XXXVII. *Experiments on Electricity, being an Attempt to ſhew the Advantage of elevated pointed Conductors.* By *Mr.* Edward Nairne, *F. R. S.*

N. B. This paper is miſplaced through a miſtake of the Secretary's; it ſhould have been inſerted before Dr. MUSGRAVE's.

Read June 18 and 25, 1778.

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[a]; 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.

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tal, and thence continue it down along the ſide of the wall to any kind of moiſture in the ground[b].

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[c].

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. Tranſ. vol. LIV. p. 247.

(c) Ibid. p. 203.

glaſs

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.

EXPERIMENT 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.

EXPERIMENT 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

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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.

EXPERIMENT 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.

EXPERIMENT 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 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.

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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

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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

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 kenks 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.

OBSERVATION 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.

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Fom 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.

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EXPERIMENT XIII.

I firſt put this moveable artificial cloud into an horizontal poſition, and placed it ſo that the braſs 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 braſs 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.

EXPE-

EXPERIMENT XIV.

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 of the electric fire as in the laſt experiment.

EXPERIMENT XV.

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.

EXPERIMENT 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.).

EXPERIMENT 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.

OBSERVATION.

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

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

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 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 compleating 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.

EXPERIMENT 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.

EXPERIMENT 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,

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 tinfoil, with a heavy weight faſtened to one end of this tube; and at about three inches above the weight was

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.

EXPERIMENT 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[(d)], 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

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, intitled, 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. Tranſ. 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 ten-
" dency 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[c]; I muſt obſerve, that I have ſometimes ſeen his apparatus at the Pantheon, with which he made his experiments,

(c) Page 8.

ſtrike

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

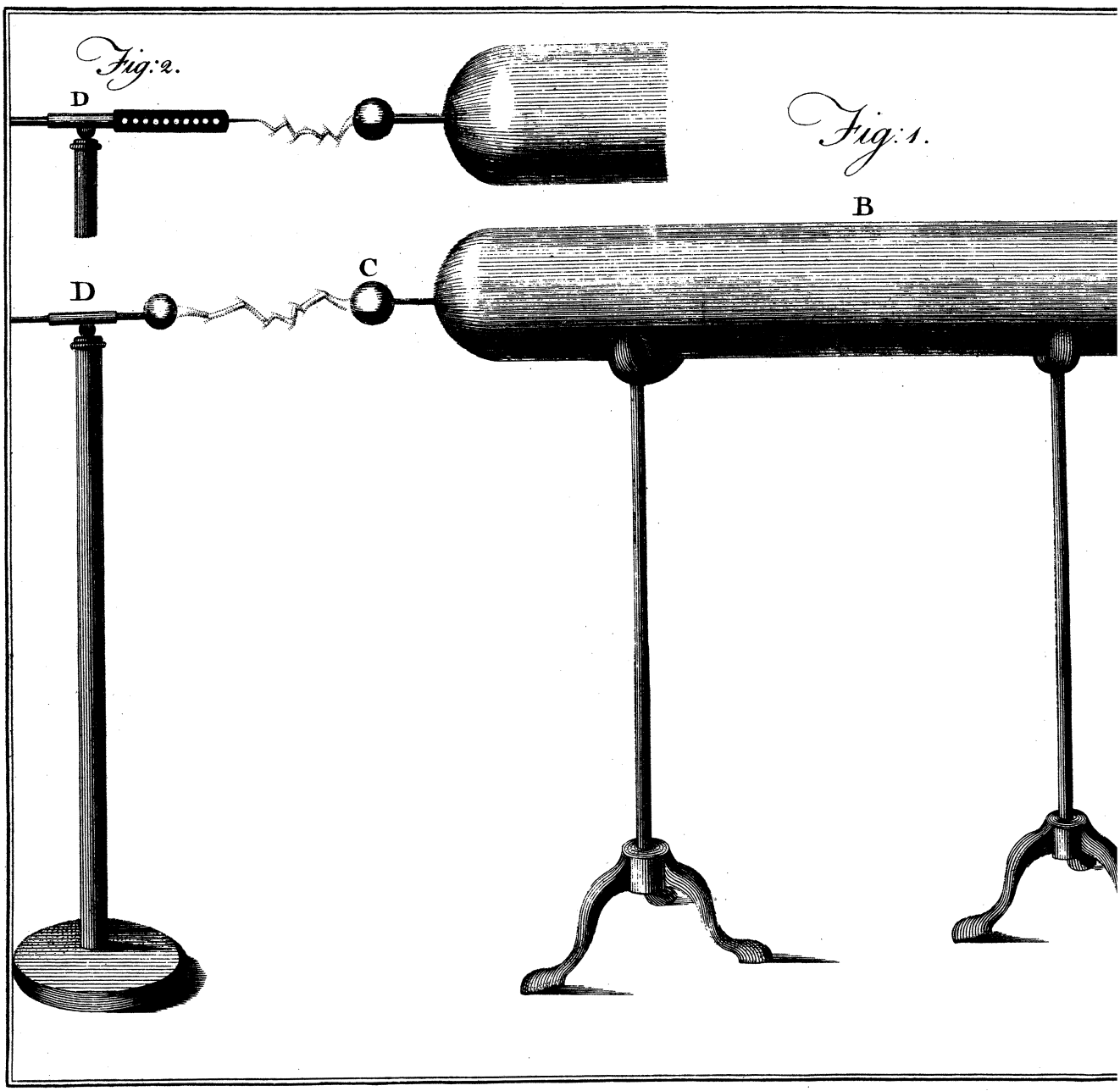
from my artificial cloud, that then the longeſt ſpark that I could get to a point was one inch and one tenth; but to a three tenth ball it ſtruck eight inches and ſeven tenths: and what further confirmed me in my opinion was, that when I placed a braſs cone, half an inch at the baſe and two inches high, 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 conſequcnce 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 con-
"tact occaſions the ſame phenomena that the great cy-

