tion of any scientific treatise, or the carrying out of any research, work, or discovery, or have been the simultaneous but independent authors of any such treatise, work, research, or discovery, the Council may, under these circumstances, receive the nomination of such two or more persons as joint recipients of the gold medal, and proceed thereupon in like manner as above mentioned with respect to the names of separate persons; and should the gold medal be ultimately awarded to such joint authors, workers, or discoverers, an impression of the gold medal shall be provided for, and given to each of such joint recipients.

The Total Solar Eclipse of 1896, *August* 9. *Reports of Observers communicated to the Joint Permanent Eclipse Committee of the Royal Society and Royal Astronomical Society.*

The following Reports have been received, and communicated by the Committee to the Royal Astronomical Society for publication. Mr. Stone's report on observations made in Novaya Zemlya will be published in the *Memoirs.*

Report on the Expedition to Japan to observe the Total Solar Eclipse of 1896, *August* 9.

By W. H. M. Christie, M.A., F.R.S., Capt. E. H. Hills, R.E., and H. H. Turner, M.A., B.Sc.

1. Thick clouds obscured the Sun at the time of Total Eclipse, and no photographs were taken or observations made. But the following notes on the Expedition may be interesting to other observers:—

2. This Expedition was organised by the Joint Permanent Eclipse Committee of the Royal Society and Royal Astronomical Society, funds being provided from a grant made by the Government Grant Committee. The observers are indebted to the Canadian Pacific Railway Company and the Allan Line for a considerable reduction of fares, and for the free carriage of their instruments from Liverpool to Yokohama and back to Montreal. By the kindness of the Lords Commissioners of the Admiralty the Expedition was assisted in Japan by several of Her Majesty's ships of war, as mentioned in detail in the next paragraph.

3. *Personal.*—The following persons took part in the Expedition:—

W. H. M. Christie, M.A., F.R.S., Astronomer Royal.
H. H. Turner, M.A., B.Sc., Sec. R.A.S., Savilian Professor of Astronomy at Oxford.
Captain E. H. Hills, R.E., Instructor in Chemistry and Photography at the School of Military Engineering, Chatham.

In what follows these are usually designated by the initials C., T., H. respectively.

It was originally proposed that Captain W. de W. Abney, C.B., F.R.S., should also take part in the Expedition, in which case the observers would have divided into two pairs, and occupied two stations. But Captain Abney ultimately found it impossible to go to Japan, and the number of observers was thus reduced to three. The Astronomer Royal could not reach Yokohama before July 27, owing to the necessity for his presence at Greenwich on Visitation Day (June 6), but the greater part of his equipment was taken out and set up by the other observers, who left three weeks earlier. Under these circumstances it was not found practicable to occupy two stations, and no attempt was made to do so. Even with this simplified programme, the whole of the time available for preparation was fully employed, and the observers feel that the restriction was justified by their experience.

4. *Itinerary.*—The observers T. and H. left Liverpool in R.M.S. *Sardinian* (Allan Line) on May 28, arriving at Montreal on June 8.

They reached Vancouver on June 21; embarked on R.M.S. *Empress of Japan* the following day, and arrived at Yokohama on July 5. They found H.M.S. *Humber* waiting to convey them to the selected station in the island of Yezo. A few days were spent in some official visits and in discussing the most suitable stations, and the observers embarked on the *Humber* on July 13, arriving at Akkeshi on July 16. In the bay five of H.M. ships were already anchored, under the command of Vice-Admiral Sir Alexander Buller, on the flag-ship *Centurion*; and the observers have to gratefully record the generous assistance given them by the Admiral and the officers of the fleet. Three ships in all rendered special aid to the Expedition, viz., H.M.S. *Humber*, which conveyed the observers T. and H. to Akkeshi; H.M.S. *Linnet*, which conveyed the Astronomer Royal thither from Yokohama, and the officers and men of which assisted the observers in their programme for totality; and H.M.S. *Pique*, which conveyed the whole party back to Yokohama. It may be mentioned that the chief reason for this division of labour was the breaking down of the Japanese railway from Yokohama to Aomori. The Astronomer Royal had proposed to travel by rail to Aomori in order to save time, and the *Humber* was to meet him there, but the above-mentioned break-down necessitated a change of plans, and fortunately the *Linnet* was able to bring him direct from Yokohama, remaining with the observers till after the eclipse. For conveying all the observers back again, the Admiral sent up the *Pique*. It will be seen how much the Expedition owes to the readiness with which Admiral Buller met an unforeseen contingency.

The Astronomer Royal left Liverpool in R.M.S. *Laurentian*, on June 18, arriving at Montreal on June 29. After some delay, through floods in the Rocky Mountains, he reached Vancouver on July 12, and sailed in R.M.S. *Empress of China* on July 13, arriving at Yokohama on July 26: left Yokohama in H.M.S. *Linnet* on July 29, arriving at Akkeshi on the morning of August 1, and was landed at once.

It may be added that the day after the arrival of the observers T. and H. at Akkeshi was spent in exploring the neighbourhood and selecting a site for the station. An American party, with Professor Schaeberle at the head, and a Japanese party under Professor Shin Hirayama, of Tokio Observatory, were already established. After consultation with them, and inspection of the neighbourhood, the observers had little difficulty in choosing a site, and arranged to land their instruments in a "sampan" (or Japanese flat-bottomed boat, which could be run up on the beach) the next morning. But owing to dense fog the "sampan" failed to find the *Humber*, and put back to shore after a four hours' search. On the morning of July 19, however, all the apparatus was safely landed, and work was commenced at once.

