If k does not exceed $1''$ for each drift, then for the range of μ considered ($0''\cdot05$ to $0''\cdot14$) the curve given by (11) approximates very closely to that given by (14). This is shown by the entries in the third and fourth columns of Table VI. The observed values of $\rho(\mu)$ are in good agreement with the entries in the third or in the fourth column, and it is impossible to deduce a definite value of k from the observations. This must be inevitably so when only large proper motions are used in the analysis. When we consider the entries in the last column, it is immediately apparent that although we cannot derive a value of the parameter k we can nevertheless fix an approximate upper limit. This limit seems to be in the neighbourhood of $1''\cdot0$, for the divergence between the observed values of $\rho(\mu)$ and the theoretical values increases very markedly as k increases from $1''\cdot0$ to $3''\cdot0$. If our proper motions had had a lower limiting value of $0''\cdot01$ per annum, the theoretical curve $y = \rho(\mu)$ would have been extremely sensitive to changes in k, especially in the range $0''\cdot01 < \mu < 0''\cdot05$, and we might have expected under these circumstances to have been able to fit one of the theoretical curves, based on (11), to the observed curve. It is just here that accurate small proper motions would have played a decisive rôle. With the present actual limitations of the observational material the evidence suggests that the upper limit to the value of k is in the neighbourhood of that adopted.

§ 8. *Conclusion.*—The apparent anomalies in the observed distribution of Luyten's proper motions have been removed by considering the theoretical effect of excluding from the mathematical analysis all proper motions less than a definite amount. In this way it has been found that the true drift-velocities are entirely normal, and that the relative numerical strengths of the true drifts are very nearly so. Further, the observed distribution, according to magnitude, of the large proper motions ($0''\cdot05$ and over) is at the worst not antagonistic to the assumed formula for the space distribution of the stars, and may even be claimed to offer substantial support to it.

Observatory, Cambridge :
1929 *October* 31.

Total Solar Eclipse of 1929 *May* 9. *Reports of the British Expeditions.*
(Plates 2–5.)

The eclipse of the Sun which took place on May 9 had the long duration of 5 minutes on the central line, and the track was such that fairly accessible stations could be selected from which the Sun would be seen high in the sky. In these respects the eclipse was more favourable than any to take place for a considerable number of years. It was early decided that a new attempt should be made to test the Einstein displacement, as the test could only be made during a long eclipse, and the Admiralty agreed to send Dr. Jackson of the Royal Observatory, Greenwich, for this purpose. The Solar Physics Observatory, Cambridge, undertook to send Dr. Carroll to make spectroscopic observations, particularly a study of the corona with an interferometer and a comparison of the H and K lines of calcium with the infra-red group X. The conditions of the eclipse were reviewed by the Joint Permanent Eclipse Committee, and it was decided to approach the Government Grant Committee of the Royal Society with a view to obtaining funds to duplicate the observations. A grant was obtained, and it was decided to invite Professor F. J. M. Stratton of Cambridge and Mr. P. J. Melotte of Greenwich to take part in the expeditions. The programme of observations to be attempted was discussed with most of the intending observers from Europe at the Meeting of the International Astronomical Union at Leiden in 1928 July.

Col. J. Waley Cohen, who had assisted the eclipse expedition to Benkoelen in 1926, very kindly visited Malaya and Siam in 1928, travelled through the belt of totality investigating sites on behalf of the observers, and interested those in authority in the intended visits of the eclipse observers. From his report, in conjunction with meteorological records kindly secured by Mr. V. A. Löwinger, the Surveyor General to the Federated Malay States, it was decided to locate the observing parties at Alor Star in Kedah and Pattani in Southern Siam. As the eclipse took place near the time when the monsoon usually changes, it was hoped that this choice of stations on the two sides of the peninsula would ensure that one, at least, of the expeditions would meet with favourable conditions. The meteorological records showed that good conditions were more likely in the coastal areas than in the higher regions in the backbone of the peninsula. The stations selected were easily within a day's journey of each other, and the observing parties could keep in touch with one another. Dr. Jackson and Dr. Carroll were stationed at Alor Star and Professor Stratton and Mr. Melotte at Pattani. Dr. T. A. Royds, Director of Kodaikanal Observatory, was sent by the Indian Government to observe the eclipse, and joined the observers in Siam. It was known that a number of volunteer observers, including Dr. Aston at Alor Star and Col. Waley Cohen at Pattani, had offered to join the observing parties, and that a considerable amount of assistance in the manipulation of the instruments at the time of the eclipse might be obtained locally. Consequently, if the apparatus could be collected and adapted in England, a considerable programme could be undertaken.

The determination of the exact value of the Einstein displacement is a matter of great difficulty. There is no rich field of stars at any point on the ecliptic except at the point where the Sun is on May 29—a circumstance which made the eclipse of 1919 so favourable. On May 9 the field is a fair average one. The difficulty in applying the test is in disentangling the scale values from the true displacement. For this eclipse it was decided to adopt the plan of photographing a second field of stars on the eclipse plates during the eclipse itself, and a comparison field in the same right ascension as the Sun, but 9° further north, was selected. It was estimated that a ninefold increase in accuracy would be obtained in this way, as compared with exposures on the eclipse field only.

By the kind permission of the Astronomer Royal and Professor Newall the work of preparing the instruments was undertaken at the workshops at Greenwich and Cambridge. The work at Greenwich was particularly heavy, as it involved the whole astrographic telescope which in itself weighed about 4 tons. The instruments were despatched from Greenwich on February 12 for shipment by s.s. *Laomedon* from Liverpool on February 16. Generous assistance was received from the Blue Funnel Company, who once again took out all the eclipse apparatus to Penang (or Singapore) and back free of all charge; and also from the Straits Steamship Company and the Siam Steamship Company, who carried the goods free from Penang to Alor Star and from Singapore to Pattani respectively and back again. Both parties of observers received many kindly services from officials of the Asiatic Petroleum Company, especially from Mr. Sturt at Penang; Mr. C. Wurtzburg at Singapore and Mr. Penrice at Penang of Messrs. Mansfield & Co. were very helpful in making shipping and transport arrangements.

(*a*) Report by Dr. Jackson.

For the eclipse at Alor Star I had three instruments. (1) Photographic telescope with a two-lens objective of 7 inches aperture and 21 feet focus, fed by cœlostat, to test the Einstein theory; (2) Mr. Worthington's 6-inch Clark lens of 45 feet focus, also fed by cœlostat, for large-scale photographs of the corona; and (3) Dallmeyer Equatorial carrying three short-focus cameras for photography of the corona through colour screens.

