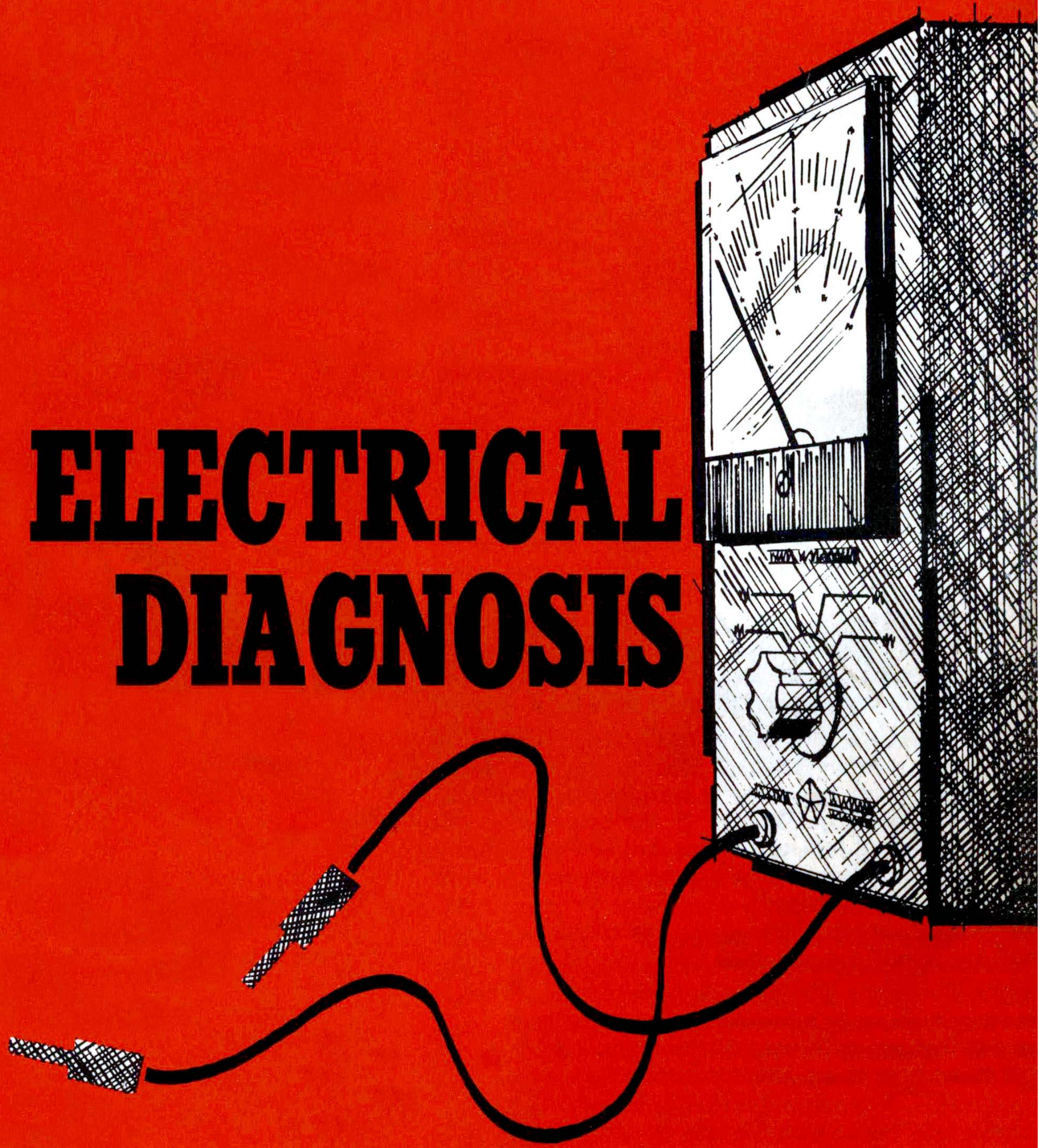
MASTER TECHNICIANS SERVICE CONFERENCE 66-4

