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Report of the Observations of the Total Solar Eclipse of August 29, 1886, Made at the Island of Carriacou

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X. *Report of the Observations of the Total Solar Eclipse of August 29, 1886, made at the Island of Carriacou.*

By the Rev. S. J. Perry, *S.J., F.R.S.*

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[Plate 11.]

The astronomers appointed by the Committee of the Royal Society to proceed to the West Indies to observe the total eclipse of the Sun on the morning of August 29, sailed together from Southampton in the R.M.S. "Nile," Captain Gillies, on July 29, and, after a fair passage, anchored at Barbados at daybreak on August 11. A committee meeting on board had partly fixed our plans with regard to the stations of observation, so that, when we found two of H.M.'s gunboats awaiting our arrival in the roadstead, the instruments of Mr. Maunder and of the Rev. S. J. Perry were, after consultation with the commanders of H.M.'s vessels, at once transferred to the "Bullfrog," whilst the remainder of the instruments found a ready berth on the deck of H.M.S. "Fantôme," which, being the larger of the two gunboats, was reserved for the observers destined for Grenada and its immediate vicinity. Both the war-vessels started the same morning for Grenada, Mr. Lockyer and Dr. Thorpe sailing on board the "Fantôme," in order to secure the earliest possible interview with the Governor of the Windward Islands. The rest of the astronomers left the same evening in the R.M.S. "Eden," Captain Mackenzie, and, after touching at St. Vincent, arrived at Grenada early on the afternoon of the 12th. The private luggage of Mr. Maunder and of the Rev. S. J. Perry was immediately placed on board H.M.S. "Bullfrog," where they received the heartiest welcome from Captain Masterman, R.N., who devoted the best part of his own cabin to Father Perry, and found a comfortable private cabin for Mr. Maunder. Captain Archer, R.N., had also arrived at Grenada in command of H.M.S. "Fantôme"; and the "Sparrowhawk," a surveying vessel, commanded by Captain Oldham, R.N., was anchored in the harbour of St. George, her officers having been placed by the Hydrographer of the Admiralty at the disposal of the expedition. Previous to our arrival Governor Sendall, most ably assisted by Captain Melling, had personally inspected most of the best sites for the astronomical observations, collected all existing records of the weather, and designed huts for the protection of the instruments. Carriacou and Green Island were told off for the northern station, to be occupied by Father Perry and Mr. Maunder, assisted by the

officers and men of H.M.S. "Bullfrog" and by Sub-Lieutenant HELBY, of H.M.S. "Sparrowhawk." It was thought, however, more advisable not to separate the members of this party by a distance of some twenty miles, and, therefore, the more northerly island of Carriacou was fixed upon as the site best suited for both observers.

The 13th of August was spent in packing the huts and getting them on board, and on the 14th H.M.S. "Bullfrog" left early for Carriacou, and cast anchor in Hillsborough Bay the same afternoon. Immediately on our arrival we received a visit from the resident magistrate, Mr. ROCHE, and from the harbour master, Mr. ISAACS, who both offered us every assistance in their power. On landing we paid our respects to the venerable Canon PETRETTO, whom Governor SENDALL had specially named, along with Mr. ROCHE, as most anxious to render us every possible aid. From information received from these gentlemen and from the resident physician, Dr. ARCHER, we concluded that the southern shore of the island might provide an excellent site for the observations, as well as good anchorage, and a fair prospect of landing safely our heavy instruments. A note to Mr. DRUMMOND, the owner of an estate in the south of the island, met at once with a cordial response, and we were invited to make "The Hermitage" our home during our stay at Carriacou.

On August 15, it being Sunday, we lay at anchor off Hillsborough, but the next morning, in spite of a heavy sea, which formed part of the cyclone that destroyed five churches and many houses at St. Vincent, only forty miles to the north of Carriacou, we steamed round to Tyrrel Bay, and took up our final position close by the estate of Mr. P. DRUMMOND. With some difficulty we found our way through the coral reefs in the captain's cutter, and were met on the shore by the land agent of Mr. DRUMMOND, who pointed out the best spot for landing and the most accessible road to "The Hermitage." This building stands on the summit of a ridge 200 feet above the level of the sea, the land stretching in a long promontory towards the South-West between Tyrrel and Manchioneal Bays. On examining carefully the bearing of the neighbouring hills we found that none would at all interfere with our view of the Sun on the morning of the eclipse, Chapeau Carré being sufficiently remote from the East point, and the others still more so; and, as everything else was as favourable as we could expect, we fixed upon this ridge as our station of observation. The following bearings of some of the chief objects in view serve to fix our position very accurately. The observations were made by Mr. MAUNDER, the angles being reckoned from the true North, through East:—West end of Sandy Island 2°·5, Chapeau Carré 43°·2, Eclipse Peak 86°·0, centre of Frigate Island 168°·3, peak at entrance to Tyrrel Bay, N. side, 329°·5.

The site chosen for our huts was at the summit of the ridge, about 300 yards from "The Hermitage," and towards the ENE. The ground in the immediate vicinity was fairly level, and the foundations for the equatorials excellent. A number of labourers and a bullock-cart were hired for the following day, and soon after daybreak the men of H.M.S. "Bullfrog" began to land our heavy packages on the sandy beach.

