COURSE
10000.2
10001.2

ALTERNATOR TRAINING HANDBOOK

SERVICE
FORD MOTOR COMPANY
TRAINING

FORD DIVISION

BACKGROUND INFORMATION

OPERATING PRINCIPLES

DIAGNOSIS AND TESTING

VOL. 66 S4 L2

INTRODUCTION

Realizing that this manual may be used by persons with various degrees of experience in servicing an automotive charging system which incorporates an alternator, a definite effort has been made to simplify the subject matter wherever possible. An effort has also been made to maintain a logical continuity to the coverage of operating principles. In effect, the component circuits of the alternator are developed from their point of origin at the stator neutral junction through to their termination at the alternator output terminal. With this information established, the text then proceeds to the regulation of output current and concludes with the recommended procedures for testing charging system performance. Interim subjects such as multiple phase operation and wave rectification are covered in their appropriate sequence in the text.

A list of safety precautions precedes the step-by-step test procedures; a trouble diagnosis chart is provided; and a glossary of pertinent electrical terms concludes the book to minimize the need for dictionaries or other reference materials.

The descriptions, testing procedures, and specifications in this handbook were in effect at the time the handbook was approved for printing. The Ford Motor Company reserves the right to discontinue models at any time, or change specifications, design, or testing procedures without notice and without incurring obligation.

NATIONAL SERVICE ACTIVITY
FORD DIVISION
Ford MOTOR COMPANY

FIRST PRINTING—AUGUST 1965

TABLE OF CONTENTS

BACKGROUND INFORMATION

OPERATING PRINCIPLES

DIAGNOSIS AND TESTING

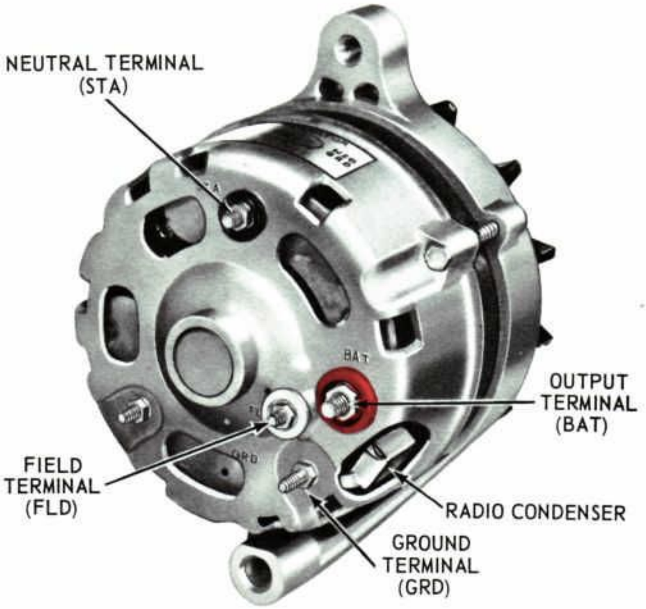
REGULATOR ADJUSTMENTS

VISUAL IDENTIFICATION OF AN AUTOLITE ALTERNATOR

Autolite alternators are used on all Ford Motor Company passenger cars. They are also available on all trucks 100 through 800 Series.

An Autolite alternator can be identified by an ink-stamped nameplate on the alternator rear housing. It is installed next to the adjusting ear on the housing. (Refer to Figure 1.) The color of the ink used on the nameplate is a code which indicates the output capacity of the alternator in amperes. (The output capacity is imprinted on the nameplate. Color-coding therefore, serves as a means of quick visual identification). The chart in Figure 1 relates color and capacity.

With the exception of the width of the stator core, all Autolite alternators are similar in appearance. The core is widened as the current rating is increased. The same front and rear housings are used on all units.



AMPERE CAPACITY	NAMEPLATE COLOR	OTHER EXTERNAL IDENTIFICATION
38	PURPLE	NONE
42	ORANGE	NONE
45	BLACK	NONE
55	RED	STATOR HAS MORE AND THINNER (0.032) LAMINATIONS
60	GREEN	

Fig. 1–Autolite Alternator Identification

ALTERNATOR REGULATOR APPLICATIONS

Regulators built for trucks are similar to those used on passenger cars, except that the points are slightly heavier. (The truck regulator is being supplied for service and can be used as a replacement unit on all passenger cars using the Autolite alternator system.) The electrical specifications for the two mechanical regulators are the same.

The transistorized regulator must be installed with the 60-amp Autolite alternator. This regulator is optional with the 42- and 45-amp Autolite alternators. When this unit is used, a short wiring harness connects the conventional wiring harness regulator disconnect to the transistorized regulator.

COMPONENT PARTS OF AN ALTERNATOR

Figure 2 is an exploded view of the alternator assembly. We are providing this illustration as a lead-off piece to give you an opportunity to familiarize yourself with part names and the relative location of each part in the total assembly.

Study this illustration as preparation for your exposure to the operating principles of an alternator. We also suggest that you use it as a reference if at any time you find that you are not able to associate theory with the part or parts to which it applies.

SPLASH PROTECTION

Road splash protection for the brushes and slip-rings is built into the alternator rear housing casting. A projection on the rear rotor pole face is called a "watershield". It rotates close to the shield portion of the rear housing so as to form a rotating seal against water entry.

Splash protection is required to prevent salt and other foreign substances from accumulating on the brushes causing them to stick in their holder. A felt seal is provided in the rear bearing as further protection against entry of contaminates into the bearing.

VISUAL IDENTIFICATION OF AN AUTOLITE ALTERNATOR (Cont.)

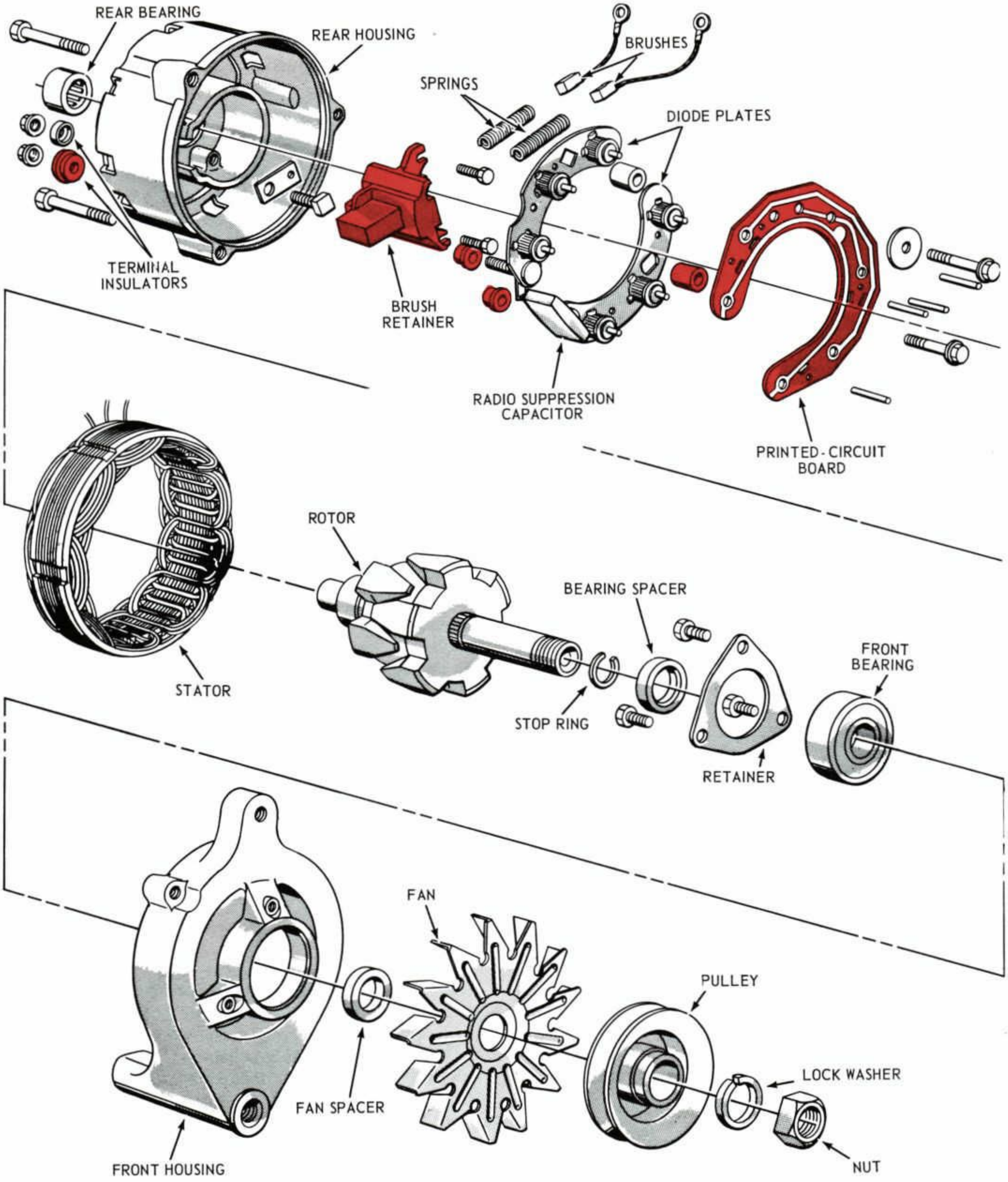


Fig. 2–Alternator Assembly (exploded view)

THE THREE WIRES

Let's begin our study of the operating principles of an alternator by considering three lengths of identical copper wire. As you will notice in Figure 3, we have color-coded these wires for purposes of identification. You will also notice that we have spliced the wires together at one end and attached two cylindrical devices to their opposite ends. These devices (representing diodes) have been given polarity markings (+ or −).

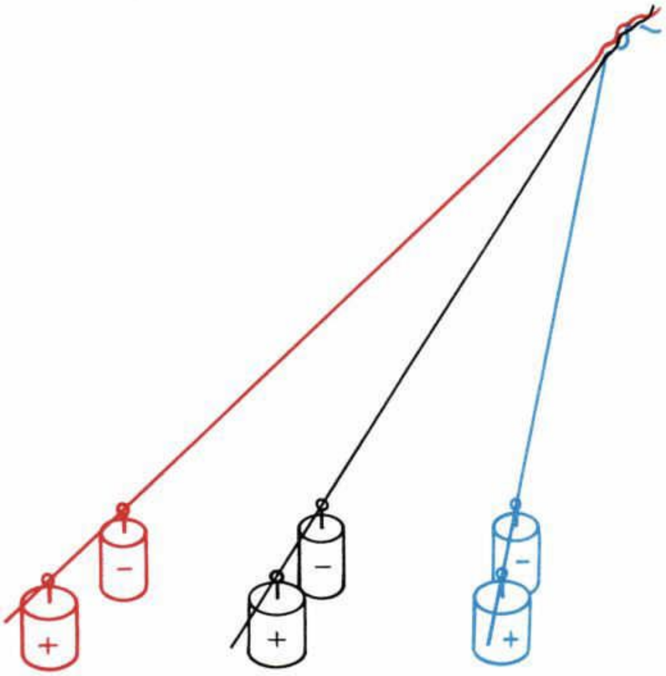


Fig. 3–Origin and Termination of Stator Windings

This is a simplified picture of the starting and terminating points of the three wires used in the alternator stator windings.

They are joined at one end in a splice, which is called the neutral junction; and then each is attached to a pair of positive and negative diodes at the other end.

MAKING A SIMPLE WINDING

In the preceding paragraph we used the term "stator windings". This implies that our three wires do not follow a straight course from their spliced end to their separate points of termination. Thus, for purposes of illustration, let's route each wire through a slotted form which will give them the appearance of a winding. (Refer to Figure 4.)

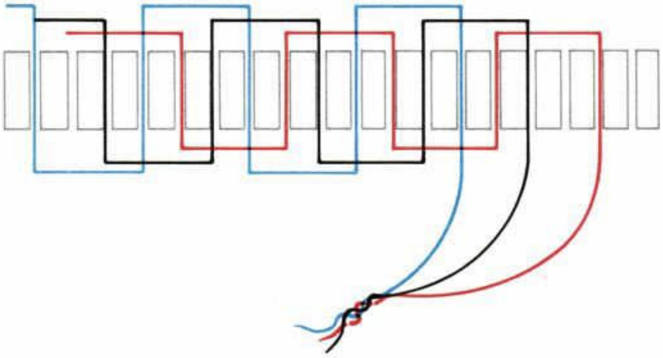


Fig. 4–Routing of the Stator Windings

Several things are to be noted in the picture. First, each wire is routed through a different slot in the form. It then skips two slots and turns in an opposite direction. As a result of this arrangement, the red, black, and blue wires are passing through the slots in sequence–reversing their direction every third slot.

ALTERNATOR STATOR WINDINGS

In Figure 5, the slotted form introduced in Figure 3 has been developed into a circle and the wires with

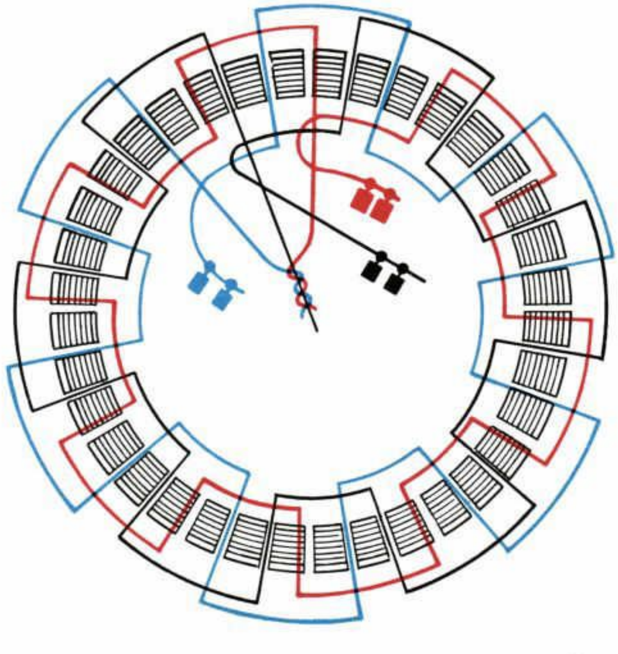


Fig. 5–Simulated Stator Core and 3-Phase Winding

ALTERNATOR STATOR WINDINGS (Cont.)

their spliced ends and diodes have been added. Now, study Figure 6–a photographic reproduction of an actual stator assembly and you will notice the similarity between this production unit and our simplified line drawings.

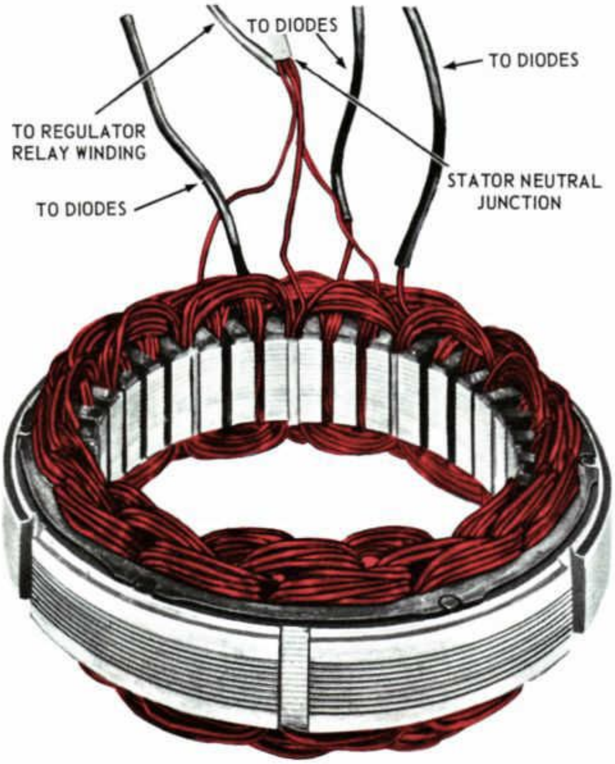


Fig. 6–Stator Core and Coil Assembly

The core portion of the core and coil assembly consists of a number of steel stampings which are riveted together. The inner surface of this core contains 36 equally spaced slots which retain the (coil) windings.