Col. Cohen arrived in Malaya at the end of 1929 February and made preliminary arrangements before Mr. Melotte, Mrs. Jackson and I arrived at Alor Star on March 16. We proceeded to set up the Einstein telescope as quickly as possible in the hope of photographing the eclipse field at an altitude of about 30° to 35° immediately after sunset. This was desirable as the lens had been delivered so near the time of our departure from England that it had been impossible to test it adequately. However, the weather was so consistently bad immediately after sunset that it was impossible to do this. Indeed, in the six weeks before the eclipse it was difficult even to get the few photographs required for focus purposes. On the day of the eclipse the sky was covered by high cirrus cloud through which the Sun was dimly seen. The conditions were so poor that all the exposures were made from the computed times by chronometer and not from observation of the beginning of totality.

The Einstein Camera.—As it was desired to photograph two fields on the same plate, and as the telescope was fed by a cœlostat, a new arrangement had to be devised. We could move either the cœlostat or the telescope. A movement of the cœlostat could only give us a second field in the same declination as the eclipse field, and apart from the fact that no very suitable field could be found by moving in right ascension only it was considered inadvisable to interfere with the cœlostat during the eclipse itself. (The cœlostat, however, was provided with an hour circle which proved invaluable for picking up star fields at night time.) It was therefore necessary to move the telescope. It would have been possible to arrange for any field to be photographed by a movement of the telescope in a suitable plane, but as a good field was found at the same right ascension, it was only necessary to move the telescope in an hour circle. One objection which can be raised against the use of a cœlostat is that a slightly different ellipse of the mirror is used in the two exposures. Care was taken to ensure that the telescope was so pointed that the ellipses used in the two exposures had the same centre. The following arrangement was used. The telescope was supported on two stands whose upper surfaces were in the plane of the desired hour circle, inclined at an angle of $6° 11'$ to the horizon. These stands carried concentric circular rails of 21 feet and 2 feet radii respectively, and on them rested the wheels of the frames carrying the telescope. The stands were so arranged that the common centre of the two circular rails was in the centre of the cœlostat mirror. By means of a system of wires working on pulleys and coupled on a shaft with wheels in a ratio of 21 to 2, the telescope could be moved easily and smoothly along the rails on which it was supported. Stops were provided so that the telescope could be moved rapidly and with certainty from the one declination to the other. For the two fields photographed at the eclipse the displacement at the object-glass end was 4 inches and at the plate end 3 feet 4 inches. The longer rail was about 10 feet in length so that the stands could be accurately adjusted on the Sun several weeks before the eclipse. Heavy concrete blocks were tied to the stands to prevent any danger of movement when the telescope was moved. It might be mentioned here that a similar arrangement could be used to enable the same telescope to photograph the flash spectrum through an objective prism, and then—by removal of the prism and movement of the telescope—to secure direct photographs of the corona.

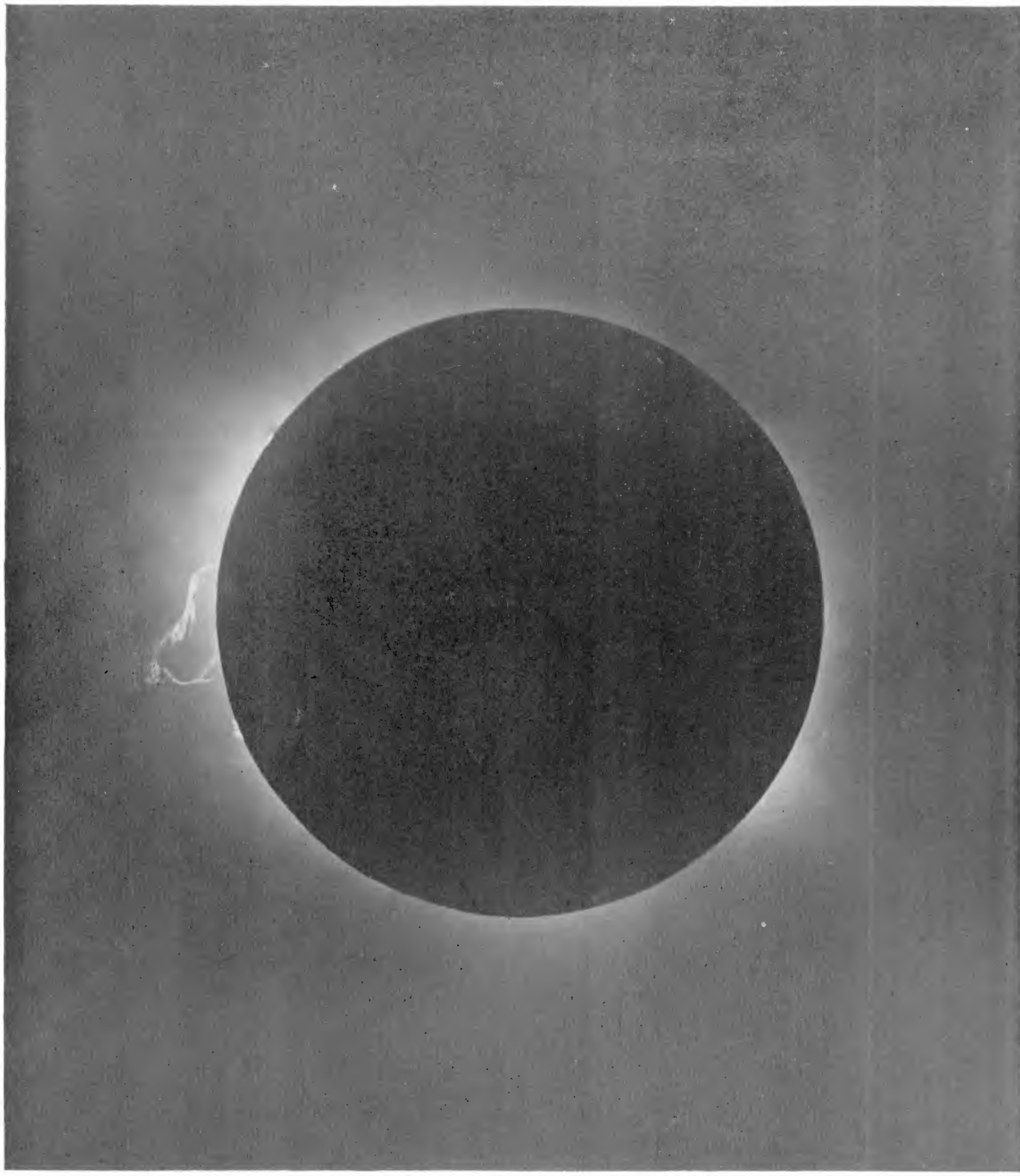
The programme was as follows, the times being counted from the beginning of totality:—

		s		s
1st Plate.	Comparison Field . .	5	to	25
	Eclipse Field . .	35	,,	60
2nd Plate.	Eclipse Field . .	75	,,	100
	Comparison Field . .	110	,,	135
3rd Plate.	Comparison Field . .	150	,,	175
	Eclipse Field . .	185	,,	210
4th Plate.	Eclipse Field . .	225	,,	250
	Comparison Field . .	260	,,	285

The programme was carried out as arranged, but all the plates are heavily fogged and no stars are to be seen on them. The great prominence on the eastern limb shows best on the plate developed for the shortest time. On the fully developed plates the scattered light prevents any real detail from being seen or the form of the corona from being made out.

