Report of the Expedition to Pineda de la Sierra, Spain.

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In the following paragraphs I summarise the principal objects for which this expedition was undertaken :—

(1) To obtain large scale images of the flash spectrum with a prismatic camera of great focal length, for the purpose of studying the actual forms assumed by the different radiating gases, and to obtain evidence regarding the probably eruptive nature of the gases giving the enhanced lines.

(2) To obtain ultra-violet spectra of the corona with prismatic cameras of glass and of quartz, using the flash-spectrum arcs as reference lines for determining wave-lengths.

(3) To study the corona spectrum in the D—F region with high dispersion, visually and by means of photographs, to ascertain the character of the continuous spectrum and of the radiation at λ 5303.

Instruments Available.

Special provision was made out of the Government Grant Fund for the construction of the essential parts of the large prismatic camera, and a concave mirror of 15 inches aperture and 29 feet focus, and a dense flint prism of 40° angle transmitting a beam of 7 inches diameter, were made for the expedition by Sir Howard Grubb.

A 16-inch cœlostat was also provided from the same fund, and a large revolving plate-carrier for exposing in rapid succession a series of 15 plates, each 15 inches × 7 inches.

For the ultra-violet work on the corona I had a glass prismatic camera of 2 inches aperture and 46 inches focal length, having two 60° prisms of special glass, transparent as far as λ 3300. The lens by Hilger is very perfectly achromatised between H_β and λ 3300.

This instrument had already seen service in India in 1898 and Algeria in 1900. It was supplied with light from a 4-inch speculum metal flat lent me by Mr. Maw, and which I attached to the upper end of the cœlostat axis parallel with the 16-inch silver-on-glass mirror.

Supplementary to this very efficient spectrograph I had a quartz prismatic camera, mounted on an equatorial telescope, and receiving light direct from the sun. It contains two double prisms of right and left-handed quartz, and a single lens of 1-inch aperture and 36 inches focus for D.

A direct-vision slit spectrograph was put together while in camp. It was built up from parts of other apparatus, and consisted of image lens, slit and collimator, three powerful direct-vision prisms of 1-inch effective aperture, and a single camera lens of 47 inches focus.

For visual work on the corona spectrum I took out my complete outfit for prominence observations, consisting of a $3\frac{1}{4}$-inch equatorial telescope and driving clock, and a high-dispersion 3-prism spectroscope.

On the Selection of the Observing Station.

As the main purpose of the expedition was to secure large scale photographs of the flash spectrum arcs, first-rate atmospheric conditions as regards definition were considered essential. Large apertures and great resolving power are of no avail unless the "seeing" is of really good quality, and it was to be feared that in the plains near the east coast of Spain, or even in the immediate neighbourhood of the town of Burgos, the chances of really good definition would be very poor, owing to the high mid-day temperatures. Another important point was to select a spot at a little distance from the central line of eclipse, where the internal contacts should occur in the sun-spot zones, as I wished, if possible, to photograph the spectrum of a metallic eruption as displayed in the lower chromosphere.

My choice of a suitable place was simplified by the circumstance that in the immediate neighbourhood of Burgos there is a mountain region accessible by railway. This line, built by the Sierra Company of London and Burgos, runs from Villafria, near Burgos, in a south-easterly direction, into the heart of the mountains. Ascending about 1000 feet above the plain it penetrates the mineral region of the Sierra Demanda range, and is intended for transporting the coal and iron and other minerals from the properties of the Sierra Company. The general direction followed by the line happens to coincide roughly with the shadow track of the eclipse, and at exactly the distance from the central line that I wished to be located. It was therefore only necessary to fix on a suitable locality at practically any point on the line at a sufficient elevation above the plain.

