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*** START OF THE PROJECT GUTENBERG EBOOK EXPERIMENTS AND OBSERVATIONS TENDING TO ILLUSTRATE THE NATURE AND PROPERTIES OF ELECTRICITY ***

EXPERIMENTS AND OBSERVATIONS

TENDING TO ILLUSTRATE THE
NATURE
AND
PROPERTIES
OF
ELECTRICITY.

In one LETTER to *Martin Folkes*, Esq; President,
and Two to the *Royal Society*.

By *WILLIAM WATSON*, F. R. S.

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THE PREFACE.

The following Sheets were not intended to be made publick, but as part of the Philosophical Transactions. As those Works are printed in the order of Time they are read; these Observations, communicated to the ROYAL SOCIETY at different Meetings, would, upon that Account, have been publish'd separate in different Numbers of those Transactions. To satisfy therefore the Impatience of several learned and very valuable Friends, to whose Importunities I have neither Will, nor Inclination to deny any thing in my Power to grant, I caused a few Copies to be printed, that the whole might be seen together, and then broke up the Press. This has excited the Curiosity of the Publick, and raised a Demand for these Experiments much beyond what I had reason to expect. I therefore found it necessary to send them to the Press a second Time, lest some of those over-officious Gentlemen, who are always ready on these Occasions, should do it for me; so that whoever has an Inclination, may now be made acquainted, by what Means the several surprizing Phænomena of Electricity have been brought about.

I chose to lay these Papers before the Publick in the same Dress wherein they appeared before the very honourable and learned Body, to whom, as the various Effects of Electricity presented themselves, they were regularly communicated, and from whom they met with a very favourable Reception. Many Members of the ROYAL SOCIETY, as well as several other Persons of great Rank and Quality, have been repeated Witnesses of the Facts which are here laid before the World; particularly the present worthy President, MARTIN FOLKES, Esq; whose extensive Abilities and great Knowledge in every Branch of useful Literature are exceeded only by his Candour and Zeal in promoting Science. The Advice and Assistance of this Gentleman, whose Friendship I shall always esteem as one of the greatest Happinesses of my Life, has been of great Moment in the Prosecution of these Discoveries. I therefore take this publick Manner of testifying my sincerest Obligations as well to him, as to Sir HANS SLOANE, Bart. who, although retired from Business, is nevertheless attentive to whatever tends to the Advancement of Philosophy. Upon a Report made to him of these Experiments and Observations, he, as surviving Executor of Sir GODFREY COPLEY, was pleased to appoint me last Year to receive the annual Prize-medal of Gold, given by the ROYAL SOCIETY in consequence of Sir GODFREY'S Benefaction. The Honour of being so particularly taken notice of by Gentlemen of such distinguished Merit, as it cannot but give me the highest Pleasure, so shall it ever continue to raise in me Sentiments of the truest Gratitude, and most profound Respect.

IF it should be asked, to what useful Purposes the Effects of Electricity can be applied, it may be answered, that we are not as yet so far advanced in these Discoveries as to render them conducive to the Service of Mankind. Perfection in any Branch of Philosophy is to be attained but by slow Gradations. It is our Duty to be still going forward; the rest we must leave to the Direction of that Providence, which we know assuredly, has created nothing in vain. But I make no Scruple to assert, that notwithstanding the great Advances, which have been made in this part of natural Philosophy within these few Years, many and great Properties remain still undiscover'd. Future Philosophers (some perhaps even of the present Age) may deduce from electrical Experiments, Uses extremely beneficial to Society in general.

NO present Advantage accrued to those Persons, or to that Age, which first discover'd the Properties of the Magnet. Many hundreds of Years interven'd, before they were applied to the great Uses of Navigation. Had these remain'd a secret till now, what other Methods could have been substituted in their Place, by which we could securely traverse the vast Ocean? All the Advantages we receive from distant Commerce, we must still have been Strangers to, but for this fortunate Application of the magnetical Power. And even the Discoveries thus far had been very imperfect, without the Knowledge of the Variation of the Compass. But the present Age, and even this Nation, boasts of a Gentleman^[1], who seems to be entrusted with the magnetical Powers themselves. He makes artificial Magnets, increases in a few Minutes the Powers of real ones to a surprizing Degree, changes at Pleasure their Poles, and makes that newly acquired Polarity, permanent. The World, I hope, will not long be deprived of the Manner, by which these extraordinary Changes are produced, which as yet this Gentleman thinks proper to conceal. As Electricity has some Properties in common with Magnetism, as will be shewn in the Course of these Observations; some new Lights probably may be thrown upon both. But to return; admitting even, that no substantial Advantages could arise from the Inquiries before us, (which, however, we can by no means grant, upon our considering the Effects we already perceive of its Operations upon human Bodies) whatever tends to enlarge the Conceptions of the Mind, and to implant in us still more lofty Ideas of the Almighty Author of Nature, deserves certainly, independent of other Considerations, our highest Regard.

