TEST OF THE OMEGA NAVIGATION SYSTEM AND OF A COMBINED LORAN A/C RECEIVER

by the Navigational and Electronics Departments
of the Royal Danish Navy
and
the Royal Danish Hydrographic Office

IBH Note. — This article is a slightly condensed abstract of a report received from the Royal Danish Navy.

The report contains a total of 64 graphs and plots but only 25 of these have been included in this article by way of examples of the measurements carried out.

The tests took place between 1 May and 1 October 1969 in Danish Home Waters, the Atlantic Ocean off the Faeroe Islands, and off the west coast of Greenland.

The purpose of the measurements was an attempt to evaluate the accuracy of both the Omega radio navigation system and the combined Loran A/C receiver when used within 15 nautical miles of the coast line.

OMEGA NAVIGATION SYSTEM

Two single frequency Omega receivers (PICKARD and BURNS) were placed at the Royal Danish Navy's disposal from 1 May to 1 October 1969 by the U.S. Navy's Omega Navigation System Project Office, Washington, D.C.

Lane identification was not possible, but read-out of three phase differences could be made simultaneously to within 1/100th of a lane.

The receivers were provided with Rustrak recorders which continuously recorded the three chosen phase differences.

The tests took place in three areas :

1. Danish Home Waters, with a fixed monitor in Frederikshavn (57°26′N - 10°32′E).

2. Davis Strait, off the west coast of Greenland, with a fixed monitor in :

   a) Godthaab (64°10′N - 51°44′W)
   b) Groennedal (61°14′N - 48°07′W)

3. Atlantic Ocean, off the coast of the Faeroe Islands, with a fixed monitor in Thorshavn (62°01′ N - 6°46′ E).

The tests included :

1. Measuring skywave correction (SWC) at the fixed monitor site, and a comparison of the measured with the tabulated SWC.

2. Testing the navigational positioning accuracy of the system in the above areas by direct measurement with a shipborne receiver. Readings were corrected using the tabulated SWC.

3. Testing the navigational positioning accuracy of the system with the readings in paragraph 2 above, using observed SWC at the fixed monitor. (The differential method).

COMBINED LORAN A/C RECEIVER

A combined Loran A/C receiver (Furuno Loran Type LC-1, made in Japan) was placed at the Royal Danish Navy's disposal by "International Ship's Radio", Copenhagen, between 1 June and 15 September 1969.

The tests took place in two areas :

1. Coastal waters off the west coast of Greenland;
2. Coastal waters off the coast of the Faeroe Islands.

They comprised :

1. Greenland : accuracy tests of the receiver for both Loran A and Loran C.
2. Faeroe Islands : accuracy tests of the receiver for Loran C.

ESTABLISHMENT AND USE OF A FIXED MONITOR

One of the Omega receivers was used as the fixed monitor station. The antenna was installed in a position previously computed in Omega coordinates. Readings were taken regularly at 2-hour intervals, except during the periods where measurements were taken for observation of the SWC or for checking the navigational accuracy. During these particular periods readings were taken at 15-minute intervals.

The readings at 2-hour intervals consisted of six signals from each pair of stations and the mean of the readings was recorded as well as GMT.

The readings at 15-minute intervals were taken continuously for over 72 hours and consisted of six signals from each pair of stations. The readings commenced 30 seconds before and ended 30 seconds after $H + 0^m$, $H + 15^m$, $H + 30^m$ and $H + 45^m$, the mean of the six readings thus corresponded exactly to the GMT 15-minute intervals.

The observed readings were compared with the computed values and the difference was named Observed Skywave Correction (OBS SWC). These values were used in three ways :

1. They were plotted as graphs to show the observed skywave correction at the fixed monitor site.

2. The observed SWC was subtracted from the tabulated SWC and the result was plotted as a graph, thus showing if there was any constant difference.

3. The observed SWC was used on readings taken on the ship-borne receiver (the differential method).

INSTALLATION AND USE OF SHIP-BORNE RECEIVERS

An Omega receiver and the combined Loran A/C receiver were installed in a naval ship with their antennae placed on the top of the wheelhouse.

Readings and control positioning were carried out as follows : Simultaneous readings were taken on the Omega and the Loran receivers at H + 0^m, H + 15^m, H + 30^m and H + 45^m G.M.T. At the same time the ship position was established by horizontal sextant angles and/or radar range measurements to points ashore, the accuracy aimed at being less than 100 metres. The ship was therefore at anchor where ever possible, or else steaming as slowly as possible.

The Omega readings were corrected for SWC since both tabulated SWC for the area (the direct method) and observed SWC at the fixed monitor site (the differential method) were being used.

In the waters around the Faeroe Islands when observing with Loran C it proved difficult for the operator to distinguish between the groundwave and the skywave signals. All the positions were therefore computed twice: firstly, from the readings as if both signals had been groundwave signals, and secondly, after the readings had been corrected for the value given on the Loran C chart of the area. The two computations were named Loran Groundwave and Loran Skywave.

COMPUTATION AND PLOTTING METHODS

The final computation and plotting were as follows :

1. Danish Home Waters

Control positions by Decca observations using Danish Decca charts.

Omega positions computed at the U.S. Naval Oceanographic Office.

Loran positions were not observed.

Differences between the control and the Omega positions were plotted by hand at the Navigational Department of the Royal Danish Navy (NAV).

b) *Differential Omega*

MDE = 0.5 n.m.
SD = 0.4 n.m.

The range from monitor to ship-borne receiver seems to have no bearing on the accuracy. The apparently constant error observed during Direct Omega has now disappeared. This is due to the fact that the errors at both monitor and receiver are equal. This is the great advantage of using the differential method.

The results would have been better if noise level had been less. In general the scatter of the signals was 5 centilanes.

c) *Loran A*

MDE = 5.4 n.m.
SD = 5.8 n.m.

The large error, and the fact that it was only possible to receive signals for one third of the total number of measurements attempted, is probably the result of the ship being too close to shore (maximum distance = 6 n.m.).

While the ship was underway between the Faeroe Islands and Greenland simultaneous Omega and Loran A observations were made, and differences of 3-5 n.m. were noted between the two systems.

d) *Loran C*

MDE = 4.8 n.m.
SD = 5.3 n.m.