5. *Selection of a Station.*—There were three sets of stations available:

(*a*) Stations on the north-east coast: Soya, Esashi (Yessassi), Mombets, &c.

(*b*) Stations inland: Shibetcha, &c.

(*c*) Stations on the south coast: Kushiro, Akkeshi, Hamanaka.

(*a*) Were perhaps best as regards weather (see below), but were condemned by the Hydrographer as regards anchorages, which are bad. The ship could not with any certainty have remained with the observers.

(*b*) Meteorological observations showed that Shibetcha was very bad. An opinion was expressed by Dr. Knipping, of Hamburg, and communicated to us by Professor D. P. Todd, that if an observer could get inland from Kushiro to the lee side of the Sulphur Mountains he would have perhaps the best chance of weather. But this would have been a considerable undertaking, requiring much time, and was not attempted. With regard to other inland stations, it may be remarked that the island of Yezo is thickly wooded inland.

(*c*) Kushiro was originally selected as the headquarters of the Expedition, on the advice of Professor Milne, F.R.S., who knew the district. But just as the observers T. and H. were leaving England, information was received from the Japanese Hydrographic Office, recommending the north-east coast (stations *a*) rather than the south coast (stations *c*), on the ground that the prevailing winds, being southerly, blew up fog to the latter stations. At the same time our own Hydrographer condemned the anchorage at Kushiro, and suggested Akkeshi or Hamanaka instead. On arriving at Yokohama the observers had thus to face the question whether to proceed to Akkeshi or to attempt an entire change of programme by going to some place on the north-east coast, in accordance with the suggestions of the Japanese Hydrographic Office.

The observers have here to acknowledge the valuable help accorded them by the British Minister, Sir Ernest Satow, who was able to obtain for them just the information they required. He first put into their hands a pamphlet by Professor Nakamura, Director of the Central Meteorological Observatory in Tokio, wherein meteorological observations at different stations in Yezo were tabulated and discussed ; and secondly, found for them a Japanese who knew the island of Yezo well, was an excellent navigator, and could speak very good English. From both sources of information it appeared that Akkeshi was equal, if not superior, to the north coast. Further, there were already three strong parties on the north-east coast (Professor D. P. Todd, M. Deslandres, Professor Terao), so that observations there would be well provided for. The decision was accordingly taken to proceed to Akkeshi (spelt Akishi on the Admiralty Chart).

A brief extract from Professor Nakamura's pamphlet is here appended :—

" The undermentioned table shows a cloud condition near the Sun's disc, which has been found from the average of the tri-daily observations (2 P.M., 2.30 P.M., and 3 P.M.) extending over three years, 1893–1895, from July 25 to August 25. Cloud conditions are denoted by five symbols :—

0	means	entirely free from clouds.
1	,,	generally scattered.
2	,,	clouds massed about the Sun.
3	,,	the Sun in fog or haze.
4	,,	the Sun invisible in thick clouds.

The number of observations, in percentage, distributed under each symbol, is given in the following table :—

	0			1			2			3			4		
Name	2.0	2.30	3.0	2.0	2.30	3.0	2.0	2.30	3.0	2.0	2.30	3.0	2.0	2.30	3.0
Soya	27	25	25	21	24	21	10	11	8	5	5	5	36	34	40
Esashi	56	56	56	12	12	12	6	6	6	4	4	4	21	21	21
Mompetsu	58	57	55	9	7	8	5	6	5	1	2	2	23	23	26
Abashiri	30	27	26	10	12	13	5	6	6	0	0	0	54	54	54
Nemuro	23	20	20	17	17	16	10	11	13	9	11	11	40	40	39
Akkeshi	40	41	41	31	28	27	2	1	2	8	9	9	18	18	18
Shibetcha	20	17	17	8	12	11	26	26	24	0	0	0	46	48	48

If we regard cloud conditions which are denoted by 0 and 1 to be suitable for observation and the others unsuitable, then the percentage at the observation hour becomes as follows :—

	2.0 P.M.		2.30 P.M.		3.0 P.M.	
	Favourable.	Unfavourable.	Favourable.	Unfavourable.	Favourable.	Unfavourable.
Soya	48	52	49	50	46	53
Mompetsu	69	30	67	33	66	34
Esashi	68	31	68	31	68	31
Abashiri	40	59	39	60	39	60
Nemuro	40	59	37	63	36	63
Akkeshi	71	28	72	28	71	29
Shibetcha	28	72	29	71	28	72

Below is given the record of weather at the time of totality at Akkeshi during the stay of the observers :—

July 19	Cloudy.	July 27	Fine.	Aug. 4	Fine.
20	Cloudy.	28	Cloudy.	5	Fine.
21	Cloudy.	29	Cloudy.	6	Cloudy.
22	Very fine.	30	Fine.	7	Cloudy.
23	Fine.	31	Doubtful.	8	Very fine.
24	Doubtful.	Aug. 1	Cloudy.	9	Cloudy.
25	Cloudy.	2	Cloudy.	10	Very fine.
26	Fine.	3	Raining.	11	Fine.

