic poles.

Ohm-Ohmmeter: A unit of electrical resistance—measured by an ohmmeter.

Open Circuit: Any break in an electrical circuit, either intentional or accidental.

Parallel Circuit: A circuit having two or more paths for current flow.

Permanent Magnet: Material (especially iron and steel) which, after exposure to a magnetic field, will retain the ability to attract or repel other similar materials.

Rectifier (diode): An electrical device which permits current flow in one direction only. Used to change alternating current to direct current.

Resistance: The characteristic of an electrical unit or circuit which prevents or reduces current flow.

Series Circuit: A single continuous circuit.

Short Circuit: Commonly, an accidental contact between two conductors which bypasses the normal flow of current in a circuit.

Volt: A unit of electrical pressure—measured by a voltmeter.

Voltage: The electrical pressure which causes current flow in a circuit.

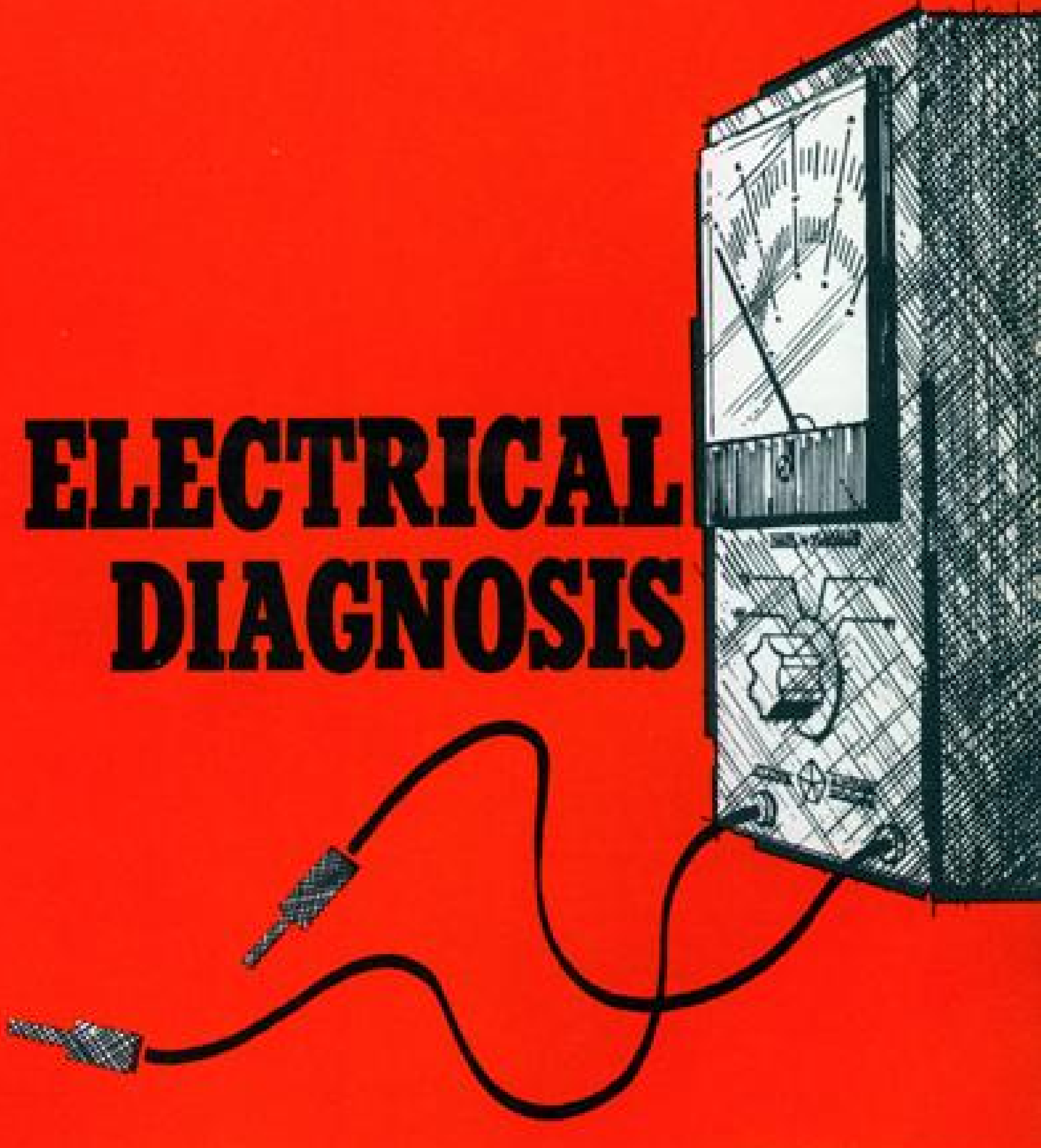
Voltage Drop: The loss of electrical pressure which is caused by resistance in a circuit.

Litho in U.S.A.

MASTER TECHNICIANS SERVICE CONFERENCE 66-4

REFERENCE BOOK

ELECTRICAL DIAGNOSIS



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Turn Principles Into Practice

By now, all you budding electrical technicians must realize that electricity isn't nearly as mysterious as it seemed before we covered some of the fundamentals. But, interesting as they may be, operating principles don't mean a thing if you're still in the dark when it comes to putting them to work.

We won't even pretend to cover all there is to know about electrical troubleshooting in the pages of this reference book . . . some troubles you'll come up against eventually haven't even been invented yet! However, you'll find basic testing procedures explained with "reasons-why" to help you put your newly acquired knowledge to work on everyday electrical service problems.

As you become more familiar with the workings of a car's electrical system, you'll be able to "think-through" the different circuits to locate trouble rather than poking around with the hope that you'll hit the cause by chance. And, when you understand what the results of electrical tests mean besides "good" or "bad", the mystery will evaporate and you'll be able to call yourself an "Elec-Technician".

Of course, you can always replace parts until the trouble is fixed. But this wastes time, and you'll never really learn to diagnose trouble properly. Besides, if the owner sees you fumbling and gets a big bill for unnecessary parts, you may lose a good customer . . . plus some of his friends.

