REPORT

OF THE

FOURTEENTH MEETING

OF THE

BRITISH ASSOCIATION

FOR THE

ADVANCEMENT OF SCIENCE;

HELD AT YORK IN SEPTEMBER 1844.

LONDON:

JOHN MURRAY, ALBEMARLE STREET.

1845.

These data may not at first sight appear important; they are however of great value in practice, as the œconomy of the fuel and the efficiency of the furnace in a great measure depend upon the height of the bridge behind, which operates as a retarder of the currents in the same way as the damper is used for checking the draught of the chimney in the flues.

Mr. Murray further treats of the temperature of the furnace, flues, &c., but these points having already been experimented upon and fully discussed in the report, it will not be necessary to notice them in this place.

WILLIAM FAIRBAIRN.

Report concerning the Observatory of the British Association, at Kew, from August the 1st, 1843, to July the 31st, 1844. By FRANCIS RONALDS, *Esq., F.R.S.*

IN August of last year (1843) I drew up a short account of the electrical observatory here, as fitted up and supplied with instruments under my direction, and principally in accordance with a plan which I had in November 1842 stated to Professor Wheatstone.

That account was annexed to a journal of about one month's electrical observations made therewith, and the meteorological journal commencing in October 1842.

From August 1843 to the present time a similar electrical journal has been maintained with all the attention to accuracy which our ways and means have permitted, and it has been presented to the Association in a condensed tabular form embodied with the other meteorological observations made here.

But as the above-mentioned statement may be deemed not quite sufficient for a due appreciation of the circumstances under which our journal has been kept, as I have since made a few variations in and additions to the collection of instruments, given to the journal a different form*, and instituted a few test and other experiments, it seems expedient to comprise in this report, first, a short description of the building itself, and of the whole meteorological apparatus employed; secondly, some necessary explanations, and a specimen of the journal; thirdly, a brief statement relative to all the experiments (of *any* moment) which have been made.

I. *Description of the Observatory and of Instruments used for the Observations.*

THE BUILDING.

The position, form, &c. of the structure (Plate XXX. fig. 1), are certainly very favourable to electrical meteorology. It was erected for His Majesty George III. by Sir William Chambers, in about the year 1768, in the old Deer Park, Richmond, upon a promontory formed by a flexure of the river, its least distance from which is 924 feet. The nearest trees (elms) are about 13 feet lower than the top of the conductor. Some elms more distant average about 13 feet lower, and the trees of various kinds, as elm, beech, poplar, &c., on the bank of the river, about 8 feet lower. Innumerable high trees exist in the royal pleasure-grounds, the nearest being about half a mile distant.

The height of the top of the conductor above the level of the sea is about feet; above the river, at low water, about 83 feet, and above the top of the dome 16 feet.

* As nearly like the Astronomer Royal's as possible.

The neighbourhood of the river and the rather marshy state of the land near the building cause sometimes very dense and interesting fogs*.

The foundation is of an extremely solid and costly kind. The basement, partly sunk in an artificial mound, is occupied by Mr. Galloway's family and that of Mr. Cripps †.

The principal entrance is by a flight of stone steps, on the north side, into a fine hall equal to and corresponding with the apartment A. B is a room which was built for the great mural quadrant, and has shutters, b^1 b^2, in the roof, &c., and in the meridian of the two obelisks near the river. [The northern window of this apartment is used for the exposure of thermometers and hygrometers.] The other wing (C) consists of the (former) transit-instrument-room, with its sliding shutters, a small apartment for an azimuth instrument, and part of a circular staircase. The north upper room, like and equal to D, is to be used as a bed-room. D is appropriated as a sort of laboratory, library, study, experimental room, &c. The central rooms (A, D, &c.) are entirely lined with glass cases, which formerly contained philosophical instruments, objects of natural history, &c. (many of the cases now subject to dry rot, but still may prove very convenient), and all the rooms are provided with stoves. The flat leaden roof of the front and back rooms (D) is surrounded by a balustrade, &c. It is entered upon by convenient stairs and a door, and serves admirably for viewing the sky, and for the reception of some instruments, &c. The smoke of the chimneys is sometimes annoying, and perhaps a little detrimental; but I think that the smoke and the hot air scarcely ever rise so high as to interfere with the electrical indications of the principal conductor; an almost imperceptible breath of wind carries them away horizontally.

The small equatorial apartment (E) is composed chiefly of wood covered externally by sheet copper; it is erected partly upon an extremely solid wall extending from the foundation of the whole building. The dome (*e*) was moveable round its axis by means of beautiful, but now scarcely efficient, internal rack-work, &c. It had above, the usual opening with sliding shutters, and below, a kind of door, corresponding with them and opening upon the plinths (*f*)‡: this room is now our principal

Electrical observatory, which has been thus adapted and furnished. [The parts of fig. 2 in diagonal shading represent a sectional plane cutting the axis of the dome; the other parts are in projection.]

Through the centre of the dome A A A has been cut a circular aperture, and in that is fitted a smooth mahogany varnished cylinder, a^1 a^1. B B is a window, the frame of which formerly carried the sliding shutter; and *g* (fig. 1) are steps by which the top of the dome may be reached.

G G G, fig. 2, is a strong cylindrical pedestal (the upper part of which becomes a warm and dry closet for little electrical articles). G^1 G^1 is a stage surrounding G, upon which the observer mounts by the steps G^2.

C C C (fig. 2) and *h* (fig. 1) is the *safety conductor*, composed of a leaden strap soldered to the leaden roof of the lower apartments, which roof is connected by various little straps and solderings with leaden pipes (h^1 h^2, fig. 1), in good conducting communication with the drains, pond, &c.

* Electric signs are usually higher upon bridges than elsewhere, all other things being equal in serene weather, and fogs present remarkable electric phænomena.

† An apartment, of which X is the window, was frequently used by His Majesty as a turning-room. We want the lathe very much.

‡ It may be as convenient to other observers as to Mr. Galloway and myself to know, that these sloping plinths or steps are in frosty weather very dangerous.

The Principal Conductor, &c.

The principal conductor, D D (fig. 2), and H (fig. 1), is a conical tube of thin copper 16 feet high. E E (fig. 2) is a strong brass tube into which D D is firmly secured, and enters about $3\frac{1}{2}$ inches, but is removeable at pleasure. F F is a well-annealed hollow glass pillar, whose lower end is trumpet-shaped and ground flat; it rests upon the centre of the pedestal G G G, where it is firmly secured by eight bolts, f^1, f^1, &c., passing through a strong wooden collar, f^2, and the table of G. This pillar, with its high conductor, has resisted gales which were strong enough to blow down large trees in the neighbourhood; a certain degree of flexibility in the conductor diminishes the danger of the glass breaking considerably. A collar of thick leather is planted between F and the table, and some strips of leather are interposed between the excavated interior of the collar and the trumpet-shaped part of F (as seen in the plan annexed).

H (fig. 2) is a spherical ring fitted on the brass cap of F, and carrying I I I, which are three of four arms at right angles with each other. I (Plate XXXII. fig. 3) is a section of one of them, and of the ring H, to which it is firmly attached by means of a strong iron screw R, and the plug S. K is a ball fixed on the other end by means of a screw, L passing through its neck and a plug M. N is a cylindrical plug sliding accurately into K, and furnished with a screw n^1, which passes through a stopper O into a clamping-ball P. K and N are perforated to fit the sliding arm Q.

It is evident that by these means Q can be adjusted to any angle, with, and its ends to any required height, from the table of G G G; also that it can be very firmly secured without being galled.

K (fig. 2) is a little lamp for warming F F appropriately, k^1 its chimney of copper, closed above, passing through the table of G and entering, but not touching, F.

By this arrangement the lower part of F is generally warmed too much and the upper too little; but the pillar F being conical, &c., some zone always exists between the two ends, which is in the best state of temperature for electrical insulation*.

L is a pair of finely pointed platinum wires soldered to D.

M is Volta's small lantern, fitted to a ring m^1, from which it can easily be withdrawn when lowered by a person mounting the steps on the dome, m^2 its lamp; m^3 is a ring or tube sliding freely on D, and attached to M, &c.; m^4 is a silken line fastened to m^3, passing over a pulley (from which it cannot escape) at m^5, descending the interior of D and E, and winding upon a reel contained in the ball m^6, worked by a winch at m^7, for the purpose of raising and lowering M.

