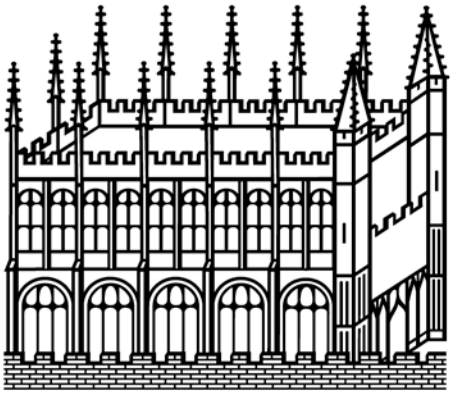

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A

SEQUEL

TO THE

EXPERIMENTS

AND

OBSERVATIONS

TENDING TO ILLUSTRATE THE

NATURE and PROPERTIES

Of ELECTRICITY:

Wherein it is preſumed, by a Series of Experiments expreſly for that Purpoſe, that the Source of the Electrical Power, and its Manner of acting are demonſtrated.

Addreſſed to the ROYAL SOCIETY.

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

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TO THE

ROYAL SOCIETY.

GENTLEMEN,

Read at their Weekly Meeting, *October* 30, 1746.

I. THE favourable reception, wherewith you honoured ſome papers I laid before you ſome time ſince, relating to electricity, emboldens me to trouble you again upon the ſame ſubject: and I am the more encouraged ſo to do, as the progreſs of our diſcoveries therein, both here and abroad, has been ſo ra-

pid; that what, little more than a year ago, we conceived to be the *ne plus ultra* of our inquiries, is now regarded as mere rudiments.

II. It were treſpaſſing too much upon you, to recount the great number of experiments I have made; for which reaſon I ſhall only take notice of ſuch, as are either in themſelves ſtriking, or tend to illuſtrate ſome propoſition.

III. At the beginning of laſt ſummer, I cauſed a machine to be made for electrical purpoſes; the wheel whereof was four feet in diameter. In the periphery of this wheel, were cut four grooves, correſponding with four globes of ten inches diameter, which were diſpoſed vertically at about three inches diſtance from each other. One, two, or the whole number of theſe globes might be uſed at pleaſure. They were mounted upon ſpindles of two inches diameter, and their mean motion round their axis was about eleven hundred

times

times in a minute. As it is next to impoſſible to have theſe globes blown and mounted perfectly true, I order'd the leather cuſhions, with which they were rubbed, to be ſtuffed with an elaſtic ſubſtance (curled hair) that the globes in their rotations might be as equally rubbed as poſſible. You might likewiſe cauſe the globes to be rubbed by the hands of your aſſiſtants; but under a certain treatment (of which hereafter) the cuſhions excite equally ſtrong. The leather cuſhions were now and then rubbed over with whiting. As a minute detail of the parts of this machine would take up too much of your time, I have herewith laid before you a draught thereof.

IV. I lined one of theſe globes to a conſiderable thickneſs with a mixture of wax and reſin, in order to obſerve whether or no the electricity would be the ſooner or more ſtrongly excited; but I found no difference in the power

of this globe from the others, which were without this treatment.

V. The power of electricity is increaſed by the number and ſize of the globes to a certain degree, but by no means in proportion to their number and ſize; therefore as the bodies to be electrified will contain only a certain quantity of electricity, of which more largely hereafter; when that is acquired, which is ſooneſt done by a number of globes, the ſurcharge is diſſipated as faſt as it is excited.

VI. After the globes had been a few times uſed, I found myſelf maſter of a much greater quantity of electrical power with much leſs labour to myſelf, than when I uſed only tubes. I could attract and repel light ſubſtances at a much greater diſtance than before; fire ſpirits of wine, camphire, and all other ſubſtances, whoſe vapours were inflammable, with great eaſe and at any diſtance, with non-electrics placed upon originally-

originally-electrics. I could fire them, I ſay, at all times; though not equally eaſy, when the weather was moiſt.

VII. I diſcover'd with this machine, and communicated to ſeveral members of this ſociety, ſeveral of the experiments ſaid to be firſt made by *M. le Monnier* at *Paris*, before the letter communicating them was received by our moſt worthy preſident from thence.

VIII. I order'd another machine to be made for a friend of mine, which carried a globe of ſixteen inches diameter. I united the power of this large globe with that of three of the others before mention'd, and found the ſtrokes from the excited non-electrics not encreaſed according to my expectation. In two experiments indeed, where the diſſipation of the whole power of theſe globes was viſible as faſt as it was excited, the effect of this additional globe was very conſiderable. The firſt was,

when two pewter plates were held, one in the hand of an electrified man, and the other by one ſtanding upon the floor; when theſe plates were brought near each other, the flaſhes of perfectly pure and bright flame were ſo large and ſucceeded each other ſo faſt, that, when the room was darkened, I could diſtinctly ſee the faces of thirteen people, who ſtood round the room. The other was from a piece of a large blunt wire hanging to the gun-barrel; from the end of which, when electrified, and any black * non-electric unexcited was brought

* In the courſe of theſe obſervations, whenever I mention either originally-electrics or non-electrics, I always underſtand the whole *genus* of each. Thus when I mention a man placed upon originally-electrics, I am indifferent, whether he is ſuſpended, either in lines of dry ſilk, hair, or wool; or (which is much more convenient) if he ſtands upon glaſs, wax, reſin, pitch, ſulphur, *&c.* or upon different mixtures of theſe, if of a ſufficient thickneſs. As we are now maſters of a greater electrical power than heretofore; I have found the electricity pervade, though in very ſmall quantity, originally-electrics of above four inches diameter.

brought near, though not near enough to cauſe a ſnap, a bruſh of blue lambent flame, totally different from the former, was very conſpicuous when the room was dark, of more than an inch long and an inch thick. I mention that what is held near the bottom of the wire ſhould be black, becauſe then you ſee this flame more ſharp. Here the phoſphoreal ſmell might be perceived at a conſiderable diſtance. If the back of your hand was brought ſo near this wire as to occaſion a ſnap, and theſe ſnaps were received for ſome time, you would feel them like ſo many punctures upon your ſkin, occaſioning red ſpots, which have laſted four and twenty hours.

IX. If, when a perſon is electrified, he brings his hand upon the cloaths of one that is not; they both have a ſenſation exactly reſembling that of many pins running into the skin, which continues as long as the globes are in mo-

This is moſt perceptible when the cloaths are of thin woollen cloth or ſilk, animal ſubſtances; leſs ſo, when of linen or cotton, which are vegetable.

X. If ſome oil of turpentine is ſet on fire in any veſſel held in the hand of an electrified man, the thick ſmoke that ariſes therefrom received againſt any non-electric of a large ſurface, held in the hand of a ſecond man ſtanding upon an electrical cake; this ſmoke, I ſay, at a foot diſtance from the flame, will carry with it a ſufficient quantity of electricity, for the ſecond man to fire any inflammable vapour. The electrical ſtrokes have been likewiſe perceptible upon the touching the ſecond man, when the non-electric held in his hand has been in the ſmoke of the oil of turpentine between ſeven and eight feet above the flame. Here we find the ſmoke of an originally electric. a conductor of electricity.

XI. Like-

XI. Likewiſe if burning ſpirit of wine be ſubſtituted in the place of oil of turpentine, and if the end of an iron rod in the hand of the ſecond man be held at the top of the flame, this ſecond man will kindle other warm ſpirits held near his finger. Here we find that flame conducts the electricity, and does not perceptibly diminiſh its force.

XII. Theſe two experiments demonſtrate, that the opinion of thoſe is erroneous, who ſuppoſe the electrical effluvia to be of a ſulphureous nature; and that theſe themſelves are ſet on fire at the ſnapping obſerv'd, when you bring non-electrics unexcited to thoſe that are. If their opinions were true, the electrical effluvia ſhould be deſtroyed by the flame in both the preceeding experiments; the contrary of which is obſerved.

