AMERICAN OBSERVATIONS OF THE TOTAL SOLAR ECLIPSES OF 1900 AND 1901.[1]

IN the year 1900 the moon's shadow swept across the southern portion of the United States of America, travelling from New Orleans, through Georgia, South and North Carolina, and leaving this continent at Cape Henry, in Chesapeake Bay. After traversing the Atlantic Ocean the shadow crossed Spain, and cut the African coast at Algiers.

The large strip of country in America over which the shadow passed drew a great number of American observers to this region, and in a volume which has quite recently been published we have a detailed account of the observations and photographs.

For the main part, this valuable addition to eclipse literature deals with the observations made by the Naval Observatory, which equipped two stations on the central line, one in North Carolina and the other in Georgia, the intention being to duplicate the work in order to minimise the danger of unfavourable weather. Since, however, a large number of other parties with varied equipments was scattered along the line of totality, the reports of several of these have been included in a separate section of this volume.

The stations fixed upon by the Naval Observatory's parties were two in the State of Georgia, namely, Barnesville and Griffin, and one in North Carolina, Pinehurst being the location selected. The reason why two stations were chosen in the former State was because it was desirable to concentrate the spectroscopic attack on the chromosphere near the end of the shadow track, Griffin being the region where the lower strata of the sun's atmosphere during totality were exposed longer to view. Griffin was twenty miles distant from Barnesville. Prof. Updegraff was placed in charge of the Georgia stations, while Prof. Skinner superintended the work at Pinehurst.

Fortunately the weather was very favourable at all the stations, so that the results here brought together are numerous and very complete. First, as regards the instrumental equipment at each of the stations. Space does not permit reference to the instruments in anything like detail, but the reader will find in the volume all the information clearly set out. The general scope of the work undertaken will, nevertheless, be gathered from the following brief summary concerning the chief instruments employed.

Barnesville.—This station was chiefly used for photographing the corona. The largest instrument employed there was an object-glass of 4-inch aperture and 40-feet focal length, the tube being pointed directly at the sun at eclipse time. The image formed was 4·36 inches in diameter.

Another instrument consisted of a battery of cameras mounted on a wooden polar axis 11 feet long and moved by a clepsydra. The cameras erected on this were as follows:—three lenses of 6-inch aperture having focal lengths of 104, 80, and 33 inches; a 4-inch Dallmeyer lens of 17-inch focal length; and a 3·5-inch Dallmeyer of 9·5-inch focal length.

In addition, there were two 5-inch equatorials for visual observations and a prism-spectrograph.

Griffin.—At this station the attack was made from the spectroscopic point of view. Here were located a 10-feet concave Rowland grating worked in conjunction with a 3·5-inch quartz lens and a cœlostat; the plates used were placed in curved backs, and the first-order spectrum was employed. There was also a large Rowland concave grating of 21·5-feet radius, worked also in connection with a quartz lens and cœlostat, but mounted after the method of Rowland. This was employed chiefly for the ultra-violet in the second-order spectrum.

Pinehurst.—Here was erected a 5-inch 40-feet coronagraph pointed directly at the eclipsed sun. Worked in connection with three independent cœlostats were:—a plane grating objective spectrograph with ruled surface 3·5×5 inches (15,000 lines to an inch); a concave (10-feet) grating slit spectrograph similar in ruling and size to the plane one; and a 4-inch prismatic camera with one flint glass prism of 60°.

As at Barnesville, a large polar axis was here erected to carry several cameras, and two Dallmeyer lenses of 38-inch focal length and a Voigtländer lens were mounted on it. Three equatorials for visual observations and a transit instrument completed the equipment.

