[Reported for the Scientific American.]

ELECTRICITY.

A Lecture delivered by President Henry Morton, at the Stevens Institute of Technology, Hoboken, N. J., December 3, 1872.

In the second lecture of the series, President Morton confined himself to the consideration of the different ways in which electricity passes from one object to another, and in treating of these he adopted, for commencement, the customary division into (1.) Conduction, (2.) Convection, and (3.) Discharge.

When electricity passes tranquilly through bodies without making any special manifestation of its presence, it is said to be conducted, and the bodies which convey it are called conductors. The best conductors are, as is well known, the metals, and the poorest, such substances as glass, hardened rubber, dry wood, and dry air. It is Professor Morton's opinion that damp air may also be a non-conductor, and that it has been classed with conductors because bodies exposed to it are apt to be covered with a film of moisture and then conduct electricity.

RED LEAD GLASS UNFIT FOR INSULATION.

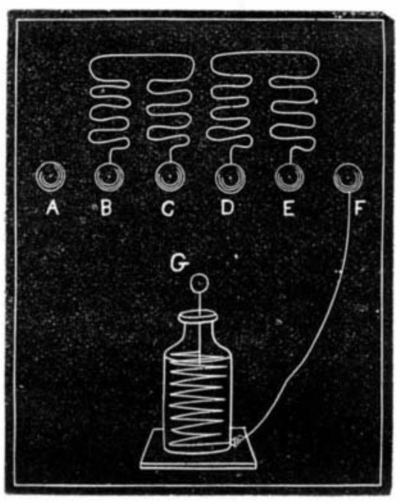
Another remark was made, in this connection, which is, in our opinion, of importance to such of our readers as have to do with the construction of electrical apparatus; it is that red lead, although one of the best of non-conductors, will render glass a very good conductor, if it enters into its composition. Such glass, which is usually of high refracting power, and therefore brilliant in appearance, is utterly unfit for purposes of insulation.

The subject of convection was but briefly alluded to. It takes place when electricity passes from an excited body into the air and sets the particles of the latter in motion. This motion was made visible in the preceding lecture, by placing a candle near the brass point of an electrical machine. The candle was nearly blown out, so strong was the current of air produced by the escaping electricity.

ELECTRICAL DISCHARGE.

What is called an electrical discharge takes place in three different ways. When an electrical machine is excited in a dark room, a glow is frequently observed around the plate or cylinder. This is one form of a discharge. Another is seen at the brass points of the prime conductor of machines, where it becomes manifest as a luminous pencil or brush. The most important, however, is what physicists call the disruptive discharge. When an obstacle is opposed to the progress of electricity of sufficient strength or tension, the electricity leaps over it, and a spark of greater or less brilliancy is the result. Now, this spark has enabled Wheatstone to measure the velocity of electricity by the following ingenious method.

FIG. 1.



VELOCITY OF ELECTRICITY.

A coil of copper wire, a quarter of a mile long, connects the two brass balls, B and C, in Fig. 1, and another similar coil connects the brass balls, D and E. F is connected with the outer coating of a charged Leyden jar. Now, if A is connected with the inner coating of the jar, a discharge will take place, and the spark will jump from A to B, from C to D, and from E to F. The three sparks, however, are not simultaneous, although the interval between them may be very small. The electricity requires a certain time to pass through the half quarter of a mile of copper wire from B to C and from D to E. To measure this interval, Wheatstone caused these sparks to be reflected in a rapidly revolving mirror, where they appeared in three lines of light of equal length, the middle one lagging somewhat behind the other two, as in Fig. 2. The mirror revolved 800 times a second.

FIG. 2.

On measuring the distance which the middle line was behind the others on the cylindrical mirror, it was found to be about ½°. The time it took the discharge to travel from B to C and from D to E, that is, a quarter of a mile, was $\frac{¼}{360} \times \frac{1}{800} = \frac{1}{1152000}$ of a second, which would give for electricity a velocity of 288,000 miles per second. We are far from obtaining such velocity, however, in our telegraph wires; and Faraday has shown that the nature of the conductor and the intensity of the electrical charge causes the velocity to vary.

