

THE  
TOTAL SOLAR ECLIPSE  
OF MAY 1900



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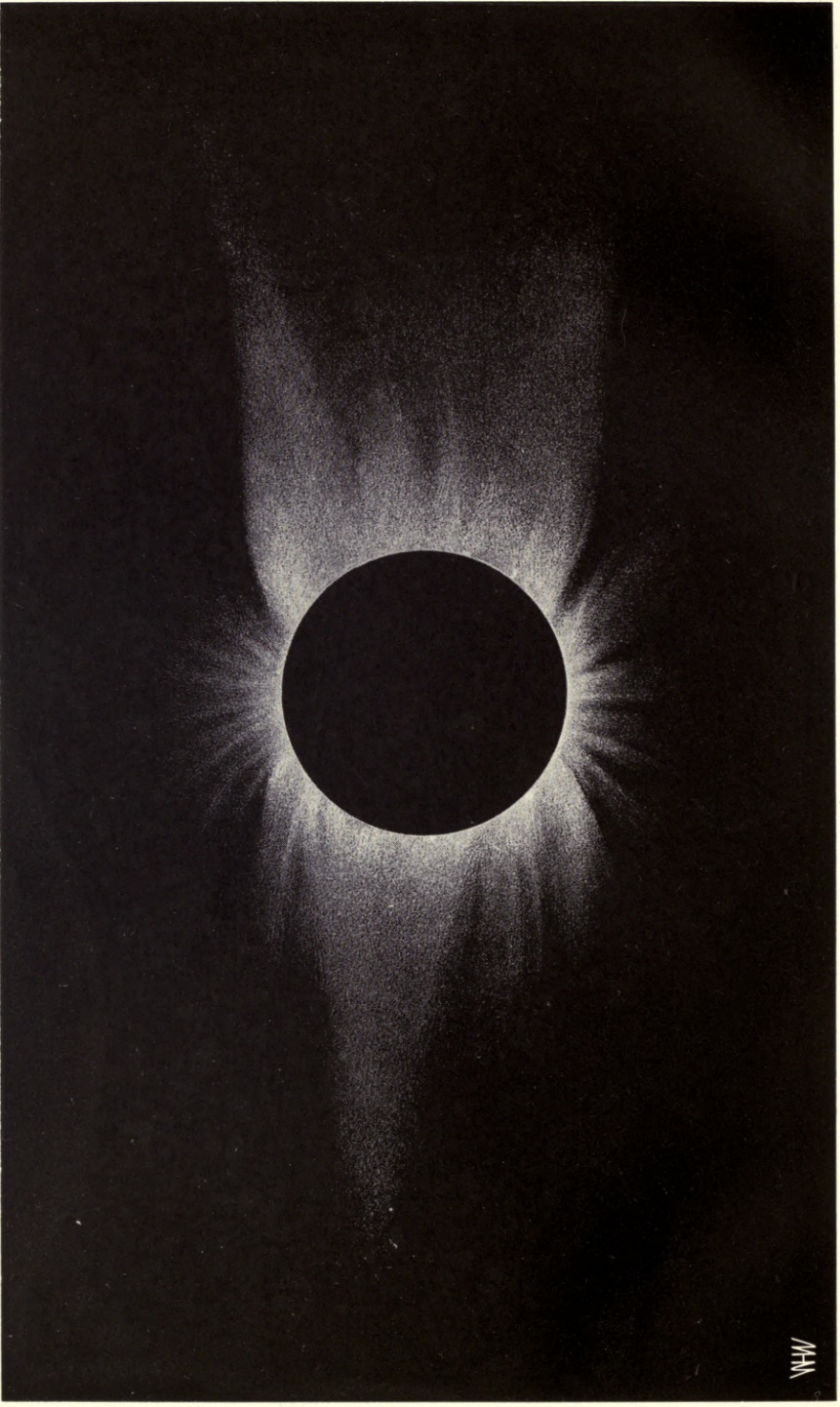
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BRITISH ASTRONOMICAL ASSOCIATION

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REPORT OF THE EXPEDITIONS ORGANIZED BY  
THE BRITISH ASTRONOMICAL ASSOCIATION  
TO OBSERVE THE TOTAL SOLAR ECLIPSE

E. WALTER MAUNDER, F.R.S.



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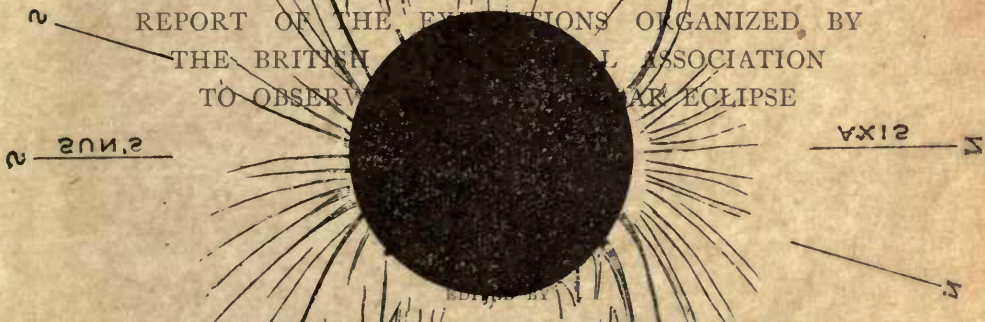
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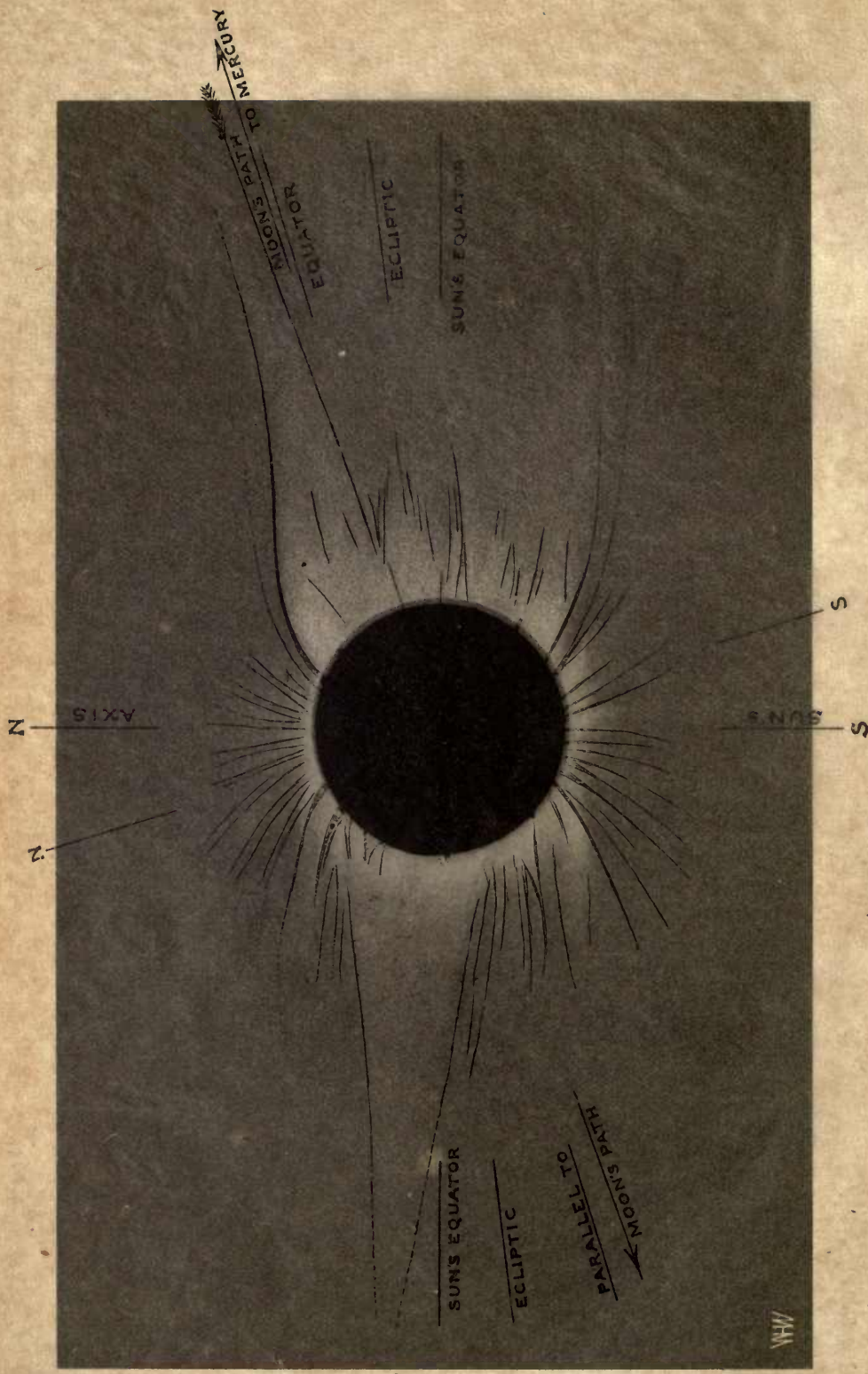
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THE CORONA OF 1900.

*BRITISH ASTRONOMICAL ASSOCIATION*

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TOTAL SOLAR ECLIPSE  
1900

REPORT OF THE EXPEDITIONS ORGANIZED BY  
THE BRITISH ASTRONOMICAL ASSOCIATION  
TO OBSERVE THE TOTAL SOLAR ECLIPSE  
OF 1900, MAY 28

EDITED BY  
E. WALTER MAUNDER, F.R.A.S.



London  
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## PREFACE.

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THE British Astronomical Association has been now sufficiently before the public for its methods and objects no longer to require detailed explanation. Founded in October, 1890, it now numbers nearly 1200 members, and its meetings are held month by month, not only in London, the headquarters of the Association, but also at the seats of the branches—Manchester, Glasgow, Edinburgh, Sydney, and Melbourne. A sixth branch is now being opened at Birmingham. As its chief purpose has been the association of observers for mutual help, and their organization for the work of astronomical observation, its operations have not been confined to its "sections," dealing with the study of the sun, moon, planets, comets, meteors, etc., but have extended to the occasional phenomena of astronomy, amongst which total eclipses of the sun are the most striking and important. Three such events have happened since the Association was strong enough to attempt to deal with them, viz., the eclipses of 1896, August 9; of 1898, January 22; and of 1900, May 28. A large party proceeded under the auspices of the Association to Vadsö, in Lapland, to observe the first of the three, but their efforts were entirely frustrated on this occasion by cloud. Two parties were organized to go to India, to observe the second, and were rewarded with complete success; and the results of their observations have appeared under the title of "The Indian Eclipse, 1898." The present volume is the report of the Association on the most recent of these three eclipses, which was observed by the members at a great number of different stations, in the United States, at sea, in Portugal, in Spain, and in Algeria.

The meetings of the Association are held on the last Wednesday of each month, except July, August and September, at Sion College, Victoria Embankment, E.C. All enquiries should be made of the Assistant Secretary, 26, Martin's Lane, Cannon Street, E.C.



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# THE TOTAL SOLAR ECLIPSE, 1900.

## CHAPTER I.

### *INTRODUCTORY.*

THE course of Total Eclipse Expeditions, like that of true love, seems never to run smooth. Of the three which the British Astronomical Association has organized, the first was baffled by cloud, the second was hampered but not thwarted by plague, and the third was hindered but not beaten by war.

The expedition to Vadsö, in 1896, had been so exceedingly enjoyable, that in spite of the adverse fortune on the day of the eclipse itself, a large number of members of the Association had been anxious that one should be arranged on similar lines for the eclipse of 1900. The desirability of such an arrangement, if possible, was obvious, for the association together, on a sea voyage of a large body of observers, offers opportunities for organization and co-operation in work, which are not easily secured in any other way, and the experiences of 1896 showed that a high amount of efficiency could be secured under such conditions. The Eclipse Committee, therefore, of the Association, turned their first attention to chartering a steamer which should carry the observers and their instruments to Alicante and Algiers, calling on its way at Oporto or Lisbon, and at Cadiz for the convenience of those observers who wished to watch the eclipse from some place in Portugal, or in the interior of Spain. Negotiations were accordingly opened with the Royal Mail Steam Navigation Company for the chartering of a ship, and the Company, which met all the requirements of the Committee with the utmost liberality and courtesy, offered their newest and best equipped vessel, the "Tagus," for the expedition. About 140 applications for berths had been received, and arrangements were almost complete when on March 5th, the Secretary of the Company notified the Committee that both the "Tagus," and an alternative vessel the "Nile," had been requisitioned by the Government as transports for South Africa, and that in consequence the Directors were no longer able to

guarantee a ship to the Association. An effort was then made to obtain a steamer from some other quarter, but the demands of the war rendered this very difficult, the only vessels available being much smaller than the "Tagus." The majority of the members who had applied for berths on the "Tagus" were unwilling to travel by a much smaller boat, and the project of the Association engaging a steamer for the sole use of its Members necessarily fell through.

Under these circumstances it was clear that members would in general select their own routes to the zone of totality, and accordingly a number of little parties were arranged, travelling in different directions, and for the most part without seeking any assistance from the Eclipse Committee. Messrs. T. Cook and Son, however, approached the Committee to know what arrangements would be most likely to meet the needs of astronomers going out to observe the eclipse, and arranged two tours in consequence, the one to Talavera and Navalморal, and the other to Algiers, both of which were joined by several of the members, and were found most convenient by them. And the Orient Steamship Company, and the owners of the steam yacht "Argonaut," formerly the "Norse King," both ran excursions intended to help those who wished to watch the great sight.

On the day of the eclipse, then, the members of the Association found themselves distributed for some 5000 miles along the belt of totality. The first party to be enveloped in the flying shadow, as it swept across the earth's surface with a speed of 2000 miles an hour, was that accompanying the Rev. J. M. Bacon, M.A., F.R.A.S., and which was stationed at Wadesborough, North Carolina, U.S.A. Totality was over for more than two hours with Mr. Bacon's party before the shadow reached the next observer, Col. E. E. Markwick, F.R.A.S., whose station was a moving one (if a somewhat Irish expression may be allowed), being on the deck of R.M.S. "Austral" of the Orient Line. Reaching *terra firma* again, the first town in the shadow belt was Ovar, where Mr. G. F. Chambers, F.R.A.S., Mr. W. B. Gibbs, F.R.A.S., and Mr. F. Lys Smith had taken their place. The Rev. Augustin Morford also observed from Ovar, and the Rev. H. P. Slade from Estarreja, six miles further south. Crossing the frontier into Spain, the shadow next passed over Plasencia, where three little companies of members of the Association were staying. The first of these was an Irish contingent, nine in number, but two only, Dr. and Mrs. A. M. W. Downing, report to this volume, the remaining members of the party having come out in connection with the Royal Irish Academy and the Royal Society of Dublin, and reporting to those bodies. The other two parties in the immediate neighbourhood of Plasencia were, one headed by Mr. T. Weir, Secretary of the N.W. Branch, and the other composed of Mr. T. W. Backhouse and Mr. Irwin Sharp. At Navalморal a considerable party came down by train from

Madrid, arriving on the ground just after the partial phase had commenced. Of the work of this party, seventeen in total number, including two who stayed at Talavera, Mr. C. T. Whitmell, M.A., F.R.A.S., President of the Leeds Astronomical



PROF. C. A. YOUNG AT WADESBOROUGH, N.C.

Society, has sent in a most careful and well-arranged report. Manzanares, in the country of Don Quixote, was occupied by three observers, Mr. H. Keatley Moore, Mr. F. Gare, and Captain Alfred Carpenter, R.N., D.S.O., F.R.Met.Soc.; whilst the last station in Spain, Elche, was selected by an exceedingly

well-organised and capable party, eight in number, who report through Mr. E. W. Johnson. Crossing the Mediterranean to Algeria, the shadow passed over the City of Algiers, where by far the largest number of our members were stationed. Of these a large party, under the leadership of Mr. E. Walter Maunder, made the Hotel de la Régence at once their home and their observatory. A smaller party took up their residence at the Hotel Continental, in Mustapha Supérieur, most of them observing the eclipse from the roof of the hotel, but a few going to the house of the Vice-Consul for that purpose. S.S. "Argonaut" arrived in Algiers on the morning of Sunday, May 27th, and its passengers divided into two principal parties, the one under the leadership of Colonel A. Burton-Brown, R.A., F.R.A.S., encamping on Cemetery Hill, above the town, and the other steaming across to Cape Matifou, the N.E. horn of the Bay of Algiers, where totality was about three seconds longer than in the city itself. The general observations from this party were collected and sent in by Mr. H. Krauss Nield.

Every arrangement must necessarily be exposed to the drawbacks of its conditions. Thus in the Lapland Expedition, of 1896, we had thoroughly appreciated the immense advantages, for the purposes of organization, which our being all together, on a single vessel, and at the same station, conferred upon us. But we also felt that we were running a serious risk, a risk which, however, we could not avoid, in thus resting all our chances on the weather at a single spot, and our apprehensions were realised when the weather at our selected station proved hopelessly cloudy. In 1900, we were so widely scattered that we had no fear at all of the weather proving bad in every case; but as by most unusual good fortune it was everywhere exceedingly fine, the disadvantages attending our scattering have been rather more apparent. There was no possibility of arranging the whole scheme of work on a single plan; the best that could be done was for each separate party to make as efficient a distribution of the observations within their reach as they could. This was done, and in several instances with most conspicuous ability and success, but it was quite out of the question to arrange a common programme for the whole. It resulted, therefore, that there was necessarily a great deal of repetition between various reports, and it was impossible to print these as they stood, excellent though they were as records of the work of the separate stations. It has been, therefore, thought well, whilst giving the actual narratives of the several parties, one by one, to combine their results under the various lines of work.

In the previous Eclipse report of the Association—"The Indian Eclipse, 1898"—a short historical sketch was given of the principal lines of eclipse research; there is no need, therefore, to repeat these facts in the present volume.

It is interesting to remark that beside the members who have contributed to this report, not a few of the most distinguished members of the Association observed the eclipse of

1900 in connection with the expeditions of other learned bodies. Without giving an exhaustive list, we may mention Professors Barnard, Burckhalter, Hale, Pickering and Young amongst American astronomers; Mr. F. W. Dyson at Ovar; the Irish astronomers, Sir Howard Grubb, Dr. A. A. Rambaut, and Mr. W. E. Wilson, at Plasencia; at Santa Pola, Dr. Ralph Copeland, Mr. A. Fowler, and Mr. T. Heath; in Algeria, Herr Archenhold, Herr Leo Brenner, Mr. John Evershed, Major Kingsley Foster, Mr. H. F. Newall, Prof. P. Tacchini, Prof. H. H. Turner, and Mr. W. H. Wesley.

One feature of our various eclipse expeditions, a feature common to them all, it is impossible to pass over without recognition. They took place at a time when there was not a little irritation and stress between Great Britain and many other nations. The Continental Press in general, and to a considerable extent that of America also, was full of unfriendly remarks upon us; nor were the replies of our own newspapers always above criticism. If we had formed an opinion of the state of international feeling from these and similar political writings, we should have concluded that we had little to expect in the way of assistance or kindness from those with whom our expeditions would bring us into contact. But our actual experience was the very reverse of this. The record of our Members at each and every station, whether it was in the United States, in Portugal, Spain, or in the French colony of Algeria, was that they received in every case the fullest and most considerate courtesy; indeed, much more than that, the most liberal and generous help. To our many friends, therefore, official and private, in these different lands to whom we are so deeply indebted, we offer our warmest remembrances, and our most grateful acknowledgments of their kindness.

## CHAPTER II.

### WADESBOROUGH, NORTH CAROLINA.\*

OUR good fortune began with our outward bound boat. It was something to be on board the largest ship afloat in all the world, two only excepted, to have a deck to walk on approximately a furlong in length; to have as a floating home the finest vessel that has ever entered London water, and perhaps the steadiest that has ever crossed the Atlantic. Such was the "Minneapolis," in which we were allotted the first pick of cabins by priority of booking. And here again was something to be proud of—viz., that a party of amateur astronomers, seven in all, had been fired with zeal enough to anticipate the inevitable crush that the Paris Exhibition would cause, and to bespeak berths out and home again many months ahead, to map out a journey of some 9,000 miles extending over more than seven weeks, and all merely to gain somewhat better conditions for witnessing an Eclipse which all other European astronomers were content to observe from their own side of the Atlantic.

But an increased probability of clear sky, the gain of 20 or 30 seconds in the duration of totality, and greater altitude were in our case strong temptations, and so it came about that the early days of May saw us in the full enjoyment of an ideal voyage, discussing and preparing for the work before us through long luxurious days, and at night under the broad moon watching the prow ploughing its silent path through the black water on into the west.

But at last there came a check; somewhere south of Newfoundland, where we entered the track of icebergs and where soundings showed in place of mud a shifting bed of sand. Here we entered fog, deep and darkening fog, so that ere Sandy Hook was reached, we had to drop anchor and lay to till better times should come.

It was then we began to fairly realise the game of hazard we were playing. There were but nine clear days before the Eclipse, in which brief space we should have to convey ourselves and our heavy instruments 1,000 miles over land to a retired spot far down in the Southern States and virtually unknown to the world at large. Moreover we were made to feel that our mission was, as far as any practical work was concerned, doomed

\* By the Rev. J. M. BACON, M.A., F.R.A.S.

to complete failure if during the critical 90 seconds of time the sun should be covered with but a thin veil of such vapour as was now blotting out the sky.

Fogs, however, are often subservient to a certain magic influence, and this proved to be so in our case. Some sudden change presently took place in atmospheric conditions. The slight breeze went about and intruded itself unexpectedly through an opposite porthole. Someone, supposed for the moment to have lost his senses, cried that he had caught a glimpse of land, and then all in five minutes a broad stretch of the American coast was outlined ahead, and the steam capstan was already at work grinding up the anchor.

An hour later all our bulky instrument cases—save one of which more anon—were ranged along the Custom House stage where an altercation took place which the officials concerned would have done well to have dispensed with. By a special act of courtesy on the part of the U.S. Government I was possessed of authority to have all scientific instruments freed of the Customs; yet someone in office that afternoon insisted that the cases should be opened and scrutinised in the usual manner. This caused a delay of some precious hours, and also a visit to the British Consul on Monday morning, when after three hours of hard work in interviewing officers, making statements and getting signatures I repaired accompanied by the Vice-Consul himself to the obdurate Custom House agent, only to find that that official had come to a better frame of mind and had passed everything without inspection that morning by break of day.

But the railway authorities more than made up for the unwarrantable annoyance and delay caused by the ministers of red tape. With frank and ready generosity, for which I have no adequate words of praise, the Pennsylvania Railway Company regarded us in the light of a scientific party engaged on a duly recognised mission. As such we were to be privileged individuals and worthy of being accorded that courtesy and kindly reception which nowhere on the face of the globe can be shown with greater open-handedness than in America.

I record it with equal gratification and gratitude that by nightfall of the second working day after landing, my daughter and myself, as pioneers, were berthed on the fastest train going south with the whole of our heavy freight on board, and the whole of it booked free of all charge whatsoever right to our destination in far N. Carolina.

Never shall I forget the luxurious feeling of relief and refreshment as the night express steamed away from New Jersey, and, gathering speed, caught the cool night wind through the sleeping fragrant country.

At Washington we were joined by our chief colleague, Mr. Nevil Maskelyne, F.R.A.S., to whom a terrible mischance had occurred. He was the designer of the kinematograph telescope, the film of which had been mysteriously stolen when in my

custody at the last eclipse in India, and now by another strange fatality the optical part of the same instrument was missing, having by an oversight never been shipped in London, and thus a second time this novel instrument seemed for the moment doomed to failure.

But our unrivalled mechanician, whose genius is so well known to every frequenter of the Egyptian Hall, had already determined on the Herculean task of manufacturing an adequate telescope and fittings from selected photographic lenses, and of completing the work within the three or four working days that

Mr. and Mrs. Maskelyne.

Miss Bacon.

Mr. Dixon.



Miss Woolston.

Miss Dixon    Rev. J. M. Bacon.

B. A. A. PARTY AT LUNCH, KLONDYKE HOTEL, WADESBOROUGH.

at most would be at his disposal. The endeavour was like that of a sailor attempting single-handed to rig a jury mast under stress of weather when his main mast had gone by the board; but our friend faced it, and so, having caught us up, was hurrying down to the front with a jaded look, in sooth, but with set purpose in his eye.

That night I saw a strange sight. We were running through low lying forest land in Southern Virginia, already 800 miles nearer the Equator, where the air had grown palpably hotter and more sultry, and multitudes of frogs were croaking round with a strange rattle in their throats. The stars were beginning to grow bright and many, when suddenly in the sky from about



the region of Scorpio I saw a burst of meteors twisting in erratic courses much as I had seen them in fewer numbers on a memorable occasion from a lofty balloon in the early morning of the last Leonid shower. I shouted this intelligence aloud that all the Pullman car might hear, meeting, however, only with a rebuke from our dusky and amused conductor, "Dem are lightning bugs, sar!" Of course they were, but I must be held blameless, for this was the first time that I had seen a fire-fly.

At six o'clock on the morning of the second day our train pulled up at our destination, a little forest clearing, where there was a modest range of wooden sheds. There, however, was nothing to indicate that we had arrived at a spot of any consequence, and yet in truth this was the railway station of



B. A. A. CAMP, WADESBOROUGH, N.C.

Wadesborough, N.C., a little township which, for the time being, was exalted to one of high importance in all the States, and this fact was soon impressed upon us. A steady climb of a mile by pine woods and cotton fields now brought us to our hotel, where we found ample accommodation reserved for all our party and breakfast already waiting.

Half-an-hour later we received a personal visit from Professor Young, and then at last we began to realise the extent of our good fortune, and how much true kindness and hospitality was being lavished upon us. On the opposite side of the little street, drawn up under the shade of the wooden houses, was a pair-horse carriage, which by an act of extreme generosity on the part of the residents had been engaged to be at our disposal through the whole of our stay. For the rest, Professor Young assured us we should learn more if we came to his camp after

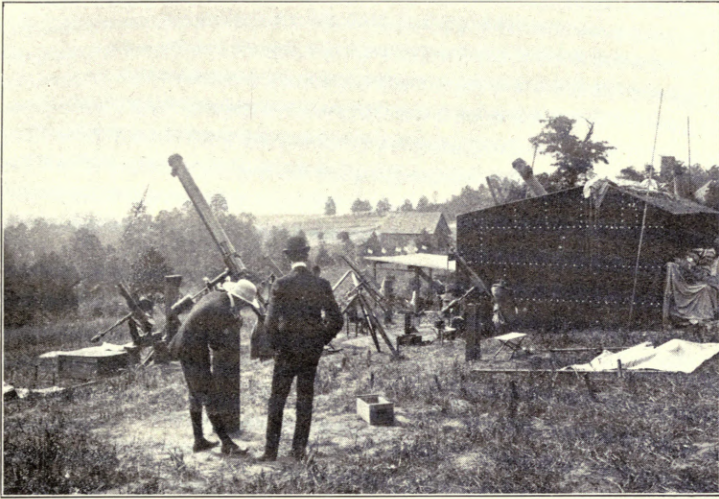
breakfast. And this was certainly so. We learned that everything had been thought out by the Professor himself for our benefit and comfort; that a portion of his own specially selected site had been reserved for us, and that a carpenter was already in attendance to receive our instructions for the erection of a suitable shed.

I shall have to say so much more about Professor Young before I have done that I had better give some description of his observing station in which we found him already fairly established. This occupied the highest ground around, being a field well removed from habitations, and open to the southwest, in which direction an uninterrupted view was obtained over a broad valley sloping upwards to the distant sky-line. A substantial wooden building had been erected for photographic purposes and to house the larger instruments brought from the Princeton Observatory, while the rest of the extensive equipment was ranged without on the southern front. It was all a fair sample of what American astronomers could and would do on their own soil, but we were to see more.

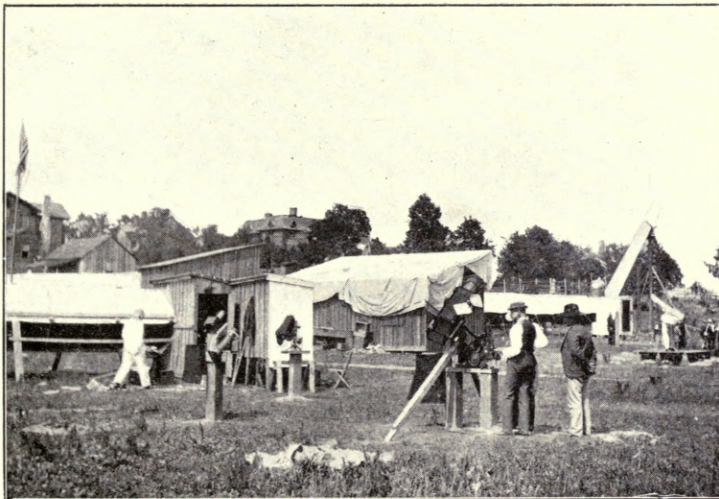
A quarter of a mile away in another enclosure was the station occupied by the chiefs of the Smithsonian and Yerkes Observatories. Professor Langley had not yet arrived, but Professors Barnard, Hale, Abbot and others had for a long while been at work on preparations which were being carried out on a giant scale, and it was easy to credit, what Professor Young claimed, that no such equipment had ever been brought together at any one station to serve in the observation of a Total Solar Eclipse.

They do things smartly in America. On arriving at Wadsworth Station we found that, notwithstanding the rapidity with which we had made our long journey, our heavy instruments had already arrived before us, and now it was our only care that they should be conveyed promptly up the long slope that led to our chosen ground. How would it be done? we asked, for our packages were awkward and heavy. At this our carpenter stepped forward and asked if they were more than seven tons, for he had already conveyed that weight of precious instruments for the American party. When I replied that they were less than seven cwt., our friend promised that they should be delivered in half-an-hour, and he was as good as his word. And next, by some magic not surpassed in the days of Aladdin, our observing hut sprang into existence while our backs were turned, and we had only, so we thought, to knock the lids off our cases and set all shipshape.

But in this we were wrong. We had forgotten to reckon with the heat. It was late May in the Southern States, and the sun, in lat.  $35^{\circ}$  N., blazed down in a way we dreamed not of. Professor Young warned us that we should not at once get accustomed to the heat, adding for our comfort that several out of the various camps had already knocked up and been in the doctor's hands.



PRINCETON OBSERVATORY CAMP, WADESBOROUGH, N.C.



YERKES OBSERVATORY CAMP, WADESBOROUGH, N.C.



But in spite of little twilight there were daylight hours early and late when work could and did get on apace, and when two days later the rest of the party joined us preparations were fairly advanced. Mr. N. Maskelyne was still slaving at his stupendous task which was eventually crowned with complete success. Mrs. Maskelyne kindly took over the management of a clock-driven actinometer which at my desire her husband had designed. Miss Woolston elected to confine her attention to photographing the Corona, Miss Dixon took charge of the opera glass spectroscope, the same instrument that she had used at the eclipse at Buxar, Mr. G. Dixon, whose skill as an operator is second to none, essayed single handed to take photographs of the Corona with a three inch o.g. by Dollond, and with a tele-photo camera. My daughter was provided with a battery of four cameras, with which she proposed to photograph the outer extensions, using Dallmeyer and other lenses ranging from  $f/6$  to  $f/12$ . I myself was using the same telescopic camera of 4.1 o.g. with which my son had successfully photographed the inner Corona at Buxar. Other work of a minor character was also undertaken, and the day before the Eclipse our camp unexpectedly received the addition of Mr. Hadden, an American member of the B.A.A., using a three inch equatorial refractor.

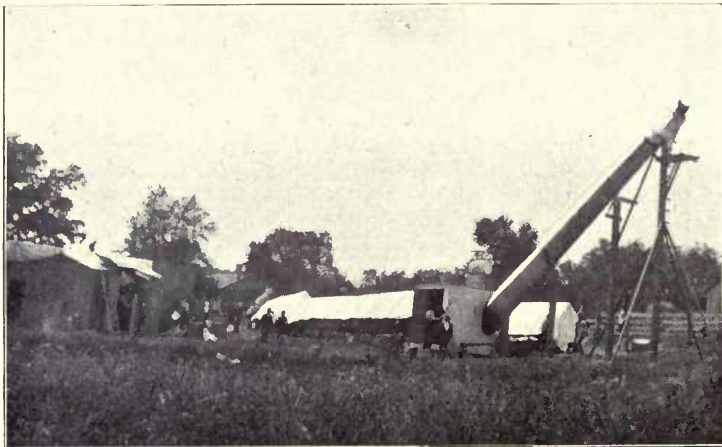
But our occupation was not all work. Recreation and social intercourse claimed their share. All the principal residents not only called but seemed to vie one with another in showing all hospitality and loading us with every kindness. Special entertainments were got up among the ladies, and prospective pic-nics and other convivial gatherings were arranged for our benefit.

In acknowledgment of these many acts of kindness the astronomical party generally, as visitors, agreed on inviting all the residents to a gathering in the Opera House, at which the entertainment should be an astronomical lecture followed by speeches from the platform by representatives of the various camps. This entertainment mooted at a late period of our stay was only finally decided on during the morning preceding the Eclipse, so that it became necessary that it should take place that same evening. But this is notice enough for a successful gathering among the hearty genial and united Southerners. Judge Bennett, principal among the inhabitants of Wadesboro', kindly consented to preside, and then the telephone was put in requisition, with the result that at 8 p.m. the hall was filled to overflowing with a representative and enthusiastic audience. It is needless to say that the lecture improvised by Professor Young was one of great ability and interest, after which Judge Bennett and Professor Hale addressed the meeting, and it fell to my own lot to speak on behalf of the English visitors.

Of Wadesboro' itself little need be said. It possesses 2000 souls and is a thoroughly typical township of the Southern States, high and healthy, with clean and busy streets, and picturesque

houses mostly wooden. The coloured natives are cheery, good-natured willing folk, and as servants most attentive and obliging. Some too would seem to relish the opportunity of waiting on English visitors, the more so when they chance to be members of an Eclipse party, or (in their vernacular) "Clippers." The dusky but excellent chamber-maid who waited on the ladies of our party, was overheard in enthusiastic colloquy in the passage with a bare-footed laundress; at length, incapable of repressing her feelings, she threw open the bed-room door exclaiming, "See my ladies! Aren't they sweet!"

The work of the Eclipse day and its results are sufficiently treated of elsewhere. Weather conditions were wholly in our



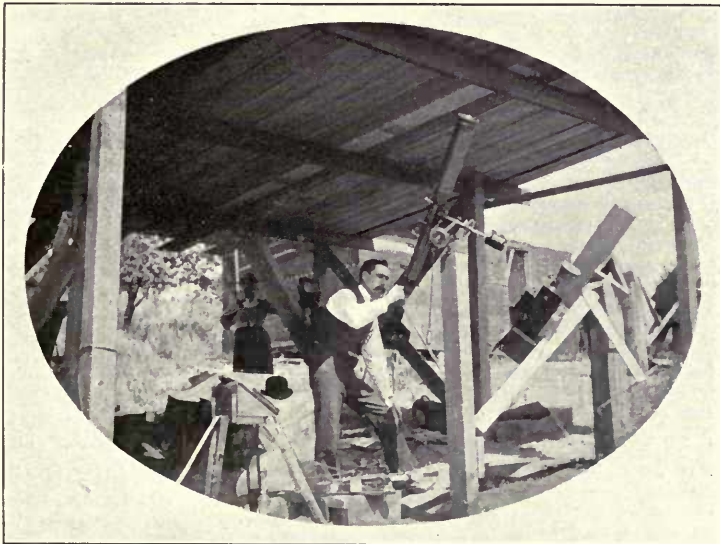
CAMP OF THE SMITHSONIAN INSTITUTE, WADESBOROUGH, N.C.

favour; a sky brilliantly clear, and a steady atmosphere with almost entire absence of wind. Special trains from far afield arriving early brought an immense concourse of visitors, and every vantage ground became occupied with crowds of eager observers. The admirable arrangements, however, made by Professor Young secured perfect privacy to ourselves, and barring slight accidents which did not affect the general success all things worked smoothly and well. In spite of our extended horizon the shadow was not seen by ourselves either on earth or sky, nor had we leisure to look for shadow bands. The Coronium line was also missed, but other observations were satisfactory, and the photographic results very successful. The total phase appeared lighter even than at Buxar, and this may in part account for the absence of any prolonged extensions

as observed or photographed. Mercury and Venus were of course well seen, but looking for visible stars did not enter into our programme.

The Eclipse over, the work of dismantling the various observatories went on with amazing expedition. Farewells, many and hearty, were exchanged, and in two days we were once again pursuing our travels intent on seeing as much as could be seen of the New World in the space of three weeks.

But our experiences from the astronomical point of view were not yet ended. Yielding to an invitation urged upon us with unexampled kindness by Professor Barnard, our whole



MR. HADDEN, F.R.A.S., WADESBOROUGH, N.C.

party, Miss Dixon only excepted, proceeded to Williams's Bay, where under the Professor's hospitable roof we enjoyed two days, perhaps the happiest of all we spent in America. It might be difficult to decide whether, out of all that impressed us most in our travels, Niagara must stand first or the Yerkes Observatory. Somehow at night the sight of the big dome outlined against the stars appealed to one somewhat as did the Taj at Agra, perhaps arousing kindred feelings.

But our view of the Yerkes Observatory was not restricted to the outside. For one very precious hour we were privileged to see through the great telescope some of the wonders that its peerless glass reveals, objects to see and dream of ever

after, nebulae and clusters ending up with Messier 13. Perhaps what strikes the visitor most about the great observatory is its completeness—the many departments where provision is made



PROF. AND MRS. BARNARD AT HOME, WILLIAM'S BAY, WISCONSIN.

for experimental and mechanical work of all kinds; the photographic rooms, the library, the laboratories and workshops, and, not least, the power house with its monster engines whose might is so wondrously manifested about the telescope. At the touch





of a handle the huge dome starts whirring round. Again a lever is depressed, and, as with a convulsion of nature the entire floor, ninety feet across, with all upon it, goes mounting skyward.

All this will long dwell in our recollection, but our most abiding memory will be of the home where at the hands of Professor Barnard and his charming English wife we learned all that true Southern hospitality means. Here is an ideal retreat, for one whose whole life is given up to his work;—a luxuriant garden of Nature's own planting, where the sumac is the undergrowth, and flowers, prized in English borders, grow as weeds. On the one side stretches the wide reach of Big Foot Prairie, on the other, far below, lie the blue waters of Lake Geneva. I cannot recall the scene without picturing a calm, clear evening with the light of the after-glow already fading in the west, and in the distance the retreating figure of a man, nearing middle life, yet hurrying with all the activity of vigorous youth across the grass to his long night's labour.

J. M. BACON.

## CHAPTER III.

### AT SEA. \*

It was with some little trepidation that I decided on viewing the total eclipse of the sun from the deck of the R.M.S. "Austral" of the Orient line, which was duly advertised to sail from Plymouth on the 26th May, and to be so navigated as to be on the centre line of the shadow track at the right time. The arguments inducing hesitation, that is to say, "*con*," were: chance of delay in the ship's getting away; chance of fog or rough weather while on the voyage which might cause delay; chance of a slight error in the navigation of the ship; and, finally, chance of a cloudy sky at a critical time. The last objection of course applies equally to *terra firma*. I do not add impossibility of using a telescope on board ship as an argument against going, as I purposed viewing the eclipse in its entirety, by means of naked eye or binocular only.

On the other hand, the arguments "*pro*," or in favour of going, were:—an assurance from the Orient Company that, barring accidents or fog, they saw no difficulty whatever in carrying out their programme; the comfort of observing from the splendid promenade deck of a liner; the facility with which I could embark at Plymouth within an hour from my own house; an invitation from a brother officer to spend a few days at Gibraltar, where I should await the next steamer back to England; and, finally, I may add, economy, as compared with the cost of a trip overland to Ovar, Algiers, or other points on *terra firma*.

My wife thought I was embarking on a "wild goose chase," but even this form of sport *sometimes* results in success. So I made up my mind to risk it, as even if I saw nothing, a short sea trip after a long spell of worrying official duties would do one no harm, to say the least of it.

The complete success of my trip, as it turns out, has, I think, justified me in my venture, for "nothing succeeds like success," and I may be congratulated on the good luck and management which attended the voyage. My chief object was to see as much as I could of the Corona in a good binocular, without encumbrance from any routine work whatsoever.

\* By COLONEL E. E. MARKWICK, F.R.A.S.

The steamer arrived well up to time in Plymouth Sound, and I embarked at 2 p.m. under a lovely sky, when the surroundings of the vicinity, Mount Edgcumbe, Staddon Heights, etc., looked their very best in their delicate spring greenery.

Before leaving, I obtained a copy of the excellent "Nautical Almanac Circular, No. 17," from which I deduced the circumstances of the eclipse for the position:—

Long. W. 9° 27'  
Lat. N. 41° 3'

these being the co-ordinates of the point at which I assumed the ship's course, as ordinarily taken, off the coast of Portugal, would intersect the centre line of totality. I then calculated the times of the different phases from the formulæ given at p. 8 of the above mentioned circular. Also I got them graphically from the map therein given, taking the data for the positions: (1) Near Ovar, and (2) S.W. of Talavera de la Reina, and by rule of three working them for (3), the ship's position. Taking the mean of these results, which agreed to a minute, I got the following:—

	h.	m.	s.	
Eclipse begins	2	41	24	} G.M.T.
Totality "	4	0	24	
" ends	4	1	55	
Eclipse "	5	12	21	
Duration of totality	0	1	31	

On arriving on board I soon found that only one other amateur astronomer had come by the ship, namely, Mr. W. Broadbent, of Huddersfield, a member of our Association. Under the freemasonry of astronomy we became at once fast friends. Such is the power and influence exercised by the B.A.A. and its excellent Journal, for I had never seen him before.

My business now was to interview our courteous and able commander, Capt. A. J. Coad. I found we agreed exactly as to the longitude of our point of observation, and he at once accepted my figures for the latitude. I subsequently found from the rigorous positions given at p. 3 of the "Circular" for G.M.T. 4h. 0m. and 4h. 2m. that the latitude given above ought to be increased by perhaps  $1\frac{1}{2}'$ , but the correction was not applied, I believe, and the ship was worked to the position given above, which could not in any case have been more than  $1\frac{1}{2}$  miles out. I also communicated to the captain the time of the eclipse as above worked out, as he had no accurate data on this point.

Soon after leaving Plymouth the sky became overcast, and we passed through a fog in the night, when sleep was rendered impossible for a time by the sounding of our fog horn, and the reply from another boat not far off. Up to then the chances looked unfavourable; next day, however, we gradually worked out of the fog, and the sky later on in the day lifted and gave a good promise for the morrow.

The 28th turned out a really "perfect" day, both in a meteorological and astronomical sense; the sky deep blue, with a few "mare's tail" clouds about, all of which kept near the horizon, as if fearing to insult his majesty the God of Day, by interfering in the least with our vision of him. The sea was "deeply, darkly, beautifully" blue, and more, so steady, that we were on an even keel, and there really seemed little or no excuse for anyone to be ill. During the whole of the eclipse the sky in the immediate vicinity of the sun was perfectly clear of the slightest trace of cloud or mist, and, therefore, it was seen under the best possible conditions.

In the morning we passed the time by looking at Venus in the eastern sky. I found a tube formed by rolling up a number of "Knowledge," an excellent guide to others in catching the tiny white speck. The ship was so steady, I held this tube against a stanchion so that others could see the Planet "in the centre of the field" (rather approximately). The Orient Company had thoughtfully provided a considerable number of very conveniently sized pieces of good thick plate glass about 2 in.  $\times$  3½ in., and these were all duly "smoked" and distributed. I know of no piece of astronomical apparatus, however complicated it be, that fulfils its purpose better than the time-honoured "smoked glass." The very inequality in the distribution of the carbon on its surface allows a person to vary the brightness (or dulness) of the solar image exactly to his or her liking, and also (if necessary) to the varying state of transparency of the sky.

My apparatus was simple; in addition to my eyes I had one of the pieces of glass aforesaid, a dark solar eyepiece cap (belonging to a telescope) slightly smoked, one binocular magnifying 5 diameters with eyepieces smoked inside, another good binocular power about six, in its natural clear state, a deck watch, 5s. slow on G.M.T., note book and pencil. These were laid out on a travelling rug secured to one of the ship's seats on the open forward part of the promenade deck.

A gentleman (not of the B.A.A.) intended to take some photographs with a hand camera, and I agreed to call out "Now" in a loud tone just when totality had begun, so that he should not spoil a plate by beginning too soon. Another shipboard acquaintance promised to look on the deck for shadow bands, and he did so, but saw nothing of them.

As far as I could judge, the first indentation in the sun's limb was noted (just at the calculated point) almost exactly at the time given above. I soon discarded my smoked binocular and piece of glass for the solar cap, which, slightly smoked, gave me a perfectly sharp clear image of the sun, of a cool grey-green tint, but of course not magnified.

When we got to the time that half the sun's diameter should have been obscured, my friend of the shadow bands observed that he thought I was "too soon with my figures," as the half

diameter did not look quite obscured. This is an optical illusion, as was at once seen by a rough diagram drawn by the aid of a penny in my note book, and which I reproduce here, drawn more carefully to scale. Through irradiation and the peculiar shape of the crescent, it looks as if the dark body ought to be a little further upwards to the left, to bisect the solar diameter. Such is not the case, and, as it turned out, my figures for totality agreed within a few seconds with the observed times. Hence the above remark does not seem to have been justified.

So things went on, until the crescent got thinner and thinner, and when the last ray of sunlight flashed out, I called out



SUN'S DIAMETER HALF OBSCURED.

BY AN OPTICAL ILLUSION THE OBSCURED PART LOOKS LESS THAN THE BRIGHT.

"Now," and seized the clear binoculars. How can I describe what I saw, when it was so really celestial, and the time so short?

Very roughly the Corona was like a band or ribbon of light, stretching from left of up to right of down, about the same width as the sun's diameter, with comparatively tiny aigrettes shooting out at the solar poles. The band extended in the direction of the sun's equator, as far as I could judge from a rough sketch which I made a few minutes after totality was over. This sketch was made without a knowledge of the position of the sun's equator. At a glance I saw it corresponded very fairly indeed with the type predicted at p. 86 of the Eclipse Volume of the B.A.A. But the detail which my glass showed me was really

too entrancing. I cannot of course remember it all, or even any part accurately. What struck me most was an exquisitely shaped ray proceeding from the N.W. limb, and forming the principal N. boundary of the W. extension of the Corona. This was shaped like the boundary of one side of a hyacinth bulb, or an old-fashioned salad oil flask of glass. From the S.W. limb proceeded another ray, not quite so marked, but of the same general hyacinth bulb shape, forming the S. boundary of the W. extension. These two rays with the included Corona formed, roughly, the figure of the flame issuing from a grenade, worn as a badge by officers of the Royal Artillery. The rays of the E. extension seemed straighter generally, and did not exhibit at all so markedly the bulb-like form. Hence the "synclinal" groups of Ranyard would appear to have been more in evidence on the W. extension.

The short aigrettes or jets of the poles were very pretty, and with more time one could easily have located the solar poles with accuracy, as they divided in different directions over them, just as a man's hair does off his "parting," when parted in the middle of the head.

There was a brilliant prominence, principally white, with a touch of pink on the lower limb, that is, a little S. of the W. point. There were also smaller prominences which I had no time to note specially, but speaking generally the light all round the moon's limb was so bright I could hardly bear it in the binocular.

A wealth of detail was apparent all through the Corona, wisps and rays interlacing, which would have occupied one, say, a couple of hours, to draw carefully. Its general effect was far more tenuous and delicate than what I was expecting from the pictures and photographs I have seen. The general hue was pure white or greyish white; the sky was blue all round the sun, and the effect of the silvery Corona projected on it, was beyond anyone to describe. I can only say it seemed to me what angels' wings will be like. The time of totality seemed to me less than  $1\frac{1}{2}$  minutes, but one quite loses count of time, in looking at one of the Arcana of the Creator from which the veil is withdrawn for a few minutes. The sunlight flashed out, and the exquisite vision passed,—a vision which will be treasured up in the writer's memory as long as he is permitted to consider the heavens.

As my intention was to be a spectator rather than an observer, I did not note by the watch how long totality really lasted.

During totality I withdrew my eyes from the binocular to study the effect of the eclipse on the sea. It looked a dark indigo, or indigo grey, showing up very sharp on the horizon against the sky. The latter for some degrees above the horizon was to me a tawny yellow, with the "mare's tail" clouds inclining to ruddy. Others called the tint of the sky lemon yellow, but to me it was distinctly warmer and richer—more approaching to Indian yellow. A gentleman who was watching for the

shadow bands said that he observed the sea to change suddenly to a dark indigo a moment or so before totality.

I attempted to note the shadow advancing over the sea, but my attention was principally directed to watch the thinning crescent of the solar light, and I did not see anything of it.



PROMENADE DECK OF S.S. "AUSTRAL" DURING THE PARTIAL PHASE.

Neither did my friend just referred to above. It enveloped us suddenly without any direct visible evidence of its approach.

Mercury to the right and just below the sun was a blazing star; quite bearing out his character as I have often seen him in tropical or semi-tropical climes. Aldebaran and Sirius were seen by some on board, but I did not notice them, my attention being pretty well rivetted on the sun.

I have never seen a total eclipse before, but I should imagine

that this was a very bright one; that is, supposing the general illumination within the shadow does vary at different eclipses. However, a gentleman said he had great difficulty in making out the labels on his photographic plates during totality.

During the increasing and diminishing phases the bright crescents, or images of the sun, were studied on the deck, by crossing the fingers of the two hands, and allowing the sunlight to pass through the interstices. It was a curious and pretty effect, but was seen much better on a sheet of paper, the sun's image being thrown through a pinhole in another sheet. The sharpness and clearness of the tiny crescent was remarkable.

The temperature during the eclipse was observed to fall from 66° to 63° Fahr. The instrument used was not a very accurate one, but I should not suppose there would be an error of more than one degree in this determination.

I made the following rough notes:—At 32m. before totality there was a noticeable diminution in the light generally on the sea; also the temperature was thought cooler.

At 28m. before, it was distinctly cooler.

At 25m. before, the sea was getting a dusky purple tint.

At 23m. before, the crescent looked "uncanny."

At 22m. before, Venus easily seen.

At 18m. before, the sky looked a greyish blue, and the sea greenish grey, or greyish blue, according to different observers.

At 6m. before, the sky was lurid all round.

Totality was noted as over at 4h. 2m. 20s. G.M.T., it having ceased some seconds before.

Two or three gentlemen on board took photographs with hand cameras, and the instructions and information contained in the Eclipse Volume (taken by the writer as likely to be of use for reference, and much studied by him) gave them a good idea of what exposure to give, as they were not well versed in astronomical photography.

A lady on board, who had witnessed the eclipse of 1896 in Norway, informed me she was much disappointed with the Corona this time, as compared with what she had seen in Norway. It was neither so large nor so bright. This no doubt was due to the different types of Coronæ seen on these respective occasions.

I am inclined to the opinion that a total eclipse would, as a rule, be brighter on the ocean than on land, for the reason that outside the shadow spot on the sea there are no inequalities such as mountains and valleys which might to a certain extent dim the general light of the landscape surrounding the shadow on land. I fancy there are not many in a position to verify the correctness of this idea, as astronomers do not often go to sea for an eclipse. Yet I am very glad I did, and can never hope to have a more pleasant astronomical trip. For one thing, I am sure that the binocular gives a much better general view of the Corona than any telescope except a very small one would ever do,



and my faith in the little instrument after years of work with it is more confirmed than ever.

Before leaving Gibraltar I had the pleasure of meeting Sir Norman Lockyer, Dr. Copeland, Messrs. Fowler, Heath and others, who had returned from Sta. Pola per H.M.S. "Theseus," and were following on to England per R.M.S. "Cuzco."

And on my return voyage home from Gibraltar I was so lucky as to fall in with Messrs. Keatley Moore, Gare and Captain Carpenter, who were returning from Madrid. The composite drawing of the Corona produced by this party seems a great advance on what has been done before in this line.

E. E. MARKWICK.

## CHAPTER IV.

### PORTUGAL.

Two small parties proceeded to Portugal. For the first of these Mr. W. B. GIBBS, F.R.A.S., gives the following report:—

The expedition to Portugal consisted of Mr. G. F. Chambers, Mr. F. Lys Smith, and myself. The Rev. Mr. Joyce, the port chaplain at Southampton, a friend of Mr. Chambers, also accompanied us. We left Southampton for Lisbon on the 11th of May, in the R.M.S. "Clyde," which had on board the Astronomer Royal's party, and also Mr. Backhouse who observed in Spain. We arrived at Lisbon on the 14th, and there found a Government tender with Lieut. Pellen, who had been deputed by the Portuguese Government to meet us, and afford us any assistance we might be in need of. Our baggage and instruments were passed free through the customs, and also through the octroi, both at Lisbon and elsewhere, and railway season tickets over the whole railway system of Portugal were given to us.

We spent two days in Lisbon visiting the chief places of interest, amongst which we may notice particularly the church and monastery of Belem, erected as an expression of gratitude for the successful expedition of Vasco da Gama, whose tomb is within its walls. We then left for Leiria so as to visit Alcobaça, Aljubarotta, and Batalha, where in the magnificent chapel is the tomb of Prince Henry the navigator.