Yet another consideration which determined me in the final selection was the character of the ground as regards vegetation. It seemed to me a mistake to erect a large horizontal telescope on bare earth or upon stony or rocky ground; quite apart from the question of dust, there is the more serious objection that the air is apt to be disturbed by convection currents by contact with the ground, particularly when the latter has been heated by the sun. Where there is thick vegetation, on the other hand, the sun's rays have little heating effect, the leaves of the plants in performing their functions directly absorbing the solar energy. It seemed best therefore to find a spot where there was plenty of herbage, and to raise the mirrors and prism as high as possible above it.

My friend, Mr. J. H. White, of Burgos, who is resident manager of the Sierra Company, had given me much useful information beforehand with regard to the railway and the character of the country, and it was owing to the indispensable aid he rendered my expedition on arrival in Spain that we were able, without any loss of time, to select an almost ideal position near the village of Pineda de la Sierra, a point on the line about 30 miles from Burgos.

This was on a heath 4000 feet above sea-level, and nearly surrounded by mountains rising about 2000 feet higher. It was north of the central line of eclipse, the internal contacts being in solar latitude $+5^\circ$ and $+15^\circ$, and the duration of totality 220 seconds.

In choosing an open heath on the side of a mountain I seem to have been especially fortunate in securing extremely good seeing conditions as well as a cool climate. The vegetation consisted of common heather in full flower, interspersed with broom and juniper-bushes. Higher up on the hills beech woods and forests of broom and stunted oak covered the ground, and even on the highest slopes of the mountain to the south of the camp, which I ascended, the bare rock was very little exposed, except on the northern precipitous face, being mostly covered with a large species of heath.

Whether this beautiful clothing of vegetation had anything to do with the homogeneous state of the air or not it is impossible to say, but it may be worth while recording the facts. I had many misgivings at first as to the probable effect of the high mountain slopes surrounding the camp, which was very much shut in by mountains, but experience showed these to be ill-founded, the definition being the best and most uniform I have ever experienced for the sun.

The expedition travelled to Spain in two separate parties. I left England on July 29, accompanied by Mr. R. C. Slater, M.A., who had kindly volunteered to act as my assistant, and to whom my best thanks are due for his very efficient aid in adjusting the instruments and in many other ways. We travelled by sea to Bordeaux, and on the steamer had the pleasure of falling in with the other official expedition to Spain under Professor Fowler, a most opportune meeting, as we had many matters to discuss and arrange with regard to our spectroscopic observations.

The second contingent left for Spain two weeks later. It consisted of my brother, Mr. H. Evershed, who had helped me at a former eclipse, and the Rev. C. D. P. Davies, M.A., who was bringing out some instruments of his own design which he intended setting up within the enclosure of my camp.

Mr. Slater and myself reached Burgos on August 2, and the next day Mr. White arranged for an engine and brake van to take us on a prospecting expedition as far as Barbadillo de Hereros, a village about 40 miles from Burgos. It was on the return journey the following day that I decided upon the heath near Pineda as the most suitable site for the camp.

After some delay in getting the instruments transported from Bilbao,* the port to which they had been shipped, to Pineda, the first party got to work on August 12.

The Sierra Company had kindly placed at my disposal a number of tents which, with bedding taken from one of their houses, afforded us ample sleeping accommodation as well as store room for the instruments and boxes. A barbed-wire fence put up round our "claim" secured us against possible incursions of wild boar at night from the great beech wood which clothed the mountain to the south of us. From human beings we had nothing to fear. Mountaineers are usually honest folk, except when they are brigands, and the people of Pineda were entirely friendly, and much too busy with their most interesting harvesting operations to pay much attention to us.

In all the initial work of erecting piers, huts, etc., we had the invaluable assistance of the engineer of the Sierra Company, Mr. C. Ellis Bevan, who obtained for us everything we needed in the way of materials, and stayed several days in the camp, superintending the work of the masons and carpenters and helping us in many other ways. I have much pleasure in expressing here my appreciation of the very satisfactory way in which all this preliminary work was carried out.