The windings themselves are installed in a manner very similar to that illustrated in Figure 5. These wires are formed into a soldered junction and then wound through every third slot. In the actual assembly, each wire is passed through these slots three times before it is directed to the set of positive and negative diodes where it terminates. The complete winding results in an alternating arrangement of three layers of the first, second, and third wire when each has made its triple circuit through the core slots.

In addition to illustrating core construction and the windings, Figure 6 shows a fourth wire attached at the soldered junction of the three wires in the winding. This wire links the stator with the regulator. Its purpose will be covered a little later in the text.

PURPOSE OF THE STATOR

At this point, you should understand the construction of the stator. Before we proceed to the rotor core and coil assembly, however, let's define the purpose of the stator . . .

> IN AN ALTERNATOR, THE STATOR IS THAT PART WHICH CONTAINS THE CONDUCTORS (WINDINGS). AS THE PART NAME INDICATES, IT IS A STATIONARY MEMBER. THE MAGNETIC FIELD (ROTOR CORE AND COIL ASSEMBLY) ROTATES INSIDE THE STATOR.

We'll cover the method by which current is sent through the conductors after we describe the rotor assembly and its purposes.

ROTOR CORE AND COIL ASSEMBLY

Figure 7 is a composite illustration of the rotor core and coil assembly. View "A" shows the unit in

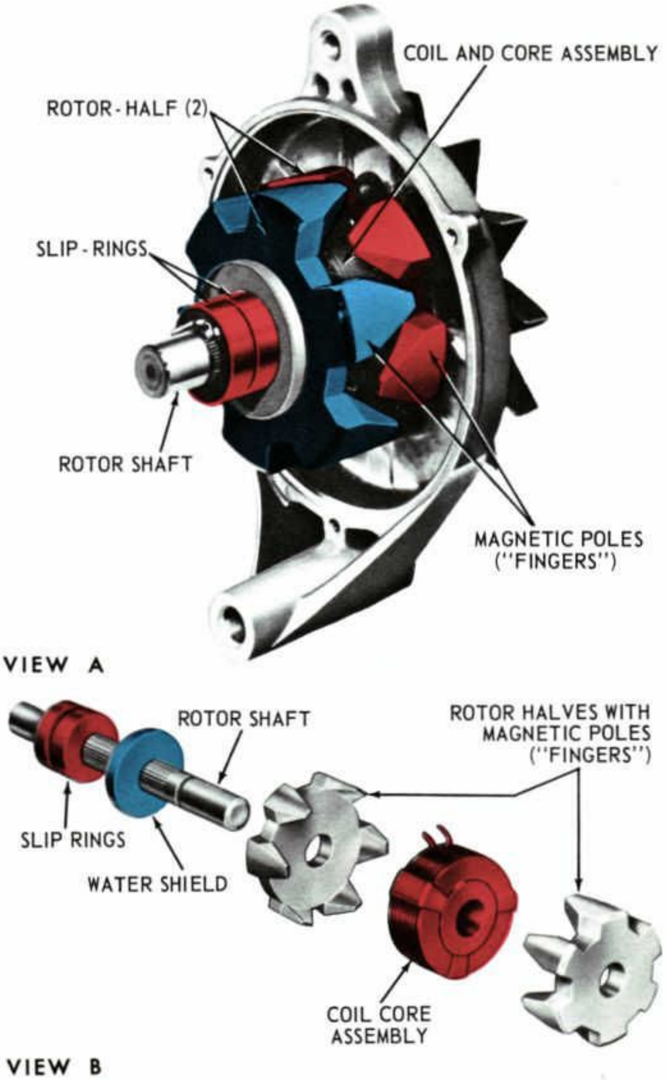


Fig. 7–Rotor Core and Coil Assembly

ROTOR CORE AND COIL ASSEMBLY (Cont.)

its assembled state and installed in the alternator front housing. View "B" is an exploded view of the moving parts. (An alternator drive belt seats in a pulley which is mounted at the forward end of the rotor shaft. This drive belt also powers the radiator fan in a manner similar to conventional generator drives.)

From a construction standpoint the rotor shaft is supported at each end by bearings. The front bearing (ball-type) is pressed into the front housing and the rear bearing (needle-type) is pressed into the rear housing. The slip rings, water shield, and coil and core assembly are press-fitted to the shaft with a rotor half enveloping each end of the core. The slip rings retain the assembly at one end of the rotor shaft and a nut retains the fan and pulley at the opposite end of the shaft.

The rotor core and coil assembly turns inside the stator core and coil assembly. As it rotates, it generates current in the stator windings (by induction) as each of the six positive and negative fingers in the rotor halves move past these windings. (A very narrow air gap exists between these two assemblies. This design clearance permits maximum magnetic power.)

A REVIEW OF TERMS

In describing the stator and rotor assemblies we have used several terms which may warrant review or further clarification before we consider more of the operating principles of an alternator.

The three wires in the stator which have been referred to as "windings" for the most part, are the CONDUCTORS in the alternator. They carry the charging current to the battery or to other electrical components in the car when the battery does not require charging.

Each rotor half contains six integral fingers. (Refer to Figure 7). When they are assembled over the rotor coil and core assembly, they interlace to form a series of twelve magnetic fingers which are alternately positive and negative. (The coil and core assembly in the rotor unit is also the rotating magnetic field.)

We stated that current available from the alternator is generated by magnetic induction or by induced voltage created by a magnetic field. Let's consider this statement in simpler terms . . .

Magnetic induction suggests the presence of three conditions:

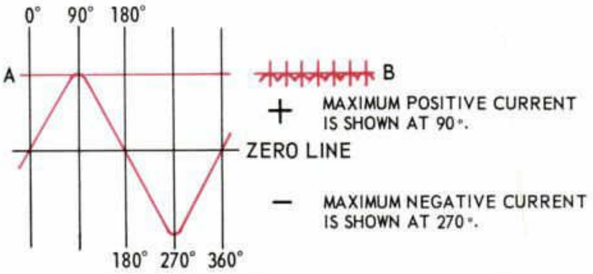
1. There is a magnet with its magnetic field.
2. There is a conductor.
3. There is motion.

In the alternator, the rotor core and coil assembly is the source of the magnetic field; the stator windings are the conductors; and the belt driven rotor shaft provides the motion as it revolves the magnetic field past the conductors.

Remembering these three items will greatly aid you in studying the operating principles which follow.

SINE WAVE

There is a standard pictorial representation of alternating current. It is called a SINE WAVE. See Figure 8.



EACH VERTICAL LINE CROSSING LINE A-B IN INSET REPRESENTS A POSITIVE CYCLE PEAK ON A RAPIDLY RECURRING BASIS.

Fig. 8—Typical Sine Wave

Your particular attention is invited to several basic points which this picture is intended to emphasize:

As a conductor in the stator is exposed to an increasing and then decreasing amount of induced current when a positive rotor finger moves past this conductor, the amplitude or strength of current increases and decreases correspondingly. The same situation occurs as the adjacent negative rotor finger moves past this same conductor. When both rotor fingers (positive and negative) have moved past the conductor, a cycle, consisting of a positive and negative segment, has been completed.

SINE WAVE (Cont.)

A cycle may be expressed in terms of time (as frequency or units per second) or in terms of distance (as electrical degrees). Figure 8 expresses the latter. Bear in mind that electrical degrees and geometric degrees are not the same. (Many 360° cycles of alternating current will be produced as the rotor makes one 360° turn inside the stator.)

Notice that maximum positive and negative current occurs at 90° and 270°, respectively. The 90° point on the curve is the design point toward which D.C. output is aimed. This output objective is to obtain as nearly a constant amplitude of positive current as possible. (Graphically, this would be shown as a straight line. See Line A-B in Figure 8.) Another objective is to bypass the negative segment of each cycle of alternating current.

These objectives are accomplished in an alternator by introducing additional or overlapping cycles at high frequency while bypassing the negative segments of these cycles through negative diodes back to their source. (The positive and negative diodes are a form of one-way electrical check valve which pass only the polarity of current which matches diode polarity. This statement will be further clarified as our explanation of operating principles continues.)

CORRELATING THE SINE WAVE WITH THE STATOR AND ROTOR

Recognizing that the sine wave is a symbol for alternating current, let's give it a practical application. We'll correlate the sine wave with the stator and rotor assemblies to illustrate how current is induced into the stator windings (conductors) by the rotor fingers (positive and negative poles).

KEEP IN MIND THAT ANY ILLUSTRATION WHICH DEPICTS THE FLOW OF CURRENT REPRESENTS AN INSTANTANEOUS CONDITION. IT IS MERELY A MEANS OF SHOWING AN EXTREMELY RAPID AND RECURRING ELECTRICAL PHENOMENON WHICH HAS BEEN STOPPED, THE VERY NEXT INSTANT WOULD REQUIRE A DIFFERENT PICTURE TO ILLUSTRATE ITS PROGRESS THROUGH THE ELECTRICAL CYCLE.

You will recall in Figure 4 that the separate wires in the stator winding passed through certain vertical slots in the inner surface of the stator. Refer now to Figure 9. In this drawing, we have a simplified, 4-view picture of what happens when a positive and negative rotor finger moves past a conductor. We

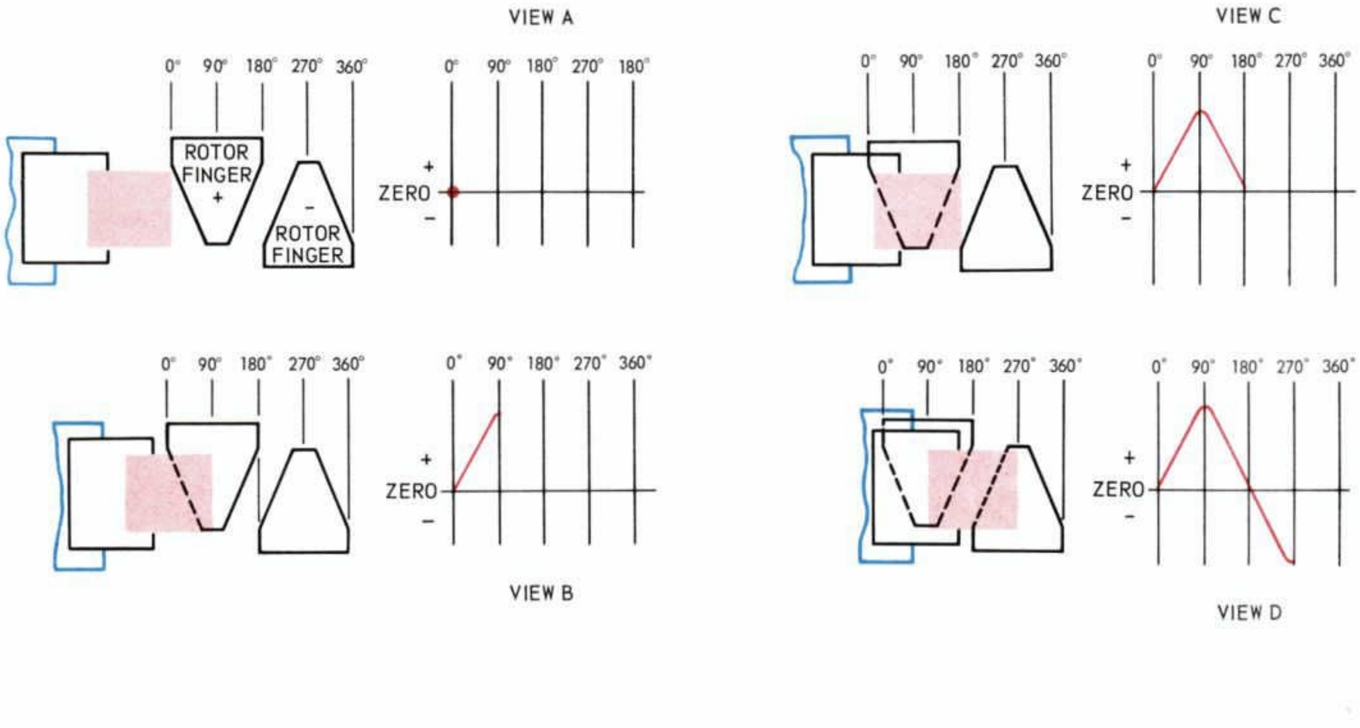


Fig. 9—How Rotor Fingers Create a Single A.C. Cycle

CORRELATING THE SINE WAVE WITH THE STATOR AND ROTOR (Cont.)

also have a diagram which develops the sine wave as rotor finger position changes in relation to the conductor.

The rotor fingers are shown as moving from right to left past the conductor. In View A, the positive finger is just about to start past the conductor and thereby induce current into that conductor. Because the action hasn't started, the sine wave is represented as a dot on the zero line at zero electrical degrees. Views B, C, and D show the relative position of the rotor fingers at 90 , 180 , and 270 electrical degrees. (There is a design gap between the positive and negative fingers which is reflected in View C when the sine wave is at 180 electrical degrees.)

We have omitted the additional view which would be needed to show that the negative finger has completed its movement past the conductor. We believe that it is obvious to the reader that the trailing edge of the finger has passed the conductor and the negative segment of the sine wave has returned to the zero line at 360 electrical degrees.

MULTIPLE PHASE WINDINGS

Now that we have an idea of how the sine wave develops when we consider one conductor, let's go a step further and add the two other conductors we illustrated originally in Figure 4.

Up to this point, we have used the term conductor or winding when referring to the wires in the stator. It is now necessary to identify these same wires with still another name . . . PHASE. This will aid us in explaining sine wave development as it applies to three conductors. It will also help with our explanation of other operating principles which follow.

Retaining the same wire sequence and color coding used in Figure 4, we will identify the red wire as PHASE 1, the black wire as PHASE 2, and the blue wire as PHASE 3 WINDINGS. When considered together, we'll refer to them as a MULTIPLE PHASE WINDING.