On arriving at Oporto several members of the English colony there afforded us splendid hospitality, and Lieut. Pellen informed us that Dr. Huet da Bacellar would be glad to receive us at Ovar, to stay at his house before and during the eclipse, but as we had several days to spare we took the opportunity of visiting Braga, the third city in the kingdom and the see of an archbishop, and Bom Jesus, a famous place of pilgrimage in the north of Portugal. On our return we paid a visit to Ovar, and arranged with Dr. Bacellar to view the eclipse from his garden, whence we had an unobstructed view. As excursion trains had been run to Ovar, and the town was full of holiday makers, we appreciated very much the facilities which had been afforded us. We had the pleasure of meeting there Dr. Jost, of the Heidelberg Observatory, who, during the eclipse, paid special attention to Mercury. Mr. G. F. Chambers and Mr. F. Lys Smith observed with small refractors. I had a Zeiss prismatic field glass, fitted with a photographic grating of about

14,500 lines to the inch, which performed splendidly. On the day of the eclipse the sky was fairly clear; there were a few very light cirrus clouds about, and a large halo round the sun, which from time to time broke up.

About a quarter of an hour before totality, the blue colour of the sky had sensibly deepened, and the brownish red on the inside of the broken portions of the halo appeared much more



VILLA NOVA, ON THE SOUTH BANK OF THE DOURO, OPPOSITE OPORTO.

vivid than in full sunlight. The shadows of the observers as cast upon the ground, notwithstanding their faintness, appeared very sharp, owing to the absence of penumbra. The darkness during totality was about the same as that of the Indian eclipse, and much less than that seen in Norway in 1896.

After the eclipse was over our party broke up, Mr. Chambers visiting the north of Portugal, Coimbra, and Busaco, whilst Mr. F. Lys Smith and I returned to Lisbon and embarking on the "Magdalena," arrived at Southampton on the 4th June.

Before closing this report I may perhaps be permitted to say that we were greatly struck with the richness of the Portuguese flora, which appeared to be a worthy rival of that of the Swiss Alps. The different species of mesembryanthemum, cistus, and lithospermum were in great profusion, and made a most brilliant show. The public gardens, and such private gardens as those of Viscount Cook, at Montserrat, and the Baron de Soutellino, at Oporto, were filled with the most beautiful specimens of tropical vegetation.

Our best thanks are due to the Portuguese Government, to the Geographical Society of Lisbon, to Senhor Marianne da Carvalho, to the Portuguese Astronomer Royal, to Lieut. Pellen, to Dr. Huet da Bacellar, to the Baron de Soutellino, and to Mr. and Mrs. Amyas Warre and Mr. John Warre for the help and hospitality they so willingly afforded to all the members of our party.

W. B. GIBBS.

At the same station, Ovar, were the Rev. AUGUSTIN MORFORD and Mr. NIELSEN, whilst the Rev. H. P. SLADE also observed the eclipse in Portugal, but from a station a little to the south of Ovar,—Estarreja,—and more nearly on the central line. Mr. Slade writes:—I arrived at Lisbon on Saturday, May 26th, in company with Mr. E. C. Boden, solicitor, of Ilkley, and found it unusually cold for the time of the year, much rain having fallen in the northern districts during the week. Happily the skies cleared, and we had a splendid view of the eclipse from Estarreja, six miles south of Ovar, where the terraced roof of one of the principal houses in the village had been kindly secured for us by the Administrator, Senhor Manuel Marques Tavares, who together with the other local officials, rendered us all the assistance which lay in their power.

We selected Estarreja for two reasons, viz., to escape the crowd flocking to Ovar, and because Mr. Boden believed that the totality at the former station would be greater than at the latter, a surmise which proved correct, 92 seconds being recorded by us as against  $84\frac{1}{2}$  by Mr. Christie, the Astronomer Royal of Greenwich, as we are informed upon apparently good authority. Not being in telegraphic communication with the Lisbon Royal Observatory, we had to find time by means of sextant observations. The eclipse began with us at 2h. 43m. 18s., and ended at 5h. 12m. 55s. Greenwich mean time. During the partial phase a few cirrus clouds at a great height threatened to interfere with the spectacle, but fortunately, at the critical moment, these passed over, and left the eclipsed sun in a blue sky. The appearance to the naked eye seemed to be annular, but on using the binoculars this was seen to be due to the inner corona extending all round the moon's disc in a perfectly even ring, shining like highly-burnished silver in an intensely brilliant light. From this, and

radiating approximately in the plane of the sun's equator, were four beautiful fasces, or sheaves of light, the lowest extending nearly as far south as Mercury, which planet was conspicuously bright.

During totality there was no darkness, but a resplendent twilight which covered earth and sky with fine chromatic effects. It was well worth coming 1000 miles to see.

On the whole the phenomena, although so beautiful, will not from its shortness bear comparison with many others of the same



FOUNTAIN AT OVAR, PORTUGAL.

kind. The corona, too, was not so striking as in many past eclipses, the sun having reached one of its periods of minimum solar spot activity, and being, therefore, in a comparatively quiescent state. Only three very small spots were observed on it, and the protuberances were consequently few and small, and the fasces did not extend any great distance from the sun's limbs.

In closing these notes we desire to express our warmest thanks to the Portuguese Government. They gave us a magnificent reception, franking all our instruments, lending army tents, railing off spaces for the various observing parties, and telling off guards to see to their general comfort and preserve privacy.

And, finally, they gave us first-class free passes over all the lines in Portugal, available for some days before the eclipse, and up to the middle of June. At Estarreja we were fêted and escorted to the station by the officials, and my friend Boden came in for a warm Portuguese embrace. We cheered them, and they cheered us, and the memories associated with the eclipse of May 28th, 1900, will not readily be forgotten.

H. P. SLADE.



## CHAPTER V.

### *MID-SPAIN.*

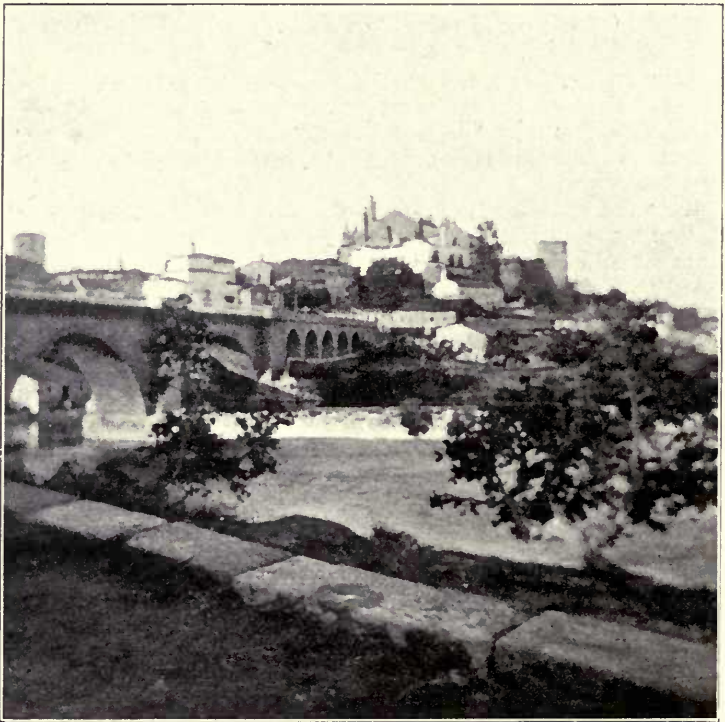
No fewer than five small parties took advantage of the railway line running south-west from Madrid, and passing through Talavera and Plasencia. Commencing with the most westerly station, Plasencia, Dr. A. M. W. DOWNING, M.A., F.R.S., reports:—

We had fixed on Plasencia, in the Province of Cáceres, as the place from which to observe the eclipse, both because it is a place where cloudy skies in May are the exception, and because we had learnt that the astronomers of the Madrid Observatory had arranged to go there, and their presence would carry with it certain advantages, such as a reserved enclosure—far from the madding crowd—and the communication to us of accurate Madrid time. My wife and I reached Plasencia on Sunday morning (May 27), and went to an inn to rest and have some refreshment. And such an inn! We were seriously considering the advisability of returning to Madrid, in the most expeditious manner possible, when we received a most courteous message from a Spanish nobleman—the Marqués de Mirabel—placing his palacio in Plasencia at our disposal during our visit. The Marqués, who was at his town residence in Madrid at the time, had heard that there was a lady in our party, and, thinking that the posadas in Plasencia were scarcely fit for a lady to stay in, had, with the most hospitable kindness, sent us his invitation, which we accepted with alacrity and gratitude. We were thus relieved from all anxiety as to matters of cuisine and accommodation, which necessarily press on the traveller in out-of-the-way places in Spain.

The observing camp was on the top of a hill called Berrocalillo, about a mile and half out of the town, which we affectionately called the "Mountain," it was such a pleasure climbing up to the top of it on a really hot afternoon! Here we found the British and Spanish astronomers amicably placed side by side. Here were Sir Howard Grubb, the world-renowned astronomical instrument maker of Dublin, and his son, Mr. Rudolf Grubb. Here also we found Dr. Rambaut, the Radcliffe Observer at Oxford, Mr. W. E. Wilson, of Daramona, Prof. Joly, the Royal Astronomer of Ireland, Prof. Bergin, of Cork, and Mr. Geoghegan, of Dublin. In all there were nine Irish observers,

including the lady of the party, on the mountain. Señor Iniguez, the Director of the Madrid Observatory, accompanied by Señor Ventosa, and other members of the staff of the observatory, were busily employed, up to the last moment, in erecting and adjusting their various instruments.

On the afternoon of the eventful day we toiled up the mountain, under a blazing sun shining in a cloudless sky, with



PLASENCIA, AND BRIDGE OVER THE RIVER JERTE.

the thermometer standing at  $83^{\circ}$  in the shade, so that we were pretty warm by the time we arrived at the top, and the first thing to be done was to rest and eat oranges. We then all got into position at our instruments, and had a couple of drills, going through the operations that were respectively to occupy us during the precious eighty-two seconds during which the total eclipse lasted. The first contact of the limbs of sun and moon was duly observed at 2h. 34m. Madrid time. Then we waited quietly for the great event. As the darkness increased the sky



and landscape assumed the weird appearance peculiar to a total eclipse of the sun, though there was more of a roseate hue prevalent on this occasion than is generally noticed. At one minute before totality a dog trotted past quite nonchalantly, but just afterwards a donkey commenced to bray vociferously, as if he thought that something strange was happening.

At 3h. 50m. the totality was upon us, but it was not possible



MILL AND MILL-STREAM, PLASENCIA.

to see the moon's shadow travelling towards us either on the ground or on the sky. In a few seconds, I, to whom the duty had been assigned, and who was watching with an opera-glass spectroscope, called "Go," as a signal to the photographers that they might commence exposing their plates. Then the corona burst on our sight, and Mercury was seen shining brightly near the sun's western limb, and so close as to obscure, to some extent, the view of the corona in that particular part. The corona was brighter than might be anticipated for an eclipse occurring

during the period when sun-spots are fewest, and any kind of artificial light for making notes at the time was unnecessary. The light was certainly considerably greater than that given by a full moon, but was, of course, of quite a different character. Before we could well realise that the eclipse had commenced I was reluctantly compelled to call "Close," as a signal to the photographers, and the total eclipse of May 28, 1900, was over. The corona was on this occasion of the general form observed in eclipses during times of sun-spot minimum. The great extensions were in the directions of the sun's equator, both on the eastern and western side, the former extension was bifurcated, but the latter could be traced further from the sun's limb, to a distance of about three lunar radii. Two large prominences were seen near the western limb.

The remainder of the day was devoted to social recreation. The Governor of Cáceres—a most courteous gentleman—accompanied by his secretary, had come to Plasencia for the day, and gave us the pleasure of their company, both at déjeuner and at dinner. During the latter function a band played in the courtyard of the palacio, and added greatly to our enjoyment.

But the crowning festivity of the day was the "English tea," given by my wife to the Governor, the Spanish astronomers, the British astronomers, and others. This was a great success, and excited the greatest interest amongst the Spaniards—the Governor, in particular, watching the process of making the tea, which had, of course, to be done by the lady herself, with the keenest enjoyment. We left Plasencia for Madrid the same evening, carrying with us a most vivid impression of the politeness and courtesy of the Spanish people.

A. M. W. DOWNING.

Two other parties of our Members observed the Eclipse from the neighbourhood of Plasencia. Mr. T. W. Backhouse, F.R.A.S., and Mr. Irwin Sharp, viewed the eclipse from the summit of a hill named Santa Barbara, about 2.6 miles E.S.E. of Plasencia, an admirable point of view for seeing the effect on the landscape, being one thousand feet above the town, 2207 feet above the sea. Mr. Thomas Weir, F.R.A.S., and his party selected their station on the east coast of the town.

Mr. WEIR's account is as follows:—

Clouds and rain on the Coast of Norway spoiled our view of the solar eclipse of 1896, and the remembrance of that experience contributed largely towards our deciding that the eclipse of 1900 ought to be observed from an inland station. Plasencia was, therefore, decided upon. Plasencia is a quaint walled town dating from mediæval times, with about 7000 inhabitants, pleasantly situated in the higher mountainous district of mid-Spain. It stands on the Jerte, a sub-tributary of the Tagus, and

lying about half way between Lisbon and Madrid can be reached conveniently by rail from either city. We preferred going by way of Lisbon, and when there had the pleasure of calling on the Portuguese Astronomer Royal, Senhor Frederico Oom, who received us in a most kindly manner, and showed us over his observatory. The principal telescope, a 14 inch refractor, is a fine serviceable instrument, and so also is the transit circle which is provided with a chair ingeniously contrived to adjust itself to any desired position of the body. By order of the Government, Senhor Oom had issued an illustrated handbook on the eclipse, which was being sold at a nominal price throughout Portugal.

The special courtesy of the Astronomer Royal was representative of the general consideration shown us by the customs, military, and other authorities with whom we came into contact. Our passport, and also a certificate from Mr. Maw, the president of the Association, which would doubtless have been of good service in case of necessity, were never opened; the magic word "Eclipse" or "Astronomer" sufficing to dispel all difficulties. In this connection one could not help thinking of the cosmopolitan character of science, and that if opportunities akin to the present were of more frequent occurrence, they would prove a not unimportant factor in the removal of jealousies and in the cementing of friendships between nations.

On arriving at Plasencia we found several members of the British Astronomical Association already there, and unwilling to disturb existing arrangements, decided—in company with an amateur astronomer from Madrid—to observe independently, selecting as a site the spur of a mountain, a few hundred feet in height, on the eastern side of the town. The day of the eclipse proved extremely favourable, being almost cloudless, and the sun, high in the heavens, was pouring down rays of intense heat, when we took up our position. We were not equipped for making observations of an original character, our main object being to witness personally, if not the most wonderful, certainly the most magnificent and most impressive, of celestial phenomena. We had in addition made provision for photographing the eclipsed sun, using a camera with  $2\frac{1}{2}$  in. lens; also, by means of a specially delicate thermometer to take the variations of temperature, and still further to watch for shadow bands, and photograph them should they appear.

The calculated time of first contact for Plasencia was 2h. 48m. 15s. p.m., Greenwich time, and ten minutes later it was apparent to the unassisted eye that the moon had encroached over the edge of the solar disc. No perceptible change of appearance in the landscape, however, occurred until about 3.15, when it was evident that comparative dulness had supervened and was gradually increasing. At 3.30 Venus was clearly seen and remained visible throughout the eclipse. 3.45 saw the duskiness advancing rapidly, and by 4 o'clock, or 5m. 27s. before the com-

mencement of the total phase, only a slender crescent of the sun remained, and things had assumed an uncommonly weird appearance. Notwithstanding our favourable situation, the passage of the lunar shadow was not detected by us, though we were conscious of being immersed in it: the semi-darkness, for there was no real blackness, came on suddenly, and during totality, computed to last 1m. 28s., everything terrestrial took on a cold

La Guidara. G. Jackson-Smith.



C. T. Whitmell. W. F. Stanley. Dr. Stokes. J. Buckley.

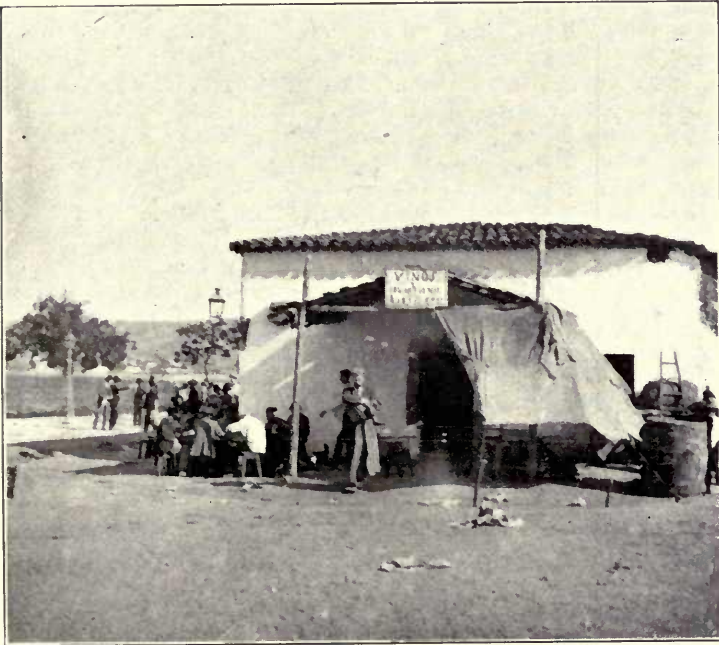
GROUP OF OBSERVERS, NAVALMORAL.

iron hue, altogether different from the gloom of evening. The distant town and more distant mountains were almost blotted out from view, whilst in the heavens above round the moon's black disc, as if by the touch of a magician's wand, there flashed out the corona in grandeur of form and of pearly whiteness. Mercury, too, in close proximity, shone with the brilliance of a miniature sun, and enveloping the whole was a halo of soft white light; a spectacle whose unique beauty words fail utterly to describe.

T. WEIR.

The next station after Plasencia travelling eastward which was occupied by members of the British Astronomical Association, was Navalmoral. Hither a party of seventeen in number, under the leadership of Mr. C. T. WHITMELL, F.R.A.S., came by a tour arranged by Messrs. T. Cook and Son; and to the willing and efficient services of Mr. La Guidara, their conductor, the party is largely indebted.

Navalmoral, a Spanish village of about 3800 people, is situated



E. Howarth.

WINESHOP NEAR NAVALMORAL.

120 miles W.S.W. of Madrid, in the valley of the Tagus, at an altitude of 984 feet. To the south the ground swells into low hills. On the N.W., N., and N.E., rises a lofty range (8730 feet) the Sierra de Grédos—the summits of which were patched with snow, although the shade temperature on the plain was nearly 90° Fahr. The ridge of the range on the N.W., at its nearest approach, is distant about 20 miles. To the W. and E. the country is open, and on the N.W., and N.E., there is a considerable stretch of low ground extending for perhaps 12 miles to the foot of the Sierra.

The conditions for observing the eclipse were in every respect favourable. The sky was clear of cloud in the morning, nor did the few light patches of cirro-cumulus which formed later in the day at any time pass in front of the sun, which shone uninterruptedly all day, with a penetrating heat that was somewhat discomforting to the travellers from more northern climes. Punctuality is not one of the virtues of the Spaniard, not even when the inexorable march of the planets permits no procrastination to those who wish to witness their movements. Though not surprising, it was certainly very tantalising to find that the train in which the observers travelled from Madrid was rather more than an hour late in starting, this being chiefly due to the very large number of Spanish people who wished to travel by it to see the total phase. It was some consolation for the delay to note the widespread interest aroused by the eclipse. The distance from Madrid to Navalморal is about 120 miles in a south-westerly direction, and owing to many stoppages it became a matter of some anxiety, before the journey was ended, as to whether they would arrive before totality began. Fortunately they were in ample time, though the first contact occurred whilst they were still in the train. Ten minutes before the calculated time of first contact, Mr. Howarth watched the sun through smoked glasses from the open window of the railway carriage, and at 2h. 48m. 40s. G.M.T. he noticed a slight flattening of the limb of the sun on the western side near to the lower edge. When the train arrived at Navalморal at 2h. 55m. the indentation caused by the moon on the sun's face could be plainly seen.

The majority of the party proceeded along the railway line till quite clear of the crowd, and took up their position in a field close to the line, and just below the village. The two large sheets for the shadow bands observations were spread on the north-western side of the railway track, which was raised some eight or ten feet above the surrounding ground, the railway metals running directly towards the then position of the sun. On the north-western side of the railway line the plain extended without any break in its surface to the base of the Sierra de Grédos, giving thus an uninterrupted view in the line of the shadow's approach.

Many thousands of Spaniards streamed out by excursion trains from Madrid, and grouped themselves about the hilly ground near Navalморal, in order to watch the eclipse. Even a bull-fight would hardly have secured a larger attendance. As the brilliant sun was blotted out, and darkness descended, an intense silence came over the assembled multitudes, awe-stricken at the weird solemnity, the incomparable grandeur, of the sublimest of celestial phenomena. Pent up feelings were relieved by the loud cheers which hailed the dazzling spark of reappearing sunlight.

Two members of the party, Mr. and Mrs. Constable, observed

the eclipse at Talavera, a considerable town 40 miles east of Navalморal.

On 26th May, whilst travelling by train from Toledo to Madrid, the sky being perfectly clear, I had an unusually good view of the earth's shadow. The sun set about 7h. 30m. p.m. to the N. of W. I observed carefully the disappearing disc, but saw no sign of the "green flash."

Turning after sunset to watch the eastern horizon, where Jupiter had just become visible, a slaty blue-grey segment of a circle appeared opposite to the sunset point, and rapidly increased in width and height. Its rising was, of course, consequent upon the falling of the now invisible sun. Fringing the segment was a rosy purple annulus, due to our atmosphere. This beautiful, but little known, phenomenon, is the Earth's Shadow. It remained in sight for, perhaps, half-an-hour.

From near Madrid, at 8 p.m. on 29th May, we saw for a few minutes, close to the western horizon, a very thin crescent moon, about 29 hours old. The geocentric elongation of the moon from the sun was nearly  $15\frac{1}{2}^{\circ}$ , so that only  $\frac{1}{55}$ th of her illuminated area was visible, the broadest part of the crescent measuring only some  $34''$ . Doubtless irradiation made it look larger.

C. T. WHITMELL.

## CHAPTER VI.

### MANZANARES.\*

THE earnest follower of any pursuit must early accustom himself to disappointment and failure: and of all pursuits he who follows astronomy: and of all branches of astronomy he who aspires to no higher rank than that of the humble eclipse sketcher: or so it seemed. For, when I undertook to organise a sketching party, the Association had a noble steamer at its command, and we started gallantly with a nucleus of four, two ladies and two gentlemen, to whom doubtless many more would have added themselves as soon as we met on board the "Tagus." But when war-necessities had robbed us of the "Tagus," and the Association was unable to carry through a fresh arrangement, all those probable accessions disappeared; and when the gentlemen determined to strike for the middle of Spain, the ladies' courage failed them; and the sketchers finally resolved themselves into two, Captain Alfred Carpenter, R.N., F.R.Met.Soc., and myself. For two men it seemed a heavy task, seeing that each would have to sketch his half of the corona in a minute. Capt. Carpenter, however, had had considerable practice in sketching coast lines on service in the East, and I had the advantage of experience of eclipse work. Since no photograph, except the famous Indian "long-tailed" one of Mrs. Maunder, has ever succeeded in giving a fair representation of the whole corona, it seemed necessary to make a serious attempt at sketching, even with such limited resources: so we bought white chalk and blue paper, and started. With us also went Mr. Francis Gare, whose photometric apparatus for measuring the intensity of the coronal light we took to India in 1898, where Mr. Ernest W. Johnson was very successful with it. Mr. Johnson was also working with it on this occasion at Elche, near Alicante, as well as Mr. Gare himself with us. Besides our sketching and our photometry we proposed to observe shadow bands and meteorological phenomena. It also seemed advisable, as we had the necessary materials, and knew how slight is the dependence to be placed on Spanish geographical accuracy, to ascertain the true position of our observing station. After some hesitation, we had fixed upon Manzanares; for excursions were running to the neighbouring

\* By H. KEATLEY MOORE.



Argamasilla la Alba from Madrid, and though Manzanares was not quite on the central line we sacrificed a few seconds to obtain that freedom and quiet which would have been impossible in the circumstances at the ever-famous birthplace of Don Quixote, and the prison of his creator.

We left London on 17th May in the "Britannia" (P. & O.), and had a delightful trip to Gibraltar. Here the contests with sharks, who disguise themselves as boatmen, dimly recalled those terrible *Kulis* in India. Our acquaintance with Spanish was only a few weeks old; and though it sufficed us to puzzle through a newspaper, it had an awkward way of breaking down on emergencies. We crossed to Algeciras, and went on the same day (21st) to romantic Ronda, through cork forests, aloe hedges, and the most lavish display of exquisite wild flowers that any of us had ever seen. It was night before we reached the glorious amphitheatre of mountains in which that ancient stronghold of cut-throats and smugglers is situated, now, alas, "fallen from its high estate, and weltering in" . . . respectability. Venus and Gemini in the west were exactly balanced by Jupiter and Scorpio in the east. Presently, in nautical phrase, Venus was observed to starboard, and Jupiter to port, and the whole world reeled in uncertainty. Examination by compass showed that we were in truth, as the planets indicated, steering due south; and at last kindly natives helped us out of our confusion by explaining that the mountain-peninsula of Ronda is only approachable from the north. It was for the moment, however, a trial of faith to make a steep up-hill journey true north and find oneself at the end of the day spinning down-hill due south!

The end of the next day saw us in the Alhambra, amidst all the magic of that unequalled place. The wealth of nightingales in the elms of the Alameda (whose planting we were glad to owe to the great Duke of Wellington) consoled us in the evenings when the architectural glories due to Yusuf and Muhammad V. were closed to us. The skies were spotlessly clear, the snows of the Nevada gleamed silver, and Venus nightly threw well-marked shadows across the path as we walked by the towers of the red palace (Alhambra) down the Cuesta del Rey Chico, or amidst the clipped cypresses of the grounds of the Generalife. We stayed, as probably all men do, to the last available moment: and when we left promised ourselves a longer stay "next time." Saturday, 26th, saw us amongst the narrow Moorish streets of Seville (where a stork adorning the pinnacle of a church was irresistible to our photographer), and very early on Sunday morning we were walking in Don Quixote's land of La Mancha, along the dusty road towards the country-town of Manzanares, unknown to the unknown. Two other members of the Association (Mr. David G. Simpson, F.R.A.S., and his son, Mr. D. C. Simpson), who had come out with us from England, parted company with us here, and went on in the train, bound for Toledo. We did not meet again till Gibraltar on the home-

ward journey. The *mozo* who carried our simple traps told us that there was but one inn at Manzanares, but that was irproachable. When we came to it we were rather taken aback by its exceeding simplicity, in spite of his warm recommendation—hotel-keeping was here reduced to the prime elements. There were, however, three guest-chambers, of a sort, opening one out of the other. We boldly entered the first, but hurriedly retired as a swartly hidalgo threw back his bare brawny arms to raise his head on the pillow that he might check the intruders on his rest. Urged by the chambermaid, and accepted by the hidalgo, we advanced: but we felt unfeignedly glad that our ladies had remained in England. Everything was equally rough, but it was clean; and the people were most kind in their endeavours



“EQUAL ALTITUDES,” MANZANARES.

to ascertain our wants, and to supply them, however queer they evidently were to them. Sometimes we ran aground, as for instance, in the article of butter. “Manteca de vaca?” (cow-butter)—there was none to be had for love or money; but “manteca de cerdo,” now, would that do? We agreed; only to find it simple lard (pig-butter). He who had most Spanish amongst us, armed with a dictionary, carefully dictated the components of each next ensuing meal: but what came of his daring endeavours invariably filled us with surprise, it was so totally unlike the intention. Still, while to some extent obliged to endorse the warnings of discomfort in country places in Spain which had so alarmed our ladies, we only suffered such humorous privations as formed materials for a good laugh; and, on the other hand, the genuine courtesy and friendliness of it all quite disarmed criticism, so that we left our rugged hostelry with

regret. On that Sunday morning, as soon as the inward and the outward man were refreshed, we sallied forth in search of the Alcalde of the town, Señor Don Pedro Antonio Caleros y Carrascosa. Every one in Manzanares seems to have a double-barrelled name, but curiously enough, one never hears it: for the particularly pleasant form of address in use hereabouts limits itself to the Christian name only. Not once was the Alcalde addressed as Señor Caleros; he was always "Don Pedro," to the humblest of his subjects. The British Embassy at Madrid had kindly caused word of our purpose to be sent to



THE "B. A. A." OBSERVATORY AT MANZANARES (LA MANCHA).  
CASTILLO DE PILAS HORRAS.

*From a Water Colour Sketch by H. KEATLEY MOORE.*

Manzanares, and we bore also about with us a large envelope with a huge seal, containing an authenticating letter from the Spanish Ambassador in London. Between the two, therefore, "Don Pedro" felt it necessary to summon the Town Council and see what he could do for us. They duly assembled, such as were not at church, and we endeavoured to converse, but with such embarrassing difficulty that until mass was over and there arrived amongst the rest of the council a professor of French to facilitate matters, we did not make much progress. When we at length obtained our honorary interpreter we were invited to state every possible requirement;

and the more we asked the more we were pressed to ask. The Alcalde promised to obtain for us the use of the Castillo de Pilas Horras, a detached old Moorish castle in the outskirts of the town, now used as a granary or storehouse—and we all went to see if it would serve our purpose. It was a great square tower with walls of massive strength, about 50 feet high, with a parapet surrounding a flat paved roof, giving uninterrupted views in every direction. There was some fun in the difficulties which beset the stoutest of us, as the whole council and its visitors ascended the narrow and ruinous stair passages in the thickness of the walls, but even the Alcalde arrived safe and dusty on the summit. Nothing could be better for our purpose. We observed some factory chimneys not far off, and spoke about their possible smoke on the eventful Monday. "They shall not smoke," averred the courteous Don Pedro: and—how it was contrived we did not know—they certainly did not. One hears of French politeness, but it is nothing to the politeness of the Spaniard when he sets his mind to it. Everything in Manzanares seemed to be at our service; half a dozen members at once invited us to make a home of the local club, a police escort watched to see our observations were not interfered with, a capital band of guitars came and serenaded us, every one was pressing us to pay visits and make excursions, and the general regret that our work necessitated so many refusals seemed quite genuine. One visit we paid to the wine-factory of Señor Quevedo was extremely interesting. The somewhat heady red wine drunk as *vin ordinaire* throughout Southern Spain (*Val de peñas*) is grown in this district. It is stored below ground in huge jars of old Moorish pattern, each of which stands in an alcove dug out of the solid rock: and of these double files of jars there are interminable corridors full. The wine presses, the great stacks of "husks" (skins, stalks, and seeds) the mighty metal tanks of spirit, all were on a colossal scale astonishing to see. The whole wound up with a charming *al fresco* supper in the twilight, with all kinds of tempting cakes and sweetmeats, and of course countless tastings of various wines and liqueurs made in the factory. Some of these were delicious, and some strong withal. Yet notwithstanding the national fondness for wine, and keen appreciation of it, drunkenness seems rare in Spain. We did not see one drunken person in Manzanares—and what was far more astonishing to any one travelling in Spain, not one beggar either. We pressed Don Pedro for an explanation of these phenomena. His reply was curiously convincing. There was no one in Manzanares who was so bitterly poor or so degraded as to beg: and as for drunkenness they had no time for such nonsense, he said: all the working folk had little vineyards of their own round Manzanares; and festivals and holidays, instead of being spent in drinking, served them as their only chance of a day's work on their own land now and then. Their regular occupation was with Quevedo or some of the other great vine-growers or wine-



CHURCH AND MARKET PLACE, MANZANARES.



CASTILLO DE SAN CERVANTES OUTSIDE TOLEDO.



makers of the district. But he was evidently very proud of the industry and sobriety of his town being such as to strike even the casual stranger. Manzanares is well supplied with electric light and with good water, both municipal undertakings; and we were condoled with because we were too soon for the opening of the *Plaza Toros* (Bull-ring) which was just being completed. Hitherto the bull fights have been held outside the church in the market place: and the only balconies available (beyond those of the houses round the space) were those which were erected two storeys high against the wall of the church, the buttresses of which were brought forward to serve as walls for them, a very quaint service for church buttresses to fulfil. We left Manzanares in a procession of the curious and extremely uncomfortable country carts (than which a Hindu *ekka* alone is more springless and backbreaking), the whole of the ayuntamiento coming with us to see us off. Our modest expenses at the inn were found to be already paid when we asked for the bill.

Our work at Manzanares, sextant observations, etc., usually brought a crowd round us. They seemed to think we were uncanny folk, but they never annoyed us in the slightest degree: more perfectly polite crowds were not possible. On eclipse day we were alone on our tower, save for four Spanish friends, every one respecting our request for quiet. Our observations are elsewhere recorded in this volume, and need not therefore be recapitulated here.

At Madrid, where we spent a few days, we did a little work with Señor Ventosa of the Observatory: and from him also we received great kindness and personal attention, still further emphasising the fine politeness which so characterises Spain. We managed to find time for a day at Toledo, and for another on our homeward way at Córdoba: and we wound up brilliantly at Gibraltar with a visit to the Mediterranean Squadron, where Captain Henderson entertained us on the "Isis." We little thought when peacefully lunching in his comfortable quarters that in a few weeks he would be hurrying his fine ship at full speed towards China, in the hope of saving British lives in deadly danger.

H. KEATLEY MOORE.

## CHAPTER VII.

### ELCHE.\*

WHEN the "Tagus" trip was suggested, I had proposed with my friends making Alicante our port of landing in Spain, for Elche, about 12 miles to the south, and almost on the central line of Eclipse; and in spite of the "Tagus" expedition eventually falling through, we still adhered to our original plan and decided upon Elche as our Eclipse Station: in fact we had already engaged rooms at the only Fonda in the place early in February.

Leaving England on the 10th May, on board R.M.S. "Egypt"—a ship familiar to many of us who went to India in 1898—our party consisted of only three members, Lady McClure, Miss Jessie McRae, and myself, but amongst the passengers were some who would observe the Eclipse at other places in Spain. We made the acquaintance of Mr. Franklin Adams, one of Professor Copeland's party, who was in charge of some of the instruments, and was to meet the remaining members of the Scotch camp, as well as Sir Norman Lockyer and his party, at Gibraltar. Here the cruiser "Theseus" was in readiness to convey them with all their instruments to Santa Pola, near Alicante, where we saw Mr. Adams again two days before the Eclipse.

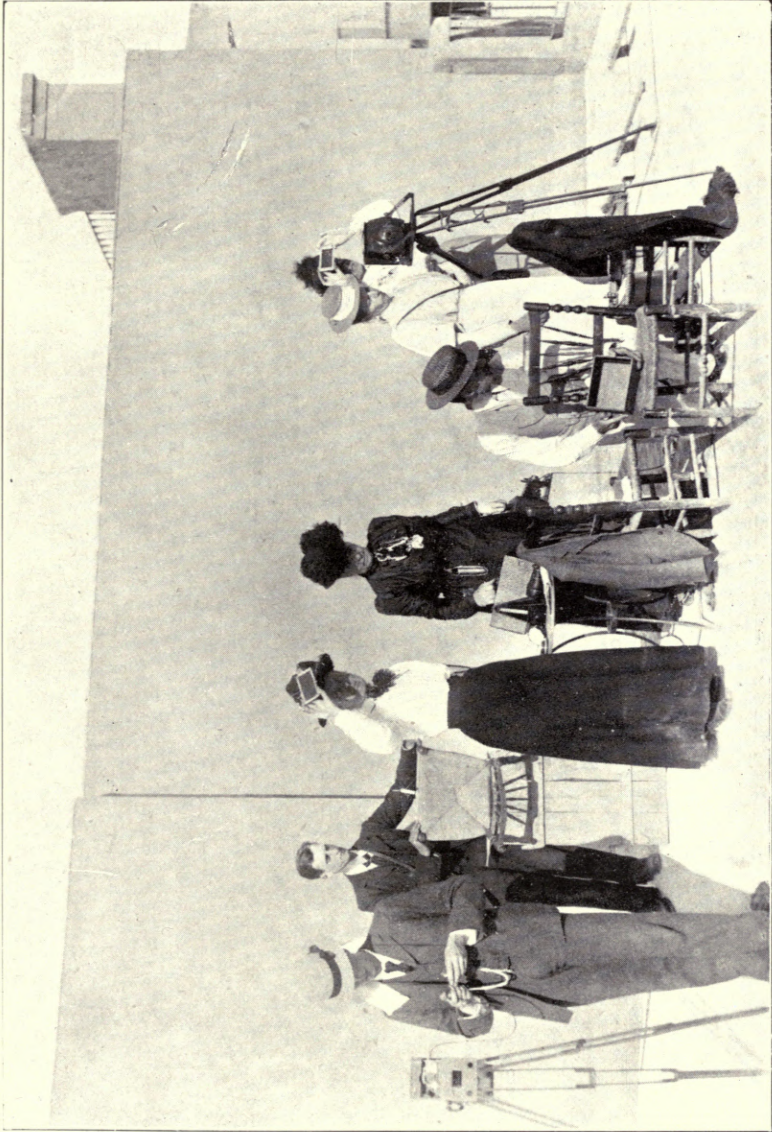
After a pleasant and quick passage, Gibraltar was duly reached on 14th May, and here all the Eclipse passengers disembarked and separated to their several localities; our own party going first to Ronda, passing *en route* most beautiful scenery through the famous Cork Woods, and two days later to Granada.

At Granada we stayed at the Washington Irving Hotel, on the Hill of the Alhambra, and close under the inner walls of that romantic pile, and here we met Mrs. Colman Willis and her family; one of her sons, Mr. E. C. Willis, being a member of the B.A.A. As they were also bound for Elche for the Eclipse, we decided to join forces and make one party.

During all this time we were somewhat dismayed at the weather, which had been most unsettled ever since we landed in Spain. Every day we had rain at some time, and generally in the afternoon at about the hour when the Eclipse would take place. At Gibraltar we were told by one of the inhabitants

\* By E. W. JOHNSON.





Mr. E. C. Willis, Mr. J. H. Willis, Mr. E. W. Johnson, Miss Willis,  
Miss J. McRae, Lady McClure, Miss E. Willis.

OBSERVERS AT ELCHE.



that even then, fourteen days beforehand, the Eclipse was exerting an evil influence upon the weather!! The wind was very boisterous, and the rain came down in heavy torrents for a short time every day, but the long intervals were bright and sunny.

From Granada we visited Seville and Cordova; at the latter place spending much time in the famous mosque of Moorish origin, a building that might well be ranked amongst the wonders of the world.

From Cordova we travelled to Alicante *viâ* Alcazar Junction, and arrived at Elche on Thursday, 24th May. This being Ascension Day, the inhabitants were all taking holiday, and as we approached the station through groves of palms, we noticed a vast crowd of people on the platforms, people who with nothing much to do, had come to see the train arrive and depart. Everywhere in Spain, in fact, the railway station seems to be the general meeting place for gossip of all sorts.

Elche is an exceedingly picturesque little Moorish town of a distinctly Oriental type, with white, flat-roofed houses, and surrounded with palm trees. These are the date palms, which here find a light sandy soil to suit them; they grow to a great height and afford pleasant shade, and amongst them run some swift streams where the women come to do their washing.

Our first concern at Elche was to find a suitable observing station, and after wandering about outside the town in search of a quiet spot, we appealed to our landlord to help us. He suggested a roof, but could not lend us the roof of his hotel as it was already bespoken by a Russian astronomer, but almost opposite the hotel was a Café Restaurant, with a large flat roof, and this we at once engaged, with a stipulation that no one else should be allowed thereon. This eventually proved to be a wise precaution, as several strangers on Eclipse day tried to gain access to it.

Having secured our roof we at once began preliminary observations by ascertaining the points of the compass, noticing the weather conditions and the position of the sun at the appointed hour, and by planning out our different stations, so that all might work smoothly on the eventful day. At one end of the roof was a white wall, nearly due north and south, which afforded us an excellent surface for "shadow band" observations. At sunset we used the roof as an observatory, where we could watch the shadow of the earth rising in the east, and the Zodiacal Light in the west, which, however, was not so clearly defined as we saw it in India in 1898. We also paid particular attention to the constellation Scorpio and the neighbourhood of the planets Jupiter and Saturn, which seemed to us a specially rich region of the heavens, and a region which we cannot observe to advantage in our northern latitudes.

On Saturday, 26th May, we drove to Santa Pola, a distance of about 8 miles from Elche, and on the coast, where were

established the two British Eclipse Camps, that of Sir Norman Lockyer and that of Professor Copeland.

Hiring an Elche pony carriage we started about 9 o'clock, and



PALMS AT ELCHE.

expected to be back by the middle of the day, but our plans were much altered for us as the day advanced.

Long before reaching Santa Pola we descried H.M.S. "Theseus" riding at anchor in the Bay, and after driving

through the town we found our way to the sea-shore, where Sir Norman Lockyer had all his apparatus set up.

Sir Norman received us very cordially, and explained to us the working of some of his instruments, and invited us to return at 4 o'clock to witness his Eclipse drill.

We then visited the Scotch camp about half a mile distant, and here we renewed our acquaintance with Mr. Franklin Adams, who introduced us to Professor Copeland, and who kindly invited us to lunch and made arrangements for us to visit H.M.S. "Theseus" afterwards.

Whilst we were at the Scotch camp the Governor of the Province of Alicante arrived and was shown the instruments by Professor Copeland. Here was the large telescope which was a familiar object to all of us who went to Vadso in 1896.

Another object which attracted our attention and which we duly admired was a large wall close by, which had been freshly whitened by the bluejackets of the "Theseus," and was to serve for the observation of shadow bands. After being most hospitably entertained at luncheon we were escorted by one of the officers to the quay, where a steam launch met us and took us to the "Theseus," a mile or so out in the Bay. Most of the officers, including the captain, were on shore, but one of the junior officers showed us every possible attention, and conducted us over the ship, explaining the working of the guns and torpedoes.

At 3.30 we returned on shore, just in time for Sir Norman Lockyer's Eclipse drill. The apparently simple way in which it was all gone through showed how thorough had been the previous drills, and we felt that, as Sir Norman said, they were quite ready for the Eclipse if it should come a day too soon!

Shortly afterwards, bidding farewell and wishing our friends every success on Eclipse day, we drove back to Elche, feeling that this day would rank as one of the most interesting in every way during our whole trip. It enabled us to correct the error of our watches, and Mr. Heath very kindly supplied us with the times of the Eclipse worked out for Elche; for all of which we were very thankful.

On returning to Elche we soon learned of the arrival of Mrs. Willis and her family, thus making our Eclipse party complete. We were now able to make our final arrangements for the Eclipse, which consisted of—

- (1) Photographs of the Corona.
- (2) Observations of shadow bands.
- (3) Gathering gloom photographs.
- (4) Meteorological observations.
- (5) Sensitometer photographs.

On Sunday, 27th May, we had a rehearsal of our several undertakings, which proved most beneficial, and we were glad also at last to notice the afternoon absolutely unclouded at the

appointed hour, which fine weather repeated itself on Eclipse day, whereas the day following there was slight cloud about. Thus, so far as the weather was concerned, we had all that could have been desired, and we rejoiced later on when we heard that all along the line of the shadow track other observers had also been equally fortunate.

The morning of the 28th broke cloudless, and as the Eclipse would not begin till nearly 3 o'clock, we had plenty of time in hand. Close outside the hotel and quite early in the day our



A LOCAL FORECAST OF THE ECLIPSE, ELCHE.

attention was directed to some large pictures being exhibited in the streets, representing comets and stars, with dragons and monsters, besides scenes of naval battles, etc., all evidently intended to impress the ignorant peasants, and perhaps deceive them about the great event of the day. The day was kept as a general holiday, and during the morning great numbers of people flocked into the town from all the country round.

The resources of our little Fonda were taxed to the uttermost to find accommodation and food for the hundreds who demanded them; in fact many who would have been glad of its hospitality were forced to go elsewhere.



Shortly before the Eclipse began, it was a curious sight to see the roofs, which until then had been deserted, suddenly teem with life, being crowded with the excited populace. Some days previously several foreign astronomers, including M. Flammarion, had arrived, and had made their headquarters a little distance outside the town.

We all kept quiet and cool through the morning, and by 2.30 took up our positions on the roof, when at 2.58 first contact was announced by gun fire. Being all of us provided with dark glasses there was no difficulty in watching the gradually diminishing disc of the sun.

At 3.38 Mr. J. H. Willis first announced the appearance of Venus almost vertically overhead. At 20 minutes and 10 minutes before totality I called the times to Lady McClure to make exposures of 10 seconds each for "Gathering Gloom" photographs; I also making identical sensitometer exposures as arranged beforehand with Mr. Gare.

Soon after the second of these exposures I was able to call the attention of Miss McRae to the rapidly moving shadow bands, and she then made special notes with reference to them.

Time was now very close to the critical moment of totality, to which our attention was now completely given, and I was able to see the Corona, as it were, unfold itself some few seconds before a second gun shot announced totality. During totality a series of photographs of the Corona were taken by Lady McClure, Miss Willis, Miss Edith Willis, and Mr. E. C. Willis, by means of ordinary half-plate cameras.

Miss McRae noted the appearance of planets and stars. I had a sensitometer exposure to make of 30 seconds duration as arranged with Mr. Gare, and reported upon by him elsewhere; I was also able to spare a few seconds to look away at the shadow band sheets, but could see no bands of any kind.

My sensitometer exposure being complete, and having some opera glasses handy, I was able to observe the Eclipse itself, and especially noted the polar rays, and was finally rewarded with a splendid sight of Baily's Beads.

Mercury was a resplendent object, close to the termination of the longest of the coronal streamers, and like Venus in the Eclipse of 1898, would seem to suggest that perhaps the planets exert some attractive influence over the Solar Corona. A second or two of valuable time was lost to us at second contact by someone on a neighbouring roof sending aloft an air balloon which dropped fireworks as it descended, consequently distracting our attention.

After totality, shadow bands were again noted, and further departing gloom and sensitometer photographs undertaken, besides photographs of our party in a group on the roof, after which we all returned to the hotel to tea, eagerly talking over together the wonders of the beautiful spectacle we had seen.

Mr. J. H. Willis undertook the whole of the meteorological work with most painstaking care and skill, and his report will

be found elsewhere. Leaving Elche the next day, we travelled from Alicante to Madrid with Dr. Lockyer and Mr. W. L. Wyllie, A.R.A., from Santa Pola; and that same evening about 7.40 we saw the young moon, then only  $27\frac{1}{2}$  hours old, and presenting a very beautiful and slender crescent.

At Madrid we met Mr. Keatley Moore, Mr. Gare, and Captain Carpenter, who had observed the Eclipse at Manzanares. We were glad to compare notes with them and to learn of their success.

After visiting Toledo and the Escorial, we proceeded to



THE BRIDGE AT ELCHE.

Biarritz and Paris, and at the latter place included a special visit to the great telescope in the Exhibition, where our fellow member, M. Antoniadi, gave us every assistance possible. Thence we went to London, thus concluding a very pleasant Eclipse excursion, with, let us hope, some results in the interests of science, which we now lay before the Members of the British Astronomical Association.

E. W. JOHNSON.



## CHAPTER VIII.

### ALGIERS.\*

THE observers choosing Algiers as their station were far more numerous than those going in any other direction, the ease with which the journey could be made, and the high probability of a clear sky and transparent air, proving a great attraction. But having arrived at their destination, the observers were almost necessarily broken up into several parties. Of these, one made their headquarters the Hotel de la Régence, in the Place du Gouvernement, a second established themselves at the Hotel Continental, in Mustapha Superieur, and of these a contingent observed the eclipse from the roof of the house of Mr. Drummond Hay, the British Vice-Consul. The passengers by the "Argonaut" divided into two chief sections, the one selecting Cemetery Hill, the other Cape Matifou, as their positions. The observers, thus coming by many different routes, arriving on the scene of action at different times, and occupying different stations, no concerted action, except of the slenderest kind, was possible. Still having been in direct communication with members of every section, and having been kindly furnished with information as to the doings of each, I have tried as far as possible to give in one single account a sketch of the work in Algiers.

The party with which I was more immediately connected, consisted at starting of Mr. and Mrs. Crommelin, my wife and two daughters, and myself. On the steamer from Marseilles to Algiers we were joined by Mr. C. L. Brook and his sister Mrs. Arthur Brook, and a day or two after our arrival at Algiers the Rev. C. D. P. Davies, Miss C. O. Stevens, and Miss L. Martin-Leake joined us.

There is a curious experience to which an over-sea journey renders one liable, namely, the sudden interruption of one's usual sources of information as to passing events. Thus, just as I went on board in the expedition to the West Indies in 1886, we got the exciting news of desperate street fighting in Belfast, and we left England with vague apprehensions of troubles which might take a very serious form. For a fortnight we heard nothing, and when at length we were again in telegraphic communication with Great Britain, we heard no more of the event which had loomed so large at our departure, for

\* By Mr. E. WALTER MAUNDER, F.R.A.S.

the Belfast riots had run their course as a nine days' wonder, and had become stale and forgotten. So, in starting to Algiers, we were somewhat similarly tantalized, for whilst we had been buckling the last straps on the last portmanteaux late in the evening of May 18th, in preparation for our early start for Algiers on the following morning, we heard the deep, vibrating roar that had seemed first devised on the night that Kimberley was relieved; and we looked at each other and said, "Mafeking is safe." The desired hours of rest were shortened at both ends by the process of "mafficking," but at London Bridge next morning Mr. Crommelin made the appalling announcement that the report of the relief was not "official," and that it possibly was not true, and we had to pass into France, a land utterly ignorant of and uninterested in the event that meant so much to us. We enquired that night in Paris if it were true, we asked again at Marseilles, we sought again and again for information when we got to Algiers, but it was not till the third or fourth day after our arrival that we got full confirmation of the news.

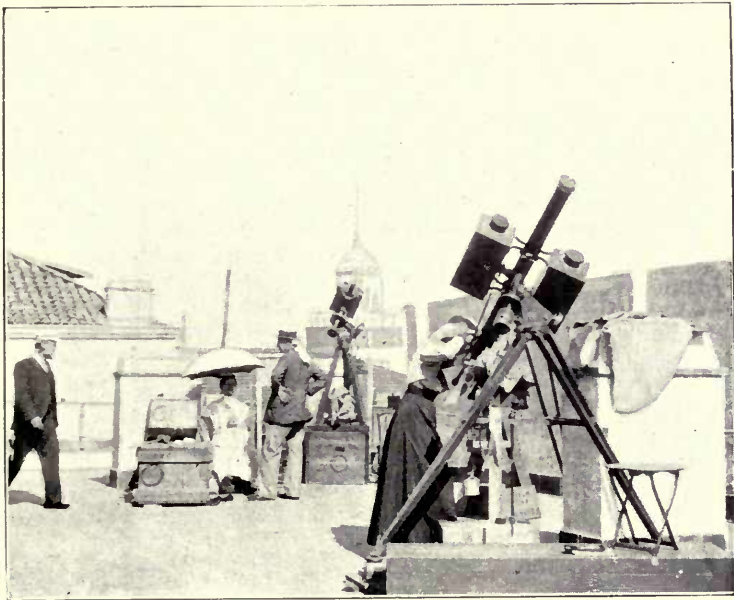
On Saturday night, in Paris, we went with Mr. and Mrs. Crommelin and M. Antoniadi to the Exhibition, to see the great telescope that M. Antoniadi was engaged in getting into adjustment. First we paused in the theatre, where a lecturer was showing on the screen some very beautiful photographs of the moon, the finest we have ever seen. The lantern was placed in the line of the optical axis of the leviathan, whose eye-end was immediately behind it, and we fear that many of the audience believed that the beautiful pictures they beheld were given directly by the great telescope; indeed, almost every published description leads this to be inferred. It must be confessed that the lecturer did not state that these lunar presentations were directly from the moon shining on the siderostat, and thence reflected through the giant telescope directly on to the screen; but the placing of the instruments would suggest this inference, and we wondered how many of the audience speculated as to what quality or virtue there could be in an aperture of 49 inches that could persuade the moon to go through its phases with such rapidity. Then we watched a number of workmen raising by chains and pulleys the plate glass cover from the mirror of the siderostat, and with other sightseers we examined the slow motions and controls situated in the mounting. Here M. Antoniadi stayed with an assistant workman to set the circles and bring the star into the field. Going upstairs to the gallery, level with the leviathan tube, we met M. Deloncle, the owner of the great instrument, and being "des astronomes" he took us into the hedged enclosure round the eye-piece, where the lay and the profane are not admitted. Mdlle. Klumpke and M. Mathieu were at this end, aiding M. Antoniadi in the adjustments, and we watched them with a delightful sense of irresponsibility. M. Antoniadi moved the circles, his assistant kept his ear to the telephone, M. Mathieu gave directions at



PLACE DU GOUVERNEMENT, ALGIERS.



the other end of the telephone wire, and Mdlle. Klumpke beside him, watched the star as it shot across the ground glass. A parti-coloured flare of light hovered on the edge of the field; "plus à droite," called M. Mathieu through the telephone; the flare shot right across, brightening as it passed through the centre and fading as it passed off on the right edge of the field; an irresistible impulse forced Mdlle. Klumpke to make a grab at the flying world. "Top," cried M. Mathieu, but the star was gone, and only returned to make a frantic rush across the field to the left, and so *du capo*. It seemed to us that it would have



B. A. A. OBSERVING PARTY, HOTEL DE LA RÉGENCE, ALGIERS.

been a great improvement if the observer at the eye-end could have been able to electrically control and move the instrument, directly himself, but apart from this criticism, we could have nothing but admiration for the size, the finish, the mounting and effectiveness of the great siderostat itself. It was a feat of engineering, as well as of ingenious mechanism.

