

MEDDELELSER OM GRØNLAND

UDGIVNE AF

KOMMISSIONEN FOR VIDENSKABELIGE UNDERSØGELSER I GRØNLAND

Bd. 127 · Nr. 3.

DANSK NORDØSTGRØNLANDS EKSPEDITION 1938–39

UDSENDT AF: ALF TROLLE, EBBE MUNCK OG EIGIL KNUTH TIL MINDE OM
DANMARK-EKSPEDITIONEN

LEADERS: EBBE MUNCK AND EIGIL KNUTH

DANO-NORWEGIAN
COOPERATION ON POLAR AURORAS IN
NORTHEAST GREENLAND 1938–39

BY

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WITH 23 FIGURES AND 9 TABLES IN THE TEXT
AND 13 PLATES

KØBENHAVN

C. A. REITZELS FORLAG

BIANCO LUNOS BOGTRYKKERI

1947

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PREFACE

In my Report on the "Dansk Nordøstgrønlands Ekspedition" and its activities during the first year it wintered in Greenland 1938—39 (M. o. Gr. Bd. 126 Nr. 1), mention is made of the fact that there was another scientific expedition in our latitudes in Northeast Greenland, the "Norwegian-French Polar Expedition to Northeast Greenland", and that we co-operated with it in photographing auroras.

When we reached Danmarkshavn in lat. $76^{\circ}46' N.$, long. $18^{\circ}37' W.$ on board the m.s. "Gamma" on August 12th 1938, we found the Norwegian-French Expedition's 70-ton motor-sealer "En Avant" (ex-"Ringsel") already there, and we made the acquaintance of those on board: the leader, architect WILLY KNUTSEN; the financier, the French count GASTON MICARD; the geophysicist KRISTEN HATLEVIK; the wireless operators SIGBJÖRN ÅMODT and JESS TILLIER, and the master of the ship, Captain KARL NICOLAISEN.

They had sailed from Tromsø on July 18th and had reached Danmarkshavn on August 7th with no difficulty of any kind. As in our case, the intention was to establish winter quarters as far north up the coast as possible, and after the "Gamma" had proceeded westwards into Dovebugt (where a bent propeller blade occasioned the landing of our gear), the "En Avant" remained at Danmarkshavn in the hope that the ice to the north along the outer coast would give. This happened on August 24th and the expedition immediately availed itself of the opportunity to sail, but was stopped again by the ice in lat. $77^{\circ}04'.2 N.$, where the equipment was taken ashore and the winter station "Micardbu" was built a little to the north of Fyrretyvekilometernæsset, the ship meantime returning south again to lie up for the winter at the north end of Store Koldewey island. This we learned when WILLY KNUTSEN on September 30th crossed from Micardbu over Storlandet and visited us at the Mørkefjord station.

On that occasion and later on, when engineer SØLVER and I paid a visit to Micardbu in November, the two expeditions familiarized themselves with each other's programme and agreed to work together.

in certain fields. One of these was photographing the aurora, a work which both expeditions had undertaken to do on instructions from home, from Professor CARL STØRMER, the Institute of Theoretical Astrophysics, Blindern, Oslo, and from Director D. B. LA COUR, Meteorological Institute, Copenhagen, respectively.

In advance the Norwegian-French Expedition had very good facilities for obtaining material for determining both the height and the position of the auroras, there being a telephone-sender both at Micardbu and on the ship at Koldewey, whereby simultaneous exposures on the same aurora could be made from these two localities. By these means the Norwegians themselves could have obtained valuable results without our participation, whereas the height determinations we might have made without the aid of the Norwegian stations, but perhaps in company with the Danish scientific station at Godhavn, were very problematical. We for our part were able to present an asset in the form of a wireless station that was superior to those of the Norwegians in power and reliability, so that now and then it could act as intermediary between the two Norwegian stations when direct communication between them broke down.

However, the question of which expedition benefited most from the co-operation was a subordinate one compared with the fact that it was possible to procure a more valuable material when the Mørkefjord station was included in the observation series and, instead of a base-line for the photography we obtained a base-triangle. Here lay the decisive argument in favour of the co-operation, just as scientific considerations later on were determinative when the material was to be worked up. With their two photographing stations the Norwegians secured a more bulky material than we did with our one, and moreover, in their association with Professor STØRMER the Norwegians had at their disposal a scientific capacity which we lacked. Therefore it was only natural that we placed all our photographs and observations before Professor STØRMER, who published his calculations in the publication series of The Norwegian Academy of Science: "Geofysiske Publikasjoner", Vol. XIII No. 13, Oslo 1944, under the title of: "Results of the Photogrammetric Measurements of the Aurora Borealis during the Norwegian-French Polar Expedition to Northeast Greenland 1938—39".

Similarly, the members of the Norwegian-French Expedition comprehended our desire that the results of this photography should also be communicated in the publications which, in "Meddelelser om Grønland", give an account of the work of the Dansk Nordøstgrønlands Ekspedition. In a letter dated March 6th 1942 to Professor STØRMER I requested him to deal with the subject once again for publication in "Meddelelser om Grønland", and, taking due regard to the particular

character and requirements of that work, to draw up the report in such a manner that it would appear as an independent study, in which more of our material was used than in the first publication mentioned above. Professor STØRMER at once declared his willingness to do so, and the contents of this volume signify the redemption of his promise.

If I am to express my gratitude on behalf the Dansk Nordøstgrønlands Ekspedition for the appearance of the report, I shall, in recollection of the co-operation with the Norwegian-French Expedition which preceded it, begin by thanking the leader of that expedition, WILLY KNUTSEN, and its financier, Comte MICARD, for agreeing to the co-operation in full recognition of its importance. All the members of our expedition were always received with the most cordial hospitality at Micardbu when their business took them that way, and moreover in several difficult situations WILLY KNUTSEN gave us valuable help in accomplishing our purpose.

Next, my thanks to the people at Micardbu with whom the collaboration in photographing the aurora in practice took place, the wireless operators SIGBJÖRN ÅMODT and JESS TILLIER, and especially the geophysicist KRISTEN HATLEVIK, the main-spring of the undertaking. When the disasters of the war fell upon Norway and Denmark shortly after our return home, my Mørkefjord comrades and I heard with great sorrow that Hatlevik was among the first Norwegians to be arrested by the Germans and carried into captivity in Germany. It was characteristic of his whole make-up and his attitude towards life that he had at once thrown down the gauntlet before the forces that would destroy justice and the freedom of scientific research. Through all those long, dark years our thoughts turned incessantly to Hatlevik in his German gaol, hoping against hope that he would come through. And no one could have felt more sincere joy than we when after the liberation a letter arrived in his own handwriting to prove that our hope had actually been fulfilled. We were spared the loss of a good friend, and we congratulate the Norwegian-French Expedition on its members' being similarly fortunate; we also congratulate Norwegian science on getting one of its young, promising sons home again, apparently safe and sound.

Finally, on behalf of the Expedition I thank Professor CARL STØRMER for the help he has given us and for the honour he had done us by putting his name to a modest chapter of the doings of the expedition.

June, 1946.

EIGIL KNUTH.

1. The Dansk Nordøstgrønlands Ekspedition's qualification's and equipment for aurora borealis work.

When making preparations in Copenhagen in the spring of 1938 for the work of the Danish Northeast Greenland Expedition discussions took place with the Director of the Meteorological Institute in Copenhagen, the now deceased D. B. LA COUR, with the result that on its programme the expedition included daily observations of aurorae borealis and photographing same for the purpose of determining their height.

Civil engineer S. V. SØLVER, one of the members of the expedition, undertook this work and from the Meteorological Institute received a "P. M. Observationer af Nordlys paa Ekspeditionen 1938—39 til Nordøstgrønland", in which the section on photographing aurorae borealis read as follows:

B. Photography. The object of taking photographs is to make a contribution towards elucidating the appearance (especially the structure) of the auroras in Northeast Greenland.

The photographer cannot be warned too strongly against trying to obtain contrasty pictures of the aurora by prolonging the time of exposure. Exposure should scarcely be calculated according to the intensity of the aurora; it must be so adjusted that at any rate some stars become visible in the picture—the aurora must be left to register as much as it can on the film. In actual fact, photographing the stars draws the limit of how much of the aurora borealis can be photographed profitably, as a picture without stars lacks a basis for discussion, and a picture exposed for such a long time that the aurora has changed, for instance a ray has moved, is a false reproduction of the appearance of the phenomenon.

Pictures must not be taken at a previously determined hour, but the time when a picture is taken should always be noted accurately. Suitable opportunities should be chosen when there are no clouds to be seen in the sky; nor may the moon be up, not only because fine clouds illuminated by the moon may lead to misunderstandings, but also because the dark blue tint assumed by the sky in moonlight affects the photographic film and provides a bad background for the securing of

fine auroral phenomena. The operations will be most profitable if one has time to make a number of exposures. In this the most important of all is the photographing of corona formations. For this it is imperative that the pictures include stars and that the exposure is so short that the position of the point of convergence in the sky can be found by means of the radial structure of the aurora. If both of these conditions are not satisfied, it is not worth the trouble. If the photographer considers he has got a corona, it will be of great interest if succeeding corona formations can be photographed too, so that by means of a series of pictures it will be possible to examine the changes in the direction of the lines of magnetic force at the great heights.

Another object for photographing is the recording of rays which appear to be double, as it were, because the middle part is missing. In such cases the upper rays usually lie at a height of some hundreds of kilometres where the sun is still shining, whereas the lower rays appear at the normal height of 100—200 kilometres and are not touched by the sun rays. Successive exposures of this phenomenon will also be interesting.

Finally it is suggested that the same part of a steady arc should be photographed at equal time intervals and with equal exposures in time in order to obtain a rendering of the changes in the intensity of the arc.

The following report was written by engineer SØLVER on the technical aspects of the expedition's auroral photography:

"From the Meteorological Institute the expedition received a grant of 250 kr. towards procuring a special, large aperture lens for auroral photography. The type of camera used was Zeiss Contax II taking strips of perforated kinofilm, 35 mm. in breadth and capable of taking about 36 exposures of the size 24×36 mm. The shutter is an oil-lubricated metal-slit shutter. The camera was equipped with an Albada direct-vision view-finder which, when light conditions are dull, is easier to use than a built-in finder. The lens was a Zeiss Sonnar with a focal length of 5 cm.; the largest relative aperture was 1:1.5, and the angle of view relative to the focal length and the diagonal of the image was $44^\circ.6$; (the angle of view of Professor Krogness's camera on the Norwegian-French Expedition was 58°).

"The quality of the lens as well as of the camera was such as to give images sharply defined to the very edge, and in all cases the images can be enlarged up to 30×40 cm. without loss of definition.

"When photographing auroras the camera was screwed on to a ball-and-socket joint, which permitted it to be directed towards all points in the sky and to be secured in all positions by a single movement of a handle. By means of a specially made reducing thread this tilting device was attached to a theodolite stand of substantial construction.

When taking the photographs, the observer usually stood on the roof of the station in order to have an unlimited view of the horizon. The camera was equipped with a cable release.

“The type of film used was Agfa Isopan Super Special of the sensitivity of 21/10 D.I.N. By means of a trial development (made in a Correx box on Nov. 10th 1938) with Agfa Rodinal, diluted 1:60, the following particulars of the exposures under normal conditions were established (aperture f 1.5, film Agfa Isopan as above):

“3 sec. exposure: The brightest stars recognizable and sufficiently exposed. Auroras of the intensity of 2 just visible (intensity scale: 0 = no aurora, 4 = very bright aurora).

“6—9 sec. exposure: Auroras, intensity 1, faint but sufficiently distinguishable.

“12—15 sec. exposure: Seen through a magnifying glass the stars near the horizon appear as small strokes, near the north pole of the sky still as dots.

“Thus it must be possible to photograph quiet auroras by means of autochrome films of 15/10° D.I.N.

“The first trial pictures of auroras were taken on September 27th 1938 to determine the time of exposure. In February and March, when the expedition ran short of its stock of Agfa Isopan films, Perutz-Peromnina Umkehr films 18/10° D.I.N. were used with unsatisfactory results.

“Apart from one drawback the above instrument material proved satisfactory. It appeared that the shutter worked inefficiently in severe frost. Even at -20° it closed very slowly (1—2 sec.), and at -37° C. it refused to move altogether.

“After a thorough investigation of the camera the manufacturer stated that dust and dirt had entered into the closing mechanism, thereby rendering the oil more viscous; but after it had been cleaned and lubricated the shutter worked faultlessly at -10° C. In order to eliminate this defect it is recommended that a folding mechanism be attached in front of the lens which can be opened and closed without jarring the camera.

“On the expedition's return to Denmark all not yet developed films were developed in Kodak D.K. 20 after exhaustive tests. The aurora pictures were printed for incorporation in the archives of The International Bureau of Auroral Research at the Meteorological Institute in Copenhagen, whereafter they were forwarded through the Institute to Professor STØRMER, Oslo, for analysis.”

2. The Norwegian-French Polar Expedition's qualification's and equipment, and the practical course of the co-operation.

During the spring of 1938 Mr. WILLY KNUTSEN, leader of the Norwegian-French Polar Expedition to Northeast Greenland, asked me if I would lend aurora cameras to the expedition and post the expedition on aurora work, this having been included in the programme.

As the expedition intended to go so far as to Lat. 80° N., and as it would be most interesting to obtain information on the height and situation of the aurora so near the magnetic axis of the earth, I lent the expedition two cameras of the type used during the polar year and belonging to The International Association of Geodesy and Geophysics, as well as three pocket spectroscopes and two copies of the photographic atlas of auroral forms with supplements, also the property of the Association, together with some star maps.

From the foundation The Scientific Research Foundation of 1919 I obtained a grant of 1500 Norwegian crowns to buy telephones, plates and photographic equipment, and I made the arrangement with WILLY KNUTSEN that the material collected should remain at my disposal when it came back to Norway. Acting on our experience in southern Norway a large stock of the excellent plates Agfa Isopan ISS in sealed iron boxes was secured. These plates, which are very sensitive to red and also sensitive to the other colours of the spectrum, are the best plates I have used for auroral work. They also keep very well; when the expedition came back to Norway I secured the rest of the plates and used them in southern Norway during the following three years with great success. Even in 1943 they were still usable, but their sensitivity was reduced to about 0.75 to 0.5 of what it was in 1938.

Before the departure of the expedition I gave Mr. KRISTEN HATLEVIK, who was in charge of the aurora work of the expedition, the necessary advice as to the use of the aurora cameras, and during some aurora nights in Oslo he and Mr. JESS TILLIER worked with us at our aurora station and gained experience in the choice of exposure times and the handling of the cameras.

As already mentioned by EIGIL KNUTH in the preface to this book, the results of the aurora work on the expedition are given in detail in a paper published in *Geofysiske Publikasjoner* in April 1944. In the present paper an extract of these results is given with special reference to the co-operation with the Dansk Nordøstgrønlands Ekspedition 1938—39.

From Mr. Hatlevik's report on the expedition (GP p. 4) I give the following extract:

"When the Norwegian-French Expedition's ship "En Avant" had unloaded the equipment for the main station "Micardbu" in lat. $77^{\circ}04'.2$ N., she sailed south and found a very fine winter harbour at the north part of Store Koldewey Island, lat. $76^{\circ}43'.2$ N., long. $19^{\circ}3'.8$ W. Until the middle of October we were busy transporting the equipment and setting up the house and radio masts, as well as hunting musk-oxen to provide fresh meat for the winter. "Micardbu" was situated in a waste and bare country, but the chief point was that the land was flat with a free horizon.

"The work was often disturbed by storm and drifting snow. This was true especially of the sub-station for the photographing of auroras, and after we had determined the position of our vessel we resolved to use it as a sub-station. TILLIER began to build a new telephone transmitter and prepared to begin the photographic work from the vessel at Koldewey.

"On November 15th EIGIL KNUTH together with engineer SØLVER and the Greenlanders SAKÆUS and ELI arrived at Micardbu on their return from a depot journey. We then agreed to photograph simultaneously from Micardbu, Koldewey and Mørkefjord, as SØLVER had an excellent radio station with telephone transmitter. On November 24th TILLIER went southwards to Koldewey to make the radio station there ready and begin the photographic work. On November 30th we made telephonic contact with both Mørkefjord and Koldewey. We were now ready, but we did not get our first set of pictures with Koldewey before December 17th.

"The first aurora was seen on September 26th at 0100 hour, faint rays in the eastern sky. In the months October to December 15th we recorded auroras at the time of the usual meteorological observations, 0100, 0700, 1300 and 1800 hours G.M.T. (Monthly tables of meteorological observations have been handed over to the Meteorological Institute, Oslo, and on these the appearance of auroras at the above-mentioned times was added). The last aurora was observed on March 30th, faint rays to SE. From December 15th the wireless operator ÅMODT and myself shared the watches between us and observed at least every hour. In the dark season I was engaged on the measuring of radiation with an Ångström pyrogeometer, and during this time I obtained fairly continuous observations of auroras. The aurora was most brilliant and most frequent in the evening, so we arranged to call Koldewey and Mørkefjord at 1800 G.M.T., and had additional contacts every half hour. Mørkefjord had the receiver continuously tuned to Micardbu; thus we could call at any time. We then watched for aurora several times during the night.

"The cold did not disturb the astro-cameras; they worked well the whole time. We arranged a dark room and tentatively developed some plates.

"The hut was covered with snow; the stand with the camera was therefore placed at the level of the roof so that I could talk to ÅMODT through the wall. I gave instructions for the photographing in the microphone, ÅMODT was inside the hut, noting down and making chronometric observations at the same time as he attended to transmitter and receiver. ÅMODT looked after Mørkefjord and Koldewey, and by means of pre-arranged knocking signals he informed me when Mørkefjord and Koldewey were ready to photograph. In this way I was relieved of both microphone and telephone, and this facilitated the work considerably. Conversations took place in agreement with the following scheme: Micardbu: description. Plate 1, Picture 1, Vega, Plate 1, Picture 1, Vega, 5 sec. . . Ready, 1.5, 2.5, . . . 5.5, finished. How did it go? Hello Mørkefjord, over to you. Mørkefjord: O.K. Micardbu: Hello Koldewey, over to you. Koldewey: O.K.

"ÅMODT then received acknowledgment from Mørkefjord and Koldewey, and he knocked signals on the wall that they were ready.

"In favourable weather I used to dictate six pictures in succession before Mørkefjord and Koldewey acknowledged, and it proved to be all right.

"The most important part of this work of observation was the radio communication, and therefore in conclusion I shall report on our equipment and how it worked.

"At Micardbu we had an American amateur short-wave transmitter with an antenna effect of 50 Watts and with the wave-lengths of 24—36—48—56—98—108 m. Further, we had a converter-driven alternating current receiver. This was probably damaged in transit, for the receiving was interrupted by noise from the converter. TILLIER constructed a telephone transmitter for Koldewey on a wave length of 100 to 180 metres, using an ordinary battery receiver. However, most frequently he had to answer by telegraph; so he stood on the roof with telephone and telegraphic key and took photographs at the same time. The apparatuses were placed in the radio room. This caused difficulty when they had to be re-adjusted.

"The transmitter had an effect of 10—15 Watts. Koldewey was off the air during January on account of an accident to the apparatus. Mørkefjord had a M. P. Pedersen transmitter of 35—40 Watts and a battery receiver¹). The wireless operator KURT BÆK attended to the radio communication and engineer SØLVER took the photographs,

¹) For fuller details of Mørkefjord's wireless equipment see KURT BÆK: Radio-technical Observations, MoGr. Bd. 127, No. 2.

receiving orders to photograph direct on the head'phones, then telling BÆK that he was ready to continue, BÆK then signalling by telephone to ÅMODT. The transmitter at Mørkefjord worked on the wave lengths 110—190 metres and very often used 151 or 184 metres.

“Short waves from 24 to 108 metres were very often disturbed, and there was much fading. The Mørkefjord wave lengths 151—184 metres proved to be the safest to use. This agrees with the experience of CHRISTIAN JENSEN during the four years he spent at the station of the Danish hunting company Nanok on Hvalrosodden, not far from Mørkefjord. Later ÅMODT built a long-wave transmitter, 650—700 metres, which proved to be good for telephoning on the line Micardbu—Mørkefjord—Koldewey.

“From this it will be seen that all the stations should have been in possession of a telephone transmitter of 20—40 Watts whose wavelength could be varied continuously from 150 to 190 metres, and also a good ship's battery receiver. This would probably have secured a good connection between the stations.”

Accordingly, the situation while photographing the auroras at the three stations was as follows:

Micardbu (Norwegian-French) on the east coast of Germania Land lat. $77^{\circ}04'.2$ N., long $18^{\circ}12'$ W.

Photographer: KRISTEN HATLEVIK.

Wireless operator: SIGBJÖRN ÅMODT.

Koldewey (Norwegian-French), the winter harbour of “En Avant” in lat. $76^{\circ}43'.2$ N., long. approx. $19^{\circ}03'.8$ W.

Photographer and wireless operator: JESS TILLIER.

Mørkefjord (Danish) on the south coast of Storlandet, outside the mouth of Mørkefjord, lat. $76^{\circ}56'.1$ N., long. $20^{\circ}18'.2$ W.

Photographer: SVEND V. SØLVER.

Wireless operator: KURT BÆK.

The three stations formed approximately an equilateral triangle, the sides of the triangle being roughly 50 km long¹⁾. The time signal was received from Nauen.

According to engineer SØLVER, the first co-ordinated photography took place in the evening of December 21st 1938, whereafter the work continued in the evenings and nights of January 9th, 14—15th, February 16th, and it was concluded on February 17th 1939. During these days 114 auroral pictures were taken at the Mørkefjord station, 17 of them

¹⁾ See next page.

taken simultaneously with corresponding pictures at both Micardbu and Koldewey, whereas the remainder, 87 pictures, were taken with corresponding pictures at Micardbu alone.

3. The three aurora stations and length and direction of the corresponding base lines.

As seen from the reports the three aurora stations were Micardbu, Koldewey and Mørkefjord.

From the observations of HATLEVIK and SØLVER the geographical coordinates of these stations were as follows:

| Station | Sign. | Latitude N. | Longitude W. Gr. |
|----------------------|-------|----------------------------|------------------------|
| Micardbu | M | $77^{\circ}04'.2 \pm 0'.1$ | $18^{\circ}12' \pm 1'$ |
| Koldewey | K | $76^{\circ}43'.2$ | $19^{\circ}03'.8$ |
| Mørkefjord | S | $76^{\circ}56'.1$ | $20^{\circ}18'.2$ |

From this the length of base line g and the declination δ_0 and time angle t_0 of the point where the base line cuts the sky, observed from the main station, were calculated with the following results:

| Base line | g | δ_0 | t_0 |
|---------------|----------|------------------|------------------|
| M-K | 44.77 km | $-11^{\circ}.41$ | $30^{\circ}.30$ |
| M-S | 54.92 - | $- 3^{\circ}.54$ | $75^{\circ}.53$ |
| K-S | 39.64 - | $7^{\circ}.93$ | $127^{\circ}.16$ |

As main stations in the three cases were chosen respectively M and K. Fig. 1, drawn from "Report on the Expedition and on Subsequent Work at the Mørkefjord Station", by EIGIL KNUTH¹⁾, Fig. 48, shows the situation of the three stations.

4. The collected material.

In my paper (GP) a complete list is given of all observations and photographs of aurora; for details we refer to this list (GP, Tables 1,2).

In Table I a list is given of the sets taken simultaneously from two or three of the stations and usable for measuring height and situation of the aurora.

¹⁾ Meddelelser om Grønland Bd. 126, No. 1, p. 159, Kjøbenhavn 1942.

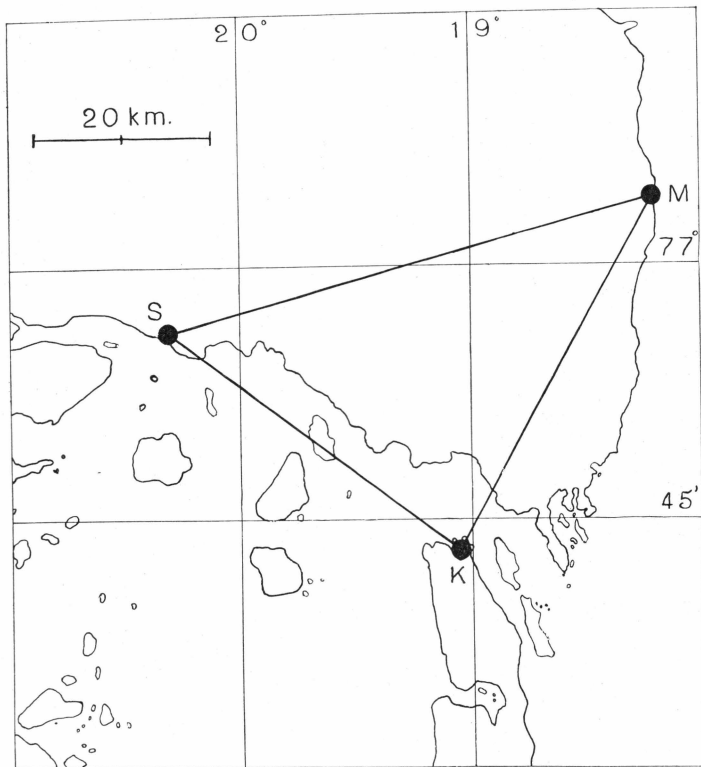


Fig. 1. Geographical position of the Aurora stations Micardbu (M), Koldewey (K) and Mørkefjord (S).

