GILBERT
Fun With Electricity

Cover

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GILBERT®

FUN WITH ELECTRICITY

THE A. C. GILBERT CO.
NEW HAVEN, CONN., U. S. A.

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PRINTED IN U.S.A.

Manual of
Instructions

ELECTRICITY
and
MAGNETISM

The A. C. Gilbert Company
NEW HAVEN, CONN., U.S.A.

PRINTED IN U.S.A.

FOREWORD

Hello Boys:—

The many wonderful results that electricity is constantly giving us has always been very interesting to me and I know that every boy marvels at the startling accomplishments of the world's great electrical wizards.

There is something about it all that is extremely fascinating and I have given you in this booklet some mighty interesting experiments for use with your electrical set.

You'll get a great thrill electrifying your toy models, and doing the many interesting experiments with frictional electricity and magnetism. A buzzer, electric bell, strong electromagnet and brush type motor can all be easily constructed with the parts in this set. You will surely have great sport performing the many other electrical stunts and mystifying tricks—rigging up your wires and ringing a buzzer at a distance—installing a telegraph line to your chum's house and constructing electro-magnets.

Just the kind of fun you've been waiting for is packed into every stunt you can perform with your electrical set.

Cordially yours,

A. C. Gilbert

President,

FRICTIONAL ELECTRICITY

Through friction it is possible to change various materials with electricity known as "Frictional" or "Static" electricity. We have all noticed the effect of combing our hair with a rubber comb in the winter time. A faint crackling noise, caused by tiny sparks, is heard and the hair tends to reach up for the comb. This effect is caused by electricity created by the friction of the comb and hair.

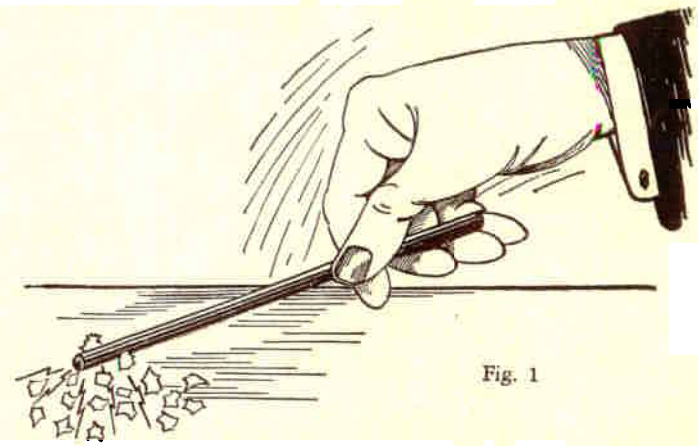


Fig. 1

Tear some small bits of paper and place them on a table as shown in Fig. 1. Rub the ebonite rod briskly with your flannel cloth until it becomes warm. Now hold the rod near the bits of paper. They suddenly come to life and jump up to the rod. You have given them a charge of electricity. A similar effect will be obtained by rubbing the glass rod with your silk cloth.

The quantity of electricity generated by friction is very small. You must, therefore, not expect a great deal of effect from your experiments. For the best results all the apparatus must be perfectly dry and used in a well heated room.

CHARGING BY CONTACT

Suspend from your stand by means of a silk thread a small piece of cork. (See Fig. 2.) Electrify the ebonite rod by rubbing with flannel and bring it close to the cork. It is strongly attracted by the rod until they touch. The cork is then repelled and flies away. We prove by this experiment that electricity attracts a neutral body. When the contact was made between the cork and ebonite some of the electricity that you generated on the rod was transferred to the cork causing it to be repelled. This is called charging by contact. The cork will retain its charge for some time and may be discharged by touching it with your finger.

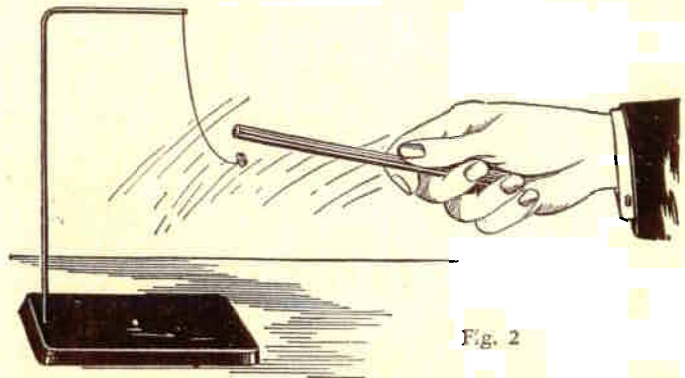


Fig. 2

POSITIVE AND NEGATIVE ELECTRICITY

Again generate electricity on your ebonite rod by rubbing with flannel and charge the cork by contact. Next rub the glass rod with the silk cloth and bring it close to the cork but do not let them touch. It is strongly attracted, instead of being repelled as we would expect.