The native workmen carried some of the lighter pieces to the top of the ridge as soon as they were landed, but most of the instruments had to be placed on the bullock-cart and dragged up the steep, rough road at great cost of time and labour, the men aiding the bullocks when necessary. The ship's carpenter, with a shore party of seamen and marines, was soon at work clearing the ground and erecting the observing huts, and these had to be fixed rather firmly in the ground, in order to resist the storms of wind so violent in these islands. The dwelling of Mr. DRUMMOND, thanks to his self-sacrifice, afforded excellent accommodation for the two astronomers and for Lieutenant HELBY; but the incessant attacks of the gallinippers, which brought on an incipient fever, rendered it necessary for Mr. MAUNDER to sleep on board H.M.S. "Bullfrog" during our stay at the island. A small cottage, consisting of two rooms, and situated close to the main dwelling, was also placed at our disposal. One of the rooms served to keep our packages dry, and the other, at the expense of the sailroom of the gunboat, was excellently fitted up as a developing room for photography. A bed of concrete was laid in one of the observing huts for the photoheliograph of Mr. MAUNDER, and concrete was also used to fix firmly in position the legs of the strongly-built tripods on which stood the equatorials of JONES and ALVAN CLARK. The landing of the instruments commenced on the 17th, thus leaving twelve days before the eclipse for the erection of huts and instruments and for all necessary preparations. The exact bearing of the polar axes of the equatorials was determined by observations of Polaris and of δ Ursæ Minoris, and we were ready on Monday, the 23rd, to commence the testing of our instruments. The Simms transit-theodolite from Stony-hurst Observatory was of great use for observing altitudes of the Sun by which to rate our chronometers, and also for determining the positions of the disks erected to obscure the inner corona for those who had undertaken to make sketches of the outlying streamers during totality. These disks were fixed firmly on the top of each hut, with sight-holes on uprights placed at a convenient distance on the side opposite the rising Sun. Captain MASTERMAN and Paymaster OSBURN kindly volunteered to observe and sketch these faint, delicate objects.

In the course of the morning of the 23rd Father PERRY adjusted the grating of his spectroscope, and obtained a very perfect spectrum. H.M.S. "Fantôme" arrived the same day from Grenada, and we learnt from Captain ARCHER that Mr. LOCKYER had just established himself at Green Island, the station appointed at first for Mr. MAUNDER.

On the 24th the weather in the early morning was all that could be desired, and the Sun could have been observed under the most favourable circumstances had the eclipse occurred on that day, although later in the morning there was a succession of heavy showers.

The detailed plan for the morning of the eclipse was definitively settled on the 25th, the assistants were chosen, and everything made ready for a complete rehearsal on the morrow. The plan finally adopted was the following:—

1. The Jones 4-inch equatorial, provided with a Hilger solar prism and power of 110, was destined for observations of first and last contacts; but, as it was raining heavily both at the beginning and at the end of the eclipse, this notice of the preparation for contact observations will amply suffice.

2. After contact, the solar prism was to be dismounted, and a large direct-vision spectroscope by Browning substituted in its place, to be used during totality as an analysing instrument by Lieutenant Pascoe, R.N., assisted by Dr. Archer.

3. Dr. Wright, R.N., had charge of the Hilger direct-vision spectroscope, mounted on its own stand, and to be used as an integrating instrument. The observations with this spectroscope, and also those undertaken by Lieutenant Pascoe, were intended to supplement any results obtained with the grating attached to the $5\frac{1}{2}$-inch Alvan Clark equatorial.

4. Mr. Maunder's work with the photoheliograph and spectroscopic cameras, which will form the subject of a separate report.

5. Drawings of the streamers of the outer corona, to be made with the aid of disks obscuring the inner corona. The sketches of Captain Masterman, R.N., and of Paymaster Osburn, R.N., will be appended to this report, with their own remarks explanatory of the nature of the results obtained.

6. Spectroscopic observations with a Rowland grating attached to the $5\frac{1}{2}$-inch Alvan Clark equatorial. The telescope to be pointed by Lieutenant Helby, and the readings taken by Father Perry.

This equatorial of Alvan Clark was the instrument used by the Rev. T. Webb in the preparation of his well-known work on "Celestial Objects." The glass was one of those guaranteed by Mr. Dawes, and it would be difficult to surpass it in excellence of defining power. The mounting was not comparable with the quality of the glass, and no driving clock was attached. Mr. Webb used only a slow motion in R.A.; but, as it was necessary to vary the position of the slit of the spectroscope during totality, in order to place it successively on different parts of the corona, it became imperative to provide a slow motion for N.P.D. before taking the instrument to the West Indies. This addition was made by Cooke, of York, and he also arranged the clamps so that the telescope might be fixed firmly in every direction. The absence of clockwork to drive the instrument made it necessary to have an assistant to point the telescope, and therefore Lieutenant Helby, of H.M.S. "Sparrowhawk," was chosen for this work. The grating used with this equatorial was kindly lent by the authorities of South Kensington; but a direct-vision spectroscope, constructed by Hilger, was also provided, by which an equal dispersion could be obtained, and which might replace the grating in case of accident. The plate of the grating was polished and figured by J. A. Brashear, and the parallel lines, 14,438 to the inch, were ruled on Professor Rowland's engine at Baltimore in 1884. The plate was mounted by Hilger on a student's spectrometer belonging to Stonyhurst. The combination answered very well, and gave little trouble in the adjustments.