" 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 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.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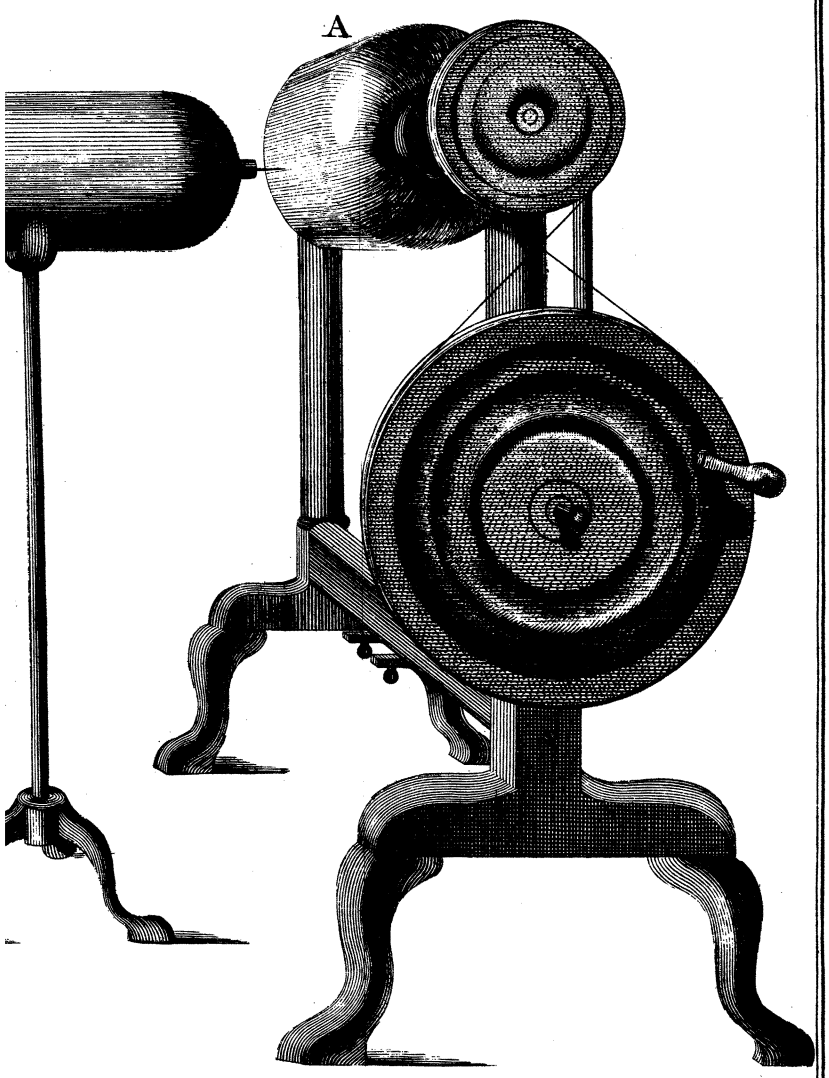
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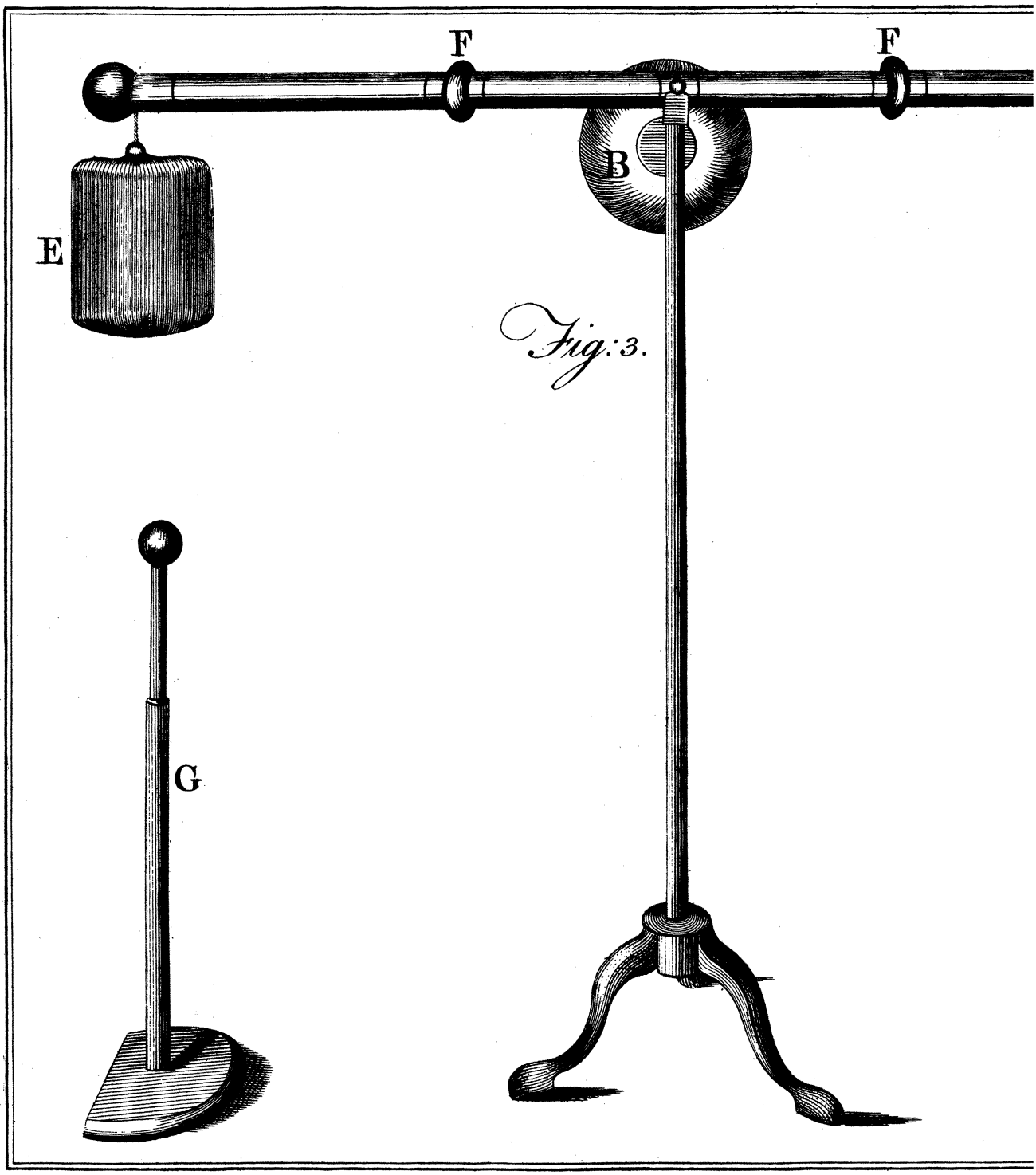

