training chart manual

SECTION r

DOUBLE CONTACT REGULATORS

Delco Remy

Delco Remy

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r SECTION

introduction

Double-contact regulators of the type covered in this manual are used with Delcotron® generators on a variety of applications including passenger cars, trucks and farm tractors. As a member of the charging circuit team, the regulator operates with the generator to charge the battery and operate electrical accessories.

A complete description of the operating principles of double-contact regulators is contained in this manual. Charging circuits having a dash indicator lamp as a charge indicator, and circuits having a dash ammeter are both included. For background material, it is suggested the following Delco-Remy training manuals be reviewed:

DR-5133A — Fundamentals of Electricity and Magnetism

DR-5133B — Storage Batteries

DR-5133K — Fundamentals of Delcotron Generators

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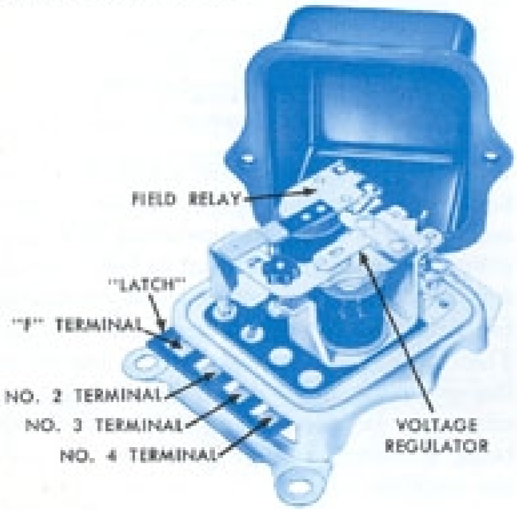
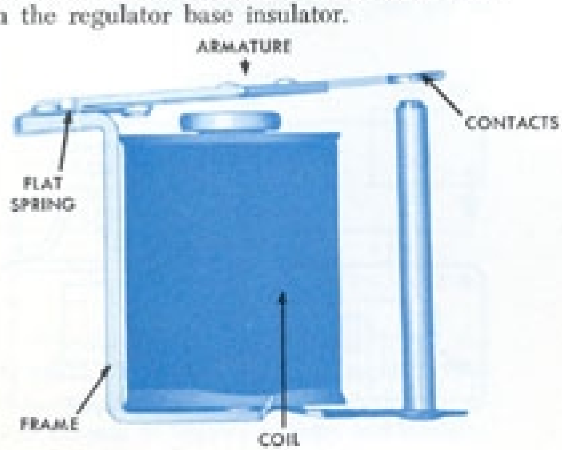
design features

A typical double-contact regulator contains a field relay unit and a voltage regulator unit. The double-contact regulator gets its name from the dual set of contacts used on the voltage regulator unit.

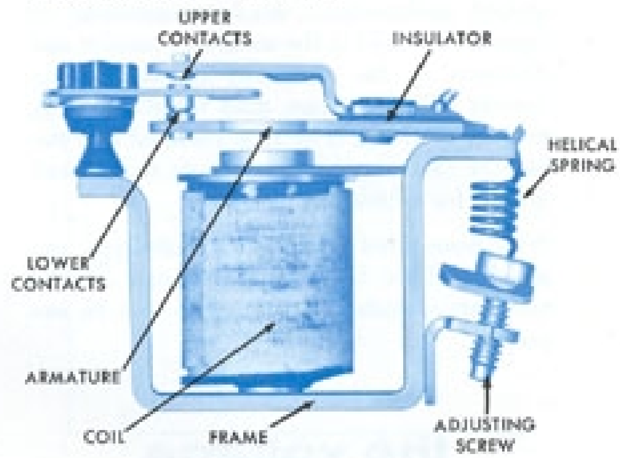


The regulator assembly is made waterproof by a soft rubber gasket between the cover and base and by molded sleeves located around the base rivets. The waterproof construction resists the entrance of harmful vapors and moisture, and greatly extends the useful life of the regulator.

The terminals are of the slip-connection type, and the mating wiring harness connector body is keyed to slots in the regulator base to insure proper connections. The terminals are fully enclosed and protected by the gang type connector, which is locked in place by a latch on the regulator base insulator.



The field relay unit consists of a winding and core mounted under a moveable flat steel armature. The armature is attached to an iron frame with a flat spring. A contact is located on the armature directly over a stationary contact. When the winding is energized, magnetic attraction overcomes the flat spring tension and causes the armature to move downward, closing the contacts.



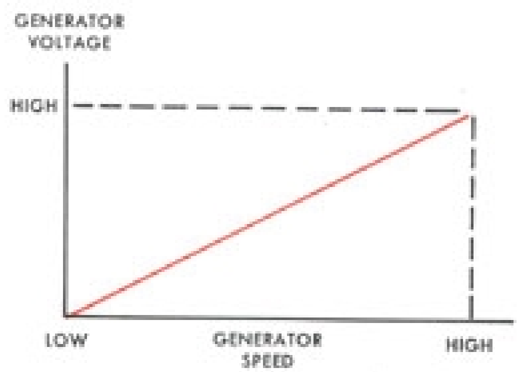
The voltage regulator unit consists of a shunt winding over an iron core which is assembled onto a metal frame. A flat steel armature is attached to the heel iron of the frame by a thermometal hinge. The hinge bends to allow the armature to move toward the core when magnetically attracted by current flowing in the shunt winding. The heel iron acts as a pivot point, and the magnetic attraction is opposed by an adjustable helical spring located on the other side of the pivot point.

The lower and upper contacts on the moveable armature are insulated electrically from each other, and a stationary set of contacts is located between the armature contacts. With this arrangement either the lower set of contacts will be closed, the upper set will be closed or both sets will be separated at any one time. The helical spring tension holds the lower contacts closed when the regulator unit is not operating.