The work expected from this instrument by the Committee of the Royal Society was an examination of the spectrum of the inner corona immediately before and after totality, and a search for the bands of carbon during totality. The observations before and after totality were to serve as a test of the accuracy of Mr. Lockyer's theory concerning the concentric layers of the solar atmosphere, in which selective absorption is supposed to take place. It is important to know whether nearly the whole of the Fraunhofer lines are produced in the layer observed by Professor Young close to the photosphere in 1870, or whether they are due to the combined absorptive action of successive layers, each producing its own characteristic lines. If the latter hypothesis be the true one, then the layers nearer the Sun's centre, being hotter than those outside them, should produce brighter lines. These, therefore, would be the first to come into view as the eclipse approaches totality, and they would also be the most enduring after totality. Belonging, as they are supposed to do, to the inner layer, they should be short and bright, and not increase in length, but only in relative intensity, as the darkness became greater. The other lines, belonging to layers farther removed from the Sun's centre, would be invisible at first, owing to their want of intensity, but they would gradually come into view as the darkness increased, and always appear less brilliant and longer than those which preceded them. Immediately after totality the previous order would be, of course, reversed, the longest lines, which are also the faintest, disappearing first, and then the others, according to their length, leaving the shortest and brightest in view, until even these are at last over-powered by the returning light of the photosphere. In 1882 the Egyptian observations had favoured this theory, and Mr. Turner was asked to repeat in 1886 the observations previously made in the F. region, whilst Father Perry watched the same phenomena in the region on the less refrangible side of *b*. The plan adopted at Carriacou was that Lieutenant Helby should keep the slit of the spectroscope radial on the centre of the solar crescent for eight minutes both before and after totality, whilst Father Perry watched the changes in the bright line spectrum of the inner corona. To enable the assistant to point the telescope with very great accuracy, a cap with a white enamelled surface had been closely fitted to the slit, and on this cap two sets of parallel lines at right angles to each other had been most carefully ruled, the distances between the lines being one-tenth of the projected diameter of the solar disk. The cap could be fixed only in one position, so there was no possible danger of one set of lines not being in exactly the same direction as the slit, and still less of the slit being partially covered. A clear image of any visible corona was thus secured, and the assistant could see perfectly whether the required portion of the image fell upon the slit.

The remaining work expected from this instrument was a search during totality for the two principal bands of the carbon spectrum. In 1883 Professor Tacchini had thought he glimpsed the carbon bands, and some few previous observations rendered their existence in the coronal spectrum not improbable. It was evidently of very

great importance to test thoroughly so interesting a fact, and Professor TACCHINI joined the British Expedition at Southampton with the intention of placing, if possible, this question beyond the region of doubt. The instructions to Lieutenant HELBY were to place the slit of the spectroscope exactly on the inner edge of the corona at the commencement of totality, and then to move it successively to distance 0·1, 0·2, 0·3, 0·4, and 0·5 of a diameter from the dark surface of the Moon, repeating afterwards at the Sun's pole what first was done near his equator. To avoid rotating the spectroscope, the slit was placed radial at the solar equator, and tangential at the poles. The same portion of the spectrum remained always in the field of view during the whole of the observations, and embraced rather more than the distance from W.L. 5600 to *b*, comprising, therefore, the positions of the two principal bands of the carbon. To fix accurately the place of any lines visible, photographs of the solar lines in the portion of the spectrum required had been taken at Stonyhurst on plates stained with eocine, and on others kindly sent by Captain ABNEY, R.E. As these did not come out distinct enough to use safely with a feeble illumination, a number of the principal lines in the field of view were measured with a micrometer, and then mapped on a large scale and reduced photographically to the scale required. Transparent scales graduated to tenths of millimetres were also prepared, so as to be ready for any change that might be required.

On August the 26th, between 6 and 7.15 A.M., we had the first all-round practice with every instrument in position, with all hands on shore who were to take part in the observations on the 29th, and each thing done just as if the eclipse had been taking place. The time was called every ten seconds by ROBERT SMITH, A.B., coxswain of the captain's cutter, in a loud and distinct tone, that could be heard easily by all present. JOHN COLLUM, signalman of H.M.S. "Bullfrog," and other reliable seamen, noted down the observations as these were called out, and affixed the corresponding times. All was found to work well, and not a few useful lessons were learnt for the morning of the 29th. Later on in the day, whilst observing with the grating, I found the heat so intense that I was forced to leave the instrument for a time and retire to the house. On my return I perceived at once that some inquisitive looker-on had been gently feeling the grating with his greasy finger, probably to ascertain its degree of smoothness. My dismay at first was great, as I was afraid I might have been obliged to abandon the grating in favour of the Hilger direct-vision prisms, with which I had supplied myself in case of accident. I removed part of the roof of my observing hut, in order to test the grating thoroughly, and I was satisfied at last that the spectrum showed no signs of being in the least affected by the stain left by the finger on the surface of the ruled metallic plate. I resolved, therefore, to retain the grating; but, finding that the second order of spectrum with a power of 4 gave a more brilliant picture than the first order with the power of $6\frac{1}{2}$, I made up my mind to adopt the second order for the day of the eclipse, although this necessitated the sacrifice of the

photographs of the solar lines, which had to be replaced by a scale divided in tenths of millimetres.