REFERENCE BOOK

ELECTRICAL DIAGNOSIS



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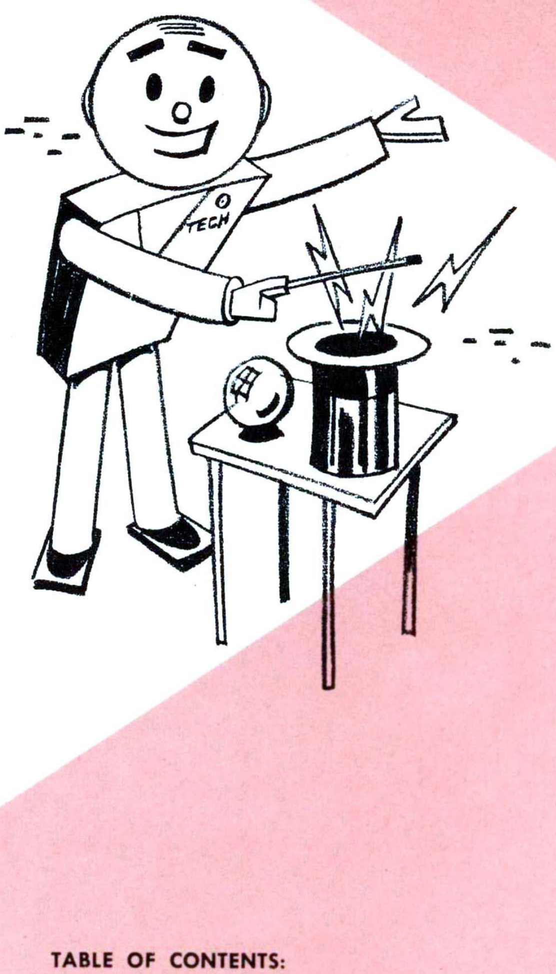
Turn Principles Into Practice

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 .

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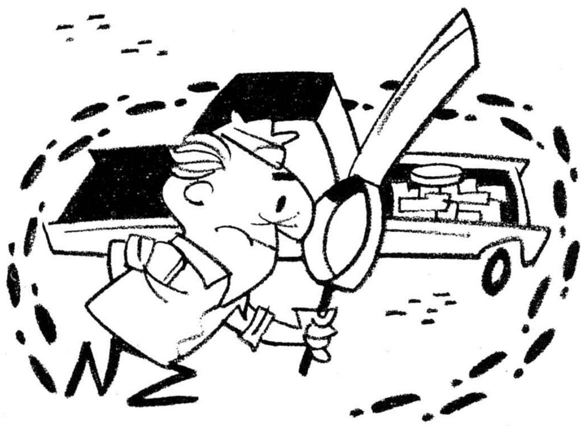
BATTERY BASICS



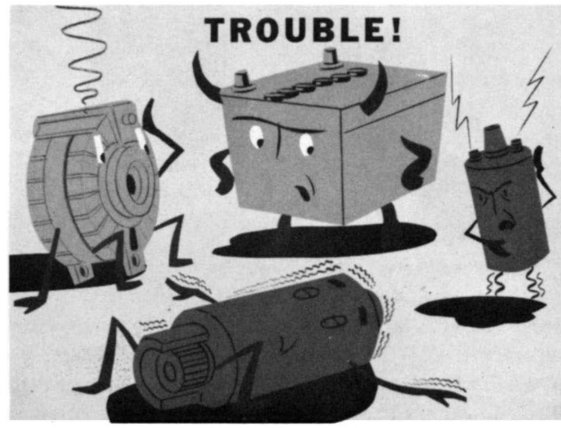


Fig. 1 — Poor battery condition causes trouble

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.

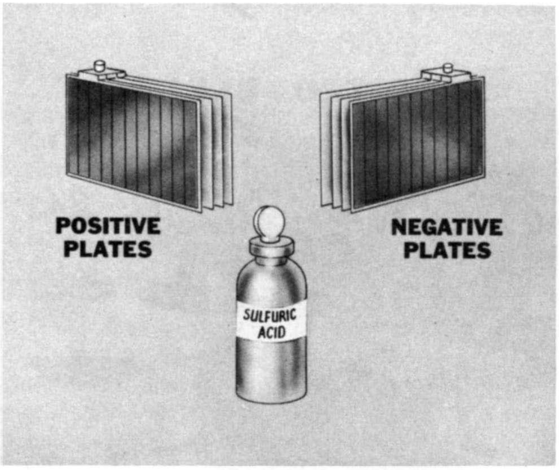


Fig. 2 — Positive and negative plates plus electrolyte

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.

