VIII. *Further* * *Experiments and Obſervations, tending to illuſtrate the Nature and Properties of* Electricity: *By* Wm. Watſon, *Apothecary, F. R. S.*

Read Feb. 6. 1745-6. AS Water is a Non-electric, and of conſequence a Conductor of Electricity, I had Reaſon to believe, that Ice was endow'd with the ſame Properties. Upon making the Experiment I found my Conjectures not without Foundation; for, upon electrifying a Piece of Ice, wherever the Ice was touch'd by a Non-electric, it flaſhed and ſnapped. A Piece of Ice alſo, held in the Hand of an electrify'd Man, as in the beforementioned Proceſſes, fired warm Spirit, chemical vegetable Oils, Camphor, and Gunpowder prepared as before. But here great Care muſt be taken, that by the Warmth of the Hand, or of the Air in the Room, the Ice does not melt; if ſo, every Drop of Water therefrom conſiderably diminiſhes the received Electricity. In order to obviate this, I cauſed my Aſſiſtant, while he was electrifying, to be continually wiping the Ice dry upon a Napkin hung to the Buttons of his Coat; and this being electrified as well as the Ice, prevented any Loſs of the Force of the Electricity. The Experiment will ſucceed likewiſe, if, inſtead of the Ice, you electrify the Spirit, *&c.* and bring the Ice

* See the former Part of theſe Experiments in theſe *Tranſactions*, N°. 477. p. 481. *&c.*

Ice not electrified near them. I muſt obſerve, that Ice is not ſo ready a Conductor of Electricity as Water; ſo that I very frequently have been diſappointed in endeavouring with it to fire inflammable Subſtances, when it has been readily done by a Sword, or the Finger of a Man.

In the firſt Paper * I had the Honour to lay before you upon this Subject, I took notice of my having obſerved two different Appearances of the Fire from electrified Subſtances; *viz.* thoſe large bright Flaſhes, which may be procured from any Part of electrified Bodies, by bringing a Non-electric unexcited near them, and with which we have fired all the inflammable Subſtances mention'd in the Courſe of theſe Obſervations; and thoſe, like the firing of wet Gunpowder, which are only perceptible at the Points or Edges of excited Non-electrics. Theſe laſt alſo appear different in Colour and Form, according to the Subſtances from which they proceed: For, from poliſh'd Bodies, as the Point of a Sword, a Silver Probe, the Points of Sciſſors, and the Edges of the Steel Bar made magnetical by the ingenious Dr. *Knight*, the electrical Fire appears like a Pencil of Rays, agreeing in Colour with the Fire from *Boyle's Phoſphorus*; but from unpoliſhed Bodies, as the End of a Poker, a ruſty Nail, or ſuch-like, the Rays are much more red. The Difference of Colour here, I am of Opinion, is owing rather to the different Reflexion of the electrical Fire from the Surface of the Body, from which it is emitted, than to any Difference in the Fire itſelf. Theſe Pencils of Rays iſſue

* See theſe *Tranſactions*, N°. 477. p. 482, 483.

iſſue ſucceſſively as long as the Bodies, from which they proceed, are exciting; but they are longer and more brilliant, if you bring any Non-electric not excited near them, though it muſt not be cloſe enough to make them ſnap. If you hold your Hand at about two or three Inches Diſtance from theſe Points, you not only feel ſucceſſive Blaſts of Wind from them, but hear alſo a crackling Noiſe. Where there are ſeveral Points, you obſerve at the ſame time ſeveral Pencils of Rays.

It appears, from Experiments, that beſides the ſeveral Properties that Electricity is poſſeſs'd of peculiar to itſelf, it has ſome in common with Magnetiſm and Light.

Proposition I.

In common with Magnetiſm Electricity counteracts, and in light Subſtances overcomes the Force of Gravity. Like that extraordinary Power likewiſe, it exerts its Force *in Vacuo* as powerfully as in open Air, and this Force is extended to a conſiderable Diſtance through various Subſtances of different Textures and Denſities.

Corollary.

Gravity is the general Endeavour and Tendency of Bodies towards the Centre of the Earth: This is overcome by the Magnet, with regard to Iron, and by Electricity, with regard to light Subſtances, both in its Attraction and Repulſion; but I have never been able to diſcern that vortical Motion, by which this

Effect was ſaid to be brought about by the late Dr. *Deſaguliers* and others, having no other Conception of its Manner of acting than as Rays from a Centre, which indeed is confirmed by ſeveral Experiments: One of which, very eaſy to be tried, is, that if a ſingle downy Seed of Cotton-graſs is dropped from a Man's Hand, and in its Fall comes within the Attraction of the rubbed Tube; the Down of this Seed, which before ſeemed to ſtick together, ſeparates, and forms Rays round the Centre of the Seed: Or if you faſten many of theſe Seeds, with Mucilage of Gum-Arabic, round a Bit of Stick, the Down of them when electrified, which otherwiſe hangs from the Stick, is raiſed up, and forms a circular Appearance round the Stick. As theſe light Bodies are directed in their Motions only by the Force impreſſed upon them, and as their Appearance is conſtantly *radiatim*, ſuch Appearance by no means ſquares with our Idea of a *Vortex*.

