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AUTOMOTIVE DIESEL MAINTENANCE 2. UNIT XVI, LEARNING ABOUT AC GENERATOR (ALTERNATOR) PRINCIPLES (PART I).

HUMAN ENGINEERING INSTITUTE, CLEVELAND, OHIO

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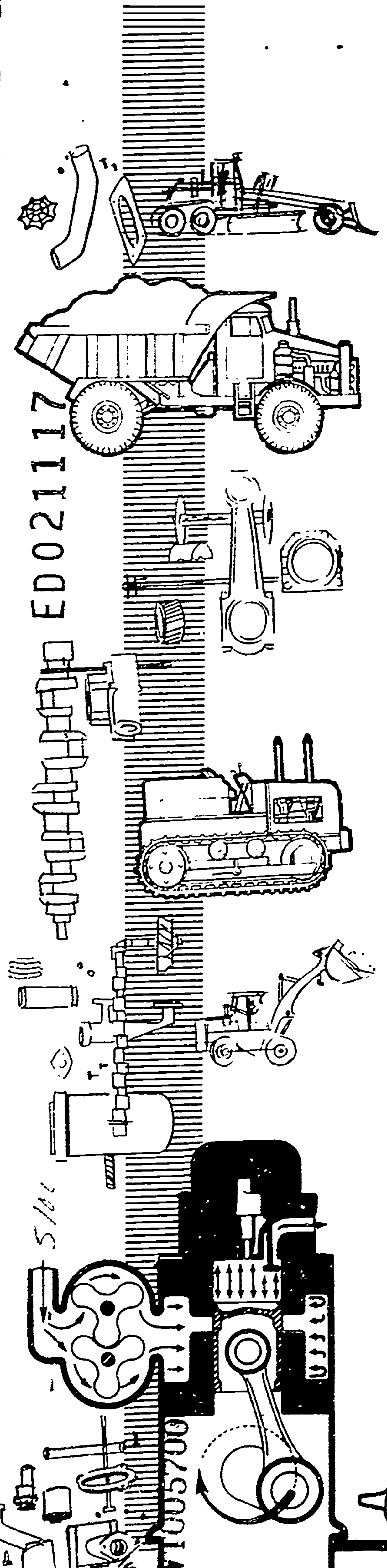
THIS MODULE OF A 25-MODULE COURSE IS DESIGNED TO DEVELOP AN UNDERSTANDING OF THE OPERATING PRINCIPLES OF ALTERNATING CURRENT GENERATORS USED ON DIESEL POWERED EQUIPMENT. TOPICS ARE REVIEWING ELECTRICAL FUNDAMENTALS, AND OPERATING PRINCIPLES OF ALTERNATORS. THE MODULE CONSISTS OF A SELF-INSTRUCTIONAL PROGRAMED TRAINING FILM "AC GENERATORS I--UNDERSTANDING ALTERNATOR PRINCIPLES" AND OTHER MATERIALS. SEE VT 005 685 FOR FURTHER INFORMATION. MODULES IN THIS SERIES ARE AVAILABLE AS VT 005 685 - VT 005 709. MODULES FOR "AUTOMOTIVE DIESEL MAINTENANCE 1" ARE AVAILABLE AS VT 005 655 - VT 005 684. THE 2-YEAR PROGRAM OUTLINE FOR "AUTOMOTIVE DIESEL MAINTENANCE 1 AND 2" IS AVAILABLE AS VT 006 006. THE TEXT MATERIAL, PROGRAMED TRAINING FILM, AND THE ELECTRONIC TUTOR MAY BE RENTED (FOR $1.75 PER WEEK) OR PURCHASED FROM THE HUMAN ENGINEERING INSTITUTE, HEAQUARTERS AND DEVELOPMENT CENTER, 2341 CARNEGIE AVENUE, CLEVELAND, OHIO 44115. (HC)

STUDY AND READING MATERIALS



AUTOMOTIVE DIESEL 2 MAINTENANCE

LEARNING ABOUT AC GENERATOR (ALTERNATOR) PRINCIPLES (PART I)

UNIT XVI

SECTION A — REVIEWING ELECTRICAL FUNDAMENTALS

SECTION B — OPERATING PRINCIPLES OF ALTERNATORS

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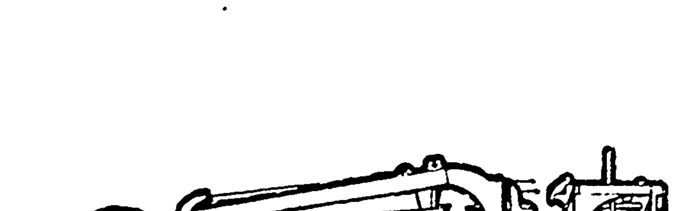


HUMAN ENGINEERING INSTITUTE

SECTION A -- REVIEW OF FUNDAMENTALS

WHAT IS ELECTRICITY?--All matter in the universe is made up of tiny particles called molecules, and each molecule, in turn, is made up of one or more atoms. An atom consists of protons, which form its core, and electrons, which revolve around the core, much like the earth revolves around the sun. An example is an atom of hydrogen, which contains only one proton and one electron, as shown in Figure 1. Other examples are an atom of copper which contains 29 protons and 29 electrons, and the uranium atom which contains 92 protons and 92 electrons. It is this difference in the number of protons and electrons that causes the various elements, such as hydrogen, copper and uranium to be different. Needless to say, an atom is an extremely small particle. When we speak of electricity, we are talking about the tiny electrons.

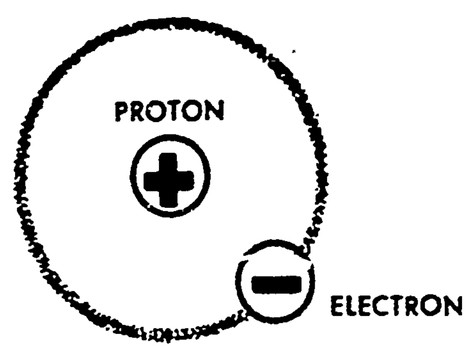


Fig. 1 An atom of hydrogen

CURRENT OR AMPERES -- Electric current is defined as a movement of electrons through a conductor. A conductor, such as a wire, is often pictured as a small circle, representing the end of the wire. Current direction through the wire is indicated by a cross or dot placed in the circle. The cross used in this sense should not be confused with the plus (+) sign often used to denote polarity, which will be explained later.

In some materials, such as copper, electrons can be caused to leave their atoms and move to other atoms. This flow of electrons is continuous, that is, every time an atom gives up an electron, it collects another one to take its place. This movement of electrons is called electric current and is measured in amperes. An analogy is the flow of water through a pipe measured in gallons per minute. When 6.28 billion, billion electrons pass a certain point in the circuit in one second, the amount of current flow is one ampere.

Electrons, however, will not move through the circuit of their own free will. There must be some kind of force to cause the electrons to move.

VOLTAGE -- The force or pressure which causes electrons to flow in any conductor, such as a wire, is called voltage. It is measured in volts and is similar to the pressure that causes water to flow in a water pipe. Voltage is the difference in electrical pressure measured between two different points in a circuit. Thus, taking a 12 volt battery as an example, the voltage measured between the two battery posts is 12 volts. An important concept is voltage potential at a certain point in the electrical circuit. This simply means the voltage or electrical pressure at a particular point with respect to another point. Thus, if the voltage potential of one post of the 12 volt battery is zero, the voltage potential at the other post is 12 volts with respect to the first post.

Another important concept is polarity. One post of a battery is said to be positive, and the other negative. The conventional direction of current flow in a circuit is from positive (+) to negative (-). This choice of direction is unfortunate, because the electrons actually flow from negative to positive; that is, the electrons leave the negative battery post, flow through the circuit, and return to the positive post. This should cause no confusion, however, because when electrons flow in one direction, current is said to be flowing in the opposite direction.

RESISTANCE -- The voltage or electrical pressure needed to produce current flow in a circuit is necessary to overcome the resistance in the circuit. Resistance to the flow of electrons is measured in ohms. One volt will cause one ampere to flow through a resistance of one ohm.

If three resistors of equal value are connected to a 12 volt battery, the battery voltage will cause current to flow through the resistors. As the current flows through the resistors, a voltage drop, or loss in electrical pressure, occurs in each resistor. In the circuit shown in Figure 2, the voltage drop across each resistor is four volts. The voltage potential at A is 12 volts, at B 8 volts, at C 4 volts, and at D zero volts, all with respect to the negative post of the battery, which is considered zero voltage potential.

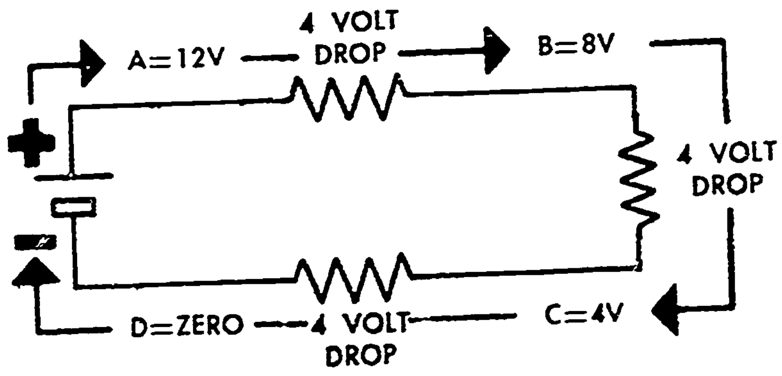


Fig. 2 Voltage drop

MAGNETISM -- Magnetism, like electricity, is invisible. Its effect, however, is well known. An example is the attraction of a bar magnet for iron filings. A magnet has a North pole designated as "N", and a South pole, designated as "S". The space around the magnet in which the iron filings are attracted is called the field of force, or magnetic field, and is described as lines which come out of the North pole and enter the South pole.

Electricity and magnetism are very closely associated because when electric current passes through a wire, a magnetic field is created around the wire. See Figure 3. When the wire, carrying electric current, is wound into a coil, a magnetic field with N and S poles is created just like a bar magnet. See Figure 4. If an iron core is placed inside this coil, the magnetic field becomes much stronger, because iron conducts magnetic lines much easier than air. This arrangement, called an electromagnet is used in generators to create strong magnetic fields by winding many turns of current-carrying wire around iron cores called pole pieces. See Figure 4.

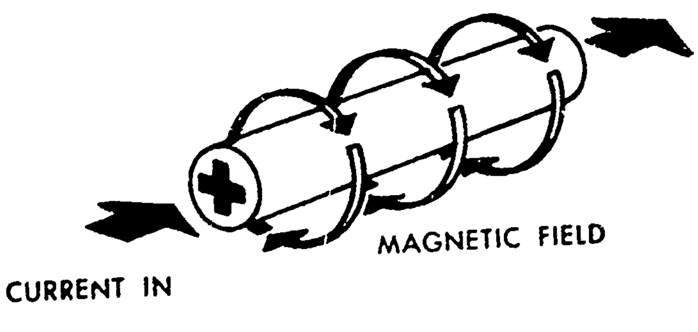


Fig. 3 Magnetic field

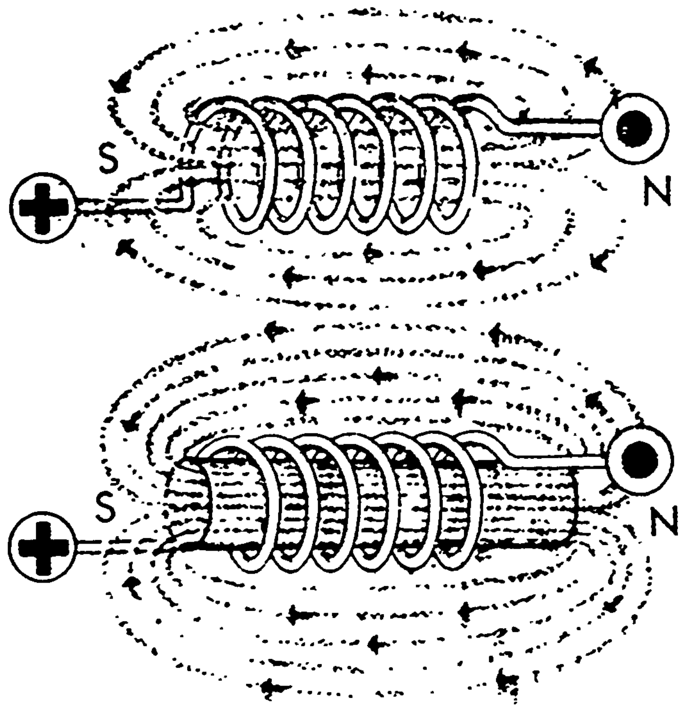


Fig. 4 A coil with an iron core and one without an iron core

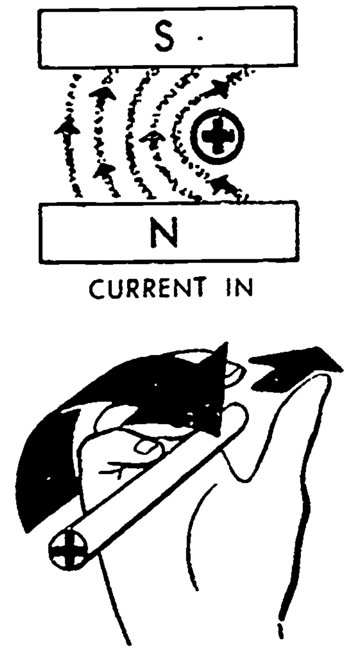


Fig. 5 Using "Right Hand Rule"

ELECTROMAGNETIC INDUCTION -- We have seen that a magnetic field, made up of lines of force, is created around a wire when current is passed through it. Conversely, if a magnetic field is moved so that the lines of force cut across a wire conductor, a voltage will be induced in the conductor. The induced voltage will cause current to flow when an electrical load, such as a resistor, is connected across the conductor. The direction of current flow is determined by the direction of the magnetic lines of force and the direction of motion of the magnetic field with respect to the conductor.

To visualize this, note the illustration in Figure 5, where magnetic pole pieces are being moved so that the magnetic lines of force are cutting across a conductor. The direction of the magnetic lines of force is upward, since the magnetic lines leave the North pole and enter the South pole. The direction of motion of the magnetic field is toward the right, as indicated by the arrows in Figure 5. With this direction of motion, the magnetic lines are striking the conductor on the left side of the conductor, which is called the leading edge or leading side.

The direction of current flow can be determined by applying the Right Hand Rule as follows: Grasp the conductor with the right hand with the fingers on the leading side of the conductor, and pointed in the direction of the magnetic lines of force. The thumb will then point in the direction of current flow.

An AC voltage in most types of AC generators is produced by moving strong magnetic fields across stationary conductors. In DC generators, the magnetic field is held stationary and the conductors are made to move so as to cut across the magnetic lines of force. In either case, the principle is the same and is called electromagnetic induction.

Although our coverage of basic electrical principles has been limited and rather brief, it will serve as a useful background when we explain the operation of regulators and of AC generators, often referred to as alternators. For a more thorough coverage of electrical fundamentals, refer to the Unit entitled, "Fundamentals of Electricity and Magnetism" (AM 2-11).

SECTION B -- OPERATING PRINCIPLES OF AC GENERATORS (ALTERNATORS)

In our review of electrical fundamentals, we observed that voltage will be induced in a conductor if a magnetic field is moving across it. For example, consider a bar magnet with its magnetic field rotating inside a loop of wire which is the conductor. See Figure 6. With the magnet rotating as indicated, and with the "S" pole of the magnet directly under the top portion of the loop, and the "N" pole directly over the bottom portion, the induced voltage, as determined by the Right Hand Rule, will cause current to flow in the circuit in the direction shown in Figure 7. Since current flows from positive to negative through the external or load circuit, the end of the loop of wire marked "A" will be positive (+) polarity and the end marked "B" will be negative (-).