On August 18 the second contingent of the expedition arrived in camp. Mr. Davies was bringing out a reflecting coronagraph of 74 inches focus, and a reflecting prismatic camera of about 60 inches focus, both of which instruments he intended to work from a cœlostat which he had ingeniously contrived out of an old equatorial stand. This was fitted with a driving clock, to which he had attached special gearing for reducing the rate to half speed. My brother was to assist me with the instruments on the day of the eclipse, he also had charge of the time determination and finding the correct position of the camp, and he soon got to work with the sextant and artificial horizon.

* Through the good offices of Mr. W. Henry Hodgson, of Bilbao, I was able to forward the 22 cases of instruments by fast train at the ordinary goods rate and to stop the train at the Sierra Company's siding for transference to their trucks. These concessions on the part of the Norté Railway were not obtained, however, without much tedious waiting and it was nearly a week before the instruments arrived at Villafria Siding.

The exact distance and bearing of San Millan, a mountain to the north-east of the camp, he ascertained by measuring a 500-feet base-line and observing the bearings of the cairn on the top from each end of his base. This gave us a determination of latitude and longitude, depending on the position of this point, the co-ordinates of which had been communicated to me from the Madrid Observatory.* The latitude so obtained was in good agreement with the observed latitude by meridian observations of the sun. The mean results are as follows:—

North latitude..............	42° 11′ 16″
West longitude	0 h. 13 m. 4 s.
Altitude above sea-level...	3986 feet

The determination of longitude was of some importance, as we had to depend entirely on observations for finding G.M.T., and it was desirable to know this within a second or two on the day of the eclipse. The longitude from San Millan differed by about 10 seconds of time from that shown on the maps I was able to consult.

We had brilliant weather and an almost entire absence of wind during the 18 days in camp, which greatly facilitated the work of erection and adjustment of the instruments. I had been assured by Mr. White that our chances of failure from cloud were no worse in the mountains than at Burgos, and our daily experience quite confirmed this.

As soon as I had the equatorial telescope mounted, daily observations were made of the prominences, and, with the exception of August 29, which was overcast and rainy, an unbroken series of observations was secured from August 14 to August 31 inclusive.

I have great pleasure in acknowledging here our indebtedness to Mr. White, not only for giving every facility which the railway afforded free of all charge, but for practically devoting himself to the interests of the expedition throughout our stay in Spain. Upon our arrival at Burgos, Mr. and Mrs. White most kindly placed their flat at our disposal, and we also enjoyed their generous hospitality on our return from Pineda after the eclipse. Our acknowledgments are also due to Mr. Williams, the courteous managing director of the Sierra Company in London.

Adjustment of the Instruments.

The cœlostat was adjusted very easily by means of the attached theodolite, using stars at considerable hour angles east and west of the meridian for azimuth. In order, however, to adjust the other instruments in relation

* I am also indebted to Mr. Hodgson and to Don José Esteban Clavillar, a surveying engineer, for obtaining this information for me.

to it, I found it convenient to put the axis out of adjustment in azimuth by unscrewing one of the two adjusting screws and pushing the lower end of the axis bodily towards the east a few degrees. It was then possible to reflect a horizontal beam of sunlight in the required azimuth, notwithstanding the greater declination of the sun at dates previous to the eclipse. The screw on the west side being left untouched, it was only necessary as the days went by to slowly screw up the east screw until the base again came into contact with the west screw on the day of the eclipse, the instrument being then again in correct adjustment..

The driving clock was mounted on a wooden frame, supported at one end by the cœlostat pier and at the other by two posts driven into the ground about a foot from the south face of the pier. The weights were hung underneath, direct on the winding barrel, the height of the clock above the ground giving a sufficient drop to keep it running about 20 minutes.

Mr. Slater had charge of the clock and regulated it to a nicety by erecting a temporary horizontal telescope, receiving light from the cœlostat; this gave an enlarged image of the sun on a paper screen, ruled with lines at right angles to the diurnal motion. The relative drift of a sun-spot could in this way be observed with great ease even at a considerable distance from the screen, and the clock adjusted accordingly.

he Reflecting Prismatic Camera

The general arrangement of the apparatus is shown in the accompanying plan-diagram, excepting that the 15-inch concave mirror was too far away from the other parts to be conveniently shown on any reasonable scale.

