

VII. *Electrical Experiments by Mr. Edward Nairne, of London, Mathematical Instrument-maker, made with a Machine of his own Workmanship, a Description of which is prefixed.*

Redde, Dec. 9, 1773. FIG. I. G. Ist. [TAB V. and VI.] is a re-

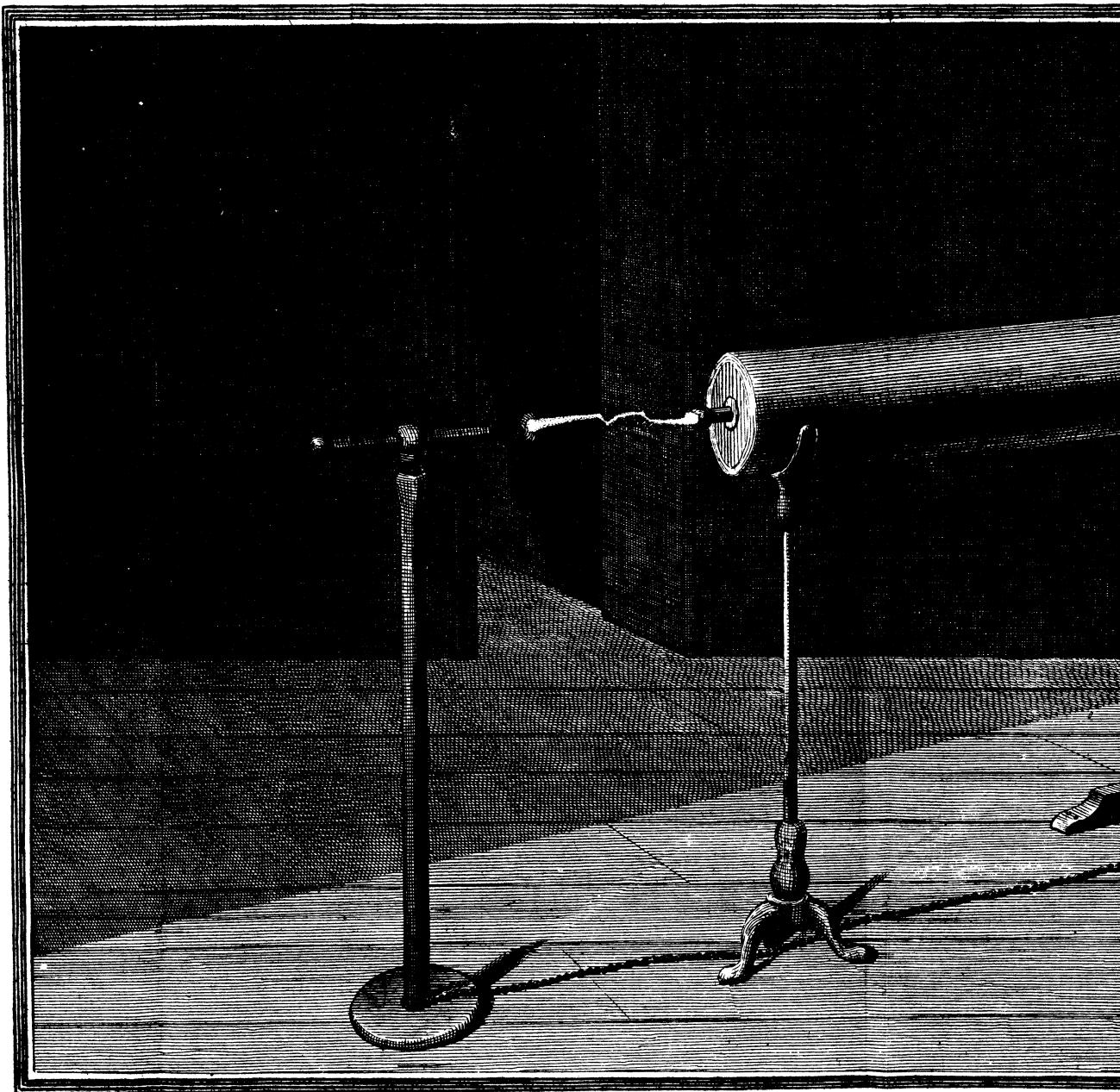
F presentation of the machine, with its apparatus, as was used when electrical sparks were drawn from the conductor, in a positive state. The glass cylinder, of this machine, is 12 inches diameter, and the cylindrical part 19 inches long, exclusive of the necks; the cushion or rubber is 14 inches long, and 5 inches broad, supported by two wooden springs; which springs are fixed on two glass rods, which lie horizontal under the cylinder, and serve to insulate the cushion. The conductor to this machine is 5 feet long, and 12 inches diameter; at the end of it is a short brass rod, with a ball; it is supported on two stands, with solid glass rods or pillars. The ball, which is represented as receiving the electrical spark from the conductor, is of brass, and fixed to the end of a brass tube, which tube is moveable, in a hole in the top of the receiving stand; from the bottom of this stand a chain passes along the floor, till it is

