

# Preliminary Report on the Results Obtained with the Prismatic Cameras during the Total Eclipse of the Sun, April 16, 1893

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XI. *Preliminary Report on the Results obtained with the Prismatic Cameras during the Total Eclipse of the Sun, April 16, 1893.*

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[PLATES 9–11.]

DURING the total eclipse of 1871 observations were made by RESPIGHI and myself with spectroscopes deprived of collimators, and a series of rings was seen corresponding to the different rays emitted by the corona and prominences. The phenomena were so distinct that I made arrangements for a repetition of the observations during the eclipse of 1875, and an instrument, which received the name of “prismatic camera,” was arranged to photograph the rings.\* The chief advantage of the instrument is that it combines the functions of a telescope with those of a spectroscope, and gives spectroscopic views of the solar surroundings in each radiation. The object-glass employed on this occasion had an aperture of  $3\frac{3}{4}$  inches and a focal length of 5 feet, while the prism had a refracting angle of 8 degrees. Two photographs were obtained, showing several protuberances in addition to continuous spectrum from the corona.

I again employed this method of observation during the eclipse of 1878, but failed to see the rings, the corona apparently giving only a continuous spectrum.

The method has also been attempted during succeeding eclipses, but on so small a scale that the results obtained have not come up to the expectations raised by my observations of 1871. Subsequent solar investigations, however, confirmed my opinion that this was the best way of studying the lower parts of the sun’s atmosphere, providing an efficient instrument were employed.

As the Solar Physics Committee is now in possession of a prismatic camera of a much larger size than those used during the eclipses in question, I determined to employ it during the eclipse of 1893, the work on photographic stellar spectra at Kensington having given abundant proof of its excellence. The object-glass of this instrument has an aperture of 6 inches, and was corrected for the photographic rays by the Brothers HENRY. The correction is such that it is unnecessary to incline the back of the camera, and hence some of the objections which have been made to the

\* ‘Phil. Trans.,’ 1878, vol. 169, p. 139.

use of this form of spectroscope are overcome. The large refracting angle of the prism employed ( $45^\circ$ ) obviously increases the value of the instrument for eclipse work. This instrument was placed at the disposal of the Eclipse Committee by the Solar Physics Committee, and was entrusted to Mr. FOWLER, who took the photographs at the African station.

It also seemed important that a series of similar photographs should be taken at another point on the line of totality, even though an equally efficient instrument were not available. A spectroscope belonging to the Astronomical Laboratory of the Royal College of Science was lent for the purpose by the Science and Art Department, and a siderostat used in conjunction with it was lent by the Royal Society. These instruments formed part of the equipment of the Brazilian expedition, and were placed in charge of Mr. SHACKLETON, Computer to the Solar Physics Committee.

The stations chosen were Fundium, on the Salum River, West Africa, and Para Curu, Brazil. The weather was fortunately favourable at both places.

The preliminary reports of work done at the stations named, by Mr. FOWLER and Mr. SHACKLETON respectively, are appended; the object of these being to indicate the kind of results obtained. The complete discussion of the results, which will occupy some time, will form the subject of a future communication.

#### (1.) AFRICAN OBSERVATIONS.

The prismatic camera employed at the African station had an aperture of 6 inches, the refracting angle of the prism being  $45^\circ$ . Spectra photographed with this instrument are 2 inches long from F to K, and rings corresponding to the inner corona are about seven-eighths of an inch in diameter.

As very little idea could be formed of the exposures required, a series of four different exposures was repeated three times during totality, a specially long one being given near mid-eclipse.

A complete list of the photographs taken is given in the appended table. Column 1 contains reference numbers to the photographic plates; column 2 the brand of plate employed; column 3 the times of beginning and ending each exposure, as recorded by a deck-watch; and column 4 the amounts of exposure, "Inst." indicating an exposure given as quickly as possible by hand.

There is a little uncertainty as to the exact time of commencement of totality, but there is reason to believe that it occurred at about 2h. 23m. 53secs. by the watch.

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TABLE of Exposures.

No.	Kind of plate.	Times by deck watch.			Exposure.	Remarks.
		h.	m.	secs.		
1	EDWARDS, Isoch.	2	17	20	Inst.	About 6½ mins. before totality.
2	"	2	17	50-52	2 secs.	" 6 " "
3	"	2	18	21-29	8 secs.	" 5½ " "
4	"	2	18	55	Inst.	" 5 " "
5	"	2	20	55	Inst.	" 3 " "
6	"	2	23	19	Inst.	" ½ " "
7	MAWSON	2	23	58	Inst.	First photo during totality.
8	"	2	24	0	Inst.	
9	"	2	24	6-11	5 secs.	
10	"	2	24	21-46	25 secs.	
11	"	2	24	48-58	10 secs.	
12	"	2	25	2	Inst.	
13	"	2	25	14-19	5 secs.	
14	"	2	25	24-49	25 secs.	
15	"	2	25	51-61	10 secs.	About mid-eclipse.
16	EDWARDS, Isoch.	2	26	10	Inst.	
17	"	2	26	12-52	40 secs.	
18	"	2	26	55-60	5 secs.	
19	MAWSON	2	27	10-35	25 secs.	
20	"	2	27	38-48	10 secs.	
21	"	2	27	50	Inst.	Last photo in totality.
22	Ilford, Isoch.	2	28	3-8	5 secs.	After totality.
23	"	2	28	10	Inst.	"
24	"	2	28	11	Inst.	"
25	Ilford, Special.	2	28	41-49	8 secs.	"
26	"	2	29	41-43	2 secs.	"
27	"	2	30	42	Inst.	"
28	EDWARDS, Isoch.	2	31	42-50	8 secs.	"
29	"	2	32	42-44	2 secs.	"
30	"	2	33	42	Inst.	"

Eleven of the plates were developed in Africa, but the remaining nineteen were brought to England and developed in the Laboratory at South Kensington.

## DESCRIPTION OF PLATES 9 and 10.

For the information of those specially interested, seven typical photographs are reproduced in Plates 9 and 10, the scale being twice that of the original negatives. A small amount of detail, particularly in the extreme ultra-violet, and in the region about G in some of the photos, is lost in the reproductions.