The reason for this is that there are two kinds of electricity. The one which we generated by rubbing the glass and silk is called "Positive" (+) and that generated by the ebonite rod and flannel is "Negative" (—). Like the laws of magnetism, similar charges of electricity repel each other and unlike charges attract. Either kind of charge will attract a neutral body.

Another experiment which will prove this law is conducted by hanging 2 corks

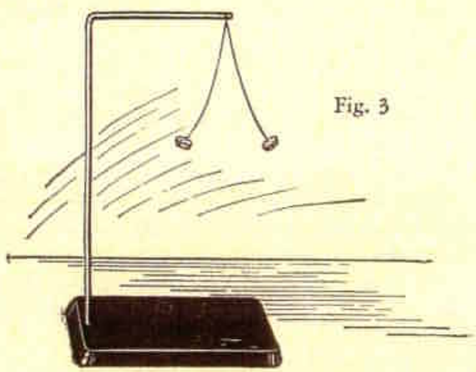


Fig. 3

from the stand by a silk thread and charging both with the electrified ebonite rod. They will then repel each other in an amazing manner, because they both contain a similar kind of electricity. Fig. 3 shows this experiment.

CHARGING BY INDUCTION

Suspend the stirrup from your stand by means of a silk thread and balance on it the 3" metal rod. At each end and the middle hang a cork as in Fig. 4. Bring your charged ebonite rod near one end of the metal rod. The two end corks will then move away from each other and the middle one remains stationary, showing that only the ends of the rod are electrified. The charge at the end nearest your ebonite is Positive and the other Negative. The ebonite being charged with Negative electricity attracts

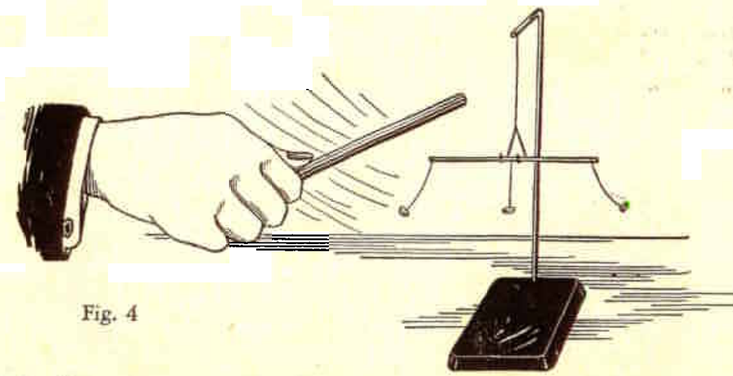


Fig. 4

the Positive and repels the Negative. The corks will resume their natural position when the ebonite rod has been removed, for the opposite charges on the metal rod then neutralize each other.

From this experiment we learn that we may not only charge a body by contact but also by Induction.

ELECTRICAL STORMS

Lightning is our most prominent form of frictional electricity and by far the most powerful. It is caused by the accumulation of electrical charges in the clouds. When this charge becomes strong enough it escapes in the form of a huge spark, one to ten miles long, to some other cloud or high object on the earth. The thunder which accompanies this electrical discharge is the result of the heat of the flash, which warms the air and causes it to expand rapidly. As it does so more air rushes in to take its place. This all happens so quickly and with such force that it produces what we know as thunder.

You can easily determine the approximate distance in miles that you are from an electrical storm by counting the number of seconds between the flash and the thunder and dividing by 5. That is, if 15 seconds elapse between the two, the lightning occurred about 3 miles away. It is possible for us to make this estimate because light travels very fast but sound is comparatively slow.

CONDUCTORS AND INSULATORS

A conductor is a material through which electricity may pass easily. Metals such as silver, copper, gold, iron and other substances like charcoal and water are good conductors. An insulator or non-conductor acts just the opposite. It resists this passage of electricity and will not let it pass freely through it. Glass, silk, rubber, wax and air are some of the better insulators.

ELECTRIC SPIDER

Take a piece of newspaper about 4" long by 2" wide and cut eight narrow strips for 3" of its length. These we will call the legs, the uncut part the head. Warm the paper slightly. Then place it on a piece of glass and hold it by the head as in Fig. 5. Rub the

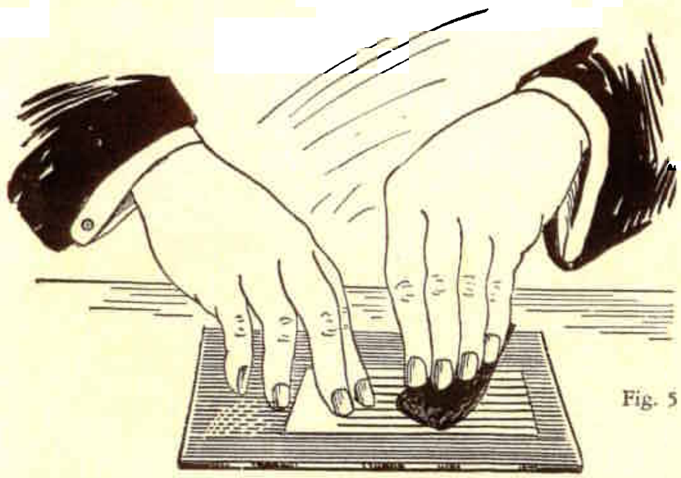


Fig. 5

legs briskly with a warmed flannel cloth which generates electricity in it. Lift the spider from the glass and watch the results. He awakens and stretches his feet in the air. Some of them curl way back and try to reach your fingers.