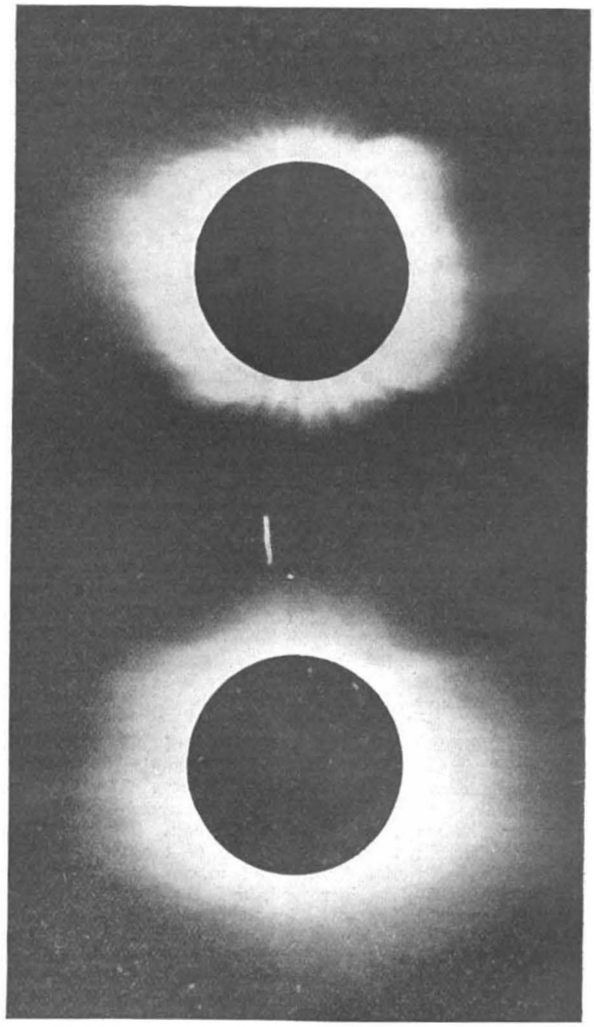

FIG. 1.—The coronas of 1900 (upper) and 1901 (lower) as photographed by the U.S. Naval Observatory parties. (The north-point of the sun is at top of each.)

In the volume before us the results obtained with each of the several instruments are individually discussed, and on the whole they have turned out very satisfactory. Further, the volume is illustrated, not only by a series of excellent reproductions from photographs of the camps and the instruments *in situ*, but of the forms of the corona and the chromospheric

[1] "Publications of the U.S. Naval Observatory." Second Series, vol. vi, appendix i. By Rear-Admiral Colby M. Chester, U.S.N., Superintendent. Washington, 1905.)

spectrum. All these will be of great interest to other observers of the same eclipse, as comparison of results is of great importance in the interest of future eclipse work.

It would lead one too far, and, indeed, it is not necessary, to enter into the very complete treatment here published of the various branches of work so well brought together, but perhaps a word or two may be mentioned with regard to some expectations that were not so successfully realised as was hoped.

In the case of the 10-feet concave grating erected at Griffin, the plates turned out to be very much under-exposed. In explanation of this, Prof. Crew not only summarises the possible causes of failure, but adds some useful suggestions for use on future occasions. In the case of the former he mentions seven possible causes, the first being that the intensity of radiation of the eclipsed sun was underestimated, and consequently only the very brightest lines of the chromospheric spectrum were recorded. The second was that the effect of astigmatism in the curved grating was underestimated.

A third reason was that an exposure of two plates instead of one during totality was more than was justified by the dispersion and slit width.

In Mr. Humphrey's report relative to the 21.5-feet Rowland grating at Griffin, a very dissatisfied tone is pronounced with regard to the instrument's efficiency. He finally states:—"It does not seem probable, however, that a grating mounted according to the Rowland method and used with a slit can, even under the most favourable circumstances, yield nearly as many flash lines as may be obtained with a prism or a concave grating used directly without lens or slit. . . . It would be well in using a spectrograph of this kind to avoid the chromatic aberration of lenses entirely and to form the image on the slit by means of suitable reflectors. It might also be best to use silver reflectors and to avoid that part of the ultra-violet of wave-length shorter than λ 3600. Direct grating or prism spectrographs should be used, if possible without reflectors of any kind, but when a reflector is used it should consist of magnalium for the ultra-violet and of silver for light of longer wave-lengths."

With regard to the plane grating spectrograph used at Pinehurst, Mr. Jewell states that the definition of the lines was good from wave-length 3850 to 4100, and "remarkably fine near the H and K lines." The definition between 3750 and 3850, and from 4100 to 4200, is described as "fair," but "very poor" at wave-lengths less than 3700 and greater than 4200. A complete and long table of wave-lengths of the chromospheric lines measured is given in the report.

The coronal lines observed were six in number, the mean wave-lengths of which were as follows:—3382.4, 3453.3, 3644.0, 3801.8, 3987.5, and 5304.1. The objective prism spectrograph at the same station also secured chromospheric and coronal spectra, and although a long list of the wave-lengths of the lines is published, great weight cannot be given to their accuracy, since the definition on the negative is described as "poor over the whole spectrogram and particularly poor for the violet end."