The headings have the following meaning:

- N is the current number of the photograph.
 St gives the name of the stations: M is Micardbu, K is Koldewey and S is Mørkefjord. The stations from which pictures are taken simultaneously are combined by dashes.
 GMT is Greenwich middle time reckoned for the middle of the exposure.
 Ex means the exposure in seconds.
 F means the aurora form according to the Photographic Atlas of Auroral Forms¹⁾, namely:

- HA Homogeneous quiet arcs
- HB Homogeneous band
- PA Pulsating arcs
- DS Diffuse luminous surfaces

¹⁾ Photographic Atlas of Auroral Forms and Scheme for Visual Observations of Aurorae, published by the International Geodetic and Geophysical Union, Oslo 1930.

Table I. List of usable aurora-photographs taken simultaneously from two or three stations.

| N | St | GMT | Ex | F | RC | Remarks | SN |
|--------------------|-----|----------|----|-------|------------------|-------------------------------|---------|
| December 17, 1938. | | | | | | | |
| 10 | M-K | 20.58.05 | 12 | RA | Ori Tau | | |
| 11 | — | — 59.42 | 8 | RB | Ori | | |
| 25 | — | 21.59.55 | 15 | — | Cet Tau | Diffuse | |
| 26 | — | 22.01.44 | 10 | — | — | — | |
| 27 | — | — 03.32 | 8 | — | — | — | |
| 28 | — | — 05.05 | 9 | — | — | — | |
| 29 | — | — 08.01 | 8 | R | CMi Gem | Diffuse Rays | |
| 30 | — | — 09.56 | 15 | RB | CMi Cnc Gem | — | |
| December 21, 1938. | | | | | | | |
| 8 | M-K | 23.08.25 | 16 | R | Psc Peg | Diffuse | |
| 9 | — | — 10.01 | 22 | — | Ori | Feeble | |
| 10 | — | — 23.27 | 11 | RB | Psc, Peg, Saturn | | |
| 11 | — | — 25.00 | 10 | — | — | Strong | |
| 12 | — | — 27.46 | 14 | RA | Tau Cet | | |
| January 9, 1939. | | | | | | | |
| 8 | M-S | 22.29.09 | 15 | D | Ori Tau | D up to zenith | 15. 1 A |
| 10 | — | — 31.25 | 23 | RA | — | Double arc. | — 3 A |
| 17 | — | — 46.11 | 50 | RB | Leo | Intensity increases | — 10 A |
| 19 | — | — 51.27 | 43 | — | Ori | | — 11 A |
| 20 | — | — 53.03 | 35 | — | CMi Gem Mon | | — 12 A |
| 21 | — | — 54.14 | 13 | D, RB | Gem Cnc | Intensity increases | — 13 A |
| 23 | — | — 57.17 | 22 | R, RB | — | | — 15 A |
| 24 | — | — 58.29 | 41 | RA | Ori Tau | | — 16 A |
| 25 | — | 23.02.21 | 29 | — | Ori | Two arcs | — 17 A |
| 26 | — | — 03.25 | 27 | — | Ori Tau | Three arcs | — 18 A |
| 27 | — | — 05.01 | 38 | — | Gem CMi | Two arcs | — 19 A |
| 29 | — | — 07.34 | 30 | HA | Ori | One strong and one feeble arc | — 21 A |
| 31 | — | — 15.40 | 37 | RA | Gem | Strong | — 23 A |
| 35 | — | — 21.39 | 35 | RB | Gem CMi | | — 27 A |
| 37 | — | — 47.30 | 31 | R | Boo Com | | — 29 A |
| 38 | — | — 49.15 | 31 | R | Boo CVn | | — 30 A |
| 39 | — | — 50.28 | 18 | RB | Boo Com | Fine curtains | — 31 A |
| 41 | — | — 57.18 | — | R | Boo | | — 33 A |
| 42 | — | 00.00.24 | 27 | — | — | | — 33 A |
| January 14, 1939. | | | | | | | |
| 7 | M-S | 22.10.13 | 24 | R | Leo Cnc | | 16.11 |
| 8 | — | — 11.00 | 17 | RB | CMi Gem Mon | | — 12 |
| 9 | — | — 13.08 | 29 | — | Ori Eri | | — 13 |
| 11 | — | — 15.28 | 12 | RB, R | — | Fine curtains | — 16 |

Table I (continued).

| N | St | GMT | Ex | F | RC | Remarks | SN |
|--------------------|-------|----------|----|-------|-------------|------------------------|-------|
| 12 | M-S | 22.16.32 | 20 | RB | Ori Eri | Fine curtains | 16.17 |
| 15 | — | — 20.01 | 16 | R | Ori | | — 20 |
| 17 | — | — 22.24 | 24 | — | CMi Gem Cnc | | — 21 |
| 19 | — | — 26.18 | 16 | RB | CMi Mon | Two RB | — 23 |
| 22 | — | — 29.36 | 21 | RA | Ori Eri | | — 25 |
| 23 | — | — 31.17 | 16 | RB | Ori | Curtains | — 26 |
| 26 | — | — 37.25 | 19 | RA, R | Ori Eri | Two curtains | — 29 |
| 29 | — | — 46.27 | 23 | RA | Ori | | — 32 |
| 37 | — | 23.17.15 | 32 | — | Leo Hyd | Three RA | — 39 |
| 38 | — | — 21.43 | 35 | RB | — | | 17. 1 |
| 39 | — | — 23.55 | 27 | R | Leo Com | | — 2 |
| 40 | — | — 27.00 | 42 | — | Gem CMi Cnc | | — 3 |
| 41 | — | — 55.04 | 24 | D | — | Fine curtains | — 4 |
| 42 | — | — 56.02 | 25 | DS | Leo | | — 5 |
| 43 | — | — 59.00 | 12 | RB | Gem CMi Cnc | | — 6 |
| January 15, 1939 | | | | | | | |
| 45 | M-S | 00.00.32 | 11 | R, RB | Gem Mon CMi | | — 8 |
| 46 | — | — 01.31 | 18 | D | Uma Leo Com | Very fine drapery | — 9 |
| 47 | — | — 02.54 | 15 | R, RA | Leo | Fine RA | — 10 |
| 48 | — | — 03.38 | — | RB, R | — | Fine RB | — 11 |
| 49 | — | — 05.50 | 20 | DS | CMi Cnc Hyd | | — 12 |
| 51 | — | — 07.36 | 16 | RA | Gem CMi Mon | Narrow lower border | — 14 |
| 53 | — | — 09.19 | 23 | — | Cnc CMi Hyd | | — 16 |
| 55 | — | — 12.42 | — | — | Leo Hyd | | — 18 |
| 56 | — | — 13.37 | 25 | — | Leo Vir | | — 19 |
| February 17, 1939. | | | | | | | |
| 2 | M-K | 21.19.44 | 24 | R | Ori | Fine arcs under R | |
| 5 | M-K-S | — 23.29 | 18 | RB, R | Leo | | 21.27 |
| 6 | M-K | — 25.02 | — | — | — | Fine | |
| 7 | — | — 26.50 | 17 | D | Gem Aur | Fine fanlike D | |
| 8 | — | — 28.19 | 18 | — | — | | |
| 9 | — | — 29.20 | — | D, R | Ori Tau | Fine | |
| 10 | — | — 30.57 | 17 | R | Tau | | |
| 11 | M-K-S | — 31.56 | 19 | RB | UMa Leo | Two fine curtains | — 21 |
| 12 | M-K | — 32.59 | 9 | — | Boo CVn Com | Very fine curtains | |
| 13 | — | — 34.51 | — | RA | Aur Tau | Very fine RA | |
| 14 | K-S | — 35.38 | 11 | HA | Gem Aur | | — 18 |
| 15 | M-K | — 36.29 | 17 | HA, R | LMi Leo Lyn | Fine double arc. | |
| 16 | M-K-S | — 37.16 | 13 | HA | Gem Cnc | The same | — 16 |
| 17 | M-K | — 38.15 | 10 | RB | Tau Per | Irregular RB | |
| 19 | — | — 46.01 | 19 | D | UMa Dra Boo | Very fine D | |
| 20 | — | — 46.56 | 10 | RB | Leo CMi | Fine | |
| 21 | — | — 51.52 | 12 | — | Gem CMi | — | |

Taale I (continued).

| N | St | GMT | Ex | F | RC | Remarks | SN |
|-----------------|-----|----------|----|-------|---------|----------------|-------|
| 22 | M-K | 21.52.32 | 17 | HB | Gem Cnc | Fine | |
| 24 | — | — 54.17 | 12 | RB | Ori Tau | | |
| 25 | M-S | — 56.39 | 18 | — | — | Very fine | 21.10 |
| 31 | M-K | 22.02.23 | 12 | RB, R | Leo | | |
| 32 | — | — 03.15 | 11 | HA | Gem CMi | Fine arc. | |
| 33 | — | — 04.02 | 18 | HA, R | Tau | | |
| 34 | — | — 04.48 | 25 | RA | Gem | Interesting RA | |
| 35 | — | — 05.47 | 27 | RB | Leo | More diffuse | |
| March 12, 1939. | | | | | | | |
| 3 | M-K | 01.22.21 | 13 | RB | Boo | | |

PS Pulsating surfaces

G Feeble glow

RA Arcs with ray structure

RB Bands with ray structure (curtains)

D Draperies

R Rays

C Corona

F Flaming aurora.

Because the aurora forms merge into one another and as I have not myself seen the photographed forms it was often difficult from the photograph to determine the form.

RC means the constellations towards which the cameras were pointed. The abbreviations are those adopted at the International Astronomical Congress in Rome 1922.

The last column with heading SN gives the film number of the corresponding pictures taken in Mørkefjord.

A great many pictures were also taken from the stations without simultaneous pictures on other stations. These single pictures were of great interest as types of aurora but could not be used for determining height. However, if we assume a reasonable height, pictures of arcs could be used to find the direction of arcs over North-East Greenland and over the Atlantic east of it.

As to the single pictures from Micardbu and Koldewey we must refer to the paper (GP), Table 1, and for pictures used for finding the direction of arcs to a later section of the present paper.

Regarding the single pictures taken from Mørkefjord a complete list is given in Table 2 of the same paper (GP). From this table we give in Table II a list of the usable pictures not contained in Table I.

Table II. Usable single pictures from Mørkefjord.

| SN | GMT | Ex | F | RC | Remarks |
|-------------------|----------|--------|--------|-------------|-------------|
| January 9, 1939. | | | | | |
| 15. 2 A | 22.30.23 | 10 | RA, HA | Tau Ori Eri | Very good |
| — 4 A | — 32.53 | — | PS | Gem | — |
| — 5 A | — 34.40 | 30 | RB | Leo Cnc | — |
| — 6 A | — 38.09 | — | HA ? | Gem CMi | — |
| — 7 A | — 39.54 | 20 | HA | Leo Cnc | — |
| — 8 A | — 41.45 | 40 | R, HA | Ori | — |
| — 9 A | — 44.04 | — | — | — | — |
| — 20 A | 23.06.16 | 30 | RA | Gem | — |
| — 22 A | — 08.45 | ? | HA, RA | Gem CMi | Good |
| — 24 A | — 17.13 | 30 | DS | Ori Tau | Feeble |
| — 25 A | — 18.57 | — | — | Ori Tau Gem | — |
| — 26 A | — 20.12 | — | HA | — | — |
| — 28 A | — 23.35 | — | — | Ori | Very good |
| — 32 | ? | 20 | R | Boo CrB | Good |
| January 14, 1939. | | | | | |
| 16. 8 | 20.15.26 | 30 | RB | Ori Tau | Good |
| — 15 | 22.14.24 | ? | — | Ori | Very good |
| — 18 | — 18.31 | 12 | RA | — | — |
| — 19 | — 19.12 | 10 | — | CMi | — |
| — 22 | — 23.41 | 20 | RB | Tau Eri | Good |
| — 24 | — 27.16 | 30 | RA | Ori | — |
| — 27 | — 32.02 | 12 (?) | — | CMi | — |
| — 28 | — 35.48 | 25 | RA, R | Ori | — |
| — 30 | — 39.44 | 15 | HA | CMi Hya | — |
| — 32 | — 46.27 | ? | RA, RB | Ori | Not so good |
| 17. 7 | 23.59.51 | 20 | RB | — | Good |
| January 15, 1939. | | | | | |
| 17.13 | 00.06.53 | 15 | HB, DS | Hya | Good |
| — 15 | — 08.28 | 20 | HA | Ori | Some clouds |
| — 17 | — 10.30 | 17 | RA | Hya Leo | Good |
| — 20 | — 14.42 | ? | RA, HA | Leo | — |

5. Results of the measurements of height and situation of the aurora during the expedition.

The negatives have been measured out by my excellent assistant OLAV EGEBERG during the years 1940 and 1941. Some of them were dropped on account of too small parallaxe, owing to unfavourable situation of the aurora relative to the base lines. In fact many of the auroras were too near the point where the direction of the base line cuts the sky or too near the horizon. Much longer base lines would have been better for the accuracy of the measurements.

As to the methods used I must refer to earlier papers, in particular to the improved methods published in 1938¹⁾.

In Table III we reproduce, from the paper (GP) all the measurements of the aurora, not only with base lines M-S and K-S, but also with base line M-K, giving the complete results from the expedition.

In that table the headings have the following meaning:

- N is the current number of the picture from Micardbu and Kolde-
wey, and N' the corresponding film number from Mørkefjord.
"Point" is the current number of the measured point of the aurora.
GMT is Greenwich middle time for the middle of the exposure in hours,
minutes and seconds.
St are the stations at the ends of the base line. First letter is the
main station, second letter the sub-station.
F is the aurora form measured, according to the designations in the
Photographic Atlas.
P is the position of the selected point on the aurora.

l means that the point is at the lower border or at the base of a ray,
l' that it is near this border or base; m means that the point is between
lowest and highest part and h that it is at the upper border or at the
summit of a ray. h' that it is near the upper border or summit.

ε_2 means the angle between the direction from the substation
to the aurora point and the plane perpendicular to the base line at that
point. ε_2 is counted positive on one side of this plane, negative on the
other. Calling ε_1 the corresponding angle for the main station the
parallaxe p is

$$p = \varepsilon_1 - \varepsilon_2.$$

See Fig. 2 and the paper in Geofysiske Publikasjoner referred to in
the preceding section. In former papers $u_1 = 90^\circ - \varepsilon_1$ and $u_1 = 90^\circ - \varepsilon_2$
were often used instead of ε_1 and ε_2 .

¹⁾ CARL STØRMER: Some Results Regarding Height and Spectra of Aurorae,
etc., p. 5—9, Geof. Publ. Vol. XII, No. 7, Oslo.

Table III. Results of the measuring of the simultaneous pictures.

| N | Point | GMT. | St. | F | P | ε_2 | p | h | a | D | H | N' |
|-------------------|-------|----------|-----|----|----|-----------------|-----|------|-------|-----|-----|----|
| December 17, 1938 | | | | | | | | | | | | |
| 10 | 1 | 20.58.05 | M-K | RA | l | -3.3 | 6.0 | 14.4 | -57.5 | 407 | 119 | .. |
| | 2 | " | " | " | l | 6.8 | 4.1 | 7.6 | -49.3 | 606 | 112 | .. |
| | 3 | " | " | " | l | 10.5 | 3.8 | 7.5 | -45.9 | 648 | 120 | .. |
| | 4 | " | " | " | h | 9.4 | 6.5 | 19.7 | -43.5 | 300 | 142 | .. |
| | 5 | " | " | " | l | 9.6 | 6.6 | 15.5 | -43.5 | 365 | 113 | .. |
| 11 | 1 | 20.59.42 | M-K | RB | l | -11.7 | 4.6 | 8.5 | -67.5 | 534 | 103 | .. |
| | 2 | " | " | " | l | -10.7 | 4.6 | 10.0 | -66.7 | 532 | 117 | .. |
| | 3 | " | " | " | l | -9.6 | 4.9 | 11.1 | -65.2 | 499 | 119 | .. |
| | 4 | " | " | " | l | -7.1 | 5.8 | 12.5 | -61.7 | 422 | 109 | .. |
| | 5 | " | " | " | l | -2.3 | 6.0 | 13.6 | -56.7 | 410 | 114 | .. |
| | 6 | " | " | " | m | -16.9 | 4.6 | 12.8 | -73.1 | 510 | 139 | .. |
| 25 | 1 | 21.59.55 | M-K | RB | h | 35.9 | 4.6 | 25.3 | -14.3 | 398 | 206 | .. |
| | 2 | " | " | " | m | 37.4 | 4.9 | 17.4 | -15.4 | 390 | 137 | .. |
| | 3 | " | " | " | l | 37.8 | 5.0 | 12.8 | -16.0 | 390 | 101 | .. |
| 26 | 2 | 22.01.44 | M-K | RB | l | 34.3 | 5.8 | 15.3 | -18.5 | 347 | 106 | .. |
| | 3 | " | " | " | l | 29.2 | 6.2 | 14.8 | -23.6 | 345 | 102 | .. |
| | 4 | " | " | " | l | 23.9 | 6.1 | 14.1 | -29.4 | 368 | 105 | .. |
| 27 | 1 | 22.03.32 | M-K | RB | l | 7.9 | 6.3 | 14.1 | -45.7 | 386 | 110 | .. |
| | 2 | " | " | " | l | 10.5 | 6.2 | 14.3 | -43.0 | 391 | 106 | .. |
| 28 | 1 | 22.05.05 | M-K | RB | l | 21.9 | 5.0 | 13.3 | -32.7 | 455 | 126 | .. |
| | 2 | " | " | " | l | 15.7 | 4.9 | 12.4 | -39.2 | 484 | 127 | .. |
| | 3 | " | " | " | h | 21.1 | 4.9 | 18.1 | -32.9 | 453 | 168 | .. |
| 29 | 1 | 2.08.01 | M-K | R | h | -14.4 | 4.1 | 18.2 | -71.4 | 559 | 215 | .. |
| | 2 | " | " | " | m | -15.5 | 4.2 | 14.2 | -72.0 | 557 | 169 | .. |
| | 3 | " | " | " | l' | -16.4 | 4.3 | 10.3 | -72.7 | 554 | 127 | .. |
| | 4 | " | " | " | l | -18.3 | 4.1 | 9.0 | -74.8 | 578 | 119 | .. |
| | 5 | " | " | " | m | 18.1 | 4.1 | 12.1 | -74.7 | 570 | 151 | .. |
| | 6 | " | " | " | h | -20.8 | 4.2 | 15.8 | -77.7 | 535 | 177 | .. |
| | 7 | " | " | " | l | -21.6 | 4.4 | 10.1 | -78.0 | 525 | 117 | .. |
| | 8 | " | " | " | h | -8.8 | 5.2 | 21.4 | -64.5 | 442 | 194 | .. |
| | 9 | " | " | " | l' | -10.1 | 5.2 | 15.4 | -65.6 | 459 | 146 | .. |
| 30 | 1 | 22.09.56 | M-K | RB | h | -30.0 | 3.3 | 16.6 | -88.3 | 624 | 225 | .. |
| | 2 | " | " | " | l | -31.6 | 3.4 | 11.1 | -89.2 | 617 | 154 | .. |
| | 3 | " | " | " | h | -24.0 | 3.7 | 12.8 | -81.1 | 600 | 169 | .. |
| | 4 | " | " | " | l | -25.2 | 4.1 | 8.8 | -81.7 | 552 | 111 | .. |
| | 5 | " | " | " | h | -18.6 | 4.4 | 21.8 | -76.8 | 497 | 225 | .. |
| | 6 | " | " | " | l | -22.3 | 4.8 | 13.6 | -78.4 | 472 | 134 | .. |
| | 7 | " | " | " | l | -20.4 | 4.3 | 9.5 | -76.6 | 542 | 116 | .. |
| | 8 | " | " | " | h | -13.4 | 4.7 | 22.3 | -69.9 | 477 | 220 | .. |
| | 9 | " | " | " | l | -15.8 | 4.9 | 10.7 | -71.3 | 487 | 112 | .. |
| | 10 | " | " | " | h | -7.8 | 5.8 | 26.8 | -72.7 | 380 | 209 | .. |
| | 11 | " | " | " | l | -10.1 | 6.0 | 16.0 | -74.6 | 398 | 129 | .. |
| December 21, 1938 | | | | | | | | | | | | |
| 8 | 1 | 23.08.25 | M-K | R | h | 59.3 | 1.6 | 12.9 | 56.0 | 771 | 233 | .. |
| | 2 | " | " | " | l | 60.3 | 1.9 | 6.9 | 56.7 | 654 | 114 | .. |

Table III (continued).

| N | Point | GMT. | St. | F | P | ϵ_2 | p | h | a | D | H | N' |
|----|-------|----------|-----|----|----|--------------|-----|------|-------|-----|-----|----|
| 8 | 3 | 23.08.25 | M—K | R | l' | 63.3 | 1.7 | 8.0 | 53.5 | 660 | 129 | .. |
| 9 | 1 | 23.10.01 | M—K | R | m | 26.5 | 3.2 | 22.1 | —27.8 | 636 | 303 | .. |
| | 2 | " | " | " | l | 28.0 | 3.6 | 13.9 | —27.6 | 595 | 179 | .. |
| 10 | 1 | 23.23.27 | M—K | RB | h | 57.0 | 2.7 | 13.5 | 56.9 | 494 | 140 | .. |
| | 2 | " | " | " | l | 57.7 | 2.6 | 10.8 | 57.4 | 509 | 119 | .. |
| | 3 | " | " | " | h | 58.1 | 2.2 | 16.0 | 54.8 | 576 | 197 | .. |
| | 4 | " | " | " | m | 59.3 | 2.2 | 11.6 | 55.6 | 572 | 146 | .. |
| | 5 | " | " | " | l | 59.9 | 2.2 | 8.2 | 56.2 | 569 | 109 | .. |
| | 6 | " | " | " | l | 62.7 | 1.8 | 6.7 | 54.2 | 640 | 109 | .. |
| | 7 | " | " | " | l | 63.0 | 2.2 | 7.1 | 53.7 | 633 | 112 | .. |
| 11 | 1 | 23.25.00 | M—K | RB | h | 58.6 | 2.3 | 12.4 | 56.2 | 555 | 149 | .. |
| | 2 | " | " | " | m | 59.0 | 2.3 | 10.5 | 56.6 | 555 | 129 | .. |
| | 3 | " | " | " | m | 60.0 | 2.0 | 8.3 | 56.5 | 623 | 124 | .. |
| | 4 | " | " | " | l | 66.8 | 2.2 | 10.0 | 48.1 | 445 | 95 | .. |
| | 5 | " | " | " | l | 66.8 | 1.8 | 8.1 | 49.4 | 548 | 103 | .. |
| 12 | 1 | 23.27.46 | M—K | RA | l | 73.8 | 1.6 | 13.0 | 23.3 | 429 | 115 | .. |
| | 2 | " | " | " | l | 71.6 | 1.6 | 12.7 | 18.8 | 457 | 121 | .. |
| | 3 | " | " | " | l | 70.2 | 1.9 | 12.5 | 16.8 | 439 | 114 | .. |
| | 4 | " | " | " | l | 67.1 | 2.2 | 12.0 | 12.8 | 437 | 110 | .. |