The azimuth of a horizontal beam of sunlight reflected west by the cœlostat was 12° 24′ south of west on the day of the eclipse, but the deviation of the prism being about 31° for the line H_γ, which it was intended should fall near the centre of the plate, the principal axis of the instrument was arranged in a direction 18° north of west and south of east, and the mirror, prism, shutter and plate-carrier were placed in line in this azimuth.

The plate-carrier, or exposing machine, was mounted on a wall of masonry about 2 feet high and 6 feet long, erected a few feet to the south-west of the cœlostat pier. This apparatus was designed to make 15 exposures in rapid succession, seven at second contact, one about mid-eclipse, and seven at third contact. The plates are held in compartments on the circumference of a steel drum, 4 feet in diameter, mounted on bearings, and enclosed within a large box of wood, having a sheet-iron light-tight cover. There is a rectangular opening in front of the box the same size as the plates, which are brought successively opposite to it by rotating the drum.

A crank handle outside the box is connected by gearing with the drum, so that one rotation of the handle moves the drum exactly one-sixteenth of a revolution. There are 16 compartments, one containing a plate of clear glass, used as a focussing screen. Behind this plate is a light-tight box, containing a right-angle prism which reflects the light through a tube at the side of the box into a small telescope attached to the outer case.

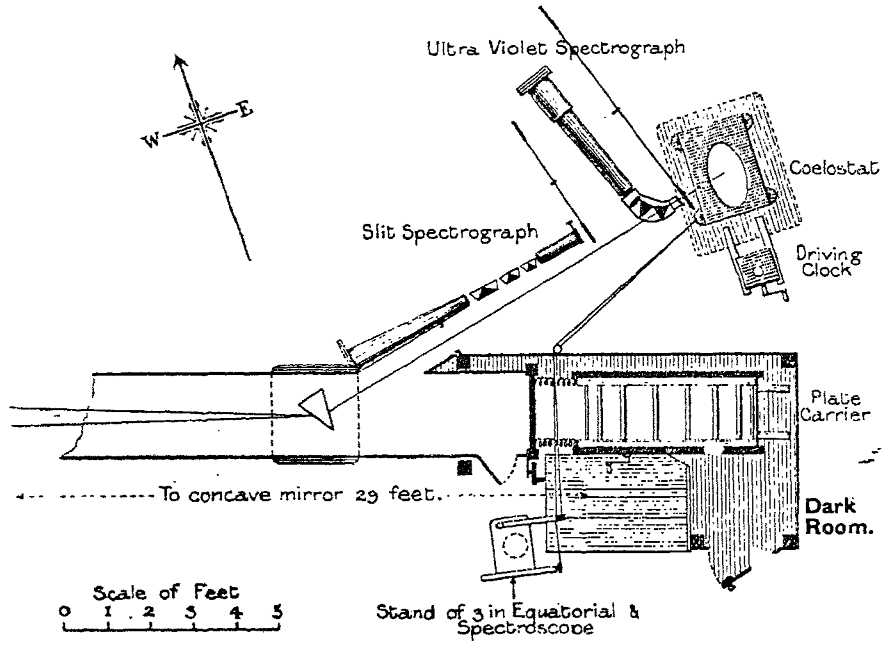

Fig. 1.—Plan of Observatory, Pineda de la Sierra, Spain.

To effect the focussing of the image on the plates, the entire apparatus was made to slide on Λ-shaped steel rails fixed on the top of the masonry. It was worked to-and-fro by means of rackwork and a pinion wheel, the latter having a handle attached outside the case.

In front of the plate-carrier and connected to it by extensible photographic bellows the large focal plane shutter was mounted on the same wall of masonry. It was worked by hand up and down by means of a steel wire rope passing over pulleys, the end of the rope being wound round a drum having a handle conveniently placed near the handle actuating the plates. With these two handles, therefore, one could change the plates and make the exposures alternately, using the right and left hands.