XIII. I now proceed to take notice of that ſurprizing effect, that extraordinary

dinary accumulation of the electrical power in a vial of water; firſt diſcovered by profeſſor *Muſchenbroek*, a man born to penetrate into the deepeſt myſteries of Philoſophy: and I hope I ſhall ſtand excuſed, if I enter into a minute detail of the circumſtances relating thereto. The experiment is, that a vial of water is ſuſpended to a gun-barrel by a wire let down a few inches into the water through the cork; and this gun-barrel, ſuſpended in ſilk lines, is applied ſo near an excited glaſs globe, that ſome metallic fringes inſerted into the gun-barrel touch the globe in motion. Under theſe circumſtances a man graſps the vial with one hand and touches the gun-barrel with a finger of the other. Upon which he receives a violent ſhock through both his arms, eſpecially at his elbows and wriſts, and a-croſs his breaſt. This experiment ſucceeds beſt, *ceteris paribus*,

1. When the air is dry.

2. When

2. When the vial containing the water is of the thinneſt glaſs.

3. When the outſide of the vial is perfectly dry.

4. In proportion to the number of points of non-electric contact. Thus if you hold the vial only with your thumb and finger, the ſnap is ſmall; larger when you apply another finger, and increaſes in proportion to the graſp of your whole hand.

5. When the water in the vial is heated; which being then warmer than the circumambient air, may not occaſion the condenſing the floating vapour therein upon the ſurface of the glaſs.

XIV. From theſe conſiderations it is to be obſerv'd, that this effect ariſes from electrifying the non-electric water, included in the originally-electric glaſs; ſo that whatever tends to make the outſide of the glaſs non-electric by wetting it, as a moiſt hand, damp air,

or

or the water from the inſide of the vial, defeats the experiment by preventing the requiſite accumulation of the electrical power.

XV. That a gun-barrel is abſolutely neceſſary to make this experiment ſucceed, is imaginary; a ſolid piece of metal of any form is equally uſeful. Nor have I yet found that the ſtroke is in proportion to the quantity of electrified matter; having obſerved the ſtroke from a Sword as violent as that from a gun-barrel with ſeveral excited iron bars * in contact with it.

XVI. I have tryed the effect of increaſing the quantity of water in glaſſes of different ſizes, as high as four gallons, without in the leaſt increaſing the ſtroke. If filings of iron are ſubſtituted in the room of water, the effect is

* If, of ſix men touching each other and ſtanding upon originally-electrics one touches the gun-barrel, the whole are electrified; all theſe then muſt be conſider'd, as ſo much excited non-electric matter. From the aggregate of all theſe, not more fire is viſible upon the touch than from either of them ſingly.

is conſiderably leſſen'd. If mercury, much the ſame as water; the ſtroke is by no means increaſed in proportion to their ſpecific gravities, as might have been imagined *.

XVII. The vial ſhould not be leſs than can conveniently be graſped. I generally make uſe of thoſe, which hold ſeven or eight ounces, and fill them about four fifths with water; and the ſtroke from one of theſe, under the ſame circumſtances, is equally ſtrong with that of a *Florence* flask held in the hand, which I have ſometimes made uſe of; though the glaſs of this laſt is equally thin with that of the vial, and the quantity of water four times as much. That the ſtroke therefore is not as the quantity of water e-

lectri-

* In this experiment and in others, wherein we aſſert that the ſtroke is not increaſed in proportion to the quantity of electrified matter; it muſt always be underſtood, that the excited non-electrics themſelves are touched without being contained in originally electrics, as water in the glaſs: for otherwiſe (as will hereafter be ſpecified) the effects of different quantities of matter will be very different.

lectrified, is evident from this experiment. This fact does not depend upon my judgment alone, but likewiſe upon the opinions of ſeveral learned members of this ſociety, who have experienced the greater and leſs quantity of water.

XVIII. If a dry twig of birch or any other wood be run through the cork inſtead of the metallic wire, the ſtroke is not greater than is uſually felt from the gun barrel without the application of the water. The ſtroke is likewiſe leſſen'd, if the vial is held in the hand with a glove on.

XIX. After the gun-barrel and vial have been ſufficiently excited, which is done in a few ſeconds, the ſurcharge is diſſipated; ſo that the continuing the motion of the machine ever ſo long after the ſaturation is compleat, does not increaſe the electrical force.

XX. The force of the ſtroke from the electrified vial does not increaſe in

proportion to the dimenſions of the glaſs, or the number of globes employed. I have been ſtruck as forcibly with one vial from a globe of ſeven inches diameter, as when I made uſe of, at the ſame time, one of ſixteen inches and three of ten. I have been lately informed, that at *Hamburgh* a ſphere was employed for this purpoſe a *Flemiſh* ell in diameter, without the expected increaſe of power.

XXI. When the vial is well electrified and you apply your hand thereto, you ſee the fire flaſhes from the outſide of the glaſs wherever you touch it, and crackles in your hand.

XXII. The vial may be electrified by applying the wire therein to the globe in motion; after which, if it is graſped in one hand and the wire touched with a finger of the other, the ſtroke is as great as from the gun-barrel. If you only bring your finger near the end of the wire without touching it,

you

you obſerve the ſame bruſh of blue flame, as from the wire hanging to the gun-barrel, before taken notice of. This inſtantly diſappears upon touching the wire, though you do not receive a ſhock, unleſs at the ſame time, you graſp the vial.

XXIII. If you graſp the vial with your hand and do not at the ſame time touch the wire, the acquired electricity of the water is not diminiſhed. So that, unleſs by accident or otherwiſe the wire is touched, the electrified water will contain its force many hours, may be conveyed ſeveral miles, and afterwards exert its force upon touching the wire.

XXIV. If, when the machine is in motion, the vial is hung upon the gun-barrel, no increaſe of the ſtroke is perceived upon touching the gun-barrel with your finger, unleſs at the ſame time the vial is taken in the hand.

XXV. If,

XXV. If, when the gun-barrel and vial are excited, you graſp the vial with one hand, and touch the gun-barrel with a piece of any metal held in the other, the ſhock is as great in your arms as though you touched the gun-barrel with your finger; but not the leaſt ſhock is felt, if, inſtead of metal, you touch the gun-barrel with a piece of dry wood.

XXVI. I have felt a very great ſtroke, when I hung two vials to the gun-barrel, and graſping them both, brought my forehead near it. The ſhock then was ſo violent, that I ſeemed ſtunned, as though ſtruck on the head with a great ſtick, and I have never ſince choſe to repeat this experiment. This increaſe of the electrical force was owing to the additional vial, whereby the points of non-electric contact were augmented.

XXVII. Likewiſe if a perſon placed upon originally-electrics, graſps two

vials, as beforemention'd; and a ſecond perſon, ſtanding upon the floor, touches any part of his body, a very ſlight ſtroke only is perceived. But if the ſecond perſon, while the globes are in motion, places one of his fingers upon the hand, or any part of the naked body of the firſt, and at the ſame time touches the gun-barrel with his other hand; both feel a ſhock equal to that juſt now mention'd, but more tolerable, becauſe not felt in the head, in the arms only and a-croſs the breaſt. In this experiment, it is not neceſſary that the outſide of the glaſſes held in the hands ſhould be dry, as in the former experiments; becauſe, whatever by the moiſture is communicated to the man, is ſtopped by the originally-electrics, upon which he is placed. If inſtead of his hand you gently touch the firſt perſon's cloaths, you only perceive a ſmall ſtroke upon your finger; but if you preſs his cloaths cloſe to his body,

you frequently perceive a double ſtroke: the one, ſlight from his cloaths; the ſecond, a violent ſhock from his body.

XXVIII. Upon ſhewing ſome experiments to Dr. *Bevis* to prove my aſſertion, that the ſtroke was, *cæteris paribus*, as the points of contact of non-electrics to the glaſs; that ingenious gentleman has very clearly demonſtrated it likewiſe by the following experiment. He wrapped up two large round-bellied vials in very thin lead ſo cloſe as to touch the glaſſes every where, except their necks. Theſe were filled with water, and corked, with a ſtaple of ſmall wire running through each cork into the water. A piece of ſtrong wire about five inches long, with an eye at each end, was provided, and at each end of this, hung one of the vials of water by the ſmall ſtaple running through the cork. A ſmall wire loop then was faſtened into the lead at the bottom of each vial, and into theſe

loops was inſerted a piece of ſtrong wire like the former. If then theſe vials were hung a-croſs the gun-barrel and electrified, and a perſon ſtanding upon the floor touched the bottom wire with one hand, and the gun-barrel with the other, he received a moſt violent ſhock through both his arms and a-croſs his breaſt.

