

**Experiments on electricity, : being an attempt to shew the advantage of elevated pointed conductors. / By Mr. Edward Nairne, F.R.S. Read at the Royal Society, June 18 and 25, 1778.**

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*from the Author*

E X P E R I M E N T S

O N

E L E C T R I C I T Y,

B E I N G A N

A T T E M P T

T O S H E W T H E

Advantage of elevated pointed Conductors.

By Mr. EDWARD NAIRNE, F. R. S.

Read at the ROYAL SOCIETY, June 18 and 25, 1778.



L O N D O N:

Printed by J. NICHOLS (Successor to Mr. BOWYER).

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## E X P E R I M E N T S, &c.

A DIFFERENCE of opinion prevailed some time ago and has of late been revived, in regard to the termination of conductors for the preservation of buildings from the effects of lightning.

Some gentlemen think that they should not terminate in a point, but be blunted; and also that they should not exceed the highest part of the buildings<sup>(a)</sup>; they likewise think, that to prevent lightning from doing mischief to great works, high buildings, and large magazines, the several buildings should remain as they are at top, that is, without having any metal above them, either pointed or not, by way of a conductor; but that on the inside of the highest part of such a building, and within a foot or two of the top, it may be proper to fix a rounded bar of me-

(a) Mr. WILSON's new Experiments on the Nature and Use of Conductors, p. 7.



tal, and thence continue it down along the side of the wall to any kind of moisture in the ground<sup>(b)</sup>.

Others again are of a directly contrary opinion; thinking a conductor should not only terminate in a point, but be considerably elevated above the highest part of the building<sup>(c)</sup>.

As it most certainly would be of great consequence to mankind to know which is the most eligible of these opinions, I have attempted, by what I could learn from the artificial lightning of our electrical machines, to determine which method is best to secure buildings from the effects of lightning: whether I have succeeded I leave to the judgement of others to decide from the following experiments and observations, which are submitted with all due deference.

In pl. XIII. fig. 1. is a representation of the electrical machine and the apparatus used in the following experiments. The diameter of the glass cylinder A, fig. 1. was eighteen inches; the length of the conductor B, which was of wood covered with tin-foil, was six feet, and the diameter of it one foot. At the end of this conductor was screwed a brass ball c, of four inches and a half diameter. This conductor, when charged by the

(b) Mr. WILSON's Letter to the Marquis of ROCKINGHAM, Phil. Transf. vol. LIV. p. 247.

(c) Ibid. p. 203.



glass cylinder, being intended to represent a cloud charged with electricity or matter of lightning will, for distinction sake, be called the *artificial cloud*, in the following experiments. D represents a brass rod on a stand covered with tin-foil, having a good metallic communication with the earth; at one end of this rod were screwed other rods, terminating with different sized balls, or a rod terminating with a point. This rod D was moveable in a socket, in order that it might be placed with its termination at different distances from the ball C at the end of the artificial cloud. As the terminations on this rod were to receive from our artificial cloud the stroke or sparks of our artificial lightning, it will be called the *receiving rod* in the following experiment. The receiving rod with its stand was intended to represent a conductor to a house, on which different terminations might be placed.

Before I relate the experiments it may be proper first to premise, that electric fire, drawn off gradually from an electric cloud, was never known to do any mischief, if the substance drawing it off had a good metallic communication with the moist earth; and that when any damage is done, it is occasioned by a stroke of lightning, or in other words the electric fire of the charged cloud suddenly discharged through that body.



## E X P E R I M E N T I.

I screwed a brass ball, of four inches diameter, at the end of the rod D, then placed it nearly in contact with the ball C, at the end of the artificial cloud: on charging the artificial cloud, the electric fire struck from the ball C to the ball at the end of the rod, and continued striking all the while it was gradually removing to the distance of seventeen inches and four tenths, and sometimes on to nineteen inches: I have had strokes twenty inches in length, but it has been very rare..

## E X P E R I M E N T II..

The apparatus remaining as in the last experiment, I changed the ball of four inches diameter on the rod D, and in its place screwed a ball of one inch diameter, then I placed this very near to the ball C as before: on charging the artificial cloud, the electric fire now struck to the ball at the end of the rod D of one inch diameter, and continued striking whilst it was gradually removing to the distance of about two inches. It then gave over striking, and was succeeded by a hissing noise and a continued light on the one inch ball, whilst it was removing very gradually from the ball C, until the distance between the  
two



two balls was about ten inches; the hissing noise then ceased, and the light disappeared on the inch ball. It now began to strike again, and continued striking to the inch ball all the time it was very gradually removed, till the distance was about fourteen inches eight tenths; and sometimes would continue to strike to sixteen inches and three tenths.

This striking to the ball ceasing, and then beginning again, when the artificial cloud is strongly charged, is a fact which I believe has not been taken notice of by any one before; I shall have occasion to speak of it again in some of the following experiments.

#### EXPERIMENT III.

The apparatus remaining as in the last experiment, I changed the ball of one inch diameter, and in its place screwed one of three tenths of an inch diameter. This small ball was also placed nearly in contact with the ball c: on charging the artificial cloud, the electric fire struck to this ball of three tenths, and continued striking to it whilst it was very gradually removed to the distance of half an inch; beyond that, it would not strike to it. But the ball was luminous all the while it was removed beyond the striking distance as far as thirty-three inches.



## E X P E R I M E N T IV.

The apparatus remaining as in the last experiment, I only changed the ball of three tenths, and in its place screwed a wire about three inches and a half long, terminating in a point: on charging the artificial cloud, I could not now get the electric fire to strike the point, though the point was almost in contact with the ball c; but when it was about half a tenth of an inch distant from it, then the electric fire ran in a very small stream to the point; but beyond that distance, though moved very gradually, it was only luminous, and continued so at the point all the while it was gradually removing to the distance of six feet from the ball c, at the end of the artificial cloud.

## E X P E R I M E N T V.

The apparatus remaining as in the last experiment, I changed the wire, and in its place screwed the ball of four inches diameter, used in the first experiment, having now a small hole through it. I then put into this hole a wire, leaving the end, which terminated in a fine point, projecting out only one tenth of an inch beyond the surface of the ball, and directly pointing to the ball c:

on



on charging the artificial cloud, the ball with the point being first placed nearly in contact with the ball c, it was then gradually removed; but not at any distance would it strike to the ball, or the point projecting out of it. The point was luminous at the distance of thirty inches;

EXPERIMENT VI.

