CINEMATOGRAPHY OF PARTIAL SOLAR ECLIPSES
II. Observations at the eclipse of 1948 November 1, at Mombasa

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Summary

The first paper in this series gave the purpose and general principles of the method. The present paper describes the apparatus and the actual work at Mombasa, where it was tried out for the first time. The optical and electrical details are given at some length, since the method is new and the result was satisfactory. The analysis of the data obtained will appear in a subsequent paper.

The purpose of the expedition which went to Mombasa from the Royal Greenwich Observatory, for the eclipse of 1948 November 1, was to obtain a timed cinematographic record of the change in position angle shown by the thin solar crescent near mid-eclipse. This was to be done with a fixed camera, so that the diurnal motion could give the zero of position angles. The general principles of the method have already been set forth*, and the present paper describes the apparatus in more detail than was then done, and gives an account of the actual work at Mombasa, together with a brief summary of the observational material secured; in all essentials this material came well up to expectations. The analysis of it will be the subject of a later paper.

1. *Optical apparatus*.—The principal optical items, which were assembled on a primitive optical bench, were a "Vinten K" 35 mm cine camera (with its lens removed); a visual telescope lens of roughly 1 metre focal length, well corrected for spherical aberration and coma; and an unsilvered glass mirror which was in fact one face of a new Hilger spectrograph prism. This mirror, which was mounted in front of the lens, served the double purpose of greatly reducing the light at the earliest possible point, and of directing the beam through the lens and into the camera at any desired time, while both the latter remained fixed. The reflecting face measured 10 cm × 5 cm, which was not as large as would, in principle, have been ideal; but the lens was always used with a stop, and even the largest aperture employed was fairly well filled. To give a further reduction in light-intensity, and also to eliminate the secondary spectrum, either one or two Wratten 58 (green) filters were used; these were in the form of a gelatine film 5 cm square, mounted between two squares of "selected" glass, the complete filter being 4 mm thick; a brass holder was attached to the camera front so that one or both of these filters could be readily slipped into it, as near to the focal plane as possible.

It is perhaps worth stressing that for the particular task that is here involved a well-designed simple lens used with a filter is likely to prove superior to even the most complicated and highly corrected apochromat; and at all events it cannot prove inferior. When the diameter of the field is little more than a degree,

* R. d'E. Atkinson, *M.N.*, **113**, 18, 1953. This paper is hereafter referred to as Paper I.

and when only moderate apertures ($f/18$ or narrower) are required, a good achromat which obeys the sine condition will show the Airy disk and the first diffraction ring over the whole field; for photographic work (especially with fully exposed images) it is still highly desirable to eliminate the secondary spectrum with a suitable filter, but once that has been done there is no further improvement which could be attained by any complication of lens design, while any actual lens, if designed for a larger field, may have made sacrifices which leave it permanently inferior to the simple one, within the restricted field of the latter.

The optical bench which supported the prism, lens, and camera was fabricated out of 5-cm angle-iron, with brass plates bolted to the upper face near both ends to serve as base-plates. A short length of tubing (telescope tube) was also bolted to the central region to act as a mount for the lens cell (Fig. 1). The

