and lower the magnet until it is directly under the steel piece. Then, as you pull the magnet, the steel will be drawn up the incline.

MAGNETS IN TELEPHONES

Some of the smallest electro-magnets are used in telephones. When you talk into a telephone transmitter your voice sends waves of air against the transmitter diaphragm (B-Figure 53). The diaphragm then vibrates from each wave stroke and in doing so compresses or releases the grains of carbon in the little cup directly in

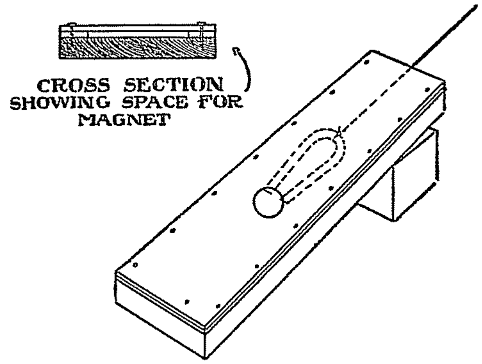


FIG. 52

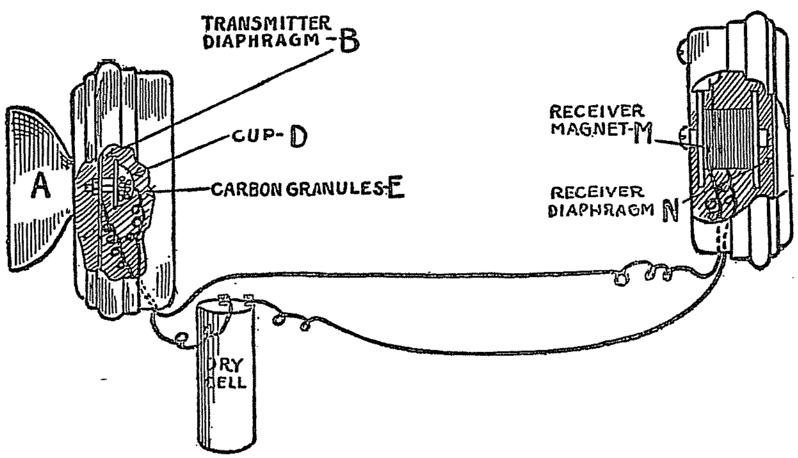


FIG. 53

the rear. This sets up a changing resistance in the circuit in which is the receiver. The receiver consists mainly of an electro-magnet in front of which is a thin disc of magnetic material.

As there is a current flowing in the phone circuit, the change of resistance caused by the action of the tones of the speaker's voice on the transmitter causes the current in the electro-magnet in the receiver to vary with each change in resistance. The change makes the electro-magnet change its strength, thus rapidly varying its pull on the magnetic disc in front of it. And these vibrations being a true copy of the vibrations of the voice speaking into the transmitter give to the ear of the listener a copy of all the sounds from the person speaking.

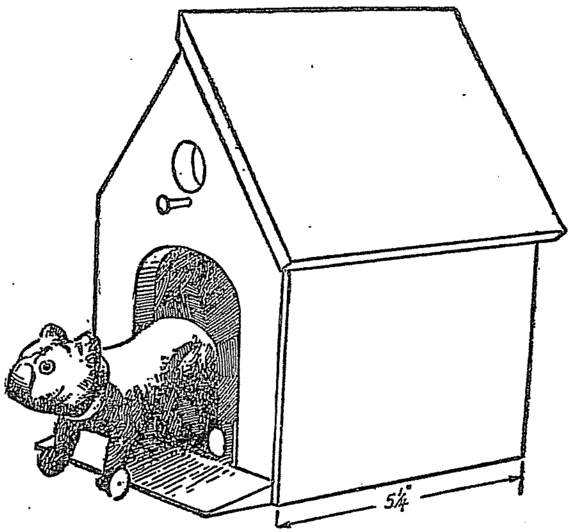
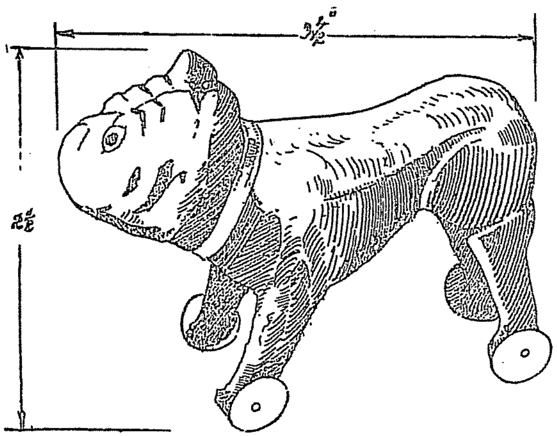