Refer to Figure 10. In this illustration, we are showing the three conductors mentioned previously

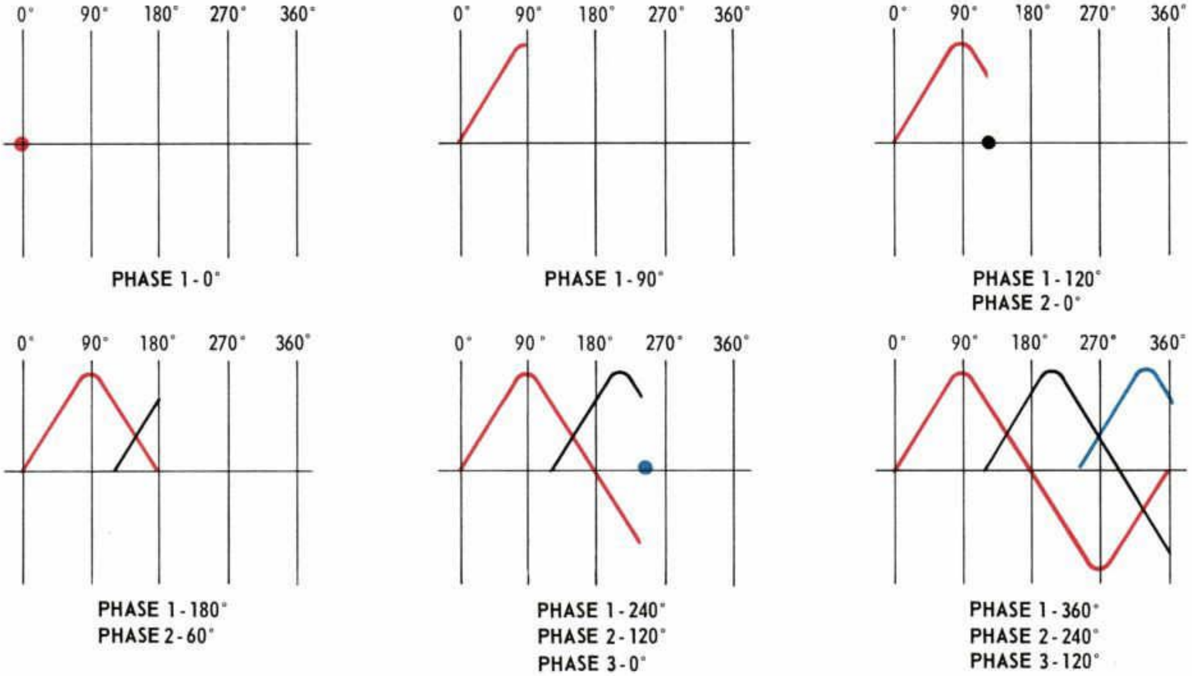


Fig. 10–3-Phase Stator Winding and Rotor Finger Relationships

MULTIPLE PHASE WINDINGS (Cont.)

in positions similar to those which they occupy in the actual stator. These are the Phase 1, Phase 2, and Phase 3 Windings in sequence. The positive and negative rotor finger positions are also simulated.

Notice that dimension lines . . . expressing electrical degrees mark off the following:

0°–With the rotor finger moving in a counterclockwise direction, the leading edge of the positive finger is at the point where it will begin to induce current in the Phase 1 winding.

90°–When the rotor has progressed to this point, Phase 1 will be at a maximum positive amplitude–the high point in the positive segment of its sine wave.

120°–At this point the positive rotor finger will intersect the Phase 2 winding. Current being induced into Phase 1 will be falling off.

180°–Here, the positive finger is building the amplitude of the Phase 2 winding, and the negative finger is just intersecting the Phase 1 winding.

240°–When the positive rotor finger reaches this point, it intersects the Phase 3 winding, Phase 1, in the meantime, has passed the peak of its negative segment, and Phase 2 has passed the peak of its positive segment.

360°–At this point, Phase 1 has completed a cycle and the positive finger is ready to begin a second cycle. Phase 2 is approaching the maximum in the negative segment of its cycle, and Phase 3 has passed its maximum in the positive segment of its cycle.

MULTIPLE PHASE SINE WAVES

The overlapping action of these three windings, we repeat, is referred to as a Multiple Phase Winding. Figure 11 transposes the information we have just covered into a single representation of the multiple waves.

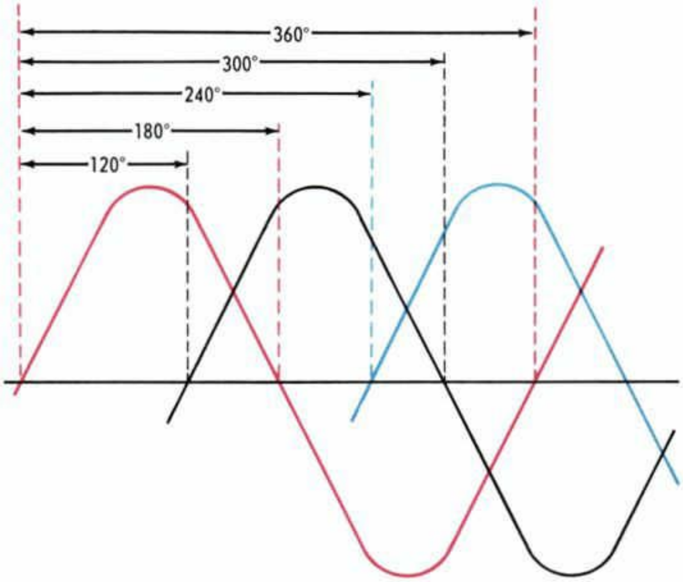


Fig. 11–Multiple Phase Sine Wave

Keep in mind that in completing one 360 degree cycle only 60 geometric degrees of stator surface has been passed by two rotor fingers. The remaining five sets of fingers are simultaneously inducing current flow in the portions of the stator windings which they are passing. (Also, remember that we are showing each wire as a single rather than triple winding.)

A REVIEW

Now, let's take a moment to review what has been covered up to this point:

Three wires are spliced together at one of their ends. Then, they are separately woven around the inside surface of the stator to form loops which pass through every third slot in the stator, beginning with their point of origin. (The second and third wires begin two and four slots away from the first wire, respectively.)

Each of these wires repeat their original path around the stator twice . . . creating a triple winding . . . they then terminate as attachments to a pair of diodes–one positive and one negative.

A REVIEW (Cont.)

(These diodes are the rectifying devices which we will be covering shortly.)

A rotor assembly–moving inside the stator–envelopes a magnet and coil. It contains twelve alternately positive and negative fingers which induce current flow in the stator windings by a process called magnetic induction.

The current thus produced is unrectified or alternating current; and it remains in this form until it is rectified in the diodes.

The standard symbol for each cycle of alternating current is a sine wave. This sine wave has two segments–one which symbolizes the period during which a positive rotor finger is inducing current flow in a given portion of the coiled conductor, and the other which graphically shows the induction created by the negative finger. (The duration of a cycle is expressed as 360 electrical degrees.)

The three wires in the stator winding are so installed that they are energized at intervals of 120 electrical degrees.

CURRENT FLOW IN THE ALTERNATOR

With this background, we are prepared to apply the multiple phase sine wave to the pattern of current flow in an alternator. The ultimate job of the alternator is to produce direct current to charge the battery or power automotive electrical equipment. Because this must be a steady current flow (one of consistent amplitude) the alternating current we have covered so far requires some changes . . . the negative segment of the alternating cycle must be filtered out . . . and the frequency of the positive peaks must be increased until they occur so rapidly that they are practically at a constant positive peak.

Eliminating Pulsations

The problem of minimizing the pulsations in current flow is handled by the electro-mechanical design of the alternator. With the six pairs of rotor fingers, revolving past the stator segments, recurring electrical cycles are being completed so rapidly that the time interval of off-peak amplitudes becomes insignificant. In fact, the frequency at which cycles are completed–even under engine idling conditions–places the alternator in a preferred position over the conventional generator used in a D.C. charging system.

Rectifying Alternating Current

The problem of rectifying the A.C. current in an alternator is a little more complex. Thus, we must revert to the sine wave for a starting point for an explanation of wave rectification.

Figure 12 repeats the multiple phase sine wave pattern illustrated in Figure 10. To this wave pattern, we have added some vertical lines. A-A, B-B, C-C. These lines intersect the zero line where Phases 1, 2, and 3 also intersect the zero line prior to starting the positive segment of their respective cycles.

Notice the points where each phase intersects the perpendicular lines:

ON LINE A-A–Phase 1 is Zero, Phase 2 is Negative, and Phase 3 is Positive

ON LINE B-B–Phase 2 is Zero, Phase 3 is Negative, and Phase 1 is Positive

ON LINE C-C–Phase 3 is Zero, Phase 1 is Negative, and Phase 2 is Positive

Now, notice these same points of intersection on lines D-D, E-E, and F-F which intersect the zero line at 180 through Phases 1, 2, and 3, respectively.

ON LINE D-D–Phase 1 is at Zero, Phase 3 is Negative, and Phase 2 is Positive

ON LINE E-E–Phase 2 is at Zero, Phase 1 is Negative, and Phase 3 is Positive

ON LINE F-F–Phase 3 is at Zero, Phase 2 is Negative, and Phase 1 is Positive

For ease of explanation, we have selected the points on the Zero line through which to drop the perpendicular lines so that they will correspond with the 0 and 180 points of intersection made by each phase. At these particular points, one phase is passing no current and the other two phases are noticeably of opposite polarity.

It is important to remember that the perpendicular lines could be dropped anywhere along the zero line and there would always be enough variation in the strength of the three phases to allow two to be considered as "working" and one "resting". If any two of these phase strengths should, through defect, equalize, a lockup would occur.

CURRENT FLOW IN THE ALTERNATOR (Cont.)

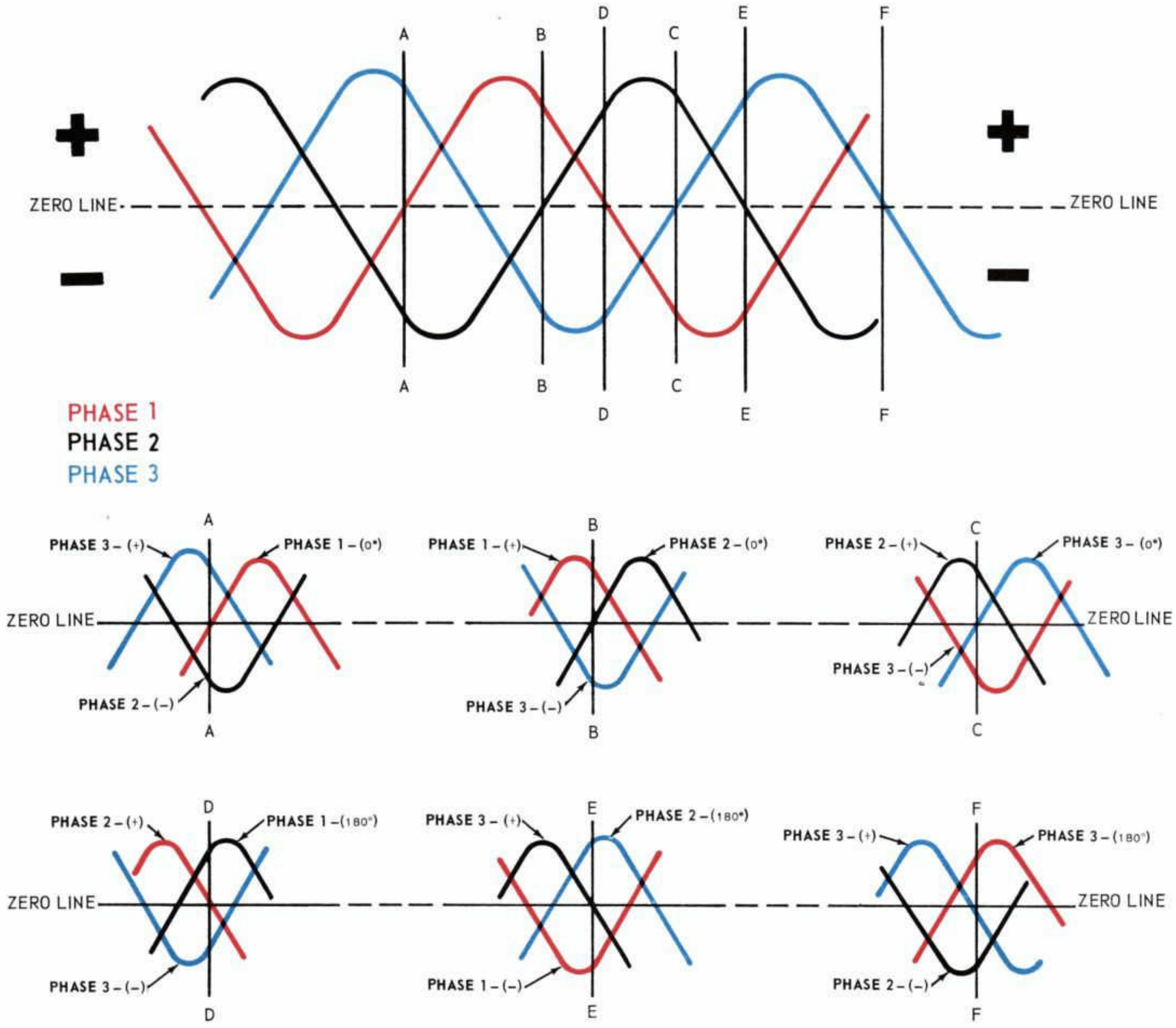


Fig. 12–Polarity Relationship

These polarity relationships we have just covered have a direct relationship to the stator windings. Again, for ease of illustration, let us assume that Phases 1, 2, and 3 are being considered at 0 and 180, just as illustrated in Figure 12, and by means of a schematic show how these polarity differences affect current flow.

CURRENT IN THE "WYE" WINDING

Figure 13 will introduce you to the schematic symbol we shall be using from now on to represent the stator windings. It is shaped like the letter "Y" and is called a "WYE" winding. The arrows in the

CURRENT IN THE "WYE" WINDING (Cont.)

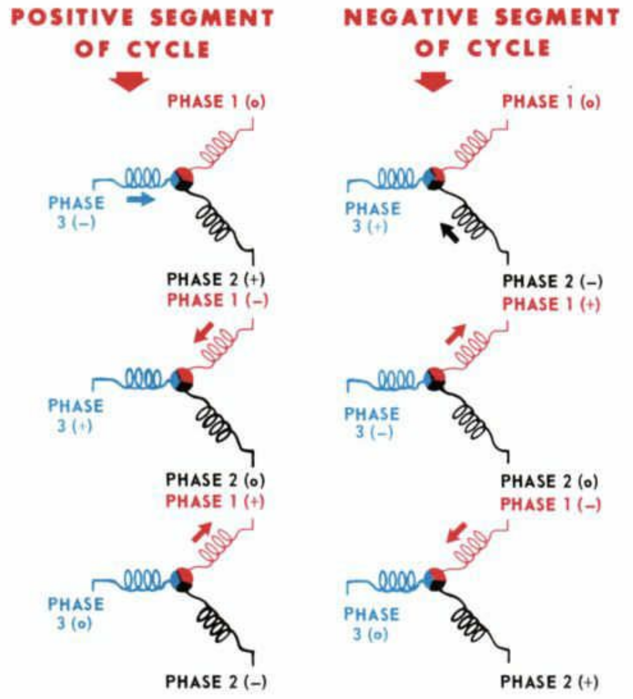


Fig. 13–Current Flow in the "Wye" Winding

illustration indicate the direction of current flow. (Notice that the direction of flow is always from negative to positive.)

To aid you in your study of Figure 13, observe that the circle from which windings emanate represents the spliced end of the wires used to make the stator coil windings. The color codings of the phases is consistent with the colors used up to this point for coverage of the windings and their sine waves. The phase polarities match those developed in Figure 12.

DIODES

When the alternating current has completed its prescribed course through the windings, it is directed to the pair of diodes which terminate each winding. It is at this point that A.C. current is converted to D.C. current.

With the recent advent of commercially available, reasonably priced silicon diodes, alternators have become feasible. The silicon diode can withstand higher temperatures, and is much more compact. These characteristics permit the diode to be mounted inside the alternator as an integral part of the unit.

