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BRITISH PREPARATIONS FOR THE APPROACHING TRANSIT OF VENUS

IN nearly all those countries of Europe in which Astronomy is nationally cultivated, preparations are being made for thorough observation of the first of the coming Transits of Venus, which will occur on December 8, 1874. In Russia, whose territory presents many favourable points for observation of the phenomenon, a committee, organised by Professor Struve, has had under consideration during the past two years the establishment of a chain of observers at positions 100 miles apart along the region comprised between Kamschatka and the Black Sea. The principal astronomers of Germany have held two conferences, each of several days' duration, which have resulted in a decision to furnish four stations for heliometric observation of the planet during its transit: one of these will be in Japan or China, and the others probably at Mauritius, Kerguelen's and Auckland Islands; and three of these, with the addition of a fourth station in Persia, between Mascate and Teheran, will be equipped for photographic observations also. A French commission on the subject sat before the war, and reported to the Bureau des Longitudes that it was desirable for their government to provide for observing stations at Saint Paul's Islands, and Amsterdam, Yokohama, Tahiti, Noumea, Mascate, and Suez. Since the close of the war the subject has been reverted to, and lately the Academy of Sciences applied to the Government for the requisite funds; but these could not be granted till next year, the budget for 1872 having been disposed of.

The British preparations, to which we shall chiefly confine our remarks, are, we believe, in a more advanced state than those of any other country. This forwardness may probably be ascribed to the circumstance that they have from the first been directed by a single mind, and have thus been freed from the inevitable delays of a committee. The Astronomer Royal first called attention to the Transits in 1857 and again in 1864. In 1868 he commenced to shape definite plans, selected the observing stations which were in all respects most suitable for British occupation, and opened communications with the Government upon the financial requirements of the undertaking.

Presuming a general acquaintance with the phenomenon under notice, and its availability for determination of the parallax of Venus, and that of the Sun (a subject that has been well popularised), we merely remark that there are several methods by which observers at opposite points on the earth may measure the parallactic displacement of Venus upon the Sun's disc: (1) by durations of Transit (Halley's method); (2) by absolute local times of ingress and egress (Delisle's method); (3) by heliometric measures of the planet referred to the limbs of the sun; (4) by similar measures obtained from photographs of the sun with the planet on his disc. The first of these has been considered disadvantageous for the 1874 Transit, which is the one that immediately concerns us. The third and fourth are of recent suggestion, and have been regarded as of doubtful accuracy, especially the fourth, whose reliability is still the subject of experimental inquiry. The second was the one which demanded foremost attention. The Astronomer Royal, therefore, as a first step, set down the stations best available for its application. These had to be selected in order to combine a sufficient altitude of the sun with the maximum attainable acceleration of ingress and retardation of egress on one side of the earth, and retardation of ingress and acceleration of egress on the other side of the earth. And after weeding the lists for each phase of such stations as were expected to be provided for by foreign governments, and of those already occupied by established colonial observatories, it was found that there were five stations which it was desirable that England should prepare to equip. These were Woahoo (for observation of accelerated ingress), Kerguelen's and Rodriguez Islands (for the retarded ingress), Auckland in New Zealand (for the accelerated egress), and Alexandria (for the retarded egress).

