SHOP TIPS FROM Autolite Ford

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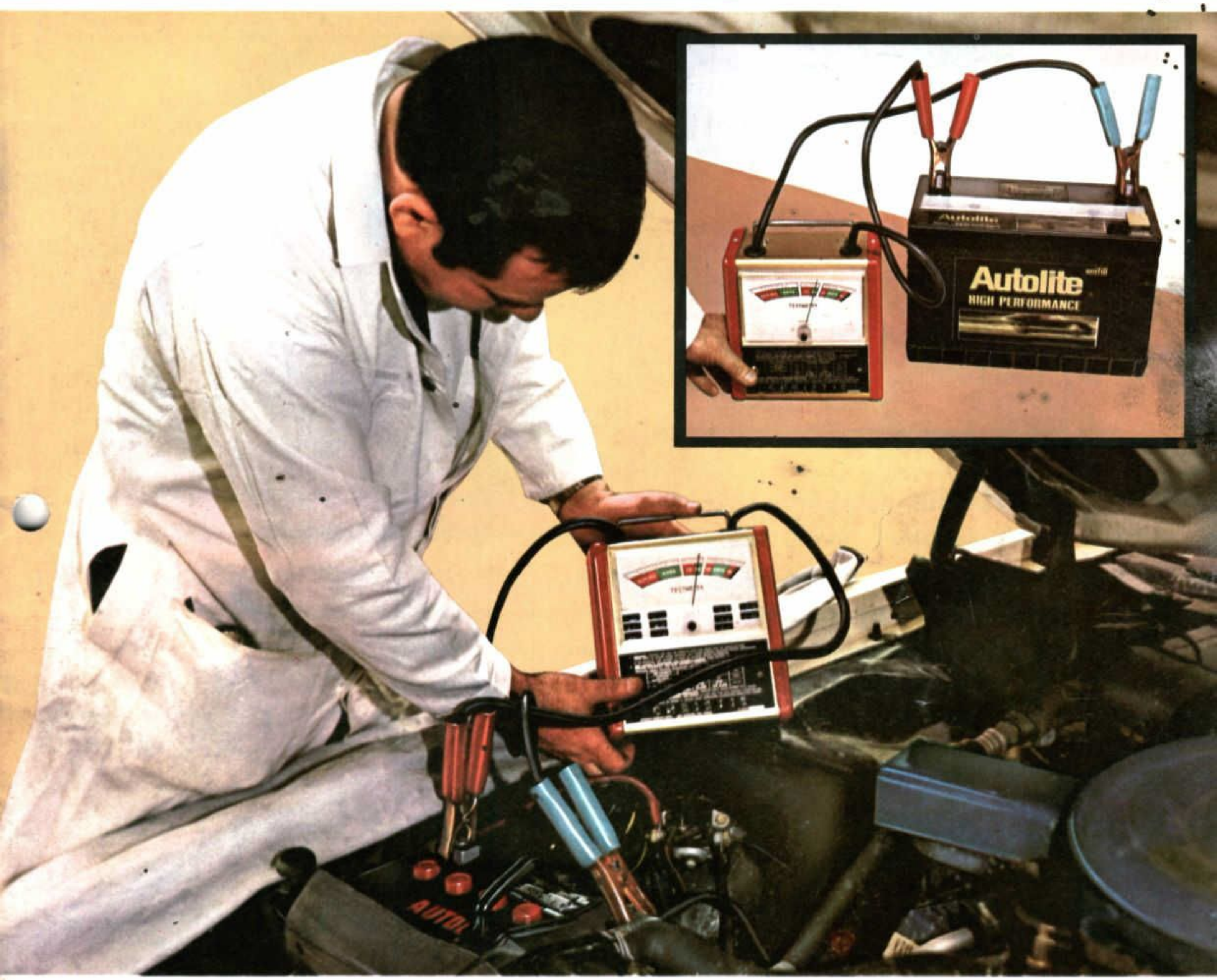

Technical parts and service information published by the Autolite-Ford Parts Division and distributed by Ford and Lincoln-Mercury dealers to assist servicemen in Service Stations, Independent Garages and Fleets.

ALL ABOUT BATTERY SERVICE AND SYSTEMATIC TESTING...

The Short Route To Accurate Diagnosis

BATTERY SERVICE

IN THIS ISSUE

Be sure and file this and future bulletins for ready reference. If you have any suggestions for additional information that you would like to see included in this publication, please write to: Autolite-Ford Parts Division of Ford Motor Company, Merchandising Services Dept., P.O. Box 3000, Livonia, Michigan 48151.

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Autolite Ford

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Time was, not too long ago, when batteries seldom lasted more than about 2 years. The advent of the alternator, however, together with improved designs have significantly increased the service life of today's battery. But they still wear out, due to their electrochemical nature. Maximum service life can only be obtained by frequent attention and preventive maintenance.

Customers are usually unaware of exactly what maintenance their car battery requires. You have an excellent opportunity to service the battery when other periodic services such as lubrication, tune-ups, or other minor repairs are performed. Even at refueling stops, under-the-hood checks for abnormal conditions such as low electrolyte level, excessive corrosion deposits, frayed cables, or other tell-tale signs may indicate some type of battery service is required. Customers appreciate this warning that battery service is required. No one really wants to wait until the battery fails, and then need service in some out-of-the-way place.

WHY BATTERIES FAIL

There are four general reasons for battery failure—

- Poor physical condition
- Prolonged overcharging or undercharging
- Under-capacity application
- Lack of proper maintenance

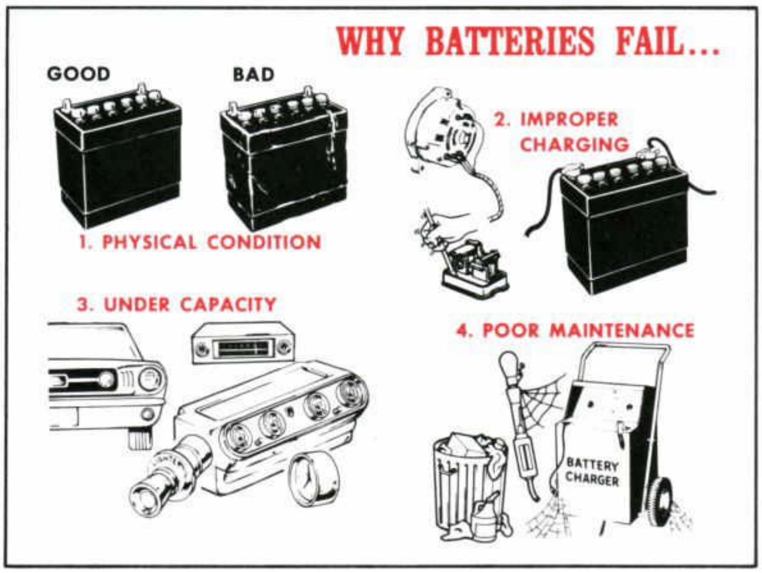

Figure 1—Why Batteries Fail

AND SYSTEMATIC TESTING

POOR PHYSICAL CONDITION

The physical condition of a battery is an obvious but nonetheless important factor in its performance. Among the causes for a poor condition we must include the normal deterioration which accompanies the aging process. The repeated charging and discharging cycles slowly wear away the active materials in the plates and deposit them in the sediment area beneath the element rests. A point is eventually reached where the surface area of the plates which is available for reaction with the electrolyte is insufficient to allow restoration to a state of full-charge.

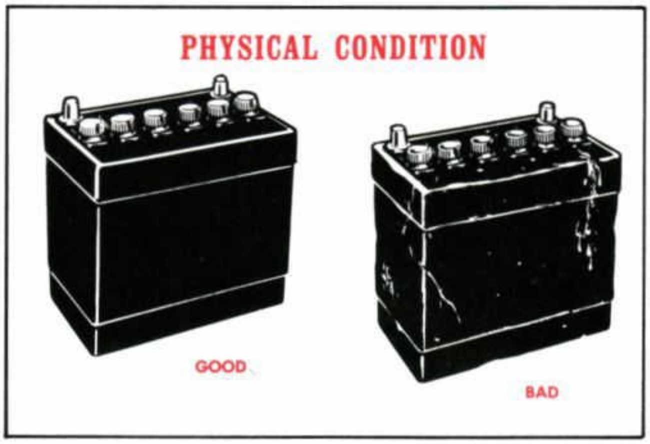

Fig. 1-A—Physical Condition

A low supply of electrolyte will cause a premature deterioration of the active material in the battery plates. If this should happen, it is possible that there will not be enough plate area remaining to produce the power needed to accommodate the load which might be placed on the battery.

Other factors contributing to inferior physical condition include damage, manufacturing defects, and inadequate preventive maintenance.