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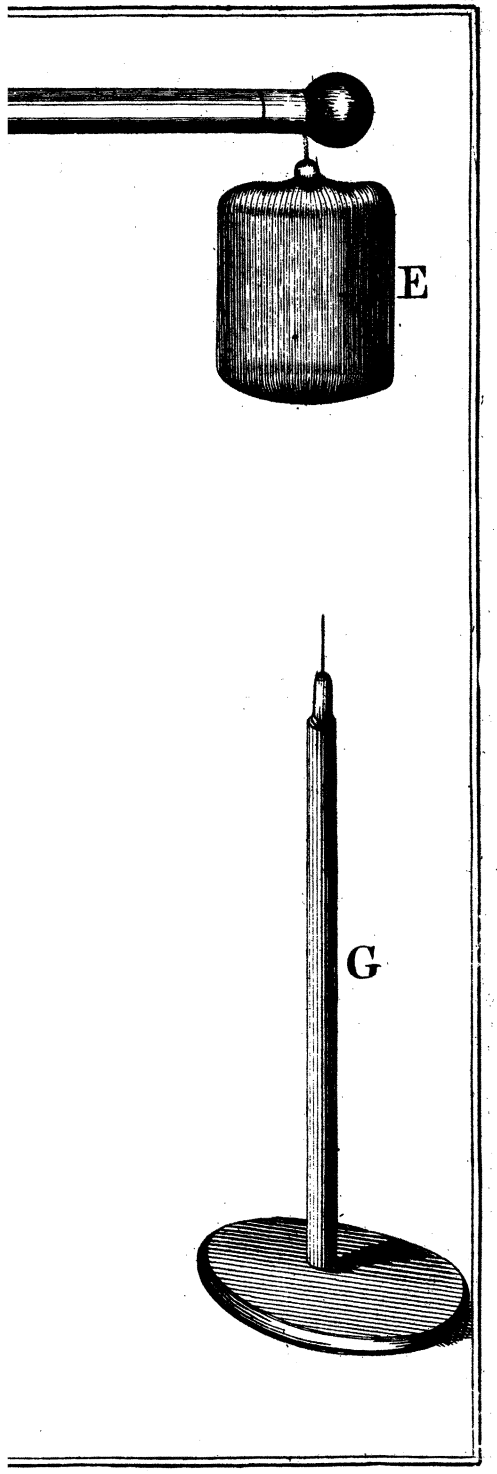
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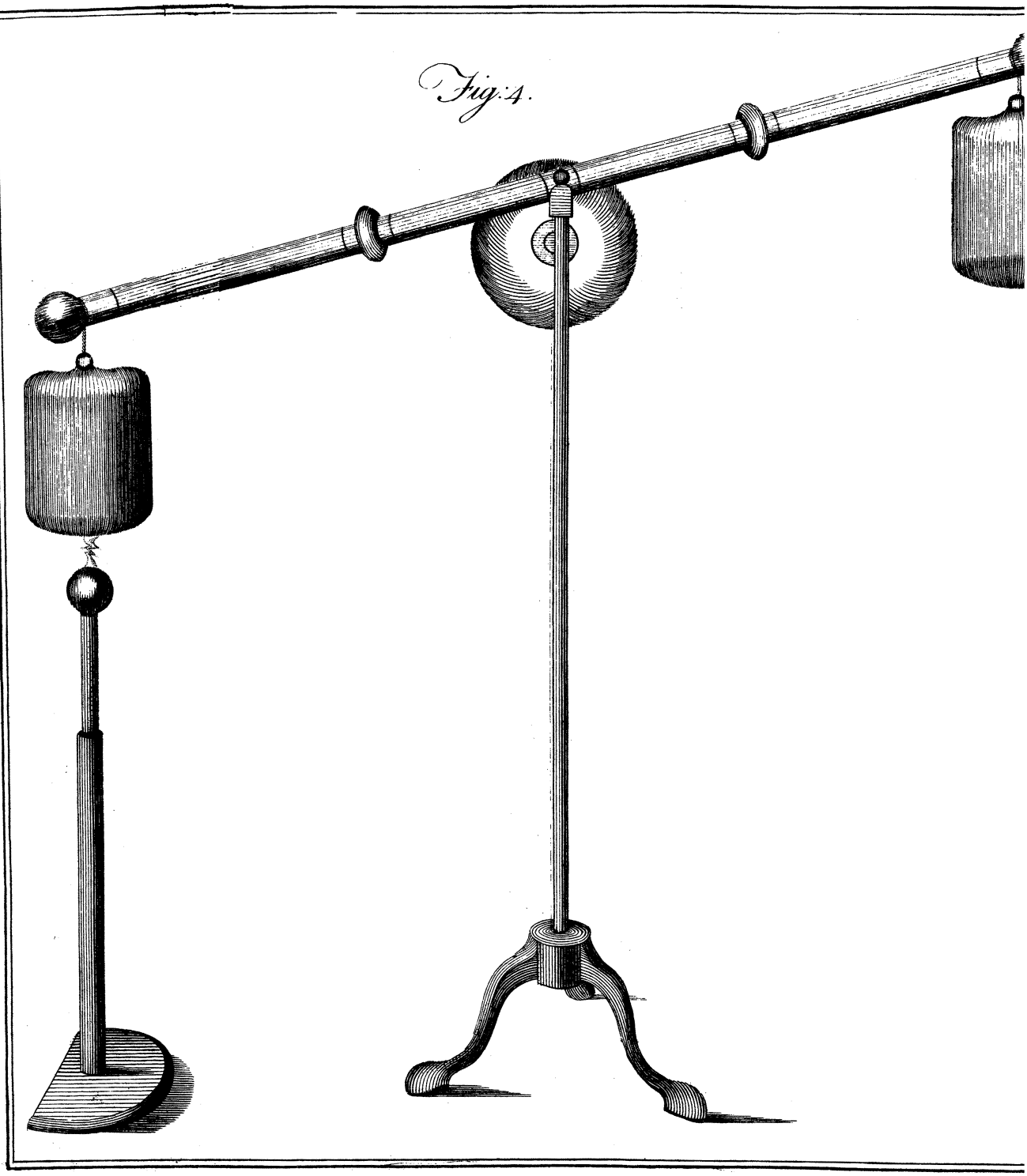
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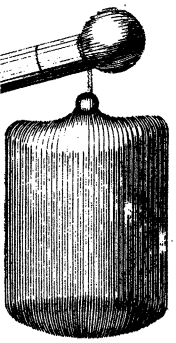