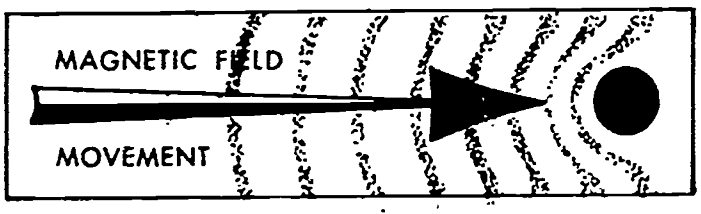


Fig. 6 Magnetic field movement

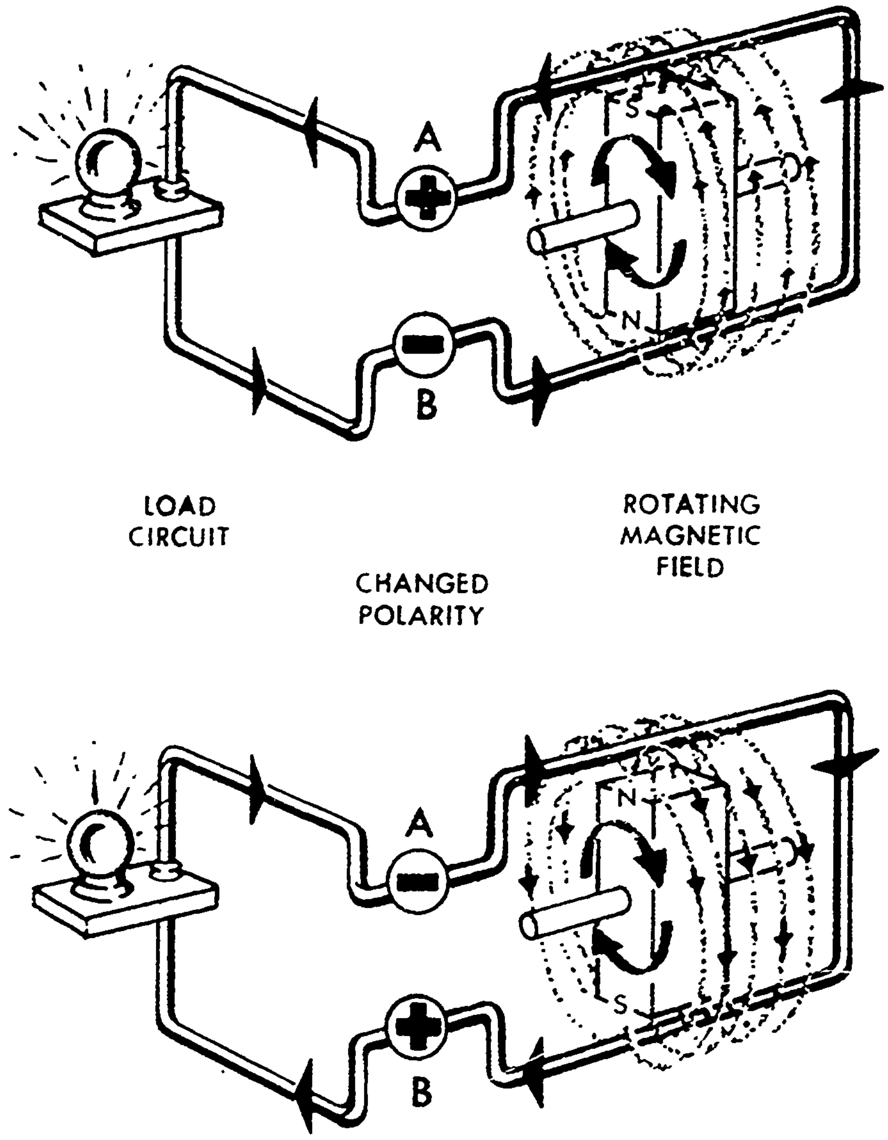


Fig. 7 Rotating magnetic field of AC generator

After the bar magnet has moved through one-half revolution, the "N" pole will have moved directly under the top conductor and the "S" pole directly over the bottom conductor. The induced voltage, as determined by the Right Hand Rule, will now cause current to flow in the opposite direction. The end of the loop of wire marked "A" will therefore become negative (-) polarity, and the end marked "B" will become positive (+). The polarity of the ends of the wire has changed. After a second one-half revolution, the bar magnet will be back at the starting point, where "A" is positive (+) and "B" negative (-).

Consequently, current will flow through the load or external circuit first in one direction and then the other. This is an alternating current which is developed by an AC generator. An alternating current generator made with a bar magnet rotating inside a single loop of wire is not practical since it is low in performance and very little current is produced. The performance is improved when both the loop of wire and the magnet are placed inside an iron frame. The iron frame not only provides a place onto which the loop of wire can be assembled, but also acts as a conducting path for the magnetic lines of force.

Without the iron frame, magnetism, after leaving the "N" pole of the rotating magnetic bar, must travel through air to get to the "S" pole. Because air has high reluctance to magnetism, only a few lines of force will come out of the "N" pole and enter the "S" pole. Iron, however, conducts magnetism very easily, and adding the iron frame greatly increases the number of lines of force traveling from the "N" pole to the "S" pole. This means that more lines of force will be cutting across the conductor which lies between the bar magnet and the frame. See Figure 8.

It is important to note that a very large number of magnetic lines of force leave the magnet and re-enter at its center, whereas there are only a few lines of force at the ends of the magnet. Thus, there is a strong magnetic field at the center and a weak magnetic field at the ends. This condition results when the distance, the air gap, between the magnet and the field frame is greater at the ends than at the center of the magnet.

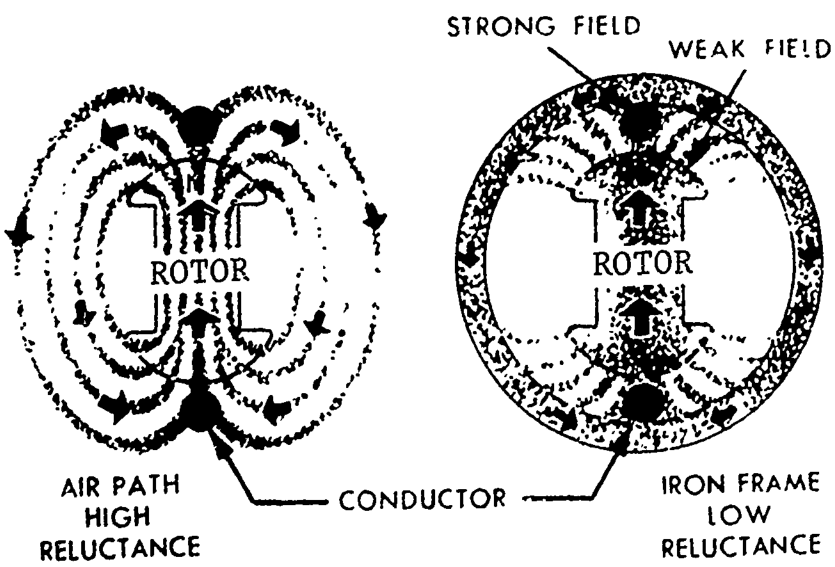


Fig. 8 Magnetic field with and without field frame

The amount of voltage induced in a conductor is proportional to the number of lines of force which cut across the conductor in a given length of time. Therefore, if the number of the lines of force is doubled, the induced voltage will be doubled. The voltage also will increase if the bar magnet is made to turn faster, because the lines of force will be cutting across the wire in a shorter period of time. It is important to remember that either increasing the speed of rotation of the bar magnet, or increasing the number of lines of force cutting across the conductor, will give an increase in the voltage. Similarly, decreasing the speed of rotation or the number of lines of force will cause the voltage to decrease.

The rotating magnet in an alternating current generator is called the rotor, and the loop of wire and outside frame assembly is called the stator.

To illustrate further how an alternating voltage is produced, consider the simple two-pole rotor and a stator that contains a single loop of wire. Only the ends of the loop of wire are shown in the diagram in Figure 9. Different positions of the rotor as it turns are shown in the diagrams below the horizontal line. The height of the curve above and below the horizontal line shows the magnitude of the voltage which is generated in the loop of wire as the magnetic lines cut across each side of the loop as the rotor turns.

The entire curve shows the voltage output generated, or the electrical pressure which can be measured across the ends of the wire, just as voltage can be measured across the terminal posts of a battery. With the rotor in the first position the voltage is zero. No voltage is being generated in the loop of wire because there are no magnetic lines of force cutting across the wire. As the rotor turns and approaches position two, the rather weak magnetic field at the tip of the rotor starts to cut across the conductor, and a voltage is developed.

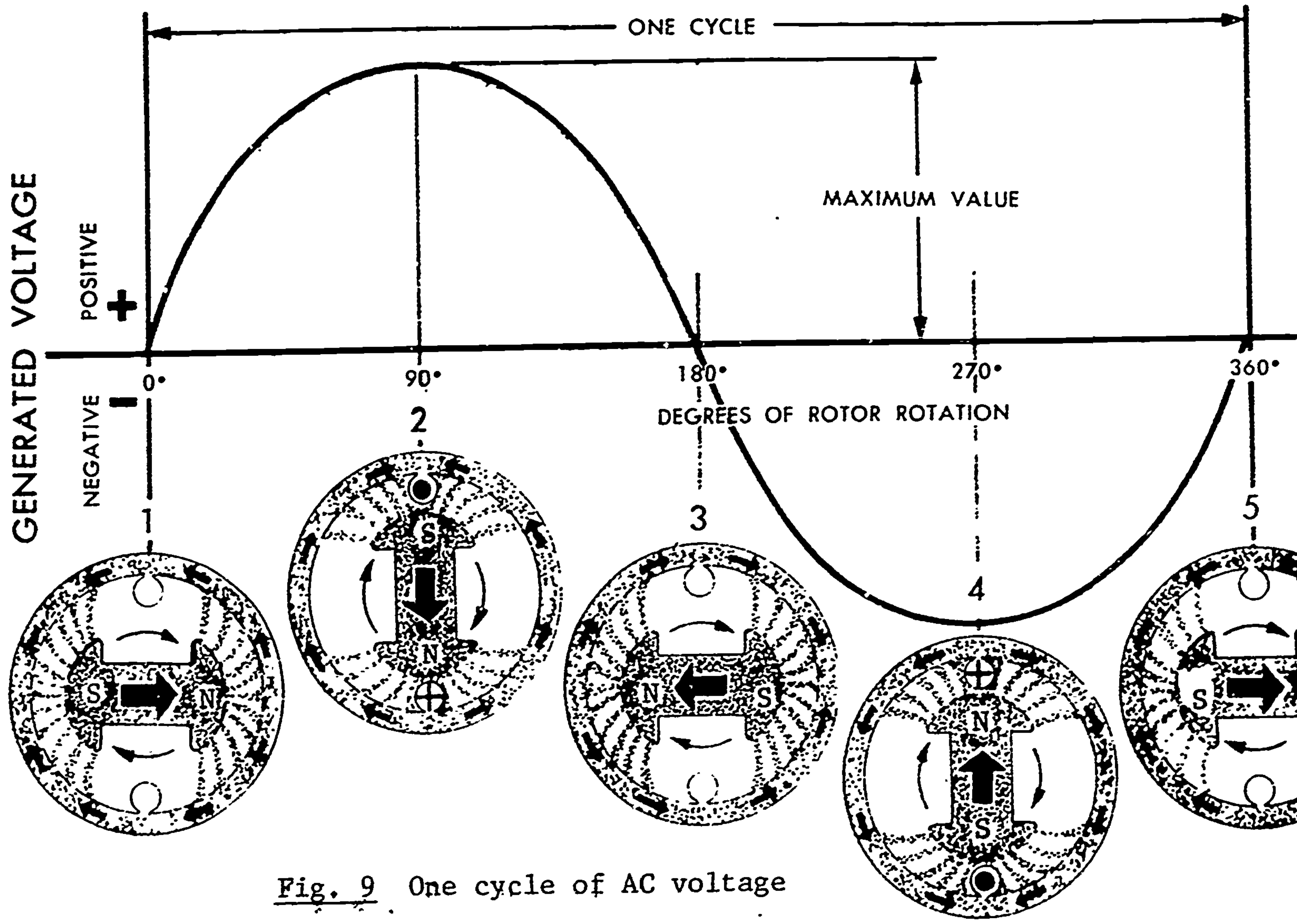


Fig. 9 One cycle of AC voltage

As the rotor continues to turn, the voltage increases and reaches its maximum value, as shown above the horizontal line in Figure 9, when the rotor reaches position two. This maximum voltage occurs when the rotor is directly under each wire in the loop. It is in this position that the loop of wire is being cut by the heaviest concentration of magnetic lines of force.

It should be noted in particular that the height of the voltage curve changes because the concentration of magnetic lines of force cutting across the loop of wire varies. This occurs because the magnetic field is rather weak at the tips of the poles and is heaviest at the center of the poles.

As the rotor turns from position two to position three, the voltage decreases until, at position three, it again becomes zero. It should be noted that from position one through three, the South is on top, and the voltage curve above the horizontal line is positive voltage. This means that the voltage will cause current to flow out of the top part of the loop, and re-enter the lower part, when a load is connected between the ends of the loop of wire.

As the rotor turns from position three, through five, the North pole is on top, and the voltage curve is below the horizontal line. The voltage curve is negative, and current will leave the lower part of the loop and re-enter the top when a load is connected. Thus, as the top and bottom parts of the loop of wire are influenced alternately by North and South poles, the current flow through the loop of wire flows first in one direction and then in the other.

For purposes of illustration, we have just described the most basic stator winding, a single loop of wire and the most basic rotor, a single bar magnet. Now we will start building up an AC generator (alternator) in a step by step procedure. Figures 10 and 11 illustrate the principle of an electromagnet that has been discussed in a previous section and reviewed in this section. It simply states that the strength of a magnetic field around a coil of wire can be increased by placing an iron core inside the coil and passing current through the coil. Since iron offers a much easier path for magnetism to pass through than air, the magnetic lines become more concentrated, and consequently the magnetic field becomes stronger.

The same principle is used in the design of the rotor assembly of alternators. A coil of wire is wound around an iron spool. When current is passed through the coil an electromagnet is formed, with its magnetic field surrounding the assembly as shown in Figure 11. The strength of an electromagnet can be altered by changing either the amount of current passed through the winding or by changing the number of turns in the coil. In alternators, the coil in the rotor assembly is called the field coil and the current that passes through it is called field current.

