PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY A MATHEMATICAL, PHYSICAL & ENGINEERING SCIENCES

Total Eclipse of the Sun Observed at Caroline Island, on 6th May, 1883

W. de W. Abney, W. Spottiswoode, J. Norman Lockyer, H. A. Lawrance and C. R. Woods

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III. *Total Eclipse of the Sun observed at Caroline Island, on 6th May*, 1883.

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[Plates 1, 2.]

Owing to the representations of the Committee on Solar Physics, who communicated with the Royal Society the desirability of observing this eclipse, an expedition was organised under the auspices of the latter body. The Council of the Royal Society having requested me to draw up a report on the Total Eclipse observed at Caroline Island, I undertook the task so far as relates to the results which were obtained with the same instruments which were employed in the observations of the Total Eclipse in Egypt in 1882.

Two observers, Mr. H. Lawrance and Mr. C. R. Woods, who had both taken part in the Eclipse Expedition to Egypt as assistants to Professors Lockyer and Schuster, were entrusted with the arduous duty of making the observations. The expedition was devoted entirely to photographic work, the main object being to continue the photographic observations which had been carried on in Egypt, consisting of photographs of the corona taken on very rapid plates with varying exposure, photographs of the corona taken with a slitless spectroscope (the prismatic camera), and a photograph of the corona spectrum, the image of the moon and the corona being thrown on the slit cutting the diameter of the former. There is no occasion to describe the instruments which were employed for the first two classes of observations, as they have been fully described in the previous communication to the Royal Society by Professor Schuster and myself which appears in the 'Philosophical Transactions' for 1884. The photographic spectroscope which was employed on this occasion differed in one detail, and in one detail only, in that the dispersion was doubled, two medium dense flint prisms of $62\frac{1}{2}°$ being employed instead of one prism of the same angle. The experience gained in Egypt seemed to show that, if the coronal light was equally bright in the two eclipses, the rapid plates used on both occasions would be amply adequate to secure photographs with the larger dispersion. Besides these observations several others were made, but did not meet with the success it was hoped they would have done. A photo-heliograph, giving a 4-inch solar image, was attached to an equatorial mount, in addition to the wooden camera carrying a lens of 5 ft. 6 in. focus, with which the smaller-sized pictures of the corona were taken in Egypt. The pictures taken with the former,

though sufficiently exposed, showed that a large image could be utilised. They were not, however, satisfactory, owing to a multiplicity of images being formed, due to the shake given to the instrument by the insertion of the slides in the smaller instrument, the large pictures requiring considerably more exposure than these latter. In the matter of spectroscopic analysis of the eclipse phenomena, Mr. LOCKYER devised an ingenious contrivance for securing impressions of the bright lines seen immediately after and before totality. These photographs were only partially successful, and will not be considered in this report. The number of instruments to be used by the two observers and the assistants they hoped to obtain were nine, entailing the use of 11 cameras. Only two equatorial mountings accompanied the expedition, and it was impossible to mount all these instruments on them, had it been advisable, indeed, to do so. A siderostat, having a 12-inch silver-on-glass mirror, was therefore taken, four of the instruments being stationary, reflected light being utilised.

The following was the disposition of the instruments :—

On the 1st equatorial—

A. A finder of $3\frac{3}{4}$-inch aperture was attached to the above for viewing the eclipse.

B. A 7-prism spectroscope, with camera attached, for obtaining photographs near the sun's limb immediately before and after totality.

C. A 6-inch achromatic telescope by COOKE, of York, the eye-piece being withdrawn. Attached to it was a RUTHERFURD grating of 17,200 lines to the inch, to be used for obtaining spectra of the corona in the 1st and 2nd order, two cameras being employed.

D. A slit spectroscope, having one prism of dense flint glass. The condenser throwing the image of the moon on the slit was a photographic lens by DALLMEYER, of 6-inch focus.

On the 2nd equatorial were mounted—

M. The photoheliograph for taking 4-inch pictures.

N. The corona camera, having a lens of 4-inch aperture, and 5 ft. 6 in. focal length.

The instruments used with the siderostat were—

F. A photographic spectroscope to be used without a condenser, consisting of one prism of white flint, a collimator $4\frac{1}{2}$ feet long, and a lens attached to the camera of 3-inch aperture, and of about 9-inch focus. In this case the photographic plate was caused to move vertically during exposure of the plate by means of clock-work for the registration of bright lines immediately before and after totality.

G. A slit spectroscope of two prisms of the same dimensions as that used in Egypt in the eclipse of 1882, and described in Dr. SCHUSTER's and my report

in the 'Phil. Trans.,' 1884. The whole apparatus was the same as that described in that paper, with the exception that the two prisms were employed instead of one. The use to which this instrument was to be put has already been referred to.

H. The prismatic camera also described in the paper just referred to.

K and L. A concave ROWLAND grating of 5 feet focus arranged for taking ring spectra in the 1st and 2nd orders.

(The same letters are attached to the above as are to be found in Appendix II. in the instructions for adjustment drawn up by Mr. LOCKYER.)

The time table of exposures is given in Appendix III., and the times indicated were very closely followed.

The party was attached to the American Expedition under the command of Professor HOLDEN, arrangements to this effect having been made by the President of the Royal Society. The instructions issued to them will be found in Appendix I. The combined parties were taken from Panama in a United States man-of-war, and landed on Caroline Island on April 20th. The instruments were ready for use on the 3rd May. Owing to bad weather it appears that the trial of the instruments was much impeded, but that they were in fair working order by the 6th, the day of the eclipse. The instruments were packed up on the 7th May and two following days, and the party left the island on the 9th.