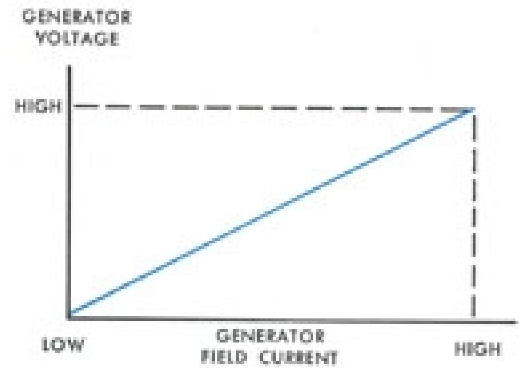
For maximum life the contacts are made of silver, platinum and gold. The upper contacts are made of an alloy of silver. The lower stationary contact is made of platinum and the moveable contact is made of gold on regulators used on negative ground systems. With this arrangement the current will flow from the gold to the platinum contact which is necessary for maximum life. If a negative ground regulator is used on a system with the positive post of the battery grounded, current will flow in the opposite direction from the platinum to the gold contact and very short contact life will result. Regulators for positive ground systems have the lower contacts reversed, with gold as the stationary contact and platinum as the moveable contact, so the current will flow from gold to platinum. A polarity marking, N or P, is stamped into the base of each regulator to denote the ground system for which it is designed.

With waterproof construction, protected terminals and the best-known materials as contacts, an extended regulator life can be expected.

the voltage regulator unit



The need for a voltage regulator unit in the charging circuit is brought about by the fact that the generator voltage increases as the generator speed increases. Since sufficient voltage must be developed at low speeds to charge the battery and operate electrical accessories, this voltage if unlimited at high speeds would increase to values that would overcharge the battery and damage the accessories. It is the sole function of the voltage regulator unit to limit the generator voltage to a safe value.

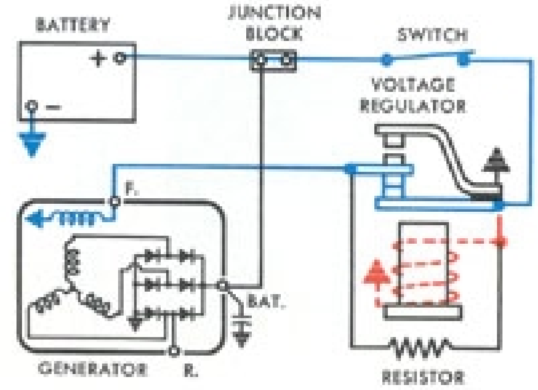


The voltage regulator unit achieves voltage limitation by controlling the amount of generator field current. Remembering that generator voltage is proportional to field current, it is seen that for any given speed decreasing the field current will decrease the voltage. Therefore, **by decreasing the field current as the generator speed increases,** a balancing effect can be obtained with the net result being a constant voltage limited by the voltage regulator unit.

The operation of the voltage regulator unit will be explained first by observing its behavior with changes in generator speed, and then by observing its behavior with changes in electrical load.

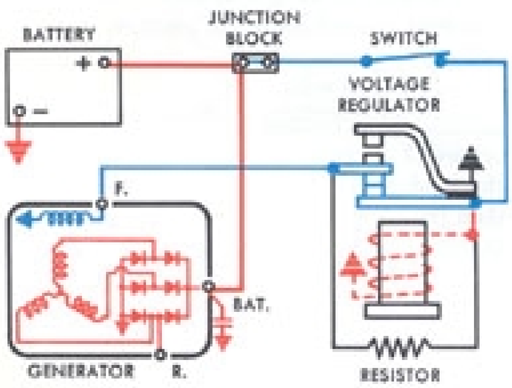
regulator operation with changes in speed

For purposes of discussion the generator speed range will be divided into three parts—low speed, medium speed and high speed. Typical speeds of 0-1000 rpm, between 1000 and 3000 rpm, and 3000 rpm and above will be used for the low, medium and high speed ranges.

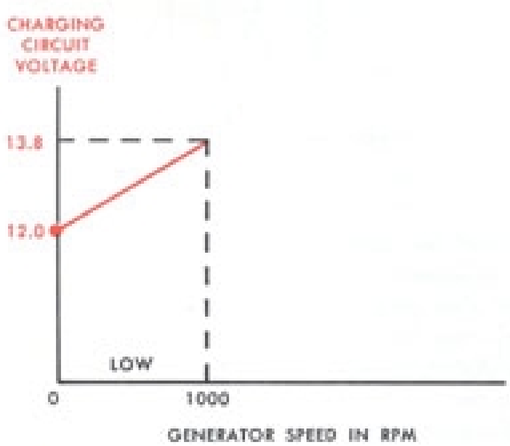


It is emphasized that these speed ranges are selected purely for purposes of discussion.

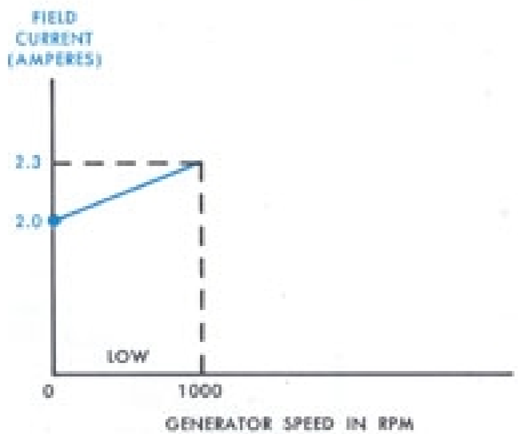
Let's consider first a basic simplified circuit, and observe the current flow path with the switch closed but with the generator not operating. The current flows from the battery through the closed lower or series contacts of the voltage regulator unit, and then through the generator field winding back to the battery. With the field winding energized by the battery, the generator will produce voltage when it begins to operate.



As the generator begins to operate and the speed increases, the generator voltage will increase to a value above the battery voltage. The generator then will charge the battery and supply its own field current.



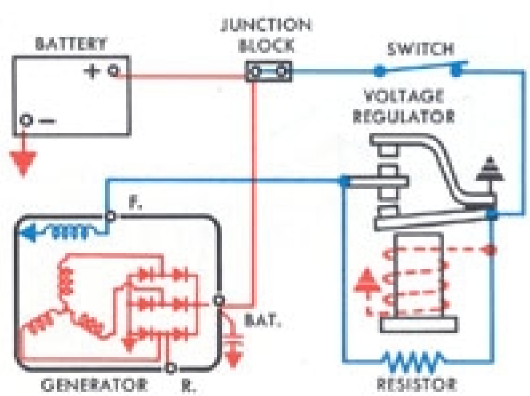
The charging circuit voltage throughout the low speed range will vary from battery voltage to some value just under the voltage regulator setting. If battery voltage is 12.0 volts, and the voltage regulator setting on the lower contacts is 13.8 volts, the voltage range will be 12.0 to just under 13.8 volts. Although this voltage will be impressed across the voltage regulator unit shunt winding, it will not be sufficient to attract the armature toward the core and open the lower contacts because the helical spring is adjusted to a 13.8 volt setting. Therefore, throughout the low speed range the lower contacts will remain closed.



