REPORT

OF THE

TWENTY-FIRST MEETING

OF THE

BRITISH ASSOCIATION

FOR THE

ADVANCEMENT OF SCIENCE;

HELD AT IPSWICH IN JULY 1851.

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declination have been in a great degree remedied. All the essential parts of the apparatus being of metal or stone, the permanency of the adjustments is secured. The light being admitted directly to the instrument, and the optical power not being so great, the photographic means are increased. The dimensions of the magnet and its appendages being much smaller, the mechanical inertia is diminished; and by the use of a very powerful copper damper, the inconvenience arising from vibration is almost wholly got rid of. The results of these improvements are such as might be expected. It has been found that a long series of registrations can be obtained without the occurrence of a single case of mechanical derangement requiring re-adjustment of any portion of the apparatus. The instrument has been found capable of recording, in a perfectly distinct manner, almost all the magnetic changes which occur, and with a delicacy of scale quite sufficient to represent even the most minute movement. In only one instance during the six months has it been unable to overtake the most rapid motions. In the disturbance of September 29, it certainly has been found deficient in power to represent with distinctness those very violent and extensive changes which occasionally do occur. This deficiency seems to have arisen—1st, from the length of time during which the plate is exposed to the action of the light being sufficient for more than one motion to take place; and 2nd, from the mechanical inertia being still so great, as in some instances to carry the magnet farther in the direction of a sudden magnetic change than is strictly due to such change. These defects seem to point to the desirability of further improvements in the same direction as those already made, namely, greater photographic power and less mechanical inertia. It should be remarked also, that in the larger disturbances the extent of scale adopted for all the instruments has been insufficient to contain the extreme excursions.

The performance of the vertical force instrument has unfortunately been so little satisfactory, from causes apparently unconnected with the means necessary to adapt it to photographic registration, that it is impossible to come to a distinct conclusion as to its value. Its performance for some time after being repaired by the maker was, however, so good, and its power of exhibiting such great and sudden motions as occurred during the disturbance of September 3–4 so considerable, as to hold out the expectation that, whenever the source of the errors already noticed shall have been discovered, it may be found to be a really efficient and trustworthy instrument.

John Welsh.

Kew Observatory, October 23, 1851.

Report concerning the Observatory of the British Association at Kew, from August 1, 1850 *to July* 1, 1851. *By* Francis Ronalds, *Esq., F.R.S., Honorary Superintendent.*

It is hoped that this eighth annual summary relative to the status and proceedings of the Kew Observatory will evince our sincere desire to promote the liberal views of the British Association, and that our diligence has been commensurate with the augmented funds which have been kindly granted by Her Majesty's Government and the Royal Society, and with the increased interest which gentlemen of the highest scientific acquirements and reputation, both at home and abroad, have manifested in the success of the Establishment.

The principal means which I have employed in its composition have been references to my former Reports of a like kind; examinations of the various instruments, &c. spoken of; descriptions, &c. from my own portfolios; the Electro-meteorological Journal; the tabulations and tracings of the magnetic curves, &c., and the Kew Diary.

The materials which I have used for supplying some omissions in our Diary have been three manuscripts concerning the Meteorological Journal, the Barometrograph, and the Hygrometers, drawn up by Mr. Welsh (our observer). In making use of the Diary and all other documents, endeavours have constantly been made to record shortly only such facts as may be, or may become useful, and to do this in the words themselves of those documents whenever a due regard to brevity permitted.

The subjects are arranged under four heads:—1st, those which relate to the Building, Instruments, &c.; 2ndly, those referable to the Observations; 3rdly, experimental (and analogous) subjects; and lastly, those which do not properly belong to any of the former.

I. THE BUILDING, INSTRUMENTS, &c.

*The edifice** has undergone no change of importance this year. The annexation of three new corbels to the wall of the great mural quadrant, for the support of a new Vertical-force Magnetograph, is probably a temporary expedient. The custody of a large quantity of apparatus, consigned to our care by the Royal Society, and of which a portion is highly valued, from the circumstances of its having been invented, or made, or even possessed by such men as Boyle, Huygens, Newton, Cook, Cavendish, Coulomb, Le Roy, Sabine, Kater, &c., renders a little reparation (of damage by dry rot) and painting very desirable (a long time has elapsed since any interior painting has been done); and it has frequently been thought advisable that the wall of the great quadrant, which instrument has long since been dismantled, and will never be again employed, should be converted into piers, pedestals, &c. for the support of experimental instruments requiring scrupulous regard to immutability of position and exemption from extraneous vibration†.

In speaking of the Instruments, I refer principally to those which have been more or less used in this year.

Electrical Apparatus.

The Principal Conductor, &c. on, and in, the Dome, and all the electrical apparatus which has been employed for the observations of atmospheric electricity, are in working order. The *Rod*, *Lantern*, &c., the *Volta-Electrometers*, *Henley-Electrometer*, *Discharger* and *Distinguisher*, retain the forms described at p. 123 (*et seq.*) of the Report for 1844. The *Observer's Clock and its scale* remain as described at p. 178 of the Report for 1850.

The Galvanometer of M. Goujon gives strong indications when connected with the conductor, in times of violent rain, &c., but is not to be depended upon as to measures.

* Described at p. 120, Report for 1844.

† Two of the magnetographs, although solidly, are inconveniently placed. The photo-barometrograph requires a much better foundation than boards and joists can afford (as will be seen); and for the due prosecution of projected observations of standard and other barometers, pendulums, &c., extremely solid bases cannot (obviously) be dispensed with.

The three Night-Registering Electrometers, described at p. 139 of the Report for 1844, are effective, but little employed. They were very useful formerly, but will soon give place to the Photo-Electrograph.

The Gold-leaf Electroscope itself remains nearly as described at p. 125 of the same volume. The little additional apparatus for preserving its insulating power, afterwards alluded to, and now described more particularly, has been found very convenient and effective.

A (Plate XVIII. fig. 2) is a thick plate of well-ground and polished glass.

B, a kind of annular tin trough, coated with sealing-wax varnish, and containing chloride of calcium.

C, the electroscope.

On the central part of A, not occupied by B, stands C; which, together with B, is covered by a glass receiver, fitting air-tight upon A when C is not in use.

By this means the electroscope may be preserved in a dry and clean state, and quite ready for use at any moment; and it is evident that a similar drying arrangement may be adopted in respect of a Volta, or any other detached electrometer or electrical instrument, &c.

The pair of *Portable Volta-Electrometers*, occasionally used on the leaden roof of the building for experiments on induction, absorption, &c. of atmospheric electricity, are in the original state alluded to at p. 140 of the Report for 1844; they were not particularly described there, because, with the exception of a few additions and alterations, they are similar to the instruments used in the dome; but several eminent meteorologists having thought that these instruments would, if used with proper precautions, afford better approximative results in observations, on mountains, &c., than the portable instruments which have been usually employed, the following short but complete account of them may possibly be found convenient.

A (Plate XVIII. fig. 1) is the lower part of one of them.

a^1, a little hollow pedestal, the side, base, and upper surface of which are formed out of one brass casting. It is about 3 inches high and 2 inches square.

a^2, a cupola of cast brass screwed firmly into its upper surface.

a^3, a lamina of thin plate-glass polished and attached, by a frame of brass and screws, to a^2: a lamina of *ground* glass is fixed in like manner to the back of a^1.

a^4, a tube of thick glass well-coated with shell-lac, applied by heating the glass until it is capable of melting the lac, but not of carbonizing it. It passes through and is firmly cemented to a cover which is screwed into a^2. Its lower end projects about an inch below the cover, and on the upper end is cemented a brass cap and screw. A wire, forming a continuation of that screw, passes through the bore of a^4, in which it is securely fixed; this wire terminates below in a flattened part, which has two minute perforations at the distance of half a Paris line from each other.

a^5, a pair of Volta's straw *penduletti*, two Paris inches long. In their upper ends are fixed hooks of fine copper wire, which pass through the perforations and suspend the straws freely: their lengths and diameters are in strict conformity with Volta's prescription for his standard instrument (No. 1).

a^6, an ivory scale fixed in front of a^3; its upper edge is an arc whose radius is equal to the lengths of a^5, and it is graduated in half Paris lines;

the zero-point being opposite to the line where the straws nearly touch each other when unelectrified.

a^7 is a small brass tube or cap fitted upon the cap of a^4, but whose interior cylindrical surface stands at the distance of about $\frac{1}{10}$th of an inch from the coating of lac on a^4; it can be removed at pleasure*.

B is an electrometer, similar to A in all respects, excepting as regards its pair of straws b^5, which are rendered so much heavier than the straws of A, by filling their cavities with the prolonged wire of their hooks, as to diverge (when both are equally electrified) exactly $\frac{1}{5}$th as much. This arrangement agrees with Volta's prescription for his electrometer No. 2, and the exact accordance of the two instruments is ascertained by his halving process†.

C is the conductor, consisting of a very light conical tube of copper about 3 feet 6 inches long, and furnished with a brass cap below, which screws upon the cap of a^4.

c^1 (fig. 1^a) is a helix of small copper wire, the lower and smaller part of which fits upon the upper extremity of C; the upper part being considerably larger.

c^2, a *solfanello* (of Volta), *i. e.* a sulphur candle, composed of about 10 threads of lamp-cotton coated and imbued with sulphur whilst in a melted state. It is placed in the larger part of c^1.

D is a mahogany case placed upon a portable staff or table, or a post.

d^1 d^1, &c. grooved pieces, between which the lower parts of A and B may be slid, and the instruments be thus properly packed for transport.

d^2, a little drawer containing a supply of *solfanelli*, &c.

A hollow walking-cane may contain C, disjointed for the sake of portability; and tubes might be occasionally slid through the bottoms of a^1 and b^1 to embrace a^5 and b^5, thus preventing their violent vibration, &c. in transport.

When these instruments are to be used in Volta's or Bennet's manner, c^1 may be slid upon C, and c^2 (lighted) into c^1; when in Saussure's manner, a pointed wire may be substituted for c^1 and c^2; when in Cavallo's, Erman's, or Peltier's (inductive) manner, a ball may be attached to the end of C, or C may be disjointed and a ball attached to its lower joint; or the instrument may be used without any such conductor, as may be most suitable to circumstances of locality, &c.

In all cases where the atmospheric charge is not extremely minute, straws are infinitely preferable to gold leaves, which can never be safely transported in their instrument.

The *Peltier Electrometer*, or (rather) Erman's, which has been particularly described by both inventors, can scarcely be said to be in working order, its insulating capacity having greatly diminished.

Electrical Observatory for transport.—The expense and difficulty of conveying to distant stations apparatus for electrical observations so large and heavy as is ours, have furnished the motives for arranging some instruments, already existing at Kew in the form represented by fig. 3, Plate XVIII., which shows that a very efficient apparatus may be constructed at small comparative expense, and presenting considerable facility of transport.

The round-house AA is drawn in half-section; its proportions are derived from a square portable house which came to Kew from Woolwich for some

* Since the above was written, an electrometer of this kind has been presented to Lieut. Cheyne for employment in Sir Edward Belcher's north polar expedition.

† Vide Opere del Volta, tome i. parte ii. p. 13 *et seq.*

proposed magnetic vibration experiments ; it is high enough to allow an observer to stand in it, and broad enough to allow him to view the electrometers in a stooping attitude. Several parts of the contained apparatus are similar to the principal corresponding parts in our Dome (vide Report for 1844, p.120). Some are improved.

a is a mahogany varnished cylinder fitted into a circular aperture in the roof, and furnished with a smooth ring or rim projecting outward from the upper end.

B, a window (which may serve for photographic purposes, &c.).

C, my strong hexapod-stand; but capable of being folded into a very small compass*.

c^1, a safety conductor of thick copper wire, in good conducting communication, with moist earth or water.

D, fig. 3ª, is the upper end of the principal conductor, which is a light conical tube of copper 12 feet long.

E, a brass tube whose upper end is $2\frac{1}{2}$ feet above the roof of A, and into which the lower end of D is firmly screwed, but from which it can be removed at pleasure by a person standing on the roof of A.

F, the usual stout hollow glass pillar, with its collar of wood, &c. It is trumpet-shaped below and firmly secured by bolts passing through the collar and table.

G, the table, which also carries the other instruments.

H, the cap with a globular ring fitted on F, and supporting

II, which are two conical tubular arms of brass.

KK, the bolts, &c. which contain the screws, plugs, and stoppers for sustaining and adjusting the sliding arms, &c.

k^1 k^1, the clamping balls.

k^2, one of the sliding arms passing through K, &c. and adjustable vertically (or to any angle). It can be secured in any required position by means of k^1, in the manner formerly described.

L, the small warming lamp.

l^1, the usual conical chimney of copper, closed above and entering F, to which it imparts warmth from L.

M, fig. 3ª, a small Volta's lantern, fitted by a socket on the top of D. It contains the collecting lamp, and is provided with a little cowl† in lieu of the former perforated cap.

