A

SUMMARY VIEW

OF THE

SPONTANEOUS ELECTRICITY

OF THE

EARTH AND ATMOSPHERE;

WHEREIN THE CAUSES OF

LIGHTNING AND THUNDER,

AS WELL AS THE

CONSTANT ELECTRIFICATION

OF THE

CLOUDS AND VAPOURS, SUSPENDED IN THE AIR,

ARE EXPLAINED.

WITH SOME NEW EXPERIMENTS AND OBSERVATIONS,

TENDING TO ILLUSTRATE

THE SUBJECT OF ATMOSPHERICAL ELECTRICITY;

TO WHICH IS SUBJOINED THE

ATMOSPHERICO-ELECTRICAL JOURNAL,

KEPT DURING TWO YEARS,

AS PRESENTED TO AND PUBLISHED BY

THE ROYAL SOCIETY OF LONDON.

RAREBOOK
QC
617
R4
1793

BY JOHN READ,

OF KNIGHTSBRIDGE, LONDON.

LONDON:

PRINTED FOR THE AUTHOR, OF WHOM IT MAY BE HAD;

SOLD BY ELMSLEY, STRAND; RICHARDSON, ROYAL EXCHANGE;

MOOKHAM & CARPENTER, BOND-STREET; DEIGHTON, HOLBORN.

1793.

National Oceanic and Atmospheric Administration

Rare Books from 1600-1800

ERRATA NOTICE

One or more conditions of the original document may affect the quality of the image, such as:

Discolored pages
Faded or light ink
Binding intrudes into the text

This has been a co-operative project between the NOAA Central Library, the Climate Database Modernization Program, National Climate Data Center (NCDC) and the NOAA 200th Celebration. To view the original document, please contact the NOAA Central Library in Silver Spring, MD at (301) 713-2607 x124 or at Library.Reference@noaa.gov

HOV Services
Imaging Contractor
12200 Kiln Court
Beltsville, MD 20704-1387
April 14, 2008

013
R283

LIBRARY
MAY 1 1892
READ

A

SUMMARY VIEW

OF THE

SPONTANEOUS ELECTRICITY

OF THE

EARTH AND ATMOSPHERE.

Price Three Shillings and Sixpence.

Blank page retained for pagination

TO

Sir JOSEPH BANKS, Bart.

PRESIDENT OF THE ROYAL SOCIETY.

I Addreſs myſelf to you as a Patron and well-known encourager of all uſeful Arts. Far from apprehending myſelf fit to be ranked in that claſs, as an Author, I have the greater reaſon to make you, Sir, my acknowledgments for condeſcending to accept of this Dedication; and your doing it with a complacency and eaſe, natural indeed to you, is what adds weight to the obligation: Since I have thereby the pleaſure of offering to the Public a Treatiſe, under your protection, on a ſubject that every man ought, at leaſt in ſome meaſure, to underſtand.

That

That you, Sir, may continue long of the number of thoſe great and exalted ſpirits, who ſeem to be born for the good of mankind, is the ſincere and ardent wiſh of,

S I R,

Your moſt obliged,

and moſt humble Servant,

JOHN READ.

KNIGHTSBRIDGE,
Feb. 2, 1792.

PREFACE.

"WHAT CAN WE REASON BUT FROM WHAT WE KNOW?"

POPE.

EVERY effort towards the elucidation of an important phenomenon, carries its apology along with it; otherwiſe I ſhould be fearful of offending that critical nicety, which in our age lays ſo much ſtreſs upon words more than matter. Purſuits in Electricity have of late been more languid than formerly—not that the ſubject is exhauſted, but that other matters have engaged the philoſophic world. If I preſume to renew the enquiry, and add a few plain facts in a *plain way*, I hope it will be forgiven.

Atmoſpherical Electricity has, in my opinion, been much leſs an object of philoſophic enquiry than it deſerves; but more particularly ſo, as it relates to Botanical Meteorology. Though we have been tolerably inſtructed in the identity of lightning and electricity, and exhibit in our experiments, many ſtriking analogies; yet the perpetuity of Atmoſpherical Electricity, has not to my knowledge been aſcertained by any writer on electricity before. Obſervations on this property

perty have been my ſtudy and amuſement for ſome years; and, I hope the ſimple narrative I have given of them in the following work, will have novelty in it at leaſt.

The Electrical Experiments on Combuſtion, I alſo preſume to think are new: they have to me thrown conſiderable light on that controverted ſubject, the riſe of vapour, as well as on the ſuppoſed affinity between electricity and culinary fire.

The Doubler of Electricity has made its appearance in the Philoſophical Tranſactions; it is an inſtrument of great curioſity. I have taken ſome pains to improve this inſtrument, but conſiderably more with a view to aſcertain its real powers and properties, and have applied them ſucceſsfully in explaining various phenomena reſpecting Atmoſpherical Electricity.

Spontaneous Electricity is no new diſcovery; many eminent Electricians have in their works juſt touched upon it, without forming any definite opinion, or applying their obſervations to elucidate the phenomenon of Lightning. I have called in its aid, or rather fixed it as a baſis, whereon to eſtabliſh the following Theory on Lightning; and which, I truſt, will afford ſome relief, eſpecially with reſpect to the vaſt quantity of it.

Atmoſpherical

Atmoſpherical Electricity will be found, when purſued experimentally, a field full of pleaſing objects, and which ariſe from cauſes ſeemingly the ſlighteſt imaginable. Scenes like theſe, in which we ſee a gradual riſe and progreſs in things, always exhibit a pleaſing ſpectacle to the human mind. Nature, in all her delightful walks, abounds with ſuch views.

As to myſelf, I find it abſolutely impoſſible to produce a work on this ſubject that ſhall be any thing like complete. My original deſign of making experiments and memorandums, was only for my own inſtruction and amuſement; nor had I the leaſt idea of communicating any part of them to the public. But ſeveral perſons converſant in electricity, have expreſſed a wiſh, that the following Eſſay might be preſerved. From a genuine love of ſcience, and of mankind, I immediately communicate to the curious, in this branch of Philoſophy, whatever has occurred in my inquiries. He who does not fooliſhly affect to be above the failings of humanity, will not be mortified, when it is proved that he is but a man; this will ever be the caſe in the progreſs of natural ſcience, ſo long as the works of God are like himſelf, infinite and inexhauſtible: how few ſteps we take therein before we approach that veil of nature which man cannot remove.

I cannot

I cannot help beſpeaking the Reader's candour with regard to my own inability, and want of learning for ſuch a work as this; and hope, that he will be induced to make ſome favourable allowances for any errors which he may diſcover, and kindly correct them for himſelf. Permit me, therefore, to conclude this Preface, with that humble *requeſt* of the illuſtrious Sir Iſaac Newton, which, although in him it might well have been ſpared; yet a more modeſt one cannot well be exhibited for the moſt defective performance, even for this of mine.

" I heartily beg that what I have here done, " may be read with candour; and, that the de- " fects I have been guilty of, upon this difficult " ſubject, may be not ſo much reprehended as " kindly ſupplied, and inveſtigated by new en- " deavours of my readers *."

* Preface to his Principia.

Blank page retained for pagination

CONTENTS.

Page

CHAPTER I.—*Containing a summary view of some Experiments on Spontaneous Electricity,* - - - - - 1

CHAPTER II.—*Experiments and Observations on Heat, tending, to prove, that heat, simply considered, acts on the electricity, both naturally and artificially applied,* 11

CHAPTER III.—*Containing some general Laws, arising from Experiments and Observations on Atmospherical Electricity,* - - - - - - - - - - - 18

CHAPTER IV.—*A Description of the Spectacle Doubler, which, by the turning of a winch, produces spontaneously, without friction, the two states of Electricity. To which is added, Experiments and Observations, to prove, that the spontaneous Electricity of the Doubler is obtained from the common electrified vapour suspended in the air,* - - - - - - - - - - - - 25

CHAPTER V.—*Containing some general Observations on Lightning,* - - - - - - - - - - - 34

CHAPTER VI.—*Containing Experiments and Observations, tending to prove, that every Flash of Lightning consists of positive and negative Light; and which rush into union from two opposite directions,* - - - 39

CHAPTER VII.—*Further Observations and Conjectures on the Phenomena of Lightning,* - - - - - 58

CHAP-

CHAPTER VIII.—*Containing some Experiments and Observations on the Leyden Bottle,* - - - - - - 75

A LETTER *on Electricity to Mr. A. Walker, Lecturer on Experimental Philosophy,* - - - - - - 85

REMARKS *on Dr. Peart's late Book on Electricity,* - - 95

A JOURNAL *on Atmospherical Electricity, read at the Royal Society, April* 14, 1791, - - - - - - 103

SOME *of the Experiments illustrated with a Copper-plate,* - - - - - - - - - - - - 160

ADVERTISEMENT.

The Author begs to inform such of his Readers as are unacquainted with the nature of printing, and may, therefore, think the price of this Book rather high, that it is occasioned by the great expence of the Journals.

Spontaneous Electricity.

CHAPTER I.

Containing a Summary View of Spontaneous Electricity.

EXPERIMENTS to produce electricity, without the aid of friction, has of late years, been diversified and combined in almost every method possible; a particular account of all the circumstances which have attended these experiments would be too prolix and tedious. I shall therefore content myself with a short recital of seven or eight of the main ones; and then make a few concise observations, that will naturally arise, and which I cannot do better than by writing the narrative nearly in the order of time in which the appearances occurred.

EXPERIMENT I.—*By warming the electric.*—I know of none prior to those made with the Tourmalin. The elec-

tricity of this ſtone is excited by heating it, and is ſo ſenſible, that Mr. Wilſon found that removing the Tourmalin from one room to another, in which there was ſome difference of heat, was ſufficient to excite it. Mr. Canton, obſerved, that the Tourmalin emits and abſorbs the electric fluid only by the increaſe or diminution of its heat.

Notwithſtanding the care and attention given to this ſtone, by theſe two eminent electricians; yet, one of its properties eſcaped their obſervation, and was reſerved for the penetrating ſagacity of Dr. Prieſtley, which is this, " that the *ſame flat ſide* of the ſtone, would often be " ſtrongly poſitive and negative at the *ſame time* *." Conſequently the middle part of that ſide of the Tourmalin, between the two electricities, muſt be in its natural ſtate.

EXPERIMENT II.—*By the liquifaction of electric ſubſtances.* —Mr. Wilke melted ſulphur in an earthen veſſel; then, letting it cool, he took out the ſulphur, and found it ſtrongly electrical. He then melted ſulphur in glaſs veſſels, whereby they both acquired a ſtrong electricity; the glaſs was always poſitive, and the ſulphur negative.

EXPERIMENT III.—*By the evaporation of water.*—The methods uſed by Mr. Volta, and other electricians, to turn water into vapour, in order to excite and examine its electricity, have been various. Several years ſince, I ſaw

* See Dr. Prieſtley's Hiſtory of Electricity, page 712.

Mr.

Mr. Volta obtain a very ſmall quantity of electricity, from the fumes of a mixture of water, oil of vitriol, and filings of iron.

EXPERIMENT IV.—From a hint received from Mr. Volta, I made the following ſimple experiment, which any body may repeat with eaſe, who has glaſs or wax to inſulate a veſſel. I collected into an earthen veſſel about a pint of red-hot cinders, which was placed upon a glaſs ſtand; acroſs the top of the veſſel was laid a braſs wire, with two fine linen threads ſuſpended at one end of it, which were to ſerve for an electrometer; a tea-cup full of water was then thrown on the red-hot cinders, and the threads inſtantly diverged two inches with negative electricity.

The method of performing this fine experiment, by the Reverend Mr. Bennet, F. R. S. is much more neat and elegant. His gold leaf electrometer being well adapted to the performance of experiments of this kind. He places a metallic cup upon the cap of his electrometer, with one or two red-hot cinders in it, and then lets fall a ſpoonfull of water upon the hot cinders, and the gold leaves ſoon open with negative electricity.

EXPERIMENT V.—But theſe two methods of performing the ſame experiment, only extend to the ſtate in which the apparatus is at the time when the vapours aſcend, and then it is always found electrified negatively. Conſequently it was natural to conjecture, that the aſcending vapours muſt have abſorbed, while they were forming, a quantity of the electric fluid, and therefore muſt be in a poſitive ſtate; which has ſince been verified by my own experi-

ments. The method I purſue to verify it is, by inſulating a large hollow tin cone, containing about four ſheets of tin plates, with many yards of ſmall wire coiled up within it: one end of the wire is made to extend from the apex of the cone, (which is open) to a very ſenſible electrometer. The cone and wire collect and condenſe the aſcending electrified vapour, as it quits the inſulated veſſel placed under it, which always electrifies the electrometer connected with the cone, poſitively; and the other electrometer, which was connected with the veſſel whence the vapours aroſe, negatively.

EXPERIMENT VI.—*By combuſtion.*—This may be conſidered as an evaporation of the higheſt degree. That bodies paſſing from a ſolid or fluid ſtate, into vapour, give unequivocal proofs of poſitive or negative electricity being combined with them in that ſtate, is now evident. I have burnt ſeveral different ſubſtances in inſulated veſſels, under the tin cone deſcribed in the preceding experiment. The conſequence was that the cone became perceptibly electrified. One of the ſubſtances conſumed in the aforeſaid manner, was dry wheat ſtraw, by which the cone became weakly electrified, poſitively.

EXPERIMENT VII.—Having by me a quantity of roſin and bees wax melted together, but in what proportion to each other I have entirely forgotten, I placed about half a pound of it in an iron ladle, and made it ſmoaking hot on a coal fire: the ladle was then taken from the fire, and placed on the glaſs ſtand under the cone, and a piece of lighted paper was thrown into it, which put the ſmoaking hot

hot compound in a blaze; which ſoon gave evident ſigns of the preſence of the electric fluid. The electrometer connected with the cone, was electrified negatively; the threads opening near two-tenths of an inch. The force of the fire having ceaſed, and the cone cooling pretty faſt, I was agreeably ſurprized to obſerve the threads opening ſtill wider, ſo that in a few minutes, they were ſtationary at near half an inch apart.

EXPERIMENT VIII.—About a quarter of a pound of ſhellac, was placed in the iron ladle, and made ſmoaking hot on the fire; the ladle was then taken from it, and placed on the glaſs ſtand, under the cone, and the hot lac was put in a blaze with lighted paper, the threads opened negatively by the electrometer connected with the cone.

EXPERIMENT IX.—A brownearthen diſh was placed on the glaſs ſtand, under the cone; in the diſh was laid a handful of dry hay, and inflamed by means of lighted paper, then more hay was thrown in, to keep up the flame a little longer; which cauſed the threads of the electrometer, connected with the diſh, to open poſitively; but that connected with the cone ſhowed no ſigns of electricity. In this, and the preceding two experiments, the charge increaſed quickeſt immediately after the blaze had ceaſed.

EXPERIMENT X.—A chafing-diſh filled with blazing coals, was placed on the glaſs ſtand under the cone, and the fire was raiſed by means of a pair of bellows; the electrometer connected with the chafing-diſh was electrified poſitively, and that with the cone was juſt ſenſibly negative. I then repeated this experiment, to ſatisfy myſelf

more perfectly, but with leſs ſucceſs than before, for no electricity appeared in the cone, and ſcarce any in the chafing-diſh, which however ſeemed to be poſitive.

EXPERIMENT XI.—Every part of the apparatus remaining as in the preceding experiment, and the embers in the chafing-diſh being red-hot, a lump of ſulphur was dropped into them, but I quickly found the noxious effluvia too ſuffocating to allow me to attend to the operation. When they were a little ſubſided, I approached near enough to make an obſervation, and found that both electrometers ſhowed ſigns of negative electricity.

However copious the diſcharge of the electric fluid may be, by combuſtion, the quantity obſerved in the preceding experiments is very ſmall. I conjecture that it may be owing to an intimate union ariſing from a ſtrong affinity that there is between flame, and the electric fluid; and that the portion of fluid detached from the burning body in our experiments, is not at all ſufficiently condenſed to quit a better conductor for a worſe. As to the ſmoke, which is unavoidably raiſed by combuſtion, it can by no means affect the experiments, becauſe ſmoke near the burning body, forcibly reſiſts the paſſage of the electric fluid. Flame on the contrary greedily abſorbs it, and carries it away; and therefore, how any, even the ſmalleſt quantity of the electric fluid, ſhould be detained by the apparatus, is to me very unaccountable. And to obtain even that little portion, which it is poſſible to collect from the flame of the combuſtible ſubſtance, depends more upon the goodneſs of the inſulation of the apparatus, than upon any other circumſtance whatever. The two following experiments evince theſe aſſertions on flame and ſmoke.

1ſt.

1ſt. Let a bottle (prepared for the Leyden experiment) be fixed to the end of a metallic rod a foot long, which will ſerve as a handle. Charge the bottle, and hold it by the metallic rod, and paſs it with a quick motion through a column of flame, raiſed from any combuſtible ſubſtance. The conſequence is, that the electrical equilibrium of the bottle will be as completely reſtored by the flame as if it had been plunged into water.

2d. Vary the experiment, by paſſing the charged bottle through a column of ſmoke, inſtead of flame; and it will come out of the ſmoke with its electric charge undiminiſhed.

It is neceſſary in both experiments, to paſs the bottle with a quick motion. In the former, to prevent the bottle from breaking; and in the latter, to avoid as much as poſſible the *ſoot* of ſmoke from fixing itſelf on the uncoated part of the bottle, which would defeat the experiment, becauſe *ſoot* ſeparated from ſmoke, is a *conductor* of electricity.

Theſe facts ſeem to have ſome connexion with another mentioned by Sir William Hamilton, in his accurate and circumſtantial deſcription of the eruption of Veſuvius in 1779. Which eruption was evidently accompanied with great quantities of electricity, which flaſhed among the flames, and in the loweſt part of the ſmoke of the burning mountain, but could not penetrate the column of ſmoke ſuſpended over the flames, and thereby aſcend into the higher and cloudy atmoſphere. He deſcribes it thus:

"Puffs of black ſmoke ſucceeded one another haſtily, and accompanied the red-hot, tranſparent, and liquid lava, within which ſmoke I perceived a bright, but pale, electric fire, briſkly playing about, in zig-zag lines. This black cloud of ſmoke was charged in its courſe with electrical matter, which darted in ſtrong and bright zig-zags, juſt like thoſe deſcribed by Pliny the younger in his letter to Tacitus. This volcanic lightning, however, very rarely quitted the cloud, but uſually *returned* to the great column of *fire*, towards the center of the volcano, from whence it originally came."

Sir William Hamilton might eaſily imagine that the volcanic lightning was connected with the lower ſurface of the column of ſmoke, becauſe there the greateſt efforts of the highly electrified flames would be exerted, in order to penetrate and paſs through it; conſequently its operations muſt be there moſt conſpicuous.

EXPERIMENT XII.—*Hot air is not a conductor of electricity.*—It is inconteſtibly proved, that glaſs heated beyond a certain degree, is a conductor of electricity. But it has not yet been diſcovered in what manner heat in glaſs contributes to that effect. It has been alſo commonly ſaid, that *hot air* conducts electricity. With a view to aſcertain this matter the following experiments were made. To one end of a long piece of wood (which ſerved as a handle) was fixed a glaſs rod, fifteen inches long; to the remote end of the glaſs was fixed a pith-ball electrometer. Having electrified the balls, I held them by the wood handle, and projected them into a large oven, immediately after the fire was drawn out of it; the conſequence was, that when I performed the operation ſlowly, the balls loſt their electricity;

electricity; but that when done quick, with as little delay as possible, their electric charge was not diminished. The loss of electricity in the first case was found to have escaped along the glass into the wooden handle, and so to the earth, owing to the great heat the glass rod had acquired, by which it became a conductor of the fluid; for until it had cooled a little the balls could not be charged again.

I shall lay before the reader one circumstance more, because it may tend to throw light on what degree of heat the oven was in, at the time the observations were made. The baker having pointed out to me the hottest part of the oven; with a quick motion in and out, I plunged the electrified balls into that part of it, by which one thread and ball was burnt off, but the remaining ball shewed that it still retained its electric charge, because it was strongly attracted on the approach of my finger. I did not choose to hazard Farenheit's thermometer, to ascertain the heat of the air in the hottest part of the oven, but being placed near its mouth it rose to 102°.

An apparatus for collecting the electricity of the atmosphere, in order to ascertain its state, and the quantity of fluid, in all sorts of weather, by day or by night, (which generally consists of high pointed and insulated conducting rods, connected with an electrometer &c.) may justly be considered as an instrument daily producing spontaneous electricity, which it simply receives from the aqueous vapours suspended in the atmosphere. The design of its first contrivers was principally to collect into bottles some lightning, during thunder storms; but they seemed to have had no idea of there being some electricity, constantly present in the aqueous vapours.

The

The common and revolving doubler of electricity, always produces the electric fluid without friction or previous communication. Thence it is that ſuch productions are termed ſpontaneous. The great powers of the revolving doubler are apparent; which from its peculiar manner of augmenting otherwiſe inſenſibly ſmall quantities of electricity, even to viſible ſparks; ſeems to aſtoniſh the beholder.

Atmoſpherical electricity, ſimply conſidered, is ſtrictly ſpontaneous, as ſome of the foregoing experiments and obſervations tend to illuſtrate and confirm. I now find no difficulty in the obtaining of it at all times, as it is always obſervable, more or leſs, even during temperate weather, where no ſeeming irregularity reigns in the atmoſphere, ſuch as conſtitutes thunder-guſts, which ſhall by and by be briefly conſidered. The difficulty accompanying the inveſtigation of atmoſpheric electricity, was formerly owing in ſome degree to the want of means ſufficient to obtain the electricity in certain ſorts of weather; this is now removed, and the means, and manner of doing it, is here I truſt, made plain and eaſy to the reader.

During moderate weather, the aqueous vapours ſuſpended in the air, are generally found by experiment, to be in a ſtate of poſitive electrification, to the height my pointed rod reaches; which is ſixty-one feet; how much higher the poſitive ſtate of the electric fluid extends, I am not certain. The intenſity of the electrified vapour within this height, gradually decreaſes as it approaches nearer the ſurface of the earth. Yet I doubt, whether this is a real fact or only a circumſtantial effect. For in this caſe it may be, that the nearer all things approach to an equal intenſity, the uſual ſigns of the preſence of the electric fluid

muſt

muſt of courſe grow leſs, and become extinct. However, I have ſometimes found the electrified vapour, within ſix inches or leſs of the earth's ſurface, negative; when at the ſame time, at a conſiderable greater height, it was poſitive. But at what height the neutral or rather natural ſtate of the vapour happens to be between the two electricities, ſo circumſtanced, is ſo nice a point, that I could never accurately determine it. At other times, when the vapour is rather more than commonly electrified, its poſitive ſtate ſeems to take place on the ſurface of the earth itſelf; but in this caſe alſo, the intenſity of the fluid increaſes as its diſtance from the earth increaſes.

CHAPTER II.

Experiments and Obſervations on Heat.

WE conſider the ſun as the primary ſource of heat upon the ſurface of the earth, and the atmoſphere; without this, all the bodies upon our globe would doubtleſs grow rigid, lifeleſs, and fixed. Hence I conſider heat to be the immediate cauſe of motion to the electric fluid, contained in the earth and waters; by agitating the corpuſcles of natural bodies, and continually ſtirring or exciting ſuch a degree of motion in the ſmall particles of matter as is ſufficient to excite their natural electricity. The truth of this remark is eſtabliſhed upon various effects, and I think, by the before-mentioned experiments, on ſpontaneous electricity.

Whether

Whether we consider heat as solar or subterraneous, or both, as relative to the electric fluid, it matters not. Because it appears both by nature and art, that generally a certain degree of heat is necessary to dislodge the electric fluid contained in the pores of bodies. It is well known that *heat* acts more powerfully on *water*, than on *air*; and many other natural bodies, "for that the same degree of heat, which rarifies air two-thirds, will rarify water near fourteen thousand times*." Thus in winter when the atmosphere appears cold to our bodies, it still contains a degree of heat sufficient to change water into vapour, though that degree of heat can scarcely affect air.

Heat communicated to water, causes a separation beyond the sphere of corpuscular attraction, by which means the volatile particles will fly off at the surface, in the form of vapour: when by heat the particles are separated from their contact, their repulsive force grows stronger, being also aided in their rise when in air, by the well known repulsive force of the electric fluid, which I suppose, has even no weight at all, and which is naturally connected with every particle of water, so that the same should be expanded into a very large space, by becoming electrified vapour, may possibly take up more than ten thousand times the room it did in the form of water; having thus become specifically lighter than air, must necessarily be buoyed up into the atmosphere, and there form the clouds, &c. If the vapour in its egress, be at all visible, and having attained the height of five or six inches of insulation in air, it will evince by proper instruments that it is permanently electrified.

* Philosophical Transactions, N° 407.

It

It has already been ſaid, that the vapours ſuſpended in the air, are generally found to be in moderate weather, electrified poſitively. If it be juſt to transfer the application of the facts, which ariſe from artificial vapour, raiſed by means of fire, to vapour raiſed naturally, we cannot avoid concluding, that natural vapour muſt be in a poſitive ſtate the moment it quits the earth and waters; as the experiments on evaporation of water abundantly confirm.

Moreover heat and water are conductors of electricity. And their being always combined in vapour, muſt increaſe their capacity for retaining electricity, ſo that water in its rarified ſtate, requires, and will abſorb more of the electric fluid, than when in its denſe ſtate as water: and the vapour by riſing into cooler air, will be gradually condenſed more and more, which muſt neceſſarily *increaſe* the *intenſity* of its poſitive charge. Thus we ſee, how heat and cold may be conſidered as a general, if not the ſole cauſe, why we almoſt always find by experiment, the vapours ſuſpended in the atmoſphere, electrified poſitively.

That heat, by its power of penetrating and expanding all groſs bodies, and thereby weakening the attractive force of their component particles, muſt by its mode of vibration amongſt the conſtituent parts of matter, move or excite the electric fluid, lodged within them; nature, as well as art, ſeems to afford ſufficient proof. Elſe why more lightning in ſummer than in winter? Are not the different degrees of heat between thoſe ſeaſons, one, if not the main cauſe? That heat ſimply conſidered is poſſeſſed of the power of conducting the electric fluid, Dr.

Prieſtley

Prieſtley obſerves. " From theſe experiments, (*viz.* on heat) and thoſe on ice, I concluded, that fluidity, as ſuch, contributes nothing to the conducting power of ſubſtances, ſeparate from the *heat* which makes them fluid." As may be ſeen more at large in his excellent Hiſtory of Electricity, SECTION IV, on the Conducting Power of Subſtances, page 609.

Dr. Prieſtley obſerved, " that a red hot poker placed between two braſs knobs, one communicating with the inſide, and the other with the outſide of the charged battery, promoted the diſcharge at about twice the uſual diſtance. *Both ſides* of the hot poker were *marked* with an imperfect *circle.*

" He brought the flame of a candle between the two braſs knobs, and obſerved, that as the flame advanced towards them, it began to be put into a quivering motion, exceedingly quick, and was ſtrongly drawn *both ways* towards each knob, leaving the wick bare at the top; and as ſoon as the flame was quite between the knobs, the battery diſcharged at once, at the diſtance of three inches and an half." He further adds that, " this is a very fine experiment. The interpoſition of the flame between the two braſs knobs is like putting fire to a train of gunpowder, which explodes immediately."

I would farther add by way of inference drawn from both the above mentioned experiments, which agree well with my ideas, that they afford ſigns equally deciſive of two oppoſite currents, running into one another, in the middle of the interrupted ſpace, within the circuit of communication

munication, between the ſides of the battery, which however, I ſhall endeavour to diſcuſs more fully in the ſixth chapter.

That heat ſimply conſidered, acts immediately on the natural electricity of the Tourmalin (and a variety of other gems) is well atteſted in the Hiſtory of Electricity; and has been noticed in the firſt page of this work. That it becomes electrified, merely by heating and cooling, without friction, has been verified by ſeveral eminent electricians. I have obſerved in the electricity of fogs, that when a fog ſuddenly became thick and dark, the intenſity of its electric charge was ſuddenly increaſed alſo; on the other hand, when a fog begins ſuddenly to ſubſide and clear up, the electric ſtate of its remains is but weak. But I never obſerved the electricity of a fog change in kind. I ſuppoſe that ſudden changes in the denſity of the fog, is owing to a quick change of heat and cold; however, thoſe ſudden changes in the intenſity of their electricity, generally reminded me of Mr. Canton's following obſervation on the Tourmalin *viz.* That the electric power of the Tourmalin does not depend on any particular degree of heat, but that the circumſtance of *changing* its degree of heat, gives electricity to this *ſtone.*

Heat acts upon the electricity of bodies artificially electrified. Mr. Canton, procured ſome thin glaſs balls, of about an inch and a half diameter, with ſtems or tubes of eight or nine inches in length, and electrified them, ſome poſitively on the inſide, and others negatively, and then ſealed them hermetically. Soon after he applied the naked balls to his electrometer, and could not diſcover the

leaſt

leaſt ſign of their being electrified; but holding them before the fire, at the diſtance of five or ſix inches, they became ſtrongly electrical; and more ſo when they were cooling. Heating them frequently, he found, would ſenſibly diminiſh their power; but keeping one of them under water a week, did not appear in the leaſt to impair it. Some of his balls retained their virtue upwards of ſix years, but in a leſs degree.

I have ſucceeded in the ſame experiments, or I would not have mentioned them here. Becauſe Dr. Prieſtley failed in his attempt to repeat them after Mr. Canton. The Doctor's failure was owing, as he himſelf juſtly ſuppoſed, to his glaſs balls being too thick. There is, however, one circumſtance worth mentioning, which accompanies theſe experiments, and which Mr. Canton ſeems to have overlooked, as he has not mentioned it, *viz.* that the electricity produced by heat, on the outſide of the glaſs balls, is always the ſame in kind with that within them. Conſequently, frequent heating the balls, muſt leſſen their electric charge; and is a ſtriking proof of the permeability of *thin warm* glaſs to the electric fluid.

I ſhall add only this one experiment more on heat. The indefinitely ſmall remains of electricity, in a diſcharged Leyden bottle, are put in motion by the heat of the hand only. It was diſcovered in the following manner. I was ſhowing a gentleman the power, and utility, of Volta's Condenſer of Electricity. In order to which a Leyden bottle was charged and then diſcharged, by touching its coated ſides with a diſcharging rod. It now appeared to be deprived of all its electricity; yet if I held it by the coating,

coating; and touched with the knob of it the metal plate of the condenſer (placed upon an imperfect conductor) and held them in contact a few ſeconds of time; then removed the bottle, and took up the metal plate by its inſulating handle, and preſented it to a ſenſible electrometer, the electricity was ſtrong enough to enable me to aſcertain its quality. But theſe beautiful effects diminiſhed by repetition; and I repeated the experiment until no electric ſigns appeared in the *condenſer*. However, while we were talking the matter over, I ſtill held the bottle in my hand; and after a long interval of time, from our laſt trial, I repeated the operation once more; and, to our aſtoniſhment, we found the bottle ſtill ſtrongly electrical. This new revival of the electricity we could attribute to nothing but the diffuſive warmth of my hand, acting on the electricity of the bottle. This ſet us to work again, and to try the bottle by turns in a warm and cold ſtate, and we found that our conjecture of the cauſe was confirmed by repeated trials.

I now ſet by the bottle all night, in its preſent ſtate of electricity, and next morning I repeated the operation with it in a cold ſtate, and could not diſcover the leaſt ſign of its being electrified; I then graſped it in ſeveral places on the coating with my hands, till it became warm, and then repeated the experiment in the uſual way, and on preſenting the plate of the condenſer to an electrometer, it charged it pretty ſtrongly. I repeated theſe trials, with the ſame bottle, but without any additional charge, three ſucceſſive mornings, and the effect was nearly the ſame.

CHAPTER III.

Containing ſome general Laws ariſing ſrom Experiments and Obſervations on Atmoſpherical Electricity.

1. THE electricity of the atmoſphere is invariably of the poſitive kind in moderate weather, both in ſummer and winter, day and night, during the ſunſhine, or in gloomy weather. It ſhould ſeem, therefore, that the electricity of the atmoſphere is eſſentially poſitive.

