

XXI. *New Electrical Experiments and Observations; with an Improvement of Mr. Canton's Electrometer. By Mr. Tiberius Cavallo, in a Letter to Mr. Henly, F. R. S.*

DEAR SIR,

Islington,
February 8, 1777.

Read March 13, 1777. **T**OGETHER with this letter I send you an account of some electrical experiments I have lately made, and most of which have been successfully repeated in your presence. As you did me the honour to mention, in your last paper to the Royal Society, some remarks I had made on Mr. VOLTA'S machine, I hope you will farther oblige me by presenting this account to that learned Body, if you think it contains any thing deserving the attention of the curious.

I am, &c.

Experiments

Experiments on Mr. VOLTA'S plates, commonly called a machine for exhibiting perpetual electricity.

THE following experiments, which shew how both sides of an electric plate are affected in different circumstances, were principally made with a plate which measured six inches and a quarter in diameter, and which consisted of a circular piece of thick glass coated on one side with sealing-wax^(a).

If, after having excited the sealing-wax, I lay the plate with the wax upon the table, and the glass uppermost, that is, contrary to the common method; then, on making the usual experiment of putting the metal plate on it, and taking the spark, &c. I observe it to be attended with the contrary electricity; that is, if I lay the metal plate upon the electric one, and, while in that situation, touch it with an insulated body, that body acquires the

(a) Having constructed several of those plates, with a view to discover which substance would answer the best for coating the glass plate, I observed that the easiest to be made, and the strongest in power, are those made of the second sort of sealing-wax. It is remarkable, that sometimes they will not act well at first, but they may be rendered very good by scraping with the edge of a knife their shining or glossy surface. This seems analogous to the well-known property of glass, which is, that new cylinders or globes made for electrical purposes are often very bad electrics at first, but that they improve by being worked, that is, by having their surface a little worn.

positive electricity, and the metallic removed from the electric plate appears to be negative.

This experiment, I find, answers in the same manner if an electric plate be used which has the sealing-wax coating on both sides; for, whichever side of this is excited, it will act like the waxed side of the above described plate, that is, will render the metal plate set on it positive, and the opposite side will render it negative.

If, instead of laying the electric plate upon the table, it be placed upon an electric stand so as to be accurately insulated, then the metal plate set on it acquires so little electricity that it can only be discovered with an electrometer; which shews, that the electricity of this plate will not be conspicuous on one side of it, if the opposite side be not at liberty either to part with, or acquire more of, the electric fluid. In consequence of this experiment, and in order to ascertain how the opposite sides of the electric plate would be affected in different circumstances, I made the following experiments.

Upon an electric stand I placed a circular tin plate, nearly six inches in diameter, which by a slender wire communicated with an electrometer of pith-balls, which was also insulated; I then placed the excited electric plate of six inches and a quarter diameter upon the tin plate, with the wax uppermost, and on removing my hand
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from it, the electrometer which communicated with the tin plate, that is, with the under side of the electric plate, immediately opened with negative electricity. If by touching the electrometer I take that electricity off, the electrometer will not afterwards diverge. But if now, or when the electrometer diverges, I present my hand open, or any other uninfused conductor, at about one or two inches over the electric plate, without touching it, then the pith-balls diverge; or, if they diverged before, they come together, and immediately diverge again with positive electricity.—Remove the hand, and the balls come together; approach the hand, and they diverge, and so on.

If while the pith-balls diverge with negative electricity, I put the metal plate upon the wax, the balls approach each other for a little time, but soon open again with the same, that is with negative electricity.

If, whilst the metallic lies upon the electric plate, I touch the former, the electrometer immediately diverges with positive electricity, which if by touching the electrometer I take off, the electrometer continues without divergence. I touch the metal again, and the electrometer opens again; and so on for a considerable number of times, until the metal plate has acquired its full charge. On taking now the metal plate up, the electro-
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meter instantly diverges with strong negative electricity.