Some have imagined a Polarity alſo, when they have obſerved one End of an excited glaſs Tube repel light Subſtances, and the other attract them; but this is a Deception, ariſing from the whole Length of the Tube not being excited, but only ſuch Part of it as has been rubb'd; ſo that as much of the Tube as is held in the Hand remains in an unexcited State, and permits light Subſtances to lie ſtill thereon, though forcibly repell'd at the other End. This attractive Power of Electricity acts not only upon Non-electrics, as Leaf-Gold, Silver, Thread, and ſuch-like, but alſo upon originally Electrics, as Silk, dry Feathers, little Pieces of Glaſs, and Reſin: It attracts all Bodies, that are not of the ſame Standard of Electricity (if I may be allowed

the Expreſſion), as the excited Body from which it proceeds. I have found no Body, however denſe, whoſe Pores are not pervious to Electricity, by a proper Management, not even Gold itſelf.

Proposition II.

In common with Light, Electricity pervades Glaſs, but ſuffers no Refraction therefrom; I having, from the moſt exact Obſervations, found its Direction to be in right Lines, and that through Glaſſes of different Forms, included one within the other, and large Spaces left between each Glaſs.

Corollary.

This rectilineal Direction is obſervable only as far as the Electricity can penetrate through unexcited Originally-electrics, and thoſe perfectly dry; nor is it at all material, whether theſe Subſtances are tranſparent, as Glaſs; ſemidiaphanous, as Porcelain, or thin Cakes of white Wax; or quite opaque, as thick woollen Cloth, as well as woven Silk of various Colours; it is only neceſſary that they be Originally-electrics. But the Caſe is widely different with regard to Non-electrics; wherein the Direction, given to the Electricity by the excited Originally-electric, is alter'd as ſoon as it touches the Surface of a Non-electric, and is propagated with a Degree of Swiftneſs ſcarcely to be meaſured in all poſſible Directions to impregnate the whole Non-electric Maſs in Contact with it, or nearly ſo, however different in itſelf; and which muſt of Neceſſity be terminated by an Originally-

Originally electric, before the Electricity exerts the leaſt Attraction; and then this Power is obſerved firſt at that Part of the Non-electric the moſt remote from the Originally-electric. Thus, for Example, by an excited Tube held over it, Leaf-Gold will be attracted through Glaſs, Cloth, *&c.* held horizontally in the Hand of a Man ſtanding upon the Floor, and this Attraction is exerted to a conſiderable Diſtance. On the contrary, the rubbed Tube will not attract Leaf-gold, or other light Bodies, however near, through Silver, Tin, the thinneſt Board, Paper, or any other Non-electric, held in the Manner before-mentioned. But if you rub the Paper over with Wax melted, and by that means introduce the Originally-electric therein, you obſerve the Electricity acts in right Lines, and attracts powerfully. And here I muſt beg Leave to remind you, not only of the former Corollary, but of ſome of the former Experiments alſo; by which it appears, that although, to make a Non-electric exert any Power, we muſt excite the whole Maſs thereof, yet we can excite what Part, and what only, of an Originally-electric we pleaſe. Thus we obſerve, that Leaf gold, and the Seed of Cottongraſs (which grows upon Boggs, and is a very proper Subject for theſe Inquiries), are attracted under a glaſs Jar made warm *, and turned Bottom upwards, upon which

* I have conſtantly obſerved, that the electrical Attraction through Glaſs is much more powerful when the Glaſs is made warm, than when cold. This Effect may proceed from a twofold Cauſe: Firſt, Warm Glaſs does not condenſe the Water from the Air, which makes

which are placed Books, and ſeveral other Non-electrics; and that the Motions of the light Bodies underneath correſpond with the Motions of the glaſs Tube held over them, the Electricity ſeeming inſtantaneouſly to paſs through the Books and the Glaſs. But this does not happen, till the Electricity has fully impregnated the Non-electrics, which lie upon the Glaſs; which received Electricity is ſtopped by the Glaſs; and then theſe Non-electrics dart their Power directly through the upper Part of the Glaſs, after the Manner of Originally-electrics. But if the thinneſt Non-electric, even the fineſt Paper, as I before mentioned, is held in the Hand of a Man at the ſmalleſt Diſtance over the Leaf-Gold, and the Electricity is not ſtopped, not the leaſt Power will be exerted, and the Gold will lie ſtill. I muſt here remark likewiſe, that this Law of Electricity is ſo conſtant and regular, that I have not found one Deviation from it; ſo that even the Quickſilver, ſpread thin, as it uſually is at the Back of a Plate of a Looking-glaſs, will prevent the Paſſing thro' of the electrical Attraction, unleſs ſtopped by an Originally-electric. This Penetration of the electrical Power through Originally-electrics is much greater than has hitherto been imagined, and has cauſed the Want of Succeſs to great Numbers of Experiments. I have been at no ſmall