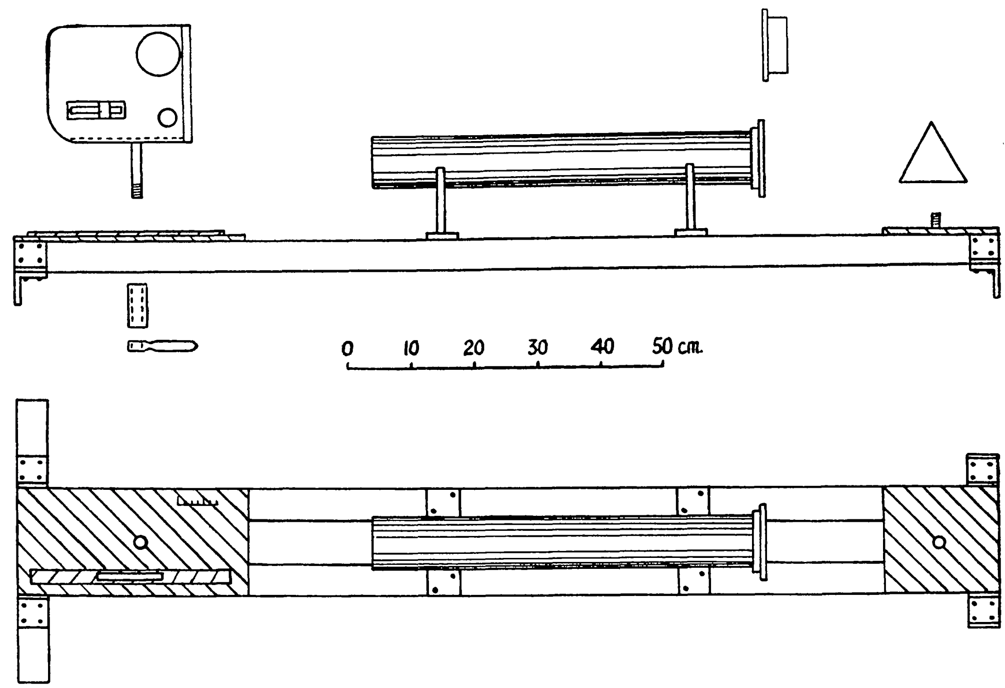


FIG. 1.

brass plate at the camera end was 9 mm thick, and was slotted so that a stout bolt which had been attached to the underside of the camera could pass through it; a clamp could be screwed up on this from below to lock the camera in place. The underside of this make of camera has a shallow longitudinal keyway machined in it, running through from front to back; a strip of brass was cut to fit this and was permanently pinned in place on the base-plate as soon as the camera had been squared on to the lens; when the clamp was slackened, the camera could then be slid forwards or backwards on the base-plate, for focusing, and always remained properly squared on. The base-plate was engraved with a millimetre scale, and under the best conditions the correct focus setting could be determined to about half a millimetre, at the widest stop used. As already mentioned (Paper I, pp. 26, 27), there was no need to cover in the space (about 28 cm long) between the end of the tube and the front of the camera, and for the purpose of setting the moving solar image accurately on the camera front, and inserting the filter, it was much more convenient to leave this space open. The camera and lens were carefully squared on to each other in the workshop at Greenwich.

The prism mounting was of a simple altazimuth type. The 5 mm thick brass plate at the prism end of the bench was made the base-plate for a turn-table, and this carried the bearings of a horizontal axis, the gunmetal trunnions of which were integral with a stout gunmetal hoop which passed behind the prism and formed the basis of the actual prism holder (Fig. 2). The two axes of motion intersected in the centre of that reflecting face which was actually used; the other face, and the back, of the prism were disregarded, and most of the incident light passed through the prism and escaped in harmless directions. To hold the prism, two triangular plates of brass were cut to fit its ends; one was rigidly attached to the hoop, close to one trunnion, while the second was pressed against the second end of the prism by a fairly strong spring inside the second trunnion. Small leaf-springs, attached to the edges of the brass triangles, pressed lightly on very small areas of the prism faces, to keep the triangles in register with the prism ends. The prism was thus firmly held, while at the same time there was no danger of stresses due to differential expansion in hot sunlight.

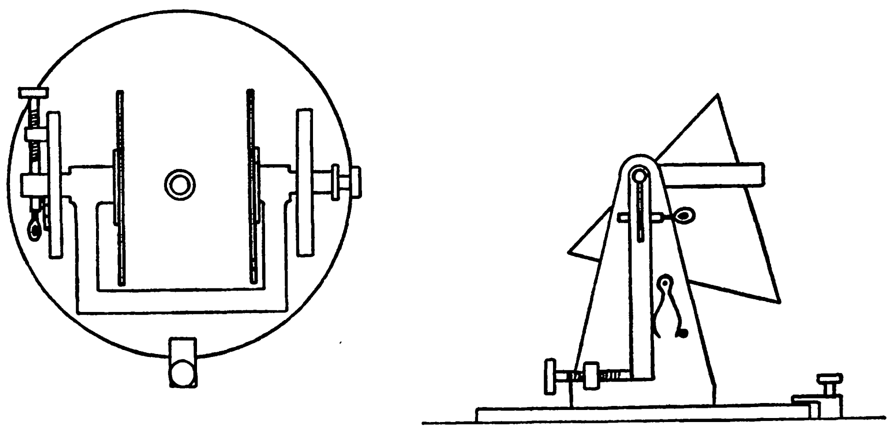


FIG. 2.

The turn-table could be clamped both by a stout nut on its centre bearing and by a rim clamp; it was not provided with any explicit slow motion, but its large diameter and smooth motion allowed it to be set very closely to any desired position. The hoop and trunnions could be clamped to a slow-motion arm controlled by a screw and a strong leaf-spring; this one possibility of slow motion was found to be enough even though the geometry was such that motion of the prism in either one of its coordinates separately caused a slanting movement of the image, and indeed even clamping the turn-table deflected it slightly. It was realized that an equatorial type of mounting would be more convenient, since the final adjustment could then be made in one coordinate only; but the extra complication could not be contemplated in the time available, and it was also feared that such an arrangement might be less rigid. Extreme stability, once the prism has been finally set for the eclipse run, is essential, and it is believed that this condition was well met.