The following are the notes made by Messrs. WOODS and LAWRANCE regarding the atmospheric conditions immediately after the eclipse :—

11.5—Fleecy clouds over sun.
11.13—Birds flocking in air; light greyish.
11.15—Fleecy clouds over sun.
11.20— ,, ,, ,,
11.30—Totality commenced; sky very cloudy.
4 minutes before totality—BAILEY's beads visible.
2.45—Totality; BAILEY's beads more plainly seen.
5 minutes after totality—Sky clouded over.

They described the corona on the following limb as being very full of detail, with many curved rays. Shortly after totality they saw the 1474 line, with a pocket spectroscope having a condensing lens and slit. Taking off the slit they saw as rings 1474, D_3, and C, D_3 and C being very faint. In mid totality they only saw the 1474 line very bright on the west side.

At end of totality the structure on the preceding limb is described by them as most beautiful, exceeding the other side in detail. In the spectroscope they saw the same rings, but the 1474 line by far the brightest. The spectrum of the corona during totality, when viewed with a pocket spectroscope, appeared continuous and bright. The light was nearly as bright as in Egypt. The corona extended to $2\frac{1}{2}$ diameters,

and strongly resembled that of 1882. Mr. Woods states that the coronal light was more natural than in Egypt, and Mr. Lawrance describes it as not so violet as in Egypt.

Results.—Although photographs were taken successfully in nearly every instrument, it is to be regretted that the majority have so far proved to be of but little use. At present I have not been able to utilise for measurement more than the photograph of the spectrum of the corona taken with the two-prism slit spectroscope, and the corona photographs taken in the camera with the lens of 5ft. 6in. focus. These last had exposures given of 1 sec., 2 secs., 3 secs., 10 secs., 20 secs., and 120 secs.

The photographs taken with the slitless spectroscopes are good, but they possess no great features of interest. The prominences were of small height and few in number, and I have been unable to mark any distinction in the light they emitted. The rings of light due to 1474, D_3, and other substances which were noticed in the eclipse of 1882 are absent, probably because of the greater angular diameter of the moon. I have, therefore, not given either drawings or measurements of these photographs.

The negatives of the corona were placed at my request in the hands of Mr. Wesley, Assistant Secretary of the Royal Astronomical Society, and he has made two drawings from them, in one of which the coronal detail near the limb is shown, being taken from the photographs which had but short exposure, and in the other the coronal detail further from the sun, being sketched from the photographs to which long exposure had been given. The general features of the corona are those which might be expected from the sun-spot period in which the eclipse took place, a matter which was discussed in the Report of the Egyptian Eclipse, and which scarcely need be restated here. The corona spectrum has been carefully measured by Mr. Lawrance and myself. The method we adopted was as follows:—First, I took some measurements of the most prominent lines and recorded them, taking out the wave-lengths by the same method employed in measuring the photograph in the Egyptian eclipse, the reference spectra taken after the eclipse on the same plate being utilised for the purpose. Mr. Lawrance then carefully and independently measured the photograph three separate times. All lines were rejected which he did not measure in all these sets of measurements. I then measured it myself in the same way, and rejected all lines which did not appear in each of my measures. Finally, the lines taken as absolutely present were those which appeared in my expurgated measures and in Mr. Lawrance's. By this means it is believed that every line of which there can be no doubt has been recorded, whilst there are many others whose existence is doubtful but which are probably present. Lists of each sets of measures are given, which may be useful in comparing the lines obtained in this photograph with the Egyptian negatives, and those which may be obtained in future eclipses. That a large number are coronal lines is a fact, and the coincidences between those found in the photograph now under discussion and the Egyptian one, in which all the lines given were undoubtedly

coronal, is important. It will be better in future eclipse expeditions to place the slit of the spectroscope tangential to the moon's limb in preference to normally. This has been done in the recent eclipse observed in the West Indies (August, 1886), with most satisfactory results. The chief point to attain is to separate all prominence light from the coronal light, as it tends to mask the true spectrum of the latter. From the photographs I have examined I have come to the conclusion that not much more is to be learnt at present from them. It may be that as more eclipses come to be observed with the same instruments, or at all events on the same lines, the photographs of the Caroline Island station will prove to be of greater value than they seem to be now.

If we compare the corona of this eclipse with that of the eclipse in Egypt, perhaps the most striking feature is the absence of the hydrogen lines. In Egypt the photograph shows, besides the lines which may be presumed to be hydrogen at H, at least two other lines of hydrogen, λ 4340 and λ 4101. In the Caroline Island photographs these lines are entirely absent. It may be well to draw attention to the fact that in the former eclipse the prominences were very marked, and in the prismatic (slitless) spectrum the hydrogen rings were very powerfully shown. In the eclipse now under consideration the prominences were very small, and the prismatic (slitless) spectrum gave no result other than rings at H and K. It would seem, then, that the corona at the time of the Egyptian eclipse was illuminated more or less by the prominence light. If this be admitted, we ought to find that the corona during the Caroline Island eclipse was illuminated by the light which emanated from the matter which gave H and K so strongly in the ring spectrum. Looking at the list of lines, we find that such is the case. Calcium was evidently present in the light, more especially near the limb of the moon. We find that three calcium lines are shown *reversed* across the dark moon, and two iron lines. It is somewhat hard to see how these reversed lines made their appearance in such a locality. It is quite evident that they must be due to reflected light. I can find no trace of FRAUNHOFER lines about G outside the corona, such as Dr. SCHUSTER and myself found in the Egyptian eclipse photograph, and which would be the first to appear in the photographic plate were any reflected sunlight as it reaches us present in those regions. It should be remarked that the reversed lines across the moon are extremely faint, but perfectly distinguishable and measurable. Most of the lines in the spectrum of the corona lie near the moon's limb, and have quite a different aspect to those delineated in the Egyptian eclipse negative, and some of them are probably prominence lines, and I think it would be dangerous to found any theory on the discovery of new lines in the coronal spectrum from the list of lines here recorded.

