The finished picture was protected by a cover glass, and the edges of the glass and plate were securely sealed by a strip of paper attached by means of an adhesive coating.

Later on a metallic binding was added, which was called the "preserver." The pictures thus mounted were fitted to cases and frames which were more or less elaborate, varying in cost from a few cents to many dollars. Many daguerreotypes were inserted in gold lockets and charms, and occasionally they were fitted to finger rings made to receive them.

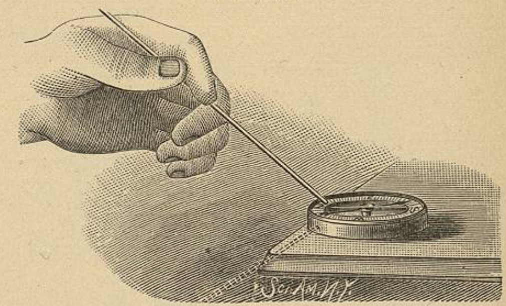
CHAPTER XVI.

MAGNETISM.

Nature furnishes permanent magnets "ready made," the lodestone being an example of such a magnet. She is able to induce magnetism in magnetic bodies, the earth itself being the great magnet by which the induction effects are secured. It is to the directive force of this great magnet that the compass owes its value.

The magnetism of the lodestone is due, doubtless, to a

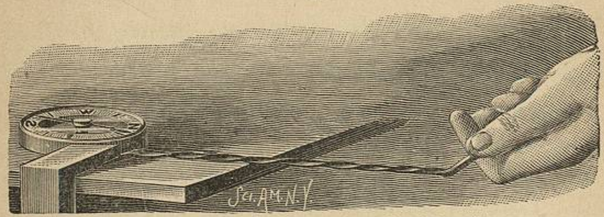
FIG. 330.



Magnetism by Induction from the Earth.

long exposure to the inductive influence of the earth's magnetism. Any body of magnetic material becomes temporarily magnetized to some extent when placed in the magnetic meridian parallel with the dipping needle, and if it be a body like soft iron, without coercive force, it loses its magnetism when arranged at right angles to this position in the same plane. This may be shown by placing a rod of well-annealed wrought iron in the magnetic meridian in an inclined position, with the lower end toward the north, as indicated in the dotted lines in Fig. 330, with its upper end in close proximity to the end of a compass needle. The needle will be instantly deflected, showing that the rod has become magnetic. When turned in the plane of the magnetic meridian to a position at right angles to its former position, it will lose its magnetism and will not repel the needle. By placing a bar of hardened steel in the magnetic meridian

Fig. 331.

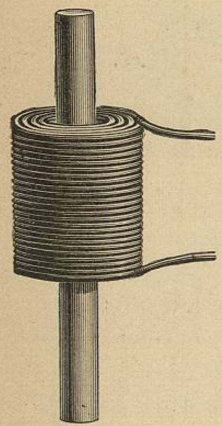


Development of Magnetism by Torsion.

and striking it several blows on the end with a hammer, it becomes permanently magnetic, not strongly, but sufficiently to exhibit polarity when presented to a magnetic needle.

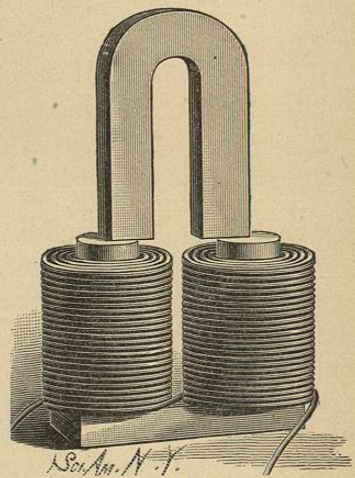
By twisting a rod of soft iron having one of its ends in

Fig. 332.



Magnetization of Bars.

Fig. 333.

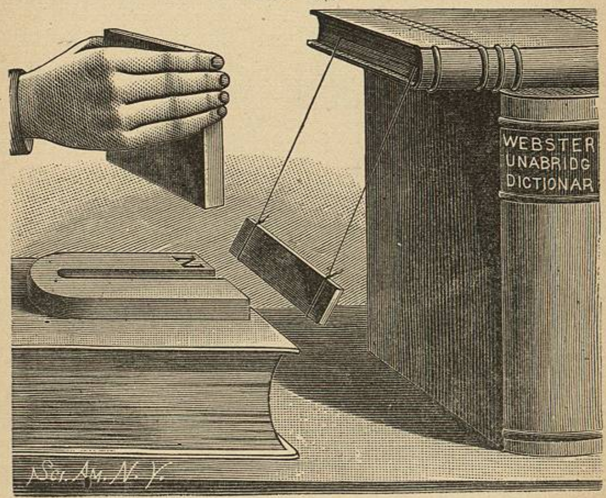


Magnetization of U-Shaped Bars.

proximity to a magnetic needle, it is shown by the deflection of the needle that magnetism is developed by torsion (Fig. 331). By this and similar experiments it may be shown that stress and compression favor magnetization.