XXIX. Theſe vials may be concealed, and the ſhock be more univerſal in the following manner: The vials may be placed in a corner of the room, and any thing laid over them, ſo as not to touch the upper wires; then a very fine wire muſt be ſuſpended to the gun-barrel, and faſtened to the upper ſtrong wire. A ſecond piece of ſmall wire, of a ſufficient length to reach from the vials almoſt under the gun-barrel, muſt be faſtened to the lower ſtrong wire, and this may be concealed under a floor-cloth. The vials then are electrified; and if a perſon, placing his

his foot upon the floor cloth over the wire which comes from the bottom of the vials, touches the gun-barrel, he receives a moſt terrible ſhock. The firſt time, I experienced it, was, when the vials were fully electrified, and both my feet were placed upon the wire. Upon receiving the ſtroke from the gun-barrel upon my finger, it ſeemed to me, uſed as I am to theſe trials, as though my arm were ſtruck off at my ſhoulder, elbow, and wriſt; and both my legs, at the knees, and behind near the ankles. So that to try the effects of this experiment, you muſt be careful of not electrifying the vials too much. If a dozen or more of theſe vials or one very large bottle, were covered over with thin lead in the above manner, and ſtrongly electrified; and this electricity were diſcharged by a man at once in the manner here mention'd, I ſhould dread the conſequences.

XXX. We muſt obſerve, that this ſhock is not felt, unleſs the wire, coming from the bottoms of the bottles, is touched; and then not, if the ſhoes are dry, and of conſequence originally electric. In this experiment we ſee the effects of the increaſe of the points of contact; and it ſeems the more ſurprizing to thoſe, who are not acquainted with the cauſe, when the wire is concealed under a floor-cloth, that the moving of their feet only one inch, ſhould occaſion them, all other circumſtances apparently the ſame, to feel a violent ſhock or none at all. A thick carpet, inſtead of a floor cloth, is liable to prevent the ſucceſs of this experiment, for the ſame reaſon as dry ſhoes. This experiment may aptly enough be called, the ſpringing an electrical mine.

XXXI. If, in the former experiment, the lower ſmall wire is faſten'd to an iron rod; and if, when the vials are ever ſo ſtrongly excited, that rod

is

is held in the hand of a man ſtanding upon the floor, and with it he touches the gun-barrel, he perceives no ſhock, for reaſons preſently to be aſſigned. But if he takes this iron rod in one hand, and touches the gun-barrel with the other, he then is violently ſtruck. We muſt here obſerve, that the violence of the ſtroke is always felt in our bodies, in proportion to the loudneſs of the exploſion, and the quantity of fire ſeen: therefore, as both theſe are equally perceptible, whether the electricity paſſes only through the iron, as in the firſt of theſe inſtances; or through our bodies equally with the iron, as in the ſecond; we conclude, that in both there is the ſame degree of electrical force. By the firſt of theſe methods, you are capable of making others ſenſible of the electrical force, without feeling it yourſelf. This experiment, as well as the laſt, will admit of infinite variation.

XXXII. If a man, ſtanding upon an electrical cake, takes the vial ſuſpended to the gun-barrel in his hand, by theſe means he acquires ſome electrical power; for, if under theſe cirumſtances he touches the gun-barrel, he only receives a ſlight ſtroke. If then, without having had any communication with unexcited non-electrics, he touches the gun-barrel again, the globes being yet in motion, he receives no ſtroke at all.

XXXIII. If to the gun-barrel an egg, either raw or boiled, is ſuſpended by a piece of wire, and a perſon, graſping the electrified vial in one hand, brings the palm of his other near the bottom of the egg; at that inſtant he receives a ſmart ſtroke, and his hand ſeems full of a more red fire than is uſually obſerved. In this experiment, the ſtroke is more confined to the hand without ſhocking the arms, than when you touch the gun-barrel itſelf; it more reſem-

reſembles a ſtroke over the hand with a *ferula.*

XXXIV. If any number of people ſtand upon originally-electrics, and communicate with each other by any non-electric medium, eſpecially metal, they are by theſe means all equally electrified; and if a perſon, ſtanding upon the floor, and holding the vial of water hanging to the gun-barrel in his hand, touches the perſon furtheſt from the gun-barrel, the whole number receives a ſhock equal to any one touching the gun-barrel ſingly.

XXXV. If a number of perſons, how great ſoever, ſtand upon the ground, communicating with each other as before, the firſt of which graſps the vial and the laſt touches the gun-barrel, the whole number receive a ſhock like the former. This, we are informed, Monſ. *le Monnier* at *Paris* communicated through a line of men, and other non-electrics, meaſuring nine hundred toiſes.

XXXVI. Seve-

XXXVI. Several experiments ſhew, that the electrical force always deſcribes a circuit; *e. g.* if a man holds the electrified vial in one hand and touches the gun-barrel with the other, he feels the ſhock in no other parts of his body than in his arms and a-croſs his breaſt. So that here we ſee the electrical power darts *rectiſſimo curſu* between the gun-barrel and vial. This is more particularly demonſtrated by the following experiment, in which, though the two lines of perſons may be of any length, we only ſpecify that each conſiſts of four, for the ſake of perſpicuity.

XXXVII. Of one line, let A touch the gun-barrel, ſtanding upon wax, and communicate with B C D likewiſe ſtanding upon wax. Of the other line, let 1 take the electrified vial in his hand and joyn with 2, 3 and 4, all ſtanding upon the floor. If, under theſe circumſtances, the firſt line is electrified,

lectrified, and 4 touches D, all eight are ſtruck through. If 4 touches C, D though electrified feels nothing, and the remaining ſeven are ſtruck; ſo that here D is left out of the circuit. If 4 touches B, only ſix feel the ſhock, and C and D feel nothing; and thus you may proceed to A, who muſt always neceſſarily feel, if either himſelf or any of his line is touched. If, when both lines are as before mention'd, D touches 3, 4 is left out of the circuit, and the remaining ſeven feel the ſtroke. If C touches 2, the circuit conſiſts of five, D, 3 and 4 being, though under the ſame circumſtances, left out: always obſerving, however theſe circuits are diverſified; that A, who touches the gun-barrel, and 1, who holds the vial, are certain to feel the ſtroke.

XXXVIII. This experiment my be reverſed, the lines being as before, in the following manner, wherein likewiſe this circuit is always obſervable.

Let

Let A touch the gun-barrel as before, and D hold the wire of the electrified vial in his finger. Let 4 graſp the vial, and 1 touch B; then A feels nothing, being left out of the circuit, and the other ſeven are ſtruck. If 4 touches C, then A and B feel nothing, the circuit conſiſting of the remaining ſix. But it is to be obſerved, as in the former experiment, that 4 who graſps the vial, and D who holds the wire, muſt of neceſſity be always in the circuit. I have been the more particular in this matter, as it demonſtrates the courſe of the electrical power to be in the moſt direct manner, between the gun-barrel and the electrified vial.

XXXIX. Likewiſe if a perſon, ſtanding upon an originally-electric, touches the gun-barrel with his right hand, a piece of wire being placed round his left leg, and a ſecond perſon ſtanding likewiſe upon the wax, takes hold of the extremity of this wire; then

then let another perſon, ſtanding upon the floor and graſping the electrified vial, touch any part of the ſecond perſon's body. Upon this touch, the ſecond perſon is ſhook as uſual; but the firſt feels the ſtroke only in his left leg and right arm, the neareſt courſe of the electrical power.

XL. If any number of perſons communicate by pieces of wire, and if any one of them brings together the ends of the two pieces of wire in his hands, upon the gun-barrel's being touched he will perceive no ſtroke. But if the ends of the wires are but a quarter of an inch aſunder, he will be ſhook in both his arms; becauſe then his body will become part of the circuit.

XLI. If, when any number of perſons joyn hands, or communicate by any metallic medium ſtanding on the floor, one graſps the vial and joyns with the reſt: Upon the gun-barrel's being touched by the laſt perſon of the line,

line, the whole number are ſtruck ; and he who graſps the vial as forcibly as the reſt. But if two vials are employed, and he graſps them both, with a piece of wire of ſufficient length held between his fingers, which wire touches both vials, and it's end is taken hold of by the ſecond perſon of the line ; if then the laſt perſon touches the excited gun-barrel, all in the line are violently ſtruck, except the perſon, who graſps the vials; but he feels little or nothing of the ſtroke.

XLII. The ſtroke is very violent; when a wire is put round the naked head, or under the peruke; and the perſon, graſping the vial, touches the gun-barrel with the end of the wire; or if he holds the wire between his teeth.

