Glue the paper securely in place. Now cut some cardboard or even thin board pieces 1 inch square, and put a hole in the center of these, so they will slip over the stick. See Figure 74.

Lock them in place by driving a nail through the end of the stick, or by building some paper ends up again as before. Lay two strings on again and wind on top of the paper some No. 36 silk and enamel insulated wire, building up this at least 3/8 of an inch. Six ounces of this wire will be plenty for this. Bring the ends of the string up and tie the coil securely in place. Now, you can remove the ends from the wooden block and knock the block out from the center.

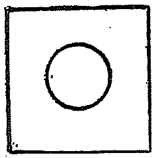
FIG. 74

Make two blocks of wood 1/2 inch thick, with a hole in the center large enough to stick the bundle of iron wire through and a small hole as near as possible to this larger one big enough to slip the end of the large wire (No. 18) through. See Figure 75. The block of wood must be big enough to project 1/8 of an inch beyond the outside of the wire coils. Slip the iron core inside the windings and then put the ends of the large wire through the small holes in the wooden blocks, and finally put the blocks over the ends of the iron wire. Screw these blocks to a board so they will fit snugly against the winding. See Figure 76.

Next fasten a piece of soft iron to a piece of spring brass, as shown in Figure 77.

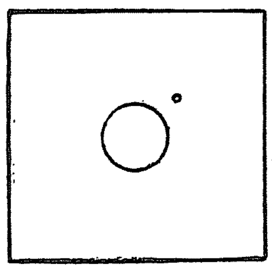
FIG. 75

The iron should be about 1/4 inch in diameter and 1/8 inch thick. Fasten to the brass by soldering or by a flat-headed screw, but be sure the outside end of the iron is smooth and bright. The brass spring should be about 1/64 of an inch thick and bent in an "L" shape, so that when mounted in place the iron will be directly in

front of and about 1/8 of an inch from the end of the iron wire.

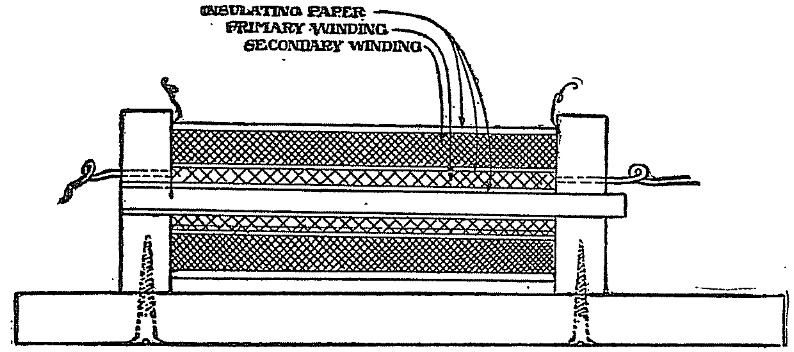

FIG. 76

Screw it to the base, as shown in Figure 78. Back of the spring put a wooden post and through it a brass machine screw with some lock-ing nuts. This is the adjusting screw. At the top of the wooden blocks put a brass wood screw and a washer (you can cut this out of brass sheet) and connect the ends of the top winding to these screws.

CONNECTIONS

Connect one end of the primary winding, that is the large wire (No. 18), under the head of one of the screws holding the brass spring. Connect the other end of the same winding to a series of at least two dry batteries. (More batteries will give more power.) Connect from the other side of the battery to the brass adjusting screw. The wires leading to the apparatus to which you want to supply the high voltage should be connected to the secondary binding screw (to which the small wire is fastened).

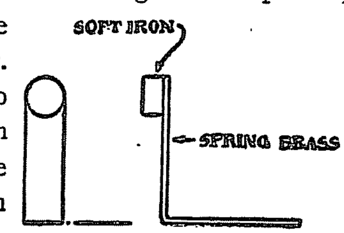

FIG. 77

OPERATION

When the circuit is complete, adjust the brass screw until the vibrator (the iron mounted on the brass spring) will bound back and forth rapidly. It will do this because the large wire magnetizes the bundle of iron wire which draws to it the small iron piece. But in drawing the iron away from the brass screw it breaks the electric current flow and the spring then flies back in position of rest only to close the circuit again, and this keeps the action going.