The principal lines, or rather portions of circles, are those of hydrogen, and the H and K lines of calcium. In Plate 9, the F line is on the extreme right, while the two prominent lines near the violet end are H and K. The same lines will be readily identified in Plate 10. The orientation of the rings will be gathered from fig. 1 in the report on the Brazilian observations.

No. 7 (Plate 9) was taken very shortly after the commencement of totality, the exposure being "instantaneous." At this phase of the eclipse a considerable arc of the chromosphere was visible, and its spectrum is therefore shown in addition to the spectrum of the higher reaches of some of the large prominences extending beyond the moon's limb. It will be seen that at H and K there are almost complete circles of chromosphere and prominences, the absent portions being of course obscured by the moon. One very small prominence is especially rich in lines, including some of iron and manganese.

No. 9 (Plate 10) was taken about 8 seconds later with an exposure of 5 seconds. Practically all the chromosphere is now covered by the moon so that only the spectra of prominences and corona are visible. With the increased exposure the ultra-violet spectrum is considerably extended, and the spectrum of one of the prominences reaches as far as *b* in the green. The continuous spectrum of the corona is also more strongly represented in this photograph. In this photograph the spectrum trailed slightly at right angles to its length owing to a defect in the driving screw of the telescope.

Nos. 12 and 16 (Plate 9) were taken at later stages with instantaneous exposures. They differ from the others only in point of phase.

No. 17 (Plate 10) was taken on an isochromatic plate with an exposure of 40 seconds. The spectrum extends from the ultra-violet to the less refrangible side of D, D<sub>3</sub> being a well-marked line. The characteristic coronal radiation at  $\lambda$  5315.95 (1474 K) is represented by portions of a well-defined ring at that wave-length.

No. 21 (Plate 9) was taken shortly before the end of totality, a portion of the chromosphere being again visible in addition to numerous prominences. It will be seen that one of the smallest prominences is rich in lines and closely resembles that which appears in No. 7.

No. 22 (Plate 10) was taken immediately after totality, the exposure being about 5 seconds.

Six of the photographs taken out of totality show bright lines in the same way, but the remainder show only the Fraunhofer lines, the thin crescent of the sun then visible acting as a curved slit. The latter plates will be of value, however, as comparison spectra for the final reductions.

A word of caution is necessary with regard to the ill-defined broad ring, a little more refrangible than D, which is seen in photograph No. 17. Experiments made since the eclipse indicate that this particular ring, and possibly other less distinct ones which are more refrangible, may be produced by a purely continuous spectrum. The isochromatic plates employed have two well-marked maxima of photographic action, one at a point a little more refrangible than D, and another about G; this appears to explain the origin of the rings in question.



## (2.) BRAZILIAN OBSERVATIONS.

The prismatic camera employed in Brazil was one of 3 inches aperture. The light from the sun was reflected on to the prisms from the mirror of a siderostat. The object glass was a Dallmeyer doublet of 19 inches equivalent focal length; the image of the inner corona, therefore, is a ring of 0·2 inch diameter.

Before the doublet were placed two prisms of 3 inches clear aperture, with their refracting edges perpendicular to the horizontal, each having a refractive angle of  $60^\circ$ . The length of the spectrum given by this combination was 1·65 inches from F to K, or 2·5 inches from  $D_3$  to K. Three specially constructed dark slides, carrying eight plates each ( $4\frac{1}{4}$  in.  $\times$   $1\frac{5}{8}$  in.), were employed, the change from plate to plate being effected by means of a rack and pinion attached to the dark slides. A complete list of the photographs taken is given in the following table :—

TABLE of Exposures.

No.	Kind of plate.	Exposure.	Interval of change.	Remarks.
1	Mawson . . . . .	Inst.	$1\frac{1}{2}$ mins.	About $1\frac{1}{2}$ mins. before totality.
2	" . . . . .	2 secs.	2 secs.	Commencement of totality.
3	" . . . . .	8 "	2 "	
4	" (Stellar) . . . . .	Inst.	2 "	
5	" " . . . . .	" "	2 "	
6	" . . . . .	5 secs.	2 "	
7	" . . . . .	30 "	2 "	
8	" . . . . .	15 "	8 "	
9	" (Stellar) . . . . .	Inst.	2 "	
10	Isochromatic (EDWARDS') . . . . .	5 secs.	2 "	
11	" " . . . . .	30 "	2 "	
12	" " . . . . .	60 "	2 "	Middle of eclipse.
13	" " . . . . .	Inst.	2 "	
14	" " . . . . .	30 secs.	2 "	
15	" " . . . . .	5 "	2 "	
16	Mawson . . . . .	30 "	10 "	
17	" . . . . .	15 "	2 "	
18	" (Stellar) . . . . .	Inst.	2 "	Last photo in totality.
19	" " . . . . .	5 secs.	2 "	After totality.
20	" " . . . . .	Inst.	5 "	" "
21	" " . . . . .	" "	10 "	" "
22	" . . . . .	8 secs.	20 "	" "
23	" . . . . .	Inst.	2 "	" "
24	" . . . . .	" "	" "	" "

The exposures were made by means of a shutter, which could be closed and opened from the camera end with a cord; when this was done as rapidly as possible the exposure is tabulated as instantaneous.

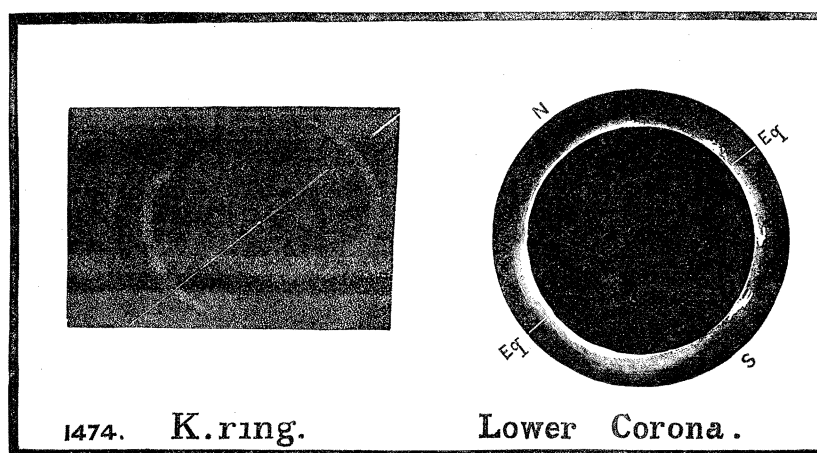
The sun was observed through a finder fixed on the camera, until it was seen that totality was very near commencement. The exposures were then begun.