THESE Experiments were all made with Glass Tubes of about two Foot long; the bore about an Inch in Diameter. But a scrupulous Exactness in these Proportions is no ways necessary. The thinner and lighter these Tubes are, the sooner they are excited; though they, 'tis true, don't retain their Power so long as those, which are more thick and substantial. But where you intend to communicate the electrical Power, as fast as you excite it, I should prefer a light Tube; though it ought never to be less than 1/12 of an Inch thick, because of the Danger of breaking it by the Friction.

THE Tube, before it is rubbed, should be always made dry and warm, which may be done by laying it before the Fire. But I cannot omit hereupon making one further Remark; viz. that Glass Tubes, exactly of the same Dimensions, made at the same Time, and with the same Materials, vary considerably with regard to their fitness for electrical Purposes. Clear and dry Air with some degree of cold is most eligible, though I have succeeded in the greatest Fogs, but with more Difficulty.

TO
Martin Folkes, Esq;
P. R. S.

SIR,

THE Society having heard from some of their Correspondents in *Germany*, that what they call a Vegetable Quintessence had been fired by Electricity, I take this Opportunity to acquaint you, that on *Friday* Evening last I succeeded, after having been disappointed in many Attempts, in setting Spirits of Wine on Fire by that Power. The preceding Part of the Week had been remarkably warm, and the Air very dry, than which nothing is more necessary towards the Success of Electrical Trials; to these I may add, that the Wind was then Easterly and inclining to freeze. I that Evening used a glass Sphere as well as a Tube; but I always find myself capable of sending forth much more Fire from the Tube than from the Sphere, probably from not being sufficiently used to the last.

I HAD before observ'd, that although^[2] Non-electric Bodies made electrical, lose almost all that Electricity by coming either within or near the Contact of *Non-electrics* not made electrical; it happens otherwise with Regard to *Electrics per se*, when excited by rubbing, patting, &c; because from the rubbed Tube I can sometimes procure five or six Flashes from different Parts, as though the Tube of two Foot long, instead of being one continued Cylinder, consisted of five or six separate Segments of Cylinders, each of which gave out its Electricity at a different Explosion.

THE Knowledge of this Theorem is of the utmost Consequence towards the Success of electrical Experiments; inasmuch as you must endeavour by all possible Means to collect the Whole of this Fire at the same Time. Professor *Hollman* seems to have endeavour'd at this and succeeded, by having a tin Tube, in one End of which he put a great many Threads, whose Extremities touch'd the Sphere when in Motion, and each Thread collected a Quantity of electrical Fire, the Whole of which center'd in the tin Tube, and went off at the other Extremity. Another Thing to be observ'd, is to endeavour to make the Flashes follow each other so fast, as that a Second may be visible before the First is extinguish'd. When you transmit the electrical Fire along a Sword or other Instrument, whose Point is sharp, it often appears as a Number of disseminated Sparks, like wet Gunpowder or *Wild-fire*; but if the Instrument has no Point, you generally perceive a pure bright Flame, like what is vulgarly call'd the *Blue-ball*, which gives the Appearance of Stars to fired Rockets.

THE following is the Method I made use of and was happy enough to succeed in. I suspended a Poker in silk Lines; at the Handle of which I hung several little Bundles of white Thread, the Extremities of which were about a Foot at right Angles from the Poker. Among these Threads, which were all attracted by the rubbed Tube, I excited the greatest electrical Fire I was capable, whilst an Assistant near the End of the Poker held in his Hand a Spoon, in which were the warm Spirits. Thus the Thread communicated the Electricity to the Poker, and the Spirit was fired at the other End. It must be observ'd in this Experiment, that the Spoon with the Spirit must not touch the Poker; if it does, the Electricity without any flashing is communicated to the Spoon, and to the Assistant in whose Hand it is held, and so is lost in the Floor.

