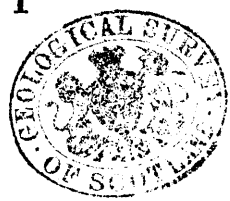
REPORT

OF THE



THIRTY-FIRST MEETING

OF THE

BRITISH ASSOCIATION

FOR THE

ADVANCEMENT OF SCIENCE;

HELD AT MANCHESTER IN SEPTEMBER 1861.

LONDON:
JOHN MURRAY, ALBEMARLE STREET.
1862.

(10) The Council are informed that Invitations will be presented to the General Committee at its Meeting on Monday, September 9, to hold the next meeting in Cambridge. The invitations formerly offered on the part of Birmingham and Newcastle-on-Tyne will be renewed on this occasion; and other invitations will be presented from Bath and Nottingham.

Report of the Kew Committee of the British Association for the Advancement of Science for 1860-1861.

The Committee of the Kew Observatory beg to submit to the Association the following Report of their proceedings during the past year.

It was noticed in a previous Report that General Sabine had undertaken to tabulate the hourly values of the magnetic elements from the curves given by these instruments. These values have been reduced under his superintendence, and some of the results have been embodied in the following papers which he has communicated to the Royal Society:—

(1) On the Solar-diurnal Variation of the Magnetic Declination at Pekin.—Proceedings of the Royal Society, vol. x. p. 360.

(2) On the Laws of the Phenomena of the larger Disturbances of the Magnetic Declination in the Kew Observatory: with notices of the progress of our knowledge regarding the Magnetic Storms.—Proceedings of the Royal Society, vol. x. p. 624.

(3) On the Lunar-diurnal Variation of the Magnetic Declination obtained from the Kew Photograms in the years 1858, 1859, and 1860.—Proceedings of the Royal Society, vol. xi. p. 73.

The Superintendent, Mr. Stewart, has also communicated to the Royal Society a description of the great magnetic storm at the end of August and beginning of September 1859, deduced from the Kew Photographs.

Mr. Chambers continues to be zealously employed in the magnetical department, and attends to the self-recording magnetographs, which have been maintained in constant operation.

The usual monthly absolute determinations of the magnetic elements continue to be made; and the dip observations from November 1857 to the present date (282 in all), a large portion of which were made by the late Mr. Welsh and Mr. Chambers, have been made available by General Sabine in connexion with some previous observations of his own for determining the secular change in the magnetic dip in London, between the years 1821 and 1860. See Proceedings of the Royal Society, vol. xi. p. 144.

The instruments for the Dutch Government alluded to in the last Report have been verified at Kew and taken away. They consisted of a set of self-recording magnetographs with a tabulating instrument, two Dip Circles, and one Fox's Dip Circle for Dr. Bergsma; also of two Unifilars, one for Dr. Bergsma and one for Dr. Buys Ballot.

Shortly after the despatch of these instruments, another set of self-recording Magnetographs were received at Kew, in order to be tested previous to their being sent to Dr. Bache, of the United States, and these were despatched in the early part of this year to America, along with a tabulating instrument, a Unifilar, and Dip Circle, all of which were verified at Kew.

The staff at Kew are at present occupied with a third set of these instruments, along with a Dip Circle and Unifilar, for the University of Coimbra; and Prof. Da Souza of that University is engaged at present at the Kew Observatory in examining his instruments, and in receiving instructions regarding them.

It will thus be seen that no fewer than three sets of these instruments

have been furnished during this last year, under the superintendence of the Committee, and it has hitherto been deemed advisable for the interests of science that no charge should be made for their verification. As this, however, is an operation involving labour and a large expenditure of time, an application was made to the Royal Society for the sum of £90 from the Donation Fund, in order to cover the expense of verifying these three sets of instruments, while it was arranged that in future a charge of £30 for verification should be added to the cost of each set. This sum was at once granted by the Council of the Royal Society, and it will be found among the receipts in the financial statement appended to this Report.

In addition to the instruments already mentioned, the following have also been verified at Kew Observatory:—

For the Havana Observatory, a set of differential magnetic instruments, also a Unifilar, Dip Circle, and an altitude and azimuth instrument for absolute determinations of the magnetic elements.

For Dr. Smallwood, Montreal, a Unifilar, Dip Circle, and Differential Declinometer.

For the Astronomer Royal, Greenwich, a 9-inch Unifilar.