N, a copper cylindrical parapluie, fitted by a collar on E, and having a smooth ring or rim, projecting nearly as much inward as the rim of a^1 projects outward‡.

O, the uninsulated part of Volta's standard or electrometer No. 1.

P, his second electrometer, both as improved and formerly described.

QQ, the usual apparatus, of suspending wire, glass tubes, covers (of O and P), rings, &c., by means of which the straw pendulums are made to depend for insulation on F only.

R, the horizontal tubular arm, fixed upon k^2, with its stoppers and notches (for the reception of the knife-edges in the rings). The eye-pieces and their adjusting apparatus used in the Dome for reading the scales of the

* First described in 1828. *Vide* "Mechanical Perspective," p. 19.

† This cowl was (long since) suggested by the Astronomer Royal and is a decided improvement.

‡ These improvements on the old parapluie, &c. (which did not exclude every drop of water during a violent driving shower) occurred to me since the reading of this Report, and are adopted in a complete electrical apparatus now constructing for the Royal Madrid Observatory.

electrometers are here omitted as not being absolutely necessary for the objects contemplated; but they can be, at any time, easily added.

A sheet of tin-foil is placed under O and P, and in good conducting communication with c^1.

S is the Henley electrometer, as modified by Volta (and formerly described).

T, the discharger (or spark-measurer), remains as also formerly described.

t^1 is a rod and balls, adjustable to height, and attached to one of the balls K, in the manner in which k^2 is attached to the other ball K.

The distinguisher, used for ascertaining the *kind* of charge possessed by the conductor, may be either the small Leyden-jar, combined with a gold-leaf electroscope formerly described; or the electroscope at fig. 2, which retains its charge very long whilst under the glass bell, and may be used for the above purpose without being removed from it*.

External Apparatus for Insulation, &c.—The apparatus represented by fig. 4, divested of the conductor (D), formed part of an instrument formerly alluded to (Report for 1844), and which was called a pluvio-electrometer. In lieu of the conductor a large copper dish was fixed upon the glass pillar (F), mounted on the tripod which was placed on the leads of the Observatory, and the dish was connected by a wire with a separate insulating apparatus in the Dome, for the purpose of examining the electricity of rain. Deeming the employment of a dish objectionable, however, I made little use of the instrument for that purpose; but it has been found very convenient in the form here described as an external and portable apparatus, placed in situations where it would have been inconvenient and expensive to have erected a round-house observatory (as fig. 3). Some electrical observers would probably derive advantage from its use, in preference to the rod projecting from a window, as in Volta's, Cavallo's, my own former, and many other experiments; for it requires a very long rod thus used to get rid of the baneful effect of the house-top, chimneys, &c., particularly when the wind passes over the house from the side opposite to that from which the rod projects.

G (the table) is, in this case, supported by 3 triangular strong boards or frames, attached, by strong hinges, to its under side, and provided with edge-pieces or "feather-boards," for diminishing vibration, &c.; they can be folded inward, for the sake of portability, &c.

g^1 g^1 are 2 of 3 pieces of sail-cloth, which, by means of studs (or buttons) on the boards or legs, and of corresponding hooks upon g^1 g^1, can be laced (with small cords) upon the legs, so as to fill up any or all the spaces between them, and thus prevent the interference of wind with the lamp.

D, the conductor, and

F, the glass pillar, &c., are nearly similar to those of fig. 3, but stronger. The warming lamp is much more powerful than the lamp of fig. 3, in order that it may counteract the colder atmosphere to which this apparatus is usually exposed.

a^1, the cylinder, shown by dotted lines, and corresponding in some respects with a^1, fig. 3, is of copper, and protects F from rain, &c.

This apparatus may be placed on the roof of a house, and a wire, or (better) a rod, led from it, may communicate with an internal apparatus as the part

* It may be convenient to attach this (with its glass bell) to one end of a *long* arm or bracket revolvable horizontally upon a strong pivot at the other end.

H, &c. of fig. 3, or it may be placed in any high situation on the earth, at a distance from buildings, &c., and a long wire may be attached to a stronger and shorter rod taking the place of D. This wire may communicate with internal apparatus, and thus Beccaria's principal method of observing the electricity of serene weather, dew, &c. may be adopted and compared with others, and with the electricity of higher strata of the atmosphere.

Or (much better), several such insulators may be distributed over a considerable space and made to support several wires connected with each other and with the internal apparatus.

A large network of small wire thus insulated has long been a desideratum with me. The pillar F, &c. might be inclined for the sake of acquiring a better position for resisting the weight of such network.

For examining the electricity of rain in Cavallo's manner, a hoop of copper supporting a net work of wire, as shown by the dotted lines, might be advantageously substituted for the above-mentioned dish or the conductor D.

Three such insulators might be placed in an equilateral triangle, and 3 light cords, containing very fine wires, might be attached to an electrical kite, thus maintained at a nearly invariable height, as was done by lines not wired, in a rough experiment made here in 1847, with a view to temperature and hygrometric observations (vide Phil. Mag. for September 1847).

The *Photo-Electrograph* remains nearly as described in the Phil. Trans. Part I. for 1847. It will be improved by the addition of a little apparatus applicable to the registration of electrical frequency, and removed into the Dome.

Anemometer, &c.

The *Wind-Vane* remains as described in the Report for 1844, p. 129.

The *Balance Anemometer* of metal—an improvement upon that described in the Report for 1844, p. 129, and precisely similar in principle, but more sensitive—will be particularly described when further contemplated improvements have been effected. It is supported upon either a pillar attached to the northern part of the balustrade of the leads, or upon one at the southern part, according to the direction of the wind. It turns to the wind on hard steel centres, and vibrates vertically upon hard knife-edges and rings, in the manner of a delicate scale-beam.

Rain Gauges, &c.

The *Rain- and Vapour-Gauge* is in the state described at p. 129 of the same Report. Wear does not seem to affect its sensibility. On November 16, 1850, it was removed from the support of the old rain-gauge and placed upon a strong tripod, very near to its former locality, viz. the southern end of the leads, and at the same height as before.

The old *Rain-Gauge* is a relic of His Majesty George the Third's collection of Kew instruments. Its aperture is a square foot. A bottle, the neck of which nearly fits the conducting-pipe, is placed beneath it, and a glass cubic-inch measuring vessel is used (in Howard's manner) to ascertain the amounts of rain.

Thermometers, Hygrometers, &c.

The *Thermometer-stand* (Plate XIX.), not before clearly described, and nearly similar to that of Greenwich, is situated in front of the northern entrance on the stone platform. The mean distance of its face from the wall (or door) is about 5 feet. The height of the base (a^1) from the grass below the steps is about 11 feet, and from the stone platform 3 feet 9 inches.

A is a wooden painted frame 2 feet 6 inches square.

a^1, a base-board attached to the lower part of A, &c.

a^2, the underside of a strong piece (represented by dotted lines) attached to the upper part of A, &c.

a^3, an interior portion of a penthouse composed of very thin boards attached to a^1 and a^2.

a^4, a similar exterior part of the roof, nailed to three narrow fillets, which are also attached to a^3, and maintain an interval of about an inch between a^3 and a^4; thus allowing a free circulation of air between them.

a^5, the remaining part of the roof.

a^6 and a^7, rails; the former adjustable for height above the latter.

B is a strong spar or post, firmly attached by wedges, &c. to the balustrade; in its upper end is fixed a cylindrical pin, which freely enters a socket in the central part of a^2, and allows A, with all its adjuncts, to be revolved on the axis of B.

The *Dry Standard Thermometer*, C, by Newman, has a brass Fahrenheit scale divided to 0·5 inch. It was found on September 21, 1850, to read 32° in pounded ice*.

A *Dry Thermometer*, D, by Ronchetti, has an ivory Fahrenheit scale divided to 0·2 inch. The tube and scale are enclosed in a hermetically sealed thin glass tube. The index corrections, when it was compared with C (on September 21, 1850), were at 32° − 0·1, at 54° + 0·2, at 73° + 0·5.

A *Wet-bulb Thermometer*, E, by Ronchetti, is exactly similar (in form, &c.) to D. The coating of its bulb is of taffetas, and the conducting threads are of floss silk. Its index corrections, when it was compared as above, were, at 32° − 0·5, at 54° − 0·2, at 73° 0·0

c^1 is a glass fountain which supplies the water. It is mounted on an adjustable support.

The *Mason's Hygrometer*, by Newman, was attached to the stand at about the place of E until September 22, 1850. Its index corrections, when it was compared with C, as above, were at 32° 0·0, at 54°—0·1, at 73°—0·5.

The *Rutherford Maximum and Minimum Thermometers*, FF, by Newman, have boxwood scales, the minimum divided to 0·067, the maximum to 0·047 inch. The index corrections (as above found) for the maximum were, at 32°—1°·5, at 54°—9°·2, at 73°—2°·0, and for the minimum at 32°—0·3, at 54°—0·4†.

* Since the above was written comparisons of this thermometer with standards, made here, gave the following results:—

Readings of Newman's.	Error of Newman's.
32°	0°·00
43·5	+0·21
53·6	+0·42
62·2	+0·52
71·7	+0·54
81·7	+0·55
86·6	+0·58

† It is evident that these instruments attached to the stand may be always protected from

A new *Daniel Hygrometer*, G, by Newman, has been used in various positions.

The index correction of its immersed thermometer (found as above) was −0·3.

The old *Daniel Hygrometer*, G, by Newman, which gave place to the above (on February 1, 1851), had a small void in the mercurial column of the immersed thermometer.

The index corrections of this instrument, found as above, were at 32° −0·5, at 54° −0·3.

The *Saussure Hygrometer*, H, of eight hours, made by Richer of Paris, in 1815, and described in the Journal de Physique, tom. xxxiv., p. 58, has a scale of 100 parts. Some experiments made in September 1850, seem to show that the range of the index had extended 5 divisions on the side of "humidity," and an equal quantity on the side of "dryness."

An old *Standard Thermometer* made by Adams, in about 1768 probably, for His Majesty George the Third's collection, is contained in a thick metallic case, open in front. It has a brass Fahrenheit scale divided to 0·059 inch. Its index corrections, when it was compared with C, as above, were at 32° −0·5, at 54° −0·5.

A *Regnault's Hygrometer and its Aspirator* in their original forms have been presented to us by Capt. Ludlow, R.E., together with several spare glass cisterns whose lower parts are formed of thin black glass, in addition to other cisterns compounded of silvered and glass tubes united by cement. These instruments have been described by M. Regnault*.

The comparisons of its two thermometers, No. 151 and No. 152, with the Newman's standard C, on September 23rd, 1850, gave the following results:—

Newman's.	No. 151.	No. 152.
32°	63°·1	90°·9
54·5	120·0	140·0
72·5	166·0	178·6

An improved Regnault's Hygrometer and Aspirator have been made, and may be thus described:—

A (fig. 1, Plate XX.) is the cistern, composed of a light and highly-polished silver tube. A little cylinder, of solid glass, occupies about an inch, measured from its bottom, and æther the principal part of the space above the glass.

direct influences of the sun's rays, wind, and rain taken separately, and sometimes collectively, by revolving A about B, but the difficult problem of always protecting them from all these influences simultaneously, of also avoiding the anomalous effects of radiation and humidity from neighbouring bodies, and of preserving a sufficiently free circulation of air, has, I fear, still to be solved.

* The distinguishing feature in the action of M. Regnault's admirable Hygrometer, as compared with that of the Daniel, is the deportation of ætherial vapour from the interior of a mass of æther (as well as from the surface) contained in a light metallic or glass cistern, by a current of air (bubbles) passed through the æther, and cooling the cistern down to, or beyond, the dew-point. The aspirator, a vessel containing water, and whose upper part communicates with the cistern of the hygrometer (only) by means of a flexible pipe and stopcock, is employed to create (and regulate with great precision) the current of air (and consequently the rate at which the cistern is cooled) by the flow of the water from its lower part.

a^1 is a brass cap soldered to A.

a^2 is part of a small vent (or cock) opening into A.

a^3, a tube (of the vent) with a small aperture at the pointed end, which when turned downward, permits fluid (above the opening of a^2 into A) to pass out, but when turned upwards that opening is entirely closed. By these means it is easily ascertained when æther enough has been poured into A.

a^4 is a stop-cock communicating with A and D, and serving as a support for A, &c.

B is the immersed thermometer, the tube of which passes (with cement) through a little pipe soldered to a disc (not shown) which rests upon a flange in a^1.

b^1, a ring (with milled edge) screwed upon a^1, and serving (with a leathern washer) to press the disc (carrying B, &c.) firmly down upon the flange in a^1.

C is a pipe for admitting air (and also for feeding A with æther) on occasion; it passes through the above-mentioned disc (with cement), and extends nearly to the solid glass cylinder in the bottom of A. Its upper end is funnel-shaped. When the instrument is not in use, this end is closed by a milled-headed stopper and leathern washer (to prevent the escape of ætherial vapour).