N

E

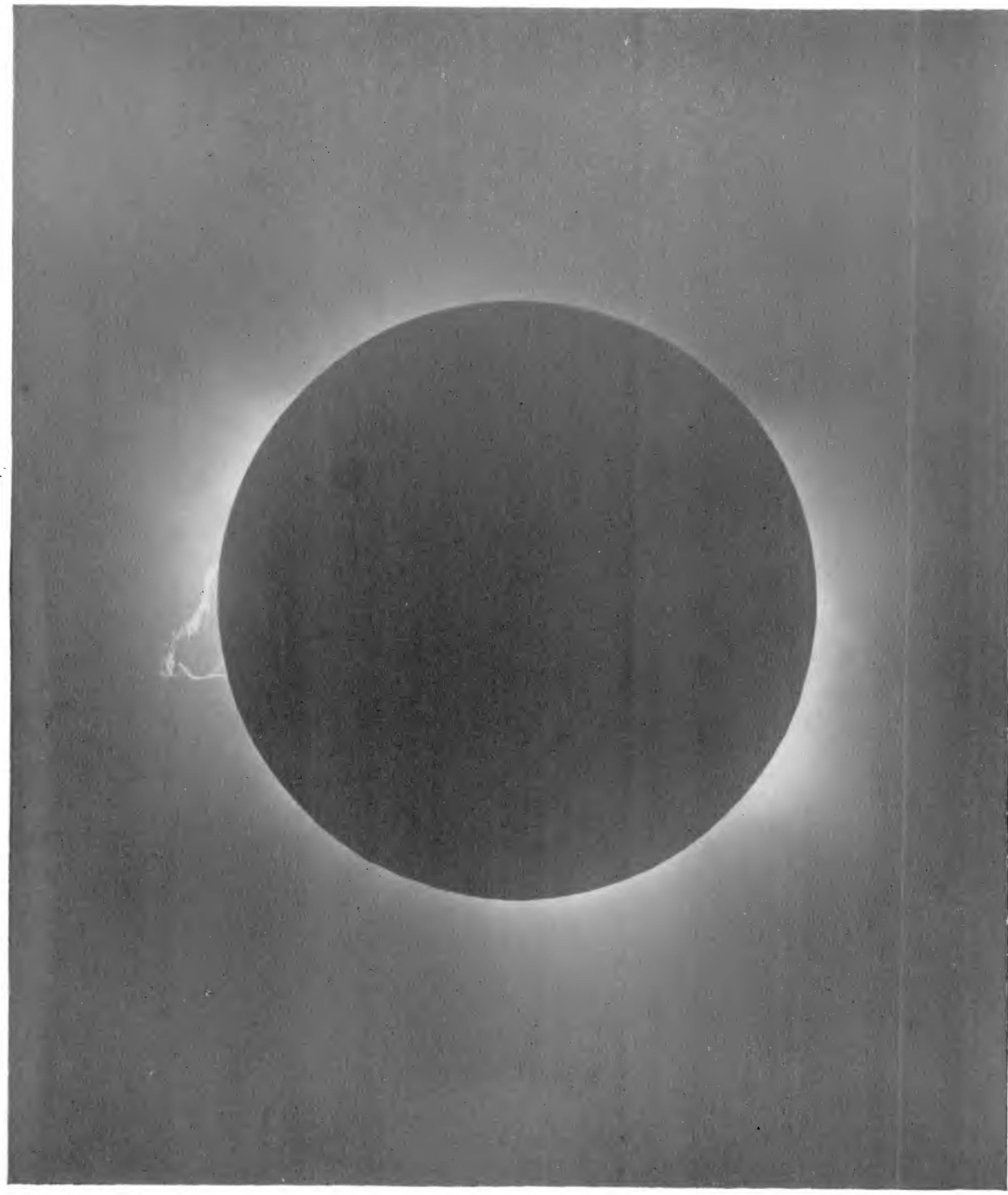


W

S

8^s exposure, beginning 42^s after beginning of totality.
Plate taken with 6-inch lens of 45 feet focal length at Alor Star.

N



W

S

10^s exposure, beginning 200^s after beginning of totality.
Plate taken with 6-inch lens of 45 feet focal length at Alor Star.

The plates were 15 inches square and $\frac{3}{16}$th-inch thick and were backed. On account of the faintness of the stars a Monarch emulsion was used.

45-foot Telescope.—Mr. James Worthington, who had lent his 6-inch Clark lens of 45-foot focus for the eclipse of 1927, kindly extended the loan for this eclipse. On this occasion it was fed by a 16-inch cœlostat. The plates used were Ilford Special Rapid (backed), 12 by 15 inches, and the telescope was so mounted that the long side of the plates was vertical, agreeing roughly with the expected equatorial extension of the corona. The plates were exposed as follows, the times being counted from the commencement of totality:—

	s		s
1.	3	to	6.
2.	42	,,	50.
3.	100	,,	120.
4.	200	,,	210.
5.	287	,,	290.

Actually the 20^s exposure does not show greater extensions of the corona than was expected from 3^s in a clear sky, and is about equal to that obtained at Giggleswick in 1927 with a similar exposure and the Sun at an altitude of only 11°. For the longest exposure there is a considerable amount of scattered light within the limb of the Moon. At the time the plates were exposed it was not expected that they would be anything like as good as they actually turned out to be, and just before totality the question of lengthening the exposures was considered. From these plates, in conjunction with those taken with the 21-foot, it appears that it is not advisable to prolong the exposure when photographing an eclipse through moderate cloud. The short exposures show the more brilliant features, while longer exposures do not bring up the fainter extensions, but merely cover the plate with scattered light from the brighter portions, and generally fog the plate.

The definition was excellent, as is shown by the fact that the same irregularities of the Moon's limb are shown on all the plates, independently of the brightness of the coronal background or the length of the exposure. There is a very large filamentous prominence on the eastern limb, and on the first plate, taken immediately after the Moon covered this limb, it is seen that there was slight continuous connection of the prominence with the Sun's limb. A considerable difference in the structure is shown on the first and last plates separated by 284 seconds. There is a fine coronal arch on the western limb. The plates accompanying this paper were made from these photographs.

