LXXIX. *Farther Experiments in Electricity*; *by Mr.* Benjamin Wilſon, *F. R. S.*

To the Right Honourable the Earl of Macclesfield, *Preſident of the Royal Society.*

My Lord,

Read Nov. 13, 1760. IN my letter upon the *Tourmalin*, which I had the honour of communicating to the Royal Society in December laſt, there are ſome experiments to ſhew, that glaſs is permeable by electricity. I have ſince made others of the like kind, which ſeem to favour the ſame opinion.

The high regard your Lordſhip has always ſhewn for experimental philoſophy, encourages me to lay before you theſe experiments, with a few others, of a very curious nature.

But I beg leave, firſt, to take notice, that our electrical apparatus is much improved, by the diſcovery of Father *Windelinus Ammerſin*, of *Switzerland*, who, in a Latin treatiſe publiſhed in 1754, has ſhewn us, that *wood*, properly dried, till it becomes very brown, is a non-conductor of electricity *; and recommends boiling the wood in linſeed oil, or covering it all over with varniſh, after being dried, to prevent any return of moiſture into its pores. He

* It appears, from the Philoſophical Tranſactions, ſo early as the year 1747, that Dr. *Watſon* having occaſion to ſupport a long wire, in the experiment made near Shooter's Hill, with a view to determine the velocity of the electric fluid, uſed ſtakes of dry wood, (which, he tells me, *were baked)* to prevent the electric fluid from eſcaping into the ground.

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adds, that wood ſo treated ſeems to afford ſtronger appearances than even glaſs *.

The following experiments were made, with the aſſiſtance of wood thus prepared.

Being provided with a large ſquare of glaſs, poliſhed on both ſides, and fixed upright upon one edge, I placed, for a conductor, a ſlender piece of ivory, about one foot long, having one end within two tenths of an inch from the center of the glaſs: at the other end were ſuſpended two ſmall balls of pith, by threads four inches long. The ivory was ſupported horizontally by a ſtand made of the *prepared wood*. When the glaſs was made a little warmer than the external air, my finger rubbed that ſide thereof which was fartheſt from, and oppoſite to, the ivory. Upon doing this, the two ſides of the glaſs were electrified *plus*, as were likewiſe the balls; which continued *plus*, even after they were removed from the glaſs into any part of the room.

From the appearance of a *plus* electricity in the ivory, as well as on the two ſides of the glaſs, the fluid muſt have flowed from the finger into the glaſs, and part of it into the ivory: otherwiſe, permit me to aſk how the ivory ſhould be electrified *plus?*

That the fluid really flowed from the finger into the glaſs, may be inferred from the following experiment.

A piece of ſilver, being fixed upon a ſlender rod of prepared wood, I rubbed the ſame glaſs with it, as I had done before with the finger; upon which the

* See the Abbé Nollet's Letters upon Electricity, publiſhed at Paris in 1760.

ſilver was electrified *minus*, and both ſides of the glaſs, with the conductor and balls, *plus*.

There are, therefore, certain circumſtances under which the electric fluid paſſes through glaſs; I repeat in *certain circumſtances*, my Lord, becauſe in others, for inſtance, the *Leyden bottle*, the fluid does not paſs through the glaſs, but electrifies one ſide *plus*, and the other ſide *minus*, as my friend Dr. *Franklin* hath ſhewn, in his letters upon electricity.

This difference, which is cauſed by the vitreous electricity in both caſes, may perhaps be explained from the *ſurrounding medium* *, and the different degrees of the *power* with which the electric fluid endeavours to enter a body.

For the *reſiſtance* owing to the *ſurrounding medium* in a poliſhed plane, without covering, is not overcome, but by bringing the *power* near the glaſs, whereby the glaſs is electrified *plus* on both ſides; whereas, when the glaſs is *properly covered*, and the *power* brought upon it, the covering conducts the fluid equally to all the parts on that ſide, where it accumulates, that is, electrifies it *plus*; whilſt the oppoſite covering carries off to the communicating earth an equal quantity of the fluid naturally belonging to the glaſs, that is, electrifies it *minus*.