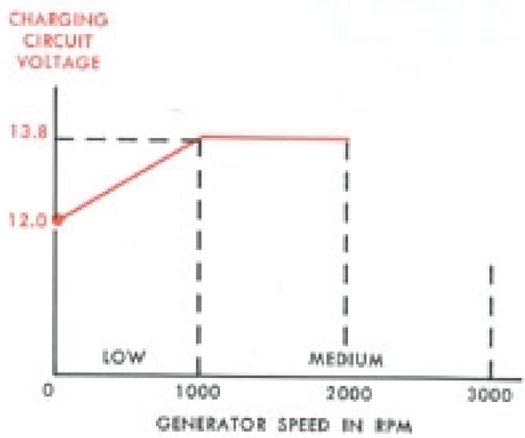
A typical generator having a field winding resistance of six (6) ohms would have a field current flow of two (2) amperes to 2.3 amperes. These values are obtained from Ohm's Law as follows:

$$\frac{12 \text{ volts}}{6 \text{ ohms}} = 2 \text{ amperes and } \frac{13.8 \text{ volts}}{6 \text{ ohms}} = 2.3$$

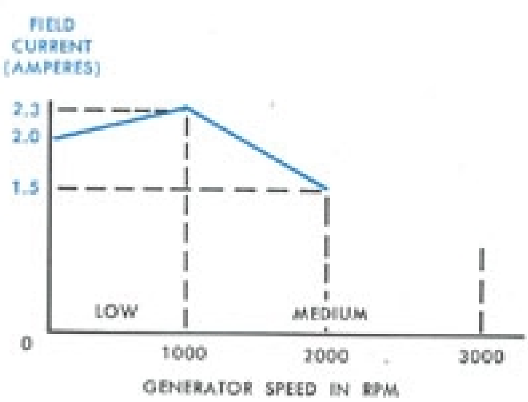
amperes. The curve shows the field winding current throughout the low speed range of the generator.



As the generator speed increases and moves into the medium speed range, the voltage reaches the 13.8 value which is the voltage regulator setting on the lower contacts. At this voltage the shunt winding creates enough magnetic pull to overcome the spring tension and attract the armature toward the core, causing the lower contacts to separate. With the contacts separated, the generator field current is diverted through the resistor which is in series with the field winding. The series resistor causes the field current to decrease, the generator voltage to decrease, and the magnetic pull created by the shunt winding to decrease. The spring then overcomes the magnetism and the lower contacts reclose.



This cycle then repeats as much as 50 cycles per second to limit the generator voltage to 13.8 volts. A curve showing the voltage at a constant 13.8 volt value for the lower part of the medium speed range, from 1000 to 2000 rpm, is shown.

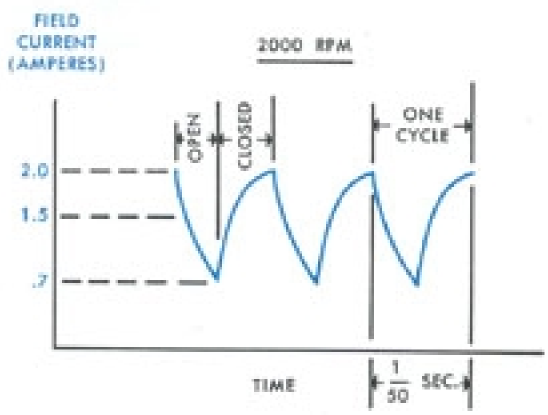


Also shown is a curve of the effective field current as the generator speed increases from 1000 to 2000 rpm. The meaning of the word "effective" will be explained later on. This curve illustrates the fact that the field current must decrease as the speed increases in order to limit the voltage to the 13.8 value. A typical value of effective field current at 2000 rpm may be 1.5 amperes. How the vibrating lower contacts control the field current to this value at this speed will now be explained.

If the resistance of the resistor is 14 ohms, and the field winding resistance is six (6) ohms, the field current with the contacts separated will be

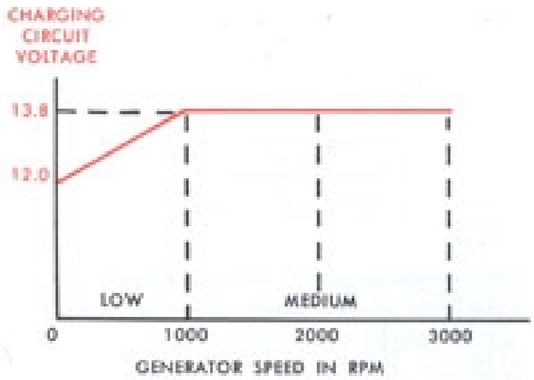
$$\frac{13.8 \text{ volts}}{14 + 6 \text{ ohms}} = .69 \text{ ampere,}$$

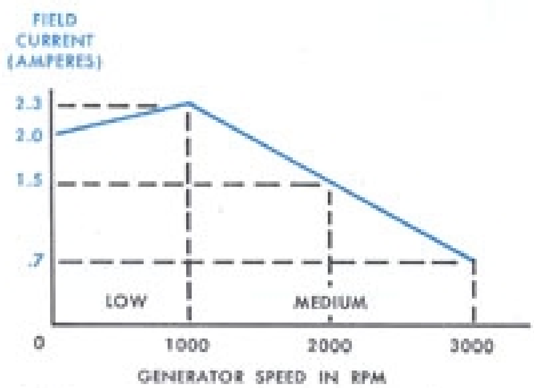
or say .7 ampere. With the contacts closed the field current will rise to 2.0 amperes and then the contacts will open. The field current, therefore, will vary between these two values as the contacts vibrate. A curve showing this variation in field current at 2000 generator rpm is illustrated.



From the curve it should be observed that a complete cycle of the contacts consists of an open period and a closed period. At 2000 rpm the length of time the contacts are open is slightly shorter than the length of time the contacts are closed. The net result is an effective current of 1.5 amperes, which is the exact field current needed at this speed to limit the generator voltage to 13.8 volts. The voltage regulator unit automatically selects the correct period of time to be open and the correct period of time to be closed in order to obtain the correct effective field current and voltage limitation.