The whole of this apparatus was protected from the weather by a hut of matched boards built over it. This was extended at the S.E. corner to form a small dark room to facilitate getting the plates in and out of the machine.

Four feet in front of the shutter a separate pier was built 1 metre high and $\frac{1}{2}$ metre square to support the 40° prism. On the top of the pier a stout mahogany board with cross pieces screwed underneath was firmly secured with cement; and a turned steel pin, 1 inch in diameter, fixed to the board on the north side formed a vertical axis for the rotation of the prism in the plane of dispersion. Centred upon this pin was a heavy brass segment with tangent screw attached, the bearings of the worm and handle being screwed to the base board. Upon the brass segment another thick mahogany board was fastened, and the carefully planed upper surface of this supported the prism, which was secured from lateral displacement by small angle pieces at the corners of the prism.

A light tube, 2 feet square in section, made of Willesden paper, nailed to a frame of wood, enclosed the space between the prism and the shutter, and extended beyond the prism a few feet in the direction of the concave mirror. A branch tube on the north side admitted light to the prism from the cœlostat. The paper covering of this tube was not fastened along the top, which could, therefore, be opened at any point or all along, in order to give free ventilation and prevent the possibility of non-homogeneity in the air inside the tube. On the day of eclipse the tube was left open for half its length until a few minutes before totality.

The concave mirror was mounted on a pier 23 feet distant from the prism. The cell was attached to a heavy cast-iron support, having a vertical face from which projected three equi-distant strong steel bolts, screwed at the ends, which passed through the corresponding holes in the mirror cell, holding the latter in a vertical position. Between the back of the cell and the casting each bolt passed through a stout spiral spring 3 inches in length. The springs were in compression when the cell was in position with fly nuts on the ends of the bolts, and the mirror could be nicely adjusted at three points by turning these nuts by hand. It was necessary to tilt the mirror about 40′ from the vertical in order that the return rays should clear the top of the prism and fall unobstructed upon the plates.

It was thought advisable to have no tube between the mirror and prism excepting the short length of paper tube already mentioned. To keep out light two oblong tents were erected, one over the mirror and the other between it and the prism, and in order to cover the whole space of 23 feet the tents were pitched a few feet apart, and the intervening space covered with a piece of canvas. The canvas at each end of the two tents could be tied back so as to admit of a good draught of air through both to equalise the temperature inside and out, and it was only necessary a few minutes before totality to let down the canvas at the end behind the mirror to exclude light from outside.

Method of Focussing.—The focal length of the concave mirror was carefully measured before leaving England with a 50-foot steel tape, using the same cœlostat and focussing on sun-spots and star images. In order to focus the prismatic camera approximately the plate-carrier was moved in its ways by means of the rackwork and pinion until the front surface of the front plate was precisely the same focal distance, measured with the same tape, from the concave mirror. But as some slight alteration of focus might occur from the action of the prism, it was intended to observe the edge of the cusp spectrum near the H_β line, about five minutes before totality, in the small telescope attached to the side of the plate-carrier.

Owing to clouds, however, it was found better to observe a strip of spectrum in the green region from the front of the plate and without using any lenses. This part of the glass plate which formed the focussing screen, was partly covered with a strip of white paper gummed to it, and the cusp spectrum, though partly obscured by thin cloud, could be clearly seen upon it and focussed fairly well.

The Ultra-Violet Prismatic Camera.

This instrument was fixed in an inclined position on the top of a packing-case near to the cœlostat. It received light from the 4-inch speculum flat attached to the upper end of the cœlostat axis. The position of the cusps at the internal contacts with respect to the refracting edges of the prisms, necessitated an inclination of the camera body of about 22° to the horizontal, in order to have the flash spectrum arcs at both contacts equally inclined to the direction of dispersion.