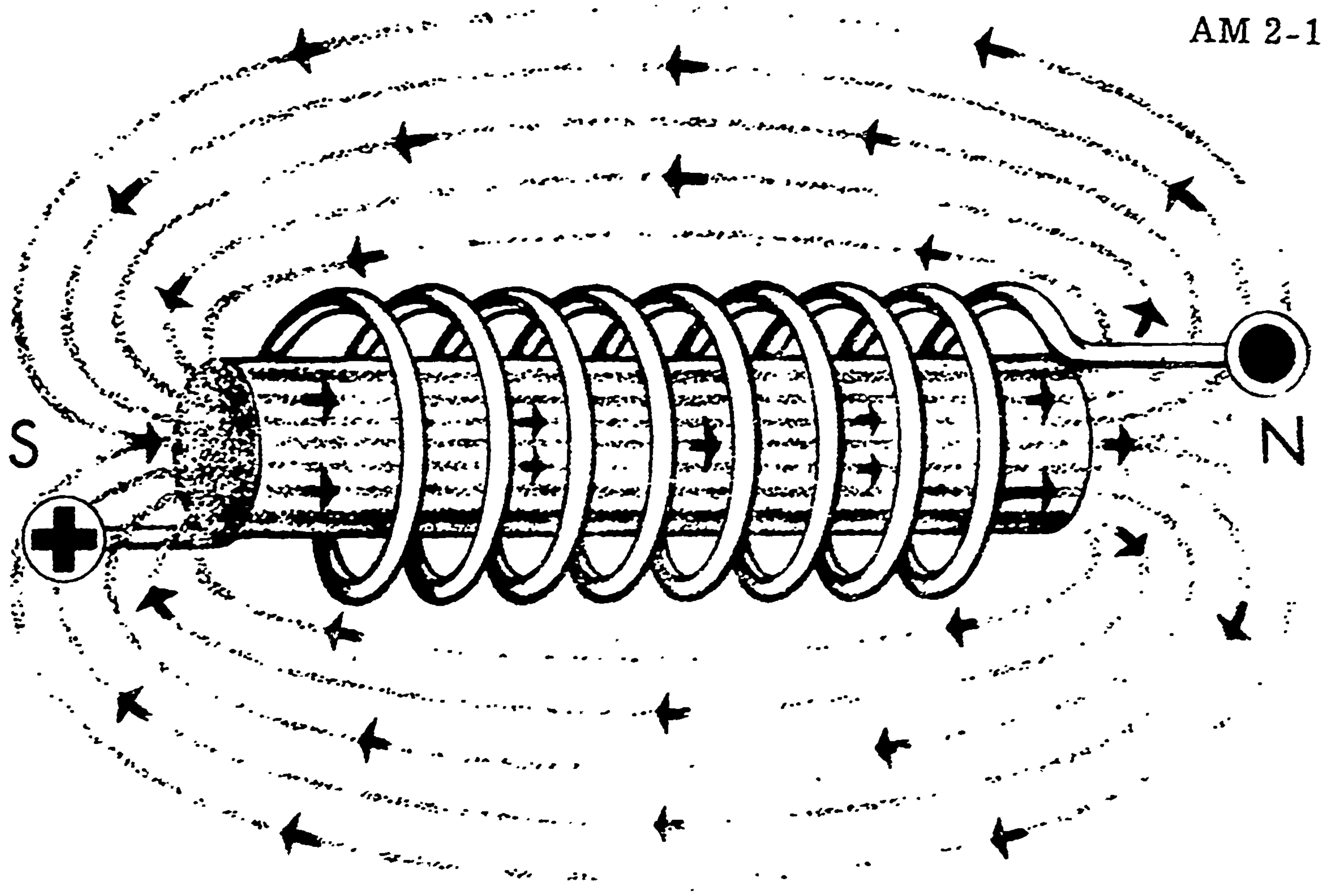


Fig. 10 Electromagnetic principles

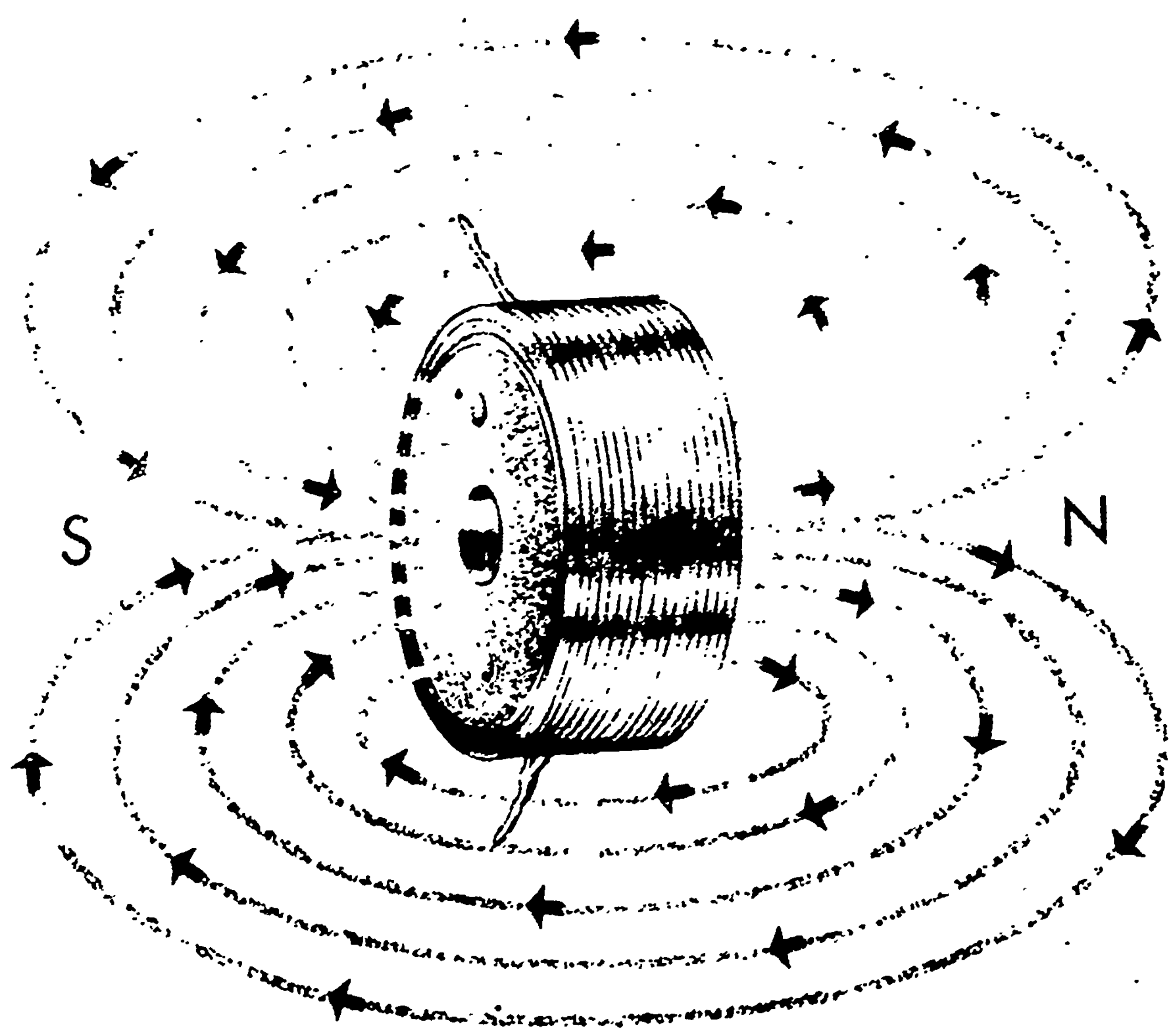


Fig. 11 Electromagnetic principles

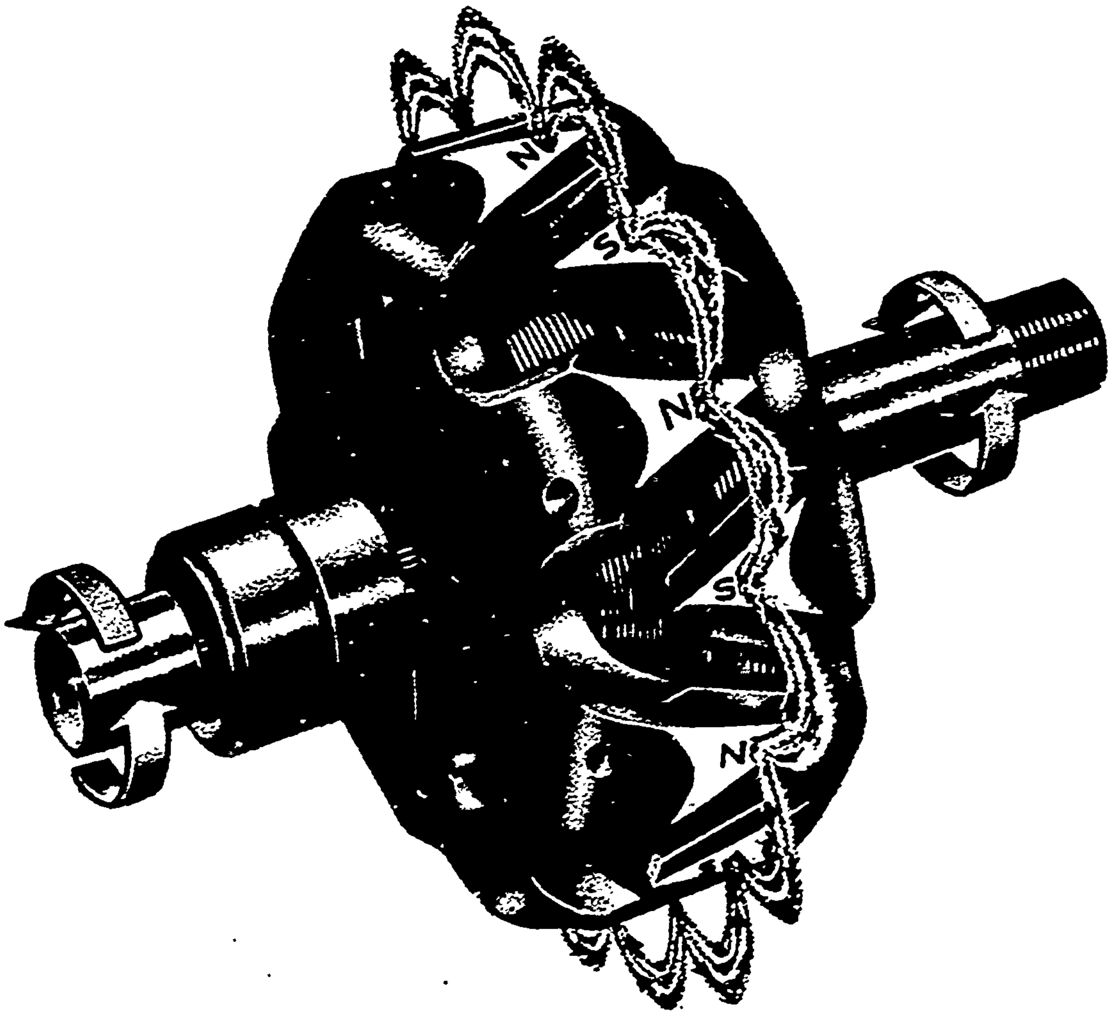


Fig. 12 Electromagnetic principles

In the rotor assembly of the alternator, the coil and iron spool are placed over the rotor shaft, and two iron end pieces with interlacing fingers are also placed over the shaft. Two slip rings, which are connected to the coil, complete the rotor assembly. See Figure 12. Two brushes ride on the slip rings, and are connected through a switch to the battery.

When the switch is closed, current from the battery passes through one brush, through the slip ring upon which the brush rides, and then through the field coil. After leaving the field coil, current flow continues through the other slip ring and brush before returning to the battery through the ground return path. This flow of electrical energy through the field winding is called field current and creates a magnetic field. The magnetism created by the field current causes the poles on the rotor to become alternately North and South poles. It has been shown before, and will be shown again that this magnetic field is used to produce alternating voltages in the stator windings. See Figure 13.

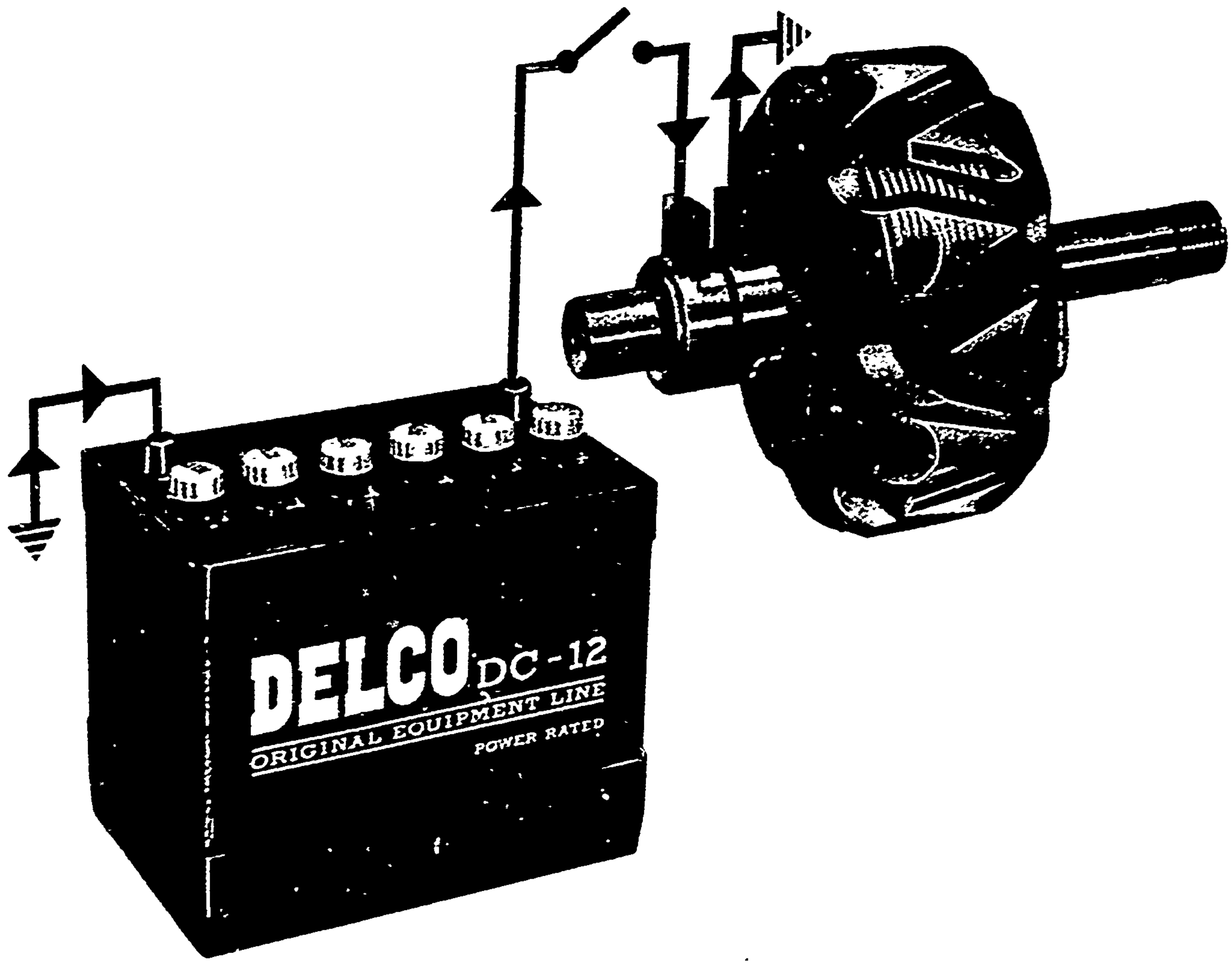


Fig. 13 Electromagnetic principles

Figure 14 illustrates connecting the ends of a loop of wire to a load, such as a light bulb, to complete the circuit. As the rotor turns, the magnetic fields from the North and South poles of the rotor cut across each wire, causing a voltage to be induced in the loop.

Since the wire is influenced alternately by a North and then a South pole, the voltage produced is called an alternating voltage. When a load, such as the light bulb is connected to the ends of the loop, the alternating voltage produced will cause current to flow first in one direction and then the other through the bulb. This is called alternating current or AC. If a meter is placed in the circuit the fluctuation of the needle will show that the current flows first in one direction and then the other.

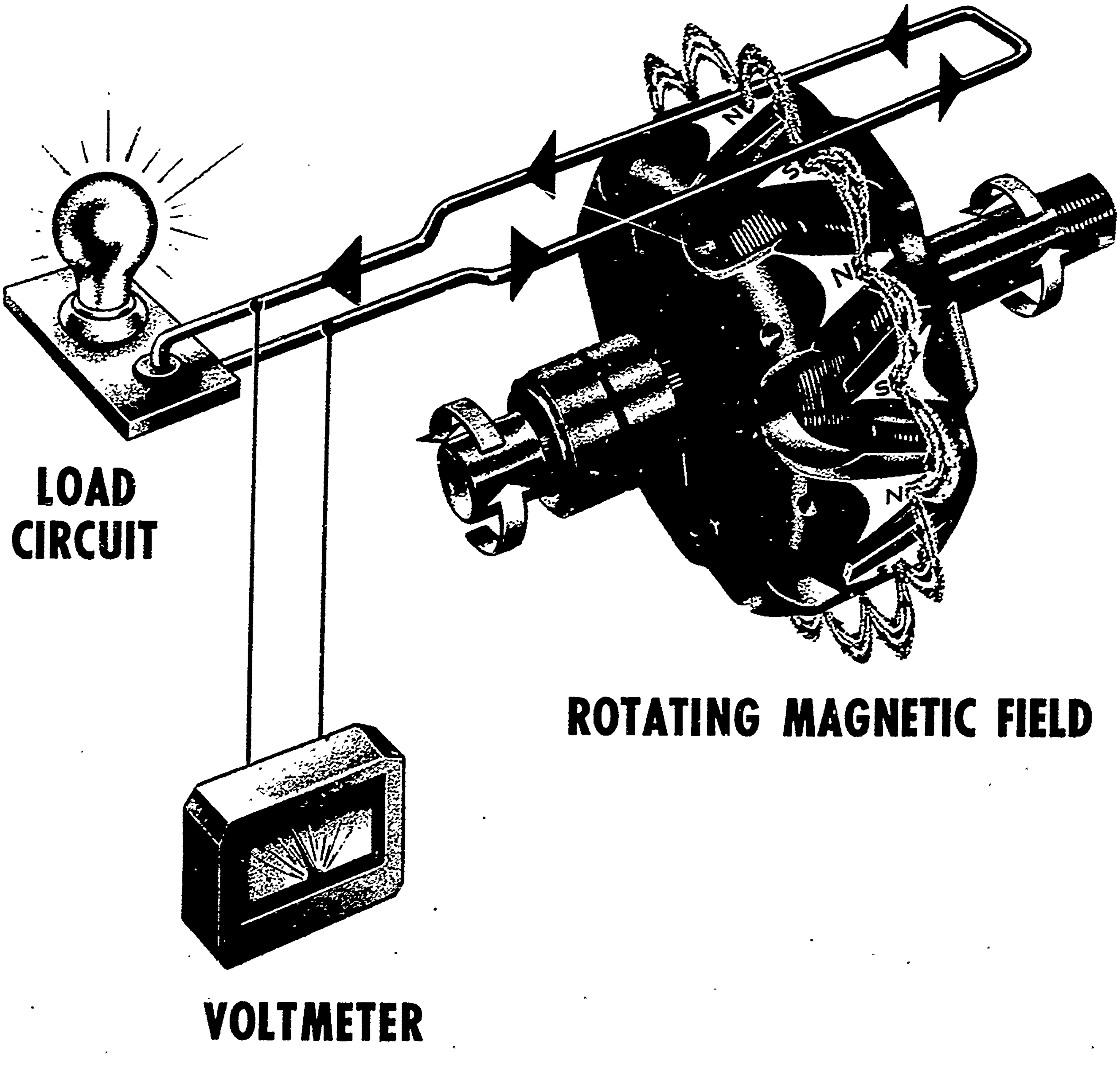


Fig. 14 Electromagnetic principles

To picture the construction of the stator used in the alternator, the illustration in Figure 15 shows how a length of wire is formed into many loops to make a coil. Many coils make a winding. This assembly is then placed into the proper slots of the stator laminations. Instead of having a single loop of wire as mentioned earlier, which would develop only a very small voltage, many loops are used to form a coil.

The individual loops in each coil are in series, and the voltage developed in each loop is added to the voltage developed in all the other loops to produce a total coil voltage. The seven coils, which are pictured, are also in series to form a winding, and the voltage induced in each coil is added to the voltage induced in the other coils to obtain a total winding voltage. One set of poles is required for each coil, and for this type of alternator fourteen poles are used. A schematic diagram of one winding is shown in Figure 16.