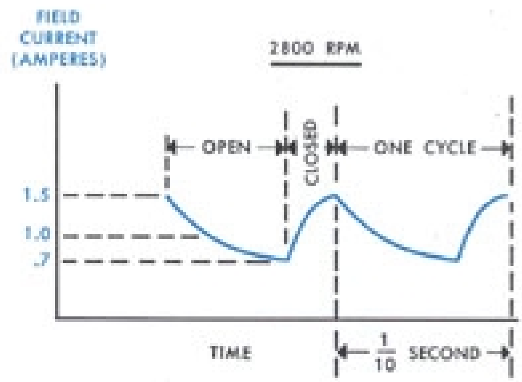
If the contacts are vibrating at the rate of 50 cycles per second, one complete cycle of open and close will require 1/50 of a second. This time period is shown on the illustration.





As the generator speed moves into the upper part of the medium speed range, the effective field current must decrease even further in order to limit the voltage to the 13.8 value. Curves showing the voltage and the decreasing field current in the 2000 to 3000 rpm range are illustrated. In the same manner as before, the voltage regulator unit will operate automatically to lower the field current, and will accomplish this primarily by changing the relationship between the open and closed periods in a cycle.

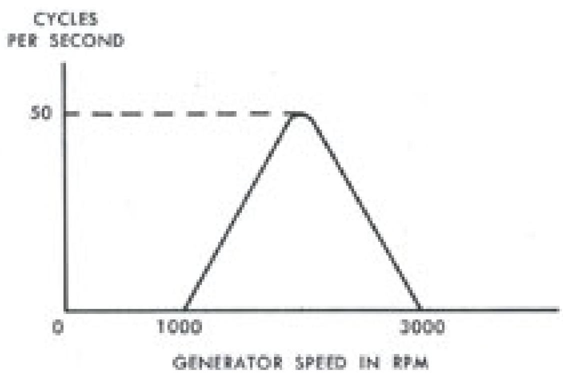
To illustrate, observe the curve of field current with time for the upper part of the medium speed range. A speed of 2800 rpm and an effective current of 1.0 ampere, will be used as an example. When the contacts close, the field current may rise to 1.5 amperes



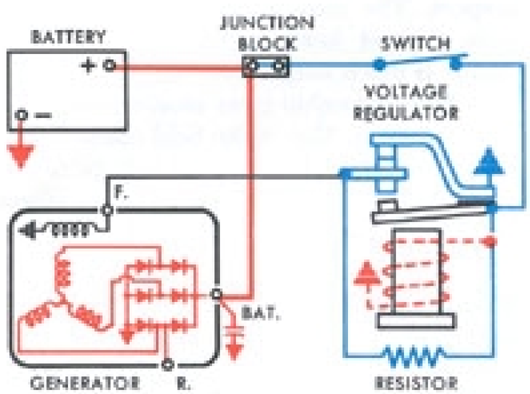
and then the contacts open. The field current then decreases to .7 ampere. As the contacts vibrate, the field current varies between these two values to give an effective current of 1.0 ampere. The contact periods have reversed from that at lower speeds; now the open period is much longer than the closed period, and this relationship gives an effective current of 1.0 ampere. This is the field current needed at this speed to limit the voltage to 13.8 volts. At this speed the contacts may vibrate at 10 cycles per second, so the time for one cycle will be 1/10 of a second as illustrated.

When the generator speed reaches the 3000 rpm value, the voltage regulator armature may "float" so that both sets of contacts remain constantly open and do not close. At this speed the 14 ohm resistor in series with the field provides the field current needed to limit the voltage, and this field current will be constant at about the .7 ampere value. The voltage across the shunt winding creates magnetism to exactly balance the spring tension and hold the armature in its unchanging position.

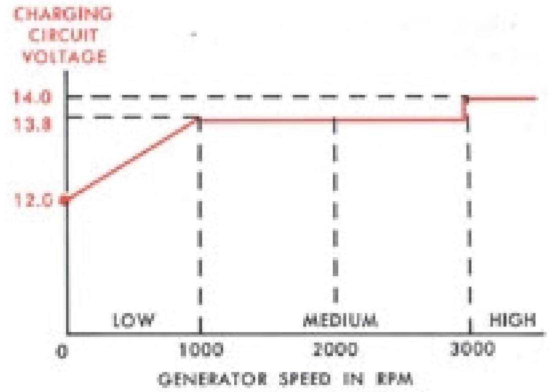
It is interesting to observe that the contacts remain closed at 1000 rpm and remain open at 3000 rpm. We have seen that in between these two speeds the contacts vibrate, and stay open for progressively longer periods of time until at 3000 rpm they are open all the time. With a vibrating frequency of zero cycles per second at both 1000 and 3000 rpm, the maximum frequency occurs somewhere in between. We have chosen as an example 50 cycles per second at 2000 rpm. Although the curve shown may not be exact, it serves to illustrate the fact that the frequency of vibra-

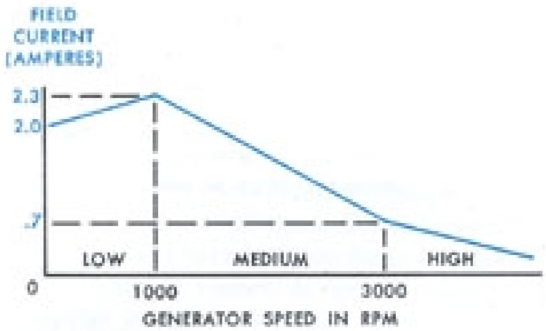


tion increases, reaches a maximum, then decreases again to zero as the speed goes from 1000 to 3000 rpm.