FIG. 54

WIRELESS PUP

A very amusing toy has been made which uses a small electro-magnet, and also works somewhat on the principle of the telephone. This is illustrated in Figure 54. The parts are simple and you can easily make one to amuse and astonish your friends.

At the five and ten-cent store you can buy a little toy dog, or, if



Back
FIG. 54A

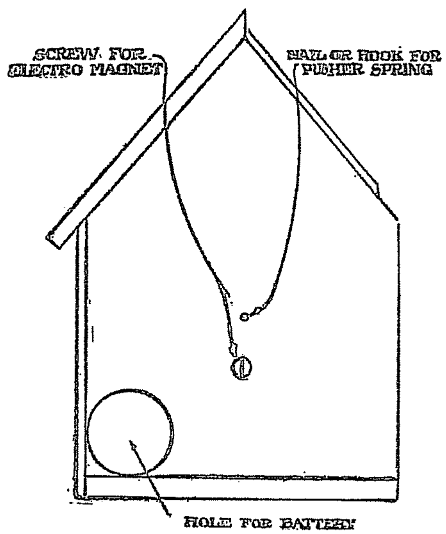


FIG. 55

you prefer, whittle one out of wood, and by means of small nails or pins fasten little wheels made of tin to each foot. Make the pup as light as possible and about as large as shown in Figure 54A.

The dog house is next. This is best made from thin wood, though heavy cardboard will serve the purpose very well. See Figures 54 and 56.

Front same as back except for door, as shown in Figure 55.

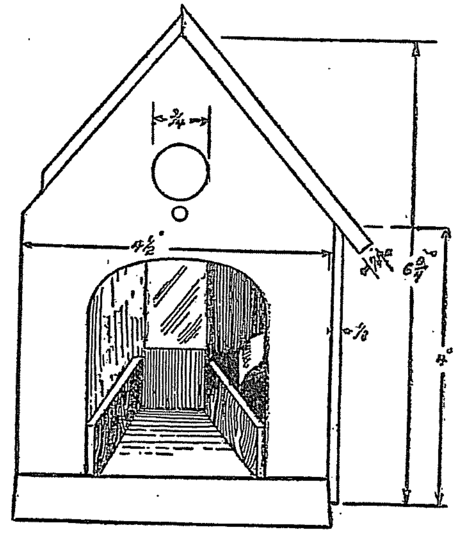


FIG. 56

The operation of this device depends on two properties: first, the action of sound waves against a swinging contact breaker; second, the action of the pull of an electro-magnet. The electric circuit contains a small metal disc, aluminum, brass or iron, suspended in back of the circular opening in the house front. This disc rests very lightly against the smooth head of a brass or nickel-plated screw. From the screw a wire is carried to one side of a small flash-light battery, and if you buy the small round batteries as shown in the picture remember that the outside of the battery is one contact—the small brass knob at the end is the other. Connect the other side of the battery to the electro-magnet. The second lead of the magnet is connected to the screw on which the diaphragm is hung. See Figures 57A, B and C for connections.

The outfit is now ready for use. Place it on a level place, such as a shelf or table. Push the dog into the house, facing the door.