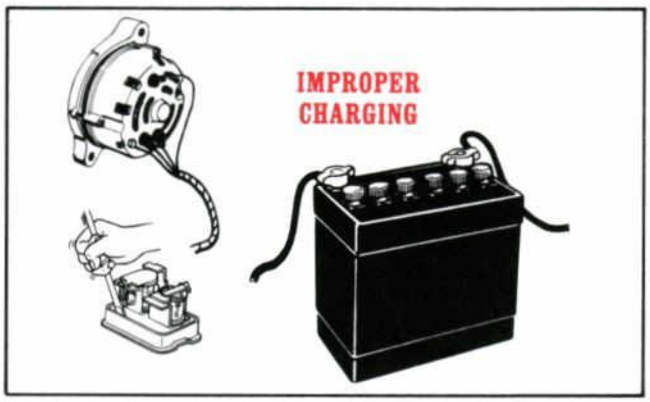

Fig. 1-B—Improper Charging

IMPROPER CHARGING

An insufficient or excessive supply of charging power can be equally damaging in the effect it has on a battery. This applies to the car's charging system, just as it applies to an external charging device. Typical results of each are as follows.

Overcharging

- Severe corrosion of positive plates.
- Decomposition of water into gaseous hydrogen and oxygen which tends to break down the active material in the plates and "boil out" acid from the cells.
- Excessive heat, which intensifies all normal chemical reactions, with resulting damage to plates, separators, case and sealing compounds.
- Severe positive plate warpage and related separator perforations. (This damaging effect is most likely to occur if overcharging follows a period of undercharging.)
- Electrolyte may blow out of the battery cells if high rate charging is excessive. The spray of acid from the cells, if not thoroughly neutralized, may damage the cables, the battery mounting bracket, or other engine compartment components.

Undercharging

- Undercharging causes the density of sulfate on the plates to increase. This heavier sulfate resists the normal electrochemical reaction which occurs when the battery is being charged.
- Prolonged periods of undercharging disturb the solubility relationship between lead sulfate and electrolyte. In time, lead particles may form in the separators causing minute short circuits between the positive and negative plates.
- An undercharged battery has a high water content in the electrolyte. During cold weather, this increases the possibility of freezing.

The causes of an improper charge may include one or more of the following:

1. Faulty regulation.
2. Faulty generator or alternator output.
3. Faulty conductors in the circuit.
4. Faulty circuit control components such as relays, solenoids, and switches.

BATTERY SERVICE

Improper Capacity

When an automobile manufacturer specifies a battery of a given capacity as original equipment, this capacity rating takes into consideration the known demands which starting, accessory operation, etc. will place upon the unit. The continuing adequacy of this rating assumes that demand potential will not change.

Several factors which might alter battery requirements are:

1. Poor ignition continuity causing excessive battery drain when starting the engine. (Starting is a prolonged effort.)

2. An electrical equipment circuit problem or an excess of electrical components is causing excessive drain. (The results of damage or an improperly operating electrical component are self-evident. The indiscriminate addition of electrical accessories which the charging circuit cannot support within the limits of battery capacity could lead to very gradual discharge and probably repeated incidents of battery failure.)

Lack of Maintenance

The results of improper maintenance are closely related to poor physical condition—a cause for failure that we have covered previously in this section. In this instance, however, we mean PREMATURE degeneration of a battery.

Premature battery failures can be reduced by:

1. Proper selection; the ampere hour capacity must be balanced with the electrical load. An undersized battery will result in poor performance or premature failure.

2. Proper activation procedures.

3. Correct installation procedures; avoid physical abuses and overtightening.

4. Periodic servicing; the customer should be made to realize that the battery is a perishable item and requires frequent attention. Satisfactory life can only be obtained when these services are performed regularly.

Belt Tension

Another contributing factor to battery maintenance and important enough to consider alone, is the tension of the fan belt. This tension requirement is critical and very often overlooked by many service technicians—not that they don't know better—only a simple maintenance item that is taken for granted. A slipping generator/alternator drive belt can cause:

1. A battery to be in a constant low state of charge.

2. A glazed fan belt, which:

   a. May squeal and squeak.

   b. Can only be cured by replacing with a new belt.

On the other hand, a belt which is overtightened will cause:

1. Belt stretching—which also necessitates replacement.

2. Premature bearing failure.

It is suggested that a belt tension gauge be used in belt-tightening, rather than the older "rule-of-thumb" of tightening until a 1-inch deflection is attained. This is necessary on recently built automobiles because of the shorter distances between drive pulleys.

If a belt-tension gauge is not available, the following procedure is recommended:

1. Tighten belt until fan pulley cannot be turned by hand.

2. Run engine for approximately 15 minutes.

3. Stop engine and adjust again until the fan pulley will not slip with hand pressure applied.

This simple procedure pre-stretches the belt and assures full bearing and belt life—thus providing sufficient charging current to maintain the battery.

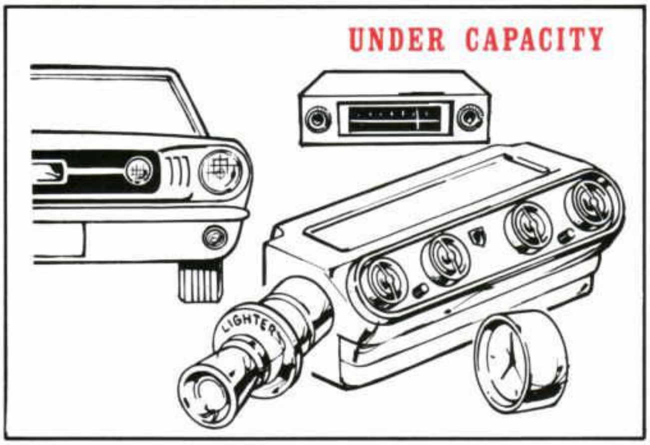

Fig. 1-C—Under Capacity

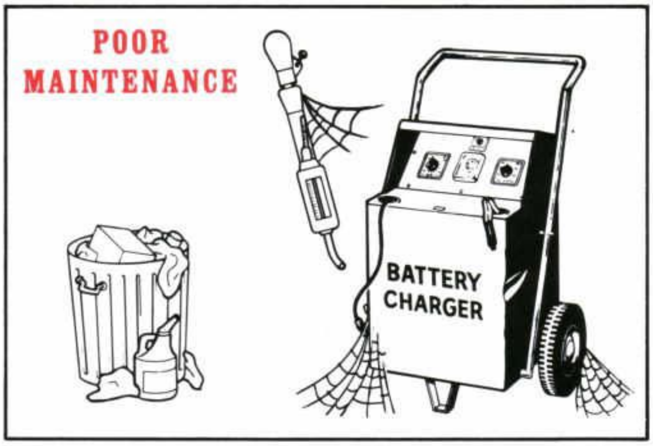

Fig. 1-D—Poor Maintenance

AND SYSTEMATIC TESTING

ROUTINE PROCEDURES

Perhaps the single most important service operation affecting battery life is keeping the cables and top of the battery clean and free from corrosive deposits. Battery manufacturers have designed the one-piece covers to help alleviate the problem of acid seepage on the tops of batteries. Further, the cleaning is very simple and many vehicle owners prefer to do it themselves, while others rely on the competent technician to care enough to see that the battery is properly serviced. The technician, of course, realizes that cleanliness is only part of the maintenance program. Several other contributing factors must be considered. These are:

1. Vehicle application—is the battery big enough to do the job of supplying load demands?
2. Charge rate—is the vehicle charging system keeping the battery fully charged?
3. Electrical system operation—are the starting motor and circuit wiring performing properly?

SERVICE PROCEDURES

The following Service Procedures are offered as a refresher for automotive electrical technicians and as a step-by-step guide for the beginner:

1. Raise hood and put fender cover in place.
2. Remove battery cables from battery posts (negative first).
   a. Clean cable terminals with acid-neutralizing solution and wire brush.
   b. Replace cables and/or cable clamp bolts as required.
3. Remove hold-down clamps.
4. Remove battery from vehicle.
5. Place battery over suitable drain.
6. Wash entire exterior of battery with acid-neutralizing solution. (Ammonia or baking soda and water.)
   a. Do not allow neutralizer to get inside cells.
   b. Rinse with clear water.
   c. Dry with compressed air.
7. Wash cradle (battery tray) with neutralizing solution.
   a. Rinse with clear water.
   b. Scrape off excess corrosion or rust deposits.
   c. Open water drain holes in bottom of tray.
   d. Dry with compressed air.
   e. Paint cradle with acid-resistant paint and allow time to dry.
8. Test battery and recommend that it be:
   a. Placed back in service.
   b. Recharged before placing back in service.
   c. Replaced.
9. Clean battery posts with wire brush.
10. Adjust electrolyte level, if required.
11. Place battery back in vehicle.
12. Tighten hold-down clamps (do not overtighten).
13. Place cables back on battery posts (positive first).
    a. Coat with mineral grease or vasoline (not the contact surfaces).
    b. Make sure felt washers were replaced, if used.
14. Start engine and allow it to reach operating temperature.
15. Read battery terminal voltage to determine overall condition of charging system.
16. Check charging system and/or ignition system if battery tests indicate that there is still a problem.