The ſame glaſs, without any covering, will be rendered *minus* on both ſides, by removing the *power* to a greater diſtance, by which it is diminiſhed, and the quantity of intermediate air, and conſequently of *reſiſtance*, increaſed.

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* See the former paper upon the Tourmalin, p. 329. of this Volume, Part I.

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The *power* therefore which cauſes the *minus* effect, is leſs than the *power* which cauſes the *plus* effect: and that this *minus* effect ariſes intirely from the *repulſive power* of the fluid, appears from this, that part of the fluid naturally belonging to the glaſs, is driven off, and electrifies *plus* other bodies placed beyond it.

From hence I collect, that the *three different* effects, *viz.* the electrifying glaſs *plus on both ſides*; or *plus on one ſide*, and *minus on the other*; or, laſtly, *minus on both ſides*; are occaſioned by the *different degrees* of the *ſame power* and *reſiſtance* in the reſpective experiments with the *ſame glaſs*.

If, on the other hand, the three laſt experiments are made with the *minus*, inſtead of the *plus* electricity, the appearances, and conſequently the reaſoning upon them, are inverted: for the *plus* appearance, in that caſe, muſt be owing to the tendency of the fluid from the earth, air, and other neighbouring bodies, towards the oppoſite ſide of the glaſs, where the *power* acts, which cauſes the *minus* appearance.

This regular converſion ſerves to confirm the truth of the principles aſſigned.

And here, with your Lordſhip's leave, I ſhall ſet down ſome farther experiments, moſt of which have been made with a view to ſhew, that a *plus* electricity may be produced by means of a *minus* electricity.

Having electrified the inſide of a large *Leyden* bottle *plus*, by means of a conducting-wire from an excited glaſs globe, I ſet it upon a ſtand of prepared wood, and took away the conducting-wire; after which, the mouth of the bottle was cloſed with a

ſtople of glaſs. Then the pointed end of the ivory conductor was brought oppoſite to the middle of the bottle, and about two inches from it. Upon doing this, the balls were electrified *minus*; and more ſo, as the ivory was moved nearer the bottle in an horizontal direction.

But, on removing the ivory to a greater diſtance, the *minus* electricity decreaſed; and, at a certain diſtance, there was not any ſign thereof remaining: and when the diſtance was increaſed to about eighteen inches from the bottle, a *plus* electricity appeared, which continued, even after the ivory was removed intirely away.

After unelectrifying the bottle, it was ſet again upon the ſtand of wood; and upon another of the ſame kind, was laid a large iron poker, ſo that the pointed end was about two inches from the outſide coating, and much nearer the bottom than the top of the bottle. I choſe the lower part thereof, for no other reaſon, than to have the poker out of the reach of any effect that might happen from the conducting-wire, which communicated with the machine, and the inſide coating of the bottle. The other end of the poker, being a large round knob, was about one inch from a rod of iron, which communicated with the earth. Under theſe circumſtances, when the inſide of the bottle was electrified *plus*, the outer coating became *minus*, as uſual.

It is to be obſerved here, that the *plus* appearance in the poker was cauſed by that portion of the fluid, which was driven off from the outſide of the bottle, by the repulſive force of the fluid conveyed into the bottle. And this confirms the reaſoning upon the remarkable

markable experiments related in the treatiſe publiſhed by Dr. Hoadly and myſelf. See p. 27 to 34, and 46, 47.

Inſtead of electrifying the inſide of the bottle, in the laſt experiment, *plus*, I electrified it *minus*, with the prepared wood, without any other change of circumſtances. In this caſe, the outſide of the bottle was *plus*, as uſual, and the poker *minus*. The fluid, therefore, which cauſed the *plus* electricity on the outſide of the bottle, muſt, in part at leaſt, have flowed from the poker; becauſe there was no other open communication with the outſide of the bottle and the earth to ſupply it.