At the beginning of the second exposure the signal that totality had commenced was given.

Between the sixteenth and seventeenth exposures, on a change of slides being made, two apparently complete rings were observed on the ground glass screen of the camera; they were coloured green and yellow, and probably correspond to the 1474 K and  $D_3$  lines.

Fig. 1 shows an enlargement of the 1474 K ring (from photograph Number 12) placed alongside a reduced copy of the corona from a photograph taken by SCHAEPPERLE in Chili. This particular one has been selected, because the exposure was short enough to make the lower corona thus obtained comparable with the spectrum ring at 1474 K.

Fig. 1.



Comparison of the 1474 K spectrum ring with the lower corona.

On comparison it will be seen that the prismatic camera has picked out the brightest parts of the corona, and where it is strongest, the spectrum ring and the continuous spectrum at those points is most intense, whilst a prominence occurring at any part of the sun's limb does not alter the intensity of the ring at the corresponding part.

Six of the photographs are reproduced in Plate 11, on a scale of three times that of the original negative.

The numbers correspond to those given in the first column of the "Table of Exposures." The parts of circles photographed are chiefly K.H.h. G and F.

#### DESCRIPTION OF PLATE 11.

No. 2 was taken as near the commencement of totality as could be estimated, and was probably exposed when the moon had just covered the photosphere. The exposure was very short, but still long enough to over-expose the plate between F and K. Beyond K at one end numerous ultra-violet lines are shown; while beyond F at the other several bright lines are discernible as far as *b*, which probably is registered as two bright lines.

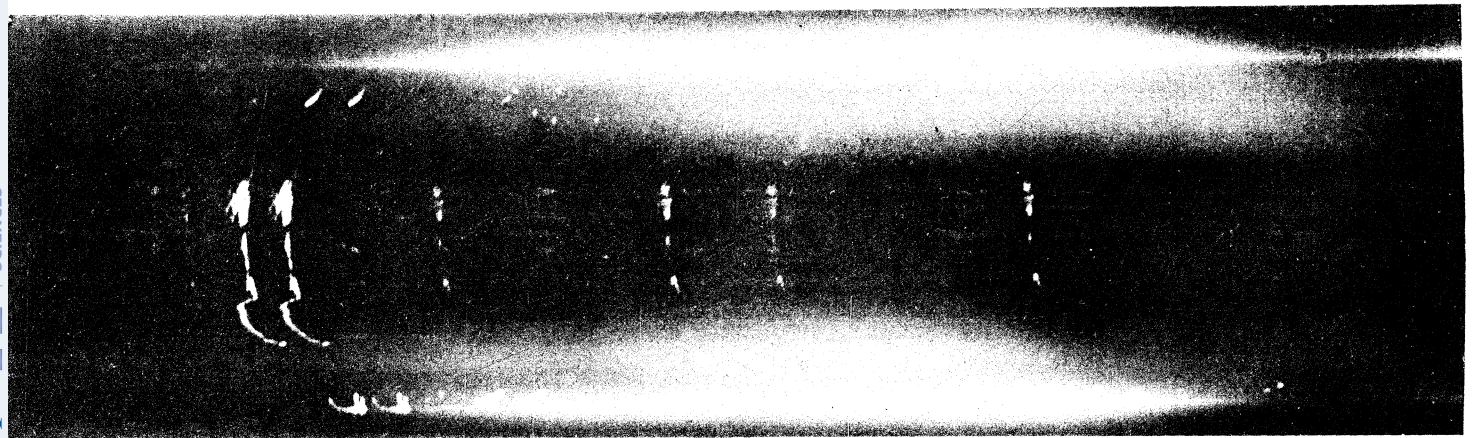
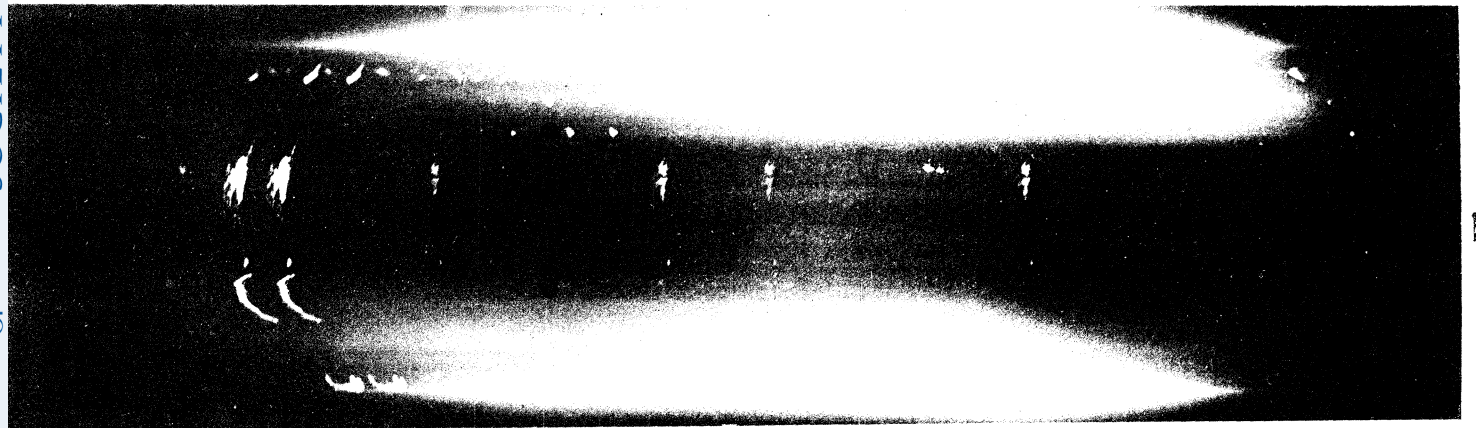
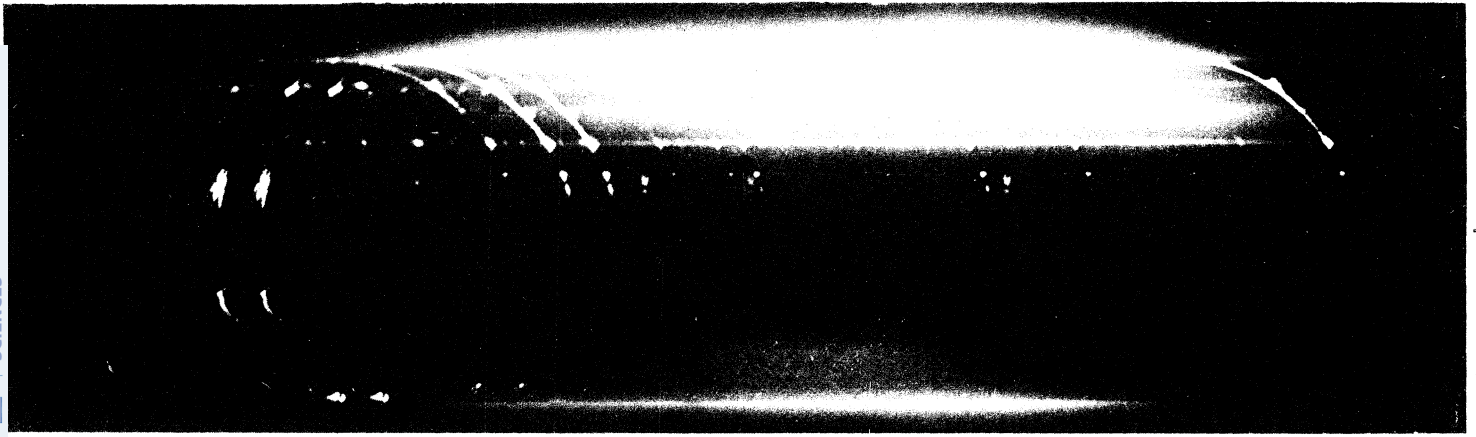
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Nos. 4 and 5 were taken at a later phase and show semicircles corresponding to the principal hydrogen and calcium lines.

