An account of a very extraordinary effect of lightning on a bullock : at Swanborow, in the parish of Iford near Lewes, in the county of Sussex / in sundry letters from Mr. James Lambert ... and one from William Green ... to William Henly. Read at the Royal Society, May 1, 1776.

Contributors

Lambert, James, 1725-1788. Green, William. Henley, William, -1779.

Publication/Creation

London, 1776.

Persistent URL

https://wellcomecollection.org/works/bs4w32fp

License and attribution

This work has been identified as being free of known restrictions under copyright law, including all related and neighbouring rights and is being made available under the Creative Commons, Public Domain Mark.

You can copy, modify, distribute and perform the work, even for commercial purposes, without asking permission.



Wellcome Collection 183 Euston Road London NW1 2BE UK T +44 (0)20 7611 8722 E library@wellcomecollection.org https://wellcomecollection.org

ACCOUNT

AN

OF A VERY EXTRAORDINARY

EFFECT OF LIGHTNING

ONA

BULLOCK,

At SWANBOROW, in the Parish of IFORD near LEWES, in the County of SUSSEX.

In fundry LETTERS from

Mr. JAMES LAMBERT, Landscape-Painter at Lewes; and One from WILLIAM GREEN, Efq. at Lewes;

TO

WILLIAM HENLY, F.R.S.

Read at the ROYAL SOCIETY, May 1, 1776.

L O N D O N: Printed in the Year MDCCLXXVI.

Digitized by the Internet Archive in 2019 with funding from Wellcome Library

1 One from WILLIAM GREDN, Mig.

WILLIAM HENLY,

NOR TATOR IN

https://archive.org/details/b30791005



ANACCOUNT, &cc.

LETTER I.

FROM MR. LAMBERT.

Sept. 13, 1774.

SHALL now inform you of a very extraordinary and fingular effect of lightning on a bullock in this neighbourhood, which happened about a fortnight fince. The bullock is pyed, white and red. The lightning, as fuppofed, ftripped off all the white hair from his back, but left the red hair without the leaft injury. I have been to fee the bullock, and have made a drawing of it, which I will fend you as foon as I can get more particulars from Mr. Rogers, the proprietor; for, when I faw him, I omitted to afk him, if the hair was all off (as it now appears) when it was first feen the next morning; and whether any hair was found in the field; and if it appeared to be finged or not? The bullock

Mr. HENLY'S Account of the

bullock does not feem to have been hurt; his fkin looks fair and well. Mr. ROGERS informs me, that he has had two other bullocks ftruck in the fame manner; one laft fummer, that was all white, was ftripped of his hair like this, though not all over his back, but chiefly on his shoulders; the other, two years fince, was pyed, and affected much like the prefent. He thinks, it cannot be the effect of any difeafe, becaufe the beafts were all in good health before and after this accident happened. He is more inclined to think it was the effect of lightning, becaufe when he has had cattle difordered, fo as to make their hair come off, he has never observed white hair to come off more than red, &c.; but that it has, if partycoloured, fallen off promiscuoufly, and generally in patches; and alfo by flow degrees, and never fuddenly, as in the cafe of these bullocks. I shall be glad to know your thoughts on this matter, whether it is a new circumftance to you or not; and if you think it much worth I am, &c. attending to.

LETTER II.

FROM WILLIAM GREEN, ESQ.

SIR,

4

Sept. 28, 1774.

THE inclosed account of the effect of lightning feems to me very extraordinary; perhaps, fuch inftances may be known to you: however, to be certain whether they

Effect of Lightning on a Bullock.

they are fo or not, I have troubled you with a defcription of this cafe; if it fhould prove to be no novelty, you will only have the trouble of reading it.

. In the evening of Sunday the twenty-eighth of Auguft, at this place, there was an appearance of a thunder ftorm, but we heard no report. A gentleman, who was riding near the marshes not far distant from this town, faw two ftrong flashes of lightning, feemingly running along the ground of the marsh, at about nine of the clock in the evening. On Monday morning, when the fervants of Mr. ROGERS, a farmer at Swanborough, in the parish of Iford, went into the marsh, to fetch the oxen to their work, they found one of them, a four-yearold fteer, ftanding up, to appearance much burnt, and fo weak as to be fcarce able to walk. This was mentioned to me about a week after the accident happened; and by the defcription of it, it feemed to have been ftruck with lightning in a very uncommon manner. The ox is of a red and white colour; the white in large marks, beginning at the rump-bone, and running, in various directions, along both the fides; the belly is all white, and the whole head and horns are white likewife. The lightning, with which it must have been undoubtedly struck, fell on the rump-bone, which is white, and diffributed itfelf along the fides, in fuch a manner, as to take off all the white hair from the white marks as low as the bottom of the ribs, but fo as to leave a lift of white hair, about half an inch broad, all round where it joined to the red; and not a fingle hair of the red, that I can perceive, is touched.

touched. The whole belly is unhurt, but the end of the fheath of the penis has the hair taken off; it is also taken off from the deulap; the horns and the curled hair on the forehead are uninjured, but it is taken off the fides of the face, from the flat part of the jaw-bones, and it is taken off from the front of the face in stripes. There are a few white marks on the fide and neck, which are furrounded with red, and the hair is taken off from them, leaving half an inch of white adjoining to the red. I looked attentively at the feet and legs, and could not difcover any hair taken from them (they were very dirty) except from the joint a little above one of the hoofs, where it was partly off. I have fent a fketch of one of the fides of the ox, which will ferve to illustrate what I have faid, and is better than any defcription. I have coloured, with faint red, those parts which were stripped of the hair. The farmer anointed the ox with oil for a fortnight; the animal purged very much at first, and is greatly reduced in flefh. I faw it about a fortnight ago, and it was then recovering. I am, &c.

LETTER III.

FROM MR. LAMBERT.

Nov. 15, 1774.

A M forry for the delay in fending you this drawing; but, as you know the caufe, I need not fay any thing further than that I have the happiness to acquaint you, that

Effect of Lightning on a Bullock.

that I am now quite recovered from my illnefs. I have not had an opportunity of feeing Mr. GREEN, therefore cannot tell how his account may agree with mine; but I have endeavoured, as much as poffible, to get an exact ftate of the matter, having carefully infpected the bullock twice, accompanied by my nephew and a gentleman at my houfe. The creature being, as I obferved to you before, remarkably gentle, we could examine every part of him very minutely. You will fee by the drawing, that the white hair was all ftripped off from his back and down the fides, as low as the greatest diameter of his body, also from the top of the nose, the upper part of both cheeks, and over the eyes, leaving the fkin quite bare; but below those places, under the belly, gullet, the under parts of the cheeks, the legs, and ring of white in the tail, together with an edge of white at the parting of the red and white hair, all remained without the leaft injury. We were the more particular in examining the legs, on account of your mentioning that Mr. GREEN had obferved traces of the ftroke down them to the ground, in which, I think, he must be mistaken; for, both the times when we faw the bullock, his legs were quite clean down to the hoofs, and the hair feemed to be in a perfect ftate. If the legs had been at all affected, I think, it could not have efcaped our notice in two examinations; and there being no marks of lightning on them, inclines me to think, that the bullock was lying down at the time, and if fo, you will readily account for the under parts not being touched. The lightning being conducted by the white hair,

Mr. HENLY'S Account of the

hair, from the top of the back down the fides, came to the ground, at the place where the white hair is left entire; but there is one remarkable circumstance, viz. though all the white hair on the upper parts was taken away, as beforementioned, yet the tuft of white hair on the forehead never received any hurt at all. I have converfed with feveral farmers, &c. in hopes of getting fome information relative to those matters, but can meet with nothing perfectly fatisfactory. The best account I have been able to obtain is from my neighbour Mr. TOOTH, a farrier and bullock-leach. He tells me, that this circumstance is not new to him; that he has feen a great many pyed bullocks ftruck by lightning in the fame manner as this, both in his father's time (his father being of the fame trade) and fince; and that the texture of the fkin under the white hair was always deftroyed, though looking fair at firft; and, after a while, it became fore, throwing out putrid matter in puftules, like the fmall pox with us, which in time falls off, when the hair grows again as before; and that the bullocks receive no further injury. In this ftate I found Mr. ROGERS's bullock, the fecond time I faw it, which was about a month after the first visit; fome of the scabs were then dropping off, and the hair was coming on afresh. I asked Mr. TOOTH, whether he could recollect among those bullocks which he, or his father, had feen ftruck dead by lightning, any that were white or pyed? But in this he could not fatisfy me; if he could, I think, it would have thrown fome light on the fubject. I remember

Effect of Lightning on a Bullock.

remember perfectly well, that all the cattle that I have feen, which were killed by lightning, were either black, brown, or red, without any white at all in them. I muft obferve to you, that this bullock is both marked and affected by the ftroke exactly alike on both fides.

I am, &c.