Now, as at all these places the absolute local time of the phenomenon is required, it is indispensable that the longitude of each be very exactly known. In no one case does a sufficiently accurate determination of this element exist, and provision must therefore be made in each case for obtaining it. This vastly increases the extent of preparations for the instrumental equipment of the stations, and renders necessary a three or four months' sojourn of the observers at each. Of the methods for determining longitude which were open to choice, the Astronomer Royal decided to employ that by vertical transits of the moon, and for observing these he resolved upon supplying altitude instruments with fourteen-inch circles and telescopes of twenty inches focus. For time determinations he proposed three-inch transits, of thirty-six inches focus, with clocks of moderately high class For observing the phenomenon he elected to employ at each station one six-inch equatorial and one four-inch portable telescope. For these an observatory of three rooms was required. With the exception of one altazimuth, two clocks, and two or three four-inch telescopes, which the Greenwich Observatory could furnish, all the specified instruments and the observing rooms had to be specially provided. An estimate for their purchase and construction, amounting to 2,154*l.*, was therefore submitted to the Admiralty. Some needful chronometers and meteorological instruments were available from home stores. To the above estimate for material requirements were added others, prepared by Admiral Richards, for the personal expenses, the conveyance, residence, pay, and contingencies, of the observing parties. These amounted, for the Woahoo detachment, to 2,500*l.*, for the Rodriguez and Kerguelen's parties to 2,000*l.* each, for the Auckland party to 1,000*l.*, and for Alexandria to 750*l.*, making a total of 8,250*l.* The grand total of 10,500*l.* was asked of the Treasury in May 1869, and immediately granted.

The construction of the requisite instruments and clocks was forthwith commenced, by Messrs. Troughton and Simms and Messrs. Dent. Three six-inch equatorials happening, however, at the time to come into the market, they were at once purchased; one of the three being that which is known to fame as the "Lee Equatorial," and is the instrument used by Admiral Smyth in the preparation of his "Celestial Cycle." The observatories were put in

hand also. They are somewhat substantial structures, formed of a stout wooden framework, covered with weather-boarding and roofed with zinc and roofing-felt. Each instrument has a separate hut. The transit huts are ten feet square, with walls six feet high, and with the shutter openings a little on one side of the centre, so as to leave good room for mounting the clock, &c. The altazimuth huts are planned on a nine-feet hexagon. Their domes are hexagonal pyramids erected on circular frames, which are grooved to run on six-inch rollers. These rollers, six for each dome, are mounted on the wall-curbs. One flap-back shutter gives sky view from the horizon to the zenith. Each hut is made portable by being constructed in sections which are connected together by bolts and nuts. For the transit instruments massive Portland stone piers and foundation slabs have been provided; for the alt-azimuths stone pier-caps only will be sent out, leaving the piers to be provided on the spot. Every part of each observatory and every packing case has been numbered and marked by stencilling, with a letter to denote the station for which it is destined.

These transit and altazimuth observatories, with their instruments and the primary clocks, are, with trifling exceptions, in perfect readiness for use. The equatorials are generally ready, though their final completion has been interrupted by the loan of portions of them to the observers of the recent solar eclipse. The telescopes will be supplied with the Astronomer Royal's prismatic eye-piece for correction of atmospheric dispersion, which will necessarily be considerable at the low altitudes at which some of the contact observations must be made. The equatorial observatories are not yet constructed; the plans for them are under consideration as we write. The four-inch telescopes, some second-class clocks for use with the alt-azimuths and equatorials, and the small accessories, have also to be provided.

It is early to speak of the *personnel* of the various observing expeditions. Officers of the army and navy will probably compose a large proportion of the observing corps. Several gentlemen of the Royal Artillery have already commenced practice at Greenwich with the time and position instruments; but, with the object of forming a more accessible school of observation for them, a temporary observatory has been fitted up near to their head-quarters at Woolwich.

