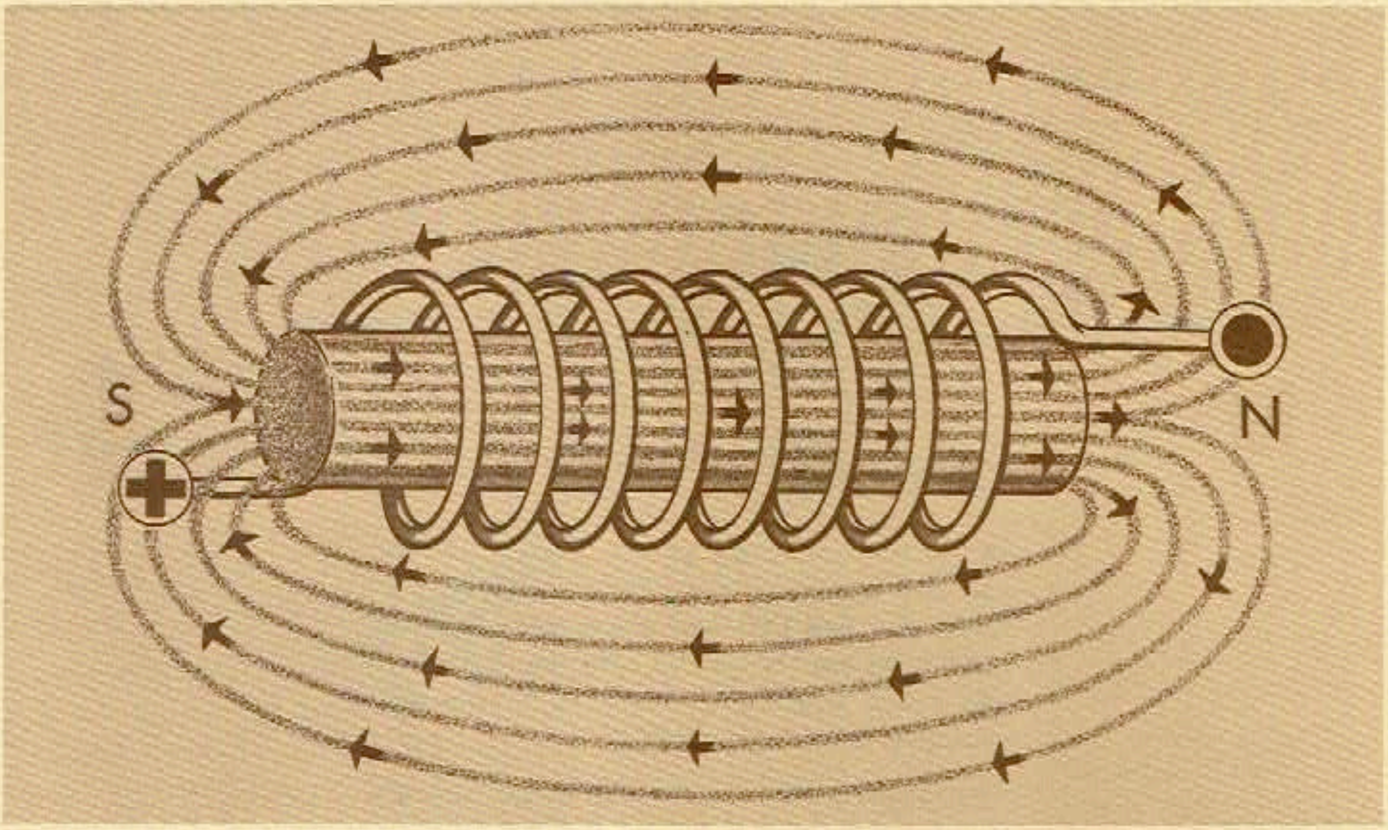
Chart 5

The strength of the magnetic field around a coil of wire can be increased even further 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. An assembly of this type creates a stronger electromagnet than that discussed in Chart 4.