Then there's the crystal ball . . . rub it and the answer appears. But even a crystal ball works for only a few, so we'd better look at some of the more dependable testing methods that any good automotive technician can use to get the right answers .

TABLE OF CONTENTS:

BATTERY BASICS

Fig. 1 — Poor battery condition causes trouble

GET TO THE POINT

The first step in finding electrical system faults is to localize the trouble. Obviously, if one rear turn signal is out and its partner works properly, you needn't worry about the battery or supply circuit. The trouble has to be somewhere beyond the selector switch, probably only a burnt-out bulb.

But it's not always that simple when the engine turns over slowly and starts hard. Sure, the cause can be a flat battery, but the trouble may also be hiding somewhere in the starter system. So, you'll have to put your knowledge of circuits and test meters to work so you can pin down the trouble.

TESTING STARTS WITH A KNOWN QUANTITY

Except when you're fixing simple troubles like lamp replacement or tightening obviously loose connections, the battery should always be checked and in good shape before you start making tests. In some cars, you may have to replace or recharge the battery if it's in doubtful condition.

Always remember that a car's electrical equipment is designed to do its best with a good battery. In some cars, a new battery or a recharge can do more to improve ignition performance than a complete tune-up.

And when it comes to troubleshooting, the battery must be in good condition or your test voltage readings can be misleading. For example, a partly sulfated battery can make the voltage control act up and you'll get misleading voltage readings. Even the battery cable clamps may cover up high-resistance oxide that can throw voltage readings off. Other tests can be affected the same way, so it's easy to see why we need a good battery and tight, clean connections to make sure we can believe and depend upon our test readings.

THE INSIDE STORY

Today's batteries give good service with very little attention, especially since the alternator came along to solve some old-time charging problems. Of course, neglect or abuse can still shorten battery life, but like other hard-working parts, batteries do wear out eventually.

Unfortunately, you can't tell whether a battery's condition is good or on the downgrade by its appearance, or even by its cranking performance at moderate temperatures. A battery that starts a car easily during summer or early fall months can fail completely in the first cold snap. The only dependable way to determine battery condition is by testing.

BATTERY OPERATION

To understand what test indications mean, we'd better know a little about how a battery works and what can go wrong to cause trouble.

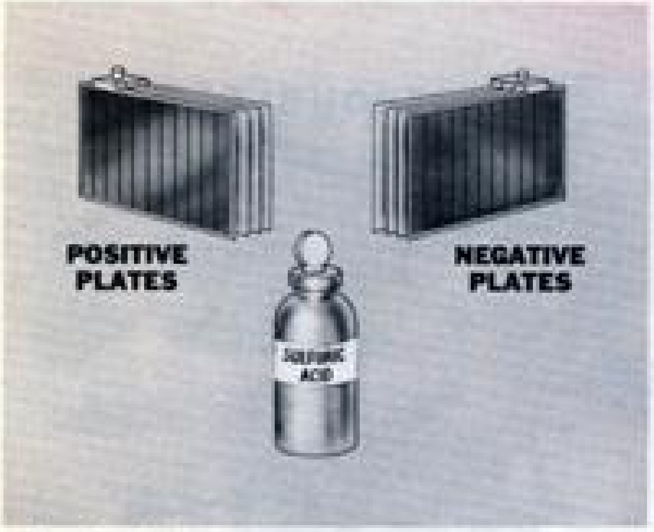


Fig. 2 — Positive and negative plates plus electrolyte

Most of you know what the inside of a battery looks like so we needn't describe it in detail. Basically, each cell has two interleaved sets of plates with insulating separators between each alternate positive and negative plate. The third active element in each cell is the electrolyte, made up of sulfuric acid and water.

A "storage battery" does not "store" electricity as such. Actually it is a reversible, electro-chemical device that can be charged to provide a source of electrical power, and recharged when exhausted to restore its power.

CHARGE IT UP

When we feed electrical current from an alternator or charger into a battery, it causes an internal chemical change. In turn, this change will reverse and cause the battery to put out current when it's connected to an external electrical load.

For example, when we close a circuit by switching on the headlights, sulfuric acid in the electrolyte immediately reacts with active material in the plates to produce an electrical current. This reaction also produces a different chemical material called lead sulfate which forms on the plate surfaces as a normal result. Don't confuse lead sulfate with "sulfation" which we'll cover later.

Fig. 3 — Chemical change produces current

As long as the load draws current, the chemical change from acid to lead sulfate continues until most of the acid is converted. The reaction gradually slows down and finally stops when the battery is completely discharged. Electrolyte at this stage is mostly water.

PUT 'ER IN REVERSE

When current from an outside source is fed back into the battery, the chemical change reverses . . . converts the lead sulfate back to sulfuric acid and restores it to the electrolyte. As soon as all the acid is back in the electrolyte, the battery is again fully charged.

WHERE DID THE POWER GO?

Now, if it's all that simple and there are no moving parts, what can go wrong? Why does a battery wear out? Well, it's like bending a sheet of metal back and forth . . . eventually a piece breaks off. And that's about what happens to the active material in the cell plates. As a battery is charged and discharged over a period of time, the repeated chemical reversal gradually loosens active material which then drops from the plates into wells in the bottom of the battery case.

THERE'S LESS TO WORK WITH

As plate shedding continues, less material remains in the plates to react with acid in the electrolyte and produce currrent. The acid also thins out because the active material losses cut down the amount of lead sulfate formed in the discharge cycle and converted back to acid when the battery is recharged.