Nine exposures were to be made by racking a series of plates along a long dark box fixed at right angles to the camera body. At least four of the exposures were to be out of totality, in order to get good images of the cusp and flash spectra, which it was hoped would provide an accurate scale for estimating the wave-lengths of the ultra-violet coronal rings. This method had been found trustworthy in some photographs obtained in 1898, showing a faint ring at λ 3388. A light metal disc covering the aperture to the prisms and attached to a long wooden rod hinged at the centre, formed a simple and convenient exposing shutter.

The focus of this instrument was very carefully determined before leaving England by attaching it to a Newtonian reflector of about three times its focal length, and using the reflector as a collimator, placing a slit in its focus and directing it to the sky. A series of plates of the Fraunhofer spectrum was obtained and the exact distance between the back of the camera lens and the front of the plate, when at the sharpest focus, was measured with a metal rod.

On setting up the instrument for the eclipse it was only necessary to make certain that this distance was preserved within 0·005 inch.

The Slit Spectrograph.

Light being available from the upper part of the 16-inch cœlostat mirror, it was possible to arrange this apparatus between the cœlostat and the large prism of the reflecting prismatic camera, the optical axis being horizontal and slightly above and to one side of the beam of light entering the large prism. The combined action of the three compound prisms caused a deviation of a few degrees of the green part of the spectrum which it was desired to photograph, consequently the camera end could be arranged quite clear of the large prism and outside the paper branch tube, as shown in the diagram.

The focus was satisfactorily found by projecting the sun's image on the slit and focussing the Fraunhofer lines on the film side of an old negative, observing with a lens through the back of the plate.

Mr. Slater had charge of this instrument and was to make two long exposures during totality with the slit tangent to the sun's limb near the point of third contact.

The Quartz Prismatic Camera.

This was clamped to the 3-inch equatorial telescope in such a way as not to disturb its balance. The prisms received light direct from the sun and it was proposed to make one exposure only during totality.

This camera was approximately focussed by using a 9-inch mirror as collimator and photographing the Fraunhofer spectrum. Owing, however, to the non-achromatic single quartz lens used, the necessary inclination of the plates made it impossible to expect a perfect focus for complete coronal rings, and it was intended to use this camera merely to obtain confirmatory evidence of faint coronal rings which might be indicated in plates obtained with the perfectly achromatised glass prismatic camera.

Observations made on the Day of Eclipse.

The morning of August 30 broke perfectly cloudless after dull rainy weather the previous day. Our hopes of a successful result, which had been considerably depressed by the rain, rose far above the miserable mean of uncertainty. There were indeed pessimists among us who thought it possible that clouds might appear later.

At 10 A.M. the position angles of the prominences were determined and a drawing made of a fine group on the east limb extending from solar latitude

+9 to +33.* I give here a reproduction of this drawing, in which the position angles, and points of contact at Pineda, are shown.† The solar spectroscope was afterwards turned in position angle and the slit set tangent at 305°, the place of first contact. The chromosphere being beautifully distinct it was hoped to observe the approach of the moon's limb some 20 seconds before the contact. In the meantime, however, a considerable amount of cloud *had* appeared in the sky and at the time of contact the sun was hidden. It reappeared after the eclipse had made fair progress and observations were continued at intervals.