D is a brass column having a cylindrical bore throughout its length, excepting the upper plane of the cube; a^4 is screwed into the cube and communicates with the bore.

A glass shade may be placed over A, D, &c., for protection from rain, dust, &c. (on occasion).

E, figs. 2 and 3, is the aspirator.

e^1 is a pipe fitted into the bore of D, and entering

e^2, which is a square piece perforated horizontally and ground to fit exactly upon

e^3, which is a tube, closed by plugs, at its left end and its central part (in the manner shown in fig. 3). A perforation through the (always) upper side of e^3 and through e^2 admits a free passage of air, ætherial vapour, &c. from e^1 into e^3.

e^4 is a squared piece perforated horizontally, and ground to fit exactly upon e^3, but having liberty to revolve upon e^3 on occasion.

e^5, a pipe entering e^4, and *now* ascending from it. Another perforation through the (always) upper side of e^3 admits a free passage of air from e^3 to e^5 when e^5 is in the position shown.

e^6 is a rectangular vessel into which e^5 opens, very near to its *now* upper surface; and e^5 is soldered at the place where it passes through the *now* lower surface of e^6.

e^7, a pipe opening at a small distance from the now interior bottom of e^6, and from the now interior top of

e^8, which is a vessel exactly similar to e^6.

e^9 is a pipe opening into the now upper part of e^8, and entering

e^{10}, which is a squared piece perforated horizontally to fit upon e^3, but having liberty to revolve upon e^3 when necessary. A third perforation through e^3, at its always lower side, and through e^{10}, admits a free passage of air from e^8 to e^3.

It is evident that if e^6, in its present position, should contain water, and that if a current of air were permitted to flow through e^1, through the left-hand hollow part of e^3, and through e^5, the water would descend through e^7, and air, in e^8, would escape through e^9, and through the right-hand end of e^3, or (*vice versâ*) that the descent of water from e^6 to e^8 (through e^7)

would create a tendency to a vacuum in e^6, which would cause air to flow through e^1, &c. into e^6; and that when all the water had descended into e^8, air would cease to flow into e^6.

e^{11} is a pipe entering e^4, and opening into the now lower part of e^8, but having at present no communication with e^3 (for there is no opening in the lower side of e^3 at this point).

e^{12}, a pipe entering e^{10}, and opening into the now lower part of e^6, but at present having no communication with e^3 (for there is no upper opening in e^3 at this point).

It is therefore also evident, that if the vessel e^8 were made to take the exact position of e^6, by simply reversing the whole aspirator E, *i.e.* by turning it on the pieces e^4 and e^{10}, the pipes e^{11} and e^9 (which open into e^8) would occupy the positions now occupied by e^5 and e^{12}, and that consequently air would again flow through e^1, &c.

But e^1 communicates with D, D, with the cistern A (fig. 1), and A with C, therefore air would flow through C, would rise (in bubbles) through the æther in A, carrying with it a large quantity of æthereal vapour, and would pass through a^4, D, and e^1, &c. (fig. 3) into e^6, and so on.

F (fig. 2) is a strong table in two perpendicular legs of which notches are cut for the reception of the ends of e^3.

$f^1 f^1$ are plates, fitted to squares at their ends and screwed upon those legs, in order to prevent e^3 from rotation when e^6 and e^8 are made to exchange positions.

It is not necessary to enter upon further details here. The construction presents no difficulties (the kind of work required being principally that which is commonly executed by makers of stop-cocks, valves, &c); the parts of e^3 whereon e^4 and e^{10} revolve are slightly conical, and clamping nuts are employed.

The apparatus is very effective and convenient. With æther of second-rate quality the mercury has been made to descend from about 63° to about 13°. Even pyroligneous æther or good naphtha are efficient, but act injuriously upon the metal.

The lower part of A remains bright when the other part begins to be clouded with dew, thus affording the advantage of contrast in the discovery of the dew-point, but the line of demarcation is not always perfect at first. Further improvements relative to this object arecontemplated. The freezing-point of B (as determined on April 3, 1851) is at 32°·2.

An Hygrometric Sliding Rule, invented by Mr. Welsh (of this Establishment), has been added to our stock of working instruments. The following is his abstract from his description of this ingenious contrivance.

"The hygrometrical sliding-rule has been devised for the purpose of facilitating the calculation of the results of observations with the moist-bulb hygrometer. The instrument is founded on Dr. Apjohn's formula, Dalton's values of the elasticity of vapour being adopted. It has been so arranged as to give by inspection the values of the following expressions:—1st. The elastic force of the aqueous vapour. 2nd. The temperature of the dew-point. 3rd. The relative humidity of the air or the ratio to complete saturation; and 4th. The weight of water contained in a cubic foot of air. The scales were divided on metal at Kew by the aid of Perreaux's dividing-engine, and afterwards copied upon wood by the optician."

A *Standard Thermometer* by M. Regnault, No. 231, has been received from Col. Sabine. The length of its arbitrary scale (beautifully etched upon the tube) is 17 inches. The range is from -5 to $+235$, and the number of divisions is 650.

The boiling-point (as determined on April 3, 1851) is at the 591st division, and the freezing-point at the 100dth.

A *Standard Thermometer* by Ronchetti, has been also received from Col. Sabine.

The freezing-point (as determined on April 3, 1851) is at the 31°·4 division.

A Machine for dividing right lines in equal parts, on Ramsden's principle, but very ingeniously modified by M. Perreaux, with appendages for fixing calibring and graduating thermometer-tubes, has been, very seasonably, imported and added to our collection under the auspices of Mr. Gassiot. The important application of M. Perreaux's machine to the above-mentioned and other purposes was effected with the aid and advice of M. Regnault; and the instrument, together with the modes of using it, have been clearly described and illustrated by M. Soulnier in a Report of July 8, 1846, inserted in the 'Bulletin des Sciences*.'

Apparatus for testing the graduation of Thermometers, and some for comparing them and for determining the freezing- and boiling-points, formed other portions of Mr. Gassiot's valuable importation.

BAROMETERS.

The Mountain Barometer by Newman (*vide* Report for 1844), formerly suspended freely, and not quite vertically, at the N.E. window of the Quadrant Room, is now fixed at the central window of that room by means of an adjustable screw above and an adjustable bracket below for ensuring perpendicularity.

"The frame-work of the barometer is of wood, a brass scale 13 inches long being affixed. The diameter of the tube is 0·17 inch. There is no adjustment for the different capacity of the tube and cistern. The neutral point is 29·764 inches. The capacity $\frac{1}{75}$ and the capillary action $+0·043$. The brass scale does not extend to the cistern. The height of the cistern above mean water is ."

A *Standard Barometer* by Newman has been sent by Col. Sabine from Woolwich, and is fixed near to the eastern wall of the Transit Room. It is mounted in a metallic frame, and is the same in principle as that made for the Royal Society. It is furnished with the improved iron cistern (for facilitating transport). It has not been compared with the Royal Society standard. "The diameter of the tube (bore) is 0·55 inch. The height of its cistern above mean water is ." A thermometer whose bulb is plunged in a short tube containing mercury has been fixed near to the column on the backboard, for temperature corrections of the column.

The Photo-Barometrograph, placed near the central window of the Quadrant Room, is the result of several improvements upon experimental apparatus used here in August 1845†. It has been alluded to in former Reports, &c.,

* A trivial addition of clamps has been made here for applying it to the graduation of magnetograph scales, &c.

† And described in the Phil. Trans., Part I. for 1847.

but has not been particularly described, because time and opportunity have scarcely permitted an examination of its qualifications as to self-correction for temperature, which was always considered a principal desideratum. The experience obtained this year, of its efficiency to a very great (if not complete) extent in this respect, may perhaps be deemed a sufficient apology for the following details.

Fig. 1, Plate XXI. represents the instrument closed and at work by daylight. Fig. 2 represents it with some of the cases withdrawn. Figs. 3, 4 and 5 are projections (drawn to one-fourth of the real size) of the barometer and compensating apparatus only. All the figures of Plate XXII. are sections, &c. drawn to one-eighth of the real size.

$AA^1 A^2$, Plate XXII., are sections of the mahogany cases which constitute the camera. A^1 has apertures, or diaphragms, about 2 inches broad, through the right and left sides.

a^1 is frame-work (composed of a pair of brackets, &c.) firmly secured in its place by long bolts and nuts, &c. at the image end of the camera.

B is the barometer compensated for temperature, in the manner to be described presently.

b^1, the surface of mercury in its tube.

C is the first condensing lens, the frame-work and the shutter apparatus; the whole supported by brackets, and forming the object-end of the camera.

c^1 c^1 are grooved pieces; between which slides, laterally and freely,

c^2, which is a plate having a rectangular aperture about 3 inches high and 2 inches broad. It can be made to admit light to the camera or exclude it at pleasure, by being slid laterally.

c^3 is a second condensing lens.

O is a diaphragm-plate. The aperture is about $\frac{1}{20}$th of an inch broad and about 3 inches high.

D, an Argand lamp (of new construction, to be hereafter described).

E is the usual mouth-piece, consisting of the two (usual) angular pieces, and of two thin plates attached to their right sides, which form the lips.

e^1, the vertical interval between the lips; it is about 4 inches high and about $\frac{1}{10}$th of an inch broad.

F is the slider-case attached to the pair of brackets at a^1.

f^1, its lower side, is as nearly plane as possible. (It *should* be of brass or marble.)

f^5, a spring roller, shown only in fig. 2, Plate XXI., attached to the interior side of the door of F.

f^6, a narrow aperture through the central part of the door of F.

G is the lens-tube, containing two groups of achromatic lenses by Voigtlander (of Vienna). The magnifying power is about $=2$ times.

g^1, apparatus, of sliding-plate, &c., for the support and adjustment to focus of G.

H is the sliding-frame.

h^4, its door, with a narrow aperture near its right end.

h^5, &c., three turnbuckles (sunk in h^4).

h^1, &c., three springs attached to the interior side of h^4, and acting upon the back of the Daguerreotype plate (or upon a pair of glass plates, pressing between them a piece of Talbotype paper) contained in H.

y (fig. 4) represents the front of that plate or paper contained in H.

h^2 h^2 are studs containing rollers. They are attached to a thin narrow plate, and constitute, with it, a kind of carriage which travels on f^1.

h^3 h^3, small screws for retaining cords.

h^6, a brass plate, capable of sliding *freely* in a groove in H and over y. Its left end is cut (in the manner shown) to form a hook, which may be made o fit (or rest upon) alittle peg projecting from the back of F.

h^7, a plate of ground glass fixed in H opposite to the narrow aperture in h^4, with its ground surface exactly in the upper plane of y. Upon this plate a scale divided to $\frac{1}{50}$th of an inch is etched.

When both h^6 and H are placed in F, h^6, before the commencement of the registration, covers y entirely, and the position of h^6 is such, that its right end stands at about $\frac{1}{20}$th of an inch to the left of e^1. The image of b^1 is visible on the scale etched on h^7 through the aperture of h^4.

I is the pulley on the barrel arbor of the time-piece.

i^1, a small gut cord passing through F and attached to I and to one of the studs h^2.

i^2, a cord passing over

i^3, a pulley, and suspending a weight (not shown).

i^4, a cord attached to I, and sustaining

i^5, which is a counteracting weight rather heavier than the weight (not shown) suspended by i^2.

i^6, a clamping milled-headed nut, screwed on the barrel arbor of I. When it is relaxed I can revolve freely on the arbor.

K, the case of the time-piece.

k^1, a pointed index fixed on K (and serving the purpose of a hand).

k^2, a milled-headed nut attached to an arbor passing through the clock-plates, and connected with a lever and fork, &c. behind, which can be made to stop or release the pendulum at any given moment (by turning k^2)*.

k^3, the support of K, and adjustable for height.

P P, bearers supporting A, A^1, A^2, B, &c. (*vide* fig. 2).

Q, a cross bearer supporting F, &c. (*vide* fig. 3).

All these bearers are of well-seasoned and straight-grained deal, and bolted together accurately.

R is a case, supported by rabbeted pieces under P P, and capable of being slid to and fro. It protects the lower part of B from dust, &c.

The manipulation and action of that part of the instrument, &c. which has now been described is (shortly) as follows:—

1st. Y having been *duly* polished (in the board, fig. 3, Plate XVIII., Report for 1850), is placed in H, and coated by placing H in the coating boxes (fig. 5. Plate XVIII. of same Report).—2nd. h^6 is slid over Y (still in the coating box).—3rd. H, &c. is placed on the carriage h^3 h^3 (fig. 3, Plate XXII. of this Report), resting at the left end of f^1; and, at the same time, the hook of h^6 is fitted on a pin projecting from the back of F.—4th. The door of F is closed; thereby causing the spring f^5 to press upon h^4, and to cause h^6 to press upon the left lip at e^1 of the mouth-piece E (*vide* fig. 2, Plate XXI. &c.).—5th. The *image of* b^1 on the ground-glass scale h^7 may then be observed through the narrow apertures in the doors of F and H, in order to verify focus, &c.—6th. The time-piece in K is started, at the proper moment, by means of k^2. The revolution of I now causes H, &c. to move, at the rate of half an inch per hour, to the right, carrying Y with it, but leaving h^6 at rest. Successive portions of V are therefore exposed to the action of light passing from D, or from a window, through C, through c^3, through the tube and vacant part of B above b^1, through G and through e^1; and if b^1 varies its height, during the motion of H, &c., unequal portions of Y are acted upon by the light.—

* *Vide* fig. 7, Plate I., Report for 1850.