On arrival in Akkeshi Bay it was not difficult to make a choice of station, aided by the experience of Professor Schaeberle, who had already been ashore eleven days. He had remarked that the sea-fog (which was only too prevalent throughout our stay) lay about the hills and inland when it was clear in the little basin in which the village lay. We accordingly put up at a tea-house, or inn, in the village, and erected our huts in the yard at the back within a ring-fence, which kept out not only inquisitive human beings, but dogs and poultry. The Governor of the place and the Chief of Police at once took us under their protection, and we were never interfered with in any way, but on the contrary received every kindness. We had never any reason to regret our choice on the score of weather. We often had it beautifully fine when there was dense fog at sea. For instance, on the day before the Eclipse, the Sun shone uninterruptedly from a clear blue sky, while Admiral Buller, who had come up in H.M.S. *Alacrity* to see the Eclipse, was kept outside the bay in a dense fog only a few miles away, and did not venture to come in till the Monday morning after the Eclipse. On the actual day of the Eclipse we could not have been better situated in the neighbourhood, for the fog and cloud did lift to us occasionally, though it remained dense elsewhere.

6. *Instrumental Equipment.—The Astronomer Royal.*—The "Thompson" photoheliograph: O.G. 9 inches aperture and

8 ft. 6 in. focal length, with secondary magnifier placed a short distance within the focus, giving an image of the Sun 4 inches in diameter. The telescope was pointed to a 16-inch plane mirror made by Dr. Common, and mounted as a cœlostat by Mr. Hammersley after design by Dr. Common; the Sun's rays being thus reflected into the telescope. The camera was furnished with eight plate-holders, taking 12 × 10-inch plates.

Professor Turner.—The double camera used in the Fundium Expedition of 1893 by Sergeant Kearney. The tube is of wood, 6 feet long and 14 × 7 inches in section, divided by a partition into two square tubes of 7 × 7-inch section. In one of these is placed the "Abney"* lens of 4 inches aperture and 5 feet 2 inches focal length, giving an image of the Sun 0·57 inch in diameter; in the other the photoheliograph objective No. 2 (used in transit of *Venus* expeditions), of 4-inch aperture and 5 feet focal length, with a Dallmeyer secondary magnifier of $7\frac{1}{2}$ inches focus placed 5 inches within the focus, and giving an image of the Sun $1\frac{1}{2}$ inch in diameter. The camera furnished with six plate-holders, each taking two plates of 160 × 160 mm., as in use for the astrographic chart; both plates being exposed by a quarter turn of one shutter. The camera pointed to a 16-inch cœlostat as above.

On the tube was mounted a polariscopic apparatus consisting of an ordinary slit spectroscope (and telescope), with an Iceland spar double image prism substituted for the ordinary prisms. Further explanation of this apparatus is given below.

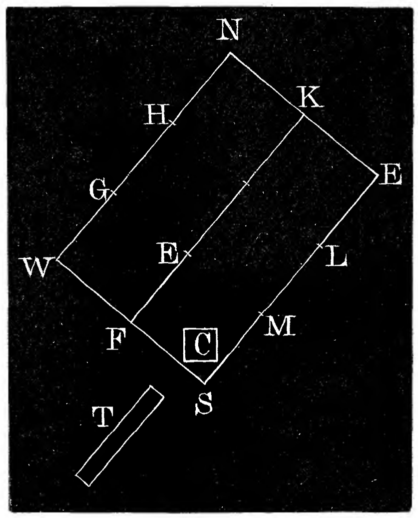
Captain Hills.—Two slit spectroscopes:

	No. 1.	No. 2.
Objective	Cooke achromatic $4\frac{1}{2}$ inch aperture, 5 feet 10 inch focus.	Single quartz lens 5 inch aperture, 4 feet 9 inch focus.
Collimator and Camera lenses	Single quartz lens $2\frac{1}{2}$ inch aperture, 30 inch focus.	Single quartz lens 3 inch aperture, 36 inch focus.
Slit	$1\frac{1}{2}$ inch × 0·004 inch.	2 inch × 0·004 inch.
Prisms	Two flint prisms of 60° $4\frac{1}{2}$ inch base, $2\frac{1}{2}$ inch height.	Four quartz prisms of 60° $3\frac{1}{4}$ inch base, $2\frac{3}{4}$ inch height.
Prisms at min. dev. for	Hγ.	Hϵ.
Position of slit	Tangential to Sun's limb at point of second contact.	Diametral.

* One half of a doublet photographic lens by Dallmeyer belonging to Captain Abney used in the Eclipse Expeditions of 1886, 1887, 1889, 1893, and 1896: acquired from him by the Royal Astronomical Society in 1893 for permanent use in Eclipse expeditions, in consideration of their replacement by two others.

7. *Huts.*—The huts for the instruments were made of wooden frames covered with Willesden waterproof canvas. These were made before starting, and taken out with the instruments. The canvas was brought away after the eclipse, and the wood left behind. This procedure is recommended for future expeditions.

The huts for observers C. and T. were arranged on the plan suggested in *Monthly Notices*, vol. lvi. p. 410. The corners were placed N., E., S., and W., and the cœlostats (C.) mounted on foundations of gravel and Portland cement in the south corner. Two sliding doors, MS and FS, met at the south corner, admitting the Sun to the cœlostat in the morning and afternoon respectively. The telescopes (T.) were placed in the azimuth indicated in the diagram. The distances SF, FW, WG, GH,



HN, &c., were all about 4 feet, slightly less than the width of canvas. There was a ridge roof, with ridge along the line KF; and T.'s hut was completely partitioned along FK to form the dark-room in the portion WNKF, a lining of brown paper being used to form the dark-room. The paper used was such as is put under carpets, with a pattern of depressions in it to make it soft to the feet; but these depressions or bulges were found to be easily pierced, and thus let in light; ordinary brown paper would have been better.