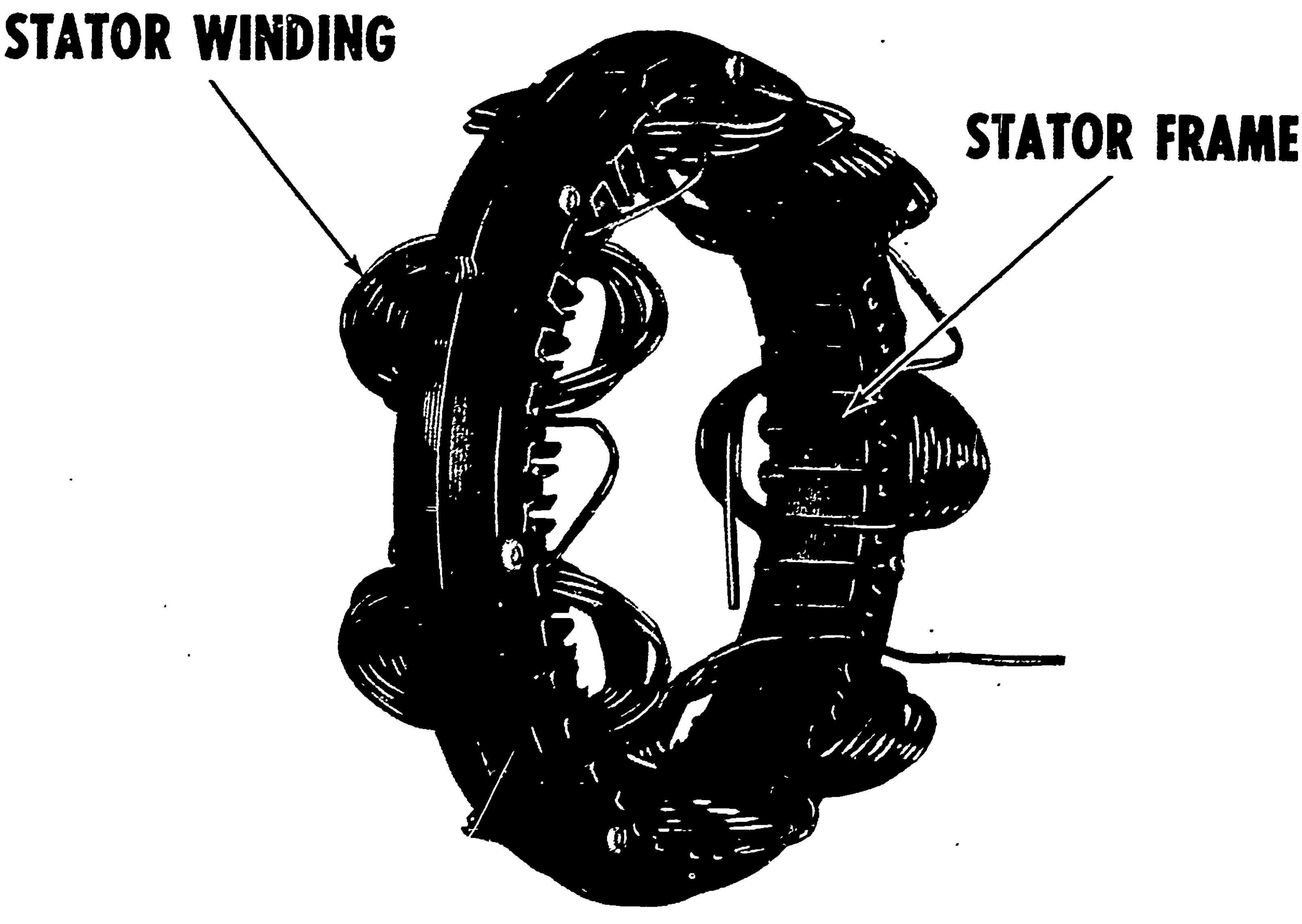


Fig. 15 Stator assembly (partial)

Fig. 16 Stator winding schematic

The actual stator construction is shown in Figure 17, with the three windings assembled onto a laminated iron frame. The schematic drawing in Figure 18 indicates the manner in which one end of each of the three stator windings is connected to form a three phase unit. This is known as the Y type connection. The other end of each winding, called the terminal end, is connected to a pair of diodes, one positive and one negative. The purpose and function of the diodes will be discussed in more detail later in the unit.

There are two basic reasons for using three stator windings rather than just one winding. First, more voltage can be developed. The total voltage between any two terminal ends, or phase voltage, always is made up of the voltage of at least two individual windings which are connected in series. Therefore, more developed voltage is available between phases, or terminal ends, than would be the case if only one winding were used.

Another purpose of the three windings is to maintain a more constant voltage between phases. The arrangement of the windings is such that each phase reaches its maximum developed voltage at a different time and a more constant voltage is, therefore, available at the diodes.

The diagram in Figure 19 graphically portrays the three phase voltages, or voltages between the three winding ends. It is interesting to note that the peak voltage for each phase occurs at equal intervals as the rotor turns. This shows graphically how maximum phase voltage is more nearly constant, as described in the previous discussion and Figure 17.

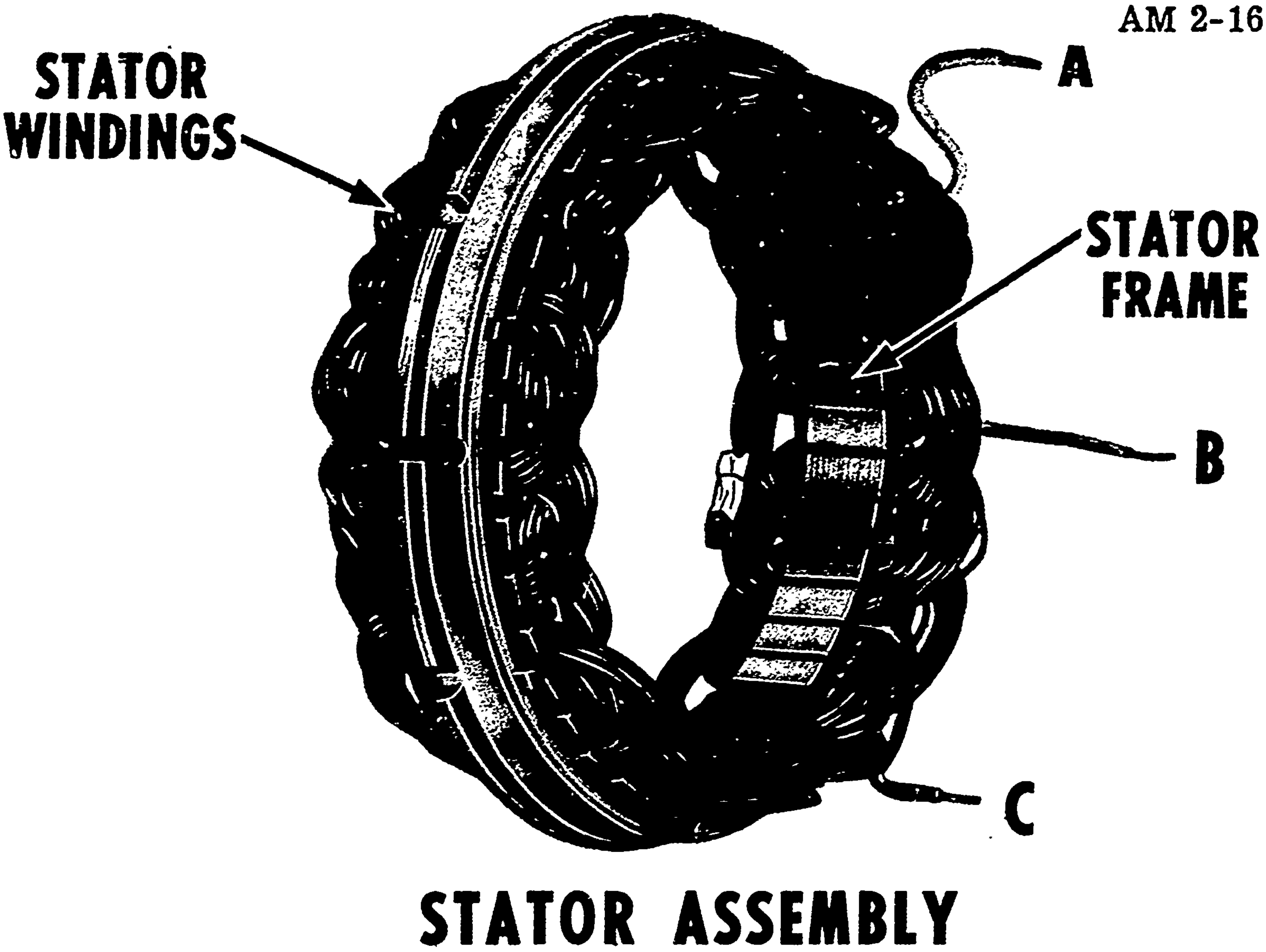


Fig. 17 Stator assembly

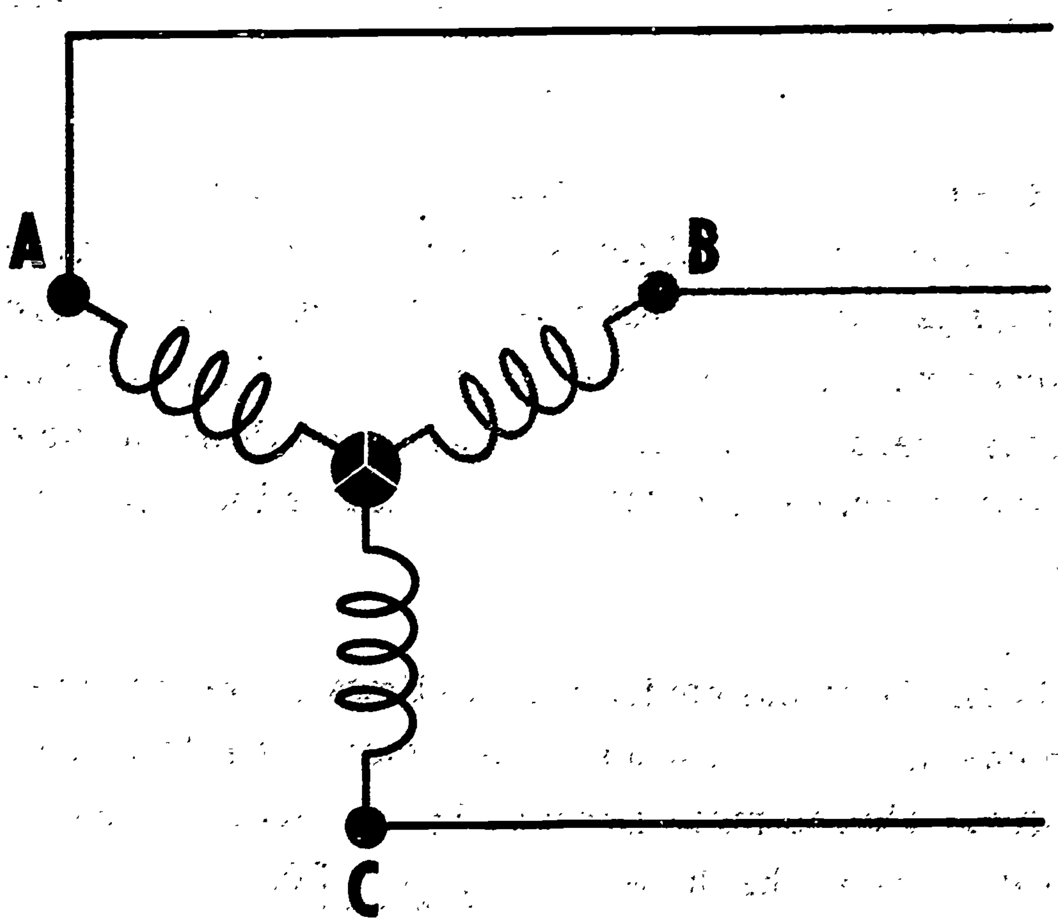


Fig. 18 Stator assembly schematic

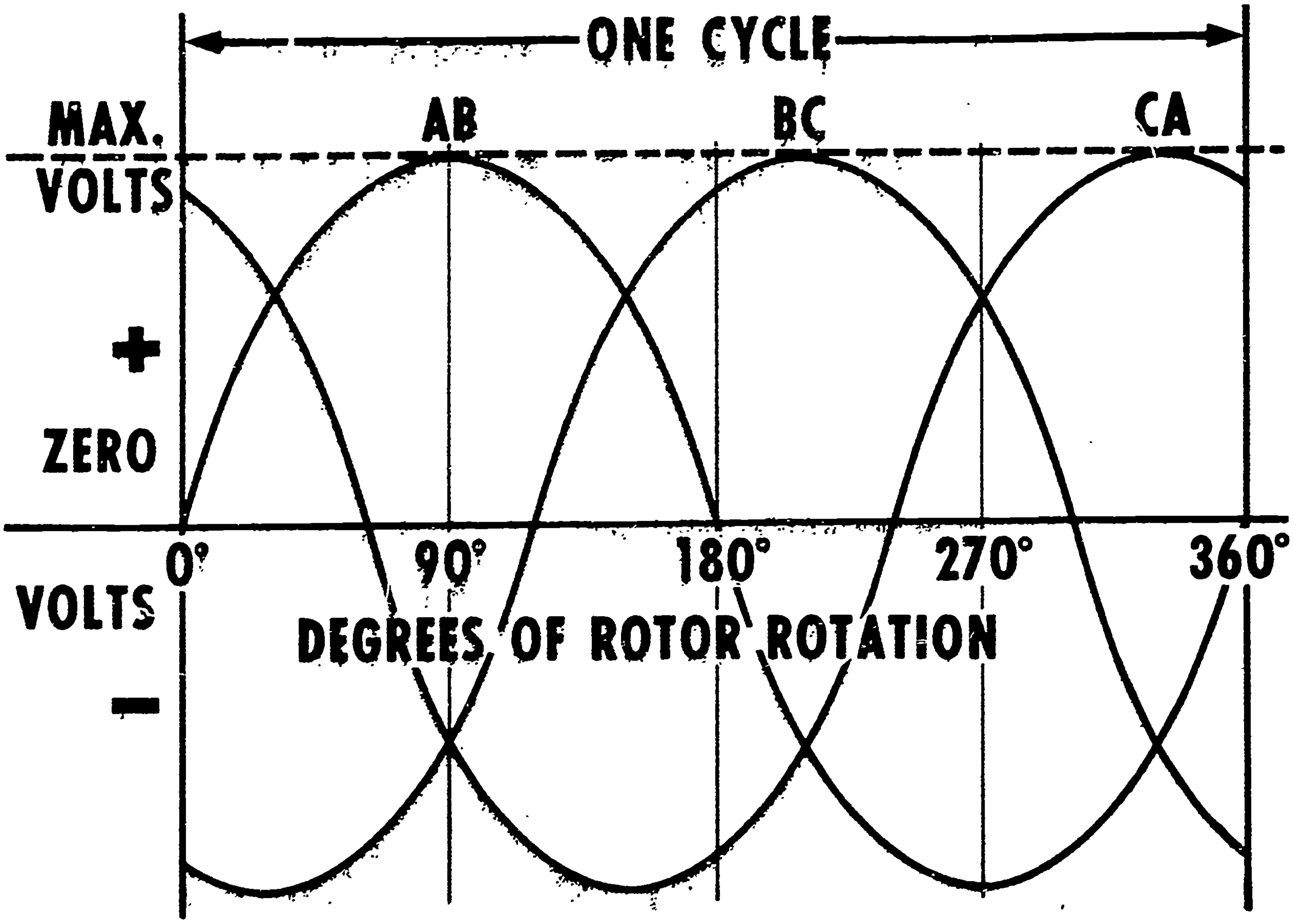


Fig. 19 Alternating voltage (three phase)

We have seen that alternating voltages are produced in the stator windings, and that alternating current flows through a load when connected to the stator windings. Also, we have seen that alternating current flows first in one direction, and then in the other. Since the battery and all electrical accessories operate on direct current, which flows in one direction only, it is necessary to change the AC to DC. This is the function of the diode rectifier.

A diode is an electrical device which allows current to pass through it freely in one direction, but not in the other. It acts much like an electrical check valve. This is made possible by the electrical characteristic of the silicon wafer within the diode. See Figure 20.

When the diode is constructed in a certain manner, for example, and a lead of positive voltage is connected to the diode lead and a lead of negative voltage is connected to the case, current will flow through the diode. If the diode is constructed in a different manner and the above connections are made, no current will flow and the circuit is blocked. The diode, therefore acts as a check valve and allows current flow in only one direction. The symbol in Figure 20 indicates by an arrow that current will flow in only the direction of the arrow.

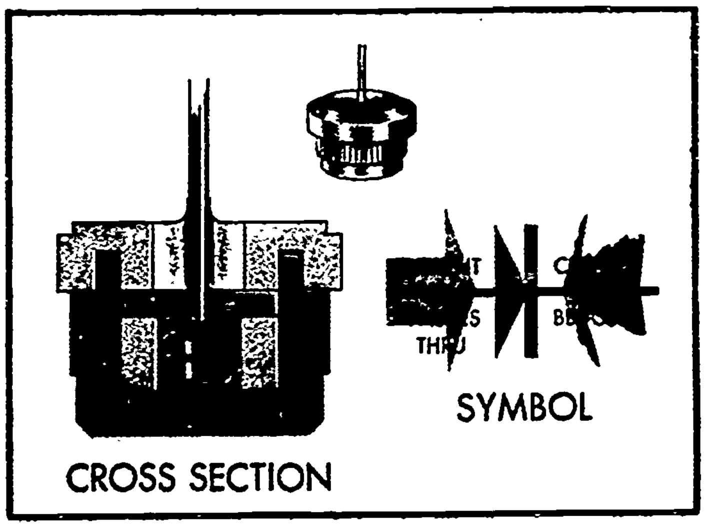


Fig. 20 Diode cross section and symbol

A cross sectional view of the diode is shown with the thin silicon wafer in position at the bottom of the diode case. The heavy case walls serve to protect the delicate silicon wafer and also to dissipate the heat produced by current flow. The diode is tightly sealed to prevent any entry of moisture. Although the diode is a comparatively rugged component, care should be exercised in handling it. Impacts should be avoided, to prevent the possibility of cracking the silicon wafer. If the diode lead is bent excessively there is a possibility of cracking the glass insulator, permitting moisture to enter the diode. Moisture in the diode could cause it to short and thus fail to operate. Pulling the diode lead should also be avoided because of the possibility of breaking the soldered joint between the diode lead and the silicon die.

Six diodes are mounted in the slip ring end frame of the alternator. Three negative diodes are mounted in the end frame, and three positive diodes are mounted in the heat sink, which is insulated from the end frame.