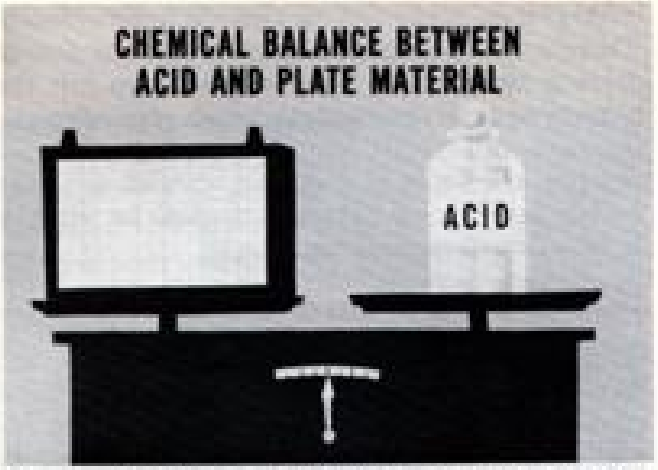


Fig. 4 — Condition = amount of acid and active material

Plate shedding goes on until there's not enough active material in the plates to produce a usable amount of current. When this stage is reached, the battery is worn out and should be replaced.

The wearing-out process speeds up considerably if the battery is abused by overcharging or undercharging, allowed to dry out through neglect, or damaged internally by severe mechanical shock.

BATTERY LIFE SHORTENERS

OVERCHARGING

Some batteries wear out long before their time because they're overcharged. Normally, the charging system replaces battery current used up in powering the car's electrical equipment, and then cuts back to let the battery "float" in the circuit . . . neither charging nor discharging. In overcharging, the process goes too far and causes internal battery damage.

Normal charging causes water in the electrolyte to "gas" or break up into oxygen and hydrogen. Since these gasses escape through the cell vent caps, water is lost and the electrolyte level drops . . . one reason why water must be added to the cells from time to time. Water can also be lost by spilling, leakage or evaporation.

When we have overcharging, it's like too much of a good thing. The water gasses away too quickly, leaving concentrated acid which attacks the plates. The active material loosens faster than normal and the plate structure corrodes, buckles, and may even break up.

Fig. 5 — Active material loosens faster than normal

An early sign of overcharging is a faster-than-normal use of water. Whenever you find a battery that literally "drinks" water, be sure to check for a high-voltage control setting. Even with the setting within specification limits it's not unusual to find an overcharged battery in a car which is regularly driven long distances during daylight hours. Where overcharging persists, the voltage control may need resetting to the lowest specification limit that will keep the battery charged. Where long daylight trips are only occasional, some drivers turn on headlights during daylight hours to offset overcharging.

Check battery water level regularly . . . more often in hot weather. Overcharging and high-temperature evaporation can ruin a battery in a hurry.

UNDERCHARGING

At the other extreme, there's another form of battery abuse caused by undercharging. The result is called sulfation . . . a sort of hardening of the arteries that can put a battery out of business without shedding plate material.

Sulfation affects lead sulfate left on the plates when the battery is not completely charged. In a fully charged battery, practically all the sulfate has been reconverted to electrolyte acid. But where a partial state of charge persists, unconverted sulfate on the plates gradually hardens and seals off a portion of the active material, preventing further reversal or chemical change.

Fig. 6 — Sulfate hardens on plates

Here again this means less active material available to produce current, and less acid returned to the electrolyte by recharging. Once started, sulfation can also change the balance between battery and charging system, causing the voltage control to cut back too soon. This cut-back leaves the battery with a still lower state of charge, further aggravating sulfation.

Any car regularly used in slow city traffic, with lights, heater and other equipment turned on, should be suspected of having a sulfated battery. Some sulfation builds up where electrical loads are low, but the car is used only for short runs. Batteries in stored cars gradually run down by internal self-discharge and if not recharged periodically they will sulfate completely.

Generally speaking, any condition that continually keeps a battery in a partially charged state will result in sulfation damage and early battery failure.

NO WATER—NO CURRENT

As we mentioned earlier, the battery normally uses up water in the charging process and by evaporation. If the water is not replaced and electrolyte drops below the plate tops, exposed plate areas will dry out, harden and lose the ability to react with electrolyte. And, as with overcharging, where a low fluid level persists, acid remaining in the electrolyte becomes more concentrated, severely attacks the plate structure, and speeds up plate material shedding. Drying-out can also break down the separators between the plates and result in short circuits.

TREAT 'EM GENTLY

There's always the possibility that a lot of driving over rough, bouncy roads can jolt the battery severely enough to break separators or internal cell walls, especially if hold-down clamps are loose. Of course, cracks or leaks visible on the case exterior can also be signs of internal battery damage.

TESTING TELLS THE TALE

So far, we've given you an idea of how a battery works and some of the things that can cause battery trouble. Now we're ready to explain battery testing so you will be able to interpret your test readings and tell whether a battery is in good condition, on the downgrade, or ready for replacement.

You can check out a battery in one step if it's in good condition . . . or two if it's doubtful.

In our first step, we check the state of charge, noting differences between cell readings as we go. If all readings are uniformly high, the battery is probably okay . . . if they're uniformly low, the battery is usually in good condition, but needs recharging.

Where the first test shows substantially different cell readings, it's usually a sign of shorted cells, sulfated cells or a worn-out battery. This calls for step two . . . the battery load test.

To stay on the safe side, it's a good idea to recharge and retest a borderline battery before you put it back in service or send it to the junk pile.

HYDROMETER TEST

The hydrometer indicates state of charge by measuring the specific gravity or concentration of the electrolyte. The principle is simple . . . more acid in the electrolyte makes the float ride higher in the fluid drawn up by the tester. And, as we mentioned before, the more acid there is in the electrolyte, the higher the state of charge.

For a fully charged battery in good condition, the gravity reading in each cell should be about 1.260. Where readings average about 1.220, the battery is approximately three-quarters charged. If the float rides at 1.215 or lower in all cells, recharge the battery to guard against sulfation. When water is added, allow it time to mix in the electrolyte before taking specific gravity readings.

