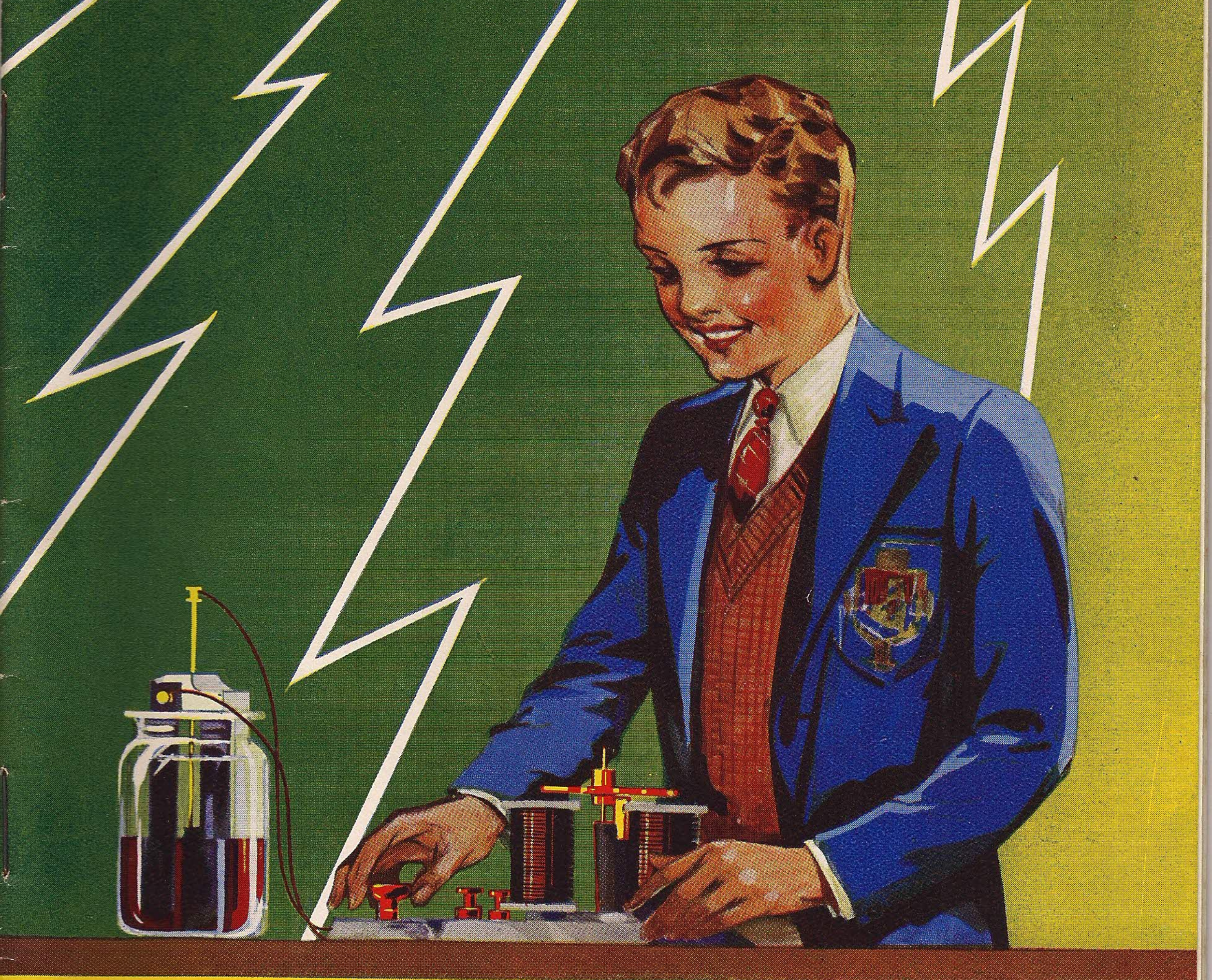
ELEKTRON

ELECTRICAL EXPERIMENTS

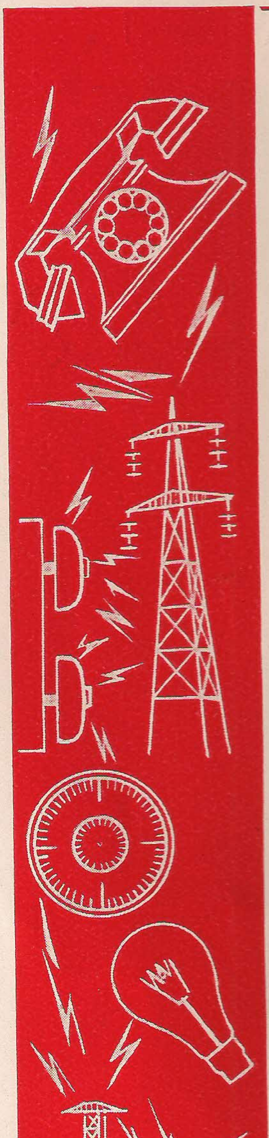


INSTRUCTIONS
FOR
Outfit No. 1

PRODUCT of MECCANO LIMITED LIVERPOOL

PRICE 1/-

No. 33-1EE



ELEKTRON

ELECTRICAL EXPERIMENTS

Electricity is being employed on an ever-increasing scale for heating, lighting, driving machinery, and many other purposes. The Elektron Outfits have been specially designed to show, by a series of fascinating experiments, how this wonderful power is generated, transmitted, and put to work to serve our every-day needs.

With the No. 1 Elektron Outfit you can explore the marvels of magnetism, map out the tracks of magnetic forces, and learn of the wonderful properties of the mariner's compass. It enables you also to carry out experiments in Electricity produced by friction, and to realise the enormous energy behind Nature's awe-inspiring displays in thunderstorms.

The No. 1A Elektron Outfit completes the scheme commenced in the No. 1 Outfit. It deals with the electric current, and explains the working of electrical apparatus of all kinds, ranging from electric bells to dynamos and electric motors.

To get the greatest fun from your Outfit, you should read the "*Meccano Magazine*," special articles in which link up with the Elektron Outfits, and describe new and interesting experiments in all branches of Electricity. The "*Meccano Magazine*" is read by over 100,000 boys every month. It is published on the 1st of the month and may be ordered from any Meccano dealer or newsagent.

MECCANO LIMITED
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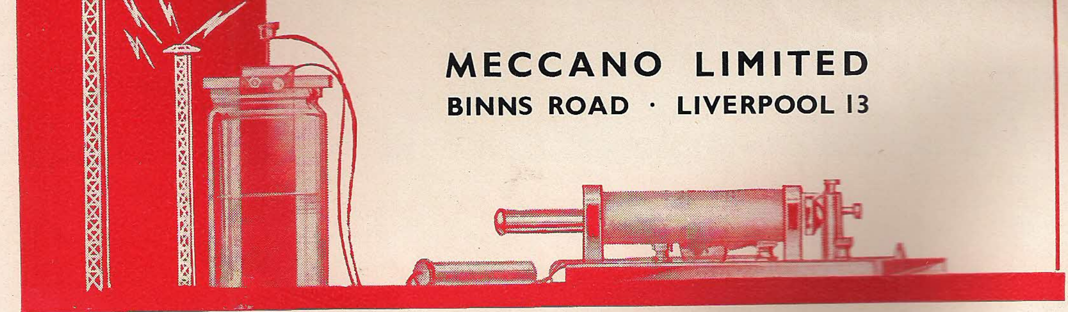


Part I. MAGNETISM

The story of magnetism began long ago with the discovery that a certain kind of iron ore has the power of attracting pieces of iron, and of setting itself in a north and south direction if suspended freely. The Chinese seem to have been familiar with this ore in very early times, and as far back as 1,000 B.C. they made use of it to guide their caravans across the plains of Tartary. A crude form of mariner's compass was certainly used by the navigators of Chinese ships that made voyages to India between A.D. 265 and 419. Indian and Arab seamen probably learned the secret from the Chinese, and through them knowledge spread to the West.

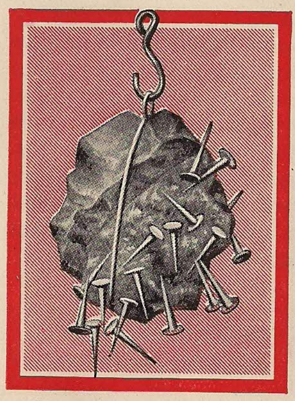


Fig. 1. Lodestone that has been dipped in a heap of tacks.

This remarkable ore, which was called the "LODESTONE" or "STONE THAT GUIDES," was well known in certain parts of Europe long before the compass came into general use in the West. It was found in large quantities in Magnesia in Asia Minor, and the word "magnetism," which is now used to denote its peculiar power, is said to be derived from the name of this province.

The lodestone is a natural magnet, but it is not very convenient for experimental use. Fortunately, artificial magnets more suitable in shape and in other ways, may be made without difficulty. If a bar of steel is rubbed several times in the same direction with one end of a piece of lodestone, the steel acquires the lodestone's properties of attracting pieces of iron and steel and turning to the north if free to do so. The steel has thus become an artificial magnet, and as the lodestone does not lose any of its own magnetism in the process, we are provided with a means of making any number of such artificial magnets. A bar of iron can be magnetised in a similar manner, and is easier to magnetise than steel; but it soon loses its magnetism, whereas steel retains it. The harder the steel the better it retains its magnetism, and so artificial magnets are made of specially hardened steel.

Bar and Horseshoe Magnets

TWO BAR MAGNETS (Part No. 1505), of hard steel are included in the Elektron Electrical Outfit, and with them many interesting experiments may be carried out. If you try to pick up needles, pen nibs, or other small pieces of iron or steel with one of them, you will find that the objects are attracted only at the ends of the magnet, the middle having no effect whatever. The same curious property of the magnet can be shown by rolling it in iron filings poured out on a sheet of card or paper. (A supply of these filings is contained in the glass tube included in the Outfit). The filings cluster thickly at the two ends of the Magnet, but few or none are attracted by the middle. The two ends are known as the poles of the Magnet.

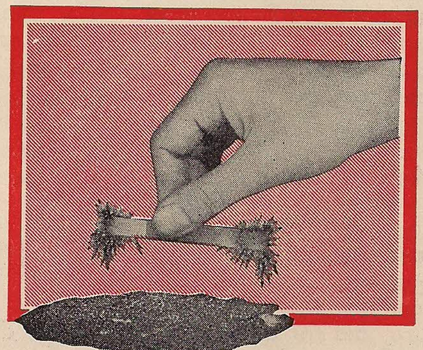


Fig. 2. Attractive power of magnet concentrated at its poles.

There is also another familiar form of magnet made in the shape of a HORSESHOE. If a magnet of this type is tested with iron filings it will be found that these cling thickly round the ends, none being attracted by the curved portion, showing that the horseshoe magnet also possesses two poles. A Horseshoe Magnet of convenient size is included in the Elektron No. 2 Electrical Outfit (Part No. 1507).