He will strike the pusher and force it back against the end of the electro-magnet core, at the same time closing the electric circuit. This sends a current through the coils of the magnet and causes the core of the magnet to grip the pusher and hold it.

Now stand a few feet in front of the house and whistle, clap your hands or call sharply to the pup. The vibrations of the air caused by your voice will make the disc sway slightly, causing a momentary open circuit. This destroys the magnetism holding the pusher back, and the spiral spring will then make the pusher shove the dog out in a hurry.

In making such a toy too much care cannot be taken in adjusting the disc so that it will swing freely, and, also, in keeping the various contacts clean and bright.

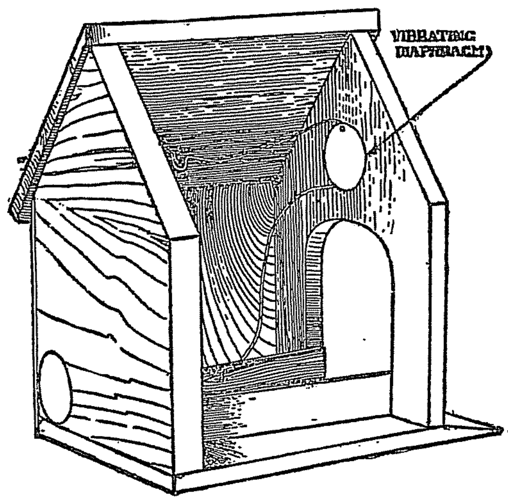


FIG. 57A

A CIRCUIT BREAKER

In the electric power houses and other places where a large amount of current is flowing, circuit breakers are used in order to save fuses. These have electro-magnets so arranged that when the current gets too strong the magnetism pulls a plunger which is attached to a switch. This switch then opens the circuit, stopping the overflow of current. Some of these are also arranged so that they

break the circuit if the pressure (voltage) gets dangerously high.

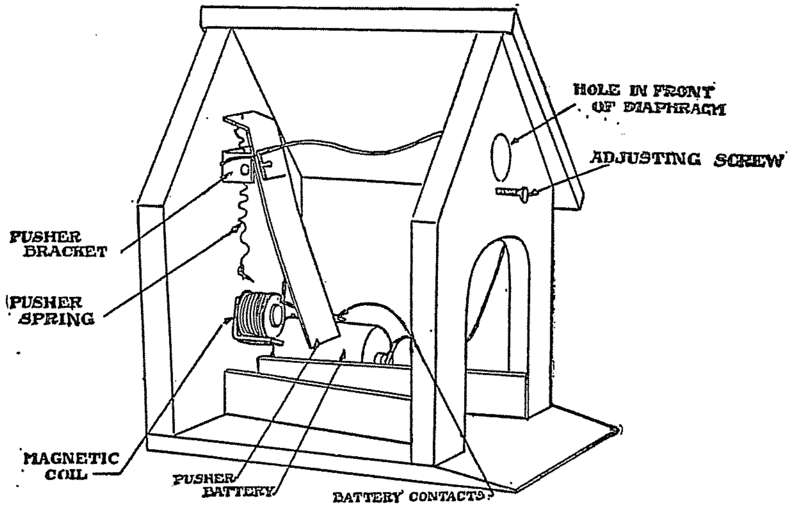


FIG. 57B

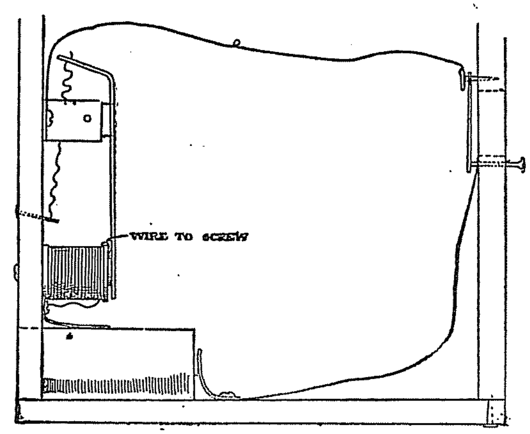


FIG. 57C

Still another kind is used where storage batteries are charged. These work backward from the other two described; that is, the magnets hold the plunger up and keep the circuit switch closed until the current (or voltage) goes down too low. When the current drops, open goes the switch, because the magnetism no longer pulls against the spring.