Although no word has yet been said about other branches of work taken up, the reader must be referred to the volume itself for the numerous reports on them. We reproduce in Fig. 1 (upper part) a picture of the corona as photographed with the 40-feet camera at Barnesville, the exposure of which lasted thirty-five seconds. It will be seen that it illustrates well the "wind-vane" form typical at epochs of sun-spot minimum. The lower part of this illustration shows the corona of 1901, taken also with the 40-feet instrument. Fig. 2 shows a general view of the station selected at Pinehurst, the method of supporting the 40-feet coronagraph, and the houses for the other instruments erected there.

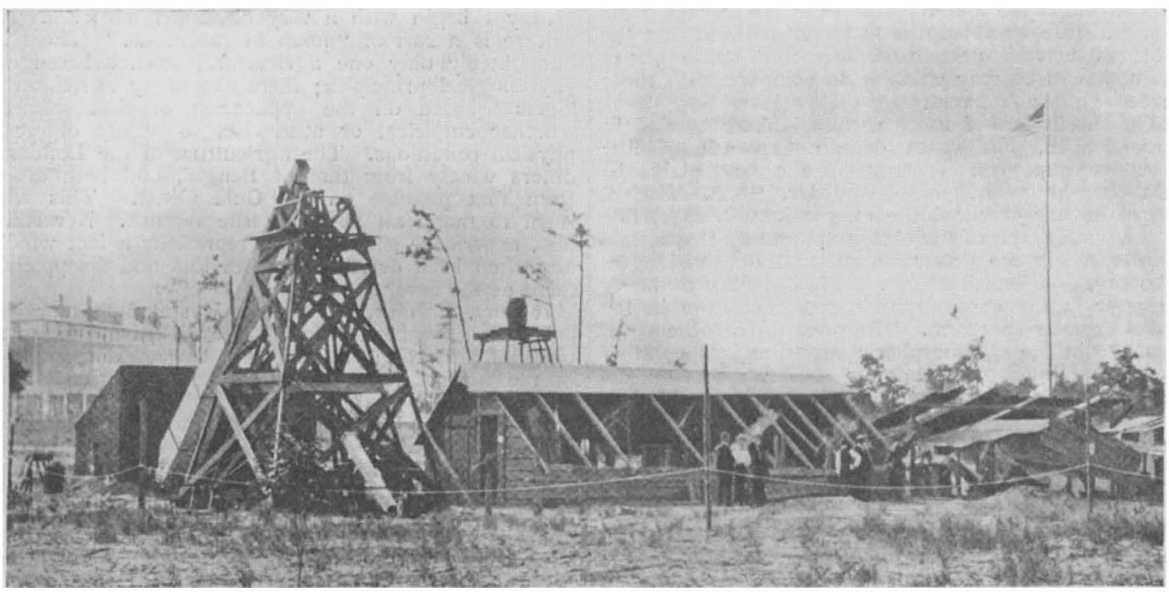

FIG. 2.—The U.S. Naval Observatory Eclipse Station at Pinehurst, North Carolina. The 40-foot Coronagraph is on the left.

The second portion of this important volume deals with the observations made during the solar eclipse in Sumatra in May, 1901, the stations selected being Solok, Fort de Kock, and Sawah Loento. At the first station clouds reigned supreme during totality, but the chromosphere was photographed at third contact through clouds. At the second station the weather is described as "perfect," while the observers at the third station only managed to obtain some results at third contact, the weather being very unfavourable.

At Fort de Kock, in addition to some beautiful corona pictures (one of which is here reproduced for comparison in Fig. 1) taken with the 40-feet coronagraph, used horizontally in this eclipse, photographs were secured with the 30-feet concave grating. In the latter, films were used in consequence of the sharp curve in the focal plane of the grating, but, as the report says, "each film showed that, unfortunately, it had not been placed exactly in focus, still the dispersion was so great that many of the lines could be very easily identified." A table is given showing the results obtained from the measures of these negatives, the spectrum covering λ 3118.5 to λ 5204.7; intensities, character, and wave-lengths from Rowland's tables are also included.

At Sawah Loento the plane grating proved a success, parallel rays falling on its surface and being brought to a focus on the photographic plate by means of a lens placed between the grating and the plate. In spite of clouds, the negative taken at third contact is said to have been fully exposed. The large dispersion employed and the definition obtained allowed very accurate wave-lengths to be deduced, so that the table of wave-lengths extending from λ 3835.2 to λ 4957.8 will be very valuable to compare with those made by other observers.