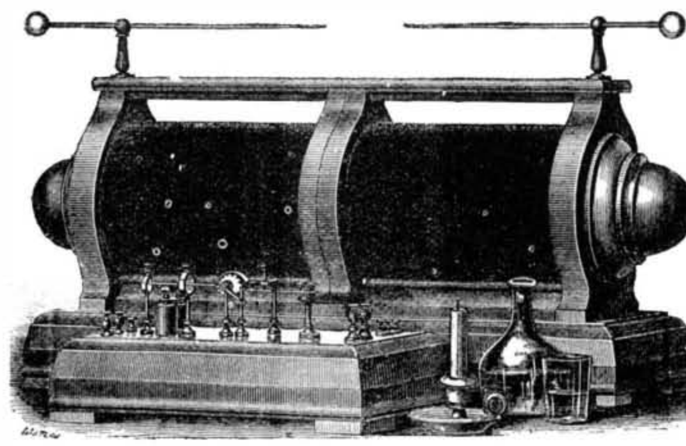
THE NATURE OF ELECTRICITY.

There is another point of considerable theoretical interest attached to the above experiment. As our readers are doubtless aware, there are two theories, or rather hypotheses, by which physicists seek to explain electrical phenomena. The real nature of electricity being entirely unknown, these hypotheses serve only to arrange and classify the facts, thus rendering it easier to remember them. Unless one of them, therefore, is disproved, it is merely a question of convenience which shall be preferred. They are known as the single fluid and the double fluid theory.

Since the text books generally regard the above experiment as demonstrating the incorrectness of the former theory, Professor Morton showed the theory to be capable of explaining the phenomenon as well as the other.

We quote the following paragraph, pointed out by the lecturer, in Müller's "Chemical Physics," page 353, for the two-fold purpose of giving the two fluid theory explanation and showing the opinion of one of the leading writers:

"This experiment affords a convincing proof of simultaneous action and reaction in the operations of electricity, and of its existence as a duplicate force; at the same time that a positive influence leaves the inner coating, an equal amount of negative influence leaves the outer coating, and these two neutralize each other at the central point of the conductor, that is, between C and D in Fig. 1. It appears from this experiment that Franklin's theory, though in many cases a simple and convenient mode of explaining facts, is not the true representation of the phenomena. The theory of two fluids, or rather of two forces acting in opposite directions, seems, by this experiment, to be demonstrated."



THE RHUMKORFF COIL.—FIG. 3.

According to Franklin's theory, however, the electricity entering at A acts upon B by induction, pushing the electricity from B into C. This crowding out of B's electricity takes place, however, against its natural resistance, and consequently C will then be charged less strongly than A. It will have to wait for re-inforcement before it can leap to D. The same thing, however, does not take place between E and F; for although E acts on F by induction, yet there is no resistance to counteract, the electricity naturally and easily passing out of F into the earth.

The lecturer then proceeded to experiment. The source of electricity was the enormous Rhumkorff induction coil of the Stevens Institute. This instrument gives a spark 21 inches in length.

HOW ELECTRICITY MOVES.

To impress the fact that electricity will not confine itself to one path if any obstacle is interposed, but will leap in different directions, a large sheet of metallic paper, suspended on a banner, was connected to one pole of the coil. A long wire from the other pole, insulated by a glass tube, was taken by the lecturer and made to touch the metallic surface of the paper, which had previously been crumpled so as to break the metal. When the room was darkened, vivid forked lightning shot over the paper in different directions, leaping over the cracks in the metallic surface.

The back of a mirror was connected with one pole of the coil, while the other pole was presented to the front of the mirror. The electricity jumped along the surface, in order to make connection by passing over the edge to the silvering behind. The flashes, together with their reflection in the mirror formed a very brilliant and effective experiment.

The greater part of the electricity will pass through the way in which it finds the fewest obstacles, and we can therefore determine its passage beforehand. The lecturer had prepared a pane of glass, on which were pasted narrow strips of tin foil close together. These he had cut at intervals with a penknife, in such a manner as to cause the spark, in passing, to exhibit the design of a butterfly.

LIGHTNING RODS—AN ARTIFICIAL THUNDERSTORM.

The practical value of the knowledge of this tendency of electricity to select several paths was illustrated by a little model of a house furnished with a lightning rod only on one side. If the thunderstorm comes from the other side, it may strike that side notwithstanding the lightning rod. On darkening the room, and approaching the house from the unprotected side with the wire from the coil, the lecturer caused an artificial thunderstorm to burst upon the house, and the audience could see one portion of the flash enter the lightning rods, while another struck the side of the house. Combustibles previously placed in the model burst into a blaze, and showed the disastrous effects of insufficient protection.

TENSION AND INTENSITY OF ELECTRICITY.