The reason for the spider's action is that you have charged all his legs with the same kind of electricity and therefore they repel each other.

ELECTRIC PENDULUM

Wrap the cork in a piece of tin foil and suspend it from your stand. Generate a

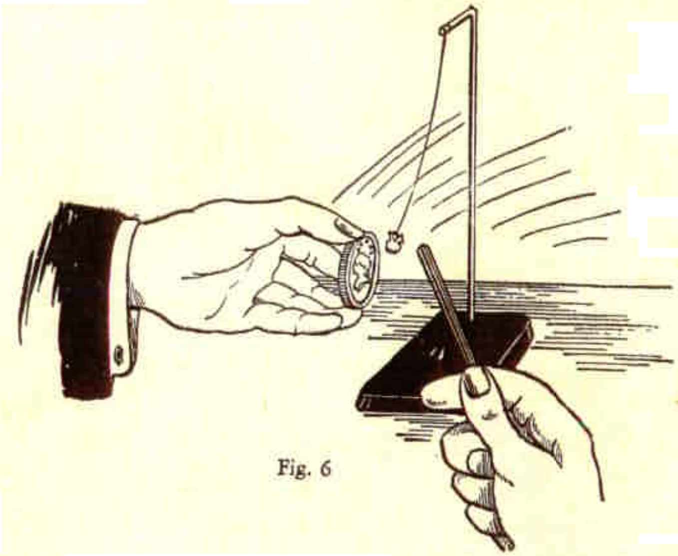


Fig. 6

charge in the ebonite rod and hold it about an inch away from the cork. (See Fig. 6.) On the other side of it hold a metal disc or large coin. The cork will be attracted to the rod and then repelled, discharging on the metal disc. This pendulum effect will continue until the ebonite has lost its charge.

MAGNETISM

The power of a magnet is called magnetism and was discovered long ago in a certain type of iron ore found in Asia Minor. This ore is called Lodestone or Natural Magnets and has the ability to attract other pieces of iron. Man soon learned to impart this effect to pieces of steel by stroking them with Lodestone, thus making an Artificial Magnet which is more powerful and much handier to use.

Magnetism and its laws play an important part in the construction of practically all electrical apparatus. We do not thoroughly understand what magnetism is but we have learned to produce and use this effect in many ways Compasses, electric motors, generators, magnetic cranes that will lift 30 tons, and electrical measuring instruments are a few of our necessities which depend on magnetism.

THE PERMANENT MAGNET

The permanent magnet is an artificial one which is made of hardened steel and will retain its magnetism for a long period of time. There is also the Electromagnet which depends for its magnetism on the effect of an electric current flowing through a coil of wire which is wrapped around an iron core.

POLES OF A MAGNET

Sprinkle some iron filings on a piece of paper, and lay one of your bar magnets in them. Then lift it and you will find that the filings cling only to the two ends of the magnet. (Fig. 7.) These ends are called poles, and there are two poles in every magnet

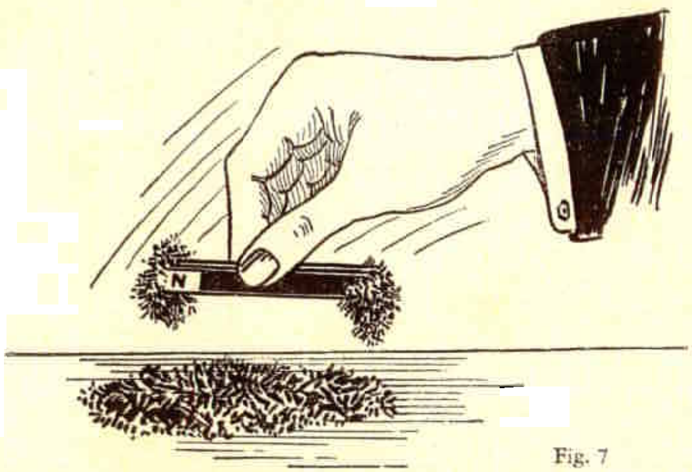


Fig. 7

regardless of its shape. The same experiment can be done using your horseshoe magnet, which will also cause the filings to cluster around its two poles.

NORTH AND SOUTH POLES

Suspend one of your bar magnets on a silk thread using your stand and wire stirrup so that it is free to turn. (Fig. 8.) Soon it will come to rest and one end will be pointing north. No matter how many times this end is turned away it will always return to this position. We have learned that a magnet has two poles, these poles are called North and South. The end of your magnet which is pointing North is called the North or "North Seeking" Pole and it is so marked. The other end is the South Pole.