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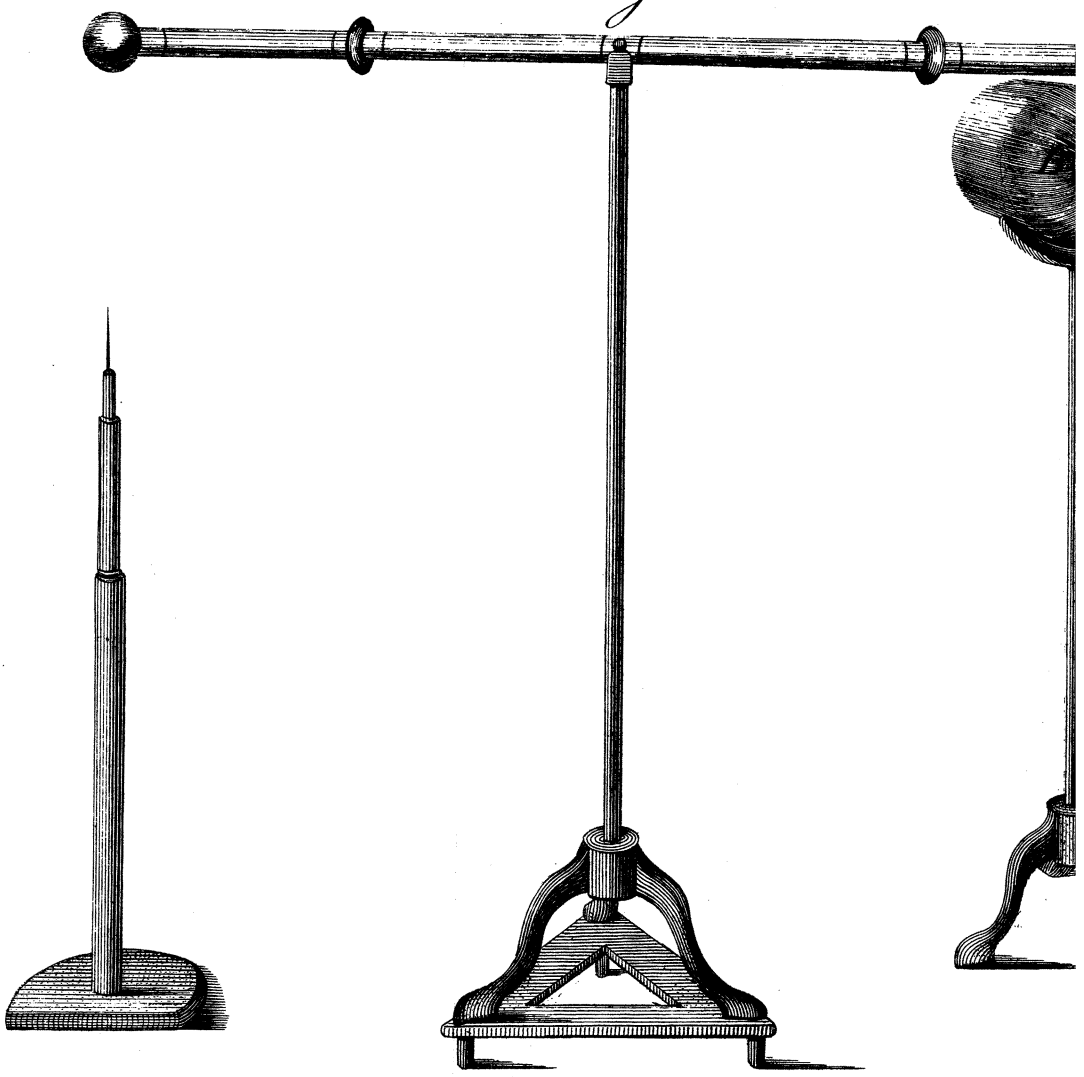