For the Rev. W. Scott, Sydney, a Unifilar and Dip Circle.

For Dr. Livingstone, Africa, a Unifilar, Dip Circle, and Azimuth Compass.

For Mr. Jackson, Bach. of Science, Ceylon, a Unifilar and Dip Circle.

Mr. Jackson and M. Capello, of the Lisbon Observatory, have also received instruction at Kew in the use of instruments.

The meteorological work of the Observatory continues to be performed in a satisfactory manner by Mr. George Whipple; and here the Committee desire to mention that, both from the report of the Superintendent and from their own observation, each member of the staff at present attached to the establishment seems to interest himself in the duties he is called upon to discharge.

During the past year, 150 Barometers, 660 Thermometers, and 8 Hydrometers have been verified at the Observatory.

Seven Standard Thermometers have also been constructed and disposed of. Dr. Bergsma and Dr. Buys Ballot were each presented with one of these instruments.

For some time telegraphic reports of the meteorological elements were daily sent to Admiral FitzRoy's office, the expense being defrayed by the Board of Trade; but these despatches were ultimately discontinued, on account of the Board of Trade having only a limited sum disposable for meteorological telegraphy, and Kew being too near London to prove a useful station.

At the last Meeting at Oxford it was announced that the Kew Heliograph was about to be transported to Spain for the purpose of photographing, if possible, the so-called red flames visible on the occasion of a total solar eclipse. That the mission had most successfully accomplished the object contemplated was known in England on the morning of the 19th of July, 1860 (the day after the eclipse), by the publication in the 'Times' newspaper of a telegram sent by Mr. Warren De la Rue from Rivabellosa, near Miranda, where the Kew party were stationed.

It will be remembered that, at the suggestion of the Astronomer Royal, the Admiralty had placed at the disposal of the expedition of astronomers H.M. Ship 'Himalaya,' and that the Government Grant Committee of the Royal Society had voted the sum of £150 for the purpose of defraying the expenses of transporting the Kew Heliograph with a staff of assistants to Spain.

As the scheme became matured, it was deemed desirable to extend considerably the preparations originally contemplated; and actual experience subsequently proved that no provision which had been made could have been safely omitted. Originally it was thought that a mere temporary tent for developing the photographs might have answered the purpose; but on maturing the scheme of operations, it became evident that a complete photographic observatory, with its dark developing-room, cistern of water, sink, and shelves to hold the photographs, would be absolutely necessary to ensure success. An observatory was therefore constructed in such a manner that it could be taken to pieces and made into packages of small weight for easy transport, and at the same time be readily put together again on the locality selected. The house when completed weighed 1248 lbs., and was made up in eight cases. Altogether the packages, including house and apparatus, amounted in number to thirty, and in weight to 34 cwt.

Besides the Heliograph, the apparatus comprised a small transit theodolite for determining the position of the meridian, and ascertaining local time and the latitude and longitude of the station, and also a very fine three-inch achromatic telescope, by Dallmeyer, for the optical observation of the phenomena of the eclipse. Complete sets of chemicals were packed in duplicate in separate boxes, to guard against failure through a possible accident to one set of the chemicals. Collodion of different qualities was made sensitive in London, and some was taken not rendered sensitive, so as to secure as far as possible good results. Distilled water, weighing 139 lbs., had to be included; and engineers' and carpenters' tools, weighing 113 lbs., were taken.

Mr. Casella lent some thermometers and a barometer, and Messrs. Elliott an aneroid barometer to the expedition.

The preparations were commenced by Mr. Beckley (of the Kew Observatory) early in the year 1860; and in June Mr. De la Rue engaged Mr. Reynolds to assist Mr. Beckley in completing them.

Mr. Beckley and Mr. Reynolds were charged with the erection of the Observatory at Rivabellosa; and so well were the plans organized that the Observatory and Heliograph were in actual operation on the 12th of July, the expedition having sailed from Plymouth in the 'Himalaya' on the morning of the 7th. This could not, however, have been so expeditiously accomplished without the energetic cooperation of Mr. Vignoles, who met the 'Himalaya' in a small steamer he had chartered to convey the expedition and their apparatus into the port of Bilbao, and who despatched the Kew apparatus, as soon as it was landed, to the locality he and Mr. De la Rue had agreed upon. This was situated seventy miles distant from the port of landing, and accessible only through a difficult pass. Mr. Vignoles had also taken the trouble to make arrangements for accommodating the Kew party, and for the due supply of provisions—a matter of some importance in such a locality.