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| | | | | | | | | | | | | |
|----|----|----------|-----|----|----|-------|------|------|-------|-----|-----|--------|
| 8 | 1 | 22.29.09 | M—S | D | l | — 6.3 | 11.9 | 18.1 | —12.7 | 249 | 87 | 15.1 A |
| | 2 | " | " | " | l | — 8.1 | 11.6 | 19.6 | —11.3 | 251 | 95 | " |
| | 3 | " | " | " | l | — 9.3 | 11.4 | 22.0 | — 9.1 | 250 | 107 | " |
| 10 | 1 | 22.31.25 | M—S | RA | l | — 0.3 | 8.5 | 14.2 | — 6.2 | 356 | 101 | 15.3 A |
| | 2 | " | " | " | l | — 8.8 | 9.7 | 16.5 | —13.7 | 304 | 99 | " |
| | 3 | " | " | " | l | —15.0 | 9.8 | 18.5 | —20.1 | 291 | 105 | " |
| | 4 | " | " | " | l | 4.5 | 7.8 | 12.1 | — 2.0 | 389 | 97 | " |
| | 5 | " | " | " | l | —18.0 | 10.0 | 19.4 | —23.2 | 280 | 106 | " |
| 17 | 1 | 22.46.11 | M—S | RB | m | —70.4 | 2.7 | 17.2 | —90.1 | 367 | 127 | 15.10A |
| | 2 | " | " | " | l | —74.5 | 1.6 | 10.6 | —91.3 | 510 | 118 | " |
| 19 | 1 | 22.51.27 | M—S | RB | h | 11.7 | 6.5 | 18.0 | 4.7 | 443 | 163 | 15.11A |
| | 2 | " | " | " | l' | 12.9 | 6.8 | 11.7 | 5.7 | 437 | 107 | " |
| | 3 | " | " | " | l | 13.5 | 6.8 | 11.0 | 6.2 | 437 | 101 | " |
| 20 | 1 | 22.53.03 | M—S | RB | m | —20.7 | 14.0 | 33.1 | —22.5 | 175 | 119 | 15.12A |
| | 2 | " | " | " | l | —21.5 | 14.2 | 30.1 | —23.0 | 177 | 107 | " |
| | 3 | " | " | " | l | —23.5 | 13.2 | 28.0 | —26.4 | 191 | 107 | " |
| | 4 | " | " | " | h | —25.4 | 13.3 | 30.9 | —28.8 | 182 | 114 | " |
| | 5 | " | " | " | l | —26.2 | 13.5 | 27.4 | —29.0 | 185 | 100 | " |
| | 7 | " | " | " | l | —20.9 | 9.9 | 19.5 | —36.4 | 277 | 106 | " |
| | 8 | " | " | " | l | —32.0 | 10.7 | 22.8 | —37.9 | 229 | 101 | " |
| | 9 | " | " | " | l | —25.4 | 9.0 | 19.7 | —32.2 | 294 | 114 | " |
| | 10 | " | " | " | l | —18.0 | 9.0 | 18.2 | —24.3 | 314 | 112 | " |
| | 11 | " | " | " | l | — 7.4 | 9.0 | 16.3 | —13.1 | 330 | 107 | " |
| | 12 | " | " | " | l | —30.4 | 5.1 | 8.8 | —40.6 | 520 | 103 | " |
| 21 | 1 | 22.54.14 | M—S | D | h' | —18.9 | 10.3 | 39.1 | —25.6 | 219 | 187 | 15.13A |

Table III (continued).

| N | Point | GMT. | St. | F | P | ϵ_2 | p | h | a | D | H | N' |
|----|-------|----------|-----|----|----|--------------|------|------|--------|-----|-----|--------|
| | 2 | 22.54.14 | M-S | D | l' | -21.9 | 12.4 | 36.2 | -25.1 | 210 | 108 | 15.13A |
| | 3 | " | " | " | h | -23.9 | 11.2 | 35.6 | -30.2 | 206 | 154 | " |
| | 4 | " | " | " | l | -26.3 | 12.4 | 26.7 | -30.2 | 202 | 106 | " |
| | 5 | " | " | RB | l | -41.2 | 12.0 | 29.0 | -48.8 | 170 | 102 | " |
| | 6 | " | " | " | l | -43.6 | 12.1 | 32.2 | -52.7 | 158 | 103 | " |
| | 7 | " | " | " | l | -46.9 | 11.5 | 32.9 | -58.1 | 155 | 105 | " |
| | 8 | " | " | " | l | -48.9 | 9.2 | 21.7 | -58.0 | 208 | 87 | " |
| | 9 | " | " | " | l | -43.6 | 9.2 | 20.9 | -51.9 | 230 | 94 | " |
| | 10 | " | " | " | l | -36.8 | 9.4 | 19.3 | -43.9 | 251 | 94 | " |
| 23 | 1 | 22.57.17 | M-S | R | h' | -28.2 | 9.0 | 38.0 | -39.2 | 237 | 196 | 15.15A |
| | 2 | " | " | " | m | -30.4 | 9.9 | 33.1 | -39.4 | 226 | 154 | " |
| | 3 | " | " | " | l | -33.3 | 10.8 | 25.7 | -39.8 | 218 | 110 | " |
| | 4 | " | " | RB | l | -37.7 | 9.7 | 23.2 | -45.4 | 234 | 106 | " |
| | 5 | " | " | " | l | -32.3 | 10.6 | 22.7 | -38.3 | 229 | 101 | " |
| | 6 | " | " | " | l | -25.9 | 10.8 | 21.8 | -30.9 | 241 | 103 | " |
| 24 | 1 | 22.58.39 | M-S | RA | l' | -0.1 | 8.1 | 13.9 | 6.3 | 374 | 105 | 15.16A |
| | 2 | " | " | " | l | 6.4 | 8.6 | 14.3 | 0.8 | 349 | 100 | " |
| 25 | 1 | 23.02.21 | M-S | RA | l | -9.0 | 11.9 | 20.0 | -11.5 | 243 | 94 | 15.17A |
| | 2 | " | " | " | l | -2.0 | 12.1 | 18.9 | -4.0 | 244 | 90 | " |
| | 3 | " | " | " | l | 8.0 | 11.1 | 17.0 | 5.6 | 267 | 89 | " |
| 26 | 1 | 23.03.25 | M-S | RA | l | -6.5 | 15.4 | 35.1 | -3.7 | 166 | 121 | 15.18A |
| | 2 | " | " | " | l | 6.8 | 13.2 | 17.3 | 8.0 | 211 | 114 | " |
| | 3 | " | " | " | l | -7.6 | 10.5 | 19.4 | -1.7 | 279 | 106 | " |
| | 4 | " | " | " | l | -0.2 | 10.2 | 18.1 | -4.0 | 291 | 104 | " |
| 27 | 1 | 23.05.01 | M-S | RA | l | -16.9 | 16.4 | 30.5 | -15.3 | 158 | 97 | 15.19A |
| | 2 | " | " | " | l | -30.0 | 15.3 | 31.4 | -31.9 | 152 | 97 | " |
| | 3 | " | " | " | l | -22.9 | 10.8 | 21.0 | -27.8 | 249 | 102 | " |
| | 4 | " | " | " | l | -25.5 | 10.2 | 22.7 | -31.4 | 255 | 113 | " |
| 29 | 1 | 23.07.34 | M-S | HA | l | 14.0 | 8.7 | 15.2 | 8.9 | 335 | 101 | 15.21A |
| | 2 | " | " | " | l | -6.0 | 12.0 | 18.4 | -8.4 | 246 | 88 | " |
| 31 | 1 | 23.15.40 | M-S | RA | l | -17.6 | 15.1 | 28.5 | -17.9 | 175 | 99 | 15.23A |
| | 2 | " | " | " | l | -27.3 | 12.7 | 26.5 | -31.0 | 196 | 102 | " |
| 35 | 1 | 23.21.39 | M-S | RB | h | -18.9 | 6.2 | 16.1 | -28.0 | 453 | 150 | 15.27A |
| | 2 | " | " | " | l' | -19.5 | 6.1 | 12.3 | -28.5 | 466 | 121 | " |
| 37 | 3 | 23.47.30 | M-S | R | l | -57.2 | 5.4 | 19.0 | -138.7 | 295 | 110 | 15.29A |
| | 4 | " | " | " | h' | -55.2 | 5.5 | 25.0 | -137.6 | 291 | 145 | " |
| | 5 | " | " | " | l | -64.2 | 4.9 | 21.5 | -127.4 | 257 | 109 | " |
| | 6 | " | " | " | h' | -61.5 | 5.2 | 26.6 | -126.4 | 253 | 134 | " |
| 38 | 1 | 23.49.15 | M-S | R | m | -52.4 | 5.9 | 32.9 | -135.5 | 266 | 182 | 15.30A |
| | 2 | " | " | " | m | -56.5 | 5.8 | 24.0 | -137.1 | 269 | 127 | " |
| | 3 | " | " | " | l' | -58.7 | 5.8 | 17.5 | -138.2 | 236 | 90 | " |
| | 4 | " | " | " | h' | -48.2 | 5.9 | 39.5 | -134.0 | 263 | 233 | " |
| 39 | 1 | 23.50.28 | M-S | RB | h' | -63.6 | 2.8 | 18.3 | -128.1 | 463 | 174 | 15.31A |
| | 2 | " | " | " | m | -65.7 | 2.5 | 12.2 | -128.8 | 498 | 129 | " |
| | 3 | " | " | " | l' | -67.4 | 2.0 | 8.5 | -127.8 | 588 | 116 | " |
| | 4 | " | " | " | l' | -69.2 | 2.4 | 12.1 | -124.7 | 448 | 113 | " |
| | 5 | " | " | " | l | -70.6 | 2.1 | 11.4 | -123.3 | 480 | 116 | " |

Table III (continued).

| N | Point | GMT | St. | F | P | ε_2 | p | h | a | D | H | N' |
|------------------|-------|----------|-----|----|----|-----------------|-----|------|--------|-----|-----|--------|
| 39 | 6 | 23.50.28 | M-S | RB | l | -74.0 | 2.1 | 13.6 | -117.2 | 396 | 110 | 15.31A |
| | 7 | " | " | " | l | -74.9 | 2.2 | 15.5 | -113.2 | 354 | 110 | " |
| | 8 | " | " | " | l | -74.7 | 2.5 | 18.0 | -107.4 | 312 | 111 | " |
| | 9 | " | " | " | l | -76.5 | 1.9 | 12.2 | -114.3 | 374 | 93 | " |
| 41 | 1 | 23.57.18 | M-S | R | m | -54.3 | 3.6 | 22.3 | -138.2 | 458 | 211 | 15.33A |
| | 2 | " | " | " | l | -56.7 | 4.0 | 11.1 | -139.5 | 420 | 97 | " |
| | 3 | " | " | " | m | -59.6 | 2.4 | 17.1 | -133.3 | 613 | 226 | " |
| | 4 | " | " | " | l' | -61.3 | 2.1 | 7.8 | -134.7 | 699 | 138 | " |
| 42 ¹⁾ | 1 | 00.00.24 | M-S | R | h | -53.3 | 4.0 | 28.9 | -135.3 | 397 | 239 | 15.34A |
| | 2 | " | " | " | m | -56.1 | 3.9 | 22.1 | -136.6 | 407 | 182 | " |
| | 3 | " | " | " | l' | -57.6 | 3.8 | 17.1 | -137.5 | 416 | 144 | " |
| | 4 | " | " | " | l | -64.9 | 3.1 | 13.6 | -129.7 | 413 | 114 | " |

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| | | | | | | | | | | | | |
|----|---|----------|-----|----|----|-------|-----|------|-------|-----|-----|-------|
| 7 | 1 | 22.10.13 | M-S | R | l | -66.3 | 4.1 | 18.9 | -83.6 | 280 | 105 | 16.11 |
| 8 | 2 | 22.11.50 | M-S | RB | l | -43.0 | 7.3 | 15.6 | -51.9 | 300 | 92 | 16.12 |
| 9 | 1 | 22.13.08 | M-S | RB | l | 2.0 | 6.5 | 9.7 | -6.2 | 471 | 99 | 16.13 |
| | 2 | " | " | " | l | 2.8 | 6.5 | 9.4 | -5.5 | 472 | 97 | " |
| | 3 | " | " | " | l' | -8.5 | 5.8 | 9.1 | -17.4 | 522 | 107 | " |
| 11 | 1 | 22.15.28 | M-S | RB | l | -2.7 | 5.6 | 7.9 | -11.8 | 551 | 101 | 16.16 |
| | 2 | " | " | " | l | 6.9 | 5.7 | 7.6 | -2.0 | 530 | 94 | " |
| | 3 | " | " | " | R | 16.3 | 5.3 | 8.4 | -7.2 | 540 | 104 | " |
| 12 | 1 | 22.16.32 | M-S | RB | l' | 11.2 | 5.3 | 10.0 | -2.1 | 563 | 126 | 16.17 |
| | 2 | " | " | " | l | 10.6 | 5.4 | 8.3 | -1.6 | 559 | 108 | " |
| | 3 | " | " | " | l | 9.4 | 5.6 | 8.1 | -0.5 | 543 | 102 | " |
| | 4 | " | " | " | l | -7.6 | 7.4 | 11.2 | -14.9 | 410 | 95 | " |
| | 5 | " | " | " | l | 12.9 | 4.9 | 7.1 | -1.6 | 613 | 109 | " |
| 15 | 1 | 22.20.01 | M-S | R | l | -1.5 | 8.4 | 16.4 | -7.6 | 354 | 116 | 16.20 |
| | 2 | " | " | " | m | -2.0 | 7.8 | 24.4 | -8.4 | 360 | 178 | " |
| | 3 | " | " | " | l | -6.0 | 8.3 | 16.1 | -12.4 | 358 | 116 | " |
| | 4 | " | " | " | m | -6.1 | 7.9 | 21.5 | -12.8 | 362 | 156 | " |
| | 5 | " | " | " | l | -6.6 | 8.1 | 16.1 | -13.2 | 366 | 119 | " |
| 17 | 1 | 22.22.24 | M-S | R | l | -40.4 | 6.7 | 16.3 | -49.7 | 369 | 121 | 16.21 |
| | 2 | " | " | " | h' | -36.5 | 6.1 | 27.2 | -49.3 | 384 | 216 | " |
| 19 | 1 | 22.26.18 | M-S | RB | l' | -15.2 | 6.7 | 13.2 | -23.5 | 485 | 119 | 16.23 |
| 22 | 1 | 22.29.36 | M-S | RA | l | 24.0 | 4.9 | 7.6 | 8.5 | 574 | 104 | 16.25 |
| 23 | 1 | 22.31.17 | M-S | RB | l | 3.2 | 4.5 | 5.7 | -7.0 | 685 | 108 | 16.26 |
| | 2 | " | " | " | l | 18.9 | 4.8 | 6.9 | 9.2 | 607 | 106 | " |
| 26 | 1 | 22.37.25 | M-S | RA | l | 11.1 | 5.2 | 6.1 | 1.7 | 584 | 90 | 16.29 |
| | 2 | " | " | " | R | 0.2 | 6.3 | 11.4 | -8.1 | 482 | 117 | " |
| 29 | 1 | 22.46.27 | M-S | RA | l | 11.4 | 4.7 | 7.0 | 1.5 | 642 | 115 | 16.32 |
| 37 | 1 | 23.17.15 | M-S | RA | l | -53.0 | 3.4 | 9.7 | -65.4 | 539 | 118 | 16.39 |
| 38 | 1 | 23.21.43 | M-S | RB | l | -62.0 | 2.6 | 9.5 | -75.4 | 551 | 118 | 17.1 |
| | 2 | " | " | " | l | -66.3 | 2.5 | 9.9 | -80.4 | 490 | 107 | " |
| 39 | 1 | 23.23.55 | M-S | R | l | -74.7 | 1.5 | 8.7 | -88.3 | 537 | 117 | 17.2 |
| 40 | 1 | 23.27.00 | M-S | R | l' | -28.5 | 5.0 | 11.7 | -38.8 | 531 | 135 | 17.3 |
| | 2 | " | " | " | l | -28.9 | 5.2 | 10.3 | -38.9 | 514 | 117 | " |

¹⁾ Betongs to January 10.

Table III (continued).

| N | Point | GMT | St. | F | P | ϵ_2 | p | h | a | D | H | N' |
|------------------|-------|----------|-----|----|----|--------------|------|------|--------|-----|-----|-------|
| 41 | 1 | 23.55.04 | M-S | D | l | -23.8 | 10.2 | 22.9 | - 29.5 | 257 | 116 | 17.4 |
| | 2 | " | " | " | l | -17.1 | 9.6 | 20.4 | - 22.7 | 290 | 117 | " |
| 42 | 1 | 23.56.02 | M-S | DS | l | -38.5 | 9.5 | 27.7 | - 48.0 | 227 | 125 | 17.5 |
| | 2 | " | " | " | l | -42.5 | 8.9 | 23.3 | - 51.8 | 236 | 108 | " |
| | 3 | " | " | " | l | -47.0 | 7.2 | 23.1 | - 58.8 | 271 | 123 | " |
| 43 | 1 | 23.59.00 | M-S | RB | m | - 2.1 | 9.4 | 27.3 | - 6.5 | 291 | 160 | 17.6 |
| | 2 | " | " | " | l | - 1.9 | 10.4 | 19.4 | - 5.7 | 283 | 107 | " |
| | 3 | " | " | " | l | -10.2 | 10.1 | 20.0 | - 14.9 | 285 | 112 | " |
| | 4 | " | " | " | l | -15.1 | 11.5 | 23.0 | - 18.7 | 241 | 109 | " |
| January 15, 1939 | | | | | | | | | | | | |
| 45 | 1 | 00.00.32 | M-S | R | l | 1.2 | 7.3 | 13.6 | - 6.1 | 413 | 115 | 17.8 |
| | 2 | " | " | " | m | 1.5 | 6.7 | 20.3 | - 6.0 | 429 | 179 | " |
| | 3 | " | " | RB | l | - 4.6 | 7.2 | 14.0 | - 12.1 | 223 | 119 | " |
| | 4 | " | " | R | l | -16.5 | 9.5 | 23.4 | - 22.4 | 287 | 133 | " |
| | 5 | " | " | " | m | 1.0 | 6.1 | 28.2 | - 6.5 | 437 | 261 | " |
| 46 | 1 | 00.01.33 | " | D | l | -58.1 | 6.6 | 22.7 | - 72.8 | 230 | 102 | " |
| | 2 | " | " | " | m | -54.6 | 6.5 | 28.1 | - 72.1 | 235 | 132 | " |
| | 3 | " | " | " | m | -52.0 | 6.6 | 32.0 | - 71.5 | 244 | 160 | " |
| | 4 | " | " | " | l | -59.1 | 6.3 | 22.1 | - 74.0 | 234 | 101 | " |
| | 5 | " | " | " | l | -60.8 | 5.5 | 20.9 | - 76.3 | 257 | 105 | " |
| | 6 | " | " | " | m | -57.7 | 5.8 | 25.9 | - 75.5 | 255 | 131 | " |
| | 7 | " | " | " | m | -53.7 | 6.1 | 31.6 | - 74.5 | 254 | 165 | " |
| | 8 | " | " | " | l | -64.3 | 4.6 | 18.7 | - 80.5 | 278 | 101 | " |
| | 9 | " | " | " | m | -61.9 | 5.0 | 22.7 | - 79.9 | 269 | 119 | " |
| | 10 | " | " | " | l | -65.0 | 4.5 | 18.3 | - 81.2 | 277 | 99 | " |
| | 11 | " | " | " | m | -62.4 | 4.8 | 22.3 | - 80.5 | 277 | 121 | " |
| 47 | 1 | 00.02.54 | M-S | R | h | -47.1 | 5.9 | 35.7 | - 68.6 | 285 | 212 | 17.10 |
| | 2 | " | " | " | l | -53.4 | 6.0 | 26.3 | - 69.8 | 274 | 144 | " |
| | 3 | " | " | RA | h | -54.8 | 6.0 | 23.2 | - 69.7 | 273 | 124 | " |
| | 4 | " | " | " | l' | -56.2 | 5.8 | 20.2 | - 69.9 | 270 | 107 | " |
| | 5 | " | " | " | h | -44.5 | 7.8 | 27.2 | - 56.8 | 251 | 136 | " |
| | 6 | " | " | " | l' | -46.0 | 7.9 | 23.7 | - 57.0 | 249 | 116 | " |
| | 7 | " | " | " | l | -38.0 | 10.0 | 23.2 | - 45.5 | 225 | 102 | " |
| 48 | 1 | 00.03.38 | M-S | RB | l | -25.8 | 10.5 | 19.8 | - 31.1 | 252 | 96 | 17.11 |
| | 2 | " | " | " | l | -21.0 | 9.5 | 18.7 | - 26.8 | 291 | 106 | " |
| | 3 | " | " | " | l | -17.5 | 8.8 | 17.1 | - 23.8 | 321 | 109 | " |
| | 4 | " | " | " | l' | -16.1 | 8.5 | 17.5 | - 22.7 | 334 | 116 | " |
| | 5 | " | " | " | m | -15.6 | 8.4 | 21.2 | - 22.5 | 330 | 139 | " |
| | 6 | " | " | R | l | -13.2 | 8.4 | 16.0 | - 19.8 | 348 | 111 | " |
| | 7 | " | " | " | m | -12.6 | 7.8 | 21.9 | - 19.9 | 358 | 157 | " |
| | 8 | " | " | " | l | - 5.4 | 7.8 | 13.8 | - 12.5 | 395 | 111 | " |
| | 9 | " | " | " | l | 1.9 | 7.0 | 12.0 | - 5.7 | 434 | 109 | " |
| | 10 | " | " | " | h | 1.5 | 6.5 | 19.1 | - 6.3 | 446 | 175 | " |
| | 11 | " | " | RB | m | -17.3 | 6.1 | 14.2 | - 26.4 | 469 | 139 | " |
| 49 | 1 | 00.05.50 | M-S | DS | l | 33.6 | 8.0 | 15.2 | - 42.5 | 313 | 94 | 17.12 |
| 51 | 1 | 00.07.36 | M-S | RA | m | - 8.7 | 6.6 | 11.2 | - 17.0 | 457 | 109 | 17.14 |

Table III (continued).