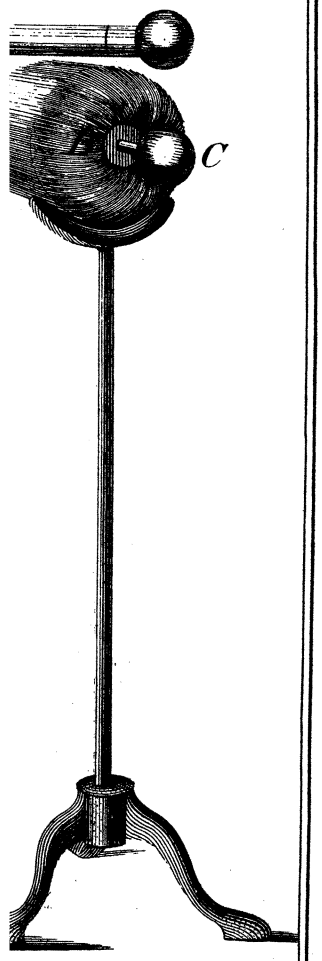

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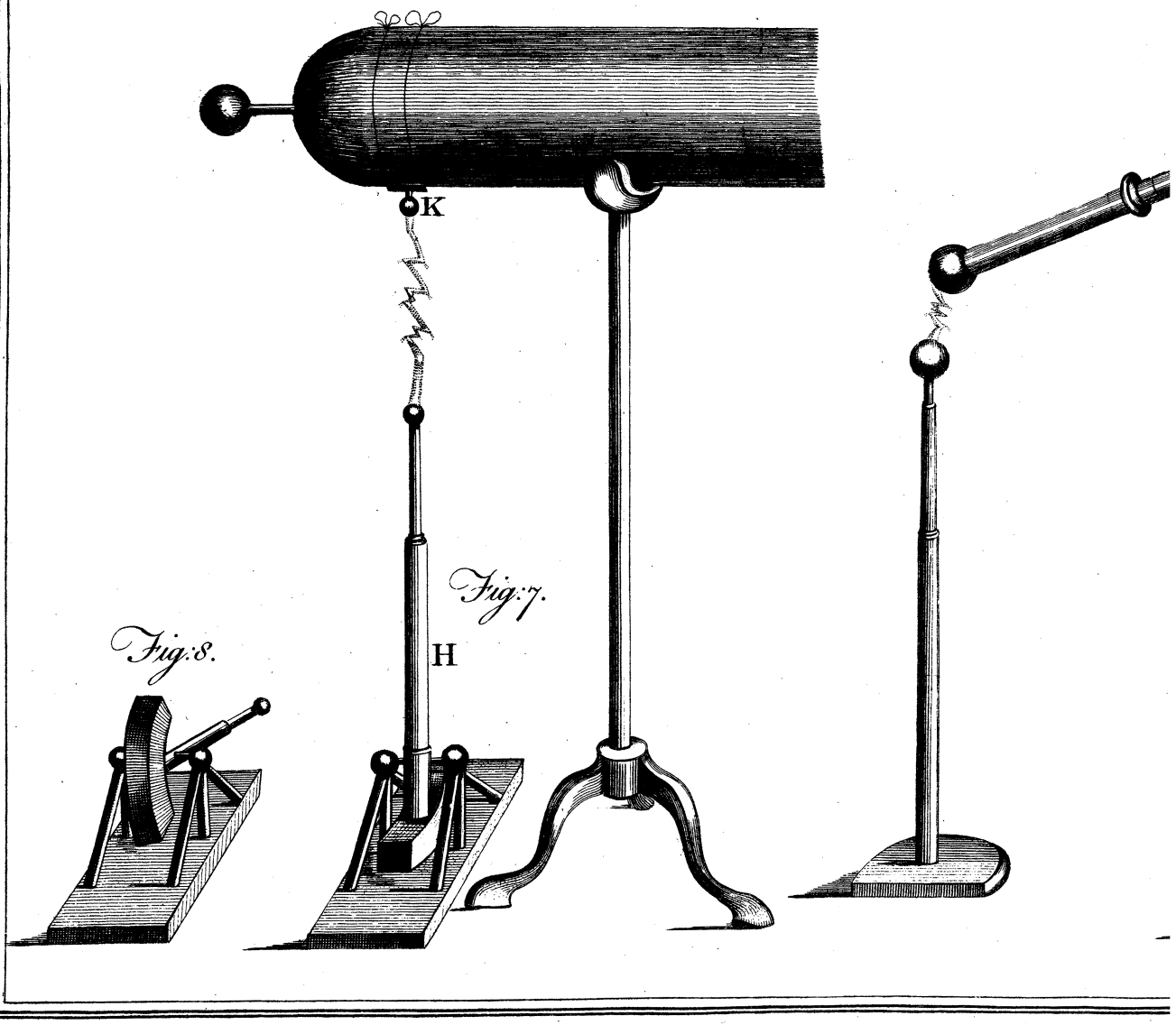
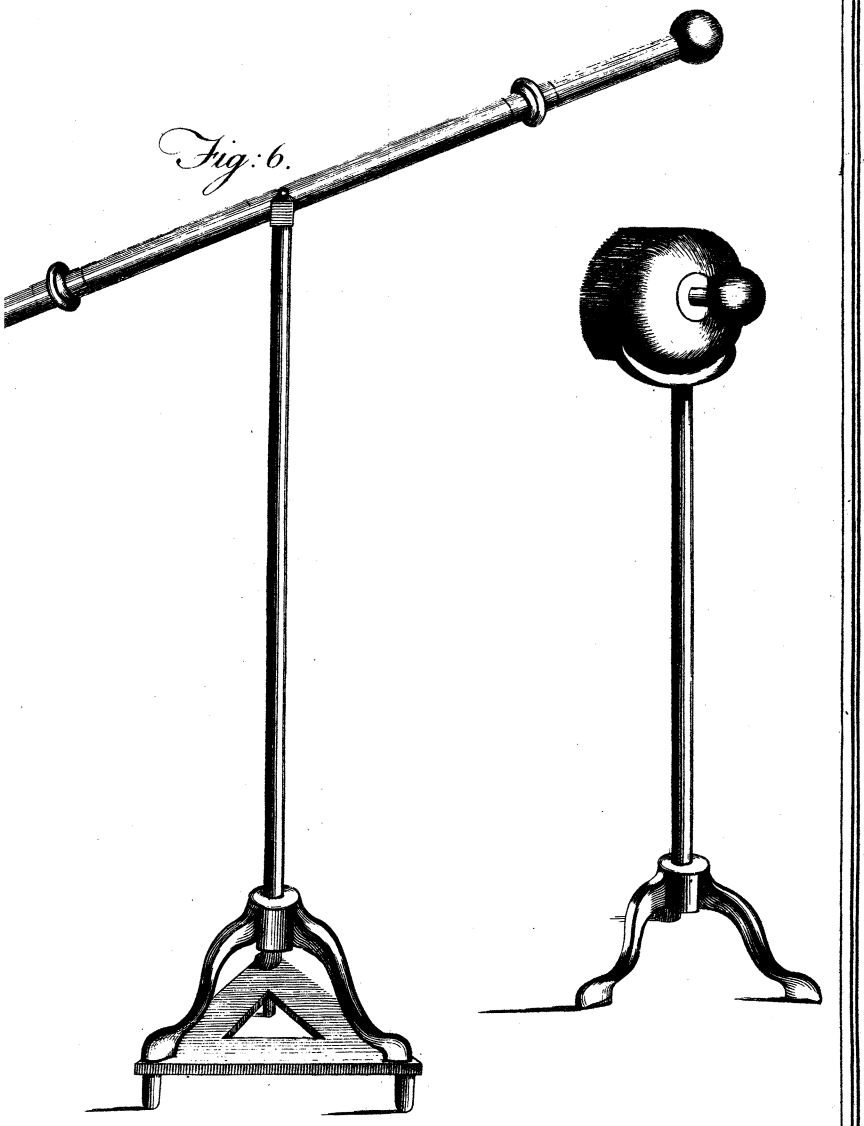


Fig: 7.

Fig: 8.

Fig: 6.