XLIII. If a perſon, ſtanding on the electrical cakes with gold or ſilver lace upon his coat, takes hold of the gun-barrel; and another perſon graſping the

the electrified vial touches the bottom of the lace, the perſon electrified, if he holds down his head, feels the blow under his chin. The lace in this inſtance has the ſame effects as a piece of metal; at the end of which, if placed in the ſame manner, you would neceſſarily feel the ſtroke.

XLIV. I now proceed to ſhew, by what ſteps, in my inquiries into the nature of electricity, I diſcovered, that the glaſs tubes and globes had not the electrical power in themſelves, but only ſerved as the firſt movers and determiners of that power.

XLV. Several months ſince, I obſerv'd that by rubbing a glaſs tube, while ſtanding upon a cake of wax, in order, as I expected, to prevent any of the electrical power from diſcharging itſelf through me into the floor; contrary to my expectation, that power was ſo much leſſen'd, that no ſnapping was to be obſerved upon another's touch-

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ing any part of my body. But if a perſon not electrified held his hand near the tube whilſt it was rubbing, the ſnapping was very ſenſible. This I ſhewed to ſeveral members of the Royal Society and others, who did me the honour to viſit me. Afterwards I met with an experiment of the ſame kind, in a treatiſe publiſh'd by profeſſor *Boſe*, entitled, *Recherches ſur la cauſe et ſur la veritable teorie de l'Electricité*, which that ingenious gentleman ſays, had given him great trouble by its oddneſs. The experiment is, that, if the electrical machine is placed upon originally-electrics, the man who rubs the globes with his hands, even under theſe apparently favourable circumſtances, gives no ſign of being electrified, when touched by an unexcited non-electric. But if another perſon, ſtanding upon the floor, does but touch the globe in motion with the end of one of his fingers, or any other non-electric, the

perſon

perſon rubbing is inſtantly electrified, and that very ſtrongly. The ſolution of this phænomenon, ſeemingly contrary to the already diſcover'd laws of electricity, had terribly tormented him: But however he has given us the following, which he modeſtly calls a plauſible ſubterfuge rather than a ſolution, *viz.* that a power cannot act at the ſame time with all its vigour, when one part of it is already employed; as a horſe, who already draws an hundred pounds, cannot draw an additional weight as freely as if he had not been loaded at all. That the hand excites the virtue already in the ſphere; therefore if the ſame power impregnates the man, there remains none for the globe. That the virtue of the globe then cannot be communicated at the ſame time to the man, by whom it is created. That he, who gives it, cannot receive it himſelf. From theſe, and ſuch like conſiderations, it appears

to him; that the man upon the ground, who holds his fingers to the globe in motion, inſtead of his diminiſhing its electrical force, throws that force back again over the man, who excited it. That the finger in this caſe ſeems to operate as an electric *per ſe*, and drives back the electrical power.

XLVI. I have ſeen an account * of Mr. *Allamand*, lately printed at the *Hague*; wherein he takes notice of this phænomenon. He tells us, that as part of the electrical power of the globes paſſes off by the frame, upon which the globes are mounted, into the floor and diſſipated thereby; he conceived, that if the machine, and the man who rubbed the globe, were placed upon pitch to prevent this diſſipation, the fire of electricity would be more ſtrong. But the conſequence is extremely odd and unexpected; for the

* *Bibliotheque Britannique pour les Mois de Janvier, Fevrier, et Mars*, 1747.

the contrary happens; and the electrical power is conſiderably diminiſhed, and ſometimes there is even none at all.

XLVII. I tried this experiment ſeveral times with my machine, and the man, who turns the wheel thereof, mounted upon the electrical cakes. If the air was dry and the machine placed at ſome diſtance from non-electrical ſubſtances, as the ſides of the room, chairs, and ſuch like; after one or two ſmall ſnaps, the gun-barrel, ſupported by ſilk lines and hanging in contact with the globes, would, though the machine were in motion a conſiderable time, attract no light ſubſtances nor emit any fire. This induced me to conceive, that the electrical power was not inherent in the glaſs, but came from the floor of the room; and if the fact were ſo, the gun-barrel ſhould ſnap upon my touching any part of the machine. The conſequence fully anſwer'd my conjectures; for while I ſtood

upon the floor, the globes ſtill in motion, I put one hand upon the frame of the machine, and touched the gun-barrel with one of the fingers of my other. Upon this fire iſſued, and the ſnapping continued as long as I held my hand upon the machine, but ceaſed upon taking it off. This at once proved to me, that the electrical fire paſſed from the floor through my body to the machine. I then order'd the man to put one of his feet from the wax upon the floor; which, as ſoon as he complied with, cauſed the electricity to ſnap at the gun-barrel, and this ceaſed upon his replacing his foot. Here I found that the electrical power came through the man; and that in theſe inſtances, either myſelf or the man who touched the floor with his foot, were to be regarded as an additional part of the machine communicating with the floor. Theſe conſiderations led me to make the following experiments.

XLVIII.

XLVIII. If my conjectures were well founded, and if the electrical power, the man and the machine being placed upon originally electrics, went through my body to the machine, a fine wire held in my hand at a few inches diſtance ought to be attracted by any part of the machine. This ſucceeded accordingly, but the attraction laſted a very ſmall ſpace of time, and the wire again hung perpendicularly from my finger, though the globes continued in motion. This induced me to believe, that the gun-barrel, and the other non-electrics ſuſpended in contact with the globes, would only contain a certain quantity of the electrical æther; and if this were the caſe, the attraction of the wire to the machine would be continual, if the electrical power found again a communication with the floor, as the wire was the only canal of communication between the floor and the machine.

Whereupon I placed one of my fingers upon the gun-barrel, and held a wire near the machine with my other hand, and found, that as long as my finger continued upon the gun-barrel the wire was attracted, but no longer.

XLIX. Here we find, that one cauſe of the electrical attraction is the current of the electrical æther ſetting to the machine through the wire: and this current is ſtopp'd from two cauſes; one when there is no diſcharge thereof from the gun-barrel, the accumulation being complete; the other, when other currents are opened, that is, when the machine is touched in other parts.

L. In theſe, and the ſubſequent experiments, I always ſuppoſe the air very dry; for if it is not, and the ſilk lines, which ſupport the non-electrics, are wetted thereby, the electrical power will be diſcharged along them, and the wire will be conſtantly attracted,

ted, as I have frequently on purpoſe experienced; and this diſcharge is in proportion as the lines are more or leſs wetted.

LI. If a man ſtands upon the machine placed upon originally-electrics, and the gun-barrel with the other non-electrics are ſuſpended as uſual in contact with the globes, no electricity is obſerved in that man: but if a wire hanging to the wainſcot of the room touches the gun-barrel, or a man ſtanding upon the floor applies his finger thereto, the man upon the machine emits fire copiouſly; and either himſelf, or the man who turns the wheel of the machine, fires inflammable ſubſtances. But this effect is no longer obſervable, when the wire, &c. are removed from touching the gun-barrel. So that in this experiment, the uſual courſe of the electricity is inverted; and that power, which in moſt other inſtances, is brought by the wood-work of the machine to the globes

and by them diſcharged upon the gun-barrel, is now brought by the wire to the gun-barrel, and from this the globes throw it all over, not only the machine, but any non-electric in contact with it, if the electricity is ſtopp'd. In this experiment, if an iron rod ſtanding upon the floor, is inclined againſt the loops of the ſilk lines, which ſupport the gun-barrel, in ſuch a manner as not to touch the gun-barrel; the electrical fire, which paſſes from the iron rod to the gun-barrel, inſtead of being ſupplied conſtantly, comes in by ſnapping ſo long as any unexcited non-electric communicates with the machine, but ceaſes upon its being removed. And if the air is very dry, and none of the electricity conducted down the ſilk lines, the ſnapping from the iron rod to the gun-barrel will frequently correſpond to the touching of the wooden machine with your fingers, and ſtop upon your taking them off.

And

And this experiment will look much like magic, even to thoſe who are acquainted with the operations of electricity; for if the perſon who turns the wheel of the machine, and ſtands upon the cakes, be properly inſtructed; upon your bidding the gun-barrel ſnap, he only puts the toe of his ſhoe upon the floor, and it ſnaps immediately, and continues ſnapping as long as he keeps it there; but if you order it to ceaſe ſnapping, he almoſt imperceptibly replaces his foot upon the cakes, and it ceaſes. This may be repeated as often and as long as you pleaſe. To corroborate this conjecture further, and to prove that the electrical power is by the means of the iron rod conducted from the floor to the gun-barrel; light ſubſtances laid upon any part of the machine ſhould be driven off, provided that the electrical blaſt is particularly determined to that part of the machine, where theſe light ſubſtances

are

are laid; and this fact is determin'd by experiments.