HAVING been favoured with thefe letters, by gentlemen of the ftricteft veracity, and likewife particularly curious in their enquiries, I have not the leaft reafon to entertain a doubt of the facts they communicate; and as they may, perhaps, be productive of fome important difcoveries, refpecting the different colours of bodies as conductors of electricity, I imagined, that it would not be improper to lay them before the members of the Royal Society.

To the preceding paper I would beg leave to add the following queries:

Ift, Are not the dark-coloured hairs ftronger in their texture than the white or light-coloured ones (a)?

2dly, If the dark-coloured hairs are the ftrongeft, may not this be owing to their being more deeply rooted, and partaking more largely of that nutritive matter which produces and fupports hair? And does not the change of dark-coloured hair to grey, in perfons advanced in years, feem to favour this fuppofition?

(a) This is a fact fo well known to house-painters, that they do not admit a dark hair into their brushes, as they would occasion a disagreeable roughness in their work. J. COVENTRY.

Mr. HENLY'S Account of the

3dly, If the above fuppofitions are allowed, may not any internal injury to the fkin (as a violent electric explofion paffing through it) prove more fatal to the white or light hair than to the black, red, or darker colours?

Should the above queries be all acknowledged, by those gentlemen who have confidered the fubject, to be truths; yet, I believe, they will fearcely be thought fufficient to account for the whole effect of lightning which has appeared in this case, and particularly for the edge of white hair adjoining to the red, which remained unhurt by it; but as they may, perhaps, in some measure have contributed towards this phenomenon, I have barely mentioned them as suppositions, and suppositions only, which have occurred to me.

A SUBSEQUENT LETTER FROM MR. LAMBERT.

tonductors of electricity, I imagined, that is nothed not be

DEAR SIR,

Dec. 6, 1774.

I HAVE, according to your defire, enquired of Mr. TOOTH, whether he ever faw a ftroke of lightning actually fall upon a pyed bullock, fo as to deftroy the white hair, and fhew the evident marks of burning, leaving the red hair uninjured? He fays, he never did; nor can he recollect any one that has. But he gives me an account of a pyed horfe of his being killed, four or five years fince, in a ftable adjoining to his houfe, by a ftroke of lightning which happened in the night; and being very great, Mr. TOOTH thinking it ftruck his houfe, immediately

10

Effect of Lightning on a Bullock.

II

immediately got up and went to the ftable, when he faw his horfe was ftruck, and almost dead to appearance, though it kept on its legs near half an hour before it expired. The horfe was pyed white on the fhoulder and most part of the head; that is, all the forehead and nose, where the greatest force of the stroke came. The hair was not burnt nor difcoloured, only fo loofened at the root, that it came off at the leaft touch. And this is the cafe, Mr. TOOTH observes, with all he has seen or heard of, viz. the hair is never burnt, but the fkin always affected, as I defcribed it in my former letters. In the above horfe, Mr. TOOTH fays, all the blood in the veins, under the white parts of the head, was quite ftagnated, though he could perceive it to flow as usual in other parts of the body, under the brown hair; and the fkin, together with one fide of the tongue, was parched and dried up to a greater degree than any he had ever feen before. The horfe ftood in a stall close to the door of the ftable, which was boarded on that fide, and through them, he thinks, the lightning ftruck him. I am, &c.

Extract of another Letter from Mr. LAMBERT, dated Oct. 10, 1775, with a Drawing N° 3.

r it can be explained from the difference of tex

I HERE fend you another inftance of the effect of lightning on a bullock of Mr. ALSE's, at Glynd, which happened on the 20th of last month; it is fimilar to the other I fent you in every refpect, except that I think the stroke on this must have been greater, as the fcarf-skin feems

Mr. HENLY'S Account of the

feems to be peeling off with the hair all over the rump, like the piece I have herewith fent, which came off from the hip. I think too, that this is more curious, as all the red fpots, even those fmall ones on the fide, remain firm and fmooth, without the least injury. You will observe also, that, as in the former inftance, after the lightning had passed the greatest diameter of the body, the white hair is left intire, particularly under the belly, on the legs, &c. Mr. ALSE, having never feen nor heard of this wonderful phenomenon, could not conceive what was the matter with the bullock, till he fent for Mr. TOOTH, who immediately told him the cause. I am, &c.

bove home, Mr. roorn lays, all the blood in the veins, inder the white parts of the head, was quite flagnated,

HAVING mentioned the foregoing particulars to my learned and ingenious friend Dr. A. FOTHERGILL, at Northampton, he has favoured me with fome conjectures, which I shall take the liberty of annexing to this paper; viz. " The recent fact you mention, of the effects " of lightning on the white hair of a bullock, is ex-" tremely curious, but feems difficult of folution. Whe-" ther it can be explained from the difference of texture " between red hair and white, is doubtful; or whether " there is not fomething peculiar in colours, as being " conductors or non-conductors of electricity, may de-" ferve enquiry. The phlogiston, or inflammable prin-" ciple, is thought to be the foundation of colour in bo-" dies, and to abound in proportion to the intenfity of " the colour. But phlogiston and the electric fluid are vidadorq " mult have been greater, as the fearf-fkin feems Ba

Effect of Lightning on a Bullock.

" probably the fame, or at leaft modifications of the fame " principle; therefore, red bodies are perhaps replete " with electric matter, while white bodies may be defti-" tute of it (*). A body faturated with it cannot receive " more, and may efcape, while a neighbouring body, not " calculated to receive it, may, on its admiffion, be de-" ftroyed (*). Or there may exift a chemical affinity be-" tween electricity and the different rays of light, which, " in attracting fome, and repelling others, may be the " foundation of many curious phenomena. But, while " we admire the effects; the habitudes and *modus ope-*" *randi* of thefe fubtile fluids may, perhaps, for ever " elude the cognizance of our fenfes."

(b) Many fubftances must certainly be excepted from this rule. w. HENLY.
(c) This effect of lightning generally happens to fuch bodies which, in fome measure, refist its entrance, &c. merely on account of their being imperfect conductors. w. HENLY.

いいい







EXPERIMENTS

I N

ELECTRICITY.



and the continon

AN ACCOUNT OF

SOME

NEW EXPERIMENTS

I N

ELECTRICITY:

CONTAINING

- I. An Enquiry whether VA- 11 IV. The Defcription and Ufe POUR be a CONDUCTOR of ELECTRICITY.
- II. Some Experiments, to afcertain the Direction of the Electric Matter, in the Discharge of the LEYDEN BOTTLE: with a new Analyfis of the LEYDEN BOTTLE.
- MI. Experiments on the LA-TERAL EXPLOSION, in the Discharge of the LEYDEN BOTTLE.

- of a new PRIME-CON. DUCTOR.
- V. Mifcellaneous Experiments, made principally in the Years 1771 and 1772.
- VI. Experiments and Obfervations on the Electricity of Fogs, &c. in Purfuance of those made by THOMAS RONAYNE, Efq; with a Plan of an ELECTRICAL JOURNAL, &C.

By WILLIAM HENLY, F.R.S.

Read at the ROWAL SOCIETY, MAY 5, 1774

LONDON, PRINTED BY W. BOWYER AND J. NICHOLS. M.DCC.LXXIV.



[5]

AN ACCOUNT OF

SOME.

NEW EXPERIMENTS

oris and spilled to L N

ELECTRICITY.

the care ally between

SECTION FIRST.

An Enquiry whether VAPOUR be a CONDUCTOR of ELECTRICITY.

EXPERIMENT I.

INSULATED a glass funnel [TAB. XIII.. fig. 1.] into which the ftreams, from a capillary tube, were directed by the electricity.. tricity. From this funnel, the electrified drops were received into a large infulated earthen difh; across which lay a long wire; and from its end hung a pair of light cork-balls. On working the machine (after about ninety or an hundred turns of the winch, and when fifty or fixty drops had fallen into the dish) the balls separated, and prefently diverged, to the diftance of half an inch. Then taking off the electricity, from all the bodies concerned, I blew the column of water out of the capillary tube, replaced it in the bucket, pointing towards the funnel as before, and worked the machine again, to try whether the electricity, iffuing from the fyphon, and paffing through the air, might not electrify all the bodies, fo as to feparate the balls, without the jet of water; but no fuch event happened. I then replaced it, with the jet falling into the funnel as before; when it fucceeded. I then tried it a fecond time, without the jet of water; and it failed. I thus repeated the experiment alternately, with, and without the jet, taking off the electricity of the apparatus carefully between the trials; till I was perfectly fatisfied, that the jet of water, received into the funnel, and falling from thence into the infulated difh below, was the medium by which the balls, hanging from the end of the wire placed therein, became electrified. Hence I inferred, that vapour from boiling water, &c. must also be a conductor of electricity, though probably in a lefs degree, as being more diffipated. Having fince repeated this experiment by receiving the electrified jet immediately





[7]

diately into a large infulated difb, I observed the effect to be much greater.