The earth itself is a large magnet having a North and South Pole. These magnetic poles must not be confused with the geographical North and South Poles as they are not the same.

THE LAW OF POLES

Again suspend your bar magnet from the stand, and bring near one end a large nail or any unmagnetized piece of iron. The magnet is immediately attracted to it. Try

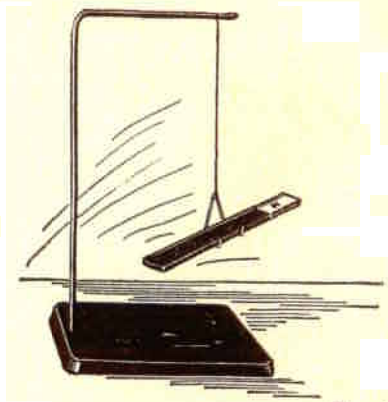


Fig. 8

the other end and you will see that it has the same effect. Here we learn that "either Pole of a magnet will attract an unmagnetized piece of iron or steel." Take your other bar magnet with the South Pole of it extended towards the North Pole of the suspended bar. Again there is a strong attraction. Reverse the position of the magnet in your hand so that its North Pole is close to the North Pole of the suspended magnet. They are not attracted but repel each other. This is our most important law to remember. "UNLIKE POLES ATTRACT EACH OTHER. LIKE POLES REPEL EACH OTHER."

HOW TO MAKE MAGNETS

Small magnets that will come in handy in your experiments can easily be made by stroking a needle or piece of hard steel with your bar magnet. First test the needle in your iron filings to see that it is not already magnetized. Place the needle on a table and slowly draw the North Pole of your bar magnet along its surface, (Fig. 9), finishing the stroke well beyond the end of the needle. About ten to twelve strokes will fully magnetize it, as shown by again testing it in the iron filings. A magnetic screw driver can be made in this manner which will prove very useful.

If you wish to produce a desired pole at a given end of a piece of steel, remember that the end of the steel which last touched the North Pole of the magnet becomes the South Pole.

Iron or steel will hold only a certain amount of magnetism, depending on its hardness and quality. When a magnet has acquired all the magnetism it will hold it is said to have reached its "Point of Saturation."

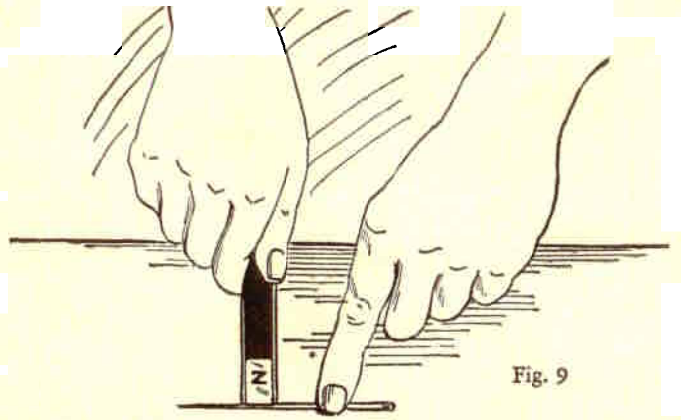


Fig. 9

CARE OF MAGNETS

Permanent magnets such as those in your set must be handled with a certain amount of care if their strength is to be preserved. A sharp blow or fall will greatly lessen the attractive power. A magnet will lose practically all of its strength if it is heated until red hot. The pieces of iron which go across the Poles are called "Keepers" or "Armatures", and they should always be in place when your magnets are not in use as this helps prevent the tendency of permanent magnets to gradually lose their power.

Notice that with the bar magnets it is necessary to keep them in pairs with keepers across the opposite poles at both ends. They should also be separated by a thin piece of wood or cardboard.

MAGNETIC INDUCTION

Suspend a medium size nail or piece of soft iron from one end of your bar magnet. Then dip the lower end of the nail into the iron filings, a quantity of which will cling to the nail. (Fig. 10.) Gently withdraw the nail from the magnet and the filings will no longer be attracted and drop off. The nail in this case acted as a temporary magnet through its contact with your permanent one. When this contact was broken the nail, which is made of soft steel, lost its attractive power. This transmitting of magnetism through a temporary magnet is called "Magnetic Induction." It can be used to your advantage in gathering up spilled iron filings, which if done with a magnet are difficult to remove.