Every thing remained the same as in the last experiment, except only that I now pressed in the point, till it was even with the surface of the four inch ball: on charging the artificial cloud, the electric fire did now strike to the ball at any distance, from being nearly in contact, all the while it was very gradually removed to as far as seventeen inches and a quarter, though before in the last experiment, where the point projected from the ball only one tenth of an inch, it would not strike at any distance.

EXPERIMENT VII.

The apparatus remaining as in the last experiment, I took a ball of three inches and a half in diameter, which had a small hole through it, and screwed it to a hollow brass stem. Then I put into this hole one end of a wire, and the other end, which was pointed, projected one inch beyond



beyond the surface of the three inch and half ball. This ball and stem, with the pointed wire to it, I fixed to a stand covered with tin-foil; having a good metallic communication with the earth, I placed this stand so that the point was directly opposite to the side of the artificial cloud, and exactly at five feet distance from it: then, on charging the artificial cloud, the greatest striking distance from the ball c to the ball of four inches diameter, on the receiving rod d, was found to be sixteen inches and seven tenths.

#### EXPERIMENT VIII.

Every thing continued as in the last experiment, only now I drew the wire out of the ball and stem so far that the point projected nine inches beyond it: on charging the artificial cloud, the greatest striking distance now was found to be but six inches and eight tenths.

Now, in order to see how far a point, or different sized balls fixed on the stand, and having a very small separation in the metallic communication with the earth, would visibly act to carry off the electric fire of the artificial cloud, I made the following experiment.



EXPERIMENT IX.

I took a stick of common sealing-wax, and having fixed a screw to each end, I pasted a slip of tin-foil the whole length of the surface, and having made a separation of the foil of about one fiftieth of an inch, I screwed the pointed wire into one end, and the other end of the wax to the brass rod, where the ball with the point projecting from it was placed in the last experiment. I also removed the other stand with the ball, to which the artificial cloud likewise struck in the same experiment; the artificial cloud was then charged, and the stand being placed in such a manner that the point was directly opposite to the side of the artificial cloud; it was then removed till I found the distance at which the light between the separation of the tin-foil no longer became visible. This distance of the point on the wax was above seven feet, how much farther it might have been luminous I had no opportunity of trying, this distance being the farthest I could remove it in my room, and under the disadvantage of having the end of the artificial cloud within thirty-three inches of the edge of the wainscot. When a ball of three tenths of an inch was put in the place of the point, the light was visible at the distance



tance of four feet six inches, but with a ball of three inches diameter only at two feet.

#### EXPERIMENT X.

I took another stick of sealing wax, one inch and three tenths diameter, and about ten inches long, and pasted on it round pieces of tin-foil of half an inch in diameter, at about half an inch distance from each other. One end of this stick of wax was screwed to the receiving rod D, fig. 2.; and into the other end was screwed the pointed wire used in the fourth experiment. I then laid a piece of brass on this wax, so as to connect all the separations of the round pieces of tin-foil except two; then the point of this wire on the wax was placed nearly in contact with the ball. On charging the artificial cloud the electric fire now struck to the point, and continued to strike to it all the while it was gradually removed to the distance of one inch and one tenth: beyond that distance it would not strike, but the point continued luminous till it was removed to the distance of three feet.

#### EXPERIMENT XI.

The apparatus remaining as in the last experiment, I only took away the piece of brass which laid on the wax

to



to connect the pieces of tin-foil together. The charged artificial cloud did not now strike to the point until it was removed from the ball c to the distance of four inches and a half; it then began to strike to it, and continued striking whilst it was gradually removing sometimes to ten inches; but when the point was removed beyond the greatest striking distance, the point was not luminous as in the last experiment, except when the artificial cloud discharged its electric fire out into the air, in a diverging pencil from the ball c: then it was luminous, but at that instant only. Every time the artificial cloud struck to the point, the electric fire made a beautiful appearance in passing off between the separations of the pieces of tin-foil. I then connected all the tin-foil on the wax so as to leave no separation, then the charged artificial cloud would not strike to the point at any distance.

EXPERIMENT XII.

I placed the rod D, with the four-inch ball at the end as in the first experiment, this I put on a glass pillar to insulate it; then from the rod I made a communication to the earth, with about three feet of silver wire, which was only  $\frac{1}{800}$ th part of an inch diameter: on charging

C

the



the artificial cloud, it struck to the ball D, as in the first experiment, *viz.* seventeen inches four tenths. Now as the wire was so small which conducted the stroke, I thought I might be sensible of its passage if I held the wire between my fingers; I accordingly pressed my fingers together, with the wire between, but there was not the least sensation; nor should I have known it had passed my fingers if I had not seen or heard the stroke from the artificial cloud to the ball with which the wire was connected. I then tried if it was visible in the dark, but there was not the least appearance of light, except where there happened to be kinks in the wire. I was accidentally very sensible of one of those sparks: for when I was trying the experiment in the dark, I happened to get so near as to receive the stroke just on my forehead; it made me reel till I fell against the wall. It may be proper to observe in this experiment, that if the fingers are held at a little distance from the wire, that a small quantity of electric fire will strike out to them the same as it does when conducted off by a larger quantity of metal.



## O B S E R V A T I O N I.

From the three first experiments it appears, that our artificial cloud strikes at distances greater as the termination of the conductor is more blunted, or as it terminates with the largest ball; and that the striking distance is less as the end of the conductor tends more to a point; and in the fourth experiment, that when the end of the conductor is pointed, the point is not struck at any distance whatever; but continues luminous to a certain distance, carrying off silently the electricity of our artificial cloud.

It seems from these experiments, that pointed conductors are to be preferred before those terminating with a large ball, the pointed one depriving the cloud silently of its electric fire; whereas the ball receives the electric fire in a strong spark. And in the fifth experiment, where a point projects but one tenth of an inch from a ball of four inches diameter, neither the ball, or point projecting from it, is struck at any distance. This seems to shew the utility of a pointed rod, even if it projects but a small distance above the highest part of a building.