Nos. 11 and 12 are photographs taken near mid-eclipse on isochromatic plates with exposures of 30 and 60 seconds respectively. Besides the arcs shown in Nos. 4 and 5 a complete ring is seen on the less refrangible side of  $b$  corresponding to the 1474 K line. Still further towards the red are several bright points, marking the position of the  $D_3$  ring, but this and those of hydrogen and calcium differ from that of 1474 K in being made up of points, whilst the latter is nearly complete. The continuous spectrum is also very marked in these photographs, as it is also in others of long exposure.

No. 18 was taken just before totality ended, and a large arc of the chromosphere is shown.

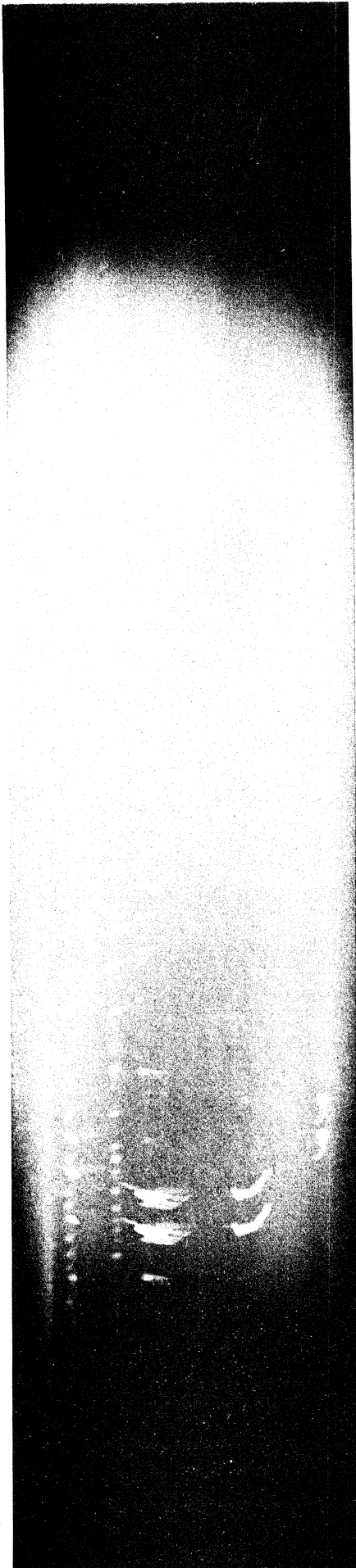




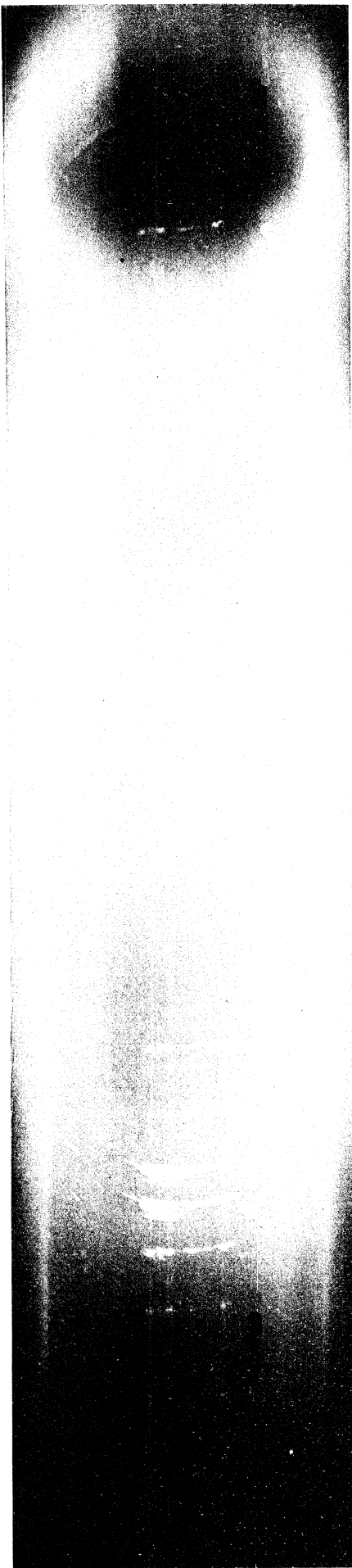


*Lockyer.*

9



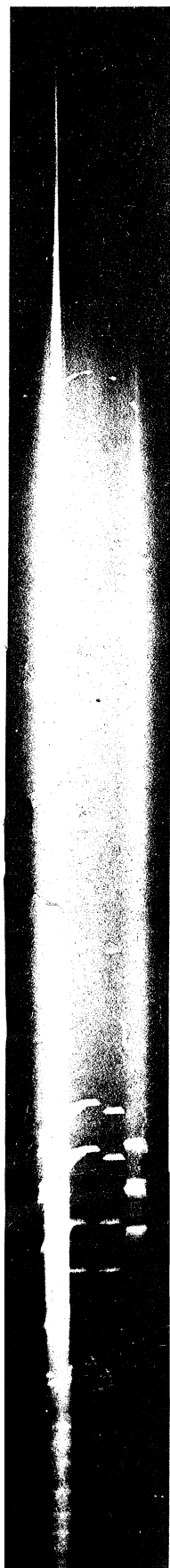
17



*Phil. Trans. 1894. A. Plate, 10.*

22

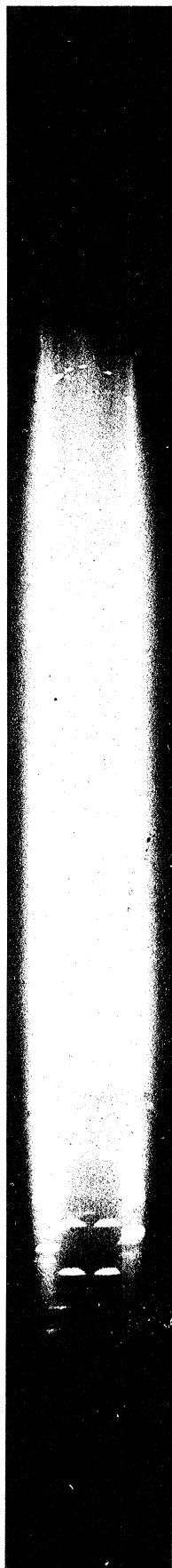




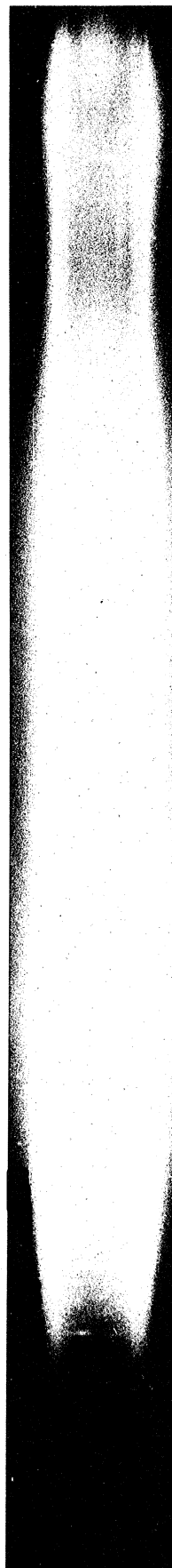
2



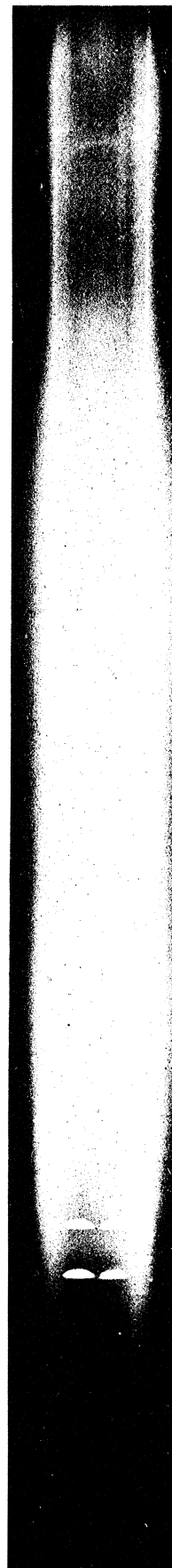
4



5



11



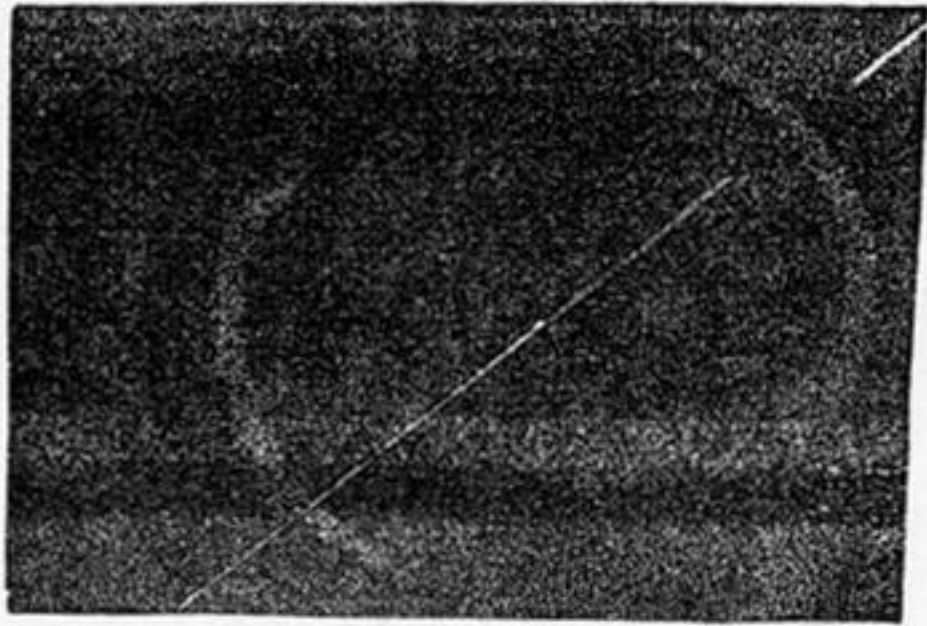
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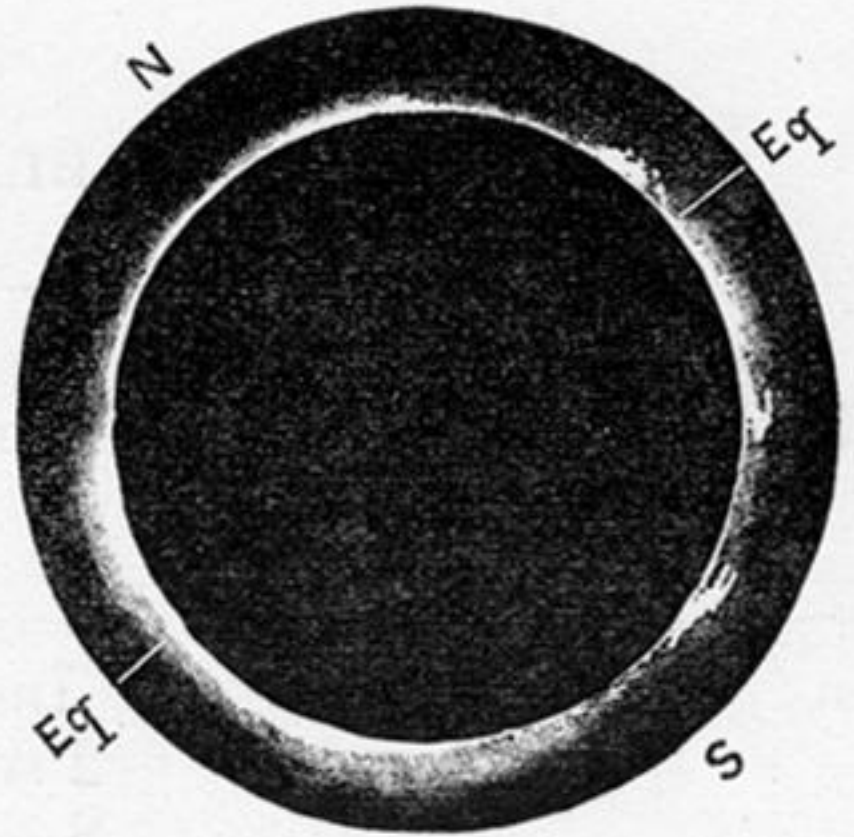
18