I repeated the above experiments with this only difference in the disposition of the apparatus: I put the electric plate with the excited sealing-wax upon the circular tin-plate, and the glass uppermost: and the difference in the result was, that where the electricity was positive in the former disposition of the apparatus, it now became negative, and *vice versa*; except that, when I first lay the electric plate upon the tin plate, the electrometer diverged with negative electricity as well in this as in the other disposition of the apparatus.

All the above experiments have been repeated with an electric plate, which, besides the sealing-wax coating on one side, had a strong coat of varnish on the other; and their result has been similar to those when the above described plate was used.

Experiments on colours.

Having accidentally observed that an electric shock, sent over the surface of a card, marked a black stroke upon a red spot on the card, I was from this induced to try what would be the effect of sending shocks over cards painted with different water colours. Accordingly

I painted several cards with almost every colour I had, and sent shocks over them when they were very dry: the effects were as follows^(b):

Vermillion was marked with a strong black track, about one-tenth of an inch wide.

Carmine received a faint and slender impression, of a purple colour.

Verdigrise was shaken off from the surface of the card.

White lead was marked with a strong black track, not so broad as that on vermilion.

Red lead was marked with a faint mark much like carmine.

The other colours I tried were, orpiment, gamboge, sap-green, red ink, ultramarine, Prussian blue, and a few others, which were compounds of the above, but they received no impression.

It having been insinuated, that the strong black mark, which vermilion receives from the electric shock, might possibly be owing to the great quantity of sulphur contained in that mineral, I was induced to make the following experiment. I mixed together equal quantities of orpiment and flower of sulphur, and with this mix-

(b) The force employed was the full charge of one foot and a half of coated glass.

ture, by the help, as usual, of very diluted gum-water, I painted a card; but the electric shock sent over this left not the least impression.

Desirous of carrying this investigation on colours a little farther, I procured some pieces of paper painted on both sides with oil colours^(c), and sending the charge of two feet of coated glass over each of them, I observed that the pieces of paper painted with lamp-black, Prussian blue, vermilion, and purple brown, were torn by the explosion; but white lead, Naples yellow, English ochre, and verdigrase, remained unhurt.

The same shock sent over a piece of paper, painted very thick with lamp-black and oil, left not the least impression. I sent the shock also over a piece of paper, unequally painted with purple-brown, and the paper was torn where the paint laid very thin, but remained unhurt where the paint was evidently thicker.

Having repeated those experiments several times, and with some little variation, they were attended with different effects; however, they all seem to point out the following proposition.

I. A coat of oil-paint over any substance, defends it from the effects of such an electric shock as would otherwise injure it; but by no means defends it from the force

(c) The colours were mixed with linseed oil.

of every electric shock that can be given. II. No one colour seems preferable to the others, if they be equal in substance, and equally well mixed with oil; but a thick coating does certainly afford a better defence than a thinner one.

By rubbing the above mentioned pieces of paper, I find that the paper painted with lamp-black and oil is more easily excited, and acquires a stronger electricity than the papers painted with the other colours; and perhaps on this account it may be, that lamp-black and oil might resist the shock somewhat better than the other paints.

It is remarkable, that vermilion receives the black impression, when painted with oil, nearly as well as when painted with water. The paper painted with white lead and oil receives also a black mark, but its nature is very particular. The track, when first made, is almost as dark as that marked on white lead painted with water; but it gradually loses its blackness, and in about two hours after it appears without any darkness, and when the painted paper is laid in a proper light appears only marked with a colourless track, as if made by a fingernail.

Promiscuous Experiments.

Considering what a strong spark is obtained from the metal plate belonging to Mr. VOLTA'S machine, when not the least spark can be obtained from the electric plate itself, I was naturally induced to make use of the above mentioned metallic plate in discovering the electricity of very weak electrics, which otherwise would be either in-observable, or so little as not to permit its quality to be ascertained. Accordingly, by the use of this plate, I obtain a very sensible electricity from the hairs of my legs and of my head, or the head of almost any other person, when stroaked.