LINES OF FORCE

Lay a bar magnet on a table and cover it with a sheet of stiff white paper. Sprinkle iron filings over the paper and tap lightly. An old salt shaker or pill box with holes

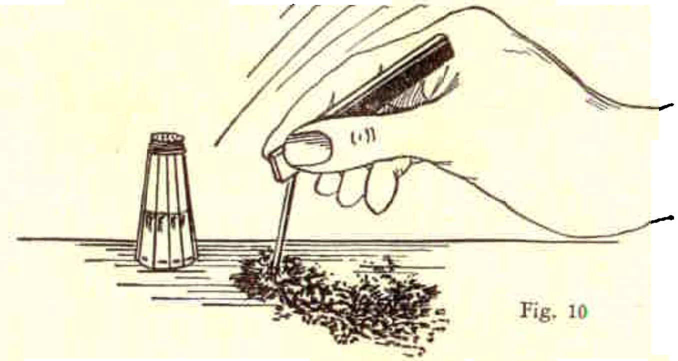
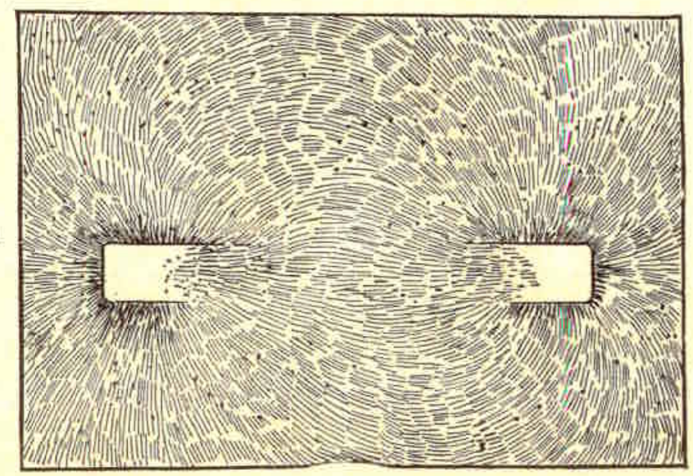


Fig. 10

punched in will make a satisfactory sprinkler. The filings arrange themselves in curved lines that extend from one pole to the other. (Fig. 11.) The lines are called "Magnetic Lines of Force" or "Flux."

Another interesting method of showing the direction of these lines can be demonstrated by laying your bar magnet on a table. Place your compass on the table about two inches away from the bar and move it parallel to the magnet. The needle will take a position in the direction of the Lines of Force, as in Fig. 12.

Fig. 11



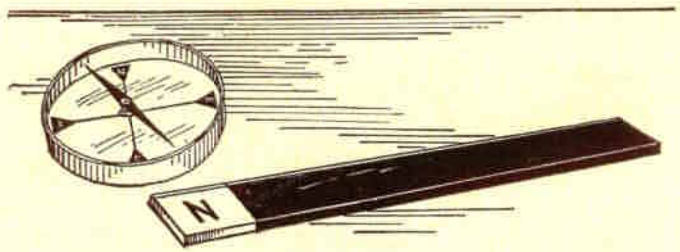


Fig. 12

These Lines of Force are able to go through any non-magnetic material. Your magnet will attract iron through glass as if nothing were there. However, through an iron plate which is a magnetic material the attraction is greatly reduced.

MAGNETIC SUBSTANCES

Experiments with various materials such as wood, glass, paper, iron, copper, steel, and rubber will prove that only iron, steel, cobalt and nickel are capable of being attracted to any degree by your magnet. Materials which are not attracted are called "Non-magnetic."

THEORY OF MAGNETISM

To explain the magnetic effect, we have to accept the theory that every little piece within a magnet, its molecules, become polarized, and lie partly and wholly in a uniform direction. This can be easily proven by breaking a magnet.

Magnetize a needle and note its poles. Break it in the middle and determine the poles of each piece. It became two magnets with the poles of the new magnets corresponding with the poles of the first one. If you imagine you could break these magnets in half, and then each piece in half again, and so on, indefinitely, until you got molecules from your needle, each molecule would represent a tiny magnet with its poles corresponding with the poles of the original magnet, which you first broke.

THE COMPASS

The ancient navigators used Lodestone suspended on a thread to guide them on their voyages. The modern mariner's compass is a far more delicate and reliable instrument. It contains several highly magnetized needles placed parallel to each other and mounted on a round card. The card is divided into equal parts called "The Points of the Compass." In the center of the card is a jewel bearing which pivots on an upright pin that is fastened to the bottom of a bowl. The card can then turn freely about its center. The bowl is filled with a liquid which steadies the card and gives it a slower motion. This bowl is mounted on a swivel which allows it to remain level regardless of the roll of the ship. Inside the bowl is a mark representing the center of the ship and known as the "Lubber Line." The helmsman must keep his bearing on this mark counteracting any swing of the card by turning the rudder of the ship.

Unfortunately the magnetic North Pole and Geographic North Pole are not located at the same place. The navigator must therefore make allowance for this difference which is known as Magnetic Declination.

MAGNETIC DIP

A needle suspended so that it may be free to move vertically, is just balanced so that it is perfectly level and then magnetized. Your needle is now out of balance. The North end tilting downward, if you are North of the Equator. At the Equator your needle would remain horizontal while south of it the needle's South Pole would dip down. (Fig. 13.) This strange action is known as "Magnetic Dip." The tilt of the needle would increase as you approached either Pole and when it was reached would take a vertical position.