Artificial magnets are produced by the contact of hardened steel with magnets or by means of the voltaic current. The latter is the more effective method, provided a strong current and a suitable helix or electro-magnet is available. For the magnetization of bars of steel a helix like that shown in Fig. 332 is needed. Its size and the amount of current required will, of course, depend upon the size of the bar to be magnetized. For all bars up to $\frac{5}{8}$ inch diameter, a helix $\frac{5}{8}$ inch in internal diameter, 2 inches external diameter, and $2\frac{1}{2}$ inches long, made of No. 16 magnet wire, is sufficient.

Fig. 334.



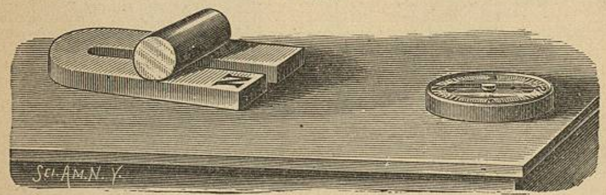
Motion produced by a Permanent Magnet.

A current from five or six cells of plunging bichromate battery is required, or in lieu thereof a similar current from a dynamo.

The bar to be magnetized is hardened at the ends and placed in the helix, the current is then applied, and the helix is moved from the center of the bar to one end, then to the opposite end and back to the center, when the current is discontinued, and the bar is removed. If several bars are to be magnetized, they may be placed end to end, and passed through the coil in succession. The magnetization of U-shaped bars may be accomplished by means of an electro-magnet formed of two coils above described and a suitable soft iron core (Fig. 333). The U-shaped bar is placed on the poles of the electro-magnet as shown, when the current is sent through the coils for a short turn and then interrupted. Another method, which is perhaps more effectual, consists in drawing the U-shaped bar several times across the poles of the electro-magnet.

In the search for perpetual motion, vain efforts have been made to discover a substance which could be interposed between the magnet and its armature, and removed without the expenditure of power, and which would intercept the lines of force, so as to allow the armature to be alternately drawn forward and released, but no such substance has ever

Fig. 335.



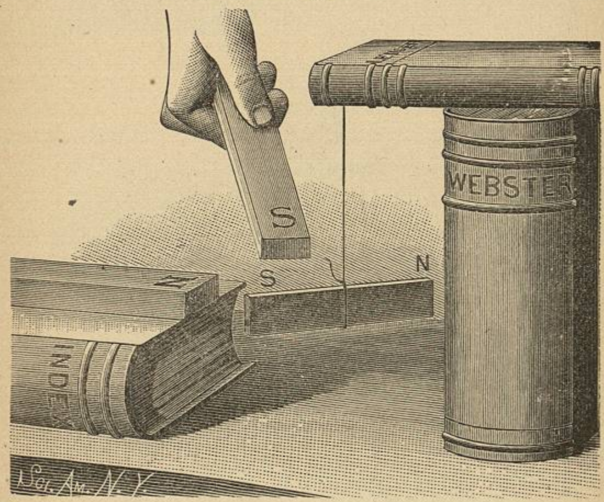
Effect of the Armature.

been discovered. The lines of force may be intercepted by a plate of soft iron placed between the magnet and its armature, but it requires more power to introduce the plate into the magnetic field, and withdraw it therefrom, than can be recovered from the armature. Fig. 334 illustrates an experiment showing how motion may be produced by the force of a permanent magnet. An armature is suspended by threads in the field of a permanent magnet. The magnet attracts the armature, slightly deflecting its suspension from a true vertical line. The introduction of a soft iron plate between the magnet and its armature intercepts the lines of force, thus releasing the armature, when it swings back under the influence of gravity. If at this instant the iron plate is withdrawn, the magnet again acts upon the armature, drawing it forward. Another introduction of the

iron plate into the field again releases the armature, when it swings back, this time a little farther than before. By moving the iron plate in this manner synchronously with the oscillations of the armature, this may be made to swing through a large arc.

When a piece of soft iron is placed in direct contact with the poles of a permanent magnet, the magnetic force is nearly all concentrated upon the soft iron, so that there is very little free magnetism in the vicinity of the poles of the magnet. This may be readily shown by arranging a U-mag-

Fig 336.