2. In foggy or thick weather, without clouds, if the air is at the ſame time ſharp or froſty, the electricity of the atmoſphere is generally vigorous; but fog accompanied with warm air, and going to reſolve into ſmall rain, is ſure to afford none, or but very weak ſigns of electricity, yet they are generally poſitive.

3. Warm moiſt air is never ſtrongly electrical. But the quantity of electricity is by no means proportional to the quantity of moiſture in the air, and it is often the contrary. An intenſe electricity depends more on the quality, than on the quantity of moiſture.

4. In dark cloudy weather, without rain or ſtrong winds, atmoſpheric electricity, is generally governed by the ſame laws, as in more clear ſerene weather, and is therefore poſitive.

5. Rain

5. Rain after a continued ſucceſſion of moderate weather is always electrified negatively; and very intenſely ſo, if the ſhower be heavy, and its drops large. Such a ſhower of rain commonly becomes poſitive about the middle of it, after that ends as it began, negative; but if otherwiſe, it is from the beginning to the end of it negative. Other rains are not ſo regular.

6. When rain falls plentifully without a ſtorm, its electricity is not ſo varied in kind nor quantity as when accompanied with a briſk wind, and black clouds.

7. Storms of wind, accompanied with heavy black clouds, rain, hail, or ſnow, are always very intenſely electrified. But the intenſity of the electricity during ſuch ſtorms is variable. Thus in ſtormy weather we ſee the electricity ſtrong, then weak, and in a moment after riſe to its former ſtrength; one inſtant poſitive, and the next negative. I have ſeen theſe changes ſucceed ſo rapidly, that I had ſcarcely time enough between the intervals to note them down.

8. The atmoſphere is generally but weakly electrified during high winds with a clear ſky; and during ſtrong eaſterly winds with or without a clear ſky. Strong gales of wind ſimply conſidered, always diminiſh the intenſity of atmoſpherical electricity let them blow from what point of the compaſs they may.

9. The intenſity of atmoſpheric electricity is augmented by *cold*. This is very eaſily obſerved in foggy weather. And from the numerous obſervations which I have made

on this ſubject, I am led to a belief, that this increaſe of electricity by *cold*, and the contrary, is a general law, and takes place in almoſt all the atmoſpherical phenomena; ſo that there is an increaſing progreſſion from the ſmalleſt ſigns of electricity, uſually obſerved in warm ſmall rain, to rain with large drops, and ſo on to ſnow and hail; for hail ſhowers of all others are the moſt intenſely electrified. There are, however, ſeveral other circumſtances which concur to the production of theſe effects, ſuch perhaps as the height whence the meteors deſcend, &c.

10. During a courſe of ſerene weather, it is eaſily obſerved that atmoſpherical electricity is ſubject to a flux and reflux, which cauſes it to increaſe and decreaſe twice in every twenty-four hours. The moments of its greateſt ſtrength are generally after the riſing, and a little before and after the ſetting of the ſun, and thoſe of its greateſt weakneſs are from mid-day to about four o'clock, and midnight.

The cauſe of this periodical flux ſeems obvious; for as ſoon as the ſun warms the earth where the obſervation is made, and in proportion as it riſes above the horizon, the atmoſpheric electricity augments, becauſe the vapours which then riſe carry the electric fluid from the earth into the atmoſphere; but when the ſun has attained the meridian, the heat increaſes in a greater proportion than the evaporation, the air becomes dry, and will therefore hardly tranſmit the electricity. The high pointed rod will now exhibit weaker ſigns of electricity, there being but little moiſture in the lower region of the atmoſphere. But when the ſun is near ſetting, the air grows cool, becomes

comes humid, and transmits more abundantly the electricity of the earth, which gradually increases in its intensity; the electrification of the rod will now rise again with the evening dew, till two, three, and sometimes four hours after sun-set; and then, as I suppose, it must gradually diminish to the next morning *. But is never quite destroyed if the insulation of the rod is not injured by the moist night air.

In pursuing the consideration of this subject it appears that the electricity of the atmosphere (the constant existence of which has been abundantly proved by experiments) and its fluctuations, are principally depending on the vicissitudes of heat and cold, and upon the aqueous vapours; but there are several other phenomena concerned in it. Thus the regular rotation of the heat occasioned by the diurnal motion of the earth, the dryness or moisture of the atmosphere in particular seasons, and various other phenomena, must naturally affect its periods of increase and diminution. And though those periods are subject to some variety in point of time, yet upon the whole the facts mentioned above are indisputable.

The electricity rises invisibly from the earth, concealed in the aqueous vapour; and as the vapour ascends higher and higher into cooler air, it becomes more condensed; by which the electricity which it contains will become

* I have said "I suppose," because I never quite sat up all night to prove it; but from a great number of observations I have more reason to suppose it must be so than the contrary.

more condenſed alſo*, in ſo much that it will now diſ-play its energy, and in whatever direction it moves it is ſure to move actively, animated with a penetrating and expanſive force; for in this ſtate proper inſtruments will eaſily accumulate and detain it, ſo as to render it viſible.

I have no idea, much leſs ſuppoſe, that any, even the leaſt quantity of electricity does ever come from air itſelf; for there is reaſon to think, that air as air, independent of the other ſubſtances, is unable to furniſh any particle of this fluid; and I conjecture that pure air and electricity are actually incapable of uniting; and therefore it is that air is never known to attract, abſorb, nor conduct electricity, but in proportion to the conducting ſubſtances with which it happens to be occaſionally mixed: nor is air excitable of electricity by any means that is yet known; therefore air does not appear to be either an electric or a conducting body.

It is in conſequence of theſe peculiar properties of air that it is found to inſulate the electric fluid more perfectly than any other ſubſtance; that is to ſay, air in even that ſtate of purity which is common to it in dry ſerene weather. Had not air poſſeſſed theſe properties the exiſtence of the electricity could never have been diſcovered. Hence

* It is well known, that if equal quantities of electricity be imparted to two unequal inſulated conductors, the electricity on the leaſt ſurface will become more intenſe than on the largeſt. Electrified vapour is alſo ſubject to this law.

it

it is alſo manifeſt, that the phenomena of lightning and thunder could not have happened in nature.

In the inveſtigation of theſe matters it is almoſt impoſſible for a man to attend every moment to them. It is therefore neceſſary to deduce the law from the general correſpondence of facts, and upon theſe grounds I hope that the aſſertion of the perpetuity of atmoſpherical electricity may not be conſidered as too precipitate and unwarrantable.

Artificial electricity is ſoon produced, and it is as ſoon diſſipated and loſt. But natural or atmoſpherical electricity is univerſal and conſtant, and is incapable of being diſſipated or deſtroyed. For, when ever I ſcrutinize this matter, whether I do it by day or by night, I always find a quantity of electricity ſufficient to aſcertain the kind which at any time is predominant in the atmoſphere; and which for its conſtancy and univerſality may properly be deemed an electrical atmoſphere within our aerial atmoſphere. It is probable that theſe two extremely ſubtile and elaſtic fluids may have ſome unknown dependence on each other, either for their own formation, or their general beneficial properties to the reſt of all created beings.

I beg leave here to relate, in concluding this chapter, an obſervation I have made upon the electricity of winds which have (by the public at large) been deemed *unhealthy*. My enquiry was only whether ſuch winds contained much or but little of electricity. My attention and remarks on this matter have been repeated with care.

A wind prevailed during the latter end of March, and the greateſt part of the month of April 1790, which was univerſally deemed by the people to be unhealthy. This wind was eaſterly, and blew with a briſk ſteady gale, rather ſharp and piercing. It contained but very little electricity; the quantity was even ſo ſmall that I was often obliged to exert my utmoſt abilities to obtain enough of it to aſcertain the kind, which I often could not do except I added to my exploring rod a lighted *torch.** The people were generally more ſickly than at other times, and their malady was attributed to the unwholeſome eaſt wind. Even vegetables, during this wind, did not grow but ſeemed to be in a ſickly dying condition. I think there is ſufficient reaſon to conclude, that dry eaſterly ſtrong winds are more barren of the electricity than any other.

There were within the courſe of the above mentioned month of April, about eight ſmall ſhowers of rain, and two of ſnow; all of which were moderately electrified.

* Flame exceeds abundantly ſharp pointed wires in the powers of collecting atmoſpherical electricity; it has never yet failed me, and I find that its collecting powers increaſe with an increaſed quantity of flame.

CHAPTER

CHAPTER IV.

A Deſcription of the Spectacle Doubler, which, by the turning of a winch produces ſpontaneouſly, without friction, the two ſtates of Electricity.

THE figures 3 and 4 repreſent the inſtrument in every particular a fourth part of the dimenſions of the original. Fig. 3 repreſents the inſtrument ſupported on a glaſs pillar. It conſiſts of the following parts: Two fixed plates of glaſs (or of any other ſubſtance) A and C, are ſeparately inſulated and diſpoſed in the ſame plane, ſo that a revolving plate ~~glaſs~~ B may paſs very near without touching them. Each of theſe plates has a ſmall hole drilled in the middle, with a diamond drill, in which pieces of braſs are riveted, tapt with a female ſcrew on their back part, which receives ſcrews made with riſing knob heads, by which the plates are ſcrewed in their places. The other parts may be diſtinctly ſeen in fig. 4. The ſhaded parts repreſent metal, and the white repreſent glaſs covered with ſealing-wax, except the plates A B C. O N is a braſs axis, that carries the revolving plate B, paſſing through the piece M, which laſt ſuſtains the plates A and C. At one extremity there is a braſs ball D, and the other is prolonged by the addition of a cylinder of ſolid glaſs, which ſuſtains the handle L, and the piece G H, which is ſeparately inſulated. The handle L, beſides the purpoſe of moving the axis, ſerves alſo as a counterpoiſe to the revolving plate, and thereby enables the axis to remain

main at reſt in any poſition. E F are pins riſing from the metal of the fixed plates A and C. The croſs piece G H, and the piece K lie in one plane, and have their ends armed with ſmall pieces of harpſichord wire, in order that they may gently touch the pieces E F in certain points of the revolution. There is a pin I in the piece M, which touches the metal of the revolving plate B. There are likewiſe ſeveral collecting wires twined round the croſs piece G H with their ends ſpread outwards.

The touching wires are ſo adjuſted, by bending, that when the revolving plate B is immediately oppoſite the fixed plate A, the croſs piece G H connects the two fixed plates; at the ſame time that the wire and pin at I form a communication between the revolving plate and the ball D. On the other hand, when the revolving plate is immediately oppoſite the fixed plate C, the ball becomes connected with this laſt plate by the touching of the piece K; the two plates A and B having then no connexion with any part of the inſtrument. In every other poſition the three plates and the ball will be perfectly unconnected with each other.

When the plates A and B are oppoſite each other, the two fixed plates A and C may be conſidered as one continued body, poſſeſſing the ſame electric ſtate; and the revolving plate B, together with the ball D, will conſtitute another continued body, poſſeſſing the contrary electric ſtate. For all the experiments yet made concur to prove that theſe two ſeparate bodies will not poſſeſs the ſame electric ſtate; but that with reſpect to one another their electricities will be poſitive and negative. Therefore the plates

plates will always take the form of a charge, if in their approximation they do not actually touch one another. The rotation, by deſtroying the contacts, preſerves this unequal diſtribution, and carries B from A to C at the ſame time that the wire K connects the ball D with the plate C, the electricity in B will now act upon that in C, and leave it with its firſt electric ſtate augmented; and reſtores B to its firſt ſituation oppoſite A. Here, if we attend to the effect of the whole revolution, we ſhall find that the electric ſtates of the reſpective ſeparate bodies muſt have been greatly increaſed. A ſecond rotation will, of courſe, produce a proportional augmentation of theſe increaſed quantities; and a continuance of the operation will ſoon bring the intenſities to their maximum, which is limited by an exploſion between the plates.

If one of the parts be connected with a ſenſible electrometer, theſe effects will be very clearly ſeen. The ſpark is uſually produced by a number of turns between fifteen and twenty, and the electrometer is ſenſibly electrified by much fewer. When one of the parts is occaſionally connected with the earth, or when the adjuſtment of the plates is altered, there are ſome variations in the effects, not difficult to be reduced to the general principles, but ſufficiently curious to excite the meditations of perſons the moſt experienced in this branch of natural philoſophy. An attention to brevity, however, renders it neceſſary to forbear enlarging upon them *

Since

* Glaſs globes, or cylinders, often meet with accidents. Query, would not a doubler of electricity, properly mounted with large braſs plates,

Since the time in which Mr. Canton made his pith-ball electrometer for exhibiting very ſmall quantities of electricity, the importance of ſuch inſtruments has occurred to many electricians; and many curious and well contrived electrometers bave been made, which by gradually advancing in their ſenſibility, have at length produced that very ingenious and moſt ſenſible inſtrument the Electrical Doubler. This inſtrument ſeems to be the laſt effort of genius; and its electrical powers are truly admirable. But the origin of its remarkable effects has been attributed to ſome ſmall quantity of electricity, generally adhering to its *plates* and other *parts*. To this, however, I could never give my aſſent.

I have therefore been curious enough to ſearch into the laws by which it acts, and the ſource whence its electricity is derived; and the more ſo, becauſe the ſpontaneous electricity of the doubler was deemed a defect, even ſo great, that the inſtrument would be rendered uſeleſs if that could not be removed. For this reaſon I determined to try ſets of plates made of various ſorts of ſubſtance, in hopes of attaining ſome ſubſtance whoſe ſuppoſed adheſive electricity would not influence the proceſs, by the approximation of its parallel plates.

To make this matter eaſy to myſelf, my doubler is ſo contrived that each plate is fixed in its place with one

plates, anſwer all the purpoſes of the moſt powerful electrical machines? I think I can conceive how it may be done. It will no doubt be difficult to make the revolving plate gradually recede proportionally as the charge advances.

ſcrew,

ſcrew, by which I can quickly take off a ſet of plates, and eaſily replace others: and to give the plates a conſiderably more extended inſulation than that made by Mr. Nicholſon, without augmenting the ſize of the inſtrument, the fixed plates are elevated above the axis that carries the revolving plate, by bending the glaſſes which ſupport them in the middle to a right angle, which gives the inſtrument, with its *glaſs plates*, the aſpect of a pair of ſpectacles inverted, and which has occaſioned it to be named the *Spectacle Doubler*.

I have carefully repeated many experiments with ſets of plates made of different ſorts of metal, and of wood, horn, leather, gypſum, ſal-ammoniac, ſal-prunella, alum, and glaſs; all of which, upon trial, produced ſpontaneous electricity of the ſame kind, and nearly of equal intenſity, a circumſtantial account of which, for the ſake of conciſeneſs I paſs over, and content myſelf with obſerving, that the ſpontaneous electric charge of the doubler, and that of my high pointed rod, were generally of the ſame kind of electricity within the room in which the lower end of my high rod terminates, though placed at the greateſt poſſible diſtance from each other. But if at any time, they varied, it was an eaſy matter to account for it. I therefore conclude, that the rod and doubler acquire their ſpontaneous electricities from one and the ſame common ſource, viz. the electrified vapour ſuſpended in the atmoſphere.

The obſervation that when the doubler was mounted with glaſs plates its effects were preciſely the ſame as when plates of braſs or other ſubſtance were uſed, is very much

much in favour of the above-mentioned conclusion, which I had drawn from numerous experiments; because smooth glass by the usual treatments never produced negative electricity; whereas by the operation of this instrument, smooth glass becomes electrified negatively or positively, just as the aerial vapour happens to be electrified with either kind.

I have, indeed, two or three times observed, that when the electric state of the rod was rather weak, and a change of kind happened in such weak state, the doubler in that case would not keep pace with the rod; which at first surprised me very much. But I soon considered that the rod became charged from electrified vapour without, and the doubler from that within the room, and that the vapour within a close room could not change its electric state so quick as that without. I therefore opened the windows, to permit the vapours more freely to mix, which in a few minutes had the expected effect, for on trial the doubler became charged with the same kind of electricity with that of the rod itself. On the other hand, when the rod is more intensely electrified, its electric charge will sometimes induce in the air of a close room a contrary state of electricity to that of its own. In this instance also the doubler and rod will vary, for their electric charges will not be of the same kind, nor ought it so to be accord- to the conclusion I have made. The doubler thus circumstanced will become strongly electrified by one revolution only.

There is one very great difficulty attending the use of the electrical doubler, and which, doubtless, will occasion many

many mistakes, unless great care be taken. On this account we have not, as yet, any criterion whereby to know when the doubler is in a neutral or unelectrified state. This difficulty arises from the perfection of this instrument, by which it is able to be a test to all others, but no one can be a test for it. It is therefore certain, that communicated electricity must be a degree more intense than that of the atmosphere at the time that the experiment is made, otherwise the results will be equivocal.

When I use the doubler of electricity, I am cautious not to carry on the doubling process too high; because I find that a weak charge is more easily got rid of than a strong one. If it is only the kind of electricity that one wants a few revolutions will be sufficient for the purpose.

I beg leave, however, here to relate, that in my two years journal on atmospherical electricity, which is placed at the end of this work, there is not one observation taken by means of the doubler. For although I am satisfied that the spontaneous electricity of the doubler is as really atmospheric as that of my high pointed rod, yet as that matter is not generally admitted, I could not venture to force my opinion upon the public. However, for the satisfaction of the curious, I shall here insert an *Electrico-Meteorological Journal*, taken by means of the doubler of electricity, mounted with *glass plates*, in three different stations, *viz.* First, The doubler was placed on a stone pavement, on the north side of my house; Secondly, on the wood handrail of a bow window, 27 feet high over the pavement; and Thirdly, in the room wherein the lower end of the high

high rod terminates. The first column shews the contemporaneous kind of electricity indicated by the high pointed rod. The time of making the observations was nine o'clock in the morning.

1790. Nov.	High Rod	Gr.	Bow W.	Roo	Wea.	Dec.	High Rod	Gr.	Bow W.	Roo.	Wea.
27.	Pos.	Neg.	Pos.	Pos.	fog	12.	Pos.	Pos.	Pos.	Pos.	fair
28.	Pos.	Neg.	Pos.	Pos.	foggy	13.	Null.	Pos.	Pos.	Pos.	rains
29.	Pos.	Pos.	Pos.	Pos.	clear	14.	Signs	Neg.	Pos.	Pos.	rains
30.	Pos.	Pos.	Pos.	Pos.	snows	15.	Null.	Neg.	Neg.	Neg.	rains
Dc. 1.	Null.	Neg.	Pos.	Pos.	fair	16.	Neg.	Neg.	Neg.	Neg.	rains
2.	Signs	Neg.	Neg.	Neg.	clear	17.	Null.	Pos.	Pos.	Pos.	foggy
3.	Pos.	Neg.	Pos.	Pos.	fog	18.	Neg.	Neg.	Neg.	Neg.	gloomy
4.	Signs	Pos.	Neg.	Pos.	clear	19.	Signs	Neg.	Neg.	Neg.	rains
5.	Signs	Neg.	Neg.	Pos.	clear	20.	Signs	Pos.	Pos.	Pos.	fair
6.	Null.	Neg.	Neg.	Pos.	rains	21.	Null.	Pos.	Pos.	Pos.	fair
7.	Pos.	Neg.	Neg.	Pos.	fair	22.	Null.	Pos.	Pos.	Pos.	fair
8.	Null.	Pos.	Pos.	Neg.	mild	23.	Signs	Pos.	Pos.	Pos.	foggy
9.	Signs	Neg.	Neg.	Neg.	mild	24.	Neg.	Neg.	Neg.	Neg.	rains
10.	Signs	Pos.	Pos.	Pos.	fair	25.	Neg.	Neg.	Neg.	Neg.	fair
11.	Pos.	Neg.	Pos.	Pos.	fair	26.	Pos.	Neg.	Pos.	Pos.	fog

I scarcely need observe that this journal of thirty days, only includes that part of each day in which the observations were made, and which was generally completed in less than half an hour.

The construction of electrometers has been varied according to the purposes for which they have been designed, and the different degrees of electricity intended to be shewn by them. When we are investigating the nature of atmospheric electricity we require the most sensible electrometer possible, that it may indicate the least perceptible portion of it existing in the humidity of the air.

I have

I have uſed, for this purpoſe, very ſmall ſilver wire, gold leaf, ſilver leaf, fine flaxen threads, &c. To the laſt of which, I now give the preference; becauſe I think they poſſeſs the greateſt ſenſibility, and are leaſt liable to accidents.

The threads are made thus: I take flax as it comes from the heckle, or flax comb, and I firſt ſplit the threads ſo fine that they will almoſt float in air; I then make a loop at one end, and ſuſpend them by it from a metallic hook or ring, after which I dip the point of a ſmall pin in hot glue, and thus join one pin to the lower end of each thread. They, by their weight, will keep the threads ſtraight; and that they may remain ſo, when the pins are cut off, I wet my finger and thumb with glue ſize, and gently preſs the threads between them from top to bottom. When they are dry I carefully remove the pins, and the threads will hang ſufficiently ſtraight. I make them of various lengths, ſome with, others without balls to them; incloſed in glaſs cylinders; for without the glaſs the threads would be ſo agitated by the leaſt motion of the air, that they would be entirely uſeleſs. The threads of my moſt ſenſible electrometer are eleven inches long.

In order to ſucceed well in electrical experiments, much depends on having a good inſulation to our electrometers. I have tried various ſubſtances with a deſign to improve the inſulating power of glaſs, viz. by coating glaſs with hard red ſealing-wax, ſhell lac, copal, amber, &c. But I cannot determine which of theſe ſubſtances (when laid on glaſs) is poſſeſſed of the greateſt inſulating power. But

 this

this is evident, that their inſulating quality is conſiderably increaſed by only warming them before the fire. Atmoſpherical electricity is ſometimes ſo circumſtanced, that it would be in vain to attempt to collect it, if the inſtruments were not previouſly warmed.

CHAPTER V.

Containing ſome general Obſervations on Lightning.

IT is ſaid that lightning happens almoſt daily in ſome hot climates; both with and without ſtorms; even in the moſt ſerene weather, if there are any clouds in the atmoſphere, ſufficient to accumulate the matter of lightning. And that the lightning happens more frequently, and in greater quantity, after the ſun has paſt the meridian, than otherwiſe.

Whether we contemplate the matter of lightning as it reſpects atmoſpheric or artificial electricity, the ſubſtance is preciſely the ſame; in both caſes, the fluid is retained, and its effects tranſmitted by the ſame mediums; than which there is not, perhaps, a ſurer criterion to determine the identity of this ſubtile matter.

I con-

I conſider lightning to be ſpontaneous electricity in the higheſt degree. I am therefore under a kind of neceſſity in writing this eſſay, to deliver my thoughts on this intricate ſubject. An electrician cannot help forming ſome idea, if not an hypotheſis, how, or in what manner, an event, which indubitably ariſes from an unequal diſtribution of the electric fluid, in the earth and atmoſphere, is produced. Which ſpontaneouſly becomes perhaps the moſt formidable and irreſiſtible agent in the univerſe. Notwithſtanding this, it appears, from various facts and experiments, that the matter of lightning in moderate quantity, is not only perfectly inoffenſive, but abſolutely neceſſary, for the well-being of animals and vegetables, ſuch as is conſtantly found connected with moderate hail, ſnow, rain, fog, and dew.* Which diſtribution of the fluid, may be conſidered as nature equipt in her beſt attire; circulating this wonderful and extremely ſubtile and elaſtic fluid, to the all wiſe beneficial purpoſes, for which it was originally deſigned, by the Author of Nature. But I conſider ſuch a diſpoſition of the elements, as conſtitute thunder-guſts, to be nature in a ſtate of apparent diſorder.

The ſame kind of diſtinction may be applied between moderate wind, and hurricanes of wind; between moderate rain, and inundations.

A ſort of lightning is ſometimes ſeen in this climate in a ſummer's evening, playing among the clouds. This

* See the Journal for July 20, and Nov. 12, 1789.

kind of lightning, generally happens in warm ſerene weather, and ſeems quite harmleſs; and is never attended with thunder. Theſe circumſtances plainly ſhow, that ſome cauſe or circumſtance is wanting, to produce miſchievous effects. I conceive that cauſe to conſiſt, chiefly, in the diſtance of the phenomenon from the earth; which is too great for the electrical atmoſpheres of ſuch clouds to diſturb the electricity of the earth. And is probably nothing more than the concourſe of two or more oppoſitely electrified clouds, darting their electrical charges into each other. When I have been able to obſerve the direction of this kind of lightning, it was generally obſerved to be horizontal, or nearly ſo; excepting when it was evidently drawn aſide by the adjacent clouds, which ſeems to indicate that it had but little, if any communication with the earth. Nor have I ever obſerved my high pointed rod, to be more than ordinarily electrified, during ſuch lightning.

Before I conſider that ſort of lightning, which often produces dreadful effects, I beg leave firſt, to correct two or three common errors, which ſeem to have ſprung from the prejudice of education in ſome perſons, and from too little attention in others.

Firſt, there is no harm in, conſequently no cauſe of fear, to be apprehended (however ſenſibly it may affect ſome) from the rumbling noiſe of thunder; becauſe it conſiſts only in a ſudden concuſſion of the air, occaſioned by the rapid and violent paſſing of lightning through it. The damage to be apprehended is abſolutely from the lightning

lightning itſelf. Therefore thoſe vulgar notions which are ſtill retained by ſome, of *thunder-bolts*, hurling deſtruction whereever they are ſaid to fall, are all deluſive dreams; which ideas, I am of opinion, originally ſprung from *heathen mythology*. Becauſe Jupiter is ſaid to be the god of thunder; and they have deſcribed him as holding thunder-bolts in his right-hand; that is to ſay, ſomething to repreſent fire, flame, and zig-zag lightning.

The ſecond, regards the direction of lightning. It is an idea mentioned in many books, and entertained by almoſt every perſon, with whom I have converſed on this ſubject, that all the lightning we ſee deſcends from the clouds. This ſentiment ſeems to have been the effect of inattention. For when the immenſe quantity of lightning, which is uſually ſeen diſplayed even in common thunder-ſtorms, is ſeriouſly conſidered, I ſhould imagine that it would ſtagger any one to think that the clouds could ever contain it all: and the more ſo, when it is further conſidered, that the earth itſelf is the grand ſource of lightning, and that none can deſcend from the clouds but what firſt aſcended from the earth. Yet the quantity of it which quits the earth in ſettled moderate weather, is ſo remarkably ſmall, as to be juſt ſufficient to determine the aqueous vapours to be electrified poſitively. But that quantity, be it great or ſmall, muſt neceſſarily render the earth in proportion thereto electrical in the oppoſite ſtate. Thus art, is only an happy imitation of nature. By which, we indiſputably know, that when an inſulated body (as is the caſe of a cloud) is rendered electrical in one kind, an uninſulated body near it, will alſo thereby become electrical of the contrary kind.

But to what height the daily electricity aſcends into the atmoſphere is quite uncertain. We are ſure that the electric fluid often returns to the earth more copiouſly, concealed in the boſom of *ſnow*, *hail*, and *rain*, which muſt in ſome degree compenſate for the loſs, daily ſuſtained by the earth; and ſo recruits and keeps up the perpetual circulation of this wonderful agent.* Now, ſhould the ſilent, and inviſible deſcent of the electricity, by means of ſeaſonable ſhowers, be equal to the daily aſcent by means of heat and vapour; whence is that amazing continued blaze of lightning, which is uſually obſerved in thunder ſtorms, and which is ſometimes continued during ſome hours?

It is a common notion, and generally adopted in the deſcription of thunder ſtorms, or of the damages occaſioned by lightning, that the matter of lightning always comes from the clouds and goes to the earth. That this is ſometimes the caſe there is no manner of doubt; but I can with confidence aſſert, that the contrary of this propoſition takes place much more frequently, viz. that the matter of lightning, or the electric fluid, proceeds from the earth and goes to the clouds. But this will be diſcuſſed more fully in the two following chapters.

Thirdly, a great variety of terms are commonly uſed in deſcribing the appearances, and effects of lightning,

* I have received the falling rain, hail, and ſnow, into an inſulated veſſel which was ſometimes found to be electrified; eſpecially ſo when my high-pointed rod indicated an intenſe electricity in the falling meteors. The manner of doing this may be ſeen in the journal for the 20th of July, 1789.

which

which are very indefinite, and do rather miſlead than inform the reader. Such as flaſh, vivid dart, forked, zig-zag, ball of fire, cable of light, and a ſheet of continued blaze, &c. If a lighted torch be whirled round like a ſling, the rapidity of the motion will exhibit to the eye, a circle of light, or if the torch be ſwiftly moved in a right line, or in zig-zags, the appearance of light will ſeem to follow the ſame direction. Therefore we ought not to ſuppoſe, when we ſee a body of electric light in its paſſage between two conductors, that it does actually fill at the ſame inſtant of time, the whole tract it paſſes through. But theſe, though the beſt arguments which the ſenſes can furniſh, of the courſe of lightning, are but faint repreſentations, when it is conſidered that the velocity of lightning has been found, by experiment, to be nearly inſtantaneous.

CHAPTER VI.

Containing Experiments and Obſervations, tending to prove that every Flaſh of Lightning conſiſts of poſitive and negative Light; and which ruſh into Union from two oppoſite Directions.

I Am not certain, that the following ideas, on the two electricities, ever entered into the mind of thoſe electricians who have been ſtrenuous advocates for the doctrine of *two electric fluids.* They ſuppoſed, indeed, that

there were two electricities, which had a strong chymical affinity with each other, at the same time that the particles of each have a strong repulsion amongst themselves; and that these two electricities were equally attracted by all bodies existing in intimate union in their pores; and while they continued in this union they exhibited no marks of their existence. They also observed, that every electric spark consists of both electricities rushing contrary ways, and making a double current. But this doctrine seems now to be intirely supplanted by the more natural theory, of *one electric fluid*; which is simple and easily conceived, and every way sufficient to explain effects and appearances. To which I subscribe, and from which I have not intentionally deviated throughout this narrative.

The greatest difficulty attending the contemplation of the phenomenon of lightning, is the vast quantity of the matter of lightning, which usually appears during great thunder storms. The perplexity attending the consideration of this fact, will (I presume) be considerably diminished, if the results of the following experiments, and the reasoning and application I have made of them, are well founded.

I conceive that this globe of earth and water, with its plants, animals, and buildings, have diffused throughout their substance a certain quantity of the electric fluid, which is termed their natural quantity: and while this equable distribution continues undisturbed, their electricity is in all respects invisible. But if the balance of this diffusion, be by any means destroyed, either in the earth or atmosphere, then it becomes visible in proportion to that

that disturbance. Hence the terms positive and negative, density and rarity, redundancy and deficiency, &c. are only applicable to the electric fluid during its disturbed state.

This being premised, we will now suppose a thunder cloud coming already highly charged with the electric fluid, which cloud, in its passage through the atmosphere, seems to hover over a high tree. The tree, and the earth to a limited distance around it, will become thereby electrified; but of an opposite kind of electricity to that in the cloud.* The electricities of the earth and cloud, being thus circumstanced, and their atmospheres approaching nearer and nearer, must necessarily act with very great attractive force on each other. One body being highly positive, and the other of course as highly negative, will urge their way with great violence through the resisting air, which intervenes between them. Now should the atmospheric conducting matter, which lies between the two powers, be equally disposed and in some small degree able to conduct the electricity of the earth above the tree, the explosive flash of lightning, will take place in the air, over the tree, at the striking distance between the two powers; and at the same time restore the equilibrium of the electric fluid, to the earth and cloud.

Now any person, perceiving the flash of lightning, and judging by the appearance, would no doubt readily con-

* It is dangerous, therefore, to take shelter under a tree during a thunder storm. It has been fatal to many, both men and beasts. It is safer to be in the open field, because wet clothes tend to prevent harm from a flash of lightning.

clude,

clude, that it all issued from that black cloud; whereas one half of such flash of lightning, must immediately ascend out of the earth, and the other descend from the cloud.

If the intervening air which lies between the two powers, should happen to be dry, and therefore not able to elevate the electricity of the earth above the tree, the explosion must in this case, take place in or near the tree, which it is very probable, would be shattered to pieces, by the force or impetuosity, whereby the two electricities unite. But in the former case, the tree might sustain no injury. The same reasoning will hold good if the mast of a ship, or lofty building, were to be a part of the conducting medium between the two electricities.