7th. At the end of a day (or any given period) K is stopped, the nut i^6 is relaxed, and H is drawn back (by pulling i^3) to its original place in F.—8th. H, together with h^6, are carried into a dark room (or closet), where Y is withdrawn from H and placed in the (warmed) mercury-box.—9th. When taken out of the mercury-box, Y exhibits a figure as (e. g.) y^1 y^2, fig. 4, which indicates that portion of Y which had been exposed to light (in F), the line y^1 being the curve of barometric variation, and the line y^2 its abscissa.—10th. After the usual washing in the hyposulphite of soda-solution, Y is fitted to the ordinate and tracing-boards (fig. 2, Plate XXI., Report for 1849), and the tabulation and tracing processes are proceeded with.

The compensating apparatus will be readily understood by reference to figs. 3, 4 and 5, Plate XXI., &c.

b^2 is the cistern; the glass cover of which is accurately fitted on it and clamped, by means of two triangular plates (*vide* fig. 4) and three long screws. This cover has a neck through which the upper part of B has been passed from below, and the lower part of B being slightly conical (the base of the cone being below), is ground into the neck, so as to suspend the cistern b^2 securely.

b^3, a ring through which the tube was slid before a globular enlargement which prevents it from sliding back again was made.

b^4, a piece attached to b^3 by two screws, and provided with a little eye, through which a short untwisted skein of silk passes and sustains the whole barometer.

b^5, a ring partially surrounding the tube (*vide* fig. 5).

b^6, &c., three adjusting screws for preventing accidental oscillations of the barometer, but not actually touching the tube.

b^7 b^7 (fig. 3) are two very old and straight-grained pieces of deal.

b^8 b^8, brass pillars connecting b^7 b^7 by means of screws and washers.

b^9 b^9, brass plates screwed upon b^7 b^7.

b^{11} and b^{12}, rods of hard zinc, upon the ends of which are soldered brass caps.

The upper cap of b^{11} is attached to b^9 at (by hypothesis) an invariable point, and its lower cap to a joint at one end of

b^{13}, which is a lever whose fulcrum is at about the distance of one-third its length from this joint. The lower cap of b^{12} is attached to a joint at the other end (of b^{13}), distant two-thirds of its length from the fulcrum. The upper cap of b^{12} is attached to a joint in

b^{14}, which is a piece capable of being slid in a mortice by the action of a milled-headed screw in

b^{15}, which is a lever whose fulcrum is at the distance of about one-third its length from the joint in b^{14}. The left end of b^{15} is provided with a piece curved to radius of its distance from the fulcrum, which distance is equal to two-thirds the length of b^{15}, and this arc receives the silken skein which sustains B. The fulcrum of b^{15} is a hard steel knife-edge working in a hard steel ring.

b^{16} is an index, of thin brass, attached to b^{15}, and pointing a scale engraved on b^9.

b^{17} b^{17} are screws which screw through pieces attached to b^7 b^7, and bear upon plates with sockets adjustable on P P. They are used for small adjustments for height, perpendicularity, &c. of the whole frame (composed of b^7, b^8, &c.).

b^{18} (*vide* fig. 2), a piece projecting from the legs to prevent oscillations of the said frame, but not fastened to it.

It is evident that, by this arrangement, B would descend through a space equal to *about* six times the amount of the expansion of b^{11} or b^{12}, occasioned by any given increment of temperature (a quantity equal to the difference of expansion between zinc and mercury), provided that no expansion should occur in b^7 b^7; but b^{14} is made adjustable to a greater or less distance from the fulcrum of b^{15}, for the purpose, not only of compensating the expansions of b^7 b^7, but for endeavouring to correct other obvious little sources of error.

MAGNETOGRAPHS.

The *Declination Magnetograph*, placed between the piers of the (transferred) transit instrument, and described in the Phil. Trans., Part I. 1847, has undergone the following improvements:—

The index (b^1) which was formerly used in producing the curve on paper, has given place to a moveable shield, with its slit similar to b^1 of fig. 1, Plate V., Report for 1849.

A diaphragm plate, similar to O, has been added, with provision for adjusting it, on the marble slab, in the direction of the length (of the slab).

A fixed shield, like o^1, has been attached to O, with the intervention of a pair of sliders, moveable vertically and horizontally, by means of micrometer screws, which allow it to be returned to its place if derangement in either of these directions should occur; and the adjustments of O, on the slab, determine its proper horizontal distance from b^1.

A socket has been fixed upon the lamp-support, which guides the lamp into a constant position when exchanged at about sunrise for a plane mirror, for which a similar kind of guide has been provided.

This mirror is at present necessary for reflecting daylight into the camera from a window (the locality not permitting direct daylight to enter it), and consequently it is also necessary to keep the mouth at E much more opened than the mouths of the other two magnetographs, in order to compensate the loss of light by a longer exposure of the photographic surface in the slider (H) to its influence; this has (evidently) a bad effect upon the magnetic curve, particularly on occasions of considerable and sudden magnetic disturbances.

The microscope (f^6) has been made capable of being slid laterally, in order that the image on the ground-glass (at e^1) may be viewed more directly; for the principal part of what was before mistaken for other kind of aberration arose in fact from the circumstance of viewing the image obliquely through the microscope.

The sliding-frame H has been provided with a scale, etched upon a piece of ground-glass, to serve for verifying scale-coefficients, &c. The scale is divided to fiftieths of an inch, corresponding to the divisions of the T square used with the scale-board (fig. 2, Plate IV., Report for 1849). Also an additional pair of rollers like b^2, fig. 2, has been attached to the left side of H; and an additional ring has been fixed on the bottom, in order that the frame may be employed in an inverted position in the slide-case (F), and that thus the trouble of either preparing two plates per diem, or the necessity and risk of withdrawing from and replacing the one plate in H (at 12 P.M.) might be avoided*.

These and some other little ameliorations in this instrument were made

* It was not originally intended that the plate should be inverted (*vide* fig. 2, Plate XXI.) for the purpose of procuring the two new lines and the two curves on it. The effect of the new arrangement has been, in a few instances of magnetic disturbance, to contract the field on the plate for the range of the image of the slit so much as to exclude a part of the curve.

with a view of adapting it to the course of experimental trials, as well as its wooden supports and other wooden appliances, and the use of a mirror (as above) would permit. It was well known to Col. Sabine and to other gentlemen of the Kew Committee, &c., before those trials began, that although a long series of good curves on paper had been produced in 1846, and some exhibited at the Royal Society in 1847, yet no expectation of accuracy approaching to that obtained by the other two magnetographs, as regards distinctness of the curves, &c., was ever entertained. It may be also remarked that its locality is a passage room, and is used for several other purposes.

The arc value of 1 inch or 50 divisions of the ordinate scale for this instrument is, when corrected by the torsion coefficient, 28·71 (*vide* p. 362, *post.*).

The time of transit of a given point of the photographic surface over the mouth at (c^1) is about $5\frac{1}{2}$ minutes (as formerly ascertained).

The *Horizontal-Force Magnetograph*, placed on the stone brackets solidly attached to the great quadrant wall (and described in the Report for 1849, &c.), has undergone the following alterations:—

A damper, 3 inches broad, $\frac{1}{2}$ inch thick, and having its interior horizontal surfaces about 1 inch apart, has been substituted for the former damper (b^4), about $\frac{3}{4}$ inch broad, with its interior surfaces about $1\frac{1}{2}$ inch apart. This variation was kindly suggested by Dr. Faraday on a visit to Kew, and has proved (as he anticipated) a very profitable one. The magnet, which always performed well, has been rendered remarkably steady by this improvement.

A new thermometer (by Cary), the tube of which passes through a stopper in the top of the case, has been affixed.

Screens have been placed between the lamp and the cases for protection of the magnet against the heat of the flame.

The sliding-frame (H) has been treated in exactly the same manner as that of the declination magnetograph.

The arc value of 1 inch of the ordinate scale is 109·4.

The diameter of the pulley (at s^6) is 0·464 in.

The distance of the ends of the wire (at S) is 0·413 in., and the angle of torsion 64°·45.

The temperature corrections on December 14 were, at 55°·3=0·000312, and at 76°·2=0·000344.

The time of passage of a point of the photographic surface over the mouth e^1 is about $1\frac{1}{4}$ minute (*vide* p. 360, *post.*).

A new *Vertical-force Magnetograph* has been constructed and fixed upon the three corbels (already mentioned) on the quadrant wall. Its magnet is nearly perpendicular to the plane of the astronomical meridian, the locality not, at present, permitting a more favourable disposition.

This instrument is, in most respects, similar to the vertical-force magnetograph which was sent to the Toronto Observatory, and described in the Report for 1850.

The following little variations and additions have been made:—

The four brass pillars (Q, fig. 1, Plate II. of that Report) have been temporarily removed, the intermediate corbel sustaining the magnet, &c. contained in the case V*.

* The slab X rests upon the two corbels which are used instead of the piers P^s and P^N, fig. 1, Plates I. & IV., Report for 1849; and the slab R, fig. 1, Plates I. & II., Report for 1850, was at first supported by the strong bolts, nuts, &c. of the pillars Q, only very near to

An improved mode of attaching the diaphragm plate O, figs. 1 & 2, to the slab X has been adopted, whereby the horizontal distance between the two shields b^1 and o^1 is now very easily adjusted.

A screen has been (occasionally) interposed between the lamp and the camera.

A new long-tubed thermometer (by Cary) has been affixed to the magnet case.

The sliding-frame H has been treated in the same manner as that of the declination magnetograph (*vide* p. 350, *antè*).

The temperature corrections of this magnet were, on December 14, 1850, at 50°·4=0·000283 and at 71°·5=0·000319.

The time of vibration (with its shield arm b^3 and all other appendages) in a horizontal plane was,—March 31, at a temperature of 52°, =17·9 seconds, and in a vertical plane at 53°, =20 seconds; but its time of vertical vibration has been found several times altered since that day.

The arc value of 1 inch or 50 divisions of the ordinate scale is 76·23.

The transit of a given point of the photographic surface over the mouth (e^1) is $1\frac{1}{2}$ minute (*vide* p. 361, *post.*).

Apparatus used in ascertaining arc values of the ordinates of the curves and errors from distortion, &c. has been made. It is of a very simple kind, but may be said to consist of four parts.

The first is a plate of transparent glass, about $3\frac{1}{2}$ inches long and $\frac{3}{4}$ths of an inch broad, supported by a pair of pillars, &c., and having a scale etched upon it divided to $\frac{1}{50}$th of an inch.

The second is a plate of glass, ground to semi-transparency of similar dimensions, fitted into a frame and similarly divided.

In making use of these two to ascertain the magnifying power of the lenses, the transparent scale is placed with its undivided face in contact with the fixed shield (o^1) of all the plates of magnetographs, its scale occupying the locus of the slit itself in the moveable shield (b^1) (if the magnet, &c. were in position), and the semi-transparent plate is placed, with its undivided face, in contact with the mouth-piece (E), its scale occupying the locus of the *Image* of the slit in the moveable shield (the thickness of both plates being properly adapted to the purpose).

The lenses (of G) are then adjusted to bring the image of the first-mentioned scale into focus as nearly as possible upon the second scale, so that the *image* of the first scale and the *second scale itself* can be conjointly and scrupulously examined by the microscope (f^6) and the corresponding readings noted.

The third part is merely a long scale, &c. which is employed to measure the exact distance between the common axis of motion (of the magnet, the shield-arm, &c.) and the moveable shield.

The fourth is (applicable to vertical force instruments only) for measuring the radius from the knife-edge (at b^6) to that part of the slit in the moveable shield which produces a corresponding spot of light at the mouth (e^1) upon the second glass plate.

one of the above-mentioned two corbels. The new short corbel is a substitute for the short pier P^N, fig. 1, Plate I., Report for 1850, but this substitution has been here found unnecessary (*vide* p. 361, *post.*). The original plan of supporting this kind of instrument, *i. e.* the method described in the Report for 1850, where the short pier and the pillars are used conjointly, and where no pier sustains the extremity of the slab X, is, however, far preferable perhaps.

It consists of a pair of sliding tubes, the outer fixed, exactly at right-angles, to a little base of copper, and a shield with a slit, similar to the ordinary moveable shield (o^1,), fitted to the upper end of the inner tube.