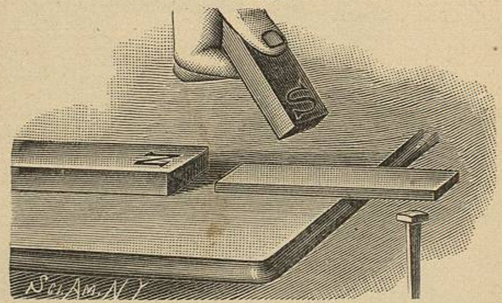


Permanent Magnet and Bar magnetized by Induction.

net parallel with the magnetic meridian, placing in front of and near the poles of the magnet a compass so adjusted with reference to the poles as to cause the needle to rest at right angles to the magnetic meridian, then applying to the poles of the magnet a massive armature. It will be found that the needle, under these conditions, immediately tends to assume its normal position, showing that the power of the magnet over the needle has been, to a great extent, neutralized. By rolling a cylindrical armature along the arms of the U-magnet, as shown in Fig. 335, it is found that as the armature recedes from the poles of the magnet the influence of the magnet upon the compass needle is increased, while the movement of the armature in the opposite direction diminishes the power of the magnet over the needle.

In Fig. 336 is illustrated an example of temporary magnetization by induction, and of the effect of a permanent magnet on the iron so magnetized, showing that the iron bar inductively magnetized acts like a permanently magnetized needle. The soft iron bar is freely suspended, and receives its magnetism from the fixed magnet. The end of the suspended bar adjacent to the N pole of the magnet becomes S, as may be shown by presenting to it the S pole of another permanent magnet. The S end of the swinging bar will be

FIG. 337.



Neutralizing Effect of an Opposing Pole.

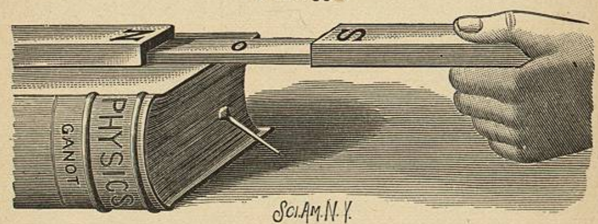
immediately repelled. If the S end of the permanent magnet be presented to the opposite end of the suspended bar, the reverse of what has been described will take place, *i. e.*, that end of the bar will be attracted, showing that its polarity is N.

In Fig. 337 is illustrated an experiment showing the neutral effect produced by induction from two dissimilar magnetic poles. A bar of soft iron is arranged near, but not in contact with, the pole (say the N pole) of a magnet, so that it becomes magnetized by induction to such an extent as to support a nail. The N pole of the magnet produces S polarity in the end of the soft iron bar adjacent to it and N polarity in the opposite end. The S end of another per-

manent magnet presented to the same end of the iron bar will produce exactly the opposite effect in the bar, and will, therefore, neutralize the magnetism induced in the bar by the first magnet, and cause the nail to drop.

A similar effect is produced when the iron bar is in actual

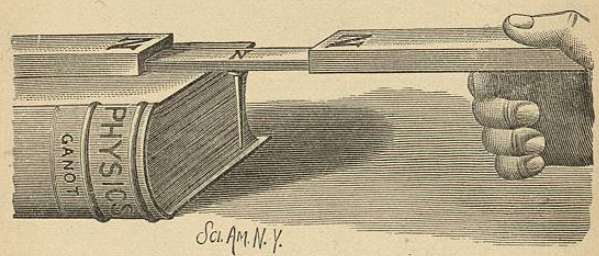
FIG. 338.



Neutral Point between Unlike Poles.

contact with the N pole of a magnet and the S pole of another magnet is brought into contact with the opposite end of the bar, as shown in Fig. 338. The nail will adhere to the bar when either magnet alone is in contact with the bar; but when dissimilar poles are brought into contact with opposite ends of the bar, its middle portion becomes neutral, and is no longer able to support the nail.

FIG. 339.



Consequent Pole.

When like magnetic poles are presented to the ends of the iron bar, as in Fig. 339, a strong consequent pole is developed in the center of the bar, which is of the same name as that of the ends of the magnets touching the bar.

MAGNETIC CURVES.

A great deal may be learned about the properties of magnets by causing them to delineate their own characteristics. The common method of doing this is to form magnetic curves by dusting iron filings on a glass plate, then jarring the plate to cause the particles to arrange them-

FIG. 340.