N is an inverted copper dish or parapluie, with a smooth ring on its edge, fitted by a collar and stays on E, and (of course) insulated by F: its least distance from a^1 is 3 inches.

One of the chief objects of this arrangement is to insulate the active parts of all the electrometers and the conductor itself by a common insulator, viz. the glass pillar F. The cord being contained in the tubular rod, cannot dissipate electricity from its fibres, and everything is well-rounded.

* Mr. Read imagined (vide his 'Summary View,' &c. p. 105) "that if the insulation of his rod could be constantly kept in due temperature, it would always be electrified; but that that could not be done without the aid of common fire, which in so large an apparatus would be very difficult."

I believe we may safely affirm, that with the exception of a few hours of drizzling weather sometimes, and on occasions when our conductor has been touched, our rod has been every day, and *all* day, sensibly electrified since the moment of its erection (in June 1843).

Electrometers, &c.

The voltaic electrometers, which we used at first for the observations, were Volta's No. 1, or standard, O, fig. 2, and his second P, so modified that the straws suspended within square glass bottles with metallic bases, &c. were not suspended from the bottles themselves; but finding it difficult to avoid parallax and distortion by uneven glass, &c., I have endeavoured to improve these electrometers, and since the 16th of June we have used the following form, having first taken special pains to render the new instruments as nearly accordant with the old as possible (vide Experiments, *post*).

P (fig. 4) is a front view and O (fig. 5) a side view of a brass case (instead of a bottle) exactly 2 English inches wide internally, and furnished with plates of thin plate glass fixed by brass plates, &c. to its front and back: the back plate is ground to semi-transparency. The radius of the ivory scale *p* is equal to the length of the pair of straws Q (*i. e.*) 2 Paris inches, and the scale is graduated in half Paris lines. The scale of No. 1 counts single degrees, and each degree of No. 2 corresponds with five of No. 1.

The straws are suspended by hooks of fine copper wire inserted into their hollows and passing freely through holes in the flattened ends of the wire R, at the distance of half a line from each other. R passes through a glass tube S, covered with sealing-wax *by heating the tube* (not by spirit varnish). T is a cover cemented upon S, and, when the instrument is not in use, closing P. U is a ring to which R and S are attached, and V (fig. 5) is a knife-edged piece of steel riveted into a slit in U*.

The base (W X Y) of the instrument consists of three parts. W is a cylinder with a kind of flange, w^1, and is screwed firmly down upon a circular plate X. Y is a stout ring turning with friction about the smaller part of W, and X is secured firmly on the table of G by a bolt, screw-washer and nut Z, the bolt passing through a hole in G much larger than itself. The lower part, or plinth of P, has a shallow cavity beneath into which w^1 fits easily.

A is a tubular arm attached to Y, and carrying a steel wire B, which supports an eye-piece C; this can be adjusted and fixed at the required height from Y, in the same manner as Q (fig. 3). The distance of C from P, when in use, is *one English foot*.

R R (fig. 6) is a horizontal tubular arm fixed upon one of the vertical arms Q (fig. 3), and S S (fig. 6) are two little tubes with stoppers which slide into R and turn on their common axis; $s^1 s^1$ are notches cut down to the diameter of S S, and the horizontal parts of V (vide fig. 5) fit these notches.

Hence it is obvious, that when the adjustments have been made, an electrometer-case can be properly placed upon its base W, &c., and the straws Q, &c. suspended from S at exactly their proper height, without destroying the insulation of the warmed glass pillar (for it is necessary to handle P only), that U, &c. will then hang with sufficient freedom without liability to turn on their axis, and that C can be brought to exactly its proper position for noting the degrees on p^1, indicated by the divergence of Q. In like manner O can be removed and closed (as shown in the side view, fig. 5) without destroying the insulation, and finally, the whole of P X, &c. can be adjusted to make the straws accord with the zero point of p^1 (when unelectrified) and firmly fixed there †. I will not enter upon further particulars concerning the manner of using the sight-piece C in estimating fractions of degrees.

* Cleverly suggested to me by Mr. Robert Murray.

† The Astronomer Royal has improved the manner of placing and displacing these electrometers at Greenwich.

$C^1 C^1 C^1$ is a strap of copper pressed under the washers at Z Z, and in good conducting contact with the strap of lead C (fig. 2)*.

The Henley electrometer (figs 7 and 8) is also constructed in conformity with Volta's improvements†.

The brass piece A is cylindrical below and flat above; on each of the smaller sides of the upper part is affixed a semicircular plate of ivory BB; through these the shanks of two little balls (CC) are screwed, which are drilled to receive fine steel pivots, carrying a little ball, into which the index (or pendulum) D is inserted: D terminates with a pith-ball E. The scale is divided into degrees of the circle: each degree should correspond with degrees of the Volta No. 2, and consequently with degrees of the No. 1 (or standard); every part is carefully rounded and smoothed.

It is supported by a piece of tube F passing through a clamping-ball and plug G, and that ball is affixed to one of the cross arms Q (vide fig. 3); the zero of the scale can be therefore accurately adjusted to coincide with the pendulum when unelectrified, and this can be made to rise in a plane cutting the axis of the conductor, &c. with the back of the instrument A turned towards the conductor, &c.; these are two essential conditions.

This electrometer has seldom been observed until the Volta No. 2 had risen beyond 90° (in terms of the first, *i.e.* 18 lines × 5); and since the uncertainty and difficulty of measuring the higher tensions increase in a rapid ratio with the increments of tension, owing to unavoidable and sometimes almost imperceptible "*spirtings*," and particularly to the falling of rain from the dish or funnel N (fig. 2), proportionably less confidence must, of course, be placed in our notations of such tensions by means of this instrument‡.

It also requires, according to Volta, De Luc, &c., small corrections for all degrees below the 15th and above the 35th, which have not been made in our Journal§.

A galvanometer by M. Gourjon, S (fig. 2), which Professor Wheatstone has placed on our table, will, I hope, prove the nucleus of a very valuable assemblage of new facts. In low intensities we have not yet been able to apply this instrument successfully, but in higher tensions the needles have been strongly affected.

The galvanometer in some improved form should perhaps supply that great desideratum in atmospheric electricity, a means of noting the dynamic effects which are perhaps coincident, if not identical, with the property discovered by Beccaria, and called by him "frequency," a property of great importance possibly considered in relation with the various opinions and theories which have been or still are entertained concerning the natural agency of atmospheric electricity, in vegetation, animal life, the magnetism of the earth, the aurora, &c.

Should we be enabled to prosecute these inquiries in the manner which the Professor has most ingeniously contemplated, or by means of a much more extensive collecting apparatus than the *single* lamp, &c., I hope that we shall do some good in this way.

* The Cavalier' Amici has (on visiting the observatory), in a very kind and flattering manner, expressed his conviction that if Volta (his friend) could now see these improvements upon his electrometers and their application, he would be much pleased.

† Vide Opere del Volta, tom i. parte 2. p. 35 *et seq.*

‡ The oscillations of the index between the 30th and 35th degrees, sometimes during a heavy shower, plainly show that the electricity of the conductor is washed off, as it were, as fast as brought.

§ I have strong hopes that our principal use of all these electrometers will be that of comparing them with one torsion electrometer, alluded to in my former communication.

The discharger (fig. 9), also our "safety valve," is perhaps an improvement upon Lane's electrometer.

The length of the spark is measured by means of a long index R, which exhibits the distance of two balls, S and S', from each other on a multiplying scale T, S being attached to a rod V, which is raised and lowered by means of a glass lever W, forked piece X, &c.; V slides accurately through the base Y and the piece A. The bolt, &c. (Z), which is in intimate metallic connection with the safety conductor C, clamps the whole down to the table in the same manner as that in which the voltaic electrometers are fixed.

Each division of the scale represents an *exact* twentieth of an inch in the length of the spark. The actual cord of each division is about a tenth. The divisions are, of course, not perfectly equal to each other: they serve very well to estimate to fortieths, or less.

We observe a tolerably near approximation to coincidence between the lengths of sparks as measured by this instrument and the degrees of tension exhibited by the Henley.

