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Photocopy of the original, which (along with a MS) is on display with the W. & S. Jones electrical cabinet (under stairs)

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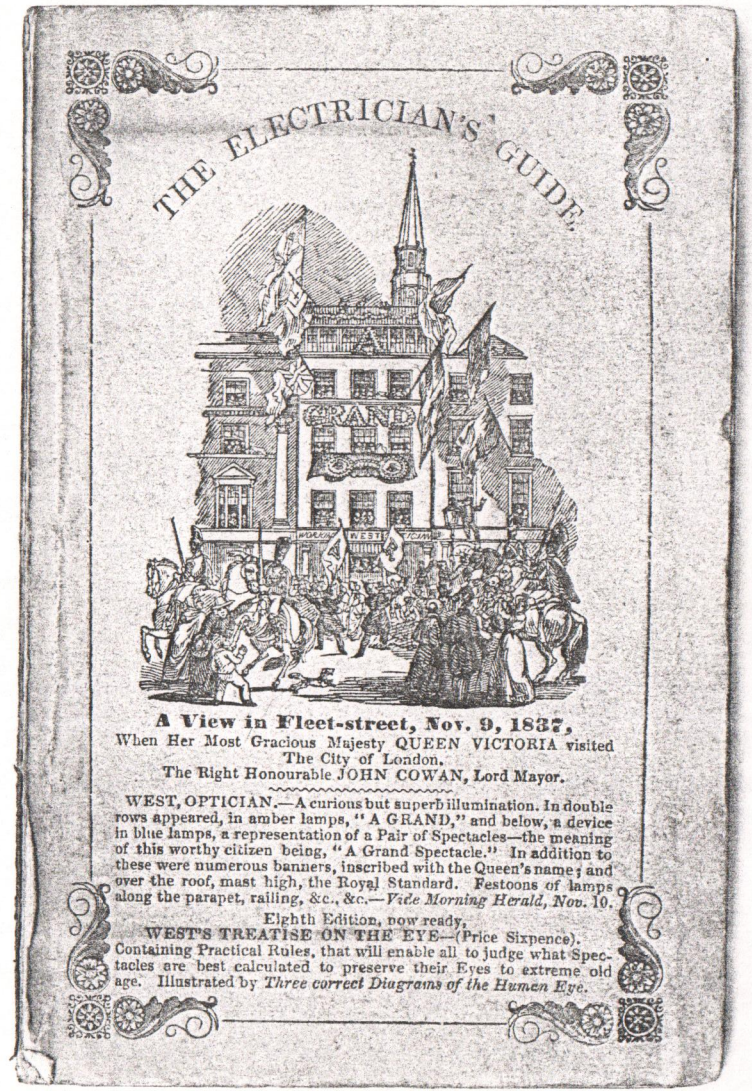
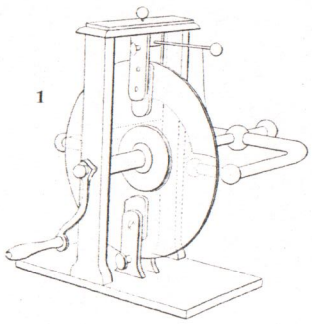


THE ELECTRICIAN'S GUIDE.

A View in Fleet-street, Nov. 9, 1837,
When Her Most Gracious Majesty QUEEN VICTORIA visited
The City of London,
The Right Honourable JOHN COWAN, Lord Mayor.

WEST, OPTICIAN.—A curious but superb illumination. In double rows appeared, in amber lamps, "A GRAND," and below, a device in blue lamps, a representation of a Pair of Spectacles—the meaning of this worthy citizen being, "A Grand Spectacle." In addition to these were numerous banners, inscribed with the Queen's name; and over the roof, mast high, the Royal Standard. Festoons of lamps along the parapet, railing, &c., &c.—*Vide Morning Herald, Nov.* 10.

Eighth Edition, now ready,
WEST'S TREATISE ON THE EYE—(Price Sixpence).
Containing Practical Rules, that will enable all to judge what Spectacles are best calculated to preserve their Eyes to extreme old age. Illustrated by *Three correct Diagrams of the Humen Eye.*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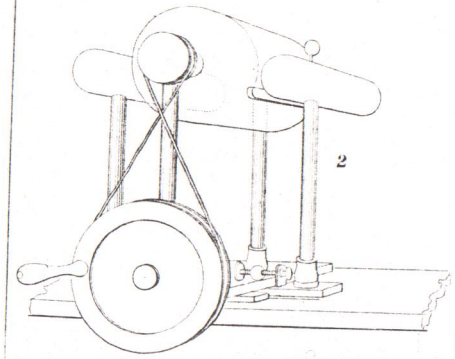
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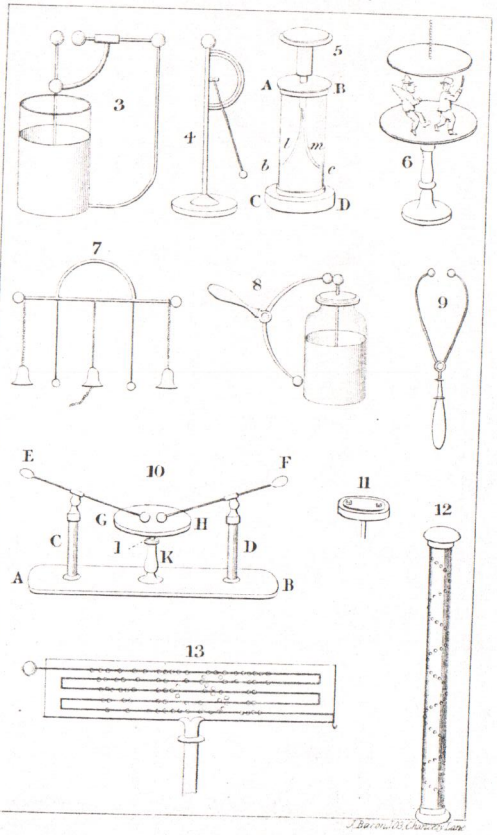
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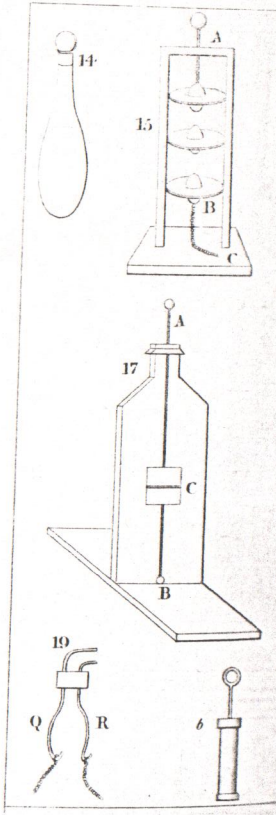
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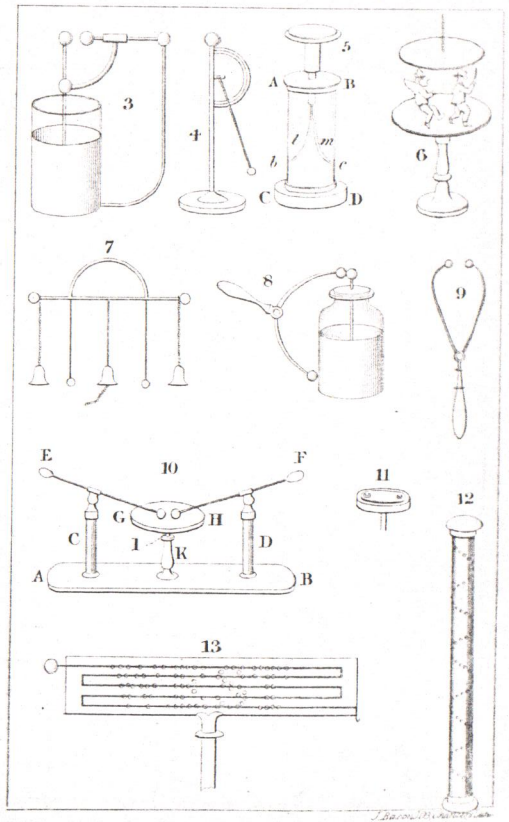