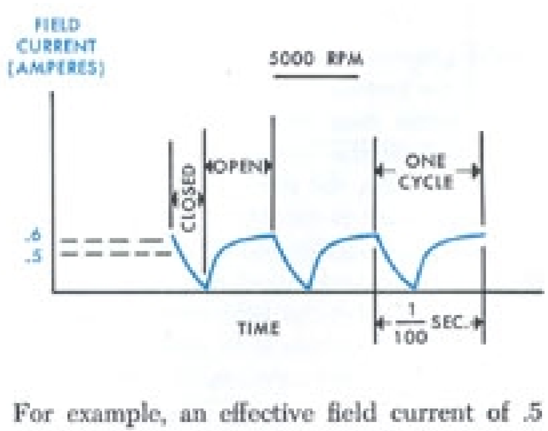


When the generator speed moves into the lower part of the high speed range, the voltage will increase slightly in order to overcome the spring tension and pull the armature closer to the core. We will use an example of 14.0 volts, which is the voltage regulator setting on the upper set of contacts. As the armature moves closer to the core, the upper contacts will close, allowing current to flow through the 14 ohm resistor directly to ground through the closed upper contacts, bypassing the field winding completely. The field current will decrease to practically zero, the generator voltage will decrease, the shunt winding magnetism will decrease, and the spring will cause the contacts to open. This will reestablish field current through the 14 ohm resistor, and the cycle will then repeat as much as 300 times per second to limit the voltage to the 14.0 value throughout the high speed range. A voltage curve is illustrated.

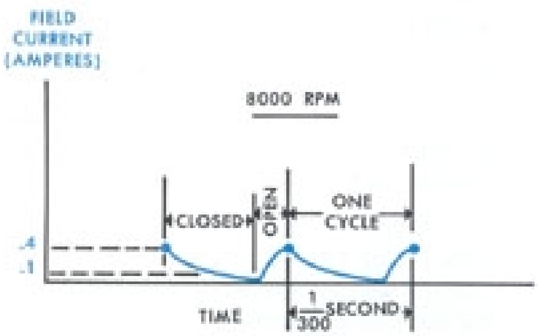




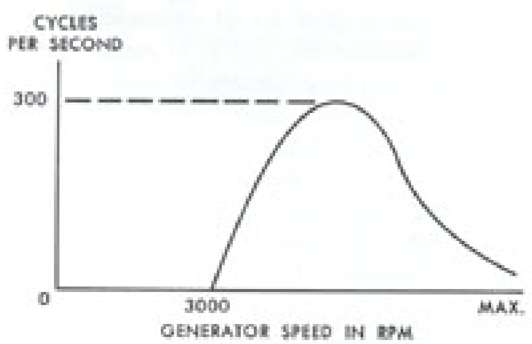
Also illustrated is a curve showing the decreasing field current as the generator speed increases to its maximum operating value. The curve shown represents an effective field current—the actual curve varies between two values at different speeds as the upper contacts vibrate.



For example, an effective field current of .5 ampere may be needed at 5000 rpm to limit the voltage to 14.0 volts. A field current curve at this speed giving an effective field current of .5 ampere is illustrated. Note that the contacts are open for a longer period of time than they are closed. With a vibrating frequency of 100 cycles per second, only 1/100 of a second is required for a complete open and closed period.



As the generator speed increases above 5000 rpm, the open and closed periods change to reduce the field current even further as required. For example, at 8000 rpm the field current requirement may be only .1 ampere, and the field current curve at this speed is illustrated. Observe that the contact periods have reversed, and are now closed longer than they are open. A vibrating frequency of 300 cycles per second under these conditions would require only 1/300 of a second for a complete open and closed period.



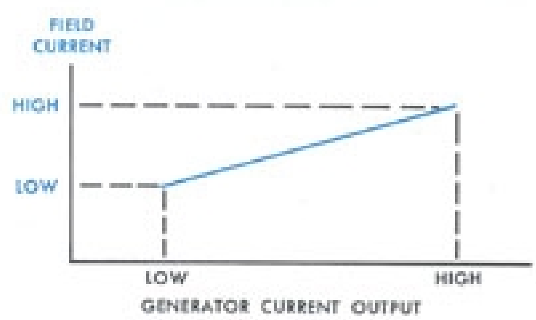
As in the medium speed range, the vibrating frequency for the high speed range increases from zero at 3000 rpm, reaches a maximum, and approaches but never quite reaches zero again (upper contacts always closed) as the generator reaches its maximum operating speed. The frequency curve shown while not necessarily exact serves to illustrate this fact.

In summary, both the lower contacts and upper contacts operate automatically to provide the field current needed at various speeds to achieve voltage limitation. In simplest terms the field current decreases as the speed increases.

In our discussion we have used numerical values and illustrations solely for the purpose of explaining the method whereby the voltage regulator unit limits the generator voltage. We have assumed that the battery state of charge, electrical load, temperature and other factors were constant throughout our discussion. Although these factors cause some variations in operation, our discussion still serves to explain the basic principles on which the voltage regulator unit operates.

regulator operation with changes in load

The electrical load in a charging circuit is determined in part by the state of charge of the battery and the number of accessories in operation. As the battery state of charge decreases, and as more accessories are turned on, the current requirement from the generator increases.



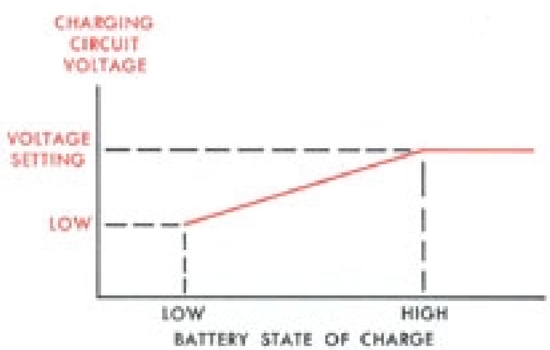
It is a characteristic of the generator that as its current output increases more field current is needed to develop the required voltage. For any given speed, the voltage regulator unit will automatically operate to change its closed and open periods and provide more field current as the generator current output increases. In simplest terms, as the output increases the field current increases.

In order to illustrate a very important effect of battery state of charge on voltage limitation, let's consider a hypothetical charging system.

Assume that the voltage regulator setting is 13.8 volts, and that electrical accessories drawing 30 amperes at this voltage are turned on. Furthermore assume that the maximum output capacity of the generator is 40 amperes.

If the battery is fully charged, it will draw a small charging current of say two amperes. Under these conditions the generator with sufficient speed will provide a total output of 32 amperes and the voltage regulator will operate to limit the voltage to 13.8 volts.