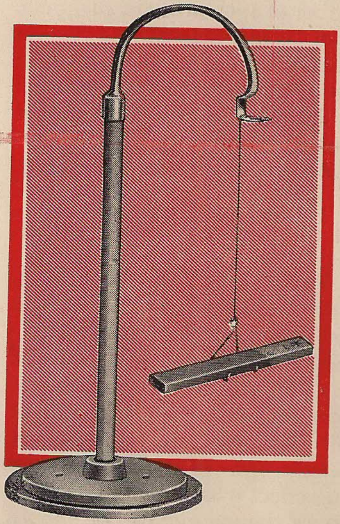


Fig. 3. A suspended magnet points north and south.

An interesting thing about magnetism is that its invisible power can pass through solid substances. This is illustrated in an amusingly simple way by sprinkling iron filings on a sheet of cardboard or glass and moving one end of a Bar Magnet slowly about underneath the card. The filings respond in a comical manner to the magnetic influence and seem to stand up and to march about like a company of soldiers.

Magnets Look to the North

To test the north-pointing properties of one of our Bar Magnets, we suspend it so that it is free to turn, and for this purpose we use the stand shown in the accompanying illustration. The Erinoid Tube (Part No. 1509) is fitted into the central hole of the Circular Base (Part No. 1508), and the Stand Bracket (Part No. 1510) is placed on top of it. The Brass Stirrup (Part No. 1511) is then hung from the end of the Stand Bracket by means of a length of silk thread from the Reel (Part No. 1518).

The Bar Magnet fits comfortably in the Brass Stirrup, and a few trials will enable a balanced position to be found for it (Fig. 3). At first it swings round, but soon it comes to rest with one end pointing to the north. No matter to which point of the compass the Bar Magnet is turned, it will always return to this north-and-south position when left free. It is always the same end of the Bar Magnet that points to the north; and this end is called the magnet's north pole, the opposite end being its south pole.

"Likes" Repel and "Unlikes" Attract

If we suspend one of the Bar Magnets in the Brass Stirrup as already described, and in turn bring near each end a needle or other piece of unmagnetised iron or steel, we find that both ends of the magnet are attracted. Repeating the experiment, but using the other Bar Magnet instead of unmagnetised steel, the result is surprisingly different. The north pole of the magnet we are holding attracts the south pole of the suspended magnet, but repels its north pole (Fig. 4). If we hold the south pole of our Magnet towards the suspended magnet, it attracts its north pole but repels its south pole. From this experiment we learn an important

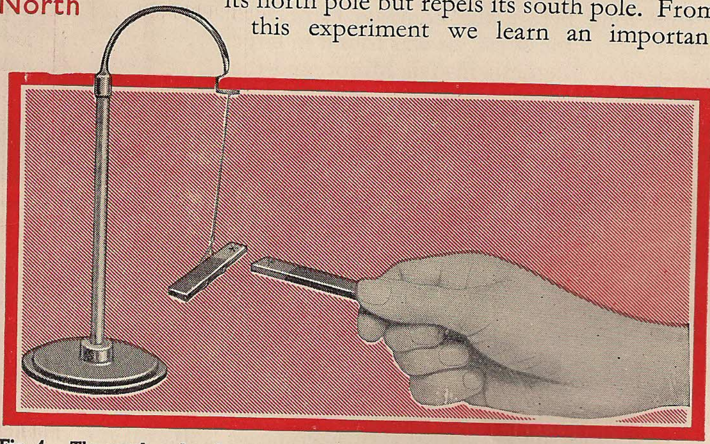


Fig. 4. The north pole of a suspended magnet is repelled when a similar pole of a second magnet is brought towards it.

principle : that opposite poles—one north and one south—attract one another, and that similar poles—two norths or two souths—repel each other.

One of the favourite experiments with a magnet is to suspend a chain of needles or Meccano Nuts from one of its poles, adding them slowly and carefully one by one to see how many the magnet will sustain. An interesting variation of this experiment is to make a loop of Nuts by suspending a chain of them from each pole of a magnet and gently bringing their ends into contact (Fig. 5). As the nuts used were not previously magnetised, these experiments show that the nut actually brought into contact with the magnet immediately becomes a magnet itself, and that the power of attraction is passed on to each nut added to the chain.

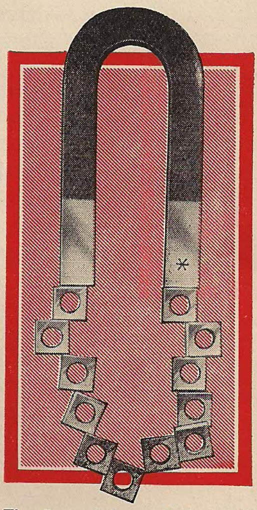


Fig. 5. A loop of Nuts held together by magnetic attraction.

Induced Magnetism

There is an easy way of testing this by suspending a large nail or a piece of soft iron from one end of the Bar Magnet, and dipping its lower end into a heap of filings, and then lifting it away. It will be found that a bunch of filings clings to it, showing that it has become a magnet (Fig. 6). If now we hold the nail in one hand and gently detach the magnet from it with the other, the filings immediately fall off, showing that the nail has lost its magnetic power. In the case of a chain of needles suspended from the end of a magnet, if we gently detach the first needle the remainder will fall away from it and from one another. This shows us that the magnetism induced in a needle by contact with a magnet is only temporary, since it ceases as soon as the magnet is taken away.

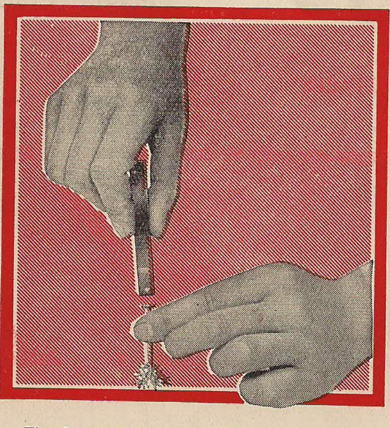


Fig. 6. A nail becomes a temporary magnet when held near a pole of a Bar Magnet.

If the iron filings used in our experiments become scattered, the natural thing to do is to pick them up with the magnet. This is quite easy, but trouble arises in persuading the magnet to part with them, and much scraping and pulling is necessary. This can be obviated by collecting the filings by means of a piece of soft iron hanging from a bar magnet, and therefore temporarily magnetised (Fig. 7). If the collected filings are then held over the container, they will be released and will fall neatly into it as soon as the magnet is taken away from the iron.

How to Make Magnets

Exactly as a piece of iron or steel may be turned into an artificial magnet by stroking it with a piece of lodestone, so may magnets be made with one of the Bar Magnets included in the Outfit. A medium-sized sewing needle makes a convenient piece of steel for the purpose, but it should first be tested with filings, to make sure that it is not already magnetic. Next, the needle is laid on the table and the north pole of the Bar Magnet is drawn slowly along it from eye to point (Fig. 8). This operation is repeated several times, care being taken to draw the magnet well beyond the point of the needle before bringing it back to the eye. Another test with filings will show that the needle has become a magnet.

It will be interesting now to find out which is the north and which the

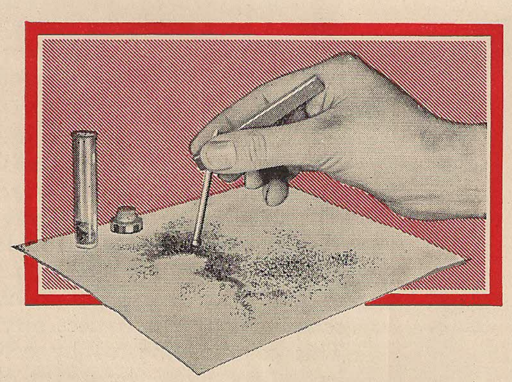


Fig. 7. Collecting scattered iron filings by means of a large nail.

south pole of the needle, making use of the suspended Brass Stirrup for the purpose. It will be found that the needle sets itself with its point directed to the south, so that the eye end is evidently its north pole. As the needle was stroked with the north pole of the Bar Magnet, it is clear that in making a magnet the pole formed at the end of the needle where the stroke begins is similar to the pole of the magnet used, and that the pole produced at the end of the stroke is of the opposite kind. This is easy to test by magnetising a second needle with the south pole of the Bar Magnet instead of the north. Another way to show the same thing is to use the north pole of the Bar Magnet, drawing it along the needle from point to eye, thus producing a north pole at the pointed end.

Magnetic Screwdrivers

To the beginner it is always very surprising to discover how many iron and steel articles are already magnetic to some extent, and it is interesting to investigate some familiar household articles in this respect. Often it will be found that a pair of scissors, a penknife blade, or a screwdriver attracts iron filings, but as a rule the attraction is only very feeble for magnets of this kind are always weak. In most cases such articles are none the worse for being magnetised, and sometimes their efficiency actually is increased. A case in point is the magnetic screwdriver, which is capable of picking up small iron or steel objects such as screws, bolts, or nuts, and of retrieving them from cracks and corners in which they are difficult to reach. Meccano model-builders find a magnetised screwdriver a great help in picking up a nut or a bolt that has dropped into an awkward position.

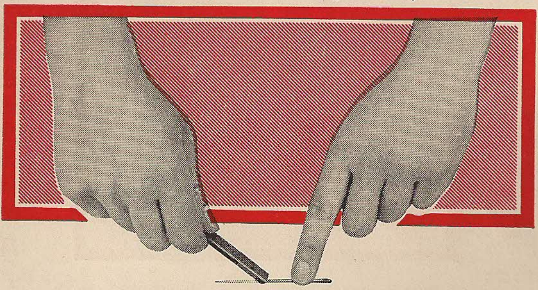


Fig. 8. Magnetising a needle by means of a Bar Magnet.

Any screwdriver can be made into a sufficiently strong magnet by stroking its blade from end to end with a bar magnet in the manner we have already described.

A so-called PERMANENT MAGNET tends to lose its magnetism gradually unless precautions are taken to prevent this. The usual method is to place a piece of soft iron, known as a keeper, in contact with poles of opposite kinds. With bar magnets this involves keeping them in pairs, separated by a piece of thin wood or card, with unlike poles adjoining and a piece of soft iron across the poles at each end (Fig. 9). With a horseshoe magnet all that is necessary is to place the iron keeper across the two ends (Fig. 10).

Magnets Dislike Rough Treatment

Violent handling of any kind is harmful to magnets, and it is easy to show that this is the case. Magnetise a steel needle by stroking it repeatedly in one direction with one of the poles of a Bar Magnet and test its power of attraction by the amount of filings it will pick up. Then throw down the needle violently several times on stone or concrete and test it again. It will be found that the rough treatment has caused it to lose some of its power. Allowing a keeper to slam violently on to a magnet will rapidly weaken the magnet, but curiously enough, pulling a keeper off suddenly has just the opposite effect, and actually helps to maintain the powers of the magnet.

Secrets Revealed by Magnetic Maps

In order to find more exactly how magnetic forces act, lay a Bar Magnet on the table and over it place a sheet of thin card, of similar thickness to a postcard. The bottom of the flat box that contains the smaller parts in the Outfit is bored with several small holes. Remove the contents of the box and pour iron filings into it; then shake the box gently over the card so as to sprinkle the filings evenly and thinly over the whole of its surface (Fig. 11). Now tap the card gently with the end of a pencil, or with one of the Rods included in the Outfit. A remarkable transformation immediately takes place, for the filings arrange themselves in lines radiating outward in all directions from the poles and forming a beautiful regular pattern (Fig. 12).