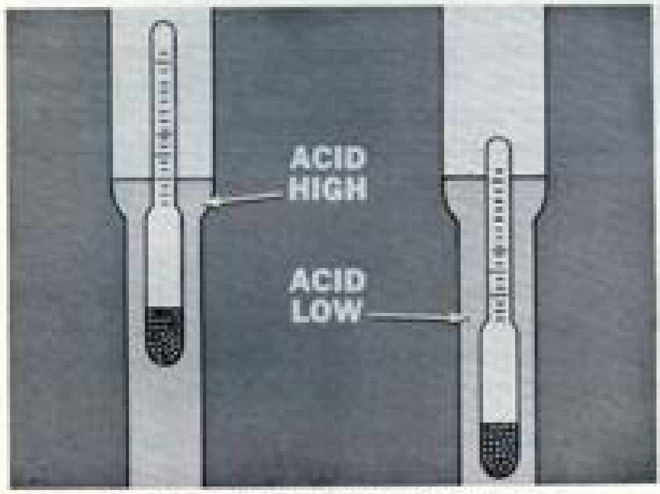


Fig. 7 — Float rides high at full charge

PLUS FOR HOT—MINUS FOR COLD

Usually, your test readings must be temperature-corrected to get accurate specific gravity indications because most battery hydrometer floats are calibrated for direct-reading at 80 degrees Fahrenheit.

For each 10-degree rise in temperature, we add .004 to the reading because electrolyte expands and gets thinner as it warms up. We do just the opposite and deduct .004 when temperatures are below 80 degrees. Here the fluid contracts and the float rides too high.

Always use the thermometer built into all good-quality hydrometers and make necessary corrections to be sure your readings are accurate. Remember, there's only .045 points difference between a fully charged battery and one that needs recharging.

CELL DIFFERENCES MEAN TROUBLE

Probably the most important part of your hydrometer test is noting any *differences between cells* . . . regardless of whether they all check out on the high or low side.

If the electrolyte in any cell reads .025 points lower than that in the highest cell, you'll have to test the battery under a load to find out if the low-reading cell is damaged or worn out. Battery load testing is explained in a following section.

Where the difference is less than .025, and average readings are 1.220 or lower, chances are the battery is in good condition and only needs recharging.

Fig. 8 — Cell reading differences indicate trouble

AND THEN THERE ARE THE ODD ONES . . .

You may find some batteries with specific gravity readings as high as 1.280, or as low as 1.250 when fully charged. High gravity batteries are usually intended for consistently cold climates where more low-temperature cranking power is needed. Low gravity batteries are commonly used in areas where year-round warm weather makes starting easy.

Now don't get ideas about adding acid to batteries to make them put out more power . . . you'll probably ruin the battery and maybe more . . . sulfuric acid is dangerous and tricky to handle.

Battery acid-water mixtures are adjusted by the manufacturer to do the best job with least wear and tear on internal parts, and therefore should not be changed. But what about the battery with only one cell reading low? Why can't we simply add acid to bring it up to the specific gravity of the other cells? The answer is still hands-off, except for acid adjustment on new batteries as described in your shop manual. In other words, don't add anything to a battery but water unless you are a trained battery technician.

OPEN CIRCUIT VOLTMETER TEST

Another method of checking general battery condition is based on measuring cell voltages with a sensitive voltmeter. Here again, we test

OPEN CIRCUIT VOLTAGES FOR BATTERY CELLS SHOULD NOT VARY MORE THAN .05 O A VOLT AND THERE IS ONLY ABOUT .06 OF A VOLT DIFFERENCE BETWEEN A FULLY CHARGE AND ONE THAT NEED

each cell and compare the differences as we did in the hydrometer test.

Voltmeter cell testing is restricted to batteries with soft-sealed tops which can be penetrated by voltmeter test prods. This method is not practical for testing solid-top batteries which completely enclose cell connectors under a molded plastic cover.

A word of caution is in order here. Serious damage can be done to cell connectors and other internal parts if the molded top cover of these batteries is drilled or pierced to reach connectors for voltmeter tests. When testing hard-top batteries, use your hydrometer or the Cad-Tip Battery Analyzer described later in this section.

Fig. 9 — Battery tops are not for drilling

SKIM OFF THE SURFACE

For the hydrometer test, we had to correct for temperature variation. In voltmeter testing of soft-sealed batteries, we must first remove the battery "surface charge" before taking readings. Surface charge reflects higher voltage needed to charge the battery and can cause misleading readings if not removed by cranking the engine several times, or by turning on the headlights for a few minutes.

Also be sure to read the instructions that come with your voltmeter. Some meters are designed to give a full-charge reading when specific gravity is 1.280, others are calibrated for lower gravities. You may need a hydrometer test to double-check voltmeter readings in borderline cases.

CHECK READINGS CAREFULLY

After removing the surface charge, all electrical loads must be turned off before you make an open circuit test. Voltage readings must be taken carefully because a difference of only 0.5 of a volt between cells can indicate a cell in poor condition. Actually, there is only 0.6 of a volt difference between a fully charged cell and one that needs recharging.

Cell voltages should read about 2.12 on a good battery with 1.260 full-charge specific gravity. If cell voltage differences are within 0.5, and the average reading for all cells is 2.08 or lower, the battery is most likely in good condition and may only need recharging.

Always heat-seal the holes left in the top sealing material by the test prods or you may get surface leakage and self-discharge.

Fig. 10 — Reseal against surface leakage

CAD-TIP BATTERY ANALYZER TEST

All car batteries, whether soft-sealed or solid-topped, can be checked quickly with the new Cad-Tip Battery Analyzer. This tester compares the voltage of adjacent cells.

The test meter indicating pointer shows state of charge on a red or green dial sector and also indicates the difference between cells on the same dial scale. A second, manually-set pointer is included to make it easy for you to compare cell reading differences. Set the pointer to match one reading and you have a reference marker to compare with the next.