As explained previously, the current makes a magnetic field around the large wire. The strength of this magnetic field is determined by the number of turns of wire, and also by the amount of

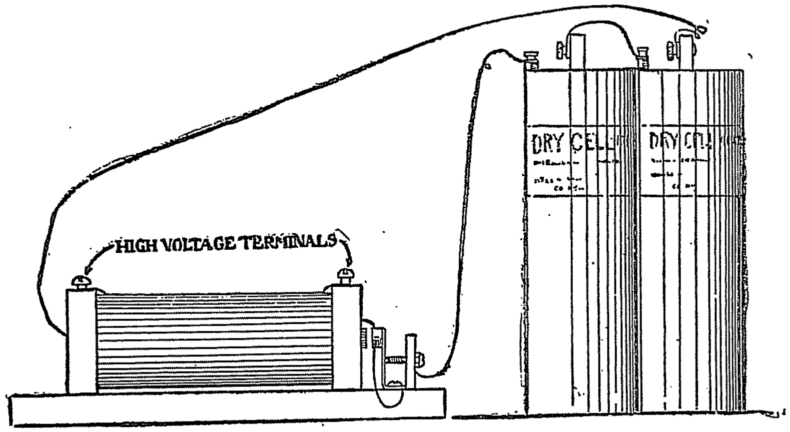

FIG. 78

current flowing. The current is changing from zero to its full value every time the vibrating arm makes and breaks the circuit. The magnetism must therefore change from zero to the high point for every current change. These changing lines of magnetism cut across the many turns of the fine wire on the secondary. It is well known that currents of electricity can be induced in a wire by moving the wire through a magnetic field so that it cuts the magnetic

lines. And the Same Result Can Be Gained if the Wire Is Stationary, but the Magnetic Lines Move So They Cut Across the Wire. In both cases the number of magnetic lines cut by the wire determines the voltage of the circuit. If the wire is coiled so as to form a long piece, it will cut or be cut by more magnetism than one short piece. Therefore, when the primary winding of the induction coil sets a varying magnetic field surging across the many

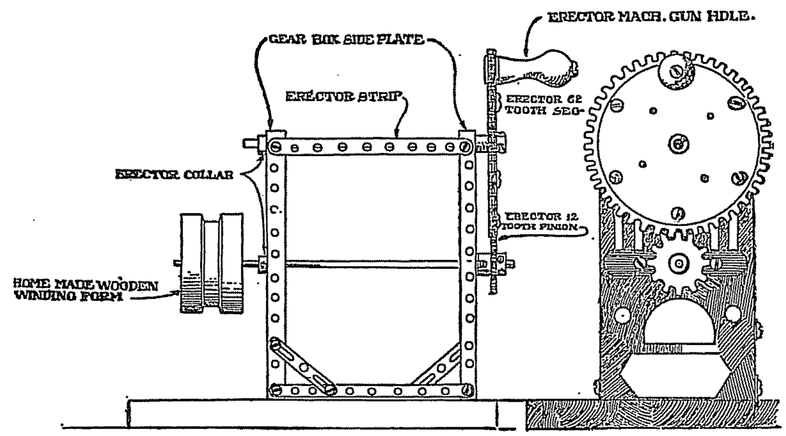

FIG. 79

turns of the secondary winding, it induces electrical flow at a higher voltage in the fine wires, and this can be taken off from the terminal posts. Caution must be observed in using such a device, for a severe shock can be received from the secondary of this machine when it is operating. Keep the hands away from the binding posts while it is working.

Figure 79 shows a simple winding machine made of construction toy parts which will be a great help in winding coils for such devices as this.

IS THE ELECTRICITY IN YOUR HOUSE ALTERNATING OR DIRECT CURRENT?

Place one of your horseshoe magnets or your electro-magnets near the glass of any lighted incandescent lamp. If you will look carefully you will see that it sets up a disturbance of the glowing filament. If there is a direct current flowing in the lamp, the filament will be bent over by magnetic attraction or repulsion. If alternating current is flowing, you will see a decided vibration of the lighted filament.

MAGNETIC DESIGNS

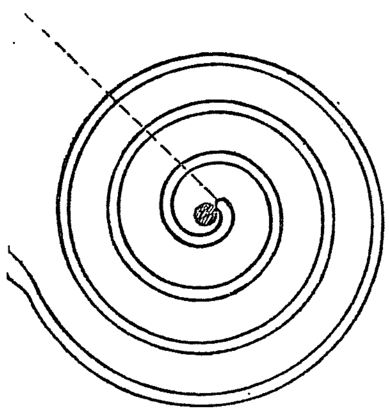

FIG. 80

BIFILAR WOUND COIL—DOTTED LINE SHOWS TAP AT MIDDLE POINT OF THE MAIN WIRE

Place several sewing needles through corks; magnetize them. Place the corks in a bowl of water. If you have placed them in the water with the ends of the same polarity sticking up and have pointed the north or the south pole of a bar magnet toward them, you will find that they group themselves into peculiar figures. After you have done this turn some of the needles upside down, some with the north poles and some with the south poles up. By approaching them with a bar magnet you will see some of them attracted and some repelled.