Dallmeyer Equatorial.—At no recent eclipse has an attempt been made to photograph the greatest possible extent of the corona. In discussing the programme the idea occurred that the zodiacal light might be the outermost portion of the corona, and that it might be possible by the use of red sensitive plates and colour screens to photograph the corona during the eclipse and the zodiacal light soon after sunset. The regularity with which the sky clouded up before sunset showed the latter proposal to be out of the question. Three cameras were mounted on one of the Dallmeyer equatorials which had originally been constructed for the Transit of Venus in 1874. The lenses used were:

1. Dallmeyer of 4 inches aperture and 32 inches focus.
2. Ross of 4 inches aperture and 16 inches focus.
3. Aldis of $3\frac{1}{2}$ inches aperture and 20 inches focus. (Lent by Dr. G. Merton.)

For the Dallmeyer lens, panchromatic plates (backed) were used, and for the others kryptocyanin, unbacked. For all exposures, except one, Wratten F Filters No. 29 were used, cutting out all light shorter than 6000 A. The other filter used was a Wratten No. 21, cutting out light of wave-lengths less than 5300 A., but as this was used in conjunction with a kryptocyanin plate it was effectively the same as the others. The filters were placed immediately in front of the plates, and for the Aldis lens the filters were actually in the plate holders. The effective wave-lengths might be taken as 6300 A. for the panchromatic plates and 7400 A. for the kryptocyanin plates.

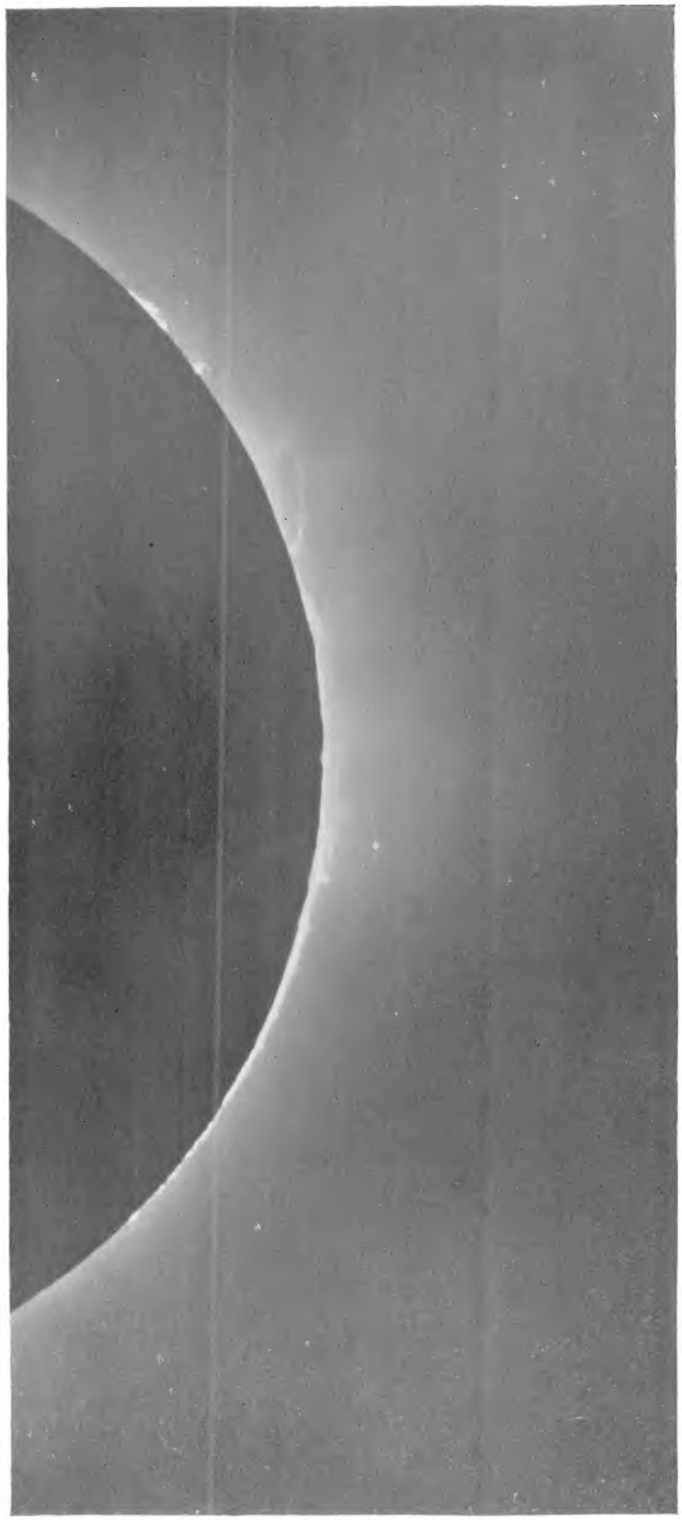
In order to prevent shaking the telescopes in changing plates, the same exposures were given with the various cameras, viz. 180^s and 60^s, beginning respectively 10^s and 215^s after the beginning of totality. A short description of the photographs may now be given.

The scattered light is much more troublesome on the panchromatic plates than on the others. It might at first sight be thought that this should be attributed to the shorter wave-length. It is, however, possible that the difference is, like the difference between the photographs taken with the 21-foot and 45-foot, due to difference in effective exposure. Although the ratio of aperture to focal length was less for the Dallmeyer lens than for the others, the speed of the panchromatic plate is much greater than that of the kryptocyanin. The panchromatic plates when examined with an eyepiece show the great prominence and some smaller ones, and a tendency for the coronal light to collect into rays. The total extension is just over a diameter from the limb, but the outer edges of the image are rather uniform in character, and probably a good deal of the light is "cloud-scattered" from the bright prominences and inner corona. Cloud formation is seen on the plates.

The photographs obtained from the two cameras using kryptocyanin plates show the form of the corona much more clearly. There are a number of streamers shown up to a distance of fully a radius from the limb and the corona is clearly of intermediate type.

For time purposes two chronometers were taken from England. The errors of these were kindly supplied by Capt. Nares of H.M. Survey Ship *Iroquois*, then stationed at Penang, some five days before the eclipse. Thereafter, Mr. Horn of the Perth Observatory, Australia, who had arrived with a wireless receiving set, got time from the Bordeaux and Malabar signals daily. As already stated, the exposures were made from the computed times, as no accurate commencement

Eastern limb of the Sun, exposure 3^s, beginning 3^s after commencement of totality.



Western limb of the Sun, exposure 3^s, ending 4^s before the end of totality.

of totality could be observed. The geographical co-ordinates of the camp were :

Longitude, 100° 22′·4 E. Latitude, 6° 8′·5 N.,

and the computed times of the beginning and end of totality :

$6^h\ 34^m\ 54^s$. $6^h\ 39^m\ 48^s$.