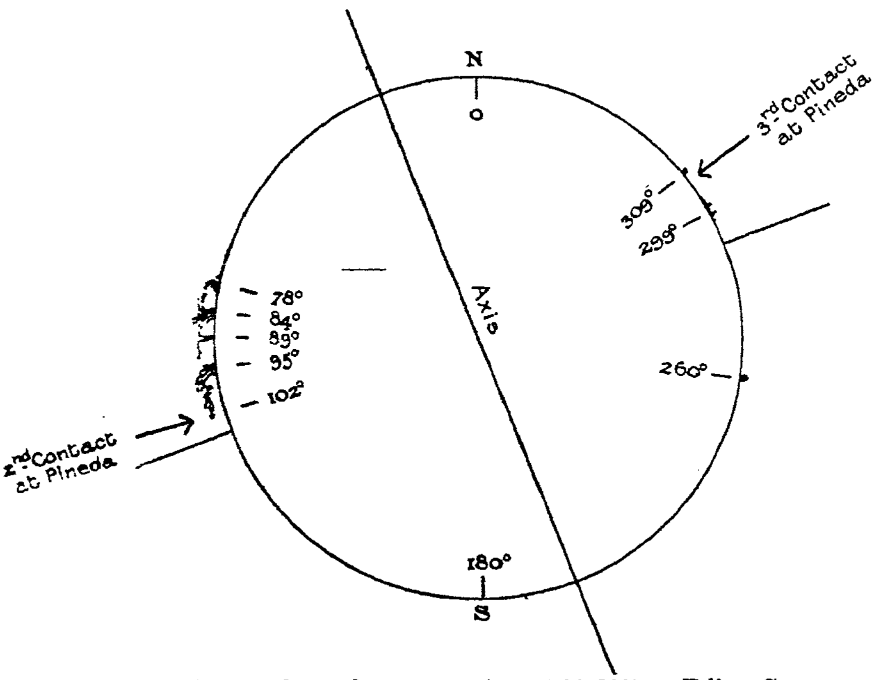

Fig. 2.—Prominences observed at 10 A.M., August 30, 1905, at Eclipse Camp, Pineda de la Sierra.

When about three-fourths of the sun was eclipsed the spectrum of a large spot near the east limb was critically examined to see whether the diminished

* This group of prominences had already been observed on the N.W. limb on August 16 and 17, when it occupied the region +10 to +31, and it was again seen on the N.W. limb on September 13, very little changed in size or general character.

† It will be seen from fig. 2 that the positions of the contacts at my station were extremely favourable for getting the spectrum of the base of the prominences during the moments of visibility of the flash spectrum, and had the sky been clear at the right moment I should have secured the spectrum of a small but brilliantly "metallic" prominence, which Professor Fowler tells me he observed at P.A. 306°.

sky illumination had any appreciable effect. The spot band appeared unusually dark, so that it was difficult to trace the Fraunhofer lines across the nucleus, but this may have been partly due to the intrinsic darkness of this particular spot.

As the sky illumination gradually diminished with the progress of the eclipse, the prominences on the east limb became more and more vivid in the H_α line, and it would have been most interesting to observe them up to the last moment before totality, but at 12.45 P.M. it was necessary to prepare for the photographic operations.

At this time the crescent sun was shining in a clear blue space between rather heavy clouds, and in a few minutes the general illumination began to assume that peculiar blueish tint only seen at total eclipses. There was no wind and the clouds appeared almost stationary.

The dim light of the thin crescent seemed already giving out, but there were yet 10 minutes of anxious waiting, and the clouds getting slowly nearer. Before 1 o'clock thin cloud had already covered what was left of the sun. Still one could see faint patches of light on the mountain sides marking the favoured spots, and there was yet a possibility that one of these might drift over the camp in time.

At 1 o'clock Mr. White, who had come up from Burgos to assist me with the visual observations, took up his station near the equatorial ready to note down any observations I might make during the eclipse.

Mr. Slater wound the cœlostat clock, let down the cover of the paper tube over the large prism, and then stood by to slightly move the prism tangent screw at my direction. My brother also went to his place by the ultra-violet prismatic camera, ready to begin his series of exposures at a signal from me.

At 1.5, looking in at the door in front of the shutter, I could see the spectrum faintly upon the glass focussing plate and by slight movements of the prism and of the cœlostat,* I adjusted it exactly to the correct position on the plate and slightly altered the focus.

The next operation was to estimate the width of the cusp spectrum by comparing it with the strip of white paper gummed to the glass plate. This strip was cut out the exact width which the spectrum should have when only 30 seconds remained before totality, and it was my intention to start a stop-watch at this instant and to begin the exposures after the lapse of 15 seconds.