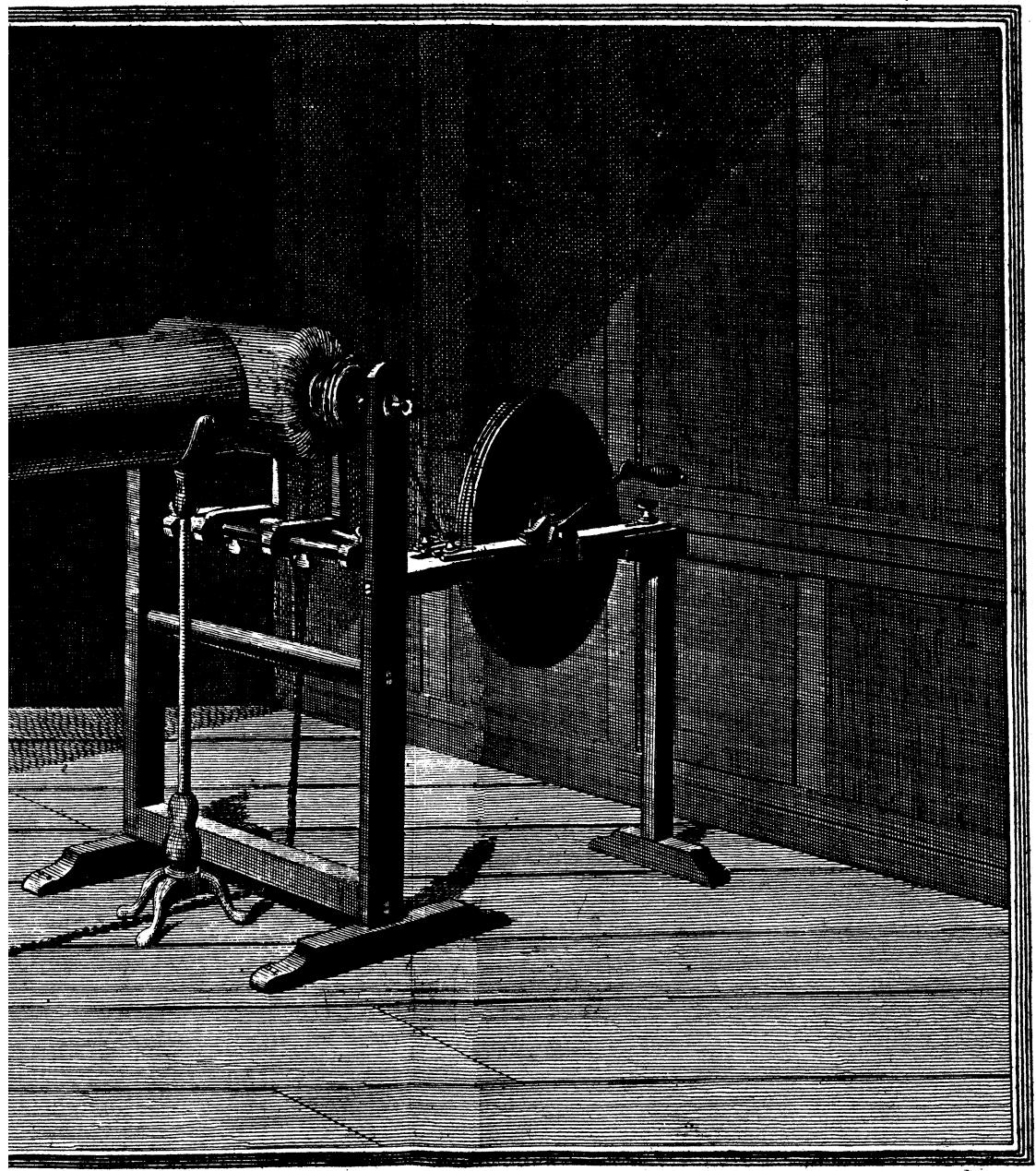
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in contact with the chain hanging from the back of the cushion, as is represented in the figure. With this machine I have frequently drawn electrical sparks, at the distance of 12, 13, or $13\frac{1}{2}$ inches from the prime conductor. These were indeed the distances, to which the electrical fire would commonly strike. It would sometimes reach the distance of 14 inches; but this was but seldom.