The reception of Loran C signals was better, and measurements were achieved for two-thirds of the total number attempted. This, together with the short distance to shore (a maximum of 6 n.m.) is probably the reason for the large scatter.

While the ship was underway between the Faeroe Islands and Greenland Loran C observations were compared with simultaneous Omega observations. The difference was observed to be 2-3 n.m.

3. Faeroe Islands

In the Faeroe Islands area observations were grouped into time intervals to try to see if there were any connection between the accuracies for daytime, night-time, and the transition periods.

For Omega these periods were taken from the graphs of observed SWC. Day and night-time periods were those where there was no significant change in the SWC. The remaining time was made up of the transition periods.

Day period	10 - 20 GMT
Night period	00 - 06 GMT
Transition periods	06 - 10 GMT and
	20 - 24 GMT

For Loran the periods were determined by sunrise and sunset times for the area :

Sunrise	0535 GMT
Sunset	1915 GMT

Thus :

Day period	07 - 18 GMT
Night period	21 - 04 GMT
Transition periods	04 - 07 GMT and
	18 - 21 GMT

a) *Direct Omega*

1. Day period :
   MDE = 0.7 n.m.
   SD = 0.6 n.m.
2. Night period :
   MDE = 1.4 n.m.
   SD = 0.3 n.m.
3. Transition periods :
   MDE = 1.0 n.m.
   SD = 0.6 n.m.

The large scatter in an NW-SE direction is caused by the large lanewidth (27 n.m.) for B-D. The scatter around A-B and A-D is much less (0.5 n.m.).

The new station D in Minnesota will improve the geometric configuration. The new lanewidth is expected to be less than half the present B-D width. The future site for a station in Japan will also give more possibility of choice of phase difference combinations.

b) *Differential Omega*

1. Day period :
   MDE = 0.4 n.m.
   SD = 0.3 n.m.
2. Night period :
   MDE = 0.9 n.m.
   SD = 0.4 n.m.
3. Transition periods :
   MDE = 0.4 n.m.
   SD = 0.2 n.m.

The increase in MDE during the night period is due to the "night effect".

The large scatter in the NW-SE direction is caused by the large B-D lanewidth, and by a high noise level at the monitor station (about 5 centilanes).

c) *Loran C*

The operators were untrained and did not find it possible to obtain an exact classification of the measured signal, and so in view of the uncertainty as to what correction to apply, computations for both sky and ground waves were made.

1. Groundwave

   a) Day period :
      MDE = 1.1 n.m.
      SD = 0.7 n.m.

   b) Night period :
      MDE = 3.8 n.m.
      SD = 1.3 n.m.

   c) Transition periods :
      MDE = 2.1 n.m.
      SD = 1.4 n.m.

2. Skywave

   a) Day period :
      MDE = 2.8 n.m.
      SD = 0.7 n.m.

   b) Night period :
      MDE = 2.3 n.m.
      SD = 1.3 n.m.

   c) Transition periods :
      MDE = 2.3 n.m.
      SD = 0.8 n.m.

It is assumed that the signal from the Master station is a groundwave signal. The range to the Master is less than 60 n.m. The classification of the Slave signal is more difficult, but we have worked on the assumption that a groundwave signal is measured in the daytime, and a skywave signal at night-time, while during the transition periods both signals were measured.

On this basis the following accuracy has been achieved for Loran C in the Faeroe Islands area :

a) Day period :
   MDE = 1.1 n.m.
   SD = 0.7 n.m.

b) Night period :
   MDE = 2.3 n.m.
   SD = 1.3 n.m.

c) Transition periods :
   MDE = 2.2 n.m.
   SD = 1.2 n.m.

CONCLUSION

Direct Omega

The tests showed that the system can be used in the North Atlantic region and in the Davis Strait for both oceanic and coastal navigation, since when passing the Greenland icecap there appeared to be no adverse effect on signals. An accuracy of 1 n.m. (day) and 2 n.m. (night) can be assumed.

The moving of station D and the establishment of a station in Japan will improve the system in these areas. A further improvement will be Omega lane charts at larger scale, since the present 1/2 188 800 charts are not sufficiently accurate for navigation in coastal waters.

Differential Omega

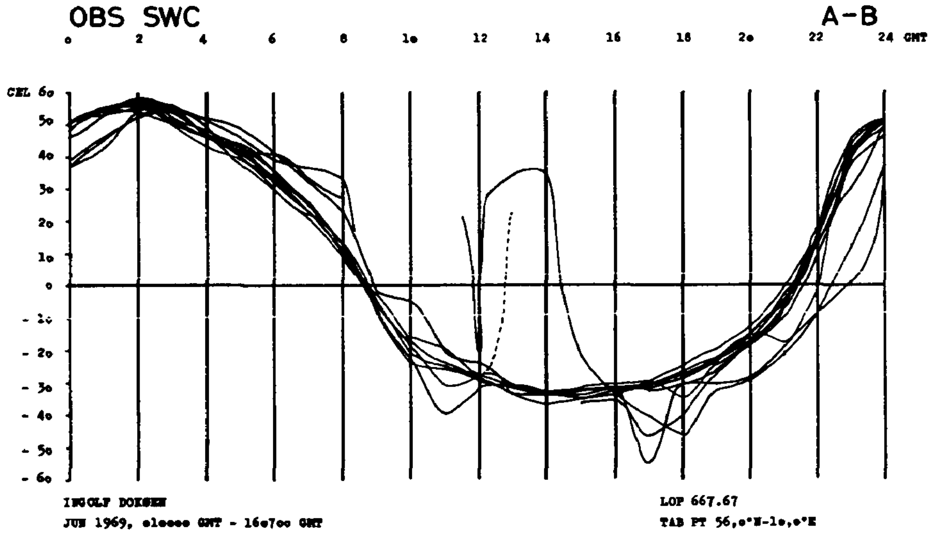
By the establishment of a fixed monitor site ashore a great improvement in accuracy can be achieved in certain areas for special purposes.