A simple circuit breaker can be made with a coil of wire wound of No. 24 Brown & Sharpe gauge copper (insulated) wire wound in spool form. If you have an old empty spool wind it full of wire. Have a round piece of soft iron wire in it.

The soft iron wire should have a hole drilled in it near the upper end and a small brass spring fastened through the hole.

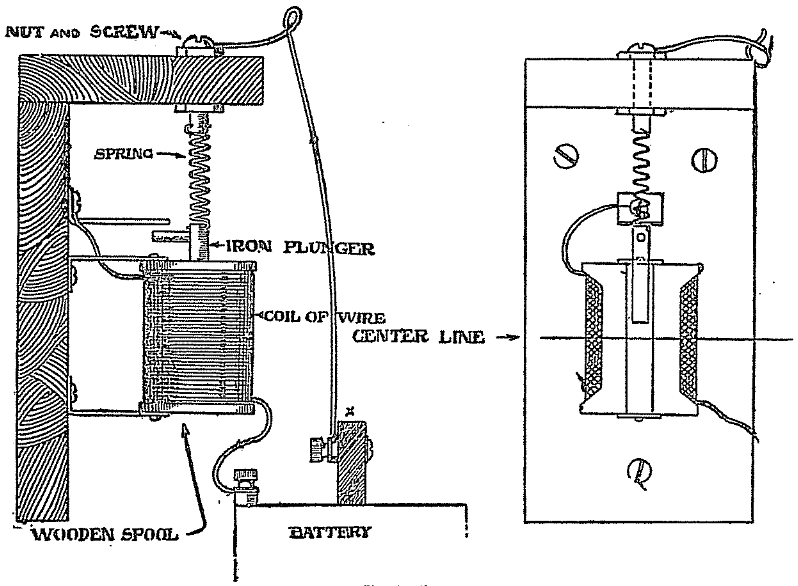


FIG. 58

The upper end of the spring is fastened in a hole in machine screw, as shown in Figure 58. The screw is locked in place in a wooden block mounted on the top of the base. Fasten one wire from the battery to the screw and the other side of the battery to one wire on the coil. The remaining wire from the coil is carried to a pin on the base board. This pin is in such a position that the

lower end of the spring, which is brought through the plunger, closes the circuit when the spring is supporting the plunger at rest. As the current flows, the plunger is drawn down into the center of the coil and then the circuit is broken at the pin. This allows the magnetism to die out and the spring then pulls the plunger back into position. This model shows the working principles of the real circuit breakers, though of course they are much more elaborate. The type of electro-magnet just described is called the plunger type, due to the fact that it tries to suck the moving plunger into its center hole. Do not use a solenoid which has a steel sleeve around its center hole. This causes the plunger to stick to it rather than permitting it to be drawn inside. Plunger magnet coils give the strongest pull at the center of the coil.

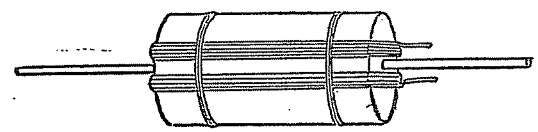


FIG. 59

SMALL MOTOR

A small motor can be made which will further prove the theories shown by previous experiments, though the motor will give very little power.

Take a cork or round piece of soft wood about ¾ inches in diameter and from an inch to 1½ inches long. Stick a long wire or a needle through the center of this cylinder just as near the center as possible, so that the armature will be in balance. Next wind on the spool about 100 turns of fine copper wire, putting 50 turns each side of the shaft.