The early morning of the 27th was cloudy and showery, and all practice impossible at the eclipse hour, but the Sun was observed later on in the day, and the position of the various points of the limb accurately determined for all circumstances that might arise in the use of direct or inverted images, of solar prisms, or of projections.

On August the 28th the sky was quite clear an hour before sunrise, and, observing the Sun at the time when first contact was to take place on the morrow, I found the definition very good, but the low altitude made the limb somewhat unsteady. I was then using the power of 110 on the Jones 4-inch equatorial. Changing my instrument, I then took a number of readings of the solar lines, using the first and second orders of the spectrum with the powers of $6\frac{1}{2}$ and 4 respectively. As I again found the second order with power 4 to be much more distinct than the other combination, I resolved to adhere to my intention of adopting the second order for any observations on the morrow.

At 2 A.M. on the 29th, the morning of the eclipse, not a cloud was to be seen, and at 4 A.M. the stars were still shining brightly in every direction, although a slight breeze had sprung up from the South. The wind then shifted gradually towards the East, and at 5 A.M. clouds were fast beginning to appear. Soon it became but too evident that rain was falling at no great distance to the North-East of our station, and heavy clouds began to show themselves in the direction of the rising Sun. External contact took place in the midst of rain, and the first glimpse of the Moon was obtained through the Jones equatorial when one-third of the Sun's surface was already obscured. The clouds then cleared off rapidly, and we could safely uncover our larger instruments. The sky, however, remained only fairly good until the near approach of totality. This was particularly unfortunate, as the interval between first contact and totality would have been most valuable for testing the more delicate adjustments of our instruments, and for preliminary observations.

As soon as the Sun's image could be seen upon the cap of the slit, Lieutenant HELBY placed the centre of the radial slit on the middle of the outer arc of the solar crescent, and kept it there as steadily as possible; but no bright lines came into view between W.L. 5600 and *b* until one minute before totality, when the first line seen was 1474 K., which stood out very brightly, and then followed almost immediately a number of bright lines close by *b*, on the less refrangible side. I estimated their number at about fifteen. They seemed to be of different lengths, but I did not see them long enough to judge of their relative intensities. The height to which 1474 K. extended from the photosphere might be about 8′ of arc. The exact position of this line and the general position of the group were fixed by the lines of the solar spectrum, which had been under my eye for some time previous. I never moved the grating, or the viewing telescope, during the observations, so that everything was in excellent adjustment the whole time, and the field of view was well known. The

captain's coxswain was counting the time aloud during the whole of totality, the seconds being taken from Mr. MAUNDER's clock.

When totality commenced, the slit of the spectroscope was radial on the inner edge of the corona, near the centre of the line where the thin crescent had just been visible; no carbon bands could be perceived. The slit was then moved successively to distances 0·1, 0·2, 0·3, 0·4 and 0·5 of a solar diameter from the Moon's dark limb as 190^s, 180^s, 170^s, 160,^{s} and 150^s were called by the coxswain. All this time I kept my eye steadily at the viewing telescope, but could see nothing of the carbon bands. The slit was then moved to the vicinity of one of the Sun's poles, and placed tangentially on the inner edge of the corona at 130^s before the end of totality. Afterwards it was gradually shifted away from the Moon's limb, the distances being 0·1, 0·2, 0·4, and 0·5 of a diameter, at 120^s, 110^s, 100^s, and 90^s respectively, and in none of these positions could I catch the slightest trace of the bands of carbon.

Thinking it hopeless to continue any longer the search for carbon, and wishing to be prepared in good time for the observation of the bright lines at the end of totality, I asked Lieutenant HELBY to place the slit at once radial at the point of re-appearance of the photosphere. Whilst this was being done, I took up a powerful binocular, which I had placed for this purpose close at hand, and viewed for a moment the eclipsed Sun. The upper rays on the western limb, to the right and left of the vertical line, were by far the longest streamers, and were situated almost at right angles to each other, a third, but shorter, ray appearing between them to the left of the vertical diameter. These rays were all well defined, and the one most to the North of West was curved on both sides like a leaf. On the Eastern, or lower, limb the rays were irregular and less extended than in the West. I did not notice any rays near the poles, but my view was scarcely more than an instantaneous glance.