That the main force of lightning, must happen nearly in the middle of all resisting mediums, which lie between the two electricities; and that when the explosion takes place, the light seen is made up of positive and negative, in one appearance of light, as above asserted, I shall endeavour to illustrate and confirm, by selecting a few experiments and observations.

The reader will easily perceive, that I consider the state of the electric fluid, during a thunder storm, to be situated in the earth and atmosphere, similar to the experiment of a charged Leyden bottle. I perceive no material difference between them, but what relates to quantity, except this; and without this, I see not how the phenomenon of lightning could ever happen in nature. It is this

this: the electric charge of the Leyden bottle principally adheres to the surface of the glass, and not to its coating; but when a plate of air is said to be electrified, the charge always adheres to the coating; that is to say, to the clouds or aqueous vapours suspended in it. This nice distinction (which nature obliges the philosopher to notice) does not arise from the great thickness or quantity of air, which, in thunder storms, may occasionally happen to be between the electrified portion of earth and clouds; but it arises from the resistance of air to the electric fluid. I find by the operation of the electrical doubler, that the Leyden experiment is perfectly formed, though the portion of *air* between the two fixed plates, and revolving plate, be only one fiftieth part of an inch.

With regard to air itself (which seems to be the most perfect non-conductor of electricity) when simply considered, it seems to be originally void of electricity (which is common to all other matter), and that air, as air, is actually incapable of absorbing or retaining it, but in proportion to the foreign matter mixt with it. And that the permeability of air to the electric fluid, is owing to its fluidity and extreme elasticity, which causes it to yield to the least partial pressure. It was necessary that air should possess these properties, in order that the two electricities might manifest themselves by those appearances which we term lightning. Consequently, during a thunder storm, the earth and clouds operate as coatings to the plate of air that lies between them. That this is a real fact, there seems no room for doubt, after that decisive experiment of charging a plate of air, so as to give a shock like that of the Leyden bottle.

EXPERIMENT

EXPERIMENT I.

The electric charge of the Leyden bottle is limited by the compact texture and thickness of the glass; for if the charge be urged too high, the electricities will force a hole through it, and the tinfoil coating will be rent up in a bur, on both sides of the glass; and will sometimes be melted. Which shows plainly, that where the positive and negative electricities re-unite, there the greatest effort is exerted. In this experiment, the two electricities seem to meet in the middle of the thickness of the glass. Which is strongly indicated by the *bur* being protruded from the middle of the glass. Similar effects will take place, if the circuit be interrupted by several folds of paper, for a hole will be made through them, and each leaf will be protruded by the two electricities, from the *middle* towards the outward leaves.

EXPERIMENT II.

With a jar highly charged, containing nearly six square feet of coated glass, I have melted small iron wire into globules of metal. This fine experiment is attended with some difficulty, for if the charge of the jar should happen to be too strong, the wire will be dispersed; if too weak, it will only be made red-hot. But sometimes the electric charge will be of a proper intensity to melt the wire into fine globules. When this surprising effect happens, I have often observed the wire to be of a more pale red heat in the *middle* than at its extremities, and the melting of it to begin *there*; leaving a part at each end unmelted,

unmelted. At other times (though less frequent) the wire was observed to be of a more glowing heat in two parts of it, than in the rest, which generally happened to be a little above and below the middle of it. These effects clearly show that the positive and negative electricities of the charged jar must have met in great force near the middle of the wire, where the resistance to their union was greatest.

EXPERIMENT III.—*By Lightning.*

Dr. Franklin, in his account of the effects of lightning, on the church of Newbury, in New England, observes "that a wire, not bigger than a common knitting needle, did in fact conduct a flash of lightning, without injuring any part of the building as far as it went; though the force of it was so great that, from the termination of the wire down to the ground, the steeple was exceedingly rent and damaged; some of the stones, even in the foundation, being torn out, and thrown to the distance of twenty feet. No part of the wire, however, could be found, except about two inches at each extremity, the rest being exploded."

From the circumstance of two inches of the wire being found to remain intire, at each extremity, I infer, that the positive and negative electricities must have met at about midway between the two extremities, and there the restoration of the electrical equilibrium, must have taken place between the earth and cloud. If the wire had been extended to the earth, possibly no damage might have happened to the building. These inferences seem to be just, from the circumstances of the case; and are also con-

confirmed by the well known effects of large electrical batteries; for when the charge of a battery is made to pass through, or meet in a very small wire, which on account of its smallness must occasion some resistance to the reunion of the two powers, yet in all cases, whether the wire be melted or exploded, the electrical equilibrium of the battery is always, without exception, found restored by the explosion.

We will now take a view of this matter, as it appears in the electrical spark, which, I am persuaded, when carefully examined, will be found to consist of both electricities, stretching or extending themselves beyond the conducting surface, in order to lessen the leap through the resisting medium of air to their union. For every moment during their disunion they are constantly endeavouring to unite, (which endeavour, or mode of action, is uniform and reciprocal,) and press into, or attract each other, like the north and south poles of two magnets*.

EXPERIMENT IV.

My electrical machine has two prime conductors, made of copper, each containing about 300 square inches of surface, both well insulated. This machine, when placed on the ground, having a brass ball of two inches and a half

* The law of electrical attraction seems not yet ascertained, nevertheless, it is sufficiently evident, that equal quantities of both electricities, separately insulated, act with equal force upon each other; and that their force increases as they approach to, and decreases as they recede from, one another; but it is not yet known whether this attraction follows any regular proportion.

diameter,

diameter, suspended from each conductor, by bent brass rods, so that the balls approach within one inch of the surface of the earth; the apparatus being thus disposed, and motion given to the glass cylinder, it is beautiful to observe how exactly the two electricities strike at the same instant of time. The negative spark issues immediately out of the earth, and the positive spark strikes into it, and thereby restores the equilibrium of the electric fluid to the earth, which had been disturbed by the action of the machine.

EXPERIMENT V.

The same apparatus affords another very fine experiment, by only elevating the metallic balls and curved rods, so as to form an arch over the glass cylinder; but as the two electricities, in this experiment, instantly dart into each other in air, the brass balls need not be placed nearer to one another than three or four inches, for on every revolution of the glass cylinder a dense spark will explode between them; it is even so strong, that if it be taken properly, it gives the Leyden sensation. This spark may be considered as a kind of ocular demonstration, that when positive and negative electricity are accumulated in, and made to meet in air, their light and force seem to be apparently doubled. If a curious observer examines this light in the dark, he may distinctly perceive the usual *signs* of *both electricities* within the resisting medium of air, and also where they unite, for their place of re-union is noticeable by being much less luminous, which is the natural effect of union; for there, in that particular part of the spark, the two electricities become again one; there the terms

terms positive and negative cease, and there the electric light vanishes.

We know that the electricity is in matter, but its properties in that state of union, are, I think, altogether unknown. It has been, however, improperly said, that the positive and negative electricities destroy one another, because, when united, their visible effects cease. It is not, therefore, the *cause* determining those effects, that is expressed by the word destroyed, but the *effect itself*.

I beg leave, moreover, to remark, that this experiment affords a striking instance of the vast quantity of electricity that is naturally contained in the pores of metal; for, in the fourth experiment, the supply of electricity was immediately from the earth, but in this the supply is wholly from the *insulated metallic conductors*.

EXPERIMENT VI.

This experiment was made by Mr. Nicholson, with a more powerful electrical machine than mine. A delineation of his seven electric sparks is given in the Philosoph. Trans. vol. 79. Spark third. "When the one ball was electrified *plus*, and the other *minus*, the signs of both electricities appeared. If the interval was not too great, the long zig-zag spark of the *plus* ball struck to the strait flame of the *minus* ball, usually at the distance of about *one-third* of the length of the latter from its point, rendering the other two-thirds very bright."

This

This is an undoubted fact with me, though noticed by very few electricians. Mr. Nicholson's description of this spark evidently exhibits, in one point of view, the positive and negative electricities, uniting in air, and rushing into each other in opposite directions. I think, however, that Mr. Nicholson, in his narrative, seems to be a little embarrassed with the old doctrine on this subject, which, indeed, should never be invaded on slight evidence; I admire his tenderness in this respect; but why the luminous appearances in his fig. 6, should differ so widely from those of fig. 3, is to me unaccountable, for the usual signs of both electricities are plainly observed in all his experiments, and delineated in fig. 1, 2, 4, 5, 6, and 7, though not quite so conspicuous as those of fig. 3.

It is well known to electricians that the appearance of electric sparks, taken in air, is subject to many variations, which are occasioned by the change even of the most trifling circumstance; yet there are certain criterions peculiar to each kind of electricity, which evidently show that every spark must consist of both electricities, one end of which always exhibits the positive, and the other the negative signs. For instance, if the negative part of a spark be small, or what has been usually termed a luminous globule, then the middle part of it is generally of a purplish colour. When ramified rays issue from the positive part, then the negative part is more extended, stretching out towards the positive; and when the positive and negative parts strike into each other in dense light in various parts of the intermediate space, then their exact place of union is generally observable by a dark spot. Hence I infer, as before observed, the loss of light, whether

total or partial, that may happen in any part of an electric spark, to be the immediate effect, and constant sign, of the re-union of the two electricities. It is further to be observed, that whether the negative light assumes the figure of an oblong flame, or of a luminous globule, in either case the positive light is seen to approach and unite with it, in all possible directions. I find, as Mr. Nicholson has determined, "that the effect of a positive surface appears to extend farther than that of a negative."

As the middle part of an electric spark often appears of a dilute purplish colour, and its ends more vivid and white, it has been conjectured by some to arise probably from the fluid meeting with the greatest resistance at its entrance and exit. I imagine, however, that this idea was suggested (for I know of no fact in the science of electricity itself to prove it) by the resistance and refraction which the rays of light suffer in passing from one substance into another. But it will appear with the least consideration, that there is a very great difference between the light of the sun and that of electricity; I therefore conclude from the foregoing experiments, that all electrical explosions consist of both electricities rushing into union from opposite directions.

We shall now proceed to examine the appearances of the two kinds of electricity which take place in vacuo.

I think it was in the year 1776 that I was employed by John Walsh, Esq. F. R. S. to procure some double barometer glass tubes, or long bent tubes of glass, and to assist Mr. De Luc to boil carefully the mercury within them,

them, in order to obtain a perfect vacuum in the arch above the mercury. One of them being completed, trial was made to pass the electric charge of the Leyden bottle through the vacuum, but it could not be done; nor was there any luminous appearance perceived in this barometer. Perhaps the electric fluid is not capable, by its own expansive power, of extending itself into spaces void of all matter.

I mounted a glass tube three feet seven inches long, of about one inch bore, with brass caps; one of the caps was fitted to the plate of an air-pump; a brass wire and ball extended a little farther within the tube than the caps did on the outside of it. This tube was screwed to the plate of an air-pump; but while the air within it remained of its natural density, the charge of the Leyden bottle could not be transmitted through it, any more than through a perfect vacuum. But if the air-pump was worked for a short time, so that the air within the glass tube might be considerably rarefied, then the charge of the Leyden bottle would easily pass through the rarefied air, and fill the whole capacity of the tube with electric light.

EXPERIMENT VII.

That to which I would wish the philosopher to attend chiefly in this experiment, is the direction and appearance of the two electricities within the glass tube, which is best done when the electric charge of the Leyden bottle is rather too weak to force its whole contents swiftly through the rarefied air, for, otherwise, the motion of the fluid is so rapid, and its light so resplendent, that the eye cannot

distinctly notice its operations. When you examine the appearances in the dark, at the moment the circuit is formed to pass the charge, you will discover some light within the tube, chiefly at each end of it. These lights are of contrary kinds of electricity, and agree with the charged side of the bottle, to which they are connected by metal. It may sometimes be clearly perceived, when the charge is of a proper intensity, that the two lights have a manifest tendency to meet near the middle of the resisting medium, (provided that the glass tube be perfectly clean and dry) and thereby restore the equilibrium to the sides of the bottle; but, in this case, the equilibrium is but partially restored, because the two powers do not unite in sufficient quantity to effect it.

I have frequently observed the light within the exhausted tube to be considerably diminished in its splendour where the two powers unite; and in air also, as we mentioned before, a dark spot is observable near the middle of many electrical sparks. These appearances are the consequence of union, and ought to be so, because in proportion as the two electricities unite, and regain their natural state, they lose their light; for the electrical substance is only luminous in a divided state, whether it be viewed in vacuo or in air.

That these two remarkably distinct powers should tend to re-unite near the middle of all resisting mediums is natural, because there the two electricities meet with a greater resistance than in any other part of the circuit, consequently there their whole force will be exerted to overcome

overcome the resistance, and, of course, will there become most conspicuous in their effects.

EXPERIMENT VIII.

Similar effects and appearances are observed, and easier performed, if the air-pump and glass tube screwed to it be placed so that an half-inch spark from the prime conductor of an electrical machine be made to strike the upper cap of the glass tube: and here also, in this mode of performing this experiment, the light seen within the tube consists of contrary kinds of electricity; for, if the electric spark communicated to the upper cap of the glass tube be of the negative kind, the cap and light within near to it will be negative also, and the light within the tube at the lower end will be of the positive kind; and also the air-pump, and the table it stands upon, though uninsulated, will give sufficient proof, if examined by a sensible electrometer, of their being electrified positively.

There is another important appearance, which has been entirely overlooked, and which (I think) is not the least, to illustrate and confirm the principles here advanced, which will appear in the most conspicuous point of view if the glass tube be placed in the following position.

EXPERIMENT IX.

Let the exhausted tube be suspended to the ceiling, parallel to the horizon, by a silken string at each end of it. One end of the tube is to be placed so as to receive an electric spark from the prime conductor of the electrical

machine; at the other end, a metallic communication with the earth is to approach within half an inch of the metallic cap of the tube. Things being thus adjusted, and motion given to the glass cylinder, it is well known that the glass tube will be filled with electric light so long as the supply of electricity, by the action of the electrical machine, is continued.

Now I am certain, that it is not so well known that at the instant of time the supply ceases the light divides near the middle of the tube, and flies back to both ends of it; for, as before observed, the light within the tube is not all of one kind of electricity; it includes both electricities in one appearance of light, and the moment the supply stops their progressive motion ceases; therefore they are not able to unite within the tube, and of course they go out of the tube the same way they went into it; one moiety returns to the prime conductor, and the other to the earth from whence it came.

I know, that electricians in general say, that air rarefied in a glass tube, to a certain degree, permits the electric fluid to pass easily through it. If this philosophy were true, it would follow, that the same kind of electricity which entered the tube at one end, must be the same all the way through, and so come out at the other end of it. But it is not so; that is to say, that the electric light within this exhausted tube consists of positive and negative light*. If the operation be continued ever so long, and

* It appears necessary here to observe, that the electrical effects of an exhausted glass tube, having a metallic cap at one end of it, and the

and even with a very great force, the fact ſtill remains the ſame; for although a part of its electricity be drawn out by the action of the machine at one end of it, yet, enough always remains viſibly active to meet a quantity of the poſitive kind, which, in this caſe, will viſibly riſe out of the earth and enter the tube at the other end; and ſo both electricities will again unite in it where their diſunion firſt began; hence it is, that this kind of exhauſted tubes never take the form of a charge with any conſiderable force.

EXPERIMENT X.

To aſcertain this matter beyond diſpute, *viz.* that the light within this kind of exhauſted tubes conſiſts of poſitive and negative light, notwithſtanding it appears to the eye, by its rapid motion, to be but one uniform light, let the glaſs tube remain ſuſpended, as in the preceding experiment, and place a Leyden bottle on glaſs ſtands, at each end, in an horizontal poſition, and in a right line with the tube itſelf, (which will lengthen the apparatus without altering the reſults) with their metallic knobs nearly in contact with the metallic caps of the glaſs tube. In this diſpoſition of the apparatus the coating of one bottle is to receive a ſpark from the prime conductor, and the coating of the other a ſpark from metal, which, for this purpoſe, muſt communicate with the earth. Turn the glaſs cylin-

the other end hermetically ſealed, differ conſiderably from thoſe of the tube deſcribed above. The electricity, in this ſort of tubes, acts forcibly on the internal and external ſurface of the glaſs, and will take the form of a charge, even ſo powerfully as to explode and perforate a hole through it, which ſhows its electrical ſtate to be that of a highly charged Leyden bottle.

der and sparks will be perceived to pass in the four intervals of air, and, at the same time, a luminous appearance within the glass tube. Remove the bottles, and examine their electric charges, and they will be found to correspond with the lights within the tube to which they were opposed. One bottle will be found electrified positively, and the other negatively.

I am of opinion, that if a curious observer were to examine this luminous appearance in a dark room, he would soon think with me, that he distinctly perceived the light divide (whenever the supply of electricity ceases) near the middle of the tube, and recede to its extremities. I imagine, however, that its rapid motion would not admit of distinction were it not for something peculiar to the inside surface of the glass tube, which may in some small degree retard the electric light in its retreat.

Persons who are not thoroughly versed in this branch of philosophy may suppose that the several facts exhibited in the *ten* preceding experiments are only of small consequence. However some may think of, or disregard them, with respect to myself, I am fully persuaded, that the whole phenomena of lightning, as well as many phenomena of artificial electricity, do entirely depend upon them. Many of these experiments have been long known, although their effects and appearances, as here remarked and applied, have the effect of novelty. Many books have been written upon this branch of natural philosophy, but none of them have yet fallen into my hands in which even the least hint of applying these experiments, in order to explain the phenomenon of lightning, has been attempted.—It does not

appear

appear to have been at all the object of the writers. Some electricians have, indeed, been curious enough to attend to the *direction* of electric light—I wish this obscure particular were better known.

I conceive that though the joining of the two electricities in our experiments is but faintly perceived, yet the fact itself promises some elucidation of the grand difficulty respecting the vast quantity of electricity observed during thunder storms; and the more immediate advantage of this discovery is, that it suggests the idea of a more easy solution of the phenomenon of lightning than has yet come to my knowledge, and it evidently deserves the most minute examination.

Lastly, these instructive experiments on electric light have not yet, perhaps, been explained to the satisfaction of the philosopher; be that as it may, if the use and remarks I have here made upon them should happen to be well founded, *viz.* that every flash of lightning consists of positive and negative light, (not wholly of one of these kinds, as has been supposed) in one apparent flash, then will that general *amazement*, respecting the immense quantity of the matter of lightning, that is usually displayed in thunder-storms *be abated*, by conceiving that the earth does actually supply *one* moiety of every flash of lightning at the moment that the clouds and vapours supply the *other*; but because of their rapid motion through the air they cannot be distinguished by the eye as here described.

CHAPTER

CHAPTER VII.

Further Obſervations and Conjectures on the Phenomena of Lightning.

IT is not my intention, in this chapter, to deſcribe the dreadful effects of lightning which happen in violent thunder ſtorms; but what I wiſh to add on this head are chiefly opinions and conjectures, ſtill further concerning the amazing great quantity of lightning obſerved in thunder ſtorms, becauſe it ſeems difficult to conceive how nature effects it.

However, I am perfectly ſatisfied of the truth of what I have here already advanced on this ſubject (ſo far as it extends) concerning lightning obſerved in the atmoſphere, conſiſting of poſitive and negative light in one appearance; and that the light or flaſh happens at the moment of reunion of the two powers, which approach one another with an unparalleled velocity, the force of which is derived from the mutual attraction of each power, that ariſes from the denſity of one and rarity of the other, and is always in proportion to the quantity of electricity that has been diſplaced in a limited diſtrict of the earth and atmoſphere; which ideas of the ſubject, I conceive, muſt leſſen conſiderably the grand difficulty relative to the quantity of electricity obſerved in thunder ſtorms; it is, therefore, very probable that they have erred, who have ſuppoſed that

that all, or every part of lightning, is of one kind of electricity, and that it all iſſued from a cloud or clouds.

Yet, when I conſider the account given from the North part of France, and from all the South of England, of a tremendous thunder ſtorm, which happened early in the morning of the 23d of December, 1790, it ſhould ſeem that there is ſtill great ſcope for further inveſtigation. I am of opinion, that the immenſe quantity of lightning obſerved during that ſtorm, cannot be accumulated by ordinary or ſimple cauſes. On the contrary, the numerous vivid exploſions of lightning which ſucceeded one another ſo rapidly, and nearly at one and the ſame inſtant, rather lead us to imagine, that a great part of the horizon and atmoſphere are, during ſuch ſtorms, in a ſtate or condition capable of charging and diſcharging themſelves very quick; and that the powers of nature are actually ſo diſpoſed, in the earth and atmoſphere, as to cauſe the electricity to aſcend out of the earth, in a luminous body or flaſhes of lightning, ſucceeding each other very rapidly. But how ſo great and extenſive a redundancy of electricity in one, and deficiency of it in the other, is effected, is hard to determine; yet it is eaſily perceived how nature operates to produce the ſame effects in a leſs degree, which has been already (I preſume) clearly manifeſted in the preceding chapter.

Dr. Franklin, long ago, juſtly obſerved, "that whether the direction of lightning aſcend or deſcend, thoſe who are verſed in electric experiments will eaſily conceive that the effects and appearances muſt be nearly the ſame in either caſe; the ſame exploſion and the ſame flaſh between

one

one cloud and another, and between the earth and clouds, the ſame rending of trees and walls which the electric fluid meets with in its paſſage, and the ſame fatal ſhock to animal bodies."

The cauſe of the tides is the ſtrong attractive power of the moon, and weaker influence of the ſun, which attract all the water in the neareſt hemiſphere, cauſing the waters of the ſea to ſtand higher in one part than in another. This wonder of nature, I conceive, is not altogether void of analogy with that natural phenomenon of electrified clouds, forcibly acting on the electricity of the earth. For, although the electric fluid be too ſubtile to ſtand on an heap like water, yet, when the electricity of the earth becomes redundant (or the contrary) on any part of it, the cauſe of that redundancy is not in the earth, but like that of the tide, is at a great height above it, in the atmoſphere, and the efficient cauſe of both is attraction.

The earth is the grand reſervoir of the matter of lightning, and may poſſibly, in a limited diſtrict, become overcharged, ſo as to throw off flaſhes of light like an overcharged electrical apparatus. I have abundant proof, that a limited part of the earth is ſometimes in an electrified ſtate, becauſe the uninſulated part of my atmoſpheric apparatus is frequently electrified, but moſt ſo during a thunder ſtorm. I therefore infer, that when that part of the apparatus is electrified negatively, the fluid is aſcending out of the earth into the atmoſphere, the former having leſs than its natural quantity in my neighbourhood; and when the ſame part of the apparatus is electrified poſitively, the fluid of courſe is deſcending into it, conſequently a limited part of the earth may be highly electrified; yet, its being inſenſible

to

to us, who even may be on the electrified part, is no proof of its non-existence, since we ourselves are involved in it; for where all things are equally involved in an electrical atmosphere there can be no visible signs of the presence of the electric fluid. For the same reason, if two or more persons be electrified, standing upon the same *insulation*, they show no signs to each other of being electrified, be the quantity of fluid they are involved in ever so great. The same fact is observed to take place in persons, and things, *uninsulated*, and will be particularly noticed by and by, with the manner of ascertaining it. See Page 71

I beg leave here to observe, that however surprizing it may appear to some electricians, who perhaps have had no experience of an atmospheric apparatus, that a metallic rod, which terminates deep in the earth, and its upper end nailed to a brick wall to give it support, should, so circumstanced, exhibit signs of an electrical charge, would be nothing wonderful, were it possible for us to conceive what a vast quantity of the fluid is at those times in motion in the earth; and that, whenever the phenomenon happens on any part of the earth, there is always over that part of it, concealed in the clouds and vapours, a proportional quantity of the electricity, but of an opposite kind to that on the earth; for, indeed, one electric charge cannot exist without the other.

I have been of opinion, that as the brick wall is a less conductor of electricity than metal or moist earth, it may on that account contribute, in some small degree, to the production of the phenomenon, but in this opinion I may be wrong.

History

Hiſtory informs us, that large quantities of lightning have been ſeen to run along the ground, break into ſeveral parts, and produce ſeveral exploſions at the ſame time; which clearly indicate that a part of the earth may be ſo circumſtanced, that it does not always quickly drink it in. Now, if a limited diſtrict of the earth, where ſuch facts happen, were not previouſly ſurcharged with the ſame kind of electricity with that ſeen diffuſed upon it, how could ſuch a phenomenon take place?

One of the beſt authenticated accounts of lightning ſpreading itſelf upon the ſurface of the earth is that in Dr. Prieſtley's excellent Hiſtory of Electricity, page 400, which I will here tranſcribe.

" But the moſt complete demonſtration of the real uſe of Dr. Franklin's method of ſecuring buildings from the effects of lightning, is Mr. Kinnerſley's account of what happened to the houſe of Mr. Weſt, a merchant of Philadelphia, in Pennſylvania, which was guarded by an apparatus conſtructed according to the directions of Dr. Franklin. It conſiſted of an iron rod, which extended about nine feet and a half above a ſtack of chimnies, to which it was fixed. It was more than half an inch in diameter in the thickeſt part, and went tapering to the upper end, in which there was an hole that received a braſs wire about three lines thick and ten inches long, terminating in a very acute point. The lower part of the apparatus joined to an iron ſtake, driven four or five feet into the ground.

" Mr. Weſt judging, by the dreadful flaſh of lightning and

and inſtant crack of thunder, that the conductor had been ſtruck, got it examined; when it appeared that the top of the pointed rod was melted, and the ſmall braſs wire reduced to ſeven inches and a half in length, with its top very blunt. The ſlendereſt part of the wire he ſuſpected had been diſſipated in ſmoke; but ſome of it, where the wire was a little thicker, being only melted by the lightning, ſunk down (while in a fluid ſtate) and formed a rough irregular cap, lower on one ſide than on the other, round the upper end of what remained, and became intimately united with it. It is remarkable, that, notwithſtanding the iron ſtake, in which the apparatus terminated, was driven four or five feet into the ground, yet the *earth* did not conduct the lightning ſo *faſt*, but that, in thunder ſtorms, the lightning would be *ſeen diffuſed* near the ſtake two or three *yards* over the *pavement*, though at that time very *wet* with rain."

Theſe effects plainly ſhow that the earth does not always with equal eaſe abſorb the electric fluid. Which I judge, as before ſaid, muſt ariſe from its electrical ſtate peculiar to a limited diſtrict where ſuch extraordinary phenomena happen; for the earth is always moiſt. But to add to that, in the above caſe it is ſaid that the pavement was very wet with rain. This conjecture of mine may at firſt ſight, I own, ſeem improbable; but the great quantity of electricity obſerved in ſuch circumſtances, muſt have an adequate cauſe, and I know of no other cauſe capable of producing that effect.

In the ſame Hiſtory of Electricity, page 394, I find that Pliny, in his ſecond book of Natural Hiſtory, mentioned

ſome

ſome luminous appearances, and tells us, that they ſettled not only upon the maſts and other parts of the ſhips, but alſo upon men's *heads*, and on the *ſpears* of the ſoldiers who kept watch by night upon the ramparts. Seneca in his natural queſtions takes notice of the ſame phenomenon. A ſtar ſettled on the *lance* of Gylippus, as he was ſailing to Syracuſe: and *ſpears* have ſeemed to be on *fire* in the Roman camp. In the month of February, about the ſecond watch of the night, there was a very extraordinary appearance in the army of Cæſar. There ſuddenly aroſe a thick cloud, followed by a ſhower of hail ſtones; and the ſame night the *points* of the *ſpears* belonging to the fifth legion ſeemed to take *fire*. Livy, chap. 32. mentions two ſimilar facts. It does not appear that the ancients had any proper ideas of theſe facts and appearances; for if they ſaw only one light it was termed Helen, an ill omen; but if two lights appeared they were called Caſtor and Pollux, and were invoked as gods.

It is now evident that theſe luminous appearances muſt have been natural or ſpontaneous electricity. And that a limited part of the earth and atmoſphere muſt when and where thoſe phenomena happened be highly electrical; and alſo every ſubſtance within the electrified diſtrict. For thoſe facts all happened without inſulation, and were ſimilar in that reſpect to the facts obſerved with my *uninſulated* metallic rod. A ſimilar event happened to Mr. Loammi Baldwin (related in the Phil. Tranſ. vol. 72) who raiſed an electrical kite in July 1771, during the approach of a ſevere thunder ſtorm, and obſerved *himſelf* to be ſurrounded by a rare medium of *fire*, which, as the cloud roſe nearer the zenith, and the kite roſe higher, continued

tinued to extend itſelf with ſome gentle faint *flaſhes*. Mr. Baldwin felt no other effect than a general weakneſs in his joints and limbs, and a kind of liſtleſs feeling; all which he obſerves might poſſibly be the effect of ſurpriſe, though it was ſufficient to diſcourage him from perſiſting in any farther attempt at that time. He therefore drew in his kite, and retired to a ſhop till the ſtorm was over, and then went to his houſe, where he found his parents and friends much more ſurpriſed than he himſelf had been; who, after expreſſing their aſtoniſhment, informed him, that he appeared to them (during the time he was raiſing the kite) to be in the midſt of a large bright *flame of fire*, attended with *flaſhings*; and that they expected every moment to ſee him fall a ſacrifice to the *flame*. The ſame was obſerved by ſome of his neighbours, who lived near the place where he ſtood.

I conſider this event as the moſt extraordinary inſtance of the kind (where no injury was ſuſtained) that I have yet been acquainted with. That a man ſhould be ſo powerfully electrified, ſtanding on the *ground*, as to be viſibly ſo to himſelf, and alſo to his friends at a conſiderable diſtance from him, and in day-light too, ſhews the immenſe quantity of electricity that he muſt be involved in; and his ſafe eſcape from danger to be little leſs than a miracle. Every one muſt be ſatisfied (who reads this aſtoniſhing account) that Mr. Baldwin was permanently electrified, though uninſulated. It alſo ſeems evident that the part of the earth whereon he ſtood, and that adjoining to it within a certain diſtance, muſt have been in the ſame electrical ſtate. The principal difficulty that will here ariſe with many, will be the apparent want of inſu-

lation to Mr. Baldwin*. But when that is accurately conſidered, it will be found, that the ſurrounding air performed that office by inſulating two highly electrified bodies, viz. the clouds above, and the ſurface of the earth beneath him, which have in ſuch inſtances the effect of coatings to a plate of air, ſimilar to the coatings of a plate of glaſs. Now it is well known, that the Leyden bottle retains its electric charge though one of its charged coatings be uninſulated, or connected with the ground.

It is in my power to ſatisfy any one during a thunder ſtorm, and ſometimes even during the paſſing of a black cloud over my high pointed rod, that the earth is to ſome limited diſtance in my neighbourhood, ſometimes in a redundant and ſometimes in a deficient ſtate of electricity. One of my ways of proving it is rather diverting, when I have a company of perſons of ſufficient courage to form a circuit, by joining hands in the uſual manner, to receive the charge of the *new Leyden bottle*, as I term it. It is thus performed—The firſt perſon in the circuit is to touch with his finger the bell of the atmoſpheric apparatus which communicates with the earth, and the laſt perſon in the circuit is to approach with his finger the braſs ball which is inſulated. The conſequence is that a denſe ſpark of electricity will iſſue, and at the ſame inſtant the whole company gives a ſudden ſpring, as if they had received the charge of the common Leyden bottle. That the rod is diſcharged by the operation is evident, becauſe the pith-ball electrometer, which is connected with it, collapſes. If the finger of the firſt perſon be continued on the bell,

* I conſider Mr. Baldwin's ſituation to be ſimilar to that of the worm and fly in the charged Leyden bottle mentioned p. 72.

and

and the finger of the laſt be removed from the ball to give the rod time to charge again and again, (for which purpoſe ſometimes three or four ſeconds are enough,) the company may repeat the experiment as often as they pleaſe. But I have ſometimes obſerved, that even electricians themſelves were too well ſatisfied of the fact to make a ſecond trial.

When the circumſtances which accompany this phenomenon are well conſidered, it may be diſcovered by ſome ſenſible effects, that the force of an electric charge does not depend at all on the ſhape of the charged ſurface. I conclude therefore, from this fact, as before obſerved, that a cloud over the rod, and the ſurface of the earth under it, may be conſidered as the electrified coatings to the ſtratum of air between them; which, between the bell and braſs ball, is only two inches. This ſmall portion of air is ſometimes diſplaced by a continued ſtream of lightning, very awful to a ſpectator.