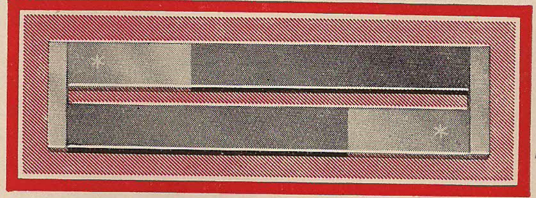


Fig. 9. How keepers are placed on Bar Magnets not in use.

A pattern formed in this manner is known as a magnetic map, for the filings show the general direction in which the forces act, and the lines marked out by them are spoken of as LINES OF MAGNETIC FORCE. Tapping helps the filings to take up positions in obedience to the magnetic force by causing them to jump up from the card, thus temporarily freeing them from the effect of friction.

It is great fun to make a series of photographs of magnetic maps, and this is easily done in a room lighted only by ruby light. The magnet or magnets are laid on the table in the desired arrangement, and a photographic plate is placed over them, film side up. Quarter-plates ($4\frac{1}{4}$ in. by $3\frac{1}{4}$ in.) will do fairly well for the purpose, but more complete maps may be obtained if half-plates ($6\frac{1}{2}$ in. by $4\frac{3}{4}$ in.) are employed instead.

Filings are sprinkled evenly over the plate, which is then gently tapped to enable the filings to arrange themselves in accordance with the magnetic forces acting on them. A lighted match is then held a few inches above the centre of the plate where it illuminates the sensitised film evenly, allowed to burn up brightly, and blown out. The plate is now tilted to allow the filings to fall off, and tapped gently on its lower edge to make sure that none of them cling to it. Development in the ordinary way gives a negative from which splendid prints may be made, showing the directions of the lines of force.

Another Method of Map Making

Magnetic maps may be made also with the sensitised paper known as gaslight paper, which does not necessitate working by ruby light. A piece of this is laid on a sheet of thin card resting on the magnet. Iron filings are then sprinkled directly on the sensitised paper in the manner already described, and are made to arrange themselves along the lines of force by gentle tapping, a single light tap usually being sufficient. A longer exposure to light is required than in the case of a photographic plate. A negative print is obtained in this manner, and a positive may be made from it by placing a second sheet of sensitised paper on it, with

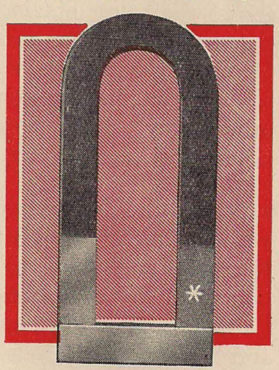


Fig. 10. Horseshoe Magnet.

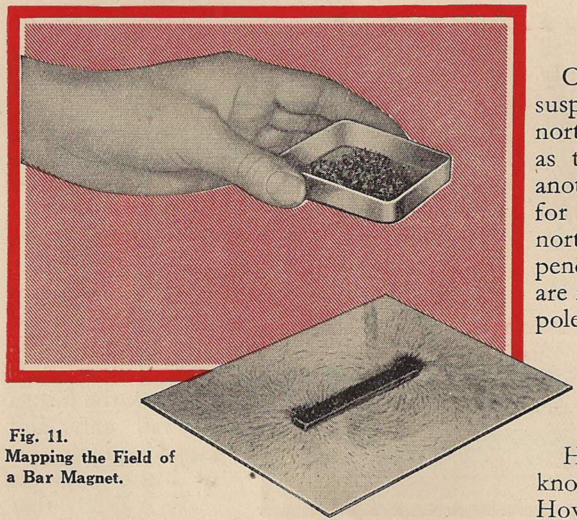


Fig. 11.
Mapping the Field of a Bar Magnet.

the film sides in contact, and repeating the exposure and development. The accompanying illustrations of magnetic maps were made in this manner, using "Velox V.G.3" paper. The exposure was made by means of a flashlamp with a $3\frac{1}{2}$ v. bulb, moved about at a distance of about 12 in. above the paper for a period of 10 seconds.

Fig. 13 shows the direction of the lines of force between two unlike poles, one north and the other south. The lines seem to stream across from one pole to the other, and they help us to understand how it is that two unlike poles attract one another. Fig. 14 shows the result obtained from two similar poles—that is two norths or two souths. Here the lines do not stream across from pole to pole, but turn aside as if pushing each other away, showing us how two similar poles repel one another.

Many other interesting maps may be made with different arrangements of the Bar Magnets, and with the Horseshoe Magnet contained in the Elektron No. 2 Electrical Outfit. The introduction of pieces of soft iron into various positions near the magnets also gives many curious designs.

The Earth a Giant Magnet

Our experiments have shown us that a suspended magnet always comes to rest in a north and south direction—in fact, it behaves as though it were under the influence of another magnet. This is actually the case, for the Earth itself is a giant magnet with a north and a south pole that act on our suspended magnet. The Earth's magnetic poles are not at the same points as its geographical poles, the north magnetic pole being in Northern Canada and the south magnetic pole in Victoria Land, in the Antarctic Continent.

Here we come to a curious problem. We know that similar poles repel one another. How is it, therefore, that the Earth's north magnetic pole attracts, instead of repelling, the north pole of a magnet ? One or other of these poles must actually possess south magnetism, and it is customary to regard this as being the case with the Earth's north magnetic pole. All confusion disappears if we think of the north pole of a magnet as being a north-seeking pole, and its south pole as a south-seeking pole.

Magnets Help Sailors

A bar magnet suspended so that it is free to set itself north and south forms a compass. Many forms of this instrument have been designed, and one of these is included in the Elektron No. 1 Electrical Oufit. It is in

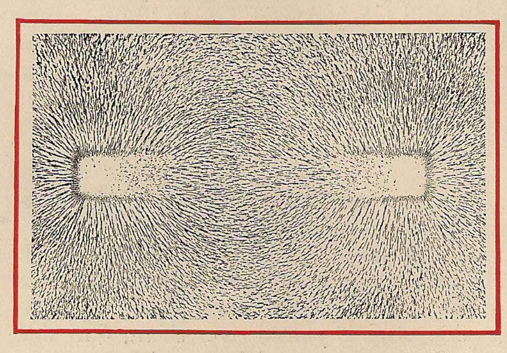


Fig. 12. Lines of Force of Bar Magnet.

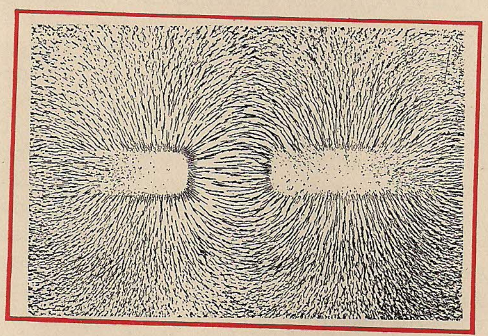


Fig. 13. Lines of force between opposite poles of two magnets.

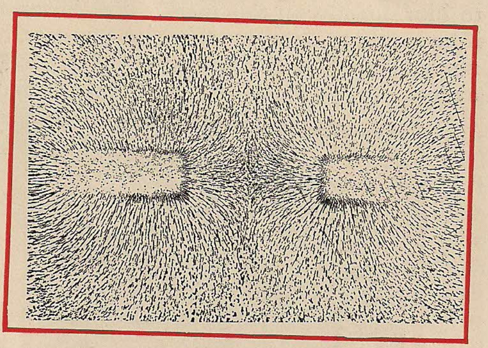


Fig. 14. Lines of force between similar poles seem to push each other away.

two parts, a Compass Needle (Part No. 1503) consisting of a small magnet with pointed ends, and a Compass Box (Part No. 1501) at the bottom of which is a Brass Slide fitted into brackets and supporting a finely-pointed pivot. At the centre of the Compass Needle is a tiny cup, and when this is placed over the pivot the needle is balanced and free to set itself north and south. The accompanying illustration shows the Elektron Compass assembled and correctly adjusted (Fig. 15).

At the bottom of the Compass Box is a card on which the points of the compass are marked, lines being drawn from the centre of the Box to indicate North, South, East, West and other directions. In order to use the Compass as a direction-finder, the Compass Box is turned round slowly until the needle is exactly over the line on the card that has an arrow-head, indicating north, at one end, and the letter S, indicating south, at the other. It is then easy to see in which direction any other point of the Compass is situated.

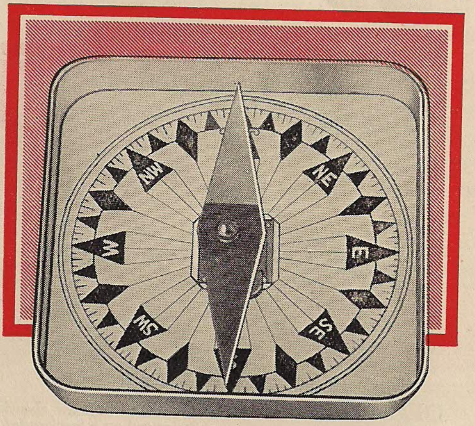


Fig. 15. The Elektron Compass.

The Compound Needle Compass

A special kind of compass has been designed for use on ships. Instead of a single needle this has a compound needle consisting of several slender strips of magnetised steel, attached to a circular card of semi-transparent paper mounted on a light aluminium framework (Fig. 16). The card and the compound needle together weigh only a fraction of an ounce, and they are delicately pivoted on a point supported in a copper bowl. In order that this bowl may retain its horizontal position, no matter how the ship may be rolling, it is supported on gimbals consisting of two concentric rings attached to horizontal pivots and swinging on axes that are at right-angles to one another.

There are also liquid compasses, in which the card floats on the surface of some such liquid as dilute alcohol.

Steering by Compass

Inside the bowl and above the card is a mark known as the "lubber line." This indicates the centre line of the ship, and the steersman must keep the bearing given to him directly on this mark. For instance, if he is told to steer due West by compass, he must manipulate the steering wheel in such a manner that the point marked W points

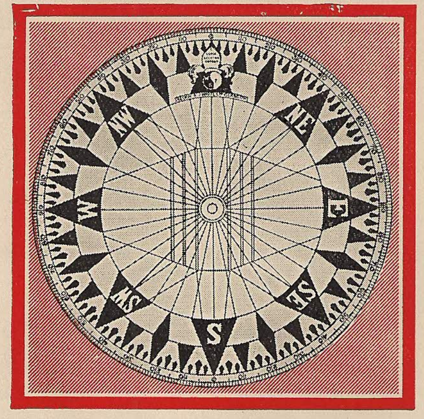


Fig. 16. Card of mariner's compass, which has several strips of steel instead of a single needle.

directly to the lubber line. He then watches carefully to detect any slight swing of the card that would take this mark away from the line, and turns his wheel as may be necessary to bring the mark back again into position.