Photography was not included in the Astronomer Royal's original plans. But from the time that his preparations were first mooted, the probable advantages of photo-heliometry of the planet during transit were strongly insisted upon. The plans for photography were advanced from photographic quarters; astronomers of the exact class who were not photographers were somewhat sceptical at the outset concerning its accuracy. They anticipated that uncertainties would attach to the photographic measurements: in the first place from optical distortion of the image formed by the camera-telescope; in the second place, from mechanical distortion produced by unequal shrinkage of the collodion film, which must receive its impression in the wet state, whereas the measurements must be taken when it is dry; and in the third place, it appeared doubtful whether sufficiently accurate scale measurements could be secured to make the results equally reliable with those to be obtained from eye observation of the contacts. No method of secondary accuracy could be tolerated, since the received value of the solar parallax (8″·95) is probably much less than 1 per cent. in error. It is considered that an eye-observation of contact, *i.e.* of formation or rupture of the "black drop," can well be made with no greater error than 4 seconds of time. As Venus moves over the sun at the rate of about 2″ in a minute of time, the 4 seconds correspond to a displacement of 0″·12 of arc in the direction of motion, or about $\frac{1}{1400}$ of the sun's diameter. Can the measurements from a photograph, with all the above noted chances of error, be relied upon for such small quantities? It is argued that they can. The probable error of a single micrometric measurement of the photographic distance of the images of a double star is cited by Mr. Asaph Hall* to be 0″·12, and Mr. De La Rue, who is naturally the English referee in such matters, has no hesitation in saying that the measurements from a solar photograph *may* be depended upon, with all due precautions, to the $\frac{1}{10000}$ of the sun's diameter. He is of opinion that the shrinkage of the collodion film takes place only in the direction of its thickness, and he considers that if any optical distortion exists, it may be determined, and the correction for it found, by photographing a scale of equal divisions upon different parts of a plate, and comparing micrometric measurements of the various images. Upon this point he is about to make some crucial experiments with a large scale erected upon the Pagoda at Kew, and photographed from the Kew Observatory with the image in all positions on the sensitive plate. Herr Paschen is also investigating the matter on the part of the German Commission, using for his test-scale a glass plate divided into squares by diamond-ruled lines. Some preliminary trials have convinced him that should it be impossible to get rid of distortion, it will yet be easy to correct for it as accurately as may be desired.

Although the thorough reliability of the photographic method has not yet been satisfactorily established, the doubts concerning it have been in part removed, and it has appeared undesirable to neglect photography in the face of the circumstance that it might be the means of obtaining some useful record of the transit at stations where from atmospheric causes the observations of contact may be lost or vitiated. Moreover, as other nations had decided to employ the photographic method, it seemed incumbent upon Britain to work in harmony if not in actual concert with them; for although there has as yet been no formal proposal for international co-operation, there have been communications between the astronomical authorities of the various countries concerned, which have prevented the formation of very divergent plans. The Astronomer Royal therefore laid the subject before the Board of Visitors of the Greenwich Observatory, at their meeting in June last, and it was fully discussed by them. They resolved that it was desirable to furnish all the English stations chosen for eye observations with the necessary photographic appliances, and an application was shortly afterwards addressed to the Treasury for a grant of 5,000*l.* to defray the expenses of the additional equipment. The money was granted, and the construction of the photo-heliographs—five in number—was forthwith placed in Mr. Dallmeyer's hands. These instruments will be of generally

* *Silliman's Journal*, vol. cii., p. 26.

similar design to one made by the same artist for the Wilna Observatory, which has produced sun-pictures that, so far as the eye can judge, leave nothing to be desired in point of sharpness of definition and freedom from such distortion as the photographed cross-wires can exhibit. The object-glasses will be of about 4in. diameter, giving focal images of the sun about half an inch in diameter. The focal image will be amplified to about 4in diameter on the photographic plate, and, in applying the enlarging lens, Mr. Dallmeyer is confident that he can entirely destroy the spherical aberration. The camera-telescopes will be mounted on equatorial stands, with latitude adjustment of 80° range; and they will be furnished with driving clocks.*

For the general photographic organisation, the Astronomer Royal has secured the co-operation of Mr. De La Rue, under whose able supervision the instruments above mentioned will be constructed, and by whom the various details of the photographic scheme will doubtless be arranged. Of the five stations already selected for eye observation of contacts, three are well suited for photographic record. These are Rodriguez, Kerguelen's, and Auckland, at all of which the whole transit will be visible. The Hawaiian station and Alexandria, though they are available, are less advantageous than the rest, because only a portion (about half) of the transit will be visible from each, and the photographs, besides being thus limited, must be obtained at low altitudes of the sun. It may become a question whether the heliographs provided with a view to furnishing these two stations cannot be more advantageously located. But before the positions are finally decided upon, it appears desirable that the intentions of other nations should be fully known, or, as would be preferable, that the ultimate distribution of observers of all kinds—telescopic, heliometric, and photographic—should be made the subject of an International Conference.