Moreover, I infer, from well known electrical phenomena, that when two ſuch highly electrified coatings are once well formed, and the attractive force of their electric atmoſpheres have entered even in a ſmall degree into each other; it is not in the power of the wind to ſeparate and diſperſe them. For as the wind in its progreſſive motion, carries the electrified cloud forward, an equal electric charge, but of a contrary kind, in a ſtate of actual operation on the ſurface of the earth, will alſo move and keep an even pace with it; until either the electric charges become more augmented in the coatings of earth and vapour, or they approach nearer and nearer towards each other, or in their path meet with ſome conducting emi-

nence capable of facilitating their re-union; the conſequence of which will be an exploſion of lightning and inſtant clap of thunder; if not ſome damage to animals, vegetables, or buildings.

Let a perſon's ſituation be where it may, either in the houſe or open field, he is liable in any place to be involved in an electric charge, whether it be ſtationary or moving with the clouds. And when he is ſo involved, he may know nothing at all of it, without proper inſtruments; for reaſons before given. I once found myſelf ſo involved, in a ſmall degree, as I was walking in Hyde Park. I obſerved that the atmoſphere began to aſſume a menacing appearance, and a heavy black cloud being at no great diſtance, I took my pocket electrometer out of its caſe, and held it in my hand, and it inſtantly diverged near one inch. Some drops of rain now fell, I therefore went to my houſe, and I found my high pointed rod ſtrongly charged and the bell of it ringing briſkly.

With regard to danger from the returning ſtroke out of or into a perſon, which happens at the inſtant a flaſh of lightning takes place, I apprehend no painful ſenſation can follow. For, although a man naturally poſſeſſes a very great quantity of electricity, and his natural portion we know may be increaſed or diminiſhed, in a ſmall degree, without harm to himſelf, yet the quality and quantity of his electrical ſtate will always have relation to the place he is in. If he ſtood in the direct path of a flaſh of lightning, moſt likely the event would be fatal; but if he happens to be clear of that, his natural quantity of electricity can undergo no greater change in its denſity or rarity than the diſtrict of earth he ſtands upon, and

and every thing elſe about him; which I ſuppoſe will be very ſmall. For inſtance, there are but few, if any people, who have arrived to maturity, but have at one time or other been as it were involved in the very blaze of lightning, and have not only ſuſtained no harm, but have actually had no ſenſation at all of a returning ſtroke; yet people ſo circumſtanced are in the moſt proper ſituation to feel a returning ſtroke. But the ſenſations and injury ſuſtained (abating ſudden terror) is generally in the eyes, the moſt ſenſible part of the body. The conſtant moiſture of the eyes, perhaps, may contribute thereto, by facilitating the paſſage of a greater quantity of fluid through them. I imagine, that if it were poſſible to deprive a man of his natural portion of electricity, by a returning ſtroke, or in any other way, or even to ſuper-add a double quantity of the fluid, though his body cannot break like glaſs, yet either way might be fatal to him: and thus I ſuppoſe are people deprived of life by lightning. Mr. Baldwin's ſenſations ſeem to imply thus much. See page 64.

I judge, from ſeveral ſenſible effects, that a certain intenſity of the electric fluid eminently contributes to the well being of animals and vegetables. And I conjecture that the energy of the brain and nerves depends on a proper intenſity of electricity; as the act of reſpiring healthfully depends on a proper intenſity of air. However, to give this conjecture ſome weight, I beg leave to tranſcribe an obſervation on the nerves of the Torpedo, by Mr. John Hunter, F.R.S. read at the Royal Society July 1, 1773. "The magnitude and the number of the nerves beſtowed on theſe organs, in proportion to their ſize, muſt on

reflection appear as extraordinary as the phenomena they afford. Nerves are given to parts either for ſenſation or action. Now, if we except the more important ſenſes of ſeeing, hearing, ſmelling, and taſting, which do not belong to the electric organs, there is no part even of the moſt perfect animals, which, in proportion to its ſize, is ſo liberally ſupplied with nerves; nor do the nerves ſeem neceſſary for any ſenſation which can be ſuppoſed to belong to the electric organs. And with reſpect to action, there is no part of any animal with which I am acquainted, however ſtrong and conſtant its natural actions may be, which has ſo great a proportion of nerves.

" If it be then probable that thoſe nerves are not neceſſary for the purpoſes of ſenſation or action, may we not conclude that they are ſubſervient to the formation, collection, or management of the electric fluid; eſpecially as it appears evident, from Mr. Walſh's experiments, that the will of the animal does abſolutely controul the electric powers of its body, which muſt depend on the energy of the nerves.

" How far this may be connected with the power of the nerves in general, or how far it may lead to an explanation of their operations, time and future diſcoveries alone can fully determine."

The powers of the electrical Eel, appear to be very much ſuperior to thoſe of the Torpedo. I have ſeen his brilliant ſparks in the day light, heard their ſnapping noiſe, and felt his ſhocks, which were, on ſome occaſions when he was much diſturbed, very ſevere.

But

But to purſue our remarks on the ſuppoſed danger from the returning ſtroke a little further. Beſides the evidence of natural facts, ſimilar phenomena attend artificial electricity. When we accumulate denſe electric ſparks, which ſtrike through air, from ſixteen to twenty inches in length, I have felt at thoſe times a motion of the air on my face, at the inſtant thoſe exploſions happened, but I did not feel the return of the fluid into my body, which I had been deprived of during the accumulation. Yet I ſaw electricity returning by the bell wire into the earth within leſs than two inches of its ſurface, and at the diſtance of eighty-three feet from the machine. But in the room next to that in which the exploſions were made, about two yards of the bell wire, in the dark, ſeemed to be on fire by the returning electricity, which was eſteemed a fine ſight by the ſpectators. Now, as no bodily ſenſations were felt, it may be ſuppoſed by ſome that no change of the natural quantity of fluid had taken place on the company; but that is by no means the conſequence; for the houſe itſelf*, and every perſon and thing in it during the accumulation of thoſe ſparks are electrified negatively; which is eaſily proved, by either placing perſons or things upon a good inſulation, the moment before an exploſion happens, as they will be found, on trial, electrified negatively; becauſe whatever electric ſtate they poſſeſſed at the inſtant they became inſulated, the ſame will remain when the exploſion is over.

On the 12th of March, 1781, by the favour of Richard Hen. Alex. Bennet, Eſq. F. R. S. F. A. S. and with his

* See the 22d of Auguſt, in the Journal for 1789—page 115.

large electrical apparatus, a ſheep was killed by the electrical ſhock, from a very large battery, in the preſence of many members of the Royal Society, aſſembled together for the purpoſe of viewing the operation. In this mode of employing a very great quantity of the electric fluid in one ſtroke, no ſenſation of a returning ſtroke was perceived by the company, who ſtood near to three ſides of the table on which the ſheep lay. It was thought neceſſary by Mr. Hunter (who had the direction of the operation) that the braſs rod, which was to conduct the electric charge to the head of the animal, ſhould be preſſed cloſe to it, or the wool of it might obſtruct the force of the charge. I readily accepted the office, and, with a ſtick that ſtood near at hand, I preſſed the metallic rod tight to its head; although my ſituation in ſo doing was judged dangerous yet I did not feel the leaſt ſenſation.

Dr. Prieſtley, and other perſons, put their hands into the water, at the time that the electric charge of the battery paſſed over its ſurface; and they felt a ſudden concuſſion in the water, without pain to themſelves. He held the bill of a robin red breaſt, and after that the noſe of a mouſe, near the electric exploſion of a large battery, but they did not ſeem to be at all affected by it. I put into a large Leyden bottle a fly, and after that a worm, and then charged the bottle, during which I kept my eye on them, and in the diſcharge alſo, but neither the charge nor diſcharge had any viſible effect upon them.

I will here tranſcribe, in concluding this chapter, a few of the many remarks and obſervations made by that eminent electrician Signior Beccaria, on lightning.

« Conſidering

"Considering the vast quantity of electric fluid that appears in the most simple thunder storms, he thought it impossible that any cloud, or number of clouds, should ever contain it all, so as either to discharge or receive it; besides, during the progress and increase of the storm, though the lightning frequently struck the earth, the same clouds were the next moment ready to make a still greater discharge, and his apparatus continued to be as much affected as ever; the clouds must consequently have received at one place, the moment that a discharge was made from them in another."

"The extent of the clouds doth not lessen this difficulty; for, be it ever so great, still the quantity ought to be lessened by every discharge."

"The same cause which first raised a cloud from vapours dispersed in the atmosphere, draws to it those that are already formed, and continues to form new ones, till the whole collected mass extends so far as to reach a part of the earth where there is a deficiency of the electric fluid; thither too will those clouds, replete with electricity, be strongly attracted, and there will the electric matter discharge itself upon the earth. A channel of communication being in this manner found, a fresh supply of electric matter will be raised from the over-loaded part, and will continue to be conveyed by the medium of the clouds till the equilibrium of the fluid between the two places of the earth be restored."

"The fact, therefore, must be, that the electric fluid is continually darting from the clouds in one place, at the same

ſame time it is diſcharged from the earth in another; and it is a neceſſary conſequence from the whole, that the clouds ſerve as conductors to convey the electric fluid from thoſe places of the earth which are overloaded with it, to thoſe which are exhauſted of it."

I am not certain whether Signior Beccaria was ever acquainted with that intereſting diſcovery of Dr. Prieſtley on the Tourmalin, as mentioned in the beginning of this work; but I have often thought that that fact of the Tourmalin gives aid to, or corroborates ſtrongly, Signior Beccaria's ſentiments of the electrical ſtate of the earth during a thunder ſtorm.

As it is now a fact, that ſo ſmall a ſubſtance as the Tourmalin ſtone is, can exhibit at the ſame time, and on the ſame flat ſide, the two ſtates of electricity, why ſhould it be thought impoſſible for the earth to ſuſtain, for a few minutes, (which would be in ſome thunder-guſts quite ſufficient) the two contrary ſtates of the electric fluid? and eſpecially when they are only ſuppoſed to happen on the earth at the diſtance of many miles;—perhaps in ſome thunder-guſts not leſs than 30 or 40.

I readily admit that the earth, even in its dryeſt ſtate, is a better conductor of electricity than the Tourmalin; but when a mile of earth is oppoſed to every twentieth part of an inch of the ſtone, their difference of capacity for conducting the electric fluid is thereby conſiderably diminiſhed.

The

The only difficulty here arifes from our want of conceiving how a quantity of electric fluid can lie condenfed in or near the furface of the earth, in one part of it, whilft its neighbouring fluid in another part is attenuated; but when experiment is ftrongly on one fide, and nothing but this difficulty of conception appears on the other, the latter ought to give way; and when the thing is carefully confidered, and experiments with appearances are duly compared, perhaps the difficulty of conception may vanifh.

CHAPTER VIII.

Containing fome Experiments and Obfervations on the Leyden Bottle.

I Begin to be afraid that perhaps, after having been confidered as a dry experimenter, I may be taken for a vifionary innovator of Dr. Franklin's theory. Dr. Franklin's difcoveries, relating either to the nature of lightning, or to the Leyden bottle, are truly amazing, and much praife is juftly due to his ingenuity. But it is neceffary to obferve, that though many of Dr. Franklin's admirers thought that he had exhaufted the whole fubject, he himfelf was far from thinking fo; and the hiftory of electricity, fince the date of his difcoveries, demonftrates that his fufpicion was true. Time has brought to light a great number

number of incomplete as well as complete experiments, and perhaps more of the former than of the latter; ſo that, though we know much more than he did at that period, we, at the ſame time, know how much remains yet unknown.

It has been my endeavour, by the following experiments and obſervations, to aſcertain in a conciſe manner, that every electrical exploſion of the Leyden bottle is the conflux or meeting of two oppoſite powers, the poſitive and negative electricities, ruſhing into union from two oppoſite directions; which I conceive muſt ariſe from two cauſes, that is to ſay, from the ſtrong tendency of the two electricities to re-unite, which attract each other with equal force, and the reſiſtance oppoſed thereto by the non-conducting quality of air.

I conceive that there is only one electric fluid in nature. But when the natural quantity of a body is divided into parts, and ſome of it given to another body having its whole quantity, we give different names to the electrical ſtate of two bodies ſo electrified, becauſe of their conſequent different effects on each other, yet they are one in their nature and operation. The ſuſceptibility of the electric fluid to ſuffer a diviſion or change in its natural ſtate and ſituation is manifeſt in all electrical experiments, but this change cannot be carried on beyond a certain degree without great force or violence, becauſe the divided parts unite their whole force againſt the diſuniting power, and will ſoon become equal to it; therefore it is, that in the charging of glaſs the operation is limited and ſoon ſtops; viz. not becauſe the negative ſide is poſſeſſed of no more electricity,

electricity, but becauſe the diſuniting and the attracting powers are then actually balanced, conſequently all further progreſs muſt ceaſe.

I am thoroughly ſatisfied of the truth of this general concluſion, that every ſubſtance in nature (except air) has naturally a certain quantity of electricity appropriated to it, which quantity may be diminiſhed, either naturally or artificially, by drawing out a part, which the body will again reſume; but its whole appropriated quantity can never wholly be drawn out of it. And by the bye, the want of attending to this circumſtance has occaſioned many miſtakes, for a ſpark iſſuing from a diminiſhed quantity is as real a ſpark of the electric ſubſtance as the contrary; I therefore infer, that negative electricity muſt be equally as active as poſitive, and that it will urge its way through every reſiſting medium to meet the poſitive; for this reaſon it does not *inactively wait in its place* until the poſitive electricity has ſupplied all its *wants*. This is, I preſume, manifeſt, not only in the foregoing ſeries of experiments on poſitive and negative light and ſparks, but alſo in their atmoſpheres, the conſideration of which would carry me too far for my original deſign.

I am aware that the validity of thoſe facts, and my reaſoning upon them, militate againſt the received *theory* of electricity, becauſe Dr. Franklin, in his firſt letter, aſſerts, and by way of inſtance ſays, "Suppoſe the common quantity of electricity in each part of the bottle, before the operation begins, is equal to 20; and at every ſtroke of the tube, ſuppoſe a quantity equal to 1 is thrown in, then, after the firſt ſtroke, the quantity contained within

within the bottle will be 21, in the outſide 19. After the ſecond, the inſide will have 22, the outſide 18, and ſo on until after 20 ſtrokes; the inſide will have a quantity of electricity equal to 40, the outſide *none*, and then the operation ends. Here we have a bottle containing at the ſame time a *plenum* of electricity, and a *vacuum* of the ſame fire, &c."

If ever Dr. Franklin wrote his obſervations in haſte, it was in this particular, without having firſt well conſidered the facts and appearances that ſtill remain, and which cannot be accounted for, on the ſuppoſition that one ſide of the bottle was exhauſted of all its electricity; for, to the extent to which we are able to carry this experiment, the poſitive and negative powers of the body are increaſed and not diminiſhed by the operation. Beſides, we will admit that his tube was able to force out of one ſide of the bottle 20 negative ſparks, and this we will ſuppoſe was the limit of its power, yet a greater power would with eaſe force out 20 more, if the condition and ſtrength of the glaſs would bear it. Bodies have no doubt a limited quantity of electricity, which probably may be more or leſs according to the nature of the ſubſtance; but we have never yet found this limit in any, otherwiſe than what the power employed creates, for when more power is applied a greater quantity of the electric fluid will be found.

To exhibit theſe effects as plain as poſſible, and beyond the power of doubt, I would inſulate the Leyden bottle as repreſented figure 5 (a contrivance obvious to every electrician). A repreſents a glaſs ſtand, which ſupports the Leyden bottle, in a ſocket turned out of the wood B.

C is

C is a metallic belt, with a female ſcrew fitted to it, in order that metallic balls and points of different terminations may be occaſionally ſcrewed to it. At a convenient diſtance from the ſide of the bottle is fixed an inſulating pillar of glaſs. A curved wire, with a knob at the lower end of it, is ſcrewed to the metallic rod D, which rod is moveable at pleaſure in the head of the pillar, and is fixed tight in its place by the ſcrew E. Place this inſtrument ſo that the knob of the bottle may be within a quarter of an inch of an equal knob proceeding from the poſitive prime conductor F; the rod D is to be connected by a wire with the negative prime conductor; the knob on the belt, and that on the curved wire, are alſo to be placed a quarter of an inch apart. Things being thus diſpoſed, and motion given to the electrical machine, the progreſſive charge of the bottle may be obſerved with eaſe. The moſt ſtriking effect of this apparatus is, that it viſibly determines the quantity of power that any electrical machine is poſſeſſed of; and it alſo ſhows, in a clear manner, the fallacy of thoſe old doctrines, viz. "that no more electrical fire can be thrown into the top of the bottle when all is driven out of the bottom," a circumſtance that never yet happened in the Leyden bottle; for in all caſes the cauſe of ceſſation of electricity in charging it, is from the electrical machine itſelf, as will plainly appear from the three following experiments.

By managing the ſilk flap of the rubber of my machine I make the glaſs cylinder act ſtrongly or weakly at pleaſure. Having put it into a weak ſtate of action, yet equal to a machine of ſmall power, and the apparatus being adjuſted as before directed, I turn the glaſs cylinder, and

and count the ſparks which are forced into the bottle until I ſee them ſtop, the number of which in this ſtate of the machine was 49, and of courſe 49 ſparks were forced out of the negative ſide of the bottle. I then increaſed the excitation of the glaſs cylinder, to repeat the experiment, the apparatus remaining as before. I again worked the machine and counted the ſparks, which I found to be 112 before they ceaſed. Laſtly, I made the glaſs cylinder act briſkly; the apparatus remaining as before, the machine was now able to force into the bottle 155 ſparks before there was a viſible ſtop; and at the ſame time, as if it were ſpark for ſpark, there was forced off the negative ſide of the bottle 155 ſparks. This quantity, great as it is, for a bottle whoſe coated ſurface on one ſide is only 80 ſquare inches, is not, I ſuppoſe, the-one thouſandth part of the electricity contained in a glaſs of this dimenſion. Nor will glaſs bear a total deprivation of its electricity on either ſurface, this we know by ſad experience, becauſe it is ſure to break long before that happens; however this laſt effect of my machine ſeemed to be its utmoſt power.

From theſe ſeveral facts we may ſafely conclude (notwithſtanding it has been affirmed, "that one ſide of charged glaſs contains a plenum and the other a vacuum of electricity") that we are not yet acquainted with the preciſe quantity of electricity contained in glaſs, or indeed in any other ſubſtance; nor do we yet know of any criterion whereby to determine a total deprivation. For the reſult of theſe experiments, being ſo widely different from what has been conſtantly affirmed, concerning the negative ſide of the Leyden bottle, is a clear proof, that thoſe conclusions

clusions were formed too hastily, having attributed to the power applied, what it was totally unable to effect.

The common criterions of positive and negative electricity, on electrified metallic points, are also exhibited in a very evident manner by this instrument, by only removing the knobs and placing in their stead four metallic points, a little flattened at their ends with a smooth file, the other parts of the apparatus remaining as in the three preceding experiments. As soon as the charge of the bottle begins, the usual signs of both electricities will be visible, illuminating the points of the interrupted circuit. The sign on the point connected with the positive prime conductor will indicate positive electricity, and the sign on the point opposite to it in the knob of the bottle will be faintly negative. The light on the point or extremity of the curved wire will be bright and negative, and the sign exhibited on the point at the belt will be the positive ramified light.

The cause of these contrary effects seems to arise from the repulsion of the electric fluid in the first case, and the resistance of the air in the second. For instance, all the time that the bottle is charging positively the point on its knob exhibits the negative sign, contrary to the charge itself, which is effected by the repulsive power of the positively electrified opposite point, which keeps the knob and point in a deficient state of electricity, and of course attracts the negative; but this repulsive power extends only to a very small distance, and its effect grows less and less as the charge of the bottle advances, therefore the sign on this point is a weak one. On the other side of the

bottle, as ſoon as charging begins, the electricity is driven out of the glaſs into the coating, and becomes condenſed on the point at the belt, even ſo powerfully as to exhibit the poſitive ramified light, though it iſſues from a negatively charged body, which is certainly owing to the reſiſtance of the air to the egreſs of the fluid at that point. Thus we ſee that metallic points, whether they are connected with a body electrified poſitively or negatively, do ſometimes exhibit electric ſigns contrary to the kind or ſource of electricity whence they proceed; yet thoſe ſigns are certain criterions of the kind on the points themſelves.

If the Leyden bottle be charged *without* a viſible *ſpark*, then, in that caſe, the electricity during the charging has but one direction, viz. from the negative to the poſitive ſide of the bottle; and in the diſcharge of it, the contrary way. But if the charging or diſcharging of it be made through the reſiſting medium of air, conſequently *with* a viſible *ſpark*, in that caſe the direction of the electric fluid is doubled, and the ſpark or light ſeen conſiſts of poſitive and negative light; as the foregoing experiments abundantly confirm. If the charge of the bottle be made at a negative conductor (which is the one I generally uſe) the electric light drawn out at the knob has the poſitive aſpect, notwithſtanding the bottle is actually charging negatively; and ſo it affords an electrical paradox.

During the time that this active agent is in a diſturbed ſtate, which commences by an unnatural diviſion of what naturally exiſts in bodies, no ſtriking phenomenon attends it that is more evident than its conſtant tendency to unite. This tendency is manifeſt by the mutual attraction of the divided

divided parts, which is more conſpicuous in this than in any other fluid; inſomuch, that it does not only exhibit a reciprocal attractive force like a divided portion of water, quickſilver, &c. but it is poſſeſſed of active power; for this fluid takes every proper means to facilitate its re-union, by drawing light bodies into the interrupted path, and crowding or condenſing itſelf at the prominent parts or extremities of all conductors, whether they are blunt or pointed, even ſo forcibly that *each* power will appear to *ſtream forth* from the conducting *ſurface* till they meet near the middle of the interrupted *ſpace*. For there begins the re-union of the two electricities, which ſometimes ends in a full exploſion of their whole divided quantities, and which is inſtantly reſumed by thoſe bodies that had been in ſome ſmall degree deprived of their natural portion of the electric fluid; after which, generally, all ſigns of electricity ceaſe.

This remarkable tendency of the divided parts of the fluid to unite, is often perceived in a *full* charged Leyden bottle; at the upper edge of the outſide coating, and at the edge of the cork in the neck of the bottle: where ſtrong efforts of active light are ſeen. If the inſide of the bottle be charged poſitively, the light which is firſt ſeen is generally the negative, on the outſide, darting upwards ſmall rays of electric light from the edge of the coating, and ſoliciting, as we may ſay, an union with that of the inſide. After this, we generally perceive, as the charge goes on, bruſhes of light iſſuing from the edges of the cork and outſide coating into the air (as if the fluid ſpent itſelf therein, which cannot be but by an act of violence,

becauſe that would be to operate againſt itſelf and its known tendency), which will viſibly incline towards each other's atmoſphere, and thereby unite in ſome ſmall degree, and in proportion thereto ſtop the further progreſs of the charge or their further diſunion. But ſhould the power applied be ſuperior to the preſent intenſity of the charge, and the diminution occaſioned by thoſe efforts, the two powers would actually form an external circuit, as repreſented at A, fig. 6, by means of their atmoſpheres, which are already in poſſeſſion of the adjacent humidity of the air, and unite in oppoſite directions in a ſpontaneous exploſion of their whole quantities.

In concluding this chapter I beg leave to obſerve that I have ſometimes been curious enough to electrify a pair of inſulated pith balls poſitively, and another pair negatively, with a view to aſcertain the difference between their attracting and ſtriking diſtance. It is well known that the attracting diſtance is conſiderably greater than the ſtriking one. It was obſerved to be nearly in the proportion of twenty-ſix to one. This was performed in a cloſe room and dry air. But my ingenuous friend, Mr. Gamble, of Bungay, informs me, that in the open field, from an electric kite which he had raiſed, he found the proportion between the length of the ſpark at the metallic knob of the kite, and the attracting diſtance of light bodies from it, to be nearly as one hundred and ſeventy to one.

A LETTER

A LETTER

TO

Mr. A. WALKER,

LECTURER ON EXPERIMENTAL PHILOSOPHY.

DEAR SIR,

I THANK you for your very candid and obliging obſervations in your letter on my manuſcript. You ſay "I write down in haſte the only circumſtance that ſtrikes me as a real objection without having really conſidered that, or any part of your work, with that attention or time it deſerves, but which my manifold occupations will not allow." When you have time, Sir, to read and re-conſider thoſe parts which ſeem moſt obſcure, and ſhould ſtill remain embarraſſed, I will endeavour to clear them of entanglement, by repeating with you any of the experiments, or make any new ones you ſhall propoſe, that you think may afford further light or ſatisfaction to either of us; in the mean while I ſhall take the liberty of making a few obſervations on ſome of your paſſages.

You obſerve, "If we are to underſtand poſitive and negative electricity as only more or leſs, I think your deſcription ſeems to imply two diſtinct principles." Then there muſt be ſome defect in my deſcription. For a *body* having more or leſs than its *natural quantity* of electricity, is completely all I mean by its being poſitively or nega-

tively electrified. That these two different states of one fluid, in their several effects and appearances, seem to indicate two distinct principles, I readily allow; which has been, I suppose, the occasion of leading some electricians into a manifest error *. Notwithstanding this we may, I think, rest satisfied that those effects and appearances are already sufficiently accounted for by the theory of only one electrical fluid.

You add "that electricity is capable of disturbing electricity through a plate of air, glass, &c. driving it off in proportion to its accumulation, I think I understand. But if positive and negative meet in air and form the flash of lightning, they look to me like two principles." Not so, Sir, they are only two states of one fluid. For instance, if air be condensed it is still air, or if it be rarified it is no other. And that the electrical fluid is capable of condensation and rarefaction every experiment of electricity proves. I know of no exception to this general assertion, for the rubber and the substance rubbed always produce dense and rare states of this fluid. Consequently such different states of one fluid must assume different appearances, and produce different effects. Hence, let the appearances be what they may, they are all electrical; therefore a negative spark is as real a spark of the electric substance as a positive one. Why their meeting in air should alter the case, or raise any difficulty, I cannot conceive. The two electricities must meet and unite somewhere, or else the equilibrium in nature can never be

* This observation seems just by Dr. Peart's late Book on Electricity.

restored.

reſtored. That the two powers meet in air where the greateſt obſtruction to their union lies, is evident, becauſe otherwiſe they could not emit light or flaſh. However, at the moment of ſtriking into each other, they cannot be diſtinguiſhed to be two balls or two flaſhes of light, becauſe of their rapid motion, which ariſes from the reciprocal attractive force of both electricities. So that when they approach each other in air, their powers and appearances are conſiderably augmented, even to the utmoſt efforts of their whole quantities.

When I place the two equal balls to the metallic curved rods (mentioned in the 5th Experiment on Lightning, conſiſting of poſitive and negative light) and examine the exploſive ſparks which rapidly paſs between them, I diſtinctly perceive the uſual ſigns of both electricities in air, and the light in that part of the reſiſting medium where the two powers unite, to be leſs luminous than in any other part, which loſs of light is the natural effect of their re-union.

Some philoſophers, even at this time, conjecture that the electric matter either is or contains phlogiſton. The electrical ſmell remaining on the body ſome time after the ſtroke is given (and which I have obtained alſo in vacuo) ſeems to confirm ſuch ideas. That ſome quality of accumulated electricity ſhould forcibly act through glaſs, which is impervious to the fluid itſelf, and repel its natural electricity on the oppoſite ſide of the glaſs, in the caſe of charging the Leyden bottle, ſeems alſo to give aid to thoſe conjectures. Which are facts that have long been admired, and though moſt, if not all the effects of

electricity depend on this property of the fluid, yet I think it has never been very satisfactorily explained.

I am confident that you will clearly perceive, that I have hitherto strictly adhered to one single electric fluid; for I always thought that the doctrine of *two fluids*, viz. the *vitreous* and *resinous*, were not founded in fact, and it has been justly exploded; because it would be quite unphilosophical to admit more causes of things than are sufficient to explain appearances.

Yet it is still true that negative electricity has very much puzzled most writers on that subject. I think they have sometimes made choice of terms too strong to denote a negative state of the fluid, such as *exhausted vacuum*, &c. such terms may have occasioned the perplexity. For were it true that a body rendered negative (even to the highest degree that art can effect it) was actually exhausted of its natural quantity of electricity, I acknowledge the difficulty to explain effects and appearances would be totally insuperable. Because it is observed, that as the supposed exhaustion advances the negative powers increase in regular progression with the positive. It is not an easy matter to illustrate the properties of the electric fluid by the powers and properties of any other, because this fluid differs considerably from all other fluids. For although negative quantities of other elastic fluids possess great powers at the moment they are rendered negative, yet it is but for a moment; whereas negative electric powers are permanent. You are pleased further to add—

« I have

« I have read your manuſcript with pleaſure and inſtruction. It contains much new and intereſting matter, but the manner of writing in our effeminate age is more recognized than the *matter*. I am ſorry to ſay, in this particular, your half and half philoſophers will think your pamphlet not elegant enough; ſorry am I that truth ſhould want embelliſhment, but lace and ruffles muſt now ornament every production, or it will not go down. Yet is your mode of communicating your diſcoveries and labours ſimple and eaſy, ſuch as works of that ſort ought to be."

It is true, hiſtory informs us that new diſcoveries are commonly ſlighted on their firſt being made public, becauſe their real uſe and importance is not at firſt perceived, therefore are they ſoon overlooked and laid aſide for the preſent. As a ſtriking inſtance of the truth of this obſervation, and in this branch of ſcience too, I cannot help expreſſing my ſurprize how ſlow ſome hints of improvement have proceeded. Mr. Canton, in the year 1751, publiſhed his diſcovery of a conſiderable improvement of the rubber, by applying ſilk to it, on which he ſpread a ſmall quantity of an amalgama of mercury and tin. It does not appear to have been in general uſe for near twenty years afterwards. Dr. Prieſtley's Hiſtory of Electricity was printed in the year 1767, in which he ſhews the mode of excitation that was then in common uſe, and alſo a great variety of electrical machines, not one of which is deſcribed as having an amalgama of mercury and tin ſpread upon a ſilk rubber.

Another

Another inſtance of the ſlow progreſs of knowledge is, I think, that on the matter of lightning. It is now forty years ſince that Dr. Franklin proved the *ſameneſs* of the electric *matter* with that of *lightning*, by charging the Leyden bottle at the key of his electrical kite. Yet it is obſervable in the writings of ſome modern philoſophers, that they ſtill retain the old form of doctrine on this ſubject, viz. that lightning conſiſts of a ſudden kindling of *nitrous* and *ſulphureous exhalations* carried into the higher regions of the atmoſphere.

I am, Dear Sir,

Your moſt obedient

Humble Servant,

J. READ.

POSTSCRIPT.

That there is ſuch a fluid as conſtitutes the matter of magnetiſm is a truth not to be controverted any more than its properties of attraction and repulſion. Effects can never ſpring up in an invariable and fixed order without the agency of ſome cauſe, whoſe mode of operating is likewiſe regular and conſtant. The cauſe of electrical attraction and repulſion ſeems widely different from that of magnetiſm, becauſe theſe effects depend on bodies being poſſeſſed of an unnatural quantity of electricity. For without this we know not whether the electricity itſelf does either attract or repel other matter. Hence a middle quantity ſeems to poſſeſs no powers.

For inſtance, inſulate three bodies A, B, C, of equal dimenſions, and of the ſame kind of ſubſtance, we will ſay three braſs rods, of courſe their natural quantity of electricity

tricity will be nearly equal in each of them. We will ſuppoſe that the quantity in each rod, before the operation begins, is equal to ten ſmall ſparks. Place the rods A and C in a ſtrait line, with their ends nearly in contact, hold an excited glaſs tube over A, but at ſome diſtance from it, and an electric ſpark naturally reſident in this will be repelled into C, then increaſe the diſtance of the rods to prevent the return of the ſpark, and remove the tube, and C will be found electrified poſitively, having eleven ſparks, and A negatively, having only nine ſparks; A and C will now exhibit the phenomena of attracting and repelling light bodies; the middle or natural quantity in B having its original ten ſparks undiſturbed, ſhows no ſigns of electricity at all. The electric charge in A and C conſiſts only of what was in them before, for their whole quantity of electricity is neither increaſed nor diminiſhed by the operation, though a change has been made in its ſituation. This will be evident if A and C are made to touch each other, by which the equilibrium will be reſtored to both of them; A and C will now like B, exhibit no ſigns of electricity. Theſe effects ſhow moſt plainly that the *cauſe* of electric and magnetic attraction and repulſion is not the ſame.