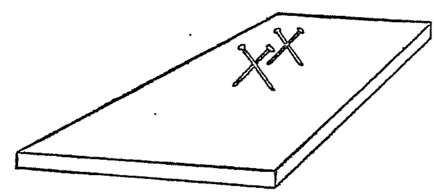


FIG. 60

Bring the start and finish of the winding out at one end, parallel to the shaft, and cut them off so they stand off about $\frac{1}{4}$ inch. Bind the winding in place with a few turns of thread, as in Figure 59.

Drive four small nails into a block of wood, as shown in Figure 60, for bearing.

Place two bar magnets on blocks so that the "N" pole of one and

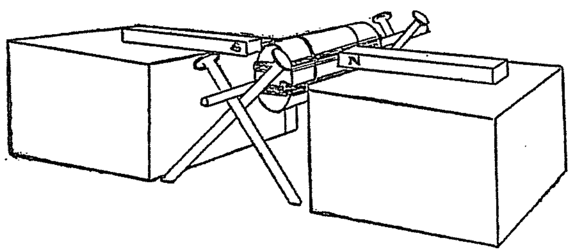


FIG. 61

the south pole of the other are opposite the armature.

Lay the armature in place on the bearings, as in Figure 61. Now connect a pair of stout wires to a dry battery and clean the opposite ends.

Hold these ends in one hand, lightly touching the tips of the armature, and with your free hand give the armature a little spin. It will go in one direction only, so you may have to spin it again in the opposite direction from what you did at first, but you will find one direction in which it will revolve quite rapidly. Of course this is a weak little thing, so you must be careful not to press the wires from the battery too hard on the armature. If you do, it will prevent the motor from running. If you happen to have a horseshoe magnet, as in Figure 62, with the

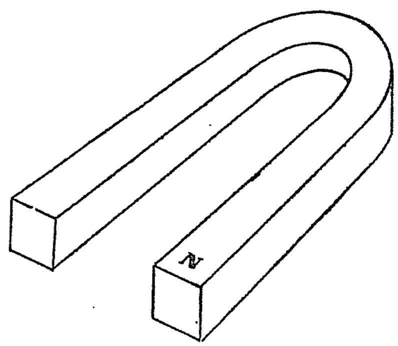


FIG. 62

poles far enough apart you can use this in place of the bar magnets.

MAGNETIC GUN

Make a solenoid coil by winding several layers of No. 26 Brown & Sharpe gauge insulated wire around a paper or brass tube. Make the tube $\frac{1}{4}$ inch in diameter. Build up the winding about as shown in the picture. Put a small round-headed screw in the center hole and place the coil in a tilted position, as shown in Figure 63. Place

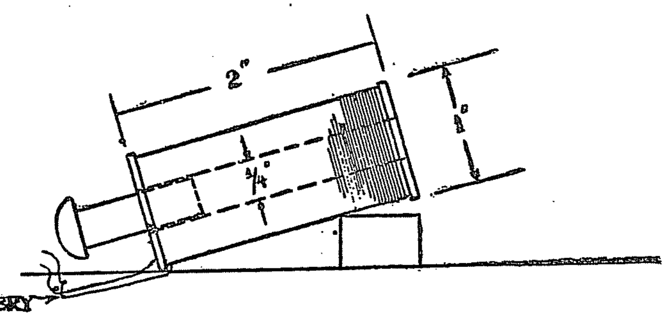


FIG. 63

little cork balls or some other light material in the cannon in front of the screw. Connect the wires from the coil to three or four dry cells and the screw will be quickly pulled into the hole, shooting the little bullet out. Be sure that the screw is less than 1 inch long. If you do not, the gun will not have the necessary force to be of any value.

A REGISTERING WIND VANE

Sometimes it would be very convenient if you didn't have to go where you could look at the weather vane to tell just how the wind is blowing. Make a vane of sheet steel, or brass, similar to that shown in Figure 64. Fasten a "U" shaped brass strip securely to the metal vane.