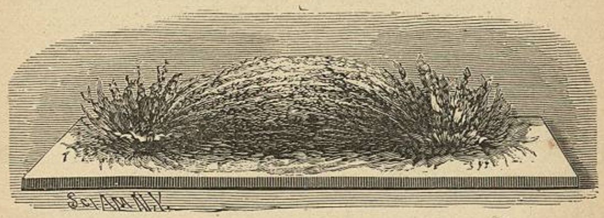
The Formation of Magnetic Curves.

selves parallel with the lines of force extending from the magnetic poles. The figures thus formed are not, of course, entirely autographic; and as they tend to develop in lines, they convey the erroneous idea that the lines of force, as spoken of in connection with magnets, are really separate lines or streams of force.

There is no way of exactly representing the magnetic field of force by forms or figures, but the annexed engravings serve to illustrate a method of forming and fixing curves which has some advantages over the method referred to above. The magnetic particles fall in the position in which they are to remain, and no jarring is required.

To make a flat plate for lantern projection or individual use, a plate of glass flowed with spirit varnish is laid upon the magnet, and iron dust reduced from the sulphate, or fine filings, or dust from a lathe or planer, is applied by means of a small magnet in the manner indicated in Fig. 340. The small magnet in this case consists of two magnetized carpet needles inserted in a cork, with unlike projecting poles arranged about one-quarter of an inch apart. A little of the iron dust is taken up on the small magnet, and the slightly

FIG. 341.



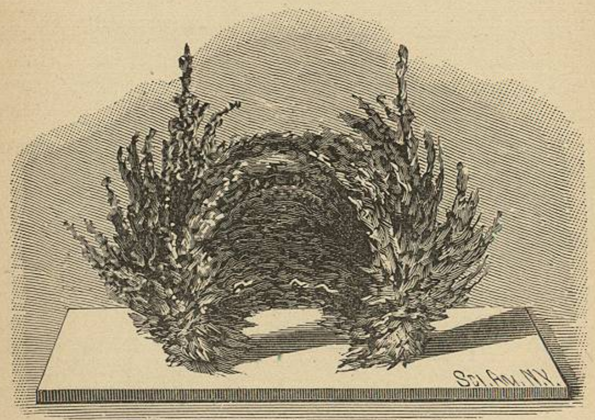
Magnetic Curves in Relief.

adhering particles are shaken off. The remaining portion is then disengaged from the small magnet by rapping the magnet with a pencil, the small magnet being held above the poles of the larger one. The particles having been polarized by the small magnet, arrange themselves in the proper position while falling. Several applications of the iron dust will be required to complete the figure. Of course the iron must be applied before the varnish dries, and the plate should be allowed to remain on the magnet until dry.

To make the curves in relief, as shown in Fig. 341, a slightly different method is employed. The glass plate is warmed, coated with paraffine, and allowed to cool. It is then placed on the magnet, and proceeded with as in the other case. With care the curves can be built up to a considerable height, especially if the larger magnet be a strong one. Iron filings or turnings of medium fineness are required in this case.

When the curves have assumed the desired proportions, a few very fine shreds of paraffine, scraped from a paraffine block or candle, are deposited very gently on the curves, and melted by holding above them a hot shovel. More shreds are then added and the hot shovel is again applied, and so on until the mass of iron filings is saturated with paraffine, when it is allowed to cool. The plate to which

FIG. 342.



Arborescent Magnetic Figures.

the filings are now attached may be removed from the magnet after having applied the armature, if it be a permanent magnet, or after interrupting the current, if it be an electro-magnet, when the curves will retain their position.

The arborescent figures shown in Fig. 342 are built upon a cap of brass, which incloses the poles of the magnet separately. The magnet in this case is arranged with its poles downward. The fixing of these curves is somewhat difficult, on account of being obliged to work under the plate, but it can be accomplished by proceeding in the manner described. Instead of the hot shovel, an alcohol lamp or

Bunsen burner is used in this case for melting the paraffine, but considerable care is required to prevent the iron dust from burning. The figure when cool may be removed from the magnet and preserved.

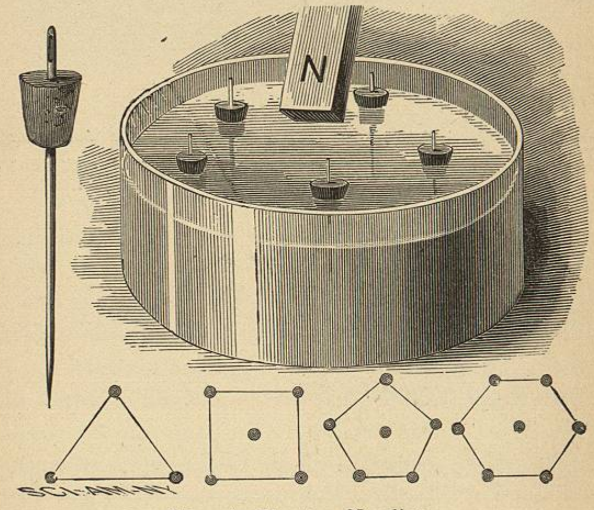
FIG. 343.