In a tropical country where the dew-point hovered round about 80° F. special difficulties in photography were encountered. A plentiful supply of ice was available and the photographic solutions were kept in an ice-chest. The plates were developed at 65°–70° in ordinary pyro-soda, and hardened for 10 to 15 minutes in a 5 per cent. bath of formalin. The washing had to be very thorough, as the least trace of hypo would prevent drying altogether. The plates were developed at night in the open, but they never dried till the following day, even when put in a cupboard with dishes of calcium chloride. The air was so moist at night that a fan was of little use in attempting to dry the plates.

It is a pleasure to record our thanks to H.H. The Regent of Kedah, the Kedah Government, and the British residents in Alor Star. The Government very generously voted a sum of money which covered all the expenses of the camp for both labour and material. A piece of public land outside the British Residency was placed at our disposal for the erection of our instruments. The British Adviser, the Hon. T. W. Clayton, literally placed his home at the disposal of the astronomers observing at Alor Star or passing through it. It was an enormous convenience in a tropical climate to live so near the observation camp and to have running water available for photographic purposes. The Public Works Department was constantly of great assistance to us in all the work of the camp and in the repairing of slight damage to instruments. To it, and especially to Mr. Jenkins and Mr. Davison, our thanks are due. The police did everything necessary for the protection of our instruments, and there was no trouble of any kind. During the eclipse itself I had the assistance of Mr. Allen and Mr. Scott in handling plates at the 21-foot telescope. The exposures with the 45-foot telescope were made by Mr. Bedlington, the surveyor to the Kedah Government, with two assistants to help in handling the plates. At the Dallmeyer equatorial Mrs. Jackson was assisted by Mr. and Mrs. Franklyn Robinson. The time was counted by Mr. Walker, assisted by Mr. Ellis. On account of the long duration of totality these gentlemen counted alternate hundreds by means of a rated metronome and checked the counting at intervals by means of a stop-watch started at the beginning of totality.

(*b*) Report by Dr. Carroll.

It was decided that the Solar Physics Observatory, Cambridge, would undertake observations of the total eclipse of 1929 May 9, and that Dr. J. A. Carroll should have charge of the design, erection, and operation of the instruments for the following programme of observations to be carried out at Alor Star :—

Spectrophotometric Observations on the Chromosphere.

1. A three-prism spectrograph was arranged to obtain a record of the flash spectrum on a moving film in the visible and near ultra-violet regions. In this arrangement a radial slit and small solar image were used, and the camera contained a plane parallel glass plate to give two images of the spectrum so that correct exposures for both the strong and weak lines could be given (*M.N.R.A.S.*, **87**, 679).

   This instrument was operated at the eclipse by Dr. J. A. Carroll.

2. A grating spectrograph to record the infra-red chromospheric spectrum in the region of the ionised Calcium X lines (λλ 8498, 8542, 8662) on a moving plate, used also with a radial slit and so small a solar image that a second slit in the focal plane was not required.

   This instrument was operated at the eclipse by Mr. C. Jenkins, the Executive Engineer for N. Kedah.

   With these instruments the comparison of the H and K lines and the X lines of Calcium could be made.

Interferometer Study of the Corona.

3. An improved and enlarged objective interferometer similar to the one designed for the Norwegian expedition of 1927 June 29 was built at the Solar Physics Observatory. With this instrument velocities in the coronal gases could be studied by means of the monochromatic image in green light, and the separation of the interferometer plates was chosen also with the object of determining whether the green line was a close doublet, as suggested by Freeman.

   This instrument was operated at the eclipse by Dr. F. W. Aston.

The Coronal Continuous Spectrum.

4. A low dispersion, large aperture spectrograph working at $f/5$ was borrowed from Mr. Wilfred Hall and adapted for a photometric study of the coronal continuous spectrum over the whole visible and near infra-red regions.

   This instrument was operated at the eclipse by Mr. Horn and Mr. Bicknell.

Erection of the instruments was commenced on the site selected in Alor Star on March 28, and proceeded under rather trying conditions but without serious hindrance, thanks largely to the very generous and skilful help given by the Public Works Department of the Government of Kedah and other public and private bodies, in particular Messrs. Huttenbach Lazarus, who installed the electrical supply, and the Penang Municipal Tramways.

Great difficulties were experienced owing to rain and especially to the excessively high humidity, whereby damage to the instruments arose and photographic work was particularly difficult. The plates for the infra-red spectrograph which had to be hypersensitised shortly before use could only be prepared with the aid of phosphorus pentoxide as a drying agent. Plates hypersensitised with borax were tried and proved satisfactory, but were not so sensitive as those treated with ammonia. The sliding parts of the moving-plate camera gave difficulty, and ultimately the camera was rebuilt on the spot and an endless travelling canvas band to which the plates could be attached was substituted for the sliding-plate holder. Mr. Davison of the Public Works Department was exceedingly helpful in this matter, and the revised camera proved entirely satisfactory.

Light clouds obscured the Sun at eclipse time and so no photographs susceptible of precise measurement were obtained with any of the instruments. Traces on the moving film camera were sufficient to demonstrate its suitability for the purpose, but it was not possible to make any use of them since no comparison spectra could be obtained on the day of the eclipse, and by the following day the dampness had damaged the film enough to ruin the regularity of any records there might have been. It is worth remarking that for work of this kind a particularly clear sky is absolutely essential, otherwise no reliable allowance can be made for the absorption of the earth's atmosphere.

The results obtained from the interferometer are regarded as highly profitable. The light was not strong enough to yield an image of measurable density, but there is an unmistakable impression on the plates. We are now in the position of being able to estimate accurately the exposures required for this experiment, and to feel justified in expenditure on larger and more elaborate apparatus. Previously it was entirely unknown whether it was possible to make such measurements at all.

(*c*) Report of the Expedition to Pattani.

Col. Waley Cohen arrived at Pattani on March 21 and at once began work on the erection of pillars and shelters on the site close to the River Pattani, which had been allotted by the Siamese authorities. Dr. Royds arrived on March 30 and Messrs. Melotte and Stratton on March 31. Later the observing party was strengthened by the arrival of Professor E. Barnes and Professor W. F. Kibble from the Free Christian College, Madras, and Capt. E. G. Sinnott, Royal Signals, Lieut. W. M. Blagden, R.E., and Lieut. J. K. Haynes, R.F.A., from Singapore—a body of volunteers all of whom did excellent work in preparation for the eclipse and assisted later in the work of packing the instruments. Two or three days before the eclipse Professor Parames Waran of the Presidency College, Madras, and Dr. Ventakes Waran arrived and set up their instruments (a 4-inch telescope and camera and a constant deviation spectrograph fed by a mirror) in the eclipse camp. The party was completed by the arrival on May 8 of Mr. C. Wingfield, British Minister at Bangkok, Mr. Coulson, District Officer at Khota Baru in Kelantan, and Mr. Abel Smith.