In using this the copper base is made to rest upon the agate planes (at s^6) in lieu of the ordinary knife-edge of the magnet; the inner sliding tube is then slid up or down until the slit in the shield comes to about its proper height in the plane of the ordinary moveable shield. Its edge is now marked exactly at that point which produces a corresponding point in its image at the mouth (e^1), and the instrument being removed from the agate planes, the distance from the lower surface of the copper base to the point marked at the edge of the slit is easily measured, and is evidently the radius required*.

The apparatus which has now been described affords *us* a much more convenient means of obtaining the required values than a mirror or a collimator (attached to the stirrup, &c.), since the shield-arm (b^3) of the declination and horizontal-force magnetographs must have the same angular motion as the magnet, and it can (as formerly shown) be properly adjusted in azimuth about the common axis of motion: also there is a provision at the base of the vertical-force magnet-support which permits a proper horizontal adjustment for the position of the moveable shield of that instrument.

The first parts may be said to be modifications of contrivances which have been formerly used for purposes of the same kind as those to which they are applicable. (They are not quite so accurate, but a little more convenient†.)

The *Scale Board, Lens,* &c. used in tabulating all the self-registered curves remain as described at p. 85, Report for 1849.

A *Drawing Board with Clamps* is used for securing the gelatine paper and Daguerreotype plate firmly in their places for the tracing process.

A *Sliding-rule*, invented by Mr. Welsh, has been constructed on the same principles as that described at p. 345, "for converting the observed changes of the horizontal and vertical components of magnetic force into variation of dip and total force."

A few specimens of the earlier and latter Daguerreotype curves on their silvered plates have been preserved; also some gelatine tracings, some impressions printed from the gelatine tracings on bank-note paper, and some

* Great inconvenience and (probably) damage to the knife-edge would ensue from any attempt to acquire this measurement by means of the shield-arm (b^3), itself in position.

† The magnifying power of the lenses of the Declination Magnetograph was, in 1846, ascertained by marking with angular notches, a space of about $\frac{3}{4}$ths of an inch on the edge of a thin lamina of brass, placed in the plane of the moveable index, and by comparing the length of the image projected upon ground glass at the place of the mouth (E) of the said space with the space itself (on the slip of brass).

The above-mentioned transparent glass scale is a modification of a metallic screen provided with a series of slits, formerly used (and described at p. 181, Report for 1850) in adjustments for focus, and a plate is preserved exhibiting good and *equally* distinct impressions of the images of those slits.

The distortion occasioned by the use of a plane in lieu of a curved surface to receive the image, was, from the first, a subject of great solicitude. It was no easy task to obtain a tolerably "flat field" from so large a lens-aperture as I am obliged to employ upon an object much removed sometimes from the axis of the lenses and at a short distance from them, whilst the lenses were required to *magnify* several times in the conjugate focus.

In November 1849, Mr. Fred. Ayrton promised to procure for me from Paris some very finely divided scales, for the mouth-piece, on semitransparent horn, "for reading the arcs of vibration described by the magnet in its diurnal variations."

lithographic impressions printed, by first procuring in the copper-plate press an impression from the gelatine tracing itself, on the lithographer's "Transfer Paper," and by then printing from that impression transferred to the stone (as usual)*.

The *Apparatus of Polishing-boards, Coating and Mercurializing Boxes*, &c., remains nearly as described at p. 184, Report for 1850.

Four *small* polishing boards of this kind have been made, and seem to be improvements upon the frames employed by Daguerreotypists usually.

Mr. Dent's Chronometer, a Sextant, and an Artificial Horizon, have been used for keeping Greenwich mean time. The two latter instruments were sent by Colonel Sabine from Woolwich.

The Apparatus not (or very little) used

in this year, and belonging to the Association, or on loan to it, is enumerated in our MS. catalogue with all the above.

Books

presented to the Association by foreign Societies and by individual Donors in this year have been added to our little library, which now comprises about 150 volumes, exclusive of pamphlets and of the MS. Catalogue of Stars, &c.; the remaining number of complete sets of the Reports of the Association (to July 31, 1850 inclusive) at Kew is 24.

Some of the Royal Society's Instruments

sent here very recently for careful preservation will be forthwith catalogued.

II. OBSERVATIONS.

The observations at Kew in this year have chiefly related to investigations on the interesting subject of Frequency of atmospheric electricity, and a prominent object of the inquiry has been the attainment of data for the addition of proper apparatus to a Photo-electrograph of the kind formerly described†, whereby the study of this subject may be facilitated by means which appear to me peculiarly well calculated for the purpose.

The form of our Electro-meteorological Journal remains as described in my Report for 1844, with the exceptions observable in the annexed specimen and the following revised account.

In column A is stated the time of each observation by the Dent's chronometer, which "was kept always very near to Greenwich mean time by occasional sextant observations of the sun and by casual comparisons, by means of a pocket watch, with standard clocks in London. The epochs noticed in this column are,—1st, the time of the barometer observation, which was about the middle time of the ordinary meteorological observations. The temperature of the air and the hygrometer were observed before the barometer, and the wind, weather, &c. immediately thereafter; 2nd. the time of observing the electrical tension of the air and of the commencement of the frequency observation; and 3rd, the time when the electrometer was considered to have re-acquired its full tension after discharge."

* The tabulations and gelatine tracings produced during "the course of experimental trials," will, at its termination, belong, I presume, to the Royal Society (by agreement).

† *Vide* Phil. Trans. Pt. I. for 1847.

In column B the letter P indicates a positive and N a negative charge of the conductor, &c., as ascertained by the use of the Distinguisher.

In C and D the electrical observations of *tension* are noted as observed by means of the Volta- and Henley-electrometers. The letter V^1 refers to Volta's standard electrometer (whose scale is divided in half-Paris lines as stated), and V^2 to his second, whose scale divisions are each equal to 5 of the V^1 (as also stated). The value of tension, as observed by means of V^2, is set down in terms of V^1; the letter H refers to the Henley, one degree of whose scale, in the lower readings, is equal to about 100 divisions of Volta. (It has seldom been used for the frequency observations.)

The columns E, F, G, H have not been used.

In I are contained from 3 to 7 daily results, carefully obtained between September 10, 1850, and March 29, 1851, by methods somewhat differing from those which were adopted under instructions to the observer last year.

"Slips of paper, about 18 inches long, were affixed to the observer's clock. The brass time-scale, which is divided in accordance with the rate at which the index travels over the paper, was applied to the slips, and spaces corresponding to every 60 seconds marked off on the paper. At commencing a 'Frequency observation,' the tension was noted, the index was set to the zero division on the paper, and the clock started; the electrometer being at the same instant discharged. As the index came successively over each mark, the tension was observed by the electrometer and the scale reading recorded against the mark on the paper. These observations were continued (for the most part) until, from the progression of the readings, the conductor seemed to have acquired the full tension corresponding to the electrical state of the air at the period. The inverse measure of frequency adopted is the number of minutes between the time when the electrometer is discharged, and the time when the readings of the electrometer have again attained to one-half of their full amount. As the observations were in general continued until the tension shown by the electrometer had reached its full amount, we have thus a means of approximately allowing for the change in the electrical tension of the air during the progress of the experiment. The numbers given in the column 'Frequency,' are therefore, when the change of tension has not been great, got in this way, viz. half the mean between the tension shown before discharging the conductor, and that after the scale readings have again become constant, is taken; and the interval of time after discharge corresponding to this reading is taken as the 'Frequency.'"

In column K are contained the *original* readings of the mountain barometer until January 9, 1851, and of the standard barometer after that time.

In L the readings are those of the annexed thermometers, whose bulbs are immersed in the mercury of the cisterns.

In M the corrections of the mountain barometer embrace temperature corrections as applied to glass scales, given in the Report of the Committee of Physics of the Royal Society, which corrections were necessary, because the brass scale does not extend to the cistern. "All the observations of this instrument have been corrected for temperature, capacity and capillarity."

"The observations" of the standard "are all corrected for temperature by Schumacher's tables. No corrections have been applied for capillarity."

It was found by fifty comparisons, made with due precautions, &c., that "the mountain barometer read 0·02 inch higher than the standard. All the observations previous to January 9, 1851, will therefore require a correction of −0·02 to make them comparable with those after that date."

In N the readings are those of the Rutherford minimum and maximum thermometers attached to the stand. "The index corrections have been applied. The minimum temperature was generally read at 10^h A.M. and the maximum at sunset."

In O are contained the corrected readings of the dry standard thermometer by Newman, until September 22 (23^h), and of Ronchetti's dry after that date; both affixed to the stand.

In P are contained the corrected readings of the small wet-bulb thermometer by Newman, which belonged to the Mason's hygrometer, until September 22 (23^h), and of Ronchetti's wet-bulb after that date.

In Q the differences between the readings of the dry and wet thermometers are stated.

In R is contained the observed dew-point by the *old* Daniel hygrometer until February 1, 1851. The little break in the mercurial column of the immersed thermometer of this instrument occasioned probably "no appreciable error in the observations, as a strict watch was kept on the constancy of the break." After February 1 the dew-point was observed by the new instrument. "The observations of dew-point, as entered in the Journal, have *not* been corrected for index error."

S has been scarcely used.

In T are contained some occasional readings of the Saussure 8-haired hygrometer, *not* corrected for the error of its scale.

In U and V are contained the results of observations of the rain- and vapour-gauge. The mode of using it was as formerly. "The reading was noted and the index set to zero at sunset. When the reading showed that the evaporation had been greater than the precipitation, the result was noted in column U; and when the reverse was the case, the entry was made in column V."

In W is contained the amount in cubic inch measure of precipitation between sunset and sunset, as ascertained by means of the old Rain-gauge and measure.

In X the direction of the wind is noted, as shown by the Vane on the Dome.

In Y the static pressure of wind is noted from observations of the Balance (standard) anemometer, used as formerly*.

In the space (*i. e.* a page) headed GENERAL REMARKS, &c., the figures adjoining the margin denote the estimated "Extent of cloudy sky, a clear sky being considered 0, and a complete covering of clouds 10."

"The general remarks and occasional observations include the kinds of clouds prevalent, general remarks on the weather and meteorological phænomena, and notes on the electrical observations."

They comprise, in addition, notices when the Lamp, in the Volta's lantern, at the head of the conductor was known to be not burning, or burning low.

Both that lamp and the lamp which warms the glass support of the conductor, &c., were constantly burning, with the above-mentioned rare exceptions. They were trimmed three or four times per diem.

A few other matters relative to the management, &c. of the apparatus, &c. are stated in this space.

Olive-oil was burnt in the lamps.

The average number of either compound† or single daily electrical obser-

* The Barometers, Thermometers, Hygrometers, &c., have been alluded to at pp. 341, 342 and 343, *antè*.

† A compound observation is understood to comprehend the notes of tension recorded on

Electro-Meteorological Observations, at the Observatory, Kew, in the Year 1850.