LII. Many experiments demonſtrate, that if the electricity is not ſtopp'd, no ſign of its preſence either by fire or attraction is obſervable in the non-electric bodies ſuſpended to the globes. That is, although ever ſo great a quantity be determined by the globes over theſe bodies, the electricity paſſes off from them *pleno rivo* to the floor, from whence it came. But if the electricity is ſtopped, it is then accumulated upon theſe non-electrics; but this can be done only to a certain degree, as is manifeſt from a former experiment. And if, when this power is accumulated, a man ſtanding upon the floor touches now and then the non-electrics with his finger; the electricity, which is here accumulated, ſnaps; and the fire is always obſervable. But this ſnapping is not, when the electrical power paſſes off continu-

ally,

ally, as from a piece of blunt wire hung to the ſuſpended gun-barrel and the hand of a man brought near it without touching; whereby the electrical power becomes viſible like a fine blue cone of flame, with its point towards the wire. When the hand is placed at a proper diſtance, the blaſt, like that of cold air, is therefrom very manifeſt. If you do not determine the electricity by theſe means to a point, the diſſipation of it is general and from all parts of the excited non electric; but if you do, by bringing your hand near the wire as beforemention'd, you ſee the manner of its being diſcharged into the floor, and ſo into the earth. Theſe facts being ſo, if my conceptions are true, that the glaſs globes circulate the electrical fire, which they receive from their friction againſt the cuſhions or the hand of a man, and which is conſtantly ſupplied to theſe laſt from the floor; the ingreſs of the electrical

electrical fire, if the machine, &c. are placed upon electrics *per ſe*, ought to be viſible, as well as the egreſs under the ſame circumſtances; and this is demonſtrated by experiment. For, if while any unexcited non-electrics touch the gun-barrel, the globes being in motion, you bring your finger or a piece of wire near any part of the wood-work of the machine, but more eſpecially the iron axis of the wheel; you obſerve the bruſh of blue flame ſet in from it to the wood-work. We always obſerve in this experiment, that the lambent flame from the end of the wire paſſes diverging into the machine, and this continues ſo long as the gun-barrel is touched. So that here, the office of the globes exactly tallies with that of the heart in animals; which, as long as the quantity of blood is ſupplied, propels it into the arteries, and theſe all over the ſyſtem; or that of the pump in hydroſtatics. In the ſame manner, by

the attrition of glaſs tubes, the electrical power is brought from the body of the man who rubs the tube, and he is conſtantly taking in a ſupply from the floor.

LIII. What I here call the electrical æther, is that atmoſphere which ſurrounds both excited originally-electrics and excited non-electrics. That this is extended to a conſiderable diſtance, appears from a fine thread or piece of cotton-graſs-ſeed and being attracted at ſome feet diſtance from them, as far as which, it is preſumed, this atmoſphere extends. Here indeed it is only perceived by its effects upon theſe light ſubſtances. But at the bruſh of flame from the end of the wire before mention'd, from ſome bran lying upon a flat piece of metal in contact with excited non-electrics, your hand being held over it, and in many other experiments; it becomes manifeſt to your feeling as a blaſt of cold wind. You

feel

feel it likewiſe in a leſs degree, when a glaſs tube is well excited, and brought near your face. If no unexcited non-electric is near, this atmoſphere ſeems to be determined equally over all the excited non-electrics in contact with the machine; but if a non-electric unexcited is brought near, the greateſt part of it is determined that way; and hereby the attraction at any other part of theſe excited non-electrics is conſiderably diminiſhed. Hence the cauſe of the repulſion of electricity, which does not operate, until the electrical æther is ſufficiently accumulated. This electrical repulſion is ſtrongeſt in thoſe parts of the excited non-electrics, where unexcited non-electrics are brought near them; for by theſe the electrical blaſt, which otherwiſe is general, is particularly determined to the floor.

LIV. Before I proceed further, I muſt beg leave to explain what I call the accumulation of electricity. To put

put a ſimilar caſe: as we take it for granted, that there is always a determinate quantity of atmoſphere ſurrounding the terraqueous globe; we conceive, when we ſee the mercury in the barometer very low, that there then is a leſs accumulated column of this atmoſphere impending over us, than when we ſee the mercury high. In the like manner, when we obſerve that the electrified gun-barrel attracts or repels only very light ſubſtances at a very ſmall diſtance; or that the ſnap and fire therefrom are ſcarcely perceptible; we conceive then a much leſs quantity of electrical atmoſphere ſurrounding the gun-barrel. This power being more or leſs, we call the greater or leſs degree of the accumulation of electricity. This is only attainable to a certain point, if you electrify ever ſo long; after which, unleſs otherwiſe directed, the diſſipation thereof is general. The vial of water of *Muſchenbrock* ſeems capa-

capable of a greater degree of accumulation of electricity, than any thing we are at preſent acquainted with: and we ſee, when by holding the wire thereof to the globe in motion, the accumulation being complete, that the ſurcharge runs off from the point of the wire, as a bruſh of blue flame. A method has been diſcovered here by a gentleman, (Mr. *Canton*) by which the quantity of accumulated electricity may be meaſured to great exactneſs. The manner of meaſuring is this. When the vial is ſufficiently electrified by applying the wire thereof to the glaſs globe, and which is known by the appearance of the bruſh of flame at the end of the wire, as before mentioned; hang a ſlender piece of wire to the ſuſpended gun-barrel, for this purpoſe detached from the globes. Upon your applying the wire of the electrified vial to that hanging to the gun-barrel, you perceive a ſmall ſnap; this you diſcharge

charge by touching the gun-barrel with your finger, which likewiſe ſnaps: and thus alternately electrifying and diſcharging, you proceed until the whole electricity of the water is diſſipated; which ſometimes is not done, under an hundred diſcharges. If you do not diſcharge the electricity every time, the ſnaps from the wire of the electrified vial to the gun-barrel are ſcarcely perceptible. In proportion to the number of ſtrokes, you eſtimate the quantity of the acquired electricity of the water. That you could by ſtopping the electricity, excite non-electrics: and by accumulating their power, make them exert more force than originally-electrics would at any point of time, was that capital diſcovery of the late Mr. *Gray*; and is to be regarded as the baſis, upon which all the preſent improvements of our knowledge in electricity are founded; and 'till which diſcovery, although ſome of the effects of electricity were obſerved a-

bove two thouſand years ago *, little progreſs was made.

LV. The electrical æther is much more ſubtile than common air, and paſſes to a certain depth through all known bodies. It paſſes moſt readily through metals, water, and all fluids except reſinous ones; then animal bodies, dead or alive, in proportion as they are more or leſs wet; then ſtones, wood, and earths. It paſſes to a certain thickneſs only through reſins, dry animal ſubſtances, wax, and glaſs. For this reaſon bodies are called electrics *per ſe*, or non-electrics; not only for their rubbing the electricity from other bodies, but likewiſe as they permit more or leſs of the electrical æther to paſs through

* *Theophraſtus* who lived above three hundred years before the date of the Chriſtian æra, takes notice of amber and the *Lyncurium* attracting not only ſtraws and ſhavings of wood, but alſo thin pieces of copper and iron. See *Theophraſtus* περὶ τῶν λίθων. ν'.

— Καὶ τὸ λυγκούριον — ἕλκει γὰρ ὥσπερ τὸ ἤλεκτρον. Οἱ δέ φασιν ὐ μόνον κάρφη καὶ ξύλον, ἀλλὰ χαλκὸν καὶ σίδηρον, ἐὰν ᾖ λεπτός. ὥσπερ καὶ Διοκλῆς ἔλεγε.

through them. This æther has not only the property with air of moving light ſubſtances; but it ſeems to have another, and that is elaſticity.