This same principle is used in the design of the rotor assembly of the Delcotron. 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 Chart 5. The strength of the magnetic field 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 the Delcotron the coil in the rotor assembly is called the "field" coil and the current that passes through it is called "field" current.

ELECTROMAGNETIC PRINCIPLES



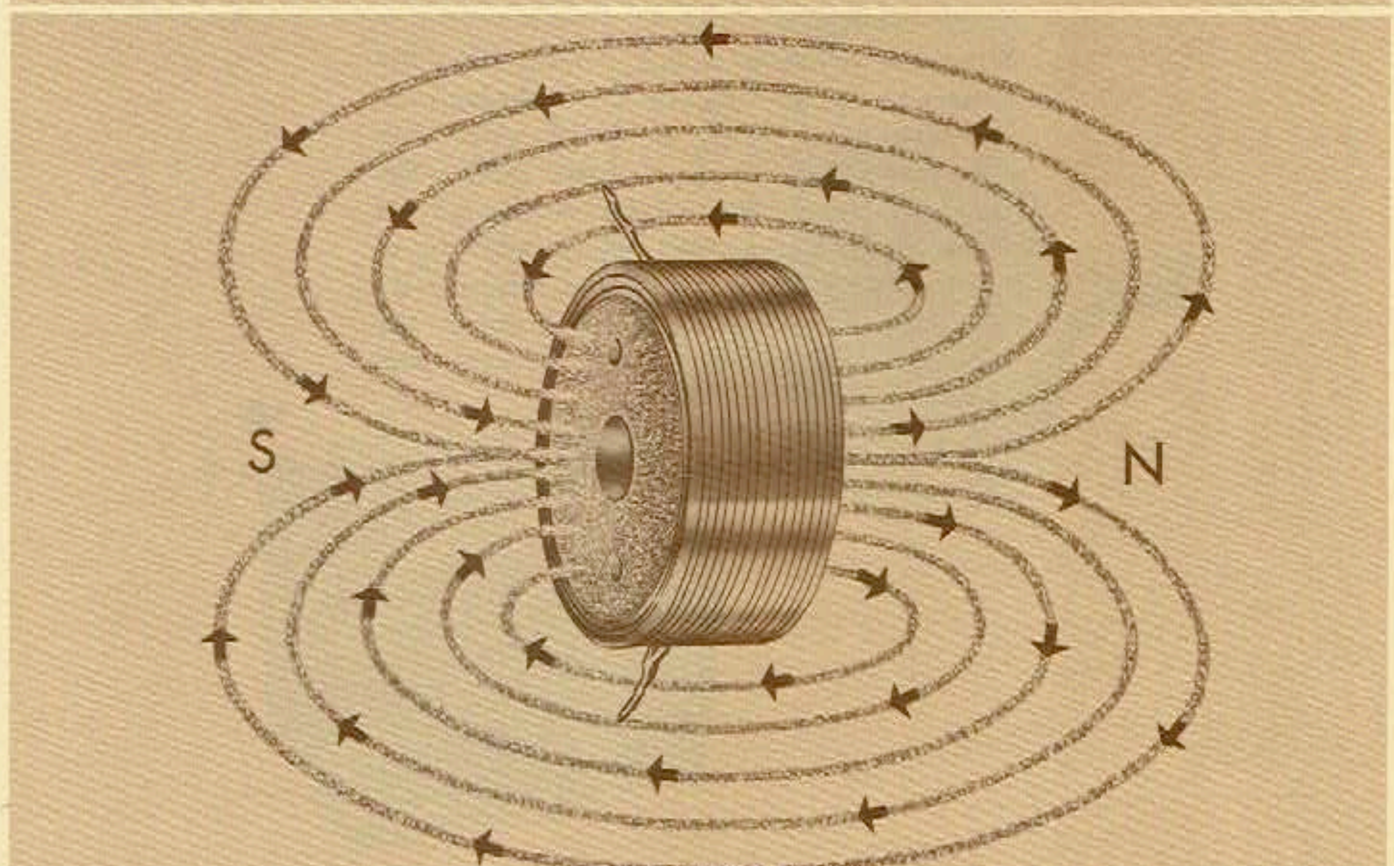


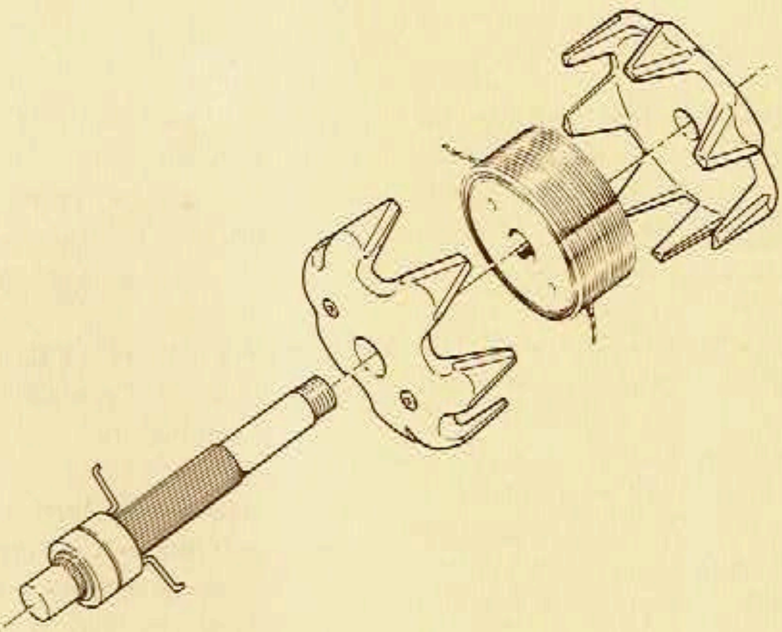
Chart 6

In the rotor assembly of the Delcotron, 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.

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.