J. CARPENTER

JUKES'S MANUAL OF GEOLOGY

The Student's Manual of Geology. By J. Beete Jukes F.R.S. Third edition, re-cast, and in great part re-written. Edited by Archibald Geikie, F.R.S. (Edinburgh: A. and C. Black, 1872.)

IF there be any one feature more strongly marked in the present age than another indicative of progress and intellectual advancement, it is the superiority of most (we will not say of all) of the books intended to promote education. School books and class books of all kinds, instead of being merely reprints, as in the days of yore, now really undergo revision every five years or so, or are superseded by new ones; whilst the introduction of natural science teaching into our Universities and public schools has created a demand for text-books to an extent greater even than the supply.

Among the various writers of the day on the science of Geology, Sir Charles Lyell must undoubtedly be placed in the front rank, as having done more than any other man to promote its study, and his "Principles" and "Elements" of Geology still hold the highest places in our estimation; but we must not forget that Phillips, Dana, and Jukes have also furnished us with geological manuals, more elementary in their style and arrangement, and therefore more serviceable for beginners than are Lyell's works. In order, however, to remedy this, Sir Charles Lyell has lately brought out a "Student's Elements of Geology," 8vo. pp. 624 (Murray), being an abridged edition of his larger work. This will no doubt prove a very useful book to beginners as an introduction to the higher class books.

Jukes's "Student's Manual of Geology" was born in 1857, and has already gone through two previous editions, each time, as is the sad fate of such books, growing more corpulent, till the poor student turns pale before the vast array of facts, neatly arranged for him to "cram," in the smallest possible type.

The original design contemplated in 1854 was an article on Geology for the "Encyclopædia Britannica," to have been carried out by the late Prof. Edward Forbes and Mr. J. Beete Jukes conjointly; but the death of Forbes for a time deferred the task. It was afterwards inserted in the Encyclopædia under "M," as "Mineralogical Science," and finally appeared as a separate work in 1857. The first edition is comprised in 610 pp., and is illustrated by 74 woodcuts, chiefly diagrams and sections of rocks, &c.

The second edition appeared in 1862, having grown an inch in the size of its page, and added 154 pages to its bulk, partly owing to the addition of 100 more illustrations, 50 of which are of fossils, or rather groups of fossils.

The idea of these figures of "Fossil groups," as they are termed, seems to have been taken from the admirable series of little woodcuts which illustrate the invertebrate portion of Owen's "Palæontology,"* prepared by the late Dr. S. P. Woodward. They are, however, arranged stratigraphically in Jukes's "Manual," not zoologically, as in Owen's "Palæontology."

The third edition, now before us, is only fourteen pages thicker than the second edition, and contains thirty-one more illustrations; but the bulk of matter is vastly increased by the use of smaller type than in the former editions.

The illness which seized Mr. Jukes, and by which he was removed from among us, had already impaired his health so much as to render it desirable he should be relieved of the labour of completing this edition, and the task was accordingly, by the author's own wish, undertaken by Professor Geikie, Director of the Geological Survey of Scotland.

The eighty pages on mineralogy (forming chapters II. and III.) have been entirely re-written by Dr. Sullivan; Chapter XIII., on trap-rocks, has been re-written by Prof. Geikie, as well as many other parts. Mr. Hull has revised the description of the English Coal-measures. Messrs. Bristow, Whitaker, and Judd have looked over the Mesozoic and Cainozoic chapters, and Prof. Huxley has contributed a new synopsis of the animal kingdom.

By a modification of the former edition, a new part is introduced (Part II.) called "Geological Agencies, or Dynamical Geology," a part of which also is from the pen

* There are grounds for hoping that the same artist will construct some precisely similar photo-heliographs for other countries, for use on the Venus Transit. There would manifestly be great advantage in the employment by all photographing observers of instruments whose optical portions at least are of identical material and manufacture.

* Second Edition, 1861 (Edinburgh: A. and C. Black).