TESTING—THE SHORT ROUTE TO ACCURATE DIAGNOSIS

Step 8 under Service Procedures brings out the fact that TESTING is an important part of battery service. After testing, the technician should know whether the battery:

- is serviceable and should be placed back in the vehicle
- should be recharged before placing back in service
- should be replaced

BATTERY SERVICE

There is no reason to rely on guesswork when trouble-shooting a battery problem. A wide variety of test instruments (Fig. 2) are available to quickly and accurately diagnose battery condition. So the question should never be . . . "Should I test this battery?" But rather . . . "What should I use to test this battery?" The answer, of course, is to select the test device that does the job accurately, completely and quickly. Experience has shown this to be "the short route to accurate battery diagnosis."

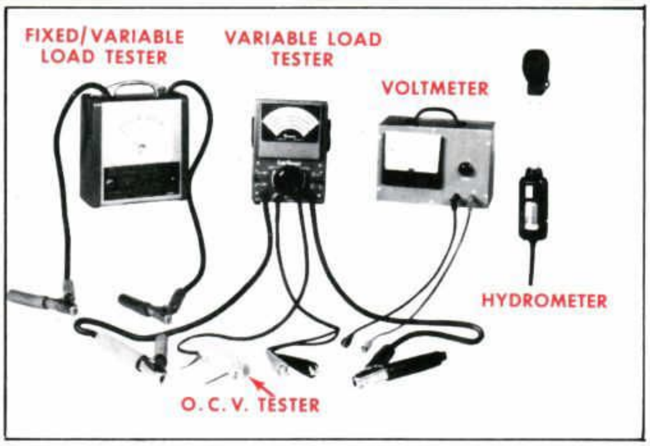

Figure 2—Introduction to Test Instruments

While traveling the "short route," there are several questions to answer.

1. What is the battery's state-of-charge? Use a hydrometer to check all one-piece "hard cover" batteries. An O.C.V. (Open Circuit Voltage) tester can be used on "soft cover" batteries where it's permissible to insert spikes into the battery connectors.

2. Is the problem a recurring condition? This important piece of information can be determined by talking to the customer, or checking the vehicle's maintenance record. For example, a constant low state-of-charge would lead you directly to a battery capacity test. If satisfactory, you would then check the vehicle's charging system.

3. Will battery respond satisfactorily to service? Determining this requires knowledge from many areas . . . battery age, conditions of service, load demands, specific charging rates, condition of internal components, etc. The technician must make use of information from the vehicle owner, service specifications and test results. Knowing which tests to perform also reduces diagnosis time. This makes it unnecessary to make *every* known test on a battery before deciding if it's serviceable. As an example, if the state-of-charge and capacity tests are satisfactory, then the charge acceptance test would probably be unnecessary.

4. Is the battery's capacity adequate for vehicle? A quick survey of how many electrical accessories are on the vehicle will determine if the battery's capacity will support vehicle load requirements. Simply add up the maximum amperes the battery might be asked to deliver at any one time. Compare this with the manufacturer's recommendations.

5. Is the battery actually causing the problem? Many times the battery is condemned when some other electrical system component is at fault. Excessive voltage losses, current leakage, and improper adjustment of charging circuit voltage limiting devices cause most electrical system failures. Knowing what test instrument to use will quickly help technicians isolate problems. Applying the proper corrective action . . . the first time . . . not only saves time, but saves the customer money and the inconvenience and frustration caused by an unexpected battery failure.

The following Test Procedures give detailed instructions on how to use instruments and interpret readings. They do not tell which instruments to use, or when to use them. These are common sense decisions based on knowledge of battery operating principles, charging system operation, load requirements, previous performance, etc. Along with these test procedures, get in the habit of looking up application data, and service information . . . and applying it to solving battery problems. It may appear time consuming at first glance, but elimination of guesswork and the application of a systematic approach to battery diagnosis is the SHORTEST ROUTE.

TEST PROCEDURES

VISUAL INSPECTION

A visual inspection is not a substitute for an instrument check when diagnosing a battery problem, or evaluating its condition. An inspection will, however, uncover tell-tale clues that can direct you toward the test instrument that will most efficiently test a battery under a given set of conditions.

When further service is indicated, check the installation date. (Length of service could be a factor—it would certainly be an aid in determining whether trouble is premature, or the result of normal degeneration.)

As a standard practice, batteries are date-coded on some special surface, such as negative ground post or on a tag (Fig. 3). The code on the negative ground post is usually standardized as follows:

1. The letters "A" through "M" (excluding the letter "I") identify the months of the year in chronological order.

2. The numerals "0" through "9" identify the terminal digit of the year.

Accordingly, code "A8" would signify a battery was placed in service in January, 1968.

AND SYSTEMATIC TESTING

Figure 3—Battery Date-Code

The following items should be visually checked for symptoms of trouble in the making, as shown in Figure 4.

Condition of Case and Cover

1. Check for cracks or buckling which could result from one of the following:
   a. Excessive tightening of hold-down attachments.
   b. Hold-down attachments too loose, causing vibration damage.
   c. Excessive temperatures.
      (1) In the engine compartment.
      (2) Internally, due to a high charging rate.
   d. Buckled plates as a result of the battery standing in an under-charged condition for long periods of time.
   e. Excessive loads (as a reminder . . . never use the starting motor to propel the vehicle).
   f. Clogged vent caps which prevent expansion of the hydrogen and oxygen gases during charge.
   g. Freezing of the electrolyte. (A battery with ¾ state of charge is in no danger of freezing. Refer to "Electrolyte and Specific Gravity" for more information about electrolyte under temperature extremes.)
2. Check the cell covers; they could be raised as a result of operating an under-charged battery over a long period of time—then subjecting it to prolonged over-charging.
3. Again, check the cell case and cover, one or both could be broken as a result of an open flame or spark being brought too close to a "gassing" battery.

Evidence of Acid on Cover

If acid deposits are noted on the cover, it is quite possible that leakage, spill-over, or gassing due to a high charging rate is a contributing cause. (A voltmeter check will determine whether leakage is taking place.) If these conditions are not serviced, they can result in an increase in the rate of self-discharge.

Figure 4—Battery Danger Signs

Color and Odor of the Electrolyte

Separately or in combination, discoloration of normally clear electrolyte and/or the presence of an odor similar to that of "rotten eggs" suggests one or more of the following:

1. The existence of an excessively high charging rate.
2. The adverse effects of deep cycling.
3. The presence of impurities in the electrolyte solution.
4. An aged battery which is approaching the end of its useful life

Signs of Abuse

Surface indications of abuse to the battery are a clue to the cause of some troubles. Check for the following:

1. Battery posts which have been damaged as a result of:
   a. Hammering.
   b. Flashing tools or wires across the terminals.
   c. Stretching short cables on applications that require longer lengths.
   d. Improper cable removing techniques.
   e. Improper connection of booster or charging equipment.
2. Sealing compounds which have been damaged as a result of:
   a. Excessive probing with pointed testing devices which have not been followed-up with repair.
   b. Placing copper objects on the top of the battery.

BATTERY SERVICE AND SYSTEMATIC TESTING

Electrolyte Level

Battery capacity is reduced in direct proportion to the amount of active plate material which is exposed to the air. If inspection reveals a low supply, pure water should be added to restore its level to ¼″ to ½″ above the top of the plates. (Most batteries have a level indicator near the base of the filler opening. If such an indicator is provided, it should be used.)

Water consumption at a rate up to two ounces per cell per 1000 miles of driving is considered to be acceptable. The need to add water in excess of this amount suggests the need to check and adjust the voltage limiter. (A running record of mileage and water consumption will aid in determining the adequacy of voltage limiter operation.)

Condition and Size of Cables

The condition and size of cables is important. The high current requirements of the starting system demand a minimum of voltage loss through the cables. To guard against difficulty in this respect . . .

1. Cable clamps should be inspected for:
   a. Excessive corrosion deposits.
   b. Acid erosion of clamp or bolt and nut.
   c. Loose clamp-to-battery-post connections.

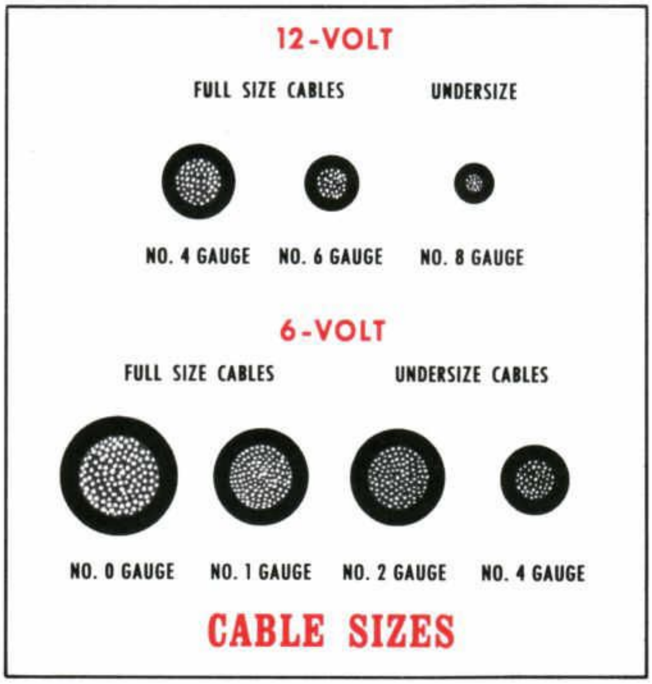

Figure 5—Cable Sizes

2. The size of the cable used should be noted and compared to manufacturer's recommendations (Fig. 5).
   a. A number 4 or 6 gauge is recommended for 12-volt applications.
   b. A number 0 or a number 1 gauge is recommended for 6-volt applications.
   c. Special applications may require heavier gauge cables than those recommended.
   d. Any separated wire strands will require that the remaining strands carry the same current load as a new cable.
   e. Periodic cleaning helps lengthen service life.