The actual working portion of the diode is a very small metallic disc or square wafer of pure silicon treated with a controlled impurity.

It is 0.008 to 0.010-inch thick and approximately 1/8-inch square (dependent on current rating). The rest of the diode package is merely hardware used to mount and attach an insulated electrical terminal to the silicon wafer.

The positive and negative diodes are attached to metal plates called heat sinks, which also serve as conductors. Current transferred from the positive diode to the positive heat sink is connected to the output terminal of the alternator. Current transferred to the negative sink by the negative diode flows back through ground to the stator windings. (Commencing with Model Year 1965, the rectifier assembly incorporates a printed circuit.)

We have mentioned the rectifying action of the silicon wafer in each diode. Figure 14 is a cross section through a typical diode showing the position of this wafer in the lower portion of the assembly.

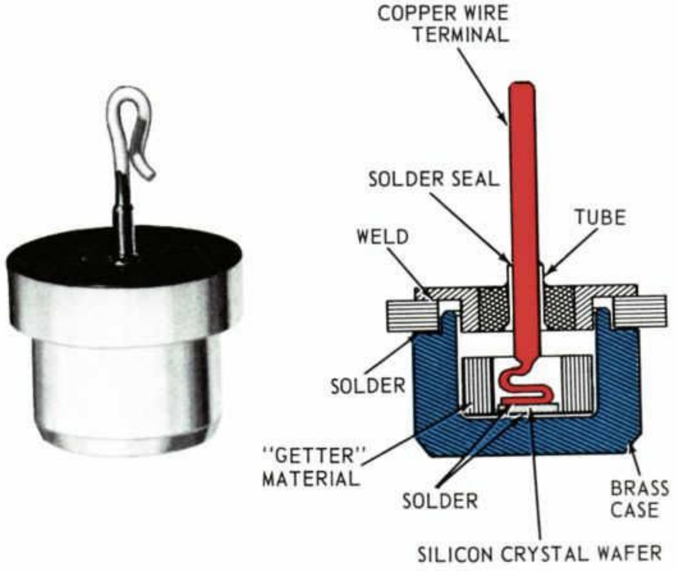


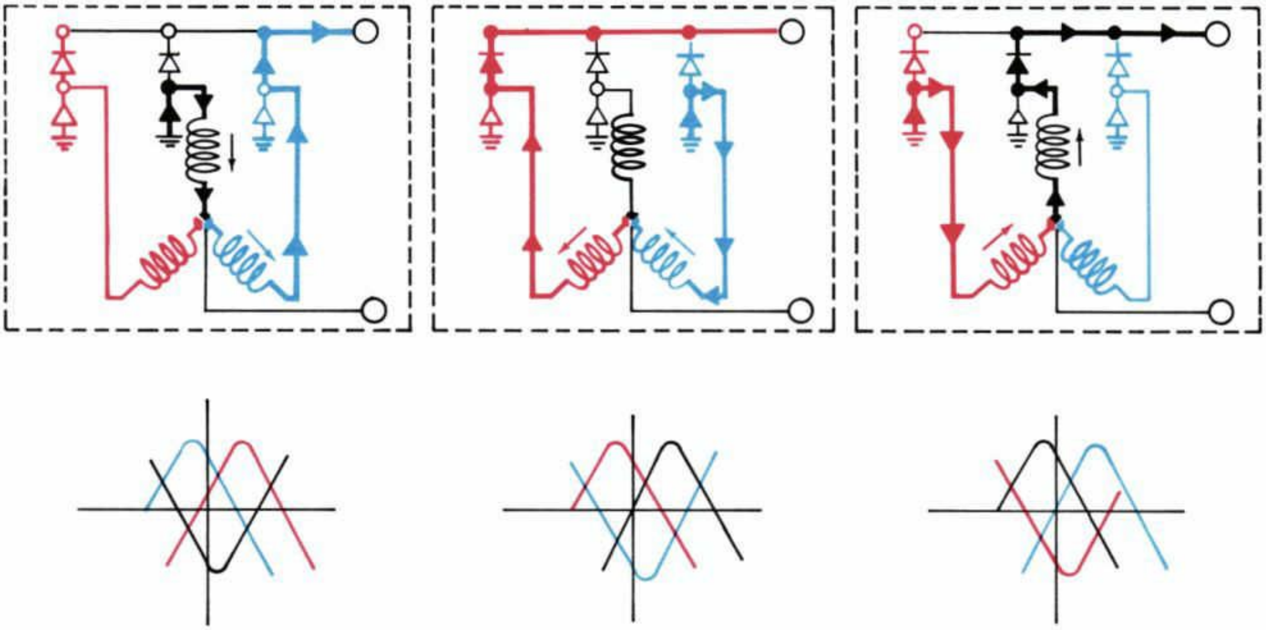
Fig. 14–Cross Section Through Diode

The chemical composition of the wafer (pure silicon-treated with controlled impurities) conditions it to pass current of one polarity only. Whether it passes positive or negative current, depends upon which surface of the wafer faces upward in its installed position.

CURRENT AT THE OUTPUT TERMINAL

In Figure 13, you have seen how current moves through the three phases of stator windings. Now, we will trace it through the diodes to the alternator output terminal. Refer to Figure 15, Views A through F. These views illustrate the current flow when each phase is at the 0° and 180° points in its electrical cycles. (A reference portion of the applicable sine wave is included with each view.)

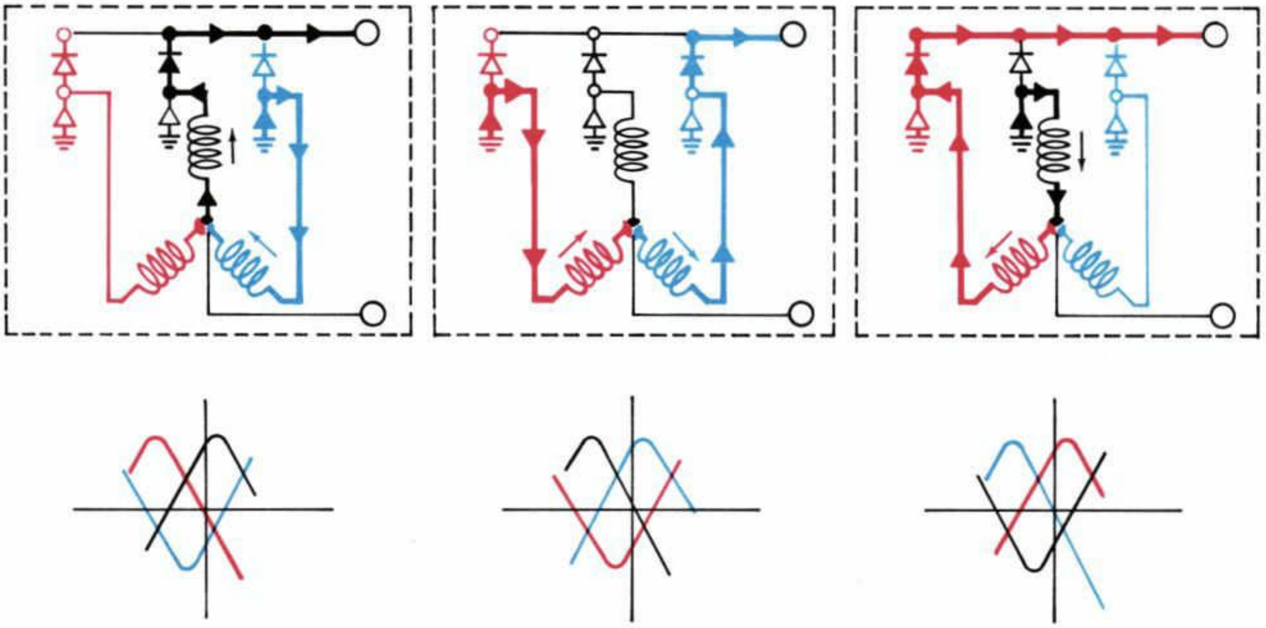
CURRENT AT THE OUTPUT TERMINAL (Cont.)



VIEW A - **PHASE 1 AT 0°**

VIEW B - **PHASE 2 AT 0°**

VIEW C - **PHASE 3 AT 0°**



VIEW D - **PHASE 1 AT 180°**

VIEW E - **PHASE 2 AT 180°**

VIEW F - **PHASE 3 AT 180°**

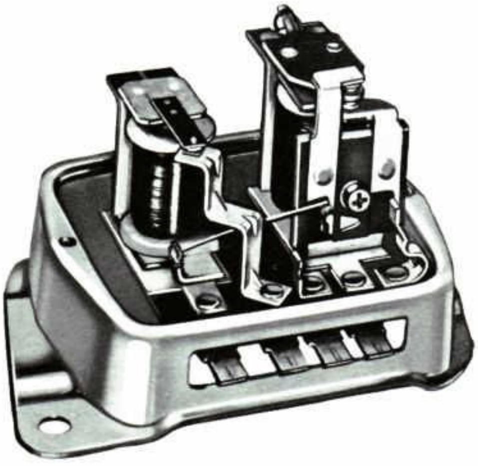
Fig. 15–Current at the Output Terminal

REGULATING AN "A.C." CHARGING SYSTEM

At this point in our study of an alternator, we have developed its operating principles from a simple 3-wire concept through the process by which it creates 3-phase alternating current. We have also covered the means by which this alternating current is rectified through diodes to deliver direct current to the alternator output terminal.

As with the conventional D.C. charging system, it is necessary to regulate the potential which an alternator is capable of producing. To fulfill this requirement, each vehicle will be equipped with an alternator regulator.

There are two types of regulators which will be installed . . . a mechanical unit . . . and a transistorized regulator to accommodate the 60-amp alternator. Figure 16 illustrates these two types of regulators.



MECHANICAL REGULATOR

TRANSISTORIZED REGULATOR

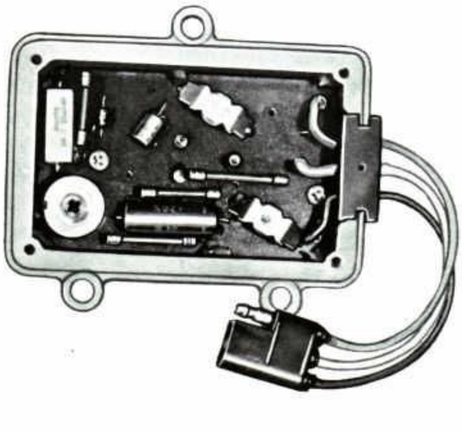


Fig. 16–The Two Types of Alternator Regulators

Now, let us consider how these regulators control the operation of the charging system.

WITH A MECHANICAL REGULATOR

The Autolite alternator is a design which is self-current-limiting; therefore, current limiting is not a function of the alternator regulator. In addition, a cutout relay is not required because the alternator diodes block the flow of battery current through the stator coils. It does contain a voltage regulator assembly consisting of a two-stage electro-mechanical voltage limiter and a field relay.

Compensation for the effect of temperature on the magnetic strength of the voltage limiter coil is provided by a magnetic shunt and a ballast resistor. The limiter voltage is compensated for different ambient temperatures by the use of a bi-metal material in the armature hinge.

Due to the relatively high flux leakage of the rotor, an alternator may not develop sufficient voltage to be self-exciting. Therefore, provision has been made to supply battery current to the rotor coil when the engine is first started.

The charging circuits in a system equipped with a mechanical regulator will vary slightly, depending upon whether they incorporate a charge indicator light or an ammeter. Accordingly, a schematic and description of each type of circuit follows.

Field Relay Operation— With Charge Indicator Light

Study Figure 17 and trace the circuit from its point of origin to its point of return. The following information will serve as a guide.

When the ignition switch is in the "IGN" (ON) or "ACC" positions, battery current will flow from the switch through the charge indicator light and the 15-ohm resistor to the voltage regulator "I" terminal. From the "I" terminal, current flows through the upper contacts of the voltage limiter to the "F" terminal of the regulator and to the rotor field coil. This relatively small current produces enough useful flux to permit the stator, when the engine is started, to develop sufficient voltage at the neutral junction to close the field relay.

When the field relay closes, full-system voltage is applied to the field circuit and the field current is no

REGULATING AN "A.C." CHARGING SYSTEM (Cont.)

Field Relay Operation— With Charge Indicator Light (Cont.)

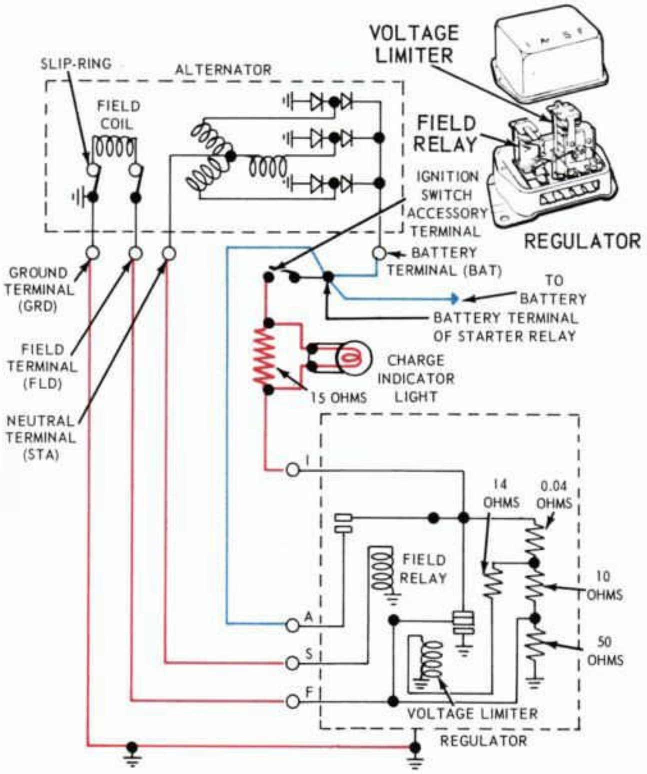


Fig. 17—The Mechanical Regulator with Charge Indicator Light in Circuit

longer required to flow through the resistor and indicator light. System voltage is also applied to both sides of the indicator light. This provides maximum alternator field current and causes the indicator light to go out. The wiring diagram shows that the regulator field circuit wire connects directly to the power circuit and not through the ignition switch. Better voltage regulation is obtained from the direct field relay connection than would be possible with the ignition switch voltage drop causing the voltage limiter to sense an unrepresentative voltage source.

Field Relay Operation—With Ammeter

Now, refer to Figure 18 and apply the same study technique to this schematic.

When the ammeter is used in the charging system, the "S" terminal (field relay) is connected to the ignition switch. With the ignition switch in the "IGN" (ON) position, full-battery current flows through the field relay and the field relay points are closed. As soon as the points close, full-battery current can flow through the field coil of the alternator. At this point, the alternator output is governed by the speed of the engine. As soon as the alternator output voltage reaches the battery, current will start to flow through the regulator and the regulator will take over the control of the alternator output as previously described.