Three cardboard stops were provided for the lens, with apertures $f/36$, $f/25$ and $f/18$; they could be slid into a sheet-metal mounting on the front of the cell, and as their outer faces were white the beam of light from the prism could readily be seen on them; as soon as this beam was adjusted to be central on the aperture, the image was normally picked up on the camera front.

As already explained (Paper I, p. 23), it was intended to arrange the camera so that the image should move parallel to the long edge of the frame, as a result of the diurnal motion. When the Sun transits south of the zenith, it is always possible (and often necessary) to arrange that the image shall approach the "window" from the right; the area to the right of the window was therefore painted white, and a horizontal line was drawn on it at the height of the frame centre, with short cross-lines at the positions where the "following" (unobscured) limb of the Sun should be at the last few whole and half minutes before switch-on time. The whole-minute marks were numbered, and the observer's task at the time of the eclipse was thus to adjust the prism so that the moving image was at the right height (as judged by the horizontal line), and with the east limb tangential to successive marks at the appropriate times; when he was satisfied, he would clamp the prism, check on another mark or two as the image moved past them, insert the green filter, and wait for switch-on time. The procedure was tried out at Greenwich, and the slight inconvenience due to the fact that any one adjustment of the prism made the image move obliquely was soon found to be insignificant.

In the field, the setting operation was rehearsed repeatedly, especially near the right time of day ($07^{h}20^{m}$), and both observers soon found no difficulty in getting the image satisfactorily "on" during the early part of a run-up, and even in then deliberately throwing it off in both coordinates and re-setting at a later stage of the *same* run-up. The adjustment is not really very critical, since only the convenience and not the accuracy of the subsequent reductions depends on it; no error in height which leaves the image still fully within the frame will do any harm beyond introducing a slight slant into the diurnal direction, and a small longitudinal error will at worst also lose a short stretch at the start or finish, and not even that if it is known and allowed for by switching on a little late or early.

What naturally could not be tested in advance was the question whether the crescent would give any more trouble than the full disk. To guard against entire failure to find it, provision was made for approximate marking of the correct prism settings, in both coordinates, during final rehearsals. This precaution might have been found helpful if the eclipse weather had been poor, but in the actual eclipse conditions it proved entirely superfluous; the patch of light from the prism was still quite visible on the lens stop, and the crescent was sufficiently in focus on the camera front to lose no brilliance from this cause, so that setting the crescent was as easy as setting the full disk.

Even if, by mischance, the observer were single-handed at the time of the eclipse, so that during the last half hour he had to receive time signals, etc., as well as to set the prism, he would in general find it quite practicable to keep the image somewhere in view all the time, by making a quick readjustment of the prism every five or ten minutes; indeed, if the Sun is visible he will probably do this in any case, and will thus arrange that the image is already conveniently placed at the time (about six or seven minutes before mid-eclipse) when the final setting is due to be made.

Two complete sets of apparatus were made up on the above lines; Fig. 1 shows the smaller, in which the lens had a focal length of 935 mm. The second bench was longer, and carried a wider telescope tube, as the focal length of the lens was 1 132 mm, but it was otherwise identical. Either bench could easily be carried and put in place on the pier by one man if necessary.

The benches were originally designed for use in a horizontal position, and they had been partly completed at Greenwich before it was found that in the actual circumstances of the Mombasa eclipse this position would result in a very large angle of incidence at the reflecting face, if the azimuth were so chosen that the diurnal motion of the image would be parallel to the long side of the frame. There were practical objections to laying the camera on its side, as well as some doubt how well the film would run then; but it appeared that the benches could be used, without alteration, in a slanting position, provided the piers were suitably constructed. A length of 5-cm angle-iron was therefore provided, and fitted with two rag-bolts, for grouting into the pier, and the side elevation of the pier as subsequently constructed at Mombasa is shown in Fig. 3, with this iron in position at A. In use, two small strips of lead were placed in the angle, so that the cross-member at the camera end of the bench would be supported only at two points near its ends, and a thin wedge of hardwood was placed under the lower