Next make a circular block of wood about 5 inches in diameter and 1 inch thick. Drill a hole through its center for the supporting shaft of the wind vane. Now screw some flat strips of brass around the top of the block, as shown in Figure 65.

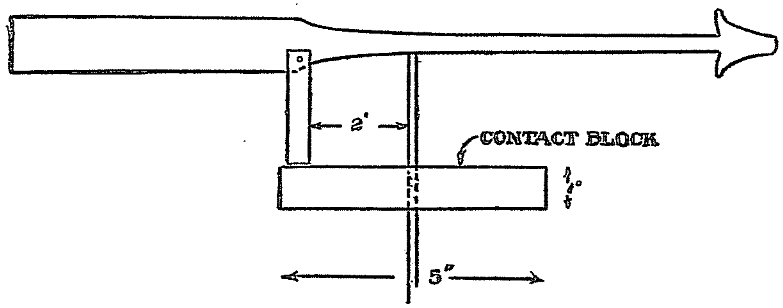


FIG. 64

The four single strips should be spaced around the circle for the North, East, South and West positions. The narrow strips should be placed halfway between the others so that when the brass contact on the vane swings over them it will rest on each one. Connect the narrow strips to the broad ones as shown in the figure. The best way to do this will be to drill holes in the wood and pushing brass or copper wire through and solder the ends to the strips. Place this contact board in position under the weather vane so that the brass strip on the vane will rub on the brass strips of the block as it turns around.

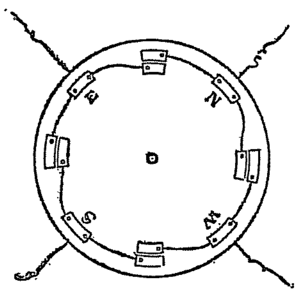


FIG. 65

In order to set the board in the proper position, it will be necessary to know just what time noon, by *sun time,* is; this may be several minutes before or after your clock time. But while you are working on the apparatus you can write to the nearest Government weather bureau and learn just what

time, sun time noon, at your home is. After you have found just when this is, you will find that at that moment shadows of any vertical body point directly north. By locating the shadow on the shaft of the weather vane at this instant, you will be able to set the North and South points of your block in line with this shadow. After setting the block in the true position fasten it securely in place, taking care that it is level and that the contact point on the vane touches all the eight points on the block. Next fasten insulated copper wires to each of the North, South, East and West points on the board, also one on the shaft of the weather vane, and carry the other ends of the wire down to the place where you want the

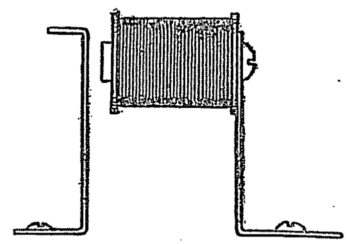


FIG. 66A

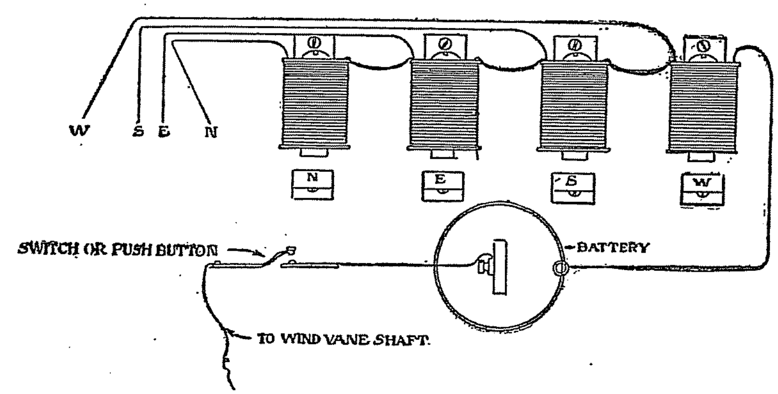


FIG. 66B

under-tug device to be placed. It will save a great deal of trouble if you put a tag or mark of some kind on each wire so you may know to which contact it is connected. A very simple indicator can be made of four coils.