THE FAKE ELECTRO-MAGNET

This is a stunt with which you can fool your friends, using what is known as the Bifilar winding, a picture of which is shown, Figure 80. Wind a coil with any number of turns of insulated wire, doubling the wire back on itself. Remember your right hand rule for current flowing through the wire. You will find that one-half of the winding will oppose the magnetism of the other half and that no magnetic effect will be produced by the coil. By placing the tap on the wire as shown in Figure 80, so that one-half of the coil can be cut from the current carrying circuit, you can produce magnetism. Arrange this tap so that it is well concealed and you have a coil by which you can produce magnetism when your friends cannot, much to their astonishment and your own enjoyment.

HANGING A RING OR KEY ON A PICTURE

A very amusing and astonishing trick can be done with the following apparatus: Behind a thin blackboard, a piece of drawing paper or some other material on which you can draw a picture, hang a strong electro-magnet, being careful to conceal it from the front of the board. Be sure that you know exactly where it is located. Now, tell your friends that you are able to draw a picture of a hook or nail so true to life that you can hang a key or steel ring or any other steel or iron piece on it. Draw a picture, then place the key or ring against the board. The magnet, of course, will hold the key in place.

MAGNETIC FINGERS

Conceal a piece of magnetized steel, the point of a sewing needle will work very well, under the finger nail of your first finger. By pointing your finger to a very small piece of iron or steel, you can attract it. The compass needle will turn around at your command.

MAGNETIC SEPARATORS

The fact that some materials are attracted by magnets and some are not have been used many years by manufacturers to separate the steel and iron filings and chips from brass, dust, etc. If you mix iron filings with dust and then hold a magnet over them, you will draw out the iron filings while the dirt particles will remain behind. One of the types of machines used by manufacturers is built as follows: An endless belt revolves over pulleys which carries the mixture to be separated downward to a magnet at the lower end of the belt. The material falls downward near the poles of a strong magnet and, as it falls, the steel or iron is pulled toward the poles, while the non-magnetic material falls in a straight line. A partition is set up, so that one pile of non-magnetic material accumulates on one side of it and on the other side of it iron or steel.

TO TELL IRON FROM BRASS

A great many pieces of furniture and ornaments are made of imitation brass. The material used is most often sheet iron plated and lacquered. You can prove whether it is real brass or imitation by attracting it with a magnet. If it is imitation, the material will, of course, stick to the magnet; whereas, with real brass the magnet will have no effect. You will also find that by attracting tin cans and other articles, made of so-called tin sheet, that these are not really made of tin, but of sheet iron with a thin plating of tin over them.

A TEST FOR LIVE WIRES

At some time or other, you may wish to know whether electric wires are carrying a current or whether there is any electricity in them. This is commonly known as finding out whether or not the conductors are live or dead. By bringing a compass near the wires or by suspending a magnetized needle near them, you will see the needle quiver if an alternating current is flowing in the wire. In case of direct current, you will have a decided deflection. If wires are of high voltage, such as found in power houses or on the so-called high tension lines, there is great danger of receiving

a shock on these circuits. Only experienced electrical men should have anything to do with them.

ELECTRICAL PENDULUMS

Electrical clocks have been made which are controlled by a pendulum. This pendulum is kept in motion by an electro-magnet. To illustrate how this can be done place a coil of wire with a screw