The arrangement was found to work well on the whole.

H. adopted a different plan. His heliostat and object-glasses were placed outside the main hut on a concrete foundation, and were protected by a small structure of the same wood and canvas, which could readily be thrown off. Inside the main hut was placed a firm table on which the spectroscopes were mounted. The tubes to connect the object-glasses with the spectroscopes were made of black paper on wooden laths on the morning of the Eclipse. This arrangement also was found to work well.

8. *Mounting and adjustment of Cœlostats and Heliostat.*—The places for the huts having been marked out on the

ground, the cement bases were made at once, so that they might have time to set while the huts were being put up. Rectangular wooden frames were made, sunk an inch or two into the ground (which was tolerably hard), and filled with shingle and Portland cement. A layer of sand and cement was placed on the top to give a good surface. Before the cement was quite hard the heavy metal bases for the cœlostats were placed in position roughly, so that they might bed into the cement.

The adjustment of the axes of the cœlostats was effected very quickly by means of the attached declination theodolites. The level attached to the telescope makes it possible to adjust in altitude without any astronomical observation, for the latitude of the place can be taken from the chart with sufficient accuracy; and setting the telescope to the south declination equal to the co-latitude, and in the meridian, the level should indicate horizontality. Index errors of the circle and level are eliminated by reversal of the instrument. There is a slight uncertainty attending the placing of the telescope in the meridian, but this does not seriously affect the adjustment in altitude. If a cross-level were made for the pivots of the telescope this uncertainty could be removed.

To adjust in azimuth we must have an observation of the Sun (or a star) at a distance from the meridian. Observing his declination (in reversed positions of the instrument and taking the mean), the instrument must be moved in azimuth until this observed declination agrees with that given in the *Nautical Almanac*. A very few trials, if the Sun can be seen for half-an-hour, will soon indicate the true azimuth without any calculations, within a minute or two of arc, though if the instrument is moved much the altitude observation should be repeated.

After the initial adjustment of the cœlostats they were not disturbed, but observations were repeated at intervals with the following results. The individual readings were only taken to minutes of arc, but both limbs of the Sun were observed in both positions of the instrument, and the mean of the four set down.

C.'s instrument: Observer T.

Date.	(G.M.T.)	Hour angle of Sun.	Observed Decl.	Tabular Decl.	O−C.
	h	h	° ′	° ′	′
July 20	19·7	+5·0	20 23·0	20 22·7	+0·3
21	9·7	−5·0	20 14·3	20 15·6	−1·3
21	17·5	+3·2	20 10·5	20 11·8	−1·3
22	12·0	−4·3	19 59·8	20 2·3	−2·5
25	17·7	+3·4	19 18·5	19 20·4	−1·9
25	19·0	+4·7	19 18·8	19 19·7	−0·9
25	19·5	+5·2	19 19·8	19 19·4	+0·4
26	10·7	−3·6	19 9·0	19 11·0	−2·0
29	11·5	−2·8	18 25·5	18 28·2	−2·7
29	18·8	+4·5	18 24·0	18 23·8	+0·2
31	11·3	−3·0	17 57·8	17 58·7	−0·9

From this general watch kept on the instrument, it seemed clear that the adjustment remained good within 2′ or 3′, which is sufficient for the purpose. The error was chiefly in altitude, and by an unfortunate oversight, observations with the level for altitude were not recorded, though one or two were made, and the history of this small displacement cannot be traced. But observations made by C. after his arrival gave the following results :—

Date.	(G.M.T.)	Hour angle of Sun.	Observed Decl.	Tabular Decl.	O−C.
	h	h	° ′	° ′	′
Aug. 7	19·3	5·0	16 0·7	15 59·7	+1·0
7	19·3	observation with level			−2·7

T.'s Cœlostat : Observer T.

This instrument was used with the driving-rod and gear at the upper end of the axis, which brings the theodolite to the lower end. The adjustments were made before mounting the mirror in the working position, and could not well be tested afterwards without reversing the mirror. Hence we have no information between July 22 and August 3, when a displacement in altitude was found as in the case of C.'s instrument.

Date.	(G.M.T.)	Hour angle of Sun.	Observed Decl.	Tabular Decl.	O−C.
	h	h	° ′	° ′	′
July 21	18·3	+4·0	20 14·0	20 11·4	+2·6
22	10·3	−4·0	20 4·8	20 3·2	+1·6
Aug. 3	12·0	−4·3	17 17·0	17 11·3	+5·7
3	12·0	observation with level			+8·5
3	17·0	+2·7	17 13·8	17 8·0	+5·8
		Instrument adjusted in altitude.			
3	17·5	observation with level			+1·0
3	18·0	+3·7	17 7·8	17 7·3	+0·5
7	15·0	+0·7	16 8·8	16 2·8	
7	15·0	observation with level			+2·0

H.'s Heliostat : Observer T.

This instrument not having any special means of adjustment provided, the following plan was used to adjust the polar axis.