By these Means, I fired several Times not only the ætherial Liquor or Phlogiston of *Frobenius* and rectified Spirit of Wine, but even common proof Spirit. These Experiments, as I before observ'd, were made last *Friday* Night, the Air being perfectly dry. *Sunday* proved wet and *Monday* somewhat warm, so that the Air was full of Vapour; Wind South-West and cloudy. Under these Disadvantages, on *Monday* Night I attempted again my Experiments; they succeeded, but with infinitely more Labour than the preceeding, because of the Unfitness of the Evening for such Trials. *Your Candour* will not permit you to think my Minuteness trivial, with Regard to the Circumstances of the Weather, who know, how many Things must concur to make these Experiments succeed. I shall wait with Impatience for a proper Opportunity to have these Experiments repeated in your Presence, and am, with the utmost Respect,

*Sir, your most obedient,
humble Servant,*

W. WATSON.

*Aldersgate-Street,
March 27. 1746.*

TO THE
ROYAL SOCIETY.

GENTLEMEN,

I lately acquainted you, that I had been able to fire Spirit of Wine, *Phlogiston* of *Frobenius*, and common proof Spirit, by the Power of Electricity. Since which (till Yesterday) we have had but one very dry fine Day; *viz. Monday, April 15.* Wind E. N. E.; when about four o'Clock in the Afternoon, I got my *Apparatus* ready, and fired the Spirit of Wine four Times from the Poker as before, three Times from the Finger of a Person electrified, standing upon a Cake of Wax, and once from the Finger of a second Person standing upon Wax, communicating with the first by means of a walking Cane held between their Arms extended. The horizontal Distance in this Case between the glass Tube and the Spirit was at least ten Feet. 10

You all know, that there is the repulsive Power of Electricity, as well as the attractive; inasmuch as you are able, when a Feather or such-like light Substance is replete with Electricity, to drive it about a Room, which Way you please. This repulsive Power continues, until either the Tube loses its excited Force, or the Feather attracts the Moisture from the Air, or comes near to some non-electric Substance; if so, the Feather is attracted by, and its Electricity lost in, whatever Non-Electric it comes near. In electrified Bodies, you see a perpetual Endeavour to get rid of their Electricity. This induced me to make the following Experiment. I placed a Man upon a Cake of Wax, who held in one of his Hands a Spoon with the warm Spirits, and in the other a Poker with the Thread. I rubbed the Tube amongst the Thread, and electrified him as before. I then ordered a Person not electrified to bring his Finger near the Middle of the Spoon; upon which, the Flash from the Spoon and Spirit was violent enough to fire the Spirit. This Experiment I then repeated three Times. In this Method, the Person by whose Finger the Spirit of Wine is fired, feels the Stroke much more violent, than when the electrical Fire goes from him to the Spoon. This Method for the Sake of Distinction, we will call the repulsive Power of Electricity. 11

THE late Dr. *Desaguliers* has observed in his excellent Dissertation concerning Electricity, "That there is a Sort of Capriciousness attending these Experiments, or something unaccountable in their Phænomena, not to be reduced to any Rule. For sometimes an Experiment, which has been made several Times successively, will all at once fail." Now I imagine that the greatest Part, if not the Whole of this Matter, depends upon the Moisture or Dryness of the Air, a sudden though slight Alteration in which, perhaps not sufficient to be obvious to our Faculties, may be perceived by the very subtle Fire of Electricity. For 12

1st, I CONCEIVE, that the Air itself (as has been observed by Dr. *Desaguliers*) is an *Electric per se* and of the vitreous Kind; therefore it repels the Electricity arising from the glass Tube, and disposes it to electrify whatever non-electrical Bodies receive the Effluvia from the Tube.

2dly, THAT Water is a *non-Electric*, and of Consequence a Conductor of Electricity; this is exemplified by a Jett of Water being attracted by the Tube, *from either Electric's per se* conducting Electricity, and *non-Electric's* more readily when wetted; but what is more to my present Purpose, is, that if you only blow through a dry glass Tube, the Moisture from your Breath will cause that Tube to be a Conductor of Electricity. 13

THESE being premised; in proportion as the Air is replete with watery Vapours, the Electricity arising from the Tube, instead of being conducted as proposed, is, by means of these Vapours, communicated to the circum-ambient Atmosphere and dissipated as fast as excited.

THIS Theory has been confirmed to me by divers Experiments, but by none more remarkably than on the Evening of the Day I made those before-mention'd; when the Vapours, which in the Afternoon by the Sun's Heat, and a brisk Gale were dissipated, and the Air perfectly dry, descended again in great Plenty upon the Absence of both, and the Evening was very damp. For between seven and eight o'Clock, I attempted again the same Experiments in the same Manner, without being able to make any of them succeed; though all those mention'd in this Paper with others of less Note, were made in Half an Hour's Time. 14

I AM the more particular in this, being willing to save the Labour of those, who are desirous of making these Kind of Trials; for although some of the lesser Experiments may succeed almost at any Time, yet I never could find that the more remarkable ones would succeed but in dry Weather. 15

*I am, Gentlemen,
Your most obedient,
humble Servant,
W. WATSON.*

*London, April
25. 1745.*



TO THE
ROYAL SOCIETY.