---

makes the Glaſs, as has been before ‡ demonſtrated, a Conductor of Electricity: Secondly, As Heat enlarges the Dimenſions of all known Bodies, and, conſequently cauſes their conſtituent Parts to recede from each other, the electrical *Effluvia*, paſſing in ſtrait Lines, find, probably, a more ready Paſſage through their Pores.

‡ See *Numb.* 477, of theſe *Tranſactions*, p. 486.

ſmall Pains to determine, how far this Power can penetrate through a dry Originally-electric; and have found, by repeated Trials, that either in a Cake of Wax alone, or of Wax and Reſin mixed, when the Electricity is very powerful, it has paſſed, I ſay, in ſtrait Lines through theſe Cakes of the Thickneſs of 2 Inches and $\frac{4}{10}$; but I never could make it act through one of 2 Inches and $\frac{8}{10}$; for in this it was perfectly ſtopped. So that the Cakes commonly made uſe of to ſtop the Electricity, by being too thin, ſuffer a conſiderable Quantity of the electrical Power to pervade them, and be loſt in the Floor. I make no Doubt, if the electrical Power could be more increaſed, it would penetrate much further through theſe Originally-electric Bodies.

Proposition III.

Electricity, in common with Light likewiſe, when its Forces are collected, and a proper Direction given thereto, upon a proper Object, produces Fire and Flame.

Corollary.

The Fire of Electricity (as I have before obſerved) is extremely delicate; and ſets on fire, as far as I have yet experienced, only inflammable Vapours. Nor is this Flame at all heightened, by being ſuperinduced upon an iron Rod, red-hot with coarſer culinary Fire, as in a preceding Experiment; nor diminiſhed by being directed upon cold Water. However I was deſirous of knowing, if this Flame would

would be affected by a ſtill greater Degree of Cold; and in order to determine this, I made an artificial Cold; by which the Mercury, in a very nice Thermometer adjuſted to *Fahrenheit*'s Scale, was depreſſed in about 4 Minutes, from 15 Degrees above the freezing Point to 30 Degrees below it; that is, the Mercury fell 45 Degrees. From this cold Mixture, when electrified, the Flaſhes were as powerful, and the Stroke as ſmart, as from the red-hot Iron. I could have made the Cold more intenſe, but the above was ſufficient for my Purpoſe. This Experiment ſeems to indicate, that the Fire of Electricity is affected neither by the Preſence or Abſence of other Fire. For as red-hot Iron, by Sir *Iſaac Newton*'s Scale of Heat, is fixed at 192 Degrees, and as the *Ratio* between Sir *Iſaac*'s Degrees and *Fahrenheit*'s is as 34 to 180, it neceſſarily follows, that the Difference of Heat between the hot Iron and the cold Mixture is 1040 Degrees; and nevertheleſs this vaſt Difference makes no Alteration in the Appearance of the electrical Flame. We find likewiſe, that as the Fire, ariſing from the Refraction of the Rays of Light by a *Lens*, and brought to a *Focus*, is obſerved, firſt, at ſome ſmall Diſtance from their Surfaces, to ſet on Fire combuſtible Subſtances; the ſame Effect, as I have before obſerv'd, is produced in like manner by electrical Flame.

I may perhaps be thought too minute in ſome of the before-mentioned Particulars; but, in Inquiries abſtruſe as theſe are, where we have ſo little *a priori* to direct us, the greateſt Attention muſt be had to every Circumſtance, if we are truly deſirous of in-

veſtigating the Laws of this ſurpriſing Power. For, as has been ſaid upon another Occaſion, by my ever honoured Friend *Martin Folkes*, Eſq; our moſt worthy *Preſident*, " That Electricity ſeems to furniſh " an inexhauſtible Fund for Inquiry: And ſure " *Phænomena* ſo various, and ſo wonderful, can ariſe " only from Cauſes very general and extenſive; and " ſuch as muſt have been deſigned by the Almighty " AUTHOR of Nature for the Production of very " great Effects, and ſuch as are of great Moment " to the Syſtem of the Univerſe."

If theſe Obſervations receive the Countenance of this learned *Society*, I ſhall think myſelf ſufficiently recompenſed; and am, Gentlemen,

With the higheſt Eſteem,

Your moſt Obedient

Humble Servant,

W. Watſon.