With a cylinder of baked wood, which ſhewed ſtronger ſigns of electricity, than I have yet been able to produce from glaſs, the balls hanging to the ivory were electrified *minus*, at the diſtance of four feet, or more, by holding the cylinder over the middle of the ivory, and continuing it there: and on moving it nearer, they were more ſtrongly electrified *minus*; but the ſame cylinder, on removing it back again to the diſtance of two or three feet, or more, electrified the balls *plus*.

When another conductor, for inſtance metal, without edges or points, was uſed inſtead of the ivory, and without any thing hanging from it, the ſame cylinder held over the metal, as was done in the laſt experiment over the ivory, at the diſtance of two feet, produced a *plus* electricity: and this was rendered weaker, as the cylinder was moved nearer; but by leſſening the diſtance to about one foot, the *minus* electricity took place.

In theſe caſes, the *plus* appearance aroſe from the earth, air, or other neighbouring bodies.

When the preceding experiments were firſt made, I was a little embarraſſed with the uncertain appearances of a *plus* electricity at one time, and a *minus* at another, in the ſame experiment: but, by repeated trials and obſervations, I have found that a *plus* or *minus* electricity may be produced at pleaſure, by carefully attending to the following circumſtances, *viz.* the form of the bodies, their ſudden or gradual removal, and the degrees of electrifying.

I ſhall now proceed to acquaint your Lordſhip with ſome other circumſtances of as nice a nature, where the ſlighteſt, and almoſt imperceptible differences in the *poſition*, or in the *force* of the *friction*, of two bodies, produce in either of them, the *plus* electricity at one time, and the *minus* at another.

Such are the effects of this ſubtile and active fluid, when the experiments are carefully made; and therefore, they require the moſt ſcrupulous attention, to trace out the cauſes which occaſion them.

Sealing wax and ſilver were the bodies uſed in the firſt two experiments; but many other ſubſtances ſeem to perform as well. The ſealing wax was clean, and undiſturbed by any friction whatever, but that of the air ſurrounding it; and had been ſo for ſome hours. The ſilver was fixed to a piece of the prepared wood, which was alſo preſerved from friction for the ſame length of time. Then taking one of theſe ſubſtances in each hand, the ſilver being at that end of the wood the fartheſt from the hand, I laid the ſmootheſt part of the ſilver upon the ſealing wax, and moved it along the ſurface gently, *once only*, and with a very *ſlight preſſure*; after which, the ſilver was electrified *plus*, and the wax *minus*.

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On repeating the experiment, with equal care, and in the ſame manner, except that the *ſmooth ſide* of the ſilver was a little inclined, ſo that the *edge* thereof preſſed againſt the wax; the ſilver, after moving it as before, was electrified *minus*, and the wax *plus*; which is contrary to what was obſerved in the laſt experiment.

Theſe oppoſite effects, occaſioned by the different applications of the flat, or edge of the ſilver, ſeem to ariſe from an alteration made in the ſurface of the wax, by *deſtroying* the *poliſh* in one caſe, and not in the other: and, in this reſpect, reſembles the poliſhed and rough glaſs mentioned in the letter upon the Tourmalin. See p. 328. of this Volume, Part I. Experiment 24.

Upon making uſe of prepared wood, inſtead of wax, and employing different degrees of preſſure in the friction, with the *ſame edge* of the ſilver, I produced the like appearances; the leaſt preſſure cauſing a *plus*, and the greateſt preſſure a *minus* appearance in the ſilver.

A flat piece of ſteel, well poliſhed, and the edges rounded off, afforded the ſame appearances, by only applying the *flat ſurface* to the wood; but it required more *preſſing* to produce the *minus* effect in this caſe, than it did in the former, where the *edge* was concerned.

Whether the reaſon offered above for explaining theſe laſt curious appearances be true or not, I do not venture to affirm, for want of farther experiments; but thus much may be ſafely advanced, that we have learned to produce at pleaſure the *plus* or *minus* electricity from the ſame bodies, by attending to the manner of their *application* and *friction*.