Fig. II. represents the same machine, with a small brass conductor, instead of the large one, for charging the batteries, which batteries are composed of four boxes, each containing 16 jars of 12 inches high and 4 inches diameter, coated 8 inches high; so that, in the 64 jars, there are very nearly 50 square feet of coated surface. The electrometer * is raised, so as to be 4 feet from the bottom, which rests on the jars, to the ball at top. I at first set it on the battery, so that the ball, at the end of the Index, was about one inch higher than the balls or wires of the battery, which is the general method of using it; but I found, on placing it so low on these batteries, that the index would move but a very little way, hardly to 15° , when the battery was full charged; at last, after trying a great variety of experiments, I found, that, placing it at the height of 4 feet, the index would rise to 60, with the same quantity of charge as, in the other case, raised it only to 15: discharging this battery, through a piece of *iron* wire (not steel) of $\frac{1}{4}$ of an inch diameter, and three feet nine inches long, it flew about the room in innumerable red hot balls; on examining these balls, they were in

* Vide Phil. Trans. Vol. LXII. p. 359.





general hollow, and seemed to be nothing but scoria. The drawing is a representation of discharging the battery through the wire. I have made a piece of the same wire, of 3 feet 11 inches long, red hot, from end to end, so that it separated into several pieces. After this, I took a piece of the fine iron wire beforementioned, of six inches in length, and, to the end of it, connected a piece of iron wire $\frac{1}{25}$ th of an inch in diameter, and 48 feet long. Then, on discharging the battery, the electrical fire from the inside passed immediately along the discharging rod to the fine wire, and afterwards had 48 feet to pass, to get to the outside coating of the battery : I then laid another piece, so that the electrical fire passed 48 feet, from the inside of the battery, before it came to the small wire; and again another, so that the electrical fire passed from the inside of the battery 24 feet, before it came to the fine wire, and had 24 feet afterwards to pass, before it could get to the outside coating of the battery ; in each case, the 6 inches of the small wire was melted into red hot balls ; and I could not perceive, that there was the least difference, in the melting of the wire, on its being placed in different parts of the circuit. Next, I connected to a piece of the same fine iron wire, of 6 inches in length, a piece of the iron wire $\frac{1}{25}$ th of an inch in diameter, and in one continued piece of 274 feet in length. In this arrangement, when the battery was discharged, the electrical fire passed immediately from the discharging rod to the fine wire, and had 274 feet to pass afterwards, to get to the outside coating ; then the fine wire was laid next the outside coating of the battery, so that the

electrical fire passed 274 feet, before it reached it. This experiment was repeated several times, with this difference, that before every discharge of the battery I shortened the fine wire, till, at last, there was but half an inch of it connected with the 274 feet of wire; but even that short piece was not made red hot by the discharge of the 64 jars. The electrical fire, in passing that 274 feet of wire, though it was one entire piece without any joinings, seemed to meet with great resistance, for the explosion from the battery was not so loud, as when a very small electrical bottle is discharged. Next, I took some silver thread, and made a circuit, of 40 feet, from the inside of the battery to the outside; and, at the distance of about 12 feet from the battery, I held the silver thread between my finger and thumb, so that the electrical fire, passing along the thread, passed between them; on discharging the battery, I received a smart shock, particularly in both my ankles, though the thread was held three feet and a half from the dry floor, on which I stood: by the electrometer, the battery did not appear to be half discharged. Then I made a circuit, of 40 feet, with iron wire $\frac{1}{25}$ th of an inch in diameter, and this was held in the same manner as the silver thread; on discharging the battery through the iron wire, there was not the least shock felt, though the whole of the battery was discharged, the iron wire of that length conducted it so perfectly.

Then I tried the effect of the battery on some *platina*, which came from Doctor Lewis, of Kingston; several of the grains, or *laminae*, were laid on

on a piece of white wax, so as to make a length of half an inch; this method being recommended by my ingenious friend Mr. HENLEY, F. R. S. who had before used it with success. On discharging the battery through the platina, I found, that not only the surface of some of the *laminae*, or grains, had been in fusion, but that part of it was melted in beautiful white spherules, visible to the naked eye.