ROTOR CONSTRUCTION



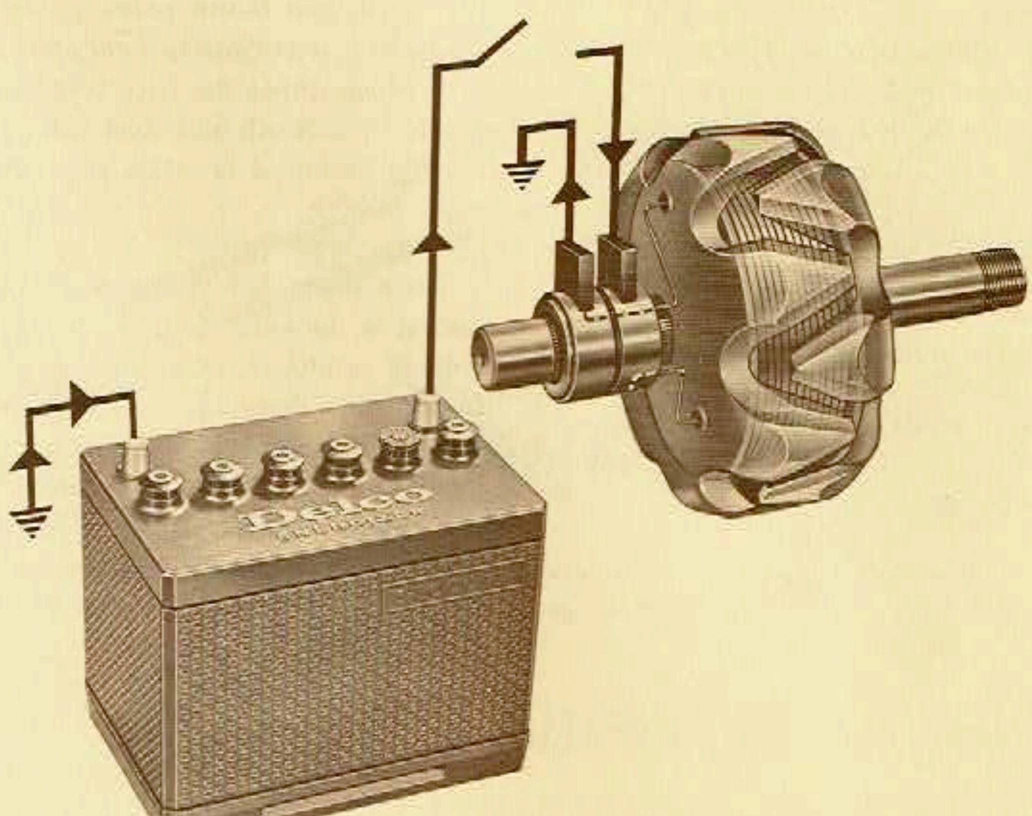


Chart 7

The magnetism created by this field current causes the poles on the rotor to become alternately North and South poles. It will be shown later that this magnetic field is used to produce alternating voltages in the stator windings.

We have seen that a magnetic field, made up of lines of force, is created around a wire when current is passed through it. 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, 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 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 gray arrows. With this direction of motion, the magnetic lines are striking the conductor on its left side, which is called the leading side.

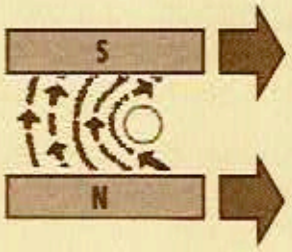
The direction of current flow can be determined by applying the Right Hand Rule as follows: Grasp the conductor with the right hand with the fingers on the leading side of the conductor, and pointed in the direction of the magnetic lines of force. The thumb will then point in the direction of current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

Voltage is generated in Delcotron generators by moving strong magnetic fields across stationary conductors.

For purposes of illustration, the most basic stator winding can be represented by a single loop of wire placed over the rotor. Connecting the ends of the loop to a load such as a light bulb, as shown in the chart, completes the circuit. As the rotor turns the magnetic field from the North and South poles on the rotor cuts 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 in the other through the bulb. This is called alternating current or a.c. current. If a meter is placed in the circuit the fluctuation of the needle will show that the voltage will cause current flow first in one direction and then the other.