VARIABLE LOAD TESTS (CAPACITY TEST)

This is probably the most important battery test. For it measures the battery's ability to deliver current and maintain minimum necessary voltage. If the battery passes a capacity test, it is in satisfactory condition. However, it may require some additional charging to bring it up to peak performance.

Either a Battery-Starter High Rate Discharge Tester (Fig. 6), with a carbon pile resistor and a voltmeter, or a Variable Load Tester (Fig. 7) can be used to make the test. In the Variable Load Tester (Fig. 7), the ammeter scale reads

(Continued on Page 13)

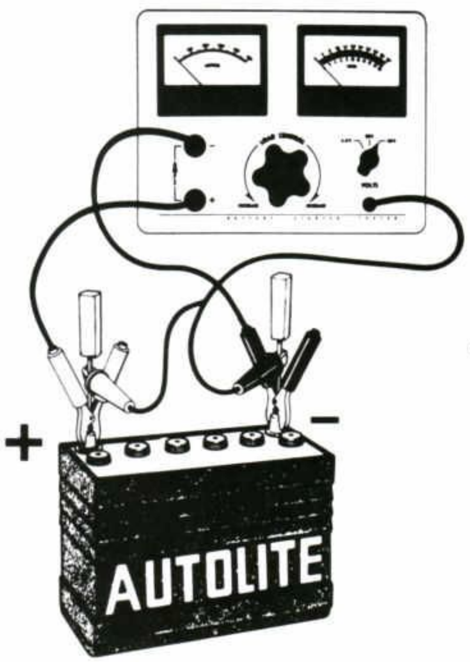

Figure 6—Battery-Starter Tester Capacity Test Connections

A NEW ADDITION

This new four-page section will be a regular feature of Shop Tips, bringing you news of parts buying opportunities and of special merchandising aids currently available at our parts counter. We have subscribed to have Shop Tips sent to you monthly, along with the annual issues of the Autolite All-Products and the Ready Reference catalogs. To body repair shops, we will send the Body and Collision catalog. These are sent with our compliments and as reminders that our stock of quality parts is as close as your telephone. Our phone number is on the back page of each publication.

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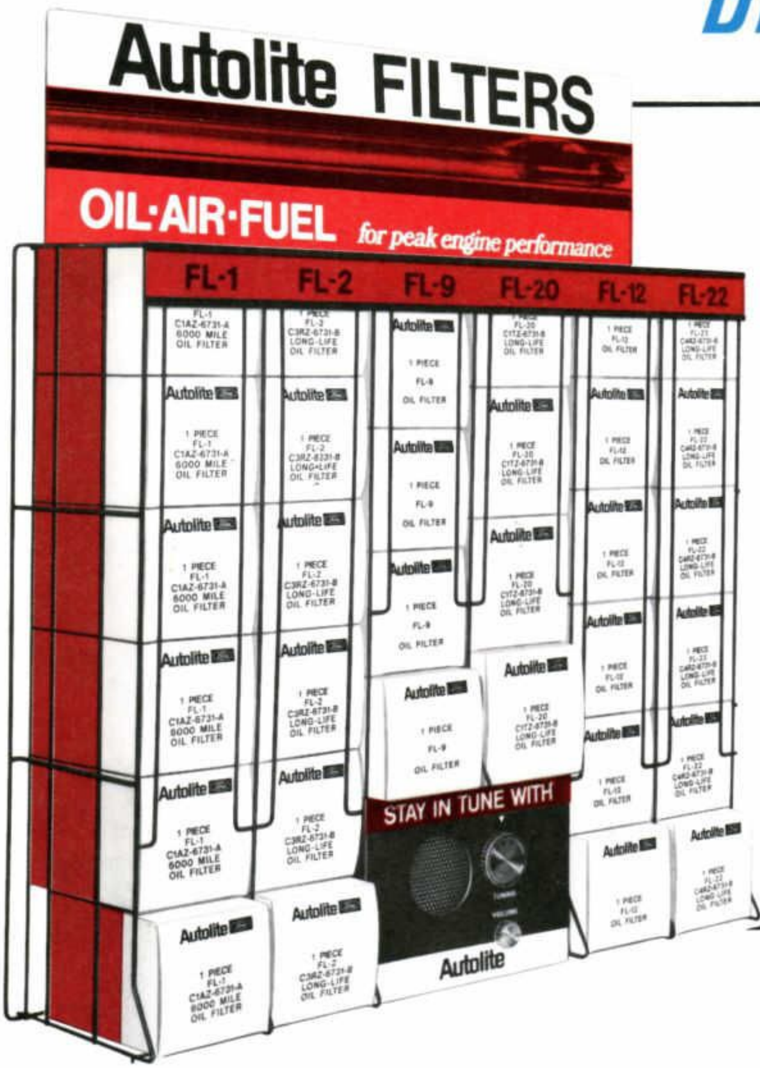

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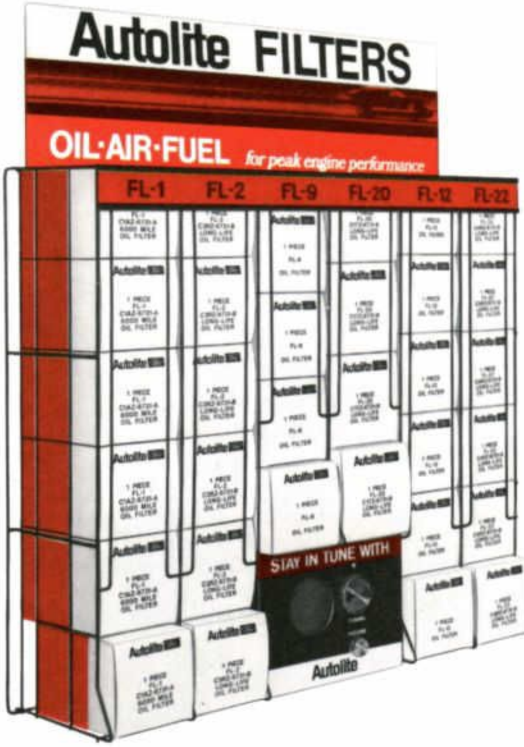

The RACK is a durable wall or counter-top fixture serving as a convenient oil filter dispenser and sales display. It stores 32 oil filters at your fingertips. Construction is of heavy gauge wire, welded for maximum strength and coated in a durable black finish. Pre-labeled spaces provide for Autolite's six fastest moving oil filter numbers. It's FREE with your purchase of the FLK-1000 oil filter assortment.

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Attractive, durable display!

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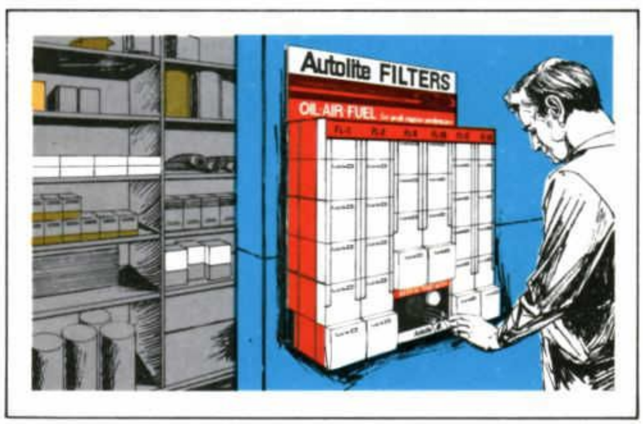
USE IT IN YOUR STOCK ROOM



Convenient gravity feed dispenser organizes your fast-movers for easy access.

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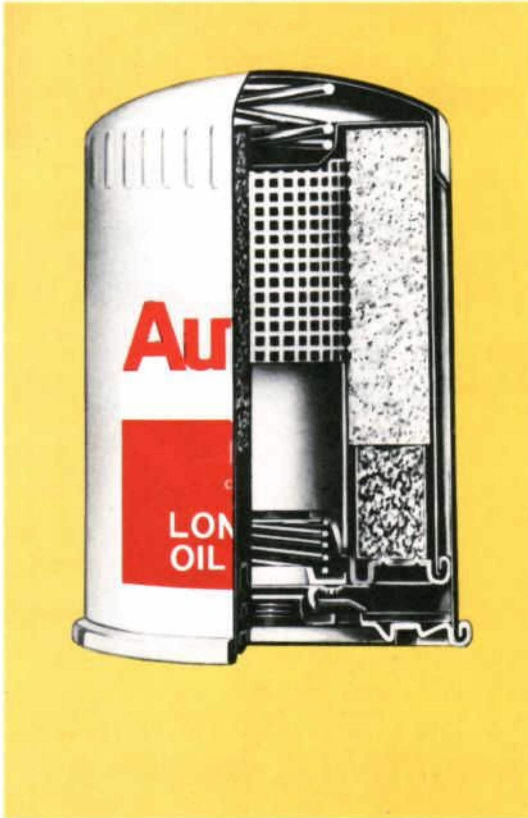

LONGER PROTECTION!