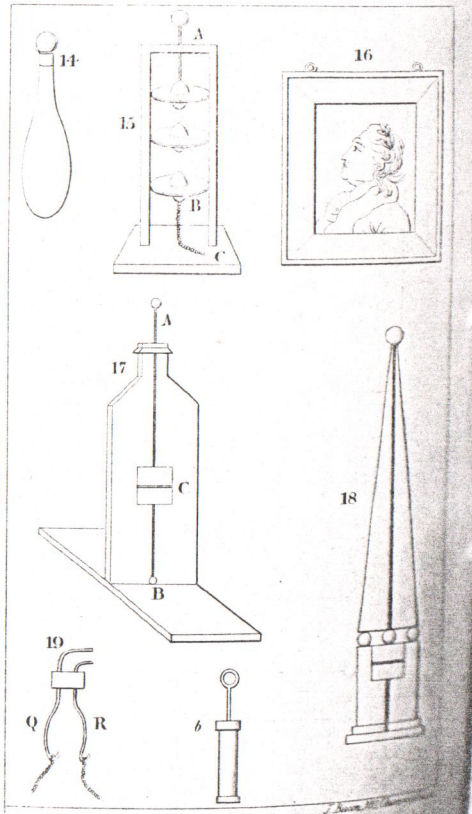

THE

ELECTRICIAN'S GUIDE;

BEING

A BRIEF OUTLINE

OF THE

Amusing and Instructive Science

OF

ELECTRICITY.

DESIGNED FOR THE AMUSEMENT AND INSTRUCTION

OF

YOUNG PERSONS.

By FRANCIS WEST,

(Successor to Mr. ADAMS)

Optical, Mathematical, and Philosophical Instrument Maker to his Majesty,

83, FLEET STREET,

AND 41, STRAND (NEAR CHARING CROSS).

1845.

One Shilling.

Printed by Chapman and Elcoate,
Peterborough-court, and 5, Shoe-lane. Fleet-street.

PREFACE.

As the present little work is designed to assist the young practitioner in performing the most instructive and amusing experiments, elaborate dissertations on the subject are not required. Simplicity and perspicuity are its distinguishing characteristics, as these are essential to the comprehension of all subjects, but more particularly those of a scientific nature.

As a theoretical science, Electricity opens a wide field of inquiry into the vast machinery of nature, far too extended for our confined limits, and we have, therefore, declined to enter on its investigation, and simply stated the general principles on which some of its most important phenomena depend, illustrating those principles by experiments selected from the works of the most approved authors on the subject, and such as, carefully performed, will afford rational amusement and valuable information.

We have touched but slightly on Positive and Negative Electricity, as, though this branch of the subject has been much dilated upon by Singer, and other authors of acknowledged celebrity, yet, as the present is but an elementary work,

and its connexion with a general course of experiments is not essential, it has been simply and clearly explained, and illustrated by a few easy and convincing experiments.

By the division into sections, the student will be enabled to investigate any particular branch of the science that may solicit his attention, and which may be important in explaining some striking phenomenon of nature.

The short notice of Medical Electricity is intended merely to exhibit its effects on the animal frame, but not to lead to the trial of such experiments as may produce dangerous consequences.

Should the student be disposed to extend his inquiries, we would refer him to the works of Cavallo, Singer, Adams, &c. &c.

The author has lately constructed, at a moderate expense, an Electrical Apparatus, capable of illustrating all the following experiments.

THE

ELECTRICIAN'S GUIDE.

SECTION I.

Form of the Electrical Machine—Its Preparation, &c.

An apparatus properly arranged for the excitation of electricity is called an Electrical Machine. Usually, for the simple purposes of exciting electricity and showing its effect, a clean and dry glass tube is held in the hand, and drawn through a piece of dry oiled silk. With this simple apparatus a small downy feather, let go from the fingers, may be driven about in the air for some minutes.

There are two forms of the Electrical Machine in general use, which have each peculiar advantages. The one was first proposed by Dr. Inglehowz, and has been perfected by Mr. Cuthbertson. The other originated with the German electricians, and was greatly improved by Mr. Nairne.

Mr. Cuthbertson's, or the Plate Machine (*Fig.* 1), consists of a circular plate of glass, turning on an axis that passes through its centre. It is rubbed by two pairs of cushions, fixed at opposite points of its circumference by elastic frames of thin mahogany, which are made to press the glass plate between them with any required degree of force by means of regulating screws. A brass conductor, supported by glass, is fixed to the frame of the machine, with its branched extre-

mities opposite each other, and near the extreme diameter of the plate, in a direction at right angles to the vertical line of the opposite cushions. The branches of the conductor are furnished with pointed wires, which serve to collect the electricity from the surface of the excited plate. This form is mostly recommended from its compactness, which renders it more portable; besides which, should the plate by any accident be cracked or broken, it may be replaced by a new one, if the diameter be given, by any optician, and the machine be quickly repaired; whereas the cylinder is difficult to be obtained true in point of form and of equal thickness throughout its surface, add to which the time and trouble required in mounting it on its frame, coating the axis, &c.

