

Received August, 1767.

XLIV. Description of an Electrometer invented by Mr. Lane; with an Account of some Experiments made by him with it: In a Letter to Benjamin Franklin, LL. D. F. R. S.

Aldersgate-Street, October 15, 1766.

S I R,

Read Nov. 26, 1767. **B**EING employed in some electrical enquiries about the beginning of the year 1762, it occurred to me, that many experiments on this subject might be made with a much greater degree of precision, if we could determine, with any tolerable accuracy, the comparative quantity of electric fluid, with which, for any given experiment, the coated phial is impregnated.

An instrument, which I have contrived for this purpose, may not improperly be called an Electrometer. I have herewith sent you a drawing thereof [TAB. XX.] with the machine * to which I have fixed it.

* This portable machine is the contrivance of Mr. Read, mathematical instrument maker at Knightbridge, near London.

M m m 2

FIGURE

FIGURE I.

- A. The cylindrical glass of the machine, used instead of a globe. The cylindrical part of the glass is six inches in length, and sixteen in circumference.
- B. The wheel, at every turn of which the cylindrical glass revolves four times.
- C. The conductor.
- D. The coated phial.
- E. A brass wire loop, passing through the wood work to a tin plate, on which the coated phial stands.
- F. The pillar of the Electrometer made of wood, bored cylindrically about $\frac{2}{3}$ of its length, and rendered electrical, by being long baked in an oven, and then boiled in linseed oil, and again baked. At first the pillar was made of brass, which, though it served very well to determine the electric stroke for medical purposes, yet was defective in many experiments, as the table thereby became a ready conductor.
- G. Brass work, having its lower part inclosed within the bore of the pillar.
- H. A screw, which passes through the brass work near the bottom, and fixes it in the pillar.
- I. A groove for the screw H to move in, when the Electrometer is moved higher or lower, as the different heights of different condensing phials may require.
- K. A well polished hemispherical piece of brass, fixed to the conductor.

L. A

- L. A steel screw, passing through the top of the brass work, whose threads are distant nearly $\frac{1}{24}$ of an inch from each other.
- M. A well polished spherical piece of brass, fixed to the screw L, and opposite to K. The polish of K and M will often be destroyed by large electrical explosions, and it should again be restored, particularly where the experiments require accuracy.
- N. A scale, with divisions equal to each turn of the screw.
- O. A circular plate fixed to, and moving with the screw, pointing at each turn to the division upon the scale. This plate is also divided into twelve, to denote the parts of each turn.

The principle on which the Electrometer acts is very simple, being merely this; the coated phial is hereby rendered incapable of accumulating and retaining any more than a certain quantity of the electric fluid, for any intended experiment, when a metallic or non-electric communication is made from the screw H to the wire loop E of the machine, and that quantity will be proportionate to the distance of K and M from each other, and consequently the explosion and stroke will thereby be regulated.

Thus if a person holds a wire fastened to the screw H in one hand, and another wire fixed to the loop E in the other, he will perceive no stroke, if K and M are in contact, notwithstanding the cylindrical glass A acts strongly. But if, by turning the screw L, the ball M is distant from K $\frac{1}{100}$ part of an

an inch, a very small stroke will be perceived, with an explosion from K to M; and if K and M are distant one inch from each other, the quantity of the electric fluid, at the time of the explosion, will be increased 100 times: for example, it appears by experiment, that, if the explosion happens after 4 turns of the wheel B, when M is distant from K $\frac{1}{4}$ of an inch, or 1 turn of the screw; the same will happen at 8 turns of the wheel, when M and K are distant 2 turns of the screw, or $\frac{1}{2}$ of an inch; and if K and M are distant 3 turns of the screw, the turns of the wheel will be 12 at the time of the explosion; the same proportion will continue so far as the distance of K and M is equal to the condensing power of the coated phial without wasting. By wasting, I mean when the phial is so fully charged, that part of the electric fluid escapes from the mouth of the bottle, or from the conductor into the air, or to some adjacent non-electric. The number of turns of the wheel, when K and M are at any of the above distances, will be more or less in proportion to the state of the air, the cylindrical glass, the cushion against which the glass is rubbed, or the coated phial; which last will not give so great an explosion when the air is damp as when dry.