| N | Point | GMT | St. | F | P | ε_2 | p | h | a | D | H | N' |
|--------------------|-------|----------|-----|----|----|-----------------|------|------|--------|-----|-----|-------|
| 53 | 1 | 00.09.19 | M-S | RA | h | 1.9 | 6.8 | 25.2 | - 5.1 | 407 | 211 | 17.16 |
| | 2 | " | " | " | l' | 2.5 | 7.5 | 18.0 | - 4.3 | 391 | 142 | " |
| 55 | 1 | 00.12.42 | M-S | RA | l | -52.3 | 4.1 | 9.8 | - 64.0 | 457 | 97 | 17.18 |
| | 2 | " | " | " | l | -55.0 | 3.4 | 8.6 | - 67.3 | 517 | 100 | " |
| 56 | 1 | 00.13.37 | M-S | RA | l | -59.9 | 2.1 | 5.7 | - 73.1 | 735 | 120 | 17.19 |
| February 17, 1939. | | | | | | | | | | | | |
| 2 | 1 | 21.19.44 | M-K | R | h | 48.9 | 3.8 | 24.8 | 1.1 | 392 | 198 | .. |
| | 2 | " | " | " | l | 54.9 | 3.6 | 15.5 | 2.1 | 389 | 121 | .. |
| 5 | 6 | 21.23.29 | M-S | RB | l | -46.9 | 4.7 | 10.9 | - 57.8 | 443 | 102 | 21.27 |
| 5 | 1 | " | M-K | R | m | - 1.4 | 6.1 | 30.5 | - 55.1 | 350 | 223 | .. |
| | 2 | " | " | " | l | - 3.0 | 7.2 | 17.5 | - 55.8 | 335 | 116 | .. |
| | 3 | " | " | " | m | - 8.6 | 5.6 | 18.6 | - 63.4 | 420 | 158 | .. |
| | 4 | " | " | " | l | - 9.3 | 5.6 | 15.0 | - 64.0 | 429 | 131 | .. |
| | 5 | " | " | RB | l | - 6.0 | 5.9 | 12.5 | - 60.3 | 417 | 107 | .. |
| | 6 | " | " | " | l | - 3.1 | 5.5 | 10.9 | - 57.8 | 451 | 104 | .. |
| | 7 | " | " | " | l' | -18.4 | 4.4 | 8.6 | - 74.4 | 540 | 105 | .. |
| 6 | 1 | 21.25.02 | M-K | RB | h' | -12.5 | 4.5 | 20.3 | - 68.9 | 507 | 214 | .. |
| | 2 | " | " | " | m | -13.7 | 4.8 | 14.5 | - 69.6 | 493 | 149 | .. |
| | 3 | " | " | " | l' | -14.2 | 5.0 | 10.7 | - 69.8 | 481 | 110 | .. |
| | 4 | " | " | R | l | -16.7 | 5.6 | 17.1 | - 72.0 | 411 | 142 | .. |
| | 5 | " | " | RB | l | -17.7 | 5.8 | 12.5 | - 72.6 | 407 | 104 | .. |
| | 6 | " | " | " | m | -11.3 | 4.8 | 10.7 | - 67.1 | 507 | 117 | .. |
| | 7 | " | " | R | m | -22.3 | 8.2 | 21.9 | - 65.5 | 264 | 114 | .. |
| | 8 | " | " | " | l | -21.9 | 7.8 | 18.9 | - 65.3 | 285 | 106 | .. |
| | 9 | " | " | R | h | - 8.7 | 7.5 | 32.4 | - 61.6 | 270 | 188 | .. |
| | 10 | " | " | " | l | - 9.9 | 7.9 | 27.5 | - 62.6 | 270 | 154 | .. |
| 7 | 1 | 21.26.50 | M-K | D | m | 25.0 | 11.6 | 42.0 | - 6.9 | 131 | 120 | .. |
| | 2 | " | " | " | m | 20.6 | 10.1 | 49.6 | - 8.0 | 139 | 169 | .. |
| | 3 | " | " | " | l' | 23.8 | 12.3 | 39.9 | - 10.2 | 129 | 111 | .. |
| | 4 | " | " | " | h | 14.0 | 8.5 | 57.8 | - 14.1 | 144 | 238 | .. |
| | 5 | " | " | " | m | 16.1 | 11.6 | 41.6 | - 21.7 | 145 | 132 | .. |
| | 6 | " | " | " | h | 10.0 | 7.5 | 59.1 | - 23.6 | 161 | 282 | .. |
| 8 | 1 | 21.28.19 | M-K | D | h' | 10.6 | 12.5 | 40.0 | - 29.5 | 152 | 132 | .. |
| | 2 | " | " | " | l | 10.7 | 13.7 | 35.3 | - 30.0 | 149 | 109 | .. |
| | 3 | " | " | " | m | 15.2 | 12.4 | 39.8 | - 23.3 | 152 | 130 | .. |
| | 4 | " | " | " | l | 16.1 | 13.5 | 35.3 | - 23.1 | 148 | 108 | .. |
| 9 | 1 | 21.29.20 | M-K | R | m | 64.4 | 2.6 | 22.0 | 35.3 | 386 | 171 | .. |
| | 2 | " | " | " | m | 69.5 | 2.0 | 16.9 | 36.3 | 431 | 145 | .. |
| | 3 | " | " | " | l | 73.0 | 1.5 | 13.1 | 37.2 | 477 | 131 | .. |
| | 5 | " | " | D | l | 71.9 | 2.0 | 14.9 | 24.0 | 379 | 113 | .. |
| | 6 | " | " | " | l | 70.3 | 2.1 | 15.3 | 21.1 | 390 | 121 | .. |
| | 7 | " | " | " | l | 67.9 | 2.5 | 15.3 | 17.2 | 366 | 112 | .. |
| 10 | 1 | 21.30.57 | K-M | R | h | -67.7 | 2.6 | 22.2 | 16.7 | 339 | 150 | .. |
| | 4 | " | " | " | h | -58.2 | 6.9 | 38.4 | 35.5 | 150 | 123 | .. |
| | 5 | " | " | " | l | -64.1 | 5.8 | 31.0 | 36.9 | 163 | 101 | .. |
| 11 | 2 | 21.31.56 | M-K | RB | l | -21.6 | 13.9 | 36.5 | - 69.9 | 137 | 104 | .. |

Table III (continued).

| N | Point | GMT. | St. | F | P | ϵ_2 | p | h | a | D | H | N' |
|----|-------|----------|-----|----|----|--------------|------|------|--------|-----|-----|-------|
| 11 | 3 | 21.31.56 | M-K | R | l | -27.5 | 12.1 | 32.1 | - 78.5 | 158 | 102 | .. |
| 11 | 1 | " | K-S | RB | l | -60.1 | 3.9 | 21.9 | - 78.8 | 265 | 112 | 21.21 |
| | 2 | " | " | " | l | -55.2 | 4.4 | 20.6 | - 86.4 | 275 | 108 | " |
| | 3 | " | " | " | l | -50.2 | 4.6 | 19.1 | - 93.2 | 294 | 110 | " |
| | 4 | " | " | " | l | -46.3 | 4.7 | 17.5 | - 98.2 | 314 | 109 | " |
| 12 | 1 | 21.32.59 | K-M | RB | m | 36.4 | 7.9 | 32.1 | -117.2 | 218 | 143 | .. |
| | 2 | " | " | " | l | 41.9 | 7.8 | 24.6 | -118.6 | 220 | 105 | .. |
| | 3 | " | " | " | h' | 41.5 | 6.0 | 23.4 | -115.1 | 289 | 134 | .. |
| | 4 | " | " | " | l | 44.9 | 5.7 | 17.9 | -115.8 | 299 | 104 | .. |
| | 5 | " | " | " | l | 45.5 | 4.9 | 15.0 | -114.4 | 349 | 104 | .. |
| | 6 | " | " | " | l | 56.1 | 3.9 | 14.8 | -125.1 | 350 | 103 | .. |
| | 7 | " | " | " | l | 54.4 | 3.3 | 11.5 | -121.0 | 437 | 105 | .. |
| | 8 | " | " | " | l | 49.8 | 3.1 | 9.6 | -115.4 | 519 | 110 | .. |
| | 9 | " | " | " | m | 42.0 | 3.3 | 12.6 | -108.2 | 553 | 150 | .. |
| | 10 | " | " | " | l' | 43.4 | 3.3 | 9.0 | -108.9 | 550 | 112 | .. |
| | 11 | " | " | " | h | 48.9 | 5.6 | 21.3 | -122.5 | 276 | 115 | .. |
| | 12 | " | " | " | l | 51.0 | 5.5 | 18.3 | -123.0 | 275 | 99 | .. |
| | 13 | " | " | " | h | 47.7 | 5.0 | 19.2 | -118.9 | 320 | 122 | .. |
| | 14 | " | " | " | l | 49.4 | 4.9 | 16.4 | -119.3 | 322 | 104 | .. |
| 13 | 1 | 21.34.51 | M-K | RA | l | 28.6 | 16.1 | 38.9 | 4.8 | 110 | 91 | .. |
| | 2 | " | " | " | l | 31.4 | 15.1 | 38.3 | 7.5 | 114 | 93 | .. |
| | 3 | " | " | " | l | 34.7 | 14.1 | 37.3 | 11.2 | 119 | 94 | .. |
| | 4 | " | " | " | l | 37.9 | 13.1 | 36.2 | 14.7 | 124 | 94 | .. |
| | 5 | " | " | " | l | 41.3 | 12.1 | 34.7 | 17.9 | 130 | 93 | .. |
| | 6 | " | " | " | l | 46.0 | 10.3 | 32.4 | 21.0 | 145 | 95 | .. |
| | 7 | " | " | " | l | 48.3 | 9.3 | 31.4 | 23.3 | 155 | 98 | .. |
| 14 | 1 | 21.35.38 | K-S | HA | l | -49.7 | 10.0 | 48.5 | - 36.5 | 98 | 110 | 21.18 |
| | 2 | " | " | " | l | -48.0 | 10.9 | 48.0 | - 36.2 | 95 | 106 | " |
| | 3 | " | " | " | l | -45.5 | 11.4 | 47.4 | - 17.8 | 96 | 105 | " |
| | 4 | " | " | " | l | -41.9 | 11.9 | 46.3 | - 8.3 | 98 | 105 | " |
| 15 | 2 | 21.36.29 | M-K | HA | l | - 7.4 | 12.5 | 30.3 | - 54.1 | 174 | 106 | .. |
| | 3 | " | " | " | l | -15.2 | 11.3 | 27.4 | - 64.5 | 193 | 104 | .. |
| | 4 | " | " | " | l | -23.5 | 9.2 | 23.5 | - 76.0 | 232 | 117 | .. |
| | 6 | " | " | " | l | - 8.6 | 13.0 | 34.3 | - 53.6 | 160 | 113 | .. |
| | 7 | " | " | " | l | -17.6 | 12.1 | 30.3 | - 66.5 | 173 | 105 | .. |
| | 8 | " | " | " | l | -26.0 | 10.0 | 25.3 | - 78.0 | 207 | 103 | .. |
| | 9 | " | " | R | m | -21.7 | 11.2 | 42.5 | - 74.5 | 155 | 147 | .. |
| | 10 | " | " | " | l' | -26.1 | 11.0 | 36.0 | - 79.0 | 108 | 127 | .. |
| 16 | 1 | 21.37.16 | M-K | HA | l | 29.2 | 11.1 | 32.0 | - 10.0 | 170 | 110 | .. |
| | 2 | " | " | " | l | 19.2 | 12.4 | 32.6 | - 21.7 | 164 | 109 | .. |
| | 3 | " | " | " | l | 8.5 | 12.7 | 31.8 | - 35.0 | 168 | 109 | .. |
| | 4 | " | " | " | l | 29.1 | 12.5 | 35.0 | - 5.7 | 146 | 106 | .. |
| | 5 | " | " | " | l | 21.8 | 13.7 | 35.3 | - 14.9 | 141 | 103 | .. |
| | 6 | " | " | " | l | 13.2 | 14.5 | 35.0 | - 25.8 | 140 | 102 | .. |
| | 7 | " | " | " | l | 5.7 | 14.0 | 33.9 | - 36.2 | 151 | 105 | .. |
| 16 | 1 | " | K-S | HA | l | -46.6 | 9.9 | 45.4 | - 17.2 | 109 | 112 | 21.1 |
| | 2 | " | " | " | l | -51.8 | 8.9 | 42.4 | - 29.0 | 117 | 108 | " |

Table III (continued).

| N | Point | GMT | St. | F | P | ε_2 | p | h | a | D | H | N' |
|----|-------|----------|-----|----|----|-----------------|------|------|--------|-----|-----|-------|
| 16 | 3 | 21.37.16 | K-S | HA | l | -55.0 | 7.8 | 41.2 | - 28.5 | 125 | 111 | 21.16 |
| 17 | 1 | 21.38.15 | M-K | RB | l | 45.8 | 9.3 | 32.5 | 16.6 | 161 | 106 | .. |
| | 2 | " | " | " | l | 47.8 | 9.1 | 32.1 | 22.4 | 159 | 104 | .. |
| | 3 | " | " | " | l | 54.9 | 7.1 | 27.2 | 23.7 | 182 | 98 | .. |
| | 4 | " | " | " | l | 57.4 | 6.1 | 26.3 | 28.0 | 201 | 104 | .. |
| | 5 | " | " | " | l | 61.7 | 4.9 | 25.1 | 32.4 | 221 | 109 | .. |
| | 6 | " | " | " | l | 62.1 | 4.4 | 21.5 | 39.0 | 250 | 105 | .. |
| | 7 | " | " | " | l | 59.3 | 4.6 | 20.1 | 46.5 | 263 | 104 | .. |
| | 8 | " | " | " | m | 63.3 | 3.1 | 20.7 | 40.9 | 340 | 141 | .. |
| | 9 | " | " | " | l | 66.2 | 2.9 | 17.5 | 41.1 | 335 | 117 | .. |
| | 10 | " | " | " | h' | 38.0 | 10.0 | 40.9 | 38.9 | 150 | 135 | .. |
| | 11 | " | " | " | l | 44.0 | 9.5 | 35.0 | 40.1 | 158 | 114 | .. |
| | 12 | " | " | " | h | 48.6 | 6.9 | 32.1 | 42.5 | 205 | 135 | .. |
| | 13 | " | " | " | l | 52.8 | 7.0 | 27.1 | 43.1 | 195 | 105 | .. |
| 19 | 1 | 21.46.01 | K-M | D | m | 24.4 | 13.6 | 48.8 | -131.4 | 113 | 130 | .. |
| | 2 | " | " | " | l | 32.5 | 14.7 | 39.5 | -134.0 | 113 | 96 | .. |
| | 3 | " | " | " | m | 27.5 | 10.5 | 46.9 | -126.2 | 146 | 160 | .. |
| | 4 | " | " | " | l | 37.9 | 12.3 | 34.0 | -129.4 | 136 | 94 | .. |
| | 5 | " | " | " | m | 23.2 | 12.3 | 47.6 | -121.3 | 138 | 143 | .. |
| | 6 | " | " | " | m | 30.0 | 13.3 | 39.2 | -123.7 | 129 | 108 | .. |
| 20 | 2 | 21.46.56 | M-K | RB | l | 3.8 | 11.6 | 27.3 | - 42.9 | 195 | 104 | .. |
| | 3 | " | " | " | l | - 1.3 | 10.0 | 22.1 | - 50.8 | 235 | 101 | .. |
| | 4 | " | " | " | l | - 4.6 | 8.3 | 18.3 | - 56.4 | 289 | 103 | .. |
| | 5 | " | " | " | l | - 9.6 | 8.3 | 18.4 | - 61.6 | 285 | 103 | .. |
| | 6 | " | " | " | l | -12.4 | 7.6 | 15.8 | - 65.2 | 315 | 98 | .. |
| | 7 | " | " | " | l | -15.4 | 6.8 | 14.2 | - 69.1 | 348 | 99 | .. |
| | 8 | " | " | " | l | 2.4 | 15.5 | 35.4 | - 38.2 | 134 | 98 | .. |
| | 9 | " | " | " | l | - 2.0 | 12.3 | 27.9 | - 48.6 | 182 | 100 | .. |
| | 10 | " | " | " | l | - 6.9 | 9.0 | 18.3 | - 58.0 | 265 | 94 | .. |
| 21 | 1 | 21.51.32 | M-K | RB | h | 33.7 | 10.8 | 30.9 | - 5.3 | 168 | 104 | .. |
| | 2 | " | " | " | h | 31.3 | 10.1 | 27.7 | - 11.9 | 190 | 104 | .. |
| | 3 | " | " | " | h | 31.9 | 6.2 | 21.3 | - 18.9 | 321 | 136 | .. |
| | 4 | " | " | " | m | 33.7 | 5.8 | 18.5 | - 18.1 | 342 | 126 | .. |
| | 5 | " | " | " | h | 26.5 | 7.0 | 20.2 | - 24.3 | 303 | 121 | .. |
| | 6 | " | " | " | m | 27.7 | 6.5 | 17.5 | - 24.2 | 328 | 114 | .. |
| | 7 | " | " | " | l | 30.9 | 5.6 | 16.2 | - 22.1 | 372 | 121 | .. |
| | 8 | " | " | " | l | 29.1 | 5.2 | 14.3 | - 24.8 | 411 | 120 | .. |
| 22 | 1 | 21.52.32 | K-M | HB | l | -38.3 | 9.6 | 34.1 | - 25.9 | 171 | 120 | .. |
| | 2 | " | " | " | m | -39.5 | 9.0 | 40.3 | - 19.8 | 165 | 145 | .. |
| | 3 | " | " | " | m | -43.5 | 9.0 | 34.1 | - 18.5 | 169 | 119 | .. |
| 24 | 1 | 21.54.17 | M-K | RB | l | 53.7 | 4.5 | 18.1 | 3.1 | 315 | 112 | .. |
| | 2 | .. | .. | " | l | 60.7 | 3.8 | 18.3 | 11.9 | 308 | 111 | .. |
| | 3 | .. | .. | " | m | 66.4 | 1.5 | 13.1 | 17.0 | 628 | 245 | .. |
| | 4 | .. | .. | " | m | 70.0 | 1.3 | 14.1 | 17.5 | 636 | 197 | .. |
| | 5 | .. | .. | " | m | 66.9 | 1.5 | 18.6 | 18.7 | 613 | 245 | .. |
| | 6 | .. | .. | " | m | 70.0 | 1.3 | 15.3 | 19.2 | 631 | 211 | .. |
| | 7 | .. | .. | " | l | 70.1 | 2.6 | 14.9 | 21.0 | 320 | 95 | .. |

Table III (continued).

| N | Point | GMT | St. | F | P | ϵ_2 | p | h | a | D | H | N' |
|----|-------|----------|-----|----|----|--------------|------|------|-------|-----|-----|-------|
| 24 | 8 | 21.54.17 | M-K | RB | l | 69.6 | 2.8 | 16.4 | 23.7 | 302 | 98 | .. |
| 25 | 1 | 21.56.39 | M-S | RB | l | 34.5 | 6.3 | 13.6 | 27.7 | 395 | 110 | 21.10 |
| | 2 | " | " | " | m | 34.1 | 7.0 | 15.1 | 28.3 | 355 | 108 | " |
| | 3 | " | " | " | m | 33.3 | 7.1 | 16.7 | 28.0 | 351 | 117 | " |
| | 4 | " | " | " | l | 32.6 | 8.6 | 19.4 | 29.7 | 288 | 109 | " |
| | 5 | " | " | " | l | 31.9 | 10.2 | 21.9 | 31.8 | 241 | 103 | " |
| | 6 | " | " | " | l | 34.0 | 10.9 | 23.5 | 35.7 | 218 | 100 | " |
| | 7 | " | " | " | l | 36.8 | 11.5 | 23.4 | 39.9 | 200 | 90 | " |
| | 8 | " | " | " | m | 42.2 | 7.1 | 20.2 | 39.4 | 304 | 121 | " |
| | 9 | " | " | " | l | 43.4 | 6.9 | 18.3 | 39.5 | 311 | 112 | " |
| | 10 | " | " | " | m | 35.7 | 6.4 | 16.3 | 29.7 | 378 | 124 | " |
| 31 | 3 | 22.02.33 | M-K | RB | l | -17.1 | 8.6 | 21.1 | -69.4 | 263 | 108 | .. |
| | 4 | " | " | R | h' | 1.0 | 9.6 | 31.7 | -47.7 | 223 | 145 | .. |
| | 5 | " | " | " | l | 0.7 | 11.4 | 26.9 | -47.8 | 199 | 105 | .. |
| | 6 | " | " | " | h | -4.3 | 10.3 | 34.2 | -53.1 | 203 | 143 | .. |
| | 7 | " | " | " | l' | -4.8 | 10.8 | 30.2 | -53.3 | 202 | 123 | .. |
| 32 | 2 | 22.03.13 | M-K | HA | l | 47.9 | 5.9 | 21.3 | -0.2 | 268 | 112 | .. |
| | 3 | " | " | " | l | 40.4 | 6.8 | 21.1 | -8.4 | 265 | 109 | .. |
| | 4 | " | " | " | l | 33.7 | 7.5 | 20.9 | -15.5 | 262 | 107 | .. |
| 33 | 1 | 22.04.02 | M-K | HA | l | 62.9 | 4.1 | 22.7 | 26.1 | 258 | 115 | .. |
| | 2 | " | " | " | l | 65.5 | 3.6 | 21.7 | 32.8 | 271 | 111 | .. |
| | 3 | " | " | " | l | 66.0 | 3.3 | 18.7 | 38.5 | 295 | 108 | .. |
| | 4 | " | " | R | l | 62.0 | 4.8 | 22.6 | 34.4 | 229 | 101 | .. |
| 34 | 1 | 22.04.48 | M-K | RA | l | 46.0 | 7.8 | 26.6 | 3.1 | 201 | 105 | .. |
| | 2 | " | " | " | l | 43.3 | 8.0 | 26.6 | -0.1 | 206 | 108 | .. |
| | 3 | " | " | " | l | 39.0 | 8.5 | 27.8 | -4.0 | 205 | 113 | .. |
| | 4 | " | " | " | l | 38.1 | 8.1 | 26.7 | -6.7 | 220 | 116 | .. |
| | 5 | " | " | " | l | 34.1 | 8.5 | 27.6 | -9.6 | 217 | 119 | .. |
| | 6 | " | " | " | l | 34.5 | 8.1 | 25.1 | -12.1 | 233 | 116 | .. |
| | 7 | " | " | " | l | 31.0 | 8.4 | 25.8 | -15.6 | 233 | 118 | .. |
| | 8 | " | " | " | l | 30.7 | 8.2 | 23.0 | -17.7 | 245 | 110 | .. |
| 35 | 1 | 22.05.47 | M-K | RB | l | 12.7 | 7.7 | 17.1 | -39.3 | 307 | 103 | .. |
| | 2 | " | " | " | l | 6.5 | 7.3 | 15.8 | -46.2 | 331 | 104 | .. |
| | 3 | " | " | " | l | 0.0 | 6.8 | 14.2 | -52.6 | 362 | 103 | .. |
| | 4 | " | " | " | h | -13.1 | 7.1 | 18.4 | -67.3 | 328 | 120 | .. |
| | 5 | " | " | " | l | -13.1 | 7.1 | 15.8 | -67.3 | 333 | 104 | .. |

March 12, 1939.

| | | | | | | | | | | | | |
|---|---|----------|-----|----|----|-----|-----|------|-------|-----|-----|----|
| 3 | 1 | 01.22.21 | M-K | RB | h | 3.7 | 9.1 | 25.7 | -45.9 | 250 | 127 | .. |
| | 2 | " | " | " | l' | 3.9 | 9.0 | 23.3 | -46.0 | 257 | 118 | .. |

p is the parallaxe.

h is the altitude of the aurora point as seen from the main station, a is its azimuth from the same station (reckoned from South positiv westwards and negative eastwards).

D is the geodetical distance from the main station to the projection of the aurora point on the earth's surface (vertically under).

H is the height of the aurora point.

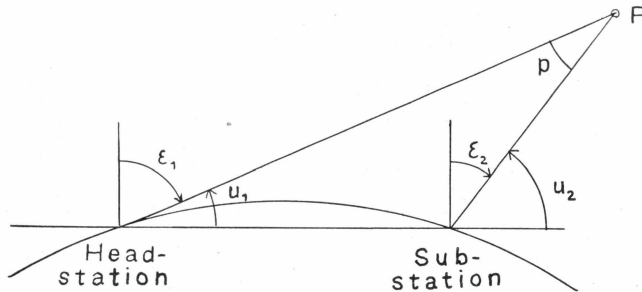


Fig. 2. Definition of angles ε_1 , ε_2 , u_1 and u_2 .

As a supplement to this table, we give a list of extrapolated heights; in fact in a series of cases the chosen points were not at the lowest or at the highest parts of the aurora, but it was not difficult by extrapolation to find the height of these parts. For rays we have used the method given in a paper from 1926¹⁾. In Table IV the results are seen:

Table IV. Results of the extrapolation to find highest and lowest points of aurorae.

| No. | St. | F | P | H | No. | St. | F | P | H |
|-------------------|-----|----|-----|-----|--------------------|-----|----|-----|-----|
| January 9, 1939. | | | | | January 15, 1939. | | | | |
| 21 | M | R | > 1 | 239 | 45 | M | R | < 1 | 108 |
| " | " | " | < 2 | 96 | 46 | M | D | > 3 | 277 |
| 23 | M | R | > 1 | 221 | 47 | M | RA | < 4 | 96 |
| 24 | M | RA | < 1 | 100 | " | " | " | < 6 | 109 |
| 35 | M | RB | < 2 | 110 | 48 | M | RB | > 7 | 300 |
| 37 | M | R | < 3 | 106 | 51 | M | RA | > 1 | 114 |
| " | " | " | > 4 | 230 | " | " | " | < 1 | 104 |
| " | " | " | > 6 | 169 | February 17, 1939. | | | | |
| 38 | M | R | > 4 | 261 | 2 | M | R | > 1 | 250 |
| 39 | M | RB | < 4 | 107 | 5 | M | R | > 1 | 287 |
| 42 | " | R | < 4 | 103 | " | " | RB | < 7 | 100 |
| January 14, 1939. | | | | | 6 | M | RB | < 3 | 103 |
| 9 | M | RB | < 3 | 100 | 7 | M | R | > 2 | 211 |
| 11 | M | R | > 3 | 137 | 12 | K | RB | > 1 | 212 |
| 15 | M | R | > 2 | 212 | " | " | " | > 9 | 218 |
| " | " | " | > 4 | 189 | 19 | M | D | > 1 | 192 |
| 17 | M | R | > 2 | 246 | " | " | " | > 5 | 133 |
| 43 | M | RB | > 1 | 260 | 31 | M | R | < 7 | 112 |
| | | | | | March 12, 1939. | | | | |
| | | | | | 3 | M | RB | < 2 | 114 |

¹⁾ CARL STØRMER: Resultats des mesures photogrammetriques etc. § 3, Geofysiske Publikasjoner, Vol. IV, No. 7, Oslo 1926.

Here No. is the current number of the picture, St. the main station, F the aurora form, P the point in question; > 1 means the summit over point 1, and < 2 the base under point 2 and so on. H is as usual the height in km.