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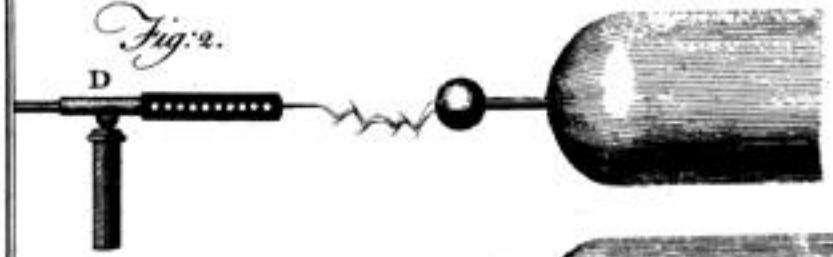

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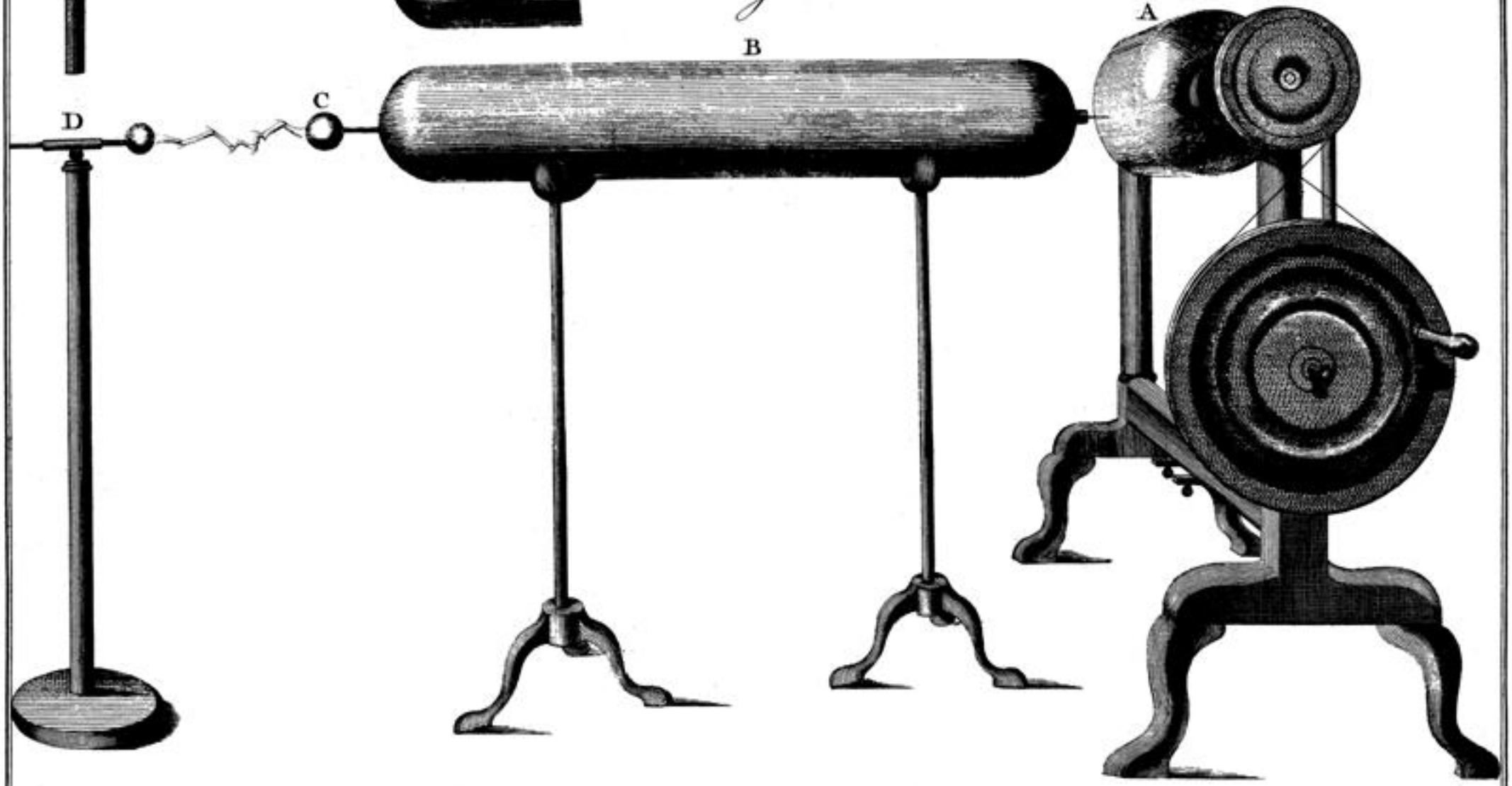