Floating Magnetic Figures.

FLOATING MAGNETS.

The ordinary magnetic fish, ducks, geese, boats, etc., are examples of floating magnets, which show in a very pleasing way the attraction and repulsion of the magnet. The little bar magnet accompanying these toys serves as a wand for assembling or dispersing the floating figures; or it may serve, in the hands of the juvenile experimenter, as a baited fish hook.

FIG 344.



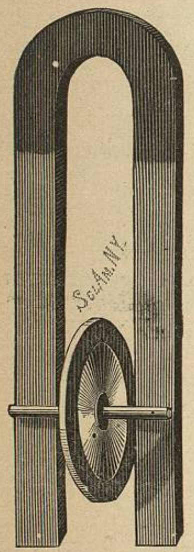
Mayer's Floating Needles.

Prof. A. M. Mayer has devised an arrangement of floating magnetic needles which beautifully exhibits the mutual repulsion of similarly magnetized bodies. A number of strongly magnetized carpet needles are inserted in small corks, as shown in Fig. 344.

When floated, these needles arrange themselves in symmetrical groups, the forms of the groups varying with the number of needles.

One pole on a bar magnet held over the center of a vessel containing the floating needles will disperse the needles, while the other pole will draw them together.

Fig. 345.

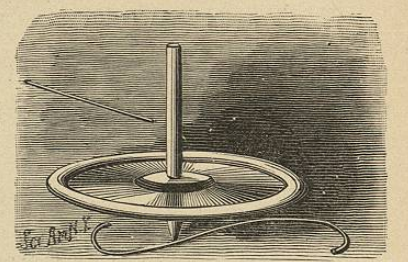


Magnet and Rolling Armature.

ROLLING ARMATURE AND MAGNETIC TOP.

The rolling armature applied to a long U-magnet exhibits the persistency with which an armature adheres to a magnet. The wheel on the cylindric armature acquires momentum in rolling down the arms of the magnet which carries it across the polar extremities and up the other side (Fig. 345).

Fig. 346.



Magnetic Top.

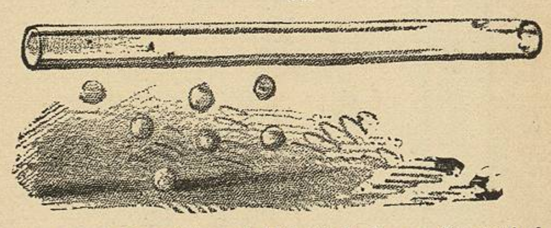
A very pretty modification of this toy has recently been devised. It consists of a top with a magnetic spindle and straight and curved iron wires (Fig. 346). The top is spun by the thumb and fingers in the usual way, and one of the wires is placed against the side of the point of the spindle. The friction of the spindle causes the wire to shoot back and forth with a very curious shuttle motion. The point of the top rolls first along one side of the wire and then along the other side.

CHAPTER XVII.

FRICTIONAL ELECTRICITY.

Many different views have been entertained regarding the nature of electricity, but notwithstanding the multiplicity of electrical inventions and discoveries and their numerous practical applications, the problem of the real nature of electricity remains unsolved. Recent experiments, however, have shown quite conclusively that electricity, like light, heat, and sound, is a phenomenon of wave motion. Laws governing its various manifestations have been discovered, so that, knowing the conditions of its production and use, results can be determined with certainty.

Fig. 347.



Attraction and Repulsion of Pith Balls by an Electrified Rod.

Electricity is evoked from bodies by friction, pressure, chemical action, and other causes. A glass rod or stick of sealing wax rubbed with dry silk or flannel becomes electrified, so that when it is held over bits of paper or small pith balls, as shown in Fig. 347, these will leap at once to the glass or sealing wax, and after a brief contact they will be repelled, to be again attracted and repelled, and so on.

It is a matter of indifference whether the rod be of glass or sealing wax; the result is the same. It is easy to determine by a very simple experiment that the electrification of the glass rod differs from that of the sealing wax. A pith ball is suspended by a silk thread from an insulating standard, and when an electrified glass rod is brought near the