GENERATED VOLTAGE



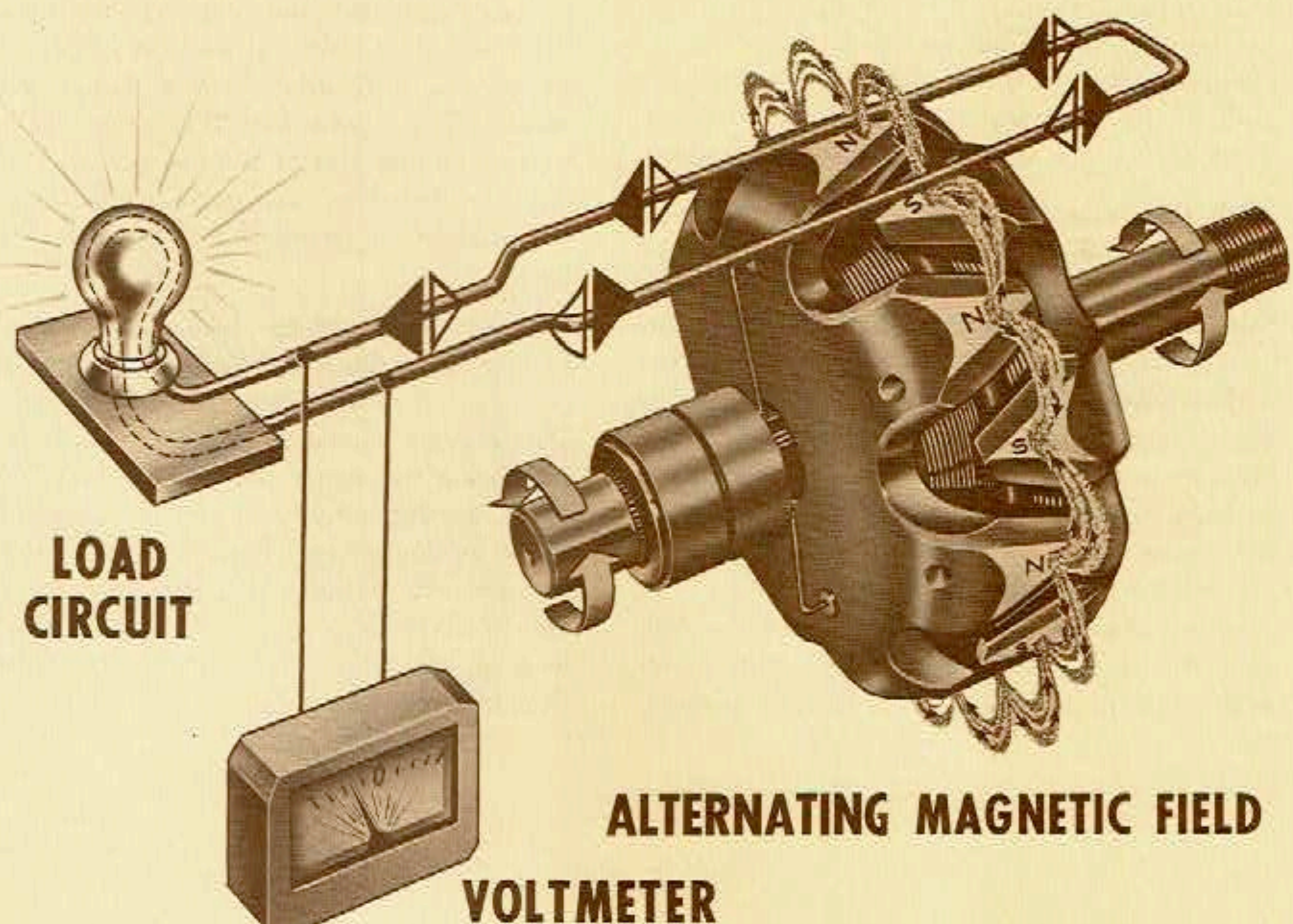


Chart 8

To illustrate further how an alternating voltage is produced, consider a simple two-pole permanent magnet type rotor and a stator that contains a single loop of wire. Only the ends of the loop of wire are shown in the chart.

Different positions of the rotor as it turns are shown in the diagrams below the solid 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 when the rotor turns. Positive voltage is shown above the solid horizontal line and negative voltage below the line. 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. As the rotor continues to turn, the voltage increases and reaches its maximum value, as shown above the horizontal line in the illustration, 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 as the rotor movement continues 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 the strongest 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* pole is on top, and the voltage curve *above* the horizontal line is called 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 the circuit is completed 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 the circuit is completed. 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.

ALTERNATING VOLTAGE
(SINGLE PHASE)