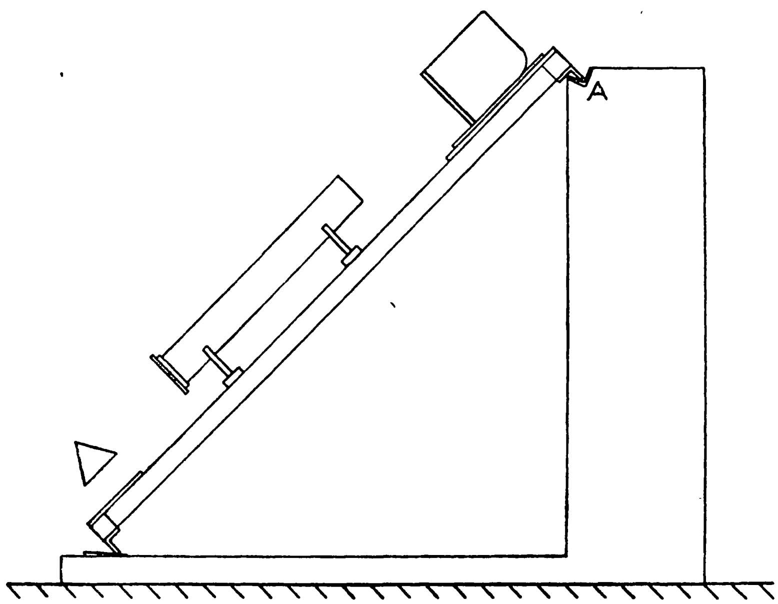


FIG. 3.

end of the bench and adjusted to give the exact tilt required. The result was a three-point support which appeared very stable. It was verified at Greenwich that the arrangement would permit a wide range of tilts, and it was computed (Paper I, p. 25) that at a tilt of 45° the angle of incidence would be reasonably small; a final decision as to the tilt (and the resulting azimuth) was left until the site should be selected.

2. *Electrical apparatus.*—For timing the exposures it was decided to use pen-recording tape chronographs, with one pen directly responding to the motion of the camera shutter, and one indicating the time. A plain rubbing contact was arranged, inside the camera, consisting of a light spring rubbing on the edge of a disk which was attached to a spindle rotating at the same speed as the shutter; 180° of the disk was metal and 180° an insulator, so that the periods of "make" and "break" were closely equal. The disk was phased so that contact was made when the shutter aperture was passing the middle of the frame, and the instant of this contact was taken to be the instant of exposure for the whole photograph. The shutter aperture used was the narrowest available, namely 10°, and the

exposure time was thus $1/(36f)$ if f was the number of frames per second. As f was about 18, this time was about $\frac{1}{650}$ sec; the total time required for the aperture to pass over all relevant parts of the frame was perhaps three times this, but this was still several times smaller than the uncertainty with which one could hope to determine the moment of mid-eclipse under the best possible conditions. It was verified that even in the most unfavourable case the diurnal motion itself caused a still smaller error; it will not displace one cusp with respect to the other by as much as $0'\cdot1$ of position angle, if the shutter opening passes over the whole crescent at the rate that was here involved.

Two new chronographs were specially made in the Observatory workshop at the Abinger station. They used modified telegraph relays which required a current of 12 milliamp, and the pens consisted of standard silver tubing of 0·5 mm external diameter and 0·2 mm bore, about 7 cm long in all, mounted on the armatures; a full response was obtained even with signals as short as 5 milliseconds. Ordinary Stephens' red ink, with the addition of a few drops of formalin and glycerin, was fed to the pens through PVC tubing. The phase difference between the two pens was adjustable by a screw, and to set this the standard Observatory practice was employed of feeding the same signal to both pens and adjusting until they indicated zero time difference. This adjustment was checked, as a routine, every time the chronograph was used for any purpose. The tape speed was 10 cm/sec, and times were nominally read to the nearest $\frac{1}{200}$ sec.

The simple rubbing contact was found more satisfactory than a cam-operated one which was first tried, and examination of the tapes showed that it was in fact very reliable. The actual motion of the pen was considerably more sluggish at the start of the "break" than at the start of the "make", but allowing for this the current was evidently flowing for half the time, pretty closely. A systematic delay of $\frac{1}{100}$ sec (which would not be serious) can hardly be present; if the "make" were always $\frac{1}{100}$ sec late, and the "break" were punctual (as it must have been, within very close limits), the time the current was on would be $\frac{\frac{1}{36}-\frac{1}{100}}{\frac{1}{36}+\frac{1}{100}}$ of the time it was off, i.e. the two times would be as $8:17$; an error of this magnitude would be conspicuous. A lag in response of the pen itself, both on make and on break, is of course possible, but would be the same whether the signal came from the camera or the chronometer; as between the two pens, it would be taken up by the zero adjustment.