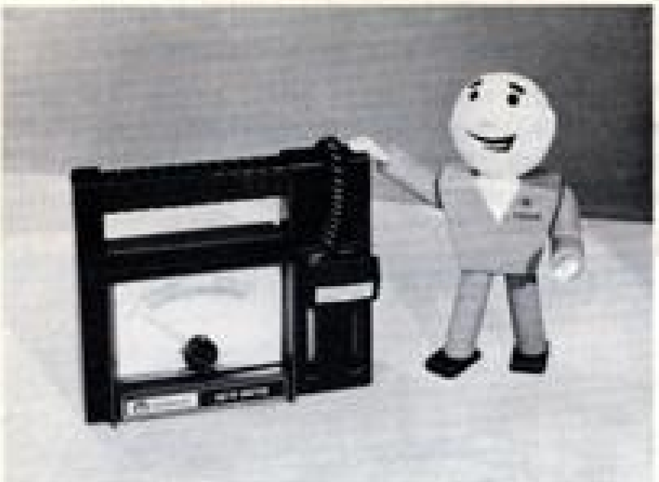


Fig. 11 — Cad-Tip Battery Analyzer

THE TEST IS SIMPLE

You can forget about temperature corrections or surface charge. All you do to make a test is wipe the battery top clean, remove the cell filler caps, place the tester probes in adjacent pairs of cell filler ports, and read the meter as you go. Because the probes are paired and placed in adjacent cells for each test, only five readings are taken.

If all five readings are within five scale divisions of each other, and fall within the green sector, the battery is charged and in good condition. Where all five readings are within five scale divisions, but fall in the red sector, the battery probably only needs recharging. More than a five-division difference between two readings indicates a questionable battery, and the need for a load test.

Fig. 12 — Place test probes in adjacent cells

BATTERY LOAD TEST

As mentioned in previous test descriptions, a sizeable difference between cell readings is the signal for you to go on to a battery load test. Basically, this test checks the battery's ability to put out power for engine cranking and starting, and quickly determines whether or not the battery is still serviceable.

Most battery load testers are also used for starter testing. They are called by various names, but each operates on the same general principle, so we'll cover all of them with one simplified explanation.

TESTER UNITS

The battery load tester includes a voltmeter, ammeter and an adjustable load resistance. Two meters may be used to indicate both readings at the same time, or their functions may be combined in one meter which provides separate readings by switching. The resistance can be reduced to zero load or adjusted to the setting desired.

Fig. 13 — Battery-Starter Load Tester

The voltmeter connects directly across the battery in the usual manner. The ammeter, however, connects across the adjustable resistance inside the test instrument and indicates voltage drop across the load in equivalent ampere units. The resistance connects directly to the battery with its heavy cables, and in effect, works both as a battery test load and a variable shunt for the ammeter.

Hookup connections are described in tester instruction manuals, so we won't cover those details. But make sure that battery specific gravity is 1.220 or over before you run a load test or the readings will not be reliable. If cell differences are on the borderline, it's usually good practice to recharge the battery before load testing.

Fig. 14 — Load test needs ¾ charge or better

LAY ON THE LOAD

To make a load test, turn up the resistance control until the ammeter indicates the current draw shown in test specifications for the battery. Hold this setting for not more than 15 seconds, and note the voltmeter indication.

During the test, voltage should not drop below 9.5 if the battery is in good condition.

Where the test voltage drops below 9.5 with the average specific gravity readings at 1.220 or over, the battery is worn out or seriously damaged internally and should be replaced.

Fig. 15 — Below 9.5 volts calls for replacement

You can depend on the load test to show up any internal defects before you okay a battery or put it back in service. Use it to double-check your other tests . . . you may save a no-profit service call when the dead battery season is at its peak.

Now that the whys and wherefors of battery testing have been covered, we can go on to the starter system and some of its troubles. As in all electrical troubleshooting, our aim is to pinpoint the source of trouble as quickly as possible. Of course, mechanical troubles are also possible, but our concern here is with electrical problems.

PICK ONE OR THE OTHER

As you know, the starter system has two separate circuits. One supplies heavy current to power the starter motor . . . the other controls the starter solenoid. This separation makes our testing job easier because the function of each circuit can be directly related to a basic starter system complaint.

In short, if the starter motor turns too slowly, the supply circuit is the main suspect. Where the starter does not respond at all, but lights, horns and other equipment work properly, we check into the starter control circuit.

CHECKING THE SUPPLY CIRCUIT

Always begin with a quick visual check of supply circuit parts to note obvious trouble sources such as corroded or loose connections. Many slow-turning starters have been corrected by simply cleaning battery terminal posts and cable clamps. Test the battery to make sure it is in good condition and inspect starter and ground cables for corrosion or damage.

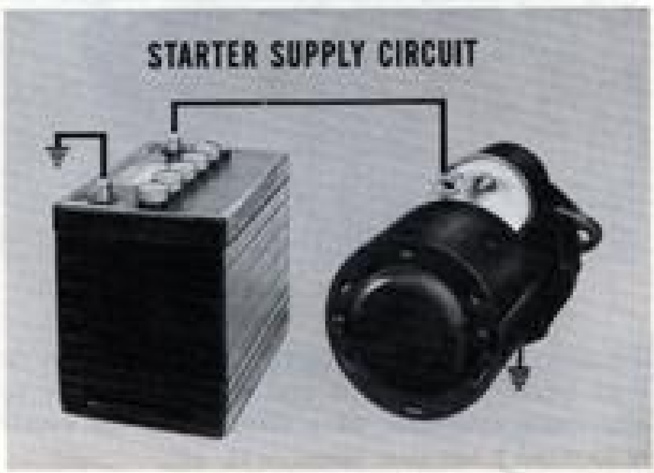


Fig. 16 — Supplies high amperage starter power

Assuming that the battery is okay, and cables, terminal clamps and starter appear in good condition, the next step in our test procedure is checking starter current draw using the same battery-starter tester we described for the battery load test.

Hook up your tester for a starter amperage draw check as shown in the instruction manual and connect a jumper between the ignition coil output terminal and ground so the engine will not start. You'll notice that we do not disconnect a battery cable to insert the ammeter in the supply circuit for our test. While this seems to disagree with normal procedure which calls for connecting the ammeter in series, that hookup isn't required here because we use a load substitution method instead of reading starter current draw directly.

You'll recall from our battery load test description that the adjustable load resistor in the tester connects directly to the heavy test cables, and the ammeter is connected internally across the resistance. This means we can substitute an equivalent resistance load for the starter draw to get the reading we want without breaking into the supply circuit.