The Cylinder Machine (*Fig.* 2) consists of a cylinder of glass, from four to sixteen inches diameter, and from eighteen to twenty-four inches long, turning between two upright pillars of glass fixed to a strong mahogany base. Two smooth metal conductors, equal to the length of the cylinder, and one-third of its diameter, are placed parallel to it upon two similar glass pillars, which are cemented into two separate pieces of mahogany, that slide across the diameter of the base, so as to keep the conductors parallel to the cylinder, while they are brought nearer to or placed farther from its surface at pleasure. One of the conductors has a cushion fastened to it by a bent metallic spring; the surface of this cushion is accurately fitted to the radius of the cylinder. It may be from eight to ten inches long, and from one inch and a quarter to one inch and three-quarters wide. To the upper part of the cushion a flap of oiled silk should be attached; it is to be

sewed on the face of the cushion, about a quarter of an inch from its upper edge, so that the silk, at its junction with the cushion, may form a neat straight line, rising a little above the surface. The silk flap should reach from the cushion over the upper surface of the cylinder to within about an inch from a row of points that are attached to the side of the opposite conductor. The conductor to which the cushion with its silk is fastened, is called the negative conductor, because it exhibits the electricity of the cushion; the opposite conductor collects and displays the electric power of the glass cylinder, and it is therefore called the positive conductor. Each conductor is perforated in various parts with holes about the size of a goose quill, for the convenience of attaching wires and different articles of apparatus; and that which carries the cushion and flap has a sliding mahogany base, attached to the bottom of the machine by an adjusting screw, that serves to regulate the pressure of the rubber against the glass. The motion of the cylinder is always in the direction of the flap; it may be communicated either by a simple handle or by multiplying wheels; the latter produces more electricity in less time, but increases the labour of turning.

To preserve the machine, and keep it in good order, the following directions are to be observed:—

Take away the cushion and conductor from the machine, then wipe the glass quite dry and clean with an old soft linen cloth, that has been just warmed by the fire. The cushion is always coated on the side which performs the office of the rubber with an amalgam composed of tin, zinc, and mercury, with a small quantity of hog's lard.

This should be spread evenly over its surface until level with the line formed by the seam which joins the silk to the face of the cushion. No amalgam should be placed over this seam or on the silk flap, which last should be wiped clean whenever the continued motion of the machine has soiled it, by depositing dust or amalgam on its surface. The surface of the cushion is also often soiled, for the excited glass constantly attracts dust from surrounding bodies, and this dust is wiped off by the rubber as the glass passes it. If the dust is removed after every course of experiments, by rubbing the amalgam gently with a piece of rough brown paper, and the glass and silk flap with a dry linen cloth, the machine may be kept nearly in uniform good order without a very frequent renewal of the amalgam, which is only necessary when that which has been applied becomes irregular on the surface of the cushion, or impregnated with dust, from long use or inattentive cleaning. In very damp weather it will be proper to dry the whole machine, by placing it before, but also at some distance from, the fire.

When you have screwed on the cushions, and placed the conductor, turn the handle, and on presenting your knuckle to the conductor, if the machine is in good order, bright sparks will dart from it, accompanied by a snapping noise. The machine will now be ready to perform any of the following experiments.

SECTION II.

Electrometers, and their Use.

ELECTROMETERS are instruments employed to measure the intensity of the electric fluid, and to decide on its kind—whether it is positive, or proceeding from the glass; or negative, proceeding from the cushion.

There are various forms of this instrument, intended for various uses; we shall, however, only describe those that are essential to the young electrician.

1. *Lane's Electrometer.*

This electrometer is represented at *Fig.* 3. It consists of two brass balls of equal size, one of which is connected with the inside coating of the jar, and the other insulated opposite to the first, yet so as to admit of its being placed in contact with it, or at any required distance from it. That which is insulated is connected by a wire with the outer coating of the jar, so as to serve as a course for the discharge, which it is very obvious, from the figure, will take place sooner or later, as the balls are placed either nearer to, or farther from each other. This instrument is of common use in the adminstration of medical electricity, sometimes attached to the Leyden jar (as shown in the figure), and sometimes made to fit into one of the ends of the conductor.

2. *Henly's Quadrant Electrometer.*

Fig. 4 represents Mr. Henly's Quadrant Electrometer, as capable of being fitted to the conductor or top of a Leyden jar. It consists of a perpendicular stem or pillar, formed at the top like a ball. To the upper part of the stem a graduated semicircle is fixed; and about the middle of the semicircle is a brass arm, which contains a pin, or the small axis of the index. The index consists of a very slender stick, which reaches from the centre of the semicircle to the brass

ferrule, and a cork or pith ball, nicely turned in a lathe, is glued to its lower extremity. When the electrometer is not electrified, the index hangs parallel to the pillar; but when electrified, the index recedes from the stem, according to the intensity of the electricity. This instrument is peculiarly useful for observing the progress of the charge of a Leyden jar or battery.

3. *The Gold Leaf Electrometer.*

This instrument (*Fig.* 5) consists of two strips of gold leaf, *m n*, suspended within a glass cylinder, A B E D. This cylinder has a brass cap, A B, a little broader than itself, in the centre of which is a hole in the inside of the cap, which receives a small wedge of wood. On each side of this wedge, two equal strips of gold leaf, free from all roughness at their edges, are fixed by a little varnish; these strips are generally about two inches long, and about a quarter of an inch broad. The inside of the cap A B, and the upper part of the glass cylinder, are coated with sealing wax. On the inside of the glass cylinder are pasted two slips of tin-foil *b c*, diametrically opposite to each other, and rising higher than the strips of gold leaf. The lower ends of the tin-foil are in contact with the brass stand, D E F, which supports the whole. For observing the electricity of the atmosphere, a pointed wire is inserted in the brass cap A B. To use the electrometer, turn round the cap A B till the surfaces of the gold leaf are parallel to the surface of the pieces of tin-foil *b c*, so that the two strips of gold leaf may hang in contact in the middle of the cylinder. Then, if a body containing a small quantity of electricity be brought in contact with the cap A B, the gold

leaves will diverge, and their extremities will strike the slips of tin-foil *b c*, and thus convey the electricity to the ground.

SECTION III.

Positive and Negative Electricity.

The terms positive and negative electricity express the difference in the *kind* of the electric fluid produced by the exciting of different bodies, and is exhibited by the gold leaf electrometer, mentioned in the last section. This theory, though curious, is of little practical use to the young electrician, as but few machines are now made to exhibit both the electricities. We may, however, observe that the electricity of the glass, whether plate or cylinder, is positive, and that of the rubber, negative. It is also a curious fact that all bodies, when excited by proper rubbers, exhibit either positive or negative electricity; and that whichever this may be, the rubber will always exhibit the other.

This theory will be rendered more clear by the following experiments:—

Experiment 1.—Roll up a warm and dry flannel, so as to admit of its being held by one extremity, whilst a stick of sealing-wax is rubbed with its opposite end. After a slight friction, present the flannel to a gold leaf electrometer, which will diverge; whilst the divergence continues, bring the stick of sealing-wax near the cap, and the leaves of the electrometer will immediately close. Sealing-wax and woollen cloth are therefore both electrified by mutual friction; but their electricities are opposite, the wax being negative and the woollen positive.

EXPER. 2.—The electrical powers thus excited are equal to each other; for if the friction be repeated, and the wax and flannel be both presented at the same time, the electrometer will show no divergence, the opposite electricities, when applied together, producing a reciprocal counteraction of effect.

EXPER. 3.—If a white and black silk ribbon, of two or three feet long, perfectly dry, be applied to each other by their flat surfaces, and are drawn repeatedly between the finger and thumb, or over dry silk velvet, or woollen cloth, they will be found to adhere to each other. On separation, the black ribbon will be found negative, and the white one positive.