The second pen was arranged to record either radio time signals or seconds impulses from a contact chronometer, the intention being to use the direct signal if reception was good enough, and if not to turn over to the chronometer; the same pair of pens could then be used, before and after the eclipse, to compare the chronometer with those portions of the special eclipse signal, or of any other, which might be well enough received. Operation of the pens from the camera or chronometer contacts was by means of a simple battery circuit, with a condenser across the contacts to minimize sparking; operation from the radio receiver output involved the use of an amplifier, which was made in one unit with a noise suppressor and the necessary change-over switches, to enable either pen to be connected to the radio, the chronometer or the camera as desired. The principle of the unit was as follows.

The output of the radio receiver was a 1 000-cycle tone, and this was fed directly to a resistance-capacitor and diode rectifying circuit, biased to cut off all signals of less than 6 volts amplitude; this eliminated all atmospheric noise of moderate intensity. The output of this circuit was fed to the grid of a triode, which was again negatively biased to cut off at low amplitudes; it delivered about 12 milliamp (mean) d.c. when the voltage fed to the grid reached 9 volts, i.e. when the total signal strength was 15 volts or more. The impedance of this output circuit was different from that of the simple battery and contact ones, but it was calculated that the time constants, with the chronograph impedance included, differed by only a few milliseconds. Two complete chronographs were taken; in one the tape was driven by a 230-volt a.c. motor, and the other had an independent clockwork-driven tape-puller.

It was hoped that the Rugby 16 kc/s (GBR) signal would be receivable, but, as this was doubtful, preparations were also made for short-wave reception. The Post Office Engineering Branch selected MIK, 9725 kc/s, as the most suitable of the available short-wave transmitters, and agreed to transmit a signal from Greenwich, both on GBR and on MIK, continuously from $04^h 05^m$ to $04^h 35^m$ and from $05^h 00^m$ to $05^h 05^m$ U.T. on the morning of November 1, and also on the previous day for a final "dress rehearsal"; the present opportunity is taken of again acknowledging with thanks their willing cooperation in this respect. The time of mid-eclipse was about $04^h 28^m$, and the transmission periods were chosen so as to allow some freedom in tuning-up and recording the chronometer errors, as well as a later check on chronometer rates, in case a chronometer had to be used.

For short-wave reception a rhombic aerial having a major axis of 94·5 metres and a minor axis of 55 metres was arranged; the portable tubular wooden masts for this were the largest single item in the expedition's equipment. The long-wave receiver could be connected either to a frame aerial or to an inverted L erected across the minor axis of the rhombic aerial.

The camera motors required 24 volts d.c., and two 24-volt lead-acid accumulators were provided. There were also two small petrol-driven generators, each of which could deliver either 12 volts d.c., for charging, or 230 volts a.c., which could be used (if no mains supply was available) for radio receivers, chronograph motor, lighting, soldering, etc. Two vibrator-packs were taken, as a stand-by H.T. supply for the radios, in case the generators failed or were otherwise occupied.

Although the first shutter opening, at the start of the eclipse run, is unmistakably identifiable on the chronograph tape, so that the entire series (3 000 or so) of contacts can be counted from this without ambiguity, the arrangement as described above does not provide any check on this count; there is, for example, no ready way of identifying on the tape the point where the film runs out, if, as was intended, this point is actually reached. Moreover, although the first exposure should also be identifiable on the film, it would not be so if the observer forgot to run off a few blank frames after loading the camera, to take up the loop which is normally fogged in loading; if that happened, there would thus be no zero for the timing system at all. It was therefore thought advisable to incorporate a positive checking device. The cameras had originally been designed for rough timing work, with an arrangement for projecting the dial and hands of a watch on to a small area at one corner of the picture. It was decided to use this projection system, without the watch, to project a small patch of light on the corner whenever a hand-operated shutter was open (keeping it normally closed), and to attach a contact to the mechanism of this shutter so that the camera pen would throw during the time the shutter was open. This involved losing the contact times of those photographs which were taken during the operation, but the camera ran so uniformly that the times could be readily interpolated. The shutter was similar to those used in cheap box-cameras, and was arranged to open for about $\frac{1}{8}$ sec, so that only two or three contact times should ideally be lost each time. This shutter gave a little trouble in the field, as it sometimes stuck open; however, this was watched for on the tape, and a second operation freed it, still without any appreciable loss of contact times. At the eclipse itself, the observers did not in fact make an error, and the first frame of the eclipse run was clearly recognizable on the film; the identification marks, which were imprinted several times during the 3-minute run, were thus not required, but they checked with the counts from the first exposure.