Monday afternoon saw us on the "General Chanzy" in Marseilles harbour, and here we were united to several members of our party and other eclipse pilgrims. Bound to the same bourne as ourselves were Mr. C. L. Brook and Mrs. Arthur Brook, Mr. Wesley was going to Bou-Zarea, to the equatorial coude of the Algiers observatory, the domes of which we could

see silhouetted against the sky on the brow of the hill to our right as we entered the Bay. Major Kingsley Foster also was on his way to Bou-Zarea to assist Prof. H. H. Turner, and Mr. Lucas and Mr. Crawford were intending to take part in the same duty. On board were also M. Stefan, director of the Marseilles Observatory, and three Swiss astronomers, Professors Gautier, of Geneva, Riggenbach, of Bale, and Wolfer, of Zurich, the three latter intending to join Prof. Tacchini at his station near Ménerville, some 30 miles from Algiers.

Very striking looked Algiers, the "White City," as we approached it, its white houses, climbing terrace after terrace up the steep sides of the hill, and flashing with dazzling points of light where the sun was reflected back from glass window or conservatory roof. Very striking also was it on a nearer approach, when having passed within the mole, the latter disfigured by a huge inscription indicative of the deplorable "Judenhatze" that has made Algiers and its mayor notorious, we reached the landing stage, a kaleidoscope of races and costumes. The crowd, the shouting, the ceaseless bustle reminded us forcibly of our arrival at Bombay, two years before, but here we had no anxiety about the landing of our instruments, for these had arrived before us, and thanks to the courtesy of the French Government had been immediately handed over on our behalf to Messrs. Cook's representative, Mr. Gould, without the slightest delay or examination at the Custom House.

Our hotel was in the very centre of the city, facing its chief *Place*, a site which in a northern clime would not be ideal for an observing station, but which here in smokeless, fireless, sub-tropical Algiers, had few drawbacks and not a few advantages, whilst our landlord, M. Marty, saw to it that we wanted for no help or convenience that we desired for our astronomical preparations. The hotel was chosen by Mr. Gould after careful examination, and consultation with M. Bulard, formerly the director of the old Algerian observatory, both gentlemen having taken much trouble to ascertain that its roof was thoroughly well adapted for our requirements in an observing station.

The roof of the hotel formed a rectangle of about 100 feet long by 60 broad, and was almost exactly oriented. Its centre was occupied by the inner quadrangle of the hotel, and by two rows of small chambers, several of which were put at our disposal as instrument rooms.

On the afternoon of the eclipse, the observers were arranged as follows:—The western side of the roof was occupied by Mr. T. Thorp, Mr. W. Andrews, with telescope and camera, Miss Martin-Leake with a three-inch telescope; Mr. and Mrs. Crommelin with several instruments; and at the south-western corner, Mr. Hodge with a camera. Along the southern side were Mr. Ellis and Miss Edith Maunder, who were acting as time keepers; Mr. Roger Du Camp who was photographing the harbour during the "Gathering Gloom"; Mrs. Maunder with

a four-inch equatorial telescope, kindly lent by Mr. W. Coleman, F.R.A.S., which was made to carry a pair of cameras, to which Miss C. O. Stevens gave the exposure; the Rev. C. D. P. Davies, with clock-driven equatorial and camera; Miss Irene Maunder with a four-inch photographic telescope, rigidly fixed myself with a pair of small cameras mounted on the Waters' equatorial; and in the south-eastern corner, Mr. C. L. Brook, with a meteorological installation, and Mrs. Arthur Brook, with a prepared sheet for the observation of shadow bands. The Rev. Dr. Quilter, Mr. Vallack and Mr. Edmonds each provided with a small telescope were ranged along the eastern side.

Mr. Allen.



Mrs. Allen, Mr. Roberts, Jr.  
Mr. Roberts. Miss Allen.

GROUP OF OBSERVERS, HÔTEL CONTINENTAL, ALGIERS.

It will be seen that most of us were engaged on one or both of two divisions of work, namely, photographing the corona or examining portions of it in the telescope. We were unable to arrange for a complete sketching party of four or five members, but fortunately possessed in Miss Stevens an artist who was able, in the 48 seconds between the uncovering and closing of Mrs. Maunder's cameras, to gather the very faithful impression which she has preserved in her drawing. But if we had only one sketcher engaged in naked-eye work, the other Algerian sections of the party paid special attention to it, and at Cemetery Hill, Cape Matifou, the Vice-Consul's house, and the Hotel

Continental, combined drawings were given a very prominent place in the programme.

The outlook from the roof was a varied one. On the west, north, and east we looked on the flat roofs of the neighbouring houses, and as our occupations kept us there through any and every hour of the day and night, it must have seriously interfered with the privacy of the "purdah" ladies. Especially towards the west, where the houses covered the hill rising up to the Kasbah, the roofs seemed to lie so close to each other that we could not divine where there was roadway or path lying between them. This was the Arab quarter, and the highways were stepped paths of a few feet width at their lowest and widest, and narrowed above to a cubit's breadth by the overhanging stories of the houses, so that the ancient edict forbidding the passage of horse and carriage seemed unnecessary, not to say ironical. The south side of the hotel formed, with the Mosque de la Pecherie, two sides of the Place du Gouvernement, where seemed to be gathered representatives of all the nations of the earth. Out beyond, the Djur-Djurra mountains cutting off the horizon, lay the Bay of Algiers, ending in the promontory of Cape Matifou.

Those of us who had larger instruments, needing time and stars for their adjustment, installed ourselves in our selected places on the roof as soon as the telescopes arrived from the Custom House. The great point of doubt and difficulty was the weather. We had been disturbed to hear that for two or three days before our arrival there had been incessant storm and rain. The day we came was very fine but not perfect, the next day was not so good, the day after was bad, and Friday, May 25th, was as dull and cold and cloudy as any autumn day in England. Of the weather Mr. Crommelin says:—"We must confess to some disappointment on the whole with the Algiers' sky. It was seldom of the intense deep blue which we had been led to expect; there was generally a distinct milky veil over it. The eclipse day was fortunately the very best during our stay, but even then though there were no clouds and no haze, there was a suspicion of milkiness in the blue, arising perhaps from scattered dust in the upper air." I cannot, however, quite agree with this, and one or two observations seem to me to indicate that the atmosphere after May 25th was in reality singularly free from dust. Thus on the morning of Saturday, May 26th, at about 10 o'clock in the morning, Mr. Brook saw the thread-like crescent of the moon only two days before it became new, in broad sunlight, with the unassisted eye, and pointed it out to several others of the party who also plainly discerned it. This is surely almost an unique observation, and points to great clearness of the atmosphere. Venus, too, was repeatedly picked up even at noon, but this is often done even in England. Again, on the day of the eclipse, at the instant of second contact, my wife who was observing Mercury in a four-inch telescope, saw that the general illumination of the field



disappeared completely and at once with the last spark of sunlight, pointing to the fact that there was no appreciable dust or haze in the atmosphere to scatter light and cause glare.

Mr. Crommelin took charge of our time department, he having one deck-watch kindly placed at his service by the Hydrographer, whilst a second had been lent me by the courtesy of Messrs. Usher and Cole. The error and rate of the deck-watches had been ascertained at Greenwich before our departure, and on the day after our coming to Algiers, Mr. Crommelin went to compare them with the standard clock at the Observatory at Bou-Zarea. He described the Observatory as beautifully situated at the top



MR. EVERSLED OBSERVING WITH THE SPECTROSCOPE,  
PONT MAZAFRAN, ALGIERS.

of the hill of Bou-Zarea, 1100 feet high, behind the town of Algiers, and commanding an unrivalled view of land, sea, and sky, the coast line being visible for 40 miles or more in each direction, whilst the blue rugged peaks of the Atlas made a magnificent background in the south.

On Thursday afternoon I went with Mr. and Mrs. Crommelin to visit Mr. Evershed, at his station on the River Mazafran, by the noisy little steam tram that the French say they are going to run on, some day, to the Congo. At present it only extends just to the south bank of the Mazafran, some twenty miles from Algiers. Mr. Evershed's encampment was immediately to the north of the river, on rising ground, which commanded a good view of the sea, the river, and the hills of Le Sahel. Mr.

Evershed and his brother had set up their hut on the ground of M. Alvado, a wine-grower of this district. The hut was at once bedroom, living-room, and observatory; more than half its scanty area being occupied by the great reflecting spectrograph. The light of the sun was reflected into this instrument by a cœlostat placed just outside the hut, and the spectrum produced by it was one of magnificent brilliancy and proportions. A four inch telescope was also mounted near the cœlostat outside the hut, and carried a small spectroscope. This was provided with a circular slit, which could be fitted to the sun's limb, and thus a large arc of the chromosphere could be seen at one time in the light of the C-line of hydrogen. M. Alvado had taken a great and decidedly intelligent interest in Mr. Evershed's instruments and their management, though they were necessarily utterly unlike in purpose and design anything of which he had had any experience. He passed one criticism on the spectroscope with which spectroscopists will be apt cordially to agree. As he noted the numerous and delicate little adjustments which the instrument required, he summed it up by observing that it was "a stack of fidgets." Mr. Evershed showed us some considerable prominences in this spectroscope, and kindly promised to send us a telegram on the morning of the eclipse giving the positions of the principal prominences in the order of magnitude. His telegram was of great service to us and to several of the party, as it enabled us to direct our attention without loss of time to the selected prominence.

The nights of Friday, Saturday, and Sunday were very fine, and we made full use of them. The background of the sky was a deep black, and the Milky Way stood out with almost disconcerting vividness, for from its unfamiliar position we did not always recognise at the first glance what it was, and it looked perplexingly like cloud. Mr. Crommelin was especially struck with the constellations of Centaurus, Scorpio and Sagittarius, the larger portions of which are unseen in the northern latitudes of England. The waiters in the hotel took a deep interest in our doings, considering that they had a personal property in the success of the eclipse. One evening when we were engaged by the help and light of the stars in making some final adjustments, they formed a deputation to know "if the eclipse were coming off *to-night*?" There was one point, however, in which Nature lamentably failed to accord with their patriotic sense of the eternal fitness of things, and for which we could offer no excuse or consolation. "It could not surely be true"; "Was it indeed true that the eclipse came to Spain before it passed through Algeria, and that it was total longer there?" We tried to comfort them, and succeeded in a measure by pointing out that Tripoli was in a still worse case, and that Algiers possessed the unique distinction of being the one and only place with a fixed observatory over which the shadow passed.

From Thursday on we had many visitors to see how the pre-



parations were getting on; Mr. and Mrs. Allen, Mr. Roberts and his son, Mrs. Bevan and Miss M. A. Orr, all of whom were staying at the Hotel Continental, came at intervals to report progress. Herr Archenhold was at our hotel, but his telescope and camera had taken upon themselves to go on an independent journey, and he beguiled his enforced idleness by turning his hand to aiding in any adjustment where he might prove useful. Herr Leo Brenner and his wife were at the Hotel de l'Opera, and raised our envy by his account of his beautiful Istrian skies. On Sunday morning the "Argonaut" came into harbour, and many of her passengers called that afternoon to ask advice as to what stations they should take up. A little later in the same day the Princess Amelie of Schleswig-Holstein, aunt of the Empress of Germany, and sister-in-law of Princess Christian, who was staying at our hotel, invited my wife and myself to visit her to explain the circumstances of the eclipse, and then came up to the roof to examine our instruments and arrangements.

On one point our visitors were all agreed, that we had very useful astronomical accessories in the great chimney stacks that rose up to a height of about five feet from the roof, and that we turned them to good account. They made most useful piers or stays for the telescope stands, and their most serious defect was in the presence of the vent, down which it was so easy to drop eye-pieces and screws and other useful or indispensable articles. Mr. Hodge turned even this defect to a good use by making the flue serve as a drop for his telescope weight.

Our station on the hotel roof afforded us a unique effect. We were isolated, entirely so, from the spectators around; they could not approach us or interfere with us in any way. But the entire city was in full view, and north, south, east and west every housetop, as the eclipse wore on, became crowded with people. There must have been twenty or thirty thousand within our sight.

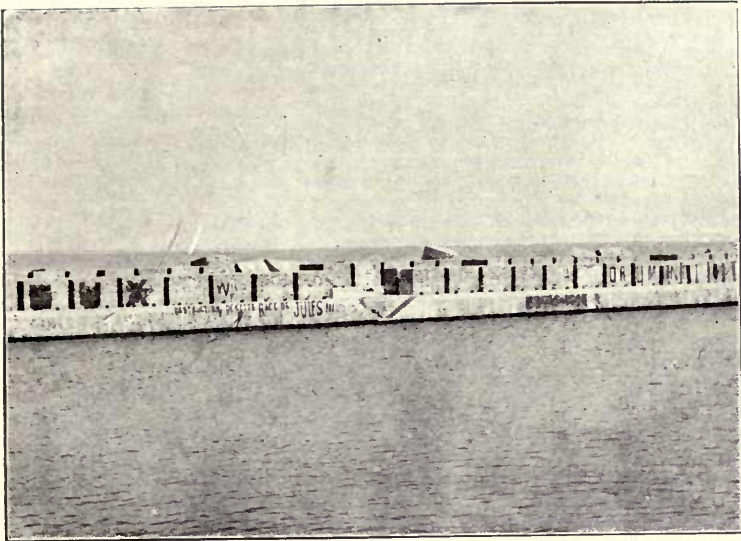
The other sections of Algerian observers were thus distributed. At an early hour in the Hotel Continental, Mr. Roberts arranged his telescope on the roof, his son, Mrs. Allen and Miss Allen took up their positions for drawing quadrants of the corona; Mr. Allen fixed his camera, and white sheets and poles were placed ready for the observation of the shadow bands.

Another contingent took their way up the hill to the villa of the British Vice-Consul, Mr. Drummond Hay. This consisted of Mrs. Bevan, who settled herself in one corner of the roof with drawing materials; Mrs. Crewdson, who took her star maps to another; Miss Orr, high up among the chimneys, watch in hand gave the time; Miss M. A. Orr, who used a three-inch telescope; and Mr. Crewdson, who fixed his camera on the stone parapet. Venus was seen early in the partial phase, and was welcomed by Mrs. Crewdson as a guiding star in her search for lesser lights. The minute of totality seemed the shortest ever experienced; and to Mrs. Bevan the streamers appeared

much fainter than in the Indian Eclipse. Both Mrs. Bevan and Miss M. A. Orr agreed that the landscape effects were more weird and wonderful in Norway.

One party from the "Argonaut" went to Cemetery Hill under the leadership of Col. Burton-Brown. With him were the Rev. A. E. Brisco Owen, Mr. J. Levick, Mr. Thompson, Mr. and Mrs. Kirkham, Dr. and Mrs. Connel, Mr. Robinson and others, who kindly helped in setting up the instruments, arranging the photographic table to  $29^{\circ}$  for cameras, and taking charge of the spectroscopic work and the camera obscura, formed by one of the telescopes equatorially mounted with an eyepiece projecting an image of the sun on to the ground glass about  $3\frac{1}{2}$  in. diameter on a 9 in. field, so that all present might watch the progress of the earlier part of the eclipse. At totality Col. Burton-Brown himself took charge of the camera obscura, in which he hoped to get an enlarged picture of the corona at mid-totality, but which unfortunately was imperfect owing to vibration during exposure.

The other contingent from the "Argonaut" went nearer the central line of totality, to Cape Matifou, where it again divided into two parts. Of these parties Mr. Krauss Niels has furnished the following account:—"At 11 a.m. we set off for Cape Matifou in a specially chartered steam launch, with about 40 or 45 lady and gentleman observers. We had a pleasant 10 mile trip across the bay, and on arrival at Matifou left our instruments in charge of two or three volunteers, and set out to select a suitable station for our observations. The first likely place we saw was the village washing shed, and Dr. Whichello and I went, much to the embarrassment of the inmates, to survey this, but although suitable in almost every other way, the front was at rather too great an angle to the direction which would be required. After this we noticed the village school, the playground of which seemed to contain all that we desired, and we at once started making enquiries. Dr. Whichello's French being vastly superior to mine, he acted as spokesman. He first of all asked some little children if the schoolmaster was in: 'No;' 'When will he be in?' 'Never.' 'What do you mean?' 'There is no schoolmaster.' 'Who is in, then?' 'The schoolmistress.' After this we found the schoolmistress, and an obliging lady she proved to be. She said that we could use the playground and veranda of the school with the greatest of pleasure, and that she would send the children home early, so that they should be out of our way. The place was ideal for sketching and for the kinematograph, there being a shed, forms and desks in abundance, and a large level stone slab on which to place the instruments. There was only one serious drawback, and that was that those who were sketching had very little chance of seeing the general effect of the eclipse on the landscape. But it was, probably, impossible to have every advantage in one place, and the comfort of desks, together with the necessity of plumb lines, outweighed other considerations, and a large portion



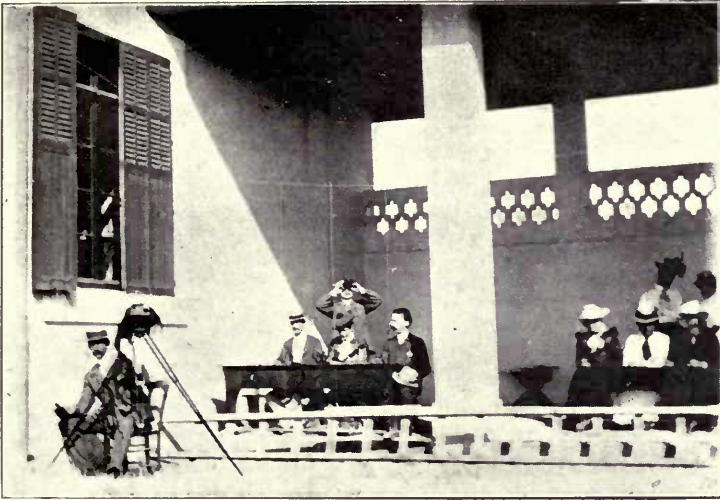
INSCRIPTION ON THE MOLE, ALGIERS HARBOUR.



ALGIERS FROM THE HILL BEHIND THE CITY.



of the party decided to stay in this station. About a dozen or more, however, went further up the hill to the edge of the cliffs, where they would have a chance of seeing the shadow coming across the sea. We were thus divided into two parties on the Cape, and each party observed the eclipse very comfortably and successfully. The party on the hill consisted of Mr. S. Evershed, who observed the "flash-spectrum," and was so enabled to call the exact instant of totality; Mr. E. Dickson, the time-caller; Mr. T. A. Dickson, who has obtained some very successful photographs; Mr. J. E. Pearce, who saw the corona



Mr. F. W. Longbottom. Mr. H. Hassall. Miss Janeway.  
Mr. W. E. Cooper, F.R.A.S. Dr. H. Whichello. Miss Ward.  
Mrs. Hassall. Dr. Heywood Smith, M.D.

SKETCHING PARTY, CAPE MATIFOU, ALGIERS.

for some time after totality; Mr. Kipling Booth, Dr. E. P. Smith, Mr. E. B. Vignoles, and several others. Among those at the school were the following:—Mr. C. M. Hepworth, with his kinematograph; Mr. F. W. Longbottom, who has obtained some good though small scale photographs of the corona; Dr. Heywood Smith, Dr. H. Whichello, and Mr. W. E. Cooper, F.R.A.S., who together with myself devoted the time to sketching the corona. There were several ladies in both parties who helped not a little in the general work, and the following handed me carefully drawn quadrants of the corona:—The Misses Janeway, E. Slater, J. Slater, and K. Slater, E. Statham, E. Thorold, C. Ward, and L. Vignoles."

To return to our own party at the Hotel de la Régence, the hours immediately before the eclipse seemed more than sufficiently filled by putting finishing touches of lamp black on the inside of cameras and of telescope tubes, and in the cleaning of lenses, and the definite work of observation began with my wife and myself at first contact, for we wished to take a series of photographs right through the partial phase.

As we were thus occupied Mr. Crommelin very kindly undertook to watch the eclipse through this earlier phase, and to give warning to the observers five minutes, one minute, and ten seconds before the commencement of totality, whilst I, taking up the watch at the ten seconds signal, was to call at the instant when totality was complete. I, therefore, give the account of the progress of this portion of the eclipse in Mr. Crommelin's own words:—"The first contact and the progress of the eclipse were observed by projection through the telescope on a sheet of cardboard to avoid fatiguing the eye. Mr. Brook kindly gave assistance in noting the time of first contact. The exact point of contact was marked on the card, and at 3h. 5m. 14s. Greenwich time a small but perfectly definite encroachment was observed which rapidly increased. True geometrical contact must have occurred a few seconds before the time noted. There were two small spot groups on the sun, and the times of disappearance of some of the spots were noted. The largest spot began to disappear at 3h. 29m. 7s., and was completely covered 39 seconds later. We used a paper screen over the telescope to shield the cardboard sheet from direct sunlight, and we noticed that the light through a small aperture in this screen produced a crescent-shaped image of the sun on the cardboard—a miniature of that formed by the telescope itself. At 4h. 4m. we noticed a very decided decrease in the illumination of the landscape; the colouring also seemed to have undergone a change and to be rather more yellow than ordinary sunlight, but this may have been fancy. An examination of the relative brightness of different regions of the sky, showed that the sky near the horizon was a light blue, the sky to the west of the zenith a darker blue, and that to the east of the zenith darkest of all.

"It was now nearly time for the first of the three signals which I had arranged to give—viz., five minutes, one minute, and ten seconds, before the commencement of totality. No great precision was required in the first two of these, so it was sufficient to go by the predicted time of the beginning of totality. But it was desirable that the ten-second signal should not be more than a second or two in error. This was secured by calculating beforehand the length of the diminishing crescent, and marking this length on the cardboard screen. It was found practicable to determine this instant pretty accurately, and the call of 'Ten' was just  $9\frac{1}{2}$  seconds before the last ray disappeared, and Mr. Maunder shouted 'Go.'

"The five and one minute signals were made by ringing a



large bell belonging to the hotel—a long ring for the first, and a short sharp ring for the second. Between the two bells we devoted our attention to the aspect of the town—roof rising behind roof up the steep slope, nearly all crowded with sight-seers, as was also the Place du Gouvernement at our feet. The



STREET LEADING TO THE ARAB QUARTER, ALGIERS.

These streets are about 12 feet wide, with the gutter down the middle. This street leads up to the Kasbah.

crowd at first seemed somewhat flippant, and the first bell was greeted with derisive jeers from a group across the street. But the onward swoop of the darkness had a sobering effect, and just before totality a deep swelling murmur of wonder, admiration and fear arose from the entire city."

Another observer, Miss Irene Maunder, describes the effect of totality:—"A bell rang and we all hurried to our places, for we knew there were but five minutes to totality. Another bell,—but one minute more. The sky was deep purple, while over the sea was a strange light on the horizon, a compromise between a thunderstorm and a sunset. The colour faded from the sea and trees, a shouting and wailing arose from the square below, the light was fading; suddenly the moon slipped over the sun and the eclipse was total. 'Go!' shouted a loud voice; a metronome began to beat seconds, and as its bell rang at each sixth stroke, my sister called the time. 'One! Two! Three! Four! Five! Six!' There! my photographs were taken, and now I could look up! I shall never forget the sight. A deep purple sky, a black globe, surrounded by a crimson glow, and above and below it a milk-like flame stretching its long streamers away into the purple. The darkness, the cold wind, the silent workers around me, and the shouting crowd below all tended to make this strange and glorious sight still more impressive, and I found myself stretching out my arms to that exquisite corona in a perfect ecstasy. Suddenly the moon slipped off the other side of the sun, and out he shone in a blaze of light, or so it seemed in comparison with his eclipse. An Englishman cheered. Some Frenchmen clapped. Totality was over!"

## CHAPTER IX.

### *TIME OBSERVATIONS.*

UNTIL comparatively recently, until in fact the great eclipse of 1868, when the spectroscopic method of observing the prominences in full sunshine was first brought into actual operation, the chief observations made at an eclipse were those of the times of contacts. And these were very useful, as they afforded the means for correcting the Tables of the sun and of the moon, and for ascertaining the diameters of both bodies. In more recent years the greater interest attaching to the physical observations possible in an eclipse—the study of the corona and prominences; the spectrum of the “Flash”;—have pushed contact observations rather into the background; and on many occasions they have been more or less neglected by professional astronomers. It is much to be regretted that this is so, and it is to be hoped that the experience of the late eclipse will lead to the restoration of contact determinations to the position of an essential item in every eclipse programme. The precise determination of the longitude and latitude of the observing station must necessarily accompany such observations.

Mr. C. T. WHITMELL has carefully collected in the annexed Report all the observations of contacts or duration of totality that were available, with the result of showing clearly that the duration of totality was less than that predicted by the British “Nautical Almanac”; Mr. H. EVERSLED adds a brief note with reference to the failure of the eclipse to become total at his station on the Mazafran; and Mr. A. C. D. CROMMELIN explains the probable reason of the over-estimate, in the “Nautical Almanac,” of the duration of totality.

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#### DURATION OF TOTALITY AND TIMES OF CONTACTS.\*

THE following Table contains such particulars of times of contacts and duration of totality as I have been able to obtain. Greenwich longitude and mean time are used throughout. Some of the data have been taken from Spanish, French, American, and English publications; others have been kindly communicated to me by the observers, for whose help I am very grateful.

\* By C. T. WHITMELL.

No.	Locality.	Longitude.	Latitude.	First Contact.	Second Contact.	Third Contact.	Fourth Contact.	Totality.	Observer.
1	Near Wadesboro'	80° 7' W	34° 51' N	0 ... 36 ... 10 ...	1 ... 23.6 ...	1 46 ... 55.6 ...	3 5 43	97.6	Predicted, N.A.
2	Wadesboro'	80° 4' 28"	34° 57' 52"	0 36 17.4	1 45 20.2	1 46 47	3 5 34.2	92.0	Predicted, Am. Eph.
3	"	"	"	"	"	"	"	86.8	A. Flint
4	Off Portugal	9 27 0	41 3 0	...	...	...	...	91.0	E. Markwick
5	Near Ovar	8 38 0	40 50 0	2 43 7	4 1 42	4 3 15	5 13 14	93.6	Predicted, N.A.
6	"	"	"	...	...	...	...	84.5	W. Christie
7	"	"	"	...	...	...	...	88.4	A. Morford
8	"	"	"	...	...	...	...	85.0	C. Nielsen
9	Estarreja	8 37 0	40 45 40	2 43 18	...	...	5 12 55	92.0	H. Slade
10	Coria	6 29 0	40 2 0	...	4 3 15	4 4 35	...	80.0	F. Miranda
11	Plasencia	6 6 0	40 3 0	...	...	...	...	88.0	Predicted, N.A.
12	Near Plasencia	6 6 43	40 2 5	...	4 5 28+	4 6 54+	...	82.0	A. Downing
13	"	6 4 0	40 2 0	...	4 5	4 6	...	86+2	T. Weir
13A	Berrocaillo	6 6 43	40 2 5	2 48 3.2	4 5 24.0	4 6 45.1	5 15 28.4	81.1	Predicted, Madrid
13B	"	"	"	2 48 13.3	4 5 21.7	4 6 45.9	5 15 18.2	84.2	Sr. Ventosa
13C	"	"	"	2 48 13.8	4 5 30.2	4 6 45.0	5 15 18.3	74.8	Sr. Puente
14	Navalmoral	5 34 0	39 52 0	2 48 45	4 6 12	4 7 39	5 15 45	87.0	Predicted, N.A.
15	"	"	"	2 49 0	4 6 56	4 8 16	...	80.0	C. Whitmell and three others
16	Talavera	4 50 0	39 55 0	2 49 45	4 7 0	4 8 6	5 15 45	66.0	Predicted, N.A.
17	"	"	"	...	...	...	...	50.0	J. Valle
18	Near Navahermosa	4 29 0	39 40 0	...	...	...	...	80.0	L. De Hoyos
19	Sonseca	3 58 27	39 40 35	2 55 35	4 11 40	4 12 33	5 19 55	53.0	C. Gomez
20	Near Manzanares	3 18 54	39 1 50	...	4 9 32	4 10 32	...	60.0	H. K. Moore
21	Argamasilla	3 5 21	39 7 44	2 52 28	4 7 28	4 8 50	5 14 10	82.0	M. Rodriguez

TIME OBSERVATIONS.

No.	Locality.	Longitude.	Latitude.	First Contact.	Second Contact.	Third Contact.	Fourth Contact.	Totality.	Observer.
22	Socuellamos	0 2 47 41 39 17 35	0 39 17 35	H. M. S. 2 57 40	H. M. S. 4 12 36	H. M. S. 4 13 36	H. M. S. 5 20 35	SECONDS. 60'0	F. Prieto
23	Alcaraz	0 29 32 38 40 0	0 38 40 0	2 58 26	4 9 35	4 10 35	5 19 46	60'0	J. Marco
24	Elche	0 41 47 38 16 0	0 38 16 0	2 58 26	4 12 38	4 13 57	5 19 46	79 0	Predicted
25	"	" " "	" " "	" " "	" " "	" " "	" " "	76 0	E. W. Johnson
26	"	" " "	" " "	" " "	" " "	" " "	" " "	78 0	G. Tramblay
27	Santa Pola	0 30 0 38 13 0	0 38 13 0	2 58 47	4 12 52	4 14 11	5 19 55	79 4	Predicted, N.A.
28	Near Santa Pola	0 33 40 38 11 20	0 38 11 20	2 58 30	4 12 38	4 13 53	5 19 55	75 0	N. Lockyer and A. Fowler
29	Alicante	0 28 35 38 20 47	0 38 20 47	3 0 31	4 12 5	4 13 13	5 19 2	68 0	E. Senante
30	Busot	0 24 0 38 30 0	0 38 30 0	3 0 15	4 12 53	4 14 11	5 19 50	78 0	C. Grifol
31	Near Mazafra	2 48 41E 36 41 47	36 41 47	" " "	4 17 36	4 18 6	5 22 32	30 0	Predicted, N.A.
32	"	" " "	" " "	" " "	" " "	" " "	" " "	00'0	J. Evershed
33	Algiers Observatory	3 2 8 36 47 50	36 47 50	3 5 0	4 17 18	4 18 25	5 22 0	67'0	Predicted, N.A.
34	"	" " "	" " "	3 5 9	4 17 18	4 18 23	5 22 16	63'0	M. S.
35	"	" " "	" " "	3 5 13	4 17 19	4 18 23	5 22 23	64'0	M. J. Tripied
36	"	" " "	" " "	" " "	" " "	" " "	" " "	63 5	H. Turner and H. Wyles
37	Algiers Hotel	3 4 6 36 47 12	36 47 12	" " "	" " "	" " "	" " "	67'0	Predicted
38	"	" " "	" " "	" " "	" " "	" " "	" " "	62 5	C. Brook
39	"	" " "	" " "	3 5 14	" " "	" " "	" " "	...	A. Croumelin
40	"	" " "	" " "	" " "	" " "	" " "	" " "	...	E. Davies
41	"	" " "	" " "	" " "	4 17 17	4 18 22	5 22 18	...	E. Maander
42	"	" " "	" " "	3 5 20	4 17 20	4 18 22	5 22 18	62'0	K. Roberts
43	Matifou	3 15 0 36 48 0	36 48 0	3 5 0	4 17 24	4 18 35	5 22 0	71 0	Predicted, N.A.
44	"	" " "	" " "	" " "	4 17 25	4 18 32 5	5 22 0	67 5	T. Dickson
45	Ménerville	3 35 0 36 43 0	36 43 0	3 5 0	4 17 42	4 18 53	5 22 0	71'0	Predicted, N.A.
46	"	" " "	" " "	" " "	4 17 30	4 18 39	5 22 0	69 0	M. Honorat

Señor Iñiguez, of the Madrid Observatory, and the Royal Geographical Society (through Mr. W. H. Wesley), have courteously sent me the longitudes and latitudes of several of the localities. I wish also to thank Dr. C. A. Young for the "Princeton Bulletin," with an account of the observations at Wadesboro', N.C., U.S.A., and M. le Comte de la Baume Pluvinel, for his very useful chart of the region of total eclipse in the Iberian Peninsula.

It will be seen that the Table is far from complete. For many of the stations I fear that the longitudes and latitudes may require some correction. It is obvious also that only in very few cases can the observed times be regarded as absolutely correct. But the *difference* between the times of second and third contact, *i.e.*, the duration of totality, is probably very near the truth.

In some instances, observers in Spain have not stated what time they used, so in these cases I have assumed the time to be that of Madrid. For the future I hope that all observers will endeavour to give full and accurate information as to their observing stations, and the times of contact.

With regard to the longitudes and the times of commencement of totality, there are some anomalies which I cannot explain, *e.g.*, Nos. 19 to 23. These may be due to watch errors.

It will be noticed that in every case for which the predicted and the observed duration of totality are given, the latter falls short, sometimes considerably short, of the former. The "Nautical Almanac" predictions were accompanied by a caution to the effect that the predicted duration might be as much as three seconds too long. It was thirty seconds too long for Mazafran, for the shadow never got there.

No. 3, Wadesboro'.—According to Prof. C. A. Young's observations, first contact occurred at 0h. 36m. 2s., and fourth contact at 3h. 5m. 40s., the discrepancies, in his opinion, being due to errors in the lunar tables.

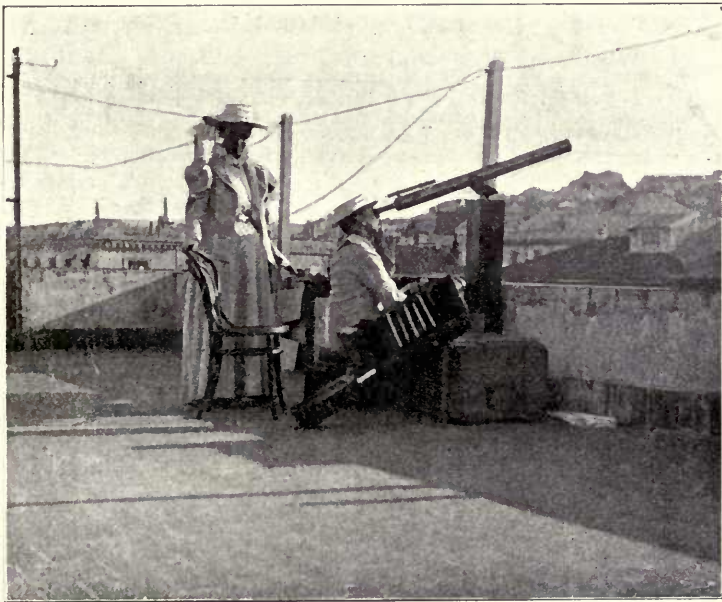
No. 11, Plasencia.—For the Palacio de Mirabel, Señor Iñiguez gives longitude  $6^{\circ} 5' 36''$ ; latitude  $40^{\circ} 1' 47''$ .

No. 13.—Mr. Weir informs me that he is not sure of the duration of totality. He gives 84s. and 88s. as limits, with an inclination to consider the latter as probably the more correct.

Nos. 13B and 13C, Berrocalillo. The following note is a translation of a passage from a most interesting pamphlet on the eclipse, by Señor Iñiguez:—The manifest contradiction between the times assigned for the second contact by the two observers, results from the method used by each. Sr. Ventosa gives, as the commencement of totality, the moment when the lunar disc showed itself as a complete circle; Sr. Puente, when he saw disappear the last ray glancing from the last bead of light. It should not be forgotten that the moon's border is not perfectly smooth, but is serrated, owing to great lunar mountains, and it is precisely in this eclipse that many observers have pointed out the existence of marked inequalities in that lunar border which entered first on the sun. By all accounts, observation

indicates for this eclipse a duration somewhat, though but little, less than that calculated. A thorough discussion of the circumstances, accompanying the phenomenon, will show to what causes are to be attributed this difference."

No. 32, Mazafran.—Mr. Evershed writes as follows:—"From accounts of observers at my station, and from a careful examination of the series of photographs obtained, I find that at mid-eclipse one small point of sunlight was shining. This point appeared at position-angle  $195^{\circ}$ , at least 45 seconds before mid-eclipse, and persisted in the same place until it was merged in the



MR. AND MRS. CROMMELIN, HOTEL DE LA RÉGENCE, ALGIERS.

reappearing arc of sunlight, a second or two after mid-eclipse. Now this point, appearing on the *western* side of the sun before mid-eclipse, must have been due to a very deep valley in the moon; but, according to Beer and Mädler's map, the general level of the moon's south limb is higher than the average, that region being occupied by the Leibnitz mountains. Whether the bottom of the valley, which let in the sunlight, is above or below the mean level of the lunar surface, it is impossible to say, but it just prevented the eclipse being total at my camp. The actual edge of the moon's shadow was clearly seen upon the sea, and it struck the coast very close indeed to my station, within a

quarter of a mile on the north side of it, according to a trustworthy observer."

By computation Mr. Evershed's camp should have been  $1\frac{3}{4}$  miles within the southern boundary of the shadow.

No. 15, Navalmoral.—For this station I computed the following additional data, based upon the "Nautical Almanac":—Sun's altitude at totality,  $39^{\circ}$ ; azimuth,  $3^{\circ}$  south of west. At 2h. 57m. G.M.T. the moon's geocentric distance was about 233,087 miles, and her synodic velocity about 2191 miles an hour. The observer's velocity, along the parallel of latitude at Navalmoral, is 795 miles an hour. At totality the apparent semi-diameter of the moon was  $16' 6''\cdot 0$ , and that of the sun  $15' 46''\cdot 6$ , the difference being only  $19''\cdot 4$ .

The diameter of the umbra, projected into a circle upon a plane through Navalmoral, perpendicular to the shadow-axis, measures about 43 miles. But, upon the surface of the ground, this umbra was really a kind of oval with its longest diameter lying nearly W. and E., and considerably exceeding 43 miles, being probably about 67 miles. The velocity of this shadow along the surface was about 42 miles a minute. The shadow path made an angle of about  $20^{\circ}$ , N. of W. and S. of E., with the observer's parallel, and, on the assumption of 87s. for totality, that diameter of the oval, actually traversed by a spectator upon the earth's surface, would be about 61 miles. We possessed no means of obtaining Greenwich time with accuracy, but Mr. Howarth had with him a rated watch, and by this he estimates the beginning of totality at 4h. 6m. 56s., and the end at 4h. 8m. 16s. G.M.T. If these times are to be relied upon, totality began 44s. later and ended 37s. later than the predicted times. The corresponding Madrid times would be 3h. 52m. 11s., and 3h. 53m. 31s. Navalmoral time is 7m. 31s. earlier than Madrid, and 22m. 16s. earlier than Greenwich, the difference between Greenwich and Madrid being 14m. 45s. About 2h. 49m. p.m., first contact had been noted from a carriage window of the train that brought us from Madrid. I pass on to consider the duration of totality. Observing the solar spectrum with a spectroscopic opera-glass, to be described hereafter, I gave the signals "go," and "gone," to Dr. Stokes, who had an accurate stop watch, made for estimating races. The duration was exactly 80 seconds, or 7 seconds less than that predicted by the "Nautical Almanac." Precisely the same duration was noted by three other observers, Mr. Howarth, Mr. Southall, and the Rev. S. J. Johnson, using only the unaided eye.

Assuming the orbital path of the moon, and the N.A. diameter of the sun, to be correct, there are two possible explanations of the loss of 7 seconds; (1) the N.A. diameter of the moon may be too large; (2) the adopted position of Navalmoral may be incorrect, so that it was not really on the central line. If the error is due entirely to (1) I compute that the moon's diameter was  $3\frac{1}{2}$  miles ( $3''$  at mean distance) too large, and this seems unlikely. If the error is due entirely to



(2), then Naval moral was about  $8\frac{1}{2}$  miles off the central line, and this also seems improbable.

If we reduce the predicted duration to 83s., the error in the moon's diameter is reduced to 2 miles ( $1''\cdot7$  at mean distance), and the loss of the remaining 3 seconds could be accounted for, if Naval moral were supposed to be about  $5\frac{1}{2}$  miles off the central line, the position error being mainly in latitude. The diameter of the projected umbra would now be only 41 miles. The sun's own circumference has not a sharp geometrical boundary, and it is possible that the real diameter of the visible photosphere varies slightly. Irregularities in the lunar limb may also account for something.

The factors connected with a solar eclipse at a given place are:—

- (1) The semi-diameter of the sun.
- (2) The semi-diameter and distance of the moon.
- (3) The direction and velocity of the moon's movement.
- (4) The earth's place in her orbit, and the observer's position on the earth.
- (5) The direction and velocity of the observer's movement.

If (1), (4), (5) are assumed to be correctly known, then errors in (2) and (3) can be determined by accurate observations of the times of contact at the various stations. Hence the importance of such observations.

It is generally supposed that the discrepancies between prediction and observation, which come out so plainly in the case of the present eclipse, are due mainly to some error in the assumed semi-diameter of the moon.

The present values of the geocentric mean semi-diameters of the moon, used in computing eclipses, are as follows:—

American Ephemeris,  $15' 31''\cdot76$ ; British "Nautical Almanac,"  $15' 32''\cdot65$ ; French "Connaissance des Temps,"  $15' 32''\cdot83$ . For this eclipse, the respective values, at the time of R.A. conjunction, were: American Ephemeris,  $15' 55''\cdot0$ ; British "Nautical Almanac,"  $15' 55''\cdot89$ ; French "Connaissance des Temps,"  $15' 55''\cdot9$ ; the American value being thus  $0''\cdot89$  smaller than the British.

It is to be hoped that the records of this eclipse, imperfect as they are, may lead to more accurate predictions in the future.

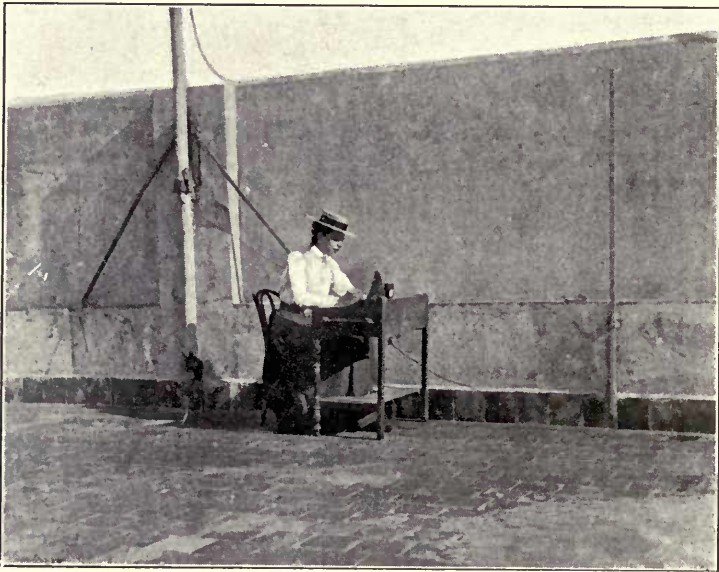
In conclusion I may add that this was an eclipse of somewhat brief totality. The maximum duration (about 134s. by N.A. data) occurred, unfortunately, far out in the Atlantic, near longitude  $45^{\circ} 1' W.$ , and latitude  $44^{\circ} 57' N.$  The time was about local noon (2h. 57m. G.M.T.).

C. T. WHITMELL.

No. 20, near Manzanares.—Mr. KEATLEY MOORE in his report gives the following additional particulars as to the time determinations made there:—"Every care was taken to check the rating of the chronometer carried by the party—first by

daily comparisons with the chronometers of the 'Britannia' (P. & O.), on the way out to Gibraltar, then at Madrid by comparison with the observatory clock (by Dent), with the courteous help of Señor Ventosa, and finally on returning to Gibraltar, by comparison with the chronometers of H.M.S. 'Isis.' This chronometer was found to be an excellent instrument, maintaining a very even rate; from first to last it altered its rate only 1.3 seconds. It was lent to the party by Messrs. Bowman, its makers.

It was of course of the first importance to know the local time correctly in order to check the computed G.M.T. times of the eclipse. Equal altitudes of the sun were therefore taken, by



MISS EDITH MAUNDER CALLING TIME, HOTEL DE LA RÉGENCE, ALGIERS.

sextant and artificial horizon, on both 27th and 28th May, at Manzanares.

Being able to place dependence on these observations the party had the presumption to supply the Madrid Observatory with a correction of the position of Manzanares, which is mapped about  $2\frac{1}{2}$  miles too far south, and  $3\frac{1}{2}$  miles too far west, taking the fine church 'Parroquia de la Asuncion' in the market place, as the centre of the town.

Longitude, really  $3^{\circ} 19' 12''$  W., not  $3^{\circ} 22' 23''$  as mapped at Madrid.

Latitude, really  $39^{\circ} 2' 3''$  N., not  $38^{\circ} 50' 39''$  as on the map of the Royal Geographical Society, London.

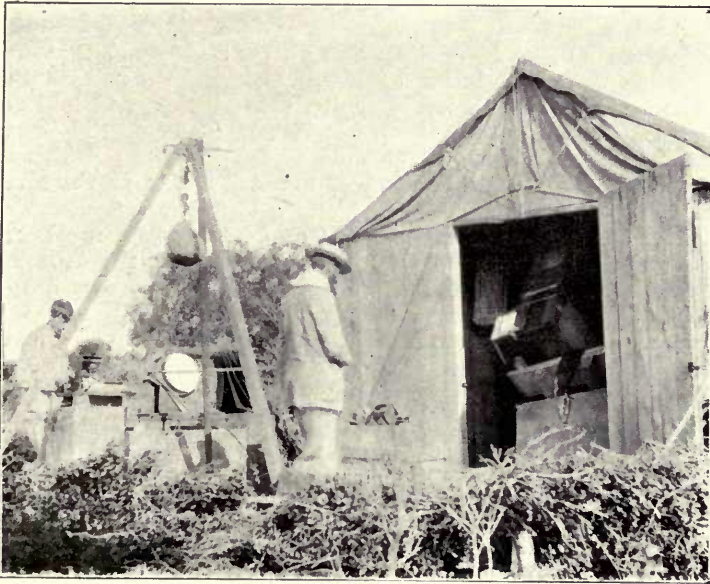
The limit of error in each case is  $\pm 30''$ .

The longitude and latitude of our tower were  $3^{\circ} 18' 54''$  W. and  $39^{\circ} 1' 50''$  N.

"These discrepancies materially altered both the anticipated times and the anticipated duration of the eclipse."

NOTE ON THE ECLIPSE AT MAZAFRAN CAMP.\*

Mons. ALVADO, whom we asked to observe the duration of totality, was observing the sun through the sextant telescope



MR. EVERSLED'S CAMP, PONT MAZAFRAN, ALGIERS.

Showing Celostat and Camera-end of Reflecting Spectrograph.

furnished with a red shade on the eyepiece. He had a watch in his hand, as had several other onlookers. At the moment when only as much light as a "pin head" remained, Alvado called out "*contez*," but no sooner had he pronounced the word, when it began to get light again. He stated that the remaining spot of light was red, but this was no doubt due to the shade glass of his telescope. His wife called it "a speck of yellow light."

Mons. Laurence, Maire de Kolea, and Mons. le Directeur des Contributions, both confirmed Alvado's statement. The latter

\* By H. EVERSLED.

stated that had we been 200 metres further north-east we should have had totality, for he saw the shadow passing over the sand dunes in that direction.

Mons. Alvado stated further that when he glanced down at the moment when the eclipse was almost total he observed a curious streak, as of moonlight, "*qui frappe sur la mer*," in a line from our hut to a point 20 or 30 metres south of the mouth of the Mazafran River. All to the right of this streak was dark.

In the evening the Arabs sat talking with Alvado of the event, and Bel Kadir the *berger* declared that some little piece at *El Simph* remained, as much he said as a "*garro*" (cigarette). This statement was contradicted by the other Arabs (our neighbour Larbi and others). These men were hoeing maize 500 metres north-east of our hut, and they all declared that the whole sun was obscured for a moment.

The farmer (Alvado) joined in the conversation, and told me what the Arabs were arguing about, and it seems the *berger* that day had taken his cattle south of the Mazafran Bridge to a point about 500 metres *south* of our hut and near the river bank.

The postmaster of Zeralda (a village  $3\frac{3}{4}$  kilometres north-east of our camp) was also requested by us to observe the duration of totality, and he with the help of the letter carrier, a stop watch, and smoked glass, determined the duration to be 9 seconds. This observation he said we could *absolutely* rely upon as being correct.

[This observation, if correct, would make our camp about two kilometres outside the shadow, but it is not confirmed by the durations found at Algiers and Cape Matifou. The argument of the Arabs would show, too, that the actual limit of the shadow must have passed very close to the camp. It is perhaps a little tantalizing to know that a small plantation of olive trees to the north-east, which we originally chose as a good camping ground, and afterwards abandoned, was actually just within the zone of totality.—J. EVERSLED.]

NOTE ON THE PROBABLE REASON OF THE OVER-ESTIMATE OF THE  
DURATION OF TOTALITY IN THE "NAUTICAL ALMANAC."\*

THE experience of all the observers, both in India in 1898 and at the recent eclipse, showed that the duration of totality was shorter by four or five seconds than that predicted by the "Nautical Almanac."

A probable explanation of this fact occurred to me a short time ago. It is a matter of common knowledge that the moon's

\* By A. C. D. CROMMELIN.

limb is exceedingly irregular, being broken by mountains and valleys. I was greatly struck with this irregularity at the recent eclipse. Twenty seconds before totality the disappearing crescent began to be broken into segments by the lunar mountains, and a few seconds before totality there was really no semblance of

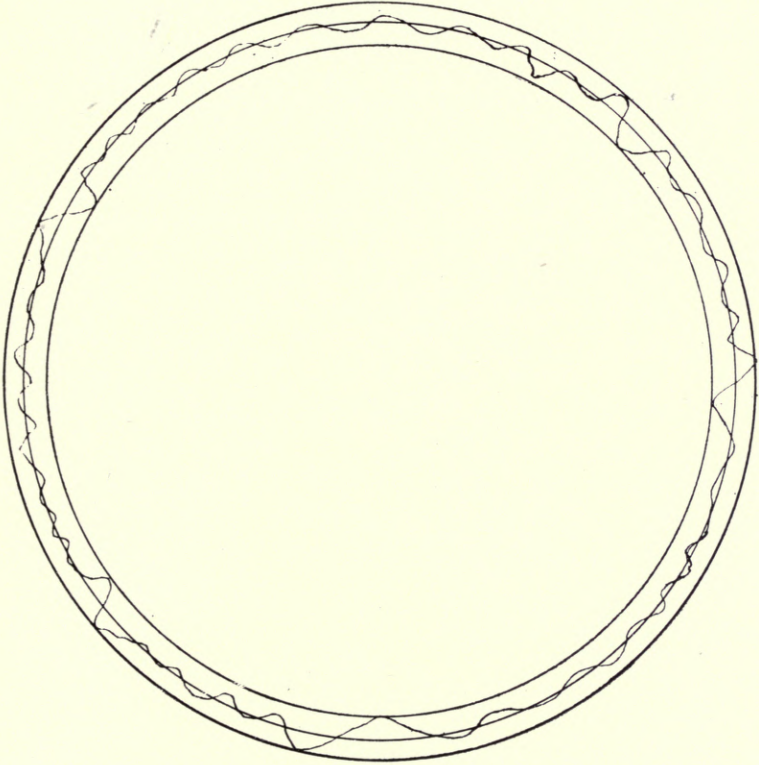


DIAGRAM ILLUSTRATING ON AN EXAGGERATED SCALE THE IRREGULARITIES ON THE MOON'S LIMB.

The diameter of the middle circle is that deduced from occultations.

The diameter of the inner circle is that which is effective for producing total eclipses of the Sun.

a crescent left, but irregular patches and beads of light. The last ray of the disappearing sun would shine through the deepest valley that there happened to be on the moon's limb near the point of disappearance.

In the diagram I have drawn three circles, the outermost drawn through the highest mountains on the moon's limb,

the innermost through the deepest valleys, and the third half way between these.

Then it seems clear that the discussion of a large number of occultations of stars at various points of the limb will give a diameter corresponding very approximately to that of the



STREET IN THE ARAB QUARTER, ALGIERS.

These are narrower than those lower down, and goods are carried there by donkeys with a pack on each side. The streets are so narrow that it is difficult for two laden donkeys to pass in them. The photograph shows a woman at a fruit and milk stall, stooping to escape the camera, and in the background is seen one of the smaller mosques.

middle circle. Now the mean diameter of the moon used for eclipses and occultations in the "Nautical Almanac," viz.,  $31' 5''.30$ , was deduced by Dr. L. Struve, from a discussion of the occultations of a large number of stars during the lunar eclipses of 1884 and 1888. Hence we may assume that this diameter corresponds to the middle circle on the diagram.

But since we do not call the eclipse total so long as any portion of the sun is visible, even through a lunar valley, it seems clear that the effective diameter for producing a total eclipse will be less than Struve's value, and will approach more or less closely to the inner circle, according to the depth of the valleys near the points of second and third contact. Mr. Seabroke has pointed out that we do not see a valley on the limb of its full depth, unless it is pointing straight towards the earth. But out of the numerous valleys that exist there are probably a few that point thus. Moreover, a depth of 5000 feet below the mean level is all that is required to produce the observed phenomenon; and when we consider the great irregularity of the moon's surface, and the great height of some of its mountains, it appears quite probable that some valleys may be much deeper than 5000 feet, so that even when their apparent depth is reduced in the manner indicated by Mr. Seabroke, it would still amount to the necessary quantity.