EXPERIMENT II.

Having procured a tin veffel, fomewhat refembling an eolipile, or a chymical retort; I placed it over a fmall lamp, upon my primeconductor [TAB. XIII. fig. 2.], and filled it about half-full of boiling water. The nofe of it was fo fituated, as to throw the electrified drops into an infulated difh, furnished with balls, as in the former experiments. After the water had been fome time poured in, and I imagined enough had evaporated to have produced fome drops in the neck; I examined the lip, to fee whether any descended, but saw none. However, on giving the machine a turn or two, I was very agreeably furprized to fee the electric ftreams iffue exactly as from a capillary tube; and a few drops having fallen into the difh, the balls became electrical, and were attracted by my finger, at the diftance of an half or three quarters of an inch. In a few turns more of the globe, they feparated half an inch. I then threw out the water; and, clearing the veffel of its vapour, I remounted it upon its stand (pointing towards the dish as before), to try whether the fharp edge on the lip of the veffel would not electrify the air, fufficiently to feparate the balls, as the evaporated water had done. I turned the winch a long time for this purpose; but the balls never diverged at all. I then poured in the boiling water a fecond time; and.

and, when the drops began to fall, the fourth turn separated the balls; and the tenth caused them to diverge to the diftance of half an inch; and in this state of repulsion they continued a confiderable time, after I had ceafed to work the machine. I then took off the electricity with my finger, and again cleared the veffel of its water, &c. and, having replaced it with the point as before, I worked the machine again as ufual. The air was now grown in fome measure electrical; for, at the feventh or eighth turn, the balls began to separate, and in forty turns they were about three eighths of an inch diftant from each other. I then ceafed to turn the winch any longer; but had no fooner flopped, than the balls began to clofe, and in a very few feconds they were in contact; whereas, in the former experiment (when the electrified drops were in the difh), on my ceafing to turn the globe, they shewed no fign at all of converging; and, I imagine, would have remained separate a long time, if I had not taken off their electricity with my finger. I apprehend, therefore, from this experiment, that the vapour of bot water is a conductor of electricity.

EXPERIMENT III.

I hung on a string, as near to the cieling of the room as I could, a pair of pith-balls, which, on working the machine a confiderable time, diverged three quarters of an inch, but no wider. Then sticking into the conductor a *finoking dealmatcb*, and working the machine again, they prefently prefently separated to the distance of two inches. The match, when placed in the same situation, and not smoking, had no such effect.

EXPERIMENT IV.

Having placed an earthen half-pint mug, upon a ftand properly infulated; I fixed to a large ball of brass, which I had placed in the bottom of it; the end of a wire, fix, or eight feet in length. The other end of the wire I connected with the prime conductor of a small electrical machine [TAB. XIII. fig. 3.]. Over this mug, and as near to ceiling of the room as I could, I fuspended a pair of light cork balls. Then filling up the veffel with boiling water, I began to work the machine; and in fifty, or fixty turns of the winch, observed the balls to feparate three eighths, or half an inch, from each other. I then took off the electricity of the bodies; emptied the veffel, and cleared it of the vapour; and having placed the apparatus in the fame manner, I again worked the machine, for a longer time; but without effect. On replacing the boiling water, I fucceeded as at first. At other times, when I have been able to feparate the balls by the air alone, to a fmall diftance; yet by pouring in the hot water, the vapour has prefently increased their divergence from one eighth, or three fixteenths, to half an inch distance; or in that proportion, according to the state of the atmosphere with respect to dryness or moisture. In fhort I have repeated these kinds of experiments fo often; and many times with fo much fuccefs; that I can have no doubt of vapour being a conductor of electricity.

EXPE-

EXPERIMENT V.

I infulated the rubber of my machine, and hung a pair of Mr. CANTON's balls upon the prime-conductor. I then worked the machine, and having taken off a spark, or two, to draw off the electricity naturally inherent in the rubber, &c. I obferved the divergence of the balls; which was very great; in fo much that the ftrings were bent: and on approaching the back of the rubber with a *fmoking green wax taper*, just blown out, (the fmoak of which was inftantly attracted to it,) they diverged no wider (a). I then took off the balls, and placed my own electrometer in its ftand, upon the prime-conductor [TAB. XIII. fig. 4]; and having taken off a spark, or two, as before; I again worked the machine, to obferve the repellency of the index from the ftem; and found it conftantly to vibrate between five, and ten degrees, of the quadrant, which was divided into fifteen. I then brought the fmoking taper, within four, or five inches, of the back of the rubber, as before; and obferved, that on the attraction of the fmoak to it, the index presently began to rife; and in a very fhort time, got up to right angles. I repeated the experiment, feveral times, with the fame fuccefs. I then tried the experiment by bringing my finger to the fame distance from the rubber, and pointing towards it; but this, in many trials, had not the least effect. The taper likewife, when held at the fame diftance, and not smoking, had no effect at all. I am

(a) For this experiment, the back of the infulated rubber should be perfectly smooth: mine, is of wood; with the leather pasted down closely to it; so as to leave no points.

EXPE

convinced

convinced therefore, that the fmoak was the medium, which conveyed the electricity, from my hand, to the infulated rubber.

[11]

EXPERIMENT VI.

I placed upon a stand, on my prime-conductor, a piece of fmoking wax taper [TAB. XIII. fig 5.], when immediately, on working the machine, the fmoak, from a large, and diffused volume, was much contracted; and its motion upwards, greatly accelerated. I then took off the electricity of the conductor, and held a pair of cork balls a quarter of an inch diameter, hung on threads two and a quarter inches long, (being the nearest at hand,) perpendicularly, over the rifing fmoak; and as high as I could poffibly reach, ftanding on a chair; this might raife the balls about five feet and an half above the prime-conductor; when (working the machine) in a few feconds the balls feparated to half an inch diftance. I then removed the taper, but could not perceive that the balls were at all affected without it; but on replacing it, they feparated as before. I repeated the experiment feveral times, with, and without the taper, and the different effect, was constantly as above recited. I then fet a tin faucer upon the fland, and placed upon the faucer, an half pint mug of boiling water [TAB. XIII. fig. 6.); and over this water, I prefented the balls, in the rifing vapour; as I had before done in the fmoak. On working the machine a few feconds, the balls diverged to the diftance of one twelfth part of an inch. On removing the water, and prefenting the balls as before, they ne-

B 2

ver

ver separated at all; though I worked the machine for a longer time; but on replacing the water, in a few seconds the balls diverged, as at first. These experiments I repeated several times, and always with the same success. The smoak, therefore, in the first experiment; and the vapour of the hot water, in this last; was certainly the medium, which conveyed the electricity, from the primeconductor, to the balls: and I think I may now very fafely pronounce, that SMOAK, and the VAPOUR of hot water, are absolutely conductors of electricity; though smoak is a far better one than the vapour of hot water, and both of them are exceedingly bad ones.

Upon the queftion, whether vapour be a conductor of electricity; I would obferve, that Dr. FRANKLIN's curious experiment, of making a vifible atmosphere, round an infulated, electrified body; cannot be made, but in an exceedingly dry state of the air. The reason is obvious; but in a very dry day, I have often succeeded in the experiment; and have shewed it to several of my friends, particularly Mr. MARSHAM, and Mr. NAIRNE.

My method of doing it, is as follows: I place the brafs cafe of a fteel-yard weight (about two and an half inches diameter,) upon a clean, dry, ftand of fealing wax: then having in readinefs, a green wax taper, with a long fnuff, I give the infulated body, a fpark, from the knob of a pofitively charged bottle; or take one from it, by the knob of a negatively charged one (the appearance is the fame in both cafes); then bringing the taper, juft blown out, very gently towards the infulated body, the the fmoak is inftantly, and with a kind of violence, attracted to it; till it becomes compleatly covered with it. It remains in this fituation for fome feconds, when it begins to difappear, at the bottom; and proceeds gradually, till it comes to the top; where it hangs quivering, like the departing flame of a lamp. It goes off in a long thin column, which rarefies, and difperfes at the top, till it occupies a great fpace. Obferve that, in giving the fpark, and bringing the taper towards the infulated body, particular care muft be taken, that the air be diffurbed as little as poffible.

The green was taper, on account of the verdegreafe it contains, answers excellently, in this, and feveral other experiments, where smoak is required without heat: and I first used it, from a hint Dr. FRANKLIN was so obliging as to give me.

SECTION SECOND.

Of THE DIRECTION of the electric matter, in the discharge of the LEYDEN BOTTLE.

EXPERIMENT I.