The sixth experiment shews, that a point within the surface of a ball does not prevent the ball being struck. The seventh and eighth experiments likewise shew, that



our artificial cloud strikes to a ball of four inches diameter, only at the distance of six inches and eight tenths, when the point is drawn out nine inches from the three inch and a half ball, placed opposite to the side of the artificial cloud; and that when the point projects only one inch, that then it strikes to the four inch ball at sixteen inches and four tenths distance.

May one not from these two last mentioned experiments conclude, that the more elevated our pointed conductors are, the greater is the chance of preserving our buildings from the effects of lightning?

For here our point being elevated or projecting nine inches out of the ball, representing the highest part of a building, was found continually depriving our artificial cloud of its electric fire to such a degree (though it was kept charging all the time) that it would not strike half the distance that it did when the point was elevated only one inch.

And from the ninth experiment we learn, that the conductor terminating in a point acts at a far greater distance than one terminating with a ball, in carrying off the electric fire, or matter of lightning from our artificial cloud. It must be further remarked, that though the point was luminous so far, yet there was no distance whatever at which our artificial cloud would strike to it.

From



From the tenth and eleventh experiments we learn, that the metallic part of our conductor being separated or discontinued is the reason that our artificial cloud does strike to the point; and that it strikes further to the point as the number of the separations are increased; and that if the metallic communication with the moist earth be made compleat, that then our charged cloud will not strike to the point.

When a conductor to a building, terminating in a point, has been struck, I am inclined to think, that there had not been a compleat and sufficient metallic communication with moist earth; and from all the accounts I have met with, this seems to have been the cause of their having been struck. From the twelfth experiment we learn, that a very fine wire will conduct a strong spark.

Fig. 3. represents a moveable artificial cloud: it consists of a hollow tube of wood, with a ball at each end, being together about six feet in length: from each end was suspended a light hollow wooden cylinder EE; these with the balls and tube were covered with tin-foil: it was placed with its axis resting on two semi-circular hollows in a piece of brass fixed on a glass pillar, by which it was insulated: it moved very easily on its axis, and was brought to a horizontal position by means of two moveable pieces FF.



## E X P E R I M E N T XIII.

I first put this moveable artificial cloud into an horizontal position, and placed it so that the brafs on which the axis rested was in contact with the end of the artificial cloud B. Then, under each of the hollow cylinders EE, I placed a stand GG, having a good metallic communication with the earth. On one of the stands there was put a pointed wire, the same as was used in the fourth experiment; and on the other, a brafs ball of three inches diameter. I then placed the point and ball each twelve inches from the middle of the bottom of its correspondent hollow cylinder: on charging the artificial cloud (which consequently charged the moveable artificial cloud in contact with it) the point was luminous, and the moveable artificial cloud still remained in an horizontal position, though there was now a point under one end and a ball under the other; and on ceasing to charge the two clouds, it was found directly after, that the point had drawn off almost all the electric fire from both.



## E X P E R I M E N T   X I V .

The two clouds being charged, I took away the stand with the three inch ball on it, the point remained luminous, and the moveable artificial cloud still continued horizontal, not being attracted to the point, though there was now only the stand with the pointed wire under one end of it, the point having carried off the electric fire as in the last experiment.

## E X P E R I M E N T   X V .

The two clouds being again charged, I replaced the stand with the ball on it; and now, instead of taking away this stand, as I did in the last experiment, I took away the stand with the pointed wire on it: the consequence was, that the end of the moveable artificial cloud was now attracted down to the ball till it came to its striking distance, where it then discharged its electricity on it in a strong spark (see fig. 4.). The moveable artificial cloud then receded a little till it was charged, it then was attracted by the ball as before, till it came to its striking distance, when it again discharged its electricity at once, and so continued striking and then receding to a little distance as long as the two clouds were charged.

E X P E -



## E X P E R I M E N T XVI.

The moveable artificial cloud continuing to strike to the ball as in the last experiment, I now replaced the stand with the pointed wire on it, then immediately the point became luminous, and the moveable artificial cloud ceased striking to the ball, and soon returned to its horizontal position as at first (see fig. 3.).

## E X P E R I M E N T XVII.

The apparatus remaining as in the last experiment, and the two clouds continuing to be charged, I took away the stand with the point; then the moveable artificial cloud was attracted down to the ball, and struck as before. I then placed the stand with the point close to the stand with the ball; on which the point became instantly luminous, and immediately the moveable artificial cloud gave over striking, soon returning from the ball and settling nearly in an horizontal position. There the point carried off the electric fire as in the thirteenth and fourteenth experiments.

## O B S E R V A T I O N.

From the thirteenth experiment, with the point under one end of the moveable artificial cloud, and a three  
inch



inch ball under the other end, it seems as if neither the ball or point attracted either end; or that they both equally attracted, or repelled each end, as in either case the moveable artificial cloud would remain horizontal.

And in the fourteenth experiment, in order to try whether the point would attract or repel the moveable artificial cloud, the ball was taken away, and only the point was left under one end, as now all the action of the point either to attract or repel would be exerted on that end which was now over the point, and consequently that end should either be attracted down to it, or repelled from it: but from the experiment it appears, that the point drew off all the electricity silently, without either attracting or repelling the end of the moveable artificial cloud which was over it, as it continued horizontal all the time it was charged.

The fifteenth experiment was made to see if the ball would either attract or repel the moveable artificial cloud, as in this experiment the ball only was under one end, and every thing else exactly the same as when the point only was under. But here we find the effect of the ball very different from that of the point; for instead of drawing off the electricity silently, as the point did, without attracting the end of the moveable artificial cloud; on the contrary, the moveable artificial cloud was

D

attracted



attracted down towards the ball, till it came within its striking distance, where it discharged its electric fire all at once on the ball with a loud and strong spark.

And again, in the sixteenth experiment, where the stand with the point is replaced at the other end, whilst the cloud is attracted down to the ball, it instantly prevents its striking to the ball by carrying off the electric fire as fast as the moveable artificial cloud receives it from the artificial one.