Now consider the operation when the battery is discharged so that it would accept a 20 ampere charging rate at 13.8 volts. With a 30 ampere accessory load the total current requirement would be 50 amperes at 13.8 volts. But the generator is capable of supplying only 40 amperes; therefore, the accessories will receive about 30 amperes and the battery about 10 amperes. With a 10 ampere charge rate to the battery some voltage less than 13.8 volts is required, consequently, the generator voltage will be below 13.8 volts. As an example, the voltage may be 13.6 volts which is the voltage needed to provide a 10 ampere charge rate to the battery. This means that under these conditions the voltage regulator is not vibrating, and the lower contacts remain closed at all times, even though the generator may be operating at high speeds.



From the foregoing discussion it is seen that the generator voltage even at high speeds may be below the regulator setting if the battery is in a discharged condition. In other words the voltage regulator unit does not necessarily operate at all times throughout the medium and high speed ranges. If the load requirements exceed the maximum generator output, the voltage regulator unit will not be operating. Of course, in time the battery will become charged and the regulator unit will then start to operate.

In summary, with changes in load:

1. The voltage regulator unit will operate at medium and high speeds if the battery is charged and load requirements are low.
2. The voltage regulator unit will not operate even at high speeds if the battery is discharged and the load requirements exceed the maximum generator output.

These conclusions are general in nature, and ignore many other factors such as battery temperature which has an important effect on the charging circuit voltage. Nevertheless, the basic illustrations serve to point out the fact that even at high speeds the voltage regulator unit may not be operating. Accordingly, no attempt should be made to adjust the voltage regulator setting under these conditions, with the voltage regulator not operating.

advantages of dual contacts

The use of a dual set of contacts on the voltage regulator unit results in contact point life better than that obtainable with a single set of contacts. If a single set of contacts is used, a primary design requirement is that the resistor across the contacts must be of sufficiently high value to limit the voltage at high speeds. Unfortunately, as the resistance value is increased the contact life decreases.

By using an upper set of contacts to limit the voltage at high speeds, the need for a resistor of high value is eliminated, and a resistor of low value (14 ohms) can be used across the lower contacts to limit the voltage at medium speeds. The lower contact point life is accordingly improved.

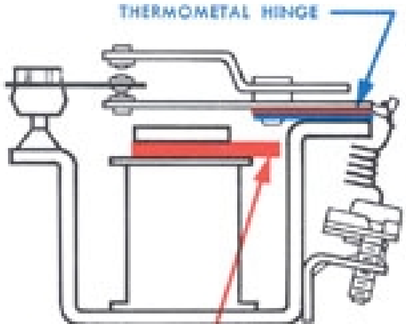
It should also be noted that the upper contacts when they separate break a resistive circuit and not an inductive circuit since no field current flows through the contacts on separation. Consequently, little arcing occurs and the upper contact point life is very good.

temperature compensation

One important feature of the voltage regulator unit is the use of temperature compensating devices. It should be recalled that a high voltage is needed to charge a cold battery, and a low voltage is needed to prevent overcharge to a hot battery.

Since the battery on many applications is subjected to a wide range of operating temperatures, it is desirable to use temperature compensating devices to change the operating voltage to suit the battery requirements. This is automatically accomplished by temperature compensating devices.

Three types of temperature compensating devices are often used on double contact voltage regulator units. The three types are the thermometal hinge, the magnetic bypass and the ballast resistor. All three operate at the same time to give a lower setting when hot and a higher setting when cold. Typical values might be 14.0 volts at 60° F and 13.0 volts at 180° F, a range of one volt.

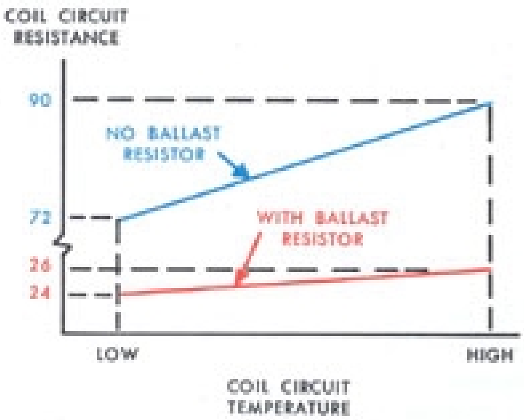


The thermometal hinge consists of two dissimilar flat pieces of metal bonded together and mounted between the voltage regulator armature and the heel iron. The two dissimilar pieces of metal have different rates of expansion and contraction with temperature changes. Due to the different rates of expansion and contraction with temperature changes, the thermometal hinge tends to create a torque aiding the magnetic pull as the operating temperature increases. This means that less magnetic pull is needed to move the armature, and the unit will operate at a lower voltage as the temperature increases. As the temperature decreases, the torque of the hinge opposes the magnetic pull and a higher voltage is needed to overcome the combined effect of the hinge and spiral spring and move the armature toward the core. Therefore, at low temperatures the regulator operates at a higher voltage.

The magnetic bypass is a flat piece of special nickel steel mounted on top of the core on the voltage regulator unit. This metal changes its magnetic permeability with temperature; that is, it conducts magnetic lines easier when cold than when hot. At cold temperatures some of the magnetic lines pass through the metal bypass to the iron frame and are diverted away from the armature, leaving a deficiency of magnetic lines in the armature and therefore reducing the magnetic pull on the armature. To make up for this deficiency, and thereby attract the armature toward the core, more current must flow through the shunt winding which must be provided by a higher operating voltage. Thus the regulator operates at a higher voltage when cold. As the temperature increases, the metal bypass conducts fewer magnetic lines and allows more lines to pass through the armature. This reduces the total magnetism that the shunt winding must provide, and the regulator setting decreases as the temperature increases.

As the outdoor temperature changes from cold to hot, and as the winding temperature increases due to self-heating caused by current flow, the temperature at which the shunt winding operates increases. This causes the resistance of the shunt winding to increase. With higher resistance, more voltage is needed to create the same magnetic pull and cause the contacts to separate. The resulting high voltage at high temperatures is just the opposite effect that is desired. To decrease this effect a ballast resistor is often used in series with the shunt winding. The resistance of the ballast resistor remains practically constant regardless of temperature.

