An essay on electricity, explaining the principles of that useful science

Adams, George

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Chap. XVIII. Of the methods of manifesting the presence, and ascertaining the quality of natural or artificial electricity.

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OF THE METHODS OF MANIFESTING THE PRESENCE, AND ASCERTAINING THE QUALITY OF NATURAL OR ARTIFICIAL ELECTRICITY.

MR. *Canton* was the first person who constructed an electrometer, or instrument capable of shewing what was then considered as a small quantity of electricity. This instrument consisted of two small balls of pith of elder, or of cork, fastened to the two extremities of a linen thread, the middle of which was fastened to an oblong wooden box, in which the thread and balls were kept when not actually in use.

Mr. *Cavallo* found, in the course of his experiments, that these were not sufficiently sensible; and that a small quantity of power, being diffused through the box, thread, and balls, had not sufficient power to separate the balls.

To obviate this, Mr. *Cavallo* made the electrometers very short; suspended each ball by a separate piece of silver wire, the upper part of which was formed into a loop, moving in a ring of wire; this he inclosed in a bottle; from whence it acquired the name of the *bottle electrometer*.

DESCRIPTION OF MR. CAVALLO'S BOTTLE ELECTROMETER.

The principal part of this instrument is a glass tube, C D M N, *plate* 4, *fig*. 76, cemented at the bottom into the brass piece, A B, by which part the instrument is to be held, when used for the atmosphere; and it also serves to screw the instrument into its brass case, A B C. The upper part of the tube C D M N, is shaped tapering to a small extremity, which is entirely covered with sealing-wax; into this tapering part a small tube is cemented, the lower extremity, being also covered with sealing-wax, projects a small way within the tube, C D M N; into this smaller tube a piece of wire is cemented, which with its under extremity touches the flat piece of ivory, H, fastened to the tube by means of a cork; the upper extremity of the wire projects about a quarter of an inch above the tube, and screws into the brass cap, E F, which cap is open at the bottom, and serves to defend the waxed part of the instrument from rain, &c.

I M and K N are two narrow slips of tin-foil, stuck on the inside of the glass C D M N, and communicating with the brass bottom, A B. They serve to convey that electricity, which, when the balls touch the glass, is communicated to it, and being accumulated, might disturb the free motion of the balls.

To use this instrument for artificial electricity, electrify the brass cap by an electrified substance, and the divergence or convergence of the balls of the electrometer, at the approach of an excited electric, will shew the quality of the electricity. The best manner to electrify this instrument is, to bring excited wax so near the cap that one or both of the corks may touch the side of the bottle, C D M N; after which they will soon collapse and appear unelectrified. If now the wax is removed, they will again diverge, and remain unelectrified positively.

When this electrometer is to be used to try the electricity of the fogs, air, clouds, &c. the observer is to do nothing more than unscrew it from its case, and hold it by the bottom, A B, to present it to the air a little above his head, so that he may conveniently see the balls, P, which will immediately diverge, if there is any electricity; *i. e.* whether positive or negative may be ascertained, by bringing an excited piece of sealing-wax or other electric towards the brass cap, E F.

OF MR. DE SAUSSURE'S BOTTLE ELECTROMETER.*

The electrometer of Mr. *De Saussure* is nearly the same as that of Mr. *Cavallo*'s. The following are the most material circumstances in which they differ; first, the fine wires by which the balls are suspended should not be long enough to reach the tin-foil which is pasted on the inside of the glass, because the electricity, when strong, will cause them to touch this tin-foil twice consecutively, and thus deprive them in a moment of their electricity. To prevent this defect, and yet give them a sufficient degree of motion, it is necessary to use larger glasses than those that are

* This electrometer may be used instead of the condenser of M. *Volta*, by only placing it on a piece of oiled silk, somewhat larger than the base of the instrument; but, in this case, it is the base, and not the top of the instrument, which must be brought into contact with the substance whose electricity is to be explored.