In this manner I obtain so strong sparks from the back of a cat, a hare's skin, a rabbit's skin, a piece of paper, or a piece of new flannel, that I can presently charge a coated phial with either of those, and so strongly as to pierce a hole through a card with its discharge.

I have often observed, that, when stroaking a cat with one hand I hold it with the other, I feel frequent smart pricklings on different parts of that hand which holds the animal. In these circumstances very pungent sparks may be drawn from the tips of the ears of the cat.

Smooth glass rubbed with a rabbit's skin, dry and warm, acquires, I find, the negative electricity; but if the skin is cold, the glass is excited positively.

New white flannel has also such strong electric power, that sometimes I have excited smooth glass negatively with it.

Considering the strong electric power of new white flannel, I thought that a piece of it rolled round the globe of an electrical machine would perhaps give a stronger electricity on the prime conductor than the glass itself. In order to try the truth of my supposition, I tied a large piece of flannel dry and warm round the globe of the machine; and for a rubber I applied the palm of my hand, then turned the winch, first slowly, and afterwards briskly; but, contrary to my expectation, I observed that the electricity at the prime conductor, although positive, was so weak, that the index of your electrometer was not moved. Surprised at this event, I resolved to take off the apparatus; but I was more surprised when, on removing the flannel from the globe, the former appeared so strongly positive, that it darted several sparks to my arm and other contiguous bodies; and the latter remained so strongly negative, that your electrometer upon the prime conductor instantly elevated its index to about 45° . I repeated this experiment several

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ral times, and the effect was always the same. The electricity of the flannel and of the glass, therefore, balanced each other.

Having had occasion to coat a ten-ounce phial, I stuck the inside coating, which was of brass filings, with varnish, agreeable to the directions given by some writers on electricity. This phial remained about a week unused; but it happened, that, whilst I was charging and discharging it for some experiments, I observed that on making a discharge it exploded with a greater noise than usual, the cork with the wire being at the same time blown out of the neck of it. Being intent upon the main experiments in hand, I omitted to examine the phenomenon of the phial. I replaced the cork on it, and went on charging and discharging it again; but it had not been charged above three or four times more, when I observed that, on making a discharge, the varnish that stuck to the brass filings was in a flame, which burned the bottom and sides of the cork considerably, and occasioned a good deal of smoke and flame to come out of the bottle. You will recollect, that I repeated this experiment in the presence of yourself, Mr. ADAMS, and Mr. COVENTRY, when it succeeded perfectly; but the varnish was this time so far burnt, that the brass filings, which
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by the combustion had changed their colour, were almost all dropped to the bottom of the phial.

I shall conclude this paper with the description of a pocket electrometer which I have lately constructed, and which, on several accounts, seems preferable to those of the most sensible sort now in use. The case and handle of the electrometer is formed by a glass tube about three inches long, and three-tenths of an inch in diameter; half of which is covered with sealing-wax. From one extremity of this tube, that is, that without sealing-wax, a small loop of silk proceeds, which serves occasionally to hang the electrometer on a pin, &c. To the other extremity of the tube, a cork is adapted, which, being cut tapering on both ends, can fit the mouth of the tube with either extremity. From one extremity of this cork two threads proceed, a little shorter than the length of the tube, suspending each a little cone of pith of elder. When this electrometer is to be used, that end of the cork which is opposite to the threads is pushed into the mouth of the tube, then the tube forms the insulated handle of the pith electrometer, as appears in fig. 1. When the electrometer is to be carried in the pocket, then the threads are put into the tube, and the cork stops it, as is represented in fig. 2. The peculiar advantages

advantages of this electrometer are, its convenient small size, its great sensibility, and its continuing longer in good order than any other I have yet seen, as you have yourself experienced ^(d). To preserve this electrometer from injury, it should be carried in a tooth-pick case, or some other of the like sort.

(d) I have lately constructed a portable electrometer of another kind, which is contrived so as not to be affected by the wind or the rain, and consequently is very convenient to examine the electricity of the clouds out of doors in time of thunder-forms: but I shall take another opportunity to present to the Royal Society a particular description of the same.



Fig: 1.



Fig: 2.