These diodes act together to change the alternating voltages developed in the stator windings to a single uni-directional voltage. Therefore, uni-directional or rectified voltage appears at the output terminal on the alternator. Consequently, the alternator supplies DC to charge the battery and to operate the electrical accessories.

The method by which the diodes are connected to the stator provides a smooth flow of direct current to the battery and other accessories connected to the alternator. Also, the blocking action of the diodes prevents battery discharge through the alternator and thus eliminates the need for a cut-out relay.

Figures 21 and 22 show how the diodes rectify the AC into DC in order that DC is supplied to the battery during the instant that current flows through only two of the stator windings. In Figure 21, the voltage in the windings (A) and (C) causes current to flow from the (A) terminal to the diode rectifier. Current then flows through the diode, connected in the proper manner to permit current flow. From this diode, current flows to the (BAT) terminal of the alternator, on through the battery to the return circuit.

Continuing its flow back to the rectifier, the current then travels through the diode connected to the (C) winding and on through to the (A) terminal where it started. In Figure 22, the voltage in the windings (A) and (C) is in an opposite direction due to the influence of rotor poles of the opposite polarity on the stator windings. The voltage developed in coils (A) and (C) will cause current to flow from the (C) terminal to the diode rectifier. Current then flows through the diode connected in the proper manner to permit current flow. From this diode, current continues to the (BAT) terminal of the alternator and on through the battery to the return circuit. Continuing its course back to the rectifier, the current travels through the diode connected to the (A) winding and on through to the (C) terminal where it started.

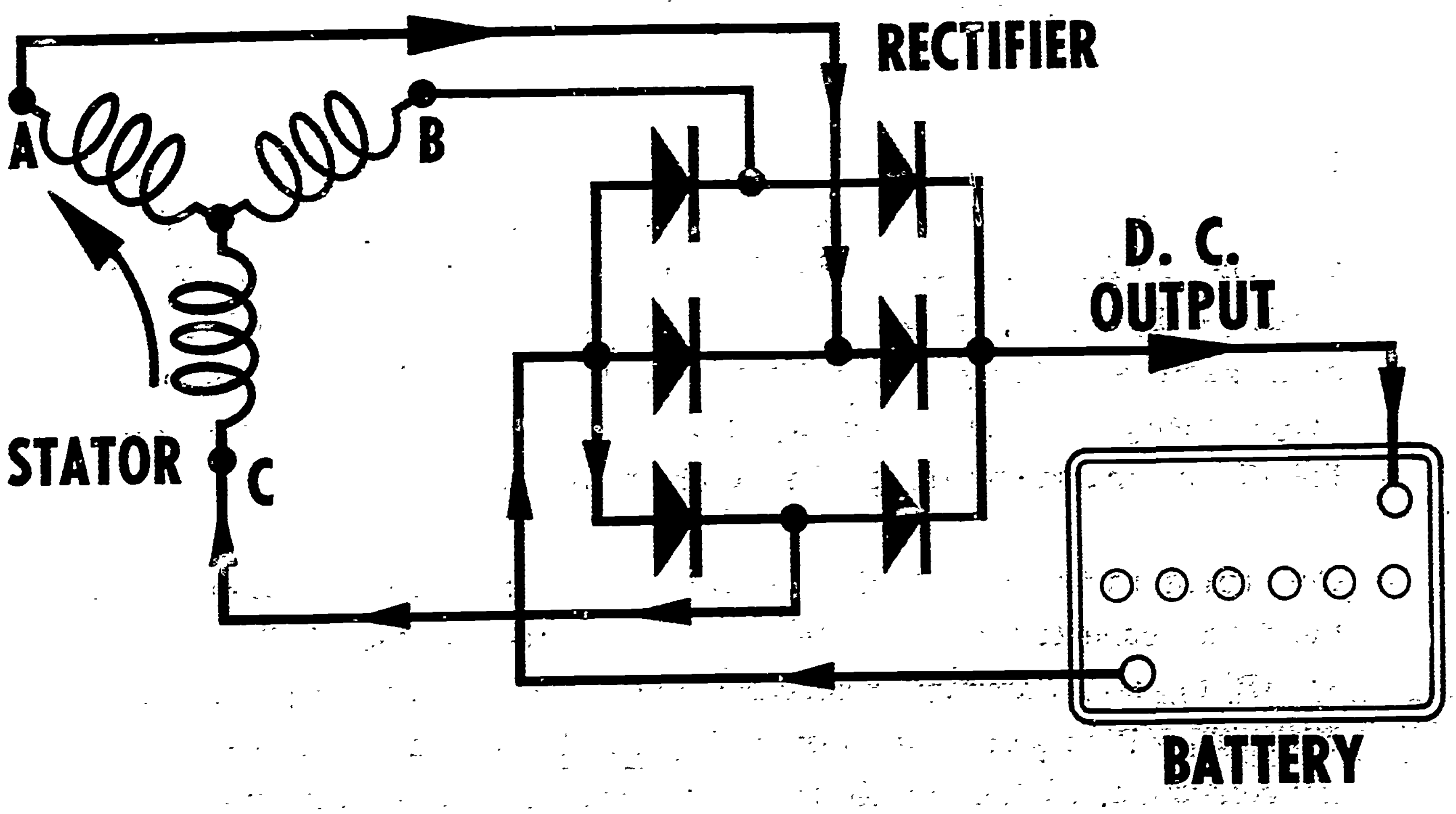


Fig. 21 Diode rectifier three phase output

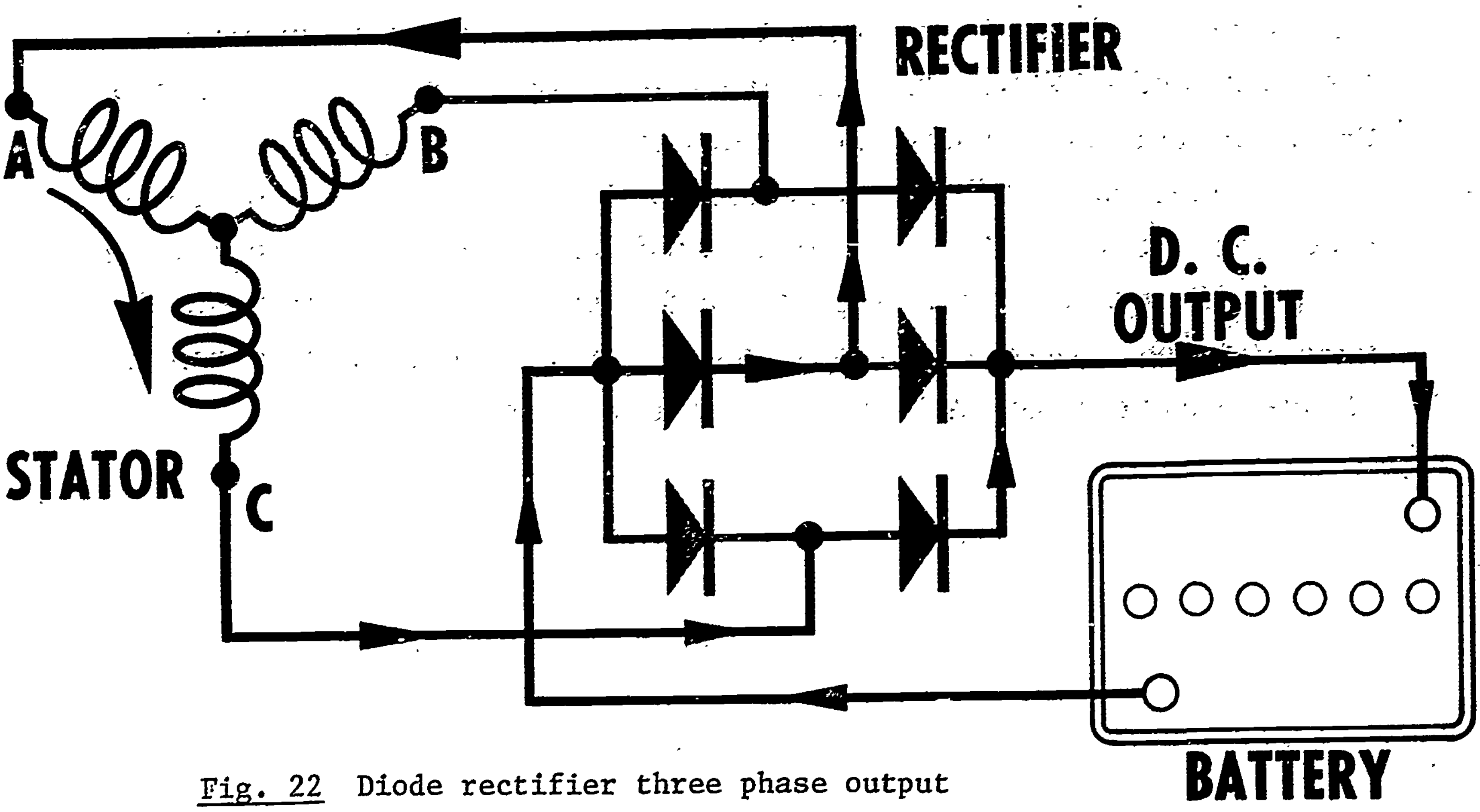


Fig. 22 Diode rectifier three phase output

From Figures 21 and 22 we can see that -- regardless of the direction of current flow in the alternator -- the direction of current flow through the battery always is in the same direction.

Figures 23 and 24 show how the diodes rectify AC to DC when the rotor poles are in a different position from that shown in Figures 21 and 22. Current now flows through coils (B) and (C). In Figure 23, the voltage in windings (B) and (C) causes current to flow from the (B) terminal to the diode rectifier. Current then flows through the diode connected in the proper manner. From this diode, current flows to the BAT terminal of the alternator and on through the battery to the return circuit.

Continuing its flow back to the rectifier, the current then travels through the diode connected to the (C) terminal and on through the windings (C) and (B) to the (B) terminal where it started. When the rotor poles have changed position from that shown in Figure 23, current now flows from the (B) coil to the (C) coil and on through the rectifier to the battery and back through the return path as in the other phases mentioned before.

This sequence of events continues as the rotor poles turn to different positions, and all stator windings are affected by the changing polarity of the magnetic fields. There are several instances during the rotor rotation when current flow is prevalent in all three windings at the same time. Since current flow in all three windings occurs for only very brief instants of time, they are not considered to be of major importance. The diode function in these cases is the same, and DC voltage and current are always present at the BAT (output) terminal of the alternator.

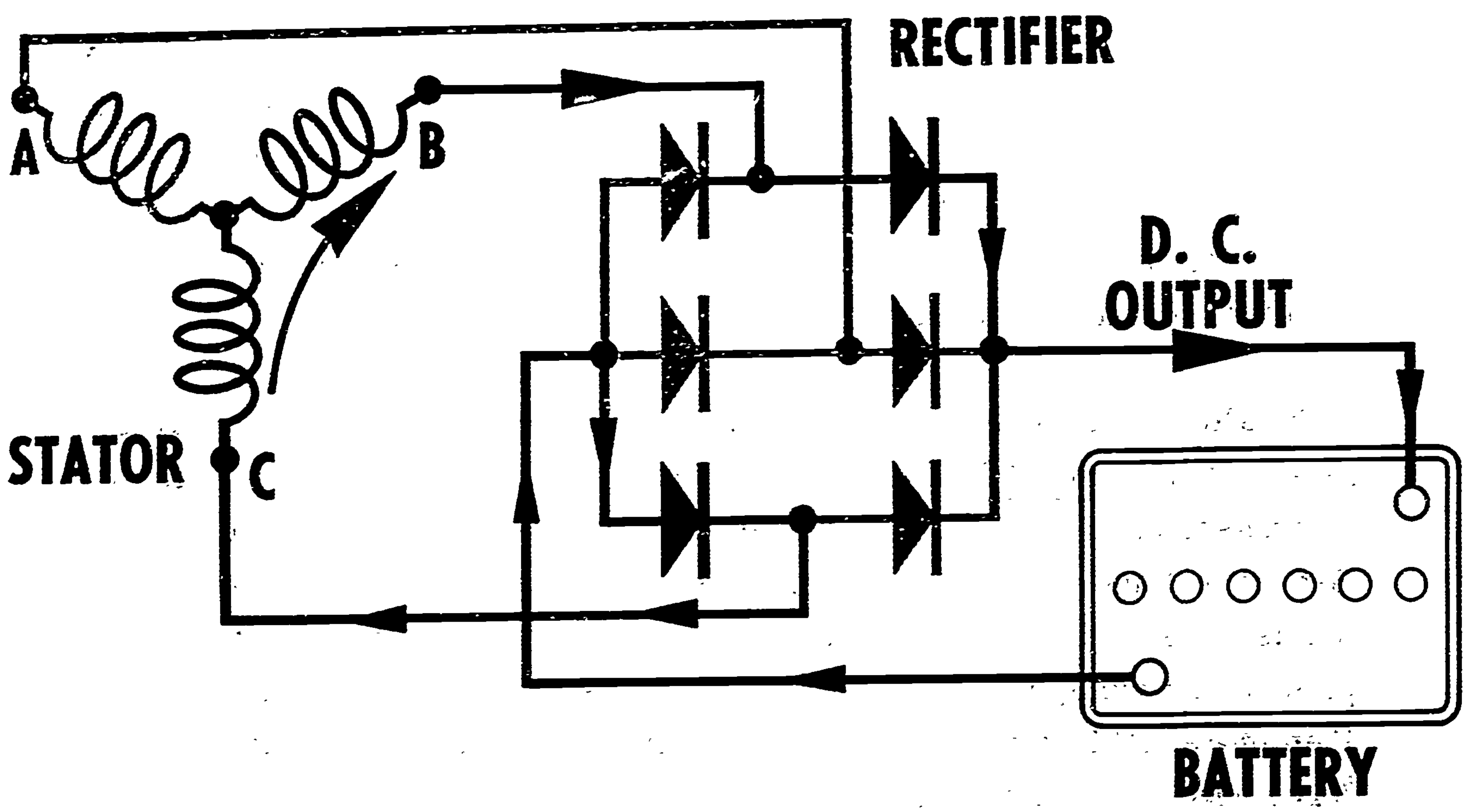


Fig. 23 Diode rectifier three phase output

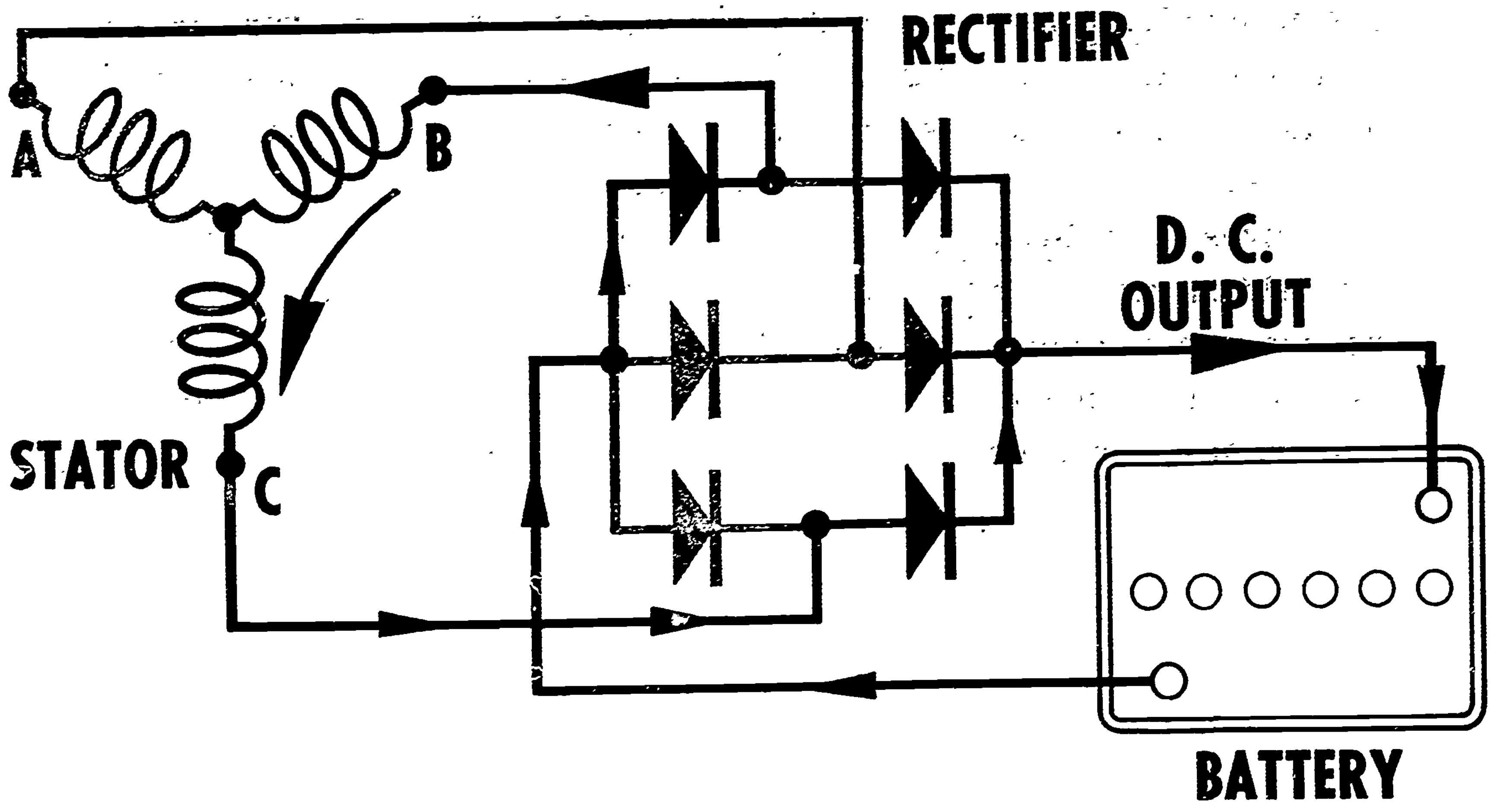


Fig. 24 Diode rectifier three phase output

Previous discussions have shown how current through the field coil, located in the rotor, creates magnetic lines of force. These magnetic lines of force cut across the windings of the stator as the rotor turns, and induce an alternating voltage within the stator windings. This voltage causes current to flow through the diode rectifier to the BAT (output) terminal of the alternator for use in charging the battery or for supplying power to the electrical accessories.