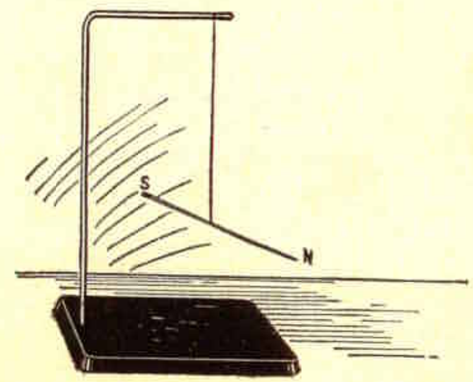


Fig. 13

NEUTRALIZING A MAGNET

Pick up a nail with the North end of your bar magnet, then slide the other bar magnet along the top of the first so that its South Pole is going towards the North, of the first magnet. When the opposite poles come above each other they neutralize each others effects and the nail drops. (See Fig. 14.)

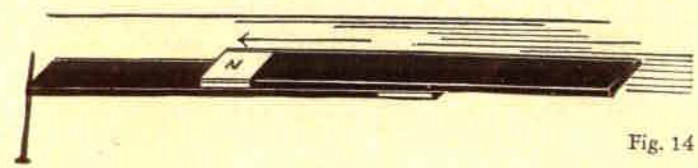
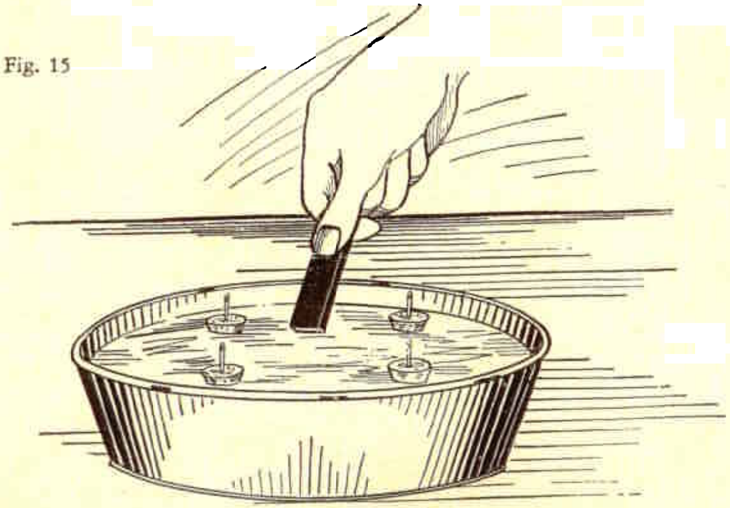


Fig. 14

FLOATING MAGNETS

Magnetize four needles and push them through corks with their North Poles uppermost. Place them in a pan of water, and they will become widely separated as their poles repel each other. Now bring the South Pole of your bar magnet above the center of the pan and they will approach it up to a certain point and form a square. The repelling force of the needles and attraction of the magnet balances. Several symmetrical designs can be obtained by adding more needles. (See Fig. 15.)

Fig. 15



MAGNETIC NAVY

Magnetize a few needles and cut out of thin wood as many boats, slightly longer

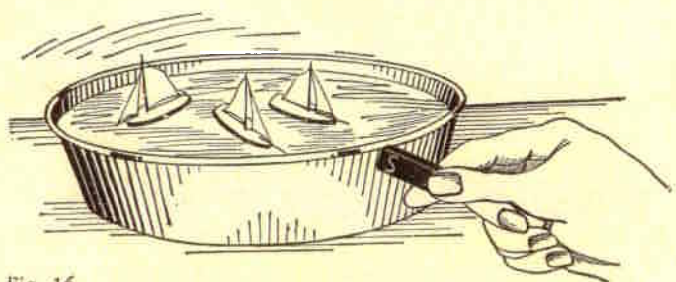


Fig. 16

than the needles. Fasten one to the bottom of each boat with hot wax from a candle. Place them in a basin of water where they can be made to sail around by the attraction of your magnet, as shown in Fig. 16.

THE CELL

Wet and Dry Cells will generate an electric current. A Dry Cell is best and can be easily purchased at electrical supply stores. It is nothing more than a Wet cell with the fluid held in paste form, but you should know how Wet cells are made.

MAKING A CELL

Fill an ordinary drinking glass two-thirds full of water and pour into it the contents of the package marked Ammonium Chloride (Sal Ammoniac). Stir this solution with a stick until the chemical has dissolved. Put the zinc and carbon rods or electrodes through the holes in the fiber holder, which is then placed on top of the glass. Be sure that the carbon and zinc do not touch each other. (Fig. 17.) Two or more cells are called a battery. It is, however, common practice to call a single cell a battery.