The instruments set up for the eclipse and the work proposed to be done with them were as follows :—

1. The Astrographic Refractor from Greenwich mounted equatorially, to be used for a redetermination of the amount of the displacement of the stars in the immediate neighbourhood of the eclipsed Sun. The stand used at Christmas Island in 1923 was employed, being suitable for the latitude of the observing station. This instrument was in charge of Mr. Melotte.

The scheme of observation to be carried out with the Astrographic Refractor was similar to that undertaken by Dr. Jackson at Alor Star, and is described in his report. The instrument was taken out complete and mounted equatorially though without the electric clock control. In view of the shortness of the exposures to be given (15 seconds) the electric control was not essential, as the governor of the clock is itself capable of very accurate adjustment. The photographic telescope is of 13 inches aperture and 135 inches focal length. For the eclipse plates the aperture was reduced to 7 inches in order to minimise the effect of sky fog. The telescope was housed in a shelter 30 by 15 feet, having a sliding roof covered with a tarpaulin 17 feet square. By giving a slope to the top rails, which were $11\frac{1}{2}$ feet above ground at the north end and $7\frac{1}{2}$ feet above ground at the south end, the sliding frame was easily drawn to one side clear of the instrument. This shelter was constructed at Greenwich of light wood, held together by bolts, and was erected in a day. The telescope was mounted, with the assistance of native labour, in seven days.

The plate centres of the two fields to be photographed were as follows :—

Eclipse Field . . .	R.A. $3^h\ 0^m\ 50^s$	Dec. $+17°\ 0'$.
Comparison Field . .	$3^h\ 0^m\ 50^s$	$+26°\ 7'$.

The settings were carefully chosen in such manner that the stars in the immediate neighbourhood of the Sun were distributed as uniformly as possible with respect to the plate centre. The fact that the eclipsed Sun's image fell to one side was immaterial.

The setting for the comparison field was similarly chosen. In order to avoid loss of time in setting the telescope, a field having the same right ascension as the eclipse field was selected. These two fields gave a number of stars at about equal distances from the plate centre, and with stars of the comparison field falling near to stars in the eclipse field.

The programme of exposures was as follows :—

Plate 1.	Eclipse Field . .	Exposure 10	seconds.
	Comparison Field . .	,, 10	,,
Plate 2.	Comparison Field . .	,, 15	,,
	Eclipse Field . .	,, 15	,,

Plate 3.	Eclipse Field	Exposure	15 seconds.
	Comparison Field	,,	15 ,,
Plate 4.	Comparison Field	,,	10 ,,
	Eclipse Field	,,	10 ,,
Plate 5.	Eclipse Field	,,	10 ,,
	Comparison Field	,,	10 ,,

Backed Ilford Special Rapid Plates were used. These were 8 inches square and coated on plate glass $\frac{3}{32}$-inch thick. During the rehearsals which took place before the eclipse the above programme was easily carried out within the limits of time available, including the accurate pointing of the telescope in declination by reading the circle at each change of setting. Thirty seconds before the time of second contact the telescope was pointed on the eclipse field. Although the sky was then completely overcast the diminishing crescent of the Sun could be dimly seen in the 2-inch finder attached to the instrument. Owing to the bad conditions no exposures were made during the first four minutes of totality. During the last minute two plates were exposed for 15 seconds each, on the eclipse field. The outline of the eclipsed Sun and the large prominence are faintly shown on these.

It is a pleasure to acknowledge the help received from Nai Chamlong Asavasena who assisted most efficiently throughout the eclipse, both in setting the telescope and changing plate holders. We are also glad to acknowledge the assistance afforded by Mr. T. Piper of the Pattani Tin Mines.

2. A Littrow spectrograph with a plane grating fed by a 16-inch cœlostat and a 15-inch mirror of 29-foot focal length. This instrument was designed by Mr. C. R. Davidson, built in the Royal Observatory workshop, and set up in the same way as at the Greenwich expedition to Giggleswick. The first order of the flash spectrum about 8800 A. was to be photographed through a red screen on half a plate dyed with neocyanin, while the second order of H and K was photographed through a green screen on the other half, for a comparison of the behaviour of Ca^+. If the observation was successfully made at the first flash, it was proposed to remove the screen, reset and refocus the grating, and photograph the second flash over the region $H\beta$ to $H\alpha$ on a panchromatic plate. Professor Stratton, assisted by Mr. Coulson, had the charge of this instrument. For this and the next instrument it was proposed to use the solar spectrum, secured just after the eclipse, for spectrophotometric comparison. The solar light was to be cut down in intensity by passage through ground quartz. The two spectra to be compared were to be taken on halves of the same plate and were to be developed together.

3. The Hills quartz spectrograph fed by a cœlostat with a 12-inch speculum flat and a 9-inch concave speculum mirror was in charge of Dr. Royds. The arrangement was much as at the 1926 eclipse, and the programme paid special attention to the Balmer series and to the distribution of light in the coronal spectrum, both the line and the continuous spectrum.

4. The 19-foot coronagraph fed by the 8-inch cœlostat and the 4-inch lens belonging to the Royal Irish Academy. As in the 1926 eclipse, the direct-vision prism of the Royal Observatory, Edinburgh, was to be placed in front of the lens for the first and second flash to give the spectrum in the region from H and K to $H\beta$. As the 8-inch cœlostat is constructed only for fairly high latitudes some alterations were necessary. It can be adapted easily to southern latitudes as the clock work can be easily levelled in a reversed position. It is impossible to put a wedge under the base and level the clock without reversing the motion of the drive. Consequently the cœlostat was erected in the position corresponding to a negative southern latitude, by tilting the base, so that what is usually the upper end of the polar axis pointed downwards to the south pole, and reversing the clock drive. The programme for the photographs of the corona during totality was agreed upon to give results comparable with those obtained by Professor Miller in Sumatra, at Alor Star and at other stations. Lieut. Blagden was in charge of this instrument, with the assistance of Capt. Sinnott and Lieut. Haynes, who also divided the task of counting seconds before and during the 5 minutes of totality.

