SOME RESULTS REGARDING HEIGHT AND SPECTRA OF AURORAE OVER SOUTHERN NORWAY DURING 1936

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Chapter I. General Remarks.

1. Introduction.

Parallel to the approaching of maximum solar activity, the frequency of large and interesting aurorae has been increasing of late years. Thanks to a net of well-equipped photographic aurora-stations in southern Norway, my assistants and I have succeeded in getting very considerable and most instructive material of simultaneous aurora pictures for measuring the height, and a series of very interesting spectra.

As the complete working up of the mass of material will take a very long time, we have in this paper first selected some of the most illuminating cases of the year 1936.

2. Stations and Instruments.

During 1936 the following aurora stations have been in action:

1° Oslo Observatory (C), double station.
2° Oscarsborg (O).
3° Tømte (T).
4° Kongsberg (K_4).
5° Lillehammer (Li).
6° Trondheim (N).
7° Gaustafjell (G).
8° Darbu (Da).
9° Aas (A).
10° Vestfossen (V).

The stations Da, A and E have successively been in action, because the head of the stations, Mr. Olaf Hassel, has moved with the photographic equipment from one place to another.

Of the stations, the 6 first have been in telephonic connection during the work. At the station (G), the summit of Gausta mountain at 1845 meters over sea-level, the weather conditions were so bad, that the station has been moved to Tuddal (Tu). Further, a new station has been organized at Askim (Ak).

The photographic equipment at the stations was:

C: 2 cameras with Astrolens[1] RK, ratio focal distance to diameter of diaphragm equal to 1.25 (F 1.25), one camera with Ernostar (F 2) and one Leica camera (F 2); further, 3 small spectrographs.
O, T, K_4, Li, N: Each station an Astrolens-camera.
The other stations: At each, a camera with the old lens Ernostigmat (F 2).

The geographical situations of the stations were as follows:

Station	Latitude North	Longitude E. Grw.	Height over sea level
1° C and[2] C* ...	59° 54′ 44″	10° 43′ 24″	33 m
2° O..........	59 40 22	10 36 49	25 »
3° T..........	60 17 39	11 4 7	290 »
4° K_4..........	59 40 18	9 39 28	165 »
5° Li..........	61 5 47	10 30 11	350 »
6° N..........	63 25 1	10 24 32	70 »
7° G..........	59 51 0	8 39 36	1845 »
8° Da..........	59 41 57	9 48 16	55 »
9° A..........	59 39 57	10 46 17	94 »
10° V..........	59 43 44	9 53 5	30 »

On Fig. 1 the situations of the principal stations are seen.

[1] Carl Størmer: Progress in the Photography of the Aurora Borealis. Terr. Magn. and Atmosph. Electricity, December 1932.

[2] C is on the western, C* on the eastern side of the roof of the old observatory in Oslo.

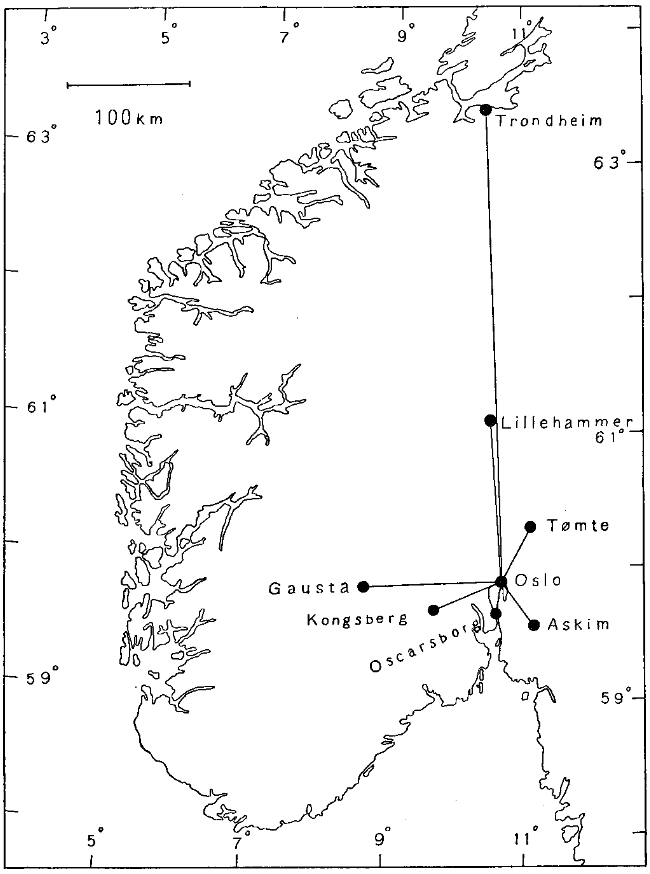

Fig. 1.

The lengths of the base lines used, were, to the nearest 50 meters:

Base-line	Length	Base-line	Length
C—O	27.35 km	O —T.......	73.75 km
C—T	46.70 »	O —K_4......	53.80 »
C—K_4	65.50 »	O —Li	158.65 »
C—Li	132.65 »	O —N.......	417.55 »
C—N.........	390.80 »	K_4—Li	165.35 »
T—K_4	104.95 »	K_4—N	419.40 »
T—Li	94.50 »	Li—N.......	258.75 »
T—N.........	349.85 »		

3. The Aurorae Photographed in 1936.

During the period in question the following aurora-pictures were taken: (See below).

Date		Stations in action	Number of successful photographs	Usable sets for height measuring
January	18—19	Da	27	-
—	24—25	C, O, K_4, Li, Da	283	86
February	2— 3	N	4	-
—	26—27	N	2	-
March	18—19	Da	6	-
—	22—23	G	3	-
—	24—25	N	56	-
—	27—28	C, K_4, T, Li, G	204	61
April	20—21	C, C', O, K_4, T, Li, V	319	105
—	21—22	C, O, K_4, T, N, V	119	48
September	12—13	A	10	-
—	26—27	C, T, K_4, Li	52	24
October	5— 6	A	38	-
—	7— 8	A	5	-
—	8— 9	A	1	-
—	15—16	V	23	-
—	16—17	C, O, T, K_4, Li, V	715	200
—	20—21	C, V, G	29	-
—	24—25	C, K_4, Li, N	124	41
November	3— 4	C, O, T, Li, A	221	56
—	10—11	A, G	68	-
—	11—12	G	25	-
			2334	621

that is, in all, 2334 pictures succeeded. Among these, the following numbers of sets could be used for determining height and situation:

Sets simultaneously from	2	stations	334
—»—	3	»	243
—»—	4	»	44

that is, a total of 621 sets.

Some results from the aurorae on January 24—25, March 24—25, April 20—21, 21—22 and October 16—17 have already been published.[1]

In this paper, some selected sets from April 20—21, 21—22 and October 16—17, 1936 will be considered in detail. These sets were chosen as being probably the most interesting. It is however possible that very interesting sets can still be found in the very extensive material collected; it is in fact often difficult to judge from the photographs alone what results they may give, when we go on to measure them.

In Table I at the end of the paper, a detailed list of all the successful photographs taken on these days is given. The headings have the following meaning:

P. N. is the current number of the picture.

St are stations from which the aurora was photographed. When the stations are connected by lines, like C—O—K_4, this means that the simultaneous pictures from these stations can be used for height measuring.

MET is the Central European Time for the middle of the exposure. (MET noon equal to 11^h Greenwich Time).

[1] Carl Størmer: Remarkable Aurora Forms from Southern Norway, II. Some arcs and bands with ray structure. Geofysiske Publikasjoner Vol. XI, No. 12, and Altitudes and Spectra of Red and Sunlit Aurora. Nature Vol. 139, p. 584, April 3, 1937.

Ex is exposure in seconds.

Fm is aurora form according to the Photographic Atlas of Aurora forms, published by the International Geodetic and Geophysical Union, Oslo 1930. It is to be observed that the choice of forms is sometimes rather difficult because the different forms merge into each other, and because forms sometimes occur which are not represented exactly in the Atlas.

Ref. Const. is the constellations in which the aurora occurs. The abbreviations are those adopted at the International Astronomical Congress in Rome 1922.

N is the number of aurora points calculated in the case where height and situation are found.

Finally, under the heading *Remarks*, some observations useful for the list are given.

In Table II the results of the measurements of the plates are given. As to the meaning of the headings ζ, ε_1, ε_2, H_1 and T see sections 6 and 7; p is the parallax, H the height and D the distance from the main station to the projection of the aurora point. In the heading "Base" the main station is always put on the first place. All angles are given in degrees, all lenghts in km.

4. Some Remarks regarding Work and Assistants at the Different Stations.

For orientation we give here a list of the work and the assistants at the different stations:

April 20—21, 1936.

The work lasted from 22^h—3^h at the following stations, all connected by telephone lines:

C and C*: Tveter, Anda, Herlofson, Miss Ording, Leiv Rosseland, Hetland and myself.

O: Bakøy.

T: Albert and Egil Tømte.

K_4: Oddleiv Busengdal.

Li: Ole Høstmælingen.

The cameras at all stations were the standard cameras from the Polar Year with lens Astro RK, F 1.25. Plates were Sonja EW from Herzog, Bremen.

Working independently of these stations was station:

V: Olaf Hassel with a similar camera with Ernemann lens (F 2) and Sonja plates.

April 21—22, 1936.

The work lasted from 22^h—3^h, with the following stations connected by telephone lines:

C: Tveter, Anda, Herlofson, Leiv Rosseland, Hetland, myself.

O: Bakøy.

T: Albert and Egil Tømte.

K_4: Oddleiv Busengdal.

N: Westin and Presterud.

Astro cameras were in use at all these stations, and at C, moreover, a Leica-camera with Superpan film. Plates Sonja EW. We also used at station C some small spectrographs which will be mentioned later.

Working independently was station:

V: Olaf Hassel, with the same camera and plates as the night before.

October 16—17, 1936.

The work lasted from 19^h to $5^h 40^m$, with the following stations connected by telephone lines:

C: Tveter, Anda, Herlofson, Hetland, myself, and as guest Dr. Martin Schwarzschild.

O: Bakøy.

K_4: Oddleiv Busengdal.

T: Albert and Egil Tømte.

Li: Høstmælingen.

Same cameras, plates and spectrographs as before.

Further, working independently:

V: Olaf Hassel, with equipment as before.

The development of the aurorae these nights will be mentioned under the results of the height measurements.

Chapter II. Improved Methods for Measurement and Calculation of Aurora-plates.

5. Improvements in the Measurements of the Plates.

Since the latest reports on the methods used were published[1], a series of very time-saving im-

[1] Carl Størmer: Bericht über eine Expedition nach Bossekop etc. Vid. Skr. 1911, Oslo. Rapport sur une expédition d'aurores boréales à Bossekop et Store Korsnes pendant le printemps de l'année 1913, Geof. Publ. Vol. I, No. 5, Oslo. Résultats des mésures photogrammétriques des aurores boréales observées dans la Norvège méridionale de 1911 à 1922, Geof. Publ. Vol. IV, No. 7. Height and Velocity of Luminous Night-clouds observed in Norway 1932, published by Det Norske Videnskaps-Akademi i Oslo, 1933, No. 2.

L. Vegard and O. Krogness: The position in Space of the Aurora Polaris from Observations made at the Haldde Observatory 1913—1914, Geof. Publ. Vol. I, No. 1.

Leiv Harang and Einar Tønsberg: Investigations of the Aurora Borealis at Nordlysobservatoriet, Tromsø 1929—1930, Geof. Publ. Vol. IX, No. 5.

provements has been introduced which might be very useful for similar work at stations where aurora photographs are taken.

First, two identical projection lanterns are simultaneously in use when sketches are being made of pairs of aurora photographs, taken simultaneously from two ends of a base line. In this manner it is easy to find corresponding parts of the aurora by comparing the projected negatives.

For increasing the contrasts of the projected image, we have found that the use of art paper is to be recommended. To identify the stars, the use of the Astro-cameras is most convenient, because the star images not lying near the optical centre generally have the form of small crosses with 4 rays, one pair pointing to the optical centre of the image, the other, normal to that direction. But the most effective means we have is the use of a series of star maps, published under the title: *Stern-Atlas enthaltend alle Sterne bis zur 9ten Größe, sowie die helleren Sternhaufen und Nebel zwischen dem Nordpol und 23° südlicher Deklination für 1855.0 gezeichnet* von Lehrer Max Beyer — Altona, herausgegeben von Prof. Dr. K. Graff, Observator der Hamburger Sternwarte, Hamburg 1925. Als Manuskript gedruckt.

What makes these maps so appropriate is that the scale is 1 degree equal to 1 centimetre, just the scale used in all our graphical work with the sketches.

On these maps, for all stars whose angular distances have been calculated, we have with red pencil connected these stars by lines, and added the names and the mutual distances in degrees.

By projecting the negatives on these maps, the identification of the stars is, in general, very easy and rapid. The scale is rapidly found from the mutual distance of stars near the centre of the picture, or from similar pictures taken before or later on the same plate. Further, on the maps, distances between stars having nearly the same right ascension, are free from deformation and can directly be used to find the right scale of the projected image. In such cases, calculation of mutual distances of stars is unnecessary.

6. Improvements in the Reduction of the Plates for Measuring Height and Situation.

I am indebted to my assistant Mr. Nicolai Herlofson for considerable improvements in the tedious work of finding height and situation from the sketches of the projected pictures. In fact, I asked him if he could possibly use known graphical methods to find the necessary angles for the reference stars because that work has hitherto required extended calculations.[1]

He succeeded in solving this problem, and has at my request given the following account of the graphical determination of the angles and the formulae for the constants of the base lines:

"The principles of the height measurements are unaltered,[2] but the systems of coordinates have been somewhat changed to make them more convenient for graphical calculation.

Consider two auroral stations, the main station A and the secondary station B. The point of intersection between the sky and the base axis A→B we call the positive base pole, the opposite point, the negative base pole. The declination δ_0 and the hour-angle t_0 of the positive base pole seen from A can be computed from the geographical situations of A and B and their heights above the sea-level. The necessary formulae will be given below.

For the height measurements the following four systems of right-angular spherical coordinates are used:

1. Declination and hour-angle at A, (δ, t). t is counted from $-180°$ to $+180°$, positive westwards. $t=0$ in the south.

2. Altitude and azimuth at A, (h, a). a is counted from $-180°$ to $+180°$, and has the same sign as t.

3. $(\delta, t-t_0)$. $t-t_0$ is counted from $-180°$ to $+180°$ like t (Fig. 2).

4. (ε, ζ). The positive base pole is the positive pole of the system. ε is counted from $-90°$ to $+90°$. ζ is counted like $t-t_0$ from $-180°$ to $+180°$, and has the same sign as $t-t_0$. $\zeta=0$ along the semicircle from the positive base pole through the south pole of the sky to the negative base pole (Fig. 3).

It may be noted that the transitions from the the system (δ, t) to (h, a) and from the system $(\delta, t-t_0)$ to (ε, ζ) correspond exactly to each other. In the former case the distance between the poles of the systems is $90°-\varphi$ (co-latitude of the main station A) in the latter it is $90°-\delta_0$.

Corresponding points on two simultaneous auroral pictures have the same value of ζ; the parallax is the difference between the values of ε. The connections between the angles ε, ζ and u, ω previously used are:

$$\varepsilon=90°-u, \quad \zeta=\omega+\text{constant}.$$

[1] I am indebted to Professor Rosseland for his help in drawing our attention to the paper of Prof. Becker, mentioned below.

[2] See references in section 5.

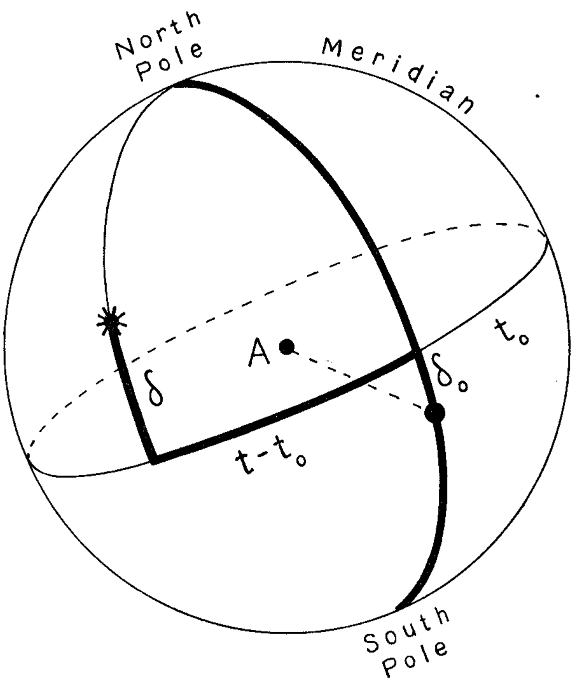

Fig. 2. The system (δ, $t-t_0$).

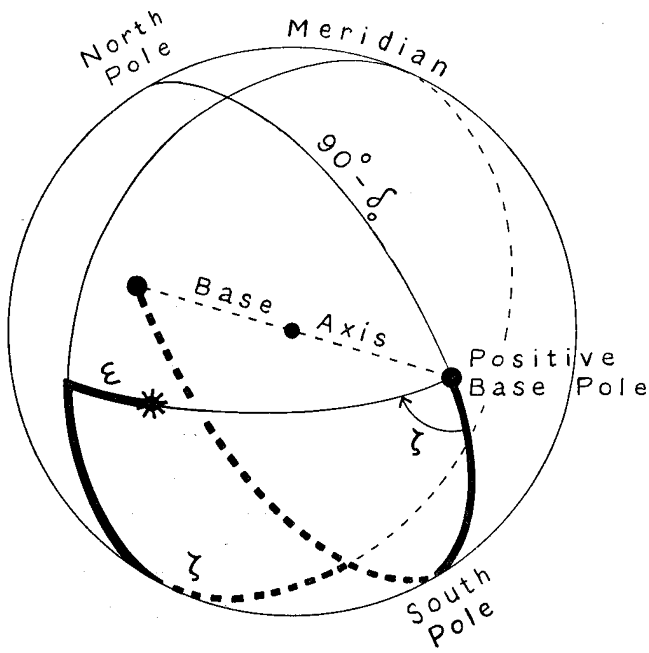

Fig. 3. The system (ε, ζ).

Let the Greenwich Mean Time of the picture be $ab^h\ cd^m\ ef^s$, and the longitude east of Greenwich of the main station A be denoted by λ_0. The sidereal time ϑ at A is computed by calculating machine from the formulae:

Before Grw. mignight:

$\vartheta^\circ =$ Sidereal time at Grw. midnight $+ \lambda_0 - 15^\circ.0411 \cdot 24 + 15^\circ.0411 \cdot \text{ab} + 25^\circ.07 \cdot 0{,}\text{cd} + 42^\circ \cdot 0{,}00\text{ef}$

and after Grw. midnight:

$\vartheta^\circ =$ Sidereal time at Grw. midnight $+ \lambda_0 + 15^\circ.0411 \cdot \text{ab} + 25^\circ.07 \cdot 0{,}\text{cd} + 42^\circ \cdot 0{,}00\text{ef}$.

It is necessary to use decimal pointers. The proof dial should not be cleared during the last three multiplications; then GMT will appear on the proof dial as a control.

Declination and right ascension of the reference stars are found from "Berliner Astronomisches Jahrbuch" and converted into degrees and fractions of degrees.

For the transitions from (δ, t) to (h, a) and from (δ, $t-t_0$) to (ε, ζ) we have introduced a nomogram drawn by L. Becker.[1]

[1] L. Becker: Monthly Not. of the Roy. Astron. Soc. *XCI, No. 2*, 226.

Cf. also E. Hammer: Trigonometrie. Stuttgart 1923. P. 444 and 466.

The nomogram is obtainable in the size 56 × 56 cm by application to: The Director, the Observatory, Dowanhill, Glasgow W. 2, Scotland.

The drawing is very carefully done, and the diagrams give rapidly and easily the angles with an accuracy corresponding to 0°.1 on the sky, i. e. 1 mm on our sketches.

In a letter to Prof. Størmer, Prof. Becker has given some supplementary remarks on the diagrams: "— — — — I am pleased to learn that the paper has so well kept its shape, considering expansions and contractions would happen under different climatic conditions. For this reason I drew reference lines at every fifth degree. All measurements should be made from the nearest reference line as is done on stellar photos on which réseau lines are imprinted. I am sure the values obtained will be got correct to a minute or two. I should suggest the following method instead of employing the celluloid scale.

Use two pairs of compasses (2 Zirkel) and a scale subdividing 5°. Let S_Q be given and $QP = n \cdot 5^\circ + m$.

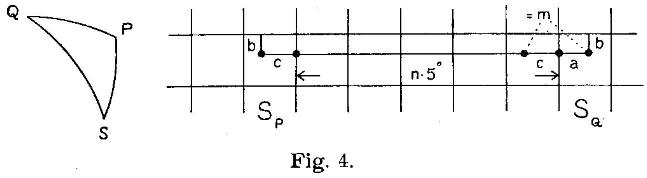

Fig. 4.

Set one pair at distance b; and the other pair at distance m and again at $m - a = c$. The coordinates b and c and the number n of intervals determine S_P. — — — —"

We note that putting the co-latitude equal to $n \cdot 5^\circ + m$ and $90^\circ - \delta_0 = n_1 \cdot 5^\circ + m_1$, the quantities m, m_1, n and n_1 are constants for each base line. It is then practical to mark m and m_1 on a celluloid plate and lay off $n \cdot 5^\circ$ and $n_1 \cdot 5^\circ$ on a slip of card-board with marks for each 5 degrees.

Besides the original black graduations, it is convenient to provide the horizontal dial of the nomogram with a graduation from 0° to —90°, and the vertical one with a graduation from 90° to 180°, for instance with a red pencil.

From Fig. 3 in Becker's paper we then get the following simple rules of work:

When entering the diagram from two dials with graduations of the same colour, we move to the left; entering from dials with different colours, we move to the right. If we run against one of the edges, we continue the movement in the opposite direction. For each reflection at the right edge we change the colour of the v-dial when reading off the result: for each reflection at the left edge we change the colour of tke U-dial when reading off the result. It is unnecessary to pay regard to the signs of t or $t - t_0$ before noting a and ζ; we then give a and ζ the same signs as t and $t - t_0$ respectively.

Numerical example: Consider a base line for which the co-latitude of the main station is $5 \cdot 5^\circ + 4^\circ.7$, $90^\circ - \delta_0 = 12 \cdot 5^\circ + 2^\circ.4$ and $t_0 = 158^\circ.71$. Find h, a, ε and ζ when $\delta = -12^\circ.15$, R. A. = 126°.08 and $\vartheta = 179^\circ.69$.

We find $t = 53^\circ.6$ and $t - t_0 = -105^\circ.1$. We enter the diagram with $\delta = -12^\circ.15$, $t = 53^\circ.6$, move to the right, return from the right edge and stop at $h = 6^\circ.0$, $a = 52^\circ.3$. We entered from the red graduation on the v-dial and black one on the U-dial; the reflection at the right edge changed the colour of the v-dial, and we get the results above. Next we enter the diagram with $\delta = -12^\circ.15$, $|t - t_0| = 105^\circ.1$, move to the left, return from the left edge and stop at $\varepsilon = -18^\circ.9$, $|\zeta| = 85^\circ.8$. $t - t_0$ being negative, we get $\varepsilon = -18^\circ.9$, $\zeta = -85^\circ.8$.

The nets are fitted in direct by means of the angles h, a, ε and ζ, whereby the calculation of the angles k and λ is omitted.[1]

$r = \frac{g}{\sin(\varepsilon_1 - \varepsilon_2)} \cos \varepsilon_2$ is easily found by a slide rule with a sine graduation on the slide; it will only be necessary to note the complementary angles beside the angles of the sine graduation.

[1] L. Harang and E. Tønsberg: Geofysiske Publikasjoner, IX, No. 5.

The systems of coordinates used above make ε and ζ independent of eventual inaccuracies in h and a. On long base lines where it will often be necessary to use separate reference stars at the secondary station, the calculation of the unnecessary angles h and a for these stars is also avoided. On the other hand, we relinquish the simplification of putting the altitude of the base pole $h_0 = 0$ on certain base lines; however, the advantages from this would be almost insignificant when using the graphical method.

For those who intend to use the "artificial stars" of Harang and Tønsberg,[1] the diagrams will be valuable for calculation of the necessary sets of angles.

Following the methods outlined above, the treatment of one pair of photographs requires from 1—1¼ up to 2 hours for especially difficult or comprehensive pictures.

Formulae for the Constants of the Base Lines.

Let the coordinates of the stations be:

	Main station	Secondary station
Latitude	φ_1	φ_2
Longitude	L_1	L_2
Height above sea-level	h_1	h_2

R = radius of the earth.

L is counted positive towards east.

The following formulae are used for calculation on machines:

Introducing

$$v = \sqrt{\cos \varphi_1 \cos \varphi_2 \sin^2 \frac{\Delta L}{2} + \sin^2 \frac{\Delta \varphi}{2}}$$

$$\alpha = \left(\frac{h_2 - h_1}{2 R v}\right)^2 + \left(1 + \frac{h_1}{R}\right)\left(1 + \frac{h_2}{R}\right) - 1$$

$$q = v \sqrt{1 + \alpha} \approx v\left(1 + \frac{\alpha}{2}\right)$$

we get

$$\text{Base line} = 2 R q$$

$$\sin \delta_0 = \frac{\sin \frac{\Delta \varphi}{2}}{q} \cos \frac{\varphi_1 + \varphi_2}{2} + \frac{h_2 \sin \varphi_2 - h_1 \sin \varphi_1}{\text{base line}}$$

[1] L. Harang and E. Tønsberg: Geofysiske Publikasjoner, IX, No. 5.

and if $\beta = \left(1 + \frac{h_1}{R}\right) : \left(1 + \frac{h_2}{R}\right) - 1$, we have

$$\operatorname{cotg} t_0 = \frac{\left(\operatorname{tg} \varphi_2 \cos \frac{\varDelta\varphi}{2} - \sin \frac{\varDelta\varphi}{2}\right)(1+\beta) \sin \frac{\varDelta\varphi}{2} + \frac{\beta}{2} + \sin^2 \frac{\varDelta L}{2}}{\sin \frac{\varDelta L}{2} \cos \frac{\varDelta L}{2}}$$

Here $\varDelta L = L_2 - L_1 \qquad \varDelta\varphi = \varphi_2 - \varphi_1$.

For $\sin \frac{\varDelta L}{2}$, $\sin \frac{\varDelta\varphi}{2}$, β and q, 6—7 decimals will be necessary; for the other quantities 5 decimals are sufficient. We give φ and L to the nearest second, and h to the nearest 10 metres, if possible. For the radius of the earth we use for stations in the southern Norway $R = \sqrt{M \cdot N} = 6388.4$ km, where M and N are the radii of curvature along the meridian and the prime vertical at Oslo".[1]

7. Graphical Method to find the Position of the Earth's Shadow in the Region where the Aurora is Situated.

When preparing the material for the publication of the paper on sunlit aurora rays[2] (1929), I used the following elementary formulae:

$$H_1 = R\left(\frac{1}{\cos h_1^\circ} - 1\right)$$

$$T = \frac{\pi}{180^\circ} R h_1$$

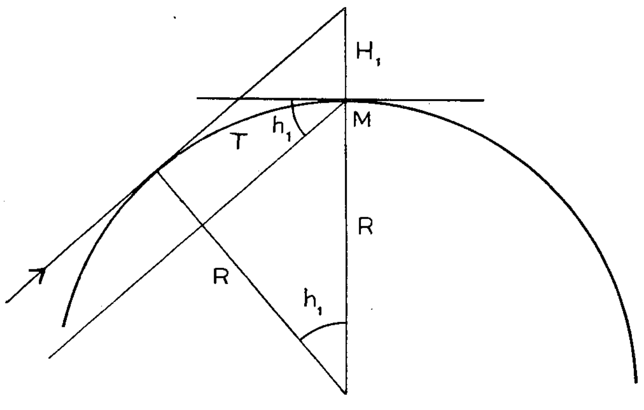

Fig. 5.

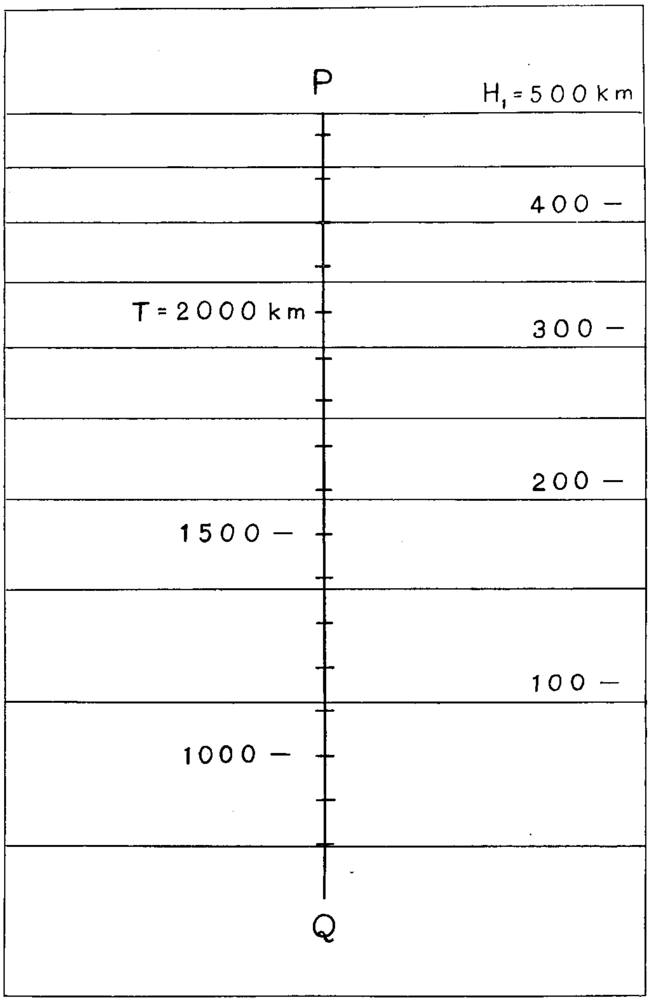

Fig. 6.

Here R is the radius of the earth in kilometers, $h_1^\circ = -h^\circ$ the depression in degrees of the sun under the horizon at the point M (opposite in sign to the altitude h), and H_1 the height of the earth's shadow over the point M. T is the geodetical distance in kilometers from M to the point where the sun-ray is tangent to the earth.

Here no regard is taken to the atmospheric refraction. In fact, for our purpose the effect of refraction is of minor importance.

If refraction is to be taken into account, the ray will be bent corresponding to the mass of air it traverses. For details, see a paper by F. Link.[1]

The formulae given above for H_1 and T are very simple, but when we have to apply them to hundreds of cases, it is preferable to use graphical methods.

[1] Here ends the contribution from Mr. Herlofson.

[2] Carl Størmer: Sonnenbelichtete Nordlichtstrahlen, Zeitschr. f. Geophysik, Vol. 5, 1929.

[1] F. Link: Nouvelles Tables des masses d'air, Journal des Observateurs, Vol. XIII, No. 3, p. 41.

As a control we can also use the well-known tables calculated by Lugeon[1] and his assistants.

Graphical diagrams for this purpose have been constructed as follows:

In the scale (1 : 2 000 000) of our geographical map, used for finding the geographical situation of the aurora, a diagram is drawn on transparent cloth (Fig. 6).

A scale along the middle line gives the values of T, from 760 to 2460 km, and straight lines drawn normal to this scale, give the height H_1 over the earth's surface for each value of T. The values of H_1 go from 45 km to 500 km, at intervals of 5 km.

On a series of other diagrams the values of H_1 corresponding to the station Oslo, are drawn as functions of the time t in minutes after sunset or before sunrise and for different values of the sun's declination δ. On the same diagrams, other curves are drawn, giving the sun's azimuth as function of t and for different values of δ.