L IGHT a fmall wax taper, and place it, with the flame exactly between two brafs balls A and B, about two inches afunder; properly introduced into the circuit [TAB.XIII. fig. 8.]. Then, having given a fmall phial two or three turns of the globe, charging it pofitively, connect *the coating of it*, by a chain, with the wire of the ball A; and upon applying the knob of the phial, to the wire of the ball B, you will obferve the flame to be plainly driven

driven from it; being often blown upon the ball A, fo as to blacken it with the fmoak. Then charge the phial negatively, and (the apparatus remaining as before) apply the knob of the phial as at first; and you will then perceive the flame to be blown quite in the contrary direction, viz. from A towards, and often upon B, as upon Dr. FRANK-LIN's principles of the Leyden bottle, it ought to be. Observe that, in this experiment it is necessary to use the least charge that can be given, just fufficient to leap the interruption in the circuit; which experience will prefently determine; for if the charge be too great, the flame will be attracted as well as repelled, in the discharge of the phial; and then, nothing can be infered from the experiment. contholet heat : and I first uted

EXPERIMENT II.

Charge a large jar *politively*, and infulate it; then take a long curved wire, *pointed*, at *both ends*, and hold it by a glafs handle, fo as to bring one end of the wire, half an inch, from the knob, and the other end of it, to the fame diftance, from the coating of the jar. You will then obferve a fmall luminous fpark, upon the point appofed to the knob of the jar, and a fine pencil, diverging from the lower point, fpreading upon the coating of the jar, which will prefently difcharge it filently. Then charge your jar *negatively*; infulate it, and apply the wire as before; and the appearances, at the points of the wire, will be directly reverfed; plainly demonstrating the direction of the electricity in the difcharge of the bottle.

Another

Another very convenient and eafy method, of exhibiting the phænomena of the politive and negative electricity of the infide, and outfide furfaces, of a charged Leyden bottle, is by flipping a cap of metal, furnished with a ball and wire, upon the outfide coating; and mounting it upon an electric ftand, in an horizontal polition; as TAB. XIV. fig. . 3.; or if the bottom of the glass be turned much upward into the body of it, a piece of wood may be worked to its fhape, and cemented thereto; and through the middle of this wood, a fhort tube of metal may be inferted, fo as to admit the wire which is connected with the ball to pass through it; and be brought into contact with the coating of the jar, at pleafure (b). By this means, experiments may be made, at either end of the bottle with great facility; and other charged or exhausted, bottles; excited ribbons; or other electrics: the curved pointed wire, &c. &c. may be readily applied; and give, or receive a spark; be attracted, or repelled; according to the kind of electricity in the two bodies, fo applied towards each other. By hanging a chain round either of the wires, and connecting it with one end of the discharging rod; and bringing the other end of the rod, so as to leave a proper fpace between that and the ball on the wire, at the oppofite end of the bottle; the flame of a taper, &c. may be interposed ; and shew the direction of the electricity in the discharge: or a cork-ball, bung by filk, may play between them, in the man-

(b) For many experiments, it needs only to be connected with the curved metal, or wood, in which the charged bottle is placed.

20

(c) The bottle being held below the edge of the coating.

ner described by Dr. FRANKLIN. If the balls are taken off from the wires of the bottle; the wires being pointed, and one of them placed before the globe; or a prime-conductor, electrified *positively*: the phænomena of charging the Leyden bottle will be discovered by the different appearances, at the end of the wires; as at TAB. XIV. fig. 4. If the bottle be thus placed before a conductor, electrified *negatively*; or *the infulated rubber* to a machine; the appearances, at the ends of the wires, will be reversed: as upon Dr. FRANKLIN's principles they ought to be; and thus explain his theory of the Leyden phial.

But a more fimple, and beautiful analyfis of the Leyden phial, hath not, I think, yet been exhibited; than the following. Let a bottle that will hold near a pint; having a long neck (about an inch in diameter,) be furnished with a small plate at the top; with a valve properly fecured, after the bottle is exhausted: from which plate, a wire about one eighth of an inch in diameter, is to project a little below the neck; and terminate with a blunt end. The top is to be covered with a round brafs cap, firmly fixed thereon; and made air-tight. The bottom of the bottle should be coated with tin-foil, which should be continued three inches up the fide. This bottle will charge and discharge several times in a minute; and the tinfoil coating, will prevent the fhock from affecting the hand of the operator (.). The phænomena of charging the Leyden bottle, is elegantly explained by this contrivance; and is made visible, by the end of the wire; on which, the appearances vary, according as the bottle is charged, viz. politively,

(c) The bottle being held below the edge of the coating.

or

or negatively; or as the conductor, from which it charged, is electrified. TAB. XIV. fig. 5. letter A. fhews fuch a bottle, charging *negatively*, at a conductor, loaded with *positive electricity*. Letter B. fhews the fame bottle, charging *positively*, at the fame conductor.

TAB. XIV. fig. 6. letter C. shews the bottle charging *positively* at a conductor, *electrified negatively*; or at the infulated rubber. Letter D. shews the same bottle, charging *negatively* at the same conductor.

SECTION THIRD.

Of the LATERAL EXPLOSION in the discharge of the LEYDEN BOTTLE.

EXPERIMENT I.

HAVING made a double circuit, the first by an iron bar, one inch and an half in diameter, and half an inch thick; the second, by four set and an half of small chain; on discharging a jar, containing five hundred square inches of coated surface, the electricity passed in both circuits, sparks being visible on the small chain in many places. On making the discharge of three jars, containing together sixteen square set of coated surface, through three different chains at the same time, TAB. XIII. fig. 7. bright sparks were visible in them all; and I have not the least doubt, but it would have been visible in as many more. The chains were of iron and brass, of very different lengths; the shortest ten, or twelve inches, the C longest,
longest, many feet, in length. When those jars were discharged through the iron bar before-mentioned, together with a fmall chain, three quarters of a yard in length ; the whole chain was illumined, and covered throughout with beautiful rays, like briftles, or golden hair. Having placed a large jar in contact with my prime conductor, I affixed to the coating of it an iron chain, which I also connected with a plate of metal, on which I intended to make the difcharge by my difcharging-rod, TAB. XIII. fig. 9. This done, I hooked another chain, much longer, and of brafs, to the opposite fide of the jar, and brought the end of it within eight inches and an half of the metal plate. In contact with this end, I laid a small oak-stick, eight inches long, which I covered with faw-dust of fir-wood. On making the discharge upon the plate, both the chains were luminous through their whole lengths; as was alfo the faw-dust, which was covered by a streak of light, making a very pleafing appearance. I repeated the experiment feveral times. Perhaps, if I had used a bar of iron, instead of the chain first-spoken of, there might have been no light upon the fecond ch in, or upon the faw-duft, efpecially as the electricity had half an inch of air to pass through, before it reached the end of the flick. But from this experiment may, I think, be inferred, the neceflity of making the conductors, erected as a security to buildings, &c. from the damage of lightning, both of the best materials, and of a very fufficient fubstance ; and, for this purpofe, perhaps nothing will be found fo proper as lead.

lead, which will remain in the earth many centuries without any confiderable decay; and the tops of chimneys being covered with it (d), and furnished with a long, sharp-pointed rod of copper, or iron pointed with copper, which I think fhould extend at least five, or fix feet, above the top of the chimney, or highest part of the building; a communication should be made from it by plates of lead, eight, or ten inches broad, with the lead, on the ridges, and gutters, and with the pipes which carry down the rain-water; which pipes should be continued to the bottom of the building, and there made to communicate, by means of other leaden pipe, or a plate of it, as before-mentioned, with the water in a well, the moift earth, or the main pipe which ferves the houfe with water.

SECTION FOURTH.

Description and Use of a new PRIME CONDUCTOR. Contrived by Mr. HENLY, and executed by Mr. EDWARD NAIRNE.

- A. TAB. XIV. fig. 7. A glass-tube, eighteen inches long, and near two inches in diameter.
- B. C. Balls of Brass, with a ferule, two inches long, to each of them; which ferules are to be cemented to the ends of the tube, and made air-tight.

(d) I mention covering the tops of chimneys with lead, as a protection to the upper courfes of bricks, from the effects of wind; and not as being of any effential fervice to the conductor, any farther than as it may affift in fixing the pointed rod, which is to be elevated above it, more fecurely.

One

One of the brafs plates, which are foldered to the ferules, hath a fmall hole drilled through it, by which the air is to be exhausted. It is covered by a strong valve, properly fecured, and concealed by the brass ball B, or C. D.E. Balls of brass, about five eighths of

- an inch in diameter, fixed upon wires, which project two inches and an half from the brass plates, at each end of the glass-tube.
- F. A fine-pointed wire, to collect the electricity from the excited glass-globe, &c.
- G. Supporters, of fealing-wax; upon which the luminous conductor is to be mounted.
- N.B. The dots in the tube are intended to reprefent the appearance of the electricity in it, in the experiments defcribed in TAB. XIV. But, when a bottle, or a large jar, is difcharged through the glafs-conductor, it is uniformly filled with light.

The USE of the GLASS CONDUCTOR.