The American ephemeris uses  $31' 3''.52$  as the moon's mean diameter for eclipses and occultations. And the predictions of this ephemeris have been very nearly accurate both in 1898 and 1900. Had Mr. Evershed gone by it instead of the "Nautical Almanac," he would have placed himself two miles further north, and would have obtained several seconds of totality.

Considering the great importance of predicting the duration and boundaries of totality with all the accuracy possible, I would suggest that the diameter of the American ephemeris (or even a slightly smaller value for perfect safety) should be used by the "Nautical Almanac" in the prediction of total eclipses. Both the above ephemerides use the same value for the sun's mean diameter, viz.,  $31' 59''.26$ , deduced by Prof. Auwers from heliometer measures, which is probably very near the truth.

Curiously enough the American ephemeris for 1902 and subsequent years uses  $31' 5''.10$  as the moon's mean diameter for eclipses and occultations. I regard this as a distinctly retrograde step as regards total eclipses, though it is probably an improvement as regards occultations.

A. C. D. CROMMELIN.

## CHAPTER X.

### *THE CORONA.*

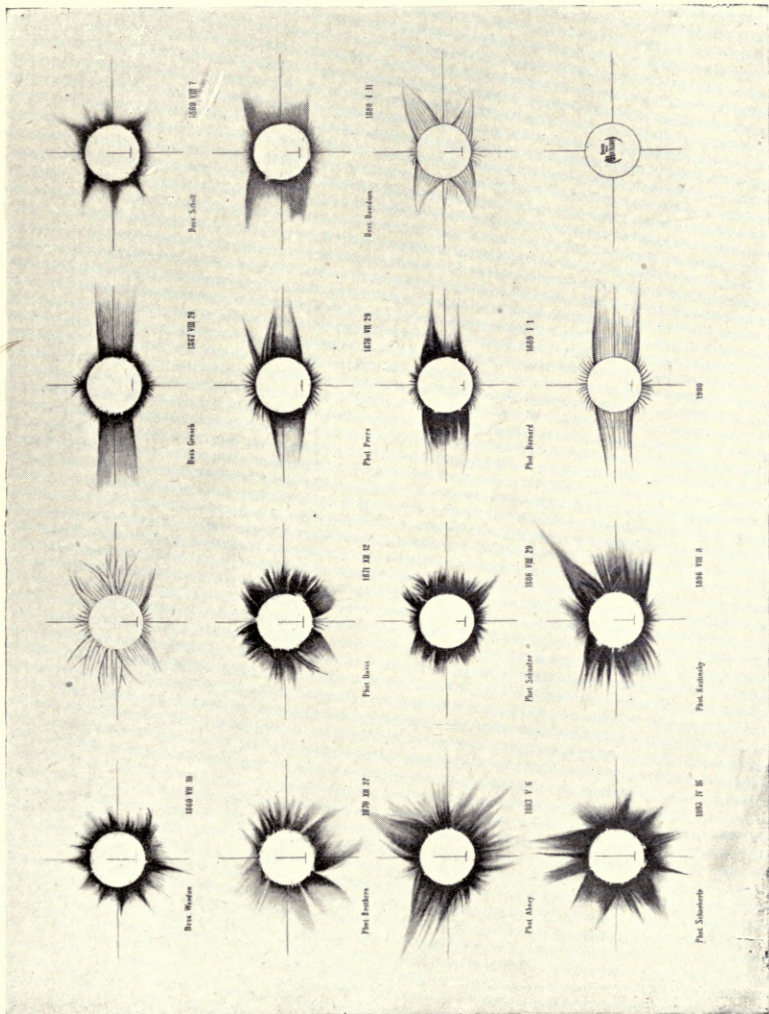
It is curious how the centre of interest in eclipses has shifted in the course of time. As noted elsewhere, our forefathers were chiefly impressed by the darkness, and by the appearance of stars in the daytime. When we come to the earlier eclipses of the present century, we find that the "Red Flames" monopolised almost all the notice; and it is only within the last forty years or so that the corona, which is to us to-day emphatically *the* feature of the eclipse, has received much study. How it was that the few stars, faintly shining, or the prominences, so much smaller than the corona, drew all eyes, whilst the corona, so beautiful, so mysterious, so unique, hardly obtained any record, is very difficult to explain. But the king has come to his own at last, and this truly royal splendour is now the chief object of study and of admiration, on each occasion that the complete withdrawal of sunlight permits it to be seen.

Though the entire length of time during which the corona has been visible, since eclipses first began to be studied with any degree of scientific precision, has but little exceeded a single hour, yet that study was very soon rewarded by a most striking discovery, the full significance of which we have still to seek. In 1878, it was first suggested, and every eclipse since has confirmed that suggestion, that the form of the corona changes in sympathy with the greater or less development of solar spots. This relationship has been so completely accepted, that M. Hansky, after the successful Russian expedition to Novaya Zemlaia in 1896, did not hesitate to forecast the form which it would present in 1900, as may be seen in the accompanying plate. The forecast did not, of course, go much into detail, but is substantially correct. It shows two great arms, directed east and west, in the line of the sun's equator; the eastern arm showing a tendency to taper, whilst round the north and south poles, were a number of distinctly separated plumes or aigrettes.

Such were, indeed, the chief features of the corona of 1900. In technical language it was "of a pronounced minimum type"; as was to be expected when the spots on the sun's surface had shrunk to something like one-twentieth of the area which they had covered at the maximum, seven years before.

From a great number of descriptions we may select a short one by Prof. MOVE (Elche): "To the naked eye and opera-glass the moon was perfectly dark and black, surrounded by a circle





After Minimum.

At Minimum.

After Maximum.

At Maximum.

FORMS OF CORONÆ AT DIFFERENT EPOCHS.

("Dress." signifies Drawing; "Phot." Photograph.)



of silvery white, almost dazzlingly bright, and recalling the text-book diagrams of an annular eclipse. It was the inner corona. To the right and left of the sun, two immense streamers, pearly as to tinge, were seen, tolerably bright and fading away gradually at their edges. They were on the ecliptic, or very nearly so, their length was two or three solar diameters; the western streamer being noticed nearly up to Mercury,  $20^{\circ}$  from the sun. The ogival form of the streamers was very conspicuous; each seemed to consist of two curved rays with a central rift. Round the sun's pole there were only faint and short plumes;—a typical form of a minimum year."

The estimates as to the colour of the corona varied considerably. Mr. KRAUSS NIELD, for the party at Cape Matifou, says:—

The corona appeared to me to be almost if not quite colourless, the rays had a silvery glow which was particularly delicate and difficult to describe. At an exhibition a little while ago, I saw, just before twilight was over, a long ray from a powerful search-light, and it struck me at once, that here, toned down by the daylight that still remained, was reproduced more nearly than in anything else I had ever noticed, the exact tone of the colour of the corona. Most of the members of our party described it as either "silvery and colourless," or "very pale blue."

Col. BURTON-BROWN (Cemetery Hill) reports that "the corona was pearly white, but not so pearly as in December, 1870. The main corona was visible about a moon's radius round it, pretty regularly grading off from the limb outwards; it was rather brighter on the apparent right side near the moon during the whole time. The streamers and, in a slighter degree, the outer corona appeared slightly tinted with a peacock green colour.

"The sky was *perfect*. Every anticipation as to Algiers being an ideal station was verified, and the glorious phenomenon more than ever confirmed the impression which I expressed to Sir G. B. Airy after the total eclipse of 1870, "That the sun appeared like an enormous electrical machine, emitting a flow of luminous electricity into space from every part of it, and if brighter round one part of the moon than round another part, it seemed due to the brightness of the radiating surface, and partly to extra energy therefrom."

Mr. WALTER MAUNDER (Hotel de la Régence, Algiers), recalling the eclipses of 1886 and 1898, considered that all three coronæ were white in colour, but that whilst the two earlier eclipses were white, and somewhat of the tendency to a steely blue which we see in the electric arc, the present corona was rather of the whiteness of ivory, a somewhat warmer tone with a slight tendency to yellow being noticeable. This impression was confirmed by Prof. H. H. Turner, who had seen the same three eclipses, but, on the other hand, the observers at Manzanares considered that the whiteness of the corona tended distinctly to the bluish side and away from the yellowish side. "If we were not afraid of indicating too pronounced a colour, we might say

that it had an exceedingly faint amethystine tinge. The returning sunlight looked magnificently orange-yellow at its first appearance, by contrast: proving the tendency towards amethyst of the coronal light. Mr. Moore who was in India in 1898 judges this corona to be of precisely the same colour as that seen in India; and the yellowness of the returning sunlight was equally marked there."

Other observers varied greatly as to their estimate of the colour. Thus at Naval Moral, Mr. HOWARTH called the corona "a circle of soft silvery light," Mr. LA GUIDARA, "dazzling silvery light"; Mr. SOUTHALL, "intense white, the streamers appeared of a creamy tint"; Mr. BUCKLEY, "close to its rim the sun was encircled by a yellow light"; Mr. W. F. STANLEY found "the moon dark red or brown, a sharp, clear aureola surrounded it about 2' in width, this had a slightly yellow tone, the corona was distinctly bluish"; Mr. and Mrs. CONSTABLE at Talavera, "the moon, as in a total lunar eclipse, appeared like transparent copper, with a lighter tone near its limb, the bright shafts of the corona had a yellowish tone near the sun."

At Ovar, the Rev. A. MORFORD thought the colour of the corona had to the naked eye a violet tinge; and Mr. GIBBS at the same place calls the corona "pearly white," and speaking of the brightness of the inner corona, uses the same simile as Prof. MOYE, that it almost gave the idea that the eclipse was not total but annular.

On the whole it is clear that the corona may properly be described as "white"; the slight creamy tinge being perhaps most noted by those observers who paid most attention to the inner region, the slight bluish tinge by those who observed rather the outer extensions.

#### THE CORONA SEEN OUT OF TOTALITY.

A FEW observations were made of the corona, either before totality was complete, or after it was over. In most cases it could only be traced for a few seconds; Mr. WEIR's observation being a most remarkable exception. As it stands it appears perfectly definite, but the length of time out of totality is so considerable that it seems safer to suppose that the appearance was due to some reflection in the camera.

Mr. WEIR (Plasencia): When adjusting the camera for photographing the total phase, quite ten minutes before totality—fully three-fourths of the sun's diameter being obscured—we were astonished, on closely observing the image on the focussing screen, to find on the south-western side lines of light which evidently proceeded from the sun. Although aware of the delicate nature of the coronal

rays, we could imagine this to be nothing less than early indications of the corona itself, and were thus prepared for the form assumed by that section of the corona when totality came on. Our conjecture may or may not have been correct, but the facts were clear. The rough note taken at the time, and written out immediately after, reads, "Saw the appearance of the corona at underside of sun quite ten minutes before totality—fuzzy appearance with lines of light." This seems to show that given the requisite conditions, viz., a suitable atmosphere and the moon favourably placed relative to the stronger coronal rays, these may be seen even if the eclipse be not total.

Mr. BACKHOUSE (Plasencia): When totality was over a complete continuous ring continued visible round the moon, the brightest part of the corona being visible I should think three or four seconds afterwards. I believe I saw the ring complete also before totality actually commenced.

Mr. J. E. PEARCE (Cape Matifou) observed the corona with a binocular, and hiding the bright crescent of the sun with part of the instrument, saw the corona from eight seconds before the commencement of totality until 4h. 20m. 20s., G.M.T., or 1 minute  $47\frac{1}{2}$  seconds after the sun's light had reappeared.

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#### DRAWINGS OF THE CORONA.\*

OBEYING the wish of the Editor, though I unfeignedly regret the work was not given to more capable hands, I have carefully studied the very numerous sketches he has sent me, and venture to make a few observations upon them. From the whole mass, since all could not be published, I have selected for reproduction eleven which seem fairly representative. Of these, Miss Stevens's beautiful sketch, much softer and more beautiful in the original than in the reproduction, having already appeared as a full-page illustration in "Knowledge," is inserted here by kind permission of the proprietors of that journal; and Mr. Moore's sketch (possibly imbued with the perverseness of its author) refused to come into line with the rest: these two, therefore, are printed by themselves. The remaining nine have all been brought to one size by the photographer—that is to say, the diameter of the moon is made  $\frac{5}{8}$  inch in each case. I have rotated to the left all the eleven sketches from the position as seen in the sky, and drawn by the sketchers, so as to bring the sun's axis vertical, and I have added Mercury, at 7.3 lunar radii from the moon's centre, to each sketch alike. One or two sketchers have blackened the moon (even Miss Stevens was guilty of this heresy), whereas one of the most remarkable things in a solar eclipse is that the moon does not seem dark: there is, as it were, a hole in the corona, and the sky as seen through that

\* By H. KEATLEY MOORE.

hole is precisely of the colour of the rest of the sky.\* Other sketchers have sent in a black pencil outline on white paper. To bring these all to the same level as the rest, for convenience of comparison, I have had the black moons neutralised in the reproductions, and I have lightly pencilled a filling-in to the reproductions of black outline sketches. These last have then been reversed in photography, black for white, so that they now appear as if drawn in chalk on a blackboard, the original lines clearly showing on the faint white background added by myself. It will be seen that no real alteration of the sketches has been made in reproduction, and of course the valuable originals are not touched. It seemed better to say exactly what has been done; and it is hoped that the necessity of these slight re-arrangements may seem as imperative to the readers as it did, after some weeks of experiment, to the writer.

It is evident, from the above, how great an advantage it would be if sketchers would agree to use one medium of expression and one scale. The plan adopted by that distinguished artist, the late N. E. Green, a former president of the Association, seems the best, and at the risk of wearisome repetition it may here be restated. Take purplish-blue paper, not too dark, and draw on it with white chalk; the chalk should be pointed at one end, and broadly flattened at the other, so that lines of varying force and thickness, and surfaces of even tint may easily be given; and by thus drawing in white upon blue, nearly in the natural colours of the object, the awkward and very dangerous translation of white upon blue into black upon white, as in a pencil drawing, is avoided—a great advantage. A half-crown supplies a disc of very convenient size, and is always available, at all events at this period, only halfway through the journey. The position of a planet (as Venus in 1898, or Mercury in 1900) should be marked beforehand; and sketchers should have previously practised as often as possible, always working strictly to time, and from a distant drawing, comparing their sketches afterwards with the original in terms of the moon's radius, and not using the same original twice in succession. It is highly desirable not to attempt more than one quadrant in actual eclipse-sketching, and when there are at least five in a party, the leader of the party (or the most rapid sketcher) should make a rough outline of the whole corona to guide him in making the composite sketch. Mr. Krauss Nield has sent in his own rough outline, which is very clever and valuable, and was done during totality; and this must have been of great help in producing the combined drawing of his party from their partial sketches. Some parties who did not make their own combined drawing have given a little needless

\* The Editor must confess himself as to some extent an heretic on this point. To his eyes—and to those of not a few other observers—the moon, though far from being black, is distinctly darker than the surrounding sky; and most certainly this conclusion is supported by not a few of the photographs.

trouble by not marking their partial sketches clearly. "Top left, top right, bottom left, bottom right," might be suggested as a set of names for quadrants quite free from confusion.

The first thing that strikes one in critically comparing these drawings is the large general resemblance of most of them. It must be the case that there is in a large number of people accidentally coming together in this way, every possible variety of skill, from the quite feeble beginner to the accomplished and rapid sketcher, and all shades of nervousness, from the highly-strung youth whose awe-struck emotion prevents his rightly estimating angles and dimensions and such trivialities in the presence of the most divinely wonderful thing he ever saw, up to the cool old veteran of two or three eclipses who is able to keep his nerves well in hand, and attend to his work almost as steadily as at one of the usual practices. Consequently it is necessary to compare a large number of sketches, paying, of course, greater attention to those which are themselves combinations of partial sketches. Every sketcher of any practice feels his own work to be the precisely true representation of what he saw, and if another sketch differs from his, by but a hair's breadth, so much the worse for the other sketch! We who sketch are so made, that we can no more help feeling the other man is all wrong (even if, as an Irishman might say, the other man is a lady or a camera) than we can fly. But when an editor demands a critical comparison common sense comes into play, and artistic self-consciousness must bow to the decision of the majority.

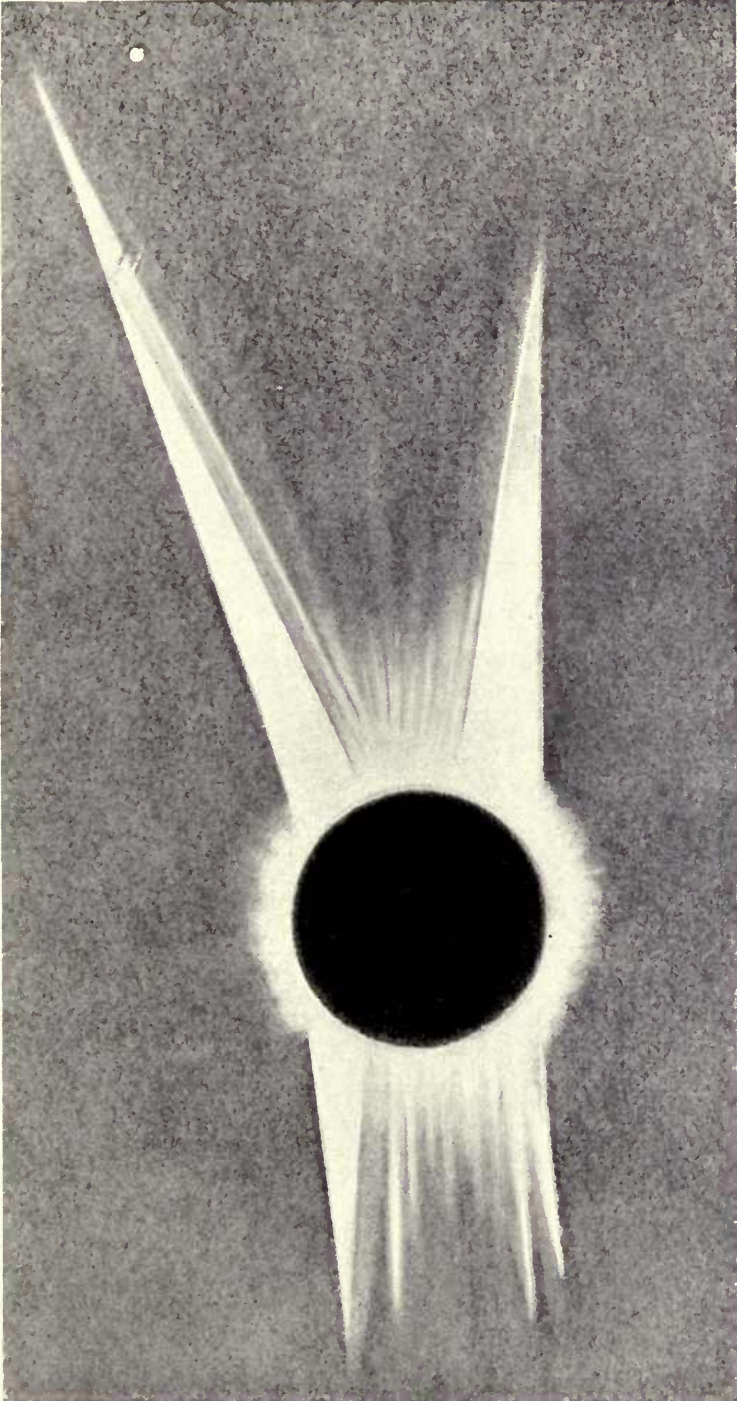
The sketches shown are—(1) By Miss C. O. Stevens, at Algiers; (2) by H. Keatley Moore (combined from sketches of hemispheres by self and Captain Carpenter), at Manzanera; (3) by Colonel Markwick, director of our Variable Star Section (at sea, on an Orient liner, which he skilfully assisted the captain to place exactly on the line of totality at the critical moment), off Ovar; (4) by C. T. Whitmell (combined from sketches of quadrants by his party), at Navalmoral; (5) by T. W. Backhouse (aided by a field-glass), at Plasencia; (6) by W. F. Stanley, at Navalmoral (a wonderful piece of chalk drawing to be produced in one minute, but actually untouched); (7) by Thomas Weir, at Plasencia; (8) by Monsieur Marcel Moye, one of our French members, at Elche; (9) by Colonel Burton-Brown (combined sketch, of importance from the large number of persons taking part in it, several of them being competent sketchers, and many having practised together on the voyage out), at Algiers and vicinity; (10) by Andrew C. D. Crommelin, director of our Cometary section, at Algiers (drawn from memory ten minutes after totality); and (11) by H. Krauss Nield (combined sketch, of importance from the number and careful practising of those who sketched quadrants, so that at least two excellent drawings of each quadrant were obtained), at Cape Matifou, Algiers. In the case of this last sketch (No. 11) the combined sketch was drawn in pencil on tracing paper over the

quadrants, and when agreed to as correct was placed, as if it were a negative, on a piece of glass and printed out with ordinary photographic paper. From the positive thus obtained the present reproduction is directly taken. Mr. Krauss Nield's party also having been sufficiently blessed with this world's goods to muster half-a-crown between them, the result comes to hand in a most available form, with a half-crown moon and a combined drawing as nearly untouched by the compiler's individuality as possible. That is why I have ventured to give the details of his ingenious device.

The drawings not produced here closely resemble one or the other of these eleven; and sketchers must not, therefore, feel that their labour, so valuable to themselves, has been valueless to others. Thus Mr. Howarth's sketch (Navalmoral) may be taken as a variant of Mr. W. F. Stanley's (No. 6, Navalmoral), but with the S.W. streamer extended to 5 radii. Mr. Nielsen's sketch (Ovar), which indicates, by the way, three red prominences in the middle of the west side of the corona, as visible to the naked eye is just Colonel Markwick's (No. 3, at sea off Ovar), but with both upper and under boundaries of the west side much more nearly straight; Mrs. Bevan's combined sketch (Algiers), and Mr. R. F. Roberts junior's combined sketch (Algiers), are both slight variants of Mr. Krauss Nield's (No. 11, Algiers), the main difference being that Mr. Roberts has the lower boundary of the west side curved almost as much as that of Colonel Markwick (No. 3), and so on with others. It is at least worthy of remark that in each unpublished case named the nearest published sketch is that from the same district. Navalmoral resembles Navalmoral; Ovar, Ovar; Algiers, Cape Matifou, *i.e.*, Algiers. As regards prominences visible to the eye it is interesting to note that Colonel Markwick and Mr. Backhouse exactly support each other in noting a fine one a little below the equator on the western limb.

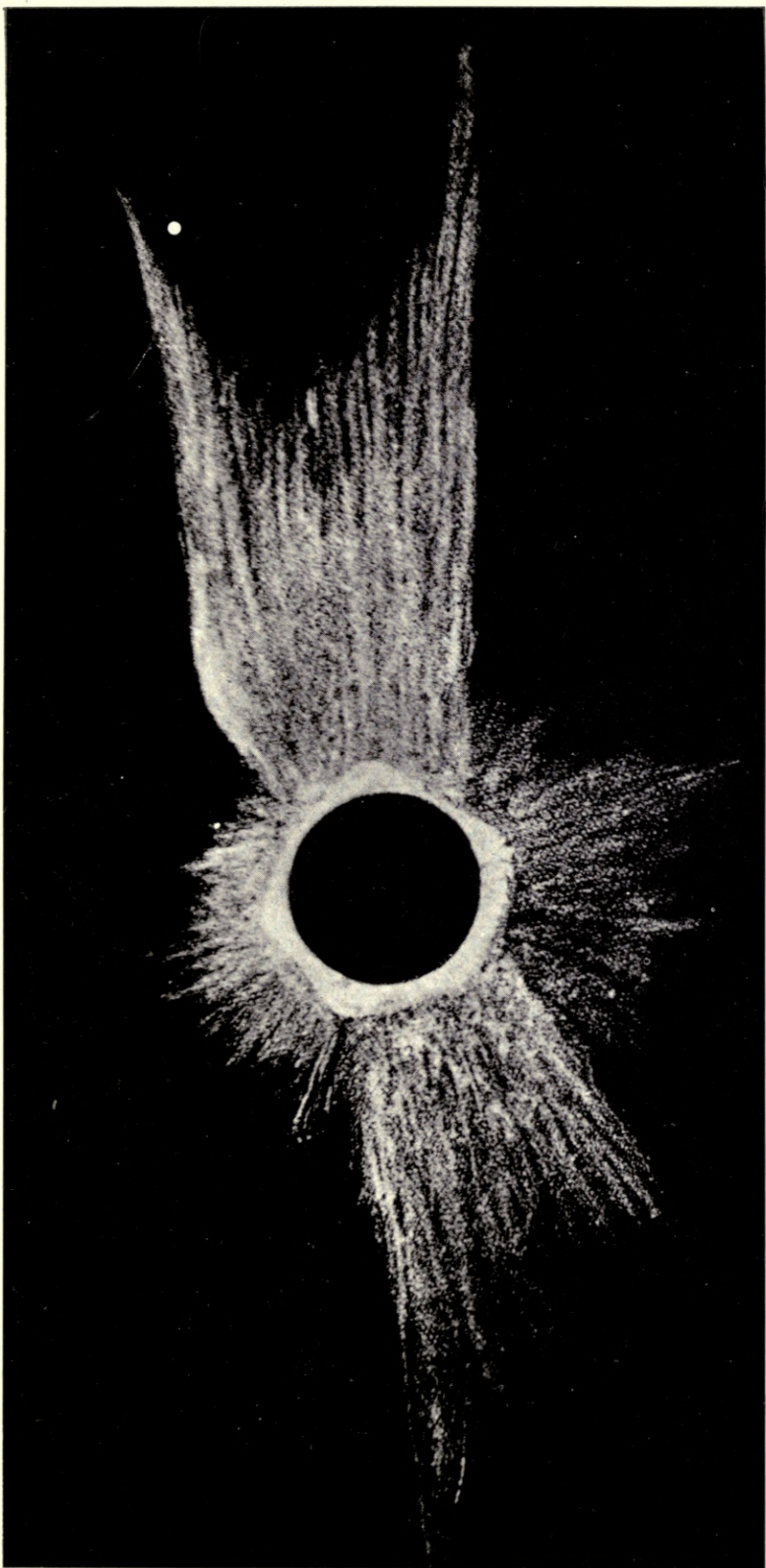
There is one feature common to all the sketches, and as this is also to be found in Mr. Wesley's most beautiful combined drawing (compiled from many photographs by Mr. and Mrs. Maunder), it may be taken as proved. I mean the upward lift of the western upper boundary of the corona. The "angel's wing" outline of this boundary, with a special brightness at the crest of the curve, which Mr. Wesley shows, is found very markedly in the Manzanares and Ovar sketches. The same outline, but without the special brightness, is distinctly though less markedly shown in the Cape Matifou sketch, and still less markedly in the Plasencia sketch (No. 7). In the Elche sketch this boundary finishes early, but if the sketcher had seen it further I think it not unlikely that it would have proved to be of this type; both the Navalmoral sketches tend towards it, while there is nothing inconsistent with it in some of the Algiers sketches (Nos. 9 and 10), which have not this boundary at full length. On the other hand, Miss Stevens (Algiers) and Mr. Backhouse (Plasencia) are either straight or slightly convex.





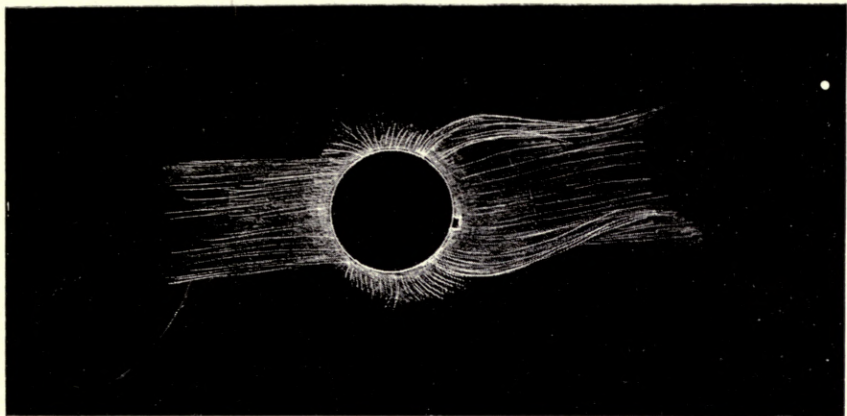
1. Algiers, Hotel de la Régence. (By Miss C. O. STEVENS.)



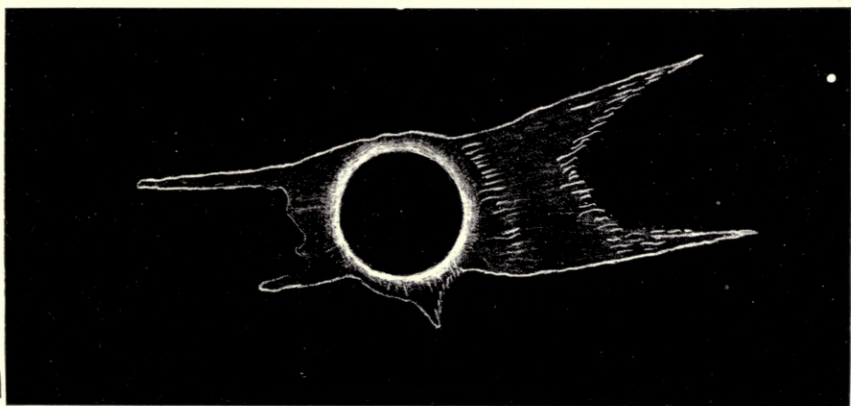


2. Manzanares. (By H. KEATLEY MOORE, B.A., and Capt. ALFRED CARPENTER, R.N., D.S.O., F.R.Met.S.)

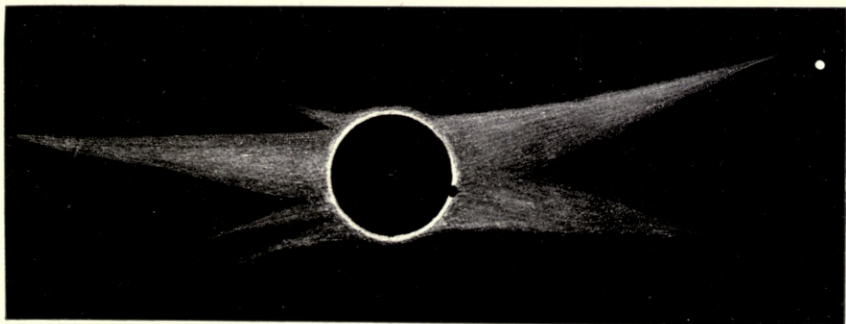




3. At sea, off Ovar. (By Col. E. E. MARKWICK, R.A., F.R.A.S.)

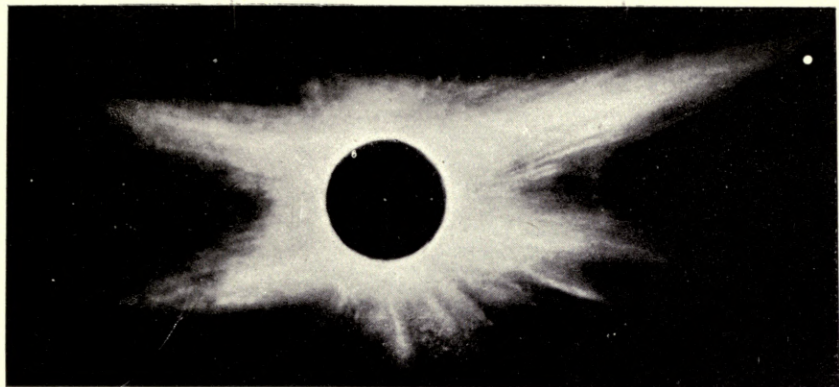


4. Navalmoral. (By CHAS. T. WHITMELL, M.A., F.R.A.S.)

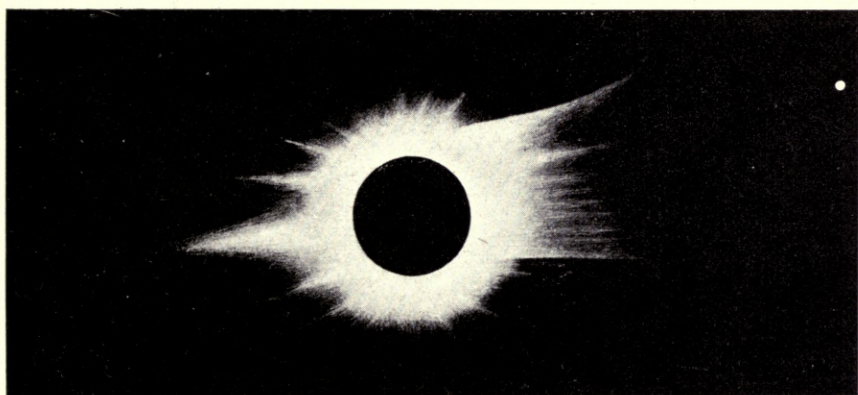


5. Plasencia. (By T. W. BACKHOUSE, F.R.A.S.)

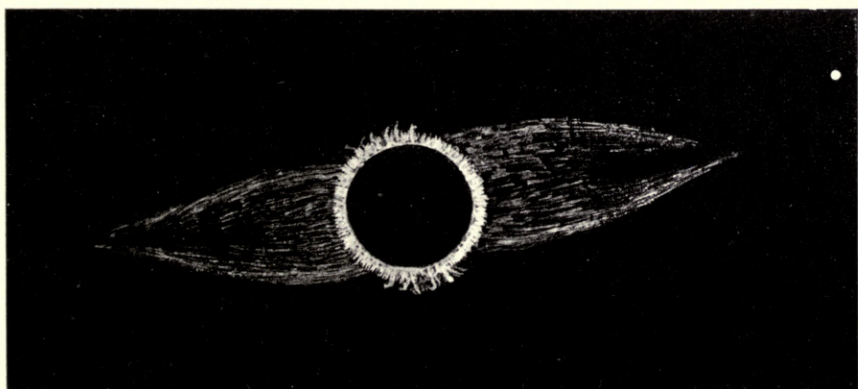




6. Naval moral. (By W. F. STANLEY, F.R.A.S.)



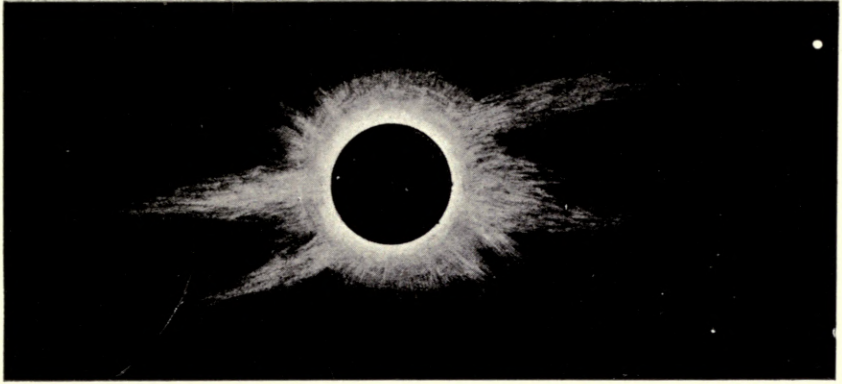
7. Plasencia. (By THOMAS WEIR, F.R.A.S.)



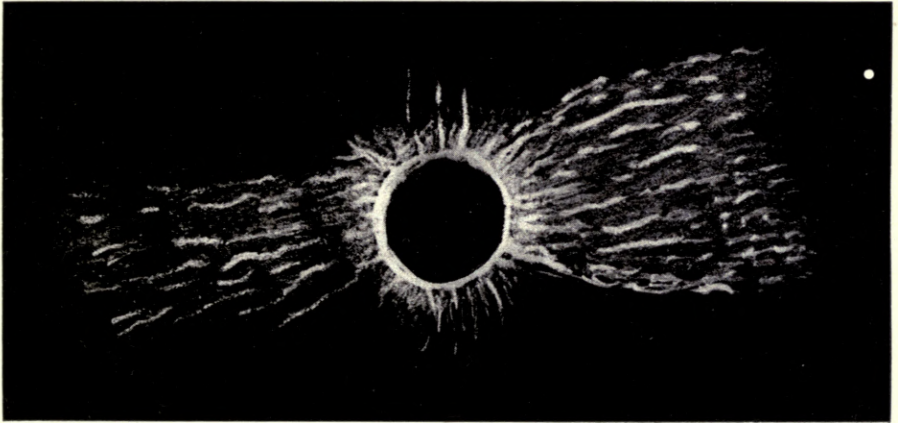
8. Elche. (By MARCEL MOYE, LL.D.)



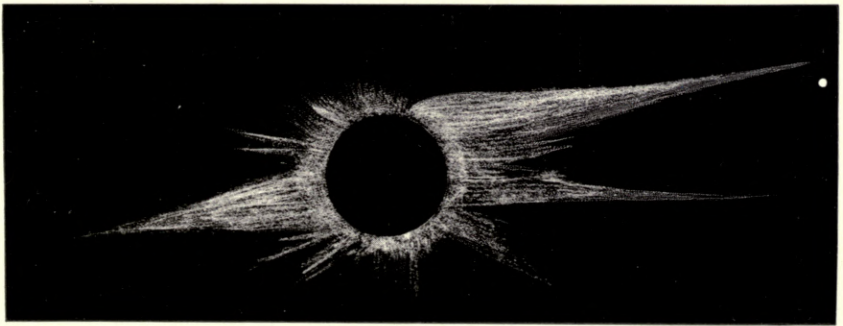




9. Algiers. (By Col. ALEX. BURTON-BROWNS, R.A., F.R.A.S.)

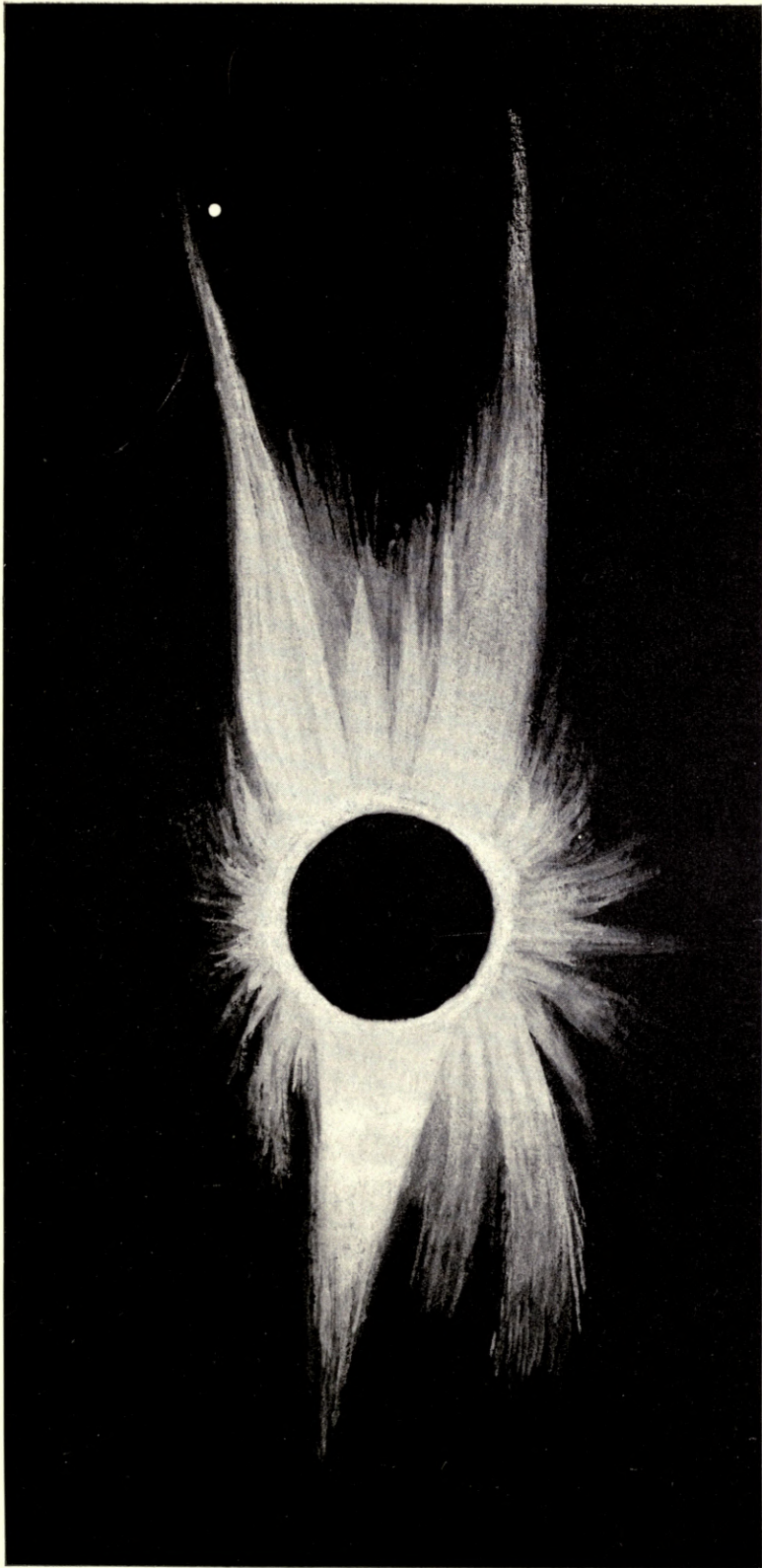


10. Algiers. (By ANDREW C. D. CROMMELIN, F.R.A.S.)



11. Cape Matifou, Algiers. (By H. KRAUSS NIELD.)





12. Combination of the eleven preceding Sketches, by H. KEATLEY MOORE, B.A.



The length of this "angel's wing" was fortunately fixed by Mercury. At Algiers, Manzanares, Cape Matifou (where Dr. Harold Whichello specially observed this point), and Navalmoral, the corona was distinctly seen to extend a little beyond and above Mercury (7.3 lunar radii from the moon's centre). This then is a point abundantly proved by many independent sketchers. The fact that others did not see it is probably due to less fresh or less skilled eyesight; it is unfortunately only too easy to watch a little too often the interesting partial phases before totality, or to endeavour to catch Bailly's beads, etc., with the inevitable result of cutting thousands upon thousands of miles off the extent of the corona. And this I say daringly, for the wrath of many indignant sketchers awaits me; but it is disastrously true, like many other unpleasant things in this world, that you cannot eat your cake and have it. At any rate this one result is ample justification for refusing ever to depend solely upon the camera to the neglect of the older, simpler, and rougher method of hand and eye. Here at least we sketchers have scored a point.

The lower western boundary is also shown by Mr. Wesley to be curved, and with him (following his originals, the Maunder photographs) it is cut off by one of those deeply interesting black lines we think so much and know so very little about. Manzanares, Ovar, and Elche, and perhaps one of the Algiers (No. 10) tend to corroborate this dark line in the definite way the western lower boundary runs right up to the moon's limb. In all other cases it melts into the inner corona vaguely. The curved outline is a little over estimated perhaps in Ovar, and a little under estimated in Navalmoral (No. 4); very well shown in two of the Algiers (Nos. 9 and 10) and in Elche, though in this last (the whole division being far too narrow) it unfortunately runs up almost to form a point with the upper boundary.

Still using Mr. Wesley's remarkably beautiful transcription of the photographs as our standard of comparison, we observe that the general features of the great western division of the corona comprise a very decided northern ray, broad at the base and tapering gradually to a point; a less decided southern ray, broader at the base and tapering much more gradually (altogether blunter in shape than the former), and between these a beautiful brush-work with two or perhaps three rays or groups of rays extending beyond it, but the whole of much less extension than the great north and south rays on this side, say roughly of half their length. The outline on the extreme west (if we may use an absurdly harshly-defined term, where the actual appearance was that of an exquisite imperceptible melting away) is hollow; so that with the definite north and south boundaries the whole figure of the western division has a rough similarity (*parvis componere magna*) with a herring's tail. This last feature is common to all the eleven sketches except No. 10. No. 3 is not very definite, but does not wholly disagree. I hold that No. 7, who has failed to see more than the roots of the great

streamers, yet quite agrees so far as he goes; and No. 8 clearly means the middle to be less extensive than the boundaries. The herring's tail feature may therefore be regarded as fixed.

Then as to the great upper ray all but No. 10 clearly have it, some to the full extent visible to the naked eye, others to a less extent; No. 9 omits the tapering effect, Nos. 3 and 8 exaggerate it, because of the narrowness of their base. But the consensus is so marked as abundantly to prove it. Next as to the great lower ray; three of these sketches make it shorter than the upper ray, namely, Nos. 1, 5, and 6. But Nos. 2, 3, and 4 make it longer, and Nos. 8 and 9 at least equal, or even slightly longer. Judging from the slowness of its tapering in Mr. Wesley's drawing, and remembering that it grew much more rapidly faint as it proceeded than did its more striking "angel's wing" brother, I am inclined to think it was longer, and that Manzanares and Naval moral (No. 4) are justified. On the other hand, this lower ray is clearly more definite throughout its length than Manzanares makes it, a feature which only No. 10 omits.

The middle portion of this western division, with its fine brushwork, and emphasised rays, shows clearly in No. 1, is too vague and probably a little over extended in No. 2 (or not sufficiently softened off, we may say), and is one of the best drawn parts in Plasencia (No. 7). It is abundantly shown by every one.

The parts around the north and south poles of the sun have with Mr. Wesley much less importance. The South Polar fine faint rays (including the dark ray) radiate fairly well from the sun's centre, but the rays at the North Pole spring from a radiant point near the limb, and extend less than those at the South Pole.

The sketches are still in agreement with this. The South Polar rays are shown as longer in nearly all the sketches, and where there is a difference in power are also fainter than those at the North Pole. The excentric effect of the northern rays is indicated in Nos. 3, 5, 7, and 11; but only slightly, as the sketchers were intent upon the more striking equatorial regions.

Finally, passing to the Eastern division of the corona we find in Mr. Wesley's drawing a fine streamer with a base extending from below the equator nearly to the pole, and visible, tapering steadily, and towards a point a little above the sun's equator, to a length nearly equal to either of the western streamers. Above this is a short roughly parallel ray, about a third of the length of its companion, radiating from the elevated radiant point affected by the other North Polar rays, and its root balancing the root of the "angel's wing." Below the great eastern streamer are three others, all rapidly decreasing in brilliancy as they advance, and all shorter than the great streamer; the lowest of these, with its great markedly curved root, balancing very closely the "dark ray" which bounds the lower western ray. As these three lower Eastern features are not very different in length from the rays of the South Polar region, a roughly

circular margin, parallel with the moon's limb, is felt in the photographs, ranging from the greater lower Western ray to the great Eastern ray.

These Eastern features are not so well produced by many of the sketchers. It is of course known to every one who handles a pencil that it is more difficult to draw to the left of a line than to the right, simply because we use the right hand, and the natural play of the hand is towards the right, as indeed the direction of our writing admirably evidences. Therefore *à priori* I should expect left-hand features occasionally to be stunted by unwary sketchers, and in marshalling my forces should put most of my best troops on that dangerous side. Nevertheless Nos. 2, 4, 5, 7, 8, 9, 11, show as great or nearly as great an extension on the east as on the west, and while No. 3 falls a little short No. 10 even extends further. No. 6 touches the edge of his paper, and leaves it a little uncertain how much further he meant to go. Only No. 1 has an Eastern side very greatly subordinate to the Western, and as this sketcher was working alone there are many practical reasons to account for this shortcoming. I regard it as proved that the great Eastern ray was nearly as long as the great Western rays.

Both the great Eastern ray and the smaller (excentric) ray are admirably shown in Mr. Backhouse's drawing, Plasencia No. 5; nothing could be better in general effect, and we only want it a little extended. Very good also is No. 9 on this point, but the magnificent base has not been sufficiently well felt. Mr. Krauss Niels is also, as usual, successful; his great ray only wants to be redrawn parallel to its present position but a little higher up the paper, it is very good in direction and general effect; and this would also bring the smaller ray, clearly indicated, nearer to the pole, as it should be. No. 7 has also got his great Eastern ray pointing below instead of above the equator. Every one has felt the tapering effect of this ray, Manzanares less than most. Its form, extent, and general position are abundantly proved.

Then as to the rest of the Eastern division, Nos. 1, 5, 7, 10, 11 show two of the three smaller streamers below the great one, and Nos. 2, 3, 6 generalise. Nos. 4 and 9 only show one of the streamers, so that it becomes over prominent by isolation. No. 8 alone shows none. The balance of both upper and lower main curving boundaries of Eastern and Western divisions is exaggerated in No. 8, but the very exaggeration shows how prominent was the effect to that sketcher. No. 7 is the only one to feel nothing of this balance; for in No. 11, though not well apparent as it stands, the correction suggested in the last paragraph would bring it out quite clearly; but many do not realise the bounding curves so well as they have done on the Western side, no doubt led by the straight boundaries of the main feature, the great Eastern ray. Looking at both upper and lower boundaries of Nos. 6 and 9, I observe the same effect indicated which has been overdone in No. 8, and this point also

seems to be proved. In general, the sketching seems to me rather poorer, and less accordant on the Eastern side than on the Western.

Looking at the corona as a whole the tilt upwards to the right and downwards to the left is excellently marked throughout. But I feel convinced that Nos. 4, 5, and 6 are right in the upward axis of their great Eastern ray, so that if the whole corona is turned so as to stand upon the "fish-tail" as a base, this great ray will trend to the right hand (as Mr. Wesley says it should do), and not, as in Nos. 1 and 2 and several others, rather to the left. And the last observation that I shall make is that except Manzanares (which I do not for a moment say is correct in result, though I commend the attempt) no one tried to mark definitely the limits of the "blaze" of the inner corona. Mr. Stanley (No. 6) told me that to save time he stuck a white ring on to his dark paper, as is apparent if the original is examined, and most of the others have treated the inner corona as a tolerably regular circular blaze. Colonel Burton-Brown (No. 9) is successful in getting the general effect of this feature, but I saw a much more irregular and more definite outline than he gives. And though I frankly admit that the Manzanares outer edge (of the inner corona) is too hard, yet there is a very great difference between inner and outer, and Nos. 2, 6, 8, and 9 have rightly emphasised this. There is of course a danger in looking too much at the inner corona (and I think No. 7 is a proof of it) as it is so dazzlingly bright that it tends to look bigger than it really is, and to blind the eye for the far fainter long extensions of the outer corona. My own plan is to take it last, on this account.

Perhaps it comes from my reproducing the poetical name of "angel's wing," given to the great N.W. steamer by a gifted friend, that I yield to a suggestion in high quarters, and like a fool "rush in where angels fear to tread." At all events it has been thought desirable to embody in an imaginary sketch (No. 12) all the points which I consider to have been proved in the foregoing article. As this sketch will differ from every one of the actual sketches my fate will lie between Actæon and Marsyas, unless my indignant colleagues pause to remember that while it differs it also agrees (in some points) with every one. Speaking as a sketcher myself, and shaking off the critic, I am quite sure that No. 12 is extremely wrong in every point where it deviates from No. 2. I cannot therefore grumble if, changing the latter number, my brother sketchers echo this sentiment.

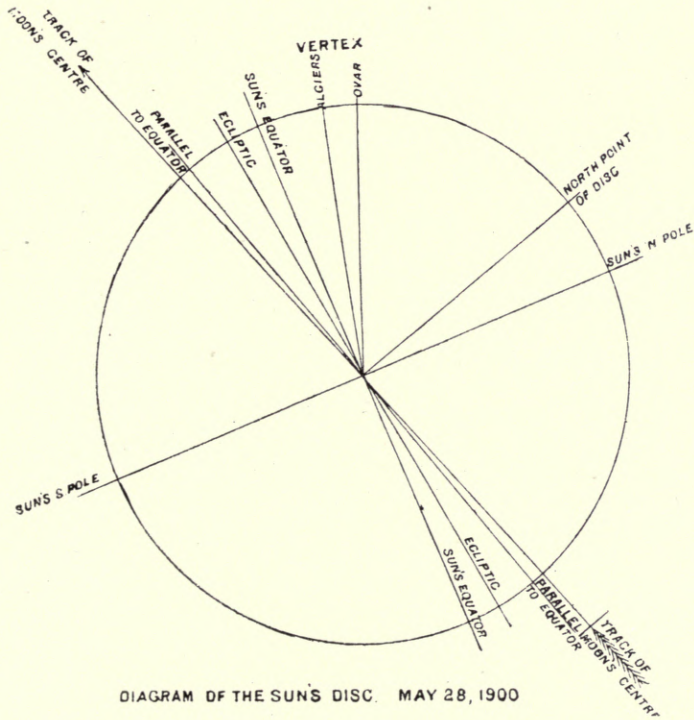
But, to end seriously, I really think that every one who carefully and without prejudice examines this group of sketches, the production of only about a minute's work, and therefore necessarily containing many errors, will be surprised to find the large number of points in which a majority is found to agree, and will come to the conclusion that sketching still remains an indispensable and very valuable means of recording an eclipse. At the same time we must endeavour to get more



practice before another eclipse, as it is clear that, in the immortal words of Goldsmith's *cognoscento* ("Vicar of Wakefield"), "the picture might have been better if the painter had taken more pains."