GENTLEMEN,

IN some Papers I lately did myself the Honour to lay before you, I acquainted you of some Experiments in Electricity; particularly I took notice of having been able to fire Spirit of Wine by what I call'd the repulsive Power thereof; which I have not heard had been thought of by any of those *German* Gentlemen, to whom the World is obliged for many surprizing Discoveries in this Part of natural Philosophy.

How far strictly speaking the Spirit in this Operation may be said to be fired by the repulsive Power of Electricity, or how far that Power, which repels light Substances when fully impregnated with Electricity, fires the Spirit, may probably be the Subject of a future Inquiry; but as I am unwilling to introduce more Terms into any Demonstration than what are absolutely necessary for the more ready Conception thereof, and as inflammable Substances may be fired by Electricity two different Ways, let the following Definitions at present suffice of each of these Methods.

BUT first give me Leave to premise, that no inflammable Substances will take fire, when brought into or near the Contact of *Electrics per se* excited to Electricity. This Effect must be produced by non-electrical Substances impregnated with Electricity received from the exciting *Electrics per se*. But to return,

1st, I SUPPOSE that inflammable Substances are fired by the attractive Power of Electricity, when this Effect arises from their being brought near excited non-Electrics.

2dly, THAT inflammable Substances are fired by the repulsive Power of Electricity; when it happens, that the inflammable Substances, being first electrified themselves, are fired by being brought near non-Electrics not excited.

THIS Matter will be better illustrated by an Example. Suppose that either a Man standing upon a Cake of Wax, or a Sword suspended in silk Lines are electrified, and the Spirit, being brought near them, is fired, this is said to be perform'd by the attractive Power of Electricity. But if the Man electrified as before holds a Spoon in his Hand containing the Spirit, or the same Spoon and Spirit are placed upon the Sword, and a Person not electrified applies his Finger near the Spoon, and the Spirit is fired from the Flame arising from the Spoon and Spirit upon such Application; this I call being fired by the repulsive Power. Of the two mention'd Kinds I generally find the repulsive Power strongest.

SINCE my last Communication, the Spirit has been fired both by the attractive and repulsive Power through four Persons standing upon electrical Cakes; each communicating with the other either by the Means of a walking Cane, a Sword, or any other non-electric Substance. It has likewise been fired from the Handle of a Sword held in the Hand of a third Person.

I HAVE not only fired *Frobenius's* Phlogiston, rectified-spirit and common proof-spirit, but also Sal volatile Oleosum, Spirit of Lavender, dulcified Spirit of Nitre, Peony Water, *Daffy's* Elixir, *Helvetius's* Stiptic, and some other Mixtures where the Spirit has been very considerably diluted; likewise distilled vegetable Oils, such as that of Turpentine, Lemon, Orange Peels and Juniper, and even those of them, which are specifically heavier than Water, as Oil of Sassafras; also resinous Substances, such as Balsam Capiivi and Turpentine; all which send forth, when warmed, an inflammable Vapour. But expressed vegetable Oils, as those of Olives, Linseed, and Almonds, as well as Tallow, all whose Vapours are uninflamable, I have not been able yet to fire; but these indeed will not fire on the Application of lighted Paper. Besides, if these last would fire with lighted Paper, unless their Vapours were inflammable, I can scarce conceive they would fire by Electricity; because in firing Spirits, &c. I always perceive that the Electricity snaps before it comes in Contact with their Surfaces, and therefore only fires their inflammable Vapours.

As an excited non-Electric emits almost all its Fire, if once touch'd by a non-Electric not excited, I was desirous of being satisfy'd, whether or no the Fire emitted would not be greater or less in proportion to the Volume of the electrified Body. In order to this I procur'd an Iron Bar about five Feet long and near 170 Pounds in Weight; this I electrified lying on Cakes of Wax and Rosin, but observed the Flashes arising therefrom not more violent than those from a common Poker. In making this Experiment, being willing to try the repulsive Force, it once happen'd that whilst the Bar was at one End electrifying, a Spoon lay upon the other, and upon an Assistant's pouring some warm Spirit into the Spoon, the electrical Flash from the Spoon snapped and fired the first Drop of the Spirit, which unexpectedly fired not only the whole Jett as it was pouring, but kindled likewise the whole Quantity in the Pot, in which I usually have it warm'd.