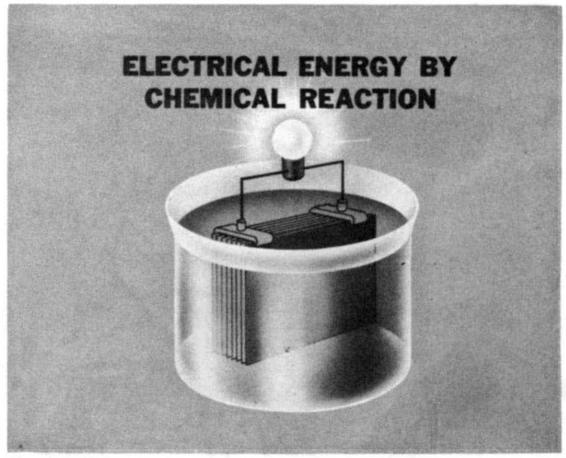


Fig. 3 — Chemical change produces current

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.

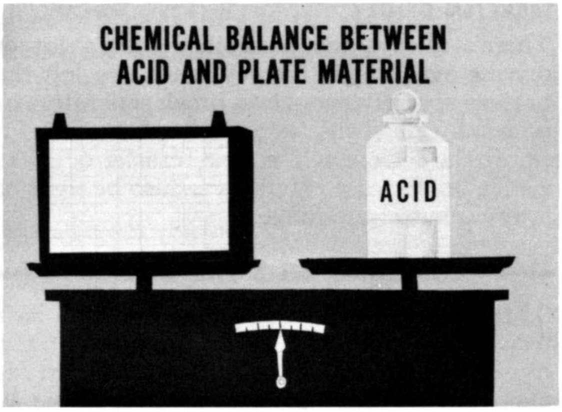


Fig. 4 — Condition = amount of acid and active material

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.

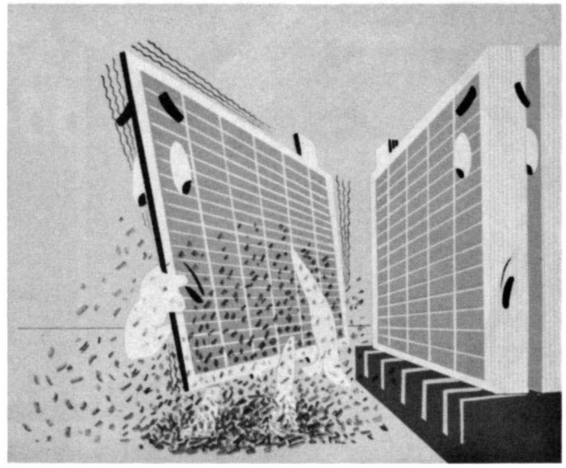


Fig. 5 — Active material loosens faster than normal

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.

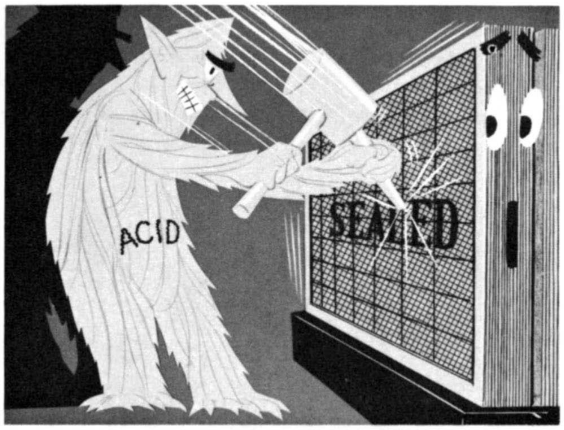


Fig. 6 — Sulfate hardens on plates

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.