Besides Mr. De la Rue, Mr. Beckley, and Mr. Reynolds, the party consisted of Mr. Downes and Mr. E. Beck, two gentlemen who gave their gratuitous services, and of Mr. Clark, who acted as interpreter, also kindly assisting during the eclipse. Each of the party had only one thing to attend to; and thus rapidity of operation and certainty of result were secured.

The total expenditure of this expedition amounted to £512; the balance of £362 over the amount granted by the Royal Society has been generously defrayed by Mr. De la Rue.

Upwards of forty photographs were taken during the eclipse and a little before and after it, two being taken during the totality, on which are depicted

the luminous prominences with a precision impossible of attainment by hand drawings. The measurements which have been made of these prominences by Mr. De la Rue show incontrovertibly that they must belong to the sun, and that they are not produced by the deflection of the sun's light through the valleys of the moon. The same prominences, except those covered over during the moon's progress, correspond exactly when one negative is laid over the other; and by copying these by means of a camera, when so placed, a representation is obtained of the whole of the prominences visible during the eclipse in their true relative position. The photographs of the several phases of the eclipse have served to trace out the path of the moon's centre in reference to the sun's centre during the progress of the phenomenon. Now, Rivabellosa being north of the central line of the moon's shadow, the moon's centre did not pass exactly across the sun's centre, but was depressed a little below it, so that a little more of the prominences situated on the north (the upper) limb of the sun became visible than would have been the case exactly under the central line, while, on the other hand, a little of those on the southern limb was shut off. It has been proved, by measuring the photographs, that the moon during the totality covered and uncovered the prominences to the extent of about 94″ of arc in the direction of her path, and that a prominence situated at a right angle to the path shifted its angular position with respect to the moon's centre by lagging behind 5° 55′. On both the photographs is recorded a prominence, not visible optically, showing that photography can render visible phenomena which without its aid would escape observation. Copies of the two totality pictures are being made to illustrate Mr. De la Rue's paper in the Report of the 'Himalaya' Expedition by the Astronomer Royal.

Positive enlarged copies of the phases of the eclipse, nine inches in diameter, have also been made by means of the camera, and will be exhibited at the Manchester Meeting.

The Heliograph has since been replaced in the Observatory; but few opportunities have occurred for using it, in consequence of the pressure of other work; latterly, however, Mr. Beckley has been requested to carry on some experiments with the view of ascertaining whether any more details are rendered visible when the full aperture of 3 inches of the telescope is used, than when it is reduced to about one inch and a half. Up to the present time no definite conclusion can be drawn from the results obtained; so that, at all events, an increase of aperture does not appear to give a strikingly better result when a picture of the same size is taken with various apertures of the object-glass. More experiments, however, are needed before this point, which is one of some importance in guiding us in the construction of future instruments, can be answered definitely. Mr. Beckley has obtained sun-pictures of great beauty during the course of these experiments.

The work of the Kew Observatory is now so increased that it has become absolutely imperative to make some provision for working the Heliograph in a way that will not interfere with the current work of that establishment; and Mr. De la Rue has been requested by his colleagues of the Kew Committee to take charge of the instrument at his observatory, where celestial photography is continuously carried on. This request Mr. De la Rue has kindly acceded to; and he will for a time undertake to record the sun-spots at Cranford, as long as it is found not to interfere with his other observations. Mr. De la Rue has contrived, and had made by Messrs. Simms at his own expense, an instrument for measuring the photographs, which will much facilitate the reduction of the results. It consists of a fixed frame in which work two slides, moving at right angles to each other. Each is furnished with a

vernier reading to $\frac{1}{1000}$th of an inch. The top slide works on the lower slide, and carries a hollow axis $4\frac{1}{2}$ inches diameter, on which rotates horizontally a divided circle reading to 10″, and this carries a second circle on the face of which are fixed four centering screws. An image intended to be measured is placed on the upper circle, and is centred by means of the adjusting screws; it is then adjusted by means of the upper circle in any required angular position with respect to the lower divided circle, so as to bring the cross lines of the photograph in position under a fixed microscope, supported on an arm from the fixed frame. By means of this instrument the sun-pictures are measured so as to determine the diameter to $\frac{1}{2000}$th of the radius; the angular position of any part of a sun-spot and its distance from the centre are thus readily ascertained; or the differences of the right ascension and declination with respect to the centre are as easily read off to the same degree of accuracy.