A Bennet's gold-leaf electroscope, in form a little differing from fig. 10, has been sometimes used for discovering the length of time which has elapsed between the alternations in *kind* of electricity during rain, &c., and *very rarely* for ascertaining whether our conductor was charged or not on other occasions*.

A wire A, terminating below in a pair of forceps, carrying the paper by which the leaves are suspended (in Bennet's manner nearly), passes through a glass stopper B, which is ground into a long-necked bottle C, with a metallic base D, and a strip of brass (E) is bent and screwed to the inside of D. The neck of C is well-covered with sealing-wax by heating both inside and out†.

If required, this instrument can be suspended from an arm, as R (fig. 6), and a chain hooked on a ring in its base, but here we depart from the principle of uniform insulation, and therefore seldom use a Bennet's electroscope in this manner, but merely touch the conductor with it.

Distinguisher.

The distinguisher, which we have found most convenient for ascertaining the kind of electricity possessed by the conductor, &c. at any given time, and in all tensions except the very lowest, is of the sort represented by fig. 11.

A is a wire connected with a brass tube which forms the interior coating of a very thin glass tube C. B is an exterior coating of the same kind, and these two coatings are at about three-fourths of an inch distant from each extremity of this little Leyden jar. The intervals D C and B C are coated with melted sealing-wax inside and out. A thus prepared is inserted through a stopper,

* In measuring low intensities, and particularly small quantities of electricity, the mode of insulation called 'Singer's' is sometimes very objectionable, for this reason; the wire (as A) carrying the gold leaves, or other pendulums, becomes partly the interior coating of a charged glass cylinder, and part of the cap of the instrument becomes the exterior coating; the contact of the electrometer with the body whose electric tension is to be ascertained, lowers consequently, and sometimes materially, the tension of that body itself. The charge received by such an instrument is retained well, principally by reason of these associated metallic coatings, &c., and it seems to lose electricity more slowly than it does, because it has more to lose than it seems to have.

† The principal conductor, its appendages and instruments in the electrical observatory, hitherto described, were *chiefly* executed by Mr. Newman of Regent Street, and do him very great credit.

fitted to a bottle D with metallic base, and is provided with a pair of gold leaves rather too short to reach the sides of the bottle, the neck of which, both inside and out, is also coated with sealing-wax as usual.

This distinguisher is charged every morning negatively, and never fails to retain a good charge for the twenty-four hours. It is conveniently placed upon a bracket, a few feet distant from the conductor, &c., to which when used it is approached by hand, to some distance proportionate to the height of the charge. If the charge is positive, the leaves of course collapse more or less, but open again when withdrawn; and if it be negative, the divergence increases, &c.

Perhaps this mode of distinguishing is preferable to Beccaria's method of the star and brush, or even to that of the dry electric column, &c., for the operation can be performed without the least danger of lowering the tension of the conductor or injuring the gold leaves, let the height of the charge be what it may *.

ELECTROGRAPH.

An electrograph (fig. 12), of the kind proposed first I believe by Landriani and afterward by Bennet and Gersdof (but of which no particulars seem to have been published before 1823 †), has also been used, but not extensively, for reasons which will be hereafter explained.

A is a plate of tin coated with a thin layer of shell-lac, &c., as carefully as possible deprived of air-bubbles, flaws and inequalities. B is a case containing a time-piece moved by the weight C. D is part of a triangular little frame fitted to the hour arbour of the time-piece and supporting A. E F is a bent lever whose fulcrum is at e', below its centre of gravity: the part F is of coated glass. G is a ball through a groove of which E F passes, and G is supported by a cross arm of the conductor.

When this instrument was used, the end E was allowed to rest with very little pressure upon A, which being carried round by the clock became electrified in the line and neighbourhood of its contact with E to an intensity proportional to the charge of the conductor. After having been allowed to perform a full revolution, or any given part of one, under these circumstances, A was removed from D and well-powdered with chalk, projected upon it from a lump rubbed upon a hard brush. The powder, of course, as in Lichtenbourg's figures, adhered almost exclusively to the parts which had been more or less electrified by and in the neighbourhood of E; and a figure was produced, of which a calotypic image, kindly executed for me by Mr. Collen, by means of his camera obscura, &c., is preserved as a specimen. Many such images could be produced in a few fine hours from A, and thus a sort of pictorial register of atmospheric electricity (of serene weather at least) be circulated amongst meteorologists, care being taken of course to note the time of putting on and taking off the resinous plate.

That figure was made contemporaneously with hourly observations of the voltaic electrometers. The plate, after the powdering, was placed upon a circular paper, divided as the hours of a dial, and the intensities (as 35°, 25°, 16°, &c.) were marked against the appropriate hour, by which it may be seen that, excepting at the hour of six, the breadth of the line or figure corresponds pretty nearly with those intensities.

* Indeed I do not know whether some some such contrivance might not be applied to *measure* as well as distinguish the charge of the rod; particularly if the insulation of the gold leaves were preserved by means of chloride of calcium in a manner hereafter to be spoken of, the distance from the rod being made the measure of tension.

† Vide Descriptions of an Electric Telegraph, &c., p. 47.

Mr. Collen's photographic impression of a one-hour plate, which was fixed upon the minute arbour of the clock, is also preserved*.

A LEYDEN JAR, of about 40 inches coating, has been sometimes used for receiving the charges from the rod, and the number of discharges up to the maximum tension of the rod in a given time has furnished a better estimate (in very high tensions and quantities) of frequency, than we at present otherwise arrive at perhaps.

A PAIR OF BELLS has been sometimes applied to the conductor in the usual way, but they are too small to give us due notice below of high charges.

AN ARGAND LAMP is burned at about 3 feet from the conductor in the evening, for lighting the electrometers, &c., and a little chimney placed above it, and opening outside the dome to prevent hot air and vapour from approaching the conductor, or anything connected therewith.

A SMALL JOYCE'S STOVE, containing a little burning charcoal at night, is generally suspended in the dome for keeping everything dry.

Great care is requisite, and diligently observed by Mr. Galloway, to guard as much as possible the whole apparatus from dust. He uses occasionally *soft* camels'-hair brushes.

I believe that every article which has been used, more or less constantly, for the *electric* observations of the tables, has now been shortly described.

I placed A CONDENSER in the room, but we have not used it. I think that Volta's objections to the employment of such instruments in comparative experiments are founded in sound reason and experience.

BAROMETERS.

The mountain barometer, lent by Colonel Sabine until we can afford the expense of a standard instrument, has been used since the commencement of the observations here; it is by Newman; the graduated scale is divided to 0·05 of an inch; the vernier subdivides the scale divisions to 0·05, and is moved by a slow screw.

The particulars given, for corrections, are as follows:—

Capacity	1·55
Neutral point	29·764
Capillary action	+0·043
Temperature	55°

It is freely suspended by a ring in the mural quadrant-room B (fig. 1), near the north window. It has been compared with the barometer of the Royal Society, and the comparison is recorded there.

The observations are set down without corrections of any kind.

A centigrade barometer hangs freely in the dome, but we use it for casual observations merely, and seldom.

THERMOMETERS.

The thermometer which we call our *standard*, by Newman, is mercurial, and divided to 0·5; it has not been compared with others. It is fixed at the outside of the north window of the apartment B (fig. 1).

The maximum thermometer is mercurial; it is made by Newman, is divided to 0·1, and the index is of blue steel. It is placed outside the north window of the room B (fig. 1), near the standard thermometer.

The minimum spirit thermometer, by Newman, is divided to 0·1, and the index is of black glass; its position is nearly the same as that of the maximum thermometer, *i.e.* on the opposite side of the same window.

* This kind of graphic exhibition is perhaps more pleasing but less useful than other modes of registration which we hope to accomplish. The tædium and difficulties of bringing the resinous coating to a uniformly fit state for receiving the electrical drawing are not inconsiderable.

Hygrometers.

The wet-bulb thermometer of *Mason's hygrometer* is mercurial: its scale is divided to 0·1. The difference between this wet thermometer and the dry, as set down in our observations, is derived from a comparison of it with our standard thermometer. This hygrometer has been placed outside of the same window, near the standard thermometer, about an hour before every observation.