A wooden cap was made for the end of the polar axis on which one of the cœlostat theodolites could be fitted, and the whole was bound up firmly with string, as the best method of mounting the theodolite on this axis at command. The adjustment was thus conducted as for the cœlostat. The nature of the mounting gave a little extra trouble, but when some few difficulties had been overcome the adjustment was successfully carried out. It is not so important for spectroscopic observations that the adjustment should be perfect, and the labour of re-testing at a later date was omitted.

9. *The Driving Clocks.*—The clocks for the two cœlostats seem unnecessarily heavy in construction, considering the small amount of work to be done, but it does not seem impossible that they may be made to work well. As a matter of fact, T.'s clock gave a good deal of trouble, though the mechanism was not directly to blame. On July 31, after having performed very well day after day, it suddenly stopped, and could not be made to go, even with much extra weight. It was taken to pieces by T. and carefully cleaned, and went well for one day, when it stopped again. A scrutiny revealed the fact that the great weight required to drive the clock had gradually strained the wooden support so that the weight-cord was now rubbing tightly against the side of the opening from the clock-case, producing great friction. The clock was moved about two inches forward and the support strengthened, and all went well for another day, two weights being now sufficient for driving instead of four. Then came another stoppage, and five weights would not drive it. It was again taken to pieces and thoroughly examined by T. and H., when it was found that the upper pivot of the governor would jam unless the plate in which it worked was pressed tightly to one side before screwing it down. When this was done the clock ran easily, and continued to do so until the day of the Eclipse. The primary cause of the series of difficulties was almost certainly the great weight required to drive the clock, which strained the support in the first instance.

The cœlostat clocks, when in good order, kept a fair rate. The governor makes a slight noise twice every second, by which the rough adjustment of rate can be made. For fine adjustment a mark was placed on one of the wheels, which revolves four times a minute, and transits of this mark were observed at intervals; or the image of the Sun was received on the ground glass of the telescope by reflection from the cœlostat, and its steadiness observed. The two methods were found to agree satisfactorily, showing that the radius of the driving sector is of the right length or rather that the teeth are properly cut. The clock stops when winding, which is an inconvenience. For instance, on the actual day of eclipse the Sun appeared about half an hour before totality, and the image was adjusted on the ground-glass. It was important not to lose it again, and so the clock was kept running; but having to be wound up some minutes before totality, the image was displaced by the stoppage of the clock. The time lost was, however, only a few seconds, and the displacement not serious. It might even have been corrected if necessary in the following way: before winding, the mark on the wheel was transiting at 6^s, 21^s, 36^s, and 51^s in each minute; after winding, at 13^s, 28^s, 43^s, and 58^s. The rate of the clock might have been increased (by a gentle twist on the driving rod) until the transits again occurred at 6^s, 21^s, 36^s, and 51^s. Or the ordinary slow motion might have been used if its relation to the clock rate was known; it could not of course be used in the ordinary way so long as the Sun was not visible.

10. *Focussing of Telescopes.*—One of the uncertainties that harass the eclipse-observer is his ignorance of the amount of fine weather he will have before the eclipse for adjusting. He must have some astronomical observations to set up his equatorial in position, and he has been accustomed to depend upon star photographs for his focussing. But the experience of the present Eclipse, and especially the introduction of the cœlostat into eclipse work, has done something towards making him independent of weather. The adjustments for position have been simplified by the introduction of the attached level, and experience has shown that the instrumental azimuth will remain steady, so that one glimpse of the Sun or a known star is sufficient to set up the instrument, and it has been found that the focus can be very conveniently and accurately obtained with the help of the plane mirror and without any astronomical observations at all. It is not the first time that methods of focussing by terrestrial means have been proposed or tried. Dr. Schuster proposed in 1886 (*Phil. Trans.* vol. 180 (1889), Ap. 302) to focus on a terrestrial object at a moderate distance. With a properly constructed tube it should be possible to do the focussing before leaving England, though the experience of this Expedition shows that it is advisable to confirm it on arrival at the station. There should in future be no difficulty about doing this in the manner described below, and the writers of this report feel that the introduction of the cœlostat into eclipse photography has simplified the problem very sensibly.

The method was briefly as follows: Pointing the telescope normally to the mirror, the image of a bright point in the focal plane will be formed in the focal plane. If the bright point be outside the focal plane its image will be within, and *vice versâ.* Now prepare a special spare back for one of the plate-holders with holes in it, through which the light of a candle may be admitted. To form a definite image, wire gauze should be placed in the holes, or some other device used, and the holes should be confined to one-half of the back. Cutting a plate in two, place one-half in the plate-holder where the back is not perforated; then when light is admitted through the holes, a reflected image will be photographed on the half-plate.

Wire gauze placed in the plane of the film was used to form the image by C. Two different devices were used by T. In the first a slip of glass, 3 inches long by $\frac{1}{2}$ inch wide, coated with black varnish, and then ruled with fine lines, was held firmly by the back of the plate-holder in a plane *inclined* to that of the film, one end being in the plane of the film and the other about an inch from it. Only one point of any of the ruled lines could thus give a good image at the same exposure, but from the position of this point it could be inferred how much further the object-glass must be moved. In the second method the half of an old plate was coated with black varnish, ruled with lines, and placed in the unoccupied half of the plate-holder. It was thus made quite certain that the origin of light was in the plane of the film. Other devices will probably occur to others.