Autolite's two-stage oil filters reduce bearing wear by more than one-third as compared with conventional paper filters!

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CLEANER OIL!

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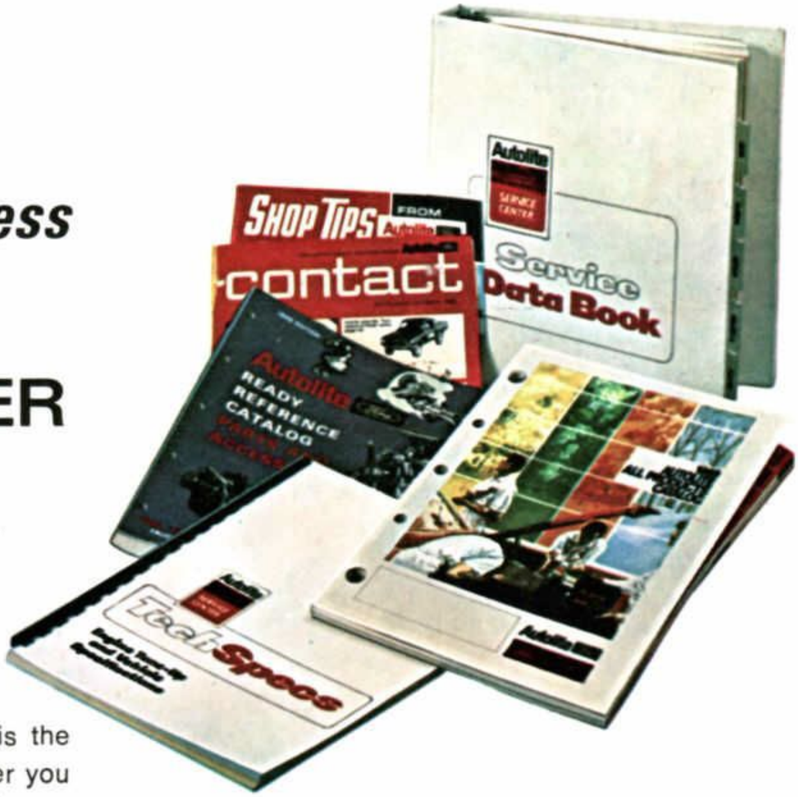

The new Autolite Service Center Program is the first and only program in the industry to offer you complete and regularly updated service information for all makes of vehicles compiled directly from the manufacturers' recommendations. This extra information will help you get more service business.

You can qualify for this Service Center Program by ordering an Autolite Starter Pack assortment of parts. These fast-moving parts cover a wide range of applications at a minimum investment. You also receive FREE a unique all-in-one parts merchandiser plus your choice of point-of-sale identification materials.

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BATTERY SERVICE AND SYSTEMATIC TESTING

straight amperes (0-500 amps) and ampere-hour rating (1/3 times amps) in upper and lower segments respectively. The voltmeter scale highlights acceptable minimum voltages, under load, of 4.8 for a 6-volt battery and 9.6 for a 12-volt battery.

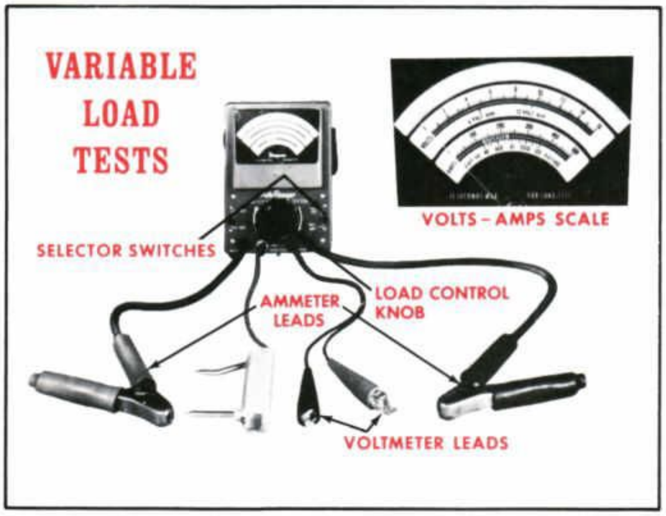

Figure 7—Variable Load Tester

Observe the following safety precautions:

1. Do not maintain load limit longer than 15 seconds.
2. Do not load test battery if electrolyte temperature is below 60°F. If battery solution is too cold, let the battery stand until warm before making capacity test.
3. Do not load test if specific gravity is below 1.225. (An exception is the tropical mixture where 1.225 is a full-charge gravity reading.)

Test Procedure

The following procedure details how to perform the capacity test as outlined in Figure 8.

1. Raise hood and put fender cover in place.
2. Add water, if necessary, to bring electrolyte to proper level.
3. Check to make sure the load control knob is "off" or all the way to the left.
4. Connect tester leads (positive to positive, and negative to negative) to battery posts (Figs. 6 and 9). Be sure voltmeter clips (small leads) connect DIRECTLY to battery posts and not to the heavy tester clips. CAUTION: Testing equipment of this type is designed to read amperage across battery terminals. DO NOT ATTEMPT TO USE OTHER THAN A HEAVY DUTY AMMETER FOR THIS KIND OF TEST INSTALLATION. THE HIGH CURRENT INVOLVED WILL BURN UP AN UNDER-CAPACITY TESTER.

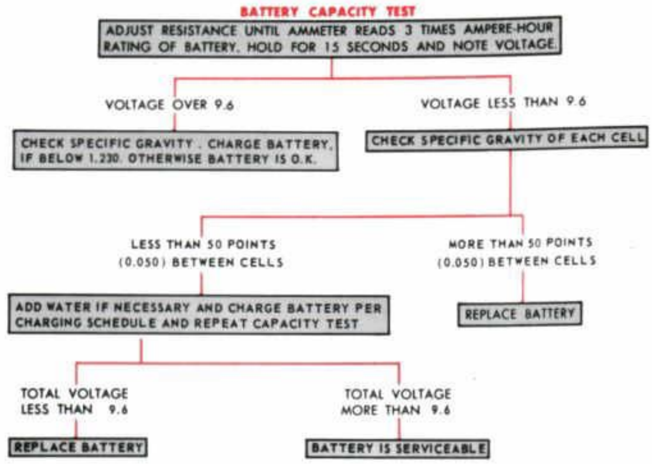

Figure 8—Battery Capacity Test Outline

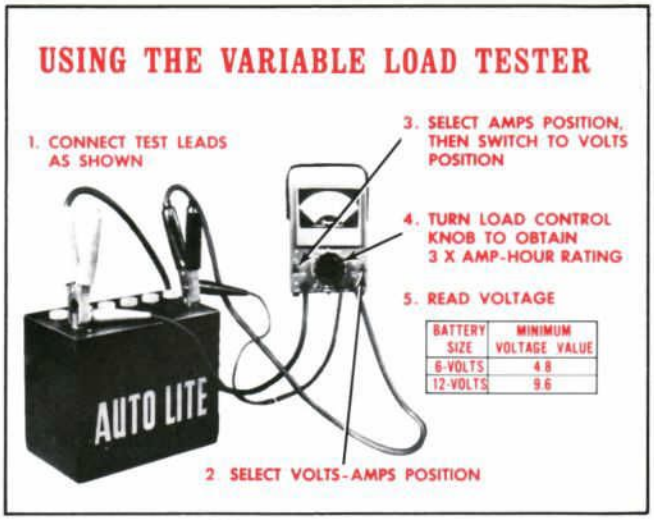

Figure 9—Using Variable Load Tester

5. (Variable Load Tester only.) Set test selector switch to volt-amps position and volts-amps selector to amps position.
6. Turn resistance load control until the ammeter reads 3 times the ampere-hour rating of the battery. (A 45 ampere-hour battery should be tested at 135 ampere load.) If rating is not available, use 60 ampere-hour rate for 12-volt battery, or a 100 ampere-hour rate for 6-volt battery.
7. (Variable Load Tester only.) Set volts-amps selector switch to volts position and read voltmeter.
8. With ammeter reading the required load, note the voltmeter reading. CAUTION: Do not leave the high load on the battery longer than 15 seconds.

BATTERY SERVICE

Test Conclusions

1. If the voltmeter reads 9.6 volts or more for a 12-volt battery (4.8 volts or more for a 6-volt battery), the battery has sufficient output capacity and will readily accept a normal charge.

   NOTE: If battery construction allows, the voltage of each cell may be measured separately while subjected to the same load discussed above.

   a. If cell voltage is below 1.5 volts or—

   b. If there is a variation of 0.15 volts or more between cells, the battery should be placed on a charger and subjected to a 3-minute charge test. The 3-minute charge test procedure is covered on pages 14 and 15.