6. Some selected sets of simultaneous pictures.

We have not found it necessary to reproduce pictures or sketches of all the photographs taken. A selection is made only among the best and most characteristic ones. Here they are:

Table V. Selected sets of pictures.

| Date | St. | PN | GMT | Fig. | Pl. | F. |
|---------------|-----|---------|----------|------|-----|------|
| Dec. 17. 1938 | M | 30 | 22.09.56 | } 3 | 1 | I |
| — — | K | 30 | " | | | |
| Jan. 9. 1939 | M | 10 | 22.31.25 | } 4 | 2 | II |
| — — | S | 15.3 A | " | | | |
| Jan. 9. 1939 | M | 21 | 22.54.14 | } 5 | 3 | III |
| — — | S | 15.13 A | " | | | |
| Jan. 9. 1939 | M | 41 | 23.57.18 | } 6 | 4 | IV |
| — — | S | 15.33 A | " | | | |
| Jan. 14. 1939 | M | 9 | 22.13.08 | } 7 | 5 | V |
| — — | S | 16.13 | " | | | |
| Jan. 14. 1939 | M | 12 | 22.16.32 | } 8 | 6 | VI |
| — — | S | 16.17 | " | | | |
| Jan. 14. 1939 | M | 17 | 22.22.24 | } 9 | 7 | VII |
| — — | S | 16.21 | " | | | |
| Jan. 15. 1939 | M | 46 | 00.01.33 | } 10 | 8 | VIII |
| — — | S | 17.9 | " | | | |
| Jan. 15. 1939 | M | 48 | 00.03.38 | } 11 | 9 | IX |
| — — | S | 17.11 | " | | | |
| Feb. 17. 1939 | M | 13 | 21.34.51 | } 12 | 10 | X |
| — — | K | 13 | " | | | |
| Feb. 17. 1939 | M | 34 | 22.04.48 | } 13 | 11 | XI |
| — — | K | 34 | " | | | |

The headings of table V have the following meaning:

- St. Station from which the picture was taken.
 PN. Current number of the picture.
 GMT. Greenwich mean time¹⁾.
 Fig. The corresponding sketch.
 Pl. The plate giving the reproduction of the aurora picture.
 F. The numbers correspond to those on Fig. 14.

¹⁾ Some misprints in (GP) of the values GMT have been corrected here.

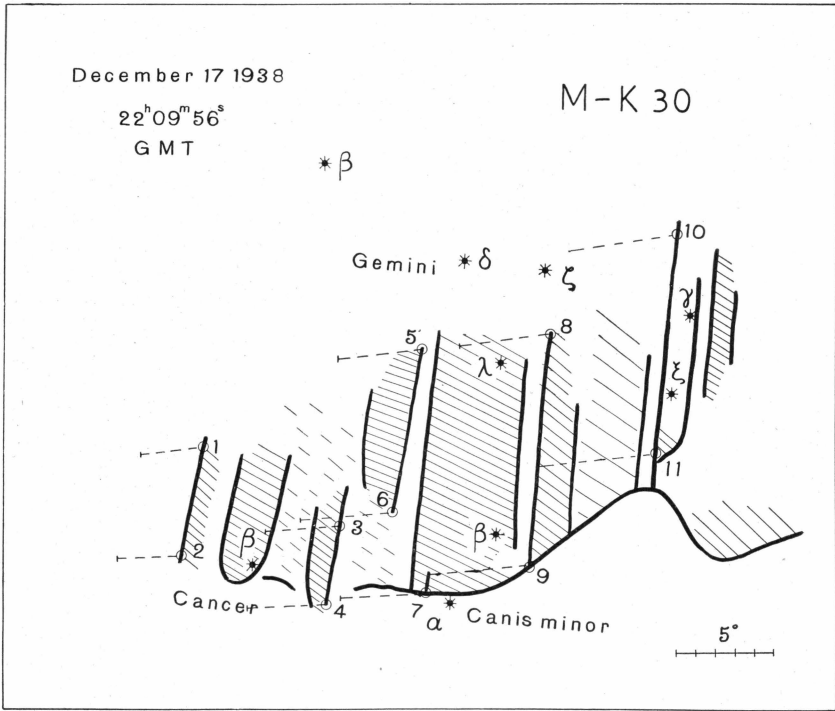


Fig. 3. Aurora December 17th, 1938 (M 30—K 30) at 22.09.56 GMT.

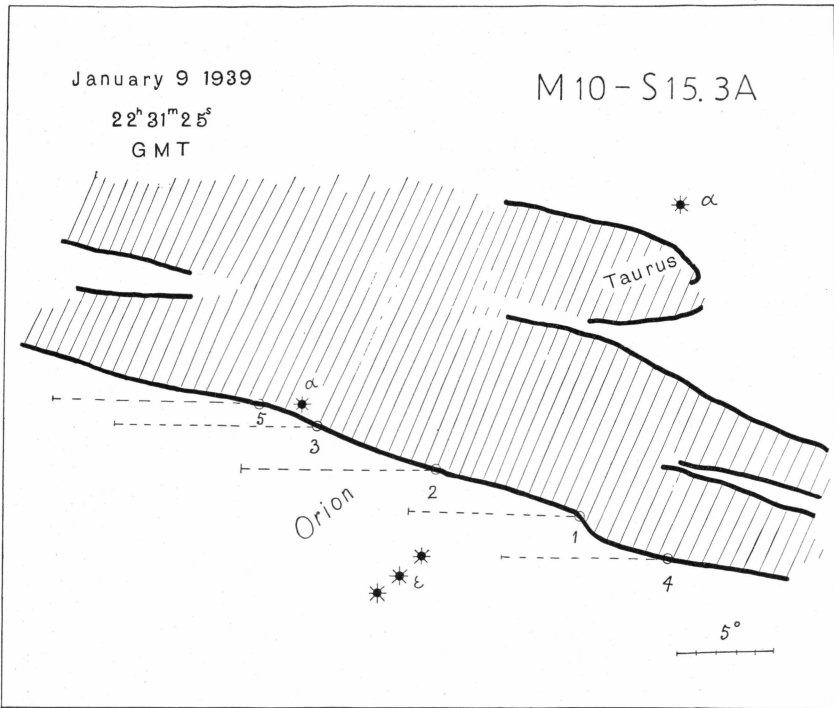


Fig. 4. Aurora January 9, 1939 (M 10—S 15.3 A) at 22.31.25 GMT.

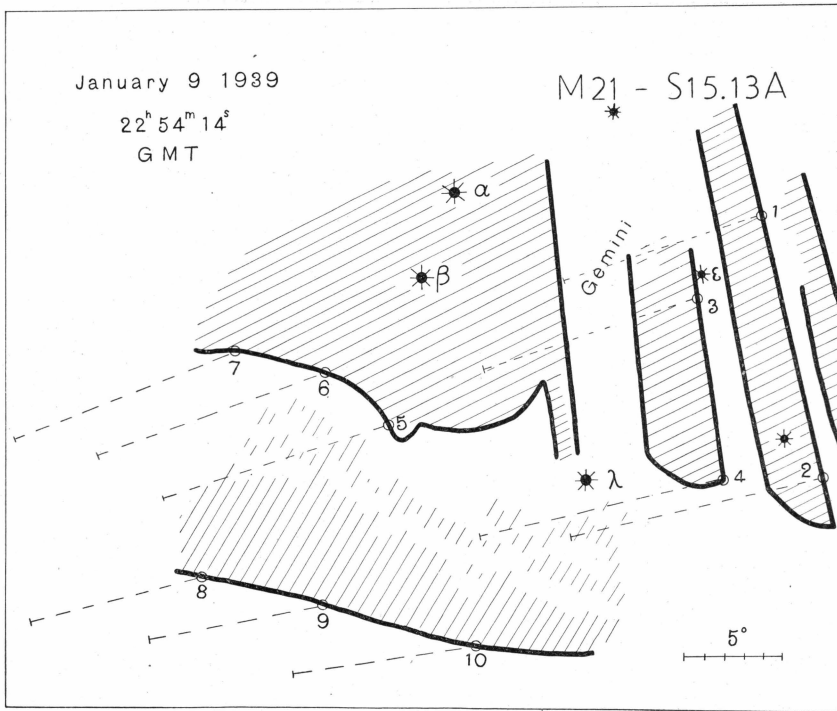


Fig. 5. Aurora January 9, 1939 (M 21—S 15.13 A) at 22.54.14 GMT.

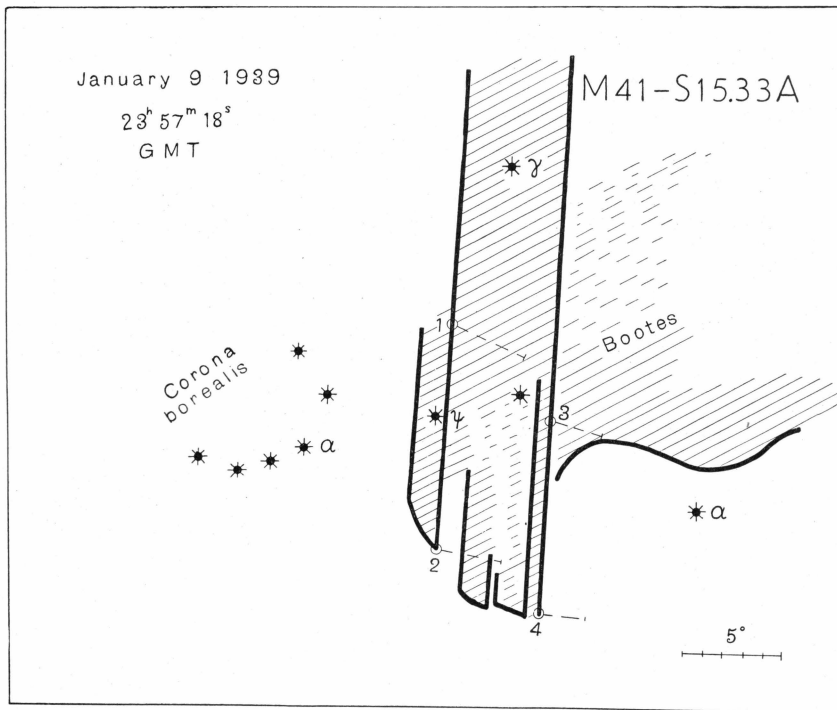


Fig. 6. Aurora January 9, 1939 (M 41—S 15. 33 A) at 25.57.18 GMT.

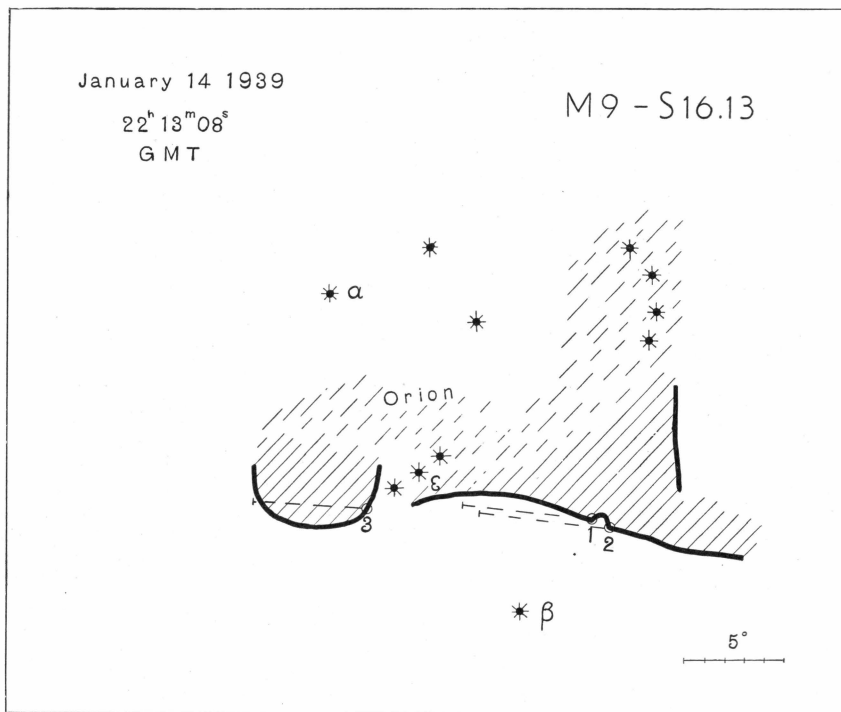


Fig. 7. Aurora January 14, 1939 (M 9—S 16.13) at 22.13.08.

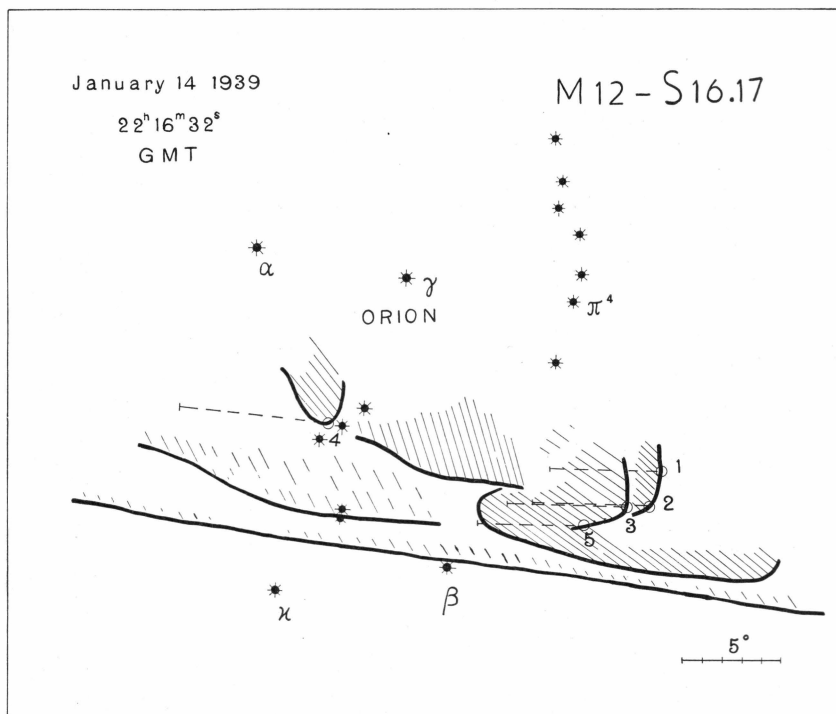


Fig. 8. Aurora January 14, 1939 (M 12—S 16.17) at 22.16.32.

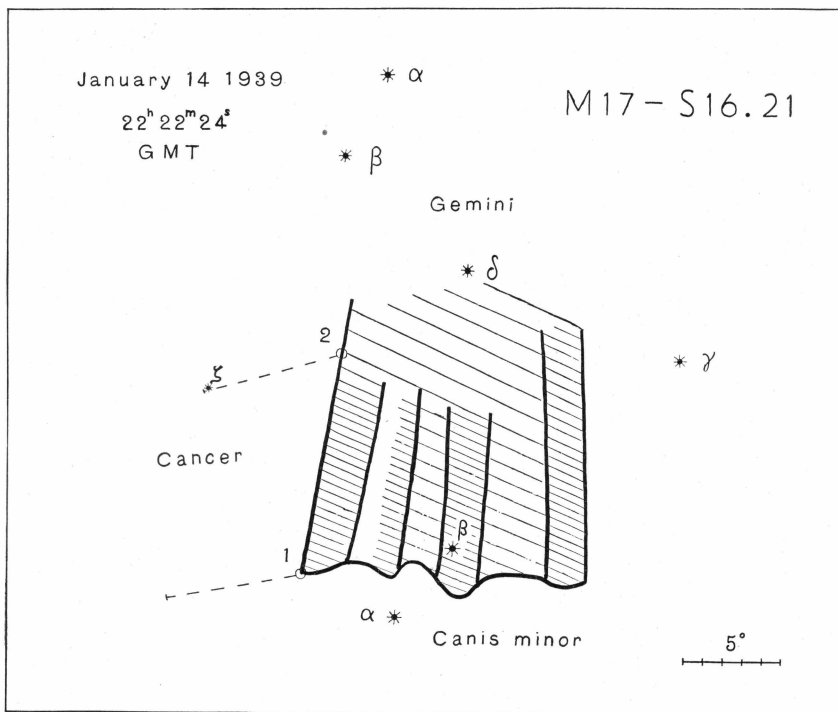


Fig. 9. Aurora January 14, 1939 (M 17—S 16.21) at 22.22.24 GMT.

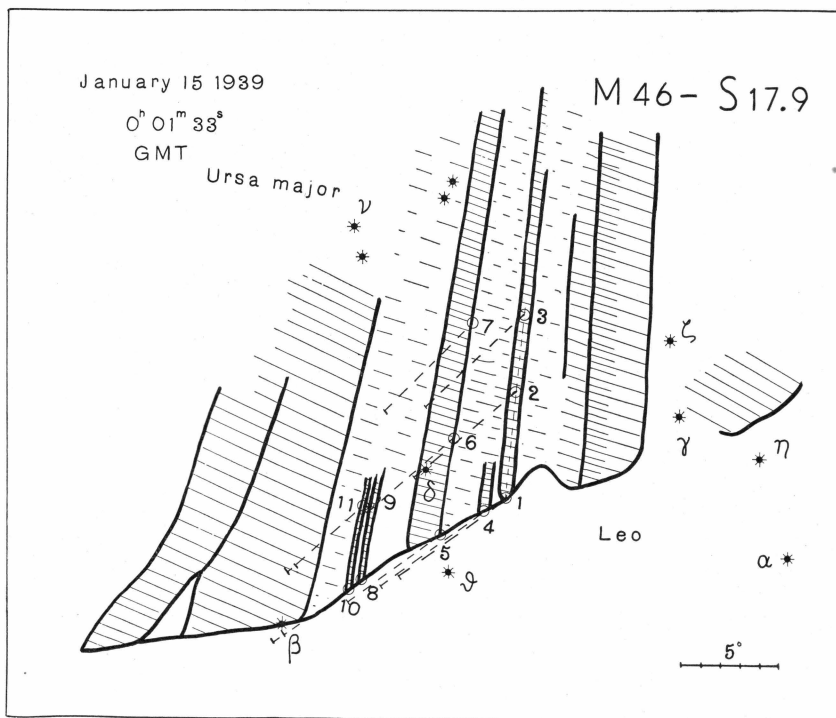


Fig. 10. Aurora January 15, 1939 (M 46—S 17.9) at 00.01.33 GMT.

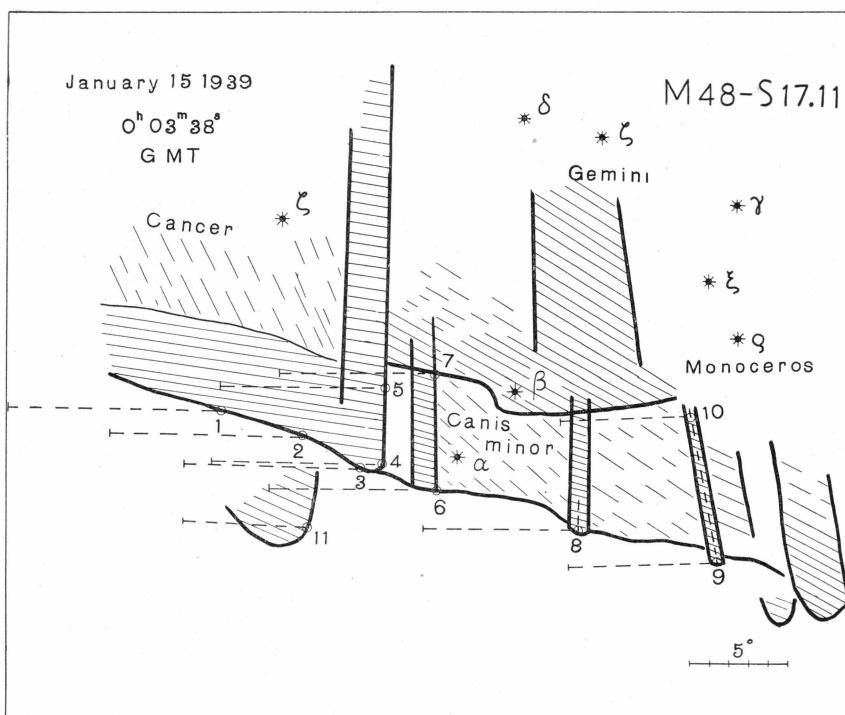


Fig. 11. Aurora January 15, 1939 (M 48—S 17.11) at 00.03.38 GMT.

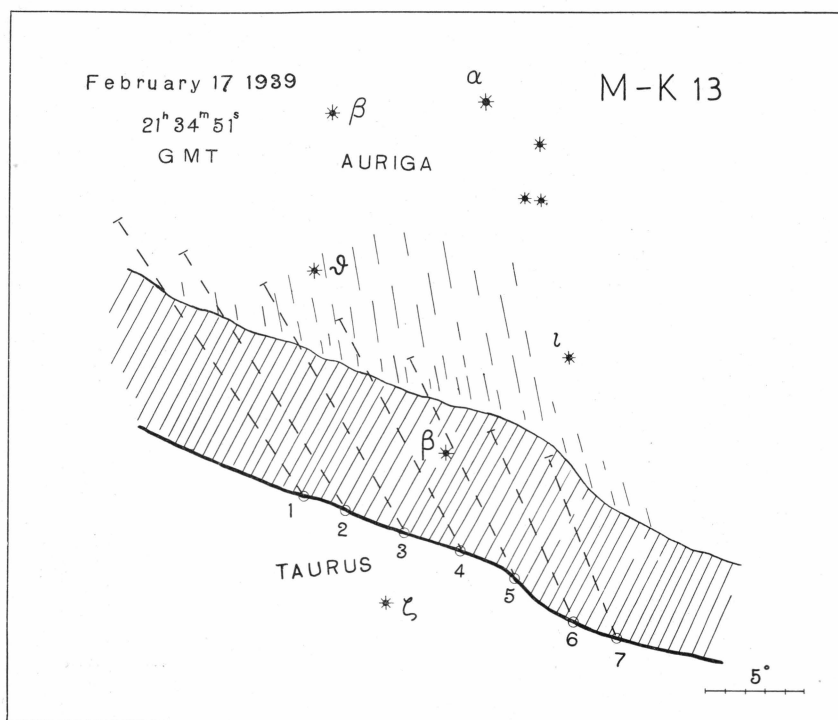


Fig. 12. Aurora February 17, 1939 (M 13—K 13) at 21.34.51 GMT.

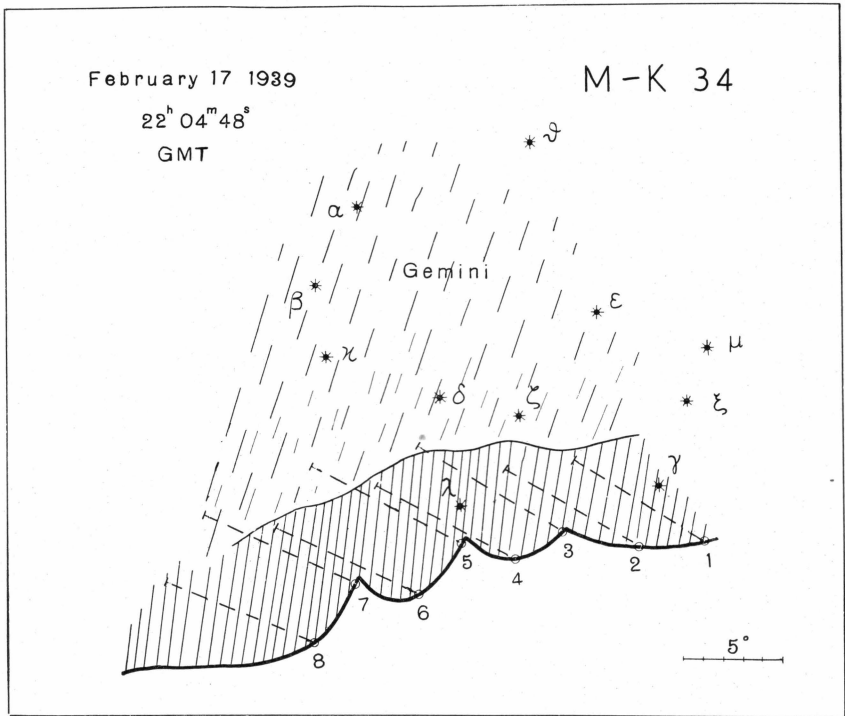


Fig. 13. Aurora February 17, 1939 (M 34—K 34) at 22.04.48 GMT.

On each sketch the outlines of the aurora as seen from the main station and some easily recognisable stars are marked. From each selected point a broken line is drawn to the corresponding situation of the same point as seen from the substation, thus giving the parallaxe.