Almost every item of equipment, except the masts for the rhombic aerial, was prepared in duplicate, and there was also a certain amount of camp gear (especially buckets, large bottles and an ice-box) and a full supply of tools, radio spares and workshop spares (bolts, shims, sheet-metal, iron strap, etc.). The complete equipment was packed in a "Container" $3\cdot5\,\mathrm{m} \times 2\cdot0\,\mathrm{m}$, $2\cdot6\,\mathrm{m}$ high, of standard Admiralty pattern, which had windows and a door and could be used as an office and laboratory (and probably also as a darkroom if necessary) in the field. The container left England, by sea, on September 8, and the observers followed by air and arrived in Mombasa on October 5.

3. *Work at Mombasa.*—On arrival at Mombasa, contact was made with the Resident Naval Officer, Lt. Cdr. Johnson, who had been advised in advance and had undertaken to give any help in his power. His assistance, and the willing cooperation of his staff, were of the greatest value throughout all stages of the work. He reported that there was room for a site in the precincts of the Coast Defence Battery (King's African Rifles) which was on a level and commanding promontory within the area of the town itself, and that he understood the Commanding Officer, Major C. F. Rouse, was prepared to give permission for its use if it was considered suitable. The situation was ideal in every respect, except that it could not fully provide for the four radio masts in the necessary rhombic array; however, a survey with a prismatic compass and tape, before the arrival of the apparatus, showed that the rhomb could just be set up, with its long diagonal at a bearing of 323° (Rugby = 334° and Washington = 312°), if two of the masts were outside the precincts and if a rather long lead-in from the end of the long diagonal was accepted. There was an excellent site for the camera itself, with the container close by, on open ground about 40 metres from an abrupt drop to the sea; and the whole situation, including its obvious freedom from the risk of interference by man or beast, and the availability of mains a.c., was so suitable that no other site was considered. The two observers were thereupon very kindly offered living quarters on the premises, and were made temporary members of the Officers' Mess; the hospitality and kindness of all the officers of the station contributed greatly, both directly and indirectly, to the success of the undertaking.

On the arrival of the container, the R.N.O. arranged for its transport from ship to site, and provided a travelling crane to lift it from the lorry. It had suffered slight structural damage in transit, but none of the apparatus was affected, and it admirably fulfilled its intended purpose of serving as a laboratory and office. A more suitable darkroom was arranged in an ammunition cellar kindly provided by the Commanding Officer, and a regular supply of ice made it possible to keep a stock of cold water, as well as of developing and fixing solutions, always on hand here, and also to store unused film properly.

An azimuth line was laid out without waiting for the masts, radio and chronometers to be brought into action, by utilizing the fact that at that latitude and season there were periods, about a couple of hours from sunrise and sunset, when the Sun's apparent motion was vertical, so that its azimuth was independent of the time. A tilt of 45° for the optical bench was definitely decided on, and a pier was laid out in the corresponding azimuth of about 224°. It was constructed of light coral blocks (the standard local building material) by a local stone-mason, and was rendered all over with cement after the angle-iron had been grouted in (Fig. 3). Since the final azimuth of the camera would be determined purely by the lie of this angle-iron, which was only about 45 cm long and somewhat difficult to set in any direction with precision, the height of the pier was made sufficient to permit a slightly steeper tilt than the intended 45°, to allow for final adjustment in tilt by means of the wedge, if the azimuth itself proved incorrect. After the cement had set, the camera assembly was placed in position on the pier, and the theodolite was sited 2 to 3 metres from the prism end and adjusted until it was in line with the lens centre and the centre of the camera frame; the azimuth of this line was determined, and was found to be about a degree off the intended value; a correction to the 45° tilt was then computed and the bench was always set at this corrected tilt by means of the wedge; the tilt was measured by a field clinometer which read to the nearest minute.

The above adjustments are considerably less easy and reliable than the ones which are possible when a horizontal camera position can be accepted; in that case, one can set up a theodolite (focused for infinity) so that it looks straight into the camera lens, and can sight directly on the centre of the frame, getting both the fore-and-aft tilt and the azimuth correct with high accuracy, even if the theodolite is slightly out of line with the bench; the cross tilt can also be adjusted with a carpenter's level. In the slanting position the theodolite must be placed very exactly in line with the lens cell and the camera front, and must be sighted on them alternately, both its focus and its dip being changed each time; the cross tilt of the camera cannot readily be checked at all. However, the subsequent measurement of the eclipse film showed that the correction applied to the tilt was sufficiently appropriate; the image of the Sun's south limb moved parallel to the long edge of the frame within about $\frac{1}{3}$ degree, which is a satisfactorily small slant.