By this instrument, it is easy to ascertain the degree of conducting power in any substance. For example, if it is placed on an imperfect conductor, as dry wood or marble, and if the instrument is electrified strongly, and afterwards the top is touched, the electricity will appear to be destroyed; but, on lifting up the instrument by the top, the balls will again open, because the imperfect conductor formed with the base a kind of electrophorus, by which the electric fluid was condensed and lost its tension, till the perfect conductor was separated from generally applied to Mr. *Cavallo*'s electrometer; two or three inches diameter will be found to answer the purpose very well. But, as it is necessary to carry off the electricity which may be communicated to the inside of the glass, and thus be confounded with that which belongs to those substances that are under examination; four pieces of tin-foil should be pasted on the inside of the glass: the balls should not be more than one-twentieth of an inch diameter, suspended by silver wire, moving freely in holes nicely rounded. The bottom of the electrometer should be of metal; for this renders it more easy to deprive them of any acquired electricity, by touching the bottom and top at the same time.* See *plate* 1, *fig.* 11, 12, 13.

the imperfect one; whereas, if the conductor had been more perfect, it would have been deprived of its electricity immediately on the application of the hand.

It is easy to discover also by this instrument the electricity of any substance, as of cloaths, hair of different animals, &c. For this purpose, it must be held by the base, and the substance rubbed briskly, only once, by the ball of the electrometer; the kind of electricity may be ascertained in the usual manner. It is proper, however, to observe here, that as the top of the electrometer acts in this case as an insulated rubber, the electricity it acquires is always contrary to that of the rubbed body.

* Voyage dans les Alpes par *H. B. De Saussure*, Tom. second.

In order to collect a great quantity of electricity from the air, the electrometer is furnished with a pointed wire fifteen inches or two feet long, which unscrews in three or four pieces, to render the instrument more portable; see *plate* 1, *fig.* 11. When it rains or snows, the small parapluie, *plate* 1, *fig.* 13, is to be screwed on the top of the instrument, as by this its insulation is preserved, notwithstanding the rain.

This instrument indicates not only the electricity of fogs, but that also of serene weather, and enables us to discover the kind of electricity which reigns in the atmosphere; and to a certain degree to form an estimate of its quantity; and that under two different points of view, the degree of intensity, and the distance from the earth at which it first begins to be sensible.

A conductor * exhibits signs of electricity, only when the electric fluid is more or less condensed in the air than in the earth. Though the air resists the passage of the electric fluid, it is not absolutely impermeable to it; it suffers it to pass gradually, and generally with more ease in proportion as its mass or thickness is less. It is, therefore, interesting to discover at what height

* A conductor raised for the purpose of making atmospherical experiments, is meant here.

it is necessary to be elevated, in order to find a sensible difference between the electricity of the earth, and that of the air. A very sensible difference may be generally discovered by this instrument, at the distance of four or five feet from the ground; sometimes it may be seen if the instrument is placed even on the ground, while at others, it must be raised seven or more feet, before the balls will open; sometimes, though seldom, this height is not sufficient. This distance is generally greatest when the electricity is the strongest, though necessarily modified by a variety of circumstances; some of which are known, as the degree of dryness or humidity of the air; and others are unknown.

The degree of intensity at a given height may be discovered thus; raise the electrometer, and judge by the divisions which are placed on the edge thereof the degree of their divergence. To find the relation between this degree of divergence and the force of the electricity, M. *De Saussure* took the following method: as he could not with certainty double or triple a given quantity of electricity; yet, as a given force may be reduced one-half, a fourth, or eighth, &c. by dividing between two equal and similar bodies the electricity contained in one, he took two of his unarmed electrometers, which were as similar as possible, and electrified one of them, so that the balls separated precisely six lines; he then touched the top thereof by the top of that which was not electrified; in an instant the electricity was equally divided between them, as was evident by the divergence of the balls, which was four lines in each; consequently, a diminution of half the density had only lessened the divergence one-third. One of these electrometers was then deprived of its electricity, and was afterwards brought in contact with the other, as before; the remaining electricity divided itself again between them, and the balls fell from four to twenty-eight lines, nearly in the same proportion as before; in the third operation, they fell to nineteen; in the fourth, to one; where he was obliged to stop, as there was not now sufficient force in the fluid to pass from one electrometer to the other, and distribute itself uniformly between them. The same experiment repeated several times gave very nearly the same results. Negative electricity decreased also in the same proportion as the positive. The following table may, therefore, be considered as giving a general, though not exact idea *(un apercu)* of the increase in force which corresponds to different degrees of divergence in the balls; it is only calculated to every fourth of a line. The force of electricity is always expressed by whole numbers, as it would be ridiculous to put a greater degree of exactness in the numbers than is to be found in the experiments which form the basis of the calculation.*

Distance of the balls in fourths of a line.			Corresponding forces of electricity.
1	——	——	1
2	——	——	2
3	——	——	3
4	——	——	4
5	——	——	5
6	——	——	6
7	——	——	8
8	——	——	10
9	——	——	12
10	——	——	14
11	——	——	17
12	——	——	20
13	——	——	23
14	——	——	26
15	——	——	29
16	——	——	32
17	——	——	36

* M. *De Saussure*, in a long note, anticipates the objections that may be made to the foregoing method of estimating the force of electricity; but, as at the most they only shew that this science is at present in a state of considerable imperfection, it will be unnecessary to take notice of them here.