LVI. That this fluid is more ſubtil than common air, is more particularly demonſtrated by its paſſing through ſeveral glaſſes at the ſame time; through any one of which, though ever ſo thin, air cannot paſs. It likewiſe paſſes, as I have mention'd before, through all known bodies, except originally electrics, and even through theſe to certain degree. It's elaſticity is proved by its extending itſelf round excited electrics, and excited non-electrics to a conſiderable diſtance; as well as by its increaſing the motion of fluids. This is demonſtrated by the experiment with a ſmall glaſs ſiphon where the elaſticity of the electrical æther overcomes the attraction of coheſion: I have frequently obſerved this experiment does not operate, unleſs the greateſt part,

if not the whole electrical blaſt, is determined to the floor through the water, by bringing ſome unexcited non-electric near the long leg of the ſiphon †. The ſtream through this ſlender tube is moſt complete, when the non-electric is brought near, ſo as when the room is ſomewhat darken'd, the ſtream of water appears as a ſtream of blue flame, much like that from the blunt wire. This ſtream is ſtopped, either by touching any part of the non-electrics in contact with the globes; by placing the machine and the man who turns the wheel upon electrics *per ſe*, by which the current of the electrical æther, from the

† There is one inſtance, where the water will run off in a full ſtream without bringing a non-electric unexcited near the long leg of the ſiphon; and that is, by ſuſpending a vial of water as uſual to the gun-barrel by a wire, and by letting a glaſs ſiphon through the cork into the water. When this vial is ſufficiently electrified, the water therein runs off in a full ſtream, though no non-electric unexcited is near; becauſe then the current of water through the ſiphon is the only way, by which the ſurcharge of the electricity can be diſſipated.

the floor to the machine is prevented; or by removing the non-electric from the leg of the ſiphon, by which the diſſipation of the electrical æther from the excited non-electric becomes general. So that we find, that although we can repel light bodies from many parts of excited non-electrics at the ſame time; the whole force of the electrical current is neceſſary, to drive off ſo ponderous a fluid as water. May we likewiſe not infer the elaſticity of electrical æther, from the ingreſs of the blue flame from the end of a blunt wire held near the axis of the wheel, or any part of the wood-work of the machine, after the revolutions of the globes are ceaſed? Certainly we ſee an influx of electrical fire to all bodies, until their determined quantity is reſtored. Is not the elaſticity of this æther deducible likewiſe, from the violent ſhock we feel in our bodies in the experiments with water?

LVII. There ſeems to be a quantity of this æther in all bodies: hence the reaſon, why though the machine is placed upon electrics *per ſe*, a ſnap or two, as I mentioned before, is obſerv'd upon touching the gun-barrel, when the machine has been ſometime in motion: but after theſe no more is perceived, if the ſilk lines are very dry, and the electrical ſupporters of the machine are of a requiſite thickneſs. As ſoon as any non-electric unexcited touches the machine, this loſs is immediately reſtored. As the electrical æther, as has been ſpecified, is an elaſtic fluid; wherever there is an accumulation thereof, there is an endeavour by the neareſt unexcited non-electric to reſtore the *æquilibrium*. The reſtoring of this *æquilibrium*, I take to be the cauſe of the attraction of excited glaſs tubes and globes, as well as that of excited non-electrics; for here the blaſt of electrical æther conſtantly ſets

in from the neareſt unexcited non-electrics towards thoſe excited, and carries with it whatever light bodies lie in its courſe. This ſetting in of the current of electrical æther towards excited non-electrics is likewiſe very perceptible to your feeling as a blaſt of cold wind; if when you are electrified, you hold your hand over a plate with ſome bran in it, by which blaſt the bran is carried againſt your hand. Theſe light ſubſtances are again repelled by the blaſt from the excited bodies, as ſoon as they come in contact and ſometimes before. The ſucceſſions of theſe alternate attractions and repulſions are extremely quick, ſo that ſometimes your eye can hardly keep pace with them. And if you put a glaſs globe of about an inch in diameter very light and finely blown into a plate of metal, and hang another over it; electrify the upper one, and bring the other under it, and you will find the ſtrokes from the alternate attractions and re-

pulſions * almoſt too quick for your ear. I have ſeen a *German* who travelled with a ſmall electrifying machine; who, by a a proceſs of this ſort, made two ſmall bells ring. One of the bells was ſuſpended to an electrified wire, which was conducted without touching along the ſides of the room; at about an inch diſtance, detached from this wire, a little clapper was hung by a ſilk line; at an equal diſtance from this laſt was hung another little bell, which communicated with the ſides of the room. As ſoon as the machine was in motion, the electrified bell attracted the clapper, which immediately by the repulſive blaſt was blown off to the unexcited bell. By the time the ſecond bell was ſtruck, the former

* The following is an argument of the velocity likewiſe, with which theſe little globes are attracted and repelled. If they are let fall from the height of ſix feet or more upon a wooden-floor or a plate of metal, they are rarely broke; but by the attractions and repulſions of them between the plates, though at the diſtance only of one ſixth of an inch, they are frequently beat in pieces.

mer attracted again; and this jingling of the two bells continued not only during the motion of the machine, but ſeveral ſeconds after it was ſtopped. This was occaſioned by the ſmall volume of the clapper, being able to convey away only a ſmall quantity of the electrical æther at each ſtroke; by which it was ſome time, before the *æquilibrium* was reſtored.

LVIII. To demonſtrate likewiſe, that the reſtoring this *æquilibrium* is not imaginary, I ſhall mention an experiment of a gentleman (Mr. *Wilſon*) who has taken great pains in theſe inquiries. Take two plates of any metal, very clean and dry, whoſe ſurfaces are nearly equal; hang one of them to any excited non-electric, and bring under it upon the other a whole leaf of ſilver. When, which you find upon application, the ſilver leaf is attracted, lower the bottom plate; if it is too low, you will obſerve the leaf ſilver jump up and down

down; if too high, it will be only attracted in part, and thereby diſſipate the electrical power. But if you get it at the proper diſtance, which will be very eaſily found upon tryal; the ſilver will be perfectly ſuſpended at right angles with their planes, like the *trapezium* of the geometers, and touch neither of the plates: it will be extended likewiſe to its utmoſt dimenſions. You frequently obſerve, both at the top and bottom of the ſilver, the electrical fire. The ſame effect is produced if you reverſe the experiment, by electrifying the bottom plate, and ſuſpending the other over it. Now I conceive, that the ſpace occupied by this leaf of ſilver, is that, where the *æquilibrium* of the electrical æther is reſtored; for if you take away the under plate, through which from the floor the flux of this æther is furniſhed; or if that plate be placed upon an electric *per ſe*, by which this flux is prevented likewiſe, the ſilver leaf is blown away.

LIX.

LIX. No body can be ſuſpended *in æquilibrio* but from the joint action of two different directions of power: ſo here, the blaſt of electrical æther from the excited plate blows the ſilver towards the plate unexcited. This laſt in its turn, by the blaſt of electrical æther from the floor ſetting through it, drives the ſilver towards the plate electrified. We find from hence likewiſe, that the draught of electrical æther from the floor, is always in proportion to the quantity thrown by the globes over the gun-barrel; or the *æquilibrium*, by which the ſilver is ſuſpended, could not be maintained. I once found, that a gentleman, at that time an invalid, whoſe ſhoes were perfectly dry, and of conſequence originally-electrics, and who was employ'd to hold the non-electric plate through which the æther was to come from the floor; this gentleman, I ſay, did not furniſh a ſufficient quantity, becauſe of the dryneſs

dryneſs of his ſhoes, to maintain the *æquilibrium*; and the ſilver was blown away. But upon employing another to this office, whoſe ſhoes were more wet, the æther came readily through him, and the ſilver was ſuſpended. I have likewiſe found a wooden pole, very dry, not conduct this æther faſt enough to keep the ſilver ſuſpended. It may be imagined, that it is poſſible for the ſilver to be ſuſpended, without ſuppoſing a flux of the electrical æther from the neareſt unexcited non-electric, as well as from the excited one; that is, by the ſimple electrical attraction. But to obviate this, it muſt be remembered; that the electrified gun-barrel both attracts and repels light ſubſtances at the ſame time. Can this attraction and repulſion be conceived without the operation of the electrical æther both to and from the gun-barrel at the ſame time? Does not this point out an afflux as well as an efflux? Are

not

not the electrical repulſions as ſtrong at leaſt as the attractions? Do not we ſee light bodies, either between excited originally-electrics or excited non-electrics, and unexcited non-electrics, dart like a ball between two rackets of equal force? It may be ſaid perhaps;

1. That the ſuſpended ſilver may only ſerve as a canal of communication, which diſcharges the electricity from the excited non-electric to the unexcited one; and that when an originally-electric is placed between the lower plate in this experiment and the floor of the room, that then the ſilver is attracted only, until the lower plate is ſaturated with electricity, and no longer. This is as much as ſaying, that this effect ariſes from electricity, without mentioning in what manner.