In conclusion, I think I may say that the two English observers, Mr. H. A. LAWRANCE and Mr. C. R. WOODS, deserve every credit for the amount of work they did. The large number of instruments they were called upon to utilise during the eclipse, and which they evidently most skilfully manipulated, could only have been

done by those who were thoroughly competent, and who possessed a freedom from a tendency to excitement, which occasions such as that on which they were engaged is apt to create, more especially when they have a heavy responsibility resting upon them. The results they brought home show how assiduously they worked, and how completely they carried out the programme with which they were entrusted.

Corona Spectrum, 1883.

Abney's measures, in wave-lengths.		Lawrance's measures, in wave-lengths.		Adopted lines.	Remarks.
1	2	1	2		
3837	3837	3836±2	3835	3836	
		3883			
3898		3898			
3934	3934	3934	3934	3934	K reversed across moon Fe Ca
	3954				
3969	3969	3969	3969	3969	H reversed across moon Fe Ca
3986		3986			
3998		3997		3998	Reversed across moon Fe
4015	4016	4014	4018	4016	E 4015
		4030	4031		
		4038	4036		
4045				4045	E 4044
4057		4055		4056	E 4057
4065	4065		4063	4064	E 4067
4071	4071			4071	Reversed across moon Fe
	4076		4074	4075	Ca (4077)
4081		4081			
4086		4085		4085	E 4085
4092	4092		4094	4092	Reversed across moon Ca
			4113		
			4125		
4131				4131	Reversed across moon Ca Fe
4137	4142	4142	4146	4144	
		4153	4158		
			4169	4169	E 4168 Ca 4167
4184	4185	4183	4187	4185	
		4191	4194	4192	E 4195
		4213		4213	E 4213 Ca Fe Sr (4215·5)
		4220			
4225	4227		4228	4227	E 4224 Ca Sr (4226·3)
			4237 }	4242	E 4241 { Fe 4235·5
		4248	4246 }		Fe 4245·2 }
4253	4249	4254	4255	4255	E 4252
		4261			
		4274±2			
4279	4279		4280	4279	
	4290	4291		4291	E 4289 Ca Cr Ce 4289·4
4310		4310			
	4313		4314		
	4331		4329		
4354	4354	4351	4353	4353	Fe 5352
		4360	4358		
4370	4370		4363±3	4370	E 4370

Corona Spectrum, 1883 (continued).

Abney's measures, in wave-lengths.		Lawrance's measures, in wave-lengths.		Adopted lines.	Remarks.
1	2	1	2		
		4377			
		4383			
		4400			
		4427			
4450		4448			
4464		4465			
4473		4473		4473	E 4473 4471·4 often in prominences
4490		4490			
4501		4502		4501	E 4501
	4518		4518		
4545		4546±1			
		4557	4555±3		
		4571			
		4577			
4602		4606			
4620	4636		4636		
		4642			
	4672		4674		
		4695			
			4706		
4720		4717	4717	4717	Fe 4717
4730	4730	4729±1		4730	Fe 4730·7
			4738		
4754		4754			
			4760		
			4764		
4780		4776			
		4798			
			4803		
			4818		
		4845			
	4949		4955		

E signifies lines found in the photograph of the corona spectrum taken in Egypt, 1882.
In the column marked 1 the lines were found in three different measurements.
In the column marked 2 the lines were found in two different measurements.

In the adopted spectrum only those lines which were each measured by the two computers on each limb of the moon have been taken as coronal, unless a coincidence was noted between lines measured on one and the coronal spectrum of 1882 taken in Egypt. It will be noted that lines occurring in Ca and Fe lie very close to those given in the adopted spectrum.

Appendix I.

Government Eclipse Expedition, 1883.

Instructions to Observers.

1. In case of any difficulty at any port, either on going out or coming home, Mr. Lawrance to hand Foreign Office letter herewith to the British Consul at that port, and ask his assistance.

2. On joining the American party, Mr. Lawrance and Mr. Woods to report themselves to the astronomer in charge of the expedition, and to hand him the accompanying letter, taking his advice and following his instructions with reference to the transference of the instruments to the United States ship of war.

3. On arriving at the place of observation, the instruments to be erected on a site to be chosen by the American astronomer in charge.

4. Packing cases to be re-closed up as far as possible, and to be protected from damage and the weather. Care to be taken not to damage tin cases.

5. The gratings to be kept together, and special precautions to be taken with regard to them, as also with the silvering of the siderostat mirrors. Mr. Lawrance to give special attention to this point.

6. For as many days as possible before the eclipse all the instruments to be arranged as during the eclipse, and from 11.23 A.M., local mean time, to 11.48 A.M., local mean time, complete rehearsals of all the observations intended to be made during the eclipse to be most rigidly carried out.

7. A statement of the days on which these rehearsals have been made to be given in the report of the operations.

8. If the aforesaid times, derived from Mr. Hind, do not agree with the times determined by the American astronomers, the instructions of the astronomer in charge are to be taken.

9. Instruments to be focussed and trial plates taken, if possible, at least three days before totality. These trial plates to be carefully preserved.

10. The rehearsal on the day before the eclipse should be a complete rehearsal with photographic plates, exactly as during the eclipse itself; and these plates to be developed at once, and brought home.

11. The observers should confer with the American astronomer in charge regarding time signals before and after totality.

12. If additional observing power can be obtained from the American party, the additional observers to be trained to obtain photographs with the photoheliographs, and, if desirable, the time table for that instrument to be handed over to them, they being placed in entire charge of that part of the operations.

13. If such assistance cannot be afforded, then, if the photoheliograph programme cannot be carried out in its entirety, the large pictures to be alone attempted.