And from the seventeenth experiment we learn, that when the stand with the point is placed close to the stand with the ball, whilst the moveable artificial cloud is striking to it, the cloud even in this case instantly ceases to strike to the ball, returning from it and soon settling nearly in an horizontal position.

#### EXPERIMENT XVIII.

I took off the cylinders *EE* from the ends of the moveable artificial cloud (the height of my room not allowing them to be suspended in the following experiments); I then placed it, together with the glass pillar whereby it was insulated, upon another foot of such a height that when the ball at one of the ends was three inches above the ball *c* at the end of the artificial cloud, then the  
moveable



moveable artificial cloud was horizontal. I then placed the stand with the point on it at the distance of eighteen inches, and directly under the ball at the other end (see fig. 5.): on charging the artificial cloud, the point was luminous; and that end of the moveable artificial cloud which was three inches above the ball c was attracted down to it, then receded from it about one inch, and then the artificial cloud kept constantly striking to it, as long as it continued to be charged. On ceasing to charge the artificial cloud, it was found immediately after, that the point had carried off almost all the electric fire.

EXPERIMENT XIX.

Every thing remaining as in the last experiment, and the artificial cloud being charged, I took away the stand with the point, and placed in its stead the stand with the three inch ball on it, exactly at the same distance as the point: then instantly that end of the moveable artificial cloud, which had continued to be attracted down near to the artificial cloud, was repelled from it, and at the same time the other end was attracted by the three inch ball till it came so near as to discharge its electricity on it in a strong spark. The end of the moveable artificial cloud then receded from the three inch ball,



the other end being now attracted by the artificial cloud, which charged it almost instantly again; it then receded with rapidity from it, and discharged its electric fire on the ball as before, and thus continued in great motion receiving strong sparks from the artificial cloud, and discharging them on the ball, representing in miniature a storm of lightning where an electrical cloud strikes into another cloud, and that discharges itself on a building that is without a regular conductor, or one terminating with a ball (see fig. 6.).

#### EXPERIMENT XX.

While this storm of lightning in miniature continued, I removed the stand with the three inch ball, and placed in its stead the stand terminating with the point; the point was immediately luminous, and in an instant the artificial storm ceased.

The end of the moveable artificial cloud, next the charged artificial one, was now attracted to it, as in the eighteenth experiment.

#### EXPERIMENT XXI.

The apparatus remaining as in the last experiment, I unscrewed the pointed wire from the stand, and screwed it



it into one end of a stick of wax of six inches in length, with eleven pieces of tin-foil stuck on it at one fortieth part of an inch asunder; then I screwed this wax with the point on the stand, and placed it so that the point was directly under the end of the moveable artificial cloud, and at eighteen inches distance as before: on charging the artificial cloud, the moveable artificial cloud was first attracted, then repelled, and so alternately as when the stand with the three inch ball was under; but with this difference, that instead of striking in a strong spark, as it did to the three inch ball, it now struck with a very small spark to the point, the point depriving the moveable cloud of most of its electricity as it approached it, which was very visibly passing away between the separations of the tin-foil.

EXPERIMENT XXII.

Every thing as in the last experiment, a chain only being hung on the pointed wire, thereby completing the metallic communication with the earth. As soon as the chain was hung on, the moveable artificial cloud instantly ceased striking to the point, and the other end of it was then attracted to the artificial cloud, which then kept constantly striking to it: the moveable artificial cloud



cloud did not return to the point as it did before the chain was hung on, as in the last experiment.

#### OBSERVATION.

In the eighteenth experiment, where the moveable artificial cloud was intended to represent a cloud in its natural state receiving electric fire from a charged cloud, we find, that the point deprived it of its electric fire which it received from the charged one so fast, that the artificial cloud could keep constantly striking to the other end, without repelling it from it; but that in the nineteenth experiment, when the ball was under the end of the moveable artificial cloud in the place of the point; then, instead of the artificial cloud continuing to strike to the other end without repelling that end, it now first attracted and charged it with electricity, or the matter of lightning; then immediately repelled it, and being attracted by the ball under the other end, it moved down with an acquired velocity, till it came within its striking distance, discharging then its electricity on the ball with a loud and strong spark, and so continued alternately receiving and discharging its electric fire on the ball. It being first attracted, at which time it received an additional quantity of electricity, and then repelled till it had discharged  
that



that additional quantity, is exactly agreeable to all the known laws of electricity.

This experiment may possibly throw some light on what we sometimes see in nature, *viz.* one cloud continuing to strike towards the earth a considerable time; for should a cloud in its natural state be so situated between a charged cloud and the earth, it may be first attracted and charged, and then repelled, and if it should be repelled so as to come within the attracting distance of any blunt body with a good or partial conductor, it would then continue to be attracted till it came within its striking distance, and then discharge its lightning suddenly on it; and if it was not repelled or attracted beyond the attracting distance of the charged cloud, it would again be attracted to it and charged, then repelled as before, and so may continue receiving and discharging the lightning till the charged cloud is nearly exhausted of its electricity or matter of lightning.

But if a cloud, in its natural state, should be so situated within the striking distance of a charged cloud, and at the same time within the power of a good metallic conductor terminating in a point; then from these experiments it does appear, that the charged cloud would continue striking to the natural cloud, and that would again  
part



part with it silently, by means of the point, without striking on it till the charged cloud is nearly exhausted.

When we see a cloud striking into another cloud several times together, we conclude from all the known laws of electricity, that the cloud which first received the stroke must have discharged part or the whole of what it received before it could receive another stroke.

In the twentieth experiment we find, that though our moveable artificial cloud was in great motion, receiving and discharging its electric fire on the ball, that, on taking away the ball, and putting the point in its place, the artificial storm immediately ceased.

In the twenty-first experiment, where the point was on a stick of wax, with separations in the metallic communication with the earth, we find that, even in that situation, the stroke on the point was very small to what it was on the ball with a good communication, great part of the electric fire visibly passing off as the cloud approached the point; and when the metallic communication was made compleat by hanging on the chain, it then ceased striking to the point.