I FIND, in firing inflammable Substances from the Finger of a Man standing upon Wax, that *cæteris paribus* the Success is more constant, if the Man instead of holding the Thread (the Use of which I communicated in a former Paper) in his Hand, the Thread is suspended at the End of an Iron Rod held in one Hand, and he touches the Spirit with one of the Fingers of the other.

IF a Man, standing upon the electrical Cake with a Dish or deep Plate of Water in one Hand, and the Iron Rod with the Thread in the other, is made electrical; and a Person not electrified touches any Part either of the Plate or Water, the Flashes of Fire come out plentifully, and wherever you bring your Finger very near, the Water rises up in a little Cone, from the Point of which the Fire is produced, and your Finger, though not in actual Contact, is made wet. The same Experiment

succeeds through three or more People.

IN firing inflammable Substances, the Person who holds the Spoon in his Hand to receive the electrical Flashes, when the Finger of the electrified Person is brought near thereto, not only feels a tingling in his Hand, but even a slight Pain up to his Elbow. This is most perceptible in dry Weather, when the Electricity is very powerful.

THERE is a considerable Difficulty in firing *Electrics per se*, such as Turpentine, and Balsam Capivi, by the repulsive Power of Electricity; because in this Case these Substances will not permit the Electricity to pass through them; therefore when you would have this Experiment succeed, the Finger of the Person, who is to fire them, is to be applied as near to the Edge as possible of these Substances when warm'd in a Spoon, that the Flashes from the Spoon (for these Substances will emit none) may snap, where they are spread the thinnest, and then fire their Effluvia. This Experiment, as well as several others, serves to confute that Opinion, which has prevail'd with many, that the Electricity floats only upon the Surfaces of Bodies. 24

IF an electrical Cake is dipp'd in Water, it is thereby made a Conductor of Electricity, the Water hanging about it transmitting the electrical Effluvia in such a manner, that a Person standing thereon can by no means be electrified enough to attract the leaf Gold at the smallest Distance; though the Person standing upon the same Cake when dry, attracted a Piece of fine Thread hanging at the Distance of two Feet from his Finger. We must here observe that the Cake being of an unctuous Substance, the Water will no where lie uniformly thereon, but adhere in separate Moleculæ; so that in this Instance the Electricity jumps from one Particle of Water to another, till the Whole is dissipated. 25

FROM the Appearance of the Threads amongst which I rub the Tube, I can frequently judge, though the Spirit may be many Feet distant from them, whether or no it will fire; because when the Persons standing upon the Wax are made electrical enough to fire the Spirit, the Threads repel each other at their lower Parts, where they are not confin'd, to a considerable Distance, and this Distance is in Proportion as the Threads are made electrical.

IF two Persons stand upon electrical Cakes at about a Yard's Distance from each other, one of which Persons, for the Sake of Distinction, we will call A, the other B: If A when electrified touches B, A loses almost all his Electricity at that Touch only, which is receiv'd by B and stopp'd by the electrical Cake; if A is immediately electrified again to the same Degree as before and touches B, the Snapping is less upon the Touch; and this Snapping, upon electrifying A, grows less and less, till B being impregnated with Electricity, though receiv'd at Intervals, the Snapping will no longer be sensible. 26

THAT Glass will repel and not conduct the Electricity of Glass, has been mention'd by others, who have treated of this Subject; but the Experiments to determine this Matter must be conducted with a great deal of Caution; for unless the glass Tube, intended to conduct the Electricity, be as warm as the external Air, it will seem to prove the contrary, unless in very dry Places and Seasons. Thus, I sometimes have brought a cold, though dry, Glass Tube near three Feet long into a Room, where there has been a Number of People; when upon placing the Tube upon Silk Lines, and laying some Leaf Silver upon a Card at one End and rubbing another Glass Tube at the other, the Silver has, contrary to Expectation, been thrown off as readily as from an Iron Rod. At first I was surpriz'd at this Appearance, but then conjectur'd, that it must arise from the Coldness of the Glass, condensing the floating Vapour of the Room; in Order then to obviate this, I warm'd the Tube sufficiently, and this Effect was no longer produced, but the Silver lay perfectly still. 27