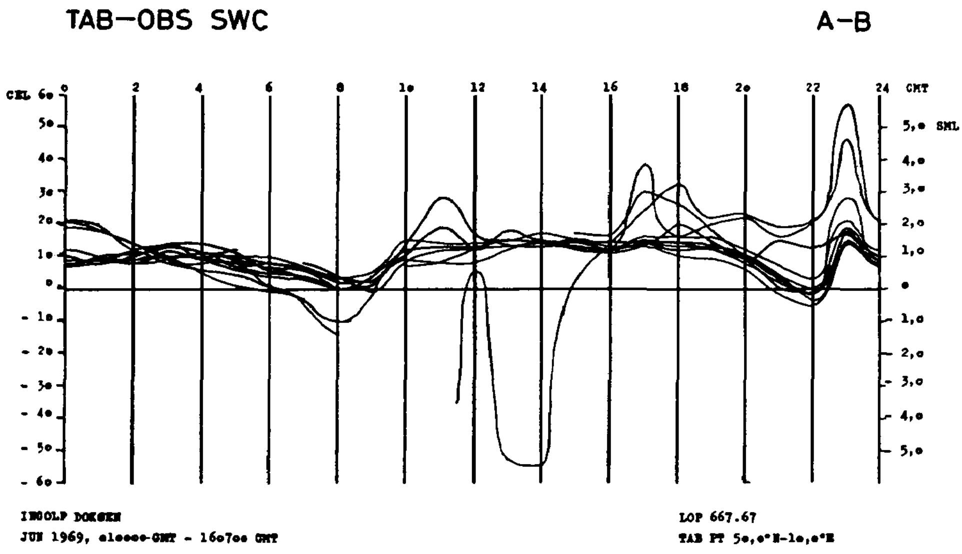
The accuracy of 0.5 n.m. during the daytime up to a range of 200 n.m. can be improved to about 0.25 n.m., after station D has been moved and is transmitting with maximum power, by improving the fixed monitor station installation, by better instrumentation and by using larger scale charts.

Loran A/C

The combined receiver can be used in the North Atlantic region and in the Davis Strait where there is Loran coverage provided the position is more than 20 n.m. from the coast. The accuracy of 1-2 n.m. obtained with Loran C off the coast of the Faeroe Islands is likely to decrease as the range to the Master station increases.

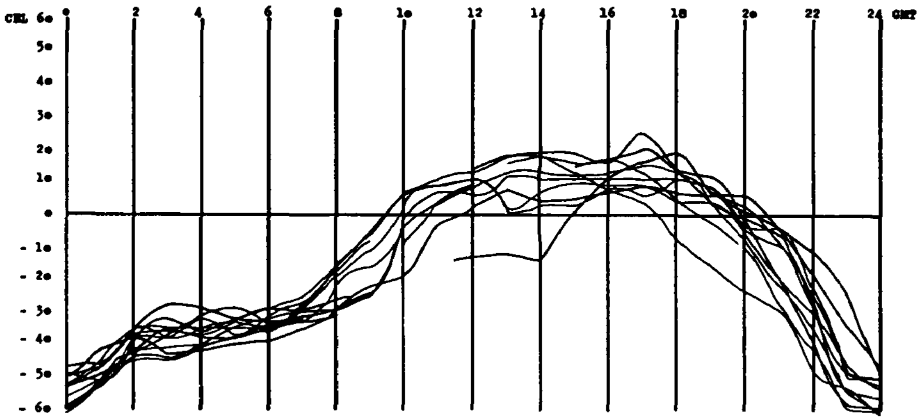
An improvement in the Loran system can be achieved through the publication of SWC tables as is already the case with the Omega system. An improvement in charts is also necessary.





Note. — For the first ten pairs of graphs, the upper shows the observed sky wave correction in hundreths of lane over 24 hours, and the lower the difference between the tabulated and the observed sky wave correction at the same place and for the same period.

