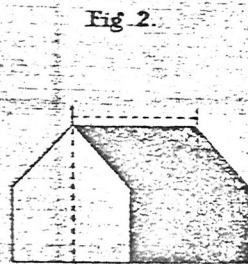
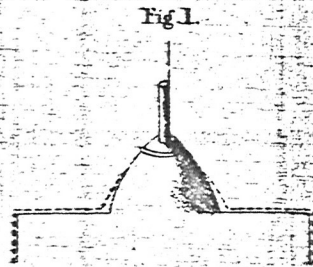
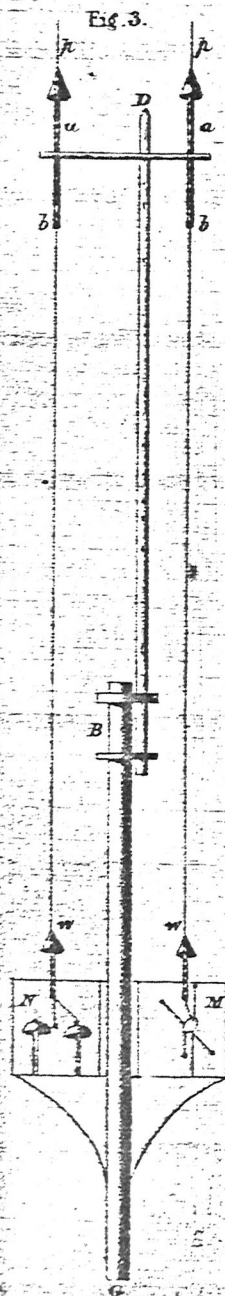


# ON HER MAJESTY'S SERVICE

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Letter from Sir W. SNOW HARRIS, F.R.S., &c. &c. on a System of  
Lightning Conductors, for Waltham Abbey.

ATHENEUM, July 17, 1858.

SIR,

IN compliance with your letter of the 2nd instant, requesting my attention to the works of the Royal Gunpowder Factory, at Waltham Abbey, with a view to some further consideration, relative to their security from lightning; I have, accompanied by the principal officers of the establishment, carefully examined the several buildings with their machinery, and also, the present means employed to guard them against atmospheric electricity.

2. After the exposition of my views of atmospheric electrical discharge, given in the Circular Memorandum, so ably drawn up by the Inspector-General of Fortifications, and promulgated for the information of the Corps of Royal Engineers, and to which you allude; it does not seem requisite for me to enter upon any further discussion of the principle upon which I conceive electrical conductors are best applied, as safeguards against lightning, or the method of their practical application; I will therefore proceed, at once, to report briefly on the points contained in the letter, with which, at the request of the Secretary of State for War, you have been so good as to honor me.

3. The old buildings at Waltham, have, I observe, lightning conductors applied as in former times, that is to say, small metallic rods attached to spars, or masts of wood, and placed at a distance from the buildings they are designed to protect. Although I make no objection to the presence of such conductors, or do I feel disposed to recommend their removal, yet, on the other hand, I cannot, in my humble judgment, place confidence in their operation, as efficient security against lightning. I think, as I have shown from actual experience in my papers, quoted in the circular above-mentioned, that a stroke of atmospheric electricity might at any time fall upon a point of the structure distant from the conductor; or even, in falling directly upon the conductor itself, might still divide upon the building and cause destructive effects,\* of which there are many instances on record.