This method I think would have been quite successful had it not been for

* I was able to control the cœlostat very conveniently by means of an endless cord which actuated the slow motion. This passed through a hole in the side of the hut, and round a pulley attached to the free end of a movable arm. A weight pulling on the arm kept the cord at a constant tension.

the clouds, which, partly obscuring the horns of the crescent, made the edges of the spectrum indistinct. As it was I estimate that I started the watch 25 seconds too soon. Having started it I called out "Are you ready," and then about 20 seconds later, "Now." I then started the exposing machine and the focal plane shutter, and my brother simultaneously began his exposures.

I glanced at the sky, and knew from the size of the cusp still visible that I had begun too soon. To allow for this I continued the exposures very deliberately until the increasing darkness warned me of the approach of totality, so that during the critical moments plates were exposed in rapid succession. I exposed in all eight plates, and then turned to examine the corona spectrum in the solar spectroscope and expose the quartz prismatic camera. The hopelessness of the situation then became evident. Thick cloud covered the place of the sun. I took up a pair of binoculars, and, after a little waiting, just glimpsed a faint ring of light for one moment. It was the inner corona showing through the clouds.

At the approach of third contact I abandoned the instruments and simply watched the wonderful effects on the sky and landscape. There were several deep violet rifts and patches of clear sky, in one of which Venus shone resplendent. The limit of the shadow was clearly visible as a long line of light low down in the north-west, and this quickly spread upwards, and the great blue shadow rushed over the mountains and disappeared to the east of us. About a quarter of an hour later the crescent was again visible.

It was small consolation to hear by telephone that at Arlanzon village, half-way between Pineda and Burgos, a perfect view was had of the whole eclipse! Mr. Bevan, the engineer of the railway, studied the effect of it on his fowls!

Results.

The first four exposures with the large prismatic camera yielded well-defined images of the cusp spectrum. Although much obscured by cloud, the Fraunhofer lines are clearly shown, and the hydrogen lines β, γ, δ, and the lines H and K are just visible as bright lines along the edges of the spectrum. Measures of the chord of the arcs in the stronger dark lines give the following times of exposure :—

Exposure No.	Interval before Second Contact.
1	43 seconds.
2	37 „
3	30 „
4	19 „
5	No trace of image

At the time of the first exposure the centre of the cusp had a width of 17″, corresponding to a linear width on the plate of 0·029 inch. The spectrum arcs are consequently not well resolved.

A much better image of the spectrum is shown on No. 4 plate taken 19 seconds before the contact; here the width of the cusp at its centre was 7·6″, or 0·013 inch on the plate. The focus in all the images appears to be as good as could be wished.

The ultra-violet prismatic camera gave two images of the cusp spectrum, at 34 and 30 seconds before second contact. The spectra are beautifully defined and in perfect focus over the whole length of spectrum photographed, from H_β to λ 3400. All the plates in both instruments exposed later than 19 seconds before second contact are blanks.

In the ultra-violet cusp spectra the thickness of the cusp at its centre was 13·4″ and 11·9″ respectively, but, owing to the comparatively short focal length of the camera, the Fraunhofer lines are narrow and very sharply defined; they have nearly, but not quite, the same intensity as in the normal solar spectrum and differ in this respect from similar spectra taken with the same instrument in 1898, in which the lines, although beautifully sharp, are much weaker than in the ordinary solar spectrum; in these, however, the cusp was but 5″ in width.

It appears that within a few seconds of arc of the limb the intensity of the dark lines falls off rapidly, and shaded lines, such as H and K, lose this character more or less completely and become narrow lines. But there is evidence of a certain amount of variation at different parts of the limb, probably caused by the presence or absence of extended areas of faculæ.

In plates taken in 1900 in the south polar region, where no faculæ could have been present, the dark lines are quite strongly impressed, even on the narrow bands of photosphere spectrum, where the thickness could not have exceeded 1″.

The general falling off in the intensity of the lines close to the limb seems to be simply explained on the supposition that the entire photosphere consists of innumerable vertical columns of incandescent gases partly penetrating the absorbing layer, the lower portion of which would be entirely hidden at the limb owing to foreshortening.