The thermometer inclosed in one of the bulbs of the *Daniell hygrometer* is also mercurial, and its scale divided into 0·1. The difference between the dew-point and the dry thermometer, as set down in our tables, is also derived from a comparison of this thermometer with our standard thermometer. We found that the exterior thermometer varied from the standard sometimes $1\frac{1}{2}°$. This excellent hygrometer is used at the same open window.

The Saussure hygrometer is of the six-haired kind, made by Richer of Paris. A system of levers is employed, by means of which the effect upon the index is the mean result of all the expansions and contractions of the hairs. It has the advantage of great strength, at least, but is slow and is much less to be depended upon than the Daniell. Before the observation it is exposed for about an hour outside the same north window of the room B (fig. 1).

Rain and Vapour Gauge.

This is, I believe, a new instrument. It indicates a mean result arising from the quantity of water which may have fallen between any two given periods, minus the quantity of vapour which has risen in the same time (and, of course, *vice versâ*) on and from a circular plane of one foot diameter.

A A (fig. 16), Plate XXXI. is a cylindrical vessel of zinc whose internal diameter is one foot.

B is another cylindrical vessel attached to A, and communicating by a little pipe *b* with it. C (vide dotted lines) is a glass vessel standing in B, and having a small perforation near its foot. D D is a circular plate of brass firmly screwed to a cap C, and $d^1 d^1$ is a copper plate attached to the cap of C also. E and F are cocks fixed upon D at a distance of about three-quarters of an inch from each other. G is a pulley upon an arbour, which runs in centres opposite to each other in the supports E and F; the centres are jewelled, and the carefully turned pivots of the arbour are of platinum. H is an index carried by G, and I I I is the scale secured upon F. K is a silken thread passing round a groove in G, descending through a hole in D, and suspending a light copper covered dish L. M is another silken thread passing in the contrary direction round another groove in G, and suspending a weight N, which is somewhat lighter. Lastly, P is a glass shade placed upon D D.

This arrangement embraces a manifest application of the principle of the wheel barometer. If a quantity of water is poured into A, exactly sufficient to bring the index H to a given point, and if afterwards any addition to that quantity of water should be made by rain, the index will point out the increase upon the multiplying scale I; or if any diminution of that quantity should be occasioned by evaporation, the loss will also be pointed out by the motion of the index in the contrary direction.

We have always therefore brought the index to zero by addition to or subtraction from the water in A at *sun-set*, and have observed at that hour the mean results of deposition and evaporation for the preceding twenty-four hours. A little reservoir is placed near it with a pipe and cock for supplying water conveniently. This instrument is fixed upon a stand at about two feet above the leaden roof (fig. 1), but would be much more properly situated if the cylinders A and B were sunk into the neighbouring earth, and I hope that we may at some future time be allowed a very little space for this purpose*.

The use of the plate $d^1 d^1$ and of the glass shade P, is to exclude rain from B, and for protection.

The platinum pivots and jewelled holes effectually prevent the inconveniences of oxidation, &c., and the instrument performs its office with great delicacy and fidelity.

If it were required to be used occasionally as a *rain-gauge* only, a funnel might be fitted upon A; if for a vapour-gauge only, the whole might be protected from rain by a sort of roof or covering placed at some feet above it.

Vane.

Our wind-vane, fig. 17, Plate XXXI., is rather more convenient and accurate than a common weather-cock. A is a small brass tube at whose upper end is fixed a hard steel cap with a conical cavity, which turns upon the hard steel point of a little rod screwed into a brass cap B, and B is fixed upon a pole C; S N is a very light tin hoop, having the points of the compass painted upon it, and attached by arms to A, therefore it is carried round by A; D is an index formed of a bent wire attached to B; E is the vane fixed to A and counterpoised by F.

This instrument is so placed, that the point of D, and whatever letter painted on S N stands above it, are always in the plane of the observer's eye viewing it through the window B of fig. 2.

Anemometers.

Lind's anemometer, as usually made by Watkins and Hill, has been consulted, but is so very much less sensible than is necessary, (for the lightest zephyr is as important, at least, as the stiffest breeze to electrical meteorology,) that we were induced to try

M. Guyot's, but with no better success; I was therefore driven to the necessity of inventing a somewhat rude but far more efficient expedient, which we call our

Balance anemometer.—This turns with a weight of ten grains (or less), and can be made to carry as many pounds (or more). A (fig. 15) is a light feather-edged deal board exactly 1 foot square; B is a cross formed by two pieces of wood and carrying A at b^1; a leaden counterpoise C, at b^2; a little arm, hook and scale-dish D, at b^3; and a counterpoise thereto at b^4. B is supported by nicely-turned brass pivots running in two little pieces of glass tube attached to the supports E E, which are firmly secured upon a large base F; G is a kind of sentry-box†, with a projecting roof for protecting D B, &c. from the wind; H is a little vane, and I a pin thrust through E E and the arm b^2, when the instrument is not in use. The whole has a coat of hard white paint.

The application of this mechanism is obvious. When the flat front of A is placed at right angles with the direction of the wind (Z), which can be done with tolerable accuracy by the help of H, D rises with weights placed in the dish proportional to the force of the wind acting upon the square foot A. We measure by grains.

Great improvements as to making it self-adjustable to the direction of the

* It might then, perhaps, indicate more accurately a certain relation to the amount in excess in evaporation, &c. from an aqueous surface on the earth. It should perhaps be made to float upon such a surface in a little boat or buoy.

† The invention of Sergeant Galloway, who made nearly the whole instrument.

wind observable out of doors, without going out, &c. will occur to everybody*.

It has been placed upon any part of the balustrade (fig. 1), which may have been freely exposed to the wind at the time of observation.

II. *Explanation and Remarks concerning the Journal, &c.*

In column A the letters "S R" and "S S" designate sunrise and sunset.

In column B, "P" means positive charge, and "N" negative charge of the conductor.

In column C, the four regular electrical observations of the day, viz. at sunrise, at 9 A.M., at 3 P.M., and at sunset, are put down.

In columns D, E, F are contained the designations of the electrometers by which each observation was made. V stands for Volta's, H for Henley's, and D for the discharger. The figures preceding D are fractions, &c. of an inch.

In column E is contained the minimum and maximum charges derived from observations made, *generally*, every hour between sunrise and meridian. N.B. The early morning charges before sunrise (usually low) are not taken into account.

In column G is contained the minimum and maximum charges derived from, *generally*, hourly observations between meridian and about 10 P.M., the nightly charges after 10 not being taken into account.

In column I is contained, *sometimes*, a few very rough intimations of the rate at which the charge of the conductor rises to a maximum after it has been touched.

Column K was intended for the deviations of the electro-magnetic needle, but the galvanometer is not yet fitted for such notations regularly.

Column L should contain notices of the side of the card to which the needle moves.

In column M, a few indications of the number of storms occurring in the course of a day are *sometimes* set down.

In column N is pointed out (by the letter S) such days as generally occur when the positive charge rises after sunrise, falls early in the afternoon, and rises again in the evening, accompanied by what is commonly understood by the term "fine weather;" but there are exceptions to this (rather vague) definition which I believe require some habit and an acquaintance with the observations of Monier, and others, particularly Beccaria, to appreciate.

Columns O, P, Q require no explanation. The dry thermometer is our standard.

In column R the observations are not copied after the 31st Dec. 1843. They were too anomalous to be of any possible use.

In columns S and T many anomalies are to be found.

In column U is contained (under E) the amount of evaporation in excess of rain from *sunset to sunset*; the degrees measure hundredths of an inch in the height of the water contained in A and B, fig. 16, Plate XXXI.

In column V is contained (under R) the excess of rain above evaporation for the same period.

In the column W, the direction of the wind, as shown by the vane on the dome, is marked.

In column X, the maximum pressure of the wind from sunrise to sunset is noted from the 1st of August 1843 to the 9th of February 1844. After this

* Dr. Robinson of Armagh suggests the employment of a chain of links, &c. winding upon a reel, for saving time and trouble in placing the weights in the dish.

date the pressure is set down at the hours of 9 and 15. [The frequent recurrence of the 0 proves the great insensibility of the Lind anemometer.]

In column Y the forces of wind acting upon the balance-anemometer are in grain weights.

In column Z the changes of the moon are placed opposite to the nearest hours (which had been previously written for other purposes) to those at which they occurred.