Distance of the balls in fourths of a line.			Corresponding forces of electricity.
18	——	——	40
19	——	——	44
20	——	——	48
21	——	——	52
22	——	——	56
23	——	——	60
24	——	——	64

Those who are desirous to carry this measure of the electric force further, may do it by having similar electrometers constructed, but made upon a larger scale, and with heavier balls, which would only separate one line, with the degree of electricity that makes the smaller ones diverge six lines; these would consequently measure a force 1024 times greater than that which forms the unity of the preceding table; and thus, by degrees we may be enabled to discover the ratio of the strongest discharge of a great battery, or perhaps even of thunder itself, to that of a piece of amber, which only attracts a bit of straw.*

* The consideration of the repulsive force is not sufficient to discover the absolute force of an explosion or electrical discharge. For Mr. *Volta* has shewn, that the force of a discharge depends principally on the quantity of the electric fluid which passes from one body to another. Now, the repulsive force of the electrometer only indicates the ratio of this quantity in equal and similar bodies, and which are also similarly situated.

Another alteration of the bottle electrometer has been lately invented by the Rev. Mr. *Bennet*, which in point of sensibility is far superior to any hitherto contrived.

If equal quantities of the electric fluid were imparted to two unequal and separate conductors, the electric fluid, being less condensed on the largest, would act with the least force on the electrometer; though it is probable, the force of the discharge in the two conductors would be equal. The repulsive force serves, however, to shew what Mr. *Volta* calls the *electrical capacity* of a body, the quantity of the electric fluid it actually contains, or is capable of containing. To effect this, and have points of comparison, we should use light metallic balls of different sizes, suspended by silk threads. One of these balls, unelectrified, being brought into contact with the substance whose electricity is to be explored, will diminish the tension or repulsive force of this substance; and the quantity diminished by the contact of the ball will give the ratio of the capacity of this substance with that of the ball. Let us suppose a Leyden jar uninsulated, but so concealed that only the knob is visible, and we are therefore ignorant of its size, and the strength of the shock it will give. Let the top of M. *De Saussure's* electrometer be in contact with the knob of the jar, and the balls of the electrometer separate six lines: from this solitary fact, we shall gain no information relative to the force of the shock; because, if the jar is very large, this degree of tension will give a very painful sensation; when, if it is very small, with the same indicated tension, the sensation may be almost imperceptible. But, if I bring a ball of a foot diameter in contact with the knob of the jar, and after having thus taken a part of the fluid therefrom, the electrometer is again put in contact with the knob thereof, the remaining quantity of repulsive force will shew the relation between its contents and that of the globe of metal, and by this means the intensity of its charge.

DESCRIPTION OF THE REV. MR. BENNET'S GOLD LEAF ELECTROMETER.* *Plate* 1, *fig*. 10.

The foot, A, may be made of metal or wood, and about three inches high, that there may be convenient room to move the instrument, without the hands touching the glass part, B.

The cylindrical glass, B, in which the gold leaf is suspended, may be about five inches high, and two inches diameter.

The cap, C, is made of metal, and flat on the top, that the various substances whose electricities are to be examined may be conveniently placed upon it.

The diameter of the cap is about an inch more than that of the glass, and its rim is about an inch deep, hanging parallel to the glass, to keep it clean and dry: within this, is another circular rim, about half as broad as the other, made to go over or within the glass, and is therefore lined or covered with leather, or other soft substance, to make it fit close; and thus the cap may be easily taken off to repair any accident happening to the gold leaf. Within this rim, and in the center of the cap, a tube is fixed wherein a peg is placed. To this peg, which is made round at one end and

* See his very valuable work, entitled "New Experiments on Electricity."

flat at the other, two slips of gold leaf are fastened with paste, gum-water, or varnish.

If gold leaf be used, it may be shorter than silver leaf. The gold is the most sensible, but the silver is easier to cut, and less liable to be torn by any accident.