If the image is not in focus, the object-glass (or the secondary magnifier) must be moved until it is, for in the tubes used in this Expedition the plate-holder came against a fixed bearing. It was found possible to focus with considerable accuracy, a displacement of 0·01 inch in the secondary magnifier making a sensible difference. To move the magnifier through such small distances, C. used thicknesses of paper cut in the shape of collars, and placed between two flanges arranged for the purpose, one on the tube holding the magnifier, and the other on the tube into which it slid. T. unscrewed the object-glass through a fraction of a turn, having no flanges available.

The following are the details of the observations for focus :—

(*a*) *The Thompson Photoheliograph.* Observer C.—Focussing of Thompson photoheliograph, 1896 August 4. Tried focus as found at Greenwich, with ring on concave magnifier marked right focus, using method by reflection from mirror, the telescope being in east direction nearly horizontal. Found focus required alteration ; put in two rings of zinc and two of paper, and took another photograph. Lens required to be moved out farther. Four photographs for focus were then taken on this and following days :—

(1) Four thicknesses of note paper added to the two of zinc and paper. August 4.

(2) Two thicknesses of cartridge paper added. August 7. Focus very nearly right.

(3) Two thicknesses of brown paper added. August 7. Focus much worse than No. 1.

(4) *One* thickness of cartridge paper added to No. 1. *i.e.* the two thicknesses of brown paper and one thickness of cartridge paper removed. This gave the best focus, better than No. 1, and was adopted August 8.

N.B.—The object photographed was the hole with net over it, just above the centre of the field, and the reflected images were in a line a little below the centre. A cross is scratched in right-hand lower corner, as placed in telescope.—W. H. M. C.

(*b*) *The Abney Lens.* Observer T.—D = distance of rim of cell of object-glass from end of wooden tube in inches. The film was 6 feet $\frac{1}{16}$ inch from the same end of tube by measurements such as can be made with a 2-foot rule.

On August 3 three exposures were made with the inclined slit : D = 10·60 inches, 10·80 inches, 11·00 inches.

Calling the end of the slit which is in the plane of the film

E, and a point distant 1 inch from E in the plane of the slit E+1, then when

$D = 10{\cdot}60$, E was in fair focus.

$D = 10{\cdot}80$, $E + 1{\cdot}3$ was in fair focus.

$D = 11{\cdot}00$, $E + 2{\cdot}0$ was in fair focus.

Now the inclination of the slit was 1 in 3; hence $E+1{\cdot}3$ was 0·43 inch distant from the film, and the plate or object-glass should be moved through half this amount to get good focus. Hence the values of D indicated by the three exposures are—

(1) . . . . . $10{\cdot}60 - 0{\cdot}0/6 = 10{\cdot}60$

(2) . . . . . $10{\cdot}80 - 1{\cdot}3/6 = 10{\cdot}58$

(3) . . . . . $11{\cdot}00 - 2{\cdot}0/6 = 10{\cdot}67$

D was set as accurately as possible at 10·65, by pushing or pulling the sliding tube, which fitted rather tightly. But as the first exposure above seemed to indicate a smaller value for D than this, and as star-trails taken on August 4 at this reading, though very good, seemed possibly capable of improvement, another plate was exposed on August 8 in three positions of the O.G., determined by unscrewing it slightly, the first having it hard up, the second unscrewed an eighth turn, the third a quarter turn. For this plate the inclined slit was removed and a half-plate blackened, and then scratched, placed in the carrier as described above. The individual images were thus: the first and second were equally good, and the third distinctly worse. Accordingly the O.G. was unscrewed $\frac{1}{16}$ turn as the adopted position for the Eclipse.

(25 turns = 1 inch.)

(*c*) *The Dallmeyer Lens.* Observer T.—(First plate). The object-glass was unscrewed through fractions of a turn (12 turns to the inch, 1 turn=0·08 inch), from a position in which its rim was $1''{\cdot}90$ from the end of the tube, the rim of the magnifier being $14''{\cdot}50$ from the *other* end.

1st exposure O.G. hard up.

2nd exposure O.G. unscrewed $\frac{1}{2}$ turn = 0·04 inch.

3rd exposure O.G. unscrewed 1 turn = 0·08 inch.

By some accident the first was not on the plate. The second and third were both fair, the second rather better. Another plate was exposed for confirmation, and all three images were on the plate, second and third being about equal, first distinctly worse. Thus a position of the O.G. about 0·06 inch or 0·05 inch further from the enlarging lens was indicated. There is no slide tube for the O.G., and as it was not considered advisable to unscrew it so much as this, the magnifier was moved $\frac{1}{16}$ inch nearer the plate by its slide tube, and clamped up tight. In this position satisfactory star-trails were obtained in the evening of August 4. But for final confirmation another plate was exposed by candle-light on August 8 with O.G. home, unscrewed $\frac{1}{8}$ turn and $\frac{1}{4}$ turn. The third was distinctly worse than the other two, and the first slightly better than the second. Hence the O.G. was screwed home for the Eclipse.

It may be noticed that no mention has been made of the inclined slit in connection with the Dallmeyer lens, though it was used for the earlier photographs. The fact is its graduation is not so effective when there is an enlarging lens. The distance that must be accurately adjusted is that between O.G. and magnifier, and a slight change in the distance of the plate from the combination does not matter very much. The displacement of the plate is in fact m^2 times the corresponding displacement of the magnifier, where m is the magnifying power.