EXPER. 4.—Melt a roll of common brimstone, and pour it into a conical wine glass, setting a stick in it while melted, to serve as a handle. It will become electric in cooling. When cold, it may easily be separated from the glass by its handle, and will then affect the electrometer. Apply it, and the leaves will diverge with negative electricity; on applying the glass in which it was made, it will be found positive. If the cone be kept in the glass in which it was made, it will preserve its power for years.

SECTION IV.

Conductors and Non-Conductors.

IT has been seen, by the former section, from the divergence of the electrometer, that electricity may be conveyed from one body to another. Some bodies, however, convey it with greater rapidity than others, and there are some that appear absolutely to arrest its progress. The divergence of an electrified electrometer may be destroyed, weakened, or maintained, by touching its cap with different bodies.

EXPER. 5.—Touch the cap with a stick of dry glass, sulphur, or sealing wax: the divergence of the leaves will continue. These substances, then, do not transmit electricity.

EXPER. 6.—Touch the cap with a rod of metal, a piece of wood, a green leaf, or the finger: its divergence immediately ceases. Such bodies, therefore, permit the transmission of electricity.

By experiments of this kind, it is found that there is a gradation of effect from one class of bodies to the other. Those which transmit electricity with facility are called conductors; those whose transmitting powers are inferior, imperfect conductors; and such as have no power of transmission, non-conductors. Non-conductors are also sometimes called electrics, and occasionally insulators; but the latter term is only applicable to the most perfect of them, as glass.

SECTION V.

Attraction and Recession.

THE motion of light bodies produced by electricity, and usually called attraction and repulsion, is occasioned by the mutual attraction existing between the electric fluid and common matter. Its nature will be best understood by the following simple experiments:—

EXPER. 6.—Take a small downy feather, or bunch of hair, and stick it into the ball of the conductor, then, by turning the machine, the parts of the

feather or hair, being electrified alike, will repel each other and bristle out; but if the head of a pin be held near, it will come and cling to it; but if the point be presented, the feather or hair will appear as if frightened, and shrink back, like the sensitive plant.

EXPER. 7.—Take a small downy feather, or a pith ball, suspended by a metal thread (such as is used for gold lace), holding the thread, bring the ball near any electrified conductor, either positive or negative; the ball will be attracted by, and adhere to it, and will remain in contact with it until its electricity is destroyed.

In this experiment, the attracted body was in conducting communication with the ground, by means of the metal thread, and thus continued to carry off the fluid it received till it was all exhausted.

EXPER. 8.—Repeat the experiment with a ball or feather suspended by a *silk* thread. The light body will first be attracted by the conductor, and will then recede from it, nor can it again be brought in contact until it has touched some uninsulated conducting substance.

The light body is here attracted as before, and for the same reason; but it is insulated, by being suspended by a silk thread, which is a non-conductor, and, consequently, cannot part with the surplus quantity of electricity it continues to receive till it touches some conducting substance.

By the operation of these principles a variety of pleasing experiments may be made; for light substances, placed between differently electrified conductors will move from one to the other, and by such alternate motion produce some singular results.

EXPER. 9.—*The Dancing Leaf.*—Place a leaf of gold, silver, or Dutch metal on the palm of the hand, and bring it within a few inches of an electrified conductor; it will be attracted, and continue to move alternately from the hand to the conductor as long as the latter is electrified.

EXPER. 10.—*The Dancing Figures.*—Suspend a brass plate from the conductor of the machine, and beneath it, at the distance of three or four inches, place a similar plate connected with the ground. On this place some bran, or small figures cut out in paper or pith of elder. When the machine is turned, the bran or figures will rise and perform an electrical dance as long as the turning continues. The plates are shown. (*Fig.* 6.)

EXPER. 11.—*The Dancing Balls.*—Place a pointed wire on the conductor, and electrify the inside of a dry glass tumbler, by holding it over the wire while the machine is in motion. Place some pith balls on the table, and cover them with the glass. They will be alternately attracted by it and the table, and continue their motion for some time.

EXPER. 12.—*The Electrical Bells.*—*Fig.* 7 represents the electrical bells, which are to be suspended by a hook to the conductor. Let the chain hang down on the table, and on turning the machine the clappers will fly from bell to bell, and continue to ring as long as the machine is turned. If a person take hold of the chain, the ringing will continue; but if he take hold of the bit of silk cord at its end, the ringing will immediately cease, because the silk is a non-conductor.

EXPER. 13.—*The Animated Ball.*—Insulate a circular ring of brass, so as to stand near an

inch and a half from the flat surface of a table. Connect the brass ring with the conductor by means of a chain, and place within it, on the table, a very light and round glass ball about two inches diameter. On turning the machine, the ball will be attracted by the ring, touch it, and become electrified at the point of contact. This point will then recede, and be attracted by the table, whilst another part of the ball is attracted by the ring. By the repetition of this process, the ball is made to revolve and travel round the circumference of the ring.

The above experiments display the attraction of the electric fluid, and show its materiality. The following serve to confirm this, as well as prove its expansive force:—

Exper. 14.—*The Brush of Threads.*—Take a dozen threads, and tie them together at top and bottom; annex them, by a loop attached to the upper knot, to the conductor, when, on turning the machine, the electrified threads will separate from each other, and the knot at the bottom rising, they will assume a spherical figure, which will continue as long as the machine is turned.

Exper. 15.—*Spinning Sealing Wax.*—Fasten a piece of sealing wax to a wire, and insert this in one of the holes of the conductor. Soften the wax by heat, and while it is yet soft turn the machine; very fine threads of wax will be separated, and if received on a sheet of paper, will cover it with minute fibres, like fine red wool.

Exper. 16.—*Electrified Water.*—Take a metal cup which has a handle of wire passing over its top, fill it nearly full of water, and hang it upon the conductor. Turn the machine to electrify the water, and, while turning, hold a

finger pointing perpendicularly over the middle of the water, and very near it. The electrified water will then rise towards the finger in the form of a cone; which shows the attraction of the unelectrified body. If this be done in the dark, a stream of fire will be seen issuing from the water to the finger.

Exper. 17.—*The Electrified Fountain.*—Hang the shorter leg of a glass syphon in the metal cup above mentioned, the longer leg of which should be drawn out into a very small bore. Apply your mouth to the longer end, and draw out the air till the point begins to drop; then turn the machine, and the electrified water will fly to a considerable distance, and with some force. In a darkened room it will be like a stream of fire.

Exper. 18.—*To Electrify the Hair.*—If a person having pretty long hair be placed on the insulating stool (with glass legs), and, by means of a chain, be connected with the conductor, and the machine be worked, the hairs of the head will, by repelling each other, stretch out in a surprising manner. If a small wooden head with long hair be fixed on the conductor, the same effect will take place.

Exper. 19.—*The Electrified Leaf.*—Cut a piece of gold, silver, or brass leaf in the form of a square or lozenge, place it on a metal plate, and hold the plate under the ball of the conductor. On working the machine, the metallic leaf will rise from the plate, and remain suspended by one corner, without touching either. If the plate be moved round the ball, the leaf will also move round without touching either ball or plate.