Two pieces of polished tin-foil are fastened with varnish on opposite sides of the internal surface of the glass, where the gold leaf may be expected to strike, and are connected with the foot of the electrometer. These slips not only carry off the superfluous electricity, but serve other important purposes.*

The upper end of the glass is covered and lined with sealing-wax as low at least as the outer rim, to render its insulation more perfect.

The following experiments shew the great sensibility of this little instrument.

1. Powdered chalk was put into a bellows, and blown upon the cap; it was electrified positively by the stream of chalk, when the nozzle of the bellows was only six inches distant from the cap; but the same stream electrified it negatively at the distance of three feet. In this experiment, the quality of the electricity is changed from positive to negative, by dispersing or widening the stream,

* Some gold or silver leaf, a cushion, a cutting knife, and wooden forceps, such as are used by the gold-beaters, are very useful articles for replacing the slips, when necessary. EDIT.

and making it pass through a longer track of air; it is also changed, by passing the stream through a bunch of fine wires, silks, or feathers placed upon the nozzle of the bellows; it is negative, when blown from a pair of bellows, the iron pipe being taken off to enlarge the stream. This last experiment seems to answer best in damp weather. The positive electricity generally remains; but in the negative, the leaf gold collapses as soon as the cloud of chalk is passed.

2. A piece of chalk drawn over a brush, or powdered chalk put into a brush and projected on the cover, electrified it negatively. The electricity was not permanent.

3. Powdered chalk blown with the mouth or a pair of bellows, *plate* 1, *fig.* 19, from a plate placed upon the cover, gave a permanent positive electricity. If a brush is placed upon the cover, and a piece of chalk is drawn over it, when the hand is withdrawn, the leaf gold gradually expands with positive electricity, as the cloud of chalk disperses.

4. Powdered chalk falling from one plate to another, placed on the instrument, electrified it negatively. Many other experiments have been tried, as projecting it from a goose wing, chalking the edges of a book, &c. The instrument being placed in a dusty road, the dust struck up with a stick near it, electrified it positively; wheat flour

and red lead gave a strong negative electricity, in all cases where the chalk gave a positive.

5. Place a metal cup upon the cap with a red hot coal in it, *plate* 1, *fig*. 20, a spoonful of water thrown upon the coal electrifies the cup negatively. If a bent wire be placed upon the cover, with a piece of paper fastened to it, to increase its surface, it will exhibit the positive electricity of the ascending vapour, when introduced into it. The electricity of rain may probably be illustrated by pouring water on hot coals placed in an insulated cullender; the ascending vapour is positive, the descending drops are negative.

6. The sensibility of this instrument may be increased, by placing a candle upon the cap; by this means a cloud of chalk, which would but just open the leaf gold before, will cause them to strike the sides for a long time together, and the electricity is now communicated so strong, that the leaves will be repelled by a stick of excited wax at ten or twelve inches distance. A cloud of chalk made in one room will electrify this instrument brought from another room, and at a considerable distance.

A thunder-cloud passing over the instrument, caused the leaf gold to strike the sides at every flash of lightning. No sensible electricity has been discovered by it on the explosion of gunpowder, or the projection of smoke, or flame over it.

Excited sealing-wax will often make the leaf gold strike the sides of the glass more than twelve times; when the sealing-wax recedes, it will strike it again, nearly the same number of times; but, if the approach is quicker than the recession, the number of times will sometimes be greater.

If a small lantern, with a candle in it, be placed upon the cap of the electrometer, and exposed to the air in an open place, or not too near high buildings or trees, it seldom fails to render the atmospheric electricity very sensible.

If the electrometer be charged with a small quantity of electricity, and the sharpest pointed needle, or edge of a razor, be brought within the least visible distance towards the cap, it will not draw off the electricity; but flame draws it off at a considerable distance.

The last experiment shews that sharp points, or edges, need not be avoided in the construction of this instrument, or of the doubler to be spoken of hereafter, or atmospheric apparatus; and that flame is better than a pointed wire for the purpose of collecting atmospheric electricity.

A small pin was fastened upon the end of a stick of sealing-wax, and charged with electricity, which was communicated from the pin to a metallic insulated conductor, fifteen inches in diameter and seven feet long; whose surface was therefore prodigiously larger than that of the pin, yet its electricity caused a very sensible divergency of the gold leaf: thus, not only shewing the sensibility of the electrometer, but the amazing divisibility and expansibility of this wonderful fluid.

Besides the method of discovering small quantities of electricity by means of very delicate electrometers, two methods have been communicated to the philosophical world, by which such quantities of electricity may be rendered manifest, as could not be perceived by other means. The first of these methods is an invention of Mr. *Volta*, called the *condenser of electricity*; the second is an invention of the Rev. Mr. *Bennet*, called the *doubler of electricity*.