We have already seen that the Earth's magnetic poles are not at the same points as its geographical poles, and therefore the compass needle does not point exactly to the geographical north and south. A navigator who followed exactly the indications of his compass would therefore be wrong in his geographical direction. For instance, if he were to steer westward by compass across the Atlantic Ocean from Land's End in order to reach the mouth of the St. Lawrence River, he would probably end up as far astray as the West Indies, for on the Atlantic Ocean the compass points west of north. On the west coast of America the opposite is the effect, the compass pointing east of north.

True North and Magnetic North

The difference between true north and magnetic north, called "DECLINATION," varies at different places. If the compass is to be a reliable guide, this difference must be known accurately at as many places on the Earth's surface as possible, and large numbers of measurements of declination have been made both on land and sea. Magnetic measurements at sea are made in special vessels constructed almost entirely of wood, for the presence of iron or steel would disturb the magnets employed. From the surveys made by these vessels a world magnetic map has been prepared and from this navigators know exactly how much to allow for declination, wherever they may be.

Magnetic Dip

The suspended Bar Magnets and the Compass Needle are only free to swing in a horizontal direction. If a magnetised needle is suspended so that it can swing vertically as well as horizontally, it not only comes to rest in a north and south position, but at any place north of the Equator it tilts with its north-pointing end downward. If the needle is taken to a place south of the Equator it tilts in the opposite direction with its south pointing end downward. Exactly at the magnetic equator the needle would not tilt at all, for the influence of the Earth's two magnetic poles would be equal; and if the needle were placed immediately over either magnetic pole, it would take up a vertical position. This tilting, known as "MAGNETIC DIP," is due to the fact that the Earth is a sphere, and Fig. 17 clearly shows how it is caused.

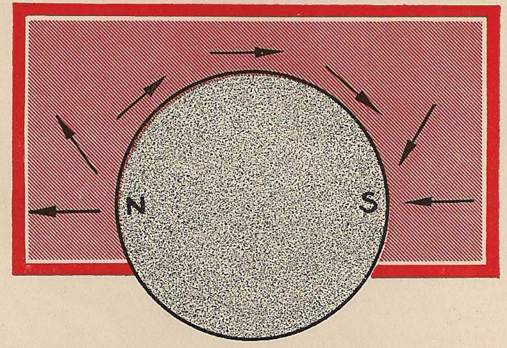


Fig. 17. Diagram showing why one end of a compass needle balanced on a horizontal axis dips owing to the attraction of the Earth's magnetic poles.

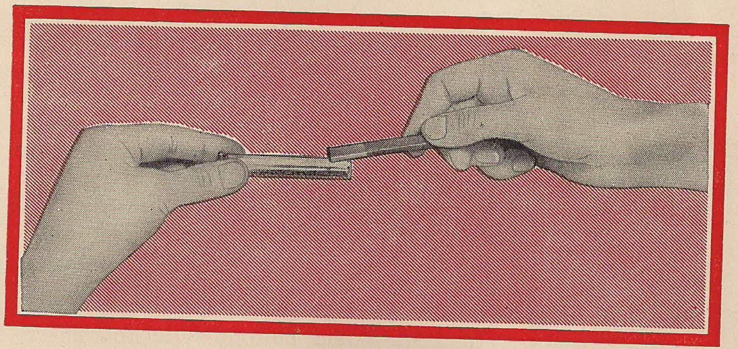


Fig. 18. Making a mass of iron filings into a feeble magnet.

Each Small Filing is a Magnet

The explanation of these interesting experiments is that each small filing is itself a feeble magnet, but the mass in the tube is not magnetic as a whole because the filings are mixed up with their poles pointing in all directions (Fig. 19A) The effect of drawing the Bar Magnet along the tube is to cause the filings to re-arrange themselves so that their north poles all point in the same direction (Fig. 19b). Their magnetic effects are thus combined instead of opposing each other, and the whole mass of filings then acts as if it were a magnetised rod of iron of similar size.

A similar change takes place in a piece of iron or steel when it is magnetised, for the metal consists of tiny particles that are themselves magnets. In this case, however, the particles are very much smaller than the filings we have just used; they are indeed too small to be seen even with the aid of the most powerful microscope. In an unmagnetised piece of iron the particles are arranged unsymmetrically, so that they neutralise one another's effects. When the iron is stroked

Re-arranging Particles

When a needle is magnetised by stroking with a magnet nothing is added to it or taken away from it, and yet a great change has come about, as our tests with filings have shown. This change is due to an actual re-arrangement of the particles of which the needle is composed, and the following experiment will give us a good idea of what takes place.

Take the Glass Tube containing filings, shake it, and test its ends in turn with the north and the south pole of the Compass Needle. Both poles of the Needle are attracted equally, which shows us that the filings as a whole are not magnetic. Now hold the tube horizontally and slowly draw the north pole of a Bar Magnet along the outside from the sealed end towards the cork (Fig. 18). The filings appear to follow the magnet, re-arranging themselves so as to take up the line it traces. Taking care not to shake the filings, test the sealed end of the tube with the north pole of the Compass Needle, and this time it will be found that the Needle swings away, showing that this end of the tube of filings is now a north pole. As the glass plays no part in the magnetic action, it is evident that the mass of filings forms a magnet. If now we shake the tube so as to upset the arrangement of the filings, we find that all magnetic power has disappeared.

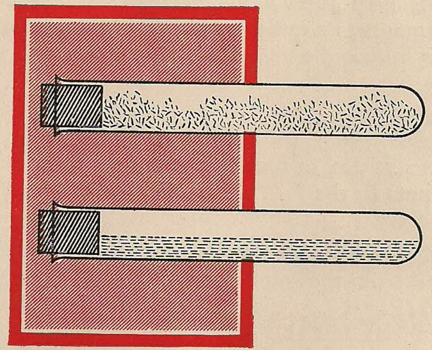


Fig. 19. (a) Iron filings before magnetising, with their north poles pointing in various directions.
(b) Filings after magnetising, arranged with their north poles all pointing in the same direction.

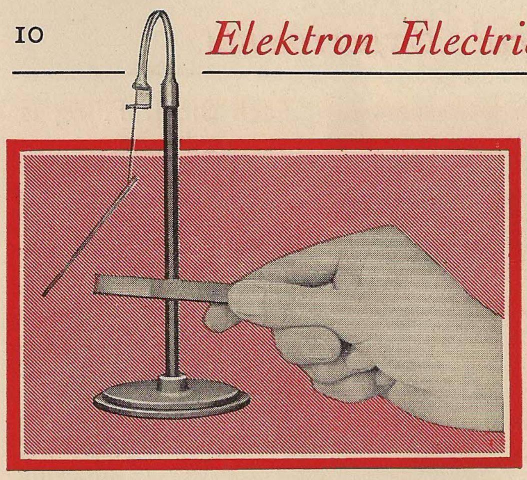


Fig. 20. Magnetic repulsion causes a needle to take up an unusual position.

with a magnet, however, the particles rearrange themselves with their north poles all in the same direction, and as a result of their combined magnetism the whole piece of iron acquires magnetic powers.

We have seen that shaking the tube of iron filings after it has been magnetised disarranges the filings and destroys the magnetic effect of the whole. In a similar manner violent treatment of a piece of magnetised iron causes its particles to lose their symmetrical arrangement, so that the iron is no longer a magnet. This explains why magnets should be handled gently, and never knocked or allowed to fall.

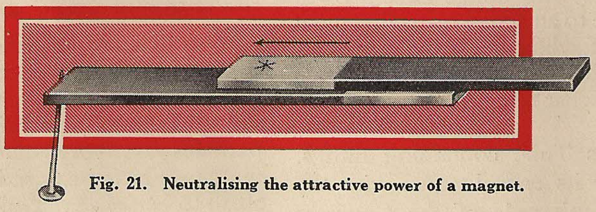


Fig. 21. Neutralising the attractive power of a magnet.

Fun With Magnets

A great deal of fun may be had with the Bar Magnets in the No. 1 Electrical Outfit and a few needles.

A magnetised needle suspended by a thread from the stand made from the Erinoid Tube (Part No. 1509), the Circular Base (Part No. 1508) and the Stand Bracket (Part No. 1510) as shown in Fig. 20, may be made to perform surprising antics by bringing near it the poles of a Bar Magnet.

Support one or two needles from the south pole of one of the Bar Magnets; then slide the second Bar Magnet along the top of the first in such a manner as to bring its north pole above the south pole from which the needles hang (Fig. 21). As soon as the second pole reaches the end of the first magnet the needles fall off, for the two poles neutralise each other's effects.

Repulsion Effects

Interesting and curious repulsion effects may be obtained with vertical floating magnets made by piercing small corks with magnetised needles. The needles used must be magnetised by stroking them from the eye to the point with the north pole of a Bar Magnet, and must be pushed through the corks in such a manner that their eyes, that is their north poles, are uppermost. (Fig. 22).

Place four of these floating needles in water in a basin. As their poles are similar they repel each other and become widely separated, but if the south pole of a Bar Magnet is brought above them they will move towards it, only to stop a short distance away from it on account of their dislike for each other's company. They form the corners of a square, and are in positions where the pole of the Bar Magnet and the mutual repulsion of the needles themselves balance one another (Fig. 23). It is interesting to add more magnetic needles to the group and to see how these arrange themselves to produce different regular patterns.

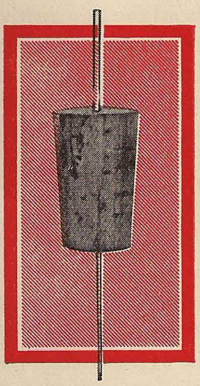


Fig. 22. Magnetised needle and cork for experiments with floating magnet.

For instance, if seven needles are used, one settles immediately below the south pole of the Bar Magnet and the remaining six form a ring around it (Fig. 24).

A surprising result follows the use of more than seven magnetised needles, for a third ring is then formed. Thus if 18 floating magnets are employed the formation already obtained is surrounded by an outer circle of 11 magnets. It is attractive to bring in the additional magnetised needles one at a time in order to see how their introduction affects the patterns.

Patience is required in all these experiments for the balance of attractions and repulsions is

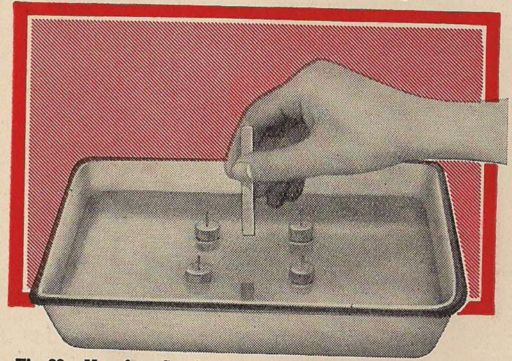


Fig. 23. How four floating magnets arrange themselves beneath pole of a bar magnet.

easily upset. Special care must be taken to keep the basin steady, for slight movements in the water may upset the arrangements.

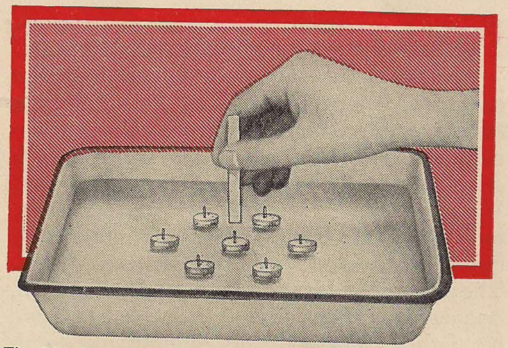


Fig. 24. The addition of three floating magnets to the four shown in Fig. 23, gives rise to a new arrangement.