Another experiment that I tried, was on a duck; a chain was fastened to its legs, and, holding it by the wings, the head was brought up to one of the rods of the battery, so that the battery was discharged through it, from the head to the feet; the consequence was, the duck was thrown into violent convulsions, and expired in two or three minutes. Then I took a turkey, and fastened a wire round its neck, and another on its rump, in such manner, that the nearest distance between the wires was along the back bone, thinking the charge of the batteries might pass down the spine, and that the turkey would be made paralytic; but, on discharging the battery, the turkey opened its bill, and died instantly. Then I took a cock, and fastened a wire on his rump, and placed one of the balls, of the discharging rod, on the middle of his back, so that the charge might not pass near his vital parts; the battery being discharged, the body of the cock was violently agitated, for about half a minute, and the head was turned, so that the bill came against its breast; the head and neck however soon recovered, so that it moved its neck, to all appearance, as well as it did before it

was struck; but the body was quite motionless, for about twenty minutes; after that it recovered very fast, and, in about ten minutes more, was able to stand, and walk a little. After this, I put a wire round its neck, in the same manner as on the turkey; the effect was exactly the same; for, on discharging the battery through it, it died instantly. The wire, that conducted the electrical stroke which killed the turkey and cock, was $\frac{1}{25}$ th of an inch in diameter.

The next experiment I tried was on some plants. I discharged the battery through a branch of a balsam, and examined it very attentively immediately after it was struck, but could not perceive, that there was the least alteration in the branch, till about ten or fifteen minutes after; and then the upper part of the branch began to droop its head, and continued drooping it, till it hung quite strait down, and in two or three days entirely withered, though the other part of the plant was very vigorous, and did not appear to be in the least affected; this experiment I repeated, several times, on several balsams, and always found the same appearances. I next tried the effect of the battery on a privet tree: what led me to try it, was the appearance, that I had often observed in trees, more particularly this summer, that some of their branches were deprived of all their leaves, while the rest of the tree was in a very flourishing state, and that many trees had lost all their leaves before the usual time; it struck me, that this might possibly be caused by lightning; I therefore resolved to try, whether I could produce

duce a similar appearance; accordingly I discharged the battery through a branch of the privet tree, without the least apparent injury to the branch, at that time; but after three weeks, or thereabouts, the leaves of that branch, as far as the electrical fire had passed, began to wither and drop off, so that, about a month after it was struck, it had just the appearance of the branches of the trees before-mentioned; and the rest of the tree was in a flourishing state, and did not appear to be the least hurt. The index of the electrometer, in all the beforementioned experiments, was raised to 60° .

September 14, 1773, the following experiments were made, in the presence of Mr. BANKS, and several other members of the ROYAL SOCIETY, upon the undermentioned plants, which Mr. BANKS procured to be brought in pots, in a healthy, and most of them in a flowering state; these were a female balsam, a marvel of Peru, a cardinal flower, an African geranium, a laurel, and a myrtle. These plants were so disposed, that a part only, of each, lay within the electric circuit; which part was carefully distinguished, by a piece of thread tied just below it. The electrometer being raised to 60° , the battery was discharged, and the effect was, that, in proportion as these vegetables were herbaceous and succulent, the sooner the parts of them, through which the shock passed, were observed to decay. Thus the main stem of the balsam, though, before the stroke, perfectly erect, drooped in a few minutes, and was quite dead the next morning; notwithstanding that the other stems of the same plant, which were not within the circuit, continued in flower;

flower ; and as a proof that the injury was local and partial, the plant, is yet alive, (November 15.)

The marvel of Peru and Geranium, such parts of them as were struck, were dead the next day, though the other parts still continue alive.

The cardinal flower, much less succulent than any of the former, seemed for some days to have suffered in its flowers only, which withered the next day after the stroke, though the flowers of the other stems, and which were not struck, went through their usual course : in a few days however the leaves changed their colour, as well as the stem, and died ; after which, the stem became perfectly dry ; the other stems did not suffer in the least.

It was a fortnight after the stroke, before the branch of the laurel, through which the electricity was directed, gave any indication of its being injured ; soon after, however, the leaves changed their colour, dropped off, and the branch died ; the rest of this shrub is in perfect health.