4. The buildings to which I would first beg leave to direct attention are, the upper and lower stove houses employed for drying the prepared gunpowder. In the first of these, I find a central chimney of considerable elevation, immediately over a steam apparatus, which apparatus sends out, right and left, metallic tubes and pipes into adjacent apartments, in which the gunpowder is placed on metallic trays to dry, the temperature of the air, and all within the apartment being greatly elevated by these steam pipes. Now, it is to be further observed, that a column of heated air necessarily proceeds from the central chimney of the furnace or stove, and rising high into the atmosphere, opens a path of little resistance to an electrical discharge in the direction of the chimney, which having no immediate means of conductive progress provided, would be very liable to fall upon the metals below, and find its way with disruptive violence into the adjacent drying houses, causing explosive action, more especially under the influence of an elevated temperature. Similar

\* Vide Occasional Papers, p. 58.

reasoning applies to the old stove house. Now, the only protection at present against this source of danger, is a small line of metal attached to a mast of wood at a distance from the building, and which even upon the old, but now exploded doctrine, that such a conductor attracts all the discharge of atmospheric electricity, which we call lightning, to itself; is still no match for a column of heated air rising high above the whole mass out of the furnace chimney into the atmosphere; and which is known to transmit electrical discharge very freely. The conductors, therefore, as now circumstanced, whilst they certainly do no harm, are still quite inadmissible as an effectual security against a stroke of lightning.

5. To guard these drying houses effectually, I recommend capacious conductors of pointed copper tubes, such as are employed in the Houses of Parliament, to be fixed to the furnace chimneys themselves, and from thence continued in convenient directions to the earth at opposite extremities of the building, connected, if requisite, by bands of copper plate, fixed on the ridges of the roof, upon the principle indicated in the sketch. (See fig. 1).

6. With respect to the low buildings of wood, clinker built, with slate roofs, and containing machinery, I think it would be well to lead bands of copper plate along the ridge of the roof, and connect these at each extremity with conductors passing immediately into the earth, as indicated in the annexed diagram. (See fig. 2). I should recommend a similar application to the press house, granulating house, and other of the small low buildings, which the principal Officers may deem most important.

7. It may, perhaps, be proper to observe here, that the wood-work of these buildings are, in most cases, saturated with gunpowder dust; hence, a question might fairly arise in the minds of many reflecting persons, as to how far metallic conductors directly applied to such buildings, are admissible. The explanation is, however, obvious. Should atmospheric disruptive electrical discharge fall upon the buildings as at present circumstanced, explosion is certain. They would at least be set on fire. Now conducting lines of copper applied to them would not cause electrical discharge to fall on the buildings, which would not equally assail them, whether such lines of metal were present or not; on the other hand, the lines of metal, by transmitting the discharge to the earth under a current of an *inexplosive* form of action, the building would escape altogether, and no fire ensue. It is well known that heavy electrical discharges may be transmitted by continuous capacious conductors, through a barrel of gunpowder without causing any explosion whatever. So that the conducting lines, whilst unproductive of any danger, are calculated to shield the building from fire, under the course of electrical discharge.

8. The proper construction of all such buildings, as regards lightning, would be, in my opinion, corrugated iron, coated with zinc, as resorted to in the new works near the water wheel, in which case disruptive electrical discharge would be impossible, and the dangers and difficulties just alluded to, altogether avoided.

9. The new mills and buildings, with their very tall and beautiful chimney, are undoubtedly secure from lightning. The chimney has a continuous conductor, judiciously and effectually applied from the highest point

to the ground, whilst the lower portions are of iron. I have only to suggest, in this case, a complete conducting communication between the iron pillars at the platforms of the substructure and the earth.

10. Should the Secretary of State for War, honor my views with his approval, I would suggest that in any further progress, an estimate be obtained for the whole, from a Mr Gray, who supplied and fixed the tubular conductors to the Houses of Parliament, and who keeps these conductors and coupling points, fixings, &c., ready for use. The work executed at the Palace at Westminster gave satisfaction to the architects, and in a financial point of view, was considered very reasonable by the Government authorities. Hence, I am led to believe, that this course would be more satisfactory, as regards the execution of the work, by clever workmen accustomed to it, and the most economical, as relating to finance, more especially if copper material, at the command of the establishment, were supplied by H.M. Government, in cases, in which such material was required. I need not, I trust, observe, that should the Secretary of State for War, deem it prudent to entertain this question, my services in carrying out the conductors, and certifying to their correct application, are at his disposal; the cost of what I have proposed, would not, I should imagine, be anything very considerable.