2. That this effect is produced by the electrical attraction, which gives the ſilver a direction towards the excited non-

non-electric, but that it is kept down near the unexcited one by the force of gravity. Was this the cauſe, the action of gravity would operate as much through originally-electrics as non-electrics.

LX. But I am able to prove the afflux experimentally as well as the efflux, in the following manner. When the ſilver lies ſtill, though the motion of the globes is continued, between the two plates, one ſuſpended to the gun-barrel, and the other placed upon an electrical cake; a perſon ſtanding upon the floor needs only bring a ſmall glaſs ſiphon in a veſſel of water, and apply the long leg thereof near the plate placed upon the wax: for upon this, the ſilver is immediately ſuſpended; and the water, which before only dropp'd, now runs in a full ſtream and appears luminous *. Does not, in this

* This experiment is more elegant, if the upper-plate

this caſe, the current of the water point out the direction of the current of electrical æther?

LXI. When the machine, &c. are placed upon originally-electrics; if a man, ſtanding likewiſe upon an originally-electric, touches the gun-barrel, while the globes are in motion, he will receive a ſnap or two; after which, tho' the motion of the globes is continued, he will perceive no more fire from the gun-barrel. While in this poſture, if he touches the wood-work of the machine with one hand, and applies a finger of his other near near the gun-barrel, at that inſtant he receives the electrical ſtrokes. Theſe continue as long

plate, attracting the ſilver, is ſuſpended high enough for a perſon ſtanding upon an originally-electric, conveniently to bring the other plate under it with one hand, and to hold a pewter plate in the other. If the originally-electric is ſufficiently thick, the ſilver will not be ſuſpended; but if the glaſs ſiphon in a ſmall veſſel of water is brought very near the pewter plate, the water runs into the plate, and the ſilver is immediately ſuſpended.

long as he touches the machine, but ceaſe upon his removing his hand therefrom. Here we ſee a circulation of part of this man's electrical fire, which operates in the following manner. Firſt, the man by applying one of his hands to the machine becomes a part thereof; and by the motion of the globes, part of the electrical fire, inherent in his body, is driven upon the gun-barrel; but it is inſtantaneouſly reſtored to him again upon his touching the gun-barrel with his other hand. Thus he continues communicating the fire with one hand, and having it reſtored to him with the other, as long as he pleaſes. If inſtead of touching the machine or gun-barrel, he holds his finger near either or both of them; you ſee the fire go out and return back as in a former experiment.

LXII. It may be perhaps imagin'd; if one man touches the machine, himſelf and the machine both being placed upon

upon the wax; and if another, ſtanding upon the floor, conſtantly or by turns touches the gun-barrel, that by theſe means the man upon the originally-electrics might be deveſted of all his electrical fire, by conſtantly continuing the motion of the globes, as he receives then no ſupply from the floor. But the contrary proves true, and, after a conſiderable time, the ſtrokes from the gun-barrel are as ſtrong as at firſt. But here we muſt obſerve, that the gun-barrel ſuſpended will not contain probably at one time a thouſandth part of the whole quantity of this man's electrical fire. Therefore I conceive, that, as ſoon as this man has parted with any portion of his neceſſary, his determined quantity, to the gun-barrel by the motion of the globes, he has it reſtored to him upon any unexcited non-electric's touching the gun-barrel, by having the uſual courſe of the electricity inverted.

LXIII. We ſee from many experiments, that dry wood does not conduct electricity ſo well as that which is wet; and that the man ſtanding upon the floor, who rubs the globes, excites the electricity ſtronger than the cuſhions. This I had reaſon to conceive was owing not to any other difference, than that of his being more moiſt, and, of conſequence, more readily conducting the electricity from the floor. Therefore I order'd my machine, and even the cuſhions to be made damp, by cauſing wet cloths to be placed upon ſeveral parts thereof; and found then, that the electricity was equally ſtrong, as when the globe was rubbed by the hand.

LXIV. It remains now, that I endeavour to lay before you a ſolution, why our bodies are ſo ſhocked in the experiments with the electrified water; the difficulty thereof I confeſs

ſeemed

ſeemed unſurmountable, until I had made the following diſcoveries.

1. That the electricity always deſcribed a circuit between the electrified water and the gun-barrel.

2. That the electrical fire came from the floor of the room.

3. That it would not paſs from the floor quick enough for the perſon to be ſhook, if his ſhoes were dry.

4. That the force was increaſed in proportion to the points of contact of non-electrics with the glaſs containing the water.

Then the ſolution of this phænomenon became more eaſy, which I take the liberty to offer.

1. I have endeavoured to prove by experiment *, that a quantity of electricity is furniſh'd from the neareſt un-

* LVI, LVII, and LVIII.

excited non-electrics, equal to that accumulated in excited originally-electrics and excited non-electrics.

2. This being ſo, when the vial of water held in one hand of a man is highly electrified, and he touches the gun-barrel with a finger of his other; upon the exploſion which ariſes herefrom, this man inſtantaneouſly parts with as much of the fire from his body, as was accumulated in the water and gun-barrel; and he feels the effects in both arms, from the fire of his body ruſhing through one arm to the gun-barrel, and from the other to the vial. For the ſame reaſons, if in the experiment with the electrical * mine, a man places his right foot upon the lower ſmall wire, and touches the gun-barrel with his left arm, the electrical force is only felt in that leg and arm.

3. As much fire, as this man then parted with, is inſtantaneouſly repla-

* XL.

ced

ced from the floor of the room, and that with a violence equal to the manner in which he loſt it. To confirm this, ſee Exp. LIV.

4. But this flux of electrical æther, either from the floor to the man, or from the man to the water, is prevented for reaſons ſufficiently obvious, if the glaſs containing the water be thick; if the points of non-electric contact are few; if the man is placed upon originally electrics; or (which is the ſame thing) if the ſoles of his ſhoes are dry.

5. As we find that the electricity paſſes at leaſt equally quick through denſe mediums, which are non-electrics, as through thoſe, which are more lax and ſpongy; may we not therefore conclude, that the cauſe, why we feel moſt pain at the joints of our arms and in the tendons of our heels *, ariſes

* This pain in the heels is felt only in the experiment with the electrical mine; and it is not perceptible

ariſes from the reſiſtance of the very compact texture in the tendons and tendinous ligaments of thoſe parts?

LXV. From a due conſideration of the phænomena before us, I take the liberty of propoſing the following queries:

1. Whether or no, the effects we obſerve, in bodies being drawn to and driven from either excited originally-electrics or excited non-electrics, are to be attributed to the flux of electrical æther?

2. Whether or no, that, which,

ceptible only when you touch the lower ſmall wire with your foot, but likewiſe if you ſtand upon non-electrics, which touch this wire. It has been ſtrongly felt by a perſon ſtanding upon a pedeſtal of *Portland* ſtone near ten inches in height, and upon one of metal more than two feet. I am of opinion, that no maſs of metal, of dimenſions however great, would in the leaſt prevent the progreſs of the electrical power from the body of the man to the water in the vials.

from

from it's being firſt diſcover'd in amber, we call electricity, electrical æther, electrical power, &c. is any other than elementary fire?

3. Whether or no, this fire does not appear in different forms according to its different modifications? Does it not, when diffuſed under a large ſurface, appear to affect us as air? When brought towards a point, does it not become viſible, as lambent flame? When nearer ſtill, does it not explode, and become the object alſo of our feeling as well as of our hearing? Although it does not affect our ſkin with the ſenſation of heat; does it not, by its lighting up inflammable ſubſtances, ſhew itſelf to be truly fire?

4. Whether or no, this fire is not connected intimately with all bodies at all times, though leaſt of all probably with pure dry air? Have we not found and ſeparated it from water, flame, even that intenſe one of oil of

turpentine, ſmoke, red-hot iron, and from a mixture thirty degrees colder than the freezing point?

5. Have we not proved its ſubtility, from its paſſing through all known bodies?

6. May we not infer its elaſticity likewiſe, from its exploſions; from its increaſing the motion of fluids; as well as from its effect in the concuſſion of our bodies, when we diſcharge it after we have accumulated it in water?

7. May not the electrical machine from its uſes, be denominated a fire-pump with equal propriety, as the inſtrument of *Otto Guerick* and Mr. *Boyle*, that of the air?