At this moment Lieutenant HELBY lost the solar image from an irregular movement of the telescope, but I was able to recover it almost immediately. Whilst thus replacing the Sun upon the slit, I obtained a hasty view of the corona upon the white enamelled cap, and this picture far surpassed in beauty anything I had seen before, although my binocular is an excellent instrument. The details of the streamers, and the short red prominences, were exceedingly well defined, showing the splendid quality of the Alvan Clark objective and the purity of the sky at the moment.

When the coxswain had called out 20^s, the slit being radial near the point of re-appearance, I saw a large number of lines flash out in my limited field of view: there might have been fifty altogether between W.L. 5600 and *b*. This lasted only a very short time, and after totality no lines were seen, as the rising wind interfered considerably with the steadiness of the telescope, and in a few minutes we were again deluged with rain. The darkness was never much less than that of a fair moonlight night, but during totality the light was not equal to that of a full Moon in a clear sky. Heavy rain prevented the observation of last contact.

Since the observations were taken I have frequently wished that my equatorial had been supplied with clockwork, which would have enabled me to dispense with the aid of an assistant for fixing, in each case, the position of the slit. I have not any reason to doubt but that the gentleman who so kindly aided me on this occasion did his duty as perfectly as could be expected; but it is not such an easy matter for one who has had only a few days' acquaintance with the slow-motion rods of an equatorial to keep the slit of a spectroscope on any precise point of a celestial object. The strength of the wind and the imperfections of the slow-motion rods added in the present instance to the difficulty of following the Sun exactly with the R.A. rod, and of changing the N.P.D. as required. I am forced to the conclusion that the time lost by the unaided observer in placing the slit of his spectroscope would be more than compensated by the security he would feel, that he was viewing exactly the desired point of the object. Without clockwork this is not practicable; but I should never think of again attempting eye observations with a spectroscope during a total eclipse without a clock to drive my equatorial, and then, if a grating was used, I should certainly dispense with any assistant at the telescope.

The two main questions to be answered by the spectroscopic observations at Carriacou were: (1.) Does the absorption, which produces the Fraunhofer lines, take place mainly in a single layer of the solar atmosphere, or in concentric layers? (2.) Does carbon exist in the corona? As far as the above results may afford any satisfactory evidence on these two points, I should be inclined to say that the difference in the length of the lines observed before totality on the less refrangible side of b seems somewhat to strengthen the view that the absorption takes place in concentric layers. And the search for carbon tells us that, if present, its spectrum was not strong enough in 1886 to make any appreciable effect upon the retina, when the eclipsed Sun was viewed through so powerful a diffraction spectroscope as that used at the island of Carriacou. It may, perhaps, be established, by later observations, that the intensity of the carbon spectrum varies in each eclipse, and may have some direct connection with the amount of solar activity.

I should mention in conclusion that the diameter of the solar image on the slit plate of my spectroscope was 20 millimetres, the width of slit used $\frac{9}{100}$, and its effective length $6\frac{82}{100}$. The dispersion was sufficient to enable me to see b_3 and b_4 very distinctly separated.

Subjoined are the Sketches of the Coronal Streamers with explanatory notes by Lieutenant Commander J. Masterman, R.N. (Plate 11), and Mr. F. W. Osburn, R.N. (p. 362).

Notes on the Solar Eclipse of 29th August, 1886, observed at Carriacou.

H.M.S. "Bullfrog," under my command, was ordered to convey the northern division of the expedition for observing the eclipse to Carriacou, an island about twenty miles N.W. of Grenada, and render what assistance she could; I and all the other officers of the ship offered our services for the observations, which were accepted.

On arriving at Carriacou, on the 14th August, we were cordially welcomed by Mr. ROCHE (the magistrate), and hospitably entertained by Mr. DRUMMOND, the owner of the property on which we selected a spot to erect the huts. This was a small plateau, on the summit of a steep ridge 175 feet above the level of the sea. The sea was on each side of the ridge, and Mr. DRUMMOND'S house was 200 or 300 yards off. The beach in the bay where the ship anchored was very suitable for landing the instruments.

I undertook the observation of one of the disks; it was mounted on the hut used by Mr. MAUNDER. The height of disk above eyepiece was 11 feet $10\frac{1}{2}$ inches, the angle subtended by the disk being 72′; the diameter of the disk was 9 inches; the cross-bar was $1\frac{1}{4}$ inch thick; the uprights were 1 inch thick; the length of uprights was 2 feet $10\frac{1}{2}$ inches; the horizontal distance of the eyepiece from the disk was 33 feet 7 inches; the apparent diameter of the disk from the point of observation was equal to $2\frac{1}{4}$ solar diameters.

On the 26th and on the 28th I practised the observations under as nearly as possible the same conditions that we should be under on the day of the eclipse. I was prevented from doing so on the 27th by the weather.

The hole in the eyepiece I had increased to $\frac{1}{4}$ inch diameter.

At 10 minutes before totality my eyes were bandaged with a thick black handkerchief, without any pressure on the eyeballs, but totally excluding the light. The bandage being taken off at the commencement of totality, I looked through the eyepiece, but found the adjustment not correct, and lost some time in correcting it before I could commence my observations.

The sketch I took of the phenomenon, as I saw it, together with a copy (which differs only in being a little more finished and shaded a little darker), accompanies this.