TIME.	ELECTRICITY.								BAROMETRIC PRESSURE.			TEMPERATURE.		HUMIDITY.								WIND.		GENERAL REMARKS AND OCCASIONAL OBSERVATIONS.
Day and Hour. Chronometer uncorrected.	Kind.	Periodical Observations.		Morning Min. and Maximum.		Afternoon Min. and Maximum.		Frequency.	Barometer uncorrected.	Attached Thermometer.	Barometer corrected.	Maximum and Min. Thermom.	Dry Thermometer.	Wet Thermometer.	Wet Thermom. below Dry.	Dew-Point.	Dew-Point below Dry.	Saussure's Hygrometer.	Vapour and Rain Gauge. Evap.	Vapour and Rain Gauge. Rain.	Rain Gauge.	Direction.	Pressure by Balance Anem.	
d h m		div.		div.		div.		min.	in.	div.	in.	div.	div.	div.	div.	div.	div.	div.	in.	in.	in.		grs.	
Nov. 13. 19 5	...	...	...	...	...	...	...	...	30·152	47·8	30·161	...	32·5	31·4	1·1	...	...	...	...	...	...	N.W.	800	2. Cirrostrati on horizon.
" 19 10	P.	80	V_2.																					
" 19 42	P.	83	V_2.	...	...	...	...	14·																
" 20 0	...	...	...	...	...	...	...	...	30·181	47·4	30·192	...	32·1	31·1	1·0	30·0	...	88	...	...	...	N.N.W.	1000	1. Cirrostrati on horizon. Fine clear morning.
" 20 7	P.	78	V_2.																					
" 20 21	P.	80	V_2.	...	...	...	...	4·7																
" 21 57	...	...	...	...	...	...	...	...	30·222	49·6	30·228	32·3	37·4	35·5	1·9	32·6	...	85	...	...	...	N.	400	0. Clear except a streak or two on horizon.—22^h 4^m. Dry 39·85. Wet 36·87. Daniel 32·3. Saussure 79.
" 22 0	P.	84	V_2.																					
" 22 19	P.	82	V_2.	...	...	...	...	9·5																
Nov. 14. 0 55	...	...	...	...	...	...	...	...	30·242	51·0	30·245	...	44·	38·9	5·1	31·8	...	67	...	...	...	N.	3000	1. Cumuli.
" 0 59	P.	76	V_2.																					
" 1 23	P.	60	V_2.	...	...	...	...	13·																
" 3 55	...	...	...	...	...	...	...	...	30·266	51·0	30·269	...	41·9	38·4	3·5	33·6	...	75	...	...	...	N. b W.	600	1. Cirrostrati on horizon.
" 3 59	P.	101	V_2.																					
" 4 11	P.	85	V_2.	...	...	...	...	1·5																
" 4 14	P.	84	V_2.																					
" 4 27	P.	78	V_2.	...	...	...	...	2·																
" 6 56	...	...	...	...	...	...	...	...	30·304	48·7	30·313	...	35·3	33·6	1·7	...	...	...	...	...	...	N.N.W.	50	0. Clear.
" 7 2	P.	81	V_2.																					
" 7 7	P.	74	V_2.	...	...	...	...	0·8																
" •10 10	...	...	...	...	...	...	...	...	30·338	47·5	30·351	...	30·2	30·	0·2	...	...	...	...	...	...	S.W.	200	0. Clear. Fog on the ground.
" 10 14	P.	67	V_2.																					
" 10 21	P.	84	V_2.	...	...	...	...	1·																
" 19 7	...	...	...	...	...	...	...	...	30·327	43·2	30·352	...	27·8	27·8	...	...	...	...	...	...	...	S.W.	350	9. Cirrostrati. Cirrocumuli.
" 19 10	P.	78	V_2.																					
" 19 32	P.	79	V_2.	...	...	...	...	10·																
" 20 14	...	...	...	...	...	...	...	...	30·328	42·7	30·354	...	28·2	...	...	...	27·8	...	...	...	...	E.N.E.	100	9. Cirrostrati. Cirrocumuli.
" 20 18	P.	85	V_2.																					
" 20 32	P.	90	V_2.	...	...	...	...	6·5																
" 22 0	...	...	...	...	...	...	...	...	30·318	43·6	30·340	26·1	32·4	31·7	0·7	31·2	...	102	...	...	...	N.N.E.	50	7. Cirrostrati. Cirrocumuli; slight fog.
" 22 3	P.	112	V_2.																					
" 22 19	P.	97	V_2.	...	...	...	...	6·5																
A.	B.	C.	D.	E.	F.	G.	H.	I.	K.	L.	M.	N.	O.	P.	Q.	R.	S.	T.	U.	V.	W.	X.	Y.	

vations recorded in the Journal between September 10 and 30, is about four. These were generally made at about 9 and 11 A.M., and 1, 3 and 5 P.M. The daily mean number between October 1 and March 28 is nearly six, usually made at about 7 and 10 A.M., and 1, 4, 7 and 10 P.M., at about one hour after sunrise and at about sunset.

The mean number of daily compound observations recorded is, from September 10 to 30, about three, and from October 1 to March 28 about five; the highest monthly mean is seven (in October).

Some of the circumstances which have operated to prevent the chosen number of eight daily observations having been *uniformly* completed, were,—absence of flame in the lantern occasioned by high wind, &c.; great and irregular disturbance of the pendulums of the electrometers occasioned by dust, &c. injuring the insulation, violent wind suggesting the caution of securing the conductor from damage by means of stays (of cord) attached to it; violent wind and rain; the necessary absence of the observer; and the intervention of Sundays (but even on these days three observations have been almost constantly made at about 7, 9 and 10 A.M.).

Five instances only are recorded of absence of signs, but the gold-leaf electroscope was not used. These were—on January $9^d\ 20^h\ 50'$, on March $5^d\ 1^h\ 0'$, on March $5^d\ 3^h\ 57'$, on March $10^d\ 4^h\ 4'$, and on March $19^d\ 3^h\ 57'$, and were marked cases of disturbance. In two or three of these instances the circumstances of weather were precisely those in which the atmosphere itself has been commonly believed to be totally uninsulating, viz. those of great and *long-continued* humidity. On March 10 the readings were high and negative in several observations before that at $4^h\ 4'$, and positive in several afterwards; a state of transition *might* therefore have existed at the observation at $4^h\ 4'$ *.

Some of the above-mentioned circumstances have operated much more frequently in unfitting a compound observation for employment in the frequency deductions (entered in column I.), than in preventing an observation entirely; and some even of those entries were obtained under circumstances of weather, conditions of the apparatus, &c., which render them somewhat objectionable in discussion.

This (so-called) Frequency course terminated, necessarily, at the end of March (in order that the Magnetic course might commence (on April 1)); but between April 14 and May 14 about forty single electrical observations, accompanied by others for pressure, temperature, &c., as above, were recorded at rather irregular intervals; most frequently at about 10 A.M., 4 P.M. and 10 P.M.

III. EXPERIMENTS, &c.

The principal operations, &c., of which I set down a brief summary under this head, scarcely commenced before September 1850. A classified statement may perhaps be found more convenient than an enumeration of them in the exact order of their dates would have been.

Horizontal-force Magnetograph.

On August 31, 1850, this instrument was rendered more sensitive than it had

the "frequency paper," and employed in deducing the value, in inverse proportion, of frequency set down in column I. (*vide* p. 354, *antè*).

* Rain attended the four last-mentioned observations. It may possibly have fallen from a neutral part of a cloud or stratum, electrified by induction, and may *not* have acquired a sensible charge in its descent.

hitherto been, by substituting one of the smaller pulleys, *i. e.* No. 9 (s^6, Plate IV., Report for 1849), diameter 0·464 inch, for that before used, *i. e.* No. 12, diameter 0·614 inch, and by making the interval at the upper ends of the wire(s) less than this quantity. A still smaller pulley (*i. e.* No. 8) had been tried with parallel wires, and found to be too small (thus used) to allow the magnet to be placed at right angles to the magnetic meridian. The adjustments were made by means of the torsion apparatus (S), and by using the image of the slit in the moveable shield (b^1), projected upon ground glass at the mouth-piece (E).

On September 2, a very unsatisfactory mechanical agitation of the magnet was evinced by the photographic curve; and on the 5th some additional precautions were taken to prevent the interference of air-currents with its natural motions.

On September 7, the instrument having still exhibited symptoms of disturbance, evidently not magnetic, was rendered less sensitive, by placing the upper ends of the wire (s^6) at an interval of 0·51 inch from each other. The angle of torsion was thus reduced by 21°, 19° more than it had been before August 31.

On September 19 and 20, new adjustments, &c. were made. The angle of torsion was fixed at 52° 25′, and the arc value of 1 inch, or 50 divisions of the ordinate scale (fig. 2, Plate XXI.), was found to be 109′·6; or the arc value, in parts of the whole horizontal force of the ordinate for $\frac{1}{50}$th of an inch, was =0·00049. On this occasion "a scale was drawn on gelatine paper, one division being made equal to $\frac{1}{12}$th of an inch, and placed beside the ground surface of glass in the camera sliding-frame" (H).

On the 26th, a little adjustment of the shields took place.

In October it was worked with some regularity. [A specimen of October 16 is reserved.]

On the 5th it was found that the time of the passage of a given point on the Daguerreotype plate over the aperture of the mouth (at E) was about 2 minutes*.

On November 1, it was minutely inspected by Colonel Sabine and some further adjustments were made.

On the 15th, Dr. Faraday visited the Observatory and recommended the use of the very broad damper alluded to at p. 351, *antè*.

On December 14, experiments were made in Dr. Lloyd's manner for determining its temperature corrections; when eight observations at the mean temperature of 55°·3 gave 0·000312, and eight observations at 76°·7 gave 0·000344.

On January 10, 1851, the new broad damper was affixed.

Between January 20 and March 20 it was worked pretty constantly. New adjustments and determinations of its coefficients were made on the latter day, when the magnifying power of the lenses was found to be 3·46 times (by means of the apparatus described at p. 352, *antè*), and the distance from the axis of motion of the magnet, &c., to the moveable shield (b^1) was ascertained (by direct measurement) to be 9·08 inches; consequently the arc value of 1 inch of the ordinate scale was, as stated, 109′·4 (p. 351, *antè*).

At the end of March the screens were attached at the object-end of the camera, and a thermometer (by Adie) was inserted in the magnet case (V). The temperature of the air of the magnet case without these screens was

* Which is a *very* much longer period than that formerly occupied by such transit.

raised about 4° by the heat of the lamp. It was found that the time of passage of a given point over the aperture of the mouth was about $1\frac{1}{4}$ minute.

On April 1 at M. it was put in motion for the due prosecution of the proposed experimental trials.

About the 2nd of May a cessation of its activity occurred for two days, spent in minor improvements, as that of substituting the larger thermometer by Cary, for that previously used, &c.

From April 1 to this time, *i. e.* July 1, the thermometer has been read at intervals of about three hours.

The Daguerreotype curves, &c. produced *daily*, with the above-mentioned exception, from the commencement of the series of trials to the present time by means of this instrument, have almost constantly afforded means of measuring ordinates (in the manner described at p. 9 of the Report for 1849) to $\frac{1}{500}$dth of an inch, and generally of describing clear gelatine tracings (in the manner alluded to at p. 185 of the Report for 1850).

Vertical-Force Magnetograph.

In September and November 1850, drawings and instructions were given to Mr. Ross, Mr. Barrow, and others, for constructing principal parts of this new instrument; preparations were made for its reception; and work on it proceeded here.

On December 14, its magnet, &c. having arrived, experiments for determining its temperature coefficient were made at the same time as, and in like manner to those on the horizontal-force magnetograph; when nine observations, at the mean temperature of $50^{d}\cdot4$, gave $0^{d}\cdot000283$, and 11 observations, at $71^{\circ}\cdot5$, gave $0^{\circ}\cdot000319$.

On the 21st Mr. Ross's part arrived.

On February 8, the apparatus described at p. 352 having been completed, observations were made to determine the magnifying power of the lenses, and to examine the effect of distortion by its means. The results from two series of observations were, that the magnifying power was 3·81 times, and that "the aberration was very small, so small indeed as to render it uncertain whether the image, in the middle of the field, was greater or less than at the ends; the whole amount of apparent difference being quite within the probable error of observation." In this case the ground glass plate, at the mouth (E), was divided to $\frac{1}{5}$th of an inch*.

On February 10, it was ascertained that no sensible difference in the Daguerreotype impression was produced by enlarging the aperture at the object-end (C) of the camera.

On February 24, measurements were made to ascertain the radius, viz. 11·9 inch, from the knife-edge to that part of the slit in the moveable shield (o^1) which corresponds with the moveable image in the conjugate focus at the mouth-piece (E), by means of the instrument described at p. 352, *antè*.

On the 25th this magnetograph was mounted upon its corbels (in the quadrant room) and partially adjusted for work.

On March 3, the transit of a given point of the Daguerreotype plate over the mouth (at E) was made to occupy $1\frac{1}{2}$ minute.

On the 10th it was ready for further trials, and on this day a good curve was produced; but soon afterwards (on the 19th) we found that the curves

* The spherical aberration of the lenses was not examined.

were gradually (and bodily) approaching the zero-line. It was therefore examined by the maker of the magnet himself, who could see nothing in the disposition of the other parts to prevent the proper action of the magnet. The screen for preventing the bad effect of heat from the lamp was applied (as to the other force instrument), and the slit in the moveable shield (b^1), having been found too narrow, was widened.

On the 31st it underwent adjustments and examinations which we hoped would be final. The radius was found to be 11·93 inches (as on the 24th inst.). The magnifying power of the lenses was 3·78 times, as ascertained by the method described above. The arc value of 1 inch of the ordinate scale was consequently 76′·23. The time of vibration (viz. 17·9 seconds) in a horizontal plane, at a temperature of 52°, was determined by suspending it, protected from currents of air, from a solid support by a small silken thread, and by using a microscope with cross wires, to view a mark on the shield (b^1). Its time of vibration in a vertical plane, viz. 20 seconds, at a temperature of 53°, was determined, by observing the oscillations of the *image* of the slit at the mouth-piece (E) and the chronometer. The time of transit of a point of the plate over the mouth was found to be about 1¼ minute.

On April 1 at M. it was brought into activity for the "trials;" but the curve soon began to exhibit great dislocations, and also the former tendency to approach the zero line. A condensing lens was afterwards mounted in front of the camera (A), in order that the lamp might be removed to a greater distance from it; but dislocations, &c. in the curve gave evidence of mechanical vibration having occurred at the times of putting the plates into the slider-case (F) and removing and replacing the lamp, *i. e.* at sunrise and set, and we believed it *possible* that some cause of unsteadiness might still exist in the mountings, particularly in the brass pillars (Q). These were therefore discarded, *for the present,* and the intermediate corbel was very firmly planted and cemented upon the plinth of the quadrant-wall to supply their place. The whole stone and marble-work was rendered as secure against vibration as an experienced mason could make it. The magnet had altered its time of vibration in the vertical plane to 10 seconds, and various changes of this kind have since occurred (as stated).

On the 9th the time of transit of a point of the plate over the mouth was 1½ minute.