## E X P E R I M E N T XXIII.

The tube which I before called the moveable artificial cloud in the former experiments, from its moving very easily on its axis, was, by means of two screws now fixed, immoveable, with the ball at one of its ends above the ball c at the end of the artificial cloud, at the height of three inches; and underneath the ball, at the other end, was placed the stand with the point, at the distance also of three inches. The artificial cloud was then charged, and an electric spark struck from the ball c at the end of it to the ball of the now fixed cloud above it, and at the same instant struck from the ball at the other end to the point at three inches.

## E X P E R I M E N T XXIV.

The tube used in the last experiment (which I now again call the moveable artificial cloud from its being made again to move freely on its axis) was placed exactly in every respect as in the last experiment; the only difference was, that it could now move easily on its axis, whereas in the last experiment it was fixed immoveable at the distances: on charging the artificial cloud, the moveable artificial cloud, instead of receiving a spark,

E

and



and discharging it on the point, as in the last experiment, was now attracted down to the artificial cloud there remaining, not striking to the point, or returning to it so long as the artificial cloud continued to be charged.

#### OBSERVATION.

By the twenty-third experiment we see, that if our cloud is fixed at a certain distance between the artificial cloud and the point, the fixed cloud, at the instant it receives the electric spark, directly discharges it again on the point. But in the twenty-fourth experiment, where there is no other alteration than making the cloud moveable on its axis, the distances being exactly the same, the end of the cloud then recedes from the point and will not strike to it. This twenty-fourth experiment is much more agreeable to nature than the twenty-third, for clouds are not fixed but floating bodies.

In order to see the effect of rods terminating with balls of different sizes, or terminating with a point, moving swiftly under my artificial cloud, I made use of the following apparatus.

In fig. 7. H is a hollow tube of wood covered with tin-foil, with a heavy weight fastened to one end of this tube; and at about three inches above the weight was an  
an



an axis, it was then suspended by this axis between two wooden pillars: in this wooden tube was a brass rod, which was moveable, so that a ball or point fixed on it could be raised to the height required.

EXPERIMENT XXV.

A ball of one inch and three tenths diameter was fixed to the under part of the artificial cloud at K, and then this apparatus was placed under it with a point, the swinging rod was held down to the floor, as in fig. 8. and the point covered: then the artificial cloud was charged by a certain number of turns of the glass cylinder; the swinging rod with the point was then let go, and passed swiftly and very near to the ball under the artificial cloud at K. This was repeated several times, removing the point lower each time till the greatest striking distance to the point was found, which was generally one inch and six tenths.

EXPERIMENT XXVI.

The point being removed, a ball of three tenths diameter was placed in its stead and tried, as the point in the preceding experiment; the striking distance was generally found to be two inches and one tenth.



## E X P E R I M E N T XXVII.

The three tenth ball being removed, another of one inch and three tenths was tried as in the two last experiments, and the striking distance was generally fifteen inches.

But when the weather has been favourable for electrical experiments, I have several times had strokes to the point from its passing swiftly, and as near as it could without touching the ball, till it was brought down to one inch and seven tenths, then the artificial cloud would cease striking to it till it was removed down to three inches and five tenths; it would then begin striking again, and continue striking to it all the while it was removing to the distance of ten inches and three tenths.

And when the three tenth ball was on in the place of the point, the artificial cloud would strike to it from its passing swiftly, and very near to the ball, and continue striking all the while it was removing to the distance of two inches and nine tenths; then the artificial cloud ceased striking to the ball till it was removed to three inches and seven tenths, and after that distance continued striking till it was removed down to ten inches and eight tenths. But when a ball of one inch and three tenths



tenths was used, the artificial cloud has struck, as it passed swiftly, very near to the ball on it, and all the time it was removed down to sixteen inches, there being no distance with this one inch and three tenth ball at which the artificial cloud left off striking, and then began again; but here with the point and three tenth ball there were two striking distances, as was before mentioned in the second experiment.

This remarkable phenomenon in electricity is, I believe, new to electricians, and may be worthy their consideration.

#### OBSERVATION.

In the twenty-fifth experiment it appears, that the point is struck by means of a swift motion; and from the twenty-sixth experiment, that the ball of three tenths was struck further than the point; and the ball of one inch and three tenths, in the twenty-seventh experiment, at a much greater distance than either, even with the swift motion.

From these experiments I should be induced, first, to prefer elevated pointed conductors; next to them those that are pointed, though they project but a little distance above the highest part of the building; and after them those.



those terminating in a ball, and placed even with the highest part of a building, though it does appear from these experiments, that they are more liable to be struck, and likewise have not the property of guarding the distant parts of a building as elevated points have; but if they have a good metallic communication with the earth, the building might not be hurt, though the lightning should strike on the conductor; yet, I believe, there are not many who would not shudder at the tremendous blow, if they were in a house when the conductor was struck. Those conductors which are recommended to be within the inside of a building, and one or two feet below the highest part<sup>(d)</sup>, are certainly very dangerous, especially for all that part of the building above the conductor.

I was a witness of the dreadful effects of a stroke of lightning on a house that had an accidental partial conductor within the inside of the upper part of the house.

It happened to a house near Ratcliff Highway, on the 29th of July, 1775. In the uppermost room stood a large iron triblet, of about three feet in height; the lightning made its way through the roof of the house, throwing off a number of tiles, rending and tearing the laths and plaster on the inside, to get to the triblet, on which it struck from thence to a hammer, which laid on the

(d) Mr. WILSON's Letter to the Marquis of ROCKINGHAM, *Phil. Trans.* vol. LIV. p. 247.



floor near it: it then made its way, by partial conductors, down into the cellar to the leaden pipe, which conveyed water from the main, and in its way rent the house in various parts, so as to make it scarcely habitable. It left marks of fusion on different metallic utensils, some of which I have now in my possession. If the conductor from the triblet had happened to have been made by a compleat and sufficient metallic communication with the earth, all parts of the house below would have been preserved; but the parts above would have been equally rent and destroyed.