The glafs-tube, thus furnished, and mounted, being properly exhausted, and perfectly dry, will act in all respects like one of metal; and the electrometer, being placed upon the brass ball B. will answer to the charge of a jar, or battery, exactly. But the principal use of this instrument, is to afcertain the direction of the electric matter, as it passes through it. And this end, it completely answers in the manner following, viz. set it with the collecting-point F. before the glob, and place the knob knob of an uncharged bottle nearly in contact with the brais ball B. or hang a chain, &c. from thence to the table; and, on working the machine, the ball D. in the tube becomes entirely enveloped, in a denie, white atmosphere of electricity. If the point F. be brought nearly into contact with an infulated rubber, and a communication be made from the ball B. to the table; the atmosphere will be upon the ball E. in the tube. If a bottle, positively charged, be prefented as in the drawing TAB. XIV. fig. 9. the appearances in the tube will be as therein delineated. But, if a bottle, charged negatively, be thus applied, the atmosphere will furround the ball E. in the tube, as in TAB. XIV. fig. 10.

CONJECTURES on these Phænomena.

It is supposed, that the impelling power of the globe, or the knob of a politively charged bottle, drives the particles of electricity through the fubstance of the balls, wire, &c. w th which they are in contact, with great velocity, and in a kind of ftraight line; but, the electricity having entered the vacuum, the repulsion of its particles immediately takes place, and the tube is inftantly filled with light. The denfe white atmosphere upon the opposite ball is supposed to proceed from the refistance of the air in the tube; a small portion of which, will, in this method of exhauftion, inevitably remain in it. And, as every particle of electricity, is supposed to be in a state of repulsion with respect to its next neighbour, the vacuum giving them free liberty of expanding themfelves,

Or

or flanding at the greateft diftance from each other; it is imagined, that they actually do fo, and will not enter the ball, and wire, at the oppofite end of the conductor, in a point, or fmall *fpace*, (as they do in the open air); but that they entirely furround them, and enter at all parts at the fame time, in order to their conveyance into those bodies placed at the end of the brafs work to receive them.

If, inftead of the brafs balls in the tube, points are ufed; or if a point be fixed at one end of the tube, and a ball at the other; the effect will be precifely the fame.——Note alfo, That the glafs-conductor, for the purpose of making Dr. FRANKLIN'S curious experiments, with a pointed and blunted wire, is far superior to one of metal, the electric atmosphere being so much better retained by it. By this easy and simple process, may an ocular demonstration, at all times, be given, in a dark room, and dry air, of the truth and propriety of Dr. FRANKLIN'S hypothesis of the Leyden bottle.

SECTION FIFTH.

Miscellaneous Experiments, made principally in the Years 1771 and 1772.

EXPERIMENT L.

IF a black filk ribband, or a piece of black filk, be laid on a quire of paper, &c. on a table, and excited by drawing over its furface fealing-wax, fulphur, fulphur, amber, or a tube of glass with the polific taken off by emery; its electricity will be positive: whereas, if it be excited, fingly, or together with a white ribband, by drawing them briskly between the fingers, it is always negative.——Laying it on the paper, and drawing over its furface a rod, or tube of smooth glass, its electricity will also be negative.

EXPERIMENT II.

If a plate of glass, ten, or twelve inches in diameter, be excited, and placed upon the top of a box, from which a pair of light pith or cork-balls are fuspended, being mounted on a stand of fealing-wax; the balls will separate, and stand repelled from each other, being electrified positively, (in a dry air), upwards of four hours. When they come into contact, on removing the glass, they diverge again, and are negatively electrified; but, on replacing it, they close. On removing it again, they separate; and thus alternately as long as any electricity remains in it (2).

If the plate of glass be placed in a frame of wood, and a light pith or cork-ball be laid on its furface; on presenting towards it the end of a finger, or the point of a pin, &c. the ball will recede from them, with a very brisk motion, and may thus be driven about upon the furface of the glass, like a feather in the air, by an excited tube, or the wire of a charged bottle. The cork-ball,

(e) For an explanation of these phænomena, see Mr. CAN-TON's experiments, Philosophical Transactions, Vol. LVIII. Part 1. N° 53.

being

being deprived of its electricity by the pin, &c. instantly flies to that part of the glass to which it is attracted the most forcibly.

EXPERIMENT III.

I hung on my prime-conductor a small phial, two inches in diameter, coated three inches and a quarter from the bottom. From the coating of this phial, I fuspended two chains; the first, in contact with a heavy weight, placed upon a card, acrofs which, I had ruled lines, at equal diftances, TAB. XIV. fig. 1. the fecond chain formed a circuit, with leaden pipe, small brass wire, small chain, &c. of one hundred and twenty feet in length. From the ball of my difcharging rod, which refted on another weight (fee the figure), I alfo hung a chain, in contact with, and compleating, the circuit of one hundred and twenty feet before-mentioned; and observed, that, if my bottle was charged quite full, the electricity would, in the discharge, pass through the long circuit, rather than over the furface of the card, when the weights were placed at nine fixteenths of an inch afunder: but, if I charged the bottle only about half-full, the electricity would, in the discharge, pass through the long circuit, rather than over the furface of the card, though the weights were placed at the diftance of only three fixteenths of an inch.- Query, Can there be a greater proof of the small refistance made by metal to the passing of the electric matter, compared with card, wood, &c. and confequently of the utility

lity of metallic conductors to buildings, fhips, &c.? The fame obfervation hath been repeatedly made, upon the effects of the natural electricity. And a remarkable inftance hath lately happened, at the church of St. John, Weftminfter; a very exact account of which hath been taken, by Dr. wATson, F.R.s. and J. BANKS, ESQ. F.R s. who, I hope, will at a convenient opportunity, favour the curious in these matters with their ingenious and interesting remarks on it. The tower of this church, I am informed, hath no *pointed* metallic termination.

EXPERIMENT IV.

Having prepared a phial, in the manner directed by Mr. LANE, for making his curious experiment; by paffing a wire through the bottom, and another through the cork, fo as to bring the ends of the two, within half an inch of each other, about the middle of the bottle (which was filled with water) I found, as that gentleman observed, that a flight flock of electricity difcharged through it, would break the bottle. But having put a very fmall wire from the top, to the bottom of it, through the water; I discharged through it, three large jars, containing fixteen square feet of coated furface, when the whole of the fmall wire was exploded; but the bottle remained unhurt. If therefore a metallic conductor (being too fmall) should happen to be deftroyed by a stroke of lightning, yet the building, &c. to which it is affixed, will probably escape uninjured.

EXPERIMENT V.

When I ftrongly electrify a large prime-conductor, three feet long, and twelve inches in diameter; if a perfon hold in his hand a brafs rod terminated by a ball, two inches in diameter, at the

D

diftance

distance of two inches, from the fide of the conductor [TAB. XIV. fig. 2.], he will continue to draw fuch ftrong sparks as will give him a fensible. shock in both his legs: but if another person at the fame time present the point of a lancet, or a wire five or fix inches long, nicely tapered to a point, tipped with steel, towards the conductor; though at the diftance of two feet, or fomewhat more, this will draw off all its electricity filently; and not fuffer a spark to pass from thence to the brass ball: it is also observable, that if the point of the wire, or lancet, be brought nearly into contact with the prime-conductor, yet no sensation is felt in the arm, &c. of the operator : hence, I think, appears clearly the preference due to points, rather than round balls, or blunted ends, for the termination of the conductors erected as a fecurity to buildings, &c. from damage by lightning : for to me, it feems probable, that the fharp point of the conductor will act upon the electric atmosphere of the cloud, and perhaps gradually and filently continue to diminish the contents, before the cloud can approach near enough to ftrike; and thus contribute to leffen, if not actually prevent, a ftroke (1). But should the point be struck, the confequence I suppose will not be great, and a curious instance I have now before me, which I shall beg leave to quote as follows. " About nine o'clock we had a " dreadful ftorm of thunder, lightning, and rain, " during which the main-maît of one of the Dutch " East Indiamen was split, and carried away by " the deck (g); the maintop-maft and top gallant-

(f) Captain WINN's conductor, though two of the links were broken, effectually answered this intention.