STARTER DRAW TEST

With the tester connected and the adjustable resistance set at zero load, turn the engine over and read the starter cranking voltage while it's cranking. Note this reading carefully because we'll use it to find the starter amperage draw. Do not crank the engine excessively or the starter may overheat.

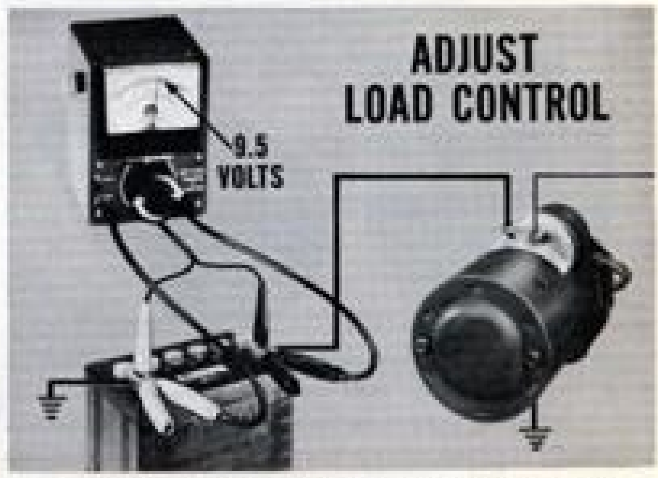


Fig. 17 — Adjust load to match cranking voltage

Now, to read current draw, we turn up the adjustable resistance until the voltmeter again reads the cranking voltage just noted. When this point is reached, you can read the equivalent of the starter draw on the ammeter scale. If your tester has a single meter, flip the selector switch to the ammeter position to read the current draw.

Where the starter draw current is higher than specification limits, the trouble is probably in the starting motor and you'll have to pull it out for a bench test.

Where the starter draw is lower, it means high resistance somewhere in the supply circuit. But don't pull the starter for a bench test until you've checked through the supply circuit for high resistance.

CIRCUIT RESISTANCE TEST

We can test for high resistance on both the starter and ground sides of the supply circuit by checking for voltage drop at each of the connections.

Use a sensitive voltmeter which will indicate tenths of a volt and connect its positive test clip or prod to the positive battery post and the other to the battery cable clamp. The meter needle will not move if the connection we're testing is good. If a voltage drop is indicated, we must eliminate the resistance by thoroughly cleaning the cable clamp and the battery post.

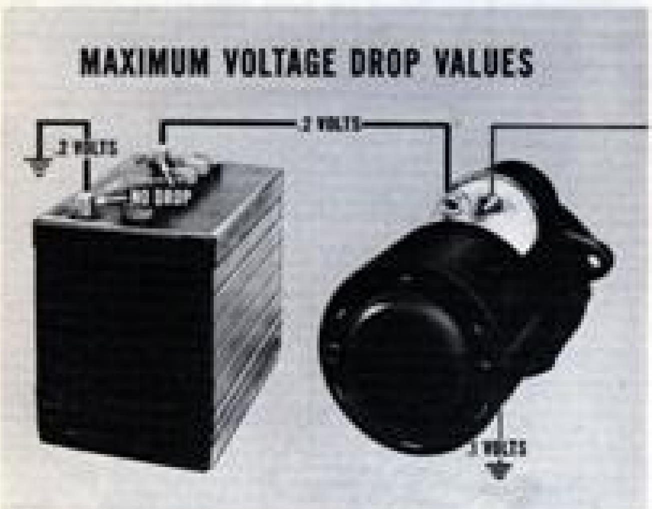


Fig. 18 — Remove high circuit resistance

Make a similar check between the battery cable clamp and the battery terminal of the starter. More than 0.2 of a volt here indicates high resistance at the starter terminal connection or in the cable itself.

Now go back to the battery negative terminal and check for a voltage drop between the negative post and the ground cable clamp. Again there should be no voltage reading if the connection is good. Next, check between the ground cable clamp and the connection on the engine. As with the starter cable, a 0.2 voltage drop is acceptable.

Finally, move the meter positive lead connection to the starter housing and the negative lead to the battery negative post and read any voltage drop between the starter housing and the engine. More than 0.1 of a volt drop at this point is too much.

After the supply circuit is checked out, repeat the starter draw test once more. If the amperage reading is still lower than specifications, the high resistance must be in the starter.

CHECKING THE CONTROL CIRCUIT

The starter control circuit includes the ignition switch, starter relay, neutral safety switch on TorqueFlite cars, starter solenoid and all the connecting wiring.

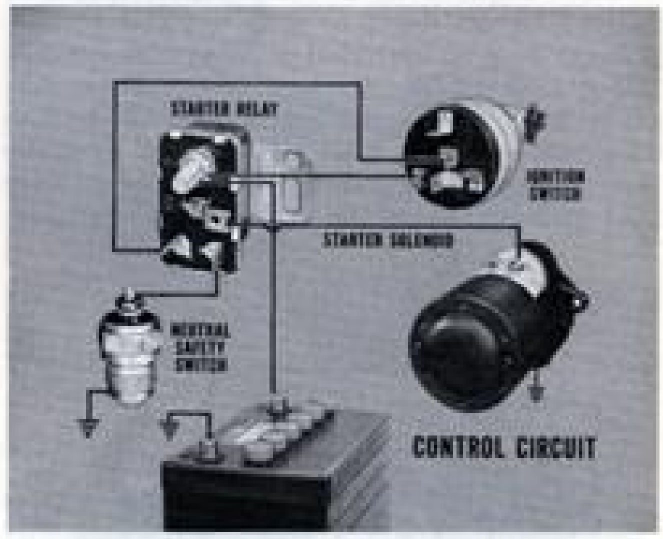


Fig. 19 — Operates starter solenoid

Trouble in the control circuit is usually easy to find because you can use a jumper wire to eliminate one unit at a time until the cause is located

Always be sure to set the parking brake and put the transmission in Neutral or Park before you check through the starter control circuit. These twelve-volt starters can really make a car jump if it is in gear. Besides, with automatic transmission, some of the tests can be performed only in Neutral or Park so the neutral start switch is grounded.