The above measurements, being made with a foot-rule, do not claim any great accuracy, but they should be sufficient to give anyone who uses the tube in the future an approximate focus on which he may refine.

Several plates not mentioned above were more or less failures, such as are common in trying a new method, however simple.

Besides the star-trails on August 4, with both instruments, two plates with six exposures each were taken of the Moon on July 30 : O.G. rim 1·90 inch from end of tube, as above, and the rim of the magnifier 14 and $x/16$ inches from the other end, where x had the values :

	(*a*)	(*b*)	(*c*)	(*d*)	(*e*)	(*f*)
1st plate	8	10	12	8	6	2
2nd plate	8	7	6	9	10	(cloudy)

In the first plate (*d*) and (*e*) were fair.

In the second plate (*b*) was the best, agreeing with the reading subsequently found by reflection from the mirror. Such confirmation of the focus by astronomical exposures is eminently desirable when possible, but it is comforting to be able to dispense with it ; for in many climates there is a heavy dew at night, which is anything but good for the instruments, as was the case on the present occasion at Akkeshi.

11. *Programme of Observations.*—C.'s eight slides were filled, and intended to be exposed as below :—

No. of Slide.	Exposure. s	Plate.	Developer to be Used.
1	1	Ilford ordinary	Pyro-soda.
2	5	Ilford rapid	Pyro-soda.
3	5	Ilford ordinary	Pyro-soda.
4	10	Rocket (backed)	Amidol.
5	2	Ilford ordinary	Amidol.
6	20	Rocket (backed)	Eikonogen.
7	10	Ilford ordinary	Pyro-soda.
8	1	Ilford ordinary	Eikonogen.

T.'s six slides were filled as below, the same plates being used for the Dallmeyer and Abney lenses in each case, and standard squares being impressed on plates 1, 2, and 5:—

No. of Slide.	Exposure.	Plate.	Developer to be Used.
	s		
1	1	Ilford ordinary	Pyro-soda.
2	2	Ilford rapid	Eikonogen.
3	20	Rocket (backed)	Eikonogen.
4	5	Mawson and Swan (backed)	Amidol.
5	2	Ilford ordinary	Pyro-soda.
6	1	Photo mechanical	Amidol.

H.'s four slides were filled as below:—

Spectroscope.	No. of Slide.	Exposure.	Plate.
No. 1	1	Twelve of 1^s	Lumiere green sen-
No. 1	2	Two of 80^s and 30^s	sitive orthochro-
No. 1	3	Twelve of 1^s	matic.
No. 2	4	Two of 80^s and 30^s	Imperial flash-light.

Slides 1 and 3 were to be exposed during the 20 seconds, commencing about the 15th preceding totality, and the corresponding period at the end of totality.

For slides 1 and 2 the slit was tangential at the point of second contact; for slide 3 the slit was tangential at the point of third contact; for slide 4 the slit was diametral.

12. *The Polariscopic Observations.*—(This paragraph by T.) In the spring of 1894 I made some measures on the photographs of the corona in 1893 with Captain Abney's revolving-sector photometer. A sufficient number of measures was made to determine the general diminution of coronal light with distance from the Sun's limb, but the time at disposal did not allow me to complete the investigation by taking some particular streamer and exploring its detail. In hopes of doing this in the near future, I did not publish the results as far as they went, though a brief account of them was given to the British Association at the Oxford meeting of the same year (B.A. Report, 1894, p. 568).

Meanwhile the simplicity and beauty of this photometric method had so much impressed me that the extension of it to other cases naturally presented itself, and, in particular, it occurred to me that if a photograph of the corona could be taken with polarised light, and the density of deposit measured at different points, we should obtain a very much more complete knowledge of the extent to which the coronal light is polarised than we have at present. In 1878 some small photographs of the corona were obtained, the light being polarised in planes at right angles (*Washington Observations*, 1876, Appendix III., plate 29), but no attempt at measuring them was made, and the method of obtaining them was rather rough.

In considering the best form of apparatus, I first thought of placing an achromatised double-image prism of Iceland spar in front of the object-glass of a small telescope. This would give two images of the corona polarised in perpendicular planes, but each impressed on the sky belonging to the other as background. If a large separation of the images could be obtained, the interference of the sky belonging to the other image might be nearly uniform, and not very great; but this would mean a great expense, at the present price of Iceland spar. On thinking over the matter further, however, a different method suggested itself. The above arrangement is analogous to the spectroscope with objective prism, which gives a series of coloured images, each impressed on the sky of the others. With the double-image prism there are only two instead of a number, but this difficulty of confusion is common to both instruments. But the colours of the spectrum can be separated from each other, and this confusion avoided, by the use of a different instrument—namely, the spectroscope of ordinary form, telescope, collimator with slit, prism, camera.

If colour is regarded as continuous, only an infinitely small slit will give a pure spectrum. But if any finite number of colours is assigned, there will be a definite width of slit for which each colour is completely separated from the rest. With half the number of colours, the slit may be just twice as wide; if we again halve the adopted number of colours, we again double the width of slit, and so on. If we have only two colours, the slit may be a considerable width, and yet the images in the two colours be completely separated. Now the Iceland-spar prism is practically a direct-vision prism giving only two colours—the two kinds of polarised light. We have then only to replace the prism of a direct-vision photographic spectroscope by our achromatised Iceland-spar prism, and we have an apparatus giving us two images of the corona (or part of it) in polarised lights without interference.