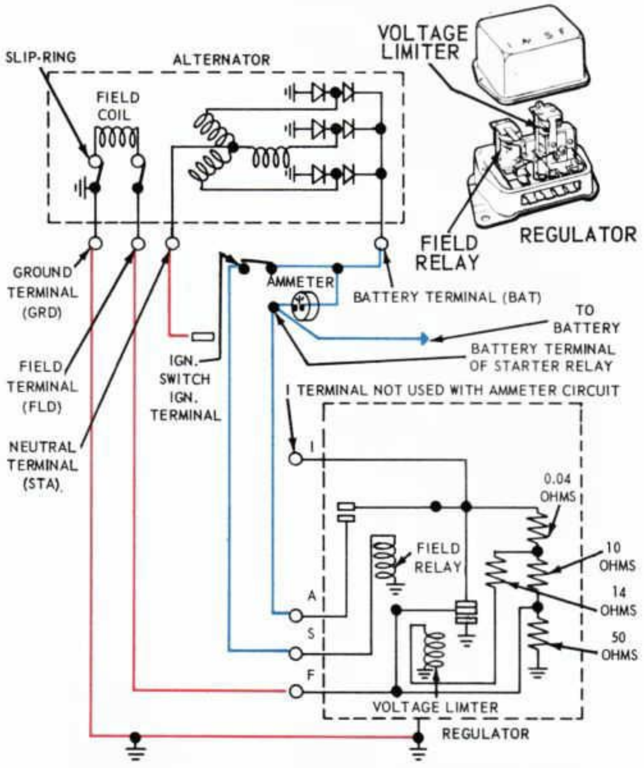


Fig. 18—The Mechanical Regulator with Ammeter in Circuit

With the ignition key in the "START" position, there is no current flowing through the field relay coil, the points are open, no battery current flows through the alternator field and the system is inoperative until the switch is returned to the "IGN" (ON) position.

You will notice that circuity for the voltage limiter portion of the regulator is the same for systems with a charge indicator light or ammeter.

Two Stage Operation

Voltage limiting is accomplished by an electromechanical limiter in the same manner as with a

REGULATING AN "A.C." CHARGING SYSTEM (Cont.)

Two Stage Operation (Cont.)

conventional generator charging system. A double-contact voltage limiter controls field current to the rotor coil. The limiter operates on the upper contacts when the load is heavy and the engine speed is relatively slow; lower contact operation occurs with light loads or at high engine speed or both.

When electrical system conditions require voltage limitation and a relatively strong field current, the limiter armature fluctuates between the upper contacts and the mid-position. When the upper contacts are closed, full-system voltage is impressed on the rotor coil and the maximum current flows. When the armature is in the mid-position, field current is reduced as it must flow through the "field" resistor.

When operating conditions require a further reduction in field current, the limiter armature fluctuates between the mid-position and the lower contacts. When the lower contacts are closed, no field current will flow as both ends of the circuit are grounded. The field current now alternates between that supplied by the "field" resistor when the armature is in the mid-position and zero current when the lower contacts are closed.

The speed at which the armature flucuates between the upper contacts and the mid-position or between the mid-position and the lower contacts is determined by the specific alternator speed and electrical load at the time.

An "accelerator coil," wound over the lower end of the limiter coil, helps to maintain these vibrations for improved limiting action.

Resistor

A 50-ohm resistor is connected across the rotor field coil to act as a damping device for electrical surges in the field circuit. Surges in the field coils would otherwise be transmitted by transformer action to the stator coils where diode damage could occur. This resistor is called an "absorbing resistor."

Voltage limiter operation is partially stabilized by the resistor connected in series with the limiter coil. When the coil is cold, the copper wire has a lower resistance and therefore, would permit more current to flow. The increased coil current would in turn produce a stronger magnetic field, thus reducing the limiting voltage of the regulator. This effect is reduced by the increased voltage drop across the resistor. This resistor is called a "ballast resistor."

Magnetic Shunt

A magnetic shunt made of carpenter metal also helps to stabilize the operation of the limiter. The shunt is located at the top of the limiter coil and is in effect a magnetic short circuit between the coil core and the yoke. At low temperatures, the shunt has good magnetic conductivity and reduces the effectiveness of the limiter magnetic field. When the regulator temperature becomes stabilized, the shunt becomes less conductive and the magnetic field acts more effectively on the limiter armature.

Temperature Compensation

Optimum battery state-of-charge results when the limiter voltage is adjusted to the battery temperature. When the ambient temperature is low, the bi-metal used for the hinge of the voltage limiter increases the effort required to open the limiter contacts. The voltage impressed on the limiter coil will increase to provide the required stronger field. Thus, when ambient temperature is low and the battery is cold, the limited voltage is higher; when the battery is hot, the limited voltage is reduced.

Considerable expense has been incurred to provide a limiter voltage that is both temperature corrected and compensated. This becomes very important to the Service Technician because it is impossible to properly test or adjust the voltage limiter until the regulator is normalized and the exact temperature is known. The importance of these two considerations cannot be overemphasized.

WITH TRANSISTORIZED VOLTAGE REGULATOR

The transistorized voltage regulator controls the alternator voltage output in a manner similar to a mechanical regulator . . . it regulates the alternator field current. This regulation is accomplished electronically with the use of transistors and diodes rather than by a vibrating armature relay. The voltage sensing element is a zener diode which has the characteristic of suddenly changing its resistance when a specified voltage is reached. Refer to Figure 19.

REGULATING AN "A.C." CHARGING SYSTEM (Cont.)

WITH TRANSISTORIZED VOLTAGE REGULATOR (Cont.)

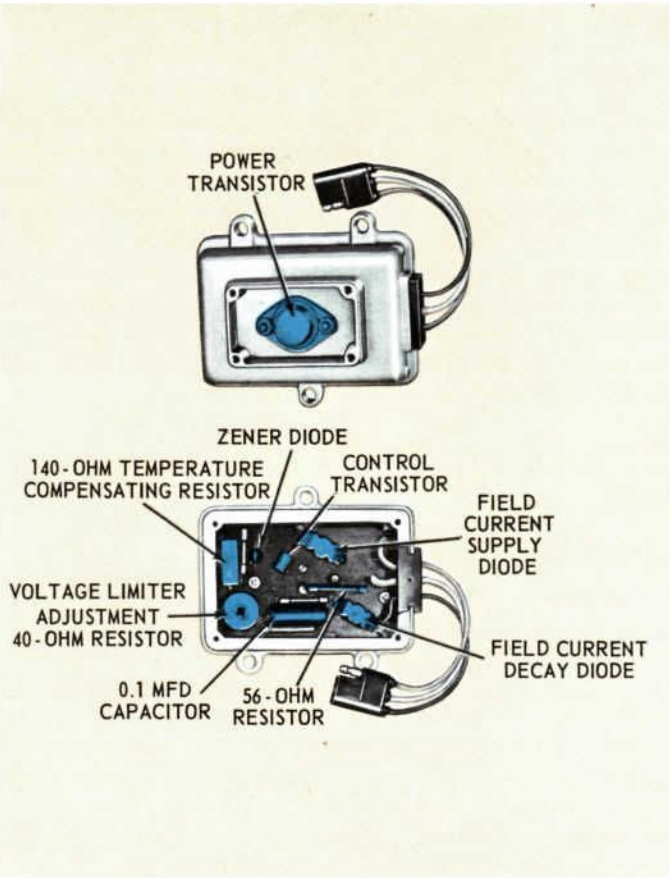


Fig. 19–Transistorized Voltage Regulator

The field current supply diode is used to protect the power transistor.

The field current decay diode performs the same function as the resistors in a mechanical regulator, providing a path to ground for the energy from the field when the field current is interrupted.

The 140-ohm resistor is made of a special material which changes its resistance as temperature varies in such a manner that during cold weather the battery charging voltage is increased. This resistor performs the same function as the bi-metal hinge on the voltage limiter armature of a mechanical regulator.

The regulator voltage limitation is adjusted by varying the 40-ohm adjustable resistor. Varying the adjustable resistor performs the same function as adjusting the voltage limiter armature spring tension on a mechanical regulator.

The 0.1 microfarad capacitor in series with the 56-ohm resistor causes the control transistor and the power transistor to switch on and off faster providing better control of the field current.

The remaining resistors in the unit provide proper operating voltages for the zener diode and the two transistors.

The field relay is still used in the transistorized system, but it is mounted separately from the voltage regulator. This field relay is not adjustable since the cover is crimped in place. Refer to Figure 20.

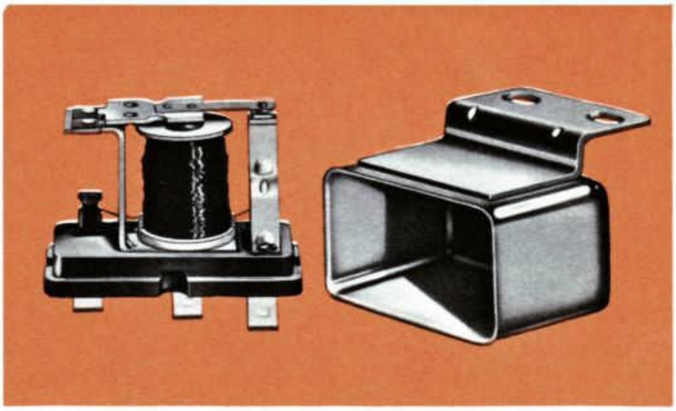


Fig. 20–Field Relay in a Transistorized System

The schematics of the transistorized voltage regulator system are shown in Figure 21. When the engine is started, battery current is supplied to the field through the field relay, field current supply diode, and the power transistor.

As the alternator begins to supply current, the battery voltage will increase. When the battery voltage reaches approximately 14.5 volts, the zener diode due to its characteristics, suddenly reduces its resistance and lowers the voltage at point B on the control transistor. The control transistor then acting as a switch applies battery voltage to point B on the power transistor. The power transistor also acting as a switch then opens, cutting off battery current to the field. The battery voltage drops slightly, the zener diode increases its resistance, opening the control transistor, which in turn closes the power transistor and battery current again flows to the alternator rotor (field).

This sequence of events repeats itself at an approximate rate of 2,000 times per second, which is faster than the rate that a mechanical regulator interrupts the field current.

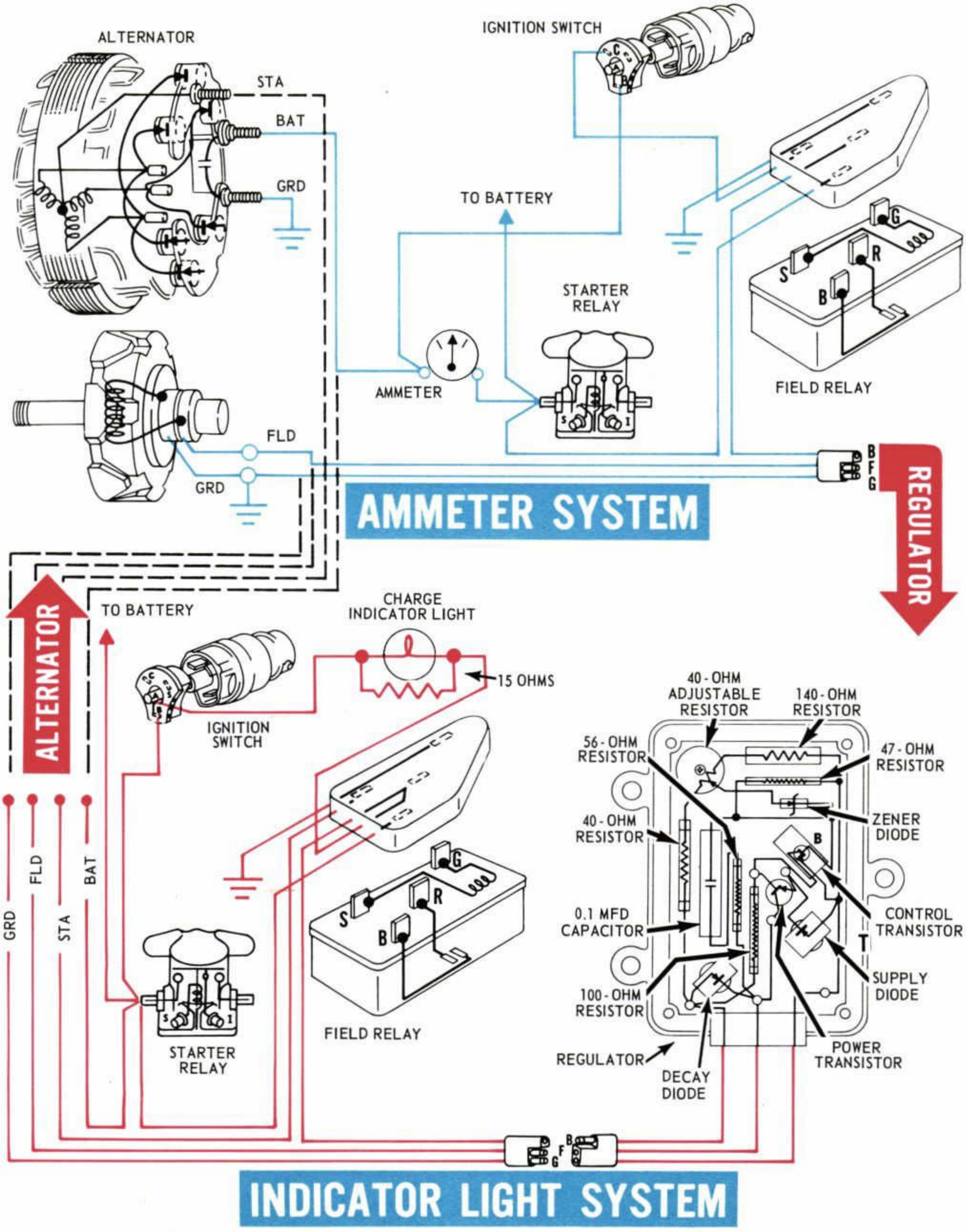


Fig. 21– Alternator and Transistorized Regulator Circuits

PLAY IT SAFE!

Several servicing procedures can cause diode damage or complete failure if carried out improperly.

1. Observe polarity when installing the battery in a vehicle. Reversed battery cable connections or installation of a battery which has been charged backwards will burn out diodes. Use a voltmeter to determine battery terminal post polarity before connecting cables. The ground cable must be connected to the negative battery terminal post.

2. Observe polarity when a booster battery is used to start the engine. Connect negative to negative, and positive to positive.

3. Disconnect both cables at the battery before connecting a charger to the battery.

4. It is not necessary to polarize an alternator. Regulator contacts can be destroyed by an attempt to do so.

5. Never operate the alternator on open circuit with the rotor (field) coil energized. Very high voltage will be developed which can burn the rotor coil or possibly damage the diodes.

6. Never ground the alternator output "BAT" terminal, it is connected directly to the battery.

Always disconnect the battery ground cable at the battery before removing the alternator or its connecting wires. Serious damage to the wiring harness and the alternator could result from accidentally grounding the output terminal.

BEGIN WITH A FULLY-CHARGED BATTERY

The capacity of a battery signifies its ability to provide current and maintain a minimum voltage potential. If a battery passes a capacity test, it may be assumed to be in satisfactory condition. However, it may need some additional charging to bring it to peak performance.

There is one condition which should be noted when considering capacity evaluations . . . a **cold battery has a lower discharge capacity.** If a battery fails to pass the capacity test during cold weather, remove it from the vehicle and allow it to stand until it reaches room temperature; then, retest the battery.

To complete the evaluation, measure the specific gravity of the electrolyte in each cell after the battery has been charged. This will show the state-of-charge in each cell. (Be sure to observe the required time interval after charging before using the hydrometer–remove the surface charge.)

Also, be sure to observe the usual safety precautions. Hydrogen and oxygen gases are produced in the course of normal battery operation. **This gaseous mixture can explode if flames or sparks are brought near the vent openings of the battery.** Further, the sulphuric acid in the battery electrolyte can cause a serious burn if spilled on the skin or spattered in the eyes. It should be flushed away immediately with large quantities of clean water.