The magnetic virtue is termed a fluid; and it is ſaid that there are corpuſcles of a peculiar form and energy, which continually circulate around and through a magnet. That the magnetic and electric fluids pervade the pores of metallic matter with equal eaſe is manifeſt, the former that of iron only, the latter of all metals. Though there are ſeveral effects which indicate a ſameneſs between theſe two fluids, yet I ſuſpect that there is hardly any other than

than the one (which can ſcarcely be accounted one) mentioned above. There is indeed another appearance in magnetiſm which bears a ſtrong analogy to the electrical phenomenon, which takes place when two bodies differently electrified are brought within the ſphere of action of each other. This may be obſerved by bringing the oppoſite poles of two magnetic bars near to each other and ſprinkling ſome iron filings between their ends. With reſpect to their laws of attraction and repulſion they ſeem to me to have no analogy at all, any more than the cauſe determining thoſe appearances. Beſides, we are not yet ſure whether what we term electric attraction and repulſion comes from the electricity itſelf, or from the body electrified, or from both. It appears moſt probable that theſe effects are the combined force of both, as the electric fluid is never known to act alone. It is not, therefore, the cauſe that bodies approach or recede, that is expreſſed by the words attraction and repulſion, but merely the effect itſelf.

The late Mr. Wilſon, F. R. S. could not be perſuaded that the electric appearances of light, and others of its ſenſible qualities, were parts of the electrical ſubſtance; but that they conſiſted of ſmall parts of groſs bodies thrown into ſtrong agitations in the air by the force and action of this fluid paſſing from one body into another, by which they become decompoſed, part with the light (that before lay hid within them) and their moſt volatile particles, and ſo ſhine and ſmell, and explode in paſſing through the air. I always conſidered this as a bold aſſertion, void of proof; and his arguments in ſupport of it rather ingenious than ſolid.

I con-

I conceive that the uniformity of the electric effects and appearances evinces the existence of a regular and uniform cause, doing the same things and exhibiting the same appearances under the same circumstances at all times. It therefore seems not likely, that the sensible qualities of the electric fluid should only be adventitious. Such ideas which reduce the electric phenomena into mere accidental effects and appearances, pushed suddenly into existence for a moment, are unworthy of an electrician.

In order to be satisfied in this matter, viz. that Mr. Wilson's reasoning, in this particular, does not accord either with the philosopher himself, nor with the electrical phenomena, we need only recur to the electric effects and appearances observed in vacuo, where there is none of the supposed gross matter for the electric substance to operate upon, and kindle into light and smell; because in that case, if his reasoning was well founded, we ought to expect but little or no light nor smell in vacuo. But we know, by experiment, that the case is far otherwise, for the same quantity of electricity exhibits far more light in vacuo than it does in air; and I have obtained the electric smell in vacuo, by means of a convenient instrument made for the purpose. To make it still more evident by an experiment in air. It will appear by the following very simple operation that electric light is sometimes produced without the supposed agatition in the luminous body. Take a stick of hard sealing-wax and lightly rub it in the dark with a woollen cloth; then lay down the cloth and approach with the end of your finger the rubbed part of the wax and electric light will be seen to issue out of your finger, and spread itself on the surface of the wax in a beautiful manner.

manner. This experiment needs no arguments of mine to inforce it; it is plain and full to the purpofe, that is to fay, that the light iffuing out of the finger is no extraneous ignited matter, and therefore luminous, but it is a part of the proper electrical fubftance, iffuing out of the finger in the form of light, to fupply a deficiency of it in the wax, occafioned by the rubbing.

Dr. Prieftley oberves, in his firft volume on different kinds of air, page 280—" That the electric matter in paffing through non-conducting fubftances always emits light. This light I have been fometimes inclined to fufpect might have been fupplied from the fubftance through which it paffes. But I find that after the electric fpark has diminifhed a quantity of air as much as it poffibly can, fo that it has no more vifible effect upon it, the electric light in that air is not at all leffened. It is probable, therefore, *that electric light comes from the electric matter itfelf.*"

REMARKS

REMARKS

ON

Dr. Peart's late Book on Electricity.

SINCE the above was written Dr. Peart's book on Electricity has been put into my hands. It contains a new theory of Electricity, "pointing out" (as the Doctor obſerves in the Title Page) "the inconſiſtency and fallacy of the doctrine of *poſitive* and *negative* electricity, and inveſtigating and explaining the true *principles*, *compoſition*, and *properties* of *electric atmoſpheres*."

Notwithſtanding theſe matters have been noticed before in this work, I cannot, however, forbear expreſſing my ſurprize on ſeveral of the Doctor's improper ſtatements of experiments and arguments deduced therefrom, in which he miſtakes the cauſe of ſome particular effects, and thus both himſelf and all his followers are put upon falſe purſuits.

Doctor Peart obſerves, in page 3, "we have *no* right to ſay that any ſimple body is poſſeſſed of electricity unleſs it ſhews ſome ſigns of attraction when a light body is preſented to it." This is ſo abſurd an infringement of truth that it hardly deſerves to be noticed. The Doctor might

might as juſtly have ſaid that we have *no* right to ſay that a dry bone is poſſeſſed of water, unleſs it ſhows ſome ſigns of wet adhering to the touching body. Had it not been for this peremptory manner of ſpeaking I know not that I ſhould have taken any notice here of his many miſtakes. However, contrary to the Doctor's aſſertion, I think I have a good right to ſay, that every ſubſtance I have tried, except air, (and which are very numerous) is poſſeſſed of electricity; for although the natural electricity reſident in bodies, undiſturbed, does not afford that kind of proof the Doctor requires, yet other proofs, equally deciſive, are always at hand. It is ſo ſelf-evident a truth, that I queſtion whether it does not attend every experiment of electricity; for if I attempt to communicate electricity to a body, the natural quantity of electricity reſident in that body, will be inſtantly put in motion by the attempt, by which motion the body itſelf will become electrified (without friction) with its own electricity, before what I intended to communicate enter it. This fact is well known, and the truth of this obſervation is of general acceptation. See p. 90 and 91.

This fact is clearly manifeſt in the electric charge of the Leyden bottle. Dr. Franklin has fully demonſtrated, beyond diſpute, that the Leyden bottle has no more electricity in it when charged than before, nor leſs when diſcharged, conſequently its electric charge conſiſts of the natural electricity which was reſident in the bottle before the operation begun. This grand diſcovery has ſtood the attacks of eminent philoſophers for upwards of forty years, and will yet, no doubt, ſurvive the late attack of Dr. Peart. Many cogent facts might be adduced of the preſence of electricity in common matter; an attention to brevity, however,

however, renders it neceſſary to forbear enlarging, I will therefore only add, that the Doctor himſelf, in the ſame third page, ſeems to allow the thing I contended for, in theſe words: " All that can be inferred from hence, is, that there is a *ſubtile fluid*, which, in its *natural ſtate*, poſſeſſes no properties by which it is evident to us; but that, by the action of the rubber upon the glaſs, it becomes excited to form an atmoſphere, around the glaſs, capable of attracting light bodies to its ſurface; this fluid, therefore, is *conſtantly* and *univerſally preſent*, but is never electric but in conſequence of a proper excitement."

Page 6. " If ſilk will impart its electricity, by being rubbed upon glaſs, what is the reaſon why it will not impart it to every other body, by being rubbed againſt it, if all are, naturally, in an equal ſtate of electricity?" Who was it that ſaid it will not? For my part I am ſatisfied that it will impart its electricity to any body, as I am of opinion that every kind of friction in bodies produces heat and electricity; but without inſulation ſomewhere (which cannot be ſaid of rubbed glaſs) the fluid of courſe muſt be inviſible. One may ſay in this, as a great perſonage ſaid in another caſe, " No biſhops, no king." No inſulation, no electricity.

Perhaps the following experiment may be adequate to the Doctor's queſtion. To a piece of wood in the wall of my room I fixed a ſmooth iron poker, I then ſtepped upon a well inſulated ſtool, and with either ſilk or woollen in one hand rubbed the iron poker briſkly, at the ſame time I touched with the other hand a ſenſible electrometer, and with pleaſure ſaw the gradual progreſs of the electric

charge. It ſeems therefore, from this experiment, that in all caſes, and whatever is the nature of the ſubſtance, friction always produces electricity; and when the effect is not ſenſible, it is only becauſe the electricity is loſt as ſoon as produced. The production of electricity, by means of friction, is analogous to the production of heat by the ſame means.

I do not admire the Doctor's explanation of the Leyden bottle, and I think that his mode of experimenting with it is fanciful rather than judicious. Indeed his obſervations on it, in their preſent form, are rather too vague to conſtitute any definite thing. Page 48. "If a jar, coated as uſual within and without, be placed upon a glaſs ſtand." Why will he place it upon a glaſs ſtand? that is not the proper mode of charging it, except at the ſame time he connects the outſide coating with the negative prime conductor. "Its inner coating" he continues "connected by proper conductors with the prime conductor, and then electrified poſitively, the *inner* coating will acquire a ſmall charge of *poſitive* electricity, which, acting through the glaſs, will *expel* all the *natural* electric fluid from the outſide coating." This I poſitively deny to be the fact; and I plainly perceive, throughout his book, that he takes it for granted, that a body, rendered negative, is actually deprived of all its natural electricity; this I aſſign as one of the Doctor's principal miſtakes. I readily admit, that ſome authors, when treating on negative electricity, have incidentally given too great occaſion for ſuch ideas; and I am ſure he has not dealt ſparingly in the uſe of them. "Which he ſays will therefore be electrified *negatively*.—The queſtion then is, *whether* is the natural quantity of the

the electric fluid driven, which was expelled from the outer coating?"—In the present case, as the circuit is but small, I hesitate not to answer, it is driven into the inside of the jar.—"The glass stand, he adds, could not conduct it away, yet, the outside coating is, what they call *completely negative.*" These particulars contain a manifest contradiction; for if his glass stand be a good insulation, (of which I am in doubt) and therefore could not conduct electricity, it is absolutely impossible that the jar should become negative on the outside, but just the reverse; for the electricity will, so circumstanced, act upon the glass jar as if it were made of brass, or any other metal, and consequently both the inside and outside, will be electrified uniformly the same in kind with that of the prime conductor itself. If he wishes to preclude every exception on the account of insulation, in this experiment, I would advise him to suspend his glass jar in dry air, to the prime conductor, then work the machine, and I am sure he will find the result as here expressed; *provided that he does not, on trying the fact, approach the outside coating with any thing but what is perfectly insulated.*

With regard to electric atmospheres, some have denied their existence, but Dr. Peart has found a double number of them, and which he says "is too evident to admit of a doubt about its veracity." With respect to myself, I conceive that electric atmospheres consist of electricity, naturally resident in the humidity of the air, surrounding an electrified body to a certain distance; that excited glass, for instance, repels the electric fluid from it, and consequently, beyond that distance makes it more dense; whereas excited wax attracts the electric fluid existing in the aque-

ous matter, nearer to it, making it rarer than it was before.

Electric atmofpheres evidently decreafe as the diftance increafes from the electrified body, but in what ratio of the diftance feems not yet afcertained. I have been very careful in repeating experiments of this kind on the two electricities, and I find that this law obtains with both powers; had Dr. Peart been thoroughly acquainted with this law of electric atmofpheres, it might have faved him a great deal of labour.

But we will purfue his doctrine of double electric atmofpheres in a more particular and experimental manner, becaufe Dr. Peart roundly affirms, page 87,—"In fhort thefe principles, and this theory alone, can rationally explain the phenomena of electricity, which never will be underftood unlefs they be admitted." But, previous to the performance of experiments, we ought to confider attentively the ftate of our apparatus. And to be plain, I do not approve of the Doctor's electrometer to examine judiciouffly things of this kind. He defcribes it as confifting only of one pith ball fixed to a filk thread; this I think muft be very unmanageable. My electrometers confift of two pith balls, fufpended by filaments of combed flax fixed to metal, which is fupported by a glafs ftand, covered with hard fealing-wax. I have feveral of this fort by me, and of different magnitudes, of courfe different in fenfibility.

Dr. Peart's definition and application of his double electric atmofpheres takes up a large part of his book, but

for

for the ſake of conciſeneſs I ſhall paſs over many of his ſmaller obſervations, and content myſelf with obſerving, that the Doctor founds his principles of double electric atmoſpheres on two effects, commonly obſerved in them; *viz.* that if a pith ball be brought into the atmoſphere of an electrified conductor, at a remote diſtance from it, the ball is only attracted without any change in its ſtate; but if the ball is made to approach nearer to it, the ball becomes electrified. For the truth of this I beg leave to refer the candid reader to the 23d, and ſeveral of his following pages; but to an electrician, enough has been ſaid already to make it plainly appear, that he builds his theory on a ſandy foundation.

That an electrometer may be immerſed in an electric atmoſphere, and withdrawn out of it unelectrified—and that if it be plunged deeper into the ſame atmoſphere it will acquire an electric charge, is well known to be nothing more than the mere effect of the various intenſity, and that thoſe effects do not happen alike with any two electometers of different ſenſibilities, at the ſame diſtance from the electrified body, yet their electric charge will be of the ſame kind of electricity with that of the body, at every diſtance in which they become electrified.

The following concluſions appear to be deducible from theſe effects: 1ſt. A body is ſurrounded with an electric atmoſphere, whether it be electrified poſitively or negatively; 2d. theſe atmoſpheres decreaſe in their intenſity as the diſtance increaſes from the electrified body, but are abſolutely formed of one kind of electricity throughout, with that of the body itſelf; and 3d. hence it follows, that

the theory of *internal* and *external* electric atmospheres, has no foundation in nature.

As the terms *positive* and *negative* only denote more or less than the *natural* quantity which a body may possess, of one and the same individual fluid, and which terms are only applicable to it during its disturbed state, I see no cause to abate the use of them from any thing Dr. Peart has said on that head. With regard to his favourite *theory* of æther and phlogiston, I at once consign it to the same grave with that *wrote* by Dr. Hoadly and Mr. Wilson; by which *theory* they laboured hard to prove the identity of *æther* and *electricity*.

Notwithstanding my intention of being concise, I have already discussed more parts of Dr. Peart's book than I at first intended, but as it seems calculated to challenge discussion, it neither can nor ought to pass unnoticed by electricians, except they are all fallen into a deep sleep, insomuch that even his electrical shock cannot awake their mental powers. I have not the least idea of making myself a principal in the dispute; my view in saying something about it is to stimulate, if possible, the attention of more able philosophers, to a fuller discussion of this interesting subject.

A Meteorological Journal, principally relating to Atmospherical Electricity; kept at Knightsbridge *from the 9th of* May, 1789, *to the 8th of* May, 1790. *By Mr.* John Read; *communicated by* Richard Henry Alex. Bennet, *Esq. F. R. S.*

Read April 14, 1791.

A DESCRIPTION of the improved state of the Instruments for collecting Atmospherical Electricity, used in the latter part of the following Journal *.

Fig. 1 and 2 represents the Instrument. A A fig. 1, is a round deal rod, 20 feet long, two inches diameter at the lower, and one inch at the upper end: into the lower end of it is cemented a solid glass pillar B, 22 inches long; the lower end of this glass stands in a socket of wood C, which is screwed on the garret floor D, and supports the whole. About seven feet above the floor, is firmly fixed to the wall a strong arm of wood E, which holds perpendicularly a strong glass tube F, through which the rod is slided gently upwards, till the glass pillar B may be lowered into the socket C. It is thus fixed, and stands 12 inches from the wall. The tube F is of sufficient width to admit a case of cork, which is fastened in the inside of it, at the part

* A representation with a description of my first Instrument for collecting Atmospherical Electricity, may be seen in the 81st vol. of the Philosophical Transactions, part ii. page 212.

 where

where the tube is ſuſtained by the arm of wood E, ſo that the rod, when bent by the wind, cannot touch the tube or break it. The upper extremity of the rod is terminated by ſeveral ſharp pointed wires G; two of them are of copper, each one-eighth of an inch thick; and, in order to ſtiffen the rod, as well as conduct more readily the electric fluid, one of them is twiſted round the rod to the right hand, and the other to the left, as low down as the braſs collar H, to which they are ſoldered, in order to render their contact perfect. A little above the upper end of the glaſs pillar B, is placed a brace I I of ſolid glaſs ſticks, to keep ſteady that part of the rod. K is a hollow cylinder of wood, 12 inches within, proceeding from the ceiling through the roof LL, above which there is a hollow tin cover M, 24 inches within, fixed to the rod; which ſerves to defend the open cylinder K from the weather. At a convenient diſtance from the foot of the rod is a hole bored through the floor and ceiling. This hole receives a glaſs tube covered with ſealing-wax (as are all the other glaſſes in this apparatus), through which a ſtrong braſs wire proceeding from the rod is conveyed into the room below, wherein, at a convenient heighth from the floor, it terminates with a two-inch braſs ball N. A ſtrong ring of braſs is made to move eaſy on the wire, and reſts on the braſs ball; into this ring is ſcrewed a braſs wire ſeven inches long, which keeps ſuſpended at its extremity a pith-ball electrometer O.

At two inches diſtance of the above-mentioned braſs ball N, a bell P is ſupported by a ſtrong wire, which paſſing through a hole made in the wall, is made to communicate, by means of a good metallic continuation Q, with

with the moiſt ground adjoining to the houſe. A braſs ball three-tenths of an inch in diameter, is ſuſpended between the bell P and ball N, by a ſilk thread faſtened to a nail R. This ball ſerves for a clapper, by ſtriking between the ball and bell, when the electrical charge of the rod is ſufficiently ſtrong. V gives nearly a front view of this part of the apparatus.

S is a ſmall table fixed to the wall under the bell and ball, at a convenient height above the floor, upon which Leyden bottles and other apparatus are occaſionally placed. Any perſon verſed in the ſcience of electricity, will eaſily underſtand that this apparatus is calculated to ſhow the various degrees of intenſity of Atmoſpherical Electricity; and at the ſame time to avoid the pernicious effects which may be occaſioned by thunder ſtorms, or in ſhort by any great quantity of electricity in the atmoſphere.

The whole perpendicular height of both parts of this apparatus taken together, from the moiſt earth to the point at the top of the rod, is 61 feet. If the inſulation could be conſtantly kept in due temperature, with reſpect to heat and cold, I imagine it would always be electrified. But I fear that cannot be done, without the aid of common fire; which in ſo large an apparatus would be very difficult, ſo that there might not be too much nor too little of it. I am inclined to this opinion, from the ſucceſs I have had in a number of experiments, in which the aid of common fire was applied to improve the inſulation, as well as to collect the electric fluid.

When I find that the moiſture in the air has ſo much injured the inſulation of my high pointed rod, that it will not retain a weak electricity, in that caſe I make uſe of my hand exploring rod, which is about the length and thickneſs of a common fiſhing-rod, with plenty of ſmall wire twined round it from end to end. The method of uſing it is ſimple and eaſy. A repreſentation of it may be diſtinctly ſeen in fig. 2. Having firſt *warmed* the glaſs legs of the ſtool, I place myſelf upon it, and raiſe the rod into a vertical poſition, keeping it ſo for a minute or two; I then with a finger of the other hand touch a ſenſible electrometer, and if the threads open it is ſufficient. But ſhould the electrical ſtate of the atmoſphere be too weak to produce that effect, which ſeldom happens, then in that caſe I add to the rod a *lighted torch* T, and place it as remote from my hand as the ſtrength of the rod will bear, and repeat the experiment; thus circumſtanced, it has never yet failed me.

It will be neceſſary juſt to mention the method I have purſued in forming the Journal of Atmoſpherical Electricity. This has been principally by means of the ſigns exhibited by the pith balls O, connected with the rod. When I find theſe cloſed, and attracted on the approach of my finger, yet not ſufficiently charged to repel each other, I write weak ſigns of electricity. When I find the balls open, and, on the approach of excited glaſs, the balls cloſe, I write they are electrified poſitively; but, if the balls open wider, I write they are electrified negatively; and the reverſe when I uſe ſealing-wax. When the balls diverge one inch and upwards, viſible ſparks may be drawn at the braſs ball N. When ſparks are

ſaid

ſaid to have been perceived in any obſervation, I have generally on that account omitted to note the variable quantities of divergency in the pith balls. Their utmoſt limit of regular divergency ſeems to be about five or near ſix inches; above that they are unſteady and diſorderly. The pith balls are near two-tenths of an inch in diameter, ſuſpended by very fine flaxen threads (in the ſtate it is in from the heckle) five inches long. When I mention the diſtance of the balls in tenths of an inch, it is to be underſtood as nearly ſo as my eye can determine.

This apparatus requires a conſtant attention, eſpecially during a diſturbed ſtate of the atmoſphere. From the room in which the apparatus is placed I am ſeldom abſent one hour, excepting the time of ſleep; but, when I leave it, the laſt thing I do at night is to examine the ſtate of the electricity, and, if I find the rod unelectrified, I then place the Leyden bottle on the table S, with its knob nearly in contact with the ball N. The next morning, if I find this bottle charged, I write the kind of electricity it is charged with againſt the day in the Journal, and add, *by the night bottle.*

It is preſumed, that the table is ſufficiently obvious. The column for poſitive and negative electricity is uſed only for the firſt obſervation of each day. I uſe FARENHEIT's thermometer, ſuſpended on the north outſide of a bow-window. The time of making the obſervation with it, and the barometer, and alſo of the direction of the wind, has uſually been nine o'clock in the morning.

Laſtly,

Laſtly, it may be uſeful to obſerve, that I have always found, when the rod is highly electrified, the lower though *uninſulated* part of the apparatus, *viz.* the metallic connection of the bell P with the moiſt earth) to be in a contrary ſtate of electricity to the upper and inſulated part. See the 22d of Auguſt, 1789.

Having made a memorandum of the ſeveral thunder-ſtorms which have happened in divers parts of this iſland, according to information by letters, and from newſpapers, I thought it uſeful to inſert them in this Journal, in order to ſhow whether ſome contemporaneous appearances in my apparatus might not be attributed to them.

Days.	Wind	Barom	Ther.	Sparks	Kind.	MAY, 1789.
		Inch.	°			
9	NW	30.	63	—	Neg	Balls open about three-tenths of an inch.
10	SW	30.15	60	—	Neg	But very weak.
11	E	30.24	61	—	Neg	Barely sufficient to separate the balls.
12	E	29.91	60	S.	Neg	The first day I have had visible sparks; weather cloudy, but fair.
13	E	29.91	61	S.	Pos.	The weather in the forenoon a little hazy; in the afternoon a thick fog. Four o'clock a little rain fell; the rod now became highly electrified positively; and the bell rang briskly: I now filled several bottles with the fluid. This strong charge in the rod did not last more than one hour, but it remained charged positively in a less degree the rest of the day. There was this day some lightning and thunder at Salisbury, and to the west of it.
14	SE	30.	56	—	Pos.	Balls open four-tenths of an inch.
15	E	29.66	58	S.	Pos.	A.M.—And P.M. negative
16	SE	29.83	61	—	Neg	A.M.—And P.M.
17	S	29.91	58	—	Neg	Balls open six-tenths of an inch.
18	SW	29.91	57	—	Neg	Balls open five-tenths of an inch.
19	N	30.20	54	—	Neg	P.M. dark heavy weather.
20	SE	30.15	56	S.	Neg	The rod has been electrified nearly the whole day.
21	E	30. 2	54	—	Neg	Nearly the same as the preceding day.
22	S	29.89	58	—	Pos.	Just sufficient to indicate the kind.
23	S	29.90	59	—	Pos.	Serene weather.
24	SE	29.75	60	—	Pos.	
25	E	29.68	62	—	Neg	Six o'clock A.M. Soon after a fog with drizzling rain, by which the rod became electrified positively.
26	NE	29.64	61	—	Neg	A.M.
27	SW	29.65	60	—	Neg	A.M. Balls open three-tenths of an inch.
28	SW	29.86	60	—	Pos.	But very weak.
29	W	29.72	61	S.	Pos.	A very cloudy morning, though at too great a height for my rod; but in the afternoon the clouds approached much nearer, and the rod became charged pretty strongly positive, which continued about one hour and a quarter. I charged some Leyden bottles with the fluid, some positive, others negative, for there were four gradual changes of the electricity.
30	S	29.70	56	—	Pos.	Balls open half an inch.
31	SW	29.57	58	S.	Pos.	Nine o'clock A. M. a heavy shower of rain, by which the rod became strongly charged with negative electricity, all the time the shower lasted, which was short and sudden. One hour afterwards, the electricity changed to a strong positive, the bell suddenly began to ring, and con-

Days.	Wind.	Barom	Ther.	Sparks	Kind.	June.
		Inch.				tinued to do so five minutes; the pith balls then closed slowly, and opened negative, and continued so the rest of the day. At Edinburgh, some lightning and thunder this day.
1	SW	29.71	53	S	Pos.	A cloudy showery morning. The electrical operations in the rod have been beautiful this day. In about six hours time I observed seven changes of the electricity; five of these changes were gradual. The balls opened from 3 to 4 inches, and remained so from 15 to 20 minutes each opening, then gradually closed; the other two charged slowly, but closed very quick.
2	SW	29.85	63	—	Pos.	But weak.
3	SW	29.92	62	—	Pos.	A.M.
4	W	29.42	52	S	Pos.	A cool cloudy morning. The rod has been strongly electrified full seven hours; the rest of the day but weakly so. There were 12 changes of the electricity, all gradual, except one, which was instantaneous; the balls sometimes exhibited a waving motion, and sometimes sudden jerks. There were several showers of rain, and two of hail; during the fall of hail the rod was most powerfully electrified, and the bell rang very briskly; the effects and appearances were so awful, that I kept at a good distance from the rod. A great deal of lightning on the east side of Kent and Essex this day.
5	NW	29.52	5	—	Neg	Balls open half an inch.
6	W	29.78	53	S	Neg	A.M.—And P.M. positive. There were small sparks emitted from the brass ball N, and the pith balls continued closing and opening many times, without any change of kind, for the space of two hours.
7	NW	29.92	52	—	Neg	Balls open from one to seven-tenths of an inch.
8	NW	30.18	50	—	Neg	
9	NW	30.12	57	—	Neg	
10	NW	30.25	56	—	——	Weak signs, balls not open.
11	NW	30.12	55	—	——	
12	E	30.25	56	—	Pos.	Balls open three-tenths of an inch.
13	E	30.28	54	—	Pos.	Balls open five-tenths of an inch.
14	NE	30.19	51	—	Neg	Very cloudy weather, but at too great a height to affect the rod powerfully.
15	E	30. 4	55	—	Neg	Balls open full half an inch.
16	E	29.90	60	—	Neg	Balls open near one inch.
17	S	29.81	62	S	Pos.	Ten o'clock A.M. a sudden shower of rain, by which the rod became highly electrified positively, and continued to emit

Days.	Wind.	Barom	Ther.	Sparks	Kind.	June.
		Inch.				
						small sparks at the ball N, long after the shower was over, without any change of the electricity.
18	SE	29,89	60	S.	Pos.	The weather showery; the rod pretty well electrified.
19	SW	29.88	56	—	Neg	Balls open six-tenths of an inch.
20	SW	29.65	63	—	——	Weak signs; balls not open.
21	SW	29.71	59	S.	Neg	This morning several heavy clouds passed over from the SW, by which the rod became moderately electrified negatively; and some rain fell, which increased its electrical charge. In the afternoon, the wind and clouds put on a more ominous appearance; near five o'clock began a storm of wind, rain, lightning, and thunder; but the main weight of the storm did not come near my rod. Its dire effects must be east of London: nevertheless, I had those usual beautiful appearances which attend a strong charge in the rod. The storm lasted one full hour, during which time there were five successive changes of the electricity, viz. four gradual attended with sudden jerks or starts, which often diminished the divergency of the pith balls from 4 inches to 2 inches or less. After those jerks the pith balls recovered their former degree of divergency, sometimes suddenly, and at other times slowly. The other change happened instantaneously, the pith balls collapsing and opening so quick that the eye could barely see their motion. There were two other instantaneous closings and openings of the balls, without a change of electricity. Much lightning at Gravesend to day.
22	SW	29.49	56	S.	Pos.	The rod has been electrified all this day.
23	SW	29,54	57	S.	Pos.	Most of the forenoon. Afternoon some rain fell, and the rod became electrified negatively, and ended positively.
24	SW	29.60	61	—	Neg	A.M.
25	NW	29,64	55	S.	Neg	A very thick cloudy morning. The electric charge in the rod has been moderately strong and very fine to-day. There were five gradual changes of the electricity.
26	W	29.80	53	—	Neg	A.M.
27	W	29.96	52	S.	Pos.	Cold showery weather. Except some small intervals, the rod has been strongly electrified all this day. The bell rang briskly for a few minutes, then suddenly stopped,

Days.	Wind.	Barom	Ther.	Sparks	Kind.	June and July.
		Inch.				and the pith balls closed and opened negatively, and continued so till a little after eight o'clock P.M. when they changed to positive. At Liverpool, this day, a tremendous storm of lightning, thunder, hail, and rain.
28	W	29.70	50	S.	Neg	A very cold, showery morning, and the drops of rain were very large. The rod has been very powerfully electrified near twelve hours this day, during which time there happened eleven changes of the electricity, all gradual but one. The balls often exhibited a waving pendulous motion, without any dimunition in their divergency. There were also a few of those jerks before noticed on the 21st inst.
29	W	29.90	51	S.	Neg	The bell rang briskly: there has been no change in the electricity this day.
30	NW	30.10	53	—	Pos.	Nearly all day. Weather serene and clear.
1	N	29.19	76	—	——	Weak signs, balls not open. An even dark sky, but fair.
2	N	30. 3	76	—	——	
3	N	30. 2	79	—	Pos.	Weather serene, very hot, and a clear sky.
4	N	30. 2	80	S.	Pos.	A.M.—And P.M. negative. At Glasgow, some lightning and thunder.
5	NE	29.19	74	—	——	Weak signs. Balls not open.
6	NE	29.17	72	S.	Neg	A heavy dark atmosphere, but fair. At Monksilver, near Bath, much lightning and thunder.
7	NE	29.16	69	—	——	Weak signs of electricity; balls not open.
8	NE	30.	60	—	——	
9	NE	29.40	72	—	——	
10	NE	29.20	72	—	Neg	A.M.
11	E	29.15	74	—	Neg	A.M.
12	E	29.13	78	—	——	Balls not open.
13	W	29. 5	72	S.	Neg	A.M.—And P.M. positive, with sparks. At Hereford, this day, a storm of rain, lightning, and thunder.
14	SW	29. 6	69	—	——	Weak signs; balls not open.
15	NW	28. 8	52	S.	Neg	A.M.—And P.M. positive, with bright sparks. At Strichen, in Scotland, a heavy thunder storm.
16	W	30.	60	—	——	Balls not open. At Edinburgh, this day, some lightning and thunder.
17	SW	29.10	65	S.	Neg	P.M. with fine sparks; but no change of kind. At Glasgow and Hamilton, this day, lightning, thunder, hail and rain; and also at Newcastle, in Northumberland, the storm was severe.
18	SW	29.15	59	—	——	Weak signs; balls not open.
19	W	29.10	50	—	Neg	P.M.