By means of these diagrams the graphical procedure is as follows:

At a given date and time of observation, the situation of the projection of the aurora-points is marked on the geographical map.

From an almanac the sunset (or sunrise) in Oslo is found, and from this we get the time t (in minutes) of the observation after sunset (or before sunrise). From the sun's declination and the diagrams, the corresponding values for Oslo of the sun's azimuth and of the height H_1 are taken out.

With these values the diagram on tracing cloth is placed on the map in such a manner that the line for the above found value of H_1 passes over Oslo and the direction PQ points towards the sun, that is, the angle between PQ and the north-south line is equal to the sun's azimuth.

The values of H_1 and T for the aurora-point can then immediately be read off on the diagram.

If the height H_1 is greater than 500 km either at Oslo or at the auroral point in question, the direct formulae must be used.

Experience has shown that the use of these graphical methods is much more rapid than the calculation by formulae. The effect from approximating the curves $H_1 =$ constant and $T =$ constant by straight lines on the tracing cloth, is also insignificant when $H_1 < 500$ km.

[1] Jean Lugeon: Tables crépusculaires donnant l'altitude au zénith des rayons rasants du soleil pour toutes les latitudes de degré en degré, Warszawa 1934.

Chapter III. The Results Obtained on the Selected Nights.

8. The Aurora on April 20—21, 1936.

I saw the aurora this night first from my house at Blindern, near Oslo, as very fine, long rays in the northern part of the sky. The rays, which undoubtedly were sunlit, had the colour white to white-violet often characteristic for such rays. I immediately warned my stations, but before they commenced working, the finest rays had disappeared.

But at Vestfossen, where my assistant Hassel worked independently, the rays were observed and photographed from $22^h\ 10^m$ to $22^h\ 38^m$ (see Table I). At $22^h\ 46^m\ 28^s$ the first photographs could be taken simultaneously from Oslo, Oscarsborg and Lillehammer, and from now on pictures were taken as rapidly as possible throughout the night. Cloud-like aurora was first photographed at $22^h\ 53^m$, and a series of good parallaxes procured. Later, after midnight, sunlit rays were again photographed, mixed up with fine examples of cloud-like aurorae. For details, see Table I at the end of the paper.

Of the considerable material collected, the following pictures are of special interest; they have all been worked out by Mr. Herlofson.

Picture No. 6, sunlit ray, $22^h\ 51^m\ 21^s$ MET.

As seen in Table II, the measured ray stretches from 182 to 440 km over the earth, and was lying over the North Sea to the west of Ålesund.

Picture No. 12, sunlit rays, $22^h\ 56^m\ 01^s$ MET.

These rays were also sunlit, with summits up to 498 and 422 km. The feet were outside the picture, but the rays could be followed down to about 180 km. The rays were situated to the east of Namsos. As the direction was unfavourable to the direction of the base line, the points 5, 6, 7, 8 were omitted. The first 4 points give the best measurements.

Picture No. 17, cloud-like aurora, $23^h\ 01^m\ 40^s$ MET.

This was a characteristic cloud-like form, which can best be judged from the Lillehammer picture. It goes down to about 91 km. The vertical extension of the border near point 1 is about 21 km. The aurora was situated in the dark atmosphere near the Norwegian coast between Bergen and Ålesund.

Picture No. 27, cloud-like aurora, $23^h\ 44^m\ 11^s$ MET. (Plate 9.)

A very good set, giving very exact measurements. Goes down to 92 km. Same situation as No. 17. Thickness in vertical direction about 12 km. In the dark atmosphere.

Picture No. 29, cloud-like aurora, $23^h\ 46^m\ 40^s$ MET.

Also very fine. Goes down to 91 km. The points 7 and 8 along a ray. Lying in the dark atmosphere near Nos. 17 and 27.

*Picture No. 1**, sunlit rays, $0^h\ 14^m\ 15^s$ MET.

These rays had their feet at 260 and 229 km, and the summit of the former reached 477 km. They were situated in the sunlit atmosphere in the region Namsos—Mosjøen. The 3 successive pictures 1*, 2* and 3* show that the highest ray moved eastwards.

*Picture No. 19**, sunlit ray, $0^h\ 52^m\ 11^s$ MET.

Very fine set of a single, sunlit ray. Reaching from 240 to 552 km above the earth, over a region east of Namsos.

Picture No. 71, cloud-like aurora, $1^h\ 30^m\ 15^s$ MET.

Very fine type of cloud-like aurora, having the form of a horseshoe-like, diffuse curtain. Extrapolation to the lower border, points a and b, show that the aurora reached down to about 93 km over the earth. The situation was over the North Sea to the west of Ålesund, in the dark atmosphere. The aurora was very quiet, which can be seen on the photographs Li Nos. 68, 69, 70 and 71 taken during 4 minutes; the diffuse form was not due to the long exposure. (See Plate 9.)

Concluding remarks.

From the pictures measured, the lower borders of cloud-like aurorae in the earth's shadow are determined very exactly to about 91—93 km.[1] The sunlit aurora rays have a situation common for this type, with summits of the rays going up to 500 km and more. The situation of the measured aurorae compared with the earth's shadow is seen on Plate 5 lower picture, the geographical situation on the same plate, upper picture.

9. The Aurora on April 21—22, 1936.

The next night a fine aurora appeared again. From my house I first saw a strong aurora-line in the spectroscope at $21^h\ 40^m$ MET, and immediately warned my stations. The weather was not so fine this evening; only Oscarsborg and Kongsberg had weather so clear that the photographic work could begin, the other stations had clouds and overcast sky. Later, after 1^h in the morning, a series of the other stations joined in, especially Trondheim, which gave base lines of the order 300 to 400 km, and very interesting results.

As to the forms of the aurora, very fine sunlit rays were photographed from $22^h\ 11^m$ till 23^h, in spite of clouds in the northern sky. At $1^h\ 40^m$ I got into telephonic connection with Trondheim, and a series of most interesting simultaneous pictures of a great arc with ray structure could be taken. The colour of the aurora was now more green-reddish. Fine sunlit rays were also seen and photographed.

Some pulsating patches appeared, but no pictures of them succeeded. Also a very intensely green curtain in the north was observed at $2^h\ 13^m$, but no measurements obtained, only single pictures.

During a period of strong flaming aurora, Mr. Westin in Trondheim, and I in Oslo, observed the aurora flames going upwards with great velocity. I saw them in the northern sky, Mr. Westin in the southern. We controlled by telephone that our observations were simultaneous.

As the flames evidently were the same and in both places went upwards, this proves that the motion in space was *upwards,* that is, from the upper atmosphere out into space.

The measurement and calculation of the pictures were first done by Leiv Rosseland and myself, and later verified and continued by Egeberg and Herlofson.

Some interesting spectra were also taken, and will be mentioned later.

The following pictures shall be mentioned here:

Picture No. 38, sunlit ray, $0^h\ 44^m\ 18^s$ MET.

Fine sunlit ray, the foot hidden behind clouds. The summit reached 550 km above the earth. The ray was lying over Namsos.

During the measurements, the two sketches were placed one on the other with coinciding stars, in which case it was not necessary to measure ζ and ε_1.

Picture No. 52, partly sunlit rays, $1^h\ 13^m\ 17^s$ MET.

These rays formed the eastern end of an imposing drapery-shaped band of rays over the whole northern sky. The colour was reddish-green. The summits here reached 400 to 450 km in height. The rays

[1] As to earlier height determinations of such forms see: Harang and Tønsberg Geof. Publ. Vol. IX, No. 5, Krogness and Tønsberg ibid. Vol. XI, No. 8 and Harang ibid. Vol. XII, No. 1.

were lying over the west coast of Finland to the north of the Åland Islands.

Picture No. 69, arc with ray structure, $1^h\ 41^m\ 07^s$ MET.

This was the second of a most interesting series of simultaneous pictures Oslo—Trondheim, giving formidable parallaxes of about 80 degrees. In Oslo the aurora was seen i NW, in Trondheim in SW, but from the measured values of the angle ω, corresponding points could easily be found on the two pictures. Probable error is of the order of 1 to 2 km.

The arc had a red-green colour as most of the aurora that morning.

The plates have been measured by myself and by my assistant Leiv Rosseland. We used the angles ω, u_1 and u_2 instead of ζ, ε_1 and ε_2.

The arc was lying over Sognefjord, stretching eastwards and westwards several hundred kilometers. For the points 7, 8, 9, 10 and 11 on the N-sketch and for the points 12, 13, 14, 15 and 16 on the C-sketch, the geographical situation has been found under the supposition that the height was 91 km.

The arc was lying entirely in the earth's shadow.

Picture No. 73, the same arc, $1^h\ 44^m\ 59^s$ MET, (Plate 10.)

This has been measured with great care by my assistant Herlofson, and it seems as if the exactitude is very great, with an error of the order of one kilometer.

The situation was very nearly the same as in picture 69. The situation of the points 6 and 7 on the N-sketch is found by supposing $H=90$ km.

Picture No. 96, green aurora curtain, $2^h\ 13^m\ 39^s$ MET.

The colour of this curtain seemed intensely green, probably as a contrast to the rest of the aurora which had a more reddish-green colour. On the picture taken simultaneously in Trondheim, it is very difficult to identify the feeble traces of stars. It seems as if they belong to Ursa Minor, with the polar star as the principal star. If this is right, the height of the lower border will be of the order of 100 km. On the picture taken in Kongsberg, clouds make any measurement impossible. At Oslo, two pictures were taken, one with an Astro-camera and the second with a Leica-camera F 2 and superpan film. The latter is very fine and is reproduced on Plate 10.

Under the three suppositions that the lower border was at 90, 100 and 110 km, it is seen that the curtain is lying partly in sunshine and partly in shadow.

Concluding remarks.

From the pictures measured it is most probable that the long, reddish-green rays on the northern sky from midnight to about 2^h had their upper parts from 300 to 600 km above the earth and in sunshine.

The fine arc with ray structure stretching all over the northern sky from $1^h\ 40^m$—$1^h\ 54^m$ had its lower border from 90 to 91 km over the earth.

The situations of the measured aurora in relation to the earth's shadow and their geographical situations are seen on Plate 5.

The spectra obtained.

Two very interesting spectra were obtained on pancromatic plates, "Agfa Isopan Platten ISS", with a small spectrograph loaned from Nordlysobservatoriet, Tromsø, by courtesy of the director, Leiv Harang. The two spectra were taken on the same plate and were supplied by helium comparison spectra on each side. Moreover, a "Zeiß-Stufenfilter", a calibrated wedge consisting of 5 steps with the following transparences: 62, 38, 25, 16 and 9.5 %, was copied on another plate of the same emulsion for intensity-measurements.

The spectrograph was handled by my assistant Enok Hetland, and the following exposures were made:

Spectrum 1: Against the upper part of high rays, from $1^h\ 30^m$ to $2^h\ 30^m$.

Spectrum 2: Against an intensely green aurora curtain (pictures 96, 97), exposure 4^m.

Spectrum 3: Against pulsating red-green patches at $2^h\ 24^m$, 2^m exposure.

Among these, the first was fairly good, in spite of a small displacement of the plate during the work, which made all lines double. The second spectrum was faint, but good enough for measurements. The third gave no impression on the plate, because the exposure was too short. (See Plate 17.)

After development, where the plate with the spectra and the plate with the photometric scale were developed in the same developer and treated in exactly the same way, the plates were sent to Director Harang for measurements.

On April 29, I got from him the following telegram (translated into English):

I have measured the spectra. It is the red oxygen line 6300 which appears with an enormous enhancement at the summits of the rays. Next week I shall try to measure the intensities. Very interesting spectra.

On May 1 and 5, 1936 I got from him the following reports on his measurements:

Identification of lines (letter of May 1, 1936). *Spectrum 1:*

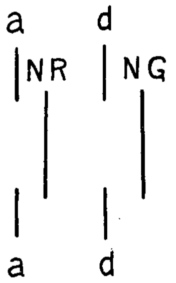

Fig. 7.

Line	Wavelength
a Helium...........	6678.2 Å
d »	5875.5 »
NG Green aurora line ..	5577.3 »
NR Red » » ..	

From this the wavelength of the red aurora line NR shall be found.

As the aurora spectrum 1 was double, the lines are indicated by I and II. On a comparator the following values were found:

Line	Value
a.....................	48.43 mm
d.....................	47.10 »
NG I..................	46.75 »
NG II	46.62 »
NR I	47.82 »
NR II	47.70 »

To measure the wavelengths of the red aurora line NR, it is necessary to know 3 lines in order to determine the parabola of dispersion. We choose the lines *a*, *d* and *NG*.

Corresponding to I and II we then find the two dispersion formulae for *NR*

$$\text{I } \lambda = 9348.1 - \frac{15363.659}{(d - NG\text{ I}) + 4.424} = 6361.4 \text{ Å}$$

$$\text{II } \lambda = 43586.2 - \frac{2306404.3}{(d - NG\text{ II}) + 61.161} = 6248.2 \text{ Å}.$$

In the aurora spectrum in red there are two strong lines which can be taken into consideration:

The positive nitrogen bands at 6580 Å.

The red oxygen doublet at 6300 and 6364 Å, of which the first at 6300 is considerably stronger than the second.

Thus in spectrum 1 there can be no doubt that the line NR is the line 6300 Å.

Spectrum 2:

Here we have a sharp and narrow line, which, without doubt, is the aurora line 5577 Å. Towards long waves, there is a faint line near the place where 6300 is usually situated for common green aurora. The distance from 5577 to the red line is measured to 1.07 mm, as a control.

Photometric measurements of the spectra (letter of May 5, 1936).

The comparison of the registrations of spectrums 1 and 2 indicates that 5577 of spectrum 2 shows the greatest blackening. As both 6300 and 4278 of spectrum 2 are much fainter than the corresponding lines in spectrum 1, it is clear — without quantitative measurements — that 6300 and 4278 in spectrum 1 appear with considerably greater intensity compared with 5577 than in spectrum 2.

The measurements of the ordinates of the curves of registration give:

	6300 Å mm	5577 Å mm	4278 Å mm
Spectrum 1 ..	48.0	48.0	30.0
» 2 ..	20.0	51.0	24.0

If the blackening curve (from the "Zeiß-Stufenfilter") is used, this gives the following intensities

	6300 Å	5577 Å	4278 Å
Spectrum 1 ..	33.0	33.0	18.0
» 2 ..	12.0	37.0	14.5

and if the intensity of 5577 is chosen equal to 100:

	6300 Å	5577 Å	4278 Å
Spectrum 1 ..	100	100	55
» 2 ..	32	100	39

The relative intensities of 6300 and 4278 in spectrum 1 compared with spectrum 2 are

$$6300: \quad \frac{100}{32} = 3.1$$

$$4278: \quad \frac{55}{39} = 1.4$$

(Leiv Harang).

The spectra are reproduced on Plate 17.

From Harang's measurements it is thus evident that the oxygen line 6300 was enormously enhanced in the upper parts of the sunlit aurora rays, as compared with the line from the green aurora curtain which probably lay much lower and partly in the earth's shadow.

This enhancement of the red oxygen line was also observed for twilight aurora by Currie and Edwards[1] at Chesterfield during the polar year, by Kosirev and Eropkin[2] for sunlit aurora at Kirowsk (March 1935) and by Vegard and Tønsberg[3] in Tromsø (October 1935) for sunlit aurora arcs.

10. The Aurora October 16—17, 1936.

The aurora this night was very fine and gave most interesting results. Like aurorae during periods of maximum activity of the sun, it showed several most fascinating characteristics, for instance, fine red colour during a long time.

When the aurora was first observed, the meteorological conditions were rather bad, much cloud being over most of our stations. However, at Kongsberg where the conditions were better, strong red parts of it were seen in the north-west at $20^h\,32^m$. The same red coloration was also seen from Uppsala at 20.12—20.15 in W over Vega.[4] As the meteorological conditions improved, simultaneous photographs could be taken at about 21.10, and the work continued all night to dawn. For details we must refer to Table 1.

At 22.24 a strong red coloration began to develop in NE, and similar colour was observed in that region more or less pronounced at about $23^h\,30^m$, $1^h\,30^m$, 2^h and $2^h\,30^m$.

At $1^h\,52^m$ and $1^h\,54^m$ some very interesting red rays were photographed in NE, which proved to be situated in the sunlit atmosphere over Archangel. The height was quite unusual: foot of the rays near 600 km and summits up to 1100 km.[1]

In the hours following, several red rays in the earth's shadow were photographed; about 24 successful sets were taken of them from 2, 3 or 4 stations simultaneously.

The sunlit rays continued to appear until dawn, and a very fine collection of about 60 successful sets were secured. The calculation of height and situation of several of these most interesting rays will be given below, together with a study of most interesting spectra of different aurora forms.

The following pictures have hitherto been measured and calculated:

Picture No. 42, auroral ray, $21^h\,49^m\,34^s$ MET.

This ray was part of a fine curtain having a luminous lower part of vertical extension of about 25 km. The highest point is calculated under the supposition that the ray follows a line of magnetic force.

The curtain was situated in the dark atmosphere from 116 up to 350 km over the North Sea WNW of Namsos.

Picture No. 110, strong red rays in ENE, $23^h\,35^m\,37^s$ MET. (Plate 10).

The light from these red rays has also contained blue and violet because they could be photographed by Sonja plates, which are insensible to red. They formed part of a fine red drapery forming the southern margin of this red aurora in the NE sky. The small parallaxes do not give great accuracy, but show that the rays went rather high up, to about 400 km, and that they were entirely lying in the earth's shadow.

The geographical situation was over Finland at about 63° latitude and 24° longitude east of Greenwich.

Picture No. 134, pulsating cloud-like curtain, $0^h\,46^m\,43^s$ MET.

This was a very interesting form. To the eye it was cloud-like and feeble, and consisted of a band intermittently illuminated by short-lived patches. It looked like a pulsating series of small patches. The measurement is very good, the long base line *Li*—*C* giving parallaxes of the order of 10 degrees.

The lower part of the patches went down to about 93 km, and their vertical thickness was measured to 13, 11, 15 and 15 km.

[1] Terr. Magn. Atmos. Elec. September 1936.
[2] Poulkovo Astr. Circular No. 18 (1936).
[3] Nature 137, 778 (May 1936).
[4] According to a letter from Professor Hilding Köhler.

[1] See also my paper: Altitudes and Spectra of Red and Sunlit Aurorae, Nature Vol. 139, p. 584, April 3, 1937.

A similar band was seen under the principal one on the *Li*-picture, but was hidden behind trees at *C*.

The geographical situation was over the sea between Ålesund and Kristiansund.

Picture No. 135, same aurora, $0^h\ 47^m\ 57^s$ MET. (Plate 10.)

This was selected from among the series of similar pictures to give a control of the picture No. 134.

The lowest points were again at about 93 km and the geographical situation the same.

Both pictures show that the pulsating curtain was in the earth's shadow, the border-line between sunlight and darkness being more than 1400 km over the aurora.

Picture No. 146, yellow-green curtain, $1^h\ 23^m\ 17^s$ MET.

This belongs to a very fine series of successive pictures taken simultaneously from *C*, *T* and *Li*. At *C* the lower part was hidden behind trees and we have therefore used the base *Li—T*.

The curtain went down to about 97 km (mean of 100, 94 and 98) and therefore seems not to go so far down as the foregoing aurorae Nos. 134 and 135. To the right the mean height was 100 km. It was lying entirely in the shadow over the sea near Kristiansund.

Picture No. 166, long ray and drapery, $1^h\ 42^m\ 51^s$ MET. (Plate 11.)

This was a fine and most interesting picture. Notwithstanding the ray was lying entirely in the earth's shadow, it reached the astonishing height of more than 500 km. The upper part was red, the lower green. The foot of the ray on station *Li* is hidden behind the visible horizon. By judging from the other ray 8, 9, the lower border of the drapery was at a height of about 108 km. The drapery bends to the north and then westwards again, and the rays 1, 2, 3 and 6, 7 belong to the most distant part. The points 5 and 6 belong to the ray and 5* and 6* to the nearest part of the drapery. The geographical situation was over northern Sweden, about 64° latitude and 15—20° E. Grw.

Picture No. 170, the same drapery towards W, $1^h\ 46^m\ 31^s$ MET. (Plate 11.)

The drapery in the west formed a big, horseshoe-shaped fold which allowed a rather good determination of its lower border and situation. We found a height of 100, 103 and 102 km and a situation over the sea near Kristiansund and Ålesund in Norway. The colour of the drapery was ordinary green-yellow. It was lying in the earth's shadow.

Picture No. 175, the same in north east, $1^h\ 51^m\ 21^s$ MET. (Plate 11.)

Now the green-yellow drapery had a most beautiful form and its lower border had descended to about 95 km. The projection of this border on the earth's surface is a very interesting spiral going from Trondheim NE into Sweden and bending W towards Mosjøen in Norway, then SW towards Namsos and again eastwards.

The geographical situation of this border was found by assuming the height to be everywhere constant equal to the mean of the measured values, 95 km. Also the top of the ray, point No. 6, was found on the supposition that the ray followed a line of magnetic force and had its foot on the lower border of the curtain.

The fact that the lower border of a curtain or a drapery can descend in the atmosphere at the same time as the curtain increases in brilliancy, was already observed on my expedition to Bossekop[1] in 1913, on March 22, 1913, pictures 188—193.

The drapery was lying in the earth's shadow.

Picture No. 177, very high red sunlit rays, $1^h\ 52^m\ 52^s$ MET.

This belongs to some of the most interesting pictures taken towards ENE of a feeble red aurora having the form of a distant curtain seen tangentially. The plates used were Sonja EW, and the fact that we got even a feeble impression on the plates shows that the light from the aurora must also have contained violet or ultra violet radiation. The curtain was entirely quiet, which allowed an exposure of about half a minute. To this series belong Nos. 173, V 99.5, 174, 177 and 178.

Already a comparison of the pictures from Oslo and Tømte shows a very small parallax, too small to be used for a reliable height determination, but indicating at all events a very great altitude. On the Lillehammer picture, however, the upper part of the limitation towards south is seen, but the lower part is hidden behind a house. This upper part, however, gives a good parallax for measuring height and

[1] Geof. Publik. Vol. I, No. 5, p. 111.

situation, the points 1, 2 and 3 being common on the two pictures.

The height was astonishing — foot of the limiting ray of the curtain at 560 km and summit over 1000 km. The situation was very distant, over the region of the White Sea near Archangel.

It is most interesting that the ray was lying in sunshine with its foot near the border between sunlight and shadow.

This case resembles a case of grey-violet curtain seen on September 8, 1926.[1]

Picture No. 178, the same rays, $1^h\ 54^m\ 12^s$ MET.

This is a most interesting set of 4 successful photographs of the same high rays, taken simultaneously from the 4 stations Oscarsborg, Oslo, Tømte and Lillehammer. At the 3 first stations, the foot of the limiting ray to the south is very well seen, but on the Lillehammer picture this foot is hidden behind the house. But a long part of the ray is common on the 4 pictures and gives a very reliable parallax. It is very interesting that the ray has its foot (point No. 10) near the border between sunlit and dark atmosphere, in spite of the great height of about 600 km of this border-line. Also the enormous height of about 1100 km of the summit of the ray is most remarkable. The geographical situation was the same as that of No. 177.

The pictures, like all the others of October 16—17, have been measured and calculated by my assistants Herlofson and Egeberg, and continually controlled by myself. We also made a trial to measure the picture from the set *T—C*, but the parallax was so small, from $0^\circ.4$ to $0^\circ.75$, that the determinations are not reliable. Only the order of magnitude is right.

On fig. 8 are seen the outlines of the high ray to the right, as seen from the four stations, with corresponding points 5, 6, 7, 8, 9, 10. The house on the Lillehammer picture is indicated. The photographs are given on Plate 12. On the original negatives the ray could be followed higher up than the reproductions show.

Picture No. 186, red rays in shadow, $2^h\ 04^m\ 21^s$ MET.

These were two very fine red rays. For the measuring we have used the pictures from Tømte and Oscarsborg, because the rays were hidden behind the house on the Lillehammer picture. On account of the small parallax, the measurements are not so accurate. The light must have contained much blue and violet radiation since the Sonja plates have given such good results.

The rays were situated from about 100—150 to 500 km over Finland at 64° latitude, in the earth's shadow.

On Plate 13 are given the 3 pictures from Oscarsborg, Oslo and Tømte.

Pictures No. 196, 197 and 198, $2^h\ 27^m\ 31^s$, $2^h\ 28^m\ 10^s$ and $2^h\ 28^m\ 48^s$ MET.

These were 3 most interesting successive pictures of very fine long rays, which first were green and then changed to red all over. A similar phenomenon I observed near 2^h in the night March 7—8, 1918, and it has been described in the report on the aurorae measured in the period 1911—1922.[1]

In spite of the fact that the rays were lying in the earth's shadow, their summits reached up to over 500 km. On the pictures, they could be followed downwards to about 150 km, but the exact height of the lower border could not be fixed from these pictures, but from the next. (See Plates 13 and 14.)

They were situated over Jämtland in Sweden between 63° and 64½° latitude, east of Trondheim.

Picture No. 102.1, Vestfossen, the same rays, $2^h\ 27^m\ 58^s$ MET. (Plate 13.)

This picture, taken independently by Mr. Hassel from Vestfossen, of the lower border of the same rays, could be used to find how far down in the atmosphere the rays reached. In fact, by inspecting the pictures 196, 102.1, 197, 102.2 and 198, it is seen that the rays were so stationary that this picture could be used together with the Lillehammer picture for height-measuring. As a control, the points 2 and 3 were measured again with base line *Li—V* and compared with the results with the base line *Li—C*. For the point 2 we found the same height, and for point 3 only 8 km deviation.

Supposing that the rays followed the lines of magnetic force, the lowest points were found to be at about 97 km height.

The geographical situation was found to be very nearly identical in the two cases *Li—V* and *Li—C*.

[1] Carl Størmer: On an aurora curtain of violet-gray colour situated at a high altitude etc. Gerlands Beiträge zur Geophysik, Vol. 17, 1927.

[1] Geof. Publik. Vol. IV, No. 7, p. 23.

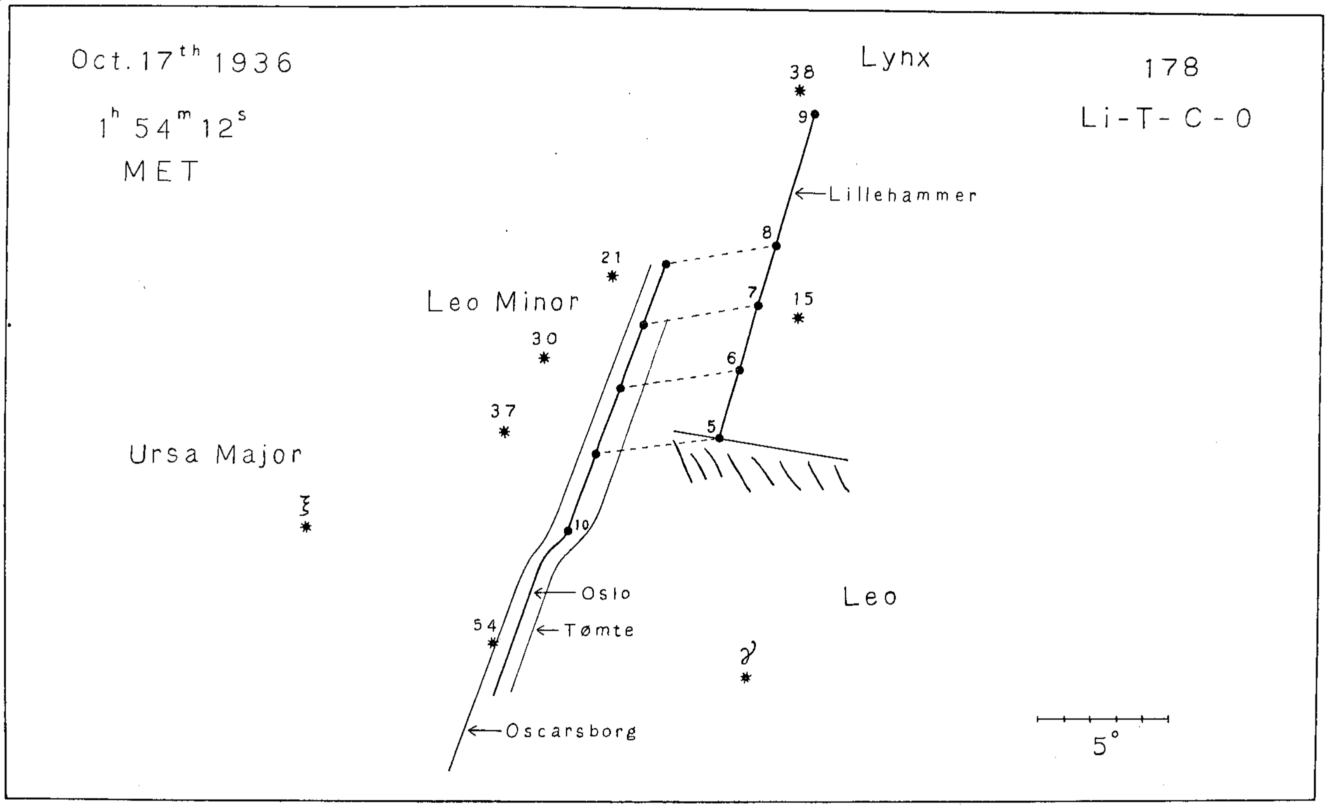

Fig. 8.

We have also here a striking case of very long rays, reaching from a height of 97 km up to over 500 km, that is, rays more than 400 km long. In a recent paper, Dr. Harang has from Tromsø measured similar long rays on November 24, 1930, having a total length of 200 km in the earth's shadow.[1]

Picture No. 206, sunlit rays, $3^h\ 26^m\ 09^s$ MET. (Plate 14.)

The earth's shadow had now descended, and a series of most interesting sunlit rays were photographed with long base lines. The present one appeared in the north-east near Ursa Major, and was photographed simultaneously from Lillehammer, Tømte and Oslo. The calculation showed that the feet of the two northern rays, points Nos. 1 and 4 were 407 and 368 km over the earth, near the border between sunlit and dark atmosphere, and the summits which could be followed somewhat higher than the points 2 and 6, reached the great heights of about 725 and 815 km respectively. The feet of the two other rays to the right were out of the field of the pictures, but here the summits near points 7 and 10 reached 700 and more than 800 km. All rays were sunlit.

The rays were situated over a region from Luleå in Sweden to Sodankylä in Finland.

Picture No. 212, divided rays, $3^h\ 53^m\ 21^s$ MET. (Plate 15.)

This picture as well as the following No. 213 is most interesting because we have to the left two divided rays, one part in sunshine and the other in darkness. The pictures are not so excellent for height-measuring, the situation being unfavourable and the outlines less sharp, but a closer study of the two pictures from *C* and *Li* have persuaded us that the lower rays 3—4 and 7—8 are the continuation of the upper ones 1—2 and 5—6, which a series of preliminary measurements also seemed to show.

From that supposition the heights of the lower rays have been found, the points 1, 2, 3, 4 as well as 5, 6, 7, 8 being supposed to lie on straight lines. This is a new evidence of divided rays, some cases of which being already published.[1]

[1] Leiv Harang: Height measurements of selected Auroral Forms, Geofys. Publ. Vol. XII, No. 1, p. 7.

[1] Nature: June 8, 1929 and Dec. 25, 1937.

Pictures Nos. 218, 219, 220 and 221, sunlit rays, from $4^h\,19^m\,55^s$ to $4^h\,24^m\,03^s$ MET.

On these pictures the same sunlit ray 1, 2, 3 is photographed 4 times after each other with base line Oslo—Lillehammer (See Plates 15 and 16). The lowest and highest points show the following variations:

Time	Picture	Lowest	Highest
4.19.55	218	275 km	555 km
4.21.35	219	258 »	640 »
4.22.55	220	273 »	672 »
4.24.03	221	273 »	590 »

As the rays fade out successively with increasing altitude, it is difficult to fix the upper limit, but the order of magnitude of the heights can be judged from the measurements.