The corresponding pictures are reproduced on Plates 1—11 after enlarged copies from the original negatives. On the pictures with the Astrolens the stars often show 4 rays very useful for finding the optical center and for distinguishing stars from faults in the plate.

The geographical situations are seen on Fig. 14. Here all the points belonging to the same aurora are connected or surrounded by a line with the corresponding number F of Table V.

7. Statistics of the heights measured.

In Table VI we have from Table III and IV given the number of cases for each given height in order to have an illustration of the frequency of the different heights.

¹⁾ On fig. 5 in (GP) the contours b and f have erroneously been exchanged.

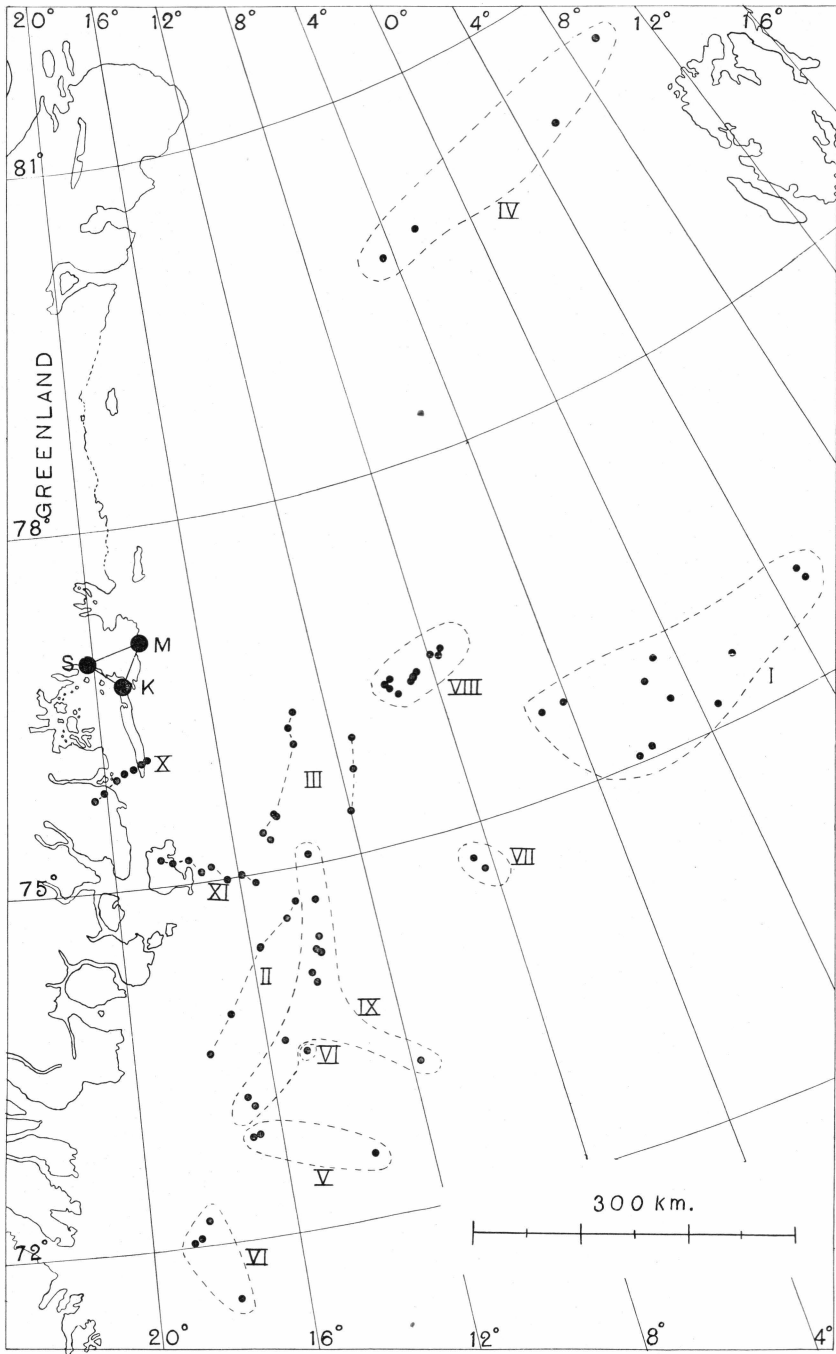


Fig. 14. Geographical positions of the selected Aurorae.

Table VI. Frequency of the heights of measured aurora points.

| H | N | H | N | H | N | H | N | H | N |
|-----|----|-----|----|-----|----|-----|----|-----|----|
| 87 | 2 | 123 | 3 | 159 | .. | 194 | 1 | 229 | .. |
| 88 | 1 | 124 | 3 | 160 | 3 | 195 | .. | 230 | 1 |
| 89 | 1 | 125 | 1 | 161 | .. | 196 | 1 | 231 | .. |
| 90 | 4 | 126 | 3 | 162 | .. | 197 | 2 | 232 | .. |
| 91 | 1 | 127 | 6 | 163 | 1 | 198 | 1 | 233 | 2 |
| 92 | 1 | 128 | 1 | 164 | .. | 199 | .. | 234 | .. |
| 93 | 4 | 129 | 4 | 165 | 1 | 200 | .. | 235 | .. |
| 94 | 9 | 130 | 2 | 166 | .. | 201 | .. | 236 | .. |
| 95 | 5 | 131 | 3 | 167 | .. | 202 | .. | 237 | .. |
| 96 | 4 | 132 | 3 | 168 | 1 | 203 | .. | 238 | 1 |
| 97 | 6 | 133 | 2 | 169 | 3 | 204 | .. | 239 | 2 |
| 98 | 5 | 134 | 3 | 170 | .. | 205 | .. | 240 | .. |
| 99 | 6 | 135 | 3 | 171 | 1 | 206 | 1 | 241 | .. |
| 100 | 8 | 136 | 2 | 172 | .. | 207 | .. | 242 | .. |
| 101 | 12 | 137 | 2 | 173 | .. | 208 | .. | 243 | .. |
| 102 | 10 | 138 | 1 | 174 | 1 | 209 | 1 | 244 | .. |
| 103 | 15 | 139 | 3 | 175 | 1 | 210 | .. | 245 | 2 |
| 104 | 19 | 140 | 1 | 176 | .. | 211 | 4 | 246 | 1 |
| 105 | 17 | 141 | 1 | 177 | 1 | 212 | 2 | 247 | .. |
| 106 | 15 | 142 | 3 | 178 | 1 | 213 | 1 | 248 | .. |
| 107 | 12 | 143 | 3 | 179 | 2 | 214 | 1 | 249 | .. |
| 108 | 13 | 144 | 2 | 180 | .. | 215 | 1 | 250 | 1 |
| 109 | 17 | 145 | 4 | 181 | .. | 216 | 1 | .. | .. |
| 110 | 14 | 146 | 2 | 182 | 2 | 217 | .. | 260 | 1 |
| 111 | 8 | 147 | 1 | 183 | .. | 218 | 1 | 261 | 2 |
| 112 | 13 | 148 | 2 | 184 | .. | 219 | .. | .. | .. |
| 113 | 6 | 149 | 3 | 185 | .. | 220 | 1 | 277 | 1 |
| 114 | 12 | 150 | 1 | 186 | .. | 221 | 1 | 282 | 1 |
| 115 | 5 | 151 | 1 | 187 | 1 | 222 | .. | 287 | 1 |
| 116 | 11 | 152 | .. | 188 | 1 | 223 | 1 | .. | .. |
| 117 | 10 | 153 | .. | 189 | 1 | 224 | .. | 300 | 1 |
| 118 | 5 | 154 | 4 | 190 | .. | 225 | 2 | .. | .. |
| 119 | 11 | 155 | .. | 191 | .. | 226 | 1 | 303 | 1 |
| 120 | 6 | 156 | 1 | 192 | 1 | 227 | .. | .. | .. |
| 121 | 10 | 157 | 1 | 193 | .. | 228 | .. | 376 | 1 |
| 122 | 1 | 158 | 1 | | | | | | |

The heights over 150 km belong for the most part to points on rays and are therefore very dispersed.

For heights less than 150 km we have made the following summations in order to eliminate as much as possible the accidental errors:

- 1°. The sum of cases for 85, 86, 87 km, for 88, 89, 90 km and so on.
- 2°. The sum of cases for 86, 87, 88 km, for 89, 90, 91 km and so on.
- 3°. The sum of cases for 87, 88, 89 km, for 90, 91, 92 km and so on.

Writing each sum in the same line as the second of the 3 heights we get the following table VII:

Table VII. Frequencies for 3 and 3 consecutive heights.

| km | Sum 1 | Sum 2 | Sum 3 |
|-----------|-------|-------|-------|
| 86 | 2 | .. | .. |
| 87 | .. | 3 | .. |
| 88 | .. | .. | 4 |
| 89 | 6 | .. | .. |
| 90 | .. | 6 | .. |
| 91 | .. | .. | 6 |
| 92 | 6 | .. | .. |
| 93 | .. | 14 | .. |
| 94 | .. | .. | 18 |
| 95 | 18 | .. | .. |
| 96 | .. | 15 | .. |
| 97 | .. | .. | 15 |
| 98 | 17 | .. | .. |
| 99 | .. | 19 | .. |
| 100 | .. | .. | 26 |
| 101 | 30 | .. | .. |
| 102 | .. | 37 | .. |
| 103 | .. | .. | 44 |
| 104 | 51 | .. | .. |
| 105 | .. | 51 | .. |
| 106 | .. | .. | 44 |
| 107 | 40 | .. | .. |
| 108 | .. | 42 | .. |
| 109 | .. | .. | 44 |
| 110 | 39 | .. | .. |
| 111 | .. | 35 | .. |
| 112 | .. | .. | 27 |
| 113 | 31 | .. | .. |
| 114 | .. | 23 | .. |
| 115 | .. | .. | 28 |
| 116 | 26 | .. | .. |
| 117 | .. | 26 | .. |
| 118 | .. | .. | 26 |
| 119 | 22 | .. | .. |
| 120 | .. | 27 | .. |
| 121 | .. | .. | 17 |
| 122 | 14 | .. | .. |
| 123 | .. | 7 | .. |
| 124 | .. | .. | 7 |
| 125 | 7 | .. | .. |
| 126 | .. | 10 | .. |
| 127 | .. | .. | 10 |

Table VII (continued).

| km | Sum 1 | Sum 2 | Sum S |
|-----------|-------|-------|-------|
| 128 | 1 | .. | .. |
| 129 | .. | 7 | .. |
| 130 | .. | .. | 9 |
| 131 | 8 | .. | .. |
| 132 | .. | 8 | .. |
| 133 | .. | .. | 8 |
| 134 | 8 | .. | .. |
| 135 | .. | 8 | .. |
| 136 | .. | .o | 6 |
| 137 | 4 | .. | .. |
| 138 | .. | 5 | .. |
| 139 | .. | .. | 5 |
| 140 | 5 | .. | .. |
| 141 | .. | 5 | .. |
| 142 | .. | .. | 7 |
| 143 | 8 | .. | .. |
| 144 | .. | 9 | .. |
| 145 | .. | .. | 8 |
| 146 | 7 | .. | .. |
| 147 | .. | 3 | .. |
| 148 | .. | .. | 3 |
| 149 | 5 | .. | .. |
| 150 | .. | 6 | .. |

In Fig. 15 the corresponding curves are superimposed giving a fairly good impression of the situation of the bulk of the measured aurora points.

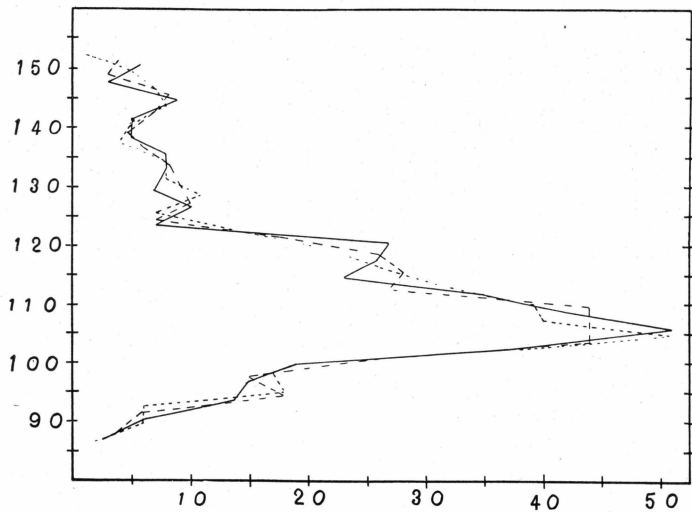


Fig. 15. Frequency curves of the measured heights taken 3 and 3.

For comparison we have made the same additions for groups of 5 heights associating each sum to the third of the heights (the height in the middle).

We then get the following Table VIII.

The 5 frequency curves superimposed give a still finer impression of the distribution of the aurora points. Maximum of frequency about 105 km, very nearly the same as for aurora observed in Bossekop¹⁾ and Halde²⁾ during 1913—1914. See Fig. 16.

Table VIII. Frequencies for 5 and 5 consecutive heights.

| Km | S 1 | S 2 | S 3 | S 4 | S 5 |
|----------|-----|-----|-----|-----|-----|
| 87..... | 4 | .. | .. | .. | .. |
| 88..... | .. | 8 | .. | .. | .. |
| 89..... | .. | .. | 9 | .. | .. |
| 90..... | .. | .. | .. | 8 | .. |
| 91..... | .. | .. | .. | .. | 11 |
| 92..... | 19 | .. | .. | .. | .. |
| 93..... | .. | 20 | .. | .. | .. |
| 94..... | .. | .. | 23 | .. | .. |
| 95..... | .. | .. | .. | 28 | .. |
| 96..... | .. | .. | .. | .. | 29 |
| 97..... | 26 | .. | .. | .. | .. |
| 98..... | .. | 29 | .. | .. | .. |
| 99..... | .. | .. | 37 | .. | .. |
| 100..... | .. | .. | .. | 41 | .. |
| 101..... | .. | .. | .. | .. | 51 |
| 102..... | 64 | .. | .. | .. | .. |
| 103..... | .. | 73 | .. | .. | .. |
| 104..... | .. | .. | 76 | .. | .. |
| 105..... | .. | .. | .. | 78 | .. |
| 106..... | .. | .. | .. | .. | 76 |
| 107..... | 74 | .. | .. | .. | .. |
| 108..... | .. | 71 | .. | .. | .. |
| 109..... | .. | .. | 54 | .. | .. |
| 110..... | .. | .. | .. | 65 | .. |
| 111..... | .. | .. | .. | .. | 58 |
| 112..... | 53 | .. | .. | .. | .. |
| 113..... | .. | 44 | .. | .. | .. |
| 114..... | .. | .. | 47 | .. | .. |
| 115..... | .. | .. | .. | 44 | .. |

¹⁾ CARL STØRMER: Rapport sur une expedition d'aurores boréales à Bossekop et Store Korsnes pendant le printemps de l'année 1913, Geofysiske Publikasjoner, Vol. 1, No. 5.

²⁾ L. VEGARD and O. KROGNES: The Position in Space of the Aurora Borealis. Observations made at the Halde Observatory 1913—14, Geof. Publ. Vol. 1, No. 1.

Table VIII (continued).

| Km | S 1 | S 2 | S 3 | S 4 | S 5 |
|----------|-----|-----|-----|-----|-----|
| 116..... | .. | .. | .. | .. | 43 |
| 117..... | 42 | .. | .. | .. | .. |
| 118..... | .. | 43 | .. | .. | .. |
| 119..... | .. | .. | 42 | .. | .. |
| 120..... | .. | .. | .. | 33 | .. |
| 121..... | .. | .. | .. | .. | 31 |
| 122..... | 23 | .. | .. | .. | .. |
| 123..... | .. | 18 | .. | .. | .. |
| 124..... | .. | .. | 11 | .. | .. |
| 125..... | .. | .. | .. | 16 | .. |
| 126..... | .. | .. | .. | .. | 14 |
| 127..... | 15 | .. | .. | .. | .. |
| 128..... | .. | 16 | .. | .. | .. |
| 129..... | .. | .. | 16 | .. | .. |
| 130..... | .. | .. | .. | 13 | .. |
| 131..... | .. | .. | .. | .. | 14 |
| 132..... | 13 | .. | .. | .. | .. |
| 133..... | .. | 14 | .. | .. | .. |
| 134..... | .. | .. | 13 | .. | .. |
| 135..... | .. | .. | .. | 11 | .. |
| 136..... | .. | .. | .. | .. | 10 |
| 137..... | 10 | .. | .. | .. | .. |
| 138..... | .. | 8 | .. | .. | .. |
| 139..... | .. | .. | 7 | .. | .. |
| 140..... | .. | .. | .. | 9 | .. |
| 141..... | .. | .. | .. | .. | 11 |
| 142..... | 10 | .. | .. | .. | .. |
| 143..... | .. | 13 | .. | .. | .. |
| 144..... | .. | .. | 14 | .. | .. |
| 145..... | .. | .. | .. | 12 | .. |
| 146..... | .. | .. | .. | .. | 9 |
| 147..... | 9 | .. | .. | .. | .. |
| 148..... | .. | 8 | .. | .. | .. |
| 149..... | .. | .. | 7 | .. | .. |
| 150..... | .. | .. | .. | 6 | .. |

In the next section we shall consider the lower border of some of the most frequent aurora forms, which give more interesting results.

8. Frequency of heights of the lower border of prominent forms.

On account of the long exposure for most of the aurora pictures it was difficult on the negatives to distinguish between the homogeneous

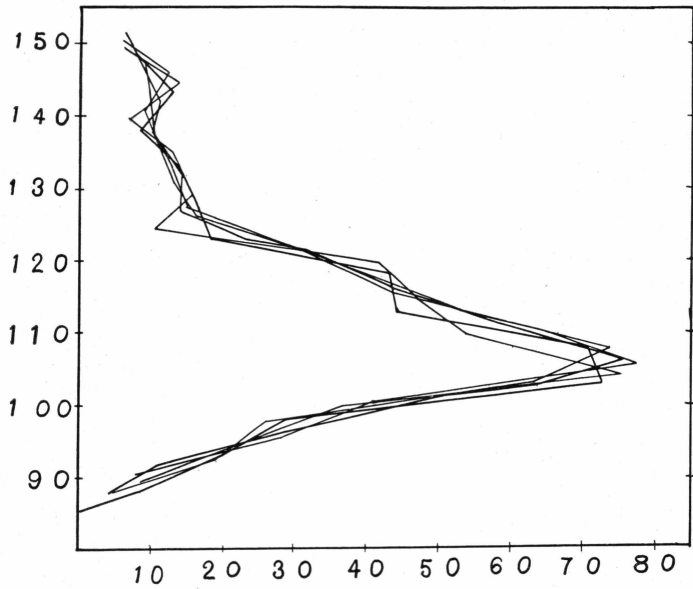


Fig. 16. Frequency curves of the measured heights taken 5 and 5.

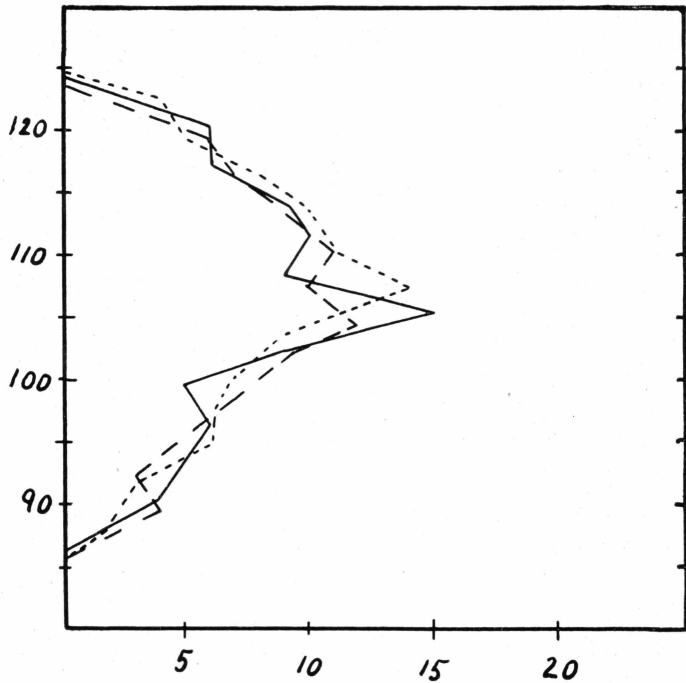


Fig. 17. Frequency curves of heights of auroral arcs (HA) and (RA).

arcs (HA) and arcs with ray structure (RA), because the last form often looks homogeneous because the rays have moved during the exposure.

In the frequency studies we have therefore combined the two forms and have studied the frequency of the heights along the lower border, taken in groups of 3 as in the foregoing section.

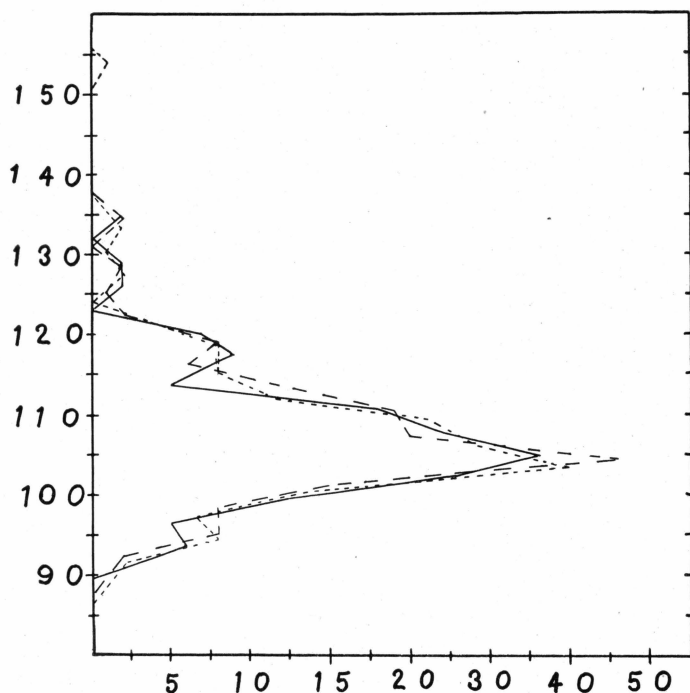


Fig. 18. Frequency curves for bands with ray-structure (curtains) called RB.

In Fig. 17 the results are seen. Most of the heights fall between 100 and 120 km.

Much more pronounced is the distribution of the form "Bands with ray structure" (Curtains), called RB.

In Fig. 18 the result of the enumeration of 3 and 3 heights of lower border is seen.

For rays, isolated or associated with curtains or arcs we have only a scanty material. We have therefore preferred to use another representation as follows.

As abscissa we have written date and number of each set where rays have been measured. The points of the same ray have been given by small streaks combined by a full line; extrapolated points along the rays are marked by small circles. If the ray stretches more downwards

or more upwards than the measured point this has been indicated by a broken line with an arrow.

Some of the rays lie rather outside the main bulk. But this is probably due to the small parallaxe, with corresponding doubtful measurements.

In Fig. 19 the diagram is seen.

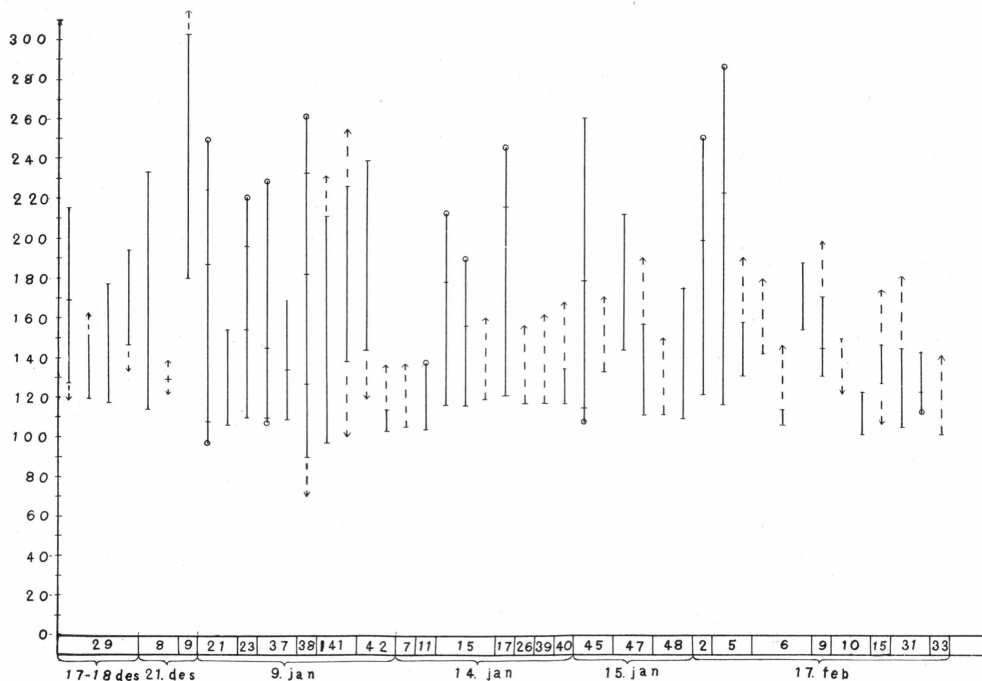


Fig. 19. Position in the atmosphere of the measured aurora rays.