Exper. 20.—*Electrified Sponge.*—Dip a

sponge in water, and then suspend it from the conductor. The water, which before only dropped from it, will now fall fast, and in the dark appear like fiery rain.

EXPER. 21.—*Conical Drop of Water.*—Place a drop of water on the conductor, turn the machine, and long zigzag sparks may be taken from it. The drop will assume a conical figure. The body that receives the spark will be wetted, and the spark will be considerably longer than can be obtained from the conductor without the water.

EXPER. 22.—*Franklin's Cloud.*—Take two or three fine locks of cotton, fasten one of them to the conductor by a fine thread, another lock to that, and a third to the second. Put the machine in motion, and the locks of cotton will expand themselves and will extend towards the table. Present a sharp point under the lowest, and it will shrink up towards the second, and this towards the first, and all together towards the conductor, where they will continue as long as the point remains under them.

EXPER. 23.—*Effect of a Point on diverging Hair.*—Fasten a number of threads, or hair, to the end of the prime conductor; when the machine is turned, these will diverge like rays proceeding from a centre. Continue turning, and present a point towards one side of the conductor, and the threads on one side will hang down, and lose their divergence, but those on the other side will still continue to diverge. This shows that the power of points to draw off electricity does not extend around the electrified body, when means are used to keep up the supply of electricity.

EXPER. 24.—*Electrical Wind.*—If a person

standing on the insulating stool, having a chain fastened to the conductor in one hand, and with the other presents the head of a large brass pin to the face of a person standing on the floor near him, a strong spark will be emitted from the head of the pin; but if he present the point, it will emit a strong wind, which, in the dark, will appear like a blue flame.

SECTION VI.

Various Forms of Conductors.

ON this subject much has been said by scientific writers, but it will be sufficient for our present purpose to observe that a spherical surface is most uniform, and best suited to collect and retain a large portion of the electric fluid. Hence balls or cylinders, with rounded ends, are usually and properly employed for insulated conductors. Whereas, on the contrary, angular or pointed bodies attract the fluid with great rapidity, and transmit it with great ease, and hence they are employed to carry off the electricity from houses, church steeples, &c. The effects of these several forms will be seen by the following experiments:—

EXPER. 25.—Present a brass ball of about three inches diameter to the conductor; sparks of brilliant white light will pass between them, accompanied by a loud snapping noise. To produce these sparks in a rapid succession, the ball must be brought near the conductor, and they will appear perfectly straight.

EXPER 26.—Annex a ball of an inch and a half or two inches in diameter to the conductor, so as to project three or four inches from it; present a large ball to this, and much longer sparks will be

obtained from the conductor itself, but they will be much less brilliant, and of a zigzag form.

EXPER. 27.—Substitute a small ball for that used in the last experiment; the fluid will pass now to a greater distance, but in the form of a divided brush of rays, faintly luminous, and producing little noise; this brush will even occur with larger balls if the machine be very powerful.

EXPER. 28.—Whilst a current of sparks is passing between a large ball and the conductor at the distance of about an inch and a half, present a sharp point at double that distance, and the sparks will immediately cease, the electric fluid being silently transmitted by the point.

SECTION VII.

The Leyden Jar, and its Use.

The most useful, and by far the most convenient, form of the Leyden Jar is that represented at *Fig.* 8. It is coated on the inside, and also on the outside, within two inches and a half of the top, with tin-foil. With the inside coating a wire or chain is connected, which rises through a lid of baked wood neatly fitted into the mouth of the jar, and terminating in a smooth brass ball. The uncoated part of the jar must be kept perfectly clean and dry, otherwise the action will be very incomplete.

EXPER. 29.—*Charging and Discharging a Jar.*—If a jar so constructed be held in one hand by the lower part, and the knob applied to the ball of the conductor when the machine is worked, sparks will be seen to pass to the knob of the jar, which, in a few turns, will be charged. If, when thus charged, a communication be formed

between its outside and inside coatings, by placing it on the table, and touching the outside with one hand and the knob on the other, a smart explosion takes place, and a peculiar sensation of a painful nature is felt, chiefly at the wrist and elbows, and across the breast. This sensation is called the electric shock, of which more will be said in another part of this work.

EXPER. 30.—When it is wished to discharge the jar without the shock passing through the person, an instrument is used called the discharging rod (*Fig.* 9), which is composed of a bent wire, or two branches ending in balls, connected by a joint, and furnished with a glass handle. In using it, it is held by the glass handle, and while one ball is applied to the outer coating of the jar, the other is made to touch the ball at its top. At the moment of contact a loud snap will be heard, and a spark of fire will pass from the jar to the rod. The jar is then discharged.

EXPER. 31.—*The Animated Spider.*—A Leyden jar is furnished with a wire fastened to its outside, which is bent so as to have its knob as high as that of the jar; a spider is made of cork, with a few short threads to represent its legs. It is fastened at the end of a silk thread from the ceiling of the room, or any other convenient support, so as to hang mid-way between the two knobs, when the jar is not charged. Let the place of the jar on the table be marked, then charge the jar, and set it down on its marked place. The spider will now begin to move from knob to knob, and continue its motion for a considerable time, sometimes for several hours. Thus the jar is gradually discharged, and when the discharge is completed the spider finishes its motion.

EXPER. 32.—*To pierce a hole through a Card.*—Take a card, or a quire of paper, or the cover of a book, hold it close to the outside coating of a charged jar; put one knob of the discharging rod upon the card or quire of paper, so that between the knob and the jar the thickness of the card or paper may be interposed; then bringing the other knob of the discharging rod near the knob of the jar, make the discharge, and on removing the card or paper it will be found pierced with a hole.

If, instead of paper or card, a very thin plate of glass, sealing wax, &c., be used, on making the discharge this will be broken in pieces.

EXPER. 33.—*To mark Paper by the Discharge.*—Take a long brass chain, pass it round the outside of the jar, and fasten each end to the knobs of the discharging rod; let the remainder of the chain lay straight on a sheet of white paper. Bring the two knobs of the discharging rod in contact with the sides of the jar, as in the last experiment; and after having made the discharge, the paper will be found tinged with a blackish tinge at the place which corresponded with the juncture of the links. If the charge be very great, the paper will be burnt quite through.

EXPER. 34. —*Passing the Charge over Fluids.*—Draw a line with a pen dipped in water on the surface of a strip of glass; place one extremity of the line in contact with the outside coating of a charged jar, and at six inches distance upon the line place one knob of the discharging rod. When the jar is fully charged, bring the other knob of the rod to the ball of the jar, and the discharge will take place luminously over the six inches of water.

If a similar line be traced with sulphuric acid

(oil of vitrol), the knob of the discharging rod may be placed at twelve inches distance on the line, and the effect produced will be the same.

The Universal Discharger and Press.