A Magnetic Fishing Game

A magnetic fishing game that will provide great amusement may be easily arranged. First obtain some small celluloid fishes from almost any toy shop. Next magnetise a number of small sewing needles, half with the north pole at the eye end and half with the north pole at the point. Insert one of these needles in the nose of each fish, in such a manner that the eye projects very slightly. There should be no difficulty in arranging that the hole is above the waterline. Short needles should be used in order that their insertion may not disturb the balance of the celluloid fish.

The fishing is done by two "anglers" each provided with a Bar Magnet suspended at the end of a piece of string (Fig. 25). If matters have been properly arranged, some of the fishes will be attracted by the "bait" whilst others will be repelled by it, and considerable dexterity is required to hook them, especially if the water is disturbed in order to keep them moving. If several anglers wish to take part in the game, strongly magnetised darning needles may be used as bait instead of the Bar Magnets, although in this case the magnetic effects will not be as strong.

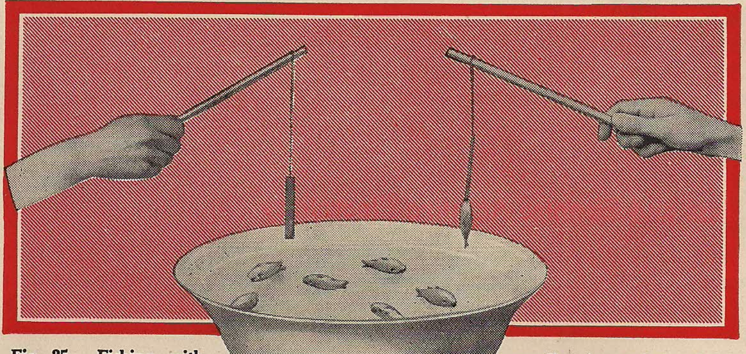


Fig. 25. Fishing with magnets for bait! The fish have magnetised needles inserted in their heads which are attracted or repelled by the poles.

Part II. FRICTIONAL ELECTRICITY

About 600 years B.C. a Greek philosopher named Thales became interested in Amber, a transparent yellow substance that when rubbed acquires the power of attracting bits of straw, feathers, and other light bodies. We now know that amber is fossilised resin, but the Greeks, in accordance with their custom, provided it with a legendary origin. They said that Phaeton, son of the Sun god, one day in a spirit of daring decided to drive his father's chariot, and quickly met with difficulties. The chariot got beyond his control and came so near the Earth that the heat radiated from it caused the land to become scorched and the oceans and rivers dried up. Zeus, the lord of the heavens, was so angry with Phaeton that he hurled a thunderbolt at him and struck him to Earth. The boy's sorrowing sisters the Heliades, were changed into poplar trees, and their tears into amber. Among the names given to the Sun god was Alektor, meaning "the shining one"; and so amber, the tears of the Heliades, came to be named elektron or "the shining thing," from which word we get our word electricity. This name was first used by Dr. Gilbert, a famous scientist whose experiments in magnetism and electricity, carried out during the reign of Queen Elizabeth, were the foundation of these sciences.

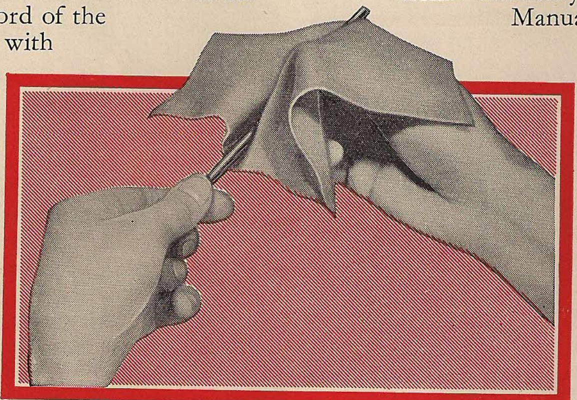


Fig. 26. An ebonite rod electrified by rubbing with flannel.

Glass and Ebonite Acquire Electricity

In addition to amber there are many other materials that when rubbed acquire the power of attracting light substances—ebonite is one. Take the Ebonite Rod (Part No. 1514), rub it smartly with the Flannel Square (Part No. 1516), as shown in Fig. 26, and test its powers of attraction with small pieces of thin paper. It will be seen that these leap towards the rod and cling to it. Now try the experiment with the Glass Rod (Part No. 1515) rubbed with the Silk Square (Part No. 1517) and the same result will be obtained. In a similar manner a glass vase may be given this power of attraction by polishing it vigorously with a silk handkerchief. A postcard rubbed with flannel, or a sheet of brown paper brushed with a clothes brush, also become attractive. The power of attraction in each of these experiments is due to the presence of a small charge of electricity produced by friction.

In these and all other experiments in frictional electricity dealt with in the Manual it is necessary to have all our material perfectly dry, for the least damp will cause failure. For this reason the best results are obtained by carrying out operations in a well-warmed room.

Two Kinds of Electricity

In our experiments in magnetism we saw that although both poles of a bar magnet will attract pieces of iron and steel, actually they are quite different, for one has north magnetism and the other south magnetism. We shall now see that a similar state of affairs exists in regard to these electrical charges. Using the stand already described in the section on magnetism, we electrify one of the Ebonite Rods by rubbing it with the Flannel Square. Laying it in the Brass Stirrup, we then rub the second Ebonite Rod with the Flannel Square and bring this towards the electrified end of the suspended rod. The latter is repelled by it for it immediately swings away from the rod held in the hand (Fig. 27). We know that the charges of electricity on the two rods

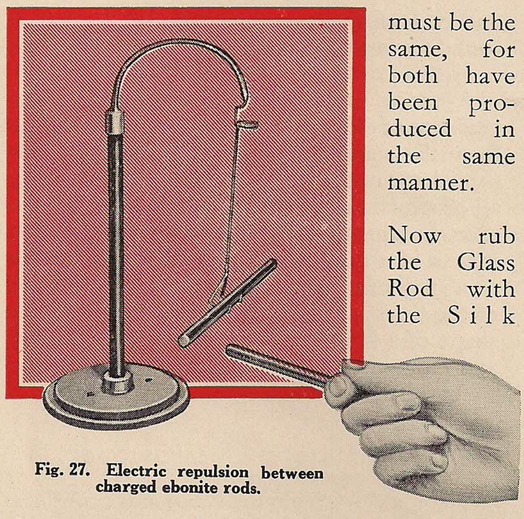


Fig. 27. Electric repulsion between charged ebonite rods.

must be the same, for both have been produced in the same manner.

Now rub the Glass Rod with the Silk Square and try its effect on the suspended Ebonite Rod. This time the latter rod is attracted by it, for it swings round to meet the glass rod.

Positive and Negative Electricity

These experiments show that the charge of electricity on the Glass Rod must be different in some way from that on the Ebonite Rod, for it produces an opposite effect. The electricity produced on the Glass Rod is said to be "positive," and that on the Ebonite Rod said to be "negative."

Our experiments show us also that there is a further similarity between electricity and magnetism. Similar magnetic poles repel, and unlike poles attract one another; and here we find that substances charged with similar kinds of electricity repel, and those charged with opposite kinds attract each other.

It is easy to find whether the kind of electricity produced by friction on a card, a sheet of paper, a stick of sealing wax, or any other material is positive or negative. All that is necessary is to bring the electrified material near the suspended Ebonite Rod. If the rod swings away the charge on the substance brought near it is positive, whilst if it is attracted the charge is negative.

The Electric Spider

An interesting experiment that will help us to remember that objects charged with similar kinds of electricity repel one another. may be carried out with an "electric spider" made from a sheet of paper about 4in. in length and 2in. in width. The paper should be cut for about 3in. of its length into eight narrow strips, which represent the legs of the spider, the uncut end representing the head. Lay the spider on a glass plate, hold it down by the head, and stroke its legs smartly with the Flannel Square (Fig. 28). Now lift the spider quickly, and its legs will immediately spread out from one another. The reason for this behaviour is that the legs have been given similar charges by friction and therefore they try to get as far away from one another as possible.

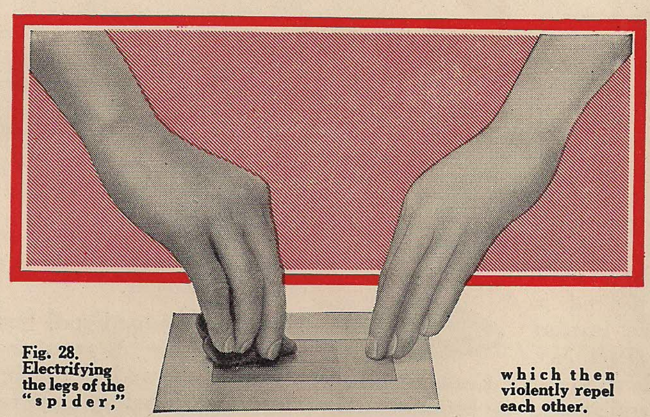


Fig. 28. Electrifying the legs of the "spider," which then violently repel each other.

In carrying out the experiments in attracting small pieces of paper to the glass or ebonite rods, it may have been noticed that some of the pieces stick to the rod whereas others soon fall off. This effect is more

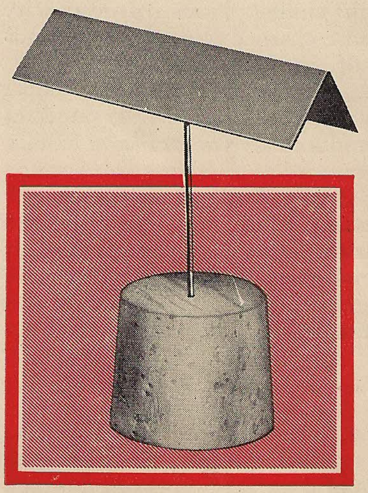


Fig. 29. The electric compass, used to detect electric charges.

noticeable if small pieces of tinfoil—or so-called "silver paper"—are laid on a metal tray, for then the pieces are first attracted by the electrified rod and violently repelled almost immediately they touch it. What happens is that when the pieces come in contact with the rod, some of the electricity on the rod is transferred to them, and they are then repelled because their charge is similar to that on the rod.

Electric Detectives at Work

Sometimes we may wish to test a piece of ebonite, glass, or other material in order to see if it is electrified. It is not always convenient to make use of small pieces of paper or of a suspended rod for this purpose, and a useful substitute is a device that may be described as an electric compass or pointer. This is made by cutting a piece of stiff paper or thin card $1\frac{1}{2}$ in. by $\frac{3}{8}$ in., folding it in two along its length, and balancing it on the point of a needle passing through a cork (Fig. 29). If desired it may be balanced instead on the Pivot (Part No. 1502) removed from the Compass Box. When an electrified rod is brought near one end of the balanced pointer, it swings round towards the rod.