On the whole, the situation of the rays is very similar to the corresponding one observed in Bossekop. No sunlit rays seem to have been measured and the extraordinary heights observed for rays in Southern Norway in the same years 1938—39 have not been found here.

9. Geographical situations of all the points measured.

In Fig. 20 we have marked the vertical projection of all aurora points measured, on a map of North Eastern Greenland.

Most of the aurorae have been observed in south east and the distribution of the points seems to run parallel to the aurora zone farther south.

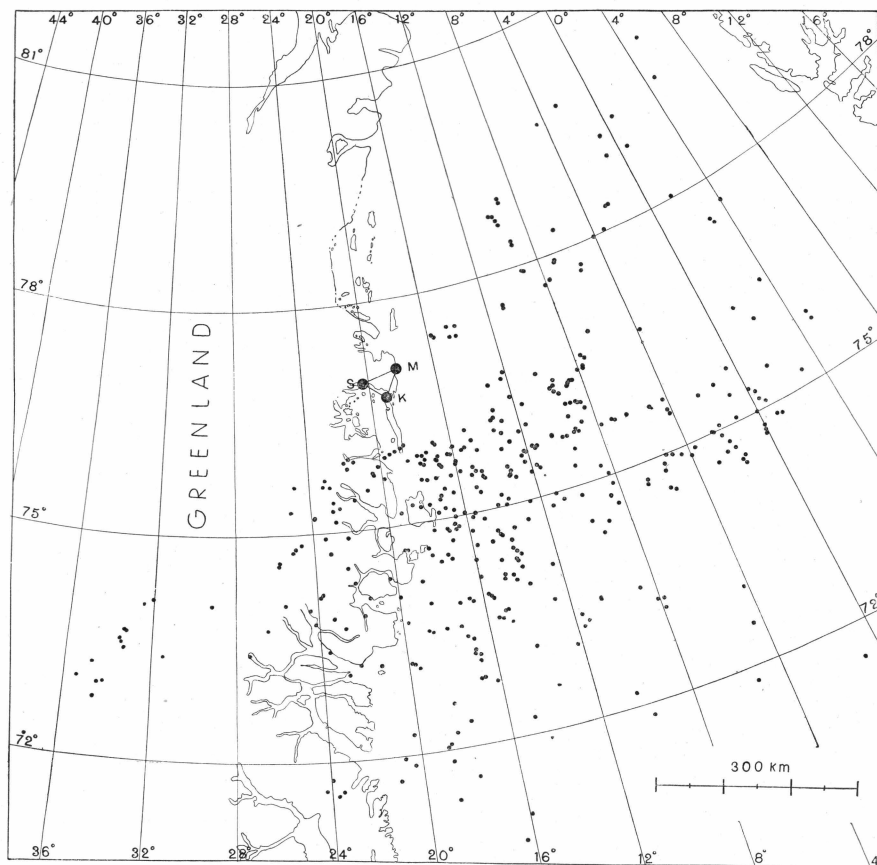


Fig. 20. Geographical situation of all the points measured.

10. Direction of Aurora Arcs.

As all evidence from measurements of aurora arcs in the earth's shadow point to the fact that the height of the lower border is constant along the arc we only need to assume a reasonable height for this lower border to find the geographical situation of the arc.

From the statistics of homogeneous arcs (HA) and arcs with ray structure (RA) we have seen that the bulk of the heights is distributed between 100 and 120 km. We have therefore plotted the geographical situations corresponding to

$$H = 110 \text{ km.}$$

If we had supposed $H = 100$ or $H = 120$ km it would only have the effect that the arcs were displaced parallel to themselves and the main direction of the arcs would only be slightly altered.

As best photographs of homogeneous arcs we have chosen 26 pictures; in Table 9 the results are given. Here PN means picture number, GMT Greenwich middle time, h, a, and D as usual altitude, azimuth and geodetical distance from the station to the projection of the aurora point, H being supposed equal to 110 km. The results are found graphically. CN means current number.

Table IX. Selected homogenous arcs with assumed height of 110 km used to find the direction of arcs.

| Date | PN | GMT | Point | h | a | D | Remarks | CN |
|---------|------|----------|-------|------|------|-----|-----------------------|----|
| Dec. 17 | M 6 | 20.51.32 | 1 | 7.1 | — 24 | 622 | Lower arc | 1 |
| " | " | " | 2 | 7.1 | — 32 | 622 | " | |
| " | " | " | 3 | 6.9 | — 40 | 633 | " | |
| " | " | " | 4 | 6.6 | — 48 | 648 | " | |
| " | " | " | 5 | 6.1 | — 56 | 675 | " | |
| " | M 32 | 22.14.27 | 1 | 9.3 | — 30 | 529 | | 2 |
| " | " | " | 2 | 9.3 | — 38 | 529 | | |
| " | " | " | 3 | 9.0 | — 46 | 537 | | |
| " | " | " | 4 | 8.4 | — 56 | 565 | | |
| Jan. 9 | M 14 | 22.39.54 | 1 | 13.7 | — 24 | 394 | Lower arc | 3 |
| " | " | " | 2 | 13.8 | — 34 | 391 | " | |
| " | " | " | 3 | 13.5 | — 44 | 399 | " | |
| " | " | " | 4 | 12.9 | — 52 | 415 | " | |
| " | " | " | 5 | 11.0 | — 62 | 469 | " | |
| " | M 16 | 22.44.05 | 1 | 8.2 | 6 | 573 | Lower arc | 4 |
| " | " | " | 2 | 9.3 | — 4 | 527 | " | |
| " | " | " | 3 | 10.2 | — 12 | 496 | " | |
| " | " | " | 4 | 10.9 | — 20 | 473 | " | |
| " | " | " | 5 | 11.5 | — 30 | 453 | " | |
| " | M 29 | 23.07.34 | 1 | 15.3 | 8 | 358 | Upper arc | 5 |
| " | " | " | 2 | 17.7 | — 4 | 314 | " | |
| " | " | " | 3 | 19.9 | — 16 | 282 | " | |
| " | " | " | 4 | 21.4 | — 26 | 262 | " | |
| " | " | " | 5 | 11.5 | 6 | 453 | Lower arc (weaker) | 6 |
| " | " | " | 6 | 13.8 | — 4 | 391 | " | |
| " | " | " | 7 | 15.3 | — 14 | 358 | " | |
| " | " | " | 8 | 15.8 | — 22 | 347 | " | |
| " | M 34 | 23.20.12 | 1 | 15.3 | 10 | 358 | | 7 |
| " | " | " | 2 | 16.8 | 0 | 330 | | |
| " | " | " | 3 | 18.3 | — 8 | 305 | | |
| " | " | " | 4 | 19.8 | — 16 | 283 | | |
| " | " | " | 5 | 21.8 | — 26 | 258 | | |
| " | M 36 | 23.23.35 | 1 | 12.0 | 8 | 437 | | 8 |
| " | " | " | 2 | 13.4 | — 0 | 402 | | |
| " | " | " | 3 | 14.5 | — 10 | 375 | | |
| " | " | " | 4 | 15.3 | — 20 | 358 | | |

Table IX (continued).

| Date | PN | GMT | Point | h | a | D | Remarks | CN |
|---------|------|----------|-------|------|------|-----|---|----|
| Jan. 14 | M 21 | 22.28.27 | 1 | 10.5 | — 34 | 486 | | 9 |
| " | " | " | 2 | 10.6 | — 42 | 481 | | 9 |
| " | " | " | 3 | 10.5 | — 50 | 486 | | |
| " | M 27 | 22.38.31 | 1 | 8.9 | — 24 | 544 | | 10 |
| " | " | " | 2 | 8.8 | — 32 | 549 | | |
| " | " | " | 3 | 8.9 | — 40 | 544 | | |
| " | " | " | 4 | 9.1 | — 48 | 534 | | |
| Jan. 15 | M 52 | 00.08.28 | 1 | 5.5 | 24 | 708 | Feeble | 11 |
| " | " | " | 2 | 6.2 | 16 | 668 | | |
| " | " | " | 3 | 7.4 | 6 | 608 | | |
| " | " | " | 4 | 8.5 | — 4 | 559 | | |
| " | M 58 | 00.16.15 | 1 | 5.5 | 32 | 708 | Feeble | 12 |
| " | " | " | 2 | 6.0 | 22 | 679 | | |
| " | " | " | 3 | 6.7 | 14 | 644 | | |
| " | " | " | 4 | 7.4 | 6 | 608 | | |
| " | " | " | 5 | 8.5 | — 2 | 559 | | |
| Feb. 13 | M 1 | 20.21.33 | 1 | 22.1 | —144 | 254 | One of the few auro- rae on the northern sky | 13 |
| " | " | " | 2 | 25.1 | —154 | 224 | | |
| " | " | " | 3 | 27.3 | —162 | 204 | | |
| " | " | " | 4 | 29.1 | —172 | 190 | | |
| " | M 62 | 23.04.49 | 1 | 10.6 | — 32 | 483 | Very diffuse | 14 |
| " | " | " | 2 | 10.4 | — 42 | 489 | | |
| " | " | " | 3 | 9.9 | — 52 | 505 | | |
| " | " | " | 4 | 9.3 | — 62 | 527 | | |
| Feb. 17 | M 2 | 21.19.44 | 1 | 12.4 | — 10 | 427 | Upper arc | 15 |
| " | " | " | 2 | 10.9 | — 2 | 473 | " | |
| " | " | " | 3 | 9.6 | 6 | 515 | " | |
| " | " | " | 4 | 8.1 | 18 | 571 | " | |
| " | " | " | 5 | 8.8 | — 6 | 548 | Lower arc | 16 |
| " | " | " | 6 | 6.9 | 6 | 633 | " | |
| " | " | " | 7 | 5.5 | 14 | 707 | " | |
| " | M 15 | 21.36.29 | 1 | 37.4 | — 46 | 139 | Upper arc | 17 |
| " | " | " | 2 | 33.7 | — 58 | 159 | " | |
| " | " | " | 3 | 30.3 | — 68 | 181 | " | |
| " | " | " | 4 | 26.2 | — 78 | 214 | " | |
| " | " | " | 5 | 33.0 | — 48 | 163 | Lower arc | 18 |
| " | " | " | 6 | 29.3 | — 60 | 188 | | |
| " | " | " | 7 | 24.4 | — 76 | 230 | | |
| " | K 15 | 21.36.29 | 1 | 42.6 | — 52 | 117 | Upper arc. The same aurora from the other station | 19 |
| " | " | " | 2 | 38.0 | — 64 | 136 | | |
| " | " | " | 3 | 33.0 | — 76 | 163 | | |
| " | " | " | 4 | 24.0 | — 90 | 234 | | |
| " | " | " | 5 | 33.1 | — 50 | 132 | Lower arc | 20 |

Table IX (continued).

| Date | PN | GMT | Point | h | a | D | Remarks | CN |
|---------|---------|----------|-------|------|------|-----|--|----|
| Feb. 17 | K 15 | 21.36.29 | 6 | 33.5 | — 64 | 161 | | 20 |
| " | " | " | 7 | 27.8 | — 76 | 200 | | |
| " | " | " | 8 | 21.9 | — 88 | 256 | | |
| " | M 16 | 21.37.16 | 1 | 35.7 | — 10 | 149 | Upper arc. The same aurora as M15 and K 15 | 21 |
| " | " | " | 2 | 35.5 | — 24 | 150 | | |
| " | " | " | 3 | 35.0 | — 32 | 152 | | |
| " | " | " | 4 | 33.4 | — 44 | 161 | | |
| " | " | " | 5 | 32.8 | — 16 | 165 | Lower arc | 22 |
| " | " | " | 6 | 32.7 | — 30 | 166 | | |
| " | " | " | 7 | 31.6 | — 40 | 172 | | |
| Jan. 9 | S 15.7 | 23.02.21 | 1 | 15.7 | 10 | 350 | The following on films from Mørkefjord | 23 |
| " | " | " | 2 | 17.9 | — 4 | 312 | | |
| " | " | " | 3 | 19.9 | — 16 | 283 | | |
| " | " | " | 4 | 20.5 | — 28 | 274 | | |
| Jan. 14 | S 16.12 | 22.11.50 | 1 | 7.0 | — 34 | 629 | Very fine picture | 24 |
| " | " | " | 2 | 6.2 | — 46 | 669 | See plate 13 | |
| " | " | " | 3 | 5.3 | — 56 | 717 | | |
| " | " | " | 4 | 4.5 | — 64 | 770 | | |
| " | S 16.30 | 22.36.31 | 1 | 8.1 | — 56 | 578 | | 25 |
| " | " | " | 2 | 8.2 | — 46 | 573 | | |
| " | " | " | 3 | 8.3 | — 36 | 569 | | |
| " | " | " | 4 | 8.2 | — 26 | 573 | | |
| Jan. 15 | S 17.10 | 00.02.54 | 1 | 10.8 | — 36 | 476 | See Plate 13 | 26 |
| " | " | " | 2 | 10.5 | — 26 | 486 | | |
| " | " | " | 3 | 9.9 | — 16 | 506 | | |
| " | " | " | 4 | 9.5 | — 6 | 520 | | |

On the map Fig. 21 the geographical situations of the arcs are seen.

As a comparison we have also mapped all the arcs of the material, both homogeneous (HA) and with ray structure (RA). The result is seen on Fig. 22.

I am sorry that so few arcs were observed in W and N, and that the same arc was not photographed successively along its whole extent; if so, the results would have been much better.

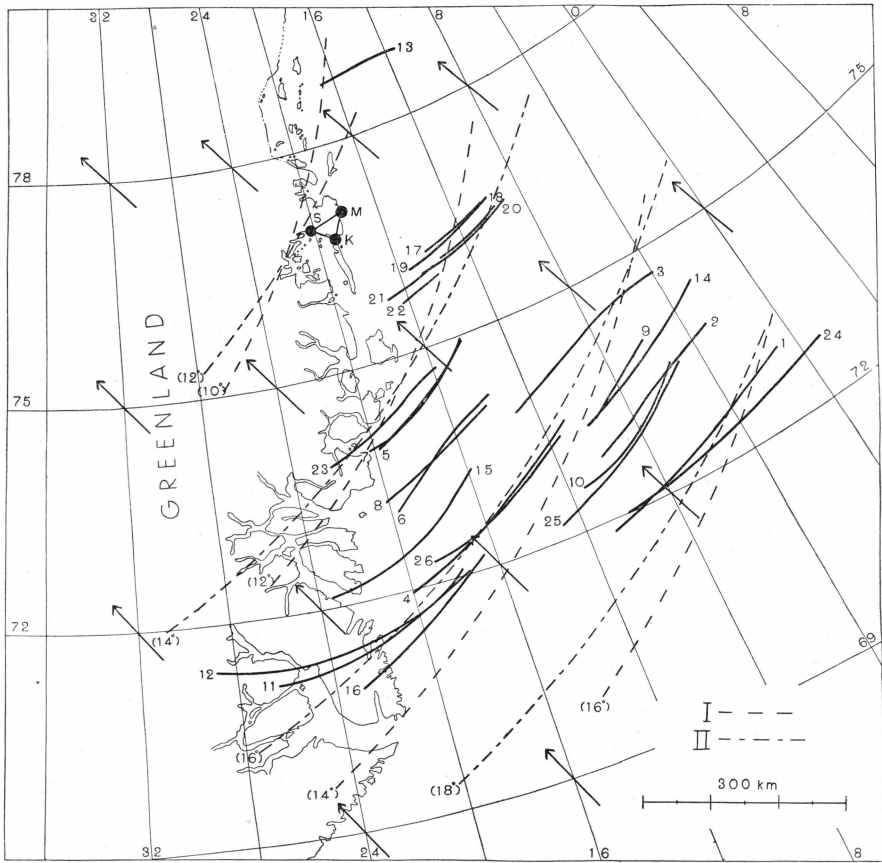


Fig. 21. Geographical situations of selected homogeneous arcs.*

11. The direction of the arcs compared with the corpuscular theory of the aurora.

The direction of the auroral arcs round the magnetic axis of the earth is of great interest in connection with the corpuscular theory of the aurora¹⁾.

Some explanations may be necessary.

For the magnetic field of the earth in space we can adopt two approximations; in both the magnetic field is approximated by the field of a dipole within the earth with fixed direction.

¹⁾ CARL STØRMER: On the Trajectories of Electric Corpuscles in Space under the Influence of Terrestrial Magnetism Applied to the Aurora Borealis and to Magnetic Disturbances, *Archiv for Matematik og Naturvidenskab*, § 5, Vol. XXVIII, 1906, and *Über die Probleme des Polarlichtes*, § 15 and § 16, *Ergebnisse der kosmischen Physik*. Vol. I, Leipzig 1931.

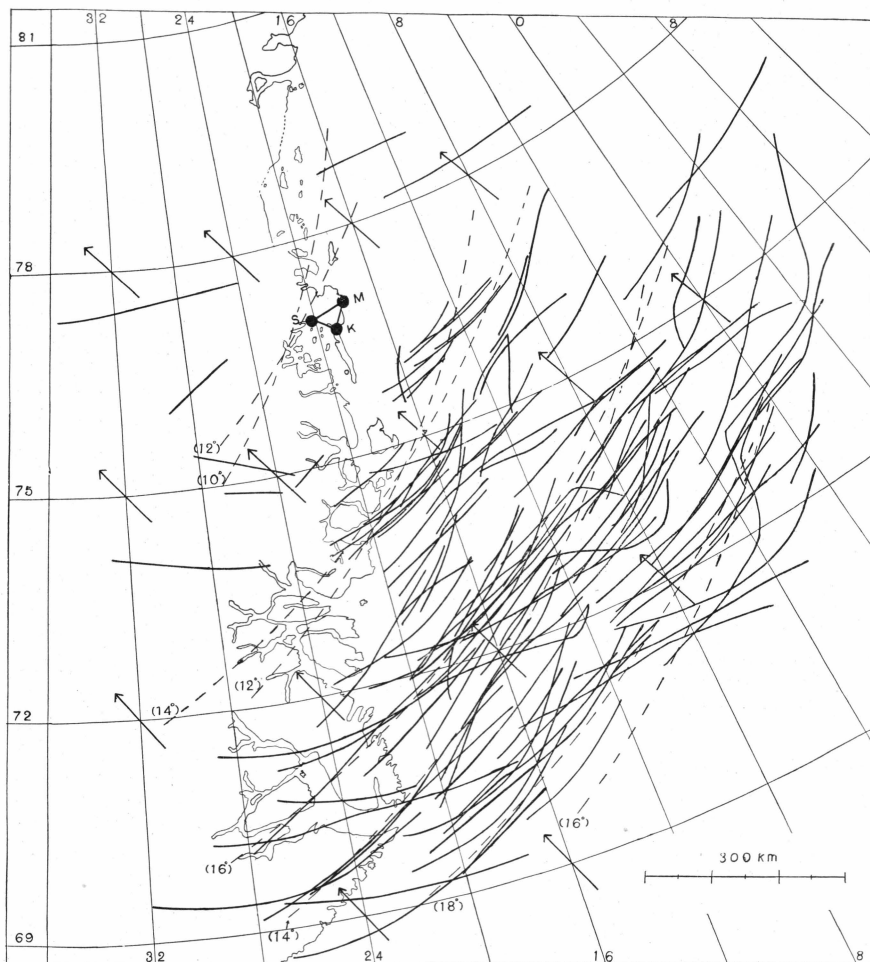


Fig. 22. Geographical situations of all the measured arcs.

In the first approximation the dipole lies in the earth's center and its axis cuts the northern hemisphere at a point with coordinates: Northern Latitude $78^{\circ}32'$ and Longitude West of Greenwich $68^{\circ}48'$. In the second approximation the dipole is placed in the so called magnetic center of the earth with its axis parallel to the axis in the first approximation. For details we refer to the papers given below¹⁾.

Now, if electric corpuscles come from the sun towards the earth and strike the upper atmosphere as an aurora, according to the theory the zone of precipitation will have a tendency to come down between two

¹⁾ ADOLF SCHMIDT: Der magnetische Mittelpunkt der Erde und seine Bedeutung, Gerlands Beiträge zur Geophysik, Vol. 41, 1934, and CARL STÖRMER: On the Trajectories of Electric Particles in the Field of a Magnetic Dipole etc. § 2, *Astronica Norvegica*, Vol. II, No. 4, 1936,

surfaces of revolution very near each other and having the magnetic axis as axis of revolution. Near the earth these surfaces lie very near a surface of revolution obtained by rotating a line of magnetic force round the magnetic axis. In polar coordinates this line has the equation

$$r = c \cdot \cos^2 \Psi$$

c being constant and can easily be drawn. (See Fig. 23.)

In the first approximation this surface of revolution cuts the surface of the earth in a circle.

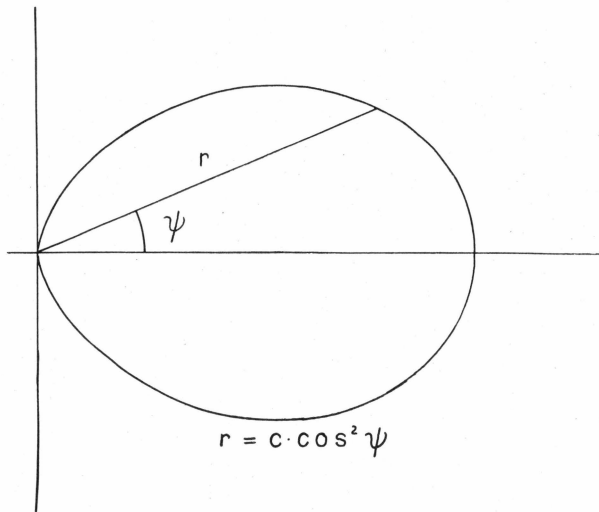


Fig. 23. Line of magnetic force of the dipole.

In the second approximation, where the dipole lies excentrically to the center of the earth, the line of intersection is not a circle but a curve of higher degree, which can be found by a rather troublesome calculation. All the necessary formulae can be found in the paper in *Astrophysica Norvegica* referred to above.

If we give c a series of values we find a series of curves giving approximately the theoretical directions of the auroral arcs. We shall not give the calculations here; they have been made by my assistant Miss JULIE KJENNERUD after my instruction.

On the maps Fig. 21 and Fig. 22 the results are seen. The lines of intersection corresponding to the first approximation are marked with I, those corresponding to the second¹⁾ approximation by II; in parentheses the angular distance from the magnetic axis are given in degrees.

We also have marked the direction of the magnetic horizontal

¹⁾ My assistant Miss JULIE KJENNERUD has calculated and mapped these directions for me.

force as arrows, taken from magnetic maps lent to us by Norges Sjøkartverk¹).

As seen from this, the direction of the auroral arcs is nearly perpendicular to the direction of magnetic force. As to the lines I and II mentioned above, the lines I deviate rather much from the arcs. The lines II, however, agree better.

But as the material is rather scanty this result must only be considered as preliminary. In fact it is necessary first to photograph more arcs N, NW and W.

12. Some interesting pictures from Mørkefjord Station.

Among the aurora pictures taken by Mr. SØLVER from Mørkefjord there are some very fine ones of arcs which are reproduced on Pl. 12 and 13.

They have been taken with his camera Zeiss Contax II on film Agfa ISS. They are:

Film no. 15, 11 A, January 9, at 22.51.27 GMT simultaneously with Micardbu no. 19. Exposure 43s. See Tables I and III.

The constellation Orion is well seen. (Pl. 12.1).

Film no. 15, 28 A, same date, at 23.23.35 GMT simultaneously with Micardbu no. 36. Not good enough for height measuring. Exposure 36^s. See Tables II and IX. Orion well seen (Plate 12, 2).

Film no. 16, 12, January 14, at 22.11.50 GMT simultaneously with Micardbu no. 8. Very fine narrow arc. Exposure 17s. See Tables I and III. Canis Minor with Procyon seen over the arc. (Plate 13.1).