Mr. *Volta*'s condenser, which has been already described in his own words, consists of a large smooth metal plate, furnished with an insulating handle, and a semi-conducting or imperfect insulating plane. See D and E, *plate* 11, *fig*. 10.

To examine a weak electricity with this apparatus, as that of the air in calm and hot weather, which is generally too weak to be rendered sensible by an electrometer, place the metal plate upon the semi-conducting plane, letting a wire, or some other conducting substance, be connected with the metal plate, and extended in the open air, to absorb its electricity; then, after a certain time, the metal plate must be separated from the same conducting plane, and being presented to an electrometer, will electrify it more than if it had not been placed on such a plane; and this, because the metal plate, while standing contiguous to the semi-conducting plane, will absorb and retain a much greater quantity of electricity than it could either absorb or retain when separate.

The office of this apparatus is not to manifest a small quantity of electricity, but to condense an expanded quantity into a small space. But Mr. *Bennet*'s doubler is designed to multiply, by repeatedly doubling a small, and otherwise unperceivable quantity of electricity, till it becomes sufficient to affect an electrometer and give small sparks.

BENNET'S OR NICHOLSON'S DOUBLER.

Plate 1, *fig*. 9, represents the apparatus, supported on a glass pillar six inches and an half long.

It consists of the following parts: two fixed plates of brass, A and C, are separately insulated, and disposed in the same plane, so that a revolving plate, B, may pass very near them, without touching. Each of these plates is two inches in diameter; and they have adjusting pieces behind, which serve to place them accurately in the required position. D is a brass ball, likewise of two inches diameter, fixed on the extremity of an axis that carries the plate, B. Besides the more essential purpose this ball is intended to answer, it is so loaded within, on one side, that it serves as a counterpoise to the revolving plate, and enables the axis to remain at rest in any position. The other parts may be distinctly seen in *fig.* 9, *No.* 2. The shaded parts represent metal, and the white represent varnished glass. O N is a brass axis, passing through the piece, M, which last sustains the plates A and C. At one extremity is the ball, D, already mentioned; and the other is prolonged by the addition of a glass stick, which sustains the handle, L, and the piece, G H, separately insulated. E, F, are pins rising out of the fixed plates, A and C, at unequal distances from the axis. The cross piece, G H, and the piece, K, lie in one plane, and have their ends armed with small pieces of harpsichord wire, that they may perfectly touch the pins, E, F, in certain points of the revolution. There is likewise a pin, I, in the piece, M, which intercepts a small wire proceeding from the revolving plate, B.

The touching wires are so adjusted, by bending, that when the revolving plate, B, is immediately opposite the fixed plate, A, the cross piece, G H, connects the two fixed plates, at the same time that the wire and pin at I form a communication between the revolving plate and the ball. On the other hand, when the revolving plate is immediately opposite the fixed plate, C, the balls become connected with this last plate, by the touching of the piece K against F; the two plates, A and B, having then no connexion with any part of the apparatus. In every other position, the three plates and the ball will be perfectly unconnected with each other.

When the plates, A and B, are opposite to each other, the two fixed plates, A and C, may be considered as one mass; and the revolving plate, B, together with the ball, D, will constitute another mass. All the experiments yet made concur to prove, that these two masses will not possess the same electric state; but that, with respect to each other, their electricities will be *plus* and *minus*. These states would be simple, and without any communication, if the masses were remote from each other; but as that is not the case, a part of the redundant electricity will take the form of a charge in the opposed plates, A and B. From other experiments, I find that the effect of the compensation on plates opposed to each other, at the distance of one-fortieth part of an inch, is such that they require, to produce a given intensity, at least one hundred times the quantity of electricity that would have produced it in either, singly and apart. The redundant electricities in the masses under consideration will therefore be unequally distributed: the plate, A, will have about ninety-nine parts, and the plate, C, one;

and, for the same reason, the revolving plate, B, will have 99 parts of the opposite electricity, and the ball, D, one. The rotation, by destroying the contacts, preserves this unequal distribution, and carries B from A to C, at the same time that the tail, K, connects the ball with the plate, C. In this situation, the electricity in B acts upon that in C, and produces the contrary state by virtue of the communication between C and the ball; which last must therefore acquire an electricity of the same kind with that of the revolving plate. But the rotation again destroys the contact, and restores B to its first situation opposite A. Here, if we attend to the effect of the whole revolution, we shall find that the electric states of the respective masses have been greatly increased; for the ninety-nine parts in B remain, and the one part of electricity in C has been increased so as nearly to compensate ninety-nine parts of the opposite electricity in the revolving plate B, while the communication produced an equal mutation in the electricity of the ball. A second rotation will, of course, produce a proportionable augmentation of these increased quantities; and a continuance of turning will soon bring the intensities to their maximum, which is limited by an explosion between the plates.