The first things that caught my attention were the two rays of light marked A and B; they seemed to be of exactly the same length, and each to make an angle of about 45° with the vertical, in length $1\frac{1}{2}$ diameter of the disk from the disk, or 4 solar diameters from the Sun's periphery. The next thing that I observed was the ray that I have marked C, very bright, but small and partially hidden by the cross piece; the observed extension was under 2 solar diameters from the Sun's limb. The two remaining rays, D and E, on the Sun's eastern limb, were very faint, and they seemed to fade into the general surrounding light instead of tapering away to a point, as the others did.

At the end of the observation I am certain that B was considerably longer than A, though, as I said before, they appeared to be exactly similar at first. I should be inclined to attribute this to the fact that the Sun was altering a little in azimuth, and towards the end of the observation I had given all the correction that the apparatus admitted of, and therefore the Sun got nearer to the side of the disk.

I found that the Sun altered in altitude so rapidly that it was difficult to keep pace with it with the rough arrangement for altering the elevation of the eyepiece; a small rack and pinion would have been a great boon.

A better arrangement for making correction in azimuth and a longer range would be an advantage.

The cross-piece, $1\frac{1}{4}$ inch wide, interfered with the observation; a thin metal rod or stout wire would have been better.

I observed with the disk until the last moments of totality, and only just looked off in time to see the burst of bright light at the second internal contact. I at once made the (original) sketch which I send, and saw nothing of any other phenomena, as, two minutes after, everything was obscured in clouds and we were in a drenching rain.

I had the tides both before and after the eclipse measured, and found the rise and fall was normal, 18 inches.

J. Masterman,
Lieutenant Commander, H.M.S. "Bullfrog."

Grenada, 1*st September*, 1886.

Notes descriptive of Drawing (Plate 11) by Lieutenant J. Masterman.

A and B.—Very distinct, especially B. They each formed an angle of 45° with the vertical. B appeared to increase in length, not in brilliance; A did not.

C.—Distinct, but small. I could not detect any sign of C above the batten, though, if the upper edge had been inclined to the horizontal at the same angle as the lower edge was, I think I must have done so.

D and E.—Very faint indeed, merging into the luminosity which was faintly apparent between all the shoots of light; but, faint as this luminosity was, it had a distinct definition, which had the appearance of going about the points of the shoots.

Copy of sketch of the phenomenon as observed by me with one of the disks mounted on the roof of a hut.

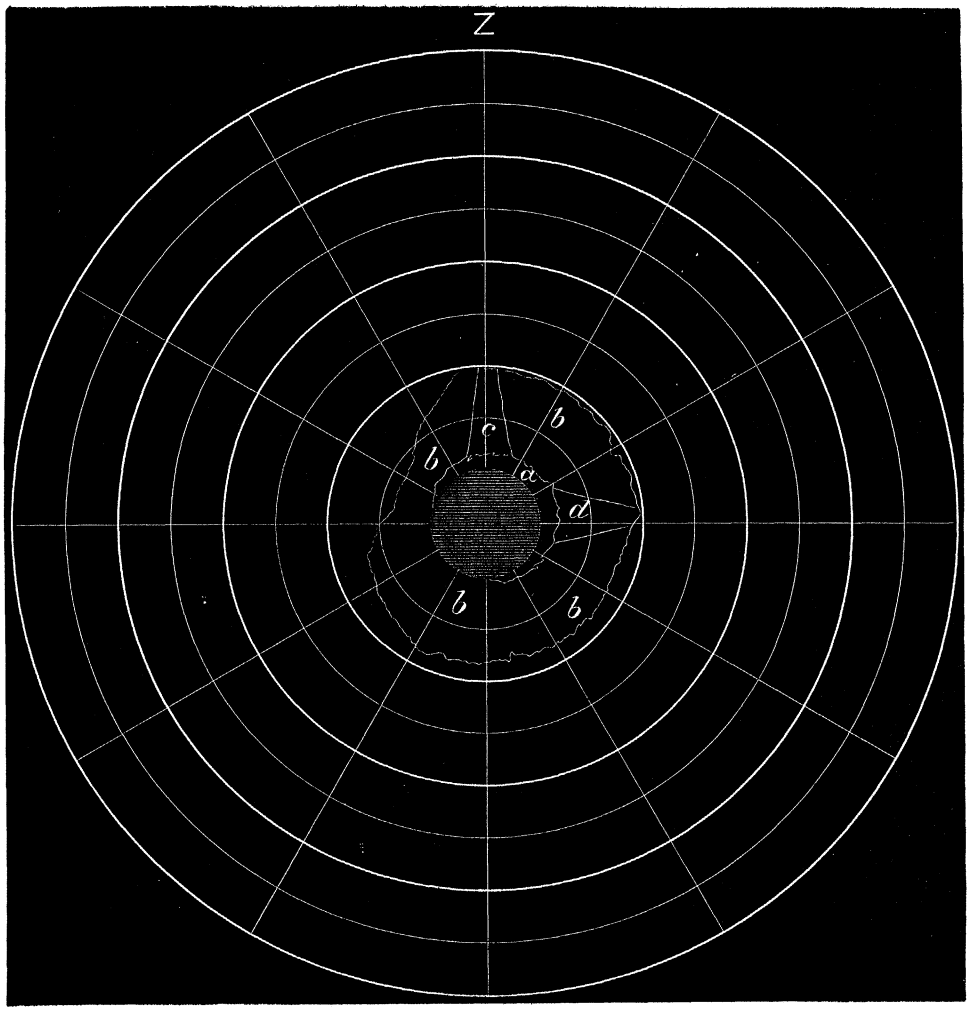
Dimensions:—Disk, 9 inches diameter; cross batten, $1\frac{1}{4}$ inch; upright battens 1 inch, length 2 feet $10\frac{1}{2}$ inches.