The geographical situation was over north-eastern Sweden, about 65° latitude and 18°—20° east of Greenwich. The ray was moving eastwards about 90 km in 4 minutes.

Picture No. 223, rays in shadow, $4^h\,32^m\,36^s$ MET.

These rays towards NW are still in the earth's shadow and show the corresponding low situation in the atmosphere; their summits reach to about 300 km, and their bases, forming part of a curtain, have the height of about 120 km. They were lying to the west of Mosjøen, at about 66°—67° latitude and about 5° east of Greenwich.

Picture No. 224, curtain in sunlight and ray crossing the earth's shadow, $4^h\,37^m\,49^s$ MET.

This picture is the first of a series of a horseshoe-formed curtain lying in the sunshine. One ray, Nos. 5 and 6, is, however, crossing the earth's shadow. The ray 1—2 can be followed up to 600 km, and the ray 7—8 to about 525.

The particular ray 5—6, which goes down in the earth's shadow, has its summit at 390 and its lowest visible point at 168 km.

The curtain was situated over the sea near Bodø.

As a control, the ray 5—6 was also measured with base line Li—K_4 (the first base line was T$-$$K_4$), and gave essentially the same result. On the Li-picture the lowest point could be seen; it was lying 130 km over the earth. The point 2 gave as control H = 280 km (before found 278 km).

Picture No. 225, the same curtain, $4^h\,38^m\,25^s$ MET.

The measurements of the same ray gave essentially the same heights. It can be followed up to 610 km and down to 240.

The lower border of the curtains can be distinguished with some difficulty.

The geographical situation is a little more towards SE.

Picture No. 226, the same curtain, $4^h\,39^m\,07^s$ MET. About the same height.

Picture No. 227, the same curtain, $4^h\,39^m\,57^s$ MET.

The lowest point about 260 km, the summit as before. As control, the heights of points 1 and 2 have also been measured with another base line C$-$$K_4$.

The geographical situation shows that the curtain from $4^h\,37^m\,49^s$ to $4^h\,39^m\,57^s$ has mowed towards SE about 120 km.

Picture No. 231, right border of ray masses, $4^h\,44^m\,44^s$ MET.

The same great heights, up to 700 km. The rays in sunlight. Situation over a region about 250 km. SE of Mosjøen.

Picture No. 232, the same, $4^h\,46^m\,02^s$ MET.

This ray is the same as the ray 1—2 of the preceding picture. It has ascended and moved NE-wards. Summit about 700 km. Entirely in sunlight.

Picture No. 234, sunlit drapery, $4^h\,47^m\,54^s$ MET.

This drapery formed by the sunlit rays measured in the foregoing pictures, is of special interest because the lower border is very well seen. For the points 1, 2, 3, 4 along this border the great heights 333, 326, 315 and 313 km were found.

The right border is formed by the ray 5, 6 which goes up to about 600 km.

The measured border is situated over Mosjøen.

Picture No. 243, sunlit rays in NE, $4^h\,54^m\,15^s$ MET. (Plate 16.)

These very fine long rays in NE were lying entirely in sunshine. 16 points were measured, from about 200 to about 600 km, situated over Norrbotten and Torneå, Lappmark in Sweden. A preliminary measurement with base line Li—C had already given essentially the same result.

Picture No. 253, sunlit rays in NNE, $5^h 03^m 36^s$ MET.

Only rays to the right were in a favourable position to be measured. The summits reached over 500 km. Situation over a region near Bodø.

Picture No. 254, the same rays, $5^h 04^m 02^s$ MET.

Very fine rays. The lowest and highest points of the rays seen on the photographs were found by extrapolation to be:

Ray	Lowest	Highest
1—2	270 km	
3—4—5	235 »	650 km
6—7—8	210 »	710 »

Situation as before.

Picture No. 255, high sunlit rays, $5^h 04^m 32^s$ MET.

This picture is of special interest, because we can follow the ray 7—8—9 on the Oslo picture as a very faint continuation up to about 865 km. On the Lillehammer picture, the same ray can be followed down to the point b, 211 km over the earth, and its total length is therefore about 650 km in vertical extension. The ray 1—2—3 can be followed up to 680 km and down to 235. Situation east of Bodø and Mosjøen.

Picture No. 256, sunlit rays, $5^h 05^m 07^s$ MET.

A very good set giving the eastern border of the ray-masses. The lowest points are very well seen, and have a height from 180 to 200 km. The summits are outside the photographic field. Situation over Luleå, Lappmark.

11. Some General Remarks on the Pictures Measured from October 16—17, 1936.

An extract of the foregoing measures of different forms of aurora may be of interest.

a. *Pulsating cloud-like curtain* (Nos. 134 and 135).
   This interesting form had the lower border at about 93 km over the earth, and the vertical thickness of the patches along this border was from 11 to 15 km. It was lying in the earth's shadow.

b. *Drapery with long rays* (Nos. 166, 170 and 175):
   In spite of the situation in shadow, the rays, in particular on No. 166, were up to 400 km in vertical extension. It shows that during strong aurorae near the maximum of solar activity, the atmosphere can be drawn upwards even in the earth's shadow. The lower border has a height varying from 100—103 km in picture 170 and down to 97 km in picture No. 175. This descending of the lower border has previously been described from my expedition to Bossekop in 1913.

c. *Red rays in shadow* (Nos. 110 and 186).
   These are the first pictures giving height and situation of the red rays. The heights were not essentially different from those of other rays in shadow this night.

d. *Red rays in sunshine* (Nos. 177 and 178).
   On the contrary, these red rays were remarkable by their enormous height from about 600 km to over 1000 km. The base of the rays was very nearly at the border-line between sunlit and dark atmosphere.

e. *Very long rays in shadow with colour changing from yellow-green to red in a few seconds* (Nos. 196—198).
   These, which were lying in the earth's shadow, were also extremely long of the order 400 km in vertical extension. On looking at them, I saw the colour very rapidly changing from green-yellow to red, like those I observed on the night of March 7—8, 1918.

f. *Divided rays* (No. 212).
   Here we have once more a case of those very rare phenomena of divided rays, one part in sunshine and another in shadow, and with a darker space between them.

g. *Sunlit aurora rays* (Nos. 206, 218—221 and the following pictures except No. 223).
   We have here a long series of most interesting sunlit rays whose situation is characteristic for such rays in the sunlit part of the atmosphere.

The situation of all these forms in relation to the earth's shadow is seen on Plate 8. This figure shows the same characteristic features as the corresponding one of the rays March 22—23, 1920,[1] but the sunlit rays on October 16—17, 1936, reached even greater heights than those observed on that occasion.

The geographical situation of the measured aurorae is seen on Plates 6 and 7.

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[1] Carl Størmer: Sonnenbelichtete Nordlichtstrahlen, Zeitsch. f. Geoph. Jahrg. 5, Heft 5/6, 1929.

12. The Spectra taken during the Night of October 16—17, 1936.

Parallel with the photographic work, my assistant Enok Hetland took spectra of the different aurora forms with two small spectrographs on Sonja plates and on pancromatic plates Agfa Isopan ISS. The Sonja plates had previously been furnished with intensity-scales (Zeiss-Stufenfilter) by Dr. Harang, Tromsø, and, for the small ISS plates, such scales had been copied on other plates from the same stock and were developed together with the spectra taken.

Among the 16 spectra taken, those on ISS plates taken by the Tromsø-spectrograph were by far the best ones. Those taken by the small 60° spectrograph on Sonja plates were not so good because the plates were fogged, which made the quantitative photometric measurements difficult.

The spectra have been measured first by Dr. Harang and then independently by Dr. Bjørlykke. I am indebted to my colleague, Prof. V. M. Goldschmidt, who permitted Dr. Bjørlykke to use the instruments of the Mineralogical Institute for this new independent measurement.

A list of the spectra taken is given here:

Plate I, taken with the Tromsø-spectrograph (Plate 18).

Plate Agfa Isopan ISS.

Spectrum 1°: 20^m exposure, from $20^h 45^m$ to $21^h 05^m$ towards the upper border of a diffuse arc.

Spectrum 2°: 20^m exposure, from $21^h 20^m$ to $21^h 30^m$ and from $21^h 45^m$ to $21^h 55^m$ towards high rays.

Spectrum 3°: 20^m exposure, from $22^h 15^m$ to $22^h 35^m$ towards central part of an arc.

Spectrum 4°: 7^m exposure, from $22^h 35^m$ to $22^h 39^m$, from $23^h 08^m$ to $23^h 10^m$ and from $23^h 33^m$ to $23^h 34^m$, towards red diffuse glow and some red rays.

Plate II, taken with the Tromsø-spectrograph (Plate 18).

Plate Agfa Isopan ISS.

Spectrum 1°: 25^m exposure, from $1^h 29^m$ to $1^h 33^m$, from $2^h 04^m$ to $2^h 11^m$, from $2^h 18^m$ to $2^h 22^m$ and from $2^h 25^m$ to $2^h 35^m$ towards red aurora.

Spectrum 2°: 20^m exposure, from $3^h 10^m$ to $3^h 30^m$ towards flaming aurora, waves going upwards.

Spectrum 3°: 68^m exposure, from $3^h 52^m$ to $5^h 00^m$, towards sunlit aurora rays.

Plate III, taken with the small spectrograph having a prism of 60° angle (Plate 17).

Plate Sonja EW.

Spectrum 1°: 22^m exposure, from $20^h 55^m$ to $21^h 17^m$ towards diffuse arc.

Spectrum 2°: 20^m exposure, from $21^h 30^m$ to $21^h 50^m$ towards high diffuse glow.

Spectrum 3°: 20^m exposure, from $22^h 01^m$ to $22^h 21^m$ towards strong yellow-green colour of the central part of the arc.

Spectrum 4°: 33^m exposure, from $22^h 30^m$ to $22^h 40^m$, from $23^h 10^m$ to $23^h 15^m$ and from $23^h 22^m$ to $23^h 40^m$ towards high rays.

Spectrum 5°: 18^m exposure, from $23^h 47^m$ to $23^h 58^m$ and from $0^h 35^m$ to $0^h 42^m$ towards high rays.

Spectrum 6°: 30^m exposure from $1^h 10^m$ to $1^h 40^m$ towards strong yellow-green colour in the middle of an arc.

Plate IV, taken with the same spectrograph (Plate 17).

Plate Sonja EW.

Spectrum 1°: 33^m exposure, from $2^h 07^m$ to $2^h 40^m$, towards red aurora and towards high rays.

Spectrum 2°: 20^m exposure from $2^h 45^m$ to $3^h 05^m$ towards high rays.

Spectrum 3°: 22^m exposure, from $3^h 08^m$ to $3^h 30^m$ towards flaming aurora, waves going upwards.

Spectrum 4°: 68^m exposure, from $3^h 52^m$ to $5^h 00^m$, towards sunlit aurora rays.

Before we give the results of the measurements of the spectra, it is necessary to quote the following general remarks which Dr. Harang and Dr. Bjørlykke, who measured them, give in the accompanying letters to me.

Dr. Harang writes about the identification of the red lines:

"Plate 1, spectrum No. 2, was measured by means of the two He-lines 6678.1 Å and 5875.6 Å together with the green aurora line 5577.3 Å. This gave for the two red lines with the greatest wavelength

6551 Å and 6344 Å.

The first line — or accumulation of bands — is to be identified with the nitrogen band spectrum, first positive group.

The second line is the red oxygen doublet 6300 6364 Å.

The situation of these lines on the other six ISS spectra was controlled in a comparator. Only these two occur."

About the ISS plates he writes:

"These plates are very well adapted for photometric measurements. The plates are quite clear, and in all spectra, except one, the lines are within the range of the intensity scale. The results ought to be considered as quite reliable (see table below).

On plate II the lines are so broad that 6550 and 6300 cannot be separated; but 6300 is by far the stronger of the two.

For the spectra on the Sonja plates, Dr. Harang would not give quantitative measurements.

Spectrum No.	Photometric deviation				Corresponding intensity			
	6550 Å	6300 Å	5577 Å	4278 Å	6550 Å	6300 Å	5577 Å	4278 Å
				Plate I, ISS				
1	12.5	18.2	43.5	-	19.0	23.0	35.0	-
2	4.5	45.5	28.0	-	12.0	36.0	28.5	-
3	22.5	28.0	85.0	-	25.5	28.0	92.5	-
4	faint	82.0	8.0	-	faint	77.5	16.5	-
				Plate II, ISS				
1	?	> 90.0	37.5	-	?	> 100	36.3	-
2	?	18.0	5.8	-	?	24	16	-
3	?	72.0	11.0	5.0	?	59.5	19.8	15

Dr. Bjørlykke writes:

"I send herewith the calculated intensities of the four plates. I am sorry that the intensity scales on the large Sonja plates are over-exposed, so that most of the intensities were situated under the blackening curve resulting from this scale. The intensities of these lines are found by prolonging the blackening curve as a straight line and the resulting values are put into parenthesis ( ). This has also been done for some lines on the plates ISS, which were more blackened than the blackening scale."

The results were as follows (see tables p. 22).

Having given these measurements, from them and from visual inspection of the negatives (see Plates 17 and 18 at the end of this paper) we can draw the following conclusions:

On the other hand, the two Sonja plates are not so good. I think it will be difficult to get reliable measurements, at least quantitative results. As far as I can see, only 3 spectra on these plates can be measured photometrically. The plates are very fogged and the intensity scales over-exposed. Not being able to give the quantitative relative intensities, I can, however, see how they change from one spectrum to another. — — —"

The results of the photometric measurements by Dr. Harang are seen below. Here "faint" means that the line is so faint that it could not be measured by the photometer, and > means that the blackening was greater than the maximal blackening of the comparison scale.

The oxygen lines 5577 and 6300 and the positive nitrogen bands near 6550 show great variability for the different aurora forms that night. If we put the relative intensity of 5577 equal to 100, the intensities of the lines, from plate I, are seen in the tables p. 22.

The measurements show the same effect which is clearly visible on the reproduced spectra:

For the *yellow-green arc*, whose altitude generally is lying from 100 to 120 km, the red bands 6550 and the red line 6300 are nearly equal, and the line 5577 about three times, or more, stronger for the middle of the arc, about twice (or 4/3) as strong for the upper part of it.

In the *high rays*, which at the time in question were situated in the earth's shadow and at a height probably from 100 to 400 km, the intensity of the line 6300 had considerably increased and was stronger than the aurora line 5577. The relative intensity of 6550 to 5577 was nearly the same as for the arc.

In the *red aurora* the intensity of the red line 6300 was even much greater, up to five times that of 5577. The line 6550 was fainter than the line 5577. The height of this red aurora was, according to picture No. 110, probably from about 150 to about 450 km.

Spectrum No.	Intensities of lines			Two lines near 4278 Å	
	6550 Å	6300 Å	5577 Å		
		Plate I, ISS			
1	27.29	31.77	46.48	-	-
2	19.05	46.56	35.48	-	-
3	34.99	48.53	(398.1)	-	-
4	-	(109.6)	19.50	-	-
		Plate II, ISS			
1	-	(316.2)	100.9	-	-
2	-	35.97	21.38	-	-
3	-	(109.6)	29.24	19.05	15.85

Spectrum No.	Intensities of lines				
	5577 Å	4278 Å	3914 Å		
		Plate III, Sonja EW			
2	-	(6.03)	(7.24)	-	-
3	-	(6.03)	(6.14)	-	-
4	-	8.59	16.98	-	-
5	-	5.62	6.95	-	-
6	(7.38)	13.37	15.70	-	-
		Plate IV, Sonja EW			
1	(7.24)	25.23	-	-	-
2	-	(6.92)	(9.51)	-	-
3	-	(6.31)	(7.41)	-	-
4	(8.40)	28.18	32.06	-	-

On the other pancromatic plate, Plate II, where the lines are too broad, the measurements of Harang and Bjørlykke give the following relative intensities, if we put the relative intensity of 5577 equal to 100 (see tab. below).

Thus for *flaming aurora,* the line 6300 is stronger than the aurora line, about 150 to 170 per cent of this line.

In the *red aurora,* the intensity of the line 6300 is again greater, up to three times that of the green line 5577.

For the *sunlit aurora rays,* lying probably between 350 and about 750 km over the earth, the intensity is even more increased. Further, the negative nitrogen band 4278 appears on the plate,

The great enhancement of the line 6300 in the sunlit aurora rays this night, was also observed by Vegard[1] (see remarks at the end of section 9).

As to the spectra on the *Sonja plates,* quantitative measurements cannot be given, but by looking at the spectra, some general remarks can be made:

From spectra 3 and 6 of plate III, a green-yellow arc, to spectra 4 and 5 of Plate III and spectrum 2 of Plate IV, of high rays, to spectrum 4

[1] L. Vegard: Red and Sunlit Auroras and the State of the Upper Atmosphere, Nature Vol. 138, p. 930, November 28, 1936.

Plate I, ISS	Harang			Bjørlykke		
	6550 Å	6300 Å	5577 Å	6550 Å	6300 Å	5577 Å
Spectrum 1, upper border of diffuse arc	54	66	100	59	68	100
Spectrum 3, central part of diffuse arc	28	30	100	(9)	(12)	100
Spectrum 2, high rays......	42	126	100	54	131	100
Spectrum 4, red rays and glow	faint	470	100	faint	(562)	100

Plate II, ISS	Harang			Bjørlykke		
	6300 Å	5577 Å	4278 Å	6300 Å	5577 Å	4278 Å
Spectrum 1, red aurora	> 275	100	-	(313)	100	-
Spectrum 2, flaming aurora .	150	100	-	168	100	-
Spectrum 3, sunlit aurora rays	300	100	76	(375)	100	(65), (54)

of Plate IV, high sunlit rays, there is an increasing difference between the intensity of the green aurora line 5577 and the negative nitrogen bands 4278 and 3914; the intensity of these bands increases and, in particular, enormously when we come to the sunlit rays.

For the high rays which at that time were lying in shadow, this increase agrees with Vegard's first statement from 1923.[1]

For the very high aurora rays lying in the sunlit part of the atmosphere, the enormous increase was already observed visually by me on March 23, 1920,[2] and by photographs of the spectra on March 16, 1929.[3]

[1] Phil. Mag. 46, p. 577, 1923. Nature, Dec. 21, 1929.
[2] Nordisk Astronomisk Tidsskrift Vol. 1, No. 4, 1920.
[3] Zeitschr. f. Geoph. Jahr. 5, Heft 5/6. 1929.

Table I.

P.N.	St.	MET	Ex.	Fm.	Ref. Const.	N	Remarks
					April 20—21, 1936.[1]		
43.1	V	22h 10m 15s	30	R, RA	Lac Cyg		Probably sunlit rays
.2	V	» 11 00	30	RA	And Cas		
.3	V	» 14 18	35	RA	And Cas		
.4	V	» 15 10	40	RA	Lac Cyg		
.5	V	» 16 05	30	R	And Cas		Sunlit rays
.6	V	» 17 00	40	R, RA	Lac		—»—
44.1	V	» 18 50	40	R, RA	Per		—»—
.2	V	» 19 50	40	R, RA	And Lac		—»—
.3	V	» 20 30	20	R, RB	Per		—»—
.4	V	» 21 20	20	R, RB	And Lac		—»—
.5	V	» 22 10	20	R, RB	Per		—»—
.6	V	» 22 40	20	R, RB	And Lac		—»—
45.1	V	» 23 45	30	R	Per		Very long sunlit rays. Colour white-violet
.2	V	» 24 45	30	R	Lac Cyg		—»—
.3	V	» 25 37	25	R	And Cas		—»—
.4	V	» 26 17	25	R	Lac Cyg		—»—
.5	V	» 27 35	30	R	Cas		—»—
.6	V	» 28 15	30	R	Lac Cyg		—»—
46.1	V	» 29 35	30	R	Per		—»—
.2	V	» 30 15	30	R	Lac Cyg		—»—
.3	V	» 31 15	30	R, F	Per		—»—, flames going upwards
.4	V	» 32 35	30	R	Lac Cyg		—»—
.5	V	» 33 45	30	R	Aur		—»—
47.2	V	» 38 50	60	R, F	Lac Cyg		—»— —»—
1	$C—O—Li$	» 46 28	21	R	Per		Sunlit rays
47.4	V	» 46 50	40	R	Lac Cyg		—»—
2	$C—O—Li$	» 47 29	21	R	Cam Cas		—»—
3	$C—Li$	» 48 18	27	R	Cam Cas		—»—
5	$C—O—Li$	» 50 44	20	RB	Per Cas		
6	$C—O—Li$	» 51 21	17	R	Aur	5	Sunlit rays, very fine
48.1	V	» 51 22	25	R	Aur Per		The same, can be used with No. 6 for measuring height
7	$C—O—K_4—Li$	» 52 30	18	R	Cas Cep		Sunlit rays
48.2	V	» 52 52	45	R	And Cas		—»—
8	$O—Li—K_4$	» 53 11	20	DS	Aur Per		Cloud-like
9	$C—O—Li—K_4$	» 53 54	22	R	Cas Cep		Fine sunlit rays
10	$C—O—Li$	» 54 43	19	DS	Aur Per		Cloud-like
11	$C—O—Li$	» 55 25	21	R	Cas		Sunlit
12	$C—O—Li—K_4$	» 56 01	20	R	Cep Cas	7	—»—, very fine
48.3	V	» 56 15	30	R	And Cas		—»—
13	$C—O—Li$	» 57 12	16	R	Per Cas		—»—, very fine
48.4	V	» 57 35	30	R	Per Cas		The same, can be used in connection with No. 13 & 14
14	$C—O—Li$	» 57 43	15	R	Per Cas		The same
15	$C—O$	» 58 39	24	DS	Aur		Cloud-like patches
17	$C—O—Li$	23 01 40	24	DS	Gem Aur	7	Very fine cloud-like patches
19	$C—O—Li$	» 04 08	25	R	Aur		
49.1	V	» 08 42	45	R	And Cas		Feeble
.2	V	» 10 20	80	HA, F	Lac Cyg		
.3	V	» 12 40	60	R	Per And		

[1] Under the heading St. the letter C is used both for C and C*.

Table I (continued).

P.N.	St.	MET	Ex.	Fm.	Ref. Const.	N	Remarks
20	$C-O-Li$	23h 34m 56s	49	R	Cep Cas		Probably sunlit
21	$C-O-Li$	» 36 02	22	DS, R	And Cas		Cloud-like patches. Rays
22	$C-O-Li$	» 36 47	21	DS, R	And Cas		The same
23	$C-O-Li$	» 38 00	30	DS	Aur Per		Like a fragment of an arc
24	$C-O-Li$	» 39 05	30	DS, R	And Cas		Fine
25	$C-O-Li$	» 42 19	30	DS	Gem Aur		Cloud-like, very fine
26	$C-O-Li$	» 43 21	30	DS	Gem Aur		—»—
27	$C-O-Li$	» 44 11	30	DS	Gem Aur	4	—»—
28	$C-O-Li$	» 45 25	30	DS	Gem Aur		—»—
51.2	V	» 46 20	60	R	Cas And		
29	$C-O-Li$	» 46 40	30	DS	Gem Aur	8	Cloud-like, very fine
51.3	V	» 47 25	50	R	Cas And		
30	$C-O-Li-K_4$	» 47 51	30	R	Cas And		
51.4	V	» 49 30	50	R	Cas And		
31	$C-O-Li$	» 49 56	38	R	Gem Aur		Feeble rays
32	$C-O-Li$	» 53 14	24	R	Gem Aur		
34	$C-Li$	» 54 52	25	RB	Gem		Curtain
35	$C-O$	» 55 37	21	RB	Aur		
52.1	V	» 57 05	30	R	Cas		
36	$C-O-K_4$	» 57 15	23	R	Cas		
52.2	V	» 58 25	40	R	Cas		
37	$C-Li$	00 08 20	60	R, RB	Aur		
38	$C-Li$	» 10 11	60	R	Aur		
1*	$C-K_4-T$	» 14 15	22	R	Cas	6	Sunlit rays
2*	$C-K_4-T$	» 15 25	23	R	Cas		The same
53.5	V	» 15 37	85	R	Cas		—»—
39	$C-O-Li$	» 15 56	30	R	Cas		—»—
3*	$C-K_4-T$	» 16 04	19	R	Cas		—»—
4*	$C-K_4-T$	» 17 45	23	R	Aur		Sunlit rays
40	$C-O-Li$	» 17 52	30	R, DS	Aur		The same, cloud-like remains of arc lower down
5*	$C-K_4-T$	» 18 25	22	R, DS	Aur		—»—
41	$C-O-Li$	» 18 41	30	R, DS	Aur		—»—
6*	$C-K_4-T$	» 19 23	22	R, DS	Aur		—»—
42	$C-Li$	» 19 24	30	R	Cam Aur		The same rays
43	$C-O-Li$	» 21 47	24	R, DS	Aur		—»—
7*	$C-K_4-T$	» 21 52	15	R	Aur		—»—
8*	$C-K_4-T$	» 22 24	30	R	Per Aur		—»—
44	$C-O-Li$	» 22 32	33	R	Per Aur		—»—
9*	$C-K_4-T$	» 23 39	30	R	Per Aur		—»—
10*	$C-K_4-T$	» 24 51	24	R	Per		—»—
45	$C-O-Li$	» 25 44	38	R, DS	Aur		—»—, lower down cloud-like aurora was seen
47	$C-O-Li$	» 29 17	32	R	Cam		Sunlit rays
11*	$C-K_4-T$	» 29 24	10	R	Cam		The same
48	$C-O-Li$	» 30 23	31	R	Cam		—»—
12*	$C-K_4-T$	» 31 24	30	R	Cam		—»—
54	$C-O-Li$	» 39 06	23	R	Cam		—»—
13*	$C-K_4-T$	» 39 30	20	R	Cam		—»—
14*	$C-K_4-T$	» 40 05	20	R	Cam		—»—
55	$C-O-Li$	» 40 27	32	R	Cas Cam		—»—
15*	$C-K_4-T$	» 40 45	30	R	Cam		—»—
56	$C-O-Li$	» 41 17	27	R	Cam		—»—
16*	$C-K_4-T$	» 41 30	30	R	Cam		—»—
17*	$C-K_4-T$	» 42 50	29	R	Per Cam Cas		—»—
57	$C-Li$	» 45 12	18	DS	Aur		Cloud-like
59	$O-Li$	» 47 11	25	DS	Aur Gem		—»—
18*	$C-K_4-T$	» 49 16	21	R	Cas		Sunlit ray
60	$C-O-Li$	» 49 43	20	R	Cam		Other sunlit rays
19*	$C-K_4-T$	» 52 11	30	R	Cas	3	The same as 18*, summit over 500 km
63	$O-Li$	» 55 22	26	DS	Per Aur		Cloud-like
66	$O-Li$	01 08 14	24	R	Per Cam		Sunlit rays
20*	$C-K_4-T$	» 08 25	27	R	Per Cam		The same
21*	$C-T$	» 09 13	24	R	Per Cam		—»—
67	$C-Li$	» 17 55	30	DS	Gem		Cloud-like
22*	$C-K_4-T$	» 23 28	36	R	Cam Cas		Sunlit
23*	$C-T$	» 25 49	24	DS	Gem		Cloud-like, like a horse-shoe formed band
24*	$C-T$	» 26 35	35	DS	Gem		The same, —»—
68	$C-Li$	» 26 36	30	DS	Gem		—»— —»—

Table I (continued)

P.N.	St.	MET	Ex.	Fm.	Ref. Const.	N	Remarks
69	C—Li	$01^h\ 28^m\ 36^s$	30	DS	Gem		Cloud-like, like a horse-shoe formed band
70	C—Li	» 29 16	20	DS	Gem		—»— —»—
25*	K_4—T	» 29 57	25	DS	Gem Aur		—»— —»—
71	C—Li	» 30 15	22	DS	Gem Aur	4	—»— —»—
26*	C—K_4—T	» 30 49	35	DS	Gem Aur	3	—»— —»—
72	C—Li	» 30 58	25	DS	Gem Aur		—»— —»—
73	C—Li	» 32 06	29	DS	Gem Aur		—»— —»—
74	C—Li	» 33 05	33	DS	Gem Aur		—»— —»—
27*	C—T	» 34 02	40	DS	Gem Aur		—»— —»—
75	O—Li	» 36 52	20	DS	Aur		—»— —»—
76	O—Li	» 38 13	22	DS	Per		Cloud-like
77	O—Li	» 39 17	25	DS	Aur		The same as No. 75
79	O—Li	» 48 03	30	HA	Aur		
80	O—Li	» 49 50	30	R, HA	And		
81	O—Li	» 58 02	30	RA, DS	Aur		A series of short rays along the arc. Cloud-like over it
82	O—Li	» 59 54	30	HA	Per And		
29*	C—K_4—T	02 00 32	6	R	Aur		Foot of rays very luminous
83	O—Li	» 01 31	7	R	Aur		—»—
84	O—Li	» 02 02	6	RA, R	Aur		Sunlit rays over strong RA along horizon
30*	C—K_4—T	» 02 17	15	RA, R	Aur	10	—»—, the RA in shadow
85	O—Li	» 02 42	9	RA, R	Aur		—»—
36*	C—K_4—T	» 36 17	10	R	Aur		Sunlit
37*	C—K_4—T	» 36 57	10	R, RB	Aur		Rays going down to RB border, both in sunlight
38*	C—K_4—T	» 37 25	15	R	Aur		Sunlit
39*	K_4—T	» 38 07	9	R	Aur Per		The same
40*	K_4—T	» 38 39	14	R	Aur Per		—»—
41*	K_4—T	» 39 24	16	R	Aur Per		—»—
42*	K_4—T	» 39 57	16	R	Per		—»—
					April 21—22, 1936.		
56.1	V	22 05 40	20	HA	Cas		
.2	V	» 07 00	60	HA	Per		Looks like a splitted sharply bordered arc
.3	V	» 08 20	60	HA	Cyg		
.4	V	» 10 00		HA	Per		Just before, the arc had dissolved in rays
.5	V	» 11 20	10	R	Cas		Fine sunlit rays
.6	V	» 13 27	45	R	Cas		Sunlit Rays
57.2	V	» 20 02	25	R	Per		—»—
.3	V	» 20 40	20	R	Per		—»—
.5	V	» 34 25	30	R	Cep		—»—
1	C—K_4	» 34 43	20	R	UMi Cep		—»—
2	C—K_4	» 35 45	33	R	Cas		—»—
3	C—O—K_4	» 36 44	31	R	Cas		
57.6	V	» 37 20	20	R	Cas		Very fine sunlit ray
4	O—K_4	» 38 34	21	R	Cas Per		Sunlit rays
5	C—O—K_4	» 39 28	31	R	Aur		—»—
6	C—O—K_4	» 40 32	31	R	Aur		—»—
7	C—O—K_4	» 42 14	25	R	Aur		—»—
12	O—K_4	23 06 39	25	R	Aur		—»—
14	C—O—K_4	» 08 53	24	R	Gem		—»—
24	O—K_4	» 37 07	12	R	Cam UMi		
28	O—K_4	00 03 02	23	R	Cas		
29	O—K_4	» 04 45	24	R	Cas		
30	O—K_4	» 06 50	26	R	Cas		
32	O—K_4	» 08 53	26	R	Cas Per		
33	O—K_4	» 09 32	13	R	Cas		
34	O—K_4	» 10 26	14	R	Cas	3	Sunlit ray up to 550 km
35	O—K_4	» 11 29	31	R	Per Cas		
36	O—K_4	» 12 23	32	R	Per		
37	O—K_4	» 43 12	28	R	Per Cas		
38	C—O—K_4	» 44 18	20	R	Cas	3	
41	C—O	» 51 37	11	R	Aur		Fine ray
52	C—O	01 13 17	11	R	Cyg	6	Partly sunlit
53	C—O	» 13 43	7	R	Cyg		
55	C—O	» 22 01	5	RB	Aur		Fine curtains
56	C—O	» 22 44	5	RB	Aur		—»—
57	C—O	» 24 05	8	RB	Gem		—»—

Table I (continued).