I now beg leave to make a few remarks on Mr. WILSON's paper, intituled, *New Experiments and Observations on the Nature and Use of Conductors*. In p. 2. Mr. WILSON mentions, that he had declared his dissent in the year 1772 against pointed conductors: I will here copy part of his dissent as it is in *Phil. Transf.* vol. LXIII. p. 48. His words are, "Every point, as such, I consider as  
" soliciting the lightning, and by that means not only  
" contributing to increase the quantity of every actual  
" discharge, but also frequently occasioning a discharge  
" where it might not otherwise have happened. Whereas,  
" if instead of pointed we make use of blunted conduc-  
" tors, those will as effectually answer the purpose of  
" con-



“conveying away the lightning safely, without that tendency to increase or invite it.”

In answer to this I can only say, that, from these experiments of mine, the direct contrary appears to be the fact; that the point, instead of increasing an actual discharge, prevents a discharge where it otherwise would happen; and that the blunted conductors tend to invite the clouds charged with lightning.

The eleven first experiments of Mr. WILSON'S are intended to shew, that pointed conductors draw off the electricity from a cloud at a much greater distance than those which are blunted. My ninth experiment proves the truth of those experiments of his; the only difference is, that in mine the point acted on my artificial cloud at a much greater distance; from which it appears, to use his own words, p. 4. “that a charged body is exhausted  
“of more of the fluid by a pointed than by a blunted  
“conductor.” In answer to his twelfth experiment, and on to the eighteenth, where the model of the house moved swiftly, under his large artificial cloud, and where the point was struck at five inches, and sometimes at a quarter of an inch further than his three tenth ball<sup>(e)</sup>; I must observe, that I have sometimes seen his apparatus at the Pantheon, with which he made his experiments,

(e) Page 8.



strike as far to the three tenth ball as the point; but in my experiments I have had it strike ten inches three tenths to a point, and ten inches and eight tenths to a three tenth ball; but to a one inch and three tenths ball it commonly struck to fifteen inches, and sometimes to sixteen inches. In answer to the eighteenth and following experiments I must observe, that the substitute being fixed is unnatural; for clouds are composed of a fluid matter, moving with the utmost facility in another fluid substance; and from my twenty-third experiment, where the substitute was fixed, the point was struck; yet in the twenty-fourth experiment, where there was no other alteration than allowing the cloud to move freely, then the point was not struck. I imagine, if Mr. WILSON's large artificial cloud at the Pantheon, which was 155 feet long and 16 in diameter, had been properly insulated, and there had been several cylinders properly mounted to have charged it, he would have found the striking distance, and every other of his experiments, very different from what he did, particularly those where his substitute was fixed about one inch and a half from his large artificial cloud.

My reasons for thus thinking are, that when I placed a substitute of exactly the same dimensions in every respect as his, and placed it also about one inch and a half



from my artificial cloud, that then the longest spark that I could get to a point was one inch and one tenth; but to a three tenth ball it struck eight inches and seven tenths: and what further confirmed me in my opinion was, that when I placed a brass cone, half an inch at the base and two inches high, on my artificial cloud, to carry off part of its electricity, in order to prevent its being charged so high, every thing else being the same, that then I could get a stroke to the point one inch and one tenth as before, and sometimes not longer to a three tenth ball; but to a one inch and three tenth ball the distance was less, being not more than half an inch. But when I made no other difference than taking off the cone from the artificial cloud, it then struck to the point as before, *viz.* one inch and one tenth, and to the three tenth ball eight inches and seven tenths; but to the one inch and three tenth ball nine inches and one tenth, instead of only half an inch, as it did when the cone was on, and of consequence the conductor not so highly charged. If the substitute was placed in contact with the artificial cloud, then there was no distance at which it would strike to the point, but only to the balls, as Mr. WILSON observes was the case with his apparatus. His words are, p. 11. "So that bringing the two substitutes into contact occasions the same phenomena that the great cylinder  
" linder



“ linder did alone; that is, the rounded end would cause  
“ an explosion at a considerable distance, and the point  
“ little or none, notwithstanding it was brought close to  
“ the substitute.”

I must beg to intrude a little more on your time to remark on that part of Mr. WILSON's paper, where from his experiments he seems to conclude, that the lightning at Purfleet first struck on the point of the rod of the conductor, and then, by a lateral part of that stroke, struck the cramp on the coping stone. I believe, if he had examined the situation of the stone, and the place where the cramp was struck, he would have found, that if the lightning had struck on the point of the conductor, that to have produced that effect on the stone, it must after it had struck on the point, and passed down a quantity of metal, have struck from the metal up into the air, then down again on the cramp, and then again to the metal it had left, for the small dent or hollow made by the lightning was on the upper surface of the stone, and yet the metallic communication to the earth continued from the point under the stone which was struck. It appears more probable to me, from the trifling damage it did, that the charged cloud had passed over the pointed conductor, and had been exhausted of a great part of its electricity in passing; and that after it had passed,  
it