14. Special attention to the rating of the clocks, including the eclipse clock and siderostat, to be given at least three days before the eclipse.

15. A quarter of an hour before totality, clocks to be wound, and caps and stops which had been hitherto used to diminish the amount of light to be removed, if necessary.

16. The timekeeper should be asked to give these instructions in a loud voice, as experience has shown that this is apt to be forgotten.

17. In the observations and adjustments during the eclipse, no deviation from the time table and adjustments to be made except after consultation, and with the approval of the American astronomer in charge.

18. The clockwork of the integrating spectroscope to be so adjusted that the plate will fall through one inch in eight minutes.

19. The distance of plate from concave grating to be that given by Captain ABNEY for vertical distortion.

20. In equatorial, the slits to be parallel and vertical in the meridian, and their centres lying on the same part of the sun.

21. All slits to be $\frac{1}{500}$ in. = No. 2 on Captain ABNEY's screw, with the exception of the integrating spectroscope, which should be $\frac{1}{250}$ in.

22. At some convenient time—say 100 secs.—near the middle of totality, the slits of equatorial to be brought to the point of reappearance.

23. The plates to be developed and copied at the first convenient time after the eclipse is over.

24. Half the positives and half the negatives to be handed to the British Consul at Callao, to be forwarded to the Foreign Office for transmission to the Science and Art Department by the next mail after that by which the observers leave.

25. On arrival at Callao, a cypher telegram to be despatched to Secretary, Kensington Museum, London, giving the results obtained with each instrument, and stating any other matter of importance.

26. Great care to be taken in repacking the instruments after the eclipse. Tin cases to be re-closed.

27. A detailed report, to be prepared before arrival at Callao, of the general results to be posted to me immediately on arrival at Callao, in case of any delay *en route*.

28. If a convenient opportunity arises for sending this report from the Marquesas, this course to be followed as well as the other.

29. It is to be understood that the records of the eclipse are the property of the British Government.

30. In case no pictures are taken with the small photoheliograph, Mr. LAWRANCE is requested to ask the American astronomer in charge for an oriented positive of the corona to facilitate reference here.

31. Mr. LAWRANCE is empowered to hand to the American astronomer in charge positives of any of the pictures taken by the English party which he may require for a similar purpose, and to obtain a receipt for them.

W. SPOTTISWOODE, Pres. R.S.,
Feb. 16, 1883.

J. NORMAN LOCKYER,
Feb. 16, 1883.

APPENDIX II.

Adjustments.

B. Seven-prism spectroscope.
F line in centre of plate.
C. Flat grating spectroscope.
First order—F in centre of plate.
Second order—F in centre of plate.
D. Dense prism.
F in centre of plate.
F. Integrating HILGER (Flash).
G in centre of plate.
G. Red end slit.
H. Red end prismatic camera.
K. First order blue. ROWLAND.
F in centre of plate.
L. Second order blue. ROWLAND.
H in centre of plate.
M. 4″ photoheliograph.
See that sun runs along horizontal wire.
N. Small photoheliograph.

J. NORMAN LOCKYER,
Feb. 16, 1883.

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Appendix III.

Time Table.

Time.	Siderostat.					Equatorial.				Photoheliographs.	
	F Hilger.	K Rowland grating. 1st order.	L Rowland grating. 2nd order.	H Prismatic camera.	G Slit spectroscope. 2 prisms.	B 7 prisms.	C Grating. Red, 1st order.	C Grating. Blue, 2nd order.	D Dense prism. Quarter-inch slide.	M Large photo-heliograph.	N Corona camera.
10 min.	..	..	..	..	..	Expose	Expose	Expose			
9											
8	..	..	..	..	..	..	..	..	Expose		
7	..	..	..	..	..	..	..	..	Expose		
6	Ref. spectrum 30 secs.	..	..	..	..	..	..	..	Expose		
5	..	..	..	..	..	..	..	..	Expose		
4	..	..	..	..	..	..	..	..	Expose		
3	..	..	..	..	..	..	Expose	Expose	Expose		
2	..	..	..	..	..	Expose	..	..	Expose		
1	..	..	..	..	..	..	..	..	Expose		
40 secs.	..	Expose	Expose	..	..	..	Run				
30	..	..	..	..	..	..	$\frac{1}{4}$ inch				
20	..	Expose	Expose								
3											
2	Expose and start clock										
1											
Totality	..	Expose	Expose	Expose col. plate	Expose	Expose	Expose	Expose	Expose	Expose	Expose 1 sec.
300 secs.											
290											
280	..	..	..	..	..	..	..	..	..	..	Expose 20 secs.
270											
260											
250											
240											
230	..	..	..	Shut							

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY A MATHEMATICAL, PHYSICAL & ENGINEERING SCIENCES

Appendix III. (continued).

Time Table (continued).

Time.	Siderostat.					Equatorial.				Photoheliographs.	
	F Hilger.	K Rowland grating. 1st order.	L Rowland grating. 2nd order.	H Prismatic camera.	G Slit spectroscope. 2 prisms.	B 7 prisms.	C Grating. Red, 1st order.	C Grating. Blue, 2nd order.	D Dense prism. Quarter-inch slide.	M Large photo-heliograph.	N Corona camera.
220	..	..	..	Expose gel. plate							
210	..	..	..	..	..	..	..	..	..	..	Expose
200	..	Expose	Expose	..	..	..	..	..	Expose	Expose	
190											
180											
170											
160											
150											
140											
130											
120	..	..	..	Shut							
110	..	..	..	Expose col. plate							
100											
90	..	..	..	..	..	..	..	..	..	..	Shut
80											
70	..	..	..	..	..	..	..	..	..	..	Expose 3 secs.
60											
50	..	..	..	..	..	..	..	..	..	Expose	
40 + x	..	..	..	..	..	..	..	..	..	..	Expose 10 secs.
30 + x											
20 + x	..	..	..	..	..	..	..	..	..	..	Expose 2 secs.
10 + x											
Just before end	..	Expose	Expose	Shut	Shut	Expose	Expose, run $\frac{1}{4}$ inch	Expose	Expose	Shut	

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY A MATHEMATICAL, PHYSICAL & ENGINEERING SCIENCES

Appendix III. (continued).