While these adjustments were in progress the second observer (J. D. P.) erected the radio masts and the short-wave and long-wave antennae, charged the batteries, studied the quality of reception of the various signals, and rated the chronometers. It was found, as had been feared, that GBR was unsatisfactory; the noise level was such that one could just read morse, but could not record a signal clear of serious noise-interference. For satisfactory tape recording, with a relay which tends either to throw fully or not to respond at all, a high degree of freedom from noise is essential, and it was decided to rely on the short waves; suitable stations gave such clear signals that it seemed highly probable the camera could be recorded directly against the signal, when the time came, but of course chronometer rating was continued as well.

The question as to the best use, if any, to make of the nearly complete set of duplicate equipment which had been brought had been left open; but one possibility had always been that if the weather seemed likely to involve broken cloud, two stations some miles apart would offer a better insurance than one station with double equipment. (As is, unfortunately, not uncommon, available meteorological reports made no distinction between a 50 per cent chance of a clear sky and a 100 per cent chance of 4/8 cloud, and the question could not be decided in England.) Even the local meteorological information was not very convincing, but the chance of broken cloud did on the whole seem very appreciable, and it was decided that two stations should be used if each observer could be provided with a suitable assistant. Fortunately, two members of R.N.O.'s staff, Mr J. E. Wheal and Mr C. G. Wragg, were anxious to help and appeared thoroughly competent to do so, and a second site was therefore looked for. A situation on the far side of the eclipse track would of course have provided an interesting check, if both stations had obtained good results; communications were, however, difficult and the two stations would have been practically isolated from each other. For a first attempt, the maximum chance of getting at least one satisfactory record was all that it seemed wise to aim for, and a site within easy reach was thought essential.

A very suitable one was found on the edge of the airfield at Port Reitz, about 10 km away, and the Officer Commanding kindly gave his permission for a pier to be erected there, close to a small hut, which he also placed at the expedition's disposal. A similar pier to that at Mombasa, but somewhat larger so as to accommodate the larger bench, was therefore erected here, in the appropriate azimuth, and a small aerial was run up to an existing mast; a few days before the eclipse all the necessary equipment, including one set of batteries and one generator, was brought to this station and placed in the hut. Focus tests were repeated (the films being developed at the main station) and all apparatus was wired up and rehearsed. The observer (R. d'E. A.) did not remain at Port Reitz overnight, but returned to Mombasa each time, carrying the chronometer with him, and chronometer errors were constantly determined as before.

The one important item which could not be duplicated at any second station was the rhombic aerial, and there was thus little hope that Greenwich signals could be recorded at Port Reitz with satisfactory clearness. The chronometer did not show serious discontinuities as a result of its trips over a road which was rough in places, but it was decided to arrange a radio check on it in the following manner. The local Cable and Wireless station was approached, and agreed to broadcast some ordinary morse signals for half an hour or so at the time of the eclipse; at pre-arranged times, the Mombasa eclipse station was to receive these against MIK, while the Port Reitz station received them against its chronometer. During the actual eclipse run, the Port Reitz station would record the camera against its chronometer, and these chronometer times could thus be tied to MIK by means of the local signal, both before and after. The necessary suppressor-amplifier unit for the Port Reitz station was constructed by J. D. P. in the field.

In addition to rehearsals to familiarize the observers with the procedure, a number of trial runs were taken with live film to determine the focus settings, the rheostat settings for the camera motors, and the stops and filters for various states of the sky, as well as to check that the minute-marks on the camera had been correctly placed, and that the computed azimuth was going to be correct. This latter point was verified by noting the time of day when the image ran horizontally, comparing the times for different days, and extrapolating to the eclipse date. Much of this work had naturally to be done with the Sun at approximately the right elevation (20°–25°), and its heating effect was then not very great; nevertheless a light shield was constructed for each camera, of sheet metal and strap iron, to keep direct sunlight from the bench, camera, and lens. The prism was often exposed to sunlight for some time before a run began. Focus tests during the heat of the day did not show any systematic difference from the others, except of course that whenever the second filter was used the setting had to be increased by about half the filter thickness. At the eclipse itself, one filter and a stop of $f/25$ were expected to be satisfactory, and in fact were so.