P.N.	St.	MET	Ex.	Fm.	Ref. Const.	N	Remarks
58	$C—O$	01h 24m 52s	8	RB	Aur Per		Very fine
59	$C—O$	» 26 03	7	R	Leo		
60	$C—O$	» 28 25	34	RB	Leo	2	Fine curtain
62	$C—O$	» 30 08	18	RB	Leo		The same
63	$C—O$	» 31 13	9	RB	Leo	5	—»—, down to about 90 km
64	$C—O$	» 32 06	12	RB	Leo	2	—»— —»—
65	$C—O$	» 32 36	13	RB	Leo	4	
66	$C—O$	» 34 40	12	R	Cep Lac Cyg		Sunlit, very long rays
67	$C—O$	» 35 37	16	R	Cep Dra Cyg	5	Sunlit, summit to 600 km. Foot 200 km
68	$C—N$	» 40 22	10	RA	Leo Cnc Vir	4	RA in the earth's shadow, down to about 90 km
69	$C—N$	» 41 07	28	RA	Leo Cnc Vir	6	—»—.
70	$C—N$	» 41 46	12	RA	Leo Cnc Vir	5	—»—.
71	$C—N$	» 42 22	10	RA	Leo Cnc Vir Gem	6	—»—.
73	$C—N$	» 44 59	17	RA	Leo Cnc Vir Lyn	5	—»—, down to about 90 km
75	$C—N$	» 46 37	13	RA	Leo Cnc Vir Gem		
76	$C—N$	» 48 27	8	RA	Leo Cnc Vir Lyn	3	
79	$T—N$	» 53 31	10	RA, R	And Aql		
80	$T—N$	» 54 03	12	RA, R	And Aql		
84	$C—K_4—T$	02 00 33	12	R	UMi Cas	3	In the earth's shadow from 100—150 km
85	$C—K_4—T—N$	» 01 33	9	RB	Cas		
88	C	» 06 03	10	RB	Gem Lyn UMa		
89	C	» 07 08	11	RB	Gem Lyn UMa		
90	$C—K_4$	» 08 13	8	RB	Gem		C: Picture taken with Leica camera
91	$C—K_4$	» 08 45	6	RB	Gem		C: —»—
96	C	» 13 39	8	RB	Aur		Drapery of intensely green colour. Also taken with Leica
97	C	» 14 52	12	RB	Per		—»— —»—
					October 16—17, 1936.		
1	K_4	20 32 26	8	DS	Lyn Her		Strong red colour
3	K_4	» 33 35	8	R	Tau		
82.2	V	» 34 10	60	R	Dra UMi		
.3	V	» 36 55	120	HA	Aql		Feeble arc
.4	V	21 01 55	90	HA	CrB		
.5	V	» 08 55	90	HA, R	UMa Her		
13	$C—K_4$	» 11 01	10	R	UMa		
14	$C—K_4$	» 11 29	12	R	UMi		
15	$C—K_4$	» 12 02	14	R	UMa		Feeble high ray
82.6	V	» 12 15	30	R	CrB		Fine rays
16	$C—K_4$	» 12 29	6	R	UMa		—»—
18	C, K_4	» 13 54	14	HA, RB	UMa		Homogeneous arc through UMa, lower down RB
19	C, K_4	» 14 40	11	HA, R	UMa Boo		Very fine rays through the western UMa, HA through the eastern UMa
20	C, K_4	» 15 22	9	HA, R	UMa		The same
83.2	V	» 17 00	20	HA, R	UMa Boo		Strong arc near the horizon, rays over it
23	$C—K_4$	» 19 03	13	R	UMa		
26	$C—K_4$	» 21 08	8	R	UMa		Fine thin ray
83.4	V	» 23 10	60	HA, R	UMa Boo		Strong HA near the horizon, rays over it
84.1	V	» 29 10	30	HA	Boo		Strong arc near the horizon
.3	V	» 32 40	60	HA	Boo		The same
.5	V	» 36 25	30	RA	UMa CVn		—»—
.6	V	» 38 25	60	RA	UMa Boo		—»—
85.1	V	» 41 55	60	RA	UMa		—»—, eastern part
.2	V	» 43 53	55	RA	CrB Boo		—»—, western part, short rays along the arc
.3	V	» 46 15	50	RA	UMa		—»—, eastern part
35	K_4	» 46 34	14	RA	CrB Boo		—»—, short rays along the arc
36	$C—K_4$	» 46 57	10	RA	UMa CVn		Fine series of short rays along the arc
37	$C—K_4$	» 47 33	8	RA	CVn		Fine series of short rays
85.4	V	» 48 10	20	RA	CrB		
39	$C—K_4$	» 48 22	8	RA	CVn UMa		—»—
40	$C—K_4$	» 48 40	9	RA	CVn UMa		—»—
85.5	V	» 48 48	25	RA	CVn UMa		—»—
42	$C—K_4$	» 49 34	10	RA	CVn UMa	3	—»—. In the earth's shadow
85.6	V	» 50 05	20	RA	CVn UMa		—»—
44	$C—K_4$	» 50 28	5	RB	CVn UMa		Very luminous part of RB
45	$C—K_4$	» 50 40	5	RB	CVn UMa		—»—
86.1	V	» 51 13	15	RB	CVn UMa		—»—

Table I (continued).

P.N.	St.	MET	Ex.	Fm.	Ref. Const.	N	Remarks
46	$C-K_4$	$21^h\,51^m\,27^s$	8	RB	CVn UMa		Very luminous part of RB
86.2	V	» 51 33	15	RB	CVn UMa		—»—
.3	V	» 52 05	20	RB	CVn UMa		The same (fading away at $21^h\,53^m$)
.4	V	» 58 38	45	HA	CVn UMa		Double arc
.6	V	22 03 55	60	HA	UMa		Single arc
87.2	V	» 24 25	60	HA	CVn UMa		Strong red colour in NE
52	$C-K_4$	» 27 33	6	R	UMa		At K_4 clouds very annoying
53	$C-K_4$	» 27 53	6	R	UMa		—»—, strong red colour in NE
87.6	V	» 30 45	60	DS	UMa		Dark red patch east of ι and $\varkappa$ at $22^h\,32^m$
88.1	V	» 38 53	25	R, HA	Boo UMa		The red colour in NE subsisted.
.6	V	» 53 40	30	HA	Boo Her		Diffuse are and a strong one near the horizon
89.2	V	» 55 53	35	HA, RB	Boo Her		Double HA and RB near the horizon
59	$C-O$	» 57 08	11	RB	Her		The same RB
60	$C-O$	» 57 47	10	RB	Her		—»—
89.3	V	» 58 03	45	HA	Her		The same double arc as no 89.2
61	C	» 58 14	7	RB	Her		The same as 59
62	C	» 58 32	7	RB	Her		—»—
63	C	» 58 54	7	RB	Her		—»—
89.4	V	» 59 15	40	RB	UMa		—»—
64	$C-O$	» 59 33	20	HA	Her		The western part
89.5	V	23 01 25	40	RB	Boo UMa		The summits of the rays red
.6	V	» 02 45	20	RB	Boo UMa		
65	$C-O$	» 02 58	10	R	UMa		3 red rays
68	$C-O$	» 04 20	9	R	Gem		Strong red
69	$C-O$	» 04 53	10	R	Gem		—»—
90.1	V	» 05 30	120	HA	UMa		
70	$C-O$	» 06 07	6	RB	Her		Horseshoe formed band. Opening towards W
72	$C-O$	» 07 20	6	RB	Her		The same
73	$C-O$	» 07 42	5	RB	Her		—»—
74	$C-O$	» 08 03	6	RB	Her		—»—
90.2	V	» 08 15	20	RB	Her		The same. Fine series of short rays along the band
75	$C-O$	» 08 27	6	RB	Her		—»—
90.3	V	» 08 48	25	RB	Her		—»— —»—
76	$C-O$	» 09 33	5	RB, R	Her		—»— —»—, 3 short rays under the band
90.4	V	» 10 20	60	RB	Her		The same
78	$C-O$	» 10 32	6	RB	Boo UMa		Eastern end of band
79	$C-O-T$	» 10 59	5	RB	Her		Western end of the same
90.5	V	» 11 38	45	RB	Boo UMa		Eastern end —»—
80	$C-O-T$	» 11 42	6	RB	Her		Western end —»—, horseshoe, opening towards E
81	$C-O-T$	» 11 59	6	RB	Her		—»—, Horseshoe disappeared.
90.6	V	» 12 55	41	RA, RB	UMa		Eastern end, RB under RA
82	$C-O-K_4-T$	» 13 29	5	RA	UMa		Eastern end
83	$C-O-T$	» 14 14	15	RA	Her		Western end
91.1	V	» 15 00	60	HA	Her		—»—
84	C, O, T	» 15 04	12	HA	Her UMa		C, O eastern end, T western end
91.2	V	» 16 30	60	HA	UMa		
85	C	» 16 39	12	HA	Her		Western end
86	$C-O-T$	» 17 25	13	HA	UMa		
87	O	» 18 00	13	HA	UMa		Eastern end
91.3	V	» 18 15	50	HA	Her		Western end
91.4	V	» 19 40	50	HA	UMa		
88	$C-O-K_4-T$	» 20 13	10	R, HA	Her		Western end
89	$O-T$	» 20 52	10	HA	Her Aql		Western end
91.5	V	» 21 (?)		HA	UMa		Eastern end
90	C, O	» 21 27	10	HA	Her		Western end
91	$C-O-T$	» 22 04	14	HA	UMa		
92	$C-O-K_4-T$	» 22 42	10	RB, HA	UMa		RB under RA
91.6	V	» 23 10	50	HA	Her		Western end
93	O	» 23 16	10	HA	UMa		Eastern end
94	$C-O$	» 24 26	7	RA	UMa		A series of short rays from the lower border
95	C, O	» 25 03	4	RA	Her Aql		Western end
96	$C-O-T$	» 25 56	12	RA	UMa Lyn, the horizon		Eastern end
97	$C-O-T$	» 26 41	9	RA	UMa		Two arcs
98	$C-O$	» 27 42	10	R, RA	Lyr		Western end. Short isolated rays over the arc
99	$C-O-T$	» 28 09	4	R, RA	Lyr		The same

Table I (continued).

P.N.	St.	MET	Ex.	Fm.	Ref. Const.	N	Remarks
100	*C—O—T*	$23^h\ 28^m\ 48^s$	7	R, RA	Lyr		The same
101	*C—O*	» 29 23	5	RA	Her		The same RA
102	*C—O—T*	» 29 52	6	R, RA	Lyr Her		The same as 100
103	*C—O—T*	» 30 16	5	R, RA	Lyr Her		—»—
104	*C—O—T*	» 31 03	6	R, RA	Lyr Her		—»—
106	*C—O—T*	» 33 25	8	D	Lyn Gem		Fine red drapery
107	*C—O—T*	» 33 57	7	D	Gem		The same. More diffuse, strong red colour
108	*C—O—T*	» 34 25	8	D	Gem		—»—
109	*C—O—T*	» 34 49	10	D	Gem		—»—
110	*C—O—T*	» 35 37	15	D	Gem	8	—»—
92.2	*V*	» 35 38	75	R, RB	Boo UMa		
111	*C—O—T*	» 36 37	14	D	Gem		The same as 107
112	*C—O—T*	» 38 08	10	D	Lyr Her		Green colour
92.3	*V*	» 39 00	60	RB	UMa		Many forms, mostly RB
.4	*V*	» 40 30	60	R	Lyr Her		Green
113	*C—O—T*	» 40 52	15	R	Lyr Her		Green
92.5	*V*	» 41 55	50	RB	UMa		The same as 92.3. $23^h\ 43^m\ 15^s$ flames began to go upwards.
.6	*V*	» 46 55	90	DS	UMa		Diffuse flaming patches
114	*C—O*	» 48 05	20	DS	Her		
115	*C—O*	» 49 57	22	DS, F	Cyg Vul Lyr		Cloud-like remains. Flaming upwards
116	*C—O*	» 50 51	20	DS, F	Lyr		The same —»—
93.2	*V*	» 52 15	90	DS, F	UMa		—»— —»—
.3	*V*	» 54 05	90	DS, F	Cyg Vul Lyr		—»— —»—
.4	*V*	» 56 15	90	DS, F	Her		—»— —»—
94.1	*V*	00 06 05	90	DS, F	Lyr		—»— —»—
117	*C—Li*	» 06 43	30	DS	Aql		—»—, fine parallax
118	*C—Li*	» 07 58	60	DS	Aql		—»— —»—
94.2	*V*	» 08 35	90	DS, F	Boo		Cloudlike, flaming
119	*C—Li*	» 10 07	60	DS, F	Aql		—»—
94.3	*V*	» 13 05	150	DS, F	Her		—»—
120	*C—Li*	» 14 30	30	DS, F	Her		—»—
121	*C—Li*	» 16 32	60	DS, F	Her		—»—
122	*C—Li*	» 17 30	30	DS, F	Lyr Vul Del		—»—
94.5	*V*	» 21 10	150	DS, F	Lyr Her		—»—
.6	*V*	» 24 20	120	DS	Boo UMa		—»—
123	*C—Li*	» 24 59	60	R, DS	Her		
124	*C—Li*	» 26 28	20	R, DS	Her		
95.1	*V*	» 28 20	60	R	Her		
.3	*V*	» 34 05	60	R, DS	Her Boo		
.4	*V*	» 37 05	90	DS	Boo		
125	*C—Li*	» 38 19	20	RB	Boo		Cloud-like RB near northern horizon
126	*C—Li*	» 39 00	23	RB	Lyr Her		Cloud-like RB
95.5	*V*	» 39 50	60	R	Her		Still flaming
127	*C—Li*	» 40 09	18	R	Her		The same rays as 95.5
128	*C—Li*	» 40 51	17	R, DS	Her		
129	*C—Li*	» 41 53	10	R	Her		
95.6	*V*	» 42 38	65	RB	Her		Cloud-like RB, flaming
130	*C—Li*	» 42 54	16	RB	Her		—»—
131	*C—Li*	» 43 32	20	RB	Her		—»—, or rather pulsating
132	*C—Li*	» 44 21	19	RB, PS	Her		Pulsating cloud-like bands RB. Interesting forms
133	*C—Li*	» 45 41	20	RB, PS	Her		—»—
134	*C—Li*	» 46 43	20	RB, PS	Lyr Her	10	—»—
135	*C—Li*	» 47 57	22	RB, PS	Her	2	—»—
136	*C—Li*	» 49 14	20	RB, PS	Her		—»—
137	*C—Li*	» 53 45	12	RB, PS	Her		—»—
138	*C—Li*	» 54 38	18	RB, PS	Her		
96.1	*V*	» 58 53	75	DS	Her		Cloud-like arc
139	*C—Li*	01 03 04	28	DS	Lyr Her		Cloud-like ray
96.3	*V*	» 03 43	45	DS	Lyr Her		Cloud-like
140	*C—Li*	» 04 02	25	DS	Lyr		—»—
96.4	*V*	» 06 10	90	DS	UMa		Cloud-like arc. Still flames
141	*C—Li*	» 06 40	25	DS	Lyr Del		Cloud-like
96.5	*V*	» 19 20	60	RB	Lyr Aql		RB begin to develop
142	*C—T—Li*	» 19 22	22	RB	Lyr		The same
143	*C—T—Li*	» 20 16	16	RB	Lyr		The same. The bands bend like a horseshoe with opening towards E

Table I (continued).

P.N.	St.	MET	Ex.	Fm.	Ref. Const.	N	Remarks
96.6	*V*	01h 20m 50s	90	RA	Boo UMa		Eastern end
144	*C—T—Li*	» 21 28	18	RA	Lyr Her		Towards NNW. Fine yellow-green colour
145	*C—T—Li*	» 22 14	22	RA	Lyr Her		—»—
146	*C—T—Li*	» 23 17	20	RA	Lyr Her	6	—»—
147	*C—T—Li*	» 24 13	21	RA	Lyr Her		—»—
97.2	*V*	» 25 03	75	RA	Boo UMa		Towards NNE
148	*C—Li*	» 25 33	16	RA	UMa		—»—
149	*C—Li*	» 26 23	16	RA	UMa		—»—
150	*C—T—Li*	» 27 04	13	R, RA	Her Dra		
97.3	*V*	» 27 50	120	RA	Lyr		Western end
151	*C—Li*	» 28 07	18	RB	Lyr Her		Horseshoe formed with opening towards E
152	*C—Li*	» 29 08	30	R	UMa CVn		Red
97.4	*V*	» 29 35	60	RB	UMa Boo		
153	*C—T—Li*	» 30 09	13	R, RB	UMa CVn	6	Red
154	*C—T—Li*	» 31 35	26	R, RB	UMa CVn		Several rays and bands. Red
97.5	*V*	» 31 40	60	RB	Lyr		
155	*C—T—Li*	» 32 45	15	R, RB	UMa CVn		The same as 154. Red
97.6	*V*	» 33 15	90	RB	UMa		Several bands
156	*C—T—Li*	» 33 44	17	RB	Lyr Her		The same horseshoe as 151. More cloud-like, yellow-green.
157	*C—Li*	» 34 44	16	RB	Lyr Her		—»— —»—
158	*C—T—Li*	» 35 40	14	R, RB	UMa CVn		Several bands
98.1	*V*	» 35 50	60	RB	Lyr		Yellow-green
159	*C—T—Li*	» 36 35	14	D	UMa		The same, fine
98.2	*V*	» 36 55	90	D	UMa		—»—
160	*C—T—Li*	» 37 45	5	D	UMa		—»—
161	*C—T—Li*	» 38 14	10	D	UMa	6	—»—
98.3	*V*	» 38 55	50	RB	Cyg		Western part, horseshoe formed, opening towards E. Yellow-green
162	*C—T—Li*	» 39 15	12	D	UMa		The same as 161, farther east
98.4	*V*	» 39 55	50	RB	Her		
163	*C—T—Li*	» 40 06	15	RB	Aql Del		The same as 98.3
164	*C—T—Li*	» 40 37	12	RB	Lyr		Pulsating or flaming
98.5	*V*	» 41 03	55	D	UMa CVn		The same as 162
165	*C—T—Li*	» 41 22	10	RB	Aql Del		The same as 163
98.6	*V*	» 42 40	60	RB	Cyg		The same as 98.3
166	*C—T—Li*	» 42 51	25	D, R	UMa	9	Very fine ray, lower part green, summit red
167	*C—T—Li*	» 43 46	10	D	Her Boo		Most beautiful multiple draperies
99.1	*V*	» 44 25	60	D	UMa Boo		Exposure too long
168	*C—Li*	» 45 05	10	D	Boo		The same, most beautiful
169	*C—T—Li*	» 45 34	10	D	Boo		—»—
99.2	*V*	» 45 40	60	RB	UMa CVn		Eastern end
170	*C—T—Li*	» 46 31	12	D	Vul Cyg	4	Horseshoe-formed western end. Opening towards E
171	*C—T—Li*	» 47 16	12	D	Boo UMa		Horseshoe-formed eastern end. Opening towards W
99.3	*V*	» 47 25	60	RB	Vul Cyg		Western end. Horseshoe gone
.4	*V*	» 48 40	60	D	UMa Boo		The same as 171
172	*C—T—Li*	» 49 08	7	D	UMa		Very fine. Two draperies
173	*C—T*	» 49 50	30	R	UMa Lyn LMi		Red, probably very high and sunlit; compare No. 178
99.5	*V*	» 50 20	90	R	UMa Lyn LMi		The same
174	*C—T*	» 50 46	17	R	UMa Lyn LMi		—»—
175	*C—T—Li*	» 51 21	8	D	UMa	4	The same as 172. Now one curtain of interesting form. Green colour
176	*C—Li*	» 51 50	5	R, D	Cyg Lyr		Rays and draperies. Green
177	*C—T—Li*	» 52 52	35	R	UMa Lyn LMi	3	Red, sunlit, see No. 178
99.6	*V*	» 53 00	90	D	Cyg Lyr		The same as 176
178	*C—O—T—Li*	» 54 12	30	R	UMa Lyn LMi	19	Red and sunlit, foot about 600 summit about 1100 km
179	*C—O—Li*	» 54 49	12	D, R	Lyr Her		Green draperies and rays
180	*C—O—Li*	» 55 25	10	D, R	Lyr Her		The same
181	*C—T—Li*	» 56 48	11	R	Lyr Cyg		Long rays
182	*C—O—T—Li*	» 59 27	13	D	Lyr		Fine drapery
183	*C—O—T—Li*	02 00 25	34	R	UMa Lyn		Red rays. Mostly in the earth's shadow
184	*C—C—T—Li*	» 01 55	36	R	UMa Lyn LMi		—»—
185	*C—O—T—Li*	» 03 07	30	R	UMa Lyn LMi		Fine red rays in shadow
186	*C—O—T—Li*	» 04 21	26	R	UMa Lyn LMi	6	—»—
187	*C—O—T—Li*	» 05 06	30	R	UMa Lyn LMi		—»—
188	*C—O—T—Li*	» 06 27	30	R	UMa Lyn LMi		—»—

Table I (continued).

P.N.	St.	MET	Ex.	Fm.	Ref. Const.	N	Remarks
189	$C-O-Li$	02h 08m 38s	13	R	UMa CVn		Fine red rays in shadow. Colour changed from green to red in few seconds
100.1	V	» 09 10	>90	RB	Cyg		Green
190	$C-T-Li$	» 09 24	25	R	UMa		Colour changed from green to red en few seconds.
100.2	V	» 11 00	>90	RB, F	Her		Gives lower border of aurora
.3	V	» 12 45	>90	RB, F	CVn		—»—
.4	V	» 14 55	90	RB, F	Cyg		—»—
.5	V	» 16 25	60	RB, F	Her		Lower border fine
191	$C-T-Li$	» 17 22	13	D, R	Cyg Lyr		Green
100.6	V	» 17 35	50	D, R	Cyg Lyr		The same
192	$C-T-Li$	» 18 46	14	R	UMa		
193	C	» 19 17	8	R	Cyg Lyr		
101.1	V	» 19 20	60	RB	Cyg Peg		
194	$C-T-Li$	» 19 47	18	R	UMa		Red rays
101.2	V	» 20 40	60	R	Lyr		
.3	V	» 21 55	60	R	Cyg		
.4	V	» 23 03	45	RB, R	Boo UMa		
.5	V	» 24 10	60	DS	CVn VMa		Cloud-like
.6	V	» 25 35	50	RB	Lyr Dra		Fine lower border
195	C	» 26 48	3	D	UMa		Fine drapery
196	$C-T-Li$	» 27 31	21	R	UMa	10	Most splendid rays, first blue-green, then changed to red all over.
102.1	V	» 27 58	25	R, F	UMa		The same, flames going upwards. To the right, red, to the left, red-green rays
197	$C-Li$	» 28 10	20	R	UMa	7	The same
102.2	V	» 28 43	35	R, F	UMa		—»—, can be used with No. 198 to height measuring, flames
198	$C-T-Li$	» 28 48	20	R	UMa	9	—»—
199	$C-T-Li$	» 29 33	10	R	UMa		—»—, lower down
102.3	V	» 30 58	35	R, F	UMa		—»— —»—
.4	V	» 32 18	75	R, F	Cyg		Flames upwards
.5	V	» 34 25	90	R, F	UMa		Red
.6	V	» 38 00	120	DS, F	Cyg Peg		Cloud-like
103.1	V	» 40 10	60	R, F	UMa		Red colour over ε, ζ, η
.2	V	» 43 10	120	R, F	UMa CVn		—»— , between ε, ζ, η and 12 CVn
200	$C-T$	» 45 31	23	R	CVn		Red
103.3	V	» 46 55	90	RB, F	Cyg		
.4	V	» 48 42	105	F	Lyr Dra		
.5	V	» 52 40	180	F	UMa		Lower border near horizon
201	$C-K_4-T-Li$	» 54 33	60	DS	Peg		Cloud-like
103.6	V	» 55 50	120	DS, F	Cyg Peg		—»—
202	$C-T-Li$	» 56 25	60	DS	Peg		—»—
203	$C-T-Li$	» 58 19	60	DS	Peg		—»—
204	$C-T-Li$	03 00 19	60	DS	Peg		—»—, Vigorous flames and pulsations up to zenith
104.1	V	» 13 55	90	DS	Lac Cyg		—»— —»—
.2	V	» 15 20	60	RB, F	Dra Her		Lower border fine
.3	V	» 16 15	30	RB, F	Boo UMa		—»—
.4	V	» 17 45	90	F	Lac Cyg		
.5	V	» 19 48	55	RB, F	Dra Lyr		Lower border fine
.6	V	» 22 23	55	RB, F	Dra Her		
205	$T-Li$	» 23 46	60	DS, PS	Cep Cyg Lac		Cloud-like. Upper border pulsating
105.1	V	» 24 48	105	F	Cyg Peg		
206	$C-T-Li$	» 26 09	20	R	UMa	11	Sunlit, feet at about 400 km, summits over 800
105.2	V	» 26 48	105	RB, F	Dra		
.3	V	» 28 55	120	D	UMa		Red
.4	V	» 30 40	60	RB, F	Dra		
.5	V	» 32 45	90	HA	Cyg		
.6	V	» 34 35	90	HA, HB	Dra		HA transforming to HB
207	$C-T-Li$	» 38 50	34	R	UMa		
106.1	V	» 38 55	90	RB, F	Cyg		
208	C, T	» 39 58	31	R	UMa		
106.2	V	» 40 40	90	RB	Dra Her		
.3	V	» 42 55	120	R	UMa		Feeble red ray up to UMa
.4	V	» 45 40	90	RB	Cyg		
209	$C-K_4-T$	» 47 05	60	DS	Lyr Cyg		Cloud-like

Table I (continued).

P.N.	St.	MET	Ex.	Fm.	Ref. Const.	N	Remarks
106.5	*V*	03h 47m 25s	90	DS	Lyr Her		
.6	*V*	» 49 25	90	RB, F	UMa		
107.1	*V*	» 51 50	90	HB	Cyg Lac		
210	*C—T—Li*	» 51 51	19	R	Boo UMa		Probably sunlit
211	*C—Li*	» 52 43	20	R	Boo UMa		—»—
212	*C—Li*	» 53 21	23	R	Boo UMa	8	Divided rays, upper part sunlit
107.2	*V*	» 53 28	75	RB	Cyg Lyr Dra		
213	*C—Li*	» 54 05	26	R	Boo UMa	12	—»—
107.3	*V*	» 55 05	90	R	Boo UMa		Feeble red ray from Boo up to UMa
214	*C—T—Li*	» 55 07	22	R	Boo UMa		Probably sunlit
215	*C—T—Li*	» 56 18	40	R	Boo UMa CVn		—»—
107.4	*V*	» 56 58	75	RB	Cyg Peg		
.5	*V*	» 58 20	60	RB	Lyr Dra		Diffuse, cloud-like
.6	*V*	» 59 35	60	R, RB	Boo		Good lower border, flaming
216	$C—K_4—T—Li$	04 03 56	26	RB	Cyg Lac		Near the horizon
108.1	*V*	» 15 05	90	RB	Cyg		Two bands
217	$C—K_4—Li, T$	» 15 28	30	DS, R	Her Boo		The Tømte picture directed as No. 218
108.2	*V*	» 16 45	90	RB, F	Her		
.3	*V*	» 18 25	90	RB (DS)	Cyg		Cloud-like
218	*C—T—Li*	» 19 55	60	R	UMa	3	Quiet, feeble grey-violet sunlit rays. Very fine
108.4	*V*	» 20 05	90	RB, F	Her		Very good lower border
219	*C—T—Li*	» 21 35	60	R	UMa	3	The same as 218. Very fine
108.5	*V*	» 22 (?)	90	RB, F	Cyg		
220	*C—T—Li*	» 22 55	30	R	UMa Boo	3	The same as 219. Very fine
108.6	*V*	» 23 (?)	90	RB	Peg Cyg		Arc very close to horizon
221	*C—T—Li*	» 24 03	30	R	Boo UMa	5	The same as 220. Very fine
109.1	*V*	» 27 10	120	RB, F	Peg Cyg		The same as 108 6
.2	*V*	» 27 55	60	RB, F	Lyr Dra		
.3	*V*	» 30 55	120	PA, F	Her		
222	$C—K_4—T—Li$	» 32 00	12	D	Lyr Cyg Peg		Fine drapery in N
223	$C—K_4—T—Li$	» 32 36	16	D	Lyr Cyg Peg	4	The same
109.4	*V*	» 33 18	75	D	Cyg		—»—
.5	*V*	» 34 40	60	D	Cyg Lyr		—»—
.6	*V*	» 36 28	105	RB	Peg Cyg		More cloud-like
224	$C—K_4—T—Li$	» 37 49	13	D	Dra Lyr	13	Horseshoe-formed drapery of sunlit aurora rays
225	$C—K_4—T—Li$	» 38 25	15	D	Dra	6	—»—
110.1	*V*	» 38 25	90	RB	Cyg Lyr		Lower border-fine
226	$C—K_4—Li$	» 39 07	19	D	Dra	5	The same as 225
227	$C—K_4—T—Li$	» 39 57	20	D	Dra	5	—»—
110.2	*V*	» 40 10	90	D	Dra		—»—
228	*C—T—Li*	» 41 41	20	R	Dra		Sunlit
110.3	*V*	» 42 25	90	RB	Peg		
229	*C—T—Li*	» 42 47	19	R	Dra		Sunlit
230	*C—T—Li*	» 43 44	20	R	Cyg Cep		—»—
110.4	*V*	» 44 25	90	RB	Cyg Lyr		Lower border good
231	*C—T—Li*	» 44 44	30	R	Dra	4	Sunlit
232	*C—T—Li*	» 46 02	24	R	Boo UMa	3	Sunlit, very fine
110.5	*V*	» 46 30	120	R	Boo UMa		The same
233	*C—Li*	» 47 18	18	R	Dra UMi		Sunlit, very fine
234	*C—Li*	» 47 54	11	D	Dra	6	—»—
235	*C—T—Li*	» 48 21	10	D	Dra		—»—
236	*C—T—Li*	» 48 51	10	D	Dra		—»—
237	*C—T*	» 49 23	14	R	Boo		Feet of sunlit rays towards ENE
238	*C—T—Li*	» 50 07	13	R	Dra		Sunlit
111.1	*V*	» 51 00	90	D	Dra		—»—
239	*C—T—Li*	» 51 32	19	D	UMa Dra		Fine sunlit rays
240	*C—T—Li*	» 52 09	16	D	UMa		—»—
241	*C—T—Li*	» 52 43	14	D	UMa		—»—
242	*C—T—Li*	» 53 30	14	D	UMa		—»—
243	*C—T—Li*	» 54 15	13	R	Boo	16	Very fine rays in NE, sunlit
244	*C—T—Li*	» 54 59	12	R	Boo		—»—
111.3	*V*	» 55 00	60	R	Boo		—»—
245	*C—T—Li*	» 56 22	60	R	UMa Boo		—»—
246	*C—T—Li*	» 57 25	22	R	Boo		The same, lower down
111.4	*V*	» 57 35	90	R	Lyr Dra		Sunlit, lower border
247	*C—T—Li*	» 58 05	25	R	Boo		The same as 246
248	*C—T—Li*	» 59 03	60	R	Boo		—»—

Table I (continued).