Wind these coils of insulated wire (No. 24 to 28). A coil ¾ inches long with a 3/16 inch hole through it, and the outside of the winding built up to ⅝ inch diameter will serve the purpose very nicely, like Figure 66A. Put a steel screw through each coil and fasten the coils in a row on a board, as shown in Figure 66B. Under each coil mount a piece of soft iron or steel ⅜ inch wide and shaped like that in Figure 66A.

Complete the electrical circuit, as shown in the picture, using two or three dry batteries and a switch or door bell push button. On

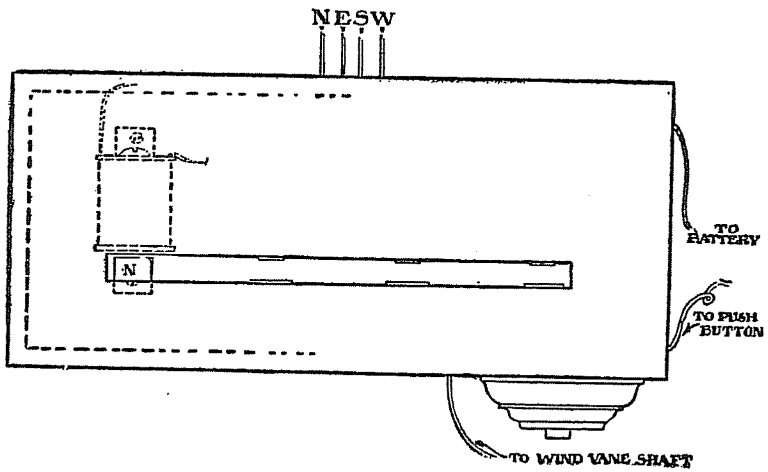


FIG. 67

the end of the arms you can paste the letters "N", "E", "S", and "W", which can be cut from any magazine or newspaper advertisement.

This device will work as follows: If the wind points the vane to the West, the contact on the vane will be touching the flat contact on the block, and if the switch is then closed, the magnet in that circuit will pull the steel arm under it up to the end of the steel screw. If the wind is blowing half way between North and West

(North West), the moving contact will be touching the two small flat plates, one in the "N" circuit and one in the "W" circuit; and closing the switch at that instant will make the "N" and "W" steel indicators jump up to the ends of the magnet cores. If the indicators show a tendency to stick to the screw heads, paste a piece of paper over the end of the screw, so the indicators cannot quite touch the cores.

It will keep the set in a much better condition if you put a little box with a glass front in it, as shown in Figure 67.

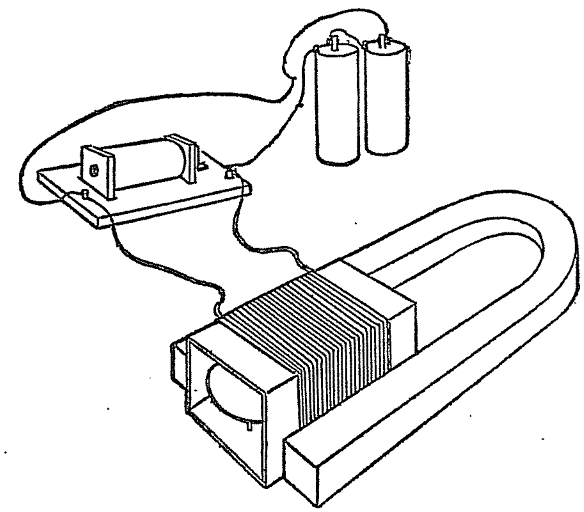


FIG. 68

ROTATING DISC

This experiment requires a magnet of the shape given in Figure 68 and a vibrating circuit breaker like that used on an induction coil.