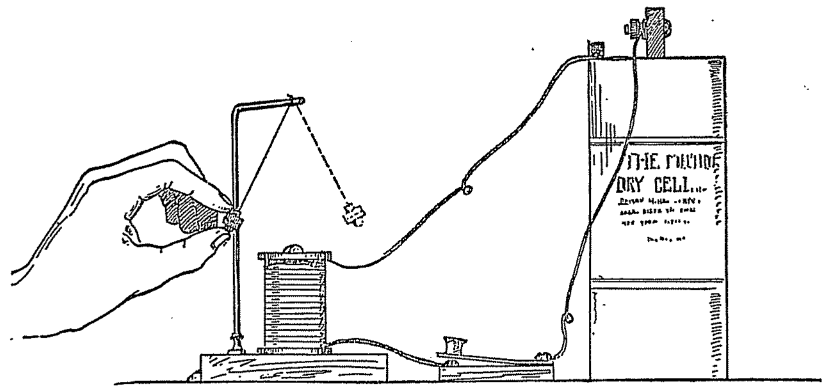

FIG. 81

through it, as shown in Figure 81; suspend over this a steel screw on which you have fastened four or five steel or iron washers or steel nuts. Hold this and let it drop toward the electro-magnet. Place a switch or some other means for breaking your electric current, so that when the pendulum is directly over the circuit, you can open the switch and no current will flow. This will allow the pendulum to pass by to the other side as shown in the dotted lines. When it reaches this position, put the current on again and by a little practice you can keep the pendulum swinging as long as you can get the current flowing. By several automatic means clocks, which are kept running by this principle, have been made.

MAGNETIC INDUCTION THROUGH A GLASS BOTTLE

Place a small quantity of iron filings in a small glass bottle and, by holding any kind of a magnet against the bottle, you will see some very interesting magnetic figures produced.

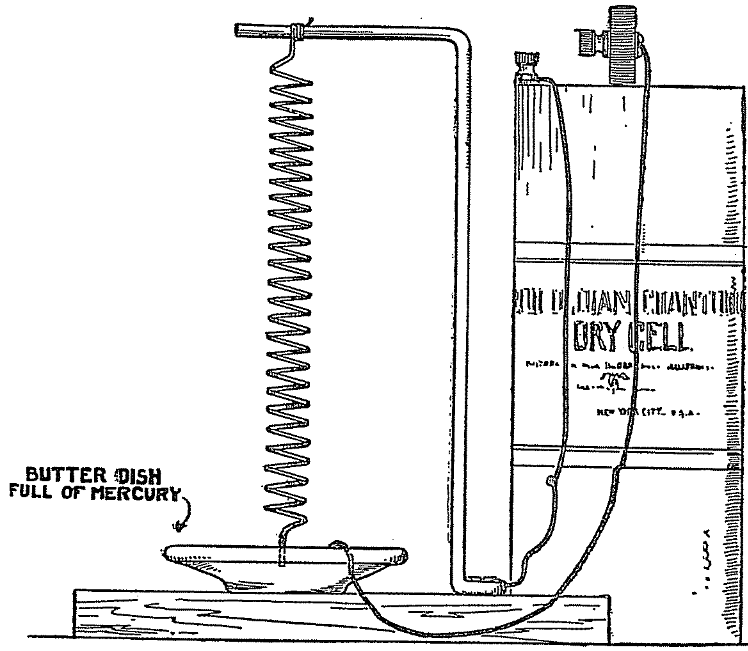

FIG. 82

ROGETS SPIRAL

Suspend a coil of bare copper wire, as shown in Figure 82, by means of a brass or iron rod in a block of wood. Make the coil

about ⅝ of an inch in diameter, using copper or soft brass wire of about .025 (No. 22 Brown & Sharpe) diameter. Pour a small quantity of mercury or quicksilver into a small butter dish or some similar dish.

Place the dish of mercury under the coil of copper wire in a position so that the bottom end of the coil is touching the mercury. Connect a wire from a battery of 5 or 6 volts with the rod holding the coil and touch the other wire to the mercury. Mercury is a good conductor, so current will flow through the spirals of the coil and the magnetism surrounding the spirals will set up an attraction between the separate spirals. This will cause the spring to contract, and, in doing so, the lower end of the wire will be pulled out of the mercury, causing a break in the circuit and a spark. The weight of the wire and also the spring effect will then send the lower end down again, closing the circuit. When the current flows again, as it will at the closing of the circuit, up jumps the coil end again and so it will go on, up and down, as long as the source of power is connected to the circuit. This experiment is known as Rogets spiral, from the name of the scientist who discovered it.

REPULSION BETWEEN TURNS OF A COIL OF WIRE

In Rogets spiral, we saw the turns of wire attract each other. If you make a coil of wire with some of the coils wound in the opposite direction from the rest—you will find that the coils wound in one direction repel the others when the current is sent through them.