(g) The flays, fhrouds, &c. being all cut asunder (Dr. so-LANDER informed me) as with a knife. diffance

maft,

" maft, were shivered all to-pieces; she had an " iron spindle at the main top-gallant-mast-head, " which probably directed the ftroke. This ship " lay not more than the diftance of two cables " length from ours, and in all probability we fhould " have shared the same fate, but for the electrical " chain which we had but just got up, and which " conducted the lightning over the fide of the fhip; " but though we escaped the lightning, the explo-" fion shook us like an earthquake, the chain at " the fame time appearing like a line of fire (b): a " centinel was in the action of charging his piece, " and the shock forced the musket out of his hand, " and broke the rammer rod. Upon this occafion " I cannot but earneftly recommend chains of the " fame kind to every thip, whatever be her defti-" nation; and I hope that the fate of the Dutch-"man will be a warning to all who shall read this narrative, against having an iron spin-" dle at the mast-head."---- See Capt. Cook's voyage. This conductor was of copper wire, three fixteenths of an inch in diameter; which I am inclined to think is rather too finall for the purpose; I am of opinion it ought to be a quarter of an inch at least: and I have been informed by Dr. SOLANDER, that the point originally belonging to the conductor, had been stolen; and that this, on which the lightning fell, was of inferior workmanship, and not so fharp ; which was another great difadvantage : perhaps if the wire of the chain had been larger, and

[27]

(b) It does not however appear, that the finall hempen cord, with which the links of the chain are closely connected, or even the strings which connected them, had received the least injury from the lightning.

the

the point more acute, the ftroke would have been much leffened; if not abfolutely prevented. If, instead of those chains, plates of copper, three fixteenths of an inch thick, and two inches in diameter, with the edges neatly rounded off, were inferted in a groove, and continued down the main-top-gallant-mast, the main-top-mast, and part of the main-mast, into the well-hole; a communication from the maft, to the under-fide of one of the decks, might be made with a plate, or rod of metal, flattened at each end; and from that rod, the conductor might be continued by plates of lead, or copper, on the under-fide of the deck, and down both the outer-fides of the ship, as low as the keel, if it be thought necessary: and this method (the conductor being always in readinefs, and kept perfectly in order) I should apprehend would be preferable to the chains, which are now in use. Particular care should be taken, to have all the plates, which form the conductor, as nearly as poffible in contact with each other, and to fix a sharp-pointed, slender rod of copper at its summit. And for the purpose of connecting the plates, inferted in the main-top-gallant-maft, the main-top-mast, and the main-mast; if an hoop of copper were fixed in a groove of its own thickness, at the top of the main-mast; and another fuch hoop at the upper end of the main-top-past; perhaps they might anfwer this end very conveniently (1). The learned and ingenious Dr. WATSON, F.R.S. hath, with

(i) If an objection fhould be made to cutting grooves in the mafts, the plates of metal, which form the conductor, might readily be fastened upon the surface, and very fecurely.

great judgement and accuracy, collected from ancient hiftory, the accounts therein recited, of electrical appearances, upon pointed bodies; as the fpears of foldiers, &c. &c. ^(k) which have been very judicioufly introduced by Dr. PRIEST-LEY into his Hiftory of Electricity ^(l): and I cannot but think, those accounts, furnish a very ftrong argument, in favour of *pointed conductors*: for had the bodies here spoken of been terminated by blunted ends, or round knobs, it is probable that many of them instead of drawing off the lightning *filently*, would have been *ftruck* with it; and this, being deemed a common occurrence, would have passed unnoticed, and consequently never have been recorded in history.

If pointed bodies had really the property of drawing down ftrokes of lightning upon themfelves, I think the pillar upon Fish-street Hill, commonlycalled the MONUMENT, could not long have escaped. This pillar is terminated by a basin of metal, four feet and fix inches in diameter. The bafin is furrounded by a great number of bended plates of metal, fbarply pointed, to represent flames of fire. From the batin, to the floor of the gallery, are fixed perpendicularly in a circular order four thick bars of iron; and in those bars are inferted twenty-eight ftrong hoops, and four fegments of circles, of the fame metal; which ferre as fleps from the gallery to the bafin. One of these bars (being one inch thick, and five inches broad) is connected with the iron rails of the.

(k) See Philosophical Transactions, vol. 48, part I. p. 210.

(1) See Hiftory and Present State of Electricity, second edition, p. 371.

stair-cafe,

building, and forms a fubftantial, regular conductor of metal the whole length. The monument was crected by Sir CHRISTOPHER WREN in remembrance of the fire of London, which happened in the year 1666. It was compleated by that great architect, in the year 1677; is, including the blazing urn at its fummit, about two hundred and two feet in height, from the pavement; and hath never (fo far as I have been able to learn) been ftruck by lightning. The antennæ and legs of the grasshopper on the Royal Exchange in Cornhill; and the tongue and tail of the dragon on the spire of Bow church in Cheapfide, London, are also remarkable instances (m): indeed I have often thought it rather a favourable circumstance, that most of the lofty public buildings in this metropolis which have metallic terminations, have generally been furnished with weather-fanes, which fanes commonly end in tharp points: for had they been terminated with large round balls of metal, perhaps many more of them might long fince have been demolifhed. Here therefore I cannot but express my earnest wifhes, that, on all future occasions, where lofty public edifices are to be erected; a good pointed conductor for the lightning, may be confidered by every architect, or furveyor, as an effential part of the edifice itfelf.

EXPERIMENT VI.

I attempted to afcertain the conducting power, of different metals, in the manner following. I

(m) A great variety might be produced, but Dr. FRANKLIN bath himfelf rendered this unneceffary. took a thick piece of paste-board, across which I ruled lines, exactly an inch afunder. Upon these lines, crofs-wife, I placed the wires; which I confined by heavy weights: the edges of which weights just touched the ruled lines; leaving exactly an inch of wire between them fee TAB. XIV. fig. 1.]. The kinds I tried were, pure gold, filver, brafs, copper filvered, and iron. They were all drawn through the fame hole, except the iron, which was fomewhat larger than the others. I proved them with two jars, containing eleven square feet of coated furface; and adjusted the charges, by an electrometer graduated in divisions of one tenth of an inch each, the diameter of the scale being two inches. The refult was as follows:

Pure Silver Iron f I gave either of the han the pure filver of the If I gave either of the wires a division less than the number above specified, it was not melted: if I gave either of them a division more, it was exploded; the greater part vanishing in fmoak: whereas these charges just burst them into balls.

Should any gentleman choose to repeat this experiment, I would recommend it to him to be very particular in fizing the wires; to use a greater length, to do it when they are all fresh drawn, to make the experiment in a very dry day, and in a room where there is no fire. With thefe precautions, probably there may be fome difference. in the refult; and this method will perhaps give a

proved

true

[32]

Having lately been prefented, in the most polite manner, by the celebrated Dr. LEWis, F.R.s. &c. with fix specimens of his platina; in as many different states: I felected the largest grains, from one of the parcels which Dr. LEWIS informed me had been repeatedly exposed to long-continued vehement fires; the most intense which he had been able to excite, or any veffels he could procure would support: and after a few small globules (confisting doubtless in great part of heterogeneous metal) had melted out, repetitions of the operation produced no further change. It was afterward boiled fucceffively in oil of vitriol, aqua-fortis, and spirit of falt, in order to its further purification; and which indeed reduced it to a ftate the most pure of any that excellent chemist had been able to produce. Having ruled a line with a blunt-ended wire, over the furface of a plate of white wax;

EXPERIMENT VII.

I preffed in the grains of *platina* lightly, and in contact with each other; fo as to form a regular line, half an inch long. At each end of the line of *platina*, and in contact with it, I placed a thick wire, with its ends nicely rounded off, and made perfectly fmooth. I covered the *platina* with a piece of thick plate-glafs; and then difcharged through it, three jars containing fixteen fquare feet of coated furface: when I obtained many beautiful fpherules of the *platina*. Several of them fluck to the wax, and glafs; and others *imperfectly* formed, upon the edges, &c. of the grains: which proved

proved that the fusion had been compleat. This experiment I made in the prefence of Mr. Ferguson, F. R. s. Mr. William Canton, Mr. Bell, and Mr. Marsham, who all acknowledged it perfectly satisfactory. Having mentioned the refult of this experiment, and the method of making it, to Mr. NAIRNE; he hath fince repeated it with equal fuccefs.

Being informed, by Mr. William Canton, that his brother, Mr. Thomas Canton, had, in preparing a dried cork for an experiment in electricity, observed some appearances which induced him to believe, that the cork had been made electrical, by only cutting it with a penknife, and that on examination he found it really was fo; I made the following experiment.

EXPERIMENT VIII.

I made a long cork perfectly dry, and held one end of it very near the fire, till it began to burn. At the fame time, I held a small, fine-toothed file, in the clear part of the fire, till that also, had become very dry, and rather hot. Then, having filed off the end of the cork, I applied it to a pair of neat, light pith-balls; when it attracted them both, and raifed them perpendicu'arly, as high as the strings would permit. Having electrified the balls by excited amber, the cork would increase their divergence from one, to near two inches; or it would repel them at an inch distance, fo as to drive them one inch and an half out of the perpendicular. Electrifying the balls by excited glafs, thefe appearances were directly reverfed. The cork therefore had parted with its electricity E

to

to the file, and plainly acted as a negative electric.

[34]

EXPERIMENT IX.