Mr. Dufay, and the Abbé Nollet, have indeed obſerved an inconſtancy in the effects, when they rubbed ſealing wax; but for want of the cautions above-deſcribed, in the choice and treatment of the bodies, they were not able to anſwer for the event of any experiment. The Abbé, in particular, who has taken remarkable pains to find out from whence this uncertainty ariſes, acquaints us, in the *thirteenth letter*, with his difficulties, and how much it perplexed him to ſee, within an hour, in the ſame place, and with the ſame inſtruments, the effects changed, and become altogether contrary to thoſe he had before obſerved. In another part of the ſame letter, he ſays:

" Je me ſuis flatté plus d'une fois d'avoir ſaiſi les " circonſtances qui faiſoient tourner à coup ſûr le ré- " ſultat de l'experience d'un côté ou de l'autre; mais " la ſuite m'a fait connoître que je m'étois trompé, " ou qu'il manquoit encore quelque choſe à ma dé- " coverte."

I might add other quotations of the ſame kind, but, as it would take up too much of your Lordſhip's time, I ſhall beg leave to refer to the letter itſelf.

From the experience now obtained, it may not be improper to obſerve farther, that ſealing wax of different hardneſs, will occaſion a difference in the effects, the hardeſt being always *plus*, and the ſofteſt *minus*; which agrees very well with the rule laid down in the letter upon the Tourmalin, p. 331, " that where electric appearances are produced by " the rubbing of any two poliſhed bodies together, " that body, whoſe ſubſtance is hardeſt, and electric " power ſtrongeſt, will be always *plus*, and the ſofteſt " and weakeſt always *minus*." Now we find that the

the Dutch wax is ſofter than the Engliſh, and the Iriſh harder: and it is not improbable that the French wax, which I ſuppoſe the *Abbé Nollet* uſed, may likewiſe be different.

Whoever, therefore, may be deſirous of trying the preceding experiments, with a view to make them ſucceed, as they are here ſet down, muſt uſe the *beſt Engliſh ſealing wax.*

I ſhall conclude with an experiment made by my friend *Mr. Hamilton*, profeſſor of philoſophy in the univerſity of Dublin, as it ſeems to illuſtrate the doctrine of *reſiſtances*, at leaſt, ſo far as reſpects the air.

Let a ſlender braſs, or iron wire, five or ſix inches long, and finely pointed at each end, be fitted in the middle, with a braſs cap, void of angles; then let half an inch at each extremity be bent in oppoſite directions, till they are perpendicular to the reſt of the wire, and in ſuch a manner, that when the wire is ſuſpended, by means of its cap, on a point of metal, it may lie in a plane parallel to the horizon. The pointed metal, which ſupports this wire, muſt be two or three inches long, and have its other end fixed into a ſmall block of wood. Now, if this block, with a wire ſuſpended, be ſet upon an electrified body, the wire will turn round with a very great velocity, moving always in a direction contrary to that in which the electric fluid iſſues from its points, without having any conducting ſubſtance near it, ſave that of the air: and if the wire be made to turn round by any other force, in the oppoſite direction, ſo that its points go foremoſt, it will, when electrified, ſoon

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be deprived of that motion, and made to turn round the contrary way.

This experiment, he ſays, was contrived, in order to try whether the electric fluid, which iſſues ſo freely from pointed bodies, would have any effect to move theſe bodies by its reaction; and that it has ſuch an effect, ſeems ſufficiently manifeſt from the event.

Mr. Hamilton apprehends, that the electric particles, by their elaſtic force, iſſue directly forwards from the points, and endeavour to expand themſelves; but meeting with ſome reſiſtance from the air, force the wire to move backward in a contrary direction, much in the ſame manner that a Catherine-wheel is made to turn round in a direction, contrary to that in which the ſmall rockets affixed to its periphery diſcharge themſelves. And therefore, he is inclined to think, that it might be made uſe of as an electrometer, by having it to turn round in a plane perpendicular to the horizon, and loading the wire with ſmall weights near one of its extremities, which will be raiſed to a greater diſtance from the perpendicular line, as the electric fluid is ſtronger.

I am, my Lord,

Your Lordſhip's

moſt obliged

and obedient ſervant,

Benj. Wilſon.

Great Queen-Street,
Nov. 5, 1760.