If the charging system does not operate properly . . . and the battery and drive belt have been eliminated as possible causes of the trouble . . . check the alternator output. (The recommended procedure is the next item covered in this manual.)

When a battery requires the frequent addition of water, it is an indication that there is excessive voltage in the charging circuit. If the battery does not maintain a high state-of-charge, it may be due to low voltage in the charging circuit. Either condition is an indication that the regulator voltage limiter should be checked and adjusted, as required.

ALTERNATOR OUTPUT TEST

The purpose of this test is to measure current output at specified speed and voltage The test result is a measure of the ability of the alternator to produce its rated output.

Test Connections

Connect the test instruments to the charging system components, as shown in Figure 22. Remove the ground cable and the positive cable; then, install the battery post adapter switch. Open the switch and connect the ground cable. Connect the field leads to the regular plug with a jumper wire (male spade lugs or spade lugs with wire leads may be used to make these connections). Turn the field rheostat OFF. Connect a tachometer to indicate the engine rpm.

Place the transmission in neutral or park and apply the parking brake.

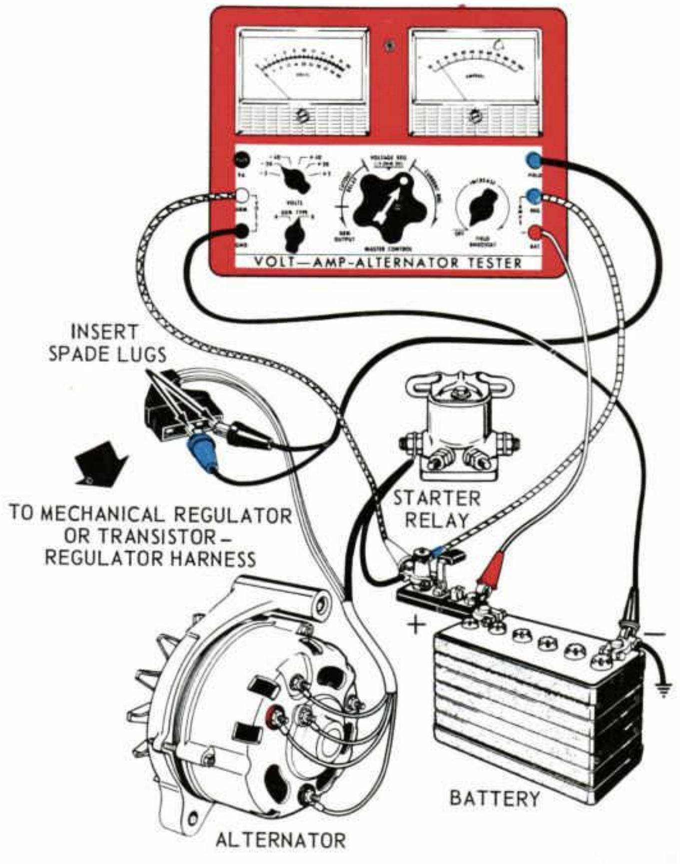


Fig. 22–Alternator Output Test

ALTERNATOR OUTPUT TEST (Cont.)

Test Procedure

1. Close the battery post adapter switch and start the engine. Open the battery post adapter switch. (All electrical accessories must be turned off, including door-operated interior lights.)

2. Increase the engine speed to the specified rpm and observe the voltmeter and ammeter.

3. Turn the field rheostat control knob clockwise until a reading of 15 volts is shown on the voltmeter.

4. Observe the ammeter reading. (To obtain the total alternator output, add two amperes to this reading for vehicles equipped with conventional ignition or six amperes with the transistor ignition system.)

If the battery was fully-charged, it might not be possible to obtain maximum-current output. If specified current is not obtained, make the following test before condemning the alternator:

a. Turn the field rheostat control knob to the OFF position. Rotate the master control knob to the CURRENT REG. position. Maintain the engine speed at the rpm used in Step 2.

b. Turn the field rheostat control and the master control clockwise, maintaining a voltmeter reading of 15 volts maximum, until the field rheostat control is at its maximum-clockwise position.

c. Readjust the master control until the voltmeter reads exactly 15 volts. Observe the ammeter reading. Add two amperes to this reading for vehicles equipped with conventional ignition or six amperes with the transistor ignition system to obtain total alternator output.

5. Stop the engine.

Test Conclusions

If the output is two to five amperes below the specified rating, it usually indicates an open diode in the rectifier. (A slipping drive belt or excessive circuit resistance can also cause this condition. Recheck the belt and the circuit resistance.)

An output of approximately 10 amperes less than the specified rating is usually an indication of a shorted diode. An alternator with a shorted diode often causes a noticeable whine at idle speeds.

A shorted positive diode often causes alternate flashing of the oil pressure warning light and the charge indicator light with the ignition switch off. Feedback from the charge indicator light circuit to the accessory terminal of the ignition switch causes this peculiar effect by activating the fuel and temperature gauge system. (When the contacts in the constant-voltage regulator on the instrument cluster close, the oil pressure light becomes dim and the charge indicator light becomes bright. When the constant voltage contacts open, the oil pressure light becomes bright and the charge indicator light becomes dim). A shorted positive diode also causes battery discharge through the field circuit due to the closed relay contacts.

Any test indicating an alternator malfunction should be followed by circuit resistance tests to determine whether the circuit is faulty or whether the alternator should be removed from the vehicle for bench testing and repair.

VOLTAGE DROP TEST

ALTERNATOR-TO-BATTERY GROUND TERMINAL

Install the battery post adapter switch and make the other test connections as shown in Figure 23. Set the voltmeter in the lowest position.

Place the transmission in neutral or park and apply the parking brake.

Test Procedure

1. Close the battery post adapter switch and start the engine. Open the battery post adapter switch. (All electrical accessories must be turned off, including the door-operated interior lights.)

2. Increase the engine speed to about 2000 rpm and adjust the field rheostat until the ammeter indicates 20 amperes.

VOLTAGE DROP TEST (Cont.)

Test Procedure (Cont.)

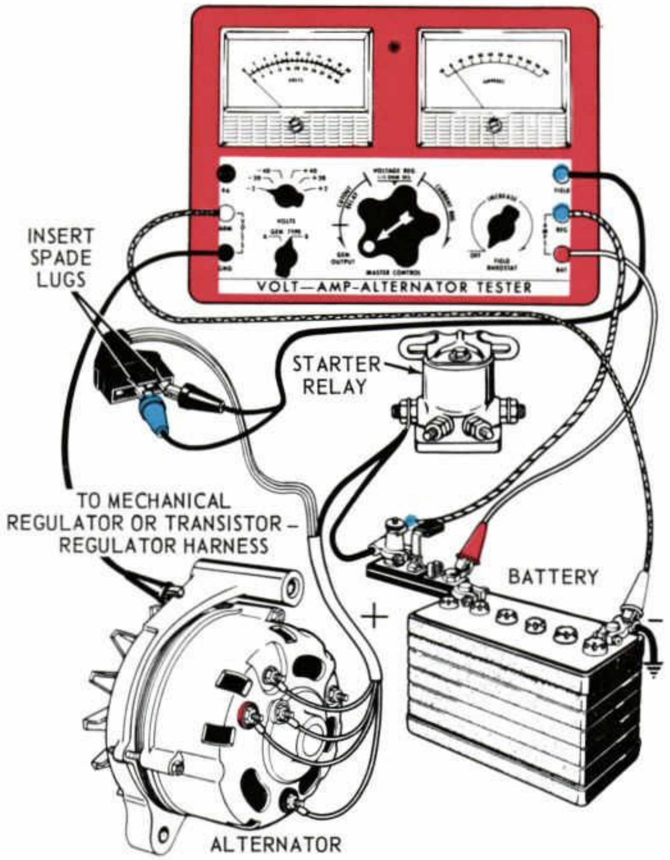


Fig. 23– Voltage Drop Test–Alternator-to-Battery Ground Terminal

3. Observe the voltmeter. The voltage indicated on the voltmeter should be less than 0.1 volt. A faulty ground circuit is indicated when the voltmeter reading is more than 0.1 volt.

Test Conclusions

If the voltage reading is higher than specified, there is excessive resistance in the circuit. Inspect the battery ground cable for corrosion or loose connections. Repair or replace any defective parts.

ALTERNATOR-TO-BATTERY POSITIVE TERMINAL

Test Connections

Except for the voltmeter, the test connections are the same as those used for the "Alternator-To-Battery Ground Terminal Test." Connect the voltmeter as shown in Figure 24.

Place the transmission in neutral or park and apply the parking brake.

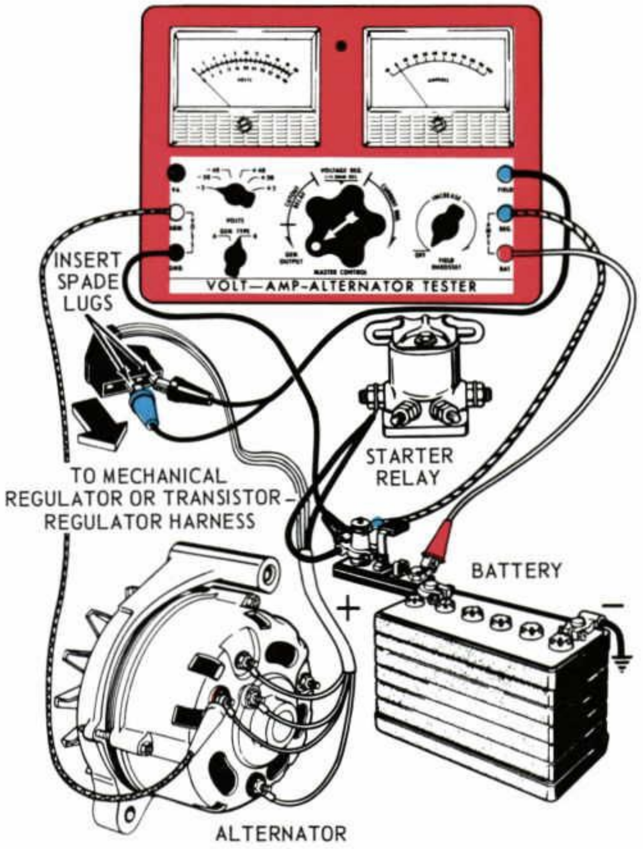


Fig. 24– Voltage Drop Test–Alternator-to-Battery Positive Terminal

Test Procedure

1. Close the battery post adapter switch and start the engine. Open the battery post adapter switch. (All electrical accessories must be turned off, including the door-operated interior light.)

2. Increase the engine speed to about 2000 rpm and adjust the field rheostat until the ammeter indicates 20 amperes.

3. Observe the voltmeter. A faulty charging circuit is indicated when the reading is more than 0.3 volt on vehicles with a charge indicator light, and 0.5 volt on ammeter systems.

Test Conclusions

If the voltage reading is higher than specified,

VOLTAGE DROP TEST (Cont.)

Test Conclusions (Cont.)

there is excessive resistance in the circuit. Inspect the battery positive cable and the wiring harness from the starter relay positive terminal to the alternator for broken wires and loose or corroded connections. Repair or replace any defective parts.

VOLTAGE LIMITER TEST

Final voltage limiter calibration tests must be made with the regulator cover and gasket in place and the regulator temperature must be normalized before making the voltage limiter tests.

If the vehicle has not been driven far enough for the engine temperature to be normalized, turn off all electrical accessories and operate the engine at approximately 2000 rpm for 20 minutes with the hood down.

Only the lower stage (lower contact mechanical regulator) regulation need be tested as a check for proper calibration.

Test Connections—Lower Stage

1. Disconnect both battery cables from the battery and install the battery switch. Connect the test ammeter as shown in Figure 25.
2. Connect the voltmeter positive lead to the battery positive cable clamp, and the voltmeter negative lead to the ground cable clamp. Set the voltmeter switch to the 20-volt position.
3. Install a thermometer to measure the temperature of the regulator.
4. Connect the battery ground cable to the battery negative post.

Test Procedure—Lower Stage

1. Close the battery switch and start the engine. Be sure all electrical accessories, including the door-operated interior lights, are turned off. Open the battery switch.
2. Operate the engine at 2000 rpm for 5 minutes with the tester control in the output relay position. If the ammeter indicates more than 10 amperes, stop the engine. Disconnect the battery cables, and charge the battery. When the battery has been properly charged, repeat the temperature stabilizing procedure.

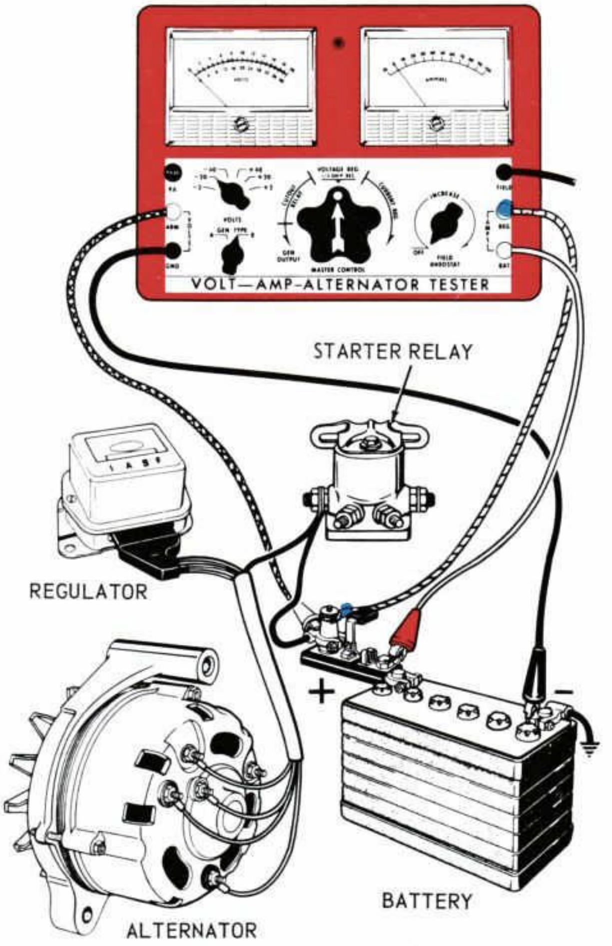


Fig. 25—Voltage Limiter Tests

3. Cycle the regulator as follows (mechanical regulator only): Close the battery switch and stop the engine. Start the engine and increase the speed to 2000 rpm. Open the battery switch.
4. Allow the battery to normalize for a short time; then, read the voltmeter and the thermometer. Voltage readings should compare with indicated thermometer readings, as shown in the applicable shop manual. If the regulated voltage is not within specifications, make the necessary voltage limiter adjustment. (The mechanical regulator must be cycled after each adjustment before a new reading is obtained. All readings must be made with the regulator cover in place.)

VOLTAGE LIMITER TEST (Cont.)

Test Conclusions—Lower Stage

If the voltage reading is within specifications, but the battery is either over, or under-charged, adjust the regulator to bring the voltage reading within the specifications given in the applicable shop manual. Cycle the mechanical regulator before each reading. Do not change the setting more than 0.5 volt from the original setting until a test period involving actual vehicle usage has indicated that a greater correction is required. (See Mechanical Regulator Adjustments on Page 29 for proper adjustment procedures.)