DE LARIVES FLOATING COIL

Figure 83 shows a large cork through which is placed a plate of zinc and another plate of copper. The top of these plates are fastened securely, soldered if possible, to an insulated coil of wire; Nos. 20 to 24 will do for this and fifteen turns should be enough.

Float this device in a small dish of dilute sulphuric acid (or even table vinegar will work). Remember that sulphuric acid can give a very bad burn, so be careful in handling it. You now have a

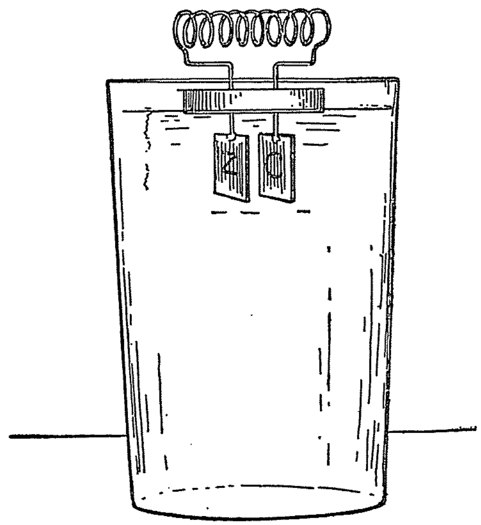

FIG. 83

wet battery with floating electrodes and a current will flow through the coil of wire. If you now hold a bar magnet near the coil, the latter will be repelled or attracted, depending whether or not the pole of the magnet and the nearest pole of the coil are alike or different. If you thrust the north pole of the bar magnet into the north pole end of the coil, the coil will draw itself off from the bar magnet, float a little way off, and then, turning around, will draw itself on the bar again until it is around the middle of the bar.

HOW TO DE-MAGNETIZE YOUR WATCH

One of the worst things which can happen to your watch is to have it become magnetized. When this happens the different turns

of the steel springs are affected and act on each other, causing the watch to keep time poorly. When such a thing happens you can de-magnetize the watch by placing it near an electro-magnet having alternating current for its source of power. A great many jewelers have a solenoid or other form of magnet attached to alternating current circuits, by which they remove magnetism from watches.

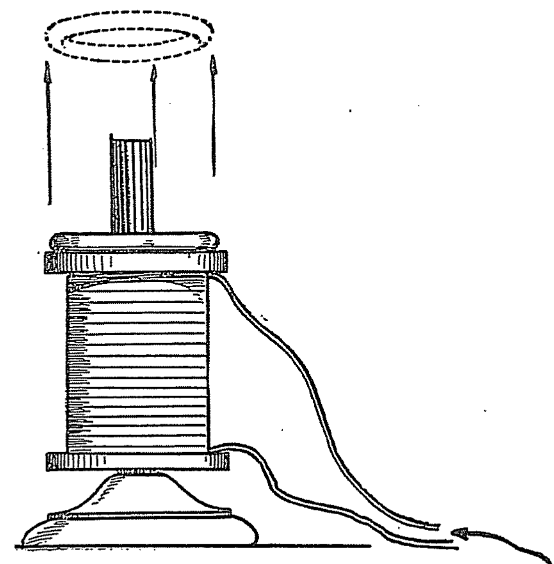

FIG. 84

MAGNET REPULSION

Alternating Current

Make a solenoid and place in it a bundle of iron wires, as shown in Figure 84. Make a ring of thin sheet aluminum which will fit loosely over the iron wire. Connect the coil to an alternating current with a switch, so you can throw the current off and on when you please.

If you place the aluminum ring over the iron wire and then throw on the current, the ring will jump up and attempt to fly off the iron.

This is caused by the fact that the alternating current induces current in the ring, which has a magnetism with it opposing the magnetism of the coil.

In performing this experiment, use a fairly large coil and a light ring. With small coils the power is so small in comparison with the weight of the ring that all the ring will do will be to quiver up and down a very short way, showing that it is trying to move away but is held down by its own weight.

A SIMPLE TELEGRAPH SOUNDER

The telephone and telegraph service depends a great deal for its success on the use of magnets. A study of these magnets would fill a large book. You can make a simple telegraph instrument, however, which will operate on one dry battery and be very good for practice work.

Make a solenoid about 1 inch long and ½ inch in diameter, with a 3/16 inch hole. Wind an insulated copper wire of about No. 22 to No. 26 gauge until ½ inch diameter is reached. Bend a strip of spring brass 1/32 of an inch thick and ½ inch wide in a square form, as shown in Figure 85, and on the end which is underneath fasten a piece of soft iron ½ inch wide and ½ inch long.