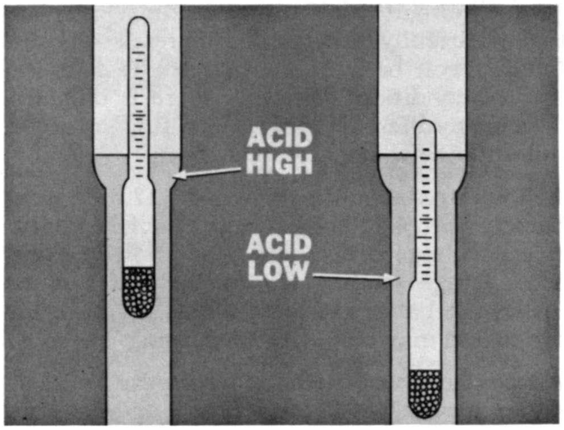


Fig. 7 — Float rides high at full charge

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 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.

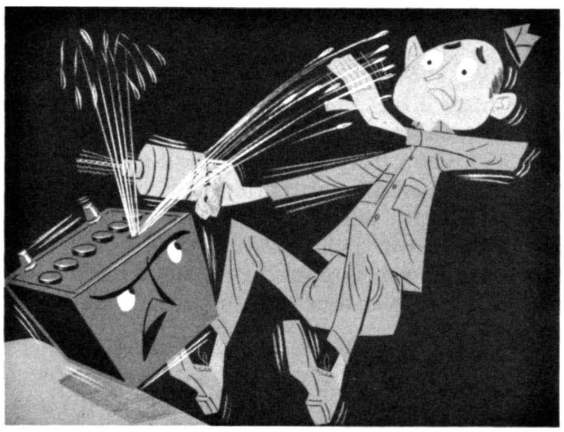


Fig. 9 — Battery tops are not for drilling

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.

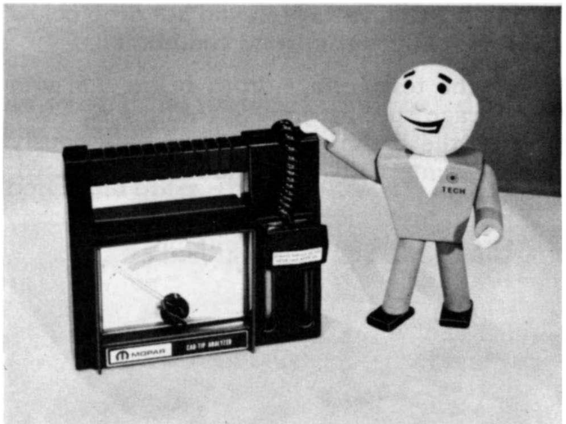


Fig. 11 — Cad-Tip Battery Analyzer

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.

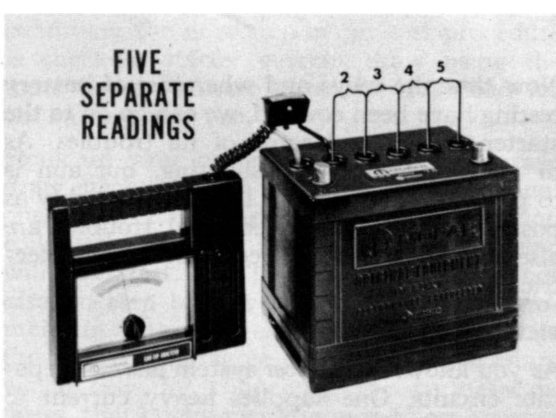


Fig. 12 — Place test probes in adjacent cells

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.

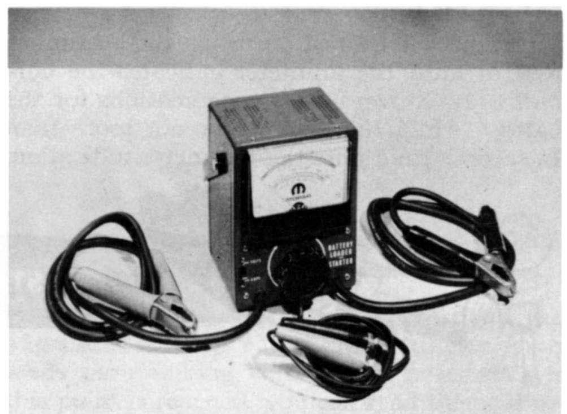


Fig. 13 — Battery-Starter Load Tester

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.