2. Check specific gravity. If it is 1.230 or below, fully charge the battery. It is fully charged when all the cells are gassing freely and the specific gravity ceases to rise for three successive readings taken at hourly intervals.

3. If the voltmeter reads less than 9.6 volts for a 12-volt battery (4.8 volts for a 6-volt battery): (1) Check the specific gravity of each cell. Note: If water is added to take a specific gravity reading, the battery must be charged until all cells are gassing freely before taking a reading. Otherwise, the readings will not be reliable; or (2) Place on a charger, and perform a 3-minute charge test. Recharge and then re-test for capacity before condemning the battery.

CAUTION: A specific gravity test should never be used by itself to determine if a battery is serviceable. The capacity test must be made first. The specific gravity test only indicates the strength of the acid in the electrolyte, or degree of charge on the battery. Only the capacity test actually checks the ability of the battery to deliver current, by putting a load on it. Only a capacity test can detect internal short circuits, excessive sulfation, and other types of internal mechanical, or chemical damage that affect a battery's ability to deliver current. Old or deteriorated batteries may pass a specific gravity test, but no doubt will soon lose their charge; again causing further electrical problems.

SPECIFIC GRAVITY TESTS WITH HYDROMETER

The electrolyte in each battery cell consists of water and acid. The acid is used up as the battery becomes discharged. By weighing the amount of acid in the water, the degree of charge on each cell can be determined. When fully charged, electrolyte at 80°F. weighs 1.260-1.280 times the weight of water. A hydrometer is used to determine the electrolyte's weight for various percentages of discharge. Figure 10 shows specific gravities for various percents of discharge. Amperage draw to start an engine is sufficiently high to make this an important comparison. For example, a fully charged battery at 80°F. is only 40% efficient at 0°F. (Fig. 11). This means it takes 2½ times as much power to crank an engine at 0°F. as at 80°F.

SPECIFIC GRAVITY	STATE OF CHARGE
1.260-1.280	100% CHARGED
1.230-1.250	75% CHARGED
1.200-1.220	50% CHARGED
1.170-1.190	25% CHARGED
1.140-1.160	VERY WEAK
1.110-1.130	DISCHARGED

Figure 10—Specific Gravity vs. State of Change

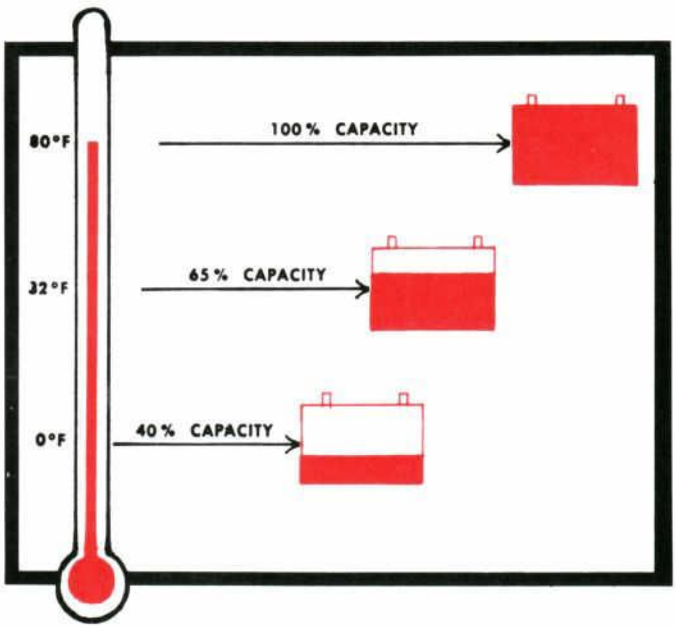

Figure 11—How Temperature Affects Battery Capacity

A temperature corrected hydrometer should always be used, since the volume of electrolyte expands when heated and contracts when cooled. The standard temperature is 80°F. For every 10°F. ABOVE 80°F., four gravity points (0.004) must be added to compensate for expansion. For every 10°F. BELOW 80°F., four gravity points (0.004) must be subtracted to compensate for contraction. Most hydrometers combine the basic hydrometer with a thermometer.

The Autolite-Climate-Eye unit (Fig. 12) used here goes a step further. To simplify obtaining a corrected reading, the float is letter-coded instead of designating gravity points. This letter code is then dialed with a thumb wheel on the back of the hydrometer. A corrected reading may be observed directly through an unbreakable lucite magnifying lens. This reading is superimposed on a colored background that tells at a glance

AND SYSTEMATIC TESTING

whether the state of charge on the battery is good or fair . . . or whether recharging is necessary. Read the column directly to the right of the thermometer tip.

Figure 12—Autolite Climate-Eye Hydrometer

Test Procedure

The procedure and service tips which follow apply to a hydrometer test made with a Climate-Eye Hydrometer. Refer to Figure 12 which shows the barrel, float, thermometer, reading scale, and thumb wheel for orientation to the instrument. (If another type of hydrometer is used, it will be necessary to handle the temperature correction step in accord with provisions the device incorporates for this necessary alteration of the basic float reading.)

1. Raise hood and put fender cover in place.
2. Remove all vent plugs.
   a. Visually check vent openings.
   b. If a plugged vent is suspected, blow out with compressed air.
3. Make sure the electrolyte level is high enough to withdraw proper amount of acid into hydrometer barrel.
   a. Take no readings immediately after adding water.
   b. Water must be thoroughly mixed with underlying electrolyte, by charging, before hydrometer readings are reliable.
4. Insert hydrometer pick-up tube into cell with bulb squeezed tightly by thumb pressure.
5. Slowly release thumb pressure until bulb is fully expanded and float is suspended freely in the barrel.
   a. Always hold barrel level to prevent float from binding or sticking to sides.
      (1) Wash barrel and float assembly periodically with soap and water.
      (2) While disassembled, inspect float assembly for leaks.
   b. Float assembly should not touch top or bottom stoppers of barrel.
6. Raise hydrometer or lower eye level to read float scale at the electrolyte level.
   (Hydrometer floats are calibrated at 80°F.)
7. Note the letter on the float scale which is intersected by the upper surface of the electrolyte in the hydrometer barrel.
8. Using the thumb wheel on the back side of the hydrometer, dial the matching letter on the correction cylinder. (The red thermometer column will be adjacent to the letter you have just dialed.)
9. Record the specific gravity reading which aligns with the tip (bottom) of the thermometer column.
10. Repeat this procedure (Steps 3 through 9) for each cell in the battery.

Test Conclusions

1. If all cells are even at 1.215 or above, the state of charge is probably good.

   WHAT TO DO . . .
   To confirm that the state of charge is satisfactory, make a capacity test; and, if okay, check the voltage limiter setting and the balance of the electrical system for short circuits or excessive voltage losses.

2. If all cells are even, but less than 1.215, the state of charge is doubtful.

   WHAT TO DO . . .
   Recharge according to manufacurer's recommendations and retest.

3. If the difference between cells is less than 50 points (0.050), the battery is probably serviceable.

   WHAT TO DO . . .
   Recharge according to manufacturer's recommendations and retest.

4. If the specific gravity between any two cells is more than 50 points (0.050), the battery is not satisfactory for service and is probably defective.

   WHAT TO DO . . .
   Recommend replacement to avoid unexpected failure.

Each manufacturer recommends a high rate charge schedule for the batteries in his product line.

Autolite recommends the following:

BATTERY SERVICE

ALLOWABLE BATTERY HIGH RATE CHARGE TIME SCHEDULE

		BATTERY CAPACITY—AMP HOURS					
Specific Gravity Reading	Charge Rate Amperes	40	45	55 HIGH RATE CHARGING TIME	65	70	80
1.125* to 1.150	35	1 Hr.	1 Hr. 5 Min.	1 Hr. 20 Min.	1 Hr. 35 Min.	1 Hr. 40 Min.	1 Hr. 55 Min.
1.150 to 1.175	35	45 Min.	50 Min.	1 Hr. 5 Min.	1 Hr. 15 Min.	1 Hr. 20 Min.	1 Hr. 35 Min.
1.175 to 1.200	35	35 Min.	40 Min.	50 Min.	1 Hr.	1 Hr.	1 Hr. 10 Min.
1.200 to 1.225	35	25 Min.	30 Min.	35 Min.	40 Min.	45 Min.	50 Min.
Above 1.225	5	NOTE: Charge at low rate only (5 amps) until specific gravity reaches—1.260 at 80° F (Standard Battery), 1.250 at 80° F (Sta-Ful Battery)					

*If the specific gravity is below 1.125, use the indicated high-rate charge, then use a low rate of charge (5 amperes) until the specific gravity reaches: 1.260 at 80° F (Standard Battery), 1.250 at 80° F (Sta-Ful Battery)

Figure 13—High Rate Charge Schedule

OPEN CIRCUIT VOLTAGE TESTS

An open circuit voltage tester (O.C.V.) (Fig. 14) is capable of measuring the state of charge of a battery cell as a voltage value. In this respect, it might be considered to be an electric hydrometer. It is the instrument used throughout the industry to conduct what is known as a "light load test."