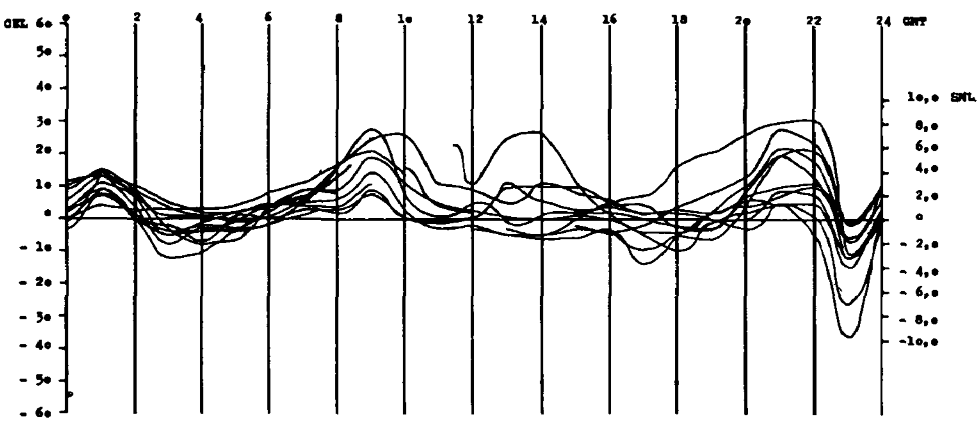
OBS SWC B–D



INGOLF DOKSEN
JUN 1969, 010000 GMT - 160700 GMT

LOP 967.71
TAB PT 56,0°N-10,0°E

TAB–OBS SWC B–D



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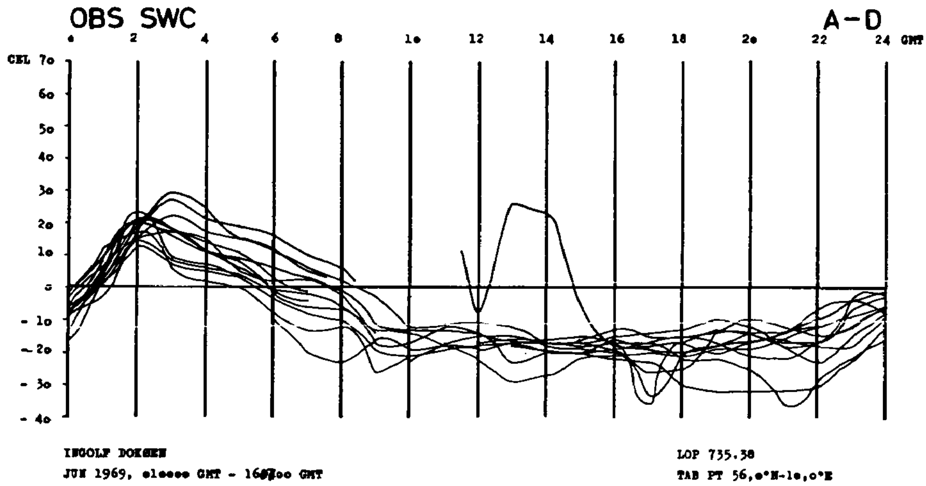
OBS SWC
A-D
GMT
CEL
INGOLF DOKSEN
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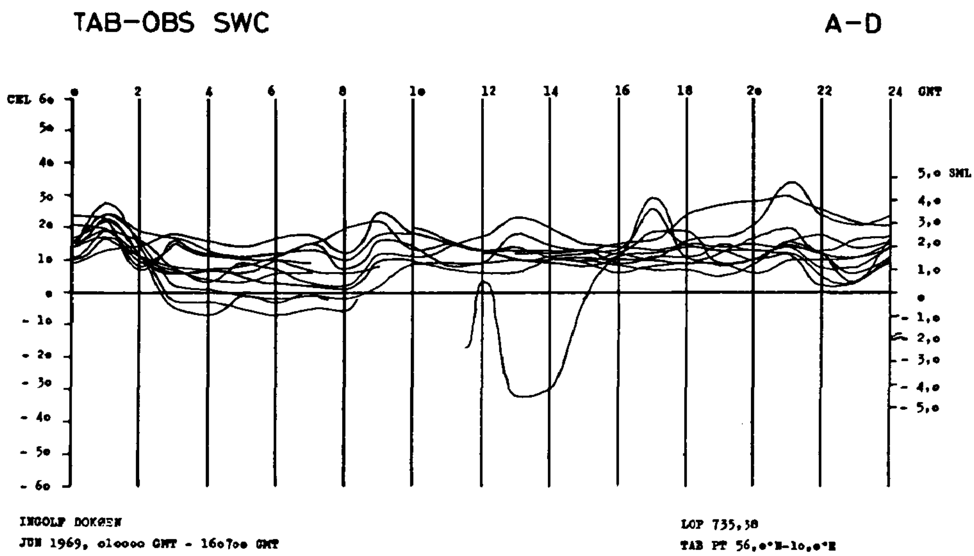
LOP 735.38
TAB PT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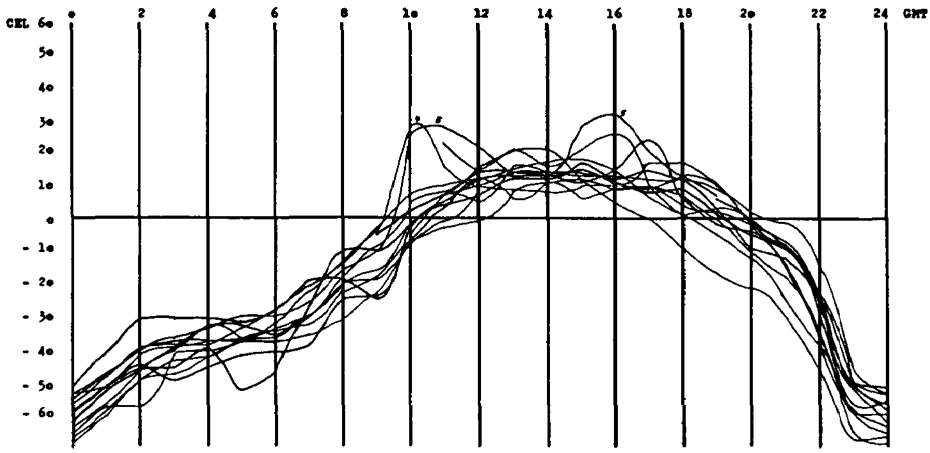
OBS SWC B-D



FREDERIKSHAVN
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LOP 971,10

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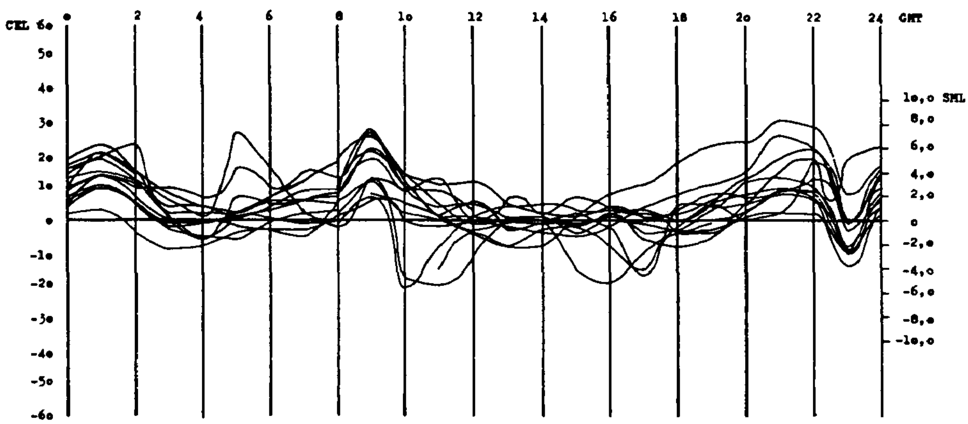