11. I find upon inquiry, that thunderstorms at Waltham, are of frequent occurrence, and that some few years since, a low roof, near one of the entrance gates, was struck by a discharge of lightning, and a person, within the chamber underneath, killed.

12. In conclusion, I venture to suggest, that an electrical indicator be erected on a convenient site, which might give notice of the approach of electrical storms, and shew the existing tension of the electricity of the air. Such an instrument could be set up with ease, and at a very small cost. I am unwilling to prolong this communication by entering into tediously descriptive details, relative to such an instrument. I shall therefore, merely offer a general view of its nature and operation, and I conceive it might be found very useful.

13. In the accompanying diagram (see fig. 3) *DBG* is one of the masts as already prepared at Waltham, for the conductor; *aa* gutta percha tubes, supported on a transverse bar, near the upper extremity of the mast pole; *pb* are two pointed wires, supported by and passing through these insulating tubes; *bc* small copper lines, leading to similarly fixed wires, passing through insulating tubes into chambers *MA*, faced with glass, and supported on brackets at the lower part of the mast; one, *N*, contains a pair of bells on Franklin's principle, and which would commence ringing on the approach of electrical clouds; the other chamber *M*, contains an Electroscope of Divergence, and, by the amount of its angular deviation from the perpendicular, would indicate freely, the greater or less degree of electrical tension of the air.

I believe the cost of this would be very small.

I have, &c.

(Signed) W. SNOW HARRIS

P S. By the system of conductors, described in this Report, the several machines, such as the granulating machine, breaking machine, &c. beneath the roofs, would be placed beyond the reach, and beyond the course of electrical discharge, from the atmosphere. Any especial treatment of such machines is quite unnecessary, indeed, it would be difficult to treat such machines as regards electrical discharge; the wood-cogs, and other rotatory means, would be always liable to cause disruptive action under any treatment which could be devised; the only perfect security therefore is to be found in placing these machines altogether, without the limit or course of electrical action,—and this, the system of conductors, I propose, will certainly do.

(Signed) W. S. H.

*On Revetments.* By STEPHEN FENWICK, F.R.A.S., of the Royal Military Academy, Woolwich.

[The following Paper on "Revetments," was drawn up principally for use with a Class of Officers, at the Royal Artillery Institution, Woolwich.]

I. ONE of the chief characteristics which distinguish masses of earth, sand, and other semi-fluids as they are sometimes called, from water, is the property they possess of remaining in a state of equilibrium with their surfaces inclined to the horizon. Now, as by the laws of friction a body may be sustained on a rough inclined plane by the friction alone, if the inclination of the plane is not greater than the limiting angle of repose, it follows that masses of earth and other similar materials, will be in equilibrium when their surfaces are not inclined to the horizon at a greater angle than the angle of repose. If then by the *angle of natural slope* of a mass of earth, we mean the greatest inclination of its surface to the horizon consistent with equilibrium, it will be clear that the angle of natural slope of such a material may be taken as the measure of the limiting angle of repose.

In assuming this relation between the slope and the limiting angle of repose, we of course neglect the *cohesion* of the particles of the earth. The relation which exists between the slope, the statical friction, and the cohesion of the particles of a bank of earth, will be investigated at the end of this paper.

## 2. *The maximum pressure on a vertical revetment.*

DEFINITION. A revetment is a wall built to support a bank of earth or other material, and it is a *vertical* one, when both faces of the wall are vertical, and its section, a rectangle.

Suppose now that a mass of earth is supported by the wall  $AB$  (Fig. 1) of a vertical revetment, and that the earth and wall are of the same height. Suppose also, that a wedge-shaped piece  $ABF$  is about to *separate* from the general mass of earth, and that it rests in this state bordering on motion, on the wall  $AB$  on the one side, and on the earth  $AF$  on the other. Now the resistance  $R$  of the face  $AF$  will act in a line  $EMO$ , so that the angle  $OEF$