On May 2, the larger thermometer having been substituted for a smaller, it was deemed ready to resume its functions; but, on the next day, dislocations, &c. corresponding with the usual times were shown by the curve; thus rendering it highly improbable that *instability* of the four very stout pillars (Q) or of any fittings had produced the bad effect.

On the 5th this conclusion was confirmed by discovering that the dislocations were occasioned, principally, by the removal of the soft iron bars of the neighbouring window-shutters, from a vertical to a horizontal position, and *vice versâ* at the above-mentioned periods (a precisely similar case to one which had long since occurred relatively to the declination instrument, and had been forgotten). The bars were therefore now (as was one bar formerly) discarded. After this time the great dislocations ceased; but a few instances have since arisen of extremely sudden variations in the curves *of all the magnets simultaneously*, which might have been mistaken for mechanical disturbances, if they had not been simultaneous; and some other small dislocations of these vertical-force curves evince unnatural motions of the magnet.

On June 4 it had altered its time of vertical vibration.

The daily Daguerreotype impressions have been almost equal in *sharpness* to those of the horizontal-force instrument. But there still exists some imperfection (probably in the knife-edge) requiring attention.

Declination Magnetograph.

In March 1851, some of the improvements, described at p. 350, *antè*, on this old instrument (*vide* Pl. XI. Phil. Trans. Pt. I. for 1847), were executed here.

On the 26th it was carefully examined. The wedges were tightened and the camera (A), &c. were adjusted, by turning them through a small arc upon the axis of the suspending skein, so as to cause the *image* of the zero slit in the fixed shield to occupy its proper place at the mouth (E) on the ground glass scale (or on the silver plate or Talbotype paper)*.

On the 27th, 29th and 31st, further examinations and adjustments were made. The suspending skein seemed to have remained nearly unaltered, since 1846, as to the condition of its fibres: a torsion of 10° only existed (which was eliminated in the computations), but the effect of a twist given to it $=90°$ of the torsion circle displaced the magnet a quantity $=44°$. The distance from the axis of motion to the moveable shield (in the place of b^1) was 18 inches. The magnifying power of the lenses was $=6{\cdot}706$ times (as ascertained by the means described at p. 352). The arc value of 1 inch of the ordinate scale, when corrected by the torsion coefficient, was $28°{\cdot}71$.

On April 1 at M. it was put into activity for the "trials," and, in the course of this month, several little improvements (not affecting its indications) were made.

On the 29th it was found that, in consequence either of the fixed shield having descended or of the moveable shield having risen, light had passed between the edges of them to the photographic plate. The delay of a day was therefore required, in order to remedy the evil, by lengthening the zero slit in the mouth-piece, and lowering the moveable shield a very little. These expedients answered the purpose at that time, but similar faults required several repetitions of the last-mentioned process afterwards; therefore,

On June 14, the wooden bearers (X) were raised, and four perpendicular supports of straight-grained deal, resting upon the rafters below, were placed under them. This expedient will not, probably, secure the instrument against errors arising from the use of *wood for bearers, fittings*, &c., and perhaps the expansion and contraction of the skein.

It has nevertheless generally presented us with curves, measurable to $\frac{1}{200}$dth of an inch at least. The exceptions occur in a few instances of magnetic disturbance. The damper (a *narrow* one composed of wood with a coat of copper electrotyped upon it) seems to have little effect.

Tabulating and Tracing the Magnetic Curves.

Colonel Sabine has in his Report (*ante*) clearly and ably described the nature and modes of procedure which have been carried out, by Mr. Welsh, relative to these operations; and the apparatus employed has been detailed at p. 84 of the British Association Report for 1849.

* In 1846 a similar kind of adjustment was made, which suggested the possibility of adapting apparatus of telescope, &c. to a metallic camera, &c., which might be moved about the axis of the suspending skein in the manner of Colonel Beaufoy's variation transit-box, and thus become a means of procuring self-registered curves of *absolute determination*, if it were desirable.

The number of daily curves tabulated and traced before the experimental trials commenced on April 1st, is not considerable. The number since then to the present time is about 200.

It only remains here to annex lithographed specimens of printed curves and their abscissæ (or zero lines), Plate XXIII., which specimens were printed in the manner described at p. 353, *antè*. It is not pretended that the lithograph is equal, in sharpness and accuracy, to the original impression from the gelatine. It is made use of merely because a sufficient numbor of impressions for this Report could not be obtained probably from the gelatine.

Impressions made in September from the gelatine on India-paper, were very good; but the use of bank-note paper was preferred, on account of its very superior toughness and less liability to adhere to the gelatine under the press. The impressions on bank-note paper were very nearly equal to the India-paper impressions. The number which could be "pulled" from the gelatine itself would be ample for distribution to other observatories, &c.

On February 18, a specimen of the action, on *Talbotype paper*, of the horizontal-force magnetograph sent to the Toronto Observatory, arrived here. About half of the curve had been produced by day-light and the remainder by lamp-light. The outline, as viewed by the naked eye, seemed tolerably well defined (in both cases); but when examined under the same magnifying power as that used in tabulating the curves received upon silver, was found to be much less perfect than in these curves: it exhibited a little fringe, evidently due to the spongy texture of the paper, and was quite inadequate to measurements, equally minute, with those of lines received upon a silver surface*.

The Magnetographs and Magnets in general.

In September 1850, it was ascertained that the cost of Lucca oil consumed in the Rumford polyflame lamps used with these instruments, was about 0·8 penny per hour for each.

In December, and at long intervals subsequently, the improvements upon the sliding-frames (H), as regards the scales (*vide* p. 350), were prosecuted. The first were engraved by Ross with a diamond point.

By the end of March it had been found that the etching process, by means of hydrofluoric acid, produced scales on the ground glass well-adapted to the purposes; and the dividing machine of M. Perreaux was very advantageously employed in this operation.

On January 24, Mr. Welsh explained his plan for applying his sliding rule system to computations relative to magnetic curves.

About June 15 a working drawing of the dip and total-force sliding-rule was made. It was put into Mr. Adie's hands, who constructed it in boxwood; it has, together with Mr. Welsh's description of it, been exhibited and delivered to the Secretary of the Physical Section.

In March, and subsequently, the Toronto vertical-force magnetograph was examined and corrected. [A screw had become loose and the knife-edge a little damaged.]

* I cannot help adverting here to an evident mistake in the Athenæum of July 12, 1851, p. 784, where the Astronomer Royal is made to imply that my method of self-registration does not embrace the use of the paper process; whereas it has been clearly shown that, between April 1844 and February 1849, I used no other; that specimens, so procured, have been approved by himself, and that the Kew magnetographs were always *equally applicable* to either the Talbotype or the Daguerreotype process at the pleasure of the observer or photographist. They can be as easily applied to *any* new photographic process I believe.

In June a little progress was made in the construction of a new Declination magnetograph, or rather in new mechanism, to be substituted for some parts of the old declination instrument.

From April 1 to this time, *i. e.* during the course of the experimental trials of the three magnetographs, the Daguerreotype plates prepared by Mr. Nicklin, our photographist, were put into the instruments daily, with the few exceptions stated, at meridian as nearly as possible, the exact time (by Dent's chronometer, with proper corrections) being known for each. They were inverted at 12 P.M. (as nearly as possible).

The course of experimental trials for six months was undertaken in accordance with a wish expressed by the Kew Committee. I should have been better pleased if I could have previously substituted a declination magnetograph, similar in general construction to the horizontal-force magnetograph, instead of the original instrument set up before many of the improvements since adopted had been made, and if I could have attempted other improvements on all the magnetographs (as that of substituting pointed for rectangular magnets, in order to diminish the time of vibration, &c.). The Royal Society granted me, in the kindest manner, a sum not exceeding £100 to be applied to the costs attending the trials, of which sum about one-third has been expended (and an exact account with vouchers maintained).

Thermometers.

On September 21 and 23, comparisons of Newman's standard thermometer were made with various thermometers; their index corrections are recorded at pp. 342 and 343.

On February 22, the dividing machine by M. Perreaux, together with the adaptations and other thermometric apparatus of M. Regnault's (alluded to at p. 346, *antè*), arrived, and soon afterwards Captain Lefroy gave some explanations concerning the former, and made satisfactory trials of their applicability to the accurate calibration and division of thermometer tubes. In these and subsequent trials a diamond point was sometimes used, and when the etching process, by means of hydrofluoric acid, was preferred, some difficulty occurred as to the choice of a proper "ground." Oil of Spike (lavender) was found to answer the purpose tolerably well. An incomplete attempt was made to etch plates of glass by Fluorine gas. Some tubing, entirely of vulcanized India-rubber, was advantageously substituted for the original tubing compounded of this material and glass in the operation of moving the calibring mercury in the thermometer tubes*.

On February 23, the maximum Rutherford thermometer (F) was found to have been destroyed.

On April 3, the Sub-committee of the Kew Observatory, appointed to direct the construction and verification of standard thermometers, &c., made experiments for determining the freezing- and boiling-points of a standard thermometer of M. Regnault, No. 229, or Woolwich standard, which Colonel Sabine brought (with another by Ronchetti); also of the standard Regnault, No. 231 (or Kew standard). The freezing-points of the above Ronchetti, Newman's standard (C), the immersed thermometer in the improved Regnault hygrometer, and the immersed thermometer of the new Daniel hygrometer, were also determined. The apparatus used was a part of that referred to at p. 346, and the results obtained are already stated, excepting that the boiling-point of the Regnault No. 229, or

* A further improvement for effecting this object is contemplated.

Woolwich standard, was at 578·1 div., and its freezing-point at very nearly 92·1 div., and that the barometer reading, reduced to 32°, was 30·093 inches, and the temperature of the room about 55°.

In June considerable progress had been made in calibring, graduating, &c. thermometers as standards; some tubes having been selected with great care for this purpose, and about six complete standard instruments have been made.

Hygrometers, &c.

On September 18, 1850, experiments had been made for testing the Saussure eight-haired hygrometer*. It had been placed in a receiver, first with chloride of calcium and then with water. After several trials and adjustments of the instrument, the result was that "dryness" corresponded to −5 degrees of the scale, and "humidity" to 105, the temperature during the experiment being about 62°.

In this month arrangements were made for some experiments on tension of vapour, according to Mr. Broun's method. A little apparatus was afterwards constructed and some progress made.

On the 18th, Captain Ludlow presented to us the Hygrometer and aspirator of M. Regnault† in their original forms, and made some satisfactory comparisons with the former and the Daniel; they corresponded to about 0°·2.

On October 11, Colonel Sykes went over a series of observations with Mr. Welsh of the wet and dry bulbs, and the (above-mentioned) Regnault hygrometer, and suggested a form of record for the hygrometric observations, and the use of one standard dry thermometer for those observations.

At about this time, and subsequently in examining and using this Regnault hygrometer and its aspirator, it was observed that at low temperatures an obstruction occasioned by the position of the cork would prevent the convenient reading of the immersed thermometer; that the cistern, composed of glass, united to metal by cement, was very apt to become leaky (in consequence of the great variation of temperature to which they are often subjected); that no trifling waste of æther was occasioned by decanting this expensive material from one vessel to another at each period of observation; that no line of demarcation (as in the Daniel) assisted the precise observation of the dew-point moment; and that the aspirator required to be refilled with water, at, sometimes, a very unseasonable moment, and always with waste of time, &c.

On November 15, drawings illustrating a proposal for methods of obviating these inconveniences, &c. were made and submitted to Colonel Sykes's consideration, and his approval was the inducement for giving instructions (on November 26) for constructing a new instrument.

It arrived at the end of February, and early in March, having been found to answer the intended purposes well in most respects, was brought into use. Subsequently various little ameliorations have taken place which have brought it to the state already described‡.

On October 25, a drawing of the parapet in front of the door of the North Hall was made for the guidance of M. Regnault in constructing his dew-point apparatus for Kew.

On Jan. 14, Mr. Welsh made a full description and diagram of his hygrometric sliding rule.

* *Vide* p. 343, *ante*. † P. 343, *ante*.

‡ P. 343, *ante*. An apparatus of the kind has been also made by Cary for St. Mary's Hospital by Dr. Ansel's desire, and others are to be made for Professor Forbes, Mr. Dixon, and other gentlemen.

On the 18th, Colonel Sabine examined and highly approved of the invention: between this time and the end of June the standard scale, of German silver, used in its graduation, was divided by means of M. Perreaux's engine, and the rule itself was completed by Mr. Adie in box-wood. The instrument was in June sent to Ipswich for exhibition to the Physical Section, together with a description of it, and both have been delivered to the Secretary of the Section.

On May 16, experiments were made by and in presence of Colonel Sykes and Captain James, R.E., for testing the action of the improved Regnault hygrometer, and for other purposes. These experiments formed five series; but there being some reason to suspect an error in the observation of the Regnault in the first series, it was declared to be not "trustworthy," and the last having been made by a gentleman visitor, not accustomed to observations of this kind, should not perhaps be included in the following summary.