Film 17.10. January 15, 00.02.54²) GMT simultaneously with Micardbu no. 47. See Tables I and III. The constellation Leo is well seen. (Plate 13.2).

13. Some remarks on future aurora work in Greenland.

For future expeditions it would be most interesting to get simultaneous pictures from two or more stations for getting the height and situation of the aurora. Such pairs of stations should be placed all over Greenland especially in the north western part near the magnetic axis of the earth, near Smith Sound.

If it is impossible to erect pairs of stations, photographs from single station might also be of great value to get the point of radiation of auroral corona and to map the situation of auroral arcs (HA) supposing for the lower border a height between 90 and 120 km. Of special interest arcs over the magnetic axis.

¹) I am indebted to the director ROLF KJÆR for lending us these maps.

²) In (GP) this picture was reproduced on Plate 4, but the time was erroneously written 00.09.19 instead of 00.02.54.

As to cameras, modern pocket cameras as Leika, Contax etc. with objective F2 or better, and film like Agfa ISS, as used in Mørkefjord 1938-39 and by myself¹⁾ in Oslo in 1935, might be used instead of the usual aurora camera.

14. Acknowledgements.

Before ending this report I want to express my hearty thanks to the following persons and institutions:

To the Norwegian French expedition, in particular to Comte MICARD and Mr. WILLY KNUTSEN for permission to use the aurora negatives taken during the expedition.

To the leaders of the "Dansk Nordøstgrønlands Ekspedition 1938-39", EBBE MUNCK and EIGIL KNUTH for permission to use the aurora films taken simultaneously in Mørkefjord, and to Engineer V. SØLVER for sending me these films and necessary information about them.

To the foundation "Det videnskabelige Forskningsfond av 1919" for grants in connection with the measurement of the aurora negatives.

To Mr. HATLEVIK for excellent work during the expedition, and for detailed reports sent me of his aurora observations and photographs.

To my assistant OLAV EGEBERG for the measuring of all the plates, and to Mr. ØSTVOLD, Mr. STORDAL, Mr. NYDAL and Miss KJENNERUD for assisting me in measuring plates and in preparing tables and drawings.

¹⁾ Geofysiske Publikasjoner, Vol. XI, no. 9, § 7.

P. S. Errata in the paper: Results of the photogrammetric Measurements of the Aurora Borealis during the Norwegian-French Polar Expedition to North-East Greenland 1938-1939, Geofysiske Publikasjoner Vol. XIII, no. 13.

I take the opportunity to correct here some errata in my first report on the expedition.

In the Aurora log made by Mr. HATLEVIK, p. 8-18, on the days December 28, 29, 30, January 17, 24, February 14 and 15, instead of snow fog read snow drift.

In Table 4, on December 17, picture 5.30, point 3, the numbers 4.7, 478 and 128 for p, D and H have to be corrected to 3.7, 600 and 169 with corresponding correction on Fig. 11. On Fig. 20 in the present report this has been corrected.

In Table 4, January 9, no. 2.10 the time shall be 22.31.25 instead of 22.30.23.

In Fig. 5, the situation of the Aurora no a, on December 17, 22.09.56 GMT was wrong. On Fig. 14 in this report it has been corrected. Moreover f is written instead of b, and b instead of f.

In § 18, p. 40 the time of picture S. 17.10, January 15 shall be corrected from 00.09.19 to 00.02.54. Same paragraph instead of "Marked on Fig. 10 as No. 26" read "Marked on Fig. 12 as No. 26".

In the Explanations of the Plates in Pl. 4, no 6 correct the time 00.09.19 to 00.02.54.

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Plate 1.

Upper picture.

Aurora photographed from Micardbu, on December 17, 1938 at 22.09.56 GMT
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Lower picture.

The same Aurora, photographed from Koldevey. (K 30).

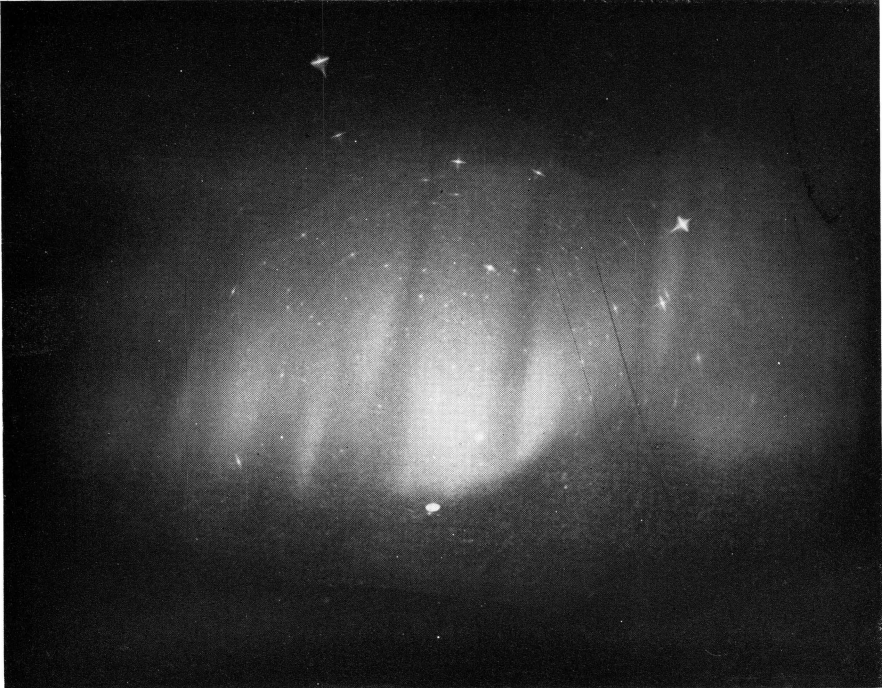


Plate 2.

Upper picture

Aurora photographed from Micardbu on January 9, 1939, at 22.31.25 GMT (M 10).

Lower picture.

The same Aurora, photographed from Mørkefjord (S 15, 3 A).

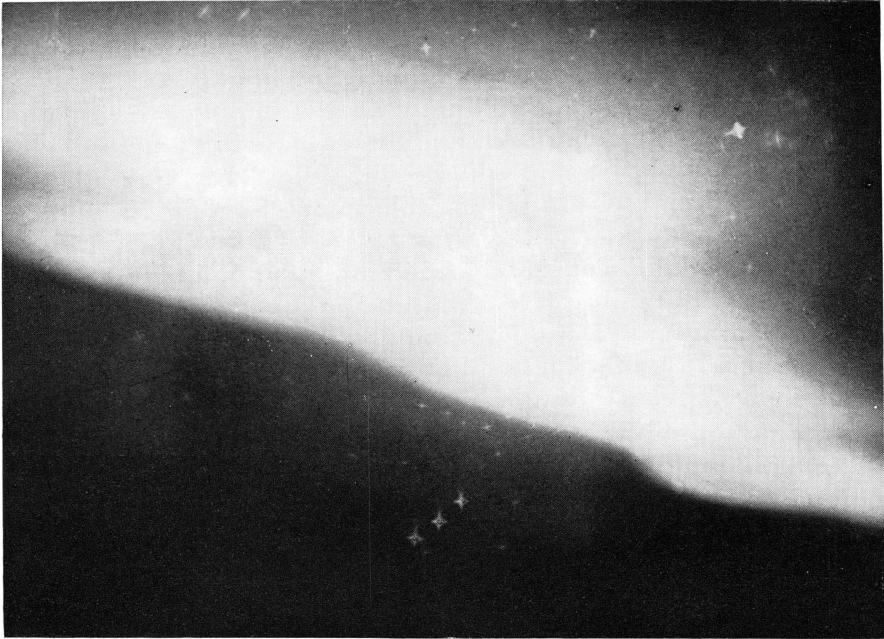


Plate 3.

Upper picture.

Aurora photographed from Micardbu, on January 9, 1939, at 22.54.14 GMT (M 21).

Lower picture.

The same Aurora, photographed from Mørkefjord (S 15, 13 A).

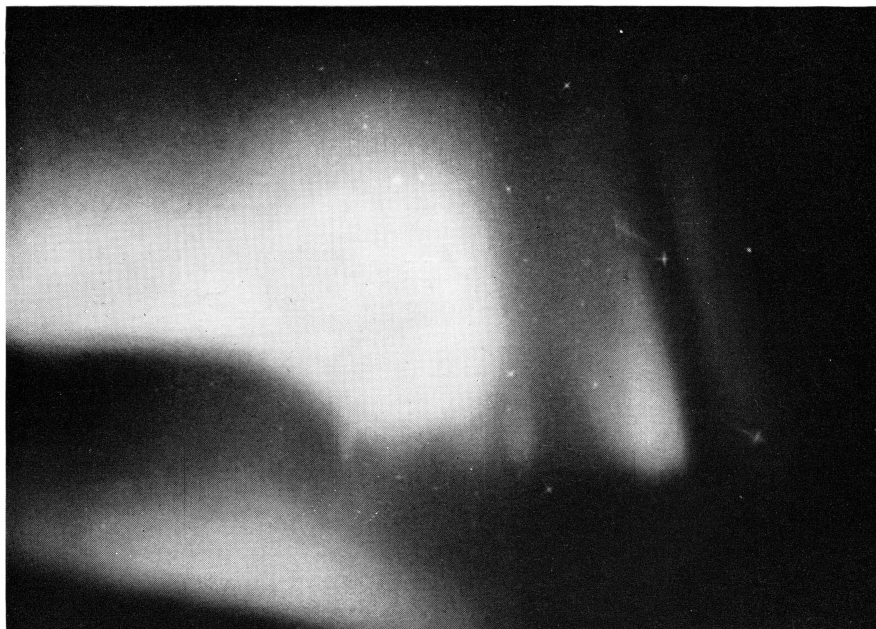


Plate 4.

Upper picture.

Aurora photographed from Micardbu on January 9, 1939 at 23.57.18 GMT (M 41).

Lower picture.

The same Aurora, photographed from Mørkefjord (S 15, 33 A).



Plate 5.

Upper picture.

Aurora photographed from Micardbu on January 14, 1939, at 22.13.08 GMT (M 9).

Lower picture.

The same Aurora photographed from Mørkefjord (S 16, 13).



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Upper picture.

Aurora photographed from Micardbu on January 14, 1939 at 22.16.32 GMT (M 12).

Lower picture.

The same Aurora photographed from Mørkefjord (S 16, 17).



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Upper picture.

Aurora photographed from Micardbu, on January 14, 1939, at 22.22.24 GMT (M 17).

Lower picture.

The same Aurora, photographed from Mørkefjord (S 16, 21).

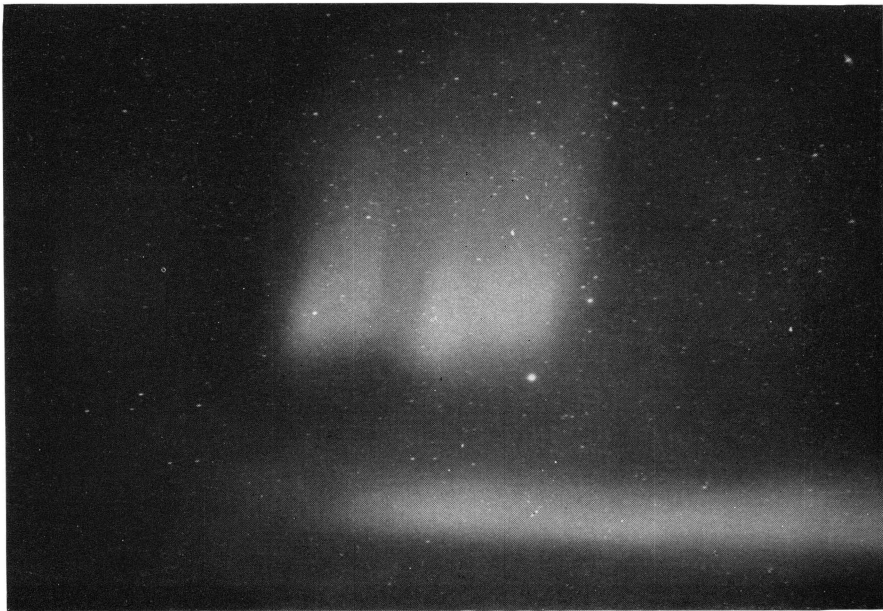
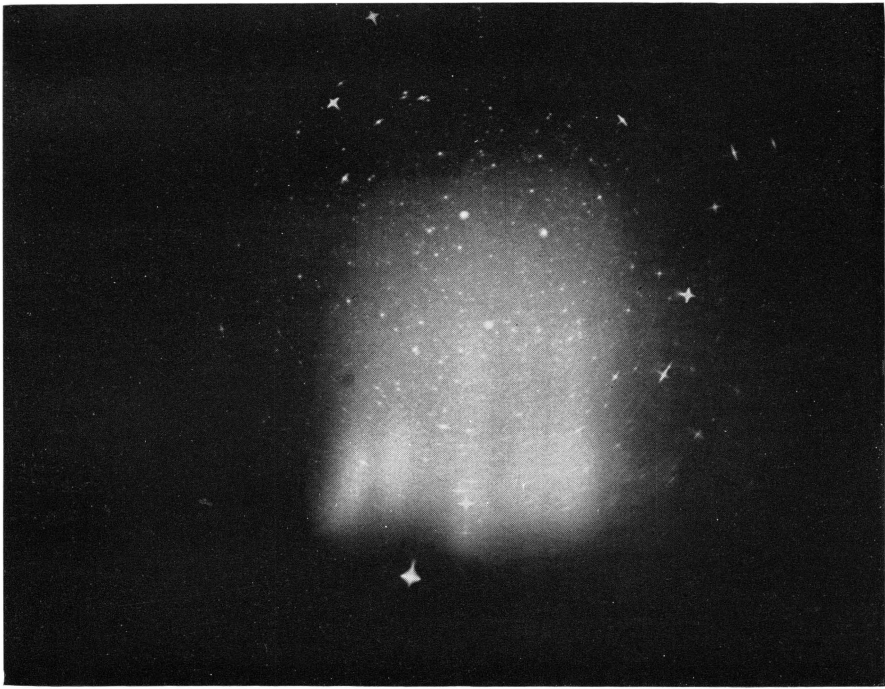


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Upper picture.

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Lower picture.

The same Aurora, photographed from Mørkefjord (S 17, 9).

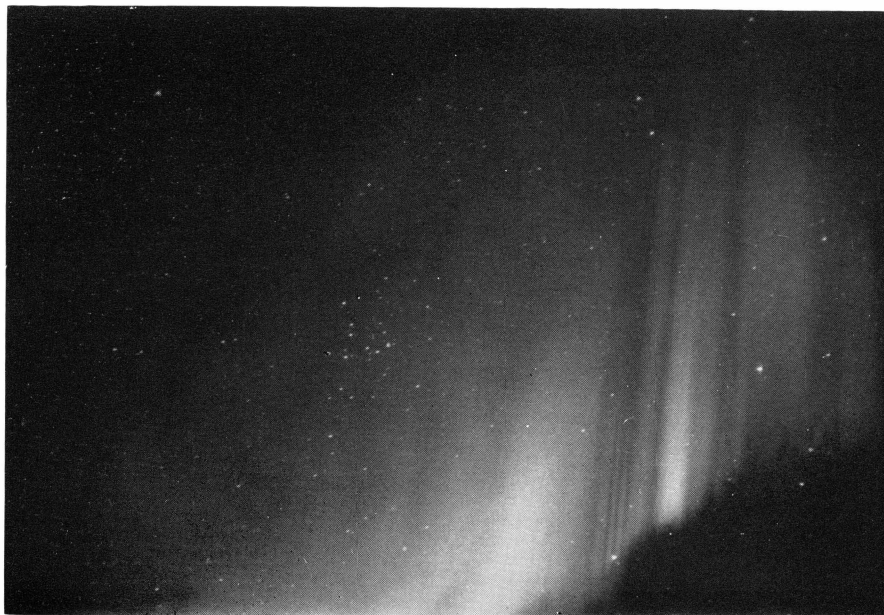


Plate 9.

Upper picture.

Aurora photographed from Micardbu on January 15, 1939, at 00.03.38 GMT (M 48).

Lower picture.

The same Aurora photographed from Mørkefjord (S 17, 11).

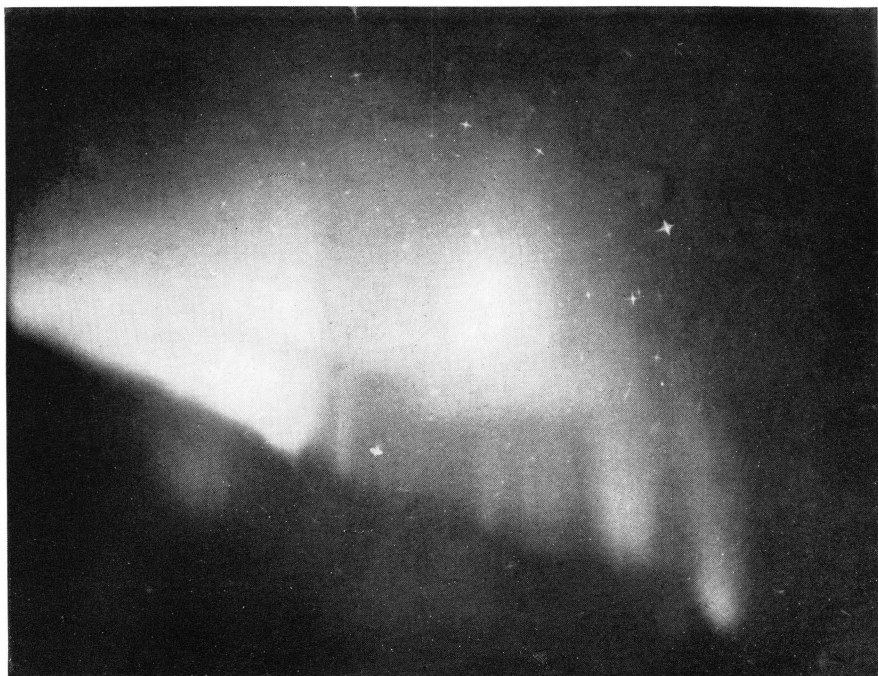


Plate 10.

Upper picture.

Aurora photographed from Micardbu on February 17, 1939 at 21.34.51 GMT (M 13).

Lower picture.

The same Aurora photographed from Koldevey (K 13).



Plate 11.

Upper picture.

Aurora photographed from Micardbu on February 17, 1939 at 22.04.48 GMT (M 34).

Lower picture.

The same Aurora photographed from Koldevey (K 34).

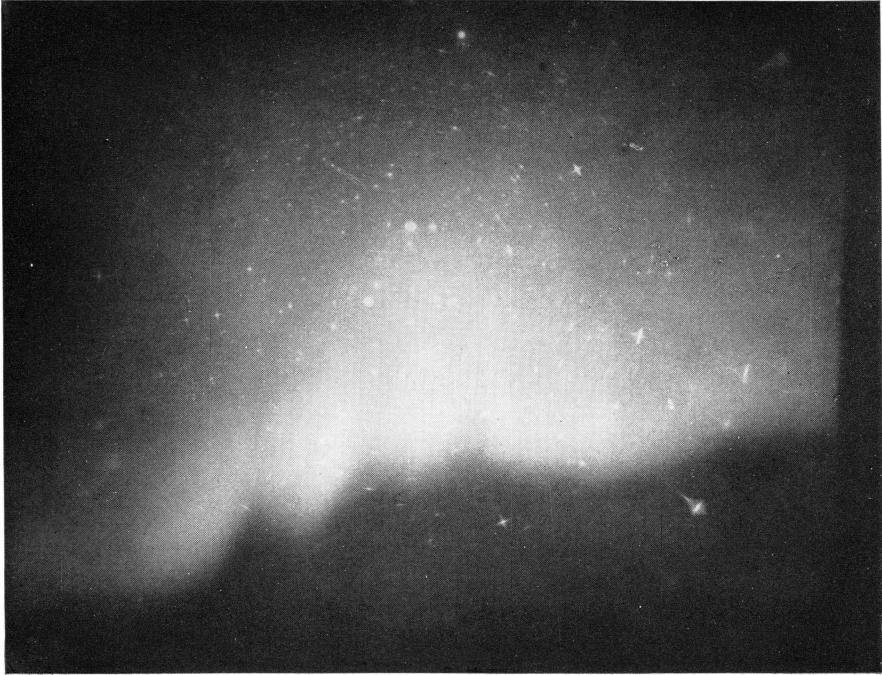
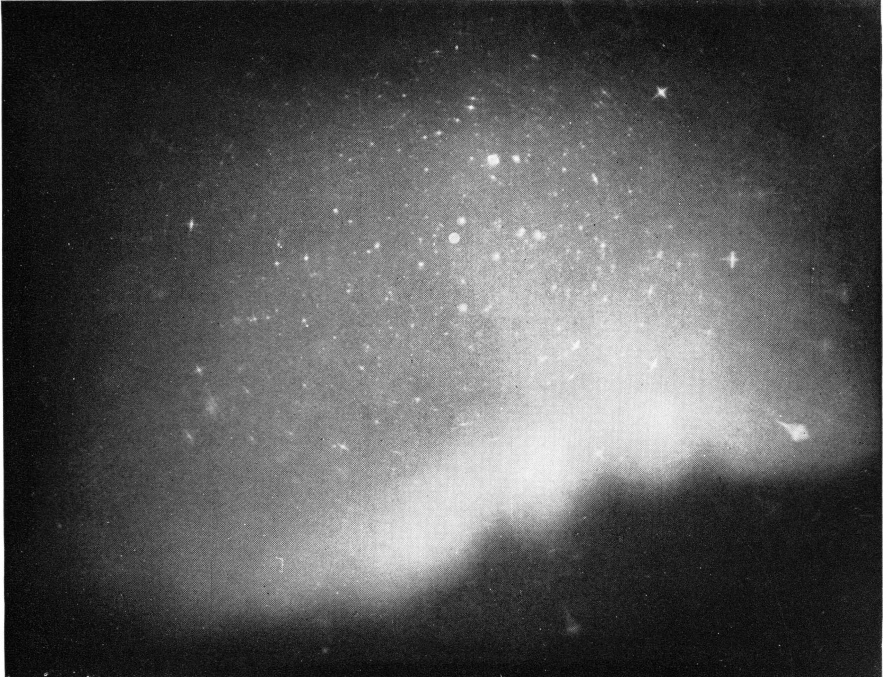


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Upper picture.

Aurora photographed from Mørkefjord on January 9, 1939 at 22.51.27 GMT (S 15,
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Lower picture.

Aurora photographed from Mørkefjord on January 9, 1939 at 23.23.35 GMT (S 15,
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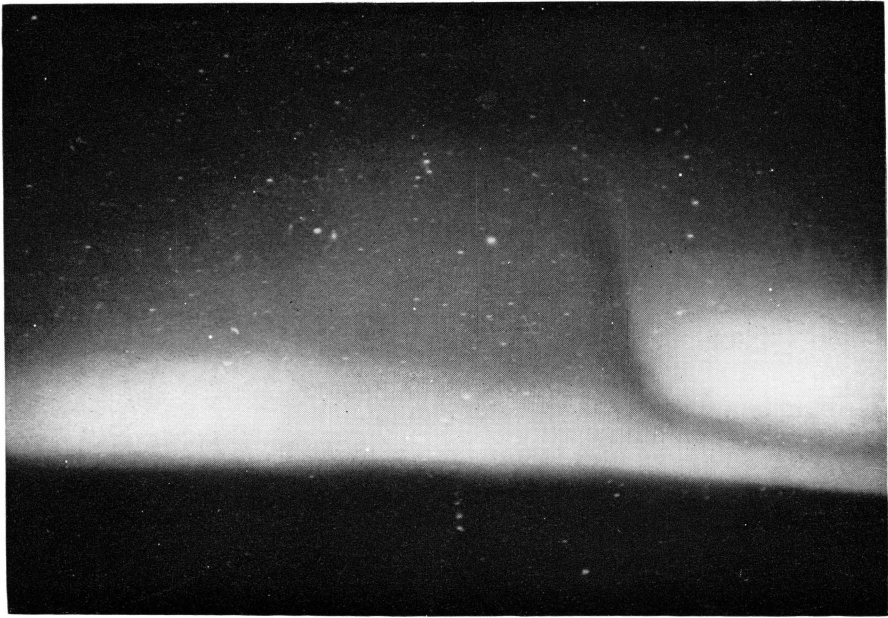


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Upper picture.

Aurora photographed from Mørkefjord on January 14, 1939, at 22.11.50 GMT
(S 16, 12).

Lower picture.

Aurora photographed from Mørkefjord on January 15, 1939, at 00.02.54 GMT
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