To illustrate, consider a shunt winding having a resistance of 72 ohms, and no ballast resistor. Due to an increase in the temperature of the



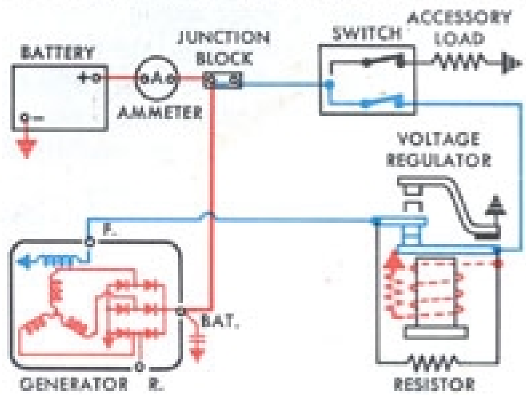
winding, the resistance may increase by 25 per cent, or 18 ohms, making the winding resistance 90 ohms. Now compare this 90 ohm value with the total resistance resulting from the same temperature rise of a coil and ballast resistor in series. The shunt coil will use larger wire but the same number of ampere turns as before. Its resistance is eight ohms before the temperature rise, and the ballast resistor has a resistance of 16 ohms giving a coil circuit resistance of 24 ohms. When the temperature increases, the coil resistance increases by the same 25 per cent to 10 ohms, but the ballast resistor remains essentially at 16 ohms. The total resistance now is 26 ohms which is an approximate eight per cent increase in coil circuit resistance rather than 25 per cent. Thus, the effect of the ballast resistor is to cause a smaller increase in coil circuit resistance with temperature rises.

In conclusion, it is seen that all three methods of temperature compensation act together to cause the regulator to operate at a lower setting when hot and a higher setting when cold. This variation in the operating voltage of the voltage regulator unit occurs automatically with temperature changes to provide a more desirable voltage across the battery for charging purposes. The three methods of compensation are combined to take advantage of the desirable characteristics of each method.

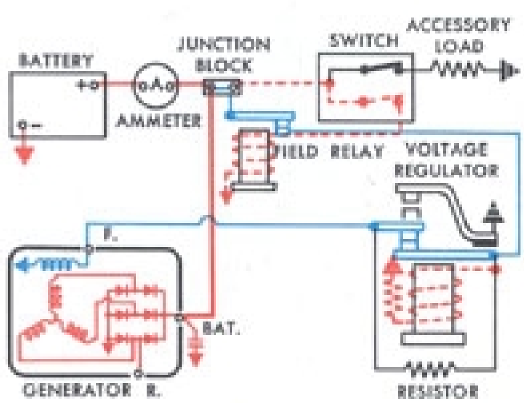
the field relay unit

The field relay unit is a simple magnetic switch that is made to close when the field relay winding is energized. The flat spring located between the moveable armature and iron frame causes the contacts to separate when the winding is de-energized. The primary function of the field relay is to provide a low resistance connection between the battery and regulator shunt coil, and also to disconnect the generator field from the battery when the switch is turned off.

In order to better understand the need for a field relay, consider first, a simple circuit arrangement, as shown. This circuit has a very undesirable feature, in that the regulator will provide a constant voltage at the switch, but the voltage across the battery, that is, from the junction block to ground, will vary



as the accessory load varies. This occurs due to the line drop between the switch and



junction block. This line drop varies as the accessory load is varied.

This undesirable operating characteristic is corrected by adding a field relay to the circuit and connecting the field relay to the junction block as shown. This causes the regulated voltage to appear at the junction block, and to remain constant and unaffected by the accessory load. In this type of circuit, the field relay winding is energized when the switch is closed, and generator field current flows through the closed field relay contacts and voltage regulator contacts to the field winding.

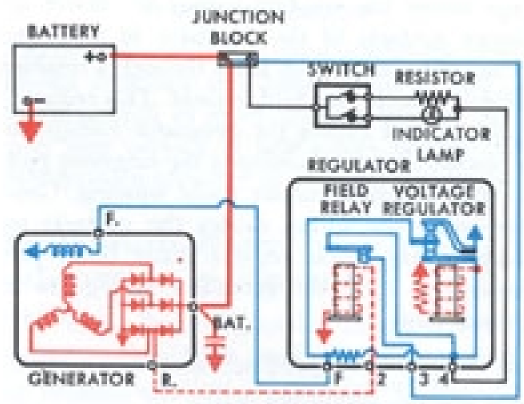
The circuit between the junction block and the ungrounded side of the voltage regulator shunt winding is called the sensing circuit. Since the voltage setting of the regulator is measured across the voltage regulator shunt winding, this circuit connects the regulated voltage to the junction block where it is impressed across the battery. The point in the charging circuit between the generator and battery to which this sensing circuit is connected is called the sensing point. In the illustration, this point is the junction block, and the sensing circuit consists of the leads and field relay connected between the junction block and the ungrounded side of the regulator shunt winding.

The circuit just described is ideally suited to an ammeter as a charge indicator. When an indicator lamp is used as a charge indicator, a different type of circuit arrangement is required. This type of circuit, along with other circuits in common usage, is covered in the following sections.

indicator lamp circuit

On many applications an indicator lamp is used in the charging circuit to indicate that the generator is producing voltage. A typical wiring diagram showing internal circuits in which an indicator lamp is used is illustrated. The operation of the regulator in this circuit is described as follows.

When the switch is closed, before the engine



has started, the indicator lamp lights to indicate the generator is not operating. The current flow can be traced from the battery to the switch, through the indicator lamp and resistor which is in parallel, and then through the voltage regulator contacts. From here it continues to flow on through the generator field winding to ground, completing the circuit back to the battery. Current through this circuit energizes the field windings sufficiently to insure voltage build-up in the stator windings when the engine starts. The voltages generated in the stator windings are then changed or rectified by the six generator diodes to a d.c. voltage which appears at the "BAT" or output terminal on the generator. The resistor in parallel with the bulb allows more current to flow through the field winding to insure initial voltage build-up in the stator windings.