Mr. De la Rue has recently produced by his large Telescope an image of a solar spot, and portion of the sun's disc, far superior to anything before effected, and which leads to the hope that a new era is opened in heliography, and that the resources of this Observatory might be further developed in that direction.

At the last Meeting of the Association the sum of £90 was voted for an additional photographer, and of this sum £50 has been received. The Committee suggest that the balance of £40 be granted again at this Meeting, as the full sum will be required during the ensuing year. A detailed account of this expenditure will be presented in the next Annual Report.

Allusion was made in last Report to an instrument constructed by Prof. William Thomson, of Glasgow, for determining photographically the electric state of the atmosphere. This instrument has been fitted up at Kew, where it has been in constant operation since the beginning of February last. It has been found to answer well in a photographic point of view, and Prof. Thomson has expressed himself much pleased with the results obtained. The mechanical arrangements connected with the fitting up of this instrument were devised and executed with much skill by Mr. Beckley, the Mechanical Assistant, who has also recently made a working drawing of the instrument for Prof. Thomson, who intends to publish a description of it.

The arrangements made by Mr. Francis Galton, in the Observatory Park, for testing sextants, and which were alluded to in last Report, are now almost complete; and six sextants sent by Captain Washington, R.N., Her Majesty's Hydrographer, have been verified.

The Observatory was honoured with a visit from His Imperial Highness Prince Napoleon on the 9th of September last. His Highness expressed much satisfaction at witnessing the efficient state of the Institution.

Application has been made to the Commissioners for the International Exhibition of 1862, for a space of 40 feet by 20, in which to exhibit as many as possible of the instruments in use at the Observatory, including those which are self-recording.

The Committee desire to express their thanks for a valuable addition which has been made to the Library at Kew, consisting of a very large number of the Greenwich publications, presented to them through the kindness of the Astronomer Royal.

It will be observed by the annexed statement that the expenditure of last year has exceeded the income by about £90; but as this year comprised five quarters, it is hoped that the usual annual grant of £500 will cover the expense until the next Meeting of the Association.

Kew Observatory,
August 30, 1861.

JOHN P. GASSIOT,
Chairman.

RECEIPTS.

	£	s.	d.
Balance from last account	11	8	5
Received from the General Treasurer	500	0	0
„ for the verification of Instruments— £ s. d.			
from the Board of Trade 7 18 0			
from the Admiralty 17 6 0			
from Opticians 56 1 0			
	81	5	0
„ from the Donation Fund of the Royal Society for the verification of Magnetographs....	90	0	0
„ from Prof. Wm. Thomson for expenses connected with his self-recording Electrometer and labour bestowed upon it.....	36	15	8
Balance	79	3	7
	£798	12	8

PAYMENTS.

	£	s.	d.	£	s.	d.
Salaries, &c. :—						
To B. Stewart, five quarters, ending October 1, 1861	250	0	0			
Ditto, allowed for petty travelling expenses	10	0	0			
C. Chambers, five quarters, ending October 6, 1861	125	0	0			
G. Whipple, four quarters, ending June 18, 1861	40	0	0			
Ditto, one quarter, ending September 18, 1861	12	10	0			
R. Beckley, 62 weeks, ending September 2, 1861, at 40*s.*	124	0	0			
T. Baker, 11 weeks, ending September 10, 1860, at 8*s.*	4	8	0			
Ditto, 26 weeks, ending March 11, 1861, at 10*s.*	13	0	0			
Ditto, 25 weeks, ending September 2, 1861, at 12*s.*	15	0	0			
				593	18	0
Apparatus, Materials, Tools, &c.				43	14	1
Ironmonger, Carpenter, and Mason				30	6	9
Printing, Stationery, Books, and Postage...				23	10	9
Coals and Gas				49	0	2
House Expenses, Chandlery, &c.				17	16	2
Porterage and petty expenses				12	6	9
Cost of surrounding enclosure with a ditch, and of planting a hedge...				17	10	0
Rent of Land to 10th October, 1861				10	10	0
				£798	12	8
Balance				79	3	7

I have examined the above account and compared it with the vouchers presented to me, and I find that the amounts expended exceed those received by the sum of £79 3*s.* 7*d.*; and that the expenditure for salaries, &c. this year is for one year and a quarter, that in the last account having been for three-quarters of a year only.

16*th August*, 1861. R. HUTTON.