Time Table (continued).

Time.	Siderostat.					Equatorial.				Photoheliographs.	
	F Hilger.	K L Rowland grating.		H Prismatic camera.	G Slit spectroscope. 2 prisms.	B 7 prisms.	C Grating.		D Dense prism. Quarter-inch slide.	M Large photo-heliograph.	N Corona camera.
		1st order.	2nd order.				Red, 1st order.	Blue, 2nd order.			
1 sec.											
2											
3											
4	..	Expose	Expose								
5											
10	..	Expose	Expose								
15											
20											
30											
40											
50											
1 min.	..	Shut	Shut	..	..	..	Expose	Expose	Expose		
2	Shut										
3	..	..	..	..	..	..	..	..	Expose		
4											
5	..	..	..	..	..	Expose	Expose	Expose	Expose		
6											
7	..	..	..	..	..	..	..	..	Expose		
8											
9	..	..	..	..	..	..	..	..	Expose		
10	Ref. 25 secs.	..	..	..	..	Shut	Shut	Shut	Shut		
Ref. spectra, say half hour after totality	1 sec.	..	..	..	2 secs.	10 secs.	10 secs.	10 secs. J. Norman *Feb.* 16,	1 sec. Lockyer, 1883.	Run	Run

The following Report was written from U.S.S. "Hartford," at sea.

April 20th, at 7 o'clock in the morning, we came in sight of Caroline Island.

A boat was sent off under Lieutenant QUALTROUGH, and on his return we learnt that there were two empty frame-houses belonging to Messrs. HOLDER BROS., of Leadenhall Street, to whom the island is leased, and seven native inhabitants.

The disembarkation commenced that afternoon, and was concluded next day; but, as at nightfall a large part of the goods were still on the shore, the "Hartford" lay-by all night, and landed strong parties at daylight, to carry the boxes up to the site chosen by Professor HOLDEN for the observatory, while W. M. PEACOCK, the cooper, put in the foundations for our three piers.

The landing was very difficult, as the boats had to be run in through a narrow opening in the reef; then the boxes had to be carried through fifty yards or so of water, varying from two to three feet deep; then over fifty yards of sharp irregular coral rock, that cut the men's shoes to pieces; and then along a soft sandy beach, up hill, for more than a quarter of a mile. Our best and most hearty thanks are due to Captain C. C. CARPENTER, who superintended the disembarkation; to Lieutenant-Commander E. WHITE, the executive officer, who saw personally to the lading of the boats; to Lieutenant-Commander J. W. MILLER, who received the goods on shore; to Lieutenant QUALTROUGH, the Cadets, and Warrant Officers, who looked after the working parties on shore.

The "Éclaireur" came in on the evening of the 22nd, just as the "Hartford" was leaving, with the French expedition, consisting of Messrs. JANSSEN, TROUVELOT, PALISA, and TACCHINI.

The landing party left with us consisted of—

Lieutenant EDWARD F. QUALTROUGH.	Seaman, JAMES HAROLD.
WILLIAM S. DIXON, Esq., M.D.	O. Seaman, JOHN MACKINNON.
Cadet, W. B. FLETCHER.	O. Seaman, C. H. PERKINS.
Cadet, J. G. DOYLE.	O. Seaman, J. SMITH (Cook).
Seaman-Gunner, H. R. YEWELL.	Steward, P. BURNS.
Carpenter, PETER MURPHY.	Servant, T. BROOKS.
Carpenter's Mate, CHARLES EMMS.	Servant, MORTIMER SPENCE.

By Saturday, the 28th of April, the siderostat, equatorial, and photoheliograph were erected and adjusted in position. The arrangement of the nest of spectroscopes for use with the siderostat was taken in hand, and the spectroscopes were attached to the equatorial.

We had a great deal of trouble with the photoheliograph, as the tube did not fit the cradle; the clock went badly, and the square box could not be perfectly adjusted for parallelism.

By Thursday evening, the 3rd of May, we were nearly ready for trial plates, which we hoped to take the following day; but it turned wet, and before noon on Friday over five inches of rain had fallen, and our dark room was destroyed, all the dye being washed out of our ruby curtain and window.

The early part of the week was taken up in arranging the various spectroscopes, which took up a good deal of time, and in rating the clockwork slide and equatorial and photoheliograph clocks.

At last the latter went fairly well, but that of the equatorial could not be made to go fast enough, so that recourse had to be made to the fine motions.

On the day previous to the eclipse the weather was very unsettled, and the rehearsals and final adjustments occupied so much time that we were unable to take trial plates.

The photoheliograph stand vibrated so badly that to steady it two cords were attached to the end of the polar axis and fastened to stakes driven in the ground.

The weather on the 6th was very unsettled till about 9 o'clock, when the sky commenced to clear and the instruments were uncovered; by 10 o'clock the sky was moderately clear. After first contact the lenses were dusted, slits cleaned, and the adjustments inspected. Forty minutes before totality the plateholders which had been filled during the night were served out.

The following are the reports of each observer of the work done during totality:—

Mr. H. A. Lawrance's Report of work done during the Eclipse.