H. KEATLEY MOORE.

The following diagram will enable the position of the sun's axis and equator to be recognised on the drawings. Mercury, shown on each of the sketches, was situated at the time of mid-totality for the centre of Spain, at position angle  $271^\circ$  from the N. point of the disc, reading in the direction N.E.S.W., and at a distance from the sun's centre of  $2^\circ 2'$  or  $7.3$  lunar radii.



## CHAPTER XI.

### *THE CORONA AS SEEN IN THE TELESCOPE.*

ONE department of observation, to which attention was given in this eclipse, was the detailed examination of the inner corona by the aid of telescopes of considerable power. Chief amongst these observers who undertook this department was Mr. W. H. WESLEY, who was sent out to Algiers by the Council of the Royal Astronomical Society, in order that science might have the benefit of his artistic skill, and absolutely unique acquaintance with coronal structure as shown on photographs, directed to the study of the corona itself, as seen in a fine refractor. In Mr. Wesley's own words, given in "Comptes Rendus," 1900, July 23, and translated in "The Observatory," of 1900, September, "As I had had occasion to study minutely the form and structure of corona as photographed during eclipses since 1870, it seemed desirable to compare the aspect of the corona as photographed and as observed visually. There was a probability that the eye would see details not shown in the photographs. My attention had been recently directed to the point in a letter from Prof. Langley on the eclipse of 1878. In his 'Report to the Superintendent of the United States Naval Observatory,' he says:—

'Now what I saw in this brief view was a surprisingly definite filamentary structure somewhat coarser and decidedly more sharply defined than I have ever seen filaments in the photosphere, not disposed radially or only so in the rudest sense, sharpest and much the brightest close to the disc, fading rapidly away into invisibility at a distance of five minutes of arc or more (possibly in some cases of ten). . . . Interesting as may be the photographs of the interior structure of the corona which have been recently obtained, this structure has not been completely studied, even on the best photographs I have seen; the means at our disposal, at present, perhaps do not permit us to do it. I hope that at the next eclipse this interior structure will be a subject of special study on the part of every party possessing the necessary photographic outfit, and I submit that wherever possible telescopic study should be made.'

In photographs taken near the maximum of sun-spots (notably on the photographs of 1871 and 1893), I have found a great amount of complicated detail in the lower regions of the corona. The photographs taken near the period of minimum sun-spots in general show little detail."

Since the eclipse of 1900 took place at a time when the sun was least spotted—and the event showed the corona to be markedly of the minimum type—it seemed a peculiarly fitting occasion on which

to put to the test the alleged superiority of the eye over the camera for detail in the inner portions of the corona. Mr. Wesley was, moreover, especially favoured in his telescope, as M. Trépied, Director of the Algiers Observatory, placed at his disposal the powerful equatorial coudé—probably the most powerful instrument as yet employed visually on the solar corona. The following is Mr. Wesley's own description of the visual structure of the corona:—"At the instant of disappearance I commenced observing, and perceived at the first glance a corona of symmetrical shape, with broad, well marked polar rifts, extending a considerable distance to the N. and to the S. These rifts



MISS L. MARTIN-LEAKE, HOTEL DE LA RÉGENCE, ALGIERS.

were filled with delicate rays, which I could follow to the edge of the disc. They were straight and in a direction nearly radial in the central portion of the rifts; then towards the extremities of the rifts they diverged more and more from the straight form and from the radial direction. They recalled in a striking manner the rays seen in many former eclipses, particularly that of 1889. The equatorial regions were, in general, of a uniform density all along the limb, and here I could not certainly find any trace of rifts reaching right up to the lunar disc. I looked especially for traces of arched or interlaced forms near the limb, but I could see none; I could only suspect some arched rays around the large prominence in the S.E. The details seen in the lower equatorial regions

consisted entirely of ill-defined masses, not more than one-fourth the lunar diameter in altitude. These masses faded off in a manner nearly imperceptible, and presented no definite contour . . . . I cannot believe that the non-appearance of arched or interlaced structure to which I principally directed my attention was due to bad definition, since the polar rays were defined with extreme clearness."

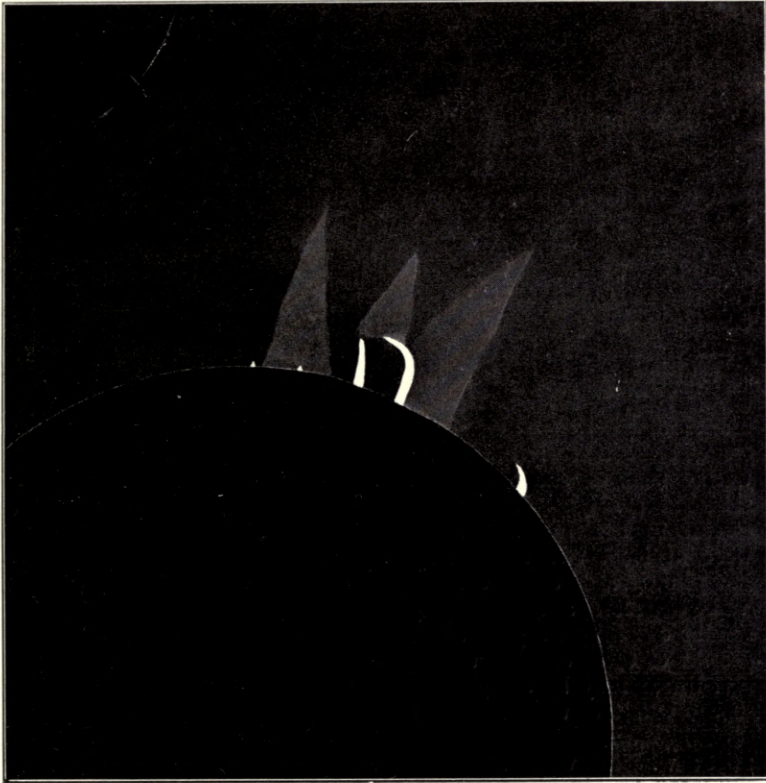
Mr. Wesley's observation emphasises two points:—(1) The solar corona varies in complexity throughout the progress of the sun-spot cycle, being richest in detail when spots are most abundant; and (2) As much detail can be seen in a photograph sufficiently exposed and developed, or rather in a series of photographs obtained with different exposures and suitable developments, as with the eye. On this point Mr. Wesley says:—"I do not believe I saw more details than are shown in the photographs, and now feel convinced that good photographs, taken on a sufficiently large scale, are capable of showing all the details which can be distinguished by the eye at the telescope. I make this statement with the more confidence since it disagrees with my preconceived ideas. I had expected to see detail of a more or less complex nature, and my attention was especially directed to this point. At the same time, the sky was absolutely transparent, and the instrument which I used was, without doubt, better than any hitherto employed for visual observation of an eclipse."

Five members of the party stationed on the roof of the Hotel de la Régence, Algiers, took up this question of the detailed examination of the structure of the corona, in the telescope. Of these, Miss LILIAN MARTIN-LEAKE, observing with a 3-inch refractor, and a power of about 50, made an exceedingly careful drawing of the corona in the S.W. quadrant, paying especial attention to the region surrounding the prominence, situated about position angle  $236^\circ$ . Miss Leake has given her observations in the form of a key-sketch to her drawing with notes upon the several structures shown, thus enabling the reader to reproduce and follow the details which she saw in the field of her telescope with great exactness.

Mr. CROMMELIN, who was armed with a refractor of 3 inches aperture, selected the same general region as Miss Leake, and paid special attention to the neighbourhood of the prominence at  $236^\circ$ , that is to say, the large double one shown in Miss Leake's picture. Besides his drawing, Mr. Crommelin supplies the following notes:—

"As soon as the 'Ten Seconds' signal was given I removed the cardboard screen, placed myself at the eyepiece of the telescope, and slightly changed the focus, so that I was ready to commence observing when Mr. Maunder gave the signal 'Go.' I directed my attention to the largest prominence (position angle about  $236^\circ$ ) which was seen at once to be a magnificent double one, the left hand member being straight, while the right hand one was bent sharply to the left. The coronal light was of course pretty bright near the moon's limb, and for some seconds I could not make out any detailed structure in the restricted region I was examining, but presently I made out

three bright projections—one rising pretty symmetrically between the two large prominences—another on the right side of the bent prominence, and the third to the left of these. I feel pretty confident of the existence of these brighter regions, but they were



CORONAL DETAIL ROUND LARGEST PROMINENCE.  
(Position Angle about  $236^{\circ}$ .)

Sketch made at Algiers with 3 in. Telescope during totality, by A. C. D. Crommelin.

so difficult to see that their positions in the drawing may be somewhat in error. An outline sketch was made during totality, and a more finished drawing immediately after, while the appearance was still fresh in the memory. These have since remained unaltered, and the accompanying drawing is made from them."

The Rev. C. D. P. DAVIES employed a refractor of 2 inches aperture and 30 inches focal length, the micrometer No. 2 (Sheepshanks 3) in No. 29 of the R.A.S. collection of instruments lent by that Society, forming the eye-piece. This gave a power of about 60, and was used in conjunction with an un-silvered diagonal. Mr. Davies describes the polar aigrettes as follows:—

“My photographic programme would not permit of my lingering more than about a second and a half to gaze on the vision, but the impression produced in that all too short moment is one that I can never lose. The picture before me in intricacy, wealth of detail, and pure beauty utterly transcended any description that I had ever met with either in drawing, photography, or language. It was a most glorious sight. That which first of all arrested attention, and in fact quite startled me, was the evident perspective in which the streamers were viewed. No photograph or drawing of a celestial object that I have ever seen looks otherwise than as a representation of a plane superficies, unless it be that of a partial phase of the moon. Certainly all pictures of a total eclipse have to me looked perfectly flat. But here were the streamers manifestly viewed as rank behind rank, like stems of trees in a dense orchard, or, better still, at least as illustrating their form more nearly, like blades of yucca planted singly but thickly on a lawn. Their colour seemed steely blue or possibly a trifle paler, not altogether unlike that of the nib end of a quill pen, as it gleams with reflected sunlight. Besides the perspective appearance of the streamers bending one behind another as in a forest, there were at least two other ways in which the visual appearance put photographs out of court. First as regards colour: This is only to be expected, and is a mere matter of course. In the second particular one might *a priori* have expected otherwise. In all photographs of total eclipses that I have seen the streamers, however rectilinear may be the general direction of them in part or even in the whole of their length, their edges are always more or less ill-defined, giving one the impression of their being a tongue of mist; whereas when I saw them they looked more like our old friend, “a yard of pump-water.” As regards at least the inner portion of the corona, I imagine that there can be little doubt that the appearance of haze in the photograph is produced by the superposition on one another of the bases of innumerable and separate streamers, and is a frantic attempt on the part of the negative to supply that very appearance of perspective in which it so sadly fails. The mention of the pump-water above suggests just one more illustration of the appearance of the scene. It was as if one were looking along the surface of a sheet of water from which numberless jets were spurting up, many of them gracefully bending over at the top, but cut off before coming down again, some longer, some shorter, some thicker, some more slender, and the whole glistening in sunlight.”

Mr. EDMONDS, using like Miss Leake a 3-inch telescope with a

power of 60, made no drawing, but examining the same region as that chosen by Miss L. Leake, selected the neighbourhood of the straight prominence for special study. Mr. Edmonds had set himself to answer the three following questions:—(1) Whether the corona consisted of broad diffused masses of light, or of filaments? (2) If filamentous in character, whether such filaments were radial, tangential to the limb, or inclined at an angle to the radius? (3) Whether or no the corona seemed to avoid the neighbourhood of prominences, as if repelled by them? Mr. Edmonds' replies to the questions were:—(1) The corona seemed to me to consist of filaments. (2) These filaments were radial. (3) They did not appear to avoid the edge of the prominence.

Mr. W. ANDREWS observed with a much smaller aperture and larger field, and his results are comparable with those which would be given by a view in a opera-glass. It will be noted that he gave his attention chiefly to the outer streamers, that is to say, to a region outside that which was studied by Mr. Wesley and the three foregoing observers. "I had long wished to witness a total eclipse of the sun, and with that intention accompanied the expedition to Vadsö in 1896. This year I went to Algiers. I used a small telescope, of 1-inch aperture, on a stand, and an inverting eye-piece giving a magnifying power of 7 diameters only, but with a field of view of 4 degrees = 8 diameters of the sun. Also a small camera to expose one plate only. Avoiding looking at the sun I centred it in the field of view by projecting the image on my sketch paper, and the moment totality commenced looked through the telescope. The eclipse was in the middle of the field. Neglecting any prominences my attention was directed solely to the corona, and I was at first struck with what seemed to be the extraordinary complication of it. The field was covered with streamers, the longest of which reached to the boundary, or in other words they were 3 diameters of the sun in length. After a few seconds, however, I judged that the phenomena could be divided into two quite distinct portions, namely:—

1. The inner corona.
2. The streamers.

The inner corona seemed to go all round the sun, and its depth seemed to be equal to about one-fourth of the sun's diameter. It appeared to be unequal or irregular in density or texture, and was very bright in places, and looked as though it were in a state of disturbance. Neglecting now the inner corona I turned my attention only to the streamers, and commenced to sketch their main outlines. In the middle of the totality I removed the cap from the camera lens, replacing it after three seconds, and continued the sketch, but the totality only lasted one minute and the time was all too short. From pictures of previous eclipses I had expected to see the streamers in long curved rays, but rather to my surprise the rays were absolutely straight. The streamers were composed of bundles of bright fine rays, hundreds in number, and very strongly resembled beams of sunlight traversing our lower atmo-

sphere through openings in the clouds above. I came to the conclusion that no sketching could possibly do justice to the details of the streamers, and that photography must be relied upon. On the small negative which I obtained I can trace the streamers to a length of about 2 diameters only from the sun on the upper or eastern side, and  $1\frac{1}{2}$  diameters on the lower or western side. This indicates that the light from the extremities of the streamers must be very feeble."

The general appearance of the corona as Mr. Andrews saw it, was such as in his opinion, might be presented if the inner corona, whatever its nature, was a structure not thoroughly transparent which covered the sun all over to a depth of about half a solar radius. Then, if we imagine the corona to be irregular in texture and density, and to contain gaps and rifts, the sunlight streaming through its weak places, would light up the cosmical dust, which we may imagine surrounds the sun in all directions. In other words, the streamers resembled in Mr. Andrews' view, those bright rays, seen when the sun is shining from behind a cloud on a moisture-laden atmosphere; or when the sunlight, streaming in through a narrow aperture into a partially darkened room, reveals to us the "motes in a sunbeam."

Mr. Andrews encloses a sketch of the corona, composed entirely of rectilinear lines. It reproduces very fairly well the general effect of the corona as presented by the consensus of photographs and drawings. But it fails in one important particular; the characteristic double curvature of the roots of the great western extension—"the angel's wing" of Col. Markwick—was quite missed by Mr. Andrews. That it was easy to miss, where attention had not been specially directed to it, several of the naked-eye drawings abundantly show, but of the actuality of this curvature, one of the most characteristic of coronal forms, there can be no doubt whatsoever. This "hyacinth bulb" or "Florence flask," or "leaf-shaped" outline is always seen in the prominent lines of the corona, and it is most important as showing to us that we are not dealing with matters distributed, like meteors in an orbit. Such an orbit must necessarily be one of the conic sections, and a conic section however presented is always a conic section. The graceful double curves of the synclinal rays cannot therefore be explained in this way, any more than they can be explained by Mr. Andrews' simile of dust illuminated by sunbeams. Further, though many of Mr. Andrews' rays are like those in the region studied by Mr. Edmonds, radial in direction, many again are as evidently tangential. Now whilst a ray which appears to be radial may in reality be tangential, the reverse cannot possibly happen; whilst lines of illumination, streaming out through gaps in a partially opaque screen, would necessarily be nearly radial in direction.

Rev. AUGUSTIN MORFORD (Hotel Painça, Ovar) "was furnished with a refractor of 109-mm., by Secretan, Paris, ocular wide angle, power 70. The instant after the light of the photosphere



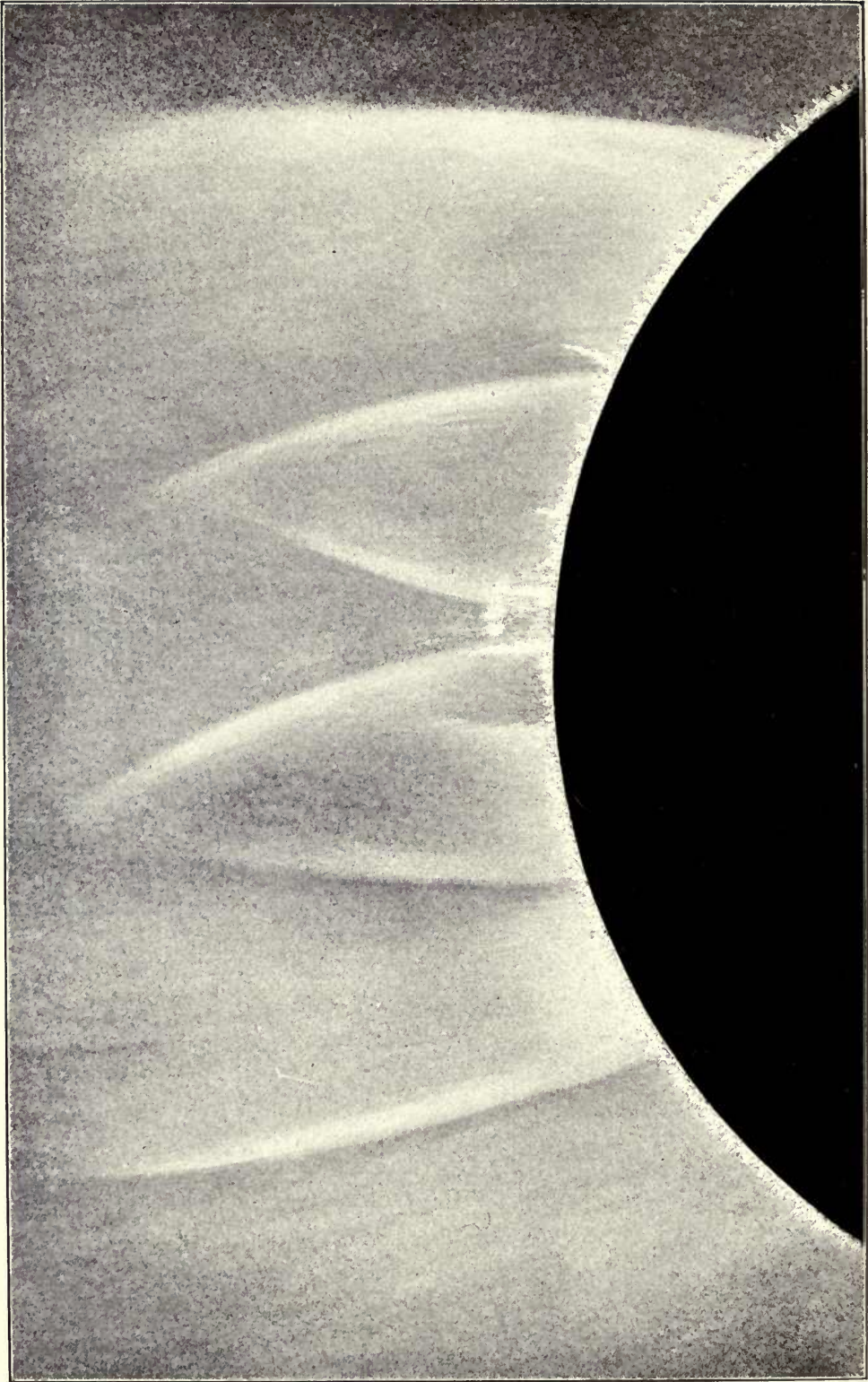
had disappeared, the arc of the chromosphere shone out with a bright glow, orange-red rather than rose-coloured. It was a thin layer, unequal, almost serrated. In an instant it was covered and the corona shone out in all its magnificence. At this moment I took two photographs returning to the telescope afterwards. The field of the ocular measuring 52 minutes, was filled with the inner corona. Bright, narrow silver rays as far as I could see evenly distributed like the spokes of a wheel; the interspaces filled with a soft radiance, silvery with a tint of violet; blended but not mixed with a pale-green like seawater. I feel I am trying to describe the indescribable. The colours were not of earth, and nothing I ever saw resembled them. But immediately after totality, trying to put my vivid impressions into words, this was the closest description I could find. Close to, if not upon, the eastern end of the sun's equator were two prominence-like forms—I judge  $1\frac{1}{2}$  to  $2\frac{1}{2}$  minutes in length—of an extraordinary brilliant white. They were slightly curved towards each other, and stood out from the background of the corona as if they belonged to the moon's disc instead of the sun's. I cannot say if they were visible before I left the telescope to photograph, but they caught my eye the instant that I returned to it. They were the brightest and most striking object of the whole phenomenon. Before I thought it possible the second side began to brighten, the limb seemed rapidly to turn orange; the chromosphere seemed to glow like fire for a second or two; a drop of light burst forth and scattered into Baily's Beads, and totality was at an end. It had lasted 88.4 seconds by my chronograph watch instead of 93.1."

This telescopic study of the corona was practically a new feature in eclipse observation, and the amount of success secured under all the drawbacks of the late eclipse, is a matter for the greatest congratulation. One poor minute, and indeed in Mr. Crommelin's case, it was not so much, is terribly short for the study of such an object as the corona. Yet one result of very great interest, though it may seem rather negative than positive, has been put on record. No man whatsoever has so full a knowledge of the corona from photographs as Mr. Wesley; and, as he himself said, never before had mortal man such a superb view of the corona itself as was afforded to him in the equatorial *coudé* of the Algiers Observatory. And his verdict was, that the corona he there saw, was a familiar object; he saw no structure nor detail which had not been made known to him by some one of the many photographs, which in the course of years have passed under his scrutiny.

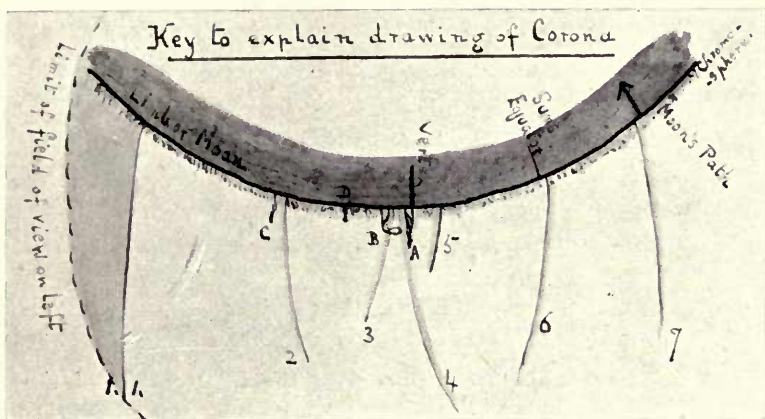
But the corollary to this result is not that such telescopic examination was either useless this time, or will be useless hereafter. In spite of the diffusion of photography, it may well be that in the future from time to time an observer may find himself at a total eclipse with a telescope but without photographic appliances. There will be still work for him to do in such a

case; and in any case we cannot assume until we have both telescopic scrutiny and photographic records throughout all the varying phases of a complete solar cycle, that the more complex and elaborate structure of the corona at the sunspot maximum may not give to telescopic examination greater minuteness of detail than any but the most exceptional photographs can supply. In spite of the increasing importance of photographs of Jupiter direct observation holds its own in the delineation of planetary detail, and is far from having been completely driven out of the field in the examination of the surfaces of the sun and moon. So, though the extreme brevity of eclipses gives photography an especial advantage over eye work, it is to be hoped that the experiment made this year will be followed on future occasions to the fullest possible extent, and that great use will be made of expert and artistic ability in the examination of coronal detail with considerable telescopic power.

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S.W. Quadrant of the Corona. (By Miss LILIAN MARTIN-LEAKE.)



CORONA. Streamers 7 in number noticed.

1. Outline, very sharply defined, of whole coronal mass of light seen in telescope. Probably southern edge of equatorial extension at root? I did not notice any coronal light to left of (1), it must have been very faint relative to light of (1), if present.

2. Outline springs from close to base of prominence C (equatorial side) and makes a sweeping curve away from C toward equator. Not nearly as sharply defined as (1).

3. Outline about as sharply defined as (2), seems to spring from between prominences A and B close to B and curving from behind B (apparently) towards (2).

4. Outline nearly as sharply defined as (1), more so than (2), and 3 originates between prominences A and B very close to A, and curves beyond tip of A in direction roughly parallel to (2); further defined in length than 3.

5. Outline fainter and shorter than any of others; curves towards (4).

6. Outline only roughly noticed; more sharply defined and longer than (3); roughly parallel to (3); originates close to Equator.

7. Outline about as sharply defined as (4); last streamer to right noticed, but coronal light quite bright beyond it.

REGION OF CORONA between and on either side of prominences A and B shows much disturbance. There are short faint streaks to left of B curving towards it from moon's limb, and space between A and streamer 5 is streaked. Space between A and B seemed to contain no chromosphere flames, and to be quivering with light, yellow and white rather than red, and to be marked with dark streaks impossible to see definitely in the very short time. The bases of streamers (3) and (4) could be traced right up to moon's limb.

PROMINENCES. Position angles, A  $236^\circ$ ; C  $216^\circ$  (?)

A and B close together. A seemed almost at Vertex Line.

A. Longest of all; conical, tapering to a fine point; strongly defined spiral markings all up it. Red in colour. Radial.

B. Thick radial stem, with strongly defined spiral markings; bends towards A sharply almost at right angles about  $\frac{2}{3}$  length of A up; the tip is blunt with curved outlines and markings like wreaths of smoke, hazy at edges. Colour: stem red like A, tip orange to bright yellow.

C. Scarcely  $\frac{2}{3}$  length of A; conical, tapering to fine point; spirally marked. Radial.

D. A very small one; conical.

## CHAPTER XII.

### *PHOTOGRAPHS OF THE CORONA.*

FOUR different subjects arising out of the photographs of the corona, secured in the recent eclipse, present themselves for consideration. I.—The structure and form of the corona. II.—An unexpected feature which certain of the photographs have brought into evidence, namely, the existence of dark markings. Mr. W. H. Wesley has very carefully studied the photographs with respect to these two subjects, and contributes a note on each of them. He has also prepared two composite drawings, the one from a study of all the negatives sent in, the other chiefly from negatives supplied from Mr. and Mrs. Walter Maunder. III.—The coronal extensions as seen on the photographs; and IV.—Photographs of the corona during the Partial Phase. Mr. and Mrs. Walter Maunder report on the last two enquiries.

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#### THE CORONA OF 1900 FROM THE PHOTOGRAPHS.\*

A LARGE number of photographs were taken during this eclipse, by members of the Association, who have kindly placed the original negatives in my hand for examination and comparison. A detailed list of the negatives examined is given at the end of this report, and from these photographs a combined drawing has been prepared, which forms the frontispiece of the present volume.

The general aspect of the corona, as shown on the photographs is that of a wind-vane, being somewhat broad and spreading on the west side, and pointed on the east. On the west side it has the least extension in the equatorial region, while on the east the greatest extension is only a little north of the equator. The corona has thus a fish-tail form on the west, remarkably like its eastern side during the eclipse of 1898.

The four groups of so-called "synclinal" structure which were very distinct in 1898 are by no means so clear in 1900. One of these groups can be seen to the north-west, much inclined from the radial in an equatorial direction, with a well marked curve

\* By W. H. WESLEY.

of double curvature on its northern edge, where it is sharply bounded by a remarkable dark streak. The ray terminates about two diameters from the limb, in a point somewhat in the direction of the planet Mercury. The southern edge of the western half of the corona is, like the northern, bounded by a dark streak. There is here no double curvature, and the extension is somewhat less than in the north-west. The western equatorial region is filled with more or less parallel rays running approximately in a westerly direction, giving to this part of the corona a "combed out" appearance.

As is so frequently the case the corona on the east side is strikingly different in character from its western aspect. On the east the only mass that seems synclinal in character is a great conical group of rays, the northern edge of which is nearly tangential to the limb. The base of the cone extends for  $70^\circ$  or  $80^\circ$  along the limb, and it runs out to more than a diameter and a half, with an approach to double curvature on each of its sides, forming the point of the "wind vane." To the north of this cone, and between it and the north polar rift, is a tuft of rays curving somewhat towards the cone, and to the south, adjoining the south polar rift, are two similar tufts of rays, curving decidedly northward towards the cone. None of these rays have nearly so great an extension as the cone itself.

The north and south polar rifts are wide, extending along the limb  $40^\circ$  and  $50^\circ$  respectively; they are very symmetrically placed with regard to the sun's axis, and much alike each other in character. Each of the rifts is filled very evenly with rays of the usual polar type—straight and radial in the centre, and more curved and inclined from the axis as they approach the extremities of the rift. Between some of the south polar rays are singular dark streaks, similar to those which bound the north and south edges of the western equatorial extension.

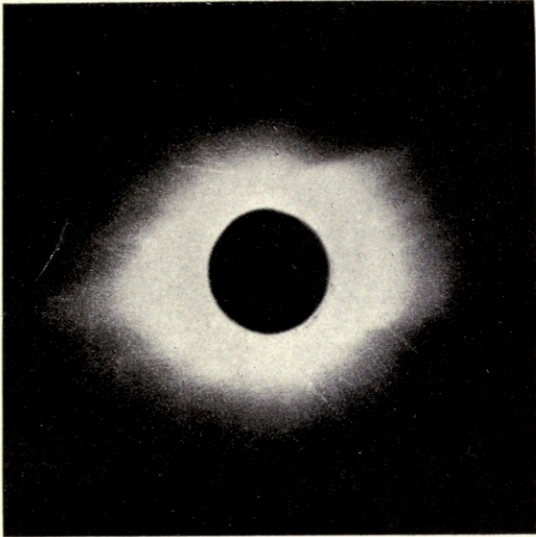
The corona of 1900 shows a much nearer approach to the type which has been usually associated with a minimum period of sunspots than that of 1898. In its most general form it most nearly resembles that of 1889, Jan. 1, but the eastern and western coronal rays are not so much depressed towards the equator as was the case during that eclipse; still less does it resemble in this respect the extreme type shown in 1878. It accords, however, with other coronas at times of sunspot minimum in its generally simple and apparently quiescent character. There are no rays which curl over or branch, and none of the indications of perturbation which were so marked in 1896. The main rays in 1900 run out east and west, generally tending towards parallelism with the solar equator, and there seems comparatively little detail in the lower parts of the corona. Its most interesting feature appears to be the occurrence of the dark rays or streaks, to which attention is more fully called in another place in this volume.

Among the photographs submitted to me for examination were negatives taken at such distant stations as North Carolina and

LIST OF PHOTOGRAPHS TAKEN DURING TOTALITY, 1900, MAY 28TH.

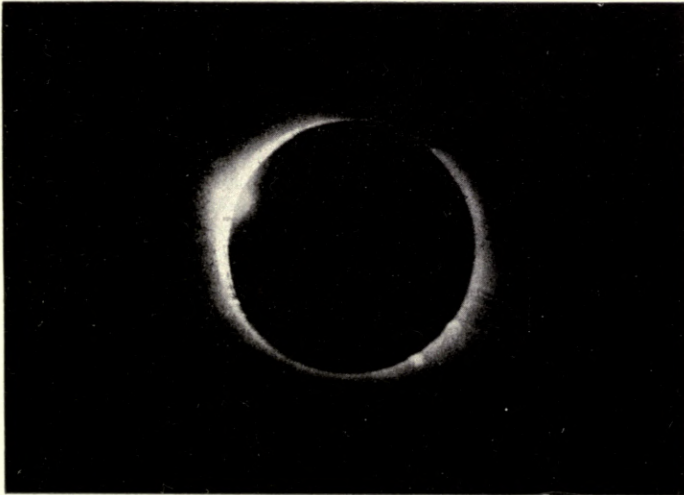
Place.	Observer.	No. of Photographs.	Size of Disc of Moon.	Instrument.	Aperature used.	Equivalent Focal Length.	F/A.	Plate or Film.	Exposures.
Wadesborough, U.S.A.	J. N. Maskelyne	299	in. 0.2	Kinematograph	in. 3.5	in. 21	6	Kinematograph Film	sec. 0.2
"	Miss Bacon	4	0.08	Dallmeyer Lens	1.5	9	6	Sandell Triple	15, 20, 30, 40
"	Rev. J. M. Bacon	2	0.54	Telescope Camera	4.1	58	14.1	Hilford Spec. Kap.	0.3
Ovar, Portugal	Rev. A. Morford	3	0.13	Zeiss Lens	0.9	14	16	Sandell Triple	0.07, 1, 0.07
Plasencia, Spain	T. Weir	3	0.18	Dallmeyer Lens	2.5	19.5	7	—	2, 4, 3
Elche, Spain	Lady McClure	1	0.06	Eastman Kodak	0.07	6	—	Sandell Triple	—
"	E. C. Willis	2	0.035	Comb. Spec. Lens	0.67	4	6	"	13, 30
"	"	1	0.08	R. R. Lens	1.1	8.8	8	Hilford Spec. Lant.	0.5
"	"	1	0.11	Zeiss Lens, Series VII.	0.9	11.2	12.5	" Chromatic	0.2
Algiers	W. Andrews	1	0.07	Dallmeyer R. R. Lens	1.1	7.8	7	" Ordinary	3
"	A. C. D. Crommelin	1	0.50	Dallmeyer Telephoto	1.7	54	32	Cadett Lighting	1
"	Rev. C. D. P. Davies	3	0.85	Dallmeyer Telephoto	2.5	90	36	Imperial Ordinary	3, 10, 3
"	R. Hodge	1	0.19	Ross Landscape Lens	1	21	21	Thomas "A1" Isochrom	0.5, 1
"	Walter Maunder	2	0.08	Dallmeyer Stigmatic	1.5	9	6	Sandell Triple	48
"	Mrs. Maunder	2	0.17	Marion R. R. Lens	1.5	18	12	"	48
"	Miss Irene Maunder	6	0.32	" Niblett" Lens	4	34	8.5	Imperial	0.5
"	E. Dickson	6	0.14	Achr. Landsc. Lens	0.67	15	22	Sandell Triple	Between 3 and 4
C. Matifou, Algeria	F. W. Longbottom	3	0.06	Voigtlander Colinear	0.95	6	6.3	" Perfect	5, 6, 7
"	J. E. Pearce	5	0.37	Dallmeyer Telephoto.	1.25	40	32	Roll Film	5, 2.5, 1, 1, 2
"	E. B. Vignoles	1	0.14	"Acme" Camera, R.R. Lens	0.8	14.5	22	Edwards' Isochromatic	3





THE CORONA, 1900, May 28th.

(Photographed at Algiers, by Mr. Walter Maunder and party. Exposure  $\frac{1}{2}$  second, taken 5 seconds after mid-totally on Imperial "Fine grain Ordinary" plate. Aperture 4 inches. Focal length 34 inches.)



SECOND CONTACT, 1900, May 28th.

(Photographed at Wadesborough, U.S.A., by Mr. J. N. Maskelyne, with 3.5-inch kinematograph.)





Exposure 0.3 second; Sandell "Triple" plate.



Exposure 0.3 second; Ilford "Special Rapid" plate.

THE CORONA, 1900, May 28th.

(Photographed at Wadesborough, U.S.A., by the Rev. J. M. Bacon. Aperture  
4.1 inches. Focal length 58 inches.)



Algiers; I have, therefore, especially examined them for any evidence of change in coronal forms. With this view I made a careful outline from the Algiers photographs, and another, quite independently, from the American negatives. On reducing these to the same scale and superposing them, I found the outlines of all the features, that were sufficiently definite to be outlined with certainty, in perfect agreement. The photographs examined appear, therefore, to afford no evidence of coronal change during the two hours and a half of the passage of the shadow from North Carolina to Algiers, although considerable changes occurred in the forms of the principal prominences as shown on the photographs.

W. H. WESLEY.

#### DARK MARKINGS IN THE SOLAR CORONA.\*

EVERYONE who has examined a series of photographs of total solar eclipses is familiar with dark rifts or gaps in the corona. Most conspicuous at times of sun-spot minimum are the polar rifts, which at such periods open widely and occupy a considerable portion of the sun's polar regions. Rifts, more or less dark, also occur in other parts of the corona, sometimes sharply cutting into the densest portions. There can be no doubt that these rifts are merely interspaces between coronal rays. They show the extremely irregular manner in which the corona is distributed over the sun's surface. In view of the fact that the corona, whatever it may be, is not flat, as it appears during an eclipse, but is an object possessing three dimensions, it is obvious that a sharply defined rift, cutting into a dense portion of the corona, and traceable to the sun's limb, represents a gap of most singular form.

But striking as are these coronal rifts, there is a still more interesting class of dark markings that in many cases cannot be explained as mere interspaces among the bright rays. Unlike the ordinary rifts these dark markings are only occasionally seen. A close examination of the original negatives is often necessary to detect them, and as a rule they are lost in any photographic reproduction.

The first instance of their occurrence of which I know was in 1871. On the eastern side of the corona, in the equatorial region, there appears on the photographs a small dark spot about 9' from the sun's limb. It does not occur near the crossing of any coronal rays, in which situation such an object might possibly be simply an interspace, but appears to encroach on bright rays. Moreover, it is the centre of three arcs of circles, concave towards the sun, with radii of 3', 6', and 10'

\* By W. H. WESLEY. (Reprinted from KNOWLEDGE for October, 1900.)

respectively, the middle one being fairly strong, while the others are excessively faint. These singular appearances were thought by Mr. Ranyard to indicate the existence of a comet, showing as a dark object on the background of the corona; but as to this I pass no opinion. If it was a comet, its appearance was

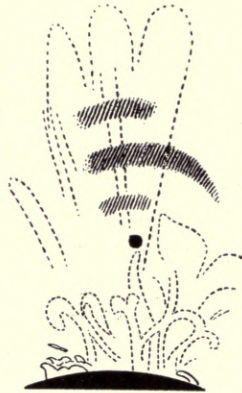


FIG. 1.—Diagram of Markings on the Corona of 1871.

unique, for the comet on the negatives of the 1882 eclipse, and the much fainter one found by Schaeberle on his photographs of the eclipse of 1893, were both *bright* objects. But in any case it seems impossible that the dark spot and concentric arcs on the corona of 1871 can be interspaces between rays, for the

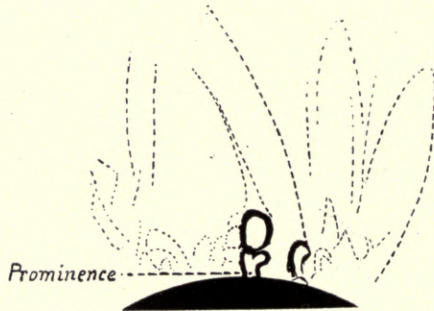


FIG. 2.—Diagram of Markings on the Corona of 1896.

arcs actually cut through several coronal rays almost at right angles, partially obliterating them. The whole appearance is extremely difficult to see, but I have traced the dark spot and the arcs on several negatives of two different series, and am certain of their existence.

The next example of dark markings occurred in the corona of 1896, the eastern side of which exhibited features of a

different kind from any I have examined. I will, however, refer only to those bearing on the subject in hand. Almost at the sun's equator is a bright double-headed prominence, which is distinctly *outlined* by a strong dark line, following all its contours. A little to the north is a small hooked coronal ray about  $2\frac{1}{2}'$  high, apparently springing from a small prominence. This ray is also outlined in the same manner. But by far the most extraordinary appearance is that of a dark roughly elliptical ring, about  $2\frac{1}{2}'$  in its longer axis, which stands on the top of the bright prominence. From the summit of the ring springs a fairly bright, fine ray, which would probably be traceable further down towards the limb but that its base seems cut off by the ring. There are many other dark streaks in this part of the corona, but we may confine our attention to the most striking features—the outline to the prominence and the ring. They are clearly seen on at least two of the negatives taken by Mr. Shackleton in Sir G. Baden-Powell's expedition to Nova Zembla, and, unlike the markings on the corona of 1871, they are quite easy to see under suitable conditions of illumination. A little reflection will convince anyone that the *outline* can be due to no known photographic effect. The image of a bright object (such as a bright prominence) may spread itself on the plate, and thus appear enlarged, or it might conceivably be surrounded by a halation ring, though I feel sure that the exposures during eclipses (except when a portion of the sun's surface was photographed) have never been nearly sufficient to cause such a ring round a prominence. But neither of these well-known photographic effects will explain the appearance in the least. Had an observer *drawn* the dark outline surrounding the bright prominence, we should have concluded at once that it was a mere effect of contrast, but the camera is fortunately not influenced by contrast. Is it possible that the prominence had edges enormously brighter than its centre, so that the dark outline is a phenomenon of reversal? This is improbable in the last degree, in view of the small aperture of the instrument and its considerable focal length; there was also slight hazy cloud, and the plates generally show no signs whatever of over exposure; their definition is admirable. There are many instances of reversal of the images of prominences in 1882, 1893, 1898, and 1900. In 1882 their centres were reversed, but there has been no case of reversal of their edges. Besides, the hooked coronal ray is also outlined, and that was certainly not bright enough for reversal, so this explanation breaks down. Then we have the elliptical ring, for which there seems absolutely no explanation, except that it is really a dark marking of some kind. It is surely absurd to suggest that it can be a mere space between coronal rays; we should have to imagine a tunnel cut through the body of the corona, directed precisely in the line of sight, and a plug of coronal matter lying along the centre of that tunnel but not touching its sides.

It will be seen that in the above cases the argument for the objective existence of dark markings is based upon the form and character of the markings, and not upon their actual darkness. Neither in 1871 nor in 1896 are they nearly as dark as the sky; but have we any instances of markings in the corona that are actually *darker* than the sky? If so, it appears to me that their objective existence is proved beyond a doubt. I believe we have such evidence, but here great caution is required, for although the camera is, as has been said, unaffected by contrast, the eye which examines the photographs is much affected by it, and we may be very easily deceived.

I have before me two negatives of the eclipse of 1898, taken by Mr. F. Bacon at Buxar, near Benares; they are rather over-developed, the lower portions of the corona are extremely dense and opaque, but the focus is excellent, and the outer portions well shown. The scale is a little over half an inch for the moon's diameter. On first looking at these I was struck

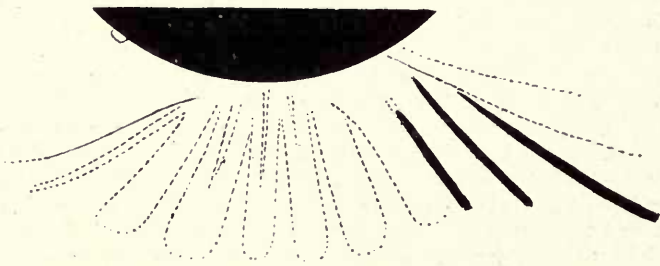
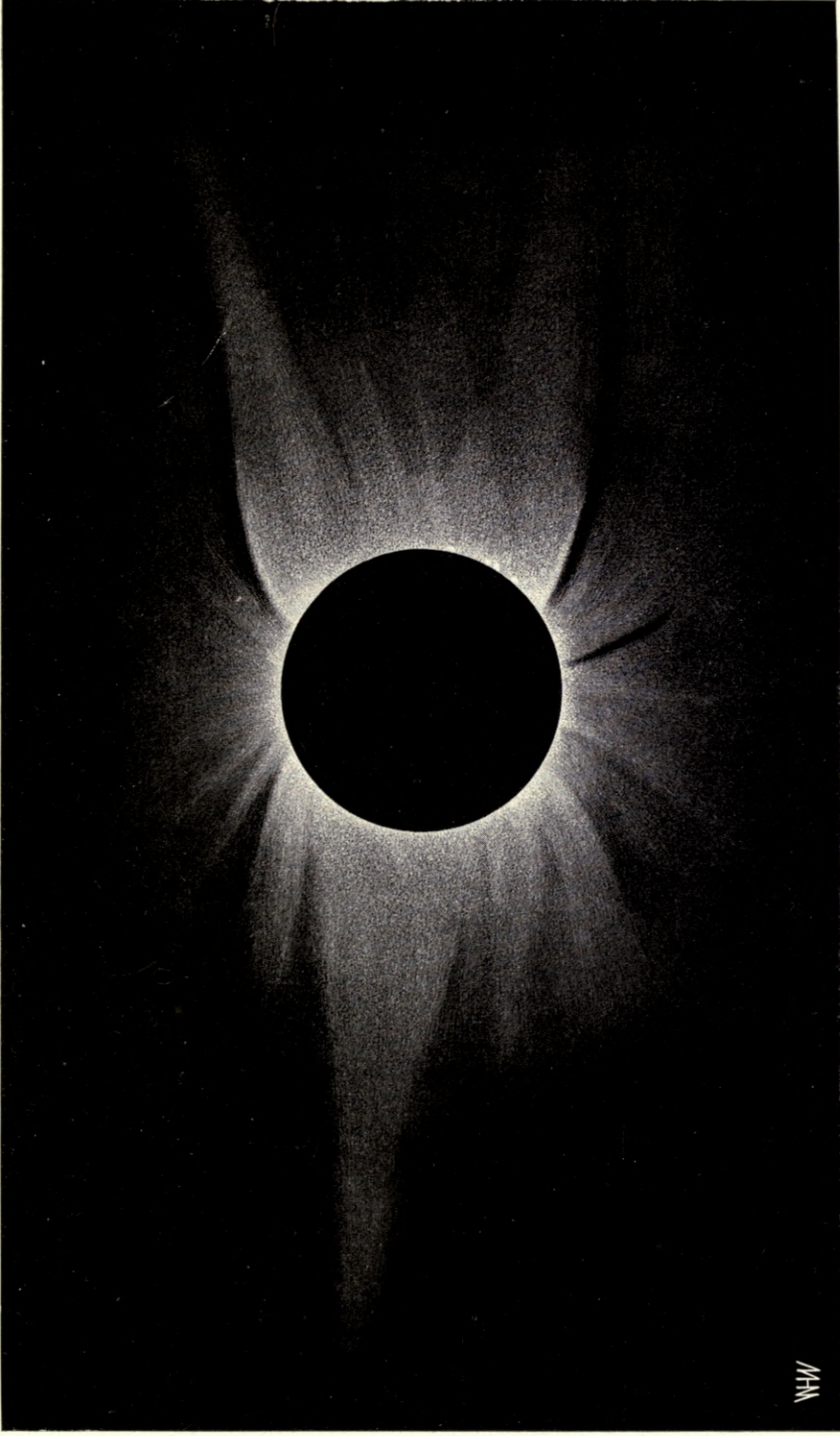


FIG. 3.—Diagram of Markings on the Corona of 1898.

by the unusual sharpness of definition of some of the rays of the great southern rift; but on more careful examination with various illuminations it seemed possible that this sharp definition is due to nothing less than to two or more fine dark rays (of course bright on the negative) lying between some of the bright polar rays near the western boundary of the polar rift. There is nothing unusual or extraordinary in the position of these dark rays. I at first considered them to be merely spaces between the ordinary polar rays, but I now think that they are slightly darker than the sky or than the faint light which forms their background. The development has been carried far enough for the light of this background to impress itself on the plates; but for this fact the markings would appear simply as interspaces, but on these plates I think I can just see the ends of the rays, terminating at about two-thirds of a lunar diameter from the limb. They cannot be traced to the limb, as they are lost among the mass of bright rays, and they are lost in long exposure negatives. These markings are far more difficult to see than those in 1896, but if they are darker than the sky,





THE CORONA OF 1900. Drawn by Mr. W. H. WESLEY from Mr. MAUNDER'S Photographs.

W.H.



we seem to have taken a considerable step towards proving their objective existence.

We now come to the negatives taken by Mr. Maunder at Algiers during the eclipse of May last. On two negatives taken on Sandell plates with very long exposures, and on a series of negatives exposed by Miss Maunder with  $\frac{1}{2}$  sec. exposures in a stationary camera, are certain dark streaks of much the same character as those of 1898, but unlike these, they are most easily seen; in fact on some of the plates they strike the eye at once. One of them forms a sharp boundary to the northern edge of the western equatorial streamer, and one bounds in the same manner its southern edge, whilst another radiates from the limb near the centre of the great southern rift; there are several others that may be suspected. The only point in doubt is whether they are unusually definite spaces or rifts between bright rays, only seeming dark by contrast, or whether they are actually darker than the sky. If they are darker than the sky we seem forced to admit that they are real, however impossible it may be to offer any physical explanation for their existence. We cannot isolate these fine, narrow dark streaks, so as to avoid the effect of contrast. They are visible on all the six plates of the short exposure series, and the dark markings forming the north and south boundaries of the western portion of the corona are very strikingly shown on the long exposure negatives. These dark rays bounding the coronal extension are extremely remarkable, and it seems impossible to regard them as effects of contrast. For while on the one side they are each bounded by the edge of the coronal streamer, there is apparently no ray bounding them on the other side, and they appear to extend beyond the coronal streamer itself. If this is so, they are obviously darker than the sky, or the faint nearly uniform light which forms their background.\* The dark marking bounding the southern edge of the western coronal extension is the most conspicuous.

The narrow, slightly curved dark ray near the centre of the southern rift is well shown on the short exposure negatives. It has a distinct termination at a distance of about half a lunar diameter from the limb—a termination in fact more definite than those of the bright coronal rays. It seems decidedly darker than its background of sky or faint coronal light. If this marking is merely a rift, or interspace, it must be a rift *closed at its outer extremity*, which appears a most improbable supposition.

I am quite unable to offer any explanation of such features as these, but I think we cannot resist the evidence of their reality. As Mr. Maunder has said, they must be caused "by the inter-

\* It is probable, as Mr. Maunder has pointed out (KNOWLEDGE, August, 1900), that there is a considerable amount of diffused coronal light beyond the limits of the detailed corona. This appears to be borne out by Prof. Turner's photometric measures of the negatives of the eclipse of 1893.

position of actual dark absorbing matter between ourselves and the general diffused coronal glow"; so that the corona appears to be "not wholly an emission, but partly an absorption effect." The nearest analogy to them are the black rays in the prominences to which Trouvelot drew attention, and which I believe Mr. Evershed has confirmed.

I have also examined some excellent negatives taken by Miss Bacon at Wadesborough, U.S.A., which clearly show the dark markings visible on Mr. Maunder's plates.

W. H. WESLEY.

#### THE CORONAL EXTENSIONS ON THE PHOTOGRAPHS.\*

INASMUCH as the pair of photographs to which, in the Indian Eclipse, the longest exposure was given, showed the coronal streamers to the greatest distance from the sun, and, as of any two comparable photographs, the one which had the longer exposure showed the streamers to the greater length, it seemed clear that the duration of the exposure was a determining element; and it left undecided the question whether the limit of effective exposure had been reached. We, therefore, resolved to give as long an exposure in the eclipse just passed as its conditions permitted, and it had been our hope to have made these exposures equivalent to 400 seconds with  $f/15$ . Circumstances obliging us to proceed to Algiers instead of Elche we had to cut down this exposure to 48 seconds with  $f/6$ , corresponding to 300 with  $f/15$ . The result was that so far from obtaining longer streamers than in 1898, the longest ray photographed was barely half the length of the great ray seen in the Indian Eclipse. Further—and this is important—the ray is traceable to *almost* the same distance upon other photographs which we took with exposures relatively but  $1/48$ th as long, and they are seen to *fully* as great an extent on photographs taken by Mr. C. Davidson under the Astronomer Royal's direction, at Ovar, with an exposure equivalent to but  $1/7$ th of our own.

The question is as to the cause of the failure to register the extensions as far as—not to say further than—two years ago. So long as lengthened exposure meant lengthened ray, so long failure to show a streamer beyond a certain point might simply mean that there was more ray beyond, but that it was too faint to record itself in the time given. But since in the past eclipse photographs with such widely different exposures agree in placing the termination of the ray practically at the same point, and that point just where the eye also placed it, it seems fair to conclude that this was where it actually ended so far as we are concerned. The termination, however, might be due to more than one cause; it might be due not only to the matter of the ray coming to an end; it might be that further out it was too

\* By MR. and MRS. WALTER MAUNDER.

faint to be perceived through the veil of our atmosphere; or it might be overpowered by the glare due to the scattered light in our own atmosphere. There can be no doubt that there was more of this diffused illumination in the late eclipse than in 1898; necessarily so, as the eclipse was a shorter one; the breadth of the shadow track was narrower; and at mid-totality less of the brightest portions of the corona were concealed. All observers concur in saying that it was a very bright eclipse—there was no real darkness. As to whether the air was as clear this year as two years ago, it seems exceedingly improbable that the conditions were the same at all the stations; at Algiers, at any rate, there was little cause for complaint. The observation recorded on p. 150 shows that there was no appreciable sky-glare in the neighbourhood of Mercury; nor was there the slightest trace of the great coronal streamer within the telescopic field which had Mercury as its centre.

It will be noted in Mr. Wesley's description of the corona from the photographs, that he points out that the synclinal rays were less strongly marked in 1900 than in 1898. But the rod-like rays, first photographed in the former year, are manifestly the terminations of the synclinal curves; we may expect then that when the synclinal structure is feebly marked, the rod-like rays will be relatively short and faint. Further, these rays are evidently very irregularly distributed round the sun, and we cannot expect them to be always at right-angles to the line of sight; on the contrary, they must be presented to us under every variety of foreshortening.

The next eclipse, that of May 18th, 1901, should, if weather conditions be favourable, give a specially good opportunity for settling this question. Being a large eclipse, it will probably be a dark one, since the shadow track will be wide, and the amount of the inner corona which will be covered at mid-totality will be considerable. It seems desirable, therefore, that every variety of exposure should be given, including some for the whole length of time available; that is to say, for the whole time that the chromosphere as well as the sun itself is covered.