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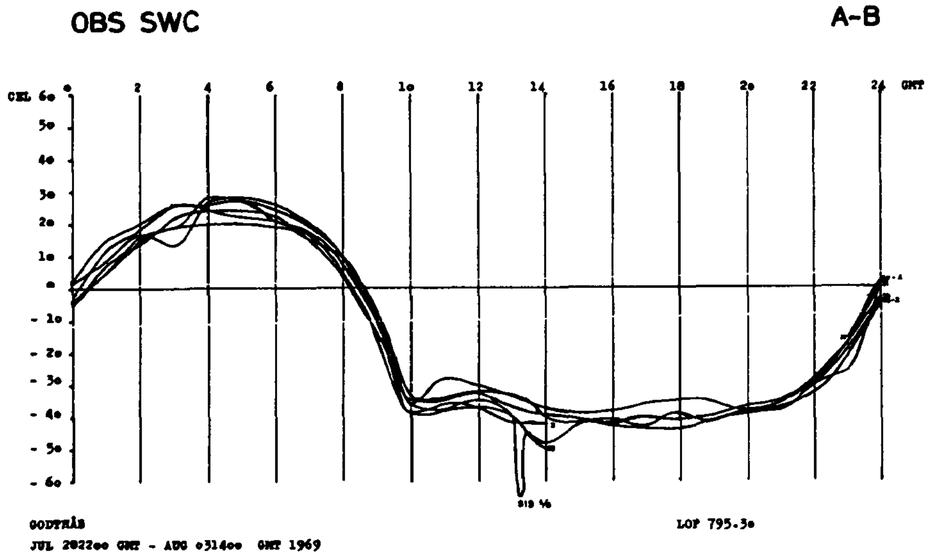
OBS SWC
A-B
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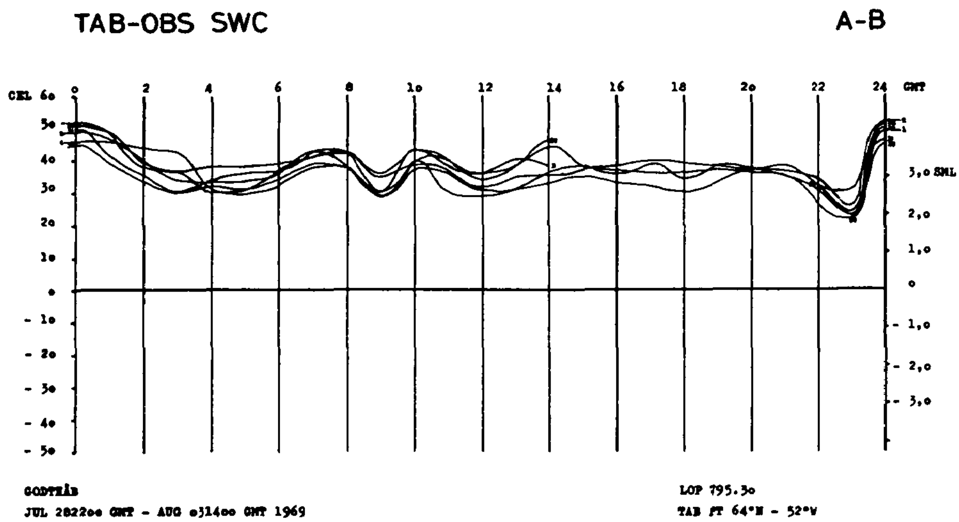
JUL 2022oo GMT - AUG o314oo GMT 1969
LOP 795.3o


TAB-OBS SWC
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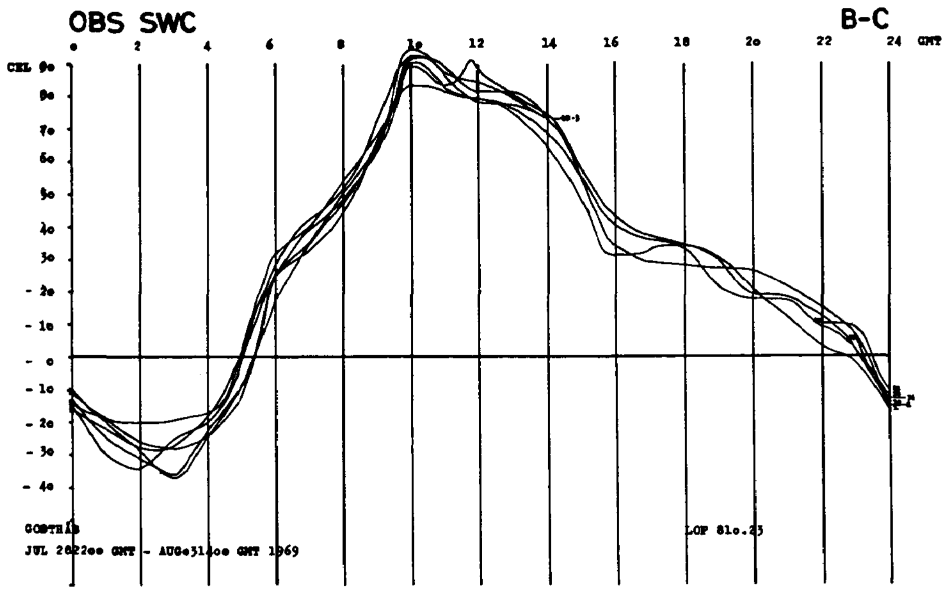
TAB FT 64°N - 52°W