About 40 minutes before totality Mr. Woods gave me the plateholders, which I put into the cameras, and examined the screens to see that the three instruments were in good adjustment, then I moved the slides ready for exposure and wound the clock. The slits of the spectroscopes were parallel and nearly tangential to the point of disappearance.

I commenced to expose 10 minutes before totality, and followed the time table, with the exception that 100 seconds after totality I shifted to the other side of the sun and made a new exposure on each plate; after totality, by mistake, I shifted the grating plates at 3 instead of 5 minutes. I took reference spectra 25 minutes after totality.

The corona, examined through the finder, was full of delicate detail near the limb, especially upon the preceding one.

With a pocket spectroscope, with lens in front of the slit, I only saw the green line 1474; and, taking off the slit and examining with the prism at mid-totality, I saw the 1474 ring very brilliant, while C and D_3 were faint, with a lot of continuous spectrum. F I could not see, although I looked for it.

H. A. Lawrance.

Mr. C. R. Woods' Report.

The instruments under my charge were arranged as proposed in England, the integrating spectroscope, slit spectroscope, and prismatic camera being adjusted and focussed with F in the centre of the plate. The Rowland grating was placed normal with the siderostat mirror, and the first and second order on the brightest side adjusted, with F and H respectively in the centres of the plates. Some difficulty was experienced in getting the clockwork to move the slide of the integrating spectroscope sufficiently slow, as the desired rate of speed had been changed too late before starting to enable the alteration to be made at home; during the 8 minutes' run of the clock the plate was moved through the space of $1\frac{1}{4}$ inches.

Five minutes previous to totality the siderostat mirror was finally adjusted and the clock wound up. A red end collodion plate, coated 15 minutes before, was then washed and placed in one of the prismatic camera slides. All other slides had been filled the night previously with gelatine plates. At one minute before totality (not 2 seconds, as stated, I believe *erroneously*, in the instructions), the clockwork of the integrating spectroscope slide was started. At 40 seconds before, total exposures were made in the Rowland grating cameras. At totality, the prismatic camera and slit spectroscope were opened. The three exposures in the former instrument were performed as arranged, the last being closed 5 seconds after the lapse of 300 seconds. The slit spectroscope was closed at the end of the 300 seconds. The exposures in the Rowland grating were carried out strictly to programme, except as to the last exposure during totality, when, owing to longer totality than was expected, the plates were moved up between 10 and 15 seconds after the lapse of the 5 minutes. The clock of the integrating spectroscope ran down at about $1\frac{1}{2}$ minutes after totality, and the slit was covered over simultaneously with the stopping of the clock.

Several long intervals during exposures enabled me to look at the corona and my surroundings. The corona resembled that of 1882 in its general character, the streamers seeming to extend to a little over 2 diameters. Several stars were visible, but the amount of illumination of the sky seemed little less than that of the Egyptian eclipse; but, unlike the latter, its light was more natural, and the landscape lacked the weird colouring that was so noticeable during the eclipse last year.

Two minutes after totality I took the red end plate into the dark room to develop it. Having to manipulate it almost in the dark, it got torn in putting it in. On letting in orange light, half of it was still on the plate, but nothing appeared on that part, which, in spite of my utmost care, also tore into several pieces, leaving nothing on the plate save the gelatine edging.

Five minutes after the eclipse a cloud passed over the sun, and shortly after the sky clouded over.

The plates were developed in the evening, and the copies made on the two following nights.

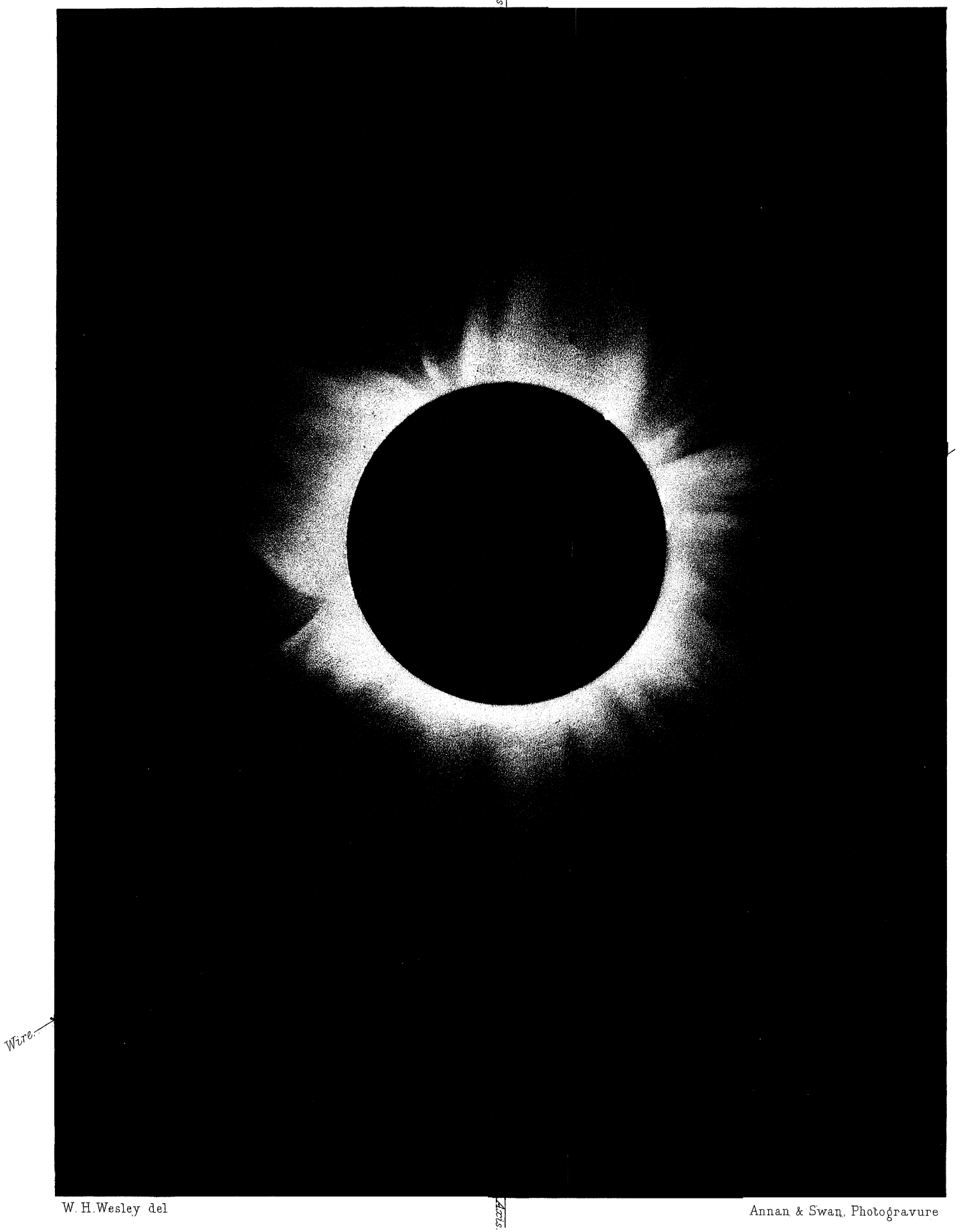
The six photographs taken with the small photoheliograph are very good, the one with 2 minutes' exposure extending as far as those of JANSSEN, which were exposed during the whole totality. All taken with the large instrument show slight shifts, probably due to the changing of the slides in the smaller instrument; still they will be useful in making out the detail near the limb, and we believe that from the nine plates a drawing can be made that will show the whole structure from the limb to the furthest extension of the corona.