The fewer the number of turns of the wheel, at any given distance, the better the machine worketh. Thus a comparative difference between any two machines may be determined.

A wire in general is better than a chain, unless the chain is held very tight; particularly in very small strokes, the electric fluid will be lost in passing from link to link of the chain.

By

By experiment it also appears, that the quantity of electric fluid, at every explosion, will be proportionate to the quantity of coated glass, either as to the size of the coated phial, or to the number of phials added. For example, if the phial D has half of the coating on each side of the glass taken off, the explosion will happen after half the number of turns of the wheel, at any of the above distances; and if a phial, with twice the quantity of coated glass, is employed instead of D, the number of turns of the wheel will be double; the same will happen if two coated phials, each equal to D, are used; and if three phials, the number of turns will be triple, &c.

The phial D, used in the following experiments, contains about 80 square inches of coating on the inside, and also on the outside of the glass; the mouth being stopped with wood, prepared like the pillar, and the coating not too near the mouth of the phial, to prevent the electric fluid's wasting, and thereby the phial may be more fully charged.

As K is part of the conductor, and of M the electrometer, the distance between them is the distance of the electrometer from the conductor; whence it will be readily understood, when I relate the distance of the electrometer, in any experiments. For example, the electrometer at 20, that is, M, is 20 turns of the screw distant from K, or $\frac{20}{4}$ of an inch.

That lightning and electricity are of very near affinity, if not the same, evidently appears from the many discoveries you have made; and as the following experiments tend to confirm the same, as well as

to illustrate the use of the electrometer, I hope they will not be unacceptable.

EXPERIMENT I.

A piece of moist tobacco-pipe clay, rolled cylindrically, *a*, fig. 2. about an inch in length, and about 2 or $\frac{3}{10}$ of an inch in diameter, having a piece of wire thrust into each end, *bb*, distant about $\frac{1}{10}$ of an inch from each other, with the solid clay between, and the end of one of the wires, *cc*, fixed to the loop of the machine *E*, and the other fixed to the small screw of the electrometer *H*, will, with an explosion at 20 of the electrometer, be inflated as in fig. 3. or if the clay is too dry, or the quantity of electricity too great, it will burst in pieces, leaving only the clay concave near the ends of the wires; and though the experiment will in appearance differ, yet it will always leave evident signs of an explosive power, or sudden rarefaction, excepting when the wires in the clay are at too great a distance from each other; then the electric fluid will only run over its moist surface. If, instead of clay, a mucilaginous vegetable paste is used, as wheat-flower and water, &c. the experiment will appear the same.

EXPERIMENT II.

Take a piece of common tobacco-pipe hard-baked, as used for smoking, about an inch in length; fill the bore with clay, and put wires into each end, as in fig. 2. which applied in the same manner to the machine, will burst into many pieces,
at

at 20 of the electrometer; sometimes the pieces will be driven near ten feet from the machine.

EXPERIMENT III.

A small square piece of Portland stone, with holes drilled at each end so as to admit the wires, was in like manner burst in pieces, when a second coated phial was added to increase the stroke.

The iron cramps in stone buildings are similar to the wires, and when a building is struck by lightning produces a similar effect. I observed, that when the tobacco pipe, or stone, was damp, the experiment succeeded better than when dry; and I frequently found, that either of them, after being first dipped in water, would be broken with a less explosion than before.

This observation is different from the received opinion of many, not well acquainted with electricity, that lightning is less likely to do mischief after a shower of rain than before: so far may be true, that the rain will bring down some of the lightning, and also render thatched houses, &c. less likely to take fire, but will not assist buildings that have metallic ornaments near their tops, as the weather-cocks of churches, &c.

As a metallic conductor from the tops of buildings to the earth will prevent the effects of lightning on them, so will the smallest wire prevent the effects of electricity on the stone, or tobacco-pipe, when in contact with the two wires, *c c*, fig. 2.

If the tobacco-pipe, instead of clay, is filled as above, with an electric substance, as wax, powdered glass, or with any non-electric substance, inferior to metals as a conductor, it will be burst in pieces with nearly the same quantity of the electric fluid.