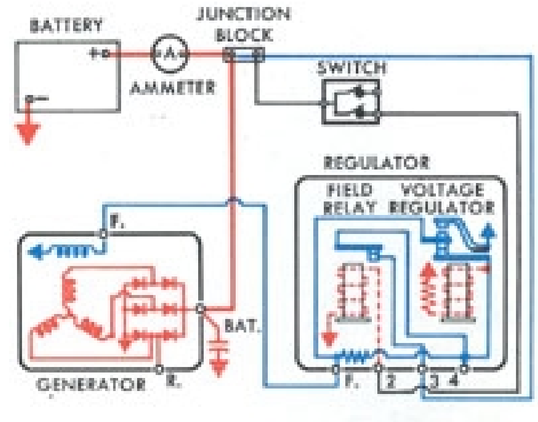
As the generator begins to operate, voltage from the "R" or relay terminal is impressed through the regulator No. 2 terminal across the field relay winding, causing the relay contacts to close. This connects the regulator No. 4 terminal directly to the battery through the field relay contacts, causing the indicator lamp to go out. Generator field current then flows from the battery to the regulator No. 3 terminal, and then through the field relay contacts and voltage regulator lower or series contacts to the field winding.

As the speed of the generator increases, the voltage at the "BAT" terminal of the generator also increases. This impresses a higher voltage through the field relay contacts and across the voltage regulator shunt winding. The increased magnetism created by this higher voltage across the winding causes the lower or series contacts of the regulator to separate. The field current then flows through a resistor which reduces the field current. This reduced field current causes the generator voltage to decrease thereby decreasing the magnetic pull of the voltage regulator shunt winding. Consequently the spring causes the contacts to reclose. This cycle repeats many times per second to limit the generator voltage to a preset value.

As the generator speed increases even further, the resistor, connected across the contacts, is not of sufficiently high value to maintain voltage control on the contacts. Therefore the voltage increases slightly causing the upper or "shorting" contacts to close. When this happens, the generator field winding is shorted and no current passes through the winding. With no current in the field winding, the generator voltage decreases, which also decreases the magnetism in the shunt winding and the upper contact points open. With these points open, field current flows through the resistor and the field winding. As the voltage increases, the contacts reclose. This cycle then repeats many times per second to limit the generator voltage to a preset value at high generator speeds. The voltage regulator unit thus operates to limit the value of generator voltage throughout the generator speed range. Consequently the electrical accessories are protected from excessive voltage which would cause damage.

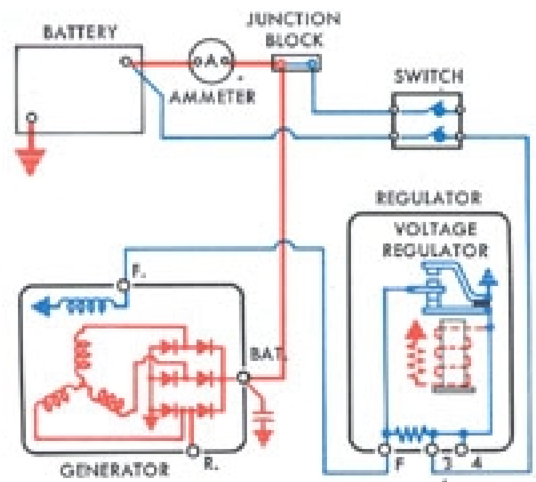
Some vehicle manufacturers may use this wiring arrangement with an ammeter between the junction block and battery as a charge indicator. In this case the indicator lamp bulb is merely removed and the same wiring harness is used. The circuit then operates in the same manner just described, except initial field current before the field relay closes flows through the resistor only. Although the resistor reduces the initial field current, the initial current is sufficient to allow rapid build-up of voltage by the generator.

ammeter circuits



A wiring diagram in which an ammeter is used as a charge indicator is illustrated. In this circuit the field relay winding is connected directly to the battery when the switch is closed. Generator field current then flows from the battery into the regulator No. 3 terminal, through the field relay contacts and the lower contacts on the voltage regulator unit, and then through the field winding back to the battery. The voltage regulator unit then operates in exactly the same manner as previously described.

Another circuit using an ammeter in which no regulator field relay is used is shown in



this illustration. A special switch having a separate set of contacts for the field current circuit eliminates the need for a field relay. In this circuit field current flows through the closed switch at all times, through the lower contacts on the voltage regulator unit, and then through the field winding back to the battery or generator. The voltage regulator unit operates in exactly the same manner as has been previously described.

adjustments and maintenance

adjustments

During our discussions throughout this manual typical numerical values have been used. It should be recognized that actual values may vary from the ones used as examples due to the many variables in the charging circuit such as temperature, battery state of charge and engine speed.

The setting of the voltage regulator unit is accurately adjusted during manufacture, and usually does not require readjustment. The spring tension can be changed if necessary in order to readjust the operating voltage. This adjustment should be made only by following the procedure outlined in the applicable Delco-Remy service bulletin. The applicable service bulletin number is listed alongside the regulator model number in the Delco-Remy Test Specifications Booklet.

The voltage regulator setting should be readjusted only if a prolonged service record of battery behavior indicates an adjustment is necessary. If the battery remains undercharged over reasonably long service periods, usually due to consistent operation at low speeds and low temperatures with heavy electrical loads, the setting should be raised as recommended by the applicable service bulletin. This conditon will be evidenced by slow cranking and little if any water usage in the battery. If consistent overcharge as evidenced by excessive battery water usage prevails over a lengthy service period, usually caused by long periods of high speed driving at high temperatures, the regulator setting should be lowered. It is emphasized that the regulator setting as originally adjusted during manufacture will be ideal for the great majority of applications, with only a very few isolated cases requiring readjustment.

maintenance

The double-contact regulator utilizes the best-known materials and design features, and is manufactured to exact specifications to provide long periods of satisfactory service. No maintenance attention of any kind is required.

the Delco-Remy education program

The Delco-Remy Education Program is designed to provide to mechanics and students up-to-date technical information on automotive electrical equipment.

This manual, one of a series, is a part of the program. Used in a classroom in conjunction with training charts, these manuals aid in explaining the theory of operation and construction of electrical units.

Also available to servicemen and students is a series of Maintenance Handbooks. Each handbook is a collection of Delco-Remy service bulletins. They serve as a reference in the maintenance and testing of electrical units.

Test Specification Booklets contain service test data for the electrical units manufactured by Delco-Remy. These booklets are designed for automotive electricians engaged in maintenance and testing.

Strip films with records and film booklets cover the basic operation and maintenance of units in electrical systems. There are many pictures and a wealth of information in diagrams and legends.

Other booklets cover various phases of maintenance and testing procedures for Delco-Remy electrical units and their related circuits.

For complete information on the availability and cost of the above material write to: Technical Literature Department, Delco-Remy Division, General Motors Corporation, Anderson, Indiana.