CHECK EACH UNIT IN TURN

Ignition Switch Test: Connect a jumper between the ignition terminal and the battery terminal of the starter relay to bypass the ignition switch.

If the engine cranks, the trouble's in the ignition switch or in the switch circuit wiring. Where there's no response from the starter, or the starter relay only clicks, move on to the next test.

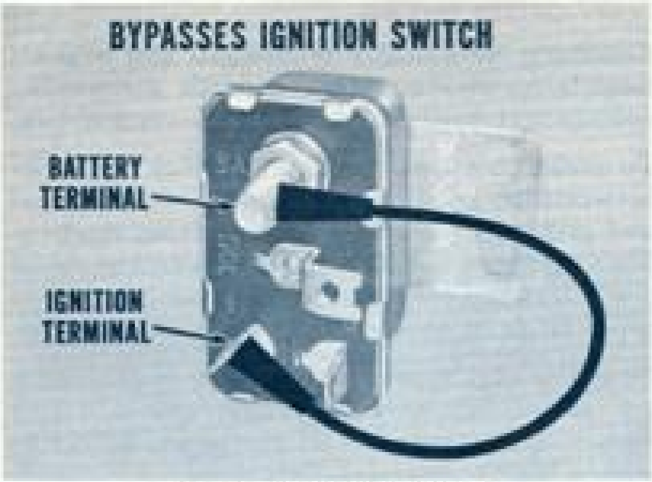


Fig. 20 — Ignition switch test

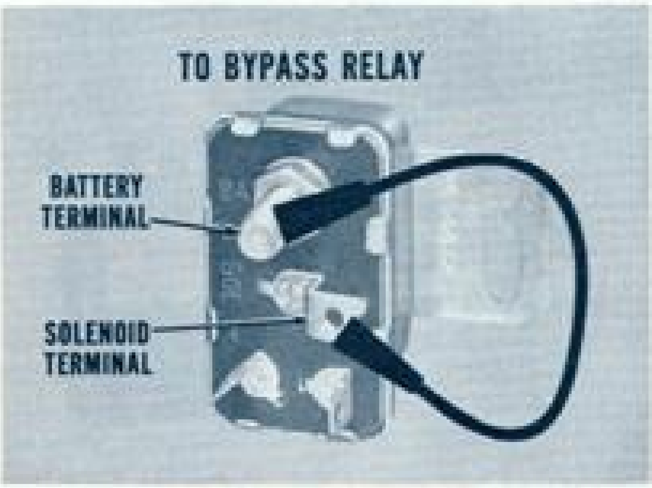


Fig. 21 — Starter relay test

Starter Relay Test: Where the relay clicks, but there's no cranking when you bypass the ignition switch, check the relay contacts by connecting a heavy jumper between the battery terminal and the solenoid terminal of the relay. This eliminates everything in the control circuit except the solenoid, solenoid wiring and the starter itself.

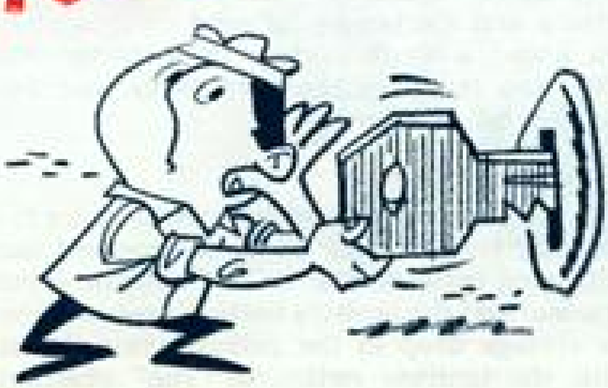
If the starter now cranks, the relay contacts are at fault. No starter response obviously means that the trouble is in the solenoid, starter or wiring.

Starter Relay Ground Circuit Test: In cars where there's no starter response, and the relay does not click when the ignition switch is bypassed, connect a jumper between the relay housing and a good ground. On cars with TorqueFlite, the relay is grounded through the neutral safety switch. You can bypass the switch to check it out by connecting a jumper between the relay ground terminal and ground.

If the engine now cranks with the ignition switch bypassed, you'll probably find the trouble in a poor ground at the relay mounting, a neutral safety switch not working properly, or in the switch wiring. No starter cranking points to trouble in the relay itself.

CAUTION: DO NOT connect the test jumper between the ignition and solenoid terminals of the starter relay. If the ignition switch is turned on, this connection will overload the switch contacts and may cause serious damage.

IGNITION CIRCUIT TESTING



In these tests we are concerned with the primary, or low-tension part of the ignition system. Like the starter system, the primary has two circuits . . . one for starting . . . the other for running.

GET ON THE TRAIL

Here again we track down the trouble by the process of elimination. Let's begin by tracing out both circuits so we can understand what we're testing and what the results mean.

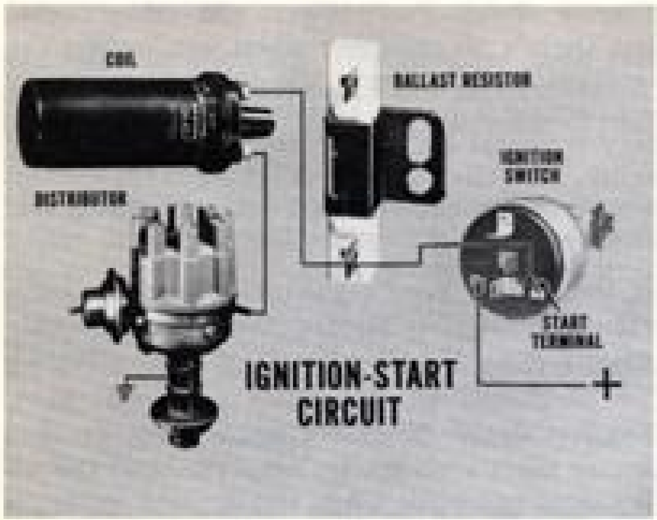


Fig. 22 — Start-circuit bypasses ballast resistor

The ignition *start* circuit begins at the *start* terminal of the ignition switch, bypasses the ballast resistor, and goes directly to the input side of the ignition coil. From the coil, the circuit continues through the distributor breaker points and the distributor housing to ground at the engine.