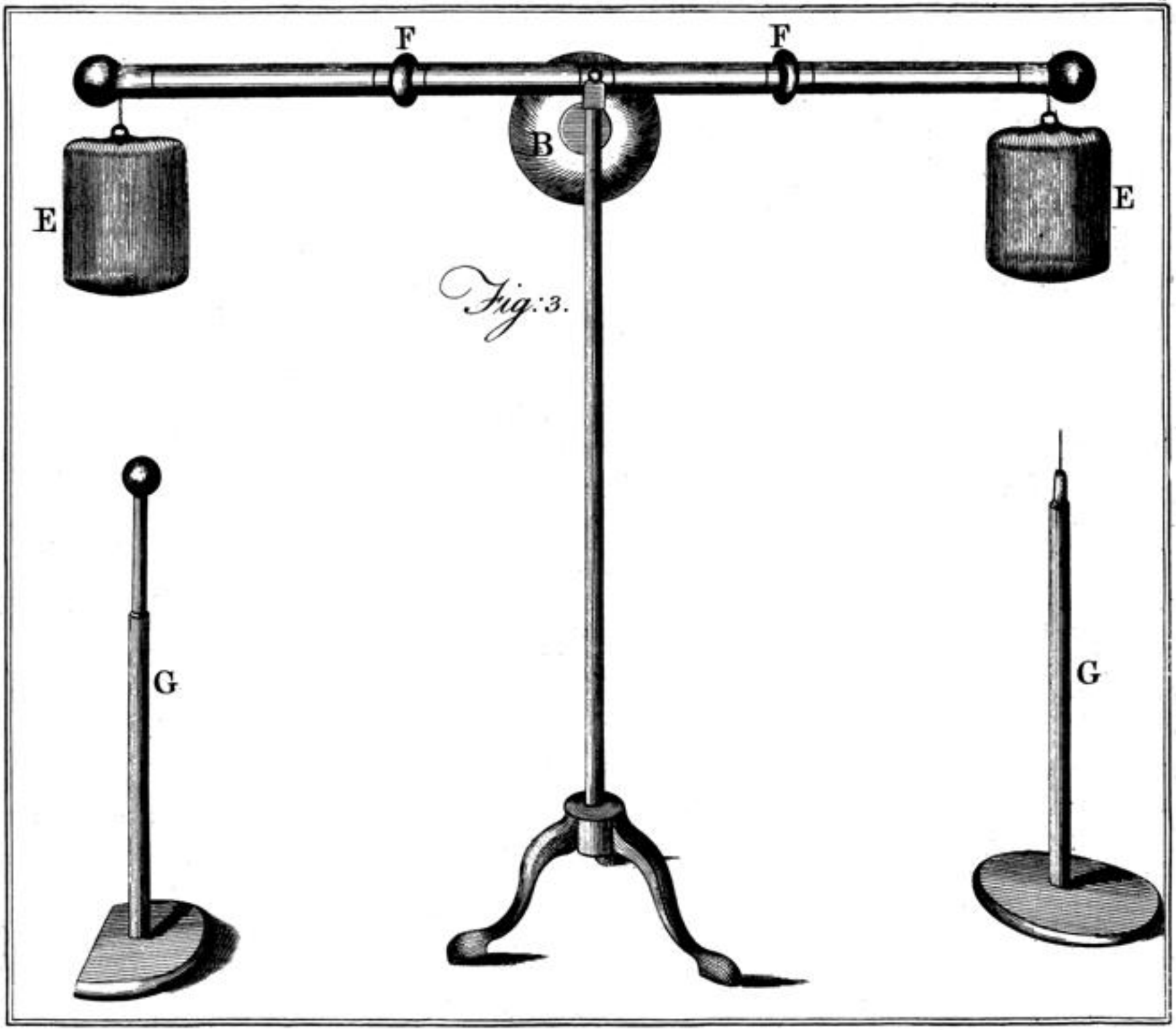

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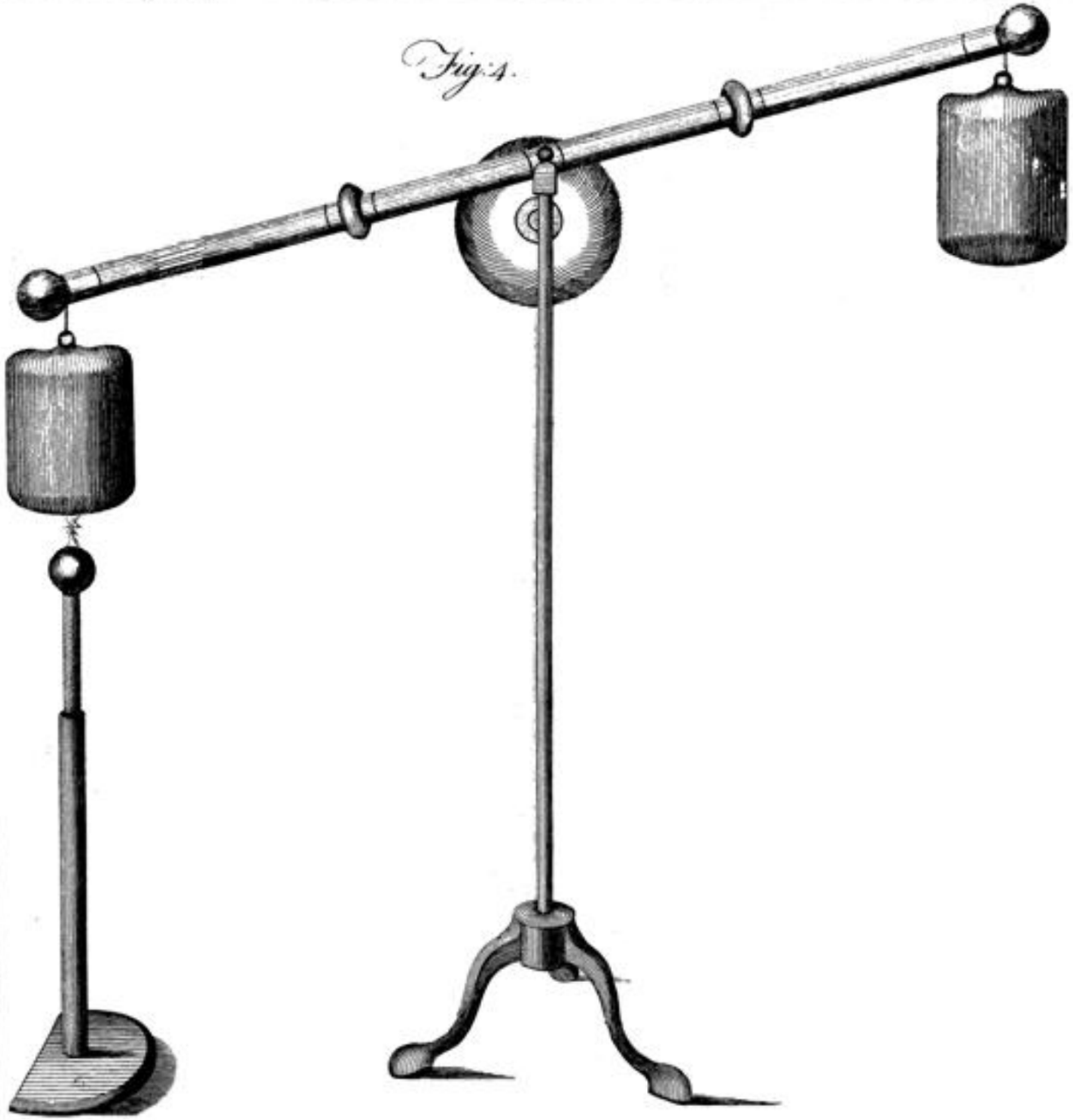