For near a month the whole myrtle continued without any seeming injury, since which time several of the sprigs near its top have died ; and though it was so long before the injury received declared itself, yet the mischief to this myrtle was more extensive, than it was to any other of the vegetables exposed to these trials.

Dr. WATSON, who has very long been conversant in electrical enquiries, was present at these experiments ; he took the plants abovementioned under his care, and used his best endeavours for their preservation, in order to observe, with the greater exactness, the progress of the effects of these electrical strokes.

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From these experiments we find, that electricity, accumulated to a certain degree, puts an end to vegetable as well as animal life.

After having recited these experiments, I would beg leave to mention a caution, which may be of service to future electricians who may use large batteries.

It is, never to discharge their batteries, if it is through a ready conductor, without the charge passes at least five feet from the inside of the battery to the outside; by making use of this precaution, which I learnt from experience, I have discharged the beforementioned battery near one hundred times, and have never, since I have used that precaution, broke a single jar by the electrical discharge, before which I was continually breaking them, by discharging the battery in the common method. There is another experiment, which I would wish to mention, as it probably may give some light in respect to balls, or points, for conductors, for buildings or ships: the apparatus and manner of trying the experiment, is as follows; in fig. 3. A represents the end of the large conductor of the electrical machine; B a brass ball screwed into the end of it, of one inch and nine tenths diameter; C a small conductor, which was 5 feet 11 inches long, and one inch and four tenths diameter; it was made of wood, covered with tin-foil, and was insulated, by being supported on a stand, the part D of which was of solid glass. The ball E, at the end of this conductor, was three inches diameter, and the ball F one inch and nine tenths diameter; under this ball, F, was a stand, G, made of wood covered with tin-foil, which had a moveable

moveable part, H, which might be raised higher or lower. On the top of this moveable part was screwed either a pointed wire, or a wire with a ball $\frac{1}{4}$ th of an inch diameter, and from the bottom of this stand a chain passed along the floor, till it was connected with the chain, which hung from the cushion; then I placed the conductor C, so that the ball E was four inches distance from the ball B, and having screwed into the top of the moveable part, H, of the stand, G, a pointed wire, I moved it till the point was directly under the ball F, at the distance of 3 or 4 inches; and, on exciting the electrical machine, the fire passed from the ball B, to the ball E, and, almost at the same instant, struck on the point from the ball F. I increased the distance slowly between the point and the ball, F, till I found the utmost distance, to which it would strike to the point, which was six inches; I continued to move the point to nine inches distance or more; it then was luminous, and the fire continued to strike, from the ball B, to the ball E, which shewed that the point carried off all the electrical fire from the conductor, C, otherwise it would not continue to strike from B to E. Then I removed the point, every thing else remaining as before, and, in its stead, placed, a wire with a ball of $\frac{1}{4}$ th of an inch diameter, at the top of it, at the distance of 3 or 4 inches, directly under the ball F, in the same manner as the point; then, on increasing this distance slowly, the electrical fire was found to strike to the ball at nine inches, which is half as far again as to the point, and with this remarkable difference, that the quantity of fire was much greater, and the explosion

plosion much stronger and louder, at its striking the ball, than at its striking the point.

It may here be observed, that a point cannot possibly be placed in circumstances more unfavourable, than these, to its operation *as a point*: the body of electric fluid falling upon it almost instantaneously, with the stroke from B to E, so that it had scarce any measurable time, wherein to act, as a point, in diminishing the quantity, before the whole fell upon it as upon a conductor. In the use of points to receive and conduct lightning, they generally act on the electrical atmosphere of a cloud, while the cloud is yet at a distance, diminishing gradually that atmosphere, before the cloud approaches near enough to give the stroke, and thus diminishing the stroke, if not quite preventing it. If the small conductor, C, is placed so as to be in contact with the large conductor, A, instead of being four inches distant, as before, the electrical fire will not strike to the point at any distance whatever; but the point will carry off silently all the electrical fire from the conductors, as fast as the cylinder supplies them, even if the point is placed at the distance of ten inches or more.

I am afraid I shall have tired you with this minute detail; but I have been thus particular, that any Gentlemen may satisfy themselves of the truth of these experiments.

To this machine there was another large conductor, 12 inches diameter, and five feet long, which being applied with its points to the back of the cushion, the machine was either negative or positive, only by hanging a chain on either conductor.

Fig. 2.