The discussion of these results is here carried to some length, but space does not permit of any extensive reference. It may, in the first place, be said that both Mr. Jewell and Dr. S. A. Mitchell record having observed the magnesium (λ 4481) line in the photograph of the chromospheric spectrum, and both agree in the determination of the wave-length, intensity, and length of arc. It is described as being stronger in the chromospheric spectrum than in the ordinary solar spectrum. The presence or absence of this line in the chromospheric spectrum is a point of such great importance that the observation above described requires to be very carefully corroborated before it can be finally accepted. It is, however, very difficult to understand how the above identification of the magnesium line with the chromospheric line has been obtained, because in the list of wave-lengths here published the evidence seems to point to a titanium origin. Thus we find in this table that the wave-length of the chromospheric line, as measured, is λ 4481.4, while the solar lines nearest this are, according to Rowland, λ 4481.298 (Mg) and λ 4481.438 (Ti). Further, has it been definitely established that the solar line λ 4481.298 is due to magnesium?

It is also stated that it seems probable that the more volatile gases of atmospheric air uncondensed at the temperature of liquid hydrogen, together with hydrogen, helium, neon, and argon, are present in the chromosphere, but with regard to krypton and xenon the evidence is not conclusive. These deductions also do not seem to be supported by sufficient evidence, but will require further discussion before they can be generally accepted.

Enough, perhaps, has been said to indicate to the reader the importance to the study of solar physics of the publication of such a volume as this. Here we have all the data and discussions relative to two eclipses brought together under one cover, rendering a comparison of results a matter of little labour. One blemish we may, however, remark, and that is that the corona reproductions are not oriented in any way.

It may be still in the minds of our readers that, for the observation of the recent eclipse of 1905, Admiral Chester, Commander-in-Chief U.S. Eclipse Squadron, was in command of four men-of-war told off for eclipse work in Algeria and Spain. Their "station bills," showing the staff at each station and the work to be accomplished, gave one a good idea of the thoroughness with which the undertaking was organised. We shall at any rate look forward to another such volume as this, with, we hope, equally successful results. WILLIAM J. S. LOCKYER.

AGRICULTURE AND THE EMPIRE.

NATURE for January 11 contains a short paper on a large subject. Seeing that the cultivation of the soil, or agriculture, is the fundamental condition of human existence with any approach to civilisation, large is a very moderate description.

I take it that the object of the writer was to discuss the part that the Home Country should play in advancing agriculture in the Empire at large. That is a matter which seems to me important enough to receive a little discussion. It is one with which I have been a good deal occupied during the past thirty years. I should like, therefore, to attempt to define the present position of the problem a little more precisely.

May I begin with a very obvious remark? Agriculture is a sort of "noun of multitude." There is undoubtedly only one agricultural science based on physiological principles; there are many agricultural "arts" based on the application of that science, whether empirical or otherwise, to widely different physical conditions. The agriculture of the Lothians differs widely from that of Bengal, and both differ from that possible on the Gold Coast. This will seem to many an absurdly trite remark. Nevertheless, experience shows that it represents a fact which has often been overlooked, with loss and disappointment as the result.

It may, I think, be confidently stated that arable cultivation has been brought in the British Isles to a pitch of perfection which is not surpassed anywhere in the world. It is, however, an "intensive" and highly specialised agriculture. This is readily illustrated by the yield of wheat per acre. On land of prairie value, where the nitrogen removed is balanced by that received from the atmosphere, it has been shown at Rothamsted that the yield is roughly some 10 bushels or less. This actually represents the state of things in the great wheat-growing countries from which we draw our supplies—Argentina, Australia, India and Russia—and the United States with 13 bushels are not much better. The yield of the United Kingdom for the five years preceding 1904 was 31 bushels, and this was only surpassed by that of our antipodal colony New Zealand, 32.

This is largely due to the scientific research in agriculture for which, I think, it may be fairly claimed this country has always been preeminent. I by no means think that it is exhausted. I remember Sir John Lawes saying to me that, having devoted half a century to the study of the soil actually cultivated, he was still absolutely ignorant as to the subsoil and the part played by it. Our knowledge of the action of manures is mainly empirical, and we have still to learn much of its physiological significance. Without this it cannot be said that we possess a rational theory of manuring. Farmers must have wasted enormous sums in the application of nitrogenous manures until Frankland showed that a considerable proportion passed off unused in the drain-water.

I must confess that I am not clear that the arable agriculture of the United Kingdom is in a backward condition, that it does not compare favourably with that of other countries, or that it stands in urgent