Under the title "General Remarks and Occasional Observations," Mr. Galloway's nomenclature of atmospheric appearances is pretty closely adhered to. It will not always be found strictly logical and consistent, but I could not improve it without risk of damaging the general sense. When we came to the 7th of Nov. 1843, it seemed better to copy his notes from the book, in which they were originally set down, than to take his general accounts compiled from that book and from memory the next morning.

A few words should be here devoted to the observer, &c.

The observations of all kinds were made almost exclusively by Mr. Galloway, whose notes were first written, some on papers prepared for the purpose, and kept in the quadrant-room below; others in the above-mentioned book, kept in the electrical observatory, and more frequently inspected.

I am quite satisfied that he has executed his task better than could have been expected; but must add *emphatically*, that had our habits and qualifications been always adequate to the attainment of extreme accuracy, our instruments and other means would have been far from being so.

In short, although the electrical part of the journal (even under these circumstances) is more complete and accurate than any such hitherto recorded, yet this year's work (*i.e.* from the 1st of August 1843 to the 31st of July 1844) must, in spite of all our efforts, be considered upon the whole, and principally, as educational and experimental.

The *form* of the Journal is copied as closely as circumstances of space, &c. would permit, from the Astronomer Royal's admirable Tables of "*Ordinary Meteorological Observations*" at the Greenwich Royal Observatory.

Specimen of Electro-Meteorological Observations,

TIME.	ELECTRICITY.												BAROM. PRESS.	TEMPERATURE.		HUMIDITY.		
Day and Hour. Chronometer uncorrected.	Kind.	Periodical Observations.		Morning Min. & Maximum.		Afternoon Min. & Maximum.		Frequency.	Galvanometer.		Storms.	Serene Days.	Barometer uncorrected.	Maximum and Minimum Thermometer.	Dry Therm.	Wet Therm. below Dry.	Dew-Point below Dry.	Saussure's Hygrometer.
1844. d h m		°		°		°			°				in.	°	°	°	°	°
July 28. SR.	P.	17	V.	......	...	......	...	...	...	...	...	...	....	...	......	...	......	......
" 9 0	P.	55	V.	......	...	......	...	...	...	...	...	...	30·306	76 52	74·25	...	19·75	63
" 15 0	P.	12	V.	......	...	......	...	...	...	...	...	...	30·224	...	81·75	...	30·75	49·5
" SS.	P.	22·5	V.	......	...	......	...	...	...	...	...	...	....	...	......	...	......	......
" SR.	P.	......	...	17	V.													
" 9 0	P.	......	...	55	V.													
" 16 0	P.	......	...	......	...	9	V.											
" SS.	P.	......	...	......	...	22·5	V.	...	...	...	...	S.						
July 29. SR.	P.	7	V.	......	...	......	...	...	...	...	...	...	....	...	......	...	......	......
" 9 0	P.	7	V.	......	...	......	...	...	...	...	...	...	30·04	82 58	62·5	...	15	63·5
" 15 0	P.	9	V.	......	...	......	...	...	...	...	...	...	30·02	...	69	...	28·5	53
" SS.	P.	15	V.	......	...	......	...	...	...	...	...	S.	....	...	......	...	......	......
" 5 0	P.	......	...	4	V.													
" 12 0	P.	......	...	17	V.													
" 14 0	P.	......	...	......	...	5·5	V.	...	...	...	...	...	....	....	......	...	......	......
" 22 0	P.	......	...	......	...	47·5	V.											
July 30. SR.	P.	19	V.	......	...	......	...	...	...	...	...	...	....	...	......	...	......	......
" 90 0	P.	32·5	V.	......	...	......	...	...	...	...	...	...	29·866	70 49	62	...	19·5	66·5
" 15 0	...	......	...	......	...	......	...	...	...	...	...	...	29·65	...	66·5	...	18·5	85·5
" SS.	P.	12	V.	......	...	......	...	...	...	...	1	...	....	...	......	...	......	......
" 10 0	P.	......	...	15	V.													
" 8 0	P.	......	...	45	V.													
" 16 0	P.	......	...	......	...	5	V.											
" 15 25	N.	......	...	......	...	3	H.											
July 31. SR.	P.	5	V.	......	...	......	...	...	...	...	...	...	....	...	......	...	......	......
" 9 0	P.	25	V.	......	...	......	...	...	...	...	...	...	29·628	67 57	65·5	...	10	79·5
" 15 0	P.	9·5	V.	......	...	......	...	...	...	...	...	...	29·74	...	68	...	20	64
" SS.	P.	40	V.	......	...	......	...	...	...	...	1	...	....	...	......	...	......	......
" SR.	P.	......	...	5	V.													
" 8 0	P.	......	...	27·5	V.													
" 15 0	P.	......	...	......	...	9·5	V.											
" 15 40	N.	......	...	......	...	40	H.											
" " "	"	......	...	......	...	$\frac{4}{10}$	D.											
A	B	C	D	E	F	G	H	I	K	L	M	N	O	P	Q	R	S	T

at the Kew Observatory, in the Year 1844.

RAIN AND EVAP.		WIND.			MOON.	
Mean of Rain & Vapour-Gauge.		Direction. by Vane.	Pressure. by Lind's Anemom.	Pressure. by Balance Anemom.	Phases.	GENERAL REMARKS AND OCCASIONAL OBSERVATIONS.
E.	R.		°	grs.		
...	...	N.N.W.	...	......	....	July 28. At SR. fine, but cloudy.—From 5 to 16 fine, cloudy, with sunshine.—At 17 and 18 fine, but cloudy.—At 19 dull and cloudy.—At SS. light rain.—At 21 and 22 dull and cloudy.
...	...	N.N.W.	0	500		
...	...	S.W.	0	1500		
26	...	S.W.				
...	...	W.S.W.	...	......	....	July 29. At SR. dull and cloudy.—At 5 light rain.—At 6 and 7 dull and cloudy.—At 8 fine, but cloudy.—From 9 to 19 fine, but cloudy, with sunshine.—At SS. fine, but cloudy.—At 21 and 21·45 clear and starlight.
...	...	N.	1	2500		
...	...	N.W.	2	4500		
21	...	N.N.W.				
...	...	....	...	......	Full.	
...	...	S.W.	...	......	....	July 30. From SR. to 8 fine, but cloudy.—At 9 fine, but cloudy, with sunshine.—At 10 heavy drops of rain.—At 11 and 12 dull and cloudy.—At 13 fine, but cloudy.—At 14 dull and cloudy.—At 16 and 17 fine, but cloudy, with sunshine.—At 18 heavy rain.—At 19 fine, but cloudy.—At SS. and 21 dull and cloudy. Between the observations of 15 and 16 a storm occurred. (Vide Storm papers, No. 4.)
...	...	S.	3	3000		
...	...	S.S.W.	3	9000		
...	6	W.S.W.				
...	...	W.S.W.	...	......	....	July 31. At SR. and 5 fine, but cloudy.—At 6 fine, but cloudy, with sunshine.—At 7 fine, but cloudy.—At 8 and 9 fine, but cloudy, with sunshine.—At 10 fine, but cloudy.—At 11 light rain.—At 12, 13 and 14 fine, but cloudy.—At 15 light rain.—At 16 fine, but cloudy, with sunshine.—At 17 fine, but cloudy.—At 18 and 19 fine, but cloudy, with sunshine.—At SS. and 21 fine, but cloudy. Between the observations of 16 and 17 a storm occurred. (Vide Storm papers, No. 5.)
...	...	W.S.W.	5	8500		
...	...	W.N.W.	4·5	5000		
12	...	W.				
U	V	W	X	Y	Z	

Specimens of Storm Papers.