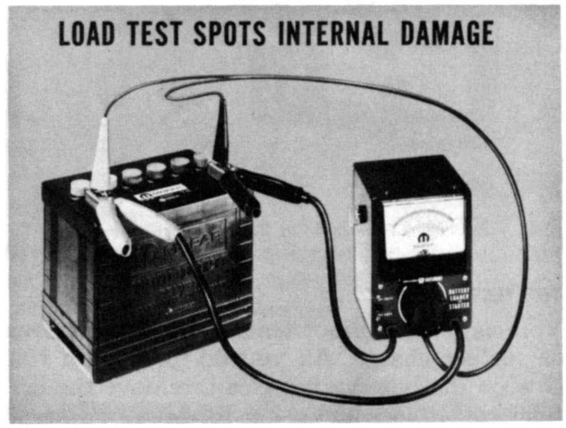


Fig. 15 — Below 9.5 volts calls for replacement

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.

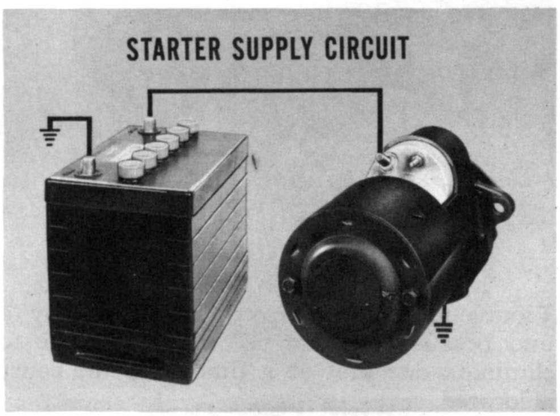


Fig. 16 — Supplies high amperage starter power

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.

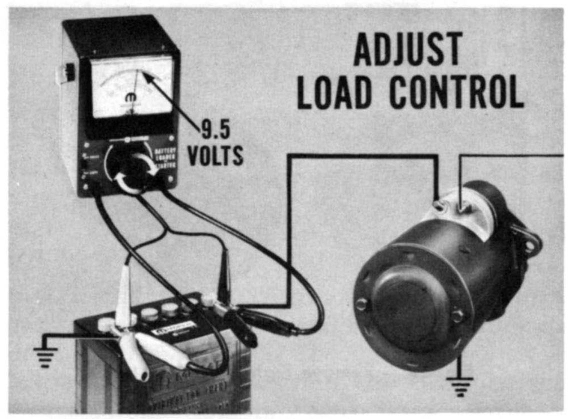


Fig. 17 — Adjust load to match cranking voltage

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.

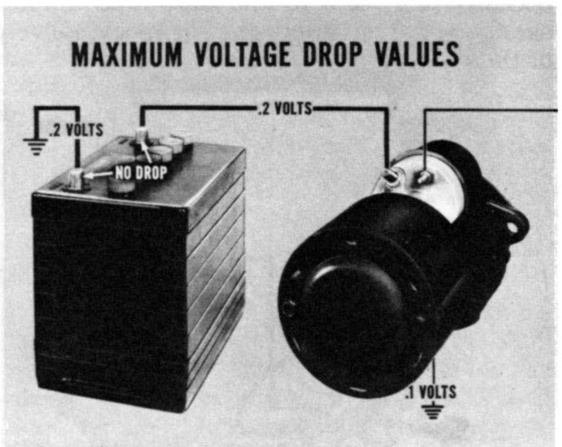


Fig. 18 — Remove high circuit resistance

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.