P.N.	St.	MET	Ex.	Fm.	Ref. Const.	N	Remarks
249	*C, Li*	05h 00m 05s	12	R	Lyr		
250	*C—T—Li*	» 00 40	10	R	Dra		Sunlit
111.5	*V*	» 00 53	165	R	Dra		Too long exposure, but lower border good
251	*C—Li*	» 01 46	10	R	Dra		Sunlit, very fine
252	*C—Li*	» 02 38	10	R, D	Cyg		3 lower borders of draperies, sunlit
253	*C—Li*	» 03 36	8	R	Dra	6	Sunlit
254	*C—Li*	» 04 02	10	R	Dra	8	Sunlit very fine
111.6	*V*	» 04 10	120	R	Cyg		
255	*C—Li*	» 04 32	8	D	Boo	8	Sunlit very fine
256	*C—Li*	» 05 07	10	D	Boo	6	Lower border of the same drapery
257	*C, Li*	» 10 41	10	R	Lyr Cyg		
258	*C, Li*	» 12 06	12	R	Lyr		
259	*C—Li*	» 13 49	7	R	Dra	6	Sunlit
260	*C—Li*	» 14 13	10	R	Dra	4	The same
261	*C—Li*	» 14 45	11	R	Dra	4	—»—
262	*C—Li*	» 16 48	17	R	Dra	4	—»—

Table II.

Picture No.	Point No.	Time MET	Base	ζ	ε_1	ε_2	p	h	a	H	D	H_1	T	Reference stars
						April 20—21, 1936.								
6	1	22h 51m 21s	$Li—O$	113.4	—24.0	—38.8	14.8	22.7	113.5	202	434	154	1390	$\beta, \vartheta, \varepsilon$ Aur, ϑ Gem
	2	-	-	132.5	—14.7	—28.3	13.6	41.9	106.7	411	417	166	1440	
	3	-	-	121.1	—20.6	—35.2	14.6	30.3	111.1	274	426	-	-	
	4	-	-	120.9	—20.2	—34.9	14.7	30.2	110.7	272	425	-	-	
	5	-	-	121.2	—20.8	—35.5	14.7	30.4	111.5	271	422	-	-	
	6	-	Li	-	-	-	-	20.4	114.2	182	438	-	-	
	7	-	-	-	-	-	-	44.5	105.5	440	407	-	-	
12	1	22 56 01	$Li—O$	—162.4	—36.0	—46.1	10.1	50.7	—157.7	498	370	168	1450	β, ι, δ Cep, β Cas, λ And
	2	-	-	—158.0	—45.1	—54.6	9.5	41.3	—160.4	380	396	-	-	
	3	-	-	—151.7	—54.0	—62.3	8.3	31.6	—162.4	282	418	-	-	
	4	-	-	—142.0	—62.5	—69.0	6.5	21.5	—164.1	201	456	146	1350	
	9	-	-	—152.0	—36.0	—46.9	10.9	45.7	—147.8	422	377	178	1490	
	10	-	-	—142.0	—47.0	—56.6	9.6	32.6	—151.3	297	423	-	-	
	11	-	-	—130.0	—55.0	—63.8	8.8	21.4	—153.7	181	416	165	1435	
17	1	23 01 40	$Li—C$	96.6	— 8.6	—22.0	13.4	9.5	93.3	108	515	-	-	$\gamma, \varepsilon, \lambda, \eta, \vartheta$ Gem, β Tau
	2	-	-	98.0	—16.2	—31.7	15.5	10.6	101.1	91	412	290	1540	
	3	-	-	102.0	—12.9	—30.4	17.5	14.7	98.0	107	363	-	-	
	4	-	-	104.0	—17.0	—35.4	18.4	16.3	102.3	105	324	-	-	
	5	-	-	104.0	—19.6	—37.8	18.2	16.1	104.9	101	318	-	-	
	6	-	-	106.0	—18.4	—36.4	18.0	18.0	103.9	115	322	-	-	
	7	-	-	114.0	—16.5	—33.5	17.0	25.6	102.8	172	333	-	-	
27	1	23 44 11	$Li—O$	102.0	—14.1	—34.1	20.0	13.2	102.0	99	369	-	-	$\varkappa, \lambda, \mu$ Gem, β Tau, ϑ Aur, ζ Cnc
	2	-	-	104.0	— 6.1	—28.9	22.8	15.3	93.8	104	342	-	-	
	3	-	-	102.0	— 6.2	—28.8	22.6	13.2	94.0	92	348	-	-	
	4	-	-	104.0	— 3.7	—27.2	23.5	15.3	91.3	102	336	-	-	
29	1	23 46 40	$Li—O$	107.6	—26.3	—47.8	21.5	17.0	115.4	91	275	-	-	$\varepsilon, \varkappa, \lambda$ Gem, β Tau, ϑ, η Aur
	2	-	-	110.0	—25.5	—47.4	21.9	19.4	114.9	102	268	-	-	
	3	-	-	106.9	—21.6	—43.0	21.4	17.0	110.2	100	301	-	-	
	4	-	-	104.0	—14.7	—37.0	22.3	15.0	102.6	94	319	-	-	
	5	-	-	103.0	—12.0	—33.8	21.8	14.2	99.8	96	340	-	-	
	6	-	-	104.8	—11.5	—33.3	21.8	16.0	99.3	108	338	-	-	
	7	-	-	112.0	—24.5	—46.4	21.9	21.4	114.1	113	270	-	-	
	8	-	-	123.0	—19.7	—41.6	21.9	32.2	110.7	175	262	-	-	
1*	1	0 14 15	$T—K_4$	139.0	—42.9	—48.3	5.4	18.9	—175.2	278	676	142	1335	$\beta, \varepsilon, \zeta$ Cas
	2	-	-	147.0	—41.2	—46.8	5.6	25.1	—174.6	346	635	-	-	
	3	-	-	154.5	—39.0	—44.8	5.8	31.2	—174.0	411	594	161	1420	
	4	-	-	150.5	—42.3	—49.6	7.3	27.0	—172.3	260	459	194	1555	
	5	-	-	161.0	—38.4	—46.1	7.7	35.8	—171.4	331	419	-	-	
	6	-	-	167.4	—35.2	—43.2	8.0	41.7	—170.8	378	388	213	1625	
	7	-	T	-	-	-	-	15.2	—175.6	229	682	-	-	
	8	-	K_4	-	-	-	-	31.8	—168.4	477	663	-	-	
19*	1	0 52 11	$T—K_4$	175.5	—37.6	—44.1	6.5	45.1	—162.7	488	437	187	1530	β, δ, ζ Cas, ι Cep
	2	-	-	165.0	—43.8	—50.2	6.4	35.0	—164.1	364	469	-	-	
	3	-	-	148.5	—50.2	—56.0	5.8	22.1	—165.4	240	520	166	1440	
	4	-	T	-	-	-	-	48.8	—162.1	552	433	-	-	
71	1	1 30 15	$Li—C$	101.1	—30.7	—44.0	13.3	12.5	115.9	102	400	-	-	α, β, ϑ Gem
	2	-	-	101.7	—33.2	—46.2	13.0	12.7	118.6	102	393	-	-	
	4	-	-	101.7	—35.6	—48.1	12.5	12.4	120.9	100	395	-	-	
	9	-	-	105.2	—34.3	—47.5	13.2	15.3	120.1	115	373	-	-	
	a	-	Li	-	-	-	-	-	-	94	-	-	-	
	b	-	-	-	-	-	-	-	-	93	-	-	-	

Table II (continued).

Picture No.	Point No.	Time MET	Base	ζ	ε_1	ε_2	p	h	a	H	D	H_1	T	Reference stars
						April 21—22, 1936.								
38	1	$0^h\ 44^m\ 18^s$	$C—K_4$	-	-	—21.8	4.8	43.4	180.0	520	488	180	1500	ε, 50 Cas, 2 H Cam
	2	-	-	-	-	—24.3	4.9	33.7	179.8	414	547	-	-	
	3	-	-	-	-	—26 0	4.8	23.6	179.5	313	615	150	1370	
52	1	1 13 17	$C—O$	-	-	—42.5	1.6	8.9	—118.7	152	698	160	1420	ι, $\varkappa$ Peg, τ Cyg
	2	-	-	-	-	—37.5	1.6	18.6	—115.3	290	705	-	-	
	3	-	-	-	-	—31.8	1.65	27.6	—111.6	411	671	180	1500	
	4	-	-	-	-	—44.1	1.9	9.7	—120.2	125	571	179	1495	
	5	-	-	-	-	—39.8	1.85	18.2	—117.5	233	598	-	-	
	6	-	-	-	-	—34.4	1.9	26.9	—114.2	335	576	190	1540	
				ω	u_1	u_2								
69	1	1 41 07	$C—N$	360—72.0	63.5	180—49.1	67.4	15.3	180—64.0	91	305	255	1780	38 Lyn, ε Leo, ι Cnc, α, γ, ζ Vir
	2	-	-	360—70.0	59.2	180—47.6	73.2	16.1	180—59.3	90	287	-	-	
	3	-	-	360—68.0	56.0	180—47.3	76.7	16.9	180—55.6	92	280	-	-	
	4	-	-	360—66.0	55.4	180—44.0	80.6	18.3	180—54.5	91	257	-	-	
	5	-	-	360—64.0	54.5	180—41.6	83.9	19.6	180—53.0	91	244	-	-	
	6	-	-	360—62.6	54.0	180—40.5	85.5	20.4	180—52.0	93	235	241	1730	
	7	-	N	-	-	-	-	17.2	30.0	(91)	272	-	-	
	8	-	-	-	-	-	-	18.6	26.0	(91)	255	-	-	
	9	-	-	-	-	-	-	20.1	24.0	(91)	236	-	-	
	10	-	-	-	-	-	-	19.0	22.0	(91)	248	-	-	
	11	-	-	-	-	-	-	20.7	20.0	(91)	228	-	-	
	12	-	C	-	-	-	-	13.8	180—70.0	(91)	333	-	-	
	13	-	-	-	-	-	-	13.2	180—72.0	(91)	344	-	-	
	14	-	-	-	-	-	-	11.0	180—73.0	(91)	400	-	-	
	15	-	-	-	-	-	-	10.8	180—75.0	(91)	407	-	-	
	16	-	-	-	-	-	-	8.8	180—77.0	(91)	471	-	-	
				ζ	ε_1	ε_2								
73	1	1 44 59	$N—C$	101.1	36.0	—17.3	53.3	9.3	50.9	91	454	264	1805	40 Lyn, ε Leo, ι Cnc, α, γ, ζ Vir
	2	-	-	103.9	39.7	—21.6	61.3	10.8	46.6	90	403	253	1770	
	3	-	-	104.9	41.0	—21.9	62.9	11.2	45.1	91	396	-	-	
	4	-	-	107.8	43.9	—26.8	70.7	12.6	41.6	90	356	-	-	
	5	-	-	110.1	46.2	—30.4	76.6	13.6	38.8	90	334	-	-	
	6	-	N	-	-	-	-	15.1	34.0	(90)	304	-	-	
	7	-	-	-	-	-	-	17.0	28.0	(90)	273	-	-	
96	1	2 13 39	C	-	-	-	-	8.9	—176	(90)	463	93	1080	η Aur, ε, β Per
	2	-	-	-	-	-	-	9.9	178	(90)	430	103	1140	
	3	-	-	-	-	-	-	10.8	170	(90)	403	114	1200	
	1	-	-	-	-	-	-	8.9	—176	(100)	505	99	1120	
	2	-	-	-	-	-	-	9.9	178	(100)	470	109	1170	
	3	-	-	-	-	-	-	10.8	170	(100)	441	121	1230	
	1	-	-	-	-	-	-	8.9	—176	(110)	546	106	1150	
	2	-	-	-	-	-	-	9.9	178	(110)	507	116	1205	
	3	-	-	-	-	-	-	10.8	170	(110)	479	127	1260	
						October 16—17, 1936.								
42	1	21 49 34	$C—K_4$	126.6	—11.4	—17.3	5.9	8.3	167.9	116	593	880	3180	ε, η UMa, 12 CVn
	2	-	-	128.4	—11.4	—17.4	6.0	10.1	168.0	131	577	-	-	
	3	-	-	130.9	—11.3	—17.3	6.0	12.5	168.0	155	570	900	3200	
	4	-	C	-	-	-	-	33.7	167.3	cr. 350	cr. 500	-	-	

				180—ω	180—u_1	180—u_2								
110	1	23 35 37	*T—O*	11.6	42.0	39.0	3.0	8.4	180+61.6	189	854	·	·	α, β, δ Gem
	2	·	·	23.3	46.1	43.4	2.7	17.1	180+64.0	396	970	·	·	
	3	·	·	13.0	40.3	37.2	3.1	9.0	180+59.8	180	793	·	·	
	4	·	·	26.5	45.5	42.6	2.9	19.0	180+62.3	382	883	·	·	
	5	·	·	12.9	38.1	35.0	3.1	8.6	180+57.8	163	755	1460	3960	
	6	·	·	33.0	47.0	43.6	3.4	23.8	180+62.5	392	742	1510	4020	
	7	·	·	14.4	36.8	33.8	3.0	9.2	180+56.2	172	755	1440	3940	
	8	·	·	32.3	44.6	41.1	3.5	22.4	180+60.3	343	698	1510	4010	
	9	·	*T*	·	·	·	·	27.1	180+63.6	448	735	·	·	
	10	·	·	·	·	·	·	24.3	180+60.9	385	716	·	·	
	11	·	·	·	·	·	·	5.9	180+56.9	128	765	·	·	
	12	·	·	·	·	·	·	6.9	180+55.6	136	742	·	·	
				ζ	ε_1	ε_2								
134	1	0 46 43	*Li—C*	108.4	—49.8	—59.7	9.9	14.0	136.2	104	371	·	·	π, ο, ι, τ Her, β Lyr
	2	·	·	111.0	—48.9	—59.0	10.1	15.8	136 0	117	369	·	·	
	3	·	·	107.2	—47.9	—58.7	10.8	13.8	134.3	98	352	·	·	
	4	·	·	109.8	—47.2	—58.1	10.9	15.6	134.2	109	351	·	·	
	5	·	·	105.4	—45.4	—56.8	11.4	13.2	131.4	93	354	·	·	
	6	·	·	108.2	—44.8	—56.2	11.4	15.3	131.3	108	354	·	·	
	7	·	·	101.3	—38.6	—50.6	12.0	11.6	124.0	93	391	·	·	
	8	·	·	103.7	—37.9	—50.0	12.1	13.6	123.7	108	390	·	·	
	9	·	·	112.3	—57.7	—65.9	8.2	13.5	144.8	98	364	·	·	
	10	·	·	115.8	—56.9	—65.1	8.2	15.5	144.8	115	371	·	·	
135	1	0 47 57	*Li—C*	106.0	—48.0	—58.8	10.8	13 1	134.2	93	353	·	·	π, ο, ι, τ Her, β Lyr
	2	·	·	105.0	—46.3	—57.1	10.8	12.9	132.4	97	370	·	·	
146	3	1 23 17	*Li—T*	·	·	—71.3	3.6	9.8	140.3	100	469	1326	3800	ο, π Her, β Lyr
	4	·	·	·	·	—71.8	3.8	10.2	140.8	94	435	·	·	
	5	·	·	·	·	—71.8	4.5	13.4	141.8	98	361	·	·	
	6	·	·	·	·	—72.0	4.8	14.8	142.9	98	333	·	·	
	7	·	·	·	·	—75.4	3.9	15.3	149.7	101	333	1336	3815	
	8	·	·	·	·	—77.5	3.3	15.1	155.4	101	337	·	·	
166	1	1 42 51	*Li—C*	—130.0	—25.6	—34.8	9.2	33.1	—126.2	396	538	·	·	λ, ψ UMa, 31 LMi
	2	·	·	—123.4	—29.5	—38.6	9.1	26.5	—128.3	319	559	·	·	
	3	·	·	—112.2	—34.7	—43.6	8.9	16.2	—131.2	201	579	·	·	
	4	·	·	—106.0	—36.9	—45.6	8.7	11.0	—132.6	144	588	973	3320	
	5	·	·	—106.9	—37.9	—46.3	8.4	11.4	—133.6	153	601	·	·	
	6	·	·	—107.2	—38.3	—46.7	8.4	11.6	—134.2	154	597	966	3310	
	7	·	·	—122.3	—32.4	—41.1	8.7	24.7	—131.2	303	573	981	3335	
	8	·	·	—112.2	—44.9	—55.7	10.8	14.0	—141.8	108	381	1096	3500	
	9	·	·	—118.0	—43.0	—54.2	11.2	18.4	—141.1	137	372	·	·	
	10	·	*Li*	·	·	·	·	41.2	—123.0	528	533	1034	3410	
	5′	·	·	·	·	·	·	11.4	—133.6	(108)	451	·	·	
	6′	·	·	·	·	·	·	11.6	—134.2	(108)	445	·	·	
170	1	1 46 31	*Li—C*	104.0	—40.1	—52.3	12.2	13.4	126.2	100	369	1354	3835	α, γ Lyr, β Cyg, ι Her
	2	·	·	110.0	—45.3	—57.5	12.2	16.4	132.5	103	319	·	·	
	3	·	·	112 0	—49.0	—60 4	11.4	16.6	136.5	102	313	1299	3770	
	5	·	·	119.0	—46.3	—58.3	12.0	21.7	135.7	131	307	·	·	
175	1	1 51 21	*Li—C*	—138.0	—63.8	—72.0	8.2	18.9	—166.3	95	258	1161	3590	8, 12 CVn, η UMa
	2	·	·	—128.0	—60.2	—69.3	9.1	17.2	—160.4	94	280	·	·	
	3	·	·	—120.0	—57.2	—66.2	9.0	14.9	—155.5	96	325	·	·	
	4	·	·	—112.0	—54.2	—62.6	8.4	11.4	—151.1	95	405	·	·	
	5	·	*Li*	·	·	·	·	10.3	—150.3	(95)	436	·	·	

Table II (continued).

Picture No.	Point No.	Time MET	Base	ζ	ε_1	ε_2	p	h	a	H	D	H_1	T	Reference stars
175	6	$1^h 51^m 21^s$	*Li*	·	·	·	·	34.8	—143.4	290	384	·	·	
	7	·		·	·	·	·	7.5	—152.0	(95)	540	·	·	
	8	·	·	·	·	·	·	6.8	—156.0	(95)	573	930	3255	
	9	·	·	·	·	·	·	7.2	—160.0	(95)	553	·	·	
	10	·	·	·	·	·	·	9.7	—164.0	(95)	454	·	·	
	11	·	·	·	·	·	·	11.0	—164.0	(95)	414	·	·	
	12	·	·	·	·	·	·	11.1	—161.0	(95)	412	·	·	
177	1	1 52 52	*Li—C*	—112.6	—17.4	—22.2	4.8	19.0	—113.3	617	1266	·	·	μ, ν UMa, 38 Lyn, μ, δ, ζ Leo, 21 LMi
	2	·	·	—118.0	—15.1	—19.8	4.7	24.1	—111.4	758	1243	·	·	
	3	·	·	—122.0	—13.4	—17.7	4.3	28.2	—110.1	948	1293	·	·	
	4	·	*Li*	·	·	·	·	31.7	—108.7	1043	1258	666	2800	
	5	·	*C*	·	·	·	·	16.2	—119.5	560	1316	627	2721	
178	1	1 54 12	*Li—C*	—114.3	—21.3	—26.0	4.7	20.0	—117.8	632	1253	610	2687	ξ UMa, 38 Lyn, 15, 54 Leo, 21, 30 LMi
	2	·	·	—116.5	—20.3	—25.0	4.7	22.2	—117.1	684	1237	·	·	
	3	·	·	—118.4	—19.5	—24.1	4.6	24.2	—116.4	752	1238	·	·	
	4	·	·	·	·	·	·	31.6	—113.6	1004	1224	646	2760	
	5	·	·	—113.0	—17.6	—22.1	4.5	19.3	—113.6	673	1344	594	2654	
	6	·	·	—115.5	—16.5	—20.9	4.4	21.8	—112.7	759	1351	·	·	
	7	·	·	—117.8	—15.4	—19.8	4.4	24.1	—111.8	818	1324	·	·	
	8	·	·	—120.1	—14.4	—18.8	4.4	26.4	—110.9	877	1297	·	·	
	9	·	*Li*	·	·	·	·	31.2	—108.9	1083	1312	640	2748	
	10	·	*C*	·	·	·	·	15.25	—119.6	573	1386	·	·	
				$180-\omega$	$180-u_1$	$180-u_2$			a—180					
186	1	2 04 21	*T—O*	44.1	44 0	40.9	3.1	29.4	55.4	482	724	827	3089	ψ, μ, ξ UMa
	2	·	·	35.4	37.9	35.0	2.9	21.3	52.8	348	741	·	·	
	3	·	·	15.2	29.7	27.0	2.7	7.8	49.0	135	692	794	3033	
	4	·	·	14.4	32.5	30.2	2.3	8.1	51.9	195	889	732	2920	
	5	·	·	25.0	35.8	33.4	2.4	14.7	53.6	312	896	730	2920	
	6	·	*T*	·	·	·	·	26.4	57.5	cr.540	880	·	·	
				ζ	ε_1	ε_2			a					
196	1	2 27 31	*Li—C*	—162.0	—22.4	—37.8	15.4	60.2	—143.6	346	186	988	3345	β, ε UMa, $\varkappa$ Dra
	2	·	·	—154.0	—35.7	—50.5	14.8	45.8	—151.0	241	223	·	·	
	3	·	·	—142.0	—48.7	—61.1	12.4	30.5	—155.3	154	252	952	3290	
	4	·	·	—146.0	—29.4	—39.1	9.7	44.7	—137.7	443	407	847	3120	
	5	·	·	—140.0	—35.0	—44.6	9.6	37.4	—140.6	359	426	·	·	
	6	·	·	—132.0	—40.9	—50.2	9.3	28.9	—143.3	270	441	827	3090	
	7	·	·	—142.0	—29.9	—40.6	10.7	41.4	—136.0	371	383	867	3155	
	8	·	·	—136.0	—34.8	—45.4	10.6	34.6	—138.4	301	399	·	·	
	9	·	·	—130.0	—38.9	—49.3	10.4	28.3	—140.4	241	407	847	3120	
197	1	2 28 10	*Li—C*	—148.0	—20.7	—31.0	10.3	50.6	—127.7	505	374	867	3155	β, ε UMa, $\varkappa$ Dra
	2	·	·	—138.0	—29.1	—40.3	11.2	38.7	—133.4	338	386	·	·	
	3	·	·	—124.0	—38.0	—48.9	10.9	24.8	—138.2	206	406	840	3110	
	4	·	·	—152.0	—29.0	—39.4	10.4	49.4	—142.0	441	345	881	3180	
	5	·	·	—144.0	—37.7	—47.7	10.0	38.6	—146.1	333	382	·	·	
	6	·	·	—132.0	—46.7	—55.6	8.9	26.5	—149.3	229	418	847	3120	
	7	·	*C*	·	·	·	·	12.2	—159.1	150	566	·	·	
198	1	2 28 48	*Li—C*	—156.0	—29.8	—40.9	11.1	51.2	—146.4	414	308	902	3210	β, ε UMa, $\varkappa$ Dra
	2	·	·	—146.0	—42.2	—52.5	10.3	36.8	—151.6	282	347	·	·	
	3	·	·	—134.0	—51.5	—60.2	8.7	25.0	—154.2	195	383	867	3155	
	4	·	·	—144.0	—28.8	—40.4	11.6	43.3	—136.0	356	348	874	3165	

	5	2	28	48	*Li—C*	—136.0	—35.4	—46.8	11.4	34.3	—139.4	270	365	·	·	
	6		·		·	—126.0	—41.6	—52.6	11.0	24.7	—142.2	188	375	867	3155	
	7		·		·	—148.0	—24.0	—35.0	11.0	48.8	—132.3	440	353	874	3165	
	8		·		·	—138.0	—32.6	—44.1	11.5	36.9	—137.2	298	366	·	·	
	9		·		·	—126.0	—40.4	—51.4	11.0	25.1	—140.8	195	382	854	3135	
102.1	2	2	27	58	*Li—V*	—137.6	—41.1	—51.8	10.7	38.7	—133.4	338	386	·	·	β, ε, UMa, α, κ Dra, 12 CVn
197	3	2	28	10	·	—125.2	—52.9	—62.4	9.5	24.8	—138.2	198	390	·	·	
102.1	x		·		V	·	·	·	·	7.2	—149.0	97	562	·	·	
206	1	3	26	09	*Li—C*	·	·	—47.6	5.9	24.5	—141.6	407	744	405	2217	ε, η UMa, 12 CVn
	2		·		·	·	·	—36.2	6.6	41.2	—135.6	646	634	439	2303	
	3		·		·	·	·	—42.6	6.4	32.5	—139.0	511	684	·	·	
	4		·		·	·	·	—46.0	5.0	16.1	—138.1	368	960	325	1996	
	5		·		·	·	·	—41.3	5.3	25.2	—135.3	527	902	·	·	
	6		·		·	·	·	—34.8	5.5	35.5	—131.7	719	833	360	2097	
	7		·		·	·	·	—34.4	4.8	27.2	—128.7	692	1051	285	1875	
	8		·		·	·	·	—38.7	4.9	19.6	—131.2	500	1063	·	·	
	9		·		·	·	·	—42.0	5.0	12.5	—133.4	335	1053	289	1886	
	10		·		·	·	·	—28.1	4.6	29.4	—122.7	828	1131	259	1790	
	11		·		·	·	·	—32.4	4.9	21.5	—124.9	585	1122	262	1799	
212	1	3	53	21	*Li—C*	·	·	—52.1	5.0	37.6	—161.8	609	678	374	2135	ζ UMa, ϑ Boo, ι Dra
	2		·		·	·	·	—61.0	4.5	27.0	—163.4	413	688	368	2120	
	3		·		*Li*	·	·	·	·	19.4	—164.4	313	727	365	2110	
	4		·		·	·	·	·	·	11.8	—165.3	208	752	363	2105	
	5		·		*Li—C*	·	·	—53.2	5.4	34.0	—157.7	510	650	368	2120	
	6		·		·	·	·	—59.7	5.0	25.5	—159.1	368	659	363	2105	
	7		·		*Li*	·	·	·	·	18.3	—160.1	277	690	361	2100	
	8		·		·	·	·	·	·	11.0	—161.2	184	714	358	2090	
218	1	4	19	55	*Li—C*	·	·	—51.4	7.4	22.6	—143.6	275	573	261	1795	ϑ, λ Boo, ι Dra
	2		·		·	·	·	—44.9	7.8	33.6	—140.9	408	543	·	·	
	3		·		·	·	·	—38.3	7.6	42.3	—138.1	555	535	262	1800	
219	1	4	21	35	*Li—C*	·	·	—51.8	6.8	18.9	—143.4	258	634	242	1730	ϑ, λ Boo, ι Dra
	2		·		·	·	·	—45.6	7.0	30.2	—140.7	415	619	·	·	
	3		·		·	·	·	—36.4	6.9	43.2	—136.7	640	589	242	1730	
220	1	4	22	55	*Li—C*	·	·	—50.8	6.6	18.9	—142.4	273	665	228	1680	ϑ, λ Boo, ι Dra
	2		·		·	·	·	—43.1	7.0	32.9	—139.0	465	623	·	·	
	3		·		·	·	·	—34.4	6.9	44.9	—135.0	672	584	237	1715	
221	1	4	24	03	*Li—C*	·	·	—49.8	6.7	18.7	—141.3	273	668	220	1655	ϑ, λ Boo, ι Dra
	2		·		·	·	·	—43.2	7.0	31.2	—138.4	445	635	·	·	
	3		·		·	·	·	—37.3	7.0	40.2	—135.6	590	604	228	1680	
	4		·		·	·	·	—52.2	8.9	33.8	—150.2	306	417	297	1910	
	5		·		·	·	·	—42.7	9.4	46.5	—146.5	445	384	300	1920	
223	1	4	32	36	*T—K*$_4$	136.9	—11.6	—19.9	8.3	22.9	151 4	296	603	416	2245	α, γ, τ, δ Cyg
	2		·		·	121.1	—14.2	—22.2	8.0	7.6	153.3	128	679	414	2240	
	3		·		·	137.0	—13.8	—21.6	7.8	22.8	153.8	312	633	409	2225	
	4		·		·	121.0	—16.2	—23.9	7.7	7.5	155.5	132	697	406	2220	
224	1	4	37	49	*T—K*$_4$	·	·	—42.2	5.2	35.5	—173.8	534	646	263	1805	ι Her, η, ξ Dra
	2		·		·	·	·	—48.7	5.0	17.0	—174.8	278	730	257	1785	
	3		·		·	·	·	—43.7	5.1	29.5	—175.5	460	694	264	1805	
	4		·		·	·	·	—47.6	4.9	15.6	—176.3	273	770	259	1790	
	5		·		·	·	·	—43.8	5.4	22.7	—179.0	353	705	275	1845	
	6		·		·	·	·	—46.1	5.3	8.8	—179.6	168	760	273	1835	
	7		·		·	·	·	—39.9	5.0	25.7	178.0	451	779	282	1865	
	8		·		·	·	·	—42.3	5.1	15.4	177.6	286	805	282	1865	
224	5		·		*Li—K*$_4$	·	·	—67.0	5.1	25.9	—176 5	350	620	·	·	ι Her, ξ, β Dra
	6		·		·	·	·	—76.0	3.2	10.5	—177.1	168	688	·	·	
	2		·		·	·	·	—73.2	3.8	19.8	—171.8	280	652	·	·	
	a		·		*Li*	·	·	·	·	7.4	—177.2	130	700	·	·	

Table II (continued).