Days.	Wind.	Barom	Ther.	Sparks	Kind.	July.
		Inch.				
20	NW	29.10	54	S.	Neg	Three o'clock P.M. I saw a thunder storm approaching. While the storm remained at a considerable distance, the rod was very highly charged with negative electricity, and continued so three quarters of an hour; during that time distant thunder was heard. The wind suddenly shifted to the SE, and a very heavy rain soon came on; the electricity now changed to positive, and the bell rang briskly; every appearance (both within and without the room) was tremendously awful. I therefore seated myself upon a large insulated stool, where I could with safety observe the apparatus. A Leyden bottle was undesignedly placed with its brass knob near to the brass ball N. This bottle charged and spontaneously discharged almost as quick as I could notice them; and at the same time there was a continual flashing of dense sparks between the bell and brass ball. These very grand appearances only lasted ten minutes, and the scene was terminated by a clap of thunder; but the storm, and its effects on the rodd lasted near two hours. I saw no lightning but what was in the apparatus. There were nine gradual changes of electricity. The pith balls exhibited sudden starts or jerks, and sometimes a waving motion. I had purposely placed a large glass bowl, upon an insulated table, in the open air, to catch the falling electrified rain. As soon as the bottom of the bowl was well covered with the rain water of the above storm, to my great satisfaction, a pair of linen threads I had placed for the purpose diverged near two inches; the water remained electrified near ten minutes after it was taken into the house.
21	SW	29.15	52	S.	Neg	P.M. a little rain fell, and the electricity changed to positive. At Edinburgh and Banff, this day, there was much lightning and thunder.
22	SW	29.10	61	S.	Neg	A very strong electricity in the rod all the forenoon. 12 o'clock some rain fell, on which the rod became highly charged positively, the bell rang weakly for a long time, it then stopped, and the balls closed and opened negative, and continued so

Days.	Kind.	Barom	Ther.	Sparks	Kind.	July and August.
		Inch.	°			full three hours. This day, near Shrewsbury, a storm of rain, lightning, and thunder.
23	W	29.10	51	S.	Pos.	Both A.M. and P.M. and ended negative as the preceding day.
24	W	29.15	71	S.	Neg	A.M.---And P.M. *positive.*
25	W	29.20	71	—	——	Weak signs; balls not open. An universal cloudy dark sky.
26	W	29.10	69	—	——	
27	N	29.15	64	S.	Neg	Four o'clock P.M. happened a sudden and short storm of wind and rain, by which the rod became powerfully electrified, the bell rang for 20 minutes, then stopped, and the electricity became positive, and strong. At Cambridge, this day, a tremendous storm of lightning and thunder.
28	N	29.20	74	—	Pos.	A.M. balls open five-tenths of an inch.
29	W	30.	56	S.	Neg	A.M.
30	NW	29.30	73	—	Neg	Balls open six-tenths of an inch.
31	W	29.20	75	—	Neg	P.M.---A regular dark sky, with small rain, which continued four hours; such rains are never electrified strongly. Air is very moist.
1	W	29.79	60	—	——	A heavy dark atmosphere, and a warm soft air. The electricity these six days amounts only to weak *signs, balls not* open.
2	W	30.12	56	—	——	
3	SE	30.	62	—	——	
4	E	30. 5	61	—	——	
5	E	29.79	66	—	——	
6	SW	30. 9	60	—	——	
7	W	30.27	56	—	Neg	P.M.
8	W	30.24	58	—	Neg	A.M
9	E	30.20	66	—	Neg	A.M.
10	E	30.17	60	—	Neg	A.M.
11	NE	30.20	66	—	——	Balls not open.
12	E	30.16	58	S.	Pos.	P.M.---A fine shower of rain, on which the rod became pretty well electrified; but soon changed to a strong negative electricity, which afforded fine sparks at the brass ball N. The pith balls closed and opened several times, without any more changes of kind.
13	E	30.14	60	S.	Pos.	A.M.
14	NE	30.13	62	—	Pos.	A.M. balls open seven-tenths of an inch.
15	NE	30. 9	59	S.	Pos.	A.M.---2 o'clock P.M. a very black cloud passed over the rod, by which it became very strongly electrified for a few minutes only; the bell rang briskly.
16	N	30.15	62	S.	Pos.	There has been much rain to-day, and the drops very large. The rod has been in high charge great part of the day. The sparks at the brass ball N were very pungent, not only so, but also the air in the

Days.	Wind.	Barom	Ther.	Sparks	Kind.	Auguſt.
		Inch.	°			room, and the uninſulated bell, and other things, ſhewed that they were electrified. The bell rang briſkly at three intervals of time. This ſtrong charge of the rod continued full four hours; and the electricity, during that time, changed in kind ten times. Eight of them were gradual, two of them were quick and attended with jerks. I heard ſome rumbling of thunder at a great diſtance. At Dunwich, in Suffolk, this day, much lightning and thunder.
17	NE	30.26	61	S.	Neg	A.M.
18	NE	30.32	61	—	Neg	Balls open nine-tenths of an inch.
19	NE	30.25	60	—	——	Weak ſigns; balls not open.
20	E	29.95	63	—	——	
21	SE	29.75	63	S.	Neg	Four o'clock P.M. a ſtrong charge in the rod, but of ſhort duration.
22	W	29.75	56	S.	Neg	The rod was in high charge ten hours this day, except a few ſmall intervals; there were nine gradual changes of the electricity, from negative to poſitive, and the contrary. The bell rang very briſkly at three different times during that period. There were ſeveral ſhowers of rain, and one of hail; during the latter, the electric charge in the rod was moſt intenſe; the ſparks darted between the ball and bell extremely ſharp and quick. I found the moiſture in the air of the room was now electrified, alſo the bell, and its metallic connexion with the earth, and even the bricks in the wall to which the metal is faſtened were all electrified with an electricity contrary to that in the inſulated part of the apparatus. An electrician (who had often in vain called at my houſe to ſee the apparatus in high charge) placed his left hand on the bell, and with his finger of the right hand approached the ball N; a denſe ſpark iſſued to it, and he received a ſmart ſhock in his arms and breaſt, like that of the Leyden bottle. We then joined hands, and made the circuit in the uſual way, between the bell and ball, and we both received a ſevere ſhock. Much lightning and thunder this day at Stirling and Dumfries, in Scotland.
23	W	29.94	52	S.	Poſ.	A.M.—And P.M. negative on a fall of rain.

Days.	Wind.	Barom	Ther. °	Sparks	Kind.	August and September.
24	NW	30.15	58	S.	Pos.	Great part of the day.
25	SW	30.19	60	—	Pos.	A.M. but very weak in the afternoon.
26	SW	30.10	58	—	——	Weak signs; balls not open.
27	N	30. 8	59	—	——	
28	W	30. 3	54	—	Pos.	A.M. a serene clear sky.
29	SE	29.90	58	—	——	Only weak signs.
30	SW	29.80	60	—	——	
31	NW	29.75	62	—	Neg	P.M. from a shower of rain, the drops of which were very large. The electricity soon changed to positive. Though every circumstance was favourable for a strong electrification, yet the charge in the rod was but weak. My suspicion led me to try the state of the uppermost end of the rod, and I found it to be in a contrary state of electricity to that at the lower end of it; the middle part of the rod was in its natural state, that is, shewed no signs of being electrified; therefore the rod was only (at this time) influentially electrified.
1	SE	29.72	58	—	Neg	A.M.
2	S	29.60	66	S.	Pos.	A.M. 2 o'clock P.M. a shower of rain fell by which the charge in the rod became negative.
3	S	29.50	69	S.	Pos.	In the forenoon. One o'clock P.M. rose a strong gale of wind, I now saw thunder clouds forming at a great height. Half after five o'clock appearances were dreadful; in five minutes time the strong gale of wind became a storm from SE. This storm of wind (for there was but little rain) carried the large black clouds to the NW, and there I saw abundance of red lightning a little above the horizon, and I once heard a rumbling of thunder. The electric state of the rod before the storm was positive, but by it was changed to negative, and continued so during the whole time, but often varied in strength, sometimes weak, sometimes strong. At Amersham, in Buckinghamshire, and at the same time at the Earl of Aylesford's park, near Packington, in Warwickshire, was a most tremendous storm of hail, rain, lightning, and thunder from four to six o'clock P.M.
4	SE	29.50	68	S.	Neg	P.M. There were four gradual changes of the electricity in two hours.
5	SW	30.	69	S.	Neg	P.M. There has been a little rain today.

Days	Wind	Barom	Ther.	Sparks	Kind.	September and October.
		Inch.				
6	SW	29.95	59	S.	Pos.	In the forenoon, and near sun-set negative by some small rain.
7	SW	30. 3	62	—	Pos.	A.M. by the night bottle, and likewise by the rod the same, but very weak.
8	SW	30.15	67	—	——	Only weak signs of electricity; balls not open.
9	SW	30.15	68	—	——	
10	SW	30.12	68	—	——	
11	N	29.95	61	—	——	
12	N	30.10	54	—	Pos.	By the night bottle.
13	W	30.10	54	—	——	Weak signs; balls not open. A dark atmosphere.
14	SW	29.85	60	—	——	
15	W	29.82	48	—	——	
16	SW	29.74	48	S	Neg	A.M. There were several heavy clouds passed from the SW. by which the rod was highly charged with positive electricity. The bell rang briskly. This charge continued from a little before 11 o'clock A.M. to full six o'clock P.M. during that time there were four gradual changes of electricity.
17	NW	29.92	44	—	Neg	By the night bottle.
18	NW	29.61	52	—	Neg	A.M. a more transient visit of the electric fluid I never before saw, only while a small black cloud passed over the rod, and let fall a few drops of rain; the whole time of the charge was about four minutes.
19	W	29.40	48	—	Neg	A.M. by the night bottle. The electrification of the rod very weak.
20	W	29.40	60	—	——	Weak signs; balls not open.
21	W	29.40	60	S.	Neg	A.M. by the night bottle. Five o'clock P.M. the rod was electrified negatively.
22	NW	30. 9	51	—	Neg	By the night bottle, and the rod also.
23	NW	30. 2	51	—	Neg	The electrical charge in the rod has been very weak these eight days, only just sufficient to indicate the kind.
24	NW	30.23	61	—	Neg	
25	NW	30.26	49	—	Neg	
26	S	30.26	49	—	Neg	
27	SW	30.	61	—	Neg	
28	W	30.	51	—	Neg	
29	S	29.71	58	—	Neg	
30	S	29. 1	48	—	Neg	
1	SW	29.22	58	S.	Pos.	A.M. by the night bottle, which was sufficiently charged to give a bright spark on making the circuit. At noon some rain fell, by which the rod became electrified negatively, and very strong, which lasted full four hours; during that time, the electricity changed four times, which were all gradual.
2	SW	29.28	47	S.	Neg	A.M. Four o'clock P.M. the rod was electrified positively, and afterwards nega-

Days.	Wind.	Barom	Ther.	Sparks	Kind.	October and November.
		Inch.				
						tively, with ſtrong ſparks at the braſs ball N.
3	SW	29.11	48	S.	Poſ.	A.M. but more intenſely poſitive in the afternoon; the bell for a ſhort time rang briſkly, after that faintly, then ſtopped, and the electricity changed to negative, which continued ſo ſome hours, then declined gradually to weak ſigns only.
4	W	29.40	51	—	Poſ.	A.M. by the night bottle.
5	S	29.53	45	S.	Poſ.	A.M.—And P.M. negative.
6	S	29.50	56	S.	Poſ.	A. M.—Three o'clock P.M. poſitive, but much ſtronger than in the morning. There has been to-day a cold ſmall rain. The electricity changed four times in two hours. This day, at Whitehaven and Lancaſter, was much lightning and thunder, rain, hail, &c.
7	W	29.27	45	S.	Poſ.	A.M. but in the afternoon a much ſtronger poſitive charge,
8	E	29.20	48	—	Poſ.	A.M.
9	SW	29.29	46	—	Poſ.	A.M.
10	SE	29.50	45	—	Poſ.	A.M.
11	SE	29.80	49	—	Poſ.	A.M.
12	S	29.46	53	—	—	Weak ſigns; ball not open. Dark, hazy weather.
13	N	29.50	53	—	—	
14	W	29.50	53	—	—	
15	W	29.52	56	—	—	
16	W	29.67	42	S.	Poſ.	A.M. juſt ſufficient to emit viſible ſparks.
17	W	29.90	40	—	Poſ.	P.M. by means of a fog.
18	S	29.67	52	—	—	P.M. Balls open ſix-tenths of an inch.
19	S	29.79	50	—	—	Weak ſigns. Balls not open.
20	SW	29.75	58	—	—	
21	S	29.89	53	—	Poſ.	A.M.
22	W.	30. 4	50	—	—	Weak ſigns of electricity; balls not open. Dark, hazy weather, and moiſt air, theſe eight days.
23	NE	30. 7	53	—	—	
24	E	30.24	48	—	—	
25	NE	30.28	55	—	—	
26	E	30 27	47	—	—	
27	E	30.27	45	—	—	
28	E	30.30	40	—	—	
29	N	30.13	46	—	—	
30	E	30. 3	40	—	Poſ.	P.M. by means of a little cold rain.
31	N	29.92	40	—	Poſ.	P.M. a very high north wind.
1	N	30.32	38	—	—	Only weak ſigns of the electric fluid; balls not open. A dark cloudy atmoſphere,
2	N	29.59	46	—	—	
3	S	29.19	39	—	—	
4	SE	29. 3	48	—	—	
5	S	29.29	50	—	—	
6	W	28.82	48	—	—	

Days.	Wind.	Barom	Ther.	Sparks	Kind.	November.
7	W	28.90	43	S.	Neg	A.M. by a shower of sleet, which for a short time occasioned the rod to emit bright sparks at the ball N.
8	NW	29. 9	40	—	Neg	A.M. by the night bottle.
9	W	29.29	30	—	Neg	
10	W	29.90	37	S.	Pos.	A.M. by means of a fog.
11	W	29.93	39	S.	Neg	A.M.
12	SW	29.70	45	—	Pos.	P.M. This was obtained in the following manner. Soon after sun-set I perceived a light-coloured dewy vapour arise 20 or 30 inches above the ground in the park; the evening being serene and fair, I stood upon an insulated stool, and waved my exploring rod among the dewy vapour, and with my finger touched a sensible electrometer, which instantly opened with positive electricity*. As the evening advanced, a strong fog filled the air; when it was of sufficient height for the high or fixed rod, this also became electrified with the same kind of electricity which I had received near the earth's surface.
13	W	29.73	40	—	——	Weak signs only; balls not open.
14	SW	29.63	46	—	——	
15	SW	29.42	47	—	——	Notwithstanding all my care and attention to my pointed rod, it has this day been intirely frustrated; for I have not perceived any signs of the electric fluid. However, it is the first day that it has wholly failed me. A moist air has prevailed for many days; and there have been six hours drizzling rain to-day, which must lessen the exactness of the insulation of the rod, and air also.
16	SW	29.43	43	—	——	Weak signs; balls not open.
17	S.	29.54	47	S.	Neg	A.M. small sparks were obtained from the rod, the greatest part of this day.

* When I find that the moisture in the air has so far injured the insulation of my high-pointed rod, that it will not retain a weak electricity; in that case, I make use of a small rod which I hold in my hand, and which I sometimes project through an upper window; having first warmed the stool legs, I place myself upon it, &c. I find this method to be a good substitute in damp weather. A representation of the rod, and mode of using it, may be seen in fig. 2.

Days.	Wind.	Barom	Ther.	Sparks	Kind.	November and December.
		Inch.				
18	S	29.51	40	—	Pof.	A.M. by means of a fog.
19	S	29.69	43	—	Pof.	
20	W	29.65	47	—	Pof.	
21	NW	29.86	44	—	Neg	A.M. by the night bottle, which I found well charged.
22	N	29.89	44	—	——	Weak ſigns only.
23	NE	30.12	42	—	——	No ſigns. This is the ſecond failure. A moiſt atmoſphere.
24	NE	30.29	41	S	Pof.	From fog, viſible ſparks were obtained during the greateſt part of the day.
25	N	30.20	37	—	Pof.	A.M. by means of a fog.
26	N	30.30	37	S	Pof.	A.M.—And P.M. with fine ſparks.
27	SE	30.45	30	—	Neg	At break of day. Afterwards poſitive, by means of a fog.
28	W	30.43	33	—	Pof.	All day, by a continued fog.
29	NW	30.30	35	S	Pof.	All day. The fog ſtill continues. I have obſerved, during theſe three days and three nights (abating a little time for ſleep, and which I curtailed for ſo noble a purpoſe) a foggy vapour to be conſtantly electrified poſitively. The pith balls diverged from a quarter to three quarters of an inch, except when the fog (which was generally moderate) ſuddenly became thick and dark; then the balls would diverge near two inches; at thoſe times I received the electric fluid into bottles. This fog began ſtrongly negative.
30	S	30.10	38	—	Pof.	Nearly all day. The fog is entirely gone.
1	SE	29.71	38	—	——	Weak ſigns; balls not open.
2	S	29.75	50	—	Pof.	P.M. A moiſt air to-day.
3	S	29.90	39	S	Pof.	All day (I mean 16 hours out of 24), the weather foggy.
4	S	30.10	43	—	——	Weak ſigns; balls not open.
5	SW	30.38	52	—	——	
6	SW	30.40	48	—	——	No ſigns of electricity. The third failure. A very moiſt air.
7	SW	30.49	42	—	Pof.	A.M.—A ſlight fog.
8	SW	30.54	40	S	Pof.	P.M.
9	SW	30.55	34	—	Pof.	A.M.
10	W	30.52	39	—	——	Weak ſigns; balls not open.
11	SW	30.54	42	—	Pof.	A.M.—And P.M. The weather ſerene and fair.
12	SW	30.41	44	—	Pof.	
13	SW	30.30	47	—	——	Weak ſigns.
14	S	29.92	44	—	Neg	A.M. from a little rain.
15	SW	28.95	45	—	——	No ſigns of electricity. The fourth day's failure.
16	SW	29.40	40	S	Pof.	P.M. a ſmall fall of ſnow, by which the rod was ſtrongly electrified.

Days.	Wind.	Barom	Ther.	Sparks	Kind.	December—And January 1790.
		Inch.	°			
17	W	29,15	38	—	——	No signs of electricity. The fifth day's failure.
18	W	30.	50	S.	Pos.	A.M. a fine serene morning.
19	SW	29.58	44	—	Neg	P.M. by small rain. On an increase of rain, the electricity changed to positive.
20	SW	29.72	44	—	——	Weak signs.
21	SW	29.78	45	—	——	No signs of electricity. The sixth day's failure. A very damp air.
22	SW	29.60	56	—	——	No signs. The seventh day's failure. A moist air.
23	W	29.78	49	—	——	Weak signs of electricity.
24	W	29.27	52	S.	Neg	At eight o'clock, A.M. a small shower of rain, which was weakly electrified negatively; as the rain increased, so did the intensity of the electric fluid, and after continuing for two hours, they both disappeared together.
25	SW	29,41	42	S.	Neg	A.M. by a shower of rain. Ten o'clock P.M. a fog strongly electrified positively.
26	W	29.89	46	S.	Pos.	A.M.
27	SW	29.80	46	—	——	Weak signs.
28	W	29.88	47	—	Pos.	P.M. from a very thin fog.
29	SW	29.75	54	—	——	Only weak signs of electricity.
30	SW	29.76	42	—	——	
31	S	29.73	48	—	——	
1	SW	29.90	35	—	Pos.	Both A.M. and P.M
2	S	30.30	36	S.	Pos.	All day.
3	S	29.98	46	—	Pos.	All the day, by means of a fog.
4	W	30.20	43	S.	Pos.	All the day, with bright sparks at several intervals.
5	N.	30.25	45	S.	Pos.	All the day, with fine sparks.
6	SE	30.19	41	—	Pos.	A.M.
7	W	30.40	41	S.	Pos.	A.M. weather dry and foggy.
8	W	30.45	36	S.	Pos.	Nearly all day in charge.
9	E	30.28	36	—	Pos.	A.M. balls open near one inch.
10	SE	30.24	39	—	Pos.	A.M.—And P.M.
11	S	30.11	41	—	Pos.	P.M.
12	W	30.20	45	—	——	Weak signs.
13	SW	30.34	42	—	Pos.	A.M.
14	S	29.95	49	S.	Neg	A.M. by means of a small rain.
15	NW	29.91	43	—	Pos.	A.M.
16	SW	29.95	42	S.	Pos.	A.M. weather very mild and fair.
17	N	30.28	40	—	Pos.	A.M.
18	NE	30.20	39	—	Pos.	A.M. in the afternoon, the same.
19	E	30.13	33	—	Pos.	A.M.
20	SE	30.24	32	S.	Pos.	A.M.
21	E	30.40	31	S.	Pos.	A.M. in the afternoon, the same.
22	W	30.38	35	S.	Pos.	All the day, from a fog. The strength of the electric charge in the rod was much governed by the occasional intensity of the fog; for as one abated in strength so did

Days.	Wind.	Barom	Ther.	Sparks	Kind.	January and February.
		Inch.	°			the other, and the contrary. At ten o'clock P.M. I received bright ſparks at the ball N.
23	W	30.33	40	S.	Poſ.	Seven o'clock A. M. I found the rod electrified, ſufficiently ſtrong to emit viſible ſparks, and often afterwards this day.
24	W	30.16	46	S.	Poſ.	A. M.
25	NE	30.11	42	S.	Neg	There was a moderate ſhower of rain this morning, by which the rod was electrified negatively.
26	W	30. 2	40	—	Poſ.	A. M. balls open from two to ſeven tenths of an inch.
27	W	29.30	42	—	Poſ.	
28	S	29.50	44	S.	Poſ.	A. M.—At noon fell a ſmall rain, which was void of electricity. Near ten o'clock P. M. there was a ſudden ſhower of rain, ſtrongly electrified negatively.
29	W	29.26	40	—	Poſ.	P. M.—A delightful clear fine day, but the atmoſpheric electricity was very weak till night came on.
30	N	29.50	41	—	Poſ.	A. M.—and P. M. negative
31	S	29.68	46	—	Poſ.	Balls open from one to nine tenths of an inch, weather fair and ſerene.
1	N	29.87	40	—	Poſ.	
2	SW	30.10	40	—	Poſ.	
3	W	30.30	44	—	Poſ.	
4	W	30.60	46	—	Poſ.	
5	SW	30.61	43	—	Poſ.	
6	W	30.63	44	—	Poſ.	
7	NW	30.35	39	—	Poſ.	
8	N	30.22	36	—	Poſ.	
9	W	30. 5	40	S.	Poſ.	With viſible ſparks.
10	NE	30. 7	43	—	Poſ.	Serene weather ſtill continues.
11	W	30.20	41	—	Poſ.	
12	W	30.20	45	—	Poſ.	
13	SW	30.34	42	S.	Poſ.	Nearly all the day, with fine bright ſparks.
14	SW	30.15	44	—	Poſ.	Balls open from two to ſix tenths of an inch.
15	W	30.22	40	—	Poſ.	
16	S	29.95	44	—	Poſ.	A. M.—Small rain P. M. which did not occaſion any change in the electric fluid.
17	W	30.20	39	—	Poſ.	Balls open half an inch, weather ſtill ſerene.
18	W	30.42	42	—	Poſ.	
19	S	30.48	45	—	Poſ.	
20	SE	30.42	40	S.	Poſ.	A. M.—A foggy day.
21	SW	30.38	42	—	Poſ.	Balls open from one to nine tenths of an inch, weather ſtill mild.
22	SW	30.43	43	—	Poſ.	
23	S	29.97	46	—	Poſ.	
24	SW	30.15	44	—	Poſ.	
25	S	29.99	51	—	Poſ.	
26	W	29.88	51	—	Poſ.	P. M.—I have often obſerved that impetuous winds leſſen the intenſity of atmoſpheric electricity in clear weather, which

Days.	Wind.	Barom	Ther.	Sparks	Kind.	February and March.
		Inch.	°			has been verified this day; for not the leaſt ſign of electricity could be obtained from the rod till after ſun-ſet, at which time the high weſt wind having ſubſided, a little low vapour ſprung up; I then received the fluid in great plenty, and of the ſame kind that it has continued to be for twenty-ſeven days paſt.
27	W	30.20	42	—	——	Weak ſigns: balls not open.
28	NW	30.22	45	—	——	
1	N	30.32	47	—	Poſ.	A. M.
2	NW	30.49	50	S.	Poſ.	A. M.—With viſible ſparks.
3	N	30.33	49	—	Poſ.	Very mild ſerene weather.
4	NW	30.27	40	—	Poſ.	
5	NE	30.31	43	—	Poſ.	
6	NW	30.47	40	—	Poſ.	
7	NW	30.45	42	—	Poſ.	
8	SW	30.44	42	S.	Poſ.	A. M.—With viſible ſparks. Still no change of kind.
9	SW	39.20	41	—	Poſ.	A. M.
10	SW	29.90	46	—	Poſ.	P. M.—A ſtrong gale of wind has been predominant to day. The atmoſphere is extremely dry; the ſun appeared bright all day. No atmoſpheric electricity could be obtained till near ten o'clock at night. This day, at Halliſax, a fall of ſnow, accompanied with a flaſh of lightning and a clap of thunder.
11	SW	30.20	41	—	Poſ.	A. M.—Still moderate weather.
12	S	30.31	51	—	Poſ.	
13	SW	30.20	41	—	Poſ.	A. M.—From nine o'clock P. M. to eleven there was a moderate ſhower of rain, which was electrified negatively. I have not till this perceived a negative charge in the rod ſince January the 28th.
14	NW	30.50	49	—	Poſ.	A. M.—At Thurſo, in Scotland, hail, lightning, and thunder.
15	N	30.57	51	—	Poſ.	P. M.
16	N	30.60	40	S.	Poſ.	A. M.—With viſible ſparks.
17	NE	30.60	40	—	Poſ.	A. M.—A very dry atmoſphere.
18	NE	30.50	45	—	Poſ.	
19	E	30.55	44	—	Poſ.	
20	E	30.44	43	—	Poſ.	A. M.—There was an hoar froſt upon the graſs this morning.
21	E	30 39	44	—	Poſ.	A. M.
22	E	30.15	42	—	Poſ.	A. M.—Divergency of the pith balls from one to nine tenths of an inch.
23	SW	29.81	46	—	Poſ.	
24	S	29.80	51	—	Poſ.	
25	NW	30.	46	—	Poſ.	
26	E	30. 4	48	—	Poſ	

Days	Wind	Barom	Ther.	Sparks	Kind.	March and April.
		Inch.	°			
27	E	30.	46	—	Neg	A. M.—From a ſmall ſhower of rain. P. M. the electricity was poſitive.
28	NE	29.98	44	—	Poſ.	P. M.
29	N	30.	48	—	Poſ.	P. M.—The air a little foggy.
30	E	29.95	44	—	Poſ.	A. M.—Not a beam of ſun has appeared this day.
31	E	29.93	47	—	Poſ.	A. M.—Balls half an inch open.
1	E	30. 5	45	—	Poſ.	A. M.
2	E	30.20	41	S	Poſ.	A. M.—With viſible ſparks.
3	E	30.25	40	—	Poſ.	Balls open from one to ſeven tenths of an inch.
4	E	30.19	40	—	Poſ.	
5	NE	30.23	47	—	Poſ.	
6	E	29.95	36	—	Poſ.	
7	E	29.75	45	—	——	Weak ſigns of electricity. This very weak ſtate of atmoſpheric electricity has not happened ſince the 31ſt of December. There has been for many days a ſtrong eaſterly dry wind, which ſeems hitherto nearly void of the electric fluid.
8	E	29.75	52	—	——	
9	E	29.57	66	S.	Neg	P. M.—From a fine ſhower of rain.
10	E	29.50	40	S.	Neg	A. M.—The rain continues, ſo does its negative ſtate of electricity.
11	E	29.36	35	S.	Poſ.	A. M.—From a little fall of ſnow. P. M. ſome ſnow mixed with rain, on which the rod became charged much more ſtrongly poſitive. The rod has been charged full four hours to-day.
12	E	29.35	39	—	——	Weak ſigns; balls not open.
13	E	29.70	38	S.	Neg	A. M.—A moderate rain, but ſtrongly electrified, and continued ſo full two hours. There were two gradual changes of electricity.
14	NE	29.81	41	—	Neg	A. M.—But after ſun-ſet the rod was electrified poſitively.
15	E	29.68	35	S.	Neg	Six o'clock A. M. a little rain fell. Half after eight o'clock, a great fall of ſnow; the rod now became ſtrongly electrified poſitively. Denſe ſparks were now received at the ball N; half after nine o'clock, the electricity changed to negative. I caught ſome of the ſnow in the apparatus mentioned the 20th of July in this journal, and I found it weakly electrified.
16	NE	29.85	41	—	Poſ	Divergency of the pith balls were from a tenth to ſeven tenths of an inch. Fine ſerene weather.
17	N	29.98	42	—	Poſ.	
18	NE	29.80	40	—	Poſ.	
19	NE	29.69	41	—	Poſ.	
20	SE	30.26	45	—	Poſ.	
21	S	30.23	47	—	Poſ.	
22	S	29.94	51	—	Poſ.	

Days.	Wind.	Barom	Ther.	Sparks	Kind.	April and May.
		Inch.	°			
23	SW	29.70	55	—	Pos.	A. M.
24	W	29.55	52	—	Pos.	A. M.—And P. M. negative from small rain.
25	SW	29.60	51	S	Pos.	Half past nine o'clock A. M. A distinct black cloud approached the rod, and some heavy drops of rain fell; the electricity of the rod then changed to negative. About half past three o'clock P. M. a very low cloud passed over the rod, and rained a little, by which the rod became strongly electrified positively.
26	NE	29.85	58	S	Pos.	A. M. Five o'clock P. M. fell some rain by which the rod was charged negatively.
27	N	29.98	47	—	Pos.	The divergency of the balls from two to six tenths of an inch. Serene fine weather.
28	W	29.80	50	—	Pos.	
29	SW	29.69	51	—	Pos.	
30	S	29.58	53	—	Pos.	
1	E	29.75	50	S	Pos.	Nine o'clock A. M. a shower of rain; the electricity now became negative. The rod has been electrified to-day from six o'clock A. M. to ten o'clock P. M. and I suppose continued so all night.
2	N	30.22	41	—	Pos.	Divergency of the pith balls from three to seven tenths of an inch.
3	NE	29.85	49	—	Pos.	
4	SE	29.63	51	S	Pos.	A. M.
5	S	29.73	52	S	Pos.	Six o'clock, A. M. Eight o'clock it rained, the electricity now became strongly negative, with fine sparks at the ball N. This shower having ceased, another soon followed, which electrified the rod positively. The rod was charged 7 hours to-day.
6	SW	29.75	50	S	Neg	Every appearance at the rod to-day was nearly as during the preceding day.
7	W	30.10	56	—	Pos.	Balls open from one to five-tenths of an inch. Such weak signs of electricity, as have been observed for these two days are the usual effects of a very strong and dry westerly wind; and in general let a strong dry wind blow from what point of the compass it may, it is attended with only weak signs of electricity.
8	W	29.84	50	—	Pos.	

The above-mentioned eighth day of May completes this Journal of one whole year, which I give to the curious in Atmospheric Electricity as a faithful narrative of facts, having never once deputed another person to make observations for me.

JOHN READ.

A Monthly Account of Electrical Sparks, and of Positive and Negative Electricity, as indicated by the Pith-ball Electrometer, and sometimes by only Flaxen Threads without Balls to them.

	Times	Times	Number of days in each month in which Sparks were perceived. Days.
23 days May, 1789 / 8 days May, 1790	Pos. 17	Neg. 18	9
June	Pos. 32	Neg. 36	12
July	Pos. 13	Neg. 22	12
August	Pos. 19	Neg. 19	9
September	Pos. 9	Neg. 23	7
October	Pos. 17	Neg. 7	7
November	Pos. 12	Neg. 8	8
December	Pos. 12	Neg. 6	7
January	Pos. 26	Neg. 4	13
February	Pos. 26	Neg. 0	3
March	Pos. 30	Neg. 1	3
April	Pos. 28	Neg. 12	8
	241	156	98

It appears from this Journal, that there were only *seven* days throughout the year in which no signs of electricity were perceived; *viz.* the 15th and 23d of November, and the 6th, 15th, 17th, 21st, and 22d of December.

Remarks on the Phænomena exhibited by the Rod on the 31st of August.

I was for a long time extremely puzzled to account for the rapid changes which the pith-balls on some days so frequently exhibited; being positive one minute, then negative

gative for another, and the next returning again to poſitive. From often conſidering this apparently whimſical changeableneſs in nature, I was at length induced to ſuſpect, what indeed was afterwards confirmed by actual experiment, *viz.* that ſome of theſe changes are only apparent, and not real, they being occaſioned not by the actual communication of a different ſort of electricity, but merely by the action of electrical atmoſpheres; thus, when an electrified cloud comes within a certain diſtance of the rod, and before it comes near enough to impart to it ſome of its own electricity, the electrical atmoſphere of the former, agreeably to the well known laws of electricity, will diſturb the electric fluid naturally belonging to the rod, and will conſequently occaſion ſeveral apparent changes in the electrometer; which changes an unexperienced obſerver would attribute entirely to the change of electricity in the clouds.