Essentially, the light load test uses 1.95 volts as an index point and 0.05 volt as the variation limit. From this basis we determine the following:

1. Whether a battery is satisfactorily charged. (All cells above 1.95 volts and within 0.05 volt between the lowest and highest reading.)
2. Whether it is discharged. (Cells above and below 1.95 volts but within 0.05 volt between the lowest and highest reading. If all cells read below 1.95 volts, the battery is too low to test without first boost-charging it.)
3. Whether it is defective. (If any one or more cells read 1.95 volts or more and the spread between the lowest and highest reading exceeds 0.05 volt.)

In its capacity as an "electric hydrometer", the cell readings obtained with an O.C.V. tester may be converted to specific gravity as shown in the adjacent chart. The voltmeter is extremely sensitive and must be read carefully to obtain accurate readings.

Briefly, in Figure 15, the chart indicates that each incremental increase of 0.01 volt, corresponds to a 10 point specific gravity increase.

An O.C.V. tester, as a preliminary state of charge indicator has an advantage over a hydrometer in that the person making the tests will not be exposed to the acid in the electrolyte solution. It also has some comparative disadvantages.

1. It cannot be used on the one-piece design of battery cover.
2. Cannot be read accurately on batteries which have just come off charge.
    a. Surface charge must be removed from plates before testing.
    b. Light load (headlights) is maintained while readings are taken.
    c. Testers that incorporate a carbon pile load may be adjusted to approximately 10-amperes for bench testing.

Figure 14—Open Circuit Voltage Tester

Test Procedure

The O.C.V. tester shown in Figure 16 is one of many designs available. If other instrumentation is used when actually performing an O.C.V. test, follow the manufacturer's instructions.

1. Insert the jack plug on the cell tester into the jack in the variable load tester and flip the right-hand toggle switch to the "cell-test" position.

AND SYSTEMATIC TESTING

VOLTAGE TO SPECIFIC GRAVITY COMPARISON CHART			
Open Circuit Voltage Reading	Corresponding Specific Gravity	Open Circuit Voltage Reading	Corresponding Specific Gravity
1.95	1.100	2.05	1.200
1.96	1.110	2.06	1.210
1.97	1.120	2.07	1.220
1.98	1.130	2.08	1.230
1.99	1.140	2.09	1.240
2.00	1.150	2.10	1.250
2.01	1.160	2.11	1.260
2.02	1.170	2.12	1.270
2.03	1.180	2.13	1.280
2.04	1.190	2.14	1.290
		2.15	1.300

Figure 15—Voltage Specific Gravity Comparison

2. Remove surface charge by:
   a. Cranking engine for three (3) seconds.
      (1) Remove coil-to-distributor high tension lead on conventional ignition systems to prevent engine starting.
      (2) Ground coil-to-distributor high tension lead with jumper wire on transistor ignition systems to prevent engine starting.
   b. Turning on low-beam headlights for one (1) minute prior to testing and leaving them on while performing tests.
   c. Letting stand for a minimum of eight (8) hours.
3. Determine battery polarity and position of cell connector straps:
   a. Large posts ($1\frac{1}{16}''$ on top) are positive.
   b. Small posts ($\frac{5}{8}''$ on top) are negative.
   c. Red markings are positive posts.

The instrument in Figure 16 has a reversing switch built into the handle. Depressing this switch eliminates the necessity for rotating the tester between terminal connectors to observe proper polarity relationships. If the needle in the variable load unit deflects to the left, depressing the red button will correct the condition.

4. Prod each cell separately and record the readings obtained.
   a. The resultant holes from the prodding operation should be resealed by thumb pressure or by smoothing with a heated metallic object.
   b. Never bring open flames close to the battery.
   c. Do not allow tester prods to span two (2) cells at once, as this may damage the tester.

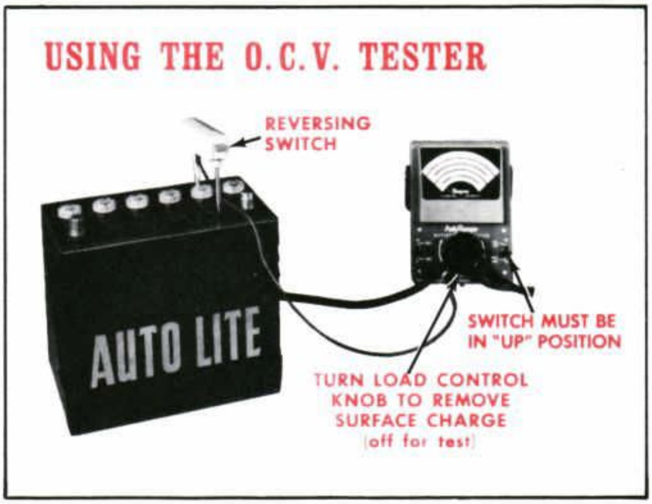

Figure 16—Using the O.C.V. Tester

Test Conclusions

1. If all cells are even at 1.95 volts or more, battery is satisfactory for service and will accept a full charge.

   WHAT TO DO . .

   Make a capacity test; and, if okay, check voltage limiter setting and balance of electrical system for short circuits or excessive voltage losses. Correct any malfunction noted; then, bring the battery up to a state of full-charge with service charging equipment or with enough vehicle operation to accomplish a state of full-charge.

2. If cells read both above and below 1.95 volts and the difference between the highest and lowest cell is less than 0.05 volts, the battery is good, but requires charging.

   WHAT TO DO...

   Recharge according to manufacturer's recommendations and re-test. Again, remove surface charge before re-testing.

3. If any cell reads 1.95 volts or more and there is a difference of 0.05 volts between the highest and lowest cell, the battery is defective.

   WHAT TO DO...

   Replace with an Autolite or equivalent battery that meets or exceeds application requirements.

4. If all cells read less than 1.95 volts, battery is too low to test accurately.

   WHAT TO DO...

   Boost-charge and re-test according to the following charging rates:

   a. 12-volt passenger and light truck batteries @ 1000 ampere minutes (20 minutes x 50 amperes).
   b. All other 6- or 12-volt batteries @ 1800 ampere minutes (30 minutes x 60 amperes).

BATTERY SERVICE

MULTI-PURPOSE TESTER

A number of specialized test instruments—many with multi-purpose designs—are available to assist in battery diagnosis. The multi-purpose tester illustrated in Figure 17 is an especially good type because it can be used on any battery, regardless of construction. The tester has no moving parts, except for relay contacts that automatically select proper voltage and polarity. It operates on the principle of voltage stabilization. Therefore when the button is depressed, it must be held until the needle remains stationary. The tester can be used to:

- Determine battery condition and state of charge
- Test battery cables
- Test electrical systems for shorts and leaks
- Make all voltmeter checks such as voltage drops

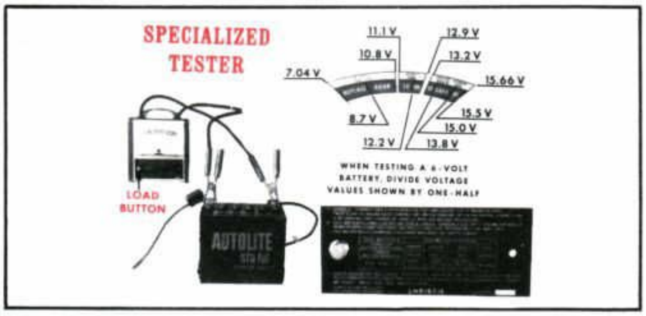

Figure 17—Multi-Purpose Specialized Tester

Testing Battery Condition and Charge

Connect positive tester lead to battery positive post and negative tester lead to battery negative post. Twist tester clips to assure good contact. Make sure vehicle's lights and electrical accessories are "off."

(1) Any reading indicates proper hook-up.

(2) If no reading, fast charge battery for 20 minutes before attempting any tests.

Press load button and hold until tester needle remains stationary—then read "battery's condition." Release load button and read "battery's charge" only after needle is stationary.

Test Conclusions

The chart in Figure 17 shows combinations of conditions that the test meter will indicate and conclusions to be drawn. A slow charge is required to fully charge a battery. Thus, the "recharge" called for in the chart permits a 20-minute fast charge for testing. Any "chattering" sound indicates a discharged battery, or poor cable connection. Be sure to hold the button as long as necessary for the needle to stabilize.

Testing for Electrical System Shorts and Leaks

This test is based on the voltmeter function. Note the voltage values in Figure 17. Any readings obtained will be approximately 12-volts.

Remove ground cable from battery post. Connect negative tester lead to negative battery post, and positive tester lead to engine ground. NOTE: These instructions apply to negative grounded systems. Reverse leads for positive grounded systems.

Test Conclusions

Any reading indicates a constant drain on the battery. Recheck to insure that all switches are off and momentarily touch negative cable back to negative battery post to rewind electric clock. The clock momentarily rewinds at approximately 3-minute intervals. It will not rewind through the test instrument with the negative cable disconnected.

Testing Battery Cables

NOTE: To perform this test:

(1) The battery must be in good condition.

(2) All lights and electrical accessories must be off.