If the alternator were connected to both the battery and to the load circuit, as shown in Figure 25, then either battery or alternator voltage would be impressed upon the field coil whenever the switch was in a closed position. Battery voltage would first provide the field current in the alternator, but as the speed of the alternator increases, the alternator itself would provide the voltage for the field current. As alternator voltage increased, then more field current would result, with an increase in magnetic lines of force within the rotor. This would develop even more voltage within the alternator and voltage would rapidly increase, as indicated in Figure 26.

The need to limit the voltage that is developed is, therefore, very critical. Without voltage control, light bulbs, external wiring, relay coils, contact points and all the other electrical components of the vehicle would be endangered by too high a voltage, which would damage or greatly shorten their lives. A voltage regulator, consequently, is employed to regulate the field current and magnetic field within the alternator in order that its voltage may be limited to a safe value. No current control of the alternator is necessary, since it is capable of delivering only a given amount of current at the regulated voltage. It is said to be self current-limiting.

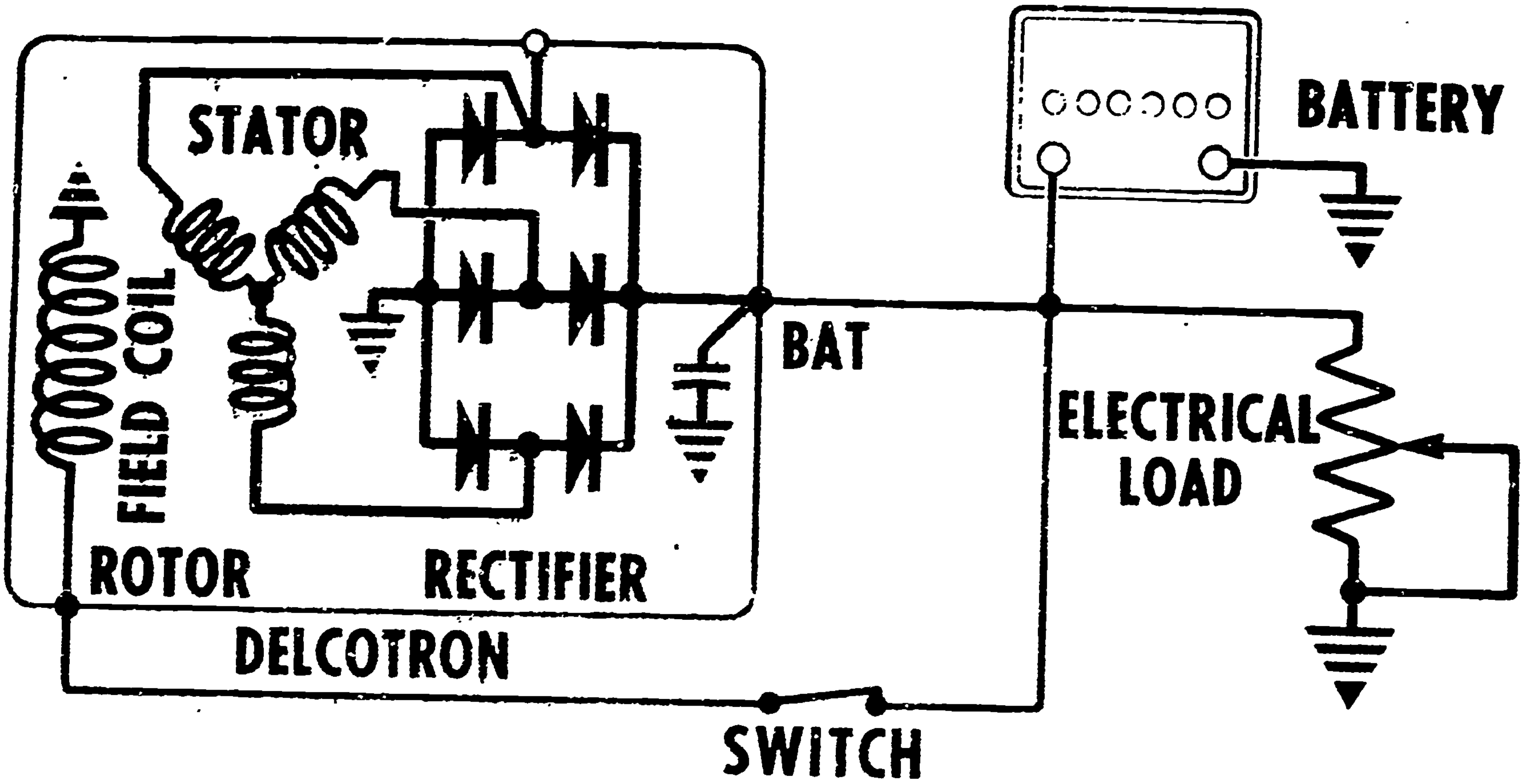


Fig. 25 Need for voltage regulation

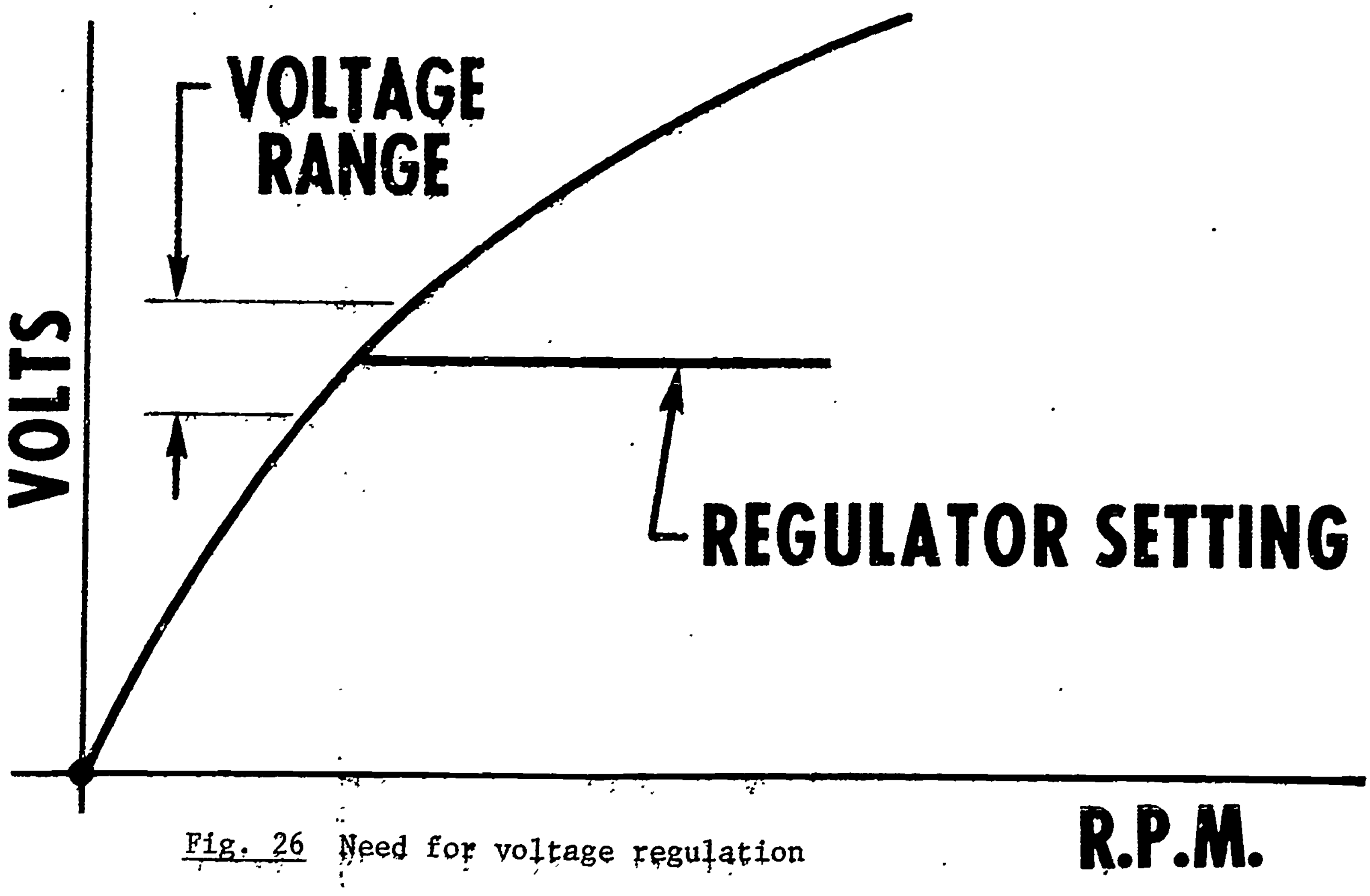


Fig. 26 Need for voltage regulation

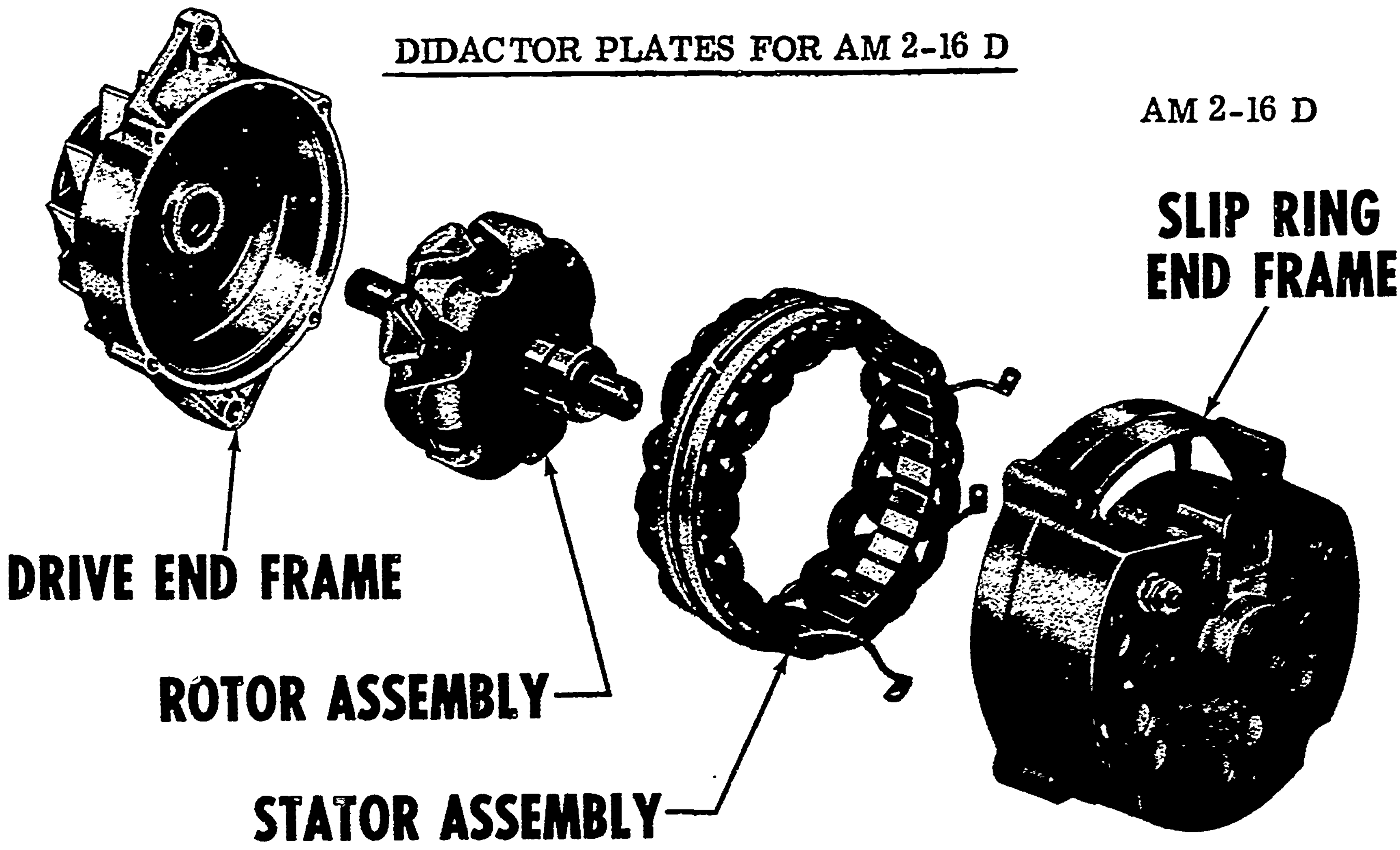


Plate I Alternator (exploded view)

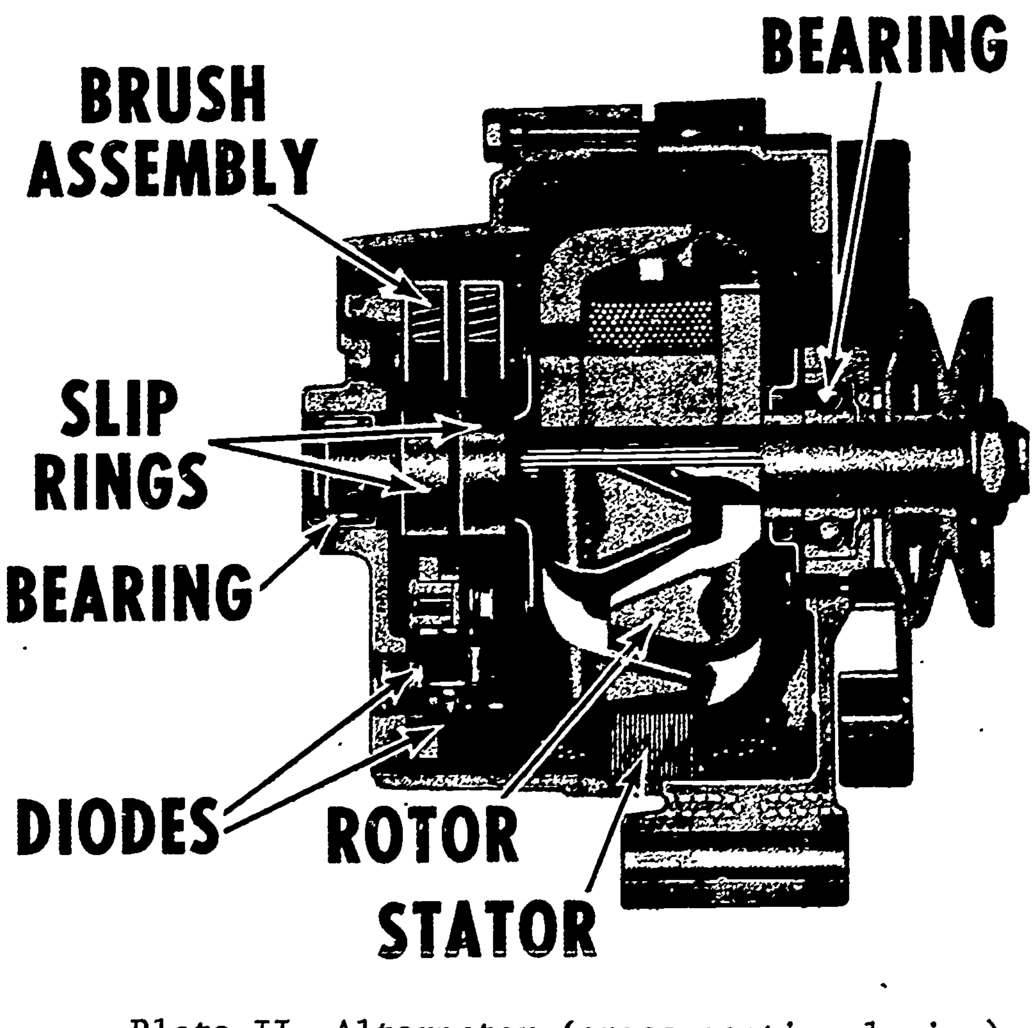


Plate II Alternator (cross-sectional view)