This obſervation was evidently confirmed by the phænomena obſerved on the 31ſt of Auguſt; and thence it appears, that the real number of changes from poſitive to negative, or from negative to poſitive electricity, cannot be ſo great as it is ſhewn by the electrometer affixed to the rod.

I beg leave to add, that I have not the leaſt doubt but that every cloud is in an electric ſtate, at all times, and in all the ſeaſons of a year; and that the electricity of the clouds is the principal cauſe of their ſuſpenſion in the atmoſphere. For however varied in kind their corpuſcles may happen to be, of which the clouds conſiſt, yet, every particle

particle of thoſe aerial meteors will attract and abſorb electricity, and the electricity having no weight of its own, muſt by its well known repulſive force tend to ſupport and keep up their rare ſtate. When a cloud approaches my high pointed rod, which cloud we will ſuppoſe is electrified poſitively, the upper end of the rod will become electrified negatively and the lower end poſitively, by its own electricity, as before obſerved; and when the main force of the cloud has paſſed the zenith, a change of kind will take place, for the electric ſigns in the rod will now be the reverſe of thoſe on its approach to it; ſo that if ten ſuch clouds ſhould paſs over the rod in the ſpace of one day, the pith-balls affixed to it would indicate ten changes of the electricity, notwithſtanding the electric ſtate of the ten clouds was invariably of one kind. It is ſcarcely needful to obſerve, that if the ten clouds had been electrified negatively, the ſame number of apparent changes would have happened.

I cannot help lamenting with Signor BECCARIA, that there are ſo few high pointed rods erected to aſcertain the electrical ſtate of the earth and atmoſphere at all times; but more particularly during thunder ſtorms. If there had been pointed rods, for inſtance, at Whitehaven and Lancaſter on the 6th of October, and well attended to at the time of the ſtorm of lightning and thunder, which happened at both places nearly at the ſame time, it would then have been known, whether the apparatus might not be poſitive at one place when it is negative at the other.

The

The Second Year's Journal, continued from the end of the First. Read before the Royal Society, April 26, 1792.

Days.	Wind.	Barom	Ther.	Sparks	Kind.	May, 1790.
		Inch.	°			
9	N	29.14	67	S.	Pos.	A clear fine morning. One o'clock P. M. a sudden shower of rain fell; the pith balls O, connected with the lower end of the rod, were now charged negatively, and increased in strength as the rain came on; in a short time the electricity changed to positive. Five o'clock, the electricity changed again to negative, I then heard some distant rumbling of thunder. This day there was some lightning at Hertford.
10	NE	29.18	66	—	Neg	A. M. sky very cloudy; and some small rain falls.
11	E	30. 5	64	—	Pos.	Strong gales of wind; and a weak electricity.
12	E	29.14	70	—	Pos.	
13	E	29. 6	72	—	Pos.	
14	NE	30. 9	72	—	Pos.	
15	N	29. 5	65	—	Pos.	A. M. weather serene.
16	NE	29. 2	57	—	Pos.	A. M. a clear sky. Some lightning at Bishop-Stortford.
17	S	29. 8	58	S.	Pos.	Half after nine o'clock A. M. fell a little rain; as it increased so did the electric charge in the rod, insomuch that it streamed forth from the brass ball N for a short time.
18	SW	29.90	59	S.	Pos.	Six o'clock A. M.—One o'clock P. M. a low black sky; by which the charge in the rod became negative, with sparks; after continuing so one hour, the electricity changed again to positive. The rod has been in charge 16 hours this day; how much more I cannot say.
19	S	29.20	65	S.	Neg	A. M.—At four o'clock P. M. fell a mild rain, void of the electric fluid*. At five o'clock the rain fell more copiously, and it was strongly charged with negative electricity.
20	S	29.14	64	S.	Neg	Early this morning I found the humidity of the air electrified negatively. At ten o'clock the electricity became more intense, so as

*My meaning is "void" of electric signs by such means as were then employed to obtain it; for rain is never totally void of electricity.

Days.	Wind.	Barom	Ther.	Sparks	Kind.	May.
		Inch.	°			
						to emit ſmall ſparks: in half an hour's time there were four beautiful gradual changes of electricity. Afterwards the rod remained negative two hours. Three o'clock P. M. the electricity changed, and continued near three hours poſitive. After this a low black cloud paſſed over the rod, and let fall a few drops of rain mixed with hail; the rod was now highly charged poſitively, and the bell rang briſkly, but ſoon ſtopped, while the electricity changed to a ſtrong negative; then it rang again for about ten minutes, after which all ſigns of electricity ceaſed in the rod. Afterwards the rod became rather ſtrongly charged for the ſpace of two hours, and changed once in that time. During this high charge of the rod, the bell, (which is connected by metal with the moiſt ground) was in a contrary ſtate of electricity to that of the inſulated part of the apparatus; and alſo the air in the room, the window-ſhutter neareſt the bell, and even the bricks in the wall, were all electrified ſufficiently to indicate the kind.
21	SW	29.98	58	S	Poſ.	A. M. by the night bottle, which had been charged while I ſlept. Four o'clock P. M. a low cloud approached the rod, and dropped a little rain, by which it became electrified ſtrongly negative. This electrification of the rod laſted near four hours, and changed three times in kind.
22	E	29.10	56	—	Poſ.	A. M.—One o'clock P. M. wind S, a ſmall rain fell, and the air being very moiſt, has leſſened conſiderably the inſulation of the rod.
23	S	29.90	56	—	Poſ.	The air is dry to-day, but the clouds are very high.
24	NE	29.10	69	S	Neg	Six o'clock A. M. Nine o'clock ſome rain fell, which increaſed the negative charge in the rod. The rain now falls more copiouſly, and the balls cloſe and open gradually with poſitive electricity, which was rather ſtrong for a ſhort time. The balls again gradually cloſe and open, without change of kind. The rod has been electrified near 14 hours this day. In the morning of to-day, at Lewes in Suſſex, much lightning and thunder.
25	NE	29. 4	70	—	Neg	A. M. A moiſt air, and wet morning.
26	E	29.95	62	S	Poſ.	A dark cloudy morning. Three o'clock P. M. on the approach of a heavy dark

Days.	Wind.	Barom	Ther°	Sparks	Kind.	May and June.
		Inch.				cloud, a few drops of rain fell, by which the rod became electrified positively; the pith balls soon opened full four inches, and by and by the bell began to ring slowly. Two gentlemen fortunately being present, and much delighted with the sight, by my desire joined hands with me to make the circuit between the bell and brass ball N, and on taking a spark at the brass ball, we all received a smart shock through our arms and breasts. The wind is now S. with a heavy fall of rain; and the bell (as usual) ceases to ring while the electricity changed to negative; then rings again briskly. The electricity gradually changed twice after this, and ended negative. These several phænomena took up the space of one hour.
27	N	29.98	69	—	Neg	A. M. with small rain. In the afternoon positive. Near midnight London was visited by vivid darts of lightning, and repeated claps of thunder, extremely awful and terrific at that time of night. I was in bed, and awaked out of sleep by it.
28	NE	30.	61	S.	Neg	By the night bottle. A heavy thick air. Seven o'clock P. M. positive with small sparks. Nine o'clock, fell a heavy shower of rain; its electricity was negative.
29	SE	30.	69	—	Pos.	A. M.—and P. M.
30	SW	30· 6	63	S.	Pos.	At seven o'clock A. M. the weather showery and the electricity rather strong, but often changing in kind. Seven o'clock P. M. one uniform black cloud darkens the air (yet the sun shines in the west;) by and by a heavy rain fell, by which the rod became very strongly electrified positively, and the bell rings briskly, and the pith balls are agitated with sudden jerks; the rain soon abated, and its electricity became negative. These operations of nature lasted only 34 minutes; during that time, the electricity was four times positive, and five times negative; and these several changes were all gradual.
31	N	30.	58	S.	Neg	The weather, and the electricity of the atmosphere have been this day nearly the same as on the preceding one.
1	S	30.12	58	—	Pos.	Serene fine weather, these five days.
2	N	30.16	69	—	Pos.	
3	SW	30.12	66	—	Pos.	
4	N	30. 8	61	—	Pos.	
5	N	30.18	58	—	Pos.	

Days	Wind	Barom	Ther.	Sparks	Kind.	June.
		Inch.	°			
6	N	30.16	62	—	Pos.	A. M. Two o'clock P. M. the sky still clear; yet the electricity of the rod became negative, and continued so two hours. During this time, the rod was only electrified with its own electricity, or what has been termed influentially electrified; for I found by trying both extremities of the rod, that they were in contrary states of electricity.
7	W	30.	62	—	Pos.	A. M. A warm moist air.
8	SW	29.91	66	—	Pos.	A. M. Some mizzling rain.
9	S	29.65	64	—	Pos.	A. M.
10	SW	26.60	65	S.	Pos.	A cloudy morning. Half after one o'clock P. M. the electric charge in the rod became negative. In a short time after, some rain fell, and the electricity again became positive, and very strong; the bell now rang slowly, and soon stopped; the pith balls closed and opened negative, and continued so a full hour: the balls exhibited one sudden jerk during that time. This latter charge of the rod lasted two hours. During the passage of a cloud over the rod, in the morning of to-day, I found it influentially electrified.
11	N	29.90	65	—	Pos.	The weather serene and clear. The electricity varying between null and the balls seven-tenths of an inch open.
12	N	30.	59	—	Pos.	
13	NE	30.29	60	—	Pos.	
14	NE	30.30	64	—	Pos.	
15	NE	30.30	69	—	Pos.	
16	N	30.23	54	—	Pos.	
17	E	30.10	61	S.	Neg	After a course of clear serene weather, this day has been dark, and hazy. Nine o'clock P. M. wind S, a prodigious large cloud approached the rod, and a little rain fell, yet there were no signs of electricity in the rod. In a few minutes after this, I was surprised by hearing the bell ring; I ran to the apparatus, and found it highly charged negatively. When the main bulk of the cloud arrived over the rod, its electricity changed to a strong positive; and in a quarter of an hour, the rain and electricity all ceased together. This day, in the evening, at Wolverhampton, fell a heavy rain, accompanied with lightning and thunder.
18	NW	29.91	63	—	Pos.	A. M.—and P. M.
19	S	30.	68	—	Neg	A dark cloudy morning. The electricity positive at five o'clock P. M.
20	SW	30.21	74	—	Pos	Weather very hot, and a weak electricity, these two days.
21	SW	30.35	76	—	Pos.	

Days.	Wind.	Barom	Ther.	Sparks	Kind.	June.
		Inch.	°			
22	E	30.20	79	—	Pos.	A. M. Serene hot weather. Near sun-set the wind W, where heavy black clouds were forming, their upper border about 25 degrees above the horizon. The lightning flashed among these western clouds from nine to eleven o'clock. But there being neither clouds nor low vapour near the rod, it was not affected thereby. In the evening of this day at Salisbury, fell a very severe storm of hail, rain, lightning, and thunder.
23	SW	30.	78	—	Pos.	A. M.
24	W	30.	68	—	Pos.	A. M.—The sky has been overcast all day, and two or three times fell a little rain, driven by a strong wind, which afforded a weak electricity.
25	W	29.90	68	S.	Pos.	At six o'clock A. M. Near eleven o'clock a shower of rain fell, strongly negative. At the same time, in a LOWER STRATUM of air, the hand exploring rod was electrified POSITIVELY. Abundance of small white clouds passed over the rod, which kept the pith balls continually closing and opening, with negative electricity. Eight o'clock P. M. some heavy drops of rain fell; the rod now became very strongly electrified; the bell rang slowly, and soon stopped, while the electricity changed to a strong positive, then rang again more briskly and for a longer time. After this there were two more gradual changes of electricity.
26	NW	29.90	63	S.	Pos.	The weather, and atmospheric electricity, have been this day nearly the same as on the preceding one; only the operations in the rod have been more powerful. For during one charge of the rod to-day, I counted about forty dense sparks, which spontaneously struck between the bell and brass ball N in quick succession. These sparks were about two inches long.
27	N	29.96	61	S.	Pos.	A. M. Four o'clock P. M. I saw heavy clouds forming; and as they came nearer and nearer, the rod became more powerfully electrified with negative electricity. It now began to rain, by which the rod became intensely electrified indeed; many dense sparks now struck through the air, between the bell and brass ball N, with a loud report for so small an opening of two inches only. There were six changes of electricity in two hours.

Days.	Wind.	Barom	Ther.	Sparks	Kind.	June and July.
		Inch.	°			
28	W	30. 5	67	—	Pos.	Mild foggy weather; and the fog moderately electrified.
29	N	30.	70	—	Pos.	
30	SW	30.	67	—	Pos.	
1	W	29.83	66	S.	Pos.	A. M.—Negative P. M. with small sparks.
2	W	29.77	63	S.	Pos.	A. M. Half after twelve o'clock P. M. a sudden gust of wind sprung up, followed by a shower of rain, which electrified the rod positively, sufficient to emit small sparks; which soon afterwards became negative. Near four o'clock P. M. a very large black cloud passed over the rod, and let fall a little rain mixed with hail, by which the rod became highly electrified negatively: the bell now rang briskly, untill a flash of lightning and instant crack of thunder happened, which occasioned a sudden change in the electricity to positive: then the bell struck up again as brisk as before. The rod has been charged ten hours without intermission this day.
3	NW	29.72	70	—	Pos.	A. M. A cloudy atmosphere, but fair.
4	SW	29.66	69	—	Pos.	A. M. Dull heavy weather.
5	SW	29.40	64	S.	Neg	This day has been showery and sunshine by turns. The rod has been rather strongly electrified, and there have been four gradual changes of electricity. One charge lasted full five hours, and the bell rang briskly.
6	N	29.70	65	—	Neg	Strong gales of wind with rain, and a weak electricity these two days.
7	N	30.10	63	—	Neg	
8	SW	30.	63	—	Pos.	A. M.
9	SW	29.86	67	—	Neg	A. M. A thick moist air.
10	SW	29.90	61	S.	Pos.	A. M. Near five o'clock P. M. there was a fine shower of rain, by which the rod first became electrified negatively, and afterwards positively, with sparks. These two charges lasted five hours.
11	NW	29.60	61	S.	Neg	Half after ten o'clock A. M. large dark clouds frequently passed over the rod, by which it became electrified negatively. When they passed somewhat nearer, and dismissed some large drops of rain, the rod then became highly charged, and the bell rang briskly, and continued its ringing near half an hour. The pith balls were very much agitated, sometimes with a pendulous motion, then started closer or wider asunder several times. But the most extraordinary phænomenon of to-day is, that the rod continued ten hours electrified negatively, with-

Days.	Wind.	Barom. Inch.	Ther. °	Sparks	Kind.	July and August.
						out change of kind: during that time the pith balls never closed.
12	N	29.70	63	S.	Neg	The operations in the rod to-day and yesterday, when compared, appear to have but little resemblance. This day the electricity has changed four times, and the bell rang briskly for a minute or two between each change of electricity.
13	W	29.62	64	S	Pos.	Two o'clock P. M. the wind S. A sudden shower of rain fell, by which the rod became electrified positively, but soon changed to negative. The bell now rang weakly one minute, and then stopped while the electricity changed to positive, which soon changed again to negative. The electricity and the weather have been much varied to-day. At New-Mills, in Scotland, some lightning and thunder.
14	NW	29.57	57	S.	Neg	The weather this day has been rather more varied than yesterday, with a continued succession of showers and sunshine: and the atmospheric electricity has been considerably more intense, and constant. There have been five gradual changes of electricity; between four of those changes, the bell rang briskly. The pith balls also exhibited some of their curious agitations; one jerk in particular was so very quick and powerful, that the balls were near striking each other. In a few minutes after this, I heard distant thunder. At Burwash, in Sussex, this day a tempest of rain, lightning, and thunder.
15	NW	29.78	60	—	Pos.	The weather these 19 days has been generally moderate; and the electricity of the atmosphere has been only what is common for serene weather, at no time sufficiently strong to afford visible sparks.
16	NW	29.95	63	—	Pos.	
17	SW	30.13	69	—	Pos.	
18	W	30.10	66	—	Pos.	
19	SW	30. 5	65	—	Pos.	
20	SW	29.75	66	—	Pos.	
21	W	29.78	63	—	Pos.	
22	NW	30. 5	61	—	Pos.	
23	SW	30.	64	—	Pos.	
24	W	30.	66	—	Pos.	
25	SW	30.12	69	—	Pos.	
26	SW	30.15	66	—	Pos.	
27	W	30.11	67	—	Pos.	
28	S	30.10	63	—	Pos.	
29	N	29.65	57	—	Pos.	
30	NW	29.65	60	—	Pos.	
31	SW	29.55	63	—	Pos.	
1	NW	29.92	59	—	Pos.	
2	SW	29.95	61	S.	Pos.	

Days.	Wind.	Barom.	Ther.	Sparks	Kind.	August.
		Inch.	°			
3	SW	29.7 7	63	S	Pos.	A heavy cloudy morning, but fair. Half after one o'clock A. M. a smart shower of rain fell, by which the rod became highly charged with negative electricity; when the cloud was fully over the rod, the electricity changed to positive; and when it had passed the zenith, the electricity changed again to negative.
4	NW	29.83	62	—	Pos.	Serene weather, and a weak electricity, these four days.
5	SW	30.	67	—	Pos.	
6	SW	29.93	67	—	Pos.	
7	SW	30.	72	—	Pos.	
8	W	29.92	67	—	Pos.	A heavy cloudy morning, but fair. The electricity of the atmosphere has been so weak to-day, that none could be obtained till after sun-set.
9	W	30.	63	—	Pos.	A. M.
10	SW	30. 5	63	—	Pos.	Serene weather: the pith balls varying between null and three-quarters of an inch open.
11	W	30.10	66	—	Pos.	
12	SW	30.10	72	—	Pos.	
13	SW	30. 5	69	—	Pos.	
14	N	30.10	64	—	Pos.	
15	S	30. 3	72	—	Pos.	
16	S W	29.90	73	—	Pos.	There have been several small showers of rain this day, some of them not sensibly electrified, others were weakly positive, but which I could not distinguish from the common electricity of serene weather, which has prevailed a long time.
17	W	30.	66	—	Pos.	Serene weather; divergency of the pith balls from one to seven-tenths of an inch.
18	N	30.10	66	—	Pos.	
19	SW	30. 1	66	—	Pos.	
20	NW	30. 4	76	—	Pos.	
21	S	29.75	77	S	Pos.	A. M. Five o'clock P. M. fell some large drops of rain, by which the rod was highly charged positively; the bell rang briskly about five minutes, then stopped, and the electricity of the rod became negative. The rain now ceased, the sky cleared up and the electric charge in the rod decreased considerably, and ended as it begun, positive.
22	W	34. 4	62	—	Pos.	Dark cloudy weather, and a very moist air, attended with a weak electricity.
23	SW	29.95	67	—	Neg	
24	W	30.	63	—	Pos.	
25	SW	29.36	62	—	Pos.	
26	N	22.70	64	—	Pos.	
27	N	29.83	62	S	Pos.	This day has been very showery, yet only one shower was strongly electrified.

Days.	Wind	Barom.	Ther.	Sparks	Kind.	August and Sept. 1790.
		Inch.	°			
28	W	29.95	59	—	Pos.	Serene weather, and a constant electricity these five days.
29	NW	30.	60	—	Pos.	
30	W	30.12	62	—	Pos.	
31	SW	30.10	66	—	Pos.	
1	W	29.95	67	—	Pos.	
2	SW	29.80	62	S.	Pos.	A. M. In the afternoon, there was a thick dark sky, with small rain, and a strong wind. On an increase of rain, the electricity became negative, with small sparks. When the rain abated, the electricity changed to positive, and continued so.
3	W	29.50	58	S.	Pos.	A. M. Near one o'clock P. M. the electric charge in the rod was negative. I then saw thunder-clouds forming in the south, and in the north. Some large drops of rain now fell, by which the charge in the rod became very strong; the bell now rings faintly, and the pith balls exhibit their waving motion, and sometimes sudden jerks. The distinct thunder-cloud, which was in the north, is now gone by the west into the south, during which the charge in the rod became weaker and weaker, until it ended as it began, negative. This electric charge of the rod continued near one hour and a half.
4	W	29.65	58	S.	Pos.	A. M. One o'clock, P. M. wind NW. Thin white clouds have been passing over the rod; but a distinct black one is now approaching, and some rain falls, mixed with hail; the rod is now highly charged with positive electricity; the bell rings loud, and a long time; and, as the shower abated, so did the strength of the electric charge abate in the rod. This charge lasted near three hours, without change of kind.
5	NW	29.70	55	S.	Pos.	A quarter before three o'clock P. M. some rain fell, by which the rod became moderately charged positively, but soon changed to a weaker negative. There were two more gradual changes of electricity within the space of one hour.
6	N	30.	58	S.	Neg	Three o'clock P. M. a large dark cloud passed over the rod with drizzling rain; its electricity was negative; the bell rang weakly. The electric charge from this cloud began, continued, and ended, negative.
7	N	30.10	51	S.	Pos.	A. M. by the night bottle. Two o'clock P. M. a dark cloud, with drizzling rain,

Days.	Wind.	Barom	Ther.	Sparks	Kind.	September.
		Inch.	°			passed over the rod, by which it was electrified positively, with sparks; and ended negative.
8	N	30. 5	57	—	Pos.	Moderate fine weather, and a weak electricity, these seven days.
9	SW	30. 8	62	—	Pos.	
10	NW	30.	58	—	Pos.	
11	SW	30. 1	51	—	Pos.	
12	SW	30.10	62	—	Pos.	
13	W	30.	61	—	Pos.	
14	S	29.84	62	—	Pos.	
15	SW	29.80	66	S.	Pos.	The rod has been electrified positively nearly all this day. At five o'clock P. M. an awful darkness covered the heavens, until near six o'clock, succeeded by a drizzling rain, from which I could not obtain (in my common way) any electric fluid: but when the dark cloud became broken, and no rain fell, I then obtained visible sparks at the ball N, which continued until I went to bed; and seemed to indicate that it would remain so all night, as the night was perfectly serene, and clear moonlight.
16	W	30.	55	S.	Pos.	Five o'clock this morning, I found the rod charged positive, but not quite so strong as when I left it last night; and it gradually went off by nine o'clock, and returned again into the rod at near four o'clock P. M. from which time the electric fluid gradually increased with the cool of the evening, until visible sparks appeared at the brass ball N. In this state of intensity I left it at near eleven o'clock.
17	W	30.28	50	S.	Pos.	This morning, a little after five o'clock, I found the rod rather stronger charged with the same kind of electricity than when I left it last night; and I have no doubt but it has been electrified all night. The pith balls have never closed this day: their divergency has been between half an inch and two inches open. Weather serene.
18	SW	30.10	54	S.	Pos.	Five o'clock A. M. I found the rod electrified positively, and nearly of the same intensity it was in when I left it last night; that is to say, capable of emitting small sparks. The atmosphere this morning is perfectly serene. There is a dew, or low fog, about five or six feet high, spread over the ground in Hyde-park, very beautiful to look upon from an upper window. For the space of two hours, this vapour gradually increased, and as-

Days.	Wind.	Barom	Ther.	Sparks	Kind.	September.
		Inch.	°			cended higher and higher, until it quite intercepted the trees from my sight, and became a pale wet fog; which very much injured the insulation of the rod: for during its increase in height, the electricity of the rod decreased, insomuch, that I had almost concluded that the pith balls touched each other. But during this short suspense the sun rose higher, and diminished the fog very fast; and the electricity in the rod soon increased to its former strength; and so continued all day.
19	S	29.85	63	S.	Pos.	Five o'clock, A. M. I found the rod electrified positively, but rather weaker than when I left it last night. The weather this day has been nearly the same with that of the preceding one; only the fog began later, and continued longer. The rod has been electrified all this day.
20	W	29.70	57	S.	Pos.	Near six o'clock, A. M. I found the rod electrified, but very weak, barely sufficient to indicate the kind, and it remained so till near three o'clock P. M. The pith balls now closed (which I suppose has not happened before during the space of 92 hours) and opened negative. A heavy cloud from the NNW now approaches the rod, and a little rain falls, by which the rod is highly electrified negatively, and the bell rings briskly; the pith balls diverge to their utmost limit, and exhibit their waving pendulous motion; these operations took up about one hour. The rod continued electrified negatively in a less degree the rest of the day.
21	NW	29.90	58	—	Neg	By the night bottle. The electricity in the rod barely sensible.
22	W	30.20	52	S.	Pos.	The pith balls have not closed this day. The weather serene.
23	S	29.95	52	S.	Pos.	This morning, a quarter before six o'clock, I found the electric charge in the rod much weaker than when I left it last night; which I afterwards found had been occasioned by a spider fixing its web from the rod to the wall of the house; for when the web was removed, the intensity of the electrical charge was soon increased.
24	N	30.30	58	—	Pos.	} Dark cloudy weather, and a strong wind
25	NW	30.30	58	—	Pos.	} these two days.

Days.	Wind.	Barom.	Ther.	Sparks	Kind.	September and October.
		Inch.	°			
26	NW	30.38	55	S.	Pos.	Between six and seven o'clock this morning, I found the pith balls quite closed; nor would they even stick to my finger when I touched them. At this instant there was a visible dewy vapour spread over the ground in Hyde-park: I examined it with my hand exploring rod, and quickly charged an electrometer sufficient to ascertain the kind, which was positive. I now suspected my daily enemies the spiders; I therefore went upon the roof of the house with my long broom in my hand, and gently swept the rod down; on examining the broom, I found a spider's web entangled in the feathers. I then went down to the apparatus, and found the pith balls a quarter of an inch open positive, which gradually increased, even to visible sparks.
27	SW	30.35	57	S.	Pos.	Six o'clock, A. M. I found the electric charge in the rod much weaker than when I left it last night. Nevertheless, when the sun got up a little above the horizon, the rod became stronger electrified. The pith balls never closed this day.
28	SE	30.12	48	S.	Pos.	The operations of the rod to-day have been nearly the same with the preceding one.
29	N	30.12	55	S.	Pos.	This morning, a little before six o'clock, I found the pith balls closed. Atmospheric electricity has been more variable during a large part of this day than for many; sometimes quite null, then weak, or strong by turns, until three o'clock P. M. when it again became constant during the remainder of the day.
30	NE	30.25	58	S.	Pos.	Six o'clock, A. M. I found the pith balls open full three quarters of an inch positive, and they continued open all day. Their least divergency (as usual) about mid-day. The weather still thick and dark in the forenoon; and clear serene weather in the afternoon.
1	E	30. 5	52	S.	Pos.	Six o'clock, A. M. I found the pith balls opened near one inch and a quarter; and they never closed this day. Their least divergency, as usual, was about mid-day, and their greatest was near midnight. Weather serene.
2	E	29.84	56	S.	Pos.	Six o'clock, A. M. I found the pith balls nearly closed, and the state of the air moist and foggy. Half after seven o'clock, the

Days.	Wind.	Barom.	Ther.	Sparks.	Kind.	October.
		Inch.	°			balls opened a little wider, and continued to increase in strength, so that between eleven and twelve o'clock, their divergency was full three inches. I saw nothing in particular to occasion it; and I thought it was above the intensity of common serene weather. I saw indeed a dark cloud, but it was at a very great height. However, this electric charge continued in the rod until seven o'clock P. M. when a shower of rain fell, and the pith balls now closed, and opened negative: a fact that had not happened for eight days. After the rain had ceased, the electricity again became positive.
3	SE	29.80	63	—	Pos.	A wet morning, the air moist, and a weak electricity.
4	NE	29.90	56	S.	Pos.	A very moist air. Half after ten o'clock, fell a very heavy rain, which continued three hours. Its electricity was positive, but not strong.
5	SW	30. 2	58	S.	Pos.	A foggy damp morning. The rod has been electrified nearly all day.
6	S	29.85	60	S.	Neg	A heavy cloudy morning. Two o'clock P. M. the clouds float in the air lower than in the morning; and the rod is electrified negatively. Four o'clock, a heavy black cloud passed the rod, by which it was strongly electrified, but still negative, and continued so a full hour. During this time there were several sudden jerks exhibited by the pith balls. Near sun-set, the balls closed, and opened positive, and remained so. In the east part of Kent, some lightning and thunder this day.
7	S	29.85	61	—	Pos.	A. M. the weather mild and fair.
8	N	29.85	54	S.	Neg	By the night bottle:—by the rod positive.
9	N	29.90	52	—	Pos.	A. M. Perfectly fine weather.
10	W	30. 4	42	—	Pos.	The electricity constant this day.
11	SW	30. 8	39	S.	Pos.	The rod electrified all this day.
12	SW	29.86	56	S.	Pos.	A little after six o'clock, A. M. I found the rod electrified, but rather weaker than when I left it last night. The weather cloudy, with a thick moist air. One o'clock P. M. fell a sudden shower of rain; the electricity now changed to negative, with small sparks.
13	W	29.75	50	S.	Pos.	A little after six o'clock A. M. I found the rod electrified positively. A warm mizzling rain and moist air. Ten o'clock P. M. balls open two inches.

Days.	Wind.	Barom	Ther.	Sparks	Kind.	October.
		Inch.	°			
14	W	29.80	61	—	Pos.	Six o'clock A. M. balls open half an inch positive.
15	W	30.	59	S.	Pos.	A. M. Fair weather, and strong gales of wind.
16	W	30.34	43	S.	Pos.	Six o'clock A. M. balls three-tenths of an inch open. The pith balls have not been unelectrified this day.
17	S	30.15	55	S.	Pos.	During a continuance of moderate weather, I have frequently observed that the atmospherical electricity has periods of increase and decrease of quantity, which are tolerably regular; I shall therefore be accurate in my account of this day's variation, as it may serve for an example of reference to many other days when similar appearances took place. When I left the rod last night, the pith balls were one inch open, positive. Six o'clock this morning, I found them three-tenths of an inch open, positive, and soon after this I perceived them to open wider and wider, so that a little before nine o'clock, the pith balls were stationary at near two inches open. But as the sun advanced towards the meridian, the electric charge in the rod decreased; and it was only possessed of various degrees of a weak intensity until four o'clock P. M.: the pith balls were then only two-tenths of an inch open. Half an hour after four o'clock, they began to increase their divergency, which gradually held on till a little after seven o'clock, when they again became stationary at full two inches open; a little after eight o'clock, they began to decrease; nine o'clock, they were one inch and a quarter open; near eleven o'clock, I left them at a bare inch open.
18	SW	29.90	62	S.	Pos.	Six o'clock, pith balls two-tenths of an inch open, positive. A dark cloudy morning. One o'clock P. M. some rain fell, yet the electric charge in the rod was positive. Near three o'clock, the fall of rain suddenly increased, so did the electric charge in the rod; and at the same time changed to negative, with sparks; and after this ended positive.
19	W	30.15	39	S.	Pos.	The rod has not been unelectrified this day: and the facts and appearances have been nearly like those of the 17th instant.