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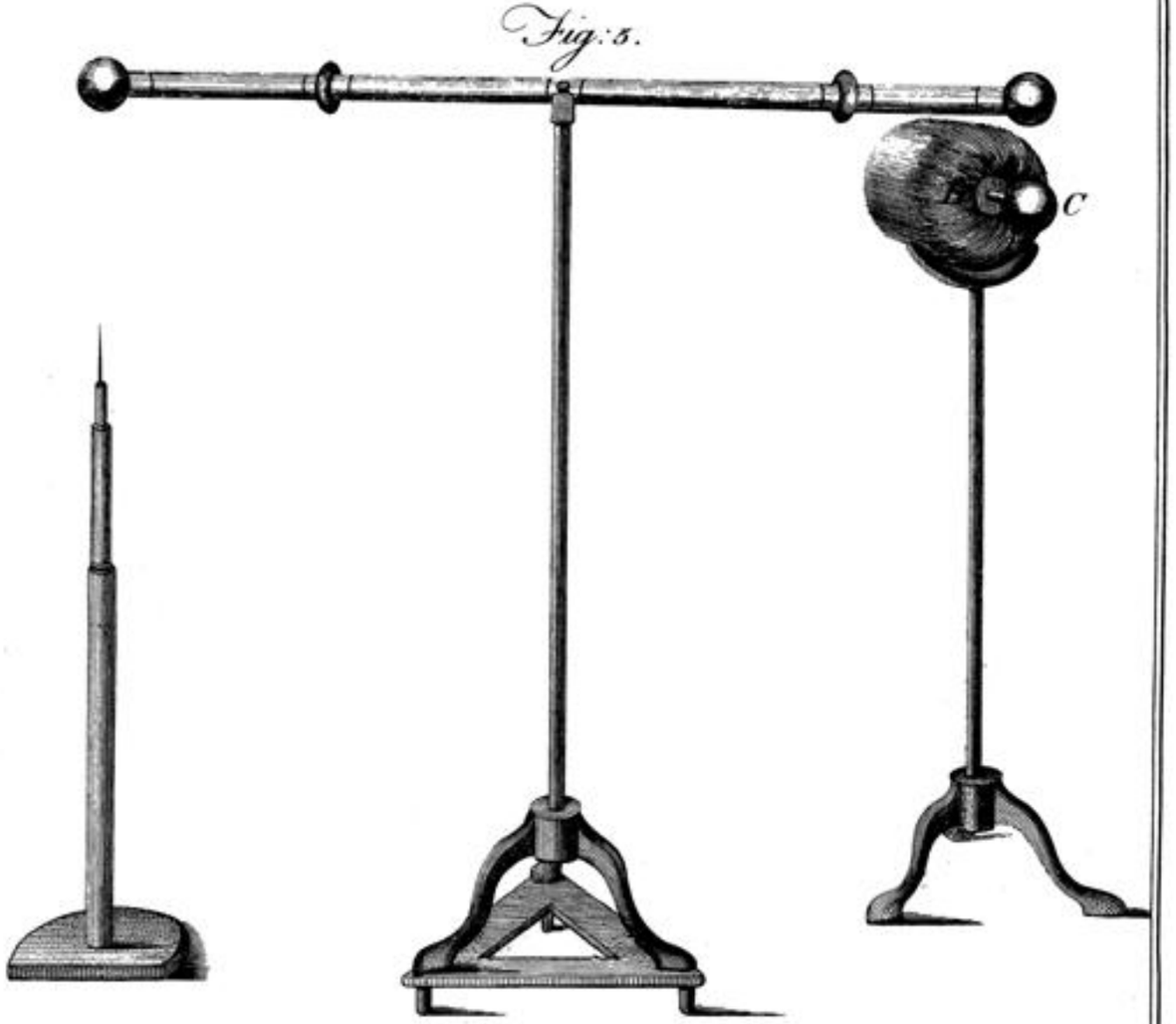

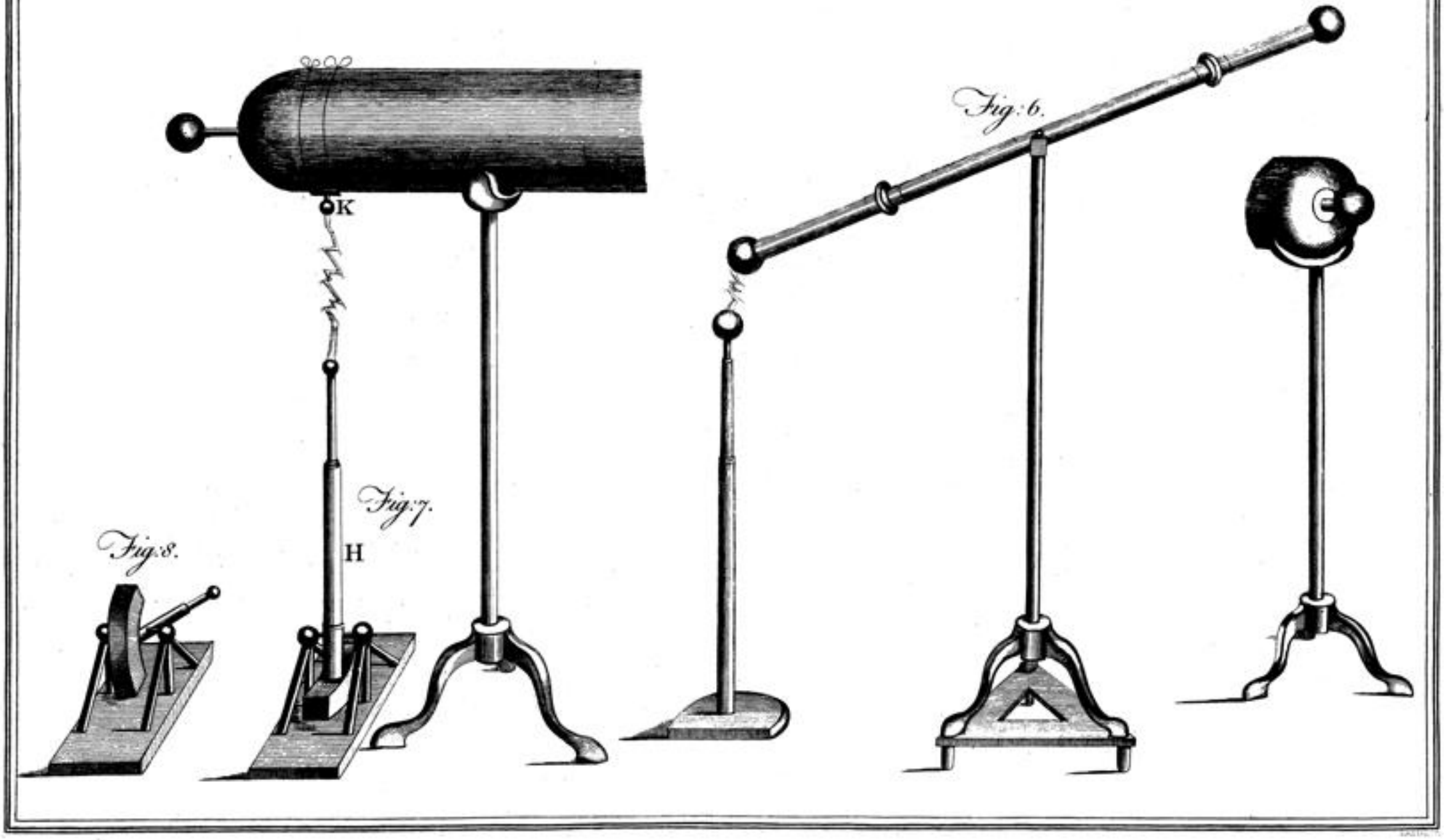
Fig: 6.
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