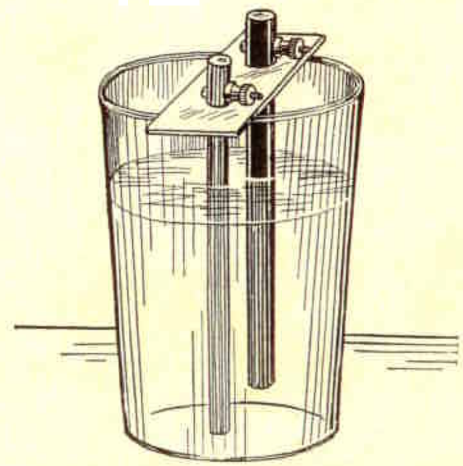


Fig. 17

POLES OF A CELL

The electrodes must be of two different materials if an electric current is to be produced. In the cell you have just made we have used zinc and carbon. When the cell is in use the current flows from the carbon electrode, which is known as the Positive pole, to the zinc electrode, which is called the Negative pole. The amount of current produced by your wet cell will be small, and while you may conduct some of the experiments with it the use of a dry cell will give much better results.

MAKING AN ELECTRIC SPARK

Connect two wires one to each terminal of your cell. The terminals are the binding posts that are fixed to the upper ends of the carbon and zinc electrodes. Set your cell in a dark room or perform the experiment at night, then touch the lead wires from the cell together and on drawing them apart, or breaking the circuit, as it is called, you will see a spark. To produce a succession of sparks connect one of the lead wires to one end of a file and then rub the other lead against the teeth of it. (Fig. 18.) You will see a score or more of sparks with every stroke.

NOTE:—Always disconnect your battery when not in use or it will rapidly lose its strength and become "dead."

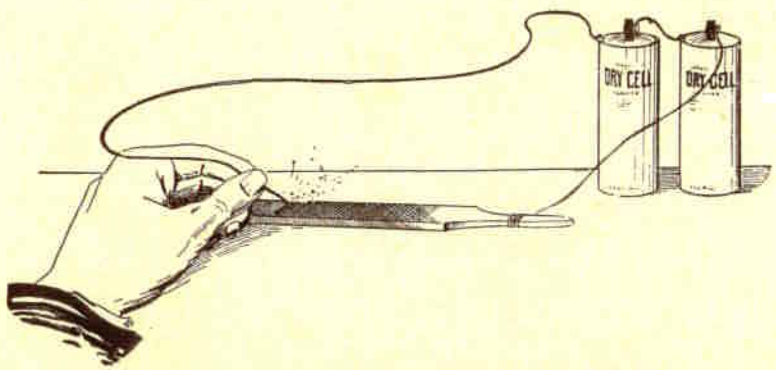


Fig. 18

HOW TO TASTE ELECTRICITY

Take one lead wire in the fingers of your left hand and the other lead in the fingers of your right hand, then touch the ends of them on the tip of your tongue. You will find that the taste the current sets up is very much like that produced by a drop of vinegar. You cannot get a shock from the cell so you don't need to be afraid to try the experiment.

YOUR OWN ELECTRIC LIGHT PLANT

Screw the small incandescent lamp into its socket and then connect one lead from a cell to one of the terminals of the socket. Now touch the other lead wire to the other terminal. (Fig. 19.) The lamp will then light up. The current heats the metal filament inside the lamp white hot. Don't keep the circuit closed for too long a time or your battery will run down.

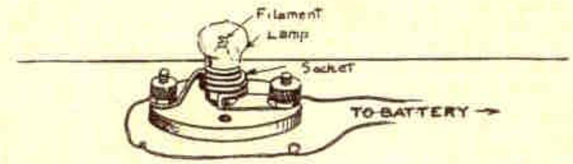


Fig. 19

HOW TO MAKE A RHEOSTAT

Dissolve a teaspoonful of common table salt in a glass of warm water. Into this solution place your carbon and zinc electrodes. Connect one battery lead to the carbon and the other to the lamp socket terminal. Then connect the other socket terminal to the zinc rod. By raising the carbon or the zinc the resistance of the circuit will be changed and the lamp dimmed accordingly, as seen in Fig. 20.

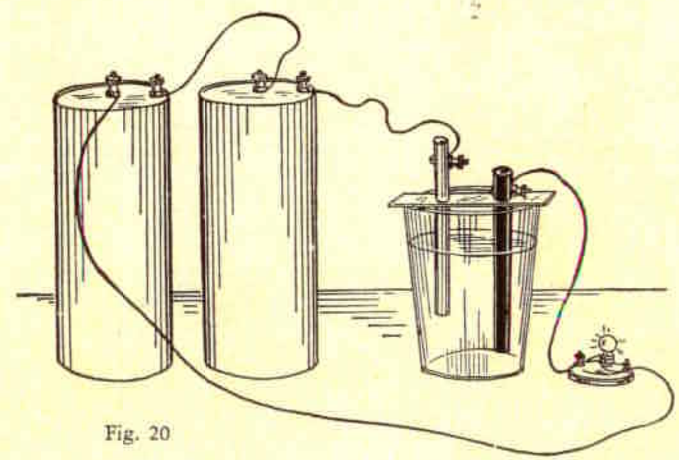


Fig. 20

ELECTRICITY SETS UP MAGNETISM

Place your compass on a table. Next take a piece of fine cotton-covered wire about 1 foot long and connect one of the ends to one of the terminals of your battery. Hold the wire close to and parallel with the magnetic needle. (Fig. 21.) Now touch the other end of the wire to the other terminal. Instantly the needle of the compass will be deflected just as if you had approached it with a magnet, and indeed this is true, for when a current is flowing through a wire it sets up magnetic lines of force around it.