Days.	Wind.	Barom	Ther.	Sparks	Kind.	October and November.
		Inch.	°			
20	E	30. 5	46	S.	Pos.	The operations of the electricity in the rod to-day have been nearly the same with those of the 17th instant.
21	SE	29.91	62	S.	Pos.	The electric charge in the rod has been constant this day; and for particulars may justly be referred to the 17th instant.
22	SE	29.78	59	S.	Pos.	A. M. The pith balls closed and opened, without change of kind, several times this day: and they have been very irregular when compared with many of the preceding. A thin wet fog has prevailed all this day.
23	SE	29.75	53	S.	Pos.	A. M. Four o'clock P. M. fell a mizzling warm rain, by which the rod became electrified negatively, and emitted small sparks. When the rain was over, the rod was electrified positively, and it continued so.
24	NE	29.76	54	S.	Pos.	The rod has been constantly electrified this day, and has been strictly periodical. See 17th instant.
25	N	29.75	54	S.	Pos.	The same as the preceding day.
26	N	29.89	50	S.	Pos.	The operations of the electric fluid in the rod this day have been nearly similar to those of the 17th instant.
27	E	29.90	49	—	Pos.	Dark moist air, but fair, and some brisk gales of wind, these four days.
28	NE	29.73	49	—	Pos.	
29	NE	29.80	47	—	Pos.	
30	NE	29.85	44	—	Pos.	
31	N	29.88	42	S.	Pos.	The thick easterly wind is now over-ruled by a clear northerly one; and the electrification of the rod this day has been of the periodical kind. The pith balls never closed.
1	S	29.80	46	S.	Pos.	Near six o'clock A. M. I found the pith balls open one inch and a quarter, positive; which is rather less than when I left them last night. Half an hour after ten o'clock, fell a heavy shower of rain: the pith balls now closed, and soon opened negative, which, with the rain, continued the rest of the day.
2	SW	29.45	49	—	Pos.	P. M. fair weather.
3	SW	29.80	44	S.	Pos.	From a continued rain of four hours.
4	W	29.74	49	S.	Pos.	Nearly all day, but strongest after sunset.
5	W	29.95	47	—	Pos.	A. M.—and P. M. A cloudy atmosphere.
6	S	29.75	53	—	Pos.	The electricity of the atmosphere this day has been so weak, that I have been obliged to content myself with obtaining the kind by a pair of flaxen threads, without balls to them. The weather warm and showery.

Days.	Wind.	Barom.	Ther.	Sparks	Kind.	November.
		Inch.	°			
7	S	29.68	57	S.	Pos.	The operations in the rod, these two days, have been of the periodical kind. See 17th of October.
8	NE	29.90	42	S.	Pos.	
9	NE	30. 3	44	—	Pos.	Pith balls not open this day. The kind was obtained by flaxen threads without balls to them. A moist air.
10	NE	30.15	46	—	Pos.	Sharp dark weather, these nine days, with a dry easterly wind; and a weak electricity.
11	E	30.	48	—	Pos.	
12	NE	30.10	47	—	Pos.	
13	NE	30.15	44	—	Pos.	
14	NE	30.25	45	—	Pos.	
15	NE	30.29	42	—	Pos.	
16	NE	30.16	38	—	Pos.	
17	E	30.	41	—	Pos.	
18	N	29.77	33	—	Pos.	
19	S	29.24	47	S.	Neg	The severe easterly wind is now gone, and a more intense atmospheric electricity is returned. Nine o'clock A. M. a large black cloud passed over the rod, and a moderate shower of rain fell, by which the rod was rather strongly electrified negatively. This shower lasted one hour; and near the middle of it, the electricity changed to a strong positive; after this, the electricity ended as it had begun, negative.
20	S	29.25	42	S.	Neg	By the night bottle. Half an hour after two o'clock P. M. fell some rain, and the rod became electrified negatively. At Calstock, in Cornwall, in the evening of this day, much lightning and thunder.
21	W	29.16	47	S.	Neg	Half an hour after mid-day, fell a moderate shower of rain, attended with a great darkness. The rod now became rather strongly electrified negatively; and the bell rang weakly. There were after this several showers, which only gave a weak positive electricity; except one, which fell at ten o'clock at night; this indeed was strongly positive. At eleven o'clock this night, both at London and Portsmouth, there was much lightning and thunder. And also, at the same time, at Salisbury, where it appeared to roll along the ground like a body of liquid fire.
22	SW	29.40	49	—	Neg	A. M. The weather showery.
23	NW	29.68	49	—	Pos.	P. M. A foggy moist air.
24	SW	29.84	37	—	Pos.	A. M. and P. M.
25	S	29.78	50	—	Neg	P. M. Weather showery.

Days.	Wind.	Barom	Ther.	Sparks	Kind.	November and December.
		Inch.	°			
26	NW	29.58	51	—	Pos.	Atmospheric electricity, these four days, has been governed by its periodical laws. The weather very mild.
27	N	30.20	36	—	Pos.	
28	N	30.35	39	S.	Pos.	
29	SE	30.12	35	S.	Pos.	
30	N	29.74	32	S.	Pos.	From a fall of snow.
1	SE	29.62	32	—	Pos.	There has been very moderate weather these 12 days. The pith balls have been variable, between null, and nearly one inch open.
2	W	29.42	44	—	Pos.	
3	S	29.83	45	—	Pos.	
4	W	29.95	42	—	Pos.	
5	NW	29.95	32	—	Pos.	
6	N	30.30	38	—	Pos.	
7	W	30.30	38	—	Pos.	
8	N	30.15	49	—	Pos.	
9	N	30.15	48	—	Pos.	
10	W	30.18	48	—	Pos.	
11	SW	29.95	52	—	Pos.	
12	SW	30. 7	37	—	Pos.	
13	SW	29.88	48	S.	Neg	There has been a constant drizzling rain, with a strong gale of wind, from early in the morning to seven o'clock P. M.; the wind then became a storm. The rod had been null to this time, but now gave signs of a negative charge, which continued increasing until near nine o'clock; at this time the storm seemed to be at its height, when the wind suddenly shifted from SW to N: every appearance is now awful; the pith balls diverge to their utmost limits, and are very much agitated; and the bell rang about half a minute. Half an hour after nine o'clock, the storm ceased; and the charge in the rod became very weak. During the space of two hours, the electricity changed six times.
14	W	29.91	39	—	Pos.	A. M.
15	W	29.40	48	S.	Neg	From five to eight o'clock A. M. there was a storm of wind and rain. The electricity changed once only.
16	S	29.71	39	—	Neg	P. M. A showery day.
17	SW	29.41	41	—	Pos.	A. M.
18	N	28.98	37	S.	Neg	A. M.—and P. M. Strong gales of wind, with rain.
19	S	29.54	33	S.	Pos.	Between eleven and twelve o'clock A. M. fell a shower of rain, mixed with snow, by which the rod became rather strongly electrified, positively; which continued, with some variation of intensity (without change of kind) near three hours. The greatest divergency of the pith balls was four inches, when fine sparks were received from the brass ball N.

Days.	Wind.	Barom.	Ther.	Spark.	Kind.	December and January, 1791.
		Inch.	°			
20	N	29.93	32	—	Pos.	Nearly all day. Divergency three-quarters of an inch. Weather serene.
21	SW	29.90	46	—	Pos.	The air is extremely moist; and some small rain fell several times this day, which was almost void of the electric fluid; for I could not obtain it in quantity sufficient to ascertain the kind, until I added a LIGHTED PITCH TORCH to my hand exploring-rod. See fig. 2.
22	W	30. 5	37	—	Pos.	The pith balls half an inch open nearly all day.
23	W	29.80	44	—	Pos.	Five o'clock this morning, a most tremendous storm of wind, rain, lightning, and thunder, visited London and other parts. I, being not well, and in bed, did not get up to make observations. I thought I heard the bell ring: however, the rod was but weakly electrified the rest of the day. The high wind continued, without rain, all day.
24	SW	30.20	39	—	Pos.	Moderate weather these six days, and nearly a constant charge of electricity in the rod.
25	N	30.	45	—	Pos.	
26	SW	30.22	29	S.	Pos.	
27	S	30. 3	31	—	Pos.	
28	N	30.	32	—	Pos.	
29	S	30.20	25	—	Pos.	
30	S	29.96	37	S.	Neg	P.M. A fair morning, and a wet evening.
31	N	30. 5	38	—	Pos.	The rod has been electrified nearly all day, by a fog.
1	S	30. 2	40	—	Pos.	A.M. In the evening negative, from a fall of rain. This evening much lightning and thunder at Canterbury.
2	SW	29.72	31	S.	Pos.	A.M. A foggy morning. Half an hour after eight o'clock P. M. happened a sudden gale of wind and rain, by which the rod became rather strongly electrified, negatively.
3	SW	29.40	29	S.	Pos.	The morning of this day was frosty, and the evening wet. The electricity of the former was positive, and the latter negative.
4	SW	29.40	38	—	Neg	P.M. Balls three-quarters of an inch open. Strong gales of wind, with rain. Nine o'clock P. M. severe lightning and thunder at Falmouth.
5	SW	29.29	35	—	Pos.	Very fine weather these four days. Divergency of the pith balls have been between null and near one inch open.
6	SW	29.46	37	—	Pos.	
7	W	29.18	51	—	Pos.	
8	W	29.26	43	—	Pos.	
9	W	28.96	42	S.	Neg	Eight o'clock A. M. I saw a large black cloud in the NNW: soon after, a strong

Days.	Wind.	Barom	Ther.	Sparks	Kind.	January and February.
		Inch.	°			wind suddenly sprang up, and a little rain fell; during which, the rod was rather strongly electrified negatively, with small sparks. This charge of the rod only lasted eighteen minutes.
10	S	29.75	42	—	Pos.	Fine weather, and almost a constant electricity these two days.
11	W	29.75	48	—	Pos.	
12	S	29.95	42	—	Pos.	P. M. A very high wind, and a weak electricity. In the evening of this day, much lightning and thunder at Plymouth.
13	W	29.48	43	—	Neg	P. M. from a shower of rain.
14	W	29.80	42	—	Pos.	Very moderate weather, and a weak electricity, these four days.
15	SW	30.	32	—	Pos.	
16	SW	29.82	50	—	Pos.	
17	SW	29.50	49	—	Pos.	
18	S	29.50	42	—	Neg	From rain, with a strong wind.
19	S	28.87	43	—	Neg.	
20	SW	28.48	43	—	Pos.	The weather for these twelve days having been moderate, the electricity of the atmosphere has only been of such intensity as is common to serene weather.
21	W	29.22	37	—	Pos.	
22	S	29.85	35	—	Pos.	
23	W	29.76	48	—	Pos.	
24	S	30.50	32	—	Pos.	
25	SW	30.27	45	—	Pos.	
26	SW	30.15	45	—	Pos.	
27	SW	29.84	45	—	Pos.	
28	N	30.	33	—	Pos.	
29	SW	30.	38	—	Pos.	
30	NW	29.85	44	—	Pos.	
31	NW	29.85	51	—	Pos.	
1	W	29.85	47	S.	Pos.	P. M. from a shower of rain, of large drops; the rod became electrified rather strongly positive, and emitted fine bright sparks at the brass ball N,
2	N	30.	38	—	Pos.	The weather these nine days have been foggy and clear by turns; and the electrification of the atmosphere constant.
3	N	30.20	32	—	Pos.	
4	N	30.40	32	—	Pos.	
5	N	30.45	36	—	Pos.	
6	SW	30.40	36	—	Pos.	
7	NW	30.32	42	—	Pos.	
8	W	30.36	43	—	Pos.	
9	SW	30.32	43	—	Pos.	
10	SW	30. 8	46	—	Pos.	
11	SW	29.80	49	—	Pos.	There has been, these three days, a strong wind, with mizzling rain; and the electricity so weak, that I was obliged to connect, with the hand-rod, A LIGHTED TORCH, to ascertain the kind.
12	W	30.11	36	—	Pos.	
13	SW	29.95	46	—	Pos.	

Days.	Wind.	Barom	Ther.	Sparks	Kind.	February and March.
		Inch.	°			
14	SW	29.88	53	—	Pos.	Fine mild weather, with a constant electricity, these five days.
15	SW	29.80	47	—	Pos.	
16	SW	29.85	43	—	Pos.	
17	SW	30.10	40	—	Pos.	
18	SW	29.35	30	—	Pos.	
19	NE	29.40	37	S.	Pos.	Five o'clock, a dark cloudy morning, with some small rain; by which the rod became rather strongly electrified, positively. During the passage of some low clouds, the electric charge in the rod changed five times; all of which changes, I have reason to think, were only influentially effected.
20	NE	29.80	40	S.	Pos.	A.M. Rainy dark weather. In the afternoon the charge in the rod became negative, and remained so full three hours, without change of kind.
21	S	29.56	42	—	Pos.	Dark rainy weather, and a very weak electricity.
22	SW	29.73	32	—	Pos.	
23	SW	29.55	47	—	Pos.	
24	W	29.90	33	—	Pos.	
25	E	30.	37	S.	Pos.	There has happened this day a continued rain, mixed with snow. The rod has been several times strongly charged; and the electricity gradually changed four times.
26	N	29.72	33	S.	Pos.	The weather and the electrification of the rod have been nearly the same as in the preceding day.
27	N	30.	38	S.	Pos.	The weather and the operations of the rod have been nearly the same as in the two preceding days.
28	N	30. 8	36	—	Pos.	The weather has been foggy these three days.
1	N	30.12	35	—	Pos.	
2	S	30.25	32	—	Pos.	
3	SW	30.50	32	—	Pos.	Serene fair weather these seventeen days; and the nights were generally frosty. The electricity of the atmosphere has been constant; but too weak to afford visible sparks.
4	SW	30.40	45	—	Pos.	
5	SW	30.44	47	—	Pos.	
6	SW	30.20	40	—	Pos.	
7	NW	30.25	41	—	Pos.	
8	N	30.55	37	—	Pos.	
9	SW	30.65	34	—	Pos.	
10	W	30.55	35	—	Pos.	
11	SW	30.46	39	—	Pos.	
12	W	30.28	40	—	Pos.	
13	SW	30.20	44	—	Pos.	
14	SW	30.18	47	—	Pos.	
15	SW	30.35	50	—	Pos.	
16	SW	30.40	51	—	Pos.	
17	SW	30.40	40	—	Pos.	
18	SW	30.28	50	—	Pos.	
19	SW	30.15	39	—	Pos.	

Days.	Wind.	Barom	Ther.	Sparks	Kind.	March.
		Inch.	°			
20	W	29.68	46	—	Neg	This morning fell a warm drizzling rain; which seems to have acted like a charm on the late constant electrification of the atmosphere: for I find it so weakly electrified since the rain fell, that I have been obliged to connect, with the rod, A LIGHTED TORCH, to ascertain the kind.
21	NW	29.15	44	S.	Pos.	Four o'clock this morning, a severe storm of wind and rain, driving full against my bed-room window, induced me to rise from my bed to see the state of the rod; which I found highly electrified, positively. This wind did not abate its force till sun-set. Four o'clock P.M. some rain fell, mixed with snow, which lasted near one hour. During this time, the rod was most powerfully electrified, positively: I counted seventeen spontaneous explosions between the brass ball and bell, notwithstanding the bell was ringing all the time. Half an hour after five o'clock, came a second shower of rain, hail, and snow, which lasted half an hour, attended with uncommon darkness: about half of this time, the electric charge in the rod was as strong as it could possibly be; for the fluid almost streamed between the brass ball and bell: I counted near two hundred very brilliant explosions between the ball and bell. The bell rang all the time. This latter very high charge, was first negative; attended with four changes of electricity, but all gradual.
22	N	29.85	44	—	Pos.	The disposition of the atmosphere has been mild and regular these four days; and the state of atmospheric electricity constant and periodical.
23	W	30. 3	54	—	Pos.	
24	N	30.50	44	—	Pos.	
25	S	30.38	43	—	Pos.	
26	S	29.85	46	S.	Neg	Half an hour after nine o'clock, A.M. fell some rain, by which the rod became electrified, negatively. Soon afterwards the wind became N, and attended with showers of rain the rest of the day: all of them moderately electrified, negatively.

Days.	Wind.	Barom	Ther.	Sparks	Kind.	March and April.
		Inch.	°			
27	N	30.	40	—	Pos.	The weather has been fair during these ten days, and the atmospheric electricity has been constant; yet it has been too weak to afford visible sparks.
28	NW	30.10	46	—	Pos.	
29	SW	30. 6	50	—	Pos.	
30	E	30.	44	—	Pos.	
31	SE	30. 8	44	—	Pos.	
1	SW	30.	50	—	Pos.	
2	E	29.81	51	—	Pos.	
3	E	29.78	50	—	Pos.	
4	NE	29.90	46	—	Pos.	
5	NE	29.72	46	—	Pos.	
6	N	29.45	43	S.	Neg	Six o'clock, A.M. I found the night bottle charged sufficiently to explode with a visible spark; the kind, negative. During the night, the weather had changed from dry to a mild rain. The rod has been electrified negatively nearly all this day.
7	W	29.78	47	—	Pos.	Mild serene weather. The divergency of the pith balls has been varying between null and nearly one inch open.
8	NW	29.92	53	—	Pos.	
9	NW	29.90	51	—	Pos.	
10	W	30.	50	—	Pos.	
11	SE	30.	50	S.	Neg	Weather still mild, and a constant electricity this day.
12	N	29.95	54	—	Pos.	From a fog.
13	NE	30.	51	—	Pos.	Mild serene weather these nine days; some of them foggy: but whether clear or foggy, the vapour in the air has been constantly electrified, positively.
14	W	30.	59	—	Pos.	
15	SW	30. 6	55	—	Pos.	
16	SE	30.10	55	—	Pos.	
17	SE	30.	61	—	Pos.	
18	SW	29.80	57	—	Pos.	
19	SW	29.75	59	—	Pos.	
20	S	29.57	59	—	Pos.	
21	SW	29.48	56	—	Pos.	
22	SW	29.25	55	S.	Neg	A wet morning. Twelve o'clock, the rain fell more plentifully, and the rod was rather strongly charged, negatively.
23	SW	29.24	54	S.	Neg	Half an hour after twelve o'clock, P.M. an extensive black cloud, without any breaks in it, approached the rod, by which it became strongly electrified, negatively; and, in the space of twelve minutes, a most awful darkness filled the atmosphere, and some rain fell, mixed with hail. The electric charge in the rod now became positive; and, for the space of ten minutes, it was as strongly electrified as it possibly could be; for I now counted 172 spontaneous explosions between the brass ball and bell; the bell ringing briskly all the time. These lucid sparks succeeded each other almost too quick to be noted. When the explosive sparks ceased, the electricity

Days.	Wind.	Barom	Ther.	Sparks	Kind.	April and May.
		Inch.	°			of the rod changed, and ended as it had begun, negative. A little after five o'clock fell a heavy shower of rain, and a second strong charge in the rod succeeded, attended with three gradual changes of kind.
24	SW	29.31	54	S.	Neg	A little after two o'clock, P. M. fell a shower of rain, by which the rod became moderately electrified, negatively. The bell rang weakly. This charge in the rod continued four hours, without change of kind.
25	W	29.84	51	S.	Pos.	A. M. Three o'clock, P. M. fell a shower of rain, which was rather strongly electrified, negatively, attended with three changes of kind.
26	E	30.	53	—	Pos.	Serene foggy weather these three days.
27	NE	29.84	53	—	Pos.	
28	N	29.81	52	—	Pos.	
29	N	29.86	51	S.	Neg	A. M. from a shower of rain.
30	N	29.90	48	S.	Neg	During the greatest part of the day. The weather showery.
1	N	29.80	48	S.	Pos.	A. M. Afternoon negative. The weather still showery.
2	N	29.85	48	S.	Neg	A. M. A mild showery morning.
3	N	30.	45	—	Pos.	A. M. but very weak. Fair weather to-day.
4	N	30.	45	—	Pos.	The atmospherical electricity has been so very weak this day, that I was obliged to connect, with the hand-rod, a LIGHTED TORCH, to ascertain the kind of electricity.
5	N	29.96	47	—	Pos.	Fair serene weather these four days; and the atmospheric electricity constant.
6	N	30.	46	—	Pos.	
7	N	30.28	45	—	Pos.	
8	N	30.32	48	—	Pos.	

A Monthly Account of Sparks, and of Positive and Negative Electricity, as indicated by the Pith-ball Electrometer, connected with the rod; excepting a few times, in very moist weather, in which it was obtained by the hand exploring-rod, with a lighted TORCH *to it.* See fig. 2.

	Times	Times	Sparks drawn, Days.
23 days May, 1790 / 8 days May, 1791	Pos. 40	Neg. 27	13
June	Pos. 45	Neg. 22	5
July	Pos. 36	Neg. 23	8
August	Pos. 33	Neg. 6	3
September	Pos. 39	Neg. 11	19
October	Pos. 37	Neg. 7	22
November	Pos. 30	Neg. 8	11
December	Pos. 35	Neg. 11	6
January	Pos. 28	Neg. 8	3
February	Pos. 36	Neg. 12	6
March	Pos. 34	Neg. 8	2
April	Pos. 30	Neg. 14	8
	423	157	106

It appears, by comparing the monthly account of this year with that of the preceding, that there has been a considerable disproportion in the electrical positive state of the atmosphere; but which, when duly weighed, will not appear so great as it now does. For when it is considered, that in the preceding year there were 73 days in which weak signs only of the electric fluid were observed; that seven days were destitute of electric signs; and that that kind of weather in which very weak signs of atmospherical electricity could be obtained, is now found, by a more sensible electrometer than was at that time used, to be always

ways positively electrified, it will, I presume, diminish the apparent disproportion. And as for the remaining difference, I also attribute a good deal of it to the accuracy of my present mode of obtaining atmospherical electricity, with a more complete apparatus; by which I have been able to collect the electric fluid, in sufficient quantity to ascertain the kind which predominates in the atmosphere, even in its weakest state. I have, therefore, found it an easy matter to fix the kind of electricity that the aqueous vapours in the air were charged with in each day throughout the year.

From repeated observations, and long experience, I am perfectly satisfied that the aqueous vapours, suspended in the air, are constantly electrified; requiring only the aid of a proper collector, to render the effects of their electricity at all times sensible. And for this reason, there may be justly said to be an electrical atmosphere within our aerial atmosphere.

During a course of moderate weather, the electricity of the atmosphere is invariably positive; and exhibits a flux and reflux, which generally causes it to increase and decrease twice in every twenty-four hours. The moments of its greatest force are about two or three hours after the rising, and some time before and after the setting, of the sun; those when it is weakest, are from mid-day to about four o'clock. The periodical electricity of the atmosphere seems to be manifestly influenced by *heat* and *cold*. Hence it plainly appears, why we always find warm small rain to

be but weakly electrified; when cold rain, which falls in large drops, is the most intensely electrified of any.

The abovementioned eighth day of May, completes my second year's Journal; which, agreeable to my promise, I have now the honour of presenting to the Royal Society, with a description of the improved atmospheric apparatus, which has been used for the foregoing observations.

I must now close that regular account which, for the last two years, has daily occupied my attention. Should any very remarkable appearances, however, in future take place, during a long course of frosty weather, which is the only state of the atmosphere that I have not yet experienced *, as my apparatus will continue in order, I shall carefully note them, and present them to the Royal Society: hoping that some more able philosopher may be induced to take his share of labour in this interesting and promising field, in order to investigate, as far as possible, the nature of so active, universal, and, in all probability, important an agent, as the atmospherical electricity seems to be; and to pursue the subject, with that diligence, and unprejudiced accuracy, which has been my principal object in the course of my observations.

* As I do not remember that there have been twenty-four hours of hard frost during the last two winters.

The six following Pages (which I beg leave to subjoin) have not been presented to the Royal Society.

Though

Though the nature and confined limits of the plan of the preceding Journals, did not admit of much variety of obſervation, or a formal enumeration of every particular fact; yet few things, I hope, of uſe and importance have been omitted. But, I wiſh, in a more particular manner, to invite the philoſophic reader to the inveſtigation of the three following effects, which are in themſelves, I think, the moſt peculiar; and have already been ſhortly noticed, when they happened to take place in the rod, in ſeveral parts of the Journals; and which I beg leave to do, for the ſake of conciſeneſs, by way of interrogation.

Firſt, When the high pointed rod is intenſely electrified, and the pith-balls annexed to it, diverging five or ſix inches, why ſhould they exhibit a waving pendulous motion, without any diminution of their divergency, but vibrate as if the threads and balls were one ſolid and inflexible ſubſtance?

Secondly, By what means, and in what manner are the electricities of the earth and atmoſphere acted upon, ſo as to cauſe the pith balls to exhibit very quick jerks, by a ſudden loſs of intenſity, from five to three, two, or even one inch aperture, while yet the balls as quickly recover their former intenſity, and ſometimes recover it but ſlowly? Theſe ſudden jerks are never attended with a change of electricity, but the facts themſelves happen in both kinds.

Thirdly, In what manner do the powers of nature effect a total diſcharge of the highly electrified rod, in an inſtant of time, and the next inſtant render it highly electrified

as at the firſt, and either with or without a change of electricity? Theſe ſtriking effects and appearances, I own, are attended with conſiderable difficulties; of which I cannot, at preſent, give a ſolution ſatisfactory to myſelf, nor can I even imitate them by artificial electricity. The following circumſtances, however, are clear, that theſe effects never happen with a weak electrification of the rod, nor always with a ſtrong one; but they are always more or leſs diſplayed, when a flaſh of lightning happens in the neighbourhood of the rod, or is ſtrongly preſumed to have happened at no great diſtance from it. As theſe effects appear to be immediately connected with an exploſion of lightning, they may poſſibly ſerve as a clue to the more complete inveſtigation of that phenomenon; and are, therefore, worthy of the regard, and the moſt minute examination of the philoſopher.

The

The following Obſervations are chiefly ſelected from the Works of Mr. ACHARD *and* Mr. CAVALLO.

Mr. ACHARD obſerves, on the imperfection of Meteorology, that little progreſs will be made in it, ſo long as barometrical, thermometrical, and hygrometrical obſervations are not accompanied with the regular obſervations of the electricity of the atmoſphere, of the electricity of rain, hail, ſnows, miſts, and aqueous meteors in general. As it is now clearly aſcertained, that electricity is a cauſe of various meteorological phenomena, it is rather ſurpriſing that philoſophers have not perceived the abſolute neceſſity of joining an inſtrument, by which obſervations may be made on the electricity of the atmoſphere, to thoſe which indicate its weight, heat, and humidity.

Without conſidering, in this place, the different proofs of the influence of electricity on meteors, it will be ſufficient to remark, that we cannot attain to an adequate knowledge

knowledge of any phenomenon occasioned by the concurrence of various causes, without being acquainted with them all; for, if any one is neglected, it will be absolutely impossible thoroughly to explain the phenomenon. If electricity is not the sole cause of several meteorological appearances, it is undoubtedly concerned more or less in their formation and elevation; so that by neglecting to observe it, as well as the barometer, &c. we loose the fruits of other, even very exact, meteorological observations.

The influence of electricity on vegetation, is proved by a set of observations made by different philosophers; but it evidently appears, that the botanic meteorological observations alone will never be so useful as might be expected, till we unite those made by an instrument, which will indicate the electric state of the atmosphere to those made with other instruments. It is owing to this cause, perhaps, that it is impossible to draw any conclusion from the botanical meteorological observations of Messrs. Gautier and Duhamel, which were continued from 1751 to 1769.

It is remarkable, that in those days in which he observed no electricity in the air, there was no dew at night; while, on the other nights, it fell in greater or less quantities. Mr. ACHARD does not think those observations sufficient to determine that dew is occasioned by electricity; but it may, he thinks, be fairly inferred, that the elevation and fall of the dew is obstructed, or promoted by the electricity of the air.

As

As electricity is often, if not always, the cause of dew, no one will doubt the necessity of attending to it in the botanical meteorology, as every one is acquainted with the influence of dew on the growth of vegetables.

Having endeavoured to prove the necessity of combining observations on the electricity of the atmosphere, with other meteorological observations, Mr. ACHARD proceeds to describe the properties requisite in a good atmospherical electrometer, the want of which accounts for the neglect and supineness of philosophers on this subject.

Mr. CAVALLO, on this subject, says it appears, from the observations which have been made on the electricity of the atmosphere, that nature makes great use of this fluid in promoting vegetation.

1st. In the spring, when plants begin to grow, then temporary electrical clouds begin to appear, and pour forth electric rain. The electricity of the clouds and of the rain continues to increase till that part of the autumn in which the last fruits are gathered.

2dly, It is this fluid which supplies common fire with that moisture; by the help of which, it actuates and animates vegetation; it is the agent that collects the vapours, forms the clouds, and is then employed to condense them into rain.

3dly,

3dly, From the ſame principle may be explained t proverb, that *no watering gives the country ſo ſmiling a lo as rain.* The clouds which bring the rain, by extendi their electric atmoſphere to the plants, diſpoſe the por of the latter to receive with greater facility the wat which is impregnated with this penetrating and dilati fluid. Beſides, it is natural to ſuppoſe, that the poſiti electricity which continually prevails in ſerene weath will contribute to promote vegetation, ſince this has be found to be the effect even of artificial electricity.

F I N I S.

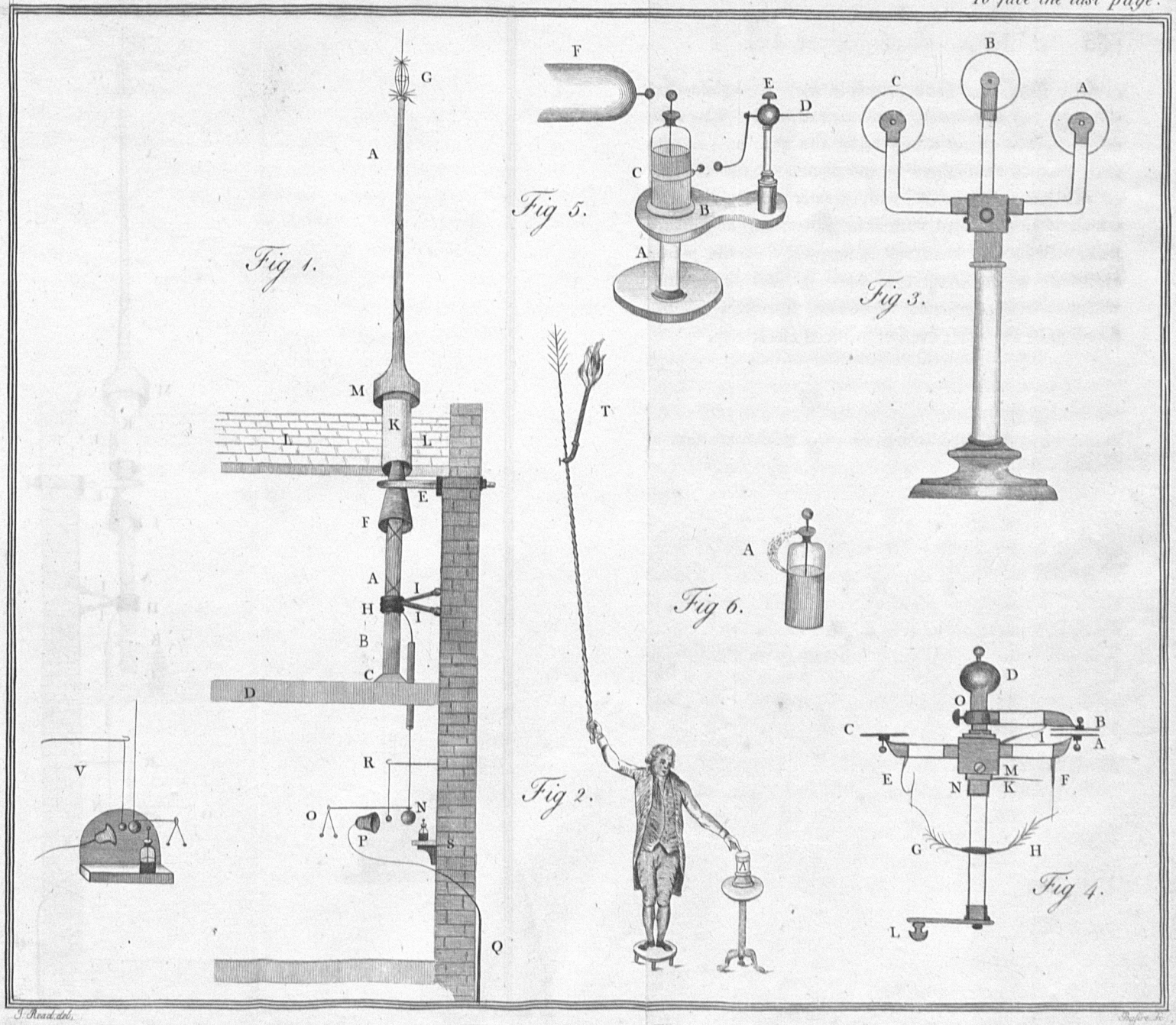
Fig 1.
G
A
M
K
L
L
E
F
A
I
H
I
B
C
D
R
N
O
P
S
Q
V
Fig 5.
F
E
D
C
B
A
Fig 3.
B
C
A
Fig 6.
A
Fig 2.
T
Fig 4.
D
O
C
B
I
A
M
E
N
K
F
G
H
L