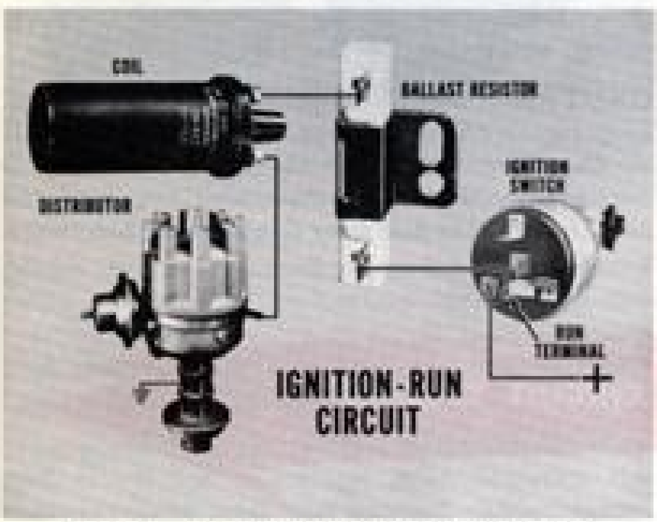


Fig. 23 — Run-circuit connects ballast in series

The *run* circuit is essentially the same as the start circuit, but it begins at the ignition switch *run* terminal and passes through the ballast resistor before it reaches the ignition coil.

Because ignition primary circuit troubles can range from outright burnouts to poor performance caused by high resistance, we'll describe complete tests for both ignition circuits to cover all the bases.

START-CIRCUIT TESTING

Assuming the battery is charged and in good condition, we can start in with a cranking voltage test to check the ignition-start circuit.

To make this test, we first connect a jumper between the ignition coil output (—) terminal and ground to keep the engine from starting. Then we hook a voltmeter between the input (+) terminal of the coil and ground to measure voltage at the coil under a cranking load.

Turn the engine over and note the meter reading. If voltage at the ignition coil is 9.6 or higher, the resistance in the start circuit is within limits.

Fig. 24 — Low voltage means high resistance

Where the cranking voltage is lower than 9.6, there's too much resistance in the start circuit, and the engine will start hard or not at all. The trouble may be caused by loose, corroded connections or the "start" contacts in the ignition switch may be faulty.

Note again, that these tests assume that the battery and starter are in good condition. As you know, a weak battery or a starter that draws too much current can throw our test readings off seriously.

RUN-CIRCUIT TESTING

First we remove the jumper wire used for the cranking voltage test. Then we connect our voltmeter between the ballast resistor input terminal and the positive battery post to measure voltage drop in the primary run circuit. With the ignition switch in "run" position, the voltmeter should not indicate more than .35 of a volt if the circuit is in good condition. Where it's higher than this, we can suspect poor connections, or burned, dirty "run" contacts in the ignition switch.

Fig. 25 — Check run-circuit voltage drop

Another possible source of high resistance in the primary run circuit is a change in the value of the ballast resistor. If you suspect trouble here, check the resistor against specifications in the shop manual. Of course, if the resistor is "open" there won't be any reading at all. Where the resistor is open, the car may start but won't run. If this happens, hook a jumper across the resistor and recheck the voltmeter indication.

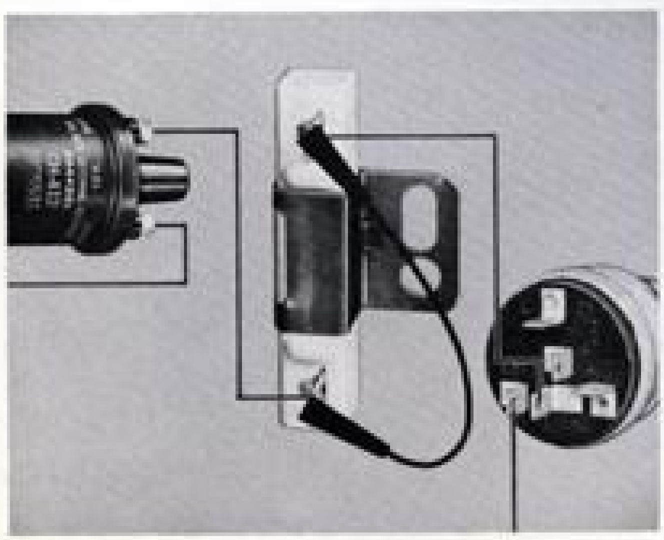


Fig. 26 — Jumper bypasses ballast resistor

DISTRIBUTOR AND GROUND TESTING

From the output side of the ignition coil to ground through the distributor, the remainder of the primary is common to the start and run circuits. We must also check this section for voltage drop to complete our test.

Connect the voltmeter between the distributor side of the ignition coil and ground on the engine block to measure voltage drop in the distributor. Turn the ignition switch to "run" position and make sure that the breaker points are closed, or the meter will indicate primary circuit voltage instead of any voltage drop. If the drop is more than .1 of a volt, distributor resistance is too high. This can be caused by loose connections, or more often, by burned or glazed breaker point contacts.

Fig. 27 — Voltage drop indicates distributor resistance

A FINAL CHECK

There's one remaining possible source of high resistance in the primary circuit . . . the ground contact between distributor and engine block. This can be a fooler, so don't assume it's okay unless you check it out.

To make this test, move the grounded voltmeter connection from the block to the distributor housing and leave the other connection in place on the coil output terminal to limit the voltage drop check to the distributor only. If the reading is still more than .1 of a volt, the resistance is in the distributor. But if the voltage drop is lower than the reading made with the engine ground connection, there's poor electrical contact between the distributor housing and the engine block.