Having neatly rounded off the corners of a piece of thin tale, about three inches fquare; I coated both the fides of it, within three quarters of an inch of the edges, with tin-foil, which I alfo rounded off at the corners. The tale, thus prepared, I observed would readily charge, without wiping, or drying the uncoated part; and the force of the shock, in the discharge, was really aftonishing.

Having been shewn, by my late truly ingenious friend Mr. CANTON, an electric spark, of a very beautiful crimson colour, which always appeared as it was drawn over, or through, a piece of smooth wood, at the top of the conductor-stand, and which was supposed by some gentlemen, to be the light of electricity, very thinly spread upon the surface of the wood; I was exceedingly defirous to know from what cause this phænomenon really proceeded; and for that purpose made the following experiment.

EXPERIMENT X.

I fixed between two balls, introduced into the circuit of an electric discharge, a piece of smooth wainscot, about two inches in diameter, and a quarter of an inch thick; when, upon making the discharge of a pretty large jar, I observed the wainscot to be nearly covered with the electric light, the outer parts, or edges of the light, were exceedingly thin, but the colour very white; as it was also in several other other experiments, made with the fame intent. I then procured a circular piece of coloured box, which was glued to the top of the fland to my prime-conductor; when, drawing ftrong fparks through this wood (of whatever colour it was), I became clearly of opinion, that the colour of the *fpark varied according to its depth in the wood*; viz. if it paffed upon the furface, it was white; a little below it, yellow, or orange; ftill lower, fcarlet; and, deeper in the wood, crimfon.

It having been mentioned, by fome gentlemen, as their opinion, that the matter of light, and the electric matter, were the fame thing⁽ⁿ⁾; I made the following experiment, in order to determine whether there was any foundation for fuch an opinion or not.

EXPERIMENT XI.

I infulated the rubber of my machine, and placed it in fuch a fituation, that the rays of the fun, paffing through the open window of my room, might fall immediately upon it; but this I obferevd produced no electricity. I then collected the rays into a *focus*, by means of a good convex glafs, and threw them upon the back of the rubber, till it was burned quite black; but this method was attended with no better fuccefs. I then mounted one of Mr. CANTON'S electrometers, furnifhed with very light balls, upon a ftand of fealingwax; and, having electrified them negatively, by excited amber, fo as to diverge a full inch, I again

(n) Query, If this were really the cafe, fhould not electrical experiments fucceed, in the most perfect manner, in the clearest light of the fun? and would not the evening, or night, be an exceedingly improper time to attempt making them?

collected

collected the rays of the fun by the convex glafs, and held it at fuch a diftance as to bring the *focus* exactly upon the end of the box, which was burnt very black, and the glue in the joints melted; but the balls were not in the leaft affected.

Extract from Mr. BOYLE's Continuation of HAWKESBY'S Phyfico-mechanical Experiments.

" I took a large piece of good amber; and, " having in a fummer-morning (while the air was " yet fresh) tried that it would not, without being " excited, attract a light body I had exposed to it, " I removed it into the fun's beams, till they had " made it moderately hot; and then I found, as I " expected, that it had acquired an attractive " virtue, and that not only in one particular " place, as it is usually observed when it is ex-" cited by rubbing, but in divers and diftant " places at once; at any of which it would draw " to it the light body placed within a convenient " diftance from it; fo that, in this climate of " ours, a folid body may quickly acquire an at-" mosphere by the presence of the sun, and that " long before the warmeft part of the day."

ANOTHER.

"I took a little, but thick, veffel of glafs, and "held it near the fire till it had got a convenient "degree of heat, which was not very great, "though it exceeded that of the amber. I found, as I imagined, that the heat of fire had made "even "even this body attractive, as that of the fun "had made the amber."

REMARK.

If Mr. BOYLE, when the amber was heated, prefied it ever fo lightly against his hand, in order to try its warmth, (though without the least friction), be excited it; and, without this, it was not electrical, neither would it become so in cooling. If the amber was too hot, the heated air about it would conduct. Therefore he was obliged to find a convenient degree of heat. This affertion may be proved in the following manner.

EXPERIMENT XII.

Hold a piece of amber near the flame of a candle, till it becomes hot; then apply it to a fufpended thread, and it will not attract it, neither will it become electrical in cooling; but prefs it ever fo lightly on your hand, in order to try its heat, though without the least friction, and (if it be not too hot) it will be electrical, and attract it violently. Heat it again at the candle, and its electricity shall be taken quite away. Pres it again gently on your finger, or hand, and the power will be reftored. Apply it again to the candle, it is loft. And thus alternately. Other electrics may probably act in the fame manner; as the flame of a candle, or hot air, will conduct away the electricity of glass, almost instantaneoufly.

EXPERIMENT

[38]

EXPERIMENT XIII.

Shewing Mr. NAIRNE the above-mentioned experiments; when the amber had been wellheated, and being prefented to a fuspended thread, having shewn no fign at all of electricity; I held it, between my thumb and fore-finger, very near the table, but not fo as to touch it, that we might entirely avoid friction. He then blew against it thirty blasts, with a pair of kitchenbellows; when prefenting it to the thread, it attracted it, at the diftance of one-eighth of an inch. He then blew against it, thirty blasts more, as above defcribed; when applying it again to the thread, we faw it attracted, at half an inch distance; and, on drawing back the amber, it drew the thread after it, fix, or eight inches. We repeated the experiment three times, with the like fuccefs; and are fatisfied, that the amber was made electrical by the friction of the particles of air against its surface; and not in the least by heating only. We afterwards excited the amber, when it must have been perfectly cold, but dry, by only blowing against it as before.

The fame procefs fucceeds with glafs.

SECTION SIXTH.

Experiments and Observations on the Electricity of FOGS, &c, in pursuance of those made by THOMAS RONAYNE, Esq;

1771, Nov. 14. Half paft eight, A. M. I find a fog, not very thick, pretty ftrongly electrified. The balls feparate full half an inch. They keep ftationary, there being little or no wind.

Nov. 19.

Nov. 19. The air is pretty ftrongly electrified; but the wind is fo very troublefome, that I cannot determine the kind with certainty.

Dec. 2. Half paît eight, A. M. a fog, moderately thick, is strongly electrified. The balls diverge half an inch; but, if they are brought near the building, they close, and open again on removing them. The mercury in the thermometer, is fifteen degrees, above the freezing point.

Dec. 18. Half paft four, P. M. a moderately thick fog is ftrongly electrified, foon after its appearance. The balls diverge, full half an inch, and regularly clofe, at the approach of excited wax. The wind is troublefome; but the balls keep their diftance, and at intervals very well admit trying the experiment.

1772, Jan. 5. A fog is strongly electrified pofitively. The balls diverge full half an inch. The air is sharp, and frosty.

Jan. 13. Nine o'clock, A. M. a fog, not very thick, is ftrongly electrified politively. The mercury in the thermometer, is feven degrees and an half above the freezing point. There is little or no wind.

Jan. 18. Ten o'clock, A. M. The air is pretty ftrongly electrified by a fall of fnow.

Jan. 21. Nine o'clock, A. M. I find the air ftrongly electrified, during a fall of thin fleet, a mixture, of fnow, and rain, very gentle. The balls feparate three quarters of an inch, and remain flationary, there being little or no wind. N. B. The electricity in the air is positive.

Jan. 29.

Jan. 29. Nine o'clock, A. M. a very thick fog, and fharp froft. The air is fo ftrongly electrified *pofitively*, that the balls feparate *full an inch and a quarter*. There is little or no wind, and they remain ftationary; fo that the experiment may be made without the leaft danger of a miftake.

Twelve o'clock, the balls diverge as wide as at nine.

Three o'clock, P. M. the balls are exceedingly difturbed by the wind; but, blow as it will, they ftill keep at a great diftance from each other. It freezes very hard. A quarter paft four: the fame as at three o'clock.

Half past five. The balls are stationary, at three quarters of an inch distance, from each other. The fog increases; and the rods are perfectly wet, from end to end. It is now too dark for further accurate observation.

Jan. 30. Nine o'clock, A. M. I find the air ftrongly electrified *positively*, in a flight froft, and thick fog. The balls feparate full half an inch: they are diffurbed by the wind; but it does not clofe them; and the experiment is tried eafily. There hath been a fmall shower of snow, which lies thinly spread upon the houses; and I have often sufficient (as I do now), that *this forms points*, and conducts the electricity faster. The electricity continued the whole day.

Feb. 4. Nine o'clock, A. M. A fharp froft, and thick fog. The air is ftrongly electrified *pofitively*: the balls diverge full three quarters of an inch. Eleven o'clock, A. M. The balls are ftationary,

[41]

stationary, at upwards of an inch distance. They close at the approach of excited wax.

Half paft two, P. M. The fame as at eleven o'clock. Three o'clock. Over-caft and cloudy: the balls are very ftill, but fhew fcarce any fign of electricity.

Feb. 11. Eight o'clock, A.M. A thick fog is fenfibly electrified *positively*. The balls diverge a quarter, or three eighths, of an inch. Wind S.W. and troublesome. Thermometer 38. Barometer, 29,94.