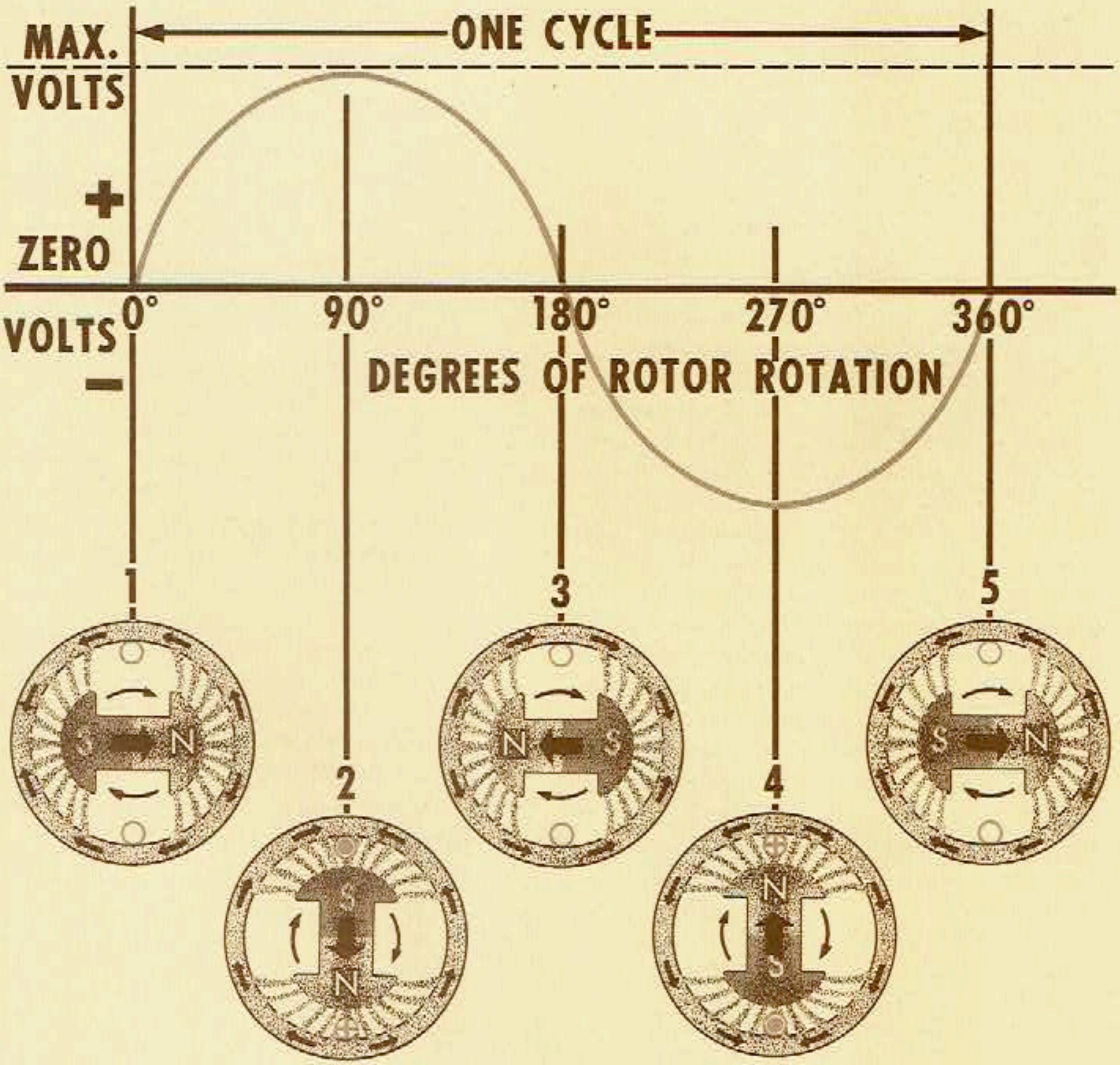


Chart 9

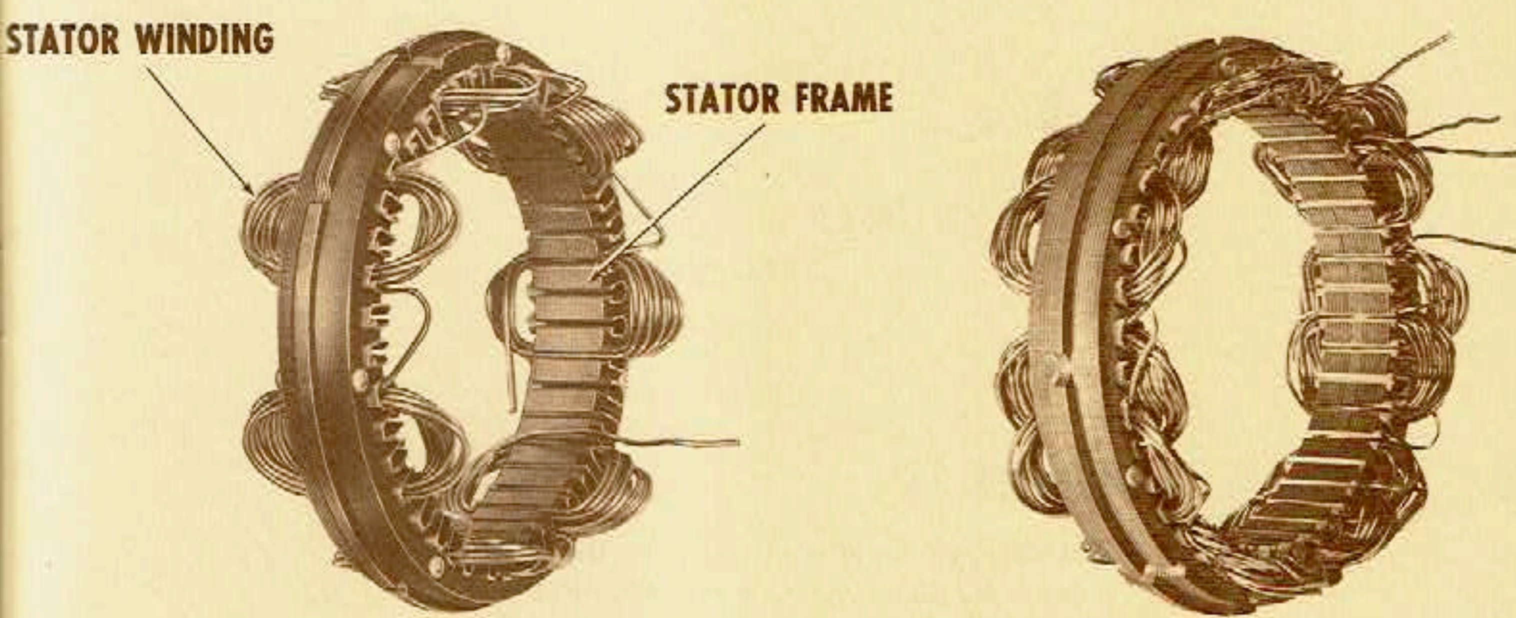
To picture the construction of the stator used in the Delcotron, the accompanying illustration shows how a length of wire is formed into many loops to make a coil. Many coils make a winding. This assembly is then placed into the proper slots of the stator laminations.

Instead of having a single loop of wire as discussed in Chart 8, 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 Delcotron fourteen poles are used. A schematic diagram of one winding is shown.