Fig. 11 represents the Universal Discharger; an instrument which is of very extensive use in forming communications to collect or convey the electric charge through any part of a given substance. A B is the base of the Universal Discharger; on this are fixed two perpendicular glass pillars C D; on the top of each of these is cemented a brass cap, to which is fixed a double joint, or one which has both a vertical and horizontal motion. On the top of each joint is a spring tube, which receives the wires E T F E. These wires may be set at various distances from each other, and turned in any direction. The extremities of the wires are pointed; the points are covered occasionally by the brass balls, which are made to fit on the wires by spring sockets. G H is a small wooden table, on the surface of which a slip of ivory is inlaid; the table is furnished with a cylindrical stem, which fits into the cavity of the pillar I. It may be raised occasionally to various heights, and fixed at any one of them by the screw K.

Fig. 0 is a little wooden press, furnished with a stem, which fits the cavity of the pillar I of the Universal Discharger, into which it is placed occasionally, when the table G H is removed. The press consists of two boards, which are brought close to each other by means of the screws *a a*. This is only used in passing the discharge of a battery.

EXPER. 36.—*The Moving Flame.*—Place a lighted taper between the wires of the Universal Discharger, having removed the knobs, which must always be done in these experiments. Let the wires be about four inches apart, and the flame midway between them; connect the outer coating of a small charged jar with one wire, and bring its knob in contact with the other. If the charge be just sufficient to pass the interval without explosion, the flame of the taper will be constantly blown from the positive wire to that which is negative.

EXPER. 37.—*To Perforate a Card.*—Place a card on the table of the Universal Discharger, and bring one of the points under the card; then connect this point with the outside coating of a charged jar; place the other point on the top of the card, and at about an inch and a half from the former. Now complete the circuit, by bringing a discharging rod from the last wire to the top of the jar, and the electricity will pass through the upper wire along the surface of the card, till it comes to the point which is underneath, where it will make a hole in the card, and pass through the wire to the coating of the jar.

EXPER. 38.—*Effect on Colours.*—Take a card, and paint both sides with cinnabar, about the breadth of the finger; fix this card vertically by a little wax on the table of the Universal Discharger. Let the pointed end of one of the wires touch one side of the card, and the end of the other wire the opposite side; the distance of the points from each other must be proportioned to the strength of the charge. Discharge a jar through the wires, and the black mark left by the

explosion on the coloured band shows the electric fluid passed from the wire communicating with the inside of the jar to that which communicates with the outside, against which it makes a hole.

Curious Configurations.

The following curious experiments exhibit some singular configurations by means of electricity. Various methods have been adopted in order to diffuse the powder over the electrified surface; the following, however, is the best:—Fix a tube of glass, wood, or metal into a small bottle of elastic gum, commonly called India rubber; put the powders which you want to project into this bottle, and then tie a double piece of flannel over the end of the tube. If this bottle, so prepared, be held in the hand, and be squeezed, by alternately opening and shutting the hand, the powders will be projected in a fine diffused manner. As for the nature of the powders, almost every substance that can be pulverized sufficiently fine to produce some configurations when projected on an electrified surface. Thus chalk, sulphur, cinnabar, resin, dragon's blood, gum arabic, &c., may be employed, either singly or mixed.

EXPER. 39.—Take a pane of glass, clean and dry, hold it suspended by one corner, and lay it flat upon a table, and draw over it the knob of a jar, moderately charged; then lifting up the glass, if laid upon a table, and holding it suspended, project upon it, by means of the elastic gum bottle, a mixed powder composed of dragon's blood and gum arabic, in equal parts. The two powders will be separated upon the glass; the red powder of dragon's blood falling in cer-

tain places, so as altogether to form an oblong radiated track, consisting of two colours intermixed in a thousand odd ways. If, instead of drawing the knob of the jar over the surface of the glass, you can only touch the surface of it here and there with the knob of the jar, and then project the mixed powders as before, separate star-like figures will be formed about those points. The stars, however, are more defined when a single powder is used.

EXPER. 40.—Take a piece of common writing paper, hold it very near the fire, so as to render it dry, and very hot; lay it flat upon a marble slab, or a very dry table, and in that situation draw over it the knob of a charged jar. Then lift the paper up by one corner, and project the powder in the last experiment over it. The configurations will be red and very beautiful. If the paper be now held very near the fire during a few seconds, the powder of dragon's blood will be melted and fastened on the paper; but the gum arabic will not melt, and may be wiped off with a handkerchief. Sulphur may be used with the dragon's blood instead of gum arabic. In these experiments the jar should be neither charged too high nor too low, for in the former case the figure will be too confined and irregular, and in the latter too faint. In order to form a neat and determinate figure, and leave the rest of the paper clean, the powders must not be projected perpendicularly to the paper, but the stream must be thrown in a direction parallel to the surface of the paper. It is also necessary to perform these experiments in as expeditious a manner as possible; for if the paper be suffered to cool too much, or the electricity to dissipate, the desired effect cannot be produced.

Electrical Battery.

From the above and similar experiments, it will be seen that Leyden jars are employed for the purpose of accumulating a quantity of electricity, and by the discharge exhibiting its effects. These are more powerfully displayed in the Electrical Battery, which consists of a number of jars of exactly similar size, and coated in a manner precisely similar. The jars are usually placed in a box with thin partitions, to prevent their mutual contact. The bottom of the box inside is covered with a trellis of wire, or with tin foil, on which the coated bottom of the jars rest; and their outer coatings are consequently in conducting communication with each other. If there are twelve jars, they may be placed in three rows of four each, every jar having its charging wire terminating in a smooth ring instead of a ball. A brass rod, with balls at its extremities, being passed through the rings in each row, will connect the inner coatings of four jars; and the rods of the three rows may be connected together by laying two shorter rods from one to the other. As the short rods are moveable, either four, eight, or twelve jars may be used.

A battery is charged in the same manner as a single jar—namely, by bringing the charging wires of its inner coatings in contact with the conductor of the machine, whilst the outer coatings are in conducting communication with the ground; and after the charge has been communicated, connecting the outer and inner coatings by the discharging rod, or any other conductor.

As the accumulation of electricity on so large a coated surface is very great, serious accidents

may happen by the discharge. It is therefore extremely dangerous in the hands of young and inexperienced electricians.

SECTION VIII.

Experiments relating to Electric Light.

EXPER. 41.—*The Spiral Tube.*—*Fig.* 12 represents an instrument composed of two glass tubes C D, one within the other, and closed with two knobbed brass caps A and B. The innermost of these tubes has a spiral row of small round pieces of tin-foil struck upon its outside surface, and lying at about one-thirtieth of an inch from each other. If this instrument be held by one of its extremities, and its other extremity be presented to the conductor, every spark that it receives will cause small sparks to appear between all the round pieces of tin-foil stuck upon the innermost tube, which in the dark appear, and afford a beautiful spectacle, the tube appearing encompassed by a spiral line of fire.

EXPER. 42.—Sometimes several spiral tubes are placed round a board, in the middle of which is screwed a glass pillar, and on the top of this pillar is cemented a brass cap with a fine steel point. In this a brass wire turns, having a brass ball at each end, nicely balanced on the wire. To make use of this apparatus, place the middle of the turning wire under the ball of the conductor, so that it may receive a succession of sparks from the ball; then push the wire gently round, and the balls in their relative motions will give a spark to each tube, and thereby illuminate them down to the board, which, from their brilliancy

and rapid motion, affords a beautiful and pleasing sight.