A more useful device for detecting the presence of electricity can be made by hanging from the stand by means of a length of silk thread one of the small Corks (Part No. 1519), all of which are pierced for the passage of the thread, which may be readily inserted by means of a fine needle. If desired a feather or a strip of thin paper could be used instead of the Cork. The paper might be cut to the shape of a butterfly (Fig. 33) or a small bird, and painted in suitable colours to add to the effect when it swings about.

A Simple Electroscope

Hang a Cork from the stand and bring near it a glass or ebonite rod that has been electrified by rubbing. The Cork is strongly attracted (Fig. 30) and as it is extremely light it may be lifted above the stand to the full extent of the thread by raising the charged rod. Similar effects are produced if a feather or a strip of paper is used. This apparatus is a simple form of electroscope, which is the name given to an instrument for detecting the presence of small charges of electricity.

In the experiment we have just described, the suspended Cork was strongly attracted by the electrified rod, but was not allowed to touch it. A great change occurs if the Cork is allowed to touch the rod, for then, instead of being attracted, it is violently

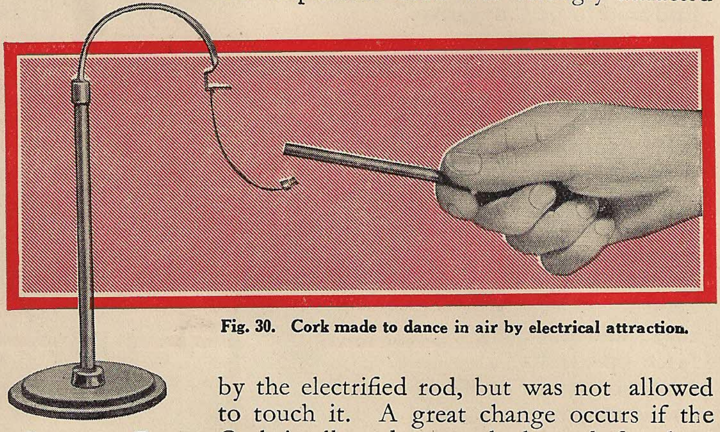


Fig. 30. Cork made to dance in air by electrical attraction.

repelled (Fig. 31). As in the case of the pieces of paper that adhere to the rod, this remarkable difference in behaviour is caused by electricity having been transferred from the rod to the Cork, so that the two repel one another because both are charged with the same kind of electricity. The best results in this experiment are obtained by wrapping the suspended Cork in tinfoil, or in a small strip of the Aluminium Foil provided in the Outfit.

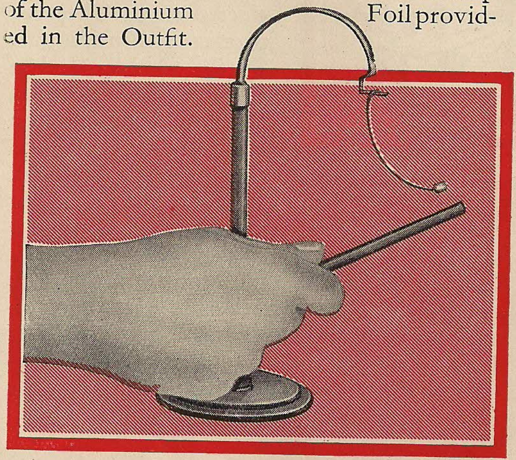


Fig. 31. Repelling a charged cork upward by means of a rod possessing an electrical charge of the same kind.

The Earth a Gigantic Electrical Reservoir

Before the Cork can be attracted again after being repelled in this manner, it is necessary to take away from it the charge of electricity it received from the rod. This is done by brushing its surface with the hand, an action known as "earthing" because the electricity on the Cork passes through the hand and the body to earth. Apparently the Earth is a gigantic reservoir, into which both kinds of electricity pass whenever they have the opportunity, and there neutralise each other. There is no doubt that the Cork has lost its electricity, for on bringing the charged rod near it, it is again attracted.

An Amusing Electrical Game

An amusing experiment may be carried out with a suspended Cork wrapped in tin or aluminium foil. A charged rod is held on one side of the Cork at a distance of about an inch, and on the opposite side of it is placed the Electroscope Plate (Part No. 1520), as shown in Fig. 32. The Cork is first attracted to the rod, but as soon as it touches it, it is repelled to the Plate, after which it swings backward and forward between the rod and the disc, forming an electrical pendulum. What happens is that the Cork is first attracted by the rod, then repelled immediately it touches it, and attracted once more after having touched the Plate, because this earths it and deprives it of the charge that caused repulsion.

This alternate attraction and repulsion is made use of in an interesting toy or game. Obtain a shallow cardboard box, with a lining of tinfoil, and divide the bottom of the box into numbered sections. Place a light paper arrow in the box, and cover it with transparent celluloid. When the celluloid is electrified, by rubbing it gently with the finger, the arrow jumps up to it, and drops back again on its becoming electrified. It is earthed when it touches the tinfoil lining, and can then be attracted once more. In the game the players score by means of the numbers on which the arrow falls, after it has been attracted and repelled by the electrified cover. An alternative is to make the device tell fortunes or read characters, in which case humorous forecasts or descriptions are substituted for the numbers in the sections.

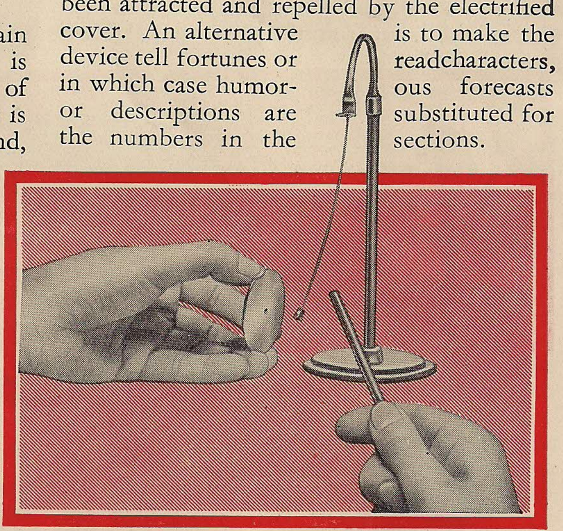


Fig. 32. An electric pendulum.

Making a Useful Electroscope

An ELECTROSCOPE that is more attractive and useful than the suspended Cork may be made from parts included in the Outfit, with the addition of a glass tumbler (see Fig. 34). The Circular Base (Part No. 1508) forms a cover for the tumbler, the flange with which it is provided resting on the glass rim. The Ebonite Bush (Part No. 1524) is placed in the central hole of the cover, and through it is passed the Electroscope Rod with screwed ends (Part No. 1521). The 1¼in. Erinoid Sleeve (Part No. 1522) is slipped over the rod above the Ebonite Bush, and the Electroscope Plate (Part No. 1520) is screwed on the upper end of the rod, where it is held in position by a lock nut. The sleeve on which the Plate rests thus prevents the Rod from slipping through the Ebonite Bush, and also holds the Plate at a convenient distance above the cover.

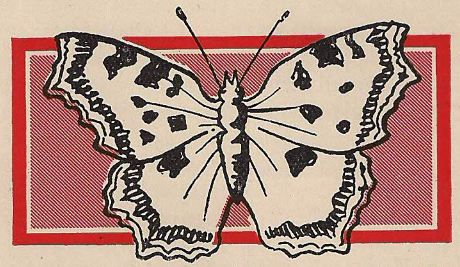


Fig. 33. This butterfly drawing may be traced on thin paper for use in interesting electrical experiments.

The indicator that is to show the presence of electricity consists of two narrow strips of aluminium foil, each about 1in. in length and ¼in. in width, cut from the piece of Foil (Part No. 1525) contained in an envelope in the Outfit. The two strips then are placed on top of each other, and a tiny hole is pierced through the pair at one end. They are then hung side by side on the Electroscope Hook (Part No. 1523), which is screwed on the lower threaded end of the Electroscope Rod.

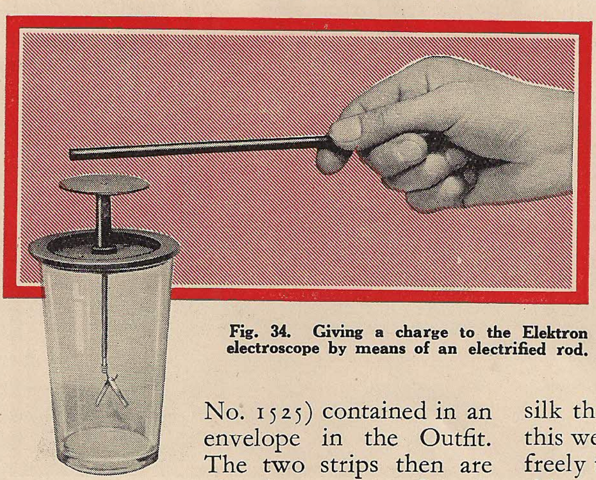


Fig. 34. Giving a charge to the Elektron electroscope by means of an electrified rod.

The aluminium strips are usually referred to as the "leaves" of the electroscope. They are protected from draughts by the tumbler, and in their normal position they are in contact with each other. When they are electrified, however, they swing apart, owing to the repulsive action of similar charges. This may be shown by charging a Glass or Ebonite Rod and touching the Plate of the electroscope with it. The leaves immediately open out and remain wide apart even after the Rod has been removed, for both are charged with the same kind of electricity. Touch the Plate with the hand, and the leaves immediately fall together again, because the electricity in them has leaked away to earth.

Conductors and Insulators

The possession of an electroscope enables us to test other materials to find out whether they allow electricity to leak through them, as it does through the hand during earthing. All that is necessary is to take the substance to be tested in the hand, and touch with it the disc of a charged electroscope. If the material under test allows electricity to pass through it, the leaves of the electroscope fall together; on the other hand, the leaves remain unaffected if the substance resists the passage of electricity. For instance, if the disc of a charged electroscope is touched with an iron nail held in the hand, the leaves collapse; but if a piece of dry silk thread is used, nothing happens. From this we see that iron allows electricity to pass freely through it, but silk does not behave in this manner.

Substances such as iron, through which electricity passes easily, are known as CONDUCTORS; and those like the silk thread, that resist the passage of electricity, as NON-CONDUCTORS. In between these extremes are many substances that allow electricity to pass to some extent, and are known as Partial CONDUCTORS.

Good and Bad Conductors

Among conductors are metals, acids, water (impure) and the human body ; cotton, linen and paper may be regarded as partial conductors ; and dry air, ebonite, glass, silk, resin, sealing wax and gutta-percha are non-conductors. When a conductor is surrounded by a non-conductor in such a manner that its electricity cannot escape, it is said to be insulated, from the Latin *insula*, an island, and non-conductors are also known as INSULATORS.

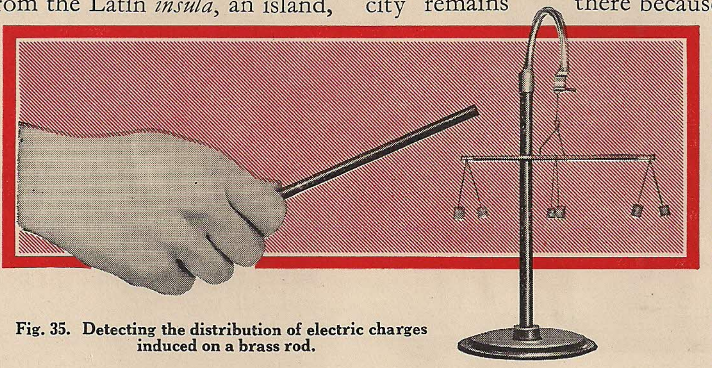


Fig. 35. Detecting the distribution of electric charges induced on a brass rod.