As the above experiments succeeded better when the stone or clay were previously dipped in water than before, I was induced to try water only.

EXPERIMENT IV.

Having made a hole, without any cracks on the side, through the bottom of the phial, *a*, fig. 4. which may easily be done if the phial is conical at the bottom, as in the figure, by holding the phial inverted in one hand, and with the other striking a pointed steel wire against the apex of the cone.

Through this hole I passed a wire, *b*, and filled the bottom, *c*, with melted sealing wax, leaving the other end of the wire out, at *d*; when the wax was cold, the phial was about $\frac{3}{4}$ filled with water, and stopped with a cork, through which a wire, *e*, was passed downwards, till the points of the two wires were distant from each other about $\frac{1}{10}$ of an inch, as near as my eye could determine a wire from the electrometer was fixed to *e*, and another from the loop of the machine was fixed at *d*; by an explosion, at 20 of the electrometer, the phial burst
in

in pieces, the top falling from the bottom near the point of the lower wire. Another phial was fitted in the same manner, and the cork cut longitudinally, that the air might freely pass at the time of the explosion, but this made no sensible difference: often times the phial is so cracked as to resemble radii from a center.

If oil is used instead of water, the event will be the same.

The quantity of electricity necessary to burst the phial, appears to vary more in proportion to its thickness than its size; many phials of various sizes may be broken at 10 of the electrometer, while others, nearly of the same size, remain sound, with a stroke at 30, or even more.

I generally found green glass more difficult to break than white.

When the phial is not broken by the electric stroke, the agitation of the water may be sensibly observed at the instant of the explosion, and the electric spark evidently seen to pass through the water, from the point of one wire to the other.

This remarkable appearance of the electric fluid's passing through water may be observed, when the electrometer is at a smaller distance from the conductor, if the wires are nearer to each other.

I have broken many phials by the electric strokes as above-mentioned, when the wires have been at the various distances, of above 1 inch to $\frac{1}{20}$ of an inch from each other, as near as my eye could determine; but the distance of about $\frac{1}{10}$ of an inch I usually prefer.

[460]

The above experiments I have often repeated, and may therefore be relied on : want of leisure has prevented me from pursuing them more minutely. But I hope they will serve as hints to others of more abilities and leisure, than

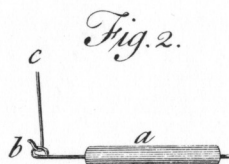
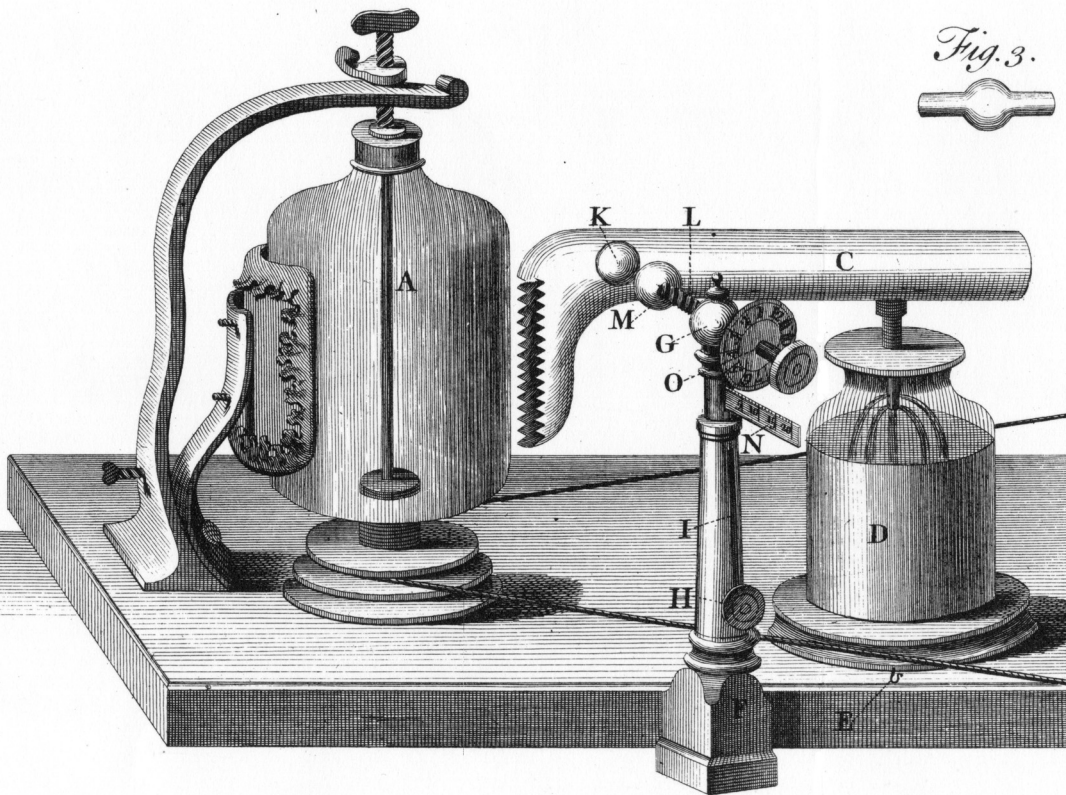
Your respectful