Fig. 1.



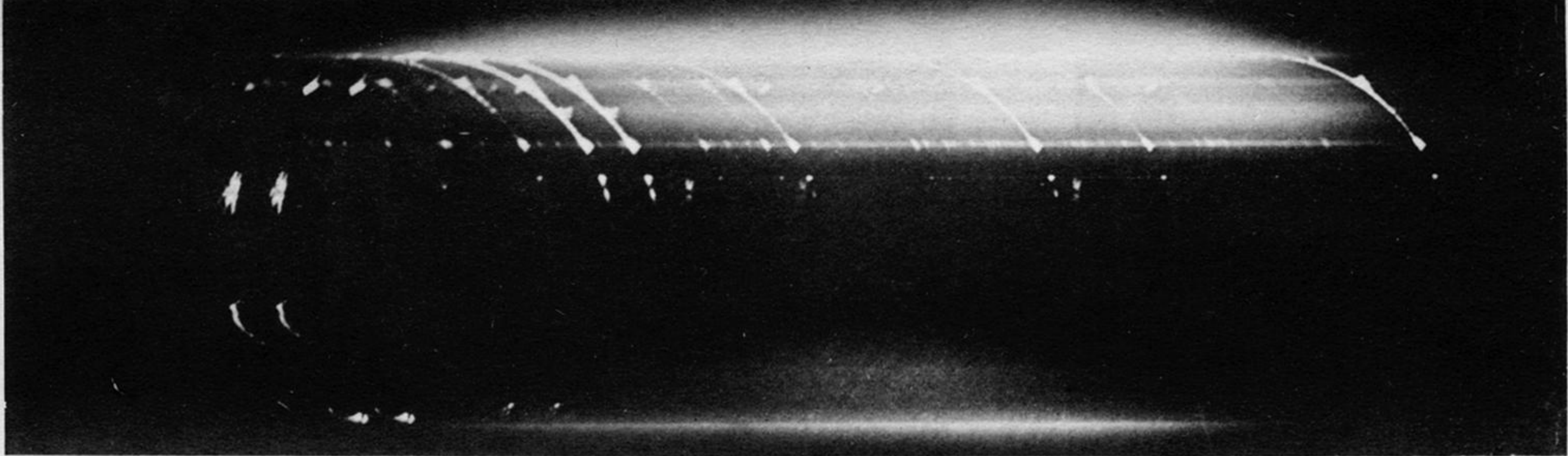
1474. K.ring.



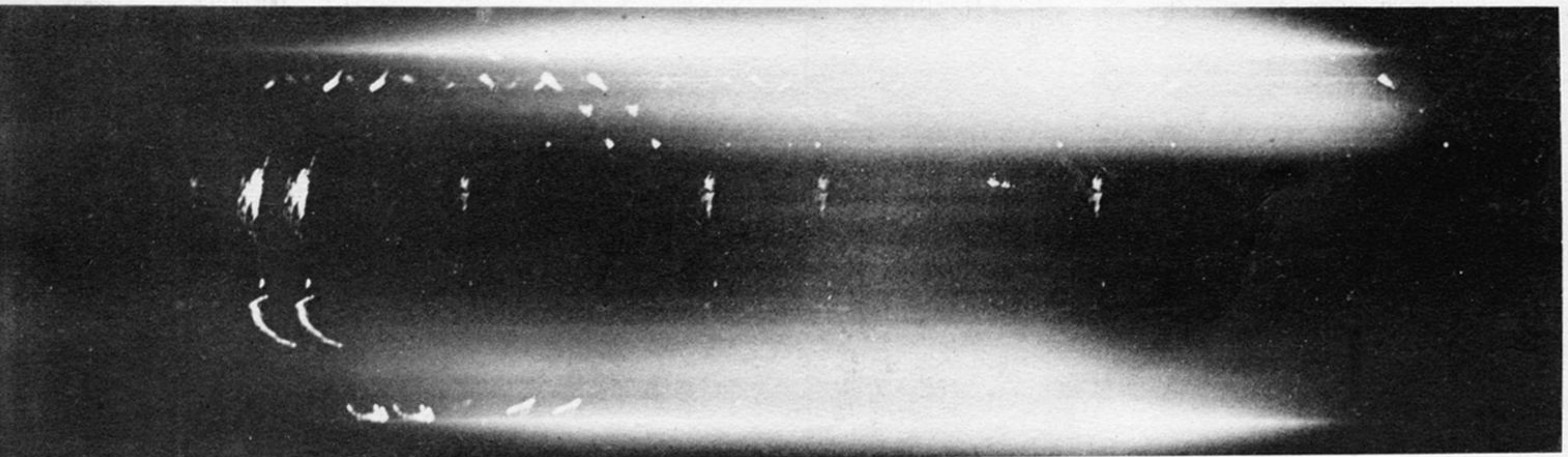
Lower Corona.