EXAMPLE

Assume that battery water usage seems excessive and a hydrometer check shows all cells to be fully charged. Under these conditions, the voltage limiter setting may be assumed to be too high. If testing shows that the limiter is operating within specifications at a temperature of 125°F. and 14.5 volts, adjust the regulator to decrease the voltage limit to 14.0 volts. Then, if under actual use, this setting indicates that the voltage is still slightly high, the voltage may be reduced by another 0.2 volt.

FIELD RELAY TEST

WITH MECHANICAL REGULATOR

Test Connections

Connect the tester as shown in Figure 26. Two jumper wires are needed to complete the hook-up. Make the battery positive post connection last to prevent a possible flash if the field resistance is not turned off.

Test Procedure

1. Place the field rheostat in the full counterclockwise (maximum resistance) position. Depress the sensitivity control button located between the meters and slowly rotate the field rheostat control clockwise from the maximum resistance position until the field relay **contacts** close.

2. Observe the voltmeter reading at the moment the relay contacts close. Repeat the test several times to verify the readings.

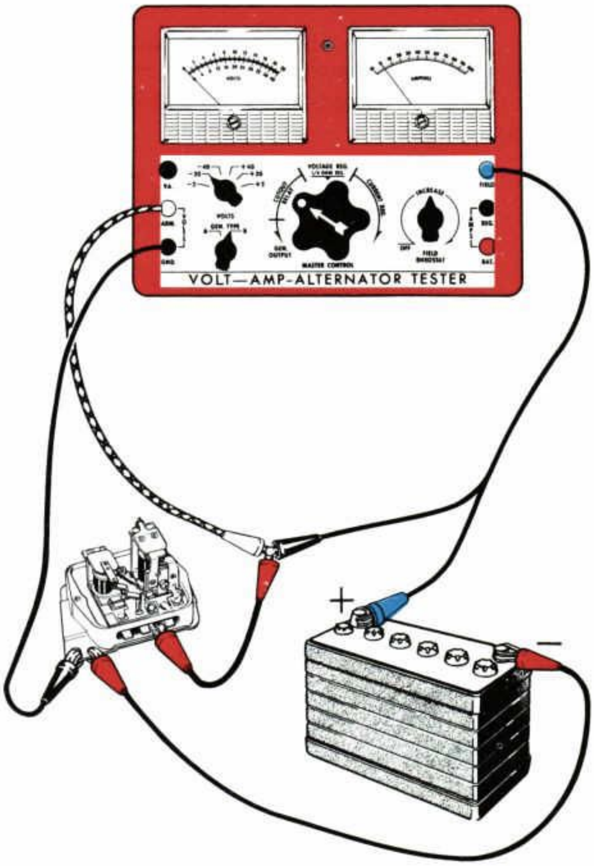


Fig. 26— Field Relay Test (mechanical regulator only)

Test Conclusion

The relay contact closing voltage should be between 2.5 and 4 volts. If the relay closing is outside the specified limits, make the proper adjustments. (See "Mechanical Regulator Adjustments" on Page 29 for proper adjustment procedures.)

TRANSISTOR REGULATOR

Test Connections

Disconnect the relay connector plug. Make the connections shown in Figure 27.

Test Procedure

1. Slowly rotate the field rheostat control clockwise from the maximum counterclockwise position until the test light comes on.

FIELD RELAY TEST (Cont.)

Test Procedure

2. Observe the voltmeter reading at the moment that the light comes on. This is the relay closing voltage.

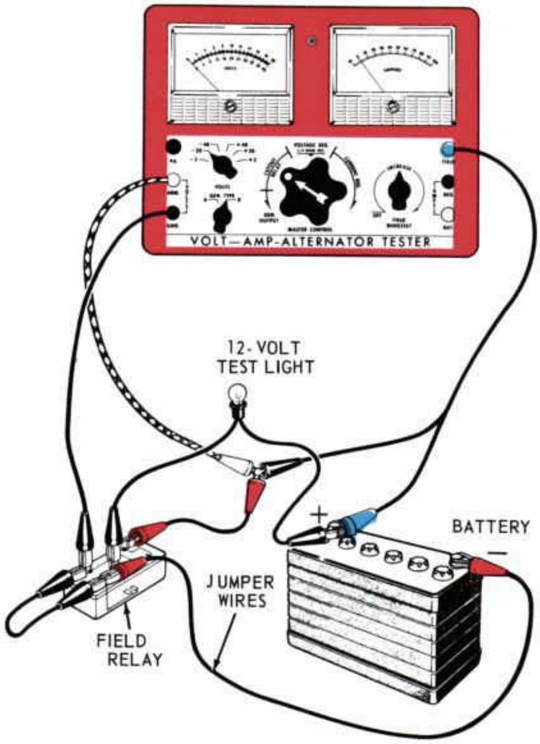


Fig. 27—Field Relay Test (Transistorized Regulation Only)

Test Conclusions

If the relay closes immediately, even with the field rheostat close to the maximum counterclockwise position, push the sensitivity control button between the two meters, and repeat the test. If the closing voltage is not to specifications, replace the relay.

DIODE TEST

This test is made with the rectifier assembly removed from the alternator and disconnected from the stator. Each individual diode is tested with this method. The connection and circuits through the stator need not be considered. Refer to Figure 28.

1. Set the ohmmeter on the Multiply by 10 Scale, touch the two probes together and adjust the meter pointer to the Set Line.

2. Connect one of the ohmmeter test probes to the diode mounting plate of the rectifier. With the other test probe, touch each of the three stator lead terminals of the printed-circuit board. Note the ohms registered. Gently push and wiggle the test probe to be sure of a good electrical connection.

3. Reverse the test probe positions in Step 2 and repeat the test.

4. A good diode has a high resistance in one direction and a low resistance in the opposite direction.

A shorted diode has low resistance in both directions. An open diode has high resistance in both directions.

5. Connect one of the ohmmeter test probes to the other diode mounting plate of the rectifier and continue the test at each of the three stator lead terminals.

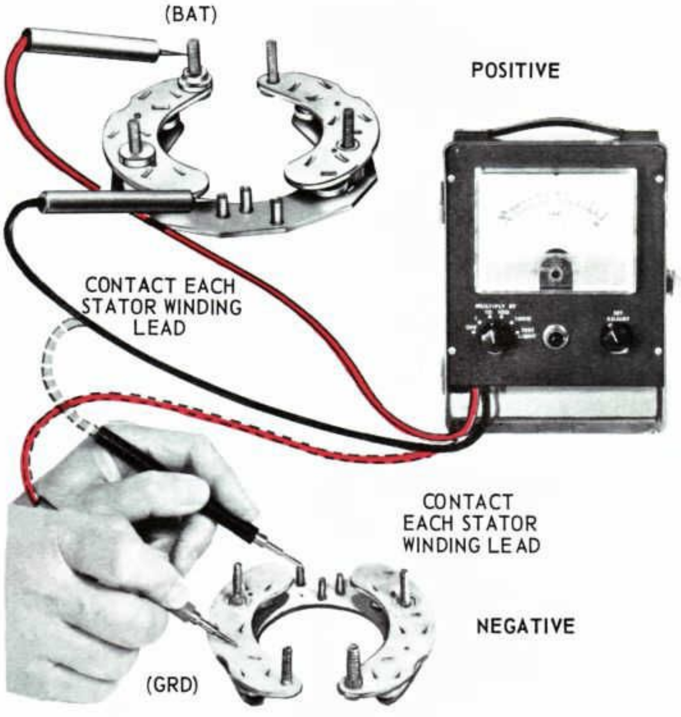


Fig. 28—Positive and Negative Diode Tests

ROTOR AND STATOR BENCH TESTS

Rotor Coil Test

Insulation will flake off a badly burned rotor coil. Replace a rotor having a discolored or burned coil.

Do not attempt to measure coil resistance through the brushes of an assembled alternator. The brushes add resistance. Refer to Figure 29.

To test the rotor coil proceed as follows:

1. Use either an ohmmeter or an ammeter to check rotor coil resistance. A fully charged 12-volt battery must be used. Ammeter readings could vary if the battery voltage is not precisely 12 volts.
2. Inspect the soldered connection at the slip ring terminals. Repair, if necessary, and check the coil.

ROTOR AND STATOR BENCH TESTS (Cont.)

Rotor Coil Test (Cont.)

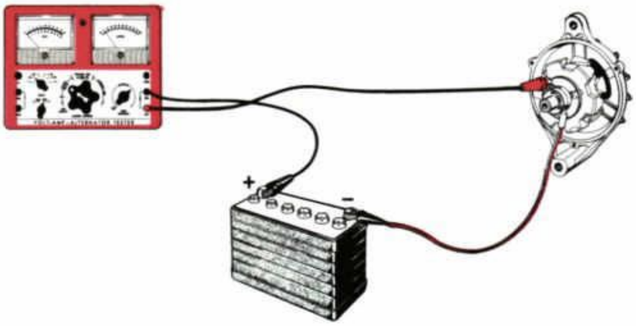


Fig. 29–Rotor Coil Test

ALTERNATOR SIZE–AMPERES	ROTOR	
	CURRENT–AMPERES	RESISTANCE–OHMS
38	2.5	4.9
42, 45, 55	2.9	4.2
60	4.6	2.6

3. Replace the rotor assembly if the coil fails the prescribed test.

Rotor Ground Test

Grounded rotor coils are caused by defective coil or lead wire insulation which allows wire contact to some metal part of the rotor. Damaged regulator voltage limiter contacts usually result from the increased field current flow.

A relatively high voltage is used in this test to detect slight leakage before actual failure occurs. Use care to avoid electrical shock from bodily contact with the test prods during use. Remove the plug from the outlet when the tester is not in use.

To check the rotor ground refer to Figure 30 and proceed as follows:

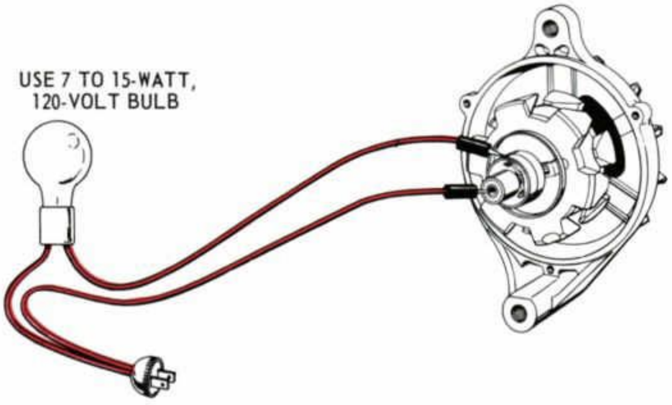


Fig. 30– Testing Rotor Ground

1. Insert from a continuity test lamp plugged into a 115-volt A. C. outlet. Use a 7 to 15-watt bulb.

2. Touch one test prod to a bare metal surface of the rotor shaft, and the other to the slip rings. The test lamp should not light.

3. Replace the rotor assembly if even the slightest glow is seen in the test lamp.

Stator Ground Test

The stator must be disconnected from the diode and plate assemblies when this test is made. Faulty or damaged insulation between the coil wires and the stator core can cause grounded stator coils.

Using a continuity test lamp as shown in Figure 31 proceed as follows:

1. Insert the plug into a 115-volt A. C. outlet. Use a 7 to 15-watt bulb.

2. Touch one test prod to a bare metal surface of the stator core, and the other prod to a bare stator lead wire. The test lamp should not light.

3. Replace the stator assembly if even the slightest glow is seen in the test lamp.

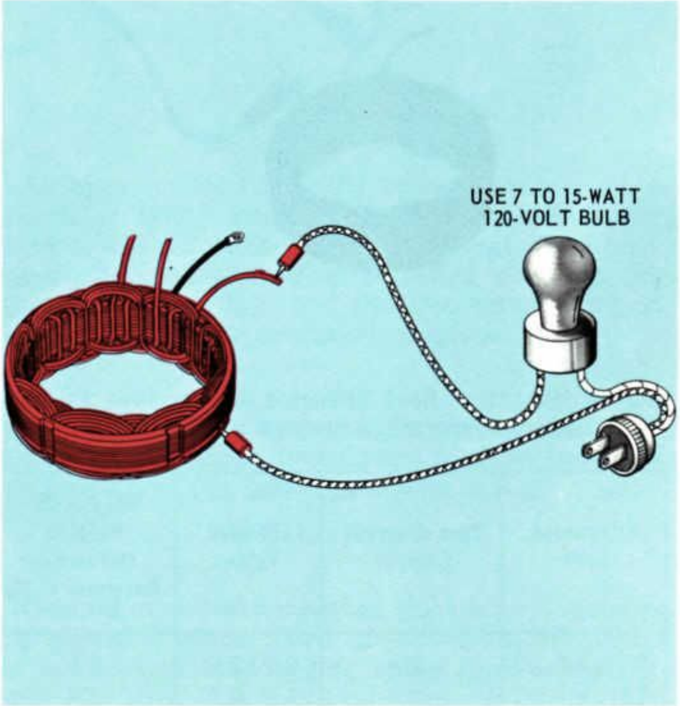


Fig. 31–Testing Stator Ground

ROTOR AND STATOR BENCH TESTS (Cont.)

Stator Coil Test

The purpose of this test is to locate shorted coils and faulty neutral junction splices.

Replace a stator having discolored or burned coils. Insulation enamel will flake off badly burned coils.

1. With the stator assembly disconnected from the rectifier assembly, connect the tester as shown to a 12-volt battery. The ammeter BAT (red) lead and the field rheostat control lead are not used in this test: This hookup places the field rheostat in series with the ammeter.

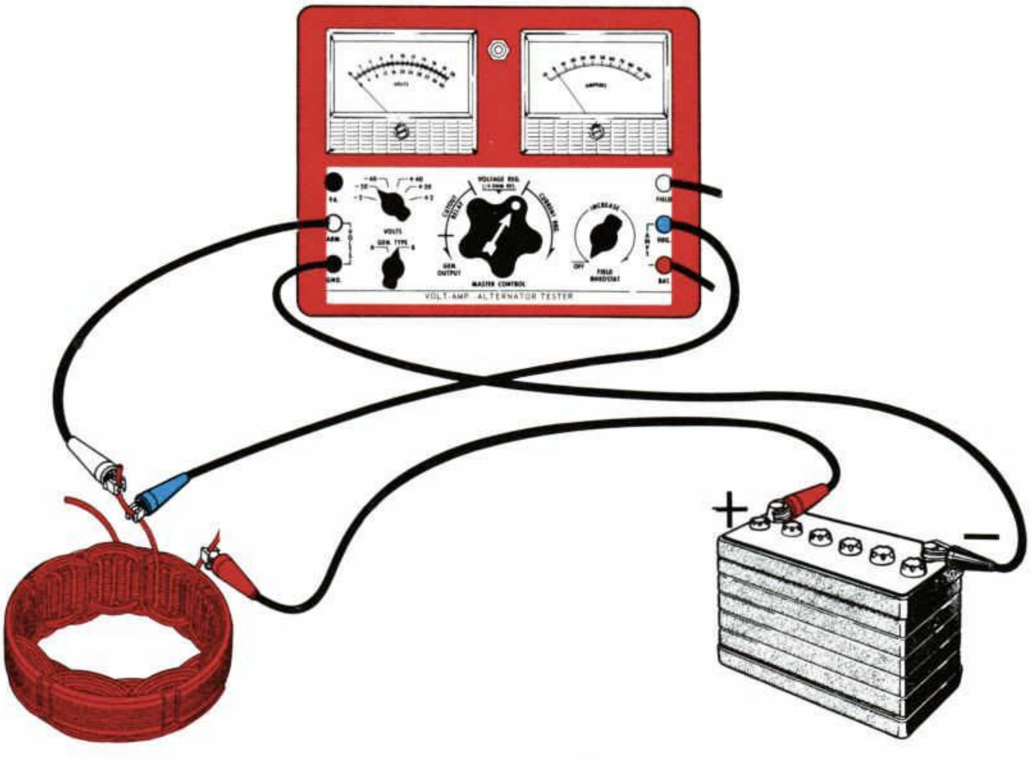


Fig. 32– Stator Coil Test

2. Adjust the field rheostat to produce 20 amperes of current flow and read the voltmeter.

Alternator Size	Test Current (Amps)	Indicated Volts	Maximum Voltage Difference Between Coils
55 and 60	20	6.7–7.2	0.5
42 and 45	20	5.5–6.5	0.6
38	20	7.2–8.2	0.7

3. If the voltage is too high, check the splice and repair. Test the stator when the repairs are complete. If voltage is still too high, replace the stator. If the voltage is too low, a section of the coil is shorted and the stator must be replaced.