Wind about one hundred feet of No. 28 cotton covered wire on a small form. The cover of a safety match box will serve very nicely. Figure 70.

Another piece required is a thin iron or steel disc about the size given in Figure 69.

Suspend this disc on a needle point by punching a little dent in the center of it. Put the coil of wire between the poles of the magnet and the disc inside the coil and on the needle point. Make sure the disc will turn freely. Connect the ends of the coil to the posts of the vibrator and also connect these posts to two or three dry batteries. When the circuit is complete, the disc will revolve rapidly.

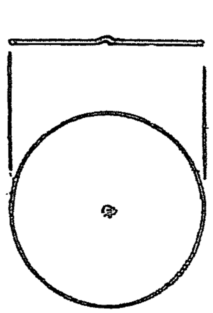


FIG. 69

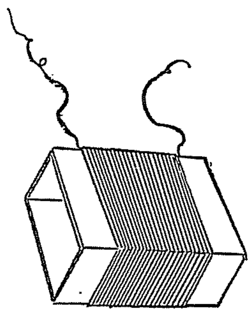


FIG. 70

INDUCTION COIL

Although the induction coil is much more than a magnetic toy, still it depends entirely on the electro-magnetic action for its make and break action, which controls the entire action of the apparatus.

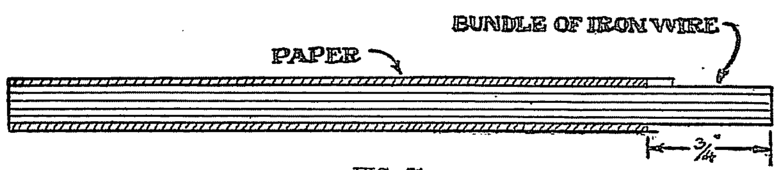


FIG. 71

An induction coil, similar to Figure 71, can be easily made and will prove very useful to the experimenter in wireless or high voltage work of any kind.

THE CORE

The core is to be made of soft iron wire. (All alternating current magnets use small iron wire, while direct current cores are made

of a solid piece. A solid bar would heat badly in an alternating current coil.) Get some stove pipe wire, size about .045 inches No. 17 Brown & Sharpe gauge. Cut 25 or 30 lengths of this wire 4¾ inches long. Make sure that these are straight. Wrap a bundle of these wires in four or five layers of paper, the thickness of ordinary writing paper. Paste the end of the paper down so that the wires will be held securely in place. The diameter of iron bundle should be about ¼ inch.

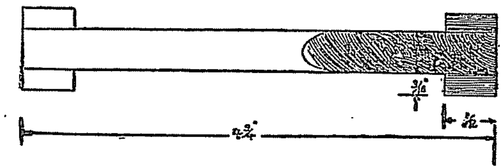


FIG. 72

Next take a round stick of wood the same length as the iron core and at least 1/16 inch larger than the outside of the paper. Wrap the ends of this stick with a paper strip ½ inch wide and glue it securely in place. It must build up the ends at least 3/16 inch. See Figure 72.

Lay two strings or threads along the stick, the strings each at least three times as long as the stick, fastening the ends around pins. See Figure 73.

Next carefully wind in even layers three layers of single cotton and enamel wire, size No. 18 Brown & Sharpe gauge (.0403), leaving about 18 inches sticking out from each end. When the winding is done, tie the string ends together over the top of the coil. Over the top of the wire wind three layers of stout paper, just about ⅛ inch longer than the coil. In order to do this you must remove the paper ends on your stick, but this can be done now that you have tied the string in place.

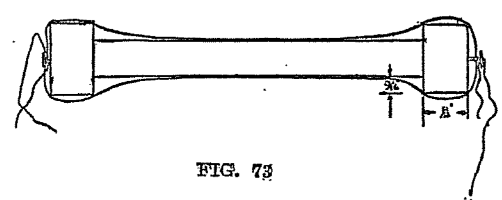


FIG. 73