Picture No.	Point No.	Time MET	Base	ζ	ε_1	ε_2	p	h	a	H	D	H_1	T	Reference stars
225	1	$4^h 38^m 25^s$	T—K_4	.	.	—42.0	5.2	38.7	—171.5	570	617	260	1795	ζ, η, ξ Dra
	2	.	.	.	.	—49.9	5.1	18.6	—172.8	282	692	255	1780	
	3	.	.	.	.	—38.6	4.6	30.0	179.0	566	814	275	1840	
	4	.	.	.	.	—40.7	4.7	23.6	178.7	446	832	.	.	
	5	.	.	.	.	—42.0	4.8	18.6	178.5	355	838	275	1840	
226	1	4 39 07	C—K_4	164.0	—27.0	—30.8	3.8	40.2	—167.6	580	595	253	1770	β, ζ, ϑ Dra, γ UMi
	2	.	.	154.0	—29.6	—33.4	3.8	31.0	—168.7	461	660	.	.	
	3	.	.	142.0	—31.6	—35.2	3.6	20.3	—169.9	342	756	251	1765	
	4	.	.	166.0	—17.4	—22.2	4.8	45.4	—179.4	533	469	304	1930	
	5	.	.	151.5	—20.6	—26.2	5.6	31.3	—179.7	331	488	303	1925	
	a	.	C	.	.	.	.	16.0	—170.5	259	722	.	.	
227	1	4 39 57	Li—C	—160.0	—38.7	—45.6	6.9	46.5	—159.1	580	487	244	1740	β, ζ, ϑ Dra, γ UMi
	2	.	.	—152.0	—50.1	—56.1	6.0	34.0	—161.9	422	552	.	.	
	3	.	.	—138.0	—61.4	—65.7	4.3	20.0	—164.2	285	656	239	1720	
227	1	.	C—K_4	165.3	29.2	32.8	3.6	39.8	—164.3	594	616	.	.	β, ζ, ϑ Dra, γ UMi
	2	.	.	152.0	32.5	36.4	3.9	28.0	—166.2	400	647	.	.	
231	1	4 44 44	Li—C	.	.	—37.6	7.3	45.7	—140.4	615	526	194	1550	γ UMi, α, η Dra
	2	.	.	.	.	—53.4	7.4	23.6	—146.3	270	542	194	1550	
	3	.	.	.	.	—33.6	7.3	52.1	—140.5	704	481	208	1605	
	4	.	.	.	.	—56.1	8.0	23.3	—148.6	228	472	208	1605	
232	1	4 46 02	Li—C	.	.	—34.6	7.0	47.0	—137.6	680	552	177	1485	η UMa, α, ι Dra
	2	.	.	.	.	—42.8	6.8	36.4	—141.4	520	612	.	.	
	3	.	.	.	.	—50.6	6.3	23.2	—144.9	340	670	167	1440	
234	1	4 47 54	Li—C	.	.	—58.2	8.1	40.6	177.4	333	357	278	1850	α, ζ Dra, γ UMi
	2	.	.	.	.	—59.1	7.8	38.7	—176.6	326	376	265	1810	
	3	.	.	.	.	—59.8	7.4	35.5	—170.1	315	403	250	1760	
	4	.	.	.	.	—60.0	7.0	33.2	—166.6	313	435	240	1720	
	5	.	.	.	.	—57.5	7.0	28.2	—156.3	296	493	212	1625	
	6	.	.	.	.	—41.8	7.3	47.8	—151.3	597	477	205	1600	
243	1	4 54 15	Li—T	.	.	—45.9	3.8	7.9	—152.2	210	956	122	1235	φ Her, γ, δ Boo
	2	.	.	.	.	—38.8	3.8	27.4	—149.3	582	909	121	1230	
	3	.	.	.	.	—45.4	3.8	8.0	—151.6	214	961	120	1225	
	4	.	.	.	.	—40.2	3.8	23.6	—149.4	511	932	118	1215	
	5	.	.	.	.	—40.8	4.2	7.9	—146.5	205	940	110	1175	
	6	.	.	.	.	—32.4	4.2	30.0	—142.0	609	864	112	1185	
	7	.	.	.	.	—38.2	6.1	11.8	—142.2	179	666	142	1335	

	8	4 54 15	*Li—T*	-	-	—32.0	5.9	27.2	—138.8	394	656	139	1320	
	9	-	-	-	-	—33.2	5.0	7.7	—137.8	185	876	102	1140	
	10	-	-	-	-	—29.5	4.8	19.5	—135.5	395	875	98	1120	
	11	-	-	-	-	—29.8	5.4	18.8	—135.0	333	785	112	1190	
	12	-	-	-	-	—25.5	5.3	29.2	—132.7	499	748	114	1200	
	13	-	-	-	-	—30.7	5.5	13.5	—135.3	251	798	110	1175	
	14	-	-	-	-	—25.6	5.5	27.1	—132.0	453	740	115	1200	
	15	-	-	-	-	—28.2	5.4	16.2	—133.0	303	813	104	1150	
	16	-	-	-	-	—24.5	5.3	26.0	—130.8	462	782	106	1160	
253	1	5 03 36	*Li—C*	-	-	—69.8	3.5	13.4	—165.1	215	708	161	1420	ξ Dra, ι, σ Her
	2	-	-	-	-	—64.3	4.3	22.4	—163.9	332	678	-	-	
	3	-	-	-	-	—57.8	4.9	30.8	—162.7	461	663	160	1415	
	4	-	-	-	-	—74.0	3.7	14.4	—170.9	164	535	185	1520	
	5	-	-	-	-	—67.7	4.5	23.1	—170.0	278	567	-	-	
	6	-	-	-	-	—60.6	5.3	31.8	—169.1	399	565	186	1525	
254	1	5 04 02	*Li—C*	-	-	—48.6	6.6	44.2	—162.3	553	503	174	1470	β, δ, ζ Dra
	2	-	-	-	-	—66.8	3.6	19.8	—166.6	329	746	162	1420	
	3	-	-	-	-	—48.3	7.2	46.5	—165.2	527	448	185	1520	
	4	-	-	-	-	—58.7	6.7	33.9	—167.5	347	465	-	-	
	5	-	-	-	-	—68.7	3.6	19.5	—169.6	295	692	174	1470	
	6	-	-	-	-	—48.7	6.5	46.7	—170.2	583	487	191	1540	
	7	-	-	-	-	—58.9	5.8	35.3	—171.7	414	520	-	-	
	8	-	-	-	-	—69.1	4.0	22.2	—172.9	285	602	189	1530	
255	1	5 04 32	*Li—C*	-	-	—53.5	6.0	19.7	—146.6	293	683	122	1235	ϑ Dra, ϑ Boo, τ Her
	2	-	-	-	-	—48.7	6.2	28.3	—144.7	423	672	-	-	
	3	-	-	-	-	—42.6	6.3	37.0	—142.5	573	654	120	1225	
	7	-	-	-	-	—62.5	4.6	17.5	—157.3	271	700	142	1330	
	8	-	-	-	-	—53.8	5.2	30.6	—154.8	480	692	-	-	
	9	-	-	-	-	—43.4	5.2	42.6	—152.0	764	701	130	1280	
	10	-	-	-	-	—64.3	5.3	17.8	—158.8	218	575	160	1410	
	11	-	-	-	-	—58.2	6.3	28.0	—157.2	323	537	161	1415	
	a	-	*C*	-	-	-	-	45.4	—155.2	865	714	-	-	
	b	-	*Li*	-	-	-	-	11.6	—158.3	211	768	-	-	
256	1	5 05 07	*Li—C*	-	-	—56.2	5.0	10.0	—147.6	200	810	106	1155	η, τ Her, μ Boo
	2	-	-	-	-	—46.9	5.6	28.8	—143.1	496	756	104	1145	
	3	-	-	-	-	—65.5	4.5	12.5	—158.7	188	667	146	1355	
	4	-	-	-	-	—54.1	6.0	31.7	—154.8	421	595	146	1355	
	5	-	-	-	-	—68.2	3.8	11.3	—162.0	186	709	150	1375	
	6	-	-	-	-	—55.8	6.0	32.2	—158.3	408	569	157	1400	

Explanations to the plates.

Plates 1—4.

These plates give the sketches of the aurora-pictures measured. The outlines as seen from the principal station are drawn as full lines and the points measured as small circles; these circles are connected by dotted lines with the corresponding points of the aurora seen from the secondary station.

Plate 5.

The map gives the geographical situation of the projections of the aurorae on the earth's surface, for the dates April 20—21 and April 21—22. Those of April 20—21 are drawn as dotted lines, of April 21—22 as full lines. The position of each ray is only indicated by a segment for each ray.

For the picture C 96, three lines are drawn for the lower border, corresponding to the suppositions height = 90 km, 100 km and 110 km (furthest north 110 km).

Under the map, the positions relative to the earth's shadow are given. The border line between sunlit and dark atmosphere (no refraction) is marked by the tangent to the earth's surface, all positions being reduced to this line independently of the time of occurrence.

Plate 6.

This map gives the geographical distribution of the red aurorae observed on October 16—17 as far as hitherto calculated. The projection of each ray is only indicated by a segment as explained before.

Plate 7.

This map gives in the same manner the geographical situation of the sunlit aurora rays on October 16—17, 1936, and also some of the aurorae in the earth's shadow, viz.: Nos. 42, 134, 135, 146, 170, 175, 196, 197, 198 and 223.

Plate 8.

This is the situation of sunlit and not sunlit aurorae on October 16—17, 1936. The individual rays and lower borders can easily be identified by the values of H, H_1 and T from table II. The red aurorae are indicated by the letter R (except Nos. 196, 197 and 198).

Plates 9—16. For identification, it is most convenient to consult the diagrams given besides the notes to each plate.

Plate 9.

Li 27	Cloud-like aurora, Lillehammer,	April 20—21,	$23^h\ 44^m\ 11^s$	
Li 68	— — —	—	01 26 36	
Li 69	— — —	—	01 28 36	
Li 70	— — —	—	01 29 16	
Li 71	— — —	—	01 30 15	
C 71	The same, Oslo,	—	- - -	

Li 27	*Li* 68
Li 69	*Li* 70
C 71	*Li* 71

Plate 10.

C 73	Arc with ray structure, Oslo,	April 21—22,	$01^h\ 44^m\ 59^s$
N 73	The same, Trondheim,	—	- - -
C 96	Green curtain (Leica picture), Oslo,	—	02 13 39
T 110	Red rays, Tømte,	Oct. 16—17,	23 35 37
C 135	Pulsating cloud-like band, Oslo.	—	00 47 57
Li 135	The same, Lillehammer,	—	- - -

C 73	*N* 73
C 96	*T* 110
C 135	*Li* 135

Plate 11.

Li 166	Long ray, Lillehammer,	Oct. 16—17,	$01^h\ 42^m\ 51^s$
C 166	The same, Oslo,	—	- - -
C 170	Bands with ray struoture, Oslo,	—	01 46 31
Li 170	The same, Lillehammer,	—	- - -
Li 175	Fine curtain, Lillehammer,	—	01 51 21
C 175	The same, Oslo,	—	- - -

Li 166	*C* 166
C 170	*Li* 170
Li 175	*C* 175

Plate 12.

Li 178	Upper row, red sunlit rays, Lillehammer,	Oct. 16—17,	$01^h\ 54^m\ 12^s$
T 178	— — the same, Tømte,	—	- - -
C 178	— — — Oslo,	—	- - -
O 178	— — — Oscarsborg,	—	- - -

The 4 lower pictures are reinforced negatives in order to see the right border of this high ray, which reached about 1100 km altitude.

Li 178	*T* 178	*C* 178	*O* 178
Li 178		*C* 178	
T 178		*O* 178	

Plate 13.

T 186	Red rays, Tømte,	Oct. 16—17,	$02^h\ 04^m\ 21^s$
O 186	The same, Osoarsborg,	—	- - -
C 186	— — Oslo,	—	- - -
V 102.1	Long rays, Vestfossen,	—	02 27 58
Li 196	The same, Lillehammer,	—	02 27 31
C 196	— — Oslo,	—	- - -

T 186	*O* 186
C 186	*V* 102.1
Li 196	*C* 196

Plate 14.

Li 197	Long rays, Lillehammer,	Oct. 16—17,	$02^h\ 28^m\ 10^s$
C 197	The same, Oslo,	—	- - -
Li 198	— — Lillehammer,	—	02 28 48
C 198	— — Oslo,	—	- - -
Li 206	Sunlit rays, Lillehammer,	—	03 26 09
C 206	The same, Oslo,	—	- - -

Li 197	*C* 197
Li 198	*C* 198
Li 206	*C* 206

Plate 15.

Li 212 Divided rays, Lillehammer,	Oct. 16—17,	03^h	53^m	21^s	
C 212 The same, Oslo,	—	-	-	-	
Li 218 Sunlit rays, Lillehammer,	—	04	19	55	
C 218 The same, Oslo,	—	-	-	-	
Li 219 — — Lillehammer,	—	04	21	35	
C 219 — — Oslo,	—	-	-	-	

Li 212	*C* 212
Li 218	*C* 218
Li 219	*C* 219

Plate 16.

Li 220 Sunlit rays, Lillehammer,	Oct. 16—17,	04^h	22^m	55^s
C 220 The same, Oslo,	—	-	-	-
Li 234 Sunlit rays, Lillehammer,	—	04	47	54
C 234 The same, Oslo,	—	-	-	-
Li 243 Sunlit rays, Lillehammer,	—	04	54	15
C 243 The same, Oslo,	—	-	-	-

Li 220	*C* 220
Li 234	*C* 234
Li 243	*T* 243

Plate 17.

To the left is seen the Agfa ISS plate with the two spectra of April 21—22, 1936. The lines (or bands) from left (red) to right (violet) are 6300 Å, 5577 Å and 4278 Å. The upper spectrum is double, because the plate was a little displaced during exposure (see the text). On both sides comparison spectra of Helium.

In the middle is seen the Sonja plate III with spectra of October 16—17, 1936. The numbers of the spectra are given on the right side. The lines (or bands) from the left (green) to right (ultra-violet) are 5577 Å, (4708 Å), 4278 Å and 3914 Å. Comparison spectra of Helium.

To the right is seen the Sonja plate IV with other spectra of the same night. Same remarks. On spectrum 1 was exposed by error the comparison scale for photometric measurements.

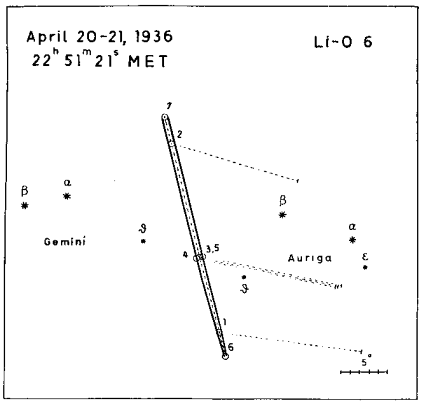
Plate 18.

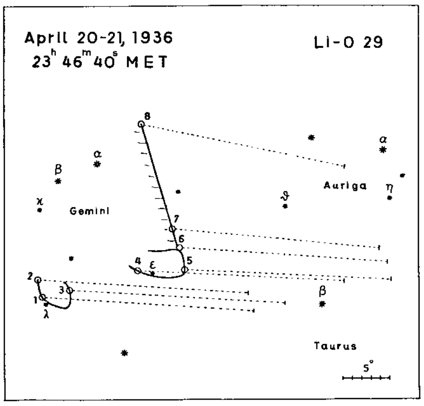
To the left is the Agfa ISS plate I with spectra of October 16—17, 1936. The lines or bands from left (red) to right (green) are 6550 Å, 6300 Å and 5577 Å. On both sides (except spectrum 3) are comparison spectra of Helium.

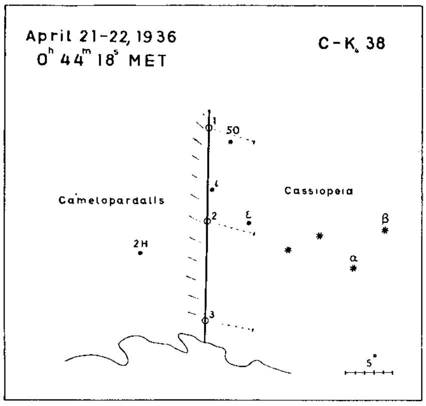
To the right is the Agfa ISS plate with other spectra of the same night. Focussing not so good. On spectrum 3 is seen the band 4278 to the right.

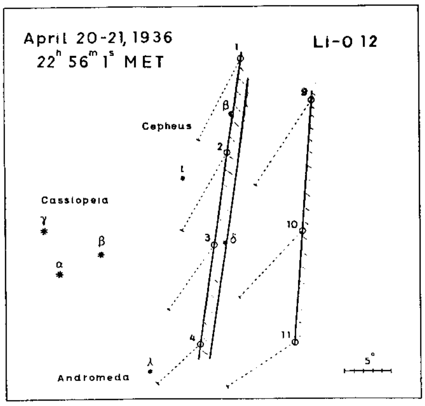
On both Plates 17 and 18 we have copied each spectral plate as a whole, in order to preserve as much as possible the relative intensities of all spectra on the same plate.

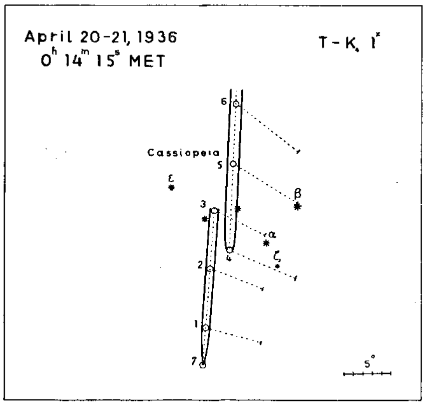
Printed September 30th, 1938.

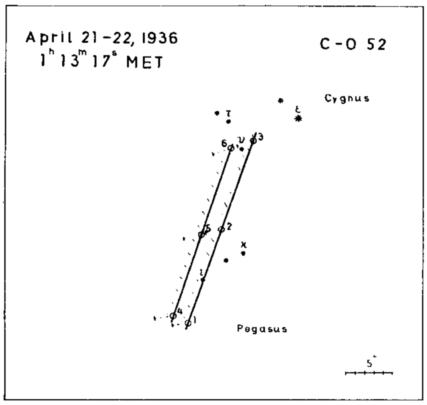

April 20-21, 1936
22h 51m 21s MET
Li-O 6
Gemini
Auriga
5°

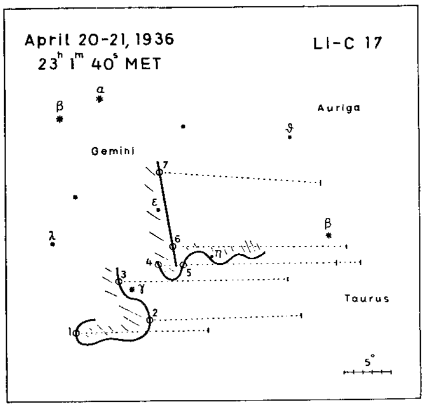

April 20-21, 1936
23h 46m 40s MET
Li-O 29
Gemini
Auriga
Taurus
5°

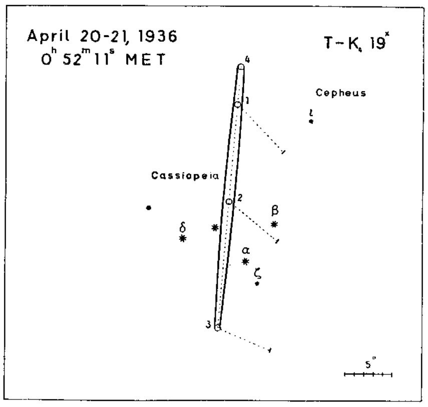

April 21-22, 1936
0h 44m 18s MET
C-K, 38
Camelopardalis
Cassiopeia
2H
50
5°

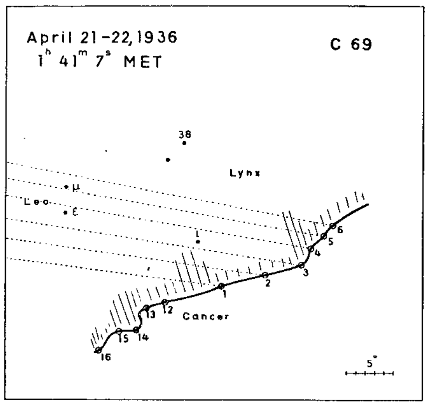

April 20-21, 1936
22h 56m 1s MET
Li-O 12
Cepheus
Cassiopeia
Andromeda
5°

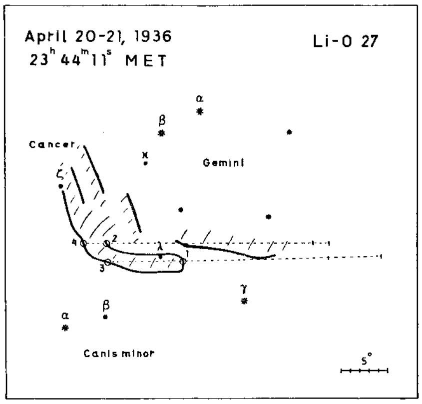

April 20-21, 1936
0h 14m 15s MET
T-K, 1x
Cassiopeia
5°

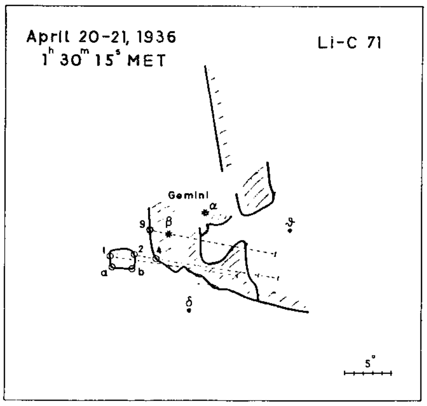

April 21-22, 1936
1h 13m 17s MET
C-O 52
Cygnus
Pegasus
5°

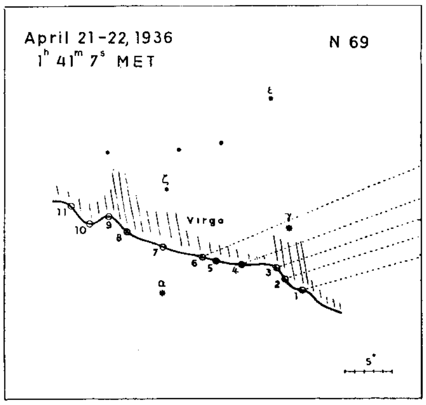

April 20-21, 1936
23h 1m 40s MET
Li-C 17
Auriga
Gemini
Taurus
5°

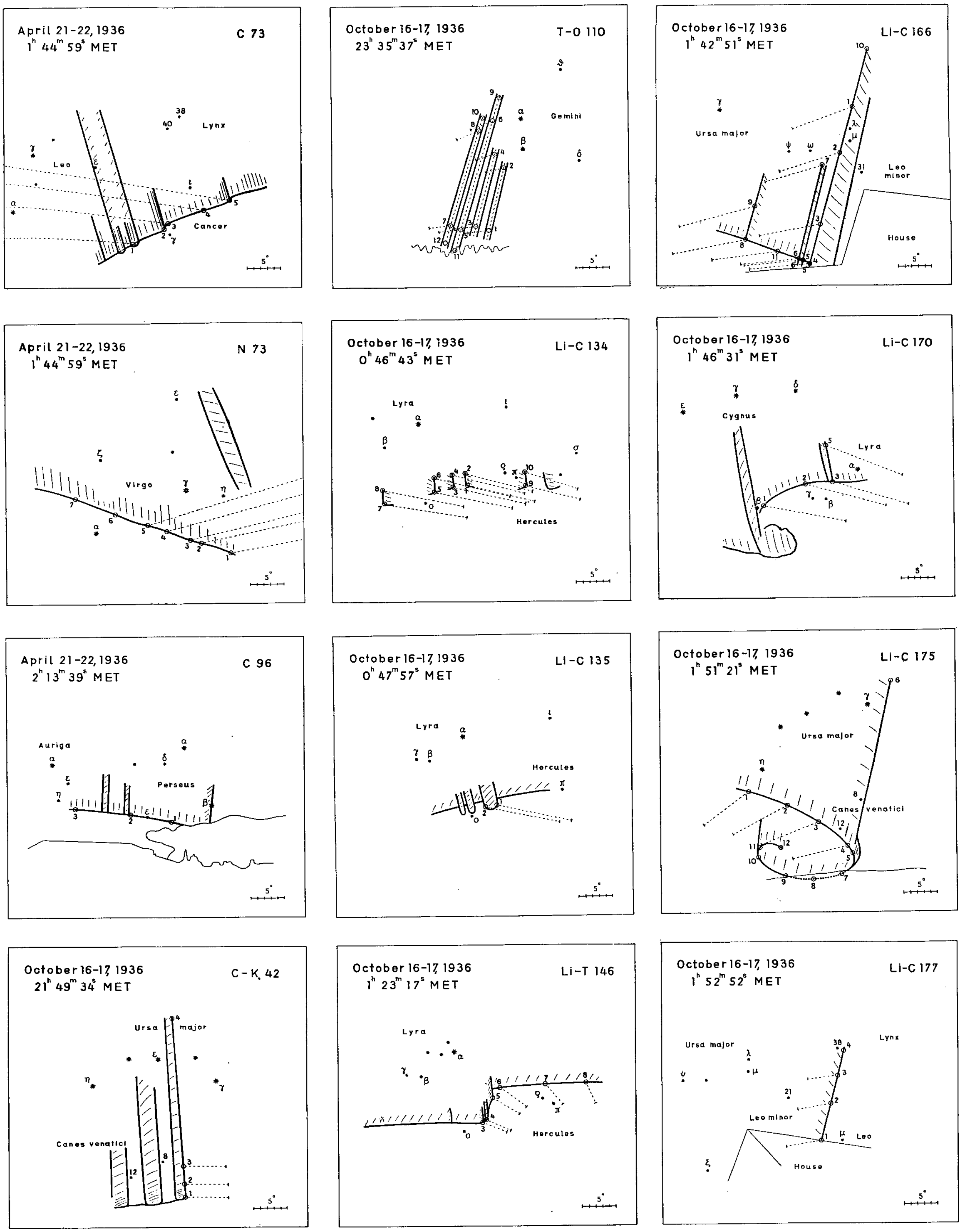

April 20-21, 1936
0h 52m 11s MET
T-K, 19x
Cepheus
Cassiopeia
5°

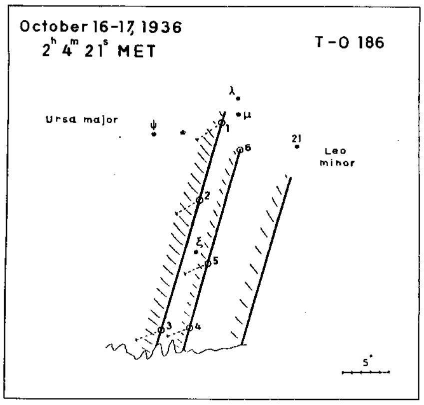

April 21-22, 1936
1h 41m 7s MET
C 69
38
Lynx
Leo
Cancer
5°

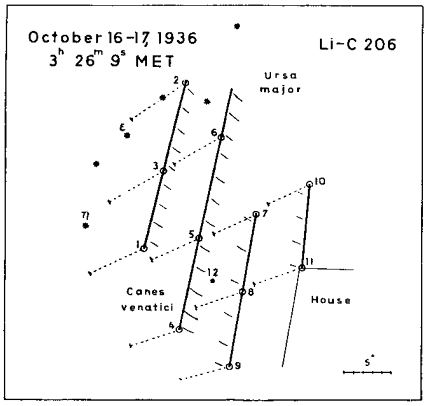

April 20-21, 1936
23h 44m 11s MET
Li-O 27
Cancer
Gemini
Canis minor
5°

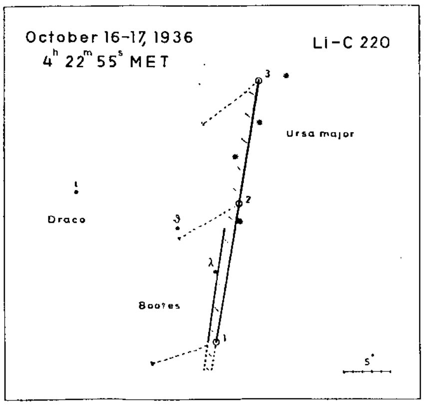

April 20-21, 1936
1h 30m 15s MET
Li-C 71
Gemini
5°

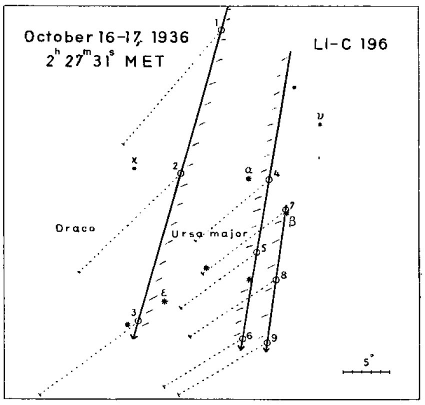

April 21-22, 1936
1h 41m 7s MET
N 69
Virgo
5°

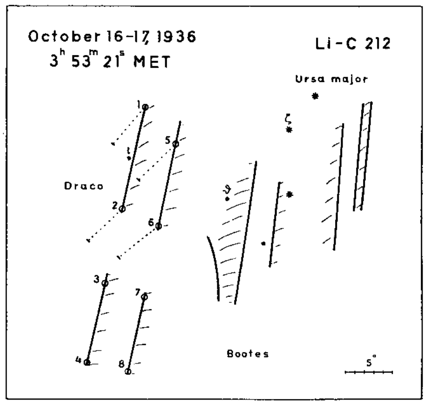

April 21-22, 1936
1h 44m 59s MET
C 73
Lynx
Leo
Cancer
October 16-17, 1936
23h 35m 37s MET
T-O 110
Gemini
October 16-17, 1936
1h 42m 51s MET
Li-C 166
Ursa major
Leo minor
House
April 21-22, 1936
1h 44m 59s MET
N 73
Virgo
October 16-17, 1936
0h 46m 43s MET
Li-C 134
Lyra
Hercules
October 16-17, 1936
1h 46m 31s MET
Li-C 170
Cygnus
Lyra
April 21-22, 1936
2h 13m 39s MET
C 96
Auriga
Perseus
October 16-17, 1936
0h 47m 57s MET
Li-C 135
Lyra
Hercules
October 16-17, 1936
1h 51m 21s MET
Li-C 175
Ursa major
Canes venatici
October 16-17, 1936
21h 49m 34s MET
C-K, 42
Ursa major
Canes venatici
October 16-17, 1936
1h 23m 17s MET
Li-T 146
Lyra
Hercules
October 16-17, 1936
1h 52m 52s MET
Li-C 177
Ursa major
Lynx
Leo minor
Leo
House
5°