IF a Number of Pieces of finely spun Glass cut to about an Inch in Length, little bits of fine Wire of the same Length of what Metal you please, and small Cork Balls, are either put all together, or each by themselves, into a dry pewter Plate, or upon a Piece of polish'd Metal, they make in the following Manner a very odd and surprizing Appearance. Let a Man, standing upon electrical Cakes, hold this Plate in his Hand with the bits of Glass, Wire, &c. detached from each other, as much as conveniently may be; when he is electrified, let him cause a Person standing upon the Ground to bring another Plate, his Hand, or any other Non-Electric, exactly over the Plate containing these Bodies. When his Hand, &c. is about eight Inches over them, let him bring it down gently: As it comes near, in proportion to the Strength of the Electricity, he will observe the bits of Glass first raise themselves upright; and then, if he brings his Hand nearer, dart directly up and stick to it without snapping. The bits of Wire will fly up likewise, and as they come near the Hand, snap aloud; you feel a smart Stroke, and see the Fire arising from them to the Hand at every Stroke; each of these, as soon as they have discharged their Fire, falls down again upon the Plate. The Cork Balls also fly up, and strike your Hand, but fall again directly. You have a constant Succession of these Appearances as long as you continue to electrify the Man, in whose Hand the Plate is held; but if you touch any part either of the Man or Plate, the Pieces of Glass, which before were upon their Ends, immediately fall down. 28

SOME few Years ago, Sir *James Lowther* brought some Bladders fill'd with inflammable Air, collected from his Coal-mines, to the Royal Society. This Air flam'd upon a lighted Candle being brought near it. This Inflammability has occasion'd many terrible Accidents. Mr. *Maud*, a worthy Member of this Society, made at that Time by Art, and shew'd the Society, Air exactly of the same Quality. I was desirous of knowing if this Air would be kindled by electrical Flashes. I accordingly made such Air by putting an Ounce of Filings of Iron, an Ounce of Oil of Vitriol and four Ounces of Water into a Florence Flask; upon which an Ebullition ensued, and the Air, which arose from these Materials, not only fill'd three Bladders, but also, upon the Application of the Finger of an Electrified Person, took Flame and burnt near the Top and out of the Neck of the Flask a considerable Time. When the Flame is almost out, shake the Flask and the Flame revives. You must with your Finger dipped in 29

Water, moisten the Mouth of the Flask as fast as it is dried by the Heat within, or the Electricity will not fire it: Because the Flask being an Electric *per se* will not snap at the Application of the Finger, without the Glass being first made non-electric by wetting. It has sometimes happen'd, if the Finger has been applied before the inflammable Air has found a ready Exit from the Mouth of the Flask, that the Flash has fill'd the Flask, and gone off with an Explosion equal to the firing of a large Pistol, and sometimes indeed it has burst the Flask. The same Effect is produced from the Spirit of Sea Salt, as from Oil of Vitriol; but as the Acid of Sea Salt is much lighter than that of Vitriol, there is no Necessity to add the Water in this Experiment.

THOSE who are not much acquainted with Chemical Philosophy, may think it very extraordinary, that from a Mixture of cold Substances, which both conjunctly and separately are unflammable, this very inflammable Vapour should be produced. In order to solve this, it may not be improper to premise, that Iron is compounded of a Metallic as well as a sulphurous Part. This Sulphur is so fix'd, that, after heating the Iron red hot, and even melting it ever so often, the Sulphur will not be disengaged therefrom: But upon the Mixture of the Vitriolic Acid, and by the Heat and Ebullition which are almost instantly produced, the Metallic Part is dissolved, and the Sulphur, which before was intimately connected therewith, being disengaged, becomes volatile. This Heat and Ebullition continues 'till the Vitriolic Acid is perfectly saturated with the Metallic Part of the Iron, and the Vapour once fired continues to flame, until this Saturation being effected, no more of the Sulphur flies off.

I HAVE heretofore mentioned, how considerably perfectly dry Air conduces to the Success of these Experiments; but we have been lately informed by an Extract of a Letter, that *Abbé Nolet* was of Opinion, that they would succeed in wet Weather, provided the Tubes were made of Glass, tinged blue with Zaffer. I have procured Tubes of this Sort, but, after giving them many candid Trials, I cannot think them equal to their Recommendation. I first tried one of them in a smart Shower of Rain after a dry Day, when the Drops were large, and the Spirit fired three Times in about four Minutes; the same Effect succeeded, under the same Circumstances, from the white one; but after three or four Hours raining, when the Air was perfectly wet, I never could make it succeed. And to illustrate this Matter further, I have been able when the Weather has been very dry, with once rubbing my Hand down this blue Tube, and applying it to the End of an Iron Rod six Feet long, to throw off several Pieces of Leaf-Silver lying upon a Card at the other End of this Rod, whereas I never have been able to throw it off by any Means in very wet Weather. Besides, I am of Opinion, that after the Electrical Fire is gone from the Tube, the Tube has no Share in the conducting of it; my Sentiments on that Head I laid before you in a former Paper: For if the Silk Lines are wetted, they diffuse all the Electricity, and the same Effects happen when the Air is wet, be your Glass of what Colour it will. It may not be improper here to observe, that Zaffer, which is used by the Glass-makers and Enamellers, is made of Cobalt or Mundick calcin'd after the subliming the Flowers. This being reduced to a very fine Powder, and mixt with twice or thrice its own Weight of finely powdered Flints, is moisten'd with Water and put up in Barrels, in which it soon runs into a hard Mass and is call'd Zaffer.