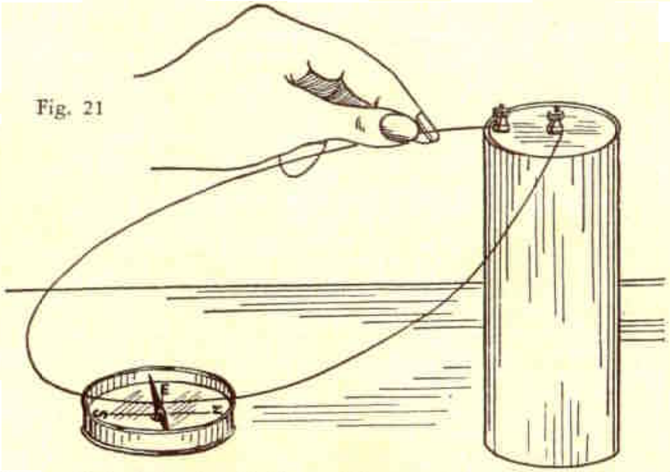


Fig. 21

Another method of showing the lines of force around a wire carrying an electric current is to take a smooth card and thrust a piece of bare copper wire through it. Connect one end of this wire to a battery terminal and then sprinkle some iron filings on the card. Next touch the other end of the wire to the other battery terminal. Rap the card gently and the filings will arrange themselves in little rings around the wire just as though it were a magnet, (Fig. 22.)

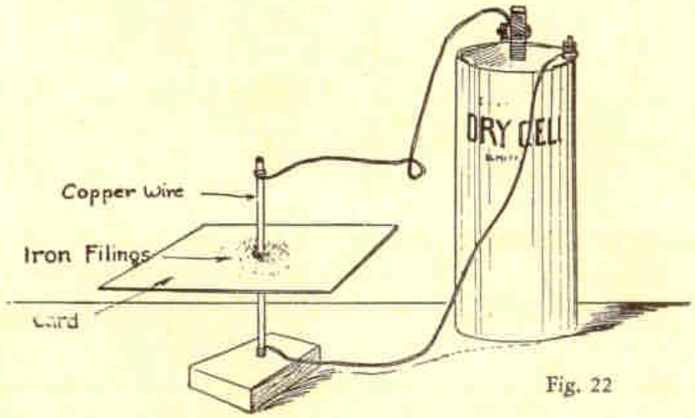


Fig. 22

GALVANOSCOPE

For measuring very feeble currents the galvanoscope is used. You can easily build one of these instruments by setting your compass in a wooden block about 2½ inches square. Wind around the compass and block 20 turns of No. 24 wire and connect the ends to two binding posts. (Fig. 23.) To use this instrument turn the base so the needle is parallel to the coil of wire then connect your battery leads to binding posts and you will see the needle fly around to a position that is at right angles to the one it first occupied.

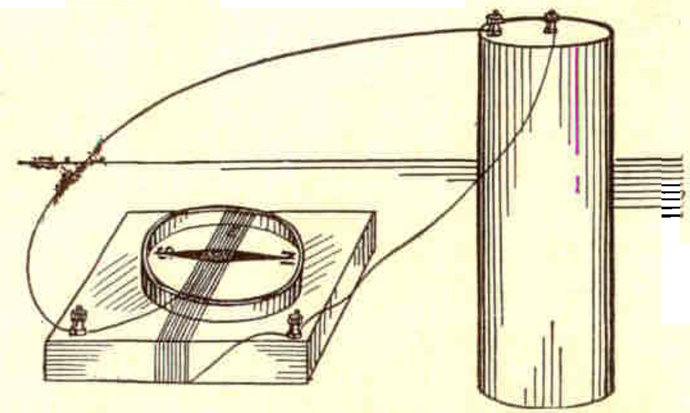


Fig. 23

ELECTRICAL UNITS

In measuring liquids we use units of measure based on the volume, such as a quart. The inch is a unit of measure showing distance. In measuring weight we use a unit known as a pound. Electricity has to be measured by its effects as it is weightless and invisible. The following units of measure are ones that you should know in conducting your experiments with electricity.

THE AMPERE

The quantity of electrical current that is passing along a wire is measured by the unit *Ampere*. The instrument used in measuring this quantity is an Ammeter.

THE VOLT

In order to force this current along a wire we need pressure and this pressure is measured by the unit VOLT. The amount of volts are determined by the use of a Voltmeter.