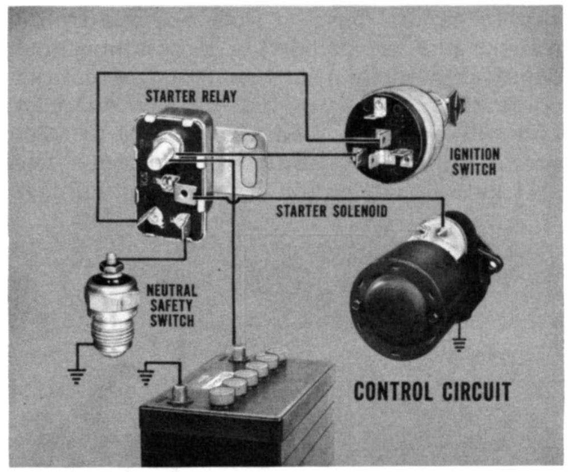


Fig. 19 — Operates starter solenoid

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.

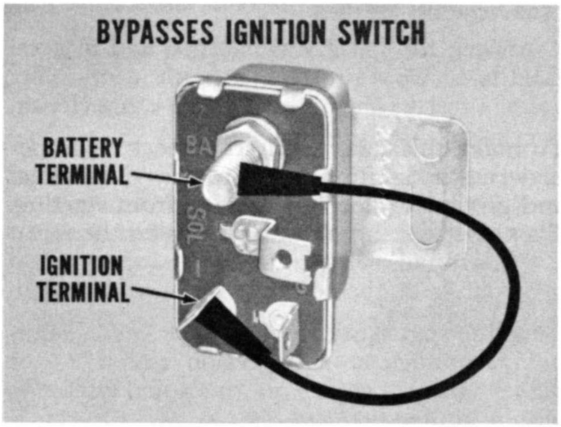


Fig. 20 — Ignition switch test

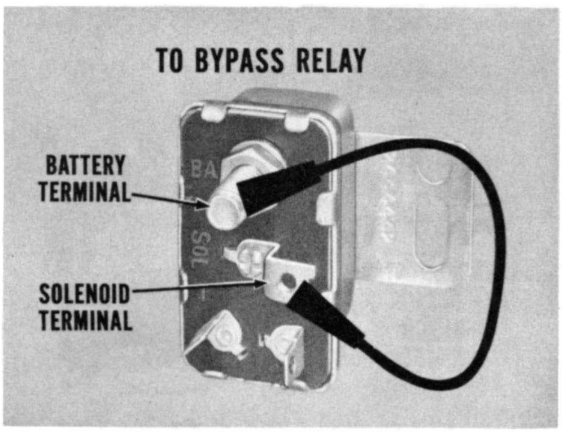


Fig. 21 — Starter relay test

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.

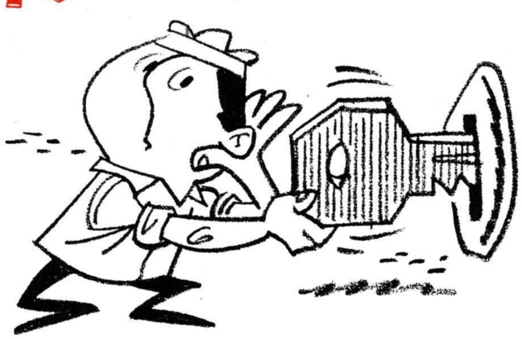
If the starter now cranks, the relay contacts are at fault. No starter response obviously means that the trouble is in the solenoid, starter or wiring.

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.

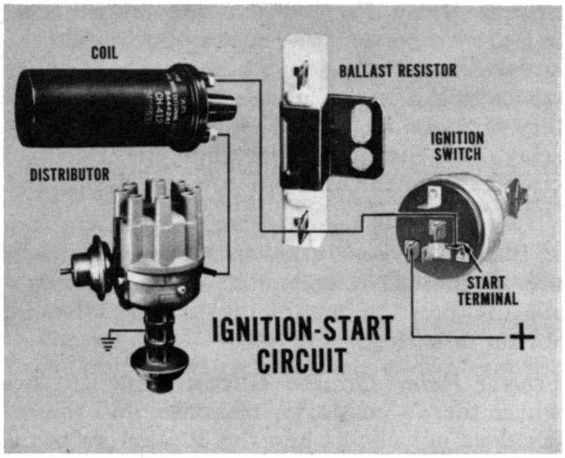


Fig. 22 — Start-circuit bypasses ballast resistor

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.