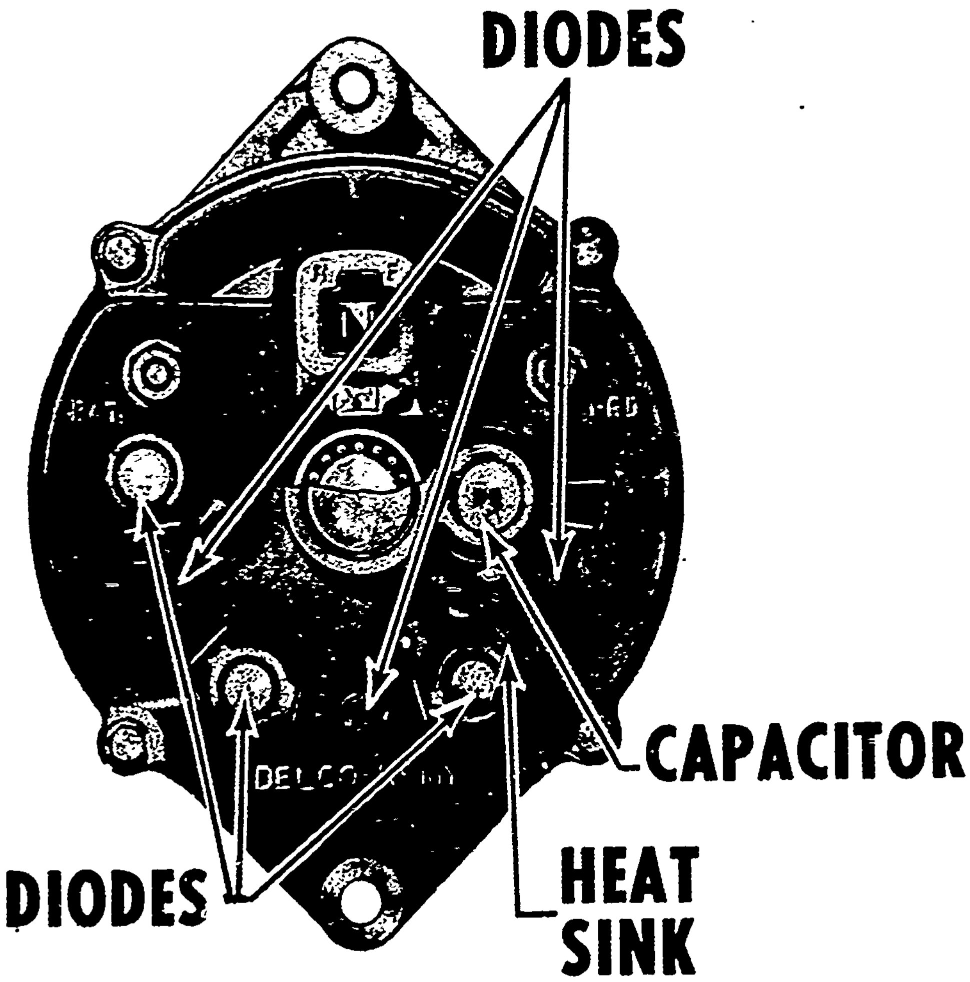


Plate III Alternator (end view)

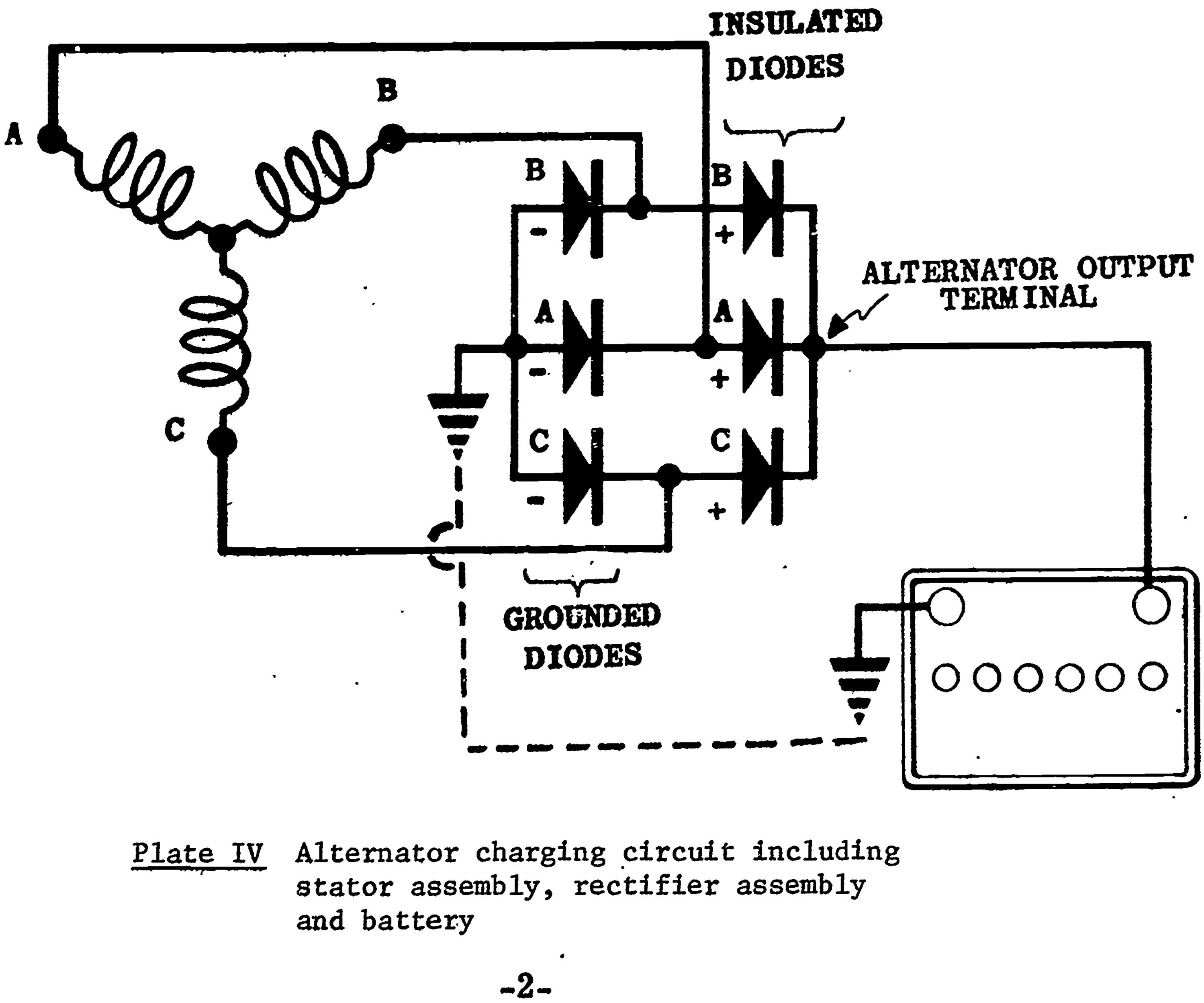


Plate IV Alternator charging circuit including stator assembly, rectifier assembly and battery

0

AM 2-16D
10/18/67

AC GENERATORS I --
UNDERSTANDING ALTERNATOR PRINCIPLES

Human Engineering Institute

Minn. State Dept. of Ed.
Vocational Education

Press A 1

Check to see that timer and index are OFF.

1

This film is the first of three on automotive AC generators (alternators) and their allied equipment. We will see how alternators are constructed, how they operate, and how they are tested.

In this film, we will discuss fundamentals of construction and operation of the alternator.

Press A 2

1-1

2

The primary function of an alternator is, of course, to produce current to fulfill the electrical needs of the vehicle.

An alternator produces current by electromagnetic induction. This is also the basis for current production in a DC generator.

A DC generator produces current electromagnetically by means of a ___(1)___ field and ___(2)___ conductors.

A. (1) moving (2) stationary 3

B. (1) stationary (2) moving 4

1-2

3

That is incorrect.

A DC generator develops current through the action of a rotating armature, which revolves in a magnetic field.

The armature contains the conductors that cut magnetic lines of force which flow between the stationary pole shoes.

In a DC generator the conductors MOVE (rotate) and the field is (relatively) STATIONARY.

Press A 4

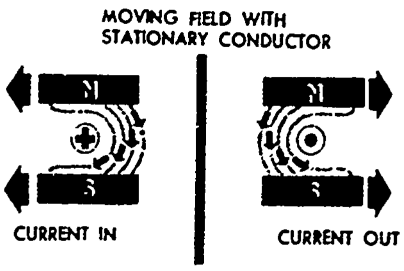
1-3

4

OK.

In an AC generator (alternator), current is produced by a MOVING magnetic field and STATIONARY conductors.

The magnetic field is produced by the ROTOR and current is induced in the STATOR WINDINGS of the alternator.



Press A 5

1-4

5

In an alternator, the magnetic field ___(1)___ and current is induced in ___(2)___ conductors.

A. (1) rotates (2) stationary 7

B. (1) remains stationary (2) rotating 6

1-5

6

Incorrect.

The action of the ROtor produces the magnetic field in an alternator -- the field ROtates.

Current is induced in the STAtionary windings of the STAtor assembly in an alternator.

Press A 7

1-6

7

OK. See Plate I.

An alternator consists of two end frame assemblies, a rotor assembly and a stator assembly. The rotor assembly is supported on one end of its shaft by the DRIVE end frame and on the other end by the SLIP RING end frame. Pre-lubricated bearings are normally used in each end frame assembly, so they usually do not require periodic lubrication.

Press A 8

1-7

DIDACTOR

2

8

The ROTOR assembly consists of the rotor shaft onto which is press-fitted an iron spool. This spool serves as a core around which the FIELD WINDINGS are wound.

Also press-fitted to the rotor shaft are two SEGMENTS which face each other and surround the field coil. The segments have interlaced fingers which serve as POLES.

Press A 9

1-8

9

Two adjacent SLIP RINGS are mounted on one end of the rotor shaft. Each slip ring is connected to an end of the field coil.

A BRUSH rides on each slip ring. See Plate II. The brushes are extra long and will provide long service under normal operating conditions. They provide a part of the path for the field current.

FIELD CURRENT flows from the battery, through one brush and slip ring, through the field coil, through the other slip ring and brush and back to the battery through the ground return path.

Press A 10

1-9

10

______________ passes through the brushes in an alternator.

A. Alternator field current 12
B. Alternator output current 11
C. I'm not sure. 9

1-10

11

You are incorrect.

The brushes in a DC generator must be designed to carry full generator output. Current is passed from the DC generator to the load circuits through the insulated brush.

In an alternator, on the other hand, the brushes normally carry only the FIELD CURRENT. Field current normally is considerably lower than full alternator output.

Press A 12

1-11

12

OK.

The STATOR assembly consists of three sets of series-wound coils which are assembled onto a laminated iron frame. (See Plate I.)

Each individual set of windings consists of several coils wound in series and spaced at equal intervals around the iron frame.

Press A 13

1-12

13

One end of each set of stator windings is used as part of a three-wire Y type connection. When the three sets of stator windings are connected together in this way, the unit is known as a three phase assembly. The stator windings are designed to produce a current-limiting effect at high rotational speeds.

Each set of stator windings is known as a __________ winding.

A. coil 14
B. loop 14
C. phase 15

1-13

14

Not quite.

Each set of stator windings consists of several coils (loops) of wire spaced equally around the iron core. The completed group of three sets of windings is called a three phase unit.

Each individual set of stator windings is called a phase winding.

Press A 15

1-14

15

OK.

One end of each set of phase windings is connected to a common Y type junction.

The other end of each phase winding (called the terminal end) is connected to its own pair of DIODES -- one positive and one negative for each. See Plate III.

Current flow in the stator windings is produced by ______________.

A. battery voltage 16
B. electromagnetic induction 17

1-15

16

Incorrect.

Current flow in the stator windings is produced by electromagnetic induction. As the rotor turns on its shaft, the interlacing fingers (POLES) provide magnetic lines of force which rotate and cut across the stator windings. This induces current in them.

Current from the battery normally is prevented from flowing into the stator windings by the diodes. We will discuss this a little later.

Press A 17

1-16

17

OK.

As the rotor assembly turns on its shaft, the interlacing POLES provide magnetic lines of force which cut across the stator windings and induce current in them.

Let's take a closer look at the rotor assembly to see how the pole magnetism is produced.

Press A 19 X(C)-18

2-17

18

OK.

The magnetic field produced in the turning rotor assembly provides lines of force which cut across the stator windings and induce current in them.

You have made an error or two on the questions we have asked so far, so let's have a quick review. When you answer all the questions correctly, we'll go into more detail as to how the alternator works.

Press A 2

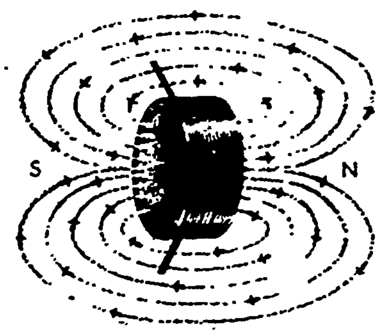
1-18

19

We already know that battery current flows in the field coil by way of connections between the brushes and the slip rings.

When current flows in a coil, a magnetic field is formed around it. This field has polarity -- just as a bar magnet has.

The iron core of the alternator field coil concentrates the lines of force created.



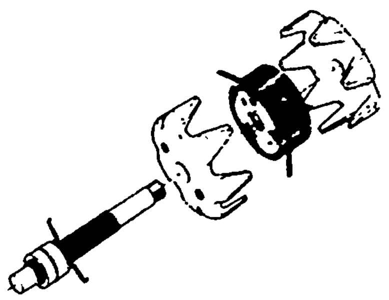
Press A 20

2-19

20

One SEGMENT of the rotor assembly comes into contact with the NORTH pole of the iron core; the other segment comes into contact with the SOUTH pole of the core.

The segments are made of iron material also, and so they conduct magnetic lines of force very well.



Press A 21

2-20

21

Each finger of one segment thus becomes a NORTH pole and each finger of the other segment becomes a SOUTH pole, when the segments are pressed onto the shaft. In the completed assembly, a progression of North-South, North-South poles exists at any given point as the rotor assembly turns.

Thus a rotating magnetic field is produced by the ROTOR assembly.

Press A 22

2-21

22

In an alternator, ________________.

A. the field coil remains stationary while the rotor segments whirl around it 23

B. the field coil rotates in one direction and the rotor segments turn in the opposite direction 23

C. the field coil and the rotor segments turn as a unit in the same direction 24

2-22

23

You are incorrect.

The iron core of the field coil unit and the rotor segments are press-fitted onto the same rotor shaft. A belt is connected to the alternator drive pulley (at the drive end), which causes the rotor shaft to turn when the vehicle engine is running.

Being fitted to the same shaft, the field coil and the rotor segments turn as a unit in the same direction.

Press A 24

2-23

24

OK.

The entire rotor assembly (shaft, field coil, segments and slip rings) turns as a unit -- all at the same speed and in the same direction.

If a single loop of wire is placed just above the rotor assembly as it turns, and the loop is connected to a completed load circuit, current will be induced in the loop as it comes under the influence of the rotating fingers (POLES).

Press A 25

2-24

25

Since the segment fingers are interlaced, a single side of the loop will be influenced alternately by a North pole, then a South pole, then a North, then a South, etc., as the rotor turns.

A North pole causes current to flow in one direction; a South pole causes it to flow in the ______________ direction.

A. same 26

B. opposite 27

2-25

26

You are incorrect.

Magnetic lines of force tend to flow AWAY from a North pole and TOWARD a South pole. (Lines of force flow from North to South.)

If a conductor is under electromagnetic influence, any time the direction of the lines of force is reversed, current direction in the conductor will also be reversed.

Press A 27

2-26

27

OK. The North poles of the whirling rotor assembly cause current flow in one direction; the South poles cause current flow in the opposite direction.

While one side of the single loop of wire is under the influence of a North pole, the other side is under the influence of a South pole.

Thus, ________________ is induced in the loop.

A. alternating current 29

B. direct current 28

2-27

28

Incorrect.

Direct current (DC) flows in one direction only. The loop is affected by the rapid progression of alternately North and South poles. Each time the polarity affecting the loop changes, the current direction in the loop reverses -- current flows first in one direction and then the other.

Current which flows first in one direction and then in the opposite direction is ALTERNATING CURRENT (AC).

Press A 29

2-28

29

OK.

For practical purposes, the current induced in a single loop conductor is not sufficient in strength.

In order to achieve satisfactory current levels for automotive applications, a three phase stator assembly is used.

The stator assembly consists of three sets of coils wound on a laminated iron frame.

A. series connected 31

B. shunt (parallel) connected 30

2-29

30

No.

The stator assembly consists of three sets of SERIES connected coils.

Each set includes several coils of wire spaced evenly around the laminated iron frame. These coils are connected in series with each other. (See Plate I.)

Press A 31

2-30

31

OK.

In each set of stator windings, the voltage induced in one coil is added to the voltage induced in all the other coils to produce a total winding voltage.

Connecting several coils in series helps to increase the output of each individual set of windings.

Press A 32

2-31

32

The output can be further increased by placing two additional sets of stator windings on the same frame and connecting all three sets together.

One end of each set forms part of a three-wire Y type-connection.

Press A 34 X (C)-33

3-32

33

OK.

Before we continue our discussion of how current is induced in the stator windings, let's have a quick review of the construction and operation of the rotor assembly.

Press A 17

2-33

34

By connecting each set of stator windings to a common source, the voltage induced in one set can be added to the voltage induced in either one of the other two sets.

For example, voltage induced in stator winding set (A) can be added to voltage EITHER from set (B) or from set (C).

Press A 35

3-34

35

The three sets of stator windings share a common connection at one end, as we have seen.

The other end of each set is connected to its own pair of DIODES -- one positive diode and one negative diode for each set of stator windings.

In all, there are _____ diodes in the alternator.

A. three 36
B. two 36
C. six 37

3-35

36

Incorrect.

There are three sets of stator windings. One end from each set is connected to its own PAIR of diodes.

Each of the three sets of stator windings has two diodes, so in all there are SIX diodes in the alternator.

Press A 37

3-36

37

OK.

Plate IV shows the relationship between the stator windings and the diodes. Note that each set of stator windings is connected both to its own POSITIVE diode and to its own NEGATIVE diode.