We have already seen two practical applications of the respective properties of conductors and insulators. In making our cork electroscope it was necessary to insulate the Cork, and this was done by hanging it by a silk thread. In the more elaborate electroscope the leaves are suspended from the brass Rod, which is a conductor, so that electricity can reach them from the brass Plate. On the other hand the Rod, the Plate and the leaves must be insulated, for otherwise they could not be charged with electricity. The non-conducting Ebonite Bush is used for this purpose.

Damp Substances cannot be Electrified

We have already drawn attention to the fact that experiments in frictional electricity must be carried out with dry apparatus and in a dry room. In a cold damp atmosphere it will be found that the leaves of a charged electroscope slowly come together, showing that their charge is leaking away, in spite of the insulating Ebonite Bush. The leakage is due to the presence of a film of moisture on the surface of the Bush, which—as water is a conductor—enables the electricity to leak away. It is for the same reason that it is difficult to electrify glass or ebonite rods in a damp atmosphere.

It will have been noticed that so far the rods we have used for producing charges of electricity have all been non-conductors, and the reason for this will now be clear. When we rub a rod of a non-conducting material, the part rubbed becomes charged, and the electricity remains there because the rod will not allow it to pass away. If we try the same experiment with a rod of metal or other conducting substance, however, we get no result. Electricity is produced, but it immediately spreads along the rod to the hand and so escapes to earth. If we wish to electrify a rod of a conducting material we must insulate it to prevent the charge from escaping. For example, a metal rod may be electrified quite easily by rubbing it with fur, if it is provided with a handle of glass or some other insulating material.

The Mysteries of Electrical Induction

We have already seen in several experiments that a cork receives a charge of electricity when it is touched by an electrified body. It is not necessary that actual contact should take place, however, for one body may be charged from another by what is known as "INFLUENCE" or "INDUCTION." A simple experiment will illustrate this.

Place the Electroscope Rod in the Stirrup of the stand, using a shorter piece of silk thread than in previous experiments. Suspend a pair of Corks from one end of the Rod, and hang similar pairs at the opposite end and on the middle of the Rod, as shown in Fig. 35. Now bring a charged Ebonite Rod near one end of the brass Rod. The Corks at the two ends immediately repel one another, showing that the ends are electrified, but no repulsion takes place between the Corks in the middle, indicating that this part of the Rod is not electrified. Tests show that the charges at the ends are of opposite kinds, that nearest the Ebonite Rod being positive and the other

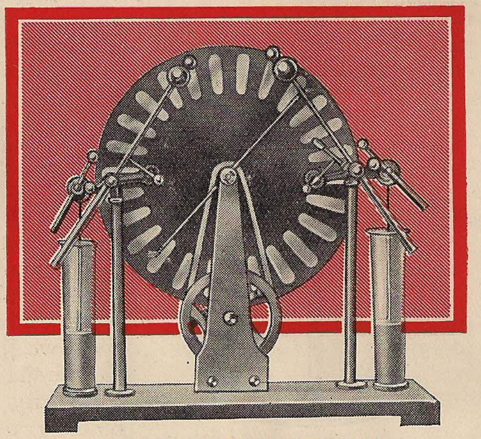


Fig. 36. Wimshurst electrical machine.

one negative. Thus the negative charge on the Ebonite Rod has attracted positive electricity towards it, and has repelled negative electricity to the farther end of the Brass Rod.

Induction Acts through Glass

When the charged Rod is taken away the Corks are no longer repelled, for the opposite charges on the Rod unite and neutralise each other. In this experiment, electrical charges are said to be " induced " on the brass Rod. Induction takes place across a considerable distance, and is not stopped by the presence of a sheet of glass or other similar obstacle.

We can now understand why an electrified rod or other body attracts one that is not electrified, such as the cork employed in our earlier experiments. The electrified rod induces a charge of the opposite kind on the side of the cork nearer to it, and one of the same kind on the side farther away. One half of the cork is therefore attracted and the other half repelled, but as the attracted half is nearer, the attraction is stronger than the repulsion, and the effect is to make the cork move towards the electrified rod.

An Electroscope Puzzle Solved

In making experiments with the electroscope it probably will have been noticed that the leaves begin to open out as soon as a charged rod is brought near the disc. This effect is not permanent, however, for if the rod is removed without touching the disc, the leaves immediately collapse. The explanation is simple. Let us suppose the charged rod to be one of ebonite, rubbed with flannel. The rod is negatively electrified, and therefore it attracts positive electricity to the disc of the electroscope and repels negative electricity to the leaves, which then repel one another. When the rod is removed the attraction and repulsion disappear, and the leaves therefore lose their negative electricity and fall together.

The Wimshurst Machine

A surprising result follows if the brass disc of the electroscope is touched momentarily with the finger while the charged Ebonite Rod is held near it. The leaves immediately fall together, because the negative electricity in them finds its way through the finger to earth. When the charged Ebonite Rod also is removed, however, the leaves again open out.

What has happened is that as there is now no negative electricity left to neutralise the positive charge, this makes its way throughout the whole of the metallic parts of the electroscope. The leaves, which previously were negatively charged, are now positively charged, and therefore repel each other.

The principle of influence or induction is employed in machines for producing much larger quantities of electricity than can be obtained by the rubbing of small rods. The best known of these appliances is the Wimshurst machine (Fig. 36). The actual operation of this machine is somewhat complicated. But in principle it consists in accumulating small charges of electricity of opposite kinds produced by induction, until they reach a large total.

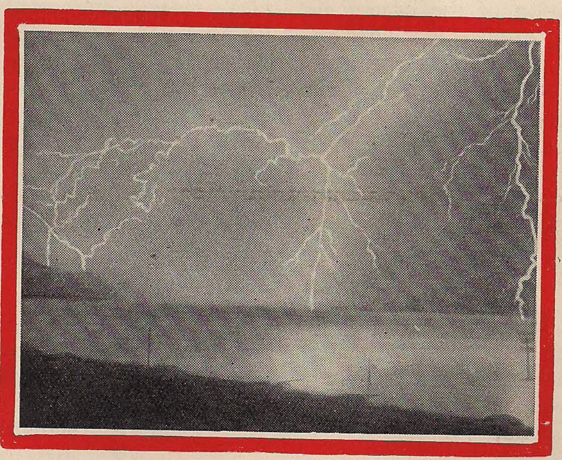


Fig. 37. Flashes of forked lightning, photographed at night.

We have already mentioned that a postcard becomes electrified when briskly rubbed with flannel, as is shown by its power of attracting light substances. The presence of electricity may be shown also in another way. If the rubbed card is brought to the tip of the ear, a very slight tingling sensation is felt, accompanied by a faint crackling sound. If the experiment is carried out in complete darkness in front of a mirror, a tiny spark is seen at the same moment. These effects are characteristic of the discharge of a highly electrified substance.

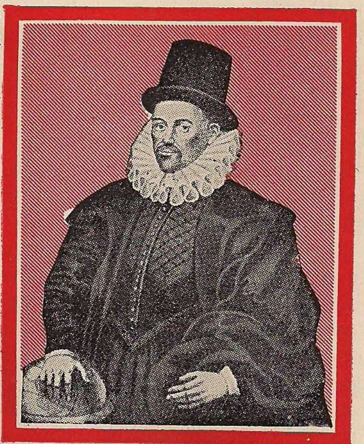
Real and Artificial Lightning

Much more striking results of this kind can be obtained from a Wimshurst machine, even a small machine being capable of producing brilliant sparks 3in. or 4in. in length between the balls at the ends of its discharging rods. These sparks do not flash straight across between the balls, but take a zig-zag course, and are accompanied by sharp cracks. Their resemblance to a flash of *forked lightning* (Fig. 37) is very noticeable, and actually they are lightning in miniature.

As the machine is operated, the balls become charged with opposite kinds of electricity, which try to reach one another across the intervening air gap. Air is a bad conductor of electricity and therefore it opposes this passage; but when the charges reach a certain strength the electricity forces its way across. The particles of air along the line of the discharge are rendered incandescent by the heat produced by the violent passage of the electricity, thus giving rise to the spark, which is accompanied by a sharp crackling sound.

Thunder and Lightning

A lightning flash is produced in a similar manner. The clouds are liable to become strongly charged with electricity, sometimes positive and sometimes negative; and at a certain strength the electricity is discharged in the form of a gigantic spark, which may be several miles in length, between two clouds or between a cloud and the earth, as shown in Fig. 37. Thunder—the noise that accompanies the discharge is very loud—and is probably caused

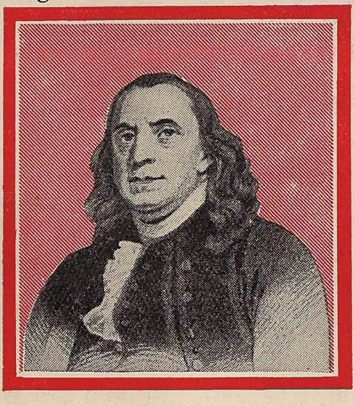


William Gilbert (1540-1603)

by the sudden expansion of the heated air along the path of the discharge. This expansion produces a partial vacuum, into which the surrounding air rushes with great violence. The sounds thus produced at different points along the track of the flash reach us in succession in a sharp rattle, followed by a more or less prolonged rumbling resulting from echoes from other clouds.

186,000 Miles Per Second

The distance from us of the seat of the lightning discharge can be roughly estimated in a very easy but interesting manner. Light travels at a speed of 186,000 miles per second, and therefore the flash reaches our eyes practically instantaneously. Sound, however, travels only at a speed of about 1,115 feet per second, so that an appreciable time elapses before we hear the thunder. If therefore we multiply the number of seconds between the flash and the thunder by 1,115, we obtain an approximation of the distance in feet of the discharge.



Benjamin Franklin (1706-1790).

What is Electricity ?

Why should such a simple action as rubbing with a piece of silk or flannel make amber, glass or ebonite capable of attracting light objects ? Apparently nothing is added to or taken away from the material rubbed, and this is unaltered in appearance. The cause of the change remained a complete mystery for more than 2,000 years. The Greeks thought that the attractive power was due to a living principle or soul that was roused to action by friction. Later it was thought that each kind of electricity was an indestructible fluid. The two fluids were supposed to be present in equal quantities in an uncharged substance, and one that was electrified was thought to contain an excess of either the positive or the negative fluid. A simpler idea was suggested by BENJAMIN FRANKLIN (see below), the famous American experimenter, who in 1747 suggested the existence of one electrical fluid. He called this the positive fluid, and supposed it to be attracted by amber. He believed that everything contained a store of it, and that forcing more into a body produced a positive charge, while taking some away produced a negative charge.