J. Masterman.

DRAWING BY MR. F. W. OSBURN, R.N., OF H.M.S. "BULLFROG."

Horizontal distance from eyepiece to disk, 26 feet 10 inches; height above level of eyehole, 9 feet 4 inches; diameter of disk, 9 inches; angular diameter, 1° 31′; breadth of upright batten, 1 inch; breadth of cross batten, $1\frac{1}{4}$ inch; height of disk above ridgeway of roof, 2 feet $10\frac{1}{2}$ inches.

NOTE.—At the commencement of totality, when my eyes were first unbandaged, I found, on looking through the eyepiece, that the eclipsed Sun was about 4 diameters above the disk, and some time was wasted in shifting the eyepiece down as far as it would go, when the Sun and corona were just covered by the disk; but before totality was over, the corona was again visible over the top of the disk.

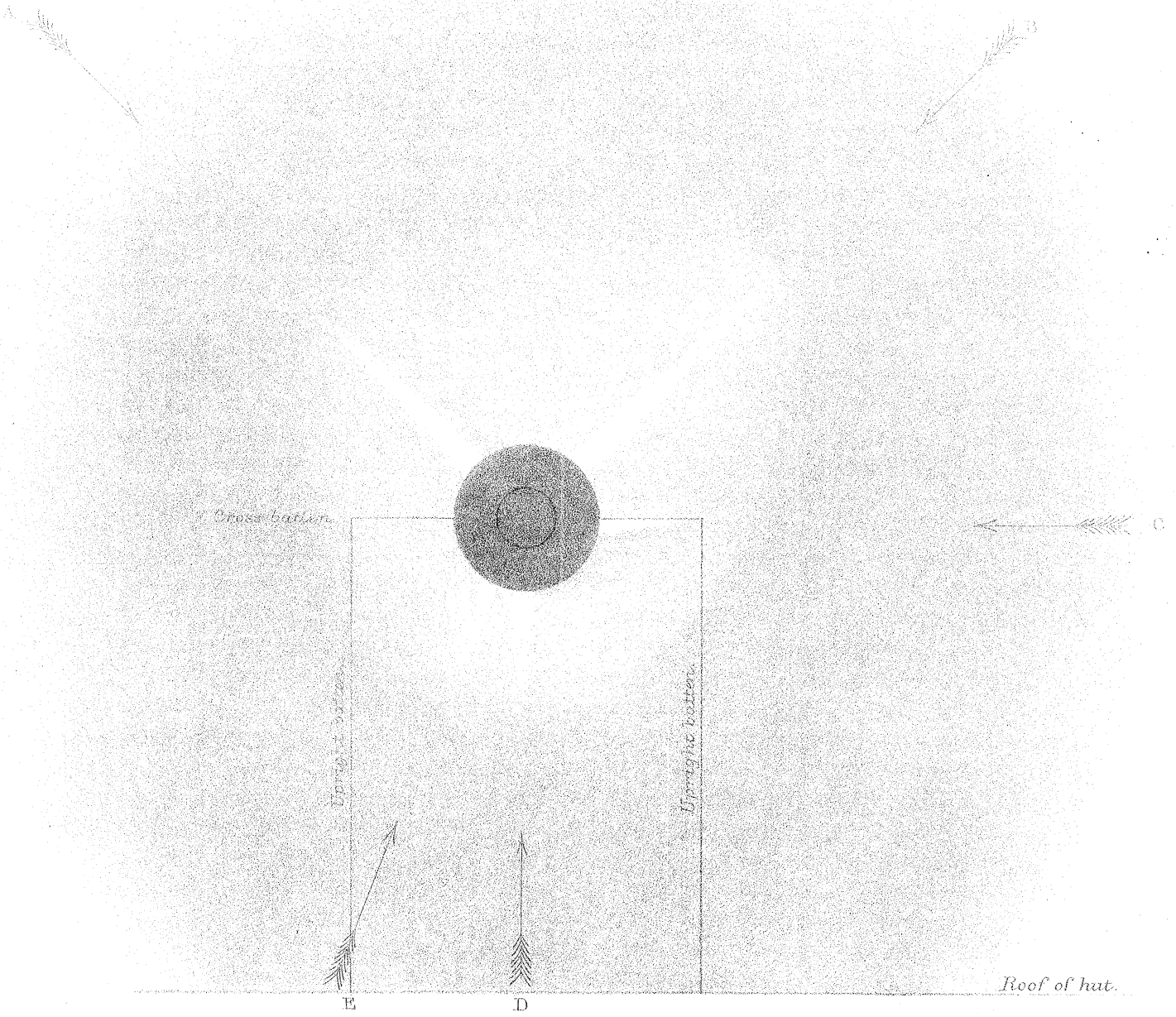


Marked *a*.—Around three parts of the disk there appeared a band of bright light, sharply defined and irregular in shape, its broadest part on the right, and gradually diminishing until, at the left lower corner, it ceased altogether.