GROUND TEST

The stator must be disconnected from the diode and plate assemblies when this test is made. (The 120-volt power supply will burn out the diodes). Faulty or damaged insulation between the coil wires and the stator core can cause grounded stator coils.

Always use care to avoid electrical shock from bodily contact with the test probes during use. Remove the tester plug from the outlet when not in use.

1. Insert the plug into a 115-volt A.C. outlet. Use a 7 to 15-watt bulb.

2. Touch one test probe to a bare metal surface of the stator core, and the other probe to a bare stator lead wire. The test lamp should not light.

3. Replace the stator assembly if even the slightest glow is seen in the test lamp.

MECHANICAL REGULATOR

VOLTAGE LIMITER

The amount the voltage changes when operation shifts to the lower contact is controlled by the contact and core gaps.

Two adjustments are required: the lower contact gap, and the core gap. The contact gap adjustment must be made first, and must be within specifications before adjusting the core gap.

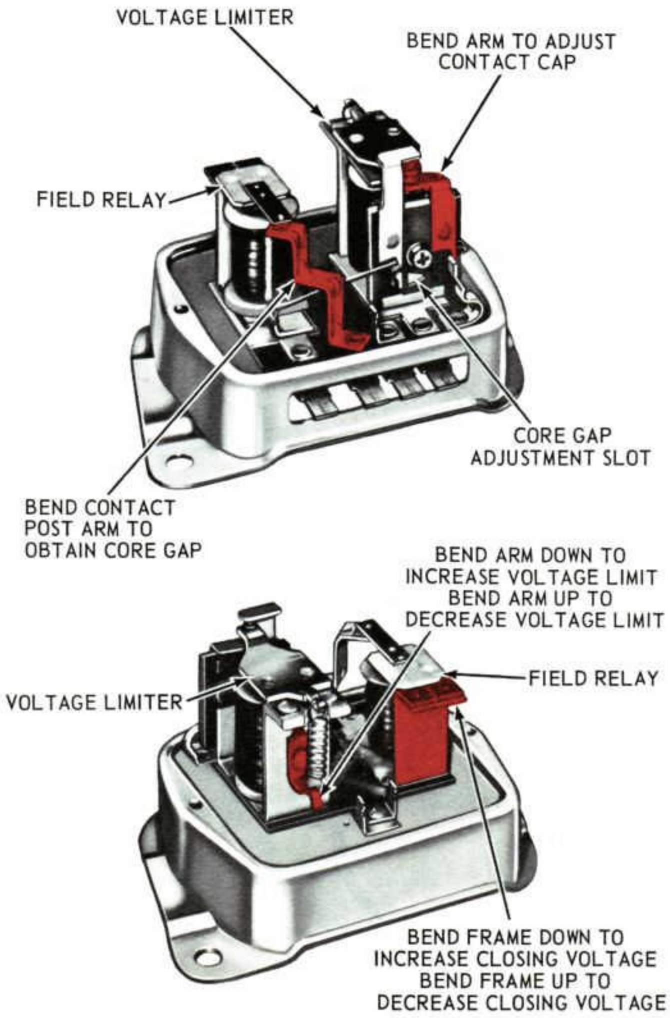


Fig. 33– Mechanical Regulator Adjustments

Lower Contact Gap

Bend the voltage limiter lower post, as required, to obtain a 0.017 to 0.022-inch gap at the lower contacts. The upper contacts are closed for this adjustment.

Core Gap

1. Adjust the lower contact gap.
2. Loosen the center lockscrew ⅛ to ¼-turn; with a screwdriver blade in the adjustment slot below the lockscrew, move the entire contact carrier block upward.
3. Place a 0.049-0.056-inch feeler gauge on top of the coil core toward the contact points and away from the armature hinge rivets.
4. Place a screwdriver in the adjustment slot and move the contact carrier block down until firm resistance to movement of the feeler gauge is felt with the upper contacts closed.
5. Tighten the lockscrew and recheck the core gap.

Manual Test—Upper Stage

An open connection at the voltage limiter coil, a broken or faulty armature spring, or dirty upper contacts will reduce the alternator output. Therefore, upper stage operation must be tested whenever the system output is low, and the alternator and field relay are known to be functioning properly.

Upper stage regulation can be checked manually to determine whether limiting and transfer functions are operative. The battery must be in a good state-of-charge.

Connect a voltmeter across the battery. Remove the regulator cover. Turn the low-beam headlights on and operate the engine speed high enough to cause the armature to vibrate (usually about 1500 rpm). Use a finger to lightly lift the voltage limiter armature toward the upper contact.

MECHANICAL REGULATOR (Cont.)

Manual Test—Upper Stage (Cont.)

The voltmeter reading should rise when the armature is lifted, and decrease to the original limited voltage reading when pressure is removed.

If the voltage does not rise, turn the headlights off and the parking lights on and repeat the test. Do not attempt to compare the voltage reading to the specification because the regulator cover must be in place for calibrated voltage readings.

FIELD RELAY

Testing and adjusting the field relay is not a part of the normal service procedure. This information is presented so that an approved procedure is available, if required.

Core Gap

1. Apply light pressure to the armature when adjusting the core gap. Do not push down on the contact spring arm.
2. Place a feeler gauge on top of the coil core and adjust the gap to 0.010-0.018 inch when the contacts just touch.
3. Bend the contact post to obtain the correct gap.

Contact Gap

Not adjustable, but varies with the closing voltage setting.

CONTACT CLEANING

Erratic operation is indicated when the voltmeter pointer is unsteady. Check for loose connections or dirty contacts. Do not pull paper through the contacts to clean them; very small bits of fiber can be caught and held by any irregularity in the contact surface. Use a fine abrasive paper such as silicon carbide, 400 grade, to clean the field relay and the voltage limiter contacts. Wear off the sharp edges of the abrasive by rubbing the abrasive surfaces together, and tap the paper to remove abrasive dust from the surface before using the paper.

Fold the paper into a strip to produce two abrasive sides and to keep the paper backing from touching the contacts. Place the strip between the contacts and, using light-contact pressure, gently pull the strip back-and-forth through the contacts. Do not use compressed air to clean the interior of the regulator. Keep fingers off the contact surfaces to prevent oily or acid deposits. Use clean feeler gauges or wires when checking or adjusting the contact gaps.

TRANSISTORIZED REGULATOR

The only adjustment on the alternator transistorized regulator is the voltage limiter adjustment. The regulator voltage limitation is adjusted by varying the 40-ohm resistor. This performs the same function as adjusting the voltage limiter armature spring tension on a mechanical regulator.

Adjustment of the transistorized regulator must be made with the regulator at normal operating temperature. Remove the regulator mounting screws and remove the bottom cover. The voltage limitation can be adjusted up-or-down by turning the screw. There is an approximate 280° adjustment from stop-to-stop.

Figure 34 illustrates this adjustment procedure.

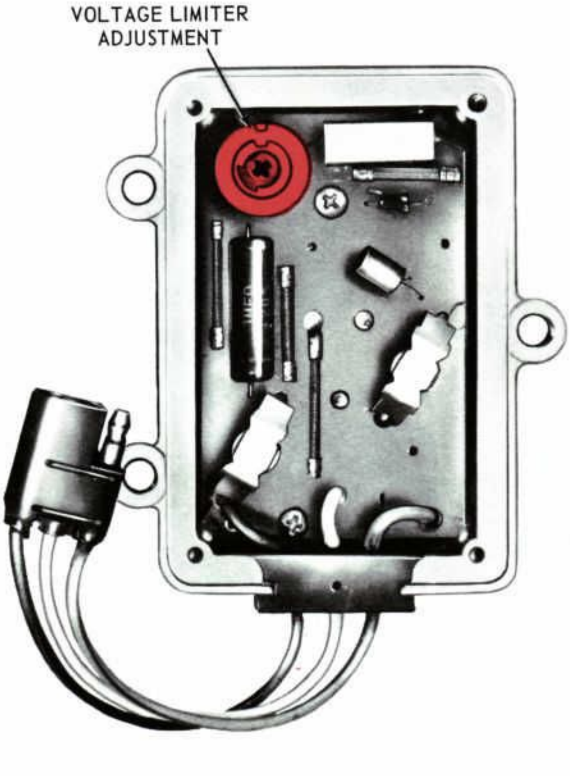


Fig. 34– Transistorized Regulator Adjustment

CHARGE INDICATOR LIGHT

Off at all times and positions of ignition switch.

Check the following for probable causes:

1. Wire to ignition switch accessory terminal loose or broken.
2. Faulty bulb or socket.
3. Regulator harness, connector plug or faulty blade terminal connection.

Flashes alternately with oil light when ignition switch is off. Dim operation occurs at times. (Battery will be discharged if trouble is not corrected immediately.)

Check the following for probable causes:

1. Shorted positive diode in alternator.
2. Field relay contacts stuck closed.

On at all times (With engine running at idle speed).

Check the following for probable causes:

1. Field relay coil open, broken wire to solder lug terminal, or loose rivet in regulator.
2. Broken wire in harness or loose connection at regulator connector plug.
3. Shorted or open rectifier.
4. Open resistor wire (wiring harness) located under instrument panel. Resistor should measure 15 ohms.
5. Stator neutral wire loose or broken at terminal in alternator.
6. Improper adjustment of relay core gap or closing voltage setting.
7. Dirty or oxidized contacts.
8. Broken drive belt(s).
9. Open field circuit or field coil.
10. Grounded or shorted stator.

BATTERY DISCHARGED

No warning from charge indicator light.

Check the following for probable causes:

1. Loose drive belt.
2. Charging circuit resistance.
3. Voltage limiter malfunction or low setting.
4. Accessory load too high for alternator rating.
5. Corroded or loose battery cable connector clamps.

BATTERY OVERCHARGED

Check the following for probable causes:

1. Voltage limiter set too high for vehicle operating conditions.
2. Voltage limiter coil open, 14-ohm resistor open, broken coil lead wire or solder connection in regulator.
3. Voltage limiter upper contacts stuck closed.
4. Ground wire loose or broken between regulator and alternator.
5. Shorted cell in battery causing other cells to use water excessively.

VOLTAGE LIMITER CONTACTS BURNED

Check the following for probable causes:

1. Shorted or grounded field coil or circuit.
2. Brush retracting wire not removed after a repair operation.

NOISY ALTERNATOR

Check the following for probable causes:

1. Defective bearing.
2. Shorted rectifier (magnetic noise).
3. Loose, worn, or frayed drive belts.
4. Bent fan blade.
5. Loose rear housing or improperly installed stator.
6. Loose pulley, or single sheave pulley installed backwards causing bent fan.
7. Loose mounting bolts.

AMMETER POINTER OR LIGHTS FLICKER

Check the following for probable causes:

1. Dirty or oxidized regulator contacts. (Pointer fluctuation is characteristic when regulation is just starting.)
2. Loose connections in charging system or damaged wiring harness.
3. Worn-out brushes or broken pig-tail wire.

GLOSSARY OF TERMS

ALTERNATING CURRENT–A periodic current which reverses itself at regular intervals.

ALTERNATOR–An electric generator which produces alternating current. In automotive applications, this current is changed by rectification to direct current.

AMPERE–The amount of electrical current produced by one volt acting through a resistance of one ohm.

BALLAST RESISTOR–A resistor which is used in a circuit to help smooth out fluctuations in line voltage.

CIRCUIT–The complete path of an electric current, including, usually, the generating device. This complete path is called a closed circuit, and when its continuity is broken, an open circuit.

COIL–A spiral of wire, or an instrument composed of such a spiral and its accessories.

CONDUCTOR–A substance or body capable of transmitting electricity.

DIODE–A device which contains unlike chemical elements in a state of covalent bonding designed to allow electricity to pass in only one direction. This characteristic enables the diode to convert alternating current to direct current.

DIRECT CURRENT–An electrical current flowing in one direction only.

DRAW (AMPERAGE)–The quantity of current used to operate an electrical device.

DROP (VOLTAGE)–The net difference in electrical pressure when measured across a resistance.

ELECTROMOTIVE FORCE–That which moves, or tends to move, electricity; the amount of energy derived from an electrical source per unit quantity of electricity passing through the source.

ELECTROMAGNET–A core of magnetic material, in practice always soft iron, surrounded by a coil of wire through which an electric current is passed to magnetize the core.

FIELD–Short for field magnet, field winding, etc. Also used to designate the area in which a magnetic flow occurs.

FLUX DENSITY–Flux is the rate of flow. Flux density is a rate-mass relationship. Also the lines of magnetic force passing or flowing in a magnetic field.

INDUCTION–The act or process by which an electrical conductor becomes electrified when near a charged body.

MAGNET–Any body having the property of attracting; specifically a mass of iron or steel having this property artificially imparted and hence called an artificial magnet.

OHM–The practical unit for measuring electrical resistance, being the resistance of a circuit in which a potential difference of one volt produces a current of one ampere.

PHASE–The position an electrical wave occupies in its cycle. (The 3-Phase current referred to in this publication relates to that current which is delivered through the three coil windings in the stator and the fact that these windings differ in phase successively by one-third cycle–or 120 electrical degrees.)

POLARITY–The quality or condition inherent in a body which exhibits opposite, or contrasted, properties or powers, in opposite or contrasted parts or directions; the having of poles, polarization.

RECTIFIER–An electrical device for changing alternating current into direct current.

RELAY–A device for interrupting an electrical circuit. Often operated automatically.

RESISTANCE–The opposition offered by a substance or body to the passage through it of an electric current.

ROTOR–In an alternator–as used in this book–the rotating member which includes the field coil and magnetic poles. It provides a revolving field inside the stator.

SHORT CIRCUIT–Most often used to identify an unintentional shortened path of current flow through a circuit.

SHUNT–A conductor joining two points in a circuit so as to form a parallel or derived circuit through which a portion of the current may pass, in order to regulate the amount passing in the main circuit.

STATOR–In an alternator–as used in this book–the stationary member inside which the magnetic field revolves.

VOLT–The unit of electromotive force; defined by the International Electrical Congress in 1893 and by U.S. statute as that electromotive force which steadily applied to a conductor whose resistance is one ohm will produce a current of one ampere.

WINDING–The coiling of a wire about itself or about some object. Often identified as a series winding, a shunt winding, etc.

FORD DIVISION Ford MOTOR COMPANY

FORM FD-7902-D

LITHO IN U.S.A.