humble servant,

T. Lane.

Received

Fig. 1.



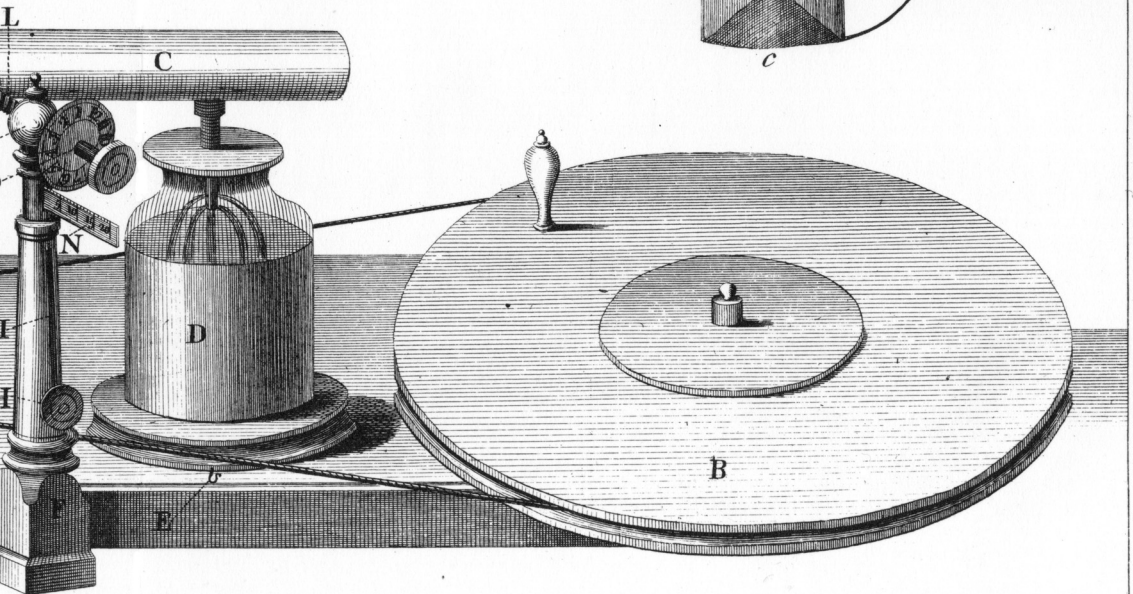
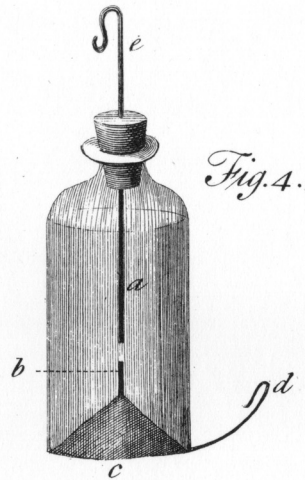


Fig. 1.



Fig. 3.



Fig. 4.