E. WALTER MAUNDER.

A. S. D. MAUNDER.

## LIST OF PLATES EXPOSED DURING THE PARTIAL PHASE, 1900, MAY 28TH.

Place.	Observer.	No. of Photographs.	Size of Disc of Moon.	Instrument.	Aperture used.	Equivalent Focal Length.	F/A	Plate or Film.	Exposures.
			in.		in.	in.			sec.
Wadesborough, U.S.A.	J. N. Maskelyne ..	887	0.2	Kinematograph ...	3.5	21	6	Kinematograph Film ...	0.2
Elche, Spain	E. C. Willis ...	1	0.08	R. R. Lens ...	1.1	8.8	8	Iford Special Lantern	0.5
"	"	3	0.11	Zeiss Lens, Series VII.	0.9	11.2	12.5	Sandell Triple ...	0.014, 0.05, 0.14
Algiers	Rev. C. D. P. Davies	3	0.85	Dallmeyer Telephoto	2.5	90	36	"	1
"	R. Hodge ...	2	0.19	Ross Landscape Lens	1	21	21	Thomas "A1" Isochrom	2
"	Walter Maunder ...	14	0.08	Dallmeyer Stigmatic	1.5	9	6	Sandell Triple ...	0.01 to 0.07
"	Mrs. Maunder ...	5	0.17	Marion R. R. Lens ..	1.5	18	12	"	Various
"	"	12	0.16	Pinhole ...	0.03	15.5	496	"	"
"	Miss Irene Maunder	12	0.32	" Niblett" Lens ...	1.5	34	23	"	0.1

## PHOTOGRAPHS OF THE PARTIAL PHASE.\*

BESIDE our attempt to photograph the long coronal streamers, one great object with us in the recent eclipse was to push a little further the experiment which we had made in India in photographing the corona out of totality. For this purpose we took in all some forty photographs during the partial phase, with varying instruments and exposures, and our experiments have been very strikingly supplemented by the work which Mr. Nevil Maskelyne, F.R.A.S., carried on with his kinematograph in America. Mr. Maskelyne's instrument had an aperture of  $3\frac{1}{2}$  inches, which was stopped down before and after totality to an aperture of  $\frac{3}{8}$ th of an inch. The instrument was run for about  $5\frac{3}{4}$  minutes, commencing some 25 seconds before totality, and running for nearly 4 minutes after totality was ended. In all 1187 exposures were made, 87 before totality, 299 during totality, and 801 after. The corona is seen very definitely on the first exposure, and can be traced right away to number 841, that is to say, to number 455 after the return of sunlight. Allowing 0.29 seconds for the mean interval between the middle of one exposure and that of the next, this gives us for the last photograph showing the corona, the time 2m. 12s. after the return of sunlight. This duration is worked out by assuming that the duration of the photographic eclipse was the same as that of the visual, the latter having been observed by Prof. Flint with a 3-inch equatorial, at the same station of Wadesborough.

The principal exposures which we ourselves made for this work were in three sets of twelve each, taken with the three following instruments:—1st, a photographic lens, aperture 4-inches, stopped down to  $1\frac{1}{2}$  inches, and focal length 34 inches. 2nd, the Dallmeyer stigmatic lens of  $1\frac{1}{2}$  in. aperture, and 9 in. focus; 3rd, a pin-hole camera, that is to say one without a lens, aperture  $\frac{1}{32}$  of an inch, and distance of plate from pin-hole,  $15\frac{1}{2}$  inches. A deep yellow glass was placed immediately in front of the sensitive plate with this last camera. The use of a colour screen materially altering the wave-length of the light most effective upon the plate, should theoretically alter the distance of best definition, but in practice, so far as our experiments upon the sun were concerned, we did not find any great difference. The theoretical distance for an aperture of  $\frac{1}{32}$  inch is 16 inches, and the diameter of the pin-hole may easily have been slightly in error. Double the aperture would of course have required four times the distance, and consequently four times the exposure. We concluded, therefore, that whilst a smaller aperture would give so small a distance that the resulting image would be too small to be of value, a much larger aperture would be open to the equally serious drawback of requiring too long an exposure.

One instrumental precaution, the necessity for which we had fully foreseen, we were not able to take. This was the provision

\* By Mr. and Mrs. WALTER MAUNDER.

of a diaphragm, so arranged as to prevent any of the direct light of the sun falling upon the plate; but our cameras were on too small a scale, and our guiding telescopes not sufficiently rigid for this to be possible. We, therefore, made no attempt to provide such a screen, and our experiments were made with the image of the sun itself falling on the plate.



MR. R. HODGE, HOTEL DE LA REGENCE, ALGIERS.

It will be seen that this radically altered the conditions of the problem before us. If the sun itself could be screened from the plate, then the problem of photographing the corona resolves itself into one of detecting a very minute difference of brightness in a very high light. For this purpose, there is no particular advantage, but rather the reverse in using a multi-coated plate. The exposure evidently should be of the very briefest, so that the action of sky-glare alone may be hardly effective, whilst the conjoint actions of sky-glare



and corona may be just appreciable. In such a case there would be no question of keeping down the effect of a very brilliant light whilst a faint light is enabled to make itself felt. Our idea, therefore, would be, in conjunction with such a diaphragm, to use a somewhat slow single-coated plate of fine grain. As it was, we were obliged to allow the sun to fall upon the plate, and therefore used, as in India, the Sandell triple-coated plate. All we could expect to gain was a knowledge of the kind of exposures which were most effective in giving the corona in the face of a small amount of sunshine, with the possibility of our tracing it further into the partial phase than we did in India. We introduced a pin-hole camera into our battery of instruments in order to gain if possible some light on a third question, namely, the influence of aperture in securing the corona, both absolute aperture and aperture relative to focal length. As regards the first and third of these points, our photographs still require much further examination before we can report upon them, but we have been able to record the presence of the corona very considerably further from totality than we did in 1898. As to the use of the coloured screen, we consider our experiments as so far inconclusive. Our hope had been that, cutting off the rays of short wave-length, which are those most effective in sky-glare, due to scattering by small particles, we might have brought the corona into a little greater relative distinctness; but of course the practical efficiency of such a screen will depend entirely upon the question as to the kind of rays in which the corona is richest. Our attempt was in no sense on the lines of Mr. Shackleton's ingenious and hopeful suggestion of photographing through screens which should only allow light of the quality of the green coronium line to pass through. This, could it be achieved, and could the distribution of coronium round the sun be thus ascertained, would be a most notable advance, one by all means to be desired, but it would not be, in the strict sense, photographing the corona itself.

Another point upon which we hoped to get some light, but for which the present experiments were not sufficient, was in relation to the principle laid down by Prof. F. L. O. Wadsworth, as to the effect of the diminution of aperture in diminishing the relative action on the plate of sky-glare. This was especially in our minds when we decided to use the pin-hole.

Mr. Maskelyne's kinematograph film is of special interest by the way in which it enables us to trace the gradual fading of the corona in the face of the increasing sunlight. The aperture was the same with all the film photographs—after the diaphragm was put on,—the exposure was the same in all cases, the only variable was the increasing arc of sunlight. The exposure was equivalent to about  $1/60$ th of a second with  $f/15$ , and the film may be considered as about as quick as an ordinary "rapid" plate. It is very instructive of the conditions of the problem to note how quickly, after the first bead of sunlight is seen, the outer corona fades and disappears; and also that when the aperture

is cut down, diminishing the exposure almost to  $1/90$ th of what it was when the aperture was full, the corona is almost lost at first, but reappears, and for some little time becomes stronger as the sunlight strengthens, fading again when the sky-glare becomes too strong for that exposure and aperture. There can be no doubt that could the exposure have been gradually shortened as the sunlight gradually increased, the corona would have been traced on the film further still.

The appearance of the corona in the partial phase is not specially corona-like. The evidence that the faint, nearly uniform ring of light is the corona, is to be found in the fact that the disc of the moon is to be seen dark against it, its outline clearly defined.

Several other observers took photographs of the partial phase; in particular we may mention a very beautiful little picture taken by Mr. E. C. Willis about 30 seconds before the commencement of totality with  $f/12\frac{1}{2}$ , and exposure  $\frac{1}{4}$  second. Two others taken respectively 8 minutes and 4 minutes before totality are even more interesting; for whilst the latter shows no trace of the moon's outline, the former, when the sunlight was so much stronger, shows, though very faintly, the whole of the moon's limb.

Many partial phase photographs show some bright, straight rays proceeding from one or both cusps of the sun. They are very well shown in a photograph taken by Mr. Hodge. These same rays are also seen on photographs taken here in England, where the eclipse of course was only partial. They are necessarily not coronal, as they are not seen in totality, and they appear to be due to some sort of reflection from the plate itself, as they do not seem to be shown on films. They are also shown on some of the photographs taken with the pin-hole camera, but here they are less strongly marked.

To sum up, we learn from Mr. Maskelyne's film, that to secure the inner corona from half-minute to one minute after totality is over, an exposure of about one-hundredth of what is necessary for a full representation of the corona in totality is required. Earlier the exposure should be somewhat longer for best effect, later it should be diminished. In this way Mr. Maskelyne has followed the corona two minutes and twelve seconds after totality on a single coated film, and we have increased our Indian record of thirty-nine seconds to five minutes, very faintly shown on a Sandell triple-coat, and this again is extended to eight minutes by Mr. Willis's photograph. The advance made is a real advance indeed, but exceedingly small as compared with the full magnitude of the problem. Indeed our progress is rather towards a truer appreciation of its difficulties than towards its solution.

E. WALTER MAUNDER.

A. S. D. MAUNDER.



## CHAPTER XIII.

### *BRIGHTNESS DURING TOTALITY.*

THE observers at every station without exception noticed how bright the eclipse was even during totality. This was of course chiefly due to the fact that the eclipse was a very short one; the excess of the moon's diameter over that of the sun was but slight, so that the most brilliant regions of the corona were exposed in mid-totality. It appears certain that the general illumination was greater than in the Indian Eclipse, 1898, but it does not therefore follow that the corona itself was brighter than in that year, that is to say, intrinsically brighter; indeed, Prof. YOUNG (Wadesborough, U.S.A.) is distinctly of opinion that it was not so bright, but that a larger area of its brighter regions was exposed to view at any time.

Mr. WHITMELL supplies the summary of the observations at Naval-moral on this question:—

At totality the light decidedly exceeded that of a bright full moon, and was of quite a different quality, being warm like a twilight illumination, and not like the cold green-grey of moonlight. The large luminous corona, and the small excess (19".4, or more probably 18".5) of the moon's semi-diameter over that of the sun, made this eclipse a bright one.

Mr. BUCKLEY: Light seemed about equal to that of a full moon, but different, and more like a very late summer twilight.

Dr. STOKES: The light was sufficient to sketch the corona by without any difficulty.

Mr. E. HOWARTH: Very little diminution in the light was noticed until the sun became quite a thin crescent. At totality the change was marked and instantaneous, though there was still light enough to enable the dial of a watch to be distinctly seen. As light flashed out at the close of totality, it was very striking to notice what an enormous difference a small portion of direct sunlight produced. Almost immediately after totality, Mercury disappeared, the corona died out like a flash, and the landscape almost at once assumed the aspect of day. In ten minutes, though a large portion of the sun was still covered, the aspect was that of a broad sunlight day, and all interest in the eclipse was over.

Mr. LA GUIDARA: It was as dark as when the first shadows of night fall on our landscapes. [I may add that Mr. Guidara was

good enough to call out during totality the seconds from a watch, and that he found it easily readable.]

Mr. W. F. STANLEY: There was light enough to distinguish the grain in a piece of grey granite.

Rev. C. J. STEWARD: Light enough to sketch by, and to read thermometers.

Miss W. FOSTER: The return of light seemed more rapid than the oncoming of darkness.

Miss L. FOSTER: No inconvenience in pencil sketching.

Mrs. CONSTABLE (at Talavera): Plenty of light to read and sketch by, far more than moonlight would give.

Mr. E. HOWARTH, in his account of his work, supplements his



SUNSET NEAR ELCHE, MAY 23TH.

note, given above, as follows:—I was specially desirous of observing the approach of the shadow across the earth and sky, and therefore gave careful attention to the light on the north-west side, the landscape along there being flat and open. As the shadow advanced over the sun, there was a perceptible and welcome cooling of the air, though the diminution of light was not very marked. A photograph of the landscape to the north-west, with the Sierra de Grédos in the distance, taken on arrival, shows all the details in the foreground, though the distant mountains can scarcely be seen on it. From this time onwards there was a very decided darkening of the landscape on the north-western side, and it was distinctly lighter on the south-eastern side. Another photograph was taken of the

landscape towards the Sierra de Grédos at 3h. 48m. G.M.T., and although in this the general features can be made out there is a total absence of the detail shown in the same view taken about half-an-hour earlier. In this later photograph, however, the distant hills can be seen more plainly than in the earlier one, though in neither of them are they prominently shown. Another exposure made about two minutes before totality showed nothing whatever on the plate. Just at this time, too, the fading light assumed a different tone, becoming decidedly rosy in colour, in marked contrast to the darkening grey just previously prevailing. This change of colour was strikingly emphasised in the few patches of cloud to the west, whose whiteness became richly diffused with a red glow. Up to the very moment of totality I was very much impressed with the great power of the direct sunlight, for when even the thinnest perceptible portion of the sun was still uncovered, it was possible to see the objects round about with perfect ease. The actual moment of totality was unmistakable, and, as a means of comparison, seemed to me like the switching off of an electric light. I immediately looked at the watch I had brought with me to note the time—this being a Kew certificated watch—and the actual time of the beginning of totality was 4h. 6m. 56s. G.M.T. This time was noted independently of any one else. Venus had been visible some minutes before, and now Mercury flashed into view below the lower western limb. During totality I carefully observed the sun, both with the naked eye and with a pair of opera-glasses, but saw no trace of a comet or any planet inside the orbit of Mercury. The end of totality was quite as unmistakable as the beginning, the great change in the light being almost startlingly rapid, and it occurred at 4h. 8m. 16s., G.M.T., the total phase lasting exactly 80 seconds. During totality the light was strong enough to show the dial of a watch without any difficulty, and the near landscape could all the time be dimly seen. As soon as totality ended, the corona and Mercury all disappeared, with no appreciable interval between, and the light so quickly increased that I took a photograph of our party about fifteen minutes afterwards, which came out quite distinctly.

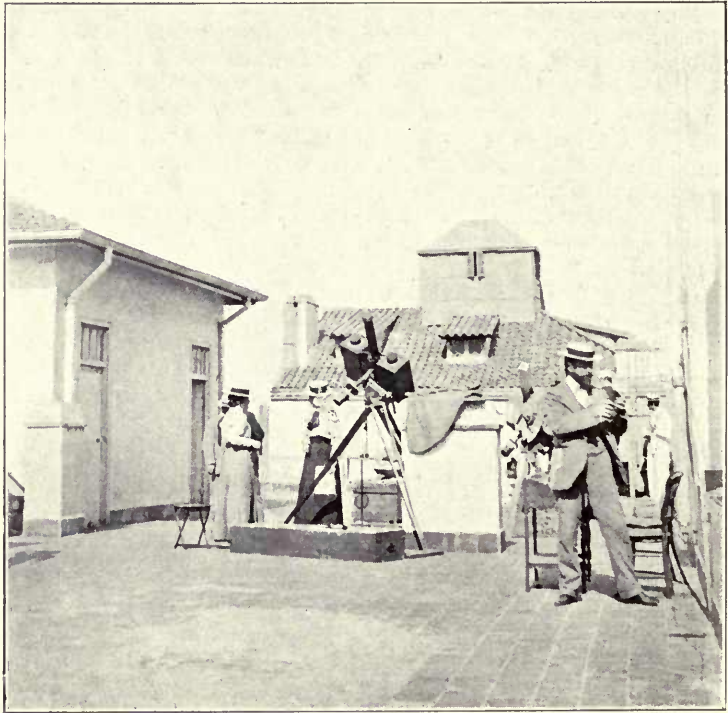
M. MOYE (Elche): The obscuration was not intense, all surrounding objects were distinctly seen; a newspaper, the divisions of a watch could be read without artificial light. The general illumination was very much greater than given by the full moon.

MR. WALTER MAUNDER (Hotel de la Régence, Algiers): This was much the brightest of the four eclipses at which I have been present, and the darkness never approached that of a bright night at the full of the moon.

But though the illumination during totality was thus very considerable, it must be remembered that the change from even

the last speck of sunlight to complete totality is very great indeed, as the following observation will show.

Mrs. WALTER MAUNDER (Hotel de la Régence, Algiers) had two photographic cameras mounted upon a 4-inch portable equatorial, kindly lent by Mr. W. Coleman, F.R.A.S. "As the equatorial had no driving clock, I proposed to direct the telescope upon Mercury, and bringing it to the crosswires in the centre



Miss Stevens. Mrs. Maunder.

Mr. H. Ellis.

ROOF OF THE HOTEL DE LA RÉGENCE, ALGIERS.

of the field, to follow by hand driving. I had found by practice that I could turn the right ascension tangent screw with great regularity and smoothness for a much longer time than the period of totality. Mercury was picked up without the slightest difficulty, and brought to the cross-wires early in the partial phase, and for the last two or three minutes before second contact I followed by it, driving by hand, without any difficulty, the spider-lines being easily seen against the background of the illuminated sky. But the instant that the eclipse became total,

that instant the field of view of my telescope became dead black, as if a shutter had fallen. But for the bright shining of Mercury I might have thought that some one had put the cap on the telescope. There was no gradual fading out of the light as second contact approached; the general illumination of the field in the telescope did not seem sensibly to diminish during the last few minutes of the partial phase; at the moment of second contact it went out entirely and at once."



THE LIBRARY, YERKES OBSERVATORY.

The photograph in the centre of the picture is from Mr. W. H. Wesley's drawing of the Corona of 1886, from the photographs taken at Grenada and Carriacou by Dr. Schuster and Mr. Maunder.

Similarly at the end of totality the appearance of the first point or fragment of the sun's disk makes an instant and enormous difference to the light. It must be remembered that speaking roughly, and in round figures, the sun is, area for area, 100,000 times as bright as the brightest region of the corona. The results of the Indian Eclipse seem to show that the corona can be traced both visually and photographically to a distance, where its brightness is scarcely  $1/1,000$ th part as great as that of the corona close to the sun. In other words we pass in one short minute from the observation of a body whose intrinsic brilliancy we may put as 100,000,000, to one, portions of which

have a brightness no greater than unity. Need the moral be drawn, that those who intend in an eclipse to draw the faint coronal extensions, will be wise not to watch the progress of the partial phase?

The light therefore diminishes suddenly at the beginning of totality; it increases again suddenly at the end. The question arises, Do both changes proceed at the same rate? To the eye, the effect certainly is of a much greater rapidity in the recovery of the light than in its loss; but this may easily be a mere psychological effect. It becomes important, therefore, to have some photographic evidence on the subject. Miss Bacon, for this purpose, in 1898 in India, conceived the plan of taking a series of photographs of the landscape at regular and equal intervals, before and after totality, giving precisely the same exposure to all the plates, and developing them at the same time and under the same conditions. The result then obtained seemed to show most conclusively that the return of sunlight was actually, as it appears visually to be, much more rapid than its withdrawal; the light five minutes after the end of totality being very much greater than that five minutes before, and, indeed, almost equal to that fifteen minutes before.

Miss Bacon's example was very widely followed during the eclipse just passed; not only English astronomers but also those of other countries following her lead. Thus a very successful series of exposures of this character were obtained by the astronomers of the Madrid Observatory at Plasencia, and by M. Leroux at Bou Zarea, Algiers.

The work of taking these "Gathering and Departing Gloom Photographs" was undertaken by the members of the Association at three stations, namely, by Miss BACON at Wadesborough, by Lady McCLURE at Elche, and by M. ROGER DU CAMP at the Hotel de la Régence, Algiers, who also exposed photographs for the same purpose on behalf of Mr. Walter Maunder. These last proved to be systematically over-exposed, the extremely actinic qualities of the Algerian sunlight having been much under-estimated. They seem, however, to point to considerable variability in the rate of progress of the change; thus of a series of eighteen exposures six pairs give the post-totality light as greater than the corresponding light in pre-totality; whilst the others—that is to say three pairs—give the pre-totality light as the greater. Miss Bacon found a similar discrepancy, but on the whole her Indian results were reversed, the recovery of light appearing to proceed more slowly than its loss. Four extremely beautiful photographs, taken by Lady McClure, at ten and twenty minutes before and after totality, also give the following anomalous result:—

20min. before totality less light than 20 min. after totality.

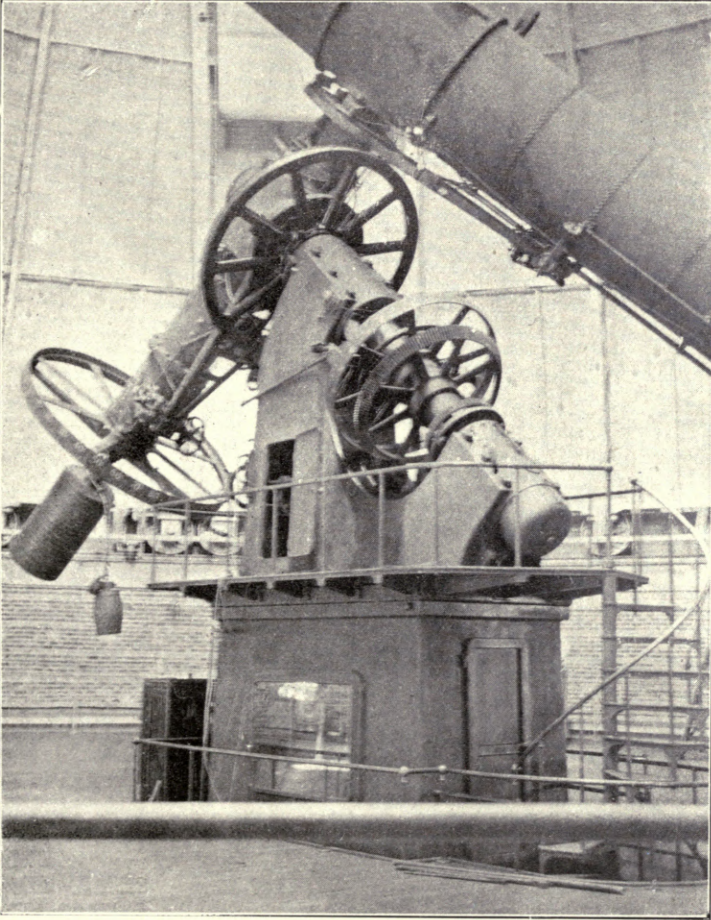
10min. before totality greater light than 10min. after totality.

It appears, then, that the question has assumed a complexity which renders it deserving of very careful attention in future eclipses.



TWILIGHT ILLUMINATION.

AFTER the eclipse of 1898, two members of the Association, quite independently, and in ignorance of what the other was doing,



POLAR AND DECLINATION AXES OF THE GREAT YERKES 40-INCH REFRACTOR.

attempted to estimate the time at which the general illumination after sundown corresponded to that during mid-totality. The results were much more accordant than might have been expected, and in consequence several observers tried the same

experiment during this eclipse. Of the six observations made on this occasion, two stand out, but the other four, which were entirely independent, are in the most remarkable agreement. This may perhaps be mere coincidence, but it is desirable that an observation, so easily made, should be repeated on every possible occasion. It seems quite possible that a really careful observer may make this observation so well as to render it a most convenient method of comparing between the illumination at different eclipses. On the present occasion, it is perhaps not safe to say more than that the results point to 1898 not having been quite so bright as 1900; and that the general illumination corresponded to that of twilight when the sun is between  $6^{\circ}$  and  $7^{\circ}$  below the horizon.

TWILIGHT ILLUMINATION JUDGED EQUAL TO THAT OF TOTALITY.

Observer.	Place.	Date, 1900.	G. M. T.		Interval.*	Sun below Horizon.	Remarks.
			h. m.	m.			
Roberts ... ..	Algiers	May 28	7	30	$37\frac{1}{2}$	$6^{\circ}8'$	As dark as totality.
Brook ... ..	Algiers	" 28	7	32	$39\frac{3}{4}$	$6^{\circ}4'$	" " "
Carpenter, Gare and Moore }	Manzanares	" 28	7	52	$27\frac{1}{2}$	$4^{\circ}6'$	" " "
Backhouse ... ..	Salamanca	" 30	8	34	$52\frac{1}{2}$	$8^{\circ}9'$	Darker than totality.
Sharp ... ..	Pobladura	" 30	16	10	$45\frac{2}{3}$	$6^{\circ}9'$	As dark as totality.
Backhouse ... ..	Vigo	June 1	8	42	43	$6^{\circ}5'$	" " "

The similar observations made after the eclipse of 1898, January 22, in India, are added for comparison:—

Observer.	Place.	Date, 1898.	G. M. T.		Interval.	Sun below Horizon.	Remarks.
			h. m.	m.			
Backhouse ... ..	Benares	Jan. 23	0	$36\frac{1}{2}$	$34\frac{1}{2}$	$7^{\circ}4'$	As dark as totality.
Backhouse and Sharp }	Benares	" 24	0	$32\frac{3}{4}$	$30\frac{1}{2}$	$6^{\circ}4'$	" " "
Maunder ... ..	Nagpur	" 26	0	$56\frac{1}{2}$	$30\frac{1}{2}$	$6^{\circ}7'$	" " "

\* After geometrical sunset or before geometrical sunrise.

INTEGRATING PHOTOGRAPHS.

MR. F. GARE at Manzanares, and Mr. E. W. Johnson at Elche, proposed to repeat and extend the experiments which had been made at Buxar, in 1898, for measuring the total photographic radiation of the corona, by exposing sensitive plates to its general light under a set of graduated screens. Good results have been obtained from the plates exposed to the corona during totality. A comparison of these with plates since exposed by Mr. Gare and Mr. A. H. Johnston to the light of a standard candle at a distance of one metre give the corona as six times the brightness of the candle; so that the recent eclipse would seem to

have been between 30 and 40 per cent. brighter than the one of 1898 at Buxar, and about ten times as bright as the Full Moon.

Plates were also exposed at both stations to the partially eclipsed sun before and after totality, but these are all much over exposed. These plates were exposed at 20, 15, 10, and 5 minutes before and after mid-totality, with an exposure of 10 seconds, and in every case the light has penetrated the whole of the screen, and the plates are consequently of little use for purposes of measurement. A comparison of the density of the deposits does not, however, appear to confirm the difference between the light before and after totality apparent in photographs taken at the eclipse of 1898.

## CHAPTER XIV.

### *THE PRISMATIC OPERA-GLASS.*

CHAPTER V. of "The Indian Eclipse, 1898," contained a short summary of the history of spectroscopic observations as applied to total eclipses of the sun, and descriptions of the chief forms of spectroscopes used in eclipse work, so that there will be no need to recapitulate. In the eclipse of 1900, several members of the Association took out with them an important spectroscopic plant, and much exceedingly valuable work was done. Thus in America, Prof. C. A. Young and Prof. G. E. Hale; in Portugal, Mr. F. W. Dyson; in Spain, at Plasencia, Sir Howard Grubb, Dr. A. A. Rambaut, and Mr. W. E. Wilson, and at Elche, Mr. A. Fowler; in Algeria, Mr. H. F. Newall at Bou-Zarea, and Mr. J. Evershed at Pont Mazafran; all made spectroscopic work the chief item in their programmes, and took powerful instruments for the purpose. But these observers, having been equipped or sent out either by Government or by some learned body other than the Association, do not report in this volume. Their objects were chiefly to register by means of photography that spectrum of bright lines which is seen for some two seconds just at the beginning and end of totality, and which is now so well known as the "Flash," and also the spectrum of the corona itself during totality. The types of instruments employed have already been described on pages 61 and 62 of the "Indian Eclipse," the forms which were most preferred being those of the "prismatic camera" and of the "analysing spectrograph." Mr. Evershed's chief instrument was, however, quite a novel form of prismatic camera, inasmuch as he used a train of two large prisms in connection with a silver-on-glass reflector, instead of a camera of the usual kind. The experiment was most successful; the mirror, of course, bringing all the rays, no matter what their refrangibility, to the same focus; the lines, therefore, on his photographs are in perfect focus throughout.

But there was one spectroscopic instrument, though but of humble size, that was made use of by several Members in the different expeditions of the Association. This was the "prismatic opera-glass"; that is to say, a binocular, one tube of which was furnished with some arrangement for producing a spectrum. In India, in 1898, Mr. Walter Maunder had such a binocular, fitted with a small direct-vision prism before the eye-piece, and the same arrangement was used in 1900, by Miss Dixon, at Wadesborough, in North Carolina. But our ingenious Member, Mr. Thorp,

having devised a means of reproducing gratings on celluloid, arranged a more efficient instrument, by providing "prismatic gratings" to be placed before one of the object glasses of the binocular, and it was such an arrangement that was most generally employed by our Members in the past eclipse. The observation, which offered a spectacle of extreme beauty, had, like most of those undertaken with far more powerful and pretentious instruments, a two-fold purpose:—(1) To note the moment at the beginning and end of totality, when the continuous spectrum due to sunlight has disappeared, and the constellation of innumerable bright lines of every colour, which we know as the "Flash," has for an instant



Mr. T. THORP; HOTEL DE LA REGENCE, ALGIERS.

taken its place. This observation is most useful, in order to enable the watcher to signify to other workers around that the total phase has actually commenced, and the reverse observation as the Sun is about to emerge enables him to give warning that it is about to end. (2) During totality the one tube of the opera glass would give an actual view of the corona itself, the other would show its spectrum. In this second case we should have an image of the corona, depicted in light of several colours, each colour representing a line in the spectrum of some coronal gas. The chief line of the corona is one in the green, known for many years as "1474K," since the position of the line when first discovered was supposed to correspond with the reading "1474," on the scale of Kirchoff's

spectroscope. The position was shown by Mr. Fowler and Mr. Evershed, in the Indian eclipse, to be considerably in error, but the name is still likely to cling to the line. At present we know of no element, accessible to us here on earth, which gives the same green line, and, therefore, we know nothing of the properties of the gas which produces it. For the sake of distinctness, however, the name of "Coronium" has been bestowed upon it. Such an instrument as the "prismatic opera-glass" enables an observer to compare, at once, and with particularity, the shape of the corona as given by the coronal line "1474K," with the corona as seen directly; in other words, to ascertain at a glance the distribution in the corona of this strange and foreign gas, "coronium."

Dr. A. M. W. DOWNING (Plasencia).—The instrument used by me was a binocular, to one of the object glasses of which Mr. Thorp had fitted one of his transmission gratings. I was able, therefore, to observe the spectrum of the corona through one tube of the binocular, and through the other to observe the corona directly.

I noticed that the coronium arc was much broader and more diffused than the neighbouring arcs of magnesium and helium, which were visible in the spectroscope at the same time. I estimated the average breadth of the coronium arc to be about one-eighth of the diameter; but at a special part it was very much broader, being approximately one-fifth of the diameter. This part corresponded to a position angle of about  $270^\circ$ , and the observation would tend to show that this additional amount of coronium was present in the corona near the base of the great coronal extension on the sun's western limb. According to this observation, therefore, the general height of coronium in the corona on this occasion was a little over 100,000 miles; but at this special part, near the base of this branch of the corona, it extended to about 180,000 miles.

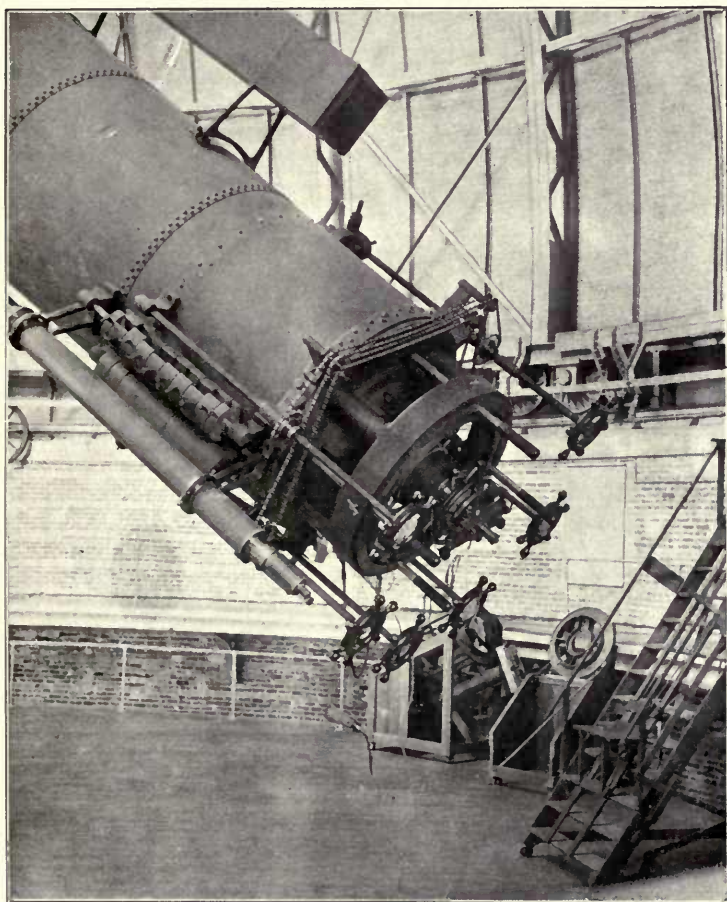
Two of the party at Navalmoral used prismatic opera-glasses, viz., Mr. C. T. Whitmell and Mr. O'Callaghan. They report as follows:—

Mr. WHITMELL.—I observed with a low-power Galilean binocular, the right object glass of which was fitted with one of Mr. Thorp's excellent diffraction gratings attached to a prism. The binocular was so held that the length of the spectrum was parallel to the moon's movement, the violet end lying in the direction towards which the moon was going. The left tube of the binocular remained as usual, so that the actual corona might be seen through it. A sliding wedge of neutral-tinted glass was in front of the right eyepiece, and an ordinary dark sunglass in front of the left one. These were removed just before totality.

The changes in the spectrum enabled me to give the signals of the beginning and the ending of totality.

As the solar area diminished, the curved black Fraunhofer lines, indicated at 3h. 50m., G.M.T., by a few shadowy bands, narrowed rapidly, increased greatly in number, and grew sharply defined, the

D sodium line becoming distinctly double just before totality. The concavity of these dark lines was turned at first towards the right lower quadrant. Besides the dark D lines, I saw the dark lines C and F of hydrogen, three magnesium lines in the green, and



EYE-END OF THE GREAT YERKES 40-INCH REFRACTOR.

many lines in the blue. The spectrum was, in fact, crowded with dark lines.

I found some difficulty in estimating the exact moment of second contact—the beginning of totality—but the ordinary spectrum suddenly seemed to vanish. I cannot say that I definitely saw the flash spectrum. I now looked at the corona without the binocular.

There was a bright silvery ring round the dark moon, and, outside this ring, were irregular extensions of fainter light—the streamers. To me these were of a colour inclined to steely blue.

Resuming observations with the binocular—the eclipse being now total—I saw a faint general spectrum crossed by four bright arcs, the concavity of which was now directed towards the left upper quadrant.

These arcs corresponded apparently to C of hydrogen, D<sub>3</sub> of helium, to coronium, and to F of hydrogen. They were coloured red, yellow, green, and bluish green, respectively. On the lower part of the red C arc appeared a brilliant star-like point of red light, due to a prominence. I do not clearly remember whether a similar point appeared on any of the other arcs, but I think that there was a yellow star on the helium arc. I did not notice any prominences by direct vision. Third contact—the close of totality—was unmistakably indicated by a very narrow, but brilliant, strip of the ordinary solar spectrum shooting centrally lengthwise through the dim coronal spectrum. It is impossible to give any adequate idea of the exquisite beauty of the foregoing phenomena. They were truly a poem in colour.

Mr. O'CALLAGHAN.—I used an opera-glass with a Thorp diffraction grating in one of the eyepieces. The length of the spectrum was parallel to the moon's movement, with the red end towards the left. As second contact approached, I saw a few of the curved dark lines. Just at second contact the narrowed spectrum split up into lines of light along its length, and then, as it faded, four bright arcs appeared, one in the green, one on the blue side of the green, and two on the red side of it. These arcs seemed all nearly equally persistent, and I watched them for probably twenty-five seconds.

Before mid-totality, I left the spectroscope, my sight much weakened by previous exposure to sunlight. Looking now through a telescope (a small refractor 1½ inch) I did not see the streamers of the corona (perhaps because the field of view was narrow), but, before direct sunlight re-appeared, I distinguished many bright prominences on the S.W. limb, near the position of third contact.

[It may be of interest to state that Mr. O'Callaghan was the only member of the Naval moral party who had previously seen a total solar eclipse, he being fortunate enough to witness the Indian one of 22nd January, 1898.—C. T. W.]

Colonel A. BURTON-BROWN, R.A. (Algiers, Cemetery Hill).—I reserved to myself three instruments:—(a) A camera obscura, formed by one of the telescopes equatorially mounted, with eyepiece, projecting an image of the sun on to the ground glass, diameter of image about 2½ inches on a 9-inch field, so that all present might note the progress of the eclipse till totality. During totality I hoped to get an enlarged picture of the corona with this instrument, but I regret to say it was imperfect, owing to vibration during exposure. (b) A tube containing a photographic lens, with



a negative lens for enlarging, associated with a deep green positive lens and spectroscopic prisms, with which I hoped to get more prominently the coronium line. (c) A powerful binocular, to one object glass of which one of Thorp's grating prisms was fitted.

As the crescent of the sun slowly diminished, many of the party, as well as myself, saw in the camera obscura most perfectly the appearance of "Baily's Beads," which seemed to linger for an unusual time. I then raised my binocular, in which I also saw them for a second, but to be immediately followed by the most marked reversal of the black lines in the spectrum it has ever



THE HORSE-SHOE FALLS, NIAGARA.

been my good fortune to witness. The coloured lines did not appear at once, but seemed to run along the field of view as the spectrum lighted up, and remained in the field what appeared to be three or four seconds, so that, in my mind, there is no necessity to go to the edge of the shadow to prolong them. I consider this grating of Mr. Thomas Thorp a great success. At the moment of reversal I called time, and the camera and spectroscopic and eye observers commenced operations 4h. 17m. 25s. I was not able to detect with any certainty the 1474 line on the corona in any part, or on the streamers. The structure of the coronal streamers was marked in the instrument "a," but no satisfactory photograph was obtained, and, owing also to an accident to the worker of "b" with the green lens, the result is not altogether satisfactory.

Mr. W. B. GIBBS (Ovar).—I was observing with a Zeiss prismatic binocular, the object glasses of which were of one-inch aperture. Over one of these Mr. Hilger had fitted for me a prismatic photographic grating of 14,500 lines to the inch. At the eye end of the other tube, to protect my eye from the sunlight, I was using a coloured solar wedge belonging to a larger telescope. The instrument was mounted on a tripod stand.

At twelve minutes before totality the light from the thin solar crescent was still so strong that a very dark portion of the wedge had to be used, and I could not look into the spectroscope tube without protection to the eye. At about three minutes before totality I could use the spectroscope tube without any dark glass, and I noticed a crescent-like disposition of the colours. This soon changed into an ordinary solar spectrum, with the principal Fraunhofer lines plainly visible and clearly defined, but, of course, curved. These then became bright lines, and, whilst scrutinizing them, a smaller spectrum appeared in the middle composed of many more bright lines, which quickly disappeared, leaving only the longer bright arcs. I specially noticed that the outer or serrated edge of these bright arcs was not nearly equal in height to the inner corona as seen through the other tube of the instrument, and that there was no trace of any faint extension of the matter giving rise to the green line into the outer or fainter portion of the corona. The serrated edge seemed to have a sharp and definite outline, and did not fade away gradually.

At the end of totality the small interior bright line spectrum appeared for a few seconds.

Mr. SYDNEY EVERSHERD (Algiers, Cape Matifou).—I am afraid my observations will not be of much value, because I went to Algiers rather more from motives of curiosity than with the intention of observing any particular phenomenon, but I took with me a grating attached to one object-glass of a field-glass by Goertz, as I had a great curiosity to see the "Flash" spectrum, and as the flash spectrum gives the beginning and end of totality very exactly, I was asked by those of the party who had cameras to give them these times. The times taken from me were noted by Mr. Dickson, and they made the time of totality 67·5 seconds. This observation depends on two persons, so that it cannot be expected to be particularly accurate. So far as my observations went I found it quite easy to determine the exact instant when totality began, because the disappearance of the last streaks of the ordinary solar spectrum is so gradual that the mind is prepared for the instant at which they disappear entirely. I am quite accustomed to accurate time observations, and although I had never previously seen a total eclipse I feel sure that the time I gave was within one-tenth of a second. The end of totality was not so easily noted; the total duration of totality not being known exactly before hand, the re-appearance of the flash spectrum takes one by surprise, and it is on that account more difficult to give the instant of re-appearance of the continuous spectrum with the same

accuracy as the determination of its disappearance. I think I may have been as much as 0.25 seconds late in giving the re-appearance of the spectrum. The errors of observations at the beginning and end of totality are of the same sense, so that to some extent they cancel each other.

## CHAPTER XV.

### *THE SHADOW BANDS.\**

ONE of the most interesting of the attendant phenomena of a total eclipse of the sun is that of the "Shadow Bands." These are strange pulsations of alternate light and shade which move swiftly, though with wavering motion, across the landscape at the beginning and end of totality. One of the earliest observations of them recorded was in the annular eclipse of 1820, when Goldschmidt remarked them some three or four minutes before the moon had completely passed on to the sun's disk. A completely total eclipse therefore is not necessary for their production; indeed, in the eclipse of 1870, December 22, Signor Say-Moleti remarked them in Messina, which was just outside the zone of totality. In appearance they resemble the ripples of light and shade reflected from moving water. Thus, in "The Indian Eclipse, 1898," the following similes are used:—"If the sun's rays reflected from the waves of a calm sea pass through the glass of a port-hole window and fall upon the farther wall of a cabin, the faint flickering shadows will, in some degree at least, resemble these mysterious shadow bands." "Only," cautions another observer, "the shadow bands were far less brilliant, smaller, more regular, and much less beautiful, but the tremulous rippling movement was similar." The same observer gives as her own description:—"As for the shadow bands, I should rather call them shadow ripples. They reminded me of the figures I have seen while bathing in the Channel Islands, when the image or shadow of the ripples on the surface of the clear water dances on the shingly bottom below."

In order to secure, as far as possible, uniformity of plan amongst the different expeditions going out to the recent eclipse, I prepared a number of directions for the guidance of observers, with a code of questions for them to answer, based upon my experiences in 1898, at Buxar, in India, and I have been favoured with the following reports of the results obtained:—

ELCHE.—A careful watch for shadow bands was kept by Mr. Johnson, Mr. E. C. Willis, and myself on the roof of a house at Elche, and for the purpose two sheets, marked with black bands

\* By Mr. E. W. JOHNSON.

exactly one foot apart, were provided, one of which was fixed on a wall, and the other was laid flat on the roof.

The first trace of the shadow bands was seen by Mr. Johnson  $4\frac{1}{2}$  minutes before totality, when they were very faint, but they rapidly increased in density, and were almost at once well defined.

About the same time as the first appearance of the shadows there was a remarkable change in the light; a deep blue shade seemed to come over everything, as if the red and yellow rays were withdrawn, and the darkness increased very rapidly.

The shadows did not appear as "bands" at all, but as irregular ripples which merged one in the other. A few seconds after their first appearance one batch rushed over the sheet at an indescribable speed, but immediately afterwards they came uniformly and very much slower.

The direction before and after totality was precisely the same, from S.S.E. to N.N.W., the wind being from S.S.E. There was very little breeze; what there was came in light puffs or gusts.

The appearance of the shadows after totality was exactly the same as before, but they were not seen for more than two minutes, and they became very faint a few seconds before their final disappearance.

None were visible during totality. (JESSIE McRAE.)

ELCHE.—Observations of shadow bands at Elche were made on a wall facing almost due west. The shadows, first seen six minutes before totality, became somewhat more distinct as totality approached, and they were again seen upon the return of sunlight. They appeared to be made up of innumerable ripples, which were oval in shape, about ten inches long and a quarter that in width. All of them were parallel, and each one was partly merged in those surrounding it. The shadows were moving at about seven miles an hour, in a direction parallel to the shorter axes of the ripples. The line of motion was towards the north end of the wall and downward, making an angle of about  $40^\circ$  with the horizontal. There was also an irregular merging and dissolving movement of the various ripples into each other. As a result of this, new ones were continually being formed whilst the old ones were lost sight of. It was, in fact, impossible to follow any of them for more than a few inches. This merging movement was exceedingly rapid, and perhaps chiefly in a direction parallel to the general motion.

An attempt to photograph the shadows was unfortunately frustrated by the non-arrival of a shutter ordered for the purpose. The opinion, however, was formed that they were a phenomenon which it would have been quite possible to photograph with the aid of suitable apparatus. (E. C. WILLIS.)

ELCHE.—For the observations of the shadow bands at Elche I was seated on a corn-threshing floor, perfectly level, and commanding a large view of country. About three minutes

before totality I saw the bands. They were regular, with the appearance of sinuous curves; they were not clearly defined, but greyish and faint on the ground. However, their intensity was sufficient to attract the attention of two Spanish policemen who were on my left. The width of the bands was two inches, the distance apart being from one foot to one and a quarter. Their motion, uniform, it seemed, was as quick as a man walking. At first the motion was maintaining precisely the same direction, east to west, but one minute before totality I saw a remarkable phenomenon, not observed before, I believe. Besides the first system already described, there was suddenly a second system of bands, showing the same general appearance, but the motion



MR. E. W. JOHNSON AT WORK.

of which was distinctly in the opposite direction, viz., from west to east. I am satisfied myself of the reality of the thing, which was borne witness to after totality by several neighbouring persons.

I must say that the wind, moderate in force, was blowing during all the eclipse from the same direction, E.S.E.

(M. MOYE.)

ALGIERS (HOTEL DE LA REGENCE).—The apparatus which my sister (Mrs. Arthur Brook) and I had at Algiers for making observations of shadow bands was simply a white sheet, 12 ft.  $\times$  9 ft. in area, which we laid flat on the red-tiled roof of the hotel, and two black rods, six feet long, to place parallel

to the bands before and after totality, so as to enable us to determine the direction of motion. We had also sewed on the middle of the sheet two concentric circles of black tape, two feet and four feet in diameter respectively, for the purpose of viewing the bands tangentially to the circles from whatever point of the compass they might happen to come; we hoped in this way to count the number of bands in a given distance, but were disappointed owing to the character of the shadows.

The word "bands" is not at all applicable to what we saw; we spent at least four minutes after totality in critically examining the structure of the shadows, and we came to the conclusion that there was no real linear arrangement, much less single bands of definite breadth stretching across the sheet; ripples raised on water by a light breeze represent best what may be termed the structure of the shadows; they all move in the same direction, each ripple element is linear in *character* but retains its individuality only for a moment, appears to dissolve away and others take its place. We chanced some days afterwards to see a very common occurrence which closely resembles the shadows in *appearance*, though much coarser and less delicate in grain, so to speak; a large field of grass about half a mile off, ready for the scythe, blowing across it a moderately strong wind, causing lights and shades to traverse the tops of the grass, all in one direction, but no definite portion of light or shade remaining the same for more than a moment; they were constantly altering in shape, disappearing, and fresh ones appearing.

The direction in which the whole phenomenon was moving was perfectly plain, and very easy to be distinguished, namely, from  $30^{\circ}$  or thereabouts west of north to  $30^{\circ}$  east of south both before and after totality, though I think after totality the ripples came slightly more from the west. Once after totality I watched the direction of motion recede considerably to the west, but only for a short time, say 15 seconds or so. The pace was quite slow enough to have allowed of their being counted, if they could have been individualized, and I estimated the speed at  $1\frac{1}{2}$  yards a second.

Further, my sister alone saw at the end of totality what she describes in a note below as very dark, oblong patches on a grey ground; this was quite a separate phenomenon from the ripples already mentioned, and lasted only a few seconds. The general direction of the wind during the eclipse was north, very light.

It seems to be generally accepted that these faint grey shadows are due to atmospheric irregularities, and I think there can be hardly any doubt of this; at the same time it must not be assumed that these atmospheric irregularities are necessarily near the earth's surface; they may be at any height up to at any rate the level of the highest clouds, say 25,000 feet. In a book called "Cloudland," by the late Mr. Clement Ley (pages 12, 53, and others), there are suggestions made with reference to the

formation of certain kinds of clouds which may be found to have some bearing on the origin of these shadows.

He imagines two layers of air, differing in velocity and temperature and humidity, in contact with each other; owing to the difference of velocity friction will arise at the contact surface which will cause ripples and waves; where a ripple of the *warmer* and moister current is forced up into the *cooler* current, a small cloudlet will appear owing to condensation, while the spaces between, where the *cooler* current is mingled with the *warmer* will remain clear, thus producing dappled or wavy clouds which he calls Cirro-macula or Stratus-maculosus, according to the height above the earth's surface. (These are the same forms of cloud which Howard calls Cirro-cumulus.)

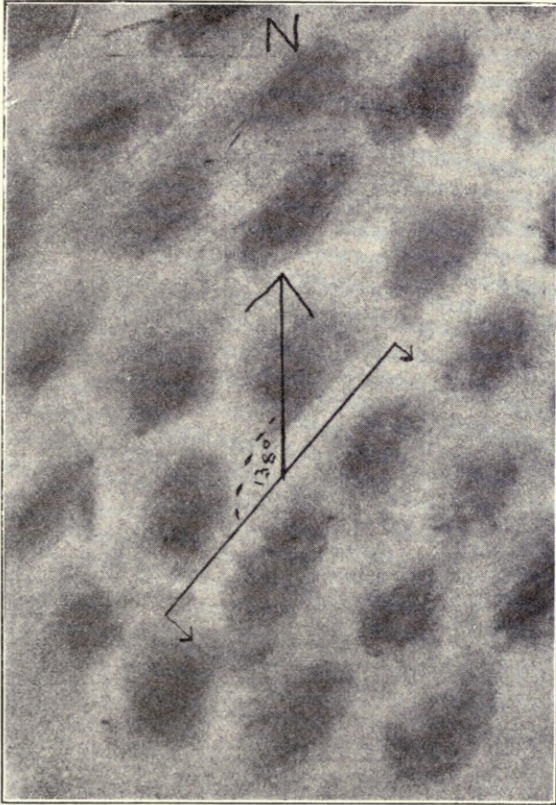
Now if we imagine this process to be going on, but of insufficient intensity to result in actual clouds, we shall have an irregular or rippled plane of contact between two strata of air of different density, at which the light coming from a thin strip of the uncovered sun will be unequally refracted, causing variations in the amount of light falling on any surface in a direct line with the sun and the two strata of air; further, the air ripples, and therefore the shadows, will in general move in the direction in which the faster of the two currents is moving, just as ripples on water move in the direction of the breeze producing them. Where, however, the two currents are moving in directions inclined to one another, the ripples would move in some direction intermediate between the two, and thus the actual direction of the wind either at the earth's surface or in the higher atmospheric strata may have no direct relation to the movement of the shadow ripples at an eclipse. May not also a similar cause account for the wavy or pulsating shadows seen crossing a star disc put much out of focus, even on a very clear night where there are no visible clouds, but much bad seeing?  
(C. L. BROOK.)

NOTE BY MRS. ARTHUR BROOK ON THE "SHADOW PATCHES."—Immediately after Miss Maunder gave the word "Stop," which denoted that 60 seconds of totality were past, I dropped my glasses and looked at the sheet. Instead of being white the sheet, owing to the absence of sunlight, was of a dull grey hue. The surface appeared to be covered with dark blotches of shadow, and these were apparently in a state of violent agitation; the patches of dark shadow were dancing about and coursing one another rapidly over the grey ground. These shadows could not be said to be in definite wavy lines, nor do any of the pictures of shadow bands represent the appearance I saw. The patches seemed to be irregular ovals in shape, about 9 inches by 6 inches, and to be arranged in rows in the direction from N.E. to S.W. (The actual direction as shown by the position of the black rod was from 42° east of north, to 42° west of south.) The rows themselves appeared to be passing slowly from N.W.



to S.E., while at the same time the patches chased one another along the rows much more rapidly, the whole effect being of a rapid undulating motion from N.E. to S.W., with a slow motion from N.W. to S.E.

This appearance lasted seven or eight seconds, and disappeared instantaneously, giving place to the faint, flickering



SHADOW PATCHES OBSERVED AT ALGIERS, BY MRS. ARTHUR BROOK.

This phenomenon lasted about 7 or 8 seconds about the end of totality. The patches vanished suddenly, leaving on the sheet the ordinary shadow ripples, which were observed for some minutes before and after totality.

shadows upon a *white* ground, which my brother and I saw both before and after totality.

As I continued to observe the sheet before totality up to, or nearly up to, the moment Mr. Maunder gave the word "Go," that is nearly up to the commencement of totality, I think these shadow patches were not visible before. (RUTH MARY BROOK.)

ALGERIA (CAPE MATIFOU).—The only one of our party who observed the shadow bands was Mrs. Hassall, and she saw them both before and after totality. It is doubtful whether sufficient points were noted to make the observations valuable, but it may happen that there is no other record of the shadows being seen on a vertical plane whose orientation was exactly similar to that of the white wall which served as a background for Mrs. Hassall's observations.