Comparison of the 1474 K spectrum ring with the lower corona.

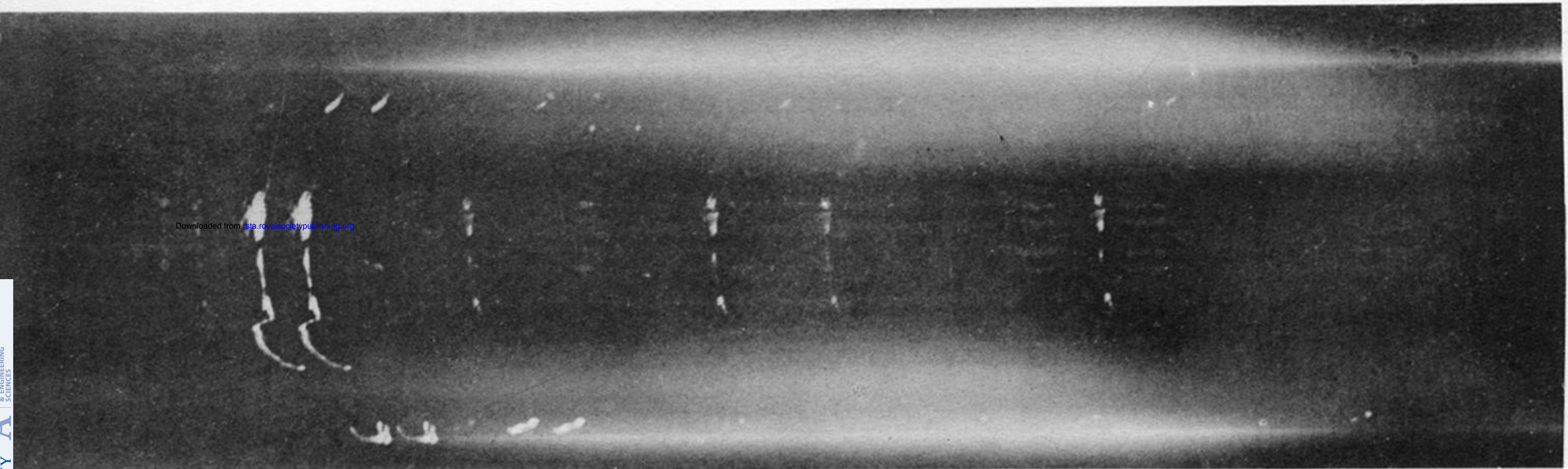




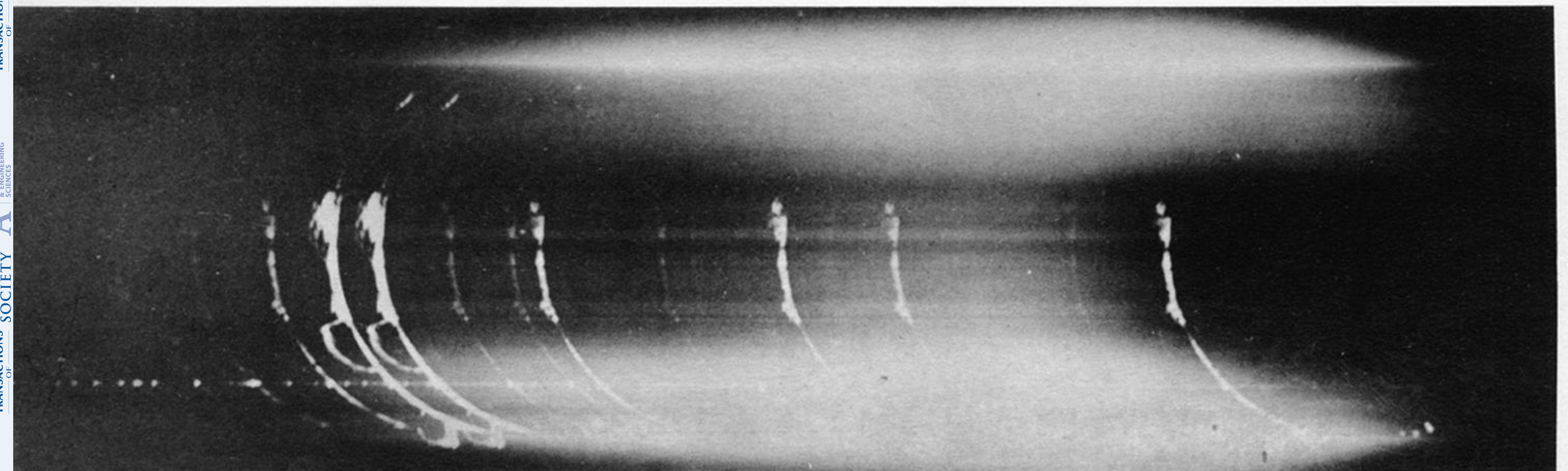
7



12



16

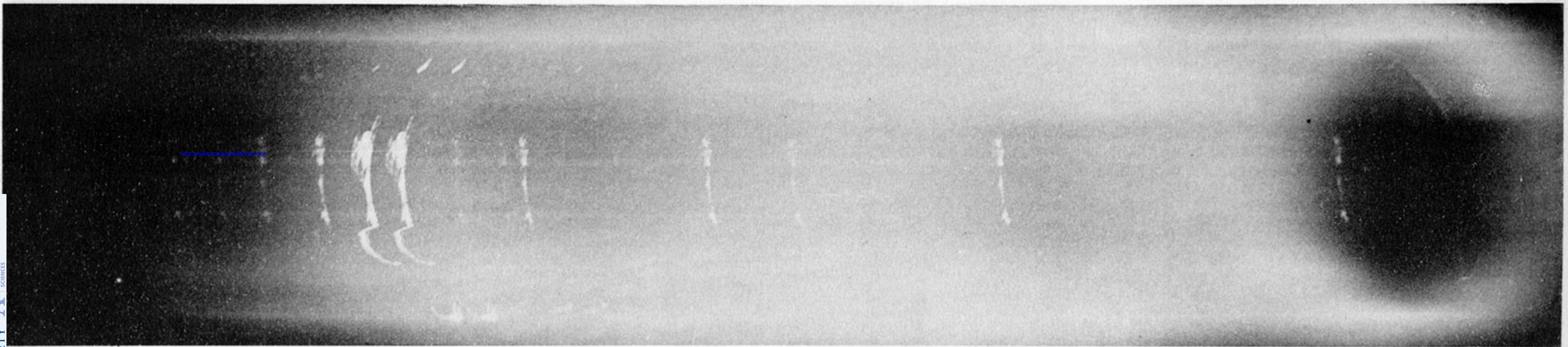


21

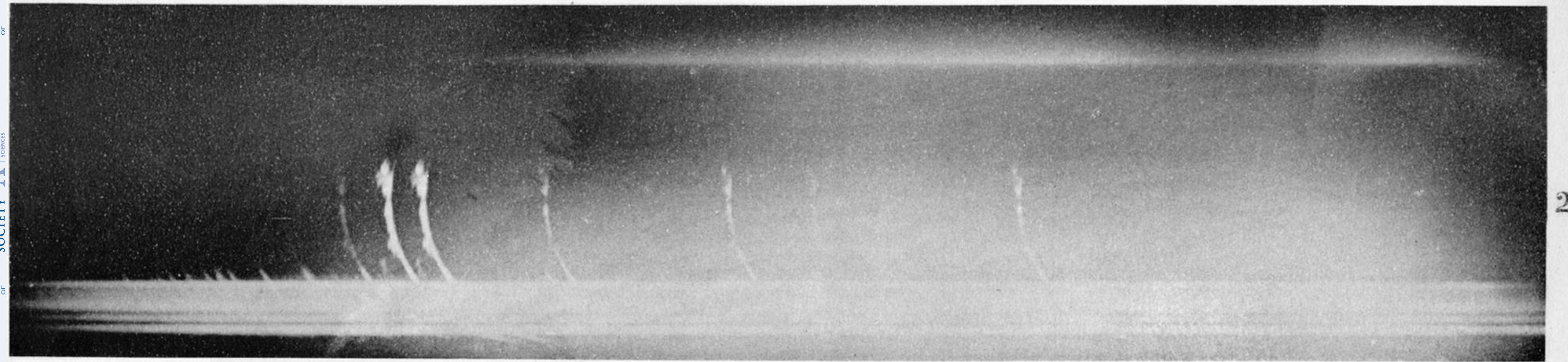




9