With the second order flat grating apparently we do not seem to have caught anything, but before stating that we have been unsuccessful we must examine the plate under better conditions of illumination; in the first order grating H and K are present as bright lines at the commencement and end of totality; the dense prism spectroscope also shows bright lines at the beginning and end, especially at the end, H, K, *h*, *f*, F being very marked.

Two gelatine red end plates in the prismatic camera were successful as photographs, but, owing to the comparative absence of prominences, will not be so fruitful in their results as the photograph obtained with this instrument in 1882. The slit spectroscope gave a good photograph from the ultra-violet to the green. The spectrum appears mainly continuous, but differs on the two sides of the disc. H and K are very marked, but do not extend across the interval, as they did in last year's. The hydrogen line near G extends out nearly a solar diameter; *h*, F, and 1474 also appear. There are other lines, but they are not so numerous as in the 1882 eclipse. The ROWLAND grating seems to have given no useful results, but this is due to the same cause as the indifferent results in the prismatic camera. The integrating spectroscope was successful. There was little or no perceptible change in the character of the spectrum till just before totality, when the brightest lines of the reversion spectrum were caught. H and K, 1474, and the hydrogen lines are most prominent. The flash was also caught at the end of totality. During totality no result appears to have been obtained.

We commenced packing up on the 7th; and on the 9th, at 5 P.M., we left Caroline Island for Honolulu.

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY A MATHEMATICAL, PHYSICAL & ENGINEERING SCIENCES



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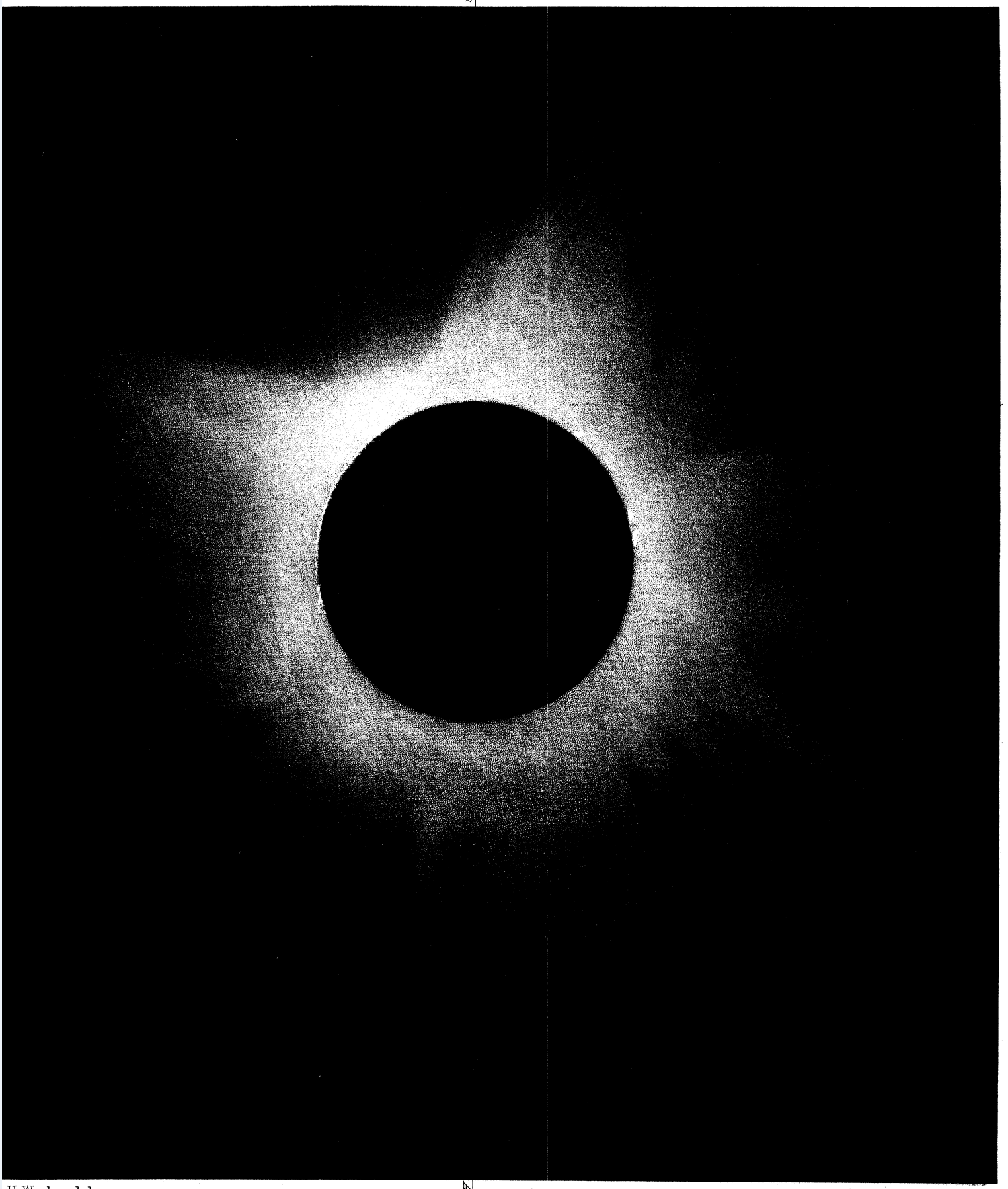