OBS SWC
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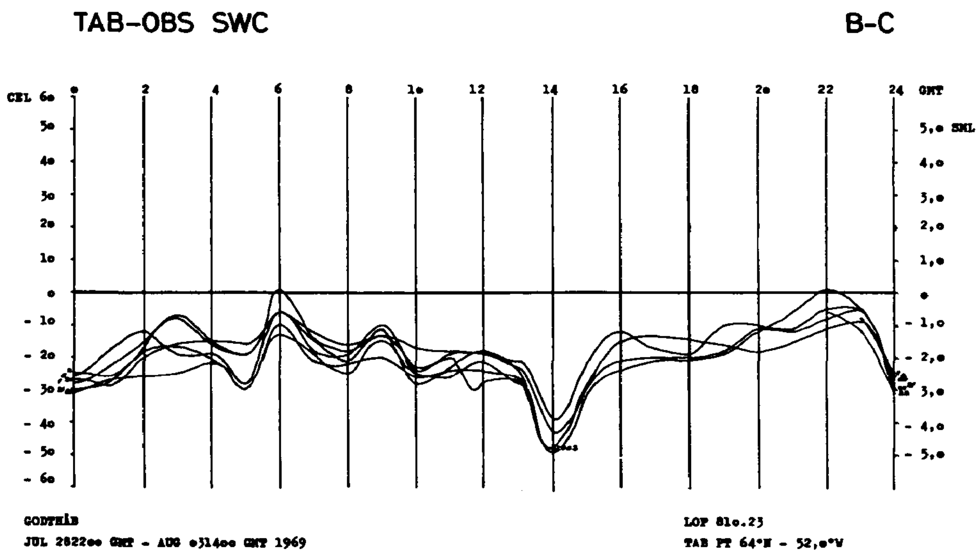
LOP 81o.23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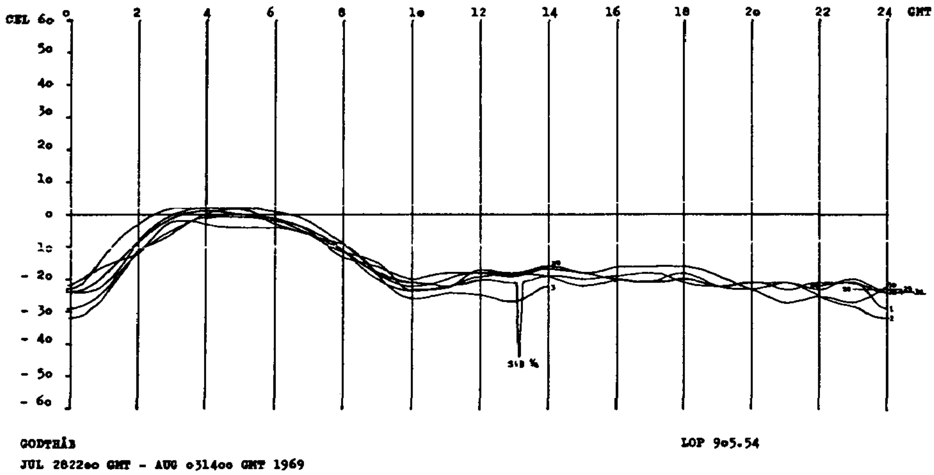
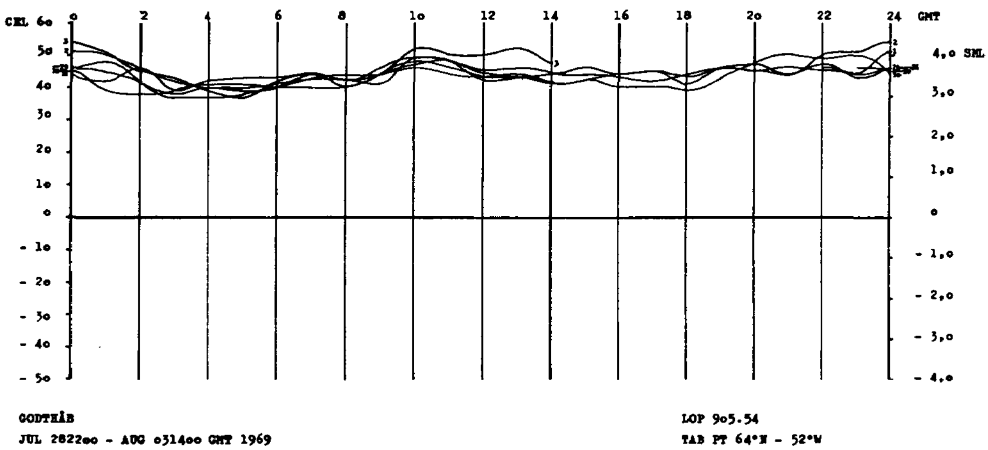
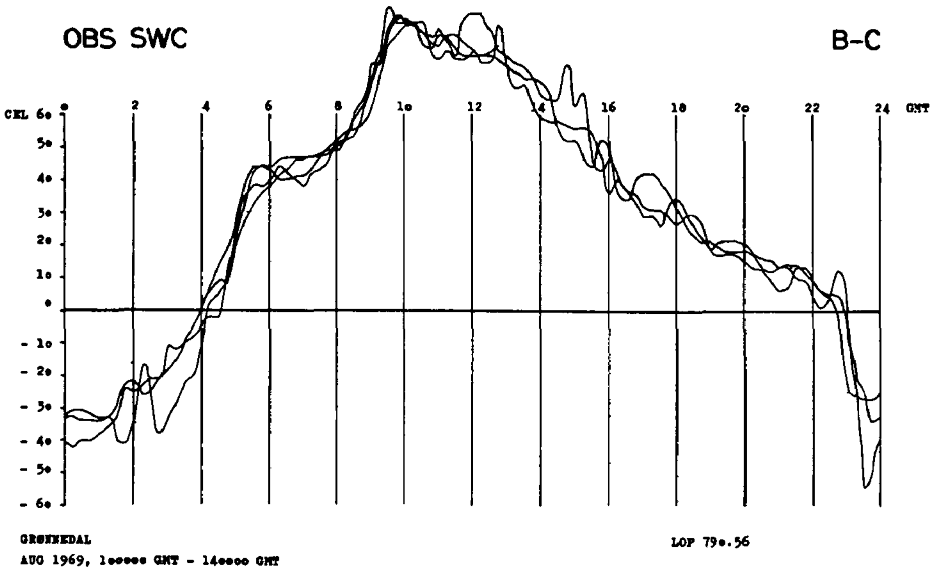
TAB PT 64°N - 52,o°W