Marked *b*.—Entirely surrounding the disk I observed an irregularly shaped field of very faint light, standing out at its widest part nearly 1 diameter beyond the disk.

Into the field above mentioned I observed two very faint rays extending, one towards the zenith (but so faint as to be hardly discernible), and the other to the right of the disk (which I saw more clearly), on each side of the horizontal support; these rays are marked respectively *c* and *d*. They appeared about equal in length, *i.e.*, 1 diameter of the disk.

FRANCIS W. OSBURN.



TOTAL ECLIPSE *of the* SUN.

Carriacou 29th August 1886.

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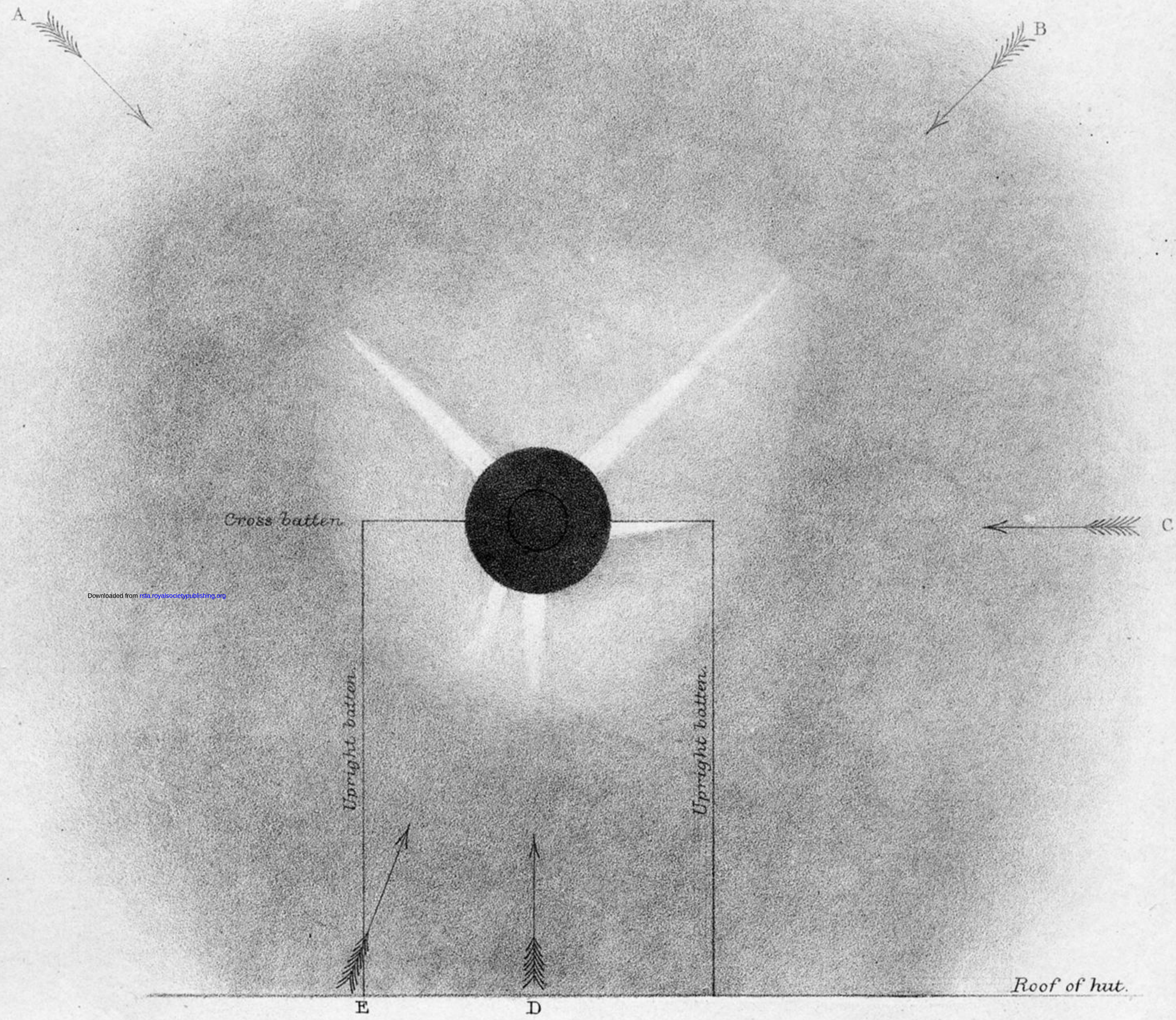

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