Make a key and key knob, as shown in Figure 85. The key should be of spring brass, the knob can be of wood or rubber. To make the sounder work, screw the solenoid and the formed brass arm to a block of wood or fibre in such a way that the round head of the screw comes below the tapped end of the brass arm. Screw the back end of the key through the brass arm to the block. Place a

round-headed screw under the knob, the outer end of the sounder key.

Put two terminal posts in the board and on the under side of the board connect one post to the screw under the knob end of the key and the other to one wire of the solenoid. Fasten the other wire from the solenoid tightly in place under the head of the screw which holds the coil in place. If you now connect a dry battery to the instrument and work the key, you will hear a "click" every time the contacts are closed.

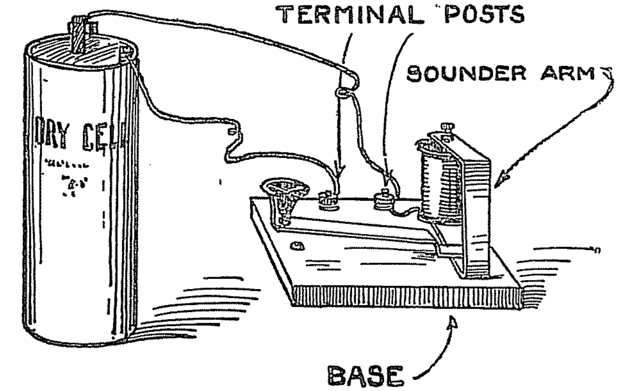

FIG. 85

The screw and nut shown in Figure 85 will improve your instrument very much, as they will adjust the steel tapped arm to the point where the most pull will be given by the magnet and this will make the sharpest sound.

ELECTRIC CLOCKS

Figure 86 shows the principal features required to make the movement for an electric clock.

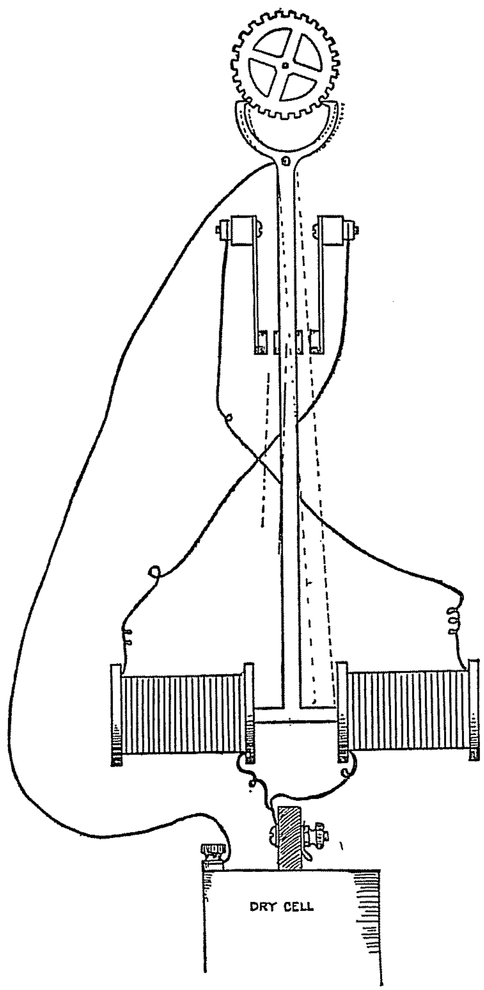

FIG. 86

The pendulum has two forks at its upper end which alternately push against the teeth of the escapement wheel of the clock. The lower end of the pendulum is T-shaped and each side of the T enters a very loosely fitting electro-magnet. On the shank of the pendulum are maintained two contact points, one on each side. As the pendulum swings, first one, then the other of the contacts is opened and closed. By studying the connection, you will see that these contacts are connected to the magnets in such a way that the iron T of the pendulum is pulled first one way and then the other.

ROTATION OF LIQUIDS

Conducting liquids will show electro-magnetic action. Put a dilute acid or mercury (ordinary table vinegar will also do) into a small tin cup. Connect one wire from a 4 or 6-volt battery to the handle of the cup. Place the second wire so that it just touches the middle of the liquid. Now if you hold the pole of a strong magnet directly over the cup, or rest the cup on the pole of the magnet, the liquid will rotate,