5. A double tube polariscope of 6-foot focal length, with a large Nicol prism placed in front of one tube. The instrument has been used by Professor Newall at several eclipses. In order that observations might be made at points of the limb which were likely to be of special interest owing to the presence of prominences or other disturbances, it was arranged by Dr. Royds that a code telegram should be sent from Kodaikanal Observatory giving the latest possible information as to the limb of the Sun. The programme of the setting of the Nicol prism for the 8 possible exposures was only finally settled after the arrival of this wire. Professor Barnes was in charge of this instrument, assisted by Mr. Abel Smith. It was also arranged that observations should be made with a Nicol and Savart prism of the direction of polarisation of the sky light in the neighbourhood of the Sun.

6. Part of the beam from the 16-inch cœlostat feeding the polariscopic camera was diverted by a right-angled prism to feed a small Rowland concave grating used as an objective grating: with this it was proposed to photograph the spectra of the flash and the corona in the region about 7500 A. for which plates stained with kryptocyanin are sensitive. Professor Kibble was in charge of this instrument.

The climate of Pattani was very hot, and although it was known that ice was available it was decided to test a small refrigerating plant as a further aid in photographic development.

The Silicagel Company specially designed and kindly lent a unit to cool 10 gallons of water through 15° F. Unfortunately the unit was damaged in transit to Pattani and we were unable to test it fully, but the experiment was successful in showing how useful such a plant would be in an eclipse camp in a tropical country out of reach of an easy supply of ice.

In advance of the eclipse Dr. Royds undertook to make some experiments on sensitising photographic plates to the infra-red by making some trials in Madras where the temperature and humidity would be similar to those at the 1929 eclipse site in Siam, and he sends the following report: "The Eastman Kodak Company of New York kindly supplied one-tenth milligram of neocyanin dye with instructions, and two dozen Kodak infra-red sensitive plates. Preliminary experiments were first made at Kodaikanal, which has a temperate climate, and methods were first worked out there before proceeding to Madras. The Kodak plates were not used until they were about three months old—that is, about the same age as those which would be available at the eclipse. Trials were first made with ordinary plates sensitised by bathing and then hyper-sensitised with ammonia, and afterwards with the Kodak infra-red plates. The procedure adopted was the same as that recommended by the Eastman Kodak Company, except that, after the ammonia bath for hyper-sensitising, the plates were rinsed for 30 seconds in methyl alcohol to ensure quick drying. The use of a drying cabinet was dispensed with as causing unnecessary loss of time when rapid drying was essential. It was found best to dry the plates in an open rack placed in the blast from an electric fan. In order to ascertain the times required for drying plates, blank experiments were first conducted with the dark room illuminated. It was found that the plates dried in less than 1 minute after the neocyanin bath and in about 3 minutes after the ammonia bath. Possibly the plates were not bone dry in these times, but they were sufficiently dry for fingers to leave no impression on the emulsion. In Madras, where the temperature was 90° F., humidity 80 per cent., and without the use of ice or electric fan these times became about $1\frac{1}{2}$ minutes and 5 minutes respectively.

"With the Kodak commercial infra-red plates about three months old and then hyper-sensitised with ammonia, it was found that their speed to the calcium infra-red lines was about the same as that of ordinary plates freshly bathed in neocyanin and then hyper-sensitised, but the former were somewhat cleaner in working. Consequently, it was decided to use Kodak commercially prepared infra-red sensitive plates at the eclipse camp. The concentrated dye solution was also taken in case of failure of the commercial plates, but was never used at the eclipse camp. When the commercial plates were one year old, it was found that they were slightly slower than the bathed plates.

"It was of great assistance to find that Kodak neocyanin plates could be desensitised with Desensitol (Ilford Company), which enabled development of trial plates to be undertaken in white light in the dark room. Naturally, it was not proposed to desensitise the eclipse plates before development.

"For economy in the use of methyl alcohol, the same alcohol was used several times until the time required for drying became about $1\frac{1}{2}$ times as long as that required for fresh alcohol. Alcohol previously used for drying hyper-sensitised plates was never used for drying bathed plates before hyper-sensitising.

"At the eclipse camp at Pattani, Siam, power for an electric fan in the dark room was fortunately available through the kindness of the Siamese Government. The time allowed for drying the hyper-sensitised plates to be used at the eclipse was lengthened to 7 or 8 minutes as a precaution, and it was found that the physical conditions in the dark room were not too trying with the fan blowing.

"*Failures.*—No failure of sensitiveness to the infra-red occurred with hyper-sensitised Kodak commercial plates at any time. Occasionally failures did, however, occur in the sensitising of ordinary plates with previously used baths and alcohol. After using a bath four or five times it was found that the sensitising power for the infra-red appeared to be suddenly inhibited. When this occurred for the first time it was thought that the plate had not been properly treated owing to some bungling in the dark, and an attempt was made to sensitise another plate with the same baths. This, too, was found insensitive, and it was thought that on the former occasion the baths might have been poured back into the wrong bottles, so that success could not again be hoped for. The same effect, however, occurred on another occasion after the baths had been used several times, but it was difficult to be certain that some mistake might not again have been made in the darkness. The causes of failure were not further investigated, but thereafter the baths and alcohol were thrown away after using three or four times, and no further failures occurred. No failures ever occurred with freshly prepared baths and fresh alcohol."

The weather was hot and fine for the most part during the weeks preceding the eclipse. The Sun was clear at eclipse time six days out of seven during the seven weeks preceding the eclipse. Preparations were easily complete in time, but a spell of bad weather set in three days before the eclipse. Heavy rain fell the whole night before the eclipse day, and at the time of the eclipse clouds obscured the Sun. The diminishing crescent was glimpsed at times through the clouds, and during totality Mr. Melotte made two exposures with the Astrographic Telescope, on which the great prominence was shown—but no image of the crescent could be seen on the slit-jaws of the spectrographs. It had not been possible to carry out any of the proposed programme of observations.

No report of this expedition would be complete which omitted reference to the most generous and friendly assistance which was received on all sides from the Siamese authorities.

His Majesty the King of Siam appointed a reception committee to welcome the two astronomical expeditions sent to Siam, that of Professor Rosenberg of Kiel and the British expedition. This committee consisted of Rear-Admiral Phya Rajvangsen, A.D.C., President, Colonel Phra Salvidhan Nides, First Councillor Phya Srishdikar Barnchong, Second Councillor Phya Sri Sena, Mr. Brandli, Government Meteorologist, and Commander Phra Riem Virajbhakaya, Secretary. In addition to building a comfortable and well-equipped bungalow camp to house the expedition, the committee also paid all the expenses for labour in building the pillars and atap shelters, and provided electric lighting sets both for the eclipse camp—for electric arcs, dark-room, etc.—and for the bungalow camp. Further, they and the local authorities saw to it that every facility possible was available to help the expedition. The Lord Lieutenant of Pattani, His Excellency Phya Udombongso Bhensvaadi, and the Governor of Pattani, Phra Vides Phattanatorn, assisted in every way, personally and through their staffs; the Lord Lieutenant put the services of his Secretary, Nai Chamlong Asavasena, freely at the disposal of the expedition as interpreter and helper in every way. A special tribute must be paid to his untiring efforts to help the expedition. The club room of the local troop of boy scouts, which adjoined the eclipse camp, was made available as a store for the apparatus, and the hut dark-room was set up inside it. Local police guarded the camp day and night without any charge on the funds of the expedition. Customs facilities for the entrance, duty free, of all the apparatus and personal luggage of members of the expedition were granted freely. And to show the thorough care with which the interests of the expedition were considered, it may be mentioned that a special doctor from Bangkok, Luang Jarn Vidli Bej, was stationed at Pattani while the expedition was there, and that he was supplied with anti-snakebite serum in case of an accident to any member of the expedition.