1844. No. 1.

Time.	Electricity.			Incidents and Remarks.	Wind.
July 1.					
h m		°			
17 30	N.	60	H.	Dull and cloudy.	
17 40	...	70	H.	Rain beginning .	W.
......	...	$\frac{11}{20}$	D.		
17 45	N.	5	H.	Rain increasing.	
17 50	N.	20	H.	Rain heavy	W.
17 52	P.	40	H.	Id.	
17 53	N.	20	H.	Storm, Squalls, Rain.	
17 53	N.	30	H.	Very heavy rain, Oscillations.	
17 54	N.	30	H.	Sudden collapse.	
17 55	N.	15	H.	Heavy rain, Collapse	W.
17 56	P.	60	H.	Id. Flash..........	W.
18 0	N.	35	H.	Id. Sparks frequent	N.W.
......	...	$\frac{3}{10}$	D.	Id.	N.W.
18 1	N.	40	H.	Id.	N.W.
......	...	$\frac{3}{10}$	D.	Id.	
18 4	N.	50	H.	Id.	N.W.
......	...	$\frac{7}{20}$	D.	Id.	
18 5	N.	60	H.	Id.	N.W.
......	...	$\frac{4}{10}$	D.	Id.	
18 7	*q.*	*q.*	...	Id. Current of fire	N.W.
18 12	N.	*q.*	...	Id. 5 charges of jar in 40″......	N.W.
18 16	N.	40	H.	Heavy rain	N.W.
18 24	P.	50	H.	Id. Flash, Collapse............	N.
18 25	N.	30	H.	Heavy rain	N.
18 26	P.	25	H.	Id.	N.
18 35	N.	20	H.	Id.	N.
18 37	N.	40	H.	Id.	E.
18 47	N.	45	H.	Id.	E.
18 55	N.	40	H.	Id. 8 charges per minute.........	E.N.E.
......	...	$\frac{3}{10}$	D.	....	E.
19 0	P.	5	H.	Rain lighter......	E.
19 5	P.	25	H.	Id.	S.E.
19 21	N.	20	H.	Rain heavier ...	S.E.
19 28	N.	35	H.	Rain lighter......	S.E.
19 34	N.	37	H.	Rain nearly ceased	S.E.
19 50	N.	5	H.	Rain ceased.......	S.E.

1844. No. 3.

Time.	Electricity.			Incidents and Remarks.	Wind.
July 19.					
h m		°			
15 20	N.	60	H.	Flash, Thunder near	N.W.
15 21	P.	65	H.	Id. .... Id....	W.N.W.
15 22	N.	40	H.	Large hail stones	W.N.W.
15 23	N.	60	H.	Hail heavy.	Id.
15 30	N.	50	H.	Hail very heavy .	Id.
15 35	N.	55	H.	Flash, Hail still heavy.	Id.
15 37	N.	40	H.	Flash, id. id...	Id.
15 40	N.	50	H.	Rain not so heavy	Id.
15 45	N.	50	H.	Id. heavier......	Id.
15 49	P.	50	H.	Id. lighter......	Id.
15 55	P.	45	H.	Id. little.........	Id.
16 0	P.	45	H.	Id. much lighter.	Id.
16 47	P.	10	H.	Fine but cloudy with sunshine.	W.S.W.

Sometimes during this storm when flashes occurred, streams of fire passed between the balls of the discharger, lasting a second or two. The noise resembled that of the violent rending of paper, but was much louder.

No. 4.

Time.	Electricity.			Incidents and Remarks.	Wind.
July 30.					
15 25	N.	$\frac{3}{10}$	D.	Heavy rain.	S.W.
15 35	N.	30	H.	Id.	Id.
15 36	N.	6	H.	Id.	Id.
15 39	N.	90	H.	Id.	Id.
15 40	P.	6	H.	Id.	Id.
15 41	N.	10	H.	Id.	Id.
15 46	P.	4	H.	Id.	Id.
15 47	N.	10	H.	Id.	Id.
15 49	N.	20	H.	Id.	Id.
15 51	P.	4	H.	Rain lighter......	Id.
15 56	P.	10	H.	Fine with sunshine.	Id.

III. *Experiments made at the Kew Observatory in* 1843 *and* 1844.

I sincerely hope that we have not wasted *much* of the sum granted for the support of this establishment at the last meeting of the Association, in endeavouring to prosecute what we conceive to be one of its chief objects. Some of the experiments (here selected from a large collection) were absolutely necessary (to authenticity), others yet imperfect may possibly become complete and useful, as they may be further pursued, and some are or may become completely useless. None of them are comprised in the many trials which were made previously and more or less subservient to the construction of the principal conductor and its appendages, or to the several improvements already described of other instruments employed in the observations. They may perhaps, in conjunction with the Journal, &c., serve at least to show that sufficient precautions have not hitherto been taken for conducting electro-atmospheric observations to even approximative *comparability*, and may possibly tend to induce far more able inquirers to favour us with wholesome advice and assistance. In fact this result has already been in some measure obtained in the instance of our zealous and able friend Dr. Robinson, and several very eminent professors.

1. Comparison of Voltaic Electrometers.

Two glass pillars (called *a* and *b*), similar to F (fig. 2), were mounted, with their collars, &c., upon a broad wooden shelf in the recess of the southern window of the southern room D (fig. 1); each was provided with its warming-lamp, chimney, &c., and an arm projecting horizontally from the cap, which arms supported the pairs of straws, &c. of the voltaic electrometers to be compared (as in fig. 4), and the caps were placed in good conducting communication by a wire. The electrometers, &c. were charged (by an electrophorus) as highly as they could be without causing the straws to strike the sides, and their divergences were not noted down until the straws had somewhat collapsed. The electrometers A and C are of Volta's first or standard kind; B and D of his second kind.

Time.	Insulator *a*. Electrometer A.	Insulator *b*. Electrometer C.
Feb. 1.	20°	20°
	15	14·5
	10	10
	5·25	5
	Electrometer B.	Electrometer D.
Feb. 3.	90	90
	80	80
	67·5	70
	47·5	50
	27·5	30
	17·5	20
	Electrometer A.	Electrometer C.
Feb. 6. 13h 48m	20	20
	16·5	16
	10·5	10

This experiment (or set of experiments) suffices to show, that our ordinary voltaic electrometers possess a tolerable approximation to comparability. [It is difficult to estimate a much smaller quantity than 2°·5 of the electrometers B and D, or half a degree of A and B.]

2. Comparative insulating Powers of two Insulators.

All things remaining as in experiment 1, the electrometers were charged, and after time had been given them to fall a little, the caps of the insulators, *a* and *b*, were contemporaneously deprived of conducting communication by withdrawing the uniting wire by means of a glass handle attached to its central part.

	Insulator *a*. Electrometer B.	Insulator *b*. Electrometer D.
Feb. 3.	67·5°	70°
	47·5	50
	27·5	30
	New charge.	
	77·5	80
	57·5	60
	37·5	40

The window was now opened and a board was fitted into the frame (of the sash), having two apertures of about 5 inches diameter, situated a little higher than the caps.

	Time.	Insulator *a*. Electrometer A.	Insulator *b*. Electrometer C.
Feb. 6.	14h 38m	20°	20°
		14·25	14
		9·5	6

The apertures of the window-board were diminished to $2\frac{1}{2}$ inches diameter, and the lamp of the insulator *b* raised a little. A double wick was used in it.

	Time.	Insulator *a*. Electrometer A.	Insulator *b*. Electrometer C.
Feb. 9.	14h 15m	20·5°	20°
		14	14
		5·5	5
		New charge.	
		20	20
		5·5	5·5

The board was removed and the window closed. Both the lamps were used with double wicks and their chimneys attached to a lower board or shelf (as in fig. 3), in order to prevent more effectually any hot air with steam (arising from the combustion) from reaching the caps, &c.

	Time.	Insulator *a*. Electrometer A.	Insulator *b*. Electrometer C.
Feb. 14.	14h 1m	19°	19°
		10	11
		6	5

The window was again opened and the board with the smaller holes used.

	Time.	Insulator *a*. Electrometer A.	Insulator *b*. Electrometer C.
Feb. 15.	10h 15m	20°	20°
		6	5
		Electrometer B.	Electrometer D.
		80	80
		60	60
		25	25
		10	10

Here we have also a very fair approach to comparability.

3. Comparison of three Insulators.

The insulators *a* and *b* remaining as in experiment 2, and the window being closed, a third insulator (*c*) was attached by its collar, &c. (as usual) to a round table placed near to the others, with its chimney-lamp, &c., but no *lower shelf* was used. The electrometer E used with C had been found to accord very nearly with A and C. A fire burned in the stove of the room.

	Time.	Insulator *a*. Electrometer A.	Insulator *b*. Electrometer C.	Insulator *c*. Electrometer E.
Feb. 24.	9h 20m	20°	20°	20°
		5	4	4
			New charge.	
		20	20	20
		6	5	4

The insulator *c*, with its table, &c. removed into the north room, without any fire in the stove.