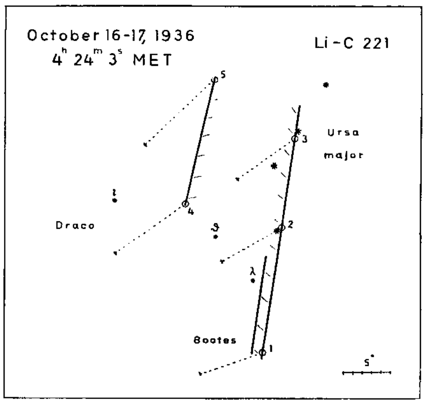

October 16-17, 1936
2h 4m 21s MET
T-O 186
Ursa major
Leo minor
5°

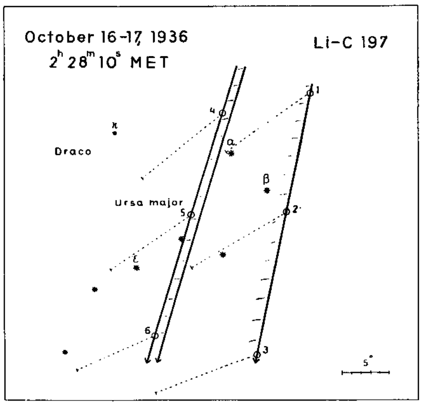

October 16-17, 1936
3h 26m 9s MET
Li-C 206
Ursa major
Canes venatici
House
5°

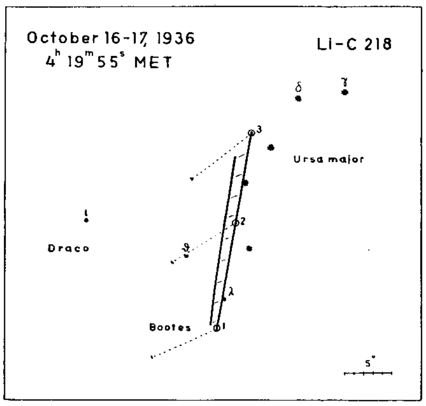

October 16-17, 1936
4h 22m 55s MET
Li-C 220
Ursa major
Draco
Bootes
5°

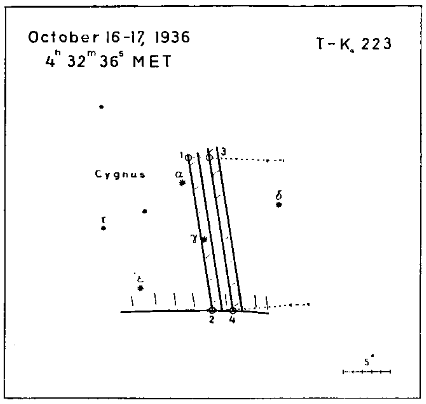

October 16-17, 1936
2h 27m 31s MET
Li-C 196
Draco
Ursa major
5°

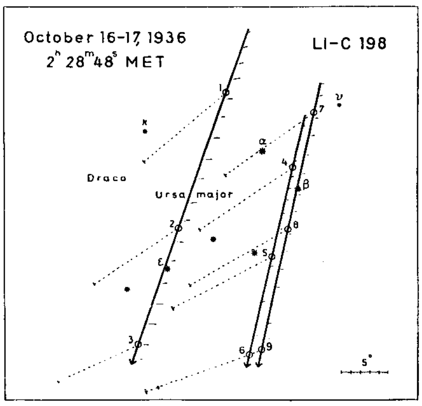

October 16-17, 1936
3h 53m 21s MET
Li-C 212
Ursa major
Draco
Bootes
5°

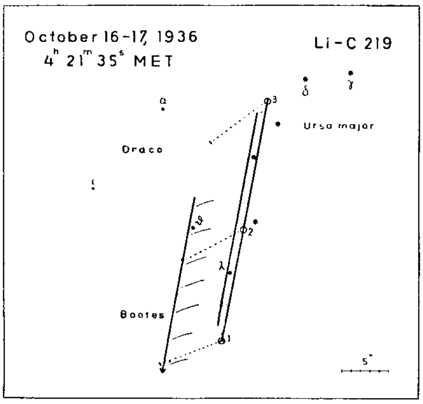

October 16-17, 1936
4h 24m 3s MET
Li-C 221
Ursa major
Draco
Bootes
5°

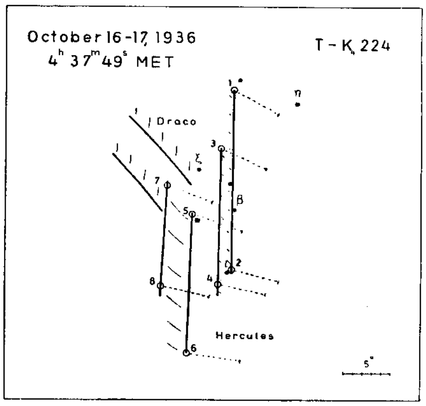

October 16-17, 1936
2h 28m 10s MET
Li-C 197
Draco
Ursa major
5°

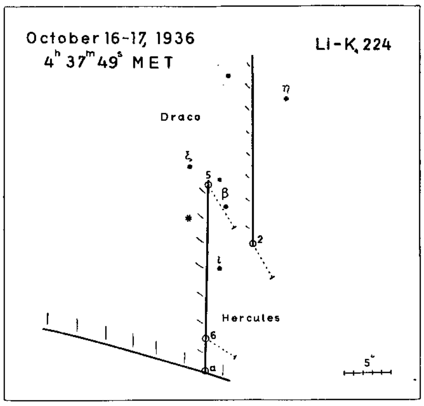

October 16-17, 1936
4h 19m 55s MET
Li-C 218
Ursa major
Draco
Bootes
5°

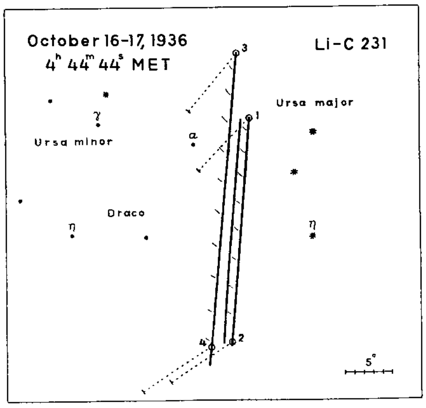

October 16-17, 1936
4h 32m 36s MET
T-K, 223
Cygnus
5°

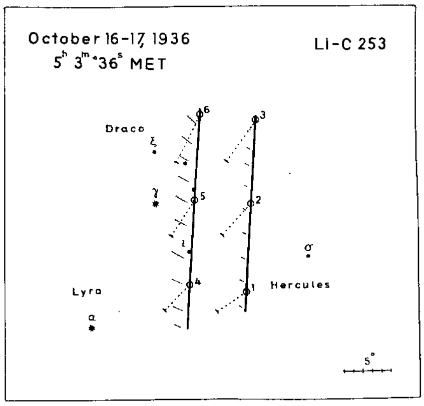

October 16-17, 1936
2h 28m 48s MET
Li-C 198
Draco
Ursa major
5°

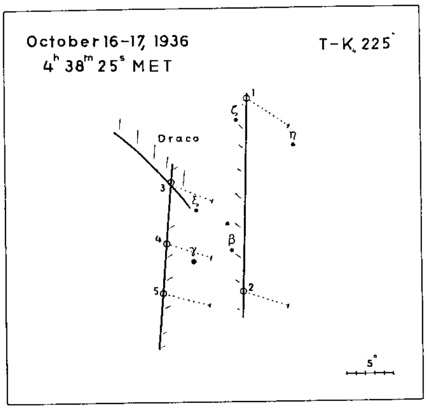

October 16-17, 1936
4h 21m 35s MET
Li-C 219
Ursa major
Draco
Bootes
5°

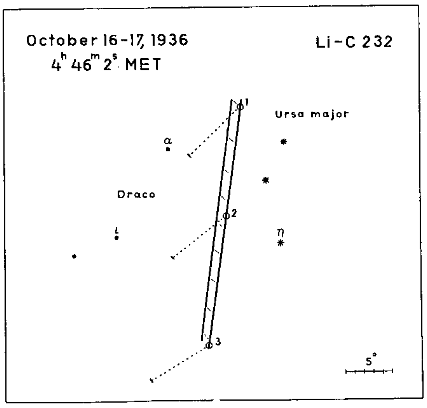

October 16-17, 1936
4h 37m 49s MET
T-K, 224
Draco
Hercules
5°

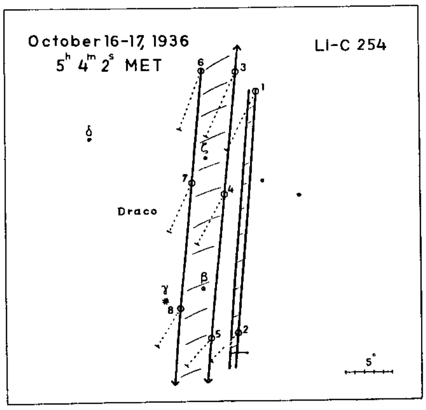

October 16-17, 1936
4h 37m 49s MET
Li-K, 224
Draco
Hercules
5°

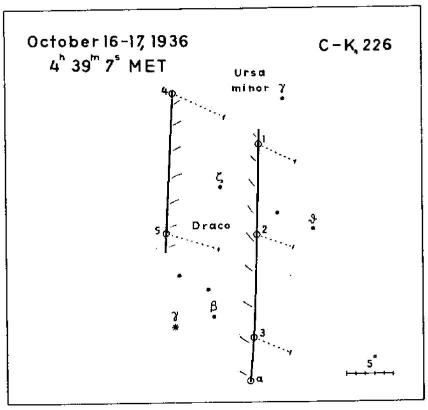

October 16-17, 1936
4h 44m 44s MET
Li-C 231
Ursa major
Ursa minor
Draco
5°

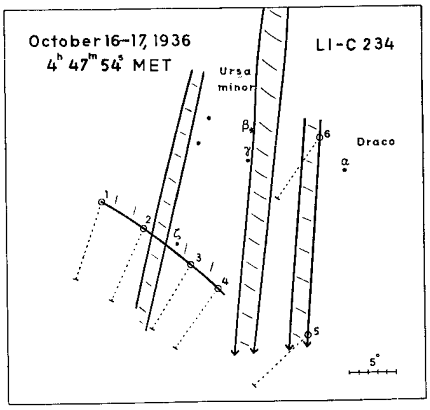

October 16-17, 1936
5h 3m 36s MET
Li-C 253
Draco
Lyra
Hercules
5°

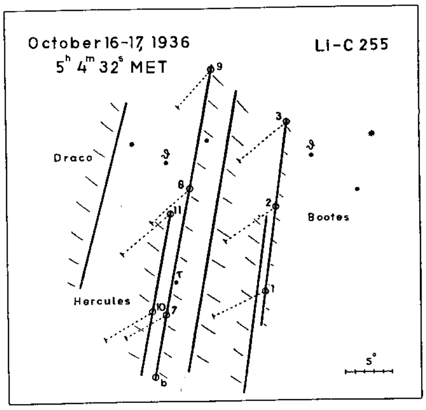

October 16-17, 1936
4h 38m 25s MET
T-K, 225
Draco
5°

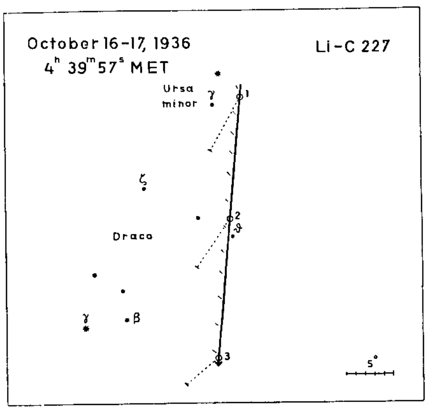

October 16-17, 1936
4h 46m 2s MET
Li-C 232
Ursa major
Draco
5°

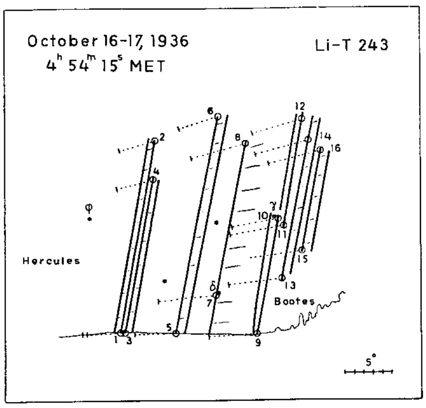

October 16-17, 1936
5h 4m 2s MET
Li-C 254
Draco
5°

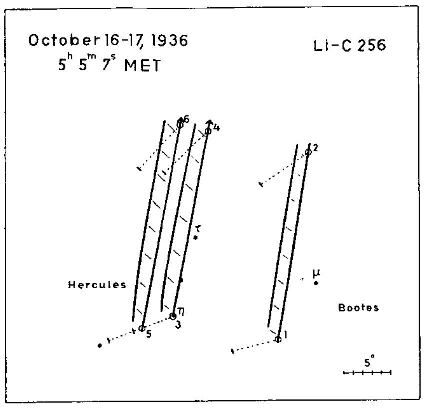

October 16-17, 1936
4h 39m 7s MET
C-K, 226
Ursa minor
Draco
5°

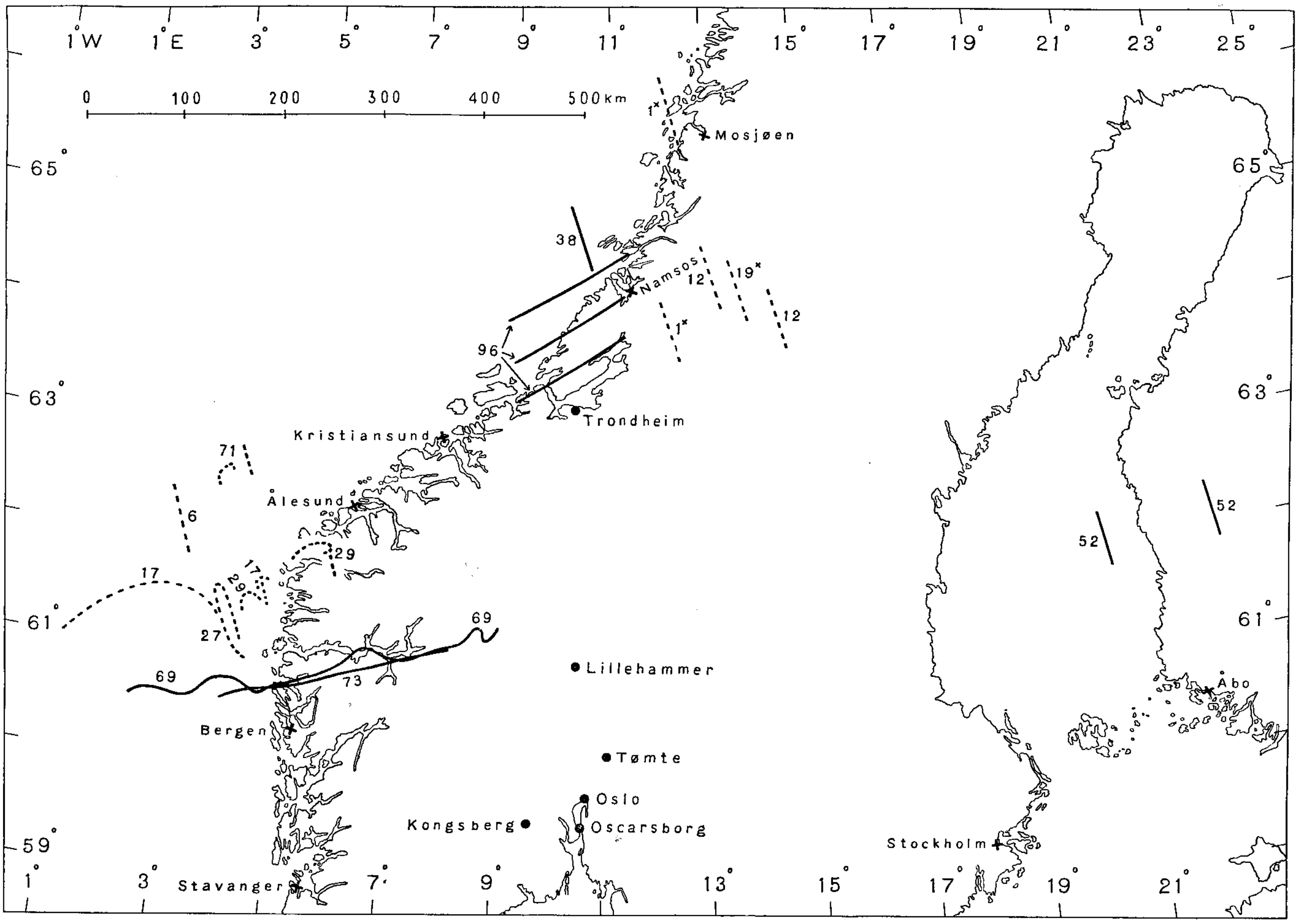

October 16-17, 1936
4h 47m 54s MET
Li-C 234
Ursa minor
Draco
5°

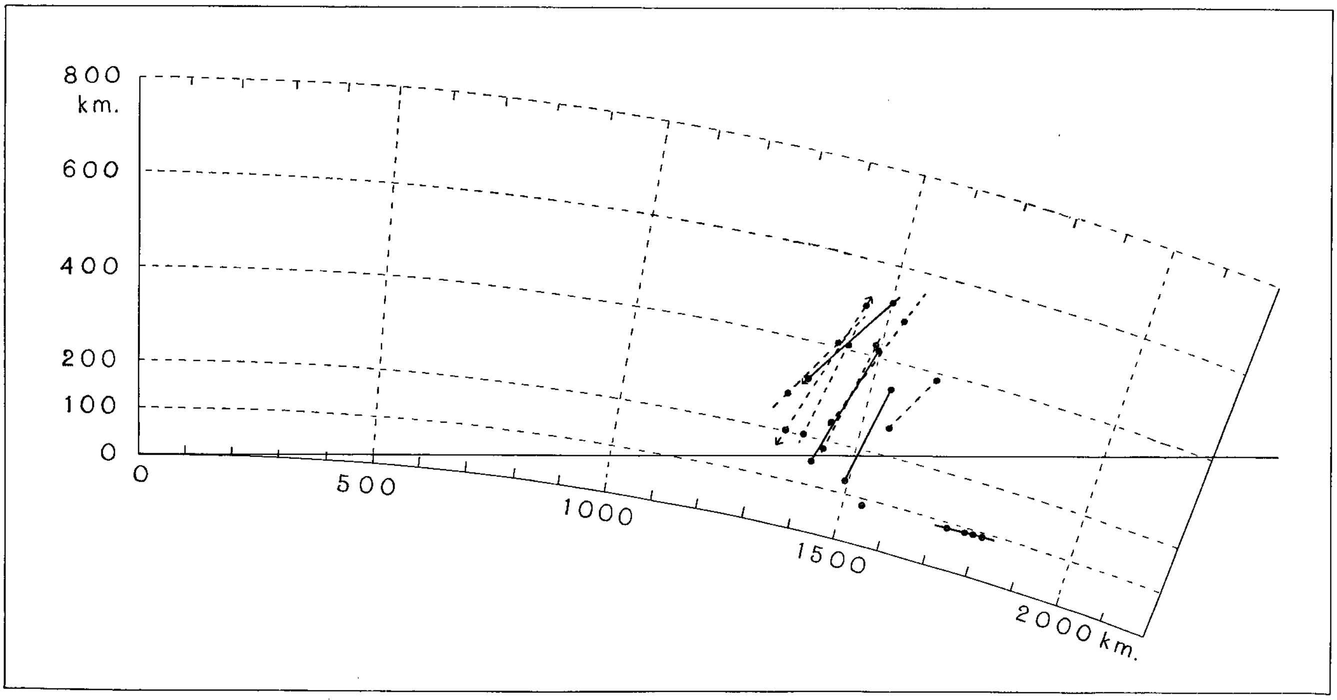

October 16-17, 1936
5h 4m 32s MET
Li-C 255
Draco
Bootes
Hercules
5°

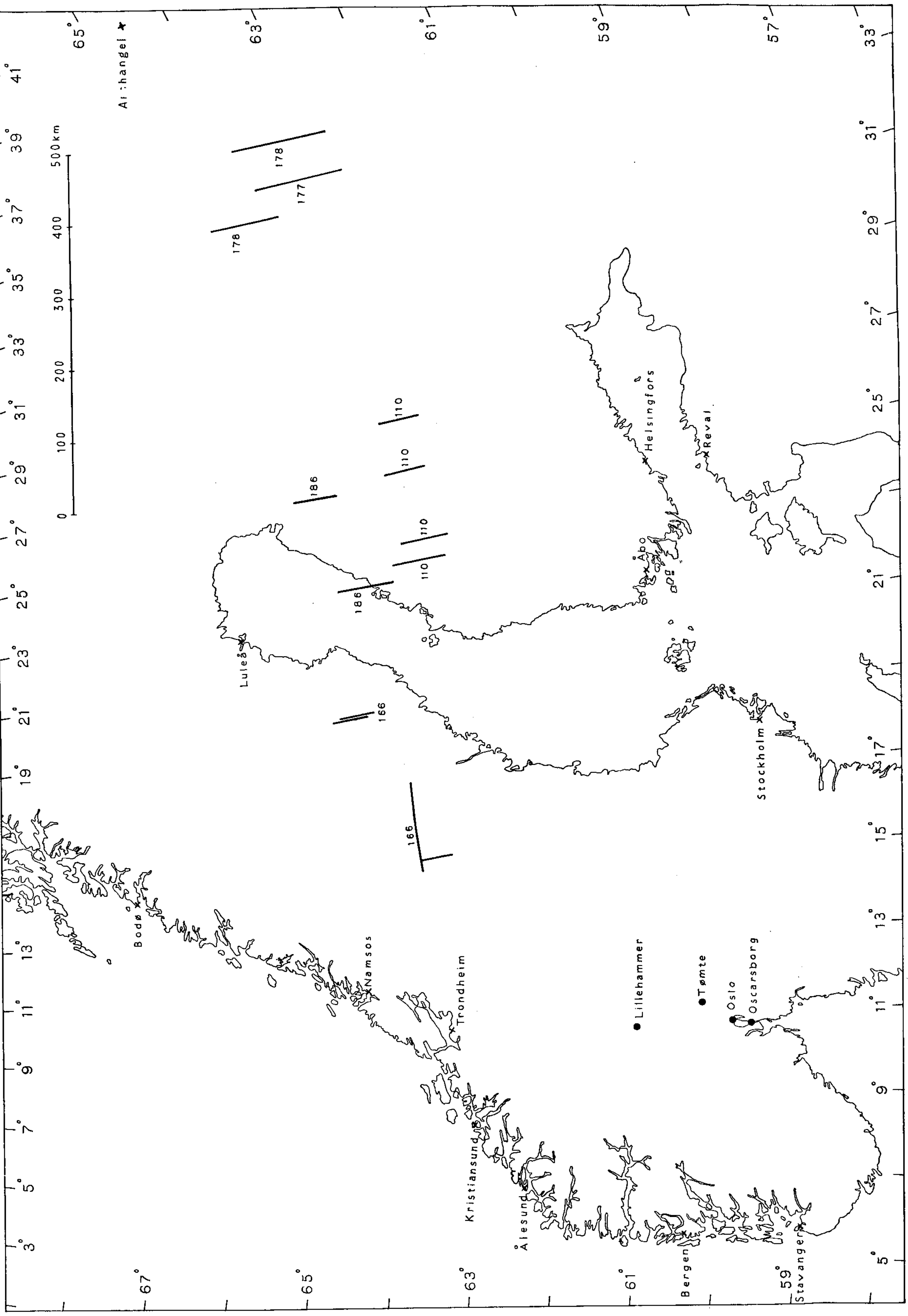

October 16-17, 1936
4h 39m 57s MET
Li-C 227
Ursa minor
Draco
5°

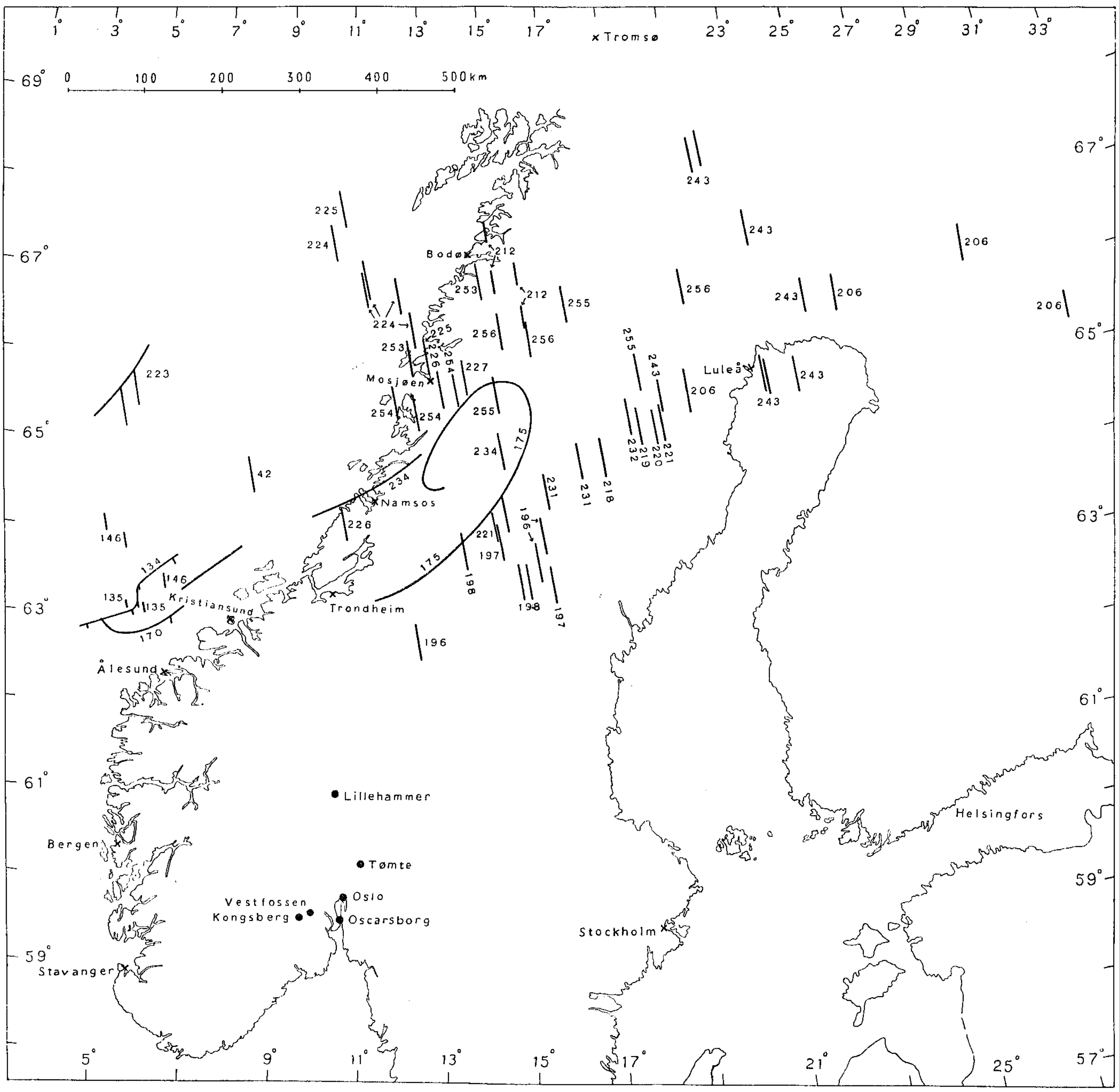

October 16-17, 1936
4h 54m 15s MET
Li-T 243
Hercules
Bootes
5°

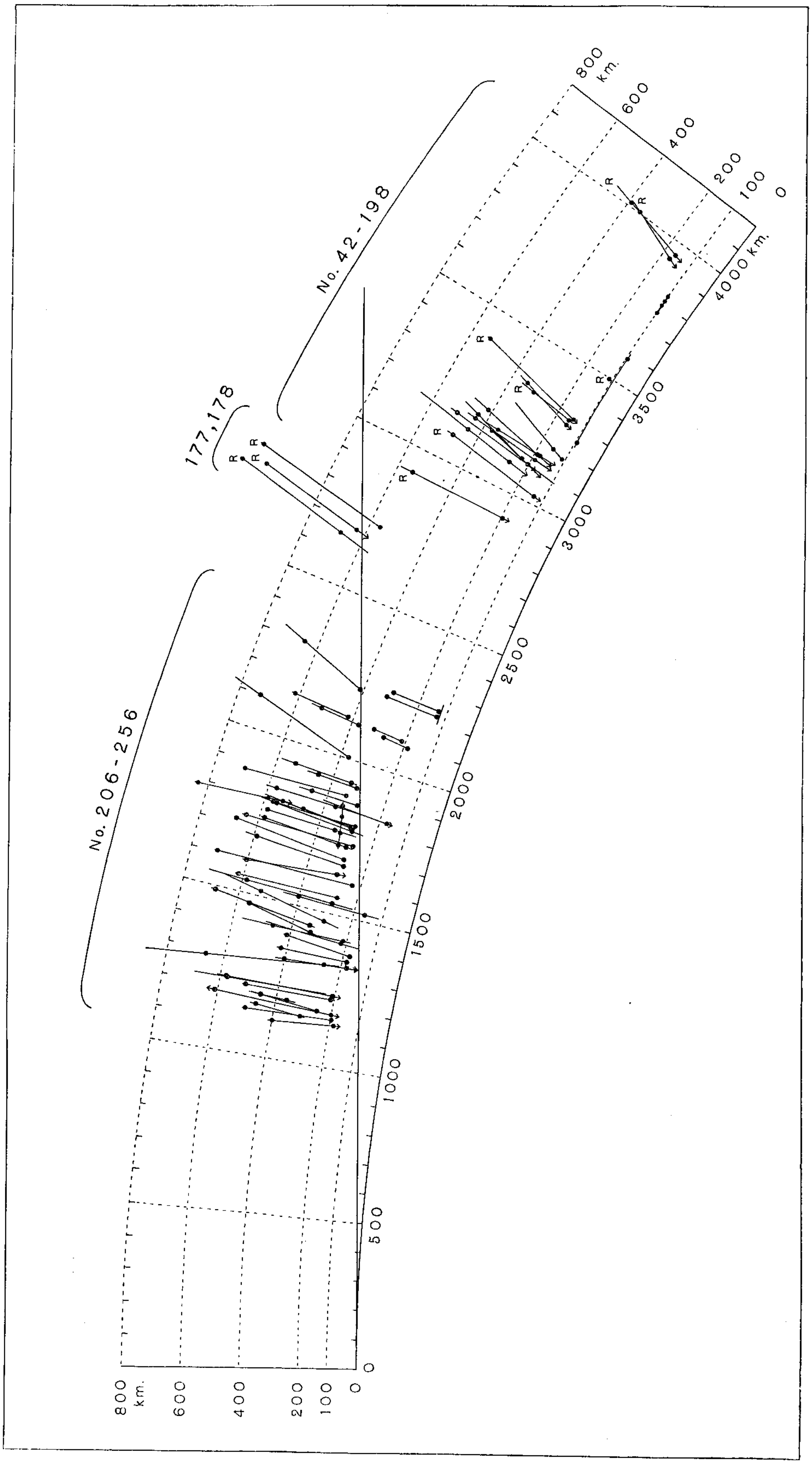

October 16-17, 1936
5h 5m 7s MET
Li-C 256
Hercules
Bootes
5°


1°W
1°E
3°
5°
7°
9°
11°
15°
17°
19°
21°
23°
25°
0 100 200 300 400 500km
Mosjøen
65°
38
Namsos
12
19
12
96
63°
Trondheim
Kristiansund
71
Ålesund
6
29
17
61°
27
69
73
Lillehammer
Bergen
Tømte
Oslo
Kongsberg
Oscarsborg
59°
1°
3°
Stavanger
7°
9°
13°
15°
Stockholm
17°
19°
21°
52
Åbo

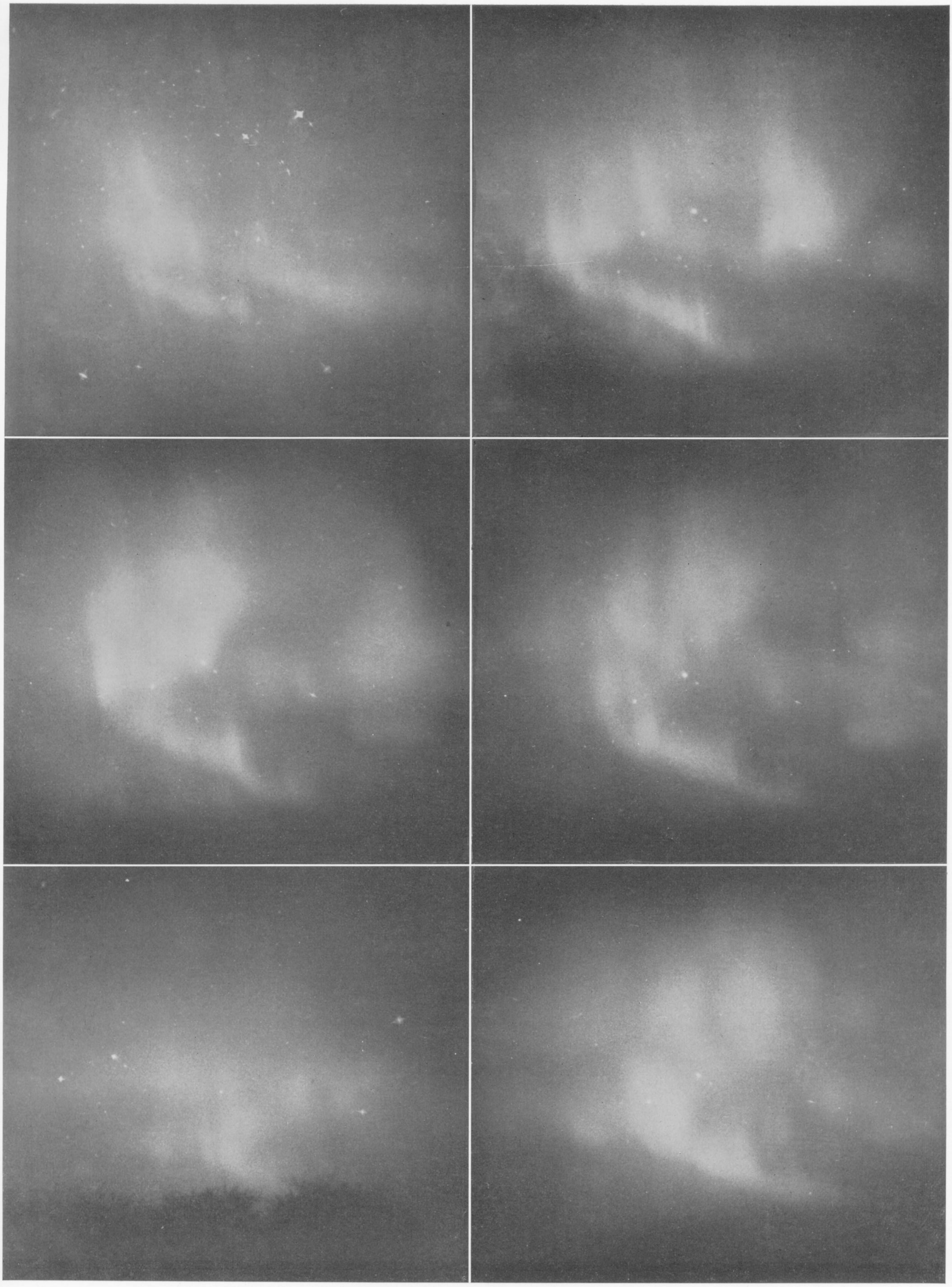

800 km.
600
400
200
100
0
0
500
1000
1500
2000 km.