Electricity Not a Fluid

We no longer believe in the existence of electrical fluids, of this kind for we now know that electricity is actually a part of every material thing. Matter is built up of minute particles named ATOMS. These atoms are far too small to be seen even with the aid of the most powerful microscope, and yet they are made up of even smaller particles, a positively charged nucleus or centre, and lighter particles known as ELECTRONS, which are actually tiny particles of negative electricity. The electrons in an atom are kept in position by the attraction of the appropriately charged nucleus, around which they rotate at high speeds, but they are easily dislodged by any disturbance, so that they may move from one atom to another. A substance that contains more than its share of electrons, due to a transference of this kind, is charged negatively; and similarly one with a shortage of electrons is charged positively. When a glass rod is rubbed with silk or an ebonite rod with flannel, disturbances take place within the atoms, with the result that the rods either gain or lose electrons, and thus become charged either positively or negatively. Electrons are very active and flow readily through conductors. When in movement they form electric currents and fascinating experiments with these may be carried out with the No. 1A Elektron Outfit referred to on the back cover of this Manual.

The Elektron Reading Lamp

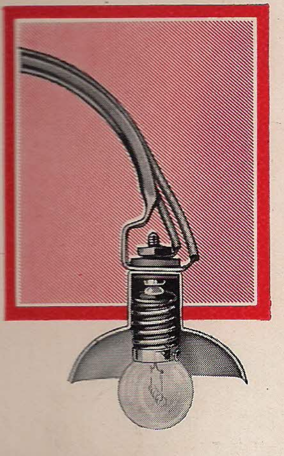


Fig. 38. Electrical connections of the reading lamp.

The useful reading lamp shown in Fig. 39 may be built from parts included in the No. 1 Elektron Electrical Outfit. The Stand is constructed by fixing the Erinoid Tube (Part No. 1509) in the central hole of the Circular Base (Part No. 1508) and fitting the Stand Bracket (Part No. 1510) on its upper end.

The necessary terminals are mounted on the Circular Base, two ½ in. 6 BA Bolts (Part No. 1575) being pushed through the small holes from beneath, each being fixed in position by means of a 6 BA Hexagonal Nut (Part No. 1562) above the Base. A Terminal (Part No. 1563) is then fitted on each Bolt. Two wires are required, and two 13-in. lengths are now cut from the coil of Connection Wire (Part No. 1566) included in the Outfit. The wires are pushed through the Erinoid Tube and over the Stand Bracket, their ends projecting about ¼ in. below the slotted end. The insulation of the projecting ends is then removed.

The Lampholder (Part No. 1534) must next be fitted on the end of the Bracket. For this purpose it is held upside down and the small Insulating Washer (Part No. 1561) is dropped into the narrow portion, followed by the Lampholder Screw (Part No. 1535) the shank of which is pushed through the Washer and the hole in the Lampholder. The blade of the Screwdriver is placed in the slot of the screw to hold it in position, and the Lampholder is turned the right way up while the large Insulating Washer (Part No. 1570) is placed in position on the shank of the Screw, followed by a 6BA Hexagonal Nut. The slotted end of the Bracket is then inserted between the Lampholder and the Washer, and the end of one of the two wires is placed under it, care being taken that the wire does not make contact with the screw. The end of the second wire is coiled between the Washer and the Hexagonal Nut.

Fig. 38 shows the appearance of the Lampholder when in position on the Bracket and wired. The small screw is now tightened, and the Connection Wire pulled gently through the Erinoid Tube until it rests in the curve of the Bracket. The ends passing below the Circular Base are freed from insulation for a length of about ½ in., and fixed under the heads of the Bolts, to which Terminals are attached.

All that now remains is to screw the Flashlamp Bulb (Part No. 1537) into the holder and to connect the terminals on the Circular Base with those of a 3-volt flashlamp battery, or better still, with those of the Bichromate Cell shown in Fig. 39. The parts to construct this useful cell, and also the switch shown, are included in the No. 1A Elektron Outfit.

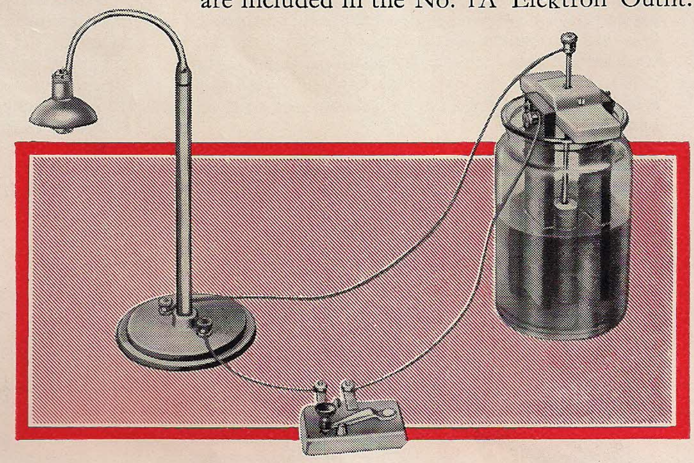


Fig. 39. Reading Lamp connected to Bichromate Cell.

Elektron Electrical Parts List

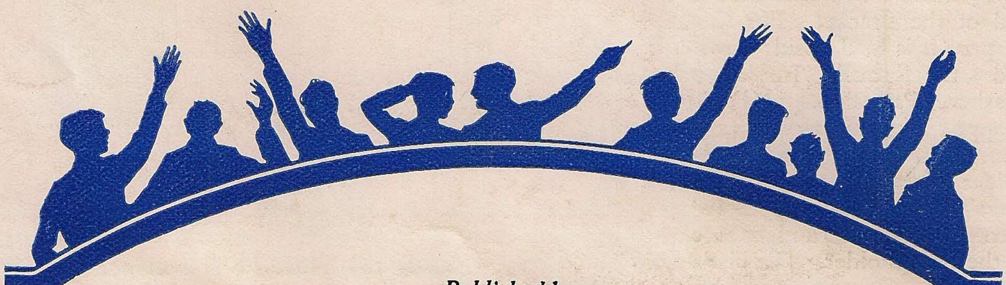
No.		Qty. in Outfit No. 1	Qty. in Outfit No. 2
1500	Universal Base	–	1
1501	Compass Box	1	1
1502	Compass Mount and Pivot ...	1	1
1503	Compass Needle and Cup ...	1	1
1504	Compass Chart	1	1
1505	Bar Magnet	2	2
1506	Bar Magnet Keeper	2	2
1507	Horseshoe Magnet	–	1
1508	Circular Base	1	1
1509	Erinoid Tube for Stand Bracket	1	1
1510	Stand Bracket	1	1
1511	Stirrup	1	1
1512	Sifter Box and Lid	1	1
1513	Tube of Iron Filings	1	1
1514	Ebonite Rod	2	2
1515	Glass ,, ...	1	1
1516	Square of Flannel...	1	1
1517	,, ,, Silk	1	1
1518	Reel of Silk Thread	1	1
1519	Cork	2	2
1520	Electroscope Plate	1	1
1521	,, Rod	1	1
1522	Erinoid Sleeve, $1\frac{1}{4}$″ long	1	1
1523	Electroscope Hook	1	1
1524	Ebonite Bush	1	1
1525	Sheet of Aluminium Foil ...	1	1
1526	Copper Plate, 2″ × 1″	–	1
1527	Zinc ,, 2″ × 1″	–	1
1528	Cell Mounting	–	1
1530	Cell Mounting Bolt	–	1
1531	Zinc Rod	–	1
1532	Carbon Plate	–	2
1533	Threaded Rod	–	2
1534	Lampholder	1	1
1535	,, Screw	1	1
1537	Flashlamp Bulb, $2\frac{1}{2}$ v. ...	1	1
1538	Magnet Coils ...	–	2
1539	,, Core (complete) ...	–	2
1540	,, Hook ...	[illegible]	1
1541	,, Yoke, Small ...	[illegible]	1
1542	,, Hook Nut ...	[illegible]	1
1543	Bell Armature (complete) ...	–	1
1544	,, Rod and Hammer	–	1
1545	Gong	–	1
1546	Gong Pillar (with Nut and Screw)	–	1
1547	Angle Yoke	–	1

No.		Qty. in Outfit No. 1	Qty. in Outfit No. 2
1548	Bell Contact Pillar (complete) ...	–	1
1549	,, ,, Locking Screw ...	–	1
1550	Armature Support	–	1
1551	,, Screw	–	1
1552	Wound Bobbin for shocking coil	–	1
1553	Shocking Coil Handle	–	2
1554	,, ,, Slide	–	1
1555	Magnet Yoke, Large	–	1
1556	Armature and Commutator ...	–	1
1557	,, Shaft	–	1
1558	Bearing Bracket	–	1
1559	Commutator Contact Brush ...	–	1
1560	Erinoid Sleeve, $\frac{11}{16}$″ long	–	1
1561	Insulating Washer, Small ...	1	1
1562	6.B.A. Hex. Nuts	3	12
1563	Terminals	2	6
1564	10 yd. Coil No. 35G E.S.C.C. Copper Wire	–	1
1565	Spanner, Screwdriver	1	1
1566	Connection Wire	1	1
1567	Connecting Link	–	1
1568	6 B.A. 1″ Special Bolt	–	1
1569	6 B.A. Contact Screw	–	1
1571	Coloured Rings	–	4
1572	Switch	–	1
1573	$\frac{3}{8}$″ 6 B.A. Bolts	–	3
1574	Wire Connector and Screw ...	–	1
1575	6 B.A. Bolts, $\frac{1}{2}$″	2	5
1576	Copper Sulphate in Container ...	–	1
1577	Bichromate of Potash in Container	–	1
1578	Container	–	–
1579	3 oz. pkt. of Copper Sulphate ...	–	–
1580	,, ,, ,, Bichromate of Potash	–	–
1581	Length of Resistance Wire 6″ ...	–	1
1582	Steel Pieces	4	4
1583	6 B.A. Square Nut	–	1
1584	26G Copper Wire, 6″ length ...	–	1
1585	Horseshoe Magnet Keeper ...	–	1
1586	26 G. S.C.C. Copper Wire ...	–	–
1587	23 G. ,, ,, ,, ...	–	–
1588	Screw for Bell Hammer and Bell Armature ...	–	1
1589	Manual of Instructions for Outfit No. 1	1	1
1590	Manual of Instructions for Outfit No. 2	–	1
182	Insulating Bush 6 B.A. ...	1	1

A NO. 1A ELEKTRON ACCESSORY OUTFIT WILL CONVERT YOUR NO. 1 OUTFIT INTO A NO. 2.

Now that you have experienced the fun and excitement of carrying out electrical experiments you will be keen on proceeding further with this wonderful hobby. You may do this by purchasing a No. 1A Elektron Accessory Outfit, which will enable you to perform a splendid series of entirely new experiments.

Among the parts included in the No. 1A Elektron Accessory Outfit are a Horseshoe Magnet, and Coils and Yokes for the construction of Electro-Magnets that can be used in building an Electric Bell and a Buzzer for use in an electric telegraph system. A specially-wound coil and other necessary parts are supplied for assembling into a Shocking Coil that will give hours of fun, and from other components two different working Electric Motors can be built. Electroplating is among the other fascinating experiments that can be performed.



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