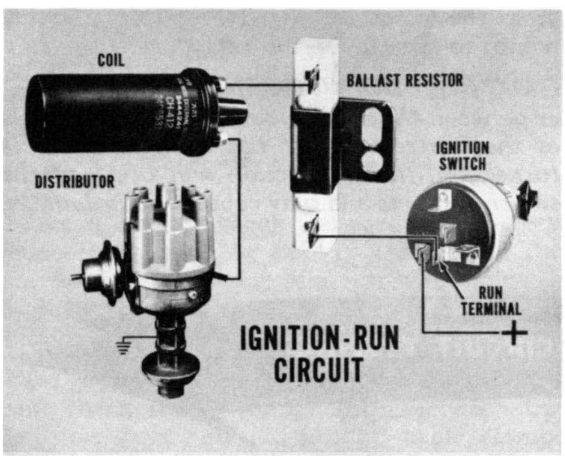


Fig. 23 — Run-circuit connects ballast in series

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.

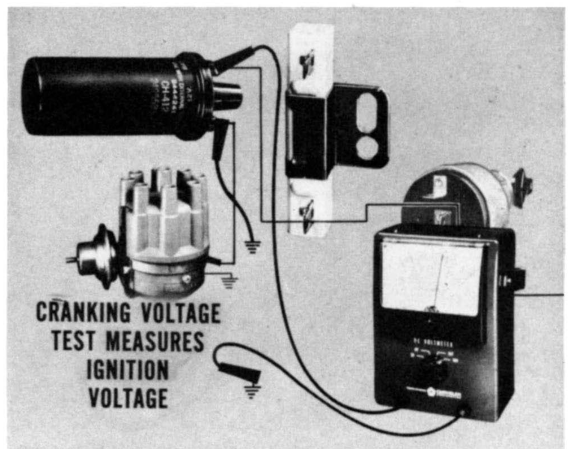


Fig. 24 — Low voltage means high resistance

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.

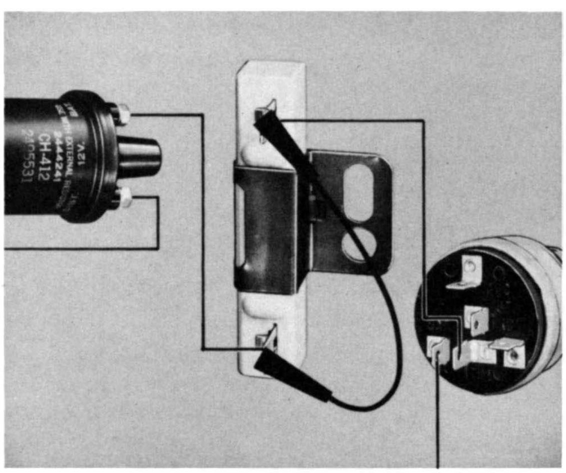


Fig. 26 — Jumper bypasses ballast resistor

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.

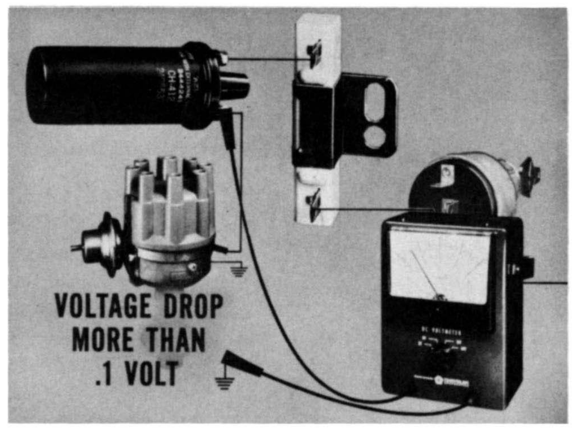


Fig. 27 — Voltage drop indicates distributor resistance

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.

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