The azimuth of the wall was  $114^\circ$ , or, in other words, a line drawn at right angles to the wall pointed  $24^\circ$  west of south, and the shadow bands were seen about 12 inches broad and the same distance apart, travelling horizontally from the eastern to the western end, in a direction at right angles to their length.

Mrs. Hassall describes them as uniform and almost straight, and from her description I judged the velocity to be about eight miles per hour.

During the eclipse the air was quite calm, with occasional light gusts of wind which never attained a velocity of more than ten miles per hour.

One or two of our party saw the moon's shadow coming over the sea, but not with that distinctness which we had been led to expect.

(H. KRAUSS NIELD.)

MANZANARES.—Shadow bands were observed on two large sheets spread side by side upon the fairly even pavement of the old Moorish tower kindly lent to us for observations, and roughly oriented to the points of the compass. A foot width was marked off as a gauge by two parallel straps. The direction of the waves was indicated, when observed, by two other straps, whose position was accurately noted, at leisure, after totality.

The bands were not seen until within two minutes of totality. They then travelled at six or seven miles an hour, twenty were counted in two seconds, they moved in nearly straight, parallel and equidistant lines, with a quivering motion; the bands were about three inches wide, and the light intervals between them also about three inches wide.

The direction of motion was from N.  $64^\circ$  E. to S.  $64^\circ$  W. (true), and the bands lay at right angles to the direction of their motion.

About twenty seconds before totality Captain Carpenter, who had turned round to reach the straps wherewith to mark the direction of motion, was surprised when again turning towards the sheet to observe that the direction of motion had changed to S.  $26^\circ$  E.—that is, at right angles. Almost at once after this the bands ceased to be visible. All agreed to the position of the straps as placed by Captain Carpenter, but to Mr. Gare and myself, who had not moved and saw no change, they indicated the waves themselves, whereas to Captain Carpenter they indicated the direction of motion. Could there be an alternating vibration in two opposed directions, without motion of translation, like the vibration of a sounding bell?

Immediately before the shadow bands came, a peculiar narrow well-defined black shadow, in shape like a bough of a tree, with a backward projection, as of a broken fork, about the middle, and roughly concave in the direction of its motion, moved across the sheet nearly east to west, which is a little more west than the direction in which the shadow bands moved immediately afterwards. We thought it likely to be the shadow of a bird, but did not look up as the shadow bands were appearing. Señor Ventosa, of the Madrid Observatory, points out that the thin slice of sunlight at this time would be likely to give a narrow, well-defined shadow.

We did not watch for shadow bands after totality.

(H. KEATLEY MOORE.)

PLASENCIA.—At Plasencia observations were made by means of four sticks, about five feet in length, which were laid on a large white cloth spread upon the ground. Two of the sticks indicated respectively the position and direction of motion of the bands before totality; the remaining two indicated the same particulars after totality.

Mr. Geoghegan, who kindly undertook to look for the bands, saw nothing of them until two minutes before totality. He was then able to see them distinctly enough to place the sticks in position. Similarly after totality, the bands were visible for about two minutes.

By means of a compass I found that before totality the direction in which the bands lay was about  $10^{\circ}$  north of east, and the direction of motion was south-east by south. After totality the direction in which the bands lay was north-east, and the direction of motion was south-east. All these bearings are magnetic. The declination of the needle for the station is  $15^{\circ}$  west.

The wind was north, light before totality, freshening to moderate afterwards.

(A. M. W. DOWNING.)

PLASENCIA.—I find it impossible to answer categorically, as suggested, the questions on shadow bands, as the shadows did not look to me at all like "bands," but resembled the undefined nature of the shadow (or whatever it may be called) of a wave in shallow water running over sand or some light coloured bottom.

The line of the crest of the waves seemed to be a wavy line with, I estimated, between five and six inches pitch (*i.e.*, from crest to crest) and an inch height of wave.

The crest of the waves was nearly in a straight line, and the distance between each wave was about three inches; the speed of progression I estimated at about one foot per second, and the waves did not, I think, come in batches, but uniformly. The time the shadows were visible seemed about two minutes before totality, and an equal time after.

I may remark that the sheet was not at all flat, as it was laid upon grass, and the ground was not level. I did not measure the shadows, which from their nature would have been difficult, and I could only estimate the distances. (S. GEOGHEGAN.)

NAVALMORAL.—At Navalmoral a white sheet was laid on the ground, but no shadow bands were observed by Mr. Buckley or by Mr. Jackson Smith, who undertook to watch for them. The Rev. C. J. Steward, observing another white sheet on higher ground, was also unsuccessful.

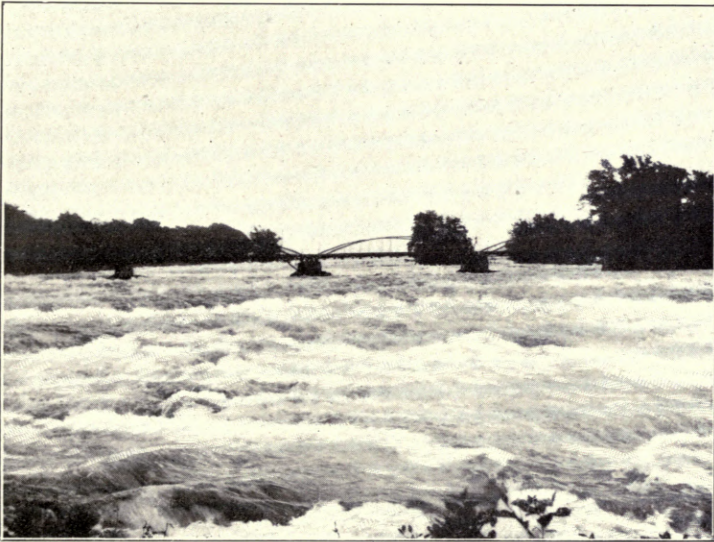
Shadow bands appear to be due to disturbances in the refractive power of the air brought about by alterations in temperature and density. We may perhaps expect such changes to be accompanied by sensible air movement or wind. At Navalmoral there was during totality complete calm. Upon optical principles the bands will be clearly defined only when the solar crescent is very narrow. (C. T. WHITMELL.)

ALGIERS (HOTEL CONTINENTAL).—With regard to the shadow bands or patches, they came on with a kind of rippling movement from a north-westerly direction, at intervals some five minutes before totality; the general direction in which they seemed to lie being from about N.E. to S.W. As the eclipse advanced the shadow bands appeared to swerve round towards the south, and some three minutes after totality they were observed to be travelling away towards the west, *i.e.*, they appeared to be moving in an almost opposite direction after totality to that in which they were moving before totality, although the general direction or parallelism of the bands or patches themselves remained much the same after the eclipse as before, *viz.*, about N.E. to S.W.

The general impression produced upon my mind by them was that they are a purely atmospheric effect, rendered visible by the reduced light area at the time, much in a similar way as an image is focussed through the slit of a spectroscope. It is noticeable also that these bands or patches appear at a time when presumably the air currents are rendered more active by decrease of temperature as the eclipse advances, and by subsequent increase of temperature as the sunlight returns. The bands or patches proceeded rapidly with an undulatory motion, and owing to their faintness and rapidity, anything like accurate counting or timing seemed impossible. (RICHARD F. ROBERTS.)

ESTARREJA.—I had previously arranged a large sheet, and also had the side of a white house to observe the bands upon. Just before totality—perhaps a minute—I arranged my camera for the side of the house, and sat with my back to the sun watching. I cannot tell how long before Baily's Beads the shadow bands appeared, but it must have been only a very few

seconds. At first I detected them very faintly, but they steadily and rapidly increased in intensity, and I took a snapshot. . . . To me when I first detected them they did not appear as bands, but exactly as the Portuguese book on the eclipse described them—reflection from rippling water under a bridge—but they soon assumed the appearance of definite bands, wavy lines, with dark blotches of shadow upon them, and moving very rapidly—about eight inches apart, as near as I can guess—from my right lower corner to my upper left, at an angle of 45°. As I had my back to the sun they would move almost at right angles to the path of the moon over the sun's disc. The rate at which they



ABOVE THE FALLS, NIAGARA.

moved I can liken to standing in a railway station, and seeing a train pass through at the rate of about thirty miles an hour. I stood about eight yards from the white wall. (J. N. MARSDEN.)

ALGIERS (CEMETERY HILL).—The shadow bands were generally observed about six inches or so apart, the movement being apparently about at right angles to their length.

(Col. A. BURTON BROWN, R.A.)

Miss EDITH MAUNDER (ALGIERS, HOTEL DE LA REGENCE), who was acting as timekeeper, and who was seated at a table facing the eclipse, saw the shadow bands moving over the flat

roof, and passing over herself and the table before her, and seemed to feel them as if they were a slight fluttering current of air.

MISS IRENE MAUNDER, at the same station, saw the bands just before second contact, moving over the ground from N.W. to S.E.

From the reports which have come to hand from various observers it would seem that the shadow bands at this eclipse varied considerably at different places, and the details given bear out the idea that they are influenced to a very great extent by the wind.

My own observations, in which I was assisted by Miss Jessie McRae and Mr. E. C. Willis, being made on a high roof at Elche, exposed to every breath of wind, correspond very closely to those of Mr. Brook and his sister, Mrs. Arthur Brook, which were made on the roof of the Hotel de la Régence, at Algiers, while Professor Moye, who was observing on a corn-threshing floor at Elche, presumably sheltered from the wind, saw the bands in quite a different form. To us on the roof at Elche they appeared, not as bands at all but as ripples, which travelled at a moderate speed but changed continually in form, one ripple merging into another.

They were well defined, but owing to their ever changing form no accurate estimate could be made of their width, though it did not seem ever to exceed two inches, while the light spaces were often more than twice that width. The real shadow of the moon was sweeping across Spain from slightly north of west to a little south of east, but the direction of the shadows was from S.S.E. to N.N.W., the wind blowing faintly from S.S.E., and from the comparatively slow movement of the shadows and their broken appearance, the supposition is that their normal direction would have been from the north-west, but they were met and forced back by the wind.

Professor Moye reports seeing regular curved bands of two inches in width and about a foot apart, which travelled from east to west; and that one minute before totality another system of bands was visible, showing the same appearance but travelling in exactly the opposite direction, namely, from west to east. It would seem that the second system of bands might be due to absence of wind, since it so often happens that at totality there is a complete calm. Reports of this perfect stillness have been received from no less than three observing stations at the recent eclipse.

Mrs. Brook's observations of dark patches immediately before the return of sunlight after totality, are of quite a new character, and no reports of their appearance have been received from any other observers, though no doubt this phenomenon is closely connected with the shadow bands or ripples. Never having

been observed before it is impossible to form any definite opinion on the subject, as for this comparison is needed, but it may be that this is the climax of the density of the shadows, and if so they might be visible for the first few seconds of



CAVE OF THE WINDS, NIAGARA.

totality, immediately after the withdrawal of the actual rays of the sun, as well as for a few seconds before the end of totality. In any case they should be most carefully looked for at future eclipses.

When I first observed the shadow bands at Buxar, in January, 1898, the wind, what little there was, travelled in the same

direction as the moon's shadow, and there were produced clearly defined parallel bands, which on that occasion were estimated at a speed of from 8 to 12 miles an hour. Based upon the observations then made, some questions and hints were drawn up with a view to assisting observers at the late eclipse, but owing to the different appearance of the shadows it has been hardly possible in some cases to answer the questions as they stand. Below will be found tabulated the questions with answers received from five different observing parties. From these it would appear that conditions varied very much, and in one other instance, namely, at Naval Moral, Mr. C. T. Whitmell reports that notwithstanding a special look out being kept by three observers, no shadow bands were seen at all. Careful watch for the approach of the moon's shadow was kept at Elche by Mr. J. H. Willis, who undertook all the meteorological observations, but it was imperceptible, neither was anything seen of its departure.

The code of questions submitted to the several observers was as follows. Their answers are given in tabular form.

#### QUESTIONS.

1. How long before totality did the bands appear?
2. What number of bands were visible say in ten seconds?
3. What was the direction of motion?
4. Were they inclined to the direction of motion?
5. What was the direction and force of the wind?
6. Did they come uniformly or in batches?
7. What was their speed?
8. What was the width of the bands?
9. What was the distance apart of the bands?
10. Were they very faint, or clearly defined?
11. Was their direction after totality the same as before?
12. How long after were they visible?
13. Did you see any bands during totality?

E. W. JOHNSON.





THE SHADOW BANDS.

	ALGIERS.	ELCHE.		MANZANARES.	PLASENCIA.
1	Mrs. ARTHUR BROOK. Mr. C. L. BROOK.	Mr. E. W. JOHNSON. Miss JESSIE MCKRAE. Mr. E. C. WILLIS.	Professor MOYE.	Mr. H. K. MOORE. Mr. F. GARE. Capt. CARPENTER.	Dr. A. M. W. DOWNING Mr. S. GEOGHEGAN.
2	3 1/4 minutes.	4 1/2 minutes.	3 minutes.	2 minutes.	2 minutes.
3	From 31 deg. W. of N. to 31 deg. E. of S.	From S.S.E. to N.N.W. (compass).	E. to W.	N. 64 deg. E. to S. 64 deg. W. (true).	S.E. by S. (compass).
4	At right angles to their motion.	At right angles to their motion.	...	At right angles to their motion.	25 Deg. less than a right angle (about 10 deg. N. of E.).
5	N. to N.N.E., force 1. Beaufort's Scale.	S.S.E., force 0. Beaufort's Scale.	E.S.E. light.	N. 13 deg. E. (true), force 2. Beaufort's Scale.	N., light, freshening.
6	Uniformly.	Irregularly first few seconds, then uniformly.	Uniformly.	Uniformly.	Uniformly.
7	From 3 to 4 miles per hour.	About 7 miles per hour.	3 to 4 miles per hour.	6 to 7 miles per hour.	About 3/4 of a mile per hour.
8	From 1 to 2 inches.	About 2 inches.	2 inches.	3 inches.	...
9	Impossible to estimate.	Impossible to estimate.	1 ft. to 1 1/2 ft.	3 inches.	...
10	Faint for first few seconds, then faint again before final disappearance.	Becoming fainter before final disappearance after totality.	Faint.	Very faint throughout.	...
11	Precisely the same.	Precisely the same.	...	Not observed.	Approximately the same.
12	5 1/2 minutes.	2 Minutes.	...	Not observed.	2 minutes.
13	...	Looked for but none visible	...	Not observed.	...

## CHAPTER XVI.

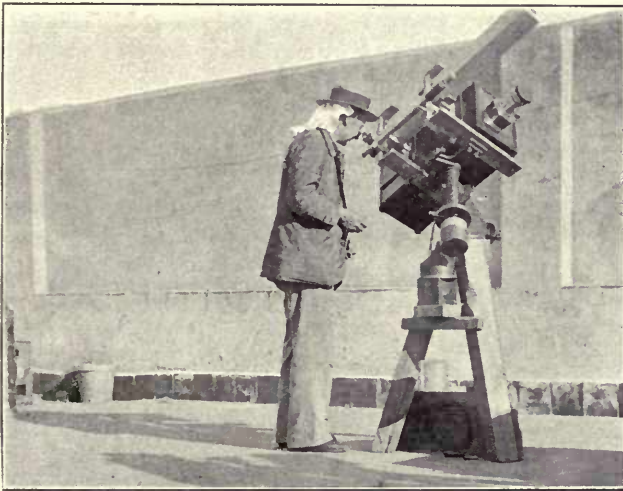
### *BAILY'S BEADS.*

THE earliest notice which we have of this phenomenon appears to be due to Halley, afterwards second Astronomer Royal. In his observation of the total eclipse of 1715, the only total eclipse of the sun that has ever been visible from Greenwich Observatory, he notes "about two minutes before the total immersion, the remaining part of the sun was reduced to a very fine horn, whose extremities seemed to lose their acuteness, and to become round like stars; and, for the space of about a quarter of a minute, a small piece of the southern horn of the eclipse seemed to be cut off from the rest by a good interval and appeared like an oblong star rounded at both ends." But they have become familiar to all students of astronomical literature since the year 1836, when Francis Baily, observing the annular eclipse of May 15th, of that year, was greatly struck with their appearance, and gave so full and striking an account of them, that they have always been looked for since, and have borne the name of the man who first made them generally well known. His account is as follows:—

"When the cusps of the sun were about  $40^{\circ}$  asunder, a row of lucid points, like a string of bright beads, irregular in size and distance from each other, suddenly formed round that part of the circumference of the moon that was about to enter, or which might be considered as having just entered, on the sun's disc. Its formation indeed was so rapid, that it presented the appearance of having been caused by the ignition of a fine train of gunpowder. This I intended to note as the correct time of the formation of the annulus, expecting every moment to see the thread of light completed round the moon, and attributing this serrated appearance of the moon's limb (as others have done before me) to the lunar mountains, although the remaining portion of the moon's circumference was comparatively smooth and circular as seen through the telescope. My surprise, however, was great on finding that these luminous points increased in magnitude, some of the contiguous ones appearing to run into each other like drops of water; for the rapidity of the change was so great, and the singularity of the appearance so fascinating and attractive, that the mind was for the moment distracted, and lost in the contemplation of the scene, so as to be unable to attend to every minute occurrence. . . . I cannot describe these phenomena (or rather this phenomenon, for it was one continuous appearance) more correctly than by supposing, for the moment, that the edge was formed of some dark glutinous substance, which by its tenacity adhered to certain points of the sun's limb, and by the motion of the moon was thus drawn out into long threads, which suddenly broke and wholly disappeared. After the formation of the annulus thus described, the moon preserved its usual circular outline during its progress across the sun's disc, till its opposite limb again approached the border of the sun, and the annulus was about to be dissolved, when all at

once (the limb of the moon being some distance from the edge of the sun) a number of long, black, thick, parallel lines, exactly similar in appearance to the former ones above mentioned, suddenly darted forward from the moon and joined the two limbs as before, and the same phenomenon was thus repeated, but in an inverse order. For, as the dark lines got shorter, the intervening bright parts assumed a more circular and irregular shape, and at length terminated in a fine curved line of bright beads (as at the commencement), till they ultimately vanished and the annulus consequently became wholly dissolved."

This description can scarcely be improved upon, but it should be noted that in an annular eclipse as was that of 1836, the two phases of the phenomenon occur in the reverse order to that seen in a total eclipse. In other words, it is at second contact, at the beginning of



REV. C. D. P. DAVIES, HOTEL DE LA RÉGENCE, ALGIERS.

totality, when but a thin arch of sunlight still remains, that the long, black, thick, parallel lines suddenly dart forward from the moon, and reach across to the limb of the sun, thus breaking up the thin bright arch into a row of beads. Whilst it is at the third contact, the end of totality, that the "row of lucid points like a string of bright beads" form around that part of the circumference of the moon that is about to enter upon the sun's disc.

In this Eclipse of 1900 several of the members of our various parties gave considerable attention to Baily's Beads, two of them, Mr. Crommelin and Mr. Chambers, by no means according in their explanation of the causes to which the phenomenon should be ascribed.

Mr. CROMMELIN (Algiers, Hotel de la Régence).—The progress of the eclipse was observed by projection on a sheet of cardboard

to avoid fatiguing the eye. About twenty seconds before totality Baily's Beads began to form. The appearance was as of the sudden leaping outwards of dark projections from the moon across the light crescent. They were first seen near the cusps, and gradually spread, so that at the ten seconds signal the whole crescent was thus broken up.

The beads had the appearance of absolutely straight perfectly black cuts out of the bright crescent; but it seems quite clear that they are simply caused by the lunar mountains, and that their peculiar aspect is due to the widening of the solar crescent through irradiation. Thus, nineteen seconds before totality, the width of the crescent in the middle was 8", tapering off to nothing at the cusps. Now, on the scale of the projection on the cardboard, about four inches to the sun's diameter, this would be equivalent to  $\frac{1}{60}$  of an inch at the widest part; but owing to irradiation it gave one the impression of being quite  $\frac{1}{12}$  of an inch, and even near the cusps it seemed to have a very sensible width. The beads in the crescent, due to the lunar mountains, would necessarily undergo a like seeming magnification, and hence would be produced those curious appearances of broad, black, straight bands. But for irradiation they would have appeared in their true form as serrated and irregular mountain peaks. It is a somewhat similar phenomenon to the "Black Drop" in transits of Venus.

Mr. G. F. CHAMBERS (Ovar).—I took with me a 2 $\frac{1}{4}$ -in. refractor, mounted on a tripod stand, and provided with a wedge solar eye-piece of neutral tint glass, made for the occasion by Mr. J. H. Steward. Not having previously seen any total solar eclipse, I studied carefully the warnings of observers with previous experience against undertaking too much, and I decided to confine my attention to (1) visual observation of Baily's Beads; (2) the Red Flames; (3) the outline of the outer Corona; (4) the passage of the Eclipse Shadow; (5) the Shadow Bands; and (6) the visibility of neighbouring stars.

My observations of the last three items may be said to have failed. Besides Mercury and Venus, I only saw two or three stars at the most, and I did not see either the passage of the Eclipse Shadow or any Shadow Bands. On the other hand, I made a successful pencil sketch of the outer corona; saw a very beautiful and extensive display of prominences in the form of carmine coloured light extending through 80° or 90° around the sun's circumference, and the "Baily's Beads."

As regards the outer corona and its extensions, I would only remark that the outlines were fairly well defined, but, owing to the general darkness of the sky being far less than I expected, there was not the contrast of light between the corona and the sky which I had anticipated.

As regards the prominences, I would say that I did not notice any particular development of them in jets or outbursts outwards; the display of carmine colour was truly magnificent, but the outline

seemed of fairly even width through the whole extent, which, as I have said, was something less than  $90^\circ$  of arc.

I look upon my observations of "Baily's Beads" as the most



THE ALCAZAR, SEVILLE.

successful feature of my day's work. I saw them sharp and clear, both at the beginning and at the end of the total phase; and I feel firmly convinced that they are not due, as commonly supposed, to

the serrated character of the moon's limb. I agree very much with Mr. Lewis Swift's remarks, made in connection with the American Eclipse of July 29, 1878:—

“The beads (which are luminous, and thus unlike the ‘Black Drop’) began to form from each end simultaneously, and in less than a half second were completed. They were nearly square, and increased in size from each end of the crescent to the centre, which was the largest in exact mathematical ratio. So symmetrical were they that if half of them had been superimposed on the other half they would have agreed in number, curvature, shape, and distance. They were visible but a short time—say two or three seconds—when, giving a few pulsating tremors, they vanished altogether. When I take into consideration the exact uniformity of their formation as to size, shape, &c., I cannot subscribe to the dogma that they are only the sun's light shining through the interstices of the lunar mountains. In this case part of the moon's contour, where they were formed, was smooth, while the other was exceedingly rough, yet the beads were the same in both localities; and those formed at the beginning are precisely similar to those at the close of totality, and those of one eclipse just like those of all—total and annular—that have occurred since they were first described by Baily. The assertion seems justifiable that the cause of Baily's Beads is still enshrouded in darkness.”

I can thoroughly confirm Mr. Lewis Swift's words as to the practical uniformity of the beads in “size” and “shape.”

Mr. WALTER MAUNDER (Algiers, Hotel de la Régence).—Quite five seconds before Mr. Crommelin gave the warning “Ten seconds,” the thin arch of sunlight, which yet remained, had been crossed by at least two black ligaments; one at each end of the arch, but not placed with perfect symmetry with regard to it. Five seconds after that warning had been given, the bright arch, now worn down to a thread of extreme thinness, was broken by black intervals, in, I should say, at least eight or ten places. I did not venture to count them, for fear of distracting my attention from noting the exact moment of totality, since it had been arranged that I was to give the word “go” immediately second contact was complete. The arch of tiny bright images, which I had now before me, did not seem to me to correspond entirely with Francis Baily's famous description; the “beads” were not circular spots of light, for their length was greater than their breadth. But the last stage in the phenomenon seemed to take place with extreme slowness. The impression on my mind was as if the moon had ceased to move over the face of the sun; the ends of the arc of light, and the breadth of the “beads” shrank so imperceptibly. Then when I began to fear that my friends around would think I had forgotten my engagement to give the signal, so slow had the final changes seemed, the arc of light collapsed all over, and was gone; just nine and a half seconds from Mr. Crommelin's “ten seconds” signal.

I observed with a Cooke refractor of  $2\frac{1}{2}$ -inches aperture, and magnifying power of 25. The dark glass was a very dark neutral-tinted one, and I ascribe the want of apparent circularity of the “beads” to the depth of the dark glass. The glass was

too dark to allow any trace of the corona to be seen through it during totality. The "beads" were not looked for at third contact.

Rev. AUGUSTIN MORFORD (Ovar).—I looked both before and after for the moon's black disc outside the cusps, but never saw it. The cusps drew in rapidly. About one minute before totality the



MOORISH WELL, RONDA.

inferior cusp was cut off by a lunar mountain about  $1\frac{1}{2}'$  from its point. The parts separated rapidly disappeared, beginning from the point. I am quite certain of this observation. "Baily's Beads" showed well, both before and after (better before). Separate beads were flattened oval in shape, rather than round.

Col. A. BURTON-BROWN, R.A. (Algiers, Cemetery Hill).—These were beautifully seen by myself and many of my party just before totality, and during a much longer time than is usual, pro-

jected on to the ground glass of a camera attached to one of my telescopes on which several also saw the corona.

“Baily’s Beads” were also noticed by Miss M. A. ORR (British Vice-Consul’s house), by Mr. RICHARD ROBERTS (Algiers, Hotel Continental); by the Rev. C. D. P. DAVIES (Algiers, Hotel de la Régence); and by the Rev. H. P. SLADE (Estarreja). Mr. ROBERTS noted expressly the rugged outline of the moon’s preceding limb as it advanced across the sun. This ruggedness of outline was perhaps scarcely surprising considering the great altitude of the mountains in the neighbourhood of the moon’s eastern limb, some of which would probably represent nearly 4’ of arc.

Mr. SYDNEY EVERSHED (Algiers, Cape Matifou), observing with a grating attached to one object-glass of a field-glass by Goertz, of course did not see “Baily’s Beads” as such, but noticed the break-up of the continuous spectrum into streaks as the lunar mountains stretched across the remaining thread of the sun’s disc. “I should guess that this time—the time that elapses from the moment when the continuous spectrum breaks up into streaks, to the instant when the last streak vanishes and leaves a pure bright-line spectrum—at certainly not less than one second; indeed, just after the eclipse I estimated this time at two seconds.”

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#### APPEARANCE OF THE DISC OF THE MOON.

It is of course perfectly well known that the moon during a total eclipse of the sun, although it usually appears much blacker than the sky, is yet strongly illuminated by earth-shine. Still there does not appear to be any record until the recent eclipse of the details of the lunar surface having been made out. The Rev. C. D. P. DAVIES, however, saw the surface rough, some parts darker and some brighter, and he adds the following description of the appearance of the lunar disc as seen in his telescope.

“During the progress of the partial phase it had steadily maintained its black, featureless, and apparently flat appearance, as we all know it so well in partial eclipses. But within the space of a second or two its limb became weirdly illuminated with a white ashy light. It was palpably a globe—not a mere lacuna in the disc of the sun—a thing of itself; a thing plainly on this side of the sun. Its surface looked white and dusty, its craters lying ghostly in the pearly rays. The only illustration that I can imagine—I have not tried it—is to put a thin coating of paste on an india-rubber ball, and pepper it over with fine white wood ashes. Shut the shutters, and suspend it at such a distance from them that a beam of sunlight through a fine hole is just large enough to envelop the ball. Then view it some little way off, and very



nearly behind it. The appearance spread well within the limb, say a sixth of the moon's apparent diameter."

This observation is of importance as showing from direct observation what we know theoretically to be the case, viz., that the moon though apparently so nearly black during an eclipse of the sun, yet is really under a by no means insensible amount of illumination.

Several other observers remark on the apparent relief in which the moon was seen; as a sphere, not as a flat disc. Thus the Rev. F. W. QUILTER saw "the body of the moon as a globe of ebon blackness, and just before totality the spherical form of our satellite was as distinctly seen as a ball would be if suspended on a string within a few yards of one's vision."

## CHAPTER XVII.

### *STARS AND PLANETS VISIBLE DURING THE ECLIPSE.*

“ The stars rush out  
At one stride comes the dark ”

is Coleridge's vivid description of the brevity of tropical twilight. But it might well serve as a paraphrase for half the descriptions of total eclipses which have come down to us from ancient times. Thus in the eclipse of the year A.D. 840, May 5, we are told “ there seemed no difference from the reality of night, that the stars shone out without any sensible diminution of light ” ; and again in that of 1140, March 20, the Saxon Chronicle relates, “ In the Lent the sun and the day darkened, about the noontide of the day when men were eating, and they lighted candles to eat by.” William of Malmesbury adds that the people “ went out and beheld the stars around the sun.” Clavius declares of the eclipse of 1560, August 21, “ There was darkness greater than that of night, no one could see where he trod, and the stars shone very brightly in the sky.”

Yet, in all the accounts which have come down to us from antiquity there are only two or three instances in which the corona is referred to, and even such references are doubtful. Whereas since eclipses have been made the subject of real and careful observation, the corona has stood out on every occasion as an object which could by no means be overlooked, as being, indeed, in its beauty, brightness, extent and mysteriousness the one feature of the eclipse beyond all others ; whilst the stars, which have been unmistakably detected and identified, have been very few indeed. Especial interest therefore attached to the eclipse of May last, since the sun was in an unusually rich portion of the heavens, and the great leaders of the heavenly host, Sirius, Procyon, Capella, Aldebaran, and the stars of Orion and the Twins, were all near at hand, and the search for stars was made a special object by several of our members. The results, though not numerous, are sufficient to show that the old accounts as to the numbers of stars seen were not wholly imaginative. For it must be remembered that in 1900 the sun was entirely hidden but for a very short time, and the sky illumination was always very great. In an eclipse of longer duration, the darkness at mid-totality would have been much increased, and, by consequence, a far greater number of stars would have been

recognised. The observation is one which should always be undertaken, as it affords a very full and unmistakable index of the



STREET SCENE IN CORDOVA.

general sky illumination during the eclipse, and of the conditions of observation.

The fullest report in this section is from Mr. C. L. Brook (Algiers, Hotel de la Régence): In the pure sky of the

Mediterranean, Venus was a fairly easy object to see at any time, the only difficulty lay in picking her up; I succeeded, however, in doing so every day from 22nd to 28th May inclusive, sometime between the hours of 11 a.m. and 3 p.m.

Pollux and Castor were very near Venus, and having thus an excellent guide to their places, I decided to try and get the exact time they appeared. I picked up Venus at 1.44 p.m., Greenwich mean time, on the day of the eclipse, and tried to point her out to several observers, but most of them failed to see her; at 3.27 p.m., Greenwich mean time, many of them began to see her, showing that already, 22 minutes after first contact, the sky was becoming darker.

Some ten minutes after this I noticed a sudden jump in the illumination; perhaps this was an illusion, but the impression was the same as if, being in a room with four or five lighted candles, one had suddenly been extinguished.

About two minutes before totality, I fixed my eyes on the place where Pollux ought to appear, and saw the star *become* visible at 65 seconds before totality, just before the minute bell sounded; I then turned round to look for Arcturus, but failed to find it, and my eyes being attracted to the colouring of the sky to the S.E., I noted as follows:—Next the horizon a band of orange red perhaps ten degrees broad, above this a band of primrose yellow of about the same breadth, this merged into blue, which in turn became indigo violet, and at and round the zenith the sky was the most intense indigo purple I have ever seen.

I then looked for Castor (about twelve seconds before totality) and found it fairly easy, and have little doubt I could have seen it thirty seconds earlier.

On the evening of the 27th and 28th, I noted the time of the appearance of Pollux as 7h. 19m., Greenwich mean time, or 7h. 31m., Algerian time.

My sister and I tried to estimate the darkness of the eclipse with reference to the twilight on the same evening; we failed in this, but from the appearance of the white sheet, she judged that at 7h. 44m., Algerian time, the light was about equal to two or three seconds after totality.

I glanced at Pollux and Castor during totality and found them shining like third magnitude stars.

I saw Aldebaran during totality, and Mercury also, shining brighter than I have ever seen it before, except once during the great frost of 1895.

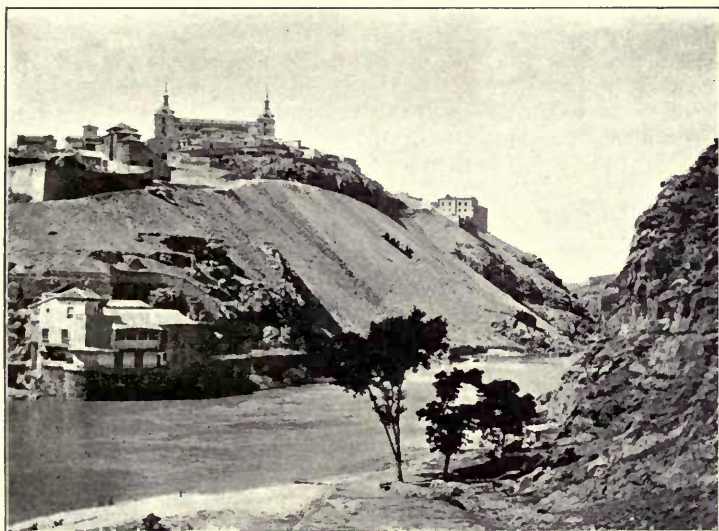
My sister notes that she saw with the binoculars  $\epsilon$  Tauri (magnitude 3.7 Oxford Photometry) in the same field with Aldebaran during totality, also that at 4h. 1m., Greenwich mean time, the swifts began hovering round just as they did on several evenings in the twilight.

My impression is that during totality I could have seen all second magnitude stars, or even  $2\frac{1}{2}$  magnitude stars, provided they had been some distance above the horizon, and provided also there had been some means of directing the eye exactly to the right place. Many stars escape being seen because there is no time to search for them.

The observers at Naval Moral report under this head as follows:—

Mr. C. T. WHITMELL.—I saw Venus for some time after totality. She appeared nearly overhead, though her actual altitude was  $72^{\circ}$ . The azimuth was  $40^{\circ}$  S. of W. Mercury was  $2^{\circ}$  (about four diameters) from the sun's centre, on a line passing through the lower right quadrant of the disc. He became invisible almost directly after totality ended. A bright star in the S.W. was, I believe, Sirius, which at totality had an altitude of  $30^{\circ}$ , and an azimuth  $24^{\circ}$  W. of S.

Mr. HOWARTH.—Mercury was brilliant and almost touching the corona. Sweeping the sun with an opera-glass, no other planet or



TOLEDO.

star was visible near it, though further away, Venus and many fixed stars came into view.

Mr. BUCKLEY.—After the sun, the most striking object was Mercury, shining with a bright red gold tint, about two degrees from the right lower part of the sun. A few stars were visible, flashing out suddenly at totality. Aldebaran, Sirius, and the planet Venus, were the most conspicuous.

Mrs. BUCKLEY.—Observed with the greatest interest the quick shining out of various stars and planets. Venus overhead was particularly fine, and Mercury, magnificent. Aldebaran, Betelgeux, and Rigel, were also seen.

Dr. STOKES.—Mercury was distinctly seen, and was extremely brilliant. No other body of the nature of a planet or comet was seen.

Miss PETHERICK.—Many stars were visible. Venus was particularly bright.

Rev. C. T. STEWARD.—Had only time to see Mercury.

Misses L. and W. FOSTER.—Venus and Mercury, the former some minutes before totality.

The Manzanares party record that "Venus was seen distinctly and with ease at 3.50 p.m., Greenwich mean time, and would have been seen much earlier if looked for. We were occupied in other matters, and our attention was drawn to Venus by the murmur of the crowd beneath.

"Mercury was a very brilliant object during totality. It appeared as bright against the light 'eclipse' sky as Jupiter had appeared the previous night against the clear dark night sky in the same place. The close proximity of the corona would of course further lessen the apparent brightness of Mercury, so that it is evident that Mercury really greatly exceeds Jupiter in brilliancy.

"Mars was seen by the Spanish gentleman with us on our tower. They also saw Aldebaran, Sirius and Capella, and correctly described their positions to us."

Miss McRAE (Elche) reports seeing Venus, Mercury, Mars, Sirius, Capella, and Betelgeux with the naked eye. M. MOYE, also at Elche, saw no star except Sirius. Of course Mercury was very bright, whilst it is needless to say that Venus was dazzling overhead. C. NIELSEN (Ovar) reports the same three objects—Mercury red-golden brown in colour. No other planets or stars were seen, though carefully looked for in their proper positions.

At Plasencia, Dr. DOWNING returns Venus as first seen at 3h. 28m., Madrid mean time, Sirius as first seen at 3h. 47m., Madrid mean time, the time of mid-totality being 3h. 51m., Madrid mean time.

During totality Mrs. DOWNING detected, by the aid of her opera-glasses,  $\epsilon$  Tauri and  $\nu$  Tauri. These stars were identified by means of a chart giving the positions of the principal stars in the neighbourhood of the sun at the time of the eclipse.

Mr. WALTER MAUNDER (Algiers, Hotel de la Régence), though not including the search for stars in his programme, found Sirius and Rigel, as well as Mercury and Venus, too bright and conspicuous to be overlooked.

Mrs. MARY CREWSDON (Algiers, House of the British Vice-Consul) saw with the naked eye:—

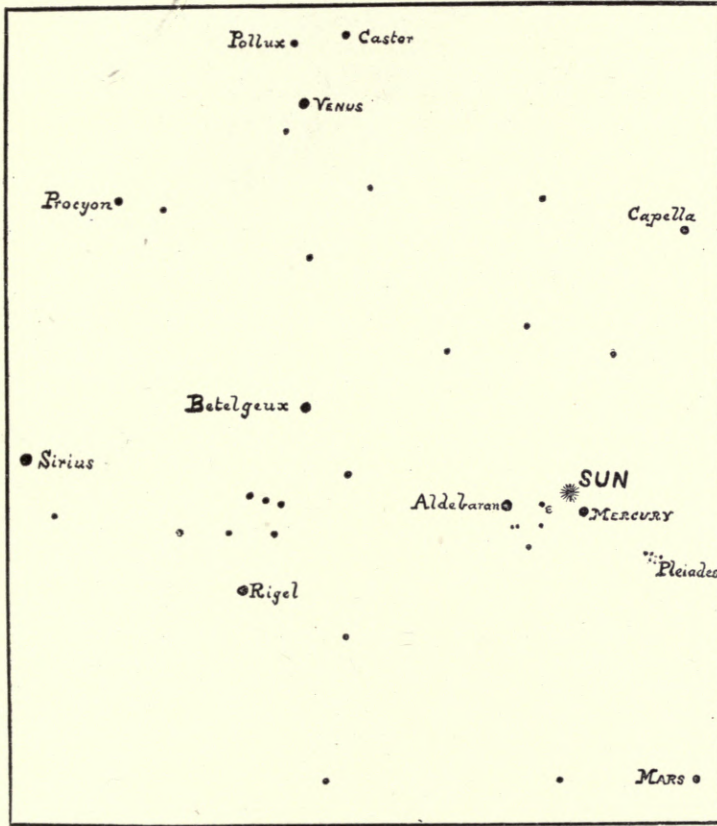
At the time of partial eclipse—Venus.

At totality, in the following order:—2. Mercury; 3. Sirius; 4. Rigel; 5. Capella.

At half time—6. Aldebaran.

At half time and one second—7. Epsilon in Taurus.

Search was made for some seconds after this for the "Pleiades," but they were not seen. Was surprised to see a very small star between Aldebaran and the sun, and made sure by repeated looks that there *was* a small one visible. From its position it was identified afterwards as "Epsilon" in Taurus.



STARS AND PLANETS AROUND THE SUN, 1900, MAY 28.

## CHAPTER XVIII.

### *METEOROLOGICAL OBSERVATIONS.*

THE fullest report received on the meteorology of the eclipse is from Mr. C. L. BROOK (Hotel de la Régence, Algiers), and is to the following effect:—I took out with me the following instruments: A hydrograph, or wet and dry bulb continuously recording thermometers, by Richard Frères, Paris; dry and wet bulb thermometers of the ordinary pattern, in order to keep a check on the above; a Stevenson thermometer screen; a black bulb thermometer in vacuo for the sun's radiation; I had also a makeshift wind-vane consisting of a 16 ft. fishing rod and a piece of tow, which answered very well.

The flat roof of an hotel is not an ideal place for exposing thermometers, but after some hesitation I chose the S.E. corner, overlooking the Place du Gouvernement, as being the least objectionable, and, considering the conditions of the weather, and the cool breeze prevailing on May 27th and 28th, I believe they were scarcely, if at all, affected by the glare of the sun on the tiles.

The chief points to be noted are:—

(1) The extraordinary flatness of the curve of the temperatures in the stand; the maximum on the 27th did not exceed 68.0 F., and the minimum did not go below 61.0 F.; on the 28th the corresponding figures were 69.5 F. and 61.8 F.; the range thus not exceeding 8.0 F. on either day.

(2) The constant struggle between the sun and the slight, but cool breeze during the day time, which caused the trace to show innumerable small variations corresponding to slight variations in the force of the wind, which, however, never exceeded Force 2 on Beaufort's scale.

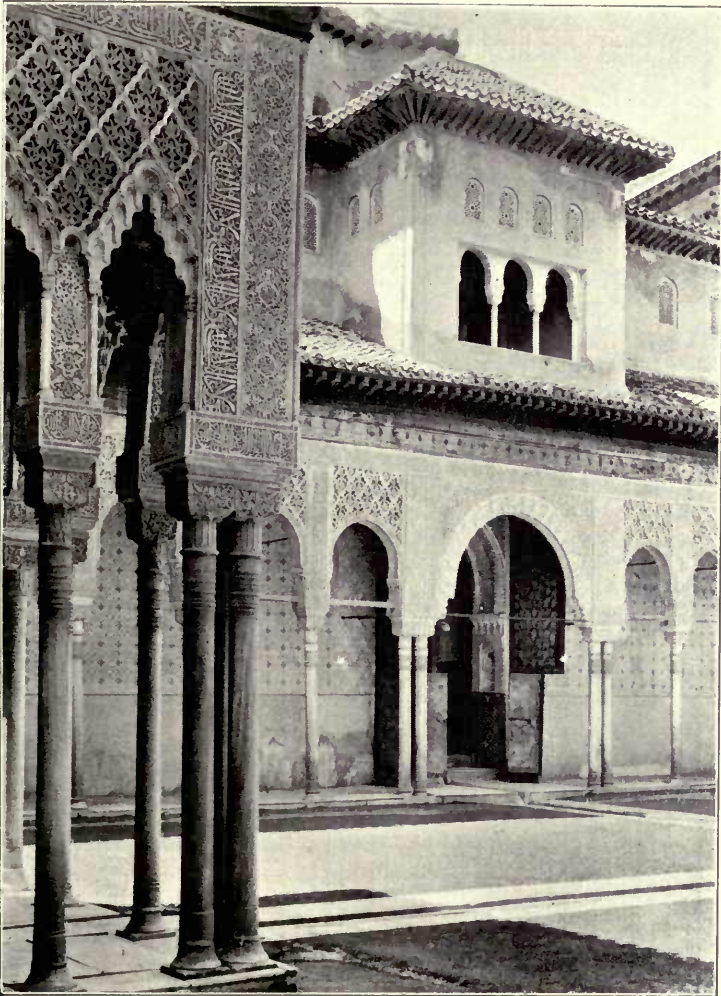
(3) The extreme smoothness of the trace during the evening and night when there was no sun to affect it; during many hours of the night the temperature remained constant at from 61.0 F. to 62.0 F.

(4) During the time of the eclipse the trace shows the same smoothness with slight interruptions.

(5) The fall of temperature, as shown by the dry bulb was, in the screen only 2.5 F., from 69.0 F. at 3.35 to 66.5 F. from 4.20 to 4.40; the lowest temperature thus taking place about 15 minutes after totality.



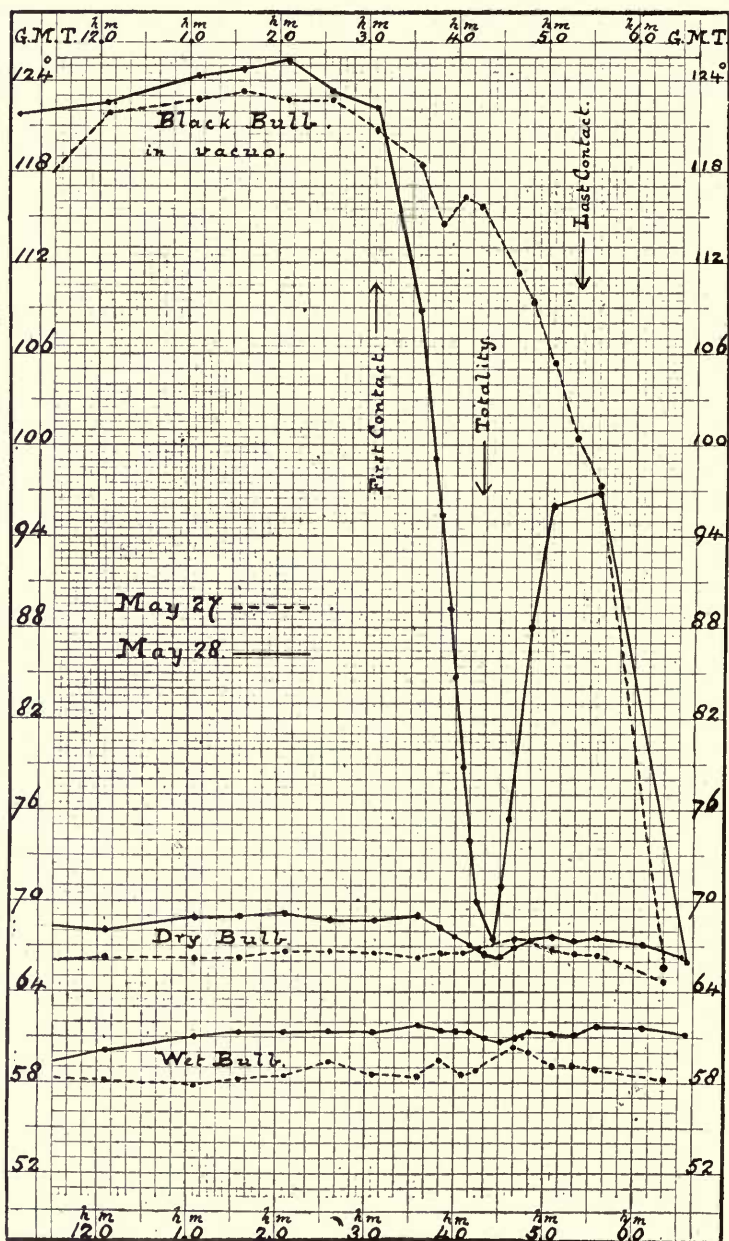
(6) The humidity, as shown by the dry and wet bulbs, rose distinctly though not to a great extent during the eclipse; it



COURT OF THE LIONS, ALHAMBRA.

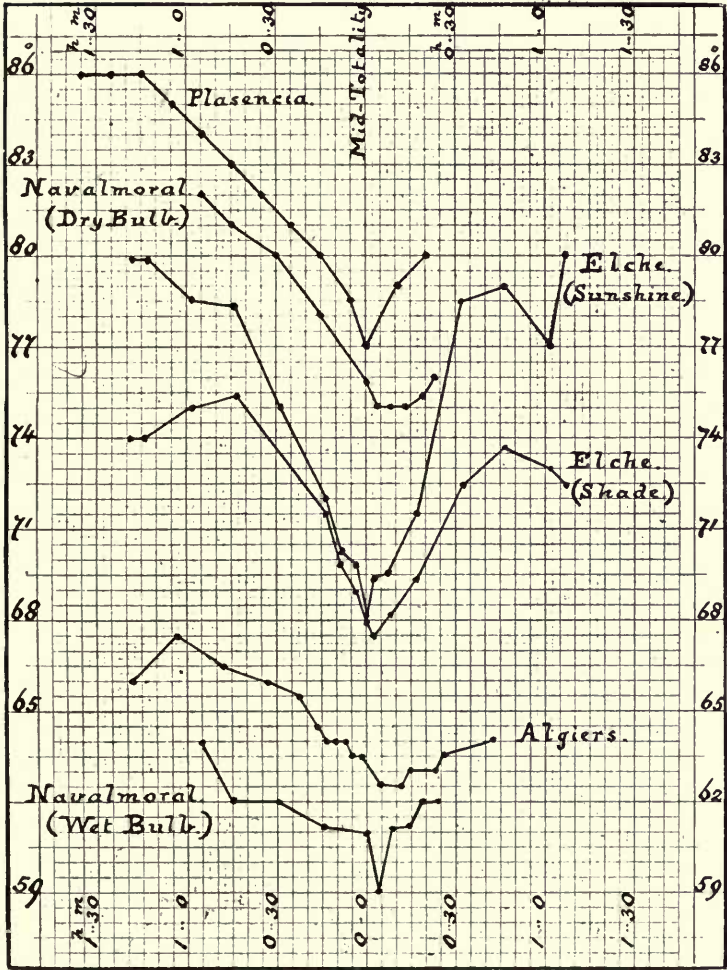
was 62 p.c. at the commencement; rose to 70 during and after the total phase, and fell again to 67 at 5 o'clock.

(7) The extremely rapid fall of the black bulb thermometer from 123 F. at 3.5 p.m., to 67.5 at 4.25 p.m., the lowest point



## TEMPERATURE OBSERVATIONS,

Made by Mr. C. L. Brook, 1900, May 27th and 28th, at the  
Hotel de la Régence, Algiers.



TEMPERATURE OBSERVATIONS,  
 Made during the Eclipse of 1900, May 28th.

observed, or 55.5 F. in 80 minutes; here also the lowest point was probably slightly after the total phase.

(8) The wind during the eclipse showed a tendency to back from N.N.E. to N.N.W., but it was very light all the time, and I do not think that it is at all certain that this was more than a coincidence.

(9) There were no clouds except a few cumuli some 30 miles away over the hills to the south.

The direction of the wind was on May 27th N.N.E., veering slightly to N.E. occasionally, and its force was very light. At 8.35 there were cumulus clouds round the horizon, and at 9.50 detached stratus overhead moving from the north. These disappeared, and from noon cumulus clouds were seen over the hills, but these by 3.35 were going so that at sundown the sky was practically cloudless.

On May 28th, the wind kept the same general direction, N.N.E. to N. until 3.5 p.m., when it was N.—N.N.W. Till 4 p.m. it came from N., and at 4.5 p.m. it was N.N.E. At 4.35 it was N.N.W., and for the rest of the afternoon from N. The force of the wind was 1 and 1—2 during the hours of passage of the moon over the sun.

From 1.35—3.5 there were small cumulus clouds over the hills to the southwards, but these were almost gone at 4.5, and from 4.30 on there were absolutely no clouds.

I am not quite sure of the value of thermometer observations during an eclipse; they do not seem to have much bearing on eclipse phenomena; another time, however, it might be advisable to have a recording solar radiation thermometer; on a clear day the fall is so rapid that some relation might be established between the temperature and the amount of the sun's disc obscured.

C. L. BROOK.

The temperature readings at Algiers were markedly different from those at the other stations where such observations were taken. The stations in Spain and Portugal all show a very much higher shade temperature before the eclipse began, and a much deeper drop at totality. The accompanying diagram shows the readings obtained at four different stations, the times being reckoned before and after mid-totality. Oporto, as shown in the note communicated by Mr. G. F. Chambers, was much hotter even than Plasencia before the commencement of the eclipse, and the drop at totality was more marked. The observations at Plasencia were communicated by Mr. T. WEIR; those at Navalmoral were made by the Rev. CHARLES J. STEWARD, the thermometers being exposed to the air under the shade of an olive tree at the height of four feet from the ground; and those at Elche by Mr. J. H. WILLIS. Mr. Willis adds:—The greatest fall in the temperature was as follows:—

“In the sunshine, 11.8. Lowest at totality.

“In the shade, 6.5. Lowest about one minute after totality.

“ The records are of little value for showing the actual decrease of temperature during the eclipse, as the state of the weather was not similar throughout. Just before the first contact the temperature was lowered by a light cool southerly breeze, which died down unsteadily to an almost dead calm towards totality; after which it rose slightly for some twenty minutes, being then south-easterly.”

Cape Matifou, though so near Algiers, corresponded rather to the Spanish conditions.

DR. HEYWOOD SMITH, who was one of the sketching party who observed from the village school at Matifou, used a Casella's maximum and minimum thermometer, and having previously set the instruments, he found when the eclipse was over the following readings:—Maximum, 79.7 F., minimum, 63.7 F., *i.e.*, a difference of exactly 16°. Mr. E. DICKSON, who observed from the hill some 40 feet higher up, and about a quarter of a mile away from the school, gives these different readings (height of recording station 127 feet above the sea level), *viz.* :—

Temperature, 3.10 p.m	...	...	75° F.
4.17 p.m.	...	...	63° F.
4.20 p.m.	...	...	63½° F.

Giving a range of only 12°. This difference in the variation of the temperature at the two stations so near to each other was certainly real; the fact that the school was protected from wind and cold by other houses, by rising ground in front, and by trees in the distance, easily accounts for the apparent discrepancy, especially when one bears in mind that the higher station was open to the sea and air in almost every direction, and would thus naturally be the cooler station under most circumstances. It is interesting to note, however, that the minimum readings are practically the same in both these cases as at the Hotel de la Régence.