Check negative cable first. Connect positive tester lead to positive battery post. Connect negative tester lead to engine ground. Press load button and read "battery's condition." Check positive cable last. Connect negative tester lead to negative battery post. Connect positive tester lead to battery side of starter relay. Press load button and read "battery's condition."

NOTE: Reverse connections for positive grounded systems.

Test Conclusions

The following readings apply to positive and negative cables:

(a) Green area—cable good.

(b) Red area—Clean cable connections and re-test. Replace cable, if required.

DISCHARGED BATTERY TEST
(3-minute Charge Test)

This 3-minute charge acceptance test is for batteries that fail to measure up to voltage specifications. Although performing this test deviates from the rule-of-thumb . . . "never test a discharged battery" . . . it's done for a purpose. If a battery is discharged, it is important to know whether it's sulfated to the point where it will not accept a charge. Charging dislodges lead sulfate from the plates, returning the sulfate back into the electrolyte solution to form sulphuric acid. Charging the battery for 3 minutes will show whether or not the battery will respond to further charging, and ultimately reach a fully charged condition.

Types of Chargers

There are two types of chargers in common service use—one is a constant potential charger . . . the other is a constant current, or slow charger.

Slow charging is the only method that will fully charge a battery. It should be at the rate of 1 ampere for each positive plate in one cell for a sufficient time to fully charge the battery. The battery is fully charged when cells are all gassing freely, and the specific gravity ceases to rise for three successive readings taken at hourly intervals. Charging is never stopped even if it takes over 24 hours—which may be necessary for a badly sulfated battery. However, if longer charging times are required, charging rates should be one-half normal rates.

Constant-potential chargers start the charge off at a high rate, and as the battery voltage builds up, the charge rate tapers off to a lower value. A battery in good condition is not harmed by this type of charging. A badly sulfated battery, however, may not come up to full-charge. Temperature must be watched carefully with this type of charging as it may rise very rapidly.

AND SYSTEMATIC TESTING

Constant potential chargers are used for the 3-minute charge acceptance test (Fig. 18).

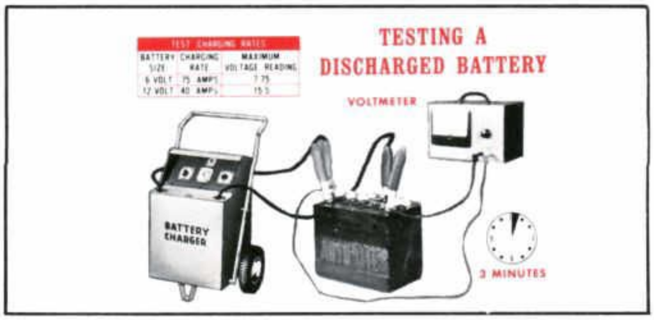

Figure 18—Three-Minute Discharged Battery Test

Three-Minute Discharged Battery Test

Check battery polarity and connect charger leads, positive to positive and negative to negative. Charge battery for three minutes at following suggested rates.

(a) 12-volt battery—40 amperes

(b) 6-volt battery—75 amperes

At the end of three minutes, with the charger still operating, connect a voltmeter across each individual cell (if applicable) or across battery terminals (especially with one-piece cover designs). Record voltage readings.

Test Conclusions

1. Battery is satisfactory and may be safely charged if reading is:
   a. Less than 15.5 volts on 12-volt battery.
   b. Less than 7.75 volts on 6-volt battery.

   WHAT TO DO . . .

   Charge according to manufacturer's recommended rates and place back in service.

2. Battery plates are probably sulfated if reading is:
   a. More than 15.5 volts on 12-volt battery.
   b. More than 7.75 volts on 6-volt battery.

   WHAT TO DO . . .

   Place battery on slow-charger at the rate of one ampere per positive plate per cell for time period needed to bring battery to a full state of charge.

3. Battery is probably defective if a reading of 0.1 volt or more between cells is obtained.

   WHAT TO DO . . .

   Replace battery.

4. In some instances, the reading will be right on the "borderline."

   WHAT TO DO . . .

   Place battery on recommended slow charge and retest.

CIRCUIT RESISTANCE TESTS

The voltmeter is a handy instrument to check excessive resistance in battery circuits. It is installed in "parallel" with the circuit. Readings reflect an electrical pressure differential. Low readings mean low resistance; high readings mean high resistance. Before making any circuit resistance tests, disconnect and ground the high tension lead from ignition coil to prevent the engine from starting.

Battery to Starter—Connect the positive lead of a voltmeter to the positive battery post (Fig. 19). Connect the voltmeter negative lead to the starting motor terminal. Crank the engine. A voltmeter reading in excess of 0.5 volts indicates excessive resistance.

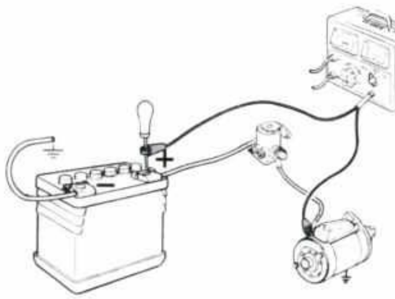

Figure 19—Battery to Starter Circuit Resistance Test

Battery Side of Relay to Battery—Connect the positive lead of a voltmeter to the positive battery post. Connect the negative voltmeter lead to the battery terminal of the relay. (Test "A", Fig. 20.) Crank the engine. A voltmeter reading in excess of 0.1 volts indicates excessive resistance.

Starter Side of Relay to Battery—Connect the positive lead of a voltmeter to the positive battery post. Connect the voltmeter negative lead to the starter terminal of the relay. (Test "B", Fig. 20.) Crank the engine. A voltmeter reading in excess of 0.3 volts indicates excessive resistance.

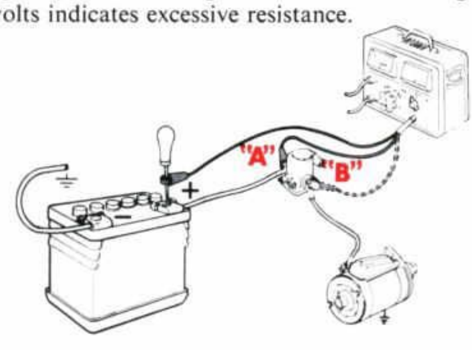

Figure 20—Circuit Resistance Test—Battery Side of Relay to Battery and Start Side of Relay to Battery

Ground Circuit—Connect the negative lead of a voltmeter to the negative battery post. Connect the voltmeter positive lead to the starter frame. Crank the engine. A voltmeter reading in excess of 0.1 volts indicates excessive resistance.

If the voltmeter readings are higher than those specified in any of the preceding tests, look for loose and/or corroded connections and defective components in the circuit part being tested.

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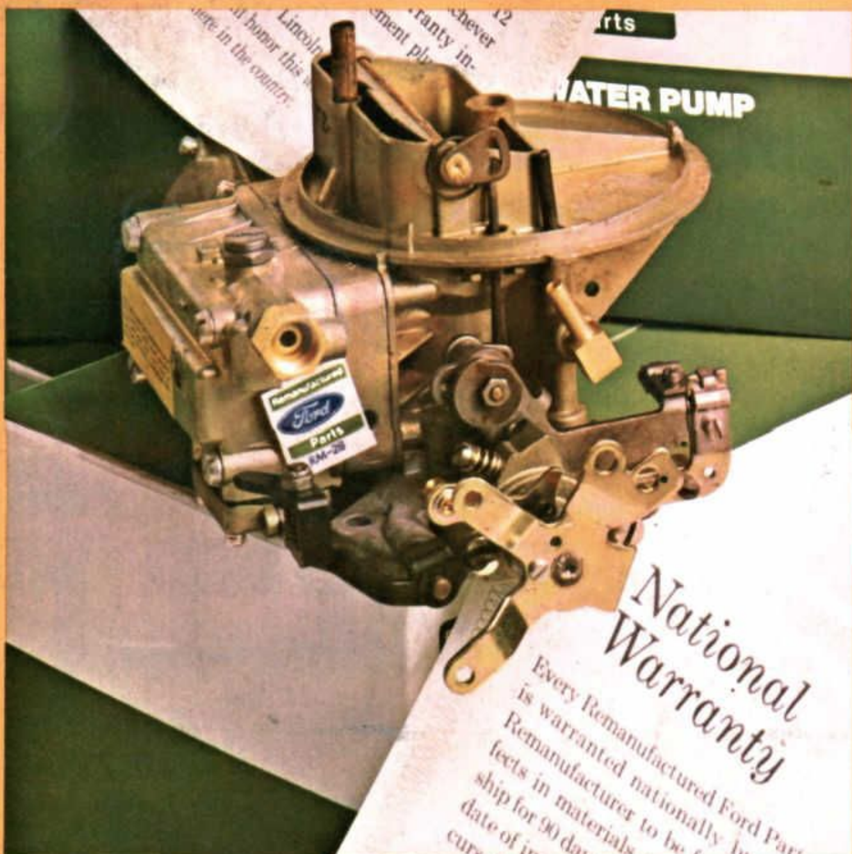

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