Two series were made in the North Entrance Hall, where the atmospheric temperature fell, during their continuance, from 62° to 61°, and the barometer stood at 30·018 and 30·14 corrected.

The general result of these two were, that the observed dew-point of the Daniel hygrometer was 0°·4 lower than that of the Regnault, and that the dew-point by the wet-bulb hygrometer, as reduced by Dr. Apjohn's formula, was 1°·5 higher than that of the Regnault, and as reduced by the use of Mr. Glashier's factors, 2°·55 higher.

Two series were made on the platform (in open air) in front of the North Hall, where the temperature fell from 60°·9 to 59°·6 during their continuance, and the barometer stood at 30·01 in.

The general results of these were, that the observed dew-point, by the Daniel and the Regnault, exactly coincided, and that the dew-point by the wet bulb, using Apjohn's formula, was 1° lower than that of the Regnault, and using Glashier's factors, 2°·75 higher.

The dew-point *apud* Apjohn was computed by means of Colonel Boilieu's tables.

The lowest temperature which we could procure by the action of the Regnault was 16°, and by the Daniel 41°. The atmospheric temperature was 62°. (but previous and subsequent trials gave a much greater difference).

An experiment was made in the North Hall, at the suggestion and by desire of Colonel Sykes, to ascertain the difference between the indications of the dry and wet thermometers when at rest, and when put into rapid motion, by whirling them, attached to a line held in the hand, through the air. The motion produced no sensible change on the dry, but a difference of −0°·9 on the wet. Precautions having been taken to obtain accurate readings, the dry, *before* the motion, stood at 61°·8, wet 52°·8, dew-point computed 44°·4, observed 42°·4; the dry, *after* the motion, read 61°·8, wet 51°·9, dew-point computed 42°·2, observed 42°·4.

Between the end of September 1850 and this time, many comparisons, observations and remarks have been made relative to the Wet-bulb, the Daniel and the Regnault hygrometers, "chiefly with the view of ascertaining to what extent the indications of the Wet-bulb, as commonly observed, are to be depended upon."

"The number of comparisons with Daniel's hygrometer has been somewhat above 500, and with Regnault's about 270," in which all the corrections for index errors, the computations (by Apjohn's formula, with the use of Colonel Boilieu's tables), and the requisite observances for attaining accuracy were made.

The details will be stated when these, together with additional comparisons, shall have received more complete discussion than they yet have.

The following experiments and remarks were made in the course of these inquiries, &c.

Instead of taking the mean between the reading of the immersed thermometer at the first appearance of dew on the bright bulb of the Daniel, and the reading at the time of its disappearance for the determined dew-point, in order to eliminate the error which might arise in the estimation of the dew-point from the continued fall of the thermometer after the first appearance of dew, the observer checked the internal evaporation from the æther in the bright bulb, "whenever the dew has shown itself by touching with the hand the covered bulb (upon which the æther is poured), and thus preventing an undue accumulation of water" on the bright bulb, and giving time for the mass of æther, the immersed thermometer and the bulb itself to acquire a uniform temperature at the dew-point moment.

In the cisterns of the Regnault hygrometers, the continual agitation of the æther (by the passage of air bubbles through it) served to produce the requisite uniformity of temperature throughout the mass of æther and the bulb of the immersed thermometer.

In experimenting with the improved Regnault, the difficulty alluded to at p. 345, of "catching the exact instant of the formation of dew," was not found to have been completely obviated by the method there described*. But "the agreement between the two dew-point instruments is generally good, the discordance rarely amounting to one degree; the dew-point by Regnault being generally somewhat lower than by the Daniel."

"The expenditure of æther is somewhat greater in the Regnault than in the Daniel, which however may perhaps be compensated by the inferior quality consumed."

Experiments similar to those made on May 16 (*vide* p. 366, *antè*), on the effect of a current of air on the wet bulb, "have been repeated several times since, and always with a like result. It has also been found that a moderate agitation of the air produces the maximum amount of depression. Similar results have been found in the ordinary comparisons in the open air; the agreement between the computed and observed dew-points being greater when a moderate wind was blowing than when the air was still."

Barometers.

Between September 23 and November 16, 1850, a series of 167 comparisons was made between the mountain barometer and the photo-barometrograph; "but as there can be little doubt that considerable discrepancies which the comparison showed might be partly owing to the imperfect standard of comparison employed, no confidence is placed in the results from this series."

In October Colonel Sykes recommended the acquisition of a good standard barometer.

In January the standard barometer of Newman (*vide* p. 346, *antè*) arrived from Colonel Sabine, and soon afterwards, by his desire, its new attached thermometer was added.

Between January 23 and March 30, about 200 comparisons, &c. were made between this barometer and the photo-barometrograph; the principal results of which were, that the range upon the Daguerreotype plate (at E,

* Further trials on this point are in progress.

fig. 1, Plate XXII.) of the image of the surface of the mercury in the tube (at b^1) is rather more than twice the range of the mercury itself; that the compensation was overdone by about $\frac{1}{20}$th of the whole amount; and that the mean error of an observation, from a whole series of 181 comparisons, was 0·0028 inch. It was thought "only fair to suppose that a portion of this mean error is to be ascribed to the standard barometer;" and I fear a portion may be attributed to dry rot or other cause of infirmity in the flooring of the quadrant-room, that end of the frame-work (P) which carries the barometer being much nearer to the wall of the building than the image end. "The comparisons do in fact exhibit some symptoms of alterations in the floor."

These comparisons, and the numerous computations, &c. required, were made with great care, and yield a very satisfactory general result. "An error of 0·002 inch in an observation would not be greater than might be expected in a standard barometer*."

Anemometer.

On September 27, Mr. Howlet, of the Ordnance Office, brought an experimental anemometer for comparison with our balance anemometer (*vide* p. 341, *antè*), and for examination.

It was speedily erected upon the leads at the southern end of the observatory, and the action of both instruments was watched during about half an hour. The mean result was, that the former gave about one-tenth more for pressure of wind than the latter.

At Mr. Howlet's request, a note was addressed to Sir John Burgoyne, in which I expressed an opinion that an instrument of the kind, exhibited by Mr. Howlet, might answer the purpose of a portable anemometer, applicable in the intended manner, if properly constructed.

Mr. Howlet made a sketch of his model, and left it at the Observatory.

IV. MISCELLANEOUS MEMORANDA.

On September 12, 1850, Mr. Jesse (of the Woods and Forests) visited the building, and promised to represent its state as regards dry rot, &c.

On October 5, an interesting account of an Aurora Borealis, which occurred on the evening of the 2nd, was received from Mr. Gassiot, who, with some friends, had carefully observed it at Clapham Common. The direction in which it appeared was from N. by W. to N.N.W. by compass. Mr. Gassiot's letter was copied in our Diary.

On November 5, Professor Graham came to confer about methods of transporting air, free from town contamination, for chemical analysis, with reference to the presence of ammonia, from this locality to the London University. Every means in our power, calculated to facilitate Dr. Graham's important researches, were (of course) tendered with great alacrity and pleasure†.

* If the instrument were mounted in as substantial a manner as are the horizontal and vertical-force magnetographs, and if a compensating apparatus of *larger* zinc rods and stout glass tubes were substituted for this of small rods and *wood*, the error of an observation would probably be less, and even the remaining error might perhaps be almost got rid of *by making use of the micrometer screw* (at b^{14}), provided expressly for preventing the compensation from being either "overdone" or underdone. The neglect of doing this is entirely my own.

Since the above was written an instrument improved as above has been ordered by Mr. Johnson for the Radcliffe Observatory.

† The aspirator (described at p. 344) would probably be found convenient in cases of this kind.

On the same day and subsequently, a few experiments were commenced on M. Claudet's actinometer.

On January 20, 1851, Mr. Phipps (of the Woods and Forests) examined the building; when its state, as to dry rot, &c., was represented, and an intimation was made that probably Lord Seymour would visit it.

On the 25th, Professor Potter's "Aërometric Balance for measuring the density of the air in which it is situated," arrived for examination and experiment, but was required to be returned before any results which could be confided in were obtained. The difficulties of observing the instrument under unobjectionable conditions seemed almost insurmountable. It is described in the Philosophical Magazine, vol. xxxvii. p. 81.

On May 8, Lieut. Fergusson, of the Indian Navy, began a little course of study and manipulation relative to all our methods of procedure in the self-registering system, and in eye observations of atmospheric electricity, &c. It was continued daily during about two weeks, at the end of which time he had become well qualified to prosecute and conduct such operations and observations.

At the end of May, Mr. A. Broun, late Director of Sir Thomas Brisbane's magnetic observatory, appointed to the Trevandrum observatory, commenced a similar course, which lasted (at intervals) about 2 weeks, and terminated with like success*.

On June 20, Colonel Sabine and Professor Stokes decided upon using the South Lower Hall for the prosecution of Professor Stokes's proposed experiments to determine the index of friction in different gases.

On the 24th, Mr. Weld, Assistant Secretary of the Royal Society, visited the Observatory, and informed me that he was directed to send a large quantity of apparatus belonging to the Royal Society to be deposited here. He examined the localities in which they could be properly lodged, viz. the glass cases, &c., formerly occupied by His Majesty George the Third's splendid collection of instruments of a similar kind; and on the 26th, many cases containing the Royal Society instruments arrived; but the operation of unpacking, &c. was deferred to an early day after this meeting of the British Association.

Some boxes (probably containing papers) locked and without keys, arrived with the instruments and were not opened.

Between this time and the end of the month all outstanding bills due by the establishment were paid, excepting three or four very small accounts (which presented a little difficulty in adjustment, &c.); and a tabulated statement embracing the whole expenditure and receipts for the (British Association) year was delivered to the Kew Committee, by which account it appears that the total sum expended on the *Establishment account* has been £309 2*s*. 2*d*. (including the above-mentioned small accounts), which sum is £29 13*s*. less than the amount of the grant made at the Edinburgh meeting on August 1, 1850, added to the residue of the former grant made (in 1849)†.

In the course of the year numerous meetings of the Kew Committee, and very many individual attendances of its President, Colonel Sykes, Colonel Sabine, and Mr. Gassiot, have taken place at the Observatory.

Our visitors have been numerous, and almost exclusively gentlemen of high scientific reputation.

* An electrical apparatus of the kind described at p. 339, *antè*, has since been put into course of construction for Mr. Broun.

† The sum annually expended has always been somewhat less than the grant and residue; sometimes considerably less.

I have great pleasure in bearing testimony here to the general services of Mr. Welsh, and particularly in making and recording, in the Diary, &c., very numerous comparisons, observations, measurements, adjustments and computations relative to the thermometers, the various hygrometers, the barometers and barometrograph, and the magnetographs*, in the laborious processes of tabulating and tracing the magnetic curves, and in making and recording all the observations and remarks entered in the form of the Electro-meteorological Journal; in suggesting a few alterations in that form, and in the mode of deducing the value of electrical frequency (*vide* p. 355); in pointing out the former defective mode of suspending the mountain barometer, and the first-mentioned inconvenience in the use of a Regnault hygrometer (*vide* p. 365); in suggesting the use of screens to protect the magnets from the heat of the lamps, and in assisting me to vary the older methods of ascertaining the magnifying powers of the lenses of the magnetographs (*vide* p. 352).

The calibrations and graduations of the new Standard Thermometers have been executed by him.

Ordnance Survey of Scotland.

THE Committee appointed at the Edinburgh Meeting in 1850, "for the purpose of urging on Her Majesty's Government the completion of the Geographical Survey of Scotland, as recommended by the present Meeting of the British Association at Edinburgh in 1834," presented the following Memorial to the First Lord of the Treasury:—

"MY LORD, "London, February 17th, 1851.

"As constituting a committee appointed for that purpose by the British Association for the Advancement of Science, we beg to call your Lordship's attention, and that of Her Majesty's Government, to the untoward condition and slow progress of the Geographical Survey of Scotland.

"In the year 1834, when, for the first time assembled at Edinburgh, the British Association prayed the Government of that day to accelerate materially the completion of a work, which, notwithstanding that the primary triangulation was commenced in 1809, had not produced in the intervening 25 years a single practical result. It was then shown, that the grossest errors pervaded every known chart and map; and although, thanks to the zeal of the Hydrographer of the Navy and his surveyors, many of the chief headlands have since been laid down, the mass of the land still remains in the same unsurveyed condition.

"In fact, on returning to Edinburgh last summer, after an interval of 16 years, the British Association deeply regretted to learn that, excepting Wigtonshire, about a sixtieth part only of Scotland, no portion of the kingdom had been mapped.

"Permit us to remind your Lordship that, although in consequence of many subsequent appeals from other public bodies (including the Royal Society of Edinburgh and the Highland Society), the Government did at length, in 1840, direct the survey to be laid down on a scale of six inches to a mile, or similar to that of the Irish survey, so feeble and inadequate has been the force employed, that in judging from what has transpired since that date,

* Which comparisons, &c. are far too numerous and complex for insertion in a summary of this kind.