Their Majesties the King and Queen of Siam honoured the British expedition with three visits to the camp. On the day before the eclipse they inspected the instruments and watched a rehearsal of the eclipse programme; in the evening they returned to look at some celestial objects through the Astrographic Telescope and the Greenwich 4-inch portable telescope, an instrument used to cast an image of the Sun on a screen for their Majesties' use during the partial phase of the eclipse. On the day of the eclipse their Majesties, with a small suite, took up a position in a Royal pavilion inside the eclipse camp. It was a special disappointment to the members of the eclipse expedition that the cloudy sky prevented the Royal visitors, to whom they were so heavily indebted, from seeing the wonderful spectacle of the eclipsed Sun.

Finally reference must be made to the zealous way in which Col. Waley Cohen, the voluntary Secretary of the expedition, helped on every hand. By taking complete charge of the living camp, making all arrangements with the local authorities, and seeing to the necessary financial arrangements, he set the observers free of the detailed worries which are normal to camp life. His services were too varied to detail, but he gave unstinted assistance when asked and placed everybody under a debt of gratitude.

(*d*) Observations made on Board H.M.S. "Iroquois."

On the morning of May 9, H.M.S. *Iroquois* (Capt. J. D. Nares, R.N.) proceeded from Penang and took up a position in Long. 99° 59′ 52″ E., Lat. 5° 54′ 15″ N., near the central line of the eclipse, and lay at anchor there during the whole of the eclipse. The times of the 2nd and 3rd contacts were observed by Capt. Nares and two other officers, while Lieut. Foulerton, R.N., made a long series of meteorological observations. The conditions were quite similar to those at Alor Star, and a short summary of them may be of interest. The sky was covered throughout by high cloud, stratus, cumulus, and cirrus. At times the Sun was completely obscured by cumulus, but generally it was visible through thin cloud. At local standard noon (5 a.m. Greenwich), just before first contact, the record was :

Wet bulb $79\frac{1}{2}°$. Dry bulb 86°. Barometer 1007·5 millibars.

Clouds alto stratus, cumulus, cumulo-nimbus. Clouds increasing, but Sun still fairly clear.

The following details for phenomena round about the time of totality are copied in full from the official report of Lieut. Foulerton. The times are 7^h fast on Greenwich.

13.30. Wet bulb $78\frac{1}{2}°$. Dry bulb 84°.

Light and shadows very queer and unreal. Exceedingly dark to the N.W., with black clouds and general appearance of the approach of a very heavy Sumatra.

13.33. Wet bulb $78\frac{1}{2}°$. Dry bulb $83\frac{3}{4}°$.

Start of totality. At first moment of totality the sky and clouds to the S.W. became a vivid emerald green which gradually changed into colour mentioned below. A faint solar corona, and, on the clouds near the Sun, all the spectrum colours. Through gaps in the clouds the sky showed a deep, dark blue. One planet, Jupiter, clearly visible.

13.38. Wet bulb $78\frac{1}{2}°$. Dry bulb $83\frac{3}{4}°$.

End of totality. A crimson flame suddenly appeared at the trailing edge of the Moon ; through this shot a thin spear of white light which in an instant became like a small, but very brilliant, arc light, and giving similar lights and shadow—within 30 seconds the sky became quite light again.

During totality the general appearance of the sky was the same as will be seen between a quarter and half an hour before sunrise. The horizon was firm and colours—though flat elsewhere—appeared in the sky and on the clouds, to the westward, as they do in the period before the Sun rises, but very much accentuated—that is, all rather hard shades of blue, green, yellow, and pink. This was most striking.

Except for the crimson flame no colours were observed round the edge of the Moon—though spectrum colours were seen inside the corona, reflected on the clouds just previous to totality. The time of the Moon uncovering the Sun was far more definite than the first moment of totality.

13.40. Conditions returning to normal. The light appeared to return quicker than it faded away.

The total drop in the dry-bulb thermometer from the start of the eclipse was only $2\frac{1}{4}°$. The movement of the wet-bulb thermometer was less regular, and the total fall rather less. The variation of the barometer throughout the day was normal.

The Greenwich times of the observed second and third contacts (mean of three observers) were as follows :—

Second contact, $6^h\ 33^m\ 26^s{\cdot}85$.
Third contact, $6^h\ 38^m\ 17^s{\cdot}35$.

The computed times from the data given in the *Nautical Almanac* were respectively $0^s{\cdot}0$ and $1^s{\cdot}6$ later. Consequently the computed times were nearly correct. This result is supported by the appearance of the photographs taken near the beginning and end of totality with the 45-foot telescope at Alor Star.

Stellar Parallaxes Determined at the Royal Observatory, Greenwich.

(Communicated by the Astronomer Royal.)

The following list is a continuation of the results obtained with the 26-inch telescope, and published annually in the November number of the *Monthly Notices.*

In the column "Proper Motion" the first value given is from meridian observations ; the second is the relative proper motion derived from the photographs. The motions in both R.A. and Dec. are expressed in arc of a great circle.

In calculating the parallax the relative proper motion has been used, *not* the meridian proper motion.

In computing the P.E. an average value $\pm''{\cdot}025$ has been adopted as the probable error of a single plate of unit weight. This value has been derived from a discussion of the residuals of 333 determinations of parallax, each of which depends on 23 plates on the average. The P.E. has accordingly been calculated by the formula

$$r = \frac{\pm''{\cdot}025}{\sqrt{w}}.$$

The first P.E. given is that of the parallax, the second is the P.E. of the relative proper motion.

Generally six comparison stars of mean magnitude 11–12 have been used, of which good images are obtained with an exposure of three minutes. The magnitude of the parallax star has been reduced to equality by means of the rotating sector and (for the brighter stars) local desensitisation by means of a weak solution of copper sulphate.

The Visual Magnitude is taken from the *Bonn Durchmusterung*, the Photographic from the *Greenwich Astrographic Catalogue.*