OBS SWC A-D



TAB-OBS SWC A-D




OBS SWC
B-C
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GRØNNEDAL
AUG 1969
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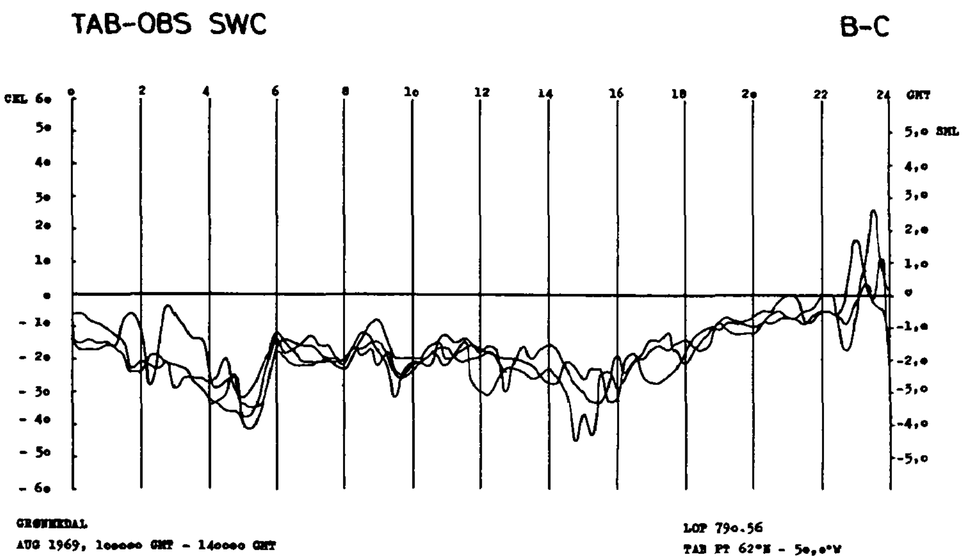
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B-C
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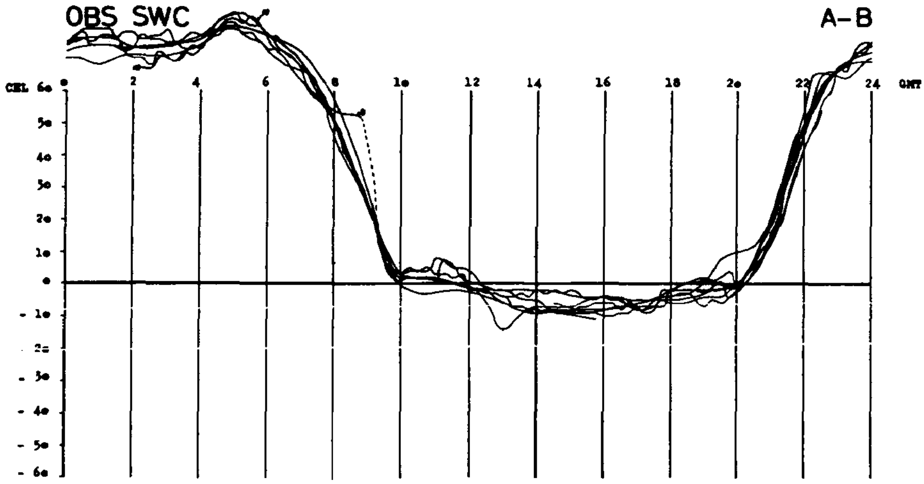
TAB PT



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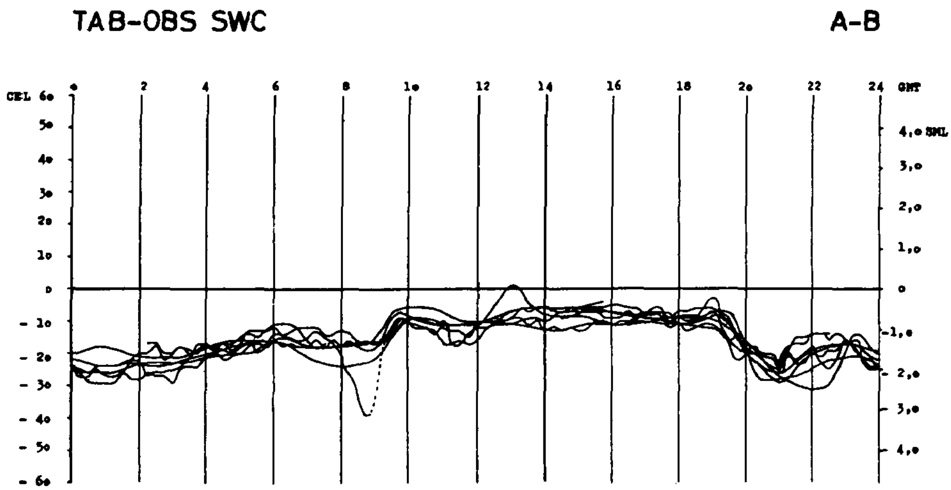

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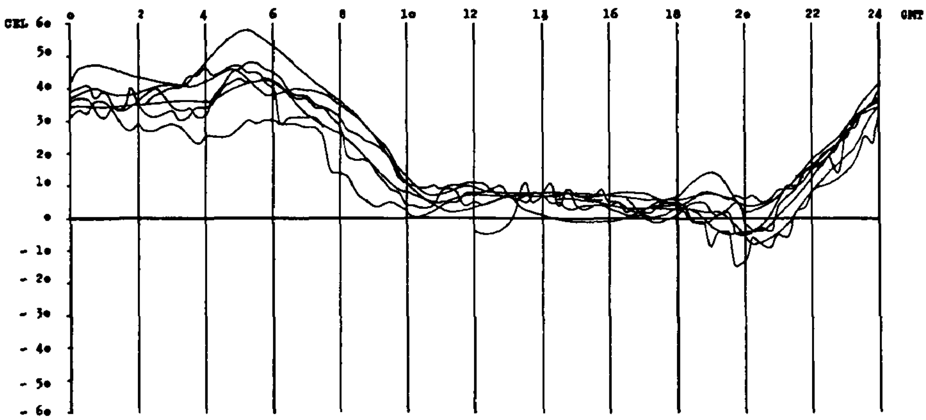
OBS SWC A-D



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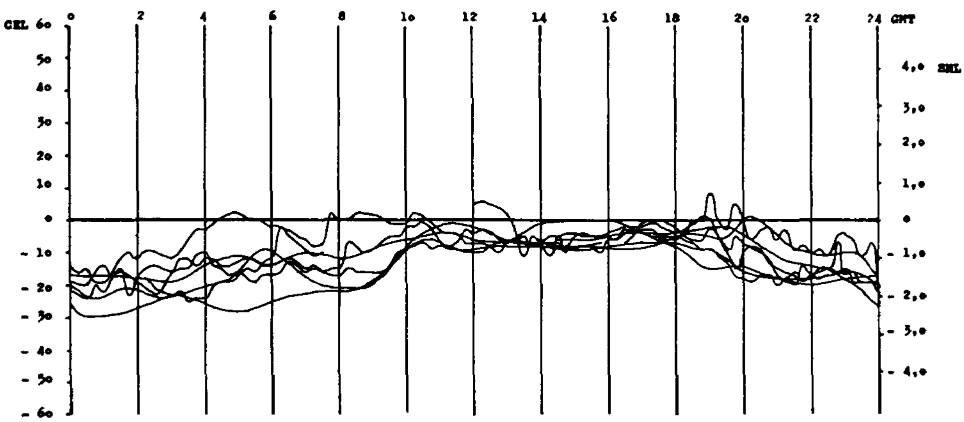

