

Received, April 22, 1773.

XXXV. *An Extract of a Letter from  
Dr. Nooth to Dr. Franklin, F. R. S.  
on some Improvements in the Electrical  
Machine.*

Read June 24,  
1773. **I**T must undoubtedly appear extraordinary, that, in the present age, when the study of electricity is become so general, and the advances that have been made in the science are so very considerable, I should attempt to recall your attention to the structure of the electrical machine. But I believe it must be allowed, that, notwithstanding the remarkable progress that has of late been made in electrical pursuits, the machine still remained the most imperfect part of the apparatus. The construction of it has been in general left to the workman, who has seldom been in a capacity of making those improvements in it, which it certainly admits of.

The subject, however, seems well worth the attention of the electricians themselves; as a knowledge of the means of correcting the capricious state of their machines will enable them to pursue

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their electrical inquiries with more certainty, success, and satisfaction.

A prospect of discovering the cause of the common uncertainty in the action of electrical machines, induced me, some months since, to make some observations on the appearances produced by a machine in motion. Being well convinced, that the electric fire, which we receive from a machine, is derived from the cushion, and from such parts as communicate with it, I first attended to the effects which the glass and rubber had on each other.

My inquiries, however, were not directed towards an investigation of the cause of that accumulation of electric matter, in consequence of the friction of the glass on the rubber, as I looked on that circumstance as a secret in nature, no less impenetrable than gravitation itself; but I endeavoured to find out the best method of increasing the excitation of a glass, and of taking from it that fire for electrical purposes which might be collected on its surface.

It is evident, that the electric matter is excited in the instant that the glass passes over the rubber, and that it becomes sensible to us by its adhering to the revolving surface of the glass. It likewise appeared to me highly probable, that the quantity of fire, which we find on the glass in motion, is not the whole of that which is excited by the passage of the glass on the rubber. The luminous appearance in the angles between the glass and rubber, and which is extremely distinct in a dark room, rendered it next to certain, that a part of the excited electric fluid returns immediately to the cushion

cushion without performing a revolution with the glass; and that, of course, a circulation of the fire is thus kept up in the substance of the cushion in the common method of constructing the machines.

To be certainly convinced of this, I attempted to make the passage of the fire from the glass to the anterior part of the cushion, or to that part which corresponds with the ascending side of the cylinder, demonstrable, by placing a piece of silk between the glass and cushion. This silk was larger than the cushion; and part of it was allowed to adhere, by the attraction of the electric fire, to the ascending part of the cylinder. My view in doing this was to cut off, in that part, the immediate communication between the excited glass and cushion, and by that means render the circulation of electric matter visible, which I suspected to take place in the machine; as it was thus forced to turn over the loose edge of the silk before it could return to the cushion. The event answered my expectation; and I then perceived, that the greatest part of the excited fluid was commonly re-absorbed by the fore-part of the cushion without becoming sensible on the superior part of the glass.

Having thus verified my supposition by actual experiments with silken flaps of different sizes, I endeavoured to discover a method of preventing that circulation of the electric fluid, and, if possible, of obliging the whole, or the greater part of it, that is once excited, to make the revolution with the glass. This, indeed, the silk, when of considerable breadth, in some measure effected; but I thought that this obstruction to the immediate re-

turn of the fire might be rendered more complete by increasing the thickness of the silk, or by applying to it some nonconducting substance, that might confine the excited fluid more perfectly to the surface of the revolving cylinder.

Bees-wax being a nonconducting substance easily procured, I rubbed the silken flap with it, and found, as I expected, that the return of the fire to the cushion at the anterior part of the machine was by that means much diminished, and consequently the excitation of the glass was apparently increased. The addition, however, of more silk was still more effectual in confining the fire to the glass; and when it was employed ten or twelve times doubled, it seemed to deny any passage from the glass to the cushion.

As I thus discovered the method of remedying the common defect in the construction of the anterior part of the cushion, I next attended to that part which corresponds with the descending side of the cylinder. Being convinced that this part of the rubber was alone concerned in the excitation, I imagined that the reverse of what was necessary anteriorly should be adopted in the structure of the posterior part; that, instead of placing nonconducting substances between the glass and cushion, we should here make the afflux of the electric matter as great as possible, by the application of the most perfectly conducting bodies. Confining therefore the amalgam to that place where the glass first comes in contact with the rubber, I placed some tinfoil close to the amalgam, and, bending it back, secured it to the metallic plate below the cushion. By this means

means the electric matter found an easy access to the place of excitation; and the effect of the machine was thereby incredibly increased. A piece of leather, covered with amalgam, and fixed to the posterior part of the rubber, in such a manner as to allow about an inch of it to pass under the cylinder, answered every purpose of the tinfoil; and, as it was not liable to be corroded by the mercury, like tinfoil, it was on that account much preferable.

From the above experiments it was apparent that the excitation was altogether performed by the posterior portion of the cushion; and that the anterior part, when made of conducting substances, re-absorbs the greater quantity of the excited matter. In the structure therefore of electrical machines, we should always have a free electric communication behind, to facilitate the excitation; and the most perfectly nonconducting substances before, to prevent the re-absorption. To answer these intentions, it will perhaps be adviseable to make the cushion of silk, stuffed with hair, and to lay some metallic conductor round the posterior part, that a free access might be allowed to the electric matter coming to the place of excitation from the inferior part of the machine. Cushions, made in this manner, and then covered with silk ten or twelve times doubled, are much more powerfully excitant than any others that I have yet tried. Various other methods, however, may be pursued in the construction of the rubber; but it should be an invariable rule, to place nonconducting bodies before, and conducting substances behind, the cylinder. From the preceding principles, it follows, that the support

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to the rubber should likewise have its conducting and nonconducting side. For this purpose, it may be necessary to employ baked wood, and to cover the posterior half with tinfoil. The place of excitation will be thus sufficiently supplied with electric matter; and the cylinder will not be robbed of a part of the excited fire, before that fire has made a revolution with the glass.

By attending to the place where the excitation is effected, it must appear evident, that the amalgam is only to be laid on the posterior part of the cushion; its presence, indeed, would be useless, if not injurious, in any other situation. It will, however, be found somewhat difficult to confine the pure amalgam to the posterior part of the rubber; but if it is mixed with a little hair-powder and pomatum, it pretty perfectly keeps its place. The strewing the amalgam thus prepared on the glass, as it revolves, is perhaps the best method of applying it; as, by that means, it is in a great measure prevented from passing on to the nonconducting substances that are placed before. Should any of the amalgam be carried forward by the revolution of the glass, it should be carefully removed. The necessity of keeping that part free from conducting bodies cannot be too much insisted on; and, when fresh amalgam is applied as before mentioned to the proper part of the rubber, the flap should be held down during half a dozen turns of the machine, lest it might collect some of the amalgam before it is properly fixed. It is a probable conjecture, that, when the flap of silk is covered with amalgam, part of the amalgam, which is not immediately subservient to the excitation,

tion, acts as a conductor in restoring the fire again to the cushion ; and that thus, by an improper disposition of it, we suppress, instead of increasing, the quantity of the excited matter.

In short, when an electrician attends to the preceding principles in the construction of his rubber, and to the proper disposition of the amalgam, he has nothing to fear from the humidity of the atmosphere, as his machine will work equally well in all kinds of weather. The rest of the electrical apparatus may be made according to the directions that have been given by the different electrical writers. Each has had his favourite machine ; and, perhaps, no one has been yet contrived that has not had its peculiar advantages.