Such an instrument was arranged for the recent Eclipse, but as no results were obtained, it seems unprofitable to describe it in detail here. This brief sketch of the method will probably be sufficient to guide anyone who wishes to try it, and to whom it had not already occurred. Two remarks may be added:

(1) The focus is not quite the same for the two images. It seems advisable to receive them on separate plates, the focus of each being adjusted independently, though some other way of getting over the difficulty may suggest itself.

(2) The angular separation of the images depends on the focal lengths of the lenses employed as well as on the prism. It is easy either to work it out theoretically, or to observe it experimentally, and then adjust the slit so that there is no overlap. The slit of an ordinary spectroscope may be employed if it will open wide enough, but a rougher slit of metal (or even paper if it be remembered not to use it on the uneclipsed Sun) may be used.

13. *Assistance.*—C. and T. each required four assistants: viz., one to expose at the object-glass end, one to record time of exposures, and two to hand and receive the plate-holders in order. The officers of the *Linnet* who assisted were :—

Recorder for C., Lieut. S. M. Agnew
Exposer for C., Lieut. H. A. Gillett.
Recorder for T., Mr. H. O. Jones.
Exposer for T., Mr. R. B. Garde.

At 15^s before totality (estimated by the previously calculated length of the diminishing crescent) T. was to give the signal "Stand by," in order that H. might make spectroscopic exposures near second contact. At totality he was to call sharply, and two signalmen, A and B, with a stop watch and chronometer, were then to count time as follows: A to record the time of the signal by the chronometer, B to start the stop watch and count from it, "One, two, three, &c." up to sixty seconds, in a loud voice; the next minute was to be similarly counted by A, the change of voice reminding the observers of the change of minute, and the 35^s or 36^s of the third minute by B again, A recording the signal given at the end of totality. The exposer exposed at a signal given to him by the observer when the plate was in position, the beginning and end of exposure being noted by the recorder. In the case of the longer exposures the recorder reminded the exposer quietly at what count he was to close up.

H. only required two assistants: an officer to make the exposures with spectroscope 2 (Lieut. Stevenson, R.N.), and a sailor to hand slides.

All these operations were rehearsed several days before the eclipse, viz. on—

August 5, four times, without plates.
August 6, five times, " "
August 7, three times, " "
August 8, once with all slides filled, once again without plates.

On August 7 and 8 all the rehearsals passed off without any hitch.

The Day of the Eclipse.—Quite cloudy and foggy in the morning. All was ready and in good order. The Sun appeared at noon through cloud, and was visible at intervals. The partial phases of the Eclipse were seen until about twenty minutes before totality, when the clouds closed in completely. The counting of seconds was begun some ten seconds after totality had commenced, as judged by the darkness; the commencement was not very well marked, but the observers all agreed afterwards that when the signal was given the darkness had been constant for about ten seconds. The end of totality was unmistakable, being sharply marked, when the counter was calling $2^m\ 22^s$.

Report on the Expedition to Vadsö, in Finmark, to observe the Total Solar Eclipse of 1896 *August* 9. By A. A. Common, LL.D., F.R.S.

In accordance with the arrangements made by the Committee I left England on July 25 in the S.S. *Norse King*, arriving at Vadsö on August 2 with my party.

During totality the sky was cloudy, and no observations were made or photographs taken.

The arrangements were made as follows :—

Observers.—My party consisted of Mr. A. Hinks, of the Observatory, Cambridge ; my son, T. A. Common, Undergraduate, Trinity College, Cambridge ; Major MacMahon, F.R.S. ; Mr. W. H. Wesley, Assistant Secretary R.A.S. ; and my workman, Alfred Wooldridge.

At the request of the Secretary of State for India Mr. K. D. Naegamvala, of the Poona Observatory, India, was attached to the party.

Mr. Naegamvala's object in going to Norway was to gain experience in view of the next Total Solar Eclipse, the central line of totality of which passes near Poona.

Mlle. Klumpké, of the Paris Observatory, also accompanied us.

Instruments.—Two cœlostats with 16-inch plane mirrors were taken, one being the property of the Royal Astronomical Society, the other my own. With these it was proposed to use—

1. The twin telescope as used in Para Caru, Brazil, in 1893. This telescope has an achromatic lens of 3·85 inches aperture and 62 inches focal length, giving an image of the Sun about $\frac{5}{8}$-inch diameter, and also a $4\frac{1}{2}$-inch lens, which in combination with a negative lens of about 8-inch negative focus gives an image about $1\frac{5}{8}$-inch diameter. This combination is arranged to give an image in the same plane as the other. Plate-holders carrying two $6\frac{1}{4} \times 6\frac{1}{4}$ plates fit to the end of the twin tube, and are held in place by a clamp during exposure.

Instead of the ordinary slide, which has to be withdrawn to uncover the plate, a flap is used which opens out into the tube, and may, if needed, be used for making the exposures. The single lens has been used in previous eclipses, and is designated the Abney lens. It is one of a pair forming a photographic lens, formerly belonging to Captain Abney, C.B., now the property of the Royal Astronomical Society. An exactly similar twin telescope was made for and used in the 1893 eclipse at Fundium, West Africa.

2. A 6-inch doublet lens by Grubb, the property of, and kindly lent for this occasion by, Mr. F. McClean, F.R.S. This had a similar negative combination to that of the twin telescope arrangement, but the image in this case was $3\frac{1}{2}$-inch diameter.