A DRY Sponge hanging by a Pack-thread at the End of an electrified Sword, or from the Hand of an electrified Man, gives no Signs of being made electrical; if it is well soak'd in Water, wherever it is touched, you both see and feel the electrical Sparks. Not only so, but if it is so full of Water, that it falls from the Sponge, those Drops in a dark Room, receiv'd upon your Hand, not only flash and snap, but you perceive a pricking Pain. If you hold your Hand, or any non-electrical Substances, very near, the Water which had ceased dropping when the Sponge was not electrified, drops again upon its being electrified, and the Drops fall in Proportion to the receiv'd Electricity, as though the Sponge were gently squeez'd between your Fingers. I was desirous to know if I was able to electrify a Drop of cold Water, dropping from the Sponge, enough to fire the Spirit; but after many unsuccessful Trials, I was forced to desist; because the cold Water dropping from the Sponge not only cool'd the Spirit too much, but also render'd it too weak; likewise, every Drop carried with it great Part of the Electricity from the Sponge. I then consider'd, in what Manner, I could give a Tenacity to the Water, sufficient to make the Drops hang a considerable Time, and this I brought about by making a Mucilage of the Seeds of Fleawort. A wet Sponge then, squeez'd hard and fill'd with this cold Mucilage, was held in the Hand of an electrified Man, when the Drops forced out by the Electricity, assisted by the Tenacity of the Liquor, hung some Inches from the Sponge, and by a Drop of this I fir'd not only the Spirit of Wine, but likewise the inflammable Air before mentioned, both with and without the Explosion. What an extraordinary Effect is this! That a Drop of cold Water (for the Seeds contribute nothing but add Consistence to the Water) should be the Medium of Fire and Flame.

CAMPHOR is a vegetable Resin, and of Consequence an Electric *per se*. This Substance, notwithstanding its great Inflammability, will not take fire from the Finger of a Man or any other Body electrified, though made very warm and the Vapours arise therefrom in great Abundance. Because, neither Electric's *per se* excited, or electrified Bodies, exert their Force by snapping upon Electric's *per se*, though not excited. If you break Camphor small and warm it in a Spoon, it is not melted by Heat like other Resins; but if that Heat were continued it would all prove volatile. To Camphor thus warm'd, the Finger of an electrified Man, a Sword or such-like, will in snapping exert its Force upon the Spoon, and the circum-ambient Vapour of the Camphor will be fired thereby, and light up the whole Quantity exposed. The same Experiment succeeds by the repulsive Power of Electricity.

A POKER thoroughly ignited put into Spirit of Wine, or into the distilled Oil of Vegetables, produces no Flame in either; it indeed occasions the Vapours to arise from the Oil in great Abundance. But if you electrify this heated Poker, the electrical Flashes presently kindle Flame in either. The

Experiment is the same with Camphor. These Experiments, as well as the following, sufficiently evince, that the electrical Fire is truly Flame, and that extremely subtil.