Mr. G. F. CHAMBERS supplies the following communication:—Mr. Tait at Ovar, and, I may add, I myself also, and several persons at Oporto, noticed that the wind freshened considerably during the progress of the eclipse up to totality, and fell off again after totality. This is indeed confirmed by the automatic record made by the anemometer at the Meteorological Observatory at Oporto, which showed that between 2.0—3.30 p.m. the velocity rose from 14 kilometres to 34 kilometres per hour; and fell between 3.30—4.30 p.m., from 34 kilometres per hour down to 20.

The following observations were made during the eclipse at 155 Entre Quintas, Oporto, by Baron DE SOUTELLINHO:—The thermometers used were avitreous clinical ones certified at Kew. The thermometer exposed to the sun was placed on a table covered with a white cloth, at a height of two feet above

the ground. The thermometer in shade was on a shelf under the table, and eight inches above the ground. It was screened on two sides, and open on the other two sides, the table being a square one.

Hour.		Temperature in Sun.	Temperature in Shade
2.20	P.M. ...	105°	92°
2.40	" ...	102	88
2.55	" ...	95	85
3.05	" ...	90	83
3.20	" ...	82	82
3.25	" ...	78	80
3.31	" ...	73	77
3.33	" ...	71	77
3.35	" ...	72	77½
3.40	" (about totality	72	76½
3.47	" ...	74	76½
4.00	" ...	81	75½
4.07	" ...	85	78½
4.12	" ...	89	79
4.20	" ...	90	79
4.25	" ...	92	80
4.30	" ...	92	80

It is noticeable that about the time of totality the exposed thermometer fell rapidly to a point *some degrees below* that reached by the shaded thermometer.

In Oporto the morning was hot and sultry, and it seemed as if a thunderstorm was brewing. This heat continued till the eclipse became total, when suddenly a cool fresh feeling came over the air, reminding one of a bright early morning or a fresh spring evening in the mountains. As the sun again became clear, the air again became hot, though not so sultry as before.

## CHAPTER XIX.

### *COLOURS ON LAND AND SKY.*

THE impressiveness of a total eclipse of the sun does not rest solely or even chiefly in the revelation of the corona, wonderful and unaccustomed though its appearance is. The daylight turned to darkness is much more the cause of awe; and the darkness, being so different from that caused by a mist or fog, and distinguishable too from the gloom of a great storm cloud, has an unwonted effect which seems therefore to partake of the supernatural. And this effect is heightened by the strange colouring seen on land and sky. Every tint that seems to speak of life or warmth in the objects around fades out, and is replaced by the ghastly hue of decay. The flowers all look withered, the grass and trees exchange their living green for lead, the faces of the watchers lose all trace of health and become not merely wan but livid. Whilst above, the blue of the sky has changed to a deep almost black funereal purple, and round the horizon, where the light is much the strongest, there is a glow of an angry gold, a sulphur-light not untinged with red.

The longer the total phase, the more pronounced are these effects, and the deeper and more awe-inspiring the gloom. A short eclipse, therefore, like that of 1900, is not a specially good one in which to watch them. Indeed, of the three expeditions in which the British Astronomical Association has taken part, the one which offered the best opportunity for noting chromatic effects on land and sea, and in which the colouring would seem to have been the most vivid, was that to Lapland in 1896, which we are apt to think of as having been fruitless. That the weather was cloudy and the total phase was not seen at all, was from the standpoint of this particular observation an advantage not a drawback, since observers unable to see the corona and prominences, were free to turn their undivided attention to the very striking atmospheric effects which were produced. And the Association were the more fortunate in that the observers, who had undertaken the duty of sketching the corona without telescopic aid, were under the direction of so eminent an artist and keen and experienced judge of colour as the late Mr. N. E. Green, F.R.A.S. At a general meeting of the passengers on the "Norse King," held on the day after the eclipse, and whilst the recollection of what had been seen was fresh in the minds of all, the subject was discussed in very great detail; and the

suggestion of Mr. Green, that the brilliant colouring which we had seen on the horizon, and in spaces between the clouds, was in truth only the same effect that we perceive at sunset, was generally felt to fully accord with our recent observation. During a total eclipse as seen from a station near the centre of the shadow track, the light on the horizon necessarily comes from regions beyond the zone of totality, and exhibits colour effects analogous to those of a sunset. In the eclipse just passed, by far the most attention was given to this question by the observers at Navalmoral; though Mr. Whitmell, who reports on their behalf, is inclined to ascribe the effects rather to illumination by the chromosphere than to any action by our atmosphere.

#### REPORT FROM NAVALMORAL.

“Mille trahens varios adverso sole colores.”—*Virgil*.

Mr. BUCKLEY: Appearance of landscape before totality very weird: dark twilight rapidly approaching; pale green and yellow lights. The Sierra de Grédos presented for some time the charming rose-flush seen during Alpine sunsets.

Mr. SOUTHAL: All round the horizon, to an altitude of perhaps 10°, was a ring of subdued light resembling dawn. To the N., over the Sierra, some thin clouds showed, towards the end of totality, a tint of orange yellow.

Mr. HOWARTH: At totality some clouds on the N.W. horizon took on a red glow like that of sunset. The atmosphere was rosy.

Rev. C. J. STEWARD: A purple light on the plains, and purple with a tinge of red on the snow of the Sierra, as totality approached. The sky was purple-blue, as if seen through a red glass. The purple light came just before totality, and vanished suddenly when this was over.

Miss W. FOSTER: A faint purple haze, becoming deeper and richer as totality progressed. The mountains looked pinkish just before totality.

Dr. STOKES: Just before and early during totality, there was a distinct rosy glow on the clouds to the N. This was very beautiful, and seemed to be diffused through the atmosphere on the right. As totality proceeded, the rosy glow on the mountains to the right was succeeded by a bluish cast.

Mr. LA GUIDARA: In the distance at totality the mountains assumed a remarkable dark blue-black inky colour, forming a pronounced contrast to their soft rose-tinted snowy peaks. On the horizon a few fleecy clouds seemed ablaze with a deep orange-red glow. Previous to totality the sky was an immaculate sheet of blue.

Miss PETHERICK: A dark shadow was creeping over the mountains, and their snowy tops appeared of a lovely softened golden tint. The sky looked like what is often seen in Alpine regions, gold, with dashes of pink.



Miss L. FOSTER: Observed sky colour, only between first and second contact. It gradually assumed a purplish blue tinge. The only clouds visible were some small streaks, low down near the horizon and above the Sierra. As totality came on, these turned from white to cream colour, deepening into sandy orange. With the rush of darkness the mountains suddenly became dull purple grey, the sky behind appearing of a pale, indefinite yellow tint—the general effect in that part of the sky being much the same as that seen after a sunset.

Rev. T. PITTS: White fleecy clouds, seen over the ridge of the Sierra, became suddenly golden orange when totality began. Before totality, when about five-sixths of the sun's disc were obscured, the remaining lune of the sun appeared deep red, when viewed through plain smoked glass. The same glass caused the ordinary unobscured sun to appear reddish yellow.

[As Mr. Pitts was observing not the chromosphere, but a lune of the sun, it seems to me that the curious alteration in hue was probably due to the fact that there is a qualitative as well as a quantitative difference between light from the sun's centre and light from near the limb. The light from the latter is not only less bright, but is also relatively poorer in the more refrangible rays—hence the increased redness.—C. T. W.]

Mr. and Mrs. CONSTABLE (at Talavera): Light failed slowly, but ended abruptly. Red glass gave a much better view than green glass. [This, I think, was to be expected from the nature of the light of the chromosphere, etc.—C. T. W.] To call the effect moonlight would hardly be right, as the shade was warmer and more weird. For painting the scene raw umber would be truer than the colour used for the green tones of moonlight. The horizon became deep burnt sienna and orange colour, the sky shading up into a dark tone of night-blue, purple, and raw umber towards the sun. The distant mountains became deep blue-purple. Clouds on the horizon were reddish yellow.

It will be noticed that observers mention in connection with totality the appearance of red, orange, purple, rose, and pink colours on the landscape, or in the sky. As the sun's altitude was  $39^{\circ}$ , I attribute these warm colours to illumination by the chromosphere. It seems hardly reasonable to suppose that mere diminution in the quantity of sunlight could produce these colours, and, obviously, the differential action of our atmosphere could not come into play, because the altitude of the sun remained practically unaltered.

C. T. WHITMELL.

Beside that from the observers at Naval Moral, brief reports have been received from other stations as follows:—

Mr. C. NIELSEN (Ovar) notes that the light disappeared very gradually towards second contact, making surrounding objects, such as the pine trees, human faces, etc., ashen-grey and livid. At the moment of totality the light round the horizon changed into gold, and from thence up to  $45^{\circ}$ . From thence up to the

zenith it was violet-purple. After totality the light increased very much more quickly than it had decreased before, even allowing for subjectivity.

Mr. T. W. BACKHOUSE (Plasencia): As regards the landscape and sky effects these were most magnificent. This part of the phenomenon we missed in India, since we were on a plain, and there were no clouds. I did not observe it particularly before or during totality, but could not help seeing it more or less. The colours were somewhat like sunset colours, though



THE LANDING STAGE OF THE COMPAGNIE TRANSATLANTIQUE, ALGIERS.

not exactly; I did not notice any red, it was more the earlier stage of sunset colouring, but in quite a different combination.

When totality was passing away from us, the colouring was much the same, the foreground being bright and orange, which colouration rapidly spread to the more eastern parts of the hill; beyond, in the shadow, was dark blue; the sky in the distance was orange low down, fading upwards into yellow, etc., and finally into dark blue above.

4h. 8½m. G.M.T.—The distant mountains to E.S.E. are in the shadow, and dark blue.

4h. 9m. G.M.T.—The mountains are now all illuminated, but the shadow is still visible in the sky reaching from them up to an altitude of perhaps 1° above them.

The middle of totality would be at 4h. 6m. 21s. G.M.T., according to calculations, so that the last observation would be about 2m. after the end of totality.

Mr. IRWIN SHARP (Plasencia): The darkness seemed about the same in intensity as it was in India, but of a different nature. There it was simply a diminished light with a softness like moonlight, but here I felt a gloom hanging over me, which I cannot exactly describe. I did not notice the shadow stalking over the land at 40 miles a minute; but after totality we could



THE OLD HARBOUR OF ALGIERS.

This photograph shows the old Moorish building formerly occupied by the harbour master of the time and now used by the French Admiralty, with the torpedo station attached. Above and behind it is seen the modern lighthouse which marks the harbour from the sea.

gradually see the more distant parts in the plain getting lighter one after the other.

The mountains looked as they do after sunset, but the clouds on the horizon were not so bright.

In one direction they were of a lemon yellow colour, and in the opposite direction they were more of an orange hue.

For some time before the eclipse became total, there was an increasingly soft "evening" light, and as the light of the sun grew less, it made the shadows of the flowers stand out with startling clearness.

Mr. H. KEATLEY MOORE (Manzanares): The colour of the sky, which before the eclipse was intensely blue, paled gradually, and was of a gentle twilight gray during totality.

The colours of the landscape dulled during the eclipse, as if looked at through gray glasses of increasing tints. On the cessation of totality the distant hills became beautifully coloured, as in a fine dawn, with roseate and yellowish hues.

Mr. E. W. JOHNSON, in his record of observations of the party at Elche, gives a note by Miss McRAE to the effect that at 3.50 there was a marked difference in the light, a weird look came over everything, the palm trees looked purple, and faces ghastly. Simultaneously with the appearance of the corona came wonderful sunset colours round the horizon; pale apricot colour below, shading to amber and red above. The corona appeared to be of the purest silvery white, one of the equatorial extensions, that towards the planet Mercury, being seen to more than three lunar diameters from the sun's centre. It was noticed by several that the light apparently returned more quickly than it had disappeared.

M. MOYE (Elche) reports that during totality the sky was dim, the blue was become an ashy grey; round all the horizon a large zone of a golden-yellow hue, with rosy and lilac streamers, produced a very artistic effect. The landscape was as if drowned in a dull grey, the colours died out of the objects, the appearance was grand and rather sorrowful.

Col. BURTON-BROWN (Cemetery Hill, Algiers) noticed some ten minutes before totality a marked yellowish haze, and a little later a ghastly look spread over things. This greenish yellow haze was much observed by one of our party, who went high up into the mountains on the central line, 100 miles from Algiers, sketching; he mentions this haze as being seen everywhere.

Dr. HEYWOOD SMITH, M.D. (Cape Matifou): The general effect on the landscape seemed more pronounced during the last few seconds before totality and its on-coming, for the waning light held all in a dusky gloom, not twilight; then the hills got dark purple, and the darkness came on at the end quite suddenly; the last point covered was about N.W.N. It was a different sort of obscurity from the light of the full moon, more diffuse and soft, and just light enough to sketch on white paper. The colour of the sky seemed to be a deep purple, not so dark as an hour or so before dawn in an Alpine night at a height of about 10,000 to 12,000 feet up.

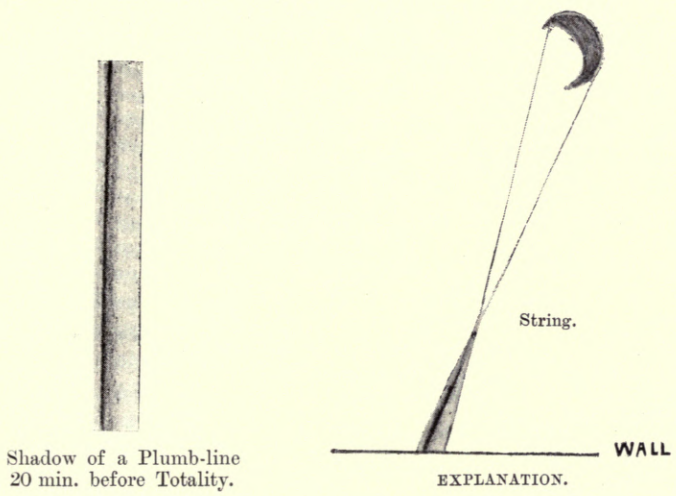
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#### SHADOWS DURING THE PARTIAL PHASE.

As the portion of the sun still visible grows smaller and smaller with the approach of totality, so the shadows necessarily become sharper, since the source of illumination has a smaller area. This is clearly seen in the accompanying photograph (p. 206),

of the harbour of Algiers taken a few minutes before second contact, and also in the photograph of the promenade deck of the "Austral," on p. 23. Another curious shadow effect is described as follows by Mr. H. KRAUS NIELD:—

As a matter of curiosity I took a photograph, about twenty minutes before second contact, of the shadow, on a vertical wall, of one of the plumb-lines. I reproduce below on a larger scale the appearance of this shadow on the print. It is, of course, perfectly natural and easily explained owing to the crescent shape and oblique direction of the source of the light at the time, but it nevertheless looked very curious and remarkable when we first saw it.



THE SHADOW OF THE MOON.

THE coming and passing of the shadow of the moon was looked for at almost every station, but was seen as a definite outline, at three only. Mr. G. F. CHAMBERS reports that the shadow was seen by his friend, Mr. A. F. WARRE, from the roof of the Serra Convent, Oporto; and at Pont Mazafran, Algeria, where Mr. EVERSLED was stationed, the people in the neighbourhood said that they saw a distinct line of demarcation out at sea between the zone in complete shadow, and that where the eclipse was only partial. Col. BURTON-BROWN, at Cemetery Hill, Algiers, though he did not see the approach of the shadow himself, says that several observers in his party saw it coming over the Bay at the rate of about  $\frac{3}{4}$  of a mile per second. The observers at Navalmoral, who were very well placed for seeing the shadow,

looked specially for it, but saw nothing definite. Mr. JOHNSON'S party at Elche also failed to see it; Mr. NIELSEN at Ovar, Mr. WEIR at Plasencia had the same negative result, and of several observers at Cape Matifou, who went to higher ground, largely in the hope of seeing the shadow, not one was satisfied that he had seen it with that distinctness which had been expected. At the Hotel de la Régence, Algiers, at the instant of third contact Mr. CROMMELIN states:—"I immediately ran to the south wall of the hotel, where I had placed a hand camera in readiness for



THE PLACE DU GOUVERNEMENT, ALGIERS, DURING THE PARTIAL ECLIPSE.

THE "ARGONAUT" IN THE HARBOUR.

attempting to photograph the retreating shadow in the sky. I saw at once, however, that the attempt was really hopeless; there was a murky yellow glow towards the south-east, and it was plain that the distant mountains were still in the shadow, but absolutely no outline to the shadow could be traced on either sky and land. I exposed the plate, however, but, as I expected, it only showed a uniform diffused light all over, and is consequently of no interest."

Mr. C. L. BROOK at the same station also "turned to observe the receding shadow, but failed to see it; all that can be said is that some few seconds after totality was over, the land across

the bay to the S.E. brightened up rapidly, while the Djur-Djurra mountains, some 30 miles or more distant, were still shrouded in gloom, their outlines only being barely, if at all, discernible; there was at no time any appearance of a definite boundary line between the shadow and the sunlight."

On the other hand, the Rev. F. W. QUILTER, also at the same station, was much impressed by the shadow, his success in detecting it being probably due to the fact that he gave more undivided attention to the watch for it than did the other observers. "The moon's shadow, like a curtain let down from the zenith to the surface of the Mediterranean, appeared to be drawn along the sea by an invisible hand. The spectacle of an immaterial shadow seen in mid-air, and not reflected on a solid substance, had a novel and supernatural appearance."

Still, the failure of so many observers to see the shadow at all would seem to show that, for some reason or other, it must have been much less dark and definite at this eclipse than it has been at some others.

## CHAPTER XX.

### *EFFECTS ON PLANTS AND ANIMALS.*

THERE is one astronomical observation which lies within the scope of even animals and plants; they notice the change from night to day and from day to night. Sunrise and sunset are felt by them, and they respond to their influence. It has been, therefore, a point of great interest to notice how they are affected by an event which, coming upon them out of the ordinary course of nature, and unexpectedly, reproduces so nearly the circumstances of the great diurnal change.

Considerable attention was paid to this department of observation during the late eclipse, and in particular we owe the following full report to Mr. G. F. Chambers, who has collected several important notes from observers in Ovar and Oporto.

MR. G. F. CHAMBERS' REPORT.—Having received offers from several competent students of nature to observe the behaviour of animals and plants during the eclipse of the sun, I thought it would be interesting to possess such a record. Mr. W. TAIT, of Oporto, sent me the following notes, which I reproduce as nearly as may be in his own words:—

“I took down to Ovar on the morning of May 28, in pots, two sensitive plants (*Mimosa Pudica*), a silver wattle (*Acacia Dealbata*), a *Sazania Splendens*, and a *Mesembryanthemum Polyanthum*. My place of observation was the garden at the back of the house of Dr. G. H. Bacellar. On unpacking my plants they showed of course the effects of the long and shaky railway journey, and deprivation of light. The leaves of the sensitive plants and of the silver wattle were closed. The flowers of the *Mesembryanthemum* were also closed, but the flowers of the *Sazania* (called by the Portuguese “Boas Noites,” or the “Good Night” plant, from its habit of closing its flowers in the evening) appeared to have been but little affected by the journey. It is possible that this may have been owing to the fact that the plant had been transplanted only four days previously, and to the flowers being rather old. Dr. Bacellar had in his garden some specimens of this same species of *Sazania*, but these were placed so that just as the eclipse began the shadow of a neighbouring building fell on them, and this would have caused them to close their petals independently of the eclipse.

“On placing my plants in the sun, which was shining through a thin haze, the leaves of the sensitive plants, of the silver wattle,



and the flowers of the *Mesembryanthemum*, gradually re-opened and remained open for some time, although the first contact had taken place and the eclipse had begun. At 3.6 p.m. the flowers and leaves were still open, but the air was sensibly cooler, the wind being about N.N.W. At 3.17 I heard all the cocks crowing vigorously; ring doves in a cage were cooing softly; the sky had assumed a peculiar lurid grey hue with a strange reddish purple tint; the plants were still open. Two minutes later I noticed a great change. The sky had become much darker. The flowers of the *Mesembryanthemum* and the leaves of the sensitive plant had become partly closed, though the silver wattle seemed to be but little affected. The swifts were flying much lower than previously, but I did not hear the shrill screams which they so often utter when chasing each other in the evening. After totality the sun re-appeared with great suddenness, like an electric arc-light hastily turned on. In another ten minutes there was plenty of light everywhere. I was much surprised to notice that though the sensitive plant had commenced to re-open its leaves the flowers of the *Mesembryanthemum* were still closed, and did not re-open during the half hour that elapsed before I left the garden to visit the party which accompanied the Astronomer-Royal. They told me that the domestic fowls in an enclosure in their garden went to roost when the darkness came on. Unfortunately I did not notice until too late that Dr. Bacellar had near his house an aviary, containing several species of birds and some rabbits, or I might have conducted my researches on a larger scale. I heard sparrows chirping during an eclipse, and in any case the explosion of the dynamite rockets would have sufficed to startle all the birds within half-a-mile of Ovar, and to render them restless for a long time, though the discharge of the rockets was made to stop at 3 p.m.

"I may supplement what I saw myself by mentioning some things noticed by my wife and by friends who remained at Oporto. My wife saw a bat flying about during totality, as it would have done at night. No special effect was produced on our domestic fowls, turkeys, and ducks. A *Mesembryanthemum* of the same species as that which I took over to Ovar partially closed. The *Escholtzias* which were in the shade closed a little, but those which were in the open and unshaded were not appreciably affected."

Miss EMILY Dow, speaking of a pair of ducks, says:—"At 3.30 they got out of their large tank, went up a flight of stone steps and through the garden to their roosting-hut, taking their usual drink at a small tank on their way. They went to sleep in their hut with their heads tucked under their wings. When forcibly ejected some minutes later they made for the dining-room window, and waited there as if expecting their usual breakfast of bread, it being customary for them to go there regularly every morning to be fed, and apparently they thought that morning had come again."

The observations of Mr. Tait and Miss Dow were confirmed by Mr. A. NUGENT, who, speaking of an *Escholtzia* in flower, said that "At 2.38 the curling of the petals preparatory to closing was quite manifest, and it appeared as if one could see the actual movement. The operation of closing continued till about 4, though the eclipse was over and the sunlight greatly



INTERIOR OF THE ARCHBISHOP'S PALACE, ALGIERS.

restored. In point of fact re-opening did not begin till about 5. It seemed as if the operation of closing having once begun must go on till completed, and that not till then could re-opening begin." Mr. Nugent reports the case of a Scotchman who, being in the habit of taking whisky and water every evening, was so affected as the totality approached that, thinking it was night, he was seized with an irresistible impulse, and rushed to

get his usual evening drink. [Mr. Tait casts doubts upon the authenticity of this statement, but I do not see why he should have done so.—G. F. C.]

Dr. CERQUEIRA SOMES, observing the eclipse at Oporto from the Crystal Palace Gardens, which overlook the Douro, saw before the eclipse many gulls flying about over the river. As the eclipse came on before totality they disappeared, subsequently reappearing after the eclipse was over. Dr. Somes, speaking of certain pigeons habitually fed every afternoon, states that their feeding was delayed on the afternoon of the eclipse until darkness distinctly came on in order to see what might happen. The pigeons were much disturbed and alarmed, and ceased to eat, stretching their necks upward to the sky as if apprehensive of the approach of some bird of prey. When the sun reappeared, they recommenced eating.

Senhor BARBOSA noticed the disappearance of the gulls at Oporto before totality, and their reappearance after. He saw pigeons go to roost, and monkeys in the Crystal Palace Zoological Department climb to the top of their cages, and take refuge in the boxes where they were accustomed to sleep. As the darkness came on a peacock ran screaming across the grounds as if frightened by some wild animal being after it. The rapidly growing darkness had evidently moved it into seeking its usual roosting-place.

Regarding Man as an animal, the following report by Mr. ARTHUR DAGGE may be said to belong to this section. He says that he saw a country-woman who was on her knees praying aloud suddenly seize a handful of earth and put it into her mouth. It would have been interesting to have inquired of her the meaning of this nasty performance, and from whence she borrowed the idea. A native spectator who was in the Crystal Palace Gardens was affected in quite a different manner. As the sun burst forth after the total phase, he cried out—"Bis! bis!" (the equivalent of "encore") as though he were pleased with the performance and wished for a repetition of it.

The following observations were made at 155 Entre Quintas, Oporto, by the Baron DE SOUTELINHO:—The plants chosen were—*Escholtzia*, growing in the ground in a sunny situation; and *Mimosa Pudica*, *Acacia Melanoscydon*, *Acacia Farnesiana*, *Acacia Acanthocarpa*, all in pots.

*Escholtzia*—

At 2.20 Fully open.

2.40 White and pale yellow ones began to close. Orange ones not affected.

3.5 White and pale yellow ones one-third close. Orange ones beginning to close.

3.30 White and pale yellow ones quite closed. Orange ones closing rapidly.

3.40 All closed.

4.30 Four or five flowers re-opened; the remainder remained closed for the rest of the day.

Bees.—There were two hives of bees under observation, and in front of the hives were some plants of borage.

At 2.20 The bees were lively at the hives and on the borage.

3.5 Still lively.

3.30 Crowding into hives and leaving the borage.

3.32 No bees on borage, a few still entering hive.

3.40 Bees rushing in crowds out of hive.

3.50 Borage again covered with bees.

The Baron said that the effect on birds was less than he expected; though fowls looked uneasy, and some of them flew into trees to roost, yet they never became silent. Wood doves cooed all the time of the eclipse, and other birds continued singing. The nurse frog (*Alytes Obstetricans*), which usually begins to pipe at sun-down, did not pipe during the eclipse but ignored the phenomenon.

G. F. CHAMBERS.

Our members in Portugal gave especial attention to this subject, and at Ovar the Rev. AUGUSTIN MORFORD gives the following notes:—We were able to see, and especially to hear, something of the effects of the eclipse on the animal creation. The sparrows were twittering about the roofs, just as they do before settling down for the night. About a quarter of an hour before totality the swallows were flitting as at twilight. A few minutes later they had disappeared, and I did not see them again till long after. The ants returned from their journeys, and collected round their holes; they did not all enter.

The fowls in the garden kept up a perpetual uneasy crowing and cackling. Mansel tells me that near totality they roosted, some in the trees, some in the fowl-house. Shortly after the lights returned they came back, and set up a triumphant crowing.

The effect on the people was diverse. I had only to do with the more intelligent, who followed every detail with the highest interest. Mansel, who can neither read nor write, helped most intelligently, and observed for himself with surprising exactness and memory. He described quite correctly the positions of Mercury and Aldebaran before seeing the chart. Our hostess, a fairly rough specimen of a peasant woman of these parts, and the inn servants could not find words to express their admiration. On the other hand, the clockmaker, who had been to the sea vainly trying to see the moon's shadow advance, had come across an old woman, weeping and lamenting bitterly, and another trying to comfort her by assuring her that the worst was past, and no harm had been done.

Mr. C. NIELSEN, also at Ovar, reports swallows that had been flying over the pinewood in their normal way, got very confused as darkness came on, and during totality uttered plaintive cries and flew about, evidently in greatest bewilderment. Older

peasantry and fisher-folk, much perturbed, crowded into church crossing and prostrating themselves; the younger (and wiser?) generation were flippant, and loudly applauding as if demanding an encore!

From Estarreja the Rev. H. P. SLADE remarks:—Some of the effects upon the world of life are worth recording. Señor



GOVERNOR'S SUMMER PALACE, MUSTAPHA SUPERIEUR.

Goncalo Sampo, a botanist of Poroto, has from observations at the Botanical Gardens, deduced the following:—(1) Several of the plants were manifestly sensitive to the influences of the eclipse, presenting phenomena similar to those produced by the common irregular variations of the sun's light and heat, and those of twilight. For instance, the sensitive plant *Mimosa*

*Pudica* closed at totality. (2) The influence upon flowers was the greatest of all. (3) The influence was more marked upon plants growing in sunny localities than on those in the shade. (4) In plants and flowers of the same time the youngest were the most sensitive.

During totality the birds ceased singing, the swallows flew low, bats suddenly appeared, and the nightingale was heard. Animals did not appear unduly excited, but upon the lower classes of the community there fell a great dread, and in Estarreja a number of peasant women sought the refuge of the church as totality drew on, and gave vent to their fears in prayer on their knees. In the country many work-people and farm labourers were afraid to leave their houses for the fields, and those who were bold enough to do so gathered at some convenient rendezvous to encourage one another as semi-darkness set in. We understood the priests had informed them that something strange was to happen in the sky, which was not the least dangerous, and consequently their faces bore the expression of suspicion rather than dread. One who was abroad early on the morning of the eclipse solemnly affirmed that he read in the sky, "Go on pilgrimage to Rome." It appears that a pilgrimage to Rome was now going on, and that several persons who ought to have gone had not done so, and this celestial exhortation was evidently meant for them. In Portugal there are only 20 per cent. of the population who can read, and we are not surprised to find that among many of these the eclipse was associated with the end of the world. One old woman said, "I have seen a moon eclipse when I was husking maize, and when the moonlight came again it was ill (*i.e.*, appeared of a sickly cast). The world will finish one of these years. If it finishes to-day I'll not see it, because I'll shut mine eyes till to-morrow."

At Plasencia Mr. WEIR says that during the oncoming of the darkness it was noticeable that the birds in our neighbourhood were disturbed, flitting rapidly about, as if frightened, while the insects made more than their accustomed noise; and both birds and insects seemed to feel relieved when the eclipse was over.

At Santa Barbara, near Plasencia, Mr. IRWIN SHARP remarks that whilst waiting for the eclipse to begin we noticed that the bees were keeping up a perpetual hum as they went from one flower to another, growing here in rich profusion.

During the totality and for a little while before and after they ceased their humming, no doubt being led astray by the gathering gloom.

The cuckoo was very busy before and after, but I cannot say whether he too ceased his note or not. Immediately after the direct sunlight recommenced the humming-bird hawk moths were hard at work on the honeysuckle flowers, but the butter-

flies (two sorts of swallow tail, clouded yellows, marble whites and various others) did not recover their equanimity for some time.

The notes of the observers at Navalmoral are as follows:—

Mr. SOUTHALL: As totality approached an awful stillness fell upon the scene. Two or three small birds were fluttering about apparently seeking to hide themselves. No other living creature was heard or seen. The absolute quiet was marvellous.

Rev. C. J. STEWARD: At 4h. 5m., G.M.T., birds observed flying as if in terror. At 4h. 13m., birds flying as if rejoicing at the return of light.

Dr. STOKES: Perfect stillness obtained at totality, a stillness accentuated by the previous and subsequent activity noticed in the crickets, ants, and lizards, in the neighbourhood.

Miss W. FOSTER: Perfect silence during totality.

Mr. and Mrs. CONSTABLE at Talavera: As darkness increased, and the temperature fell, hawks collected, and ascended some 400 feet, sailing around in small circles, and repeatedly calling as if alarmed. At totality a most extraordinary stillness came over everything.

The Manzanares party supply the following note:—Swifts were flying in considerable numbers round our tower, screaming in their usual manner, at the commencement of the eclipse. They had all disappeared 20 minutes before totality.

The Alcalde of Manzanares (who noted the times of totality by a good watch, and confirms our observation that it lasted precisely 60 seconds) noticed the animals in his garden during totality. Numerous small birds fluttered in a frightened way to and fro; and several clung by their claws to the face of a rough wall, trembling greatly. Bats came out, and fluttered round him. The domestic cock led off his hens to roost.

Few observations upon either plants or animals were made by any of the Algerian parties. The observers on the roof of the Hotel de la Régence noticed—indeed it was impossible to overlook—the excitement and apparent distress of the swifts and martens, as the eclipse drew on towards totality; and the passengers on the “Argonaut” were impressed by the same circumstance. In general birds seemed far more affected by the change in the light than quadrupeds, and Mr. KRAUSS NIELD at Cape Matifou says that from his position during totality a goat was observable, but like the *tonga* ponies mentioned by Mr. Henry Cousens, at Jeur, in 1898, it displayed a total want of appreciation of the event, or at any rate, it was doing so at the moment when a hurried glance could be spared.

## CHAPTER XXI.

### *PLACES OF INTEREST VISITED.*

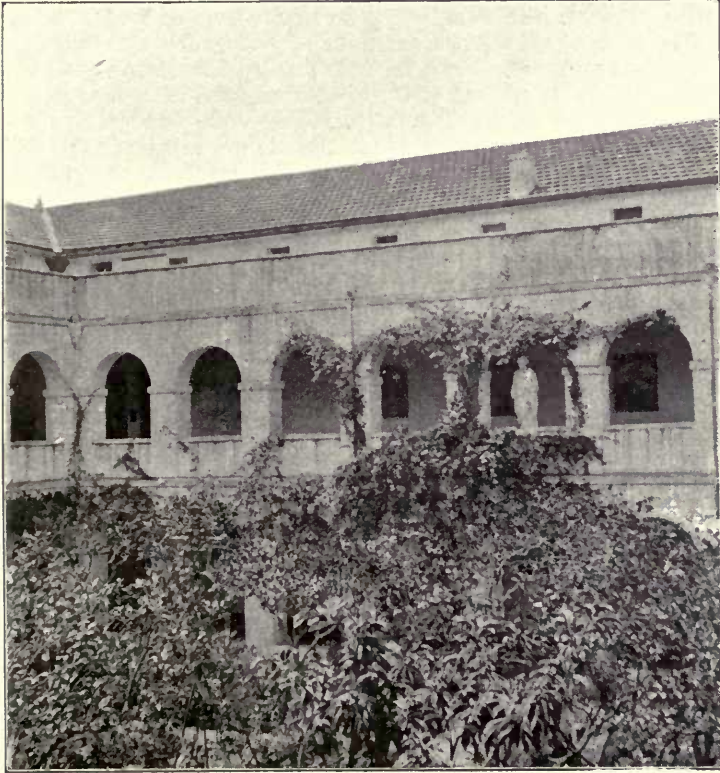
BESIDE the drawings and photographs which have a direct scientific bearing on the eclipse, and the photographs of the several stations, of the observers and of their instruments, some illustrations have been added, representing some of the places visited in the course of the expeditions. This is following the precedent set in the Indian Eclipse Report, in which it met with general approval, although one or two critics seemed to take the view that astronomers should have no appreciation of beauty in nature or art, or interest in historical associations. Against so sombre a doctrine we protest. But apart from this, we would point out that much of our work in the late eclipse was of the nature of hand-drawing or of photography, and that the photographs we give, besides their value to ourselves and our friends, as records of the places visited, afford some evidence that those who took them possess both artistic perception and photographic skill.

INTERIOR OF THE ARCHBISHOP'S PALACE, ALGIERS (p. 210).—This shows the gallery of the quadrangle of a palace built by one of the old Deys for his son. All the Moorish buildings are in this style, and in the large houses, such as this is, a great quantity of marble is used which makes these quadrangles beautifully cool. The tiles of blue and white are also a feature of the architecture. None of the Moorish houses have any windows in the outer walls, but there are in some instances small barred casements. The casement in the top centre of the picture is a good sample of these, although this one happens to be facing inwards.

GOVERNOR'S SUMMER PALACE, MUSTAPHA SUPERIEUR (p. 213).—Mustapha Superieur is a suburb of Algiers, where all the modern villa residences and best hotels are situated. It is two or three miles to the east of the town. The palace is charmingly situated overlooking the town and bay, with the Atlas mountains bounding the horizon to the south and east. It is a fine specimen of Moorish architecture, parts are old, and additions have been made after the original style in recent times. The grounds are full of various kinds of palms and other trees, which grow to great perfection. On the right of the picture is a fine group of banana trees.



QUADRANGLE IN THE TRAPPIST MONASTERY AT STAVUELI (p. 217).—This monastery is between two and three hours drive from Algiers. Many years ago it was used as barracks by the French, but in consequence of the heavy mortality from disease which occurred among the soldiers, it was evacuated by them and given to the monks, who, by their appearance and longevity seem to have managed matters as regards health better than



QUADRANGLE IN THE TRAPPIST MONASTERY AT STAVUËLI.

the men of war. The monks have a large acreage of land under vine cultivation, and carry on an extensive trade in wine and liqueur.

There is a fine library with a good collection of coins and curios. The rule as to "silence" is not carried out to the extent that is generally imagined, as the monks are permitted to converse with visitors in many parts of the building and with each other by permission of the abbot. There is a beautiful garden in the quadrangle full of various flowers of gorgeous

colours. Ladies are not admitted further than an outer hall, where visitors are supplied with a good and varied vegetarian repast. The monk who showed our party over was very proud of being a British subject; he was born in Malta.

**STREET SCENE IN CORDOVA** (p. 187).—The narrow and dull streets of Cordova are enlivened by such scenes as that shown in the photograph, but they have a curiously deserted appearance on the whole. The exteriors of most of the houses are dreary and plain, though there are pleasant glimpses of cool, shady patios through the beautifully wrought iron doors. The city boasts of a picturesque Roman bridge over the Guadalquivir, but the centre of interest is undoubtedly the famous Moorish mosque, with its endless vistas of columns and arches.

**COURT OF LIONS, ALHAMBRA** (p. 193).—This photograph shows the most beautiful and most characteristic work in the Alhambra, bringing in as it does the slender marble columns, the graceful arches, the lace-like filagree stucco with the innumerable Arabic inscriptions, and the roofs with the rounded, many-coloured tiles.

At the side of the Court is shown the entrance to the Hall of the Abencerrages, where, according to tradition, several of the illustrious nobles of this name were treacherously murdered by order of Boabdil, the last King of Granada.

It may be well to remind our readers that the Alhambra occupies a prominent position on a hill overlooking the city of Granada, its outer walls enclosing an area of about 35 acres; it was originally built as a fortress. Not much now remains but the palace, with the mosque and several towers.

Granada was the final stronghold of the Moors in Spain, and it was not until the reign of Ferdinand and Isabella, that their power was completely broken, and Boabdil surrendered in the year 1492.

**THE ALCAZAR, SEVILLE** (p. 181).—Next to the Alhambra, this is the most perfect specimen of Moorish work left in Spain. It was the Royal Palace, and a considerable part of it is in a wonderfully perfect state of preservation. The walls and mosaics are brilliantly coloured, and the pillars are all of precious marbles.

**MOORISH WELL, RONDA** (p. 183).—The well shown in this photograph is in the patio of a ruined Moorish palace, which is now inhabited by a family of peasants. Ronda has many Moorish remains, and is a very picturesque town about six hours by rail from Gibraltar, built on a high rock, and almost surrounded by the River Guadalvin. The streets are narrow and steep, and the old town is divided from the new by an immense ravine or chasm, called the Tajo, which is spanned by two bridges. The steep sides of this ravine are covered with luxuriant vegetation, and a profusion of wild flowers.

**TOLEDO** (p. 189).—The ancient capital of Spain and one of the oldest cities in Europe. It stands on a hill, and is surrounded on three sides by the Tagus; the other side is defended by two

walls, the inner one having been built in the 7th century. As one approaches the city, its first appearance is bare and stern, but this is soon forgotten when once inside the gates; here everything is full of interest—the gateways, the churches and mosques (all bearing traces of the Moorish occupation) and above all the magnificent cathedral of pure Gothic architecture, with superb Flemish glass in the windows.

The streets are extraordinarily narrow and tortuous, and in very few is there room for two carriages to pass. The building on the summit of the hill is the Alcázar, or Royal Palace, lately converted to a military academy.

Toledo has gradually declined since the time when Philip II. moved the Court to Madrid in 1560. This city, more than any other in Spain, is worth a lengthy visit.

CASTILLO DE SAN CERVANTES, TOLEDO (p. 45).—Not far from the railway station of Toledo stands the fine ruinous castle of Saint Cervantes, on the great rocks which form the left bank of the Tagus, here flowing in a gorge. It guards the Alkantarrah Bridge, by which alone can the city be reached on this side. Hence its name "Servando" (guardian) for Cervantes is a corruption, unfortunately, and has no relation with the immortal creator of Don Quixote. From the castle, looking across the river, deep below, one has what is perhaps the best view of Toledo, perched upon the precipitous rocks of the right bank, the road zigzagging steeply up to the great Moorish city from the bridge foot.

## CHAPTER XXII.

### *SUMMARY OF RESULTS AND SUGGESTIONS FOR FUTURE WORK.*

EVERY eclipse has its own peculiar difficulties, and since in 1900 the members of the Association were distributed into so many different parties, and over so great a length of country, it was necessarily a matter of great difficulty to arrange for thoroughly concerted work. Yet the success obtained has been on the whole certainly not less than in 1898, and much experience has been gained which will be valuable on future occasions.

The results of the Indian Eclipse were briefly summarized under fourteen heads. Of these four related to the spectrographic work of Mr. Evershed, who in the late eclipse was observing under the auspices of the Joint Permanent Eclipse Committee, and who, therefore, reports to that body and not to this Association. But apart from the absence of work of the nature of Mr. Evershed's from the programme of the Association, its results in 1900 show a distinct advance on those of 1898, as will be seen from the following summary:—

#### SUMMARY OF RESULTS.

1. A much larger number of drawings of the naked eye appearance of the corona were made than in 1898; indeed, a far larger number than were ever made before upon a concerted plan in any single eclipse.

2. These drawings have been carefully collated and discussed by Mr. H. Keatley Moore; this again is a new feature in eclipse work.

3. Several studies have been made of the structure of limited portions of the corona as seen in the field of a telescope. This is the first time that anything like a combined attempt has been made to draw the corona as seen under moderate telescopic power.

4. More attention was paid to meteorological observations in 1900 than in 1898; and Mr. Brook's report at Algiers was especially full and complete.

5. A very complete series of shadow-band observations was arranged for and successfully carried out in accordance with the programme drawn up by Mr. E. W. Johnson.

6. In the course of the shadow-band work Mrs. Arthur Brook detected a peculiar phase of the phenomenon, apparently not previously noted.

7. The three following enquiries started in 1898, have been successfully repeated in 1900:—

- (A) The total illumination given by the corona has been measured in several independent ways.
- (B) The comparison of the brightness of the eclipse before totality with that after totality, by means of photographs of the landscape, has been attempted at several stations.
- (C) The distribution of "coronium" in the corona has been examined by means of the prismatic opera-glass.

8. Mr. Thorp's modification of the prismatic opera-glass has proved to be most successful; his prismatic grating used before the object-glass proving more suitable for the purpose than a direct-vision prism in the eye-piece.

9. A much larger number of photographs of the corona have been taken than during the Indian Eclipse; most of these being secured with fixed cameras, which proved quite suitable for the purpose.

10. Exposures relatively more prolonged than those given in India were given in several instances.

11. The discovery made in 1898 that the synclinal curves terminated in rod-like rays, has been confirmed. But though the exposures were longer than in India, these rays could not be traced to anything like the same distance from the sun.

12. Dark markings have been shown in the corona in some of these photographs.

13. A cinematograph record of the eclipse has been successfully made by Mr. Nevil Maskelyne.

14. The corona has again been definitely photographed during the partial phase, and in a much greater amount of sunlight than in 1898.

15. Increased attention was given to the detection of stars and planets during totality.

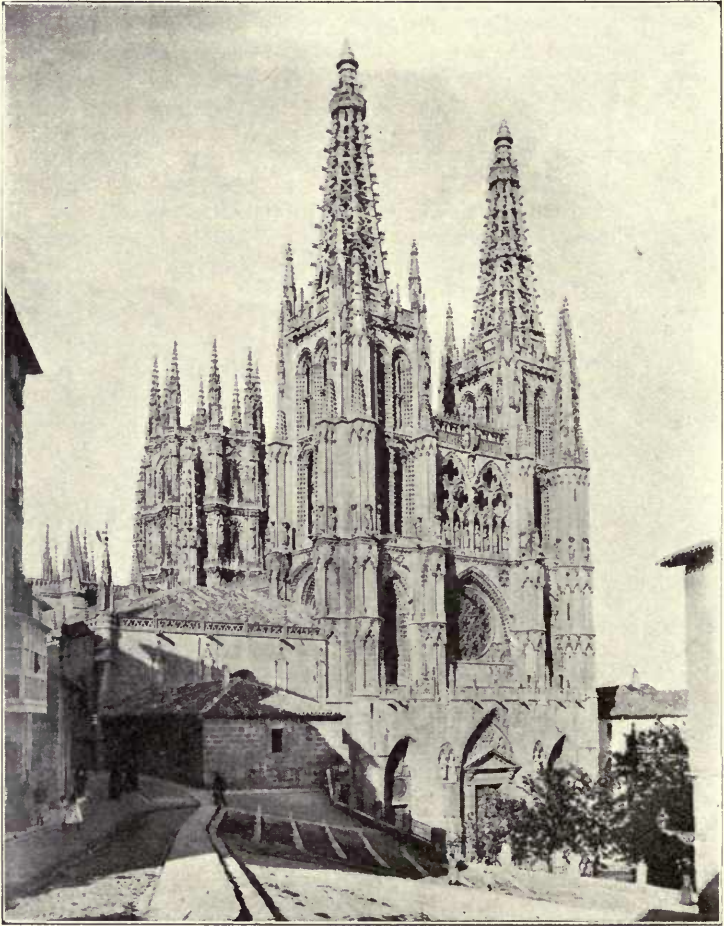
16. The contact observations show distinctly that too large a value for the lunar diameter is used in computing the duration of eclipses in the British "Nautical Almanac."

#### SUGGESTIONS FOR FUTURE WORK.

A comparison of the work actually effected in this late eclipse, with the suggestions which concluded the report on the Indian Eclipse, and those which were published in the "Journal" of the Association, Vol. X., No. 4, leads to the gratifying conclusion that these suggestions were in the main well attended to, and with good success. The following points seem, however, to require emphasis:—

1. Naked eye drawings of the corona. It is very much to be

desired that these should always be made upon the same scale. Mr. Keatley Moore's suggestion that a circle drawn round a half-crown, should always be employed for the black body of the moon,



BURGOS CATHEDRAL.

Burgos, the principal city in the north of Spain, was formerly the capital of Old Castile, and, alternately with Toledo, the Royal residence. The cathedral is one of the finest specimens of 13th century Gothic architecture in Spain.

is a very simple and convenient one, and might with advantage be universally adopted. As to the drawing materials, Mr. Green's suggestion of white chalk on purplish-blue paper has not been bettered.

2. Photographs of the corona. The suggestion that where equatorial mountings and driving clocks were not available, photographs might yet be taken with fixed cameras and with short exposures, has been freely acted on and with good results. But the tendency has been in these cases to employ cameras of far too short focal length, and to give too long exposures. It is clear that where the focus is very short, and the image consequently very small, it is not possible to get much detail. The proper employment of such cameras would rather appear to be in the photographing the outer rays or streamers of the corona; but for this considerable exposures are required, and these involve clock driving. The focal length for a fixed camera should be at least two feet, and for  $f/15$  the exposure should not much exceed half a second, with an "extra rapid" plate, and some exposures should certainly be taken much shorter than this. The exposures which are most desirable, and which are proportionately least frequently given, are those from  $1/10$ th to  $1/3$ rd of a second; remembering always that the longer the duration of totality, *i.e.*, the greater the magnitude of the eclipse, the less there will be of the brightest portions of the corona exposed, and consequently that the exposures may then be slightly increased, without risk and with good effect.

3. It is much to be desired that triple-coated plates should be tried on photographs of ample scale, and with comparatively short exposures. It should not be impossible to obtain by their help on a single plate both the details of the bright inner corona and a very considerable amount of extension. Normal development for about eight or ten minutes might be used.

4. The eclipse of 1901 being one of exceptionally long duration, is one which, so far as this feature is concerned, will be most favourable for the attempt to photograph the extreme outer extensions of the corona. We may expect that it will be essentially a dark eclipse, so much of the brightest part of the inner corona being covered at mid-totally.

As, however, to see the eclipse it will be necessary to travel to Mauritius, the East Indian Islands, or New Guinea, and as for the eclipse of 1904 we should have to go further still—to the Pacific—there seems little likelihood that the Association will be strongly represented at any eclipse until that of August 30th, 1905, when again the shadow track will pass across North America, the Atlantic, Spain, and North Africa, giving a totality of over  $3\frac{1}{2}$  minutes in Spain, and passing over a city of such renown and so accessible as Burgos.

Let us look forward, then, to a strong muster of our members along the shadow track in 1905. And may neither cloud, as in 1896, nor plague, as in 1898, nor war, as in 1900, intervene to thwart our efforts or hinder our preparations; but, instead, may our expeditions be furthered by the kindly influences of Clear Skies, Health, and Peace!





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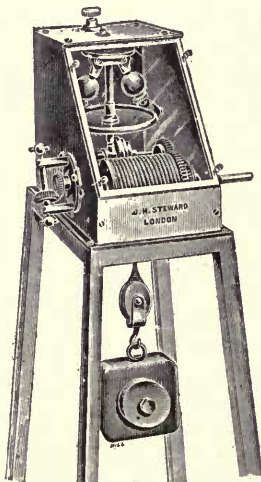


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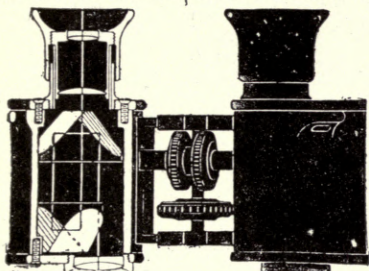
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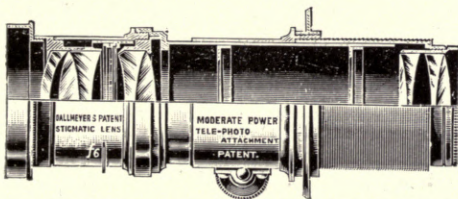
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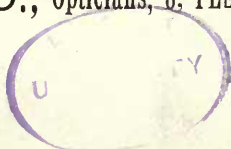
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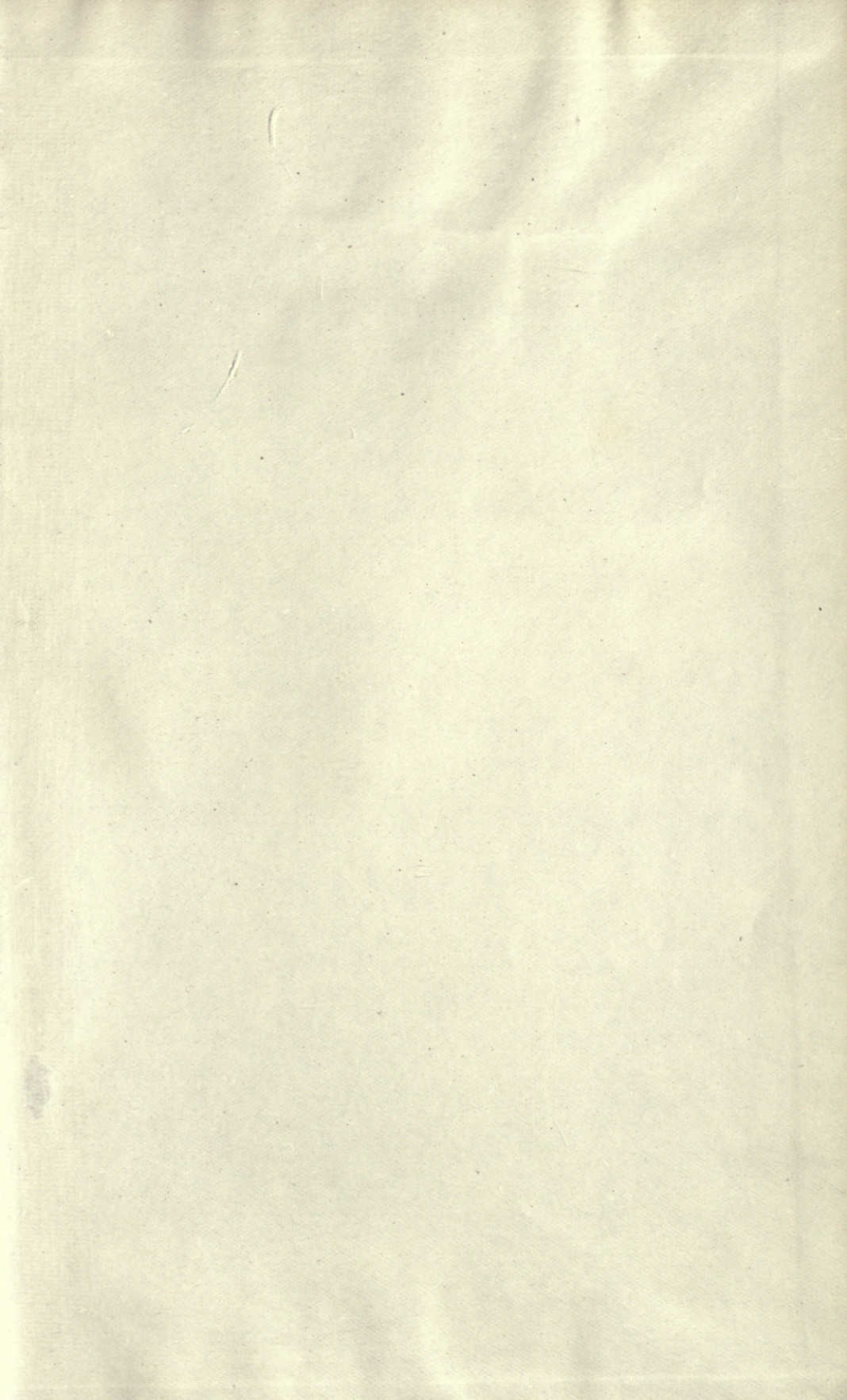
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