H. Wesley, del.

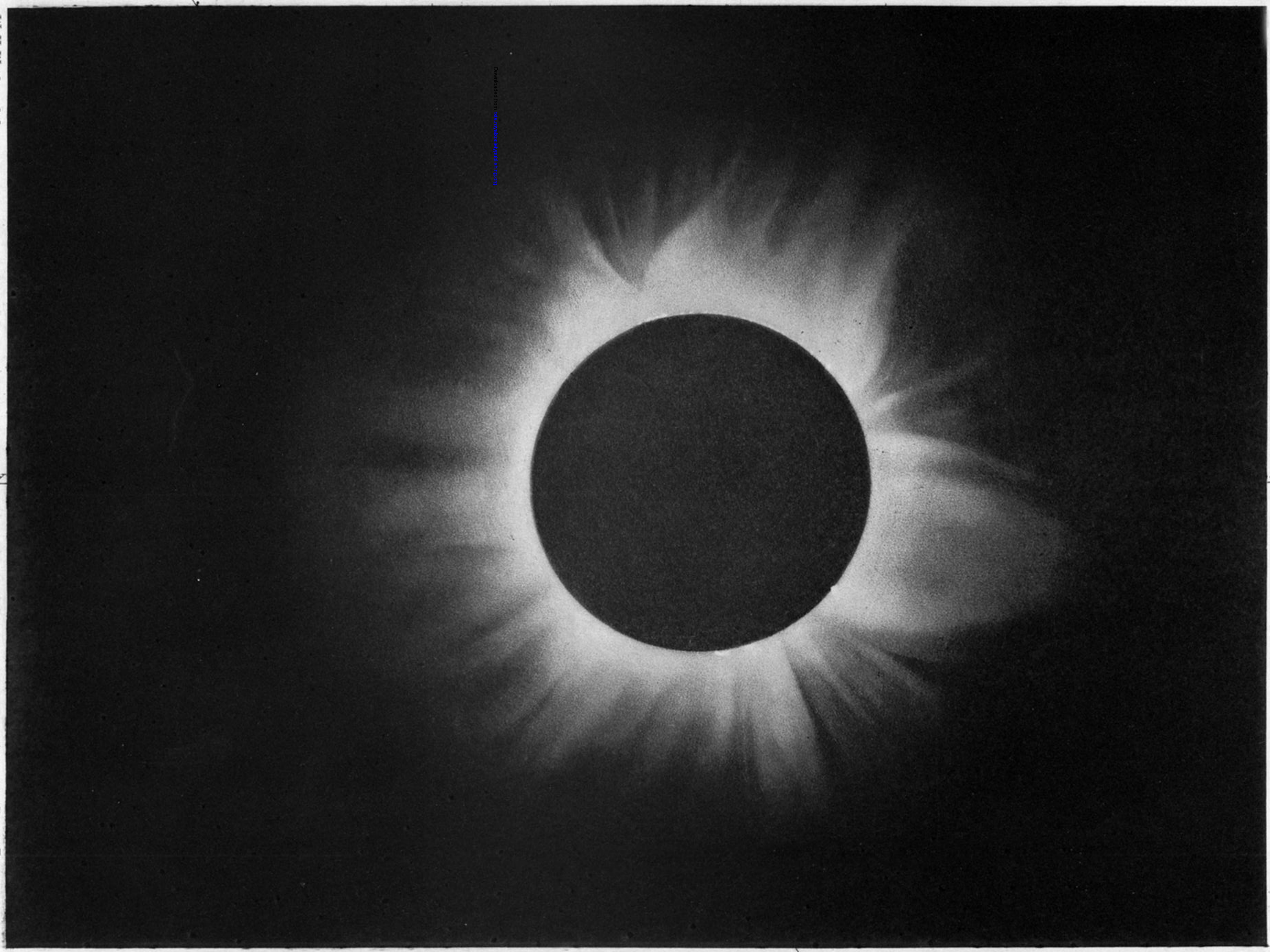
Annan & Swan, Photogravure.

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY A MATHEMATICAL, PHYSICAL & ENGINEERING SCIENCES

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY A MATHEMATICAL, PHYSICAL & ENGINEERING SCIENCES

Fire.

W. H. Wesley, del.



Axis.

Sun's

Annan & Swan, Photogravure.

W. H. Wesley. del.

Annan & Swan. Photogravure.