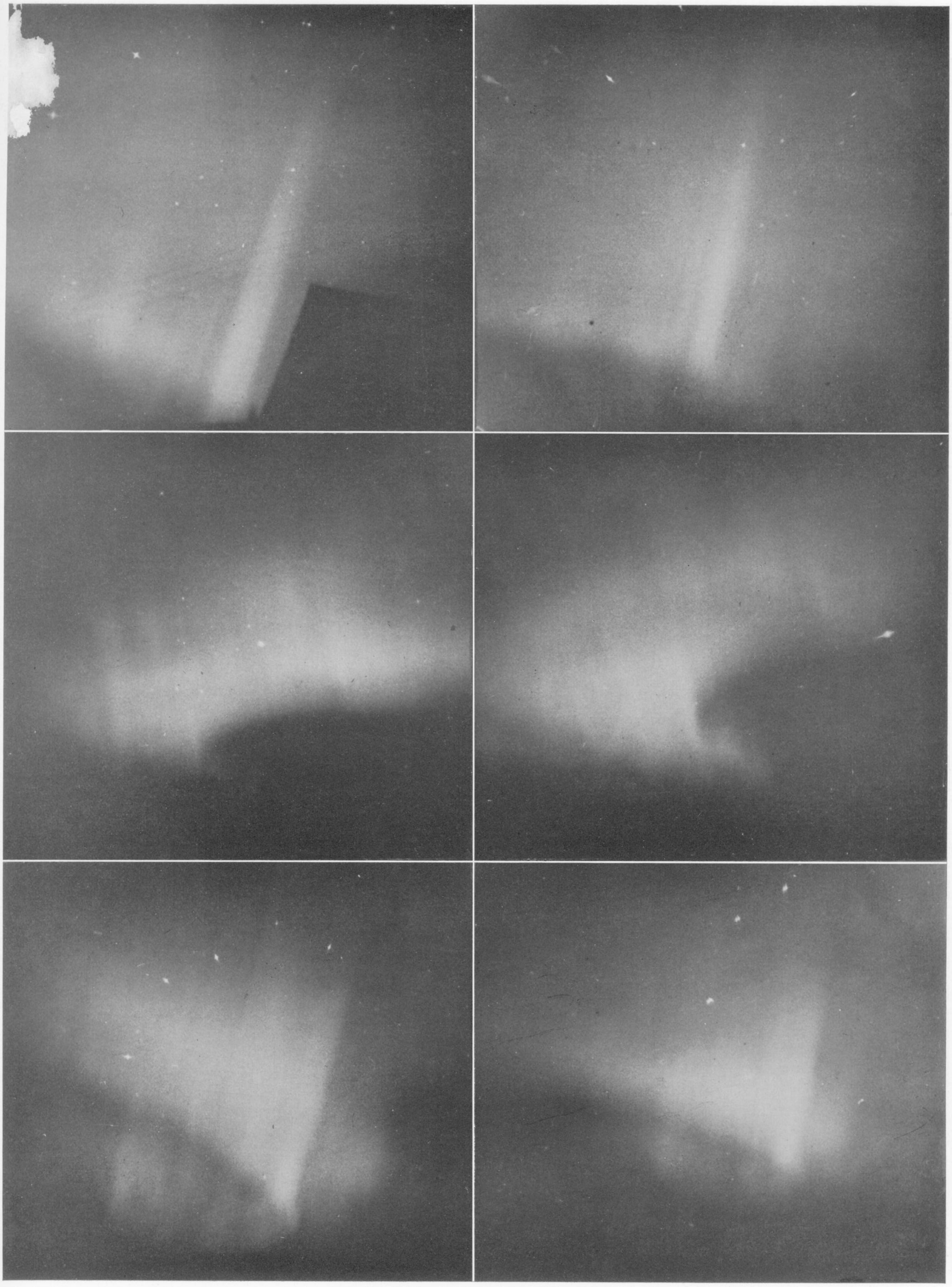

Archangel
500km
Luleå
Helsingfors
Reval
Åbo
Stockholm
Bodø
Namsos
Trondheim
Kristiansund
Ålesund
Bergen
Stavanger
Lillehammer
Tømte
Oslo
Oscarsborg
178
177
186
110
166

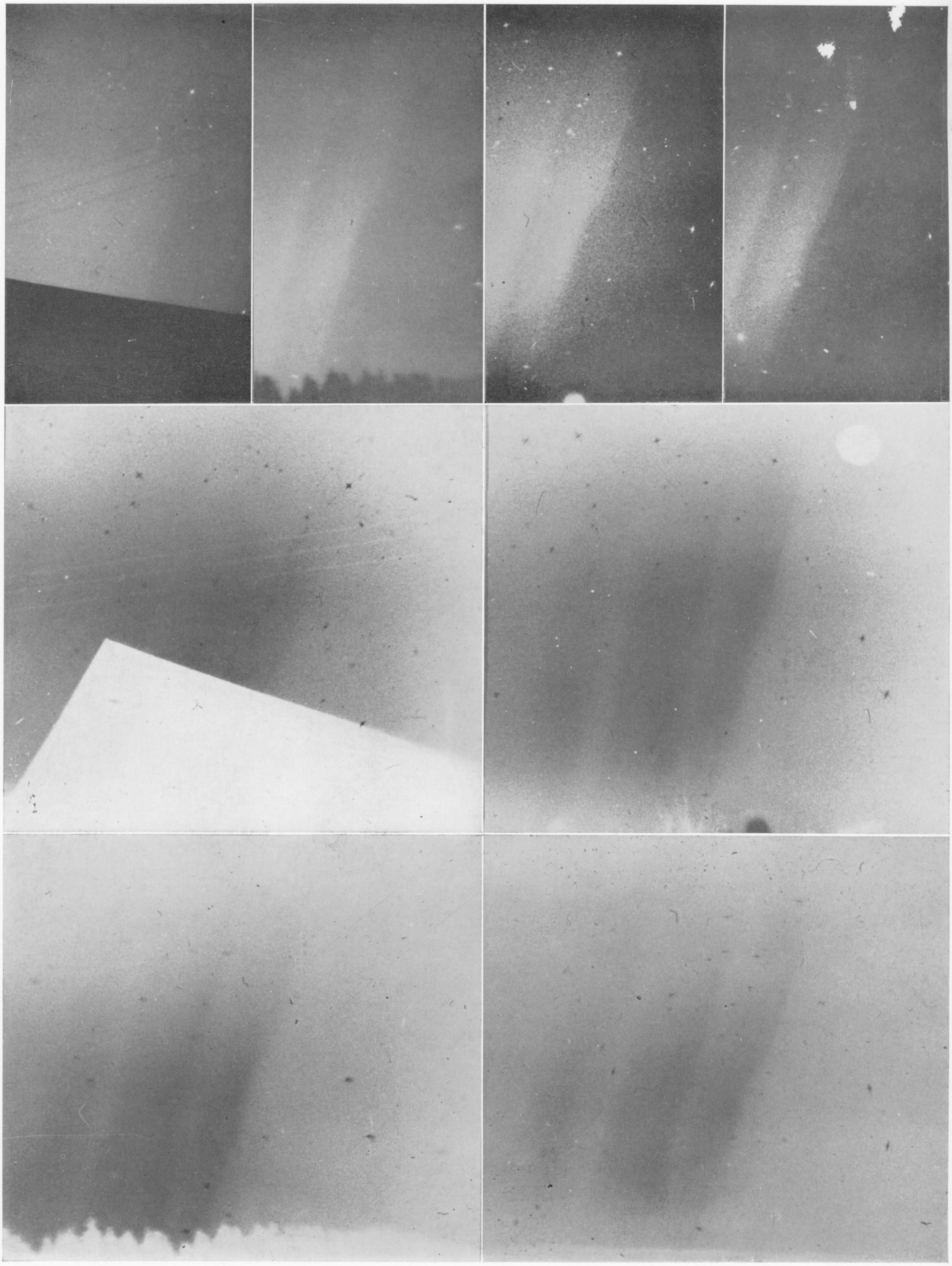

Tromsø
Bodø
Mosjøen
Namsos
Trondheim
Kristiansund
Ålesund
Bergen
Stavanger
Lillehammer
Tømte
Oslo
Vestfossen
Kongsberg
Oscarsborg
Stockholm
Luleå
Helsingfors
0 100 200 300 400 500 km

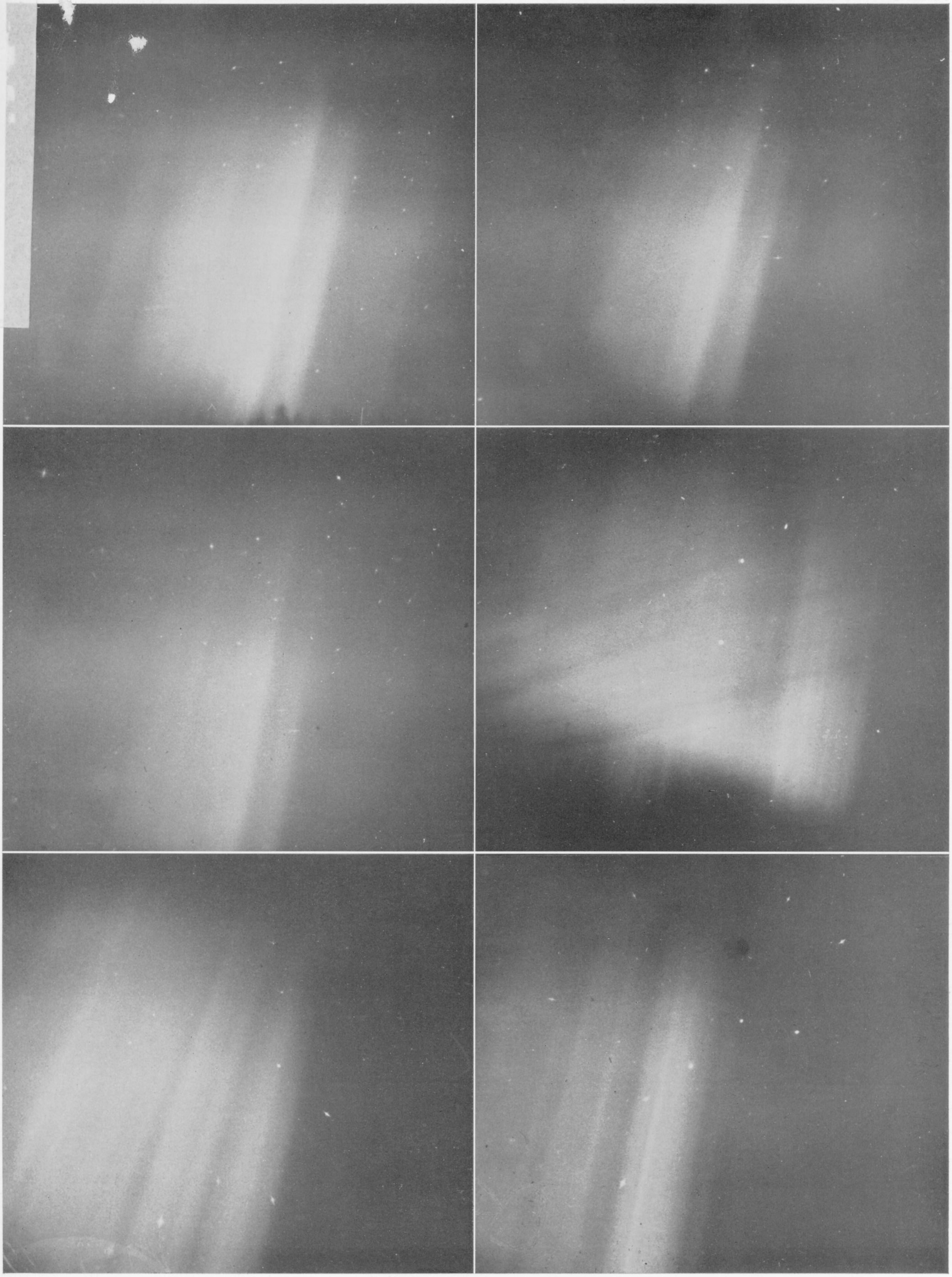


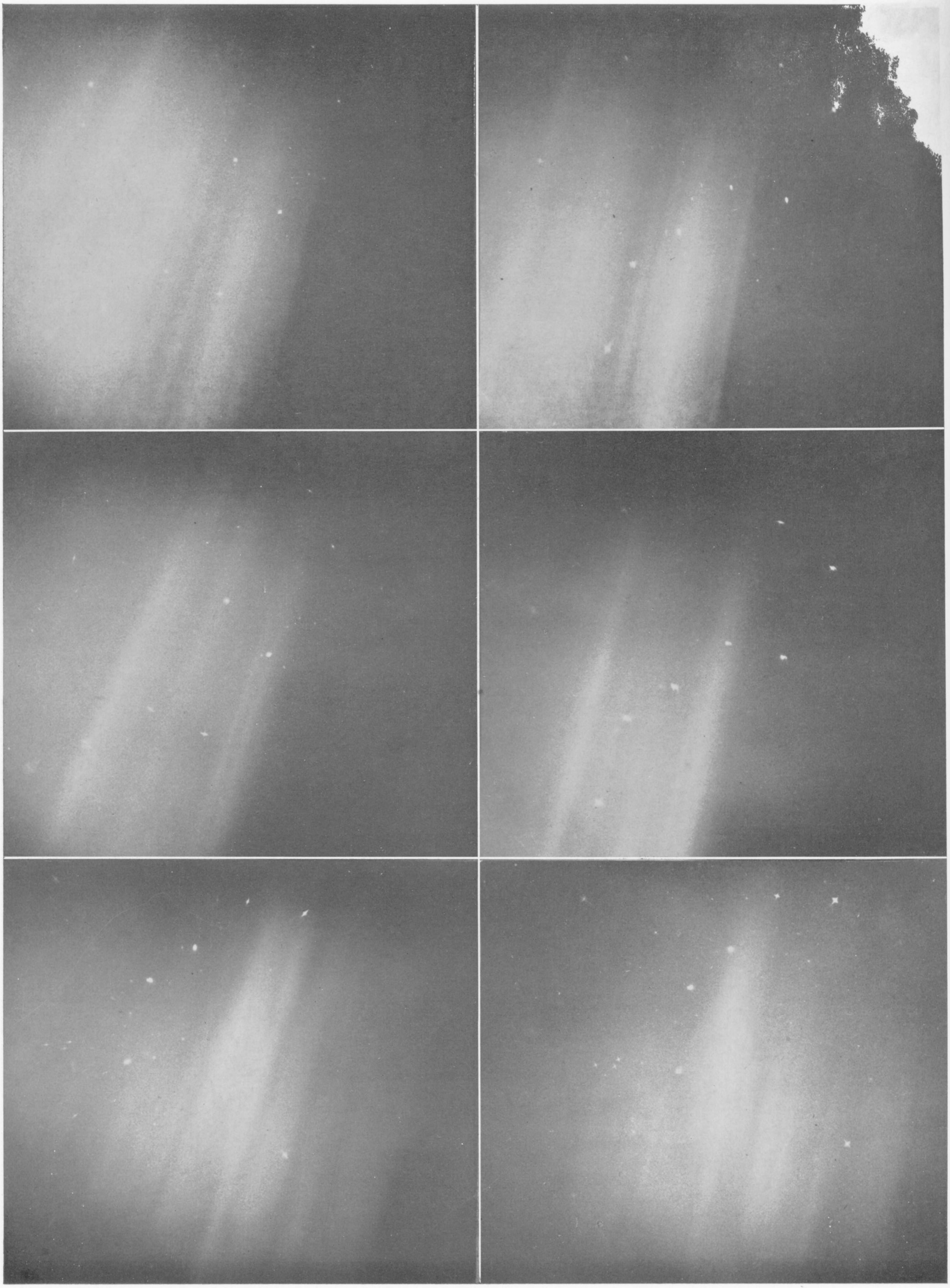
No. 42-198
177,178
No. 206-256
800 km.
600
400
200
100
0
500
1000
1500
2000
2500
3000
3500
4000 km.
R

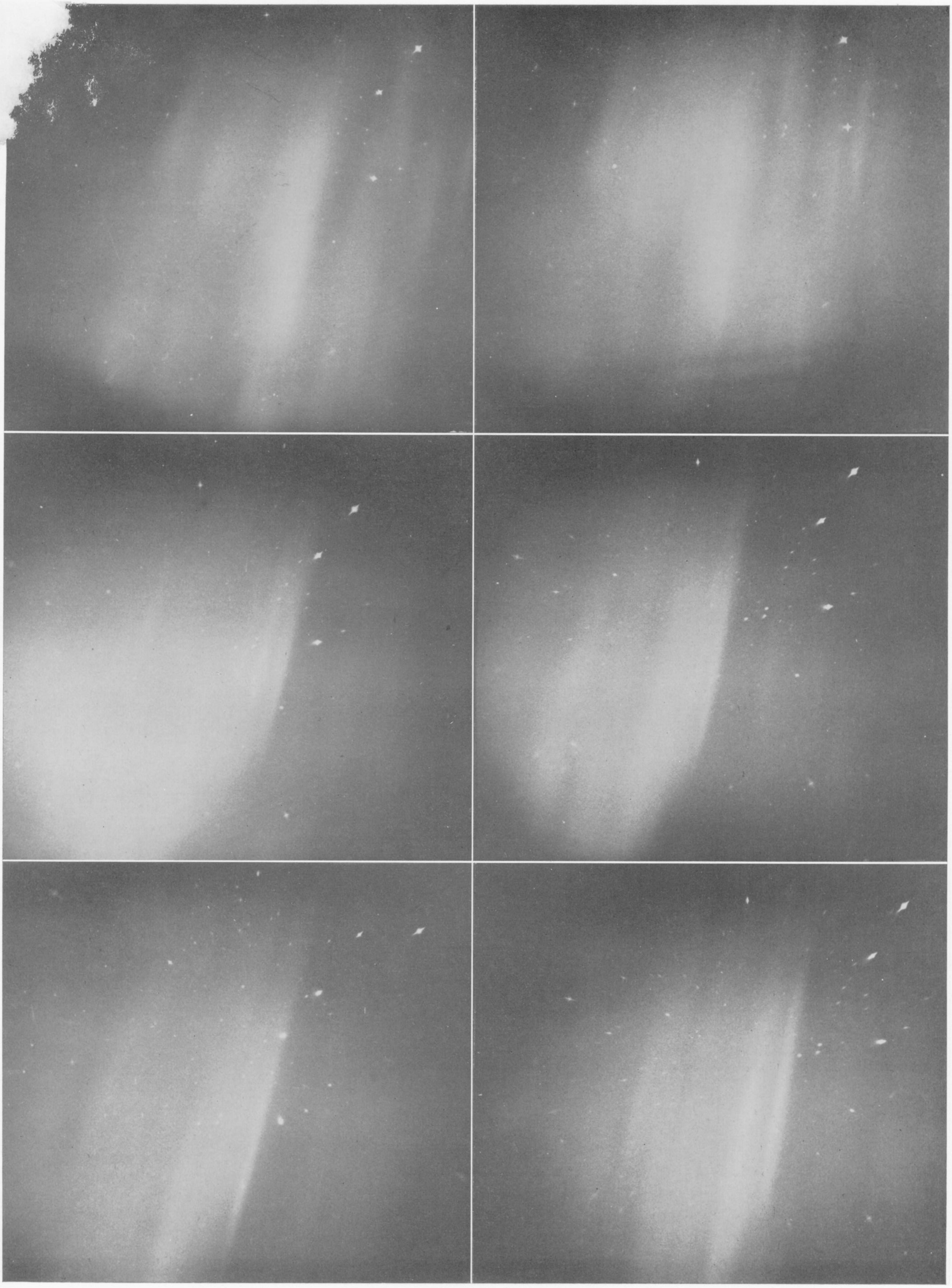


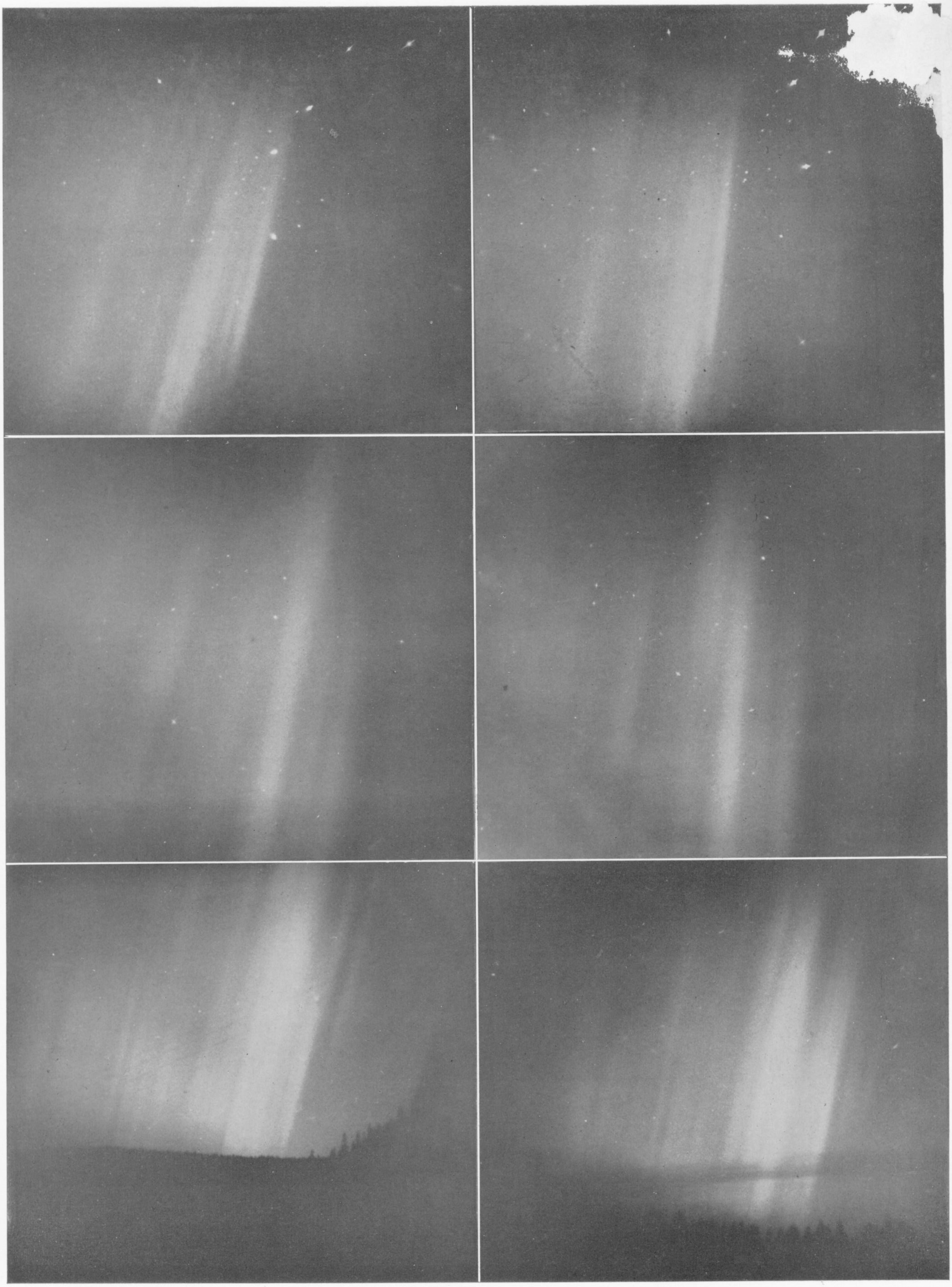


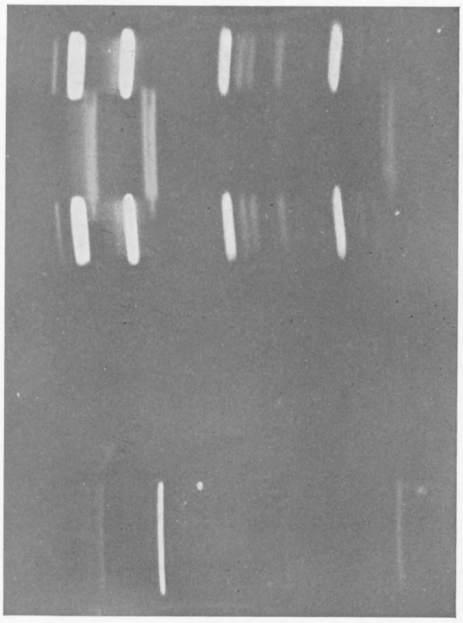




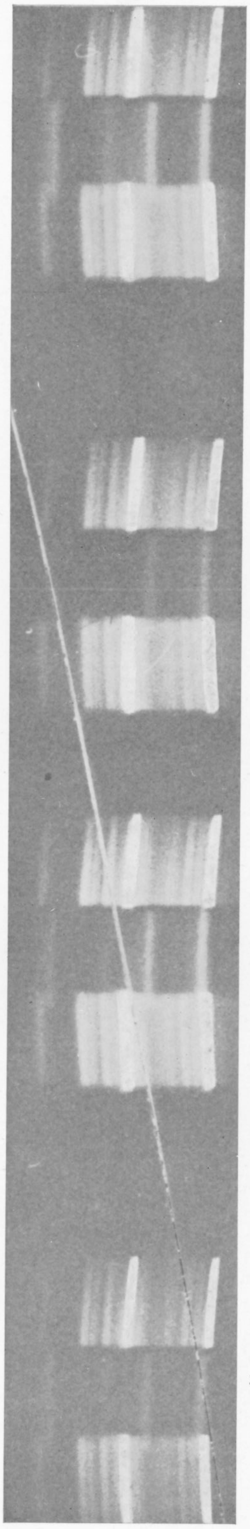








III



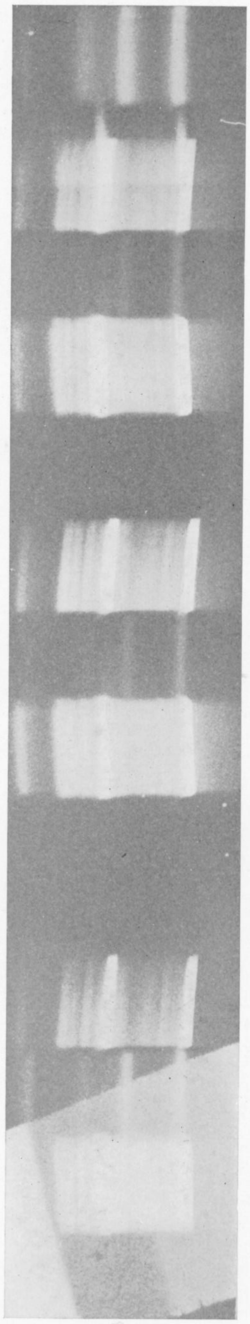
6

5

4

3

IV



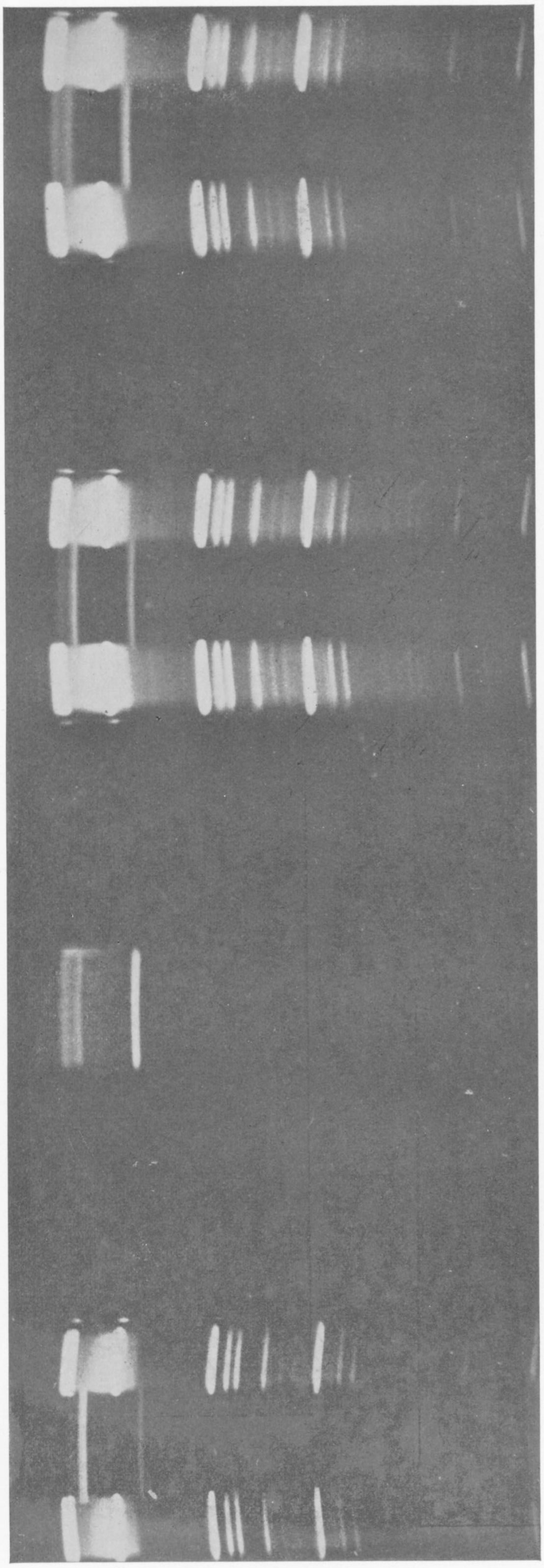
4

3

2

1

I



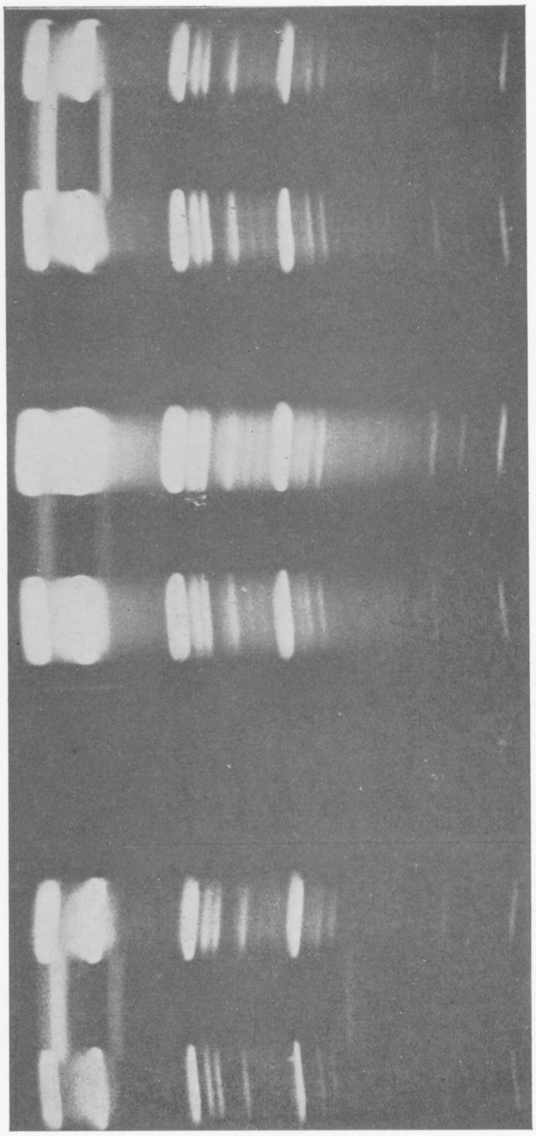
1

2

3

4

II



1

2

3