In a negative ground alternator, the positive diodes are mounted in the heat sink of the slip ring end frame. The positive diodes are INSULATED.

The negative diodes are mounted in the end frame itself and are GROUNDED. Press A 38

3-37

38

In the alternator illustrated in Plate IV, the POSITIVE diodes are ___(1)___ and the NEGATIVE diodes are ___(2)___.

A. (1) grounded (2) insulated 39

B. (1) insulated (2) grounded 40

3-38

39

Incorrect.

The positive diodes (illustrated in Plate IV) are installed in the HEAT SINK portion of the slip ring end frame. (See Plate III also.) The heat sink is insulated from the rest of the end frame, so the positive diodes are INSULATED.

The negative diodes are installed in the grounded portion of the slip ring end frame, so the negative diodes are GROUNDED. Press A 40

3-39

40

OK.

Under normal operating conditions, current leaves the alternator through the positive diodes and completes its electrical circuit through the negative diodes.

The function of a diode is to permit current to flow in one direction, but to BLOCK the flow of current in the opposite direction. The diode acts as a sort of one way gate, or electrical check valve.

Press A 41

3-40

41

This is the symbol for a diode: 

If this symbol appears in a diagram in the position shown, it means that the diode will allow current to flow to the ________ ____.

A. right but not to the left 43

B. left but not to the right 42

3-41

42

You are incorrect. 

Note that the diode symbol contains two parts -- one part resembles an arrow and the other part resembles a solid wall.

If the symbol is in the position shown above, the arrow points to the right. This means that the diode will allow current to flow to the right. The wall prevents current from flowing back to the left.

Press A 43

3-42

43

OK.

In an alternator, the diodes perform two basic functions:

1. They rectify the AC induced in the stator windings (they change AC to the DC necessary for battery charging and electrical system operation).
2. They prevent battery discharge current from flowing back into the alternator.

Considering the second function listed above, the diodes in an AC charging system take the place of the ________ used in DC charging systems.

A. voltage regulator 44
B. commutator 45
C. cutout relay 46

3-43

44

You are incorrect.

We said that the diodes, because of their position in the AC charging circuit, prevent battery DISCHARGE current from flowing back into the alternator.

The component which performs that function in a DC charging system is the CUTOUT RELAY.

An AC generator requires a voltage regulator just the same as a DC generator does. Press A 46

3-44

45

The diodes do take the place of the commutator, in that they normally allow only DC to leave the alternator.

But the diodes also perform another important function. They prevent battery discharge current from flowing back into the alternator. What component in a DC charging system, placed between the generator and the battery, performs that same function?

Try the question again. Press A 43

3-45

46

OK.

Since the diodes normally prevent battery discharge current from flowing back into the alternator, no cutout relay is necessary in an AC charging system.

The diodes also change the AC induced in the stator windings to DC. DC is necessary for proper operation of automotive electrical system components, and for battery charging.

Press A 48 X(C)-47

4-46

47

OK.

The diodes in an AC charging system take the place of the cutout relay found in DC systems.

Since you have made an error on a question or two, let's have a quick review of the stator assembly and the diodes.

Press A 31

3-47

48

Let's take a look at how alternating current is induced in the stator windings and is changed to DC by the diodes.

We can refer to Plate IV again to show how DC is supplied to the battery, for example, during the instant that current flows through only two of the stator windings.

Press A 49

4-48

49

See Plate IV.

As we already know, the North poles of the rotor cause current to flow in one direction; the South poles cause current to flow in the opposite direction.

If the (A) winding and the (B) winding, for example, are under the influence of North poles simultaneously, current will flow in one direction from the (A) winding through the (B) winding. This pulse of current will then pass through the POSITIVE (B) DIODE and will appear as DC at the alternator output terminal.

Press A 50

4-49

50

The DC will then flow either to the battery or to the load circuit. Let's follow it through the battery charging circuit.

DC leaves the alternator output terminal, travels to the insulated battery post, through the battery, out through the grounded battery terminal and back to the alternator through the ground return path. You may trace this path on the diagram in Plate IV.

Press A ~~53~~ 51

4-50

51

Current which travels first through winding (A) and then winding (B) leaves the alternator through the ___(1)___ diode which serves winding ___(2)___.

A. (1) positive (2) (A) 53
B. (1) negative (2) (A) 52
C. (1) positive (2) (B) 54
D. (1) negative (2) (B) 53

4-51

52

Both parts of your answer are incorrect.

Under normal circumstances, current leaves the alternator through the POSITIVE (insulated) diode which serves the last stator winding through which the current flows. If current flows first through winding (A) and then winding (B), current will leave through the POSITIVE (B) DIODE.

Note that the negative (B) diode normally will prevent the current from flowing to ground.

Press A 54

4-52

53

Only part of your answer is correct.

Under normal circumstances, current leaves the alternator through the POSITIVE (insulated) diode which serves the last winding through which the current flows.

If the current flows first through winding (A) and then winding (B), it will leave the alternator through the POSITIVE (B) DIODE. (See Plate IV.)

Press A 54

4-53

54

OK. The negative (B) diode prevents the output current from going immediately to ground.

The current completes the circuit by re-entering the alternator through the NEGATIVE (grounded) diode which serves the winding in which it originally flowed.

Current which flows first in the (A) winding and then in the (B) winding will re-enter the alternator through the negative ____________ diode.

A. (A) 56
B. (B) 55
C. (C) 55

4-54

55

Incorrect.

Current re-enters the alternator through the negative diode which serves the winding in which it originally flowed.

Since the current flowed first in winding (A) and then in winding (B), it will re-enter the alternator through the NEGATIVE (A) DIODE.

Press A 56

4-55

56

OK.

Current re-enters through the negative (A) diode, then flows back to the (A) winding where it originated.

Since the rotor turns rapidly, the (A) and (B) windings will be simultaneously under the influence of North poles for only an instant. Very quickly, they will come under the influence of South poles. This causes the current direction through the two windings to reverse.

When the (A) and (B) windings simultaneously come under the influence of South poles, current will flow ________________.

A. first in winding (A) and then in winding (B) 57
B. first in winding (B) and then in winding (A) 58

4-56

57

You are incorrect.

We said that current will flow first in winding (A) and then in winding (B) when the two windings are simultaneously under the influence of North poles.

When they are simultaneously influenced by South poles, current will flow first in winding (B) and then in winding (A).

Press A 58

4-57

58

OK.

Since the current reverses its direction in the two windings as the influencing polarity changes, __________ current is said to flow in the two windings.

A. direct 59
B. alternating 60

4-58

59

No.

As the influencing polarity changes from North to South, the current direction in the two windings reverses.

Current that flows first in one direction and then the other is ALTERNATING CURRENT (AC).

Press A 60

4-59

60

OK. Alternating current flows in the stator windings.

Current flows first in winding (B) and then in winding (A) during the instant they are simultaneously under the influence of South poles.

Under these conditions, current will leave the alternator via the ___(1)___ diode and will re-enter via the ___(2)___ diode. (Refer to Plate IV if necessary.)

A. (1) positive (A) (2) negative (B) 62
B. (1) positive (B) (2) negative (A) 61
C. (1) negative (A) (2) positive (B) 61
D. (1) negative (B) (2) positive (A) 61

4-60

61

Your answer is incorrect.

The basic rule to remember is this:

> Current leaves the alternator through a POSITIVE diode. It re-enters through a NEGATIVE diode.

In our question, current flowed first in the (B) winding and then in the (A) winding. Since it flowed last in the (A) winding, current will LEAVE via the POSITIVE (A) diode and will RE-ENTER via the NEGATIVE (B) diode.

Press A 62

4-61

62

OK.

Current will leave the alternator through the POSITIVE (A) DIODE and will re-enter through the NEGATIVE (B) DIODE. It then flows back to the (B) winding where it originated.

Since the positive diodes allow current to flow only away from the alternator, we say that __________ flows in the external load circuits.

A. DC 64
B. AC 63

4-62

63

You are incorrect.

The diodes allow current to flow in one direction only. The positive diodes allow current to flow only AWAY from the alternator under normal conditions.

Current which flows in one direction only is DIRECT CURRENT (DC).

Press A 64

4-63

64

OK.

Thus we have seen that regardless of the direction of current through windings (A) and (B), direct current (DC) always flows in the battery charging circuit and in the vehicle load circuit.

We have traced one complete cycle of alternating current as it flows in the (A) and (B) stator windings (the A-B phase).

If you would like to review this section, press A. 42

If you would like to go on to see what happens during other instants in alternator operation, press B. 66

X(c)-65

4-64

65

OK.

The alternating current generated in the A-B phase of the stator assembly is rectified by the positive A and B diodes -- the diodes change AC to DC, which is usable in the charging circuit and the load circuit.

Let's have a quick review of the complete cycle of AC induced in the (A) and (B) windings, since you had trouble with a question or two.

Press A 48

4-65

66

Thus far we have considered only one phase (the A-B phase) of alternator operation. But current is induced in the other two phases of the stator assembly also -- in the B-C phase and the C-A phase.

Press A 67

5-66

67

See Plate IV.

The arrangement of the stator windings is such that each phase develops its maximum voltage at a different time. A relatively smooth, constant DC voltage is therefore available at the alternator output terminal.

As the voltage developed in the A-B phase of the stator assembly begins to fade, voltage is building up in the B-C phase. The process repeats in the C-A phase also.

When current flows first in the (B) winding and then in the (C) winding, current will leave the alternator at the ___(1)___ diode and will re-enter at the ___(2)___ diode.

A. (1) positive (B) (2) negative (C) 68
B. (1) positive (C) (2) negative (B) 69

5-67

68

Incorrect.

Remember that current leaves through the positive diode of the LAST winding in which it flowed. It re-enters through the negative diode of the winding in which it originally flowed.

Press A 67

5-68

69

Good. As current flows in one direction in the B-C phase, direct current leaves via the positive (C) diode and re-enters via the negative (B) diode.

When current reverses its direction and flows first in winding (C) and then in winding (B), direct current leaves via the positive ___(1)___ diode and re-enters via the negative ___(2)___ diode.

A. (1) (B) (2) (C) 71
B. (1) (C) (2) (B) 70

5-69

70

You are incorrect.

If current flows last in the (B) winding, it will leave via the positive (B) diode.

Since it leaves via the (B) diode, it will re-enter via the negative (C) diode.

Press A 71

5-70

71

OK.

Now let's look at the remaining phase -- the C-A phase. (Refer to Plate IV as necessary.)

If current leaves through the positive (A) diode and re-enters through the negative (C) diode, we know that it originated in winding ___(1)___ and then flowed into winding ___(2)___, prior to leaving the alternator.

A. (1) (C) (2) (A) 73
B. (1) (A) (2) (C) 72

5-71

72

You have the correct answers reversed.

Since current re-enters via the negative diode of the winding in which it originated, the current in this case originated in winding (C). Then the current flowed on into winding (A) prior to leaving the alternator.

Press A · 73

5-72

73

OK.

In the C-A phase of alternator current generation, if current originates in the (A) winding it will leave the alternator via the ___(1)___ diode and re-enter via the ___(2)___ diode.

A. (1) positive (A) (2) negative (C) 74
B. (1) negative (A) (2) positive (C) 74
C. (1) positive (C) (2) negative (A) 75
D. (1) negative (C) (2) positive (A) 74

5-73

74

You are incorrect.

In the C-A phase, if current originates in the (A) winding, it will leave via the POSITIVE (C) diode (the positive diode of the last winding in which it flowed).

Since this is the C-A phase, and current leaves via the positive (C) diode, it will re-enter via the NEGATIVE (A) diode (the negative diode of the winding in which it originated).

Press A 75

5-74

75

OK.

Let's take a final look at some of the basic rules which apply to alternator three phase current generation.

In the alternator, ________ current is induced in the stator windings.

A. alternating (AC) 77
B. direct (DC) 76

5-75

76

No.

Remember that in each phase of the stator assembly, current flows first in one direction and then the other.

This is ALTERNATING CURRENT.

Press A 77

5-76

77

OK.

Alternator output is made up of overlapping pulses of direct current. Each pulse of alternator output is created by ________________.

A. one set of stator windings 78
B. two sets of stator windings acting together 79
C. all three sets of stator windings acting together 78

5-77

78

Incorrect.

The alternator is a three phase current generator. The stator windings make up the separate phases.

See Plate IV. Pulses of output may be created by the A-B phase, the B-C phase, or the C-A phase. In any case, a single pulse of output is created by TWO sets of stator windings acting together.

Press A 79

5-78

79

OK.

The diodes form the RECTIFIER ASSEMBLY in an alternator. There are six diodes in all -- three positive and three negative. (See Plate IV.)

All the positive diodes are ___(1)___; the negative diodes are ___(2)___.

A. (1) insulated (2) grounded 81
B. (1) grounded (2) insulated 80

5-79

80

Incorrect.

Note that in Plate IV the three negative diodes are directly connected to the GROUNDED side of the rectifier assembly. The negative diodes are grounded.

The three positive diodes are connected to the ungrounded battery terminal. The positive diodes are INSULATED.

Press A 81

5-80

81

OK.

The alternator illustrated in Plate IV is a NEGATIVE-GROUND unit and can be used ONLY on a vehicle with a negative ground electrical system.

Current normally leaves the alternator via ___(1)___ diode and re-enters via ___(2)___ diode.

A. (1) a grounded (2) an insulated 82
B. (1) an insulated (2) a grounded 83

5-81

82

Incorrect.

The grounded diodes are normally installed in such a position as to allow current to pass through them only on its RETURN path.

Current normally leaves via an INSULATED diode and returns via a GROUNDED diode.

Press A 83

5-82

83

OK.

Current normally leaves the alternator via the insulated diode of the phase winding in which it ________.

A. originated 84
B. last flowed 85

5-83

84

You are incorrect.

Under normal conditions, current re-enters the alternator via the grounded diode of the phase winding in which it originated.

Current normally Leaves via the positive diode of the phase winding in which it Last flowed.

Press A 85

5-84

85

OK.

Current normally completes its circuit through the ___(1)___ diode of the phase winding in which it ___(2)___.

A. (1) insulated (2) originated 87
B. (1) insulated (2) last flowed 86
C. (1) grounded (2) last flowed 87
D. (1) grounded (2) originated 88

5-85

86

Both parts of your answer are incorrect.

Current normally re-enters the alternator through a GROUNDED diode.

To complete the circuit, the current must pass through the grounded diode of the phase winding IN WHICH IT ORIGINATED.

Press A 85

5-86

87

Only part of your answer is correct.

Current normally re-enters the alternator through a GROUNDED diode.

To complete the circuit, it must pass through the grounded diode of the phase winding IN WHICH IT ORIGINATED.

Press A 85

5-87

12

88

Good.

This concludes our discussion of how current from the stator windings is rectified and made available to the electrical accessories.

If you would like another look at this section, in which we have reviewed fundamental alternator principles, press A. 67

Otherwise, press B. 90 X(c)-89

5-88

89

OK.

Current normally completes its circuit through the grounded diode of the phase winding in which it originated.

We have reviewed fundamental principles of alternator current generation in this section. Since you have had trouble with a question or two, let's take another look at the section.

Press A 67

5-89

90

Congratulations! You have successfully completed this film. "Understanding Alternator Principles."

In the next film. "AC Generators II." we will discuss operating principles of the alternator voltage regulator and field relay unit. We will also go into Alternator Testing Procedures.

Press REWIND.

5-90

INSTRUCTOR'S GUIDE

Title of Unit: LEARNING ABOUT AC GENERATOR (ALTERNATOR) PRINCIPLES (PART I) AM 2-16 9/9/67

OBJECTIVES:

1. To review the fundamentals of electricity, magnetism, electromagnetic induction, and their relation to each other.
2. To discuss the operating principles of an AC generator, commonly called an alternator, in the automotive and truck field.
3. To discuss the construction of an alternator, and describe the components, their function and relation to each other, in a step by step procedure.
4. To discuss the sequence of events that occur during alternator operation, how AC and voltage is rectified or changed to DC and voltage, and the method of controlling the current and voltage output of the alternator.

LEARNING AIDS suggested:

Visual Aids:

Delco-Remy Training Charts and Manuals

DR 5133-H AC CHARGING CIRCUITS

DR 5133-M "DELCOTRON" GENERATOR AND THE CHARGING CIRCUIT

Models:

Any alternator components or an assembly that could be brought into a classroom for disassembly and discussion. Ammeter, voltmeter and ohmmeter as well as a diode tester may be demonstrated.

QUESTIONS FOR DISCUSSION AND GROUP PARTICIPATION:

1. Why are some conductors of electricity better than others?
2. What causes electrons to move through a conductor?
3. What is meant by the term voltage potential? Explain.

4. Why is the concept of polarity important to the automotive (off-highway) mechanic?

5. Should we be more concerned with resistance in an electrical system that is equipped with an alternator, or less concerned? Explain.

6. What effect, if any, does placing an iron core inside a current carrying coil have on the magnetic field around the coil?

7. How is current transferred from the magnetic field of an alternator rotor to the stator winding?

8. What determines the direction of current flow in relation to the magnetic lines of force?

9. Explain the difference between the principle of a DC generator as compared to an AC generator (alternator).

10. What effect would doubling the magnetic lines of force have on the induced current and voltage in an alternator?

11. What is the purpose of the two slip rings on the rotor assembly?

12. How are the three windings of the stator connected, and why?

13. What is the purpose of diodes?

14. How many diodes are in a typical alternator, and how are they connected?

15. How is the magnetic field controlled in an alternator? How is the voltage limited to a safe value?