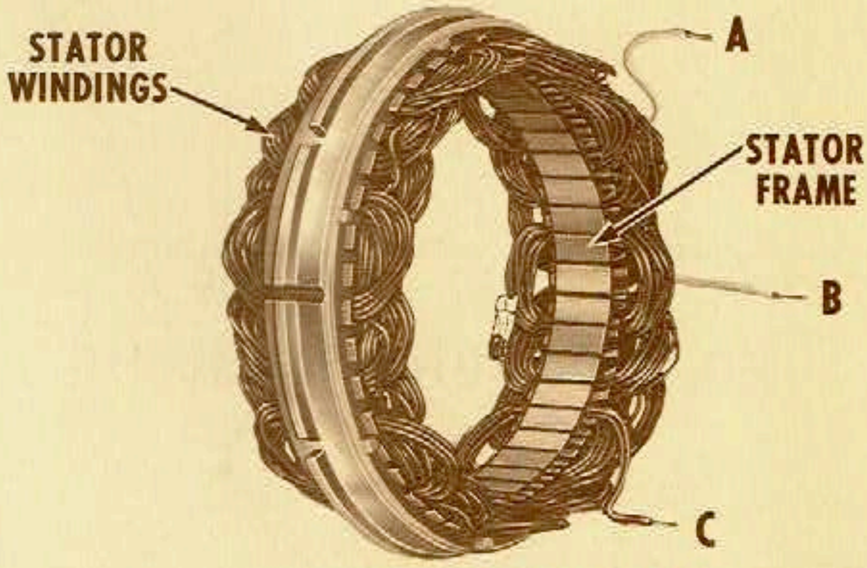
After a second and third winding has been assembled, the actual stator construction is shown with the three windings assembled onto a laminated iron frame. There are two basic reasons for using three stator windings rather than just one winding. First, more voltage can be developed. The total voltage 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.

STATOR CONSTRUCTION



STATOR ASSEMBLY



STATOR ASSEMBLY