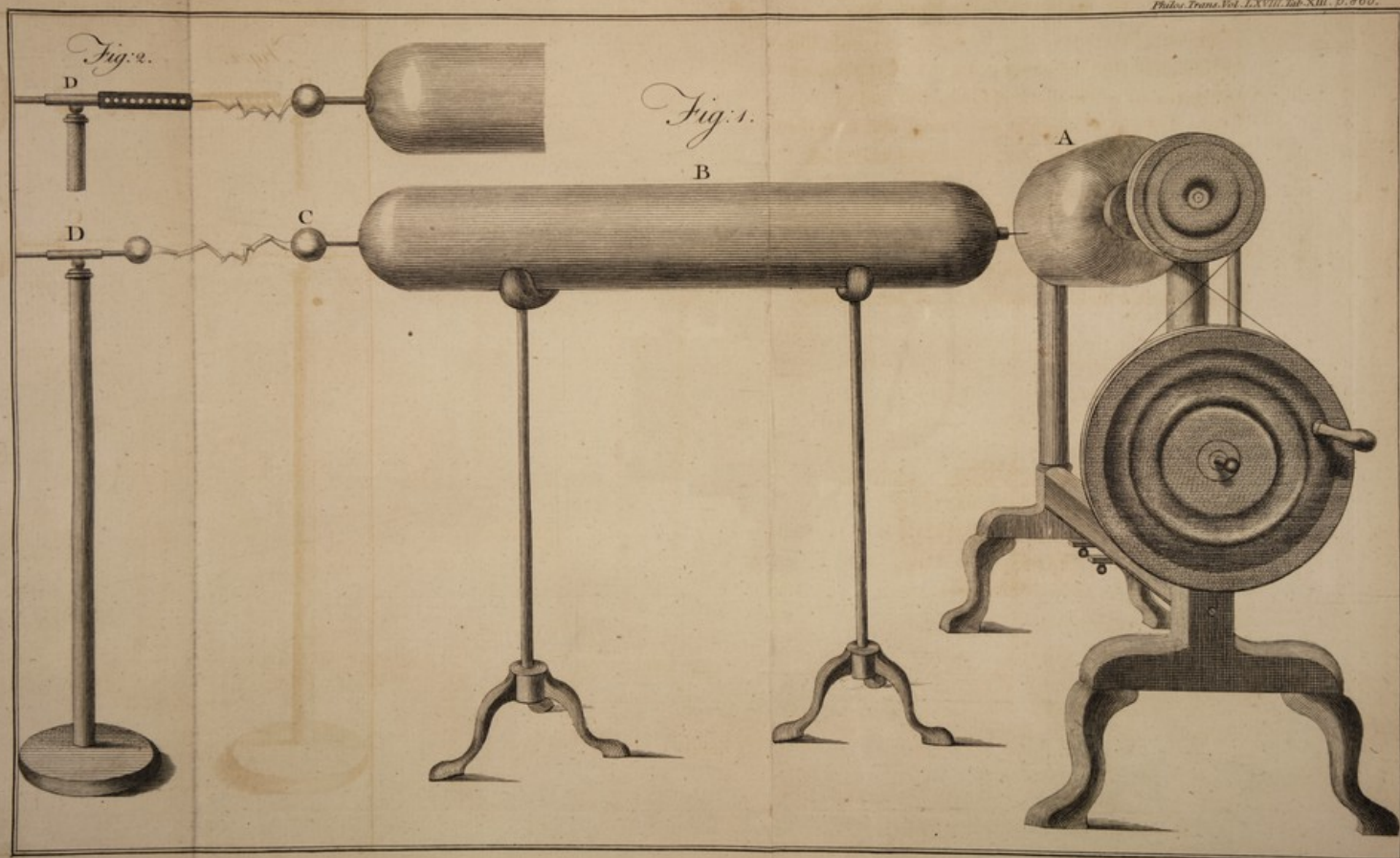


it was attracted down lower by a ridge of hills that was beyond, and that the cloud being out of the influence of the point to prevent its striking, the end of the cloud might strike at an angle in the cramp, and so to the metallic part of the conductor, which was only about seven inches below.

I shall conclude with observing, that Mr. HENLY and myself had the pointed rod of the conductor at Purfleet taken down to examine the point; but we found no appearance on it that shewed that it had been struck.