Some trouble was experienced in developing the test films; even the cellar was fairly hot, and reticulation almost always appeared. Various temperatures for the developer, washing water, and fixing bath were tried, but all had necessarily to be considerably cooler than the air to which the wet film was intermittently exposed in processing, and no satisfactory arrangement was ever found. However, this did not prevent a reliable estimate of the best focus, still less of the best stop and filter combination, and it had never been intended to develop the eclipse films themselves before returning to England.

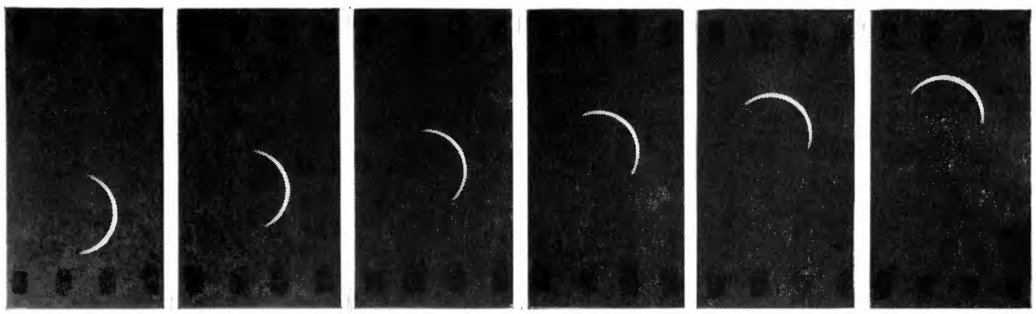
On October 31 a full dress rehearsal, with complete rolls of film, was run through at the proper time; there was some cloud, but it did not actually interfere with the programme. The developed films appeared satisfactory. On November 1 there was a heavy thunder-shower at the Port Reitz station until about $04^{h}\,00^{m}$ U.T., but the observers (R. d'E. A., assisted by Mr Wheal) were then able to set the bench in position and proceed in general as planned; one chronograph pen clogged up ten minutes before switch-on time, but this was successfully cleared and reconnected before the final prism setting was due. The image was correctly located and the camera switched on at the intended time. The camera speed was nearly correct and the film ran out at approximately the intended time. The chronograph record was satisfactory, except for sticking of the hand-operated shutter when this was used. The local station was audible, but was not successfully recorded on the tape. On developing the film in England it was found that the images were correctly placed, and fully exposed, with the background completely clear, but quite unexpectedly they were double, and the film was not considered worth measuring. The doubling was not of the kind sometimes seen with a badly wrong focus setting, but was always in the direction of motion of the film, and is thought to have been caused by a phasing fault in the camera. This was not observed in rehearsals, but it was subsequently verified that it was in all cases nearly possible; the widest shutter opening for which the mechanism was designed was 180°, and the pressure plate released for nearly all of the remaining 180°, so that a 10° exposure took place before the pressure plate had fully locked the film in place.

At the Mombasa station (J. D. P., assisted by Mr Wragg) the programme ran without any mishap. The images were correctly located, and the camera was switched on at the correct time; it ran slightly fast, so that the film ran out after 172 seconds instead of 190 as planned, but the loss due to this is hardly significant since the stretch that was observed was observed with correspondingly increased weight. The chronograph record was satisfactory, and the direct radio signals were clearly recorded with only a very occasional disturbance due to atmospherics. On developing the film in England it was found to be very satisfactory, with well-defined images throughout; although the crescent is only 9 mm long, a considerable amount of obviously real detail appears at the cusps when they reach mountains on the lunar limb. A selection of 6 of the 3 100 pictures is shown in Plate 10, with the approximate U.T. of each. There was, as had been expected, no trace of general sky fog and thus no indication at all where the edge of the frame had been (except when the identification mark was imprinted near one corner), and the direction of diurnal motion had therefore to be obtained with reference to the line joining two of the perforations; it was, as stated above, within about $\frac{1}{8}$ degree of being parallel to this line. It is evident from Plate 10 that the south (right-hand) limb of the Sun was unobscured throughout, and that a very large swing in position angle was obtained. There was a trace of haze near one cusp in the early part of the run; it may be seen on the first exposure of Plate 10, but it did not seem ever to get very close to the cusp.

The analysis of the results has been completed, and will appear in a later paper.

Royal Observatory,
*Greenwich, S.E.*10:
1953 *July* 15.

Royal Greenwich Observatory,
Abinger Common,
Surrey.



04 : 26 : 20 04 : 26 : 54 04 : 27 : 28 04 : 28 : 02 04 : 28 : 36 04 : 29 : 10

(Approximate U.T. instants of exposure.)
There are about 620 exposures between each of these six and the next.