	Time.	Insul. *a*. Elect. A.	Insul. *b*. Elect. C.	Insul. *c*. Elect. E.	Daniell's Hygrom. in S. Room.	in N. Room.
	h m	°	°	°	°	°
Feb. 25.	14 5	20 3	20 1·5	20 0	14	8
„ 26.	9 15	20 4	20 2·5	20 2	13	12
„ 26.	13 2	20 6·5	20 4	20 4·5	14	12
Mar. 7.	14 17	20 6·5	20 7	20 4	30	22
„ 8.	11 43	20 4	20 2	20 4	26	21
„ 10.	9 20	20 6·5	20 4·5	20 3·5	16	9
„ 14.	14 45	20 5	20 3·5	20 5	19	12

It appears from these observations that very little difference arises in the insulating powers of our warmed glass pillars, from the circumstance of their being placed in an atmosphere a little more or less humid and cold.

4. Comparison of two united with two single Insulators.

In the *united* state of the insulators *a* and *b*, in these experiments everything was disposed as in experiment 1.

In their *single* state the uniting wire was withdrawn in the manner stated in experiment 2.

	Time.	Insul. *a*. Elect. A.	Insul. *b*. Elect. C.	Daniell's Hygrom.	Mean Loss in	Time.	
	h m	°	°	°	°	h m	
Aug. 31.	11 21	20	20	23	......	......	
	13 22	3·5	3·5	...	......	......	united.
					16·5	2 0	
	13 35	20	......	...	......	......	
	15 35	3·5	......	...	......	......	single.
					16·5	2 0	
Sept. 11.	14 5	20	20	...	......	......	
	15 25	3·5	3·5	...	......	......	united.
	14 30	......	......	24	16·5	1 20	
	15 29	20	20	...	......	......	
	16 52	4	3·5	...	......	......	single.
	15 33	......	......	26	16·25	1 23	
	10 6	20	20	...	......	......	
	11 3	3·5	3·5	...	......	......	united.
	10 25	......	......	18	16·5	1 24	
	11 34	20	20	...	......	......	
	13 25	4	3·5	...	......	......	single.
	11 37	......	......	21	16·25	1 51	
	13 30	20	20	...	......	......	
	15 17	5·5	3·5	...	......	......	single.
	13 34	......	......	22	15·5	1 37	
	15 13	20	20	...	......	......	
	17 44	4	3·5	...	......	......	united.
	15 45	......	......	24	16·25	2 31	

From this 4th set of experiments, it would seem that two warmed insulators retained the charge as well as one; and that therefore in the same situation each insulated "*perfectly*," using this expression in Coulomb's sense. But circumstances may arise in applying this kind of test to render the conclusion defective. The *two* caps, &c. (having greater capacity and quantity) should retain the charge better than one, &c.

It is evident that certain mysterious conditions of the ambient air interfere sometimes with our operations of this nature, and (as Sir David Brewster justly remarks) experiments should be undertaken to find them out*.

5. Experiments on Insulation by means of Chloride of Calcium.

The object of these experiments was to ascertain how far it might be practicable to construct electrometers which should lose the lower and more usual charges, received from the principal conductor, at given periods, in some near approximation to constant rates, yet not lower the tension of the conductor materially, on contact with it. For it is necessary to a more exact prosecution of our inquiries, that the true electrical state of the conductor, as regards both tension and kind, should be known at certain intervals of the night more accurately than it can be by means of the resinous electrograph described at p. 126.

In order to procure the greatest possible constancy of loss, it was (obviously) very desirable to obtain the greatest possible retention, and for this purpose non-conducting or semi-conducting laminæ, coated on both faces with good (or better) conductors, naturally presented themselves as being capable of retaining low charges for very great lengths of time. But these require, proportionably, much larger *doses* of electricity to produce equal effects on *tension* electrometers than simple conductors (not thus "compensated"), and would, consequently, lower the tension of the principal conductor *materially* at the time of receiving their charge from it.

In endeavouring to discover the best means of retaining a *small quantity* of tension ("frictional") (q) electricity a long time, I first employed receivers, air-tight and of various dimensions, containing vertical rods of glass (cut from the same piece) about $3\frac{1}{2}$ inches long and a $\frac{1}{4}$ of an inch in diameter. They carried horizontal brass wires from which were suspended pairs of *natural* voltaic straws (as in fig. 4), and were coated with the best *engraver's* hard sealing-wax, applied by heating the glass sufficiently to melt the wax (not by *spirit* varnish, which is far less effective). The receivers also contained each 2 or 3 ounces of chloride of calcium (below). The electrometers were charged (by an electrophorus) after lifting the receiver up from the flat glass plate on which they were placed (with a little oil in the joint).

These experiments proved that an electrometer originally charged to about one inch divergence of Volta's No. 1, or standard pair, would retain for the space of from 114 to 124 hours (by the above means), some remainder of its charge†; also that small receivers were better than large, &c.

But it soon appeared that after the straws had been for two or three days exposed to the action of the chloride, *they* became insulating in a very inconvenient degree, for when the wires supporting them were touched (continu-

* Vide Encyclopædia Britannica, vol. viii. p. 589, seventh ed.

1st. What relation has the *actual quantity of "dry steam,"* in a given measure of air, to the insulating power of that atmosphere?

2nd. What relation has the *temperature* of such an atmosphere with its insulating power?

3rd. In what degree is insulation influenced by the *density* of the atmosphere?

4th. Has oxygen gas and dry steam a different insulating power from nitrogen, &c.?

The solution of *this* query would not serve *our* purposes perhaps.

† An *uncoated* rod retained some remainder for 102 hours. Had the receivers been *perfectly* air-tight perhaps this would have insulated as well as the others.

ously) they would not collapse for five or ten minutes; and after these supporting wires had been charged, the straws continued *slowly* to *increase* in divergence during an hour or more sometimes*. This was proved by comparing them with natural undried straws.

I therefore tried many experiments upon straws *gilded* in various ways, but even these did not appear to afford such complete freedom from the above-mentioned defect as was required.

Passing over many details (tedious but not instructive perhaps), I will now describe shortly the apparatus, &c. which I call my registering (or night) electrometers, the results of many trials.

Three receivers, $5\frac{1}{2}$ inches high and 4 inches diameter, were fitted air-tight to ground brass plates at their bases and necks. In these the electrometers, supported as before, could be charged by means of moveable and insulated wires, without interfering with the air-tightness of the receivers, and they contained a rather larger quantity of the chloride.

In lieu of the straw electrometers recourse was had to a modification of my old instruments of fine wires†, very accurately straightened, and in order to prevent as much as possible dissipation, without materially increasing their weight, minute globules of gum-arabic were applied at their extremities, whilst they were electrified for the occasion.

A scale which could be read in terms of the standard voltaic electrometer was thus prepared: a slip of ivory was properly cut (to the radius of the wires) and fixed at one extremity of a ruler one foot long; the other end of the ruler carried a sight-piece, like C (fig. 5); this ruler was held in the hand, and the scale-end made to touch the receivers when used. The graduation was easily effected (not in *exactly* equal divisions of course) by marking on the scale (before engraving) the degrees of divergence of the wires, as seen through the sight, which corresponded with the divergences of the ordinary standard electrometer, placed in good conducting contact with these wire electrometers.

In order to compare these registers with each other and with the standard, the moveable insulated wires and the standard were placed in contact with an insulated horizontal wire, so that they might be all charged simultaneously; then their contact with the horizontal wire was suddenly broken, and at the same moment the contact of the moveable wires with the electrometric wires.

The following Table on the next page exhibits a specimen of the performance of these registers, called C, D, and E.

If a quarter of a degree of this scale be added for every hour which may elapse betwen the time at which any one of these registers was charged, and the time at which it is read, up to the 45th degree, we may perhaps be tolerably sure of knowing what the charge was within something less than a tenth of a degree (and this is a quantity which cannot be appreciated by any observation of a voltaic electrometer).

After the 45th degree (upwards) the loss per hour begins to increase in a much more rapid rate, and after the 90th uncertainty prevails, because *spirtings* "spruzamenti" begin, as Volta found in his electrometers.

However, the *nightly* charges of our conductor (after 10 P.M.) in serene weather seldom exceed 45 degrees.