I HAVE made several Trials in order to fire Gunpowder alone, which I tried both warm and cold, whole and powder'd, but never could make it succeed; and this arises in part from its Vapours not being inflammable, and in part from its not being capable of being fir'd by Flame, unless the Sulphur in the Composition is nearly in the State of Accension. This we see by putting Gunpowder into a Spoon with rectified Spirit, which, when lighted, will not fire the Powder, 'till by the Heat of the Spoon from the burning Spirit, the Sulphur is almost melted. Likewise, if you hold Gunpowder ground very fine in a Spoon over a lighted Candle, or any other Flame, as soon as the Spoon is hot enough to melt the Sulphur, you see a blue Flame, and instantly the Powder flashes off. The same Effects are observ'd in the *Pulvis fulminans*, compos'd of Nitre, Sulphur, and fixed Alkaline Salt. Besides, when the Gunpowder is very dry and ground very fine, it (as you please to make the Experiment) is either attracted, or repell'd; so that in the first Case, the End of your Finger when electrified, shall be cover'd over with the Powder, though held at some Distance; and in the other, if you electrify the Powder, it will fly off at the Approach of any non-electrified Substance, and sometimes even without it. But I can at Pleasure fire Gunpowder, and even discharge a Musket, by the Power of Electricity, when the Gunpowder has been ground with a little Camphor or with a few Drops of some inflammable chemical Oil. This Oil somewhat moistens the Powder, and prevents its flying away; the Gunpowder then being warm'd in a Spoon, the electrical Flashes fire the inflammable Vapour, which fires the Gunpowder: But the Time between the Vapour firing the Powder is so short, that frequently they appear as the same and not successive Operations, wherein the Gunpowder itself seems fired by the Electricity; and indeed the first Time this Experiment succeeded, the Flash was so sudden and unexpected, that the Hand of my Assistant, who touch'd the Spoon with his Finger, was considerably scorch'd. So that there seems a fourth Ingredient necessary to make Gunpowder readily take Fire by Flame, and that such a one, as will heighten the Inflammability of the Sulphur. In common Cases the lighted Match or the little Portion of red hot Glass, which falls among the Powder, and is the Result of the Collision from the Flint and Steel, fires the Charcoal and Sulphur, and these the Nitre. But if to these three Ingredients you add a fourth, *viz.* a Vegetable chemical Oil, and gently warm this Mixture, the Oil by the Warmth mixes intimately with the Sulphur, lowers its Consistence, and makes it readily take fire by Flame. In these Operations, notwithstanding I always made use of the finest scented Oils of Orange Peel, Lemons, and such like, yet upon the least warming the Mixture, the rank Smell of Balsam (*i. e.* the ready Solution) of Sulphur was very obvious.

Read before the R. S.
Oct. 24. 1745.

A Continuation of the Above.

Read, Feb. 6. 1745.

As Water is a non-electric, and of Consequence a Conductor of Electricity, I had Reason to believe that Ice was endowed 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 touched by a non-electric, it flashed and snapped. A Piece of Ice also held in the Hand of an electrified 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 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^[3] 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 mentioned 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 polished 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 Reflection 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 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 Center 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 Center, 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 Center 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 Deception, arising from the whole Length of the Tube not being excited, but only such Part of it as has been rubbed; 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 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 Cotton-grass, (which grows upon Boggs and is a very proper Subject for these Inquiries) are attracted under a Glass Jar made warm^[4], and turned Bottom upwards, upon 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 through 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 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 straight 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 $\frac{8}{10}$, 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 heightned by being superinduced upon an Iron Rod, red hot with coarser culinary Fire, as in a preceeding Experiment; nor diminished by being directed upon cold Water. However I was desirous of knowing, if this Flame would be effected 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 investigating the Laws of this surprizing 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.*

FINIS.

[1] Dr. *Gowin Knight*, F. R. S.

[2] I call *Electrics per se* or originally-*electrics*, those Bodies, in which an attractive Power towards light Substances is easily excited by Friction; such as Glass, Amber, Sulphur, Sealing-wax, and most dry Parts of Animals, as Silk, Hair, and such like. I call *Non-electrics* or Conductors of Electricity, those Bodies, in which the above Property is not at all or very slightly perceptible; such as Wood, Animals living or dead, Metals and vegetable Substances. See *Gray, Du Fay, Desaguliers, Wheler*, in the Philosophical Transactions.

[3] Page 6.

[4] 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 two-fold Cause: First, warm Glass does not condense the Water from the Air, which makes the Glass, as has been before^[5] 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 straight Lines, find probably a more ready Passage through their Pores.

[5] Page 13.

Transcriber's note:

All footnotes moved to the end of the text.

Page 5, 'Contract' changed to 'Contact,' "the Contact of Non-electrics..."

Page 6, 'Power' changed to 'Poker,' "I suspended a Poker in silk Lines;"

Page 7, second 'it' struck, "if it does..."

Page 9, 'o'Clock' rejoined.

Page 9, period added to 'E. N. E.'

Page 22, 'erectified' changed to 'electrified,' "and a Person not electrified..."

Page 49, 'it' changed to 'itself,' "not even Gold itself."

*** END OF THE PROJECT GUTENBERG EBOOK EXPERIMENTS AND OBSERVATIONS TENDING TO ILLUSTRATE THE NATURE AND PROPERTIES OF ELECTRICITY ***

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