If one of the parts be connected with an electrometer, more especially that of *Bennet*, these effects will be very clearly seen. The spark is usually produced by a number of turns, between eleven and twenty; and the electrometer is sensibly acted upon by still fewer. When one of the parts is occasionally connected with the earth, or when the adjustment of the plates is altered, there are some variations in the effects, not difficult to be reduced to the general principles, but sufficiently curious to excite the meditations of persons the most experienced in this branch of natural philosophy: an attention to brevity, however, renders it necessary to forbear enlarging upon them. If the ball be connected with the lower part of *Bennet's* electrometer, and the plate, A, with the upper part, and any weak electricity be communicated to the electrometer, while the position of the apparatus is such that the cross piece, G H, touches the two pins; a very few turns will render it perceptible. But here, as well as in the common doubler, the effect is rendered uncertain by the condition, that the communicated electricity must be strong enough to destroy and predominate over any other electricity the plates may possess. I scarcely need observe, that if this difficulty should hereafter be removed, the instrument will have great advantages as a multiplier of electricity in the facility of its use, the very speedy manner of its operation, and the unequivocal nature of its results.

MR. BROOKE'S ELECTROMETER FOR CHARGED JARS AND BATTERIES.*

This article might have been introduced with greater propriety in the beginning of this work; but, as the plate was then altering, to render the drawing conformable to that given by Mr. *Brooke* himself, I chose rather to postpone it till the plate was finished.

An accurate admeasurement of the quantities of electricity is among the desiderata in this branch of philosophy; and, as the electrometers which have heretofore been invented have in that respect been found deficient, Mr. *Brooke* has endeavoured to supply this deficiency by a new instrument.

Plate 5, *fig*. 95, exhibits the electrometer in miniature, as it appears when it is ready to be used.

Fig. 96, B, is an arm, the ball of which is to be laid to make a communication with a battery.

Fig. 97, is the lower part of the electrometer, separate from the upper part.

The arms, F H, f k, *fig*. 97, are, when in use, to be placed as much as possible out of the atmosphere of a jar, battery, &c.

* *Brooke's* Miscellaneous Experiments and Observations on Electricity.

The dial plate, *fig.* 96, is divided into 90 equal parts; the index of this plate is carried once round when the arm, B C, has moved through 90 degrees, or a quarter of a circle. That motion is given to the index by the repulsive power of the charge acting between the ball D and the ball B.*

The arm, B C, being repelled, shews when the charge is increasing, and the arm, F H, shews what this repulsive power is between two balls of this size in grains, according to the number the weight rests at when lifted up by the repulsive power of the charge: at the same time the arm, B C, points out the number of degrees to which the ball, B, is repelled; so that, by repeated trials, the number of degrees, answering to a given number of grains, may be ascertained, and a table formed from these experiments, by which means the electrometer, *fig.* 96, may be used without that of *fig.* 97.

Mr. *Brooke* thinks that no glass, charged, as we call it, with electricity, will bear a greater force than that whose repulsive power, between two balls of the size he used, is equal to sixty grains; that in very few instances it will stand sixty grains weight; and he thinks it hazardous to go more than forty-five grains.

Hence, by knowing the quantity of coated surface, and the diameter of the balls, we may be

* Phil. Trans. vol. lxxxii. p. 384.

enabled to say, so much coated surface, with a repulsion between balls of so many grains, will melt a wire of such a size, or kill such an animal.

Mr. *Brooke* also thinks, that he is not acquainted with all the advantages of this electrometer; but that it is clear, it speaks a language which may be universally understood, which no other will do; for, though other electrometers will shew whether a charge is greater or less, by an index being repelled to greater or smaller distances, or by the charge exploding at different distances, yet the power of the charge is by no means ascertained: but this electrometer shews the force of the repulsive power in grains; and the accuracy of the instrument is easily proved, by placing the weights on the internal ball, and seeing that they coincide with the divisions on the arm, F H, when the slide is removed to them.