EXPER. 43.—*Luminous Words, &c.*—The small pieces of tin-foil are also stuck upon a flat plate of glass, so as to represent curved lines, flowers, &c., and they are illuminated in the same manner as the spiral tube. But the best way of exhibiting a luminous word is to stick a long slip of tin-foil in a zigzag manner upon a flat plate of glass, one end of this slip communicating with a brass knob on one side of the glass, and the other extremity communicating with a hook, or another brass ball on the opposite side of the glass. The letters are formed by cutting small interstices in the parallel slip of tin-foil. A plate of this kind is represented at *Fig.* 13, where *h* is the hook to which a chain is suspended, and G is the brass ball, which, being presented to the conductor, receives the spark.

EXPER. 44.—*The Exhausted Flask, or Aurora Borealis.*—Take the flask (*Fig.* 14) by the bottom, and present the knob to the conductor. On turning the machine, if the room be darkened, the glass will be full of electric fluid, which will stream and flash, exactly resembling the Aurora Borealis in the heavens, and the flashing will continue for some time after the glass is removed from the conductor. When the flashing ceases, continue to hold the flask in your hand, and by rubbing the palm of the other hand on the body of the flask, the fire will appear again. The luminous conductor is on the same principle, but is affixed to a foot, for the purpose of standing on the table.

Fig. b is a syringe employed to exhaust the luminous conductor or flask used in the above ex-

periments. To do this, unscrew the ball of the flask, or the plate of the luminous conductor, and then screw the syringe in the place of either of these pieces, being careful that the bottom of the female screw G bears close against the leather which covers the shoulder *a b c d*. Then work the syringe, and in a few minutes the glass will be sufficiently exhausted.

EXPER. 45.—*The Luminous Thread.*—To an insulated ball, four inches in diameter, fix a silver thread about four yards long. This thread—the end which is most remote from the ball—must be fixed to another insulated substance. Bring the ball within the striking distance of the conductor, and the spark, in passing from the conductor to the ball, will appear very brilliant; the whole length of the thread will appear faintly luminous at the same instant. When the spark is confined within the dimensions of a sphere one-eighth of an inch in diameter, it will be bright; but when diffused over the surface of air which received it from the thread, its light will be so faint as to be seen only in a dark room. If you lessen the surface of air which receives the spark, by shortening the thread, it will not fail to increase the brightness of the spark.

EXPER. 46.—*The Luminous Eggs.—Fig.* 15 represents a mahogany stand, so constructed as to hold three eggs, at a greater or smaller distance, according to the position of the sliding pieces. A chain, C, is placed at the bottom, in such a manner as to touch the bottom of the egg at B with one end, and with the other the outside coating of a charged jar. The sliding wire A, at the top, is made to touch the upper egg; and the distance of the eggs asunder should not exceed a quarter or the eighth of an inch. The electric spark being made to pass down, by means of the discharging rod, through the wire and ball A, will, in the darkened room, render the eggs very luminous.

EXPER. 47.—*To Illuminate the Thumb.*—Let the extremities of two wires, one of which proceeds from the outside coating of a charged jar, and the other is connected with one branch of the discharging rod, be laid upon a table at about one-tenth of an inch distance from each other; then place the thumb exactly over the interruption of the circuit, pressing it flat down. Now bring the discharging rod in contact with the knob of the jar, and on making the discharge, which necessarily takes place under the thumb, it will be illuminated in such a manner as to show the bone and the principal blood-vessels. In this experiment the operator need not be afraid of receiving a shock, for the discharge of the jar passes from wire to wire, and, at most, it only affects the thumb with a sort of tremor, which is far from being unpleasant.

EXPER. 48.—*To Illuminate Water.*—Let everything be disposed as in the last experiment, excepting that, instead of the thumb, a large, clear glass decanter, full of water, be laid over the interruption of the circuit. On making the discharge, the water will be illuminated throughout. After the same manner—viz., by passing the charge of a Leyden jar over the surface of a variety of bodies, or under them, or, lastly, through them, these bodies will mostly appear illuminated at the time of the discharge, and sometimes for a few seconds after it.

The ignition of inflammable substances may be thus exhibited :—

EXPER. 49.—*To Ignite Resin.*—The common method of kindling resin by the electric spark is to pulverize it, and dust the powder on some dry cotton wool. Thus, if a small quantity of flax or cotton wool is loosely tied on one of the knobs of the discharging rod, and a little finely powdered resin dusted on it, and a jar be discharged, by bringing the end of the rod thus prepared in contact with the knob of the jar, the charge will pass through the flax or wool, and in so doing will melt and ignite the resin, and set the whole on fire. But the inflammation of resin is rendered still more striking by the following—

EXPER. 50.—*To Ignite Resin in Water.*—Let a flat porcelain dish be filled with water, and on the surface of the water strew a quantity of finely-powdered resin. Place two wires at the opposite sides of the dish, having their ends near the surface of the water, and at about the distance of four inches from each other. Pass the charge of a large jar through the wires, and the resin, which forms part of the circuit, will be beautifully inflamed.

EXPER. 51.—*To Ignite Spirits of Wine or Ether.*—Rectified spirits of wine or ether may be thus inflamed by a single spark from the conductor, or the machine when in action. Hang on the conductor a short rod, having a small ball at its end. Then pour some spirits of wine, a little warmed, into a metal spoon ; hold the spoon by the handle, and place it so that the small knob of the rod may be about one inch above the surface of the spirit. In this situation turn the machine, and the spark from the knob will set the spirit on

fire. This experiment may be varied, and rendered very agreeable to a company of spectators. A person standing upon the insulating stool, and communicating with the conductor, may hold the spoon with the spirit in his hand, and another person, standing upon the floor, may set the spirit on fire by bringing his finger within a small distance of it. Instead of his finger, he may fire the spirit with a piece of ice, when the experiment will seem much more surprising. If the spoon is held by the person standing upon the floor, and the insulated person brings some conducting substance over the surface of the spirit, the experiment succeeds equally well. This experiment is sometimes rendered still more striking in the following manner :—Near the conductor, place on the table three wine glasses. Connect the first glass with the conductor by a brass chain which will reach to the bottom of it, and with it let the second and third be connected by a piece of fine brass wire, bent in the form of the letter A. Fill the first and second glasses with water, and into the third pour a little ether. Turn the machine, and, with a wire having a ball affixed to it, draw a spark from the ether, and it will be immediately inflamed. In this experiment the electric fluid has to pass through two distinct portions of water before it can come to the ether.

SECTION IX.

On the Shock and Spark.

EXPER. 52.—*Giving a Person the Electric Shock.*—Let a person put a finger to the outer coating of a charged jar, near the bottom, and then put a finger of the other hand to the ball. He will then act as a discharging-rod, and receive a shock through his arms and breast. The person should not grasp the jar by the coating, much less lift it up from the table, as he might, by the suddenness of the shock, let it fall.