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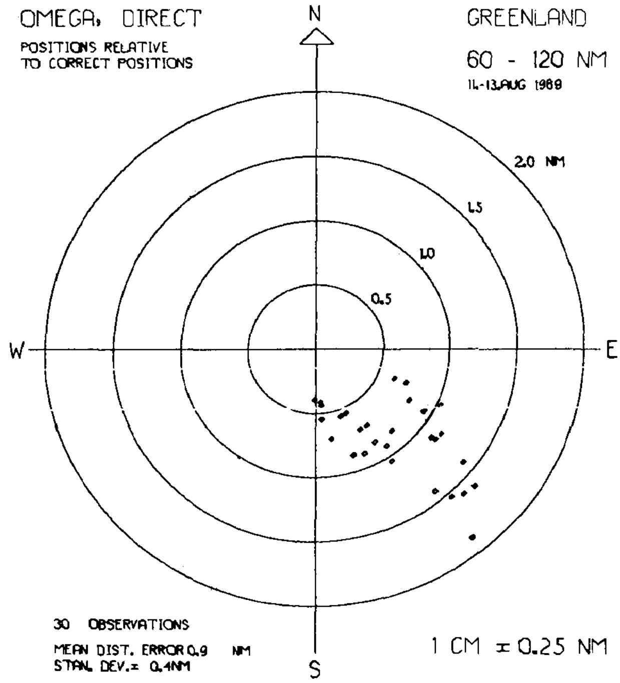
OMEGA, DIRECT
POSITIONS RELATIVE
TO CORRECT POSITIONS
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2.0 NM
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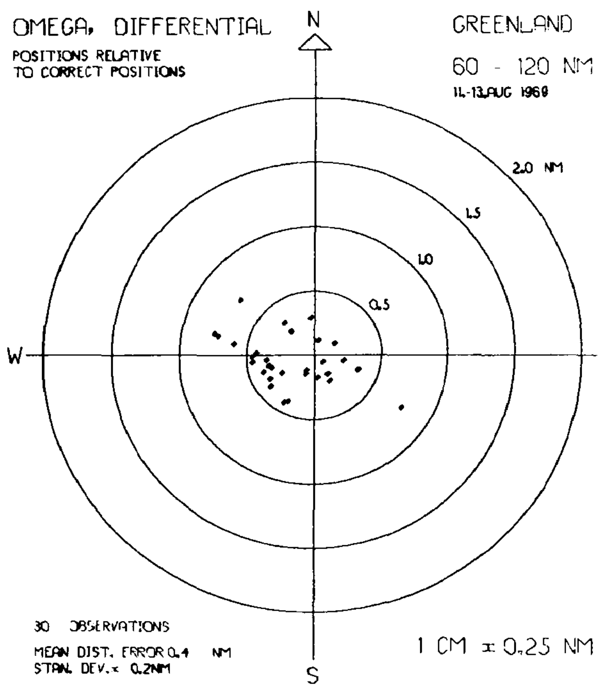
OMEGA, DIFFERENTIAL
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11-13 AUG 1969
2.0 NM
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30 OBSERVATIONS
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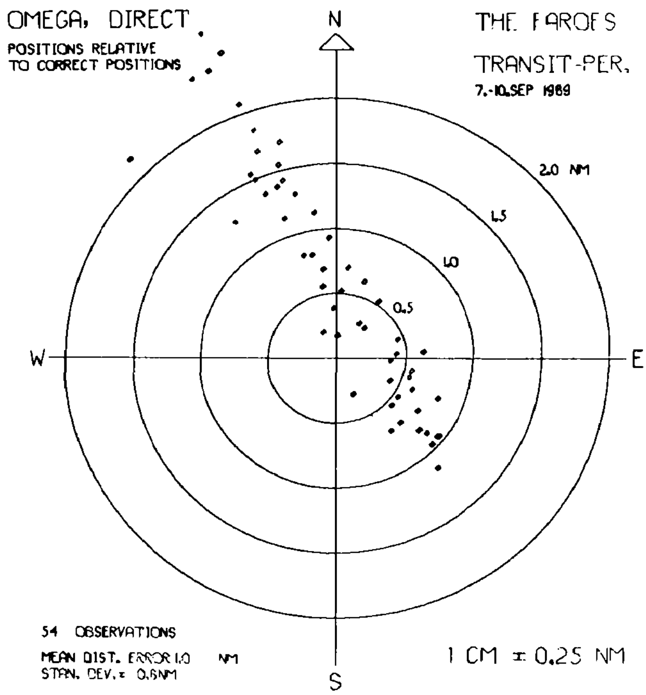
1 CM = 0.25 NM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2.0 NM
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54 OBSERVATIONS
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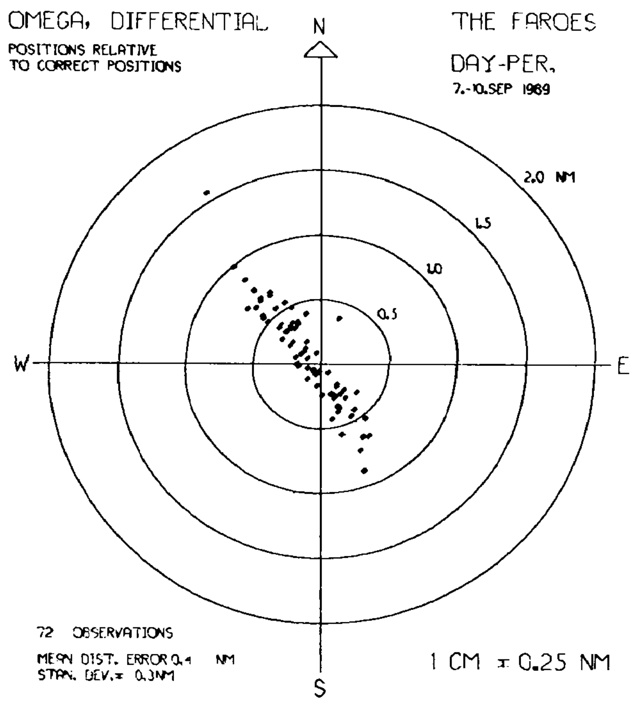
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POSITIONS RELATIVE
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DAY-PER.
7.-10.SEP 1969
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1.5
1.0
0.5
W
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S
72 OBSERVATIONS
MEAN DIST. ERROR 0.4 NM
STAN. DEV. = 0.3NM
1 CM = 0.25 NM

FREDERIKSHÅB — RAVNS STORØ VESTGRØNLAND