8. Does not the power we are now maſters of, of ſeeing the ſeparation of fire from bodies by motion *; and of ſeeing it reſtored to them again, even

* The ſetting in of the fire to the glaſs tubes and globes has always, in theſe experiments, been viſible both from the hands and cuſhions, by which they were

even after that motion has ceaſed; cauſe us rather to incline to the opinions of *Homberge* [a], *Lemery* the younger [b], *s'Graveſand* [c], and *Boerhaave*,

were rubbed. But as till now this fire was conſider'd as coming from the glaſs; that, obſerved upon the hands and cuſhions, was always believed to be ſo much loſt by running down the inſtruments of friction into the floor. I endeavour'd to prevent this loſs by ſtanding upon originally-electrics; and found, to my great ſurprize, that ſo far from increaſing the electrical power by ſtopping what I conjectured was ſo much loſs, I could excite then no electricity at all in the tube and globes. This diſappointment, which, I afterwards found, had occurred to Meſſ. *Boſe* and *Allamand*, was the foundation of my diſcovering the ſource of the electricity, and the manner of its ingreſs to the machine.

[a] *Homberg* du ſouphre principe. *Mem. de l'acad. Royale des Sciences*, 1705. La matiére de la lumiére eſt la plus petite de toutes matiéres ſenſibles—— elle paſſe librement au travers et par les pores de tous les corps, que nous connoiſſons.—— que tout l'univers eſt rempli de la matiére de la lumiére—— J'ai mieux donner à nôtre ſouphre principe le nom de matiére de la lumiére, que celle du feu, quoique ce ſoit proprement la même choſe.

[b] *Lemery* le fils. *Mem. de l'acad.* 1709. p. 527. La matiére de feu doit être regardée comme un fluide d'une certaine nature, et qui a des proprietez particu-

haave [d], who held fire to be an original, a diſtinct, principle, formed by the creator himſelf; than to thoſe of

particulieres, qui le diſtinguent de tout autre fluide. Pag. 8. —qu' une matiére beaucoup plus ſubtile et plus agitée, qui remplit tous les vuides de l'univers, et ne trouve point les pores ſi étroits, qui ne lui laiſſent un libre paſſage, coule inceſſament dans les lieux où elle eſt enfermée, et entretient ſon mouvement.

[c] *s'Graveſand philoſoph. Newton inſtitutiones. cap.* 1. Ignis in corpora omnia quantumvis denſa et dura penetrat.—— corporibus ſeſe jungit—— ignem ad certam diſtantiam a corporibus attrahi—— nulla novimus, quæ ignem non continent——non ignis æque facile corpora omnia intrat—— corporibus contentus in his a corporibus circumambientibus retinetur.—— motu celerrimo ignem affici poſſe.

[d] *Boerhaavii Elementa Chem. de igne.* p. 287. et ſeq.——ipſe ignis——ſemper præſens exiſtit in omni loco——imo vero in omni tempore, etiam rariſſimo, vel ſolidiſſimo, æqualiter diſtributus hæret——Haud ergo potui detegere, quod in rerum natura ſit vel ullum ſpatium ſine igne.

Pag. 283. Huc uſque conabar—— tradere ea, quæ veriſſima addiſcere potui de natura illius ignis, quem elementalem appellant philoſophi. Illum ſcilicet, ita conſiderando, prout creatus ipſe in rerum (natura) exiſtet ſeorſum, extra reliqua omnia creata, quæcunque demum ſint, corpora.

our

our illuſtrious countrymen, *Bacon*, *Boyle* [f] and *Newton* [g], who conceived it to be mechanically producible from other bodies?

9. Muſt we not be very cautious, how we connect the elementary fire, which we ſee iſſue from a man, with the vital flame and *calidum innatum* of the ancients; when we find, that as much of this fire is producible from a dead animal as a living one, if both are equally replete with fluids?

10. Whether or no, it is not highly probable, that by increaſing the number and ſize of the vials of water in a certain manner, you might not inſtantly kill even large animals by the electrical [h] ſtrokes?

[e] Vide tractatum *De formâ calidi.*

[f] *Mechanical origin of heat and cold. ſect.* 2.

[g] See queries at the end of his *Opticks.*

[h] Monſ. *Le Monnier* at *Paris* killed birds by theſe; and with me, a linnet and a rat much more than half grown (the largeſt I was then able to procure) have been ſtruck dead.

LXVI. I cannot conclude theſe papers without congratulating that excellent philoſopher and learned member of this Society, the *Abbé Nollet* of *Paris*. This gentleman, almoſt two years ſince, in a letter to profeſſor *Boſe* (an extract of which, this laſt publiſhed with a work * of his own) without the knowledge of ſeveral experiments ſince diſcovered, at leaſt none of his diſcoveries have yet fallen into my hands, did declare his opinion, [a] that the electricity did not only proceed from the electrified bodies, but from all others about them to a certain diſtance: [b] that the electricity, as well from bodies electrified, as from thoſe which were not, paſſed more readily through denſe mediums than air: [c] that the electricity is preſent in all bodies: [d] that this matter always

* *Recherches ſur la cauſe et ſur la veritable teorie de l'electricité.* Wittembergue, 1745.

[a] *Voyez Nollet dans les Recherches &c. du M. Boſe.* Pag. xlv. — La matiere electrique vient non ſeulement du corps électriſé, mais auſſi de tous ceux, qui

always tends to an *æquilibrium*, and endeavours to occupy thoſe ſpaces in bodies, which have not their neceſſary quantity : [c] that when electrics were excited and brought near non-electrics unexcited, the electricity moved in oppoſite directions : all which aſſertions may now be proved by experiments.

LVII. You ſee, Gentlemen, by my aſſerting that what we have hitherto called electrical *effluvia* do not proceed from the glaſs or other *electrics per*

qui ſont autour de lui, juſques à une certaine diſtance.

Pag. xlix. — Si vous pouvez vous convaincre comme moi, que la matiére qui va au corps électrique vient primitivement de tous le corps environnans, de l'air même, vous aurez bien plus de facilité à expliquer tous les autres éfets.

[b] Pag. xlvi. La matiére electrique, tant celle, qui ſort du corps électriſé, que celle, que vient des environs à ce même corps, ſe meut plus facilement dans les corps denſe que dans l'air même.

[c] Pag. xlvii.

[d] *La même.* Cétte matiére tend à l'équilibre, et s'émpreſſe de remplir les eſpaces, qui ſe trouvent vuides des parties de ſon eſpece.

[e] Pag. xlvii.

ſe, I differ from *Cabeus*, *Digby*, *Gaſſendus*, *Brown*, *Des Cartes*, and very great names of the laſt as well as the preſent age. My differing from them would be preſumption indeed, were I not induced thereto by obſervations drawn from a ſeries of experiments carefully conducted, to which many of you have been witneſſes, and to whom I may therefore appeal for taking, what may ſeem ſo extraordinary a ſtep. I have conſtantly had in view that excellent maxim of Sir *Iſaac Newton* laid down in his *Opticks*, that, " as in Mathematics, ſo in natural " philoſophy, the inveſtigation of " difficult things by the method of " analyſis ought ever to precede the " method of compoſition. This ana- " lyſis conſiſts in making experi- " ments and obſervations, and in " drawing general concluſions from " them by induction, and admitting of " no objections againſt the concluſions,

" but ſuch as are taken from experi-
" ments, or other certain truths. For
" hypotheſes are not to be regarded in
" experimental philoſophy. And al-
" though the arguing from experi-
" ments and obſervations by induction
" be no demonſtration of general con-
" cluſions; yet it is the beſt way of
" arguing which the nature of things
" admits of, and may be looked up-
" on as ſo much the ſtronger, by how
" much the induction is more gene-
" ral".—— " By this way of analyſis
" we may proceed from compounds
" to ingredients, and from motions
" to the forces producing them; and
" in general, from effects to their
" cauſes, and from particular cauſes
" to more general ones, till the ar-
" gument ends in the moſt general."

I am deſirous, that what is contain'd in theſe papers, you will be pleaſed to regard, rather as the rude outlines of a ſyſtem, than as a ſyſtem itſelf; which

I am

I am in hopes, men of better heads and more leiſure will proſecute: and if hereafter from being poſſeſſed of more obſervations than we at preſent are maſters of, any opinions in theſe papers ſhall be found erroneous; I at all times ſhall be willing readily to retract them. I rely upon your wonted candour;

and am, with the greateſt truth,

Gentlemen,

Your moſt devoted

and moſt humble Servant,

Oct. 20, 1746. W. WATSON.