EXPER. 53.—*To confine the Shock to any Part of the Body.*—Suppose it were required to confine the whole of a shock to that part of the arm which is between the shoulder and the elbow. Tie one end of a brass chain to the elbow by a ribbon or a piece of silk cord, and put the other end of the chain round the bottom of a jar set to be charged at the conductor. Then tie one end of another chain in the same manner to the shoulder, and desire an assistant to take hold of that chain about a foot from the other end, holding it quite clear from the former chain, and so as he may conveniently strike the conductor with the loose end that hangs down from his hand. When the jar is charged, let the assistant strike any part of the conductor with the loose end of the chain; this will discharge the jar, and the person to whom the chains are tied will receive the shock, which will go through the part of his arm between the chains, and he will feel it nowhere else. The assistant who holds the chain will experience no shock.

EXPER. 54.—*To give a Shock to any Number of Persons who desire it.*—Let all the persons join hands, so as to form a chain, and stand so as the first person at either end of the chain may hold one extremity of a brass wire, or chain, in the hand that joins not, the other end of the wire or chain being placed below the bottom of the jar to be charged; and the person at the other end of the chain, or circuit may touch the conductor (when desired) with the hand which the one next him does not hold. Then charge the jar, and let the last person touch the conductor with his loose hand, which will discharge the jar, and give them all a shock at the same instant. If a basin of water be placed between every two persons who desire to have a shock, they will have no occasion to join hands, nor even to touch each other, but only to dip into the water the fingers of the hands which would otherwise have joined. When the jar is discharged they will all receive a shock.

In giving the shock in the above experiment, the charge should be but slight, as a strong charge might produce unpleasant effects.

EXPER. 55.—*The Magic Picture* (*Fig.* 16).—This curious and amusing experiment is thus performed. Having a large mezzotinto print (suppose of the king), with a frame and glass, take out the print, and cut a panel out of it, near two inches distant from the frame all round. If the cut be through the picture, it is not the worse. With thin paste, or gum water, fix the board that is cut off on the inside of the glass, pressing it smooth and close; then fill up the vacancy by gilding the glass well with leaf gold or brass leaf. Gild likewise the inner edge of the back of the frame all round, except the top part, and form

a communication between that gilding and the gilding behind the glass; then put in the board, and that side is finished. Turn up the glass, and gild the fore side exactly over the back gilding; and when it is dry, cover it by pasting on the panel of the picture that has been cut out, observing to bring the corresponding parts of the board and picture together, by which the picture will appear of a piece as at first, only part is behind the glass, and part before. Lastly, hold the the picture horizontally by the top, and place a little moveable crown on the king's head.

If now the picture be moderately electrified, and another person take hold of the frame with one hand, so that his fingers touch its inside gilding, and with the other hand endeavour to take off the crown, he will receive a smart shock, and fail in the attempt. The operator, who, to prevent it from falling, holds the picture by the upper part, where the inside of the frame is not gilt, feels nothing of the shock, and may touch the picture with impunity, which he pretends to do as a test of his loyalty. If a ring of persons take a shock among them, the experiment is called *The Conspirators*.

Exper. 56.—*Drawing the Spark.*—The experiment of drawing the spark from the body is thus performed. Having warmed the insulating stool a little before the fire, and wiped it clean from dust, set it on the floor, and let any person stand upon it, holding one end of a chain, the other end of which is hooked to the conductor; the chain being held up at some distance from the table, and taking care that the clothes of the person do not touch the ground or any other conducting substance. Now turn the machine, and if the person standing on the floor approach his finger to the person on the stool, he may draw sparks from any part of his body.

Exper. 57.—*The Electrical Kiss.*—Suppose the two above-mentioned persons to be a gentleman and a lady. Let either of them be electrified on the stool, while the other stands at a little distance on the floor, so that the clothes of the one may not touch those of the other. Then if they incline their heads and offer to salute each other, the fire will snap from the lips of the electrified person to those of the other, and will make them both feel such a smart rebuff, as will cause them to separate without being able to accomplish their purpose, unless they have been apprised of the circumstance before, and have resolution enough to bear the smart of the electric fire. In this experiment the lips alone should touch; for if the gentleman puts his hand upon the lady, it will draw off the fire.

Exper. 58.—*The Diadem of Beatification.*—Put a hoop of leather that is silvered and lacquered round a person's head, who is standing on the stool; then let a person on the floor hold the tips of his fingers near the hoop, and move them round and round it, and bright flashes of electric light will come from the hoop to the fingers, and be felt like a gentle breeze of wind.

Exper. 59.—If a few little boats be made of cork or light wood, with small brass-headed pins for guns, and set to swim in a broad and shallow dish on the table, a person standing on the stool may guide them about with the finger, or with a knobbed rod fire the guns.

EXPER. 60.—*Giving a Shock to the Teeth.*—Let the person on the stool hold a piece of money between his teeth, and a person on the floor touch it. The shock will be so strong as will probably make him drop the money, especially if his lips do not touch it.

SECTION X.

The Identity of Thunder and Lightning with Electricity.

Though it has been allowed by philosophers that there is the most perfect identity between the phenomena of natural electricity in thunder storms, and that produced by means of the electrical apparatus, since by means of the electrical kite it has been drawn from the clouds, phials charged with it, sparks taken, and shocks given; it will be impossible in this brief sketch to enter into any detailed account of the process by which it is accumulated and discharged.

The usual method employed to illustrate the above identity by the effects of artificial, compared with natural, electricity on buildings, is by the following experiment:—

EXPER. 61.—*The Thunder-house.*—The thunder-house (*Fig.* 17), or the obelisk (*Fig.* 18), are made use of to show the necessity of perfect conductors to buildings, to defend them from lightning.

Put the ball of the jar to the end of the conductor; bring a chain from the bottom of the jar and fasten it to the hook B at the bottom of the thunder-house, or obelisk. Then put the piece

C transversely, as represented in the figure, that it may be a non-conductor, by the communication between the two ends of the wires being interrupted. This being done, turn the machine till the jar is charged: then by moving the ball at the top of the thunder-house to within three-quarters of an inch of any part of the conductor, it will discharge it, and the square piece of wood will be driven out a considerable distance; and if the experiment be made with the obelisk, it will fall down. But if the piece C be put in upright, the wire making the communication perfect, you may discharge it in the same manner without removing the wood out of its place.

SECTION XI.

Medical Electricity.

As this is often employed in various cases, we have added the following short notice on the subject:—

The machine employed for medical purposes should have sufficient power to furnish a constant stream of strong sparks, for in many cases an application of this kind is essential. If it be a plate machine, the diameter of the plate should not be less than from eighteen inches to two feet; if it be a cylinder, the diameter may be from eight to fourteen inches. The auxiliary apparatus are very simple; the most essential are:—1st. A jar fitted up with Lane's electrometer, by which the shocks can be given with any required degree of force.—2nd. A pair of directors, each consisting of a glass handle, surmounted by a brass cap,

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