Feb. 15. Half paft ten, A. M. I find a thick fog, fenfibly electrical. The balls diverge fiveeighths of an inch, full. Prefently, after I had fixed my rod, there fell fome fmall drops of rain. Upon the moment of its falling, the balls increafed their divergence near, or quite, a quarter of an inch. I never faw a fog more ftrongly electrified when the weather was fo warm, the mercury in my thermometer, in the open air, being feven and an half degrees above the freezing point. I fuppofe *bigher in the atmosphere* it is now uncommonly cold.

Fifty minutes past two, P. M. It snows very fast. The air is now strongly electrified *positively*. The balls separate full three quarters of an inch. Wind S. W.

From the fmall number of experiments I have been able to make, on the electricity of the atmofphere, I cannot help being of opinion, that fogs are much more ftrongly electrified *in*, or *immediately after*, *a froft*, than at other times; and that the electricity in the fogs is often the ftrongeft, F

foon after their appearance. I also now hold it for a certain rule, that, whenever there appears a thick fog, and the air is at the fame time sharp and frofty, that fog, is strongly electrified positively. Though rain may not be an immediate, yet I am inclined to think it is by no means a very remote confequence of electricity in the atmosphere; and, from the trifling observations I have had an opportunity to make on that fubject, I have not failed to find, that, in two or three days, after I have difcovered the air to be ftrongly electrified, (especially if that electricity continued for as long a time), we have had rain, or other falling weather, and I incline to believe, more plentifully, in proportion to the ftrength, and continuance, of the electricity; if not rain, fnow, &c. according to the state of the atmosphere, with respect to heat and cold. If electricity be not a cause, I think it at least a prognostic, of falling weather. But, for further satisfaction in this particular, I would recommend it to any gentleman curious in these enquiries, and having leifure, to keep an electrical journal, upon a plan of the following kind.

Let a large book be provided, and ruled in the manner of a bill-book, ufed by tradefmen. The columns fo ruled may contain a collection of obfervations in the following order: Date and day; hour, latitude and longitude, or place; divergence of the balls; kind of electricity; variation of the needle; dip of the needle; barometer, thermometer, hygrometer, wind, weather, occafional obfervations; to which may be added, the rain-gage, windgage, &c. Thefe things being carefully noted, and

and kites being frequently raifed, to the greateft heights possible, together with a thermome-ter (.), in different states of the weather, would probably foon throw new light upon this fubject, and perhaps produce discoveries, of which we now have not the least idea. From my experiments, and obfervations, on the electricity of fogs; I once imagined, that, whenever I faw a very thick one, and the air was at the fame time fharp, and frofty; that fog, was ftrongly electrified politively: but I have met with feveral exceptions to this rule, for on Dec. 24, 25, 26, 27, 28, 29, 1772, in all which days there were thick fogs, thermometer from 36 to 33, wind conftantly N. E. I could perceive no feufible electricity. Hence I conjectured, that though I could discover none in my situation, yet higher in the atmosphere it might probably be found in plenty, and this conjecture was prefently afterward verified by Mr. NAIRNE, who observed the air to be electrical, when he flood in the golden gallery of St. Paul's cathedral, which is about two hundred and eighty feet in height, though he could difcover none in the ftone gallery, which is confiderably lower: and the fame obfervation hath fince been made by others; and by myfelf, when I found the divergence of the balls to be increased, if I projected the rod, (from which they were fuspended) through one of the lights, in the lanthorn; which is still higher. And it is with fome pleafure that I have fince obferved that Dr. LIND, and Mr. BRYDONE, have made the

(0) If Lord CHARLES CAVENDISH'S can be raifed properly, perhaps that may be preferable to any other.

F 2

fame

fame remark in raifing their electrical kites (p). I have made many obfervations on the electricity of the atmosphere, of which I kept a journal more than a year: but I have no defire to publish it; as I hope the curious in these matters will be favoured with a much more accurate one, by gentlemen better qualified to undertake it.

[44]

It may not perhaps be improper to obferve, that in the courfe of my experiments upon the electricity of fogs, I have frequently observed the balls to diverge full two inches: but this never happened except in a thick one; when the wind was S. W., and the mercury in the thermometer, under 40. In the inftances I met with, where I could discover no electricity in fuch a fog, though the mercury stood at 35 or 36, the wind was always N.E. The apparatus I used, confisted of a light rod about feven feet long, furnished with a box containing a pair of light cork balls, hung by linen threads, feven inches long. This rod was placed in a piece of wood, (over the top of one of the highest windows in the house, most remote from other buildings) properly fitted to receive it. The end of the rod, from which the balls were fufpended, was elevated to an angle of about forty-five degrees. Another rod, of equal length, was provided with a tin focket, into which went a long, fubstantial, flick of hard fealing wax, or shell lac; which being excited, and projected out at the window, was brought near the balls; and thus readily, determined the kind of electricity in the atmosphere.

(p) See Dr. PRIESTLEY'S Hiftory of Electricity, fecond edition, p. 333. Experiments by Mr. DE ROMAS.

2

But

But in an open fituation, fuch an apparatus is unneceffary, as one of Mr. CANTON'S electrometers having light balls, fucceeds very well, when held at the diftance of about two feet from the body: the back of the obferver being turned towards the wind. This method alfo ferves to determine the kind of it, when there is a much larger quantity of electricity in the atmosphere; and which would electrify the balls fo ftrongly, if held at the end of a long rod, high in the air; that excited wax, &c. being brought under them, would not produce the leaft alteration in their divergence.

Notwithstanding the balls hanging from the end of my rod, in the open air, have in some fogs diverged full two inches; yet I have never been able to make a pair of very light ones, hanging from an infulated conductor, in my room, diverge in the leaft, by means of the electricity collected from fuch a fog, by a long filling-rod, round which a fine pointed wire was twifted, and made to communicate with the conductor. On mentioning this circumstance to my worthy friend Dr. FRANKLIN; he defired me to try whether having electrified the air in one room, I could by introducing the end of fuch an infulated rod into that air, make the balls diverge, when hanging at the opposite end of it, in another room. I have fince tried the experiment in two rooms, separated by a passage, nine feet long, in the following manner: I drew off the charge of a large jar, without fuccess; but having recharged it, and drawn it off a fecond time; the balls hanging from the end of the rod, (upwards of twenty feet long) in the other room, diverged a full

full inch; and I suppose the effect would have been greater, but there being a large fire in the room where the experiment was made, on opening the door, in order to introduce the pointed wire, which was twisted round the infulated rod, I apprehend, much of the electrified air was displaced, by the outer air prefling in upon it; and driving it to the chimney, &c.

A pair of balls hanging from my hand, near the end of the rod, in the electrified air, diverged one inch and an half: but being held near the other end of the rod, in the unelectrified air; they diverged only half an inch. I then infulated the rubber of my machine, and fluck a long fharppointed needle in the back of it. Then hanging a chain from my prime-conductor to the table, I began to turn the winch; when the air of the room, the end of the rod, &c. were prefently affected: and the balls at the oppofite end of it, in the other room, foon feparated confiderably more than an inch.

I cannot prevail on myfelf to quit this pleafing, yet difficult fubject, without exprefling a wifh, that an electrical machine may be conftructed, to work from ten, to fifty large cylinders, furnifhed with a prime-conductor, batteries, and other apparatus, proportionably large; the whole to be inclofed by brick walls, having flews quite round it, (like an hot-houfe, for botanic purpofes) to keep the air in the room in a due temperature for experiment. With fuch a machine as this, properly managed; new, unexpected, and wonderful difcoveries might be





be made: and, to use the words of my learned and? ingenious friend Dr. PRIESTLEY, they are not philofophers who think no advantages could be gained by it. Electrical bells should also be fet up, to give notice of electricity, in the atmosphere; and by a pair of light pith or cork balls, hanging by linen threads from the apparatus, the kind, continuance, and changes of the electricity should be carefully noted. It would also be proper to put out occasionally, a long flick, or the ftrongest parts of a fifting-rod, having a box, with a pair of light cork balls hanging from thence, at the end of it, which would difcover much fmaller degrees of electricity in the air, than is fufficient to ring bells; and by these, the kind of it may be readily afcertained. Such a course of experiments as I have recommended in this paper, would foon throw new light upon the fubject of electricity; hitherto, I believe, but little underftood ; though fo interefting to mankind, and fo highly deferving the niceft inveftigation, of the most curious enquirers into nature. But these pursuits can be properly attended to, by those only, who are gentlemen of fortune, and lei-fure: and could fuch be prevailed on to undertake them, I have not the least doubt but the exquisite knowledge of this fecret part of the operations of nature, which they would foon attain in the practice, would prove an ample reward of their labours; an honour to their country, and perhaps a benefit: to the whole human race.