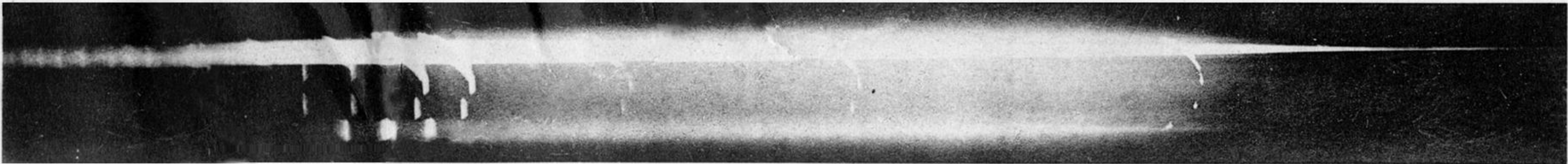
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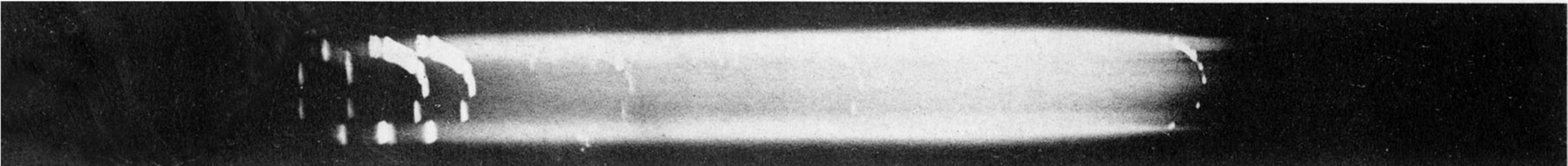
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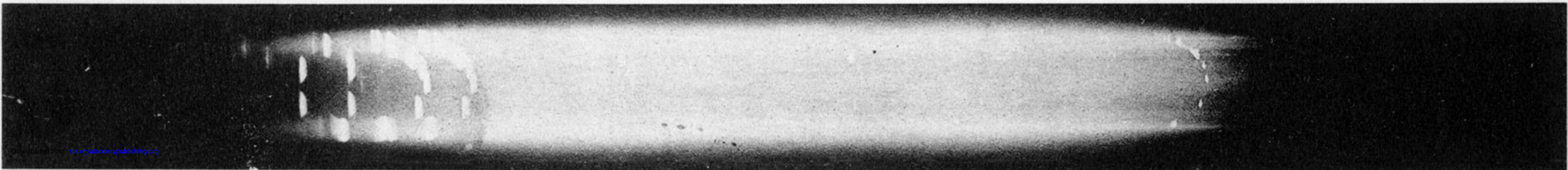
2



4



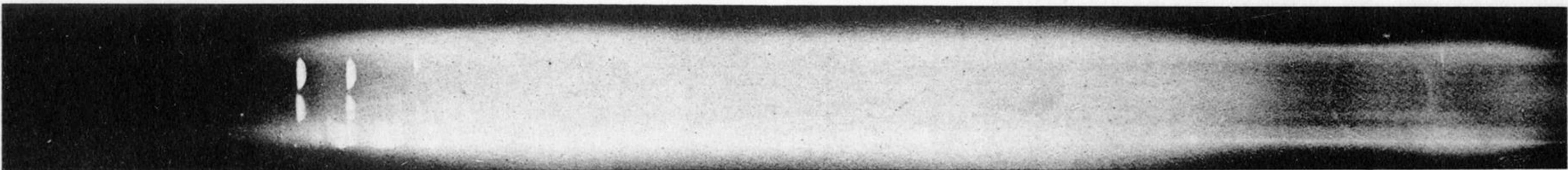
5



11



12



18