When considerable electricity is set free at once it has what is called tension, or force, to overcome obstacles. While the spark from the Rhumkorff coil is about twenty-one inches long and faint blue, its electricity, when bottled up in a Leyden jar and then set free in one single spark, is intensely brilliant, and sounds like the report of a pistol. By making the electricity pass through his condenser, consisting of a number of glass plates coated with tin foil and connected like a battery of Leyden jars, Professor Morton obtained a spark fourteen inches long, which was of intense brilliancy and accompanied by a loud noise. (See Fig. 4.)

DURATION OF THE ELECTRIC SPARK.

The extremely short duration of the spark was shown by causing it to illuminate a rapidly revolving disk of paper containing a number of slots. Although it was moving so rapidly that the slots could no longer be seen, it seemed to stand still every time the spark flashed; it had no time to move perceptibly while the spark lasted. Short as is the duration of the spark of a Leyden jar, Professor Rood, of Columbia College, has shown by his beautiful researches that it is composed of several. (*American Journal of Science and Arts*, 1871, p. 160). This was exhibited by means of a revolving disk containing four slots, which was illuminated from behind by means of the electric spark. Each slot appeared like two or three, showing that the spark must be composed of two or three. Professor Rood found the duration of a single spark to be less than ninety-four billionths of a second (·000,000,094), a quantity which is entirely inconceivable.

ELECTRICAL FLOW IN VACUO.

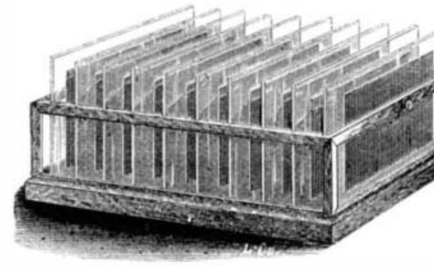
The most beautiful experiments of the evening, however, were those illustrating the electrical discharge in a vacuum, or rather in exhausted glass tubes containing minute quantities of various gases and vapors. The most magnificent colors and soft tints of light were produced as the discharge passed. Some of these tubes, known as Geissler tubes, were arranged on frames to show the contrast of their colors, but there was one especially, containing, near its two ends, several globes blown one inside of the other, and filled with minute quantities of hydrogen, carbonic acid, and nitrogen, which showed the splendors of the light to the greatest advantage. In it, too, was perceptible that curious classification or layering of the electric light, which has never been satisfactorily explained. A large number of the tubes were connected together, forming a circle over five feet in diameter, with a large initial S in the center, also composed of tubes. When the spark was passed through them the effect of the different soft colored lights was entirely beyond our powers of description.

Gassiot's cascade was also shown. It consists of a goblet made of uranium or canary glass, and coated partially with tin foil. When this was placed under a receiver of the air pump, the air being exhausted, an electric spark made itself luminous (fluorescence being a property of uranium glass), and it seemed as if floods of yellow light were welling up from the interior of the goblet and gently flowing over its sides.

CONTINUOUS LUMINOSITY.

The concluding experiment showed the effect of an electric spark on circular tubes filled with traces of anhydrous sulphuric acid. These have the curious property of continuing luminous for about half a minute after the electricity has ceased to pass. Becquérel supposes that the particles have the property of keeping up the vibration after the cause has ceased to act; but it seems as though this were but another way of stating the fact instead of an explanation. Others

FIG. 4.



endeavor to explain it by supposing chemical decomposition takes place, and that the afterglow results from the recombination. It hardly seems possible, however, that the infinitesimal quantity of sulphur they contain is able to keep burning for half a minute. For this reason we are still obliged to wait for the true explanation of this, as indeed of many other phenomena in electricity.

Taking Cold.

If a cold settles on the outer covering of the lungs, it becomes pneumonia, inflammation of the lungs, or lung fever and in many cases carries off the strongest man to the grave within a week. If cold falls upon the inner covering of the lungs, it is pleurisy, with its knife-like pains and its slow, very slow recoveries. If a cold settles in the joints, there is rheumatism with its agonies of pain, and rheumatism of the heart, which in an instant sometimes snaps asunder the cords of life with no friendly warning. It is of the utmost practical importance, then, in the wintry weather, to know not so much how to cure a cold as how to avoid it.

Colds always come from one cause, some part of the body being colder than natural for a time. If a person will keep his or her feet warm always, and never allow himself or herself to be chilled, he or she will never take cold in a lifetime; and this can only be accomplished by due care in warm clothing and avoidance of drafts and exposure. While multitudes of colds come from cold feet, perhaps, the majority arise from cooling off too quickly after becoming a little warmer than is natural from exercise or work, or from confinement to a warm apartment.

THE educated live longer than the illiterate: the rich, longer than the poor; the good, longer than the bad.