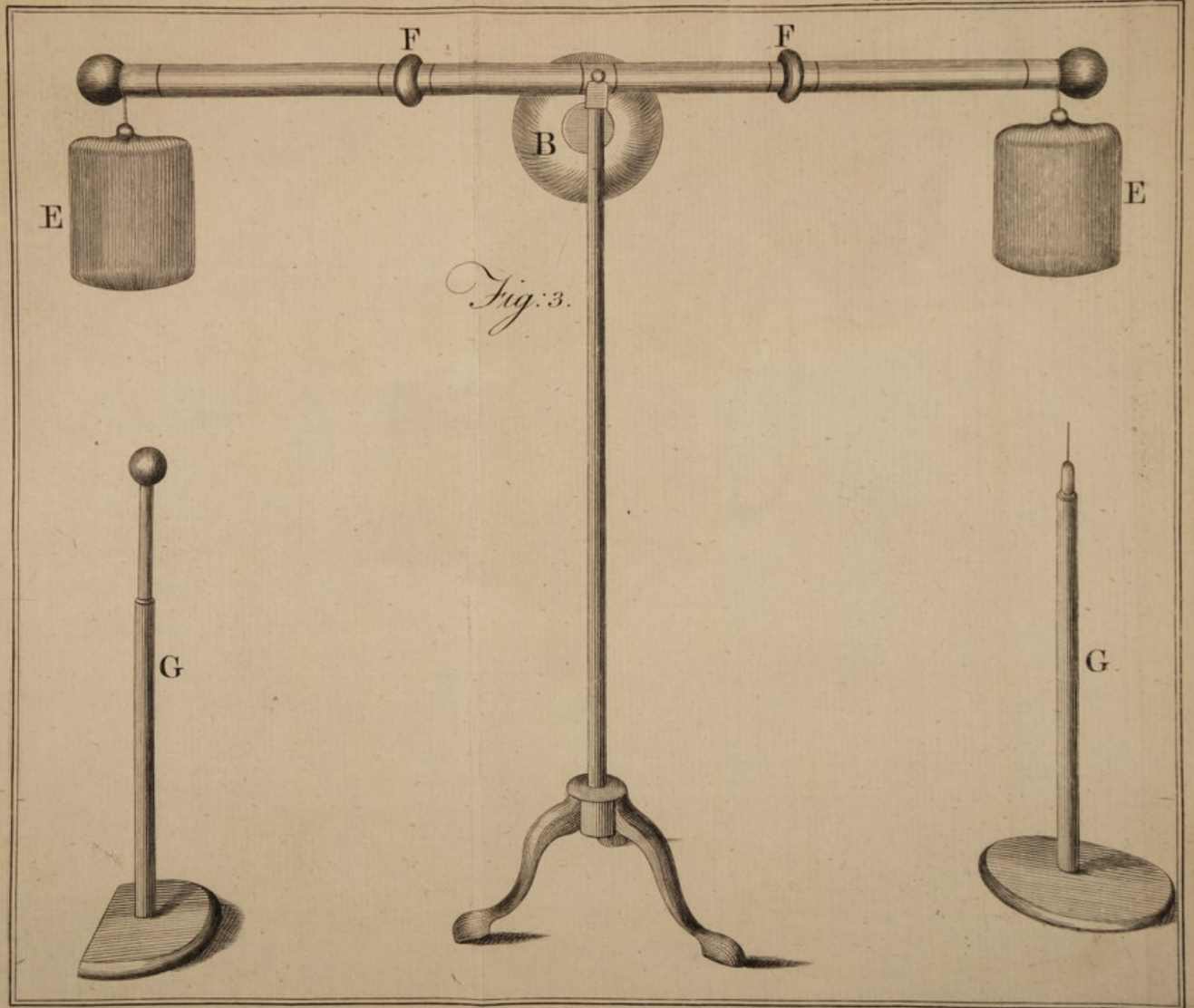




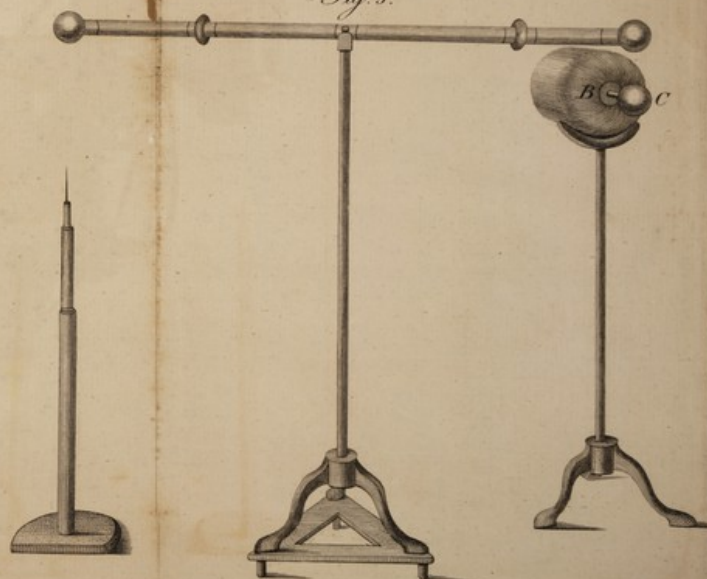




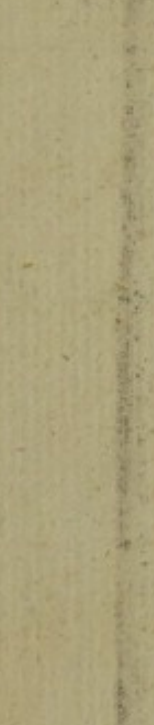
Fig. 4.



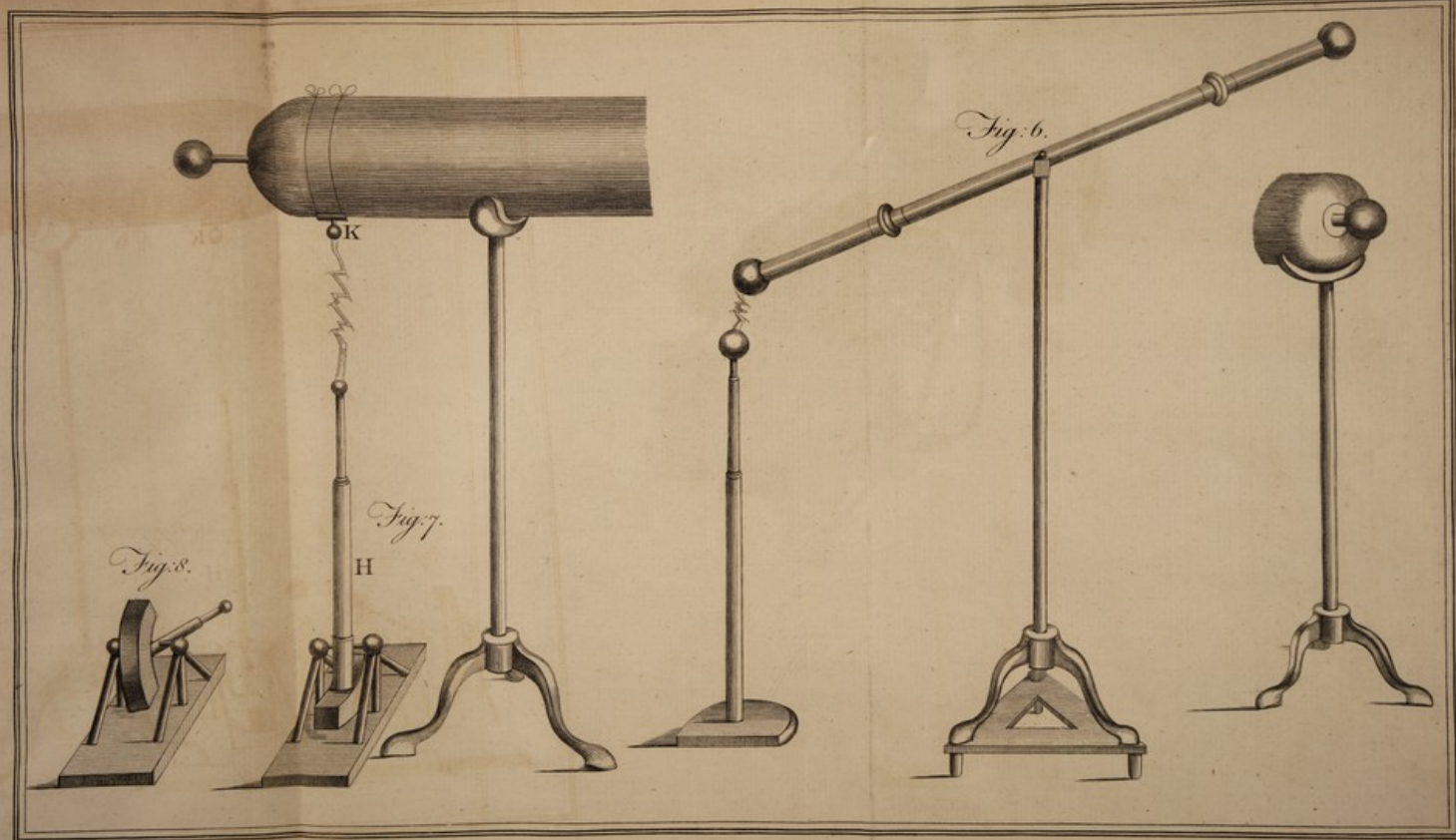
Fig. 5.













*Fig. 1.*