New experiments must be made on this subject. In the mean time we apply these instruments to the purpose intended, and hope to improve our journal thereby. The particular mode of application and a more detailed

* We have observed the same kind of effect (in much smaller degree) in the electrometers (exposed to the open air) in the observatory in *very* dry weather.

† Vide Descriptions of an Electrical Telegraph, &c., 1823, p. 33.

account of them will perhaps be a subject for report when the observations made with them are recorded.

A sort of minute Leyden jar, mounted in the chloride as above, retained a remainder of a low charge 15 days, but it lowered the tension of the conductor from 2 to 5 degrees, and more accordingly as the electricity of the air was *frequent* or *slow*.

1844.	C.			D.			E.			Mean Loss of the 3 per hour.
Day.	Hour.		Loss per hour.	Hour.		Loss per hour.	Hour.		Loss per hour.	
June 15.	4 20	57·5°		4 0	65°		4 47	57·5°		
"	6 50	55		11 45	62·5		10 7	55		
"	12 41	52·5		16 30	60		17 44	52·5		
"	16 29	50								
"	....	......	0·63	....	......	0·4	....	......	0·38	0·47
16.	6 23	45		5 0	55		8 10	47·5		
"	15 10	42·5		13 55	52·5		18 40	45		
"	....	......	0·28	20 20	50	0·33	....	......	0·24	0·28
17.	7 45	37·5		4 15	47·5		4 45	42·5		
"	16 57	35		13 23	45		17 0	40		
"	....	......	0·27	....	......	0·27	....	......	0·2	0·25
18.	5 0	32·5		7 20	40		4 15	37·5		
"	15 17	30		17 0	37·5		15 20	35		
"	....	......	0·24	....	......	0·26	....	......	0·23	0·24
19.	4 0	25		5 30	35		4 0	32·5		
"	17 0	22·5		13 0	32·5		13 45	30		
"	....	......	0·2	....	......	0·33	....	......	0·26	0·26
20.	4 45	20		4 0	30		8 0	25		
"	17 0	17·5		11 45	27·5		17 0	22·5		
"	....	......	0·2	20 30	25	0·3	....	......	0·28	0·26
21.	4 0	15		5 0	22·5		4 0	20		
"	14 17	12·5		13 30	20		16 0	17·5		
"	....	......	0·25	....	......	0·29	....	......	0·2	0·25

6. Experiments on Induction, &c. by Atmospheric Electricity.

Professor Wheatstone has several times repeated, in a very striking and pleasing manner, the experiments of Herr Erman and M. Peltier, &c. relative to this subject, and such kinds of operations have never failed when tried upon the flat roof, and in fine or appropriate weather.

The electroscope used was of Bennet's kind but square, and the conductor about 15 inches high, with a hollow copper ball on its summit of 3 inches diameter.

I have also occasionally substituted a "*solfanello*" (following Volta) for the ball, in order to exhibit the difference between electrisation by induction and absorption.

In the first case, after the electrometer has been touched in its high position, the leaves do not (of course) diverge again until absorption takes place, after the lapse of a considerable length of time, and when the insulation is extremely good. In the second case they instantly begin to diverge, and attain to a greater divergence than by induction, all else being equal.

Small gold leaves being very liable to derangement, &c., and being less applicable to a scale-measurement than straws, I have constructed a pair of voltaic electrometers for these experiments (and others requiring portability), similar to those of figs. 4 and 5, excepting that the cover T is screwed upon the case, and a very *light* conical-jointed tube about 3 feet 3 inches long can be screwed upon the wire, which supports the straws, and either a hollow light ball or a *solfanello* can be fixed on the top of it. The glass tube S is longer and stronger, and protected from rain, dust, &c. by a cap. This pair of electrometers fits into a case and the conductor into a walking-stick. The conductor might be jointed and its length increased with great advantage.

7. Experiments on Frequency of Atmospheric Electricity.

By these terms is understood the rate at which a new charge rises to its maximum, after a former charge of an atmospheric insulated conductor has been destroyed.

The old experiments of Beccaria on this property appear to me to have been much less attended to than they should have been. It seems to form a sort of link between natural high-tensioned (frictional) electricity, and galvanic, or Voltaic or Œrstedic electricity (electro-magnetism).

We have as yet merely instituted a few very rough observations of this kind, not having obtained opportunities for prosecuting the inquiry in a satisfactory manner.

The apparatus employed consists partly of that described at p. 135. The two insulators (*a* and *b*) were carefully compared as to insulating power. An arm (of wood, which is not a proper material) projected from the cap of each, outside of the window of the room D (fig. 1), and to these arms were firmly lashed two exactly equal copper conical tube-conductors, carrying small and equal lanterns on their summits.

After abundant time had been given for these conductors to attain their maxima charges, one only was discharged, and the time which elapsed before that one acquired a new charge equal to the charge of the other is my measure of "frequency."

	Time.	Tension.	Frequency.	
	h m		′ ″	
May 2.	20 21	20	2 15	Fine clear evening succeeding a fine day.
"	21 32	42	13 35	
May 3.	21 0	22·5	20 30	
"	21 46	25	20 45	
May 6.	20 0	28·5	2 45	The evening fine and starlight, but somewhat cloudy.
May 8.	19 51	5	13 25	The weather dull and overcast.
May 9.	20 45	8	16 0	At 20^h dull and cloudy; at 21^h clear and starlight.
May 16.	20 55	7	3 0	At 21^h dull and overcast. The day had been fine but rather cloudy.

These few and imperfect observations serve to prove little more than that at different times and under different circumstances (of weather, &c.) *very great* differences in the relations of tension to frequency occur*. Fogs and heavy dews have always great frequency.

8. Pluvio Electrometer.

We are fully convinced that a hard shower of rain, &c. as frequently robs our conductor of large doses of electricity as that it brings them.

* The first maximum charges, viz. 10° of these lower rods on the 8th of May at 18^h 55^m was *greater* by one degree than the charge at the same moment of the high conductor on the dome, but after the destruction of the first charge they never rose again to the same height as that of the high conductor by 5 degrees. On the 16th of May, at about 18^h 55^m, the lower rods at the time of their first charge exhibited a tension equal to that of the high rod, and the maximum charges afterwards were at 20^h 55^m 13 degrees lower. These singular facts might possibly be accounted for on principles by which I would explain the experiments of Erman, but shall forbear from theorising here.

A copper dish (vide fig. 1.) of 3 feet 6 inches diameter and about 6 inches deep, quite smooth and with a well-rounded ring on its edge, has therefore been very recently mounted upon one of our usual insulators, and we hope to observe some circumstances worth notice with this apparatus when we have time to pursue investigations of this kind.

9. Storm Clock.

It has been remarked in our MS. Journal that the difficulty of noting down the various and transient phænomena of a storm is too great for any single observer to overcome without assistance.

I have therefore projected a time-piece carrying an index down a long page of paper in half-an-hour, by which means, in lieu of having first to read the times by our chronometer and then to set them down, erroneously perhaps (in the hurry of the moment), the observer will have only to record the events as fast as they occur (nearly) opposite to the point of the index, *if he can* (for even this will be *sometimes* too much for one person to accomplish: Beccaria employed *several* observers frequently on such occasions).

This instrument is in progress.

10. New Coulomb Electrometer.

In my "plan," &c. sent to Mr. Wheatstone in November 1842, is described a proposed modification of Coulomb's electrometer, which seemed to possess great advantages for atmospheric electricity, and I constructed a rough kind of model which clearly showed that the project was feasible.

The principle consists in suspending a *conducting* moveable needle in lieu of the usual insulating needle, by a torsion *wire*, or by a pair of torsion *wires* (instead of Mr. Snow Harris's *silken threads*) in such manner as to be always in perfect conducting communication with a *fixed conducting needle*.

A drawing for a complete instrument of this kind was placed in the instrument-maker's hands in May. It is *now* nearly finished.

11. Spring Anemometer.

In order to know something about the force of the wind by simple inspection and without leaving the observatory, we have fitted a little slider to the part (A) elongated of fig. 17, which slider is made to rise or fall by the action of the wind on a set of flyers situated on the top of the wind vane, and by a spiral (volute) spring, &c.; but this arrangement is not yet complete.

Kew Observatory, Sept. 25th, 1844.